Annual Report 2004

HELSINKI INSTITUTE OF PHYSICS

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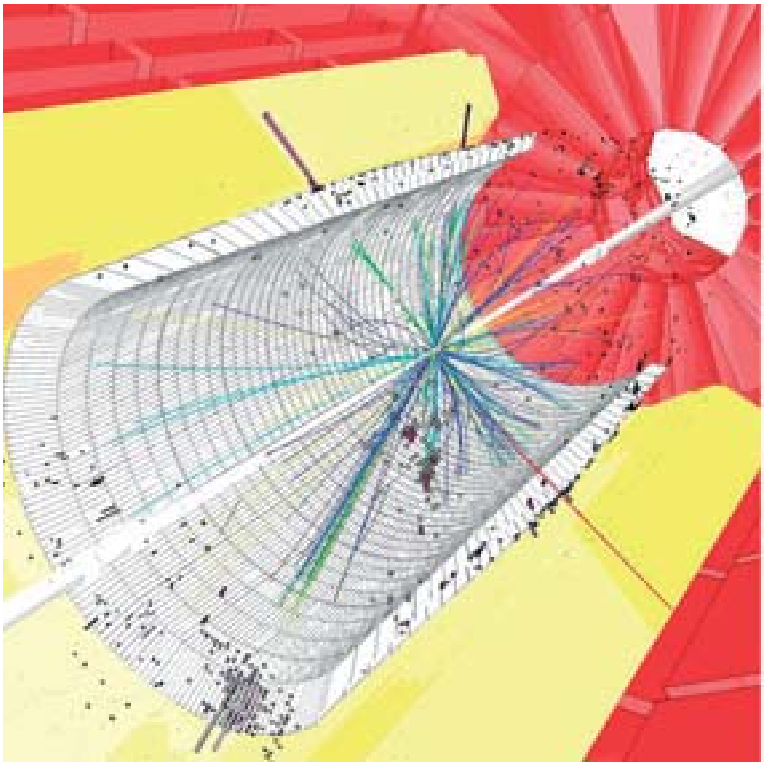

Geant4 based simulation of a SUSY event in the CMS detector containing missing transverse energy, jets and several leptons in the barrel detector. (Picture: IguanaCMS.)

Annual Report 2004 Helsinki Institute of Physics

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Introduction

Dan-Olof Riska

The Helsinki Institute of Physics (HIP) is a national Finnish institute for research in physics and physics related technology development. The Institute is operated jointly by the Universities of Helsinki and Jyväskylä and the Helsinki University of Technology. The Institute has a mandate from the Finnish Ministry of Education for coordinating the Finnish research at CERN.

The Institute was given an additional national mandate during the year when the Finnish minister of education Ms. Tuula Haatainen authorized the director of HIP to sign the memorandum-of-understanding for Finnish collaboration with the Facility for Antiproton and Ion Research FAIR that will be constructed as an international facility at the GSI Accelerator Laboratory in Darmstadt.

The modus operandi of the Institute is to carry out time limited significant research projects, that are either too resource intensive or too cross disciplinary or novel to fit into the standard framework of academic research funding 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 12 project leaders and researchers of the Institute have in the past 5 years been appointed to professorial positions at several universities both in Finland and abroad. Another three have been appointed to university lecturer positions.

During the year 2004 the research activities at HIP fell into 5 separate 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 Theory Programme was formed 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 first three of these theory projects were started at the beginning of 2002 and were reviewed during the year. As a consequence of the very positive review reports they were subsequently granted continuation for a second 3-year period by the Board of the Institute.

The High Energy Physics Programme continued its projects for detector development for forward proton-proton physics study in the TOTEM experiment at the LHC at CERN and at the CDF-II experiment at the Tevatron accelerator at the Fermi National Accelerator Laboratory. A memorandum-of-understanding was signed with the CDF-II collaboration up to the end of 2007. The analysis of the data accumulated by the completed DELPHI experiment at the previous LEP collider at CERN continued.

The CMS programme is responsible for the Finnish contribution to the building of the CMS detector at the LHC and preparation of the experiment. The research programme is divided into two projects: (1) building and operation of the tracker of the CMS detector and (2) development of the reconstruction and analysis software for the CMS data analysis as well as preparation of the physics analysis.

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. Separate funding was obtained for planning the Finnish contribution to the GSI/FAIR project.

The Technology Programme of the Institute aims to develop industrial applications of CERN generated innovations in technology. During 2004 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 for E-science in Europe project and an associate of the new CERN OpenLab for Grid applications project. During the year members of the group participated in the development of the LHC@home screen saver project, which has made a substantial amount of additional computer power available to the LHC design effort.

The Institute is the Finnish partner of the LHC Computing Grid Project at CERN (LCG-1) for the establishment of the distributed high-throughput computing capacity that will be required by the analysis of the data taken at the LHC detectors. During the year the Institute was awarded a significant grant for enhancing the computing infrastructure by the Academy of Finland. An equally significant infrastructure grant was obtained for new instrumentation at the Detector Laboratory of the Institute.

The Institute has continued its strong efforts in graduate student training in frontline research. This activity is supported in part by the research projects themselves, and in part by the national graduate school programmes. The graduate training efforts were greatly strengthened by generous grants by several Finnish foundations, first and foremost by the Magnus Ehrnrooth Foundation. During 2004 6 PhD and DSc degrees and 10 MSc degrees were awarded on the basis of research conducted within the research projects of the Institute.

The summer student programme at CERN continues to be a highly significant component of the educational efforts of the Institute. During the year the Institute also hosted 12 visits by groups of students and 2 visits by teachers in Finnish “gymnasiums” to CERN. In connection with the 50 years Anniversary of CERN a group of high school students that had visited CERN produced an impressive and very well received booklet about their experiences at CERN.

During the year 2004 a midterm strategy for HIP for the period 2004–2006 was developed. The strategy is based on the national strategy for the Finnish collaboration with CERN, which was approved in 2003. This strategy spells out the goals of the research that HIP conducts at CERN, and defines the role of the project of the National Technology Agency TEKES for collaboration between Finnish industry and CERN. This project, which has been extraordinarily successful during the past 4 years, is carried out in collaboration with the Finpro association with support from TEKES.

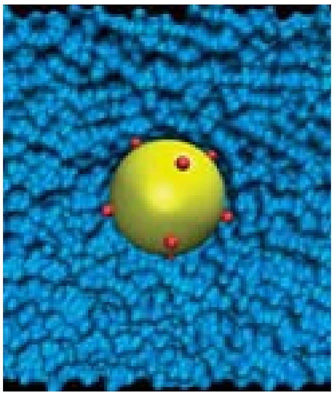
At the CERN 50 year Anniversary celebrations in Geneva, the government of Finland was represented by the Finnish minister of trade and industry Mr. Mauri Pekkarinen. A CERN Anniversary colloquium was arranged on October 28. The morning session, which was focused on the industrial collaboration between Finland and CERN, was co-hosted with the Helsinki University of Technology. The research oriented afternoon session was hosted by HIP at the Kumpula campus of the University of Helsinki.

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.

HELSINKI INSTITUTE OF PHYSICS

Highlights of Research Results

Theory Programme



In Cosmology we suggested an infrared-ultraviolet connection between the equation of state of dark energy and the cut-off in the cosmic microwave power spectrum based on holographic considerations. The second order formalism for non-Gaussian fluctuations was developed for the case of two fields and was applied to preheating. In collaboration with the Department of Physical Sciences, the Cosmology project continued to participate in the Finnish Planck Surveyor Consortium.

In Particle Physics Phenomenology an extensive study on CP asymmetries was performed. Contributions from supersymmetric gluino and chargino were calculated in QCD factorization, and compared to naïve factorization. Correlations of mixing asymmetries and branching ratios of $B \rightarrow \phi K_S$, $B \rightarrow \eta' K_S$, and direct asymmetry of $b \rightarrow s\gamma$ were studied, with the requirement that experimental constraints are satisfied. We find that while explaining the observed asymmetries by chargino contributions may not be very natural – although the situation improves, if a light charged Higgs exists – gluinos easily accommodate the experimental results.

In Biophysics we conducted extensive modelling to clarify atomic-scale properties of a variety of different lipid membrane systems. It has further developed novel ways to coarse grain atomistic descriptions of lipid membranes in a systematic fashion, thus bridging atomistic aspects with large-scale properties. The coarse-graining strategy provides a speed-up of approximately seven orders of magnitude compared to atomistic simulations and has subsequently clarified large-scale ordering phenomena in phospholipid-cholesterol mixtures.

In 2004, the HIP String and Quantum Field Theory team reported progress on two very central problems. One of them relates to the properties of unstable branes in string theory. In a HIP-UCLA-Amsterdam-UPenn collaboration, general formalism for computing string scattering from decaying branes was developed using random matrix model techniques. Another problem relates to the symmetry interpretation of noncommutative space-time. The HIP team has proposed a twisted version of Poincaré symmetry as the underlying structure.

The Heavy Ion project has developed a successful description of transverse momentum spectra of hadrons in Au+Au collisions at the Relativistic Heavy Ion Collider (RHIC): perturbative QCD (pQCD) + saturation + hydrodynamics predict the small-momentum spectra while pQCD combined with nuclear parton distributions (nPDFs) and parton energy losses in the dense medium describe the large-momentum parts. Global pQCD analysis of nPDFs has been carried further. Quark-antiquark production from classical gluon fields in primary AA collisions has been studied. Calculation of the hot QCD free energy up to g^6 has been advanced significantly: the required intermediate analytic and numerical steps have now been completed and the remaining calculations are in progress.

High Energy Physics Programme

On the basis of its reputation built in the CERN LEP-DELPHI experiment, the Helsinki group was recently accepted to join the CDF experiment at the Fermilab Tevatron antiproton-proton collider. Since this experiment is considered to be a leading project in the field, the invitation represents a major recognition of the group's scientific accomplishments. Tevatron is currently the energy frontier instrument in investigating the basic structure of matter and the processes between the fundamental constituents and currently represents the only active high energy physics experiment in Finland.

The Helsinki group is participating in the physics planning, design and construction of the TOTEM experiment at CERN's forthcoming LHC collider. Already during the preparatory stages of the experiment, the group has gained the co-ordinating role in TOTEM physics analysis (physics co-ordination and chairmanship of the physics advisory board) and has been given major responsibilities in construction of some of the key parts of the experiment. In 2004 the group has continued the simulation studies of the central diffractive process: $pp \rightarrow p + H + p$ and has gained a central role as an expert group concerning diffractive physics at the LHC. As a bench mark, limits of observation of the standard model Higgs boson at the LHC have been established.

The group is responsible for the Gas Electron Multiplier (GEM) detector based T2 tracking station of TOTEM. During the autumn of 2004 the first GEM detectors, specifically designed for TOTEM, were tested in a CERN test beam. The group has made important new innovations in the field of 3D silicon detector structures in co-operation with the VTT Technical Research Centre of Finland. Novel detector performance has been simulated in 3D for the first time and test structures have been processed at VTT and tested at the Detector Laboratory in Kumpula.

In 2004, the Helsinki group has had, in the DELPHI collaboration, a central role in searches for the charged Higgs bosons, which are predicted by many extensions of the Standard Model. A. Kiiskinen co-ordinated the charged Higgs analysis within the DELPHI collaboration and defended his PhD thesis in spring 2004. No indications for the charged Higgs bosons were found and a model independent lower limit on the charged Higgs mass of 74.4 GeV was established.

In the field of strong interaction physics, the group has, in the DELPHI experiment, investigated Bose-Einstein correlations (BEC) between the identical bosons emitted from the two different W's in $e^+e^- \rightarrow W^+W^-$. A group member served as the co-ordinator of the BEC analysis (N. van Remortel). The results support the existence of Bose-Einstein correlations in this process. A fundamental feature of colour coherence in QCD, the dead cone effect, was analysed and reported by the group at the ICHEP04 conference in Beijing this year. The observation of depletion of fragmentation particles at small angles in b-jets represents a direct proof of the concept of colour coherence in QCD.

The Detector Laboratory at HIP has gained more visibility and improved its possibilities to provide services for research projects during 2004. With the successful application for the infrastructure programme of the Academy of Finland, it has been possible to refurbish the Laboratory equipment substantially. This will most likely make the Laboratory also more attractive to users outside HIP.

As a part of the generic detector development, three prototypes of GEM detectors with two GEM foils and with two-dimensional readout were designed and constructed in the Detector Laboratory. The last prototype was designed according to the design criteria of space quality instruments.

CMS Programme

In the preparation of the physics analysis of the CMS experiment at the CERN LHC the HIP CMS Programme is carrying responsibilities in several sectors of detector and physics simulation as well as in the development of the physics analysis tools. In detector simulation it is responsible for implementing intra-nuclear cascade models in the cascade energy region of the Geant4 software toolkit. The Bertini cascade code, designed by the HIP CMS Software team, is distributed as part of the physics list for a typical HEP detector. The LCG Simulation Physics Validation project has optimized and validated these cascade models, and the HIP made models are now widely used in LHC detector simulation, such as calorimetry, and other applications, such as dose estimation and hadronic treatment planning.

The HIP CMS Physics team is responsible for the definition of the photon candidates in the CMS reconstruction and data analysis program, based on the information from the Tracker and the Electromagnetic calorimeter. Several updates have been implemented in 2004, offering end-users the possibility to access the best knowledge of the photon energy and position measurement directly in the program output.

Preparation for the work on the Technical Design Report of Physics and Analysis started in 2004 with a massive generation (CMS Data Challenge 2004) of events to be used in the development of the selection and reconstruction programs and for the final evaluation of the discovery capacity of CMS in the important physics channels. As a new result for the discovery potential, a study on the production of the lightest CP-even MSSM Higgs boson was performed and the sensitivity to the SUSY parameter variation investigated.

In the computing sector a consortium of HIP and seven other universities and research institutes in Finland obtained infrastructure funding from the Academy of Finland for buying clusters of Linux computers to be connected together with Grid middleware. From HIP, the CMS Programme, the Technology Programme, and the Theory Programme participated in the Material Sciences National Grid Infrastructure (M-grid) application.

The M-grid Linux cluster at the Kumpula campus (Ametisti) is a joint project between the Department of Chemistry, the Department of Physical Sciences and the CMS and Theory Programmes of HIP. Ametisti consists of a total of 132 computer CPUs, two of which are in the front-end and a single CPU acts as the administration node. Ametisti is the second most powerful academic computing resource in Finland and the largest of the M-grid clusters.

In detector construction, the assembly work of the rod elements for the CMS Outer Barrel Tracker has advanced well. Some 320 of the total of 688 elements have been delivered to CERN for installation of the readout electronics. The first 100 have been transported to the US for the integration of the detector modules. The special boxes for the RPC trigger links that were designed by the HIP Mechanics team in Kumpula were manufactured by a commercial company and prepared for transportation to CERN, where they will be installed in the CMS structure at the surface hall.

A test set-up (Cosmic Rack, CRack) for the testing of the final TOB detector units in the test beam or with cosmic muons was constructed at CERN. Its mechanical structure was designed and built by the HIP team in collaboration with the CERN TA1 group. A second identical structure, being built at CERN, is to be transported to the Kumpula Detector Laboratory in 2005 once it is equipped with fully connected production rate detector units. The readout electronics for the FinnCRack was purchased via CERN.

In the HIP CMS Detector R&D team a new kind of radiation resistant silicon strip detector, based on p-type silicon, was studied by the CMS HIP Detector group. It was demonstrated that when processing boron-doped p-type high-resistivity Cz-Si, the thermal donor generation process can be utilized in order to produce p+/n-/n+ detectors. With the method developed, it is possible, with low cost, to fabricate detectors with high oxygen concentration and, moreover, to tailor the full depletion voltage of detectors from 30 V to 1000 V by changing the heat treatment. In irradiation tests, these types of detectors have proved to be more radiation hard than our previously reported n-type Cz-Si detectors.

Collaboration of the Detector team with the RD50 and RD39 collaborations was continued successfully. In RD39 Jaakko Härkönen was elected as vice spokesman of the collaboration. The RD50 collaboration decided to have its next collaboration meeting in May 2005 in Helsinki.

Nuclear Matter Programme

There are only two years left before the first LHC beam is expected to collide inside ALICE but in spite of the growing time pressure the construction of the detector proceeds on schedule. The Finnish team has a significant part in this success. We are involved in bonding of the tracker components, construction of the T0 detector and development of the track reconstruction software. We have also contributed to the first physics publication by ALICE: Physics Performance Report, Volume I, that has appeared in the Journal of Physics G 30 (2004) 1517–1763.

The two largest layers of the ALICE Inner Tracking System will contain about 2000 Silicon Strip Detector (SSD) modules. The production of these modules is shared between France, Italy and Finland. The assembly of the Finnish share of SSD modules is being done in the HIP Detector Laboratory. Module assembly was seriously launched during the summer of 2004. Up to the end of 2004, more than 2000 HAL25 chips, 292 hybrids and 109 modules had been assembled in Helsinki. Along with the prototype production for the SSD assembly, our group has addressed the reliability issues. Optical and non-destructive methods have been used to investigate the bonding and component quality of ALICE samples. These techniques hold potential to become suitable inspection methods for microelectronics in general.

The T0 detector for ALICE will give the key trigger and timing signals, measure on-line vertex position and give rough centrality. In 2004 we completed a major milestone towards the commissioning of the detector by publishing, jointly with FMD and V0, the ALICE Technical Design Report (ALICE-TDR-011, CERN-LHCC-2004-025). In this 150 page document the three forward detectors, their operation, electronics, readout and slow control are described in full detail. Currently we are testing the 3rd generation prototype of this unit. It has been performing so well that the ALICE Technical Board has recommended that it also be used for the V0 detector.

The study of strange particle production in heavy-ion collisions is one of the main goals of the ALICE experiment. The methods are being developed and tested with Monte Carlo simulations using the ALICE software framework (ALIROOT). The preliminary estimates of the reconstruction efficiency, precision and background conditions are very encouraging.

Research at the PS-booster ISOLDE focuses on studies of exotic nuclei far from the valley of beta-stability employing radioactive ion beams. On instrumentation, the Finnish group at ISOLDE has initiated a Si-ball R&D detector project, which aims for a high-granularity charged particle detector array. The full detector consists of 104 detectors in rhombicuboctahedron geometry made of squares and triangles. In 2004 further tests were carried out at JYFL, where it was applied in four different spectroscopic studies, namely beta decay studies of ^{13}O, ^{31}Cl and ^{58}Zn and in the study of triple alpha states in ^{12}C.

New measurements have been performed toward resolving long-standing questions about the triple alpha process – operating in stars – that creates the fourth most common element in our solar system, carbon. The data has been obtained in a series of experiments by studying inverse 3-alpha decay of excited states of ^{12}C populated in beta decays of short-lived ^{12}B at ISOLDE and ^{12}N at IGISOL. With this new, more precise information, it became possible to calculate a revised triple alpha rate over a wide temperature range, from 10^7–10^{10} K. Compared to the previously calculated rate, the new rate is significantly faster at low temperatures (10^7 to 10^8 K), the same in the middle range dominated by the Hoyle resonance, and slower at high temperatures (10^9 to 10^{10} K). The revised rate has a wide variety of astrophysical implications. The first results have been published in Physical Review Letters and the newest are in press for NATURE.

The structure of very neutron-rich nuclei near the doubly magic ^{132}Sn is an ideal laboratory to explore how the neutron-richness and large proton-neutron asymmetry impact both shell structures as well as collective excitations. In 2004 we studied at ISOLDE excitation schemes of $^{122,124,126}Cd$ as a continuation of our studies at JYFL of $^{116,118,120}Cd$.

The ISOLDE ion cooler and buncher project has concentrated on the technical design and manufacturing drawings. At the end of 2004 most of the mechanical parts had been delivered to CERN and the first assembly of the apparatus is foreseen in 2005 followed by intense test measurements. In 2004, a new collaboration was also started, when ECR experts from JYFL collaborated in charge breeding studies at ISOLDE. Charge breeding of rare exotic isotopes, often extracted as singly charged ions, is of importance for a cost-effective post acceleration.

Finally, a new project in the Nuclear Matter Programme has been founded to support the Finnish participation in the FAIR project at GSI. FAIR stands for the international Facility for Antiproton and Ion Research. The final formulation of the participation will be worked out in 2005.

Technology Programme

During 2004 the Programme successfully concluded the EU DataGrid project and contributed to the planned security services for Grid testbed. The overall results of this CERN orchestrated EU project led to a new research consortium with over 70 partners called Enabling Grids for E-Science in Europe (EGEE). Within this project the Technology Programme as one of the Nordic members takes part in the further development of the Grid middleware. In accordance with its traditions the Technology Programme concentrates on identity management, this can be divided into user identification, privacy and trust aspects of the Grid use.

