Helsinki Institute of Physics – the first twenty years 1996-2016

Mikko E. Sainio

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Front cover:

A cross section of the open CMS detector. The image is an edited version of the CERN/CMS photo gallery image CMS-PHO-GEN-2008-028.

Back cover:

The path integral for the quantum action S.

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Contents

PREFACE

The Helsinki Institute of Physics was created in 1996 by merging three institutes in two universities. The form of governance, as a joint institute of two universities, was new in Finland. The main motivation for the new organization was the scope of the activity at CERN, of which Finland became a member in 1991. The purpose was to exploit the opportunities brought by CERN membership in the field of science and technology as efficiently as possible by combining the resources of the two universities in certain fields of physics research and technology development. An additional justification for the new institution was the effort to improve the conditions for high-level basic research more broadly than just particle physics. Continuity of the activities and traditions of the Research Institute for Theoretical Physics (TFT) was an important element towards that goal. There was also an aim to have more effective coordination of physics activities when they involved broader national research and economics importance. Graduate education has been one of the topics of importance.

How to measure the success of a research institute for physics? There are several aspects to that: scientific articles in high-impact journals, the number of completed MSc and doctoral thesis projects, patents, spin-off companies, the amount of external funding, the career development of the research staff of the institute, and, of course, institute's contribution to major scientific discoveries. The Helsinki Institute of Physics has, in addition, the responsibility for Finland's scientific collaboration with CERN, Geneva, and of the Finnish activities at the Facility for Antiproton and Ion Research (FAIR) under construction in Darmstadt, Germany.

Of the first twenty years of operation of the Helsinki Institute of Physics, I was involved in an administrative role for a little over 17 years. At the time of my retirement at the beginning of September 2016, I thought that I could, maybe, write something about it on the basis of my experience. During the approximately three years in the beginning of operation and the years before that, when the ideas for the new institute were developed, I was not involved, nor was I particularly well informed about the plans. There, I have based my discussion on documents alone – no interviews were made. That may lead to an underestimate of the amount of effort that went into the preparation phase and omission of some essential details in creating a new research organization.

During the process of writing this document many people have been very helpful. Especially I wish to thank Keijo Kajantie and Jorma Tuominiemi for their continuous encouragement. In addition, Jorma has read the whole manuscript and made many useful comments. His book on the five first decades of experimental particle physics in Finland has in addition been a very useful source of information on the CMS activity. Numerous persons have commented on sections of the text, provided checks on details or helped to find photos. Especially I would like to thank Juha Aaltonen, Tapio Ala-Nissilä, Riku Hakulinen, Ari-Pekka Hameri, Taina Hardén, Matti Heikkurinen, Jouni Heino, Christina Helminen, Eva Isaksson, Laura Karppinen, Tuija Karppinen, Heidi S. Kinnunen, Hannu Kurki-Suonio, Katrianne Lehtipalo, Tomas Lindén, Taina Onnela, Antti Pirinen, Dan-Olof Riska, Sami Räsänen, Tarja Sandelin, Minna Toivonen, Wladyslaw Trzaska, Eija Tuominen, Antti Väihkönen, David Weir, Juha Äystö, and Kenneth Österberg. Any remaining inaccuracies are, of course, solely the responsibility of the author. Furthermore, I wish to thank Dr Christopher TenWolde for his valuable help in improving the language of the text. Photos are from the HIP photo archive unless otherwise specified. Financial support of the Magnus Ehrnrooth Foundation is gratefully acknowledged.

Helsinki, November 24, 2023

Mikko Sainio

THE BIRTH OF HIP

On July 26, 1996, the President of Finland, Mr Martti Ahtisaari, ratified legislation (Finlex 560/1996) that established a research institute of physics operating at the University of Helsinki. On the same day, a presidential decree (561/1996) was issued that specified the mission and governance of the new institute. The legislation entered into force on September 1, 1996.

New legislation was needed because the university laws in Finland did not recognize institutes that were jointly administered by several universities. The new research institute of physics was created as a joint unit of the University of Helsinki and the Helsinki University of Technology. The university legislation was later modified (645/1997 entering into force on 1.8.1998) to allow for jointly administered institutes more generally.

The new research institute of physics started operations on 1.9.1996 and soon assumed the name Helsinki Institute of Physics (HIP, Fysiikan tutkimuslaitos, Forskningsinstitutet för fysik). The new institute merged three existing units in the founding universities: the Research Institute for Theoretical Physics (TFT, Teoreettisen fysiikan tutkimuslaitos) and the Research Institute for High Energy Physics (SEFT, Suurenergiafysiikan tutkimuslaitos) of the University of Helsinki, with the Institute of Particle Physics Technology (HTI, Hiukkasteknologian instituutti) of the Helsinki University of Technology.

Background

The Research Institute for Theoretical Physics (TFT) was founded in 1964 as a separate institute of the University of Helsinki; i.e., it was not part of the science faculty, but an independent institute directly under the Consistorium of the University. The aim of the institute was to conduct research in theoretical physics, support graduate education, and promote co-operation in research, both at the national and international level. The national role of the institute was ensured from the beginning by the representation of other universities on its Board. TFT turned out to be remarkably successful despite its relatively modest financial resources. The institute brought Finland to the forefront of research in specific areas

and trained generations of future professors in theoretical physics and physics. The Institute was formally closed at the end of January 1997, as its activities had been transferred to the new institute, HIP, already in the autumn of 1996.

Research in experimental particle physics started in Finland in the 1960's, at first on an ad hoc basis at CERN and a little later at JINR (Dubna). The Department of Nuclear Physics of the University of Helsinki, headed by professor K.V. Laurikainen, took the leading role in this activity. A detailed account of the developments was published in 2018 by Jorma Tuominiemi (in Finnish) "Kuplakammiofysiikasta Higgsin bosoniin – Suomalaisen kokeellisen hiukkasfysiikan viisi ensimmäistä vuosikymmentä" (From bubble chamber physics to the Higgs boson –The first five decades of the Finnish experimental particle physics). In 1975, professor Laurikainen proposed in a letter to the Faculty of Science the conversion of the Department of Nuclear Physics into a separate high-energy physics research unit directly under the Consistorium of the University. The main motivation was to secure the continuity of the field in the university. The Consistorium of the University asked a committee, chaired by professor J.J. Lindberg, to prepare a detailed proposal. In its report the committee suggested founding a research institute for high energy physics, but the Consistorium decided at the end of 1977 that a new institute should not be established at that stage. Research activity continued at the Department of High Energy Physics, the new name of the Department of Nuclear Physics, including the highly visible participation in the UA1 experiment at CERN. The department also became involved with the construction of the DELPHI detector at LEP (the Large Electron-Positron Collider), including an industrial contribution; therefore, in 1987 the Ministry of Education set up a working group, led by academician Pekka Jauho, to discuss the status and possible extension of the collaboration between Finland and CERN. In its report (OPM 1987:43) the working group did not recommend membership at CERN, but rather starting negotiations with CERN for a long-term agreement on participation in specific projects. The report contained, in addition, a recommendation to establish a research laboratory in experimental high-energy physics to co-ordinate the collaboration with CERN. However, soon afterwards the political will for full CERN membership started to grow, and finally materialized in the beginning of 1991. As a consequence the need for a research laboratory became apparent, and the Research Institute for High Energy Physics (SEFT) was established in 1990 as a separate unit. Most of the

teaching positions remained in the Department of High Energy Physics of the Faculty of Science. The details of the steps that led to the CERN membership are set out in Tuominiemi's book.

In anticipation of the forthcoming CERN membership, the Helsinki University of Technology also established an institute in 1990, the Institute of Particle Physics Technology (HTI), in order to co-ordinate the university's CERN activities. The focus of the activities was on the development of advanced technologies that would be applicable at CERN and by the Finnish industry. Once HIP was established the institute was closed at the end of 1996.

Experimental particle physics involves the design and construction of sophisticated particle accelerators and detector systems and, therefore, technological development forms an integral part of the work. In 1990 a company, Cerntech Oy, was founded by a number of technology development and innovation organizations of Finnish universities and the state in order to promote technology transfer and business relations between Finland and CERN and other leading science organizations.

In the early 90's Finland experienced a severe economic recession; the GNP fell from 1990 to 1993 by 11 %. This, together with the wider push to improve the efficiency of the government, forced the universities to look in detail at their spending structure. At the University of Helsinki, working groups led by Vice-Rector Arto Mustajoki published the reports "Universitas Renovata" (1993) and "Universitas Renovata Continuata" (1994), with detailed assessments of the university's structure and resources. These reports recommended the merger of the two independent institutes, TFT and SEFT, into one research institute for physics, amongst other things. Initially both institutes, TFT and SEFT, and their staffs did not welcome such a development. Both of the institutes invited high level international evaluation panels to evaluate their research activities. TFT was evaluated in April 1993 by E. Brézin and R.J. Glauber, both famous physicists. The report was very positive, and the main concern related to the possible merger with SEFT was the scope of theoretical research and its independence in the future. SEFT was evaluated in June 1993 by a prestigious panel consisting of G. Charpak, S. Kullander, L.M. Lederman, H. Schopper, and S.C.C. Ting. Their evaluation of the research, technology development, and education was also very positive. Both institutes, TFT and SEFT, were able to demonstrate the high quality of their individual

work and question the benefits of the proposed merger. As a consequence the process ended in a stalemate, even though another working group, led by Vice-Rector Mustajoki, had outlined in their September 1993 report the modus operandi for the merged institute and drafted the applicable Regulations. In an attempt to advance the process, professors Paul Hoyer, Keijo Kajantie, and Juhani Keinonen of the Department of Physics wrote a letter to the Rector of the University of Helsinki in June 1994 encouraging a new start of the negotiations on the merger of the two institutes, also taking into consideration the cooperation with other Finnish universities.

Contacts between the rectors of the University of Helsinki (UH), the Helsinki University of Technology (HUT), and the Ministry of Education paved the way for a survey of the possibility of establishing a joint institute between the two universities. The Vice-Rectors Arto Mustajoki (UH) and Toivo Katila (HUT) were given the task of promoting the merger, and they held a Town Meeting in early 1995 to discuss the prospects for a new national physics research institute. In particular, the views of the physics departments of other universities were sought for. The meeting took place on 12.1.1995 and 33 individuals participated, including representatives of the Universities of Joensuu and Jyväskylä as well as the Tampere University of Technology in addition to scientists from the University of Helsinki and the Helsinki University of Technology. A working group was set up to write a report on the issues raised in the meeting. Professor Juhani Keinonen (UH) was chosen as the chair, and the members were professors Risto Nieminen (HUT), Kimmo Kaski (Tampere University of Technology), and Juha Äystö (University of Jyväskylä). The report, dated 9.2.1995, stated that the merger of the three existing institutes - TFT, SEFT, and HTI – could promote improvement in both physics research and graduate education. In the beginning, the focus should be on subatomic and materials physics. Research at large international infrastructure centers and related technology development would be the core activity for the new institute. The report also contained a roadmap of the necessary steps towards achieving a joint organization. Based on the report, in spring 1995 the University of Helsinki proposed, in connection with the annual target negotiations with the Ministry of Education, the establishment of a joint research institute with the Helsinki University of Technology.

The Helsinki University of Technology had the activities of the HTI evaluated in early 1995. Dr Hannu I. Miettinen was given the task of

analyzing the activities and plans of the HTI, as well as the prospect of merging the HTI with the University of Helsinki institutes TFT and SEFT. The report was published on 15.3.1995, and supported the proposal of the universities for a joint research organization but emphasized the importance of national coordination and a flexible form of governance.

In May 1995 the Rectors of the universities, Risto Ihamuotila (UH) and Paavo Uronen (HUT), invited, on the initiative of the HTI director professor Eero Byckling, professor Jorma Routti, President of SITRA and the Chair of the SEFT Board, to work out a proposal outlining the tasks, structure, administration, and funding of the new institute. Routti invited Dr Erkki Pajanne as the secretary for his one-man fact-finding group. The report was published on 6.9.1995, and proposed the merger of the three existing institutes into a new physics research institute with special responsibility for the collaboration with CERN. A proposal for the administrative structure was given, and a draft for the Regulations was provided. Routti furthermore proposed that a specific independent advisory committee should be formed to advise the institute board on scientific matters. It was also noted that the funding level should correspond to the funding of the three existing institutes together. Furthermore, the staff situation at TFT and SEFT was analyzed. In the summer of 1995 professor Routti was nominated for the Director General position at the European Commission DG XII – Science, Research and Development, starting in January 1996, which gave particular weight to his proposal. On the basis of Routti's report, in the autumn of 1995 the universities made the decisions to aim for a joint institute created from a merger of the three existing institutes.

Independently of these on-going discussions, in April 1995 the Ministry of Education gave academy professor Olli V. Lounasmaa the task of working out proposals for the structural development of the research and education within the exact sciences and related technologies, as well as assessing the possibilities for cost savings and resource reallocations in Finland. The report, "Huippuyksikköä ei perusteta vaan se syntyy" (OPM 3:1996; A center-of-excellence cannot be founded but is born), was published on 30.1.1996. The section of the report discussing the proposed joint institute was available already in October 1995. In the report, Lounasmaa considers a new research organization in a specialized field to be a very rigid approach for allocating research funds. The CERN-related research funds should, according to Lounasmaa, be distributed by a high level panel that would evaluate all of the applications. In addition,

the large number of permanent personnel at SEFT was a great concern for Lounasmaa; in his view the new organization should not have too many staff members with permanent appointments.

On 17.11.1995, the Ministry of Education set up a working group to prepare for the establishment of a joint research institute of physics between the University of Helsinki and the Helsinki University of Technology on the basis of Routti's proposal. Counsellor of Higher Education Juhani Hakkarainen (Ministry of Education) was appointed as the chair, and the membership consisted of the Vice-Rectors Arto Mustajoki (UH) and Toivo Katila (HUT) as well as the Director of Administration Esa Luomala (HUT), Quaestor Marja Nikkarinen (UH), Senior Counsellor Ulla Lång (Ministry), Senior Officer Marja Pulkkinen (Ministry), and Legal Counsel Olli Muttilainen (UH). The task of the group was to clarify and concretize the proposal of professor Routti, in particular from the point of view of the administrative, economic, and legislative aspects. In its report (OPM 14:1996) dated 13.2.1996, the working group proposed that a joint research institute for physics should be founded by a merger of the three existing institutes, TFT, SEFT, and HTI, and that the new institute should operate in connection with the University of Helsinki. The annual funding level should be about 21 Mmk, corresponding the sum of the budgets of the merged institutes. In addition, the working group drafted the law and decree regarding HIP. In May 1996, the Government sent the proposed legislation to the Parliament. During the parliamentary deliberations, the Education and Culture Committee emphasized in its report the possibility of such a development that the institute would in the future act as a joint institute for several universities.

Provisional Board

Once the universities had decided in the autumn of 1995 to establish a new research institute for physics through a merger of the three existing institutes, the preparations started in early 1996 with the appointment of a provisional board. The members of the Board, appointed by the universities, Ministry, and staff meetings, were Vice-Rectors Arto Mustajoki (UH) and Toivo Katila (HUT), professors Juhani Keinonen (UH) and Rainer Salomaa (HUT), Senior Officer Marja Pulkkinen (Ministry of Education) and Dr Katri Huitu (staff representative); Olli Muttilainen served as Legal

Counsel. The first meeting took place on 14.3.1996. Dr Erkki Pajanne was invited to be the secretary of the Board. In addition, a steering group was formed to draft the Rules of Procedure for the new institute, to plan the evaluation of the future research, and to plan the budget and staff. The directors of the existing institutes, professor Eero Byckling (HTI), director Risto Orava (SEFT), and professor Stig Stenholm (TFT), were invited to comprise the group, and Doc. Erkki Pajanne and administrative manager Jukka Petänen were invited to participate as secretaries. The provisional Board appointed Eero Byckling as the Finnish representative in the spring meeting of the ATLAS and CMS Resource Review Boards (RRB). The name Helsinki Institute of Physics appears for the first time in the nomination letter sent to the CERN Research Director on 15.4.1996. The name was tentatively approved in the provisional Board meeting on 5.6.1996. In the same meeting, the Finnish representation in the CERN Council was discussed. The view of the Board was that HIP should have a role in the CERN Council; i.e. the scientific delegate should come from the Institute or from the Board. Furthermore, in the same meeting the provisional Board established a working group to clarify the breadth of the detector research and development. Professor Juhani Keinonen was appointed as the chair of the working group. The final meeting of the provisional Board was on 13.8.1996, when the draft for the Rules of Procedure was approved for the Board to decide on. The permanent discussion topics in the provisional Board were the research and budget planning as well as the role of the personnel of the three existing institutes in the new organization. External experts (Lorenzo Foà, CERN; Jarl Forstén, VTT (Technical Research Centre of Finland); Henrik Stubb, Åbo Akademi; Juha Äystö, University of Jyväskylä) were invited to assess the research plan for 1997.

Regarding the election of the staff representative to the Board, the Rector's decision was issued on 21.8.1996 (182/96) and the election took place at the turn of the month. Dr Katri Huitu was elected to represent the staff in future Board functions. By the time of the start of the new institute the staff meetings of the three institutes - TFT, SEFT, and HTI – had given their approval for the new organization.

Research at HTI, SEFT, and TFT

The CERN activities of the HTI (Hiukkasteknologian instituutti) focused on topics where the technical expertise on the Helsinki University of Technology and its industrial contacts were relevant. The most important contributions were to the model design and construction of the LHC superconducting dipole magnet, to the SMC dilution refrigerator, to the CMS central tracker support mechanics, and to the engineering data system TuoviWDM. In collaboration with CERN and University of Uppsala, HTI designed and built a model magnet of the LHC main bending dipole magnets. Tests in 1995 showed that the reduced length prototype achieved the design specification of 10 T without problems. The Low Temperature Laboratory of HUT helped CERN by constructing a dilution refrigerator to achieve the "frozen" spin target needed for the Spin Muon Collaboration (SMC) to measure the spin dependent structure functions of protons and neutrons. The Central Tracker forms the innermost layer of the Compact Muon Solenoid (CMS) detector at the CERN LHC. The mechanical support system of the Tracker has particular requirements concerning rigidity, stability, weight, and radiation hardness. It has to position the detector elements with high precision and remove the generated heat. HTI designed and constructed two prototypes for the support system. Large projects, such as the LHC or particle detectors, require the means to control and manage globally distributed design, engineering, and assembly operations. HTI developed tools for those tasks that eventually led to the TuoviWDM (TuoteVisualisointi, Web Document Management) software.

SEFT (Suurenergiafysiikan tutkimuslaitos) concentrated its efforts largely on e^+e^- physics at LEP at CERN, in particular at the DELPHI detector. The Institute contributed in an important way to the Hadron Calorimeter front-end electronics, data acquisition, and control systems. Part of the DELPHI silicon Microvertex Detector was built by Finnish physicists, who also contributed to its operation. Furthermore, SEFT scientists participated actively in the DELPHI physics analysis, notably in flavor identification in jets and in color reconnection effects. Detector R&D, which started in connection with the DELPHI experiment, developed into a well-equipped laboratory with some unique capabilities, which not only fulfilled its goal of contributing substantially to the DELPHI hardware but also carried out innovative R&D in gaseous and semiconductor detectors and associated electronics (for example Micro-Strip Gas Chambers; MSGC). The CMS

activity of SEFT focused on detector and physics simulation of CMS as well as the development of the general software for simulation and analysis. In particular, the SEFT contribution to the detector simulation was essential for CMS in the design phase. The design and development of the CMS data acquisition system was also pursued.

TFT (Teoreettisen fysiikan tutkimuslaitos) research was organized into three research groups: particle physics, nuclear physics, and solid state physics, covering a broad range of topics. The particle physics group was active in the study of quantum field theories, quantum groups, heavy ion physics, electroweak and QCD phase transitions, and particle physics in the early Universe. The group was also working in mathematical physics, on the theory of integrable quantum systems, in an Academy of Finland funded collaboration project with the Steklov Mathematical Institute, St. Petersburg. The main focus of the nuclear physics group in the early 90's was the quark descriptions of few-body systems using Monte Carlo lattice simulation, and mesonic effects in light nuclei. The activities of the solid state group covered various problems in quantum electronics, statistical physics, materials science, and the application of cluster methods in many-body physics. From the very beginning TFT was also expected to play an important role in graduate education in physics. In the early 70's the joint graduate course program started in the Helsinki area and TFT played an essential role in that activity; later, TFT acted as the coordinating institute for the national program for graduate education in particle and nuclear physics.

BYCKLING ERA

The first steps

The research institute of physics started its operations on 1.9.1996. The start was smooth, and the projects of the three merged units were able to continue their work without any interruption. Financing was secured through the existing budgets of the three organizations. What changed immediately was the governance and administration of the institute. According to the law the institute was established as an independent organization, and not as an independent institution directly under the Consistorium like other research institutes of the University of Helsinki.

The mission and governance of the institute were specified in the presidential decree. The mission of the institute was to carry out and facilitate research in basic and applied physics and to provide graduate education in physics. In addition, the institute was given the responsibility of coordinating the Finnish research collaboration with CERN. Participation in other international research cooperation was also mandated. The board and the director were given the task of managing the institute. The University of Helsinki and the Helsinki University of Technology each appointed two members to the board, the Ministry of Education appointed one member, and the staff of the institute one member. The board was responsible for deciding on the budget, research projects, and the Rules of Procedure as well as on appointing the director. The task of the director was to manage the activities and supervise finances, as prescribed in the Rules of Procedure.

The first meeting of the Board took place on 9.9.1996. The University of Helsinki and the Helsinki University of Technology were both represented by the Vice-Rector and the physics department head, the Ministry of Education selected physics professor Juha Äystö from the University of Jyväskylä, and the staff had elected docent Katri Huitu as their representative. Vice-Rector Arto Mustajoki (UH) was elected as the Chair of the Board, and Vice-Rector Toivo Katila (HUT) as the Vice-Chair. Docent Erkki Pajanne was invited to participate as the secretary of the Board. A number of decisions were made on the basis of the preparatory work of the steering group, which was composed of the

directors of the three institutes, TFT, SEFT, and HTI. The Rules of Procedure were adopted, the research program structure was decided on, and the Director and Administrative Manager together with the Program Directors were appointed. The presidential decree allowed for initially filling the positions without an open search. Professor Eero Byckling was appointed Director of the Institute for a period of three years beginning on 1.9.1996, docent Erkki Pajanne was appointed Administrative Manager for four years. Four research programs were established: the Theory Program, High Energy Physics Program, LHC Program, and the Technology Program. Professor Stig Stenholm was initially appointed for four months to lead the Theory Program, docent Risto Orava for three years the High Energy Physics Program, and Dr Ari-Pekka Hameri for three years the Technology Program. The search for the LHC Program Director was initiated, as was the search for the Finance Manager.

Docent Erkki Pajanne. Administrative Manager 1.9.1996-31.3.1999.

"How can a small country obtain significant visibility in large international projects to justify its participation?" was the question which the new Director, professor Byckling, addressed in the Europhysics News article "Helsinki Institute of Physics: Strengthening National and International Collaboration" (Vol. 29, No. 1 (1998) p. 32). The creation of a new organizational structure, HIP, was one response to this challenge, with the aim of increasing collaboration both between universities and between physics and technology. Another element in the overall picture was the company Cerntech Oy, which promoted the connection between Finnish industry and CERN by, e.g., providing information on calls for tender and initiating joint technology projects. In addition to pooling national resources, other features of the new structure were flexibility and focus, which implied that the Institute was a project organization with fixed-term research projects and fixed-term appointments for the research staff. The selection of projects was based on the topicality of the field and on the assessment of scientific merit. The Board was expected to provide administrative expertise. In addition, the possibility of attracting talented people to form a suitable mix of senior scientists and graduate students was considered to be a key factor in the success of the new institute.

The Rules of Procedure adopted by the Board, in addition to specifying the responsibilities of the Board and the Director in the governance of the Institute, also defined a new body, the Scientific Advisory Board (SAB), to assess the activities of the Institute and provide advice to the Board on scientific matters. Inviting to the Scientific Advisory Board was the task of the Rectors of the University of Helsinki and the Helsinki University of Technology. Furthermore, a Steering Group was established for HIP, which consisted of the Director, the Program Directors, and the Administrative

The HIP Scientific Advisory Board in 1997: J. Steinberger, B.H. Wiik, J. Iliopoulos, K. Ahlström, H. Wenninger, and N. Kroo.

Manager. The main task of the Steering Group was to assist the Director in planning and preparing the activities and decisions of the Institute and to coordinate the collaboration between the research programs. The internal guidelines of the Institute, providing detailed information on the most important daily processes of the Institute, were approved in the Steering Group meeting on 12.11.1996. The Institute adopted administrative practices that had been found efficient at the Institute of Biotechnology, an independent institute under the Consistorium of the University of Helsinki in operation since 1989.

In the autumn of 1996 a number of additional issues of importance were addressed and resolved by the Board. It was decided that the institute would sign the "Interim Memorandum of Understanding for the Execution of the Initial Phase of the CMS Experiment" and a similar MoU for the ATLAS

detector collaboration. Civilekonom Hannu Luutonen was appointed as the Finance Manager. In order to form the Scientific Advisory Board, in accordance with the Rules of Procedure, a working group consisting of professors Byckling, Keinonen, and Salomaa was set up. The report of the Detector Working Group, set by the provisional Board and led by professor Juhani Keinonen, was submitted to the Board. One of the merged units, SEFT, had maintained a Detector Laboratory, and the provisional Board had given the Working Group the task of assessing the role of the laboratory in the newly established institute. The Board agreed with the recommendations of the Working Group, but concrete decisions were postponed until further preparations were completed. In addition, a budget and research plan for 1997 were decided on.

HIP expansion

From the very beginning, the legislation that made it possible to create HIP as a joint unit of two universities also allowed other universities to join the consortium to operate the Institute. In 1997 discussions started with the University of Jyväskylä on extending the research program of the Institute to include relativistic heavy ion physics and the ALICE experiment at CERN. Also, the ISOLDE activity of Jyväskylä at CERN would be a part of a new research program: Nuclear Matter Physics. The physicists of the University of Jyväskylä were well informed on the activities of the new research institute, because the Ministry of Education had appointed professor Juha Äystö of the Department of Physics of the University of Jyväskylä (UJ) to the Board of the Institute. The initiative was discussed in the Board on 28.5.1997 on the basis of a letter by professor Äystö dated 13.5.1997. The initiative was welcomed by the Board, but further action was left to wait for decisions on the funding required by the expansion of the research program. The new Universities Act (645/1997), which entered into force on 1.8.1998, made it possible to establish joint units by agreement between different universities, and the old law with the special article concerning HIP was repealed. However, the decree regarding HIP remained in force (Act on the implementation of the Universities Act, 646/1997). On 17.6.1998 a meeting was held at the Ministry of Education on the initiative of HIP to discuss the possibility of the University of Jyväskylä becoming a contracting party to operate HIP and, secondly, the funding of the Finnish contribution to the construction of the CERN

The HIP Board in the autumn of 1997: Antti Räisänen, Rainer Salomaa, Katri Huitu, Arto Mustajoki (Chair), Juha Äystö, and Juhani Keinonen.

LHC experiments. Arvo Jäppinen of the Ministry of Education chaired the meeting with Eero Byckling (HIP), Jorma Hattula (Academy of Finland), Matti Lähdeoja (Ministry of Education), Arto Mustajoki (UH), Risto Nieminen (HUT), and Juha Äystö (UJ) participating. The prospect of the University of Jyväskylä joining as a HIP partner was welcomed, and it was suggested that the management of the Institute be organized by agreement between the universities once the decree was repealed. In the same meeting a tripartite scheme for the financing of the LHC detector contributions (about 21 Mmk ≈ 3.532 M€) was outlined, but the parties did not make any commitments.

On the basis of the discussion at the Ministry of Education on 17.6.1998, Counsellor of Higher Education Juhani Hakkarainen prepared a memo, dated 12.10.1998, which was discussed by the Board on 14.10.1998. The proposal was that the universities negotiate an agreement on HIP in such a way that the matter could be settled in the target negotiations of the universities concerning the year 2000, i.e., in early 1999. Once the universities had reached an agreement, the Ministry would issue the revocation of the previous decree. The Board decided that the Chair of the HIP Board should contact the Rectors to set up a working group to prepare the agreement. The universities appointed Vice-Rector Ilkka Niiniluoto (UH), Vice-Rector Antti Räisänen (HUT), and professor Juha Äystö (UJ) to the working group, and Olli Muttilainen was invited

as the Legal Counsel. The draft of the agreement, together with a draft for the Regulations, was discussed in a Board meeting on 19.5.1999. However, it took quite a while, until early 2001, before the universities could reach an agreement that was also acceptable to the Ministry of Education.

The Hakkarainen memo of 12.10.1998 also included a proposal for financing Finland's share in the LHC experiments. Some preliminary discussions with OPM had taken place already in 1995, when the CERN Research Director Lorenzo Foà visited Finland and the possible Finnish commitment of 5 MCHF for the CMS construction had been taken up. The total estimated cost for the Finnish contributions to different LHC experiments was 21.2 Mmk (3.566 M€), corresponding to about 6.1 MCHF. The memo proposed that the Ministry cover one third of the cost, the Academy of Finland one third, and the three universities - UH, HUT, and UJ - together one third of the total cost. The HIP Board decided on 14.10.1998 to approach the universities to ask for commitments to the Hakkarainen plan. All the parties gave their commitments without delay; the Ministry of Education on 2.12.1998 committed to annual contributions for 2001-2004 at the level of 1.75 Mmk, and the Academy of Finland on 27.10.1998 committed to 7 Mmk in their 1998 supplementary budget. The universities committed to their share as well; UH on 17.11.1998, HUT on 26.10.1998, and UJ on 14.12.1998. It turned out later that the committed amounts did not fully cover the total cost for Finland, and requests for additional funding had to be submitted to the Ministry of Education.

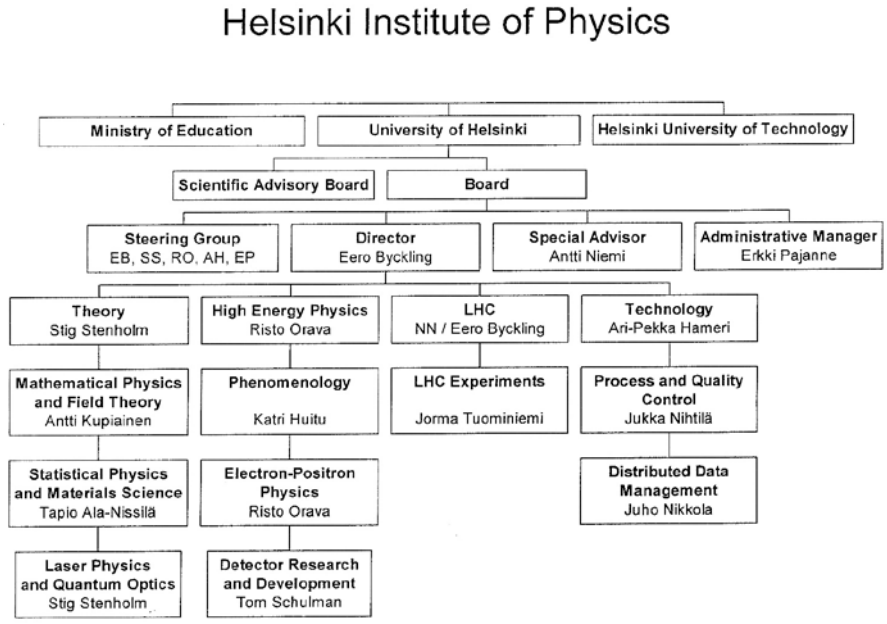
Research

Initially, the research project structure of HIP followed the continuation of the previous projects at the three research units, TFT, SEFT, and HTI, of the University of Helsinki and the Helsinki University of Technology. On the basis of the presidential decree, HIP was responsible for the Finnish research at CERN, and the CERN projects, initially DELPHI and CMS, required the largest share of HIP's financial resources. The final decision to build LHC had been made by the CERN Council in December 1994. The "Memorandum of Understanding for Collaboration in the Construction of the CMS Detector" was approved

by the HIP Board on 11.5.1998 with a 5 MCHF financial commitment, and similarly the MoU for the construction of the ATLAS detector with a 0.1 MCHF commitment. The decision concerning the "Interim Memorandum of Understanding for the Execution of the Initial Phase of the ALICE Experiment" with 1 MCHF commitment was postponed until the negotiations between the Ministry of Education, HIP, and UJ. In the Board meeting on 14.10.1998 the Director was finally authorized to sign the interim MoU for the ALICE detector. The funding issue had been settled in accordance with the plan of Juhani Hakkarainen dated 12.10.1998.

SEFT had maintained a Detector Laboratory that had made significant contributions to the DELPHI hardware, and its role in the new organization had to be defined. The provisional Board had appointed a working group to address the question and the report was available in the autumn of 1996. However, the implementation of the recommendations was postponed. In a meeting on 17.9.1998 the SAB recommended that the Director of HIP should seek outside expert advice to evaluate and define a good detector development program for HIP. The task was given to an evaluation group led by professor Rolf-Dieter Heuer (U. Hamburg). The other members of the group were Dr Austin Ball (U. Maryland) and Dr Bernhard Schmidt (U. Heidelberg). The evaluation group published their report on 29.1.1999. The main conclusions of the group were that "to provide a well-balanced education program for experimental particle physicists as well as well-balanced contribution to an experimental high energy program, an experimental laboratory is mandatory", and that maintaining the design, development, and construction capabilities of detector hardware provides "the best opportunity of making well-founded and recognized contributions to the physics output" in high energy physics experiments. The activities should have, however, a better focus on LHC experiments, CMS in particular. Cooperation in the detector activities with VTT (Technical Research Centre of Finland) and the U. Jyväskylä cyclotron laboratory were encouraged. On 9.2.1999 the Board asked professor Juhani Keinonen to outline specific measures for implementing the recommendations. The proposal was dated 12.5.1999 and was addressed in the meeting on 19.5.1999, where the Board approved a number of steps to be taken. The merger of the High Energy Physics and LHC Programs starting in 2000, or 2001 at the latest, was one of the measures decided by the Board to improve the efficiency of the use of the laboratory resources.

The research activities in theoretical physics of the new physics research institute were initially mostly a continuation of the work at TFT. In the Theory Program there were the projects in Mathematical Physics and Field Theory, Laser Physics and Quantum Optics, and Statistical Physics and Materials Science. The project in particle phenomenology was initially in the High Energy Physics Program, and was moved to the Theory Program in 1998. In the SAB assessments all of these projects were highly appreciated and, in particular, the strengthening of the phenomenological group was encouraged in order to enhance support for experimental activity. The collaboration with the Steklov Mathematical Institute (St. Petersburg) was continued until 1999, and academician Ludwig Faddeev was a regular visitor until 2000. In 1998 quantum information and quantum computation were established as major research fields in the Laser Physics and Quantum Optics project and, e.g., the work of Norbert Lütkenhaus on quantum cryptography collected numerous citations. Around 1998, the Particle Cosmology project began its participation in the work of the ESA Planck Mission Low Frequency Instrument (LFI) Consortium. The aim of the Planck Satellite Mission was to measure temperature variations in the cosmic microwave background



The HIP organization in the autumn of 1996. The boxes contain the names of the research programs/ research projects together with the names of the program directors/project leaders.

radiation with unprecedented precision. The Helsinki group, led by Dr Enqvist, contributed to the science part of the Mission, and MilliLab, a joint organization of the Technical Research Centre of Finland VTT and the School of Electrical Engineering of the Helsinki University of Technology, was responsible for the Finnish hardware contribution, the 70 GHz radiometers of the Low Frequency Instrument.

In experimental particle physics, the main activity in the beginning focused on the DELPHI detector at CERN. Finland had joined the DELPHI collaboration at LEP in 1984, well before its CERN membership. Finland's main responsibilities in DELPHI were within the Hadron Calorimeter and the Vertex Detector, where, for the first time, Finnish physicists were participating in the development and construction of a subdetector in a large particle physics experiment. An important local collaborator in the development of the silicon detectors was VTT. The LEP e^+e^- collider was closed on 2.11.2000, but the data analysis continued for several years, and the Electron-Positron Physics project of the High Energy Physics Program participated in that activity. In 1993 SEFT also became involved with the L3 Collaboration at LEP. Initially SEFT contributed to the tracking upgrade simulation work, and later to silicon micro strip detector development and off-line data analysis. The L3 activity continued at HIP for a couple of years. At the end of 1999, a new proposal was brought forward by professor Risto Orava. The proposal concerned a feasibility study of a very forward detector system for measuring QCD processes in the unexplored rapidity region of proton-proton interaction. Orava's proposal for a forward detector for LHC was discussed and approved by the Board on 3.2.2000. The aim was to measure a variety of quantities, e.g. luminosity and total cross section. The plan was a response to a Heuer group recommendation and to the work that had already started at CERN, and it relied on the expertise of the HIP group in gaseous GEM (Gaseous Electron Multiplier) detectors. The High Energy Physics Program also contributed to the Technical Design Report of the 500 GeV e^+e^- linear collider proposal TESLA at DESY, Hamburg, published in early 2001.

Finland participated in the development of the CMS detector at the LHC from a very early stage, starting in 1990, and had contributed to the Letter-of-Intent (LoI) in 1992. The collaboration proposed to build a general-purpose detector designed to run at the highest luminosity at the LHC. The CMS (Compact Muon Solenoid) detector was optimized for the search for the Standard Model Higgs boson over a mass range

from 90 GeV to 1 TeV, but it also allowed the detection of a wide range of possible signatures from alternative electro-weak symmetry breaking mechanisms. The LoI was approved in 1993 and the Technical Proposal was submitted at the end of 1994. The Technical Proposal was signed by 18 Finnish scientists representing six different institutions. CERN approved the realization of the two general-purpose detectors, CMS and ATLAS, in the beginning of 1996. The next stage of the project was to complete the Technical Design Reports for the main detector subsystems involving design and prototype construction. The HIP hardware contribution was mainly for the mechanical support system for the CMS Tracker Outer Barrel and the silicon strip detectors for the tracker, where HIP also collaborated with the Microelectronics Instrumentation Laboratory of the University of Oulu. The CMS Tracker Technical Design Report was published in April 1998 with 29 Finnish signatories from six institutions. On the software front, the work focused on the CMS detector simulation and data analysis package. In addition, work on the GEANT4 toolkit for detector simulation continued for several years. For the Nuclear Matter Physics project of the LHC Program, started in the beginning of 1998, the main task was the ALICE Inner Tracker System. Another important hardware contribution was the T0 detector for ALICE, which provided the starting signal for time-of-flight detectors. The ALICE (A Large Ion Collider Experiment) Letter-of-Intent had been submitted in March 1993 without Finnish participation. Likewise, there was no Finnish participation in the Technical Proposal submitted in December 1995. The proposal was to build a dedicated heavy ion detector for exploiting the physics potential of nucleus-nucleus collisions at the LHC energies. The aim of the collaboration was to study the physics of strongly interacting matter at extreme energy densities, where the formation of a new phase of matter, the quark-gluon plasma, was expected. The Nuclear Matter Physics project also contained the theoretical activity on very high energy heavy ion collisions, a field where the University of Jyväskylä had a very strong tradition, as well as the radioactive ion beam studies in nuclear and solid state physics at the CERN ISOLDE facility, of which Finland had become a full collaborator in 1998.

In the technology program, activities initially focused strongly on the work started at HTI to create tools for controlling and managing globally distributed design, engineering, and assembly operations like LHC or the particle detectors. The development eventually led to the TuoviWDM (TuoteVisualisointi, Web Document Management)

software. HIP continued the work, especially to adapt to the needs of CERN in particular to use the software as a CERN EDMS (Engineering Data Management System) system interface. An agreement with CERN concerning the management and work content of the Tuovi project was signed on 22.1.1997. The Copyright and Licensing Agreement with CERN was signed on 14.3.1997. The responsibility for the maintenance of the TuoviWDM software was transferred to a commercial software company, Single Source Oy, on 4.7.1997 to secure long-term customer support. Agreements with several scientific organizations for the testing or usage of Tuovi were signed in 1997-1998, including DESY, MPI for Plasma Physics, and IPN Orsay. Furthermore, several industrial users were found. Most of the Tuovi project staff moved to Single Source Oy around the year 2000, and the project at HIP ended with a very positive outcome, resulting in a spinoff company, Kronodoc Oy. The company Single Source Oy had adopted a new name. The TuoviWDM project has been described in detail as an example of an industrial spinoff from CERN activity in the article by E. Byckling et al., Technovation Vol. 20 (2000) p. 71. The project also received international visibility through a report in the Science & Technology pages of The Economist on 5.1.2001. The article focused on prospects for analyzing the communication within large international companies.

Research is closely linked to educational activities and, from the outset, one of the basic tasks of the Institute has been graduate education in physics, in accordance with the founding decree. Working together with universities, HIP maintained the national Graduate School in Particle and Nuclear Physics (GRASPANP), which funded a number of graduate student positions in HIP, among other institutions. Furthermore, undergraduate students were hired as research assistants in various HIP projects, and as summer trainees at CERN. Furthermore, HIP maintained an extensive visitors' program and organized seminars, workshops, and conferences. The most notable example of the latter, which HIP co-organized, was the International Europhysics Conference on High Energy Physics (HEP99) held in Tampere on 15-21 July 1999.

In 1994 SEFT started to work on the development of educational programs at CERN. This activity grew to include HIP's participation in two research projects coordinated by the Tampere University of Technology and funded by Tekes, the Finnish Technology Funding Agency, addressing issues in the distance-learning environment. The first

project was Etäkamu (Distance Learning in Multimedia Networks), where HIP participated in the Web University pilot project starting in 1997. The aim was to study the possibility of using the educational programs at CERN for distance learning purposes and to test the technologies in real-time, interactive learning situations. The project, led by the Digital Media Institute of the Tampere University of Technology, continued in 1999 under the title Open Learning Environment, until 2002. The Web University project later developed into a very successful Finnish high school activity at CERN. The leading figure in these projects at HIP was Riitta Rinta-Filppula, MSc.

To facilitate the development of the industrial relationship between CERN and Finland, in 1997 HIP signed an agreement with Finntech, the Finnish Technology Ltd Oy, which was the primary trading name for Cerntech and Licentia activities. In this arrangement the partners agreed to jointly finance a technology expert at CERN to promote the industrial relationship between Finnish industry and CERN.

In 1998 the University of Helsinki decided to conduct a Research Assessment Exercise, to be done in 1999, on the research output from the university during 1994-98. Those HIP activities which were connected to research at the University of Helsinki were part of the assessment. Because the Institute had been operating only a short time by the date of the panel visit on 23.6.1999, the Institute did not yet have a well-defined identity. In experimental particle physics, the evaluation panel was concerned about the visibility of the Helsinki effort; a higher level of ambition in the hardware contributions was expected. Regarding the theory activity, the panel favorably compared the quality of the work with that of the best European groups working in similar fields. The panel also called for longer-term appointments for outstanding scientists. The Institute was graded at level 6, i.e. the unit was considered to be in the top 25 % of European departments of physics.

During 1997-2000 the HIP publication list contained 461 refereed journal articles, i.e. on the average about 115 items annually. The role of the Theory Program in this scientific output was quite significant in the beginning; almost 50 % of the papers were theory papers. The LEP publications emerging from LEP activity (DELPHI and L3) accounted for about 38 % of the total result. The remainder, about 14 %, came from the LHC Program and the Technology Program.

Premises

At the start of the HIP operations the three units, TFT, SEFT, and HTI, continued their work in their earlier premises, offices, and laboratories, located at Siltavuorenpenger, Otaniemi, and CERN. In October 1996 HIP was able to reduce somewhat the laboratory space in Otaniemi Science Park in the Innopoli building (Tekniikantie 12) to lower the cost. In the beginning of 1997 the former TFT and SEFT premises were transferred to the governance of HIP. However, a lease agreement entered into force only in the beginning of 1999. The rents for 1997 and 1998 were removed by a Rector's decision from the basic funding of HIP, which caused some stir at HIP, because the Institute was supposed to have financial autonomy even though the money transactions went through the University of Helsinki accounts. Decisions regarding HIP money were supposed to be handled by the Board or the Director. Another issue that caused some exchanges of letters with the UH leadership was the question of whether the rent was part of the basic funding or not. In the beginning, HIP was one of the few units within the University of Helsinki that paid rent with "real" money. In 1997 HIP was able to secure some space on the HUT campus at the address Tekniikantie 4 D, and that space was used by the LHC and Technology Programs. In the beginning of 1999 the Statistical Physics and Material Science project of the Theory Program moved to the HUT campus, and HIP was then operating at three different locations in Otaniemi. This distributed mode of operation was in line with the Board decision on 9.12.1996 approving several operational branches.

An important development concerning the Faculty of Science of the University of Helsinki was the move to a new campus area in Kumpula. A new accelerator laboratory had been constructed there already in the early 80's to house a tandem Van de Graaff accelerator. The chemistry building was the second phase of the development, and its construction started in 1992. The preplanning for phase three of the Kumpula development program, containing the physical sciences and geography programs, took place in 1993, and the final report was published in October. In that plan, there was a provision for the two UH units, TFT and SEFT, and in November 1996 HIP confirmed that those premises were sufficient for the HIP needs. The construction was expected to start in 1999 and the new physics building was expected to be finished in 2001.

The Kumpula Phase III building received the name Physicum. The construction works started on schedule and the foundation stone was laid on 13.12.1999. The topping out ceremony took place on 11.5.2000.

An important aspect of the research infrastructure was the connection to the information network. On 17.1.1997 professor Byckling wrote a letter to FUNET (Finnish University and Research Network) director Markus Sadeniemi applying for membership in FUNET and a domain name (hip.fi) for HIP. The membership was approved in February. To control the cost, HIP resigned from FUNET membership starting 1.4.2002 and started to use the University of Helsinki gateway to FUNET.

Personnel developments

The key to the success of a research institute is, of course, the highly qualified staff the institute needs to achieve the objectives set for its research projects. For the personnel of the three merged institutes the creation of the new organization caused changes, as not all of the staff of the three units was transferred to HIP. Work contracts were not, however, terminated; some staff was moved to other units within the University of Helsinki, typically to the Department of Physics or the Computer Center. At first, the Institute granted 1-2 year contracts to all of its staff, with the exception of the Director, Program Directors, and Administrative Manager, who received 3-4 year contracts. From its first meeting on 4.9.1997, the Scientific Advisory Board recommended long-term or permanent positions for some key members of the research staff. Similar conclusions were reached by RECFA (Restricted ECFA, European Committee for Future Accelerators) in its 1997 country visit to Finland.

