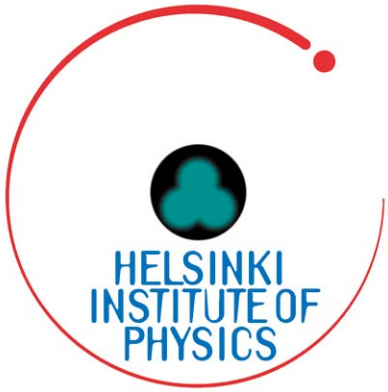
HELSINKI INSTITUTE OF PHYSICS

Annual Report 2011



Annual Report 2011

CERN Director General Rolf Heuer at HIP.

Annual Report 2011 Helsinki Institute of Physics

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Introduction

Dan-Olof Riska

The main events during 2011 were the remarkable proton-proton collision run of the Large Hadron Collider LHC at CERN, which led to an integrated luminosity of ~5 fb^{-1} collected at the CMS detector by the end of the year, and the final closing of the Tevatron collider at Fermi National Laboratory (FNAL). The year also witnessed the completion of the construction of the TOTEM experiment at the LHC and its first remarkably precise values for the cross sections for proton-proton collisions at 7 TeV.

The Helsinki Institute of Physics (HIP) has since 1997 had a national mandate from the Finnish Ministry of Education and Culture for the co-ordination of the collaboration between CERN and Finland. After the ratification of the Convention for the Facility for Antiproton and Ion Research (FAIR) in Darmstadt by the Finnish Government on November 25th, HIP also carries the responsibility for co-ordination of the Finnish activities at FAIR.

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 and research training, the development of technology know-how of Finnish industry and business applications and the exploitation of CERN - and from now on also of FAIR - 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 2011 the Institute was able to host a record of 19 study visits to CERN by Finnish high school students and 1 course for teachers at CERN.

During 2011, 9 PhD and DSc (Tech) degrees and 14 MSc and MSc (engineering) degrees were awarded by the HIP partner universities on the basis of work conducted within the research projects of the Institute. The number of MSc degrees was more than double compared to those awarded in 2010. The summer student programme at CERN represents a key educational effort. During the summer of 2011, 18 Finnish students worked at CERN in HIP research projects.

The research activities of the Helsinki Institute of Physics in 2011 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 were (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" continued for the first year of their second 3-year periods. In 2011 the leader of the Cosmophysics project, Dr. Kimmo Kainulainen, was appointed Professor of Cosmology at the University of Jyväskylä.

The High Energy Physics Programme participated in the analysis of the data from the TOTEM experiment at the LHC and continued the physics analysis of the data from the final run of the CDF-II experiment at the Tevatron collider at Fermi National Laboratory. The CLIC collider project was supported by an EU Marie Curie Industry-Academia Partnerships and Pathways project (IAPP) "MeChanICs - Marie Curie linking Industry to CERN", which brought 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 the project on detector development for the CMS luminosity upgrade. In 2011 the CMS Programme also carried the responsibility for the operation of the Finnish Tier-2 Grid computing facility, which is part of the Worldwide LHC Computing Grid WLCG.

The Nuclear Matter Programme 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 planning the Finnish contribution to the FAIR project, which consists of equipment for the accelerator complex and the experiments within the NUSTAR Collaboration.

The ISOLDE project was successfully reviewed during the year, and granted continuation for the period 2012-2014. The leader of the project, Docent Ari Jokinen, was appointed Professor in the Physics Department of the University of Jyväskylä from the beginning of August 2011.

The Technology Programme was composed of 3 research projects. The first dealt with software development for distributed data-intensive Grid computation. The aim of the second - the Green IT project - was to develop methods and operational practices to improve the energy use efficiency of high throughput computing clusters. The goal of the third - the PET project - is to find ways to commercialise new types of Positron Emission Tomography (PET) scanners using AXPET detectors developed at CERN.

The research results of these programmes and projects were reported in a record number of 251 scientific publications.

During 2011 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 Philippe Bloch, Director of the Physics Department at CERN.

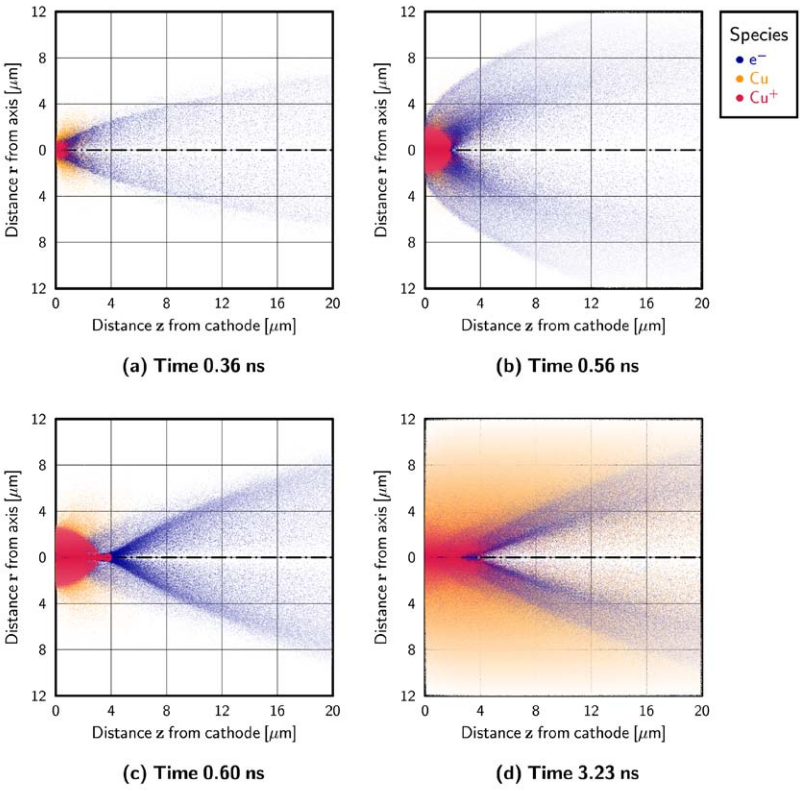
HELSINKI INSTITUTE OF PHYSICS

Highlights of Research Results

Theory Programme

In the *Cosmophysics* project we have estimated the contribution of non-Gaussianities to the galaxy cluster mass function. When correcting earlier analyses where the mass function was used out of its range of validity, we found that the values of f_{NL} previously claimed to completely reconcile the cluster data with ΛCDM are unphysically small. However, for WMAP cosmology and at 95% confidence, we arrived at the limit $f_{NL} > 411$, which is similar to previous estimates. We also explored a large g_{NL} as the cause of the observed excess of the massive clusters. For $g_{NL} > 2 \times 10^6$ this scenario appears to be in more agreement with the CMB and LSS limits and could also provide an explanation for the overabundance of large voids in the early universe.

In the *Laws of Nature and Condensed Particle Matter Phenomenology* project the central focus was on LHC phenomenology, both for p+p and Pb+Pb collisions, and for BSM model building. We have considered walking Technicolour models and supersymmetric extensions of the Standard Model, and obtained constraints on the parameter spaces of these models. Large-scale lattice simulations to determine the conformal window in SU(2) gauge theory with fundamental representation matter fields were carried out. In heavy-ion phenomenology, we have continued our pioneering developments to the hydrodynamical picture in describing the space-time evolution of the produced QCD matter. Remarkably, the new experimental results from Pb+Pb collisions at the LHC are now confirming the validity of this picture.



In the *Low Dimensional Quantum Systems* project we have studied quantum dots which are formed in graphene, a single layer of graphite. Despite being only one atomic layer thick, graphene is remarkably chemically as well as thermally stable. The graphene quantum dots are theoretically very interesting, showing confinement of massless relativistic fermions. In addition, we have studied the effects of a silicon dioxide substrate on graphene. Furthermore, our transport studies have shown that the scaling theory can be used to predict the mesoscopic properties of graphene structures starting from the microscopic simulation results.

The team working in the *Radiation Damage in Particle Accelerator Materials* project is one of the leaders in the studies of the electric breakdown near metal surfaces at high electric fields; the conditions relevant for the next generation particle accelerators. We have shown that the dislocations activated in the surface of accelerating structures can be responsible for the triggering of breakdown events. In the presence of a near-to-surface void, the tensile stress due to the electric component of the field can give rise to surface protrusions initiating field emitting spots. The same idea was

used to fit the experimental data for the dependence of breakdown rates on the accelerating gradient, giving us an estimate of the size of prismatic loops responsible for the formation of surface protrusions. These numbers lie in the range between 30 and 100 nm in diameter for the accelerating gradients used in the experiments. This correlates well with our simulations and hypothesis of the surface protrusions of nanometre scale, responsible for the triggering of the breakdown.

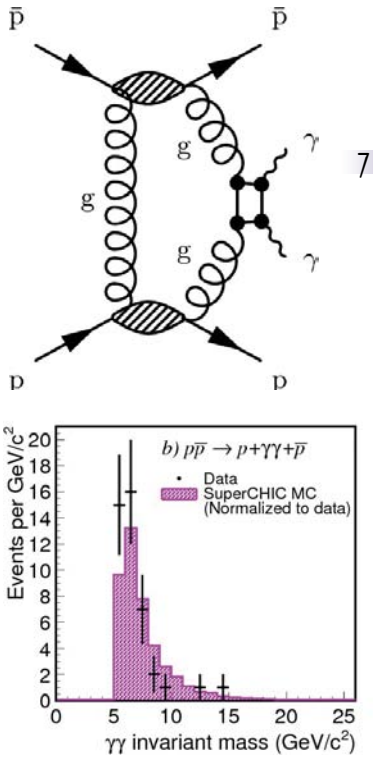
High Energy Physics Programme

Due to further improvements, data with significantly better quality than before could be taken with the TOTEM T2 telescope during LHC special runs in 2011, and the first physics result based on T2, the forward charged particle pseudorapidity density, is being prepared for publication.

The availability of the $\beta^* = 90$ m optics opened up the possibility for TOTEM to collect data in dedicated special optics runs in 2011 allowing for the first total, elastic, and inelastic cross section measurements.

In 2011, the very rare process of two gluons colliding and producing a pair of energetic gamma rays via a quark loop was observed for the first time at Tevatron (PhD thesis by Erik Brücken). The photon pair is produced via strongly interacting double pomeron exchange without any other particles in the final state (see the attached figures showing the Feynman diagram and the measured invariant mass distribution). This observation opens a new window on the Higgs boson search at the LHC. Even though difficult to predict, the Higgs boson should be produced by the same quark-loop process (if it exists). By tagging the forward outgoing protons, the Higgs boson properties can be uniquely measured, as no other particles are produced. New limits for the Higgs boson production in proton-antiproton interactions at the Tevatron (Fermilab) were also obtained.

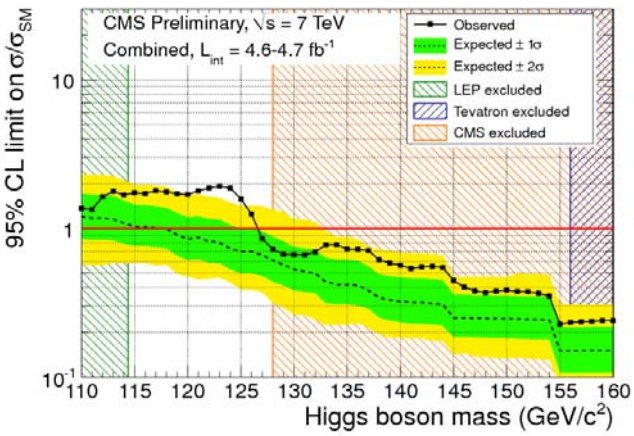
During 2011, the HIP group showed the feasibility of the integration of the various subsystems to a functional CLIC two-beam module and continued the R&D on the RF structures assembly as well as the industrialisation of the production of the RF structures.



CMS Programme

For the CMS, the year 2011 was the second successful full year of data taking, with the LHC providing proton-proton collisions at 7 TeV centre-of-mass energy, as well as heavy-ion collisions during a special run period. The LHC delivered a total integrated luminosity of 5.7 fb^{-1} of pp collisions, and 167 μb^{-1} of heavy ion collisions. Highlights of the year were in particular new results for the Higgs boson, Supersymmetry and rare B decays. The total number of papers published by CMS on collision data is now 87.

The allowed Standard Model Higgs boson mass range was pinned down to a narrow region between 115 and 127 GeV/c^2. Furthermore, an intriguing excess of events, compatible with the production of a Standard Model Higgs boson, was observed at a mass around 125 GeV/c^2. The statistics are, however, not sufficient to



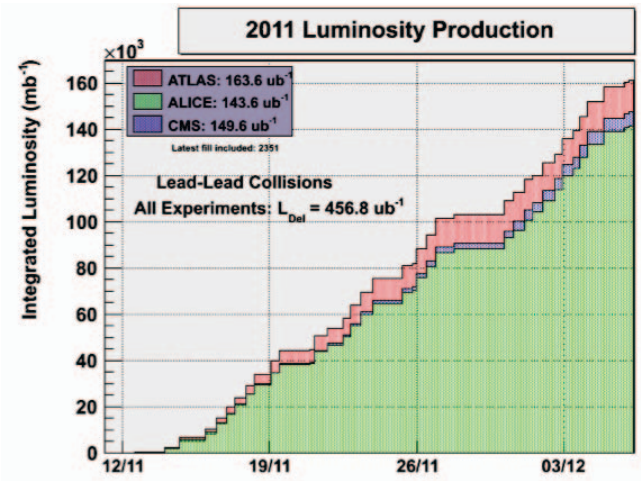
claim a discovery, and the excess is also compatible with a statistical fluctuation of the background. More data, which will be collected in 2012, should clarify the situation.

The Finnish HIP team was at the forefront of the non-Standard Model Higgs boson analyses. The team made a significant contribution to the charged Higgs boson results. A new world-best upper limit of 4-5%, about three times better than the limit from the Tevatron experiments, was obtained for the $t \rightarrow bH^{\pm}$ branching fraction in the charged Higgs boson mass range from 80 to 160 GeV/c^2.

The HIP CMS Upgrade project started a new activity, production of pixel modules to be implemented during the CMS Phase I pixel detector upgrade in 2016-2017. The module production will be done in collaboration with VTT.

Nuclear Matter Programme

Several important highlights have been seen in 2011. The active participation in physics runs at REX-ISOLDE, contributing to HIE-ISOLDE experiment planning and utilisation of the Finnish R&D in ion cooling and bunching has opened new opportunities for collinear laser spectroscopy of rare isotopes, such as a study of the evolution of charge radii of a long series of Ga isotopes from ^{63}Ga to ^{80}Ga. The unique availability of heavy, post-accelerated radioactive ion beams at REX-ISOLDE was again exploited in a number of measurements to study isotopes of Pb, Rn and Ra. The studies at ISOLDE nicely complement similar experiments carried out with stable ion beams at JYFL.



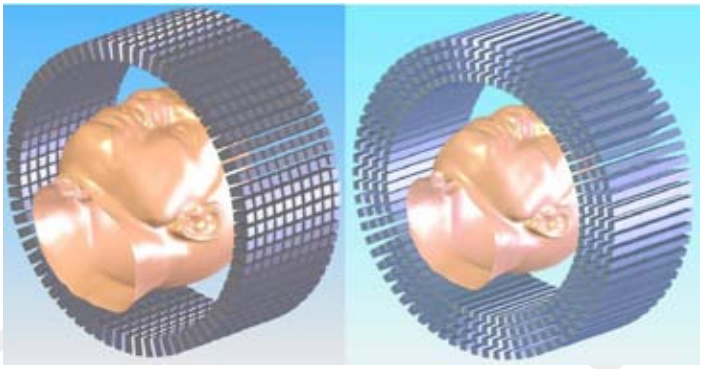
A very successful exploitation of a full year of running collisions with record luminosities both for protons and heavy ions by the ALICE experiment was a truly remarkable achievement. In 2011, the ALICE experiment was routinely taking proton-proton data at $\sqrt{s}$ = 7 TeV from March to October. At the end of 2011 the second heavy-ion run took place and ALICE recorded about 150 μb^{-1} of integrated luminosity. This corresponds to about 15 times more statistics than in the first 2010 Pb+Pb run. This huge data sample certainly opens an exciting opportunity to study many new physics phenomena not only due to the 15-fold statistics but also because of the enlarged acceptance of important detector components like the Electro-Magnetic Calorimeter (EMCAL), the transition-radiation detector etc. Before the 2011 run started, 6 more EMCAL super-modules were installed in addition to the 4 super-modules used in 2010. This was also a very important achievement for the Jyväskylä-HIP group because of our involvement in high-p_T photon and jet physics. Furthermore, our group is responsible for the level-0 single-photon trigger electronics which has been successfully commissioned together with the new EMCAL super-modules installation. The 2011 Pb+Pb run was also important because it is very likely the last heavy-ion run before the long shut-down in 2013. The main scientific event in 2011 was the Quark Matter conference held in Annecy, France, where the first and long awaited results from the heavy-ion run at the highest ever recorded centre-of-mass energy were presented. The highlights from this conference may be found elsewhere

(http://qm2011.in2p3.fr/node/12), however, let us mention a few of them here. Probably the most exciting and surprising result was found in the high-p_T sector where the jet quenching by exited Quark Gluon Plasma (QGP) is observed. Another important result presented in Annecy is related to particle emission with respect to the reaction plane defined as a plane formed by a beam axis and the vector connecting the centres of the two colliding nuclei. Many other important and surprising results from, e.g., the heavy quarkonia sector, were also reported and many more are certainly to come.

Finally, the Finnish physics community welcomed with great pleasure the decision to start construction of the FAIR facility. Of particular interest is the continuation of the work towards a novel GEM-TPC concept for the diagnostics of the secondary radioactive ion beams in the Super Fragment Separator, a key instrument serving all the experiments of the NUSTAR Collaboration.

Technology Programme

The year 2011 marked the official start of two new projects in the Technology Programme, the PET project, looking at CERN research commercialisation in Medical Imaging and the Green IT project already active in publishing energy efficiency best practices. According to the results so far it is possible to have a 45% reduction in energy usage in eScience Grids. The European Middleware Initiative (EMI) project entered its second project year with the DataGrid project team in the leading role for security activity.



Theory Programme

Kari Rummukainen,
Theory Programme Director

The Theory Programme is structured around fixed term projects, chosen according to their scientific quality and complementarity with the research at HIP and at the host universities. For the project leaders the HIP projects provide a reference frame on which to build a high class research group, and the leaders are expected to secure significant external funding for their projects. In 2011 the Theory Programme consisted of four projects: Cosmophysics, Laws of Nature and Condensed Particle Matter Phenomenology at the LHC; Low Dimensional Quantum Systems; and Radiation Damage in Particle Accelerator Materials. These will continue until the end of 2013. During 2011 a new initiative was decided upon: Professor Mark Hindmarsh (Sussex University) has been invited to visit HIP for the year 2012. He is one of the leading authorities in the physics at the intersection of particle physics and cosmology, and his presence will strongly enhance research in the Cosmophysics and the Laws of Nature projects.

Kimmo Kainulainen,
Cosmophysics
project leader

Cosmophysics

The fact that the universe is homogeneous on average does not imply that average quantities behave as if they are from a truly homogenous universe. An occurrence of such a deviation is generically referred to as a "backreaction". We have studied the strong backreaction, i.e., the possibility that non-linear effects might affect the overall background evolution, showing in particular that no backreaction occurs in perturbation theory. On the other hand, treating the backreaction at a non-perturbative level is immensely difficult. We have thus constructed a model universe where a gradient expansion of the metric renders the backreaction fully calculable. We found that the backreaction can be large enough to be measurable, but likely not large enough to be responsible for the apparent accelerated expansion of the universe.

We have, on the other hand, studied weak lensing and its impact on cosmological observables, continuing to develop the stochastic gravitational lensing (sGL) method to compute the lensing probability distribution function for model universes. The sGL method is based on generating stochastic configurations of inhomogeneities along the line of sight. These inhomogeneities are described according to an improved version of the so-called "halo model", in which the non-linear structures are also described by extended filaments besides the usual dark-matter halos. We are currently extending sGL on two fronts: first, to include a modelling of observational biases which may potentially affect the cosmological parameter estimations and second, to compute weak lensing distortions to the angular power spectrum in the CMB.

We have also studied models with large local voids to see if the dark energy can be mimicked by large-scale non-linear structures, and in particular exact spherically symmetric and inhomogeneous models with many perfect fluids. These models allow study of the non-linear structure formation in the presence of different dynamical dark energy components and thus constrain dark energy within a fully non-linear modelling. We have also studied the effect of shear on the backreaction in the context of matching voids and walls, finding it to be strongly suppressed even for voids well beyond any observed scale, relative to an analysis that treats walls and voids as disjoint Friedmann solutions. Whether this suppression is a generic feature remains to be proven however. Indeed, we are currently working with another exact solution where small randomly distributed structures may cause a sizeable backreaction.

We have also studied galaxy-clustering data to constrain the LCDM model. We found in particular that the usual statistical test on high redshift clusters is biased, and that when an un-

biased test is used, contrary to earlier claims, at most a subtle hint of tension remains with the LCDM model. We have also studied a possible tension between the theory and observations of the integrated Sachs-Wolfe (ISW) effect, which causes a photon that passes through very large structures in the universe to receive a net shift in its energy. A sophisticated analysis that accounts for the expected density profiles of these intervening structures significantly reduces the tension, but does not remove it completely. We have also used the matter and galaxy bispectrum to study local non-Gaussianity at small scales. We have used the Halo Model approach so we can access the very non-linear scales. Our predictions agree very well with the N-body simulations in the range of the mildly non-linear scales that the latter can probe.

We have estimated the contribution of non-Gaussianities to the cluster mass function. Correcting earlier analyses where the mass function was used out of its range of validity, we found that f_{NL} values previously claimed to completely reconcile the cluster data with ΛCDM are unphysically small. However, for WMAP cosmology and at 95% confidence, we arrived at the limit $f_{NL} > 411$, which is similar to previous estimates. We also explored a large g_{NL} as the cause of the observed excess of the massive clusters. With $g_{NL} > 2 \times 10^6$ this scenario appears to be in better agreement with the CMB and LSS limits and could also provide an explanation for the overabundance of large voids in the early universe.

We have continued our investigation of the curvaton mechanism for the inflationary perturbation spectrum. We showed in particular that the simplest curvaton model is not self-consistent, since the loop-corrections arising from the interactions necessary for the decay of the curvaton always make the potential strongly non-quadratic.

We continued working on several projects related to inflation. We found that the "Higgs inflation" model, where the inflaton is a non-minimally coupled standard model Higgs, is hampered by a unitarity violation below the energy scale of inflation. We then pointed out possible ways to reduce or avoid the unitarity problem in a model with a hierarchy of non-minimal couplings. In the context of MSSM infection point inflation, we showed that by adding a hybrid field with a large vacuum energy to the MSSM potential one can match observations while substantially reducing the fine-tuning inherent in these models. We used this approach to construct a genuinely small-field model of inflation that generates observably large primordial gravitational waves, but may also lead to the existence of primordial black holes. We have also studied a gravitational wave spectrum in lattice simulations and found a good agreement between the continuum-based TT metric perturbations and the new lattice-based ones. We are currently studying gravity wave production from a fermionic source in a model where a scalar inflaton or curvaton field decays to fermionic DOFs.

The quantum transport theory including non-local coherences, based on the coherent quasiparticle approximation (cQPA) developed in the Cosmophysics group is approaching completeness. This year we extended the formalism to mixing bosonic and fermionic fields including the self-energy corrections to dispersion relations. In its current form the formalism is applicable, for example, to neutrino flavour mixing, coherent particle production, coherent baryogenesis problems and after some modification also to the electroweak baryogenesis problem. We are currently extending the formalism to include first order dispersive corrections that may be important for a leptogenesis application. We have also used the semiclassical limit of the quantum transport equations to study electroweak baryogenesis in the two Higgs doublet models.

Laws of Nature and Condensed Particle Matter Phenomenology at the LHC

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 electroweak symmetry breaking (EWSB) mechanisms and as-

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

sociated Beyond the Standard Model (BSM) phenomenology and on 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 active research collaborations with various international colleagues, organise and participate in international conferences and workshops, European graduate school activities and EU networks. We are also in close contact with the local CMS (Helsinki) and ALICE (Jyväskylä) experimental groups

EWSB and BSM phenomenology: The first discovery at the LHC is expected to be the mechanism of the breaking of electroweak symmetry and the Higgs boson(s). Theoretical arguments on the naturality of the Higgs sector suggest that the Higgs boson is a composite particle or should appear in a supersymmetric setting.

So far the supersymmetric partners of quarks, squarks, have not been detected at the LHC indicating that they are heavier than a few hundred GeVs, if they exist. We have studied the possibility that stop, the supersymmetric partner of the top quark, is the next-to-lightest supersymmetric particle in the constrained supersymmetric Standard Model. The allowed parameter space for this scenario agrees well with the possibly observed Higgs mass around 125 GeV. However, observing stop at the LHC may be difficult in this scenario.

The detection of a pair of Higgses directly probes the scalar potential, and the basics of the electroweak symmetry breaking. We have studied the production of two Higgs bosons in a benchmark CP violating supersymmetric scenario at the LHC, and found that in the so-called LEP hole area, the experimental bound for the lightest Higgs boson mass can be reduced to less than 50 GeV. The hole can be closed with an integrated luminosity of $\sim$100 fb^{-1}, and in special parameter regions already by early LHC data.

We have studied single top production in association with a charged Higgs in the type II two Higgs doublet model at the LHC. The polarization of the top, reflected in the angular distributions of its decay products, can be a sensitive probe of new physics in its production. We showed that an azimuthal symmetry, constructed from the decay lepton angular distribution in the laboratory frame, is a sensitive probe of top polarization and can be used to constrain model parameters.

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. We have studied the model in the weak and strong coupling regimes of N=4. We have considered the contributions of vector states in Minimal Technicolour models and obtained new stringent constraints on the model parameters.

We have analysed the flavour violation in warped extra dimensions due to radion mediation. We showed that several flavour violating processes impose stringent constraints on the radion mass and the relevant scale. In particular, for the scale $\sim$ O(1) TeV, neutral B_d meson mixing implies that the radion mass is $\sim$ 65 GeV. We have considered radion contributions to lepton flavour violating processes, and considered the radion search at the LHC through the flavour violating decays into $\tau+\mu$ or top-charm quarks.

Dynamics of strong interactions: Within this part of the project our aim is on one hand to use lattice simulations and holographic methods to gain insight into non-perturbative dynamics of strongly interacting quantum field theory; the main motivation here is provided by the applicability of these theories in BSM model building. For example, during 2011 we carried out large-scale lattice simulations of a SU(2) gauge theory with fundamental representation matter fields in order to determine the location of the conformal window in this theory. The holographic methods were applied to determine the properties of shear viscosity in hot Yang-Mills theory, and thermodynamics and the vacuum spectrum of a generic Walking Technicolour theory. For the latter we are currently extending the model analyses to better account for the fermion degrees of freedom. Also, quantum entanglement as a measure of entropy and approach to thermal equilibrium in a strongly interact-

ing non-relativistic quantum field theory has been studied. Systems with Lifschitz scaling, thermalizing from a far-from-equilibrium initial state have been analysed by modelling the process by holographic duality as a gravitational null collapse in an asymptotically Lifschitz-AdS space-time.

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 year 2011, with the big *Quark Matter 2011* meeting in Annecy, offered various exciting new results from Pb+Pb collisions at the LHC. Remarkably, these results are now confirming the validity of the hydrodynamical picture in describing the space-time evolution of the produced QCD matter. In the hydrodynamical modelling, using our pQCD&saturation-based initial states, we have studied the hadron production systematics from RHIC to LHC against the LHC results. We have developed a Monte Carlo -based event-by-event hydro framework, which accounts for the initial QCD-matter density fluctuations. Such a framework, consistent with the experimental analysis method of the azimuthal asymmetries, is crucial for extracting the QCD matter viscosity from the measurements. Related to this, H. Holopainen received the 2011 Nuclear Physics *A Young Scientist Award* for the best theory talk in *QM2011*. We have studied the production of thermal photons, focusing especially on their elliptic flow for which some very exciting results were published by PHENIX at RHIC. Also the importance of the density fluctuations in enhancing the thermal photon yields has now been pointed out by us.

Regarding hard processes and nuclear parton distribution functions (nPDFs), we have applied our EPS09NLO package and its error sets to direct photon production in nuclear collisions, launched studies of the spatial dependence of the nPDFs, and participated in the planning of the possible p+Pb runs at the LHC.

