Annual Report 2006

HELSINKI INSTITUTE OF PHYSICS

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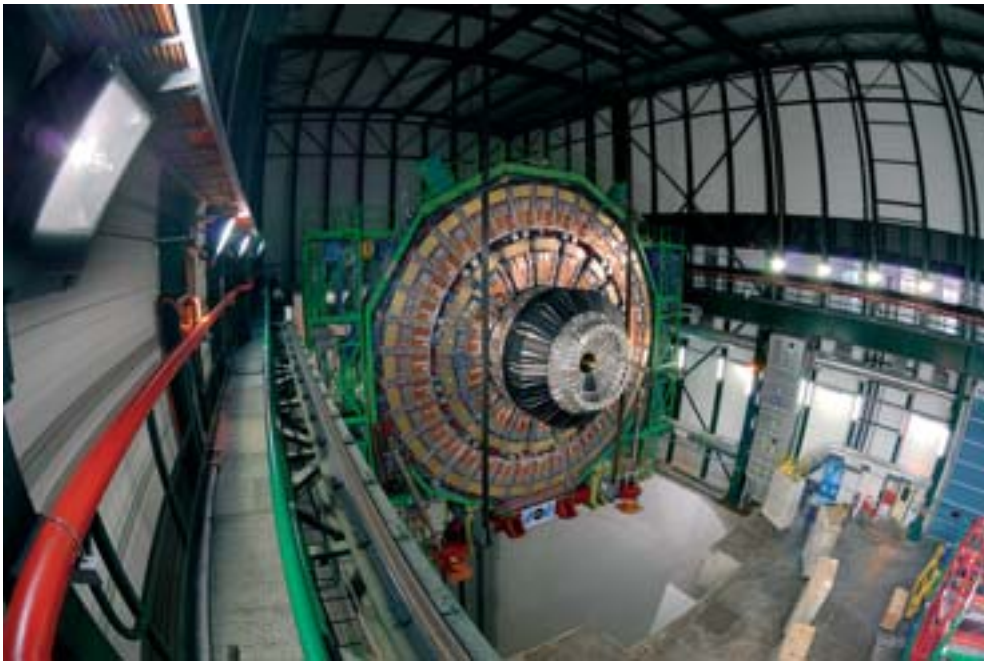


The lowering of the big parts of the CMS detector to the underground cavern was started at the end of 2006. In the picture one of the end-caps of the detector is nearing touchdown in the cavern, after a 100 meter long descent from the surface building, where the CMS detector has been in construction since 2001. The proton beams will traverse the cavern along the axis of the detector and collide in the centre. The four cable bundles of the gantry, holding the end-cap, are visible in the picture. The picture also shows how the forward myon detectors are fixed to the end-cap. The "nose" is the very forward hadron calorimeter.

Annual Report 2006 Helsinki Institute of Physics

Contents

Introduction

Dan-Olof Riska

The year 2006 was the tenth year of operation of the Helsinki Institute of Physics (HIP). The Institute, which was formed by legislation by the Parliament of Finland in 1996, commenced its work on January 1, 1997. The three operating partners of the Institute – the Universities of Helsinki and Jyväskylä and the Helsinki University of Technology – were joined during the year by Lappeenranta University of Technology.

In addition to the mandate of the Institute given by the Finnish Ministry of Education for co-ordinating the Finnish research at CERN an additional mandate was given to the Institute in 2005 for the planning of the Finnish collaboration with the Facility for Antiproton and Ion Research FAIR. This mandate was continued in 2006 until the end of 2007. The FAIR facility shall be constructed as an international facility at the GSI Accelerator Laboratory site in Darmstadt 2008–2014.

The modus operandi of the Institute is to carry out time limited research projects that are too resource intensive or too cross disciplinary or novel to fit into the standard framework for funding of academic research in Finland. An important task of the Institute is to support the research and teaching departments in its member universities by means of joint research projects and by graduate training within these research projects. An example of the success of this collaboration is the fact that 16 project leaders and researchers of the Institute have been appointed to professorial positions at several different universities both in Finland and abroad.

During the year 2006 the research activities at HIP fell into the following research programmes: (1) the Theory Programme, (2) the High Energy Physics Programme, (3) the CMS Programme, (4) the Nuclear Matter Programme and (5) the Technology Programme.

The Theory Programme serves as a Finnish project oriented national institute for theoretical physics. During the year the Programme consisted of the following five projects: (1) string theory and quantum field theory, (2) the physics of biological systems, (3) the theory of ultrarelativistic heavy ion collisions, (4) cosmology and (5) particle physics phenomenology.

The High Energy Physics Programme continued its projects for detector development for forward proton-proton physics study in the TOTEM experiment at the Large Hadron Collider LHC at CERN and at the CDF-II experiment at the Tevatron collider at the Fermi National Accelerator Laboratory. Because of the very successful experimental discoveries with the CDF detector the memorandum-of-understanding for participation in the CDF-II collaboration was continued until 2009, which will be the terminal year of the Tevatron. The memorandum-of-understanding for the TOTEM experiment collaboration was signed during the year. The analysis of the data accumulated by the completed DELPHI experiment at the previous LEP collider at CERN was brought to completion.

The CMS Programme was divided into two projects: one for the development of the tracker and the trigger of the CMS detector at the LHC and the other for software development for the CMS data analysis. The CMS Software and Physics project was brought to completion at the end of the year with the development of the CMS Physics Technical Design Report. During the year the project underwent a satisfactory in-depth review. On the basis of this review the Board of the Institute established a new project for CMS physics research to commence at the beginning of 2007, which will be the first year of data taking at the LHC.

The Nuclear Matter Programme of the Institute was divided into 2 projects. The first is a nuclear structure research project at the ISOLDE facility at CERN. The second is a project for physics analysis at and instrumentation for the ALICE detector for relativistic heavy ion collisions at the LHC. In addition the Programme contained a special project for planning the Finnish contribution to the FAIR project. During 2006 the contributing partners to FAIR continued the memorandum-of-understanding for the planning phase of FAIR to the end of 2007.

The Technology Programme of the Institute develops industrial applications for CERN generated innovations. During 2006 the focus of the Technology Programme was on software development for distributed data-intensive Grid computation. The project is the Finnish member of the European Union funded Enabling Grids in E-sciencE project and an associate the CERN Openlab for Grid applications project. The latter is carried out in collaboration with the Finnish IT center for science CSC. The Programme runs a project "Netgate" for the development of Grid technology for industry, with support of the National Technology Agency of Finland TEKES.

The Institute is the Finnish partner of the LHC Computing Grid Project at CERN for the establishment of the distributed high-throughput computing capacity that will be required by analysis of the data taken at the LHC detectors.

The successful review by an international expert panel of those components and activities of the Institute, which have a clear association with the University of Helsinki, led to a decision in 2006 by the University to reward the Institute with an additional financial reward grant for the 6 year period 2007–2012.

The Institute has continued its strong efforts in graduate student training in frontline research. This activity is supported in part by the national graduate school programmes. The graduate training efforts were greatly strengthened by generous grants by several Finnish foundations. During 2006, 8 PhD and DSc degrees and 13 MA and MSc degrees were awarded on the basis of research conducted within the research projects of the Institute.

The summer student programmes at CERN and Fermilab represent a key educational effort. During the summer of 2006 14 Finnish students worked at CERN and 1 at Fermilab in HIP research programmes. The science education sessions for Finnish high schools at CERN represent a significant outreach activity. In 2006 the Institute hosted a record 14 study visits by Finnish high school students and 2 training sessions for teachers in Finnish "gymnasiums" at CERN. In addition a CERN visit was arranged for a group of rectors of Finnish "gymnasiums".

In 2006 the Board of the Institute approved a strategy for HIP for the period 2007–2009. The strategy is based on the national strategy for the Finnish collaboration with CERN. The strategy is commensurate with the expected budget frame of the Institute during that 3 year period.

The extraordinarily successful co-operation between the Institute and the Finpro association for co-ordination of the collaboration between CERN and Finnish industry continued in 2006.

The 10 years of HIP operations have proven the efficiency of the Institute as the main national agent for the Finnish research and technology development efforts at large international accelerator laboratories. The broad and high visibility outreach and technology transfer achievements in that period would have been unlikely without the co-ordinating national institute. At the same time the Institute proved able to carry on the tradition in theoretical physics that it inherited from the previous national Research Institute for Theoretical Physics.

HIP is governed by a tripartite board appointed by the universities that operate the Institute. During the year the Board was chaired by Vice Rector Marja Makarow of the University of Helsinki. The scientific activities of the Institute were overseen by an international Scientific Advisory Board, which was chaired by Dr. Wolf-Dieter Schlatter, director of the Physics Department at CERN. The Institute is deeply grateful for the service of the 3 members of the Advisory Board, professors Maurice Rice and Hans Specht and Dr. Martti Mäenpää, who completed their terms in 2006.

Highlights of Research Results

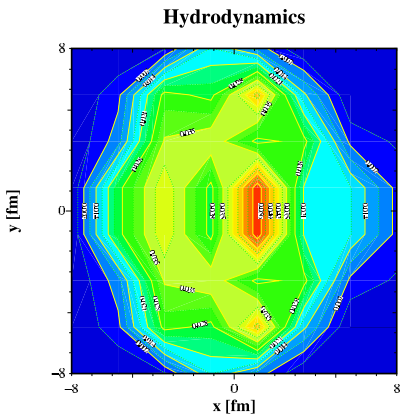
Theory Programme

In Cosmology we presented a novel model of inflation, based on the flat directions of the Minimally Supersymmetric Standard Model, which are gauge invariant combinations of squarks and sleptons. We also considered alternative explanations of dark energy by studying both the effects of inhomogeneities and models with extended Einstein gravity. In collaboration with the Department of Physical Sciences, the Cosmology project continued to participate in the Finnish Planck Surveyor Consortium.

In Particle Physics Phenomenology the detection of the mixing between the supersymmetric partner of the neutrino, called the sneutrino, and its antiparticle has been studied in a linear electron photon collider, and its existence has been found to be possible in specific models. Thus information on the parameters affecting the very weakly interacting neutrino sector can be obtained, and through the sneutrino-antisneutrino mixing, neutrino masses and mixing angles can possibly be studied in the laboratory.

The Biophysics group expanded its activities to Tampere University of Technology (Finland) and the University of Western Ontario (Canada). In terms of research, it focused on the multi-scale modelling of cellular membrane systems, paying particular attention to highly ordered membrane domains known as lipid rafts. The most recent related work was published in PLoS Computational Biology.

The String Theory and Quantum Field Theory group has considered the famous question whether the experience of "time" could be viewed as an emergent concept. We present a string theoretic example, where time evolution is mapped to a sequence of points of thermodynamic equilibrium of a simple statistical mechanical system, with the arrow of time emerging from increasing relative Shannon entropy. In addition, inspired by the twisted Poincaré symmetry introduced by the group, the existence of a principle of "twisted symmetry" in noncommutative Field Theory was investigated.



The Heavy Ion Project has studied the prospects of QCD matter tomography in A+A collisions at RHIC through high-p_T hadron-hadron and photon-hadron correlations by considering radiative energy losses of energetic partons propagating in a QCD medium. Bulk hadron spectra in the LHC Pb+Pb collisions have been predicted in a hydrodynamic framework. Thermalization of the QGP has been addressed via quark-antiquark production from classical gluon fields. The properties of hot QCD matter have been explored by presenting an exact time-dependent solution of classical Einstein gravity equations in 5d space and studying its boundary values in physical 4d space. We have also considered cosmological implications and dark matter candidates from a new class of Technicolour models.

High Energy Physics Programme

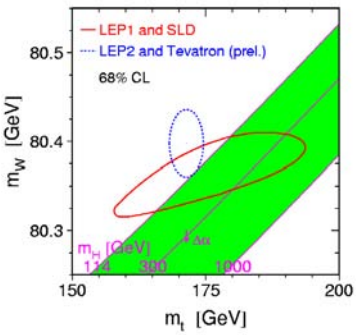
The Tevatron accelerator, located at Fermi National Laboratories, Chicago, USA currently represents the high energy frontier of High Energy Physics, hosting two multi-purpose experiments D0 and CDF, the latter being an international collaboration with intense participation from the Helsinki particle physics group. In 2006, the large effort invested in re-designing the CDF software, simulation and analysis framework, together with the excellent performance of the Tevatron accelerator allowed us to present the community with a large amount of stunning new results, three of which are highlighted here: the first observation of $B_s^0 \to \overline{B}_s^0$ oscillations, the discovery of four new heavy baryons $\Sigma_b^{\pm}$ and $\Sigma_b^{*\pm}$, and the single most precise measurement of the W boson mass.

First observation of $B_s^0 \to \bar{B}_s^0$ oscillations. The oscillation of the B_s^0 meson, a particle containing a b quark and an anti-s quark, to its antiparticle, the $\bar{B}_s^0$ meson, and vice-versa was first observed in 2006 by the CDF experiment [*Phys. Rev. Lett. 97 (2006) 242003*]. The more than 5 standard deviation significance was extracted from a time-dependent measurement of the $B_s^0 \to \bar{B}_s^0$ oscillation frequency, Δm_s. The measured Δm_s value is 17.77 ± 0.10 (stat.) ± 0.07 (syst.) ps^{-1}. The measurement is an important ingredient in constraining the unitarity triangle for CP violation in the b quark sector in the Standard Model for particle interactions. The unitarity triangle is in turn intimately related to understanding the creation of the imbalance between matter and antimatter in the early universe.

Discovery of four new heavy baryons: $\Sigma_b^{\pm}$ and $\Sigma_b^{*\pm}$. Collider machines provide a wealth of experimental data on bottom mesons. Yet at this time only one bottom baryon, Λ_b^0, has been directly observed. Currently, the CDF Collaboration possesses the world's largest data sample of bottom baryons, due to a combination of two factors: the CDF displaced track trigger and the >1 fb^{-1} of integrated luminosity delivered by the Tevatron.

The QCD treatment of quark-quark interactions significantly simplifies if one of the participating quarks is much heavier than the QCD confinement scale. In the limit of $m_Q \to \infty$, where m_Q is the mass of the heavy quark, the angular momentum and the flavour of the light quarks become good quantum numbers. This approach, known as Heavy Quark Effective Theory, thus views the Σ_b baryons as a heavy quark colour field, surrounded by a cloud corresponding to the light diquark system. The quark composition of the Σ_b is (uub) for the positively charged baryons and (ddb) for the negatively charged baryons. As the heavy quark is not infinitely massive, there is a small mass splitting between the spin doublet $\{\Sigma_b, \Sigma_b^*\}$. There is also an additional isospin splitting between the $\Sigma_b^{(*)+}$ and $\Sigma_b^{(*)-}$ states. The extensive range of theoretical predictions concerning the mass differences of these states and their widths are consistent with the CDF measurements: using the fully reconstructed decay mode $\Sigma_b^{(*)\pm} \to \Lambda_b^0 \pi^{\pm}$, CDF observed in 2006 the four lowest lying charged $\Lambda_b^0 \pi$ resonant states with masses $m(\Sigma_b^+) = 5808^{+2.0}_{-2.3}$ (stat.) ± 1.7 (syst.) MeV/c^2, $m(\Sigma_b^-) = 5816^{+1.0}_{-1.0}$ (stat.) ± 1.7 (syst.) MeV/c^2, $m(\Sigma_b^{*+}) = 5829^{+1.6}_{-1.8}$ (stat.) ± 1.7 (syst.) MeV/c^2, and $m(\Sigma_b^{*-}) = 5837^{+2.1}_{-1.9}$ (stat.) ± 1.7 (syst.) MeV/c^2.

First measurement of the W boson mass with CDF in Run II. Using about 200 pb^{-1} of Run II data, with 63,964 $W \to e\nu$ candidates and 51,128 $W \to \mu\nu$ candidates, CDF extracted the W boson mass from a template fit to the transverse mass, transverse momentum and transverse missing energy distribution. The lineshape of the template distribution is obtained using a fast Monte Carlo simulation. These lineshape predictions depend on a number of physics and detector effects which are constrained using control samples or simulation. Important physics effects include internal QED radiation, the intrinsic W boson transverse momentum and the proton parton distribution functions. Important detector effects include external bremsstrahlung and ionization energy loss in the detector material, tracker momentum scale, calorimeter energy scale and resolutions of both detectors. The final measurement yields M_W = 80413 ± 34 (stat.) ± 34 (syst.) MeV/c^2. With a total uncertainty of 48 MeV/c^2, this represents the single most precise M_W measurement to date. The mass of the W boson, being an important parameter of the Standard Model (SM), combined with the mass of the top quark, significantly constrains the mass of the as yet unobserved Higgs particle. The new combined world average value of M_W = 80398 ± 25 MeV/c^2 shifts the SM Higgs mass estimate from $M_H = 85^{+39}_{-28}$ GeV/c^2 to $M_H = 80^{+36}_{-26}$ GeV/c^2. An illustration of the current experimental constraints on the mass of the SM Higgs is shown in the figure to the right.

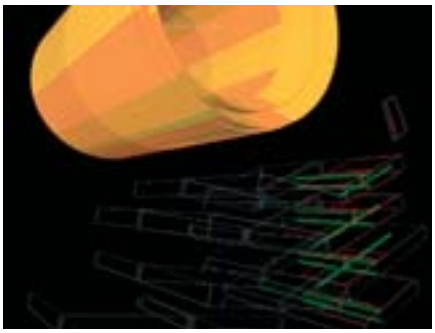


Having established a series of important measurements, surpassing the goals of the Tevatron main physics programme, a large effort is now concentrated on the direct observation of a light SM Higgs boson. Several discovery channels were examined in the Tevatron Higgs sensitivity study of 2003. The most promising modes are associated production of a Higgs and an intermediate vector boson, i.e., $p\bar{p} \to WH$ or $p\bar{p} \to ZH$, where the Higgs boson predominantly decays into two bottom quarks. The expertise gained in the analysis of the mass of the top quark in several decay channels, together with the expertise on the tagging of heavy quarks and the performance of the Silicon Vertex Detector will allow the Helsinki group to make significant contributions to future Higgs hunts.

CMS Programme

An important highlight for the CMS Programme in 2006 was the evaluation of the Software and Physics project in May. The result of the evaluation can be summarized by a citation from the evaluators' report: "In conclusion, we congratulate the HIP team on their excellent work and for the well focused programme that they have presented to us. We recommend continuing the CMS project into the next phase of data taking and analysis. We consider the HIP group very experienced and well prepared to make substantial contributions to CMS and to produce important scientific results."

The year 2006 was very successful for the CMS project overall. For the physics analysis a very important milestone was the CMS Physics Technical Design Report, published in two volumes. The report demonstrates the strength of the design of the CMS trigger and event reconstruction software and the comprehensive physics discovery potential of the experiment. The HIP Software and Physics team made important and visible contributions to the PTDR in the alignment studies and in the assessment of the CMS discovery potential for the search of MSSM Higgs bosons.



Work was pursued to prepare the computing facilities in Helsinki to comply with the CMS Computing Model. This is an important part of the CMS Programme, as appropriate computing facilities in Helsinki are indispensable for the efficient participation of the HIP team in the CMS physics analysis. Plans for the Finnish Tier-2 site at CSC were developed.

A new version of the Geant4 software package was released in December with significant improvements of many key features. In Geant4 hadronics, co-coordinated by HIP, the team continued the development and validation of the Bertini models. In a systematic validation study of all Geant4 hadronic models applied to tumour treatment with 60 MeV protons, the Bertini models were found to provide the best agreement with experimental data.

The HIP team implemented the first working alignment algorithm for the CERN TOB Cosmic Rack. This algorithm was also used in the Computing, Software & Analysis Challenge 2006 (CSA06) exercise with simulated data, in which TIB modules and TOB rods were aligned and the alignment constants were successfully applied.

An outstanding milestone in hardware activities of the CMS Programme was the completion of the CMS Tracker Outer Barrel (TOB) detector at CERN. This brought the long term HIP Mechanics project to a brilliantly successful end, within the budget and well within the CMS general construction schedule.

The commissioning of the FinnCRack at the Kumpula Detector Laboratory proceeded successfully in 2006. The FinnCRack will be used as a test station providing measurement data for testing of the TOB subsystem level functionality as well as for development of TOB software. It will also play an important role in the testing of the novel radiation hard detector prototypes for the CMS upgrade and for future experiments.

During 2006, the HIP CMS Tracker project contributed significantly to the Cryogenic Transient Current Technique (C-TCT) project of the CERN RD39 Collaboration. The first C-TCT results show that the performance of silicon detectors damaged by heavy particle radiation can be recovered at temperatures below 200 K. This finding is of outmost importance since in the conditions of the LHC luminosity upgrade the irradiation dose received by silicon detectors would be far beyond the operational limits of current sensor solutions.

The production of the trigger data link boards for the CMS Resistive Plate Chambers developed together with the Warsaw High Energy Physics group and Warsaw University of Technology was started successfully. RPCs will be used in the CMS as dedicated trigger detectors both in the barrel and in the end-caps. The first production prototype data link boards were sent to CERN at the end of 2005 to be

tested at the beginning of the year 2006. System testing was also a preparation for the Magnet Test and Cosmic Challenge campaign at P5, where the CMS magnet was tested and part of the CMS detectors were used to measure cosmic muon events. Link Boards were a crucial part of the trigger and the read-out system of MTCC. MTCC was a great success with a measurement of 14 million cosmic muon tracks in a magnetic field.

Finally, organization of the CERN School of Computing 2006 gave good visibility for high energy physics at HIP and at the Department of Physical Sciences of the University of Helsinki. The event took place at the Kumpula Campus in August, hosted by HIP. This highly regarded school was organized for the first time in Finland. The HIP CMS Programme members carried responsibilities as Local Organizers.

Nuclear Matter Programme

The Nuclear Matter Programme focuses on studies of two aspects of nuclear and hadronic matter at CERN. These are cold exotic matter with extreme composition of its proton and neutron numbers studied at ISOLDE and hot and dense matter created in relativistic heavy ion collisions. The latter theme is carried out at ALICE which aims to study the phase transitions of hadronic matter and possible signatures for a new form of matter, the quark and gluon plasma. The Nuclear Matter Programme is also co-ordinating the Finnish participation in the planning of the FAIR project at GSI. FAIR stands for Facility for Antiproton and Ion Research.

The centre of gravity of the HIP ALICE activity was clearly shifted from Helsinki to Jyväskylä during the second half of 2006. The ALICE SSD assembly was successfully completed in the Kumpula Detector Laboratory where the largest detector assembly project in the history of Finnish science was successfully finished during summer 2006.

A new data analysis group was initially established at JYFL together with continuation in R&D and construction of the T0 trigger detector. The Helsinki group continued in establishing the framework for the data analysis infrastructure for the Finnish ALICE group within the Nordic and domestic resources. The Physics group responsible for the data analysis deploys experience from the data analysis of the PHENIX experiment at RHIC and concentrates on the exploration of partonic properties and their modifications in the excited nuclear medium.

