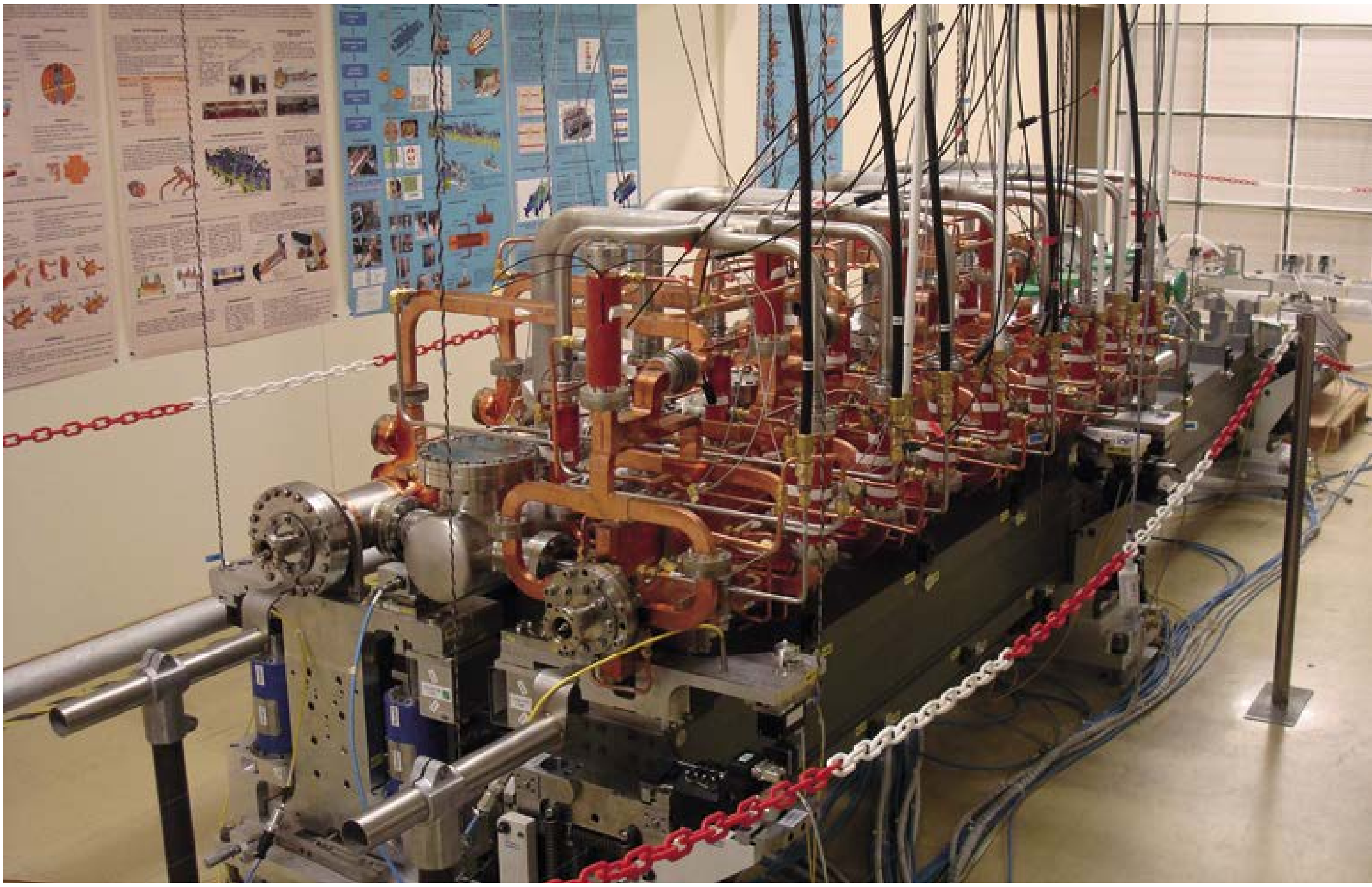
HELSINKI INSTITUTE OF PHYSICS

Annual Report 2013

HELSINKI INSTITUTE OF PHYSICS

Annual Report 2013



A first full-scale CLIC prototype module assembled in a laboratory at CERN for the thermo-mechanical test programme.

Annual Report 2013 Helsinki Institute of Physics

Contents

Introduction

Juha Äystö

The year 2013 marked the 17th year of operation for the Helsinki Institute of Physics. Following the spectacular discovery of a new Higgs-boson like particle in 2012 this period continued as highly productive on all fronts of activities as exemplified in the Research Highlights section of this Annual Report. In its research HIP addresses fundamental science questions from quarks to the Cosmos as well as applied research and technology transfer from semiconductors to medical applications and climate research. The research results of the HIP programmes and projects were reported in a record number of 281 refereed scientific journal articles. In 2013, the CMS and ATLAS experiments confirmed that the new particle found at the LHC and reported in July 2012 is indeed "a" Higgs boson. This result led to two major science prizes, first the European Physical Society High Energy and Particle Physics Prize to the CMS and ATLAS Collaborations "For the discovery of a Higgs boson, as predicted by the Brout-Englert-Higgs mechanism" and the Nobel Prize in Physics for 2013 awarded to François Englert and Peter W. Higgs "for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles". Two other LHC experiments, ALICE and TOTEM with a strong HIP involvement also had a record year in their physics output. In particular, the ALICE run on asymmetric proton-ion collisions carried out early in 2013 produced spectacular data necessary for further understanding of the "extreme form of matter", the quark qluon plasma. The LHC machine was closed down in February 2013 for major maintenance and repair for its planned new start in early 2015 at its full design energy.

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. HIP also carries the responsibility for co-ordination of the Finnish activities at the new international Facility for Antiproton and Ion Research (FAIR) under construction in Darmstadt, Germany. HIP is operated by the University of Helsinki, Aalto University, the University of Jyväskylä and Lappeenranta and Tampere Universities of Technology. Administratively HIP is an independent institute under the Rector of the University of Helsinki. The HIP operations are based on the Finnish CERN strategy, which emphasises, in addition to research and researcher training, the development of technology know-how for Finnish industry and business applications and the exploitation of CERN and FAIR research results in science education and literacy. The success of these outreach efforts is demonstrated by the sustained Finnish coefficient of return for industrial supplies at CERN and by the great interest in CERN shown by Finnish high schools. In 2013 the Institute was able to host a record of 18 science-study visits to CERN by 366 Finnish high school students and 3 courses for 110 teachers at CERN. During 2013, 10 PhD and DSc (Tech) degrees and 16 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 summer student programme at CERN represents a key educational effort. During the summer of 2013, 15 Finnish university students worked at CERN in HIP research projects.

The research activities of the Helsinki Institute of Physics in 2013 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 cosmic background radiation 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 last year of their second 3-year periods. A selection process for new 3-year projects was carried out and led to the establishment of five new projects starting in 2014. A special visiting professor position was created in the Theory Programme for Professor Mark Hindmarsh from Sussex University.

The High Energy Physics Programme continued to participate 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 project continued with an EU Marie Curie Industry-Academia Partnerships and Pathways project (IAPP) "MeChanICs - Marie Curie linking Industry to CERN", allowing engineers from 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 upgrade for the foreseen CMS luminosity upgrade. In 2013 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 CMS Upgrade project received a significant upgrade grant from the Academy of Finland. As an interesting new initiative, the CMS group is also involved in the Open Data initiative with the Centre for Scientific Computing CSC (IT Center for Science Ltd) in Finland.

The Nuclear Matter Programme included 3 projects. The first is a nuclear structure research project at the ISOLDE facility at CERN. The second is a project for physics analysis and instrumentation for the ALICE detector for relativistic heavy ion collisions at the LHC. The ALICE project initiated a major participation in an upgrade project for the ALICE TPC readout based on GEM technology with funding from the Academy of Finland. In addition the Nuclear Matter Programme contained a project responsible for the Finnish contribution to the FAIR project, which consists of equipment for the accelerator complex and the experiments within the NUSTAR Collaboration. The leader of the ALICE project, Dr. Jan Rak was appointed as a full Professor in the Physics Department at the University of Jyväskylä from the beginning of January 2014.

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 AX-PET detectors developed at CERN.

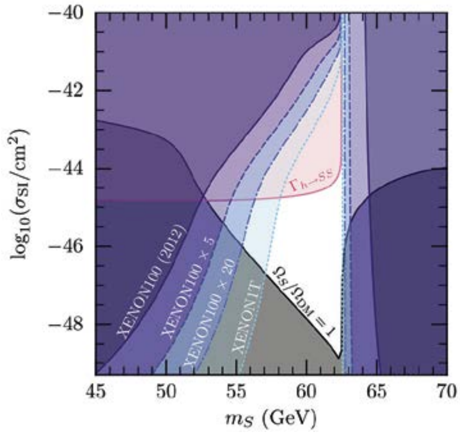
In 2013 the total basic budget of the Institute remained on a constant level in euros as compared to the previous years. The "earmarked" funding from the Ministry of Education and Culture for the construction of the FAIR facility compensated for the reduction of about 5% which the Institute's other research programmes suffered in their budgets for 2013. This trend will continue in 2014. Due to this and to new challenges in the experimental projects a plan for optimising the programme structure was produced and approved by the HIP Board. The research activities from 2014 on will fall into 4 main research programmes and four independent research projects. The research programmes will be (1) the Theoretical Physics Programme consisting of five new projects, (2) the CMS Programme also now including the TOTEM project, (3) the Nuclear Matter Programme and (4) the Technology Programme. The independent special projects will be (a) the CLOUD project at CERN, which aims at the determination of the role of cosmic radiation in climate warming, (b) the newly defined Planck/Euclid data project as continuation of the former Planck project and (c) a new Forward Physics project exploiting its implementation in ALICE; in addition, (d) the Detector Laboratory will be organised as a dedicated infrastructure in order to serve the needs of various upgrades and detector construction projects, in particular, related to CERN and FAIR.

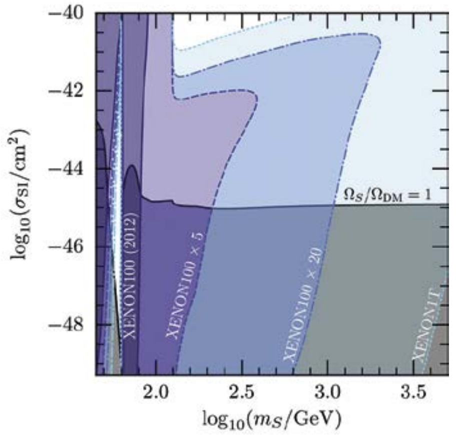
During 2013 HIP hosted five international workshops or conferences. These were “Holograv 2013, Applied Holography Workshop” in March, “Cosmological Perturbations post-Planck Workshop” in June, “EDS Blois 2013, the 15th Conference on Elastic Diffractive Scattering” in Saariselkä in September, the “FAIR-NUSTAR Week 2013” in October and the “2013 Particle Physics Day” in October. On February 23rd, 2013 Dr. Alexander Stubb, Finnish Minister for European Affairs and Foreign Trade, visited CERN. The visit was hosted by the CERN Research Director Professor Sergio Bertolucci and the HIP Director. Dr. Stubb was also given a tour in the CMS experimental area where he was met by the Finnish CMS scientists.

During 2013 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.

Highlights of Research Results

Theory Programme





In the Cosmophysics project we have studied a scalar singlet field model of dark matter, where the dark matter scalar S interacts with the Standard Model Higgs field H through a |H|2S2 coupling. We have made a thorough analysis of all existing constraints, including LHC searches for invisible Higgs decays, dark matter searches and cosmological observations, and found out that a singlet scalar is a viable dark matter candidate for a wide range of model parameters.

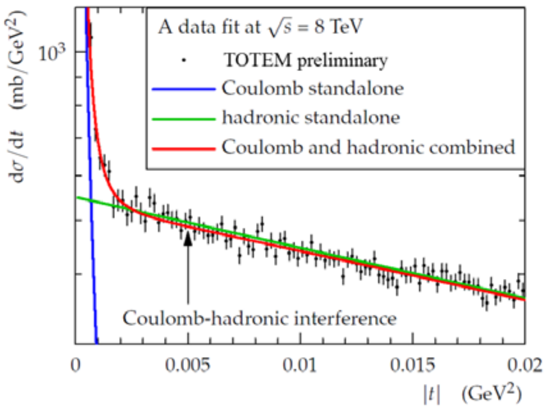
In the Laws of Nature and Condensed Particle Matter Phenomenology at the LHC project we have used lattice simulations and holographic methods to gain insight into non-perturbative dynamics of strongly interacting quantum field theory; the main motivation here is provided by the applications in BSM model building. Large scale simulations of SU(2) gauge theories with improved Wilson fermions in fundamental or higher representations were carried out. Another highlight is our study of a bottom-up holographic model of the phase diagram of QCD in the Veneziano limit as a function of temperature and finite quark number density.

The most significant achievements in the Low Dimensional Quantum Systems project are related to the electronic properties in graphene: as an example, we showed a suppression of electron-vibron coupling in graphene nanoribbons that were contacted via a single atom. Our findings were published in Nature Communications.

The focus of the research in the Radiation Damage in Particle Accelerator Materials project is the study of the breakdown of metal surfaces under the extreme accelerating field gradients in the planned CLIC particle accelerator. We are developing a multi-scale and multi-physics model dealing with the processes which precede and succeed breakdown events. In 2013, by combining the algorithms developed for the simulation of dislocation nucleation on a near-surface void under tensile stress and the electric field effects, we showed that the dislocations can nucleate on the inner surface of the near-surface void, which would lead to a catastrophic growth of the protrusion because of strong self-reinforcement.

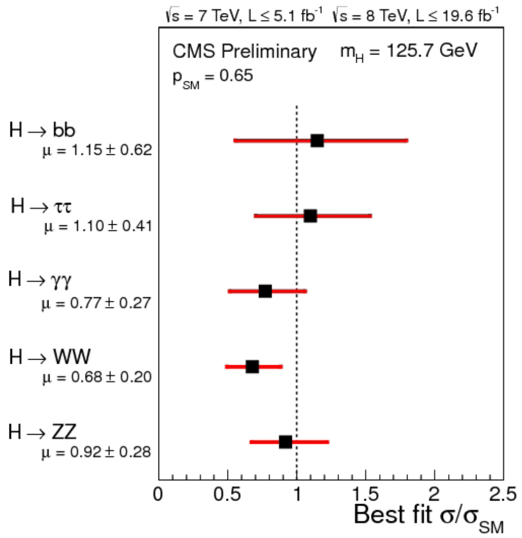
High Energy Physics Programme

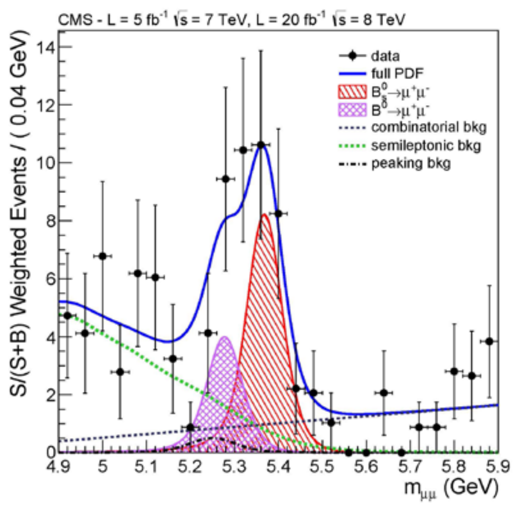
In 2013, the TOTEM Collaboration published a measurement of the double diffractive proton-proton cross section in the forward region at the LHC centre-of-mass energy of 7 TeV [Phys. Rev. Lett. 111 (2013) 262001]. This measurement relies on the reconstruction of the diffractive system in the T2 telescope made up of the Helsinki-built GEM-chambers as well as on the reconstruction of rapidity gaps with the T1 telescope. The result indicates a breaking of factorisation in double diffractive scattering at the LHC when compared to a preliminary measurement by TOTEM of the single diffractive cross section in the same mass range for the diffractive system.