High-p_T tomography of the medium created in heavy-ion collisions is a cornerstone of the experimental programme at both RHIC and the LHC, but it is in practice difficult, due to the ambiguities between modelling the parton-medium interaction and modelling the bulk medium geometry. We have started a systematic investigation of different types of parton-medium interaction scenarios in various hydrodynamical models against several different observables. Exploiting the RHIC and LHC data, stringent constraints for both the medium model and parton-medium interactions emerge. The Monte-Carlo code YaJEM, capable of simulating the full in-medium evolution of a parton shower is available as the result of this work.

We have also continued our studies of high energy QCD in the Colour-Glass-Condensate (CGC) framework. During the year 2011 we have published the first results from our new numerical code for solving the JIMWLK renormalization group equation that describes the energy dependence of QCD cross sections. It has been applied both to single inclusive gluon production in ultrarelativistic heavy ion collisions and to multigluon correlations.

Low Dimensional Quantum Systems

Ari Harju,
Low Dimensional
Quantum Systems
project leader

Advances in experimental techniques have changed the role of the low-dimensional quantum systems from toy models into systems of experimental and technological interest. Prime 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 moving from studies of two-dimensional semiconductor quantum dots in strong magnetic fields more towards graphene. In a semicon-

ductor quantum dot, a controllable number of electrons are confined in space to a tuneable environment. One interesting application area of these is quantum information and computing, where the electron spin can be used as a quantum bit (qubit). Our work in this direction has focused on qubit dynamics and decoherence.

It turned out that quantum dots can also be formed in graphene, a single layer of graphite. Despite being only one atomic layer thick, graphene is remarkably chemically as well as thermally stable. The graphene quantum dots are theoretically very interesting, showing confinement of massless relativistic fermions. In addition, we have studied the effects of a silicon dioxide substrate on graphene. Furthermore, our transport studies have shown that the scaling theory can be used to predict mesoscopic properties of graphene structures starting from the microscopic simulation results.

Finally, we have started a project where the graphics processing units are used to significantly speed up our simulations, mainly the exact diagonalization technique. The focus in this is on using the method to scan the topological phases of various lattice models in a very efficient fashion.

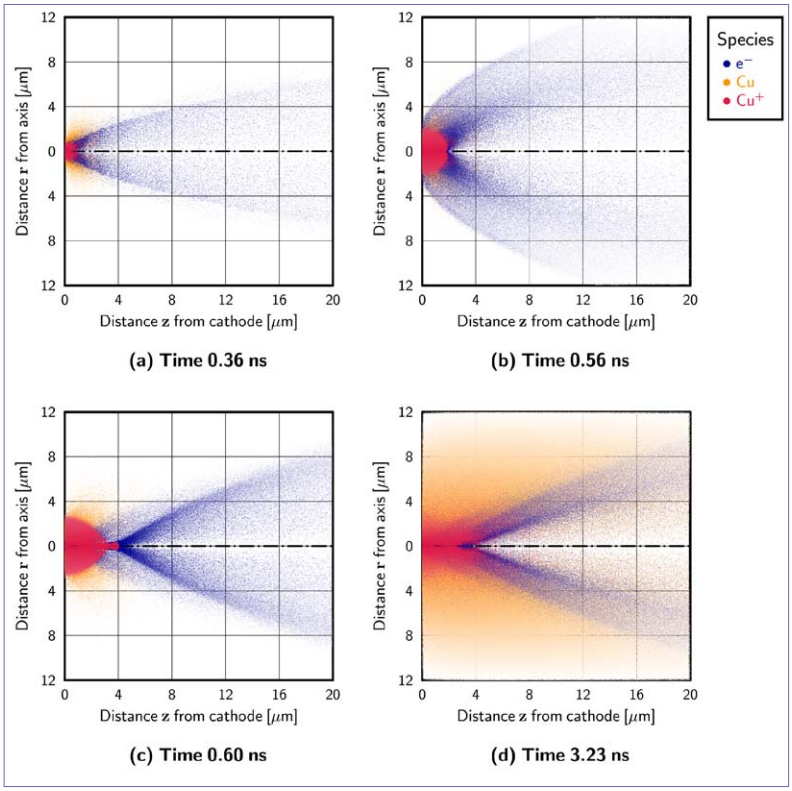
Flyura Djurabekova, Radiation Damage in Particle Accelerator Materials project leader

Radiation Damage in Particle Accelerator Materials

The latest progress in the Linear Hadron Collider measurements at CERN has encouraged the particle physicists to double the new results. The necessity for constructing a powerful linear collider, which will allow for collisions of particles with energies in the range of TeV has become vital. However, the challenging design of the new generation of colliders reveals many unclear questions in the physics of construction materials, which are used to build the accelerating structures and meant to withstand the high power and high gradient electromagnetic waves used to accelerate the particles. The high energy of colliding particles implies long pipes of advanced and costly machinery. The lower the accelerating gradient used, the longer the physical size of the collider is required to output the particles with sufficient energy. The ability to predict the behaviour of the construction materials operating in the extreme condition can significantly increase the efficiency of the collider.

One of the key problems is the loss of power in the accelerating structures due to the highly frequent breakdown events along the electron beam. These are known as momentary plasma discharges due to the interaction of the electric component of the electromagnetic wave with the surface. Although many similarities can be found between these discharges and cathode plasma, broadly studied experimentally over many decades, the triggering process has not yet been discovered. Nowadays the simulation team working at HIP led by Doc. F. Djurabekova is one of the leading theoretical groups, which are working on the puzzle of the electric breakdowns near metal surfaces held at high electric fields. In our work we are focusing on all the stages of plasma development: (i) triggering, (ii) evolution of plasma and (iii) surface damage caused by plasma. One of the key results of 2011 is that we have shown that the dislocations activated at the surface of accelerating structures during its operation by stress can be responsible for the triggering of breakdown events. At first, we showed that in the presence of a near-to-surface void, the tensile stress due to the electric component of the field can give rise to surface protrusions initiating field emitting spots. The same idea was used to fit the experimental data for the dependence of breakdown rates on the accelerating gradient. We have assumed a direct proportionality of breakdown rates and the equilibrium concentration of dislocations at the given stress corresponding to the given accelerating gradient. The fit based on this assumption has given an estimation of the size of prismatic loops responsible for the formation of surface protrusions. These numbers lie in the range between 30 and 100 nm in diameter for the accelerating gradients used in the experiments. This correlates well with our simulations and hypothesis of the surface protrusions of nanometre scale, responsible for the triggering of breakdowns.

We are also working on the interaction of



From field emission to a developed vacuum arc: different stages of the plasma initiation as simulated with the 2D ARC-PIC code. For illustration purpose the cylindrical geometry has been taken into account.

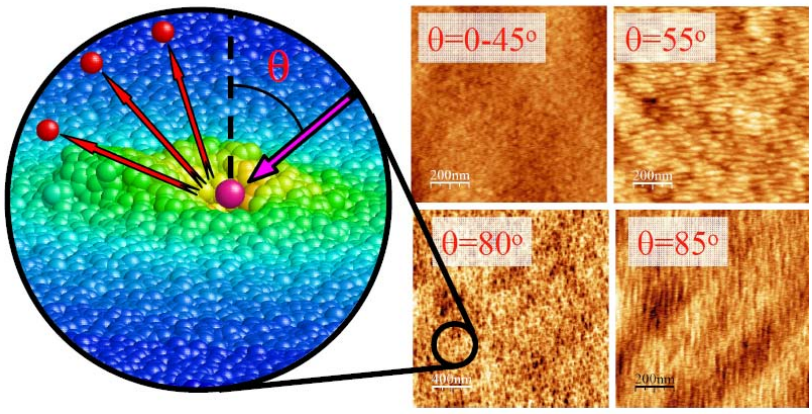
ion beams with solid surfaces. Recently the formation of ripples on the surface during the long ion irradiation has attracted a lot of interest from researchers due to the strong potential for industrial applications.

The impacts, lasting a few trillionths of a second, are simulated using intensive computer calculations. The theory then "up-scales" the cumulative effect of individual energetic particle impacts to predict surface topography evolution over thousands of seconds or longer. The results illustrate how large-scale computer simulations can be combined with rigorous mathematical analysis to yield precise predictions of new phenomena on length and time-scales that would otherwise be computationally impossible.

The researchers were surprised to discover that stability/instability is not determined by the atoms that are blasted away, but instead by the atoms that are knocked around and re-settle nearby. The discovery overturns a long-held paradigm about what causes surfaces under energetic particle bombardment to erupt into patterns. The blasting away of individual atoms from energetic particle impacts has long been thought to determine whether a surface is stable or unstable. The results show, however, that the effect of atoms blasted away turns out to be so small that it is essentially irrelevant. The lion's share of the responsibility of what makes a surface stable or unstable under irradiation comes from the cumulative effect of the much more numerous atoms that are just knocked to a different place but not blasted away.

The research further shows that the cumulative effect of these displacements can be either ultra-smoothening, which may be useful for the surface treatment of surgical tools, or topographic pattern-forming instabilities, which can degrade materials. The outcome depends on the type of material, energetic particle, and irradiation conditions.

The discovery, while interesting in its own right, may also help to solve a mysterious degradation problem in tungsten plasma-facing reactor walls in prototype fusion reactors.



Surface patterning by ion irradiation. We explain the ripple formation on the surface of amorphous silicon by the material flow rather than the surface sputtering, which is clearly seen in our molecular dynamics simulations.

High Energy Physics Programme

Heimo Saarikko,
High Energy Physics
Programme director

The activities of the High Energy Physics Programme in 2011 concentrated 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, enabling the first measurement of the total, elastic and inelastic proton-proton cross section at $\sqrt{s} = 7$ TeV. 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. The Helsinki group is contributing significantly to Higgs searches for the CDF experiment at Fermilab's Tevatron antiproton-proton collider. A vigorous R&D effort continued, to demonstrate the feasibility of the Compact LInear Collider (CLIC) -technology, in view of a decision on the future direction of the high energy frontier in 2013-2014. In 2011 the Detector Laboratory activities have supported the major experiments of HIP to a very significant extent. 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 at the University of Helsinki. Intense educational programmes were carried out in connection with the research activities, both at the undergraduate and graduate levels.

Risto Orava,
TOTEM Operation
project leader

TOTEM Operation Project

Background

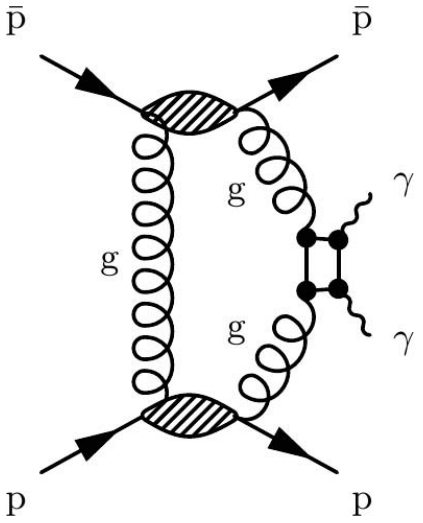
In 2011 the forward physics activities concentrated on: (1) finalising the CDF based analysis on exclusive gamma-gamma interactions (PhD thesis by Erik Brücken), top quark studies in the all-hadronic channel (PhD thesis by Petteri Mehtälä), and the Higgs analysis in the WH channel (PhD thesis by Timo Aaltonen) and in the WBF channel (PhD thesis by Francesco Devoto) at Fermilab Tevatron, (2) running-in the Helsinki built T2 spectrometer (PhD thesis by Timo Hildén) and (3) beginning the physics analysis activities of the TOTEM/CMS experiment at CERN (PhD theses by Fredrik Oljemark and Jan Welti).

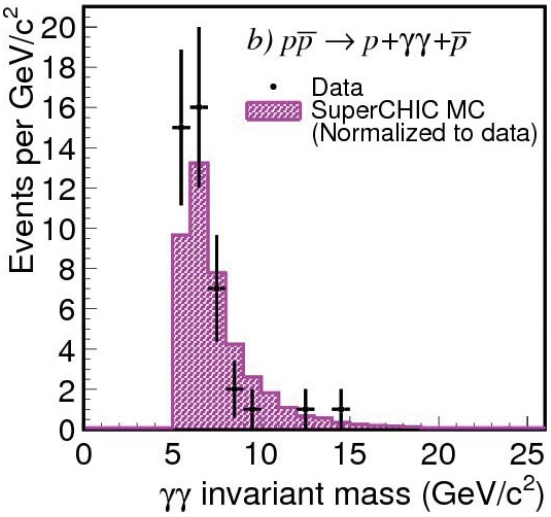
The highlights of the physics analyses include: the first observation of the exclusive gamma-gamma process, and new limits for the Higgs boson production in proton-antiproton interactions at the Tevatron (Fermilab), and the first measurement of elastic and total proton-proton cross sections at the LHC (CERN).

The Tevatron running at Fermilab finished in September 2011; a special energy scan was carried out during the last days of Tevatron operation.

A number of MSc students contributed to the physics analysis by the group in 2011, and studies on bremsstrahlung in elastic proton-proton scattering at the LHC (Hanna Grönqvist), event classification and anomaly search (Eric Malmi, Mikael Mieskolainen, Mikael Kuusela, Tommi Vatanen), and simulation of backgrounds at the LHC (Gillis Danielsen) were carried out together with the senior members of the group.

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.





Exclusive gamma-gamma process (left) and the measured invariant mass distribution of the gamma-system (right).

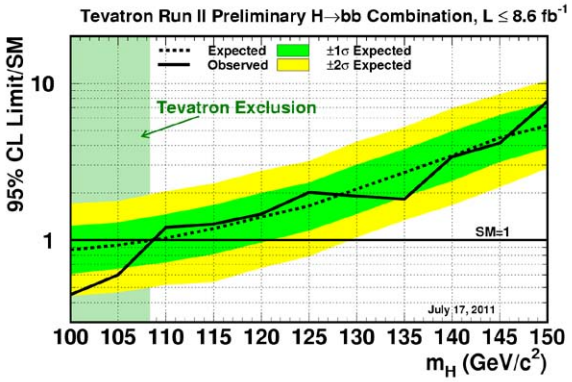
CDF-analysis: top quark, Higgs and exclusive gamma-gamma

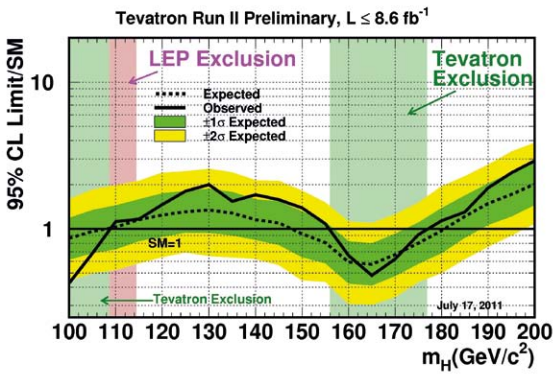
During the past three years the Helsinki group has systematically built up its presence in the CDF physics analysis activities. In 2011, the group is a leading group in the analysis of the 'all hadronic' decays of the top quark, and has introduced novel methods of background analyses for the Higgs searches in the WH and WBF channels. The group has been actively developing artificial intelligence based multivariate analysis techniques for event classification and for searches of novel physics phenomena.

In 2011, the very rare process of two gluons colliding and producing a pair of energetic gamma rays via a quark loop has been observed for the first time at Tevatron (PhD thesis by Erik Brücken). The photon pair is produced via strongly interacting double pomeron exchange without any other particles in the final state (see the figures above showing the Feynman diagram and the measured invariant mass distribution). This observation opens a new window on the Higgs boson search at the LHC. Even though difficult to predict, the Higgs boson should be produced by the same quark-loop process (if it exists). By tagging the forward outgoing protons, the Higgs boson properties can be uniquely measured, as no other particles are produced.

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

The CDF team of the Helsinki group (members & advisors) in 2011 are: Timo Aaltonen (PhD student), Erik Brücken (PhD





The CDF measured mass limits of the SM Higgs boson.

student), Francesco Devoto (PhD student), Valery Khoze (advisor), Petteri Mehtälä (PhD student), Risto Orava (professor, Helsinki group leader). Eric Malmi, Mikael Kuusela, Mikael Mieskolainen and Tommi Vatanen are participating in specific analyses and doing work for their MSc (Eng.) studies.

TOTEM experiment

TOTEM achieved several important milestones in 2011. With the installation of the T1 telescope during the LHC winter shutdown of 2010-11 and commissioning of the special $\beta^* = 90$ m optics from the LHC machine side in summer 2011, TOTEM is now able to pursue its full standalone physics programme. The availability of the $\beta^* = 90$ m optics opened up the possibility for TOTEM to collect data in dedicated special optics runs in 2011 allowing for a first total cross section measurement. In 2011, TOTEM also published its first two physics measurements: the differential elastic proton-proton scattering cross section for the $0.36 \leq |t| \leq 2.5$ GeV^2 range based on data taken in 2010 with standard LHC optics and the total proton-proton cross section based on data taken in a short $\beta^* = 90$ m run in June 2011. Finally in the December 2011 heavy ion run, the TOTEM and CMS experiments proved the capability of common data taking by collecting data synchronously in their own data streams. This allows off-line combination of the data of the two experiments and thus opens up vast opportunities related to minimum bias physics (in special low-luminosity runs) as well as large p_T physics (in medium- and high-luminosity runs).

TOTEM T2. The 40 Gas Electron Multiplier (GEM) detectors of T2 were assembled between 2007 and 2009 in the Kumpula Detector Laboratory. The GEMs were first tested in the Laboratory by using radioactive sources, and then beam tests were carried out at CERN in autumn 2007. The final VFAT-based readout electronics was not, however, available and tests had to be based on so-called APV readout electronics developed for the

One half of the T2 spectrometer installed in its final location + 14 meters from the CMS interaction point (IP5) in the LHC tunnel.

CMS experiment. The new VFAT electronics was completed in summer 2008, and only a limited quantity of VFAT hybrids has been delivered to the group. Major additional work had to be done in adjusting the detectors with the new electronics and in special demands placed on the shielding and HV distribution of the T2 detectors. Most of the refitting and testing had to be carried out at CERN. Since commissioning of the T2 spectrometer in 2009 (see the picture above), large volumes of data has been collected and they are currently being used for understanding the detector and its signal processing electronics.

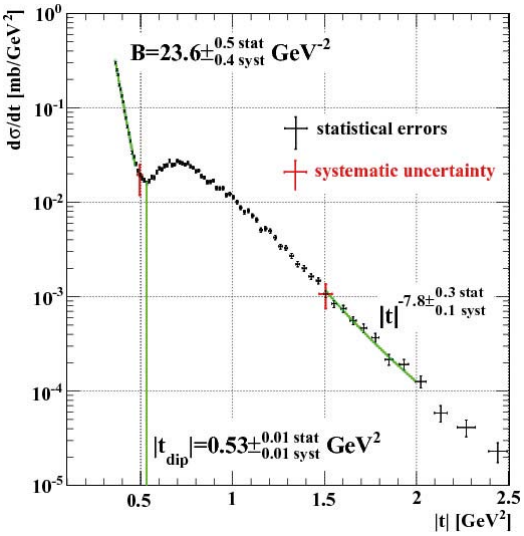
With the T2 spectrometer detectors of TOTEM as its hardware responsibility, the Helsinki group continued to concentrate on data collection and analysis of the T2 spectrometer in 2011. The performance of the spectrometer was optimised during this period up till the end of heavy ions beams in November 2011. An electrical trigger for the RP was developed to provide the TOTEM leading proton trigger to CMS. A sample of T2 events has now been associated with the CASTOR calorimeter recordings.

Some electronics components and the cooling and low voltage power connections were repaired during the winter shutdown in

December 2011 - January 2012 (see the picture below). The Helsinki group was also active in studies towards a possible T2 upgrade for higher luminosity runs. Electronics optimisation, measurement gas, HV supply and detector internal structure changes were considered.

In 2011, the Helsinki group participated in the data taking for the T2 telescope as well as in the replacement of faulty GEMs and installation of additional protection circuits for the HV lines during the LHC winter shutdown of 2010-11. In addition, the VFAT data taking settings were considerably improved enabling a lower HV to be used with an improved noise performance for the whole T2 telescope. All of these improvements meant that data with significantly better quality could be taken with the T2 telescope during special runs in 2011. The first physics result based on T2, the forward charged particle pseudorapidity density is being prepared for publication in the first half of 2012 and several other physics analyses using T2 are ongoing. During 2011, the group also 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 Analysis. The focus of the TOTEM physics analysis during the first half of 2011 was on elastic scattering in the |t|-range between 0.36 and 2.5 GeV^2 using data taken in 2010 at $\sqrt{s}$ = 7 TeV with the RP detectors approaching the beam as close as 7 times the transverse beam width. The elastic event topology was selected by requiring protons in the vertical RPs at 220 m on both sides of the IP in a diagonal configuration. In addition the reconstructed protons were required to be collinear and have a momentum consistent with the beam protons. Our group focused on studying the trigger efficiency and the reconstruction inefficiency for elastic events as well as making a significant contribution to the writing of this first TOTEM publication.



The differential elastic proton-proton cross section measured by TOTEM at $\sqrt{s}$ = 7 TeV. The superimposed fits and their parameters are described in the text.

The differential cross section dσ/dt in the range 0.36 < |t| < 0.47 GeV^2, see the figure above, can be described by an exponential with a slope parameter B, followed by a significant diffractive minimum at $|t_{dip}|$. For |t|-values larger than ~ 1.5 GeV^2, the cross section exhibits

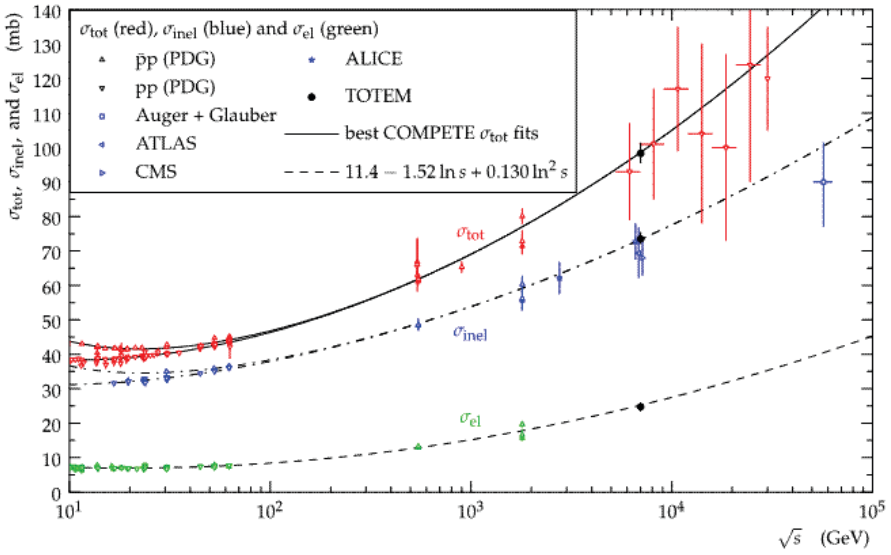
T2 HV connections being assembled in the CMS cavern (IP5).

a power law behaviour. This peculiar structure of dσ/dt, first observed in proton-proton scattering at ISR almost 40 years ago, has now been confirmed at LHC at 100 times the energy. The √s-dependence of the dσ/dt structure exhibits an increase of the slope B and a decrease of the |t|-value of $|t_{dip}|$, which can be interpreted as an increase of the effective proton radius with increasing √s.

In June 2011, TOTEM was able to take data for the first time for half-an-hour with the special β* = 90 m optics in very clean conditions with the RP approaching the beam to 10 times the transverse beam width. This allowed the reconstruction of elastic scattering events in the range 0.02 < |t| < 0.45 GeV^2. The analysis was analogous to the one above but with significantly smaller corrections and higher efficiencies. Our group contributed to the same items as in the previous analysis and publication.

Now the differential elastic proton-proton cross section can be described by a single exponential with a slope parameter B = (20.1 ± 0.5) GeV^{-2}. After extrapolation of the differential cross section to |t| = 0, a total elastic proton-proton scattering cross section of (24.8 ± 1.4) mb is obtained through integration. Applying the optical theorem, a total proton-proton cross section of (98.3 ± 3.0) mb is obtained which is in good agreement with the expectation from the overall fit of previously measured data over a large range of energies, see the figure below, as well as consistent with the interpretation that the effective size of the proton increases with increasing √s. An inelastic proton-proton cross section of (73.5 + 2.4 - 1.9) mb is deduced when removing the elastic contribution from the total cross section measurement. In the figure, the values of the TOTEM total, inelastic, and elastic cross sections are compared with results from lower energies and cosmic ray experiments together with an overall fit of the total proton-(anti)proton cross section by the COMPETE Collaboration (full line in the figure). To guide the eye, a parabolic fit is shown for the energy dependence of the elastic cross section (dashed line in the figure).

The TOTEM measurement of the total, elastic, and inelastic proton-proton cross section at √s = 7 TeV compared to other measurements of the same quantities in proton-(anti)proton collisions at lower energies as well as measurements deduced from cosmic ray experiments. The superimposed fits are described in the text.



In October 2011, TOTEM had a 10-hour data taking session with the special β* = 90 m optics at √s = 7 TeV with the RPs approaching the beam as close as 4.8 to 6.5 times the transverse beam width. This data is being used by our group to determine the inelastic cross section and to measure the differential single diffractive cross section dσ/dt. The inelastic rate is measured using the T1 and T2 detectors as event counters correcting for trigger, reconstruction and acceptance inefficiencies. The first direct inelastic cross section measurement is expected to be presented and combined with an elastic rate measurement for a first luminosity-independent total cross section measurement in spring 2012. The single diffractive events are selected by requiring a single proton on one side (with all other RPs empty) and charged particles reconstructed in the T1 and/or T2 telescopes in a configuration compatible with the measured momentum of the proton if we assume that single diffraction takes place. Preliminary results of the analysis shown at the December LHC committee meeting indicate a diffractive dσ/dt described by a single exponential with a slope parameter B of about 10 GeV^{-2}.

During 2011, one MSc thesis (J. Welti) was completed within the TOTEM physics analysis work of our group. The thesis concerned the classification of inelastic events to non-diffractive, single and double diffractive events using the information from the T1 and T2 telescopes for measurements of the individual pro-

cess cross sections as well as the measurement of the inelastic rate for the total cross section measurement using the luminosity-independent method. Especially ways to estimate the fraction of events with all final state particles beyond the T2 η-acceptance was discussed in the thesis.

To reach the physics goals discussed above, TOTEM could be integrated in the trigger and data recording systems of the CMS experiment and in case of the signatures depending on the central CMS detectors (e.g., the CED Higgs process), a common plan of utilisation of the two experimental set-ups will be prepared.

The TOTEM team of the Helsinki group (members & advisors) in 2011 are: Erik Brücken (PhD student), Francisco Garcia (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), Jan Welti (PhD 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.

Linear Collider Research Project

The focus of the Linear Collider project was on participation in the Compact LInear Collider (CLIC) study. The aim of the study is to develop the CLIC technology as well as demonstrate its feasibility for a multi-TeV electron positron collider in view of a decision on the future direction of the high energy frontier in the coming years. HIP contributed to the CLIC study on different issues regarding the R&D for its module and its RF structures, in particular, the study of the thermo-mechanical behaviour of the CLIC module, the development of dynamic vacuum measurement techniques for RF structures as well as significant contributions to the cost study, manufacturing and precise assembly for the RF structures. The R&D was done in close collaboration with the CERN CLIC group, notably Drs W. Wuensch and G. Riddone, and several Finnish industrial and academic partners, notably the Technical Research Centre of Finland (VTT). The project employed three CERN-based researchers in 2011: J. Turunen, R. Raatikainen and J. Väinölä, and in addition, T. Niinikoski as project consultant. Two MSc (Eng.) theses were completed in 2011 within the project.

The RF structure manufacturing and precise assembly work involved five Finnish industrial partners through the HIP coordinated and EU funded "MeChanICs"-project. Within this framework, one engineer from Lewel Group Finland worked at CERN for 12 months on the mechanical design of RF structures for the CLIC module to be tested in the CLIC Test Facility 3 (CTF3) in 2013 and one researcher from CERN at Metso Materials Technology for two months in 2011 on alternative methods for RF structure assembly and component manufacturing. The aim of the MeChanICs-project is to enhance the industrialisation of the CLIC RF structure manufacturing through the secondment of researchers between CERN and industry. Tests of the high precision machining of disks for the CLIC accelerating structures were made at North Karelia University of Applied Science (NKUAS) in conjunction to the MeChanICs-project.