The work at ISOLDE and JYFL has continued with emphasis on studies of weak interaction phenomena via nuclear beta decay and on nuclear astrophysics related experiments. For example, superallowed $0^+ \rightarrow 0^+$ nuclear beta decays have been used to obtain precise values for a number of fundamental weak interaction parameters, such as the up-down element V_{ud} of the Cabibbo-Kobayashi-Maskawa (CKM) matrix and its role in testing the unitarity of the CKM matrix. The precision and reliability of the value for V_{ud} has a direct impact on the search for Physics Beyond the Standard Model.

Technology Programme

The Technology Programme has achieved a visible position with numerous responsibilities in EU-wide research projects concerning security in Grid computing networks. This work has facilitated the inauguration of two key Finnish software and communication security companies to the CERN Openlab initiative of technology transfer. In addition, collaboration has been active with domestic information and communication technology industry in initiating pilot installations exploiting Grid technologies. These activities continue to be funded by Finnish industry and TEKES. The mainstream work has been allocated to align Nordic Grid computing with the needs of LHC computing as the due day for the real LCH data challenge is closing in. On the research frontier the Programme has been organizing and contributing to numerous Grid related conferences and has produced several Masters' theses and numerous research papers.

Theory Programme

Kari Enqvist,
Theory Programme director,
Cosmology project leader

The Theory Programme provides a platform for the project leaders to conduct high-profile research in a few selected subject fields. The projects are fixed term with a default duration of 3+3 years. They are chosen on the basis of their scientific merits and complement the research in experimental physics at the Institute, as well as research at the host universities. The project leaders are expected to be able to secure considerable external funding for their projects; in fact all the present project leaders get their salaries from sources external to HIP. In 2006 there were five projects: Cosmology; Particle Physics Phenomenology; Physics of Biological Systems; String Theory and Quantum Field Theory; and Ultrarelativistic Heavy Ion Collisions. Outside the projects, there is also research activity in hadron physics.

Cosmology

The physics of inflation has been the focus of several studies. We have constructed a novel, low scale inflation model based on the flat directions of the Minimally Supersymmetric Standard Model (MMSM). We have shown that out of many gauge invariant combinations of squarks, sleptons and Higgses, there are two directions, LLe and udd, which are promising candidates for the inflaton and which give rise to a tilted spectrum with correct amplitude with an inflationary scale of about 1 GeV. We argue that parts of the inflaton potential can be determined independently of cosmology by future particle physics experiments and have studied the stability of the MSSM flat direction inflation models, including one-loop radiative corrections. Curvaton models based on the MSSM flat directions have also been considered, and non-Gaussianities have been studied in models of inflation with two scalar fields by computing the curvature perturbation up to second order in the δN formalism.

We have considered several alternatives to dark energy. An inhomogeneous but spherically symmetric Lemaitre-Tolman-Bondi model has been used to demonstrate that spatial variations of the expansion rate can have a significant effect on the cosmological supernova observations. A model with no dark energy but a local Hubble parameter about 15% larger than its global value fits the supernova data better than the homogeneous model with the cosmological constant. The evolution of matter fluctuations in f(R) models within the Palatini approach has been studied to find constraints that force the models to be practically indistinguishable from general relativity with a cosmological constant. The cosmological consequences of a string motivated dark energy scenario featuring a scalar field coupled to the Gauss-Bonnet invariant have also been investigated. We have shown that the model could explain the present cosmological observations, and discuss how various astrophysical and cosmological data, from the Solar system, supernovae Ia, cosmic microwave background radiation and large scale structure, constrain it.

The theory of cosmological curvature perturbations has been further developed in a completely covariant formulation to include dissipative and interacting relativistic fluids. We have also presented an approach to cosmological perturbations based on a covariant perturbative expansion between two worldlines in the real inhomogeneous universe. As an application, at an arbitrary order we have been able to define an exact scalar quantity which describes the inhomogeneities in the number of e-folds on uniform density hypersurfaces and which is conserved on all scales for a barotropic ideal fluid.

In collaboration with the Department of

Physical Sciences, the Cosmology project continued to participate in the Finnish Planck Surveyor Consortium. We are active members in the CTP working group, the purpose of which is to establish ways to estimate the temperature and polarization spectra of CMB. The activity has centred on concrete issues in map making, in particular destriping (Hannu Kurki-Suonio, Torsti Poutanen, and Reijo Keskitalo, a student), which is a tool for removing different kinds of systematic effects in CMB experiments. We have also used the improved data on the cosmic microwave background (CMB) anisotropy to show that CMB favours a significant contribution of a primordial isocurvature mode where the entropy perturbation is positively correlated with the primordial curvature perturbation and has a large spectral index.

In 2006 there were 2 PhDs in Cosmology: Antti Väihkönen and Tomi Koivisto.

Particle Physics Phenomenology

In particle phenomenology research, the focus has been on signals of new physics in future collider experiments.

In the framework of supersymmetric models, sneutrino-antisneutrino mixing was studied. The mixing occurs in supersymmetric models, where neutrinos have non-zero Majorana masses. This can lead to the sneutrino decaying into a final state with a "wrong-sign charged lepton". The studied signal at the linear electron photon collider is free of any Standard Model background and the supersymmetric backgrounds are small. It has been shown that such a signal can be observed experimentally, e.g., in an anomaly-mediated supersymmetry breaking scenario. Information on a particular combination of the neutrino masses and mixing angles can also be extracted through the detection of sneutrino-antisneutrino mixing.

The discovery of flavour violation in neutrino oscillation has opened up a new era for flavour physics in the leptonic sector. This discovery encourages the search for flavour violation in the charged lepton sector, and if low energy supersymmetry is discovered, then in the slepton sector. The potential of the linear collider was investigated in discovering lepton flavour violation in the class of scenarios where the gravitino is the lightest supersymmetric particle, and the stau is the next-to-lightest supersymmetric particle. The estimated sensitivity is compared with the constraints stemming from the non-observation of rare decays.

The production of a Standard Model Higgs boson with a mass in the range 120-140 GeV has been analyzed at the LHC in association with two jets plus a central photon, and for the Higgs boson decaying into a b-b(bar) pair. Compared to the Higgs production via vector-boson fusion without radiation, the request of a further photon with large transverse momentum enhances the signal/background ratio, after optimized kinematical cuts are applied. Thus, the determination of the cross section for the associated production of a Higgs boson, decaying into a b-b(bar) pair, plus a central photon in vector-boson fusion could help in measuring the b-b(bar)-Higgs coupling, and the W-W-Higgs coupling as well.

The photon splitting phenomenon is studied in external and constant magnetic/electric fields induced by the coupling of ultra-light spin zero neutral particles to two photons. To this class of models belongs the axion, which is the pseudo Goldstone boson of the Peccei-Quinn symmetry. The mechanism of photon splitting in a magnetic field induced by ultra-light scalar and pseudoscalar fields for laboratory experiments has been analyzed.

The group has actively participated in the Nordic network "Discovery physics at the LHC", and organized a network meeting in Helsinki.

Hadron Physics Activity. It was demonstrated that the present data on the strangeness form factors of the proton may be interpreted as arising from the $uud\bar{s}$ configuration that has the lowest energy if it has a very compact spatial extent. The data indicate that the longest range kaon loop fluctuations are suppressed.

A dynamical model calculation that takes into account the coupling between valence and sea-quark configurations was shown to indicate that the low lying N(1400) positive

Katri Huitu, Particle Physics Phenomenology project leader

parity nucleon resonance is formed as a mixture of an excited qqq configuration and the lowest energy $qqqq\bar{q}$ configuration.

It was shown that with only minor admixtures of $qqqq\bar{q}$ configurations it becomes possible to obtain realistic estimates of the pionic and electromagnetic decay rates of the $\Delta(1232)$ and $N(1440)$ resonances. It was also shown that inclusion of minor $qqqq\bar{q}$ components makes it possible to describe the magnetic moments of the ground state baryons more accurately than what is possible with the qqq constituent quark model.

The Skyrme model for the α-particle was canonically quantized in the collective coordinates approach. It was shown that the empirical charge form factor of the α-particle is bracketed by that given by the ground state solution and that, which is obtained with the product ansatz that applies at large internucleon separation.

The polarizabilities of the charged pion have been evaluated to two loops in Chiral Perturbation Theory.

The work on a pion-nucleon phase shift analysis with fixed-t constraints has continued.

A new set of lattice configurations from UKQCD has been utilized. These are expected to be an improvement over earlier ones by increasing the amount of smearing in the time direction of the heavy quark propagator. In addition, the resultant lattice data were analyzed in more detail than earlier using, amongst other improvements, Bayesian ideas. Particular attention was paid to the P- and D-wave spin orbit splittings – a topic of current interest.

Ilpo Vattulainen, Physics of Biological Systems project leader

Physics of Biological Systems

The Biological Physics and Soft Matter (BIO) group focuses on the theory and computational modelling of biologically relevant soft-matter. This work is guided by the idea of combining the methods and ideas of statistical physics with novel computational techniques to deal with topical problems of complex soft-matter systems.

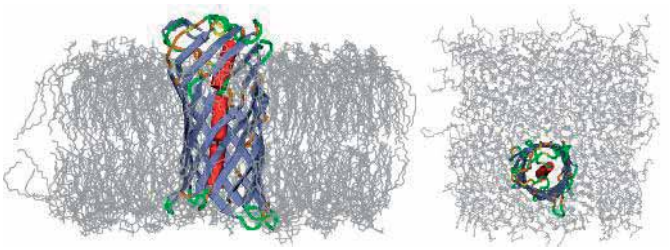
The BIO group was initiated at the Laboratory of Physics (Helsinki University of Technology/HUT) in January 2001 and it joined the Theory Programme of the Helsinki Institute of Physics (HIP) (www.hip.fi) in January 2002. Consequently, the BIO group operates jointly at HUT and as part of HIP. Further, in 2006 the BIO group expanded to Tampere University of Technology, where it is also co-ordinating substantial research activities in the field of biological physics.

The BIO group is part of various networks, including SimBioMa (ESF), MOLSIMU (COST), FuncDyn (ESF), and the NORDITA network on biological physics. In 2006, the group published 14 articles in international high-quality journals, 6 articles are in press, and many under review. The BIO group is also part of the Computational Condensed Matter and Complex Materials Group (COMP) at the Laboratory of Physics in HUT, which in 2005 was selected as a Centre of Excellence by the Academy of Finland for 2006–2011. Further, the group is an associate member of the MEMPHYS biophysics group in Odense, Denmark, which was chosen as a Centre of Excellence by the Danish National Research Foundation.

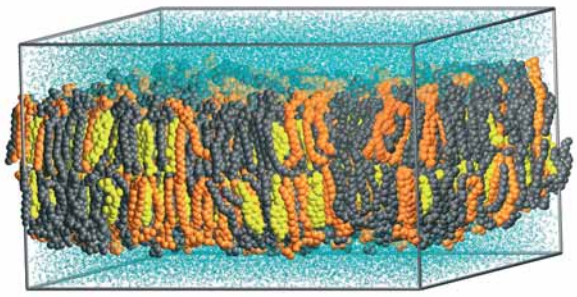
Overall, the activities of the BIO group are comprehensive and strongly networked including numerous experimental and theoretical collaborators with varying backgrounds. In particular, the BIO group works very closely with Dr. Mikko Karttunen's group at the University of Western Ontario (Canada). The team comprised of the two groups includes roughly 20-25 people focusing on a wide range of issues related to biologically relevant soft-matter systems.

The research of the BIO group consists of three main themes that complement each other. First, we develop novel techniques for studies of soft matter. Second, we apply these methods to characterize the atom-scale properties of biomolecular systems. Third, we employ multiscale modelling to gain insight into the large-scale properties of given systems.

The development of new theoretical and modelling techniques is keenly focused on the coarse graining of soft-matter systems. We have used the "bottom-up" approach, with an objective to develop coarse-graining techniques that allow one to simplify atomistic descriptions of soft-matter systems in a systematic fashion. The systematic nature of coarse graining means that the effective intermolecular interactions used in



Structure found through simulations for a membrane protein known as one of the autotransporters. (Courtesy of Jarmila Repáková, BIO/HUT)



Snapshot from a highly ordered lipid raft membrane comprised of POPC (gray), PSM (orange) and cholesterol (yellow) molecules. (Courtesy of Perttu Niemelä, BIO/HUT)

the coarse grained model are systematically derived from detailed atom-scale MD simulations or experimental data using, e.g., the Inverse Monte Carlo technique. When this approach is coupled to novel mesoscale simulation techniques, it provides a means for considering large-scale properties of soft matter while preserving a bridge to the underlying microscopic world. We have used this approach to coarse grain and model many-component lipid membrane systems and lipoproteins, among other topics. In this manner, one obtains a speed-up of seven orders of magnitude compared to atomistic simulations.

In the atomistic limit, we have considered a variety of different systems comprised of proteins, lipids, and DNA. The aim is to understand the mechanisms that govern the structure and dynamics of these systems using both analytical and computational techniques. As for lipid membranes, we have examined lipid rafts composed of saturated glycerophospholipids, sphingomyelin, and cholesterol. Lipid rafts have been shown to play an important role in a variety of cellular processes such as signal transduction and protein sorting. Additionally, we have elucidated mechanisms associated with pore formation in cellular membranes, investigated the role of the lateral pressure profile on membrane protein functionality, and considered the unique structure-function relationship of cholesterol with respect to other sterols. Closely coupled to experiments, we have further addressed questions related to the structure of lipoproteins and the interplay of drugs such as antibiotics with lipid membranes, and the influence of small molecules such as alcohols on membrane systems.

String Theory and Quantum Field Theory

String Theory and Quantum Field Theory are frameworks for models of Nature. They give languages for new scenarios, which may or may not end up being incorporated into fully developed models, which are then experimentally tested if they correspond to actual physical reality.

The physics context is not limited to elementary particle physics or quantum gravity. Many problems are originally motivated from condensed matter physics. An example of this is recent investigations of Boundary Conformal Field Theory, originally motivated by condensed matter topics such as the Kondo problem, dissipative quantum mechanics, and critical phenomena with defects. The theoretical problems turned out to be isomorphic to a topic in String Theory which was investigated by the HIP group last year. Generalizing and continuing investigations pioneered by Affleck and Oshikawa in the context of the Ising model with defect lines, the HIP group constructed a new class of string theoretic objects they called fractional S-branes. Fractional S-branes are a time-dependent counterpart of fractional D-branes, which are branes located at singular points of Euclidean orbifolds and which play a key role in smoothing out such singularities. The hope is that fractional S-branes could play a similar role in resolving spacelike singularities, such as the Big Bang singularity. The new calculational techniques developed by the HIP group could also find their way back into condensed matter physics applications.

The HIP group also investigated Euclidean fractional D-branes, in the context of some

Esko Keski-Vakkuri, String Theory and Quantum Field Theory project leader

Kari J. Eskola, Ultrarelativistic Heavy Ion Collisions project leader

models motivated by particle physics phenomenology. They studied orientifold type IIA theory, and whether fractional branes exist in the orientifold and can be given a natural geometric interpretation.

In a different geometrical direction, there has been a programme on Generalized Kähler Geometry (GKG). Its complete explicit solution in terms of a generalized Kähler potential was the mathematically most pleasing result of 2006. This potential also has an interpretation as a generating function for symplectomorphisms that interpolate between certain important sets of coordinates. A related result was the complete sigma model realization of GKG in a Hamiltonian setting. The on-going work on projective superspace has this year resulted in the description of a number of new Hyperkähler metric. Finally, we were able to find a diffeomorphism and gauge invariant version of the Dirac-Born-Infeld-Myers action.

In addition to String Theory, the group has been vigorously continuing investigations of noncommutative (NC) Quantum Field Theory. There, the concept of "twist", based on the twisted Poincaré symmetry previously found by the group, was presented as a "symmetry principle". This led to a natural extension of the Abelian twist to a non-Abelian one in the formulation of NC gauge symmetry. A no-go theorem reminiscent of the Coleman-Mandula theorem was derived in the sense that to combine internal gauge symmetry with the external Poincaré symmetry under the same twist is impossible. Further, the construction of a consistent NC version of gravity has been initiated by formulating the Riemannian Geometry of NC surfaces. Also, a NC version of the MSSM has been presented for the first time, based on a previous approach of the group to the NC Standard Model.

Finally, research on colour confinement, based on BRST symmetry and connection between asymptotic freedom and confinement, led to the conclusion that confinement implies massive gluons.

Ultrarelativistic Heavy Ion Collisions

The studies of QCD matter and its phases, quark-gluon plasma (QGP) and hadron gas, form a subfield of particle and nuclear physics with an active interplay between experimental and theoretical research. Since summer 2000 the BNL-RHIC collider has generated an impressive amount of high-quality data from ultrarelativistic heavy ion collisions (URHIC), revealing QGP signatures such as very high energy densities, collective flow, significant suppression of large-p_T hadrons and disappearance of away-side jets. Even more exciting possibilities will soon be offered by the ALICE experiment at the CERN-LHC. The URHIC project in the HIP Theory Programme started in 2002 and is now on its second three-year term. We are located at the Department of Physics, University of Jyväskylä, and at HIP and the Department of Physical Sciences, University of Helsinki. We focus (1) on URHIC phenomenology by making calculations for observables measurable at RHIC and LHC/ALICE, and (2) on studying the QCD matter properties through first-principle calculations. We participate actively in international conferences and workshops, European graduate school activities and EU networks, and collaborate with researchers from, e.g., CERN, Rome, Bielefeld, Frankfurt, NBI, Odense, Heidelberg, LBNL, BNL, Duke U., McGill U. and Nagoya.

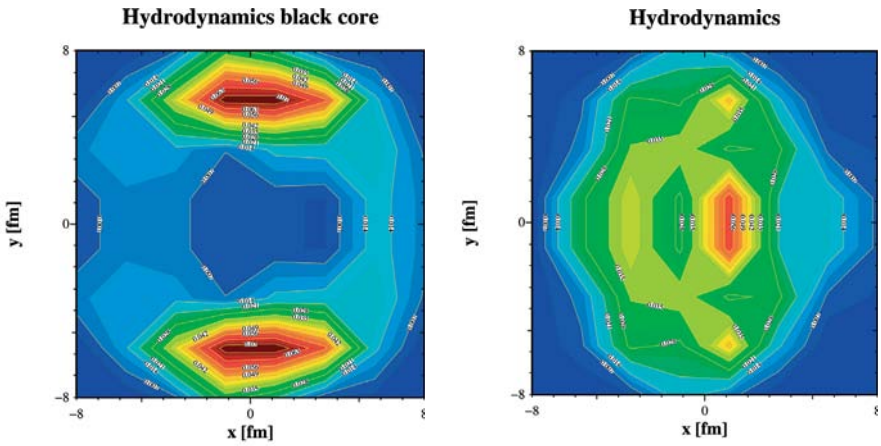
One of our specialties has been the development of a comprehensive description of URHIC, where the initial QGP densities are computed in a closed framework based on perturbative QCD (pQCD), collinear factorization and gluon saturation, and the space-time evolution of the produced system is described by relativistic hydrodynamics. After successful tests against RHIC data, we have predicted bulk hadron spectra, multiplicities and net-baryon number for central Pb+Pb collisions at the LHC. Regarding the QGP initial conditions, also classical gluon fields and quark-antiquark production thereof have been studied, and the obtained results suggest rapid chemical thermalization of the produced QGP.

We have computed the non-thermal large-p_T parts of hadron spectra in URHIC by using factorized pQCD, nuclear parton distribution functions (nPDFs) and fragmentation functions, modelling in also the radiative energy losses of energetic partons in the QCD matter which is evolving according to (1+2 or 1+3 d) hydrodynamics. Again, after successful tests at RHIC, we have predicted these spectra for the LHC. At RHIC, both one- and two-hadron inclusive hard cross sections have been studied in detail, with the goal of extracting information about the bulk QCD matter properties and evolution dynamics. We have addressed the prospects of medium tomography also by studying high-p_T photon-hadron correlations. The origin of the Mach cone -like structures, observed opposite to a hard trigger-hadron in Au+Au collisions at RHIC, has been investigated. Studies of incorporating elastic energy losses and non-eikonal kinematics have been launched. Electromagnetic signals in URHIC have been studied further: a successful description of detailed features of the SPS/NA60 high-precision dimuon data has been achieved. Studies for improving the hydrodynamic decoupling criterion and predicting the amount of elliptic flow in non-central Pb+Pb collisions at the LHC as well as production rates of electromagnetic thermal signals are in progress.

We have continued the pQCD studies of nPDFs, which are needed in the computation of collinearly factorizable hard-process cross sections in nuclear collisions. Our error estimates on the nPDFs from a global pQCD analysis are now ready to be published. The next steps are the next-to-leading order evolution and inclusion of RHIC data from d+A collisions. Also, studies for pinning down the nuclear gluons with the data from e+Au collisions, a possible future extension of RHIC, have been initiated. In addition, we have suggested that mutually differing nuclear modifications of valence u and d quark distributions in iron could well explain the "NuTeV anomaly", the large value of the weak mixing angle obtained from deep inelastic neutrino+Fe and antineutrino+Fe collisions at Fermilab.

A new approach for understanding the QCD free energy in the temperature range $T_C<T<5T_C$ is that one might get quantitative information on four-dimensional physics in this strongly interacting domain by solving classical Einstein gravity equations in five dimensions. Quantum physics in our usual 4d space is then obtained from the boundary values of the 5d theory. Having finite temperature on the boundary implies that there is a black hole deep in the 5d space. However, the gravity equations giving correct QCD physics are not yet known. We have explored various alternatives by deriving their consequences and by comparing with various known facts about QCD. As the experiments producing quark-gluon plasma are very strongly time-dependent, it is also of great importance to find out what kind of 5d physics would correspond to such time-dependent phenomena. We have presented an exact time-dependent 5d solution which corresponds to radially expanding hot matter in 4d. Various properties related to thermalization of hot matter can be read from this solution.

Applying effective theory methods, we have constructed a new class of Technicolour models which do not suffer from problems with flavour-changing neutral currents and can accommodate a light Higgs particle. By confronting these models with the precision electroweak measurements, we have shown that some of the models are compatible with the precision measurements within one standard deviation. We have studied the cosmological implications of these models and identified the possible dark matter candidates.