The TOTEM Collaboration also published the luminosity-independent measurement of the total, inelastic and elastic proton-proton cross sections in Europhysics Letters and Physical Review Letters for centre-of-mass energies of 7 and 8 TeV, respectively. The inelastic rate parts of these measurements are essentially completely based on data from the T2 telescope. All of the above mentioned measurements were performed by the Helsinki TOTEM group. In addition, the TOTEM Collaboration observed for the first time at the LHC the effect of Coulomb-hadronic interference in the absolute momentum transfer squared (|t|) differential elastic proton-proton cross section at $\sqrt{s}$ = 8 TeV using data from a special β^* = 1 km run. Furthermore, in June 2013 the TOTEM Collaboration submitted an upgrade proposal to LHCC.

In 2013, the first full-scale Compact Linear Collider (CLIC) prototype module was completed for a thermo-mechanical laboratory test programme. This allowed a validation of the thermo-mechanical simulation model for the CLIC module. Also the developments of a rapid ultralow pressure manometer for measuring outgassing inside the RF structures during operation as well as of an optical method to measure the internal shape of a RF structure disk stack showed good progress in 2013.





CMS Programme

In 2013, the CMS and ATLAS experiments could confirm that the new particle found at the LHC is indeed "a" Higgs boson. The particle properties such as spin, parity, couplings, and branching ratios were found to be compatible with those of a Standard Model Higgs boson. More data are, however, needed to find out whether the new particle is "the" one and only Higgs boson, or one of many.

Another highlight by the CMS and LHCb experiments was the observation of the very rare decay $B^0_S \to \mu^+\mu^-$. The decay is very sensitive to eventual new physics beyond the Standard Model, and therefore the hunt of this rare decay mode has been ongoing for over 30 years. The measured branching fraction was found to be consistent with the Standard Model expectation.

Many more results were produced: by the end of 2013 the total number of CMS publications reached 286.

The year culminated in two major prizes. In spring, the European Physical Society High Energy and Particle Physics Prize was awarded to the ATLAS and CMS Collaborations "For the discovery of a Higgs boson, as predicted by the Brout-Englert-Higgs mechanism", and to Michel Della Negra, Peter Jenni, and Tejinder Virdee "For their pioneering and outstanding leadership rôles in the making of the ATLAS and CMS experiments". Then, in autumn, the Nobel Prize in Physics for 2013 was awarded to François Englert and Peter W. Higgs "for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider".

Nuclear Matter Programme

The strength of the ALICE experiment is in the capability to study identified particles down to low transverse momenta and thus the main highlights in 2013 could be found, for example, in publications related to π, K, p [Phys. Rev. C 88 (2013) 044910] or K_S^0, Λ [Phys. Rev. Lett. 111 (2013) 222301] production in Pb-Pb data taken at a c.m. energy of $\sqrt{s_{NN}}$ = 2.76 TeV. The study of the flow-like long range correlations in p-Pb collisions first observed by ALICE [Phys. Lett. B 719 (2013) 29] with the use of identified particles revealed a surprisingly similar mass ordering of the flow-like azimuthal particle distribution [Phys. Lett. B 726 (2013) 164] as the one seen in Pb-Pb collisions. This kind of mass ordering is traditionally interpreted as a manifestation of the Quark Gluon Plasma (QGP). Many other interesting results related to, for example, Quantum Statistics Correlations [arXiv:1310.7808] or jet production [arXiv:1311.0633] in Pb-Pb collisions have been submitted for or are in preparation for publication.

A clear highlight in 2013 was the publication in Nature of the results of an experiment carried out at REX-ISOLDE using the MINIBALL germanium detector array. The experiment shed light on octupole collectivity in radon and radium nuclei. This information may be helpful in the search for electric dipole moments in atoms. Also, results of the direct study of the cross section for the reaction $^{44}Ti(\alpha,p)^{47}V$ at low energies reported in 2012 became available. This reaction has relevance for understanding core collapse supernovae. On the instrumentation side, work has continued with the development of the SPEDE conversion electron spectrometer which has entered the construction phase. Due to the LHC shutdown, no experiments were carried out in 2013 at ISOLDE.

Preparatory work for FAIR (Facility for Antiproton and Ion Research) has continued throughout 2013. The agreed Finnish contributions will be concentrated on the construction of experimental equipment for the NUSTAR Collaboration and for the Superconducting Fragment Separator (SFRS). The entire Finnish in-kind contribution will be directed towards the Super-FRS. A new collaboration with Lappeenranta University of Technology (LUT) was started for the purpose of producing power cabinets for SFRS magnets. Finland is also actively involved in the cryogenic gas catcher project with GSI and KVI-Groningen to provide low-energy cooled ion beams for experiments. The SFRS beam diagnostic project consists of (i) 32 GEM-detectors and (ii) grid detectors needed for intense beams. Results obtained from recent beam tests have given confidence that the concept of using GEM based TPC's will fulfil all requirements in terms of efficiency and position resolution.

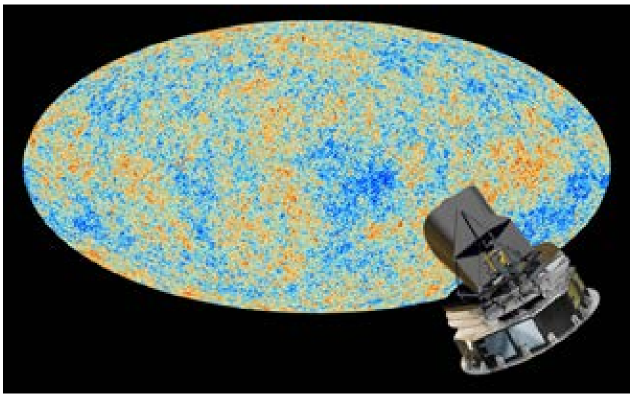
Technology Programme

In 2013 significant changes were made to the Technology Programme. Firstly, the Cloud and Grid computing project had reached its targets and it was subsequently discontinued as a project following the ending of the FP7 EMI-project. Secondly, the Green Computing project was also significantly enlarged to include big data concerns. Thirdly, the CLIC project was transferred to the Technology Programme. All of these changes will take effect at the start of 2014. Below are outlined the achievements and activities of the three continuation projects in the Technology Programme, namely GreenIT, Grid Middleware and Cloud Applications and AX-PET. Of these projects, AX-PET will continue as planned for the year 2014.

The GreenIT project has focused on optimising energy consumption of scientific computing. Analysis of log data of several physics computing clusters has shown how operations management principles can be applied to scientific computing. It was found that virtualisation is a usable technology for both CMS analysis and simulation jobs. In autumn 2013, the project started collaboration with Aalto University in addition to its existing collaborations with CERN and Lausanne.

The EU Framework Programme 7 came to an end in 2013 together with the European Middleware Initiative (EMI) project, where the HIP Technology Programme's DataGrid project had participated for the past three years. From the beginning of the EMI project, HIP had the responsibility to manage and co-ordinate the various security working groups that determined the strategic direction of the EMI project Security area. The Security area of the EMI project was favourably mentioned in the EU review report and all its tasks were completed.

At CERN, a new type of a positron emission tomography (PET), Axial PET (AX-PET), has been developed. In Finland at Tampere University of Technology TUT jointly with the HIP Technology Programme, we are seeking ways to commercialise a new type of PET scanner using AX-PET type detectors to design a compact and small-sized AX-PET type demonstrator which can be used for neck, wrist and chest scanning for humans as well as for small animals.



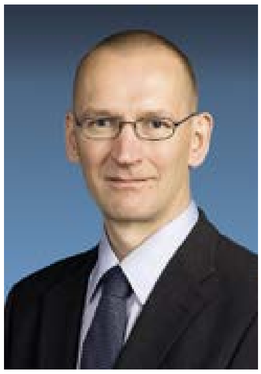
Planck

The first cosmological results of the Planck satellite were published in March 2013 (Planck Collaboration, "*Planck* 2013 results I. Overview of products and scientific results", arXiv:1303.5062, and 29 other "*Planck* 2013 results" papers). At the same time, the first 15 months of Planck data were released. The results include a new map of the cosmic microwave background with unprecedented resolution. Planck confirms the 5-parameter standard cosmological model, with revised values of its parameters. These give the composition of the universe as 68.3% dark energy, 26.8% dark matter, and 4.9% ordinary matter and the current expansion rate of the universe (the Hubble constant) as 67.3±1.2 km/s/Mpc. Compared to earlier, less precise, results from the WMAP satellite, the amount of ordinary and dark matter was revised upwards and the expansion rate downwards, meaning that the universe is slightly older, 13.8 billion years instead of 13.7 billion years. The spectral index of primordial perturbations was measured as 0.960±0.007, meaning that the primordial structure of the universe was stronger at large scales than at small scales (a spectral index equal to 1 corresponds to scale-invariant perturbations).

No evidence favouring any "extended models" was found. In particular, the primordial perturbations were shown to be Gaussian with a much higher accuracy than known before. One measure of deviations from Gaussianity is the non-linearity parameter f_{NL}. The previous measurement by the WMAP satellite gave its value as $f_{NL} = 37\pm20$. Planck now gives $f_{NL} = 2.7\pm5.8$. We also found no evidence for any primordial isocurvature perturbations, so the standard model with adiabatic primordial perturbations remains favoured.

Theory Programme

The core of the HIP Theory Programme consists of fixed term projects, chosen for their scientific excellence and how they complement the research at HIP and at the host universities. The year 2013 ends the era of the current four theory projects, after running very successfully for six years. The four projects are: Cosmophysics (Kimmo Kainulainen, Jyväskylä), Laws of Nature and Condensed Particle Matter Phenomenology at the LHC (Kimmo Tuominen, Jyväskylä), Low Dimensional Quantum Systems (Ari Harju, Aalto), and Radiation Damage in Particle Accelerator Materials (Flyura Djurabekova, Helsinki). These will be replaced by new projects in 2014. Additionally, Professor Mark Hindmarsh (Sussex University) continued his visit at HIP for six months in 2013. He is one of the leading authorities in the physics at the intersection of particle physics and cosmology, and his presence strongly enhanced research in the Cosmophysics and the Laws of Nature projects.



Kari Rummukainen,
Theory Programme Director

Cosmophysics

The current Standard Cosmological Model (SCM) is a very simple and successful theory, which explains almost all existing observational data. On the other hand, it contains several ingredients of unknown origin, such as dark matter (DM) and dark energy (DE). It also incorporates inflation, which is responsible for the initial density perturbations, but it does not say anything about the nature of the inflaton or of the precise dynamics that created these perturbations. There are also unsettled issues related to observations of the large scale structures and the evolution of the actual inhomogeneous universe is still not completely understood. We have studied each of these questions from several different points of view.

Inflation: Planck data puts strong constraints on single-field inflaton models. These are in general viewed as effective theories where all other fields are integrated out. However, inflaton decay is an essential part of any inflationary scenario which requires coupling of an inflaton to other fields, and including such interactions induces radiative corrections to the effective inflaton potential. We show that these corrections may help to reconcile some simple chaotic inflation with the Planck data. On the other hand, if the inflaton couples to a gauge field, the gauge field perturbation could generate an observable statistically anisotropic contribution to the primordial curvature perturbation. We give a simple and complete calculation of the spectrum and bi-spectrum of this contribution using only the classical perturbations. Our results suggest that the entire curvature perturbation, both the statistically isotropic and anisotropic parts, is generated either during a slow-roll phase of inflation, or after inflation. We also investigated a curvaton-Higgs model, where the curvaton scalar is coupled only to the Standard Model Higgs boson. We paid particular emphasis to the effects induced by the thermal background and presented the first full study of this model confronting it with the cosmological observations. We found that the model is compatible with recent constraints from Planck, and gave detailed predictions for the non-Gaussianity of the model.

Large scale structure of the universe: We have studied the problem of identifying cosmic superstructures (large voids and superclusters) in real world surveys, taking into account numerous problems that arise due to variable selection functions and survey boundaries. We found that neglecting these effects had resulted in significant contamination of the previously published "void" catalogues. Our new catalogues may be used to study the detailed properties of these superstructures, including their gravitational signals through lensing and the ISW effect. We also examined the hemispherical power asymmetry observed on large angular scales in the CMB by WMAP. We re-examined this anomaly in the Planck data, extending the analysis to small scales. We confirmed the existence of the feature

Kimmo Kainulainen,
Cosmophysics
project leader

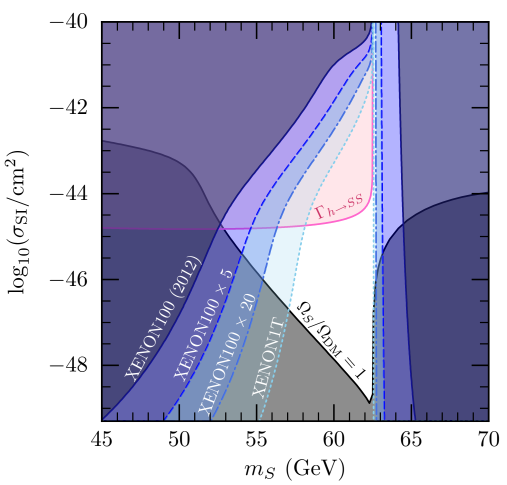
on the large scales, but found no evidence of it on the small scales. Our upper bound on the small scale asymmetry puts a strong constraint on models that attempt to explain the large scale asymmetry. We also presented preliminary results from the Jubilee Integrated Sachs-Wolfe project, which uses a very large-scale N-body simulation and ray-tracing to calculate the expected ISW effect and the gravitational lensing signal in the LCDM model. The exceptional size and resolution of the simulation allows a production of full-sky maps of the ISW and lensing signals with an accurate estimation of the power up to the largest observable.

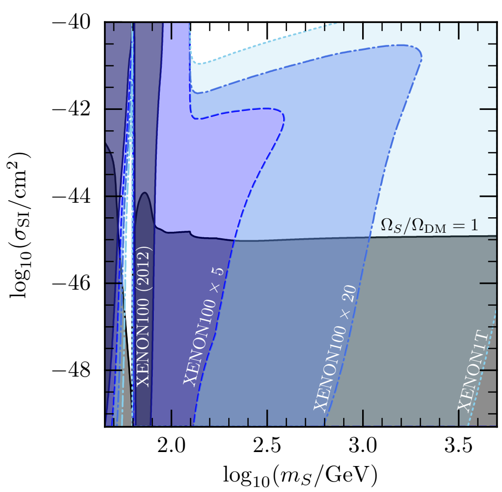
On the model building side, we constructed the first exact statistically homogeneous and isotropic cosmological solution in which inhomogeneity has a significant effect on the expansion rate. We used the Swiss Cheese construction, whose average expansion rate has been thought to agree with the FRW model. We proved that this is indeed true under some rather general conditions, and then built a model where we violate one of these conditions. We also studied the relation between the average expansion rate to the observable redshift and angular diameter distance in this setting. We also fitted a back-reaction toy model with realistic features to Union2.1 supernova data and showed that it provides a good fit even though the expansion history is quite different from the LCDM model. We studied the violation of the FRW consistency condition between distance and expansion rate and showed that it is within an order of magnitude of the current observational constraints, and noted that this is likely to also be the case in the real universe if backreaction is significant.

Cosmic parallax is a fundamental observable in the programme to measure cosmological distances. It is particularly interesting now, after the launch of a dedicated parallax measurement satellite Gaia in December 2013. We studied the parallax using a general covariant formalism. We proposed a new kinematical consistency test for the FRW metric, and showed that deviations from the FRW metric have to be taken into account when analysing cosmic parallax, even if the mean optical properties of the universe are well described by the FRW metric.

Cosmic Microwave Background: We studied distortions due to primordial magnetic fields (PMFs) on the spectrum of the cosmic microwave background. The energy of PMFs dissipates in the diffusion scale. When this occurs after the chemical decoupling of the CMB, their energy turns into CMB distortions and since PMFs are not homogeneous, these distortions inevitably have anisotropies. We computed the angular power spectra of these anisotropies and showed that they might be seen by future CMB observations. We also studied the cosmological implications of 21 cm line fluctuations due to the presence of minihalos, which are halos too small to host galaxies. Since the formation of minihalos is sensitive to matter fluctuations on small scales, the ensuing fluctuations can be used to probe cosmological models. In particular, we studied isocurvature perturbations with blue-tilted spectrum and cosmic strings, and showed that future 21 cm observations will be able to observe their signals, leading to tighter constraints on these models.

