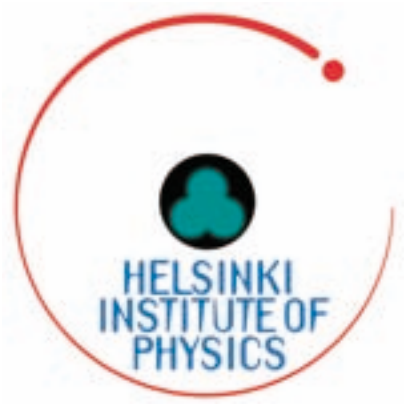
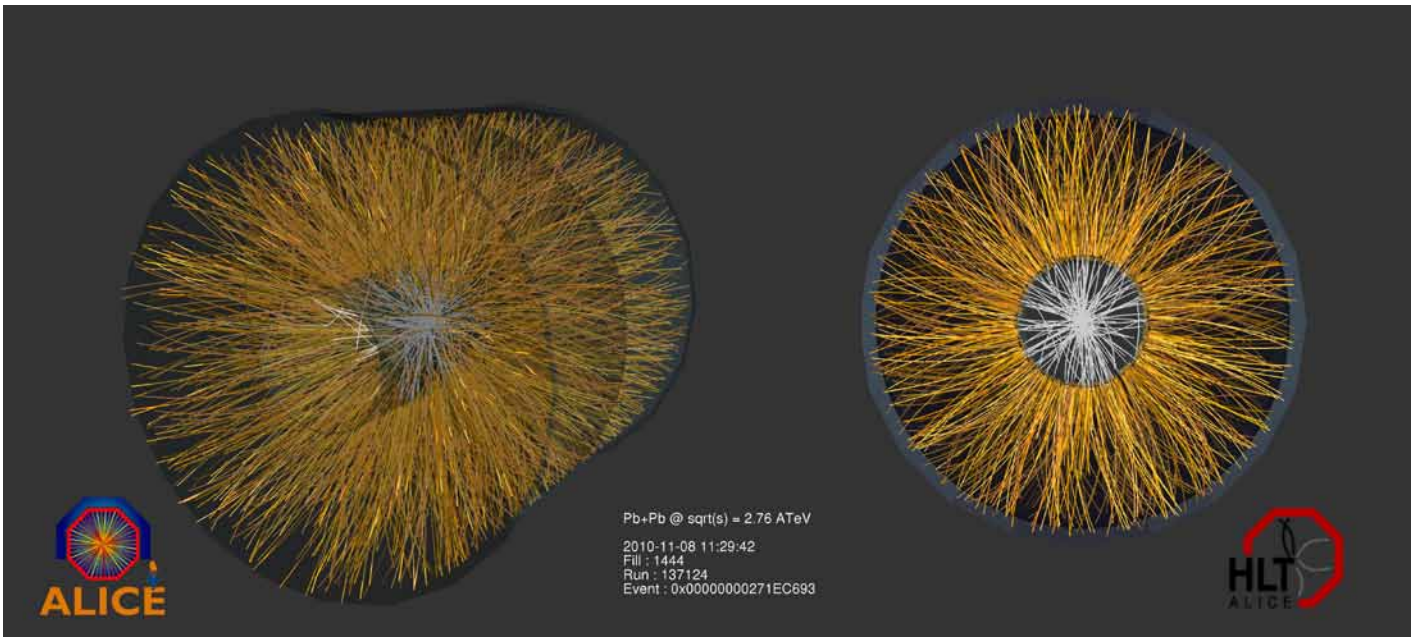
Annual Report 2010



Annual Report 2010



Event display of one of the first Pb+Pb collisions at c.m. $\sqrt{s_{NN}}$ = 2.76 TeV recorded by the ALICE collaboration.

Annual Report 2010 Helsinki Institute of Physics

Contents

Introduction

Dan-Olof Riska

The main events during 2010 were the successful start-up for physics experiments of the Large Hadron Collider LHC at CERN at the beginning of April and the signing of the Convention for the Facility for Antiproton and Ion Research FAIR in October.

The LHC collider concluded its proton-proton run with a collision energy of 7 TeV in November after having successfully reached its design beam luminosity. This was followed by a productive run colliding lead ions at the end of November. The new physics results were reported in a large number of publications by all the detector collaborations.

The Helsinki Institute of Physics (HIP) has since 1997 had a national mandate from the Finnish Ministry of Education for co-ordination of the collaboration between CERN and Finland. After the signing of the FAIR Convention, the Finnish Ministry of Education and Culture gave HIP the task of co-ordination of the Finnish activities at FAIR. A Finnish-Swedish Consortium agreement for collaboration and joint representation in FAIR GmbH was formed by the University of Helsinki and the Swedish Research Council.

HIP is operated by the University of Helsinki, the Aalto University, the University of Jyväskylä, and Lappeenranta and Tampere Universities of Technology. Administratively HIP is associated with the University of Helsinki. The HIP operations are based on the Finnish CERN strategy, which emphasises, in addition to research in physics, 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 success of these outreach efforts is demonstrated by the sustained large Finnish coefficient of return for industrial supplies at CERN and by the great interest in CERN shown by Finnish high schools. In 2010 the Institute was able to host 14 study visits to CERN by Finnish high school students and 2 courses for teachers at CERN (3 of the 17 planned visits for 2010 had to be postponed till 2011 because of airline strikes).

In June HIP and the Division of Particle Physics of the Department of Physics at the University of Helsinki organised the 2010 CERN School of Physics in Raseborg. The School attracted 105 students from 25 countries.

During 2010, 8 PhD and DSc (Tech) degrees and 5 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 2010, 21 Finnish students worked at CERN in HIP research programmes.

The research activities of the Helsinki Institute of Physics in 2010 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.

In the Theory Programme the projects "Cosmophysics", "Laws of nature and condensed particle matter phenomenology at the LHC", "Low dimensional quantum systems" and "Radiation damage in particle accelerator materials" were successfully reviewed during the year, and granted continuation for a second 3-year period. The earlier project on String theory and mathematical physics was brought to a successful conclusion at the end of the year.

The High Energy Physics Programme began the analysis of the data from the TOTEM experiment at the LHC and continued the physics analysis at the CDF-II experiment at the Tevatron collider at the Fermi National Accelerator Laboratory. The CLIC collider project was awarded an EU Marie Curie Industry-Academia Partnerships and Pathways project (IAPP) "MeChanICs – Marie Curie linking Industry to CERN", which will bring engineers from 5 Finnish industrial enterprises to work at CERN.

The CMS Programme continued its project on physics analysis and operation of the tracker and the trigger of the CMS detector at the LHC and started a new project on detector development for the CMS luminosity upgrade.

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.

During 2010 a focus of the Technology Programme was software development for distributed data-intensive Grid computation. The Programme was responsible for the Finnish Tier-2 Grid computing facility. The Finnish Tier-2 centre has also been part of the ALICE Tier-1 network.

In June the European Physical Society, through its Nuclear Physics Division awarded the Lise Meitner Prize 2010 to the director of the Nuclear Matter Programme, Professor Juha Äystö. Academy Professor Markku Kulmala received the quadrennial Fuchs Memorial Award at the International Aerosol Conference in September.

At the end of September Professor Jorma Tuominiemi, who has led the HIP CMS Programme since its inception, retired. At the end of the year Professor Kari Enqvist stepped down as leader of the Theory Programme in order to focus on research as Academy Professor. The Institute is indebted to the outstanding service of Jorma Tuominiemi, who successfully oversaw the HIP contribution to the construction of the CMS tracker and to Kari Enqvist for his outstanding leadership of the Theory Programme.

During 2010 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, which was chaired by Professor Jos Engelen (The Netherlands Organization for Scientific Research NWO).

HELSINKI INSTITUTE OF PHYSICS

Highlights of Research Results

Theory Programme

In the Cosmophysics project we have investigated the scale dependence of the Cosmic Microwave Background (CMB) non-Gaussianity parameter in the self-interacting curvaton model, showing that the scale dependence, encoded in the spectral index, can be observable by future cosmic CMB observations. Together with the information about the tri-spectrum parameter, the self-interacting curvaton model parameters could be completely fixed by observations.

The long-awaited LHC era in Ultrarelativistic Heavy Ion Collisions finally started in autumn 2010. Concerning the Laws of Nature and Condensed Particle Matter Phenomenology project, our predictions, made already in 2001 based on perturbative QCD (pQCD), gluon saturation and hydrodynamics, agreed well, within 7%, with the measured multiplicity in central collisions. In Beyond the Standard Model phenomenology, we introduced a Superconformal Technicolour model by supersymmetrizing Minimal Walking Technicolour. This model, interestingly, features the N=4 sector with the maximal supersymmetry broken only by electroweak gauging. The model is a calculable, ultraviolet complete extension of the Standard Model.

In the String Theory and Mathematical Physics project we constructed soliton solutions in holographic superfluid/conductor models and discovered features which are analogous to those found in the BEC-BCS crossover in fermionic cold atom condensates. We have also investigated thermalization in a strongly coupled field theory following a quench. In holographic models at strong coupling we show that thermalization proceeds "top-down".

In the Low Dimensional Quantum Systems project the main focus has been on studies of two-dimensional semiconductor quantum dots in strong magnetic fields. 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.

In the Radiation Damage in Particle Accelerator Materials project we have continued the development of the multiscale model for vacuum arcing and surface behaviour of materials at extreme electric fields, relevant for future linear colliders (CLIC). We have developed a model for the dynamical simulation of an electric field effect and subsequent modification of a metal surface in the framework of an atomistic molecular dynamics (MD) approach. The model concurrently accounts for both electrodynamical effects and interatomic interactions between the atoms.

High Energy Physics Programme

In 2010, TOTEM successfully commissioned and optimised the data taking settings of the T2 telescope and the Roman Pot (RP) detectors at 220 m and was able to take its first physics grade data in autumn 2010. In special dedicated TOTEM runs, data

with the vertical RP's at distances as close as 7 σ_{beam} from the beam centre could be taken that will allow TOTEM to complete its first physics measurement, the measurement of the elastic proton-proton cross-section at $\sqrt{s}$ = 7 TeV for the $0.4 \leq |t| \leq 5$ GeV^2 range, in the first months of 2011. T2 and RP data taken during 2010 in a special run with one bunch per beam having a lower number of protons (~10^{10}) will allow TOTEM to study the forward charged particle multiplicity in the pseudorapidity range of $5.3 \leq |\eta| \leq 6.5$ as well as the kinematics of soft single and central diffractive events in collisions without pile-up. The installation of the T1 telescope during the LHC winter shutdown of 2010–11, will allow TOTEM to start pursuing its full physics programme in 2011, especially a first measurement of the total proton-proton cross section at LHC energies.

In 2010, the Helsinki group has introduced novel methods of background analyses for the Higgs searches.

In September 2010, the EU funded and HIP co-ordinated MeChanICs project involving five Finnish high precision manufacturing firms in the industrialisation of the CLIC RF structure manufacturing, started with a kick-off meeting. The first seconded research of the project began at CERN in October 2010.

In 2010 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, for example the completion of the manufacture and testing of 40 + 10 T2 GEM detectors for TOTEM, and their installation at CERN.

In close connection with its research activities, the Helsinki group has carried out successful educational programmes both at the undergraduate and graduate levels.

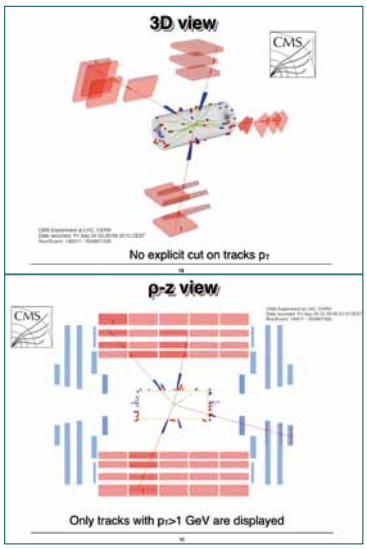
CMS Programme

The Large Hadron Collider (LHC) at CERN, Geneva, produced its first and long-awaited 7 TeV proton-proton collisions on March 30, 2010. After the start-up an incredible progress took place – LHC improved its performance continuously, and by the end of the year over 40/pb of proton-proton data were collected, as well as lead-lead heavy-ion collisions during the last weeks of operation. The accelerator exceeded the goals set for the first year of operation, reaching an instantaneous proton-proton luminosity of $2x10^{32}$ cm^{-2}s^{-1}.

The Compact Muon Solenoid (CMS) experiment is one of the two large multi-purpose experiments at the LHC. All the components of the CMS experiment – detectors, data taking, software, calibration, data processing, production of simulated data, and production of physics results – worked seamlessly and efficiently right from the start. In 2010, the CMS scientific output consisted of 19 publications on physics results from proton-proton collisions, making CMS the most productive of all the LHC experiments during the first year of operation.

Researchers in the Finnish CMS teams have made strong contributions to the CMS scientific output during 2010. In the physics analysis we have contributed in particular to the B-physics results. The B-physics analysis group was co-led by P. Eerola. Three out of the 19 publications were about B-physics: cross-section measurements of heavy mesons (J/Ψ, Υ(nS), B^+) at the highest energy ever.

Another field of physics in which the Finnish teams have been heavily involved is Higgs searches. The light charged MSSM Higgs bosons were searched for in the fully hadronic



$tt \rightarrow tbH^{\pm}$, $H^{\pm} \rightarrow \tau\nu$ channel. The amount of data collected by CMS in 2010 was not yet sufficient to reach sensitivity comparable to the Tevatron experiments for light charged Higgs, but a large fraction of the groundwork needed for the Higgs searches, such as investigation of backgrounds from the data, could be performed. The Tevatron sensitivity for the $t \rightarrow bH^{\pm}$ branching fraction can be exceeded early in 2011 when an integrated luminosity of 80 pb^{-1} will have been collected.

The Finnish CMS teams also made many contributions to the operations of this large and complex experiment. Monitoring the data quality and data certification required incessant work almost in real-time, and had certainly a decisive role in the outstanding production rate of scientific results. During 2010, V. Azzolini held the task of data certification manager. Precision measurements owe a lot to the work made in HIP with the tracker alignment. In addition our researchers contributed to the collaboration-wide activities through shifts and service work, such as software user support and training. K. Lassila-Perini continued co-ordinating user support in CMS. The Lappeenranta group made valuable contributions to the RPC operations.

The HIP Tier-2 computing cluster has been an integral part of the CMS worldwide computing and storage network. CMS analysis jobs have been executed at the HIP Tier-2 cluster through an ARC User Interface developed by the Nordic Data Grid Facility collaboration and HIP. The HIP Tier-2 centre has been one of the few Tier-2 centres hosting B-physics analysis group data.

Tests of Super-LHC fluence irradiated detectors were continued with the Silicon Beam Telescope (SiBT) at the CERN SPS H2 test beam. In autumn 2010 the SiBT was used for studying so-called CMS tracking trigger prototype detector modules from the CMS Pisa group in addition to p- and n-type sensors from the RD39 collaboration. P. Luukka continued as the CMS Tracker upgrade test beam co-ordinator. J. Härkönen continued as RD39 spokesperson. An irradiation campaign of novel detectors was performed at the Accelerator Laboratory of the University of Jyväskylä. The irradiated detectors were characterized by the Transient Current Technique (TCT) method using the measurement set-up constructed at the HIP Detector Laboratory at Kumpula.

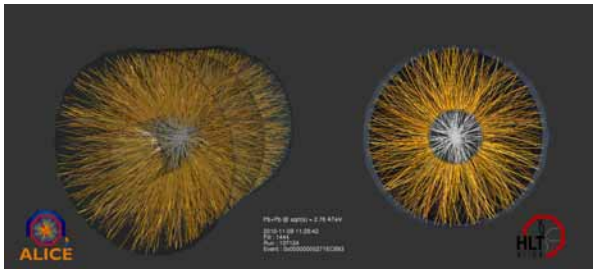
In 2010, the Finnish CMS groups in Helsinki and at CERN also put special emphasis on outreach to meet the large general interest in particle physics due to the LHC start-up.

Nuclear Matter Programme

The Nuclear Matter Programme provides participation of the Finnish teams at CERN in studies of two aspects of nuclear and hadronic matter. The first project is carried out at the ISOLDE Facility and the second one has concentrated in 2010 on data taking in ALICE. The project leaders of these two projects are Docent Ari Jokinen for ISOLDE and Docent Jan Rak for ALICE.

The approval by CERN of the upgrade of the REX-ISOLDE to a HIE-ISOLDE concept means major opportunities in the field of accelerated radioactive ion beams. In addition, the Nuclear Matter Programme has continued co-ordinating the Finnish participation in the planning of the FAIR project at GSI. The Finnish physics commu-

nity welcomed with great pleasure the official founding of FAIR GmbH which should provide an exciting long-term future for complementary research opportunities in subatomic physics.



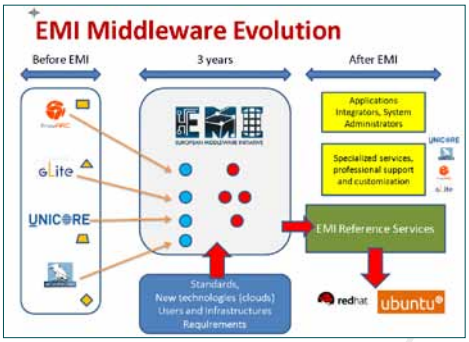
Probably the most important milestone in ALICE's history was reached on Monday, November 8th, 2010 when the first collision of Pb ions at the c.m. energy per nucleon $\sqrt{s_{NN}}$ = 2.76 TeV was recorded. ALICE collected over 17 million minimum bias *Pb+Pb* events during the first heavy ion run. A first glance at the *Pb+Pb* data provided quite convincing evidence that a deconfined nuclear medium is created in the LHC energy regime. An analysis of global observables like particle multiplicity [*Phys.Rev.Lett.* **105**, 252301 (2010)] of particle flow [*Phys.Rev. Lett.* **105**, 252302 (2010)] confirms an expected trend based on earlier measurements at RHIC, USA. The heavy ion theory group in Jyväskylä has been one of the pioneering groups in multiplicity predictions. Their prediction [*Nucl.Phys.* **A696**, 715 (2010)] was found to be in good agreement with the ALICE measurements.

The Jyväskylä group analysis concentrated on the two-particle correlation both in proton-proton and heavy ion collisions aiming to gain a better understanding of the jet fragmentation in *p+p* and the medium modifications into it in *Pb+Pb* collisions. Jan Rak was the convener of the correlation analysis in ALICE in 2010. The Jyväskylä group had significant responsibility in designing, building and developing the level-0 single photon trigger hardware for the ALICE Electromagnetic Calorimeter. This project was successful and the trigger showed an excellent performance in real data taking during 2010.

The Jyväskylä group also contributed in various ways to the ALICE experiment: Jan Rak served as run co-ordinator for 2009 and the beginning of 2010. Filip Krizek was run co-ordinator of the T0 detector in 2010 and the post continues in 2011. A new computing cluster, "Jade", was integrated into the ALICE computing frame in collaboration with CSC. DongJo Kim made a significant contribution in building the ALICE Shift Management System and the ALICE collaboration database, both of which he is the system administrator.

Technology Programme

The year 2010 marked the start of production use of the computing resources that have been tested and implemented during the past years in the GridCluster project jointly with the Finnish IT Center for Science (CSC). Towards the end of the year the GridCluster project was handed over to the CMS Programme. Also the EGEE-III project came to an end and the European Middleware Initiative (EMI) project was approved by the European Commission. The Technology Programme was successfully evaluated and as a result a new Green IT project was approved and the first research results on energy efficient cluster computing were reported. At the same time collaboration with Tampere University of Technology was formalised with a new PET project in the Programme. Finally, the Academy of Finland approved a project between the Programme and the University of Tampere.



Theory Programme

Kari Enqvist,
Theory Programme director

The Theory Programme is structured around fixed term projects, chosen according to their scientific quality and the complementarity with the research at HIP and at the host universities. For the project leaders the HIP projects provide a framework within which to build a top class research group, and the leaders are expected to secure significant external funding for their projects. In 2010 the Theory Programme consisted of 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 Accelerator Materials. The String Theory and Mathematical Physics project ended in 2010, whereas the other projects continue for a further three years. At the end of 2010 Professor Kari Enqvist relinquished the Theory Programme Director position after ten very successful years.

Kimmo Kainulainen,
Cosmophysics
project leader

Cosmophysics

We have extended our stochastic Gravitational Lensing (sGL) method for computing the weak gravitational lensing effects on light propagation in an inhomogeneous universe, including both arbitrary halo mass distributions (the Halo Model) and modelling of filaments. The extended sGL results were confronted with the Millenium simulation results with an excellent agreement. The sGL method (at a level of single mass HM) was used to study weak lensing effects on cosmological parameter extraction. Potentially large corrections were found, which may affect the cosmological parameter estimation from supernova magnitude measurements. Along with the sGL papers we released new upgraded versions of our numerical code package *turboGL*.

We have studied hybrid models with both a large local void with an LTB metric and a cosmological constant. Subjecting this model to available cosmological data we found that, barring the baryon acoustic oscillation (BAO) data, both the pure void and the pure ΛCDM are equally good solutions, but that the mixed models are disfavoured. BAO data favours the ΛCDM model, but the conclusion is not tight, because the BAO-feature cannot yet be computed with a good enough precision in the LTB-background. In addition, we have evaluated the effect of cosmic structures at small non-linear scales for a ΛCDM universe applying the effective fluid method. The density contrast is found to receive a scale dependent correction and an effective anisotropic stress sources a shift between the two gravitational potentials.

We have also studied extensions of the theory of gravity introducing a novel class of $f(R)$ theories where the connection is related to the conformally scaled metric with a scaling that depends only on the scalar curvature R. The Einstein and Palatini gravities are obtained as special limits of these theories, which however include a completely new class of gravity theories. With a non-linear $f(R)$ these theories interpolate and extrapolate the Einstein and Palatini cases and may avoid some of their conceptual and observational problems.

We continued developing the quantum transport theory with non-local coherence, which is based on the coherent quasiparticle approximation (cQPA) on the dynamical two-point functions. During this year we reformulated our coherent transport theory in the usual 4-spinor notation and derived a compact set of (extended) Feynman rules for defining and computing a loop expansion for the self energies including coherence excitations. The theory was developed in parallel for both fermionic and bosonic fields and its use was demonstrated with examples including particle creation and

a simple toy model for coherent baryogenesis. We are currently finishing up the extension of the cQPA QTT to the case of mixing scalar and fermion fields, as well as applying the formalism to the neutrino mixing.

We have also constructed a model for delayed electroweak symmetry breaking that takes place in a cold universe with T << 100 GeV and proceeds by a fast quench rather than by a conventional thermal phase transition. This is achieved by coupling the Standard Model Higgs to an additional scalar field. We have shown that the quench transition can be made fast enough for successful Cold Electroweak Baryogenesis, while leaving known electroweak physics unchanged.

We have studied dark matter in a class of Minimal Walking Technicolour models, which can provide a dynamical electroweak symmetry breaking consistent with the precision electroweak constraints along with a good 1-loop gauge unification. The most general DM sector of the model is similar to the neutralino sector in the MSSM. During 2010 we worked to perform a comprehensive scan of the entire parameter space of the model. We are currently finishing up this work, which has provided us with interesting parameter regions containing viable DM candidates.

We have continued our investigation of the curvaton mechanism for the inflationary perturbation spectrum. We have investigated the scale-dependence of the CMB non-Gaussianity parameter f_{NL} in the self-interacting curvaton model, showing that the scale-dependence, encoded in the spectral index $n(f_{NL})$, should be observable by future cosmic microwave background observations, such as CMBpol. Together with the information about the trispectrum g_{NL}, the self-interacting curvaton model parameters could be completely fixed by observations.

There is an observational excess of high-redshift massive clusters, which have a small probability of having originated from Gaussian initial curvature perturbations within ΛCDM. We have carefully estimated the contribution of non-Gaussianities to the cluster mass functions, and we find that if the bi-spectrum is used to reconcile the existence of the clusters with ΛCDM we must have $f_{NL} > 411$. If the observed excess is associated with the trispectrum instead, we need $g_{NL} > 2 \times 10^6$. The latter option could also provide an explanation for the overabundance of large voids in the early universe.

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 the properties of hot and dense QCD matter measurable at the LHC. We are in research collaboration with various international colleagues, 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. For the latter we have established a Technicolour model where a small number of new matter fields lead to the unification of the SM coupling constants and a viable DM candidate exists.

In supersymmetric theories we have investigated sneutrino-antisneutrino mixing at LHC energies. We have demonstrated that the boost factor and travelling distance can significantly alter the probability of the oscillation when the sneutrinos are ultrarelativistic and have a very small total decay width. We

propose a scenario where these requirements are fulfilled at the LHC.

Implications of the supersymmetry breaking mechanism on neutralino and chargino masses and decay cascades as well as on the DM characteristics have been studied. Our analysis shows that by measuring the masses and decay properties of the neutralinos, one can distinguish between different patterns of supersymmetry breaking.

In our studies of top polarization in an R-parity violating supersymmetric model we have found that the longitudinal polarization asymmetry of the top quark production in association with a charged slepton is significantly different from that in the production of a single top or a top pair in the Standard Model for a wide range of slepton masses. We have shown that the top-slepton associate production leads to final states, which can be resolved from the Standard Model background.

The possible structure of flavour in view of the experimental constraints on the muon electric dipole moments (EDM) and tau decays was studied. We investigated how natural a large value, of the order (10^{-24}–10^{-22}) ecm, is within the general minimal supersymmetric extension of the Standard Model with CP violation from lepton flavour violation. In models with hybrid gauge-gravity mediated supersymmetry breaking a large muon EDM is indicative for the structure of flavour breaking at the Planck scale, and points towards a high messenger scale.

We have also considered supersymmetrization of Minimal Walking Technicolour. This model, interestingly, features the N=4 sector with the maximal supersymmetry broken only by the electroweak gauging. The model is an ultraviolet complete extension of the Standard Model providing a direct link between a phenomenologically viable particle physics model and string theory via AdS/CFT correspondence.

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, during 2010 we completed the renormalization of the improved Wilson fermion action for Minimal Walking Technicolour. On the other hand, a large fraction of our research efforts is devoted to QCD, both non-perturbatively and perturbatively, for applications in URHIC. The main research avenues here are the modelling of the space-time evolution of URHIC and nuclear parton distribution functions.

In the hydrodynamical modelling of URHIC, we have developed a Monte Carlo (MC)-based event-by-event framework which accounts for the initial QCD matter density fluctuations and which is consistent with the experimental analysis of azimuthal asymmetries. Studies on thermal photon production are in progress.