Vertex distribution of high-p_T back-to-back partons in central Au+Au collisions at RHIC in two different energy loss scenarios. The transverse plane coordinates are x and y and the trigger parton propagates to the left. (Courtesy of T. Renk, HIP)

High Energy Physics Programme

Heimo Saarikko,
High Energy Physics
Programme director

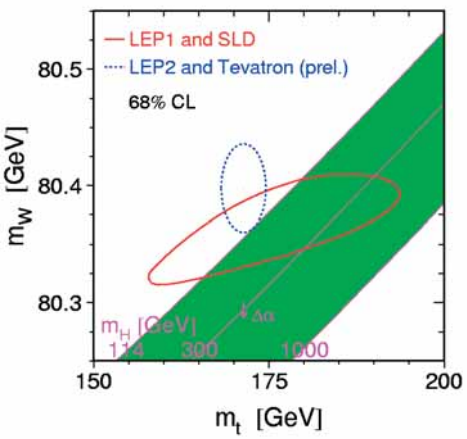
In 2006 the activities of the High Energy Physics Programme concentrated on top quark studies in the CDF experiment at the Tevatron antiproton-proton collider at Fermilab and on preparations for the forward physics experiment TOTEM at the CERN LHC proton-proton collider. In 2006, Helsinki became one of the leading groups in the top mass measurement using the all-hadronic decay channel and contributed significantly to the top mass measurement in the di-leptonic decay channel. In addition, the group developed efficient data analysis algorithms for the CDF silicon detector system. Important observations were made in the CDF experiment in 2006: the $B_s^0 - \bar{B}_s^0$ oscillation frequency was measured for the first time, this was referenced to in Nature, two new sigma-b baryon states were discovered, and the single most precise measurement of the W boson mass achieved. The group is one of the major contributors to the TOTEM forward spectrometer and in the development of a competitive physics programme for it. In 2006 the group concentrated on construction, testing and commissioning of the TOTEM T2 spectrometer detectors. This strained the resources, personnel, finances and infrastructures to the maximum. By the end of 2006, almost half of the triple-GEM detectors for the T2 telescope, the group's main responsibility in TOTEM construction, had been manufactured. In November 2006, a first set of GEM detectors with appropriate digital readout electronics were tested with success in a test beam at CERN. A physics document describing the prospects for diffractive and forward physics at the LHC in common runs of the CMS and TOTEM experiments was completed by the end of the year and submitted to the LHC committee. A vigorous R&D effort is ongoing to demonstrate by 2010 the technical feasibility of an electron positron collider, the Compact LInear Collider (CLIC), capable of reaching into the multi-TeV energy domain. In the Detector Laboratory the year 2006 was characterized by an active participation in the detector module construction for the LHC experiments aiming to start taking data in 2007. A highly visible project continuing throughout the year has been the above mentioned assembly of the Gaseous Electron Multipliers (GEM's) for the TOTEM experiment. The assembly project for the ALICE Silicon Strip Detector modules continued until summer. In addition, the so-called FinnCRack test platform was eventually installed on the premises. Intense educational programmes were carried out in connection with the research activities, both at the undergraduate and the graduate level.

Risto Orava,
LHC Forward
Physics project
leader

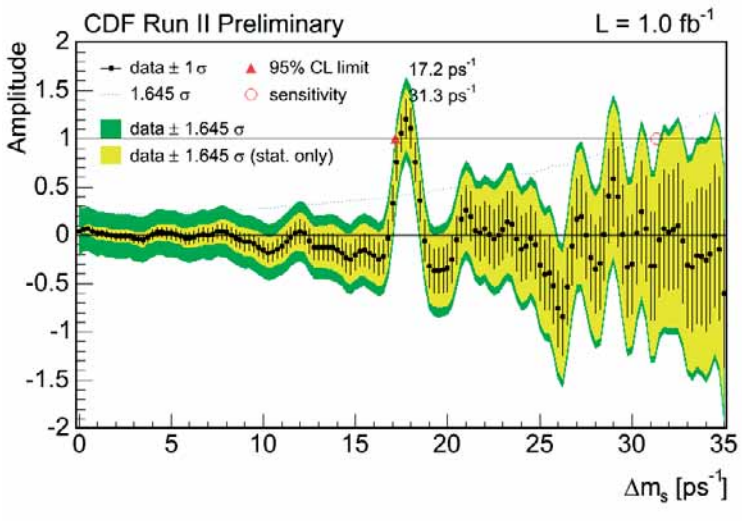
Forward Physics Project

CDF experiment

The Tevatron accelerator, located at Fermi National Laboratories, Chicago, USA currently represents the high energy frontier of High Energy Physics. It collides protons and anti-protons at a centre of mass energy of 1.96 TeV at instantaneous luminosities exceeding 2×10^{32} $cm^{-2}s^{-1}$ and has delivered to each of its two multi-purpose experiments (CDF and D0) an integrated luminosity exceeding 2 fb^{-1}. It aims for an ambitious final integrated luminosity of 8 fb^{-1} per experiment by the end of 2009. CDF is an international collaboration with intense participation from the Helsinki particle physics group. The experiment was upgraded in 2002. In 2006, the large effort invested in re-designing the CDF software, simulation and analysis framework, together with the excellent performance of the Tevatron accelerator allowed us to present the community with a large amount of stunning new results: the first obser-



The constraints of the SM Higgs boson mass as of January 2007.



The measured amplitude values and uncertainties as a function of the B_s^0–$\bar{B}_s^0$ oscillation frequency, Δm_s. The more than 5 standard deviation significant deviation from zero of the amplitude just below 18 ps^{-1} proves the existence of B_s^0–$\bar{B}_s^0$ meson oscillations with corresponding oscillation frequency.

vation of $B_s^0 \to \bar{B}_s^0$ oscillations, the discovery of four new heavy baryons, $\Sigma_b^{\pm}$ and $\Sigma_b^{*\pm}$, and the single most precise measurement of the W boson mass (see Highlights of Research Results).

In addition, the Helsinki group strengthened its position as a leading group in the measurements of the top quark properties in both the dilepton and the all-hadronic channels, and the group contributed significantly to the studies on the semileptonic decay channels. In the all-hadronic channel, the first top quark mass measurement using RUN II data was submitted to Physical Review Letters at the end of 2006 (*Measurement of the Top-Quark Mass in All-Hadronic Decays in p pbar Collisions at CDF II*) and was accepted for publication at the beginning of 2007.

The group had a major responsibility in improving the data analysis efficiency of the CDF vertex detector (SVX) and in the run control of the detector. *The CDF responsibilities and intended contributions to the CDF experiment included:*

* Support of the operation of the RUN II detector. Specific responsibilities (up to the end of 2006) included the SVXII DAQ board testing and maintenance, as well as daily operational responsibilities of the silicon detector.
* Participation in off-line SVXII calibration.
* Participation in validating the jet energy scale calibration.
* Postdocs, senior group members and graduate students participating as Aces, CO's and SciCO's.
* Physics: top mass analysis in the all-hadronic and dileptonic channels, CP asymmetry measurement in the semileptonic top channel, Higgs task force.

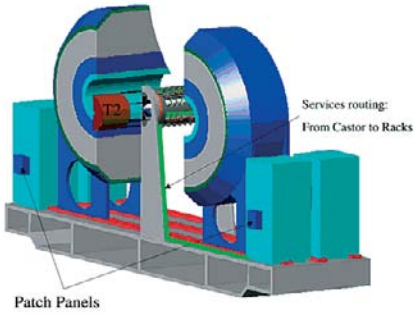
Having surpassed its baseline physics programme and by using the expertise acquired by performing these delicate measurements, the CDF Collaboration has now opened the hunt for the Standard Model Higgs boson.

TOTEM experiment

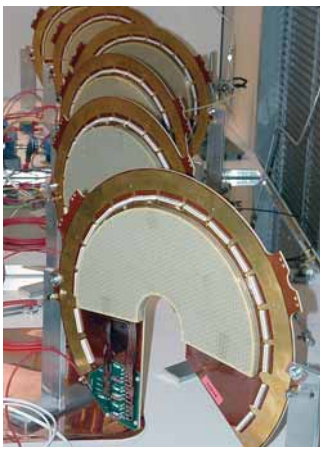
The physics scenario of TOTEM/CMS is based on (1) short special high statistics runs which begin during the running-in stages of the machine and (2) forward physics runs in conjunction with the CMS experiment with the nominal low-β^* machine conditions. Investigations of QCD can be carried out at relatively modest luminosities, and large statistics gluon studies will become available at the beginning of the TOTEM/CMS runs.

At later stages of LHC operation, the Central Exclusive Diffraction interaction $pp \to p + H + p$ is considered as a benchmark process, with an exclusive access to the J^{PC} structure of the Higgs boson. With the leading proton tagging (and a possible later extension to the 420 meter region) and the T1 and T2 spectrometers, a threshold scan is done for spin-parity selected new particle states, including the Higgs boson, SUSY particle states, radions, extra dimensions etc.

The TOTEM T2 tracking station. The semi-circular GEM detector planes (green) are seen at the core of the opened jaws of the detector shield.



Six fully assembled TOTEM GEM detectors being tested in the Detector Laboratory at the Kumpula Campus.



Kenneth Österberg, Electron-Positron Physics project leader

The team has since long worked on *leading proton detection at the LHC* and can be considered as the world expert on the subject. It is in the group's interest to continue the work on leading proton detectors and studies on their performance vs. different LHC optics scenarios. A physics document describing the prospects for diffractive and forward physics at the LHC in common runs of the CMS and TOTEM experiments was completed by the end of the year and submitted to the LHC Committee.

During 2006, the TOTEM team of the Forward Physics Project was heavily committed to the construction of the TOTEM T2 spectrometer, to be commissioned by the LHC start-up. The TOTEM team concentrates on both hardware (in particular *GEM detectors*) and software (*reconstruction*) contributions to T2.

Starting in 2006, construction of the Gas Electron Multiplier (GEM) detectors was the main activity of the Detector Laboratory of the Helsinki Institute of Physics. The Forward Physics group of HIP is responsible for constructing and maintaining the T2 tracking station. Kari Kurvinen of the HIP Detector Laboratory serves as the co-ordinator of the TOTEM T2 manufacturing. More than 40 individual semi-circular GEM detector planes for the TOTEM T2 tracker will be manufactured in Finland.

The production of GEM detector planes is carried out in the HIP clean rooms (class 1000 and 100) and in a separate laboratory which is specially equipped for testing and validating the detectors. The T2 manufacturing phase requires a major effort from the group and occupies most of the Laboratory resources during the 2006–2007 period. The testing of the detectors includes X-ray irradiation in a tailor made test bench. The long term stability and sparking sensitivity is analyzed by alpha irradiation induced by radon gas injected into the fill gas of the detectors. Development of UV laser technology is continued for producing the miniscule holes into the GEM electrodes.

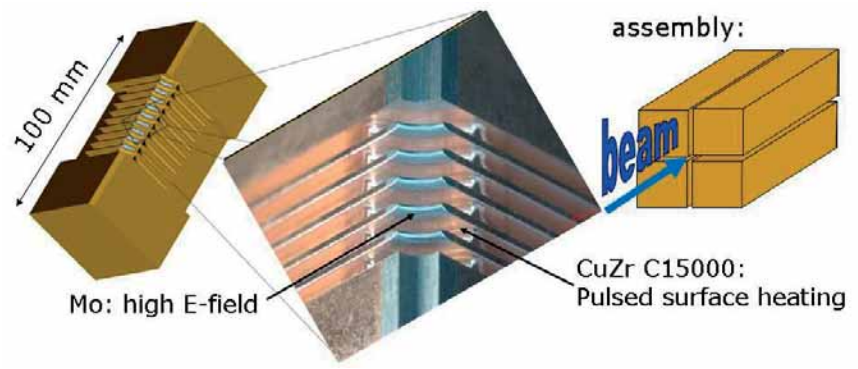
Nine finished GEM's were transported to CERN in November for a beam test. The main goal of the test was to check the compatibility of the readout electronics and the GEM operation. The readout electronics of the T2 telescope is based on a fully digital readout chip, VFAT, which was designed by the CERN-MIC group. The data collected from the pads and strips of four GEM's in the beam test confirmed the compatibility and full production of the chips and the GEM's according to the present design may be carried on.

In overall, the TOTEM responsibilities and intended contributions included:

*T2 spectrometer GEM detector construction, data analysis & trigger scenarios.
*Leading proton measurement – detectors & reconstruction, performance studies vs. LHC optics options.
*Low p_T jet reconstruction in combined CMS/TOTEM data taking.
*TOTEM physics potential – central diffraction & single diffraction.
*TOTEM physics scenarios.
*TOTEM service contributions: beam test participation, analysis of beam test data, on-line and off-line software development.

Electron – Positron Physics Project

The Compact LInear Collider (CLIC) study explores the technical feasibility of an electron positron collider capable of reaching into the multi-TeV energy domain. Presently a vigorous R&D effort is ongoing to demonstrate its feasibility by 2010. The key ingredients of the CLIC scheme are acceleration at high-frequency (12–30 GHz) and high-gradient (> 100 MV/m) in normal conducting structures and use of a high-current electron drive beam to provide the RF power for the main beam. During 2006, the project participated actively in the R&D work for the accelerating structures of CLIC performed in close collaboration with the CERN CLIC group, the Technical Research Centre of Finland (VTT) and Finnish industrial partners. In addition,



Left: a CLIC accelerating structure quadrant, centre: a photo of a machined bi-metallic prototype, right: an assembly sketch for a complete accelerating structure (one of 300,000 in CLIC).

the last Finnish PhD thesis (L. Salmi's) using data from the DELPHI experiment at CERN's Large Electron Positron collider was successfully defended in 2006, concluding an era of Finnish experimental high energy physics that spans more than two decades.

The high gradient of the CLIC scheme imposes considerable constraints on the materials, the machining precision and surface quality of the structures. The key challenges are: limiting the RF breakdown and increasing the resistance of the material against pulsed surface heating. The most promising structures are bi-metallic structures with refractory metals (e.g., Mo) in the high electric field regions (i.e., the irises) and copper alloys (e.g., CuZr) in the rest of the structure, where most of the heat is dissipated. The required machining precision is about 1 μm with a surface roughness of 0.1 μm Ra. In addition, the four quadrants of the structure need to be assembled with a precision similar to the one required from the machining and cooled so that the temperature increase and vibrations in the structures are minimized.

Our R&D focuses on high precision micromachining of the structures as well as the production of the bi-metallic material. So far a machining precision of ±8 μm for the critical features of the prototype structures has been achieved. Bi-metallic Mo-CuZr bars with sufficient bonding strength have been produced by Finnish industry using High-Isostatic-Press (HIP) diffusion bonding. Structures machined from these bars show the same ±8 μm precision. Finally, the group has investigated in detail optimal cooling and assembly methods for the four quadrants of an accelerating structure.

Detector Laboratory

ALICE Silicon Strip Detector modules construction

Since the LHC is aiming to start taking data in 2007, the year 2006 in the Detector Laboratory was still characterized by an active participation in the detector module construction. The assembly project for the ALICE Silicon Strip Detector modules continued until summer: the 716th Helsinki-made double-sided SSD module was finished at the end of July and the ladder cable assembly continued until the end of August. The ALICE SSD Project manifests itself as the largest (channels, interconnections) individual particle detector project in the history of Finnish science.

Markku Oinonen, Detector Laboratory coordinator

TOTEM support

Another highly visible project has been the assembly of the Gaseous Electron Multipliers (GEM'S) for the TOTEM experiment that continued throughout the year. The manufacturing of 40 GEM detectors for the TOTEM T2 telescope is the responsibility of the Helsinki group. Since an additional ten detectors are needed as a reserve, altogether 50 detectors will be assembled. The production of the GEM's started during 2006 and at the

Ten T2 GEM detectors in the CERN test beam in November 2006

end of the year, 18 of them were finished and 5 GEM's were under construction. The supporting frames of the GEM and drift foils and also some small components were approved by the collaboration to be manufactured by Finnish industry.

Nine finished GEM's were transported to CERN in November for a beam test. The main goal of the test was to check the compatibility of the readout electronics and the GEM operation.

CMS Tracker support

During 2006, the main activity of the CMS Tracker Project at the Detector Laboratory was the installation of the Finnish Cosmic Rack (FinnCRack). The FinnCRack is used for reconstructing tracks of incoming cosmic particles. It has a maximum of ten layers of CMS silicon detectors. At the beginning of 2006, the FinnCRack was transported from CERN and commissioned at the Detector Laboratory. In addition, by the end of the year, a large cooling chamber was built at the Detector Laboratory in order to operate FinnCRack in cold temperatures. The set-up will form a very important resource for the Laboratory in exploiting cosmic rays in studies of particle detector technologies. Furthermore, it forms a versatile tool for educating students to become experts in the instrumentation of high energy physics.

Manufacturing of the semi-circular GEM detector planes in the clean room section of the HIP Detector Laboratory.

Furthermore, the CMS Tracker Project has continuously used the versatile probe station and the attached measurement set-up in the clean room of the Detector Laboratory for characterizing silicon detectors and test samples. The objective of the silicon detector research is to develop new sensor solutions for the challenges set by the high radiation doses present in the future high energy physics (HEP) experiments, including the upgrade of the CMS Tracker.

New projects

The ramp-down of the LHC construction will cause the module construction to cease in 2007. To maintain the high-level intellectual resources and to exploit the extensive material resources present in the Laboratory, new possibilities to participate in international projects have been investigated.

PANDA at the FAIR facility stands for Anti**p**roton **An**nihilations at **Da**rmstadt and the experiment aims at studying fundamental questions of hadron and nuclear physics in interactions of antiprotons with nucleons and nuclei, using the universal PANDA detector. There are still two options to form this main tracker of the PANDA experiment: a straw tube tracker and a time projection chamber (TPC) coupled with Gaseous Electron Multiplier (GEM) readout. Our plan is to concentrate on the GEM assembly for providing a readout plane for TPC. The full-scale establishment of the project depends on the high-level Finnish-German negotiations.

Meanwhile, to gain experience on the operation of GEM's with Time Projection Chambers construction of a small TPC+GEM prototype has been started at the end of 2006. The idea is to

develop the most advanced TPC+GEM combination up to date. This allows for investigations of the crucial issues, like ionic feedback, concerning the applicability of the GEM readout in PANDA and future experiments in general.

Since the ALICE SSD Project was successfully finished, many international players have been attracted by the capabilities of the Laboratory. Possibilities to launch large-scale detector assembly projects have been and will continuously be examined.

The Laboratory was keeping close relations with the Electronics Research Unit (ERU) of the Department of Physical Sciences in Helsinki. Collaborations included studies of non-destructive quality control techniques for ultrasonic bonds and investigations of the ultrasonic bond process in general. An international research network on ultrasonic bonding technology is being formed and the process will yield a TEKES application during spring 2007.

An overview of the Detector Laboratory activity was given at the Imaging 2006 Conference in Stockholm in June 2006 and will be published in a research journal in the near future.

Education

In connection with the research activities, the group carried out educational programmes both at the undergraduate and the graduate level. In 2006, the group produced four PhD's, one at Helsinki University of Technology and three at the University of Helsinki. Three MSc theses were completed in 2006. Domestic summer student and technical trainee programmes, intended for university and polytechnic's students, were continued both at CERN and at Fermilab.

The group is supported by the Helsinki Institute of Physics, the Academy of Finland (a 3-year grant for top quark physics) and a European Union Integrated Infrastructure Initiative grant. The EU Research Training Network -project which ended in spring 2006, was replaced by the EU sponsored detector R&D project, EUDET, and a related Marie Curie programme was applied for.

CMS Programme

Jorma Tuominiemi,
CMS Programme director

The CMS Programme is responsible for the Finnish participation in the Compact Muon Solenoid (CMS) experiment at the CERN Large Hadron Collider that will collide protons at an energy of 7 + 7 TeV, about an order of magnitude larger than at the existing accelerator facilities. The main scientific goals of CMS are the study of the mechanism of the spontaneous breaking of the electroweak symmetry (search for Higgs bosons) in the Standard Model of the basic structure of matter and the quest for new physics beyond the Standard Model, such as supersymmetry and extra dimensions. It also includes a heavy ion research programme, searching for quark gluon plasma predicted by QCD. The CMS detector concept was first proposed in 1990, and the Finnish team has played an important role in its development from the beginning. The HIP CMS team hence has an extensive and thorough knowledge of the key features of the experiment. With the CMS experiment HIP will be in the frontline of High Energy Physics research to take the next fundamentally important step in understanding the basic structure of matter and the origin of the Universe. In 2006 several important milestones were reached by CMS. The magnet was operated with the design field of 4 Tesla. Cosmic ray runs with a closed detector showed that CMS can operate as a real experiment. The distribution of data from the CERN T0 to T1 and T2 centres in participating institutes was demonstrated with simulated data at a rate of 25% of what is expected in 2008. The subdetectors of the CMS Silicon Tracker were all completed and brought to CERN and are now in process of being integrated. Preparation for the physics analysis is well advanced with the publication of the two volumes of the CMS Physics Technical Design Report, based on massive Monte Carlo event simulation. The first volume demonstrates the power of the CMS trigger selection and event reconstruction software and the second the vast physics potential of the experiment. HIP has been actively involved in all these activities. The LHC experiments are scheduled to begin in 2008 with a pilot run planned for late 2007. With the progress in construction in 2006 the full detector system is foreseen to be ready for beams in September 2007. The HIP CMS Programme is divided into two projects: 1) the CMS Software and Physics project, the goal of which is to develop simulation and analysis software for the CMS experiment and to evaluate the discovery potential of CMS for new physics, 2) the CMS Tracker project that carries responsibilities in the design, construction and testing of the central tracking detector. It also contributes hardware to the muon trigger system.

Veikko Karimäki,
CMS Software
and Physics
project leader

CMS Software and Physics

General

The achievements of the project in the past years were evaluated by two independent experts in a full day symposium held at CERN in May. The success of the evaluation can be summarized by a citation from the evaluators report: “In conclusion, we congratulate the HIP team on their excellent work and for the well focused programme that they have presented to us. We recommend continuing the CMS project into the next phase of data taking and analysis. We consider the HIP group very experienced and well prepared to make substantial contributions to CMS and to produce important scientific results”. Based on the excellent recommendations the Board of HIP decided to continue the project for three years under the new name “Physics Analysis of the CMS Experiment”.

In 2006 the CERN School of Computing (CSC06) was held for the first time in Finland. CSC06 attracted almost eighty students to the Kumpula Campus, shown here together with the school lecturers and organizers. (Courtesy A. Hirstius)

The year 2006 proved very successful for the preparation of the CMS experiment. The team contributed in a visible way to the two volumes of the "Physics Technical Design Report" (PTDR), which were issued during 2006. In PTDR Volume I, "Detector Performance and Software", the HIP alignment algorithm was markedly presented. In PTDR Volume II, "Physics Performance", the Physics Simulation team made outstanding contributions to the analysis of the MSSM Higgs search in the tau decay channels.

Other important CMS activities in which the HIP team was involved in 2006 were Magnet Test and Cosmic Challenge (MTCC), and Computing, Software and Analysis Challenge 2006 (CSA06). In MTCC the team participated in the analysis of the magnetic field measurements and the work on parameterization of the field started. For CSA06, and further on, the team took responsibility for the co-ordination of computing and software user support. The HIP alignment algorithm was used for the track-based position calibration of the detector modules in the CSA06 productions. Important contributions to the work of the Geant4 collaboration continued. Computing in terms of cluster maintenance and development as well as the work on computing grid made steady progress. Activities in these different fields are described below in more detail.

The highly appreciated CERN School of Computing 2006 took place at the Kumpula Campus in August, hosted by HIP. The school is organized annually by CERN in its member states and took place for the first time in Finland in its 25-year history. There were 79 participants from 25 different nationalities. The project members took the responsibility as Local Organizers.

The project team consists of eight PhD physicists V. Karimäki, R. Kinnunen, K. Lassila-Perini, S. Lehti, T. Lindén, S. Slabospitsky (adjoint member), J. Tuominiemi, six PhD students A. Heikkinen, A. Hektor (adjoint member), T. Lampén, J. Nysten, L. Wendland, M. Voutilainen (adjoint member) and an undergraduate student P. Kaitaniemi.