Dark Matter: We have studied particle DM in the minimal walking Technicolour models (MWTC), showing that MWTC can induce a dynamical electroweak symmetry breaking, solve the hierarchy problem, give a gauge coupling unification and provide a viable DM particle, all while being fully consistent with all existing cosmological and laboratory constraints. The strongest tests on the model come from the precision electroweak constraints and from the direct DM detection experiments. We also investigated the case of a singlet scalar DM. After making a thorough analysis of all existing constraints on the





Shown is the allowed region (white) in the singlet scalar DM model as a function of DM mass m_S and the predicted direct detection cross section σ_{SI}. The gray area corresponds to too much DM and the dark blue areas show the current (2012) and projected constraints from the XENON experiment. The red area is ruled out by the Higgs particle decay width constraint from the LHC experiment.

model we found that a singlet scalar DM is a viable option in a rather wide range of model parameters. In particular, there is an interesting allowed window at $m_S \approx 55$ GeV–62.5 GeV, which cannot be ruled out by any foreseeable experiment.

Laws of Nature and Condensed Particle Matter Phenomenology at the LHC

Our focus is on electroweak symmetry breaking (EWSB) mechanisms and associated Beyond the Standard Model (BSM) phenomenology, and on perturbative and non-perturbative strong interactions with applications to BSM physics and properties of hot and dense QCD matter. 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 local experimentalists of the CMS Collaboration (Helsinki) and ALICE Collaboration (Jyväskylä).

EWSB and BSM phenomenology: The discovery of a Higgs-like boson with a mass around 125 GeV was announced by researchers at the CERN Large Hadron Collider (LHC) in July 2012. The measured properties of the boson, together with the cosmological precision observations, are hoped to hint towards the physics responsible for the electroweak symmetry breaking, the origin of luminous and dark matter and to a possible theory beyond the Standard Model.

Models with enlarged scalar sectors, which can be composite or elementary, and supersymmetric models remain well motivated candidates for BSM physics. During 2013 models featuring the Higgs sector with scalars in triplet representations have been studied and the full radiatively corrected Higgs mass has been calculated. The rare B-meson decays in the model with a vanishing hypercharge triplet were considered. A charge and parity violating version of the minimal supersymmetric Standard Model was tested by searching for several benchmark points and considering specific signals in those. As a highlight of the research, a new method was developed to test a theoretically favoured light stop squark at the LHC [Phys. Rev. Lett. 110 (2013) 141801]. In addition, we have constructed phenomenologically viable composite models, and confronted them with LHC data.

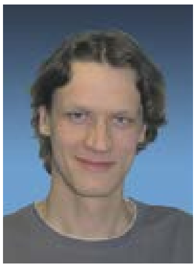
Technicoloured or supersymmetric extensions to the Standard Model also provide viable dark matter candidates, and can introduce the additional charge-parity (CP) violation needed for obtaining the observed baryon asymmetry of the universe. The recent data from the XENON and LUX experiments provide stringent constraints for dark matter candidates coupled with the Standard Model matter via spin independent couplings.

Dynamics of strong interactions: One of our goals within this part of the project is to use lattice simulations and holographic methods to gain insight into the non-perturbative dynamics of strongly interacting quantum field theory; the main motivation here is provided by the applications in BSM model building. Large scale simulations of SU(2) gauge theories with improved Wilson fermions in fundamental or higher representations were carried out. As a particular example, we studied the SU(2) gauge theory with two adjoint Dirac flavours and established the location of the infrared fixed point.

Non-perturbative strong dynamics can also be studied with holographic methods, i.e., gauge/gravity dualities. Using a bottom-up holographic model we have studied the phase diagram of QCD in the Veneziano limit as a function of temperature and finite quark number density. The model can next be extended to study the dependence on the number of quark flavours and the approach towards the boundary of the conformal window at finite temperature and density. We have also constructed a simple holographic model of QCD-like theories based on the D3/ probe-D7 models of chiral symmetry breaking.

Another goal is to provide solid theory studies for applications in ultrarelativistic heavy ion collisions (URHIC). The recent LHC results from Pb+Pb collisions have strengthened the status of relativistic hydrodynamics, a long-time expertise of our group, as a cornerstone of URHIC physics. In computing the produced QGP initial densities for hydrodynamics, we extended our NLO-improved perturbative QCD + saturation + hydro (EKRT) framework to non-

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



Ari Harju,
Low Dimensional Quantum Systems project leader

central collisions and dissipative hydrodynamics: analysing simultaneously the LHC and RHIC multiplicities, p_T spectra and elliptic flow (v_2), we charted the temperature dependence of the QCD-matter shear viscosity. Combining the thermal photon production from our event-by-event hydro with the NLO pQCD baseline calculations, we addressed the big open question of understanding the direct photon p_T spectra and v_2 simultaneously, both at the RHIC and the LHC. We also charted the importance of the 2nd-order terms in relativistic dissipative hydrodynamics, computing them from kinetic theory.

High-p_T observables, such as single hadron spectra, hard hadron correlations and jets, are another cornerstone of the experimental URHIC programme at the RHIC and the LHC. The in-medium parton shower code YaJEM, developed by us, has been tested successfully against a large body of experimental data. Using this framework, we made predictions for several observables probing the QCD dynamics of parton-medium interaction in novel ways, which are of interest experimentally. For example, we predicted the strength of hard D-D correlations and obtained the yield of conversion photons for the first time from an evolving parton shower, ultimately allowing to better pin down the properties of the hot QCD medium.

Our nuclear parton distribution function (nPDF) package EPS09 defines the current state-of-the-art for the nPDFs and their uncertainties. Our EPS09-based NLO predictions for high-p_T pion and dijet production in p+Pb collisions served as a pQCD comparison-baseline for the LHC experiments. With our recent EPS09s set of spatially dependent nPDFs, we addressed the centrality dependence of prompt photon production in nuclear collisions at the RHIC and the LHC. We also showed how to include the available neutrino-DIS data in the global nPDF analysis. The applicability of the current NLO fragmentation functions in computing the inclusive charged-hadron spectrum at the LHC was critically studied.

In the Colour-Glass-Condensate framework we resolved a longstanding controversy in the field by showing that a proper treatment of the nuclear geometry in a CGC dipole model allows for a good simultaneous description of HERA electron-proton cross sections and the LHC nuclear modification ratio for charged particles in proton-nucleus collisions. In 2013 we also calculated incoherent exclusive diffractive vector meson cross sections in nuclear collisions. Our calculation was the most successful of the theory predictions for the result released by the ALICE experiment later in the year.

Low Dimensional Quantum Systems

The field of low-dimensional condensed-matter systems has been shown to be full of interesting physics that has been actively researched both theoretically and experimentally. Two recent examples 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 to study two-dimensional semiconductor quantum dots in strong magnetic fields and graphene. In a semiconductor 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).

Despite being only one atomic layer thick, graphene is remarkably chemically as well as thermally stable. We have studied the functionalization of graphene, and we have developed numerical techniques to study in more detail the transport properties of defected graphene.

Finally, we have continued to develop methods for using graphics processing units to significantly speed up various simulations. In the best cases we have studied, the computation time was shown to be around hundred times faster than on the central processing unit.

Radiation Damage in Particle Accelerator Materials

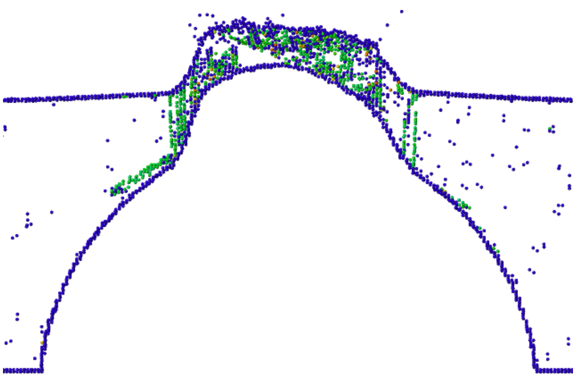
Atomistic simulations of high electric field effects: The observation of a 125 GeV mass Higgs-like particle [Phys. Lett. B 716 (2012) 1, Phys. Lett. B 716 (2012) 30] at CERN's Large Hadron Collider (LHC) confirmed the theoretical discovery of a mechanism of mass generation of elementary particles made in 1962 independently by Peter Higgs and François Englert and highly recognised by the Nobel prize committee in Physics in 2013 [http://www.nobelprize.org/nobel_prizes/physics/laureates/2013/]. The discovery encourages particle physicists to deepen this knowledge and seek the exact nature of the theory containing this new particle. This requires high precision studies at multi-TeV energies for electrons, for which the most promising electron-positron collider candidate is the Compact LInear Collider (CLIC) [https://edms.cern.ch/document/1235960].

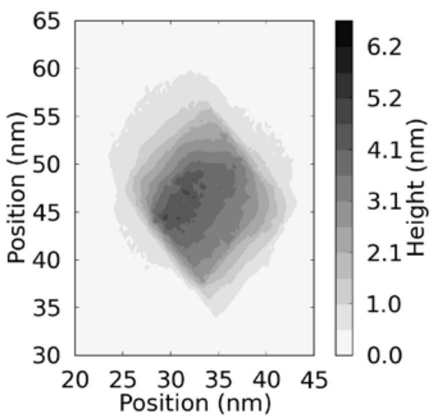
The CLIC design with two-beam acceleration and travelling-wave accelerating structures, an international project under development at CERN, meets the expectations of the post-LHC high energy frontier of the global particle physics community. The CLIC Two-Beam Acceleration technique generates the high-frequency, high-power microwaves needed to accelerate a low-intensity beam to very high energies by decelerating a high-intensity low-energy beam, i.e., basically working as a transformer, turning high current and low voltage to lower current and higher voltage. The central issue in this design is reaching high accelerating gradients (≥ 100 MV/m) to keep the collider length and cost within reasonable limits, which by the present estimations is of the order of 50 km to reach a collision energy of 3 TeV. The length is defined by the accelerating gradient, which still can be applied without extensive power loss due to breakdowns near metal surfaces of accelerating structures. The design of such materials which can tolerate the extreme CLIC conditions without breaking frequently during the operational time, is one of the main courses of the current status of the project.

The multi-scale and multi-physics model under development at HIP in the group led by Doc. F. Djurabekova is dealing with the processes which precede and succeed breakdown events. This research aims to find the key mechanisms affecting the breakdown rate in order to keep it at an acceptable limit. The model is based on the consideration of plastic deformations initiated by the tensile stresses inevitable in the presence of high electric fields. Our novel approach allows for atomistic simulations of a metal surface held under a high electric field, calculating the dynamic local modifications of the applied electric field around momentously appearing rough features on the surface during the simulations. These modifications are taken into account self-consistently in the calculation of the partial atomic charge depending on the value of the local field around the atom [Phys. Rev. E 83 (2011) 026704].

In 2013 by combining the algorithms developed for the simulation of dislocation nucleation on a near-surface void under tensile stress and the electric field effects, we showed that indeed, dislocations can nucleate on the inner surface of the near-surface void, which would lead to a catastrophic growth of the protrusion because of the strong self-reinforcing mechanism of this growth (see the figure below) [J. Appl. Phys. 114 (2013) 033519]. The result lies well in line with experimental measurements of field

Flyura Djurabekova, Radiation Damage in Particle Accelerator Materials project leader





Protrusion catastrophically growing on a Cu (110) surface in the presence of a strong external electric field. The side view is on the left and the top view is on the right. The protrusion originates at a near-surface void, which can be formed during technological processing of the metal. Self-reinforcing growth of the protrusion can explain the sudden peaks of field emission currents, found to appear from seemingly random spots on the copper surface. For the shape of the electric field around the forming protrusion, see the figure to the right at the top of the following page.

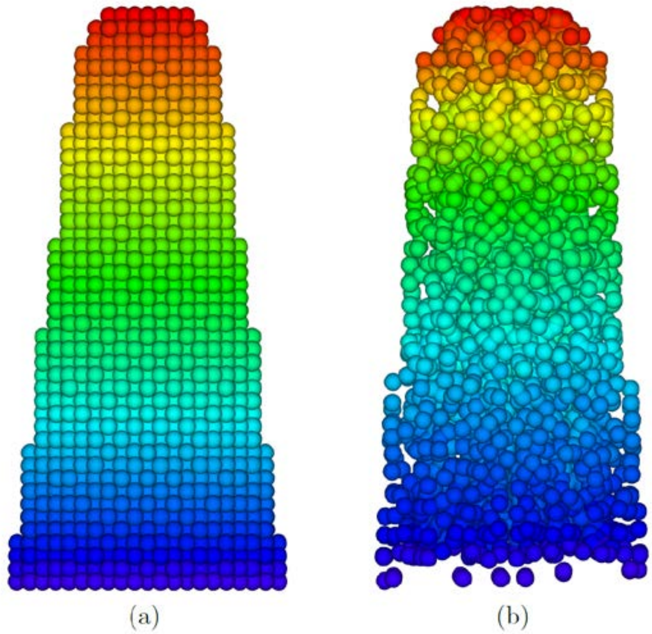
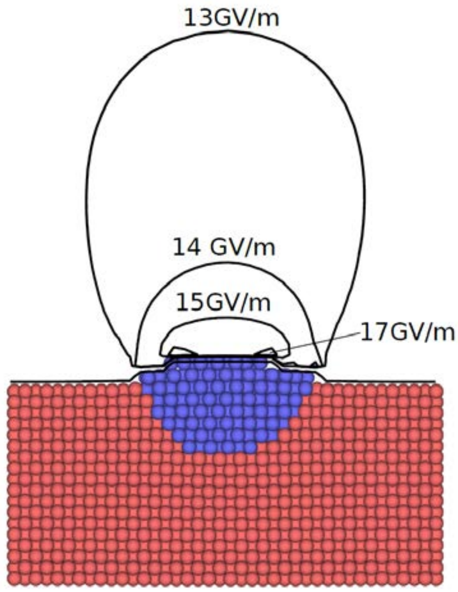


Image (b) of a perfect (no defects, inclusions or voids present) Cu tip (a) reconstructed from the APT simulated experiment. Although at first sight the reconstructed image resembles the original one, a close inspection reveals the intermixing of atoms from different layers. This aberration becomes more complex if a void or an inclusion is present under the surface.

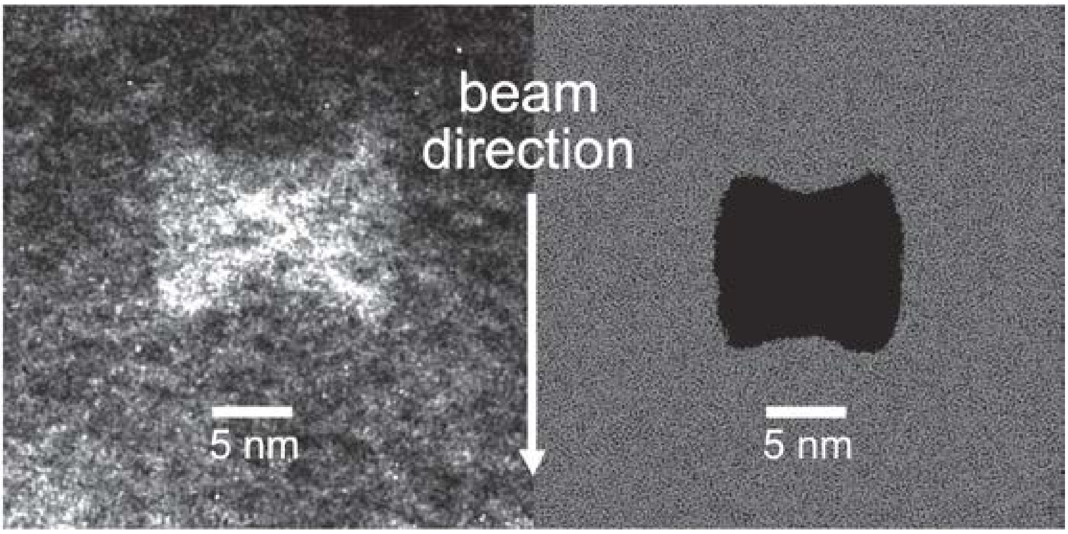


Contour lines outlining the shape of an applied electric field as it is seen in our EDMD concurrent model. Any modification of the surface topology is self-consistently reflected in changes of the local field around the rough features.

emission currents from a seemingly flat surface. The currents appear at random spots in a sudden manner (time resolution is not possible within the experimental set-up).

