HELSINKI INSTITUTE OF PHYSICS

Annual Report 2009

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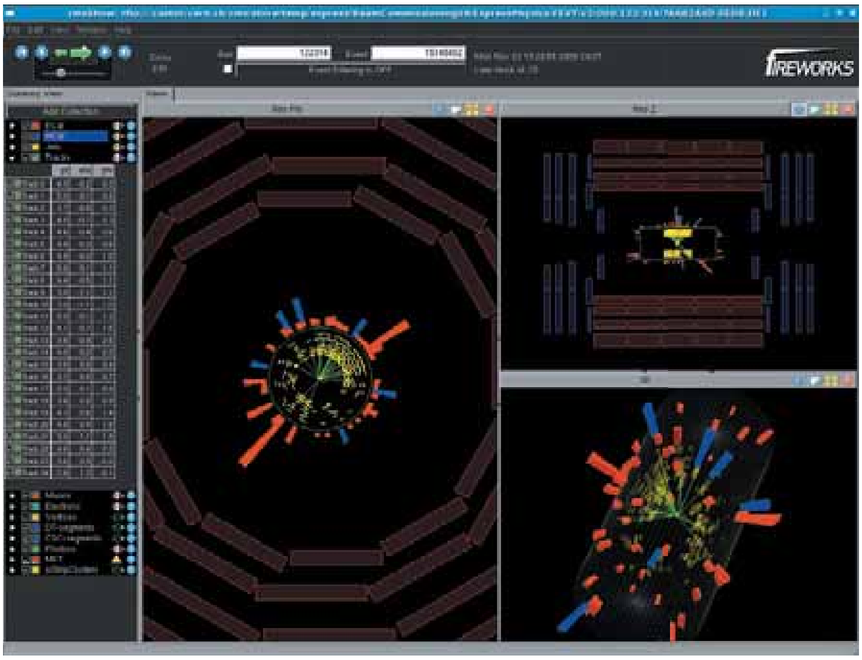

First Collision Event at CMS Nov 23, 2009.

Annual Report 2009 Helsinki Institute of Physics

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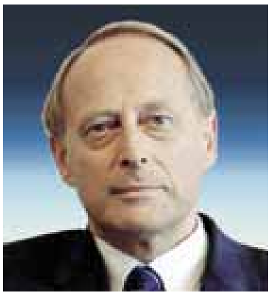
Introduction

Dan-Olof Riska



The Helsinki Institute of Physics (HIP) has a national mandate from the Finnish Ministry of Education for the co-ordination of the collaboration between CERN and Finland. A second mandate has been given for the planning and construction of the Finnish contribution to the Facility for Antiproton and Ion Research FAIR.

The Finnish CERN strategy, along with its emphasis on research in the forefront of nuclear and particle physics as well as applied science, also emphasizes the development of technology know-how of Finnish industry and business applications and the exploitation of CERN research results in science education and literacy. The latter two goals are pursued in collaboration with the Finnish Big Science Activation Team at CERN and through science education sessions for Finnish high schools students and teachers at CERN.

The success of these outreach efforts are demonstrated by the sustained large Finnish coefficient of return for industrial supplies at CERN and by the great interest in Finnish high schools for the CERN visits. In 2009 the Institute was able to host a record of 17 study "camps" by Finnish high school students as well as 2 training sessions for teachers in Finnish gymnasiums at CERN.

The press release issued in connection with the visit to CERN of the Directorate of the Academy of Finland in March noted that the organisation of the Finnish CERN activities provides an excellent example of how the many faceted utilisation of an international research organization can be achieved through national co-ordination, and how fruitful this resourcing may be for both science and the economy.

HIP is operated by the Universities of Helsinki and Jyväskylä and the Helsinki, Lappeenranta and Tampere Universities of Technology. The modus operandi of the Institute is to carry out such research projects in theoretical physics and in accelerator based research and associated technology development, which are too resource intensive or too cross disciplinary to fit into the standard framework of academic research funding in Finland. The Institute collaborates with its partner universities in joint research projects and graduate training in ongoing research.

An example of the success of this collaboration is the fact that 22 researchers of the Institute have been appointed to professorial positions at universities both in Finland and abroad. During 2009, 10 PhD and DSc (Tech) degrees and 9 MSc and MSc (engineering) degrees were awarded on the basis of work conducted within the research projects of the Institute. The summer student programme at CERN represents a key educational effort. During the summer of 2009, 20 Finnish students worked at CERN in HIP research programmes.

The research activities of the Helsinki Institute of Physics in 2009 fell into 5 research programmes and 2 special research projects. The research programmes were (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 special projects are (a) the CLOUD experiment project at CERN, which aims at the determination of the role of cosmic radiation in climate warming and (b) the Planck project for the analysis of the data from the Planck satellite, which was launched in May 2009.

The 4 projects in the Theory Programme, which were launched in 2008, i.e., (1) Cosmophysics, (2) Laws of nature and condensed particle matter phenomenology at the LHC, (3) Low dimensional quantum systems, and (4) Radiation damage in particle accelerator materials, attained full productivity in 2009.

The High Energy Physics Programme completed its GEM detectors for the TOTEM experiment at the Large Hadron Collider LHC at CERN and continued the study of top quark physics at the CDF-II experiment at the Tevatron collider at the Fermi National Accelerator Laboratory. The project on accelerating structures for the CLIC accelerator project complemented the theory project on surface RF breakdown phenomena.

The CMS Programme continued in two projects: one for the commissioning and operation of the tracker and the trigger of the CMS detector at the LHC and the other for software development for the CMS data analysis, which commenced with the start-up of the LHC in November.

The Nuclear Matter Programme of the Institute was divided into 3 projects. The first is a nuclear structure research project at the ISOLDE facility at CERN. The second is a project for physics analysis at, and instrumentation for the ALICE detector for relativistic heavy ion collisions at the LHC. In addition the Programme contained a project for the planning of the Finnish contribution to the FAIR project.

The Technology Programme of the Institute continued the development of industrial applications for CERN generated innovations. During 2009 one focus of the Programme was on software development for distributed data-intensive Grid computation. The Programme is a member of the European Union funded Enabling Grids for E-sciencE project and the Programme is responsible for the construction of the Tier-2 Grid computing facility. During the year the project participated in the CMS data transfer effort, which has transferred more than 25 TBs of data between different Tier-1 centres and the transfer links to the Finnish Tier-2 centre. The Finnish Tier-2 centre has also been part of the ALICE Tier-1 network.

In 2009 the leader of the Theory Programme Professor Kari Enqvist was appointed Academy Professor by the Academy of Finland for the period 2010–2014, and Dr. Mikko Voutilainen, who is presently a CERN Fellow, received the Fermilab and Universities Research Association Outstanding doctoral thesis award in June.

During 2009 the Board of HIP was chaired by Vice Rector Johanna Björkroth of the University of Helsinki. The scientific activities of the Institute were overseen by an international scientific advisory board. The Institute is indebted for the advice provided by the three outgoing members of the advisory board, Professor em Heinrich Leutwyler, Dr. Wolf-Dieter Schlatter and Dr. Heikki Sipilä. At the same time the Institute welcomed Dr. Philippe Bloch (CERN), Professor Wilfried Buchmüller (DESY) and Professor Aarne Oja (VTT Technical Research Centre of Finland) as new members of the advisory board.

Highlights of Research Results

Theory Programme

In the Cosmophysics group we have developed a new method for computing the weak gravitational lensing effects of inhomogeneous matter distribution on light propagation. We released a public code package turboGL, which calculates these effects for an arbitrary homogenous background geometry. Our method can be used to incorporate inhomogeneities in the analysis of cosmological parameter extraction from supernova redshift data.

Regarding the Laws of Nature and Condensed Particle Matter Phenomenology at the LHC -project, we have determined the running of the coupling constant in an SU(2) gauge theory with two Dirac flavours in the adjoint representation. This theory is interesting for possible applications in model building for Beyond the Standard Model physics: it may serve as an underlying gauge theory for the dynamical breaking of electroweak symmetry or unparticles provided that its infrared behaviour is governed by a non-trivial fixed point. Our results suggest that this is the case.

The String Theory and Mathematical Physics group found dark soliton and vortex solutions in a holographic model of superfluidity, and studied their properties such as charge density depletion and coherence lengths. The dual solutions correspond to inhomogeneous scalar and gauge hair around a black hole in anti-de Sitter space.

Ever since graphene was discovered in 2004, this one-atom thick carbon layer has been seen as a potential material for future electronics. Having this as an ultimate goal, the Low Dimensional Quantum Systems group has proposed a device that operates as a gate-controlled current switch. In this set-up, the electronic properties of graphene are crucial for efficient performance.

Within the Radiation Damage in Particle Accelerator Materials group, we have developed a one-dimensional particle-in-cell model of plasma build-up in vacuum arcs to understand electric breakdown in CLIC components. The results showed that two key criteria need to be fulfilled for a breakdown to occur: a high enough initial local field and a high enough neutral density to enable an avalanche of ionisation.

High Energy Physics Programme

An intense five-year period of design, construction, testing and validation of the T2 detector sections, delivered for the CERN LHC TOTEM experiment by the Helsinki group of HIP was completed, and - most importantly - on schedule. The quality control and operation testing of the remaining GEM detectors was completed during the first months of 2009. An important milestone was reached during the second week of December 2009 when the T2 spectrometer recorded some tens of thousands of pp collision events.

The Helsinki group has led the preparation of the analysis of TOTEM data from the TOTEM early physics runs, in close collaboration with the other groups involved in TOTEM. The Helsinki team has worked on leading proton detection at the LHC for a long time and can be considered as the world expert on the subject.

In 2009, the Helsinki group is a leading group in the analysis of the 'all hadronic' decays of the top quark in the CDF experiment at the Fermilab Tevatron Collider, and has introduced novel methods of background analyses for the Higgs searches.

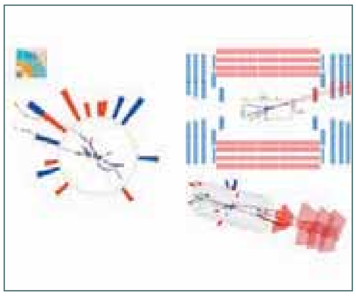
The Linear Collider Research project has made important contributions to studying the precise assembly of RF structures for the foreseen future linear collider CLIC as well as in thermo mechanical modelling of the CLIC module, taking into account all necessary accelerator components and systems. Finnish firms have, in collaboration with the Helsinki team, contributed significantly to the development of suitable machining techniques for manufacturing the RF structures. At the moment, the best achieved machining accuracy is in the order of ±3 μm for the most critical parts.

During 2009, the Detector Laboratory with its remarkable infrastructure as well as experienced active personnel in the Laboratory has successfully supported the activities of the main experimental programmes of HIP, as well as of other users.

In close connection with its research activities, the Helsinki group carries out successful educational programmes both at the undergraduate and graduate levels. The extensive infrastructure of the Detector Laboratory and the wide know-how of its personnel have provided an exceptional opportunity for organising practical hands-on detector courses for the students of the Physics Department.

CMS Programme

The highlight of the year 2009 was the start of the LHC operations in November. The CMS detector recorded the first proton-proton collisions on November 23rd at 450+450 GeV collision energy, i.e., at the LHC injection energy. On December 8th LHC reached the highest beam energy ever achieved with a particle accelerator, 1.18 TeV. During the following week LHC was set to run for short periods with stable beams without interventions to provide the experiments conditions to record collisions at this unprecedented 1.18 + 1.18 TeV collision energy. The CMS detector system performed superbly and the data were analysed in a few days to give the first physics results. The analysis showed excellent agreement with the results of Monte Carlo studies performed over the years. The first physics paper of CMS was sent out to the Collaboration for review. This successful beginning demonstrated the readiness of the CMS experiment to start recording continous data at high energies in February 2010.



The data collected were promptly analysed by the CMS *B*-physics group, to look for dimuon events in both the 900 GeV and 2.36 TeV data. In parallel, Monte Carlo samples produced with the same centre-of-mass energies were analysed for comparison. The statistics was too low to see a J/psi mass peak, but one candidate event was found. These results were approved by the CMS Collaboration in the plenary meeting of December 16, 2009. The HIP group participated in the dimuon analysis in particular through co-ordination and data quality certification.

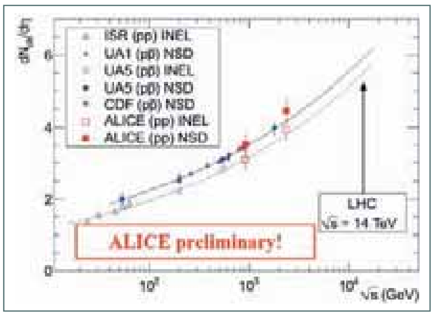
Another important data-taking operation was the cosmic ray run in August-September, CRAFT09 (Cosmic Run At Four Tesla). An abundant sample of cosmic muons traversing the detector was recorded and used to align the CMS detector. During CRAFT09 a five-day Prompt Alignment Exercise was performed to test the performance of the alignment workflow with a 24 hours repetition cycle. As part of these exercises, the HIP team took the responsibility of validation and comparison of different alignment constants.

An interesting result in Monte Carlo physics studies, obtained by the HIP team, was that a light charged MSSM Higgs boson, originating from top quark decays, could be discovered early in CMS, when decaying into a fully hadronic final state. As the cross section for production of top quarks is large at the LHC, an integrated luminosity of the order of ~1 fb^{-1} would suffice for the discovery. The largest background for this channel, the QCD multi-jet production, was shown to be efficiently reduced with the identification of the tau-jet in the final state. The identification algorithm is based on the capability of the CMS Tracker to find tracks and allow the reconstruction of the track momenta down to a few hundred MeV/c. It was shown that the backgrounds can be measured from the early data and methods were developed to obtain estimates of the background levels with sufficient precision to maximise the discovery potential.

The commissioning of the HIP Tier2 centre at the Finnish IT Center for Science (CSC) was completed during the year. The two major CMS Tier-2 tasks, Grid data analysis and Monte Carlo data generation, were run in production mode on the HIP resources for the first time. From the CMS Analysis Operations view HIP started working in a fully transparent way when the ARC submission patch had been deployed on the gLite Workload Management System servers, allowing job submission with no special configuration from any system with a gLite User Interface. CMS analysis jobs could for the first time be submitted to HIP from an ARC User Interface by any CMS user using the CRAB ARC plug-in developed by the Nordic Data Grid Facility Collaboration and HIP. The HIP Tier-2 was one of the four Tier-2 centres used by the *B*-physics analysis group in the analysis of the first data in December.

Tests of Super-LHC fluence irradiated detectors were continued with the Silicon Beam Telescope (SiBT) at the CERN SPS H2 test beam in collaboration with Fermilab and with the Universities of Karslruhe, Rochester and Brown. Due to the successful beam conditions and software improvements, it was possible to collect more than 1 TB of high quality data during the test beam period in 2009. The data analysis exercise did not only give the detector parameters such as Charge Collection Efficiency (CCE), cluster resolution and signal-to-noise ratio, but also increased the general level of understanding of the operation of heavily irradiated position sensitive detectors when attached to appropriate readout electronics and DAQ. Dr. Panja Luukka was nominated as co-ordinator of the CMS Tracker upgrade test beam operations at the H2 beam.

Nuclear Matter Programme



The Nuclear Matter Programme provides participation for the Finnish teams at CERN in studies of nuclear and hadronic matter explored at the ISOLDE and ALICE experiments, respectively. In addition, the Nuclear Matter Programme is co-ordinating the Finnish participation in the FAIR project at GSI.

The year 2009 was important for ALICE and the Finnish ALICE team. A major milestone took place on 23rd November 2009 as ALICE measured the first p+p collisions when low intensity (0.5×10^{10} p/bunch) pilot beams crossed inside the ALICE interaction region. The first ALICE publication (Eur. Phys. J. C 65 (2010) 111), based on the analysis of these events, was released to arXiv only 5 days later on 28th November.

It certainly demonstrated an excellent performance of the detectors and both on-line and off-line reconstruction. By the end of the year 2009 ALICE had collected roughly 0.5 million p+p events, corresponding to an integrated luminosity of the order of 10 μb^{-1} at $\sqrt{s}$ = 900 GeV.

An experimental period at the ISOLDE laboratory had again been productive. Apart from the steady scientific programme, a major breakthrough was achieved, when the HIE-ISOLDE project was fully endorsed by the CERN Research board. This paves the way for an energy and intensity upgrade of the present REX-ISOLDE from typically 3 MeV/u up to 10 MeV/u, thus allowing a wider physics programme in the future at ISOLDE.

Preparatory work for FAIR (Facility for Antiproton and Ion Research) was started in 2006 and continued through 2009. Our main participation in FAIR will concentrate on the NUSTAR experiments with a focus on three experiments called MATS, LaSpec and HISPEC/DESPEC. The technical design reports of the first two were finished in 2009 and are now going through a final evaluation. The third experiment is finishing its technical design report. The Super-FRS beam diagnostics project will be the responsibility of the HIP Detector Laboratory. The main source of funding for the FAIR construction is organised through HIP.

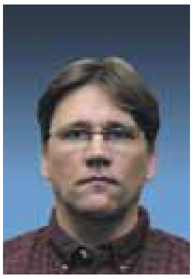
Technology Programme

The main highlights of the HIP Technology Programme in 2009 concern the continued collaboration with the CERN Grid community and CSC, the Finnish IT Center for Science. Through the construction of the physical Tier computing infrastructure and participation in several global preparatory tests this collaboration proved to be ready for the LHC re-start in 2009. Work with the EU-funded EGEE-III project has continued with the planned transition to sustainable e-Infrastructures led by the European Grid Initiative, EGI. The Programme has continued to disseminate Grid technologies and practical know-how among the computing community and students. The researchers have been active in international conferences and numerous Masters' theses have been produced.

Theory Programme

Kari Enqvist,
Theory Programme director

The Theory Programme provides a platform for the project leaders to conduct high-profile research in a few selected subject fields. The projects are fixed term with a default duration of 3+3 years. They are chosen on the basis of their scientific merits and complement the research in experimental physics at the Institute, as well as research at the host universities. The project leaders are expected to be able to secure considerable external funding for their projects. There are now five projects: Cosmophysics; Laws of Nature and Condensed Particle Matter Phenomenology at the LHC; String Theory and Mathematical Physics; Low Dimensional Quantum Systems; and Radiation Damage in Particle Accelator Materials.



Kimmo Kainulainen,
Cosmophysics
project leader

Cosmophysics

We have developed a new method for computing the weak gravitational lensing effects on the light propagation based on stochastic distribution of dark matter halos, and we released a numerical code package turboGL which can calculate the magnification probability distribution function for an arbitrary background universe model. In particular our methods can be used to quantify the effects of inhomogeneities on the cosmological parameter extraction from supernova data. We also built up a reasonable toy model combining the weak lensing corrections with a modest local LTB-void in an EdS background without a cosmological constant. In another track of related research, we have shown that a spherically symmetric perturbation of the EdS model in the Newtonian gauge can lead to an apparent acceleration of standard candles and provide a good fit to the observed supernova magnitude-redshift relation. We also demonstrated that the SN data does not imply the presence of strong back-reaction effects by showing that any LTB-model fitting the SN data will be equivalent to a perturbed FRW spacetime along the past light cone.

We studied the Palatini f(R)-gravity solutions for compact stellar objects. In particular we showed how the density profiles and the maximum masses of white dwarfs and neutron stars are altered in comparison with General Relativity and concluded that observations on compact stars may be used to constrain and exclude alternative gravity models.

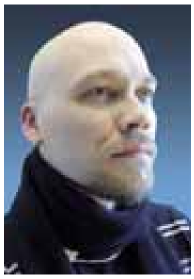
We have investigated several aspects of the curvaton mechanism for the inflationary perturbation spectrum. We find in particular that the background evolution can have a significant effect on the curvature perturbations and on the non-linearity parameters f_{NL} and g_{NL} generated by the curvaton. The size of this dependence is related to the deviation of the potential from the quadratic form, and we showed that there is a relation between f_{NL} and g_{NL} that can be used to probe the curvaton potential and the equation of state of the background fluid. We then investigated non-Gaussianities in the self-interacting curvaton models, treating both renormalizable and non-renormalizable polynomial interactions. We found that even in the interaction dominated regime there are large regions consistent with the current observable bound, and we showed that also in this context the observations of the non-linearity parameters f_{NL} and g_{NL} may offer a window for an experimental test of the curvaton interactions.

In parallel research on inflationary physics, we have computed analytic expressions for the non-linearity parameters characterizing the bi- and tri-spectrum curvature perturbations in the multi-field inflationary scenario. The formalism was applied to an exactly solvable toy model where the conditions were found under which observably large non-Gaussianities can be produced. We also investigated the feasibility of particle production via a parametric resonance in the multi-field inflationary models by means of lattice simulations. We observed a strong dependence of the efficiency of the parametric resonance on the form of the coupling between the inflaton and the (scalar) matter fields; in particular we find that the presence of three-leg interactions is necessary for the preheating after multi-field inflation to be efficient.

We have developed a formalism for quantum transport including non-local coherence effects. The formalism is based on the observation that with certain space-time symmetries the free dynamical non-equilibrium two-point functions have new spectral solutions at off-shell momenta that encode quantum coherence information. When this extended, or coherent quasiparticle approximation (cQPA) is used as an ansatz to the full theory, a consistent transport theory results, which includes the coherence information and evolution at the same level of consistency that is found for the mass-shell contributions in the usual Boltzmann theory. The theory was developed for both fermionic and bosonic fields and its use was demonstrated with several examples including particle creation and decoherence in the early universe.

We have studied dark matter in a class of new Minimal "Walking" Technicolour (MWTC) models, which can provide a dynamical electroweak symmetry breaking consistent with the precision electroweak constraints. With a modest expansion of the particle spectrum the model can also provide very good 1-loop gauge unification. Moreover, such an extended MWTC-model naturally contains a neutral sector reminiscent to neutralinos in the MSSM. When the new particles are given an additional Z_2-symmetry, similar to the R-parity in the MSSM, the lightest member of the neutral sector becomes a natural dark matter particle in close analogy to the LSP in the MSSM. We have computed the dark matter abundance coming from this new sector in two asymptotic limits: pure doublet singlet mixing, and a pure adjoint-singlet mixing. In both cases parameters satisfying all observational constraints were identified. We are currently making a comprehensive scan of the entire parameter space of the model in the most general case of 3-state mixing.

Laws of Nature and Condensed Particle Matter Phenomenology at the LHC



Kimmo Tuominen, Laws of Nature and Condensed Particle Matter Phenomenology at the LHC project leader

The LNCPMP project in the HIP Theory Programme is located at the Department of Physics, University of Jyväskylä, at HIP, and at the Department of Physics, University of Helsinki. Our focus is on (1) electroweak symmetry breaking (EWSB) mechanisms and associated Beyond the Standard Model (BSM) phenomenology and (2) perturbative and non-perturbative strong interactions with applications to BSM physics and properties of hot and dense QCD matter. We are in research collaboration with various international colleagues, we organise and participate in international conferences and workshops, European graduate school activities and EU networks. We are also in a close contact with the local CMS (Helsinki) and ALICE (Jyväskylä) experimental groups.

EWSB and BSM phenomenology: Collider signatures and candidates for cold dark matter (DM) have been studied both in non-supersymmetric and supersymmetric BSM scenarios.

The Minimal Walking Technicolour model contains a natural fourth generation of leptons, and we studied their most general mass and mixing patterns. First, we analysed the oblique corrections and the resulting constraints on the model parameters. Allowing the fourth generation leptons to mix with the Standard Model (SM) leptons, several observable signatures at the LHC were predicted. Second, assuming no mixing with the SM generations, we showed that the lightest fourth neutrino mass eigenstate is a DM candidate compatible with all present dark matter searches. We have also studied the composition of the lightest neutralino and the identity of the next-to-lightest supersymmetric particle when non-universal gaugino masses originate from representations of SO(10). A thermal relic density compatible with the observations was found and compared with the universal case.

Several BSM models predict triplet scalars. We have studied prospects for searching for the neutral Higgs bosons of the triplet model in central exclusive production at the LHC and shown that an excellent mass measurement is possible. In the supersymmetric model with triplets light doubly charged higgsinos can occur. We have studied the signals of doubly charged higgsinos in hadron colliders, and show that it is possible to disentangle the effects of doubly charged higgsinos.

Sneutrino mixing, which can provide information on the neutrino parameter space in a model where neutrinos have non-zero Majorana masses, has been studied. Possible observable signals carrying information about the neutrino masses and mixing angles have been identified and shown to be experimentally observable at the LHC under certain conditions accessible in an anomaly-mediated supersymmetry breaking scenario.

We have also considered a model similar to bosonic Technicolour. This model features, in addition to Technicolour which provides for the origin of mass for electroweak gauge bosons, a fundamental scalar whose interactions with Technicolour degrees of freedom induce a vacuum expectation value which in turn provides for the masses of the Standard Model matter fields. Our model provides a calculable framework for, e.g., flavour observables and we demonstrated that the model is compatible with current electroweak precision data for a large range of model parameters.

CP asymmetries of *B*-meson decays to kaons and pions show a 5σ difference. We have analysed this within the Soft Collinear Effective Theory. We found that in the Standard Model, such a big difference cannot be achieved and then classified the requirements for the possible New Physics models, which can be responsible for the experimental results. As an example of a New Physics model we studied minimal supersymmetric models, and found that the measured asymmetry can be obtained with non-minimal flavour violation.