Following the decision by the Academy of Finland together with other Nordic research councils to fund the Nordic Data Grid Facility, the collaboration intensified and different clusters operated by HIP were linked to the NorduGrid Facility. On the national level the overall integration initiative resulting in the Material Sciences National Grid Infrastructure, called M-grid, became a reality in 2004. The Technology Programme actively participated in these integration efforts together with the CMS Programme.

Following the popular SETI@home computing engine, researchers of the Technology Programme worked on a project in collaboration with students from the University of Copenhagen, the University of Basel and U.C. Berkeley to develop LHC@home, which enables individual people to offer their computing power to compute simulated LHC events. Thousands of users downloaded the software and the project had to set a limit of 5000 users to ensure that the large flow of data being sent back could be handled adequately. LHC@home established itself as a permanent service and the work will continue in 2005.

The first industrial HIP initiated Grid research project in Finland, NetGest, was successfully concluded. The project explored various possibilities to exploit Grid technologies in information communication technology (ICT) businesses. Based on the encouraging feedback from the participants and other companies, a new domestic consortium was set up with eight companies to bridge mobile platforms with Grid technologies.

Theory Programme

Kari Enqvist

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 member 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 2004 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. One-loop thermal effects on the decay of the inflaton were considered assuming fermionic decay channels and taking into account the effects due to both particle and hole excitation. We showed that the reheat temperature can be greater than the inflaton mass if the inflaton decays into more than one fermionic species. Reheating was also discussed in a brane world context, where we argued that a warped, infinite extra dimension allows for the inflaton to decay into the bulk so that after inflation, the effective dark energy disappears from our brane. Second order inflationary perturbations were considered in the case of hybrid-like inflaton models. We derived an expression for the non-Gaussianity of perturbations and isolated the contributions due to the “waterfall” field σ and showed that σ-induced non-Gaussianities can under certain circumstances dominate over inflaton-induced non-Gaussianities. We further demonstrated that in two-field models with preheating there can be a considerable enhancement of non-Gaussianity sourced by the local terms generated through the coupled perturbations.

We also suggested that MSSM flat direction condensates, which break conformal invariance, can give rise to seed magnetic fields in the early Universe. During inflation the condensate receives spatial perturbations, whereby gauge currents are generated together with (hyper)magnetic fields.

Regarding the cosmic microwave background (CMB), we have investigated a possible connection between the suppression of the power at low multipoles in the CMB spectrum and the late time acceleration. Assuming a cosmic IR/UV duality between the UV cut-off and a global infrared cut-off given by the size of the future event horizon, the equation of state of the dark energy can be related to the apparent cut-off in the CMB spectrum. Performing a fit to the CMB, LSS and supernova data we found that such a model describes the low l features extremely well. The best fit to the CMB and LSS data turns out to be better than in the standard Lambda-CDM model, but when combined with the supernova data, the holographic model becomes disfavoured.

We also studied cosmological perturbations in the case that present-day matter consists of a mixture of inflaton and curvaton decay products. Taking into account that the decay products of the inflaton can also have perturbations results in an interesting mixture of correlated adiabatic and isocurvature perturbations. In particular, negative correlation can improve the fit to the CMB data by lowering the angular power in the Sachs-Wolfe plateau without changing the peak structure. Allowing for different spectral indices for the power in each mode and for their correlation a likelihood analysis with 11 independent parameters yields an upper limit for the isocurvature fraction of 18% around a pivot scale k = 0.01/Mpc. The upper limit to the nonadiabatic contribution to the CMB temperature variance was found to be 7.5%.

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 (Elina Keihänen, Hannu Kurki-Suonio, Torsti Poutanen, and Ville Heikkilä, a student), which is a tool for removing different kinds of systematic effects in CMB experiments. The basic idea in destriping is to model the noise stream by a linear combination of simple arithmetic functions. During 2004 we have further developed an improved destriping algorithm using a maximum-likelihood approach.

Particle Physics Phenomenology

In Particle Phenomenology research, the focus has been on signals for Beyond the Standard Model Physics, mostly using the frameworks of supersymmetric models and higher dimensional models.

Signals of supersymmetric models are largely determined by the breaking method of supersymmetry as well as by the possible breaking of R-parity. Models with anomaly mediated supersymmetry breaking (AMSB) have attracted considerable attention in recent years, and signatures of these models have been investigated in the project. A special feature of AMSB is the UV insensitivity of the soft SUSY breaking parameters. The very slow decay of the lighter chargino in AMSB results in a heavily ionizing charged track and one soft charged pion with a characteristic momentum distribution, leading to unique signals in linear colliders which are essentially free of background. The determination of chargino and slepton masses from such events is an interesting possibility. We also found that sumrules can be used to separate between different supersymmetry breaking methods, especially the AMSB models have a distinct type of sumrule for neutralinos and charginos.

Violation of R-parity through nonconservation of the lepton number has been considered. We have investigated single production of sneutrinos, when R-parity is broken. Single production enlarges the kinematic range of a collider. We found that while it may be possible to detect the sneutrinos in a four b-jet decay channel at the LHC, separation between a Higgs boson and a sneutrino requires detailed knowledge of the branching ratios.

Theories with more than three spatial dimensions have become of intense phenomenological interest after it was realized that it might be possible to study such models experimentally. We have investigated the Higgs detection in the case of large extra dimensions. We found that in most parts of the parameter space the detection of a Higgs looks promising. In the models with small extra dimensions we have investigated disentangling a Higgs boson from a radion. We found it useful to study the gluon decay channel of the scalars in a linear collider.

A clear indication for Physics Beyond the Standard Model is that neutrinos have a small mass, which naturally leads to oscillation between different neutrino species. One of the important questions in theories of large extra dimensions is whether they can accommodate a bimaximal type of neutrino mixing, hinted by the data. We have analysed certain models of higher dimensional light Majorana neutrinos in the light of experimental and observational constraints. Models with flavour blind brane-bulk couplings plus three or four flavour diagonal light Majorana neutrinos on the brane, with subsequent mixing induced solely by the Kaluza-Klein tower of states, are found to be excluded by data on the oscillations of solar, atmospheric and reactor neutrinos, taken together with the cosmological upper bound on the sum of neutrino masses. Extra dimensions, if relevant to neutrino mixing, need to discriminate between neutrino flavours.

We have analysed tree-level scattering processes mediated by a massless graviton in the s-channel. In particular, it was found that orthogonality is broken when considering the interference with a scalar-particle s-channel exchange, whenever external states are massive. As a consequence, we showed that angular momentum selection rules are violated in quantum gravity mediated scattering.

Hadron Physics Activity. Deformation of the nucleon and the Δ(1232) wave functions was studied with phenomenological quark model wave functions that were constructed to describe the electromagnetic form factors of the proton in the impulse approximation with three different subgroups of the Poincaré group as the kinematic subgroup. It was shown that in all cases a small admixture of a mixed symmetry *S*-state wave function is sufficient for a description of the experimental electric form factor of the neutron.

It was found that in contrast the nucleon elastic form factors displayed very little sensitivity to spatially "deformed" *D*-state admixtures. The calculated *E2/M1* ratio in electromagnetic decay of the Δ(1232) proved to be sensitive to *D*-state admixtures in both the nucleon and the Δ(1232) wave functions. In contrast to this the calculated *C2/M1* ratio was found to be insensitive to such *D*-state admixtures. The empirically found structure in the *E2/M1* ratio at low momentum transfer could not be described by *D*-state admixtures alone, and may most likely be ascribed to sea-quark or "meson cloud" configurations.

The magnetic moments of the strange and charm hyperons were calculated in instant, point and front form kinematics in the impulse approximation with phenomenological quark model wave functions. The sensitivity to the constituent mass was shown to be small in all cases, a result that is very different from that obtained in the nonrelativistic quark model. Overall the impulse approximation appears to provide the best phenomenological description of the experimental magnetic moments in instant and front form kinematics.

The axial transition form factors and the pion decay widths of the low lying nucleon and Δ(1232) resonances were calculated in the covariant quark model in instant, point and front form kinematics. The calculated pion decay widths were systematically smaller than the experimental decay widths both in the case of the Δ(1232) and the other low lying positive parity resonances. This suggests that these resonaces contain significant sea-quark configurations, which are not contained in the constituent valence quark model.

Physics of Biological Systems

The activities of the Biological Physics and Soft Matter (BIO) group focus on the theory and computational modelling of biologically relevant soft-matter systems. 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.

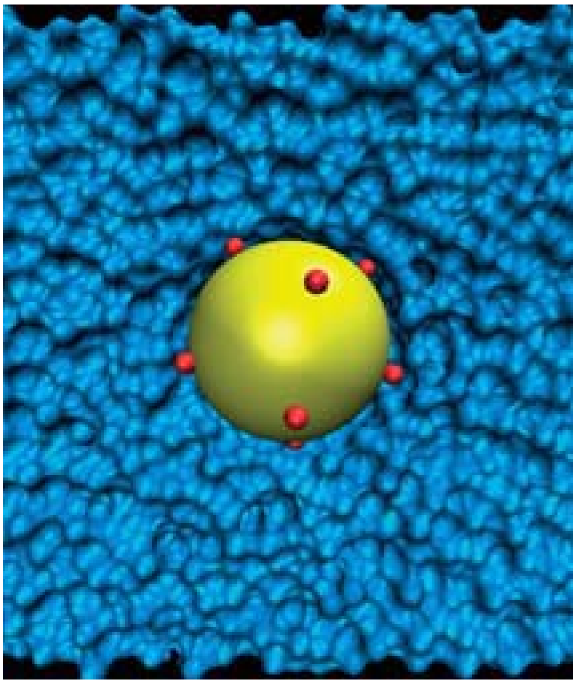
The BIO group was initiated at the Laboratory of Physics (Helsinki University of Technology) in January 2001 and it joined the Theory Programme of the Helsinki Institute of Physics (HIP) (www.hip.fi) in January 2002. Consequently, the BIO group operates jointly at HUT and as part of HIP. In April 2004, the activities of the BIO group were evaluated by two external reviewers. The achievements of the group were found to be first class and the evaluation committee recommended HIP funding to be continued for a second three-year period (2005–2007).

The BIO group is part of various networks, including SIMU (ESF), MOLSIMU (COST), COSBI (ESF, proposal under review), FuncDyn (ESF, proposal under review), and the NORDITA network on biological physics. In 2004, the group co-published a book dealing with state-of-the-art soft-matter simulation techniques (Novel Methods in Soft Matter Simulations, Springer-Verlag, 2004), and published 20 articles in international high-quality journals.

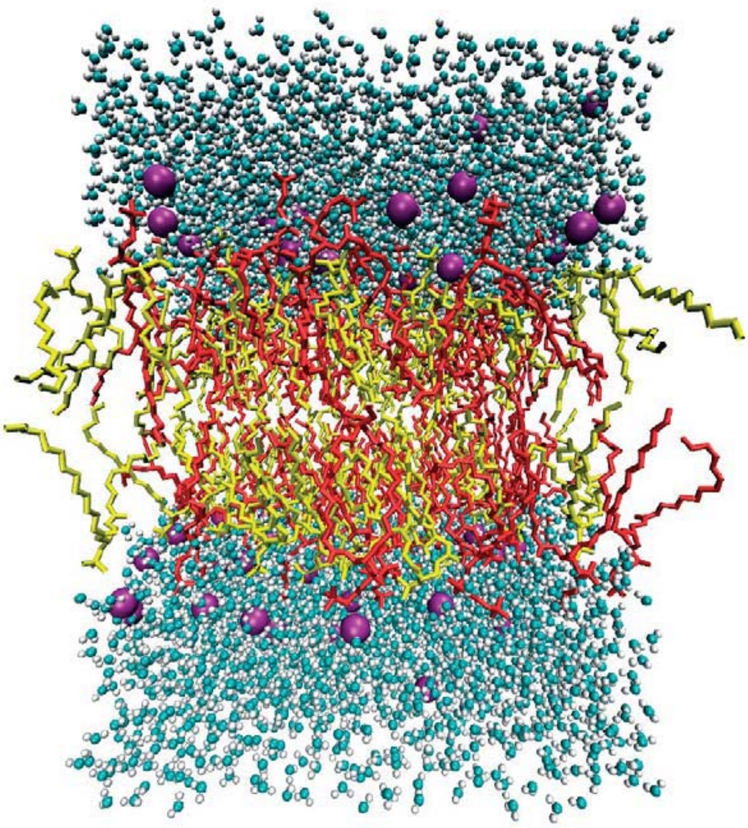
The activities of the BIO group are comprehensive and it has a wide range of both theoretical and experimental collaborative partners whose fields range from medical sciences to chemistry, physics, and computational sciences. In particular, there is a very close and highly active collaboration with Dr. Mikko Karttunen's group at the Laboratory of Computational Engineering (HUT). The two groups have created a team of roughly 20 people working on the same campus and focusing on a wide range of issues related to biologically relevant soft-matter systems. In December 2003, the team was selected as a Helsinki University of Technology Young Center of Excellence for 2004–2005.

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 atomic-scale properties of biomolecular systems. Third, we employ multi-scale modelling to gain insight into the large-scale properties of given systems. Below, we present a few examples of related recent projects.

The development of new theoretical and modelling techniques is an essential part of our work since biological systems are highly complex and characterized by a multitude of different length and time scales. This fact implies that nanoscale studies of biological phenomena must be complemented by mesoscale as well as macroscale (continuum) investigations of related phenomena. In practice, this calls for novel attempts to design coarse grained models for large-scale studies of biosystems. We have used the "bottom-up" approach, where the objective is to first develop coarse-graining techniques, and second to apply them 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 the coarse grained model are systematically derived from detailed atomic-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 to consider the large-scale properties of soft matter while preserving a bridge to the underlying microscopic world. Additionally, in the atomistic limit in biomolecular systems, we have explored various ways to deal with electrostatic interactions in an accurate and efficient manner. Of particular interest is the treatment of electrostatics in parallel computations in "cheap" architectures, which is often the case in GRID networks.



Snapshot of non-equilibrium simulations of a colloidal particle under dielectrophoretic motion. Blue reflects the surrounding solvent, and red the counter ions associated with the colloid. (Courtesy of Emppu Salonen.)



Lipid membranes comprised of cationic and neutral lipids are used as vehicles in drug and gene delivery. The snapshot shown here is based on atomistic simulations of these systems under the influence of salt (shown in violet). (Courtesy of Andrei Gurtovenko.)

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 single-component lipid bilayers composed of various saturated and polyunsaturated glycerophospholipids (PC's), and sphingomyelin. The studies have concentrated on a variety of structural aspects such as ordering effects and void distributions inside a membrane, and their interplay with dynamic properties such as the lateral diffusion of lipids in the plane of the membrane. We have further clarified the properties of two-component systems composed of PC's and cholesterol, the focus being on the influence of cholesterol on the structure and dynamics of lipid bilayers. Additionally, we have investigated the properties of lipid bilayer mixtures of PC's and cationic lipids commonly used in non-viral techniques for gene delivery, and initiated work to address the influence of salt on these systems. Closely coupled to experiments, we have addressed questions related to fluorescent molecules often used in experiments to probe lipid bilayer systems.

The third theme of the BIO group deals with large-scale properties of soft-matter systems. On the one hand, this work involves the development of multi-scale modelling and coarse-graining techniques. On the other hand, the above-discussed techniques are applied to complex biomolecular systems. Most recently, the research has focused on the influence of hydrodynamics on the diffusion of 2D colloids, non-equilibrium properties of colloids under the influence of dielectrophoresis, and structural transitions in DNA. Additionally, we have used the Inverse Monte Carlo approach discussed above to coarse grain and model lipid membrane systems comprised of saturated glycerophospholipid and cholesterol molecules. It has allowed us to, for the first time, predict the formation of cholesterol-rich and cholesterol-poor domains at intermediate cholesterol concentrations, in agreement with experiments. This approach provides a speed-up of approximately seven orders of magnitude compared to atomistic simulations.

String Theory and Quantum Field Theory

One of the outstanding recent results from String theory is the surprising duality between gravitational theories in asymptotically anti-de Sitter space-times and lower dimensional non-gravitational field theories in Minkowski space. This relation, called the AdS/CFT correspondence, gives a holographic mapping of space-time and has many important consequenses in different directions. The discovery is related to the properties of D-branes.

Our Universe however has a different asymptotic behaviour. It is very important to examine if the holographic mapping could be generalized also for asymptotically de Sitter space-times. One possibility for unraveling such a relation is to replace ordinary (stable) timelike D-branes by spacelike ones (decaying D-branes) as a starting point. The path to AdS/CFT correspondence started from studies of scattering of strings from D-branes. So it is natural to ask questions about scattering from decaying D-branes. Last year this was studied by a HIP-Amsterdam-UCLA-UPenn collaboration.

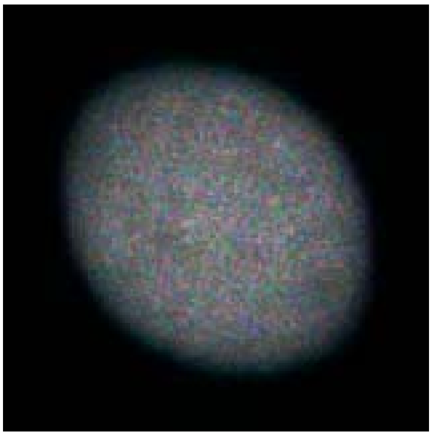
The computations involved in the case of decaying branes are much more difficult than in the case of stable branes. The collaboration developed a general formalism for the calculations and found that problems can be efficiently reformulated as mathematical problems in random matrix theory. Using tools such as Toeplitz determinants, the Szego limit theorem, and Selberg integral formulae, the group was able to significantly improve the state-of-the-art in scattering calculations. For example, it was possible to find how initial open string perturbations affect the subsequent decay of the brane into closed strings. The group also showed an important relation to a very recent mathematical achievement, the Borodin-Okounkov identity for Toeplitz determinants. It was also shown how properties of decaying branes are related to the thermodynamics of classical two-dimensional Coulomb gases.

Another approach to de Sitter space from String theory was also studied last year at HIP, an exact treatment in two dimensions based on a different matrix model that emerges from an ensemble of decaying D-particles. One uses a hidden symmetry of the effective action for tachyon condensation in two dimensions to relate this process to de Sitter physics. This allows one to conjecture candidates for the endpoint of the condensation process and then study its backreaction. The HIP group also investigated D-branes in curved space. We developed Wakimoto free field and Coulomb gas conformal field theory techniques for the study of scattering from D-branes in an SU(2) group manifold (three-sphere). This gives an alternative, in many ways a more straightforward way to organize the calculations. We computed examples of correlation functions in this case. The group has also investigated the holographic super-Weyl anomaly of a supersymmetric gauge theory in the context of the AdS/CFT correspondence as a further test that the AdS_5/CFT_4 correspondence at supergravity level holds.

In a different direction, the group continued its studies of quantum field theory on noncommutative (NC) space-time, investigating its space-time symmetries. In this direction the group has made a breakthrough by showing that, although NC QFT's violate the Lorentz invariance in the usual sense, they have a twisted Poincaré symmetry, whose generators are the same as the usual Poincaré generators. Therefore, the particles in NC space-time are classified, just like in commutative space-time, according to their mass and spin. This new symmetry gives justification to all the previous treatments and calculations, such as perturbative unitarity, UV/IR mixing, NC instantons and relation to matrix models, made in the literature in a formally Lorentz invariant form in spite of its violation. Such a symmetry, in addition, leads to a new concept of relativistic invariance defined for the noncommutative space-time, which has been explored in the formulation and proof of an analog of Haag's theorem in QFT. The group has further obtained all the exact results of QFT, i.e., the dispersion relations, CPT and spin-statistics theorems and the Froissart bound on the high energy growth of the total cross section, also in the case of NC space-time, using the developed axiomatic formulation of such theories. The group has also continued the study of model building in the noncommutative context, proposing a gauge-invariant and anomaly-free noncommutative version of the Standard Model.

Ultrarelativistic Heavy Ion Collisions

The studies of QCD matter and its two 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. The RHIC collider at Brookhaven successfully brought the field of ultrarelativistic heavy ion collisions (URHIC) into a collider era in summer 2000. Even more exciting possibilities are offered by the ALICE experiment at the CERN-LHC, operating from 2007 onwards. The URHIC project in the HIP Theory Programme started in 2002 and it was reviewed in 2004 and another three-year term was granted. 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 the phenomenology of URHIC by making calculations for observables measurable in the experiments at the CERN-SPS, BNL-RHIC and CERN-LHC/ALICE, and (2) on studying the properties of the QCD matter through first-principle calculations. We participate actively in international conferences, theory collaborations such as Hard Probes, European graduate schools and EU networks. We organized the Strong and Electroweak Matter 2004 Meeting in Helsinki.



Energy density in the chromoelectric fields at the central slice z=0 fm and a proper time 0.39 fm/c in a noncentral Au+Au collision at RHIC. Red and green are the energy densities in the transverse fields and blue in the longitudinal field.