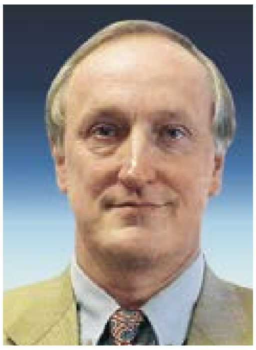
We have further extended by adding the Monte Carlo step the method used in the previous study to incorporate the effect of partial electric charge on surface atoms on the dynamic of surface evolution in the presence of high electric fields [S. Parviainen, F. Djurabekova, S. P. Fitsgerald, A. Ruzibaev, and K. Nordlund, Concurrent Electrodynamics-Molecular Dynamics-Monte Carlo simulations of field assisted evaporation in atom probe tomography, J. Appl. Phys., submitted for publication (2013)]. This step allows simulating the field evaporation process at cryogenic temperatures, which are usually not accessible by classical molecular dynamics methods. The rapidly developing field of Atom probe tomography (APT) [Materials Today 57 (1998) 7556] is very promising for reconstructing material structures from atom level knowledge obtained by applying the experimental tools. The idea behind the method is rather simple - atoms in an ionized state are pulled out from a surface of a sharp tip by a strong electric field and registered on the detector screen with an account of the field shape and time-on-the-flight resolution. However, an exact knowledge of atom behaviour in such conditions is necessary to enable the realistic estimation of possible sources of image aberrations. At the moment this technique uses relatively simple approximations of electric field shapes around nanoscale apexes (about 20 nm) of studied tips (an example is shown in the figure above to the left). In our simulations we see that the shape of the field around dynamically forming rough features on the surface (cf. the figure above to the right) can change significantly, affecting the value of the local field. This, in turn, affects the trajectory of the flying ionized atoms. The result of our simulations in the figure above to the left shows that, although, some aberration corrections are possible, it is difficult to predict the layer intermixing, which may appear dynamically during the evaporation process. The presence of any defect, such as a void or an inclusion, will strengthen this uncertainty.

Nanostructuring of materials by using swift heavy ion irradiation: Last year we have shown in collaboration with the Australian National University (the group of Prof. M. Ridgway) experimentally and by computer simulations that ion tracks can be formed in amorphous semiconductors. The under-dense core/over-dense shell tracks in amorphous germanium result from quenched-in radially-outward material flow. In the figure below a comparison of the experimental TEM image and the corresponding image from molecular dynamics simulations is shown. Following a solid-to-liquid phase transformation, the volume contraction necessary to accommodate the high-density molten phase produces voids, potentially the precursors to porosity, along the ion direction. Within the group we have reproduced the intriguing bow-tie shape of voids observed in experiments along the swift heavy ion path, which results from radially inward resolidification. Moreover, in amorphous silicon the observed tracks after irradiation by swift heavy ions were proven to have an over-dense core and slightly under-dense shell structure. These observations resulted in publications in Physical Review Letters ("bow-tie" voids in irradiated amorphous Ge [Phys. Rev. Lett. 110 (2013) 245502]) and Physical Review B (irradiation of amorphous silicon [Phys. Rev. B 88 (2013) 174111]).



Comparison of "bow-tie" shaped voids seen in amorphous germanium after irradiation by Au ions with 185 MeV and those obtained in molecular dynamic simulations with similar irradiation condition. The size of the void in the experiment is 11.1±0.2 nm.

High Energy Physics Programme



Heimo Saarikko,
High Energy Physics
Programme director

In 2013, several important physics analyses were completed by the Helsinki group based on the data collected in the TOTEM experiment at the CERN LHC, as well as in the CDF experiment at the Fermilab Tevatron. The Helsinki TOTEM group has given major contributions in the physics of inelastic diffractive scattering, and a member of the group acted as the Physics Co-ordinator of the experiment. In the TOTEM experiment the group had a key role in operating the T2 spectrometer detectors. The Compact LInear Collider (CLIC) study entered a new phase of technical development and optimisation that will lead to a Technical Implementation Plan by 2018. The focus of the HIP contribution is on R&D for the CLIC RF structures and the integration of the RF structures into the CLIC module. In 2013, the Helsinki Detector Laboratory hosted several HIP projects concentrating on the CMS, TOTEM and ALICE experiments at CERN, and the NUSTAR/SUPER-FRS experiment at FAIR. New detector technologies are actively developed in the framework of the CERN CMS, RD39, RD50 and RD51 Collaborations. 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.

Risto Orava,
TOTEM Operation
project leader

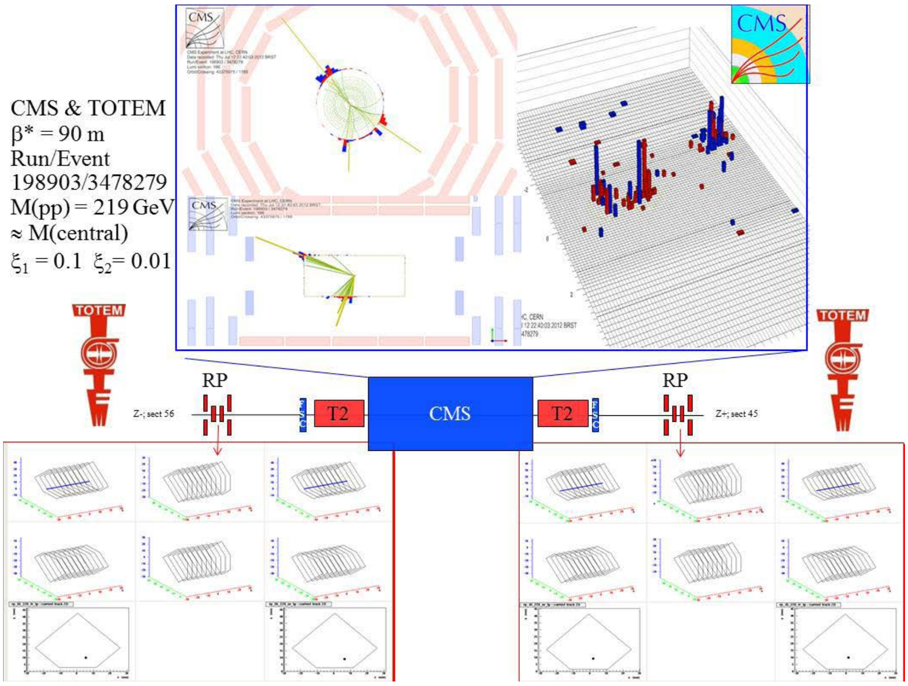
TOTEM Operation Project

In 2013, several important physics analyses were completed by the Helsinki group based on the data collected in the CDF experiment at the Tevatron (Fermilab), and in the TOTEM/CMS experiment at the LHC (CERN). As physics highlights, Erik Brücken completed his PhD study of exclusive gamma-gamma production - the first observation of the process - in spring 2013. A comprehensive analysis of Higgs production was completed by Francesco Devoto in summer 2013 (PhD defence on 13 November 2013). PhD thesis studies on Higgs production (Timo Aaltonen) and on the all hadronic decay modes of the top quark (Petteri Mehtälä) have been completed and are awaiting their formal completion.

Since 2012, the TOTEM experiment has published several important physics results including the first total cross section measurement at the LHC, measurement of the forward charged particle pseudorapidity density, and the differential cross section for elastic proton-proton scattering.

In the TOTEM/CMS experiment, the Helsinki group has had a key role in constructing and operating the T2 spectrometer detectors (GEM detectors). The success of these detectors is based on the novel method of quality assurance developed in Helsinki; a PhD thesis study on this topic was conducted by Timo Hildén. The first precision measurement of the doubly diffractive pp cross section was carried out by Tuula Mäki in autumn 2013, and has been submitted for publication by the TOTEM Collaboration. PhD studies on proton-proton inelastic processes were completed by Jan Welti and have been published by the TOTEM Collaboration. The physics analysis by Fredrik Oljemark on single diffractive cross section has advanced well and will be published soon. Novel multidimensional analyses and event classification approaches have been introduced and tested by Mikael Mieskolainen (MSc.Eng. completed in September 2013 at Tampere University of Technology).

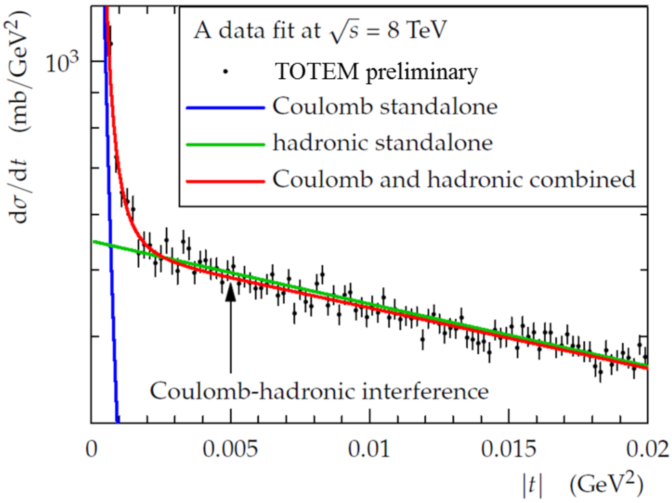
In close connection with its research activities, the Helsinki group carries out educational programmes both at the undergraduate and



A candidate event of central diffractive jet production from the common CMS-TOTEM data taking at $\beta^* = 90$ m. Top: the CMS event display with the reconstructed jets. Bottom: the TOTEM Roman Pot display with the reconstructed protons.

graduate level. Within the past four years, six PhD's and five 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 and polytechnic students, are continued at CERN. Since the beginning of 1990, the Helsinki group has produced 27 PhD's, 41 MSc's and trained numerous physics and technical students in its experimental high energy physics projects at CERN and Fermilab.

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



The TOTEM |t|-differential elastic cross section at $\sqrt{s}$ = 8 TeV from a special $\beta^* = 1$ km run. This constitutes the first measurement of Coulomb-hadronic interference in elastic scattering at the LHC.

The Helsinki group (members & advisors) in 2013 were: Timo Aaltonen (PhD student), Erik Brücken (PhD completed in spring 2013), Francesco Devoto (PhD completed in November 2013), Francisco García (post-doc), Jouni Heino (lab.eng.), Timo Hildén (PhD student), Valery Khoze (advisor), Rauno Lauhakangas (detector scientist), Jerry Lämsä (advisor), Petteri Mehtälä (PhD student), Mikael Mieskolainen (MSc.Eng. completed in September 2013), Tuula Mäki (post-doc), Fredrik Oljemark (PhD student), Risto Orava (professor, Helsinki group leader), Heimo Saarikko (professor, HIP Programme leader), Alex Winkler (PhD student) and Kenneth Österberg (University lecturer and TOTEM Physics Co-ordinator).

Kenneth Österberg, Linear Collider Research project leader

Linear Collider Research Project

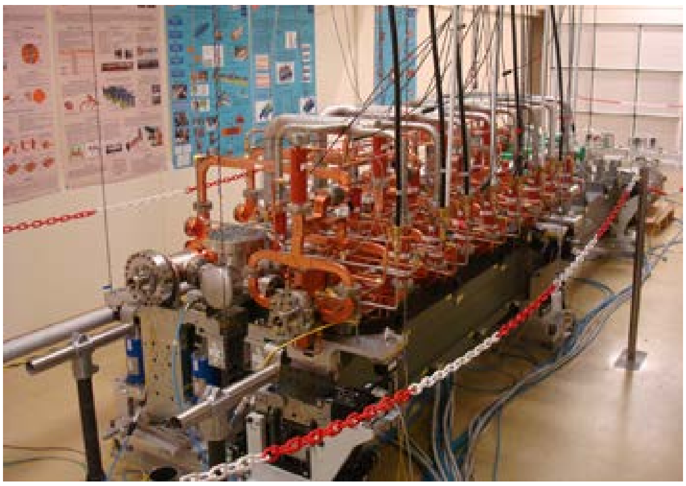
The Linear Collider Research project participates in the Compact LInear Collider (CLIC) study that is developing the CLIC two-beam technology for a multi-TeV electron positron collider in view of a decision on the future direction of the high energy frontier in the coming years. After the completion of its Conceptual Design Report (CDR) during 2012, the CLIC study has now entered a new phase of technical development and optimisation that will lead to a Technical Implementation Plan by 2018. The focus of the HIP contribution is on R&D for the CLIC RF structures and the integration of the RF structures into the CLIC module.

The topics covered during 2013 included industrialisation and a cost study of the RF structure manufacturing, the development of dynamic vacuum and internal shape measurement techniques for RF structures as well as studies of the thermo-mechanical behaviour of CLIC prototype modules and properties of candidate materials for the module support structures. The R&D was done in close collaboration with the CERN CLIC RF structure development and production groups, notably Drs W. Wünsch and G. Riddone, and several Finnish industrial and academic partners. The project had in 2013 three MSc students (L. Kortelainen, V. Mäkinen and W. Zhou), two researchers (Dr. M. Aicheler and J. Väinölä) and a summer trainee at CERN plus the project leader and two PhD students (A. Meriläinen and R. Montonen) based in Helsinki.

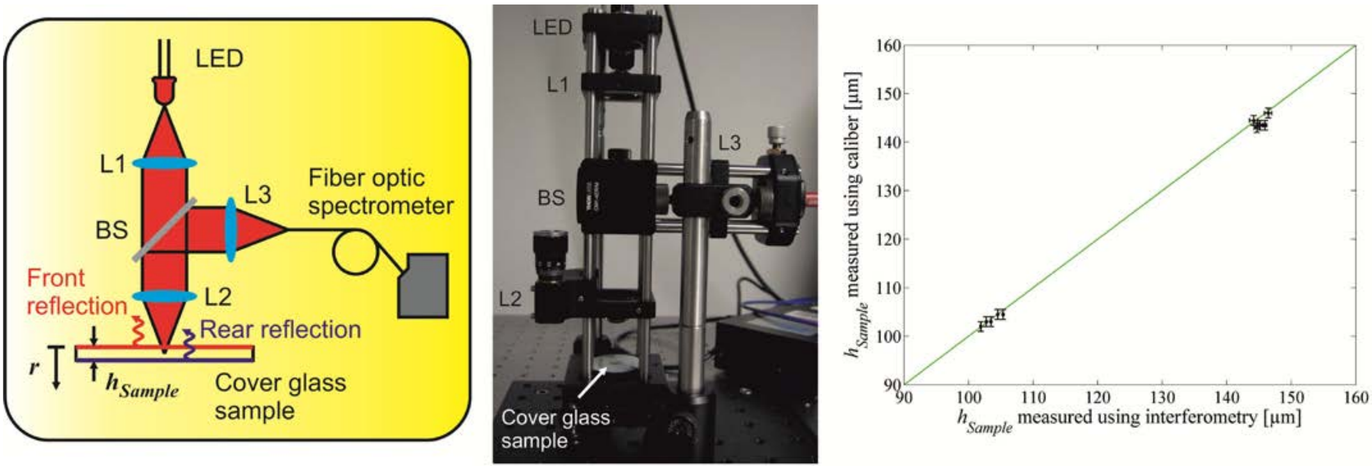
The R&D on RF structure manufacturing and precise assembly aims at involving Finnish companies in the manufacturing of components for the CLIC RF structures, notably five companies are involved through the HIP co-ordinated and EU funded "MeChanICs" (Marie Curie Linking Industry to CERN) project between 2010 and 2014. In 2013 within MeChanICs, one researcher from Loval Oy worked at CERN for 12 months on brazing and bonding aspects of the RF structure assembly and one researcher from Mectalent Oy at CERN for 10 months with optimisation of RF structure assembly processes required for industrial manufacturing. The MeChanICs project was described in a profile article in Science & Technology review 04/2013.

A critical issue for the CLIC overall cost is the optimisation of the manufacturing costs for the RF structures, since they constitute a significant fraction of the overall cost of CLIC. HIP was involved in a study that estimated the possible cost-reduction that would be achieved if the RF structures were made in considerably longer units than currently planned. The results were documented in an MSc (Eng.) thesis completed in 2013.