High-p_T observables, ranging from single-hadron spectra and few-particle correlations to hadronic jets, are important QCD matter probes in URHIC at RHIC and especially at the LHC. We are currently developing MC simulations for modelling the hard-parton interactions with a hydrodynamically evolving QCD medium. Our systematic studies of different combinations of medium evolution and parton-medium interaction models show that the microscopic mechanism underlying the parton-medium interaction cannot be incoherent. We have also for the first time illustrated the role of bulk matter viscosity for high-p_T observables. Currently, we are investigating the role of the initial bulk matter fluctuations for hard probes.

Regarding hard nuclear QCD processes, we have applied our earlier work on nuclear parton distribution functions, the EPS09NLO package and its error sets, to direct photon production in nuclear collisions at RHIC and the LHC, with the aim to show that this process can offer important further constraints for the still poorly-known nuclear gluon densities.

We have continued our studies of the nuclear gluon densities in the Colour-Glass-Condensate framework. We have investigated long-range correlations in gluon production

in A+A and p+p collisions, addressing the new observations of a ridge-like correlation in p+p collisions reported by the CMS experiment. We have also studied nuclear diffractive deep inelastic scattering, an important part of the research programme of next generation experiments.

Using effective models for chiral fields and the Polyakov loop, constrained by lattice data and observed vacuum properties, we have studied the interplay of chiral symmetry restoration and center symmetry breaking as a function of the explicit chiral symmetry breaking at finite temperature and densities. The application of these phase diagrams and equations of state to modelling of the space-time evolution of URHIC is in progress.

String Theory and Mathematical Physics

The String Theory and Mathematical Physics project was launched as a three-year project with two main missions: i) front-line research at the interface of string theory, mathematics, and other areas of physics, and ii) to act as a bridge between various groups studying mathematical applications to physical problems, at the Kumpula campus and elsewhere. The group included as members personnel from the Physics Department and the Department of Mathematics and Statistics at the University of Helsinki.

The project begun in 2008, and completed its three years at the end of 2010. Its activities were evaluated in 2010, and the final report found the project had successfully accomplished its missions. During the lifetime of the project, string theory and mathematical physics activity has both intensified and widened. The project members will continue their work in new positions in Kumpula and elsewhere.

In 2010, the group continued studying applications of holographic gauge-gravity duality. In a pioneering work, the group investigated solitons in holographic superfluids, and constructed gravitational duals to both dark solitons (kinks) and vortices. By studying the charge density depletion at soliton cores, we found distinct features for the different condensates. We discovered that holographic solitons have many similarities with solitons in fermionic condensates undergoing a BEC-BCS crossover. This supports the viewpoint that holographic superfluids are useful toy models for their real life counterparts at strong coupling.

We also investigated thermalization in strongly coupled field theories far away from equilibrium. We studied a holographic model for a system experiencing a quench, and illustrated that thermalization proceeds "top-down", with small scales thermalizing first, in contrast to the "bottom-up" thermalization in weakly coupled models.

In the activities related to mathematical physics, one theme for the group has been to apply random matrix theory to study the decay of unstable D-branes in string theory. We have shown that random matrix techniques can be effectively used in the complicated amplitude calculations for different decay channels. We discovered a double scaling limit, where the calculations can be mapped to electrostatic problems of point charges in a background charge density in two dimensions. We also used the same limit in other random matrix applications, such as calculating probabilities for lattice paths in generalized random walk or growth models.

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

Quantum Field Theory

The Quantum Field Theory group has continued to work in several areas of research: non-commutative field and gauge theories, Very Special Relativity and Dirac's monopole quantization, modified Hořava-Lifshitz gravity with its Hamiltonian analysis and implication as a way to accelerating FRW cosmology and unification of early-time inflation with late-time acceleration, astrophysical implications of superstring-inspired unification with a shadow world, twistor formalism for chiral supermultiplets and stochastic description of particles clustering in turbulent flows by Wiener path integrals.

Ari Harju, Low Dimensional Quantum Systems project leader

Kai Nordlund, Radiation Damage in Particle Accelerator Materials 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 the 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 of the transport properties of graphene nanoribbons, utilise the tight-binding model of electrons.

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. The simulation work has also been extended to 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

The development of a new generation of linear colliders requires extensive knowledge of material science. Specifically, being able to predict the behaviour of the construction materials operated in extreme conditions can significantly increase the efficiency of costly machines. At the same time, the attempt to explain the mechanisms responsible for the surface detriment in such materials can deepen the understanding of the processes, which still remain a mystery to modern science. One of such mysteries, in spite of the intense interest of scientists over the decades, is the vacuum arcing and surface behaviour during the operation in extremely high electric fields. This phenomenon seen as frequent breakdowns damaging the surface of accelerating structures in the Compact Linear Collider (CERN, Geneva) is a challenging question to understand. The numerous analytical models developed to date in order to understand the mechanisms of ionization of surface atoms observed at very high electric fields fail, however, to predict the actual behaviour of the metal surface in this condition. The distortion of the electric field on the surface asperities changes gradually with the surface evolution during its operation. The significant enhancement of the field in its turn can cause erosion of the surface. This might happen due to the fact that the enhanced value of the electric field induces a partial charge (a fraction of the elementary charge) on the top atoms of the tip. Such a charge on an atom is sufficient for the electric

forces to contribute to the evaporation process of this atom, which leads to the preferential erosion of tip atoms. Since the derivation of analytical models does not explicitly include the structural properties of metals, they miss the link between the instantaneous effects owing to the applied field and the consequent response observed in the metal surface as a result of an extended application of an electric field.

Within the current project we have developed a concurrent electrodynamic molecular dynamic model for the dynamical simulation of an electric-field effect and subsequent modification of a metal surface in the framework of an atomistic molecular dynamics (MD) approach. We have assessed the partial charge induced on the surface atoms by the electric field by applying the classical Gauss law. The model concurrently accounts for both electrodynamic effects and interatomic interactions between the atoms. In our simulations we include both electric forces, Lorentz and Coulomb, acting on those atoms which gain an induced partial charge due to the field. At each molecular dynamics step we calculate the distribution of the electric field by solving the Laplace equation with the dynamically changing Neumann boundary condition on the surface and the Dirichlet boundary above the surface. The results obtained by the present model compare well with the experimental and density-functional theory results. The model allows for the dynamic simulation of surface modification under the electric-field effect, including the lattice expansion under the field and the migration of charged adatoms. It is a part of the multiscale approach, which is under development within the current project to elucidate the processes responsible for the vacuum arcing phenomenon. It can also be applied for image reconstruction in Atom Probe Tomography Microscopy.

The Compact Linear Collider team at the University of Helsinki visited by Dr. Walter Wünsch and Sergio Calatroni from CERN, Dec 15-16, 2010.

High Energy Physics Programme

Heimo Saarikko,
High Energy Physics
Programme director

The activities of the High Energy Physics Programme in 2010 concentrated on Higgs searches in the CDF experiment at the Fermilab Tevatron antiproton-proton collider, and on commissioning and operation 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. The group is one of the major contributors to the forward physics experiment at LHC TOTEM 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 2013–2014. In 2010 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

Background

In 2010, the Forward Physics project concentrated on: (1) finalising the CDF based analysis on exclusive gamma-gamma interactions (PhD thesis by Erik Brücken), top quark studies in the all-hadronic channel (PhD thesis by Petteri Mehtälä), and the Higgs analysis in the WH channel (PhD thesis by Timo Aaltonen) at Fermilab Tevatron, and (2) running-in the Helsinki built T2 spectrometer and (3) commissioning the TOTEM experiment for the first physics runs at the LHC at CERN.

Four MSc students joined the group in 2010, and are currently working on studies on bremsstrahlung in elastic proton-proton scattering at the LHC (Hanna Grönqvist), event classification and anomaly search (Eric Malmi, Mikael Kuusela, Tommi Vatanen), and simulation of backgrounds at the LHC (Gillis Danielsen).

The CDF top quark and Higgs analysis continued to be supported by the Academy of Finland through personal grants received by Prof. R. Orava for the years 2005–2010, a new proposal was submitted to the Academy in October 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

In 2010, the group 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 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 2010 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). Eric Malmi, Mikael Kuusela and Tommi Vatanen participate in specific analyses and work for their MSc (Eng.) studies.

In 2010 the Helsinki CDF group had three major responsibilities in CDF analysis: (1) precision measurement of the top quark mass (PhD thesis by Petteri Mehtälä), (2) Higgs search in associated production with the W-boson (PhD thesis by Timo Aaltonen) and in VBF analysis (PhD thesis by Francesco Devoto), in this analysis R. Orava serves as a 'godfather', and (3) exclusive gamma-gamma analysis (PhD thesis by Erik Brücken).

The CDF responsibilities and contributions to the CDF experiment include:
*SVXII off-line calibration.
*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 and in the VBF channel, exclusive gamma-gamma interactions.

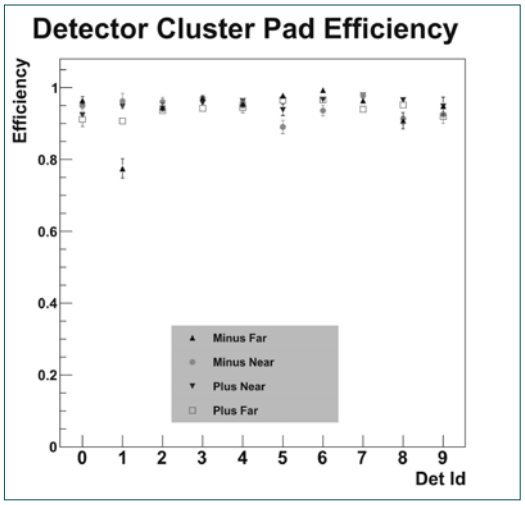
TOTEM experiment

In TOTEM, during 2010 a large effort was put into commissioning the T2 telescope and the Roman Pot (RP) detectors at 220 m leading to a successful optimisation of the data taking settings for both detectors and, during autumn 2010, to successful taking of TOTEM's first physics grade data. TOTEM could take data with the vertical (horizontal) RP's at a distance of 7 σ_{beam} (16 σ_{beam}) from the beam centre in special dedicated TOTEM runs and at a distance of 18 σ_{beam} (20 σ_{beam}) in nominal LHC runs. This data will allow TOTEM to complete its first physics measurement, the measurement of the elastic proton-proton cross-section at $\sqrt{s}$ = 7 TeV for the $0.4 \leq |t| \leq 5$ GeV^2 range, in the first months of 2011. The data from a special run with one bunch per beam having a lower number of protons (~10^{10}) will allow TOTEM to study the forward charged particle multiplicity and the forward-backward charged particle multiplicity correlation in the pseudorapidity range of $5.3 \leq |\eta| \leq 6.5$ as well as the kinematics of soft single and central diffractive events in collisions without pile-up.

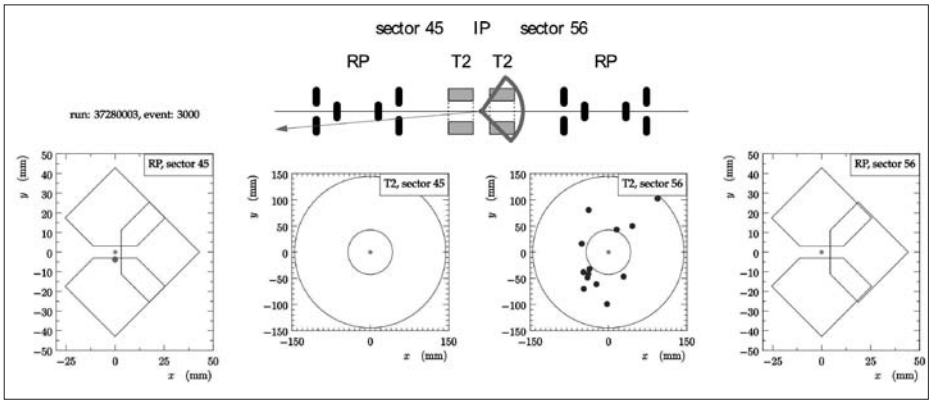
With the installation of the T1 telescope and the RP detectors at 147 m during the LHC winter shutdown of 2010–11, the experimental apparatus will be completed. This, in conjunction with the preparation of the β^* = 90 m optics from the LHC machine side, will allow TOTEM to start pursuing its full physics programme in 2011, especially a first measurement of the total proton-proton cross section at LHC energies.

TOTEM T2. With the T2 spectrometer detectors of TOTEM as its hardware responsibility, the Helsinki group concentrated on initial physics runs at the LHC. The aim is to be ready for routine data collection and analysis of the T2 spectrometer in 2011. The T2 spectrometer and its trigger & signal processing electronics have to be properly understood.

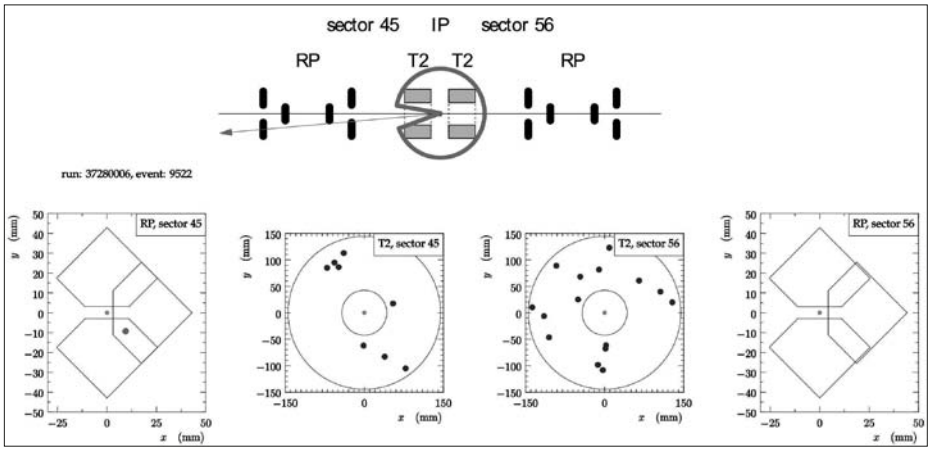
The Helsinki group participated actively in several aspects of the commissioning and data taking of the T2 telescope: preparation of hardware settings, development of data taking tools, taking of calibration and physics data as well as data analysis and debugging. This enabled the data taking settings to be optimised for the T2 telescope resulting in excellent charged particle detection efficiency for the pad readout of the



The charged particle detection efficiency of the T2 telescope pad readout for all installed 40 GEM chambers as measured from LHC proton-proton collision data.



A low mass single diffraction candidate in the 2010 TOTEM data. Top: a sketch of the detector setup and the expected signature. The proton is depicted as an arrow and the pseudorapidity coverage of the produced hadronic system as the indicated part of a circle. Bottom: the reconstructed particles in the Roman Pot (RP) detectors and T2 telescope halves on both the Jura ("sector 45") and lake side ("sector 56") of the TOTEM interaction point (IP). The green dot depicts the beam centre.



A high mass single diffraction candidate in the 2010 TOTEM data. Top: a sketch of the detector setup and the expected signature. The proton is depicted as an arrow and the pseudorapidity coverage of the produced hadronic system as the indicated part of a circle. Bottom: the reconstructed particles in the Roman Pot (RP) detectors and T2 telescope halves on both the Jura ("sector 45") and lake side ("sector 56") of the TOTEM interaction point (IP). The green dot depicts the beam centre.

T2 GEM chambers of above 90%. In addition, three faulty GEM chambers were replaced and additional protection circuits for the HV lines were produced and installed during the LHC winter 2010–11 shutdown. Finally, the group completed the building and testing of 10 spare GEM chambers in the Kumpula Detector Laboratory with a view to possible replacement of faulty chambers in the future.

TOTEM Physics. In 2010, the focus was on commissioning the installed detectors and optimising their data taking settings to get good physics data. On the request of the LHC committee, our group studied the impact on the physics potential of TOTEM, especially on the total cross section measurement, in a scenario with one half of the T1 telescope installed compared to having the complete T1 installed. After having convinced the LHC committee of the necessity for the total cross section measurement of having the complete T1, the group continued to study the determination of the inelastic rate using the latest version of the TOTEM simulation and reconstruction program with a special emphasis on estimating the fraction of low mass diffractive events that have all particles produced at pseudorapidities beyond the T2 and thus will not be detected by neither T1 nor T2. These studies will be summarized in the MSc thesis of Jan Welti.

The data taken in 2010 contain about 100 000 elastic candidates in the $|t|$-range between 0.5 and 5 GeV^2 without almost any background. This sample will be used in the first months of 2011 to determine the elastic cross section vs. $|t|$ as a first TOTEM physics measurement. Our group studies the trigger and selection efficiency of the elastic protons and their corresponding systematical errors for this measurement. The same method can be applied for the protons in single and central diffraction.

To show the potential of TOTEM in diffractive event studies, single diffractive event candidates with low and high diffractive masses taken in collisions of bunches with a low

number of protons are shown in the figures to the left. The high and low diffractive masses, M, are confirmed by both the horizontal displacement w.r.t. the beam centre of the RP measured proton (proportional to the proton momentum loss ξ) as well as by the size of the rapidity gap, Δη, between the proton and the diffractive system as detected by T2. For single diffraction $\xi = M^2/s$ and $\Delta\eta = -\ln(M \cdot s)/2$. Thus, low mass single diffraction is characterized by essentially no displacement (small ξ) and large Δη, i.e., no particles in T2 on the same side as the detected proton and high mass single diffraction by significant displacement (large ξ) and small Δη, i.e., particles in T2 also on the same side as the detected proton.

With the T2 spectrometer fully commissioned, the focus of the group's research activity will shift towards the Forward Physics Programme of TOTEM, with important analysis prospects already at a very early stage of LHC running. The physics scenario of TOTEM is based on (1) short special high statistics runs which begin during the running-in stages of the machine and (2) forward physics runs in conjunction with the CMS experiment with the nominal low-β* machine conditions. Investigations on QCD can be carried out at relatively modest luminosities, and large statistics gluon studies will become available at the beginning of the TOTEM/CMS runs.

The TOTEM team of the Helsinki group (members & advisors) in 2010 are: Erik Brücken (PhD student), Francisco García (post doc), Jouni Heino (lab.eng.), Timo Hildén (PhD student), Valery Khoze (advisor), Rauno Lauhakangas (detector scientist), Jerry Lämsä (advisor), Fredrik Oljemark (PhD student), Risto Orava (Professor, Helsinki group leader), Heimo Saarikko (Professor, HIP Programme leader, TOTEM CB member and team leader at CERN), Jan Welti (student), and Kenneth Österberg (University lecturer and TOTEM Physics Co-ordinator).

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 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.

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.

Linear Collider Research Project

Kenneth Österberg, Linear Collider Research project leader

The main activity in 2010 was participation in the Compact LInear Collider (CLIC) study, whose main aim is to demonstrate the feasibility of the CLIC-technology in view of a decision on the future direction of the high energy frontier in 2013–2014. The project contributes to the R&D for the CLIC RF structures and to the integration of all necessary systems into a functional CLIC module, a 2 m long repeated part of the CLIC collider. In particular, the project contributed to the cost study for the RF structures, the manufacturing and precise assembly of the RF structures plus their supporting mechanism in the CLIC module as well as the study of the thermo-mechanical behaviour of the complete CLIC module. The project continuously employed the following three researchers in 2010: R. Nousiainen and T. Uusimäki/J. Turunen based 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 is partially funded by EuCARD, a European wide EU network on accelerator R&D. In September 2010, the EU funded and HIP coordinated MeChanICs project started on the industrialisation of the CLIC RF structure manufacturing involving five Finnish high precision manufacturing firms in the R&D. At the end of 2010, a new Academy of Finland funded activity with close collaboration with the Electronics Laboratory of Helsinki University's Department of Physics started with the aim to develop a method to dynamically measure the outgasing from the RF structure surfaces during one RF pulse train. Lately the predictions from simulation on the level of this outgasing have turned out to be so high that maintaining the vacuum during a CLIC bunch train might become a feasibility issue and thus direct measurements are required to test the predictions. This study is part of the NorduCLIC project, where HIP joins forces with the Universities of Oslo and Uppsala for a joint Scandinavian contribution to the RF structure development for CLIC.

A critical issue for the CLIC overall cost is the optimisation of the production costs for the RF structures, especially the machining of their parts, since they constitute a significant fraction of the overall cost of CLIC. The project is involved in a cost-study with several European high precision manufacturing firms and research institutes on the mass production of the RF structures to provide a reliable cost estimate for CLIC to be included in the Conceptual Design Report (CDR) that will be published in 2011.

To achieve sufficient beam stability in CLIC, the accelerating structures made from µm precision machined disks need to be assembled and integrated into the CLIC module with the same precision. The stresses induced in the disks during the whole machining and assembly process has been studied in order to refine the machining and assembly methods for accelerating structures made from disks and a design of the supports for the accelerating structures and power extraction and transfer structures in the CLIC module has been made and validated with thermo-mechanical simulations.

The CLIC module with all the accelerator components and services integrated has to maintain this kind of precision also during CLIC operation. To verify this, the whole CLIC module needs to be modelled in detail and validated in different set-ups, both in the lab and in the CLIC Test Facility 3 (CTF3). A thermo-mechanical model of the CLIC module to validate the proposed solutions in view of the CDR has been developed in the project and the thermo -mechanical behaviour of a recent standard CLIC module design has been studied in detail for various CLIC operation scenarios.

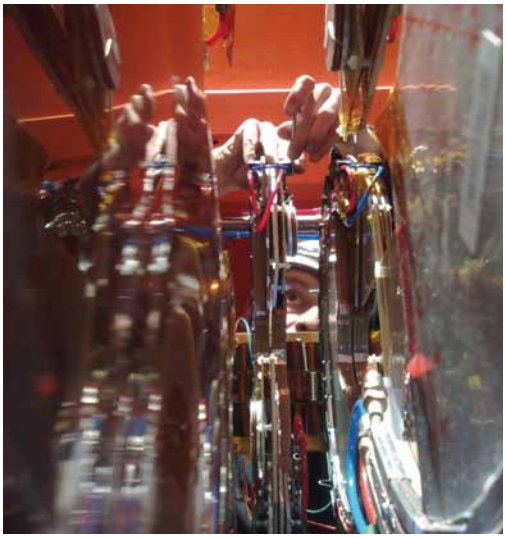
Another key issue for CLIC is to limit the RF breakdown ("sparking") probability in the accelerating structures to achieve a stable beam with a sufficiently high accelerating gradient (> 100 MV/m). The breakdowns most probably originate from spontaneous roughening of the accelerating structure surface with subsequent creation of tips with significantly increased fields as a result. We are collaborating with Prof. K. Nordlund and PhD F. Djurabekova who have developed a multi-model for the physics processes leading to an RF breakdown and thereby hope to be able to reduce the effects of breakdowns by an appropriate choice of material, preparation and design for the accelerating structures.

Eija Tuominen, Detector Laboratory coordinator

Detector Laboratory

The Detector Laboratory supports Finnish experimental research on collider-based physics. It is a joint laboratory between the 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.

Totem T2 GEM structure being studied at the Detector Laboratory clean room.



During the LHC winter stop in December three spare GEM detectors were replaced at the CERN T2 telescope.

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 of the Department of Physics.

Support for the CERN TOTEM experiment

After having assembled and tested the 40 semicircular GEM detectors required for the TOTEM T2 telescope already in 2009, the research group working in the Detector Laboratory concentrated during 2010 on constructing 10 spare GEM detectors in order to be prepared for any possible losses of the detectors already installed at CERN. Besides, the TOTEM Helsinki group actively took part in the commissioning and data taking of the TOTEM T2 telescope at LHC Interaction Point 5 (IP5). During the LHC winter stop in December, three pieces of the spare detectors were already utilised, when the group participated in the replacement operation of three faulty GEM detectors within T2.

Support for the CMS Tracker experiment

The Detector Laboratory hosts the Finnish Cosmic Rack (FinnCRack) and its data-acquisition and cooling system, operated by the CMS Tracker research group. FinnCRack is a telescope containing the same functionality as the CMS silicon Tracker. It serves as a platform for software and hardware development for the CMS upgrade. The HIP CMS Tracker group has also greatly profited from the wide selection of manufacturing and testing equipment of the Laboratory. Furthermore, in 2010, the TCT (Transient Current Technique) set-up for the characterization of silicon detectors was made operational in the Laboratory. These measurements provide all the necessary information for the studies of the properties of silicon detectors.

Support for the FAIR SUPER-FRS experiment

The Helsinki FAIR group working in the Detector Laboratory 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 2010, the first GEM-TPC prototype was constructed and tested together with the research group from Comenius University Bratislava, responsible for the TPC part, and GSI Detector Laboratory, responsible for the electronics. The prototype is serving as the basis for the design, development and manufacture of a total of 40 similar GEM-TPC detectors in the Detector Laboratory. In addition, the optical camera system with one square metre XYZ-table was commissioned in the Laboratory clean room. This system is serving as an essential tool for the quality control of GEM-foils.

Students of the course of measurement technologies studying ESail tether structure.

Support for ERL wire bonding projects

The Electronics Research Laboratory (ERL) of the Department of Physics works actively in the Detector Laboratory. ERL participates in the Electric Solar Wind Sail project coordinated by the Finnish Meteorological Institute and financed by EU FP7. The aim of this international research activity is to develop a method to harness solar wind as a propulsion source for spacecraft. The sail is made of several long tethers that are built from 25–50 µm diameter aluminium. During 2010, ten metres of tether structure using 50 micrometre round aluminium wire was successfully constructed using the ultrasound wire bonder equipment in the Laboratory clean room. Sergiy Kiprich (Kharkov Institute of Physics and Technology, Ukraine National Science Center) supported the Finnish research group for several months during 2010 developing the bonding process for the tether production.

Participation in CERN RD51 Collaboration

The Detector Laboratory within HIP is a member of 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 participants of the RD51 Collaboration, the scientists of the Detector Laboratory have worked tightly together with the 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

Rauno Lauhakangas informing new physics students about detector technologies.

serves as the basis of education and training in experimental high energy physics. Summer student and technical training programmes at CERN and Fermilab have 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 four 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 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 2011, three PhD's will be completed in CDF physics analysis (Aaltonen, Brücken, Mehtälä) and two PhD's in TOTEM/CMS related topics (Hildén, Oljemark).