A critical issue for the CLIC overall cost is the optimisation of the manufacturing costs for the RF structures, especially the machining of their components, since they constitute a significant fraction of the overall cost of CLIC. HIP was involved in a cost-study with several

Kenneth Österberg, Linear Collider Research project leader

European high precision manufacturing firms and research institutes on the mass production of the RF structures to provide a reliable cost estimate. This estimate is included in the Conceptual Design Report (CDR) that will be published in early 2012. In addition, a study was made to estimate possible cost-reduction achieved if the machining tolerances regarding the shape precision and surface roughness were relaxed. The results are documented in an MSc (Eng.) thesis.

The CLIC module with all the accelerator components and services integrated has to maintain a high precision also during CLIC operation. To achieve this, different configurations of the whole CLIC module, among these the standard CLIC module described in the CDR, have been modelled in detail to estimate their stability with various loading conditions. Several changes have been made during 2011 to the model to improve its predictability and reliability. The model results have been reported at IPAC'11 and documented in an MSc (Eng.) thesis. The results of the model will be validated first in full-scale test modules in the lab (without beam and vacuum) in 2012. This work has partially been funded by "EuCARD", a European wide EU network on accelerator R&D. In addition, the stress and creep of the RF structure assembly during the assembly process and CLIC operation has been studied.

Eija Tuominen, Detector Laboratory coordinator

The collaboration with the Electronics Laboratory of Helsinki University's Department of Physics continued with the aim to develop methods to dynamically measure the outgasing from the RF structure surfaces during a single RF pulse train. Recent simulations predict such a high outgasing that maintaining a sufficient vacuum during CLIC bunch trains might become a feasibility issue. Therefore direct measurements of the vacuum at 10 ns time scales in real CLIC RF structures are required to test these predictions. In 2011, a set-up has been built at the Accelerator Laboratory in Kumpula to test different laser-based vacuum measurement techniques sensitive to these time scales. In the set-up, different quantities of copper vapour can be created inside a "RF structure-like" object to mimic the outgasing during CLIC operation.

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 that significantly increase the field locally. We collaborate closely with Prof. K. Nordlund and F. Djurabekova, PhD, who have developed a multi-scale model for the physics processes leading to a breakdown. The multi-scale model should be able to guide us to appropriate choices for the material, for surface preparation and for the design for the accelerating structures, in view of reducing the breakdown probability.

Detector Laboratory

The Helsinki Detector Laboratory is a nationally significant and unique resource supporting Finnish experimental particle physics. It is a joint laboratory of the **Helsinki Institute of Physics (HIP) and the Department of Physics at the University of Helsinki (UH)**. The Laboratory provides premises, equipment and extensive know-how for research projects related to international particle and nuclear physics experiments. The researchers of the Laboratory have an internationally praised reputation for their expertise in SSD (silicon strip detectors) and in GEM (Gaseous Electron Multiplier) detectors.

The premises and the equipment of the Laboratory are well suited for small-scale microstructure fabrication, assembly and testing. During 2011, the Laboratory **infrastructure** was significantly improved. The Laboratory obtained a new clean room air-dryer system, financed by the UH Department of Physics. In addition, the Laboratory was able to purchase new, fast testing devices, thanks to UH general infrastructure funds granted to the Laboratory.

Radiation hard silicon detector technologies are being developed in the **HIP CMS Upgrade project** for the future upgrade of CERN ex-

periments. The project group has access to the detector processing system at Aalto Micronova. In 2011, two new high-performance detector characterization set-ups were constructed in the Laboratory: the Transient Current Technique (TCT) set-up and the Capacitance/Current-Voltage (CV-IV) set-up. In addition, data analysis from detector beam tests performed at CERN and Fermilab took place in the Laboratory. Furthermore, the Finnish Cosmic Muon Rack (FinnCRack), a telescope containing the same functionality as the CMS silicon Tracker, was used for educational purposes.

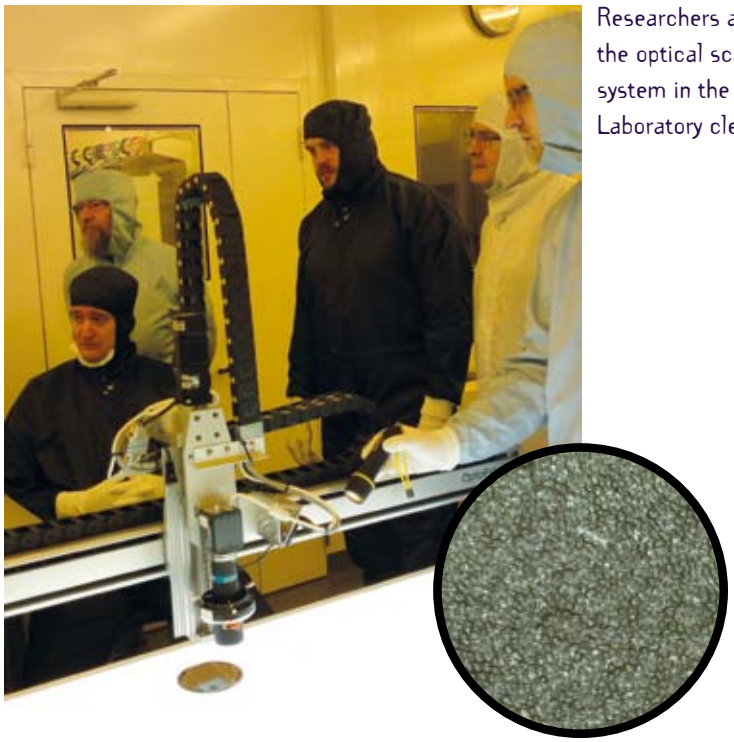
The aim of the **HIP FAIR project** is to simulate, design, prototype, test, manufacture and commission 32+spares GEM-TPC detectors for the FAIR Super-FRS beam diagnostics. FAIR is planned to be launched in 2018. In 2011, the second TPC-GEM prototype was constructed in close collaboration with Comenius University in Bratislava and GSI/FAIR. In addition, the **Optical Scanning System** for the quality control of GEM detectors was commissioned in the Detector Laboratory clean room. The system has an area of one square metre and a resolution of 7 micrometres.

The **HIP TOTEM Operation project** has constructed 40 GEM detectors for the CERN **TOTEM T2** test station. In 2011, the group participated in T2 detector maintenance and data taking. In addition, further spare GEM detectors were assembled.

Researchers from the **UH Electronics Research Laboratory (ERL)** develop an electrical sail (E-Sail) for applications in space physics in collaboration with the Finnish Meteorological Institute in the EU FP7 framework. In 2011, the group has applied wire-to-wire bonding to make 100 metres of tether structure. The final objective is to produce 1 km of tether structure. Researchers from the **UH Division of Elementary Particle Physics** collaborate with research and industry partners in order to study materials and deposition methods for thermal neutron conversion layers. In 2011, the group built a movable station for measuring the neutron induced secondary radiation, e.g., alpha particles or electrons, produced in the conversion layers.

Other activities in the Detector Laboratory include the **Joint-GEM** work package for the EU FP7 Hadron Physics 2 Collaboration. The purpose of the project is to develop ultra-light and ultra-large tracking systems based on GEM technology. The Laboratory is also participating in the **CERN RD51** Collaboration for the development of micro-pattern gas detector technologies. As a member of the RD51 Collaboration, the scientists of the Laboratory have worked together with the international gas detector community and benefit from the extensive expertise and infrastructure of CERN and other participating institutes.

Due to the versatile infrastructure of the Detector Laboratory and the wide know-how of its personnel, the Laboratory participates actively in **teaching and societal interaction**. In 2011, the Laboratory offered laboratory exercises and special assignments concerning detector technologies for physics students. In addition, several students performed their doctoral and graduate studies in the Laboratory. Furthermore, several groups of high school students and teachers visited the Laboratory every month for demonstrations about detector technologies. A group of ten high school students also participated in Master Class activities.



Researchers and the optical scanning system in the Detector Laboratory clean room.

Stomata of Epipremnum Aureum in a picture taken by the optical scanning system.

Students participating in a course on measurement technology in the Detector Laboratory clean room.

Education

In close connection with its research activities, the Helsinki group continued to carry out educational programmes both at the undergraduate and graduate level. Within the past four years, five PhD's and six 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 continuing at CERN. Since the beginning of 1990, the Helsinki group has produced 26 PhD's, 45 MSc's and trained numerous physics and technical students in its experimental high energy physics projects at CERN and Fermilab. By the end of 2012, 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 perform their doctoral and graduate studies in the Laboratory. The Laboratory also actively participates in interactions with society: in 2011 several groups of high school students and teachers visited the Laboratory.

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

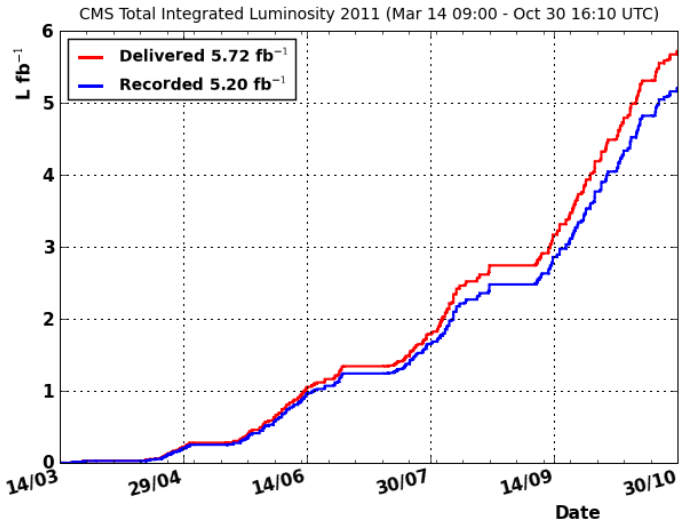
The Compact Muon Solenoid (CMS) experiment is one of the two large multi-purpose experiments at the LHC. During 2011, the LHC provided a record amount of proton-proton collisions at 7 TeV centre-of-mass energy, as well as heavy-ion collisions during a special run period. The CMS experiment operated stably and with a high efficiency during the whole year. Highlights during the year included new results on the Higgs boson, Supersymmetry and rare B decays.

Paula Eerola,
CMS Programme director

Introduction

For the CMS, the year 2011 was the second successful full year of data taking. The LHC provided proton-proton collisions at 7 TeV centre-of-mass energy, as well as heavy-ion collisions during a special run period. The LHC performed well over expectations during the year. The target set for the collected integrated proton-proton luminosity in 2011, 1 fb^{-1}, was reached already in June, and by the end of the proton-proton run, at the end of October, the LHC had delivered a total integrated luminosity of 5.7 fb^{-1} of pp collisions. The record peak instantaneous luminosity was 3.6×10^{33} $cm^{-2}s^{-1}$, operated with 1380 bunches per beam colliding with 50 ns separation.

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. During 2011, researchers in the Finnish CMS teams made strong contributions in particular in Higgs boson searches. The light charged MSSM Higgs bosons were searched for in the $t \to bH^{\pm}$, $H^{\pm} \to \tau\nu$ process in the fully hadronic final state from the data collected during the first half of 2011. The results were combined with those from the semi-leptonic final states. A new world-best upper limit of 4-5%, about three times better than the limit from Tevatron experiments, was obtained for the $t \to bH^{\pm}$ branching fraction in the charged Higgs boson mass range from 80 to 160 GeV/c^2.



CMS total integrated luminosity collected in 2011.

Finnish CMS teams also made many contributions to the operations of CMS. K. Lassila-Perini continued co-ordinating the user support in CMS, and 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. The Lappeenranta group contributed to the RPC hardware maintenance.

The HIP Tier-2 computing cluster has been an integral part of the CMS world-wide computing and storage network. CMS analysis jobs were executed at the HIP Tier-2 cluster through an ARC User Interface developed by the Nordic Data Grid Facility Collaboration and HIP.

The HIP CMS Upgrade group performed two test beam campaigns in 2011. The test

Katri Lassila-Perini, CMS Experiment project leader

The CMS Experiment Project

Introduction

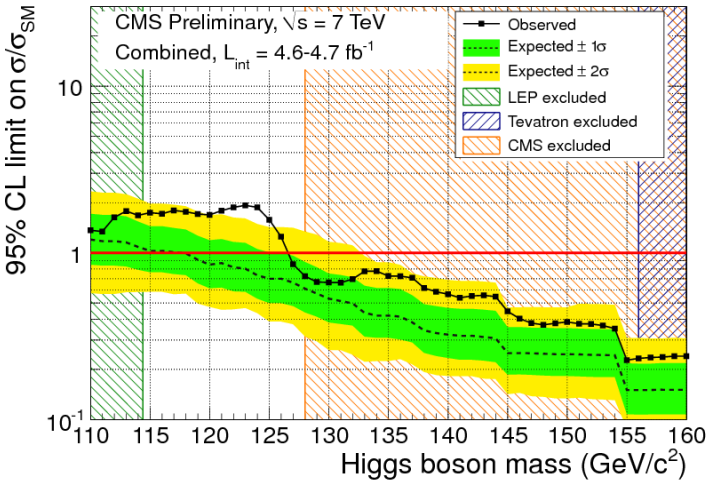
The year 2011 has been a rewarding year in terms of performance of the CMS experiment and the amount of data collected, which has exceeded all expectations. The HIP CMS experiment team has been busy exploiting these data and has produced excellent results which are detailed in the following.

Physics analysis

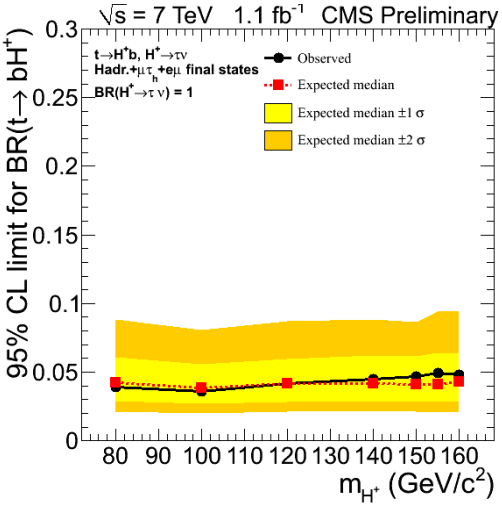
B-physics. The LHC provides extremely high rates of B-hadrons due to the high b-production cross section, favourable signal-to-background ratio, and high luminosity. In 2011, the flexibility of the CMS trigger system made it possible to adapt the triggers to the increasing luminosity by making use of selections on invariant mass, decay length, distance of closest approach, transverse momentum, and rapidity. Due to trigger constraints, the scope of the CMS heavy flavour programme is defined by final states with di- or multimuons, and b-jets. The strength of CMS is that it will collect much more integrated luminosity than the dedicated heavy flavour experiment LHCb.

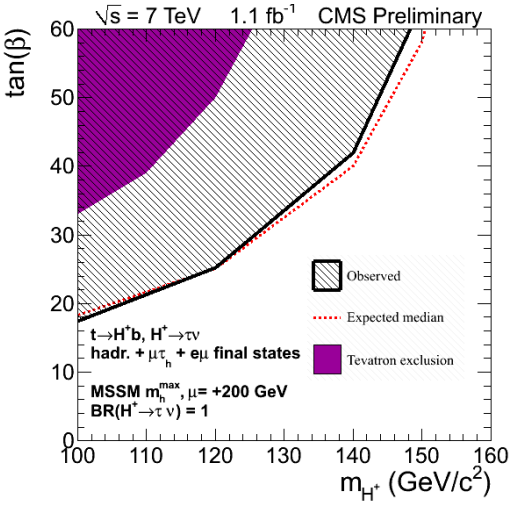
CMS has so far published cross section measurements on J/Ψ, Ψ(2S), Υ(nS), exclusive B's (B^+, B^0, B_s), b-jets, and b-pair correlations. The highlight of 2011 was a new upper limit for the branching fraction of the rare decay $B_s \rightarrow \mu^+\mu^-$ ($Br(B_s \rightarrow \mu^+\mu^-) < 1.9 \times 10^{-8}$ at 95% CL, Phys. Rev. Lett. 107 (2011) 191802), constraining the high-tanβ parameter space in models beyond the Standard Model. During 2011, the working group for exclusive B decays was co-convened by P. Eerola.

In 2011, 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 ϕ_s in the decays $B_s \rightarrow J/\Psi\phi$ is expected to be very small in the Standard Model, while effects from new physics beyond the Standard Model could easily alter the phase by adding new contributions. The first goal was to measure the differential production cross section, and to cross-check the well-known properties of the B_s meson. The



The combined 95% CL upper limits on the signal strength modifier $\mu = \sigma/\sigma_{SM}$, as a function of the SM Higgs boson mass in the range 110–160 GeV/c^2.





Left: 95% CL upper limit for BR(t → bH±), right: excluded region in the MSSM tanβ-m_{H^+} parameter space, derived from the CMS charged Higgs results.

cross section measurement was published during 2011 (Phys. Rev. D 84 (2011) 052008). The next steps will be the measurement of the width difference of the B_s eigenstates ($\Delta\Gamma_s$), which is well underway, and then the measurement of the weak phase ϕ_s. The weak phase measurement requires tagging of the B flavour. A HIP summer student, T. Järvinen, made preliminary studies of B flavour tagging by using B^+ mesons reconstructed from data, and comparing the results to simulations. An MSc student, A.-M. Visuri, has also been working with tagging development.

Higgs boson physics. The main project of the HIP Higgs analysis group has been the search for the light charged Higgs bosons in the $t \to bH^\pm$, $H^\pm \to \tau\nu$ process from the data collected during the first half of 2011. Other commitments of the group have been the τ trigger measurement, work with the event generation, and participation in the LHC Higgs cross section working group.

During 2011 the CMS Collaboration has intensively searched for Higgs bosons in proton-proton collisions, which also received extensive media coverage. The HIP Higgs group has been responsible for the search of light ($m_{H^\pm} < m_{top}$) charged Higgs bosons from top quark decays in the $t \to bH^\pm$, $H^\pm \to \tau\nu$ process in the fully hadronic final state. The first results, made public in July, were based on an integrated luminosity of 1.1 fb^{-1}. The second version of the analysis, improved in several aspects, will be based on data corresponding to an integrated luminosity of 2.2 fb^{-1}. These results will become public in spring 2012.

The number of observed events was found to be compatible with the expected Standard Model background. The model-independent observed upper limit for the $t \to bH^\pm$ branching fraction was found to be 9-19% in the charged Higgs boson mass range from 80 to 160 GeV/c^2. When combined with the results from the final states containing one isolated lepton and a τ jet an observed upper limit of 4-5% was obtained for the same mass range. This is currently the world-best upper limit for the charged Higgs boson in this mass range. The result has important implications for models beyond the Standard Model. In the Minimal Supersymmetric Standard Model (MSSM), a significant fraction of the parameter space for $\tan\beta > 20$ was excluded.

The participation of the HIP Higgs analysis group in the LHC Higgs Cross Sections Working Group continued in 2011. The contribution from the Higgs analysis group was a comparison of programs calculating the top quark and charged Higgs boson decay widths. The main part of the work was done by a HIP summer student, M. Hauru, under the supervision of the Higgs analysis group. The work resulted in a publication as a CERN yellow report, which is an excellent achievement for a summer student.

Jet Energy Corrections

The CMS Jet Energy Corrections (JEC) group was co-led in 2011 by M. Voutilainen, who will also continue leading the group in 2012. The CMS JEC group has a mandate to provide the collaboration with corrections for measured jet energy and p_T, including detailed estimates on correction uncertainties as well as recommendations on best practices to use in analysing jets. The JEC are a vital input to the whole collaboration, as most final states in proton-proton collisions produce jets, both for signal and for background.

The output of the JEC group has been of high quality throughout 2011. The final calibration results for the 2010 data were published in the Journal of Instrumentation in July ("Determination of Jet Energy Calibration and Transverse Momentum Resolution in CMS", JINST 6 (2011) 11002). These corrections reached a level of uncertainty fully competitive with the mature Tevatron experiments, and up to a factor of two ahead of ATLAS 2010. The results were submitted to the European Physical Journal C in December 2011. The group monitored the JEC for the 2011 data throughout the year, and provided calibration constants for the full 4.7 fb^{-1} data set with uncertainties and uncertainty correlations in December 2011/January 2012, soon after the end of the 2011 proton-proton running. These uncertainties were further reduced compared to the 2010 results in regions not limited by residual JEC time-dependence before the full 2011 data reprocessing, boding well for the group in 2012.

In 2011, the main contribution from HIP was in co-ordinating the JEC subprojects to produce consistent results, and in evaluating the systematic uncertainties and their correlations. Another major contribution was in validating the corrections with a complementary jet composition analysis and testing them in practice with the inclusive jet cross section analysis. HIP had a summer student, J. Pekkanen, working on the jet composition analysis, and he will continue the project in 2012 for his Master's Thesis.

As a spin-off of co-operation between the JEC and the missing-E_T (MET) groups at CMS, the HIP group (M. Voutilainen and MSc student A.-M. Visuri) developed a new "type-0" algorithm for improving the MET resolution in the presence of pile-up, based on correcting MET with information from cleanly identified charged hadrons from pile-up. This is now being integrated in the official software by the MET group.

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 2011, the "Offline Workbook", containing essential instructions and basic and advanced tutorials, underwent a regular review of its main parts. 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 further improved and the user interface now allows for quick and easy access to the class descriptions despite the large number of software packages included.

The training programme on CMS software analysis tools has continued in 2011. The flagship project is the intensive training on "Using Physics Analysis Toolkit (PAT) in your analysis". The course was organised on three occasions in 2011, bringing the number of CMS physicists trained to the efficient use of the common analysis tools up to more than 250. The last course in December benefitted from a major restructuring of the courseware. All the materials are available to the full CMS Collaboration and they can be used by any newcomer to get acquainted with the CMS software framework and to learn the details of the common tools.

Tracker alignment

One of the most demanding calibration activities for the CMS Tracker is the geometrical

alignment of its 15 148 modules with respect to each other. These activities started successfully in 2010 with high energy pp collisions, and continued in 2011 by refining the alignment constants further. Increasing attention was paid to time-dependent effects and systematic distortions of the Tracker. Some 100 000 alignment parameters were computed at regular time intervals by analysing computed particle trajectories in order to optimise the reconstruction precision. The detector alignment is a highly important issue in view of physics discoveries. In 2011 the HIP team continued its long-term participation in the alignment activities of the CMS Tracker, focusing on the software development of the H.I.P. alignment algorithm.

The effect of non-planarity ("bow") of the silicon sensors was studied by simulation. Points of interest in the study were i) the precision of the bow-parameters as a function of the number of tracks used for fitting, ii) a model independent study of the non-planarity, and iii) the importance of the bow correction for the hit resolution. The results of the study were presented (V. Karimäki) in the CMS Alignment Workshop in May 30-31, 2011 at DESY.

Geant4 development

The Geant4 development effort was focused on integrating a completely new native C++ implementation of the Liège intra-nuclear cascade model into the Geant4 simulation toolkit in collaboration with a group at the Commissariat à l'Énergie Atomique (CEA), Saclay. The new implementation, INCL++, is based on the new public version of the Liège intra-nuclear cascade model called INCL4.5 that was used in the IAEA spallation model benchmark. In addition to the model itself a new physics list, QGSP_INCLXX, was added to the Geant4 toolkit. The new physics list allows Geant4 users to start using the INCL++ model easily. The new INCL++ model and the QGSP_INCLXX physics list were included in the Geant4 9.5 official release in December 2011.

The CMS Tier-2 Operations Project

Tomas Lindén, Tier-2 Operations project leader

Grid computing activities

In 2011, the CMS data analysis and production of simulated reference data were running on the Finnish CMS Tier-2 resources. The CMS Programme project CMS Tier-2 Operations was responsible for the Finnish Tier-2 resources. The project was represented in the Nordic Data Grid Facility (NDGF) CERN committee. The close collaboration between HIP, CSC (IT Center for Science Ltd) and NDGF resulted in improvements of many aspects of the CMS computing performance that are summarised in the following.

Hardware. The main CPU resource for CMS and ALICE was the 768 core Linux cluster Jade, situated at the CSC premises. In addition to that, the 400 core Linux cluster Korundi in Kumpula was also used for CMS Grid jobs. The 10 Gb/s Optical Private Network (OPN) link between CSC and Kumpula allowed for an effective use of Korundi. The Finnish Grid Infrastructure (FGI) received funding from the Academy of Finland, which allowed the purchasing of a new 840 core Linux cluster Alcyone. Alcyone uses scaleout nodes and has also graphics cards for GPU-calculations. Alcyone uses InfiniBand as the interconnect, and a CSC-developed Scientific Linux 6 -based installation system instead of Rocks. The old 260 core Linux cluster Ametisti acquired in 2004 was taken out of service in Kumpula and replaced by Alcyone.

Software. The hardware of the dCache system at CSC was reliable in 2011, but at high load the performance dropped significantly for some types of CMS software jobs limiting the CPU efficiency. The performance drop during high load limited the site utilisation. HP DL360G7 servers and HP D2600 disk shelves for a total of 552 TB raw disk space were ordered to upgrade the dCache system and to increase the performance, to match the

available CPU resources, and to keep the CPU resource utilisation high. Production of simulated data could be increased at the Finnish Tier-2 after ARC-gLite BDII fixes, allowing for a uniform job submission procedure for the submission team. Work on the test and development of the CRAB server continued and an ARC plug-in for WMAgent was implemented.

Several aspects of the dCache disk system were investigated to improve the overall efficiency of the Finnish Tier-2 resources. The ZFS filesystem on dCache was configured with a blocksize of 16 kB instead of 128 kB, and this improved the performance significantly. The monitoring of dCache was improved, which allowed for earlier detection of problems, thus resulting in increased CPU efficiency. CMS software I/O optimisation decreased the load on storage hardware, and improved the CPU efficiency as well. One of the Sun X4540 servers was taken into dCache usage, with the disks in a software RAID 5 configuration. This single Sun X4540 server was performing much better than the Hitachi AMS 1000 and AMS 2500 connected dCache pool servers. 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 CMS usage.

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 availability of the Finnish Tier-2 was very high, being at the top of the CMS Tier-2 Readiness ranking list on several occasions in 2011. There were 196 thousand CMS JobRobot jobs run at HIP with a mean success rate of 97.9% (93% in 2010). 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 several Compute Elements for redundancy. Also the joint monitoring by CSC, HIP and NDGF as well as the CMS and WLCG Site Availability Monitoring jobs helps to spot problems early.

The CMS Frontier calibration service was run on silo3 in Kumpula and the CMS PhEDEx file transfer service was moved to a new dedicated server. PhEDEx transferred 113 TB of production data (282 TB in 2010) and 271 TB of test data (284 TB in 2010) to HIP. In 2010, parts of the data were reconstructed many times. This happened less frequently in 2011, which explains the smaller amount of transferred data in 2011 compared to the previous year. 63 TB of production data (85 TB in 2010) and 175 TB of test data (195 TB in 2010) were shipped from HIP to elsewhere. In total 621 TB of data were transferred (845 TB in 2010). The CMS disk area became practically full during 2011 soon after adding the Sun X4540 dCache pool server, and some transfer requests had to be denied due to lack of disk space.