The CLIC module with all the accelerator components and services integrated also has to maintain high precision during CLIC operation. This is verified on one hand by measurements on a prototype module and on the other hand by modelling the thermo-mechanical behaviour of the module for various loading conditions. The HIP-led MeChanICs project has supported the construction of the first full-scale prototype module (without a beam) in the laboratory as well as the implementation of a system to precisely measure its thermo-mechanical behaviour. This was completed in spring 2013 and reported in a contribution to IPAC'13. In parallel, the group continued developing the simulation model for the CLIC module to describe the current prototype module and its measurement environment. During 2013, the first set of measurements of the



A first full-scale CLIC prototype module assembled in a laboratory at CERN for the thermo-mechanical test programme.

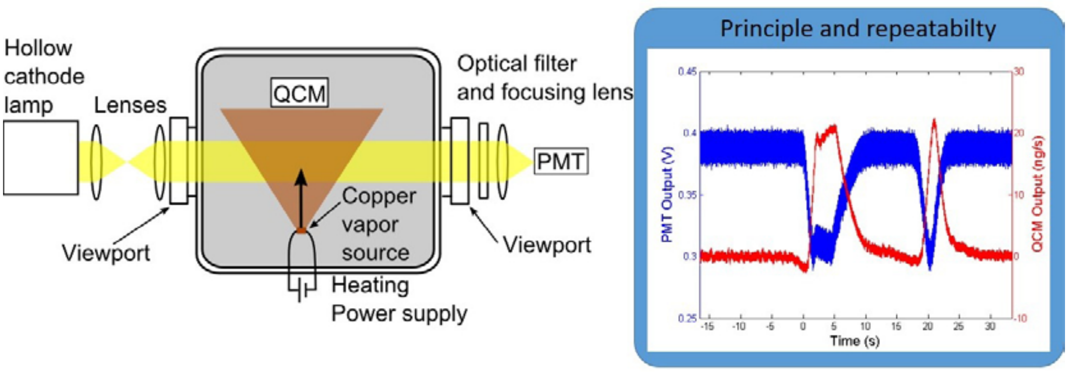


Schematic (left) and photograph (centre) of the set-up for verification of the sub-micron precision of Fourier Domain Short Coherence Interferometry. Right: set-up measurement compared to µm calibration measurement for the same glass sample.

thermo-mechanical behaviour of the prototype module was performed. These measurements were compared to the simulations and found to agree. The development of the model and the comparison with the measurements on the actual prototype module was documented in an MSc (Eng.) thesis in 2013. HIP also contributed with one MSc student on the study of the properties of candidate materials for the module support structure and the results of those studies have been documented in an MSc (Eng.) thesis to be completed in 2014.

During assembly as well as during RF loading, the CLIC RF structure disks experience permanent µm scale shape deformations. To quantify these deformations, an effort was launched in autumn 2012 in collaboration with Prof. E. Hæggström and his group at University of Helsinki's Department of Physics to develop a non-destructive method with sub-micron precision to measure the internal shape of the RF structure disk stack using Fourier Domain Short Coherence Interferometry (FDSCI). The verification of the proposed method is proceeding in steps. A first set-up was constructed in 2013 that demonstrated the sub-micron precision of FDSCI for thickness measurements of standardised glass plates. The next step is the construction of a set-up to show that the depth range of 10 mm required for the measurement of the RF structure disk stack can be achieved with FDSCI using Fabry-Perot filtering.

Also the collaboration with Prof. Hæggström and his group continued on the development of a rapid ultralow pressure manometer to dynamically measure the outgassing from a RF loaded structure during one pulse train. Simulations predict outgassing levels at CLIC that are below the critical levels of feasibility, but direct measurements of 10^{-7}–10^{-8} mbar local pressure at 10–100 ns time scales in the RF structures are necessary to test the validity of the predictions. Sensitivity to 10^{-5}–10^{-6} mbar copper partial pressures in single pass measurements was obtained with a dedicated test set-up in Kumpula's Accelerator Laboratory in 2013. The next steps, before installation at one of CERN's 12 GHz test stands for measurements on real RF structures, are an absolute manometer calibration as well as an increase of both the sensitivity and speed by using a more sensitive and faster photo multiplier.



Test set-up (left) and principle (right) of the rapid ultralow pressure manometer. A photo multiplier tube (PMT) detects a light intensity decrease proportional to the evaporated density of copper atoms. A quartz crystal microbalance (QCM) is used for absolute calibration.

A critical issue for CLIC is to limit the electrical breakdown probability in the RF structures in order to achieve a stable beam with sufficiently high accelerating gradient (> 100 MV/m). We continue to collaborate closely with F. Djurabekova, PhD, whose group is developing a multi-scale model for the physics processes leading to electrical breakdown and other defects on the surface of the RF structures. Their work will give useful information on appropriate choices for the design, the preparation and the production for the RF structures, in view of reducing the breakdown probability during operation. A new line of collaboration with them is on the deformation of the RF structure disks during assembly and possibilities of atomistic simulations to give information on the optimisation of the bonding process. An effort to initiate the involvement of research groups from Aalto University into material related CLIC activities was made in 2013.

Detector Laboratory

Eija Tuominen, Detector Laboratory coordinator

The Helsinki Detector Laboratory is an infrastructure specialised in the **instrumentation of particle and nuclear physics**. It is a joint laboratory between the Helsinki Institute of Physics (HIP) and the Department of Physics of the University of Helsinki (UH/Physics). The Laboratory provides premises, equipment and extensive know-how for research projects developing detector technologies for large international physics experiments. The personnel of the Laboratory has extensive expertise in the design, construction and testing of silicon and gas-filled radiation detectors. In addition, the Laboratory organises teaching for UH/Physics students and demonstrations for visiting high school students.

All the projects present in the Detector Laboratory have the objective to provide reliable instruments for large international experiments. Therefore, special effort is being put into component testing and long-term reliability, as well as on detector assembly. In 2013, the Laboratory hosted several HIP projects concentrating on the CMS, TOTEM and ALICE experiments at **CERN**, and the NUSTAR/SUPER-FRS experiment at **FAIR**. To maintain the outstanding expertise of the Laboratory, new detector technologies are actively developed in the framework of the CERN CMS, RD39, RD50 and RD51 Collaborations.

The Laboratory collaborates strongly with several HIP projects. Together with the **HIP CMS Upgrade project**, the Laboratory is in charge of the quality assurance of about 250 pixel detector modules for the CMS Tracker Phase I Upgrade, to take place in 2016–2017. The first pre-series modules were already manufactured and tested in 2013 in co-operation with Advacam Ltd. Simultaneously, R&D work was ongoing for the needs of the CMS Tracker Phase II Upgrade.

Together with the **HIP FAIR project**, the final aim of the Laboratory is to provide 32 + spare GEM-TPC (Gaseous Electron Multiplier - Time Projection Chamber) detectors for the diagnostics of the FAIR NUSTAR Super-FRS, planned to be launched in 2018. In 2013 the R&D phase was still ongoing, and the work involved detector design and prototype construction, prototype testing and preparations for in-beam testing at Jyväskylä and GSI.

During 2013, with the **HIP TOTEM Operation project**, the Laboratory maintained the 40 GEM detectors previously manufactured and tested in the Laboratory and installed and commissioned in the TOTEM T2 spectrometer. The Laboratory also maintained its readiness to commission spare GEM detectors for T2.

The **HIP ALICE project** became a new partner in the Laboratory in 2013. The Laboratory prepared for the quality assurance of totally 100 m^2 GEM foils needed for the upgrade of the ALICE TPC detectors. An essential part of the work will be done with the Optical Scanning System (OSS) that is a key infrastructure also for the FAIR project. Thus, the OSS was significantly improved and upgraded in 2013.

The Laboratory supports several **UH/Physics** research activities. The connection to the Division of Elementary Particle Physics is naturally very tight. In addition, the Laboratory collaborates with the Electronics Research Laboratory (ERL), especially supporting their activities in optical imaging techniques and ultrasonic interconnection technologies. In 2013, the first Electric Sail tether structure manufactured by ERL using the Laboratory wire

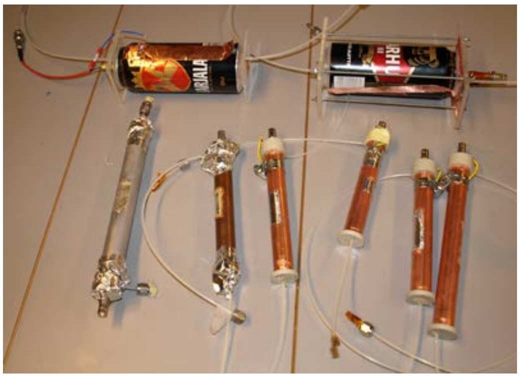
One four-member group soldering the wire for the proportional chamber during the Nordic Detector Course arranged by Detector Laboratory staff.

bonding facilities was launched to space with the EstCube-1 satellite. Furthermore, the co-operation with the Division of Material Physics Accelerator Laboratory is strong in the field of radiation hard silicon detectors. Additionally, there are strong connections with the University of Jyväskylä Accelerator Laboratory and with the Aalto University Micronova/Nanofab facility.

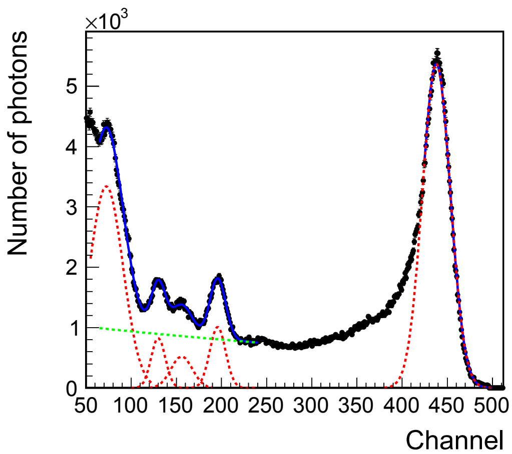
Teaching is an essential part of the Laboratory. Exercises and special assignments concerning detector technologies are organised for UH/Physics students. In addition, several students work continuously with their doctoral and Master studies in the Laboratory. Furthermore, groups of high school students and teachers visit the Laboratory monthly for demonstrations of detector technologies. In 2013, the Laboratory also organised a one-week research training course in detector technologies for Nordic post-graduate students.

The Laboratory participated actively in University **outreach** efforts, such as open-day activities for new students and alumni. In October, the Laboratory participated actively in the organisation of the FAIR NUSTAR 2013 Collaboration Week at Kumpula Campus. Consultancy, based on our own expertise, was given to research groups from other universities and research institutes.

The versatile **infrastructure** of the Laboratory forms a strong basis for the research activities. In 2013, the infrastructure was again significantly improved thanks to the special funding organised by the Division of Elementary Particle Physics. The Laboratory has an especially outstanding infrastructure for the quality assurance of novel, fast detector technologies.



Various single wire proportional chambers manufactured by students of the course.



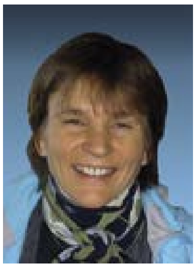
A representative Am-241 energy spectrum measured by one beer can radiation detector assembled during the course.

CMS Programme

Paula Eerola,
CMS Programme
director

The Compact Muon Solenoid (CMS) experiment is one of the two large multi-purpose experiments at the LHC. In 2013 no new proton-proton collision data were collected, because the LHC went into a two-year-long service break. The LHC dipole magnets will be repaired so that the collision energy can be raised to 13-14 TeV when the LHC is restarted in 2015. The CMS detector is undergoing basic maintenance and repairs during this break. The year 2013 has nevertheless been very productive: a large number of physics analyses have been completed with the full Run 1 statistics (~5 fb^{-1} at 7 TeV and ~20 fb^{-1} at 8 TeV). The CMS Collaboration submitted about 65 papers for publication in 2013. By the end of 2013 the total number of CMS publications was 286.

Introduction



Katri Lassila-Perini,
CMS Experiment
project leader

The Finnish member institutes of CMS are the Helsinki Institute of Physics (HIP), the University of Helsinki and Lappeenranta University of Technology. HIP has an overall co-ordinating role in the Finnish CMS involvement. The CMS Programme at HIP is divided into three projects: the *CMS Experiment project*, responsible for the physics analysis and operations, the *CMS Upgrade project*, responsible for the Finnish involvement in the CMS upgrades, and the *CMS Tier-2 Operations project*.

The *CMS Experiment project* was involved in Higgs searches, B physics analysis, and jet physics. The HIP CMS Programme has taken a leading role in presenting the CMS data to the public: at CERN, the CMS Data preservation and open access project is led by K. Lassila-Perini, and in Finland we are leading a pilot project together with the CSC to bring the scientific data to public use in schools.

The *CMS Upgrade project* was busy in particular with the CMS pixel detector upgrade. Pixel sensor module production was started at the Aalto-VTT Micronova facility, and a pre-series of bare pixel modules was produced with excellent results.

The *CMS Tier-2 Operations project* continued to provide reliable computing and data storage resources. In the cloud computing project "Data Indirection Infrastructure for Secure HEP Data Analysis" virtualised resources on the Ukko cluster at the Department of Computer Science, University of Helsinki, could be tested with real CMS user physics analyses.

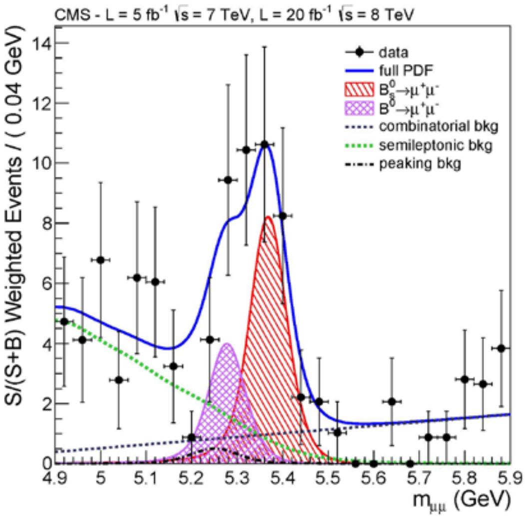
The CMS Experiment Project

Introduction

The HIP CMS experiment project is involved in the CMS physics analyses, concentrating in particular on B physics, Higgs searches and jet physics. The project also contributes to the tracker alignment and leads the CMS efforts in data preservation and physics support.

Physics Analysis

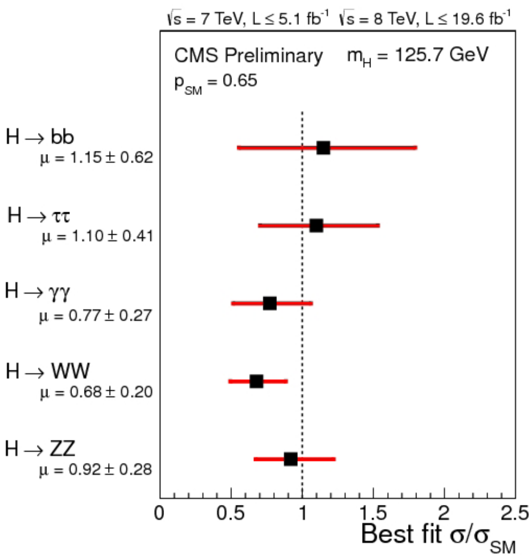
B physics: In 2013, the HIP group was involved in the analysis of the decay channel $B_S \rightarrow J/\psi\ \varphi$ with the J/ψ decaying into two muons and the φ decaying into two kaons. The B_S decay is interesting since it can indicate contributions from new physics beyond the Standard Model. The weak phase measurement requires tagging of the B flavour, i.e., extracting the flavour of the bottom quark inside the B_S meson. T. Järvinen completed her Master's thesis on flavour tagging with opposite-side muons and continued flavour tagging analysis as her PhD project.



Observation of the $B_s \to \mu^+\mu^-$ signal.

The tagging analysis was further proceeded by implementation of opposite-side electron and jet-charge taggers using Monte Carlo samples as well as data. The aim is to publish a paper on weak phase measurement in spring 2014.

Higgs Physics: The search to discover charged Higgs bosons in the $H^\pm \to \tau\nu$ final state continued in 2013 with all available data with the centre-of-mass energy 7 TeV from 2011 and 8 TeV from 2012.



The different decay modes of the Higgs boson (black squares) compared to the Standard Model expectation (vertical line).