At its first meeting on 9.9.1996, the HIP Board decided to begin the search for a LHC Program Director. Until this leader was found, the Director managed the duties of the LHC program director. The LHC program director was expected to take responsibility for the design and implementation of the strategy for Finnish participation in LHC experiments, in particular CMS. This responsibility also included the LHC related experimental activities at the Institute. The dead-line for applications for the three-year position was at the end of 1996, and the Institute received 9 applications. The Steering Group consulted three

experts, Michel Della Negra (CERN), Dan Green (FNAL), and Lorenzo Foà (CERN), interviewed three applicants and found two of them, professor Gerald Eigen (U. Bergen) and docent Jorma Tuominiemi (UH) qualified for the position. It was decided that the candidate to be presented to the Board would be professor Eigen. It was expected that he could bring a new vision to the LHC group and new international contacts. The matter was addressed in the Board meeting on 13.2.1997 and the proposal of the Director was that professor Gerald Eigen would be appointed for the period 1.9.1997-31.8.2000 to the position of LHC Program Director. It turned out, however, that after the agenda of the meeting had been distributed to the Board members, professor Eigen had set an additional condition for accepting the offer. This request was essentially to be granted a permanent professorship at the University of Helsinki, a condition the Board could not fulfill. As a consequence, the Director put forward a new proposal to appoint docent Jorma Tuominiemi to the Program Director position and the decision was made accordingly, with the three-year appointment starting on 1.8.1997.

In December 1996, in a letter to the Faculty of Science the Head of the Department of Physics, professor Juhani Keinonen initiated the process of creating a professorship in high energy physics, to be filled by invitation. Associate professor Masud Chaichian of the Department of Physics was to be called to the chair. In January 1997 HIP made the commitment to finance the salary difference between full professor and associate professor, and in April 1997 the Rector created the position starting 1.1.1998. This was the first joint position with a university department. Several panels of experts had recommended that HIP create permanent positions for outstanding scientists, and the chosen strategy for HIP, in the beginning, was to seek for collaboration with one of the universities to create such joint positions.

At the time of the start of HIP operations, there was not a single professorship in experimental particle physics in Finland. This was considered to be a major shortcoming in the reports of the RECFA and SAB discussed in the Board meeting on 9.2.1998. The Restricted ECFA , which is an advisory body for the European high energy physics community, made a country visit to Finland in September 1997, and received a report on the high energy physics activities in Finland. The considerations and conclusions were reported in a letter by the chair, professor Enrique Fernández, dated 30.9.1997, to Director General Markku Linna (Ministry of Education)

and Research Director Jorma Hattula (Academy of Finland). In the letter the creation of HIP was considered very positive because it could provide long-term support during the construction and data analysis periods in high energy physics experiments. In addition, the RECFA strongly urged the universities to create at least one chair in experimental particle physics. The same issue was taken up by the SAB in their first meeting on 4.9.1997. On 13.1.1998 the Executive Group of the Department of Physics of the University of Helsinki decided to propose to the Faculty of Science the establishment of a professorship in experimental particle physics together with HIP. The HIP Board decided on 9.2.1998 to approve the proposal to be made to the Faculty of Science with a 45% contribution to the salary by HIP, and on 13.2.1998 the Department Head sent the proposal to the Faculty of Science. On 15.4.1998 HIP and the Department of Physics of the University of Helsinki signed an agreement concerning the joint position. The official job description was approved by the Chancellor of the University of Helsinki on 17.8.1998. The professorship was advertised internationally and the Faculty of Science received 16 applications by the deadline of 3.11.1998 (4 Finnish and 12 foreign applicants). The external experts, Hans F. Hoffmann (CERN), David Hitlin (Caltech), Albert de Roeck (DESY), and Horst Wenninger (CERN) submitted a joint report placing docent Risto Orava in the first place. Dr Orava was appointed to the professorship starting 1.12.1999.

Similarly, a joint professorship with HUT came to the agenda, and was discussed at the Board meeting on 19.5.1999. The decision was to consult the SAB before proceeding. In its June 1999 meeting the SAB welcomed the idea of creating a joint professorship in theoretical physics and considered professor Antti Niemi (U. Uppsala) a good choice to be invited to the new position. On 14.6.1999 the Board authorized the Director to negotiate an agreement with HUT and to bring it to the Board for consideration. Consequently, HUT created a professorship of dynamical systems at the Department of Electrical and Communications Engineering effective from 1.8.1999. On 6.10.1999 the Rector of the Helsinki University of Technology decided to initiate an invitation procedure to appoint Antti Niemi to a professorship in computational engineering with a specialty in dynamical systems. The HIP Board approved the agreement on the joint professorship in the meeting on 3.11.1999. The position was agreed upon as a joint position starting 1.7.2000. However, the Board stipulated that signing the agreement could be done only after professor Niemi had been appointed to the professorship. Expert opinions from Predrag Cvitanović

(Northwestern U.) and Jouko Mickelsson (U. Adelaide) were sought, and they found Niemi well qualified for the position. On 12.6.2000 the Board of the Helsinki University of Technology appointed professor Antti Niemi to the position of professor of computational engineering with a focus on dynamical systems starting 1.7.2000. The agreement between HIP and HUT on the joint professorship was signed on 12.6.2000. Professor Niemi applied for a partial leave of absence for the period 1.7.-31.8.2000. With a letter dated 11.8.2000 Niemi applied for a leave of absence for two years or, if that was not granted, resignation of the position starting 1.9.2000. This leave of absence was not granted.

Additional joint professorships were discussed at the HIP Board on 3.2.2000. The research fields discussed were quantum optics and cosmology. On 22.8.2000 the Department of Physics of the University of Helsinki and HIP signed an agreement for a joint professorship in cosmology, to be filled by invitation. The position had been created by the decision of the Consistorium as a five-year fixed-term position on 17.5.2000, and was funded completely by the University of Helsinki; no HIP financial contribution was needed. HIP had filed a proposal to invite docent Kari Enqvist to such a position together with the Department of Physics. The external experts, professors Mikhail Shaposhnikov (Lausanne U.) and Wilfried Buchmüller (DESY) found Enqvist well qualified for the professorship, and Dr Enqvist took the office in the beginning of 2001.

The creation of joint senior positions was one approach to proceeding with the SAB recommendation of establishing permanent or long-term positions for the research staff. Of course, it would have been beneficial for HIP if the universities had created the professorships solely with their own money, without HIP contribution; however, at least it was possible to speed up the processes with financial commitments. The HIP Board discussed the issue of long-term positions further in their meeting on 9.2.1999 and authorized the director to prepare the matter. In the meeting on 6.4.1999 the Board proceeded with the plan for long-term appointments, first for the theory program. Dr Esko Keski-Vakkuri was offered a 3+3 year appointment starting 1.10.1999. However, he moved to an Academy of Finland Research Fellow position at the end of July 2001. Dr Emidio Gabrielli was hired for a 3+3 year position in the Board meeting on 18.4.2000 to strengthen the particle phenomenology group, research on the standard model and beyond. Dr Gabrielli took the position starting 1.11.2000.

The need for longer term or permanent appointments for the key personnel had been brought to the attention of the HIP management on several occasions. This also concerned the support staff, both administrative and technical. At the Board meeting on 14.10.1998 a letter from the Chief Shop Steward of the Staff Association of the University of Helsinki was considered. In the letter it was pointed out that several persons belonging to the support staff had been given fixed-term contracts even though they had had continuing appointments at SEFT. From the HIP point of view the argument was that at the early stages of a new organization the need for administrative support staff was uncertain. For the technical support staff the issue was partly that the role of the Detector Laboratory was under evaluation, and the implications of that were awaiting actions of the Board. The personnel consultancy firm Mercuri Urval was hired in the beginning to search for administrative support staff, starting with the Finance Manager. Civilekonom Hannu Luutonen started as the Finance Manager in November 1996. In 1999 the first permanent positions or continuing appointments were granted, and in early 2000 the core technical staff was given continuing appointments. The basic principle adopted after that time was that the support staff were hired on a permanent basis unless the question was of a fill-in task or a fixed-term technical assignment to a specific project.

The HIP Administrative Manager, docent Erkki Pajanne, announced his wish to retire at the end of March 1999 at the HIP Board meeting on 14.10.1998, and the Board accepted the resignation. The Board decided on 1.12.1998 to declare the position open and require that the candidates for the position have knowledge of the HIP research field. The Board appointed professors Niiniluoto, Keinonen, and Byckling to the search committee. Meanwhile, docent Matti Kaivola was invited to take care of the duties starting 1.2.1999 until the position was filled permanently. The position was advertised in Helsingin Sanomat on 10.1.1999 and by the time of the deadline, 8.2.1999, 10 applications were received. At the Board meeting on 8.3.1999 docent Mikko Sainio was appointed to the position starting 1.4.1999, and in the same meeting a leave of absence was granted for him until 30.6.1999.

In February 2000 the Finance Manager Hannu Luutonen announced his resignation from HIP starting 21.3.2000. HIP acquired temporary help for finance management from the Eilakaisla staffing service company, and Mercuri Urval started the search for a new Finance Manager. The

position was advertised in Helsingin Sanomat on 20.2., and the deadline for applications was 1.3. Mercuri Urval provided a short list of three candidates, and the interviews took place under the leadership of the Chair of the Board, Vice-Rector Ilkka Niiniluoto. An employment contract with Tarja Kalpio, MSc(Economics) was signed, and she started as the HIP Finance Manager on 16.4.2000.

In anticipation of the end of the three-year term of professor Byckling as the Director of the Institute on 31.8.1999, the Board decided on 1.12.1998 to extend his appointment until 31.12.2000. In the Board meeting on 3.2.2000 the process of the search for a new Director starting 1.1.2001 was initiated. The Board decided to conduct an international search with advertising in the CERN Courier and Physics World in addition to Helsingin Sanomat, with a deadline of 31.3.2000 at the latest. A search committee for filling the position was also appointed. The committee consisted of Vice- Rectors Niiniluoto (UH) and Räisänen (HUT) and professor Äystö (UJ). By the deadline 15.3.2000 eight applications were received, one of them by a foreign applicant. In the Board meeting on 18.4.2000 professor Byckling announced his intention to go into retirement already on 30.6.2000. In the same meeting the Board discussed the director issue on the basis of the list of applicants. In the meeting on 9.5.2000 the Board decided to appoint professor Dan-Olof Riska to the position of Director starting 1.7.2000. The pending issues related to the program structure, recommended by the SAB, were left to be addressed in collaboration between the new Director, the Board, and the SAB.

Professor Eero Byckling. Director 1.9.1996-30.6.2000 (Photo: Studio Tapio/Aila Teräväinen).

After his retirement, professor Eero Byckling was interviewed by Jyrki Saarinen for the magazine Fotoni, of the Photonics Society of Finland. In the article, “Professori Eero Byckling – Modernia optiikkaa ja muutakin tekniikkaa” (Professor Eero Byckling – Modern optics and other technology), published in Fotoni Nr 2 (2001) p. 4, the versatile career of professor Byckling was highlighted and, in addition, the steps that led to the establishment of HIP were reported.

RISKA ERA

Professor Dan-Olof Riska started his five-year term as HIP Director on 1.7.2000. At that point, the outlook for the Institute did not look bright. The national funding provided by the Ministry of Education for the planning period 1997-2000 had been stable, and covered the full basic funding of the Institute. For the period 2001-2003 the Ministry had changed the scheme for the allocation of funds to the universities. In the new model the basic funding for HIP in the budget of the Ministry of Education for the national task was 15 Mmk (2.523 M€) instead of the 22 Mmk (3.700 M€) during the previous planning period, i.e. a reduction of 32 %. However, in the new scheme there were provisions for additional resources. The University of Helsinki was expected to provide 4 Mmk (0.673 M€) as a host university contribution, and all of the other partner universities together 3 Mmk (0.505 M€) as a result-based contribution towards the basic funding of the Institute. The main measure of performance was the number of academic degrees completed in connection with the HIP research projects. Another problematic matter was the departure of some key individuals from the organization; but, fortunately, new capable people could be recruited to fill the positions. An additional concern was the decision of the Board of the Academy of Finland in November 2000 to initiate a critical review of all Finnish CERN activity, as ten years had passed since Finland became a CERN member country in the beginning of 1991. Furthermore, the status of HIP was somewhat unclear, because the law establishing HIP had been abolished, but an agreement between the three universities, the University of Helsinki, University of Jyväskylä, and Helsinki University of Technology, was still being negotiated.

The first Board meeting during the Riska tenure took place on 4.9.2000. There a number of important decisions were made. The Director was authorized to sign the Memorandum of Understanding for Collaboration in the Construction of the ALICE Detector with a Finnish commitment of 1 MCHF. The Finnish representatives for the Resources Review Boards (RRB) of the large LHC detectors were appointed. In an attempt to broaden the Finnish representation in CERN committees, professor Juhani Keinonen of the Department of Physics of the University of Helsinki was appointed to the ALICE RRB and professor Mikko Paalanen of the Low Temperature Laboratory of the Helsinki University of Technology was appointed to the ATLAS RRB. Director Riska took over the CMS

RRB. Docent Kari Enqvist's appointment to the Theory Program Director position was continued and Lic. Tech. Eija Tuominen was appointed as the Leader of the CMS Tracker project starting 1.9.2000.

The evaluation of Finnish CERN activity

In November 2000 the Board of the Academy of Finland decided that Finnish activity at CERN should be evaluated, and the Research Council for Natural Sciences and Engineering was given the task of organizing the review. The following individuals were invited to join the evaluation panel: Professor Peter Paul (chair, Brookhaven National Laboratory), Vice President Kari-Pekka Estola (Nokia Research Centre), President Pauli Juuti (Helsoft Ltd.), and Professor Sven Kullander (U. Uppsala). Senior Advisor Eeva Ikonen (Academy of Finland) and Professor Jukka Maalampi (U. Jyväskylä) were invited as secretaries and coordinators of the Panel. The assignment of the Panel was to carry out an evaluation of the state, visibility, and impact of the Finnish membership at CERN, particularly in terms of research activities in the fields of physics and applied sciences, research training, and industrial collaboration. The Panel summarized its findings in a final report (Publications of the Academy of Finland 3/01) presented to the Academy of Finland on 15.5.2001, in the following manner:

"The first ten years of the Finnish membership in CERN have been successful. In the future as well Finland has great opportunities and benefits deriving from the membership in CERN. The Finnish presentations at the review clearly show progress and rapid development in experimental particle physics since Finland has joined CERN. In this development the Helsinki Institute of Physics (HIP) and previously the Finnish Research Institute for High Energy Physics (SEFT) have played key roles. Finland is still a young Member State in CERN, but one of the most dynamic new partners" and

"A key finding of the Panel was the unclear instructions given to HIP what concerns activities and policies involved with CERN. To maximize the benefits of CERN membership Finland needs a general Government strategy to efficiently use all opportunities offered by CERN in science and in training of scientists and engineers in an international environment."

In addition, the Panel provided 15 statements of a more detailed nature. These included the remark that there was no Finnish scientist in the CERN permanent scientific staff. In addition, there was concern over the integration of the theoretical and experimental research effort in Finland. Furthermore, the importance of the Detector Laboratory was emphasized. The uncoupling of the link between Finnish CERN activity and the Finnish universities was considered as a possible negative side effect of HIP. Most of the Technology Program activities were concentrated in CERN, and in the LHC Program a large part of the senior staff resided at CERN, which influenced the lecture course program offered at the University of Helsinki. The establishment of a second professorship in experimental particle physics was also recommended. As an institutional concept HIP was considered unquestionably successful. The report was overall very positive.

National CERN strategy

Due to the recommendation of the Evaluation Panel regarding the need to have a Government strategy to fully exploit the opportunities related to CERN membership, on 11.12.2001 the Board of the Academy of Finland created a working group to draft a proposal for a national CERN strategy and its implementation. The Chair of the Working Group was professor Riitta Keiski of the Board of the Academy of Finland and the Vice-Chair was Ministerial Adviser Mirja Arajärvi (Ministry of Education). The members were Professor Rauno Julin (U. Jyväskylä), Research Director Anneli Pauli (Academy of Finland), Director Petri Peltonen (Tekes), and IT Manager Pekka Sinkkilä (Ministry of Transport and Communications). The Finnish CERN delegates professor Jorma Hattula and academy professor Risto Nieminen were invited as permanent experts, together with professor Dan-Olof Riska of HIP and Science Adviser Pentti Pulkkinen of the Academy of Finland. The secretary of the Working Group was Administrative Manager Mikko Sainio (HIP). Initially the report was expected to be completed by 31.5.2002, but the Working Group asked for an extension until 31.10.2002. The Group was also supplemented by inviting Department Head Timo Kekkonen (Ministry of Trade and Industry) to be a member of the Group. During its work, the Working Group invited a number of representatives of industry to present their views on industrial collaboration. The final report “Finnish

national CERN strategy for 2003-2010, the working group proposal" (Suomen kansallinen CERN-strategia vuosille 2003-2010: työryhmän ehdotus) was published in the Academy of Finland Publications Series (13/02). The Working Group set the goals of Finnish CERN membership as follows:

1. Visible participation in international collaboration at the forefront of basic research in high energy physics and nuclear physics.

2. Promoting applied research on accelerators, accelerator-based physics, radiation detectors, and computing.

3. Advanced research training in physics and new technologies in a project-based, challenging international research environment.

4. Promotion of the technology know-how of Finnish companies and the commercial utilization of CERN projects.

5. Use of CERN research results and expertise in science education and the promotion of public awareness of science.

The Working Group gave a number of recommendations for each of these items, altogether 18. These included strengthening experimental subatomic physics in HIP partner universities and broad participation in projects before the start of the LHC, exploitation of CERN opportunities in applied research, the development of grid computing in collaboration with the Centre for Scientific Computing, the internationalization of graduate education, activation at the national level of the industrial utilization of Finnish CERN engagement, and utilization of the pedagogical material developed at CERN to advance physics school education. In addition, support for the career advancement of Finnish researchers at CERN was recommended.

The national strategy proposed by the Working Group was approved by the Academy of Finland in 2003. In March 2009 a delegation led by the Director General of the Academy of Finland, professor Markku Mattila, visited CERN, and in the press release related to the visit it was stated that "the organization of the Finnish CERN activities is an excellent example of how to nationally support the utilization of the manifold opportunities

provided by an international research organization and how fruitful this engagement can become for both science and business". The framework provided by the national strategy continues to define the mission of the HIP.

HIP expansion

Already in 1998, when the new Universities Act entered into force (1.8.1998), the Universities of Helsinki and Jyväskylä together with the Helsinki University of Technology had agreed that their HIP cooperation should be based on an agreement between the universities. In early 1999 the rectors of the universities appointed a working group consisting of professors Niiniluoto, Räisänen, and Äystö to draft an Agreement and Regulations, and the drafts were discussed in the HIP Board in May 1999. An update of the status of the negotiations was a regular item in HIP Board meetings in 1999 and 2000. Finally, in 2001, the universities reached an agreement in a form acceptable to the Ministry of Education and the formalization process could be started. The Regulations were approved by the governing bodies of the universities in early 2001 and the Chancellor of the University of Helsinki ratified them on 28.3.2001. By the summer of 2001, an agreement was reached on the content of the contract, and on 27.6.2001 the Chair of the Board reported to the Ministry of Education and provided the Agreement and the Regulations. Thereafter the Minister of Education, Ms Maija Rask, was able to issue on 17.10.2001 a decree (Finlex 851/2001) that revoked the decree on the governance of HIP (561/1996) starting 1.1.2002. In a letter to the University of Helsinki, dated on 14.12.2001, the Minister confirmed that the Finnish scientific collaboration with CERN continued to be a task for HIP and that the intention of the Ministry was to provide funding for the national tasks in the target negotiations between the Ministry and the University.

The new statutes defined the HIP mission as before, with only minor changes. The task of the institute, as defined in the agreement, was to carry out and facilitate research in basic and applied physics, as well as to conduct technology development associated with accelerator laboratories and to provide graduate training in physics. In addition, the institute was also responsible for the Finnish collaboration with CERN and

engagement in other international research collaborations. Joint projects between the Universities were also considered to be within the mandate of HIP. The Board approved the new Rules of Procedure reflecting the changes in the statutes on 11.9.2002. The main changes in the governance were in the power of appointing the director and the composition of the Board. Earlier, the Board had appointed the director, while the new ruling moved the power to the Rector of the University of Helsinki. The role of the Board was to propose the director. Before, the Board consisted of two representatives of both the University of Helsinki and the Helsinki University of Technology, as well as one representative appointed by the Ministry of Education and by the staff of the Institute. The new Board, appointed from 1.1.2002, had three members from the University of Helsinki and two members from both the Helsinki University of Technology and the University of Jyväskylä, together with one staff representative. All of the Board members had a personal substitute.

From the beginning of 2002 the structure of the Institute was changed; a new research program, the Nuclear Matter Program, was created, replacing the Nuclear Matter Project of the LHC Program, which had included the University of Jyväskylä CERN activities during 1998-2001. Professor Juha Äystö of the University of Jyväskylä was appointed as the Program Director, and ALICE and ISOLDE activities were incorporated as projects in the program. Dr Wladyslaw Trzaska became the leader of the ALICE activity and Dr Ari Jokinen of the ISOLDE.

The next phase of HIP expansion took place in 2006, when the Lappeenranta University of Technology (LUT) joined the agreement on HIP. LUT had joined the CMS Collaboration at CERN on 19.9.2003 and the research group of professor Tuure Tuuva took responsibility for the design and fabrication of the link and splitter boards of the CMS Resistive Plate Muon Chamber (RPC) trigger link. In the autumn of 2005 LUT approached HIP inquiring about the possibility of joining the agreement on HIP. The HIP Director and Administrative Manager visited LUT on 28.9.2005, meeting Rector Markku Lukka, professors Tuure Tuuva and Matti Alatalo, as well as Planning Manager Marja Hirvikallio. LUT had already had interactions with HIP in projects involving grid computing in addition to the CMS activities; hence, joining the agreement on HIP was only a formality. In May 2006 an agreement between the four universities was finalized, and from the beginning of 2007 LUT became a partner in the consortium of universities operating HIP. In spring 2007 the agreement

was amended by an agreement regarding the LUT membership in the HIP Board. The Chancellor of the University of Helsinki ratified the corresponding changes to the Regulations on 12.4.2007.

In the early 90's the CMS Collaboration approached the Tampere University of Technology (TUT) and proposed cooperation in the development of the CMS data acquisition system. New methods for signal processing had been developed in TUT, and it was a contributor to the Technical Proposal of the CMS detector in 1994. However, the Tampere University of Technology did not become a member of the CMS Collaboration. In any case, summer trainees from Tampere were participating in the HIP summer student program at CERN on a regular basis, and in due course MSc thesis projects became attractive for Tampere students. In November 2007 the HIP director had discussions with the representatives of the TUT information technology institutes on the various technology challenges in LHC data processing. In addition, detector technologies developed at CERN had found applications in medical imaging; one example was the AXPET project (Axial PET), a project of interest to the TUT researchers. The aim of the project was to develop a R&D program focused on a novel geometrical concept of Positron Emission Tomography (PET), featuring a parallax-free 3D reconstruction of the positron source distribution with high spatial and energy resolution. To enable seamless access for Tampere students and researchers to the CERN technology development projects, the Dean of the Faculty of Computing and Electrical Engineering, professor Ulla Ruotsalainen, wrote on 21.4.2008 to the Rector of the Tampere University of Technology, professor Jarl-Thure Eriksson, proposing that TUT seeks membership in the consortium operating HIP. On 2.5.2008 Rector Eriksson wrote to Director Riska, and on 20.5.2008 to the rectors of the partner universities, inquiring about membership. The approval of the partner universities was obtained without delay, and by autumn the Agreement on HIP was modified to include the Tampere University of Technology. A broad delegation from Tampere visited CERN on 6.-7.10.2008 under the leadership of Rector Markku Kivikoski. The Chancellor of the University of Helsinki ratified the appropriate changes to the Regulations on 29.10.2008. Dean Ulla Ruotsalainen represented TUT on the HIP Board. On 6.10.2008 the Ministry of Education granted a 100 k€ additional contribution to the HIP budget to support the start of the TUT projects at CERN.

Theory Program development

In the summer of 2000 Riska drafted policy documents for HIP and the HIP Theory Program. The HIP policy document stated the mission of HIP and provided an outline of the program and project structure together with guidelines for a personnel plan and for the interaction with the HIP member universities. The policy document for the Theory Program, drafted with input from the Theory Program Director, docent Kari Enqvist, stated that the HIP Theory Program plays the role of a national Finnish theoretical physics institute, i.e. in the spirit of TFT before 1997. The theory projects were expected to complement and support the research in experimental and applied physics at the Institute, as well as at the physics departments of the member universities. In addition, the theory projects were planned to be of fixed term, with a running time of 3+3 years, the second three year period depending on the success during the first three-year period. The career development of young researchers and graduate student training were important components of the Theory Program, as was international networking. The policy documents were finally adopted by the HIP Board on 5.2.2002.

The coffee machine is one of the most important instruments of a research institute. Here, professor Kari Enqvist is waiting by the coffee machine for the end of the maintenance work to get a cup of coffee.

In its meeting on 4.9.2000, the Scientific Advisory Board called for a “town meeting” of the Finnish theoretical physics community in the member universities to elaborate the Theory Program. The resulting program should demonstrate the need to perform the chosen theoretical physics projects at the HIP rather than performing them at the universities. An open call for proposals for research projects in the Theory Program of HIP was published in early 2001 (Arkhimedes 1/2001, p. 6) and advertised widely. By the deadline,

26.3.2001, 9 proposals were received. For the public oral presentation on 4.5.2001 the panel, consisting of professors Kari Enqvist, Keijo Kajantie, Matti Manninen, and Risto Nieminen, chose five proposals, from which three projects were recommended to be presented to the SAB. The theoreticians of the SAB, M. Rice and G. Veneziano, received all of the proposals in advance, before the SAB meeting. In the Board meeting on 5.6.2001 the projects Ultrarelativistic Heavy Ion Collisions of Dr Kari J. Eskola (UJ), String Theory and Quantum Field Theory of Dr Esko Keski-Vakkuri (UH), and Physics of Biological Systems of Dr Ilpo Vattulainen (HUT) were approved for three years starting 1.1.2002, as had been endorsed by the SAB in the meeting on 21.5.2001.

The mid-term review of the projects took place in spring 2004. The Ultrarelativistic Heavy Ion Collisions project was evaluated by D. Rischke (Frankfurt U.), the String Theory and Quantum Field Theory project by P. Di Vecchia (Nordita), and the Physics of Biological Systems project by R. Metzler (Nordita) and J. Yeomans (U. Oxford). On the basis of the positive reviews and endorsements, the HIP Board granted a second three-year period, 2005-2007, in its meeting on 2.6.2004.

Two theory projects that had started in 2001, Cosmology led by Kari Enqvist and Particle Physics Phenomenology led by Katri Huitu, were evaluated in 2003 by F. Ravndal (U. Oslo) and P. Osland (U. Bergen) respectively. After receiving very positive evaluation reports and endorsement by the SAB, the HIP Board granted a continuation of the projects until the end of 2006 in its meeting on 3.6.2003. An additional continuation of both projects by one year was decided by the Board on 21.8.2006.

A call for new projects was published in early 2007 (Arkhimedes 1/2007, p. 8), with the deadline for Letters-of-Intent on 31.3.2007. Nine proposals were received, and five of them were selected for consideration by the SAB. In the May 2007 meeting SAB endorsed the selection, and on 20.8.2007 the HIP Board decided on five three-year projects starting 1.1.2008: String Theory and Mathematical Physics of Dr Esko Keski-Vakkuri (UH and HIP), Laws of Nature and Condensed Particle Matter Phenomenology at LHC of Dr Kimmo Tuominen (UJ), Cosmophysics of Dr Kimmo Kainulainen (UJ), Low Dimensional Quantum Systems of Dr Ari Harju (HUT), and Radiation Damage in Particle Accelerator Materials of professor Kai Nordlund (UH). The mid-term reviews took

place in 2010 and the respective reviewers were L. Thorlacius (Nordita), D. Rischke (Frankfurt U.), S. Hannestad (Aarhus U.), I. Zozoulenko (Linköping U.), and H.M. Urbassek (TU Kaiserslautern). The reviews were very positive for all of the projects, and in its meeting on 19.8.2010 the HIP Board granted a continuation for four of the projects for the period 2011-2013. The project String Theory and Mathematical Physics had been an exceptional continuation of Keski-Vakkuri's project String Theory and Quantum Field Theory (2002-2007) to secure string theory research in Finland, while research in mathematical physics was reorganized at the University of Helsinki. Furthermore, Dr Flyura Djurabekova took over the leadership of the Radiation Damage in Particle Accelerator Materials project from the beginning of 2011.

In the early 2000's two successful theory projects that had started at TFT came to an end at HIP, while their leaders received university professorships and the research activity moved to a more permanent home elsewhere. The Statistical Physics and Materials Science project of Tapio Ala-Nissilä came to a close at the end of 2002 and moved to the Helsinki University of Technology. The Laser Physics and Quantum Optics project of Kalle-Antti Suominen came to a close at the end of 2003 and continued at the University of Turku. Much of the activity of the projects during their final year at HIP was concentrating on students finishing their thesis work and spending the remaining external funding. Professor J. Michael Kosterlitz (Brown U., Nobel Prize in physics in 2016 "for theoretical discoveries of topological phase transitions and topological phases of matter") was a frequent visitor to Ala-Nissilä's group and two refereed journal articles with HIP affiliation were published as a result of this collaboration. In the biographical information pages related to the Nobel Prize, Kosterlitz specifically mentions his longstanding collaboration with Ala-Nissilä on the phase field models of growth, a method for the numerical study of growth in fluids and solids. It so happened that professor Kosterlitz was visiting Ala-Nissilä's group at Aalto University just at the time he found out about the Nobel Prize in 2016. Through the connections Ala-Nissilä had created as a post-doc at Brown University in 1988-90 he came into contact with G. Ertl of the Fritz Haber Institute of Max-Planck-Gesellschaft in Berlin. The collaboration led to one joint refereed journal article with HIP affiliation published in 2002. The article was cited in the background report "Chemical Processes on Solid Surfaces" of the Royal Swedish Academy of Sciences related to the awarding of the Nobel Prize in chemistry to professor Gerhard Ertl in 2007. For the Laser Physics

and Quantum Optics project, the most important research topics were on interactions of laser-cooled atoms, atomic Bose-Einstein condensates, fermionic systems in atomic gases, and quantum information. In most topics, the unifying factor has been time-dependent simple quantum systems and the dynamics of wave packets. The project was also a member of two EU funded research networks: EQUIP (Entanglement in Quantum Information Processing and Communication) and CAUAC (Cold Atoms and Ultraprecise Atomic Clocks).

The main focus of the Theory Program had been in carrying out theoretical research related to CERN and other large scale national research programs. In the selection of the research projects it was considered important, in addition to the scientific excellence of the research, that the project had a clear HIP profile and there were prospects for external funding. Furthermore, relatively young project leaders were sought rather than established professors with large associated groups. Examples of such projects were the particle phenomenology, cosmology, and relativistic heavy ion projects. In addition, some topics not directly related to the HIP experimental activities were included in the Institute research program. The wide spectrum of research topics was motivated by history; the Theory Program was continuing the tradition of the Research Institute for Theoretical Physics (TFT). Also, a flexible approach for choosing research topics was considered the best way to establish new and interesting fields in Finland and to include the differing interests of the member universities in the HIP Theory Program. The future format of the HIP Theory Program was discussed at the SAB meeting in 2006. The motivation was the report of the University of Helsinki Research Assessment Exercise 2005 evaluation panel, where the sustainability of a long-term theory program based on the 3+3 model was questioned and a more long-term, coordinated strategy for HIP and the university departments was promoted. The SAB, however, encouraged HIP to continue the successful model where the projects were established according to the scientific excellence of the proposals from the research community. HIP was also advised to maintain its activity in particle phenomenology in view of the upcoming LHC results.

The main themes in the cosmology projects were studies of the Cosmic Microwave Background radiation, including the preparatory work for the Planck Surveyor satellite mission before that activity formed its own project in the beginning of 2008, string cosmology, SUSY models of inflation, electroweak baryogenesis, dark energy, and preheating after

inflation. In the particle phenomenology project the focus was the study of theories of particle physics of relevance for current and future laboratory experiments, accelerator based electroweak phenomenology, aspects of supersymmetry and supersymmetry breaking, i.e. beyond the Standard Model physics. In the mid-term evaluation in 2003 by professor Osland, the Particle Phenomenology project was considered to be the strongest in the Nordic countries, especially in accelerator-related electroweak phenomenology. The ultrarelativistic heavy ion collision project had a broad range of interests, including parton distribution functions, hadron spectra at RHIC with a perturbative QCD plus hydrodynamics approach, and the first principles QCD calculations of the pressure of hot QCD. The string theory and mathematical physics project covered a broad range of topics in string theory, including time-dependent issues, quantum field theory, applications of holography, AdS/CFT, and non-commutative QFT. The Physics of Biological Systems project focused on the theory and modeling of biologically relevant soft matter systems and the development of theoretical and computational techniques for multi-scale studies of these systems (e.g. lipid membranes, DNA, proteins, steroids, antibiotics, alcohols). The 2005 Incentive Award of the Academy of Finland was granted to the group. Together with Mikko Karttunen's group at the Laboratory of Computational Engineering at HUT, the group was selected in December 2003 as a HUT Young Center of Excellence for 2004-2005. In the Low Dimensional Quantum Systems project the topics of inquiry included graphene, 2D semiconductor nanosystems, and quantum computing. The Radiation Damage in Particle Accelerator Materials project was motivated by the materials challenges faced by the future development of particle accelerators, including the higher risk of electrical breakdown damaging the accelerating structures. The specific problem of interest was the RF breakdown in CLIC.

The String Theory and Mathematical Physics project ended at the end of 2010. The final evaluation of the project was made by professor Lárus Thorlacius, Director of NORDITA. According to the report, dated 19.7.2010, the decisive factor in the success of the project was the broad range and quality of the work. The graduate students and postdoctoral fellows had received high-level training. In addition, through the project "Helsinki Institute of Physics, and more generally the physics community in Finland, had had a substantial presence in an important and highly dynamic field of research at a relatively low financial cost". In the years 2004-2006, professor Ulf Lindström (U. Uppsala) worked in the group as a visiting professor. He

contributed significantly to the publication record of the group.

In the SAB meeting in June 2010 possible new initiatives, either in the form of a new project or a visiting scientist program, were discussed. In the SAB meeting in August 2011, the plans for a senior visitor program were presented. Professor Mark Hindmarsh (U. Sussex, UK) was expected to stay at HIP as a long-term visitor for the full calendar year 2012. His research interests matched very well with the cosmology and LHC phenomenology projects at HIP. The theme of the visit was field theory applications to cosmology. Eventually, the stay of professor Hindmarsh lasted until June 2013. Attempts at a longer-term arrangement were also made, and FiDiPro proposals (Finland Distinguished Professor) were filed to the Academy of Finland, however without success.

The 3+3 model for the theory projects has turned out to be remarkably successful, at least in terms of the career advancement of younger generation researchers. During 1996-2016, twenty individuals worked as project leaders in the Theory Program. From the beginning of their appointment four were already professors. During the project, or soon afterwards, 11 researchers received a professorship or tenure track position in a Finnish university and, in addition, four individuals received a permanent position as a university lecturer or senior researcher. Of course, several other theoreticians were appointed to professorial positions after their post-doc research at HIP. In terms of publications, the role of the Theory Program was very prominent in the early phases of HIP. Until 2009, the publication volume of refereed journal articles of the Theory Program covered half or more of the total publication volume of the Institute. The situation changed once the LHC experiments started to produce data and the detector collaborations started to publish papers.

Large Hadron Collider (LHC)

The LHC construction project was approved by the CERN Council in December 1994. The planning had taken more than 10 years, while the first official recognition of the concept of constructing the LHC in the LEP tunnel took place in March 1984 at the ECFA-CERN workshop. The LHC project was approved as a two-phase procedure, with one third of the magnets initially left out, bringing the LHC to 9-10 TeV center-of-

mass energy in 2004. The upgrade to 14 TeV was envisaged for 2008. The estimated cost for the machine was 2230 MCHF, with additional funds required for the experimental areas and for the CERN contributions towards the experiments. The plan was to finance the construction within the regular annual budgets. Measures were taken in CERN's budget planning, including reductions of staff and closure of facilities. Contributions from the non-member states were also expected, and the intention was to use the additional resources to speed up the construction. An important factor in the approval of the LHC was the cancellation of the Superconducting Super Collider (SSC) project at Waxahachie, Texas, in October 1993 due to escalating costs. The planned proton-proton collider, SSC, had a circumference of about 87 km and each proton beam had the energy of 20 TeV.

The LHC is a particle accelerator with a circumference of almost 27 km, located underground in the border area between Switzerland and France near Geneva. The full design energy for protons accelerated in each of the beam pipes was 7 TeV. The particles travel in opposite directions in the two beam pipes and thus, at the collision points, a maximum energy of 14 TeV was foreseen. The magnets of the LHC need to remain at superconducting temperature, 1.9 K (i.e. -271.3 ˚C), to maintain the required magnetic field strength.

The LHC tunnel seen in October 2005 (Photo: CERN).

In 1997 a co-operation agreement with the United States was signed, and this provided a significant contribution, 531 M$, towards the LHC project. The target year for completion of the LHC project was 2005, in a one-stage process. In 1997 the Council also allowed CERN to take loans to keep the non-member states on board. In 2001 an in-depth examination of the cost-to-completion of the LHC revealed a significant cost overrun of the project. The solution was to increase the level of borrowing (e.g. European Investment Bank), to close the Proton Synchrotron (PS) and Super Proton Synchrotron (SPS) for the year 2005, and to extend the construction period. The latter was necessary in any case on technical grounds for both the machine and the detectors.

The first beam of protons was travelling around the machine on 10.9.2008. On 18.9.2008, while the current in the magnets was being increased, a faulty connection between two of the dipole magnets caused an electrical arc resulting in mechanical damage and the release of helium into the tunnel. A large number of magnets were damaged and had to be removed from the tunnel for repair. The repair work took eight months. In addition, a major cleaning operation was needed for the vacuum tube and a re-design of the LHC diagnostic system to improve the safety of the operation. Furthermore, it was decided that, to begin with, LHC would be operated at half of the design energy, 3.5+3.5 TeV, to avoid further delay of the start of the operation. On 23.11.2009 the first proton-proton collisions were registered at an injection energy of 450 GeV for each beam. Thereafter the acceleration of the beams was started, and before the Christmas break an energy level of 1.18+1.18 TeV was reached. The 3.5+3.5 TeV collision energy was reached on 30.3.2010, marking the start of the LHC research program. The cost of the machine by its completion in 2008 exceeded by about 13 % the original cost estimate, if an approximate 2 % inflation adjustment is taken into account.

The construction phase of the Large Hadron Collider provided significant opportunities for the Finnish industry to supply materials and components for the machine. For example, Outokumpu Poricopper/Luvata delivered the superconducting niobium-titanium wire, Metso Powdermet the end-caps for the dipole magnets, Rocla transport robots for the LHC, and Kempower power supplies for the magnets. In 2004 and 2005 the CERN return coefficient for supplies from Finland exceeded 2 when the goal set by CERN was 0.9. The return coefficient is the ratio between that member state's percentage share of the value of all supply contracts and that member state's percentage contribution to the CERN budget over the same period.

The inauguration of the LHC Collider took place at CERN on 21.10.2008. The Finnish delegation at the event was led by Undersecretary of State Esko Hamilo (Ministry of Foreign Affairs) and the delegation consisted of members representing the Ministry of Education, the Academy of Finland, and HIP.

Interest in physics research at the LHC emerged in Finland much before the final decision to construct the machine was made. There was a Finnish contingent in both the CMS (Compact Muon Solenoid) and ATLAS (A Toroidal LHC ApparatuS) Letters-of-Intent in 1992, as well as in the Technical Proposals in 1994. The Memorandum of Understanding for Collaboration in the Construction of the CMS Detector was approved by the HIP Board on 11.5.1998, with a Finnish commitment of 5 MCHF for the construction. Similarly, a construction MoU for the ATLAS detector was approved with a commitment of 0.1 MCHF. In effect, this was a membership fee for the collaboration intended for common projects, and no hardware contribution was committed to ATLAS.

The study of theoretical physics of relativistic heavy ion collisions had a strong tradition at the Department of Physics of the University of Jyväskylä. In the 1997 letter to the HIP Board, professor Juha Äystö of the University of Jyväskylä brought up the interest in ALICE research in Jyväskylä, and in 1998 HIP joined the Interim MoU for the Execution of the Initial Phase of the ALICE Experiment. The HIP Board authorized the Director to sign the Memorandum of Understanding for Collaboration in the Construction of the ALICE Detector in a meeting on 4.9.2000. There were six participants in the Collaboration from the Department of Physics, University of Jyväskylä, and HIP.

In 2001 it turned out that the initial cost estimates of the LHC detectors were not sufficient to finish the construction work, and about a 10 % increase in the funding was needed. An additional cost increase was due to a change in the exchange rate of the Swiss franc (CHF). On 12.9.2001 the Director, professor Riska, sent a memorandum to the Ministry of Education providing a new cost estimate, and on 21.5.2002 the Ministry and HIP signed a memorandum for additional financing for the Finnish share of the LHC detector construction. As a part of the agreement, on 5.2.2002 the HIP Board decided to leave the ATLAS Collaboration on 30.6.2003. On the basis of the memorandum HIP received additional funding during 2004-2006 of about 850 k€ towards the cost-to-completion of the CMS detector

and towards the exchange rate changes. Another part of the agreement also stipulated that HIP would bear the cost-to-completion of the ALICE detector from HIP's operating budget.

The LHC Run 1 lasted until 14.2.2013 with winter breaks, and during the Run 1 the collision energy was raised to 8 TeV in April 2012. Lead beams were accelerated for the first time already on 8.11.2010 at the center-of-mass energy per nucleon $\sqrt{s_{NN}} = 2.76$ TeV. Run 1 was followed by the Long Shutdown 1 (LS1) of about two years, and that time was used to consolidate the accelerator and raise the proton-proton collision energy to 13 TeV.

CMS

In the beginning of HIP operations the Finnish activity related to the CMS experiment at CERN was part of the LHC Program. In 2002 a new research program, the Nuclear Matter Program, was established and the ALICE and ISOLDE activities were included in that program. Therefore, on 1.7.2002 the LHC program was renamed the CMS Program, as only the CMS activity was part of it.

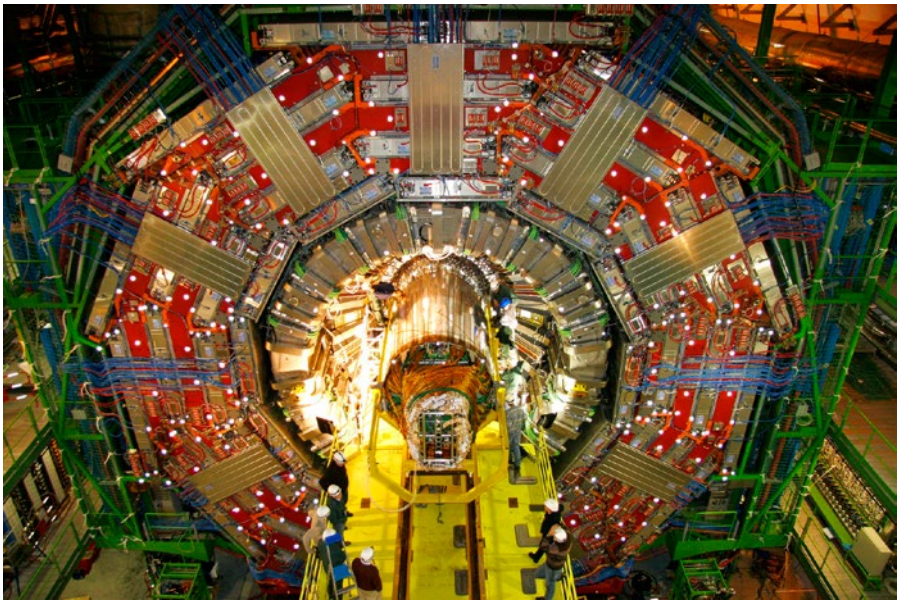
The CMS detector is one of the two general-purpose detectors at the CERN LHC collider; the other is the ATLAS detector. The detectors were designed for detecting a multitude of phenomena, but the primary goal was to find the Higgs boson. The Higgs particle was the last remaining undetected particle in the Standard Model of elementary particle physics. The general idea in the Finnish CMS contribution was to maximize the visibility and impact of the HIP group and its physics contribution by focusing the resources on one subdetector, the CMS Tracker. The core issues were the functioning, read-out, and alignment of the silicon detectors. The Finnish responsibilities in the CMS detector hardware included design and construction of the mechanical support structure for the Tracker Outer Barrel (TOB) and construction and operation of the Finnish Cosmic Rack, a telescope based on silicon detectors measuring tracks of cosmic particles and designed for testing the CMS TOB detector systems and software. In addition, the development of radiation hard silicon detectors and the assembly and quality testing of detector modules was pursued. HIP collaborated with the CERN Research and Development collaborations in the development of radiation hard silicon detectors, and also with several

Finnish research organizations including the Microelectronics Centre of the Helsinki University of Technology, of which the HIP LHC Program became a member in 2001. This membership provided access to clean room facilities and equipment for complete semiconductor processing. For the purposes of testing CMS detector materials, the Silicon Beam Telescope at the CERN Super Proton Synchrotron (SPS) H2 test beam was used, and HIP contributed to the design, construction, and operation of this infrastructure. The telescope was used to measure tracks of the incoming beam particles to test the spatial resolution and detection efficiency. Optical link boards for the triggering system of the Resistive Plate Chamber (RPC) detectors were also part of the HIP contribution to the CMS detector. Docent Esko Pietarinen led this activity. After his retirement in 2002, the development project was taken over by the CMS groups at the Lappeenranta University of Technology and the University of Warsaw, in close collaboration. The core funding for RPC was used for the production of link boards in Finland. The Lappeenranta University of Technology coordinated the design and tested the link boards. Manufacturing took place at a Finnish company, Electro-Hill Oy. RPC's are fast gaseous detectors providing a muon trigger system. In 2005 the assembly of the high-precision, lightweight support structures - rods - for the TOB had been completed at the HIP Detector Laboratory, and a total of 750 rod frames were tested and delivered to CERN. An important milestone in 2006 was the completion of the CMS Tracker Outer Barrel detector at CERN, where the HIP team of technicians had moved in order to contribute to the final assembly of the TOB after the production of the rods in Helsinki was finished. The commissioning of all the CMS Tracker subsystems started at the end of 2006 and the complete CMS Tracker was lowered into the CMS cave at LHC (interaction point 5) at the end of 2007. For the software development the main issues were the track finding and reconstruction and software alignment of the detector. The Hits and Impacts Positioning (H.I.P.) algorithm, developed at HIP, became an important tool for the alignment of the tracker for CMS. Furthermore, detector simulation

MSc Donatella Ungaro processing silicon strip detectors at the HUT Microelectronics Centre clean room (diffusion furnace).

for acceptance analysis and physics simulation software for physics analysis were on the agenda. The CMS Physics Technical Design Report was published in 2006, and demonstrated the strength of the CMS trigger and event reconstruction software as well as the discovery potential of the experiment. In the report, HIP was noted as having made important contributions to the alignment studies and in the assessment of the MSSM (Minimal Supersymmetric Standard Model) Higgs boson search discovery potential. In addition, participation in the CMS Computing, Software and Analysis Challenge 2006 with the resources available at that time was an important step in preparation for data taking.