Due to the versatile infrastructure of the Detector Laboratory and the wide know-how of its personnel, the Laboratory offers detector courses and advanced laboratory assignments for the students of the Physics Department. In addition, several students are doing their doctoral and graduate studies in the Laboratory. The Laboratory also actively participates in the interaction with society: in 2010 several groups of high-school students and teachers visited the Laboratory. The Laboratory also took part in the launch of the new F2k Educational Laboratory of the Physics Department at the end of the year.

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 experiments are collected and experiences of the day exchanged between participants in other European universities.

CMS Programme

Paula Eerola, CMS Programme director (starting 1.10.2010)

The CMS Programme co-ordinates the Finnish participation in the Compact Muon Solenoid (CMS) experiment at the Large Hadron Collider (LHC) at CERN. After more than 20 years of research and development, construction, assembly and testing, the CMS experiment could finally start its actual physics programme with 7 TeV proton-proton collisions on March 30, 2010. By the end of the year, LHC had already provided more pp data than foreseen (40/pb) as well as lead-lead heavy-ion data during the last weeks of its 2010 operation. In 2010, the CMS scientific output consisted of 19 publications on physics results from proton-proton collisions, making CMS the most productive of all the LHC experiments during the first year of operation. The Finnish member institutes of CMS are the Helsinki Institute of Physics (HIP), the University of Helsinki and Lappeenranta University of Technology. HIP has an overall co-ordinating role in the Finnish CMS involvement. The HIP CMS Programme was re-organised for the years 2010–2012, consisting of the CMS Experiment project (CMS Physics analysis and operations), and the CMS Upgrade project. During 2010, the Finnish teams were involved in many aspects of the experiment: physics analysis, operation of the experiment, data certification and data processing, tracker alignment, muon trigger, software support, and detector upgrade research and development.

Jorma Tuominiemi, CMS Programme director (until 30.9.2010)

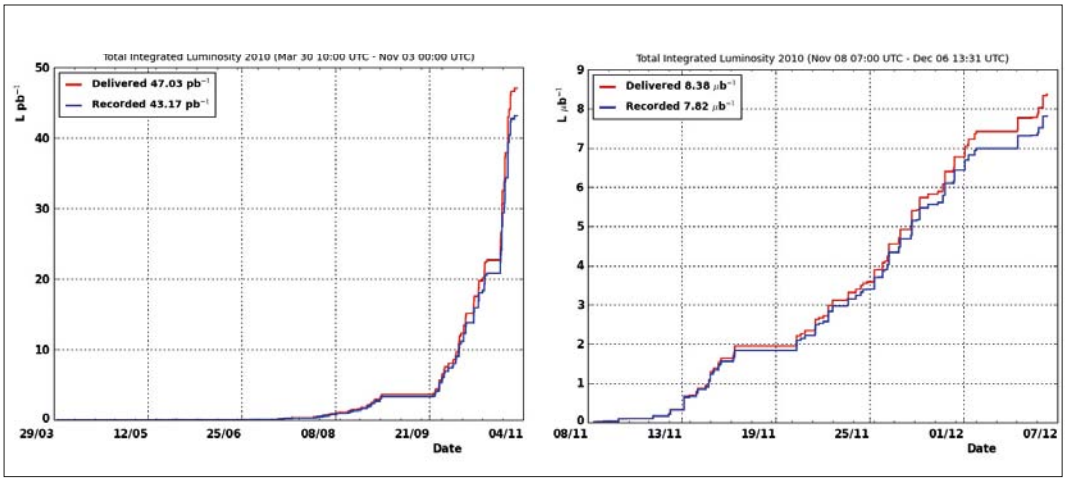
Paula Eerola, CMS Experiment project leader

CMS Experiment Project

Introduction

The Large Hadron Collider (LHC) at CERN, Geneva, produced its first and long-awaited 7 TeV proton-proton collisions on March 30, 2010. After the start-up an incredible progress took place – LHC improved its performance continuously, and by the end of the year over 40/pb of proton-proton data were collected, as well as lead-lead heavy-ion collisions during the last weeks of operation. The accelerator exceeded the goals set for the first year of operation, reaching an instantaneous proton-proton luminosity of $2x10^{32}$ $cm^{-2}s^{-1}$.

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



Left: Total integrated pp-luminosity in 2010: delivered and recorded by CMS. Right: Total integrated Pb-Pb-luminosity in 2010: delivered and recorded by CMS.

group and the HIP team continued to take the responsibility for the analysis of the $H^{\pm}$ in the τ lepton decay channel. The responsibilities for tracker alignment, data certification, and user support of the CMS software package CMSSW were other important Finnish activities during the year. The Finnish involvement in the CMS physics analysis and operations are described in more detail below.

Physics analysis

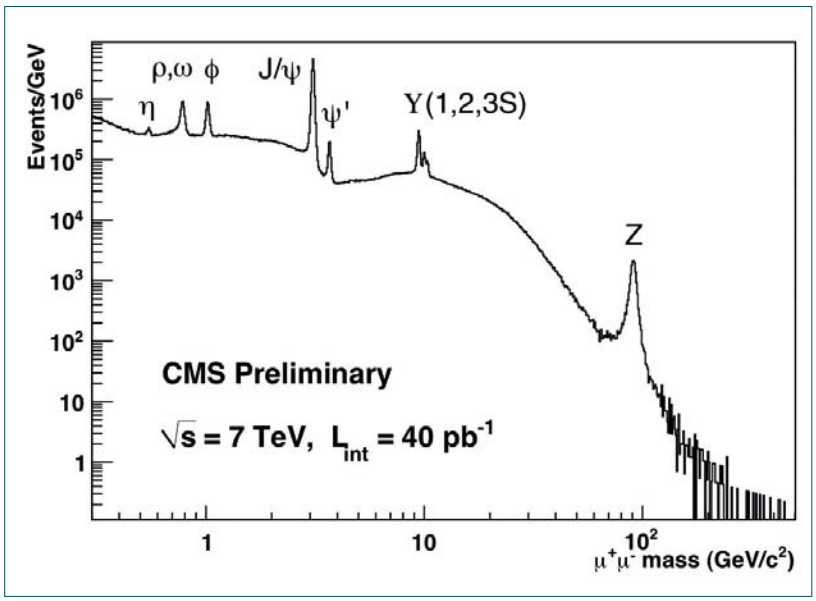
B-physics. LHC provides extremely high rates of B-hadrons due to the high b-production cross section, favourable signal-to-background ratio, and high luminosity. B-physics is a timely field in particular during the first years of data taking at the LHC, when the luminosity will be relatively low, providing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

The B-physics activities got a flying start in 2010. At the ICHEP2010 Conference in July 2010, CMS could already present four full-fledged analyses based on the integrated luminosity of 300 nb^{-1} collected by that time: J/Ψ production cross-section, including a measurement of the fraction of J/Ψ coming from B-decays (CMS PAS BPH-10-002); Υ(nS) meson production cross-sections (CMS PAS BPH-10-003); production cross-section of b quarks (CMS PAS BPH-10-007 and CMS PAS 10-009), plus a mass peak for $B^+ \rightarrow J/\Psi\, K^+$ and an event display for $B_s \rightarrow J/\Psi\phi$.

By the end of the year, the analyses turned into final publications were: Prompt and non-prompt J/Ψ production in pp collisions at $\sqrt{s}$ = 7 TeV, arXiv:1011.4193 (submitted to Eur. Physical Journal C); Upsilon production cross section in pp collisions at $\sqrt{s}$ = 7 TeV, arXiv:1012.5545 (submitted to Phys. Rev. D); Measurement of the B^+ Production Cross Section in pp Collisions at $\sqrt{s}$ = 7 TeV, arXiv:1101.0131 (submitted to Phys. Rev. Lett.).

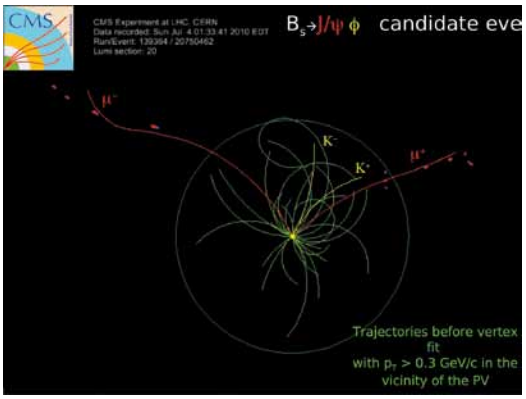
In addition, papers in the final collaboration review at the end of 2010 were analyses on b-quark cross section and on bbbar-correlations. The plans for the first year deliverables in B-physics were thus well achieved – in fact, CMS turned out to be the most productive of all the LHC experiments on the B-physics front.

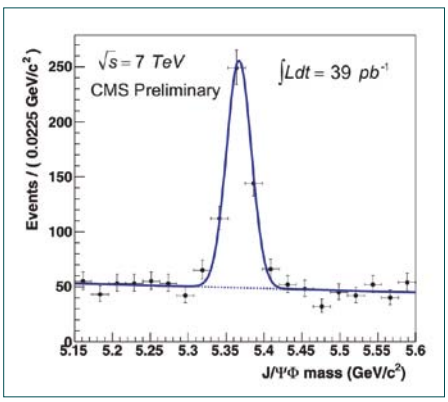
All these measurements present new knowledge: probing the heavy flavour production at a new centre-of-mass energy. Furthermore, compared to the Tevatron experiments CMS has much larger angular coverage, and has access to higher transverse energies. The measurements also act as crucial standard candles for the detector performance, and will later on serve as control channels for new and/or rare decays.



Full invariant-mass spectrum of opposite-sign muon pairs, using the whole CMS 2010 data.

In 2010, the HIP group was particularly involved in the analysis of 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. The first goal for 2010 was





Left: An event display of a $B_s \rightarrow J/\Psi\phi$ candidate. Right: Invariant mass peak of reconstructed $B_s \rightarrow J/\Psi\phi$ candidates.

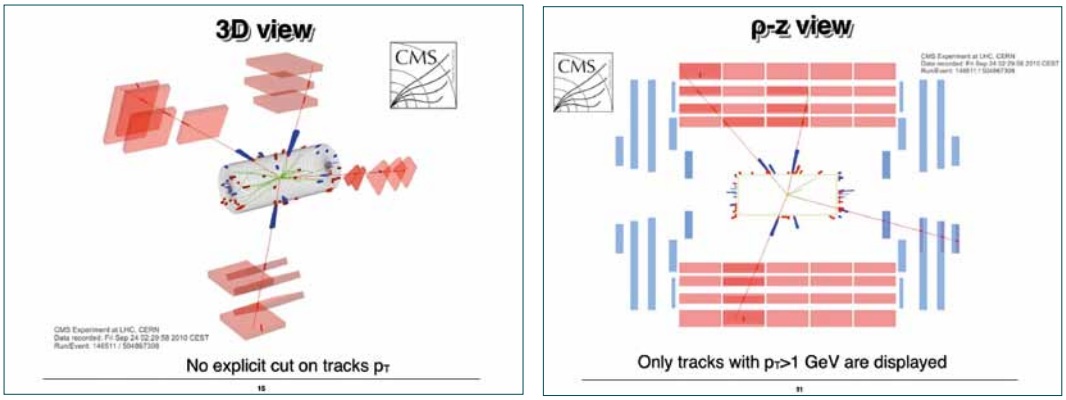
to measure the differential production cross section, and to cross-check the well-known properties of the B_s-meson. The cross section measurement was well underway by the end of 2010, and the related paper should be published in winter-spring 2011.

Work on Higgs boson searches. The main project of the HIP Higgs analysis group has been the search for the light charged Minimal Supersymmetric Standard Model (MSSM) Higgs bosons in the $tt \to tbH^{\pm}$ process from the CMS data collected during 2010. Other commitments have been the τ-reconstruction and identification code development, the Level-1 τ trigger measurement, the τ jet commissioning study, work for event generation and participation in the LHC cross section group.

Production of the light ($m_{H^{\pm}} < m_{top}$) charged MSSM Higgs bosons from top quark decays in the $tt \to tbH^{\pm}$ process, followed by the $H^{\pm} \to \tau\nu$ decay, is one of the important early discovery channels for Higgs bosons in CMS. The HIP group is responsible for the analysis of the fully hadronic final state. The analysis was based on data corresponding to an integrated luminosity of 35 pb^{-1}. The events were triggered demanding a single τ jet at Level-1 and isolation and a significant missing transverse energy at higher trigger levels. In the off-line analysis, events with one well identified and isolated τ jet, large missing transverse energy from the neutrinos, one b-tagged jet and two additional hadronic jets, were selected. The Particle Flow method was used for the reconstruction of τ jet, hadronic jet and missing transverse energy observables. Methods based on multi-variant techniques were tested for τ-jet isolation. The τ helicity correlations were exploited in the τ-jet identification. Events with any identified and isolated electrons or muons were rejected. The Higgs boson transverse mass was reconstructed from the τ jet and the missing transverse energy at the end of the selection, to distinguish the signal distribution from the residual background contamination. No excess of events was observed over the expected Standard Model background. Model-independent upper limits were calculated for the $t \to bH^{\pm}$ branching fraction. The results indicate that the limits published by the Tevatron experiments will be exceeded with an integrated luminosity of 80 pb^{-1} over the expected Higgs boson mass range.

The fully hadronic channel is subject to a large and poorly known QCD multi-jet background, which was therefore measured from the data. The probability for the standard QCD jet to fake a τ jet was first measured from the data taken with the jet triggers. The measured probability was then applied to the hadronic jets in the events taken with the signal trigger. As many hadronic jets are required, the contamination from tt and W+jet production was found to be significant. Therefore other alternative methods, also exploiting events from multi-jet triggers were developed and their application to the data is presently in progress.

Other large backgrounds are the tt production and W production in association with hadronic jets. A method was developed and tested with simulated events to measure these backgrounds as well from the LHC data with muonic multi-jet events, triggered by a single muon. At least three hadronic jets and a significant missing transverse energy were required in addition to one isolated muon. The muon



First ZZ → 4μ event observed in CMS. These kinds of events are possible signatures for a Standard Model Higgs.

was then transformed to a simulated τ with the "Tau Embedding" method. Development of this method has been one of the projects of the HIP group. The τ was left to decay and the event was reconstructed again. The full signal selection, including the τ-jet identification, was then applied to the transformed events.

Development of the τ-energy correction method based on tracks was continued during 2010. The method was implemented in the CMSSW software. The tests with the data indicate that results comparable to those from the Particle Flow method can be obtained. One of the important tasks within the event generation group was testing and maintaining the Tauola program package in the CMSSW software for proper generation of τ decays.

Shift work and work on data quality monitoring. The whole HIP-CMS Programme, including people from both the CMS Experiment and the CMS Upgrade projects, participated in the CMS operations through Data Quality Monitoring (DQM), Trigger Offline, Tracker and Detector Control System (DCS) shifts. During 2010 V. Azzolini maintained her involvement in the DQM, acting as the data certification manager, off-line field manager and on-call duty person. The DQM system and data certification have two main tasks: to (a) monitor the detector and reconstruction performance in order to find problems, and (b) to provide data evaluation as a basis for data selection for physics analysis.

The group also performed service work with the off-line DQM software, with the tau-trigger, and with the CAEN monitoring system for the CMS Tracker low and high voltage power supplies. The performance of the off-line DQM software was studied between CMS software releases 3_5_0 and 3_7_0. A common set of timing and IgProf benchmarks with collision data was run for almost each development prerelease. Within these releases an improvement of a factor of 3 in CPU time was achieved mainly by the cleaning of unnecessary dynamic memory allocations. Furthermore, testing of the Intel Performance Tuning Utility (PTU) for CMS software performance studies was started.

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 2010, the "Offline Workbook" containing essential instructions and basic and advanced tutorials was fully reviewed and the structure was adapted to the new phase of CMS operation. In particular, the common physics analysis tools are now fully covered, and up-to-date tutorials and examples are available for newcomers to get quickly started with the analysis of the CMS data. The "CMS Software Reference Manual" containing the class and object descriptions of the CMS software has been improved and the user interface now allows for quick and easy access to the class descriptions despite the large number of the software packages included.

The training programme on CMS software analysis tools has continued in 2010. The flagship project is the intensive training on "Using Physics Analysis Toolkit (PAT) in your analysis". The course has now been organised eight times, the last of these being in Fermilab in November. More than 200 CMS physicists have now been trained for the efficient use of the common analysis tools. Furthermore, a set of exercises on the basic CMS analysis and computing concepts to be completed before the course was designed this year. This set is based on the material available in "The CMS Offline Workbook" and can be used by any newcomer to get acquainted with the CMS software framework.

Tracker alignment

The CMS detector alignment is a very demanding calibration procedure crucial for physics discoveries. The task involves geometrical alignment of some 16 thousand Tracker modules with respect to each other. In 2010 the alignment was performed for the first time with high energy pp collisions combined with cosmic ray data. About 10^5 alignment parameters were fitted by analysing computed particle trajectories in order to optimise the reconstruction precision. The procedure was repeated

from time to time in order to take into account possible movements of the Tracker elements.

Important alignment operations took place when the CMS collaboration prepared for the summer 2010 conferences – particularly for the ICHEP10 Conference held in Paris in July. The HIP team participated in the validation of these alignment parameters. The work included adjustment of the Lorentz angle of charge carriers in a 3.8 Tesla magnetic field. Investigation of the 'peak'- and 'deconvolution' readout modes of the strip detectors was performed in order to validate the necessary corrections.

It was observed that non-planarity ('bow') of the silicon wafers needs to be taken into account in the calibration procedure. The hit correction is significant especially in the case of tracks with a large inclination angle with respect to the normal. Investigation of the mathematical formalism to be applied in the correction procedure was performed and verified with a Monte Carlo program. Modification for the bow of the H.I.P. alignment algorithm, originally introduced by the HIP team, was initiated.

Geant4 development

The Geant4 development effort was focused on the INCL intra-nuclear cascade model in collaboration with a group at the Commissariat à l'Énergie Atomique (CEA), Saclay. The model can be used for incident nucleons, pions and light ions on nuclei ranging from carbon to uranium with projectile energies from 200 MeV up to 3 GeV. In 2010 we completed implementation of the INCL light ion projectile extension. The model now supports light ion projectiles up to and including carbon. Light ion projectiles, especially carbon-12, are of interest to the Geant4 medical user community. The first results of this new version of INCL were presented at the Monte Carlo 2010 Conference in Tokyo, Japan. The light ion projectile extension of INCL is included in the official Geant4 9.4 version released in December 2010.

Grid computing activities

In 2010, CMS physics analysis and Monte Carlo production jobs were successfully running on the Finnish CMS Tier-2 resources. During the course of the year, the Tier project at the Technology Programme was gradually transferred to the CMS Programme to become a new project, called the CMS Tier-2 Operations project, starting formally at the beginning of 2011. The project was represented in the Nordic Data Grid Facility (NDGF) CERN committee. The project participated in the FIRI 2010 Finnish Grid Infrastructure application to the Academy of Finland to get funding to be able to replace the old Ametisti M-Grid cluster acquired in 2004. The close collaboration between the HIP CMS and Technology Programmes, CSC (IT Center for Science Ltd) and NDGF resulted in good progress on many aspects of the CMS computing that are summarized in the following.

Hardware. The main CPU resource for CMS and ALICE was the 768-core Jade Linux cluster situated at the CSC premises. Jade was commissioned and taken into use at the beginning of 2010. In addition to that the 400-core Linux cluster Korundi in Kumpula was also commissioned for all the CMS Grid jobs. The 10 Gb/s Optical Private Network (OPN) link between CSC and Kumpula, which was taken into use, allowed for the effective use of Korundi. The 260-core Linux cluster Ametisti in Kumpula was still available but less used because it was not connected to the OPN. The 512-core Linux cluster Sepeli at CSC was taken out of service. A new HP 1U DL 360 G7 server was acquired to be used as a new PhEDEx server.

Software. Performance studies on the dCache disk system were continued to understand its low performance. This resulted in an improved stability of the xrootd protocol that allowed the protocol to be taken into default use with better performance than the native dCache dcap protocol. This increased the CPU efficiency of the CMS JobRobot jobs by 30% CPU, but at a high load, the performance drops significantly limiting the CPU efficiency

for the CMSSW jobs. The dCache system at CSC was very stable in 2010, but the dCache performance drop during high load limited the site utilisation significantly. Also more disk space will be needed in the future to match the available CPU resources and to keep the CPU resource utilisation high.

One of the Sun X4540 servers was used for Lustre on Jade. The system provided a fast work disk area on Jade both for ALICE and for CMS usage once the initial problems were solved.

The Local Scope DBS service was taken into test use. The CRAB server was configured and the first CRAB test jobs from lxplus through the CRAB server were successfully completed.

The Korundi test and development cluster tb64 was upgraded to Rocks 5.4 to prepare for the corresponding planned upgrades of Ametisti and Korundi.

Operations. The Finnish CMS Tier-2 resources are operated, maintained and monitored jointly by HIP, CSC and NDGF. According to the statistics collected with the CMS monitoring tools, the Finnish Tier-2 resources performed very well and they were at the top of the CMS Tier-2 Readiness ranking list on several occasions in 2010. There were 186 thousand CMS JobRobot jobs run at HIP with a mean success rate of 93%. The reason for the good availability and reliability of the HIP CMS Tier-2 can be attributed to the stability and maintenance ease of ARC middleware allowing the use of three Compute Elements for redundancy. Also the joint monitoring by CSC, HIP and NDGF helped to spot problems early on.

The CMS PhEDEx and Frontier services were run on silo3 in Kumpula. More than 281 TB of Monte Carlo data and 276 TB of test data were transferred with PhEDEx to Finland and almost 85 TB data were exported from Finland. In total more than 642 TB data were transferred. The highest PhEDEx transfer rates were approaching 300 MB/s in 2010. The CMS disk area became practically full during 2010 and some transfer requests had to be denied due to a lack of disk space.

A total of 567 thousand CMS Grid jobs using 3.8 million HEPSPEC06 CPU hours were run in 2010. In addition to this a significant amount of local batch jobs were also run.

Outreach activities

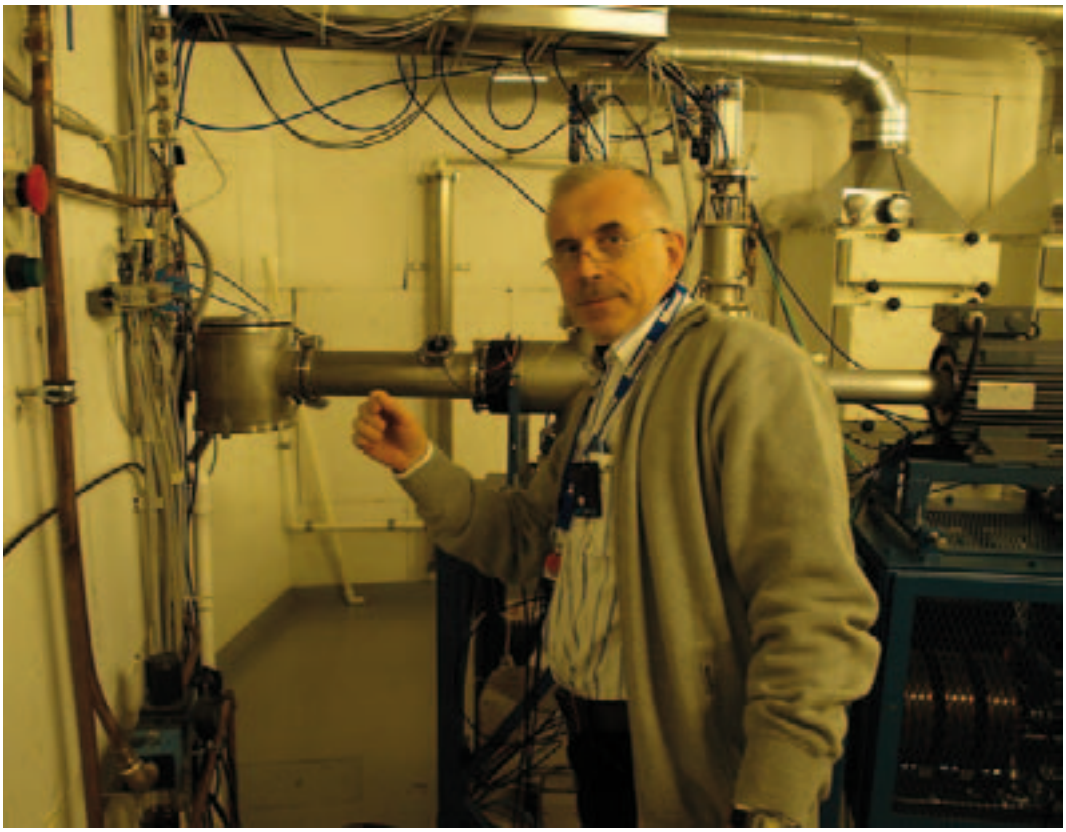
In 2010, the CMS groups in Helsinki and at CERN put a special emphasis on developing activities targeted towards students and the general public. In connection with the LHC start-up a media event was arranged at Kumpula Campus in Helsinki, which got a very good media coverage, including even prime time TV news on most of the channels. The team 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 of the LHC and recent news from CMS. Special outreach sessions were arranged to recruit graduate level summer students. The group members were also active in presenting CERN and the LHC experiments to high school student groups and high school teachers from Finland.

CMS Upgrade Project

Jaakko Härkönen, CMS Upgrade project leader

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

During 2010, the research on radiation hard silicon detectors continued in the framework of the CERN RD39 (60 members, 15 institutes) and RD50 (280 members, 55 institutes) research programmes. The network of these research and development programmes links together practically all the important research groups worldwide in this field and provides access to a wide selection of characterization and simulation tools. Furthermore, CERN experiments including CMS carry on more specific R&D programmes targeting different technologies which may need to be implemented during the future upgrades. In addition, the collaboration continued with the Accelerator Laboratory of the University of Helsinki. In 2010, P. Luukka continued as the CMS Tracker



I. Kassamakov performing silicon detector irradiations at the Physics Department of Jyväskylä University.

upgrade test beam co-ordinator, nominated in 2009. J. Härkönen who was nominated in 2003 continued as RD39 spokesperson.

The main activity of the HIP CMS Upgrade group was to maintain and develop the Silicon Beam Telescope (SiBT) situated at the CERN SPS H2 test beam area. The SiBT is an essential test and measurement platform to characterize full size detector systems in real beam-like conditions with appropriate readout electronics and data acquisition (DAQ) system. In autumn 2010 the SiBT was used for studying so-called CMS tracking trigger prototype detector modules from the CMS Pisa group in addition to p- and n-type sensors from the RD39 collaboration. Unlike previously, in 2010 the analysis of the SiBT data was a responsibility of the CMS Upgrade project. These kinds of measurements are needed since the characterization of test samples in laboratory conditions is not sufficient in order to establish a reliable scenario of detector performance in very harsh radiation environments, such as the CMS Tracker after the planned luminosity upgrade. Thus, the SiBT forms an essential part of the upgrade programme of the CMS collaboration.