Both charged Higgs bosons produced in top quark decays ($m_{H^\pm} < m_{top}$) and in the associated production with top and bottom quarks $gg \to tbH^\pm$ ($m_{H^\pm} > m_{top}$) were analysed. If charged Higgs bosons were found, it would be a clear indication of physics beyond the Standard Model. The first results for searches of the light ($m_{H^\pm} < m_{top}$) charged Higgs bosons were published in 2012 [JHEP 07 (2012) 143], combined with results from the semi-leptonic final states of the same process, on data collected during the first half of 2011 at the centre-of-mass energy of 7 TeV.

A new method to measure the QCD multijet background in the charged Higgs boson analysis was developed. The new method is based on reversing the τ jet isolation of the τ candidate selection in a sample of signal-type multijet events. The backgrounds with genuine τ's from tt production and from electroweak processes were measured with events resembling tt topology and containing an energetic muon and jets, by replacing the muon by a simulated τ lepton. The event selection and the calibration of simulated events were improved.

The group continued its commitment to τ trigger development and measurement. The trigger development for the next data taking period in 2015 was started. The collaboration within the LHC Higgs Cross Section Working Group was also continued. The group continued to participate in the maintenance and in off-line data quality control of the trigger system. Participation in τ-software validation was initiated in 2013.

Jet Physics

Jet physics is a 3-year project funded by the University of Helsinki for 2013–2015 and led by M. Voutilainen. The project aims to take advantage of the highly precise jet energy scale at CMS to do precision QCD measurements. The first analysis looked at the ratio of inclusive jet cross sections with two jet clustering radii (R=0.5 and R=0.7) at 7 TeV to better understand the role of final state radiation and theory scale uncertainties. The results of this novel analysis were first presented at Lepton-Photon in June, and the corresponding paper is now in the final stages before being submitted to PRD.

Jet Energy Corrections

HIP has made leading contributions to the CMS jet energy corrections through co-ordination of the overall effort and through evaluation of the systematics and their correlations (M. Voutilainen, J. Pekkanen). The last set of corrections and uncertainties for the re-reconstructed 8 TeV data was completed in October, and reached a record low uncertainty of 0.6%. An important part of this success was the re-factorization done on the pile-up and jet flavour systematics to reduce double-counting between subcorrections.

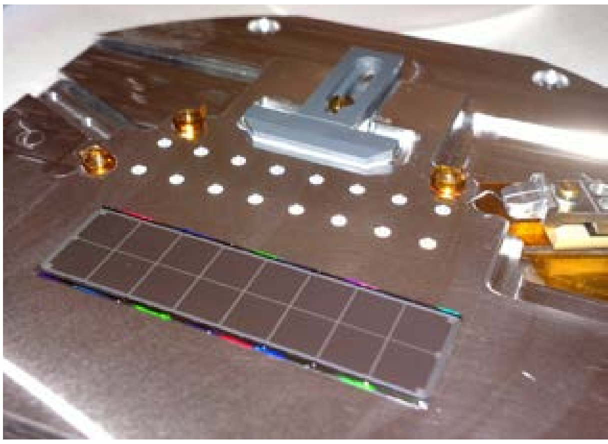
Data Preservation and Open Access


Jaakko Härkönen, CMS Upgrade project leader

The data preservation and open access project in CMS is led by K. Lassila-Perini from HIP. The project is in an active phase, defining tools and practices to make the data, analysis and knowledge preservation part of the everyday work in the collaboration. The first release of reconstructed CMS data is being prepared. HIP is a proactive partner in the data preservation project and leads a pilot project to bring the scientific data to public use at schools.

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. Detector alignment has been a highly important issue for the physics discoveries, and it will be one of the essential ingredients again in 2015 when the Large Hadron Collider restarts operation, since alignment needs to be carried out from scratch. In 2013 the HIP team continued its long-term participation in the alignment work of the CMS Tracker focusing on questions of monitoring and validation. T. Lampén was in charge of maintenance and development of the off-line track-based alignment validation tools, and contributed to the validation process of alignment constants as well as studies of time-dependent changes of Lorentz Angle calibration of the Pixel detector.


CMS pixel detector module in a measurement jig.

The CMS Upgrade Project

The main activity of the HIP CMS Upgrade project in 2013 was to start up the pixel sensor module production at the Aalto-VTT Micronova facility. The innermost measuring element of the CMS detector, the silicon pixel detector, will be completely rebuilt and accompanied with new readout electronics that will be capable of handling the higher amounts of data foreseen after the LHC maintenance break (LS1). The number of channels, i.e., pixels and related interconnections, will simultaneously be increased from the current 64 million up to 125 million channels allowing significantly better tracking performance. The HIP CMS group has committed to produce 50% of the 500 so-called bare pixel modules for the third layer (L3) of the upgraded pixel tracker.

A bare pixel module consists of a sensor and 16 readout CMOS circuits (ROC) that are flip-chip (FC) bonded with the sensor. Altogether the module has about 67 thousand pixels. Processing of the bare modules consists of several metal thin film depositions, lithography steps, silicon wafer thinning, etching, electrochemical metal growth and silicon wafer dicing. It is carried out in the class 10 clean room premises of the Micronova facility. The acceptable level of bad interconnections in the module is less than 0.1%, thus quality assurance (QA) during the different process steps is crucial. First, characterization of the pixel sensors is done by current-voltage (IV) testing with a probe station. The second important QA step follows after the FC bonding of the 16 readout chips. The FC bonded pixel module will be tested with an automated probe station equipped with appropriate data acquisition (DAQ) hardware and software in order to reveal possible bad interconnections. If a malfunctioning readout chip is found, it is possible to lift-off an individual chip, and to replace it with a new one without sacrificing the whole 16 chip module.

In 2013 we have successfully produced a pre-series of the bare pixel modules. Module test measurements revealed less than ten bad interconnections out of more than 350 000 pixels and better than 98% yield of readout ASICs.

To extend its physics potential, the LHC accelerator will be extensively upgraded after 2020. The rate of collisions will increase by a factor of 10 from the original design value. The luminosity increase will push the currently existing silicon detectors installed in the CMS Tracker system well beyond their performance limits. The radiation induced defects will seriously degrade the operation of the Tracker sensors, especially in the pixel region. The HIP CMS group has launched R&D for the development of next generation silicon pixel detectors together with the Laboratory of Inorganic Chemistry (HU), the Accelerator Laboratory (HU) and the Electron Physics Group of Aalto. The research objective is to utilise Atomic Layer Deposition (ALD) method grown thin films for the effective capacitive coupling of the signal from the measured particles. It is possible to produce very high capacitance density structures with ALD, which is a fundamental prerequisite for the high granularity pixel devices. In this approach the elevated leakage current is not directly connected to the ROC and thus allows significantly longer operation life-times for the pixel modules in harsh radiation environments.

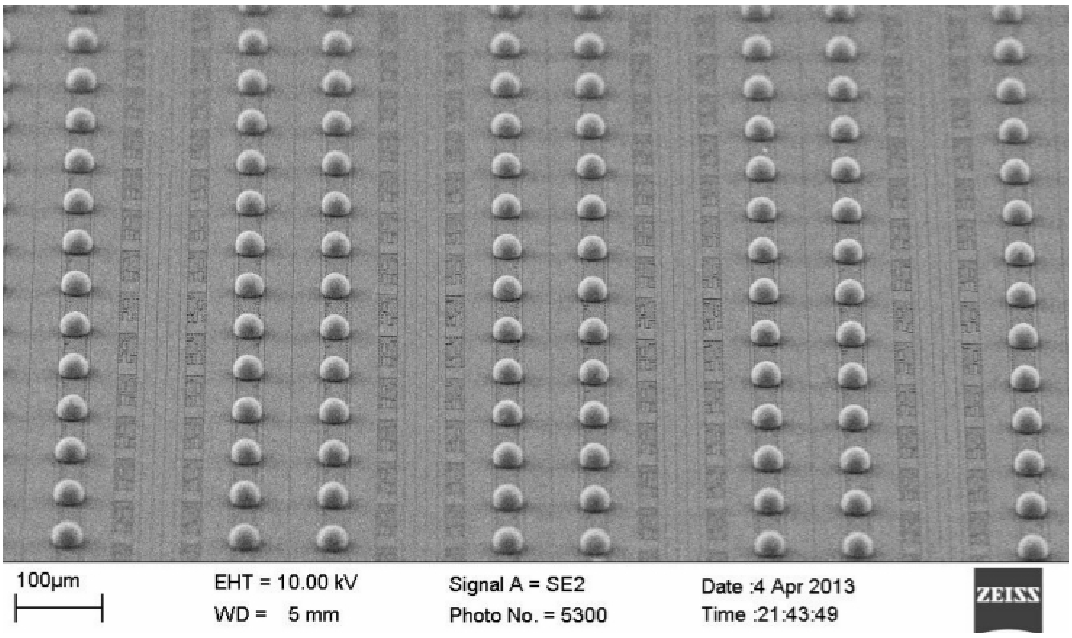
The CMS Tier-2 Operations Project

Grid Computing Activities

In 2013 CMS grid analysis and Monte Carlo production jobs were running on the Finnish CMS Tier-2 resources to analyse the data from LHC Run 1 and to simulate CMS detector upgrades and the Run 2 conditions.

HIP was represented in the Nordic e-Infrastructure Collaboration (NeIC) Nordic WLCG (NLCG) steering committee. The close collaboration between HIP, CSC (IT Center for Science Ltd) and the Nordic DataGrid Facility (NDGF) of NeIC resulted in good progress on

Tomas Lindén, Tier-2 Operations project leader



CMS pixel detector: solder bumps for flip-chip bonding.

many aspects of the CMS computing that are summarised in the following.

Hardware: The main CPU resource for CMS and ALICE was the 768 core Jade (2009) Linux cluster situated on the CSC premises. In addition to that, the 400 core Linux cluster Korundi (2008) and the 840 core Linux cluster Alcyone (2011) in Kumpula were also used for CMS grid jobs as well as the cloud service running on the Ukko cluster in the Department of Computer Science at the University of Helsinki. The 10 Gb/s Optical Private Network (OPN) link between CSC and Kumpula was in use on both Korundi and Alcyone. The disk capacity on one Sun Fire X4540 server was doubled by replacing 1 TB disks with 2 TB disks.

Software: The Advanced Resource Connector (ARC) middleware was upgraded to version 3.x on Alcyone and Jade. The dCache and Lustre systems at CSC were very stable in 2013. The operating systems on Jade and Korundi were upgraded from Rocks 5.x to Scientific Linux 6.x with SLURM instead of SGE as the batch queue system.

A virtual ARGUS server was taken into use and used with glexec on Alcyone.

The Academy of Finland -funded project concerning cloud computing, Data Indirection Infrastructure for Secure HEP Data Analysis together with the Department of Computer Science at the University of Helsinki implemented an OpenStack virtualised ARC set-up on the Ukko cluster. The resource was validated with CMS production workflows. Also CMS user analysis jobs were run successfully on the service. Experiences and results from the cloud service were presented at the CMS Offline and Computing Workshop in March and in a panel discussion during the Nordic e-Infrastructure Collaboration: Lessons, Opportunities and Future Directions Conference in Trondheim, Norway in May 2013. A poster was presented at the 20th International Conference on Computing in High Energy and Nuclear Physics in Amsterdam, The Netherlands in October.

Operations: The Finnish CMS Tier-2 resources are operated, maintained and monitored jointly by HIP, CSC and NDGF. According to the statistics collected with the CMS monitoring tools, the Finnish Tier-2 resources were in “ready” state 81.87% of the time (80.41% in 2012). There were 23 Savannah tickets (35 in 2012) and 13 GGUS tickets (7 in 2012) issued concerning HIP. 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 stability and maintenance ease of ARC middleware allows the use of several Compute Elements for redundancy, which is important for development, testing, deployment and reliability.

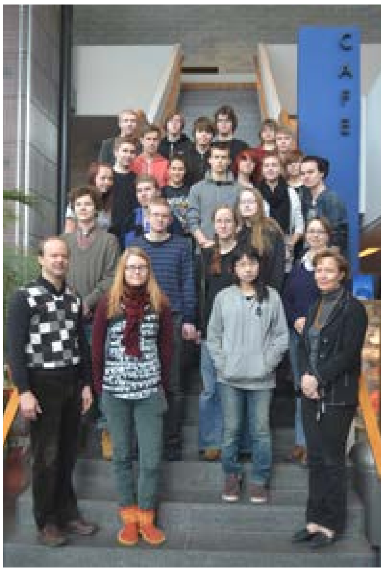
PhEDEx transferred 184 TB of production data (66 TB in 2012) to HIP and 280 TB of test data (253 TB in 2012) to HIP. From HIP to elsewhere 88 TB of production data (76 TB in 2012) and 195 TB of test data (178 TB in 2012) was shipped. In total 747 TB of data was transferred with PhEDEx to or from HIP (573 TB in 2012).

A total of 1 million 873 thousand CMS grid jobs (1 million 37 thousand in 2012) using 23.2 million HEPSPEC06 CPU hours (28.3 million HEPSPEC06 CPU hours in 2012) were run with an average CPU efficiency of 76% (91.4% in 2012). In addition to this a significant amount of local batch jobs were also run.

Outreach

Outreach activities consisted of organising our own public events, such as the TEDxCERN event in Kumpula, giving information about CERN summer student practice in several universities, as well as blog writing, giving interviews and presenting lectures to physics students, school pupils and to the general public. We also participated in joint PR-events in Kumpula, such as the alumni and new student days in 2013.

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.



Left: Master class participants at Physicum. Right: Master class videoconference.

The CMS Programme participated together with Santander and Trieste in the CMS Master class on the 4th of March. The programme for the 21 participating students consisted of lectures, data analysis exercises, a detector laboratory visit and a videoconference.

Experimental particle physics and the status of CERN and the LHC were presented in the Alumni evening of the Kumpula Campus on the 21st of March with a seminar and videos. The Kumpula Campus Science Bazaar was targeted at new students on the 28th of August. Posters, videos and detector modules were exhibited with scientists answering questions and handing out brochures. A science quiz was very popular.

The Physical Society in Finland (Swedish speaking physicists) visited CERN in September. The CMS Programme contributed significantly to the planning, organisation and guiding of the visit.

The 2013 Nobel Prize in Physics was awarded to F. Englert and P. Higgs for their work on spontaneous symmetry breaking. This generated a lot of media coverage in the form of interviews and news articles.

The HIP CMS group members are celebrating the Nobel prize of F. Englert and P. W. Higgs on October 8, 2013.

Nuclear Matter Programme

Matti Leino,
Nuclear Matter
Programme director

The Nuclear Matter Programme involves the participation of 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 on the one hand and dense matter created in relativistic heavy ion collisions on the other hand. Exotic nuclei are studied at the ISOLDE facility while the study of quark-gluon plasma and related phenomena takes place at ALICE. The project leaders are Professor Paul Greenlees (ISOLDE) and Professor Jan Rak (ALICE). The Nuclear Matter Programme has also continued co-ordinating the Finnish participation in the planning and construction of the FAIR project in Darmstadt. Here, the project leader has been Professor Ari Jokinen. 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 in the NUSTAR Collaboration for nuclear structure, reaction and astrophysics studies. Industrial participation for constructing FAIR is being explored in collaboration with TEKES.