Among our specialities is the computation of initial densities of the QGP produced in AA collisions, based on perturbative QCD (pQCD) and gluon saturation. The fermion-antifermion content of the formed QGP can also be addressed in this closed framework, and predictions for RHIC and LHC can be made. An approach complementary to the pQCD + saturation model is the lattice evaluation of classical Yang-Mills equations of motion of the gluon fields. After this problem was correctly solved, phenomenologically relevant results for the initial QGP state have been obtained. Rapidity distributions of produced gluons have also been studied. A method to calculate quark-antiquark production from the classical gluon fields has been developed. The first results for the 1+1 dimensional case have been obtained and numerical implementation of the full 1+3 dimensional case is in progress. *(Collaboration with Saclay.)*

Further evolution of the produced dense, strongly interacting system is describable by relativistic hydrodynamics. The pQCD + saturation + hydrodynamics approach correctly predicted the multiplicities in central Au+Au collisions at RHIC. Also, the bulk of the p_T-spectra of identified hadrons at RHIC come out correctly with just a single, high, decoupling temperature $T_{dec} \sim 150$ MeV.

Predictions for the hadron p_T-spectra at the LHC are to be published. We are also actively investigating the origin of the azimuthally asymmetric spectra in non-central collisions, and the sensitivity to the QCD matter equation of state. Dynamics of the decoupling process will be studied further and work towards a fully 3+1 dimensional hydro code is in progress. Kink-kink collisions in classical scalar field models have been numerically studied as a model of nucleus-nucleus collisions. Once the space-time evolution of the system is under control, the electromagnetic probes of the QGP, thermal photons and dileptons, can be computed for RHIC and LHC. A special challenge is the chemical equilibration of the QGP. These studies have already been initiated in collaboration with LAPPTH/Annecy and Saclay.

One of the most exciting results from RHIC so far, one of the proposed QGP signals, is the strong suppression of high-p_T hadrons in central Au+Au collisions. We have studied the origin of such a suppression by using factorized pQCD cross sections, nuclear parton distributions, fragmentation functions and parton energy loss probabilities. A comparison with the RHIC data and quantitative predictions for the phenomenon at the LHC have been reported. A comparison with the hydrodynamical results is to be published. *(Collaboration with CERN/TH.)*

We have carried further the pQCD studies of nuclear parton distribution functions (nPDF) needed in the computation of factorizable hard processes in nuclear collisions. A global DGLAP analysis of nPDF, similar to that for the free proton is in the final stretch. We have also studied the effects of non-linear corrections to the DGLAP evolution in light of the HERA ep data. An increase in the gluon distributions at small momenta and few-GeV scales was discovered. Consequences for heavy quark production at the LHC, as well as the possibility to observe such an effect at ALICE, have been studied. Gluon saturation issues and new evolution equations have also been considered. *(Collaboration with CERN/TH, Iowa SU, LBNL, ALICE and Regensburg.)*

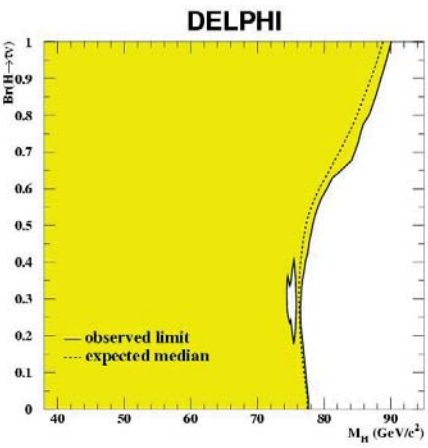
The free energy of hot quark-gluon plasma is remarkable in that its perturbative expansion, which due to asymptotic freedom could be expected to be very accurate at very high temperature, actually at sixth order contains a non-perturbative term. Like any particle mass, it can only be computed numerically. It has been a long-standing problem how this computation should be organized. We have finally solved this problem by formulating a precise set-up for it, by performing several required intermediate analytic and numerical steps and by defining precisely what still has to be done: one extremely demanding but feasible analytic computation (computation of the 4-loop vacuum energy in a full 4-dimensional calculation but in the msbar regularisation scheme) and one numerical computation (relating the lattice and msbar regularisation schemes to 4 loops). Both are under way. (*Collaboration with CERN/TH and Bielefeld.*) In addition, effective theories have been developed to better understand phase transition dynamics in QCD and QCD-like theories. For QCD, these imply that confinement is driven by the dynamics of chiral symmetry restoration. Multicritical behaviour has also been studied. *(Collaboration with NBI.)*

High Energy Physics Programme

Heimo Saarikko

On the basis of its reputation built in the CERN LEP-DELPHI experiment, the Helsinki group was recently accepted to join the CDF experiment at the Fermilab Tevatron antiproton-proton collider. Tevatron is currently the leading energy frontier instrument in investigating the basic structure of matter and the processes between the fundamental constituents. The Helsinki group has gained co-ordinating roles in the TOTEM experiment at CERN's forthcoming LHC collider, i.e., the physics analysis co-ordination and chairmanship of the physics advisory board, and the group is also co-ordinating the Gas Electron Multiplier (GEM) detector based T2 tracking station project of TOTEM. In 2004, the Helsinki group has had, in the DELPHI collaboration, a central role in searches for the charged Higgs bosons, which are predicted by many extensions of the Standard Model (A. Kiiskinen has co-ordinated the analysis), and a group member (N. van Remortel) served as the co-ordinator of the analysis of Bose-Einstein correlations (BEC) between the identical bosons emitted from the two different W's in $e^+e^- \rightarrow W^+W^-$. In the analysis of the dead cone effect, the observation of depletion of fragmentation particles at small angles in b-jets represents a direct proof of the concept of colour coherence in QCD. The Detector Laboratory at HIP has gained more visibility and improved its possibilities to provide services for research projects during 2004. With the successful application for the infrastructure programme of the Academy of Finland, it has been possible to refurbish the Laboratory equipment substantially. As a part of the generic detector development, a prototype of GEM detectors with two GEM foils and with two-dimensional readout was designed according to the design criteria of space quality instruments.

The observed and expected exclusion regions at 95% confidence level in the plane of leptonic branching fraction vs. the charged Higgs boson mass. These limits were obtained from a combination of the search results in the leptonic, semileptonic and hadronic channels at centre-of-mass energies 189–209 GeV. The lower mass limit for a charged Higgs boson with any value of leptonic branching fraction is set at 74.4 GeV/c².



Background

The research of the Experimental High Energy Physics group of HIP (Helsinki Institute of Physics) and SEFO (Division of High Energy Physics, Department of Physical Sciences, University of Helsinki) aims at physics contributions to energy frontier experiments at CERN and Fermilab. The group has placed its long term emphasis on QCD, especially in the heavy quark sector. To be able to have an impact in a leading experiment, the group has systematically invested in development of experimental instrumentation and software tools for b- and t-quark analysis. This development work represents a long term investment on precision detectors and software intended for jet reconstruction and heavy quark tagging.

The research efforts of the Helsinki group are closely connected with the educational and detector development activities; the group has a proven track record of providing an efficient physics driven framework for education and technology transfer.

Electron – Positron Physics

In 2004, the DELPHI collaboration focused on finalizing the analyses of the data collected during 1989–2000 at the Large Electron Positron (LEP) collider at CERN. The Helsinki group has had a central role in searches for the charged Higgs bosons, which are predicted by many extensions of the Standard Model. A. Kiiskinen co-ordinated the charged Higgs analysis within the DELPHI collaboration and defended his PhD thesis in spring 2004. No indications for the charged Higgs bosons were found and a model independent lower limit on the charged Higgs mass of 74.4 GeV was established.

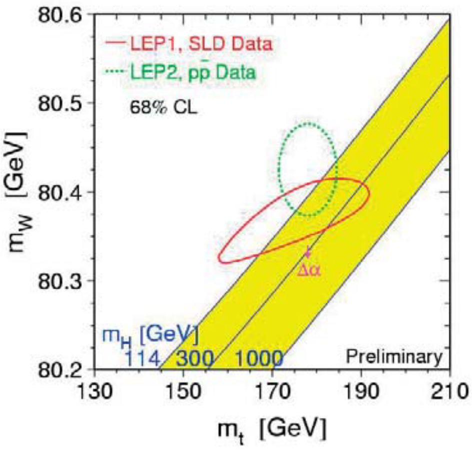
In the field of strong interaction physics, the group has investigated Bose-Einstein correlations (BEC) between the identical bosons emitted from the two different W's in $e^+e^- \rightarrow W^+W^-$. A group member served as the co-ordinator of the BEC analysis in DELPHI (N. van Remortel). The results support the existence of Bose-Einstein correlations in this process.

A fundamental feature of colour coherence in QCD, the dead cone effect, was analysed and reported by the group at the ICHEP04 conference in Beijing this year. The observation of depletion of fragmentation particles at small angles in b-jets represents a direct proof of the concept of colour coherence in QCD. Further in the field of heavy flavour physics, the group is pursuing an inclusive measurement of the lepton momentum spectra in semileptonic B decays to determine the value of B decay model parameters. The results are being published together with the measurement of the hadronic mass spectrum and a combined interpretation according to B decay models. This will lead to a significant improvement in the accuracy of the determination of the quark mixing matrix element $|V_{cb}|$. Laura Salmi is currently finalizing her PhD thesis on these subjects. The group has traditionally had a prominent role in b-quark tagging in the DELPHI experiment and K. Österberg served as the last DELPHI MVX project leader.

With the final LEP results being published, the efforts of high energy e^+e^- physics are moving towards high luminosity linear colliders. Our project is focusing on participating in the technical development related to the CLIC-scheme within the "CLIC accelerated R&D programme" that CERN has opened for outside institutes. Based on a survey of the interest of Finnish industry, it has been decided to enter the workpackage "Structure technology" that aims to find, adapt and integrate technologies for making the high-gradient rf structures for CLIC. The focus of the development will be on refractory metals (e.g., Mo) and various copper alloys.

Forward Physics at Tevatron and LHC

On the basis of its reputation built in the LEP-DELPHI experiment, the Helsinki group was recently accepted to join the CDF experiment at the Fermilab Tevatron antiproton-proton collider. Since this experiment is considered to be a leading project in the field, the invitation represents a major recognition of the group's scientific accomplishments. Tevatron is currently the energy frontier instrument in investigating the basic structure of matter and the processes between the fundamental constituents and currently represents the only active high energy physics experiment in Finland.

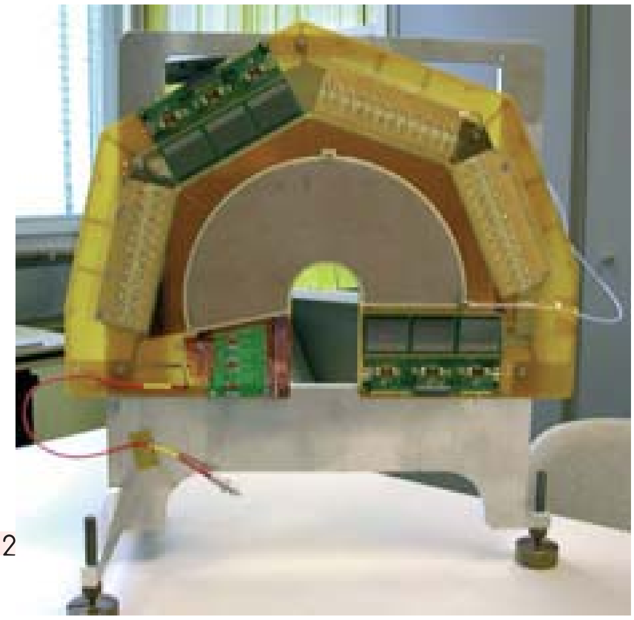


The Tevatron measurements of the top-mass plotted against the LEP and Tevatron W-mass values. The green dotted line indicates the region allowed for the Standard Model Higgs boson (at 68% CL).

At present, Tevatron is the only collider facility with which the heaviest matter particles, the top-quarks, can be produced. The collider fills the gap between the recently finished LEP programme and the forthcoming new LHC collider now under construction at CERN and provides an indispensable training ground for experimentalists aiming to make physics contributions at the LHC. The Helsinki group plans to analyse the properties of the top-quark in detail and, in particular, to develop novel ways of precisely measuring the top-quark mass in its dominant decay mode where only hadrons are produced. Combined together with the W-mass measurement, the more precise top-mass pins down the allowed region of the Higgs boson.

Reconstruction and selection of the hadronic final states is challenging due to the low signal/background ratio and large combinatorics when associating reconstructed jets to initial partons. The group is well equipped in this effort due to its long term experience in quark and gluon studies, jet reconstruction and heavy quark tagging at the LEP collider. Over a long period of time, the group has also developed special hardware techniques for tagging the short-lived heavy quarks. This was initiated by the construction and successful operation of the silicon vertex detector of the DELPHI experiment at LEP. This expertise is now being exploited in the involvement in both the on-line and off-line operations of the CDF silicon vertex detector.

Tuula Mäki (a graduate school fellow now full time at Fermilab) and Petteri Mehtälä (presently completing his MSc thesis) both



The first GEM prototype constructed for the TOTEM beam test in November 2004 at CERN.

will concentrate on top-quark studies for their PhD thesis subject.

The CDF experiment has up to date collected over one PetaByte of data. The handling and processing of this data and its corresponding Monte Carlo simulation equivalent is on the limit of what one single laboratory can cope with. Global distributed computing, better know as GRID technologies, are an alternative and are already successfully used wihin the CDF collaboration. The Helsinki group plans to participate in this effort by developing CDF dedicated GRID clusters in Helsinki and Rovaniemi in close collaboration with the Department of Physical Sciences of the University of Helsinki, HIP, and the Rovaniemi Polytechnical Institute.

The group is a member of the European Research Training network specialized in heavy quark physics and has established close collaboration with the phenomenologists at SEFO/HIP, Durham University and with the software groups at the Rovaniemi and Pohjois-Savo Polytechnical Institutes.

The Helsinki group is participating in the physics planning, design and construction of the TOTEM experiment at the LHC collider. The project offers a direct continuation of the group's earlier LEP and ongoing Tevatron based QCD analysis and, from the year 2007 on, provides unprecedented access to precision studies of gluons – the carriers of the strong force. Already during the preparatory stages of the experiment, the group has gained the co-ordinating role in TOTEM physics analysis (physics co-ordination and chairmanship of the physics advisory board) and has been given major responsibilities in the construction of some of the key parts of the experiment (T2 tracking station and microstations).

In 2004 the group has continued the simulation studies of the central diffractive process: $pp \rightarrow p + H + p$ and has gained a central role as an expert group concerning diffractive physics at the LHC. As a bench mark, limits of observation of the standard model Higgs boson at the LHC have been established. The group is responsible for the Gas Electron Multiplier (GEM) detector based T2 tracking station of TOTEM. During the autumn of 2004 the first GEM detectors, specifically designed for TOTEM, were tested in a CERN test beam.

The group has made important new innovations in the field of 3D silicon detector structures in co-operation with the VTT Technical Research Centre of Finland. Novel detector performance has been simulated in 3D for the first time and test structures have been processed at VTT and tested at the Detector Laboratory in Kumpula. These detectors are intended for the leading proton measurement within the microstations under development in Finland.

The following PhD students are involved in these LHC related studies: Christian Antfolk, Erik Brücken, Peter Cwetanski, Markku Eräluoto, Timo Hilden, Juha Kalliopuska, Elias Noschis, and Mikael Ottela. In addition, Fredrik Oljemark and Frej Torp are in the process of completing their undergraduate studies.

The group activities are supported by the SEFO/HIP and Durham theory groups, the Iowa State University group and the electronics and software groups of the Pohjois-Savo Polytechnical Institute.

Detector Laboratory

In 2004, the Detector Laboratory activities comprised the Common Running part and the Generic Radiation Detector Development part: the Detector Laboratory at HIP has gained more visibility and improved its possibilities to provide services for research projects during the year 2004. With the successful application for the infrastructure programme of the Academy of Finland, it has been possible to refurbish the Laboratory equipment with 190,000 EUR. This will most likely make the Laboratory also more attractive for users outside HIP. Related to this upgrade, a new WWW site has been developed for the Detector Laboratory. The aim of the new site is to distribute information concerning the Laboratory premises, hardware and know-how to a broader audience. This will happen in due time since one of the largest projects in the Laboratory, namely the ALICE SSD module assembly, will be finished at the end of 2005 and release premises for new projects, still under consideration. The CMS, ALICE and TOTEM projects will be the largest users still during 2005.

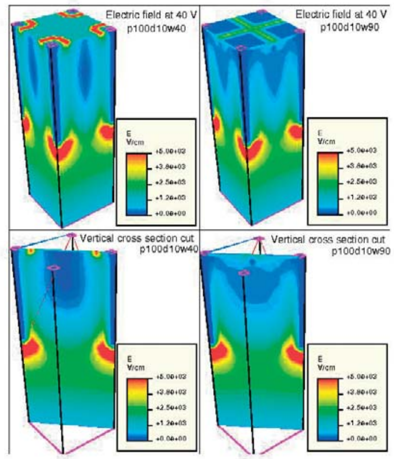
In 2004, generic radiation detector development of the detector group has been focused on the Gas Electron Multiplier (GEM) for high energy physics experiments and for X-ray astronomy. Another active research topic has been the aging phenomenon of the gaseous radiation detectors. At present, the main project of the group aims at constructing the GEM detectors needed for the T2 tracking station of the TOTEM collaboration. The extensive simulation of the detector characteristics with the MC method (GEANT4) has been started during 2004 and will be continued in 2005 by analysing the neutron response of the GEMs.

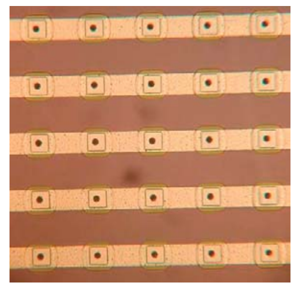
The group has continued its participation in space research projects and X-ray astronomy. Three prototypes of GEM detectors with two GEM foils and with two-dimensional readout were designed and constructed. The characteristics of the prototypes were studied with low energy X-rays and with several gas mixtures. The last prototype was designed according to the design criteria of space quality instruments.

The development of semiconductor and gas amplified precision detectors is closely connected with the medical and industrial hopes of replacing the ancient X-ray film techniques with modern digital sensors. In this, the Detector Laboratory created during the LEP-DELPHI project has proven to be highly competitive.

Educational programmes embedded into research activities

The group members are responsible for basically all the graduate level university education of high energy experimentalists in Finland. The PhD candidates of the group presently include students from the University of Helsinki, Helsinki University of Technology, the University of Heidelberg and ETH Zurich. The Detector Laboratory also serves as the basis of education and training in experimental high energy physics. Presently, Tom Schulman is about to complete his PhD thesis on semiconductor detectors. In addition, the group has established summer student and technical training programmes at CERN and Fermilab in connection with its own research projects. The Helsinki group is one of the eleven members – and the Finninsh co-ordinator – of a European Union Research Training Network (RTN) "New generation of quarks as a probe for new physics". The RTN collects together a number of leading European research groups working in the field of heavy quark physics at CERN and Fermilab. The group collaborates with a number of Finnish Polytechnical institutes and has established R&D and training programmes with the Polytechnics in Kuopio and Rovaniemi. The group is involved in organizing a national event for the European MasterClasses for High School Students: Hands on Particle Physics 7.–19.3.2005.





The simulated electric fields (40 V) for dopant regions of different size (top) and the surface of a test detector processed at the VTT (above).

CMS Programme

Jorma Tuominiemi

The HIP CMS Programme is responsible for the Finnish participation in the Compact Muon Solenoid (CMS) experiment at the CERN Large Hadron Collider (LHC). The CMS experiment is designed to study proton-proton collisions and also heavy ion collisions at the LHC. Its main scientific goal is the clarification of the three big open questions in High Energy Particle Physics today: the mechanism of the spontaneous breaking of the electroweak symmetry (existence of Higgs bosons), the existence of supersymmetric particles, and the existence of quark-gluon plasma. In addition, there are new fundamental questions that are gaining increasing interest, like the study of the existence of extra dimensions in the Universe. 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. The LHC experiments are scheduled to begin in summer 2007. In 2004 all parts of the CMS detector system were in construction and the time schedule for its installation in the experimental cave was consolidated. The construction of the CMS Tracker was suffering from delays in the industrial production of some important items but solutions to these problems were found and an accelerated construction schedule was formulated. Preparation for the physics analysis was advancing, the first steps towards the Physics Design Report were taken with a massive Monte Carlo simulation of events and testing of the CMS selection and reconstruction software. HIP is actively involved in both of these activities. The HIP CMS Programme is divided into two projects: 1) the CMS Software and Physics project, whose goal is to develop simulation and analysis software for the CMS experiment and to evaluate the discovery potential of the CMS detector design for new physics, 2) the CMS Tracker project that carries responsibilities in the design, construction and testing of the central tracking detector. Both projects encompass an active educational programme for PhD and undergraduate studies.