The HIP-CERN team, Auli Kuronen, Antti Onnela, Pauli Engström, Erkki Anttila, and Jarmo Kortesmaa, assembling the CMS Tracker Outer Barrel in 2005. At the top right, one can see one rod fixed to an assembly tool ready to be pushed into the TOB-Wheel (Photo: CERN).



Installation of the silicon tracker inside the CMS detector in December 2007 (Photo: CERN).

HIP was also a member of the GEANT4 Collaboration, where the HIP focus was on medium energy hadronic physics modelling. GEANT4 (GEometry ANd Tracking) is a platform for the simulation of the passage of particles through matter using Monte Carlo methods. It is a standard tool for the detector design, e.g. in particle physics experiments, including the CMS experiment.

The HIP CMS work was initially organized within two projects, the Software and Physics project under the leadership of docent Veikko Karimäki and the CMS Tracker project led by Dr Eija Tuominen after Dr Miikka Kotamäki. The Software and Physics project was responsible for the software development, detector simulations, alignment issues, and physics potential analyses. The rest of the HIP CMS responsibilities including the Tracker Outer Barrel construction, the silicon detector development, the manufacture of the rods and the link boards for the Resistive Plate Chambers remained in the Tracker project.

In anticipation of the expected start of the LHC experiments in 2008, the HIP CMS Software and Physics project was evaluated in 2006 by Dr Nick Ellis (CERN) and Dr Matthias Kasemann (DESY). In the report, dated 1.6.2006, the evaluation panelists expressed their appreciation for the coherence of the HIP CMS program, which included tracker hardware, track reconstruction software, tracker alignment algorithms, and Higgs physics with b-quark and tau final states that rely strongly on tracking and vertexing. In conclusion, the report was very positive, pointing to the potential of the different aspects of the HIP activity in making a significant contribution to the analysis of CMS data. In the preparation phase, the project had published only relatively few refereed journal articles, but the reviewers did not consider this problematic, as the conference articles and the CMS Notes increased the publication volume. The importance of solving the problems related to computing was an essential recommendation. That problem was solved when the Ministry of Education granted an annual contribution of 0.8 M€ towards the computing during 2008-2010. The project activity was continued under a new name, CMS Physics Analysis, for the years 2007-2009, with Veikko Karimäki as the project leader.

The CMS Tracker project was evaluated in March 2007 by Dr Christian Joram (CERN) and Dr Michael Tyndel (Rutherford Appleton Laboratory). The evaluation panel summarized the past achievements and current activities thusly: “The HIP team made major contributions to CMS which

were of highest quality and delivered in time and budget. A relatively small team has made important contributions to the construction of CMS. These are visible achievements with high scientific impact. Their silicon R&D effort is recognized in the community and is of highest relevance for possible CMS tracker upgrade scenarios. The CMS project continues to deserve its flagship status in HIP." For the future, the evaluators put forward five items for consideration: exploitation of the FinnCRack and Silicon Beam Telescope in track reconstruction research and software development; silicon sensor development; looking for opportunities to exploit the electronic expertise within HIP to contribute to the readout and triggering of an upgraded tracker; completion of the trigger project as efficiently as possible; and continuation of R&D on materials and engineering design concepts for an upgraded LHC detector. As a consequence of the positive evaluation the Tracker project was continued by the HIP Board with a new name, CMS Tracker Operations, and with an increased emphasis on silicon tracking detector development for future high energy physics experiments. Dr Eija Tuominen continued to lead the project for the year 2008.

The HIP Board authorized the director to sign the Memorandum of Understanding for the Maintenance and Operation of the CMS Detector in a meeting on 11.9.2002. At that time the detector was not anywhere near completed, but there was the need to agree on the procedures related to maintenance and operation for the pre-exploitation and exploitation phases of the CMS detector. CERN had assigned to the CMS Resources Review Board (RRB) the role of proponent of the maintenance and operation procedures, and also the monitoring of its functioning. In addition, the RRB had the task of endorsing the annual maintenance and operation budget of the detector. The purpose of the Maintenance and Operation MoU was to set out the organizational, managerial, and financial guidelines for the Collaboration. An essential part of the MoU were the guidelines for cost sharing. In CMS the maintenance and operation cost was grouped into two categories, A and B. The category A cost was proportional to the number of the scientific staff who held a PhD and were entitled to be named as authors of the scientific publications of the collaboration. The Category B cost was connected to the upkeep of the subdetector systems for which the Institute had responsibility in the Construction MoU.

The commissioning of the CMS detector system was successfully completed by the end of the summer of 2008, and the apparatus was ready for recording collisions in September. Due to the incidence of 18.9.2008,

the focus had to be shifted and, in late 2008, the CMS Collaboration conducted a commissioning run with cosmic muons, Cosmic Run At Four Tesla, with the CMS detector without LHC beam to exercise data taking in a continuous complete experiment to gain operational experience. The cosmic muon data collected were used to study the performance of the detectors, to commission the alignment and calibration techniques, and to make several cosmic ray measurements. The results were published by the CMS Collaboration in the Journal of Instrumentation 5 (2010) T03001.

The first proton-proton collisions the CMS detector recorded on 23.11.2009 were at the LHC injection energy of 450+450 GeV. A special event was organized at HIP on the first physics day, 30.3.2010, with a live video connection to CERN and a screen showing the first collision events from CMS. The event had excellent visibility in Finland, with prime-time TV-news broadcasts, radio programs, and numerous articles in Finnish newspapers.

The commissioning and calibration of the detector with LHC beam was done with well-known physics samples, e.g. Z and W decays. In the initial phase of the LHC physics operation, the HIP CMS Program contributed to the physics analysis in the search for MSSM charged Higgs bosons with $H^{\pm} \rightarrow \tau\upsilon \rightarrow$ hadrons + υ decay mode in fully hadronic final state, tau trigger efficiency measurement and B-physics. Professor Paula Eerola of HIP was the convener of the CMS B Physics Analysis Group for 2009-2010. Of particular interest was the analysis of the $B_s \rightarrow J/\psi\varphi$ reaction as a test of physics beyond the Standard Model. An important role was played by the track-based alignment of the CMS Tracker modules employing the H.I.P. alignment algorithm. Jet Energy Corrections (JEC) later became an important area of HIP activity with applications, e.g., for the top quark mass measurement in hadronic channels. JEC were vital input for the whole collaboration, as most final states in proton-proton collisions produce jets, both for signal and for background. Furthermore, HIP was contributing to the CMS user support, which aimed at providing comprehensive training and documentation suites for physics analysis tools. For the preparation of the CMS Data Preservation and Open Access Policy, the Collaboration set up a working group under the leadership of Dr Katri Lassila-Perini with the aim of preparing the policy and the implementation plan in collaboration with CERN. The CMS policy for data preservation, re-use, and open access was approved by the CMS Collaboration Board in March 2012.

The CERN Large Hadron Collider was designed to reach a luminosity of 10^{34} cm^{-2} s^{-1} at the center-of-mass energy of 14 TeV. During Run 1 the machine was operating at energies of 7 TeV and 8 TeV with gradually increasing peak luminosity. To broaden the physics capabilities of the LHC, work started at CERN to increase the luminosity beyond the design value to 10^{35} cm^{-2} s^{-1} , i.e. an increase by a factor of ten. The purpose was to improve the statistical accuracy of the measurements and to make it possible to see more rare events. The CMS Expression-of-Interest in the SLHC was published on 15.3.2007 and it gave the motivation and scope for the CMS detector upgrades for the high-luminosity SuperLHC. The Technical Proposal for the Upgrade of the CMS Detector was completed in June 2011.

When high-energy particles travel through silicon detectors, crystallographic defects emerge and the electrical properties of the detectors degrade. The objective of the HIP CMS Tracker silicon detector research was to develop radiation hard sensor solutions for the CMS detector upgrades and for the planned High-Luminosity LHC (HL-LHC). For the CMS Phase 1 upgrade project, a major Finnish responsibility was to produce half of the Pixel Tracker modules for layer 3 of the 4-layer tracker. The technology is so-called bump bonding, with which the VTT Technical Research Centre of Finland had experience and a good reputation. For the CMS Phase 2 upgrade basic R&D was needed on novel detector technologies, in view of the harsh radiation environment after the intensity upgrade of the LHC accelerator. At HIP, extensive research on magnetic Czochralski silicon was pursued in co-operation with Okmetic Oy. In the development of detectors HIP actively participated in the activities of the CERN RD50 (Development of Radiation Hard Semiconductor Devices for Very High Luminosity Colliders) and RD39 (Radiation-hard cryogenic silicon detectors) Research and Development collaborations. Dr Jaakko Härkönen served as a co-spokesperson of the RD39 collaboration and a project leader in RD50. The upgrade plans for the RPC detectors included the increase of the coverage in the forward directions, and the group at the Lappeenranta University of Technology participated in the production of a significant part of the off-detector electronics.

Good visibility for high-energy physics at HIP and at the Department of Physics of the University of Helsinki was obtained in 2006 by hosting the CERN School of Computing at the Kumpula Campus between 21.8.-1.9, with 79 participants of 25 different nationalities. Another important school

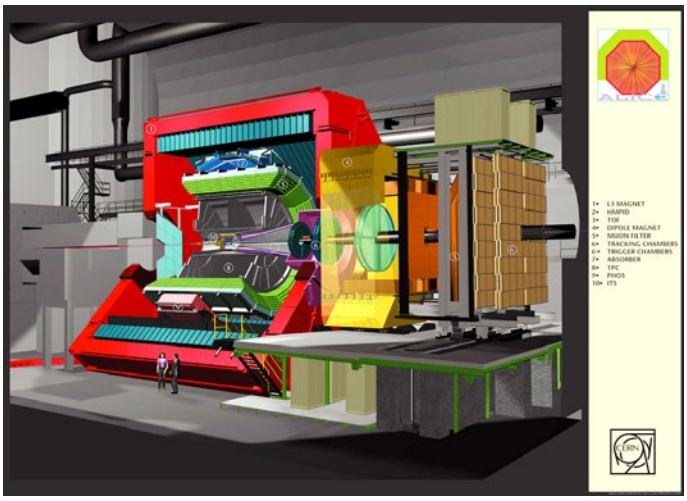
event was the joint CERN JINR 2010 European School of High-Energy Physics, which was held in Raseborg 20.6.-3.7.2010 with 105 students from 25 countries.

Tuominiemi's book gives a very thorough account of the Finnish participation in the development, design, and construction of the CMS experiment.

CERN School of Computing (CSC 2006) was organized in Kumpula 21 August – 1 September 2006. In the middle of the front row is the Director of the School, François Flückiger of CERN (dark suit), and to the right of him is Aatos Heikkinen of HIP in a red T-shirt (Photo: CERN).

ALICE

The purpose of the ALICE experiment at CERN is to study the physics of strongly interacting matter at extreme densities and temperatures created in relativistic heavy ion collisions, where a phase of matter called quark-gluon plasma is formed. The idea is to study the phase diagram of strongly interacting matter, with lead-lead collisions produced in the laboratory reflecting the conditions in the early Universe just after the Big Bang, and the interiors of neutron stars. The existence of quark-gluon plasma and its properties is an important issue in the theory of strong interaction physics - quantum chromodynamics (QCD) - for the understanding of confinement and chiral restoration.



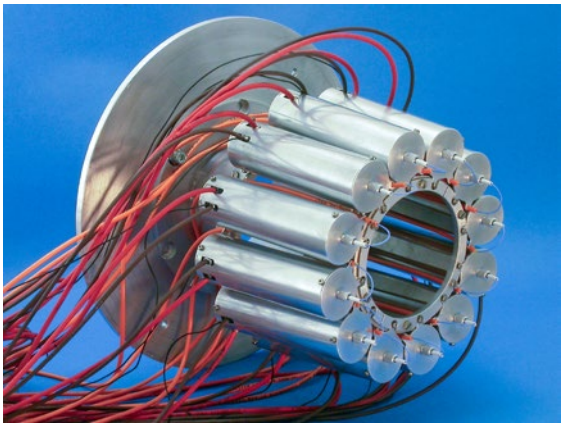
A view of the ALICE detector (Image: CERN infographics gallery).

HIP joined the ALICE Collaboration late, in 1998. The planning of the main features of the detector was finished at that point, and the decisions concerning the different hardware responsibilities had already been taken. However, the ALICE Collaboration was short of resources for the Inner Tracker System (ITS) and, in addition, there were overlapping detector interests for both the Collaboration and the Finnish partners, HIP and the Department of Physics of the University of Jyväskylä. Therefore, the Finnish core contribution was allocated to ITS, in particular to the Silicon Strip Detector subsystem, in both the Interim and Construction Memorandum of Understanding. Participation in the ITS software development and data analysis started well.

Initially, most of the Finnish ALICE core funding (1 MCHF) had been assigned to the tracker Silicon Strip Detector (SSD) assembly. An important decision was made in 2001 and it was decided that the assembly would be done at the HIP Detector Laboratory under the leadership of Dr Markku Oinonen instead of an industrial partner. The main reason for the decision was the high cost of assigning the work to a company capable of the task. Savings in the assembly made it possible to fund the HIP T0 contribution. The two outer layers of the ALICE ITS, layers 5 and 6, contained about 2000 Silicon Strip Detector modules, and the production of these modules was shared between France, Italy, and Finland. The mass production started in June 2004, and the Detector Laboratory finished the assembly task of 716 modules by the end of July 2006. Ukrainian scientists from Kharkov and Kiev contributed substantially to the successful completion of the assembly at HIP. They were the experts in exploiting thin and flexible interconnections based on Ukrainian Tape Automated Bonding (TAB) technology. All of the modules were eventually shipped to NIKHEF, where the integration of the ALICE SSD

took place throughout the year and, at the end of 2006, the complete SSD was transported to CERN to wait for the final integration as part of the ALICE ITS during 2007.

The long-term reliability of the bonded components became an important issue to investigate. In particular, thermal stress as the cause for long-term failure of the bonded components was under study. For the non-destructive bond quality control, Laser Scanning Microscopy and Scanning White-Light Interferometry were developed in collaboration with the Electronics Research Unit of the Department of Physics of the University of Helsinki.



The first part of the T0 trigger detector: T0-C in 2006 (Photo: Wladyslaw Trzaska).

The other hardware contribution to ALICE was the T0 detector, which provided fast vertex positioning and a start time for time-of-flight measurements; Dr Wladyslaw Trzaska played a significant leadership role in this effort. The HIP-Jyväskylä group also had the required experience and expertise for the task. In 2002 the ALICE Collaboration assigned Finland the project lead for T0. Several possible concepts were developed including microchannel plates, which the HIP-Jyväskylä group was working on. In the end, the Collaboration chose a more conservative and less expensive technical solution based on Cherenkov radiators coupled to photo-multiplier tubes. The work on fast electronics was, however, applicable to the photo-multiplier tube pulses as well. The ALICE Technical Design Report on Forward Detectors including T0 was published on 10.9.2004.

In a meeting in 2002 the HIP Scientific Advisory Board called for creating a physics analysis team for ALICE research. HIP and the Department of Physics of the University of Jyväskylä established a joint, fixed-term position at the senior assistant level at the University of Jyväskylä, and from December 2005 Dr Jan Rak took over the position. He had substantial experience from the PHENIX Collaboration at the RHIC accelerator in Brookhaven. The recruiting process is discussed in the section on Personnel Developments. Jan Rak served as the ALICE run-period coordinator from June-November

2008 during the very important phase of ALICE commissioning. In addition, he served as run coordinator at CERN for 2009 and the beginning of 2010.

The first physics publication by ALICE was published in 2004 (Physics Performance Report, Volume I, J. Phys. G30 (2004) 1517), and there were 7 co-authors from the HIP-Jyväskylä group. The first volume contained a general introduction to the physics of nucleus-nucleus collisions at the LHC and a description of the experimental apparatus. The second volume of the ALICE Performance Report, discussing the expected performance of the apparatus in the main areas of the ALICE research with simulated measurements, was published in J. Phys. G32 (2006) 1295. The number of co-authors from the HIP-Jyväskylä group was 9.

Since the interests of the physics analysis group were focused on high-p_T photon and jet production, the hardware involvement in the ALICE experiment was expanded to include the electromagnetic calorimeter (EMCAL), which plays a crucial role in photon and π^0 identification, the main signatures of the existence of the dense and opaque QCD medium observed in RHIC. The group participated in the construction of trigger unit boards and the development of Field-programmable gate array (FPGA) firmware for them. The Finnish group was able to optimize the trigger decision making very significantly, which was needed for the successful commissioning of the single photon trigger.

The first proton-proton collisions were recorded at the LHC on 23.11.2009, and the ALICE Collaboration was the first to get a publication out using LHC data. The paper was based on 284 events collected at the SPS injection energy in just over 40 minutes. The article, "The first proton–proton collisions at the LHC as observed with the ALICE detector: measurement of the charged-particle pseudorapidity density at $\sqrt{s}$ = 900 GeV", Eur. Phys. J. C65 (2010) 111, was published online already on 11.12.2009, and was signed by 13 authors from HIP and the University of Jyväskylä. The first Pb-Pb collisions were recorded on 8.11.2010 at the center-of-mass energy per $\sqrt{s_{NN}}$ = 2.76 TeV.

The Jyväskylä team played an active role in leading-particle correlation analysis to explore the basic properties of perturbative QCD phenomena at the new energy frontier, as well as in the maintenance and operation of the T0 and Trigger Region Units for the electromagnetic calorimeter single-photon triggering. The jet quenching was found to vanish in the high-p_T

sector, providing the most direct manifestation of the deconfined quark gluon plasma. Jet quenching was expected due to the energy loss of particles traversing the QCD medium.

Dr Jan Rak celebrating the first collisions on 23.11.2009 at CERN (Photo: CERN).

Initially the HIP ALICE activity was part of the Nuclear Matter Physics project of the LHC Program under the leadership of professor Vesa Ruuskanen of Jyväskylä. In 2002 the Nuclear Matter Physics program was established and the ALICE research became a project within that program. The leader was Dr Wladyslaw Trzaska until the end of 2004. Dr Markku Oinonen was the leader from 2005 until he became the Director of the Laboratory of Chronology of the Finnish Museum of Natural History at the end of February 2007. Dr Jan Rak was appointed by the HIP Board as the project leader on 6.3.2007.

The Department of Physics of the University of Jyväskylä hosted the ALICE Physics Week 2011 from 28.8.-2.9.2011 with 138 participants, and there the physics analysis of the Pb+Pb run was discussed.

Professor Juhani Keinonen of the University of Helsinki had been appointed in 2000 to represent HIP at the ALICE RRB. In the beginning of 2002 he expressed his wish to resign and make room for a representative of the University of Jyväskylä.

Forward physics

The evaluation panel, led by Heuer, which had been appointed to evaluate and define a good detector development program for HIP, had in their report dated 29.1.1999 emphasized that “a visible and well defined contribution to the detector apparatus is essential for effective participation in the physics output of a modern particle physics experiment”. The technical designs for the large LHC detectors had been completed and

Participants of the 5th ALICE Physics Week on a boat trip on Päijänne lake. Dr Wladyslaw Trzaska wearing a green coat is waving his hand (Photo: Timo Tihinen).

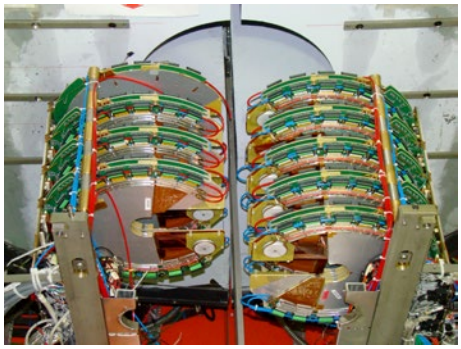
responsibilities assigned, and therefore it was difficult or impossible to have any additional significant detector contribution assigned to HIP in, e.g., the CMS detector. In anticipation of the LEP closure (which took place on 2.11.2000), the Electron-Positron Physics project of the High Energy Physics Program, responsible for the HIP DELPHI activity, started to look in new directions in 1999. The intention was to exploit the expertise of the group in silicon and gaseous detectors. A feasibility study for a very forward detector system at LHC was approved in the HIP Board meeting on 3.2.2000. The aim was to design detector components that would allow for the luminosity and total cross section measurements at LHC together with diffractive physics studies. Training of students in forward physics was planned to take place at the Tevatron accelerator at Fermilab, USA. Initially the idea was to connect with the LHC ATLAS detector, and the concept was presented during the ATLAS Week in June 2000. The ALICE Collaboration also expressed their interest in exploring the possibilities for forward physics at the ALICE detector and, similarly, the CMS Collaboration. However, the CMS Collaboration referred to discussions with the TOTEM Collaboration for addressing issues in forward physics. SAB expressed interest in their meeting on 4.9.2000 in the development of the project. A dedicated workshop “Forward Physics and Luminosity Determination at LHC” was held on November 1-3, 2000 in Helsinki to prepare for decisions concerning the project. The LHC

Forward Physics project was formed in the High Energy Physics Program in the beginning of 2001, initially for one year, and professor Risto Orava became the project leader.

The proposal for forward physics, including participation in the CDF upgrade (The Collider Detector at Fermilab), was presented to the SAB on 21.5.2001, and an in-depth review of the physics and technology of the project was called for by the committee. On 5.6.2001 the HIP Board decided in favor of the evaluation and, on the advice of the SAB and CERN management, professors John Dainton (U. Liverpool) and Günter Wolf (DESY) were invited to do the assessment. Their report was published on 27.10.2001. There they paid attention to the highly demanding R&D needed to design and build detectors working in harsh radiation environment close to the beam, where, in addition, the space is very limited. Furthermore, they recommended that the group join the CDF Collaboration to gain first-hand experience in forward physics before the LHC operations started and, after the start of LHC, that it join forces with the TOTEM initiative, which was associated with the CMS detector. The HIP Board decided on 21.11.2001 that the preparations to join the TOTEM and CDF Collaborations could start.

On 15.11.2001 the CDF Executive Board accepted the membership of the Helsinki group in the collaboration starting 1.1.2002. At that time the CDF Collaboration involved 12 countries, 58 institutions, 607 physicists, and 140 students. In the HIP Board meeting on 4.6.2002 the Director was authorized to sign the Memorandum of Understanding between the Fermi National Accelerator Laboratory, the CDF-II Collaboration, and the Helsinki Institute of Physics. The financial commitment for cost sharing in the MoU was initially on the level of 5 k$ per physicist per year, i.e. 30 k$ annually for the 6 PhD level physicists initially involved. Signing the MoU was delayed, however, because of the details of the HIP contribution towards the upgrade of the CDF detector could not be agreed upon and, furthermore, the CDF Collaboration itself changed its plans. The MoU was finally signed in September 2004. The High Energy Physics Division of the Department of Physical Sciences of the University of Helsinki joined HIP in signing the MoU. The responsibilities for the Helsinki team included the CDF Silicon Detector support and development activities, database support, and assistance in the L2 trigger test stand project. The Universities of Applied Sciences of Rovaniemi and Pohjois-Savo provided significant contributions towards fulfilling the commitments specified in the MoU.

In early 2002, 31.5.2002, the group was invited to join the TOTEM Collaboration at CERN. The Letter-of-Intent of the TOTEM Collaboration (TOTal cross section, Elastic scattering and diffraction dissociation Measurement at the LHC) had been submitted in August 1997, and the Technical proposal in March 1999. The Technical Design Report of the TOTEM detector system was completed in January 2004, and 13 names from HIP appeared as co-authors. Professor Risto Orava became the physics coordinator of the TOTEM Collaboration in 2004. On 28.11.2005 the HIP Board authorized the director to sign the Memorandum of Understanding for Collaboration in the Construction of the TOTEM Detector, and the signing took place on 26.7.2006. The Finnish share of the construction cost was 524 kCHF. The MoU for the Maintenance and Operation of the TOTEM Detector was signed in October 2007. The HIP's responsibility regarding the detector in the Construction MoU was the coordination of the construction and operation of the T2 tracking telescopes, based on GEM (Gas Electron Multiplier) detector technology and placed 13.5 m away from the CMS/LHC Interaction Point. Initially, HIP also contributed to the development of the required electronics. The 40 GEM detectors (plus 10 spares) were assembled by January 2008, and performance tests with quality tests including long-term stability tests were completed. In the autumn of 2010 the TOTEM Collaboration was ready to take the first physics grade proton-proton data at $\sqrt{s}$ = 7 TeV. The first papers on proton-proton elastic scattering and the total cross section were published in 2011. Doc. Kenneth Österberg became the physics coordinator of the TOTEM Collaboration in December 2008.



A single arm of the TOTEM T2 telescope being commissioned at the CMS interaction point (IP5) in the LHC tunnel (Photo: Jouni Heino).

A fully commissioned T2 arm ready for insertion into the CMS hadron forward calorimeter (Photo: Jouni Heino).

The physics analysis of the Finnish group at CDF focused on the top quark properties, in particular the top quark mass determination. The Tevatron proton-antiproton collider of Fermilab was closed on 30.9.2011, but the

data analysis continued for several years. During 2005-2010 the CDF activity at Fermilab was also supported by Academy of Finland grants through the Department of Physics of the University of Helsinki. The participation in the CDF-II experiment at Fermilab was an extremely successful project; with a modest initial contribution HIP was a contributor to 422 refereed journal articles between 2003-2016, including many publications in Physical Review Letters. In addition, several PhD theses were completed in the project. Timo Aaltonen has been in the author list of the CDF Collaboration since 2007, and after that has been the first author in the CDF publications.

Grid computing

Facing an immense computing challenge, with petabytes of data to be collected in the LHC experiments at CERN, in 1999 the detector collaborations agreed to manage the data handling with a multi-tier hierarchical model where the data storage and computations are performed in a distributed mode in four-levels. The raw data from LHC are kept at the CERN Data Centre, which is the Tier-0. Tier-1 centers are regional, and responsible for storing a share of raw and reconstructed data, as well as performing large-scale reprocessing and storing of the corresponding output, distributing data to Tier-2s and storing the simulated data that the Tier-2s produce. Optical-fiber links connect CERN to each of the Tier-1 centers around the world. Tier-2 centers are typically maintained by universities and other scientific institutes that can store sufficient data and provide adequate computing power for specific analysis tasks. They also handle a proportional share of the production and reconstruction of simulated events. Individual scientists can access the data through local (or Tier-3) computing resources, which can consist of local clusters in a university department or even an individual PC.

In early 2000 preparations started at CERN for an application for European Union funding for developing a sustainable computing model for the effective sharing of computing resources and data for scientific communities, in particular for the high-energy physics collaborations at CERN. HIP experimentalists at CMS became involved with the proposal quite early, and the role of HIP as an assistant partner through CERN was established. In April 2000 some internal Finnish confusion arose over

the role of HIP and the Academy of Finland in the consortium, and the project coordinator at CERN expressed his frustration: "I don't want to look uncooperative, but I am spending personally more time with the Finnish administrative representation than with all the other partner's administrative matters all together. This is particularly unfortunate at this time, when we need to get our proposal out to the EU in an incredible short time and with a tremendous work pressure. Please try to clarify the situation asap. On May 3rd we will be too late." Fortunately, the Finnish issues were settled in time and in agreement between all the stakeholders docent Ari-Pekka Hameri, the Director of the Technology Program, was chosen as the coordinator of the Finnish node. From the start, physicists wanted to get the Center for Scientific Computing (CSC) involved in the project, and CSC became a subcontractor for HIP. The proposal, "Research and Technological Development for an International Data Grid (DataGrid)", was approved by the EU and the project started on 1.1.2001. The project, which was part of the Information Society Technologies (IST) sector of the 5th Framework Program of EU, had 21 partners and about 10 M€ funding for three years. The aim of the DataGrid project was to provide infrastructure and software tools for distributed computing based on research in the field of the grid network technologies. The purpose of the project was especially to provide the LHC experiments with the necessary computational power using commodity systems, and to develop tools for working with very large amounts of data over the globally distributed network. DataGrid was not, however, a project restricted to the high-energy physics community, but included contributions from astronomy and space science, earth science, and biology as well as contributions from many computer science institutes and industrial partners. HIP was committed to contributing to two work packages: Grid Data Management and High-Energy Physics Applications. In the summer of 2000 the HIP Technology Program was re-structured, and the DataGrid activity became the focus of the Program. The work with distributed computing technologies, including applications, started vigorously. From the beginning of 2001 the Technology Program included a DataGrid project, with MSc Matti Heikkurinen as the project leader. In 2001 the project obtained a grant from the Magnus Ehrnrooth Foundation for setting up a PC cluster for testing the grid technologies and for training purposes. The DataGrid project of the HIP Technology Program was, in addition to contributions to the high-energy physics computations, seeking applications and industrial partners for grid technologies.

In 2000 discussions started within academic institutes on the establishment of a Tier-1 center in one of the Nordic countries. The primary aim was to serve the groups working in the ATLAS or ALICE collaborations at CERN. The discussions led to a proposal for "A Nordic test bed for wide area computing and data handling" in October 2000. The intention was to provide an infrastructure for interdisciplinary feasibility studies of grid computer structures and a testbed for supporting the DataGrid project coordinated by CERN. HIP, which represented Finland, played an active role in the planning of the project. The Nordic Council of Ministers initially funded the project, the NorduGrid project, for the years 2001-2002 through the Nordunet2 program. The project provided the testbeds and, in addition, developed the middleware, the Advanced Resource Connector (ARC), for facilitating grid computations, because it had become clear that the existing tools were not suitable for the computation needs of the LHC data analysis. It also became apparent that the physicists working at LHC needed a more permanent arrangement to gain the Tier-1 status for a Nordic center. The Joint Committee of the Nordic Research Councils for Natural Sciences (NOS-N), which is a collaborating body for Nordic research councils that finance research in the natural sciences, decided in its meeting in June 2001 to set up a working group to address the technical and financial requirements for a multi-disciplinary Nordic Data Grid Centre. The Finnish members of the working group were Dan-Olof Riska (HIP), Jari Järvinen (CSC), and Eeva Ikonen (Academy of Finland). The working group report was published in November 2001, and one of the recommendations was that Nordic cooperation is well suited for the establishment of a full capacity Data Grid Centre. Furthermore, the group recommended that NOS-N take on the coordinating and advisory responsibility for the development of the Nordic grid computation capacity. The Nordic Data Grid Facility (NDGF) was initially established as a pilot project funded in 2002 by NOS-N for 2003-2005. NDGF also took the role of the distributed Nordic Tier-1 center for the LHC computing grid.

At CERN, the HIP Technology Program focused on the Data Management Work Package (WP2) in the EU DataGrid project, especially on coordination of the security task and metadata management related activities. Since 2003 HIP's DataGrid activities had been managed by MSc Miika Tuisku. The EU project ended in early 2004, but another, even larger, consortium was established for the EU funded project Enabling Grids for eScience in Europe (EGEE), which ran for two years from 2004-2006. The aim

of the EGEE project was to build on advances in grid technology and to develop a service grid infrastructure in Europe available to scientists 24/7. The group in HIP's Technology Program participated in the security team. The work was a continuation of the earlier activity in grid security issues. Furthermore, the Technology Program contributed, together with the HIP CMS Software and Physics project, to the work package related to the high-energy physics applications. The EGEE project activity continued in the EGEE-II and EGEE-III projects until 2010, and HIP experts had leading roles in middleware and security development. In the EGEE projects the idea was to develop a grid as a service for sharing computer power and storage capacity over the internet comparable to the electric power grid, in which the power generators are distributed but the users are able to access electric power without thinking about the source of the energy or its location. The EGEE project has made the vision of the seamless sharing of computing resources on an international scale a reality. It has expanded beyond Europe, consolidating international relationships with groups in the US and Asia in its second phase, EGEE-II. To organize and integrate the disparate computational facilities belonging to such a grid, and to make their resources easily accessible to the user, the project has produced its own middleware, gLite. It was re-engineered by the project from a range of best-of-breed middleware components to contain a full range of foundation services as well as support for field- and application-specific high-level services. The CMS collaboration adopted the gLite middleware for managing their grid computations. The NDGF had developed ARC middleware for the Tier-1 and Tier-2 operations, which caused some additional work for the Finnish CMS group. The CMS usage of the ARC middleware spread from the Finnish CMS group to Estonia, the UK, and elsewhere.

Mikko Pitkänen defended his doctoral dissertation on "Data availability in challenging networking environments in presence of failures" on 14.1.2011 at the Aalto University. In the picture are Dr Tapio Niemi, Mikko Pitkänen, and professors Jörg Ott (AU) and Ari-Pekka Hameri (Photo: Antti Pirinen).

In September 2001 the first phase of the LHC Computing Grid (LCG) project was approved at an extraordinary meeting of the CERN Council. The first phase, which was activated in 2002 and continued in 2003 and 2004, was developing the prototype equipment and techniques necessary for the data-intensive scientific computing of the LHC era. HIP joined the Memorandum of Understanding concerning the LCG Phase one in December 2002. In the MoU, HIP committed to contribute 100 kCHF in cash and a major in-kind portion in terms of the work by the HIP Technology Program. The Technical Design Report "CMS The Computing Project" (CERN-LHCC-2005-023) was finished 20.6.2005 and provided a description of the organization of the CMS Offline Computing systems, including a software framework for high-energy event streams, workload management tools for coordinating the work at the computer centers, and tools for using the resources efficiently. The ALICE computing TDR (CERN-LHCC-2005-018), with similar content, was released on 15.6.2005. At HIP, Dr Tomas Lindén of the CMS Program was appointed as the grid-coordinator starting 1.7.2005. HIP signed the Memorandum of Understanding for Collaboration in the Deployment and Exploitation of the Worldwide LHC Computing Grid (WLCG) on October 23rd 2007. The MoU defines the Tier-1 and Tier-2 centers, their computing capacities and annual average availabilities together with maximum delay times in responding to operational problems. On 13.11.2007 HIP and CSC concluded a service contract related to the HIP WLCG responsibilities. CSC became part of the Nordic distributed Tier-1 center and the Finnish Tier-2 service provider. In 2008 CSC made their Sepeli cluster available for the HIP Tier-2 in order to meet the CMS requirements in 2008-2009. Common Computing Readiness Challenges took place in early 2008 to test the grid infrastructure before data taking at LHC. The Rutherford Appleton Laboratory (RAL) in UK became the Tier-1 facility for the HIP CMS grid computing.

Kimmo Koski (CSC) and Dan-Olof Riska signed the contract for the construction and operation of the Finnish Tier-2 Grid computing facility on 13.11.2007.

In October 2004 the results of the NDGF Pilot Project, in the form of "A Proposal for a Nordic DataGrid Facility" covering the period 2006-2010 was submitted to NOS-N. The proposal

was that the NDGF pilot would run until the end of 2005. The NDGF would then start on 1.1.2006, with production beginning 1.8.2006. In the proposal the mission of the NDGF was to operate a Nordic grid based on national production grids, to operate a core facility focusing on Nordic storage resources for collaborating projects, to develop and enact the policy framework needed to create the Nordic research arena for computational science, to co-ordinate and host Nordic level development projects in high performance computing (HPC) and grid computing, to create a forum for HPC and grid users in the Nordic countries, and to be the interface to international large scale projects for the Nordic HPC and grid community. In the spring of 2005 an evaluation of the NDGF was performed by an international panel, and the report was published on 1.6.2005. The panel, which consisted of D. Vandromme (Rouen), M. Livny (Wisconsin-Madison), and P. Rice (Cambridge, UK), agreed with the idea of establishing a common Nordic grid so that a sufficient critical mass of the infrastructure could be achieved to become an attractive partner for larger grid projects worldwide.

In Finland, the Ministry of Education set up a working group to draft a national grid strategy on 7.3.2005. Academy professor Risto Nieminen (HUT) was appointed as the chair of the working group and Klaus Lindberg (CSC) as the secretary. The working group had six tasks and, in addition to drafting the strategy, these included the task of proposing actions to be taken with respect to the founding and operation of the Nordic grid center. The working group included representation from the Ministry of Education, the Academy of Finland, Tekes, CSC, and several universities. Professor Dan-Olof Riska represented HIP in the working group. An intermediate report was published on 15.9.2005, in which the working group made several recommendations: Nordic collaboration should be strengthened by creating the NDGF organization, a strong national Center of Expertise should be created at CSC, the computation and storage facilities needed by the Finnish LHC research groups should be constructed, and their operation should be the responsibility of the national Center of Expertise for grid computations. In addition, different fields of research should create grid networks, industrial connections were encouraged, and the communication networks should be top quality. On the basis of the intermediate report of the working group, the Minister of Education, Antti Kalliomäki, committed in a letter of 12.1.2006 to the Finnish participation in the founding and financing of the Nordic Grid organization for 2006-2010. CSC was nominated as the Finnish

responsible partner, and Kimmo Koski (CSC) and Dan-Olof Riska (HIP) were appointed as the Finnish representatives in the Steering Board. The final report of the working group, "Finlands eScience -program", was published on 29.1.2007. In March 2007 the Finnish Ministry of Education decided to fund the building of a Tier-2 grid facility at CSC in 2008-2010 through a grant of 2.4 M€ for HIP. To manage setting up the Tier-2 capability and coordination with CSC, HIP established the GridCluster project for 2008-2010 within the Technology Program. MSc(eng.) Antti Pirinen was appointed leader of the project. In mid-August 2010 Antti Pirinen moved to the private sector and Dr Tomas Lindén took over the leadership of the project.

At the end of 2005 it was agreed that the best way to establish the legal entity for the new NDGF organization was to seek collaboration with NORDUnet, which is a collaboration between the National Research and Education Networks (NRENs) of the five Nordic countries. NOS-N made an inquiry to NORDUnet A/S to host NDGF, and in February 2006 they received a positive answer and NDGF was organized under the NORDUnet umbrella. On 19.12.2006 NOS-N sent a letter to NDGF requesting an evaluation of the activities of NDGF. The evaluation was a self-evaluation assisted by two external experts, M. Dæhlen (Oslo) and K.-F. Berggren (Linköping). The main recommendations in the report, dated 23.3.2007, were that the Steering Board should assume a more political role and leave the strategy issues to the management team. In addition, an expansion of the activities from the CERN related Tier-1 activities to, at least, two new areas of scientific inquiry was recommended. The final report of the NDGF, dated 10.3.2010 and written by K. Nordlund (Helsinki, chair), D. Kranzlmüller (München), and R. Pennington (NSF, USA), noted that the Tier-1 activity worked very well and was essential for the Nordic research groups working at the LHC, and that the WLCG activity was very prominent in the organization. By the end of 2009 the WLCG had reached close to full readiness, with availability in the 95-100 % range. NDGF obtained sustained funding by the Nordic research funding agencies starting in 2011.

Electric power was a concern at the Data Center of the CERN campus, and in 2008 discussions were ongoing at CERN over the possibility of outsourcing part of the Tier-0 facility, which was storing the raw data the LHC produced. Possibilities for remote hosting were studied and, in Finland, preparations for a proposal started. CERN set a deadline of

30.11.2010 for bidding for a new Tier-0 center. The CSC – IT Center for Science Ltd of Finland made a bid with HIP endorsement, but CERN chose the Wigner Research Centre for Physics in Budapest to host the new facility. The facility was brought into use starting in 2013, and it basically doubled the capacity at the CERN Meyrin site. The IT infrastructure deployed in Budapest was virtualized and managed remotely from the CERN's Geneva control room.

CERN Director General Rolf Heuer was visiting Helsinki on 30.8.2011. On that day, the Minister of Communications, Ms Krista Kiuru, came to HIP to meet Heuer and to talk about Kajaani Data Center of the CSC (Photo: Tapio Lampén).

ISOLDE

The first experiments at ISOLDE (Isotope Separator On Line Device) started in 1967 at the CERN 600 MeV Proton Synchrocyclotron. After several upgrades, in 1992 it was moved to the Proton Synchrotron Booster (PSB), providing a pulsed proton beam of about 1 GeV on a thick target, where the radioactive nuclei are produced via spallation, fission, or fragmentation reactions. ISOLDE offers a wide variety of radioactive isotopes, and the installation of a post-accelerator at ISOLDE (REX-ISOLDE), with energies up to 3.1 MeV/u, opened up new fields of research with radioactive ion beams of higher energies, complementing other European radioactive ion beam accelerators. The physics motivation of the research carried out at ISOLDE lies in studies of the structure of exotic nuclei, with special emphasis on weak interaction phenomena and nuclear astrophysics. Applications in condensed matter physics and life sciences are on the agenda as well.

Finland became a full member of the ISOLDE Collaboration in 1998. At the time that Finland joined the ISOLDE Collaboration, the research at ISOLDE was mainly conducted by scientists from the Department of Physics of the University of Jyväskylä and, at HIP, it was part of the Nuclear Matter project of the LHC Program. From 2002 the ISOLDE activity was included in the Nuclear Matter Program as a separate project led by Dr Ari Jokinen. The Memorandum of Understanding for Collaboration in

the Exploitation and Upgrade of the ISOLDE Facility at the PS-Booster was signed by HIP on 2.2.2007, and the updated version on 30.8.2012. About 20 researchers were participating in the Collaboration, with about 30 % from the University of Helsinki and the rest from Jyväskylä. The membership fee in the ISOLDE Collaboration was 60 kCHF/a, which was basically HIP's contribution to the ISOLDE activity, and the main part of the research costs was covered by the departments involved. Professor Juha Äystö of the Department of Physics of the University of Jyväskylä served on the ISOLDE Scientific Committee from 1991-1994, as the ISOLDE Group Leader at CERN from 1999-2002, as the chair of the ISOLDE and Neutron Time of Flight Committee (INTC) from 2003-2006, as an ex-officio member of the Scientific Policy Committee (SPC) of CERN from 2003-2006, and as an invited member of SPC from 2008-2014.

The Finnish research at ISOLDE has covered a broad range of topics in nuclear physics and solid state physics, complementing the research at the Jyväskylä Accelerator Laboratory. The study of the ^{74}Rb decay, e.g., has provided new information on the charge dependent effects, such as Coulomb mixing, in super allowed beta decay. This information, together with muon decay data, gave a precise value for the up-down mixing matrix element V_{ud} in the Cabibbo-Kobayashi-Maskawa matrix. An example from nuclear astrophysics was the rate measurement of the stellar triple-α process from measurement of ^{12}C nuclear resonances (Hans O.U. Fynbo et al., Nature 433 (2005) 136), which have an impact on the evolution of the first stars. In solid state physics radiotracers were used to study diffusion in materials.

The Jyväskylä-HIP group also contributed to the instrumentation developments, such as cooling and bunching technique of ion beams to improve the emittance, energy spread, and time structure of the radioactive ion beams. The Si-ball project, a high-granularity Si-ball detector array for charged particle decay and reaction studies, was another example of an instrumentation project with Finnish involvement. The next major upgrade of the facility is the HIE-ISOLDE, High Intensity and Energy ISOLDE, which boosts the post-accelerated radioactive ion beams to higher energies, eventually up to 10 MeV/u. The upgrade project, involving a superconducting post-accelerator, was approved in 2009 and its construction started in 2010. Higher energies will permit the exploration of Coulomb excitation and transfer reactions in the full domain of nuclei produced at ISOLDE.

HIP's ISOLDE research activity was evaluated in 2011 by professors André Vantomme (KU Leuven) and Marek Pfützner (U. Warsaw), representing expertise in solid state physics and nuclear physics respectively. The evaluation meeting took place in Jyväskylä on 5.5.2011. In the report the evaluators found the ISOLDE activity in HIP and Jyväskylä mutually beneficial. The advances in detectors, ion sources, and other specific experimental techniques developed in the Jyväskylä Accelerator Laboratory were instrumental in obtaining excellent results in experiments at ISOLDE. On the other hand, the EU-funded and Jyväskylä led collaboration with the ISOLDE ion trap group became crucial for the creation of the ion trapping technology, including the Penning trap set-up and its associated instruments in Jyväskylä Accelerator Laboratory. In general, the complementarity and synergy between ISOLDE and the Jyväskylä Accelerator Laboratory was considered exemplary in their approach to research topics. In conclusion, continuing the funding for the Finnish ISOLDE projects was strongly recommended.

The HIP Board decided on 7.9.2011 to continue the ISOLDE project at HIP, and appointed professor Paul Greenlees of Jyväskylä as the project leader from 1.1.2012. Dr Jokinen moved to lead the FAIR project from the beginning of 2012.