Jan Rak, ALICE
project leader

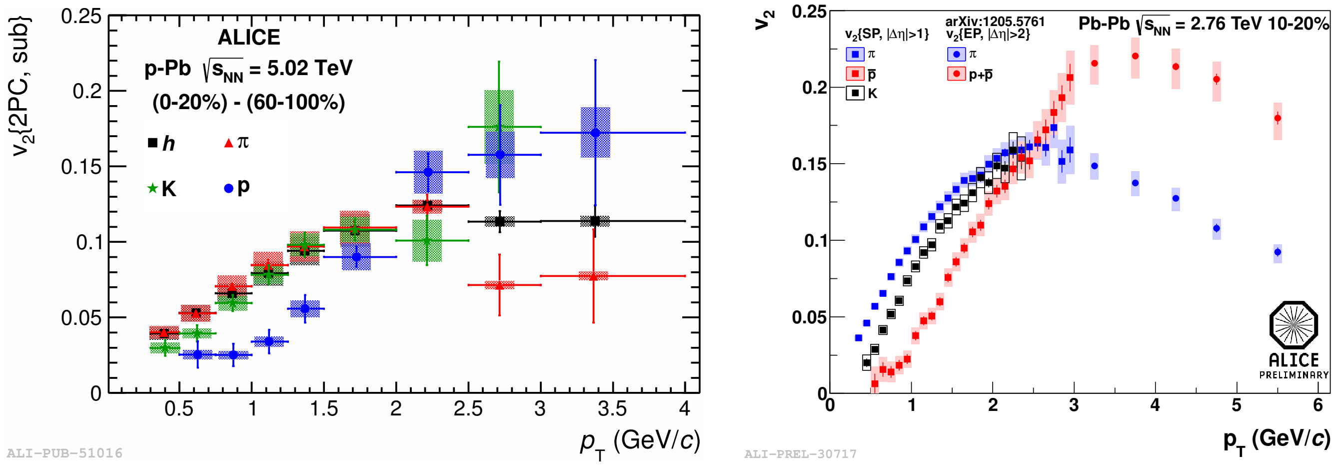
ALICE

After 3 years of successful data taking the Large Hadron Collider (LHC) at CERN entered the first long shutdown period in 2013–2014. The main focus of the ALICE Collaboration in 2013 was on the analysis of the $\sqrt{s_{NN}}$ = 5.02 TeV p-Pb data taken in February 2013 and on the preparation for the upcoming LHC Run II (2015–2017).

The strength of the ALICE experiment is in the capability to study identified particles down to low transverse momenta and thus the main highlights in 2013 could be found, for example, in publications related to π, K, p [Phys. Rev. C 88 (2013) 044910] or K^0_S, Λ [Phys. Rev. Lett. 111 (2013) 222301] production in Pb-Pb data taken at a c.m. energy of $\sqrt{s_{NN}}$ = 2.76 TeV. The study of the flow-like long range correlations in p-Pb collisions first observed by ALICE [Phys. Lett. B 719 (2013) 29] with the use of identified particles revealed a surprisingly similar mass ordering of the flow-like azimuthal particle distribution [Phys. Lett. B 726 (2013) 164] as the one seen in Pb-Pb collisions. This kind of mass ordering is traditionally interpreted as a manifestation of the Quark Gluon Plasma (QGP). A more detailed discussion will follow below. Many other interesting results related to, for example, Quantum Statistics Correlations [arXiv:1310.7808] or jet production [arXiv:1311.0633] in Pb-Pb collisions have been submitted for or are in preparation for publication.

The main motivation for the p-Pb run was to improve the knowledge of the so-called "cold" (unexcited) nuclear effects: the nuclear shadowing or the transverse momentum broadening induced by cold nuclear matter. These measurements are important for reducing the theoretical uncertainty in the evaluation of QGP induced phenomena observed in ultra-relativistic heavy ion collisions. One of the most interesting results, however, seems to be an observation of the long-range correlations in p-Pb collisions.

These correlated particle pairs with a large pseudo-rapidity separation are seen when the per-trigger yield measured in low-multiplicity collisions is subtracted from that measured in high-multiplicity collisions. The double-ridge structure previously observed in correlations of unidentified particles [Phys. Lett. B 719 (2013) 29] is present also in correlations of identified particles. The strength of this long-range correlation can be parameterized by the second Fourier coefficient v_2 of the particle azimuthal distribution $dN/d\varphi \propto (1 + v_2 \cos\varphi)$ where φ refers to an angle with respect to the trigger particle, in the case of p-Pb collisions, or the angle with respect to the reaction plane in Pb-Pb. The



The Fourier coefficient v_2 of identified charged particles from p-Pb (left) and Pb-Pb (right) collisions.

figure above shows surprisingly similar transverse momentum dependencies of the measured v_2 coefficients in p-Pb (left) and Pb-Pb (right) data. In both collision systems, one observes a mass ordering in v_2 which, in the case of heavy ion collisions, is interpreted as a manifestation of collective expansion due to the QGP.

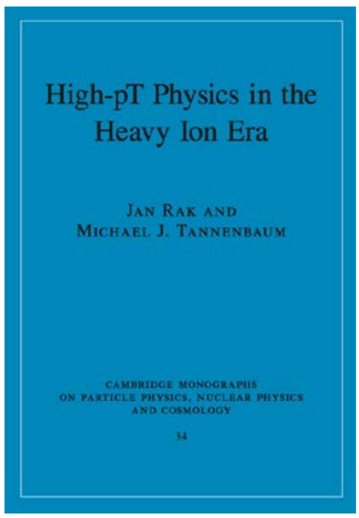
Observation of the long-range correlations in p-Pb and their qualitative similarities to the measurements in heavy ion collisions are rather intriguing. There are at least two possible interpretations: (i) It could be a sign of the similar collective phenomena induced by the presence of the QGP also in p-Pb collisions (e.g., arXiv:1301.3314) or (ii) manifestation of the saturation phenomena expected in the framework of the Colour Glass Condensation (e.g., Phys. Rev. D 87 (2013) 094034). Both of these two interpretations are intriguing and the implications for our understanding of the ultra-relativistic nucleon and heavy ion physics are enormous.

Many of the new phenomena observed at the LHC are discussed in the book "High-pT Physics in the Heavy Ion Era" by J. Rak and M. J. Tannenbaum (Cambridge University Press, 2013) released in March 2013.

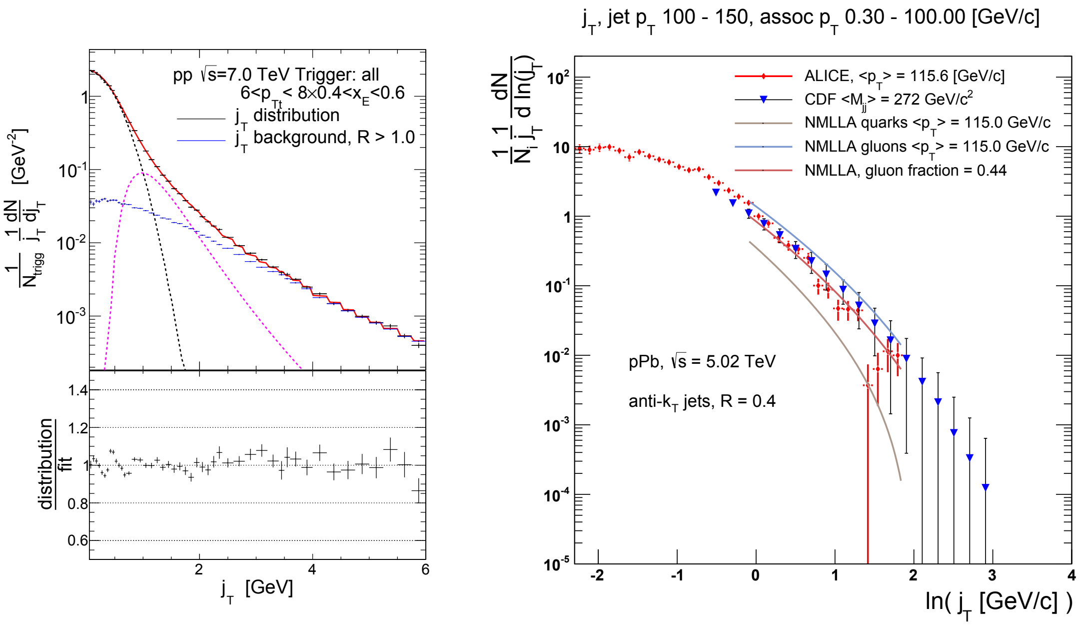
Data Analysis

Our group is involved in the analysis of all data sets taken by ALICE. The main focus is on high-p_T correlations but we are also involved in direct photon analysis, x_T-scaling studies and jet analysis. In 2013, we mainly focused on manuscript preparation for a transverse jet shape measurement by studying the charged particle or jet associated yield in p-p and p-Pb collisions at various centre-of-mass energies. The physics of the transverse fragmentation is related to quantum coherence effects (see, e.g., Phys. Lett. B 115 (1982) 242). This measurement can also help to strengthen the understanding of the parton energy loss mechanism in heavy ion collisions (see, e.g., arXiv:hep-ph/0506218). We have studied dijet acoplanarity using the two particle correlations. Currently we have extended these measurements to fully reconstructed jets, in which case there is no need to unfold the fragmentation functions.

The left panel in the figure at the top of the next page shows the jet transverse fragmentation momentum distribution (j_T) from the di-hadron analysis. The uncorrelated background (blue histogram) is constructed from pairs with a large difference in pseudo-rapidity and azimuthal angle. The signal is assumed to be a sum of a Gauss function (black dashed line) and a Levy function (magenta dashed line). This approach is motivated by the possibility to distinguish between different processes, i.e., the QCD parton shower (Levy component) and the hadronization (Gaussian component) in the measured j_T distribution. It seems that, unlike in the case of the lower c.m. data from ISR and RHIC, a single component fit (Gaussian) is not



"High-pT Physics in the Heavy Ion Era" book by Jan Rak and Mike Tannenbaum.



Jet transverse fragmentation from di-hadron correlation (left) and jet reconstruction (right).

sufficient to describe the whole range of j_T values. When the two component fit is used the agreement with data is much better. It is giving us a hint of a possible separation of the QCD parton shower and the hadronization process. This study is being finalised by J. Viinikainen for his PhD thesis. The right panel in the figure at the top of the page shows the j_T distribution associated with the fully reconstructed jets and it is compared to a theoretical prediction obtained for partons within the framework of resummed perturbative QCD (Modified Leading Log Approximation) [Phys. Rev. D 78 (2008) 014019]. This jet analysis is the main topic of J. Kral's PhD thesis.

Recently, Prof. Risto Orava, an expert in Central Exclusive Diffraction (CED) physics, joined our ALICE group. The ALICE experiment has demonstrated its capability to provide interesting data in the CED field and thus the contribution of Prof. Orava's group could strengthen the physics outcome from our team.

ALICE Experiment and Upgrade Activities

Our group is also involved in three hardware projects: (i) The T0 timing detector, part of the ALICE trigger system (project leader Dr. Trzaska). The T0 detector provides the fast L0 trigger and the start signal for the Time-of-Flight detector and plays an important role in the ALICE data taking. (ii) The single photon trigger system utilising the fast FPGA-based electronics designed for the on-line search for energetic signals in the ALICE electromagnetic calorimeter. (iii) Upgrade of the Time-Projection Chamber (TPC) with the goal to improve the TPC readout speed.

The T0 timing detector: The main challenge for the T0 team in 2013 was to upgrade the T0 readout system to reduce the latency of the trigger signals from 620 ns to below 425 ns. The only way to meet this requirement was to relocate the entire T0 electronics to the racks close to the Central Trigger Processor and reroute and shorten the cables. After that the detector will have to be commissioned and calibrated anew. This work is still in progress.

The single photon trigger system: This system, mainly thanks to the tremendous contribution from our PhD student J. Kral, has been fully operational since 2009 and was also part of the ALICE trigger in the last p-Pb run in February 2013. ALICE has recently decided that the Trigger Region Units (TRU), the heart of this trigger system developed and produced by our group, will be used also for PHOS (PHOton Spectrometer). The main goal in 2013 was to adapt the readout scheme, mainly the FPGA code, to meet these new requirements and to produce and commission new modules for Run II.

TPC Upgrade: TPC, the main tracking detector, is a central part of the ALICE detector. With the current design and readout configuration the maximum data acquisition rate in Pb-Pb collisions is about 500 Hz. The main limitation comes from the TPC gating grid, which is needed to prevent the ion flow back to the drift volume, and which can be operated with a maximum rate of about 3.5 kHz. In order to optimise the ALICE performance after the second long LHC shutdown in 2018 the ALICE Collaboration decided to upgrade TPC to be able to record Pb-Pb collisions at a rate of 50 kHz. It requires replacing all the multi-wire proportional readout chambers with the Gas Electron Multiplier (GEM) technology, which allows preserving the same tracking performance. This requires a production of 120 m^2 GEM foils. Our group together with HIP committed to this TPC upgrade by providing a suitable infrastructure (100 m^2 clean room of class 1000) and expertise in the GEM technology area. Our new postdoc E. Brücken and a PhD student T. Hildén were hired to lead the quality assurance activity (optical scanning, leakage current and the gain measurements of GEM foils).

Computing and Run Operations

Besides the data analysis our group is also involved in the run operations. 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 part of the Nordic Data Grid Facility (NDGF), where we provide the maximum 370 CPUs and 100 TBytes of disk storages to ALICE. In the 2013 run, a p-Pb run was taken and successfully integrated into the grid analysis.

Education

N. Novitzky (second from the left in the picture above) successfully defended his Doctoral Thesis "Study of the Neutral Pion and Direct Photon Production in Au+Au Collisions at $\sqrt{s_{NN}}$ = 39–200 GeV" on 19th September. The opponent was Dr. D. d'Enterria from CERN (left in the picture), currently working in the CMS experiment. Two of our students participated in the CERN summer lectures. T. Snellman got a CERN summer student position and worked with the ATLAS trigger. P. Paakkinen from Jyväskylä was our trainee in the HIP summer trainee position. By the end of the year, T. Snellman finished his Master's Thesis "Identified Charged Particle Flow and Unfolding Event-by-Event Flow in Heavy Ion Collisions" and will join our group as a new PhD student in the beginning of the year 2014. P. Paakkinen had a very successful training period at CERN but decided to direct his MSc studies towards theoretical particle physics.

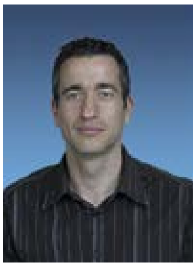
Picture taken during the PhD defence of Norbert Novitzky (in the middle) in September 19th 2013. Opponent Dr. David d'Enterria from CERN (left) and Jan Rak (right).

Personnel

In September 2013 Rector Matti Manninen signed a Professor contract with Jan Rak who became the first professor of experimental particle physics at the University of Jyväskylä starting 1st January 2014. This event is significant in establishing even more firm ground for experimental particle physics at the University of Jyväskylä.

E. Brücken and T. Hildén joined the group to mainly work in the TPC upgrade project which also gets a significant benefit from HIP's Detector

Laboratory trough equipment and through the work by F. García and E. Tuominen. T. Snellman will start as a PhD Student at the beginning of the year 2014, while N. Novitzky moved to BNL to work in the PHENIX experiment as his first postdoc position and A. Morreale moved to another ALICE group.



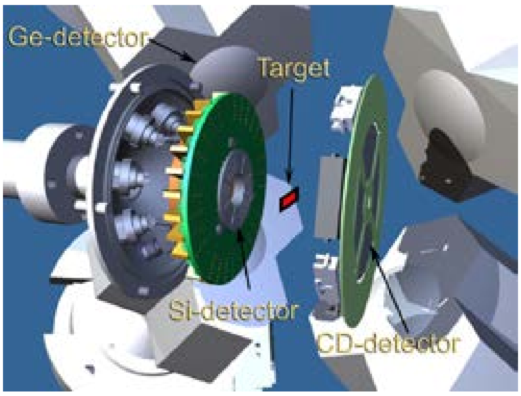
Paul Greenlees, ISOLDE project leader

ISOLDE

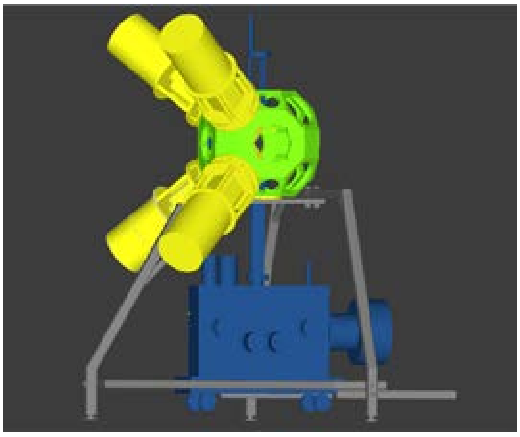
Due to the LHC shutdown LS1, no experiments were carried out in 2013 at ISOLDE. However, the local ISOLDE team based in CERN has been extremely busy preparing the ground for the imminent arrival of HIE-ISOLDE in 2015. A huge number of changes to the infrastructure in the ISOLDE hall have been made in order to accommodate the new accelerator that will replace REX-ISOLDE.