Dynamics of strong interactions: Within this part of the project our aim is on one hand to use lattice simulations to gain insight into the non-perturbative dynamics of strongly interacting SU(N) gauge theories with matter; the main motivation here is provided by the applicability of these theories in BSM model building. For example, since the phenomenologically successful new Walking Technicolour models should be infrared conformal, we embarked on a large scale lattice analysis of an SU(2) gauge theory with two adjoint (techni)fermion flavours. The analysis, now completed for unimproved Wilson fermion action, lends strong support to the fact that this theory is exactly or nearly conformal in the infrared. We are currently engaged in a refined analysis using improved fermion actions. On the other hand, a large fraction of our research efforts is devoted to QCD, both non-perturbatively and perturbatively, for applications in Ultrarelativistic Heavy Ion Collisions (URHIC). The main research avenues here are nuclear parton distribution functions and modelling of the space-time evolution of URHIC.

Nuclear parton distribution functions (nPDFs) are needed for the computation of all collinearly factorizable hard-process cross sections in URHIC. Our pioneering contribution in the global analysis of nPDFs, set EKS98, is now a standard reference in the field. In our latest release, set EPS09, we extended the analysis to the next-to-leading order pQCD, and established a detailed error analysis based on which one may now study how the nPDF uncertainties propagate into actual cross sections. Hannu Paukkunen's thesis on this topic was approved with honours. We have also continued our studies of the nuclear gluon densities in the so-called Color-Glass-Condensate (CGC) framework using both effective field theory methods and lattice simulations.

High-p_T particle production in URHIC provides an important class of QCD matter probes. The measurements extend from single-hadron spectra and few-particle correlations to the observation of full hadronic jets. These observables will also be a crucial part of the LHC heavy-ion programme, thus we are currently developing Monte Carlo (MC) simulations for modelling the interactions of hard partons with a hydrodynamically evolving QCD medium. The first comparisons with both single-hadron spectra and preliminary results on jet structure have been published and more systematic studies are to follow. Within the CGC framework, we have developed a quantitative description of multigluon correlations in AA collisions.

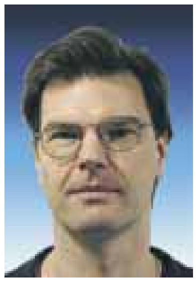
In our hydrodynamical modelling of URHIC, we are in the process of developing a MC simulation of the effects of initial density fluctuations on the observable momentum anisotropies. Our goal here is to develop an event-by-event analysis of the elliptic flow. Also, studies of the effects of asymmetric transverse flow on thermal photon production are on the way.

Recently, using effective models for chiral fields and the Polyakov loop, constrained by lattice data and observed vacuum properties, we have analysed QCD thermodynamics in temperatures and densities relevant for URHIC dynamics. We have studied the interplay of chiral symmetry restoration and center symmetry breaking as a function of explicit chiral symmetry breaking.

Hadron Physics Activity. A study has been made of the effect of $qqqq\bar{q}$ and $qqqqq\overline{qq}$ configurations on the static properties of the nucleons. The results reveal that with at least 3 different mixed symmetry $qqqq\bar{q}$ configurations it becomes possible to improve on the description of the conventional qqq quark model so that both the magnetic moments and the axial coupling agree with the corresponding empirical values.

The pion-nucleon data analysis has continued. The aim is to fix the coupling constant and some of the low-energy constants for pion-nucleon scattering.

String Theory and Mathematical Physics



Esko Keski-Vakkuri, String Theory and Mathematical Physics project leader

The String Theory and Mathematical Physics project has two main missions. It investigates frontier problems at the interface of string theory, mathematics and other areas of physics. On the other hand, the project acts as a bridge between various groups studying mathematical applications to physical problems, in the physics and mathematics communities at the Kumpula campus and elsewhere.

The group includes physicists and members from the Department of Mathematics and Statistics at the University of Helsinki, including a postdoctoral fellow supported by the University of Helsinki interdepartmental fellowship. The project begun in 2008 and has thus completed two years.

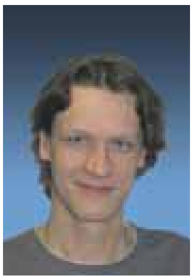
In 2009, one of the main activities of the group was to explore new applications of the holographic duality between strongly coupled gauge theories at finite temperature and gravitational systems in anti-de Sitter space. We were the first to construct and analyse the properties of holographic dark solitons, related to the dark solitons observed in ultracold atomic condensates. We found that the relative charge density depletion and coherence length scales of holographic solitons are very similar to the standard superfluid counterparts. We also constructed vortex solutions and performed a similar analysis of their properties. The results are encouraging - holographic duals may become a useful framework to study the properties of bosonic and fermionic superfluid solitons.

In a different direction motivated by condensed matter physics, we analysed electromagnetic response in a string model for quantum Hall plateau transition. We calculated the finite temperature AC conductivity tensor, and found unexpectedly good agreement with a previous field theory model calculation by Sachdev. Furthermore, we have found interesting universal features in the high-frequency behaviour of the conductivity.

In a particle physics motivated context, graduate students Alanen and Suur-Uski investigated with K. Kajantie gauge/gravity models for the thermodynamics of gauge theories with running coupling. By modifying previous work, they formulated a framework for constructing gravity-scalar dual models for a range of gauge theories with different beta functions and thermodynamic behaviour. In particular, this class of models includes theories with both ultraviolet and infrared fixed points.

We also continued to investigate multi-string emission by decaying D-branes in string theory. By borrowing and further developing techniques of random matrix theory and Coulomb gas electrostatics, we solved a long-standing problem and derived a result for the high-energy limit of the closed string pair production amplitude with t- and s-channel poles.

The activity in Quantum Field Theory has continued with research mainly on non-commutative gauge theories. A new gauge-covariant star product has been introduced between differential forms defined on symplectic manifolds and exploited for the construction of non-commutative gauge field and gravitational theories. The relation between the no-go theorem for non-commutative gauge symmetries, previously formulated by the group, and the Seiberg-Witten map has also been elucidated. The Dirac quantization condition for monopoles has been shown to remain unchanged in non-commutative space-time. The group has also presented the solution of the stochastic Langevin equations for clustering of particles in turbulent flows in terms of Wiener path integrals, allowing the use of a variety of approximative methods, such as the instanton and WKB approximations, appropriate to the physical conditions of different problems.



Ari Harju,
Low Dimensional
Quantum Systems
project leader

Low Dimensional Quantum Systems

Recent advances in experimental techniques have promoted low-dimensional quantum systems from toy models into systems of experimental and technological interest. Examples of these are two-dimensional semiconductor structures and graphene, a two-dimensional allotrope of carbon. From the theoretical point of view, the field of two-dimensional nanoscale quantum physics forms an interface between hard-core theoretical physics and traditional condensed matter physics. The lowered dimensionality both enhances correlation effects - in many cases necessitating the use and development of non-perturbative methods - and allows for powerful analytical techniques such as bosonization and Bethe ansatz.

The main focus of the project has been on studies of two-dimensional semiconductor quantum dots in strong magnetic fields. In such structures, a controllable number of electrons are confined to a quantum dot. Besides applications in quantum information and quantum computing, quantum dots are interesting in their own right as an example of strongly correlated interacting quantum systems, in which the influence of the magnetic field gives rise to a diverse range of phenomena. Moreover, results extrapolated from computationally feasible few-electron droplets may frequently be used to understand macroscopic quantum phenomena such as the quantum Hall effect.

In addition to quantum dots, we have studied graphene, a single layer of graphite. Despite being only one atomic layer thick, graphene is remarkably stable, chemically as well as thermally. Thus graphene-based nanoelectronic devices, such as field-effect transistors which remain stable under ambient conditions, have already been manufactured. Our studies, in particular those of the transport properties of graphene nanoribbons, utilise the tight-binding model of electrons. Based on these results, we have put forward a device that operates as a gate-controlled current switch. The electronic properties of graphene turn out to be crucial for the efficient performance of the proposed device.

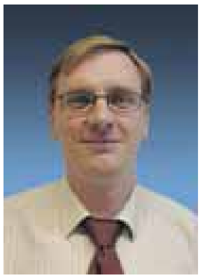
We have also studied graphene in terms of quantum field theory, which provides an instructive framework for describing collective behaviour in condensed matter physics. Lattice Monte Carlo simulations of quantum field theories are emerging as a powerful computational tool, as they permit an unapproximated treatment of quantum fluctuations, as well as a non-perturbative solution of strongly interacting problems. Our pioneering simulations of graphene describe the system in terms of electrostatically interacting Dirac quasiparticles, which are the relevant degrees of freedom at low energies. Our results indicate that the standard theory of graphene predicts dynamical gap generation in suspended graphene samples.

We are currently extending our simulation work to other condensed matter systems such as bilayer graphene and strongly interacting Fermi gases, as well as towards the characterization of the conductivity of graphene in the presence of strong Coulomb interactions.

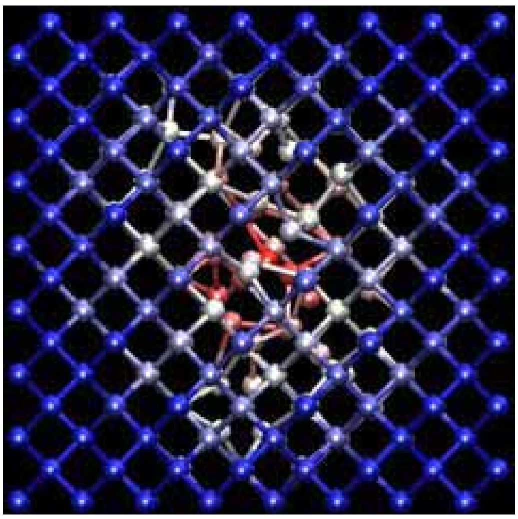
Radiation Damage in Particle Accelerator Materials

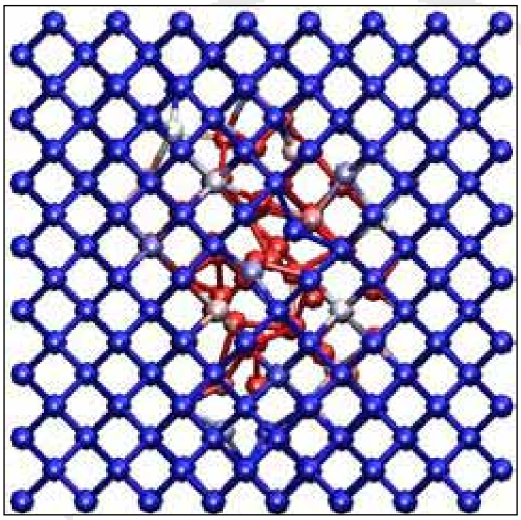
An extensively researched problem in the physics of particle detectors is the effective type inversion from n- to p-type of Si detectors as a consequence of energetic particle bombardment. The effect is caused by lattice defects that form upon the interaction between the incident energetic particles and the lattice atoms. The defects trap electrons, and hence negative charge is accumulated in the n-type bulk of the detector. This leads eventually to the inversion of the sign of the space charge and an increase in the full depletion voltage of the device. Ultimately, this phenomenon destroys the functionality of the detector. The effect is a critically limiting factor for the lifetime of Si detectors in high luminosity colliders such as the LHC and its prospective followers.

Traditionally, the effort to identify the main responsible electron traps has focused on point-like defects or impurities, such as vacancies and oxygen-related defects. However, the fact that the same effect is observed in a wide range of different types of Si detectors suggests that a specific defect cannot explain the type inversion under all circumstances. Instead, a more generic explanation independent of the type of Si should be sought. Recently, there has been an increasing emphasis on cluster-related defects, which are now believed to be responsible for the phenomenon. However, despite much research, the electron traps mainly responsible still remain unidentified. In 2009, we used large-scale ab initio simulations to show that amorphous defect clusters of pure Si, which are intrinsic defects generated by particle bombardment, may alone explain the type inversion observed in particle detectors. The presence of these clusters in Si after energetic particle bombardment is evidenced by several experimental studies. Our results show that they act as powerful electron traps in the lattice.



Kai Nordlund, Radiation Damage in Particle Accelerator Materials project leader

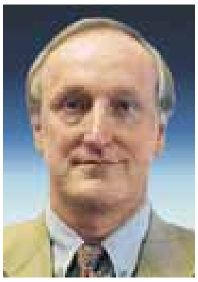




Atomic models of small amorphous pockets in crystalline silicon. Such pockets are created by hadrons in Si detectors, and recent results of a HIP research group indicate they are responsible for the degradation of the detector performance during long-term use.

High Energy Physics Programme

Heimo Saarikko,
High Energy Physics
Programme director



The activities of the High Energy Physics Programme in 2009 concentrated on top quark measurement and Higgs production studies in the CDF experiment at the Fermilab Tevatron antiproton-proton collider, and on construction, testing and validation of the Helsinki built T2 spectrometer for the TOTEM forward physics experiment, as well as preparing and leading the physics analysis activities of the TOTEM data from the early LHC runs. Helsinki is one of the leading groups for the CDF experiment in the top mass measurement, and is contributing significantly to Higgs searches. The group is one of the major contributors to the TOTEM forward spectrometer and in the development of a competitive physics programme for it. A vigorous R&D effort continued, to demonstrate the feasibility of Compact LInear Collider (CLIC) -technology, in view of a decision on the future direction of the high energy frontier in 2012–2013. In 2009 the Detector Laboratory activities have supported the major experiments of HIP to a very significant extent. Intense educational programmes were carried out in connection with the research activities, both at the undergraduate and graduate levels. The extensive infrastructure of the Detector Laboratory and the wide know-how of its personnel have provided an exceptional opportunity for organising practical hands-on detector courses for the students of the Physics Department.

Risto Orava,
Forward Physics
project leader

Forward Physics Project

In 2009 the Forward Physics project concentrated on: (1) finalising the CDF based top quark studies in the all-hadronic channel (PhD thesis by Petteri Mehtälä), improving the methods for Higgs analysis in the WH channel (PhD thesis by Timo Aaltonen), and analysing the exclusive gamma-gamma processes (PhD thesis by Erik Brücken); (2) commissioning the Helsinki built TOTEM T2 spectrometer and (3) preparing for the physics analysis activities of the TOTEM experiment at CERN.

The CDF top quark and Higgs analysis continues to be supported by the Academy of Finland through the personal grants received by Prof. R. Orava for the years 2005–2010.

The CDF and TOTEM activities of the Helsinki group are supported by the Helsinki Institute of Physics (HIP) and the Division of Elementary Particle Physics (AFO) of the Department of Physics at the University of Helsinki.

CDF experiment: top quark and Higgs boson analyses

During the past three years the Helsinki group has systematically built up its presence in the CDF top analysis activities. In 2009, the group is a leading group in the analysis of the 'all hadronic' decays of the top quark, and has introduced novel methods of background analyses for the Higgs searches. The group is developing multivariate analysis techniques together with students of artificial intelligence techniques of Helsinki University of Technology.

The group has a major responsibility for the on-line operations of the SVX, the fine tuning of the SVX simulation software and the off-line SVX calibration. By its contributions to the b-quark physics analysis of the CDF experiment the group has gained expertise in extracting the top quark and Higgs signals from the QCD backgrounds.

The CDF team of the Helsinki group (members & advisors) in 2009 are: Timo Aaltonen (PhD student), Erik Brücken (PhD student), Francesco Devoto (PhD student), Valery Khoze (advisor), Petteri Mehtälä (PhD student), Risto Orava (Professor, Helsinki group leader), Heimo Saarikko (Professor, HIP Programme leader), Kenneth Österberg (University lecturer).

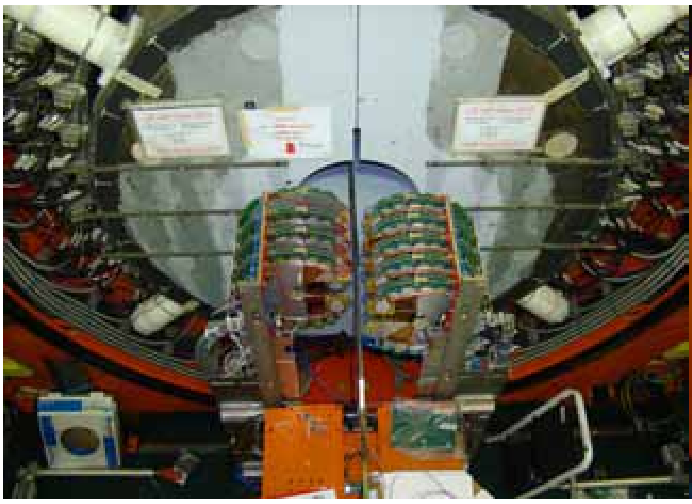
In 2009 the Helsinki CDF group had two major responsibilities in the CDF analysis: (1) precision measurement of the top quark mass (PhD thesis by Petteri Mehtälä), and (2) Higgs search in associated production with the W-boson (PhD thesis by Timo Aaltonen), in this analysis R. Orava serves as a 'godfather'. In addition, exclusive gamma-gamma reactions have been investigated as a precursor for the common forward physics programme of the TOTEM and CMS experiments at the LHC (PhD thesis by Erik Brücken).

The CDF responsibilities and contributions to the CDF experiment include:
*Support for the Run II detector; SVXII DAQ board testing and maintenance & daily operational responsibilities of the silicon detector.
*Participation in development and maintenance of both on-line and off-line database support.
*SVXII off-line studies: charge deposition models and tracking studies.
*SVXII off-line calibration.
*Determination and calibration of the Jet Energy Scale.
*Postdocs, senior group members and graduate students participate as Aces, CO's and SciCO's.
*TOP mass analysis in the all-hadronic channel & Higgs search in association with the W-boson.

TOTEM experiment

The TOTEM experiment was conceived to cover elastic scattering, total cross section and diffraction dissociation at the LHC as stated in the Letter of Intent (LoI) submitted to the LHC on 15th August 1997. Since the initial LoI, the experiment and its goals have been specified further in the Technical Design Report of 7th January 2004. Together with the CMS experiment, TOTEM could cover more phase space than any other detector installation at a hadron collider. In 2010, it is a major challenge for the TOTEM Collaboration to commission, in addition to the T2 spectrometer, both the Roman Pot detectors and the T1 spectrometer in order to initiate the preparations for the planned physics analysis.

The main responsibility of the Helsinki group in TOTEM centres around the *T2 spectrometer* and, in particular, its GEM detectors. The TOTEM team concentrates on both hardware and software (*reconstruction*) contributions to T2. The team has worked on *leading proton*



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

A fully commissioned T2 arm ready for insertion into the CMS HF calorimeter.

detection at the LHC for a long time and can be considered as the world expert on the subject. It is in the group's interest to continue the work on leading proton detectors and studies on their performance vs. different LHC optics scenarios. With the T2 spectrometer detectors of TOTEM as its hardware responsibility, the Helsinki group continued to concentrate on testing and commissioning of the T2 detectors in 2009 until the first collisions were recorded by the T2 spectrometer in December 2009.

After the incident following the first LHC start-up in autumn 2008 the TOTEM T2 GEM quarter already installed was taken back to the H8 testing hall at CERN for testing and further beam tests during winter 2009. Quality control and operation testing of the remaining GEM detectors was completed during the first months of 2009. By April 2009, 40 out of the 46 detectors finished so far were sent to CERN for installation. To have the planned 10 spare detectors for later replacement, and because several detectors were found to be lacking in quality assurance, the assembly of 10 extra detectors was started immediately. By the end of 2009, 5 spare detectors were assembled and fully tested in the Detector Laboratory in Helsinki. Of these detectors 3 have already been sent to CERN. The Helsinki group has been participating in TOTEM commissioning activities in December 2009.

An important milestone was reached during the second week of December 2009 when the T2 spectrometer recorded some tens of thousands of pp collision events. However, due to the failures in the signal readout chain, only half of the complete T2 detector could be read out. The faulty 11th card and failing connectors have been repaired during the January 2010 shut-down period. Due to a late redesign of the mechanical installation support, the T1 detector cannot be installed in time for the 2010 LHC runs. Thus it is foreseen that the T2 spectrometer and the Roman Pot detectors are the parts of the TOTEM experiment that will register LHC collisions for physics analysis in 2010.

At the beginning, the LHC will run with beams of reduced energy (< 3.5 TeV), number of bunches and number of protons per bunch. Under these conditions, TOTEM will have ample opportunities to make its first physics measurements covering large-|t| elastic scattering and high mass central and single diffraction, as well as the measurement of inelastic rates and event topologies. In close collaboration with the TOTEM off-line software group, the Helsinki group is preparing for the analysis and interpretation of the first TOTEM data. Examples of the preparation work done in 2009 are systematic comparisons of different event generators and models for diffraction and minimum bias events, the development of the trigger algorithm for T2 and its implementation in the TOTEM simulation software. In addition, the group has developed a classification method for inelastic events using the measured information on the event topology in the T1 and T2 telescopes.

The TOTEM team of the Helsinki group (members & advisors) in 2009 are: Erik Brücken (PhD student), Francisco García (post doc), Jouni Heino (lab.eng.), Timo Hildén (PhD student), Valery Khoze (advisor), Kari Kurvinen (detector scientist), Rauno Lauhakangas (detector scientist), Jerry Lämsä (advisor), Fredrik Oljemark (PhD student), Risto Orava (Professor, Helsinki group leader), Heimo Saarikko (Professor, HIP Programme leader), and Kenneth Österberg (University lecturer and TOTEM Physics Co-ordinator).

The TOTEM responsibilities and intended contributions include:

*T2 spectrometer GEM detector construction.

*T2 spectrometer data analysis & trigger scenarios.

*Leading proton measurement - detectors & trigger.

*Leading proton measurement - performance studies vs. LHC optics options.

*TOTEM physics scenarios.

*TOTEM service contributions: participation in tests, analysis of test data.

Kenneth Österberg, Linear Collider Research project leader

Linear Collider Research Project

The main activity in 2009 was participation in the Compact LInear Collider (CLIC) R&D

programme, whose aim is to demonstrate the feasibility of CLIC-technology in view of a decision on the future direction of the high energy frontier in 2012–2013. The project focuses on the precise assembly of RF structures for CLIC as well as thermo mechanical modelling of the CLIC module taking into account all necessary accelerator components and systems. The project had two researchers in 2009, R. Nousiainen at CERN and J. Huopana based in Oulu who makes frequent visits to CERN.

The research was done in close collaboration with the CERN CLIC group, notably Drs W. Wünsch and G. Riddone, and Finnish industrial and academic partners, notably the Technical Research Centre of Finland (VTT). The work on the precise RF structure assembly was from April 2009 partially founded by EuCARD, a European wide EU network on accelerator R&D. In December 2009, an EU application on an industry and academia partnership network, MeChanICs, related to the industrialisation of the RF structure manufacturing and an Academy of Finland application on experimental investigation of electrical breakdown were recommended and respectively approved for funding. The latter will be part of the Finnish contribution to the NorduCLIC project, where HIP joins forces with the universities of Oslo and Uppsala for a joint Scandinavian contribution to the RF structure development programme for CLIC.

To achieve sufficient beam stability in CLIC, the CLIC RF structures, both the accelerating structures and the power extraction and transfer structures, need to be produced, assembled, aligned and supported in a full CLIC module with μm precision. Finnish firms have over the years contributed significantly to the development of suitable machining techniques for manufacturing the RF structures. At the moment, the best achieved machining accuracy is in the order of ±3 μm for the most critical parts. Not only is the machining precision important for performance but also the alignment precision of the full accelerating structure assembly must meet the tight μm level requirements. In 2009, the project analysed assembly tests that used the elastic averaging method, made finite element modelling of residual stress in manufacturing and assembly as well as designed the supports for the RF structures in the CLIC module, all in view of improving the precision of the final RF assembly.

The assembled RF structures needs further to be integrated into the full CLIC module maintaining μm precision also during CLIC operation. The second focal point of the project's research was on the thermo mechanical modelling of a full CLIC module including all necessary accelerator components and systems and taking into account different CLIC operation modes with the aim to validate the proposed solutions. Even though many critical issues related to the CLIC module will be validated in experimental set-ups either in the lab or in an accelerator environment, this modelling will be the only verification of the functionality of the CLIC module as a whole for the CLIC Conceptual Design Report to be published at the end of 2010 and thus is of vital importance.

One of the key issues for CLIC is to limit the RF breakdown ("sparking") probability in the accelerating structures to achieve a stable beam with a sufficiently high accelerating gradient (> 100 MV/m). The origin of the breakdowns is not well known but most probably they are due to spontaneous roughening on the surface of the accelerating structure with subsequent creation of tips with a significantly increased electric field as a result. Our group is closely collaborating with Prof. K. Nordlund and PhD F. Djurabekova who are pursuing a multi-model simulation of the electrical breakdown process and thereby trying to understand the underlying physical processes leading to increased breakdown probability. If the physical processes are known, they can be taken into account in the material choice, design and production to minimise the breakdown probability. This collaboration will be deepened through the Academy of Finland project consortium on experimental and theoretical investigation of electrical breakdown.

Eija Tuominen, Detector Laboratory coordinator

Detector Laboratory

The Detector Laboratory supports Finnish experimental research on collider-based physics. It is a joint laboratory between Helsinki Institute of Physics and the Department of Physics of the University of Helsinki. The Laboratory provides premises, equipment and know-how for research projects developing radiation detectors for international particle and nuclear physics experiments.