CMS Software and Physics Project

General

The HIP Software team has been participating in the CMS project since the beginning of the 1990's, when it was initiated. The team is involved in the CMS software and computing effort, which has been estimated to require a total of about 700 person years by the time of the fulfillment of the major milestones by 2006. The main emphasis of the HIP team is on the simulation and event reconstruction for the CMS Tracking system. In computing the team is contributing to the data intensive GRID project which involves massive Monte Carlo production of simulated LHC events in close collaboration with other CMS institutes in Europe and the USA, using GRID tools. The team continues to work on the challenging calibration problem of detector alignment with the goal to prepare effective software tools for precise determination of the detector module positions by using reconstructed tracks. Other contributions by the HIP team are in the fields of detector simulation with the objective to develop the event reconstruction software and in physics simulation with the goal to check the discovery potential of the CMS experiment. The team is also responsible for the on-line and off-line software of the Helsinki Silicon Beam Telescope and participates in the analysis of the CMS Cosmic Rack data.

Computing activities

Linux clusters. The operating system, NPACI Rocks Cluster Distribution, of the 64-CPU Linux cluster *mill* was upgraded in spring 2004. Mill was then connected to NorduGrid and during the autumn it was officially declared to be in production use. After the upgrade some 12600 batch jobs have been submitted to mill mostly by local users in Kumpula. Some 10% of the batch jobs were submitted through NorduGrid.

A new Linux cluster *ametisti* was acquired as a joint project between the Department of Chemistry, the Department of Physical Sciences and HIP. Ametisti is part of the Material Sciences National Grid Infrastructure (M-grid) funded by the Academy of Finland (75%) and by a consortium of ten participating Finnish universities and institutes (25%). Ametisti consists of 66 dual-CPU computing nodes, each housed in 1U boxes (1U=1.75 inch), a 4U dual-CPU server acting as the cluster front-end and a 1U server used for system administration. In total the system has 168 GB of memory, 2 TB of shared disk and 9 TB of local disk space. With its nearly 132*2 GHz computing power, ametisti is the second most powerful academic computing resource in Finland and the largest of the M-grid clusters. By the end of 2004 ametisti passed the acceptance tests performed by the Center for Scientific Computing (CSC) and it was taken in local test usage.

Based on the good experience acquired with the mill cluster by the HIP team, the NPACI Rocks Cluster Distribution and the NorduGrid ARC middleware were chosen as the basis for the software platform for all the M-grid clusters. The ametisti cluster was placed in the Physicum building in a new machine room with 60 kW of cooling power. The new machine room construction was supervised by a member of the HIP CMS Software and Physics project.

Another test cluster *testbed1*, a supplement to *testbed0*, was set up using NPACI Rocks Cluster Distribution for development and testing purposes. Its main use has been integrating the Parallel Root Facility (PROOF) with Rocks. The flexibility of Rocks makes it easy to transfer computational nodes between testbed0 and testbed1 when needed. On testbed1 there were six computational nodes in addition to the front-end node by the end of the year.

Disk servers. A new disk server, *silo2*, was purchased for the HIP CMS computing mostly funded by the Magnus Ehrnrooth Foundation. The initial installation has 1.5 TB of RAID-5 disk space with one hot spare, 2 GB RAM and 2 * 2.8 GHz Intel Pentium 4 CPUs. During 2005 the disk capacity is planned to be upgraded to 6.5 TB by purchasing another controller card and 16 more disks. Scientific Linux CERN 3.0 was installed on silo2 and it is connected to the mill cluster. According to preliminary benchmarks the data rate is 234 MB/s in reading and 64 MB/s in writing with one reading or writing process using a hardware RAID 5 disk array with XFS.

The standard CMS-software packages were installed on silo2 so that they are accessible through NFS from the mill front-end as well as from the mill computing nodes. The AFS-client (Andrew File System) software has been installed on the server, so that the contents of the CERN AFS-directories can be directly accessed from that machine. Remounting AFS on all wanted nodes needs more work.

The new 132+3 CPU ametisti cluster.

Grid computing. HIP participates in the NorduGrid project, which has produced the Advanced Resource Connector (ARC) middleware used on most clusters run by HIP. HIP also participates in the Large Hadron Collider Computing Grid (LCG) project, which is a pilot project for the Enabling Grids for E-science in Europe (EGEE) project. The HIP Software group members represented Finland and HIP in various meetings and workshops. Grid middleware on mill has been administered together with the Technology Programme. Grid usage on ametisti is expected to start by the beginning of 2005.

Tomas Lindén discussing with a ROOT software team member at the CHEP04 conference, Interlaken, Switzerland.

Monte Carlo production. The HIP Software team continued its participation in the CMS Monte Carlo Production activities. The big task of CMS during 2004 was to demonstrate the data transfer capabilities between the CERN Tier-0 and the major Tier-1 centers during the Data Challenge 04. In addition to a simulated LHC data taking rate of 25 Hz, quasi on-line data reconstruction with a latency of 20 min was demonstrated between the Tier-0 and Tier-1/2 centers. Analysing the simulated data samples from 2003 and 2004 and writing the Physics Technical Design Report (TDR) will be one of the main activities for CMS during 2005.

Geant4 development and CMS detector simulation

GEANT4 development. Bertini cascade models, provided by HIP, are among the principal theory-based models available for hadron-nuclear interactions within the general detector simulation toolkit Geant4. Hadronic models in Geant4 toolkit are now widely used to produce physics results, but recently significant efforts have been concentrated on the validation of Geant4 physics. This work includes detailed comparisons with experimental data, as well as benchmark studies of various geometries and materials.

The verification of the classical Bertini models has been performed using the data on spectra of hadrons produced by a proton beam, up to 10 GeV incident energy, upon various targets. The Bertini code can reproduce well the experimental thin-target double-differential cross section data with an accuracy equal to or better than Geant3 or FLUKA.

Users from various fields are using the stable Bertini cascade code successfully, and the spectrum of various applications will increase. A recent improvement to the Bertini cascade code is an extension to treat strange particles like incident kaons and lambdas. The Geant4 6.2 release also includes for the first time the High Energy Transport Code based evaporation and de-excitation models provided by HIP.

CMS detector simulation. In December 2004, after more than ten years of intensive use in CMS, the Geant3 based CMS detector simulation package CMSIM, maintained by HIP, was declared superannuated. It was replaced by the Geant4 and C++ based OSCAR package in CMS simulation productions.

The HIP team maintains and develops the package CMKIN which provides physics events for the detector simulation. By the end of 2004 about a dozen different physics generators were optionally available in CMKIN, to mention maybe the most important ones: PYTHIA, Isajet and Herwig. In addition interfaced with CMKIN are a number of “external generators” like TopReX, AlpGen and MadGraph, which work in the PYTHIA context.

The HIP team developed an efficient and precise formula to calculate the magnetic field in the region of the CMS Tracker. The formulation is based on an ideal solenoid formula, exact, in terms of infinite series expansion, and accurate when only the first few terms of the expansion are taken. The formulation was presented at the CHEP04 conference.

Calibration and event reconstruction

Alignment calibration. An important mission of the HIP Software and Physics project is to develop software for the calibration of the sensor positions in the Pixel and Silicon Strip Tracker detector systems. This calibration task, called detector alignment, is based on reconstructed tracks and aims at finding corrections to sensor positions and orientations so that the optimal trajectory reconstruction is obtained. The group has the responsibility to develop alignment methods and strategies especially for the CMS Pixel detector. An invited talk on this work was given at the vertex detector specific conference, Vertex2004, in Como, Italy.

Furthermore in 2004, the HIP team participated in the software alignment activities of the CMS Tracker by taking an active part in the software design of a general alignment algorithm interface and by implementing an alignment toolkit for the CMS Pixel detector. Implementation of the toolkit classes also considerably assisted the misalignment studies of the CMS. The group was also involved in the task of implementing similar methods for the CMS Cosmic Rack as well as in its alignment.

The analysis of the geometric precision measurements of the rod frames of the CMS Tracker support structure continued in collaboration with the HIP Tracker project throughout the year. The analysis served as well as quality assurance for the approval of the precision gluing of the sensor supports and pins as for calibration measurements for the final detector module positions.

The team also carried out the alignment task of the HIP Silicon Beam Telescope as well as the on-line and off-line analysis of its beam tests in summer 2004. An extensive analysis of these data was performed by the team in order to investigate the performance of heavily irradiated Czochralski type silicon detectors.

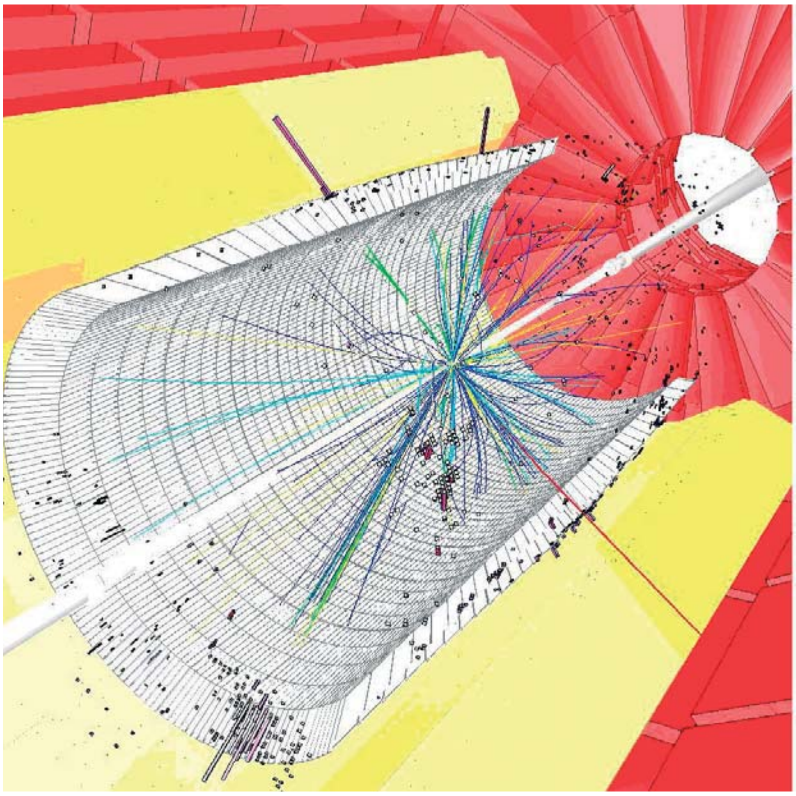
Event reconstruction. The HIP team has been active in the software development for the electron and photon reconstruction. The new version of the simulation program – coming in use for the massive production of simulated data for the Physics TDR studies – was validated by studying the simulated response of the detector to electrons and photons.

The team has taken on responsibility for the implementation of the photon object in the reconstruction software. This item is intimately connected to the physics study of the important Higgs $\rightarrow \gamma\gamma$ decay channel. Several updates to the existing description have been made concerning the photon position and energy measurement. The photon energy measurement may degrade due to the position of the electromagnetic shower in the calorimeter and, in many cases, correction functions can be defined to recover the lost precision. The team is also active in the analysis of the test beam data from an electromagnetic calorimeter module. This data will produce a valuable input to the detector simulation and for physics analysis of real data.

Physics analysis

One of the responsibilities of the HIP group is to investigate in detail the two-lepton and two-jet final states $H/A \rightarrow \tau\tau$ and the fully hadronic final states from $H^{\pm} \rightarrow \tau\nu$ in the region $m_{H^{\pm}} > m_{top}$ for the Technical Design Report of Physics and Analysis, to be published at the end of 2005. The event samples for the signal and for the backgrounds were generated with PYTHIA, CompHEP, TopRex and MadGraph event generators. A program package, HiggsAnalysis, was developed and published for the reconstruction of the digitized Monte Carlo events and for their analysis and presentation with the ROOT package.

Geant4 based simulation of a SUSY event in the CMS detector containing missing transverse energy, jets and several leptons in the barrel detector. (Picture: IguanaCMS.)



Development of the algorithms for hadronic τ identification with vertexing, τ tagging with impact parameter measurement as well as algorithms for b tagging were initiated.

A C++ interface was built to link the HDECAY and cross section calculation programs to the ROOT system. The new program package facilitates access to the exact calculation of the Higgs boson cross sections and branching fractions by M. Spira et al.

The Higgs boson discovery potential with the lepton+jet final states from gg $\rightarrow b\bar{b}$ H/A, H/A $\rightarrow \tau\tau$ was studied. The τ-jet identification was performed exploiting the narrowness, low multiplicity and isolation of the τ jet from H/A $\rightarrow \tau\tau$. The backgrounds were further suppressed by tagging one of the associated b jets, with the impact parameter measurements for the lepton and the hadrons from the decays of the two τ's and with a veto on additional central jets. A method to estimate the systematic uncertainty on the background determination was developed.

In the MSSM, tanβ is one of the most important parameters of the theory. The precision, with which the value of tanβ can be measured from the event rates in the H/A $\rightarrow \tau\tau$ decay channel with two-lepton, lepton+jet and two-jet final states already at an integrated luminosity of 30 fb^{-1}, was studied. The rate of the H/A $\rightarrow \tau\tau$ events is particularly sensitive to tanβ through the $\tan^2\beta$ dependence of the cross section. Systematic uncertainties from the event rate determination and SUSY parameter determination were also investigated.

The study for the discovery potential of the SM Higgs boson in the H$\rightarrow \mu\mu$ decay channel with m_H = 120 GeV/c^2, initiated in 2003, was finalized with the estimation of the systematic uncertainty of the background level under the invariant mass peak of the signal. The HIP group took the responsibility to write a publication on the study of the discovery potential for the lightest CP-even MSSM Higgs boson and its sensitivity to the SUSY parameter variation (HIP-2004-04/EXP).

CMS Tracker

The activities of the HIP CMS Tracker project include the responsibility for the design and construction of the mechanical support structure for the Tracker Outer Barrel (TOB), development of radiation hard silicon detectors for detector upgrade, operation of the HIP Silicon Beam Telescope (SiBT) for testing detectors in LHC-like conditions, and quality testing of Tracker silicon detector modules. In addition, the HIP Tracker Project has participated in the CMS Trigger and Data Acquisition (Tridas) project, where the HIP group held responsibilities in the design and fabrication of fibre optic link board boxes for the RPC (Resistive Plate Chamber) muon detector trigger.

Tracker Outer Barrel Mechanics

The main activity of the HIP Mechanics group is the construction of high-precision lightweight support structures, rods, for the CMS tracking detector. This construction covers the assembly work of rod frames and their quality assurance. In addition, the group is responsible for the design and manufacturing of the electronics boxes for the CMS Resistive Plate Chamber (RPC) Link Boards.

The assembly work is being done at the Physicum Laboratories in Kumpula. A total of 500 serial production rod frames have been manufactured, 320 of which had been delivered to CERN by the end of 2004. With two technicians the assembly rate has been 3–4 rod frames per day, which is estimated to guarantee the production of all the required 688 rod frames by April 2005.

Part of the rod frame quality control is performed at the assembly laboratory. Rod frames undergo a thermal shock of -30°C in a deep-freezer. Visual inspection follows to study flaws etc. After a thermal cycle, the performance of each rod frame cooling system is measured. In addition, the quality assurance includes the measurement of the physical dimensions of the assembled rod frames. A contacting measurement system and special tooling are used for this operation. The measurements take place at the Laboratory of Machine Design of the Helsinki University of Technology. The measurement results are analysed with an on-line algorithm developed together with the CMS Software and Physics group. Eighty per cent of the rods met the "excellent" quality criteria, the rest being acceptable. Measurement results are stored in the CMS Tracker Database and are later applied in the detector positioning and alignment.

RPCs are detectors that form the CMS first-level muon trigger system, and in which the Link Boards operate as the heart of the readout system. A total of 12 LB boxes that will be mounted on the nose of the CMS end-caps were manufactured for the CMS experiment. These boxes meet strict space and maintenance constraints, and provide practical service routings. The housing provides means for the precise LB attachment/detachment. Well-engineered thermal management ensures low temperatures at the component level.

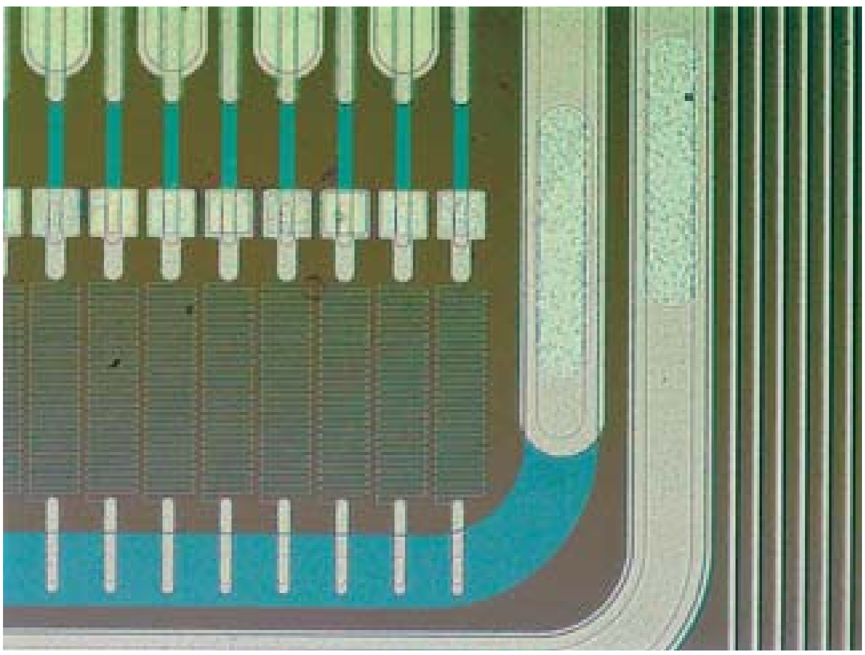
Silicon Detector Development

The objective of the HIP CMS Tracker silicon detector research is to develop radiation hard sensor solutions for the CMS detector upgrade and for the planned high luminosity super-LHC. Radiation hardness up to 10^{16} n_{eq}/cm^2 is required in the future HEP experiments. The main measure of radiation hardness of the detectors is the Charge Collection Efficiency (CCE), which is affected by both the detector sensitive volume (depletion depth) and charge trapping by radiation-induced trapping centers. Recently, p-type silicon materials have received growing interest in the scientific community working on the improvement of radiation hardness of silicon devices. The advantage of p-type materials is the absence of SCSI (Space Charge Sign Inversion), i.e., change of silicon conductivity type caused by the introduction of electrically active radiation induced defects. Furthermore, there are clues that the charge collection efficiency might be higher in very heavily irradiated p-type detectors than in n-type detectors.

The essential difference between Cz-Si and Fz-Si materials is the oxygen concentration. It is known that the aggregation of oxygen atoms will lead to the formation of electrically active defects, commonly named thermal donors (TD). The formation of thermal donors is strongly dependent on the temperature and the oxygen concentration in the silicon material. Heat treatment between 400–600°C can yield a TD concentration comparable to that of the background doping of high resistivity magnetic Cz-Si and thus lead to significant deviation in the full depletion voltages of the detectors.

We have demonstrated that when processing boron-doped p-type high-resistivity Cz-Si, the TD generation process can be utilized in order to produce p+/n-/n+ detectors. The last thermal process step, i.e., the sintering of aluminium, is intentionally carried out at the temperature where TDs are created. Due to the generated donors, the p-type bulk will eventually be compensated to n-type bulk. With this method it is possible, with low cost and with a low thermal budget process, to fabricate detectors with high oxygen concentration and moreover, to tailor the full depletion voltage of detectors from 30 V to 1000 V by changing the heat treatment at 400–450°C duration from 20 to 60 minutes. In irradiation tests, these types of detectors have proved to be more radiation hard than our previously reported n-type Cz-Si detectors.

Proton irradiated Cz-Si microstrip detector.



Quality Testing of Tracker Detector Modules

Silicon detector modules inside the CMS Tracker must fulfill tight requirements during the running of the experiment. Therefore, prior to the installation of the modules into the CMS Tracker, their functionality must be extensively tested. As there are a large number of detector modules, the responsibilities of the quality testing are distributed over several institutes participating in the CMS experiment. The HIP Tracker team has a small test set-up at CERN. With this set-up, detector modules can be tested one at a time, housed in metallic boxes. This set-up has also been used to test cryogenic silicon detector modules in the framework of the CERN RD39 collaboration.

The qualified modules are assembled into rods and shipped to CERN. After these stages each of the rods are inspected and characterized. Due to the high number of rods and the limited time available, automatic rod testing is needed. HIP has participated in producing a test station at CERN, which can characterize three rods at a time. The responsibility of HIP was error detection & recovery.