Physics simulation

In 2006, a major challenge for the Physics Simulation team was the preparation of the Physics Technical Design Report (PTDR) Volume II. The team carried responsibility in the study of the two important MSSM Higgs boson discovery channels $H/A \rightarrow \tau\tau$ and $H^{\pm} \rightarrow \tau\nu$. The discovery potential for the final states jet+jet, e+μ, e+jet for H/A and jet+missing E_T for $H^{\pm}$, which can be efficiently observed in CMS, was studied in detail. For $H^{\pm}$, fully hadronic final states in the region of $m_{H^{\pm}} > m_{top}$ were analyzed.

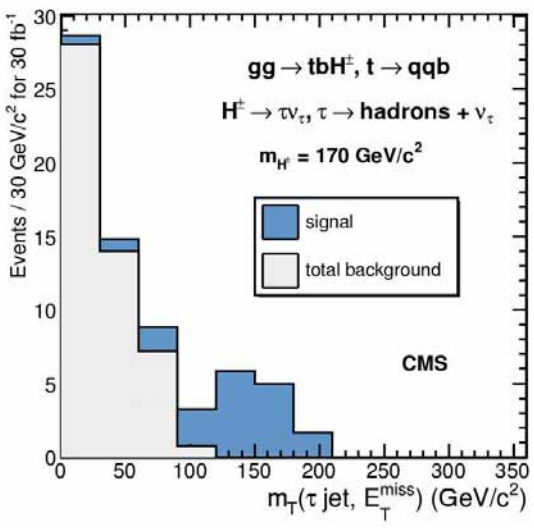
For the PTDR studies, large event samples containing hits in the CMS detector were first reconstructed for the signal and the backgrounds.

The reconstruction was performed mainly with the GRID based ASAP tool. The identification of τ jets and tagging of b jets were tuned for each channel separately. For the 2-jet final state of the H/A → ττ channel, the QCD multi-jet events represent a particularly difficult background due to the large cross-section. Selection methods were developed to suppress this background by a factor of 10^8, sufficient to obtain a visible signal. The electron identification algorithm was tuned for the e+μ and e+jet final states from H/A → ττ, with particular attention to separating the electron from a one-prong τ jet. Helicity correlations in the hadronic τ decay and reconstruction of the associated top quark were exploited for the background suppression in the $H^{\pm} \rightarrow \tau\nu$ decay channel. The measurement of missing E_T was exploited in the reconstruction of the H/A → ττ decay channels. Visible signals were obtained for the Higgs mass in a large part of the parameter space.

As an example, the transverse mass in the fully hadronic decays for the process $H^{\pm} \rightarrow \tau\nu$ (Higgs boson mass 170 GeV) is shown in the figure below. A signal with almost no background is observed.

The Drell-Yan production of τ pairs, a major background in the H/A → ττ search, was efficiently suppressed with b tagging. An algorithm to measure the b-jet from the data was developed in a separate work studying the associated process bbZ, Z → ℓℓ. Furthermore, the Z → ττ → ℓℓνννν decay process in the absence of associated jets was used to develop a method for calibration of the missing E_T for the Higgs boson mass measurement.

The work for tagging the hadronic τ decay with impact parameter or vertex measurement was continued during 2006. The effect of systematic uncertainties based on the pattern recognition problems in the CMS Tracker, like that of shared hits and misalignment, was studied. For the development and validation of the new CMS software (CMSSW) a package was written for τ tagging with impact parameter measurement.



Reconstructed transverse mass for the $H^{\pm}$ candidates.

CMSSW user support

The development of an "all in one" CMS software package (CMSSW) continued intensively during the year 2006. The HIP team took the responsibility of the co-ordination of the user support for the physicists using CMSSW for analysis. This task consists of taking care of the documentation of the software used in the physics analysis and organizing a user support help desk. The help desk is located at CERN and staffed during the morning hours. Furthermore, a problem reporting system based on Savannah was set up.

During 2006, the main documentation entry point – The CMS Workbook – was completed. This document is designed as a comprehensive tutorial for new CMS members to learn the usage of CMSSW in data analysis. It is an on-line document based on wiki technology with an editor team supervising and coordinating its development and updating. At the end of 2006, the Workbook was thoroughly reviewed and updated. The Workbook contains information which is needed to get started. Further documentation is provided with the CMSSW Reference Manual and widely spread and inhomogeneous documentation pages. The first steps were taken to gather the documentation into a common structure which will form

the CMSSW User Manual and Developer's Guide with a well-defined structure.

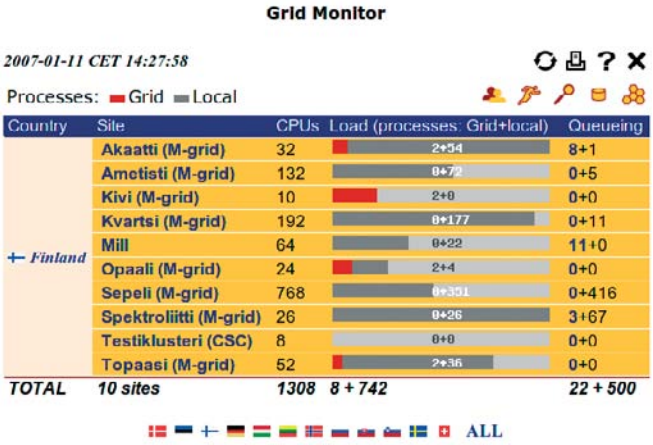
Physics generators

Maintenance and development of the CMS generators package CMKIN continued during 2006. The black hole simulation code Charybdis was implemented and updated versions were issued for the generators TopReX, Stagen, Tauola, HYDJET and PYQUEN. Several Monte Carlo generators were implemented in CMSSW in 2006. For this purpose several special C++ functions were written and included in CMSSW. A general rule on how to include Fortran code in CMSSW was developed. The following packages were included in CMSSW: TopReX, CompHEP, ALPGEN and StaGen.

Computing activities

Computing in 2006 concentrated on the following activities: i) cluster maintenance and development, ii) collaboration with the Nordic Data Grid Facility (NDGF), and iii) planning of a Finnish Tier-2 centre and work to obtain project funding.

The disk server Silo2 was upgraded to the total of 7.5 TB disk space. The new server Silo3 was installed in the Ametisti cluster rack to act as a new PhEDEx server. The University of Helsinki IT-department recycled their four 2.4 GHz Pentium 4 machines to be used for HIP cluster development and testing. The Rocks cluster management system was upgraded to the version 4.2.1 on Testbed1 to prepare for the corresponding upgrade on the Mill cluster. For the upgrade of Ametisti a new acquisition project was launched in a co-operation between HIP, the Department of Chemistry and the Department of Physical Sciences. The maintenance of Mill and ARC middleware (Advanced Resource Collector) were maintained together with the HIP Technology Programme. The operating system on Ametisti was upgraded to Rocks 4.1, compatible with Scientific Linux CERN 4 (SLC4), which will be the official system at the LHC start-up. Also, the frequently used software toolkits Geant4, ROOT and PROOF were updated on Ametisti. A study of Neural net classification of Higgs events was done using Ametisti and presented at the PARA'06 Workshop on state-of-the-art in scientific and parallel computing in Umeå, Sweden, in June.



The grid in Finland grew to over 1000 CPUs in 2006.

The continuation of NDGF was granted for the next two years by the Nordic countries. An NDGF CERN committee was formed with two HIP representatives, Jukka Klem from the Technology Programme and Tomas Lindén. It was decided within NDGF to use the dCache data management tool for disk and tape storage. The smaller 2.5 TB RAID 5 array of Silo2 was configured as a dCache pool as part of the NDGF dCache instance. The Finnish section of the Nordic grid evolved considerably during 2006 (see figure).

A CMS proposal to the "Nordic Computational Grand Challenge Survey" was issued for the consideration of the NDGF Steering Body.

Planning of the Finnish Tier-2 site made progress. Several meetings between HIP and CSC were organized on the subject. An updated estimate for computing resources and their costs due to the changed LHC schedule, energy and luminosity was prepared and submitted to the Ministry of Education with the application for funding for the years 2008–2012.

Eija Tuominen, CMS Tracker project leader

Geant4 development

Geant4 8.2 was released in December with significant improvements of many key features. In Geant4 hadronics, co-ordinated by HIP, updated cross-sections and new elastic scattering models were introduced. The team continued the development and validation of the Bertini models. In a systematic validation study of all Geant4 hadronic models applied to a hadron treatment with 60 MeV protons, the Bertini models were found to provide the best agreement with experimental data. In addition to medical physics, the Bertini models have now proved useful in studying LHC background radiation, hadron induced isotopes, and accurate pion production in nuclear reactions induced by 30 MeV – 3 GeV hadrons.

A new project was initiated together with CEA, Saclay (Commissariat à l'Énergie Atomique) to implement INCL and ABLA codes in Geant4 and to further develop the related models. The new simulation features provided by INCL are needed to ensure accurate hadronic shower calibration for the next generation calorimeters. Furthermore, INCL extends the intranuclear cascades to ion-ion processes. An INCL-ABLA interface was provided for the Geant4 collaboration.

Tracker alignment

The team continued to work on the track-based calibration of the sensor positions in the CMS Pixel and Strip detectors. This calibration task, called detector alignment, aims at finding corrections to sensor positions and orientations in order to achieve the optimal trajectory reconstruction. The group has the responsibility to develop alignment methods and strategies especially for the Pixel detector. The team has participated actively in the work of the CMS Tracker alignment group. The HIP team implemented the first working alignment algorithm for the CERN TOB Cosmic Rack, in which genuine CMS hardware and reconstruction software are used. This algorithm was also used in the CSA06 exercise, in which TIB modules and TOB rods were aligned and the alignment constants were successfully applied. The team has continued the alignment studies of the CERN TOB Cosmic Rack in collaboration with the CERN CMS CMT group, and is looking forward to collaborating with the HIP Tracker project, when the upgraded FinnCRack becomes operational. CMS will most likely not record data suitable for alignment before 2008.

Outreach activities

The group participated actively in the demonstration of CERN and the LHC experiments to visitor groups from Finland. The groups included high school students and members of the Finnish Parliament. The group also approached the general public by writing popular articles on the status and goals of the LHC experiments.

CMS Tracker

In 2006, the HIP CMS Tracker project concentrated its efforts on three main activities: 1) commissioning of the CMS Tracker Outer Barrel (TOB) at CERN, 2) testing of TOB detector modules and their readout using the Finnish Cosmic Rack (FinnCRack) and 3) development of radiation hard silicon detectors for future high energy physics experiments.

Commissioning of Tracker Outer Barrel

By 2006, the HIP Mechanics team had, in the Physicum Laboratories in Kumpula, successfully designed, constructed and tested high-precision, lightweight support structures, so-called rods, for the CMS TOB detector modules. A total of 750 rod frames had been delivered to CERN. After that, each rod was equipped with six or twelve silicon detector modules at CERN and in CMS institutes in the USA, to form single-sided or double-sided detector rods, respectively.

During 2006, the Finnish Mechanics team,

consisting of an engineer and three technicians, participated in the installation of the detector rods into the CMS Tracker at CERN. In January the empty Tracker Outer Barrel Wheel was moved to a new clean room, i.e., to the Tracker Integration Facility, where the whole Tracker is to be commissioned and tested. The workspace was then equipped with integration tools, test equipment and work platforms. Cooling pipe lines and power cables and optical ribbons were installed for testing.

Integration work was done in two shifts with 10 technicians. The work included preparing rods, inserting them into the TOB wheel, making optical and electrical connections and soldering cooling connections, routing cables, testing and registering everything into a database. Also new tools, components and testing procedures were developed. The outermost rod layers were integrated outside the Tracker Support Tube. In June the TOB was moved inside the Tracker Support Tube to its final position, where also the final cable routing could be done. The 688 rods in the TOB are divided into 44 cooling segments. Cooling connections were soldered in situ and each circuit was validated by pressure and leak testing it. Leak testing was done with helium using the vacuum method. As the cooling was connected, the TOB physicists tested the segment and each individual rod for functionality and verified that all the optical and electrical connections were fine.

The TOB integration was completed before the end of 2006. The commissioning of all Tracker subsystems was started in December 2006.

Technician Auli Kuronen in front of the CMS Tracker Outer Barrel.

Finnish Cosmic Rack (FinnCRack)

The Finnish Cosmic Rack (FinnCRack) is a telescope consisting of TOB detector rods for measuring and reconstructing tracks of cosmic particles. The FinnCRack mimics a six degree (in azimuth) slice of the TOB barrel structure. It will be used as a test station providing measurement data for testing of the TOB subsystem level functionality as well as for development of TOB software, e.g., analysis software (CMSSW), software alignment code, on-line software, and run control software. It also plays an important role in the testing of the novel radiation hard detector prototypes for the CMS upgrade and for future experiments.

FinnCRack was initially constructed and tested at CERN as a joint effort with the CERN TOB group. At the beginning of 2006, it was disassembled at CERN and transported to the HIP Detector Laboratory in Kumpula. It was commissioned at Kumpula using the final baseline CMS readout electronics. By the end of 2006, a total of eight detector rods were received for the FinnCRack. At the end of the year a cooling system, consisting of a cold chamber, refrigeration equipment, control electronics and pipes was purchased to allow operation of the FinnCRack at a temperature of -10°C.

During 2006, the FinnCRack has also

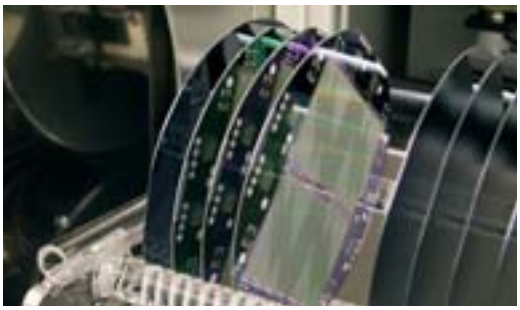
FinnCRack and its cold chamber in the Detector Laboratory.

served as a platform for the development of Tracker Detector Control software. During the year the software was updated from the previous CMS control software (ORCA) to the new CMS Software system.

Silicon Detector Development

In the future high energy physics experiments, radiation hardness will be a major limitation associated with the use of silicon sensors. For example, in the proposed upgrade of the CERN LHC the fluence of fast hadrons will reach 10^{16} cm/s^2 with luminosities of up to 10^{35} cm^{-2}s^{-1}. This is far beyond the operational limits of present silicon sensor solutions. The LHC upgrade is expected to take place in 2017. However, the first upgrades and detector replacements of the LHC experiments, e.g., CMS, are foreseen to take place already in 2012.

During 2006, the HIP CMS Tracker project has actively participated in the development of radiation hard silicon particle detectors in the framework of the CMS Upgrade programme and of the CERN RD39 (60 members, 19 institutes) and RD50 (280 members, 55 institutes) research programmes. This network links together practically all important research groups worldwide in this field and offers access to an extensive selection of sensor characterization and simulation tools. It is worth emphasizing that the members of both RD39 and RD50 are currently studying test structures and detectors processed by the HIP group at the clean room facilities of the Helsinki University of Technology (Micronova), where the HIP Tracker project is a member team. In addition, detector irradiation campaigns were done in collaboration with the Accelerator Laboratory of the University of Helsinki. Electrical characterizations were conducted at the clean room facilities of HIP and of the Department of Physical Sciences of the University of Helsinki.



Silicon detectors processed by Esa Tuovinen at TKK Micro and Nanofabrication Centre.

Sample holder being prepared for irradiations at HU Accelerator Laboratory.

Due to the challenge of the LHC upgrade, the international R&D community is strongly encouraged to implement their latest inventions in detector technology into fully operational systems that would be capable of detecting tracks of particles. In order to meet this challenge, following an initiative of the HIP CMS Tracker group in mid-2006, several CMS institutes have formed a collaboration to upgrade the Helsinki Silicon Beam Telescope (SiBT), a reference telescope operated since 1998 at the CERN H2 beam area. The upgraded SiBT will employ standard CMS Data Acquisition system (DAQ) components and make use of electrical equipment previously used in the CMS Tracker operational tests. The commissioning of the SiBT upgrade, co-ordinated by the HIP CMS Tracker group, started at the end of 2006 in the CMS Tracker Integration Center (TIC) at CERN.

In 2006, the HIP CMS Tracker project has actively participated in the Cryogenic Transient Current Technique (C-TCT) project of the CERN RD39 Collaboration. The C-TCT is a powerful research tool for the measurement of important material and defect parameters in heavily irradiated silicon detectors. Furthermore, the operation in cryogenic temperatures below 40 K is unique. Our first results show that in heavily irradiated silicon detectors the deterioration of some essential detector performance parameters, e.g., the full depletion voltage and the trapping time constant, can be recovered at temperatures below 200 K. This finding is of extreme importance since the

operation of silicon detectors under the high luminosity of the upgraded LHC is fundamentally limited by the trapping of charge carriers and, so far, the material engineering of silicon has not provided any comprehensive solution for the problem of radiation tolerance in extremely harsh irradiation environments.

During 2006, Dr. Jaakko Härkönen continued as the spokesperson of the CERN RD39 Collaboration.

RPC Trigger and DAS

Trigger data link boards for the CMS Resistive Plate Chambers (RPCs) have been developed together with the Warsaw High Energy Physics group and Warsaw University of Technology. RPCs will be used in the CMS as dedicated trigger detectors both in the barrel and in the end-caps. There are altogether some 200,000 channels in the CMS RPC system, divided into 96 strip chambers. Detectors are very fast and there is time to compress and multiplex the data before it is sent to the Level-1 trigger and DAS via 1.6 GB/s optical links.

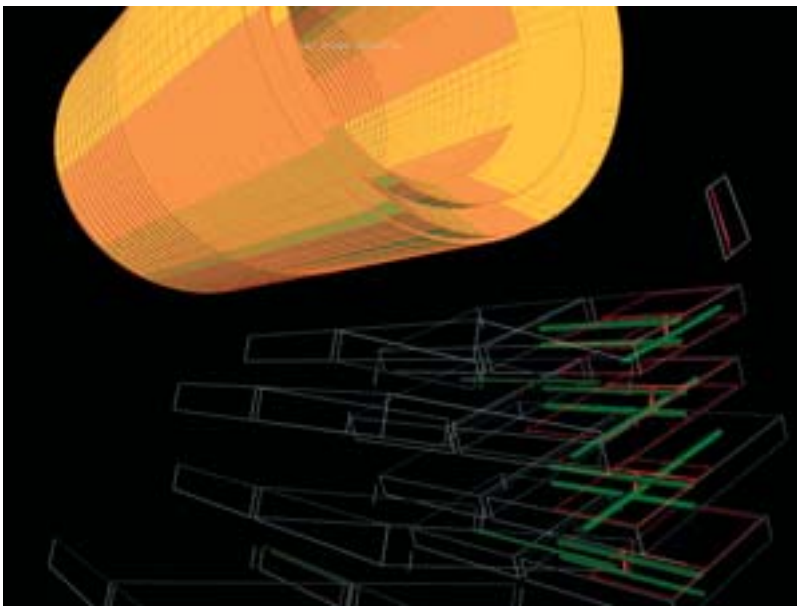
The layout of the link boards and crates has been made to match the CMS requirements. Altogether 5 different cards were designed for the Link Board system, i.e., link board crate with a high density back plane, Master Link Boards (MLB), Slave Link Boards (SLB), Control Board (CB) and Front Planes (FP). A rack with 3 Link Board Crates is shown in the figure above. Cables are connected to the control boards in the middle and right of the crate. The Front Planes can be seen below the cables.

The first production prototype boards were sent to CERN at the end of 2005 to be tested at the beginning of 2006. The cards performed well in the tests and only some minor corrections in Front Plane and Link Board mechanics were needed before full production of the cards. System testing was also a preparation of the MTCC (Magnet Test and Cosmic Challenge at P5) to test the CMS magnet and record cosmic muon events. A total of 25 more Link Boards were sent to CERN for the MTCC. The Link Boards were a crucial part of the trigger and readout system of the MTCC. The MTCC was a great success and first curved muon tracks were seen. An event display is shown in the figure below.

A rack with 3 Link Board Crates.

After the MTCC full production of the boards was started. The boards have been assembled at Electro Hill Ltd and tested at Lappeenranta University of Technology. All the boards will be tested and sent to CERN before the end of 2007. Altogether 906 SLBs, 510 MLBs, 220 CBs and 220 FBs have been produced. Installation of boards into CMS is now being undertaken. Control of the full chain of Link Boards was achieved before the end of the year in one of the end-caps (YB+1).

A curved track in CMS.



Nuclear Matter Programme

Juha Äystö,
Nuclear Matter
Programme director

The Nuclear Matter Programme provides full participation of the Finnish teams at CERN in studies of two aspects of nuclear and hadronic matter. These are cold exotic matter with extreme composition of its proton and neutron numbers and hot and dense matter created in relativistic heavy ion collisions. The first project is carried out at the ISOLDE Facility and the second one concentrates on the construction of certain parts of the ALICE detector for the LHC machine as well as increasingly more on developing the Finnish Physics Programme for ALICE. The ISOLDE project has its physics motivation in studies of exotic structures of nuclei, with a special emphasis on weak interaction phenomena and nuclear astrophysics. The ALICE project aims to study the phase transitions of hadronic matter and possible signatures for a new form of matter, the quark and gluon plasma. The project leaders of these two projects are Docent Ari Jokinen for ISOLDE and Dr. Markku Oinonen for ALICE. In addition, the Nuclear Matter Programme is co-ordinating the Finnish participation in the planning of the FAIR project at GSI. FAIR stands for Facility for Antiproton and Ion Research. The present plan includes participation in two experimental collaborations which are PANDA for antiproton driven hadron research and NUSTAR for nuclear structure and astrophysics studies. Moreover, industrial participations in constructing the FAIR Facility are being explored in collaboration with Finpro.

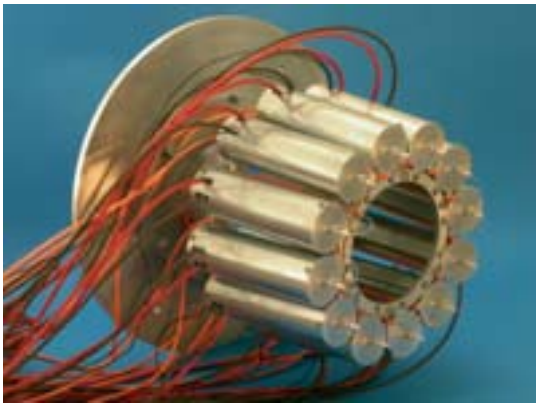
Markku Oinonen,
ALICE project
leader

ALICE

General

The centre of gravity of the HIP ALICE activity was clearly shifted from Helsinki to Jyväskylä during the second half of 2006. The ALICE SSD assembly was successfully completed in the Kumpula Detector Laboratory during summer 2006 and a new data analysis group was initially established at JYFL together with continuation in R&D and construction of the T0 trigger detector. The Helsinki group continued in establishing the framework for the data analysis infrastructure for the Finnish ALICE group within the Nordic and domestic resources.