During the execution of the past projects, the scientists working within the Laboratory have acquired a vast amount of knowledge on the design, construction and testing of gaseous and semiconductor detectors. Presently, the Laboratory hosts active projects concentrating on the CMS and TOTEM experiments at CERN, and the NUSTAR/SUPER-FRS experiment at FAIR. In addition, the Laboratory offers support for projects at the Electronics Research Unit of the Department of Physics of the University of Helsinki. Furthermore, according to available resources, the Laboratory also provides services for outside users.

Support for the CERN TOTEM experiment

During the year 2009, the work with the semicircular GEM detectors for the CERN TOTEM T2 telescope still continued in the Detector Laboratory. The T2 telescope is made up of 40 pieces with GEM detectors in four quarters. The assembly of all the rest of these 40 GEMs was completed in the Laboratory. Also, the final electric tests for the assembled GEM detectors continued to meet the design criteria. The basic characteristic measurements of the GEMs included gas gain and energy resolution measurements over all of the active area with different bias voltages. The stability of the response of the detectors is also of vital importance. This is why after these tests the detectors were still left at the nominal high voltage (4.15 kV) for several days, normally at least for a week, to guarantee stable operation under normal running conditions. The environmental test chamber of the Laboratory was additionally used to measure detector properties in different humidity conditions. After successfully completed tests in the Laboratory, the detectors were transported to CERN and commissioned at the LHC Intersection Point 5 (IP5) of the TOTEM experimental underground area.

To be prepared for any possible losses of the detectors already installed at CERN, the Detector Laboratory has already started the assembly, testing and validation process for some spare GEM detectors. The purpose is to build at least 10 more fully functional GEMs. By the end of 2009, 5 spare detectors were assembled and fully tested in the Detector Laboratory at Helsinki. Of these detectors 3 have already been sent to CERN.

One new set-up for GEM detector testing has been introduced in the Laboratory during late 2009, viz. the TTP apparatus (TOTEM Test Platform). This system can be utilised to

As part of the TOTEM T2 GEM quality assurance procedure the stability of the detector HV system is tested for external humidity in an environmental test chamber.

study the characteristics of the GEMs more precisely than before: through the VFAT chips used it is now possible to measure each of the readout channels (512 + 1560) separately.

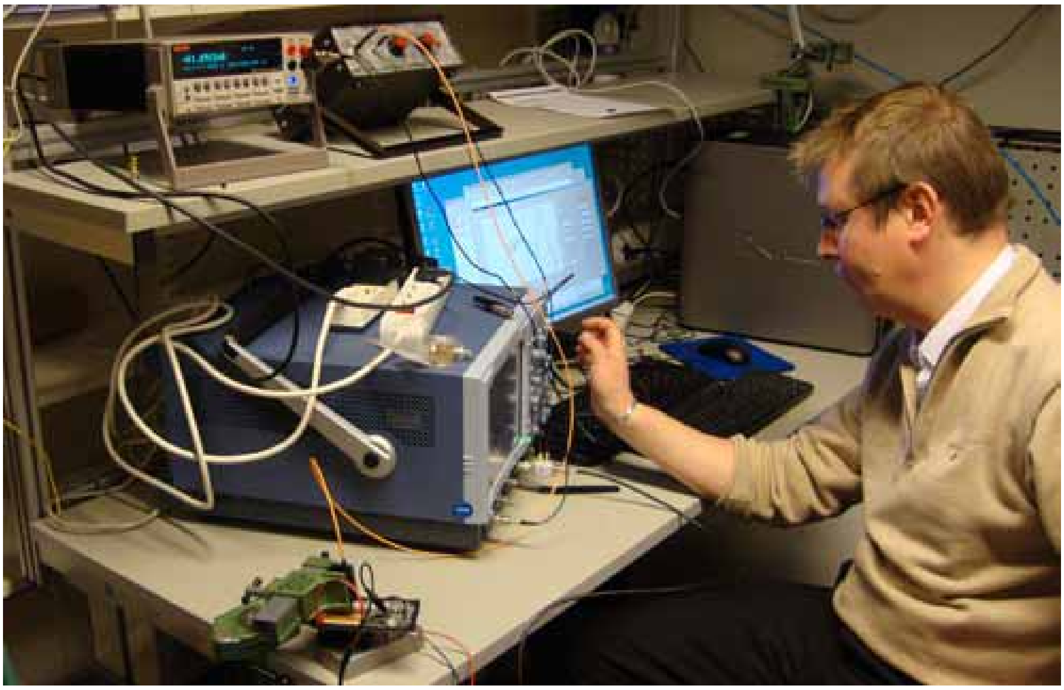
Support for the CMS Tracker experiment

The CMS Tracker Operations project has the Finnish Cosmic Rack (FinnCRack) as well as adjacent electrical equipment and a cooling system installed on the premises of the Detector Laboratory. FinnCRack is a telescope built from eight layers of CMS silicon detectors measuring the tracks of cosmic particles. It is used as a test station providing real data for testing the CMS Tracker Outer Barrel (TOB) functionality as well as for development of TOB software. FinnCRack also provides a platform for the testing of the novel radiation hard detectors being developed in the CMS Tracker Operations project.

The CMS Tracker Operations project has greatly profited from the selection of equipment of the Detector Laboratory. Using the wafer/chip probing station situated in the clean rooms of the Detector Laboratory essential electrical properties, e.g., current-voltage and capacitance-voltage characteristics were measured from the silicon detectors directly after their manufacture at the semiconductor processing line at Helsinki University of Technology Micronova and after the irradiations. Some of these detectors have also been connected to electronics using the versatile bonding equipment in the clean rooms. In addition, the common project between the CMS Tracker Operations project and the Accelerator Laboratory of the Department of Physics at the University of Helsinki is greatly benefiting from the electrical equipment of the Detector Laboratory. Furthermore, the TCT (Transient Current Technique) set-up is being commissioned in the Laboratory. These measurements will provide all the necessary information for studies of the properties of silicon detectors.

Support for the FAIR SUPER-FRS experiment

FAIR (Facility for Antiproton and Ion Research) is an international accelerator research facility to study nuclear physics. It is being built in Darmstadt, Germany as an extension to the current GSI research institute. The Finnish FAIR effort is concen-



Transient Current Technique set-up at the Detector Laboratory.

trated on the NUSTAR (NUclear STructure, Astrophysics and Reactions) experiment. Although the major part of the Finnish FAIR research is being conducted at the University of Jyväskylä, the Helsinki Detector Laboratory group focuses specifically on the production of GEM-TPC (Gaseous Electron Multiplier - Time Projection Chamber) detectors for the diagnostics of the FAIR superconducting fragment separator, i.e., Super-FRS.

During 2009, the first GEM-TPC prototype was constructed together with the research group from Comenius University Bratislava, responsible for the TPC part, and the GSI Detector Laboratory, responsible for the electronics. The prototype will later serve as the basis for the design, development and manufacture of a total of 40 similar GEM-TPC detectors in the Detector Laboratory. At the end of the year, an optical camera system with a one square meter XYZ-table was installed in the Laboratory clean room. This system will serve as an essential tool for the quality control of GEM-foils.

Support for ERU wire bonding projects

The Electronics Research Unit of the Department of Physics works actively in the Detector Laboratory. In 2009, ERU has successfully participated in the so-called Electric Sail project co-ordinated by the Finnish Meteorological Institute. The aim of this international research activity is to develop a method to harness solar winds as a power source for spacecraft. The sail is made of several long tethers that are built from 25–50 micrometers thin metal wires. Tether structures using 25 and 50 micrometer round wires have been successfully constructed using the semiautomatic ultrasound wire bonder equipment in the Laboratory clean room. Also, the contact resistance method to monitor the wire bond process in real time was developed further. Sergiy Kiprich (Kharkov Institute of Physics and Technology, Ukraine National Science Center) supported us for three months in 2009 developing the bonding process for the E-sail tether production.

Participation in CERN RD51 Collaboration

In 2009, HIP and the Detector Laboratory joined the CERN RD51 Collaboration “Development of Micro-Pattern Gas Detectors Technologies” aiming to facilitate the development of advanced gas-avalanche detector technologies and associated readout systems, for applications in basic and applied research. As a member of the RD51 Collaboration, the scientists of the Detector Laboratory will work tightly together with the vast international gas detector community and benefit from the extensive expertise and infrastructure of CERN and other participating institutes.

Education

The research and experimentation activities at CERN and Fermilab constitute a platform for educating and training students in physics and technology, and the *Detector Laboratory* also serves as the basis of education and training in experimental high energy physics. Summer student and technical training programmes at CERN and Fermilab have been continued. In connection with the research activities, educational programmes both at the undergraduate and graduate levels have been established.

In close connection with its research activities, the Helsinki group carries out educational programmes both at the undergraduate and graduate levels. Within the past three years, five PhD’s and four MSc’s have been completed in the group. Importantly, these former students of the group have rapidly been recruited to important positions in research institutions, notably at CERN, and in various industries. Domestic summer student and technical trainee programmes, tailored for university students and students of polytechnic universities, are continued at CERN. Since the beginning of 1990, the Helsinki group has produced 25

Physics students participating in a laboratory course in the Detector Laboratory clean room.

PhD's, 40 MSc's and trained numerous physics and technical students in its experimental high energy physics projects at CERN and Fermilab. By the end of 2010, two PhD's will be completed in CDF physics analysis (Aaltonen, Mehtälä) and three PhD's in TOTEM related topics (Brücken, Hildén, Oljemark).

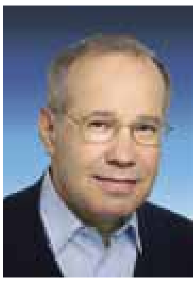
The extensive infrastructure of the Detector Laboratory and the wide know-how of its personnel provide an exceptional opportunity for organising practical hands-on detector courses for the students of the Physics Department. Several post-graduate students are doing their doctoral studies in the projects operating in the Laboratory. In addition, the Laboratory is providing tuition within the official study programme of the Physics Department. In autumn 2009, a group of students performed an exercise involving both gas and silicon detector measurements in the Laboratory as a part of their course on measurement technologies. Additionally, by the end of 2009, a permanent set-up to perform a full-chain gas detector measurement was commissioned in the Laboratory. The set-up forms a part of laboratory projects that are obligatory for all the students with physics as their major subject. Furthermore, several groups of high-school students and even elementary school students visited the Laboratory during 2009.

The group has been involved in preparations for organising a national event for the "European Master Classes for High School Students: Hands on Particle Physics". This event is typically arranged jointly in more than 60 European university departments from about 20 countries. The programme of the Master Classes event includes high standard lectures in Modern Physics, visits and experimental work in local laboratories, as well as a common European video conference, where the results of the experimentation are collected and experiences of the day exchanged between participants in other European universities.

CMS Programme

Jorma Tuominiemi,
CMS Programme director

The HIP CMS Programme carries the responsibility 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 at a collision energy of 14 TeV at the LHC and also heavy ion collisions. The main scientific goals of CMS and the LHC involve a search for the mechanism of the spontaneous breaking of electroweak symmetry in the Standard Model of the basic structure of matter, i.e., a search for Higgs bosons, and the quest for new physics beyond the Standard Model, such as supersymmetry and extra dimensions. It also includes a heavy ion research programme, searching for quark gluon plasma. The CMS detector concept was first proposed in 1990. The Finnish team was one of the founding groups of CMS and has played an important role in its development and construction. The HIP CMS team hence has an extensive and thorough knowledge of the key features of the experiment. With the CMS experiment HIP is in the frontline of High Energy Physics research, which will take the next fundamentally important step in understanding the basic structure of matter and the origin of the Universe. The LHC started its operation at the end of 2009 at low energies (0.9 and 2.36 TeV) for commissioning purposes. CMS made an excellent start, all the subdetectors are functioning according to the design and first proton-proton collisions in LHC were recorded and analysed successfully. A fast analysis of the data collected at 0.9 and 2.36 TeV produced the first physics results. These were found to be in good agreement with the results of Monte Carlo studies performed in the preparatory phase of the experiment. A first physics paper was submitted to the Collaboration review. Before this start of proton-proton collisions, several experiments using cosmic rays had been performed over the year. The analysis of these data was completed in autumn 2009, resulting in a first step alignment and calibration of the CMS detector system. This work led to more than 20 publications. In 2010 LHC will start with 7 TeV collision energy in mid-February, with plans to increase it to 10 TeV in June. The HIP CMS Programme has been divided into two projects: 1) the CMS Analysis project, the goal of which is to develop simulation and analysis software for the CMS experiment, and to perform physics analysis of the data, 2) the CMS Tracker Operations project, which has carried responsibilities for the completion of the Outer Barrel part of the silicon tracking detector as well as for its testing.



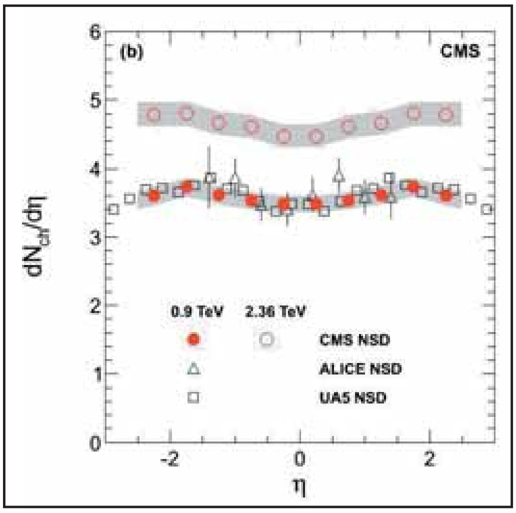
Veikko Karimäki,
CMS Physics
Analysis project
leader

CMS Physics Analysis

Introduction

While the LHC was being repaired, intensive activities in CMS took place in the field of calibrations as well as in preparations for the physics analysis. The LHC shutdown allowed the CMS groups to do refinements and repairs to the CMS detector hardware as well as to tune the event reconstruction and analysis software. The LHC restarted operations in November with a 900 GeV collision energy. In December the LHC achieved a world record energy of 2.36 TeV. The total number of collision events recorded by CMS approached one million. A draft article on these first mesaurements was ready for the Collaboration review by the end of the year.

Earlier in the year, prior to the collisions, about 500 million cosmic events were recorded in the CRAFT09 runs (CRAFT=Cosmic Run At Four Tesla). These events proved very useful for the tracker alignment in which the HIP group actively participated. A “Prompt Alignment Exercise” was organised in



Mean number of charged particles per unit of η measured in CMS at a world record collision energy of 2.36 TeV.

September in order to test CMS procedures for repetitive tracker alignment on a daily basis. In 2009 a total of 24 Collaboration articles were prepared on cosmic events and submitted to scientific journals.

Another large scale CMS Collaboration activity was the "October Exercise" in which a total of 900 TB of simulated data was processed and exchanged between the T1 and T2 computing centres. The Helsinki T2 centre participated successfully in the exercise. The purpose of the exercise was to rehearse the CMS T2 analysis model and to test the readiness of the participating institutes to produce high quality results.

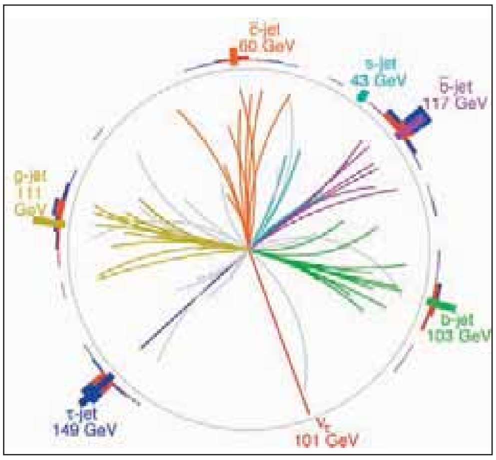
The two main fields of the CMS physics analysis in HIP were *B*-physics and the search for the charged Higgs boson. P. Eerola was the co-convener of the CMS *B*-physics analysis group and the HIP team continued to take responsibility for the analysis of the $H^{\pm}$ in the τ lepton decay channel. Our responsibility for the user support of the CMS software package CMSSW was another important HIP activity issue. The activities during the year 2009 are described in more detail below.

Physics analysis and simulation

Work on Higgs searches. The preparative study on the searches of the light charged MSSM Higgs bosons in a new discovery channel, $gg \rightarrow tt \rightarrow bWbH^{\pm} \rightarrow bqqb\tau\nu$ with a fully hadronic final state, and studies on the background measurements from data for charged Higgs boson searches were the main responsibilities of the HIP Higgs physics group (R. Kinnunen, M. Kortelainen, S. Lehti and L. Wendland). Other major responsibilities were the co-ordination of the τ trigger efficiency measurement from data, participation in the CMS October exercise for data analysis, participation in the CMS test runs and development of software and computing facilities with the local Grid cluster.

The $gg \rightarrow tt \rightarrow bWbH^{\pm} \rightarrow bqqb\tau\nu$ channel with a hadronic final state will be a potential discovery channel for the light charged Higgs bosons already during the first years of LHC operation. With this channel, the exclusion limits by the Fermilab experiments for charged Higgs bosons can be superseded with an integrated luminosity of 200 pb^{-1}. A complete search strategy for the region $m_{H^+} < m_{top}$ was developed during 2009. The major challenge of this channel is the suppression of the QCD multi-jet background, reducible mainly with τ-jet identification and missing E_T cut. A detailed study was performed on the identification of τ jets, reconstructed with the particle flow (PF) method, with luminosity-independent optimisation of the cuts (L. Wendland). To select fully hadronic final states and thus a visible $H^{\pm}$ signal, methods to identify the electrons, muons and hadronically decaying τ's from the associated top quark were developed for vetoing the leptonic events. Methods for the measurement of the associated W and top masses were introduced. The algorithms to measure the missing E_T with the calorimetric, track-corrected, and PF methods were tested for further suppression of the QCD multi-jet background.

Important progress was achieved in the development and tests of the methods for measuring the residual ttbar, W+jet, and QCD



An event display showing a simulated event with charged Higgs boson production and the decay process $gg \rightarrow tbH^{+}$, $t \rightarrow Wb \rightarrow scb$, $H^{+} \rightarrow \tau\nu \rightarrow$ hadrons with a radiative gluon jet simulated inside the CMS detector and visualized in the projection normal to the beam. The curved lines correspond to the reconstructed tracks of electrically charged particles and the rectangular bars visualize the amount of deposited energy in the electromagnetic and hadronic calorimeters.

multi-jet backgrounds from data. To measure the ttbar and W+jet backgrounds, a data driven method, based on replacing the identified isolated muon with a simulated τ in the muonic multi-jet events, was developed and tested with simulated data and implemented in the CMSSW software. Furthermore, the development of an energy correction algorithm for τ's based on combining the tracker and calorimeter information was continued. Measurement of the QCD multi-jet background from the early data with events from hadronic multi-jet triggers was investigated, assuming the probability for the hadronic jet to pass the τ-jet identification to be also measured from data. It was shown that this probability can be measured with the multi-jet events with a statistical uncertainty better than 2% for $E_T > 60$ GeV with an integrated luminosity of 200 pb^{-1}.

The development of methods to measure the τ trigger efficiencies with the early LHC data first in the multi-jet events and later with genuine τ jets from W and Z decays was continued with simulated Monte Carlo data. Work on software and computing, and the development work for new tools and methods for data analysis were continued. The activities for the multivariate analysis tools (TMVA) were also continued. The method was applied to the τ identification in the $H^{\pm} \rightarrow \tau\nu$ channel in the presence of the QCD multi-jet background.

Shift work and work on data quality monitoring. The group participated in the CMS test runs through shifts in the data quality monitoring group at CERN. Dr. Virginia Azzolini who became a member of the DQM (Data Quality Monitoring) group, has the task of data certification management, and acts as a DQM shift supervisor at P5. The results were presented regularly in the working group meetings at CERN and in group meetings and seminars at HIP.

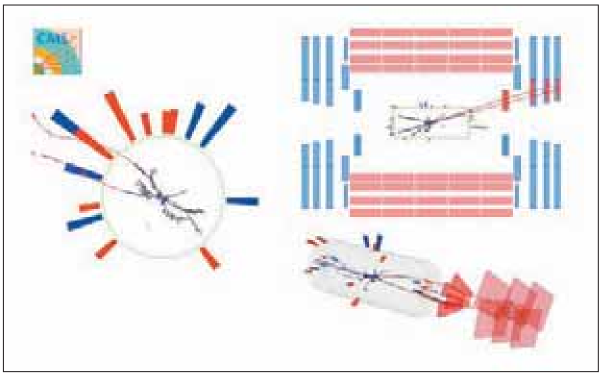
Work on B-physics. *B*-physics analyses have been started as a new physics activity in the HIP CMS Programme. The activities at HIP are led by Paula Eerola, who is also the CMS *B*-physics analysis group co-convener for 2009–2010. The *B*-physics analysis group is responsible for all aspects of *B*-physics in CMS.

The LHC provides extremely high rates of *B*-hadrons due to the high b-production cross-section, favourable signal-to-background ratio, and high luminosity. *B*-physics is a timely field in particular during the first years of data taking at the LHC, when the luminosity will be relatively low, providing a clean event environment and low trigger thresholds.

During 2009, the plans for the first year's *B*-physics deliverables (i.e., the *B*-physics analyses which should be performed and published) have been specified. Assuming 200–300 pb^{-1} of collected data, our analysis plans include at least the following channels: J/Ψ production cross-section, including a measurement of the fraction of J/Ψ coming from B decays; ϒ meson production cross-sections; J/Ψ and ϒ polarization; production cross-section and lifetimes of exclusive B decays $B \rightarrow J/\Psi\ K^0_S$, $B^+ \rightarrow J/\Psi\ K^+$, $B_S \rightarrow J/\Psi\ \Phi$, $\Lambda_b \rightarrow J/\psi\ \Lambda$; *B*-quark production cross-section; and bbbar-correlations, will be among the first physics analysis topics. Apart from physics measurements, these channels also serve as crucial standard candles for the calibration of the mass and momentum scale of the Tracker and the muon system. Furthermore, these standard decays will serve later on as control channels for new and/or rare decays.

In 2009, the HIP group was particularly involved in the analysis preparations for the decay channel $B_S \rightarrow J/\Psi\ \Phi$. This B_S decay is interesting for testing possible contributions from new physics beyond the Standard Model. The mixing induced CP-violation weak phase in the B_S decays $B_S \rightarrow J/\Psi\ \Phi$ is expected to be very small in the SM, while effects from new physics beyond the SM could easily alter the phase by adding new contributions. A relatively large statistics, corresponding to several years of LHC running, is, however, required to measure the weak phase. During the start-up phase of the LHC in 2010, the first goal is therefore to measure the differential production cross-section, and to cross-check the well-known properties of the B_S meson.

During the data taking in 2009, the *B*-physics group analysed promptly all the data, looking for events with two muons in both the 900 GeV and 2.36 TeV data. In parallel, MC samples produced with the same centre-of-mass energies were analysed for comparison. The statistics was too low to see a J/Ψ signal peak, but one candidate event was found. These results were approved by the CMS Collaboration



A two-muon event observed amongst the first one million pp collisions in CMS.

at the plenary meeting on Dec 16, 2009, and shown by the spokesperson in his report to the CERN Council on Dec 18, 2009.

CMS computing and off-line user support

The HIP team continues the co-ordination (K. Lassila-Perini) of the user support to CMS physicists. In 2009, several improvements were made to the CMS Software Documentation Suite based on the results of the usability tests of the documentation. The "Offline Software Guide" containing full details of the CMS Software went through a comprehensive review. All major stake-holders providing software or software tools for physics analysis were involved in the review and the main emphasis was given to the accessibility and availability of the information. The "Offline Workbook" containing essential instructions and basic and advanced tutorials is being fully reviewed and the structure has been adapted to the new phase of CMS operation.

For the user training, the User Support team set up a model based on a new concept emphasizing the importance of integrating acquired skills into the practical work. A successful pilot course "Using Physics Analysis Toolkit in your analysis" was organised at the beginning of 2009. The course was well appreciated and it is now regularly given before major Collaboration meetings. Approximately hundred physicists have now followed the course and many of them are actively contributing to the common software in CMS. A similar concept was followed for a course on statistical tools organised as a common effort between the CMS and ATLAS Collaborations.

Grid computing activities

To take advantage of the LHC repair time CMS organised two large computing exercises in 2009 to stress test the computing system. HIP participated both in the "Scale Testing for the Experimental Program in 2009" (STEP09) and in the "October Exercise" (T. Lindén). Both exercises gave important lessons on how to develop further the performance and procedures of the Finnish CMS Tier-2 resource. The Finnish CMS Tier-2 resource accepts CMS Grid analysis jobs in a fully transparent way and it is commissioned for analysis work. The close collaboration between HIP CMS and Technology Programmes, CSC (Finnish IT Center for Science Ltd) and the Nordic DataGrid Facility (NDGF) resulted in good progress on many aspects of the CMS software that are summarized here.