In 2010, we carried out an irradiation campaign of novel detectors at the Accelerator Laboratory of the University of Jyväskylä. The irradiated detectors were characterized by the Transient Current Technique (TCT) method using the measurement set-up constructed at the HIP Detector Laboratory at Kumpula. Later, selected detectors were measured with the SiBT in November.

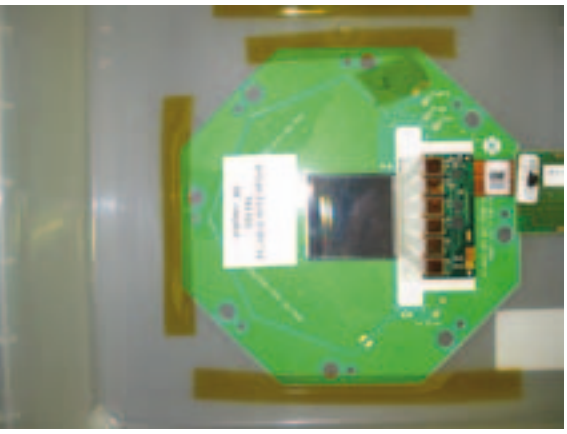
Our other major development in 2010 was the technology of a capacitively coupled (AC-coupled) pitch adapter. A modern strip detector module consists of three parts: a sensor, a readout hybrid and a pitch adapter (PA) between them. If the capacitive isolation of the detector leakage current were done using the AC pitch adapter, there would be large cost-savings in the construction of large detector systems, such as the CMS silicon tracker. The AC-coupled pitch adapters were processed at the Aalto University Micronova, Research Centre for Micro- and Nanotechnology. The key technologies include the deposition of

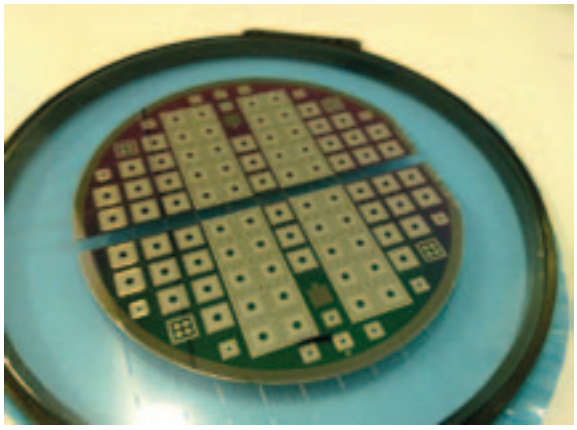
Teaching silicon detector measurement technologies to physics students in the Kumpula clean room.

aluminium oxide (Al_2O_3) dielectric thin films by Atomic Layer Deposition (ALD) as well as room temperature processing of integrated bias resistors. Later, SiBT test beam results showed excellent properties for the detector modules constructed with the AC-coupled pitch adapter. In 2010, the University of Helsinki submitted a patent application for this technology.

Outreach

The Kumpula Detector Laboratory has supervised students' laboratory projects and hosted school and other visits. The Laboratory is participating in the activities of the F2k-laboratory at the Physics Department as well. At CERN, the group members hosted visits of high school student groups and high school teachers from Finland.





Left: A silicon detector module including the patented AC coupled pitch adapter. Right: A silicon detector wafer processed at the Aalto University Micronova.

Nuclear Matter Programme

Juha Äystö,
Nuclear Matter
Programme director

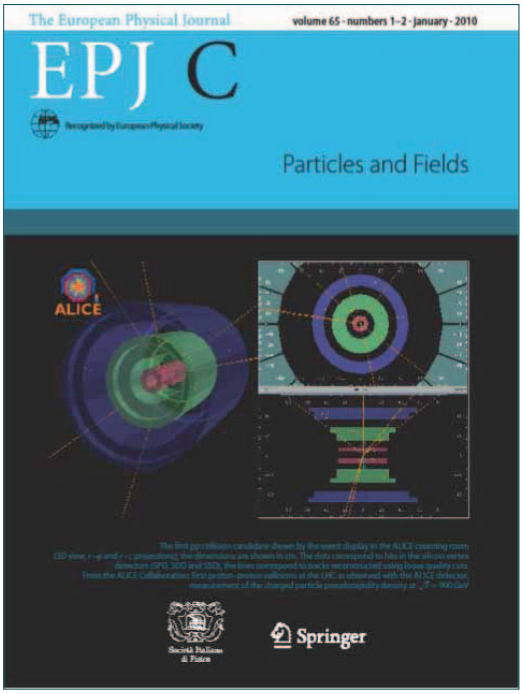
The Nuclear Matter Programme provides participation of the Finnish teams at CERN in studies of two aspects of nuclear and hadronic matter. These are cold exotic matter with the extreme composition of its proton and neutron numbers and hot and dense matter created in relativistic heavy ion collisions. The first project is carried out at the ISOLDE Facility and the second one has concentrated in 2010 on data taking in 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 project leaders of these two projects are Docent Ari Jokinen for ISOLDE and Docent 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. Three important highlights have been reached in 2010. A very successful exploitation of a full year of running collisions at the LHC by the ALICE experiment was a truly remarkable achievement. The approval by CERN of the upgrade of the REX-ISOLDE to a HIE-ISOLDE concept means major opportunities in the field of accelerated radioactive ion beams. Thirdly, the Finnish physics community welcomed with great pleasure the official founding of FAIR GmbH which should provide an exciting long-term future for complementary research opportunities in subatomic physics.

Jan Rak, ALICE
project leader

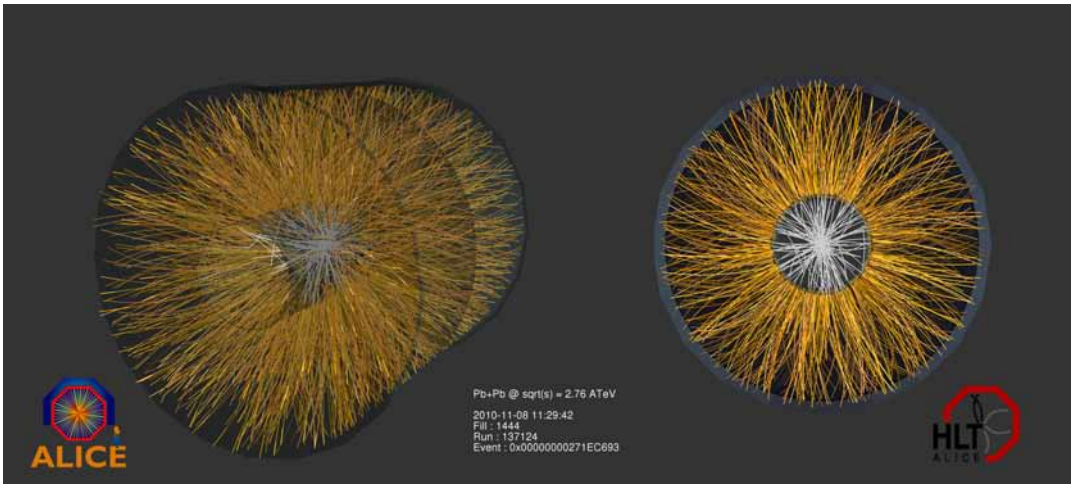
ALICE

Introduction

November 23rd 2009 marked one of the most important milestones in CERN's history – all four major LHC experiments (CMS, ATLAS, ALICE, LHCb) recorded their first proton-proton collisions at centre-of-mass energy $\sqrt{s}$ = 900 GeV. The ALICE collaboration managed to publish the very first paper on LHC data analysis [*Eur.Phys.J.* **C65**, 111–125 (2010)] and the ALICE event display appeared on the cover page of the January EPJC issue.



During March 2010 the LHC accelerator successfully commissioned the 3.5 TeV proton beam. At the end of the 2010 p+p LHC run the ALICE collaboration recorded almost 1 pb^{-1} of minimum bias data. This large sample of unique data provides an excellent test bench for the pQCD description of hard scattering phenomena at the highest centre-of-mass



Event display of one of the first Pb+Pb collisions at c.m. $\sqrt{s_{NN}}$ = 2.76 TeV recorded by the ALICE collaboration.

energy *p+p* collisions ever recorded. Up to January 2011 there had been seven ALICE papers published in high-impact journals and many new papers are in preparation.

However, probably the most important event in ALICE's history happened on Monday, November 8th, 2010 when the first collision of *Pb* ions at the c.m. energy per nucleon $\sqrt{s_{NN}}$ = 2.76 TeV was recorded.

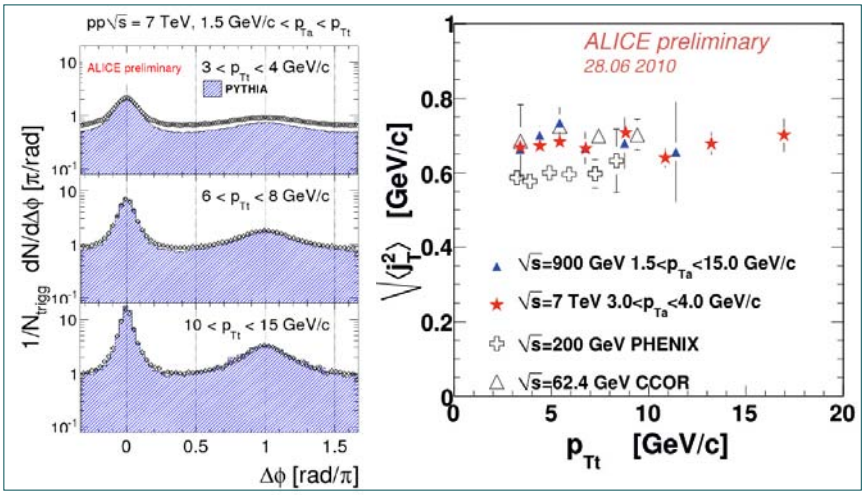
Later, over 17 million minimum bias *Pb+Pb* events were collected during the first heavy ion run in November – early December 2010. ALICE performed extremely well and the analysis of heavy ion data resulted, so far, in five publications reporting on: Charged particle multiplicity distribution [*Phys.Rev.Lett.* **105**, 252301 (2010)] and its centrality dependency [arXiv:1012.1657], elliptic flow [*Phys.Rev.Lett.* **105**, 252302 (2010)], jet suppression [*Phys. Lett.* **B696**, 30–39 (2011)] and the two-pion Bose-Einstein correlations [*Phys.Lett.* **B696**, 328–337 (2011)].

Proton-proton data analysis

A sizable amount of *p+p* data was collected in 2010 providing several "basic" results from the data analysis: charged particle multiplicity densities in 0.9, 2.36 and 7.0 TeV collision energies, proton to anti-proton ratios and two-pion Bose-Einstein correlations. The year 2011 will provide very interesting results as the excellent tracking and particle identification capabilities of ALICE start to be fully exploited with a growing understanding of the detectors.

Our group focuses on the study of the hard-scattering phenomena utilising the high-p_T correlation technique. Data taken in 2010 at $\sqrt{s}$ = 0.9 TeV and $\sqrt{s}$ = 7 TeV were analysed with the goal to study the properties of jet-fragmentation (evolution of the jet fragmentation transverse momentum j_T with $\sqrt{s}$) and the di-jet acoplanarity characterized by the magnitude of the mean transverse partonic momentum k_T.

The magnitude of j_T reflects a characteristic momentum scale of the jet fragmentation process arising from the angular ordering of jet fragments (see the right panel of the figure below). Exploration of the momentum dependency of j_T allows us to study the quantum interference effects which are vital for understanding of parton fragmentation processes.



Left: Per trigger normalized yield of associated particles as a function of pair relative azimuthal angle $\Delta\phi$ from p+p at $\sqrt{s}$ = 7 TeV (left panel). Top, middle and bottom panels show the distribution for trigger particle momenta restricted to the ranges 3 < p_{Tt} < 4 GeV/c, 6 < p_{Tt} < 8 GeV/c and 10 < p_{Tt} < 15 GeV/c. The magnitude of associated particle transverse momentum was restricted to 1.5 < p_{Ta} < p_{Tt}. Experimental data (open circles) are compared to a prediction of Pythia 8.135 (hatched histogram). Right: Extracted value of $\langle j_T^2 \rangle$ as a function of trigger transverse momentum p_{Tt}. Comparison of results obtained from ALICE p+p at $\sqrt{s}$ = 0.9 TeV and $\sqrt{s}$ = 7 TeV measurements and the available data from CCOR and PHENIX collaborations. Systematic errors are not shown.

In the analysis we used tracks reconstructed in the Time Projection Chamber (TPC) and the Inner Tracking System (ITS). Filip Krizek used extensive Pythia6 Monte Carlo simulations (Perugia 0 tune) [arXiv:0905.3418] to estimate the correction on charged track reconstruction efficiency.

The relative azimuthal angle ($\Delta\phi = \phi_{trigg} - \phi_{assoc}$) distributions of per trigger normalized yield of associated particles produced in p+p at c.m. energy $\sqrt{s}$ = 7 TeV is shown in the left panel of the figure on the previous page. Experimental distributions for various trigger particle momenta are compared with Pythia calculations. The near side peak (centred around $\Delta\phi \sim 0$ rad) and the away side peak (centred around $\Delta\phi \sim \pi$ rad) emerge from pairs coming from the same and away-side jet fragmentation, respectively. Uncorrelated pairs form the flat continuum where one or both particles originate from the underlying event (processes related to the soft QCD radiation). The near-side peak is formed by pairs where both particles come from the same jet. The width of this peak is, therefore, dependent on the magnitude of the jet fragmentation transverse momentum j_T. The right panel of the figure shows a comparison of the mean values of $\sqrt{\langle j_T^2 \rangle}$ obtained from the ALICE data analysis together with results from similar measurements done at lower c.m. energies at ISR and RHIC [*Phys.Rev.* **D74**, 072002 (2006)].

ALICE operation

The Jyväskylä/HIP ALICE group participates actively in the hardware development and is involved in the ALICE experiment operations. Jan Rak served as run co-ordinator for 2009 and the beginning of 2010. Filip Krizek was run co-ordinator of the T0 detector in 2010 and the post continues in 2011. DongJo Kim made a major contribution in building the ALICE Shift Management System (SMS) and the ALICE Collaboration Data Base (ACDB), both of which he is now the system administrator. Sami Räsänen and DongJo Kim contributed to the development of the ALICE Central Trigger Processor (CTP) software. Jiri Kral continued his work with the EMCal single photon trigger and in 2010 ALICE collected the data using this trigger. More details of the hardware commitments are given in the sections below. Members of the Finnish group also were active shifters. By 14th November 2010 we had fulfilled 168% of the due shift quota, i.e., exceeded our fair share.

In the data analysis the Jyväskylä group concentrated on two-particle correlations as mentioned in the previous section. J. Rak served as convener of the trigger particle correlation physics working group in ALICE in 2010.

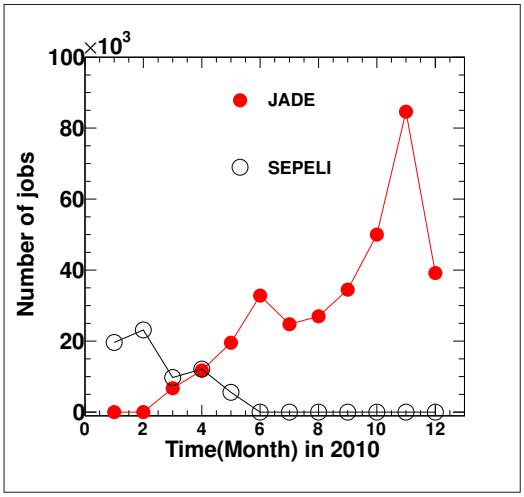
Besides these activities, J. Rak participated in the organisation of the 5th International Workshop on High-pT Physics at LHC 10 in Mexico City in Mexico (http://www.nucleares.unam.mx/highpt2010/) and the Workshop on Critical Examination of RHIC Paradigms in Austin, Texas, USA (http://www.ph.utexas.edu/conferences/rhicparadigms/). Sami Räsänen was a member of the local organization committee in the 2010 European School of High-Energy Physics (http://physicschool.web.cern.ch/PhysicSchool/ESHEP/ESHEP2010/default.html) held in Raasepori, Finland, in collaboration with CERN and JINR.

Computing

Since 2007, we have worked on the ALICE Grid project collaborating with the Helsinki Institute of Physics (HIP) and the Finnish IT Center for Science (CSC) in Helsinki. This effort has resulted in fulfilling the pledged numbers for LHC/GRID and given us a big advantage to speed up the analysis. The new cluster "Jade" was integrated into the ALICE Grid computing frame in 2010 and is being used for the LHC data analysis including the large-size heavy ion data (500 TB) recently taken. The cluster has been fully occupied over the year and we plan to increase its capacity by the first half of the coming year. It turned out that this is quite important when considering high-luminosity LHC runs to be taken in 2011 and 2012.

The figure at the top of the next page shows the number of executed jobs per month in 2010. In May, the new cluster "Jade" took over

the "Sepeli" cluster and the performance has been improved significantly.



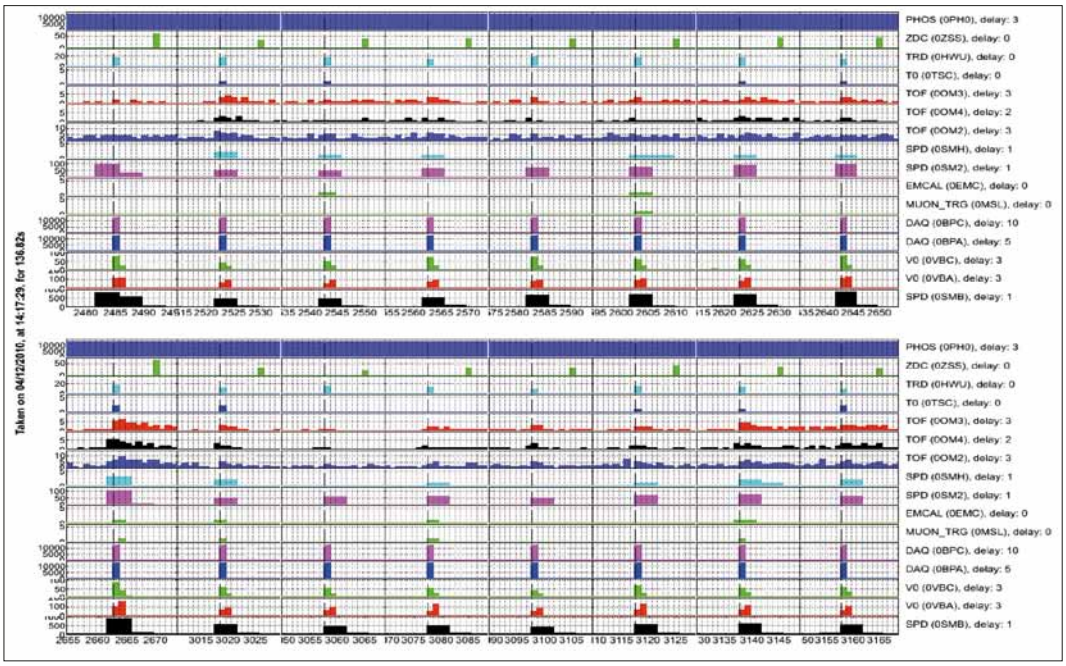
Finland ALICE Grid Computing activity in 2010. The number of jobs executed in various computing sites which has been built over the time. The new modern "Jade" took over the "Sepeli" cluster in May 2010.

CTP activities

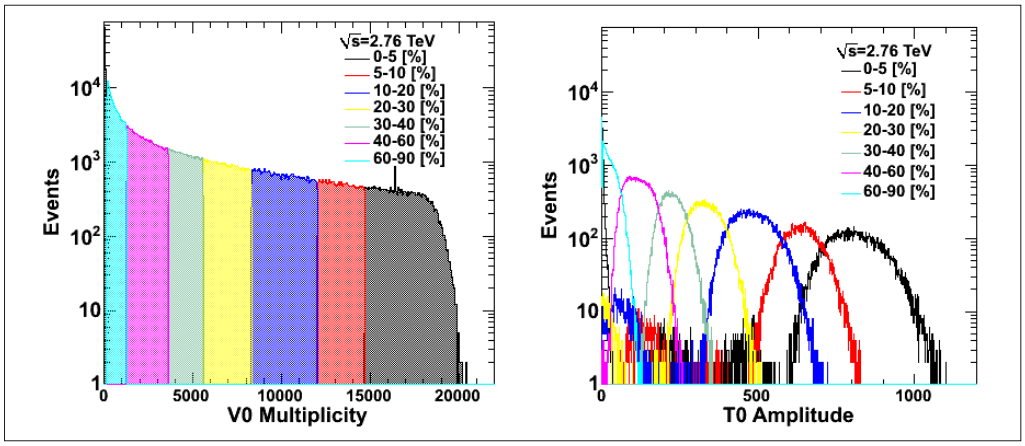
DongJo Kim participated in the development of the trigger on-line monitoring software (AMORE) together with the Birmingham group. Sami Räsänen, with the help of David Chinellato and Ulrich Fuchs, built the graphical user interface (GUI) for running the on-line trigger alignment software (SMAQ), originally written by J. Rak. This significantly simplified the CTP shifter operations during data taking. The figure at the bottom of the page shows an example of a SMAQ plot taken by a shifter during a heavy ion run in December 2010. This example shows only 16 out of 130 interacting heavy ion bunches in the fill while the framework performs the analysis simultaneously for all the bunches. The original "manual version" of SMAQ would have required running a few scripts 130 times in a row and studying every bunch crossing one-by-one.

T0 detector maintenance and operation

The T0 detector measures with high accuracy the exact interaction time. This information is crucial for particle identification. The T0 start signal is combined with the stop determined by the TOF detector to yield the final time of flight of the registered particles. For instance, during the first heavy ion runs in November 2010, T0 achieved a record value of sigma = 35 ps for the collision time. When combined with the 75 ps resolution of the TOF detector it gives 83 ps for the final ALICE time of flight value. T0 is used in heavy ion data also for reaction plane and centrality determination as demonstrated in the right-hand side panel of the figure at the top of the next page where T0 amplitude distributions are plotted



An example of a SMAQ trigger alignment analysis that a shifter does regularly.



Left: Centrality bins in Pb+Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV utilising the multiplicity measured by the V0 detector. Right: Distributions of signals for various centrality bins.

in different centrality bins defined according to the V0 multiplicity measurement.

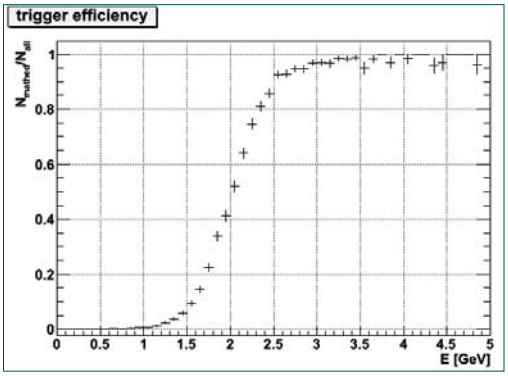
In 2010, the T0 detector successfully participated in all *p+p* and heavy ion data taking events. During the *p+p* data taking period the achieved resolution ranged from 45 ps to 60 ps, depending on the particular beam configuration. During the spring shutdown the T0 team installed a new system for remote control of the Constant Fraction Discriminators. Further upgrades are scheduled for the winter shutdown.

Ari Jokinen, ISOLDE project leader

EMCal

Development of the EMCal single photon trigger system also continued in 2010. The first real life tests of the Trigger Region Units (TRU) showed considerable delays in trigger timing performance. Jiri Kral worked on the optimisation of the FPGA algorithm to speed up the trigged decision. This effort was successful, which allowed us to perform trigger efficiency studies in the second half of 2010. These studies confirmed an expected performance of the TRU system and since then it has been used in the regular data taking. The figure at the bottom of the page presents the trigger efficiency as a function of photon energy with a sharp transition around the trigger threshold.

A second production of TRUs was done in 2010. New boards were placed in the newly installed EMCal super modules during the winter shutdown period. It turned out that the TRU modules developed in Jyväskylä became an attractive option also for other ALICE subdetectors like the photon spectrometer.



EMCal level-0 single photon trigger efficiency as a function of the photon energy.

ISOLDE

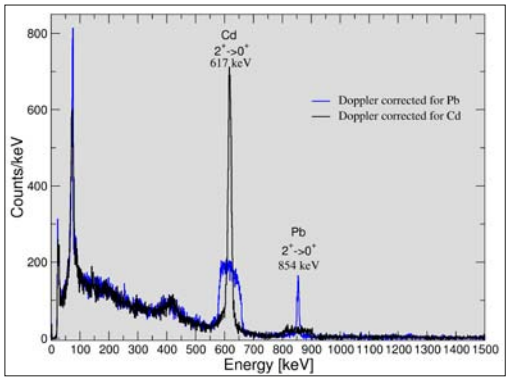
An experimental period at the ISOLDE laboratory was again productive. Apart from the steady scientific programme, a major breakthrough was achieved, when the HIE-ISOLDE project was fully endorsed by the CERN Research board. This paves the way for an energy and intensity upgrade of the present REX-ISOLDE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

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

The availability of intense post-accelerated radioactive beams as heavy as Ra at the REX-ISOLDE linear accelerator was further exploited in 2010. A phenomenon of shape co-existence in atomic nuclei, where configurations

possessing markedly different shapes occur with very similar binding energies, was studied in detail in two experiments. Coulomb excitation measurements IS465: "Evolution of nuclear shape in the light radon isotopes" (A. Robinson – University of Manchester, P. Rahkila – JYFL) and IS494: "Measurements of competing structures in neutron-deficient Pb isotopes by employing Coulomb excitation" (Spokespersons: T. Grahn – JYFL, J. Pakarinen – CERN) were carried out at the REX-ISOLDE linear accelerator utilising the MINIBALL segmented Ge-detector array and the CD particle detector.

In the figure to the right a spectrum recorded with MINIBALL following Coulomb excitation of a ^{192}Pb beam (IS494) is shown. The aim of the experiment is to extract the reduced transition probabilities for the 2^+ to 0^+ transitions in ^{188,190,192}Pb nuclei. These are the key isotopes as they are located in the region where the proton multi-particle multi-hole configurations start to intrude down to energies close to the ground state. With transition probabilities one can extract information of the nuclear wave functions and thus study the shape co-existence in detail. The ongoing analysis of the experiment IS494 will yield valuable information about shapes and their evolution of atomic nuclei. The first part of the experiment (^{192}Pb) was completed in 2010 with the beam time granted for ^{188,190}Pb pending.