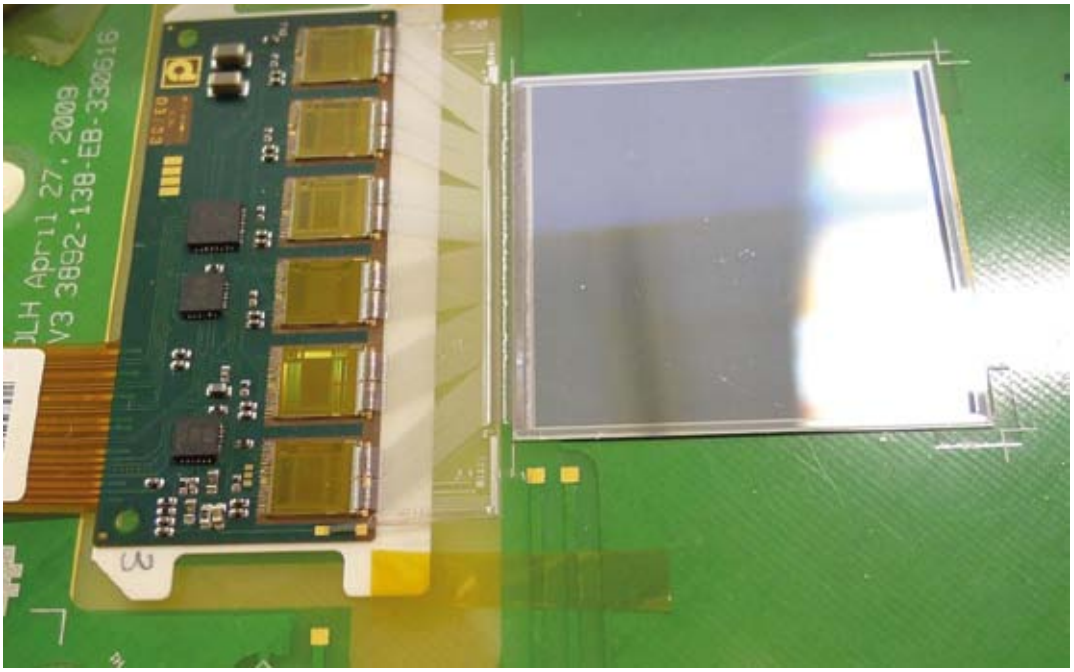
A total of 997 thousand CMS Grid jobs (567 thousand in 2010) using 12.1 million HEPSPEC06 CPU hours (3.8 million HEPSPEC06 CPU hours in 2010) were executed. In addition to this, a significant amount of local batch jobs were also run.

Jaakko Härkönen, CMS Upgrade project leader

The CMS Upgrade Project

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

During 2011, 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 world-wide in this field and provides access to a wide selection of characterization and simulation tools. Furthermore, CERN experiments, including CMS, carry out more specific R&D programmes targeting different technologies foreseen for implementation during future upgrades. In addition, the collaboration with the Accelerator Laboratory of the University of Helsinki (UH) continued. In 2011, P. Luukka, nominated in 2009, continued as the CMS Tracker upgrade test beam



An experimental Magnetic Czochralski silicon (MCz-Si) strip sensor connected to a CMS APV readout board through a pitch adapter. The silicon sensor and pitch adapter have been processed at the Micronova centre of Aalto University. The sensor properties were measured during the 2011 test beam campaigns in FNAL and CERN.

co-ordinator. J. Härkönen, nominated in 2003, continued as RD39 spokesperson.

The main activity of the CMS Upgrade project is participation in the CMS hardware upgrades, which are sequentially named Phase I and Phase II. We are active partners in the CMS silicon sensor R&D programme related to the Phase II upgrade of the CMS Tracker. The main responsibility of the group is 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) systems. We performed two test beam campaigns in 2011, the first at Fermi National Laboratory (FNAL) and the second at the CERN H2 area. More than 30 experimental silicon detector modules produced by CMS and the Hamamatsu corporation were measured during these test periods. The analysis of the SiBT data was the responsibility of the CMS Upgrade project.

In 2011, the RD39 Collaboration started a project aiming at developing Beam Loss Monitor (BLM) detectors for the LHC accelerator. The loss of even a very small fraction of the LHC beam may induce a quench in the superconducting magnets or cause physical damage to accelerator components. The BLM detectors for the future High Luminosity LHC (HL-LHC) need to be placed inside the liquid helium cryostats and, furthermore, they must be very radiation hard. The RD39 benefited from the Transient Current Technique (TCT) expertise of the HIP group during the two test beam experiments in 2011.

Phase I Pixel Upgrade

Our new activity is to contribute to the Phase I upgrade by producing new CMS pixel barrel modules together with the VTT micropackaging group at the Micronova centre. The pixel modules are complex items, with 16 readout chips (ROC) to be flip-chip (FC) bonded to each pixel sensor, and therefore, quality assurance (QA) plays an important role in pixel module production. In order to ensure sufficiently high overall FC process yield, one has to characterize the sensor and the ROCs prior to the FC bonding, and after the FC bonding the modules have to be tested. The implementation of automated measurement and characterization set-ups started in 2011.

The Phase I upgrade includes the implementation of a newly designed pixel sensor ROC. This leads to the need for test beam experiments. The CMS Tracker integration facility at CERN is planning to construct a new pixel beam telescope (PBT). The PBT project is closely related to FC bonding at VTT and module testing at the Kumpula Detector Laboratory. Participation in the pixel test beam campaigns gives the HIP group a possibility to measure novel pixel sensors processed at the Micronova centre.

Service work and shifts

The whole HIP-CMS Programme, including people from the CMS Experiment, CMS Upgrade and CMS Tier-2 Operations projects, participated in the CMS operations through so-called service work and shifts, as required by the CMS Collaboration.

During 2011, members of the group participated in the Trigger Offline, Tracker and Data Control System shifts. V. Azzolini maintained her involvement in the Data Quality Monitoring, acting as the data certification manager, off-line field manager and on-call duty person. HIP also contributed to the High Level Trigger software performance testing. A common set of timing and IgProf benchmarks were run for almost every CMS software development pre-release. The Intel Performance Tuning Utility was occasionally used to obtain more detailed and precise analysis of the software by utilising the CPU performance monitoring events.

Outreach

Experimental particle physics and the status of CERN and the LHC were presented in the Alumni evening of the Faculty of Science of the University of Helsinki on the 17th of March. Posters, a live CMS event display, videos and detector modules were exhibited with scientists answering questions and handing out brochures. A science bazaar for the students who had been newly admitted to the Faculty of Science was organised on the 16th of June together with the Department of Physics in a similar way. Members of the HIP team also approached the general public by giving popular talks, giving interviews and maintaining a blog describing the status of the LHC and recent news from CMS. The team members also joined a panel discussion on the OPERA neutrino results at the bookstore Arkadia on the 15th of October.

The Kumpula Detector Laboratory supervised students' laboratory projects and hosted school and other visits. At CERN, the group members contributed to the visit programme for high school student groups and high school teachers from Finland. Furthermore, several HIP members have been working as guides for the groups visiting CERN.

Nuclear Matter Programme

Juha Äystö, Nuclear Matter Programme director

The Nuclear Matter Programme involves the 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 continued in 2011 with 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 for constructing the FAIR facility is being explored in collaboration with TEKES and Finpro. Several important highlights have been seen in 2011. A very successful exploitation of a full year of running collisions with record luminosities both for protons and heavy ions by the ALICE experiment was a truly remarkable achievement. The active participation in physics runs at REX-ISOLDE, contributing to HIE-ISOLDE experiment planning and utilisation of the Finnish R&D in ion cooling and bunching has opened new opportunities for collinear laser spectroscopy of rare isotopes. The Finnish physics community welcomed with great pleasure the decision to start construction of the FAIR facility.

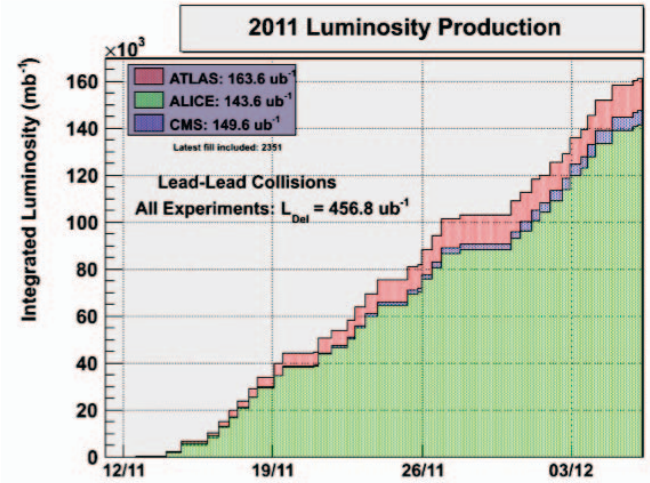
ALICE

Introduction

Jan Rak, ALICE project leader

In 2011, the ALICE experiment was routinely taking proton-proton data at $\sqrt{s}$ = 7 TeV from March to October. At the end of 2011 the second heavy-ion run took place and ALICE recorded about 150 μb^{-1} of integrated luminosity. This corresponds to about 15 times more statistics than in the first 2010 *Pb+Pb* run. This huge data sample certainly opens an exciting opportunity for studying many new physics phenomena not only due to the 15-fold statistics but also because of the enlarged acceptance of important detector components like the Electro-Magnetic Calorimeter (EMCAL), the transition-radiation detector etc. Before the 2011 run started, 6 more EMCAL super-modules were installed in addition to the 4 super-modules used in 2010. This was also a very important achievement for the Jyväskylä group because of our involvement in high-p_T photon and jet physics. Furthermore, our group is responsible for the level-0 single-photon trigger electronics which has been successfully commissioned together with the new EMCAL super-modules installation. The 2011 *Pb+Pb* run was also important because it is very likely the last heavy-ion run before the long shut-down in 2013.

The main scientific event in 2011 was the Quark Matter conference held in Annecy,



Total integrated Pb+Pb luminosity collected by three LHC experiments.

France, where the first and long awaited results from the heavy-ion run at the highest ever recorded centre-of-mass energy were presented. The highlights from this conference may be found elsewhere (http://qm2011.in2p3.fr/node/12), however, let us mention a few of them here. Probably the most exciting and surprising result was found in the high-p_T sector where the jet quenching by exited Quark Gluon Plasma (QGP) is observed. This phenomenon has for the first time been observed at the Relativistic Heavy Ion Collider (RHIC) at an c.m. energy of $\sqrt{s}$ = 0.2 TeV already back in 2000. However, the magnitude of the high-p_T jet quenching was found to be, contrary to the theoretical expectation, independent of the jet transverse momentum. At the LHC, the available jet momentum range is by a factor of 10 larger than it was at RHIC and the jet quenching was found to vanish in the high transverse momentum region not accessible at RHIC. This phenomenon is considered to be a most direct manifestation of the deconfined quark gluon plasma. Another important result presented in Annecy is related to particle emission with respect to the reaction plane defined as a plane formed by a beam axis and the vector connecting the centres of the two colliding nuclei. The LHC energy regime allows us to study these observables in unprecedented detail and these results allow us to understand not only the details of primordial nuclear matter evolution but also to constrain the string-based models using the duality conjecture between the super gravity in the anti-de Sitter space and conformal field theory. These models allow evaluating the dynamical properties of the deconfined quark gluon plasma like the sheer viscosity which can be deduced from the azimuthal anisotropy of emitted particles with respect to the reaction plane.

Many other important and surprising results from, e.g., the heavy quarkonia sector, were also reported and many more are certainly to come.

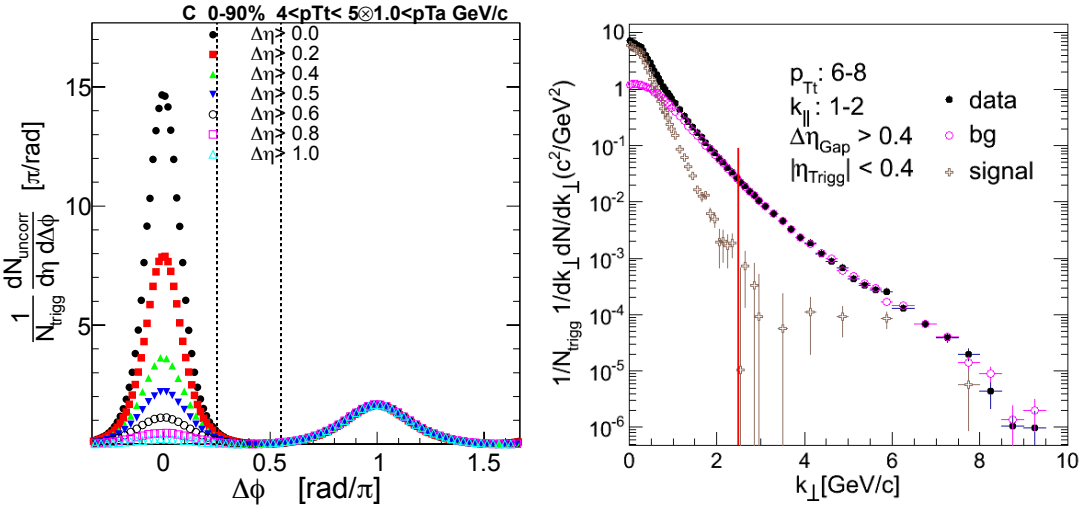
Data analysis

Our group is involved in the analysis of data taken with *p+p* beams at a c.m. energy of $\sqrt{s}$ = 0.9, 2.76 and 7 TeV and with *Pb+Pb* at $\sqrt{s}$ = 2.76 TeV. The main focus is on the high-p_T sector and the jet transverse fragmentation function. These phenomena are related to quantum coherence effects and their modification in nuclear collisions and serve as tools to study the details of parton interaction with the deconfined medium.

The main achievement in 2011 is related to the reconstruction of the transverse momentum component of the associated particle with respect to the jet axis ($k_\perp$). The distributions of $k_\perp$ carry information about the destructive coherence phenomena that occur during parton fragmentation. In the pQCD regime the partons emerging from the hard scattering are produced with large virtuality. This virtuality then decreases by a sequence of radiation of hard fragments where the emission angle is expected, due to the destructive coherence, to be ordered in magnitude and the emission angle. This phenomenon is known as an Angular Ordering (AO). F. Krizek developed Monte Carlo methods for the estimation of the background coming from the underlying events and these studies are now being prepared for a PRD publication.

In order to study the contamination of the underlying event in the $k_\perp$ distribution we analysed the particle yield associated with the leading trigger particle in an event as a function of the pseudorapidity separation $\Delta\eta$. The per trigger yield as a function of an azimuthal angle with respect to the trigger particle for various pseudorapidity separations is shown in the left panel of the figure on the opposite page.

The expectation is that the pairs with large $\Delta\eta$ are free from the jet fragmentation signal and thus these pairs can be use to simulate the background distribution in the signal region (right panel of the figure on the opposite page). Important ingredients to the background estimate are p_T spectra of associated particles that have a large pseudorapidity separation $\Delta\eta$ with respect to the trigger particle and their relative



Left: Per trigger normalized distribution of relative azimuthal angle of associated particles with respect to the trigger particle at different pseudorapidity gaps $\Delta\eta$. Data are from Pb+Pb at 2.76 ATeV. The centrality of the collisions was 10–30%. The trigger p_T range was 5 to 6 GeV/c and the associated p_T range was larger than 1 GeV/c but less than the trigger p_T in the given event.

Right: Per trigger normalized distribution of the transverse component of the associated track momentum with respect to the direction of the jet thrust that is approximated by the leading particle momentum. The trigger pseudorapidity range was limited to $|\eta_{Trigg}| < 0.4$. The measured distribution is marked by the full black circles. The open circles show an estimated contribution of the underlying event particles. This estimate is based on p_T spectra of associated particles that have a pseudorapidity gap with respect to the trigger particle larger than 0.4 and their relative azimuthal angle w.r.t. the trigger is close to 90 deg. The pseudorapidity and azimuthal angle of these particles are then randomly sampled from the uniform distribution. The vertical red line indicates the lower edge of the range that was used to normalize the background on top of the measured data. The Swiss crosses correspond to the extracted signal. In this data sample the size of the trigger transverse momentum was required to be between 6 and 8 GeV/c and the projection of the associated particle momentum to the trigger momentum direction is between 1 and 2 GeV/c. The data are from p+p at 7 TeV.

azimuthal angle w.r.t. the trigger close to 90 deg. The pseudorapidity and azimuthal angle of these particles is then randomly sampled from the uniform distribution.

In order to strengthen our role in the EMCAL data analysis we have hired A. Morreale in October 2010. In December 2011, A. Morreale and J. Kral started analysing PbPb data from the 2010 dataset to begin assessing the limitations/capabilities of the EMCAL for pi0 identification within a particle correlation analysis framework. This new participation in an ALICE EMCal based analysis encompasses involvement with other ALICE team members that are responsible for the QA/calibrations, which optimise the identification of neutral pions and direct/decay/conversion photons. The EMCAL efforts that started in late 2011 focus on obtaining a clean sample of neutral pions at high transverse momentum. Once a satisfactory sample of neutral pions is identified, these will then be used as triggers which will then be correlated to other hadrons found in the event. Exploratory studies show that a separation between hadron energy depositions - an important background - and electromagnetic energy depositions is possible.

As the interaction length of the EMCAL

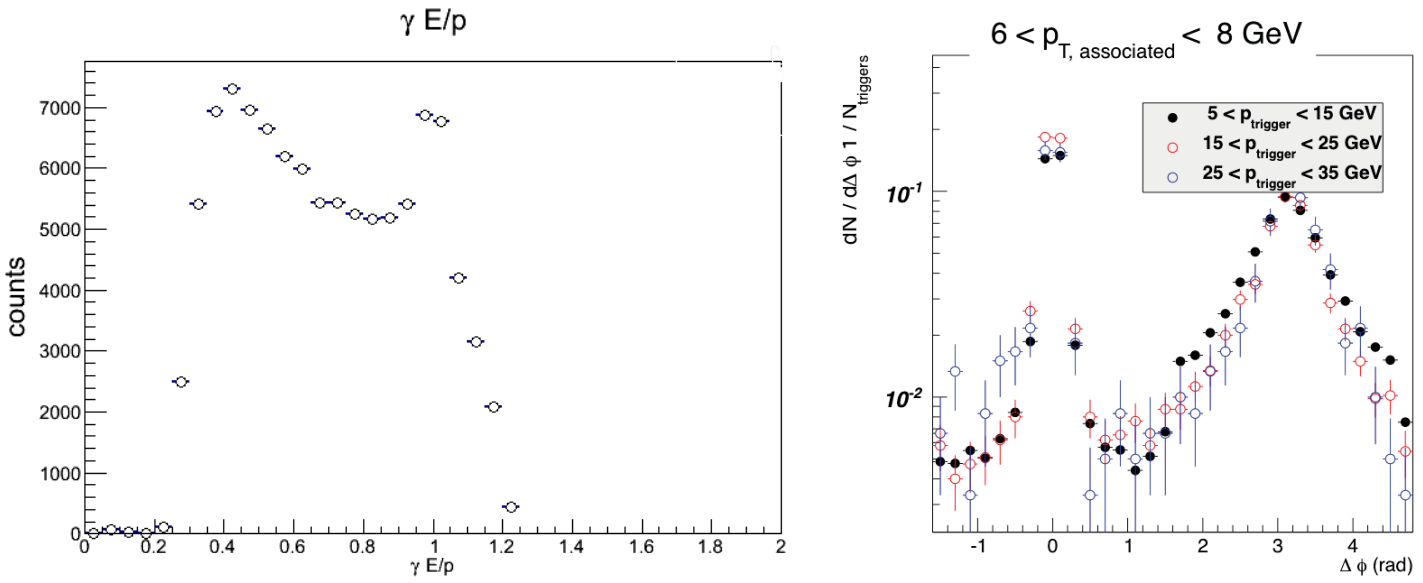
is 1, the electrons and the photons proceeding from the neutral pion to two-photon decay are expected to deposit all of their energy in the calorimeter. Hadronic showers on the other hand will only represent a fraction of the energy of the interacting hadron. The figure below shows an exploratory energy/momentum (E/p) distribution obtained from the 2010 Lead-Lead data. A clear peak is seen around unity giving an indication of the electromagnetic energy depositions of electrons and photons. Lower values of E/p are understood to be the background proceeding from either conversion electrons: photons which interact with the detector material and result in the decay to two electrons which typically have lower energy depositions than real electrons, and hadrons (i.e., charged pions.) Another EMCAL related measurement of our group currently being explored, is the measurement of an invariant cross section of neutral pions. A cross section measurement compared to next-to-leading order (NLO) pQCD calculations will serve as a baseline which will test and compare the factorised framework which pQCD relies upon. A cross section of neutral pions will be the first measurement performed in ALICE using the pion two-photon mass reconstruction method which will use the EMCAL information.

B. Chang and D. J. Kim made a major contribution in establishing the common tool of the ALICE Event plane method via forward detectors (VZERO detectors), which minimises the non-flow contribution. The VZERO detectors are two scintillator arrays providing both amplitude and timing information, covering the pseudorapidity range $2.8 < \eta < 5.1$ (VZERO-A) and $-3.7 < \eta < -1.7$ (VZERO-C).

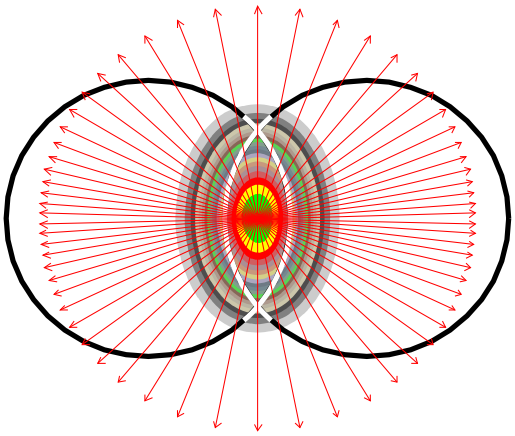
When nuclei collide at a non-zero impact parameter (non-central collisions, i.e., shown in the figure at the top of the opposite page), the geometrical overlap region is anisotropic. This initial spatial asymmetry is converted into an anisotropic momentum distribution of the produced particles.

This transverse momentum spectra of hadrons can be written as a Fourier series: $dN/(d^2p_T dy) = (1/\pi) dN/(d^2p_T dy)\,(1 + 2\sum_{n=1}^{\infty} v_n \cos(n\varphi))$, where φ is the particle azimuthal angle with respect to the event plane defined by the impact parameter. The flow coefficients v_n can then be computed from $v_n = \langle \cos[n(\varphi - \Psi_n)] \rangle$, where φ is the azimuthal angle of the particle, Ψ_n is the angle of the initial state spatial plane of symmetry, and n is the order of the harmonic.

After all event plane calibration procedures, the clear correlation between the event planes



Left: The ratio of energy over momentum of particle energy depositions in the EMCAL. The clear peak around unity indicates a clear separation between electromagnetic energy depositions and hadronic/conversion energy depositions. The figure corresponds to Lead-Lead collisions in 2010. Right: The azimuthal correlation between the photon cluster and charged particles reconstructed using the central tracking system of ALICE. The intra-jet (peak around $\Delta\phi \sim 0$) and inter-jet (peak around $\Delta\phi \sim \pi$) correlations are clearly visible.



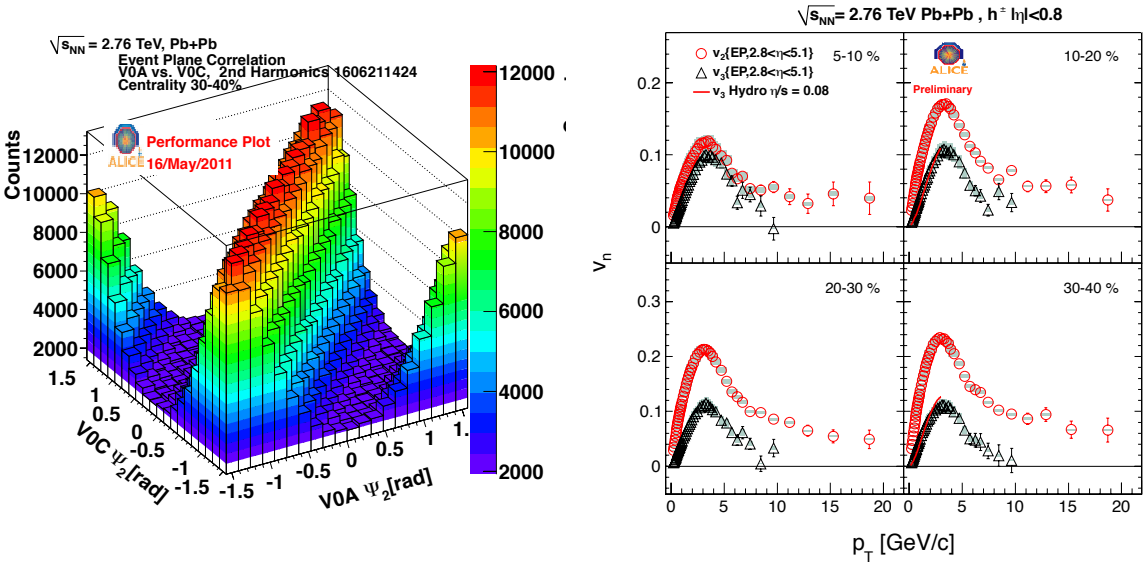
A heavy ion collision seen in the plane perpendicular to the beam.

with two different detectors is observed and the measured flow as a function of transverse momentum in various centralities is shown on the right of the figure below. The measured 2nd harmonic flow (v_2) up to 20 GeV/c and the triangular flow (v_3) up to 10 GeV/c with this precision are achieved for the first time and this will help us to understand the path length dependence of the energy loss in detail. This result has been shown in the Quark Matter 2011 conference in Annecy and the result is being prepared for a PRL publication; D. J. Kim is a member of the paper preparation group and B. Chang is the contact person for ALICE event plane calibration for VZERO detectors.

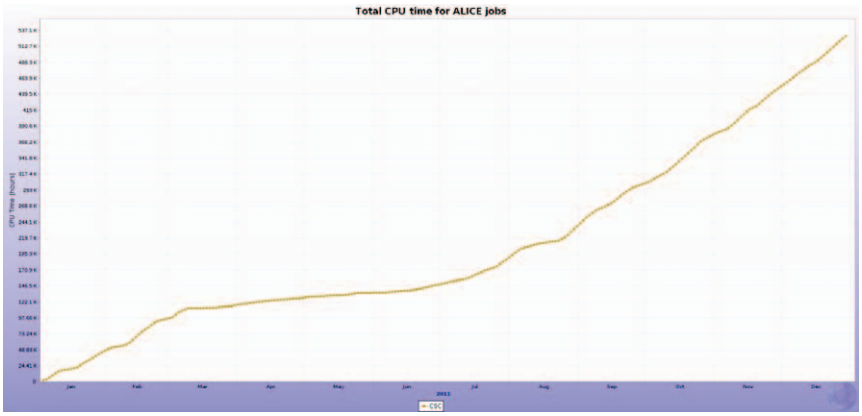
In addition to the ALICE activities our group is also involved in the PHENIX experiment at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory (BNL) on Long Island, New York. The analysis of the PHENIX data allows us to compare the results from very different energy regimes. In 2010 the main goal of the RHIC experimental programme was to study the *Au+Au* collisions at lowest available c.m. energy. The purpose of this so-called beam energy scan was to search for possible threshold behaviour of the jet quenching phenomena. N. Novitzky performed an analysis of the neutral pion suppression in the colliding energies $\sqrt{s}$ = 39 and 62.4 GeV. He was selected by the PHENIX Collaboration to present his results at the Quark Matter 2011 conference in Annecy, France. He is now chairing the paper preparation group with the aim to publish these results in PRL. J. Rak and F. Krizek are also members of the paper preparation group.

Computing

The ALICE computing model is driven by the large amounts of computing resources that are necessary to store and process the data gener-



The event plane angle correlation between VZERO-A and VZERO-C detectors is on the left. The 2nd harmonic and triangular flow measured with the event plane method are shown on the right in various centrality bins.



Finland ALICE Grid Computing activity in 2011. The CPU time executed in the "Jade" Cluster in CSC over the months.

ated by the experiment. The required resources cannot be consolidated in a single computing centre like CERN; hence Grid computing has been utilised. 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 as a part of the Nordic Grid Computing Faculty (NDGF), where we provide about 200 CPUs and 100 TBytes of disk storages to ALICE. The cluster "Jade" has been integrated into the ALICE Grid computing frame in CSC since 2010 and is being used for the ALICE data analysis including the large-size heavy ion data.

As for the *Pb+Pb* 2011 run, data were read out with the rate of about 65 Tbits/sec for all detectors, which seems to be the first time that the data record of such a rate was observed and these data were transferred and reconstructed over the Grid. The average number of data reconstruction jobs was about 12 000 this year and the raw data size for one month of *Pb+Pb* collisions in the end of this year reached up to 900 TBytes (representing 140 million *Pb+Pb* collisions, 10 times more than the 2010 run). The figure above shows the CPU time of executed jobs in the Jade cluster over the months in 2011. The cluster was fully operational and the reconstruction and end-user analysis activities were increased over time. Additional CPUs and disk servers will be prepared for the coming high-luminosity LHC Heavy ion run and the *p+p* run during 2012.