Hardware. The main CPU resource for CMS and ALICE was the 512 core Sepeli Linux cluster situated on the CSC premises, which has been very stable. In addition to that the 260 core Linux cluster Ametisti in Kumpula was used for CMS tasks. The 400 core Linux cluster Korundi also in Kumpula was connected to M-grid and configured for the CMS software environment. The 170 TB dCache disk system was upgraded with 100 TB of disk for CMS usage. The new Hitachi AMS 2500 disk space showed improved performance compared to the old Hitachi AMS 1000 racks, but still the disk I/O performance limited the CPU efficiency of CMS analysis jobs. A new cluster called Jade was purchased, which will replace Sepeli in 2010. The acquisition was made together with CSC and several other Finnish universities. The Jade cluster consists of 64 HP BL465c blades with dual 2.6 GHz AMD Istanbul six core CPUs totalling 768 cores connected with both 4x DDR Infiniband and gigabit Ethernet networks. Each blade has a 300 GB 10 000 rpm SAS disk for scratch usage and 32 GB of RAM. In addition to the HP DL385 cluster front-end, CMS and ALICE will have separate Grid front-ends to the cluster consisting of HP DL380 servers. Lustre and BeStMan will be studied as a replacement for dCache, so two Sun X4540 disk servers with 48 TB of raw disk each and a HP DL 360 server to be used as a Lustre metadata server have also been purchased.

Software. During 2009 many software services at the Finnish CMS Tier-2 became operational. Production Monte Carlo jobs started running at HIP in February. In March the CMS JobRobot started running at HIP. This is a site monitoring tool that is very useful for debugging and performance optimisation. The stability of and usability of the dCache system improved when the access protocol was changed from xrootd to dcap, which was also seen in the JobRobot statistics. Studies of the dCache system performance was carried out to measure the available bandwidth and to improve the CPU efficiency of the CMS Grid jobs. CMSSW Grid installation jobs could also be run successfully. The CRAB ARC plug-in was taken into use. During the October exercise the glidinWMS was reconfigured to work as during CSA08. The CMS Site Availability Monitoring (SAM) Compute Element (CE) jobs started running at HIP in November. Work on implementing a Local Scope DBS service and a CRABserver was started.

Operations. The Finnish CMS Tier-2 resources are operated, maintained and monitored jointly by HIP, CSC and NDGF. The beginning of the October exercise showed operations problems at CSC in connection with the Sepeli upgrade and dCache manpower allocation, but these problems have been addressed. According to the statistics collected with the CMS JobRobot, the Finnish Tier-2 resources performed very well and it was at the top of the CMS Tier-2 Readiness ranking list in December 2009.

The dCache system at CSC was very stable in 2009, but the available disk bandwidth was not enough to ensure good CPU efficiency for the CMSSW jobs.

The CMS PhEDEx and Frontier services were run on silo3 in Kumpula by the HIP Technology Programme. More than 213 TB (Monte Carlo and test) of data was transferred with PhEDEx to Finland. A total of 433 thousand CMS Grid jobs using 541 thousand SI2k CPU hours were run in 2009. In addition to this a significant amount of local batch jobs were also run.

Tracker alignment

One of the most demanding calibration activities for the CMS Tracker is the geometrical alignment of its 15 148 modules with respect to each other. The work aims at a determination of some 100 000 calibration parameters which need to be recomputed in regular time intervals. Most of the parameters are determined by analysing computed particle trajectories in order to optimise the reconstruction precision. The detector alignment is a highly important issue in view of physics discoveries.

As in the previous year, a large number of cosmic events were recorded in 2009 during several periods and used for alignment. Alignment studies were also immediately started with the first collision events in December 2009. The alignment algorithm mainly used in these alignment studies, the HIP algorithm, was originally introduced by our team (V. Karimäki and T. Lampén). In July 2009, the CRAFT09 exercise was carried out. As a continuation, a 5-day "Prompt Alignment Exercise" took place in August 2009. During this exercise new alignment constants for the CMS Tracker were calculated on a daily basis with a cumulative sample of cosmic muons. In October-November, yet another sample of cosmic muons were recorded, and alignment with these data revealed a significant deformation of the pixel detector caused by a cooling problem in the TIB detector. Therefore a new alignment calibration was performed with the latest data as a preparation for the data from the first collisions.

As part of the CMS Tracker alignment group, the HIP team participated actively in all these exercises, this time they were devoting mainly to validation and comparison of different alignment constants.

Geant4 development

The Geant4 development effort was focused on the INCL intra-nuclear cascade and ABLA de-excitation model development in collaboration with a group at the Commissariat à l'Énergie Atomique, Saclay (A. Heikkinen and

P. Kaitaniemi). These models can be used for incident p, n, d, t, He-3, alpha and pions on nuclei ranging from carbon to uranium with projectile energies from 200 MeV up to 3 GeV. In 2009 we developed a new physics list that makes INCL/ABLA models easier to use in Geant4 based applications. This new physics list has been included in the latest official Geant4 9.3 release. We have also started the implementation of the entirely new redesigned version of the INCL cascade code.

The light ion projectile support of the INCL intra-nuclear cascade model was extended up to carbon. This allows us to calculate ion-ion reactions, such as carbon on oxygen target that are relevant to the Geant4 medical user community. We also participated in the development of the Geant4 Hadrontherapy application in an IAEA co-ordinated research project 'Heavy charged-particle interaction data for radiotherapy'. This application allows us to test the new ion-ion features of the INCL model and directly benchmark it against other Geant4 models, such as the Binary cascade.

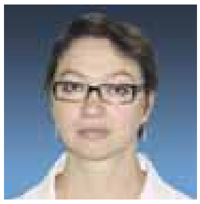
Test beam off-line data analysis

The development of the CMSSW-based off-line analysis code for the Silicon Beam Telescope (SiBT) Collaboration continued together with the CMS Tracker Operations project. Our project provided software and analysis support during the beam tests of summer 2009 (M. Kortelainen and T. Lampén). The project participated actively in the following data analysis, for which the CMS Tracker Operations project carried the main responsibility.

Outreach activities

The group members were active in presenting CERN and the LHC experiments to visitor groups from Finland. The groups included high school students and a group of high school teachers. The members also approached the general public by writing popular articles and giving popular talks, by giving interviews and by maintaining a blog describing the status and goals of the LHC experiments. Special outreach sessions were arranged to recruit graduate level summer students.

CMS Tracker Operations



Paula Eerola, CMS Tracker Operations project leader

Operation of the CERN CMS Tracker

In autumn 2009 the commissioning of the CMS Tracker with cosmic muons was completed and the first collision data from the LHC was recorded. In addition to basic service work related with Tracker commissioning, the HIP group designed and delivered an electrical noise monitoring system, which is integrated in the CMS Tracker low and high voltage power supply chain. The first version of the CAEN power supply monitoring system is designed by Dr. S. Czellar and was installed in the CMS cavern just before the annual closure of CERN. The system will be upgraded later to accommodate more advanced functions.

In September 2009 Dr. Virginia Azzolini became a member of the DQM (Data Quality Monitoring) group and has the task of data certification management. Data certification is very important in the scope of data analysis, since it defines the quality of the recorded data. In addition, Dr. Azzolini acts as a DQM shift supervisor at P5.

Development of Radiation Hard Silicon Detectors, including the Silicon Beam Telescope (SiBT)

During 2009, the research on radiation hard silicon detectors continued in the framework of the CMS upgrade programme and of the CERN RD39 (60 members, 15 institutes) and RD50 (280 members, 55 institutes) research programmes. Dr. Panja Luukka was nominated as CMS Tracker upgrade test beam coordinator and Academy Research Fellow Jaakko Härkönen continued as RD39 spokesperson. The network of these RD programmes links together practically all important research groups worldwide in this field and provides access to a wide selection of characterization and simulation tools. Detector irradiation campaigns were continued at the Accelerator Laboratory of the University of Helsinki (UH) in collaboration with the local group.

In addition to laboratory measurements on test devices, comprehensive characterization based on real particle tracks is rather mandatory to establish a reliable scenario of detector performance in very harsh radiation environments. Tests of Super-LHC fluence irradiated detectors were continued with the Silicon Beam Telescope (SiBT) at the CERN SPS H2 test beam area. The SiBT is a telescope that accurately measures reference tracks of beam particles. The readout electronics and data acquisition (DAQ) system of SiBT consists of CMS Tracker Outer Barrel hybrids and CMS Tracker data acquisition cards. The telescope consists of eight reference detector planes and two slots for the detectors to be tested. The test beam experiment and related data analysis was done in collaboration with Fermilab and with the Universities of Karslruhe, Rochester and Brown. Due to the successful beam conditions and software improvements, it was possible to collect more than 1 TB of high quality data during the test beam period in 2009. The data analysis exercise did not only reveal the detector parameters such as Charge Collection Efficiency (CCE), cluster resolution and signal-to-noise, but also increased the general level of understanding of heavily irradiated position sensitive detectors operation when attached to appropriate readout electronics and DAQ. These findings were reported in international journals and conferences in 2009.

SiBT beam tests in summer 2009: a silicon sensor with readout.

The investigated detectors were processed at Helsinki University of Technology Micro and Nanotechnology Centre (Micronova). The baseline of our detector development has been high resistivity magnetic Czochralski silicon (MCz-Si) produced by the Finnish manufacturer Okmetic Oyj. Our previous studies reported in 2009 have shown that MCz-Si detectors made by standard industrially adopted fabrication techniques will tolerate a radiation load up to 1×10^{15} n_{eq} (neutron equivalent) / cm^2, i.e., sufficiently to cover more than 90% of the silicon needed for the future upgrade of LHC experiments. In 2009 we tested full-size strip detectors processed with advanced techniques aiming to push the radiation hardness even further to 1×10^{16} n_{eq}/cm^2, which is required for the innermost pixel layers in the future Super-LHC. In addition, measurements of S-LHC fluence irradiated 3-dimensional (3D) detectors were performed in collaboration with the University of Freiburg and the University of Glasgow.

CMS Tracker Operations Project at HIP/UH Detector Laboratory

During 2009, the HIP/UH Detector Laboratory supported several of the activities of the CMS Tracker Operations project. The Finnish Cosmic Rack (FinnCRack) was hosted at the premises of the Laboratory, the Transient Current Technique (TCT) measurement unit was being commissioned and irradiation studies were done in co-operation with the Physics Department. In addition, various educational activities for physics students were organised. Furthermore, the probe station set-up at the Laboratory clean room was continuously used for the characterization of the silicon detectors processed by the HIP Tracker group.

TCT is a tool to measure the Charge Collection Efficiency (CCE) of an irradiated detector. It is based on the detection of the dominant type of charge carriers, electrons or holes, which are trapped by the radiation defects while drifting through the detector thickness. The excitation of the electron-hole pairs is achieved either by a picosecond laser pulse or by a radioactive source. During 2009, the electrical part of a novel TCT measurement system was manufactured and tested at the Detector Laboratory. In addition, the design of the mechanical part, including the sample holder, was started by a student, T. Peltola, who had joined the research group. The first tests of the Helsinki TCT system were performed with a red laser (670 nm) and pulse generator, constructed by Dr. Sandor Czellar. The Helsinki TCT resembles the CERN RD39 cryogenic TCT, e.g., the 3 GHz oscilloscope and the operating software are identical.

During 2009, the close collaboration between the Tracker project and the **Accelerator Laboratory** of the UH Physics Department continued. Successful experiments were performed concerning the breakdown of silicon particle detectors under proton irradiation and the effects of activation by proton irradiation on silicon particle detector electric characteristics. Using the lessons learned during these studies, the interesting effect of an electric field on the radiation tolerance of Float Zone and Magnetic Czochralski silicon particle detectors was explored.

RPC Trigger at Lappeenranta University of Technology

The first production series of link boards for the readout of the six RE11 Resistive Plate Chambers (RPCs) installed in CMS were produced and tested at Lappeenranta University of Technology (LUT). A new design of all the boards, i.e., the link board, the control board and the back plane was made. These boards were delivered to CERN and tested to fit inside RE11 mechanics in CMS. These boards require a dedicated firmware which will be developed by the Warsaw group. We expect them to be ready for the next installation period.

In the future, there will be some production or testing required for the RPC link boards, but the main activity of the LUT group has

TCT set-up: AutoCAD design of the TCT sample holder.

been shifted back to the Tracker project. To make use of the experience and the infrastructure gained in the RPC Trigger project it was natural to get involved in the Track Trigger of the CMS Tracker Upgrade.

Education

During 2009, one PhD degree was accomplished in LUT in the RPC project (Giacomo Polese, *The Detector Control Systems for the CMS Resistive Plate Chamber at the LHC*). One Master of Science degree was obtained at Helsinki University of Technology (TKK) about the characterization of silicon detectors (Maria Maksimow, *Transient Current Technique (TCT) Characterization of Silicon Particle Detectors*). The Helsinki project group gave tuition to students from the UH Physics Department. Two undergraduate students (H. Moilanen, T. Peltola) and one post-graduate (T. Mäenpää) worked for their theses within the group. In addition, a group of students were performing silicon detector measurements in the clean room as a part of their course on measurement technologies. Furthermore, one student already exploited the novel TCT as a platform for his special exercise.

Nuclear Matter Programme

Juha Äystö,
Nuclear Matter
Programme director

The Nuclear Matter Programme provides participation of the Finnish teams at CERN in studies of two aspects of nuclear and hadronic matter. These are cold exotic matter with the extreme composition of its proton and neutron numbers and hot and dense matter created in relativistic heavy ion collisions. The first project is carried out at the ISOLDE facility and the second one has concentrated in 2009 on developing/carrying out the Finnish Physics Programme for ALICE. The ALICE project aims to study the phase transitions of hadronic matter and possible signatures of a new form of matter, the quark and gluon plasma. The ISOLDE project has its physics motivation in studies of exotic structures of nuclei, with a special emphasis on weak interaction phenomena and nuclear astrophysics and reaccelerated radioactive beams. The project leaders of these two projects are Docent Ari Jokinen for ISOLDE and Dr. Jan Rak for ALICE. In addition, the Nuclear Matter Programme has continued co-ordinating the Finnish participation in the planning of the FAIR project at GSI. FAIR stands for Facility for Antiproton and Ion Research. The Finnish involvement in FAIR includes participation in the construction of the Super-FRS facility and the NUSTAR Collaboration for nuclear structure and astrophysics studies. Industrial participation in constructing the FAIR facility is being explored in collaboration with TEKES and Finpro.

ALICE

Introduction

Jan Rak, ALICE project leader

The year 2009 was important for ALICE and the Finnish ALICE team. A major milestone took place on 23rd November 2009 as ALICE measured the first p+p collisions when low intensity ($0.5x10^{10}$ p/bunch) pilot beams crossed inside the ALICE interaction region. The first ALICE publication (Eur. Phys. J. C 65 (2010) 111), based on the analysis of these events, was released to arXiv only 5 days later on 28th November. It certainly demonstrated the excellent performance of the detectors and both on-line and off-line reconstruction. By the end of 2009 ALICE had collected roughly 0.5 million p+p events, corresponding to an integrated luminosity of the order of 10 μb^{-1} at $\sqrt{s}$ = 900 GeV.

Jan Rak served as run co-ordinator for the first real data taking period and will continue also during the first part of 2010. Jiri Kral and Norbert Novitzky participated in the EMCAL single photon trigger project. DongJo Kim and Jiri Kral were involved in the Central Trigger Processor (CTP) activities. All of us spent a significant fraction of our time with data analysis, EMCAL calibration and we participated in the ALICE cosmic and the first injections data taking. At the end of the run on 18th December the Finnish group had fulfilled 78% of the due shift quota in 2009.

Besides the above mentioned involvements in the ALICE commissioning, operation and data analysis our team also organised a student visit to CERN. We will organise a similar CERN/ALICE visit in February 2010. We participated in the organisation of the “4th international workshop High-pT physics at LHC 09” in Prague (see http://cquark.fjfi.cvut.cz/~hpt09/index.html) and Jan Rak was also selected as a member of the International Organizer Committee of the “5th International Workshop on High-pT Physics at LHC”, September 27th - October 1st 2010, in Mexico City, Mexico and of the workshop “Critical Examination of RHIC Paradigms”, at The University of Texas at Austin, Austin, Texas. We supervised one summer student at CERN (Jussi Viinikainen) and another summer trainee in Jyväskylä (Mikko Kervinen). Both of them expressed an interest in continuing with our group on their Masters' degree and PhD.

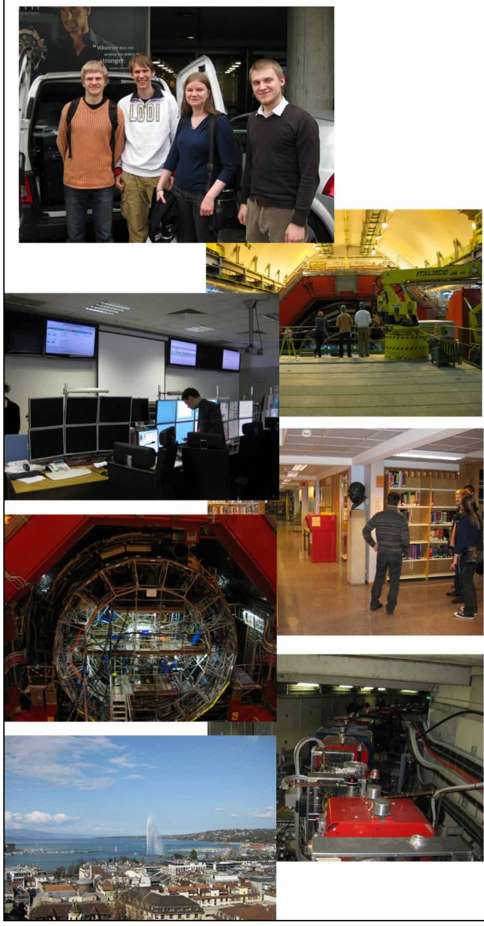
Detector operation and run co-ordination

The Finnish team **participated actively** in all cosmic, beam-injection and first data taking achieved in 2009. Our goal was to participate in the CTP activities involving the trigger L0 signal alignment, tuning the first minimum bias trigger classes based on bunch crossing ID, silicon pixel, V0 and T0 detectors. DongJo Kim took a major responsibility for trigger on-line monitoring software (AMORE) and we developed the off-line tools for trigger alignment monitoring.

Because of our participation in the EMCAL commissioning Jiri Kral is now one of the key experts for the operation of the EMCAL readout electronics (RCU), Trigger Region Units (TRU) and Summary Trigger Units (STU). Jiri Kral has developed the FPGA firmware for the cosmic and single photon trigger. His role was to ensure the optimal performance of the trigger hardware, analyse the trigger data to understand the trigger efficiencies, biases etc. He was invited to Bergen, Norway PHOS (the low-pT photon calorimeter for ALICE) to accommodate his firmware to PHOS electronics. That is a clear demonstration of the quality of his work. There is a need to find him a new student to unload part of his duties and maintain the knowledge transfer. His next focus should be on the data analysis.

Jan Rak will continue to serve as a run coordinator during 2010. Some of the results achieved during Jiri Kral's run co-ordination term are documented at http://aliceinfo.cern.ch/Collaboration/Run_Coordination/Run09/ (see Timetable, extraction and injection tests).

Last year's CERN visit



Day 1
morning, afternoon: travel; pick-up at the airport

evening: hostel check-in; dinner

Day 2
morning: anti-matter lecture by Michael Doser; guided visit of anti-proton decelerator; AEGIS experiment presentation

afternoon: Microcosmos exhibit visit; summer student habitation visit
evening: St. Genis-Pouilly visit; social event with JYU group students @ Charlies Pub

Day 3
morning: ALICE experiment visit; Jan Rak's lecture on contemporary experimental physics

afternoon: Computing Center visit; JYU office and EMCAL lab visit; CERN Control Center visit

evening: barbeque with JYU group

Day 4
morning: east-hall visit, CERN detector seminar by Hans Dijkstra on trigger (basic level, JYU group building trigger for EMCAL)

afternoon: free afternoon for Geneva visit

evening: young@cern party possibility

Day 5
morning: departure

"I learned actually a lot. Mainly basic principles of the experiments done in CERN but also a lot of details I did not previously know. I learned that living and working in CERN involves a lot of communication with other enthusiastic people. Simply it has been great."

CTP activities

Because of our interest in high-pT physics, the Jyväskylä group participates actively in the operation of the ALICE Central Trigger Processor (CTP). We have prepared the tools for lowest level (L0) timing alignment of various trigger detectors, debugging tools to elimination spurious L1 signals and we are developing the on-line monitoring system (AMORE) which allows on-line checking of trigger timing, bunch crossing rates etc.

We will continue with the development of the debugging and monitoring tools together with the Birmingham group responsible for the CTP hardware. We will also carry on the simulations needed for the proper trigger set-up, bandwidth partitioning etc. Furthermore, we plan to actively participate in the setting-up and operation of the ALICE trigger system.

Hardware commitments - T0, EMcal

During the first half of 2009 the T0 team lead by W. Trzaska successfully finished the commissioning of the T0 timing detector. The

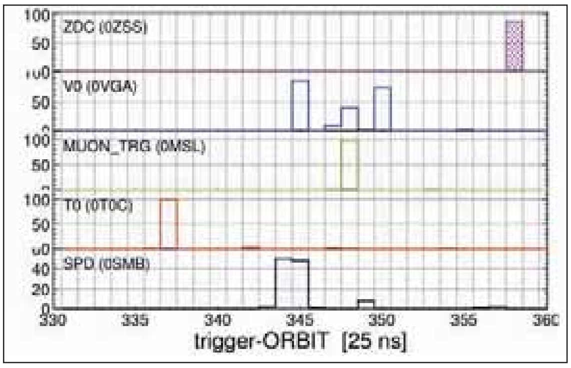


Figure 1. ALICE trigger timing: arrival time of the various trigger detector signals with respect to the LHC orbit signal measured in LHC bunch crossings (25 ns). Channel 17 0T0C comes about 7 bunch crossing = 175 ns before the main trigger signal generated by the Silicon Pixel array OSMB.

detector was tested in TI2 extraction tests (beam from SPS dumped at the TED before reaching LHC) during 10th–13th July and 25th–26th September and even with the first heavy ion beam going through ALICE to P3 on 23rd–26th October. Figure 1 shows the L0 time latency with respect to the orbit signal generated by LHC. The T0 signal demonstrates an excellent timing.

It is important to continue maintenance and operation of the T0 detector in 2009–2030 and beyond. We hired Filip Krizek from Prague to strengthen the T0 team from 1st January 2010. His role will be to play a leading role in the T0 activities, to operate, maintain and develop the running strategies as a deputy project leader. He is expected to be involved also in the ALICE data analysis and physics.

The Electromagnetic calorimeter (EMcal) is an important addition to the ALICE physics capabilities. The main purpose of this ALICE upgrade is to provide a high-pT trigger, which will allow the extending of the pT reach of the ALICE experiment by a factor of 4 and more. In 2007, the Jyväskylä group joined the USA/France/Italy collaboration and took responsibility for development and commissioning of the Trigger Units (TRU). TRU is a FPGA based processor, which is able to perform an on-line analysis of the signals of one EMcal module. It evaluates sums of the individual tower signal in a 2×2 sliding window and generates the L0 signal based on comparison of the sliding window sums with the threshold values. All this is done within 800 ns after the collision. This trigger is sensitive mainly to high-pT single photon hits.

We were responsible for production of the 34 TRU boards, commissioning and developing the FPGA firmware. We are currently considering design improvements based on our current experience. This would be a minor investment since all the components for the remaining boards are already purchased. Jiri Kral will continue developing the firmware and will be responsible for operating the L0 EMACAL trigger.

First physics

The main goal, however, of the Finnish ALICE group in 2009–2010 is a preparation for physics analysis. On 23rd November 2009 the ALICE experiment reached one of the most important milestones: the first p+p collisions were recorded. Already the first recorded run containing in total only 284 events acquired in just over 40 minutes, sufficed for ALICE to produce the first paper (ALICE Collaboration, Eur. Phys. J. C 65 (2010) 111) with the pseudorapidity dependence of dNch/dη for inelastic and non-single diffractive collisions, and with the charged-particle density in the central rapidity region. The measured values agree with the UA5 results at the same centre-of-mass energy (UA5 Collaboration, Z. Phys. C 33 (1986) 1). As the luminosity increased ALICE collected 0.5 million proton-proton events, corresponding to an integrated luminosity of the order of 10/μb, at √s = 900 GeV accumulating sufficient statistics for a comprehensive analysis. Just one week after the first collision LHC has reached a new world record for beam energy. The first preliminary results for the charged particle pseudo-rapidity density at √s = 2.36 TeV are shown in Figure 2.

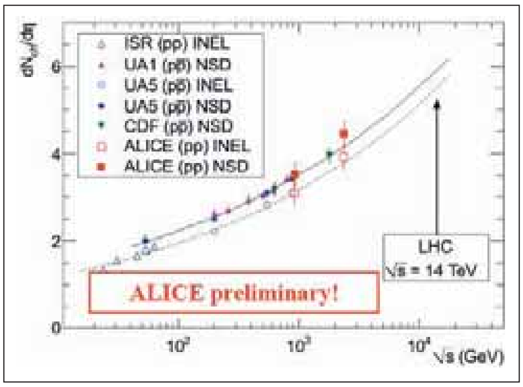


Figure 2. Charged particle rapidity density as a function of collision energy. The ALICE √s = 2.36 TeV points present the new (preliminary) results in this world record energy.