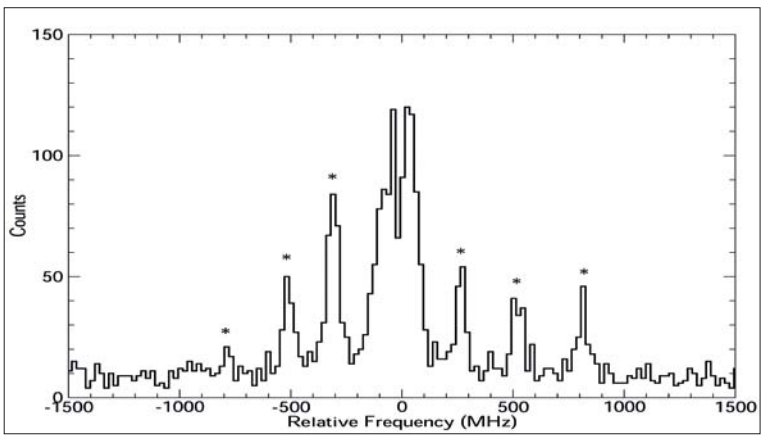
Background subtracted gamma-ray spectra in coincidence with particles detected in the low centre-of-mass angles in the CD detector. The same spectrum is shown with different Doppler correction; blue for projectile (^{192}Pb) and black for target (^{112}Cd) nuclei.

Discovery of a long-lived low-lying isomeric state in ^{80}Ga with optical spectroscopy

It was previously reported in the 2009 Annual Report that a successful campaign of high resolution optical spectroscopy measurements on the gallium isotope chain was performed at ISOLDE using the ISCOOL device. In the current report we summarize one of the main highlights of that earlier work, namely the discovery of a new nuclear state in ^{80}Ga (Z = 31, N = 49), unambiguously established via the model-independent technique of laser spectroscopy [B. Cheal *et al., Phys.Rev.* **C82**, 051302(R) (2010)].

Almost all N = 49 isotones have isomeric states with large spin differences compared to the ground states. In the case of ^{80}Ga however, no such isomeric state has been discovered until now. An optical scan of the 417.3 nm $4p^2P_{3/2} \rightarrow 5s^2S_{1/2}$ atomic line is shown in the figure at the bottom of the page. The spectra labelled with asterisks denote the six resolved peaks for a single nuclear state. A full hyperfine structure analysis using a chi-squared minimization routine leads to a preference for spin I = 3 for this state. For the central structure the peaks are not fully resolved and the situation is more complicated. However, via shell-model calculations the other state is suggested to have spin I = 6. When the ISCOOL bunching time was increased from 50 to 200 ms, the relative intensities of the two structures were not affected. This suggests the isomeric state has a half-life much greater than 200 ms.

An earlier high precision mass measurement using JYFLTRAP in Jyväskylä revealed no indications of the existence of an isomeric

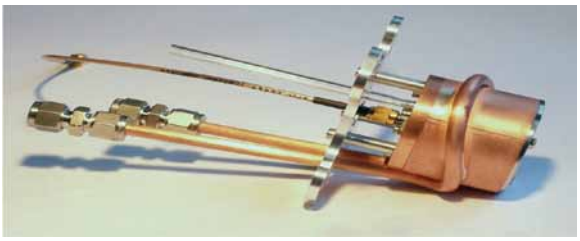


Optical scan of the 417.3-nm $4p^2P_{3/2} \rightarrow 5s^2S_{1/2}$ atomic line in ^{80}Ga.

state in ^{80}Ga [J. Hakala *et al., Phys.Rev.Lett.* **101**, 052502 (2008)]. This suggests that both levels must be within approximately 50 keV, equivalent to the resolving power of the mass measurement. Further Penning trap mass measurements and other studies are called for to determine experimentally which of the two states is isomeric and to measure fundamental properties such as the excitation energy and half-life.

Solid state physics

During 2010 new radiotracer based diffusion studies were initiated; beryllium diffusion in GaN and AlN as well as the diffusion of cobalt in cobalt silicides. One manuscript related to migration of beryllium in ZnO was completed and submitted for publication.



The Q-COMIC ion source for radioactive molecular ion beam production.

Ion source development

Pekka Suominen was a member of the ISOLDE technical team developing targets and ion sources. His main activities were in two projects aiming for higher ionization efficiencies for radioactive ion beams of light noble gases and molecules, such as CO, CO_2, N and NO. In order to improve these beams, a new COMIC-type ion source (2.45 GHz) with a fully quartz made plasma chamber was tested. Another project develops a radiation hard Helicon-plasma ion source operating at 100 MHz. The most promising source will be tested on-line during 2011.

Juha Äystö, FAIR project leader

FAIR (Facility for Antiproton and Ion Research)

A critically important milestone was reached in 2010 when FAIR (Facility for Antiproton and Ion Research) was founded in Wiesbaden on October 4, 2010. The founding countries were Finland, France, Germany, India, Poland, Russia, Slovenia and Sweden. Our involvement in FAIR has continued along the same principles as in 2009, e.g., focussing on NUSTAR experiments and Super-FRS beam diagnostics.

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. The construction of FAIR started in late 2010 and the first commissioning experiments with the Super-FRS are expected to take place in 2016–2017.

NUSTAR Collaboration

Preparatory work for FAIR started in 2006 and has continued through 2010. 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). Our main participation in FAIR experiments focuses on three experiments called MATS, LaSpec and HISPEC/DESPEC. The technical design reports of the first two were finished in 2009 and approved in 2010. 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 involving several persons for each experiment. Ari Jokinen is a co-spokesperson for the MATS experiment and Iain Moore for the LaSpec experiment. The Super-FRS beam diagnostics project is mainly the responsibility of the HIP Detector Laboratory.

FAIR Super-FRS activities in Helsinki during 2010

The beam diagnostics system for the FAIR Superconducting Fragment Separator (Super-FRS) consists of several detection stations rely-

ing on the use of position sensitive diamond detectors, gas detectors and silicon strip detectors. From previous CERN related projects, the researcher scientists working in the HIP Detector Laboratory have a long experience in manufacturing gas and silicon detectors. This experience can be used in the international collaboration of the beam adjustment and diagnostics of Super-FRS. The FAIR research group working at the Helsinki Detector Laboratory focuses specifically on the design, prototyping and production of a total of **40 GEM-TPC** (Gaseous Electron Multiplier – Time Projection Chamber) detectors for Super-FRS.

During 2010, the first GEM-TPC detector **prototype** was constructed and tested in laboratory conditions. The prototype consists of a Field Cage, GEM foils, frames, readout boards and its electronics, high voltage connectors, and a housing box. Some of the components were designed in the Detector Laboratory and manufactured by the CERN workshop and by Finnish companies. The prototype was constructed in close **co-operation** with research groups from Comenius University Bratislava, CUB, responsible for the field cage and integration, and the GSI Detector Laboratory, responsible for the readout electronics and data acquisition (DAQ). In September 2010, common beam tests with heavy ions were successfully performed for the GEM-TPC prototype at GSI.

Alongside the prototype design and construction, **simulations** were made. GEANT4 simulation models were developed to study the performance of the GEM-TPC detectors as tracking detectors and to analyse the effects of detector materials and the efficiency of readout configuration. The drift inside the detector volume and the GEM amplification were studied with the Garfield simulation program. Detailed models describing detector elements were developed for the prototype GEM-TPC and for a 10x10 GEM detector obtained for research purposes.

The data acquisition and analysis were developed for the **optical scanning system** situated in the Detector Laboratory clean room. The system serves as an essential tool for the quality control of GEM-foils and readout boards. The system consists of three computer controlled linears with a scanning area of one square metre. The scanning is done with a 9 megapixel camera with telecentric optics. With the current telecentric lenses one pixel is equivalent to 1.8 or 5.6 microns of the scanned object.

GEM test detector being scanned with a radiation source.

Studies were continued with the **10x10 cm GEM-detector** with XY readout obtained from the CERN workshop. Inside the detector, the number of GEM foils used in the amplification can be changed. With this ability and with the results obtained by the scanning system, the GEM foils can be characterized.

Data taking at GEM-TPC beam tests at GSI.

Technology Programme

Ari-Pekka Hameri,
Technology Programme
director

The computing infrastructure built during the past years was finally put into production use when the LHC was started. The GridCluster project was handed over to the CMS Programme, while the Programme itself was audited by two external experts. The Programme, its achievements and future focus areas were reviewed and the main advice given was that the Programme should concentrate on the Data Intensive Science paradigm. The EGEE-III project was coming to an end and a new EU-wide project to foster and consolidate the developed middleware was approved. At the same time based on its initial results, a new Green IT project was approved to develop ways to improve energy efficiency in cluster computing. Collaboration with Tampere University of Technology was enhanced as a new project in PET-technology commercialization was approved for 2011. In all, the year 2010 prepared the Programme for structural change as one project was finished and two new ones were initiated.

Tomas Lindén,
GridCluster
project leader

Miika Tuisku,
DataGrid project
leader

Physics and Cluster Computing

The GridCluster project was initiated in 2008 to implement and test the computing resources Finland was to offer for the LHC-Grid. Backed with funding from the Ministry of Education and intense collaboration with the Finnish IT Center for Science (CSC) the project managed to organise the purchasing, implementation and testing of the Finnish Tier computing facility. This distributed computing facility took part in various global data challenge tests and improved its functionality to a mature level establishing itself as part of the LHC production Grid in 2010. The facility provides computing services for the CMS and ALICE experiments.

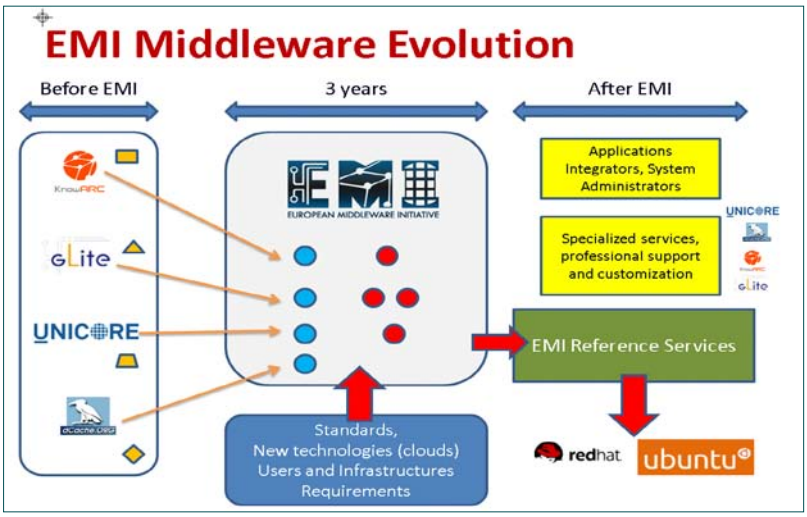
Altogether 920 computing cores and close to 400 terabytes of disk space with a supporting tape station have been implemented. Following the recommendations of the external audit team that the Programme should put emphasis on innovation and new technologies, rather than steady-state operation of research infrastructures and routine research activities, the project and its results were handed over to the CMS Programme. When handing over the project know-how was documented and passed on through intense collaboration with key resource providers.

Grid Middleware Development

The EU funded and CERN led EGEE-III project finished successfully with HIP people acting as the deputy middleware manager and security middleware development co-ordinator for development, integration and support. The overall EGEE security middleware product team was co-ordinated by the HIP Technology Programme ensuring that consistent security software was produced for integration. The group was also active in the editorial and negotiations process with the EU for the EMI (European Middleware Initiative) project. The required software under HIP management was successfully released for the EGEE-III project and was also consequently certified by HIP personnel.

Throughout last year, the HIP Technology Programme has supported the Nordic ARC middleware part of the new EGEE Workload Management System (WMS) release for interoperability purposes. This has resulted in the gLite-ARC interoperability deployment supporting a wider range of job management features.

In the new EMI project, which could be considered a branch of previous projects, HIP Technology personnel are responsible for the co-ordination of the security area and develop-



The newly launched EMI project is a middleware spin-off from the trilogy of projects labelled Enabling Grids in eScience (EGEE).

ment and maintenance of security components. The first EMI security milestone, where the first decisions were made, was organised and led by HIP. The subsequent milestone document was produced by HIP and the various security workgroups were set up according to this document. The first EMI security deliverable document, that determines the first year work plan, was produced by the HIP Technology Programme personnel. Also, major contributions were made through the EMI Project Technical Board (PTB) to the overall EMI technical overview. HIP also organised the second security milestone workshop to gather the Authentication & Authorization Infrastructure (AAI) needs of other eScience projects.

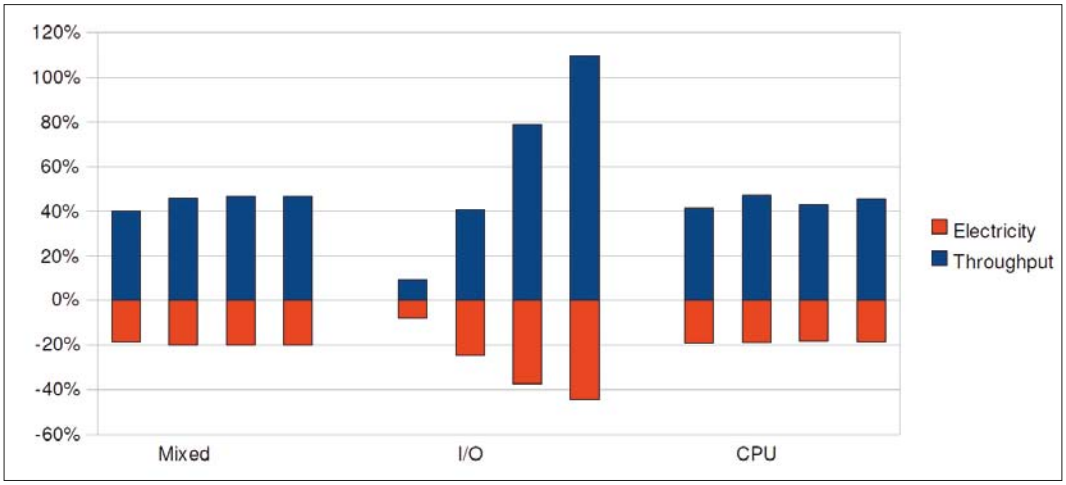
From the beginning of the EMI project, HIP has had the responsibility for setting up and coordinating the various security working groups that will determine the strategic direction of the EMI project security area. The work on the design of the Security Token Service (STS) has continued with close collaboration with the Swiss partner SWITCH. HIP has also been responsible for the maintenance and certification of various components and these tasks are ongoing. The encrypted data storage system has been tested with commercial partners external to the EMI project, and is being accounted as a concrete technology transfer effort.

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 continued, covering persons' identity management and also other network entities such as computer hosts and services. The key focus areas were related to strong authentication, security token translations, identity delegation and single sign-on in environments supporting a large number of devices such as mobile phones. Technologies for detecting and preventing identity theft 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 cost. Inspired by this the Programme started a new research track on green computing in late 2008. In 2011 this work will continue in a new Green IT project.

The research on Green IT has focused on developing operational practices and software tools for optimising Grid computing clusters. In 2010 a new track was applying operations management principles on scheduling and allocation of computing clusters. Methodologically, the design science approach was used. Using a modern test cluster, data on CPU and memory utilisation were collected along with energy



Improvements of 2, 4 tasks/core, fixed memory, and fuzzy memory scheduling methods compared to 1 task/CPU core setting.

consumption when allocating jobs in different ways. The main observation was that mixing different tasks and increasing memory utilisation increases throughput and decreases energy consumption. In practice, this was done by scheduling multiple parallel tasks per CPU core based on the amount of free memory in the system and the output of a fuzzy control algorithm. The test showed that at best this method both decreased energy consumption down to 45% and increased throughput up to 100% compared to the standard practices used in scientific computing.

Additionally, simulation software for studying scheduling for multicore computers was developed. The simulator can be used to test different scheduling methods much faster than using a real computing cluster. Moreover, solid state disks were tested with an LHC data analysis application. The tests showed that this modern storage solution can improve efficiency by removing the bottleneck of slow disk access. Finally, a GPU processor was tested with CERN GEANT simulation software. The tests indicated that with optimised algorithms this technology can be a competitive alternative.

The aim for 2011 is to continue basic research and also start closer industrial collaboration with external research funding. The main collaborating partners are Finnish IT companies and both Finnish (the Aalto University) and international (CERN, EPFL, the University of Lausanne) research institutions. For research funding a project proposal has been submitted to the Academy of Finland and the preparation of a TEKES proposal has been started.

Mobile devices are an increasingly important means to share and access information in the network service cloud. To enable an efficient and usable data management experience for mobile users, research into applying distributed storage technologies for mobile Internet access is carried out in the Programme. The work is done in co-operation with the Department of Communications and Networking at the Aalto University in Helsinki, Finland. The research led to several publications in 2010 including successful pre-examination of a doctoral thesis. The thesis was approved for publication and will be defended in January 2011 at the Aalto University.

Collaboration

The exploitation of emerging new innovations around Grid and Cloud technologies requires close collaboration with industry and other research organizations. The forthcoming Cloud applications focus area was initiated with the Northern European Cloud collaboration (NEON) in 2010, which produced a technical report for the Nordic DataGrid Facility (NDGF) on the feasibility to use Cloud technologies for High-Performance and High-Throughput computing workloads. The

HIP Technology Programme participated in both technical and economic study areas. The energy-efficiency aspects in Cloud computing were actively promoted in 2010 by the EPFL initiative EcoCloud.ch, while HIP invited the leading professor to talk at CERN in June, and also participated in the ECO2 computing Research Day in Lausanne. The group was also active in setting up the CloudMon project with the University of Applied Sciences in Western Switzerland (Yverdon and Geneva). The momentum continued with the EU FP7 project preparations with Green Clouds IAPP and Resource Exchange for Internet Media STREP proposals. In 2010 the HIP Technology Programme was accepted to also take part in Cloud standardisation activities at ITU and ISO through the CERN EU-EMI Networking Activity and the Finnish Standards Association (SFS) memberships.

The long collaboration with the University of Tampere materialised in a two-year consortium project related to semantic data analysis methods, to be funded by the Academy of Finland. The project will start in January 2011.

The Technology Programme will continue to collaborate with several IT experts representing both academia and industry. In 2010 these partners included the University of Tampere, the Aalto University, the Helsinki Institute of Information Technology (HIIT), the KTH Royal Institute of Technology, the Nordic DataGrid Facility (NDGF), the University of Applied Sciences in Western Switzerland, the University of Lausanne HEC, the Swiss Federal Institute of Technology (EPFL), SWITCH Zurich, Nokia Research Center Lausanne, the Canton of Geneva, CERN Openlab for datagrid applications, the Citizen Cyberscience Center (CCC) and the Big Science Activation Team Finland of TEKES.

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, 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, providing a part-time opportunity for a HIP scientist to work with local medical imaging researchers.

CLOUD

Markku Kulmala, CLOUD project leader

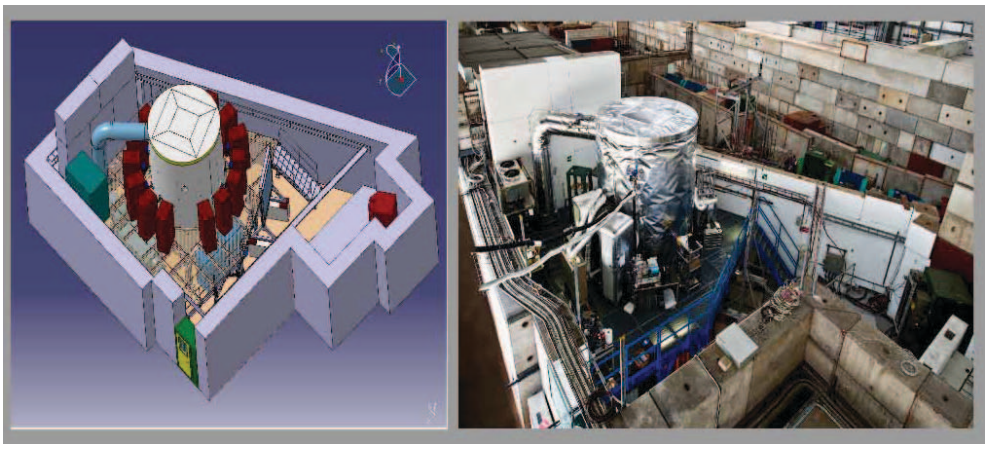
Background

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 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. Some studies have observed a variation of low clouds by about 1.7% in absolute units over one solar cycle corresponding 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.

Experiments in 2010

In 2010, two further intensive measurement campaigns took place at the CLOUD chamber at CERN: the "spring run" in June/July, and the "fall run" in October/November. A wide variety of instruments was deployed during the experiments. The backbone of the experiment relies on several condensation particle counters (CPCs), mass spectrometers, and electrical mobility analysers. Trace gases were investigated and monitored, and aerosol particle concentrations measured starting at diameter sizes smaller than 2 nm.



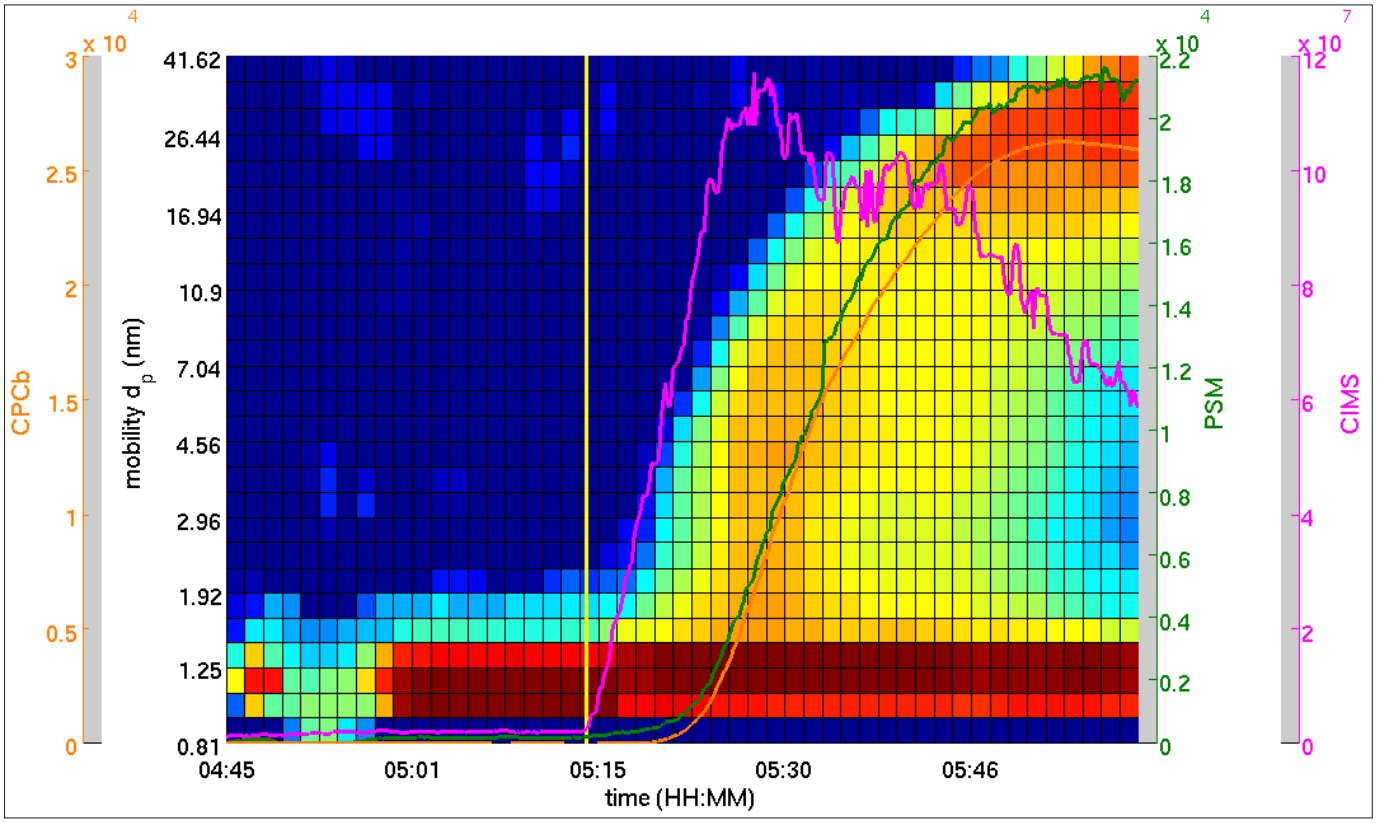
Schematic of the CLOUD chamber as set up in the T11 area in CERN. The red boxes around the chamber are placeholders for the instruments connecting to the chamber via sampling probes. The pion/muon beam provided by the Proton Synchrotron exits at the right, and hits a hodoscope that monitors the beam intensity before it passes through the chamber. The right-hand side shows the chamber in operation during the summer run 2010.

The Finnish team was primarily responsible for the measurement of clusters and ions, and brought four instruments to CERN for the two campaigns: an Airborne Neutral cluster and Air Ion Spectrometer (ANAIS), a Particle Size Magnifier (PSM), a Gerdien counter prototype, and an Atmospheric Pressure interface Time of Flight mass spectrometer (APi-TOF). In comparison to the 2009 run, some modifications have been made to each of these instruments based mainly on the lessons learned from the first campaign with the new chamber in 2009:

- The PSM used in 2010 was a version that had been further developed to be ready for commercial use, based upon the first prototype used in 2009. Apart from more reliable operation, a "scanning mode" could be used for the first time delivering size information on the smallest particles/clusters.
- The ANAIS, designed for taking 60 l/min sample, was equipped with a sample dilution system as the amount of air that should be taken from the CLOUD chamber was to be minimized. This dilution system was carefully redesigned for the "spring run".
- The APi-TOF used in 2010 was a slightly modified version of the 2009 instrument, featuring increased ion transmission. Thanks to tuning experiments conducted prior to the campaigns, the performance of the instrument could be significantly increased.