For some time plans have existed to also build a module testing set-up at HIP on the Kumpula campus. In 2004 funds were obtained to allow the construction of such a set-up, the Finnish Cosmic Rack – FinnCRack, in 2004–2005. FinnCRack is modelled on the cosmic rack of CERN (CRack), the mechanics of which was designed and built by a member of the HIP Tracker team (Erkki Anttila). During the construction of the Tracker in 2004–2005, most of the CMS test stations do routine, well-defined module testing following the production flow. FinnCRack is planned to be used as a test station providing real data for more specific tests on software alignment, run control, burn in, subsystem level functionality, and Cz-Si detectors in a minitracker configuration with several modules. The planning, procurements and networking necessary to build the FinnCRack were carried out in 2004. The preparation for the FinnCRack software part was carried out by participating in the CERN-based Cosmic Rack simulation project (Teppo Mäenpää). Tasks included implementing a cosmic muon-like particle source for CRack use; construction of CRack geometry for simulation use; finding imperfections in the ORCA code, and modifying either the CRack simulation or ORCA to overcome those. The participation in the hardware and software projects of the CERN CRack has served the purpose of actively involving HIP in the work of the TOB community in a visible way.

HIP has also participated in the design, development and production of test, control, monitoring and safety systems for the CMS Tracker. An important activity in 2004 has been the production of low voltage supply units for tests and calibration of the silicon detector modules and their front-end electronics for the CMS Tracker groups. The HIP team had earlier developed a special power supply unit with highly improved non-standard specifications. A basic function version with all the protection interlocks and monitoring facilities was built and 46 power supplies of this type were delivered during 2004.

The FinnCRack project was started in 2004. (Photo taken March 16th, 2005.)

Silicon Beam Telescope

HIP has operated the Silicon Beam Telescope (SiBT) at the CERN H2 test beam for several years. The telescope is used to measure the high-resolution tracks of the incoming beam particles. It offers a reference track measurement for the needs of the HIP CMS Tracker group testing the spatial resolution and the efficiency of detectors. SiBT is based on position sensitive silicon detectors attached to adequate readout electronics and a data acquisition system with a commercial Analog-to-Digital Converter. During the summer 2004 beam tests, the telescope was used for measurements of a cooled irradiated Cz-Si detector.

RPC Trigger

The activity of HIP in the Trigger and Data Acquisition System has been the design and fabrication of fibre optic links for the Pattern Comparator Trigger (PACT) system of the CMS Resistive Plate Muon chambers (RPC). The fabrication of the Link and Splitter boards of the trigger link will be completed in 2005, in collaboration with the CMS team of the Lappeenranta University of Technology.

One member of the HIP Trigger team (D. Ungaro) became a CERN Project Associate working on the infrastructure controls (DCS) for the magnet test. The Controls team builds the environmental and infrastructure sensoring and controls for the magnet test. This test is a milestone in the CMS construction that consist of activities with the double goal of training the coil to reach its working parameters and of mapping the field inside the central detector region and the magnet yoke. Moreover, the test allows the commissioning of the Magnet System (Coil + Yoke) before lowering it into the cavern.

Nuclear Matter Programme

Juha Äystö

Two aspects of nuclear matter are studied. Participation in the construction of the ALICE detector for LHC and related theoretical research aims to study the properties of strongly interacting hot matter at very high energy densities, which should be achieved in the heavy ion collisions at LHC. Research at the PS-booster ISOLDE focuses on studies of exotic nuclei far from the valley of beta-stability employing radioactive ion beams. This research includes nuclear structure, nuclear astrophysics, fundamental symmetries and interactions as well as nuclear solid state physics. A new project in the Nuclear Matter Programme was founded to support the Finnish participation in the FAIR project at GSI. FAIR stands for the international Facility for Antiproton and Ion Research. Initially, our participation will mainly focus on the NUSTAR Facility devoted to studies on nuclear structure, nuclear astrophysics and fundamental interactions. Also, participation is planned in general detector development and construction projects as well as in accelerator design and construction. The final formulation of the participation will be worked out in 2005.

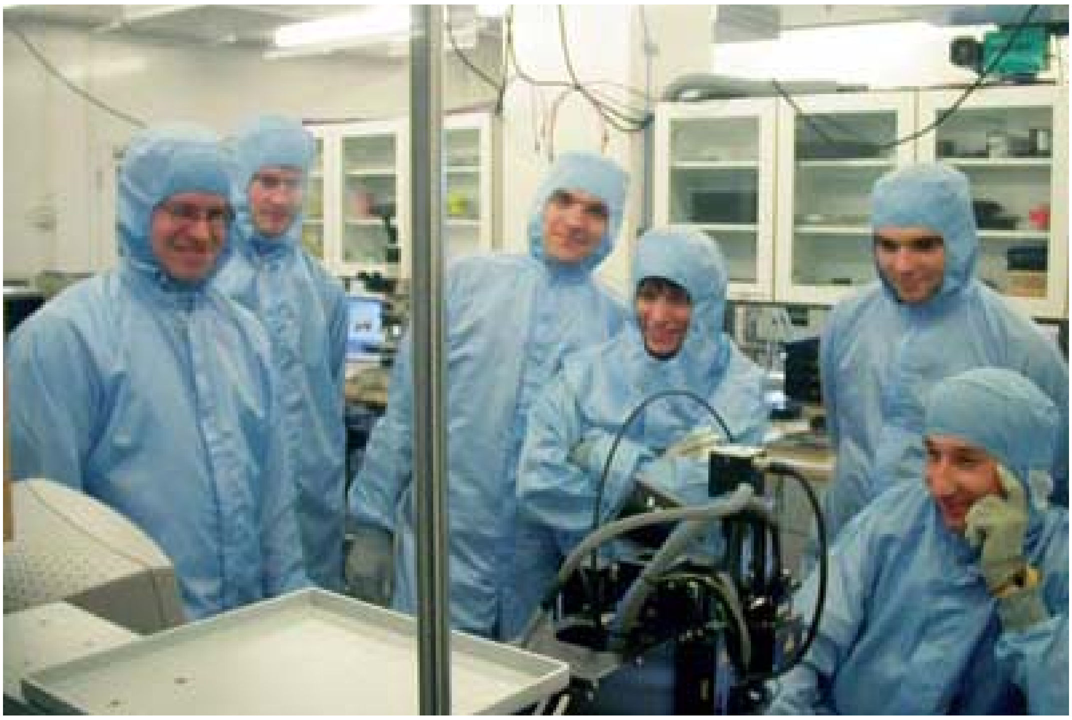
ALICE

There are only two years left before the first LHC beam is expected to collide inside ALICE but in spite of the growing time pressure the construction of the detector proceeds on schedule. The Finnish team has a significant part in this success. We are involved in bonding of the tracker components, construction of the T0 detector and development of the track reconstruction software. We have also contributed to the first physics publication by ALICE: Physics Performance Report, Volume I, that has appeared in the Journal of Physics G 30 (2004) 1517–1763. The growing importance of physics and data analysis in the work of our group has been strengthened by the creation of a new research position at the University of Jyväskylä. We are happy to reveal that this position was awarded to Dr. Jan Rak (currently working in the Phenix experiment at RHIC) and will be filled starting from the middle of 2005.

ALICE/ITS/SSD module assembly

The two largest layers of the ALICE Inner Tracking System (layers 5 & 6) will contain about 2000 Silicon Strip Detector (SSD) modules. The production of these modules is shared between France, Italy and Finland. The assembly of the Finnish share of SSD modules (defined by so-called core funding) is being done in the Detector Laboratory located at the Kumpula campus in Helsinki.

The SSD assembly has suffered considerable delays in the past: design of the preamplifier chip was changed along with the project and lack of components has made the tuning of the assembly process difficult. This delay created a new opportunity for Finnish participation in the assembly. Instead of delegating the work to industry, as was initially assumed, we were able to convince the collaboration to transfer the entire work-load to the Detector Laboratory in Helsinki. The new clean rooms were very suitable for that purpose but the Lab had no adequate equipment, personnel, nor know-how for the task. To solve these problems we have persuaded the collaboration to



The ALICE team in the Detector Laboratory.

commit part of the core funding into equipping the Lab and into travel compensation for the experts in the production and bonding involving aluminium/Kapton microcables. These experts are our ALICE colleagues from the Ukraine. The scheme was accepted and during 2002–2003 our research group has equipped the Laboratory and acquired the needed know-how. The biggest single investment was a new fully automatic bonder (F&K Delvotec 6400). It was installed in June 2003 and already one month later a fully automatic bonding scheme for the ALICE components was successfully demonstrated in Helsinki.

This breakthrough in the assembly has put the Helsinki Laboratory into the front line of the ALICE SSD assembly project and we have remained there ever since. Due to the requirement of minimizing the mass around the experiment vertex the collaboration started to use thinned amplifier chips (300 microns → 150 microns). Furthermore, it was decided to remove the polyimide passivation layer on the chips. Successful assembly of both varieties of the chips was demonstrated in Helsinki in January 2004. The first hybrid, containing 6 chips on a passive flex, and a module using these new components were assembled during spring 2004 following the realistic assembly schemes. Module assembly was seriously launched during the summer of 2004. Up to the end of 2004, more than 2000 HAL25 chips, 292 hybrids and 109 modules had been assembled in Helsinki.

Along with the prototype production for the SSD assembly, our group has addressed the reliability issues. A typical TAB contact is an interface between 5 different materials with different coefficients of thermal expansion. Even at a constant ambient temperature the flow of current through the bonds causes thermal stress leading, in the long run, to possible failures. During the spring of 2004 a set of assembled HAL25 chips was exposed to temperature cycles varying from -20°C to +80°C for about 1500 cycles – corresponding to >>10 years of ALICE operations.

None of the chips failed and the proportion of failed individual bonds was 0.09%. This confirms the very reliable nature of the HAL25 chips and the Al-Al single-point TAB interconnections against environmental stresses.

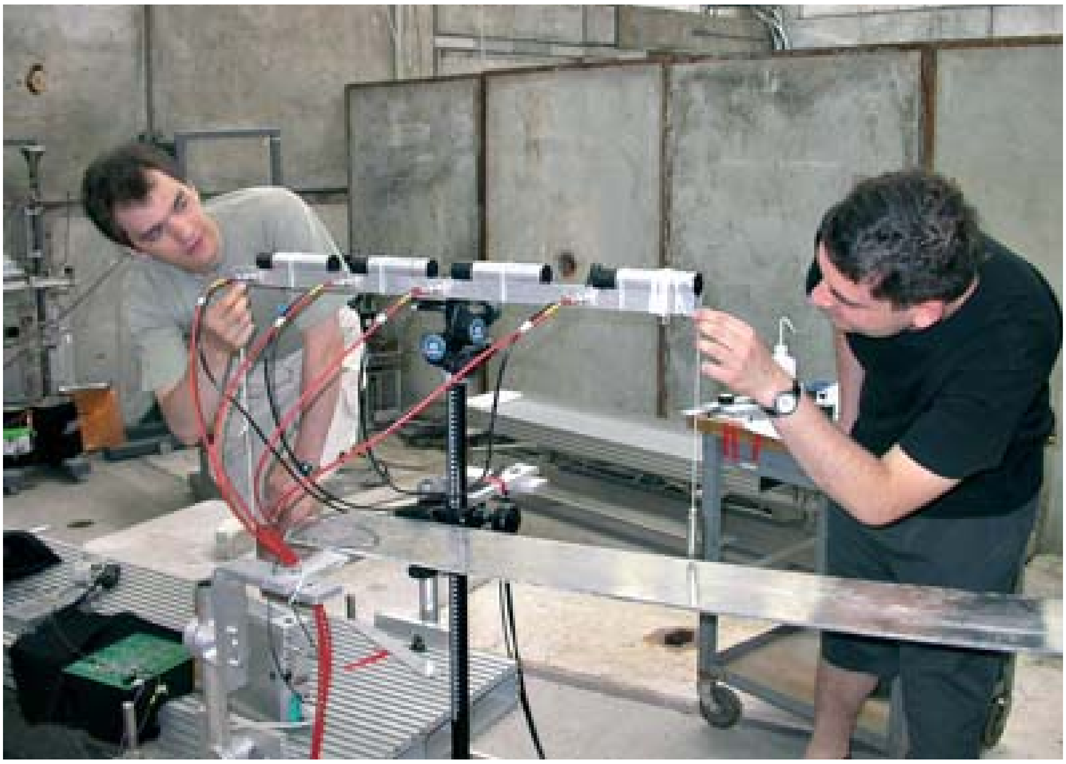
Optical and non-destructive methods have been used to investigate the bonding and component quality of ALICE samples. Scanning-White-Light Interferometer (SWLI) images reveal that the best bonding process parameters correlate with an Al bond thickness of about 3 microns. Preliminary studies indicate that it is even possible to tune and control the bonding process by using this non-destructive technique only. In addition, transient IR imaging has been successfully used to detect bonding failures. These techniques hold potential to become suitable inspection methods for microelectronics in general.

T0 Detector

T0 is the fast timing and trigger detector for ALICE. It will give the key trigger and timing signals, measure on-line vertex position and give rough centrality. Among its many technical challenges are: a dead time below 25 ns needed to cope with the bunch crossing rate in p-p collisions, a sustained count rate of 0.2 MHz, a required time resolution below 50 ps, radiation hardness of up to 500 krad, operation in the 0.5 Tesla magnetic field, compact design, high reliability and maintenance-free operation during the entire life-time of ALICE. It must be ready and operational from day one. Data from T0 will be crucial not only for extraction of the precise interaction time but also for normalization between proton-proton and heavy ion runs.

In 2004 we completed a major milestone towards the commissioning of the detector by publishing, jointly with FMD and V0, the ALICE Technical Design Report (ALICE-TDR-011, CERN-LHCC-2004-025, 10 September 2004). In this 150 page document the three forward detectors, their operation, electronics, readout and slow control are described in full detail. Our TDR includes the latest test results from an in-beam experiment carried out in June 2004 at CERN with a mixture of 6 GeV/c negative pions and kaons. In this run we have tested the full electronics chain as it will be used in ALICE including the actual length of the signal cables of the final set-up. In the measurements we have reached a new record in time resolution with Cherenkov detectors. By reducing the diameter of the radiator to match that of the photocathode of the photomultiplier tube we have pushed down the resolution from 37 ps (our 2003 record) to 28 ps. It was achieved without the need of any off-line corrections. This result is better by nearly a factor of 2 than what similar systems were able to achieve. For instance, a very similar detector called Beam-Beam Counter that is part of the Phenix experiment at RHIC reports only 100 ps on-line resolution and 50 ps after slewing corrections (NIM A 411 (1998) 238).

ALICE T0 run at CERN.



One of the challenges in the electronics design of T0 is the need to provide a wake-up signal to the Transition Radiator Detector (TRD) well in advance of the Level 0 trigger. The maximum acceptable latency of around 100 ns excludes the use of any electronics outside the magnet as the delay on the signal cables alone would be in excess of 250 ps. This means that a functional duplicate of the trigger electronics has to be designed and built for the use in the hostile and congested environment inside the ALICE magnet. The key element of that arrangement is a fast amplifier unit. Currently we are testing the 3rd generation prototype of this unit. It has been performing so well that the ALICE Technical Board has recommended that it also be used for the V0 detector.

ALICE Tracking

The study of strange particle production in heavy-ion collisions is one of the main goals of the ALICE experiment. The motivation is based on the prediction that the density of strange quarks in quark-gluon plasma should approach that of light quarks, enhancing production of strange particles. In order to reconstruct hyperons and identify kaons via their decay topologies one has to detect their products in the tracking system and find the decay vertices. To do that, we have developed a method of finding secondary vertices and the kinematical reconstruction of the decay. We detect charged kaons and neutral strange particles using their kink and V0-like decay topologies in the Time Projection Chamber (TPC) of the ALICE set-up. The main challenge in this work is a very high multiplicity expected in the Pb-Pb collisions at the LHC energies, resulting in a very high background. Nevertheless, the first results, based on the detailed simulations indicate the possibility of the successful identification of charged kaons and neutral strange particles using the ALICE TPC. The methods are being developed and tested with Monte Carlo simulations using the ALICE software framework (ALIROOT). The preliminary estimates of the reconstruction efficiency, precision and background conditions are very encouraging.

ISOLDE

Level structure of neutron-rich Cd isotopes

The structure of very neutron-rich nuclei near the doubly magic ^{132}Sn is an ideal laboratory to explore how the neutron-richness and large proton-neutron asymmetry impact both shell structures as well as collective excitations. In this context we have carried out a dedicated experiment at ISOLDE in 2004 to systematically study collective (vibrational, quasiparticle) states of Cd isotopes in order to understand the influence of neutron excess on these excitation modes. In addition to prominent collective behaviour, the excitation spectra of neutron-rich Cd isotopes are affected by so called intruder states originating from particle excitation over major shells. The interplay of the collective excitations and intruder states is one of the interests of these studies. In 2004 we studied at ISOLDE excitation schemes of ^{122,124,126}Cd as a continuation of our studies at JYFL of ^{116,118,120}Cd.

Advanced timing measurements on Mg isotopes

Among light neutron-rich nuclei we have studied excited states in heavy Mg isotopes close to the "island of inversion" by applying advanced timing techniques. With this method it is possible to obtain complementary information on transition strengths, which to date have only been extracted from Coulomb excitation measurements with radioactive ion beams. Coulex data obtained in different laboratories (GANIL, MSU, RIKEN, and CERN) have disagreed and thus a complementary method is requested. The analysis of the data is still going on, but the first results are encouraging and further studies are foreseen in 2005. Fortunately for ISOLDE, Coulex data from REX-ISOLDE and timing measurements seem to agree. This project will continue in 2005 with possible extension to E0-measurements.

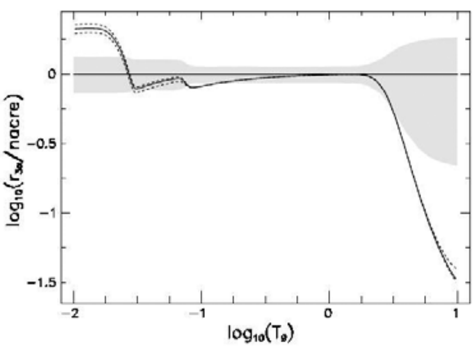
Si-ball project

As we have reported earlier, the Finnish group at ISOLDE has initiated a Si-ball R&D detector project, which aims for a high-granularity charged particle detector array. The full detector consists of 104 detectors in rhombicuboctahedron geometry made of squares and triangles. The detector provides very high geometrical efficiency close to 100%, wide energy range with a very low energy threshold and high enough granularity for angular distribution measurements between emitted particles. The first half of the Si-ball was successfully commissioned in 2002, and the array was applied in the beta-delayed proton decay study of ^{58}Zn in 2002 and 2003. In 2004 further tests were carried out at JYFL, where it was applied in four different spectroscopic studies, namely beta decay studies of ^{13}O, ^{31}Cl and ^{58}Zn and in the study of triple alpha states in ^{12}C. The two latter projects combine spectroscopic data from both ISOLDE and IGISOL and will be described in greater detail below. The two other projects deal with isospin asymmetries, cluster structures and nuclear astrophysical questions.

Beta decay of ^{58}Zn

Assuming that isospin is a good quantum number, we can expect symmetry between transitions from T=1, $T_z=\pm1$ nuclei to the common excited states in the $T_z=0$ nucleus between them. Such a symmetry test can be performed by comparing the strengths of Gamow-Teller (GT) transitions obtained from (p,n)-type charge-exchange reactions with those obtained from the beta decay. Mass A=58 provides an ideal case for such a comparison, since the same states in ^{58}Cu can be populated in the charge-exchange reaction ^{58}Ni(^{3}He,t)^{58}Cu and in the beta decay of ^{58}Zn. The charge-exchange reaction has been studied in great detail in Osaka and the beta decay of ^{58}Zn was observed by our group for the first time at ISOLDE in 1998, and the decay was revisited in a series of experiments in 2002 and 2003 with an improved experimental set-up. These studies involved high efficiency beta-gamma spectroscopy as well as a dedicated search for proton decay from higher lying excited states in ^{58}Cu. The latter part of the experiment applied the Si-ball array discussed above. In 2004 we have analysed the data from the beta-gamma spectroscopy part and the data from beta-delayed proton spectroscopy, obtained in 2003 at ISOLDE and in 2004 at JYFL, is under evaluation.

The new triple alpha reaction rate relative to the current NACRE compilation. Grey band: estimated error band for NACRE.



Molecular alpha structures of ^{12}C fed in beta decays of ^{12}N and ^{12}B

New measurements have been performed toward resolving long-standing questions about the triple alpha process that creates carbon nuclei. The data has been obtained in a series of experiments by isolating short-lived isotopes of ^{12}B at ISOLDE and ^{12}N at IGISOL. These transform via beta decay into ^{12}C, populating resonances in carbon that then break into three alpha particles. By precisely measuring the timing and energies of alpha particles emitted by the samples, it was possible to infer the energy, spin, and parity of the carbon nuclei just before decay. The triple alpha process is more probable only because ^{12}C can exist at particular energies close to the combined energies of ^{8}Be and ^{4}He.