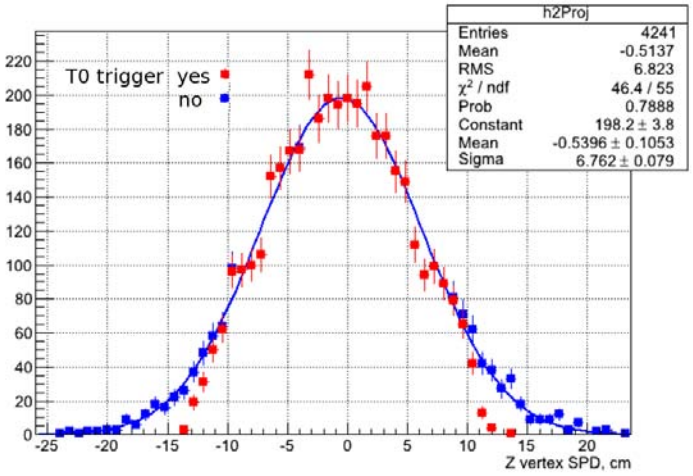
T0 detector maintenance and operation

The T0 is a small sub-detector of ALICE. It provides a fast timing signal when a reaction occurs. It consists of 24 photomultipliers optically coupled with quartz scintillators. The photomultipliers are placed at large pseudorapidities around the beam line.

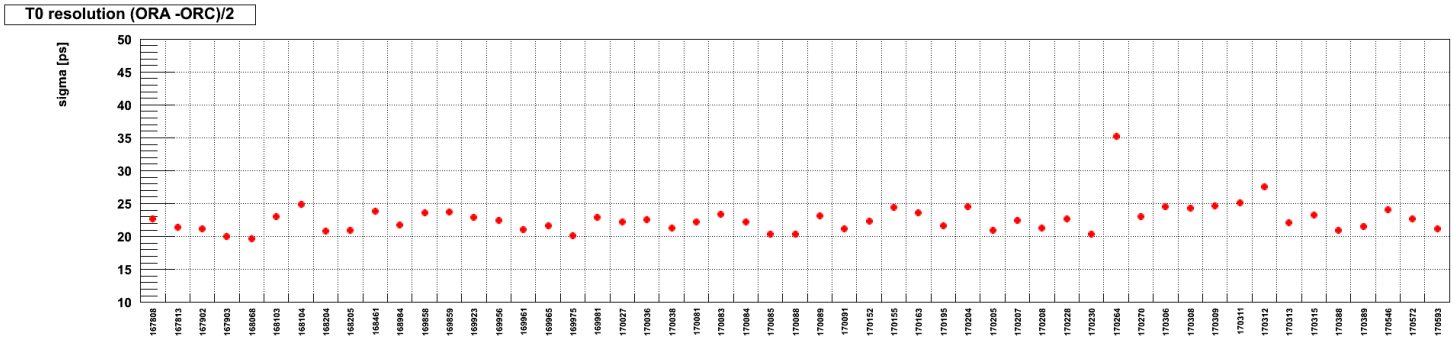
In 2011, the T0 performance was stable and successful. It continued to deliver start time data for other ALICE sub-detectors. Due to its excellent timing resolution, the T0 was used as a handy tool for beam quality diagnostic being able to monitor satellite bunch interactions and pile-up. Moreover, during the heavy ion run at the end of the year, the T0 vertex signal was employed in the ALICE trigger, see the figure at the top of the opposite page. The efficiency of this trigger for vertices within the z = (-10; 10) cm region was close to 100%. The timing resolution of the T0 detector in the heavy ion run was better than 30 ps. We have developed a code allowing run-by-run monitoring of the stability of the detector performance and the resulting trending plots, see the figure in the middle of the opposite page, are published on the web page http://www.inr.ru/~alla/trend.

EMCal single photon L0 trigger

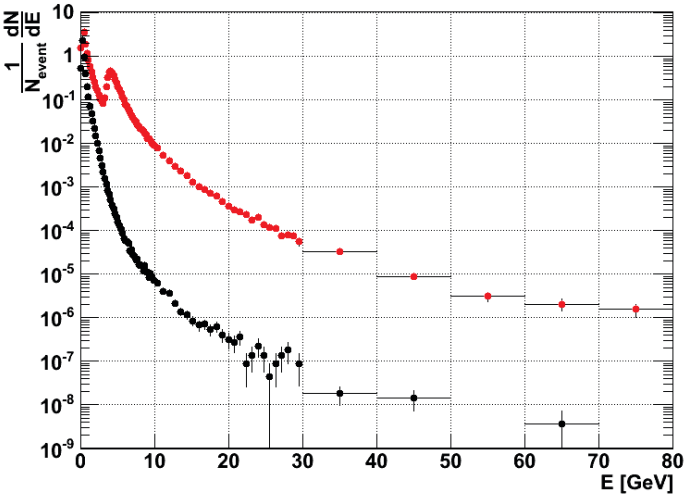
The single photon trigger system for the ALICE detector was included in the 2011 data taking. The first operation and performance evaluation happened at the end of 2010 with 4 EMCal super-modules (SMs). An additional 6 SMs were installed during the 2010/2011 winter shutdown. A fast performance check was done by J. Kral for the full EMCal in the first days of 2011 running, so the trigger could join the 2.76 TeV *p-p* data taking at the beginning of the year. A full scale performance evaluation followed right after the 2.76 TeV data taking and the EMCal level-0 trigger was accepted by the ALICE Collaboration as a valid trigger early in spring. The excellent performance of the EMCAL level-0 trigger is demonstrated in the figure at the bottom of the opposite page where where the untriggered minimum bias energy distribution of EMCal hits (left panel, black points) is compared to the level-0 trig-

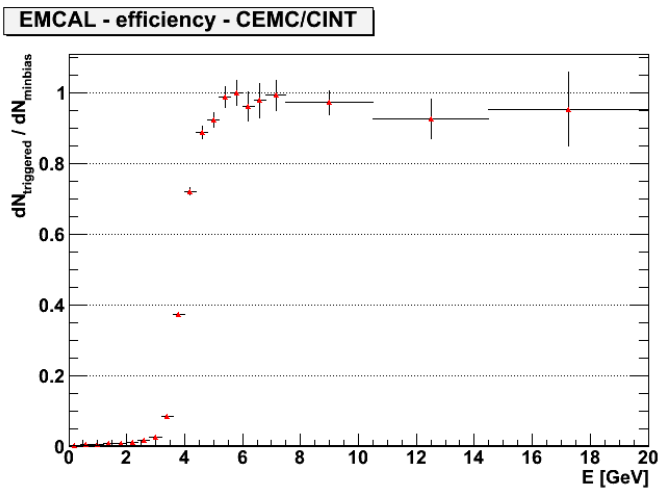


The position of the reconstructed SPD vertex with (red) and without (blue) requiring a T0 trigger decision. The T0 provided positive trigger when the event vertex occurred in the z range from -10 to 10 cm.



Run by run time resolution of the T0 detector during Pb+Pb at 2.76 ATeV data taking in November 2011. The average per run value fluctuates about 22 ps.





Left: The minimum bias energy distribution of the EMCal hits (black points) compared to the triggered energy distribution (red points). Right: The trigger efficiency as a function of the hit energy.

Participants of the 5th ALICE Physics Week on a boat trip on lake Päijänne.

Ari Jokinen, ISOLDE project leader

gered distribution (left panel, red points). The overall enhancement at the high-p_T region in the triggered data sample reaches almost three orders of magnitude.

The trigger development continued with minor updates requested by the level-1 system, which re-processes the level-0 data. J. Kral helped significantly with debugging of the level-1 system, so it could be ready for the *Pb-Pb* data taking at the end of the year. T. Naaranoja, a summer student in the group, developed an upgrade of the level-0 data acquisition (DAQ) module, so that the TRUs are ready for the EMCal DAQ upgrade scheduled to happen during 2012. The level-0 trigger contribution to the ALICE experiment is highly regarded in the collaboration.

ALICE Physics Week, August 29th - September 2nd in Jyväskylä

The ALICE Collaboration selected the Jyväskylä group for organising the 5th Physics Week in late summer 2011. The main goal of this meeting was to discuss the data analysis and physics interpretations. It was the first physics meeting where ALICE discussed the analysis of the large data sample taken in 2010 and with 138 participants and 83 talks it has been the largest ALICE Week so far.

ISOLDE

As in previous years, the experimental programme carried out at the ISOLDE facility has continued in the same vein, with a focus on nuclear structure studies using post-accelerated radioactive ion beams (RIBs), laser spectroscopy of exotic nuclei and solid-state physics studies with implanted radioisotopes.

HIE-ISOLDE

The HIE-ISOLDE project to produce post-accelerated RIBs with higher energy and intensity has also progressed with the commencement of civil engineering work to extend and reconstruct the present ISOLDE buildings. The increase in beam energy means that a wider range of nuclear reactions (such as fusion-evaporation) will become possible. This in turn calls for a wider range of experimental tools, and a new project was started to investigate the scientific and technical requirements for a vacuum-mode recoil separator to be constructed at HIE-ISOLDE. To this end, a workshop was held in Lund, Sweden. A number of working groups were formed, one of which is responsible for the ion optical simulation of the spectrometer.

Due to his experience with construction of the RITU and the new MARA separator at JYFL, J. Uusitalo (JYFL) was selected as leader of this working group.

Nuclear Structure Studies with Radioactive Ion Beams

The unique availability of heavy, post-accelerated radioactive ion beams at REX-ISOLDE was again exploited in a number of measurements to study isotopes of Pb, Rn and Ra. The studies at ISOLDE nicely complement similar experiments carried out with stable ion beams at JYFL.

The study of shape co-existence and collectivity in ^{188,190,192}Pb is the subject of experiment IS494 "Measurements of competing structures in neutron-deficient Pb isotopes by employing Coulomb excitation" led by T. Grahn (JYFL) and J. Pakarinen (CERN). As reported in the 2010 Annual Report, the first part of the experiment allowed the reduced transition probability for the 2^+ to 0^+ transition in ^{192}Pb to be determined. In 2011, an extremely productive experiment was carried out to study the remaining isotopes ^{188,190}Pb. The improved laser performance in the production of the ion beam meant that the scientific goals could be achieved with less beam time than initially expected, which allowed a wider number of Pb isotopes to be studied. The preliminary analysis suggests that the transition strengths of the first excited 2^+ states can be deduced in the sequence of isotopes from $^{188\text{-}198}$Pb, providing excellent systematic data.

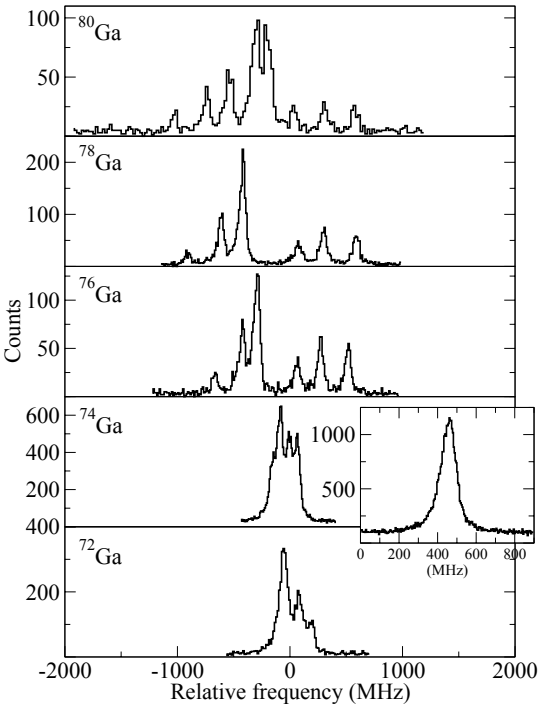
The development of nuclear structure as a function of nucleon number in going away from the closed-shell at magic numbers is addressed by experiment IS506 "Mapping the boundaries of the seniority and regime and collective motion: Coulomb excitation studies of N = 122 isotones ^{206}Po and ^{208}Rn" led by T. Grahn (JYFL). In 2011, it was possible to deliver a ^{208}Rn beam for this experiment and the analysis of the data is ongoing.

A number of new proposals for experiments at REX-ISOLDE and Letters of Intent for HIE-ISOLDE have been submitted to the INTC at CERN, thus it is envisaged that this programme of studies will continue for the foreseeable future.

Continuation to the laser spectroscopy programme of Ga nuclei

Earlier annual reports covered the laser spectroscopic investigation of the inversion of ground state spin in the gallium isotopic chain [B. Cheal *et al.*, Phys. Rev. Lett. 104 (2010) 252502], suggested to be caused by the monopole component of the tensor interaction. This work was performed at the collinear laser station in ISOLDE, using the radio-frequency quadrupole cooler-buncher, ISCOOL. In 2010 a further highlight of the earlier work was summarised, namely the discovery of a new nuclear state in ^{80}Ga [B. Cheal *et al.*, Phys Rev. C 82 (2010) 051302(R)].

Here an extension to these studies is reported, the investigation of the odd-odd gallium isotopes and thus the role of odd-even effects with neutron number. Full hyperfine structures of the ^{72,74,76,78}Ga ground states were measured on the 417.3-nm $4p^2P_{3/2} \rightarrow 5s^2S_{1/2}$ atomic line, shown in the figure below, along with the ^{80}Ga ground and isomeric states reported in 2010.



Hyperfine structures of the ground states of ^{72,74,76,78,80}Ga, measured on the 417.3-nm $4p^2P_{3/2} \rightarrow 5s^2S_{1/2}$ atomic line. The inset shows an additional scan of ^{74}Ga measured on the 403.4-nm $4p^2P_{1/2} \rightarrow 5s^2S_{1/2}$ transition.

Juha Äystö, FAIR project leader

For ^{74,76,78}Ga the ground state nuclear spin values were previously unconfirmed. The laser measurement permitted an unambiguous assignment of $I = 2$ for both ^{76}Ga and ^{78}Ga. The hyperfine splitting of ^{72,74}Ga is not fully resolved due to a condensed structure, however a spin of $I = 3$ for ^{72}Ga supports previous work, and a careful chi-squared analysis yields a preference for $I = 3$ for ^{74}Ga. Nuclear moments were also measured and compared with state-of-the-art shell model calculations in order to provide a detailed probe of the nuclear wave function. This work has recently been published in Phys. Rev. C [E. Mané *et al.*, Phys Rev. C 84 (2011) 024303].

Finally, beam time awarded for an addendum to the original gallium proposal resulted in the study of neutron-deficient $^{63-71}$Ga isotopes in 2011. The primary motivation for extending the study to neutron-deficient nuclei arose from the anomalous behaviour of the matter radii, measured at GANIL, which was seen to increase monotonically with decreasing neutron number from $N = 36$ to $N = 32$. It was argued that this cannot be associated with any substantial change in deformation and thus is evidence for the development of a proton skin. Laser spectroscopic measurements performed at ISOLDE in 2011 established the mean-square charge radii for these isotopes which showed no such increase. It may therefore be concluded that a proton skin, which had been suggested as an explanation, can be ruled out.

Solid State Physics

In the early part of the 2011 ISOLDE running period, beam was allocated to the project to study the diffusion of ^{56}Co in the silicides GaN and AlN. The project is carried out in collaboration with K. Johnston (CERN) and F. Tuomisto (Aalto University). Unfortunately the beam intensities obtained were insufficient for obtaining the required samples. It is hoped that further beam time will be awarded to this project in 2012.

Change of Project Leader

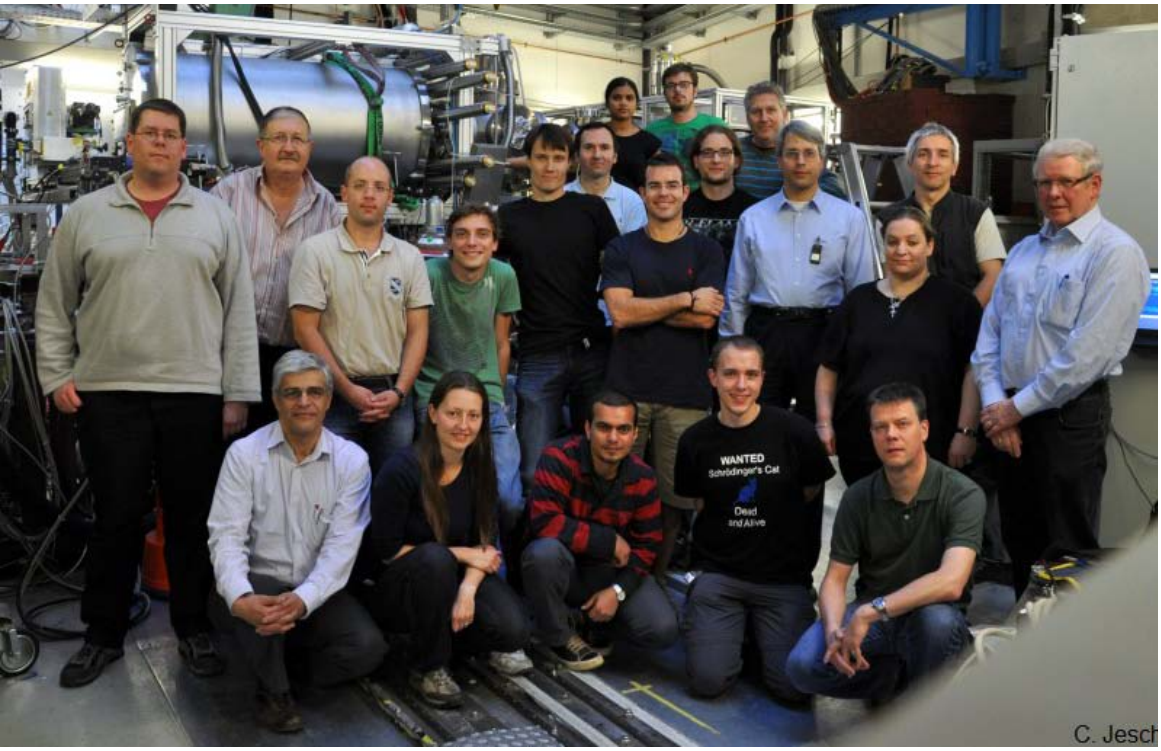
After 6 years of acting as ISOLDE project leader, A. Jokinen stepped down from his duties at the end of 2011. In 2012 he will be replaced by P. Greenlees (JYFL).

FAIR (Facility for Antiproton and Ion Research)

NUSTAR Collaboration

Preparatory work for FAIR (Facility for Antiproton and Ion Research) started in 2006 and has continued through 2011. The actual construction of the FAIR facility was launched in autumn 2011. The agreed Finnish contributions will be devoted to 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 have been published and approved in 2010, see Eur. Phys. J. A 183 (2010) 1. The third experiment is finishing its technical design report. The main funding source 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. A. Jokinen is a co-spokesperson for the MATS experiment and I. Moore for the LaSpec experiment. The Super-FRS beam diagnostics project is mainly the responsibility of the HIP Detector Laboratory.

Finland is actively involved in the cryogenic gas catcher project with GSI and KVI-Groeningen to provide low-energy cooled ion beams for the MATS/LaSpec experiments. A milestone was achieved in October 2011 at GSI: the first ever test of a cryogenic ion catcher in realistic experimental conditions. At the FRS, relativistic nuclei were slowed down to a few eV within a cryogenic stopping cell with a length of 1 m and a diameter of 25 cm.



A team of physicists from GSI, Groningen and Jyväskylä during the first successful tests of the cryogenic ion catcher at GSI.

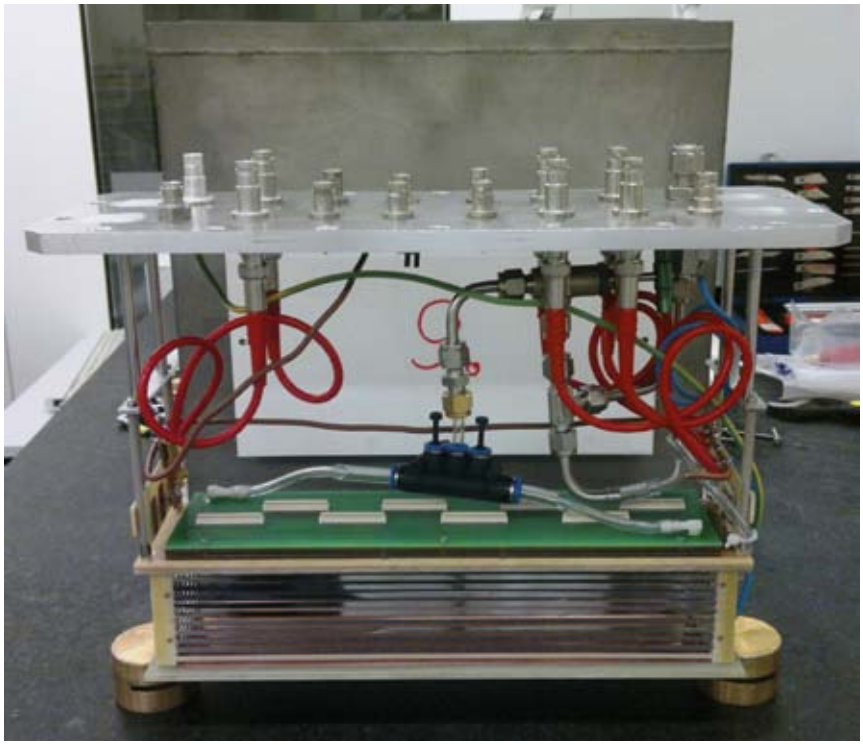
During the tests, a helium gas density several times larger than that achieved with comparable, room temperature ion catchers was used. Electric fields guided the stopped ions towards a fine-structured RF carpet on the exit side and following extraction the ions were transferred towards a multiple-reflection time-of-flight mass spectrometer for analysis. An efficient stopping and extraction of ^{223}Th was realised.

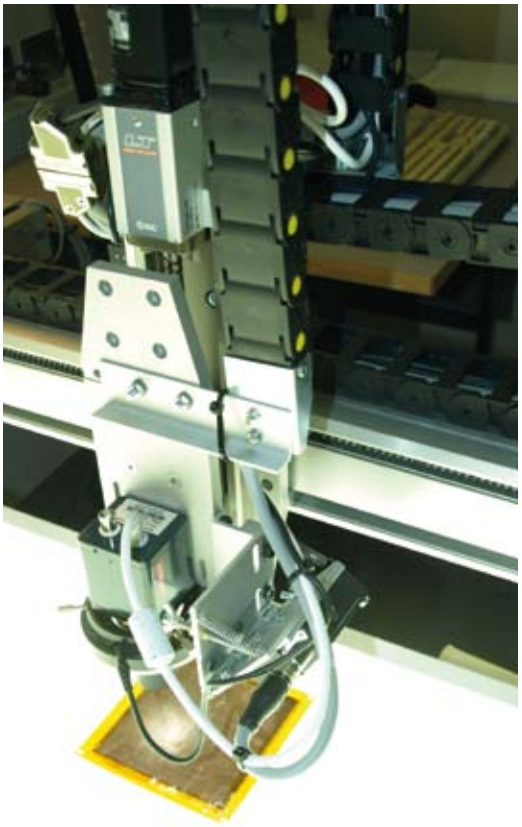
FAIR Super-FRS activities at HIP Detector Laboratory

The beam diagnostics system for the FAIR Superconducting Fragment Separator (Super-FRS) consists of several detection stations relying on the use of position sensitive diamond detectors, gas detectors and silicon strip detectors. From the 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 2011, the second GEM-TPC detector prototype HB2 for the AFTER read-

A GEM-TPC prototype.

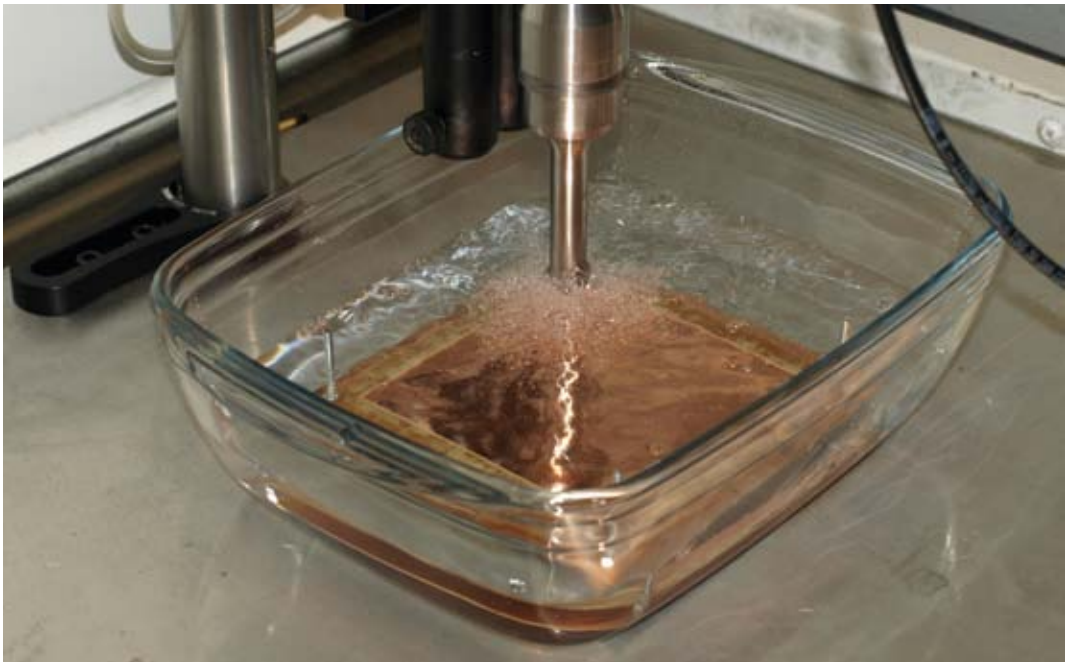




A GEM-foil being photographed by the optical scanning system.

out was constructed. In addition, the HB3 GEM-TPC for N-XYTER/XYTER readout is under development and tests of the electronics and the DAQ have been done. Both prototypes consist of a Field Cage, GEM foils, frames, readout boards and their 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 a close co-operation with the research groups from Comenius University in Bratislava, CUB, responsible for the field cage and integration, and the GSI Detector Laboratory, responsible for the readout electronics and data acquisition (DAQ).

In addition, the development work on the Optical scanning system was continued. New methods, including different methods for locating short-circuits and blocked holes from GEM-foils, were included in the control software. The first analyses based on the mapping of the dimensions of the holes in GEM-foils were also made. Furthermore, different methods for repairing shot-circuited foils were developed. These include different sonic and ultrasonic methods. The quality of the methods were evaluated using the optical system and GEM-measurements. Additionally, a readout system based on the commercial FlexRIO platform was developed. With the system it is possible to read-out 64 channels with a rate of 50 megasamples per second. The number of channels can be expanded by adding new modules to the system.



A GEM-foil in an ultrasonic bath.

Technology Programme

In 2011 three projects were hosted by the HIP Technology Programme. The Green IT project has already established ways to enhance energy efficiency in distributed computing infrastructures and the results so far are encouraging. The DataGrid project has successfully continued the EU sponsored EMI project and has secured TEKES Innovation recognition and external funding for next year. The PET project was started and it incorporates a new collaboration with Tampere University of Technology (TUT). A considerable effort in the group was channelled towards obtaining external project funding. This would allow an increase in critical mass and allow the Programme to engage in industrial collaboration. External outreach has been maintained with various parties. The HIP Technology Programme stands in good shape for the change of leadership in 2012.

Ari-Pekka Hameri,
Technology Programme
director

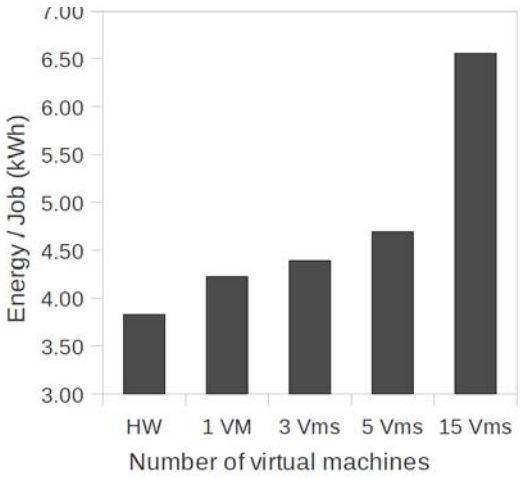
Green Computing

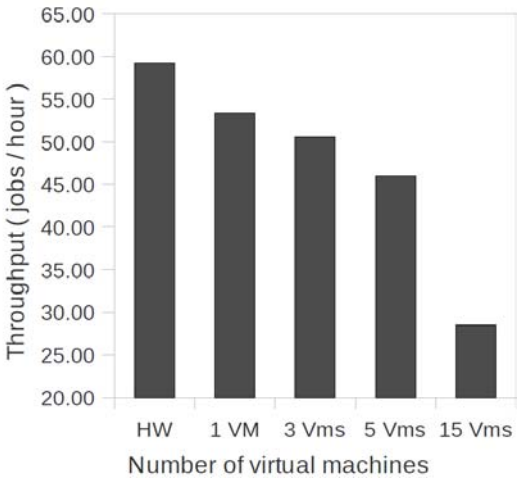
Energy-efficiency is a new issue arising in high performance and high throughput computing. When taking into account the whole lifetime of the hardware, the electricity cost can easily exceed the initial investment cost. The Programme started a new research track on green computing in late 2008. From January 2011 this work has continued in a new Green IT project.