The first part of the T0 to be assembled: T0-C.



The year 2006 was characterized by both pleasant and tragic events. The PhD thesis of Mariana Bondila – defended in May – can be considered as reaching an important milestone of the Finnish preparation effort for ALICE. On the other hand, one of the most important group members, Vladimir Lyapin, was taken with a very aggressive illness and unexpectedly passed away in June. With coherent action from all of the group members this huge blow could be overcome during the last half of the year.

T0 trigger detector

In 2006, the ALICE T0-C and T0-A arrays were built and pre-commissioned as planned, in spite of the shift in installation. According to the new LHC schedule, the arrays will be installed in the cavern in March and July of 2007. The final round of simulations aiming at verifying the role of T0 in trigger and luminosity measurements has advanced well. The work on T0 fast electronics and the integration with readout, slow control, and DAQ have proceeded as planned, although the unexpected death in June of the Technical Coordinator of T0 was a very heavy blow to our team and to our work.

High-p_T physics

Our group deploys experience from the data analysis of the PHENIX experiment at RHIC and concentrates on the exploration of partonic properties and their modifications in the excited nuclear medium. We have developed various methods for extraction of the parton intrinsic transverse momentum k_T and jet fragmentation transverse momentum j_T from the two-particle azimuthal correlation function. The activity during 2006 aims to prepare the analysis tools for extraction of these quantities from ALICE data to test various predictions related to the k_T-broadening and jet transverse heating.

Methods were under development for extraction of the fragmentation function from the direct-photon associated distributions and from the particle distributions associated to fully reconstructed jets. These measurements are vital not only for an understanding of QGP creation and evolution but also for exploration of fundamental QCD properties. There is a growing interest even in the field of String Theory to confront heavy ion data with various predictions emerging from Maldacena's conjecture of duality between a compactified M/String Theory in anti-de Sitter space-time and large-N Conformal Theory which provides a connection between String Theory and high-temperature QCD.

We have also developed, using decay topology, a reconstruction algorithm for charged kaons registered by TPC. In particular, we have addressed the question of whether the identification range we achieve in ALICE allows us to use charged kaons – the dominant carriers of strange quarks – to get insights into the properties of deconfined matter. The results of these studies have formed the basis of the first Finnish PhD thesis on ALICE. The thesis "Detection of charged kaons using the decay topology in ALICE TPC" was defended by Mariana Bondila on May 22, 2006. The opponent was Prof. Rene Bellwied from Wane State University in Detroit, Michigan, and her supervisor was Doc. W. H. Trzaska.

Since the Tier-1 level data analysis in the Nordic countries is co-ordinated by the Nordic Data Grid Facility, it is natural that we have also started to enhance our connections to the other Nordic ALICE groups. This activity is coherent with the aim to set up modest local computing resources at JYFL and that of relying on the future CSC-located resources for the Finnish LHC-related data analysis. The first step towards including Finland in the ALICE computing grid was taken by installing the AliEn middleware at JYFL at the end of 2006.

ALICE SSD module assembly in Helsinki

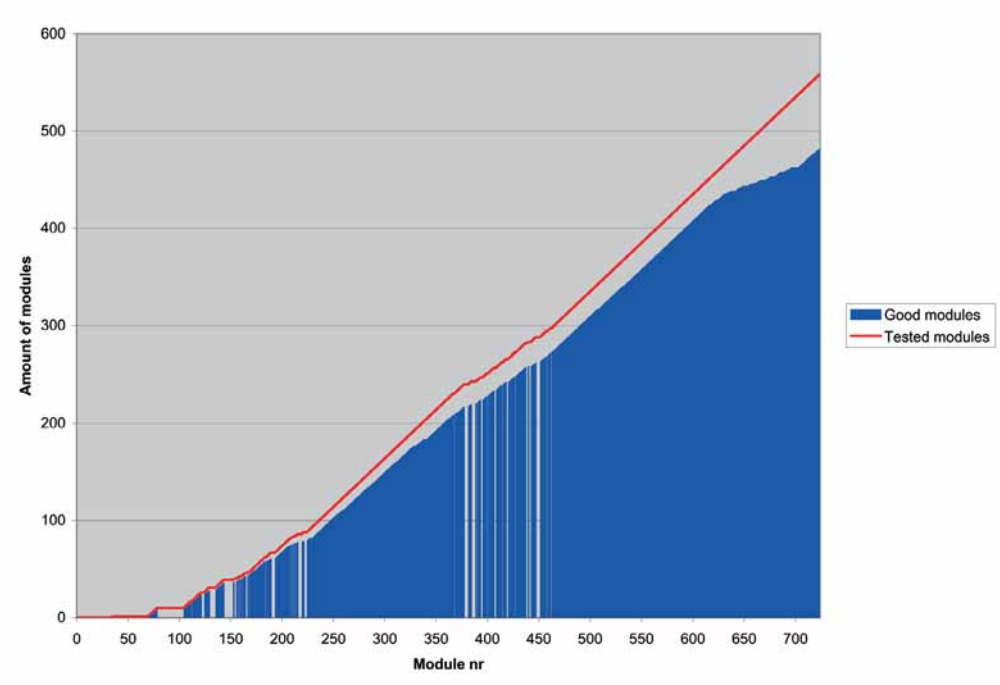
The largest detector assembly project in the history of Finnish science was successfully finished during summer 2006. Altogether 716 silicon strip detector modules were assembled (out of 2041) by the end of July at the premises of the HIP Detector Laboratory, containing about 1 million individual detector channels and 3 million ultrasonic Al-Al bonds. It is now time to summarize the history of the project and start considering the future ALICE upgrade.

The ALICE SSD assembly was shared between three countries in Europe: Finland/Helsinki, France/Strasbourg and Italy/Trieste. Whereas Italy was relying on the microelectronics industry, Finland and France decided to perform the work in laboratories. Particularly, Helsinki based the project strongly on Ukrainian interconnection & assembling experts and local expertise in quality control. Although starting several years after the others, the Helsinki Laboratory quickly achieved a pioneering role in the assembly process development. After commencing the project in January 2002, the Laboratory pioneered most of the assembly phases – facing also the corresponding problems: automatized ultrasonic bonds on ALICE components, assembly phases, first modules within the mass production scheme & speed, component storing, handling and transport.

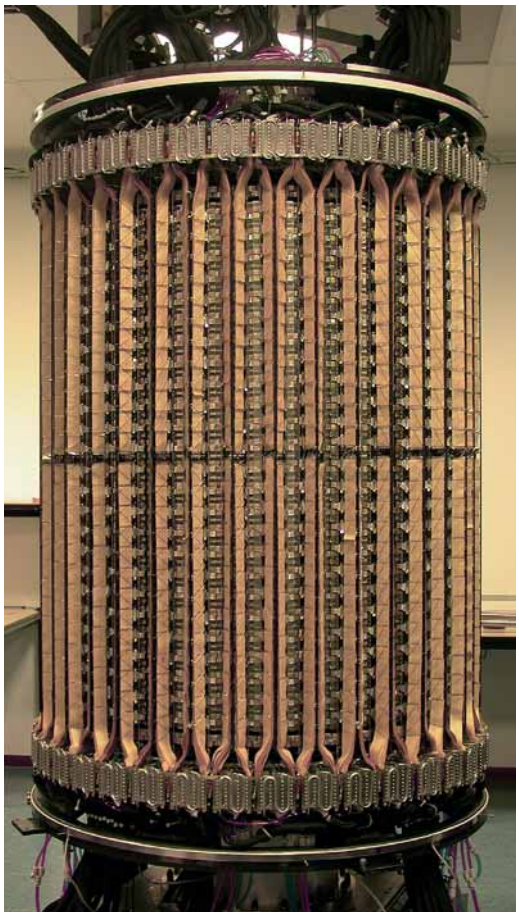
The mass production of the modules started in June 2004. The official goal was reached on May 29, 2006: the 700th ALICE silicon strip detector module was successfully produced and later the last 16 were added. In addition, insulation of all the so-called ladder cables was performed in Helsinki during the first half of 2006.

The module quality is defined as

History of the ALICE SSD module assembly at HIP as told by the module acceptance tests.



The complete ALICE SSD with 1698 modules installed in the SSD frame. The modules are hidden below the yellow ladder cables.



Q = 100 - defected channels. Requiring the quality Q > 70 for a good module, the yield of the modules assembled and tested in Helsinki was eventually 88%. Most of the modules falling out of this category peaked at the last 2 months of the mass production. This was due to imperfect sensors that eventually were decided to be included in the assembly. Particularly, the bonding yield reached 99.9% due to careful process tuning and quality control. The legacy of the ALICE SSD project is upheld in the Laboratory by expertise related to the ultrasonic bonds absorbed during the assembly. The overall history of the project will be summarized in a Master's thesis by Serja Aaltonen in 2007.

All the modules were eventually shipped to NIKHEF where the integration of the ALICE SSD took place throughout the year. At the end of 2006, the complete SSD was transported to CERN to wait for final integration as part of the ALICE Inner Tracking System during 2007.

V. Lyapin in memoriam

Vladimir Lyapin (21.8.1949–18.6.2006)

On June 18, 2006, our friend and colleague – Vladimir Lyapin – passed away. He was overcome by a very violent form of lung cancer that took him away in less than 3 weeks after he was diagnosed.

V. Lyapin's association with the Department of Physics of the University of Jyväskylä and later also with HIP dates back to 1994. At that time a team of physicists from St. Petersburg's Radium Institute, in fulfilment of the bilateral agreement signed in 1992, brought to the new Accelerator Laboratory the first parts of HENDES – High Efficiency Neutron Detection System. Volodia (as he was known to his friends) was in charge of the fast electronics and MCP detectors but his competence included nearly all aspects of experimental nuclear physics. For instance, he developed an excellent instrument for pulse analysis from fast phototubes, a sophisticated Master Trigger Unit, several generations of fast amplifiers and CFD modules, etc. His devices were used in experiments at CERN, GSI in Darmstadt, ILL in Grenoble, KVI in Groningen, and laboratories in Catania, Legnaro, Dubna and Warsaw.

In 1998 Volodia was part of the consulting team evaluating feasibility of carrying out bonding for ALICE SSD in Finland. Since that time Volodia's involvement in ALICE continued to grow and already in 2000 he became a full-time employee of HIP. At that time he worked on the design and tests of the MCP-based Forward Multiplicity Detector (FMD) for ALICE. Although the collaboration finally opted for a less sophisticated but cheaper option for FMD, Volodia's expertise and the excellent timing results achieved in test experiments at CERN have won for HIP the leadership of T0 – the key timing and fast trigger detector in ALICE. His professional know-how and pleasant personality quickly convinced the collaboration to entrust Volodia with the mandate of Technical Coordinator of T0. In that capacity he was supervising the work of a dozen of research engineers in 4 institutes. His electronics was adopted in part by other ALICE detectors (V0 and TRD wake-up). Fast timing techniques perfected with Volodia's significant contribution for the needs of the LHC experiment were also used at JYFL. Especially impressive is the impact made by the new picoseconds-timing on TOF-based energy loss measurements of charged ions. Last but certainly not least is Volodia's contribution to teaching. His patience and thoroughness in explaining the fundamentals of electronics and experimental techniques to scores of MSc and PhD students at JYFL were truly exemplary. We all miss him a lot.

Ari Jokinen, ISOLDE project leader

ISOLDE

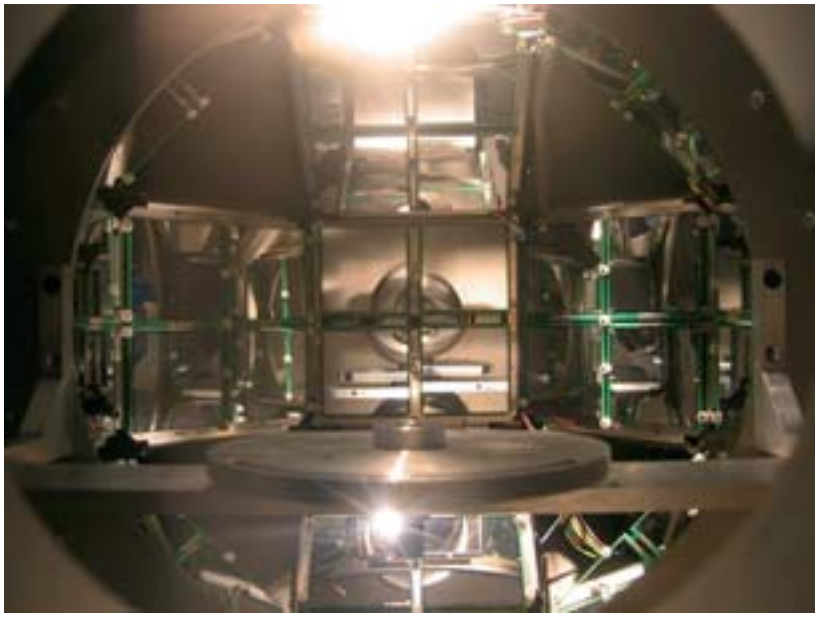
Solid state physics

Diffusion studies employing the modified radiotracer technique were continued with the concluding Mn implantations of Mn in GaAs and SiGe alloys. The preliminary results of the project were presented at the 2nd International Conference on Diffusion in Solids and Liquids in Aveiro, Portugal.

Beta-delayed particle emission of ^{17}Ne

Beta-delayed particle emission of ^{17}Ne was studied in experiment IS420 at ISOLDE on Oct 14th–19th 2006 by the Århus-CERN-Göteborg-HIP-Madrid collaboration. The purpose of the experiment was to probe the structure of ^{17}F and its particle decay branches to ^{16}O and ^{13}N. One of the main objectives of the experiment was to identify the p + alpha + ^{12}C final state which is of great astrophysical interest. Other interests of study are a possibility of a direct two proton decay of ^{17}Ne into ^{15}O and isospin mixing in the decay from ^{17}Ne to the IAS of ^{17}F. The ^{17}Ne beam was produced by bombarding a thick MgO target with 1.4 GeV protons from the CERN PSB accelerator. The MgO target was coupled to a cooled plasma ion source and the ISOLDE HRS (High Resolution Separator). The actual experimental set-up was located at the end of the LA2 beamline. The ^{17}Ne beam was implanted into a thin C-foil situated in the middle of the ISOLDE Si-Ball 2pi detector array. Other detectors in the set-up were a single DSSSD with a thick back detector and a 3 mm thick plastic scintillator. Collected on-line data looks promising and the analysis was only at a preliminary stage at the end of 2006.

A detector assembly used in the ^{17}Ne experiment at ISOLDE. Only the Si-layer (Si-ball project) is shown before an installation of auxiliary detectors.



Precision mass measurements at ISOLTRAP

Superallowed $0^+ \rightarrow 0^+$ nuclear decays can be used to obtain precise values on a number of fundamental weak interaction parameters. In particular, the value of the up-down element V_{ud} of the Cabibbo-Kobayashi-Maskawa (CKM) matrix was determined from the superallowed data. Since V_{ud} is a key component of the most demanding available test of the unitarity of the CKM matrix, the precision and reliability of the value for V_{ud} has a direct impact on the search for Physics Beyond the Standard Model. It is therefore important to determine the QEC value of the decay with high precision ($<10^{-8}$). Penning traps are ideally suited for the task, and in recent years a number of measurements have been conducted at different Penning trap facilities. As part of this ongoing effort, the masses of two super-allowed beta-decaying nuclides were measured at ISOLTRAP in 2006. To reduce the statistical uncertainties, these measurements were conducted using Ramsey excitation schemes with two separate excitation fringes. This technique results in narrower resonances improving the precision achieved for given statistics by a factor of three. The studied nuclei were ^{26}Al and ^{38}Ca; the data for ^{26}Al is still being analyzed, but the preliminary results agree with the results previously obtained at JYFLTRAP in Jyväskylä, which were published in 2006. The

analysis of the ^{38}Ca has already been concluded. The resulting mass value agrees well with older measurements.

In a separate measurement campaign, several neutron-rich isotopes of manganese and iron were studied. Iron is not usually available as a radioactive beam from ISOLDE. To overcome this limitation, the manganese was stored in the first of the two Penning traps for a prolonged period in order to allow the nuclei to beta-decay to iron. These decay products could subsequently be studied in the precision trap.

^{229}Th case

There is a strong interest in the properties of the exceptionally low first excited state in ^{229}Th. One reason for this interest is that it offers a unique opportunity to study the coupling between the nuclear and atomic degrees of freedom. The experiment at ISOLDE was aimed at searching for the alpha decay branch from the 3.5 eV state in ^{229}Th into the states in ^{225}Ra and to measure its half-life by alpha decay spectroscopy. Earlier experiments gave conflicting reports on the half-life, or half-life limits for this state.

The experiment at ISOLDE had the advantage over previous work in that it used the mass separation technique. The A=229 activity was produced using proton induced spallation of ^{238}U, mass separated and then implanted onto foils. ^{229}Th is populated via the beta decay chain of ^{229}Fr-^{229}Ra-^{229}Ac-^{229}Th. Unfortunately the beta decay background was still too high to be able to cleanly resolve short-lived components from the alpha decay of the Thorium isomer. In the future, a more careful spectroscopy set-up could be used to minimize sources of background, however the on-line mass separation available at ISOLDE is a valid method for producing A=229.

Ion beam preparation research and development

An ion cooler and buncher was tested in off-line conditions for the first time with Cs ions. After tedious characterization of the cooling and trapping parameters, a transmission efficiency of the order of 70% was reached. Further off-line tests are currently being performed to fulfil the requirements for an on-line installation in 2007–2008.

Technology Programme

Ari-Pekka Hameri,
Technology Programme
director

During 2006, the HIP Technology Programme continued to contribute to numerous international and domestic Grid activities. The focus of the research and development work remained on Grid security both in the CERN-orchestrated Enabling Grids in E-SciencE (EGEE & EGEE-II) and in the industrial NETwork identity, Grid service Access and Telecom Enabled provisioning (NETGATE 1 & 2) projects funded by TEKES. In addition the cluster activities around the Finnish Material Sciences Grid (M-Grid) reached an important collaboration agreement with CSC, the Finnish IT center for science. A new training cluster in order to prepare for the LHC data challenge was purchased in December. Other LHC Physics-related activities such as the deployment of Grid-enabled software in Finland and the co-ordination of the CERN Openlab initiated LHC@home project continued. A Grid for Scientists PhD research project funded by the Academy of Finland successfully finished at the end of 2006. In addition, the Programme produced four MSc students, and organized the second Nordic Grid Neighbourhood (NGN) Conference in Espoo together with CSC. In the EGEE'06 Conference in Geneva, the group had its own stand and the researchers were also invited to give a talk at the JBossWorld Conference in Berlin.

Miika Tuisku,
DataGrid project
leader

HIP Technology Programme stand at the EGEE'06 Conference in Geneva.

Grid middleware development

European Grid Security work

The experts of the HIP Technology Programme continued their work in the EGEE-II project and also took responsibilities as the deputy middleware manager (Joint Research Activities) and security middleware coordinator. From the start of EGEE-II HIP Technology Programme personnel have been determining the course of the security middleware development through their participation in the Technical Coordination Group. Also, the HIP Technology Programme software effort has continued directly on the security middleware with bug-fixing, hardening and evaluation efforts. The Programme has been responsible for producing several project deliverables and other peer-reviewed publications. During 2006 they also organized and attended the EGEE'06 Conference. Due to increased interest in Grid from industry, the HP Innovation Center in Geneva arranged together with CERN Openlab an EGEE Industrialization Workshop in June, to which the HIP Technology Programme was also invited.

Despite the fact that EGEE is spread out in numerous federations throughout Europe, CERN remains the competence centre in the project. The presence of the HIP Technology Programme at CERN helped to increase its responsibilities in the EGEE. The success of the project will likely result in a second sequel as preparations for EGEE-III has already started.

Two PhD students worked in the Grid for Scientists research project funded by the Academy of Finland. The project successfully finished at the end of 2006. It produced proto-

type software for reliable distributed data storage together with several conference publications during the three year project.

Physics Computing and Clusters

Physics Grid

The Large Hadron Collider (LHC) will begin operating by the end of 2007 and it will produce roughly 15 Petabytes of data annually. The LHC Computing Grid (LCG) is built by CERN together with about 200 other computing centres to store and analyze this data. According to current statistics, it provides more than 30,000 processors and 13,000 terabytes of storage. Within this context the HIP Technology Programme participates in the LCG Grid Deployment Board (GDB). The Finnish IT center for science (CSC) provides resources for the LHC computing Grid in Finland. There are also Finnish computing resources provided for LHC computing through the M-Grid project. The HIP Technology Programme has also participated with its own computing cluster infrastructure for the LHC Computing Grid.

The Nordic Data Grid Facility (NDGF) is a collaboration between the Nordic countries that allows Nordic researchers to participate in computationally challenging science projects. At the moment, the main goal of NDGF is participation in the LCG project. The HIP Technology Programme is represented in the NDGF CERN sub-committee that defines CERN and LHC physics needs for Nordic computing centres.

The NDGF is actively preparing a distributed Tier-1 centre for the LHC. A central part of this is a distributed data storage system using dCache. One of the dCache pools is located in Finland and will be used by the tools of the CMS experiment. The Technology Programme plays an important role in making these systems available in Finland and in combining them with CMS software and their requirements.

Grid Cluster activities in Finland

The HIP Technology Programme has actively continued its efforts in cluster computing and development. In 2006 the old cluster was gradually shut down. The machines from the cluster were used for providing EGEE with a small test cluster for their middleware developers. This will support the cluster computing efforts of the HIP Technology Programme by introducing a new widely-spread platform to be supported for future needs.

In accordance with the memorandum-of-understanding between HIP and CSC, the Jaspis cluster was moved to the CSC premises, this will support the ability of the HIP Technology Programme to focus on its cluster projects. The move of the Jaspis cluster allowed HIP to purchase a new cluster mainly for administrator training and cluster software development. This purchase also included a storage solution. The new cluster will further increase HIP's involvement in cluster and Grid activities.

The HIP Technology Programme has been active in the M-Grid project in 2006. In addition to the normal collaboration, HIP has also been tightly involved with the M-Grid Security Working Group. This group has written a set of security policies and guidelines to improve the security of the M-Grid.

New training cluster being built at Innopoli2 premises in Espoo.

The recruitment of new personnel for cluster and server administration has made it possible for the HIP Technology Programme to start consolidating its IT infrastructure. The main goals of the project will be to better support the needs of the researchers, to improve the security of the systems, to reduce the administration overhead, and to provide faster recovery times in case of system failure. This work will be finished in 2007.

The second Nordic Grid Neighbourhood (NGN) Conference and the NorduGrid ARC Technical Meeting were arranged by HIP and the Finnish IT center for science, CSC in June, 2006. Additional funding was provided by Nordplus. The conference was a two day event which was held in Innopoli in Otaniemi. The main purpose of the conference was to encourage and help Nordic and international collaboration with common Grid projects, and also to be a channel for information dissemination. The main themes were Grid and Bioinformatics, Adapting Applications to the Grid, Interoperability and Interoperations, National and Regional Activities, and Grids in Business. The conference had speakers from nine countries, both from academia and business.