At the temperatures in most stars, 10^8–10^9 K, the so-called Hoyle resonance of carbon at 7.65 MeV determines the triple alpha rate. But at higher and lower temperatures, other resonances – some observed, some theorized – come into play. With the new, more precise information, it became possible to calculate a revised triple alpha rate over a wide temperature range, from 10^7–10^{10} K. Compared to the previously calculated rate, the new rate is significantly faster at low temperatures (10^7 to 10^8 K), the same in the middle range dominated by the Hoyle resonance, and slower at high temperatures (10^9 to 10^{10} K). The revised rate has a wide variety of astrophysical implications. The first results have been published in Physical Review Letters and the newest are in press for NATURE.

Beam preparation research and development

Finally, an ion cooler and buncher development has concentrated on the technical design and manufacturing drawings. In 2004 the optical properties of the ion beam delivered by the test ion source were characterized, while the mechanical parts of the RFQ itself were manufactured in various workshops around Europe (Manchester, Orsay, Mainz, Munich and JYFL). At the end of 2004 most of the mechanical parts had been delivered to CERN and the first assembly of the apparatus is foreseen in 2005 followed by intense test measurements.

In 2004 a new type of scientific collaboration was also started, when ECR experts from JYFL were invited to collaborate in charge breeding studies at ISOLDE. Charge breeding of rare exotic isotopes, often extracted as singly charged ions, is of importance for a cost-effective post acceleration. After a very fruitful start a close collaboration within the existing charge breeding project is foreseen.

Technology Programme

Ari-Pekka Hameri

The DataGrid project continued research and development work in the area of Grid computing during 2004, as well as increased outreach efforts in the form of industrial collaboration. The project results are presented here in four specific focus areas. As a new Grid security development activity, the HIP Technology Programme joined the CERN-led EU project called Enabling Grids for E-Science in Europe (EGEE) initially for 2004–2006. A commodity cluster project took part in the Material Sciences National Grid Infrastructure procurement co-ordinated by CSC together with the CMS Programme. The LHC physics -related activities in the Programme included the LHC@home experiment under the CERN OpenLab, and in the industrial collaboration area the TEKES-funded NetGest project was completed and several follow-up projects were initiated. At the end of the year the man-power of the group was well-balanced with seven scientists at CERN, and eight scientists and students in Finland.

Security work in European Grid projects

The year 2004 marked the end of the EU DataGrid project that started in 2001. Since then HIP has been actively participating in Grid security middleware development together with other European partner institutes. As a direct follow-up CERN launched an even bigger Grid collaboration project in 2004, more precisely EGEE, that hosts 70 partners around Europe. HIP is taking part in the project as a member of the North-European Grid (NEG) federation that includes members from the Nordic countries, the Netherlands, Belgium and Estonia. NEG's main research contribution is in the area of security middleware and policy management. Currently, HIP acts as the sole Finnish representative in the NEG and EGEE boards.

The EGEE project is run in parallel with the LHC Computing Grid (LCG), in that both projects try to tackle the data management challenges of the LHC experiments. The only difference is that EGEE is a multi-scientific effort where the technologies are also leveraged outside the physics community. These 2nd wave Grid projects are biased more towards the deployment aspects of a seamless Grid infrastructure as described in the larger eInfrastructure initiative funded by the European Union. Along these lines, considerable effort is put into providing support and training functions to be able to operate in a fulltime (24/7) fashion in the future. Currently, LCG alone connects more than 7000 CPUs worldwide. As such, joint research activities do have internal clients and thus middleware development aims to produce production quality software.

The experts of the HIP Technology Programme are working in EGEE on re-engineering and hardening current Grid security middleware and coping with recurring technology cycles that originate from more general Information and Communication Technology trends. HIP scientists took part in two official EGEE project conferences, the first arranged in Cork, Ireland, in April and the second in the Hague, the Netherlands, in November, as well as in the 10th Global Grid Forum in March in Berlin.

Cluster activities and the Nordic Grid Facility

The new Jaspis cluster is part of the CSC-led M-grid and is located on the premises of HIP in Otaniemi.

In 2004 the Academy of Finland took the decision together with other Nordic research councils to fund the Nordic Data Grid Facility (NDGF) and its LHC-computing related Tier operations starting from 2006. By that time, the work of the NorduGrid project is merged into NDGF. The contribution by the Programme to the LHC Computing Grid Project (LCG) will likely be pursued through NDGF, which should establish itself as the LHC Computing interface for the Nordic countries. During 2004, the Programme also joined the Nordic Grid Neighborhood (NGN) that pursues collaboration and networking activities in the Nordic and Baltic countries. The first meeting was arranged in Linköping, Sweden, in October.

The HIP Technology Programme has researched cluster computing in practice by operating and maintaining a small Linux cluster in Otaniemi, Finland, funded by the Magnus Ehrnrooth Foundation. This cluster has several multiscientific research groups and it has been accessible from NorduGrid as well. Subsequently the project partners in Finland have taken part in the Material Sciences National Grid Infrastructure (M-grid) for which the Academy of Finland granted the majority of the funding in 2004. M-grid is a joint project between CSC, seven universities and HIP. The project consists of building a computer network in which computers are situated at different locations by logically forming one processing and storage resource by using Grid technology. The M-grid will later be connected to the Nordic NorduGrid.

The hardware system that has been acquired is particularly suitable for sequential and easy-to-parallelize programs. The theoretical computing capacity of the system is approximately 1.5 Tflops. The system administration of the clusters will be done in co-operation between CSC and the university partners. The operating system, Grid middleware and other core system software will be installed and maintained by CSC. Local administrators will install the software needed by their own research groups, monitor the state of their cluster and manage and support local users. The M-grid is based on state-of-the-art servers equipped with 381 processors, each of them based on 64 bit architecture. Each sub-cluster uses the Linux operating system and Grid middleware developed by the NorduGrid project. The system can be remotely administered through an easy-to-use interface. The sub-cluster resources acquired by HIP are located in Kumpula and Otaniemi and managed by the CMS Programme and Technology Programme, respectively.

The LHC@home public computing initiative was launched in summer 2004 with the help of students from the Technology Programme.

CMS Software, Physics and LHC Grid

The development and operation of Grid computing for the LHC experiments reached a new level in 2004. The Technology Programme has participated in both the NorduGrid and LCG projects. The Programme members have represented HIP in several meetings and workshops. One of the main goals of this activity is to define how Finland and the Nordic region can best participate in the LHC Grid projects. The Technology Programme has contributed to funding applications for a Finnish Grid facility for LHC computing as well as represented Finland in the LCG Grid.

The Advanced Resource Connector (ARC) middleware from the NorduGrid project has been installed in HIP facilities and it has been used with physics software packages from the CMS experiment. The ARC middleware has proven to be very useful and reliable Grid software that can be used with many applications. CMS specific software such as CMKIN, OSCAR and ORCA have been used in both CERN central facilities and in external machines by using the XCMSI tool. XCMSI provides a way to install CMS packages in clusters that do not have the CERN software environment available. The CMS jobs have been described using a Grid-specific job description language that allows executing them in facilities where the correct runtime environment is available. This has been demonstrated with available machines and will be done on a larger scale when new clusters become available.

The Technology Programme operates high-level Grid index servers (GIIS servers) that allow researchers from other locations to participate in running physics software. For example, clusters from Bern and Geneva universities have participated in an LHC data challenge using these index servers.

In 2004, CERN's IT Department began an effort to adapt a specific program, called SixTrack, to run on Berkeley Open Interface for Network Computing (BOINC) which is the generalized SETI@home computing engine launched in 2003. The well-known screensaver SETI@home, which analyses radioastronomical signals in a search for extra-terrestrial intelligence, has been downloaded by more than 5 million users, and is by many measures the most powerful distributed computer on Earth. The SixTrack simulates particles traveling around the LHC to study the stability of their orbits, and produces results that are essential for verifying the long-term stability of the high energy particles in the Large Hadron Collider (LHC). Students funded by HIP worked on this project over the summer, in collaboration with students from the University of Copenhagen, the University of Basel and U.C. Berkeley. After some testing, LHC@home was launched to the general public in September 2004. The first thousand users joined in less than 24 hours, and the project had to set a limit of 5000 users to ensure that the large flow of data being sent back could be handled adequately. The results so far are very promising: being able to increase computing power by more than two orders of magnitude, compared to available in-house resources for SixTrack, allows CERN physicists to gain qualitatively new insights into the performance of the LHC, uncovering, for example, narrow regions of beam instability that would have been overlooked in coarser parameter searches.

Compared with Grid computing, public

resource computing such as LHC@home is a useful complementary approach. It has intrinsic limitations set by the bandwidth and storage capacity of remote PCs. But for problems that can be adapted to this mode of operation, it provides huge and essentially free computing resources. The HIP Technology Programme is continuing to contribute to the development of LHC@home, which includes investigating the possibility of building a bridge between the LCG and BOINC.

Industrial and research collaboration

In 2004, the Programme continued the first industrial Grid research project, NetGest, with Finnish academic and industry partners. This project explored how to integrate Grid technologies with known solutions and best practices in Web & Mobile environments for Information Communication Technology (ICT) businesses, especially regarding how users are authenticated and authorized and how resource management is handled in a distributed infrastructure. The project also studied the business issues of the Grid technologies in order to gain an understanding of the possible effects of the Grid in the business models of various players in the ICT sector.

The final demonstration and review was arranged for TEKES and the industry participants at the end of May in Finland and gave the first concrete indications to Finnish IT companies how Grid technology can help their business. The project resulted in a number of proof-of-concept Grid applications and technical reports mirroring the state-of-the-art in Grid computing research. According to recent studies, the biggest obstacle in the way of business impact by Grid technologies is the lack of knowledge of its potential usage. Based on the feedback from the participants, NetGest succeeded at least in this respect to increase the overall awareness of Grid technologies among Finnish industry. Before the end of the year, the Programme succeeded in establishing a new TEKES-project consortium to follow-up the NetGest project and to solicit TEKES government funding for the years 2005–2006.

In 2004, the group also provided subcontracting services to the Helsinki Institute of Information Technology (HIIT) in the area

The collaboration partners and venues of HIP's Technology Programme.

of distributed Search engine research, led by their Complex Systems Computation Group. This activity, that is part of the TEKES-funded Search-in-a-Box project, will continue into 2005.

In addition, the Programme facilitated the participation of four Finnish summer students in the second CERN OpenLab summer student programme that gathered a group of a dozen students from around Europe and the United States. Finnish students were partly sponsored by CERN, HIP and the home universities of the students. They took part in joint-development projects, including Digital Logbook, LHC@home, and attended numerous activities such as visits to the IBM Research Lab in Zurich and the HP Labs in Grenoble. The results of both of these projects were also presented during the CERN 50th Anniversary Open House as part of the GridCafe demonstrations (see www.gridcafe.org). Of the students that arrived in 2004, the majority came from the Helsinki University of Technology (HUT), and for the first time also from Arcada, the Finland-Swedish University of Applied Science (Polytechnic). The Programme also took an initiative in exploring closer collaboration with member universities in Grid technology facilitation with personal contacts in the HUT Material Sciences group and in taking part in the process of defining a common IT strategy for the University of Helsinki Kumpula campus.

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). A large number of undergraduate students also join the research groups and complete their Masters' thesis work at the Institute. This has turned out to be a very fruitful way of recruiting graduate students. In particular, summer jobs at CERN are extremely efficient in this respect. During 2000–2004 25 doctoral degrees and 47 Masters' degrees have been earned in HIP research projects.

The National Board of Education (Opetushallitus) has started in collaboration with HIP and the city of Jyväskylä a CERN co-operation high school network and in collaboration with the city of Helsinki 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 2004 this programme attracted 202 Finnish students and 34 of their teachers. Another related programme has been to bring to CERN high school physics teachers participating in continuing education courses, in 2004 12 teachers. In addition, shorter visits to CERN were made by a group of 43 teachers and a group of 16 high shool rectors.

In 2004 the Academy of Finland, the Finnish research funding agency, was sponsoring a nationwide infrastructure programme to improve the research facilities in universities and other organizations. HIP received funds for two such projects: the national GRID-infrastructure for materials research (90,000 euro) and the strengthening of the Detector Laboratory infrastructure (144,000 euro). In addition to the Academy funding the Institute had to provide 25% of the total cost of the equipment.

In matters of technological and commercial co-operation HIP collaborates with Finpro, which is an independent association providing services to Finnish companies, e.g., with international Big Science projects such as CERN. The Finpro co-operation at CERN is financed by TEKES.

A group from Pyhäjoki High School standing in front of the electron cooling unit (blue) of the CERN Antiproton Decelerator, which slows down the antiprotons produced by the CERN Proton Synchrotron. (Photo: Miikka Salminen.)

Organization and Personnel

Organization

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- **CMS Tracker** – Edward Hæggström

Nuclear Matter Physics – Juha Äystö
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- **ISOLDE** – Ari Jokinen

Technology – Ari-Pekka Hameri
- **Data Grid** – Miika Tuisku

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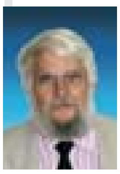

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Martti Mäenpää, Director General (Technology Industries of Finland)

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O. Dannenberg, grad. student
J. Koponen, grad. student

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K. Kurvinen, lab. engineer
R. Lauhakangas, lab. engineer
J. Ojala, researcher
A. Numminen, lab. technician

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F. Garcia, scientist
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A. Heikkinen, grad. student
T. Lampén, grad. student
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N. Jiganova, senior system analyst
J. Aaltonen, lab. engineer

Seminars

Seminars held in Helsinki

January 8th A. Ipp (Technical University of Vienna, Austria)
Thermodynamics of QCD with large flavor number

January 20th E. Keski-Vakkuri (HIP)
Decaying D-branes and random matrices

January 27th M. Vepsäläinen (Department of Physical Sciences)
Mesonic correlation lengths in high-temperature QCD

February 2nd (Colloquium) P. Braun-Munzinger (GSI, Darmstadt, Germany)
Ultra-relativistic nuclear collisions and the QCD phase transition

February 10th L. Stodolsky (Munich, Germany)
Neutrino flight times in cosmology

February 17th R. Kinnunen (HIP)
CMS potential for the Higgs boson discovery

February 24th S. Räsänen (Oxford, UK)
Dark energy from backreaction

February 26th D. Rischke (Frankfurt, Germany)
Chiral symmetry restoration in linear sigma models

March 1st (Colloquium) J. Äystö (Jyväskylä/HIP)
Studying the extremes of nuclear matter

March 2nd M. Roos (Department of Physical Sciences)
Dark matter: the evidence from astrophysics and cosmology

March 15th (Colloquium) M. Leskelä (Department of Chemistry)
Recent thin film studies in Laboratory of Inorganic Chemistry

March 16th K. Enqvist (HIP)
Cosmology with curvatons

March 23rd R. Schlickeiser (Ruhr-Universität Bochum, Germany)
Astrophysical beam-plasma instabilities

March 25th Y. Zhang (Inst. of Theor. Physics, Chinese Academy of Sciences, Beijing, China)
Conformal transformations of S-matrix in scalar field theory

April 1st-2nd Workshop “From Nuclear to Nucleon Structure”
April 1st:
T. Lähde, **Meson masses to two loops in partially quenched chiral perturbation theory**
B. Juliá-Díaz, **Baryon form factors of relativistic constituent quark models**
J. Niskanen, **Charge symmetry breaking meson production**
J. Koponen, **Energy spectrum of a heavy-light meson on a lattice**
P. Piirola, **Partial wave analysis of pion-nucleon scattering**
R. D. McKeown (Colloquium), **Neutrino masses and oscillations: triumphs and challenges**
B. Höistad, **Meson production in few body collisions**
K. F. Liu, **Nucleon resonances from lattice QCD**
F. Gross, **Relativistic nucleon and nuclear physics**
April 2nd:
R. Schiavilla, **Interactions, currents and light nuclei**
U. Meissner, **Modern theory of nuclear forces**
T.-S. H. Lee, **Nucleon resonances and pion clouds**
K. Kajantie, **QCD at finite temperature: theory and experiment**
G. Brown, **What hath RHIC wrought**
J. Tuominiemi, **New physics with LHC**
A.-P. Hameri, **Engineering and managerial view to high-energy physics**

April 6th S. Hemming (HIP)
Strings on the BTZ black hole

April 19th (Colloquium) J. White (HIP)
GRID computing for the LHC; a practical approach

April 20th P. di Vecchia (Nordita, Denmark)
Gauge theories from D-branes

May 4th I. Vattulainen (HIP/HUT)
Multi-scale modeling of lipid membrane systems

May 11th G. Volovik (HUT/Landau Institute, Russia)
Vacuum energy and cosmological constant in the effective QFT

May 14th V. A. Khoze (IPPP, Durham, UK)
Looking forward to Forward Physics

May 17th (Colloquium) H. Rubinstein (Albanova Center, Stockholm, Sweden)
Magnetic fields in the Universe and the photon mass

May 25th K. Huitu (HIP)
Effects on Higgs physics from extra dimensions

June 3rd N. Törnqvist (Department of Physical Sciences)
My passion for physics; some recollections on 65 years

June 8th S. Khalil (University of Durham, UK)
CP asymmetries of B-decays in SUSY and extra dimensional models

June 16th-19th
Conference on "Strong and Electroweak Matter 2004"

June 22nd A. Romanino (CERN, Switzerland)
Approaches to the hierarchy problem

July 27th M. Rangamani (UC Berkeley, USA)
Cosmic censorship in AdS/CFT

July 28th V. Hubeny (Stanford University, USA)
Holographic description of singularities

July 29th R.-G. Rojo (University of Stuttgart, Germany)
Discrete element methods for the micro-mechanical investigation of granular ratcheting

August 2nd U. Wiedner (Uppsala, Sweden)
Hadron physics with PANDA

August 16th (Colloquium) S. Bludman (DESY, Germany and the University of Pennsylvania, USA)
Astronomical dating of the birth and death of Jesus

August 17th M. Noga (Comenius University, Bratislava, Slovak Republic)
Inequivalent representations of commutator and anticommutator relations of field operators and their practical applications

August 18th S. Bludman (DESY, Germany)
Dark energy: what can it be?

August 24th F. Froemel (Giessen University, Germany)
Correlations in quark matter

September 7th S. Majaniemi (HUT)
How to go from microscopic to macroscopic description: constructing dynamic density functionals of slow variables

September 14th A. Kupiainen (Department of Mathematics and Academy of Finland)
Mathematics out of equilibrium

September 21st P. Roy (Tata Institute, Mumbai, India)
Probing the maximal nature of muon neutrino flavour mixing

October 7th O. Scholten (KVI, Groningen, The Netherlands)
Photo-induced strangeness production off the nucleon

October 12th U. Lindström (Uppsala, Sweden/HIP)
Supersymmetry and complex geometry

October 19th A. Salmela (Theoretical Physics Division, Deptartment of Physical Sciences)
Unconstrained canonical variables for Yang-Mills theory

October 28th CERN 50 Years Anniversary Colloquium
J. Tuominiemi, **CERNin historia**
M. Della Negra, **Collider Physics at CERN**
R. Orava, **LEP ja DELPHI**
J. Äystö, **Ydinaineen tutkimus ääritiloissa**
A-P. Hameri, **CERNin vaikutus yhteiskuntaan**

October 29th Particle Physics Day
S. Roy, **Higher dimensional models of light Majorana neutrinos confronted by data**
J. Laamanen, **Effects of non-universal gaugino masses in SUSY models and at LHC**
T. Rüppell, **A model with spontaneous R-parity and CP violation and implications for masses**
M. Järvinen, **The hydrogen atom in relativistic motion**
W. Trzaska, **ALICE Physics on LHC Day One**
P. Mehtälä, **Top mass determination at CDF**
T. Enqvist, **Underground multimuon experiment in the Pyhäsalmi mine**
J. Nysten, **Photon energy reconstruction at CMS**
M. Oinonen, **Detector Laboratory at Physicum & ALICE Silicon Strip Detector assembly at HIP**
A. Heikkilä, **Finnish industry at CERN**
T. Lindén, **Building a HIP infrastructure for LHC Grid computing**
T. Lampén, **Alignment of CERN CMS tracking detector modules**

November 2nd J. Majumder (HIP),
Crosscaps in Gepner models and orientifolds of type IIA theory

November 9th A. Tureanu (Department of Physical Sciences and HIP)
Noncommutative space-time and quantum field theory

November 23rd S. Wycech (Soltan Institute for Nuclear Studies, Warsaw, Poland)
Deeply bound states

November 25th V. Abaev (PNPI, Gatchina, Russia)
Multidimensional data analysis in the pion-nucleon sector

November 30th K. Tuominen (Jyväskylä)
New technicolor theories from higher representations

December 7th A. Collin (HIP)
Centre of mass rotation and vortices in an attractive Bose gas

December 13th (Colloquium) C. Cronström (Theoretical Physics Division, Department of Physical Sciences)
Personal recollections of four decades of theoretical physics – from Siltavuori to Kumpula

December 15th (Colloquium) D. J. Gross (Santa Barbara, USA)
The Future of Physics: 25 questions that might guide physics, in the broadest sense, over the next 25 years

Visitors

Theory Programme

Cosmology

F. Ravndal (Norway) 8.-30.1.

Particle Physics Phenomenology

V. Khoze (UK) 13.-16.5.
S. Peigné (France) 1.-21.6.
S. Khalil (UK) 1.6.-1.7.
A. Romanino (Switzerland) 18.6.
P. Roy (India) 30.8.-31.9.