The research on Green IT has focused on developing operational practices and software tools for optimising Grid/Cloud computing clusters. These include studying different visualisation solutions and efficient data storage. The research builds on production optimisation and operations management principles on scheduling and allocation of computing resources. The aim is to minimise energy consumption and maximise throughput and utilisation of existing resources. In this sense, the project differs from the mainstream of green computing research which focuses on hardware and infrastructure issues.

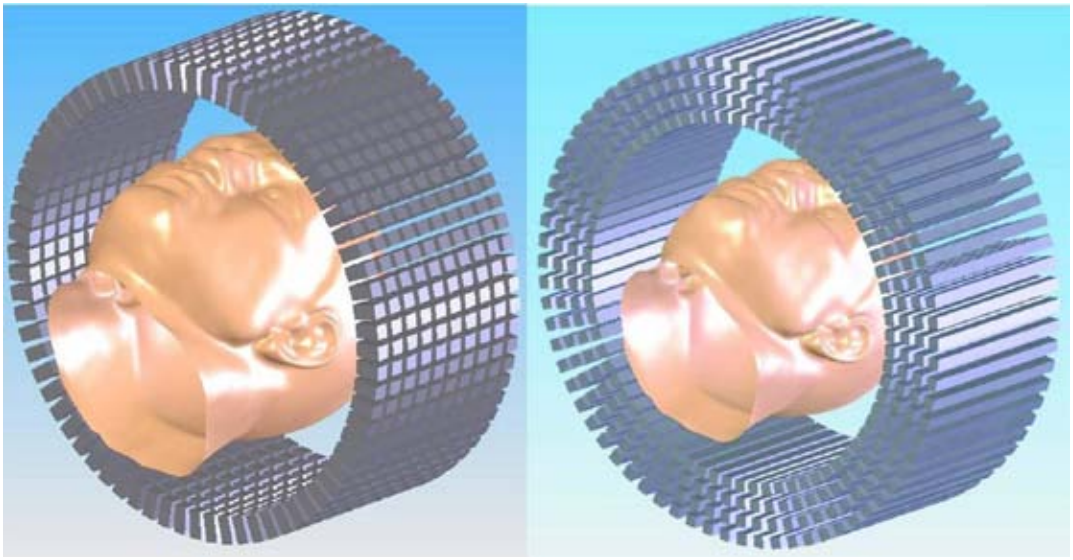
The project has a modern test environment at CERN. The tests have showed that it is possible to decrease energy consumption by 45% and to increase throughput up to 100% compared to the standard practices used in scientific computing.

Tapio Niemi,
Green IT
project leader





Running 15 physics analysis jobs in different number of virtual machines. Using 15 virtual machines running one job is 6.8 times less energy efficient than running 15 jobs on one virtual machine.



The AX-PET demonstrator promises advances in medical imaging. (Courtesy of the AX-PET Collaboration.)

Ulla Ruotsalainen, PET project leader

In 2011 the project has studied different solutions for data storage such as solid state disks. The tests showed that this modern storage solution can improve efficiency by removing the bottleneck of slow disk access.

The Green IT project has also been involved in data analysis research through the EXHADA project. EXHADA is a collaborative project between the Helsinki Institute of Physics at CERN and the University of Tampere, Finland. The project has gained funding for 2011-2012 from the Academy of Finland.

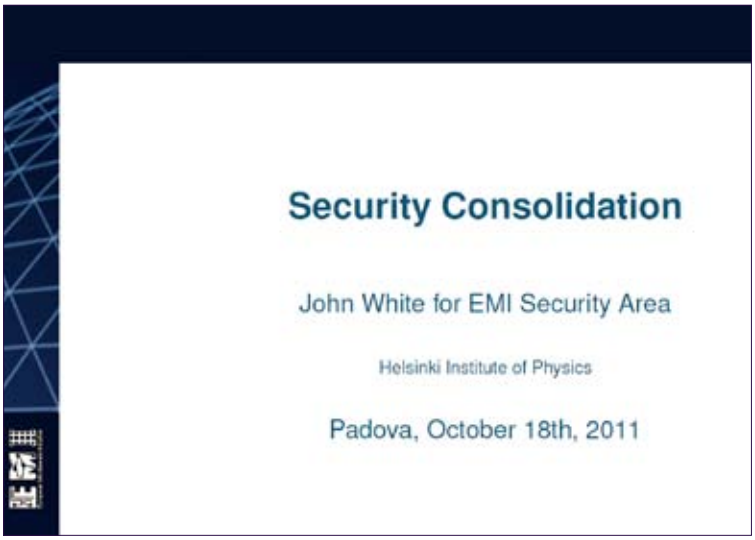
The main collaborating partners of the Green IT project are both Finnish (the Aalto University, the University of Tampere) and international (CERN, EPFL, the University of Lausanne) research institutions and Finnish IT companies.

The aim for 2012 is to continue basic research and also start closer industrial collaboration with external research funding. For research funding two project proposals have been submitted to the Academy of Finland. Also possibilities for EU or Swiss research funding will be investigated.

AXPET Collaboration with CERN

At CERN, a new type of positron emission tomography (PET), Axial PET (AXPET), has been developed. The AXPET demonstrator (with two detector heads) is based on a new concept in PET detectors, where scintillation crystals are aligned along the axial or z coordinate and Wave-Length Shifter strips are placed orthogonal to them. This structure avoids parallax errors due to different depths of interaction of the photons in the crystals, resulting in a significant improvement in spatial resolution and sensitivity of a PET scanner designed with this new radiation detector.

In Finland and at Tampere University of Technology we aim to seek ways to commercialise a new type of PET scanner using AXPET type detectors. Because of the special structure of the detector several new constructions of PET scanners have already been designed in a TEKES funded project. During the year 2012 the aim is, together with some companies and with TULI funding, to build the first prototype that could be used in real PET measurement environments. We will have a post-doctoral researcher V. Koivu hired for this work. The main task will be to connect together with the CERN group the detectors with new electronics from Philips and test the constructed measurement system with “phantoms” at CERN.



The HIP Technology Programme led Grid security work area was promoted this year in Padova, Italy in the EU EMI project conference.

Grid Middleware Development

In the European Middleware Initiative (EMI) project, HIP Technology personnel are responsible for the co-ordination of the security area and development and maintenance of security components. The third EMI security milestone, the EMI Security workshop at the EGI conference in Lyon, was organised and led by HIP. The subsequent milestone document was produced by HIP. The second EMI security deliverable document, that outlined the progress and future plans, was also produced by the group. Moreover, major contributions were made through the EMI Project Technical Board (PTB) to the overall EMI technical overview.

From the beginning of the EMI project, HIP has had the responsibility to set up and co-ordinate 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 been finished in 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. Also the pseudo-anonymity service, essential to privacy-minded users and NGIs, has been developed and packaged by HIP. Other EMI-related efforts during the year included organisation of the EMI Security area participation to the EGI conference in Lyon and contributions to the EMI EU review.

Grid Applications and Industrial Collaboration

The Programme has continued to integrate grid security components with arising technology standards, especially the ones related to Cloud security. The research effort on 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 privacy, security token translations, identity delegation and single sign-on in environments supporting ubiquitous devices. In addition to the identity management, our research also covered secure Cloud storage technologies. This area produced one successful project proposal that was accepted for external funding by the Finnish national technology agency TEKES.

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 on applying distrib-

Miika Tuisku, DataGrid project leader

uted storage technologies for mobile Internet access has been carried out in the Programme. The work has been done in co-operation with the Department of Communications and Networking at the Aalto University in Helsinki, Finland. The research led to a doctoral thesis that was successfully defended in January 2011 at the Aalto University.

Collaboration and Outreach

The exploitation of emerging new innovations around Grid and Cloud technologies requires close collaboration with industry and other research organizations. The common interests in the energy-efficiency aspects of distributed computing continued with EPFL through the EcoCloud initiative, while the HIP Technology Programme was also awarded with an Honourable mention in the TEKES Green ICT innovation competition. The group was also active in setting up new proposals including the Swiss CloudMon follow-up project with the University of Applied Sciences in Western Switzerland (Geneva) and several EU FP7 and TEKES project proposals with KTH, Sweden.

In 2011, the HIP Technology Programme hosted and mentored six summer students and one CERN Technical student not only from traditional member universities, but this year also from the University of Oulu, and the University of Jyväskylä. The DataGrid project took also part in the CERN Openlab summer student programme, co-supervising a student, who will continue as a CERN Technical student in 2012.

The Technology Programme will continue to collaborate with several IT experts representing both academia and industry. In 2011 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, Swiss Federal Institute of Technology (EPFL), SWITCH Zurich, Nokia Research Center Lausanne, the Canton of Geneva, CERN Openlab, the Citizen Cyberscience Center (CCC) and the Big Science Activation Team Finland of TEKES.

CLOUD

Markku Kulmala, CLOUD project leader

Background

Atmospheric aerosol particles influence the Earth's radiation budget and therefore the whole climate system by two distinct mechanisms. First, they directly interact with solar radiation (reflection, scattering, absorption). Second, aerosol particles act as seeds for cloud condensation and therefore indirectly influence the radiation budget by affecting the cloud albedo, extent, precipitation and lifetime. Understanding of the dynamical behaviour of ambient aerosol particles requires understanding of the formation and growth processes of aerosols.

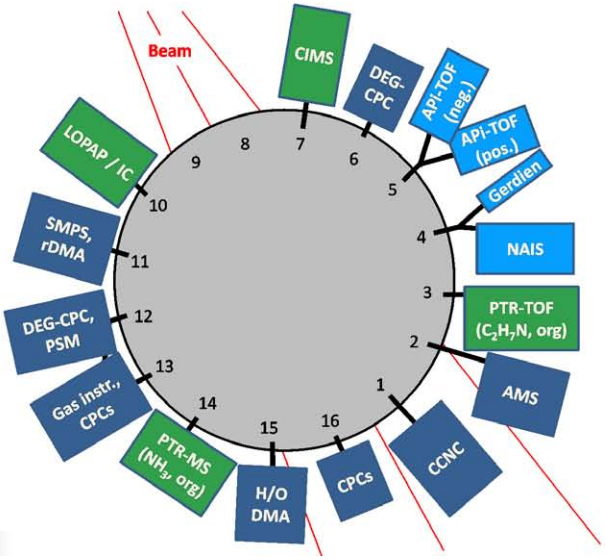
The CLOUD (Cosmics Leaving OUtdoor Droplets) experiment is motivated by numerous indirect observations and theoretical studies suggesting that galactic cosmic rays (GCRs) may exert a significant influence on the Earth's cloud cover and climate. Some studies have observed a variation of low clouds by 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 to the estimated radiative forcing due to anthropogenic greenhouse gas emissions (2.64 Wm^{-2} in 2005). The main proposed mechanism is 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, this mechanism has not 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.

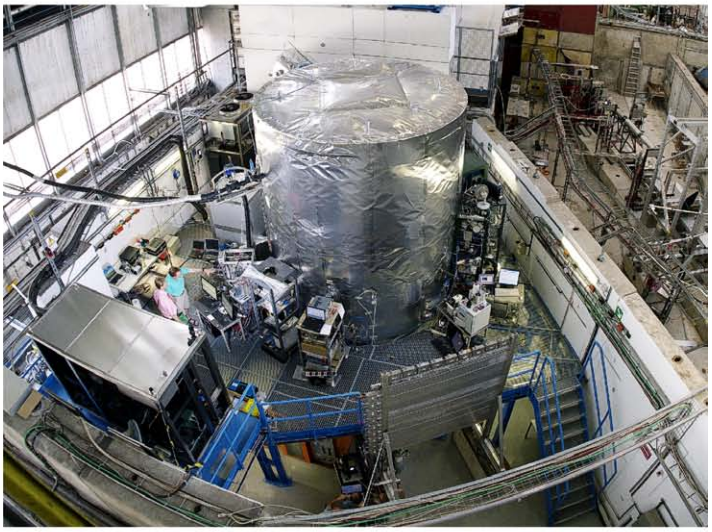
Experiments in 2011

In 2011, two 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.

The Finnish team was primarily responsible for the measurement of clusters and ions, and brought a comprehensive set of instruments to CERN for the two campaigns: an Airborne Neutral cluster and Air Ion Spectrometer (ANAIS), a Particle Size Magnifier (PSM), a Gerdien counter, two Atmospheric Pressure interface Time-of-Flight mass spectrometers (APi-TOF), and a Proton-Transfer-Reaction Time-of-Flight mass spectrometer (PTR-TOF). In comparison to the 2010 runs, some modifications have been made to each of these instruments based mainly on the lessons learned from the previous campaigns:

- The PSM used in 2011 was further developed from the 2010 version (now commercialised as Airmodus model A-09). The present version also yields the size distribution and growth rates of molecular clusters formed upon beam ionization in the CLOUD chamber.
- The Gerdien counter was a version developed at the University of Helsinki for the 2011 spring run, featuring more compact dimensions and a higher sensitivity to low ion concentrations.
- The ANAIS continued operation with the sample dilution system developed for the 2010 runs.



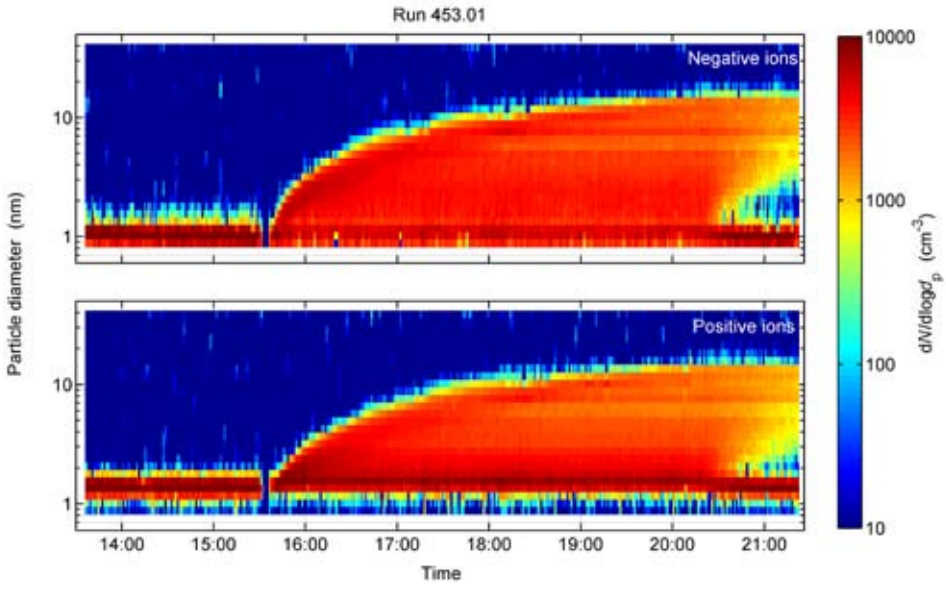


Schematic and picture of the CLOUD chamber as set up in the T11 area in CERN during the campaign in summer 2011. In the schematic, the pion/muon beam arrives from the top and along the red lines; in the picture it arrives from the bottom. It hits a hodoscope that monitors the beam intensity before it passes through the chamber, which is visible near the bottom of the picture. Instruments that were employed on the 16 ports around the chamber are: a Chemical Ionization Mass Spectrometer (CIMS) for H_2SO_4 measurements, two Diethylene Glycol-based Condensation Particle Counters (DEG-CPC), two Atmospheric Pressure interface Time-Of-Flight mass spectrometers (APi-TOF, one for each polarity), a Gerdien counter, a Neutral cluster and Air Ion Spectrometer (NAIS), a Proton-Transfer-Reaction Time-Of-Flight mass spectrometer (PTR-TOF), an Aerosol Mass Spectrometer (AMS), a Cloud Condensation Nuclei Counter (CCNC), water- and butanol-based Condensation Particle Counters (CPC), a Hygroscopicity/Organic tandem Differential Mobility Analyzer (H/O DMA), a Proton-Transfer-Reaction Mass Spectrometer (PTR-MS), instruments for gas measurements (SO_2, O_3, H_2O), a Particle Size Magnifier (PSM), a Scanning Mobility Particle Sizer (SMPS), a radial Differential Mobility Analyzer (rDMA), and a LOng Path Absorption Photometer (LOPAP) or an Ion Chromatography system (IC) for measuring NH_3 and C_2H_7N.

- Optimisation of the APi-TOFs continued throughout the year and the ion transmission was still enhanced in comparison to the 2010 experiments.
- A PTR-TOF, which measures concentrations of different volatile organic compounds (VOC), was brought to CERN for the spring run 2011. In comparison to the standard PTR-TOF, modifications to the instruments sample inlet were made to improve the detection probability of lowly volatile and sticky gases. The PTR-TOF can measure whole mass spectra of volatile organic compounds in real-time with high mass resolution, so that the chemical composition of many measured masses can be identified.

The CLOUD chamber itself and its peripheral equipment were also upgraded for the 2011 runs. The main improvement is the capability to perform experiments in upper tropospheric temperatures down to -70 °C.

In the experiments performed prior to 2011, both ammonia and different kinds of amines were found to take part in ion-induced sulphuric acid nucleation in the CLOUD chamber. The experiments in 2010 focused on controlled chamber nucleation, varying several parameters - mainly sulphuric acid concentration, ammonia concentration, ion concentration, temperature, and relative humidity. In 2011 the variable space was extended to organic amines (dimethyl amine) and volatile organic compounds and their oxidation products (pinanediol oxidation by hydroxyl radical). Also, the studied temperature range was extended from 248 K down to 208 K. In the experiments, several ion-induced and neutral nucleation events were observed.



Size distributions of negative (upper panel) and positive ions (lower panel) during a nucleation experiment in the CLOUD campaign in summer 2011. Nucleating vapours in the chamber are water, sulphuric acid (produced by photo-oxidation of sulphur dioxide) and dimethyl amine. The beam from the CERN Proton Synchrotron is ionizing the gas inside the chamber.

Besides experiments performed at CERN, a calibration workshop of particle detectors and sample lines took place at the University of Helsinki. The Finnish team was responsible for the organisation of the workshop and the production of standard-sized particles for calibration purposes.

Data Analysis, Education and Reporting of Results

The data obtained by almost all the 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 2011 campaigns were based on the three runs in 2010 and 2009 and the data obtained from those previous runs, most of the results from all five campaigns cannot stand alone, and a comprehensive data analysis is necessary, encompassing all results obtained so far. This data analysis is still on-going. A data analysis workshop took place at the University of Vienna in February 2011. Most of the analysis is expected to be completed during the next data analysis workshop that will take place at the Hyytiälä field station in February 2012.

Finnish doctoral students working for CLOUD participated in the Marie Curie ITN / CLOUD summer school in Frankfurt (25/09/2011–02/10/2011).

Results from the 2011 summer campaign have been partly reported during the European Aerosol Conference 2011 in Manchester, UK, in September. The first physics paper reporting the results from the 2010 experiments at CLOUD, focusing on the GCR effect on binary (sulphuric acid - water) and ternary (sulphuric acid - water - ammonia) nucleation, was published in Nature (Kirkby et al., Nature 476 (2011) 429). We found that galactic cosmic radiation enhances the nucleation rate of new particles in a pure sulphuric acid - water system. An enhancing effect of ammonia was also found. Conclusions about the significance of these processes in the Earth's atmosphere cannot be drawn before the analysis of the 2011 runs has been completed and enough understanding of the role of organic amines and oxidized volatile organic compounds in particle nucleation has been gained.

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.

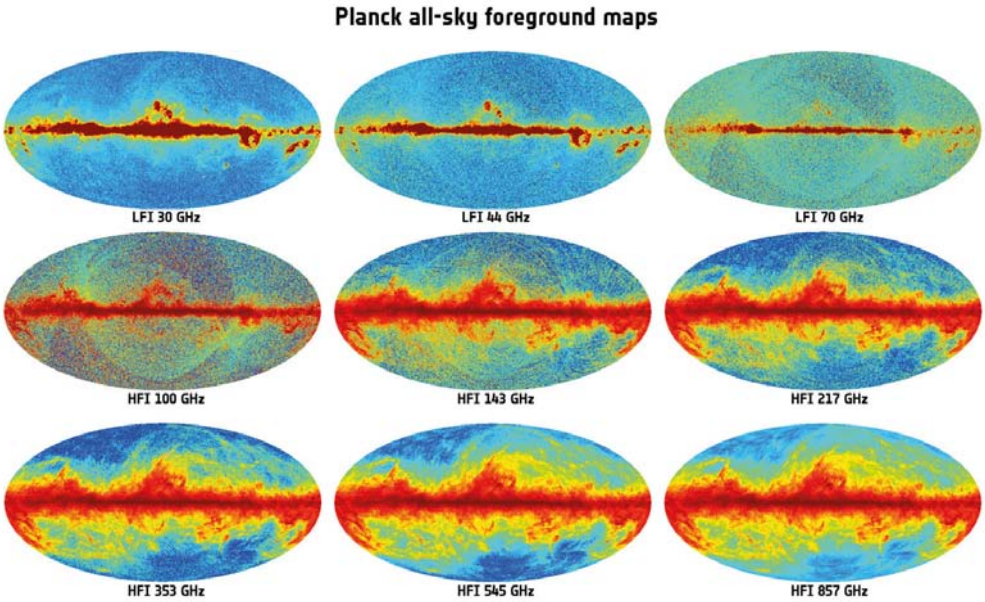
Planck is a European Space Agency (ESA) satellite whose purpose is to observe the CMB over the whole celestial sphere with high resolution and sensitivity and extensive frequency coverage. Planck is a collaboration of over 10 European countries, the USA, and Canada.

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).

Observation Programme

Planck began science observations in August 2009, and by the end of 2011 it had observed the full sky almost five times at all nine frequencies. By then the coolant for the last stage of the satellite's cooling system had almost run out, as scheduled. The operating temperature of LFI is higher than that of HFI, so LFI does not need the last stage, and observations with LFI will continue during 2012 for as long as the instrument remains functional.

The Planck satellite and the Milky Way as seen by it. Credit: ESA/Planck.



All-sky maps of foreground radiation at the nine different Planck frequencies. These are in galactic coordinates, so the strong radiation from the Milky Way appears as a horizontal band. Credit: ESA/Planck Collaboration.

Early Results

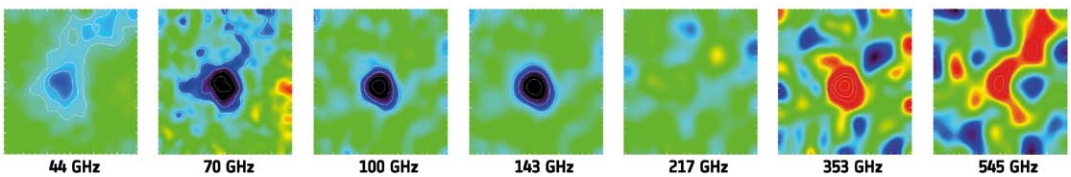
While the analysis of the cosmic microwave background and the derivation of cosmological results will take longer, the first results on the astrophysical foregrounds, based on the first full-sky survey, were published in 2011. This included the release of the Planck Early Release Compact Source Catalogue, containing over 15 000 objects observed by Planck: radio galaxies, blazars, infrared-luminous galaxies, features in the galactic interstellar medium, cold molecular cloud cores, stars with dust shells, galaxy clusters and unidentified objects. We discuss below some of the highlights of these early results from Planck.

Cosmic Infrared Background

Besides the cosmic microwave background, at its higher frequencies Planck has detected the cosmic infrared background, which consists of the light emitted by all galaxies since their formation. At different Planck frequencies the CIB is dominated by different redshifts, and so these observations show the evolution of cosmic structure over time.

Galaxy Clusters

Galaxy clusters contain hot ionized gas in their intergalactic space. This plasma emits X-rays; but it can be observed also via the Sunyaev-Zeldovich effect: CMB photons interacting with the electrons of this plasma are scattered from lower frequencies to higher frequencies. Thus these clusters cast a shadow on the CMB observed by the lower Planck frequencies, but shine at the higher Planck frequencies. This way Planck has detected 189



The galaxy cluster Abell 2319 seen by Planck. At frequencies below 217 GHz, the cluster appears as a shadow in the cosmic microwave background, because it scatters photons to higher frequencies, where the cluster therefore appears as a hot spot. Credit: ESA/ LFI & HFI Consortia.

galaxy clusters; 20 of them new discoveries. For many of the other 169, this was the first time their SZ effect was observed. Since the intensity of the X-ray emission falls as the second power of the electron density, but the SZ effect as the first power, the SZ effect allows observation of the outer, less dense, parts of the clusters.

Spinning Dust

The separation of the CMB from the foreground radiation requires a good understanding of the different kinds of astrophysical foreground radiation. Previously three different kinds of diffuse radiation from our own galaxy were known to be important at Planck frequencies: synchrotron radiation and free-free radiation at the lower frequencies; and thermal emission from dust at the higher frequencies. The results from the WMAP satellite hinted at yet another foreground component at the lower frequencies. This was hypothesized to be radiation from small spinning dust particles. Planck has now confirmed this hypothesis. These are extremely small, nanoscale dust particles spun up by collisions with atoms and photons. They rotate up to ten thousand million times per second and emit radiation at between 10 and 60 GHz.

Main Data Analysis

We have continued participating in the main data analysis of Planck and derivation of the cosmological results from them. We are responsible for producing the sky maps for the three lowest frequencies, as well as a number of related tasks, including calibration, estimation of residual noise correlations on the maps, and producing large Monte Carlo simulations (performed at CSC - the Finnish IT Centre for Science) of the data. These simulations are needed to support the analysis of flight data. For this purpose we received an award of 2.5 million CPUh of computing time at the CSC supercomputer Louhi, from the European supercomputer consortium PRACE for the period November 2011 - October 2012.

We also participate in the estimation of cosmological parameters and constraints on inflation models from the CMB angular power spectra. The cosmological results from the first 15 months of Planck data should be ready by the end of 2012 and published in early 2013, when these 15 months of data will be published, as their proprietary period ends.

Administration

Mikko Sainio

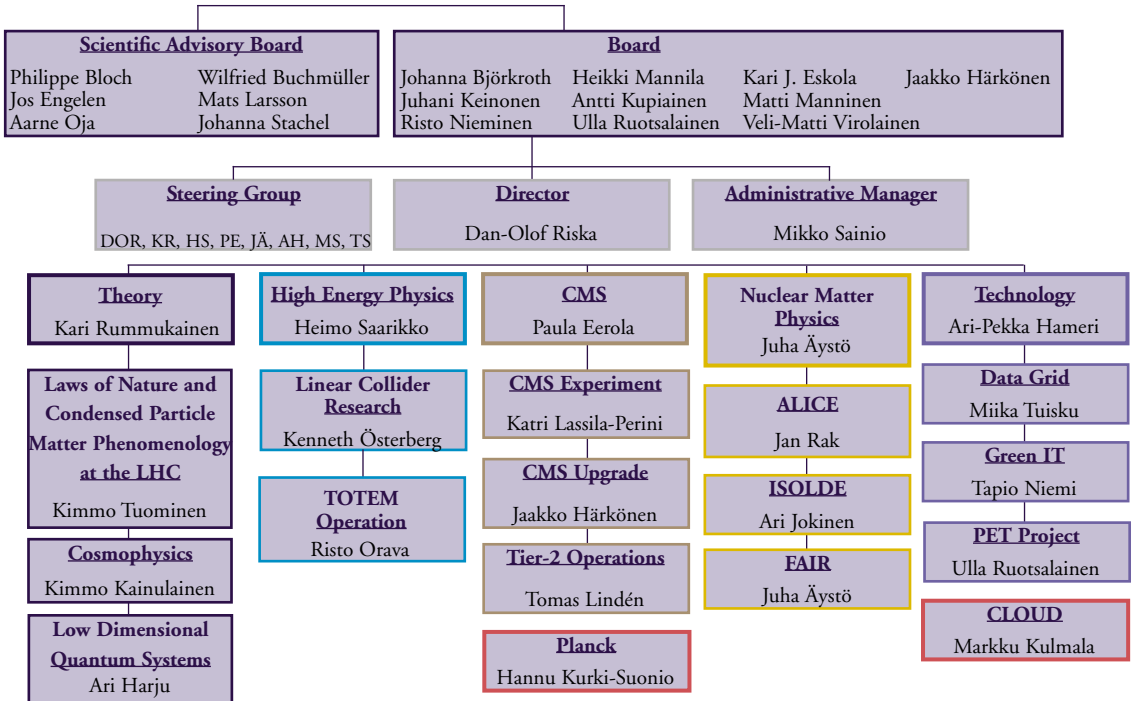
The graduate education of physics students continues to be one of the main tasks of the Institute. During the past year HIP has collaborated with the Graduate School in Particle and Nuclear Physics (GRASPANP) and the Finnish Doctoral Programme in Computational Sciences (FICS) that are sponsored by the Ministry of Education. In addition to the graduate students who 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 2007-2011, 42 doctoral degrees and 60 Masters' degrees have been earned in HIP research projects.