COMPASS

HTI had contributed to the construction of the frozen spin target system of the CERN SMC Collaboration. In 1997 CERN approved the COMPASS (Common Muon and Proton Apparatus for Structure and Spectroscopy) proposal for the SPS accelerator, and the Low Temperature Laboratory of the Helsinki University of Technology joined the COMPASS collaboration in 1998 with the aim of adapting the target for the needs of the COMPASS detector. From the beginning of 2001 the project was moved under the umbrella of HIP, with funding shared between the Low Temperature Laboratory and HIP. The project was active at HIP from 2001-2003 under the leadership of docent Peter Berglund, and produced several highly cited articles. In the first phase, the COMPASS experiment used the 160 GeV/c muon beam of the SPS accelerator of CERN to study

the spin structure of the nucleon, in particular the gluon polarization and transverse-momentum-dependent correlations, with polarized proton and deuteron targets. The Low Temperature Laboratory decided, however, to leave the COMPASS Collaboration at the end of 2003 in order to focus more on their core activity. On the other hand, the SAB advised in their meeting on 2.-3.6.2003 that HIP should not get involved with the target and become a member of the COMPASS Collaboration. Ending the engagement in COMPASS was considered reasonable in view of the financial burden of the HIP projects. The responsibility for the dilution refrigerator was taken over by the University of Bochum group in the COMPASS Collaboration.

CLOUD

In late 90's the question of the effect of cosmic rays on the climate was raised, and in that connection Dr J. Kirkby of CERN approached the Helsinki group of professor Markku Kulmala. Kulmala's group had special expertise on aerosol physics, which was essential to the understanding of the processes behind the potential cosmic ray – aerosol – cloud interactions. On 8.9.1998 Kirkby gave a talk in Helsinki with the title "Are cosmic rays a cause of global warming?" The Helsinki group joined the project proposals aimed at studying the effects of cosmic rays on aerosols and clouds at the CERN Proton Synchrotron (PS), and finally the experiment CLOUD (PS215) was approved on 1.3.2006 by the CERN Research Board. The Memorandum of Understanding for the Execution of the Experiment PS215 (CLOUD; Cosmics Leaving OUtdoor Droplets) was finalized in March 2012. The original collaborating institutions from Finland, in addition to HIP, were the Department of Physics of the University of Helsinki, the Finnish Meteorological Institute, and Faculty of Science and Forestry of the University of Eastern Finland. HIP was since its establishment responsible for the Finnish collaboration with CERN and, therefore, it was natural for Markku Kulmala to approach HIP with the CLOUD proposal. He presented the ideas at the HIP Steering Group meeting on 18.2.2005, and Jasper Kirkby presented the CERN CLOUD experiment to the HIP Scientific Advisory Board on 24.5.2005. Though the experiment was not yet, at that stage, approved by CERN, the HIP SAB considered the proposal interesting and relevant and saw a possibility for HIP to play an important role in the experiment. In the

Board meeting on 28.11.2005 academy professor Markku Kulmala was appointed HIP CLOUD project leader starting 1.1.2006. The first results of the pilot experiment at CERN in October-November 2006 were published in 2009, and essential lessons could be drawn for the final design of the CLOUD experiment. During 2009 the next generation CLOUD detector was constructed on the PS T11 beam line. The role of the Finnish team in the experiments was the measurement and analysis of the first phases of particle formation, ions, and clusters. The first quantitative results were published in 2011 (Nature 476 (2011) 429) and the effect of cosmic rays could been seen in the first steps of aerosol formation from sulfuric acid. This opened up new study lines, especially regarding the molecular level understanding of particle formation processes.

CLIC

After the closure of the LEP accelerator at CERN on 2.11.2000 the main activity of the HIP electron-positron project was the analysis of the DELPHI data. The analysis continued with gradually diminishing levels of activity, and the last doctoral thesis at HIP based on DELPHI data was defended in 2006. In addition, the group studied the precision and the discovery potential of the Higgs sector with a 500 GeV e^+e^- linear collider (TESLA project at DESY) and completed a conceptual design of a vertex tracker based on silicon pixel detectors. The TESLA Technical Design Report was published in 2001. In 2003 the German Federal Government decided not to further pursue the electron-positron linear collider at DESY, but instead focused on the development of the X-ray Free-Electron Laser (XFEL) project at the DESY site.

A new concept for a linear collider had been in development since the 80's at CERN. The approach was based on a two-beam acceleration method where high-intensity, low-energy electron beams, so-called drive-beams, running parallel to the main accelerator are used to power the lower intensity high-energy beam in the main linear accelerator. In July 2000 the CLIC (Compact Linear Collider) Study Team at CERN published a possible design for a 3 TeV electron-positron linear collider. The approach involved extensive R&D efforts, and different aspects of the technology have been investigated at the CLIC Test Facilities (CTF's) at CERN. The design report for the test facility CTF3 was published in April 2002, and there the aim

was to demonstrate the generation of a drive-beam with an appropriate time structure. In March 2004 the CERN Council approved the accelerated R&D program to demonstrate, before 2010, the feasibility of key issues of the CLIC scheme. In June 2004 the CLIC Physics Working Group, with some HIP participation, published a report on the physics at the CLIC multi-TeV linear collider. The HIP Electron-Positron Physics research project then started to focus on the technical development of the CLIC scheme. It was decided to join the work package "Structure Technology Development" on the basis of a survey of interest within the Finnish industry. The HIP Board and the Scientific Advisory Board were informed of these developments in June 2004, and in May 2005 the SAB encouraged HIP to sign the CTF3 MoU. In the autumn of 2005 the Memorandum of Understanding with the CTF3 collaboration was signed for the contribution to the CERN linear collider technology R&D project. The aim of the R&D program was to demonstrate the feasibility of the proposed CLIC technology in view of the decision on a future linear collider. It included a survey of different machining methods for prototypes of the CLIC accelerator structures. HIP concluded an agreement with the VTT Technical Research Centre of Finland, and one of the research engineers started to work on the project at CERN in September 2005. Finnish industry was from the very beginning heavily involved with the work. In addition to the micromachining technologies, the focus areas of the project were possible new materials, joining techniques for bimetallic structures, survey methods and quality control, assembly of acceleration structures with high precision, and full integration of whole CLIC modules. One of the key issues for CLIC is to limit the RF breakdown probability in the accelerating structures in order to achieve a stable beam with a sufficiently high accelerating gradient (> 100 MV/m). In its meeting on 22.11.2007 the HIP Board established two projects starting 1.1.2008 to advance the CLIC R&D. In the Theory Program the project "Radiation damage in particle accelerator materials" was started under the leadership of professor Kai Nordlund (UH), and in the High-Energy Physics Program the Electron-Positron project was replaced by the project "Linear Collider Research" under the leadership of docent Kenneth Österberg (UH). Dr Flyura Djurabekova took over the lead of the radiation damage project in 2011. In an Addendum to the CTF3 MoU concerning the period 2008-2010, signed in December 2009, the study of the mechanism of breakdown in CLIC RF structures using computer simulations was added to the HIP contribution. The personnel commitment for the CLIC activity was also increased by a factor of about three.

The HIP financial contribution to the Linear Collider Research project was relatively modest. However, the project was very successful in attracting external funding; e.g., significant funding was obtained through the EuCARD project, which ran from 1.4.2009-31.7.2013. EuCARD was a part of the EU Seventh Framework Programme Infrastructures scheme. CERN coordinated the project, which was expected to contribute to the formation of a European Research Area in accelerator science, effectively creating a distributed accelerator laboratory across Europe. R&D was conducted on a multitude of topics including two-beam acceleration, CLIC accelerating structures, and the modeling of thermomechanical behavior of CLIC modules. The industrialization and mass production of CLIC RF structures was studied in an EU Industry-Academia Partnerships and Pathways (IAPP) project "MeChanICs – Marie Curie linking Industry to CERN", which brought engineers from five Finnish industrial partners to CERN. HIP coordinated the project, which ran from 1.9.2010-31.8.2014. Additional resources for CLIC activity were channeled through the Department of Physics of the University of Helsinki.

The CLIC Conceptual Design Report (CDR) was published in three volumes in 2012: A multi-TeV Linear Collider based on CLIC Technology, Physics and Detectors at CLIC and The CLIC programme: towards a staged e^+e^- collider exploring the terascale. There were 21 signatories from Finland in the CDR from HIP, the University of Helsinki, and the VTT Technical Research Centre of Finland.

Detector Laboratory

The HIP Detector Laboratory has its roots in the Finnish DELPHI hardware contribution, starting in the 80's when the University of Helsinki LEP group initiated the R&D program on the hadron calorimeter and microvertex detectors. A laboratory was set up in Otaniemi in 1989. The motivation was the proximity of the Helsinki University of Technology and the Technical Research Centre of Finland VTT, together with high tech companies. The activity became part of the SEFT research institute when it was established in 1990. In 1991 the laboratory moved to the new Innopoli building in the Otaniemi Science Park. The laboratory contributed to the development and testing of silicon strip detectors for the upgrade of the DELPHI microvertex detector. The semiconductor

detector research had started in the laboratory in cooperation with the VTT Semiconductor Laboratory. Alongside with the semiconductor detector research, work started on the gaseous detectors for the upgrade of the DELPHI hadron calorimeter. Gradually, the focus of that research moved towards the microstrip gas chambers (MSGC) in view of the anticipated LHC detector needs.

In the autumn of 1996, when HIP started operations, the detector development activities formed the Detector Research and Development project at HIP. The project leader was Tom Schulman, MSc, and in 1997 Kari Kurvinen, MSc, during Schulman's leave of absence. From 1998 on the detector development activity was part of the Electron-Positron Physics project of the High Energy Physics Program. During 1998-2000 the Program Director, docent Risto Orava, had significant external funding, 5.3 Mmk (0.89 M€), through the Academy of Finland research project "Tracking detector development for high rate particle physics experiments" for R&D on two different kinds of tracking detectors: semiconductor pixel detectors and MSGC detectors. The long-term characteristics and radiation hardness of the MSGC and GEM (Gas Electron Multiplier) detectors were of particular interest. During 2001-2004 the development of the GEM detectors was part of the national space research program ANTARES, funded by the Academy of Finland and the Finnish Funding Agency for Technology and Innovation Tekes, where one of the 11 projects was a project on high energy astrophysics and space astronomy coordinated by the Observatory of the University of Helsinki. One of the goals of the project was the development of GEM detectors for X-ray astronomy.

The importance of a detector laboratory as an essential part of the home base of particle experimentalists was recognized in the reports of a working group and an evaluation panel addressing the future of detector development at HIP. The Academy of Finland panel, led by professor Peter Paul, which evaluated the Finnish CERN activities in 2001, drew the same conclusions, but the re-direction of the activities more towards silicon technology and the needs of the CMS and ALICE experiments at the LHC was encouraged.

In 2001 the Detector Laboratory was able to move to new premises in the Kumpula campus, and the Institute terminated the lease at the Innopoli building at the end of February 2001. The new laboratory was set up as a joint laboratory of HIP and the Department of Physics of the University of

Helsinki. The new premises consisted of a large main laboratory with two smaller laboratory rooms (an irradiation room and a wet chemistry room) and a large clean room in the basement. The clean room complex was divided into several sections containing a small class 100 (ISO 5) room, two large class 1000 (ISO 6) rooms, a service corridor, and an entrance room. The University of Helsinki provided special funds to equip the new laboratory in addition to the normal annual investments; in total about 150

Overview of the new joint Detector Laboratory at the Kumpula campus.

k€ was used for acquisitions during 2000-2003. In 2004 the Academy of Finland sponsored a nationwide infrastructure program to improve the research facilities in Finnish universities and other research organizations. The laboratory equipment was refurbished through this funding, to a total of about 190 k€. In 2011 the University sponsored a new clean room air-dryer system.

The core laboratory personnel, three laboratory engineers and one technician, were granted continuing appointments at HIP starting 1.3.2000. In addition to the salaries of the laboratory staff, a sizeable part of the operation cost was the rent of the laboratory space. As a part of the reorganization of the Detector Laboratory, on 21.10.2002 the directors of the HIP experimental programs signed an agreement for the cost sharing of the rent. On the recommendation of the SAB, from 2003 on the nature of the laboratory was gradually changed towards a general infrastructure to support all of the experimental projects of the Institute, and Dr Markku Oinonen was appointed as the coordinator of the laboratory. Starting with the budget year 2004 the budget of the Detector Laboratory appeared as a separate item in the Institute spending plan. Dr Oinonen served as the laboratory coordinator until 28.2.2007, and thereafter Dr Eija Tuominen was appointed to that position.

During the construction phase of the large detectors for the LHC, the Detector Laboratory made significant contributions to the assembly of subdetector systems, including mechanical support structures for the CMS Tracker, Silicon Strip Detector modules for the ALICE Inner Tracker System, and GEM detectors for the TOTEM T2 telescope. For the upgrade projects of CMS and ALICE the laboratory was also an important contributor to the quality assurance of silicon pixel detectors and GEM foils respectively. Finland signed the Memorandum of Understanding of the Preparatory Phase of the International FAIR Project in 2004, and in the same year work started in Jyväskylä on the possible Finnish contribution to FAIR (Facility for Antiproton and Ion Research). The Detector Laboratory also gradually became involved and, in particular, their expertise in GEM technology was exploited in the work on the GEM-based Time Projection Chamber (TPC) for the outer tracker of the PANDA Target Spectrometer. However, in 2006 the SAB recommended that the work on PANDA should not be driven solely by the technology of GEM detectors, and that a physics involvement was needed as well. Thereafter the laboratory focus in the FAIR activity shifted to the GEM-

TPC beam diagnostics detectors for the Superconducting Fragment Separator. Dr Francisco Garcia led that activity.

In 2009 HIP and the Detector Laboratory joined the CERN RD51 Collaboration "Development of Micro-Pattern Gas Detectors Technologies" and a Memorandum of Understanding was signed in March 2010. The aim was to facilitate the development of advanced gas-avalanche detector technologies and associated read-out systems for applications in basic and applied research. Dr Garcia coordinated the project at HIP.

In November 2008 the Detector Laboratory hosted a research training course for 20 Nordic graduate students. The aim of the course was to provide practical experience in hands-on detector construction and testing. The two-week course was sponsored by NordForsk, which is an organization under the Nordic Council of Ministers that provides funding for and facilitates Nordic cooperation in research and research infrastructure. The laboratory also took an active role in the national annual event "European Master Classes for High School Students: Hands on Particle Physics".

In November 2008 the personnel of the Detector Laboratory tutored the exercises of a group of Nordic postgraduate students during the Nordforsk course on detector technologies.

Planck

The activity related to the Planck Satellite Mission had started at HIP within the Cosmology Project of the Theory Program. From the beginning of 2008 the Planck research became an independent project, the HIP Planck project, under the leadership of docent Hannu Kurki-Suonio. The main mission of the Helsinki group was to develop the map-making software and to remove the correlated noise and other instrumental effects from the measured data. The satellite launch took place on 14.5.2009

The Planck satellite in attitude tests, March 2008 (Photo: Thales Alenia Space and ESA).

and the science observations started on 12.8.2009 (first full-sky survey). The science objectives of the mission were to map the entire sky in nine microwave frequencies with unprecedented sensitivity and resolution, in order to separate the cosmic microwave background and foreground, i.e. galactic and extragalactic components, catalog the extragalactic point sources, produce CMB temperature and polarization maps and their angular power spectra, and extract cosmological parameters together with composition and geometry of the Universe, the reionization history of the Universe, and the formation of the first stars.

The publication record of the project has been remarkable; 24 "Planck early results" articles were published in 2011 and there were many more to come.

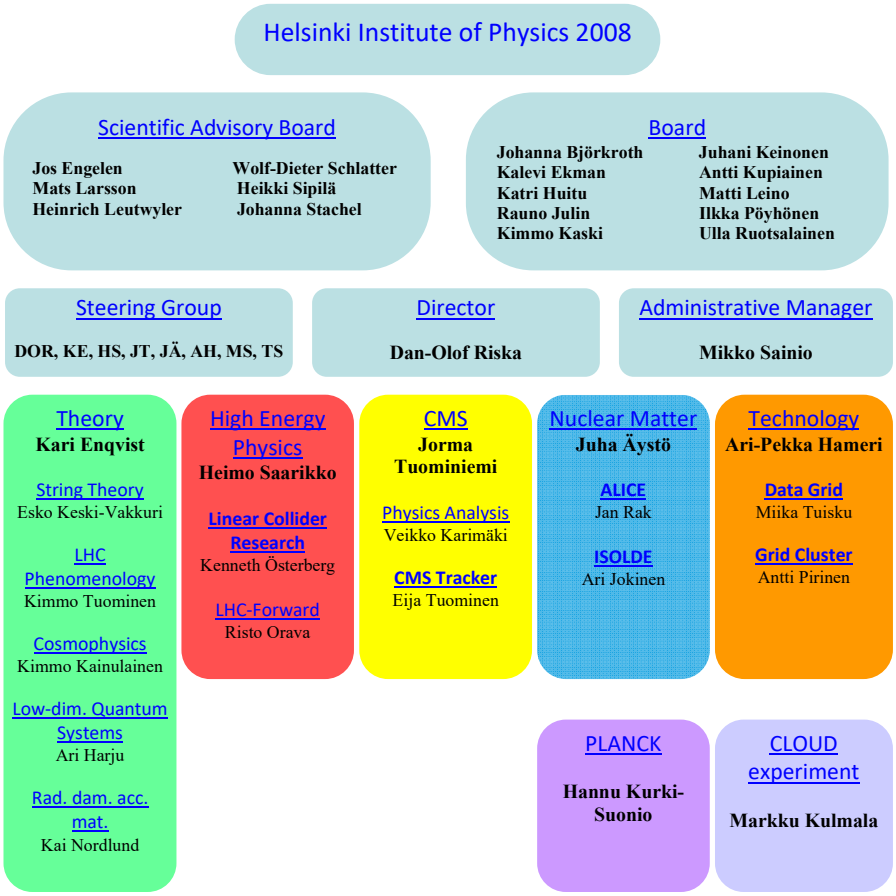
Technology Program

In the summer of 2000 the focus of the Technology Program moved to grid computing. The grid activity has been addressed in a separate section. One of the directions of interest for the Program was to look out for the possible industrial benefits of the research. Professor Erkko Autio (HUT) was a senior visitor in the Technology Program at CERN during 1.9.2001-31.12.2002 and worked, e.g., on a survey of the technology dissemination potential of CERN. The project was presented to the HIP Scientific Advisory Board on 3.6.2002 with the title "Enhancing Industrial Knowledge Spillovers in Big-Science Collaborations". The results of the survey were published by Erkko Autio, Marilena Bianchi-Streit, and Ari-Pekka Hameri in "Technology transfer and technological learning through CERN's procurement activity" (CERN-2003-005; 11.9.2003). The report analysed the technological learning and innovation benefits derived from

CERN's procurement activity during the period 1997-2001. The benefits (e.g. technological learning, organizational capability development, marker learning) tended to occur together. The procurement activity was associated with many additional advantages, e.g., the development of new products and broader international exposure.

The HIP physics research projects were evaluated over the years in different research assessments organized by HIP, the universities, or the Academy of Finland. An evaluation of the Technology Program was included in the HIP target program for the years 2010-2012. The auditors were professor Erkko Autio (Imperial College Business School; innovation and technology management, growth company studies) and research professor Mika Rautila (VTT, Technical Research Centre of Finland; information and network security). A one-day seminar was held on 29.1.2010, and the evaluation report was released on 15.3.2010. The report contained ten recommendations; the Technology Program should pursue innovative projects at the intersection of the Big Science technologies and industry, particularly within the data-intensive science paradigm, and hand over the operation of research infrastructures to other programs at HIP. In addition, the connectivity to other HIP research and other Big Science facilities beyond CERN was considered important.

The Technology Program was renewed accordingly from the beginning of 2011. The Grid Cluster project was moved to the CMS Program with a new name, Tier-2 Operations, under the leadership of Dr Tomas Lindén. The new project on Positron Emission Tomography, which was started in the beginning of 2011, was presented to the SAB on 30.8.2011 by its leader, professor Ulla Ruotsalainen (TUT). The AxPET consortium at CERN was studying a new geometry that would avoid parallax error and therefore provide an improved resolution. The goal of the HIP involvement was to look for industrial interest in this technology. The GreenIT project started in 2011 under the leadership of Dr Tapio Niemi. The goal of the project was to improve the energy-efficiency of distributed computing by developing operational practices and software tools for optimizing Grid/Cloud computing clusters.



The HIP organization in the autumn of 2008. The boxes contain the names of the research programs/research projects together with the names of the program directors/project leaders.

Cerntech activities

In the construction phase of the LHC (1998-2008) and the LHC detectors - the Cerntech project that was responsible for the industrial collaboration with CERN - was very successful in terms of the Finnish industrial return from the CERN projects. The company structure changed from 2001 and Cerntech and Finntech Finnish Technology Ltd became trading names for the company Licentia Oy, which also merged with the Helsinki University Licensing Ltd. The Finnish Funding Agency for Technology and Innovation (Tekes) continued to provide the main part of the funding.

In 2003 the Cerntech project for industrial collaboration between Finland and CERN was taken over by Finpro ry (Finnish Foreign Trade Association) and a memorandum of understanding for the collaboration between HIP and Finpro was signed on 11.4.2003. Finpro was a consulting organization focused on accelerating the internationalization of Finnish companies. In Big Science Centers Finpro carried out its mission by providing R&D and commercialization services for industry with the aim of leveraging Big Science Center's expertise and the strict requirements for commercial technology development. On 15.7.2006 HIP, Finpro, and the CSC- IT Center for Science signed a MoU for collaborative practices related to grid technology. Finpro provided the link to industry, HIP provided the development team, and CSC the test platform. The CERN industrial return coefficient for 2003-2006 was 1.72 (target 0.94). Finpro's very successful industrial activation work at CERN ended in June 2009, and Tekes granted the operation to Top Science Services LLC, which had the contract until 31.3.2014. HIP also had an agreement with Top Science Services LLC starting 1.8.2009 concerning administrative support.

Research assessments

The quality of the HIP research activity is continuously scrutinized. The Scientific Advisory Board of the Institute has annual meetings where the progress of the existing projects and the new initiatives are evaluated. In addition, external evaluators have been used to assess individual projects and proposals. In the Theory Program, this approach has been systematically applied. Furthermore, parts of the HIP research have been included in the university wide research evaluations; the first in the University of Helsinki took place in 1999.

The second time research at the University of Helsinki was evaluated was in "The Research Assessment Exercise 2005", which covered the research activities during the years 1999-2004. The members of the Astronomy and Physics Panel were professors Endel Lippmaa (NICPB, Tallinn), Helena Aksela (U. Oulu), Barbara Hale (U. Missouri), Klas Malmqvist (U. Lund), Nikolai Piskunov (U. Uppsala), Johanna Stachel (U. Heidelberg), Peter Wadhams (U. Cambridge), and James Whitmore (Pennsylvania State U.). The Institute's rating in the evaluation was 7/7, reflecting the improvements since the 1999 evaluation when HIP obtained

the score 6/7. The panel expressed some slight concerns related to the balance between theoretical and experimental physics at the Institute as well as in the development of the research environment and infrastructure. The remarks related to the Theory Program have been addressed above. As a consequence of this top score, the University granted HIP a small result-based addition to its annual budget, 70 k€, for the years 2007-2012.

The next university wide evaluation of research and doctoral training was carried out in the years 2010-2012. The steering group, appointed by the Rector in January 2010, set the conditions for participation in the evaluation, the evaluation procedure, and its criteria. The publications and other scientific activities included in the evaluation covered the years 2005-2010. The participating unit in the assessment was defined as a researcher community. That meant that the participating HIP activities were evaluated together with the corresponding activities of the Department of Physics of the University of Helsinki in the community Particle Physics and Cosmology (PaCo), with 118 members under the leadership of professor Katri Huitu. The physics members of the Panel of Natural Sciences were professors Jan-Otto Carlsson (U. Uppsala), Jean-Pierre Eckmann (U. Geneva), and Mats Larsson (U. Stockholm). The evaluation score of PaCo was 23/25, with room for improvement especially in doctoral training, in cooperation in research and doctoral training, and in mobility.

Another regular evaluation mechanism has been the country visits of the RECFA (Restricted ECFA, European Committee for Future Accelerators) to all CERN member states. The committee has one representative from each of the CERN member states and Russia, together with the representation of the CERN management and the management of other major European laboratories. During the country visits, the committee hears presentations on a country's activities in subatomic physics and gives an assessment of the related developments, in particular with respect to the previous visit. The third country visit to Finland by the RECFA took place on 26-27.9.2003. In his letter of 27.10.2003 to the Minister of Education, Ms Tuula Haatainen, the Chair of the RECFA, professor B. Foster, brought up the ECFA's perception that "the establishment of the Helsinki Institute of Physics (HIP) has been the seed around which this upsurge of activity could grow, providing a very helpful central coordination and a focus for particle physics in Finland". In addition, a number of recommendations were made in the letter, including additional

long-term and permanent positions in experimental particle physics, better coordination between the experimental projects, and improvement of the supervision of graduate students. The fourth RECFA visit to Finland took place on 8-9.10.2010. The Chair, professor T. Nakada, reported in his letter of 22.11.2010 to the Minister of Education, Ms Henna Virkkunen, the findings of the committee. The Committee acknowledged that the HIP was essential for nuclear and particle physics in Finland. It also repeated the recommendation for creating more permanent positions for both the scientific and the technical staff.

In addition to the University of Helsinki, other universities who participated in HIP have also had their research evaluated. However, the role of HIP in the totality of the research volume of most of the other universities has been rather modest, and therefore the HIP activities do not emerge in any prominent way in the evaluation reports. An exception is the University of Jyväskylä, with its strong tradition in subatomic physics. In the report "Evaluation of Research Activities 2005-2009" of the University of Jyväskylä the joint activities with HIP are considered very fruitful in cosmology and ALICE related activities. The participation in the FAIR activity was also seen to be of high priority in the department strategy. The members of the science evaluation panel were P. Braun-Munzinger (GSI), A. Biggeri (U. Florence), P. Bridgewater (Global Garden Consulting, UK), C. Brönmark (Lund U.), E. Constable (U. Basel), K. Hämäläinen (UH), and K. Seip (NUST, Trondheim).

At the national level, the Academy of Finland, the funding agency for basic research, conducts a comprehensive review of the state and quality of scientific research in Finland every three years. In addition, the Academy of Finland conducted a discipline-specific evaluation for physics in 2012, covering the research that took place between 2007-2011 (Publications of the Academy of Finland 8/12). The members of the evaluation panel were: C. Enss (U. Heidelberg), A. Bracco (U. Milan), J. Büchner (MPI for Solar System Research), F. Cacialli (University College London), H.-F. Graf (U. Cambridge), U. Karlsson (KTH, Stockholm), F. Ravndal (U. Oslo), and C. Yu (U. California, Irvine). In its report, the Panel gave a number of recommendations, e.g. a call for the funding of laboratory equipment and the establishment of a long-term funding scheme for large international infrastructures were put forward. Increasing the financial contribution to international infrastructures such as CERN and FAIR was seen as an opportunity to enhance the visibility and role of the groups involved in such

experiments. The close interaction between the Division of Elementary Particle Physics of the University of Helsinki and HIP was commented on: "The big overlap in activities and personnel between a university physics division and research institute is an unusual constellation on the international scene. It creates a very diverse and creative atmosphere that provides the best possible environment for education and research." The administrative role of HIP was also remarked on: "In the present situation, the unit has adequate administrative help. With all the time-consuming interactions with international organizations and foreign groups, this support is important for the functioning of the unit. Today, such help seems to be uncommon in Finland." The main recommendations in the report were addressed to the Academy of Finland and the Ministry of Education, Science and Culture. One concrete recommendation for HIP was to increase the number of foreign, long-term visiting scholars at the Institute.

Premises

The Physicum building project progressed on schedule. In November 2000 it was possible to inspect the new premises. In March 2001 the Institute moved from Siltavuorenpenger to the new Physicum building in Kumpula. The first coffee break at the new premises was on 14.3.2001 at 10 a.m., and after that one could say that the Institute had truly moved. The great advantage of the new premises was that the Detector Laboratory was relocated from Otaniemi, Innopoli, to the Physicum building, and was then developed as a joint laboratory with the Department of Physics. Also, the move of the Departments of Mathematics and Computer Science to the Kumpula Campus Exactum building in 2004 brought together the main body of the Faculty of Science. The lease agreement with the Technical Department of the University of Helsinki came into force on 1.5.2001. There the area allocated for HIP was 950 m^2. In addition, HIP made separate agreements with the Department of Physics for the usage of some workshop areas.

The new building was inaugurated in a two-day celebration. On 6.9.2001 the Inaugural Symposium was held, where the main speaker was professor Robert A. Eisenstein of the US National Science Foundation, and on 7.9.2001 the inaugural party was held in the presence of the Minister of Education, Ms Maija Rask.

Since 1997 the Helsinki University of Technology had made available office and laboratory space for HIP in the so-called Ekono building (Tekniikantie 4 D, Espoo). The area of the space was about 340 m^2, and it was used by the Technology Program and the LHC/CMS Program. At the end of September 2005 HIP had to vacate the area and new office space, about 260 m^2, was rented in the Innopoli 2 building (Tekniikantie 14) for the Technology Program. Gradually the need for office space diminished, and from the beginning of 2012 only one room of about 20 m^2 was used by HIP in the Innopoli 2 building.

At CERN there was always a shortage of office space, but HIP could maintain the Finnish Office – CERN (room 32 – 1B – 020) and a room for the management in Building 32. The researchers were located in the offices provided by the collaborations. HIP researchers also had offices at HUT/Aalto and the University of Jyväskylä, depending on the group they belonged to.

Personnel developments

In the autumn of 1996 the HIP Board had discussed the possibility of applying for the title of professor for the HIP director or program director, in case they were not already university professors. Universities had the right to grant such titles. The decision was that no action was needed at that point. In early 2002 HIP started to explore possibilities for obtaining the title of professor for docent Jorma Tuominiemi. He was the only HIP Program Director without a professorship and, in addition, there was only one professorship in experimental particle physics in Finland at that time, and the addition of another professor-level scientist was considered helpful for the research community. The question of competence did not arise, as docent Tuominiemi had already been found well qualified for a professorship, e.g. in the process of filling the chair in experimental particle physics in 1999. The Chair of the HIP Board, Vice-Rector Ilkka Niiniluoto, took an active role in the undertaking. The required material was delivered to him in early June, and in the meeting on 11.9.2002 the HIP Board decided to propose to the Rector that the title of professor be awarded to Tuominiemi. A formal application was sent to the Rector on 20.9.2002, and on 23.10.2002 the Rector of the University of Helsinki granted docent Jorma Tuominiemi the title of professor during the time when he was the Program Director of the HIP CMS program (Rector's decision 121/2002).

The first five-year appointment of professor Dan-Olof Riska as the HIP director came to an end on 30.6.2005, and in its meeting on 22.11.2004 the HIP Board authorized the Chair and the Vice-Chair of the Board to prepare the matter and make a proposal to the Board. The position was advertised in Helsingin Sanomat on 26.1.2005 and on the web pages of the University of Helsinki, the Helsinki University of Technology, and CERN. By the deadline of 21.2.2005 two applications were received. Both applicants were found highly qualified in science and CERN experience, but the search group placed particular emphasis on professor Riska's experience as a Director of HIP and a member of the CERN Council. In a meeting on 8.3.2005 the HIP Board unanimously decided to propose to the Rector of the University of Helsinki the appointment of professor Riska as Director of HIP for five years starting 1.7.2005.

In meetings in 2001 and 2002 the HIP Scientific Advisory Board started to pay attention to the need to prepare for the physics analysis of the ALICE detector data. In 2002 the hardware and software contributions to the T0 trigger were considered of high quality and focused, but HIP was strongly encouraged to build up a physics analysis group, preferably trained on real physics at RHIC in Brookhaven National Laboratory or at the NA60 experiment at CERN SPS. The recommendation was reiterated in 2003 by the SAB. In May 2004 the Director of the Department of Physics of the University of Jyväskylä wrote a letter to the Director of HIP proposing a joint five-year position at the senior assistant level for ALICE physics. In the meeting on 2.6.2004 the HIP Board authorized the Director to sign a contract with the University of Jyväskylä. The position was advertised without delay, and by the deadline of 22.7.2004 six applications were received. The agreement on the position was signed on 10.11.2004, with 50 % of the salary cost to be covered by each party. Dr Jan Rak of the University of New Mexico, Albuquerque, a member of the PHENIX Collaboration at RHIC, was appointed for the period 1.1.2005-31.12.2009. After a leave of absence he started in the position in the beginning of December 2005. He followed Dr Markku Oinonen as the HIP ALICE project leader in March 2007. After the joint, fixed-term senior assistant position, Jan Rak had a continuing appointment as a university researcher at the Department of Physics of the University of Jyväskylä.

The first professorship in experimental particle physics in Finland was filled in 1999. However, in several assessments and reports it was strongly recommended that additional positions should be created in

Finland. The panel that evaluated the Finnish CERN activities strongly encouraged the establishment of at least one additional professorship in its 2001 report. Possibilities for additional positions had been explored by the HIP management, e.g. at the Helsinki University of Technology, where Riska met with professors Martti Salomaa (HUT) and Paula Eerola (U. Lund) and Rector Paavo Uronen on 29.3.2001. In June 2002 SAB strongly supported the efforts to widen the base of experimental high-energy physics education in HUT and TUT. Professor Salomaa intended to have a discussion meeting with physics professors concerning the matter, but, in the end, HUT decided not to include experimental particle physics in its curriculum.

In a letter to the Minister of Education in October 2003, after the country visit, the RECFA Chair, professor B. Foster, described the additional positions as a matter of urgency. The average age upon finishing a doctoral degree in experimental particle physics was relatively high and, to improve the supervision of research students, additional positions at the professorial level would be necessary. Also, in its report in 2006 the HIP Scientific Advisory Board had strongly supported the establishment of a professorship in experimental particle physics. The HIP Board adopted a target program for the Institute for 2007-2009 in its meeting on 21.8.2006, with the objective of supporting the establishment of teaching positions in experimental subatomic physics and related technology in member universities. The Board approved the agreement between HIP and the Department of Physical Sciences of the University of Helsinki concerning a new professorship in experimental particle physics in a meeting on 14.11.2006, and the agreement was signed on the same day. The cost sharing of the position was such that HIP covered 45 % and the Department of Physical Sciences 55 %. The Rector of the University of Helsinki established the position on 20.11.2006. In addition to Helsingin Sanomat, the position was advertised broadly in Europhysics News, the CERN Courier, and on the CERN Human Resources web pages. By the deadline on 21.2.2007 13 applications were received; four of the applicants were Finnish. The Faculty of Science set up a search committee, which consisted of professors Juhani Keinonen and Keijo Hämäläinen together with university lecturer Eero Rauhala and student representative Hanna-Mari Kivinen. Professor Riska was the committee member representing HIP. The external experts consulted by the committee were professor B. Badelek (U. Uppsala and U. Warsaw), Dr G. Rolandi (CERN), and Dr D. Schlatter (CERN). In a meeting on 14.2.2008 the Faculty of Science put

professor Paula Eerola (U. Lund) in the first place. Professor Eerola started in the University of Helsinki professorship of experimental elementary particle physics on 1.9.2008. On the same date, she started at HIP as the CMS Program Vice-Director and, in addition, on 1.1.2009 as the CMS Tracker Operations project leader. She took over the directorship of the HIP CMS Program when professor Jorma Tuominiemi retired on 1.10.2010, in accordance with the decision of the HIP Board on 4.3.2010.

In the anticipation of the end of the second five-year term of professor Dan-Olof Riska as the HIP Director, on 18.11.2009 the HIP Board appointed a working group to prepare the nomination of a director for HIP starting 1.7.2010. The members of the working group were Vice-Rector Johanna Björkroth (UH) and Vice-Rector Kalevi Ekman (HUT). The working group brought the proposal to the Board meeting on 4.3.2010, and its recommendation was that Riska would continue in the position. The HIP Board unanimously approved the exceptional procedure, i.e. appointment without a search process, because the appointment would only span a short time just before his retirement, and Riska's experience as HIP Director as well as his position of trust at CERN (Council Vice-Chair). On 1.4.2010 the Rector, professor Thomas Wilhelmsson, appointed Riska HIP Director for the period 1.7.2010-31.3.2012.

In 2003, the Ministry of Education took an important step by appointing the Director of HIP as the scientific delegate to the CERN Council for 1.6.2003-31.5.2006. This had already been the goal of the provisional Board in 1996. The other delegate, Dr Pentti Pulkkinen, represented the national funding agency for basic research, the Academy of Finland. Professor Riska served on the CERN Council until the end of 2013, in the role of the Vice President starting 1.1.2010. On 21.6.2007 the CERN Council appointed professor Riska to the governing board of the CERN pension fund, where he became Vice-Chair for 2007-2010, and after which he was the Chair for 2011-2013. The membership of the HIP Director in the CERN Council was very important for the CERN activities at the Institute. Information on the plans at CERN became available at an early stage at HIP, which was responsible for the coordination of CERN activities in Finland. Furthermore, it provided an informal access for the HIP Director to the management of CERN.

The Academy of Finland appointed the HIP Theory Program director, professor Kari Enqvist, as an academy professor for the five-year term 1.1.2010-31.12.2014. In order to focus on his research, professor Enqvist

stepped down as Director of the Theory Program on 31.12.2010, at the end of his fixed term. On 18.11.2009 the HIP Board appointed a working group to prepare a proposal for the selection of a new Theory Program director. The members of the working group were professor Wilfried Buchmüller (DESY) representing SAB, professor Antti Kupiainen (UH) representing the HIP Board, and the director, professor Dan-Olof Riska. The working group decided to consider the recently appointed professors of theoretical physics in HIP partner universities, who had considerable experience in CERN related theoretical physics research. Therefore, they asked professors Kari J. Eskola (University of Jyväskylä), Katri Huitu (University of Helsinki), and Kari Rummukainen (University of Helsinki) whether they would be available to be interviewed for the position. After professors Eskola and Huitu declined, the working group asked professor Rummukainen to present his vision for the program. After considering Rummukainen's vision for the Theory Program, taking note of his outstanding qualifications in both research and teaching and his extensive experience of research at CERN, the working group decided to recommend to the Board that Kari Rummukainen be appointed Director of the Theoretical Physics Program of the Helsinki Institute of Physics for the three-year period starting 1.1.2011. The HIP Board decided accordingly on 4.3.2010.

Dr Ari-Pekka Hameri had served as the Director of the HIP Technology Program from the start of HIP operations on 1.9.1996. Since 1995 he had worked as a project manager in an operations management project at the Institute of Particle Physics Technology (HTI) at the Helsinki University of Technology. His leadership was very important for the Institute. However, the HIP Board considered it desirable that the Program Director come from one of the universities governing HIP. Hameri had been professor of operations management at the University of Lausanne (HEC) since January 1, 2001. The HIP Board created a working group to prepare the appointment of a part-time, fixed-term Director for the Technology Program in a meeting on 4.3.2010. The members of the working group were Dean Ulla Ruotsalainen (TUT), Director Dan-Olof Riska, and professor Risto Nieminen (Aalto University, School of Science). The Board decided on 7.4.2011 to declare the position open, and by the deadline on 13.5.2011 seven applications were received. The search committee interviewed four of the applicants. Based on the proposal of the search committee, the HIP Board decided on 7.9.2011 to appoint professor Saku Mäkinen of the Tampere University of Technology (TUT)

as the Program Director starting 1.1.2012. Professor Mäkinen's chair in industrial management at TUT was defined as "Strategic Management of Technology and Innovation".

The long-serving laboratory engineer, Tapio Vehviläinen, went into retirement on 30.6.2003. The position was declared open and, by the deadline 5.9.2003, 10 applications were received. Four of the applicants were interviewed and the position was offered to Juha Aaltonen, Lic. Phil. Juha Aaltonen started at HIP on 1.10.2003, and his duties included the maintenance of the general infrastructure of the institute, including information technology. In addition, he contributed to the activities in the Detector Laboratory.

In its meeting on 7.9.2011 the HIP Board started the search process for a new director. Professor Dan-Olof Riska would reach the mandatory retirement age on 31.3.2012. Vice Rectors Johanna Björkroth (UH) and Heikki Mannila (AU) and professor Kari Eskola (UJ) were appointed to the search committee. The Board decided in addition that an international search was necessary. By the time of the deadline 17.10.2011 ten applications were received (three foreign, six Finnish, and one Finland-based foreign applicant). The search committee interviewed three applicants. The HIP Board decided on 9.12.2011 to propose to the Rector of the University of Helsinki that professor Juha Äystö of the University of Jyväskylä be appointed Director of HIP for the period 1.4.2012-30.6.2016 and the Rector, professor Thomas Wilhelmsson, decided accordingly on 25.1.2012

New salary system (UPJ)

At the end of 2004 a new collective agreement was concluded with the government service. In the government salary system the job title basically determined the salary grade, and the seniority allowances followed directly from the duration of service. At HIP the salaries, with the exception of the few civil servant positions, did not follow the salary grades, but were agreed on separately for each employee; although, a broad bracket of salaries was followed depending on the type of position. The system allowed HIP to change the salaries quickly by any amount when, e.g., graduate students advanced in their studies by finishing their course work or publishing their first article.

In the new system, a job description was produced for every position and then assessed by a particular university-wide evaluation group that also set the requirement level according to the estimate of the requirements for the position. Personal performance was evaluated on a regular basis in salary discussions between the supervisor and the employee. For the teaching and research staff there were 11 requirement levels and nine performance categories, and for the specialist and support staff 15 requirement levels and nine performance categories. A web-based program, UPJWeb, was used to operate the salary system. Fortunately, for most of the graduate students and post-docs a common HIP job description was applicable, which reduced the amount of work involved. For example, for starting graduate students the requirement level was two and for post-docs the level was five in the teacher and researcher staff category. Occasional difficulties were encountered with using the starting value of two as the requirement level for graduate students, especially for graduate students with particular skills in engineering or information technology; salary competition was real, and it had to be dealt with to secure students for HIP projects.

The HIP staff belonged to the staff of the University of Helsinki and, therefore, HIP started the preparations for the new salary system in early 2005 with discussions in the Steering Group on 18.2.2005. The matter was on the agenda of the HIP Board on 8.3.2005, and the Director was authorized to take all the necessary measures required by the reform and as instructed by the University of Helsinki.

The agreement on the salaries was reached on 16.12.2005 and involved a 7.24 % raise of the total salary sum. The new salaries came into force on 1.1.2006, with a transition period until 30.9.2009 for specific groups of employees. It was also agreed that no one would have a salary cut.

The salary system reform had the consequence that the leaders of research groups became more involved with the bureaucracy than before. For most of them, the change was not dramatic, in particular with the HIP default job descriptions for graduate students and post-docs the change went rather smoothly. On the positive side, in addition to the overall 7.24 % salary sum increase, the opportunity for a regular discussion of their salary with their supervisor was a welcome change for many employees.

New university legislation

The Finnish university legislation changed starting from 1.1.2010 (Finlex 558/2009; 24.7.2009). The basic change was the separation of the universities from the state and the formation of the universities as legal entities of public law. Two exceptions were made, for those universities governed by foundations. Both cases were HIP partner universities. The Helsinki University of Technology merged with the Helsinki School of Economics and the University of Art and Design Helsinki to form Aalto University. The other university operated by a foundation was the Tampere University of Technology.

The aims of the change were to strengthen the economic independence of the universities, to improve their strategic leadership and international competitiveness, and to tighten their connections with society by setting a minimum requirement for external representation in the governing boards of the universities. The main body of the funding was expected to come from the Ministry of Education and Culture. To secure the buying power of the funding it was tied to a special university index. Already in 2011, however, the funding of the university system for 2012 was reduced by halving the index (Finlex 1324/2011; 16.12.2011), and the following year the whole index was temporarily abandoned.

The new legislation did not change the status of HIP, but it did change the day-to-day operations in many respects. HIP had supported the research activity at CERN by granting fellowships. After 1.1.2010 no new fellowships for full-time research at CERN were awarded to Finnish scientists. In addition, all university staff became employees, and the civil servant appointments were converted to regular employment contracts. At HIP this was not a major change, because the number of civil servants at the Institute was quite low. Initially, civil servant positions had been created for the decision-making process at HIP, and only the director and the administrative manager were civil servants.

Honors and awards

On December 9, 2008 Dr Robert Aymar, the CERN Director-General, was awarded the decoration of Commander, first class, of the Order of the Lion

of Finland by the President of the Republic of Finland. This decoration, one of the highest in Finland, was presented in a ceremony by the Ambassador Hannu Himanen, Permanent Representative of Finland to the UN and other international organizations in Geneva. Robert Aymar was honored for his service to CERN, the LHC, and his role in the cooperation between Finland and CERN, as well as his contribution to science in general. In his speech, the ambassador underlined CERN's efforts in the field of education, mentioning the high school teachers program. Dr Aymar was Director General of CERN 2004-2008, during the completion of the LHC and the detectors.

The 2010 Lise Meitner prize for nuclear science of the European Physical Society was awarded to the HIP Nuclear Matter Program Director, professor Juha Äystö of the University of Jyväskylä, for his "accurate determination of fundamental nuclear properties by the invention of innovative methods of ion guidance and its applications to radioactive ion beams".

The 2010 quadrennial Fuchs Memorial Award, the premier international prize in aerosol science, was awarded to academy professor Markku Kulmala, project leader of the HIP CLOUD project.

Numerous Finnish prizes and decorations were also awarded to HIP researchers during the Riska tenure.

Administrative developments

In 2003, a process started within the University of Helsinki to estimate the cost of administrative and other services. In particular, the purpose was to find an approach to allocating the cost of the services provided at the campuses of the University. In part, this was due to the increased external funding of the University. The goal was also to increase cost awareness concerning the services and thus promote operational efficiency. Each faculty and independent institute, like HIP, was expected to agree with the central administration of the university on a service contract for the services and related costs. In addition, the contract included a plan for the development of services.

In 2004-2005 the University of Helsinki conducted the first external evaluation of its administration. The main themes of the evaluation

HIP has organized spring excursions for its staff since 2003. In the picture, from left to right, are Finance Manager Tarja Sandelin, secretary Taina Hardén, and Administrative Manager Mikko Sainio waiting for m/s J.L. Runeberg to depart for a cruise to Porvoo on 28.5.2003.

were the management system and the organization of administrative work within the University. The evaluation report stated that "Many tasks are decentralised to a level where the administrative staff of departments and institutes cannot cope with all their demanding responsibilities. Staff members also often lack proper administration-oriented education and support from their superiors. There is often no backup staff at all. The most difficult tasks for departments and institutes are the ones relating to the administration of finances, human resources and research projects." The panel, chaired by professor Jorma Sipilä, Chancellor of the University of Tampere, also made 27 recommendations covering strategy work, the operational management process, improving management conditions at different levels, and the appropriate organization of the administration. In addition, the report contained four recommendations for the Government.