Hadron Physics Activity
P. Braun-Munzinger (Germany) 1.-3.2.
E. Norvaišas (Lithuania) 9.-13.2.
G. E. Brown (USA) 28.3.-4.4.
T.-S. H. Lee (USA) 30.3.-3.4.
R. Schiavilla (USA) 30.3.-4.4.
F. Gross (USA) 31.3.-3.4.
B. Höistad (Sweden) 31.3.-3.4.
K.-F. Liu (USA) 31.3.-3.4.
R. D. McKeown (USA) 31.3.-3.4.
U. Meissner (Germany) 31.3.-3.4.
V. Abaev (Russia) 5.-24.4.
L. Rubacek (Germany) 17.-28.5.
F. Froemel (Germany) 26.5.-31.8.
S. Austin (USA) 23.-24.6.
L. Rubacek (Germany) 26.7.-6.8.
U. Wiedner (Sweden) 2.8.
O. Scholten (The Netherlands) 6.-7.10.
V. Abaev (Russia) 1.-27.11.
S. Wycech (Poland) 1.-30.11.

Physics of Biological Systems

J. Asikainen (Switzerland) 10.-13.2.
P.-L. Hansen (Denmark) 19.-24.2.
S. Lyulin (Russia) 19.-24.4.
J. Yeomans (UK) 21.-23.4.
R. Metzler (Denmark) 21.-24.4.
P.-L. Hansen (Denmark) 23.-31.5.
P. B. Sunil Kumar (India) 9.-11.6.
M. Foster (USA) 5.-6.9.
O. G. Mouritsen (Denmark) 21.9.
P.-L. Hansen (Denmark) 10.-17.10.

String Theory and Quantum Field Theory

P. Prešnajder (Slovakia) 1.1.-31.8
P. Di Vecchia (Denmark) 18.-24.4.
A. Niemi (Sweden) 29.5.-2.6.
D. Nemeschanski (USA) 14.-28.7.
M. Mnatsakanova (Russia) 21.7.-14.8.
Y. Vernov (Russia) 21.7.-20.8
V. Hubeny (USA) 24.-30.7.
M. Rangamani (USA) 24.-30.7.
K. Nishijima (Japan) 1.-21.8.
L. Mersini (USA) 4.-10.8.
M. Mnatsakanova (Russia) 13.11.-31.12.
Y. Vernov (Russia) 13.11.-31.12.
J. Wess (Germany) 15.-21.11.
K. Nishijima (Japan) 15.-22.11.

Ultrarelativistic Heavy Ion Collisions

A. Ipp (Austria) 2.-12.1.
D. Rischke (Germany) 13.-26.2.
E. Keski-Vakkuri (Finland) 20.2.
F. Sannino (Denmark) 27.-31.5.
P. Aurenche (France) 12.-15.6.
R. Pisarski (USA) 20.-21.6.
I. Vitev (USA) 7.-13.8.
W. Cassing (Germany) 8.-14.8.
S. Heppelmann (USA) 8.-14.8.
P. Hoyer (Finland) 8.-14.8.
W. Kuehn (Germany) 8.-14.8
U. Mosel (Germany) 8.-14.8.
J. Ritman (Germany) 9.-13.8.

Nuclear Matter Programme

G. Buyerov (Ukraine) 21.1.–17.2.
D. Isichenko (Ukraine) 21.1.–17.2.
A. Kurylov (Ukraine) 21.1.–17.2.
I. Tymchuk (Ukraine) 21.1.–17.2.
F. Didierjean (France) 8.–10.2.
J.-R. Lutz (France) 8.–10.2.
G.-J. Nooren (The Netherlands) 8.–10.2.
M.-H. Segward (France) 8.–10.2.
N. Chernykova (Ukraine) 10.–31.3.
S. Kiprich (Ukraine) 10.–31.3.
A. Kurylov (Ukraine) 15.4.–15.5.
S. Shyshko (Ukraine) 15.4.–15.5.
I. Tymchuk (Ukraine) 15.4.–15.5.
V. Kaplin (Russia) 22.–30.4.
A. Karakash (Russia) 22.–30.4.
O. Chykalov (Ukraine) 30.5.–28.6.
D. Isichenko (Ukraine) 30.5.–28.6.
N. Chernykova (Ukraine) 12.7.–14.8.
A. Tsenner (Ukraine) 12.7.–14.8.
I. Tymchuk (Ukraine) 12.7.–20.9.
Y. Kostyshyn (Ukraine) 18.8.–20.9.
S. Pankov (Ukraine) 18.8.–20.9.
N. Chernykova (Ukraine) 27.9.–30.10.
L. Klimova (Ukraine) 27.9.–30.10.
M. Protsenko (Ukraine) 27.9.–30.10.
I. Tymchuk (Ukraine) 27.10.–22.12.
D. Isichenko (Ukraine) 30.10.–21.12.
A. Tsenner (Ukraine) 30.10.–21.12.
J. Rak (Czech Republic) 22.–23.11.
V. Kaplin (Russia) 24.11.–8.12.

Conference participation, Talks and Visits by Personnel

Theory Programme

Cosmology

UC Davis,
19-29 March, Davis, CA, USA (talk by M. S. Sloth)

The Density Perturbation in the Universe - Beyond the Inflaton Paradigm,
25-26 June, Athens, Greece (invited talk by K. Enqvist, A. Väihkönen)

CERN Theory Division,
28 June - 12 July, Geneva, Switzerland (M. S. Sloth)

4th NorFA Network Meeting on Particle Physics and Cosmology,
9-10 September, Helsinki, Finland (talk by J. Högdahl, talk by V. Muhonen, talk by A. Väihkönen)

NORDITA,
12-23 October, Copenhagen, Denmark (A. Väihkönen)

NORDITA,
6-17 December, Copenhagen, Denmark (A. Väihkönen)

Institut d'Astrophysique de Paris,
10 December 2004 - 22 January 2005, Paris, France (F. Vernizzi)

Particle Physics Phenomenology

Durham University and IPPP,
22-29 February, Durham, UK (talk by E. Gabrielli)

The Annual Meeting of the Finnish Physical Society,
18-20 March, Oulu, Finland (K. Huitu, T. Rüppell)

CERN Theory Division,
1 April - 31 May, Geneva, Switzerland (E. Gabrielli)

University Autonoma of Madrid,
7-14 May, Madrid, Spain (talk by E. Gabrielli)

The 12th International Conference on Supersymmetry and Unification of Fundamental Interactions,
17-23 June, Tsukuba, Japan (talk by J. Laamanen, talk by S. Roy, T. Rüppell)

ECFA,
9 July, Hamburg, Germany (K. Huitu)

Beyond the Higgs,
7-15 August, Santa Fe, NM, USA (K. Huitu)

PSI Zuoz Summer School: The Challenge of Supersymmetry,
15-21 August, Zuoz, Switzerland (T. Honkavaara)

CERN Theory Division,
1-31 October, Geneva, Switzerland (E. Gabrielli)

University of Bergen,
5-6 November, Bergen, Norway (K. Huitu)

Tenth Nordic LHC Physics Workshop,
12-13 November, Stockholm, Sweden (talk by E. Gabrielli, K. Huitu, talk by J. Laamanen, talk by T. Rüppell)

University of Bergen,
9-12 December, Bergen, Norway (talk by E. Gabrielli)

Hadron Physics Activity

W. K. Kellogg Radiation Laboratory,
6-12 January, Pasadena, CA, USA (talk by D.-O. Riska)

The 3rd EURIDICE Collaboration Meeting,
12-14 February, Vienna, Austria (talk by B. Juliá-Díaz, M. Sainio)

The Annual Meeting of the Finnish Physical Society,
18-20 March, Oulu, Finland (M. Sainio)

Department of Physics, University of Illinois,
13-16 April, Urbana-Champaign, IL, USA (talk by D.-O. Riska)

International Workshop on Parity Violation and Hadronic Structure,
8-11 June, Grenoble, France (invited talk by M. Sainio)

Partial Wave Analysis Workshop,
28 June - 9 July, Abilene, TX, USA (invited talks by M. Sainio)

Mini-Workshop on Hadron Physics,
12-19 July, Bled, Slovenia (invited talk by D.-O. Riska)

Hadron Deformation Workshop,
6-9 August, MIT, Cambridge, MA, USA (invited talk by D.-O. Riska)

10th International Symposium on Meson-Nucleon Physics and the Structure of the Nucleon,
29 August - 4 September, Beijing, China (invited talk by D.-O. Riska, talk by M. Sainio)

Quark Confinement and the Hadron Spectrum VI,
21-25 September, Villasimius (Cagliari), Sardinia, Italy (talk by A. M. Green)

Institut für Physik, Universität Giessen,
3-5 November, Giessen, Germany (colloquium by D.-O. Riska)

Institute of Theoretical Physics, University of Bern,
5-9 December, Bern, Switzerland (M. Sainio)

Physics of Biological Systems

Biophysical Society 48th Annual Meeting,
14-18 February, Baltimore, MD, USA (E. Falck, E. Salonen)

Computational Soft Matter: From Synthetic Polymers to Proteins,
29 February - 6 March, Bonn, Germany (E. Salonen, E. Terämä)

The Annual Meeting of the Finnish Physical Society,
18-20 March, Oulu, Finland (talk by E. Falck, O. Punkkinen, E. Salonen, E. Terämä, I. Vattulainen)

University of Southern Denmark,
29 March - 8 April, Odense, Denmark (O. Punkkinen)

Particle-Based Mesoscale Simulation Techniques Symposium,
31 March - 2 April, Minneapolis, MN, USA (E. Falck, talk by I. Vattulainen)

74th European Atherosclerosis Society Congress,
17-20 April, Seville, Spain (M. T. Hyvönen)

Summer School of Biophysics,
31 May - 2 June, Kiljava, Finland (talk by M. T. Hyvönen, M. Kupiainen, talk by I. Vattulainen)

University of California Davis,
1 June - 31 August, Davis, CA, USA (E. Terämä)

The 7th International Conference on Computer Simulation of Radiation Effects in Solids (COSIRES 2004),
28 June - 2 July, Helsinki, Finland (E. Salonen)

22nd Carbohydrate Symposium,
23-27 July, Glasgow, UK (I. Vattulainen)

University of Southern Denmark,
16-22 August, Odense, Denmark (I. Vattulainen)

The 5th International Conference on Biological Physics ICBP2004,
23-27 August, Gothenburg, Sweden (E. Salonen, I. Vattulainen)

NORDITA Soft Matter Meeting,
28-31 August, Copenhagen, Denmark (E. Salonen, talk by I. Vattulainen)

NCSS-5 (Fifth Nordic Conference on Surface Science),
22-25 September, Tampere, Finland (talk by E. Falck, O. Punkkinen, talk by I. Vattulainen)

IPP Greifswald (Institut für Plasmaphysik) and University of Greifswald,
8-11 December, Greifswald, Germany (E. Salonen)

String Theory and Quantum Field Theory

University of Jyväskylä,
20 February, Jyväskylä, Finland (colloquium by E. Keski-Vakkuri)

Yukawa Institute, Kyoto University,
16 April, Kyoto, Japan (talk by S. Kawai)

Institute for Studies in Theoretical Physics and Mathematics,
26 April - 8 May, Tehran, Iran (A. Tureanu)

11th Regional Conference on Mathematical Physics and IPM Spring Conference,
3-6 May, Tehran, Iran (invited talk by A. Tureanu)

Tohoku University,
6 May, Sendai, Japan (invited talk by S. Kawai)

University of Pennsylvania,
14-22 May, Philadelphia, PA, USA (E. Keski-Vakkuri)

Universidade Federal de Pernambuco,
14-28 May, Recife, Brazil (talk by B. Carneiro da Cunha)

University of Iceland,
18-25 May, Reykjavik, Iceland (talk by S. Hemming)

University of California at Los Angeles,
22-29 May, Los Angeles, CA, USA (E. Keski-Vakkuri)

Bayrischzell Workshop on Noncommutativity and Physics,
4-7 June, Bayrischzell, Germany (M. Chaichian)

Ludwig-Maximilians-Universität,
7-9 June, Munich, Germany (invited talk by E. Keski-Vakkuri)

Steklov Mathematical Institute,
11-20 June, Moscow, Russia (seminar by M. Chaichian)

Lebedev Physical Institute,
11-20 June, Moscow, Russia (seminar by M. Chaichian)

Moscow State University,
11-20 June, Moscow, Russia (seminar by M. Chaichian, A. Tureanu)

Strings 2004,
28 June - 2 July, Paris, France (B. Carneiro da Cunha, E. Keski-Vakkuri)

International Conference on High Energy Physics,
17-22 August, Beijing, China (M. Chaichian, A. Tureanu)

Institute of High Energy Physics,
23 August - 2 September, Beijing, China (seminar by M. Chaichian)

Xian University,
23 August - 2 September, Xian, China (seminar by M. Chaichian)

Conference on Fundamental Symmetries and Fundamental Constants,
14-19 September, Trieste, Italy (invited talk by M. Chaichian)

Uppsala University,
22-24 September, Uppsala, Sweden (E. Keski-Vakkuri)

Uppsala University,
6-8 October, Uppsala, Sweden (invited talk by E. Keski-Vakkuri)

19th Nordic Network Meeting on Strings, Fields and Branes,
18-20 November, Uppsala, Sweden (B. Carneiro da Cunha, S. Kawai, invited talk by E. Keski-Vakkuri, J. Majumder)

Conformal Field Theory Reunion Conference II,
12-17 December, Lake Arrowhead, CA, USA (invited talk by E. Keski-Vakkuri)

Indian Association of Cultivation of Science and Saha Institute of Nuclear Physics,
5 December 2004 - January 2005, Kolkata, India (J. Majumder)

Indian String Meeting (ISM 2004): Workshop in String Theory,
15-23 December, Khajuraho, India (J. Majumdar)

Ultrarelativistic Heavy Ion Collisions

Lawrence Berkeley National Laboratory,
5-10 January, Berkeley, CA, USA (H. Niemi)

Quantum Phenomena at Low Temperatures,
7-11 January, Lammi, Finland (talk by K. Kajantie)

The XVII International Conference on Ultra-Relativistic Nucleus-Nucleus Collisions: Quark Matter 2004,
11-17 January, Oakland, CA, USA (H. Honkanen, P. Huovinen, talk by V. J. Kolhinen, T. Lappi, talk by H. Niemi)

Lawrence Berkeley National Laboratory,
18-23 January, Berkeley, CA, USA (talk by V. J. Kolhinen)

Phenomenology Seminar Series,
28 January, Helsinki, Finland (talk by M. Sallé)

Workshop on Lattice QCD at finite temperature and density,
8-12 February, BNL, Upton, NY, USA (talk by K. Kajantie)

NORDITA and Niels Bohr Institute,
10-17 February, Copenhagen, Denmark (talk by K. Tuominen)

Phenomenology Seminar Series,
18 February, Helsinki, Finland (talk by T. Lappi)

The Annual Meeting of the Finnish Physical Society,
18-20 March, Oulu, Finland (talk by H. Honkanen, V. J. Kolhinen, talk by H. Niemi)

Phenomenology Seminar Series,
21 April, Helsinki, Finland (talk by K. Kajantie)

Finnish ALICE Meeting,
23 April, Helsinki, Finland (talk by K. J. Eskola)

Department of Physics, University of Jyväskylä,
7 May, Jyväskylä, Finland (talk by K. Kajantie)

CERN,
9-23 May, Geneva, Switzerland (A. Hietanen)

Meeting of the NSAC Subcommittee on Relativistic Heavy Ions,
2-6 June, BNL, Upton, NY, USA (invited talk by K. Kajantie)

Strong and Electroweak Matter 2004,
16-19 June, Helsinki, Finland (organizer K. J. Eskola, A. Hietanen, organizer K. Kajantie, invited talk by T. Lappi, H. Niemi, organizer K. Rummukainen (chair), P. V. Ruuskanen, organizer M. Sallé, talk by K. Tuominen)

CERN,
29 July - 7 August, Geneva, Switzerland (K. Kajantie)

Lecture Week on The Physics of Hadrons and Ultrarelativistic Heavy Ion Collisions,
9-14 August, Jyväskylä, Finland (organizer K. J. Eskola, H. Honkanen, lecture by P. Huovinen, V. J. Kolhinen, T. Lappi, H. Niemi, organizer P. V. Ruuskanen, K. Tuominen)

HERA and the LHC: A workshop on the implications of HERA for LHC physics,
11-13 October, CERN, Geneva, Switzerland (invited talk by V. J. Kolhinen)

Hard Probes 2004, International Conference on Hard and Electromagnetic Probes of High Energy Nuclear Collisions,
4-10 November, Lisbon, Portugal (P. V. Ruuskanen)

High Energy Physics Programme

Electron-Positron Physics

The Annual Meeting of the Finnish Physical Society,
18-20 March, Oulu, Finland (talk by K. Österberg)

HERA-LHC Workshop: DESY Meeting,
1-4 June, Hamburg, Germany (talk by K. Österberg)

BEACH 03,
27 June - 3 July, Chicago, IL, USA (talk by L. Salmi)

Forward Physics

Phenomenology Seminar Series,
11 February, Helsinki, Finland (talk by N. van Remortel)

The Annual Meeting of the Finnish Physical Society,
18-20 March, Oulu, Finland (T. Mäki)

Iowa State University,
3 May, Ames, IA, USA (invited talk by R. Orava)

Workshop of EU Research and Training Network "Probe for new physics",
5-7 May, Pisa, Italy (talk by N. van Remortel)

The Future of QCD at the Tevatron,
20-22 May, Fermilab, Batavia, IL, USA (talk by T. Mäki)

Workshop on Forward Proton Taggers at the LHC,
9 June, Manchester, UK (invited review talk by R. Orava)

Nordic LHC Workshop,
16-18 June, Copenhagen, Denmark (talk by T. Mäki)

XIII International Symposium on Very High Energy Cosmic Ray Interactions,
6-12 September, Pylos, Greece (invited plenary talk by R. Orava)

Low-x Workshop,
15-18 September, Prague, The Czech Republic (invited plenary talk by R. Orava)

Midterm Review of EU Research and Training Network "Probe for new physics",
27-29 September, Paris, France (talks by N. van Remortel)

CERN-DESY Workshop,
September (invited plenary talk by R. Orava)

Phenomenology Seminar Series,
20 October, Helsinki, Finland (talk by A. Kiiskinen and N. van Remortel)

Phenomenology Seminar Series,
3 November, Helsinki, Finland (talk by A. Kiiskinen and N. van Remortel)

Special Topics in Experimental High Energy Physics Series,
November, Helsinki, Finland (talk by N. van Remortel)

Top Mass Meeting,
1 December, Fermilab, Batavia, IL, USA (talk by T. Mäki)

Working visits to Fermilab,
Batavia, IL, USA (A. Kiiskinen, T. Mäki, R. Orava and N. van Remortel)

Detector Laboratory

2004 IEEE Nuclear Science Symposium,
16-20 October, Rome, Italy (J. Heino, talk by J. Kalliopuska, talk by K. Kurvinen, R. Ojala)

CMS Programme

Software and Physics

Higgs Working Group,
13 January, CERN, Geneva, Switzerland (talk by S. Lehti)

Higgs Working Group,
13 February, CERN, Geneva, Switzerland (talk by K. Lassila-Perini)

CMS SPROM/RPROM Meeting,
15 March, CERN, Geneva, Switzerland (talk by V. Karimäki, talk by K. Lassila-Perini)

ECAL-electron/photon Working Group,
17 March, CERN, Geneva, Switzerland (talk by K. Lassila-Perini)

The Annual Meeting of the Finnish Physical Society,
18-20 March, Oulu, Finland (A. Heikkinen, talk by T. Lampén, M. Voutilainen)

LHC Computing Grid Workshop,
23-24 March, CERN, Geneva, Switzerland (T. Lindén)

M-grid Consortium Meeting,
26 March, Espoo, Finland (talk by T. Lindén)

NorduGrid Technical Meeting,
29-30 March, Espoo, Finland (talk by T. Lindén)

CSC Grid Workshop,
31 March, Espoo, Finland (A. Heikkinen, V. Karimäki, T. Lampén, T. Lindén)

Higgs Working Group,
2 April, CERN, Geneva, Switzerland (talk by S. Lehti)

CMS SPROM/RPROM Meeting,
20 April, CERN, Geneva, Switzerland (talk by V. Karimäki)