The National Board of Education (Opetushallitus) has continued the collaboration with HIP and the Jyväskylä Educational Consortium 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 2011 this programme attracted 371 Finnish students and 60 of their teachers. A related programme has been to bring high school physics teachers to CERN for continuing education courses. In 2011, 16 teachers participated in this programme. These visits have generated considerable coverage in local newspapers all over the country: about 20 articles in total in 2011. In addition, Askola High School has had broad coverage of the CERN study visit in their school magazine.

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



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M. Valtonen, prof., adj. senior scientist
O. Dannenberg, grad. student
M. D'Onofrio, grad. student

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V. Marra, scientist
O. Taanila, scientist
J. Virkajärvi, scientist
A. Ferrantelli, adj. scientist
D. Figueroa, adj. scientist
S. Hotchkiss, adj. scientist
B. Hoyle, adj. scientist
R. Lerner, adj. scientist
M. Mattsson, grad. student
T. Meriniemi, grad. student
J. Pasanen, grad. student
M. Pääkkönen, grad. student
P. Rahkila, grad. student
U. Bertello, student
A. Helou, student

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P. Hoyer, prof., adj. senior scientist
K. Huitu, prof., adj. senior scientist
J. Maalampi, prof., adj. senior scientist
E. Keski-Vakkuri, adj. senior scientist
H. Fukano, scientist
K. Ghosh, scientist
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K. Rao, scientist
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T. Alho, grad. student
M. Antola, grad. student
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I. Helenius, grad. student
H. Holopainen, grad. student
T. Honkavaara, grad. student
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V. Keränen, grad. student
S. Kurki, grad. student
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A. Mykkänen, grad. student
J. Rantaharju, grad. student
T. Rüppell, grad. student
A. Sabanci, grad. student
J. Suorsa, grad. student
V. Suur-Uski, grad. student
P. Tiitola, grad. student
T. Alanne, student

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E. Tölö, scientist
I. Makkonen, adj. scientist
M. Ervasti, grad. student
M. Ijäs, grad. student
J. Särkkä, grad. student
T. Hiltunen, student
T. Vanhala, student

Radiation Damage in Particle Accelerator Materials

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O. Pakarinen, adj. scientist
K. Avchachov, grad. student
E. Holmström, grad. student
S. Parviainen, grad. student
A. Pohjonen, grad. student
A. Ruzibaev, grad. student
H. Timkó, grad. student
F. Granberg, student
A. Leino, student

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TOTEM Operation

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T. Aaltonen, grad. student
E. Brücken, grad. student
F. Devoto, grad. student
T. Hildén, grad. student
P. Mehtälä, grad. student
J. Welti, grad. student
A. Winkler, grad. student
M. Kuusela, student

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J. Väinölä, researcher
F. Oljemark, grad. student
S. Laine, student
R. Raatikainen, student
J. Turunen, student

Detector Laboratory

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E. Tuominen, lab. coordinator
J. Heino, lab. engineer
R. Lauhakangas, lab. engineer
R. Turpeinen, lab. technician

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A.-M. Visuri, student

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V. Azzolini, senior scientist (at CERN)
V. Karimäki, senior scientist
R. Kinnunen, senior scientist
S. Lehti, senior scientist (at CERN)
T. Lampén, scientist
L. Wendland, scientist
M. Voutilainen, adj. scientist
G. Fedi, grad. student
P. Kaitaniemi, grad. student (in Saclay)
M. Kortelainen, grad. student
J. Pekkanen, student

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I. Kassamakov, senior scientist
E. Tuominen, senior scientist
P. Luukka, scientist (at CERN)
T. Mäenpää, scientist
E. Tuovinen, scientist
D. Fusi, grad. student
T. Peltola, grad. student
T. Arsenovich, student
H. Moilanen, student

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T. Lindén, Dr., proj. leader, grid coordinator
J. Välimaa, grad. student
K. Happonen, student
J. Orava, student

Nuclear Matter Programme

J. Äystö, prof., programme director

ALICE

J. Rak, docent, proj. leader
F. Krizek, scientist
S. Räsänen, scientist
B. Chang, grad. student
J. Kral, grad. student
N. Novitzky, grad. student

ISOLDE

A. Jokinen, prof., 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, MSc, proj. leader (at CERN)
J. White, senior scientist (at CERN)
J. Hahkala, scientist (at CERN)
H. Mikkonen, scientist (at CERN)
M. Närjänen, student
A. Peltoniemi, student
M. Tuominen, student

Green IT

T. Niemi, Dr., proj. leader (at CERN)
M. Niinimäki, scientist (at CERN)
J. Kommeri, grad. student (at CERN)
O. Helin, student
Y. Laqbayli, student
M. Sevalnev, student

PET Project

U. Ruotsalainen, prof., proj. leader
V. Koivu, scientist

CLOUD

M. Kulmala, prof., proj. leader
J. Duplissy, scientist
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, adj. scientist
M. Savelainen, grad. student
A.-S. Suur-Uski, grad. student
K. Kiiveri, student
V. Lindholm, student
S. Rusak, student

Administration and Support

D.-O. Riska, prof., director
M. Sainio, docent, adm. manager
T. Sandelin, financial manager
T. Hardén, secretary
T. Karppinen, secretary (at CERN)
T. Kiljunen, secretary (starting 27.6.2011)
T. Onnela, secretary (at CERN)
P. Rantanen, secretary (until 18.4.2011)
A. Heikkilä, tech. coordinator (at CERN)
R. Rinta-Filppula, ped. expert (at CERN)
J. Aaltonen, lab. engineer

Seminars

Seminars held in Helsinki

January 13th
Particle theory 2-minute meeting

February 1st S. Kurki (Helsinki)
Measuring transverse shape with virtual photons

February 8th V. Khoze (Durham, UK)
Luminosity measurements at the LHC: theoretical assessment

February 10th V. Ziemann (Uppsala, Sweden)
A milestone on the road to CLIC: testing the the two-beam acceleration scheme in the two-beam test stand at CERN

February 15th A. Polosa (Roma Sapienza Univ., Italy)
From scalar mesons to XYZ spectroscopy

March 1st R. Lerner (HIP)
Higgs inflation: what happens next?

March 22nd C. Pica (CP3-Origins, Odense, Denmark)
Topics in strong gauge dynamics with infrared fixed points

March 24th J. Casalderrey Solana (CERN, Switzerland)
Jet quenching via jet collimation

April 5th D. Weir (Imperial College, London, UK)
Dynamics of classical and quantum monopoles

April 12th E. Sefusatti (CEA/Saclay, Paris, France)
Testing the initial conditions with the large-scale structure of the Universe

April 14th J. Rantaharju (Helsinki)
Walking dynamics on the lattice

April 18th A. Hietanen (Swansea, UK)
Eguchi-Kawai model with adjoint fermions

April 19th M. Långvik (Helsinki)
Dirac quantization of monopoles in noncommutative space-time

April 26th K. Kajantie (Helsinki)
Response functions of hot QCD matter from 5-dimensional gravity

May 3rd J. Lehtola (Helsinki)
Inelastic X-ray scattering as a tool in materials science

May 10th D. Blas (Lausanne, Switzerland)
Quantum gravity without relativity

May 17th S. Szybka (Jagellonian Univ., Cracow, Poland)
Angular diameter distance in Swiss-cheese models

May 31st L. Wendland (Helsinki)
Status of Higgs boson searches in the CMS experiment at the CERN LHC

June 6th C. Montonen (Helsinki)
On Arnold's principle and further digressions

June 7th J. García-Bellido (Madrid, Spain)
The growth factor as a key observable for exploring the nature of dark energy

June 14th P. Bandyopadhyay (KIAS, Republic of Korea)
Aspects of Higgs searches in CP-violating MSSM at the Large Hadron Collider

June 21st O. Kong (NCU, Taiwan)
A new paradigm for dynamical symmetry breaking with supersymmetry

June 22nd J. Louko (Nottingham, UK)
Localised quantum information for accelerated observers

July 5th M. Strikman (Penn State Univ., USA)
Transverse structure of fast nucleons and pp collisions at the LHC

August 16th K. Fujikawa (Institute of Quantum Science, Nihon Univ., Tokyo, Japan)
Remark on the subtractive renormalization of quadratically divergent scalar mass

August 23rd J. Erdmenger (Munich, Germany)
String theory methods for the real world

August 30th S. Sheikh-Jabbari (IPM, Tehran, Iran)
Gauge-flation: inflation from non-Abelian gauge fields

September 6th R. Kinnunen (Helsinki)
Higgs results from CMS

September 13th K. Österberg (Helsinki)
First physics results from TOTEM at LHC

September 16th S. Khalil (BUE, Cairo, Egypt)
Phenomenological aspects of SUSY B-L extension of the SM

September 20th K. Splittorff (NBI, Copenhagen, Denmark)
The Wilson spectrum close to the continuum

September 27th D. Mulryne (Queen Mary, Univ. London, UK)
Evolution of non-Gaussianity in multi-field models

October 4th A. Kurkela (McGill, Montreal, Canada)
Thermalisation in collisions of extremely large nuclei at extremely large energies

October 18th P. Hoyer (Helsinki)
Bound states in field theory

October 25th O. Antipin (Odense, Denmark)
Light dilaton

November 1st M. Roos (Helsinki)
Glashow's cake problem

November 3rd J. Laamanen (Nijmegen, The Netherlands)
Stop NLSP in cMSSM

November 8th M. Antola (Helsinki)
Supersymmetric technicolor

November 15th K. Ghosh (Helsinki)
Diphoton events with large missing transverse energy at the LHC

December 8th L. Fritz (Cologne, Germany)
Interaction effects in transport in Dirac systems

December 13th H. Weigert (Cape Town, South Africa)
The Color Glass Condensate: QCD at modern collider facilities

Visitors

Theory Programme

Cosmophysics

B. Hoyle (Spain) 11.-19.1., 28.2.-4.3., 11.-15.4., 2.-6.5., 23.-25.5., 11.7.-12.8., 15.-19.8.
W. Valkenburg (Germany) 20.-26.3., 15.-19.8.
S. Nadathur (UK) 11.-13.4., 15.-19.8.
E. Sefusatti (France) 12.-15.4.
A. Rajantie (UK) 28.-29.4.
F. Sylos Labini (Italy) 4.-6.5.
D. Blas (Switzerland) 9.-13.5.
T. Takahashi (Japan) 11.-19.5.
S. Szybka (Poland) 16.-20.5.
G. Rigopoulos (Germany) 30.5.-21.6., 15.-19.8.
J. García-Bellido (Spain) 6.-10.6.
C. Byrnes (Germany) 9.-10.6.
K. Bolejko (UK) 15.-19.8.
P. Bull (UK) 15.-19.8.
M.-N. Celerier (France) 15.-19.8.
C. Clarkson (South Africa) 15.-19.8.
Ø. Elgarøy (Norway) 15.-19.8.
S. Green (USA) 15.-19.8.
S. Hannestad (Denmark) 15.-19.8.
T. Haugboelle (Denmark) 15.-19.8.
A. Ishibashi (Japan) 15.-19.8.
H. Kodama (Japan) 15.-19.8.
R. Kolb (USA) 15.-19.8.
M. Mattsson (New Zealand) 15.-19.8.
T. Mattsson (New Zealand) 15.-19.8.
R. Nishikawa (Japan) 15.-19.8.
L. Perivolaropoulos (Greece) 15.-19.8.
K. Saito (Japan) 15.-19.8.
D. Schwarz (Germany) 15.-19.8.
T. Shanks (UK) 15.-19.8.
T. Singh (India) 15.-19.8.
A. Stebbins (USA) 15.-19.8.
O. Umeh (South Africa) 15.-19.8.
E. Villa (Italy) 15.-19.8.
R. Wald (USA) 15.-19.8.
D. Wiltshire (New Zealand) 15.-19.8.
C.-M. Yoo (Japan) 15.-19.8.
J. Zibin (Canada) 15.-19.8.
K. Kohri (Japan) 6.-12.9.
D. Mulryne (UK) 26.-30.9.
K. Jones-Smith (USA) 28.9.-3.10.
J. Urrestilla (Spain) 6.-12.10.
F. Sannino (Denmark) 7.-9.10.
J. Bueno Sánchez (Spain) 10.10.2011-31.1.2012
F. Riva (Spain) 18.-25.10.
J. M. No (France) 21.-28.10.
O. Taanila (Germany) 27.10.-10.11.

Laws of Nature and Condensed Particle Matter Phenomenology at the LHC

Y. Zhu (Germany) 3.-6.1., 8.-14.8.
J. Laamanen (The Netherlands) 3.-9.1., 6.-20.3.
H. Niemi (Germany) 4.1.
P. Huovinen (Germany) 17.-21.1.
A. Vuorinen (Germany) 3.-7.2., 24.3.-8.4., 30.5.-1.6., 25.7.-31.8., 19.12.2011-5.1.2012
M. Ruggieri (Japan) 7.-11.2.
A. D. Polosa (Italy) 13.-16.2.
D. Rischke (Germany) 18.2.-1.3.
J. Kuokkanen (Finland) 21.-24.2.
A. Rajantie (UK) 23.-25.2., 28.-29.4., 11.-12.8.
C. Pica (Denmark) 19.-24.3.
J. Casalderrey Solana (Switzerland) 19.-26.3.
T. Brauner (Germany) 27.3.-3.4., 1.-11.8.
M. Krššák (Germany) 3.-8.4., 15.-19.8.
D. J. Weir (UK) 3.-9.4.
M. Alvioli (Italy) 10.-30.4.
A. Hietanen (UK) 17.-21.4.
P. Bandyopadhyay (Repbulic of Korea) 4.-19.6.
S. Hannestad (Denmark) 8.6.
M. Strikman (USA) 20.-22.6., 3.-5.7.
O. Kong (Taiwan) 20.-26.6.
A. Kurkela (Canada) 21.6.-11.7., 24.9.-10.10., 14.10.
A. Tranberg (Denmark) 25.-29.7., 29.10.-2.11.
S. F. Ross (UK) 8.-11.8.
D. Teaney (USA) 14.-17.8.
J. Erdmenger (Germany) 22.-25.8.
B. Schenke (USA) 22.-26.8.
K. Splittorff (Denmark) 19.-21.9.
S. Hossenfelder (Sweden) 6.-7.10.
L. Bhattacharya (India) 13.10.
M. Vanderhaeghen (Germany) 13.-15.11.
H. Weigert (South Africa) 12.-15.12.
M. Järvinen (Greece) 19.12.2011-5.1.2012

Radiation Damage in Particle Accelerator Materials

W. Wuensch (Switzerland) 8.-11.12.

CMS Programme

H. Sadrozinski (USA) 26.-28.5.

Conference participation, Talks and Visits by Personnel

Theory Programme

Cosmophysics

Queen Mary, University of London,
16 January, London, UK (talk by R. Lerner)

University of Southampton,
17 January, Southampton, UK (talk by R. Lerner)

Bielefeld University,
17-19 January, Bielefeld, Germany (O. Taanila)

Imperial College,
23-31 January, London, UK (talk by D. Figueroa)

Saclay SPhT,
4-13 February, Paris, France (talk by D. Figueroa)

University of Oxford,
21-25 February, Oxford, UK (talk by S. Hotchkiss)

NORDITA,
6-14 March, Stockholm, Sweden (talk by S. Räsänen)

ICTP,
7-11 March, Trieste, Italy (talk by S. Hotchkiss)

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

University of Sussex,
18 March, Sussex, UK (R. Lerner)

46th Rencontres de Moriond,
18-28 March, La Tuile, Italy (D. Figueroa)

The Annual Meeting of the Finnish Physical Society,
29-31 March, Helsinki, Finland (talk by R. Lerner, T. Meriniemi)

Finnish Cosmophysics Meeting,
20-21 April, Tampere, Finland (K. Enqvist, talk by D. Figueroa, talk by S. Hotchkiss, K. Kainulainen, talk by R. Lerner, talk by V. Marra, talk by T. Meriniemi, talk by M. Pääkkönen, talk by P. Rahkila, talk by S. Räsänen, talk by O. Taanila, talk by J. Virkajärvi)

Euclid Science Workshop,
23-24 May, Space Science Center, Copenhagen, Denmark (talk by K. Kainulainen, P. Rahkila)

Niels Bohr International Academy,
24-27 May, Copenhagen, Denmark (O. Taanila)

University of Sussex,
25 May, Sussex, UK (talk by S. Räsänen)

University of Oxford,
26 May, Oxford, UK (talk by S. Räsänen)

University of Nottingham,
3 June, Nottingham, UK (talk by S. Räsänen)

PPC 2011,
13-20 June, CERN, Geneva, Switzerland (invited talk by D. Figueroa, R. Lerner)

University of Sussex,
20-23 June, Sussex, UK (talk by R. Lerner)

University of Utrecht,
21-23 June, Utrecht, The Netherlands (K. Kainulainen)

University of Barcelona,
27-29 June, Barcelona, Spain (talk by R. Lerner)

IFT-Madrid,
27 June - 8 July, Madrid, Spain (D. Figueroa)

University of Sheffield,
4 July, Sheffield, UK (talk by R. Lerner)

Lancaster University,
5-8 July, Lancaster, UK (R. Lerner)

Imperial College,
10-15 July, London, UK (D. Figueroa)

Inhomogenous Cosmologies,
15-19 August, Jyväskylä, Finland (talk by S. Hotchkiss, K. Kainulainen, talk by V. Marra, M. Mattsson, talk by M. Pääkkönen, talk by S. Räsänen)

Cosmo 11,
21-27 August, Porto, Portugal (K. Enqvist, talk by D. Figueroa, S. Hotchkiss, talk by R. Lerner, T. Meriniemi, talk by O. Taanila)

CERN,
1 September 2011 - 31 August 2012, Geneva, Switzerland (K. Kainulainen)

Baryogenesis and First Order Phase Transitions in the Early Universe,
7-9 September, Lorentz Center, Leiden, The Netherlands (talk by K. Kainulainen)

Clusters of Galaxies as Cosmic Laboratories,
12-14 September, Alba Nova, Stockholm, Sweden (talk by S. Hotchkiss)

The Dark Universe Conference,
4-7 October, Heidelberg, Germany (talk by K. Kainulainen)

IFT-Madrid,
16-27 November, Madrid, Spain (D. Figueroa)

IAP,
22-23 November, Paris, France (talk by S. Räsänen)

University of Oxford,
24-25 November, Oxford, UK (talk by K. Enqvist)

University of Pavia,
25 November, Pavia, Italy (talk by S. Räsänen)

University of Copenhagen,
8-9 December, Copenhagen, Denmark (talk by K. Enqvist)

UNIGE,
11-20 December, Geneva, Switzerland (D. Figueroa)

Bielefeld University,
12-16 December, Bielefeld, Germany (talk by S. Hotchkiss)

Laws of Nature and Condensed Particle Matter Phenomenology at the LHC

Laboratoire de Physique Theorique et Hautes Énergies, Universite P. et M. Curie,
5-7 January, Paris, France (talk by P. Hoyer)

Workshop: AdS/CFT and Condensed Matter,
10-11 January, Institute for Mathematical Sciences, Imperial College, London, UK (E. Keski-Vakkuri)

University of Bielefeld,
17-21 January, Bielefeld, Germany (talk by M. D'Onofrio)

University of Jyväskylä,
31 January - 3 February, Jyväskylä, Finland (M. Antola)

The Niels Bohr Institute,
1 February - 31 March, Copenhagen, Denmark
(T. Markkanen)

Workshop PANDA,
3 February, Paris, France (talk by P. Hoyer)

In-Medium Effects in Hadronic and Partonic Systems,
21-25 February, Obergurgl, Austria (talk by P. Hoyer)

Imperial College,
28 February - 5 March, London, UK (talk by M. D'Onofrio)

University of Jyväskylä,
1-3 March, Jyväskylä, Finland (M. Antola)

LAGUNA General Meeting,
3-5 March, CERN, Geneva, Switzerland (J. Maalampi)

Institut für Kernphysik, Johannes Gutenberg Universität Mainz,
6-12 March, Mainz, Germany (talk by P. Hoyer)

Uppsala University,
7-9 March, Uppsala, Sweden (E. Keski-Vakkuri)

J. W. Goethe University,
7-12 March, Frankfurt, Germany (talk by H. Holopainen)

RECFA Meeting,
11-12 March, Vienna, Austria (K. Huitu)

The Annual Meeting of the Finnish Physical Society,
29-31 March, Helsinki, Finland (J. Auvinen, M. D'Onofrio, talk by K. J. Eskola, I. Helenius, P. Hoyer, K. Kajantie, talk by S. Kurki, talk by T. Lappi, talk by J. Rantaharju, K. Rummukainen)

6th International Workshop High-pT Physics at LHC 2011,
4-7 April, Utrecht, The Netherlands (talk by J. Auvinen, K. J. Eskola, I. Helenius, talk by T. Renk)

University of Oulu,
12 April, Oulu, Finland (K. Rummukainen)

Finnish Cosmophysics Meeting,
20-21 April, Tampere, Finland (talk by M. D'Onofrio, K. Rummukainen)

LAGUNA Meeting,
5 May, Pyhäjärvi, Finland (K. Rummukainen)

Kosmologie Tag,
5-6 May, IBZ, Bielefeld, Germany (M. D'Onofrio)

ECFA Neutrino Panel Meeting,
5-6 May, Daresbury Laboratory, Warrington, UK
(J. Maalampi)

CP3-Origins, University of Southern Denmark,
8-20 May, Odense, Denmark (P. Hoyer)

University of Bielefeld,
9-11 May, Bielefeld, Germany (talk by K. Rummukainen)

Origin of Mass 2011,
9-13 May, Odense, Denmark (T. Alho, M. Antola, P. Hoyer, K. Huitu, T. Karavirta, K. Tuominen)

Quark Matter 2011,
23-28 May, Annecy, France (talk by J. Auvinen, K. J. Eskola, I. Helenius, talk by H. Holopainen, K. Kajantie, T. Kähärä, talk by T. Renk)

CSC Summer School in Scientific and High-Performance Computing,
23 May - 3 June, Nuuksio National Park, Espoo, Finland
(M. D'Onofrio, A. Mykkänen)

RECFA Meeting,
27-28 May, Kosice, Slovakia (K. Huitu)

Johannes Gutenberg Universität Mainz,
29 May - 9 June, Mainz, Germany (S. Kurki)

2nd International Workshop towards the Giant Liquid Argon Charge Imaging Experiment (GLA2011),
5-9 June, Jyväskylä, Finland (J. Maalampi)

University of Jyväskylä,
6-8 June, Jyväskylä, Finland (M. Antola)

ICTP Summer School on Particle Physics,
6-17 June, The Abdus Salam ICTP, Trieste, Italy
(M. D'Onofrio)

Workshop: Black Hole Answers for Condensed Matter Questions,
13-17 June, Lorentz Center, Leiden, The Netherlands
(E. Keski-Vakkuri)

Enrico Fermi Institute, University of Chicago,
14 June, Chicago, IL, USA (P. Hoyer)

2011 STRONGnet Summer School,
14-25 June, ZiF, University of Bielefeld, Germany
(A. Mykkänen, talk by K. Rummukainen)

Phenomenology Institute, University of Wisconsin,
16-17 June, Madison, WI, USA (talk by P. Hoyer)

STRINGS 2011,
27 June - 1 July, Uppsala University, Uppsala, Sweden
(E. Keski-Vakkuri)

ESF Network: Holographic Methods for Strongly Coupled Systems,
29 June, Paris, France (talk by K. Kajantie)

GSI and TU Darmstadt,
4-8 July, Darmstadt, Germany (talk by T. Kähärä)

The XXIX International Symposium on Lattice Field Theory,
11-16 July, Squaw Valley, CA, USA (talk by T. Karavirta)

Prospects in Theoretical Physics: "Frontiers of Physics in Cosmology",
18-29 July, Institute for Advanced Studies, Princeton, NJ, USA
(talk by M. D'Onofrio)

CERN,
19-23 July, Geneva, Switzerland (K. Kajantie)

EPS HEP Conference and European Strategy Kick-Off Meeting,
21-27 July, Grenoble, France (K. Huitu)

Conference on "Cold Materials, Hot Nuclei and Black Holes",
16-20 August, The Abdus Salam ICTP, Trieste, Italy
(E. Keski-Vakkuri)

Scalars 2011,
26-29 August, Warsaw, Poland (talk by M. Antola, K. Huitu)

19th International Conference on Supersymmetry and Unification of Fundamental Interactions,
28 August - 2 September, Fermilab, Batavia, IL, USA
(T. Honkavaara, T. Rüppell)

Transversity 2011,
29 August - 2 September, Losjin, Croatia (talk by P. Hoyer)

ALICE Collaboration Meeting,
2 September, Jyväskyla, Finland (talk by K. J. Eskola, talk by K. Kajantie, talk by T. Renk)

The Network Workshop 'TORIC',
5-8 September, Crete, Greece (talk by J. Auvinen, talk by I. Helenius)

12th International Conference on Topics in Astroparticle and Underground Physics (TAUP 2011),
5-9 September, Munich, Germany (J. Maalampi)

Strategy Preparatory Group Meeting,
9 September, Geneva, Switzerland (K. Huitu)

University of Jyväskylä,
13-15 September, Jyväskylä, Finland (M. Antola)

CP3 Origins,
19-23 September, Odense, Denmark (M. Antola)

SM & FT 2011, The XV Workshop on Statistical Mechanics and Nonperturbative Field Theory,
21-23 September, Bari, Italy (talk by A. Mykkänen)

XLI International Symposium of Multiparticle Dynamics (ISMD2011),
26-30 September, Miyajima Island, Japan (talk by T. Renk)

Partons in Nucleons and Nuclei 2011,
26-30 September, Marrakech, Marocco (talk by P. Hoyer)

The Niels Bohr Institute,
1-31 October, Copenhagen, Denmark (M. D'Onofrio)

ICFA Seminar,
2-6 October, Geneva, Switzerland (K. Huitu)

CERN,
10-12 October, Geneva, Switzerland (talk by J. Rantaharju)

NORDITA,
13-14 October, Stockholm, Sweden (E. Keski-Vakkuri)

Workshop: Chiral Dynamics with Wilson Fermions,
14-18 October, ECT* Trento, Italy (talk by K. Rummukainen)

CERN,
17-18 October, Geneva, Switzerland (talk by K. J. Eskola)

LAGUNA-LBNO General Meeting,
17-19 October, CERN, Geneva, Switzerland (J. Maalampi)

Strategy Preparatory Group Meeting,
21 October, Geneva, Switzerland (K. Huitu)

Particle Physics Day 2011,
28 October, Helsinki, Finland (talk by M. Antola, talk by J. Auvinen, K. J. Eskola, talk by I. Helenius, K. Kajantie, talk by T. Lappi, K. Rummukainen, K. Tuominen)

Vrije Universiteit Brussel / Solvay Institute,
8-11 November, Brussels, Belgium (talk by E. Keski-Vakkuri)

Helsinki Institute of Physics and Aalto University, HIP Board Working Group Meeting,
15 November, Helsinki, Finland (K. J. Eskola)

De Finlandssvenska Fysik- och Kemidagarna 2011,
19-20 November, Silja Cruise, Finland and Sweden (talk by P. Hoyer)

Workshop on Multi-Parton Interactions at the LHC,
21-25 November, DESY, Hamburg, Germany (talk by T. Lappi)