Our main focus is on photon physics and high-p_T particle correlations and jets. One of the most important open questions is how the excited QCD medium generated in the ultra-relativistic heavy ion collision interacts with penetrating probes like high-p_T partons, photons or heavy quarkonia. RHIC results revealed many unexpected features such as a universal suppression pattern for quarks and gluons and also for light and heavy quarks. It is known that the inclusive particle yields expressed in terms of a nuclear modification factor are not very sensitive to the details of partonic interactions. Two particle correlation or direct photon-hadron correlation techniques provide cleaner insights into collision evolution. In particular, the direct photon correlation provides nearly a direct measure of the away-side parton energy loss due to the lack of any final state interaction. This picture is modified, to some extent, by the primordial partonic transverse momentum (k_T) smearing. We are developing analytical techniques to extract the unsmeared parton kinematics, which will allow us to directly measure the modification of the fragmentation function induced by the excited QCD medium.

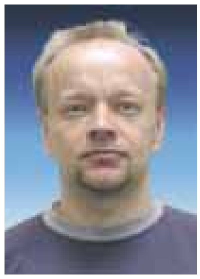
For high-p_T physics, a main focus of our group is on the EMcal and Photon spectrometer (PHOS), a lead scintillator electromagnetic calorimeter. PHOS has small acceptance ($|\eta|<0.12$ and 60^o in azimuth) but on the other hand it allows the measuring of the photon spectra down to the very low momenta ($pT \geq 1$ GeV/c), which is so important for Heavy Ion physics.

We are leading the "high-pT leading particle correlation" subgroup of the PWG4 physics working group. We are preparing a manuscript for the first paper concerning unidentified hadron correlations and leading charged particles associated yield analysis.

Data analysis and computing

Since 2007, we have worked on the ALICE Grid project, collaborating with HIP (Helsinki Institute of Physics) and CSC (the Finnish IT Center for Science) in Helsinki. This effort resulted in fulfilling the pledged numbers for the LHC/Grid since 2008 and gave us big advantages for speeding up the analysis. The integration of 256 new CPU's that have been purchased this year into an ALICE Grid computing frame is being finalised. With the improvements of the Finnish Grid and opening up of the Ethernet link to CERN for large volume data transfer, we were able to perform our analysis almost in real time from the first collision we took in the ALICE control room. The possibility of parallelizing the AliRoot (ALICE off-line framework) processes with language independent libraries used specifically for parallel supercomputers was investigated and we intend to set it up at the Jyväskylä site in 2010. Currently, we are performing the full data-analysis chain with the simulated, cosmic and LHC collision data.

ISOLDE



Ari Jokinen, ISOLDE project leader

An experimental period at the ISOLDE laboratory was again productive. Apart from the steady scientific programme, a major breakthrough was achieved, when the HIE-ISOLDE project was fully endorsed by the CERN Research board. This paves the way for an energy and intensity upgrade of the present REX-ISOLDE from typically 3 MeV/u up to 10 MeV/u, thus allowing a wider physics programme in future years at ISOLDE.

Research with radioactive post-accelerated beams - Coulomb excitation of light Hg isotopes

The highly efficient MINIBALL Ge-detector array combined with inner particle detectors, i.e., the CD and Barrel detectors, coupled with the REX-ISOLDE facility have enabled unique studies of nuclear matter at extremes by employing Coulomb excitation and transfer reactions.

The low-lying states in odd mass neutron-deficient ^{107,109}Sn isotopes were investigated in a Coulomb excitation experiment. Due to spin selection rules, these dominantly "one quasi-particle" states are difficult to populate in beta-decay or fusion evaporation reactions, whereas E2 excitation from the ground state via Coulomb excitation is more favourable. This work aims to shed light on the evolution of collectivity and the single particle properties in the ^{100}Sn region, where much of the most crucial structure information remains unknown.

Collectivity and single particle properties were also studied in a Coulomb excitation experiment of neutron-rich ^{28,29,30}Na nuclei, addressing the borders of the 'island of inversion' around Z=12 at N=20. In these nuclei, a different transition from the usual filling of the neutron levels into the region with low lying 2p-2h cross shell configurations is predicted by theory.

The T-REX transfer reaction set-up was used to study the single particle character of the ground and first excited states of ^{67}Ni. The experimental results will provide important input and a test for large-scale shell-model calculations and also shed more light on the fragile nature of the N=40 sub-shell closure. T-REX was also employed in the nuclear structure study of ^{12}Be through the ^{11}Be(d,p)^{12}Be transfer reaction.

Analysis of two earlier reported Coulomb excitation studies, one for light ^{182,184,186,188}Hg isotopes (Z = 80) and another one for neutron-deficient Rn nuclei (Z = 86), continued in 2009. Some preliminary results were published in A. Petts et al., "Lifetime Measurements and Coulomb Excitation of Light Hg Nuclei", AIP Conf. Proc. 1090, 414 (2009). Figure 3 shows a gamma-spectrum obtained for the Coulomb excitation of ^{204}Rn on a ^{120}Sn target. An excitation of the first 2+ state is clearly visible as well as X-ray lines. In addition, a new experiment on light ^{198,200,202}Po isotopes (Z = 84) was performed. In the cases of Hg and Rn, a complementary experiment at JYFL with the recently commissioned SAGE spectrometer is planned for the spring of 2010 and an additional Coulex run is planned at ISOLDE.

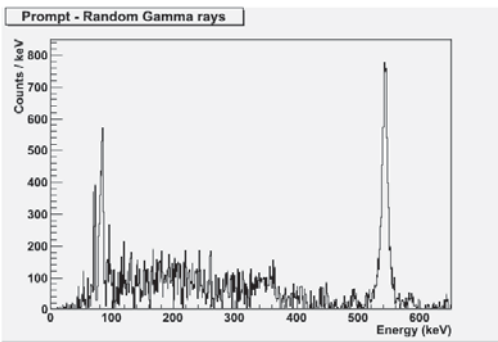


Figure 3. A gamma-spectrum obtained in Coulomb excitation of ^{204}Rn.

In-depth study of beta-delayed proton decay of ^{31}Ar

Beta decay of ^{31}Ar is an excellent laboratory for the study of 1p, 2p or even 3p emission. Our first studies were performed already in the early 90's but since then various experimental upgrades have become possible allowing a more detailed investigation. In August 2009, a compact high granularity set-up was applied to study beta-delayed particle emission of ^{31}Ar at ISOLDE by the Århus-Bordeaux-CERN-Göteborg-HIP-Madrid collaboration. A cube of six thin DSSSD, thick Si-pad telescopes in addition to two Miniball clover Ge-detectors were used to probe possible 3p decay channels. The preliminary on-line analysis showed no such channel, but the experiment yielded far higher statistics for the 2p channels thanks to the high granularity of the set-up.

Laser spectroscopy of neutron-rich gallium isotopes using the ISCOOL RFQ cooler and buncher

The year 2009 heralded a successful campaign of high resolution optical spectroscopy measurements at ISOLDE using cooled and bunched beams from the newly installed ISCOOL device. Previous measurements performed in 2008 were quickly repeated, namely isotopes from stability to ^{79}Ga. In addition, these were extended to $^{80-82}$Ga, across the N=50 shell closure.

Figure 4 illustrates the performance of ISCOOL. Panel (a) shows the raw photon signal for a continuous ion beam compared to (b) in which a bunched beam was combined with a 6 μs time gate applied to the photon signal, defining the atom-laser interaction time. The ion time of flight (measured using the resonant photon signal and shown in panel (c)) was monitored to ensure the gate covered the ion bunch profile, which has a weak mass dependence.

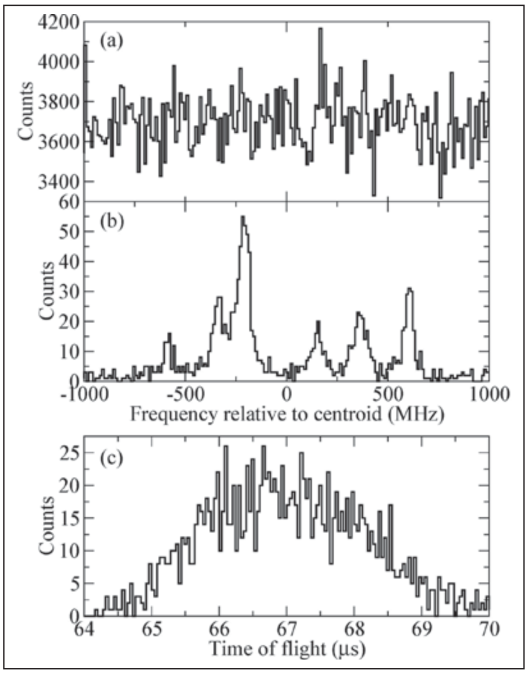


Figure 4. An illustration of the performance of the ISCOOL device. For details, see the text.

Nuclear spins, magnetic and quadrupole moments and isotope shift measurements were extracted from the 2009 data and were largely unknown prior to these measurements. The primary physics motivation, an investigation of the phenomenon of monopole migration, was validated via the ground state nuclear spin determination which showed a spin inversion taking place between ^{79}Ga and ^{81}Ga. A similar inversion was observed in the copper isotopes between N=44 and N=46, also performed at ISOLDE, recently published in PRL. Presently an addendum to the gallium proposal is being prepared for the INTC in 2010 requesting beam time to study the neutron-deficient isotopes of gallium.

Solid state physics

The solid state physicists participated in a new ISOLDE project related to precision measurements of the decay rate of ^{7}Be implanted in various host materials. The aim is to determine the ^{7}Be half-life dependence on the hosting material via small modifications of the electron density around the ^{7}Be nucleus. During the year 2009 a publication based on the solid state physics activities of previous years appeared in Semiconductor Science and Technology 24 (2009), as "The effect of material growth technique on ion implanted Mn diffusion in GaAs" by O. Koskelo, J. Räisänen, F. Tuomisto, J. Sadowski, and the ISOLDE Collaboration.

FAIR (Facility for Antiproton and Ion Research)

Juha Äystö, FAIR project leader

NUSTAR Collaboration

Preparatory work for FAIR (Facility for Antiproton and Ion Research) has started in 2006 and has continued through 2009. The Ministry of Education has awarded HIP 1 M€ in 2008, 1.2 M€ in 2009 and 1.25 M€ for 2010 towards the Finnish in-kind contributions for the construction of the FAIR facility. The main contributions will be spent for the construction of the experimental equipment within the NUSTAR Collaboration and the Superconducting Fragment Separator (SFRS). The foundation of the FAIR Company is the next necessary step for finalisation of the Finnish contributions for the construction of the FAIR facility. Our main participation in FAIR experiments will focus on three experiments called MATS, LaSpec and HISPEC/DESPEC. The technical design reports of the first two were finished in 2009 and are now going through a final evaluation. The third experiment is finishing its technical design report. The main source of funding for the FAIR construction is organised through HIP. The actual work force for the experiments is located at the University of Jyväskylä. The Super-FRS beam diagnostics project will be one of the responsibilities of the HIP Detector Laboratory.

Several industrial projects are also being worked on with the help of Finpro. They

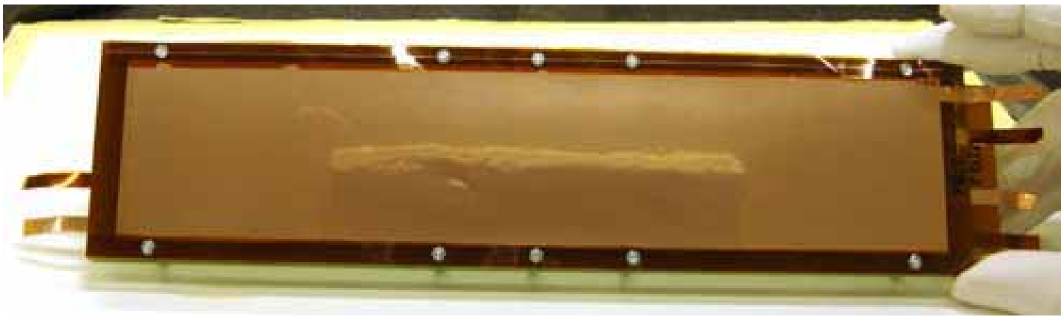


Figure 5. A stack of three GEM foils for the FAIR GEM detector prototype.

include a superconducting magnetic energy storage system (SMES), a state-of-the-art desktop computing environment with Grid capabilities and radiation hard Si-strip detector technology for the CBM detector. These activities are being carried out independently by the industrial partners and TEKES.

Construction of the FAIR facility will be based on a modular approach starting with the construction of the SIS100 synchrotron followed by the experimental facilities related to plasma physics, antiproton physics and radioactive beam physics. The last one will employ the aforementioned Super-FRS separator. According to the present plan the construction of FAIR will start in late 2010 and the first commissioning experiments with the Super-FRS are expected to take place in 2016–2017.

Superconducting Fragment Separator (Super-FRS)

The beam diagnostics system for the FAIR Superconducting Fragment Separator (Super-FRS) consists of several detection stations relying on the use of position sensitive diamond detectors, gas detectors and silicon strip detectors. From its CERN-related projects, the Detector Laboratory of Helsinki Institute of Physics (HIP) has a long experience in manufacturing the gas and silicon detectors that could be used for the Super-FRS beam diagnostics.

The FAIR research group working at the Helsinki Detector Laboratory focuses specifically on the design, prototyping and production of totally **40 GEM-TPC** (Gaseous Electron Multiplier - Time Projection Chamber) detectors for Super-FRS diagnostics. During 2009, the first **GEM detector prototype** was designed at the Detector Laboratory and all its components were carefully tested in laboratory conditions. The components were manufactured by both CERN and Finnish companies. Alongside the prototype design and construction, **simulations** were made using GEANT4 and Garfield simulation programs.

At the end of the year, an **optical scanning system** was installed in the Detector Laboratory clean room. This system will serve as an essential tool for the three-dimensional quality control of GEM-foils and readout boards. For various research purposes, a **10x10 cm GEM-detector** with two-dimensional readout was obtained from CERN. Inside the detector, the detector specifications can be modified. With this ability and with the results obtained by

Figure 6. The readout board of the FAIR GEM detector prototype.

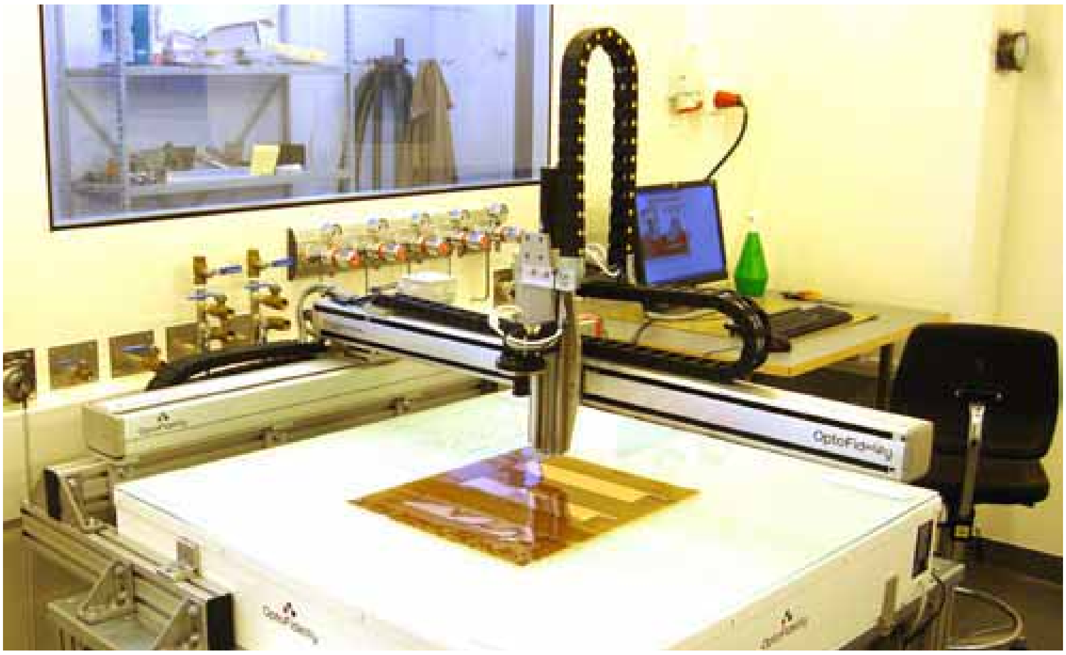


Figure 7. A set of three GEM foils are being monitored by the new optical scanning system in the Detector Laboratory clean room.

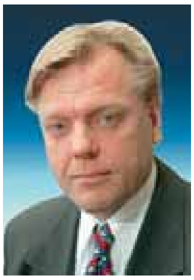
a scanning system, the characterization of the GEM foils can be carried out. A Totem Test Platform card (**TTP**) obtained from CERN can be used for GEM foil characterization with the 10x10 GEM detector. The software used to operate the TTP was developed in collaboration with the research group from the TERA foundation at CERN.

The GEM-TPC detector prototype is being constructed in a close **co-operation** with research groups from Comenius University Bratislava, CUB, responsible for the field cage and integration, and the GSI Detector Laboratory for supplying the readout electronics and data acquisition (DAQ). This first prototype will serve as the basis for the design of the final 40 GEM-TPC detector that will be located at the Super-FRS.

Furthermore, the GSI Detector Group working with the Super-FRS diagnostics have shown continuous interest in the Helsinki expertise in radiation hard silicon **detector technology**. A common project to develop applicable silicon detector technologies is being undertaken as a co-operation between the HIP research group and Helsinki University of Technology, Laboratory of Materials Science.

Technology Programme

Ari-Pekka Hameri,
Technology Programme
director



The year 2009 provided some additional time to build up the Tier computing capabilities in Finland due to the repairs to the LHC accelerator. The required national Grid infrastructure is in place as planned. Our contributions to the EU-funded EGEE-III project have continued with the emphasis on Grid security system development and certification. New research trajectories related to energy efficient cluster computing continued to provide useful results on how new load-based job scheduling has favourable energy consumption effects in a Grid facility. Collaboration initiatives with Finnish industry have been launched. Moreover the second Grid seminar course for IT students and researchers at Helsinki University of Technology was organised in spring 2009.

Antti Pirinen,
GridCluster
project leader

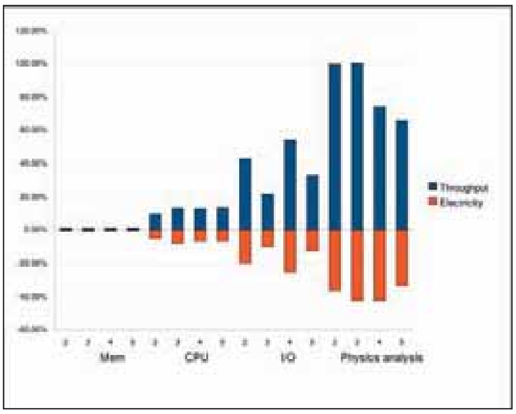
Physics and Cluster Computing

The Finnish Tier computing project continued officially for the second year in 2009. This project is performed in collaboration with CSC and financially backed by the Ministry of Education to build, operate and maintain a Grid computing centre in Finland. The raison d'être of the GridCluster project is to coordinate Finnish Tier activities and to provide assistance for CERN CMS and ALICE experiments.

Physics Computing

In 2009 the main action of the Finnish Tier computing was to stabilise the system built in 2008. In practice this meant that HIP provided pledged resources to the distributed Tier-1 centre of the Nordic DataGrid Facility (NDGF) regarding the ALICE experiment and the project continued to build an independent Tier-2 centre for CMS together with the CMS experiment. The whole Tier work was done in close collaboration with CSC - the Finnish IT Center for Science. In practice HIP has bought the operating system level maintenance of the computing nodes and the storage capacity from CSC while itself concentrating on solving challenges at the Grid middleware and at the end user application level.

The hardware of the Tier-1 and Tier-2 computing systems is distributed between Helsinki, Espoo and Jyväskylä. From the computing point of view, the main resource was the *Sepeli* Linux cluster. This cluster has 512 AMD 2.2 GHz computing cores, roughly 1 TB of memory and 20 TB of local disk space. For the CMS experiment, the secondary resource was the *Ametisti* Linux cluster which has 260 AMD Opteron CPUs and is located in Kumpula. There is also a cluster called *Korundi* that has 400 computing cores but it was mainly used for local jobs in 2009. For the ALICE experiment the secondary computing resource was located in Jyväskylä and was called the *Opaali* cluster. *Opaali* has 52 computing cores and 5 TB of storage capacity. From the storage point of view, the existing Hitachi AMS 1000 disk system (170TB) was upgraded with a new Hitachi AMS 2500 disk system. After this upgrade the total amount of disk storage capacity was 310 TB. HIP pledged 128 TB



Improvements on a multi core Opteron PC machine when running multiple tasks simultaneously compared to 1 task/ CPU core setting.

of tape space in 2009 but because less than 1 GB of the tape was used, the actual amount of tape space is still 64 TB. The storage space was served to clients via nine dCache servers (three for ALICE, six for CMS) and the connection point of the system was at the premises of CSC with an uplink speed of 10 Gbps.

Due to the considerable age of *Sepeli*, *Ametisti* and *Opaali*, it was necessary to start the retirement process of the named resources. To help alleviate an imminent lack of resources, a new HP Linux cluster was acquired at the end of 2009. This cluster contains 64 HP BL465 servers (2 × 2.6 GHz CPU per server) that provide altogether 768 computing cores. The total amount of memory is 2 TB and the system has 20 TB of local disk space. In addition to this, two Sun's X4540 disk servers were acquired. Each of these storage servers provides 48 TB of raw disk space (40 TB with RAID). It has been planned that these servers will provide the disk space for computing nodes using the Lustre file system. Also, to ensure efficient communication between the nodes and acquired workspace, the components are connected using Voltaire's InfiniBand network. At the time of writing, the software installation of the system was not ready. However we have all reason to believe that the performance of the system will be superior in all respects compared to the previous systems.

Apart from mere hardware operations in 2009, probably the greatest merit of the GridCluster project was that together with the CMS Programme it was able to push some vital modification to the gLite Workload Management System (WMS). Thanks to updated NorduGrid ARC middleware components and some configuration changes, the gLite WMS is now able to submit jobs to ARC middleware. The patch was certified in June 2009 and it has been in production since then.

The GridCluster project was also actively helping the development of a CRABARC plug-in. This plug-in provides the possibility to submit CRAB jobs directly to resources that are using ARC middleware. The first version of this plug-in was committed to the CERN software repositories in March and at the end of 2009 the plug-in had reached the stage where it was working reliably. Technically speaking the plug-in relies on an ARC client package, but we can expect that this requirement will be removed sometime in the future. The GridCluster project was also operating the CMS data transfer system (PhEDEx) and conditions data access (FroNTier). The project also had a representative in the CMS data analysis task force, in NDGF's CERN committee and in the Grid deployment board of the Worldwide LHC Grid (WLCG).

Finnish Cluster Activities

The GridCluster project has also been active outside the Finnish Tier project. The project has continued to build nationwide user certificate infrastructure for academic research. The purpose of this system is to lower the threshold for Grid use. Programming is completed and we can expect that CSC will take the system into production in the spring of 2010.

One of the highlights for the project was the Cloud computing seminar of the FennoGrid association where we assumed the role of event organizer together with CSC and BaseN. The seminar was held in August and it attracted

New Jade Tier computing cluster purchase merchandise in late 2009.

FennoGrid ry organised a well-received Cloud computing seminar at CSC premises in October.

more than 60 attendees. The speakers of the event represented the wide variety of different Cloud computing providers, for example BaseN, Microsoft, and Monty Program AB.

Grid Middleware Development

Miika Tuisku, DataGrid project leader

The Grid experts of the HIP Technology Programme's DataGrid project have contributed to the current EGEE-III project and the proposal work for the future European Middleware Initiative (EMI). In 2009 HIP played an important role in the EGEE-III project. These roles included deputy middleware manager, security middleware co-ordinator, and the work involved research, development and support for various important security components. HIP continued to hold a decisive role in the security middleware development through participation in the technical co-ordination groups and other technical management bodies of the project. As for the EMI project, the proposal was submitted to the EU at the end of 2009 with HIP as the proposed security task leader.

In EGEE-III, the software related effort of the Programme delivered the required updated security components and their subsequent certification for the production environment. The EGEE-III work continued to focus on the security middleware with special emphasis on bug-fixing, hardening and upgrading software in response to user requirements. An important addition was HIP participation in the research and development of the new gLite authorization system (Argus). For this work several components were supplied that provide security policy information for the system. Also, work continued on the secure data storage system as required by the biomedical community. In addition, the Programme now assumed a role in the testing and certification process of EGEE-III development work. Several important software packages were certified and are currently in production use on the EGEE Grid.

Grid Applications and Industrial Collaboration Projects

The Programme has continued to integrate Grid security components with new technology standards providing new use cases benefiting both academic and industrial users. Research into digital identities for persons and other network entities such as computer hosts and services continued to produce publications and conference talks. The key focus areas were related to strong authentication and single sign-on in environments supporting large numbers of devices such as mobile phones. Technologies for detecting and preventing identity thefts were also covered in the research.

Energy efficiency is a new issue in high performance and high throughput computing. When taking into account the whole lifetime of the hardware the electricity cost can easily exceed the initial investment costs. Inspired by this the Programme started a new research track on green computing in late 2008 and the work continued in 2009. A grant from the Magnus Ehrnrooth Foundation made it possible to purchase a modern test environment for "green computing". The research focused on developing software tools and operational practices to reduce energy used in Grid computing clusters and in this way to enable more energy efficient computing of the LHC data. Our studies so far indicate that optimising the system configuration can both decrease energy consumption by 50% and increase the system throughput by 100%. The results were published in two conference articles. In 2010 green computing will remain one of the focus areas of the Technology Programme.