Pixel Workshop,
28 April, CERN, Geneva, Switzerland (talk by V. Karimäki)

Department of Physics, University of Cyprus,
28 April, Nicosia, Cyprus (invited seminar by R. Kinnunen)

ECAL-electron/photon Working Group,
11 May, CERN, Geneva, Switzerland (talk by K. Lassila-Perini)

CMS Workshop on B/Tau Physics,
28 May - 1 June, Bari, Italy (talk by S. Lehti)

The 2004 European School of High Energy Physics,
30 May - 12 June, Sant Feliu de Guixols, Spain (T. Lampén, M. Voutilainen)

M-grid Consortium Meeting,
9 July, Espoo, Finland (talk by T. Lindén)

Physics at LHC,
13-17 July, Vienna, Austria (talk by S. Lehti)

Former Students' Meeting, Kypäräjärven kansakoulu,
24 July, Heinävesi, Finland (talk by R. Kinnunen)

Hadron Structure 2004,
30 August - 3 September, Smolenice Castle, Slovakia (invited plenary talk by R. Kinnunen)

4th Four-Seas Conference in Physics,
5-10 September, Istanbul, Turkey (invited talk by J. Tuominiemi)

ECAL-electron/photon Working Group,
15 September, CERN, Geneva, Switzerland (talk by K. Lassila-Perini)

Vertex2004 Conference on Vertex Detectors,
15-19 September, Menaggio, Lake Como, Italy (invited talk by V. Karimäki)

Hollola High School,
17 September, Hollola, Finland (invited talk by A. Heikkinen)

Computing in High Energy and Nuclear Physics (CHEP 2004),
27 September - 1 October, Interlaken, Switzerland (talk by A. Heikkinen, T. Lindén)

CMS Physics Review II: Higgs,
29 September, CERN, Geneva, Switzerland (talk by R. Kinnunen, talk by S. Lehti)

SMFL Autumn Days,
2-3 October, Siuntio, Finland (invited talk by V. Karimäki)

Geant4 Workshop,
4-9 October, Catania, Italy (talk by A. Heikkinen)

2004 LHC Days in Split,
5-9 October, Split, Croatia (invited talk by R. Kinnunen)

2004 IEEE Nuclear Science Symposium,
16-22 October, Rome, Italy (invited talk by A. Heikkinen)

5th Annual Workshop on Linux Clusters for Super Computing,
18-19 October, Linköping, Sweden (T. Lindén)

First Nordic Grid Neighborhood Workshop,
20 October, Linköping, Sweden (T. Lindén)

ECAL-electron/photon Workshop,
21 October, CERN, Geneva, Switzerland (talk by K. Lassila-Perini)

B/Tau Workshop,
26 October, CERN, Geneva, Switzerland (talk by V. Karimäki)

Alignment Meeting, B/Tau Week,
27 October, CERN, Geneva, Switzerland (talk by V. Karimäki)

CERN 50 Years Anniversary Colloquium,
28 October, Espoo, Finland (talk by K. Lassila-Perini)

Higgs Working Group,
2 November, CERN, Geneva, Switzerland (talk by S. Lehti)

SPROM,
8 November, CERN, Geneva, Switzerland (talk by K. Lassila-Perini)

ECAL-electron/photon Working Group,
10 November, CERN, Geneva, Switzerland (talk by K. Lassila-Perini)

Tenth Nordic LHC Physics Workshop,
12-13 November, Stockholm, Sweden (invited talk by R. Kinnunen)

Tracker alignment Meeting,
23 November, CERN, Geneva, Switzerland (talk by V. Karimäki, talk by T. Lampén)

ECAL-electron/photon Working Group,
24 November, CERN, Geneva, Switzerland (talk by K. Lassila-Perini)

ECAL-electron/photon Working Group,
12 December, CERN, Geneva, Switzerland (talk by K. Lassila-Perini)

Meetings of Restricted ECFA,
26-27 March, Innsbruck, Austria; 21-22 May, Rome, Italy; 8 July, CERN, Switzerland; 1-2 October, Bratislava, Slovakia; 25 November, CERN, Switzerland (J. Tuominiemi)

Meetings of EPS HEPP Board,
16 January, 14 May, 8 October, 3 December, CERN, Switzerland; 23 July, Lissabon, Portugal (J. Tuominiemi)

CMS Tracker

University of Karlsruhe,
21-23 January, Karlsruhe, Germany (J. Härkönen, P. Luukka)

10th Vienna Conference on Instrumentation,
16-21 February, Vienna, Austria (talk by J. Härkönen)

Plyform s.r.l,
11 March, Varallo Pombia, Italy (H. Katajisto)

The Annual Meeting of the Finnish Physical Society,
18-20 March, Oulu, Finland (talk by P. Luukka, T. Mäenpää, talk by E. Tuovinen)

University of Warsaw,
31 March - 3 April, Warsaw, Poland (T. Laihomäki)

2nd SIRAD Workshop,
1-2 April, Legnaro, Italy (talk by J. Härkönen)

RD39 Workshop,
2-4 May, CERN, Geneva, Switzerland (talk by J. Härkönen, talk by P. Luukka)

4th RD50 Workshop,
5-7 May, CERN, Geneva, Switzerland (talk by J. Härkönen, talk by E. Tuovinen)

5th International Symposium on Development and Application of Semiconductor Tracking Detectors,
14-17 June, Hiroshima, Japan (invited talk by J. Härkönen)

IEEE Nuclear and Space Radiation Effects Conference,
19-23 July, Atlanta, GA, USA (E. Tuovinen)

5th International Conference on Radiation Effects on Semiconductor Materials, Detectors and Devices,
10-13 October, Florence, Italy (talk by J. Härkönen, P. Luukka)

5th RD50 Workshop,
14-16 October, Florence, Italy (talk by P. Luukka)

RD39 Workshop II/04,
15 October, Florence, Italy (talk by J. Härkönen, P. Luukka)

2004 IEEE Nuclear Science Symposium,
16-22 October, Rome, Italy (talk by J. Härkönen)

CERN 50 Years Anniversary Colloquium,
28 October, Espoo, Finland (talk by J. Härkönen)

73rd Meeting of the Large Hadron Collider Committee,
24-25 November, CERN, Geneva, Switzerland (talk by J. Härkönen)

Graduate Seminar,
26 November, Jyväskylä, Finland (invited talk by J. Härkönen)

University of Jyväskylä,
15-20 December, Jyväskylä, Finland (J. Härkönen, P. Luukka, E. Tuovinen)

Nuclear Matter Programme

ALICE

INFN Legnaro,
22 January, Padova, Italy (talk by W. H. Trzaska)

Physics Department, University of Lodz,
11 February, Lodz, Poland (talk by W. H. Trzaska)

Soltan Institut of Nuclear Problems,
12 February, Warsaw, Poland (talk by W. H. Trzaska)

CERN,
16-19 February, Geneva, Switzerland (talk by M. Oinonen)

CERN,
23 February, Geneva, Switzerland (talk by W. H. Trzaska)

CERN,
15-18 March, Geneva, Switzerland (talk by M. Oinonen)

Forward Detector Workshop,
16 March, Geneva, Switzerland (talk by W. H. Trzaska)

ALICE Technical Forum,
17 March, Geneva, Switzerland (talk by W. H. Trzaska)

The Annual Meeting of the Finnish Physical Society,
18-20 March, Oulu, Finland (M. Oinonen, talk by H. Seppänen)

LHCC Comprehensive Review,
23 March, Geneva, Switzerland (talk by W. H. Trzaska)

FIN-ALICE 2004,
23 April, Helsinki, Finland (talk by M. Bondila, talk by M. Oinonen, talk by Z. Radivojevic, talk by H. Seppänen, talk by W. H. Trzaska)

CERN,
10-13 May, Geneva, Switzerland (talk by M. Oinonen, talk by W. H. Trzaska)

Workshop on trigger electronics,
11 May, Geneva, Switzerland (talk by W. H. Trzaska)

FWD Meeting,
19 June, Geneva, Switzerland (talk by W. H. Trzaska)

ALICE Week,
21-25 June, Colmar, France (talk by M. Oinonen, talk by W. H. Trzaska)

7th International Conference on Quantitative Infra-Red Thermography,
5-8 July, Rhode-St-Genese, Belgium (Z. Radivojevic)

EXON 2004,
5-11 July, Peterhof, Russia, (invited talk by W. H. Trzaska)

CERN,
20-23 September, Geneva, Switzerland (talk by M. Oinonen)

Photonics North 2004,
27-29 September, Ottawa, Canada (H. Seppänen)

CERN,
29 September, Geneva, Switzerland (talk by W. H. Trzaska)

STOP Meeting,
4 October, Odense, Denmark (invited talk by W. H. Trzaska)

2004 IEEE Nuclear Science Symposium,
16-24 October, Rome, Italy (W. H. Trzaska)

JYFL,
22 October, Jyväskylä, Finland (talk by M. Oinonen)

ALICE ITS beamtest,
27 October - 10 November, Geneva, Switzerland (H. Seppänen)

ALICE ITS beamtest,
10-15 November, Geneva, Switzerland (M. Oinonen)

CERN,
16-19 November, Geneva, Switzerland (talk by M. Oinonen)

Lyon,
22 November, Lyon, France (talk by V. Lyapin)

CERN,
22 November, Geneva, Switzerland (talk by W. H. Trzaska)

CERN,
23 November, Geneva, Switzerland (talk by W. H. Trzaska)

Universiteit Utrecht,
7-10 December, Utrecht, The Netherlands (H. Seppänen)

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

ISOLDE

Department of Physical Sciences, University of Helsinki,
1 March, Helsinki, Finland (talk by J. Äystö)

The Annual Meeting of the Finnish Physical Society,
18-20 March, Oulu, Finland (talk by A. Jokinen)

Workshop on Physics with a Multi-MW Proton Source,
25-27 May, Geneva, Switzerland (talk by J. Äystö)

International Nuclear Physics Conference, INPC 2004,
27 June - 2 July, Gothenburg, Sweden (A. Jokinen)

CERN 50 Years Anniversary Meeting,
10 September, Jyväskylä, Finland (talk by J. Äystö)

The Fourth International Conference on Exotic Nuclei and Atomic Masses (ENAM04),
12-16 September, Gallaway Gardens, Pine Mountain, GA, USA (A. Jokinen, talk by J. Äystö)

Scientific Policy Committee of CERN,
14 December, Geneva, Switzerland (talk by J. Äystö)

Technology Programme

Second Across Grids Conference,
28-30 January, Nikosia, Cyprus (talk by M. Silander)

2nd European HealthGrid Conference,
29-30 January, Clermont-Ferrand, France (M. Tuisku)

10th Global Grid Forum,
9-13 March, Berlin, Germany (M. Gindonis, J. Karppinen, T. Niemi, M. Tuisku, J. White)

NorduGrid Technical Meeting,
29-30 March, Helsinki, Finland (talk by J. Klem)

ICEIS 2004 6th International Conference on Enterprise Information Systems,
14-17 April, Porto, Portugal (presentation by T. Niemi, presentations by M. Niinimäki)

1st EGEE Conference,
18-22 April, Cork, Ireland (J. Hahkala, M. Silander)

Conference on Information Management in Networked Maritime Industry,
6-7 May, Karjaa, Finland (talk by A.-P. Hameri)

CERN IT Event,
27 May, Geneva, Switzerland (talk by A.-P. Hameri)

7th NorduGrid Workshop,
16-18 June, Copenhagen, Denmark (talk by J. Klem)

6th Workshop on Distributed Data and Structures,
8-9 July, Lausanne, Switzerland (T. Niemi, M. Tuisku)

TRIUMF,
17 August, Vancouver, BC, Canada (invited presentation by J. White)

DEXA'04 - Workshop: GLOBE'04, 1st International Workshop on Grid and Peer-to-Peer Computing Impacts on Large Scale Heterogeneous Distributed Database Systems,
30 August - 3 September, Zaragoza, Spain (talk by T. Niemi)

NorduGrid Technical Meeting,
13-15 September, Lund, Sweden (M. Pitkänen)

Computing in High Energy and Nuclear Physics (CHEP 2004),
27 September - 1 October, Interlaken, Switzerland (J. Klem)

CSC Grid Seminar,
13 October, Espoo, Finland (talk by J. Klem, talk by J. White)

5th Annual Workshop on Linux Clusters for Super Computing,
18-21 October, Linköping, Sweden (M. Gindonis, H. Mikkonen, T. Nissi)

First Nordic Grid Neighborhood Workshop,
20 October, Linköping, Sweden (talk by M. Gindonis)

CERN 50 Years Anniversary Colloquium,
28 October, Espoo, Finland (invited talk by A.-P. Hameri)

Supply Chain Summit,
2-3 November, Helsinki, Finland (talk by A.-P. Hameri)

EGEE JRA1 All Hands Meeting,
15-17 November, Padova, Italy (talks by J. Hahkala)

2nd EGEE Conference,
22-26 November, The Hague, The Netherlands (talk by J. Hahkala, J. White)

Administration and Support

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

Computing in High Energy and Nuclear Physics (CHEP 2004),
27 September - 1 October, Interlaken, Switzerland (N. Jiganova)

Huomenta Suomi TV Program,
28 October, Helsinki, Finland (interview with R. Rinta-Filppula)

EPOG Meeting,
29-30 October, CERN, Geneva, Switzerland (R. Rinta-Filppula)

Publications

Theory Programme

Cosmology

K. Enqvist,
Curvatons in the minimally supersymmetric standard model,
Mod. Phys. Lett. A 19 (2004) 1421

K. Enqvist and J. Högdahl,
Scalar condensate decay in a fermionic heat bath in the early universe,
J. Cosmol. Astropart. Phys. 0409 (2004) 013

K. Enqvist, A. Jokinen, A. Mazumdar,
Dynamics of minimal supersymmetric standard model flat directions consisting of multiple scalar fields,
J. Cosmol. Astropart. Phys. 0401 (2004) 008

K. Enqvist, A. Jokinen, A. Mazumdar,
Seed perturbations for primordial magnetic fields from minimally supersymmetric standard model flat directions,
J. Cosmol. Astropart. Phys. 0411 (2004) 001

K. Enqvist, S. Kasuya, A. Mazumdar,
Minimal supersymmetric Higgs bosons with extra dimensions as the source of reheating and all matter,
Phys. Rev. Lett. 93 (2004) 061301

K. Enqvist, A. Mazumdar, A. Pérez-Lorenzana,
Dumping inflaton energy density out of this world,
Phys. Rev. D 70 (2004) 103508

K. Enqvist, M. S. Sloth,
Possible connection between the location of the cutoff in the cosmic microwave background spectrum and the equation of state of dark energy,
Phys. Rev. Lett. 93 (2004) 221302

K. Enqvist and A. Väihkönen,
Non-Gaussian perturbations in hybrid inflation,
J. Cosmol. Astropart. Phys. 0409 (2004) 006

F. Ferrer, S. Räsänen and J. Väliviita,
Correlated isocurvature perturbations from mixed inflaton-curvaton decay,
J. Cosmol. Astropart. Phys. 0410 (2004) 010

Laser Physics and Quantum Optics

J. Javanainen, M. Koštrun, Y. Zheng, A. Carmichael, U. Shrestha, P. J. Meinel, M. Mackie, O. Dannenberg, and K.-A. Suominen,
Collective molecule formation in a degenerate Fermi gas via a Feshbach resonance,
Phys. Rev. Lett. 92 (2004) 200402

E. Lundh, A. Collin, and K.-A. Suominen,
Rotational states of Bose gases with attractive interactions in anharmonic traps,
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M. Mackie, O. Dannenberg, J. Piilo, K.-A. Suominen, and J. Javanainen,
New directions in degenerate dipolar molecules via collective association,
Eur. Phys. J. D 31 (2004) 273

M. Mackie, O. Dannenberg, J. Piilo, K.-A. Suominen, and J. Javanainen,
Raman photoassociation of Bose-Fermi mixtures and the subsequent prospects for atom-molecule Cooper pairing,
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M. Mackie, K. Härkönen, A. Collin, K.-A. Suominen, and J. Javanainen,
Improved efficiency of stimulated Raman adiabatic passage in photoassociation of a Bose-Einstein condensate,
Phys. Rev. A 70 (2004) 013614

S. Maniscalco, F. Intravaia, J. Piilo, and A. Messina,
Misbelief and misunderstandings about the non-Markovian dynamics of a damped harmonic oscillator,
J. Opt. B: Quantum Semiclass. Opt. 6 (2004) S98

S. Maniscalco, J. Piilo, F. Intravaia, F. Petruccione, and A. Messina,
Simulating quantum Brownian motion with single trapped ions,
Phys. Rev. A 69 (2004) 052101

S. Maniscalco, J. Piilo, F. Intravaia, F. Petruccione, and A. Messina,
Lindblad- and non-Lindblad-type dynamics of a quantum Brownian particle,
Phys. Rev. A 70 (2004) 032113

J. Piilo, E. Lundh, and K.-A. Suominen,
Radiative collisional heating at the Doppler limit for laser-cooled magnesium atoms,
Phys. Rev. A 70 (2004) 013410

Particle Physics Phenomenology

M. Chaichian, A. Datta, K. Huitu, S. Roy, Z.-H. Yu,
Single sneutrino production at hadron colliders,
Phys. Lett. B 594 (2004) 355

A. Datta, E. Gabrielli, B. Mele,
Violation of angular momentum selection rules in quantum gravity,
Phys. Lett. B 579 (2004) 189

A. Datta, K. Huitu,
Hunting radions at linear colliders,
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A. Datta, K. Huitu, J. Laamanen, and B. Mukhopadhyaya,
Linear collider signals of an invisible Higgs boson in theories of large extra dimensions,
Phys. Rev. D 70 (2004) 075003

J. L. Hewett, P. Roy, and S. Roy,
Higher dimensional models of light Majorana neutrinos confronted by data,
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K. Huitu, J. Laamanen and P. N. Pandita,
Constraints on sparticle spectrum in different supersymmetry breaking models,
Pramana 62 (2004) 663

S. Roy,
Anomaly mediated supersymmetry breaking and its test in linear colliders,
Mod. Phys. Lett. A 19 (2004) 83

Hadron Physics Activity

A. Acus, J. Matuzas, E. Norvaišas and D. O. Riska,
The deuteron as a canonically quantized biskyrmion,
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A. M. Green, J. Koponen, C. Michael, C. McNeile, and G. Thompson,
Excited *B* mesons from the lattice,
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J. He, B. Juliá-Díaz, Y. Dong,
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B. Juliá-Díaz, D. O. Riska, F. Coester,
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B. Juliá-Díaz, A. Valcarce and F. Fernández,
The p(d, d') reaction and the $\sigma NN^*(1440)$ coupling constant,
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B. Juliá-Díaz, A. Valcarce, P. González and F. Fernández,
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Energy spectrum of a heavy-light meson,
Nucl. Phys. B (Proc. Suppl.) 129-130 (2004) 367

Physics of Biological Systems

E. Falck, J. M. Lahtinen, I. Vattulainen, and T. Ala-Nissila,
Influence of hydrodynamics on many-particle diffusion in 2D colloidal suspensions,
Eur. Phys. J. E 13 (2004) 267

E. Falck, M. Patra, M. Karttunen, M. T. Hyvönen, and I. Vattulainen,
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E. Falck, M. Patra, M. Karttunen, M. T. Hyvönen, and I. Vattulainen,
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A. A. Gurtovenko, M. Patra, M. Karttunen, and I. Vattulainen,
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J. Repáková, P. Capková, J. M. Holopainen, and I. Vattulainen,
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R. Biswas, E. Keski-Vakkuri, R. G. Leigh, S. Nowling, and E. Sharpe,
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A. Bredthauer, U. Lindström, J. Persson, L. Wulff,
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B. Carneiro da Cunha,
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On a Lorentz-invariant interpretation of noncommutative space-time and its implications on noncommutative QFT,
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M. Chaichian and P. Prešnajder,
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M. Chaichian, M. M. Sheikh-Jabbari, A. Tureanu,
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Eur. Phys. J. C 36 (2004) 251

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U. Lindström,
Generalized N = (2,2) supersymmetric non-linear sigma models,
Phys. Lett. B 587 (2004) 216

Ultrarelativistic Heavy Ion Collisions

A. Dainese, R. Vogt, M. Bondila, K. J. Eskola and V. J. Kolhinen,
D-meson enhancement in pp collisions at the LHC due to nonlinear gluon evolution,
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P. Huovinen and J. Kapusta,
Rate equation network for baryon production in high energy nuclear collisions,
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K. Kajantie, M. Laine, T. Neuhaus, A. Rajantie, K. Rummukainen,
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High Energy Physics Programme

Electron-Positron Physics

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Searches for invisibly decaying Higgs bosons with the DELPHI detector at LEP,
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Measurement of the W-pair production cross-section and W branching ratios in e^+e^- collisions at $\sqrt{s}$ = 161-209 GeV,
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Search for charged Higgs bosons at LEP in general two Higgs doublet models,
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