The CLOUD chamber itself and its peripheral equipment had also been modified for the 2010 runs:

- A second mixing fan was installed underneath the top chamber cover, supplementing the mixing fan on the bottom chamber cover and enhancing the mixing of gases.
- Some of the sampling of the instruments from the chamber were put into thermally insulated racks the temperatures of which could be controlled to a limited extent. This allowed some instruments to operate at a temperature close to the temperature inside the chamber, especially in those experiments with lower chamber temperatures (down to -25 °C).
- The thermal insulation was generally made sturdier, and enhanced for the sampling lines.
- The gas system was extended to allow the controlled introduction of ammonia and amines into the chamber, an improvement suggested by the Finnish team. Both ammonia and different kinds of amines had been found to take part in ion-induced sulphuric acid nucleation in the CLOUD chamber during the 2009 campaign.



Typical experiment performed in the CLOUD chamber. The particle beam is turned on around 5:00 resulting in the appearance of small ion clusters with diameters in the range of 1-1.5 nm (surface plot, measured with NAIS). UV lights are turned on around 5:15 (marked with a vertical yellow line) initiating the photochemical sulphuric acid production (CIMS, magenta line). In a few minutes the first new aerosol particles appear in size channels larger than ~1.5 nm and continue their growth until the end of the experiment. The orange and green lines show the integral concentrations of particles larger than 1.5 nm (measured with PSM) and 3 nm (measured with CPCb), respectively.

The experiments conducted during both campaigns in 2010 were based on the first results that had been obtained in the first campaign in 2009. Those early results were systematically and significantly extended, with the bulk of experiments in 2010 being controlled chamber nucleation, varying several parameters, mainly sulphuric acid concentration, ammonia concentration, ion concentration, temperature, and relative humidity. In the experiments, several ion-induced and neutral nucleation events were observed. The figure above shows an example of the typical experiment with some basic measured quantities. APi-TOF results showed that besides sulphuric acid, ammonia and amines were found to be present in freshly nucleated clusters. Future experiments will focus on the role of these bases in the nucleation process.

Besides experiments performed at CERN, an inter-comparison and calibration workshop of particle detectors took place at Goethe University, Frankfurt. The Finnish team was responsible for the production of standard-sized particles for calibration purposes.

Data analysis, education and reporting of results

The data obtained by almost all instruments is of high quality due to the state-of-the-art instrumentation used, and because of the extreme cleanliness of the chamber.

As all measurements in both 2010 campaigns were based on the 2009 campaign and the lessons learned at that time, most of the results from all three campaigns cannot stand alone, and a comprehensive data analysis is necessary, encompassing all results obtained so far. This data analysis is still ongoing. In January 2010 a data analysis workshop was organised at the Paul Scherrer Institute, Switzerland. The next workshop will take place at the University of Vienna in February 2011.

Results from the first two campaigns were reported during the International Aerosol Conference 2010 in Helsinki in August. About 15 abstracts had been submitted to this conference, 2 thereof from the Finnish team. More than a third of these submissions (including both Finnish contributions) were selected for oral presentations.

As yet, no results have been published in peer-reviewed journals. Results were also reported at the International Workshop on Atmospheric Nucleation hosted by the Finnish group at the Hyytiälä forestry field station.

The Finnish team also organised the Marie Curie ITN CLOUD summer school "Formation and growth of atmospheric aerosols" that took place in Hyytiälä, in August 2010.

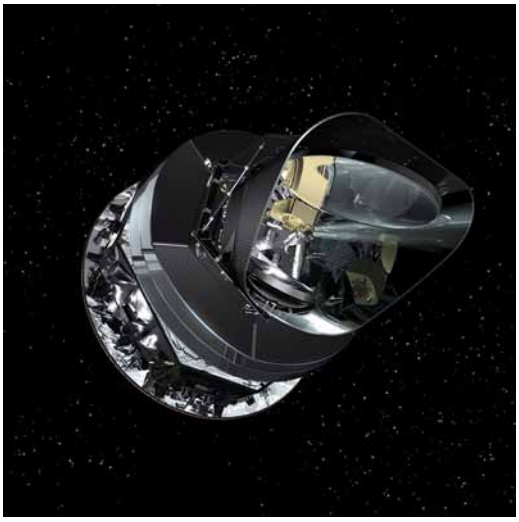
Planck

Hannu Kurki-Suonio, Planck project leader

Background

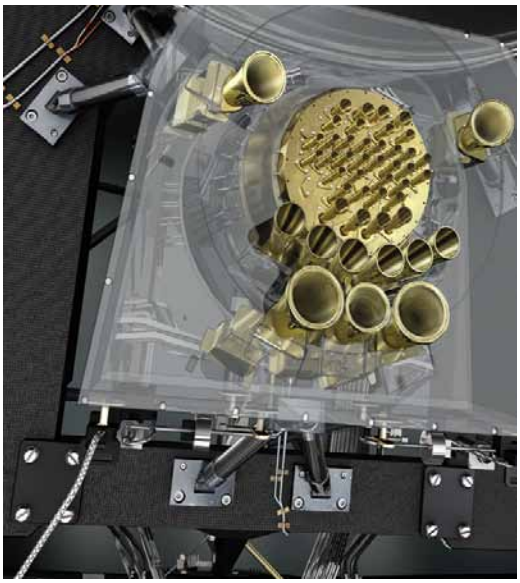
The cosmic microwave background (CMB) is radiation coming from the early universe. It was emitted when the universe was about 400 000 years old. Its intensity and polarization varies over the sky, and these variations reflect the properties and structure of the early universe as well as the later history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

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 USA, and Canada.



An artist's view of Planck. Between the primary and secondary mirrors is the focal plane unit (see the following picture), to where the mirrors direct the microwave radiation. These are protected from straylight by a baffle. Below and to the left of the baffle we see three layers of thermal shields that provide passive cooling. On the other side of the shields there is the warm service module. The solar panels and the antenna for communication with ESA's ground stations are on its other side and are not visible in this view. Credit: ESA/AOES Medialab.

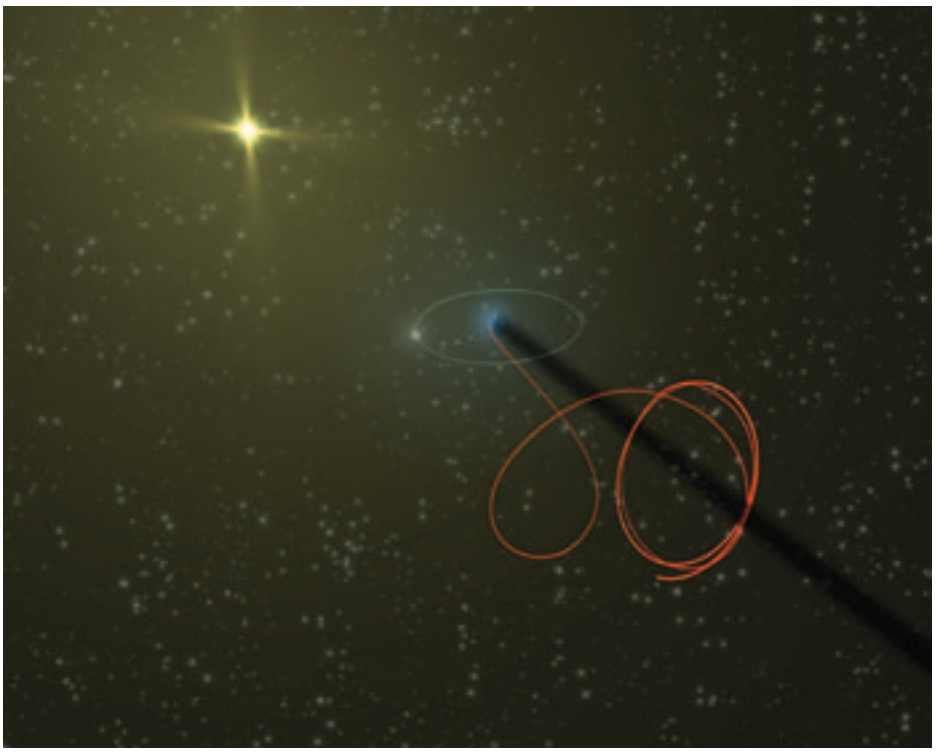
CMB measurements are contaminated by microwave radiation from our own galaxy and extragalactic objects. To be able to remove this "foreground", the observations are carried out at nine different frequencies. While being a nuisance to cosmology, this foreground is of great interest to astronomers. The 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).



The feedhorns of the Planck receivers at the focal plane of the Planck telescope. The smaller horns at the centre belong to the HFI. They are surrounded by the six 70 GHz, three 44 GHz, and two 30 GHz LFI feedhorns. Credit: ESA/AOES Medialab.

Observation programme

Planck was launched on May 14th, 2009, and began science observations in August. Planck completed the originally planned 15-month observation programme in November 2010, having covered the entire sky twice. This 15 months of data will be made public after a two-year proprietary period. During the proprietary period, the data will be analysed carefully and used within the Planck collaboration to obtain the scien-



Planck's cruise to and orbit around the second Lagrange point of the Earth-Sun system. Credit: ESA - C. Carreau.

tific results of the project. The first scientific results dealing with astrophysics will be published in early 2011, but cosmological results will take longer, and are expected to be published together with the data release, near the end of 2012.

In 2009, ESA 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 last stage of the satellite's cooling systems.

The operating temperature of LFI is higher than that of HFI, so LFI does not need the last stage. In November 2010 ESA extended the mission by another year, to near the end of 2012, for observations with LFI only.

Main data analysis

The analysis begins by differencing the sky signal and the signal from the reference load carried within the satellite. The signal is then calibrated using the Doppler effect due to the motion of the satellite. The outcome of this is the time-ordered data (TOD) from each radiometer.

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 our team is the main map-making code for the LFI instrument, and we have the responsibility for map-making at the LFI DPC, and the estimation of the covariance matrix of residual correlated noise on the maps. We also participate in a number of related data analysis tasks, including calibration. 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.

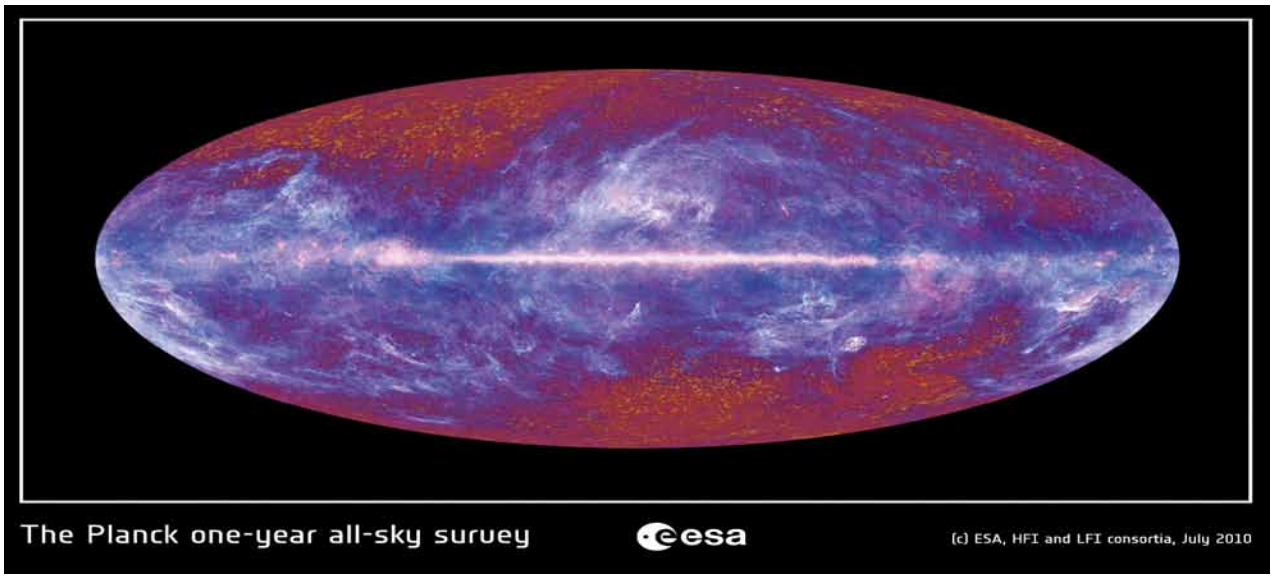
For angular power spectrum estimation, the effect of pixel-to-pixel correlations in the noise can be estimated with timeline-to-map Monte Carlo (MC). These MC stud-

ies are also used to study systematic effects and for error estimation. MC studies require the use of large supercomputers. We have been running such simulations at the Finnish supercomputer centre, CSC. 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). We have now completed the production and analysis of 102 realizations of simulated LFI data corresponding to the first 12 months of Planck real data.

Quick Detection System

The Quick Detection System (QDS) is a software package designed to detect interesting point sources (for example, active galactic nuclei, AGNs) in the time-ordered data stream of the Planck satellite within one or two weeks from the time of the observation. QDS alerts observatories for follow-up observations when it detects something interesting in the Planck data. The software is operated at Aalto University Metsähovi Radio Observatory.

The QDS software was first used during the Planck First Light Survey (FLS) in August 2009. In 2010 QDS was routinely run when new data were available at the LFI DPC. Its results are consistent with other Planck data extraction methods, and have been used, for example, for flagging variable extragalactic objects in the Planck Early Release Compact Source Catalog (ERCSC). The large multifrequency observing campaigns, connected to the QDS, are also ongoing as planned.



A full-sky image of the microwave sky from the first Planck full-sky survey. This image combines different frequencies so that astrophysical foregrounds have been given the most weight, and therefore the cosmic microwave background, shown in red and orange is only visible far from the galactic plane. In other parts of the sky the image mainly shows emission from the gas and dust in our own galaxy.
From http://www.esa.int/Planck (www.esa.int). Credit: ESA/ LFI & HFI Consortia.

Administration

Mikko Sainio

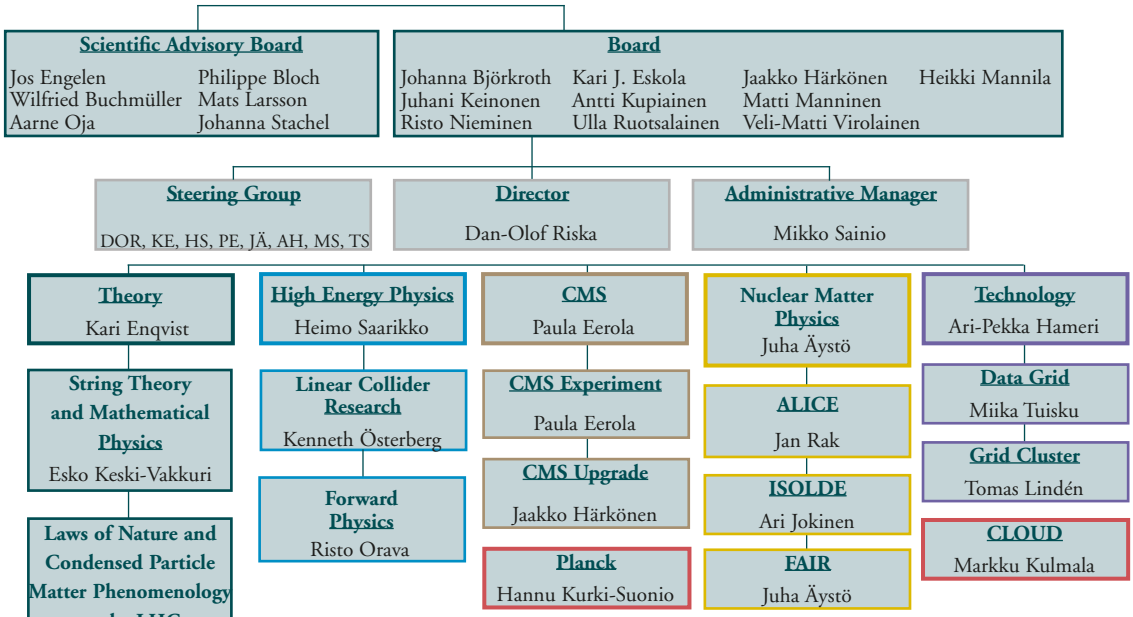
The graduate education of physics students continues to be one of the main tasks of the Institute. During the past year HIP has collaborated with the Graduate School in Particle and Nuclear Physics (GRASPANP) and the Finnish Doctoral Programme in Computational Sciences (FICS) that are sponsored by the 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 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 2006–2010, 41 doctoral degrees and 58 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 2010 this programme attracted 273 Finnish students and 48 of their teachers. A related programme has been that which brings high school physics teachers to CERN where they participate in continuing education courses. In 2010, 33 teachers participated in this programme. These visits have generated considerable coverage in local newspapers all over the country: about 19 articles in total in 2010. The schools have also produced a publication with 12 articles about the CERN study periods.

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 a contractor of TEKES, the National Technology Agency of Finland.

Organization and Personnel

Organization



The Institute Board

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	Jaakko Härkönen (starting 1.7.2010) (Chosen by personnel of HIP)
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	Ulla Ruotsalainen, Dean (Tampere University of Technology)
	Veli-Matti Virolainen, Vice Rector (starting 1.7.2010) (Lappeenranta University of Technology)

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Johanna Stachel, Professor (U. Heidelberg)

Personnel

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K. Rummukainen, prof., adj. senior scientist
M. Valtonen, prof., adj. senior scientist
O. Dannenberg, grad. student

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G. Rigopoulos, scientist
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S. Hotchkiss, adj. scientist
R. Lerner, adj. scientist
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M. Mattsson, grad. student
L. Mether, grad. student
P. Rahkila, grad. student
V. Reijonen, grad. student
O. Taanila, grad. student
J. Virkajärvi, grad. student

Laws of Nature and Condensed Particle Matter Phenomenology at the LHC

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P. Hoyer, prof., adj. senior scientist
K. Huitu, prof., adj. senior scientist
J. Maalampi, prof., adj. senior scientist
O. Antipin, scientist
H. Fukano, scientist
K. Rao, scientist
A. Tranberg, scientist
T. Lappi, adj. scientist
T. Renk, adj. scientist
M. Antola, grad. student
J. Auvinen, grad. student
M. Heikinheimo, grad. student
H. Holopainen, grad. student
T. Honkavaara, grad. student
T. Karavirta, grad. student
S. Kurki, grad. student
T. Kähärä, grad. student
L. Leinonen, grad. student
A. Mykkänen, grad. student
J. Rantaharju, grad. student
T. Rüppell, grad. student
A. Sabanci, grad. student
P. Tiitola, grad. student

String Theory and Mathematical Physics

E. Keski-Vakkuri, docent, proj. leader
M. Chaichian, prof., senior scientist
A. Tureanu, adj. senior scientist
S. Nowling, scientist
K. P. Yogendran, scientist
J. Alanen, grad. student
V. Keränen, grad. student
V. Suur-Uski, grad. student

Low Dimensional Quantum Systems

A. Harju, docent, proj. leader
T. Lähde, scientist
I. Makkonen, adj. scientist
J. Särkkä, grad. student
E. Tölö, grad. student
M. Ervasti, student
T. Hiltunen, student

Radiation Damage in Particle Accelerator Materials

K. Nordlund, prof., proj. leader
F. Djurabekova, scientist
O. Pakarinen, adj. scientist
M. Backman, grad. student
E. Holmström, grad. student
A. Ruzibaev, grad. student
H. Timkó, grad. student
F. Granberg, student
A. Leino, student

High Energy Physics Programme

H. Saarikko, prof., programme director

Forward Physics

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F. García, lab. engineer
T. Aaltonen, grad. student
E. Brücken, grad. student
F. Devoto, grad. student
T. Hildén, grad. student
P. Mehtälä, grad. student
G. Danielsen, student
A. Winkler, student

Linear Collider Research

K. Österberg, docent, proj. leader
J. Huopana, grad. student
F. Oljemark, grad. student
R. Nousiainen, researcher (at CERN)
T. Uusimäki, researcher (at CERN)
J. Welti, student

Detector Laboratory

H. Saarikko, lab. director
E. Tuominen, lab. coordinator
J. Heino, lab. engineer
R. Lauhakangas, lab. engineer
A. Numminen, lab. technician (until 31.10.2010)
R. Turpeinen, lab. technician (starting 16.11.2010)

CMS Programme

P. Eerola, prof., programme director (starting 1.10.2010)
J. Tuominiemi, prof., programme director (until 30.9.2010)

CMS Experiment

P. Eerola, prof., proj. leader
V. Azzolini, senior scientist (at CERN)
V. Karimäki, senior scientist
R. Kinnunen, senior scientist
K. Lassila-Perini, senior scientist (at CERN)
S. Lehti, senior scientist (at CERN)
T. Lindén, senior scientist, grid coordinator
T. Lampén, scientist
L. Wendland, scientist
G. Fedi, grad. student
P. Kaitaniemi, grad. student (in Saclay)
M. Kortelainen, grad. student
J. Välimaa, grad. student
T. Hartonen, summer trainee (at CERN)
J. Piili, summer trainee (at CERN)
A.-M. Visuri, summer trainee (at CERN)

CMS Upgrade

J. Härkönen, proj. leader (at CERN)
S. Czellar, senior scientist (at CERN)
I. Kassamakov, senior scientist
E. Tuominen, senior scientist
P. Luukka, scientist (at CERN)
E. Tuovinen, scientist
T. Mäenpää, grad. student
H. Moilanen, student
T. Peltola, student
K. Steiniger, student
J. Lehikoinen, summer trainee (at CERN)
J. Salpakari, summer trainee (at CERN)

Nuclear Matter Programme

J. Äystö, prof., programme director

ALICE

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S. Räsänen, scientist
B. Chang, grad. student
J. Kral, grad. student
N. Novitzky, grad. student

ISOLDE

A. Jokinen, docent, proj. leader
J. Äystö, prof.
R. Julin, prof., adj. senior scientist
P. Greenlees, adj. senior scientist
I. Moore, adj. senior scientist
P. Rahkila, adj. grad. student

FAIR

J. Äystö, prof., proj. leader
E. Tuominen, proj. coordinator
F. García, lab. engineer
M. Kalliokoski, grad. student

Technology Programme

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

DataGrid

M. Tuisku, proj. leader (at CERN)
T. Niemi, senior scientist, coordinator (at CERN)
J. White, senior scientist (at CERN)
J. Hahkala, scientist (at CERN)
J. Kommeri, scientist (at CERN)
H. Mikkonen, scientist (at CERN)
M. Niinimäki, adj. scientist (at CERN)
M. Pitkänen, grad. student
J. Kemppainen, student (at CERN)

GridCluster

T. Lindén, proj. leader (starting 16.8.2010)
A. Pirinen, proj. leader (until 15.8.2010)
J. Klem, senior scientist (at CERN)
K. Happonen, scientist (at CERN)
J. Koivumäki, student
M. Närjänen, student

CLOUD

M. Kulmala, prof., proj. leader
S. Gagné, grad. student
M. Sipilä, grad. student
P. Aalto, lab. engineer

Planck

H. Kurki-Suonio, docent, proj. leader
A. Lähteenmäki, adj. senior scientist
T. Poutanen, scientist
M. Savelainen, grad. student

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M. Sainio, docent, adm. manager
T. Sandelin, financial manager
T. Hardén, secretary
T. Karppinen, secretary (at CERN)
K.-M. Karttunen, secretary
T. Onnela, secretary (at CERN)
P. Rantanen, secretary (starting 1.12.2010)
A. Heikkilä, tech. coordinator (at CERN)
R. Rinta-Filppula, ped. expert (at CERN)
J. Aaltonen, lab. engineer

Seminars

Seminars held in Helsinki

January 12th M. Raidal (National Institute of Chemical Physics and Biophysics, Tallinn, Estonia)
The origin of dark matter

January 19th L. Del Debbio (Edinburgh Univ., UK)
Strongly interacting theories beyond the Standard Model

January 26th M. Vepsäläinen (Helsinki)
Dimensionally regularized Polyakov loop correlators in hot QCD

February 2nd S. Nowling (Helsinki)
Solitons in holographic superfluids

February 9th J. Piilo (Turku)
Open systems with memory

February 11th W. Horowitz (Ohio State Univ., USA)
Jet quenching, perturbative QCD and AdS/CFT

February 16th M. Panero (ETH Zürich, Switzerland)
Hot, colorful and strongly interacting

March 9th J. Alanen (Helsinki)
Thermodynamics of infrared fixed point and walking technicolor field theories from gauge/gravity duality

March 23rd V. Nesvizhevsky (Institute Laue-Langevin, Grenoble, France)
Gravitational and centrifugal quantum states of neutrons and fundamental short-range interactions

March 30th D. Weir (Imperial College, London, UK)
The quantum mechanics of topological defects

April 13th S. Maniscalco (Turku)
Long life to quantum correlations!

April 20th W. M. Morse (Omega group, Brookhaven National Laboratory, USA)
g-2 of the muon, and electric dipole moment of the muon, proton, and deuteron

April 21st S. Kauffman (Tampere Univ. Technology, Univ. Calgary, Canada, and the Santa Fe Institute, USA)
Mind, brain, consciousness, and the quantum observer: a speculative lecture

April 27th S. Sheikh-Jabbari (IPM, Tehran, Iran)
M-flation: inflation from matrix valued scalar fields

May 4th J. Drut (Ohio State Univ., USA)
From lattice QCD to cold atoms and graphene: new methods for strongly interacting fermions

May 11th L. Thorlacius (NORDITA, Stockholm, Sweden)
Non-Fermi-liquid behavior via gravity

May 25th M. Günaydin (Penn State Univ., USA)
Minimal unitary representations, AdS/CFT dualities and supersymmetry

June 1st J. Gracia-Bondia (Univ. Zaragoza, Spain)
Quantum gauge models without classical Higgs mechanism

June 15th C. M. Bender (Washington Univ. St. Louis, USA)
Making sense of non-Hermitian Hamiltonians

June 22nd P. Bandyopadhyay (KIAS, Seoul, Republic of Korea)
Displaced Higgs production in type III seesaw at the LHC

June 28th A. Pich (Valencia, Spain)
Flavour phenomenology on the "aligned" two-Higgs-doublet model

August 3rd A. Dolgov (Univ. Ferrara, Italy)
Condensation of electrically charged bosons in solid state and cosmology

August 5th E. Rabinovici (Hebrew Univ., Jerusalem, Israel)
Holography of AdS bubbles

August 17th F. Englert (Universite Libre de Bruxelles, Belgium)
The hidden horizon and black hole unitarity

August 18th F. Englert (Universite Libre de Bruxelles, Belgium)
Broken symmetries

August 31st C. E. Carlson (College of William and Mary, Williamsburg, USA)
Connecting dark matter to electrons and positrons: low energy terrestrial experiments and the galactic center 511-keV line

September 14th S. D. Odintsov (Space Research Institute (ICE) CSIC and ICREA, Barcelona, Spain)
Modified gravity as unification of inflation with dark energy: from conventional theory to Horava-Lifshitz gravity

September 21st S. Rindani (Physics Research Lab, Ahmedabad, India)
Probing new physics at an e+e- collider with polarized beams

September 23rd J. Tuominiemi (HIP)
Puoli vuosisataa kokeellista hiukkasfysiikkaa

September 28th P. Eerola (HIP and FL, Helsinki)
New results from CMS

October 5th H. Holopainen (Jyväskylä)
Event-by-event hydrodynamics and elliptic flow from fluctuating initial state

October 19th A. Kupiainen (Department of Mathematics, Helsinki)
Did the Fields medals go to physics?