Mobile devices are an increasingly important means to share and access information through a network. To enable an efficient and usable data management experience for mobile users, research on applying Grid technologies for mobile Internet access is carried out in the Programme. The research led to several publications in 2009 and continues to be an active research topic in 2010. The work is done in co-operation with the Department of

Communications and Networking at the Aalto University in Helsinki, Finland. Moreover one concrete Grid computing application in the Programme was data analysis using Semantic Web/Grid technologies. This research aims to develop novel methods for analysing data stored on the Internet by combining the computing power of the Grid with the intelligent methods of the Semantic Web.

Collaboration

The exploitation of emerging new innovations around Grid and Cloud technologies requires close collaboration with industry and other research organizations. The joining of Tampere University of Technology (TUT) to the Helsinki Institute of Physics in late 2008 opened new possibilities both for research and industrial collaboration in Finland. Two students from TUT wrote their Master's theses at CERN while working as technical students in CERN projects. Both of these HIP-CERN collaboration projects, i.e., planning of manufacturing of components for the future CLIC accelerator, and remote monitoring of LHC, will continue in 2010. The Technology Programme will continue to collaborate with several IT business experts representing both academia and industry. In 2009 these partners included the Big Science Activation Team Finland of TEKES, the Canton of Geneva, CERN Openlab, the GSI-FAIR particle physics centre in Darmstadt, Helsinki Institute of Information Technology (HIIT), Lappeenranta Technology Business Research Center (TBRC), Nokia Research Center Lausanne, the Swiss

Remote monitoring train (TIM) passing a sector door in the LHC tunnel.

Federal Institute of Technology (EPFL), the Technical Research Centre of Finland (VTT), the University of Lausanne HEC and the University of Tampere.

With the close ties between the IT-department of the Canton of Geneva and CERN, the HIP Technology Programme has continued collaboration in selected open source initiatives to be used in local government. These include areas such as federated identity management, secure remote access and server based solutions for language laboratories. The Programme also contributed to medical Grid research together with the University Hospital of Geneva with a joint project proposal for 2010 that received a positive funding decision, which provides a HIP scientist a part-time opportunity to work with local medical imaging researchers.

CLOUD

Markku Kulmala, CLOUD project leader

Background

Atmospheric aerosol particles play an important role in atmospheric physics and chemistry. They influence the climate by two distinct mechanisms: the direct interaction of aerosols with solar radiation (reflection, scattering, absorption), and the indirect increase in cloud reflectivity caused by greater numbers of cloud condensation nuclei. Understanding the dynamical behaviour of ambient aerosol particles requires an understanding of the formation and growth processes of aerosols.

The CLOUD (Cosmics Leaving OUtdoor Droplets) experiment is motivated by numerous indirect observations and theoretical studies that suggest galactic cosmic rays (GCRs) may exert a significant influence on the Earth's cloud cover and climate. The observed variation of low clouds by about 1.7% in absolute units over one solar cycle corresponds to a change in the Earth's radiation budget of about 1.2 Wm^{-2}. This is comparable with the estimated radiative forcing due to anthropogenic greenhouse gas emissions (2.64 Wm^{-2} in 2005). The main proposed mechanisms are ion-induced nucleation, enhancing production of new aerosol particles which can act as cloud condensation nuclei, and enhanced ice particle formation due to ionization by GCRs. However, none of these mechanisms have been experimentally verified. The CLOUD experiment aims to accurately determine the pathways and significance of the phenomenon. The CLOUD Collaboration comprises 21 institutes from 9 countries with a strong Finnish contribution.

Outcome of analysis of 2006 run

Data analysis from the 2006 run was finished and the results were published (Dublissy et al., Atmos. Chem. Phys. Discuss., 9, 18235-18270, 2009). The results yielded knowledge for the design work for the next generation CLOUD detector that was constructed by the end of 2009. Concerning technical aspects, the most important lessons for the CLOUD design include the stringent requirement of internal cleanliness of the aerosol chamber, as well as maintenance of extremely stable temperatures (variations below 0.1 K). The results also gave the first insight into the processes behind the hypothesis. During the 2006 run, a total of 44 nucleation bursts were produced and recorded, and in few cases the observed nucleation bursts appear to have a contribution from ion-induced nucleation and ion-ion recombination to form neutral clusters. However, in order to quantify the conditions where the role of ions becomes significant, several improvements in the new CLOUD detector have been introduced to control the experimental variables and the reproducibility of the experiments.

Construction of the CLOUD chamber

During 2009, the next generation CLOUD detector was constructed on the CERN PS T11 beam line. The CLOUD chamber is a cylinder 27 m^3 in volume, made of stainless steel. With the inside surfaces electropolished, it is put on four thermally insulated feet. For the 2009 run, the chamber was equipped with 35 Pt100 temperature sensors, and a thermal system was installed that allows for maintaining a set temperature (usually around 20°C) stable within less than ±0.1°C. Field cage electrodes in the chamber can provide a high voltage field that rapidly removes ions. Via fibre feed-throughs and electronic apertures, a UV system provides UV radiation < 317 nm from 0 to 50 mW/m^2. The gas com-

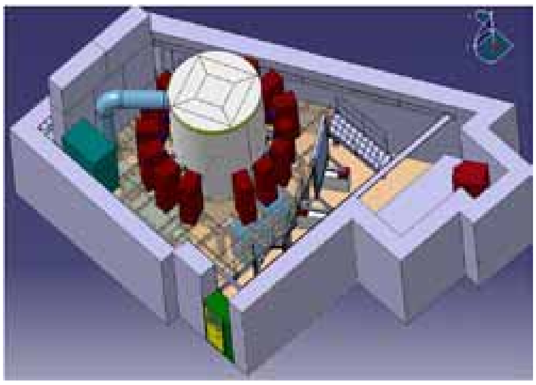


Figure 1. Schematic of the CLOUD chamber as set up in the T11 area in CERN, Switzerland. The red boxes around the chamber are placeholders for the instruments connecting to the chamber via sampling probes. The pion/muon beam provided by the Proton Synchrotron exits at the right, and hits a hodoscope that monitors the beam intensity before it passes the chamber.

position in the chamber is regulated by flushing it with cryogenic ultrapure air, water vapour from a humidifier using Millipore-cleaned water, O_3 from an ozone generator, and trace gases (e.g., SO_2) from gas bottles. A variable speed mixing fan is installed on the bottom chamber cover. The aerosol measurement instruments are connected around the chamber via sampling probes with a total length of 1 m. Figure 1 shows the chamber in its position in the T11 area at CERN, along with schematic depictions of instruments connected to it. The chamber itself is covered completely by the insulation of the thermal system.

Aerosol measurement instrumentation

A wide variety of instruments was deployed during the experiments of the 2009 run in November and December 2009. The backbone is formed by several condensation particle counters (CPCs), mass spectrometers, and electrical mobility analyzers. Trace gases were investigated and monitored, and aerosol particle concentrations measured starting at less than 2 nm.

The Finnish team was primarily responsible for the measurement of clusters and ions, and brought four instruments to CERN for the chamber measurements: ion mobility distribution measurements were done using a (Airborne) Neutral cluster and Air Ion Spectrometer (ANAIS, Airel ltd., Tartu, Estonia) that had been tested extensively at the University of Helsinki (UHEL) in co-operation with the University of Tartu in May/June 2009. Designed for operation at the low pressures and temperatures that will be experienced in the final CLOUD chamber in the 2010 experiments, this instrument has been constructed and tested on board a jet aircraft in upper tropospheric conditions.

Lots of effort has been put into the evolution of condensation-based aerosol particle detectors with an aim to extend the detectable particle size range towards molecular sizes. By the end of 2008 this size range had been extended from ca 2 nm down to molecular sizes. One such prototype (preliminarily named Particle Size Magnifier or PSM) took part in the 2009 run. It is developed by the University of Helsinki and has been continuously tested and improved throughout 2009 in various laboratory facilities (UHEL, FMI, IfT Leipzig, FZ Jülich) prior to its deployment at CERN, and it is still being developed further at the moment.

Total ion concentrations were measured using a Gerdien counter prototype. This instrument has been designed and built at UHEL in summer/autumn 2009 and it is continuously being developed and improved. It delivered scientific data for the first time during the 2009 run at CERN.

An Atmospheric Pressure Interface Time of Flight mass spectrometer (APITOF) was first tested at UHEL earlier in 2009 and proved capable of analysing the chemical composition of electrically charged molecular clusters from 20 to 1500 amu. Prior to its use at CERN, it has since been used in field measurements in Hyytiälä, Finland, as well as in laboratory campaigns (UHEL, FMI, IfT Leipzig, FZ Jülich).

Experiments in the 2009 run and data analysis

In November and December 2009 a total of 71 independent experiments were performed with the CLOUD chamber. About half of them could make use of the beam. A constant temperature of ca 19°C was maintained throughout the experiment. The typical experiment started off with a chamber clean of aerosol particles (< 2 particles per cubic centimetre). Then, the sulphuric acid concentration was raised significantly by opening up UV irradiation, triggering the reaction between SO_2, water and hydroxyl produced photo-chemically from ozone, to form sulphuric acid in the chamber in a homogeneous manner. Above a certain concentration of sulphuric acid, sulphuric acid clusters built, initiating the nucleation of particles at a nucleation rate *J*, with subsequent growth of those particles. One of the main objectives of the 2009 run was to determine the nucleation rate *J* for different conditions. Parameters that were changed between different nucleation experiments were: sulphuric acid concentration, beam intensity, relative humidity and mixing fan speed. By switching the HV clearing field on, and the beam off, electrically neutral nucleation (i.e., not involving ions) could be investigated.

Apart from these "physics experiments", an important task was running "technical experiments" as well, with the goal of determining the working properties of the CLOUD chamber and the associated systems: the lifetime of sulphuric acid, ozone, SO_2, and aerosol was to be determined, as well as the effect of various parameters on the sulphuric acid concentration and the effect of different beam intensities on small ion concentrations for various fan speeds. In addition, calibration experiments for the individual instruments were conducted on site.

The instrumentations provided and operated by the Finnish team made valuable contributions to the results of these experiments. The ion measurements were done by the ANAIS (ion mobility distribution corresponding to ion sizes from 0.8 to 40 nm), and the Gerdien (total ion concentrations). Most nucleation experiments

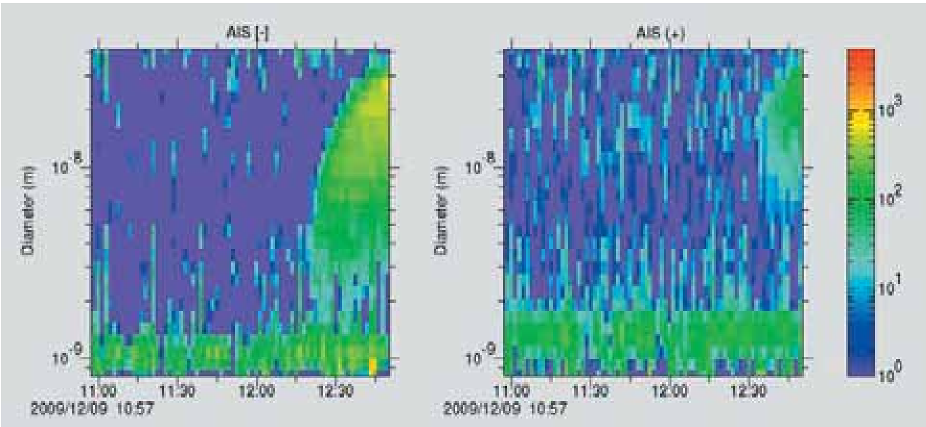


Figure 2. Ion mobility distribution as measured by the ANAIS during one particle formation event in the chamber - negative ions on the left panel, positive on the right. The beam was off for this particular event, hence the band of small ions (0.8-1.5 nm mobility diameter) is due to natural radiation only. One can clearly see the dominance of the negative ions in the particle formation.

resulted in clear events of ion-induced nucleation of aerosol particles with their subsequent growth. One such event is depicted in Figure 2.

The APITOF recorded negatively charged sulphuric acid clusters up to >1000 amu (i.e., containing more than 10 sulphuric acid molecules). Several of those clusters are suspected to contain ammonia and amines. Even though great efforts had been undertaken to keep the chamber free of such trace compounds, still very small yet presumably significant amounts of those might have remained. The PSM proved to be the most sensitive CPC in operation at the chamber. It reacted to sulphuric acid nucleation earlier than the other particle counters or mobility spectrometers. This will give information on the initial steps of sulphuric acid nucleation.

The prevailing opinion in the Collaboration is that the 2009 run was very successful, producing high-quality results. With the CLOUD chamber we managed to provide very clean and well-defined conditions for sulphuric acid nucleation, and during one month of measurements (which included 3 weeks with the beam available), we could investigate nucleation events changing only single parameters between them.

The analysis of the significant amount of data collected has just started and there are no final results available yet. Data analysis will continue well into 2010, with a data analysis workshop taking place at the Paul-Scherrer-Institut (PSI) in Switzerland at the end of January.

Planck

Background

The cosmic microwave background (CMB) is radiation that comes from the early universe. It was emitted when the universe was about 400 000 years old. Its intensity and polarization varies over the sky, and these variations reflect the properties and structure of the early universe as well as the later history of the universe through which this radiation has travelled.

Hannu Kurki-Suonio, Planck project leader

Planck is a European Space Agency (ESA) satellite whose purpose is to observe the CMB over the whole celestial sphere with high resolution and sensitivity and extensive frequency coverage. Planck is a collaboration of over 10 European countries, the U.S., and Canada.

CMB measurements are contaminated by microwave radiation from our own galaxy and extragalactic objects. To be able to remove this "foreground", the observations are carried out at nine different frequencies. While being a nuisance to cosmology, this foreground is of great interest to astronomers. The detectors for the different frequencies are divided into two instruments, the Low-Frequency Instrument (LFI: 30 GHz, 44 GHz, and 70 GHz channels), and the High-Frequency Instrument (HFI: six channels from 100 GHz to 857 GHz), which use different technologies: radiometers for LFI, and bolometers for HFI. The 70 GHz radiometers were developed and built in Finland by Ylinen Electronics and MilliLab (VTT).

Launch and first operations

Planck launch on May 14th. Credit: ESA - S. Corvaja.

Planck was launched, together with the Herschel infrared telescope, with the Ariane 5 launcher from the ESA spaceport in Kourou, French Guiana, on May 14th, 2009. It reached its orbit, around the L2 point of the Sun-Earth system, on July 3rd, by which time the instruments had also been cooled down to their operational temperature. The following calibration and performance verification phase lasted until August 12th, after which Planck began the two-week First Light Survey (FLS).

During FLS, Planck operated in survey mode, scanning the sky at 1 rpm, the spin axis reoriented by about 2 arcmin with intervals of about an hour or less. In the survey mode the whole celestial sphere is observed in about 7 months. During the two weeks of FLS a 15 degree wide strip of the sky was observed. Preliminary analysis of the FLS data indicated that the quality of data was excellent, and FLS data will thus be considered as part of the first full-sky survey.

After FLS, Planck has continued operating in survey mode, and by the end of 2009, it has observed three quarters of the sky.

The actual observing programme (two full-sky surveys) lasts 14 months. The Planck data will be made public two years after completion of the mission, near the end of 2012. Prior to this, during the proprietary period, the data will be analysed carefully and used within the Planck Collaboration to obtain the scientific results of the project. In October 2009, ESA's Science Program Committee approved an extension of the observing programme by one year, to near the end of 2011, which will facilitate two additional full-sky surveys. This corresponds to the expected lifetime of the satellite's cooling systems.

Main data analysis

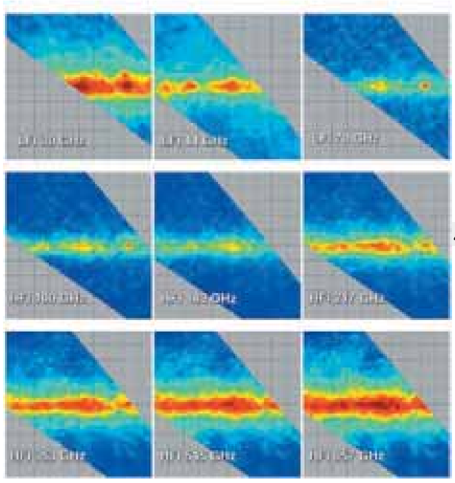
The analysis begins by differencing the sky signal and the signal from the reference load carried within the satellite. This reduces the low-frequency noise from the instruments, as the detectors are continuously switched between the sky and the reference load. The signal is then calibrated using the signal dipole due to the motion of the satellite. The outcome of this is the time-ordered data (TOD) from each detector.

From the time-ordered data, frequency maps are computed for each of the 9 frequency channels. Up to and including this map-making step, the data analysis is carried out separately for each instrument (LFI and HFI) in their respective Data Processing Centres (DPC). The map-making code Madam developed by the Finnish team is the main map-making code for the LFI instrument, and we have the responsibility for map-making at the LFI DPC. The frequency maps are then exchanged between the two DPCs, and the later analysis steps are done in parallel by the two DPCs using the full data from both instruments.

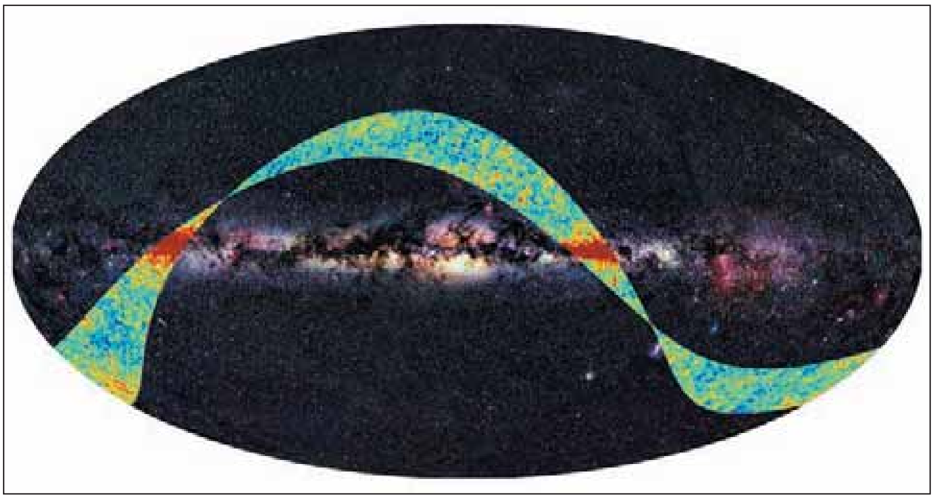
The second phase of the end-to-end (E2E) tests of the LFI DPC data analysis pipeline was completed in fall 2009. In August 2009 real data started arriving, and the pipeline has then been applied to it. On December 31st, 2009, the frequency maps including data up to October 31st were exchanged between the DPCs.

For later data analysis, an estimate of the residual noise and its correlations in the maps are needed. The uncorrelated part of the residual noise in the map, and also the correlation between the different polarization Stokes parameters (I, Q, and U) of the same map pixel can be calculated as part of the map-making step. This information for the three LFI frequencies was also delivered on December 31st.

For angular power spectrum estimation, the effect of pixel-to-pixel correlations in the noise can be estimated with timeline-to-map Monte Carlo (MC). These MC studies require the use of large supercomputers. Such a MC pipeline was set up at the NERSC supercomputer centre in the U.S. in 2008, and at the Finnish supercomputer centre CSC and the Italian supercomputer centre CINECA in 2009. For this and other Planck work, the European supercomputer consortium DEISA awarded Planck LFI a Virtual Community status, with 2 million CPUh of computing time per year (1.5 million at CSC and 0.5 million at CINECA). MC studies corresponding to simulated full-sky data and to the first two months of real data were performed in 2009.



Parts (20°x20°) of all 9 FLS frequency maps (temperature component) from a region around the Galactic plane.
Credit: ESA, LFI & HFI Consortia (Planck).



The First Light Survey 70 GHz frequency map (temperature, i.e., Stokes I, component) superimposed on an optical map of the sky. This 70 GHz map was calculated from Planck data by E. Keihänen and T. Poutanen.
Credit: ESA, LFI & HFI Consortia (Planck), background image: Axel Mellinger.

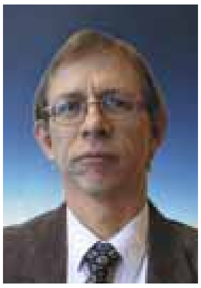
Quick Detection System

The Quick Detection System (QDS) analyses the time-ordered data of the Planck satellite daily to detect point sources, particularly Active Galactic Nuclei (AGN). If a source is detected, its properties, such as flux and spectral shape, are compared to pre-defined alert criteria. If the source is found to be interesting enough, an alert for simultaneous multifrequency follow-up observations can then be triggered. The software is operated at Metsähovi Radio Observatory, Helsinki University of Technology (TKK), in co-operation with Tuorla Observatory, University of Turku.

The QDS software was first used during the Planck First FLS in August 2009. The parameters needed by the software for making ideal detections were tuned and then thoroughly tested. At the moment the QDS is routinely run when new data are available at the LFI DPC. The software operates as expected, and numerous detections of AGNs have been made up to the present time. The results have been compared to other point source extraction methods (for example, extracting the sources directly from maps) as well as to WMAP 5-year data, and found to be consistent. The large multifrequency observing campaigns, connected to the QDS, are also ongoing as planned.

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 the Graduate School in Particle and Nuclear Physics (GRASPANP) sponsored by the Ministry of Education. In addition to the graduate students that are supported by the graduate school and by the Institute, a fair number of undergraduate students also join the research groups and complete their Masters' thesis work at the Institute. Many of these students have continued as graduate students in the Institute projects upon graduation. In particular, the popular summer student jobs at CERN have attracted students to graduate studies. During the period 2005–2009, 39 doctoral degrees and 63 Masters' degrees have been earned in HIP research projects.

The National Board of Education (Opetushallitus) has continued its collaboration with HIP and the municipality of Jyväskylä in the CERN co-operation high school network and the collaboration with the city of Tampere in the TekNatur/CERN network for Swedish speaking high school students. The aim is to develop the role of subatomic physics in school curricula in co-operation with CERN. In 2009 this programme attracted 341 Finnish students and 48 of their teachers. A related programme has been to bring high school physics teachers to CERN. They participate in continuing education courses. In 2009, 32 teachers participated in this programme. 7 teachers participated in a shorter course at CERN. These visits have generated considerable coverage in local newspapers all over the country: about 30 articles in total in 2009.

The technological and commercial co-operation between Finnish industry and CERN is co-ordinated by HIP in collaboration with Top Science Services LLC, which is the new contractor with TEKES, the National Technology Agency of Finland. Until June, Finpro ry, which is an independent association that provides services to the Finnish export industry, held this contract with TEKES.

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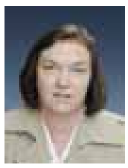

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J. Aaltonen, lab. engineer

Seminars

Seminars held in Helsinki

January 8th M. Järvinen (Odense, Denmark)
The electroweak phase transition in nearly conformal technicolor

January 13th P. Eerola (HIP and FL, Helsinki)
First physics at LHC when and what?

January 14th and 16th M. Gaberdiel (ETH Zurich, Switzerland)
An overview of logarithmic conformal field theory

January 15th V. Azzolini (HIP and FL, Helsinki)
Study of charmless inclusive semileptonic B decays and measurement of the CKM matrix element $|V_{ub}|$ with the BaBar detector

February 17th D. Rischke (Frankfurt, Germany)
From kinetic theory to dissipative fluid dynamics

February 24th J. Laamanen (Dortmund, Germany)
Relic density and SUSY GUT models with non-universal gaugino masses

March 3rd T. Lappi (Saclay, France)
Initial conditions of heavy ion collisions and high energy factorization

March 10th F. Djurabekova (HIP and FL, Helsinki)
Multiscale modelling of sparking in the Compact Linear Collider components

March 24th V. Khoze (IPPP, Durham, UK)
Studying the BSM Higgs sector with forward protons at the LHC

March 26th F. von Feilitzsch (TUM, Munich, Germany)
A new European large infrastructure for particle astrophysics at low energies: search for proton decay, low energy neutrino physics and neutrino astronomy

March 31st K. Rao (HIP)
Probing anomalous Higgs couplings at electron-positron colliders

April 14th Z.-Z. Xing (Institute of High Energy Physics, Chinese Academy of Sciences, Beijing, China)
Neutrino masses via TeV seesaws

April 21st J. Koponen (FL, Helsinki)
Heavy-light mesons on a lattice

April 28th M. M. Sheikh-Jabbari (IPM, Tehran, Iran)
A realization of Cohen-Glashow very special relativity on noncommutative space-time

May 12th M. Vepsäläinen (FL, Helsinki)
Heavy quarkonia in QCD plasma

May 19th O. Antipin (HIP, Jyväskylä)
Discriminating between technicolor and warped extra dimensional models via the pp → ZZ channel

May 26th H. Timkó (HIP and CERN, Switzerland)
"CLIC for the future" - the plasma physics of breakdowns

May 28th T. Lähde (Univ. Washington, Seattle, USA)
A new prospect for graphene-based electronics

June 2nd H. Kurki-Suonio (FL, Helsinki)
Planck satellite and cosmology

June 4th E. Gabrielli (CERN, Switzerland)
Flavor changing fermion-graviton vertices

June 9th Z. Berezhiani (Univ. L'Aquila, Italy)
Baryogenesis and dark matter genesis: unified model

June 16th O. Kancheli (ITEP, Moscow, Russia)
Spontaneous breaking of Lorentz-invariance and gravitons as Goldstone particles

June 23rd K. Kajantie (HIP and FL, Helsinki)
Hot QCD matter: lattice, perturbation theory and AdS/QCD

August 11th A. Sako (Kushiro National College of Technology, Japan)
Smooth noncommutative deformation of instantons and the ADHM construction

August 13th T. DeGrand (Univ. Colorado, Boulder, USA)
Lattice gauge theories with an infrared-attractive fixed point

August 14th A. Niemi (Université de Tours, France and Uppsala University, Sweden)
Weinberg-Salam model and its de Sitter ground state

September 1st O. Taanila (HIP and FL, Helsinki)
The subdominant curvaton

September 8th M. Gogberashvili (Institute of Physics and Tbilisi State University, Georgia)
Higher-dimensional models - past and future

September 10th V. Eremin (Ioffe Institute, St Petersburg, Russia)
Avalanche multiplication - a new bases for radiation hard silicon detectors?