Grid Applications and Industrial Collaboration Projects

NetGate

The first phase of the NetGate project ended in May 2006 and the second phase, NetGate 2, started in October 2006. NetGate is an industrial research project co-ordinated by the HIP Technology Programme. Other research partners are the Technology Business Research Center (Lappeenranta Technical University) and the Department of Computer Sciences of the University of Tampere. The project is financed by the Finnish National Technology Agency (TEKES) and 6 Finnish companies. This project exploits national and international research on Grid technologies and aims to leverage these research results in Finnish industry. The project has three focus areas: Security, Terminal Grid computing, and Grid business research.

The security work focuses on how users are authenticated in heterogeneous technology domains and how payment authorization for distributed 3rd party Grid services is accomplished. In practice, the project develops prototypes for yet non-existing key components for Grid service provision taking advantage of existing e-ID and billing infrastructures. This involves providing end-users with a federated network identity, support for integrated security policies & distributed payment authorization across Virtual Organizations, as well as interfacing the operator accounting and billing system. Of these focus areas, Terminal Grid computing, or so-called extended server-based computing, develops methods for utilising Grid resources in desktop applications and studies how security components developed in the project can be integrated to work with common desktop applications. The work is validated by a pilot system and tested with real users. In December 2006, several pilots were running at the University of Tampere, in both the offices of the HIP Technology Programme, and in the CERN library. The results have been very promising. Finally, the NetGate 2 project studies possible business models of various service scenarios in terms of earnings logic opportunities, roles in the value network, and general functionality of the value network.

The group organized a demonstration day for project partners in Espoo in April 2006. The participating companies were especially interested in the mobile-Grid authentication system, a reliable distributed storage solution, and server-based computing technology. The demonstrations showed that Grid technologies are beneficial in industrial applications. For example, in one demonstration a network-bootable diskless thin client acted as a normal desktop PC which was able to play full-screen video in Espoo although the server was located in Tampere. In another pilot a user was identified to a Grid service using the digital signature of the SIM card in a mobile phone.

CERN Openlab collaboration – Security Activities in Openlab-II

CERN is leading an EU-funded project called Integrated Site Security for Grids (ISSeG) that started in 2006. The purpose of this project is to provide practical guidelines to combine all the different dimensions of site security. In practice, Site Security concerns not only technical security issues (network security, server security, workstation security) but also non-technical ones like security-oriented administrative procedures as well as education and training.

The ultimate goal of the collaboration is to derive experience on how the combination of Intrusion Detection System (IDS) and anti-virus protection can be used to improve overall Integrated Site Security. In this context, two Finnish security companies, F-Secure and Stonesoft, are participating as contributors to the CERN Openlab from January 1, 2006. The HIP Technology Programme has provided technical support and participated in the evaluation and development of a prototype for anti-virus and IDS integration.

During the year 2006, F-Secure's anti-virus protection software has been evaluated at CERN. Based on the feedback from CERN, the products have been developed to fulfil the requirements of a very heterogeneous and demanding corporate network. At the end of 2006, also the evaluation of Stonesoft's IDS was started. This evaluation will continue into 2007.

Summer Student Programme

The 2006 summer student programme welcomed five students from Helsinki University of Technology. Two out of the five students participated in CERN Openlab-initiated industrial collaboration projects. One project was linked to developing mobile access to the Satellite Imagery Grid for the UN funded UNOSAT group and the other project related to benchmarking available Java application servers on the market for the CERN IT department. Enabled by the CERN Openlab co-funding scheme, 2006 was also the first year that the Technology Programme hosted and supervised a student from Spain, who worked on tasks closely related to the core group's activity. Three Finnish students who spent their summer at CERN are also continuing their work by writing their theses under HIP Technology Programme supervision.

Other Collaboration

The Technology Programme's industrial research collaboration venues apart from EGEE and CERN Openlab included also JBoss Federation, Planet-Lab initiative, and FennoGrid ry which was registered and started its operation in 2006. The aim of the FennoGrid association is to increase the co-ordinated dissemination of national and international Grid activities in Finland. Naturally Finnish partners that have signed the collaboration agreement with the Technology Programme such as Finpro Big Science and CSC have played and will continue to play a very important role in the future.

Other research of the group has included Semantic Web/Grid activities in co-operation with VTT and the University of Tampere as well as applying erasure correcting codes to Grid data storages in co-operation with the University of Delaware. Important forthcoming collaborations were initiated with Helsinki Institute of Information Technology (HIIT) around a national educational Grid initiative that has the potential to expand also outside Finland. Last but not least local collaboration in the Geneva area (e.g., the University Hospital of Geneva and the Technology Observatory of the Canton of Geneva) has opened up new possibilities for technology transfer through CERN activities.

CLOUD

Markku Kulmala, CLOUD project leader

The CLOUD (Cosmics Leaving OUtdoor Droplets) experiment is motivated by numerous indirect observations and theoretical studies that suggest galactic cosmic rays (GCRs) may exert a significant influence on the Earth's cloud cover and climate. The observed variation of low clouds by about 1.7% absolute over one solar cycle corresponds to a change in the Earth's radiation budget of about 1.2 Wm^{-2}. This is comparable with the estimated radiative forcing due to anthropogenic greenhouse gas emissions (2.4 Wm^{-2} in 2000). The main proposed mechanisms are ion-induced nucleation, enhancing production of new aerosol particles which can act as cloud condensation nuclei, and enhanced ice particle formation due to ionization by GCRs. However, none of these mechanisms have been experimentally verified. The CLOUD experiment aims to accurately determine the pathways and significance of the phenomenon. The CLOUD Collaboration comprises 21 institutes from 9 countries with strong Finnish contribution.

During October and November 2006 an 8 m^3 prototype reactor was constructed on the CERN PS beam line and the first preliminary experiments were performed. A π-beam was applied to simulate the cosmic radiation. Other variables in the experiment were SO_2, O_3, H_2O and UV-radiation. The Finnish CLOUD team contributed to the gas supply system and ion mobility and ion concentration measurements. The aim of the prototype runs was to gather supporting data for the hypothesis and gain experience for the design work of the final CLOUD detector. This was the first time when a particle accelerator has been utilized directly in atmospheric research. Results from the experiments and supporting modelling studies are expected in 2007.

The design work and instrument development for the final CLOUD detector has been continuing. The detector will comprise a fully temperature and pressure controlled reactor chamber and an expansion cloud chamber with relevant external and internal analyzers and gas and aerosol system. The basic idea behind the detector design is in fact the same as in C. T. R. Wilson's cloud chamber widely used as a particle detector decades ago. The difference is that while in Wilson's cloud chamber "cloud" formation was used to study subatomic particles, the CLOUD experiment uses particles to study aerosol and cloud processes. With the CLOUD detector the full scale of atmospheric conditions (from boundary layer to upper troposphere) can be simulated. A π/μ secondary beam from CERN PS will be used as an artificial source of cosmic rays. The physical processes to be studied during the CLOUD experiment are highly non-linear. Therefore it is important to re-create experimental conditions that are as close to natural as possible and extremely well known. This demand puts a great strain on the detector to be constructed. The Finnish team is responsible for ion mobility distribution measurements and partly for aerosol size distribution measurements with related instrument development, and also for process modelling.

Administration

Mikko Sainio

The graduate education of physics students continues to be one of the main tasks of the Institute. During the past year HIP has collaborated with one graduate school sponsored by the Ministry of Education: The Graduate School in Particle and Nuclear Physics (GRASPANP). In addition to the graduate students that are supported by the graduate school and by the Institute, also a fair number of undergraduate students join the research groups and complete their Masters' thesis work in the Institute. Many of these students have continued as graduate students in the Institute projects upon graduation. In particular, the very popular summer student jobs at CERN have attracted students to graduate study. During the period 2002–2006, 33 doctoral degrees and 51 Masters' degrees have been earned in HIP research projects.

The National Board of Education (Opetushallitus) has continued the collaboration with HIP and the municipality of Jyväskylä in the CERN co-operation high school network and the collaboration with the city of Tampere in the TekNatur/CERN network for Swedish speaking students. The aim is to develop the role of particle physics in school curricula in co-operation with CERN. In 2006 this programme attracted 277 Finnish students and 39 of their teachers. A related programme has been to bring to CERN high school physics teachers, who participate in continuing education courses. In 2006, 30 teachers participated in this programme. In addition, a shorter visit to CERN was made by a group of 10 high school principals. These visits have generated considerable coverage in local newspapers all over the country: about 30 articles in total in 2006.

In 2006 the Lappeenranta University of Technology joined as a partner university of the Helsinki Institute of Physics. LUT has participated in the HIP activities already in the past; in the CMS and Technology Programmes.

The technological and commercial co-operation between Finnish industry and CERN is co-ordinated by HIP in collaboration with Finpro, which is an independent association that provides services to Finnish export industry. The Finpro project at CERN is financed by TEKES.

Helsinki Institute of Physics 1997-2006

HIP finances (in M€)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Budget exp.	3.44	3.50	3.69	3.76	3.33	3.75	3.52	3.31	3.47	3.57
External funding	0.58	0.73	0.98	0.77	0.32	0.66	0.68	0.82	0.57	0.50
Total	**4.02**	**4.23**	**4.67**	**4.53**	**3.65**	**4.41**	**4.20**	**4.13**	**4.04**	**4.07**

The amounts until 2001 have been converted to €'s with the factor 1 € = 5.94573 FIM

HIP manpower (in person years)

	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	na	na	39.5	37.9	35.8	37.4	27.1	23.0	22.4	24.5

HIP scientific activity

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
# refereed journ. articles	86	118	123	134	103	87	107	130	129	149
Coll. articles	33	44	47	68	24	14	30	44	42	66
HIP preprints, internal reports	87	96	93	51	75	75	71	74	62	68
Coll. notes	8	18	13	18	15	10	6	13	15	30
Seminars in Helsinki	63	51	51	57	54	61	62	47	41	43

Collaboration articles are included in the number of refereed articles.

Degrees granted in connection with the HIP research activities:

MSc/MSc (eng.)

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

Doctoral degrees

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

UH = Univ. Helsinki, TKK = Helsinki Univ. of Technology, UJ = Univ. Jyväskylä,
LUT = Lappeenranta Univ. of Technology

Organization and Personnel

Organization

Scientific Advisory Board
Wolf-Dieter Schlatter, Heinrich Leutwyler, Maurice Rice, Jos Engelen, Martti Mäenpää, Hans Specht

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Steering Group
DOR, KE, HS, JT, JÄ, AH, MS, TS

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Dan-Olof Riska

Administrative Manager
Mikko Sainio

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  - **String Theory and QFT** — Esko Keski-Vakkuri
  - **Particle Physics Phenomenology** — Katri Huitu
  - **Cosmology** — Kari Enqvist
  - **Physics of Biological Systems** — Ilpo Vattulainen
  - **Ultrarelativistic Heavy Ion Collisions** — Kari J. Eskola
- **High Energy Physics** — Heimo Saarikko
  - **Electron-Positron Physics** — Kenneth Österberg
  - **LHC Foward Physics** — Risto Orava
- **CMS** — Jorma Tuominiemi
  - **Software and Physics** — Veikko Karimäki
  - **CMS Tracker** — Eija Tuominen
- **Nuclear Matter Physics** — Juha Äystö
  - **ALICE** — Markku Oinonen
  - **ISOLDE** — Ari Jokinen
- **Technology** — Ari-Pekka Hameri
  - **Data Grid** — Miika Tuisku
  - **CLOUD** — Markku Kulmala

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	Juhani Keinonen, Professor (University of Helsinki)
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Personnel

Theory Programme

K. Enqvist, prof., programme director
A. Green, prof., adj. senior scientist
A. Collin, grad. student
O. Dannenberg, grad. student
J. Koponen, grad. student

Cosmology

K. Enqvist, prof., proj. leader
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F. Vernizzi, scientist
A. Ferrantelli, grad. student
J. Högdahl, grad. student
R. Keskitalo, grad. student
T. Koivisto, grad. student
T. Mattsson, grad. student
L. Mether, grad. student
V. Muhonen, grad. student
V. Reijonen, grad. student
T. Tahkokallio, grad. student
A. Väihkönen, grad. student
M. Ronkainen, student

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J. Maalampi, prof., adj. senior scientist
E. Gabrielli, senior scientist
J. Laamanen, scientist
Q. Li, scientist
S. Roy, scientist
T. Honkavaara, grad. student
T. Rüppell, grad. student
P. Tiitola, grad. student

Physics of Biological Systems

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S. Majaniemi, scientist
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J. Repáková, scientist
Z. Wei, scientist
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A. Hall, student
M. Heikelä, student
K. Heikkilä, student
S. Ollila, student
S. Pöyry, student
T. Vuorela, student

String Theory and Quantum Field Theory

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J. Hietarinta, prof., adj. senior scientist
A. Niemi, prof., adj. senior scientist
P. Kulish, senior scientist
J. Majumder, scientist
J.-T. Yee, scientist
M. Arai, adj. scientist
N. Uekusa, adj. scientist
N. Jokela, grad. student
T. Liimatainen, student

Ultrarelativistic Heavy Ion Collisions

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V. Ruuskanen, prof., senior scientist
K. Rummukainen, prof., adj. scientist
T. Renk, scientist
K. Tuominen, adj. scientist
A. Gynther, grad. student
A. Hietanen, grad. student
T. Kähärä, grad. student
H. Niemi, grad. student
J. Virkajärvi, grad. student
H. Paukkunen, student

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Electron-Positron Physics

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J. Paro, scientist
L. Salmi, scientist
F. Oljemark, student

LHC Forward Physics

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E. Brücken, grad. student
T. Hilden, grad. student
J. Kalliopuska, grad. student
P. Mehtälä, grad. student
T. Mäki, grad. student (Fermilab)
E. Noschis, grad. student
T. Aaltonen, student
M. Ottela, student

Detector Laboratory

M. Oinonen, lab. coordinator
F. Garcia, scientist
J. Heino, lab. engineer
R. Lauhakangas, lab. engineer
A. Numminen, lab. technician

CMS Programme

J. Tuominiemi, prof., programme director
M. Stettler, senior scientist, engineer (at CERN)

Software and Physics

V. Karimäki, docent, proj. leader (at CERN)
R. Kinnunen, senior scientist
K. Lassila-Perini, senior scientist (at CERN)
S. Lehti, senior scientist
T. Lindén, senior scientist, grid coordinator
S. Slabospitsky, senior scientist (at CERN)
A. Heikkinen, grad. student
T. Lampén, grad. student (at CERN)
J. Nysten, grad. student (at CERN)
M. Voutilainen, grad. student (Fermilab)
L. Wendland, grad. student
A. Hektor, adj. grad. student
P. Kaitaniemi, student
G. Bårdsen, summer trainee (at CERN)
T. Salminen, summer trainee (at CERN)
J. Vanninen, summer trainee (at CERN)

CMS Tracker

E. Tuominen, proj. leader
S. Czellar, senior scientist (at CERN)
J. Härkönen, senior scientist (at CERN)
I. Kassamakov, senior scientist
A. Kesti, scientist
P. Luukka, scientist (at CERN)
Y. Shah, scientist (at CERN)
T. Mäenpää, grad. student
E. Tuovinen, grad. student
E. Anttila, engineer (at CERN)
P. Heikkilä, engineer
J. Kortesmaa, lab. technician
P. Sane, student
M. Autioniemi, summer trainee (at CERN)
J. Kokko, summer trainee (at CERN)
H. Nylund, summer trainee (at CERN)

Nuclear Matter Programme

J. Äystö, prof., programme director
W. Trzaska, docent, vice director
K. Peräjärvi, scientist, GSI/FAIR coordinator

ALICE

M. Oinonen, proj. leader
V. Ruuskanen, prof., senior scientist
M. Bondila, scientist
H. Seppänen, grad. student
V. Lyapin, engineer (deceased)
S. Nikkinen, student
R. Vierimaa, student

ISOLDE

A. Jokinen, docent, proj. leader
J. Äystö, prof.

Technology Programme

A.-P. Hameri, prof., programme director (at CERN)

DataGrid

M. Tuisku, proj. leader (at CERN)
J. Hahkala, scientist (at CERN)
J. Karppinen, scientist (at CERN)
J. Klem, scientist (at CERN)
T. Niemi, scientist (at CERN)
M. Punceva, scientist (at CERN)
J. White, scientist (at CERN)
M. Gindonis, scientist
M. Niinimäki, scientist
A. Pirinen, scientist
M. Silander, scientist
M. Pitkänen, grad. student (at CERN)
J. Kommeri, student (at CERN)
J. Dahlblom, student
K. Defée, student
K. Happonen, student
J. Koivumäki, student
K. Lundahn, student
H. Mikkonen, student
T. Nissi, student

CLOUD

M. Kulmala, prof., proj. leader
M. Sipilä, grad. student

Administration and Support

D.-O. Riska, prof., director
M. Sainio, docent, adm. manager
T. Sandelin, financial manager
M. Flygar, secretary (at CERN)
T. Hardén, secretary
T. Karppinen, secretary (at CERN)
P. Lehto, secretary
A. Heikkilä, tech. coordinator (at CERN)
R. Rinta-Filppula, researcher (at CERN)
N. Jiganova, IT specialist
J. Aaltonen, lab. engineer

Seminars

Seminars held in Helsinki

January 17th R. Orava (Department of Physical Sciences/HIP)
Forward physics scenarios at the LHC

January 24th P. Janhunen
(Department of Physical Sciences/FMI)
Electromagnetic sails for spacecraft propulsion

January 26th R. Eichler (PSI, Switzerland)
The research program of the Paul Scherrer Institut (PSI) in Switzerland

January 31st K. Kainulainen (Department of Physical Sciences, University of Helsinki/University of Jyväskylä)
Dark energy, scalar-tensor-gravity and extra dimensions

February 14th A. Collin (HIP/University of Turku)
Applications of rotational excitations in Bose-Einstein condensates

February 21st D. O. Riska (HIP)
The strangeness form factors of the proton

February 23rd Y. Kobayashi
(Tokyo Metropolitan University, Japan)
Twisted symmetries on noncommutative space

February 28th A. Väihkönen (HIP)
Non-Gaussian cosmological perturbations

March 13th O. Heinonen (IAEA Deputy Director General and Head of the Department of Safeguards)
IAEA:n toiminta ydinaseiden leviämisen estämiseksi

March 13th M. Roček (Stony Brook, USA/Amsterdam, the Netherlands)
Does smoothing matter?

March 14th A. Gynther (Department of Physical Sciences, University of Helsinki)
Pressure of the standard model

March 16th L. Salmi (HIP)
Improving V_{cb} measurement using the lepton energy spectrum in semileptonic B decays

March 23rd A. De Roeck (CERN, Switzerland)
Future colliders: physics at the high energy frontier

March 28th D. Schwarz (Bielefeld, Germany)
The microwave sky at large angles: do we see local large-scale structures?

April 11th H. Jungner (Dating Laboratory, Finnish Natural History Museum/ University of Helsinki)
Activities in the Dating Laboratory – from cosmic rays to climate change

April 25th A. Annila (Department of Physical Sciences, Institute of Biotechnology and Department of Biosciences, University of Helsinki)
The diversity of matter

May 9th K. Enqvist (HIP)
Preheating after inflation

May 23rd S. E. Koonin (British Petroleum, UK)
Energy trends and technologies for the coming decades

May 30th D. Ghosh (Delhi University, India)
Probing the light neutral Higgs boson scenario of the CP violating MSSM Higgs sector at the LHC

June 1st A. Naqvi (Swansea, UK)
The small black hole in N=4 Super Yang-Mills

June 6th T. Mattsson (HIP)
Is dark energy needed in an inhomogeneous universe?

June 13th N. van Remortel (Department of Physical Sciences, University of Helsinki/HIP)
Recent CDF results on B_s mixing

June 15th A. Niemi (Uppsala, Sweden)
Spin-charge separation, conformally flat space-times and SU(2) Yang-Mills

August 15th O. W. Greenberg (University of Maryland, USA)
A schematic model of generations of quarks and leptons

August 29th O. W. Greenberg
(University of Maryland, USA)
The discovery of color

September 12th F. Spanier (Lehrstuhl für Astronomie, Universität Würzburg, Germany)
HESS and MAGIC: new results in high energy astrophysics

September 21st C. Carlson
(College of William and Mary, USA)
Nuclear physics and modern evaluations of atomic hydrogen hyperfine splitting

September 22nd S. J. Brodsky
(SLAC, Stanford University, USA)
The impact of AdS/CFT on QCD phenomenology

October 3rd G. Bhattacharyya
(Saha Institute, Calcutta, India)
Power law running in universal extra dimension

October 5th A. Sibirtsev (Jülich, Germany)
Phi meson photoproduction from nuclei

October 10th H. Machner (Jülich, Germany)
Recent results at BIG KARL

October 17th E. Keski-Vakkuri (HIP)
A thermodynamical interpretation of time for a rolling tachyon

October 24th P. Niemelä (HIP/HUT)
Molecular dynamics of biological membranes

October 31st L. Laperashvili (Niels Bohr Institute, Denmark/ ITEP, Moscow, Russia)
Are preons dyons? Naturalness of three generations

November 2nd C. Herdeiro (University of Porto, Portugal)
On AdS_5 supersymmetric black holes

November 7th T. Koivisto (HIP)
Dark energy and dark gravity

November 9th P. Palazzi (particlez.org)
Are hadrons shell-structured?

November 14th K. Österberg (Department of Physical Sciences, University of Helsinki/HIP)
Technological challenges of CLIC

November 16th C. Baccigalupi (SISSA/ISAS, Trieste, Italy)
Scientific expectations and challenges from future CMB experiments

November 21st H. Kurki-Suonio (Department of Physical Sciences, University of Helsinki)
The Nobel Prize in Physics 2006 and its relation to cosmology

November 28th T. Tahkokallio (Department of Physical Sciences, University of Helsinki/HIP)
Thermodynamics of AdS/QCD

December 12th A. Hietanen (Department of Physical Sciences, University of Helsinki)
Quark number susceptibility at high temperature

December 19th E. Gabrielli (HIP)
Photon splitting in magnetic field as a probe of ultra-light spin-zero particles

Visitors

Theory Programme

Cosmology

T. Multamäki (Finland) 10.3.
I. Vilja (Finland) 10.3.
D. Wands (UK) 23.-25.3.
D. Schwarz (Germany) 27.-28.3.
A. Mazumdar (Denmark) 28.-30.3.
M. Sloth (USA) 27.4.-1.5.
S. Kawai (Japan) 8.-24.8.
M. Sloth (Denmark) 8.-24.8.
S. Kasuya (Japan) 15.-22.8.
C. Baccigalupi (Italy) 15.-18.11.
M. Tsumagari (UK) 5.-31.12.

Particle Physics Phenomenology

D. K. Ghosh (India) 22.5.-22.6.
G. Bhattacharyya (India) 1.-4.10.
G. Hiller (Germany) 24.-27.10.
M. Raidal (Estonia) 25.-27.10.
P. Azzi (Italy) 25.-28.10.