In 2006 the University of Helsinki adopted a development program for its administration and other support activities for the planning period 2007-2009, and this had to be included in the strategy of all faculties and institutes. The program included service centers at each of the four campuses of the University, which were expected to start operation gradually on 1.4.2007. Regarding HIP, the discussions on administrative arrangements started in the spring of 2007. The particular administrative challenges for HIP were the distributed mode of operation, including three international accelerator laboratories, and its role as a joint institute of four universities. The aim of the HIP administration was, in addition to the normal university administration, to shield the director and the researchers as much as possible from routine administrative work. The service agreement concerning the period 2007-2009 was signed on 20.6.2007. There the main items were the transfer from HIP of some tasks in the financial management of externally funded projects, corresponding

to 0.2-0.3 FTE, and the centralization of a part of the IT services, corresponding to about 0.7 FTE. In 2006 the administrative workforce in HIP was 5.4 FTE, i.e. 5.8% of the total, of which 1.4 FTE was at CERN. HIP's workforce for IT services was about 1.5 FTE. Although HIP's service contract itself did not include any personnel transfers, it led to the transfer of HIP's IT-related position to the campus service center. At the end of 2007, HIP's IT Specialist moved to the IT Service Center in Kumpula. In April 2008 the HIP project secretary moved elsewhere in the University and HIP signed an agreement with the Laboratory of Chronology of the Finnish Museum of Natural History, located in the same Physicum building in Kumpula, to share equally the secretary's workload between the two organizations. That collaboration lasted until the end of 2010. Thereafter, HIP sought secretarial collaboration with the Division of Elementary Particle Physics of the Department of Physics of the University of Helsinki, and a new joint secretary was hired starting 1.12.2010. That solution was ideal from the point of view of overlap between the activities of HIP and the Division of Elementary Particle Physics. However, the Department of Physics reconsidered their position once the joint secretary departed in April 2011, and decided to end the cooperation in secretarial work. Thereafter, HIP hired a part-time secretary in Kumpula. At CERN, the long-time secretary left to work in the CERN organization at the end of 2008; she had already been seconded part-time to the CERN VIP services in the autumn of 2008. A new part-time secretary was hired at CERN in January 2009. After these rearrangements, in 2009 the administrative workforce at HIP was 4.5 FTE, corresponding 4.9% of the total HIP workforce.

There were also developments on the national level. A productivity program within the Ministry of Education's sector of administration was adopted in 2005. The goal was to reduce the number of personnel by filling only half of the positions that became available due to retirement. On 26.10.2006 the Ministry of Education decided to establish a financial and human resource management service center for universities in Vaasa, and Certia started to operate in 2008. In 2010 it was transformed into Certia Oy. The University of Helsinki decided, however, not to become a client of Certia and to organize its administrative services itself. The main reason was the size of the university.

From the beginning, quality assurance was an important matter in all HIP operations. The Scientific Advisory Board had a specific role as the advisory

body for the HIP Board in scientific matters, including the quality of research conducted at HIP. HIP activities were, for most part, directly connected with large international research infrastructures, especially with CERN. At CERN, every research proposal goes through a multi-step evaluation procedure before it can be approved and, even thereafter, a continuous scrutiny is applied to all steps in the preparation of experiments. Therefore, the HIP Detector Laboratory had adopted quality control and assurance as a part of its normal operation. In addition, evaluations of individual projects were performed at HIP regularly. The Higher Education Evaluation Council in Finland and the Ministry of Education agreed that an audit procedure of quality assurance systems for higher education Institutions should be developed during 2005-2007. The background of the audit was the need to demonstrate the quality of Finnish higher education and degrees nationally and internationally, and to support higher education institutions in their quality management and development. Within the University of Helsinki it was decided (Rector's Decision 11/2006;25.1.2006) that a quality assurance system should be developed, as was depicted in the university's strategy for 2007-2009, and the university prepared for an audit of the system at the end of 2007. At HIP, this meant that the existing quality assurance mechanisms were documented and an Operations Manual for HIP was produced. In addition to the research activities, the Operations Manual covered process descriptions of the daily activities. As HIP was not a degree granting organization, the processes related to education were limited. For many support functions, the Institute relied on the university's processes. The HIP Operations Manual was completed in August 2007. The visit of the audit group, under the leadership of Chancellor Eero Vuorio, took place in November 2007, and the Higher Education Evaluation Council in Finland decided in February 2008 that University of Helsinki met the criteria set for quality assurance system as a whole and for quality assurance in its primary missions.

HIP research was organized in research projects led by project leaders with a position at HIP or in one of the HIP partner universities. To develop the management, as was stipulated in the HIP target program for 2010-2012, and to instruct them in the UH administrative practices, HIP and the Institute of Molecular Medicine Finland (FIMM) organized a leadership training session for project leaders and program directors at the Rantasipi hotel in Hyvinkää on 4-5.3.2011. The program of the session included presentations by professor Olli Kallioniemi of FIMM (Establishment of an international research institute in Finland – challenges in the recruitment

and setup phase), professor John Antonakis of U. Lausanne (Leadership in expert institutions and beyond), Chancellor emeritus Kari Raivio of U. Helsinki (Experience of leading large research universities), Dr Kristiina Fromholtz-Mäki of Cresco Oyj (Scientific team leadership), and professor Dan-Olof Riska of HIP (University response when international research collaboration leads to trouble: two cases).

Professor Dan-Olof Riska. Director 1.7.2000-31.3.2012. (Photo: Studio Tapio/ Sirpa Nygren).

ÄYSTÖ ERA

Professor Juha Äystö of the Department of Physics, University of Jyväskylä, started his tenure as the Director of the Helsinki Institute of Physics on 1.4.2012. The Government of Finland appointed him as scientific delegate to the CERN Council for 1.1.2014-30.6.2016, and to the FAIR Council for 1.4.2012-30.6.2016. He also served as an invited member of the CERN Scientific Policy Committee (SPC) for 2009-2013.

HIP status

On 25 October 2011 the Rector of the University of Helsinki appointed a Reform Group to present their views on how the university's profiling should be made more concrete and its economy could be built on a more sustainable basis. Vice-Rector Ulla-Maija Forsberg led the group. The goal was to find within the University the resources needed to implement the strategy for 2013-2016. In the report, published on 10.4.2012, the group proposed 63 measures to be taken. These included improving the basic education and making the administration more efficient. The Group also addressed the number of independent institutes. Within the faculties, there seemed to be the opinion that researchers working in independent

The HIP Board in 2013: Risto Nieminen, Jaakko Härkönen, Kari J. Eskola, Johanna Björkroth (Chair), Juhani Keinonen, Ulla Ruotsalainen, and Tuure Tuuva (substitute member) (Photo: Juha Aaltonen).

institutes were privileged because they had more time for research and their teaching load was limited. On the other hand, the permanent positions of the teaching and research staff were typically in departments within faculties, and the research positions in independent institutes were fixed-term. The report of the Group did not propose any change to the status of HIP. However, the Group made a number of recommendations that also affected HIP. These concerned the most efficient use of research equipment on campuses and the coordination of university's infrastructure funding.

The strategy of the University of Helsinki for the years 2013-2016, "Excellence for Society", was approved by the Board of the University on 18.1.2012. One of the measures to implement the strategy was the structural development of the university, including independent institutes. Another important measure was a cut of at least 4% in each unit's basic funding in order to form a strategic fund for reallocation to the units based on profiling at the university. Cooperation in the development of research infrastructures was also included in the implementation plan.

On 5.4.2013 the leadership of the University of Helsinki had a meeting at the Ministry of Education and Culture detailing the university's strategy for 2013-2016. The structural development of the university was addressed, among other things. In the autumn of 2013 the Rector of the University of Helsinki asked the independent institutes and faculties to put forward initiatives for structural development. In particular, the research institutes had to seek closer collaboration with the faculties. On 11.11.2013, the Dean of the Faculty of Science, professor Keijo Hämäläinen, met with the representatives of HIP, the director and administrative manager, to discuss the relationship of the two organizations. It was agreed that a paper would be prepared on the key factors of HIP's operation. The Rector of the University of Helsinki, professor Jukka Kola, visited the independent institutes in early 2014 to discuss the possible new initiatives. The visit to the Kumpula campus took place on 14.1.2014, at which time both the Helsinki Institute of Information Technology (HIIT) and HIP presented their activities to the Rector. HIIT is a joint institute of the University of Helsinki and Aalto University. The University of Helsinki activities in HIIT were part of the Department of Computer Science. The steering responsibility of HIIT was within Aalto University. In the meeting, HIP was represented by the director and administrative manager together with the CMS Program Director, professor Paula Eerola. The activities of both

research institutes were discussed, as well as the compatibility of both of their strategic goals with the university's strategy. The Rector, professor Jukka Kola, expressed the view that the steering role of the institutes could ideally be with the faculty instead of the rector.

The University of Helsinki Director of Planning, Mr Jussi Karvinen, prepared a Memorandum, dated 2.4.2014, that outlined the development of the strategic steering of independent institutes. One of the goals of the reform was to combine the target negotiations with rector with the target negotiations of the relevant faculty. For HIP the appropriate faculty was the Faculty of Science. A follow-up discussion on the relevant steps was organized on 24.4.2014, when the Rector met with the representatives of HIP, HIIT, the Department of Physics and the Department of Computer Science, together with the Dean and the Head of Administration of the Faculty of Science. The Rector asked HIP and the Faculty of Science to also make a report on HIP's position in the University of Helsinki by 6.10.2014. A committee was formed, the members of which were Dean of the Faculty of Science, professor Jouko Väänänen, professor Paula Eerola (CMS Program Director), professor Hannu Koskinen (Head of the Department of Physics), Administrative Manager Mikko Sainio (HIP), professor John Westerholm (Department of Geography), and professor Juha Äystö (Director of HIP). The Head of Administration of the Faculty of Science, Arto Halinen, was invited to act as the secretary of the committee. In the meeting, it also became clear that the Rector preferred HIP becoming part of the Faculty of Science.

The committee explored three different schemes for the administrative arrangement of HIP: continuation as before as an independent institute, as part of the Department of Physics, or as an independent institute within the Faculty of Science. The HIP representatives in the committee preferred the first alternative, but the rest of the committee did not share that view. The Dean, as chair of the committee, worked for a unanimous conclusion that would also satisfy the Rector's expectations. This meant that the committee listed the conditions under which HIP could function as part of the Faculty of Science. There were 10 requirements set by the committee. These included maintaining HIP's role as a national research organization with responsibilities related to the CERN and FAIR cooperation. The report was completed on 26.9.2014 and, on the same day, the HIP Board discussed the matter. The Dean, as the Chair of the HIP Board, stated that the national nature, internationality, and multidisciplinarity of HIP would

remain essential characteristics of the Institute. The move to operations in connection with the Faculty of Science could start in the beginning of 2016. The matter was discussed in the HIP Staff Meeting on 9.2.2015. The consent of the universities in the HIP consortium and the Ministry of Education and Culture was acquired. On 20.3.2015 the University of Helsinki Board decided on HIP's move to the Faculty of Science starting 1.1.2016. The 10 requirements were included in this decision.

The Board of University of Helsinki approved the new regulations for the University on 15.4.2015, and they entered into force on 1.8.2015. The possible consequences for HIP's Regulations were discussed by the Head of Administration of the Faculty of Science, Mr. Arto Halinen, and HIP's Administrative manager on 27.8.2015. In addition, the implications of HIP becoming part of the Faculty of Science from the beginning of 2016 were considered. It was concluded that there was no need for modification of the Regulations at that time.

HIP expansion

On 15.12.2011 the Finnish governmental Research and Innovation Council decided to appoint an expert group to prepare a proposal on the overall reform of the national research institute sector. The expert group was given the task of preparing a proposal for "a model to be employed in the structural reform of the state research institute sector, while strengthening the steering of research institutes, reforming their funding and improving the targeting of resources in accordance with the needs of society". The chair of the group was Permanent State Under-Secretary Timo Lankinen from the Prime Minister's Office, and the members were Managing Director Christine Hagström-Näsi and professor Sixten Korkman. In its report, published on 20.9.2012, the group proposed three measures: merging research institutes into stronger ones; the centralizing of research resources in order to increase their social effectiveness through the establishment of a funding instrument for strategically targeted research, to be employed in solving significant social challenges and problems; and intensifying the cooperation between research institutes and universities. Based on the report, the Finnish Government made a decision on the reform in September 2013, and in the beginning of 2015 several mergers took place. The Radiation and Nuclear Safety Authority of Finland (Säteilyturvakeskus, STUK)

remained independent in the reform but started to explore possibilities for cooperation with universities, including the Helsinki Institute of Physics. The primary goal of STUK is to protect people, society, the environment and future generations from the harmful effects of radiation. On 5.11.2014 a seminar was held on radiation safety research in Finland, and in June 2015 STUK published the document "National Programme for Radiation Safety Research" (STUK-A 260/June 2015) in order to describe their research needs and to ensure a high level of national competence in radiation safety research, as well as to fulfill the information needs of national authorities. The common field of interest between HIP and STUK was radiation sensor technologies and their applications. Director General Petteri Tiippana of STUK, together with Drs Kari Peräjärvi and Teemu Siiskonen, visited HIP on 26.5.2015 to discuss cooperation and the possibility of STUK becoming a contracting party in the consortium operating HIP. On 15.6.2015, Petteri Tiippana wrote a letter to the HIP Director, professor Juha Äystö, and to the rectors of the universities operating HIP. In his letter, Tiippana expressed STUK's interest in joining the consortium operating HIP and asked for the universities' consent to the membership. The HIP Board discussed the matter on 25.9.2015. In principle, the HIP Board had a positive attitude towards STUK cooperation, but the issue was delegated to a working group to be led by professor Paula Eerola with representation of the universities. The question needing clarification was the nature of membership in the consortium operating HIP, member or associate member. The fact that STUK was under the Ministry of Social Affairs and Health, whereas the universities were under the Ministry of Education and Culture caused some thought from the result-based funding point of view. The universities were represented in the working group by professors Mikko Alava (AU), Ari Jokinen (UJ), Saku Mäkinen (TUT), Kai Nordlund (UH), and Tuure Tuuva (LUT). In addition to the STUK matters, the working group was given the task of contributing to the planning of the strategy for 2017-2020.

ESFRI

The representatives of Aalto University on the HIP Board expressed their wish on 26.9.2014 for a larger role for HIP in international research infrastructures, including synchrotron radiation research. A working group was appointed to explore the possibilities. The members were Tuija Pulkkinen (chair), Keijo Hämäläinen, Jouko Väänänen, and Juha Äystö.

The discussions in the group were reported to the Board on 25.11.2014, and the group was supplemented by the addition of Rauno Julin. What was discussed was the expansion of HIP's activities to include accelerator-based international infrastructures, so that the profiling of the universities would be taken into account. In addition to research and technologies, trainee and school activities were under review. In the HIP Board meeting on 10.4.2015, the Director reported on the discussions with the chair of the FSRUO organization (Finnish Synchrotron Radiation User Organization). Finland participated in the activities of the European Synchrotron Radiation Facility (ESRF) in Grenoble as part of the Nordic NORDSYNC consortium. Another facility exploited by Finnish groups was the MAX-lab in Lund. For the European Spallation Source (ESS) it was noted that this facility was not included in the Finnish ESFRI roadmap (European Strategy Forum on Research Infrastructures). As a concrete step, in 2016 HIP started to partially support one summer student at ESRF. Regarding the coordination of the research activities at CERN and FAIR, the Ministry of Education had issued a mandate with the expressed intention to provide funding. The Finnish synchrotron light source community was large and diverse, with a significant life science component. The Ministry of Education did not give the coordination responsibility to HIP. The research groups active in ESRF and MAX-lab had significant funding from the Academy of Finland.

The European Strategy Forum on Research Infrastructures was established in 2002, with a mandate from the EU Council to support a coherent and strategy-led approach to policy-making on research infrastructures in Europe. In 2006 ESFRI published its first roadmap for the construction and development of the next generation of pan-European research infrastructures. The roadmap was updated, e.g. in 2008 and 2010, to include projects to foster European leadership across a broad range of scientific fields. The EU Competitiveness Council urged the member countries to prepare national roadmaps of research infrastructures. The Ministry of Education gave the task of carrying out the survey of research infrastructures at the national level to the Federation of Finnish Learned Societies and appointed a broad-based Steering Group for the project. The first Finnish roadmap of the national level infrastructures was published in 2009 (Publications of the Ministry of Education 2009:2). Out of the 24 significant national level infrastructures in the report, three were of particular importance for HIP, namely the Micronova Centre for Micro- and nanotechnology, the Jyväskylä Accelerator laboratory, and CSC computing resources. The Steering Group approved 20

infrastructures for inclusion in the roadmap, and 13 of them were on the ESFRI list, including the Facility for Antiproton and Ion Research (FAIR) in Darmstadt Germany. The report also provided a list of established international infrastructures to which Finland was a member. These include CERN, ESRF, and MAX-lab, which Finland had joined 1991, 1989, and 1991 respectively. Three international expert panels were established to evaluate new proposals for the roadmap, one each from physical sciences, e-science, and engineering.

In the Research and Innovation Council's research and innovation policy for the years 2011–2015, research infrastructure policy was identified as one of the key development projects for research and innovation system structures. In the guidelines, it was proposed to establish a permanent research infrastructure body to develop the national research infrastructure policy, to network Finland with international research infrastructures, and to manage the funds allocated to research infrastructures. In April 2012 the Academy of Finland appointed an expert group (the FIRI expert group) as a research infrastructure institution, with a mandate from the Ministry of Education and Culture. The task of the FIRI (Finnish Research Infrastructures) expert group was to draw up Finland's research infrastructure strategy, update the 2009 research infrastructure roadmap, and manage the annual FIRI allocations. The infrastructure strategy for Finland and the update to the roadmap was published in 2014 (Suomen tutkimusinfrastruktuurien strategia ja tiekartta 2014-2020, Suomen Akatemia 2014). The FIRI expert group was led by professor Marja Makarow of the Academy of Finland, and the membership included Vice-Rector Johanna Björkroth (UH) and professor Paula Eerola in her capacity as the Chair of the Academy of Finland Research Council for Natural Sciences and Engineering during 2013-2017. In the document, CERN and FAIR were listed as research infrastructures to which Finland was a member through state treaty. The ESRF had a similar status.

Theory Program

The HIP theory projects were ending at the end of 2013, and therefore a call for Letters-of-Intent for new fixed-term (3+3 years) theoretical physics projects was published late in 2012 (Arkhimedes 6/2012, p. 5) with a deadline of 28.2.2013. The projects were expected to be related

to the research at CERN and other large-scale research programs. By the deadline, 15 proposals were received. A pre-selection of the projects to be considered by the Scientific Advisory Board was made by professors Kari Rummukainen (UH and HIP), Kimmo Kainulainen (UJ), and Päivi Törmä (AU). The theoreticians in the SAB, professors W. Buchmüller and W. Weise, had access to all of the Letters-of-Intent. The main criteria for the selection were the scientific quality, alignment with the research strategy of HIP and the member universities, career stage, and additional secured funding. On 18.9.2013 the HIP Board approved five theory projects for the years 2014-2016 based on the recommendation of the SAB. The projects were Cosmology of the Early and Late Universe of Doc. Syksy Räsänen (UH), High Energy Phenomenology in the LHC Era of Doc. Aleksi Vuorinen (UH), QCD and Strongly Interacting Gauge Theory of Doc. Tuomas Lappi (UJ), Nuclear Structure for Weak and Astrophysical Processes of Dr Markus Kortelainen (UJ), and Domain Wall Dynamics of Dr Lasse Laurson (AU).

Doc. Räsänen's project continued HIP's long tradition in combining cosmology, particle physics, and astrophysics. The initial fields of interest were late Universe inhomogeneities, inflationary perturbations, and LHC cosmology, as well as cosmological observations and simulations. Doc. Vuorinen and his group had a broad phenomenology-oriented scientific agenda including BSM (Beyond the Standard Model) phenomenology at the LHC and in the early Universe, and deconfined QCD matter in heavy ion collisions and compact stars. Doc. Lappi's project was also a continuation of a strong tradition in Finland in relativistic heavy ion physics, perturbative QCD, and finite temperature field theory. All of the main HIP experiments at the LHC detectors, ALICE, CMS and TOTEM, were relevant for this project. The main issues in the proposal were the partonic content of proton/nucleus, the development of the partonic initial state to a collective system, and the hydrodynamical evolution of QCD matter. Doc. Lappi was awarded the Zimányi medal in May 2014 in the Quark Matter 2014 conference in Darmstadt for his work on Color Glass Condensate and the Glasma models of initial conditions in high energy A+A reactions. The overall scientific goals of the project of Dr Kortelainen were in the application of theoretical methods based on nuclear density functional theory to questions of astrophysics interest and to weak interaction processes. Part of the effort were the methodological developments, including new forms of energy density functional that incorporates complex many-body correlations. Dr Laurson's work on

domain wall dynamics in low-dimensional ferromagnetic structures was driven by both the fundamental physics interests and the possibilities for numerous technological applications, e.g. in memory and logic devices. The focus in the beginning was on the effect of disorder and thermal fluctuations.

In 2014, two articles published in Physical Review Letters by HIP researchers received exceptional publicity. One figure from the article by Mark Hindmarsh, Stephan J. Huber, Kari Rummukainen and David J. Weir "Gravitational Waves from the Sound of a First Order Phase Transition" (Phys. Rev. Lett. 112 (2014) 041301) appeared on the cover of issue 4 of volume 112. Furthermore, the 22.2. issue of the journal New Scientist included a summary of the contents of the article in its This Week pages. In the article, the first three-dimensional simulation of bubble nucleation involving coupled field-fluid system was reported, and it was found that the compression waves in the fluid – sound waves – continued to be an important source of gravitational waves after the bubble merger had completed. The second article by Matti Herranen, Tommi Markkanen, Sami Nurmi, and Arttu Rajantie "Spacetime Curvature and the Higgs Stability During Inflation" (Phys. Rev. Lett. 113 (2014) 211102) was chosen as the "Editors' Suggestion" in Physical Review Letters. The article showed that even a small non-minimal coupling of the Higgs field to gravity was sufficient to stabilize the Higgs potential during inflation and thus prevent the collapse of the Universe. Based on an Imperial College press release, the Daily Mail published an article in its science pages on 19.11.2014 that was titled "Did gravity save the Universe after the Big Bang?" and referred to the results of the paper.

The Theory Program projects active during 2008-2013 were: Laws of Nature and Condensed Particle Matter Phenomenology at LHC of Doc. Kimmo Tuominen (UJ), Cosmophysics of professor Kimmo Kainulainen (UJ), Low Dimensional Quantum Systems of Doc. Ari Harju (HUT), and Radiation Damage in Particle Accelerator Materials of Doc. Flyura Djurabekova (UH). These projects were completed according to the 3+3 year schedule. The focus of Doc. Tuominen's project was on electroweak symmetry breaking mechanisms and associated BSM phenomenology, and on perturbative and non-perturbative strong interactions with applications to BSM physics and the properties of hot and dense QCD matter, topics of particular relevance for the experimental work at the LHC collider. Professor Kainulainen's project explored a number of

topics including inflation, gravitational lensing and galaxy distribution, cosmological phase transitions, baryogenesis, and quantum transport theory. The focus of Doc. Harju's project was the study of two-dimensional semiconductor quantum dots in strong magnetic fields and graphene. The project also developed tools for speeding up computer simulations. Doc. Djurabekova's project contributed to the CLIC development by studying the electrical breakdown of materials in CLIC accelerating components. Furthermore, the group worked on radiation damage in silicon detectors and nanostructures in silica.

During 2012-2015 the Theory Program produced about 31% of HIP's refereed journal articles and 73% of the doctoral degrees completed in HIP research projects.

CMS Program

The CMS detector collaboration started its experimental research program on 30.3.2010. Gradually, with improving luminosity, i.e. collision rate, it was possible to collect enough data to be able to conclude something about the Higgs boson. On 13.12.2011, in a seminar at CERN, the general-purpose detectors at the LHC collider, CMS and ATLAS, presented the results of their data collected in 2010 and 2011. The CMS Collaboration was able to exclude at 95% confidence level a Standard Model Higgs with mass larger than 127 GeV and the ATLAS Collaboration masses below 115.5 GeV and above 131 GeV. In April 2012 the collision energy of the proton beams was increased to 8 TeV, which increased the luminosity. With more accumulated luminosity, on 4.7.2012 particle physicists around the world linked with CERN to hear the latest news on the search for the Higgs boson at the LHC. The seminar was aligned with the start of the 2012 International Conference on High Energy Physics in Melbourne. In the seminar, the CMS and ATLAS collaborations announced that they had observed clear signs of the production of a new boson in the LHC proton-proton collisions consistent with it being a Higgs boson, with a mass of around 126 GeV. A public event was organized in Kumpula in connection with the announcement of the Higgs results. The event received sizeable media coverage both globally and in Finland. All Finnish TV news channels were present, and the discovery was the first news item in the evening's main TV news. In addition, at least two radio channels and 16

newspapers carried the Higgs news. The CMS Collaboration published their results in "Observation of a new boson at a mass of 125 GeV with the CMS experiment at the LHC", Phys. Lett. B716 (2012) 30. The result was based on integrated luminosities up to 5.1 fb^{-1} at 7 TeV and 5.3 fb^{-1} at 8 TeV collision energy. The results were consistent with the Standard Model Higgs, but additional data and analysis were required to confirm that the particle was, indeed, the Higgs particle. In 2013, the CMS and ATLAS experiments could confirm that the new particle found at the LHC had the physical properties of the Higgs boson. The spin, parity, couplings, and branching ratios were found to be compatible with those of a Standard Model Higgs. The 2013 High Energy and Particle Physics Prize of the European Physical Society was awarded to the ATLAS and CMS collaborations "for the discovery of a Higgs boson, as predicted by the Brout-Englert-Higgs mechanism" and to Michel Della Negra, Peter Jenni, and Tejinder Virdee "for their pioneering and outstanding leadership rôles in the making of the ATLAS and CMS experiments".

The HIP CMS group members celebrating the Nobel prize of F. Englert and P.W. Higgs on 8.10.2013. The individuals from left to right are docent Eija Tuominen, professors Paula Eerola and Jorma Tuominiemi, Dr Panja Luukka, docent Ritva Kinnunen and Dr Tapio Lampén. At the door is HIP's project secretary Tarja Heikkilä (Photo: Juha Aaltonen).

With the discovery of the Higgs boson one of the main goals of the LHC experiments was achieved. The ATLAS and CMS detectors were general purpose detectors designed to study the Standard Model of elementary particle physics and, in addition, new physics, i.e. physics beyond the

Standard Model, which was the other main goal of the LHC experiments. The HIP CMS Experiment group, led by Dr Katri Lassila-Perini, was involved, in particular, with the search for charged Higgs bosons, which were predicted e.g. in the Minimal Supersymmetric Model (MSSM) representing new physics. In addition, B-physics and jet physics remained in the focus of the HIP CMS group. HIP also contributed to the software alignment of the CMS Tracker. The LHC Run 1 lasted until 14.2.2013 and was followed by Long Shutdown 1 for two years. The Long Shutdown at the LHC collider was used to consolidate and strengthen it for running at higher energies. Recommissioning with a beam began on 5.4.2015, and physics data with stable beams started to be collected on 3.6.2015 at a collision energy of 13 TeV, one TeV less than the original design energy of the accelerator. That was the start of Run 2. At the start of the run there were difficulties with the CMS cryogenic system, which were resolved in a cleaning operation during the following winter break.

The focus of the HIP CMS Upgrade project was on the pixel detector Phase 1 upgrade of the CMS detector and R&D for the Tracker Phase 2 upgrade. The leader of the project was Dr Jaakko Härkönen. The CMS Technical Design Report for the Pixel Detector Upgrade was published on 26.9.2012. The aim was to prepare the CMS pixel detector for the high instantaneous luminosities and total integrated radiation doses. The main Finnish contribution to the pixel tracker was half of the layer-three barrel pixel modules, plus spares. The technology applied was flip-chip (bump) bonding, connecting the pixel sensors with read-out chips via solder bumps instead of solder wires. The work was performed in cooperation with the VTT spinoff company Advacam Ltd at Micronova. The modules were also tested in the Micronova clean room. The quality of the bonds was studied with White Light Interferometry at the Electronics Research Laboratory of the University of Helsinki. The project was funded through the Academy of Finland Finnish Research Infrastructure (FIRI) funding instrument. The corresponding addendum (Nr 8), comprising an upgrade of the pixel subsystem, to the MoU for Collaboration in the Upgrade of the CMS Detector was signed in April 2014. The full module construction and testing took place at CERN. For the Phase 2 upgrade, the plan was to replace the whole CMS silicon tracker with a new one with improved granularity and radiation hardness. The CERN R&D projects, RD39 and RD50 with HIP participation, were involved in these developments. In the CMS detector construction stage, the Lappeenranta University of Technology group of professor Tuure Tuuva contributed to the Resistive Plate Chamber (RPC)

trigger link board design and fabrication. In the course of Run 1 the group contributed to the RPC operation and repairs. During the Long Shutdown 1, the RPC coverage was increased in the forward regions and the Lappeenranta group became involved in the muon system readout upgrade.

The HIP Technology Program made a significant contribution to the development of grid computing for high energy applications at HIP. From the beginning of 2011, the grid support activity of the GridCluster project of the Technology Program was transferred, with SAB endorsement, to a new Tier-2 Operations project in the CMS Program. Dr Tomas Lindén continued to lead the project. The Finnish CMS Tier-2 resources were operated, maintained, and monitored jointly by the HIP, CSC, and NDGF (Nordic Data Grid Facility). Linux clusters, both at the CSC premises and in Kumpula, were used for the CMS grid jobs. Archiving data was handled at the CMS Rutherford Appleton Laboratory Tier-1. In 2012-2014 the Academy of Finland funded a joint project between HIP and the Department of Computer Science, University of Helsinki, called "Datacenter Indirection Infrastructure for Secure HEP Data Analysis" (DII-HEP), within the Strategic Centres for Science, Technology and Innovation (SHOK) program the Future Internet and Cloud Software. The principal investigators were professors Paula Eerola and Sasu Tarkoma. The goals of the project were to explore the latest software stacks for distributed computing infrastructures and to construct a secure and scalable setup for scientific applications using the CMS analysis and production framework as a test case.

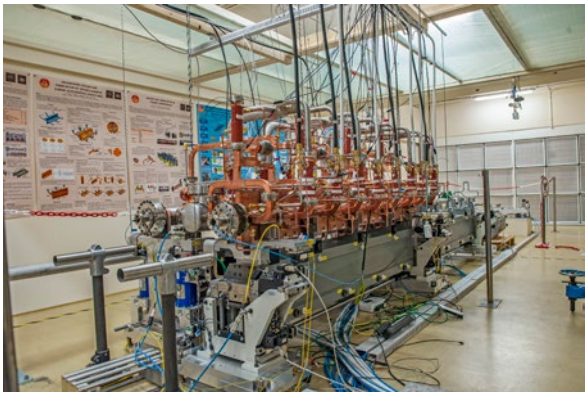
In May 2012 Dr Katri Lassila-Perini of HIP was asked to lead the CMS data preservation and open access project based on a policy accepted by the CMS Collaboration Board in March 2012. The two-fold goals were long-term preservation of CMS data and public open access to it. HIP and Finland were leading actors in CMS data preservation (in collaboration with CSC – IT Center for Science and Lapland University of Applied Sciences). CMS was the global leader of the data preservation effort in high energy physics. Data preservation in long-term analysis in high energy physics had become a pressing topic for the entire high energy physics community. The aim was to foster discussion, archive consensus, and transfer knowledge on technological solutions and the diverse governance applying to the preservation of data, software, and know-how in the field of high energy physics. In addition, cross-disciplinary partnership around open data was sought, which involved pedagogical expertise, practical knowledge

in teaching, and software and user interface skills. The Collaboration Agreement for the Data Preservation in High Energy Physics (DPHEP) Project of the International Committee of Future Accelerators (ICFA) was signed in June 2014. The first public release of CMS high-level data took place in November 2014. The HIP group coordinated a pilot project aimed at offering learning applications for high schools and higher education. The journal Nature reported on that activity in an article "LHC plans for open data future" in the News section (E. Gibney, Nature 503 (2013) 447).

The High-Luminosity LHC project was announced as the top priority in the 2013 European Strategy for Particle Physics, as mandated by the CERN Council. The first phase of the project began in 2011, and was partially financed by the European Commission through the FP7 Infrastructures High Luminosity Large Hadron Collider Design Study. The report "High-Luminosity Large Hadron Collider (HL-LHC): Preliminary Design Report" was published on 17.12.2015 (G. Apollinari et al., CERN-2015-005).

High Energy Physics Program

During 2012-2013 the Program consisted of two projects, Linear Collider Research led by Doc. Kenneth Österberg and the TOTEM Operation project led by professor Risto Orava. The TOTEM project also included the activities related to the CDF Collaboration at Fermilab. In addition, the HIP Detector Laboratory was operated under the umbrella of the HEP Program. The Program Director, professor Heimo Saarikko, was the Laboratory Director. The operations at the Laboratory were coordinated by Doc. Eija Tuominen. The Conceptual Design Report of the CLIC (Compact LInear Collider) machine was completed in 2012. In the new phase of the CLIC study, the focus of the HIP contribution was on R&D for the CLIC RF structures and the integration of the RF structures into the CLIC module. In the TOTEM Detector Collaboration the HIP activities



The first prototype of the two-beam module for the CLIC (Photo: CERN).

concentrated on the operation of the Helsinki-built T2 spectrometer, as well as on preparing and leading the physics analysis of the TOTEM data enabling the measurement of cross sections in proton-proton collisions. In particular, the Helsinki group contributed to the analysis of inelastic and diffractive cross sections. In May 2012, the first joint data taking of the TOTEM and CMS detector collaborations was completed and the data were merged for common data samples.

The CERN TOTEM Collaboration published the Upgrade Proposal on 12.6.2013. The Technical Design Reports (TDR's) for two upgrades were published in September 2014. They concerned "Timing Measurements in the Vertical Roman Pots of the TOTEM Experiment" and "CMS-TOTEM Precision Proton Spectrometer", and the plan was to improve the experimental capability to study central diffractive processes, $p + p \rightarrow p + X + p$, in runs with common CMS-TOTEM data taking. In the TOTEM upgrade program, HIP participated in the diamond-based proton time-of-flight detector upgrade. Funding was provided through the Academy of Finland FIRI grant.

The HIP Board discussed the HIP program structure in its meeting on 5.3.2013, and the matter was also the main topic in the expanded Steering Group meeting in early June 2013. In the Board meeting on 18.9.2013 the decisions concerning the program structure were made. Professor Saarikko's term as Program Director was coming to an end, and the HIP Board decided to discontinue the High Energy Physics Program at the end of 2013. The TOTEM Operation project was moved to the CMS Program, reflecting the increased integration of the two experiments taking place at CERN. Professor Saarikko took over the leadership of the HIP TOTEM project for 2014. The Linear Collider Research project of the HEP Program ended and the CLIC research activity continued in the Accelerator Technology project in the Technology Program under the leadership of Doc. Kenneth Österberg. The Detector Laboratory became an independent project for 2014-2016 led by Doc. Eija Tuominen.

In the SAB meeting in August 2013, professor Risto Orava presented a new proposal for forward physics at the LHC. The idea was to equip the ALICE detector with forward shower counters in order to study central exclusive production of high mass states. The choice of ALICE was motivated by the moderate luminosity at the ALICE interaction point, reducing pileup effects. The SAB considered the proposal interesting, but still in

a conceptual stage. The HIP Board decided to establish an independent project in Forward Physics for the year 2014 to allow professor Orava to further develop the proposal. Professor Orava presented a more detailed proposal at the meeting of HIP's Scientific Advisory Board in August 2014. The first stage of the proposal, the installation of forward/backward shower counters, had been approved by the ALICE collaboration and therefore the SAB also endorsed that part of the proposal. The second stage of the proposal involved modification of the beam pipe and, as such, required acceptance by CERN and the ALICE collaboration before the SAB could consider that part of the proposal. The HIP Board approved the ALICE-Forward project for the Nuclear Matter Program for the years 2015-2017 at its meeting on 26.9.2014. Professor Orava was appointed as the project leader. He had already joined the ALICE Collaboration.

Nuclear Matter Program

In 2012 there were three projects in the Nuclear Matter Program: ALICE, ISOLDE, and FAIR. The Program Director was professor Matti Leino of the University of Jyväskylä from the beginning of April, 2012. A fourth project, ALICE-Forward, was added in 2015.

The first lead-lead collisions were recorded in November 2010 at $\sqrt{s_{NN}} = 2.76$ TeV. Additional lead-lead data was collected in 2011. In 2012 and 2013 data on p-Pb collisions was recorded at $\sqrt{s_{NN}} = 5.02$ TeV to complete the systematic study of vacuum (p-p), cold (p-Pb), and deconfined nuclear matter (Pb-Pb) phenomena. Lead-lead data (at $\sqrt{s_{NN}} = 5.02$ TeV) was collected again during Run 2 in November-December 2015. The physics analysis of the HIP group focused on jet properties and their modifications in quark-gluon plasma. The primary focus was on the high-p_T correlations. The ALICE hardware responsibilities of the HIP group concerned the T0 detector providing fast vertex positioning and start time for time-of-flight measurements and the electromagnetic calorimeter (EMCal) to enhance the capabilities of ALICE to study the produced medium through measurement of jets and high-p_T photons, π^0s, and electrons. One of the EMCal design criteria was to provide a fast single-shower trigger to achieve this enhancement. HIP contributed to the EMCal through the firmware development of the internal logic for the Trigger Region Units (TRUs) for single photon triggering.

In 2013 Cambridge University Press published a book by Jan Rak, the project leader of the HIP ALICE project, and Michael J. Tannenbaum (BNL), "High p_T Physics in the Heavy Ion Era", describing many of the new phenomena observed at the LHC.

A Letter-of-Intent for the upgrade of the ALICE Experiment was published on 8.9.2012, with 15 signatories from the HIP-Jyväskylä collaboration. The goal was to utilize the full potential of the LHC in fundamental studies of QCD with an emphasis in heavy-ion collisions in high luminosity runs. The main tracking detector of ALICE - the Time Projection Chamber (TPC) - with its multi-wire proportional readout chambers, was limited in its maximum readout speed. Therefore, the ALICE Collaboration decided to replace all readout chambers with Gas Electron Multiplier (GEM) technology with new readout electronics, which allowed for improving the data collecting rate by about a factor of 100. The Technical Design Report for the Upgrade of the ALICE Time Projection Chamber was published on 3.3.2014. There was considerable in-depth knowledge of GEM technology in the HIP Detector Laboratory due to the T2 tracking telescopes produced for the TOTEM detector for Run 1 and the beam diagnostics system for the Superconducting Fragment Separator (Super-FRS) at FAIR. Therefore, it was natural for HIP to be involved with the TPC upgrade. The main task for HIP was to perform quality assurance studies on about 300 m^2 of GEM foils (three layers, about 100 m^2 each). The work included optical scanning to map the gain uniformity and leakage current measurements of the newly produced GEM foils.

The HIP-Jyväskylä group had a significant role in the design, construction, maintenance, and operation of the T0 detector. Upgrade of the T0 was vital for ALICE, and Dr Wladyslaw Trzaska had the required expertise for the work. Therefore, it seemed natural for the group to keep the leading role it had in T0. The Technical Design Report (TDR) for the Upgrade of the ALICE Readout and Trigger System was published on 3.7.2014. During Run 1 ALICE had three forward detector systems, and T0 was one of them. In the TDR there was a plan to replace them with a single detector system called the Fast Interaction Trigger (FIT). In the new concept the quartz radiators were directly connected to multichannel plate – photo-multiplier tube –based light sensors. In November 2015 HIP signed Addendum 39 to the MoU for Collaboration in the Construction of the ALICE Detector Upgrade of the Readout & Trigger System with HIP's contribution to Fast Interaction Trigger.

The ALICE upgrade projects were funded through the Academy of Finland Finnish Research Infrastructure (FIRI) funding instrument.

The Nordic Data Grid Facility (NDGF) provided the distributed Tier-1 computing resources for the Nordic ALICE groups in collaboration with national computer centers. In Finland the contributor was the CSC - IT Center for Scientific Computing. Since 2007, HIP has had a contract with CSC for Tier-2 computing resources.

The HIP ISOLDE project used the CERN ISOLDE facility. The research program involved forefront experimental studies of nuclear structure, fundamental interactions, and materials physics, applying a wide range of experimental techniques. The ISOLDE facility was unique worldwide, having a wide range of radioactive ion beams. The applicable energy range was from the keV range to 3 MeV/u and, with the first phase of the HIE-ISOLDE upgrade, to 5 MeV/u. Many of the experimental themes were complementary to those at the University of Jyväskylä Accelerator Laboratory. The renewal of the Memorandum of Understanding for Collaboration in the Exploitation and Upgrade of the ISOLDE Facility at the PS-Booster was signed in August 2012, with Finnish contributions to the spectrometer for the REX and RFQ Cooler. The annual collaboration fee was 60 kCHF. On the instrumentation side, a new conversion electron spectrometer, SPEDE (SPectrometer for Electron DEtection), was developed under the leadership of Academy Research Fellow Janne Pakarinen. In 2013 a special highlight was an article published in Nature magazine (L.P. Gaffney et al., “Studies of pear-shaped nuclei using accelerated radioactive beams”, Nature 497 (2013) 199); a figure from the paper appeared on the cover of the magazine Nature. The experiment was carried out at REX-ISOLDE using the MINIBALL array of germanium detectors. The experiment shed light on octupole collectivity in radon and radium nuclei. Atoms with octupole-deformed nuclei are important in the search for permanent atomic electric-dipole moments (EDMs), which could help to reveal physics beyond the Standard Model.

On 4.10.2010 the Convention on the FAIR facility was signed in Wiesbaden, Germany. Finland joined the FAIR through the FAIRNORD consortium agreement with Sweden. Since 2009 HIP has had a dedicated FAIR project to manage the Finnish contribution to the construction of the facility. The actual construction of the FAIR facility was launched in the autumn of 2011. The FAIR activities are described in a separate section.

Participants of the FAIR/NuSTAR Week 7.-11.10.2013 in Helsinki. Professor Ari Jokinen is in the front row, second from the left, and professor Juha Äystö the sixth.

In the beginning of 2015 a project on forward physics, ALICE-Forward, was launched in the Nuclear Matter Program. The project leader was professor Risto Orava. The focus of professor Orava's group was the central exclusive diffraction physics at the ALICE detector. The forward ALICE Diffractive detectors were installed in December 2014 and data was collected in May 2015.

Technology Program

Professor Saku Mäkinen of the Tampere University of Technology started as the HIP Technology Program director from the beginning of 2012. The projects in the Technology Program in 2012 were Data Grid, Green IT, and PET Project. The project leaders were Mr Miika Tuisku, MSc, Dr Tapio Niemi, and professor Ulla Ruotsalainen (TUT), respectively.

The Data Grid project continued to be responsible for the coordination of the security area development in the European Middleware Initiative (EMI), a CERN coordinated EU funded collaboration project between the middleware providers ARC, gLite, and UNICORE. The Green IT project was seeking ways to improve the throughput and energy efficiency of computing clusters. The PET Project was seeking ways to commercialize a new type of PET (Positron Emission Tomography) scanner using AXPET

(AxialPET) type detectors. With Tekes funding, prototypes were designed and tested. In order to distinguish the design from the AXPET design, a new name, AvanTomography, was adopted. The first patent application related to the AvanTomography technology was filed in November 2012.

The Helsinki University of Technology was very active in the CERN related projects after Finland joined CERN in the beginning of 1991. The HUT activities were coordinated under the umbrella of the Institute of Particle Physics Technology (HTI). After HIP was founded in 1996, HUT made a strong contribution to the computational materials research at HIP and to the CERN based engineering data management system development, as well as to grid computing. HUT was also involved in the CMS detector design and construction. HIP became a member of the Microelectronics Centre of HUT in 2001. During professor Riska's tenure as the HIP director several informal discussions with the HUT representatives were held to identify common research interests in CERN related physics and technology. Numerous MSc and doctoral degrees were completed at HUT in HIP's research projects. A typical path to thesis work started as a summer student at CERN. During 1997-2016, 59% of all HIP summer students at CERN came from HUT/AU. In 2013, the HIP director started discussions with representatives of Aalto University to identify topics of mutual interest in CERN related research. In April and May 2013 three sessions were held at Aalto University to present HIP research activities. The topics of the sessions were detector technologies, accelerator technologies, and computing, including energy optimization, security for distributed storage, and LHC grid computing.

In the expanded HIP Steering Group meeting on 3.6.2013 the prospects for the renewal of the Technology Program were discussed. The general aim was to bring the activities closer to HIP's other projects. For Big Data in scientific computing, closer interaction with Aalto University was sought. In its meeting on 18.9.2013 the HIP Board decided on the future of the projects in the Technology Program and the respective project leaders. Accelerator Technology and Biomedical Imaging projects were established for 2014-2016, and a Green Big Data project for 2014. Doc. Kenneth Österberg was appointed project leader for 2014 for the Accelerator Technology project, professor Ulla Ruotsalainen for 2014-2016 for the Biomedical Imaging project, and Dr Tapio Niemi for 2014 for the Green Big Data project to further develop the project plan. On 24.9.2014, the HIP Board made additional decisions concerning the projects in the Technology Program.

The Accelerator Technology project was extended to cover the years 2015-2017. The project leader was Dr Markus Aicheler. The project had two components. The Material for Accelerator Technologies (MAT) group under the leadership of Dr Flyura Djurabekova continued the earlier work on the determination of fundamental mechanisms triggered in metal surfaces in the presence of high electric fields. The Module, Structures and Manufacturing (MSM) group of Dr Aicheler mainly participated in the CLIC study at CERN. The reason for the extension of the Accelerator Technology project was the K-Contract with CERN for the period 1.10.2014-30.9.2017. The agreement concerned R&D activities relating to accelerating structures and modules for CLIC (KE2488/BE/CLIC), and provided almost 700 k€ of CERN research funding for the project.

The Green Big Data project was continued for 2015-2017, and professor Jukka K. Nurminen of Aalto University was appointed as the project leader. The project focused on optimizing the energy consumption of scientific computing clusters used for high energy physics computing. Some of the topics of interest were the development of tools to visualize energy consumption, analysis of the influence of processor architectures on performance and energy-efficiency, development of work-load management methods, and analysis of the communication patterns of HEP computing, as well as evaluating the effect of network quality on computing time and energy efficiency. The last topic was investigated in an EU-funded and Aalto University coordinated research project "Scalable and Secure Infrastructures for Cloud Operations", active in 2015-2018.