RECFA Meeting,
24-25 November, Geneva, Switzerland (K. Huitu)

Strategy Preparatory Group Meeting,
28 November, Geneva, Switzerland (K. Huitu)

University of Santiago de Compostela,
29 November - 2 December, Santiago de Compostela, Spain (talk by J. Auvinen)

NORDITA, Meeting of the Subfield Committee of Subatomic Physics,
8 December, Stockholm, Sweden (K. J. Eskola, E. Keski-Vakkuri)

Helsinki Institute of Physics, HIP Board Meeting,
9 December, Helsinki, Finland (K. J. Eskola)

University of Oulu,
10-11 December, Oulu, Finland (K. Rummukainen)

Nikhef and Vrije Universiteit,
16-21 December, Amsterdam, The Netherlands (P. Hoyer)

Hadron Physics Activity

1. FAIR/AFC Meeting,
1-2 February, Darmstadt, Germany (M. Sainio)

The Annual Meeting of the Finnish Physical Society,
29-31 March, Helsinki, Finland (M. Sainio)

2. FAIR/AFC Meeting,
11-12 May, Darmstadt, Germany (M. Sainio)

International Europhysics Conference on High Energy Physics,
24-27 July, Grenoble, France (M. Sainio)

School of Amplitude Analysis in Modern Physics from Hadron Spectrocopy to CP Phases,
1-4 August, Bad Honnef, Germany (M. Sainio)

3. FAIR/AFC Meeting,
4-5 October, Darmstadt, Germany (M. Sainio)

Low Dimensional Quantum Systems

The Annual Meeting of the Finnish Physical Society,
29-31 March, Helsinki, Finland (A. Harju)

Imaginenano 2011,
11-14 April, Bilbao, Spain (A. Harju)

Lancaster Comp2DM,
14-16 September, Lancaster, UK (talk by A. Harju)

Radiation Damage in Particle Accelerator Materials

European Materials Research Society Annual Spring Meeting,
9-13 May, Nice, France (talk by F. Djurabekova, symposium co-organizer, K. Nordlund, chairman, symposium organizer, talk by O. Pakarinen, S. Parviainen)

CERN,
22-24 May, Geneva, Switzerland (K. Nordlund)

CERN,
22-27 May, Geneva, Switzerland (F. Djurabekova)

CERN,
22 May - 11 June, Geneva, Switzerland (S. Parviainen)

International Workshop on Mechanisms of Vacuum Arcs (MeVArc),
28-30 June, Helsinki, Finland (invited talk by F. Djurabekova, organizer, K. Nordlund, organizer, talk by S. Parviainen, talk by A. Pohjonen, talk by H. Timko)

Radiation Effects in Insulators,
14-21 August, Beijing, China (invited talk by F. Djurabekova, talk by K. Nordlund)

Materials Research Society Annual Fall Meeting,
27-30 November, Boston, MA, USA (F. Djurabekova, invited talk by K. Nordlund, S. Parviainen)

High Energy Physics Programme

TOTEM Operation

ECT Workshop,
6 January, Trento, Italy (invited plenary talk by R. Orava)

The Tanner Academy, Väinö Tanner Foundation,
17 February, Helsinki, Finland (invited talk by R. Orava)

TOTEM Collaboration Board Meeting,
28-30 March, Kirchberg, Austria (H. Saarikko)

The Annual Meeting of the Finnish Physical Society,
29-31 March, Helsinki, Finland (J. Welti)

AFO Day,
31 May, Helsinki, Finland (talk by R. Orava)

Low-x Meeting 2011,
3-7 June, Santiago de Compostela, Spain (talk by E. Brücken, invited plenary talk by R. Orava)

TOTEM Collaboration Board Meeting,
15-17 June, CERN, Geneva, Switzerland (H. Saarikko)

International Europhysics Conference on High Energy Physics, HEP 2011,
21-27 July, Grenoble, Rhone-Alpes, France (talk by E. Brücken)

Helsinki Institute of Physics, HIP Scientific Board,
31 August, Helsinki, Finland (talk by R. Orava)

Wilhelm and Else Heraeus Summerschool: Diffractive and Electromagnetic Processes at High Energies,
5-9 September, Heidelberg, Germany (best poster by E. Brücken)

TOTEM Collaboration Board Meeting,
21-22 September, CERN, Geneva, Switzerland (H. Saarikko)

CDF Collaboration Meeting,
26 September - 3 October, Batavia, IL, USA (E. Brücken)

Particle Physics Day 2011,
28 October, Helsinki, Finland (talk by E. Brücken, J. Welti, co-organizer)

TOTEM Collaboration Board Meeting,
7-9 December, CERN, Geneva, Switzerland (H. Saarikko)

TOTEM Physics and Analysis Meetings,
Geneva, Switzerland (talk by J. Welti)

Linear Collider Research

TIARA Kickoff Meeting,
23-24 February, CERN, Geneva, Switzerland (K. Österberg)

LHC Committee Open Session,
23 March, CERN, Geneva, Switzerland (invited talk by K. Österberg)

TOTEM Collaboration Meeting,
28-30 March, Kirchberg, Austria (F. Oljemark, talk by K. Österberg)

The Annual Meeting of the Finnish Physical Society,
29-31 March, Helsinki, Finland (K. Österberg, session chairman)

EuCARD Annual Meeting and EuCARD Governing Board,
11-13 May, CNRS-IN2P3, Paris, France (K. Österberg)

International Workshop on Mechanisms of Vacuum Arcs (MeVArc),
27-30 June, Helsinki, Finland (talk by K. Österberg)

2nd Interactional Particle Accelerator Conference (IPAC11),
4-9 September, San Sebastian, Spain (R. Raatikainen)

Marie Curie IAPP MeChanICs Annual Project Meeting,
5-6 September, CERN, Geneva, Switzerland (talk by J. Turunen, J. Väinölä, organizer, K. Österberg, organizer)

Particle Physics Day 2011,
28 October, Helsinki, Finland (talk by K. Österberg, co-organizer)

CLIC Collaboration Meeting on 2012-16 Work Packages,
3-4 November, CERN, Geneva, Switzerland (J. Väinölä, talks by K. Österberg)

3rd International Workshop on Multiple Partonic Interactions at the LHC,
21-24 November, DESY, Hamburg, Germany (invited talk by K. Österberg)

CLIC/CTF3 Collaboration Board Meetings,
CERN, Geneva, Switzerland (K. Österberg)

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

TOTEM Physics and Analysis Meetings,
Geneva, Switzerland (talks by F. Oljemark and K. Österberg, co-organizer)

CLIC Module Working Group,
CERN, Geneva, Switzerland (talks by R. Raatikainen)

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

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

Marie Curie IAPP MeChanICs Meetings,
CERN, Geneva, Switzerland (J. Väinölä, organizer, K. Österberg, organizer)

Detector Laboratory

7th RD51 Collaboration Meeting,
13-14 April, CERN, Geneva, Switzerland (talk by F. García)

8th RD51 Collaboration Meeting,
2-3 September, Kobe, Japan (talk by F. García)

2nd JointGEM Meeting,
25 November, Vienna, Austria (talk by F. García)

CMS Programme

CMS Physics Week,
7-11 February, CERN, Geneva, Switzerland (P. Eerola)

Fermi National Laboratory,
12 March - 3 April, Batavia, IL, USA (P. Luukka, T. Mäenpää, T. Peltola, E. Tuovinen)

The Annual Meeting of the Finnish Physical Society,
29-31 March, Helsinki, Finland (P. Eerola, talk by J. Härkönen, V. Karimäki, R. Kinnunen, talk by M. Kortelainen, T. Lampén, T. Lindén, talk by L. Wendland)

Beauty 2011,
4-8 April, Amsterdam, The Netherlands (P. Eerola, member of the International Advisory Committee)

University of Jyväskylä Colloquium,
29 April, Jyväskylä, Finland (talk by L. Wendland)

The 4th LHC Higgs Cross Section Working Group Workshop at BNL,
4-6 May, Brookhaven National Laboratory, Upton, NY, USA (S. Lehti)

Nordugrid 2011,
9-12 May, Sundvolden, Norway (P. Eerola, talk by T. Lindén)

Mass 2011 Conference and School,
11-13 May, Odense, Denmark (P. Eerola)

Fifth Workshop on Data Preservation and Long Term Analysis in HEP,
16-18 May, Fermi National Laboratory, Batavia, IL, USA (talk by K. Lassila-Perini)

18th RD50 Workshop,
23-25 May, Liverpool, UK (talk by P. Luukka)

RD39 Workshop I-2011,
26 May, Liverpool, UK (talk by P. Luukka, talk by E. Tuominen)

CMS Tracker Alignment Workshop,
30-31 May, DESY, Hamburg, Germany (talk by V. Karimäki, T. Lampén)

University of Stockholm,
1 June, Stockholm, Sweden (P. Eerola)

SNIC Board Meeting,
8-10 June, Reykjavik, Iceland (P. Eerola)

CERN-Fermilab Hadron Collider Physics Summer School,
8-17 June, CERN, Geneva, Switzerland (M. Kortelainen)

Standard Model Benchmarks at High-Energy Hadron Colliders,
15-17 June, DESY, Zeuthen, Germany (talk by M. Voutilainen)

Vertex 2011,
19-24 June, Rust, Austria (invited talk by J. Härkönen)

CMS Collaboration Week,
28 June - 1 July, CERN, Geneva, Switzerland (P. Eerola)

AIDA WP4 Workshop,
30 June, CERN, Geneva, Switzerland (talk by J. Härkönen)

The 2011 Europhysics Conference on High Energy Physics,
21-27 July, Grenoble, France (P. Eerola, member of the International Organizing Committee)

CMS Physics Week,
11-15 September, Brussels, Belgium (talks by P. Eerola, talk by K. Lassila-Perini, M. Voutilainen)

CERN,
20 September - 7 October, Geneva, Switzerland
(H. Moilanen, T. Mäenpää, T. Peltola, E. Tuovinen)

ICFA Seminar,
3-5 October, CERN, Geneva, Switzerland (P. Eerola)

Studia Generalia, University of Helsinki,
6 October, Helsinki, Finland (public talk by P. Eerola)

CMS Offline and Computing Week,
16-21 October, CERN, Geneva, Switzerland (T. Lindén)

Cryogenic Beam Loss Monitors Workshop,
18 October, CERN, Geneva, Switzerland (talk by J. Härkönen)

University of Jyväskylä Colloquium,
21 October, Jyväskylä, Finland (talk by R. Kinnunen)

Particle Physics Day 2011,
28 October, Helsinki, Finland (P. Eerola, talk by M. Kortelainen, talk by S. Lehti, talk by T. Lindén, talk by A.-M. Visuri, talk by M. Voutilainen)

University of Stockholm,
4 November, Stockholm, Sweden (R. Kinnunen)

CMS Upgrade Week and Workshop,
7-10 November, Fermi National Laboratory, Batavia, IL, USA (talk by J. Härkönen, talk by P. Luukka)

Royal Swedish Academy of Sciences, Physics Symposium,
15 November, Stockholm, Sweden (invited talk by P. Eerola)

De Finlandssvenska Fysik- och Kemidagarna 2011,
19-20 November, Silja Cruise, Finland and Sweden (invited talk by P. Eerola, talk by T. Lindén)

19th RD50 Workshop,
23-25 November, CERN, Geneva, Switzerland (talk by P. Luukka)

RD39 Workshop II-2011,
26 November, CERN, Geneva, Switzerland (talk by J. Härkönen)

CMS Collaboration Week,
28 November - 2 December, CERN, Geneva, Switzerland (P. Eerola, V. Karimäki, talk by K. Lassila-Perini, talk by M. Voutilainen)

14th Workshop on Elastic and Diffractive Scattering (EDS Blois Workshop),
15-21 December, Qui Nhon, Vietnam (talk by M. Voutilainen)

FAIR

RD51 Simulation School,
19-21 January, CERN, Geneva, Switzerland (M. Kalliokoski)

NUSTAR Annual Meeting 2011,
27 February - 2 March, GSI, Darmstadt, Germany (F. García, A. Jokinen, M. Kalliokoski, I. Moore, J. Äystö)

3rd DITANET School on Beam Diagnostics,
7-11 March, Stockholm, Sweden (M. Kalliokoski)

The Annual Meeting of the Finnish Physical Society,
29-31 March, Helsinki, Finland (talk by M. Kalliokoski)

Technology and Instrumentation in Particle Physics - TIPP 2011,
9-14 June, Chicago, IL, USA (talk by M. Kalliokoski)

2nd International Conference on Micro Pattern Gaseous Detectors,
29 August - 1 September, Kobe, Japan (talk by M. Kalliokoski)

2nd International Particle Accelerator Conference IPAC'11,
4-9 September, San Sebastian, Spain (talk by M. Kalliokoski)

GSI,
5-16 September, Darmstadt, Germany (I. Moore)

GSI,
3-12 October, Darmstadt, Germany (I. Moore)

NUSTAR Week,
17-21 October, Bucharest, Bulgaria (talk by F. García)

The 2011 IEEE Nuclear Science Symposium, Medical Imaging Conference,
23-29 October, Valencia, Spain (talk by F. García)

Particle Physics Day 2011,
28 October, Helsinki, Finland (talk by M. Kalliokoski)

GSI,
10-11 November, Darmstadt, Germany (talk by F. García)

Working visit to CERN
(F. García, M. Kalliokoski, E. Tuominen)

Working visit to GSI
(F. García, M. Kalliokoski, E. Tuominen)

Working visit to University of Frascati
(F. García)

Working visit to University of Jyväskylä
(M. Kalliokoski, E. Tuominen)

Nuclear Matter Programme

ISOLDE

ISOLDE Review,
5 May, Jyväskylä, Finland (invited talk by A. Jokinen)

Nordic Conference on Nuclear Physics,
13 June, Stockholm, Sweden (invited talk by I. Moore)

Istituto Nazionale di Fisica Nucleare Laboratori Nazionale di Legnaro,
29 November, Legnaro, Italy (invited seminar by I. Moore)

Technology Programme

2nd International Conference on Exploring Service Science,
16-18 February, Geneva, Switzerland (M. Tuisku)

The First International Conference on Smart Grids, Green Communications and IT Energy-Aware Technologies, ENERGY 2011,
22-27 May, Venice/Mestre, Italy (talk by J. Kommeri)

EcoCloud's Opening Event,
31 May, Lausanne, Switzerland (T. Niemi, M. Tuisku)

The 21st European Japanese Conference on Information Modelling and Knowledge Bases,
6-10 June, Tallinn, Estonia (talk by J. Kommeri)

EGI Technical Forum,
19-23 September, Lyon, France (H. Mikkonen, talk by J. White)

Swiss Distributed Computing Day (SWING 2011 Event),
28 November, Bern, Switzerland (J. Hahkala, J. White)

CLOUD

IFV,
28 January, Mulhouse, France (talk by J. Duplissy)

CLOUD ITN Meeting,
14-18 February, Vienna, Austria (J. Duplissy)

Hyytiala Spring Campaign,
March, Hyytiälä, Finland (J. Duplissy)

CLOUD 4 Campaign,
June-July, CERN, Geneva, Switzerland (J. Duplissy)

The 2011 European Aerosol Conference EAC2011,
4-9 September, Manchester, UK (talk by J. Duplissy)

CLOUD ITN Meeting,
25 September - 1 October, Frankfurt, Germany (J. Duplissy)

CLOUD 5 Campaign,
October-December, CERN, Geneva, Switzerland
(J. Duplissy)

LATMOS,
1 December, Paris, France (talk by J. Duplissy)

Saclay,
2 December, Orsay, France (talk by J. Duplissy)

Planck

LFI Core Team Meeting 21,
17-18 January, Bologna, Italy (K. Kiiveri, H. Kurki-Suonio, invited talk by A.-S. Suur-Uski)

LFI Core Team Meeting 22,
9-10 March, Bologna, Italy (H. Kurki-Suonio, M. Savelainen, A.-S. Suur-Uski)

Polarization Busy Week,
11-15 April, Manchester, UK (A.-S. Suur-Uski)

Finnish Cosmophysics Meeting,
20-21 April, Tampere, Finland (talk by K. Kiiveri, talk by H. Kurki-Suonio, talk by M. Savelainen, talk by A.-S. Suur-Uski)

LFI Core Team Meeting 23,
2 May, Orsay, France (H. Kurki-Suonio, M. Savelainen, A.-S. Suur-Uski)

Joint Core Team Meeting,
3-4 May, Orsay, France (H. Kurki-Suonio, M. Savelainen, A.-S. Suur-Uski)

LFI Core Team Meeting 24,
6-7 July, Santander, Spain (K. Kiiveri, H. Kurki-Suonio, V. Lindholm, M. Savelainen, invited talk by A.-S. Suur-Uski)

LFI Core Team Meeting 25,
5-6 September, Bologna, Italy (K. Kiiveri, H. Kurki-Suonio, V. Lindholm)

Joint Core Team Meeting,
14-17 November, Bologna, Italy
(invited talk by H. Kurki-Suonio, M. Savelainen)

Administration and Support

Koulutuspäivät yleisivistävän koulutuksen kansainvälisyydestä kiinnostuneille,
25-26 August, Yyteri, Finland (R. Rinta-Filppula)

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

IPPOG Meeting,
4-5 November, CERN, Geneva, Switzerland
(R. Rinta-Filppula)

Publications

Theory Programme

Cosmophysics

L. Amendola, K. Enqvist, and T. Koivisto,
Unifying Einstein and Palatini gravities,
Phys. Rev. D 83 (2011) 044016

V. V. Bobylev, A. T. Bajkova, A. Mylläri, and M. Valtonen,
Searching for possible siblings of the sun from a common cluster based on stellar space velocities,
Astronomy Lett. 37 (2011) 550

C. T. Byrnes, K. Enqvist, S. Nurmi, and T. Takahashi,
Strongly scale-dependent polyspectra from curvaton self-interactions,
J. Cosmol. Astropart. Phys. 1111 (2011) 011

J. M. Cline, K. Kainulainen, and M. Trott,
Electroweak baryogenesis in two Higgs doublet models and *B* meson anomalies,
J. High Energy Phys. 1111 (2011) 089

K. Enqvist, S. Hotchkiss, and O. Taanila,
Estimating f_{NL} and g_{NL} from massive high-redshift galaxy clusters,
J. Cosmol. Astropart. Phys. 1104 (2011) 017

K. Enqvist, R. N. Lerner, and O. Taanila,
Curvaton model completed,
J. Cosmol. Astropart. Phys. 1112 (2011) 016

K. Enqvist and G. Rigopoulos,
Non-linear mode coupling and the growth of perturbations in ΛCDM,
J. Cosmol. Astropart. Phys. 1103 (2011) 005

D. G. Figueroa, J. García-Bellido, and A. Rajantie,
On the transverse-traceless projection in lattice simulations of gravitational wave production,
J. Cosmol. Astropart. Phys. 1111 (2011) 015

S. Hotchkiss,
Quantifying the rareness of extreme galaxy clusters,
J. Cosmol. Astropart. Phys. 1107 (2011) 004

S. Hotchkiss, A. Mazumdar, and S. Nadathur,
Inflection point inflation: WMAP constraints and a solution to the fine tuning problem,
J. Cosmol. Astropart. Phys. 1106 (2011) 002

K. Kainulainen and V. Marra,
Accurate modeling of weak lensing with the stochastic gravitational lensing method,
Phys. Rev. D 83 (2011) 023009

K. Kainulainen and V. Marra,
Weak lensing observables in the halo model,
Phys. Rev. D 84 (2011) 063004

R. N. Lerner and J. McDonald,
Distinguishing Higgs inflation and its variants,
Phys. Rev. D 83 (2011) 123522

B. Hoyle with E. J. Lloyd-Davies et al.,
The *XMM* Cluster Survey: X-ray analysis methodology,
Mon. Not. R. Astron. Soc. 418 (2011) 14

V. Marra and A. Notari,
Observational constraints on inhomogeneous cosmological models without dark energy,
Class. Quantum Grav. 28 (2011) 164004

M. Mattsson and T. Mattsson,
On the role of shear in cosmological averaging II: large voids, non-empty voids and a network of different voids,
J. Cosmol. Astropart. Phys. 1105 (2011) 003

A. Paranjape, C. Gordon, and S. Hotchkiss,
Extreme tail of the non-Gaussian mass function,
Phys. Rev. D 84 (2011) 023517

M. J. Valtonen, H. J. Lehto, L. O. Takalo, and A. Sillanpää,
Testing the 1995 binary black hole model of OJ287,
Astrophys. J. 729 (2011) 33

M. J. Valtonen, S. Mikkola, H. J. Lehto, A. Gopakumar, R. Hudec, and J. Polednikova,
Testing the black hole no-hair theorem with OJ287,
Astrophys. J. 742 (2011) 22

Laws of Nature and Condensed Particle Matter Phenomenology at the LHC

J. Alanen, T. Alho, K. Kajantie, and K. Tuominen,
Mass spectrum and thermodynamics of quasiconformal gauge theories from gauge/gravity duality,
Phys. Rev. D 84 (2011) 086007

O. Antipin and K. Tuominen,
Constraints on conformal windows from holographic duals,
Mod. Phys. Lett. A 26 (2011) 2227

M. Antola, S. Di Chiara, F. Sannino, and K. Tuominen,
Minimal supersymmetric technicolor,
Eur. Phys. J. C 71 (2011) 1784

F. Arleo, K. J. Eskola, H. Paukkunen, and C. A. Salgado,
Inclusive prompt photon production in nuclear collisions at RHIC and LHC,
J. High Energy Phys. 1104 (2011) 055

S. J. Brodsky and P. Hoyer,
The $\hbar$ expansion in quantum field theory,
Phys. Rev. D 83 (2011) 045026

M. Caselle, L. Castagnini, A. Feo, F. Gliozzi, and M. Panero,
Thermodynamics of SU(*N*) Yang-Mills theories in 2 + 1 dimensions I - The confining phase,
J. High Energy Phys. 1106 (2011) 142

M. Caselle, A. Feo, M. Panero, and R. Pellegrini,
Universal signatures of the effective string in finite temperature lattice gauge theories,
J. High Energy Phys. 1104 (2011) 20

R. Chatterjee, H. Holopainen, T. Renk, and K. J. Eskola,
Enhancement of thermal photon production in event-by-event hydrodynamics,
Phys. Rev. C 83 (2011) 054908

A. Dumitru, K. Dusling, F. Gelis, J. Jalilian-Marian, T. Lappi, and R. Venugopalan,
The ridge in proton-proton collisions at the LHC,
Phys. Lett. B 697 (2011) 21

A. Dumitru, J. Jalilian-Marian, T. Lappi, B. Schenke, and R. Venugopalan,
Renormalization group evolution of multi-gluon correlators in high energy QCD,
Phys. Lett. B 706 (2011) 219

H. S. Fukano, M. Heikinheimo, and K. Tuominen,
Flavor constraints in a bosonic technicolor model,
Phys. Rev. D 84 (2011) 035017

D. K. Ghosh, T. Honkavaara, K. Huitu, and S. Roy,
Sneutrino-antisneutrino oscillation at the Tevatron,
Phys. Rev. D 84 (2011) 075001

H. Holopainen, H. Niemi, and K. J. Eskola,
Event-by-event hydrodynamics and elliptic flow from fluctuating initial state,
Phys. Rev. C 83 (2011) 034901

H. Holopainen, S. S. Räsänen, and K. J. Eskola,
Elliptic flow of thermal photons in heavy-ion collisions at energies available at the BNL Relativistic Heavy Ion Collider and at the CERN Large Hadron Collider,
Phys. Rev. C 84 (2011) 064903

P. Hoyer and S. Kurki,
Measuring transverse shape with virtual photons,
Phys. Rev. D 83 (2011) 114012

K. Huitu, K. Kannike, A. Racioppi, and M. Raidal,
Long-lived charged Higgs at LHC as a probe of scalar dark matter,
J. High Energy Phys. 1101 (2011) 010

K. Huitu, L. Leinonen, and J. Laamanen,
Stop as a next-to-lightest supersymmetric particle in constrained MSSM,
Phys. Rev. D 84 (2011) 075021

K. Huitu, S. K. Rai, K. Rao, S. D. Rindani, and P. Sharma,
Probing top charged-Higgs production using top polarization at the Large Hadron Collider,
J. High Energy Phys. 1104 (2011) 026

K. Kajantie, M. Kršśák, M. Vepsäläinen, and A. Vuorinen,
Frequency and wave number dependence of the shear correlator in strongly coupled hot Yang-Mills theory,
Phys. Rev. D 84 (2011) 086004

K. Kajantie and M. Vepsäläinen,
Spatial scalar correlator in strongly coupled hot $N = 4$ Yang-Mills theory,
Phys. Rev. D 83 (2011) 066003

T. Karavirta, A. Mykkanen, J. Rantaharju, K. Rummukainen, and K. Tuominen,
Nonperturbative improvement of SU(2) lattice gauge theory with adjoint or fundamental flavours,
J. High Energy Phys. 1106 (2011) 061

H. Kuismanen, J. Maalampi, and I. Vilja,
Numerical study of leptogenesis in a 5D split fermion model with bulk neutrinos,
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Energy dependence of the saturation scale and the charged multiplicity in pp and AA collisions,
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Gluon spectrum in the glasma from JIMWLK evolution,
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T. Lappi and H. Mäntysaari,
Incoherent diffractive J/Ψ production in high-energy nuclear deep-inelastic scattering,
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H. Petersen, T. Renk, and S. A. Bass,
Medium-modified jets and initial state fluctuations as sources of charge correlations measured at energies available at the BNL Relativistic Heavy Ion Collider (RHIC),
Phys. Rev. C 83 (2011) 014916

T. Renk,
YaJEM - a Monte Carlo code for in-medium shower evolution,
Int. J. Mod. Phys. E 20 (2011) 1594

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Phys. Rev. C 83 (2011) 024908

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Hard dihadron correlations in heavy-ion collisions at energies available at the BNL Relativistic Heavy Ion Collider and CERN Large Hadron Collider,
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Systematic comparison of jet quenching in different fluid-dynamical models,
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String Theory and Mathematical Physics

V. Balasubramanian, A. Bernamonti, J. de Boer, N. Copland, B. Craps, E. Keski-Vakkuri, B. Müller, A. Schäfer, M. Shigemori, and W. Staessens,
Holographic thermalization,
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O. W. Greenberg,
Review of the N-quantum approach to bound states,
Int. J. Mod. Phys. A 26 (2011) 935

V. Keränen, E. Keski-Vakkuri, S. Nowling, and K. P. Yogendran,
Solitons as probes of the structure of holographic superfluids,
New J. Phys. 13 (2011) 065003

Y. Sasai,
Closed string transport coefficients and the membrane paradigm,
Phys. Rev. D 84 (2011) 105006

Y. Sasai and A. Zahabi,
Shear viscosity of a highly excited string and the black hole membrane paradigm,
Phys. Rev. D 83 (2011) 026002

Quantum Field Theory

C. R. Das, L. V. Laperashvili, H. B. Nielsen, and A. Tureanu,
Baryogenesis in cosmological model with superstring-inspired E_6 unification,
Phys. Lett. B 696 (2011) 138

Low Dimensional Quantum Systems

J. E. Drut, T. A. Lähde, and T. Ten,
Momentum distribution and contact of the unitary Fermi gas,
Phys. Rev. Lett. 106 (2011) 205302

P. Havu, M. Ijäs, and A. Harju,
Hydrogenated graphene on silicon dioxide surfaces,
Phys. Rev. B 84 (2011) 205423

S. K. Hämäläinen, Z. Sun, M. P. Boneschanscher, A. Uppstu, M. Ijäs, A. Harju, D. Vanmaekelbergh, and P. Liljeroth,
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M. Ijäs, P. Havu, A. Harju, and P. Pasanen,
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Identification of substitutional Li in n-type ZnO and its role as an acceptor,
Phys. Rev. B 83 (2011) 245208

J.-M. Mäki, I. Makkonen, F. Tuomisto, A. Karjalainen, S. Suihkonen, J. Räisänen, T. Yu. Chemekova, and Yu. N. Makarov,
Identification of the V_{Al}-O_N defect complex in AlN single crystals,
Phys. Rev. B 84 (2011) 081204(R)

C. Rauch, I. Makkonen, and F. Tuomisto,
Identifying vacancy complexes in compound semiconductors with positron annihilation spectroscopy: A case study of InN,
Phys. Rev. B 84 (2011) 125201

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Towards experimental identification of vacancy complexes in InN,
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K. A. Wendt, J. E. Drut, and T. A. Lähde,
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