Hadron Physics Activity

V. Abaev (Russia) 23.1.-10.2.
R. Eichler (Switzerland) 24.-26.1.
V. Abaev (Russia) 13.3.-2.4.
B. Juliá-Díaz (Spain) 18.3.-1.4.
S. Koonin (UK) 22.-24.5.
C. S. An (PR China) 3.7.-30.8.
O. W. Greenberg (USA) 29.7.-4.9.
E. Norvaišas (Lithuania) 28.8.-1.9.
V. Abaev (Russia) 16.10.-24.11.
S. Wycech (Poland) 1.-30.11.

Physics of Biological Systems

E. Falck (USA) 23.-29.1.
P.-L. Hansen (Denmark) 7.-11.2.
P. B. S. Kumar (India) 12.-15.3.
A. Gurtovenko (UK) 13.-19.3.
S. Ramachandran (India) 30.4.-7.5.
M. Karttunen (Canada) 1.5.-16.7.
P. Pomorski (Canada) 1.5.-16.7.
R. van Gaalen (Canada) 1.5.-16.7.
P.-L. Hansen (Denmark) 25.-28.6.
H. Riezman (Switzerland) 31.10.-2.11.
E. Falck (USA) 20.11.-1.12.
M. Franova (Czech Republic) 25.11.-2.12.
J. Curdová (Czech Republic) 30.11.-14.12.
M. Karttunen (Canada) 7.-12.11.
J. Aittoniemi (UK) 11.-15.12.
M. Sammalkorpi (USA) 15.-22.12.
M. Karttunen (Canada) 27.12.-12.1.

String Theory and Quantum Field Theory

Y. Kobayashi (Japan) 22.-28.2.
S. Sasaki (Japan) 22.-28.2.
P. Kulish (Russia) 11.4.- 10.10.
A. Naqvi (UK) 30.5.-7.6.
K. Nishijima (Japan) 2.-29.7.
G. Zet (Romania) 14.8.-13.10.
M. Mnatsakanova (Russia) 23.10.-7.12.
Y. Vernov (Russia) 23.10.-7.12.
C. Herdeiro (Portugal) 30.10.-5.11.
S. Hemming (Iceland) 17.-31.12.
K. Larjo (USA)

Ultrarelativistic Heavy Ion Collisions

Y. Li (USA) 5.-14.2.
D. H. Rischke (Germany) 10.-26.2.
A. Vuorinen (USA) 9.-17.4.
T. Lappi (USA) 10.-17.4.
J. Ruppert (USA) 5.-12.5.
R. Vogt (USA) 11.-18.5.
A. Patkos (Hungary) 21.-24.5.
G. Baym (USA) 25.-27.5.
A. Vuorinen (USA) 14.6.-13.7.
A. Rajantie (UK) 15.6.
K. Rummukainen (Finland) 3.11.
K. Rummukainen (Finland) 7.-8.12.
A. Vuorinen (USA) 18.-31.12.
M. Laine (Germany) 27.-29.12.

High Energy Physics Programme

R. Seto (USA) 27.-28.4.
E. Kistenev (USA) 6.-8.8.

CMS Programme

Software and Physics

F. Baud-Lavigne (Switzerland) 3.-5.4.
F. Flückiger (Switzerland) 3.-5.4.
A. Hirstius (Switzerland) 3.-5.4.
S. Slabospitsky (Russia) 29.11.-1.12.
S. Slabospitsky (Russia) 23.-26.12.

Nuclear Matter Programme

Y. Pyatkov (Russia) 12.1.-10.2.
A. Boyko (Ukraine) 16.1.-24.2.
Y. Kostyshyn (Ukraine) 16.1.-24.2.
Y. Rosenko (Ukraine) 16.1.-24.2.
I. Tymchuk (Ukraine) 16.1.-24.2.
N. Chernykova (Ukraine) 5.2.-4.3.
V. Loginov (Russia) 13.-19.2.
V. Tiflov (Russia) 23.-26.2.
Y. Kostyshyn (Ukraine) 25.2.-4.3.
I. Tymchuk (Ukraine) 25.2.-4.3.
S. Pankov (Ukraine) 8.3.-21.4.
M. Protsenko (Ukraine) 8.3.-21.4.
V. Kaplin (Russia) 10.-19.3.
A. Reshetin (Russia) 14.-24.3.
Y. Rosenko (Ukraine) 19.3.-21.4.
O. Striliana (Ukraine) 19.3.-21.4.
A. Reshetin (Russia) 9.-15.4.
N. Chernykova (Ukraine) 21.4.-1.6.
N. Okunieeva (Ukraine) 21.4.-1.6.
I. Tymchuk (Ukraine) 21.4.-1.6.
V. Zhupinsky (Ukraine) 14.5.-3.6.
A. Boyko (Ukraine) 25.5.-3.6.
V. Kaplin (Russia) 26.6.-25.7.
I. Tymchuk (Ukraine) 11.7.-2.8.
R. Kupczak (Poland) 18.-26.7.
A. Boyko (Ukraine) 20.7.-9.8.
G. Buyerov (Ukraine) 20.7.-9.8.
Y. Rosenko (Ukraine) 17.-25.8.
A. Reshetin (Russia) 3.-9.9.
V. Longinov (Russia) 27.11.-3.12.
P. Christiansen (Sweden) 29.-30.11.
D. Röhrich (Norway) 29.-30.11.
A. Reshetin (Russia) 3.-9.12.
M. Kowalski (Poland) 3.-10.12.
V. Kaplin (Russia) 5.-13.12.
R. Kupczak (Poland) 28.12.-9.1.

Technology Programme

M. Swany (USA) 6.7.-4.8.

Conference participation, Talks and Visits by Personnel

Theory Programme

Cosmology

Portsmouth and Sussex University,
22 January - 1 February, Portsmouth and Brighton, UK
(talk by F. Vernizzi)

42nd Karpacz Winter School of Theoretical Physics "Current Mathematical Topics in Gravitation and Cosmology",
6-11 February, Ladek, Poland (T. Koivisto)

Institut d'Astrophysique de Paris (IAP),
11-19 March, Paris, France (talk by F. Vernizzi)

Facts and Fiction in Cosmology,
26 March - 2 April, Sils Maria, Switzerland (talk by F. Vernizzi, talk by A. Väihkönen)

Cosmology, Strings and Black Holes,
18-21 April, Nordita/NBI, Copenhagen, Denmark (L. Mether)

Non-Gaussianity from Inflation,
18-21 April, Cambridge, UK (talk by K. Enqvist, talk by F. Vernizzi, A. Väihkönen)

University of Bielefeld,
16-17 May, Bielefeld, Germany (talk by K. Enqvist)

University of Lancaster,
5-9 June, Lancaster, UK (F. Vernizzi)

Inflation +25,
26-30 June, IAP, Paris, France (talk by F. Vernizzi)

Institut d'Astrophysique de Paris (IAP),
29 June - 9 July, Paris, France (F. Vernizzi)

Workshop on Hadrons and Strings,
17-22 July, ECT*, Trento, Italy (T. Tahkokallio)

Workshop in non-Gaussianities in Cosmology,
24-28 July, ICTP, Trieste, Italy (talk by F. Vernizzi)

Key Approaches to Dark Energy,
7-15 August, Barcelona, Spain (talk by T. Koivisto)

Summer School on Strings, Gravity and Cosmology,
7-18 August, University of British Columbia, Vancouver, Canada (L. Mether)

University of Jyväskylä,
21-25 August, Jyväskylä, Finland (V. Reijonen)

Cosmo-UK 2006,
26-31 August, Ambleside, UK (talk by K. Enqvist)

Dubna International Advanced School on Theoretical Physics,
3-12 September, Dubna, Russia (invited lectures by D. Podolsky)

Non-perturbative dynamics in the early Universe,
13-15 September, Madrid, Spain (talk by D. Podolsky)

COSMO-06,
25-29 September, Tahoe City, CA, USA (J. Högdahl, L. Mether, V. Muhonen)

University of Oslo,
25-29 September, Oslo, Norway (talk by T. Mattsson)

Galileo Galilei Institute for Theoretical Physics,
2-28 October, Florence, Italy (K. Enqvist)

Astroparticle and Cosmology Workshop, Galileo Galilei Institute for Theoretical Physics,
2 October - 4 November, Florence, Italy (talk by V. Muhonen)

University of Jyväskylä,
5-6 October, Jyväskylä, Finland (V. Reijonen)

University of Jyväskylä,
1-5 November, Jyväskylä, Finland (V. Reijonen)

Landau Institute for Theoretical Physics,
14-29 November, Moscow, Russia (D. Podolsky)

University of Jyväskylä,
22-24 November, Jyväskylä, Finland (V. Reijonen)

Seminar on Problems of Measurability in Quantum Gravity and of Dark Part of Universe,
30 November - 2 December, St. Peterburg, Russia
(talk by D. Podolsky)

University of Tokyo,
7 December, Tokyo, Japan (talk by K. Enqvist)

Kanagawa University,
9 December, Yokohama, Japan (talk by K. Enqvist)

University of Jyväskylä,
13-14 December, Jyväskylä, Finland (V. Reijonen)

Particle Physics Phenomenology

The 19'th Nordic Particle Physics Meeting,
4-6 January, Spåtind, Norway (K. Huitu, T. Rüppell)

The Annual Meeting of the Finnish Physical Society,
9-11 March, Tampere, Finland (talk by T. Honkavaara, K. Huitu)

Abdus Salam International Centre for Theoretical Physics (ICTP),
1-31 May, Trieste, Italy (talk by S. Roy)

RECFA Meeting,
12-13 May, Paris, France (K. Huitu)

Flavour in the era of LHC Workshop,
15-18 May, Geneva, Switzerland (E. Gabrielli, K. Huitu)

14th International Conference on Supersymmetry and the Unification of Fundamental Interactions,
12-17 June, Irvine, CA, USA (T. Honkavaara, J. Laamanen, T. Rüppell)

Jyväskylä Summer School,
31 July - 5 August, Jyväskylä, Finland (lectures by K. Huitu)

Charged Higgs Workshop,
12-14 September, Uppsala, Sweden (invited talk by K. Huitu)

Particle Physics Seminar,
6 October, Helsinki, Finland (talk by K. Huitu)

MCWS Workshop,
22-25 October, INFN, National Laboratory of Frascati, Frascati (Rome), Italy (talk by E. Gabrielli)

ILC Workshop,
25 October, INFN, National Laboratory of Frascati, Frascati (Rome), Italy (talk by E. Gabrielli)

13th Nordic LHC Physics Workshop,
25-27 October, Helsinki, Finland (talk by E. Gabrielli, talk by T. Honkavaara, K. Huitu, J. Laamanen, T. Rüppell)

Particle Physics Day,
24 November, Helsinki, Finland (K. Huitu, J. Laamanen)

CERN, RECFA and ECFA Meetings,
29 November - 2 December, Geneva, Switzerland (K. Huitu)

Kumpula Colloquium,
5 December, Helsinki, Finland (invited talk by K. Huitu)

Hadron Physics Activity

California Institute of Technology,
3-13 January, Pasadena, CA, USA (D. O. Riska)

IV EURIDICE Collaboration Meeting,
8-11 February, Marseille, France (M. Sainio)

The Annual Meeting of the Finnish Physical Society,
9-11 March, Tampere, Finland (J. Koponen, M. Sainio)

3rd International Workshop on From Parity Violation to Hadron Structure and more...,
16-20 May, Milos, Greece (invited talk by D. O. Riska)

Hadrons, Nuclei and Stars Symposium,
7-8 June, Darmstadt, Germany (invited talk by D. O. Riska)

Electron-Nucleus Scattering IX,
19-23 June, Marciana Marina, Italy (invited talk by D. O. Riska)

Summer School on Effective Theories in Particle Physics,
16-22 July, Zuoz, Switzerland (M. Sainio)

The XXIV International Symposium on Lattice Field Theory - Lattice 2006,
23-28 July, Tucson, AZ, USA (talk by J. Koponen)

The Final EURIDICE Meeting,
24-27 August, Kazimierz, Poland (talk by J. Koponen, M. Sainio)

Particle Physics Day,
24 November, Helsinki, Finland (talk by J. Koponen)

Institute of Theoretical Physics, University of Bern,
7-8 December, Bern, Switzerland (M. Sainio)

Physics of Biological Systems

Biophysical Society 50th Annual Meeting,
18-22 February, Salt Lake City, UT, USA (E. Terämä, I. Vattulainen)

The Annual Meeting of the Finnish Physical Society,
9-11 March, Tampere, Finland (talk by J. Aittoniemi, M. Heikelä, S. Ollila, J. Repáková, E. Terämä, I. Vattulainen)

Ihminen ja Kosmos,
17-19 March, Kuhmo, Finland (invited talk by I. Vattulainen)

Mesoscale Simulation Techniques for Soft Matter Systems,
5-7 April, Jülich, Germany (invited talk by I. Vattulainen)

Physics Department, University of Southern Denmark,
7-8 May, Odense, Denmark (I. Vattulainen)

Nordita Biological Physics Workshop,
8-11 May, Nordita, Copenhagen, Denmark (I. Vattulainen)

Structure, Dynamics and Function of Proteins in Biological Membranes,
14-19 May, Ascona, Monte Verita, Switzerland (invited talk by I. Vattulainen)

ESF Steering Group Meeting,
28-30 May, Strasbourg, France (I. Vattulainen)

WCSB 2006 Workshop on Computational Systems Biology,
12-13 June, Tampere, Finland (A. Hall, S. Pöyry, I. Vattulainen)

XIV International Symposium on Atherosclerosis,
18-22 June, Rome, Italy (M. Hyvönen)

Boulder School for Condensed Matter and Materials Physics,
26 June - 21 July, Boulder, CO, USA (E. Terämä)

Nordita Master Class,
30 July - 6 August, Hillerød, Denmark (A. Hall, S. Pöyry)

Physics Department, University of Southern Denmark,
7-18 August, Odense, Denmark (I. Vattulainen)

The Annual Meeting of the Glycosciences Graduate School,
30 August - 2 September, Oulanka, Finland (I. Vattulainen)

47th International Conference on the Bioscience of Lipids,
5-11 September, Pecs, Hungary (M. Hyvönen)

Venice Working Group Meeting,
8-11 October, European Center for Living Technology, Venice, Italy (invited talk by I. Vattulainen)

CECAM Workshop Multi-scale Modeling of Soft and Biological Matter,
18-20 October, Lyon, France (co-organized by I. Vattulainen)

Jyväskylä Nanoscience Days,
26-27 October, Jyväskylä, Finland (I. Vattulainen)

National Lipid Meeting,
14 November, Turku, Finland (A. Hall, M. Heikelä, M. Hyvönen, S. Ollila, S. Pöyry, talk by E. Terämä, I. Vattulainen, T. Vuorela)

String Theory and Quantum Field Theory

CERN,
16-21 March, Geneva, Switzerland (M. Chaichian)

High Energy/Cosmology Seminar,
17 March, Helsinki, Finland (talk by N. Jokela)

Black Rings, Black Holes and Topological Strings,
31 March - 4 April, Munich, Germany (J.-T. Yee)

IPM String School and Workshop,
10-19 April, Tehran, Iran (N. Jokela)

Cosmology, Strings, and Black Holes,
18-21 April, Nordita/NBI, Copenhagen, Denmark (N. Jokela, talk by J. Majumder, talk by J.-T. Yee)

University of Uppsala,
26-28 April, Uppsala, Sweden (M. Chaichian)

Department of Physics, University of Pennsylvania,
9-25 May, Philadelphia, PA, USA (N. Jokela, J. Majumder)

Summer School in Cosmology,
25 May, Tvärminne, Finland (invited lecture by E. Keski-Vakkuri)

APCTP Workshop on Liouville Theory,
31 May - 11 June, Pohang, South Korea (talk by J.-T. Yee)

Moscow State University and Russian Academy of Sciences,
1-11 June, Moscow, Russia (invited talks by M. Chaichian)

Strings 2006,
19-24 June, Beijing, China (N. Jokela, J. Majumder)

CERN,
1-31 July, Geneva, Switzerland (J.-T. Yee)

Workshop on Recent Advances in Black Hole Physics in String Theory,
26 August - 10 September, Aspen, CO, USA
(invited talk by E. Keski-Vakkuri)

Dublin Institute for Advanced Studies,
29 August - 8 September, Dublin, Ireland
(invited talks by M. Chaichian)

RTN Eurostring Workshop II,
10-17 September, Brno, Czech Republic (talk by J.-T. Yee)

University of Stockholm,
8-10 October, Stockholm, Sweden (M. Chaichian)

Workshop and PhD School on Inflation and String Cosmology,
26 October, Aarhus, Denmark (invited lecture by E. Keski-Vakkuri)

Department of Physics, University of Illinois,
5-18 November, Urbana-Champaign, IL, USA (seminar by N. Jokela)

The third Vienna Central European Seminar on Particle Physics and Quantum Field Theory "Challenges in Particle Phenomenology",
1-3 December, Vienna, Austria (talk by N. Uekusa)

Indian Strings Meeting, ISM06,
12-19 December, Toshali Sands, Puri, India (J. Majumder)

Institute of Physics, Bhubaneswar,
19-21 December, Bhubaneswar, India (talk by J. Majumder)

Saha Institute of Nuclear Physics,
21-28 December, Kolkata, India (J. Majumder)

Black Hole Meeting,
27 December, Saha Institute of Nuclear Physics, Kolkata, India
(talk by J. Majumder)

Indian Association for the Cultivation of Science,
29 December - 12 January, India (talk by J. Majumder)

Ultrarelativistic Heavy Ion Collisions

Technical University of Munich,
5-11 January, Garching, Germany (talk by T. Renk)

Department of Physical Sciences, University of Helsinki,
25-27 January, Helsinki, Finland (K. Tuominen)

NBI and Nordita,
29 January - 10 February, Copenhagen, Denmark (K. Tuominen)

European Graduate School Complex Systems of Hadrons and Nuclei,
20-24 February, Grünberg, Germany (talk by H. Paukkunen)

ALICE/HEP Seminar,
7 April, Jyväskylä, Finland (talk by T. Renk)

HEP Seminar,
18 April, Jyväskylä, Finland (talk by A. Gynther)

Strong and Electroweak Matter 2006,
10-13 May, BNL, Upton, NY, USA (talk by A. Gynther, A. Hietanen)

Hot Quarks 2006,
14-21 May, Villasimius, Sardinia, Italy (invited talk by T. Renk)

ALICE/HEP Seminar,
23 May, Jyväskylä, Finland (talk by T. Renk)

Duke University,
4-9 June, Durham, NC, USA (T. Renk)

2nd International Conference on Hard and Electromagnetic Probes of High-Energy Nuclear Collisions,
9-16 June, Pacific Grove, CA, USA (invited talk by T. Renk)

Heavy Ion Reactions at Ultrarelativistic Energies,
26-30 June, ECT*, Trento, Italy (invited talk by H. Niemi)

Lattice 2006,
23-28 July, Tucson, AZ, USA (talk by A. Hietanen)

Lecture Week on The Physics of Hadrons and Ultrarelativistic Heavy Ion Collisions,
25-30 September, Hyytiälä, Finland (in the Organization Committee K. J. Eskola, T. Kähärä, invited lectures by D.-O. Riska, in the Organization Committee P. V. Ruuskanen, invited lectures by K. Tuominen)

ALICE/HEP Seminar,
7 October, Jyväskylä, Finland (talk by T. Renk)

CERN/TH,
8-22 October, Geneva, Switzerland (T. Renk)

ALICE Week/ Heavy Ion Forum,
10 October, CERN, Geneva, Switzerland (invited talk by T. Renk)

13th Nordic LHC Physics Workshop,
25-27 October, Helsinki, Finland (K. J. Eskola, K. Tuominen, H. Paukkunen)

The 19th International Conference on Ultra-Relativistic Nucleus-Nucleus Collisions; Quark Matter 2006,
14-20 November, Shanghai, China (talk by T. Renk)

Johann Wolfgang Goethe University,
17-18 December, Frankfurt am Main, Germany (talk by T. Renk)

High Energy Physics Programme

Electron-Positron Physics

Technology Industries of Finland's Symposium on Tooling and Machining,
26-27 January, Naantali, Finland (talk by J. Paro)

Open Symposium for the Future Strategy for European Particle Physics,
30 January - 2 February, Orsay, France (K. Österberg)

The Annual Meeting of the Finnish Physical Society,
9-11 March, Tampere, Finland (F. Oljemark, L. Salmi, K. Österberg)

Meeting of the Finnish CLIC R&D industrial network,
24 March, Espoo, Finland (talk by J. Paro, K. Österberg)

13th Nordic LHC Physics Workshop,
25-27 October, Helsinki, Finland (L. Salmi, talk by K. Österberg)

Particle Physics Day,
24 November, Helsinki, Finland (F. Oljemark, L. Salmi, K. Österberg)

Working visits to Finnish CLIC R&D industrial partners,
Espoo, Joensuu, Oulu, Riihimäki and Tampere, Finland (J. Paro)

Forward Physics

NIKHEF,
4 January, Amsterdam, The Netherlands (N. van Remortel)

EU Silicon Tracking Meeting,
4-5 January, NIKHEF, Amsterdam, The Netherlands (R. Orava)

TOTEM Board and Physics Coordination Meetings,
10-13 January, CERN, Geneva, Switzerland (R. Orava)

Silicon Operations Meeting,
23 January, Fermilab, Batavia, IL, USA (talk by T. Mäki)

Fermilab,
23 January - 4 February, Batavia, IL, USA (N. van Remortel)

TOTEM Engineering Design Review Meeting,
30 January - 2 February, CERN, Geneva, Switzerland (R. Orava)

7th RTN Workshop on "The 3rd Generation as a Probe for New Physics",
8-11 February, Charles University, Prague, Czech Republic (invited talk by N. van Remortel)

TOTEM RP EDR Meeting,
13-15 February, CERN, Geneva, Switzerland (R. Orava)

Top Group Meeting,
2 March, Fermilab, Batavia, IL, USA (talk by T. Mäki)

TOTEM CB and Physics Coordination Meeting,
6-8 March, CERN, Geneva, Switzerland (R. Orava)

US Congress visit,
7-10 March, Washington D.C., USA (T. Mäki)

The Annual Meeting of the Finnish Physical Society,
9-11 March, Tampere, Finland (talk by E. Brücken, talk by N. van Remortel)

Yle Radio Interview,
17 April, Helsinki, Finland (talk by N. van Remortel)

Top Mass Meeting,
26 April, Fermilab, Batavia, IL, USA (talk by T. Mäki)

Top Mass Meeting,
3 May, Fermilab, Batavia, IL, USA (talk by T. Mäki)

CDF Silicon Workshop,
10-13 May, Santa Barbara, CA, USA (invited talk by T. Mäki)

2nd HERA-LHC Workshop,
6-9 June, CERN, Geneva, Switzerland (invited talk by R. Orava)

Low-x Workshop,
28 June - 1 July, Lisbon, Portugal (invited talk by R. Orava)

NIKHEF Colloquium,
29 June - 1 July, Amsterdam, The Netherlands (invited talk by N. van Remortel)