September 29th J. Piilo (Univ. Turku)
Econophysics: What can physicists say about financial markets?

October 6th E. Heijne (CERN-PH Department, Switzerland)
Developments in radiation sensors

October 7th V. Khoze (IPPP, Durham, UK)
Physics of heavy quarkonia: as seen through the eyes of central exclusive production

October 7th S. Baranov (Lebedev Institute, Moscow, Russia)
Production and polarization of Upsilon mesons at the Tevatron

October 8th Y. Burnier (Univ. Bielefeld, Germany)
Effective theory for a five-dimensional domain wall and branon physics

October 13th W. Unger (Univ. Bielefeld, Germany)
The chiral phase transition in QCD: on critical scaling and Goldstone fluctuations

October 15th M. Valtonen (HIP and Univ. Turku)
Arrow of time in the classical three-body problem

October 20th L. Jenkovszky (Bogolyubov Institute for Theoretical Physics, Kiev, Ukraine)
Diffraction at the LHC

October 22nd P. Bandyopadhyay (Harish Chandra Research Institute, Allahabad, India)
Higgs searches under supersymmetric cascades with non-universal gaugino masses

October 26th J. Andersen (Norwegian University of Science and Technology, Trondheim, Norway)
Convergent hard-thermal-loop resummation for thermal field theories

October 27th D. Demir (Izmir Institute of Technology, Turkey)
Search for an extra supersymmetric U(1) at the LHC CMS experiment

November 3rd J. Alanen (HIP and FL, Helsinki)
A gauge/gravity duality model for hot QCD matter: application to bulk thermodynamics and string tensions

November 10th A. Tranberg (HIP and Univ. Oulu)
Cold electroweak baryogenesis from Standard Model CP-violation

November 23rd A. Rajantie (Imperial College, UK)
Non-Gaussianity from resonant curvaton decay

December 8th B. Arbuzov (Institute for Nuclear Research, Moscow State University, Russia)
Application of Bogoliubov compensation principle to QCD and electroweak theory

December 15th A. Chernin (Sternberg Astronomical Institute, Moscow University, Russia and Tuorla Observatory, Turku)
Dark energy in local cosmology

December 17th A. Vuorinen (Univ. Bielefeld, Germany)
Perturbative nuclear physics

December 22nd A. Kurkela (ETH, Zurich, Switzerland)
Cold quark matter

Visitors

Theory Programme

Cosmophysics

D. Sunhede (Sweden) 2.-10.3.
A. Vuorinen (Germany) 11.-15.5.
S. Räsänen (Switzerland) 25.5.-5.6.
C. Byrnes (Germany) 28.-29.5.
P. Vaudrevange (USA) 8.-9.6.
T. Prokopec (The Netherlands) 8.-14.6.
A. Vuorinen (Germany) 27.7.-7.8.
A. Niemi (Sweden/France) 11.-13.8.
T. Takahashi (Japan) 16.-22.8.
A. Rajantie (UK) 17.-18.8.
S. Nurmi (Germany) 17.-24.8.
P. Chingangbam (Republic of Korea) 14.-21.9.
M. Herranen (Germany) 21.-29.11.
A. Vuorinen (Germany) 20.12.2009-3.1.2010

Laws of Nature and Condensed Particle Matter Phenomenology at the LHC

T. Lappi (France) 11.-13.2.
J. Laamanen (Germany) 12.-25.2.
D. H. Rischke (Germany) 14.-24.2.
T. Lappi (France) 17.-19.2., 25.-26.2.
F. Arleo (France) 14.-17.4.
E. Gabrielli (Switzerland) 4.6.
J. Qiu (USA) 25.-29.6.
H. Niemi (Germany) 7.-11.8.
T. DeGrand (USA) 12.-14.8.
Y. Burnier (Germany) 7.-9.10.
W. Unger (Germany) 12.-13.10.
P. Bandyopadhyay (India) 19.-23.10.
D. Demir (Turkey) 23.-30.10.
J. Andersen (Norway) 26.-27.10.
L. Laperashvili (Russia) 1.-30.11.
A. Rajantie (UK) 23.-24.11.
A. Vuorinen (Germany) 14.-23.12.
A. Kurkela (Switzerland) 17.-23.12.

Hadron Physics Activity

T. Lähde (USA) 22.5.-1.6.

String Theory and Mathematical Physics

V. Savrin (Russia) 3.-11.1.
M. Gaberdiel (Switzerland) 13.-16.1.
L. Laperashvili (Russia) 14.1.-4.3.
G. Zet (Romania) 1.3.-30.4.
M. Mnatsakanova (Russia) 15.-30.3.
Z. Xing (China) 1.-15.4.
R. Banerjee (India) 3.4.-2.5.
M. M. Sheikh-Jabbari (Iran) 20.-30.4.
P. Prešnajder (Slovakia) 26.5.-11.6.
Z. Berezhiani (Italy) 31.5.-31.7.
O. Kancheli (Russia) 2.-30.6.
M. Gogberashvili (Georgia) 5.8.-2.10.
A. Sako (Japan) 11.-12.8.
A. Niemi (Sweden/France) 11.-15.8.
R. Zhang (Australia) 17.8.-6.9.
O. Pavlovsky (Russia) 10.9.-10.10.
G. Zet (Romania) 14.9.-15.11.
L. Laperashvili (Russia) 1.-30.11.
Y. Vernov (Russia) 23.11.-22.12.
B. Arbuzov (Russia) 1.-15.12.
P. Prešnajder (Slovakia) 1.-16.12.

High Energy Physics Programme

S. Kiprich (Ukraine) 29.4.-29.5., 3.-22.8., 27.10.-27.11.

CMS Programme

N. Ellis (Switzerland) 28.-29.5.
H. Haller-Mauger (Switzerland) 28.-29.5.
T. Carli (Switzerland) 12.-14.8.
E. Lytken (Sweden) 26.-28.8.
V. Eremin (Russia) 10.9.
T. Sepp (Estonia) 23.-26.9.
S. Baranov (Russia) 5.-8.10.
M. Schumacher (Germany) 26.-28.11.

Planck

A. Melchiorri (Italy) 28.-30.6.

Conference participation, Talks and Visits by Personnel

Theory Programme

Cosmophysics

SIGRAV School in Cosmology,
26-29 January, GGI, Firenze, Italy (talk by V. Marra)

CERN Winter School on Supergravity, Strings and Gauge Theories,
9-13 February, CERN, Geneva, Switzerland (L. Mether)

University of Jyväskylä,
18-20 February, Jyväskylä, Finland (talk by V. Reijonen)

University of Jyväskylä,
4-6 March, Jyväskylä, Finland (talk by V. Reijonen)

The Annual Meeting of the Finnish Physical Society,
12-14 March, Espoo, Finland (M. Herranen, K. Kainulainen, P. M. Rahkila, O. Taanila, J. Virkajärvi)

University of Utrecht,
20-25 March, Utrecht, The Netherlands (G. Rigopoulos)

Particle Physics and Cosmology: From the Smallest Scales to the Largest,
1-3 April, NBI, Copenhagen, Denmark (talk by A. Ferrantelli, talk by V. Reijonen, talk by O. Taanila)

Non-linearity in Cosmology Workshop,
11-26 April, Yukawa Institute, Kyoto, Japan (talk by G. Rigopoulos)

Workshop: Astroparticle Physics - A Pathfinder to New Physics,
23-30 April, NORDITA, Stockholm, Sweden (K. Kainulainen)

Summer School in Cosmology,
18-22 May, Laukaa, Finland (talk by K. Enqvist, talk by K. Kainulainen, talk by V. Reijonen, talk by O. Taanila)

Workshop in Electroweak Phase Transition,
22-24 June, NORDITA, Stockholm, Sweden (K. Kainulainen)

Workshop in Electroweak Phase Transition,
22-27 June, NORDITA, Stockholm, Sweden (talk by M. Herranen, P. M. Rahkila)

PASCOS-09 Conference,
22-27 June, DESY, Hamburg, Germany (talk by J. Virkajärvi)

Invisible Universe International Conference,
29 June - 3 July, Palais de l'UNESCO, Paris, France (talk by V. Marra)

COSMO-09 Conference,
7-11 September, CERN, Geneva, Switzerland (A. Ferrantelli, M. Herranen, V. Marra, P. M. Rahkila, talk by O. Taanila, J. Virkajärvi)

Progress in Nonequilibrium Green's Functions IV,
17-19 September, University of Glasgow, Glasgow, UK (invited talk by K. Kainulainen)

3rd UniverseNet Meeting,
28 September - 3 October, Barcelona, Spain (talk by A. Ferrantelli, V. Reijonen, talk by O. Taanila)

Institute for Theoretical Physics, University of Heidelberg,
5-9 October, Heidelberg, Germany (talk by V. Marra)

University of Helsinki,
16 October, Helsinki, Finland (talk by K. Kainulainen)

Workshop, Lambda-LTB Cosmology,
20-23 October, KEK, Tsukuba, Japan (invited talk by V. Marra)

DESY,
15-20 November, Hamburg, Germany (talk by A. Ferrantelli)

University of Heidelberg,
23-26 November, Heidelberg, Germany (talk by O. Taanila)

University of Bielefeld,
30 November - 2 December, Bielefeld, Germany (talk by O. Taanila)

University of Orsay LPT,
13-17 December, Paris, France (talk by G. Rigopoulos)

Laws of Nature and Condensed Particle Matter Phenomenology at the LHC

Cracow Epiphany Conference,
4-7 January, Krakow, Poland (talk by P. Hoyer)

University of Jyväskylä,
23 January, Jyväskylä, Finland (talk by K. Rummukainen)

International Workshop on Effective Field Theories: From the Pion to the Upsilon,
1-6 February, Valencia, Spain (M. Antola)

4th International Workshop in High-pT Physics at LHC,
4-7 February, Prague, Czech Republic (J. Auvinen, K. J. Eskola, talk by H. Paukkunen, talk by T. Renk)

University of Jyväskylä,
10-11 February, Jyväskylä, Finland (M. Antola)

CATHIE-RIKEN Workshop: Critical Assessment of Theory and Experiment on Correlations at RHIC,
25-26 February, BNL, Brookhaven, NY, USA (T. Renk)

University of Jyväskylä,
27 February, Jyväskylä, Finland (talk by K. Kajantie)

RECFA Meeting,
5-7 March, Lausanne, Switzerland (K. Huitu)

The Annual Meeting of the Finnish Physical Society,
12-14 March, Espoo, Finland (M. Antola, J. Auvinen, talk by K. J. Eskola, M. Heikinheimo, talk by T. Honkavaara, K. Huitu, T. Rüppell, A. Sabanci, K. Tuominen)

NORDITA,
26-27 March, Stockholm, Sweden (talk by T. Renk)

Quark Matter 2009,
30 March - 4 April, Knoxville, TN, USA (J. Auvinen, K. J. Eskola, T. Kähärä, talk by T. Renk, K. Tuominen)

Meeting on Quantum Field Theory in Extreme Environments,
23-25 April, CEA/Saclay, Paris, France (talk by K. Kajantie)

17th International Workshop on Deep-Inelastic Scattering and Related Subjects (DIS'2009),
26-30 April, Madrid, Spain (talk by H. Paukkunen)

Planck2009: From the Planck Scale to the Electroweak Scale,
25-29 May, Padova, Italy (O. Antipin, talk by K. Tuominen)

University of Jyväskylä,
2-4 June, Jyväskylä, Finland (M. Antola)

SUSY09, the 17th International Conference on Supersymmetry and the Unification of Fundamental Interactions,
5-10 June, Boston, MA, USA (talk by T. Honkavaara, talk by K. Rao, talk by T. Rüppell)

5th International Workshop on Critical Point and Onset of Deconfinement (CPOD),
8-12 June, BNL, Brookhaven, NY, USA (T. Kähärä)

Tenth Workshop on Non-Perturbative Quantum Chromodynamics,
8-12 June, Paris, France (talk by K. Tuominen)

NORDITA Workshop on Electroweak Phase Transition,
15 June - 30 July, Stockholm, Sweden (talk by K. Rummukainen)

Workshop on the Transverse Partonic Structure of Hadrons,
21-28 June, Yerevan, Armenia (talk by P. Hoyer)

13th International Conference on Elastic & Diffractive Scattering (13th "Blois Workshop"),
29 June - 3 July, CERN, Geneva, Switzerland (talk by K. Huitu)

CERN,
29 June - 18 July, Geneva, Switzerland (talk by K. Kajantie)

HadronPhysics I3 Steering Committee Meeting,
11 July, Frankfurt, Germany (P. Hoyer)

2009 Europhysics Conference on High Energy Physics,
16-23 July, Krakow, Poland (talk by P. Hoyer, T. Renk)

CERN,
16 August - 10 October, Geneva, Switzerland (P. Hoyer)

XXIV International Symposium on Lepton Photon Interactions at High Energies (Lepton Photon 09),
17-22 August, Hamburg, Germany (talk by K. Huitu, talk by T. Renk)

Universe in a Box: LHC, Cosmology and Lattice Field Theory,
24-28 August, Leiden, The Netherlands (talk by K. Rummukainen, talk by K. Tuominen)

NORWIP 2009,
26-28 August, Helsinki, Finland (K. Huitu, talk by A. Sabanci)

Harish-Chandra Research Institute (HRI),
28 August, Allahabad, India (talk by S. K. Rai)

2nd CERN-ECFA-NuPECC Workshop on the LHeC,
1-3 September, Divonne-les-Bains, France (talk by K. J. Eskola)

University of Southern Denmark,
1 September 2009 - 31 August 2010, Odense, Denmark (K. Tuominen)

Indian Association for the Cultivation of Sciences (IACS),
2 September, Kolkata, India (talk by S. K. Rai)

HadronPhysics I3 Meeting,
3-4 September, Frascati, Italy (P. Hoyer)

Saha Institute of Nuclear Physics (SINP),
7 September, Kolkata, India (talk by S. K. Rai)

European Graduate School Complex Systems of Hadrons and Nuclei,
28 September - 2 October, NBI, Copenhagen, Denmark (M. Heikinheimo, T. Karavirta)

Collider Phenomenology,
29 September - 2 October, DESY, Hamburg, Germany (talk by A. Sabanci)

University of Southern Denmark,
3-7 October, Odense, Denmark (M. Heikinheimo, T. Karavirta)

CERN,
8 October, Geneva, Switzerland (talk by P. Hoyer)

RECFA Meeting,
8-11 October, Moscow, Russia (K. Huitu)

University of Southern Denmark,
11-17 October, Odense, Denmark (talk by M. Antola)

ECT*,
5 November, Trento, Italy (talk by P. Hoyer)

Orbital Angular Momentum of Partons in Hadrons,
9-13 November, Trento, Italy (talk by P. Hoyer)

University of Torino,
19 November, Torino, Italy (talk by P. Hoyer)

Particle Physics Day,
20 November, Jyväskylä, Finland (talk by J. Auvinen, K. J. Eskola, M. Heikinheimo, K. Huitu, T. Kähärä, talk by K. Rao, T. Renk, A. Sabanci)

CP3 Inauguration Meeting,
24 November, Odense, Denmark (talk by P. Hoyer)

Origins of Mass Mini Workshop,
25 November, Odense, Denmark (talk by K. Kajantie, talk by K. Rummukainen, K. Tuominen)

RECFA Meeting,
26-28 November, CERN, Geneva, Switzerland (K. Huitu)

TU Munich,
4 December, Munich, Germany (talk by P. Hoyer)

Frankfurt University,
7 December, Frankfurt, Germany (talk by T. Renk)

PANDA Theory Advisory Group,
7-8 December, Darmstadt, Germany (P. Hoyer)

Strong Coupling Gauge Theories in the LHC Era (SCGT09),
8-11 December, Nagoya, Japan (talk by K. Tuominen)

University of Bielefeld,
8-11 December, Bielefeld, Germany (talk by K. Kajantie)

University of Mainz,
10 December, Mainz, Germany (talk by P. Hoyer)

Joint CATHIE/TECHQM Workshop,
14-18 December, BNL, Brookhaven, NY, USA (J. Auvinen)

Hadron Physics Activity

California Institute of Technology,
22 January - 1 February, Pasadena, CA, USA (D. O. Riska)

Workshop on Polarization Observables and Partial Wave Analysis,
1-3 March, Bad Honnef, Germany (invited talk by M. Sainio)

The Annual Meeting of the Finnish Physical Society,
12-14 March, Espoo, Finland (M. Sainio)

The 5th International Pion-Nucleon PWA Workshop and Interpretation of Baryon Resonances,
1-5 June, ECT*, Trento, Italy (invited talk by M. Sainio)

Mini-Workshop on Problems in Multi-Quark States,
29 June - 6 July, Bled, Slovenia (invited talk by D. O. Riska)

6th International Workshop on Chiral Dynamics (CD09),
6-10 July, Bern, Switzerland (talk by M. Sainio)

Fifth International Conference on Quarks and Nuclear Physics,
21-25 September, Beijing, PR China (invited talk by D. O. Riska)

String Theory and Mathematical Physics

Fundamental Challenges of QCD,
28 February - 7 March, Schladming, Austria (J. Alanen, V. Suur-Uski)

The 23rd Nordic Network Meeting on "Strings, Fields and Branes",
16-18 April, Copenhagen, Denmark (J. Alanen, V. Keränen, invited talk by E. Keski-Vakkuri, V. Suur-Uski)

Gottlieb Fest - Workshop in the Honour of Ioan Gottlieb's 80th Birthday,
9 May, Iasi, Romania (invited talks by M. Chaichian and A. Tureanu)

4th International Sakharov Conference on Physics,
18-23 May, Lebedev Physical Institute, Moscow, Russia (M. Chaichian, talk by A. Tureanu)

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

"String Duals of Finite Temperature and Low-Dimensional Systems", Aspen Center for Physics,
24 May - 14 June, Aspen, CO, USA (invited talks by E. Keski-Vakkuri and S. Nowling)

Fifth Aegean Summer School, From Gravity to Thermal Gauge Theories: The AdS/CFT Correspondence,
21-26 September, Adamas, Milos Island, Greece (J. Alanen, V. Keränen, V. Suur-Uski)

New Horizons in Gravity,
28 September - 2 October, Copenhagen, Denmark (J. Alanen, V. Suur-Uski)

Weizman Institute of Science,
9-13 October, Rehovot, Israel (M. Chaichian)

50 Years of the Aharonov-Bohm Effect: Concepts and Applications,
11-14 October, Tel Aviv University, Israel (M. Chaichian, A. Tureanu)

Tel Aviv University,
14-21 October, Tel Aviv, Israel (M. Chaichian)

Hebrew University of Jerusalem,
22-25 October, Jerusalem, Israel (M. Chaichian)

24th Nordic Network Meeting on Fields, Strings, and Branes,
3-5 December, Groningen, The Netherlands (talk by S. Nowling)

Low Dimensional Quantum Systems

The Annual Meeting of the Finnish Physical Society,
12-14 March, Espoo, Finland (chairman A. Harju, talk by J. Särkkä, talk by E. Tölö)

XIIIth International Congress of Quantum Chemistry,
22-27 June, Helsinki, Finland (J. Särkkä)

18th International Conference on Electronic Properties of Two-Dimensional Systems,
19-24 July, Kobe, Japan (A. Harju, J. Särkkä)

Summer School, Computational Nanoscience for Renewable Energy Solutions,
14-17 September, Helsinki, Finland (organizer A. Harju)

Radiation Damage in Particle Accelerator Materials

CERN,
1 January - 31 December, Geneva, Switzerland (H. Timkó)

Spring MRS Meeting, Symposium Ion Beams and Nano-Engineering,
13-17 April, San Francisco, CA, USA (talk by F. Djurabekova)

International Conference on Defects in Semiconductors ICDS,
20-24 July, St. Petersburg, Russia (E. Holmström, invited talk by K. Nordlund)

Max-Planck Institute for Plasma Physics,
16-30 August, Greifswald, Germany (H. Timkó)

19th International Conference on Ion-Surface Interactions,
20-24 August, Zvenigorod, Russia (invited talks by F. Djurabekova and K. Nordlund)

Workshop 'Nanostructures in Silica',
6-9 September, Saariselkä, Finland (talk by M. Backman, session chair and talk by F. Djurabekova, session chair and talk by K. Nordlund, talk by O. Pakarinen)

CLIC Workshop,
12-16 October, CERN, Geneva, Switzerland (plenary talk by F. Djurabekova, talks by H. Timkó)

UzPEC, Uzbek Conference on Physical Electronics,
28-30 October, Tashkent, Uzbekistan (invited talk by F. Djurabekova)

Fall MRS Meeting, Symposium Materials Research Needs to Advance Nuclear Energy,
29 November - 4 December, Boston, MA, USA (invited talk by F. Djurabekova, E. Holmström, invited talk by K. Nordlund)

Towards Reality in Simulation of Nanoscale Materials,
6-10 December, Levi, Finland (F. Djurabekova, talk by O. Pakarinen)

High Energy Physics Programme

Forward Physics

Physics Analysis Workgroup,
7 January, Helsinki, Finland (talk by E. Brücken)

RD-51 Workshop on Micropattern Gas Detectors,
16 February, CERN, Geneva, Switzerland (talk by T. Aaltonen)

Silicon Calibration Taskforce,
20 February, FNAL, Chicago, IL, USA (talk by T. Aaltonen)

TOTEM Collaboration Meeting,
18 March, CERN, Geneva, Switzerland (talk by R. Orava)

Summer School of the Savonia University of Applied Sciences,
25-26 May, Kuopio, Finland (invited lecturer R. Orava)

Joint Physics,
27 May, FNAL, Chicago, IL, USA (talk by T. Aaltonen)

MPGD 2009 Conference,
14 June, Crete, Greece (talk by T. Hildén)

WH-Meeting,
17 June, 1 July, 22 July, 13 August, FNAL, Chicago, IL, USA (talk by T. Aaltonen)

EDS '09, the 13th International Conference on Elastic & Diffractive Scattering (13th "Blois Workshop"),
26 June, CERN, Geneva, Switzerland (summary talk and invited summary talk by R. Orava)

Higgs Discovery Group,
7 August, 14 August, FNAL, Chicago, IL, USA (talk by T. Aaltonen)

Physics Analysis Workgroup,
3 September, Helsinki, Finland (talk by E. Brücken)

Low x Workshop,
8-13 September, Ischia Island, Italy (invited plenary talk by R. Orava)

University of Helsinki,
23 October, Helsinki, Finland (talk by R. Orava)

WH and Single-Top Meeting,
28 October, 9 December, FNAL, Chicago, IL, USA (talk by T. Aaltonen)

XXth Hadron Collider Physics Symposium,
19 November, Evian, France (talk by T. Aaltonen)

Colloquium,
20 November, University of Jyväskylä, Jyväskylä, Finland (talk by R. Orava)

Tähtitieteellinen yhdistys Keski-Uudenmaan Altair ry,
3 December, Järvenpää, Finland (talk by R. Orava)

Forward Physics at the LHC,
12-14 December, Manchester, UK (invited plenary talk by R. Orava)

Linear Collider Research

The Annual Meeting of the Finnish Physical Society,
12-14 March, Espoo, Finland (F. Oljemark, K. Österberg)

EuCARD/NCLinac Kickoff Meeting and EuCARD Governing Board,
27 March - 1 April, CERN, Geneva, Switzerland (K. Österberg)

LHCC TOTEM Minireview,
6 May, CERN, Geneva, Switzerland (talk by K. Österberg)

Workshop Soft Diffractive Physics at LHC,
25-26 June, CERN, Geneva, Switzerland (invited talk by K. Österberg)

13th International Conference on Elastic & Diffractive Scattering,
29 June - 3 July, CERN, Geneva, Switzerland (session convenor K. Österberg)

CLIC Two-Beam Module Review,
15-16 September, CERN, Geneva, Switzerland (J. Huopana, talk by R. Nousiainen, K. Österberg)

CLIC'09 Workshop and CLIC/CTF3 Collaboration Board,
12-16 October, CERN, Geneva, Switzerland (J. Huopana, talk by R. Nousiainen, K. Österberg)

Particle Physics Day,
20 November, Jyväskylä, Finland (F. Oljemark, K. Österberg)

ECFA Meeting,
26-27 November, CERN, Geneva, Switzerland (K. Österberg)

TOTEM Collaboration Meetings,
Geneva, Switzerland (talks by K. Österberg)