In April 2012, CERN established the first Business Incubation Centre (BIC) with UK's Science and Technology Facilities Council. The idea was to provide new technology transfer opportunities to bridge the gap between basic science and industry by supporting businesses and entrepreneurs in taking innovative CERN technologies from technical concept to market reality. In July 2014, the Head of the CERN Knowledge Transfer Group, Mr Giovanni Anelli, expressed in a letter his support for the establishment of a Business Incubation Centre in Finland. In the BIC scheme, CERN would contribute with the transfer of technology and know-how through technical visits to CERN, support at the BIC, and preferential-rate licensing of CERN intellectual property. The BIC project in the HIP Technology Program was established for 2015-2017. Professor Saku Mäkinen became the project leader. The agreement on

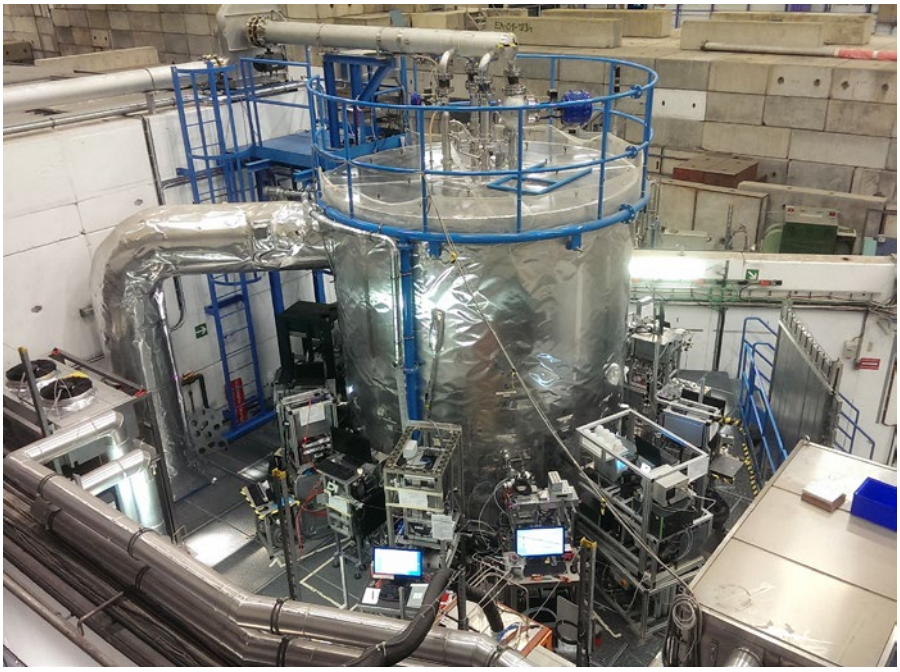
setting up a new Business Incubation Centre of CERN technologies at HIP (KN2709/KT) was signed at CERN on 15.9.2015, with the Tampere University of Technology joining the agreement. The plan was that BIC would explore ideas that were based on technologies developed at CERN, or with a direct contribution from CERN, with Finnish companies developing technologies of interest to CERN or innovative projects that could benefit from the support of CERN experts in their core fields of competences.

On 25.11.2014 the HIP Board established the NINS3 project in the Technology Program for 2015-2018 and appointed professor Peter Dendooven as the project leader. The Tekes funded FiDiPro project "Novel Instrumentation for nuclear safety, security and safeguards" (NINS3) and the FiDiPro professorship were very important for HIP. The professorship was the first placed solely at HIP. The joint positions that HIP had had earlier were placed at the partner departments. The NINS3 project had three topics for research and development: passive tomography of spent nuclear fuel, alpha radiation threat detection and imaging from a distance, and active neutron interrogation of unknown objects. The research partners of the consortium were, in addition to HIP, the Tampere University of Technology and STUK. There were eight industrial partners that contributed either cash or in-kind support for the project. The Steering Group of the project was chaired by Dr Heikki Sipilä of the HS Foils Oy. The Tekes funding was 70% of the total project cost, with a maximum of 1.182 M€ over four years. The rest was expected to come from the partners. In addition to the part-time professorship, the project had two post-doctoral researchers and one graduate student on its payroll.

CLOUD

The primary intention of the CLOUD experiment at CERN was to investigate the influence of galactic cosmic rays on aerosols in the atmosphere and clouds and their implications for climate. HIP signed the Memorandum of Understanding for the Execution of Experiment PS215 (CLOUD) in May 2012. Although its design was optimized to address the cosmic ray question, CLOUD was also able to reach the demanding

technological performance and ultralow contaminant levels necessary to be able to measure aerosol nucleation and growth under controlled conditions in the laboratory. The CLOUD project at HIP has been extremely successful in publishing in high impact scientific journals. During 2012-2015 the project had, in addition to other publications, three articles in the magazine Nature, two in Science, and two in the Proceedings of the National Academy of Sciences (PNAS).



The CLOUD facility in the T11 area at CERN during the CLOUD10 campaign in the autumn of 2015. The pion/muon beam arrives from the right and hits a hodoscope that monitors the beam intensity before it passes through the chamber to the left. Instruments were installed on the 16 ports around the chamber (Photo: CERN).

Planck

The Planck project was responsible for HIP's contribution to the Planck Satellite Mission of the European Space Agency (ESA). The Planck satellite measured the temperature variations across the Cosmic Microwave Background with much better sensitivity, angular resolution, and frequency range than the previous satellites. The satellite

completed seven sky surveys and was then switched off on 23.10.2013 upon exhaustion of its helium coolant. During 2012-2015 the Planck Collaboration published 60 papers, 28 of them belonging to the batch Planck Intermediate Results and 32 to the Planck 2013 Results. Some of the Planck papers have very high citation counts.

In its meeting in 2010 the SAB considered the participation in the Planck Satellite Mission highly relevant and expressed the wish to hear about plans to participate in future missions, e.g. Euclid. In the HIP strategic outlook paper for high energy physics in Finland published on 13.7.2012, the HIP program directors included the Euclid satellite mission as a continuation of the Planck participation. In its meeting on 18.9.2013 the HIP Board established the Planck-Euclid project for 2014-2016 to complete the Planck data analysis and to prepare for the Euclid mission under the leadership of Doc. Hannu Kurki-Suonio. The University of Helsinki signed the Multi-Lateral Agreement on the Euclid Mission with ESA on 28.11.2013. The participating universities from Finland were the Universities of Helsinki, Jyväskylä, and Turku. The main purpose of Euclid is to study the so-called "Dark Energy Question": why is the expansion of the Universe accelerating? Is it due to a mysterious "dark energy" permeating the universe, does the law of gravity deviate from General Relativity at cosmological distance scales, or is there yet another explanation, possibly related to the poorly understood effects of inhomogeneities on observations? Over the course of six years, Euclid is planned to photograph over one third of the sky in the visible and near-infrared domain, obtaining images of over a billion galaxies and spectra of tens of millions of galaxies. Based on this data, the Euclid Consortium planned to determine the three-dimensional distribution of galaxies and dark matter in the Universe. The Finnish consortium does not have any hardware contribution to the satellite, but is hosting one of the nine Science Data Centers and participating in the Euclid System Team work to develop Euclid computing infrastructure. In particular, the planned contribution was towards the production of simulated Euclid data, data quality monitoring, and data analysis.

Detector Laboratory

The development of the joint HIP and Department of Physics infrastructure, the Detector Laboratory, towards a common infrastructure serving all HIP research programs started in 2003 with the appointment of a coordinator for the laboratory. In 2004 a separate line for the laboratory appeared in the HIP annual budget. At that point, however, the budget covered only one technician in addition to coordination, rent, and material expenses. During the construction phase of the large LHC detectors, the laboratory contributed significantly to the realization of the Finnish contributions to the detectors, especially CMS, ALICE, and TOTEM. The next steps of organizational development were taken with the advent of the tenure of professor Äystö as HIP director. He appointed a working group to prepare a plan for the development of laboratory operations. The members of the group were professors Paula Eerola (chair), Risto Orava, and Heimo Saarikko, as well as Doc. Eija Tuominen. The Scientific Advisory Board discussed the plans in their meetings in 2012 and 2013, and recommended that a higher level of centrally managed resources could be more effective; i.e., the budget of the Detector Laboratory should cover all the permanent staff in addition to premises, materials and equipment, maintenance, and repairs. The preliminary plans were discussed in the HIP Staff Meeting on 27.9.2012. The HIP Board decided on 18.9.2013 to establish a separate project that had operational responsibility for the Detector Laboratory under the leadership of docent Eija Tuominen for the period 1.1.2014-31.12.2016. The main tasks assigned to the laboratory were the support of instrumentation for the large experiments in subatomic physics, education in experimental particle physics, and participation in externally funded R&D projects. The priorities for the activities were set by the steering group, which consisted of representatives of stakeholders. Initially the members of the Steering Group were Paula Eerola (UH and HIP), Edward Hæggström (UH), Ari Jokinen (UJ), Risto Orava (UH), Jan Rak (UJ), Heimo Saarikko (UH and HIP), Kenneth Österberg (UH and HIP), Eija Tuominen (HIP), Tuure Tuuva (LUT), Juha Äystö (HIP), and a representative of Micronova/AU.

The Detector Laboratory continued to host educational activities targeted at students, both at the school and university level. In 2013 and 2015, the Laboratory organized one-week research training courses in detector technologies for Nordic post-graduate students. In addition to students from Helsinki, there were students from the U. Uppsala and the Niels

Bohr Institute in Copenhagen. One of the tasks in the course was to make a particle detector from a beer can. The design for a gaseous proportional counter suitable for detecting ionizing radiation was published by a group of young people working in the laboratory, Alexander Winkler et al., American Journal of Physics 83 (2015) 733, "A gaseous proportional counter built from a conventional aluminum beverage can".

Personnel developments

A continuing issue in the various evaluations related to HIP was the number of positions in experimental high energy physics in Finland. The subject became particularly relevant after the retirement of professor Tuominiemi in 2010. In 2013 the University of Jyväskylä created a professorship in physics, especially experimental physics of ultra-relativistic heavy-ion collisions. The position attracted five applicants, and in their joint evaluation report dated 26.7.2013 the experts, professor Johanna Stachel (U. Heidelberg), Dr Nu Xu (Lawrence Berkeley National Laboratory), and professor Jorma Tuominiemi (HIP), placed Dr Jan Rak in first place, and from 1.1.2014 Dr Rak was appointed to the professorship.

To advance the internationalization of the University of Helsinki, the Rector decided on 11.12.2012 (decision 231/2012) to start a program for inviting part-time, fixed-term visiting professors. On 18.9.2013 the HIP Board approved the appointment by invitation of professor Mark Hindmarsh (U. Sussex) as a visiting professor for a five-year term starting 1.1.2014 (part-time, 20 %). HIP and the Department of Physics (UH) shared equally the cost, and the respective agreement was signed on 23.9.2013. The HIP Theory Program had two additional senior visitors in 2015 when professor Mikko Laine (U. Bern) spent part of his sabbatical at HIP in the autumn of 2015 (0.5 year) and professor Heribert Weigert (U. Cape Town) visited HIP for 1.5 months on two occasions.

In 2013, the HIP Scientific Advisory Board expressed its concern over the lack of senior staff in faculty positions. The appointment of Dr Jan Rak to the professorship in experimental high energy physics, especially in relativistic heavy ion physics, in Jyväskylä starting in 2014, was welcomed by the SAB. In 2014, the Department of Physics of the University of Helsinki decided to open a tenure-track assistant professor position in

experimental particle physics with an emphasis on the CMS experiment. The deadline for applications was 12.12.2014. The number of applicants was 13 and professors Philip Bambade (Laboratoire de l´Accélérateur Lineáire), Barbara Erazmus (CERN), and Klaus Kirch (ETH Zürich) were asked to give external expert opinions on the applicants. The HIP Board discussed the matter on 10.4.2015 and authorized the director to sign an agreement concerning the position with the Department of Physics, University of Helsinki. On 18.9.2015, HIP and the Department of Physics signed an agreement on the cost sharing of the assistant professor position for the period 1.10.2015-31.1.2019, with both covering 50% of the cost. The Rector of the University of Helsinki appointed Dr Mikko Voutilainen to the position starting 1.11.2015.

Over the years, HIP had sponsored some FiDiPro applications. The Finland Distinguished Professor Program (FiDiPro) was a funding program jointly established by the Academy of Finland and Tekes in 2006 to offer Finnish universities and research institutes the opportunity to hire top researchers from abroad, or those who have worked abroad for a long time, to work in Finland for a limited period. The goal was to establish long-term, international research cooperation to strengthen Finland's scientific and technological know-how. In 2014, HIP filed a plan of intent to Tekes for a FiDiPro project, "Novel Instrumentation for nuclear safety, security and safeguards" (NINS3). The plan was approved for the actual application process and the project received approval at Tekes on 26.9.2014 for the period 1.1.2015-31.12.2018. The principal investigator of the project was professor Paula Eerola, and the FiDiPro professor invitee was professor Peter Dendooven of the University of Groningen. Tekes provided the three anonymized expert opinions of the qualifications of professor Dendooven, and the Chancellor of the University, professor Thomas Wilhelmsson, decided on 25.2.2015 that professor Dendooven should be accepted as a FiDiPro professor at the University of Helsinki. The appointment was made for 1.3.2015-28.2.1019. The expected working time in Helsinki was four months annually.

In January 2015, professor Juha Äystö informed the chair of HIP's Board that he would leave the position of HIP Director at the end of 2015, six months before the end of his term of office. The main motivation was that the new director should be able to participate in the planning of the institute's strategy for 2017-2020 already at the beginning of 2016, which was important due to the planning schedule of the University of Helsinki.

The HIP Board discussed the director issue in its meeting on 10.4.2015 and appointed a search committee to prepare the appointment of a new director. The Board elected to the search committee professors Jouko Väänänen (UH, chair), Rauno Julin (UJ), Hannu Koskinen (UH), and Tuija Pulkkinen (AU), and decided on an international search. Professor Kari J. Eskola (UJ) replaced professor Julin in the committee because one of the applicants for the position was Julin's former student. The secretary of the committee was HR specialist Hannamari Helander. By the deadline of 8.6.2015 five persons applied for the position, two of them foreigners. The foreign applicants did not, however, have the required doctoral degree. The search committee unanimously proposed appointing professor Paula Eerola to the position. The HIP Board decided on 25.9.2015 to propose to the Rector of the University of Helsinki the appointment of professor Paula Eerola to the position of director for five years starting 1.1.2016, and the Rector decided accordingly in September 2015.

Cerntech activities

In the construction phase of the LHC and the LHC particle detectors, the Cerntech project responsible for the industrial collaboration with CERN, was very successful in terms of the Finnish industrial return from the CERN projects. In 2003 the Cerntech project for industrial collaboration between Finland and CERN was taken over by Finpro ry (Finnish Foreign Trade Association). Finpro's industrial activation work at CERN ended in June 2009 and the funding agency, Tekes, granted the operation to Top Science Services LLC, which held the contract until 31.3.2014. HIP had an agreement with Top Science Services LLC starting 1.8.2009 concerning administrative support at CERN. After the construction phase, the industrial return diminished. During 2010-2013 the industrial return coefficient was 0.45; the target at CERN was 0.91. After 2014, a Tekes representative was the CERN Industrial Liaison Officer for Finland. However, due to the fact that there was no full-time person responsible for industrial activation, the results remained modest. In particular, since the completion of the LHC accelerator and the large detector facilities, the volume of CERN procurement diminished. In an attempt to stimulate industrial collaboration with CERN, HIP signed an agreement for a Business Incubation Centre in September 2015.

Premises

Since March 2001 the main site of HIP was the Physicum building at the Kumpula campus. In addition, several research groups were working at the premises of the universities of the HIP operating consortium and at CERN. The rental contract of the office space at the Innopoli 2 building in Otaniemi was terminated by HIP from the beginning of 2013. In the final stages, those using the room in Innopoli 2 were students of Aalto University participating in the activities of the Technology Program.

Change program

The government formed after the April 2015 parliamentary elections started an austerity program on public spending, also implying cuts to the university sector. The University of Helsinki was hit particularly hard by the cuts, because in addition to the cuts facing all universities, some long-time privileges of the University were removed. The most important in terms of money was the pharmacy privilege, which allowed the University to own a chain of pharmacies with special tax treatment. Due to the cuts, the Board of the University of Helsinki decided on 16.9.2015 to start a change program. As a part of the program, on 30.9.2015 the University launched cooperation negotiations with staff representatives (trade unions), the goal of which was a savings of 86 M€ and staff reductions of up to 1200 persons over five years. During the cooperation negotiations, a recruitment ban for all positions was in effect. Due to the cuts in the university index already in 2012 and 2013, the University of Helsinki had decided in 2012 (Rector's decision 120/2012; 15.6.2012) on a recruitment ban effecting all positions other than research and teaching staff. The cooperation negotiations ended at the end of November 2015. After that, recruitment was again allowed by special permission of the Director of Administration of the University. As a part of the process to reduce the staff, the University made a survey of the planned retirements before the end of 2017. At HIP, four individuals indicated their wish to retire during 2016.

As part of the change program, on 8.10.2015 the Rector appointed a working group to survey the number of laboratory and research support personnel, their job descriptions, and the nature of their employment

(permanent, part-time, fixed-term). The chair of the working group was Mr Arto Halinen, the Head of the Administration of the Faculty of Science. The main target of the survey was the, by far largest, body of laboratory support personnel in the life science departments and institutes. In the final report, published on 27.11.2015, the group proposed a higher level of networking and coordination of the laboratory personnel. The laboratory personnel in the Kumpula campus would form one pool with a laboratory coordinator. The pools have a special role in the recruitment of new laboratory personnel.

Administrative developments

Part of the change program was the centralization of the university's administration. In May 2014 the Director of Administration of the University of Helsinki launched a project to address the competence management, development, and leadership of the university's administration. The leader of the project was the Director of Administrative Services, Mr Antti Savolainen, and it involved representatives from different branches of the university administration and two persons from Renesans Consulting, a consulting company specialized in building strategy-driven organizational capabilities. In January 2015 the project completed its work. The basic outcome of the project was that a reform of administration based on competence management would improve the administrative services, would free up resources for research and teaching, and would provide better conditions for competence development and career paths. A matrix organization was seen as the direction to go with. During the spring semester the results of the project were discussed at different levels of the university administration, and on 31.8.2015 Antti Savolainen submitted the final report, "Sirpaleisuudesta kokonaisuuksiin – Selvitys hallinnon organisoitumisen vaihtoehdoista" (From fragmentation to wholenesses – a review of the alternatives for organizing the administration) to the Rector. The report described three different alternatives for the organization of the administration: faculty model, campus model, and university model. The common denominator of these alternatives was a transition to larger entities from the current fragmented situation, where every department and institute had its own administrative staff. The report focused on the management and steering structure of the administrative staff. The overall recommendation was that the university should start to prepare to move

to a solution where the university's entire administrative staff formed a new united service organization. With the new financial constraints, the administrative reform got a quick start.

Professor Juha Äystö. Director 1.4.2012-31.12.2015. (Photo: Studio Tapio/Sirpa Nygren).

In 2007 an audit of the quality assurance system of the University of Helsinki was performed, and in 2008 the Higher Education Evaluation Council of Finland decided that the University's quality assurance system met the criteria for the quality assurance system. In 2014, an international panel set by the Finnish Education Evaluation Centre (FINEEC) audited the quality assurance system of the University for the second time. Degree-oriented education was emphasized in the audit. The audit evaluated how well the quality system met the needs of strategic management and operational control, as well as how comprehensive and effective the quality management of the university's basic tasks was. The HIP Operations Manual was updated and submitted in June 2014 as a part of the University Operations Manual. The auditors visited the University of Helsinki in early October. The panel also interviewed administrative and support staff from independent institutes. From HIP, laboratory engineer Juha Aaltonen was interviewed as a representative of the support staff. In February 2015, FINEEC certified that the quality system of the University of Helsinki fulfilled the national criteria set for the quality management of higher education institutions, and that the system corresponded to the European quality assurance principles and recommendations for higher education institutions.

EEROLA ERA

Professor Paula Eerola of the Department of Physics, University of Helsinki, started her tenure as the Director of Helsinki Institute of Physics on 1.1.2016. The Government of Finland appointed her as scientific delegate to the CERN Council for three years starting 1.7.2016 and as the Finnish representative to the FAIR Council from the beginning of July, 2016.

Professor Paula Eerola. Director 1.1.2016-31.12.2017. (Photo: University of Helsinki/Linda Tammisto).

Change program

The cooperation negotiations with the university staff ended at the end of November 2015, and in January 2016 the university announced the employer's report on decisions under consideration. The employer decided, e.g., that a new centralized organization, University Services, be established for the administration. Therefore, a process was launched the purpose of which was to place the university's administrative staff in the new service organization, which was estimated to have a total of 800 positions, i.e. about 200 positions less than before. Personnel were asked to enter their expressions of interest in the positions into the university's electronic recruitment system in order to fill the positions. This meant that the salaries could be redefined for all staff members employed within the administration. The supervisor positions in the new organization were filled first, and then the supervisors participated in the selection of new service teams. The process was completed in late March 2016. The administrative staff was transferred to University Services on 1.5.2016.

In the winter and spring of 2016, the University terminated the employment contracts of a total of 372 employees, of whom 48 were teachers and researchers, including a few professors, on economic and production-related grounds. The process was a major change in the University of Helsinki. From the beginning of the planning period 2013-2016 the personnel of the University was reduced by 10 %. For the administrative staff the reduction was about 20 %. In addition to the terminated employment contracts, the reduction also included voluntary departures from the University and

retirements. In 2015 the amount of administrative work at HIP was 4.6 FTE's (5.3 % of the institute's total person power). In 2016, the Finance Manager of HIP left the University and the Administrative Manager retired. The rest of the administrative staff kept their positions and moved to University Services on 1.5.2016. There were no permanent research positions at HIP and, therefore, the process had no effect on HIP's researchers. The reduction of funding influenced only the new recruitments to HIP.

On the initiative of professor Sarah Green, the University of Helsinki conducted an external review of the change process. The Helsinki University Change Review Group (HUCRG) was established for that purpose, and professor Sue Scott (U. York) was invited to act as its chair. The Group had two tasks. The first was to give members of the university the opportunity to reflect on their experiences regarding the university's change process. The second was to give feedback on their views about, and the lessons to be learnt, from the change process. The final report of the Group was published in October 2017.

The HIP Board in 2015 and early 2016: Jari Hämäläinen, Kenneth Österberg, Jouko Väänänen, Hannu Koskinen, Mikko Ritala, Tuija Pulkkinen, Risto Nieminen, Ulla Ruotsalainen, and Kari J. Eskola (Photo: Juha Aaltonen).

Simultaneously with the change program, the University of Helsinki renewed its degree programs in the so called Big Wheel process starting in 2015. The curricula were designed according to the three-tier degree structure of the Bologna model in order to make the degree programs more attractive and internationally competitive. This process had only a limited effect on HIP.

The operational structure of the university came into consideration again in 2016, and on 8.4.2016 the Rector of the University appointed a working group to make an assessment. Professor Arto Mustajoki, Dean of the Faculty of Arts, chaired the group. The final report of the working group was published on 9.9.2016. It contained, e.g., a recommendation that the individual departments in faculties would cease to exist as financially independent units from the beginning of 2018.

The University of Helsinki Board decided accordingly on 19.10.2016. It also decided that the role of independent institutes as part of the operational structure of the university would be considered during 2017. On 21.11.2016 the Rector appointed a working group to prepare such a proposal. The outcome of the process was that HIP remained financially independent.

The HIP organization in the beginning of 2016. The boxes contain the names of the research programs/research projects together with the names of the program directors/project leaders.

Theory Program

From 2014 the HIP theory projects were Cosmology of the Early and Late Universe of Doc. Syksy Räsänen (UH), High Energy Phenomenology in the LHC Era of Doc. Aleksi Vuorinen (UH), QCD and Strongly Interacting Gauge Theory of Doc. Tuomas Lappi (UJ), Nuclear Structure for Weak and Astrophysical Processes of Dr Markus Kortelainen (UJ), and Domain Wall Dynamics of Dr Lasse Laurson (AU). The mid-term evaluations of the projects were made in April and May 2016. The Cosmology of the Early and Late Universe project was evaluated by Dr Steen Hansen (NBI, U. Copenhagen), the High Energy Phenomenology in the LHC Era project by professor Guy Moore (TU Darmstadt), the Strongly Interacting Gauge Theory project by Dr Urs Wiedemann (CERN), the Nuclear Structure for Weak and Astrophysical Processes project by Dr Paul Stevenson (U. Surrey), and the Domain Wall Dynamics project by associate professor Lars Bergqvist (KTH, Stockholm). The reports of the reviews were made available to the SAB, which recommended the continuation of all the projects for another three years. In addition, SAB recommended strengthening collaboration within the theory projects and with experiments. The HIP Board decided in its meeting on 2.9.2016 to continue the theory projects for 2017-2019, and on 23.11.2016 appointed the project leaders.

Professor Kari Rummukainen, the HIP Theory Program Director since 2011 (Photo: Juha Aaltonen).

The Cosmology project investigated the role of the Higgs field in inflation in various settings, and baryogenesis in a model with two Higgs doublets and a single scalar field, and demonstrated the importance of including the lensing contribution in galaxy cluster analyses with large galaxy redshift surveys. The High Energy Phenomenology project carried out active research on the physics of neutron stars and their collisions, the properties of the various BSM theories, as well as topological defects in gauge theories. At the end of 2016 Doc. Vuorinen was awarded a European Research Council (ERC) Consolidator grant for the project “High-density QCD matter from first principles (Dense Matter)” starting in 2017. In the Strongly Interacting Gauge

Theory project a new global analysis of nuclear parton distribution functions was completed, including, for the first time, LHC constraints. The project leader, Doc. Lappi, received a ERC Consolidator grant starting in 2016 for his project "The nonlinear high energy regime of Quantum Chromodynamics". Furthermore, various flow correlators were computed in hydrodynamical studies of heavy ion collisions. In the Nuclear Structure project, photo absorption cross section in rare earth nuclei was investigated, with the conclusion that an improvement of the energy density functional models should also incorporate data of giant dipole resonance properties in order to improve the description of collective excitations. The project also studied elastic and inelastic scattering of Weakly Interacting Massive Particles (WIMPs) on target nuclei to help to reduce the background signal in direct WIMP detection searches for dark matter. In the Domain Wall Dynamics project, various one- and two-dimensional systems were investigated, yielding a better understanding on several key issues of domain walls and their dynamics. These included linear creep dynamics in narrow ferromagnetic strips, domain wall dynamics in wide permalloy strips, coarsening dynamics of topological defects in permalloy films, and temporal correlations in crackling noise.

CMS Program

Professor Paula Eerola was appointed as HIP Director from the beginning of 2016. On 20.11.2015, the HIP Board appointed docent, University Lecturer, Kenneth Österberg as the new Program Director for the HIP CMS Program for 1.1.2016-31.12.2018.

The LHC Run 2 continued in 2016. In the 2015 data, a tentative 750 GeV diphoton signal raised wide interest, but with the 2016 data it was concluded to have been a statistical fluctuation.

From the beginning of 2016 assistant professor Mikko Voutilainen was nominated the project leader of the CMS Experiment project. The project was mostly focused on detector operations on tracker alignment and in jet energy corrections. It also led CMS efforts in data preservation. In physics topics, HIP researchers contributed especially to Higgs, jet, and B-physics analyses. The Higgs physics group extended the search for

the charged Higgs boson to the mass range extending to 3 TeV. The jet physics team contributed to both new physics searches (dijet resonances) and Standard Model measurements (inclusive jets). In the B physics team the focus was on the analysis of the weak mixing phase and effective lifetime of the decay channel $B_s \rightarrow J/\psi\, \varphi$.

The CMS Upgrade project was responsible for the HIP contribution to the Phase 1 and Phase 2 upgrades of the CMS detector. For the Phase 1 upgrade, HIP had committed to deliver 50% of the bare pixel detector modules for the third layer of the barrel pixel detector. The production took place in collaboration with Advacam Ltd and was completed in 2016. The integration to full modules was done at CERN, where precision-mechanics trainees from the Finnish School of Watchmaking did most of the construction work. The upgraded pixel detector was ready for installation and commissioning during the winter technical stop at the beginning of 2017. For the Phase 2 upgrade, the group carried out research on next generation silicon pixel detectors needed for the high luminosity conditions at LHC. At the end of April 2016, the CMS Upgrade project leader, Dr Jaakko Härkönen, moved to the Ruđer Bošković Institute, Zagreb, to establish a detector laboratory there. Dr Panja-Riina Luukka was chosen to lead the project starting 1.5.2016.

The Tier-2 Operation project, led by Dr Tomas Lindén, was responsible for the smooth running of the HIP Tier-2 site in collaboration with CSC and NDGF.

Since 2014 the TOTEM project was part of the HIP CMS Program. In 2016 the project leader was Doc. Kenneth Österberg, who was also the physics coordinator of the CERN TOTEM Detector Collaboration. TOTEM was the leading forward physics experiment at the LHC, which focused mainly on elastic scattering, total cross section, and diffraction. The TOTEM program was extended in 2016 to exclusive and hard diffractive processes through common data taking with CMS, i.e. CMS-TOTEM Precision Proton Spectrometer (CT-PPS). Data taking with CT-PPS started in June 2016 using the TOTEM silicon strip detectors. The data taking with CT-PPS was accelerated to clarify the situation with the 750 GeV diphoton signal in the 2015 data. HIP was also involved in the diamond-based time-of-flight detector upgrade for both the vertical and horizontal Roman Pots. The Helsinki contribution to the upgrade was covered by the infrastructure funding provided by the Academy of Finland.

Nuclear Matter Program

In 2016 there were four projects in the Nuclear Matter Program. Three of the projects involved the participation of Finnish teams at CERN, and one the coordination of the Finnish participation in the planning and construction of the FAIR facility in Darmstadt (Facility for Antiproton and Ion Research). The FAIR activities are described in a separate section. The Program Director was professor Ari Jokinen of the University of Jyväskylä.

In 2016 LHC continued to collect proton-proton data at 13 TeV, but at the end of the year LHC started a special program to deliver proton-lead collisions, first at 5.02 TeV as previously, and then at 8 TeV. The level-0 single photon EMCal trigger system, where HIP was a contributor, performed according to expectations. On the hardware side, the quality assurance studies of the GEM foils for the Time Projection Chamber upgrade continued. The Memorandum of Understanding for the Upgrade of the ALICE Time Projection Chamber was signed in May 2016. The project was also deeply involved in the development of the Fast Interaction Trigger system, the successor of the T0 detector. The main directions of the physics analysis performed by the HIP-Jyväskylä group involved high-p_T triggered correlations and studies of the jet transverse structure in pp, pPb, and PbPb. The results provided insights into the QCD radiation and its modifications in cold nuclear matter and in the quark-gluon plasma.

The ISOLDE project, with Dr Janne Pakarinen as the project leader, was involved in the commissioning of the SPEDE spectrometer with stable ion beam. The majority of the measurement campaign at HIE-ISOLDE was devoted to Coulomb excitation experiments at MINIBALL, where the main focus was on the evolution of quadrupole collectivity at both ends of the Sn isotopic chain. The updated Memorandum of Understanding for Collaboration in the Exploitation and Upgrade of the ISOLDE Facility at the PS-Booster was signed on 2.9.2016. It included Finnish technical participation in the spectrometer for REX and RFQ Cooler.

Professor Risto Orava was the leader of the ALICE-Forward project during 2015-2018. The aim of the project was to study central exclusive production of high mass states. In addition, a multivariate technique based classification and analysis of diffractive events was on the agenda. In 2016, Orava and his collaborators proposed a method to scan centrally produced particles by exploiting the LHC beam loss monitoring system. New Scientist magazine

featured the proposal in their News section on 25.4.2016. Professor Orava was also a member of the MoeDAL Collaboration at CERN LHC, searching for magnetic monopoles and other highly ionizing particles. The largely passive detector was constituted of stacks of nuclear track detectors and an array of aluminum samples trapping charged particles.

Technology Program

Professor Saku Mäkinen of the Tampere University of Technology was the Director of the Technology Program in 2016. There were four research projects in the program, as well as the Business Incubation Centre for advancing technology transfer between CERN and Finland. The research projects were Accelerator Technology of Drs Markus Aicheler and Flyura Djurabekova, Green Big Data of professor Jukka K. Nurminen (AU), Biomedical Imaging of professor Ulla Ruotsalainen (TUT), and Novel Instrumentation for Nuclear Safety, Security and Safeguards of professor Peter Dendooven (HIP and U. Groningen).

In the Accelerator Technology project there were two components, one focused on investigating the modification of material properties in the harsh operational conditions of powerful accelerators, and the other devoted to research and development of the manufacturing of CLIC accelerator modules. Due to the CERN K-Contract funding and other funding sources, the volume of the research on accelerator technology achieved a new level.

The Green Big Data project aimed at developing methods and software tools for optimizing the performance and minimizing the energy consumption of computing, communication, and storage resources used in big data analysis, especially high energy physics computing. The project was a collaboration with Aalto University, the universities of Helsinki and Lausanne, CERN, CSC, and industrial partners. In the meeting in September 2015, SAB called for an external review of the project. The evaluation was performed by associate professor Hassan Charaf (Budapest University of Technology and Economics). The evaluation report was published on 27.5.2016 and the project was judged to provide value and contribution to the related goals of the ICT community.

The Biomedical Imaging Avan Tomography project aimed at developing a dual panel positron emission scanner with axial PET geometry. In

conventional PET devices, there was a trade-off between sensitivity and resolution. With the concept of axially oriented crystals and orthogonally placed wavelength shifter strips, it was possible to achieve good resolution as well as high sensitivity. It was also possible to solve the so-called parallax error caused by the unknown depth of interaction in the detector crystal. In 2016, the focus was on simulation studies of the performance of partial ring, dual panel PET configurations that were under development for treatment planning in proton therapy. The plan was to compare the imaging quality of the dual panel PET scanners with the axial PET geometry.

The Novel Instrumentation for Nuclear Safety, Security and Safeguards (NINS3) project of the FiDiPro professor Peter Dendooven was established in 2015 for four years with the support of Tekes. The project was an integral part of the National Radiation Safety Research Program. Through the development of new technological concepts, the project aimed to increase the technology readiness level in each of the three R&D topics, namely passive tomography of spent nuclear fuel, alpha radiation threat detection and imaging from a distance, and active neutron interrogation of unknown objects. In addition, a Research-to-Business topic for commercialization of the most promising applications of the R&D topics was part of the project.

The Finnish Business Incubation Center of CERN Technologies was established late 2015. The project aimed at supporting commercialization of CERN-related technologies, especially in start-ups and small and medium-sized enterprises in Finland. Additionally, the project conducted technology commercialization and incubation related research. In 2016, several screening cases of ideas, innovations, and incubatees were conducted.

Projects outside of the research programs

The Planck-Euclid and CLOUD projects continued their work in 2016 under the leadership of Doc. Hannu Kurki-Suonio and professor Markku Kulmala, respectively. The HIP Detector Laboratory was a separate project during 2014-2016 under the leadership of Doc. Eija Tuominen, but the Steering Group of the laboratory proposed in 2016 that, in fact, the detector laboratory at HIP was a permanent support organization of the Institute and should be recognized as such. The HIP Board made the respective decision on 23.11.2016, and from the beginning of 2017 the Detector

Laboratory became a national permanent infrastructure specialized in the instrumentation of particle and nuclear physics. The Laboratory was jointly operated by HIP and the Department of Physics of the University of Helsinki.

In 2016, the CLOUD project had an eight-week intensive measurement campaign at CERN utilizing one of the most advanced laboratory set-ups for studying the formation and growth of atmospheric aerosol particles. The campaign simulated particle formation in conditions relevant to the Amazonas, boreal forest, and urban environments. In 2016 the publication record of the project was again impressive: two Nature magazine articles, one in Nature Communications, two in Science, and one in PNAS in addition to other scientific publications.

The European Space Agency cosmology missions, Planck and Euclid, addressed two issues: cosmic microwave background and the dark energy question, respectively. In 2016, Planck data was reanalyzed for the final release of the Planck results. The aim was to improve calibration and instrument beam determination and to correct for bandpass differences between detectors. During 2016 the Planck Collaboration published 49 papers, 21 of them belonged to the batch Planck Intermediate Results and 28 to the batch Planck 2015 Results. For the Euclid mission, the Finnish responsibility was the operation of one of the nine Science Data Centers, particularly the development of two parts of the Euclid data analysis: the production of simulated data and the last step of the data analysis, which produces, e.g., galaxy correlation functions and their power spectra.

Ms Riitta Rinta-Filppula, MSc, was the initiator of HIP's highly successful high school program, and was steering those activities until her retirement at the end of July 2016. At the HIP Board meeting on 2.9.2016 a new project, Education and Open Data, was established for 2017-2019 to coordinate the high school activities and the data preservation and open access to CMS data. Dr Katri Lassila-Perini was appointed to lead the project.

Personnel developments

In October 2015 the HIP Administrative Manager, docent Mikko Sainio, informed professor Paula Eerola, the designated director of HIP from the beginning of 2016, of his intention to retire during the year 2016. The HIP

Board was informed of the matter on 24.3.2016. The University of Helsinki had decided to reorganize all of the administration under the umbrella of the University Services and, therefore, no new administrator could be recruited for HIP. There were, however, a number of tasks within the research institute that required a person with a doctoral degree, including coordinating roles on the national and international level, as well as the Vice-Director's task. The HIP Board decided on 24.3.2016 to start a search for a Research Coordinator. The position was declared open and applications were received until 18.5.2016. Five persons applied for the position. Dr Antti Väihkönen stood up as a candidate with the best qualifications for the position. He had a doctoral degree in cosmology, which was an active research field at HIP, post-doctoral experience at the University of Geneva, and extensive experience in the Finnish national basic research funding agency, the Academy of Finland. There he had experience in international research infrastructures as well as in infrastructure roadmap and research strategy development. Science Advisor, Dr Väihkönen started as HIP Research Coordinator on 1.8.2016.

Since professor Eerola had become the Director of HIP, the Department of Physics of the University of Helsinki declared a professor position in experimental particle physics open, with the deadline for applications 30.11.2016. Six persons applied. The external experts consulted were professors David Milstead (U. Stockholm) and Ian Bearden (U. Copenhagen). Docent Kenneth Österberg was appointed to the position starting 1.5.2017. He had been the Director of the CMS Program since the beginning of 2016.

Professor Paula Eerola stepped down as HIP director at the end of 2017 to become the Dean of the Faculty of Science of the University of Helsinki.

HIP 20 Years Jubilee

The Helsinki Institute of Physics started operation on 1.9.1996. To celebrate 20 years of operation the Institute organized a celebration event on 11.11.2016. After the Welcome of the Director, professor Paula Eerola, five alumni of the Institute gave a presentation under the title "HIP and I: Why did my HIP career matter for my current job?" The speakers were professors Ilpo Vattulainen (UH), Kari J. Eskola (UJ), and Edward Hæggström (UH), director Markku Oinonen (Laboratory of Chronology, UH), and senior advisor Matti Heikkurinen (LMU Munich).

They had all served as HIP project leaders at some point in their careers. The session was concluded by professor Johanna Björkroth (UH) with her presentation “My 6 years with HIP”. She had chaired the HIP Board for six years in her capacity as Vice-Rector for Research of the University of Helsinki.

Research

The Helsinki Institute of Physics is a research institute active in both basic and applied research. The publication record of the Institute is a significant measure of the success of the unit in its mission. There both the quantity and quality of the publications need to be considered. Additional important information on the quality of the research program has been obtained through the peer review evaluations that have taken place over the years. The Scientific Advisory Board (SAB) has been an important player in the development of research quality. An additional relevant measure of the research activity is the number of degrees granted to the students in the research projects of the Institute. HIP is not a degree granting institution, but naturally the universities that operate HIP are. The number of MSc and doctoral degrees was also established as an indicator by the Ministry of Education in 2000 to determine the result-based funding of the Institute. Therefore, comprehensive statistics have been collected of the number of university degrees granted in HIP research projects. Most of the HIP research projects are collaborative projects with universities, so the sharing of credit has not always been straightforward, but at least the numbers from year to year are comparable. For the PhD projects, however, the identification of genuine HIP theses has been on more solid ground.

Publications

In the following tables the publication record of the Institute during 1997-2016 is displayed. Minor corrections to the numbers published in the HIP Annual Reports 2006 and 2016 have been made.

The numbers from the HIP "Annual report" and "University of Helsinki database" refer to refereed journal articles (classes A1 and A2 in the Ministry of Education and Culture publication classification). "Web-of-Science" and "Scopus" have their own journal and book lists, which they use when adding articles to their databases. For the first years of operations, the tables include some articles where the affiliation SEFT was used. This concerns, in particular, some experimental collaborations. On some occasions a conference proceeding has been published as an issue or volume of a journal. This may lead to some uncertainty in the classification

Publications

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Ann. Report	85	117	123	134	103	87	107	130	129	149
UH database	89	116	136	106	91	87	107	119	150	155
WoS	75	118	150	142	118	90	117	142	144	163
Scopus	67	100	134	132	113	96	123	146	133	157

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ann. Report	152	156	165	191	251	260	280	291	258	341
UH database	163	172	171	194	256	267	292	305	262	332
WoS	174	173	190	211	296	274	299	305	266	332
Scopus	179	203	197	214	292	298	309	302	256	342

of an article, whether it should be A1 or A4 (refereed article in conference proceedings). This could explain some of the differences between lines 1,2 and 3,4 in the table. Over time, the Ministry has clarified their instructions for the classification of publications. HIP has not been a member of the PHENIX collaboration at the RHIC Collider operating in Brookhaven, but starting in 2015 the PHENIX publications are included in the statistics due to the fact that individual HIP researchers have contributed to PHENIX as part of the Jyväskylä team. The figures referring to the "Annual Reports" have been fixed every year in February to finish the annual report for production. Therefore, the University database numbers are expected to be slightly larger than the numbers in the annual reports, because for some journals there is a delay in the actual time of publication.

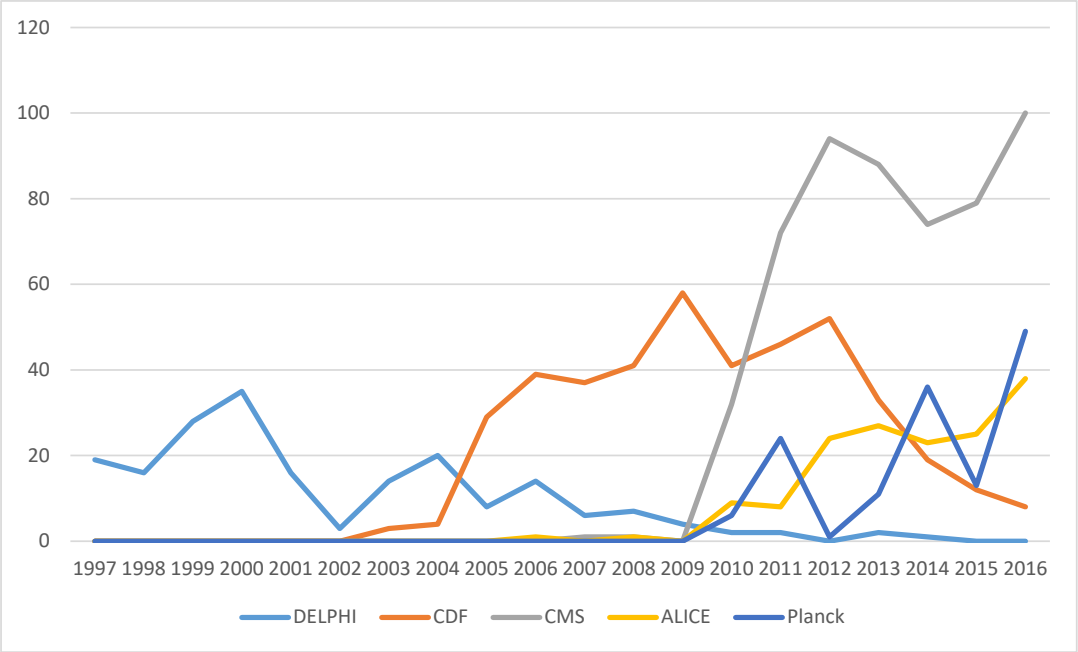
In the table on the following page the figures listed in the top section are split into theory papers, collaboration articles, and the rest. The experiments, which have produced most of the collaboration articles, were DELPHI and L3 at LEP, CMS, ALICE, and TOTEM at LHC, CDF at Fermilab, and ISOLDE and COMPASS at CERN, together with the Planck satellite mission of ESA. A graphical presentation of selected collaboration articles is given below the table.

The start of the LHC experiments is clearly visible in the figure. The first proton-proton collisions were observed late 2009, and in 2010 the publications from the CMS and ALICE experiments start to appear. It can be seen, as well, that Planck publications appear in batches, which generates fluctuations even in the total publication volume of the Institute. Furthermore, the dip of 2001-2002 in the number of publications is not

Refereed journal articles

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Theory	42	63	58	58	67	60	63	69	63	61
Collaboration	33	44	47	68	24	14	26	39	42	66
Other	10	10	18	8	12	13	18	22	24	22
Sum	85	117	123	134	103	87	107	130	129	149

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Theory	74	88	66	74	79	79	91	99	72	83
Collaboration	52	52	66	92	154	172	167	155	141	210
Other	26	16	33	25	18	9	22	37	45	48
Sum	152	156	165	191	251	260	280	291	258	341



solely due to the reduction of funding that took place in 2001 but, in addition, is also due to the gradual decline in the publication volume of the DELPHI experiment before the CDF Collaboration, which HIP had joined, started to produce publications with HIP affiliation. In the early stages of HIP, until the start of LHC, the Theory Program was responsible for about one half of the scientific publications. The theory publication level has increased, but the collaboration articles have become the dominant component since the start of the LHC.