October 25th-29th Lectures of the International Graduate School Bielefeld-Paris-Helsinki:
P. Eerola (Helsinki, HIP): **Physics at the LHC**
K. Kajantie (Helsinki, HIP): **AdS/QCD**
M. Panero (Helsinki, HIP): **Introduction to lattice**
M. Sainio (Helsinki, HIP): **Chiral symmetry**
K. Splittorff (NBI, Copenhagen, Denmark): **Random matrix models**
A. Tranberg (NBI, Copenhagen, Denmark): **Field theory simulations in cosmology**
K. Tuominen (Jyväskylä): **Technicolor**

November 19th W. Wünsch (CERN)
Introduction to CLIC and the quest for high-gradients

November 23rd Y. Sasai (HIP and FL, Helsinki)
Shear viscosity of a highly excited string and black hole membrane paradigm

November 30th S. Räsänen (HIP and FL, Jyväskylä)
First LHC results on the charged particle multiplicity and elliptic flow in Pb+Pb collisions at 2.76 TeV

December 2nd I. Dymnikova (Univ. Warmia and Mazury, Poland and A.F. Ioffe Physico-Technical Institute, St. Petersburg, Russia)
Possibilities and surprises of vacuum dark fluid

December 7th M. Roos (FL, Helsinki)
Dark matter in galaxies

December 9th D. Bödeker (Univ. Bielefeld, Germany)
Thermal production of Majorana neutrinos

December 16th D. Figueroa (HIP, Helsinki)
Gravitational waves from reheating and phase transitions after inflation

December 17th N. Jokela (Technion, Haifa, Israel)
Holographic quantum Hall fluid

December 21st M. Voutilainen (CERN and Helsinki)
Jet quenching in heavy ion collisions, new results from CMS

Visitors

Theory Programme

Cosmophysics

R. Lerner (UK) 18.-23.1.
L. Del Debbio (UK) 19.1.
A. Riotto (Switzerland) 27.1.
J. Väliviita (UK) 16.-19.2.
S. Hannestad (Denmark) 6.-10.3.
K. Dimopoulos (UK) 15.3.
S. Nurmi (Germany) 29.3.-1.4.
D. Figueroa (Spain) 11.-16.5.
T. Takahashi (Japan) 6.-12.6.
T. Koivisto (The Netherlands) 14.-18.6.
L. Amendola (Germany) 23.7.
T. Koivisto (The Netherlands) 16.-20.8.
T. Mattsson (New Zealand) 23.-27.8.
T. Koivisto (The Netherlands) 4.-8.10.
F. Sannino (Denmark) 7.-9.10.
M. Herranen (Germany) 18.-22.10.
A. Mazumdar (UK) 15.-17.11.
L. Mether (Germany) 22.-26.11.
D. Bödeker (Germany) 7.-10.12.
S. Nurmi (Germany) 13.-17.12.
G. Rigopoulos (Finland) 13.-17.12.
T. Takahashi (Japan) 13.-17.12.
M. Sloth (Switzerland) 15.12.

Laws of Nature and Condensed Particle Matter Phenomenology at the LHC

J. Laamanen (The Netherlands) 4.-11.1.
H. Niemi (Germany) 12.-13.1.
L. Del Debbio (UK) 18.-20.1.
P. Pandita (India) 20.1.-28.2.
G. Moschelli (USA) 1.-6.2.
W. Horowitz (USA) 8.-10.2.
M. Panero (Switzerland) 15.-17.2.
R. Chatterjee (India) 15.-20.2.
D. Rischke (Germany) 15.-25.2.
A. Vuorinen (Germany) 29.3.-1.4.
D. J. Weir (UK) 29.3.-1.4.
J. Laamanen (The Netherlands) 3.-12.5.
A. Hietanen (USA) 29.5.
P. Bandyopadhyay (Republic of Korea) 30.5.-24.6.
E. Laermann (Germany) 1.-30.6.
S. K. Rai (USA) 2.6.-4.7.
S. Rindani (India) 1.8.-30.9.
H. Petersen (USA) 15.-20.8.
A. Kurkela (Switzerland) 20.8.-1.9.
H. Niemi (Germany) 23.-27.8.
K. Splittorf (Denmark) 25.-26.10.
A. Tranberg (Denmark) 25.-26.10.
M. Luzum (France) 25.-29.10.
N. Evans (UK) 4.-6.11.
A. Rajantie (UK) 10.-12.11.
D. Bödeker (Germany) 7.-10.12.
E. Fraga (Brazil) 8.-11.12.
T. Toll (USA) 13.-21.12.
A. Vuorinen (Germany) 18.-31.12.
M. Krssak (Germany) 19.-22.12.

Hadron Physics Activity

J. Stahov (Bosnia and Herzegovina) 7.-20.3.
O. W. Greenberg (USA) 8.7.-6.8.
C. Carlson (USA) 23.8.-14.9.

String Theory and Mathematical Physics

W. Horowitz (USA) 11.2.
L. Thorlacius (Sweden and Iceland) 10.-12.5.
N. Jokela (Israel) 17.12.

Quantum Field Theory

G. Zet (Romania) 1.2.-31.3.
V. Nesvizhevsky (France) 22.-27.3.
A. Zheltukhin (Ukraine) 25.3.-24.4.
M. M. Sheikh-Jabbari (Iran) 24.4.-7.5.
J. Gracia-Bondia (Spain) 25.5.-17.6.
P. Prešnajder (Slovakia) 26.5.-11.6.
I. Merches (Romania) 1.-25.6.
C. Bender (USA) 14.-17.6.
A. Dolgov (Italy) 1.8.-1.9.
E. Rabinovici (Israel) 2.-13.8.
F. Englert (Belgium) 13.-25.8.
J. Chkareuli (Georgia) 25.8.-25.9.
V. Manta (Romania) 1.-8.9.
S. Odintsov (Spain) 1.-30.9.
S. Ghosh (India) 6.-28.9.
L. Laperashvili (Russia) 15.10.-13.11.
G. Zet (Romania) 14.11.-13.12.
R. B. Zhang (Australia) 15.-26.11.
I. Dymnikova (Poland) 15.11.-16.12.
A. Toporensky (Russia) 18.-20.11.
A. Dariescu (Romania) 5.-20.12.
C. Dariescu (Romania) 5.-20.12.

Low Dimensional Quantum Systems

J. E. Drut (USA) 16.4.-14.5.

Radiation Damage in Particle Accelator Materials

S. Calatroni (Switzerland) 15.-16.12.
W. Wünsch (Switzerland) 15.-16.12.

CMS Programme

M. Chizhov (Russia/Bulgaria) 20.6.-3.7.
N. Ellis (Switzerland) 20.6.-3.7.
A. Gladyshev (Russia) 20.6.-3.7.
G. Hiller (Germany) 20.6.-3.7.
F. Joaquim (Switzerland) 20.6.-3.7.
A. Pich (Spain) 20.6.-3.7.
A. Pomarol (Spain) 20.6.-3.7.
M. Raidal (Estonia) 20.6.-3.7.
A. Romanino (Italy) 20.6.-3.7.
P. Skands (Switzerland) 20.6.-3.7.
M. Spiropulu (Switzerland/USA) 20.6.-3.7.
G. Villadoro (Switzerland) 20.6.-3.7.
R. Mori (Italy) 6.-18.12.
M. Voutilainen (Switzerland) 21.-22.12.

Nuclear Matter Programme

M. Tannenbaum (USA) 24.5.-14.6.
R. Ramos-Perez (Spain) 8.-13.11.

Planck

J. Väliviita (Norway) 16.-19.2.
R. Keskitalo (USA) 18.-24.2.
J. Väliviita (Norway) 7.-16.6.
R. Keskitalo (USA) 20.9.

Conference participation, Talks and Visits by Personnel

Theory Programme

Cosmophysics

Thesaloniki, Ioannina, Heraklion and Athens Universities and the National Technical University,
9 February - 1 March, Thesaloniki, Ioannina, Heraklion and Athens, Greece (talk by G. Rigopoulos)

The Annual Meeting of the Finnish Physical Society,
11-13 March, Jyväskylä, Finland (A. Ferrantelli, talk by P. Rahkila, talk by J. Virkajärvi)

45th Rencontres de Moriond, Cosmology Session,
13-20 March, La Thuile, Italy (K. Kainulainen, talk by V. Marra)

University of Aachen,
14-17 March, Aachen, Germany (talk by K. Kainulainen)

Lancaster University,
15-18 March, Lancaster, UK (talk by O. Taanila)

Crete Workshop on the Frontiers of Cosmology,
28 March - 5 April, Heraklion University, Heraklion, Greece (G. Rigopoulos)

Lancaster University,
14-18 June, Lancaster, UK (A. Ferrantelli)

PPC-2010,
12-16 July, University of Torino (ITA), Torino, Italy (A. Ferrantelli)

Out-of-Equilibrium Quantum Fields in the Early Universe,
6-8 September, University of Aachen, Aachen, Germany (talk by K. Kainulainen)

The 4th UniverseNet School - Frontiers of Particle Cosmology,
13-18 September, University of Salento, Lecce, Italy (talk by O. Taanila)

COSMO/CosPA 2010,
27 September - 1 October, University of Tokyo, Hongo, Tokyo, Japan (talk by D. Figueroa, K. Kainulainen, V. Marra, V. Reijonen, talk by O. Taanila)

Technical University of Munich,
4-5 November, Munich, Germany (talks by A. Ferrantelli)

University of Cambridge,
15-26 November, Cambridge, UK (talk by D. Figueroa)

Niels Bohr International Academy,
21-24 November, Copenhagen, Denmark (O. Taanila)

Lancaster University,
14-15 December, Lancaster, UK (R. Lerner)

Annual Theory Meeting,
16-18 December, IPPP Durham, Durham, UK (R. Lerner)

Laws of Nature and Condensed Particle Matter Phenomenology at the LHC

Spaatind 2010, Nordic Conference in Particle Physics,
2-8 January, Spaatind, Norway (talk by M. Heikinheimo)

Workshop on High Energy Physics Phenomenology (WHEPP XI),
2-12 January, Ahmedabad, India (K. Rao)

CP3, University of Southern Denmark,
10 January - 22 May, Odense, Denmark (P. Hoyer)

University of Bielefeld,
10 January - 4 June, Bielefeld, Germany (J. Rantaharju)

Second Workshop on Beyond 3 Generation Standard Model - New Fermions at the Crossroads of Tevatron and LHC,
14-16 January, Taipei, Taiwan (talk by O. Antipin)

Copenhagen Discovery Center Inauguration,
20-22 January, Copenhagen, Denmark (K. Huitu)

University of Oulu,
22 February, Oulu, Finland (talk by A. Tranberg)

RECFA Meeting,
4-6 March, Brussels, Belgium (K. Huitu)

PANDA Collaboration Meeting at GSI,
10-12 March, Darmstadt, Germany (talk by P. Hoyer)

The Annual Meeting of the Finnish Physical Society,
11-13 March, Jyväskylä, Finland (O. Antipin, M. Antola, J. Auvinen, K. J. Eskola, talk by M. Heikinheimo, talk by H. Holopainen, T. Honkavaara, K. Huitu, K. Kajantie, talk by T. Karavirta, T. Kähärä, T. Lappi, J. Maalampi, A. Mykkänen, talk by A. Tranberg)

EMMI Workshop "String Theory and Extreme Matter",
15-20 March, Heidelberg, Germany (talk by K. Kajantie)

Aspects of Perturbative Quantum Chromodynamics,
22-31 March, Paris, France (J. Rantaharju)

Workshop on Critical Examination of RHIC Paradigms,
14-17 April, Austin, TX, USA (talk by T. Renk)

CP3-Origins, University of Southern Denmark,
14-17 April, Odense, Denmark (talk by A. Tranberg)

Duke University,
18-24 April, Durham, NC, USA (talk by T. Renk)

CP3-Origins, University of Southern Denmark,
26 April - 7 May, Odense, Denmark (S. Kurki)

Origin of Mass 2010,
3-7 May, Odense, Denmark (O. Antipin, talk by M. Antola, M. Heikinheimo, talk by P. Hoyer, T. Karavirta, S. Kurki, A. Mykkänen, K. Tuominen)

ASPERA Joint Secretariat Meeting,
7 May, Paris, France (talk by K. Rummukainen)

"Saturation, the Color Glass Condensate and Glasma: What Have We Learned from RHIC?" Workshop,
10-13 May, Brookhaven, NY, USA (talk by T. Lappi)

Particle Physics Summer School,
24-28 May, Tvärminne, Finland (talk by P. Hoyer, talk by K. Huitu)

Quantifying the Properties of Hot QCD Matter,
24 May - 16 July, INT, Seattle, WA, USA (talk by H. Holopainen, talk by T. Lappi, talk by T. Renk)

CERN, Theory Division,
5-12 June, Geneva, Switzerland (talk by K. Kajantie)

Physics at LHC 2010,
7-12 June, Hamburg, Germany (talk by M. Heikinheimo)

50 Cracow School of Theoretical Physics,
9-14 June, Cracow, Poland (talk by P. Hoyer)

Lattice 2010, The XXVIII International Symposium on Lattice Field Theory,
14-19 June, Villasimius, Italy (talk by T. Karavirta, A. Mykkänen)

University of Nottingham,
15 June, Nottingham, UK (talk by A. Tranberg)

University of Sussex,
16 June, Brighton, UK (talk by A. Tranberg)

Imperial College,
18 June, London, UK (talk by A. Tranberg)

The 2010 European School of High-Energy Physics,
20 June - 3 July, Raseborg, Finland (talk by P. Hoyer, K. Huitu, talk by T. Renk)

"Hot Quarks 2010" Conference,
21-26 June, La Londe Les Maures, France (talk by T. Lappi)

ECFA and RECFA Meeting,
30 June - 3 July, Frascati, Italy (K. Huitu)

Conference on Strong and Electroweak Matter,
2-7 July, Montreal, Canada (talk by A. Tranberg, talk by K. Tuominen)

Particles, Strings and Cosmology 2010,
19-23 July, Valencia, Spain (talk by M. Antola, talk by K. Tuominen)

Cargese 2010: Physics at TeV Colliders - From Tevatron to LHC,
19-31 July, Cargese, France (L. Leinonen)

Future Directions in Lattice Gauge Theory - LGT10,
25 July - 8 August, CERN, Geneva, Switzerland (talk by K. Rummukainen)

Photonuclear Reactions,
1-6 August, Tilton, NH, USA (talk by P. Hoyer, S. Kurki)

"High Energy Strong Interactions" Workshop,
1-13 August, Kyoto, Japan (talk by T. Lappi)

Erwin Schrödinger Institute Workshop "AdS Holography and the Quark-Gluon Plasma",
9-21 August, Vienna, Austria (talk by K. Kajantie)

Jets in p+p and Heavy-Ion Collisions,
12-14 August, Prague, Czech Republic (talk by T. Renk)

StrongBSM Kickstart Meeting,
16-20 August, Odense, Denmark (talk by K. Tuominen)

UniverseNet Workshop,
16-20 August, Copenhagen, Denmark (talk by A. Tranberg)

SUSY10, 18th International Conference on Supersymmetry and Unification of Fundamental Interactions,
23-28 August, Bonn, Germany (talk by M. Antola, talk by T. Honkavaara, K. Huitu)

International Summer School and Conference on High Energy Physics ISSCSMB-2010,
26 August - 1 September, Akyaka-Mugla, Turkey (talk by P. Hoyer)

Tartu University,
30-31 August, Tartu, Estonia (K. Huitu)

Conference "Quark Confinement and the Hadron Spectrum",
30 August - 3 September, Madrid, Spain (talk by K. Rummukainen)

CERN Theory Institute Workshop "The First Heavy Ion Collisions at the LHC",
1-11 September, Geneva, Switzerland (K. Kajantie)

TT Workshop on Non-Equilibrium Quantum Fields in the Early Universe,
6-8 September, Aachen, Germany (talk by A. Tranberg)

LAGUNA General Meeting,
6-10 September, Aussois, France (J. Maalampi)

"Gluons and the Quark Sea at High Energies" Program,
13 September - 1 October, INT, Seattle, WA, USA (talk by T. Lappi)

TORIC 2010,
26-30 September, Villasimius, Italy
(talk by J. Auvinen, talk by K. J. Eskola, talk by H. Holopainen)

COSMO 2010,
27 September - 1 October, Tokyo, Japan (K. Tuominen)

York University,
29 September - 1 October, Toronto, Canada
(talk by M. Heikinheimo)

RECFA Meeting Helsinki,
8-9 October, Helsinki, Finland (talk by J. Maalampi)

Hard Probes 2010,
10-15 October, Eilat, Israel
(talk by K. J. Eskola, talk by H. Holopainen)

Physics of Fundamental Symmetries and Interactions - PSI2010, Paul Scherrer Institut,
11-14 October, Villingen, Switzerland (talk by T. Rüppell)

Physics of Strongly Interacting Field Theories,
25-29 October, Helsinki, Finland (M. Antola, talk by K. Kajantie, T. Karavirta, A. Mykkänen, K. Rummukainen, talk by A. Tranberg, talk by K. Tuominen)

The Many Faces of QCD,
1-5 November, Ghent, Belgium (talk by T. Kähärä)

3rd Odense Winter School,
1-5 November, Odense, Denmark (talk by K. Tuominen)

The First International Workshop on LHC Era Physics, LHEP2010,
15-19 November, Nanning, Guangxi, China
(talk by M. Heikinheimo)

EMMI Workshop "Structure Functions, Geometric Scaling and Parton Saturation: Assessment and Perspectives for the LHC",
22-24 November, GSI, Darmstadt, Germany (talk by T. Lappi)

ECFA and RECFA Meeting, EPS-ECFA Session Committee Meeting,
24-27 November, Geneva, Switzerland (K. Huitu)

NORDITA,
13 December, Stockholm, Sweden (K. J. Eskola)

Hadron Physics Activity

The Annual Meeting of the Finnish Physical Society,
11-13 March, Jyväskylä, Finland (M. Sainio)

International Nuclear Physics Conference,
4-9 July, Vancouver, Canada (D.-O. Riska)

International Conference on High Energy Physics,
25-28 July, Paris, France (M. Sainio)

EuroFlavour 2010,
8-10 September, Munich, Germany (M. Sainio)

Physics of Strongly Interacting Field Theories,
25-29 October, Helsinki, Finland (invited lectures by M. Sainio)

String Theory and Mathematical Physics

Queen Mary University of London,
18 February, London, UK (talk by S. Nowling)

The Annual Meeting of the Finnish Physical Society,
11-13 March, Jyväskylä, Finland (J. Alanen, V. Keränen, E. Keski-Vakkuri, V. Suur- Uski)

EMMI Workshop "String Theory and Extreme Matter",
15-20 March, Heidelberg, Germany (J. Alanen, V. Suur -Uski)

University of Turku,
19 March, Turku, Finland (talk by S. Nowling)

25th Nordic String Network Meeting on Fields, Strings, and Branes,
25-27 March, Stockholm, Sweden (J. Alanen, V. Keränen, S. Nowling, V. Suur-Uski)

NORDITA Workshop on Integrability in String and Gauge Theories, AdS/CFT Duality and its Applications,
1-11 June, Stockholm, Sweden (invited talks by E. Keski-Vakkuri and S. Nowling)

The Second International Conference: Nonlinear Waves - Theory and Applications,
26-29 June, Beijing, China (invited talk by S. Nowling)

Mathematica School on Condensed Matter and Two-dimensional Physics, Oporto Physics Department,
10-16 July, University of Oporto, Oporto, Portugal (V. Suur-Uski)

ESI Programme on AdS Holography and the Quark-Gluon Plasma, The Erwin Schrödinger International Institute for Mathematical Physics,
1-12 August, Vienna, Austria (J. Alanen, V. Suur-Uski)

Kavli Institute for Theoretical Physics China Workshop on AdS/CFT and Novel Approaches to Hadron and Heavy Ion Physics,
23 October - 6 November, Beijing, China (J. Alanen, V. Suur-Uski)

The Galileo Galilei Institute for Theoretical Physics Workshop on Applications of AdS/CFT to Condensed Matter Systems,
31 October - 7 November, Florence, Italy
(E. Keski-Vakkuri, invited talk by S. Nowling)

Uppsala University,
29-30 November, Uppsala, Sweden (E. Keski-Vakkuri)

Meeting of the NORDITA Research Committee,
13 December, Stockholm, Sweden (E. Keski-Vakkuri)

Quantum Field Theory

"Al.I. Cuza" University,
3-10 January, Iasi, Romania (A. Tureanu)

International Workshop "Cosmology, the Quantum Vacuum, and Zeta Function",
5-12 March, Barcelona, Spain (invited talk by A. Tureanu)

Russian Academy of Sciences,
11-23 May, Moscow, Russia (A. Tureanu)

Moscow State University,
11-23 May, Moscow, Russia (invited seminar talk by M. Chaichian)

National Conference of Theoretical Physics,
23-25 June, Iasi, Romania (invited talk by A. Tureanu)

CERN,
14-22 July, Geneva, Switzerland (M. Chaichian)

International Conference "Quarks, Strings and the Cosmos - Hector Rubinstein Memorial Symposium",
8-11 August, Stockholm, Sweden (M. Chaichian)

"Gh. Asachi" Technical University,
8-13 August, Iasi, Romania (invited lectures by A. Tureanu)

International Workshop "Nuclear Physics and Elementary Particle Physics at the Frontiers of Knowledge",
18-25 September, Bucharest, Romania (A. Tureanu)

Horia Hulubei National Institute of Physics and Nuclear Engineering,
23 September, Bucharest, Romania
(invited seminar talk by A. Tureanu)

Low Dimensional Quantum Systems

The Annual Meeting of the Finnish Physical Society,
11-13 March, Jyväskylä, Finland (talk by A. Harju, talk by I. Makkonen, J. Särkkä)

INT-10-1 Workshop: Simulations and Symmetries: Cold Atoms, QCD and Few-Hadron Systems,
15 March - 2 April, University of Washington, Seattle, WA, USA (invited talk by T. Lähde)

ECT* Workshop: New Frontiers in Graphene Physics,
12-15 April, Trento, Italy (invited talk by T. Lähde)

Quantum Dot 2010,
26-30 April, Nottingham, UK (A. Harju, J. Särkkä)

Psi-k Conference 2010,
12-16 September, Berlin, Germany (A. Harju, T. Lähde, I. Makkonen, talk by J. Särkkä, E. Tölö)

Radiation Damage in Particle Accelerator Materials

CERN,
18-20 March, Geneva, Switzerland (F. Djurabekova, K. Nordlund)

EUCard Annual Meeting,
14-16 April, Oxford, UK (talk by K. Nordlund)

Workshop on Electrical Breakdown in CLIC Components,
5-7 May, CERN, Geneva, Switzerland (chairman and invited talk by F. Djurabekova, chairman K. Nordlund, talk by H. Timko)

International Conference on Computer Simulation of Radiation Effects in Solids,
19-23 July, Cracow, Poland (plenary talk by F. Djurabekova, invited talk by K. Nordlund)

International Conference on Ion Beam Modification on Materials,
23-27 August, Montreal, Canada (talks by F. Djurabekova and K. Nordlund, O. Pakarinen)

High Energy Physics Programme

Forward Physics

Diffractive and Electromagnetic Processes at the LHC,
3-8 January, ETC*, Trento, Italy (invited talk by R. Orava)

TOTEM Collaboration Extended CB Meeting,
21 January, CERN, Geneva, Switzerland (H. Saarikko)

Fermilab,
23 January - 23 April, Batavia, IL, USA (E. Brücken)

CDF Collaboration Meeting,
29 January - 7 February, Puerto Vallarta, Mexico (talk by T. Aaltonen)

Fermilab,
7-20 February, Batavia, IL, USA (talk by T. Aaltonen)

Municipal Parliament of the City of Vantaa,
11 February, Vantaa, Finland (talk by R. Orava)

Fermilab,
5-22 March, Batavia, IL, USA (talk by T. Aaltonen)

TOTEM Collaboration Week and CB Meeting,
9-11 March, CERN, Geneva, Switzerland (H. Saarikko)

AFO Spring Meeting,
10 May, Helsinki, Finland (talk by R. Orava)

Summer School, Savonia University of Applied Sciences,
18 May, Kuopio, Finland (talks by R. Orava)

Forward Physics at LHC Workshop and TOTEM Collaboration Meetings,
23-29 May, La Biódóla, Elba, Italy (H. Saarikko)

Particle Physics Summer School,
25-26 May, Tvärminne, Finland (talks by R. Orava)

Supplementary Training Course for Physics Teachers,
10 June, Helsinki, Finland (talk by R. Orava)

The 2010 European School of High-Energy Physics,
21 June, 2 July, Raseborg, Finland (H. Saarikko)

Low-x Workshop,
26 June, Kavala, Greece (invited talk by R. Orava)

International Conference on High Energy Physics (ICHEP) 2010,
21-28 July, Paris, France (H. Saarikko)

Fermilab,
19 August - 3 September, Batavia, IL, USA (E. Brücken)

Diffraction 2010,
10-15 September, Otranto, Italy (invited talk by R. Orava)

Workshop on Diffractive and Electromagnetic Processes at High Energies,
10-15 September, Acquafredda, Italy (invited talk by R. Orava)

TOTEM Collaboration Week and CB Meeting,
14-17 September, CERN, Geneva, Switzerland (H. Saarikko)

WH-Workshop,
20-27 September, Fermilab, Batavia, IL, USA (talks by T. Aaltonen)

Models in Physics and Cosmology,
27-28 September, Helsinki, Finland (H. Saarikko)

Meeting for CMS and TOTEM Upgrade,
30 September, CERN, Geneva, Switzerland (H. Saarikko)

Linear Collider Research

Diffractive and Electromagnetic Processes at the LHC,
4-8 January, ECT*, Trento, Italy (talk by F. Oljemark, invited talk by K. Österberg)