Event Display Fest,
7 July, Fermilab, Batavia, IL, USA (talk by T. Mäki)

Hadron Collider Physics Summer School,
9-18 August, Fermilab, Batavia, IL, USA (T. Mäki)

Top Mass Meeting,
16 August, Fermilab, Batavia, IL, USA (talk by T. Mäki)

Silicon Operations Meeting,
4 September, Fermilab, Batavia, IL, USA (talk by T. Mäki)

Diffraction 2006 Workshop,
5-9 September, Milos Island, Greece (invited talk by R. Orava)

Silicon General Meeting,
6 September, Fermilab, Batavia, IL, USA (talk by T. Mäki)

Sixth International "Hiroshima" Symposium on the Development and Application of Semiconductor Tracking Detectors,
11-15 September, Carmel, CA, USA (talk by T. Mäki)

Top Mass Meeting,
27 September, Fermilab, Batavia, IL, USA (talk by T. Mäki)

Top Group Meeting,
28 September, Fermilab, Batavia, IL, USA (talk by T. Mäki)

Silicon Operations Meeting,
9 October, Fermilab, Batavia, IL, USA (talk by T. Mäki)

Top Mass Meeting,
11 October, Fermilab, Batavia, IL, USA (talk by T. Mäki)

Top Group Meeting,
12 October, Fermilab, Batavia, IL, USA (talk by T. Mäki)

Top Group Meeting,
19 October, Fermilab, Batavia, IL, USA (talk by T. Mäki)

13th Nordic LHC Physics Workshop,
25-27 October, Helsinki, Finland (talk by M. Ottela)

Joint Meeting of Pacific Region Particle Physics Communities (DPF2006+JPS2006),
29 October - 3 November, Honolulu, HI, USA (talk by T. Mäki)

DESY,
30 October - 4 November, Hamburg, Germany (N. van Remortel)

Silicon General Meeting,
10 November, Fermilab, Batavia, IL, USA (talk by T. Mäki)

Top Dilepton Group Meeting,
15 November, Fermilab, Batavia, IL, USA (talk by T. Mäki)

Particle Physics Day,
24 November, Helsinki, Finland (R. Orava)

Fermilab,
4-17 December, Batavia, IL, USA (N. van Remortel)

Top Group Meeting,
7 December, Fermilab, Batavia, IL, USA (talk by T. Mäki)

University of Manchester,
9-12 December, Manchester, UK (R. Orava)

Detector Laboratory

Particle Physics Seminar,
10 February, Helsinki, Finland (talk by F. Garcia)

Geant4 Tutorial for Medical, Space and Particle Physics,
7-10 March, SLAC, Palo Alto, CA, USA (F. Garcia)

Jyväskylä Accelerator Laboratory,
17-22 April, Jyväskylä, Finland (F. Garcia)

Helsinki University Hospital, Department of Oncology,
26-28 May, Helsinki, Finland (F. Garcia)

Imaging 2006 Conference,
27-30 June, Stockholm, Sweden (talk by M. Oinonen)

XVIII Collaboration Meeting, Austrian Academy of Science,
2-5 September, Vienna, Austria (talk by F. Garcia)

PHENIX NCC Workshop,
20-21 October, Prague, Czech Republic (talk by M. Oinonen)

2006 Nuclear Science Symposium, Medical Imaging Conference and 15th International Room Temperature Semiconductor Detector Workshop,
29 October - 4 November, San Diego, CA, USA (talk by F. Garcia)

4th Geant4 Space Users' Workshop and 3rd Spenvis Users' Workshop,
5-10 November, NASA Jet Propulsion Laboratory, Pasadena, CA, USA (talk by F. Garcia)

PANDA Collaboration Meeting,
11-15 December, GSI, Darmstadt, Germany (F. Garcia)

CMS Programme

Software and Physics

Cairo International Conference on High Energy Physics,
14-17 January, Cairo, Egypt (invited talk by R. Kinnunen)

5th Nordic Grid Neighbourhood Workshop,
18-20 January, Uppsala, Sweden (T. Lindén)

Geant4 Japan Workshop,
26-27 January, Kisato University, Japan (invited talk by A. Heikkinen)

M-grid Administrators Meeting,
27 January, Espoo, Finland (T. Lindén)

CERN Council Strategy Group, Open Symposium,
30 January - 1 February, LAL - Orsay, France (K. Lassila-Perini, J. Tuominiemi)

Kobe University Seminar,
31 January, Kobe, Japan (invited talk by A. Heikkinen)

CHEP 06, International Conference on Computing in High Energy and Nuclear Physics,
13-17 February, TIFR, Mumbai, India (A. Heikkinen, talk by T. Lampén)

Finnish Grid Strategy Committee Meeting,
15 February, Helsinki, Finland (talk by T. Lindén)

DZero Winter Physics Workshop,
20 February, Fermilab, Batavia, IL, USA (talk by M. Voutilainen)

Meeting of EPS HEPP Board,
24 February, CERN, Geneva, Switzerland (J. Tuominiemi)

Particle Physics Seminar,
24 February, Helsinki, Finland (talk by L. Wendland)

The Annual Meeting of the Finnish Physical Society, Annual Meetings of the Particle Physics & Accelerator Physics Divisions,
9-11 March, Tampere, Finland (invited talks by J. Tuominiemi)

Rencontres de Moriond, Electroweak Interactions and Unified Theories,
11-18 March, La Thuile, Italy (talk by K. Lassila-Perini)

All DZero Meeting,
14 April, Fermilab, Batavia, IL, USA (talk by M. Voutilainen)

XIV International Workshop on Deep Inelastic Scattering,
20-24 April, Tsukuba, Japan (talks by M. Voutilainen)

M-grid Administrators Meeting,
21 April, Jyväskylä, Finland (talk by T. Lindén)

Workshop of the CERN Council Strategy Group,
2-6 May, DESY, Zeuthen, Germany (J. Tuominiemi)

Particle Physics Seminar,
5 May, Helsinki, Finland (talk by L. Wendland)

Project Evaluation Meeting,
22 May, CERN, Geneva, Switzerland (talks by A. Heikkinen, V. Karimäki, T. Lampén, K. Lassila-Perini, S. Lehti, and L. Wendland)

2nd Nordic Grid Neighbourhood Conference,
30 May - 2 June, Espoo, Finland (talk by T. Lindén)

Fermilab Users' Meeting,
31 May - 1 June, Fermilab, Batavia, IL, USA (talk by M. Voutilainen)

WLCG Tier2 Workshop and Tutorials & Experiment Sessions,
11-16 June, CERN, Geneva, Switzerland (T. Lindén)

PARA06, Workshop on State-of-the-Art in Scientific and Parallel Computing,
18-21 June, Umeå, Sweden (talk by T. Lindén)

Joint Algorithms/Physics Conveners' Meeting,
19 June, Fermilab, Batavia, IL, USA (talk by M. Voutilainen)

Geant4-INCL-ABLA Mini Workshop,
19-21 June, CERN, Geneva, Switzerland (talk by A. Heikkinen)

Geant4 Verification and Validation Workshop,
17-19 July, CERN, Geneva, Switzerland (talk by A. Heikkinen)

Joint Algorithms/Physics Conveners' Meeting,
18 August, Fermilab, Batavia, IL, USA (talk by M. Voutilainen)

CERN School of Computing 2006,
21 August - 1 September, Helsinki, Finland (P. Kaitaniemi)

NDGF CERN Committee Meeting,
29 August, Copenhagen, Denmark (T. Lindén)

LHC Alignment Workshop,
4-6 September, CERN, Geneva, Switzerland (V. Karimäki, T. Lampén)

11th Annual RDMS CMS Collaboration Conference,
12-16 September, Varna, Bulgaria (invited talk by V. Karimäki)

Prospects for Charged Higgs Discovery at Colliders,
13-16 September, Uppsala, Sweden (invited talks by R. Kinnunen)

M-grid Administrators Meeting,
6 October, Espoo, Finland (T. Lindén)

11th Geant4 Collaboration Workshop and Users Conference,
8-12 October, Lisbon, Portugal (talks by A. Heikkinen, invited talk by P. Kaitaniemi)

Meeting of EPS HEPP Board,
13 October, CERN, Geneva, Switzerland (J. Tuominiemi)

13th Nordic LHC Physics Workshop,
25-27 October, Helsinki, Finland (invited talks by R. Kinnunen, S. Lehti, and L. Wendland)

NorduGrid Steering Committee Meeting,
27 October, Helsinki, Finland (T. Lindén)

IEEE Transactions for Nuclear Science Symposium,
29 October - 4 November, San Diego, CA, USA
(invited talk by A. Heikkinen)

4th Geant4 Space Users' Workshop and 3rd Spenvis Users' Workshop,
6-10 November, NASA Jet Propulsion Laboratory, Pasadena, CA, USA (talk by A. Heikkinen)

INCL4-ABLA Hadronic Models in GEANT4 Working Group Meeting,
20 November - 1 December, Paris, France (talk by A. Heikkinen, talk by P. Kaitaniemi)

Particle Physics Day,
24 November, Helsinki, Finland (talk by R. Kinnunen)

Particle Physics Seminar,
1 December, Helsinki, Finland (talk by S. Slabospitsky)

Joint Algorithms/Physics Conveners' Meeting,
6 December, Fermilab, Batavia, IL, USA (talk by M. Voutilainen)

The Japan Taiwan Symposium on Simulation in Medicine,
12-15 December, Tsukuba, Japan (invited talk by A. Heikkinen)

NDGF CERN Committee Meeting,
15 December, Copenhagen, Denmark (T. Lindén)

Working visits to CERN,
Geneva, Switzerland (talk by A. Heikkinen, talk by V. Karimäki, talk by R. Kinnunen, talk by S. Lehti, talk by L. Wendland)

Meetings of CMS Management Board, Finance Board, Collaboration Board, Resource Review Board,
CERN, Geneva, Switzerland (J. Tuominiemi)

CMS Tracker

2nd Trento Workshop on Advanced Silicon Detectors (3D and p-type),
13-14 February, Trento, Italy (J. Härkönen, talk by E. Tuovinen)

The Annual Meeting of the Finnish Physical Society,
9-11 March, Tampere, Finland (talk by J. Härkönen, talk by T. Mäenpää)

Workshop of CMS Upgrade,
2 April, Padova, Italy (talk by J. Härkönen)

5th International Forum on Advanced Material Science and Technology,
11-14 June, Xiangtan, China (invited talk by J. Härkönen, key note talk by P. Luukka, invited talk by E. Tuovinen)

8th RD50 Workshop on Radiation hard semiconductor devices for very high luminosity colliders,
25-28 June, Prague, Czech Republic (J. Härkönen, talk by P. Luukka)

RD39 Cryogenic Tracking Detectors Workshop I-2006,
29 June, Prague, Czech Republic (talk by J. Härkönen, P. Luukka, E. Tuominen)

Sixth International "Hiroshima" Symposium on the Development and Application of Semiconductor Tracking Detectors,
11-15 September, Carmel, CA, USA (invited talk by J. Härkönen)

Extended Defects in Semiconductors EDS 2006,
17-22 September, Halle (Saale), Germany (talk by E. Tuominen)

6th International Conference on Radiation Effects on Semiconductor Materials, Detectors and Devices,
10-13 October, Florence, Italy (talk by J. Härkönen)

9th RD50 - Workshop on Radiation hard semiconductor devices for very high luminosity colliders,
16-18 October, CERN, Geneva, Switzerland (J. Härkönen, talk by P. Luukka)

RD39 Cryogenic Tracking Detectors Workshop II-2006,
19 October, CERN, Geneva, Switzerland (talk by J. Härkönen, P. Luukka, talk by E. Tuominen)

Particle Physics Day,
24 November, Helsinki, Finland (talk by P. Luukka)

Working visit,
Lappeenranta University of Technology, Lappeenranta, Finland (J. Härkönen, E. Tuominen)

Nuclear Matter Programme

ALICE

ALICE SSD Meeting,
18 January, CERN, Geneva, Switzerland (talk by M. Oinonen)

CERN/ALICE Meeting,
19 January, CERN, Geneva, Switzerland (talk by W. Trzaska)

Warsaw University of Technology,
24 January, Warsaw, Poland (talk by W. Trzaska)

LNS/Catania,
3 February, Catania, Italy (talk by V. Lyapin)

T0 PRR Meeting,
10 February, CERN, Geneva, Switzerland (talk by W. Trzaska)

The Annual Meeting of the Finnish Physical Society,
9-11 March, Tampere, Finland (M. Oinonen, H. Seppänen, W. Trzaska, R. Vierimaa)

CERN/ALICE Meeting,
13-17 March, CERN, Geneva, Switzerland (talk by W. Trzaska)

CERN,
20 March, Geneva, Switzerland (talk by W. Trzaska)

JYFL,
13 April, Jyväskylä, Finland (talk by W. Trzaska)

ALICE SSD Meeting,
21 April, CERN, Geneva, Switzerland (talk by M. Oinonen)

CERN,
1 June, CERN, Geneva, Switzerland (talk by W. Trzaska)

Scientific Advisory Board Meeting of HIP,
6 June, Helsinki, Finland (talk by M. Oinonen)

FAIR/PANDA Collaboration Meeting,
1-6 September, Vienna, Austria (M. Oinonen)

NDGF resources for ALICE,
9 October, Kastrup, Denmark (talk by M. Oinonen)

CERN,
10 October, Geneva, Switzerland (talk by M. Bondila)

Warsaw University,
8 November, Warsaw, Poland (talk by W. Trzaska)

Nordic ALICE Meeting,
30 November, Jyväskylä, Finland (talk by M. Oinonen)

CERN,
11 December, Geneva, Switzerland (talk by W. Trzaska)

ISOLDE

CERN High School Seminar, University of Jyväskylä,
September, Jyväskylä, Finland (talk by A. Jokinen)

Workshop on Advanced Laser and Mass Spectroscopy "ALMAS-1",
19-20 October, Darmstadt, Germany (talk by J. Äystö)

Technology Programme

CHEP 06, International Conference on Computing in High Energy and Nuclear Physics,
13-17 February, TIFR, Mumbai, India (talk by J. Klem)

ICIW 2006, International Conference on Internet and Web Applications and Services,
23-25 February, Guadeloupe, French Caribbean (talk by M. Pitkänen)

University of Delaware,
3-14 April, Newark, DE, USA (M. Pitkänen)

Condor Week 2006,
26 April, Madison, WI, USA (invited talk by J. White)

CEOS WGISS 21 Meeting,
8 May, Budapest, Hungary (talk by J. White)

The 17th Global Grid Forum - GGF17,
10-12 May, Tokyo, Japan (J. Hahkala)

2nd Nordic Grid Neighbourhood Conference,
1-2 June, Espoo, Finland (talks by J. Klem, H. Mikkonen)

HPDC Workshop on Next-Generation Distributed Data Management,
20 June, Paris, France (presentation by M. Pitkänen)

Institute of Biocomputing and Physics of Complex Systems (BIFI), Universidad de Zaragoza,
29 June, Saragossa, Spain (invited talk by M. Silander)

International Conference on Networking and Services,
16-19 July, Silicon Valley, CA, USA (presentation by H. Mikkonen)

Liberty Alliance Project Technology Expert Group Interim Meeting,
19-21 September, Paris, France (talk by H. Mikkonen)

2nd Pan-Galactic BOINC Workshop,
20-21 September, University of Geneva, Geneva, Switzerland (talk by J. Klem)

The EGEE'06 Conference,
25-29 September, Geneva, Switzerland (J. Karppinen, H. Mikkonen, T. Nissi, M. Pitkänen)

First KnowARC Conference,
7-9 November, Oslo, Norway (talk by M. Punceva)

JBossWorld Berlin 2006,
20-22 November, Berlin, Germany (invited talk by J. Karppinen and M. Pitkänen)

Fall 2006 Internet2 Member Meeting,
4-7 December, Chicago, IL, USA (H. Mikkonen)

Administration and Support

CERN Co-operation High School Network Seminar,
15 September, Jyväskylä, Finland (invited talk by R. Rinta-Filppula)

EPPOG Meeting,
6-7 October, CERN, Geneva, Switzerland (R. Rinta-Filppula)

Publications

Theory Programme

Cosmology

R. Allahverdi, K. Enqvist, J. Garcia-Bellido and A. Mazumdar,
Gauge-invariant inflaton in the minimal supersymmetric standard model,
Phys. Rev. Lett. 97 (2006) 191304

R. Allahverdi, K. Enqvist, A. Jokinen and A. Mazumdar,
Identifying the curvaton within the minimal supersymmetric standard model,
J. Cosmol. Astropart. Phys. 0610 (2006) 007

K. Kainulainen and D. Sunhede,
Dark energy, scalar-tensor gravity, and large extra dimensions,
Phys. Rev. D 73 (2006) 083510

T. Koivisto,
A note on covariant conservation of energy-momentum in modified gravities,
Class. Quant. Grav. 23 (2006) 4289

T. Koivisto,
Matter power spectrum in *f(R)* gravity,
Phys. Rev. D 73 (2006) 083517

T. Koivisto and H. Kurki-Suonio,
Cosmological perturbations in the Palatini formulation of modified gravity,
Class. Quant. Grav. 23 (2006) 2355

T. Koivisto and D. F. Mota,
Dark energy anisotropic stress and large scale structure formation,
Phys. Rev. D 73 (2006) 083502

D. Langlois and F. Vernizzi,
Nonlinear perturbations for dissipative and interacting relativistic fluids,
J. Cosmol. Astropart. Phys. 0602 (2006) 014

T. Poutanen, G. de Gasperis, E. Hivon, H. Kurki-Suonio, A. Balbi, J. Borrill, C. Cantalupo, O. Doré, E. Keihänen, C. R. Lawrence, D. Maino, P. Natoli, S. Prunet, R. Stompor and R. Teyssier,
Comparison of map-making algorithms for CMB experiments,
Astron. Astrophys. 449 (2006) 1311

F. Vernizzi and D. Wands,
Non-Gaussianities in two-field inflation,
J. Cosmol. Astropart. Phys. 0605 (2006) 019

Laser Physics and Quantum Optics

A. Collin,
Collective modes and the broken symmetry of a rotating attractive Bose gas in an anharmonic trap,
Phys. Rev. A 73 (2006) 013611

O. Dannenberg and M. Mackie,
Rogue decoherence in the formation of a macroscopic atom-molecule superposition,
Phys. Rev. A 74 (2006) 053601

Particle Physics Phenomenology

E. Gabrielli, K. Huitu and S. Roy,
Photon propagation in magnetic and electric fields with scalar/pseudoscalar couplings: a new look,
Phys. Rev. D 74 (2006) 073002

T. Honkavaara, K. Huitu and S. Roy,
Signals of sneutrino-antisneutrino mixing in an $e\gamma$ collider in anomaly-mediated supersymmetry breaking,
Phys. Rev. D 73 (2006) 055011

Hadron Physics Activity

A. Acus, E. Norvaišas and D. O. Riska,
The α particle as a canonically quantized multiskyrmion,
Phys. Rev. C 74 (2006) 025203

C. S. An, Q. B. Li, D. O. Riska and B. S. Zou,
The $qqqq\bar{q}$ components and hidden flavor contributions to the baryon magnetic moments,
Phys. Rev. C 74 (2006) 055205

C. S. An, D. O. Riska and B. S. Zou,
Strangeness spin, magnetic moment, and strangeness configurations of the proton,
Phys. Rev. C 73 (2006) 035207

J. Gasser, M. A. Ivanov and M. E. Sainio,
Revisiting $\gamma\gamma \to \pi^+\pi^-$ at low energies,
Nucl. Phys. B 745 (2006) 84

B. Juliá-Díaz and D. O. Riska,
The role of $qqqq\bar{q}$ components in the nucleon and the N(1440) resonance,
Nucl. Phys. A 780 (2006) 175

Q. B. Li and D. O. Riska,
The role of five-quark components in gamma decay of the Δ(1232),
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Five-quark components in $\Delta(1232) \to N\pi$ decay,
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Role of $q\bar{q}$ components in the N(1440) resonance,
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D. O. Riska and B. S. Zou,
The strangeness form factors of the proton,
Phys. Lett. B 636 (2006) 265

Physics of Biological Systems

J. Aittoniemi, T. Róg, P. Niemelä, M. Pasenkiewicz-Gierula, M. Karttunen and I. Vattulainen,
Tilt: major factor in sterols' ordering capability in membranes,
J. Phys. Chem. B 110 (2006) 25562

E. Falck, J. T. Hautala, M. Karttunen, P. K. J. Kinnunen, M. Patra, H. Saaren-Seppälä, I. Vattulainen, S. K. Wiedmer and J. M. Holopainen,
Interaction of fusidic acid with lipid membranes: implications to the mechanism of antibiotic activity,
Biophys. J. 91 (2006) 1787

A. A. Gurtovenko, S. V. Lyulin, M. Karttunen and I. Vattulainen,
Molecular dynamics study of charged dendrimers in salt-free solution: effect of counterions,
J. Chem. Phys. 124 (2006) 094904

M. Heikelä, I. Vattulainen and M. T. Hyvönen,
Atomistic simulation studies of cholesteryl oleates: model for the core of lipoprotein particles,
Biophys. J. 90 (2006) 2247

T. Murtola, T. Róg, E. Falck, M. Karttunen and I. Vattulainen,
Transient ordered domains in single-component phospholipid bilayers,
Phys. Rev. Lett. 97 (2006) 238102

P. S. Niemelä, M. T. Hyvönen and I. Vattulainen,
Influence of chain length and unsaturation on sphingomyelin bilayers,
Biophys. J. 90 (2006) 851

M. Patra, E. Salonen, E. Terama, I. Vattulainen, R. Faller, B. W. Lee, J. Holopainen and M. Karttunen,
Under the influence of alcohol: the effect of ethanol and methanol on lipid bilayers,
Biophys. J. 90 (2006) 1121

J. Repáková, J. M. Holopainen, M. Karttunen and I. Vattulainen,
Influence of pyrene-labeling on fluid lipid membranes,
J. Phys. Chem. B 110 (2006) 15403

S. Vainio, M. Jansen, M. Koivusalo, T. Róg, M. Karttunen, I. Vattulainen and E. Ikonen,
Significance of sterol structural specificity: desmosterol cannot replace cholesterol in lipid rafts,
J. Biol. Chem. 281 (2006) 348

L. I. Vergara, F. W. Meyer, H. F. Krause, P. Träskelin, K. Nordlund and E. Salonen,
Methane production from ATJ graphite by slow atomic and molecular D ions: evidence for projectile molecule-size-dependent yields at low energies,
J. Nucl. Mater. 357 (2006) 9

String Theory and Quantum Field Theory

M. Arai, M. Chaichian, K. Nishijima and A. Tureanu,
Non-anticommutative supersymmetric field theory and quantum shift,
Phys. Lett. B 639 (2006) 124

M. Arai and M. Nitta,
Hyper-Kähler sigma models on (co)tangent bundles with *SO(n)* isometry,
Nucl. Phys. B 745 (2006) 208

M. Arai and N. Okada,
Color superconductivity in $N = 2$ supersymmetric gauge theories,
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