As the completion of the LHC approached, the principles of future publishing became an issue of particular interest at CERN. The aim for the particle physics community was to ensure the widest and most efficient dissemination of the LHC results. To this end, in December 2005 CERN established a tripartite task force on open access publishing in particle physics, representing authors, publishers, and funding agencies, to explore and develop sustainable business models for open access for existing and new journals and publishers in particle physics. The task force envisioned free and unrestricted Web-based access to peer-reviewed journals as the ultimate goal of Open Access (OA) publishing in particle physics. The "Report of the Task Force on Open Access Publishing in Particle Physics" was published in June 2006. With the strong support of the Director General of CERN, Dr Robert Aymar, CERN took a leading role in this enterprise. The situation in particle physics was special in the sense that relatively few journals published a very large share of all the articles in the field. This led eventually to setting up the SCOAP^3 collaboration (Sponsoring Consortium for Open Access Publishing in Particle Physics) hosted by CERN. The consortium's membership consists of libraries, universities, research institutions, and funding agencies. Their contributions to SCOAP^3 cover the costs of the contracts CERN has with publishers. The publishers, in turn, eliminate or reduce the subscription fees for the customers, thus making the articles Open Access. The operation of SCOAP^3 started on 1.1.2014. The Finnish member of the consortium is FinELib/The National Library of Finland.

Citations

The quality and impact of publications is not easy to assess. That would require a combination of various tools including an expert evaluation. An element in such an assessment is a citation analysis, which, although it has its limits, provides one straightforward approach to identifying publications that have had significant impact. In the analysis here, done on 31.5.2019, two databases have been used, the INSPIRE-HEP and Web-of-Science (WoS). The INSPIRE-HEP database is limited to particle and nuclear physics with cosmology and closely related fields. The citations there include citations in the arXiv database as well as in preprints (arXiv is an open-access repository of electronic preprints and postprints). Therefore, the INSPIRE-HEP citation numbers are

usually significantly larger than the WoS numbers. For the large research collaborations there is an additional issue that substantially influences the outcome of the analyses. Namely, the question of sharing the credit, i.e. publications and citations, between the different research organizations in the collaboration. For example, in the HIP statistics the CMS Collaboration has published 579 refereed journal articles during 2010-2016. Three Finnish organizations are members of the Collaboration: the Department of Physics of the University of Helsinki, the Lappeenranta University of Technology, and HIP, with typically 3, 4, and 21 group members respectively (these numbers are exact for the Higgs discovery paper, where there were 167 institutions from 41 countries). If the credit related to the number of publications is shared first between countries and then within Finland in the ratio of authors, the outcome is that the number 579 converts to about 11 articles, which is very little for a large number of full-time persons over 7 years. A fair way of calculating or defining the number of fractionated publications in the case of large collaborations is the subject of active debate. The h –index is a simple measure of the impact of the research publications. The INSPIRE-HEP gives HIP the value h=163 (with self-citations excluded) and the WoS the value h=160. The h –index is sensitive to self-citations; INSPIRE-HEP gives h=205 if the self-citations are kept. This probably reflects the large number of collaboration articles with a large body of co-authors in the HIP publication record. The h –index value of about 160 means that at the time of the analysis and for publications published during 1997-2016 HIP had 160 publications with 160 citations or more. The h – index is, however, a slightly problematic indicator, as it does not reflect the trend of the publication activity, which can only grow.

In the HIP publication record, there are eight papers with more than one thousand citations in WoS (in INSPIRE-HEP there are 13 such papers). The most cited articles are:

1. S. Agostinelli et al., “GEANT4 – a simulation toolkit”, Nucl. Instrum. Meth. A506 (2003) 250 with A. Heikkinen, T. Lampén and J. Sulkimo in the author list.

2. S. Chatrchyan et al., “Observation of a new boson at a mass of 125 GeV with the CMS experiment at the LHC”, Phys. Lett. B716 (2012) 30 with 21 HIP co-authors.

3. P.A.R. Ade et al., “Planck 2013 results. XVI. Cosmological parameters”, Astronomy&Astrophysics 571 (2014) A16 with the HIP contribution of H. Kurki-Suonio, A. Lähteenmäki, T. Poutanen, M. Savelainen, A.-S. Suur-Uski and J. Valiviita.

4. P.A.R. Ade et al., “Planck 2015 results. XIII. Cosmological parameters”, Astronomy&Astrophysics 594 (2016) A13 with the HIP contribution of H. Kurki-Suonio, A. Lähteenmäki, M. Savelainen, A.-S. Suur-Uski and J. Valiviita.

5. C. Patrignani et al., “Review of Particle Physics”, Chinese Phys. C40 (2016) 100001 with P. Eerola in the author list.

6. J. Allison et al., “Geant4 Developments and Applications”, IEEE Trans. Nucl. Sci.53 (2006) 270 with a contribution of A. Heikkinen.

7. S. Chatrchyan et al., “The CMS experiment at the CERN LHC”, JINST 3 (2008) S08004 with 37 HIP contributors.

8. P.A.R. Ade et al., “Planck 2013 results. XXII. Constraints of inflation”, Astronomy&Astrophysics 571 (2014) A22 with the HIP contribution of H. Kurki-Suonio, A. Lähteenmäki, T. Poutanen, M. Savelainen, A.-S. Suur-Uski and J. Valiviita.

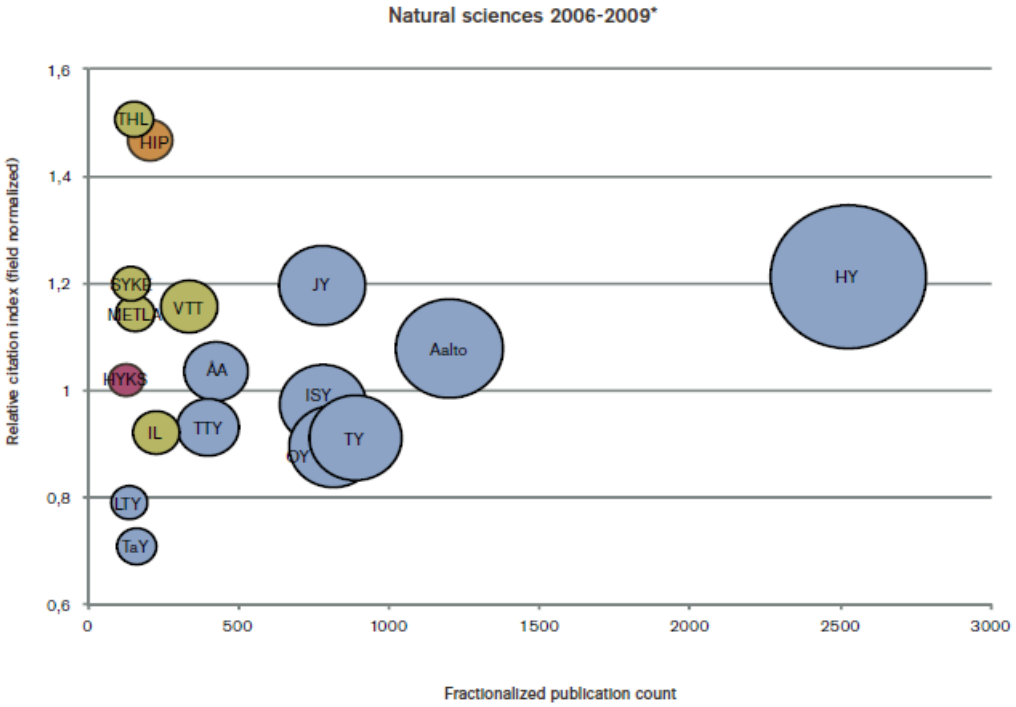
Publications one and six address the Geant4 software, which is used to simulate the passage of particles through matter, e.g. in particle detectors. Publication five is the regularly published summary of particle properties. Of the remaining five articles, two are publications of the CMS Collaboration, including the Higgs discovery article, item two, and three were published by the Planck Collaboration, which measured cosmic microwave background radiation with high precision. The most cited theory article of HIP in the period considered had 694 citations: G. Bassard, N. Lütkenhaus, T. Mor and B.C. Sanders, “Limitations on Practical Quantum Cryptography”, Phys. Rev. Lett. 85 (2000) 1330, where N. Lütkenhaus belonged to the HIP staff.

If one looks at the articles with 250 citations or more in WoS, there are 78 of them, and about 27 % of them are publications of the CMS Collaboration, 24 % of the Planck Collaboration, and 22 % of the Theory Program. In

addition, there are several highly cited articles by the ALICE and CDF Collaborations and the CLOUD project, which has published numerous papers in Nature and Science. CLOUD is an experiment at CERN studying the formation and growth of aerosol particles and, therefore, is important for the understanding of the climate system.

Based on the WoS data, the publications and citations of Finnish research organizations during 1990-2009 have been analyzed by a working group broadly representing the interest groups in research (Ministry of Education and Culture report 2012:8). The report also provides information on the HIP publication record. It is noteworthy that the analysis covers the period before the large LHC detector collaborations started to produce publications. This is significant because with the very large collaborations at the LHC experiments the question of fractionalization becomes important. In the figure below, taken from page 20 of the report, the relative citation index and fractionalized publication count for the years 2006-2009 are given for a number of universities and research organizations. The fractionalization is performed by first dividing equally the publications between the countries involved and then the Finnish share is further divided equally between the participating research organizations. The field normalized citation index for 2006-2008 counts the citations in the respective fields in comparison with the world average. From the figure it can be seen that the HIP publications achieved about 1.5 times the citations of the world average. The other organization with high impact was The National Institute for Health and Welfare (THL). The Universities of Helsinki (HY) and Jyväskylä (JY) also did well.

In May 2007 a representative of the Thomson Scientific approached the Director of HIP with a note that in an analysis of total citations performed by Essential Science Indicators (ESI) HIP had entered the top 1 % of institutions in terms of total citations in the field of physics. A feature article on the institute was requested to accompany the report of the results of the analysis. Essential Science Indicators is an analytical tool to help to identify top-performing research in the Web of Science Core Collection. In the report it was mentioned that the HIP citation record in physics included 392 highly cited papers with 4,488 total citations; at the time the article by G. Brassard et al., mentioned above, had the highest citations count, 145.



Research evaluations

Evaluation of the HIP research has been a continuous process. The Scientific Advisory Board has met annually to hear the presentations of all the research programs and of some selected research projects. In general, the SAB has given recommendations to help improve the projects. More detailed recommendations have been put forward for new proposals. In the Theory Program the research was organized in terms of 3+3 –year projects involving a mid-term evaluation by external experts. External experts have also been used to assess the work at the large LHC experiments. Furthermore, an expert group was invited already during the first years of HIP to evaluate the work of the Detector Laboratory and to define a good detector development program for the Institute.

In the last couple of decades, universities in Finland have started to conduct comprehensive evaluations of their research and doctoral training activities to support the strategic decision making. A large part of the HIP

research has been done in cooperation with the Department of Physics of the University of Helsinki and, therefore, most of the research activity has been part of the research assessment exercises of the University of Helsinki.

The research activities of the University of Helsinki were evaluated in 1999, 2005, and 2012, covering the research in 1994-98, 1999-2004, and 2005-2010 respectively. The research during 2010-2016 was included in the evaluation in 2019. During the time of the 1999 assessment, HIP had been in operation for only two years and the visibility of the Institute was still limited. The panel recommended action be taken to improve that. In general, for its involvement in large international collaborations the panel wrote: "For a smaller group to achieve recognition and to be able to claim interesting physics results, the identification with a sub-component of the experiment is desirable, preferable paired with a specialty area in technology that plays a critical role in the setup." The Institute gained the grade 6/7, i.e. the Institute was ranked in the top 25 % of European physics departments. In the 2005 evaluation the grade of the Institute was raised to 7/7, i.e. the Institute was ranked within the top 10 % in Europe. With the higher grade the panel acknowledged the advances made at the Institute since the previous evaluation, although they pointed out that there was still room for improvement. As a consequence of the new grade, the Institute was rewarded the annual bonus of 70 k€ for the years 2007-2012. The following evaluation in 2012 was no longer done on a departmental or institutional basis; instead, a Researcher Community was defined as the participating unit. This meant that the relevant parts of HIP and Department of Physics together formed the Particle Physics and Cosmology (PaCo) community, with 16 Principal Investigators and 118 researchers all together. A smaller group of individuals were part the Materials and Nanophysics Researcher Community (MATENA), but there the HIP activity was a minor component. In the 2012 evaluation PaCo received the grade 5/5 in quality of research and societal impact categories, but 4/5 in doctoral training and collaboration and mobility categories. It seems that the main problems in view of the panel were the recruitment process for graduate students and the missing plans for the participation in the Euclid mission after the Planck project.

For the 2018-2019 Research Assessment of the University of Helsinki, a separate bibliometric analysis of the publication record between 2010-2016 was completed in February 2019 as a collaboration between the

Library of the University of Helsinki and CWTS (Centre for Science and Technology Studies) of the Leiden University. The unit considered was the whole Faculty of Science of the University of Helsinki. In the research assessment, the Department of Physics and the Helsinki Institute of Physics were evaluated together by a nine-member Natural Sciences Panel, where the physics members were professors R. Eichler (Chair, ETH, Zürich), L. Bergström (U. Stockholm), and R. Elliman (ANU). The grade "excellent" was obtained for all three development areas: scientific quality, societal impact, and research environment and viability. The Department of Physics and HIP Unit was acknowledged for its "successful participation in world leading, large international projects and having several widely internationally known professors. The bibliometric indicators showed excellence: a very high number of publications, predominantly in top international journals with a citation rate above average and more than 90% involving international collaboration. A strong outreach program along with successful research commercialization and industrial collaboration contributed to excellent societal impact. The infrastructure was assessed to be remarkably strong and the training of early-career researchers and graduate students excellent." The Panel recommended efforts to increase EU funding and high-level publications with high impact factor. In addition, consideration of gender equality in appointment processes was emphasized.

The other HIP partner universities also had research evaluations during 1997-2016, but the role of HIP did not appear there as a separate entity. The national basic research funding agency, The Academy of Finland, had an evaluation made of the physics research in Finland 2007-2011 (Publications of the Academy of Finland 8/12). The report provided a summary of the resources, both financial and personnel, of all the units involved with physics research in Finland, 30 in total, and gave some comments and recommendations for each unit. For HIP, a closer integration of theory and experiment in high energy physics was recommended, as well as an emphasis on new physics beyond the Standard Model. The strengthening of the staff by the recruitment of more long-term foreign guests was also emphasized. The report commented on the special requirements for administrative arrangements needed due to the interactions with international organizations and foreign groups. In the panel's view the mode of operating was adequate.

Thesis work

In 2000 a new model to determine the resources of different universities for the planning period 2001-2003 was adopted by the Ministry of Education. In that model, part of the basic funding for HIP was expected to be result-based and be a contribution of the participating universities to the operations budget of HIP. Initially the result was essentially the number of degrees, both Master's and doctoral degrees, acquired in connection with the HIP research activities. The basic funding of the universities was, in part, determined by the number of degrees they granted and, therefore, they were considered to be beneficiaries of the HIP research activity and obliged to contribute. Many of the students who became involved with the HIP research projects worked first as summer students at CERN. On many occasions, the summer student project grew into a MSc thesis project. Once the MSc thesis was finished, selected students continued as graduate students at HIP. HIP typically sponsored 16 undergraduate students to work at CERN annually. Varying numbers of summer student positions have also been offered locally, in Kumpula and other places. Since the number of degrees was an essential indicator for funding, the Institute collected the statistics of the academic degrees acquired in the connection with the HIP research activities, as shown below:

MSc/MSc (eng.)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
UH	6	4	3	5	3	6	3	3	3	5
HUT	7	3	5	7	2	3	4	5	3	6
UJ	-	-	-	1	-	-	-	1	1	1
LUT	-	-	-	-	-	-	1	1	2	1
TUT	-	1	1	-	-	-	-	-	1	-
Other	-	2	2	1	-	-	1	-	-	-
Sum	**13**	**10**	**11**	**14**	**5**	**9**	**9**	**10**	**10**	**13**

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
UH	6	8	2	2	6	4	8	6	9	9
Aalto	2	6	3	1	1	3	2	2	4	1
UJ	5	1	3	1	3	4	2	-	1	4
LUT	-	1	-	-	-	-	2	-	1	-
TUT	-	1	1	2	3	1	-	3	2	-
Other	1	-	-	-	1	1	2	-	-	-
Sum	**14**	**17**	**9**	**6**	**14**	**13**	**16**	**11**	**17**	**14**

Abbreviations: UH, University of Helsinki; HUT, Helsinki University of Technology (N.B. starting 1.1.2010 HUT became a part of the newly created Aalto University); UJ, University of Jyväskylä; LUT, Lappeenranta University of Technology; TUT, Tampere University of Technology.

Doctoral degrees

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
UH	3	1	2	1	3	4	4	3	3	5
HUT	1	1	2	-	2	2	3	2	2	2
UJ	-	-	-	-	-	-	-	-	1	1
LUT	-	-	-	-	-	-	-	-	-	-
TUT	-	-	-	-	-	-	-	-	-	-
Other	-	-	1	-	-	-	-	1	-	-
Sum	**4**	**2**	**5**	**1**	**5**	**6**	**7**	**6**	**6**	**8**

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
UH	1	5	5	4	6	8	7	7	7	6
Aalto	3	3	2	1	2	-	1	-	-	-
UJ	-	2	2	3	1	1	2	3	1	1
LUT	-	1	1	-	-	-	-	-	-	-
TUT	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-
Sum	**4**	**11**	**10**	**8**	**9**	**9**	**10**	**10**	**8**	**7**

The tables show fluctuations for the first years, but towards the end of the period under review the situation became more stable. The average annual number of MSc degrees was about 12, and doctoral degrees about seven, in the period 1997-2016.

HIP personnel

Since the establishment of HIP in 1996, the HIP staff has belonged to the University of Helsinki. Research at HIP was organized in fixed-term projects and the research staff had fixed-term appointments. At first the appointments were short-term, typically for two years. Research at CERN was supported by grants. The Scientific Advisory Board emphasized the importance of longer-term appointments and permanent positions for the key personnel. For the permanent positions of the research staff, the approach pursued by the Institute was to seek the establishment of joint positions with the partner universities. The development was slow, but over time several positions were established. In addition, a couple of 3+3 year appointments were made in the Theory Program. As a rule, HIP researchers had fixed-term positions and, after the start phase, the appointments were basically made for the whole duration of the project. Usually the projects lasted three years, but continuation was possible.

For the administrative and technical support staff it was necessary to make continuing appointments. The staff of the Detector Laboratory obtained continuing appointments starting 1.3.2000. Thereafter, the laboratory engineers and technicians were hired on a permanent basis unless there was need to have a person for a fixed-term task. The administrative staff received continuing appointments starting in 1999.

The first personnel plan was approved by the HIP Board in April 2000. The particular goals set in the plan were: creating a stimulating and inspiring atmosphere; taking care of the wellbeing and safety of the personnel; developing operating principles and increasing flexibility so that successful activities are rewarded at both the individual and group level; promoting of cooperation; taking care of the training necessary to maintain professional skills and advance in one's career; promotion of gender equality; an equal personnel policy regarding personnel hired with external funding and budget funding. The personnel plan was updated in 2008 to incorporate the principles outlined in the University of Helsinki Human Resource Policy for 2007-2009.

A long-term development area for HIP was the social security for the personnel at CERN. HIP supported the research activities at CERN by granting fellowships. These did not include any insurance coverage or social security. The researchers were expected to obtain the necessary

coverage themselves. The fellowships were generous enough to make this possible. HIP only checked for minimum insurance coverage, covering accidents and acute illnesses, as required by CERN when the researcher was registered as a user at CERN. No pension insurance was required. In addition, family benefits were not included unless the Social Insurance Institution of Finland, KELA, accepted the individual as a resident of Finland who is only temporarily abroad. Normally KELA accepted the requests to remain in the Finnish social security system, but HIP was also recruiting researchers who did not come directly from Finland, and for them it was not possible to get into the KELA system. The HIP system worked reasonably well as long as the research visits lasted a year or two; then the missing pension insurance did not hurt too much. However, gradually HIP activities at CERN became established and the number of staff staying for an extended period of time at CERN increased. In February 2003 the status of fellowship recipients at CERN was thoroughly discussed at a HIP Staff Meeting. The discussion was based on the guidelines of both the University of Helsinki and KELA. The purpose was to inform the research staff supported by a grant about issues related to social security.

Issues were also tackled at the national level. In March 2003 the Ministry of Social Affairs and Health of Finland appointed a working group to examine the defects related to scholarship work, especially in the social insurance legislation. The working group was chaired by the Head of Department, Tarmo Pukkila, from the Ministry. The final report was published in June 2004 and a number of measures, including pension insurance, were proposed. From the beginning of 2009 changes in the legislation (Finlex 990,992/2008) concerning grant recipients came into force. Myel insurance, covering pension and accidents, became mandatory when certain conditions were met. Myel insurance was provided by the Farmers' Social Insurance Institution, MELA. The new scheme concerned the HIP staff at CERN if they belonged to the Finnish social security, i.e. KELA. The insurance premium was typically in the range 12-14%, which had to be covered by the grant.

At HIP, the discussion about CERN research grants continued in 2008. This was due to the anticipation of the future university reform on the one hand and the new EU research project in the FP7 program on the other hand. Working time accounting was required in the EU project, and that implied an employment contract for the staff working in the

project. In addition to the regular Finnish salary, a mobility allowance was granted to cover the higher living cost in the Geneva area. In 2009 the whole HIP system of fellowships for research at CERN came under discussion within the administration of the University of Helsinki. The conclusion was that HIP research staff at CERN should have employment contracts instead of conducting research with a grant. The Academy of Finland scheme, which included mobility allowances, was the guideline. Fortunately, a slight increase in the basic budget for HIP could be negotiated to cover in part the higher cost of HIP's CERN research in the new scheme. The university reform, which came into force 1.1.2010, limited further the possibilities to support research at CERN with grants, as the universities were no longer part of the government. Therefore, no new fellowships for full-time research at CERN were awarded to Finnish scientists and HIP entered into employments contracts with the staff. The social security aspects continued, however, to be problematic while there were researchers not eligible for Finnish social security insurance. The reform of the university legislation changed the conditions for university employees to work abroad and, in the summer of 2010, the University of Helsinki launched a survey of such situations. It turned out that special arrangements were required for work at CERN because it was an international organization and the normal EU regulations were thus not applicable. Due to the new legal status of the universities the insurance coverage problems in international situations extended beyond the HIP staff at CERN, and finding solutions took longer than expected. Some individuals of the HIP CERN staff contacted the Swiss authorities inquiring about the possibility of joining the Swiss pension scheme. The Swiss pension administration informed them that holders of special legitimation cards granted to personnel of International Organizations could not be admitted to the Swiss pension system. The Permanent Mission of Switzerland to the United Nations Office and to the other international organizations in Geneva was informed of this problem, and it asked CERN to make sure that all personnel admitted to CERN under special Swiss legitimation cards and employed by external institutes or universities were and remained insured within the social security system of their respective employer. The issue was addressed in a meeting at CERN on 11.12.2012 between the Head of Legal Department of CERN, Dr Eva-Maria Gröniger-Voss, and the representatives of the University of Helsinki, HR specialist Heidi Lassila and the HIP administrative manager. Fortunately, with the help of the Marsh Insurance Broker, the University

of Helsinki already had an existing plan to resolve the matter and thus the meeting ended in a positive spirit. On the same day, the HIP staff at CERN was informed of the situation in a staff meeting. The pension insurance came into force on 1.5.2013 through a Finnish company, OP Henkivakuutus Oy, and retroactively covered pension contributions since 2006.

External funding was important for the HIP research activities. The budget cut that came into effect at the beginning of 2001, when HIP lost about 11% of its basic funding, caused additional pressure on activities that were mainly financed by external funds. For example, the Academy of Finland funded the research project "Tracking detector development for high rate particle physics experiments" during 1998-2000 and the end of the project coincided with the budget cut. A new project was begun in high energy astrophysics and space astronomy, coordinated by the Observatory of the University of Helsinki and funded by the Finnish National Technology Agency, Tekes. One of the goals of the project was the development of GEM detectors for X-ray astronomy, and there the experience developed in the Detector Laboratory of HIP was important. However, such patchwork approaches to funding resulted in one researcher having 18 consecutive employment contracts between 1998 and 2005, until the last fixed-term employment ended on June 30, 2005. On 31.3.2006 HIP received a letter from a law firm. The question was whether the Institute had legal grounds for fixed-term employment contracts in that particular case. The answers HIP gave did not satisfy the legal firm and they took the University of Helsinki, as the legal body of HIP, to court. The University responded to the lawsuit in September 2006 by denying all claims. The main hearing in the court was on 20.3.2007, and the court gave its resolution on 12.4.2007. The court agreed with the plaintiff's demands and the University of Helsinki paid compensation corresponding to 16 months' salary and all the legal fees. In the end HIP paid most of the expenses, while the Observatory covered about 10% of the cost. The process was painful not only for the researcher himself but also for his colleagues and the entire Institute. Helsingin Sanomat reported on the case in a four-column article on 13.4.2007. It so happened that on 17.4.2007 the University's administrative management had its regular meeting, chaired by the Head of the University's Administration and including all the administrative managers of the faculties and independent institutes. The meeting started, as usual, with topical issues including the article in Helsingin Sanomat. The Head of Administration

of the University said that he was not looking for culprits "especially because the administrative manager of the relevant institution is sitting in the audience". The HIP administrative manager went during the coffee break to talk to the Head of Administration, who was only interested in whether the consecutive work contracts were made in consultation with the person concerned. That was, of course, the case. The lesson learned at HIP was that several consecutive employment contracts become, in a legal sense, equal to a continuing appointment. In case the need for a fixed-term employment contract arises in project work, the contract had to be made for the whole duration of the project independently of the funding decisions. The matter was reported to the HIP Board on 20.8.2007, and there it was pointed out that participation in the Antares project was, in the end, beneficial for the Institute in a financial sense, because HIP was able to receive substantial funding from the project for maintaining the activities of the Detector Laboratory.

The wellbeing of the personnel at work is an essential factor for the success of every organization. Before 2008 the University of Helsinki conducted occupational wellbeing surveys through random sampling inquiries. In 2008, two faculties and a few institutes and departments were specifically chosen to answer the questionnaires. From 2011 onwards every unit responded and, therefore, development at the institute level in the different items in the survey became possible. HIP usually did very well in these surveys. There were a few items where the marks were low within HIP compared with the rest, but overall it was comparable to the rest of the university. HIP's staff consistently felt that strategic work and decision-making at the university level were not transparent, and that the opportunities for influencing the decisions made there were small. Two additional items in the surveys received low scores at HIP, namely communication and career opportunities. HIP's communication environment was challenging, as the institute operated in several locations in Finland and abroad. The HIP News bulletin was the main joint weekly medium for communicating information to all members of the organization. In addition, regular staff meetings in Helsinki and at CERN provided the possibility of addressing issues of interest to the personnel. Furthermore, the minutes of the HIP Board meetings were accessible to the staff. HIP has an excellent record on academic career advancement, judging by the success of HIP's alumni in filling professor and university lecturer positions in Finland and abroad. The HIP staff was relatively young, mostly students, graduate students, and post-docs, and at

that career phase the opportunities may not have looked too bright. After all, HIP was a project oriented organization with no permanent researcher positions. In the wellbeing surveys in 2013 and 2015 some improvement was seen, in particular with respect to communication.

The working group set by Rectors' Council of Finnish Universities to consider employment conditions, recruitment, career development, mobility, and remuneration in Finnish universities published their report in January 2004. One on the proposals of the working group was a four-stage career development model for the teachers and researchers in universities. In October 2004 the Ministry of Education appointed a committee chaired by Chancellor Eero Vuorio of the University of Turku "to formulate a proposal for a strategy to develop professional careers in research, explore what kind of strategic measures are needed to ensure wide and versatile expertise both in the public and private sector, and ascertain how different funding bodies can contribute to the funding and development of the system; to make research career more attractive, promote women's research careers and equality in careers in research as well as examine how internationalization should be taken into account at different stages of research career." The final report of the committee was published on 3.5.2006. "The committee saw that the greatest challenges of a research career were short terms of employment, obstacles to intersectoral mobility, difficulties in combining external research funding and career development, career advancement of women researchers, a low degree of international mobility, the small number of foreign researchers in Finland, the attractiveness of a research career, economic position of researchers, and the volume of researcher training. The committee put forward that a four-stage research career system should be developed in Finland." In the context of the New Salary System reform in 2005, it had become apparent that the position title Researcher was used at quite differing levels of seniority. On 28.12.2006, the Rector wrote in a letter to the faculties and institutes that the University of Helsinki was introducing a four-stage career path model starting 1.1.2007. Thereafter, the UPJ evaluation panels would attach the appropriate title to each job description according to the four-stage model. The steps of the model applied at HIP were: Step 1, Research Assistant, Doctoral Student, Project Researcher; Step 2, Postdoctoral Researcher; Step 3, Senior Researcher, Research Coordinator; Step 4, Research Director. For each of the steps a range of UPJ requirement levels was attached. By 2014 the title Project Researcher was removed from the list of possible titles and that caused

some trouble at HIP, where technology development was a part of the research activity. Not all researchers in the technology development projects wanted to enroll as graduate students.

In the table below the person power of HIP is given in FTEs for the period 1997-2016. The amount of personnel at CERN is also shown, as well as the personnel funded by external funds. The numbers are indicative in the sense that research supported by fellowships is converted to FTEs. The time development is, however, expected to be realistic.

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Total	92.3	101.3	102.2	91.2	85.2	99.6	96.3	91.1	96.4	93.8
At CERN	35.0	39.6	39.5	37.9	35.8	37.4	27.1	23.0	22.4	24.5
Ext.	22.0	21.6	26.2	18.2	11.8	27.5	29.8	29.7	28.9	24.3

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total	94.6	91.7	90.7	86.9	88.7	88.8	83.1	78.3	87.2	79.5
At CERN	23.8	23.8	24.1	25.9	23.9	21.0	20.1	12.6	12.7	12.9
Ext.	20.2	21.7	28.7	25.4	23.1	23.6	20.2	18.3	24.8	29.0

In the second table, below, covering 2007-2016, the FTE's of the research staff, support staff, and administrative personnel are displayed. The numbers are indicative in this table as well. Only the line with Employees is from the University of Helsinki human resource information system. The difference between the total person power in comparison with the employees is due to the fellowship recipients. In the beginning, the research at CERN was conducted with the support of grants. After 2010 this number became negligible. Also, a large part of the graduate students who were supported by grants provided by private foundations had a 25 % work contract in addition. In this way they had access to the university's information systems, e.g. the travel system, and some teaching assistant duties could be assigned to them. In this case one employment FTE displays itself as four FTEs in the table.

In general, during 2010-2016 the HIP staff was quite junior, i.e. 60-70% of the personnel consisted of trainees, students, graduate students and post docs. HIP was also contracting adjoint scientists, who were typically employees of the member universities but were deeply involved with HIP research projects. These individuals are not included in the statistics

HIP person power (in FTE's)

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total	94.6	91.7	90.7	86.9	88.7	88.8	83.1	78.3	87.2	79.5
Research staff	82.5	80.8	80.1	75.3	77.0	77.1	70.1	65.2	74.9	71.3
(%)	(87.2%)	(88.1%)	(88.3%)	(86.7%)	(86.8%)	(86.8%)	(84.4%)	(83.3%)	(85.9%)	(89.7%)
Support staff	6.7	5.7	6.2	7.0	7.0	7.0	8.2	8.4	7.7	6.3
(%)	(7.1%)	(6.2%)	(6.8%)	(8.0%)	(7.9%)	(7.8%)	(9.8%)	(10.8%)	(8.8%)	(7.9%)
Administration	5.4	5.2	4.5	4.6	4.7	4.7	4.8	4.7	4.6	1.8
(%)	(5.7%)	(5.7%)	(4.9%)	(5.3%)	(5.3%)	(5.3%)	(5.8%)	(5.9%)	(5.3%)	(2.3%)
Employees			52.7	62.9	67.1	68.3	63.8	63.2	67.9	62.6
Permanent staff	11.1	9.0	9.2	11.1	11.7	11.7	11.6	11.6	11.6	8.2
(%)	(11.7%)	(9.8%)	(10.1%)	(12.8%)	(13.2%)	(13.2%)	(14.0%)	(14.8%)	(13.4%)	(10.3%)

discussed above. Occasionally, recipients of a private foundation fellowship were also granted adjoint scientist status if they did not have any part-time work contract, and, in that case, they are represented in the statistics.

HIP finances 1997-2016

HIP started its operations on 1.9.1996 with a positive outlook for the financial future.

On 3.9.1996 the Ministry of Education and the University of Helsinki concluded an agreement for the planning period 1997-2000 covering the objectives of the University, key measures for the associated performance targets and tasks, as well as the appropriations allocated on the basis of these. HIP was listed in the agreement as a national task with the special responsibility of coordinating CERN related cooperation. For this, an earmarked annual funding of 22 MFIM (3.700 M€) was granted. As HIP was created by a merger of three existing research institutes in two universities, the University of Helsinki (UH) and the Helsinki University of Technology (HUT), some of the HUT funds (0.395 M€) were transferred to the University of Helsinki, but most of the funding was presumably new money.

In addition to the basic funding for the institute's operations, resources for the large scale construction and development projects were obtained. The most important of these, in the early phase of the Institute, was the commitment of the Ministry, the Academy of Finland, and the three participating universities (UH, HUT, and the University of Jyväskylä) to fund the construction of the Finnish contribution to the large CERN LHC particle detectors, CMS and ALICE. The funding scheme was based on the 12.10.1998 memorandum of the Counsellor of Higher Education Juhani Hakkarainen of the Ministry of Education, which granted 21 MFIM (3.532 M€), corresponding at that time, with some HIP contribution, to about 6.1 MCHF, to be divided such that 5 MCHF for CMS, 1 MCHF for ALICE, and 0.1 MCHF for ATLAS. The Academy of Finland paid its contribution (7 MFIM) in 1998 and the Ministry (7 MFIM) and the universities (7 MFIM together) in equal portions during 2001-2004.

For the next planning period, 2001-2003, the overall situation became very different. Whereas in the previous period the Ministry grant fully covered the basic operation budget, the new funding model applied by the Ministry granted only 15 MFIM (2.523 M€) annually for the national task. An additional 4 MFIM was supposed to come from the host university, UH, on the basis of the "extent factor" reflecting the size of

the HIP staff, and a result based 3 MFIM from participating universities on the basis of MSc and doctoral degrees granted in their HIP projects. The thinking in the Ministry was reflected by the statement by a high official that, if the universities consider this sort of research important, then they should contribute. Unfortunately, the universities did not find the resources the Ministry had expected them to provide, and the basic operations budget sunk to 3.362 M€ for the year 2001, about an 11 % reduction. The University of Helsinki contributed most of the difference of 0.839 M€. Significant construction funding was secured in this period through a memorandum of understanding between the Ministry of Education and HIP on 21.5.2002. This covered the cost increase of the CMS detector, ”Cost-to-Completion”, as well as the additional cost due to the change in the Swiss franc exchange rate, together 0.849 M€ during 2004-2006. In the memorandum HIP also agreed to withdraw from the ATLAS Collaboration, which took place on 30.6.2003.

The Ministry had the goal of reducing the number of activities that were classified as national tasks. For the following planning period, 2004-2006, HIP was successful in obtaining an increase in the basic funding granted by the Ministry, up to 2.85 M€, but the grant was awarded for “societal service” and not for any national task. Similar terminology was used for the planning period 2007-2009 for the annual grant of 3 M€. An important new project, participation in the construction of the FAIR facility in Darmstadt, Germany, started to receive Ministry grants from 2005 on, in the beginning aimed at planning activities. In November 2007 Finland joined the declaration of the launch of the FAIR project and the first major construction contribution, 1 M€, was received in 2008. In 2009-2010 the FAIR funding continued at an annual level of 1.25 M€. The FAIR organization, FAIR GmbH, was created by signing the Convention on 4.10.2010, in which Finland committed 5 M€ (in €’s of the year 2005) to the construction of the facility. The initial intention was to contribute 70% of the amount in-kind and 30% in cash. An additional 1.5 M€ was granted by the Ministry in 2010-2012 to cover the cash contribution, and by the end of 2015 all of the cash commitment had been transferred to FAIR GmbH (altogether 1.831 M€, corresponding to 1.5 M€ in 2005 €’s). For the Tier-2 grid computing for the LHC experiments, the Ministry granted an annual 0.8 M€ funding for 2008-2010. These resources were used to set up the grid computation facilities, including disc space at the Center for Scientific Computing (CSC) premises.

For the planning period 2010-2012, major changes took place in the whole financial picture. Namely, the legislation concerning the organizational status of the Finnish university system was changed as of 1.1.2010. All universities in Finland were made independent legal entities as corporations under public law. Two universities, Aalto University and the Tampere University of Technology, were created as foundation universities governed by the Foundations Act. This meant that the university system was no longer part of the Government, which, however, was still the main source of funding as before. HIP was granted 3.2 M€ annually for a national special task. The increase of 0.2 M€ was connected to the new FAIR activity, as well as the Tampere University of Technology (TUT) joining HIP as a consortium partner at the end of 2008.

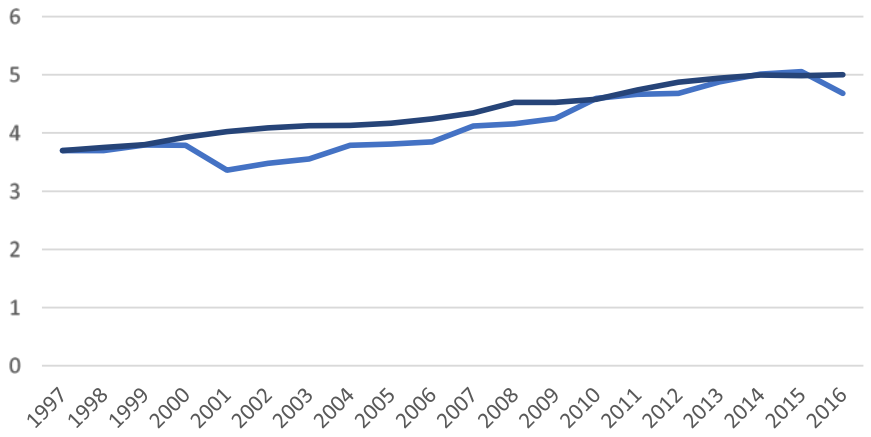
While planning for the period 2013-2016, the University of Helsinki changed the handling of the accumulated balance with the decision on 7.5.2012 (UH Rector's Decision 93/2012). For HIP this implied that the FAIR in-kind and Tier-2 project funds not used by 31.12.2011 were moved away from the HIP balance. However, separate accounting was maintained, and therefore these projects did not suffer; but the related expenses do not appear in the HIP outlays. Even so, about 0.7 M€ of the accumulated basic funding balance was lost as a consequence of this decision. The initial new Government grant for the national task was 3.5 M€ for 2013.

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Gvmt	3.700	3.700	3.700	3.700	2.523	2.523	2.523	2.850	2.850	2.850
Partners	-	-	-	-	0.050	0.113	0.113	0.113	0.200	0.260
Total	3.700	3.700	3.794	3.786	3.362	3.479	3.555	3.790	3.809	3.845

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Gvmt	3.000	3.000	3.000	3.200	3.200	3.200	3.500	3.590	3.644	3.505
Partners	0.280	0.280	0.310	0.340	0.340	0.340	0.335	0.335	0.335	0.335
Total	4.122	4.155	4.249	4.593	4.666	4.681	4.880	5.010	5.055	4.679

The HIP basic operation funding for 1997-2016 is shown in the tables above (in M€). The conversion factor for the amounts before 1.1.2002 is 1 € = 5.94573 FIM. The first line gives the Government basic funding, the second the contributions of the partner universities (excluding UH), and the third line is the total basic funding. The "missing" piece is the UH part, which may contain different types of contributions, e.g. in 2007-2012 there is

the annual 70 k€ contribution due to the success of HIP in the University of Helsinki research assessment of 2005. Furthermore, from 2013 on the basic funding contains the university's self-financing contributions for the infrastructure investments (Academy of Finland FIRI funding) for the FAIR facility as well as for the CERN CMS, ALICE, and TOTEM upgrade projects. In addition, the graduate school positions, which earlier were funded by national programs such as GRASPANP and PANU, became part of the basic university funding from 2013 on. In the figure below, the basic funding is displayed by the blue line (in M€) during 1997-2016. The black line gives the development of the Cost-of-Living index for Finland, normalized to 3.7 in 1997. In particular, during 2001-2009 the funding of HIP was substantially below the index curve. From 2010 on the situation looks somewhat better, because of the additional items becoming part of the basic funding.



The Institute expenditures are displayed in the following tables. These numbers are taken from the annual summaries to the Board (excluding the Ministry special funding for construction, e.g. of FAIR).

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Basic	3.44	3.50	3.69	3.76	3.33	3.75	3.52	3.31	3.47	3.57
External	0.58	0.73	0.88	0.77	0.32	0.66	0.68	0.82	0.57	0.50
Total	4.02	4.23	4.57	4.53	3.65	4.41	4.20	4.13	4.04	4.07

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Basic	4.09	4.11	4.39	4.19	4.44	4.63	4.91	4.73	5.09	4.12
External	0.63	0.72	0.77	0.79	1.04	1.06	1.24	0.80	1.97	1.31
Total	4.72	4.83	5.16	4.98	5.48	5.69	6.14	5.53	7.07	5.42

In 2010 the University adopted the SAP accounting system, and the third table displays these official numbers. From 2012 on the Ministry special resources were moved away from the HIP accounts, and from 2015 on the contributions of the partner universities, Aalto, UJ, LUT, and TUT, were moved from the basic funding to the external funding (N.B. in the operation funding table the latter is considered as a part of the basic funding, unlike in the expenditures tables).

	2010	2011	2012	2013	2014	2015	2016
Basic	4.73	4.67	4.53	4.86	4.70	5.20	3.96
External	0.84	1.51	1.15	1.28	0.83	1.86	1.46
Total	5.57	6.18	5.69	6.14	5.53	7.07	5.42

In addition to the basic funding and the Ministry special funds for construction, there was also external funding, i.e. grants awarded by EU, CERN, and the Finnish national funding agencies, the Academy of Finland, and Tekes, the national technology agency of Finland. The external funding acquired by HIP has been relatively modest compared to other physics departments and institutes in Finland, typically 15-20 % of the total expenditure, but in recent years the situation has improved somewhat and the share of the external funding has exceeded 25 % of the total. The Government earmarked funding remains, however, the main part of the operations budget. The main reason for the fact that the external funding remains relatively meager is the nature of HIP as a joint research organization of five universities. The majority of the HIP project leaders belong to the senior research staff of one of the partner universities, and it is advantageous for them to channel the external research funding they acquired through their permanent base. For example, several of the project leaders of the Theory Program 3+3 year research projects have had a Academy of Finland Research Fellowship, but none of them through HIP. One may also think that HIP operates as a funding agency for experimental particle physics research and, as such, takes some of the responsibility from the national research funding organizations. However, in 1998-2000 professor Risto Orava had major tracker detector development funding (0.891 M€) from the Academy of Finland. Several Academy funded post-doc positions have been available over the years, and one Academy Research Fellowship was granted to HIP, for Dr Jaakko Härkönen in 2007-2012. In recent years the situation has changed, because the Ministry of Education and Culture does no longer finance the large construction projects directly, but instead channels the research infrastructure funding through the Academy of Finland. There

HIP has been successful in acquiring resources for the upgrade projects of the LHC large detectors at CERN – CMS, ALICE, and TOTEM – as well as for the FAIR/NuSTAR construction, 1.646 M€ in total for 2014-2017.

The HIP activities not directly connected to particle physics have been, relatively speaking, reasonably successful in winning research grants. The Technology Program is the prime example. In addition to several Tekes projects, the program has participated in the EU-funded grid security development projects, Enabling Grids for E-sciencE (EGEE), EGEE II and EGEE III, bringing in about 0.8 M€ during 2004-2010. CERN has also outsourced some of their CLIC accelerator development activities to HIP with a K-contract worth about 0.77 M€ during 2014-2017. A major new achievement was the Tekes FiDiPro professorship awarded for 2015-2018, in Novel Instrumentation for Nuclear Safety, Security and Safeguards (NINS3), where professor (FiDiPro) Peter Dendooven and his team address issues related to spent nuclear fuel, active neutron interrogation of unknown objects, and alpha radiation threat detection and imaging from a distance.

HIP educational and outreach activities

In the national CERN strategy published in 2002, several goals for promoting education and public scientific awareness were set for CERN-related activities. Graduate education at HIP has been closely connected to the research projects, and the thesis work is, therefore, summarized in the section discussing HIP research. In this section the HIP summer student and high school student programs at CERN are discussed, as well as outreach activities aimed at the general public.

The Finnish CERN activity was organized on an ad hoc basis in 1968, and a CERN committee was established within the State Committee for Natural Sciences. In 1971 a new name was introduced for the committee, the Particle Physics Committee, because the tasks included cooperation with JINR (Dubna). From 1968 a summer student program was part of the activities funded by the Committee. Until the late 80's the typical number of summer students funded by the Committee was two, but occasionally no funds existed at all for this purpose. In the late 80's a slight increase in the number of summer students took place. The work of the Particle Physics Committee ended when the Research Institute for High Energy Physics (SEFT) was established in 1990 at the University of Helsinki and the coordination of funds for CERN activities became part of its responsibilities. In the early 90's SEFT and the Institute of Particle Physics Technology (HTI) of the Helsinki University of Technology started extensive summer student and trainee programs at CERN. HTI usually had seven summer students at CERN, and SEFT had from 10 to 15. In addition, SEFT and HTI offered internships to technical students at CERN.