EuCARD Annual Meeting and EuCARD Governing Board,
14-16 April, STFC-RAL, Didcot, UK (K. Österberg)

4th Annual X-band Structure Collaboration Meeting,
3-5 May, CERN, Geneva, Switzerland (talk by R. Nousiainen)

Diffraction@LHC Day,
7 May, CERN, Geneva, Switzerland (talk by K. Österberg)

Forward Physics at LHC Workshop and TOTEM Collaboration Meetings,
23-29 May, La Biódóla, Elba, Italy (F. Oljemark, invited talk by K. Österberg)

HIP Scientific Advisory Board,
1-2 June, Helsinki, Finland (talk by K. Österberg)

Marie Curie IAPP MeChanICs Project Kickoff Meeting,
6-7 September, CERN, Geneva, Switzerland (J. Huopana, organised by R. Nousiainen and K. Österberg)

XXV Linear Accelerator Conference (LINAC10),
12-17 September, Tsubuka, Japan (J. Huopana, R. Nousiainen)

Restricted European Committee for Future Accelerators,
8-9 October, Helsinki, Finland (talk by K. Österberg)

International Workshop on Linear Colliders and CLIC CB Meeting,
18-22 October, Geneva, Switzerland (J. Huopana, R. Nousiainen, K. Österberg)

Marie Curie IAPP Project Coordinators Meeting,
25 November, Brussels, Belgium (K. Österberg)

CLIC Meeting (Modeling of CLIC Two-Beam Module),
17 December, CERN, Geneva, Switzerland (talk by R. Nousiainen)

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

Meetings with the LHCC Referees of TOTEM,
CERN, Geneva, Switzerland (talks by K. Österberg)

TOTEM Software and TOTEM T2 Optimization Meetings,
Geneva, Switzerland (talks by F. Oljemark and J. Welti, organised by K. Österberg)

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

CLIC Cost and Schedule Working Group Meetings,
CERN, Geneva, Switzerland (talks by T. Uusimäki)

EuCARD WP9.2 Meetings,
CERN, Geneva, Switzerland (talks by K. Österberg)

CMS Programme

Spaatind 2010, Nordic Conference in Particle Physics,
2-8 January, Spaatind, Norway (talk by P. Eerola)

Higgs Working Group Meeting,
18-23 January, CERN, Geneva, Switzerland (R. Kinnunen)

EPS-HEPP Board Meeting,
21-22 January, CERN, Geneva, Switzerland (P. Eerola)

SNIC Board Meeting,
27 January, Swedish Research Council, Stockholm, Sweden (P. Eerola)

CMS Working Group Meetings,
9-11 February, CERN, Geneva, Switzerland (P. Eerola)

100th Open Session of Large Hadron Collider Committee,
17-18 February, CERN, Geneva, Switzerland (talk by J. Härkönen)

CMS Trigger and Physics Days,
22-26 February, CERN, Geneva, Switzerland (P. Eerola)

The 2010 European School of High-Energy Physics, Programme Committee Meeting,
7-8 March, CERN, Geneva, Switzerland (P. Eerola)

The Annual Meeting of the Finnish Physical Society,
11-13 March, Jyväskylä, Finland (P. Eerola, invited talk by J. Tuominiemi, talk by L. Wendland)

CMS Collaboration Week,
15-19 March, CERN, Geneva, Switzerland (P. Eerola, R. Kinnunen)

Proton Irradiation Campaign, University of Jyväskylä Accelerator Laboratory,
15-19 March, Jyväskylä, Finland (J. Härkönen, I. Kassamakov, J. Lehikoinen, T. Peltola, J. Salpakari, E. Tuominen, E. Tuovinen)

The Annual Meeting of the Physical Society in Finland,
24 March, Helsinki, Finland (talk by T. Lindén)

LHC Higgs Cross Section Working Group, Inauguration Workshop,
12-13 April, Freiburg, Germany (talk by S. Lehti)

Instituto de Pesquisas Energéticas e Nucleares IPEN,
14-21 April, São Paulo, Brazil (J. Härkönen)

SNIC Board Meeting,
16 April, Swedish Research Council, Stockholm, Sweden (P. Eerola)

CMS Higgs Working Group Meetings,
20 April - 1 May, CERN, Geneva, Switzerland (R. Kinnunen)

Infrastructure Committee Meeting,
5 May, Swedish Research Council, Stockholm, Sweden (P. Eerola)

CMS Physics Week,
16-20 May, CERN, Geneva, Switzerland (P. Eerola, R. Kinnunen)

Particle Physics Summer School,
24-28 May, Tvärminne, Finland (lectures by V. Azzolini, lectures by P. Eerola)

CMS Tracker Week,
24-28 May, La Biódóla, Elba, Italy (J. Härkönen, J. Tuominiemi)

CERN Committee Meeting,
1 June, NDGF, Kastrup, Denmark (talk by T. Lindén)

16th RD50 Workshop on Radiation Hard Semiconductor Devices for Very High Luminosity Colliders,
1-3 June, Barcelona, Spain (talk by J. Härkönen, P. Luukka, T. Peltola, E. Tuominen, E. Tuovinen)

SNIC Board Meeting,
3 June, Swedish Research Council, Stockholm, Sweden (P. Eerola)

2010-I Workshop on CERN RD39 Cryogenic Tracking Detectors,
4 June, Barcelona, Spain (talk by J. Härkönen, P. Luukka, T. Peltola, talk by E. Tuominen, E. Tuovinen)

"LHC and Beyond" NordForsk Workshop,
8-11 June, St. Petersburg State University, St. Petersburg, Russia (P. Eerola, talk by I. Kassamakov, talk by T. Lindén)

CMS Collaboration Week,
14-17 June, CERN, Geneva, Switzerland (P. Eerola, R. Kinnunen)

The 2010 European School of High-Energy Physics,
20 June - 3 July, Raseborg, Finland (P. Eerola, V. Karimäki, T. Lampén)

LHC Higgs Cross Section Working Group, The Second Workshop,
5-6 July, CERN, Geneva, Switzerland (S. Lehti)

International Conference on High Energy Physics (ICHEP) 2010,
21-29 July, Paris, France (P. Eerola)

SNIC Board Meeting,
31 August, Swedish Research Council, Stockholm, Sweden (P. Eerola)

CMS Working Group Meetings,
1-3 September, CERN, Geneva, Switzerland (P. Eerola)

CERN Committee Meeting,
2 September, NDGF, Kastrup, Denmark (T. Lindén)

CMS Physics Week,
13-19 September, Bodrum, Turkey (P. Eerola, V. Karimäki, R. Kinnunen, S. Lehti, J. Tuominiemi)

CMS Offline and Computing Workshop,
26 September - 1 October, CERN, Geneva, Switzerland (talk by T. Lindén)

3rd International Workshop on Prospects for Charged Higgs Discovery at Colliders,
27-30 September, Uppsala, Sweden (R. Kinnunen, talk by M. Kortelainen, talk by L. Wendland)

SNIC Board and Infrastructure Committee Meetings,
5-7 October, Swedish Research Council, Stockholm, Sweden (P. Eerola)

FP7 Physics Panel Meeting,
11-15 October, Brussels, Belgium (P. Eerola)

8th International Conference on Radiation Effects on Semiconductor Materials Detectors and Devices,
12-15 October, Florence, Italy (talk by J. Härkönen)

The Joint International Conference of the 7th Supercomputing in Nuclear Application and the 3rd Monte Carlo (SNA + MC2010),
17-21 October, Tokyo, Japan (talk by P. Kaitaniemi)

CMS Higgs Working Group Meetings,
17-22 October, CERN, Geneva, Switzerland (R. Kinnunen)

The International Conference on Computing in High Energy and Nuclear Physics 2010,
18-22 October, Taipei, Taiwan (talk by M. Kortelainen, T. Lampén, K. Lassila-Perini, T. Lindén)

SiBT Beam Tests,
5-20 November, CERN, Geneva, Switzerland (J. Härkönen, P. Luukka, H. Moilanen, T. Mäenpää, T. Peltola, E. Tuovinen)

CMS Working Meetings,
8-10 November, CERN, Geneva, Switzerland (P. Eerola)

User Training "Using Physics Analysis Toolkit (PAT) in your analysis",
15-19 November, Fermilab, Batavia, IL, USA (K. Lassila-Perini)

2010-II Workshop on CERN RD39 Cryogenic Tracking Detectors,
16 November, CERN, Geneva, Switzerland (talk by J. Härkönen, P. Luukka, T. Peltola, talk by E. Tuominen, E. Tuovinen)

17th RD50 Workshop on Radiation Hard Semiconductor Devices for Very High Luminosity Colliders,
17-19 November, CERN, Geneva, Switzerland (talk by J. Härkönen, P. Luukka, T. Peltola, E. Tuominen, E. Tuovinen)

CMS Higgs Working Group Meetings,
17-20 November, CERN, Geneva, Switzerland (R. Kinnunen)

Researcher Selection Committee Meeting,
22 November, Royal Institute of Technology, Stockholm, Sweden (P. Eerola)

CERN Committee Meeting,
25 November, NDGF, Kastrup, Denmark (P. Eerola, T. Lindén)

Funet Technical Days,
30 November - 1 December, Aalto University, Espoo, Finland (talk by T. Lindén)

CMS Higgs Review Workshop,
1-5 December, CERN, Geneva, Switzerland (R. Kinnunen, L. Wendland)

CMS Collaboration Week,
6-10 December, CERN, Geneva, Switzerland (plenary talk by P. Eerola, talk by V. Karimäki, R. Kinnunen)

Multivariate Analysis Workshop,
13 December, CERN, Geneva, Switzerland (V. Karimäki)

Thesis Examination Boards for Doctoral Thesis Defense,
28 January, 4 June, 24 September, University of Stockholm, Stockholm, Sweden (R. Kinnunen)

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

Nuclear Matter Programme

ALICE

ALICE Physics Working Group 4,
11 January, 15 February, 22 March, 26 April, 19 May, 28 June, 30 August, 4 October, 8 November, 29 November, CERN, Geneva, Switzerland (talks by J. Rak)

ALICE Physics Forum,
17 February, 24 March, 28 April, 2 June, 30 June, 6 October, 10 November, 1 December, CERN, Geneva, Switzerland (talks by J. Rak)

The Annual Meeting of the Finnish Physical Society,
12 March, Jyväskylä, Finland (talk by J. Rak)

Workshop on Critical Examination of RHIC Paradigms,
16 April, The University of Texas at Austin, Austin, TX, USA (talk by J. Rak)

35th International Conference on High Energy Physics (ICHEP),
22 July, Paris, France (talk by J. Rak)

ALICE Physics Working Group 4,
26 July, CERN, Geneva, Switzerland (talk by F. Krizek)

Jets in Proton-Proton and Heavy-Ion Collisions,
12 August, Prague, Czech Republic (talk by J. Rak)

Quark Confinement and the Hadron Spectrum IX,
30 August, Universidad Complutense de Madrid, Madrid, Spain (talk by F. Krizek, talk by J. Rak)

Junior's Day,
11 November, CERN, Geneva, Switzerland (talk by F. Krizek)

4th International Conference on Hard and Electromagnetic Probes of High-Energy Nuclear Collisions (HP2010),
14 November, Eilat, Israel (talk by J. Rak)

Zimányi 2010 Winter School on Heavy Ion Physics,
30 November, Budapest, Hungary (talk by N. Novitzky)

ISOLDE

NUSTAR Annual Meeting 2010,
3-5 March, GSI, Darmstadt, Germany (A. Jokinen, I. Moore, J. Äystö)

The Annual Meeting of the Finnish Physical Society,
11-13 March, Jyväskylä, Finland (talk by I. Moore)

Nordic Winter Meeting on Physics @ FAIR,
22-26 March, Lund University, Lund, Sweden (talk by A. Jokinen)

EURORIB'10,
9 June, Lamour, France (talk by J. Äystö)

11th Symposium on Nuclei in the Cosmos (NIC XI),
19-23 July, University of Heidelberg, Heidelberg, Germany (talk by A. Jokinen)

Frontiers In NUclear STructure, Astrophysics and Reactions, FINUSTAR2010,
23-27 August, Rhodos, Greece (talk by J. Äystö)

South African Institute of Physics, 55th Annual Conference,
27 September - 1 October, Pretoria, South Africa (talk by I. Moore)

NUSTAR Week 2010,
4-8 October, University of Lund, Lund, Sweden (A. Jokinen, I. Moore)

FAIR

Working visit to Comenius University Bratislava CUB and CERN,
11 February - 13 March, Bratislava, Slovakia and Geneva, Switzerland (F. García)

The Annual Meeting of the Finnish Physical Society,
11-13 March, Jyväskylä, Finland (talk by M. Kalliokoski)

First International Particle Accelerator Conference, IPAC'10,
23-28 May, Kyoto, Japan
(talk by M. Kalliokoski)

Working visit to GSI,
13-24 September, Darmstadt, Germany
(F. García, M. Kalliokoski, E. Tuominen)

Nuclear Science Symposium and Medical Imaging Conference 2010,
30 September - 6 October, Knoxville, TN, USA (talk by M. Kalliokoski)

NUSTAR Week 2010,
4-8 October, University of Lund, Lund, Sweden (F. García, M. Kalliokoski, J. Äystö)

International Conference on Monte Carlo,
17-21 October, Tokyo, Japan
(talk by M. Kalliokoski)

Working visit to University of Frascati,
28 October - 4 November, Frascati, Italy (F. García)

Technology Programme

5th EGEE User Forum,
12-15 April, Uppsala, Sweden (K. Happonen, talks by H. Mikkonen, J. White)

NorduGrid 2010: ARC Empowering EGI,
3-7 May, Ljubljana, Slovenia (talk by J. White)

European Identity Conference 2010,
4-7 May, Munich, Germany (H. Mikkonen)

Research Day: "ECO² Computing: Towards Ecologically-Friendly and Economical IT",
17 June, Rolex Learning Center, EPFL Campus, Lausanne, Switzerland (M. Tuisku)

The 2nd Conference "Rapid Modelling - Quick Response: Intersection of Theory and Practice",
30 August - 1 September, Neuchâtel, Switzerland
(talk by A.-P. Hameri, T. Niemi)

GridKa School,
6-10 September, Karlsruhe, Germany (talk by J. White)

EGI Technical Forum 2010,
14-17 September, Amsterdam, The Netherlands (J. Hahkala, H. Mikkonen, talk by J. White)

"Fêtons Linux" Conference,
8 October, HEPIA, Geneva, Switzerland (talk by M. Tuisku)

Fall 2010 Internet2 Member Meeting,
1-4 November, Atlanta, GA, USA (H. Mikkonen)

Federated Identity for Cyberinfrastructure Workshop,
4-5 November, Atlanta, GA, USA (H. Mikkonen)

Supercomputing 2010,
13-19 November, New Orleans, LA, USA (J. Kommeri)

Devoxx 2010,
15-19 November, Antwerp, Belgium (H. Mikkonen)

EMI All-Hands Meeting,
22-24 November, Prague, Czech Republic (J. Hahkala, H. Mikkonen, talk by J. White)

Planck

LFI Core Team Meeting 16,
20-21 January, Bologna, Italy (invited talk by H. Kurki-Suonio, invited talk by T. Poutanen, M. Savelainen)

LFI Core Team Meeting 17,
1-2 March, Bologna, Italy (invited talk by H. Kurki-Suonio, invited talk by T. Poutanen)

Joint Core Team Meeting,
1-3 May, Orsay, France (invited talk by H. Kurki-Suonio, invited talk by T. Poutanen, M. Savelainen)

Origin of Mass Conference,
4-5 May, Odense, Denmark (invited talk by H. Kurki-Suonio)

The 2010 European School of High-Energy Physics,
24-26 June, Raseborg, Finland (invited lectures by H. Kurki-Suonio)

LFI Core Team Meeting 18,
7-8 July, Bologna, Italy (invited talks by H. Kurki-Suonio, M. Savelainen)

LFI Core Team Meeting 19,
13-14 September, Bologna, Italy (H. Kurki-Suonio, invited talk by T. Poutanen)

Joint Core Team Meeting,
8-12 November, Bologna, Italy (invited talk by H. Kurki-Suonio, talk by M. Savelainen)

Administration and Support

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

EPPOG Meeting,
14-16 October, CERN, Geneva, Switzerland (R. Rinta-Filppula)

Publications

Theory Programme

Cosmophysics

L. Amendola, K. Kainulainen, V. Marra, and M. Quartin,
Large-scale inhomogeneities may improve the cosmic concordance of supernovae,
Phys. Rev. Lett. 105 (2010) 121302

C. T. Byrnes, K. Enqvist, and T. Takahashi,
Scale-dependence of non-Gaussianity in the curvaton model,
J. Cosmol. Astropart. Phys. 1009 (2010) 026

K. Enqvist, A. Mazumdar, and P. Stephens,
Inflection point inflation within supersymmetry,
J. Cosmol. Astropart. Phys. 1006 (2010) 020

K. Enqvist, A. Mazumdar, and O. Taanila,
The TeV mass curvaton,
J. Cosmol. Astropart. Phys. 1009 (2010) 030

K. Enqvist, S. Nurmi, O. Taanila, and T. Takahashi,
Non-Gaussian fingerprints of self-interacting curvaton,
J. Cosmol. Astropart. Phys. 1004 (2010) 009

K. Enqvist, P. Stephens, O. Taanila, and A. Tranberg,
Fast electroweak symmetry breaking and cold electroweak baryogenesis,
J. Cosmol. Astropart. Phys. 1009 (2010) 019

A. Ferrantelli and J. McDonald,
Cosmological evolution of scalar fields and gravitino dark matter in gauge mediation at low reheating temperatures,
J. Cosmol. Astropart. Phys. 1002 (2010) 003

M. Herranen, K. Kainulainen, and P. M. Rahkila,
Coherent quantum Boltzmann equations from cQPA,
J. High Energy Phys. 1012 (2010) 072

K. Kainulainen, K. Tuominen, and J. Virkajärvi,
Naturality, unification, and dark matter,
Phys. Rev. D 82 (2010) 043511

K. Kainulainen, J. Virkajärvi, and K. Tuominen,
Weakly interacting dark matter from the minimal walking technicolor,
J. Cosmol. Astropart. Phys. 1002 (2010) 029

E. W. Kolb, V. Marra, and S. Matarrese,
Cosmological background solutions and cosmological backreactions,
Gen. Relativ. Gravit. 42 (2010) 1399

V. Marra and M. Pääkkönen,
Observational constraints on the ΛLTB model,
J. Cosmol. Astropart. Phys. 1012 (2010) 021

M. Mattsson and T. Mattsson,
On the role of shear in cosmological averaging,
J. Cosmol. Astropart. Phys. 1010 (2010) 021

T. Mattsson,
Dark energy as a mirage,
Gen. Relativ. Gravit. 42 (2010) 567

T. Prokopec and G. Rigopoulos,
Path integral for inflationary perturbations,
Phys. Rev. D 82 (2010) 023529

M. J. Valtonen, S. Mikkola, H. J. Lehto, T. Hyvönen, K. Nilsson, D. Merritt, A. Gopakumar, H. Rampadarath, R. Hudec, M. Basta, and R. Saunders,
Measuring black hole spin in OJ287,
Celest. Mech. Dyn. Astr. 106 (2010) 235

M. J. Valtonen, S. Mikkola, D. Merritt, A. Gopakumar, H. J. Lehto, T. Hyvönen, H. Rampadarath, R. Saunders, M. Basta, and R. Hudec,
Measuring the spin of the primary black hole in OJ287,
Astrophys. J. 709 (2010) 725

Laws of Nature and Condensed Particle Matter Phenomenology at the LHC

O. Antipin, M. Heikinheimo, and K. Tuominen,
The next generation,
J. High Energy Phys. 1007 (2010) 052

O. Antipin and K. Tuominen,
Resizing the conformal window: a β-function ansatz,
Phys. Rev. D 81 (2010) 076011

M. Antola, M. Heikinheimo, F. Sannino, and K. Tuominen,
Unnatural origin of fermion masses for technicolor,
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M. Arai, K. Huitu, S. K. Rai, and K. Rao,
Single production of sleptons with polarized tops at the large hadron collider,
J. High Energy Phys. 1008 (2010) 082

J. Auvinen, K. J. Eskola, H. Holopainen, and T. Renk,
Elastic energy loss with respect to the reaction plane in a Monte Carlo model,
Phys. Rev. C 82 (2010) 051901(R)

J. Auvinen, K. J. Eskola, and T. Renk,
Monte-Carlo model for elastic energy loss in a hydrodynamical background,
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B. Bhattacherjee, A. Kundu, S. K. Rai, and S. Raychaudhuri,
Multijet discriminators for new physics in leptonic signals at the LHC,
Phys. Rev. D 81 (2010) 035021

J.-P. Blaizot, T. Lappi, and Y. Mehtar-Tani,
On the gluon spectrum in the glasma,
Nucl. Phys. A 846 (2010) 63

K. Dusling, F. Gelis, T. Lappi, and R. Venugopalan,
Long range two-particle rapidity correlations in A+A collisions from high energy QCD evolution,
Nucl. Phys. A 836 (2010) 159

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Ultrarelativistic sneutrinos at the LHC and sneutrino-antisneutrino oscillations,
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R. M. Godbole, K. Rao, S. D. Rindani, and R. K. Singh,
On measurement of top polarization as a probe of $t\bar{t}$ production mechanisms at the LHC,
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G. Hiller, K. Huitu, T. Rüppell, and J. Laamanen,
Large muon electric dipole moment from flavor?,
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P. Hoyer and S. Kurki,
Transverse shape of the electron,
Phys. Rev. D 81 (2010) 013002

K. Huitu and S. Khalil,
New physics contribution to $B \to K\pi$ decays in soft collinear effective theory,
Phys. Rev. D 81 (2010) 095008

K. Huitu, J. Laamanen, P. N. Pandita, and P. Tiitola,
Implications of different supersymmetry breaking patterns for the spectrum and decay of neutralinos and charginos,
Phys. Rev. D 82 (2010) 115003

T. Kähärä and K. Tuominen,
Effective models of two-flavor QCD: finite μ and m_q dependence,
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T. Lappi, S. Srednyak, and R. Venugopalan,
Non-perturbative computation of double inclusive gluon production in the Glasma,
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J. Maalampi and J. Riittinen,
***CP*-phase effects on the effective neutrino mass m_{ee} in the case of quasidegenerate neutrinos,**
Phys. Rev. D 81 (2010) 037301

J. Maalampi, I. Vilja, and H. Virtanen,
Thermal leptogenesis in a 5D split fermion scenario with bulk neutrinos,
Phys. Rev. D 82 (2010) 013009

C. Marquet and T. Renk,
Jet quenching in the strongly-interacting quark-gluon plasma,
Phys. Lett. B 685 (2010) 270

R. B. Neufeld and T. Renk,
Mach cone signal and energy deposition scenarios in linearized hydrodynamics,
Phys. Rev. C 82 (2010) 044903

A. Rajantie and A. Tranberg,
Counting defects with the two-point correlator,
J. High Energy Phys. 1008 (2010) 086

T. Renk,
Nuclear suppression factor for P_T increasing towards the kinematic limit,
Phys. Rev. C 81 (2010) 014906

String Theory and Mathematical Physics

J. Alanen and K. Kajantie,
Thermodynamics of a field theory with an infrared fixed point from gauge/gravity duality,
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J. Alanen, K. Kajantie, and K. Tuominen,
Thermodynamics of quasiconformal theories from gauge/gravity duality,
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Inhomogeneous structures in holographic superfluids. I. Dark solitons,
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Inhomogeneous structures in holographic superfluids. II. Vortices,
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Quantum Field Theory

S. Carloni, M. Chaichian, S. Nojiri, S. D. Odintsov, M. Oksanen, and A. Tureanu,
Modified first-order Hořava-Lifshitz gravity: Hamiltonian analysis of the general theory and accelerating FRW cosmology in a power-law *F(R)* model,
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Phys. Rev. D 81 (2010) 085026

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Can Seiberg-Witten map bypass noncommutative gauge theory no-go theorem?,
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M. Chaichian, A. Tureanu, and A. Zahabi,
Solution of the stochastic Langevin equations for clustering of particles in random flows in terms of the Wiener path integral,
Phys. Rev. E 81 (2010) 066309

M. Chaichian, A. Tureanu, and A. A. Zheltukhin,
Massless chiral supermultiplets of higher spins and the θ-twistor,
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C. R. Das, L. V. Laperashvili, and A. Tureanu,
Cosmological constant in a model with superstring-inspired E_6 unification and shadow θ-particles,
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M. Raasakka and A. Tureanu,
UV/IR mixing via a Seiberg-Witten map for noncommutative QED,
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Low Dimensional Quantum Systems

S. Bargi, J. Christensson, H. Saarikoski, A. Harju, G. M. Kavoulakis, M. Manninen, and S. M. Reimann,
Vortices in rotating two-component boson and fermion traps,
Physica E 42 (2010) 411

Y. Hancock, A. Uppstu, K. Saloriutta, A. Harju, and M. J. Puska,
Generalized tight-binding transport model for graphene nanoribbon-based systems,
Phys. Rev. B 81 (2010) 245402

M. Ijäs and A. Harju,
Lattice density-functional theory on graphene,
Phys. Rev. B 82 (2010) 235111

I. Makkonen, A. Snicker, M. J. Puska, J.-M. Mäki, and F. Tuomisto,
Positrons as interface-sensitive probes of polar semiconductor heterostructures,
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Control of a two-electron quantum ring with an external magnetic field,
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E. Tölö and A. Harju,
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Reduced density-matrix functional theory in quantum Hall systems,
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Radiation Damage in Particle Accelerator Materials

F. Djurabekova, M. Backholm, M. Backman, O. H. Pakarinen, J. Keinonen, K. Nordlund, T.-R. Shan, B. D. Devine, and S. B. Sinnott,
Amorphization of α-quartz and comparative study of defects in amorphized quartz and Si nanocrystals embedded in amorphous silica,
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Density evolution in formation of swift heavy ion tracks in insulators,
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D. J. Sprouster, R. Giulian, L. L. Araujo, P. Kluth, B. Johannessen, N. Kirby, K. Nordlund, and M. C. Ridgway,
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H. Timko, F. Djurabekova, K. Nordlund, L. Costelle, K. Matyash, R. Schneider, A. Toerklep, G. Arnau-Izquierdo, A. Descoeudres, S. Calatroni, M. Taborelli, and W. Wuensch,
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High Energy Physics Programme

Forward Physics

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Measurement of the top pair production cross section in the dilepton decay channel in $p\bar{p}$ collisions at $\sqrt{s}$ = 1.96 TeV,
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