CLIC Module Working Group and CLIC RF Structure Development Meetings,
Geneva, Switzerland (talks by J. Huopana, talks by R. Nousiainen)

CMS Programme

CERN Seminar,
20 January, Genveva, Switzerland (talk by V. Azzolini)

LHC and Beyond Workshop,
2-3 February, Lund, Sweden (meeting chair P. Eerola)

CMS Physics and Trigger Days,
3-6 February, CERN, Geneva, Switzerland (meeting chair P. Eerola, J. Tuominiemi)

Seminar,
13 February, University of Jyväskylä, Jyväskylä, Finland (talk by P. Eerola)

4th Trento Meeting on Advanced Detectors,
17-19 February, Trento, Italy (talk by J. Härkönen)

EPS-HEPP Board Meeting,
27 February, CERN, Geneva, Switzerland (P. Eerola)

The Annual Meeting of the Finnish Physical Society,
12-14 March, Espoo, Finland (V. Azzolini, P. Eerola, P. Kaitaniemi, V. Karimäki, talk by I. Kassamakov, R. Kinnunen, T. Lampén, talk by H. Moilanen, talk by T. Mäenpää, J. Tuominiemi)

Technology and Instrumentation in Particle Physics, TIPP09,
12-17 March, Tsukuba, Japan (talk by E. Tuovinen)

CMS Tracker Steering Group Meeting,
17 March, CERN, Geneva, Switzerland (talk by J. Härkönen)

Swedish National Infrastructure for Computing (SNIC) Board Meeting,
18 March, Stockholm, Sweden (P. Eerola)

W-LCG Workshop and Collaboration Board Meeting,
21-22 March, Prague, Czech Republic (P. Eerola)

17th International Conference on Computing in High Energy and Nuclear Physics,
21-27 March, Prague, Czech Republic (talk by A. Heikkinen, K. Lassila-Perini)

CMS Offline & Computing Workshop,
20-24 April, University of California, San Diego, CA, USA (talk by K. Lassila-Perini, talk by T. Lindén)

SNIC Board Meeting,
22 April, Stockholm, Sweden (P. Eerola)

CMS Physics Week and EPS-HEPP Board,
11-16 May, CERN, Geneva, Switzerland (meeting chair P. Eerola, J. Tuominiemi)

NDGF CERN Committee Meeting,
18 May, Kastrup, Denmark (meeting chair T. Lindén)

SNIC Board Meeting,
27 May, Stockholm, Sweden (P. Eerola)

14th RD50 - Workshop on Radiation Hard Semiconductor Devices for Very High Luminosity Colliders,
1-3 June, Freiburg, Germany (talk by J. Härkönen, talk by T. Mäenpää, E. Tuominen, E. Tuovinen)

I-2009 Workshop on Cryogenic Tracking Detectors,
4-5 June, Freiburg, Germany (talk by J. Härkönen, T. Mäenpää, talk by E. Tuominen, E. Tuovinen)

W-LCG Overview Board Meeting, CMS Meetings, CERN School Programme Committee Meeting,
8-10 June, CERN, Geneva, Switzerland (P. Eerola)

2nd IAEA Research Coordination Meeting on Heavy Charged-Particle Interaction Data for Radiotherapy,
8-12 June, INFN-LNS, Catania, Italy (talk by A. Heikkinen)

The 2009 European School on High Energy Physics,
14-27 June, Bautzen, Germany (M. Kortelainen)

CMS Collaboration Week,
22-27 June, CERN, Geneva, Switzerland (meeting chair and talk by P. Eerola, R. Kinnunen, J. Tuominiemi)

European Physical Society Europhysics Conference on High Energy Physics, EPS-HEPP 2009,
16-22 July, Krakow, Poland (talk by P. Eerola, J. Tuominiemi)

SNIC Board Meeting,
17 August, Stockholm, Sweden (P. Eerola)

CERN School of Computing,
17-28 August, Göttingen, Germany (invited talk by A. Heikkinen, J. Välimaa)

7th Hiroshima Symposium on the Development and Application of Semiconductor Tracking Detectors,
29 August - 1 September, Hiroshima, Japan (talk by E. Tuovinen)

Nordic Data Grid Facility (NDGF) CERN-committee Meeting,
31 August, Copenhagen, Denmark (P. Eerola, meeting chair T. Lindén)

Frontier Physics at the LHC - CMS Physics Week,
7-11 September, Bologna, Italy (V. Azzolini, meeting chair P. Eerola, J. Tuominiemi)

CMS Quarkonia Workshop,
12-13 September, CERN, Geneva, Switzerland (P. Eerola)

25th Nordunet Conference,
16-17 September, Copenhagen, Denmark (P. Eerola, T. Lindén)

1st INFN International School on Architectures, Tools and Methodologies for Developing Efficient Large Scale Scientific Computing Applications - ESC09,
12-17 October, Bertinoro, Italy (M. Kortelainen)

Detector Seminar,
15 October, Université Catholique de Louvain à Louvain-La-Neuve, Belgium (talk by J. Härkönen)

14th Geant4 Users and Collaboration Workshop,
19-22 October, Catania, Italy (talk by P. Kaitaniemi)

IEEE NSS Nuclear Science Symposium,
25-31 October, Orlando, FL, USA (talk by T. Mäenpää)

CMS Offline and Computing Workshop,
26-30 October, CERN, Geneva, Switzerland (talk by T. Lindén)

EPS-HEPP Board Meeting,
6 November, CERN, Geneva, Switzerland (P. Eerola)

Finnish Swedish Physics Days 2009,
13-15 November, Stockholm, Sweden (talk by T. Lindén)

NDGF CERN Committee Meeting,
16 November, Copenhagen, Denmark (P. Eerola, T. Lindén)

15th RD50 - Workshop on Radiation Hard Semiconductor Devices for Very High Luminosity Colliders,
16-18 November, CERN, Geneva, Switzerland (talk by J. Härkönen, E. Tuominen, E. Tuovinen)

II-2009 Workshop on Cryogenic Tracking Detectors,
19-20 November, CERN, Geneva, Switzerland (talk by J. Härkönen, talk by E. Tuominen, E. Tuovinen)

Public talk "Hiukkasfysiikan uusi supertörmäytin LHC - miksi, mitä, miten, milloin?",
21 November, Fysikerfest '09, Espoo, Finland (talk by P. Eerola)

NDGF Board and CERN Committee Joint Meeting,
30 November, Stockholm, Sweden (P. Eerola)

CMS Collaboration Week,
6-12 December, CERN, Geneva, Switzerland (P. Eerola, V. Karimäki, R. Kinnunen, T. Lampén, J. Tuominiemi, L. Wendland)

SNIC Board,
8 December, Stockholm, Sweden (P. Eerola)

Seminar,
14 December, CEA/Saclay, Paris, France (talk by P. Kaitaniemi)

Seminar,
18 December, University of Helsinki, Helsinki, Finland (talk by L. Wendland)

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

Nuclear Matter Programme

ALICE

ALICE PWG4 Meeting,
19 January, 21 September, CERN, Geneva, Switzerland (talks by J. Rak)

ALICE Technical Board Meeting,
22 January, CERN, Geneva, Switzerland (talk by J. Rak, talk by W. H. Trzaska)

3rd Nordic "LHC and Beyond" Workshop,
2 February, Lund, Sweden (talk by J. Rak)

3rd Nordic "LHC and Beyond" Workshop,
3 February, Lund, Sweden (talk by S. S. Räsänen)

ALICE Technical Board Meeting,
25 February, 26 March, 23 April, 28 May, 30 July, 27 August, 24 September, 19 November, 17 December, CERN, Geneva, Switzerland (talks by J. Rak)

The Annual Meeting of the Finnish Physical Society,
12-14 March, Espoo, Finland (talk by W. H. Trzaska)

ALICE Week,
23 March, CERN, Geneva, Switzerland (talk by J. Rak)

ALICE Collaboration Board Meeting,
27 March, CERN, Geneva, Switzerland (talks by J. Rak)

General LAGUNA Meeting,
2 April, Wroclaw, Poland (talk by W. H. Trzaska)

ALICE Management Board Meeting,
11 May, 13 July, 19 November, 17 December, CERN, Geneva, Switzerland (talks by J. Rak)

ALICE Week,
29 June, CERN, Geneva, Switzerland (talk by J. Rak, talk by W. H. Trzaska)

Advanced Studies Institute on Symmetries and Spin, SPIN-Praha-2009,
27 July, Prague, Czech Republic (talk by J. Rak)

16th Nuclear Physics Workshop "Marie & Pierre Curie",
25 September, Kazimierz Dolny, Poland (talk by W. H. Trzaska)

EMMA Meeting,
29 September, Pyhäjärvi, Finland (talk by W. H. Trzaska)

EXON09,
2 October, Sochi, Russia (talk by W. H. Trzaska)

ALICE Week,
20 October, CERN, Geneva, Switzerland (talk by J. Rak)

LHC Physics Coordination Meeting,
2 November, 9 November, 7 December, 14 December, CERN, Geneva, Switzerland (talks by J. Rak)

General LAGUNA Meeting,
9 December, Boulby, UK (talk by W. H. Trzaska)

Warsaw University of Technology,
15 December, Warsaw, Poland (talk by W. H. Trzaska)

Neutrino Workshop,
22 December, Jyväskylä, Finland (talk by W. H. Trzaska)

ISOLDE

Workshop on Heavy Ion Accelerator Facility "KoRIA" for Producing Rare Isotope Beams,
24-26 August, Sunkyunkwan University, Seoul, Republic of Korea (talk by A. Jokinen)

HRIBF, Upgrade for the FRIB Era; An HRIBF Users Workshop,
13-14 November, Oak Ridge, TN, USA (talk by J. Äystö)

ISOLDE Workshop and Users Meeting 2009,
18-20 November, Meyrin, Switzerland (talk by R. Julin)

HRIBF, Upgrade for the FRIB Era; An HRIBF Users Workshop,
9-11 December, INFN-LNS, Catania, Italy (talk by A. Jokinen)

FAIR

Helmholtzzentrum für Schwerionenforschung (GSI),
10-14 February, Darmstadt, Germany (M. Kalliokoski)

GSI/FAIR Silicon Detector Workshop,
11 February, Darmstadt, Germany (talk by E. Tuominen)

The Annual Meeting of the Finnish Physical Society,
12-14 March, Espoo, Finland (M. Kalliokoski)

The 2009 European School on High Energy Physics,
14-27 June, Bautzen, Germany (M. Kalliokoski)

IEEE NSS Nuclear Science Symposium,
25-31 October, Orlando, FL, USA (F. García)

Technology Programme

4th EGEE User Forum/OGF25 & OGF-Europe's 2nd International Event,
2-6 March, Catania, Italy (J. Hahkala, talk by J. White)

Computing in High Energy Physics,
21-27 March, Prague, Czech Republic (talk by J. Klem)

4th International Conference on Grid and Pervasive Computing,
4-8 May, Geneva, Switzerland (talks by J. Hahkala and J. Kommeri)

EGEE JRA1/SA3 All Hands Meeting,
6-8 May, Nicosia, Cyprus (J. Hahkala, K. Happonen, J. White)

LinuxDays 2009,
3-5 June, Geneva, Switzerland (talk by H. Mikkonen, M. Tuisku, talk by J. White)

Swiss-Japanese Seminar on Life-Science Grids,
6-9 July, Geneva & Grimentz, Switzerland (talks by T. Niemi, M. Tuisku)

International Conference on Grid Computing and Applications (GCA) 2009,
13-16 July, Las Vegas, NV, USA (talk by H. Mikkonen)

EGEE'09,
21-25 September, Barcelona, Spain (J. Hahkala, K. Happonen, J. White)

Terena EuroCAMP,
17-18 November, Budapest, Hungary (H. Mikkonen)

17th Annual International Conference on Advanced Computing and Communications,
13-17 December, Bangalore, India (talk by J. Kommeri)

Planck

LFI Core Team Meeting,
7-8 January, Bologna, Italy (invited talk by H. Kurki-Suonio, invited talk by T. Poutanen)

LFI Core Team Meeting,
2-3 March, Trieste, Italy (R. Keskitalo, invited talk by H. Kurki-Suonio, invited talk by T. Poutanen)

The Annual Meeting of the Finnish Physical Society,
12-14 March, Espoo, Finland (R. Keskitalo)

Planck Working Group 3 (CTP) Meeting,
30 March - 3 April, Paris, France (H. Kurki-Suonio)

Joint Core Team Meeting,
28-30 April, Orsay, France (R. Keskitalo, talk by H. Kurki-Suonio, A. Lähteenmäki)

LFI Core Team Meeting,
8-9 July, Bologna, Italy (talk by H. Kurki-Suonio, invited talk by T. Poutanen)

Planck Working Group 6 (Extragalactic Point Sources) Meeting,
3-5 September, Espoo, Finland (A. Lähteenmäki)

LFI Core Team Meeting,
7-8 September, Bologna, Italy (H. Kurki-Suonio, A. Lähteenmäki, invited talk by T. Poutanen, M. Savelainen)

Planck Working Group 3 (CTP) Meeting,
28 September - 2 October, Warsaw, Poland (H. Kurki-Suonio)

Joint Core Team Meeting,
2-4 November, Bologna, Italy (talk by H. Kurki-Suonio, A. Lähteenmäki, invited talk by T. Poutanen, M. Savelainen)

Planck Consortium Meeting,
5-6 November, Bologna, Italy (H. Kurki-Suonio, invited talk by A. Lähteenmäki, invited talk by T. Poutanen, M. Savelainen)

Administration and Support

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

EPPOG Meeting,
30-31 October, CERN, Geneva, Switzerland (R. Rinta-Filppula)

Publications

Theory Programme

Cosmophysics

D. Battefeld and T. Battefeld,
Multi-field inflation on the landscape,
J. Cosmol. Astropart. Phys. 0903 (2009) 027

D. Battefeld and T. Battefeld,
On non-Gaussianities in multi-field inflation (N fields): bi- and tri-spectra beyond slow-roll,
J. Cosmol. Astropart. Phys. 0911 (2009) 010

D. Battefeld and T. Battefeld,
The relic problem of string gas cosmology,
Phys. Rev. D 80 (2009) 063518

D. Battefeld, T. Battefeld, and J. T. Giblin, Jr.,
Suppression of parametric resonance and the viability of tachyonic preheating after multifield inflation,
Phys. Rev. D 79 (2009) 123510

K. Enqvist, M. Mattsson, and G. Rigopoulos,
Supernovae data and perturbative deviation from homogeneity,
J. Cosmol. Astropart. Phys. 0909 (2009) 022

K. Enqvist, S. Nurmi, G. Rigopoulos, O. Taanila, and T. Takahashi,
The subdominant curvaton,
J. Cosmol. Astropart. Phys. 0911 (2009) 003

K. Enqvist and T. Takahashi,
Effect of background evolution on the curvaton non-Gaussianity,
J. Cosmol. Astropart. Phys. 0912 (2009) 001

A. Ferrantelli,
Scattering of massive W bosons into gravitinos and tree unitarity in broken supergravity,
J. High Energy Phys. 0901 (2009) 070

M. Herranen, K. Kainulainen, and P. M. Rahkila,
Kinetic theory for scalar fields with nonlocal quantum coherence,
J. High Energy Phys. 0905 (2009) 119

M. Herranen, K. Kainulainen, and P. M. Rahkila,
Towards a kinetic theory for fermions with quantum coherence,
Nucl. Phys. B 810 (2009) 389

K. Kainulainen and V. Marra,
New stochastic approach to cumulative weak lensing,
Phys. Rev. D 80 (2009) 123020

K. Kainulainen and V. Marra,
Supernovae observations in a "meatball" universe with a local void,
Phys. Rev. D 80 (2009) 127301

D. Podolsky,
Dynamical renormalization group methods in theory of eternal inflation,
Grav. Cosmol. 15 (2009) 69

D. Podolsky and K. Enqvist,
Eternal inflation and localization on the landscape,
J. Cosmol. Astropart. Phys. 0902 (2009) 007

Laws of Nature and Condensed Particle Matter Phenomenology at the LHC

J. Alanen, K. Kajantie, and V. Suur-Uski,
Spatial string tension of finite temperature QCD matter in gauge/gravity duality,
Phys. Rev. D 80 (2009) 075017

J. Alanen, K. Kajantie, and V. Suur-Uski,
Gauge/gravity duality model for gauge theory thermodynamics,
Phys. Rev. D 80 (2009) 126008

O. Antipin, M. Heikinheimo, and K. Tuominen,
Natural fourth generation of leptons,
J. High Energy Phys. 0910 (2009) 018

O. Antipin and K. Tuominen,
Discriminating between technicolor and warped extra dimensional model via $pp \to ZZ$ channel,
Phys. Rev. D 79 (2009) 075011

S. A. Bass, C. Gale, A. Majumder, C. Nonaka, G. Y. Qin, T. Renk, and J. Ruppert,
Systematic comparison of jet energy-loss schemes in a realistic hydrodynamic medium,
Phys. Rev. C 79 (2009) 024901

M. Chaichian, P. Hoyer, K. Huitu, V. A. Khoze, and A. D. Pilkington,
Searching for the triplet Higgs sector via central exclusive production at the LHC,
J. High Energy Phys. 0905 (2009) 011

D. A. Demir, M. Frank, D. K. Ghosh, K. Huitu, S. K. Rai, and I. Turan,
Doubly charged Higgsinos at the Tevatron,
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M. Dvornikov and J. Maalampi,
Oscillations of Dirac and Majorana neutrinos in matter and a magnetic field,
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K. J. Eskola, H. Paukkunen, and C. A. Salgado,
EPS09 - A new generation of NLO and LO nuclear parton distribution functions,
J. High Energy Phys. 0904 (2009) 065

D. K. Ghosh, T. Honkavaara, K. Huitu, and S. Roy,
Correlations between sneutrino oscillations and signatures at the LHC in anomaly-mediated supersymmetry breaking,
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R. M. Godbole, S. K. Rai, and S. D. Rindani,
Use of transverse polarization to probe R-parity violating supersymmetry at ILC,
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A. Hietanen, K. Kajantie, M. Laine, K. Rummukainen, and Y. Schröder,
Three-dimensional physics and the pressure of hot QCD,
Phys. Rev. D 79 (2009) 045018

A. J. Hietanen, J. Rantaharju, K. Rummukainen, and K. Tuominen,
Spectrum of SU(2) lattice gauge theory with two adjoint Dirac flavours,
J. High Energy Phys. 0905 (2009) 025

A. J. Hietanen, K. Rummukainen, and K. Tuominen,
Evolution of the coupling constant in SU(2) lattice gauge theory with two adjoint fermions,
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K. Huitu and J. Laamanen,
Relic density in nonuniversal gaugino mass models with SO(10) GUT symmetry,
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T. Kähärä and K. Tuominen,
Effective models of two-flavor QCD: From small towards large m_q,
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H. Niemi, K. J. Eskola, and P. V. Ruuskanen,
Elliptic flow in nuclear collisions at ultrarelativistic energies available at the CERN Large Hadron Collider,
Phys. Rev. C 79 (2009) 024903

T. Renk,
Comparison study of medium-modified QCD shower evolution scenarios,
Phys. Rev. C 79 (2009) 054906

T. Renk,
γ-hadron correlations as a tool to trace the flow of energy lost from hard partons in heavy-ion collisions,
Phys. Rev. C 80 (2009) 014901

T. Renk,
Medium-modified jet shapes and other jet observables from in-medium parton shower evolution,
Phys. Rev. C 80 (2009) 044904

Hadron Physics Activity

C. S. An and B. S. Zou,
The role of the $qqqq\bar{q}$ components in the electromagnetic transition $\gamma^*N \to N^*(1535)$,
Eur. Phys. J. A 39 (2009) 195

S. Wycech and A. M. Green,
The kaon-few-nucleon levels and lifetimes calculated by a variational method,
Few-Body Syst. 45 (2009) 95

S. Wycech and A. M. Green,
Variational calculations for $\bar{K}$ -few-nucleon systems,
Phys. Rev. C 79 (2009) 014001

String Theory and Mathematical Physics

T. C. Adorno, M. C. Baldiotti, M. Chaichian, D. M. Gitman, and A. Tureanu,
Dirac equation in noncommutative space for hydrogen atom,
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J. Alanen, E. Keski-Vakkuri, P. Kraus, and V. Suur-Uski,
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J. High Energy Phys. 0911 (2009) 014

M. Arai, C. Montonen, and S. Sasaki,
Vortices, Q-balls and domain walls on dielectric M2-branes,
J. High Energy Phys. 0903 (2009) 119

M. Arai, N. Okada, K. Smolek, and V. Šimák,
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C. Cronström and T. Raita,
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***N*-point functions in rolling tachyon background,**
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Energy-momentum tensor of perturbed tachyon matter,
Phys. Rev. D 79 (2009) 106005

N. Jokela, M. Järvinen, and E. Keski-Vakkuri,
Electrostatics approach to closed string pair production from a decaying D-brane,
Phys. Rev. D 80 (2009) 126010

N. Jokela, M. Järvinen, and S. Nowling,
Winding effects on brane/anti-brane pairs,
J. High Energy Phys. 0907 (2009) 085

S. Kawai and S. Sasaki,
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V. Keränen, E. Keski-Vakkuri, S. Nowling, and K. P. Yogendran,
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BPS D0-D6 branes in supergravity,
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N. Uekusa,
The lightest Higgs boson mass in effective field theory with bulk and brane supersymmetry breaking,
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Low Dimensional Quantum Systems

G. Bårdsen, E. Tölö, and A. Harju,
Magnetism in tunable quantum rings,
Phys. Rev. B 80 (2009) 205308

J. Särkkä and A. Harju,
Effect of nuclear polarization on spin dynamics in a double quantum dot,
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J. Särkkä and A. Harju,
Control of a two-electron double quantum dot with an external magnetic field,
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K. Sääskilahti, A. Harju, and P. Pasanen,
Gate-controlled current switch in graphene,
Appl. Phys. Lett. 95 (2009) 092104

E. Tölö and A. Harju,
Effects of thickness in quantum dots in strong magnetic fields,
Phys. Rev. B 79 (2009) 075301

E. Tölö and A. Harju,
Quantum Hall droplet laterally coupled to a quantum ring,
Phys. Rev. B 80 (2009) 045303

Radiation Damage in Particle Accelerator Materials

M. Backman, F. Djurabekova, O. H. Pakarinen, K. Nordlund, L. L. Araujo, and M. C. Ridgway,
Amorphization of Ge and Si nanocrystals embedded in amorphous SiO_2 by ion irradiation,
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F. Djurabekova, M. Backman, O. H. Pakarinen, K. Nordlund, L. Araujo, and M. C. Ridgway,
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J. A. Pakarinen, M. Backman, F. Djurabekova, and K. Nordlund,
Partial melting mechanisms of embedded nanocrystals,
Phys. Rev. B 79 (2009) 085426

O. H. Pakarinen, F. Djurabekova, K. Nordlund, P. Kluth, and M. C. Ridgway,
Molecular dynamics simulations of the structure of latent tracks in quartz and amorphous SiO_2,
Nucl. Instr. Meth. B 267 (2009) 1456

Physics of Biological Systems

H. Martinez-Seara, T. Róg, M. Karttunen, I. Vattulainen, and R. Reigada,
Why is the *sn*-2 chain of monounsaturated glycerophospholipids usually unsaturated whereas the *sn*-1 chain is saturated? Studies of 1-stearoyl-2-oleoyl-*sn*-glycero-3-phosphatidylcholine (SOPC) and 1-oleoyl-2-stearoyl-*sn*-glycero-3-phosphatidylcholine (OSPC) membranes with and without cholesterol,
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Multiscale modeling of emergent materials: biological and soft matter,
Phys. Chem. Chem. Phys. 11 (2009) 1869

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High Energy Physics Programme

Forward Physics

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T. Aaltonen et al.,
Search for narrow resonances lighter than ϒ mesons,
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T. Aaltonen et al.,
Search for the rare decays $B^+ \to \mu^+ \mu^- K^+$, $B^0 \to \mu^+ \mu^- K^*(892)^0$, and $B^0_s \to \mu^+ \mu^- \phi$ at CDF,
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Measurement of the fraction of $t\bar{t}$ production via gluon-gluon fusion in $p\bar{p}$ collisions at $\sqrt{s}$ = 1.96 TeV,
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Measurement of the $t\bar{t}$ production cross section in 2 fb^{-1} of $p\bar{p}$ collisions at $\sqrt{s}$ = 1.96 TeV using lepton plus jets events with soft muon *b* tagging,
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Top quark mass measurement in the lepton plus jets channel using a modified matrix element method,
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Measurement of the top quark mass at CDF using the "neutrino φ weighting" template method on a lepton plus isolated track sample,
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T. Aaltonen et al.,
Measurement of the *b*-hadron production cross section using decays to $\mu^- D^0 X$ final states in $p\bar{p}$ collisions at $\sqrt{s}$ = 1.96 TeV,
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Search for new particles decaying into dijets in proton-antiproton collisions at $\sqrt{s}$ = 1.96 TeV,
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Measurement of particle production and inclusive differential cross sections in $p\bar{p}$ collisions at $\sqrt{s}$ = 1.96 TeV,
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Measurement of the $t\bar{t}$ cross section in $p\bar{p}$ collisions at $\sqrt{s}$ = 1.96 TeV using dilepton events with a lepton plus track selection,
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Search for WW and WZ production in lepton plus jets final state at CDF,
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