Most students participating in the HIP summer student program at CERN came from the technical universities, the Helsinki University of Technology in particular. For them, a fixed-term project based endeavor in the multicultural international environment at CERN was particularly attractive. HIP was able to finance only part of the applicants to these programs. To some extent, the number of applicants was dependent on the summer job market in Finland. HIP was not able to compete on wages. In addition to university students, the HIP summer student programs attracted a number of students from universities of applied sciences. For them, more extended training periods at CERN could be offered in addition. In the table below the number of summer students at CERN between 1997-2016

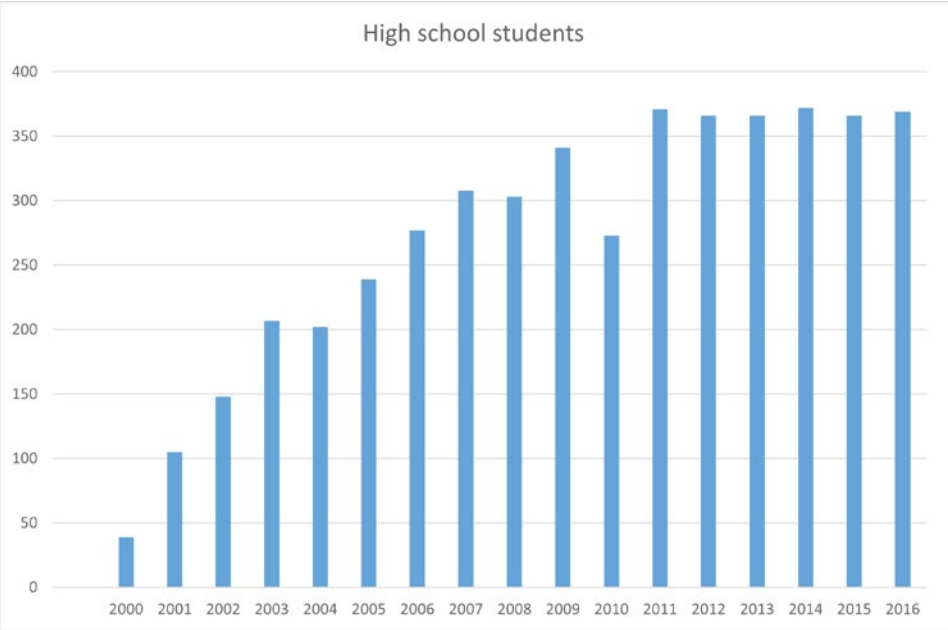
is displayed. During 1997-2016 there were 343 summer students in total, and 71% of them were from technical universities, 59% from the Helsinki University of Technology/Aalto University alone.

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Total	16	19	18	17	17	18	17	14	16	14

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total	18	16	20	21	18	18	15	17	18	16

In addition, in 2006 HIP had one summer student at Fermilab and in 2016 one summer student at ESRF (European Synchrotron Radiation Facility) in Grenoble. The CERN summer student program and the CERN openlab program also hired a few Finnish students. HIP was, of course, hiring numerous summer students in Finnish locations.

SEFT started to develop educational programs at CERN in the fall of 1994. At first, the aim was to develop a virtual university that would make use of the CERN Academic Training Program in the graduate education of particle physics in Finland. HIP participated in two research projects on distant learning issues, led by Riitta Rinta-Filppula, MSc, coordinated by Tampere University of Technology and funded by Tekes. The aim was to study, within the Web University (WU) pilot project in collaboration with the CERN Education and Technology Transfer division, the possibility of using the educational programs at CERN for distance learning purposes and to test the technologies for real-time, interactive learning situations. From early on, the intention was also to offer courses to the general public. WU started to produce and transmit digital material where the CERN and Finnish scientists made the latest physics research results understandable at the high school level. In the autumn of 2000 WU started to organize visits for high school students to CERN. In 2002 the National Board of Education, in collaboration with HIP and the municipality of Jyväskylä, started a CERN co-operation school network, where the main aim was to develop the role of particle physics in school curricula. A similar network among the Swedish-speaking students was organized under the TekNatur/CERN network. The research project on WU ended in January 2003, and thereafter school activities became the focus of the project. In the histogram on the following page, the number of high school students that visited CERN through the HIP program is displayed.



In 2010, there were two incidents that caused a dip in the histogram. In April 2010 most of European airspace was closed to traffic, causing the delay of one group. The reason was the volcanic ash cloud from the eruption of Eyjafjallajökull in Iceland. In December 2010 there was a Finnair air traffic strike, which caused one group to be transferred and two groups to be cancelled.

The camp schools at CERN included preliminary preparation, which the schools decided on themselves, and three days of studies at CERN. Based on the preparation, typically involving introductory lessons at school and possibly a visit to a nearby physics laboratory, the level of the science study program at CERN suitable for each group was defined. At CERN, the lecturers and guides at the test stations were CERN researchers or HIP researchers based at CERN. A few of the lectures were in English, but teaching was mainly in the mother tongue. Therefore, the Finnish researchers working at CERN were in an important position as lecturers.

Commissioned by the National Board of Education, Jyväskylä University's separate institutes, the Finnish Institute for Educational Research and the Finnish Education Evaluation Council, carried out an external evaluation of the CERN network activities in 2009. The evaluation was performed by sending a survey to the teachers who had participated in the activity.

Dr Katri Lassila-Perini lecturing in May 2008 about particle accelerators, detectors and future challenges in particle physics to a group of students of the Kainuu high school network (Photo: Juhani Juntunen).

The evaluation report, ”The CERN network performance evaluation”, was published on 28.9.2009. In the report it was stated, for example, that “All in all, the CERN project has achieved the goals set for it extremely well. As a result of the project, students’ motivation to study physics has been perceived to have increased. Studying science is also seen to have developed students’ general skills in a quite versatile way. For teachers, participation in the CERN project has especially increased their work motivation as teachers. Teachers and schools have networked in ways that have spawned new regional cooperation relationships. According to the participating teachers, the network-like project activity suited the CERN project well.” Among the practical issues of the project, the biggest problem was funding, which was very time and energy consuming to obtain by seeking sponsors and holding sales, unless the training organizer contributed a significant amount. An increase in the contribution of the National Board of Education was hoped for. Too much depended on the activity of individual teachers. Only about 20 groups could be accepted each year and, therefore, the high interest in CERN visits among the schools caused scheduling difficulties.

The high school visiting program at CERN was also important in disseminating information on the Finnish activities at CERN to the wider public. The school visits received significant visibility in local newspapers, radio programs, and, occasionally, TV programs. By 2016 more than 500 articles were published in more than 160 papers or magazines. The school

High school science camps at CERN

Year	Participants in the student groups				Teachers' 1wk course		Teachers' 1-2 day course	
	Students	Teachers	Sum	Groups	Teachers	Groups	Teachers	Groups
2000	39	3	42	3				
2001	105	14	119	6	7	1		
2002	148	33	181	9	15	1		
2003	207	33	240	11	52	4		
2004	202	34	236	11	12	1	59	2
2005	239	34	273	13	16	1	10	1
2006	277	39	316	14	30	2	11	1
2007	308	50	358	15	47	3	9	1
2008	303	44	347	15	32	2		
2009	341	48	389	17	32	2	7	1
2010	273	48	321	14	33	2		
2011	371	60	431	19	16	1		
2012	366	64	430	19	9	1	11	1
2013	366	61	427	18	16	1	33	2
2014	372	54	426	18	11	1	8	1
2015	366	57	423	18	15	1	10	1
2016	369	55	424	18	11	1		
Sum	**4652**	**731**	**5383**	**238**	**354**	**25**	**158**	**11**

network also produced publications about CERN network activities that were distributed in the thousands. International visibility for the Finnish school activity was obtained through a brief report in CERN Courier in 2002 (Nr 9, page 48). In addition, the activities were presented in numerous exhibitions and displays.

In June 2012, Riitta Rinta-Filppula presented the high school activity to two parliamentary committees that visited CERN, the Education and Culture Committee and the Employment and Equality Committee. The presentations were received with great interest.

The table on the previous page contains information on the number of student groups and their teachers, as well as the numbers of teachers participating in the continuing education courses at CERN.

The World Year of Physics (WYP) was celebrated in 2005 to commemorate Einstein's 1905 "miraculous year". The European Particle Physics Outreach Group (EPPOG), an information exchange forum between science institutions and laboratories for fostering better outreach initiatives, took the initiative to introduce "European Masterclasses for High School Students: Hands on Particle Physics" in 2005 as a part of the WYP activities. Particle physics masterclasses had began in Great Britain already in 1997. At HIP, the Detector Laboratory was involved in organizing a national event where high school students from five schools participated. The program included lectures on modern physics, a visit and experimental work in the laboratory, and a common European video conference where the results of the experiments were collected and experiences of the day exchanged with participants in other European universities. The Masterclasses program became part of the regular activity of the Detector Laboratory. Numerous student groups also made excursions to the Detector Laboratory.

On 3.5.2013 HIP, together with the Faculty of Science, organized a TEDxCERN event, which attracted a large crowd of people to HIP's premises. TED is a nonprofit organization that brings together fascinating thinkers and doers from different fields who are challenged to give a talk in 18 minutes or less. The presentations are then made available to the whole world. TEDxCERN events have been organized since 2013 with the purpose of having a platform dedicated for sharing ideas and initiatives from scientific, technological, educational, and artistic fields.

In 2006, as a part of the European strategy for particle physics, the CERN Council established EPPCN (European Particle Physics Communication Network), a network of persons in the CERN Member States who serve as local contacts for the media and general public in connection with CERN developments, press releases, exhibitions, etc. The EPPCN members were expected to be full-time science communicators who know the national target audiences well. In 2014 HIP signed an agreement with CERN and University of Helsinki (Kumpula campus) press officer Minna Meriläinen-Tenhu on her EPPCN membership (EPPCN Agreement KE2213). The EPPCN member was expected to promote the visibility of CERN research and assist in CERN related media events in Finland. Already before the formal EPPCN contract, Minna Meriläinen-Tenhu, in her role as the campus press officer, had helped HIP researchers in reporting their results to the general public.

The HIP Theory Program Director, cosmology professor Kari Enqvist, was particularly active in popularizing science, and had received several awards for his books. In 1999 he received the Tieto-Finlandia National Book Award, in 2004 the State Award for Public Information (Valtion Tiedonjulkistamispalkinto) and WSOY Foundation Prize, in 2005 the Nonfiction writers' award of the Association of Finnish Nonfiction Writers, and in 2007 the J.V. Snellman prize of the University of Helsinki for his achievements in spreading scientific information. Another J.V. Snellman prize recipient from HIP, in 2014, was Dr Syksy Räsänen, leader of the HIP project "Cosmology of the Early and Late Universe".

Scientific Advisory Board (SAB)

In 1995 the rectors of the University of Helsinki and the Helsinki University of Technology gave to professor Jorma Routti, at that time the chair of the board of the Research Institute for High-Energy Physics (SEFT), the task of working out a proposal for a joint research institute for physics for the two universities. The report was published on 6.9.1995 and contained, as a part of the proposal, a recommendation that a SAB to be set up for the new research institute. The operations of the Helsinki Institute of Physics (HIP) started on 1.9.1996, and the newly appointed board approved the Rules of Procedure for the institute on 9.9.1996. In the RoP, §5, it was required that the institute establish a SAB with 6-10 members having expertise in the basic research and technology development relevant for the institute. At least half of the membership should be from abroad, and the length of the term was 3 years. The board of the institute proposed the members, and the rectors of the universities invited them.

The HIP board set up a working group on 6.11.1996 to prepare a proposal for the possible composition of the SAB. In their recommendation the working group proposed a 6-member SAB with one of the members being Finnish. The group consulted a number of chairpersons of the physics departments in Finland and came up with six lists of names representing Nobel prize winners, high-energy theoreticians, low-energy theoreticians, CERN management, individuals from other accelerator centers, and researchers from Finland. The board decided on 9.12.1996 to proceed according to the proposed model: six members, one representing each of the above groups. Eventually, J. Steinberger, J. Iliopoulos, N. Kroo, H. Wenninger, B. Wiik, and K. Ahlström agreed to serve on the SAB of HIP. The first meeting took place on 4.9.1997 in Helsinki. The SAB endorsed the research plans of the four research programs for 1998, and emphasized the need for a chair in experimental particle physics at the University of Helsinki. Also, a laboratory infrastructure was considered essential for the activities in major international accelerator centers. The same SAB met on 17.9.1998 at CERN, and on 14.6.1999 in Helsinki. However, professor Björn Wiik died on 26.2.1999 and the HIP board decided on 6.4.1999 to ask the rectors to invite Dr H.F. Hoffmann of CERN to the SAB of HIP for the remaining term, until the year 2000.

In 2000 the board set up a working group to prepare a proposal for inviting the new SAB members. The six members were proposed to represent the CERN

management, experimental particle physics, nuclear matter physics, industry, condensed matter theory, and particle physics theory. H.F. Hoffmann, A. Wagner, H. Specht, M. Mäenpää, M. Rice, and G. Veneziano agreed to serve for a 3-year term starting 1.9.2000.

The fields of expertise of the members of the SAB have remained much the same over the years: CERN management, experimental particle physics, experimental high-energy nuclear physics, theoretical high-energy physics, theoretical low-energy physics, and industry and technology development. In 2010 new Rules of Procedure were adopted and the appointment of the SAB was moved from the rectors to the HIP board. In 2012 one additional member representing FAIR physics was added, and their term was also prolonged to four years, reflecting the new planning period of the university.

Over the years the following individuals have served on the Scientific Advisory Board of the Helsinki Institute of Physics (HIP):

H. Wenninger (CERN), 1997-1999, chair

K. Ahlström (A. Ahlström Corporation), 1997-1999

J. Iliopoulos (École Normale Supérieure), 1997-1999

N. Kroo (Hungarian Academy of Sciences), 1997-1999

J. Steinberger (CERN), 1997-1999

B.H. Wiik (DESY), 1997-1998 (26.2.1999)

H.F. Hoffmann (CERN), 1999-2003, chair 2000-2003

M. Mäenpää (Federation of Finnish Metal, Engineering and Electrotechnical Industries), 2000-2006

M. Rice (ETH, Zürich), 2000-2006

H. Specht (U. Heidelberg), 2000-2006

G. Veneziano (CERN), 2000-2003

A. Wagner (DESY), 2000-2003

W.-D. Schlatter (CERN), 2003-2009, chair 2004-2009

J. Engelen (CERN), 2003-2012, chair 2010

H. Leutwyler (U. Bern), 2003-2009

M. Larsson (U. Stockholm), 2006-2012

H. Sipilä (Oxford Instruments Analytical), 2006-2009

J. Stachel (U. Heidelberg), 2006-2011

P. Bloch (CERN), 2009-2016, chair 2011-2016

W. Buchmüller (DESY), 2009-2016

A. Oja (VTT), 2009-2016

B. Erazmus (CERN and CNRS), 2012-

G. Rosner (FAIR and U. Glasgow), 2012-

W. Weise (TU Munich), 2012-

B. Åsman (U. Stockholm), 2012-

N. Glover (U. Durham), 2016-

K. Härkki (Outotec Oyj), 2016-

M. Krammer (CERN), 2016-

Facility for Antiproton and Ion Research (FAIR)

At the beginning of the new Millennium, plans for a major new international research facility were developed at the GSI laboratory (Gesellschaft für Schwerionenforschung) in Darmstadt, Germany. These plans were in line with the recommendations of the NuPECC (Nuclear Physics European Collaboration Committee) Working Group on Radioactive Nuclear Beam Facilities published in a report in April 2000. The Conceptual Design Report for "An International Accelerator Facility for Beams of Ions and Antiprotons" was published in November 2001. In February 2003 the German Federal Government approved the project with the condition that 25 % of the construction costs be carried by other countries.

In August 2003 the Federal Minister of Education and Research of Germany, Ms Edelgard Bulmahn, approached the Finnish Minister of Education and Science, Ms Tuula Haatainen, with a letter inquiring about Finnish interest in participating in two major infrastructure projects planned in Germany: the XFEL (X-Ray Free-Electron Laser Facility) in Hamburg, and a large-scale facility for hadron and nuclear physics at GSI. In her reply in October, based on the excellent existing working relations with GSI, Ms Haatainen expressed Finnish interest in participating to a minor extent in the hadron and nuclear physics facility at GSI. The Counsellor of Education, Ms Mirja Arajärvi, of the Ministry of Education was appointed as the Finnish representative in the working group that was discussing the organization, administration, and financing of the new facility.

The Steering Committee of the GSI-International Accelerator Facility (ISC) started its work in 2004. In the first meeting two working groups were set up, the Scientific and Technical Issues (STI) working group and the Administrative and Funding Issues (AFI) working group. Professor Juha Äystö was appointed as the Finnish member of the STI, and professor Dan-Olof Riska as the substitute member. Mirja Arajärvi took on the AFI representative task in addition to the International Steering Committee membership. The name FAIR (Facility for Antiproton and Ion Research) appeared for the first time in March 2004 in STI meeting documents. On 18.8.2004 a meeting took place at the Ministry of Education to discuss Finnish participation in the FAIR project. The participants were from

the Ministry of Education, the Academy of Finland, and HIP. It was agreed that Dan-Olof Riska would sign the non-binding Memorandum of Understanding on the Preparatory Phase of the International FAIR Project. The formal authorization was signed by the Minister of Education and Science, Tuula Haatainen, on 25.8.2004 (5/501/2004), and subsequently Dan-Olof Riska signed the MoU on 22.9.2004. Initially the Preparatory Phase was expected to be completed by mid 2006 but extensions were needed – first by one year, as decided in July 2006, and later, in May 2007, until the entry into force of the final act of the FAIR company.

In the NuPECC Long Range Plan of 2004, the highest priority for a new construction project was the construction of the international FAIR facility. The physics interest in the new facility lay, in general, in the microscopic understanding of strongly interacting nuclear matter, both in terms of the fundamental interactions as well as through the study of multi-particle systems. The facility pursued research on heavy-ion collisions at intermediate energies, structure studies of very short-lived or exotic nuclei, antimatter, properties of high density plasmas and applications to materials research and medical physics. The FAIR research was planned within four pillars: CBM (Compressed Baryonic Matter experiment), NuSTAR (Nuclear Structure, Astrophysics and Reactions), PANDA (Antiproton Annihilation at Darmstadt experiment) and APPA (Atomic, Plasma Physics and Applications). The Finnish interest focused on the properties of cold, dense nuclear matter and short-lived nuclei, together with nuclear astrophysics studied within the NuSTAR Collaboration. It therefore complemented research activities at the University of Jyväskylä in the relativistic heavy-ion research collaboration ALICE at CERN, and the low-energy nuclear physics in the Jyväskylä Accelerator Laboratory. The planning of the Finnish part of the FAIR project was started in 2004 and was concentrated in Jyväskylä. Dr Kari Peräjärvi was appointed as the coordinator of the project starting 1.8.2005. There were initially plans to set up a project to develop and construct the GEM (Gas Electron Multiplier) detectors for the PANDA TPC (Time Proportion Chamber) in the HIP detector laboratory. However, this was abandoned due to workforce and financial limitations.

The Baseline Technical Report for FAIR was finished in 2006, most of it in March, and ISC accepted it – with the price tag of 1187 M€ – in July as the basis for the negotiations with the potential FAIR member states. The Joint Core Team (JCT), led by Hans Gutbrod, began to work in 2006

on preparing all aspects for the creation of the company FAIR GmbH. FAIR also appeared on the first list of the European Strategy Forum on Research Infrastructures (ESFRI), published in October 2006. On 7.11.2007 the project was officially started in the presence of the German Federal Minister for Education and Research, Ms Annette Schavan, once a sufficient amount of commitment from foreign countries had been received.

In Finland, in June 2006, the Ministry of Education inquired into the interest in FAIR of the various potential stake holders. In its statement, the University of Helsinki (4.9.2006) supported joining the FAIR project, but expected that the resources would be found from existing national nuclear physics resources without new investment. Furthermore, it stated that it does not have the possibility to fund FAIR activity. In general, it was contemplated that the high level of the nuclear physics research at the University of Jyväskylä, demonstrated by its success in scientific evaluations and Centre of Excellence applications, justified the participation in a leading international infrastructure project in the field. The educational importance of such facilities was also recognized. In addition, a major construction project would be expected to provide opportunities for collaboration between universities and industry. The unofficial discussions of Finnish participation in the FAIR project with the German BMBF (Bundesministerium für Bildung und Forschung) were started on 16.10.2006, and the official delegation was appointed in March 2007. The members of the FAIR negotiation team were Mirja Arajärvi (Ministry of Education), Antti Joensuu (Ministry of Trade and Industry), and Reijo Munther (Tekes – the Finnish Funding Agency for Innovation). For the Finnish participation in FAIR, an important issue at the beginning was the question of the minimum investment in the construction project. In 2006 BMBF set the minimum investment at 1 % of the construction costs, corresponding to about 12 M€ in euros of the year 2005. This implied that Finland had to seek a consortium partner to participate in the project. The possible partners in various discussions included Austria and Sweden. The latter had decided to commit 10 M€ and, therefore, the minimum investment limit was easily accessible. On 19.9.2007 the Minister of Education and Science, Ms Sari Sarkomaa, signed a declaration of the intention of Finland to participate in the construction and operation of the FAIR facility. The Finnish contribution would be at least 0.5 %. Hence, Mirja Arajärvi was able to sign the Communiqué of 7.11.2007 on the official launch of the Facility for Antiproton and Ion Research.

In 2009 two findings had major implications for the financing of the FAIR project. Firstly, a detailed geological survey of the GSI site revealed that the ground stabilization required considerably more pillars than originally estimated. Fortunately, the Federal Republic of Germany and the State of Hesse made the commitment to cover these additional site specific costs (95 M€ in 2005 euros). Secondly, a new cost estimate showed that the construction cost would significantly exceed the earlier estimate given in the Baseline Technical Report. Therefore, a new approach for the scope, the Modularized Start Version (MSV), was developed to fit within the financial boundaries set by the Partner States. The new price tag was 1027 M€ (in 2005 euros).

Once the MSV had been agreed on the FAIR project could proceed, and the initialing the FAIR founding documents took place on 27.8.2010 in Berlin after a two-day Cross-Checking Conference. The Finnish representative was the Counsellor of Education, Mr Petteri Kauppinen, of the Ministry of Education and Culture. The discussions between Sweden and Finland had also reached a conclusion, and the consortium agreement "Agreement Concerning FAIRNORD" between Vetenskapsrådet, Sweden, and the University of Helsinki/Helsinki Institute of Physics was signed on 1.10.2010. The Convention concerning the Construction and Operation of a Facility of Antiproton and Ion Research in Europe (FAIR) was signed by nine countries in Wiesbaden on 4.10.2010. The Finnish representative at the event was State Secretary Ms Heljä Misukka, of the Ministry of Education and Culture. The legal entity, the company FAIR GmbH, was registered in Darmstadt on 10.11.2010. On 25.11.2011 a presidential decree (108/2011) was issued in Finland on the temporary application of the FAIR Convention. The Convention formally entered into force on 1.3.2014 after the last notification was received by the German Foreign Office.

After the founding of the organization, the FAIR Council, as the shareholders' assembly, became the highest decision making body of the FAIR GmbH. In the Council the shareholders of each contracting party have at most two delegates and, therefore, both members of the FAIRNORD consortium, Sweden and Finland, can have a seat in the Council. The formal shareholder in FAIR is the Swedish Research Council (Vetenskapsrådet). Finland has adopted the custom of appointing the HIP Director as the Finnish representative in the Council. The Administrative and Finance Committee (AFC) is organized similarly, and there the Academy of Finland appoints the Finnish representative.

In 2014 it became evident that the cost estimate for the FAIR MSV was not realistic. State Secretary Georg Schütte of BMBF charged an international group of experts, led by Professor Rolf Heuer, Director-General of CERN, to conduct a renewed critical evaluation of the FAIR project. The project organization and management structures were assessed, as well as the quality of the research program. The FAIR Council decided to invite external advisory boards and panels to support the management in the reorganization. A new cost assessment was also carried out in 2015. The delays in the construction, as well as the newly interpreted fire and radiation safety requirements, led to a cost estimate which was 248 M€ (in 2005 euros) higher than the earlier estimate. The Finnish share of this additional cost was 1.2 M€, and in its meeting on 2.9.2015 the Finnish Research Infrastructure Committee made a decision to prepare to fund 1.24 M€ during 2018-21.

The Ministry of Education granted funding for the planning of the FAIR participation starting from 2005. Initially the amount was 47 k€ for 2005, then 80 k€ for 2006 and 60 k€ for 2007 and 2008. During 2008-2012 the Ministry of Education and Culture granted altogether 5 M€ to cover the Finnish participation in the construction of the facility. The funds were channeled through the Helsinki Institute of Physics, which has responsibility for the coordination of the Finnish participation in the construction work and research activities. The European Union funded the design study of the facility as well as the JCT operations from the 6th and 7th Framework Programs. Some of these funds were used at the University of Jyväskylä. In the HIP organization, a separate project for FAIR activities in the Nuclear Matter Research Program was created from the beginning of 2009. The project was initially led by the Program Director, professor Juha Äystö. From 1.4.2012 the position was taken over by professor Ari Jokinen and, starting 1.1.2015, by docent Tuomas Grahn.

For the technical evaluation of the potential in-kind contributions, which form an essential part of the total construction cost, an In-Kind Advisory Board (IKAB) was set up in 2007 as a subcommittee of the STI. Finland was represented in the IKAB by Juha Äystö. After the creation of the FAIR GmbH in 2010 this role was taken by the In-Kind Review Board (IKRB), and there the Nuclear Matter Program directors were appointed as the HIP representatives: Juha Äystö 2011-2012, Matti Leino 2012-2013, and Ari Jokinen starting 2014. In September 2012 the FAIR Management

sent an invitation to participate in the process of reviewing the resources available to the experiments at FAIR by appointing a representative to the Resource Review Boards (RRB) of the appropriate experiments; for Finland this is the NuSTAR RRB. Juha Äystö served as the funding agency representative and Ari Jokinen as an advisor in 2013-2014. Starting in 2015 Ari Jokinen was appointed as the HIP representative and Tuomas Grahn as the advisor.

APPENDIX A: The Board of the Helsinki Institute of Physics

In early 1996 a provisional board for the new research institute for physics was set up by the University of Helsinki, Helsinki University of Technology and Ministry of Education. The first meeting took place on 14.3.1996. The provisional board held five meetings.

(Abbreviations: UH, University of Helsinki; HUT/AU, Helsinki University of Technology/Aalto University; UJ, University of Jyväskylä; LUT, Lappeenranta University of Technology; TUT, Tampere University of Technology)

Provisional board:

Arto Mustajoki (UH, chair)

Toivo Katila (HUT, vice-chair)

Katri Huitu (UH, personnel representative)

Juhani Keinonen (UH)

Marja Pulkkinen (Ministry of Education)

Rainer Salomaa (HUT)

Board (1.9.1996-):

Arto Mustajoki (UH, chair), 1.9.1996-19.8.1998

Toivo Katila (HUT, vice-chair), 1.9.1996-31.7.1997

Juhani Keinonen (UH), 1.9.1996-31.3.2014

Rainer Salomaa (HUT), 1.9.1996-31.8.1999

Juha Äystö (UJ, appointed by the Ministry of Education), 1.9.1996-31.12.2001

Katri Huitu (UH, personnel representative), 1.9.1996-30.6.2010

Antti Räisänen (HUT, vice-chair), 1.8.1997-31.8.2001

Ilkka Niiniluoto (UH, chair), 19.8.1998-31.7.2003

Peter Lund (HUT), 1.9.1999-30.9.2007

Mauri Airila (HUT, vice-chair), 1.9.2001-31.7.2005

Rauno Julin (UJ), 1.1.2002-30.6.2010, 13.1.2014-13.2.2018

Antti Kupiainen (UH), 1.1.2002-31.3.2014

Salme Näsi (UJ), 1.1.2002-13.11.2002

Timo Tiihonen (UJ), 13.11.2002-31.7.2005

Marja Makarow (UH, chair), 1.8.2003-31.12.2007

Kalevi Ekman (HUT, vice-chair), 1.8.2005-26.2.2010

Matti Leino (UJ), 1.8.2005-30.6.2010

Markku Lukka (LUT), 1.1.2007-31.7.2008

Kimmo Kaski (HUT), 1.10.2007-26.2.2010

Johanna Björkroth (UH, chair), 1.1.2008-31.3.2014

Ilkka Pöyhönen (LUT), 1.8.2008-30.6.2010

Ulla Ruotsalainen (TUT), 13.11.2008-31.12.2009, 4.2.2010-6.2.2014, 13.1.2015-31.12.2016

Heikki Mannila (AU, vice-chair), 26.2.2010-24.2.2012

Kari J. Eskola (UJ), 1.7.2010-

Jaakko Härkönen (HIP, personnel representative), 1.7.2010-31.3.2014

Matti Manninen (UJ), 1.7.2010-31.7.2012

Risto Nieminen (AU, vice-chair 1.1.2014-31.3.2016), 26.2.2010-31.3.2016

Veli-Matti Virolainen (LUT), 1.7.2010-20.11.2014

Ilkka Niemelä (AU, vice-chair), 24.2.2012-31.12.2013

Kaisa Miettinen (UJ), 1.8.2012-13.1.2014

Jouko Väänänen (UH, chair), 1.4.2014-23.8.2017

Jari Hämäläinen (LUT), 20.11.2014-

Hannu Koskinen (UH), 1.4.2014-31.3.2018

Jaakko Puhakka (TUT), 6.2.2014-13.1.2015

Tuija Pulkkinen (AU, vice-chair 2.9.2016-31.10.2018), 1.1.2014-31.10.2018

Mikko Ritala (UH), 1.4.2014-31.3.2018

Kenneth Österberg (UH, personnel representative), 1.4.2014-31.3.2018

Mikko Alava (AU), 1.4.2016-

APPENDIX B: HIP research programs and projects 1996-2016

Theory Program

Program Directors: Stig Stenholm 1.9.1996-31.12.1997, Antti Niemi 1.1.1998-31.12.1998, Kari Enqvist 1.1.1999-31.12.2010, Kari Rummukainen 1.1.2011-

Mathematical Physics and Field Theory 1.10.1996-31.12.2001

Antti Kupiainen 1.10.1996-31.12.2000

Masud Chaichian 1.1.2001-31.12.2001

Laser Physics and Quantum Optics 1.10.1996-31.12.2003

Stig Stenholm 1.10.1996-31.5.1997

Kalle-Antti Suominen 1.6.1997-31.12.2003

Statistical Physics and Materials Science 1.10.1996-31.12.2002

Tapio Ala-Nissilä

Particle Cosmology 1.1.1998-31.12.1998

Kari Enqvist

Particle Phenomenology 1.1.1998-31.8.1999

Katri Huitu

Particle Theory and Cosmology 1.9.1999-31.12.2000

Katri Huitu

Cosmology 1.1.2001-31.12.2007

Kari Enqvist

Particle Physics Phenomenology 1.1.2001-31.12.2007

Katri Huitu

Physics of Biological Systems 1.1.2002-31.12.2007

Ilpo Vattulainen

String Theory and Quantum Field Theory 1.1.2002-31.12.2007

Esko Keski-Vakkuri

Ultrarelativistic Heavy Ion Collisions 1.1.2002-31.12.2007

Kari J. Eskola

Cosmophysics 1.1.2008-31.12.2013

Kimmo Kainulainen

Laws of Nature and Condensed Particle Matter Phenomenology at the LHC 1.1.2008-31.12.2013

Kimmo Tuominen

String Theory and Mathematical Physics 1.1.2008-31.12.2010

Esko Keski-Vakkuri

Low Dimensional Quantum Systems 1.1.2008-31.12.2013

Ari Harju

Radiation Damage in Particle Accelerator Materials 1.1.2008-31.12.2013

Kai Nordlund 1.1.2008-31.12.2010

Flyura Djurabekova 1.1.2011-31.12.2013

Cosmology of the Early and Late Universe 1.1.2014-31.12.2019

Syksy Räsänen

High Energy Phenomenology in the LHC Era 1.1.2014-31.12.2022

Aleksi Vuorinen

QCD and Strongly Interacting Gauge Theory 1.1.2014-31.12.2022

Tuomas Lappi

Nuclear Structure for Weak and Astrophysical Processes 1.1.2014-31.12.2019

Markus Kortelainen

Domain Wall Dynamics 1.1.2014-31.12.2019

Lasse Laurson

High Energy Physics Program (1.9.1996-31.12.2013)

Program Directors: Risto Orava 1.9.1996-28.2.2001, Heimo Saarikko 1.3.2001-31.12.2013

Phenomenology 9.12.1996-31.12.1997

Katri Huitu

Electron-Positron Physics 1.10.1996-31.12.2007

Risto Orava 1.10.1996-31.12.2000

Kenneth Österberg 1.1.2001-31.12.2007

Detector Research and Development 1.10.1996-31.12.1997

Tom Schulman 1.10.1996-31.12.1996

Kari Kurvinen 1.1.1997-31.12.1997

LHC Forward Physics 1.1.2001- 31.12.2010

Risto Orava

COMPASS 1.1.2001-31.12.2003

Peter Berglund

Linear Collider Research 1.1.2008-31.12.2013

Kenneth Österberg

TOTEM Operation 1.1.2011-31.12.2013

Risto Orava

CMS Program (change of name, until 30.6.2002 LHC Program)

Program Directors: Eero Byckling 1.9.1996-31.7.1997, Jorma Tuominiemi 1.8.1997-30.9.2010, Paula Eerola 1.10.2010-31.12.2015, Kenneth Österberg 1.1.2016-

LHC Experiments 1.10.1996-31.8.1997

Jorma Tuominiemi

Software and Physics 1.11.1997-31.12.2006

Veikko Karimäki

CMS Tracker 1.11.1997-31.12.2007

Miikka Kotamäki 1.11.1997-31.12.1999

Eija Tuominen 1.9.2000-3.6.2004, 1.9.2005-31.12.2007

Edward Hæggström 15.6.2004-31.8.2005

Nuclear Matter Physics 1.1.1998-31.12.2001

Vesa Ruuskanen

CMS Physics Analysis 1.1.2007-31.12.2009

Veikko Karimäki

CMS Tracker Operations 1.1.2008-31.12.2009

Eija Tuominen 1.1.2008-31.12.2008

Paula Eerola 1.1.2009-31.12.2009

CMS Experiment 1.1.2010-

Paula Eerola 1.1.2010-31.12.2010

Katri Lassila-Perini 1.1.2011-31.12.2015

Mikko Voutilainen 1.1.2016-

CMS Upgrade 1.1.2010-

Jaakko Härkönen 1.1.2010-30.4.2016

Panja-Riina Luukka 1.5.2016-

Tier-2 Operations 1.1.2011-

Tomas Lindén

TOTEM 1.1.2014-

Heimo Saarikko 1.1.2014-31.12.2014

Kenneth Österberg 1.1.2015-

Technology Program

Program Directors: Ari-Pekka Hameri 1.9.1996-31.12.2011, Saku Mäkinen 1.1.2012-31.12.2017

Process and Quality Control 1.10.1996-31.12.1999

Jukka Nihtilä 1.10.1996-31.7.1997

Mika Lahti 1.8.1997-31.8.1999

Distributed Data Management 1.10.1996-31.12.2002

Juho Nikkola 1.10.1996-30.9.1998

Rainer Puittinen 1.10.1998-30.9.2000

Marko Niinimäki 1.1.2001-31.12.2001

Miika Tuisku 1.1.2002-31.12.2002

Project Management Tools 1.11.1997-31.12.2000

Eero Tervonen 1.11.1997-31.12.1999

Timo Hakulinen 1.1.-31.3.2000

DataGrid 1.1.2001-31.12.2013

Matti Heikkurinen 1.1.2001-31.12.2002

Miika Tuisku 1.1.2003-31.12.2013

GridCluster 1.1.2008-31.12.2010

Antti Pirinen 1.1.2008-15.8.2010

Tomas Lindén 16.8.2010-31.12.2010

Green IT 1.1.2011-31.12.2013

Tapio Niemi

PET Project 1.1.2011-31.12.2013

Ulla Ruotsalainen

Accelerator Technology 1.1.2014-31.12.2017

Kenneth Österberg 1.1.2014-31.12.2014

Markus Aicheler/Flyura Djurabekova 1.1.2015-31.12.2017

Green Big Data 1.1.2014-31.12.2017

Tapio Niemi 1.1.2014-31.12.2014

Jukka K. Nurminen 1.1.2015-31.12.2017

Biomedical Imaging 1.1.2014-31.12.2016

Ulla Ruotsalainen

Finnish Business Incubation Center of CERN Technology (BIC) 1.1.2015-31.12.2020

Saku Mäkinen

Novel Instrumentation for Nuclear Safety, Security and Safeguards (NINS3) 1.1.2015-31.12.2018

Peter Dendooven

Nuclear Matter Program

Program Directors: Juha Äystö 1.1.2002-31.3.2012, Matti Leino 1.4.2012-31.12.2013, Ari Jokinen 1.1.2014-

ALICE 1.1.2002-

Wladyslaw Trzaska 1.1.2002-31.12.2004

Markku Oinonen 1.1.2005-28.2.2007

Jan Rak 6.3.2007-31.12.2018

ISOLDE 1.1.2002-

Ari Jokinen 1.1.2002-31.12.2011

Paul Greenlees 1.1.2012-31.12.2014

Janne Pakarinen 1.1.2015-

FAIR 1.1.2009-

Juha Äystö 1.1.2009-31.3.2012

Ari Jokinen 1.4.2012-31.12.2014

Tuomas Grahn 1.1.2015-

ALICE-Forward 1.1.2015-31.12.2018

Risto Orava 1.1.2015-30.9.2018

Projects outside research programs

CLOUD 1.1.2006-

Markku Kulmala

Planck 1.1.2008-31.12.2013

Hannu Kurki-Suonio

Detector Laboratory 1.1.2014-31.12.2016

Eija Tuominen

Forward Physics 1.1.2014-31.12.2014

Risto Orava

Planck-Euclid 1.1.2014-31.12.2019

Hannu Kurki-Suonio

Education and Open Data 1.1.2017-

Katri Lassila-Perini

APPENDIX C: HIP personnel 1996-2016

Directors:

Professor Eero Byckling 1.9.1996-30.6.2000

Professor Dan-Olof Riska 1.7.2000-31.3.2012

Professor Juha Äystö 1.4.2012-31.12.2015

Professor Paula Eerola 1.1.2016-31.12.2017

Administrative staff:

Administrative manager:

Doc. Erkki Pajanne 1.9.1996-31.3.1999

Doc. Matti Kaivola (substitute) 1.2.-30.6.1999

Doc. Mikko Sainio 1.4.1999-31.8.2016 (on leave 1.4.-30.6.1999)

Finance manager:

Civil ekonom Hannu Luutonen 7.11.1996-20.3.2000

Jaana Juhola 6.3.-30.4.2000 (substitute from Eilakaisla personnel services)

MSc (Economics) Tarja Sandelin (formerly Kalpio) 16.4.2000-13.4.2016

Secretaries:

The HIP administrative staff moved to University Services on 1.5.2016, and as a result, the end date 30.4.2016 mentioned below follows.

Kristiina Hakala 1.1.1997-31.12.1998

Tarja Vallius 1.1.1997-26.11.1998

Maija Rauhamäki 1.1.1997-30.11.1998

Tarja Jokinen 19.11.1998-6.4.2001 (on leave 14.6.-10.9.1999, 6.7.-8.9.2000)

Kristiina Kraappa 16.11.1998-8.7.2000

Taina Hardén 26.6.2000-30.4.2016

Hannele Myllykangas 1.9.2001-22.1.2002 (substitute)

Susanna Niemi 18.1.2002-15.6.2002 (substitute)

Päivi Lehto 1.5.2001-2.4.2008 (on leave 1.6.-31.8.2002)

Katri-Meri Karttunen 1.5.2008- 31.12.2010 (joint position)

Tarja Heikkilä (formerly Kiljunen) 27.6.2011 -30.4.2016

Lea Repo 3.6.-30.9.1999, 1.6.-15.9.2000 13.3.-31.5.2001 (substitute)

Pirjo Rantanen 1.12.2010-18.4.2011

Secretaries at CERN:

Marika Flygar 1.1.1997-31.12.2008

Christine Sivori 1.2.1998-30.9.2000

Tuija Karppinen 9.10.2000-30.4.2016

Taina Onnela 6.1.2009-30.4.2016

Laboratory staff:

Kari Kurvinen 1.1.1997-28.2.2009 (on leave 1.6.2000-31.1.2001)

Rauno Lauhakangas 1.1.1997-31.5.2016 (on leave 9.2.-8.7.2005)

Jouni Heino 1.1.1997-31.8.2023

Antti Numminen 1.1.1997-31.10.2010 (laboratory technician)

Tapio Vehviläinen 1.1.1997-30.6.2003

Juha Aaltonen 1.10.2003-

Tomas Lindén 1.1.2010-

Eija Tuominen 1.1.2008-30.4.2023 (on leave 1.1.2008-31.12.2016)

Francisco Garcia Fuentes 1.1.2009-

Pirkitta Koponen 7.9.2016-

Jarmo Kortesmaa 1.4.2004-30.6.2005 (micro mechanic)

Auli Kuronen 8.12.2003-30.6.2005 (micro mechanic)

Mirja Luoma 1.1.-31.10.1997 (laboratory technician)

Jarmo Suomalainen 1.1.-28.2.1997

Kalle Hanhijärvi 3.3.-14.8.2008

Raimo Turpeinen 16.11.2010- (laboratory technician)

Felix Smeds 1.1.2013-30.6.2014

Kari Rytkönen 1.9.2013-31.8.2015

IT staff:

Marko Myllymäki 1.4.1998-12.5.2000 (senior system analyst)

Natalia Jiganova 13.6.2000-31.12.2007 (IT specialist; moved to University's IT Services)

Juho Vähäkangas 16.4.-30.9.2003 (micro support person)

Other support staff:

Olli Vuola 1.1.-31.12.1997, 1.3.-30.4.1998 (technology transfer)

Riitta Rinta-Filppula 1.1.2010-31.7.2016 (pedagogical expert)

HIP's researchers are not listed here, nor are the appointments of support staff members to research positions.

ACRONYMS AND ABBREVIATIONS

ALICE	A Large Ion Collider Experiment, an experiment at the LHC at CERN
ATLAS	A Toroidal LHC Apparatus, an experiment at the LHC at CERN
AU	Aalto University
AXPET	Axial PET
BNL	Brookhaven National Laboratory, NY, USA
Caltech	California Institute of Technology
CDF	Collider Detector at Fermilab
CERN	Conseil Européen pour la Recherche Nucléaire, European Council for Nuclear Research
CLIC	Compact Linear Collider
CLOUD	Cosmics Leaving Outdoor Droplets
COMPASS	Common Muon Proton Apparatus for Structure and Spectroscopy, an experiment at CERN
CMS	Compact Muon Solenoid, an experiment at the LHC at CERN
CSC	Center for Scientific Computing
CTF	CLIC Test Facility
DELPHI	Detector with Lepton, Photon and Hadron Identification, an experiment at the LEP collider at CERN
DESY	Deutsches Electronen-Synchrotron, a research center in Hamburg

ECFA	European Committee for Future Accelerators
EDMS	Engineering Data Management System
EGEE	Enabling Grids for eScience in Europe
ESA	European Space Agency
ESFRI	European Strategy Forum on Research Infrastructures
ESRF	European Synchrotron Radiation Facility, Grenoble
ETH	Eidgenössische Technische Hochschule, Zürich
FAIR	Facility for Antiproton and Ion Research, Darmstadt
FNAL	Fermi National Accelerator Laboratory, “Fermilab”
FTE	Full Time Equivalent
GEM	Gaseous Electron Multiplier
GRASPANP	Graduate School in Particle and Nuclear Physics
GSI	Gesellschaft für Schwerionenforschung, Darmstadt
HIP	Helsinki Institute of Physics
HL-LHC	High Luminosity LHC
HTI	Hiukkasteknologian instituutti, Institute of Particle Physics Technology
HUT	Helsinki University of Technology, TKK
ISOLDE	Isotope Separator On Line DEvice, a facility at CERN
JINR	Joint Institute for Nuclear Research, a research center in Dubna, Russia
KTH	Kungliga Tekniska Högskolan, Stockholm

L3	A large detector at the LEP Collider at CERN
LEP	Large Electron-Positron collider, a collider at CERN
LHC	Large Hadron Collider, a proton-proton collider at CERN
LMU	Ludwig-Maximilians-Universität München
LUT	Lappeenranta University of Technology
MoU	Memorandum of Understanding
MPI	Max Planck Institute
MSGC	Micro-Strip Gas Chamber
MSSM	Minimal Supersymmetric Standard Model
NDGF	Nordic Data Grid Facility
NICPB	National Institute of Chemical Physics and Biophysics, Tallinn
NIKHEF	Nationaal Instituut voor Kernfysica en Hoge-Energiefysica, Dutch National Institute for Subatomic Physics
NINS3	Novel Instrumentation for Nuclear Safety, Security and Safeguards
NORDITA	Nordic Institute for Theoretical Physics
NOS-N	The Joint Committee of the Natural Science Research Councils in the Nordic Countries
OPM	Opetusministeriö, Ministry of Education
PANU	Doctoral Programme in Particle and Nuclear Physics
PET	Positron Emission Tomography

PHENIX	Pioneering High Energy Nuclear Interaction eXperiment, an experiment at the RHIC at BNL
QCD	Quantum Chromo Dynamics
RAL	Rutherford Appleton Laboratory
RECFA	Restricted ECFA, the executive team of ECFA
RF	Radio Frequency
RHIC	Relativistic Heavy Ion Collider, a collider at BNL
RPC	Resistive Plate Chamber
RRB	Resource Review Board
SAB	Scientific Advisory Board
SEFT	Suurenergiafysiikan tutkimuslaitos, Research Institute for High Energy Physics
SITRA	Suomen itsenäisyyden juhlarahasto, The Finnish Innovation Fund Sitra
SMC	Spin Muon Collaboration, an experimental collaboration at CERN
SPS	Super Proton Synchrotron
STUK	Säteilyturvakeskus, Radiation and Nuclear Safety Authority in Finland
TDR	Technical Design Report
Tekes	Finnish Technology Funding Agency
TFT	Teoreettisen fysiikan tutkimuslaitos, Research Institute for Theoretical Physics
TOTEM	Total, elastic and diffractive cross-section measurement, an experiment at the LHC at CERN

TPC	Time Projection Chamber
TUT	Tampere University of Technology
UH	University of Helsinki
UJ	University of Jyväskylä
VTT	Technical Research Centre of Finland
WU	Web University

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NAME INDEX

Note: Italic page numbers indicate illustrations.

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The Helsinki Institute of Physics was established in 1996 through the amalgamation of three institutes in two universities: the Research Institute for Theoretical Physics (TFT) and the Research Institute for High Energy Physics (SEFT) at the University of Helsinki, along with the Institute of Particle Physics Technology (HTI) at the Helsinki University of Technology. The primary impetus behind this consolidation was the deepening collaboration with CERN, of which Finland became a member in 1991. This publication provides an overview of the Institute's endeavors in research, education, and community engagement spanning the initial two decades until 2016.