Outside CERN, the ISOLDE Collaboration has also been active, both in analysing data from previous experiments and in developing new instrumentation to be employed at ISOLDE in the future. A clear highlight of the year was the publication of an article in Nature, related to "pear-shaped" nuclei. The article received a great deal of publicity and is discussed further below.

On the instrumentation side, work continues with the development of the SPEDE conversion electron spectrometer, which has now entered the construction phase. The project is led by Academy Researcher J. Pakarinen and SPEDE is being developed in partnership with several European institutes, most notably the University of Liverpool. It is envisaged that the first in-beam tests of SPEDE will be made in 2014. The figure below shows a schematic of SPEDE and some of the parts that have recently been constructed at JYFL.



A design drawing of the SPEDE conversion electron spectrometer to be used in conjunction with the MINIBALL array of germanium detectors. SPEDE has now entered the construction phase.



A schematic of the ISOLDE Decay Station (IDS).

A second development on the instrumentation side was the signing of a Memorandum of Understanding to join the ISOLDE Decay Station (IDS) Collaboration. The IDS will be a dedicated installation for studies of the decay properties of nuclei produced at low energy in ISOLDE. Radioactive nuclei will be implanted into and transported by a tape system to the detection system which may consist of plastic scintillators, silicon strip detectors, germanium detectors and/or lanthanum bromide detectors for fast timing studies. The exact configuration can be changed depending on the experiment. The main Finnish contribution is likely to be a loan of Nutaq digital electronics from JYFL and assistance in setting up and running the electronics and data acquisition system. The Nutaq electronics have already been used successfully by the groups at JYFL. As there will be no post-accelerated beams at ISOLDE in 2014, the IDS is likely to be one of the foci of the experimental campaign when protons return to ISOLDE in July. A schematic of the IDS is shown above.

The Finnish community is now involved in over thirty active experiments at ISOLDE, ranging from solid state physics, through ground state nuclear properties, nuclear astrophysics and nuclear structure studies. Once again, a number of new proposals were submitted to the latest INTC call in October.

Cover of Nature, highlighting research carried out at ISOLDE and involving Finnish physicists. Reprinted by permission from Macmillan Publishers Ltd: *Nature*, **497**, 199 (2013), copyright 2013.

Nuclei go Pear-Shaped

As mentioned above, a clear highlight of the year was the publication in Nature of the results of an experiment carried out at REX-ISOLDE using the MINIBALL array of germanium detectors. The experiment aimed to study the development of octupole collectivity in radon and radium nuclei. Aside from the basic nuclear physics interest, the results of the study can help to inform the search for electric dipole moments (EDMs) in atoms. It is expected that the data from nuclear physics experiments can be combined with the results of atomic trapping experiments. The latter experiments aim at measurement of EDMs to make stringent tests of the Standard Model. The EDMs should be enhanced for atoms where the atomic nucleus has a permanent octupole deformation or “pear shape”. The nuclear physics experiment reported in Nature showed that the octupole correlations are relatively strong in ^{224}Ra.

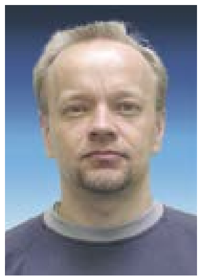
Nuclear Astrophysics

As reported in 2012, in order to better understand the explosion mechanism in core-collapse supernovae, experiment IS543 was performed to measure the cross section for the reaction $^{44}Ti(\alpha,p)^{47}V$ at low energies. This cross section has an effect on the amount of ^{44}Ti produced in supernovae, the abundance of which can be calculated using models of supernovae. A direct study of the reaction within the Gamow window for core collapse supernovae was conducted. No yield above background was observed, enabling an upper limit for the rate of the reaction to be determined at the centre-of-mass energy of 4.15 MeV. The result was below expectations, suggesting that the $^{44}Ti(\alpha,p)^{47}V$ reaction proceeds more slowly than previously thought. A manuscript related to these findings is almost ready for submission.

Participants of the NUSTAR Week 7.-11.10.2013 in Helsinki.

FAIR (Facility for Antiproton and Ion Research)

NUSTAR Collaboration



Ari Jokinen, FAIR project leader

Preparatory work for FAIR (Facility for Antiproton and Ion Research) started in 2006 and has continued through 2013. 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 scientific participation in FAIR experiments focuses on three existing experiments called MATS, LaSpec and HISPEC/DESPEC.

In the present modularised start version of FAIR, the earliest start-up of these experiments is foreseen to be 2018. To bridge the scientific gap we have re-directed our mid-term strategy to focus on the very first experiments with Super-FRS. As a result of that we are in charge of producing a section of the working document describing the physics case of the Super-FRS Collaboration. The first draft of the document was prepared at the end of 2013 and it will be finalised in 2014.

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 co-spokesperson for the MATS experiment and I. Moore for the LaSpec experiment. T. Grahn and S. Rinta-Antila are connected to present FRS experiments and future campaigns aiming for Super-FRS. During 2013, a long shutdown of GSI prevented on-line experiments, but those will be continued in 2014.

Status of In-Kind Projects

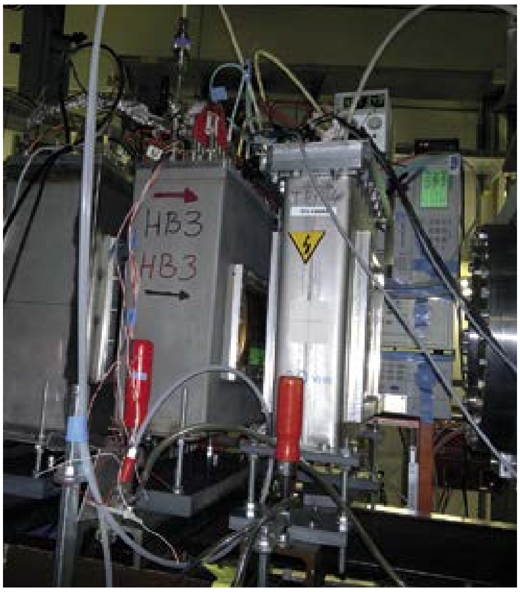
Due to the modular construction of FAIR with Super-FRS being one of the first experiments to provide new physics results, the entire Finnish in-kind contribution will be directed to the construction of Super-FRS. As a result, new in-kind projects were searched for and initiated in 2012 and 2013. A new collaboration with Lappeenranta University of Technology has been started aiming to produce power cabinets for selected Super-FRS magnets. A set of mobile cranes and lifting solutions for various service purposes will be provided as a Finnish in-kind contribution. Final specifications are still to be agreed before the tendering phase can start. The Finnish in-kind package also includes the so-called flask-project, which contains design and construction of a movable radiation shielded manipulation unit for highly active beam-line components of Super-FRS. Collaboration with Aalto University and the Holming company was initiated within this project.

Finland is also 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. In 2013 data from the 2012 experiment has been analysed. Based on the experience with the gas cell prototype, specifications for the final version will be fixed in 2013 and 2014 and the Finnish in-kind contribution will be fixed.

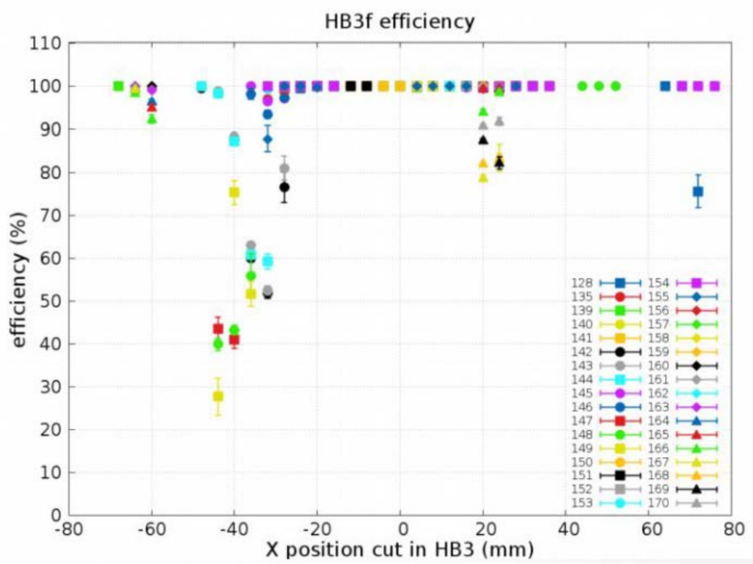
The Super-FRS beam diagnostics project consists of two major items: (i) 32 GEM-TPC detectors will be designed and constructed in HIP under the supervision of F. García and (ii) grid detectors needed for intense beams will be developed by K. Rytkönen, who was hired for this task in 2013. The latter project has just started and specifications are to be determined together with scientists from GSI. The status of the GEM-TPC project is summarised separately below.

GEM-TPC Project for the Diagnostics of Super-FRS

The Helsinki Institute of Physics has devoted resources for several years in collaboration with



Test set-up with ^{197}Au primary beam at 770 MeV/u for GEM-TPC in the S2 beam line at GSI.



The tracking efficiency of the GEM-TPC.

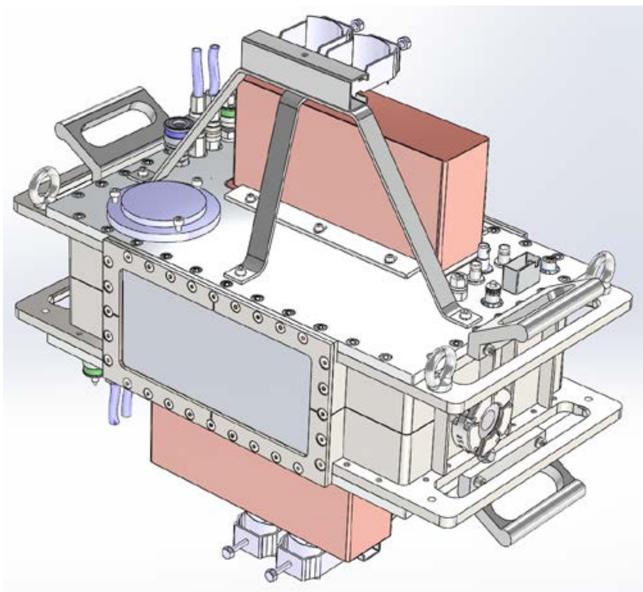
Comenius University and the Centre for Heavy Ions GSI, in order to establish a R&D project that can develop GEM-TPC detectors, which belong to the Finnish in-kind contribution to the FAIR facility. These detectors will be located in several Diagnostic Stations along the Main separator and its three branches. The initiative is driven by interest to accommodate our know-how of GEM technology, in particular after the contribution to the LHC. Therefore the work package that will provide a set of **32 Gas Electron Multiplier based Time Projection Chambers** will be taken over by the Helsinki Institute of Physics.

The results obtained from beam tests during this time have given the confidence that the concept of using a GEM based TPC can fulfil all requirements imposed by the Super-FRS in terms of tracking efficiency and position resolution. In particular, the position resolution obtained was of the order of 300 microns in both coordinates, which is well below the requirements. Nevertheless the tracking efficiency needs some more improvement, in order to cope with 10^7 particles/spill.

During 2013 the design and construction of the fourth generation prototype of a GEM-TPC in twin configuration has been launched. The HGB4 GEM-TPC which stands for Helsinki-GSI-Bratislava prototype 4, is two GEM-TPCs placed close to each other and one of them flipped in the horizontal plane with respect to the other in such a way as constraining a time window for the hits in both pad planes; this method can drastically remove the ambiguity of the hit association to the same track under high rate conditions.

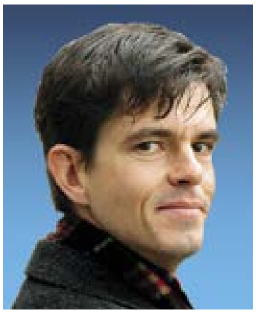
The production of the components has been going on during 2013 and characterization has been done for most of them. After the assembling of the prototype, extensive tests will be performed in two different facilities; the Accelerator Laboratory of the University of Jyväskylä in order to determine the long term operation stability in a harsh radiation environment and the Fragment Separator at GSI in Darmstadt to determine the position and rate capability.

These results will be used to freeze the design and move into mass production at the HIP Detector Laboratory, which is mainly responsible for delivering, final installation and commissioning at the Super-FRS.



The design of the GEM-TPC in twin configuration.

Technology Programme



Saku Mäkinen,
Technology Programme
director

In 2013 three continuation projects were hosted by the HIP Technology Programme: The GreenIT project continued to explore new ways to enhance energy efficiency in distributed computing infrastructures with encouraging results and strengthening the collaboration with the University of Lausanne and Aalto University. The AX-PET project has found promising commercialisation avenues in medical imaging and is preparing for application pilots in Finland. The DataGrid project came to a successful end as the FP7 EU sponsored EMI project ended. At the same time with these continuations the structure of the Technology Programme and its projects were considerably changed and GreenIT was enlarged to include the Green Big Data approach with Aalto University. Similarly, the CLIC project of HIP was moved to the Technology Programme. External outreach has been maintained and intensified with various parties.

Green Information Technologies

Tapio Niemi,
Green IT
project leader

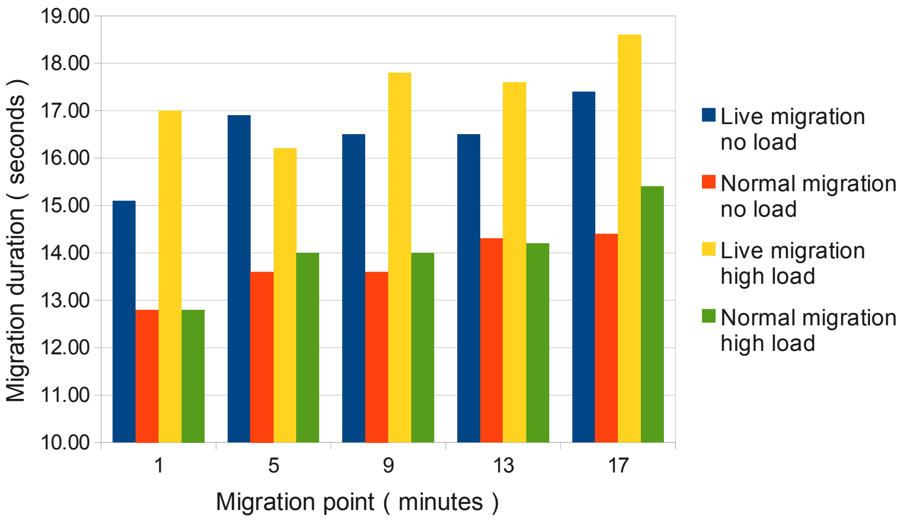
In many applications the sizes of the data sets have become extremely large and complex causing challenges for data analysis. At the same time, energy consumption has become one of the main costs of computing, usually exceeding hardware and personnel costs. Therefore, there is an obvious need for new research to find more efficient hardware and software solutions for big data analysis. Especially in computing intensive sciences, such as high-energy physics (HEP), powerful but still energy-efficient solutions are essential. For example, it has been estimated that the computing needs of CERN LHC experiments will be ten times higher in 2020 than now.

The GreenIT project has focused on optimising energy consumption of scientific computing clusters used for HEP computing related to CERN experiments. This research has included building a test environment for physics applications, statistical analysis of log data of CERN batch processing clusters and the Finnish Tier-2 centre, developing an operations management model for a computing centre, a prototype implementation of a fuzzy load-based scheduling algorithm, testing modern storage systems such as solid state disks (SSD), developing a simulator for testing scheduling policies and optimising virtualisation environments for physics computing. These studies have indicated significant improvement possibilities in both operational and energy efficiency.

In 2013, we contributed to this neglected area of research in two ways: 1) by viewing a computing facility as a production unit on which we apply well established operations management principles to run it more efficiently; and 2) developing methods to optimise computing clusters by applying virtualisation technologies.

In the first approach, we aimed at finding ways to improve throughput and energy efficiency by loading all the components (CPU, memory, and network) of the computing servers in an optimal way. The applied research approach followed that of operations and production optimisation research. The research has been conducted in close collaboration with the Department of Operations of the University of Lausanne and funded by The Swiss National Science Foundation (SNFS) until the end of 2015. Analysis of log data of several physics computing clusters has shown how operations management principles can be applied to scientific computing. The next phase in this research is to develop a proof of concept tool for monitoring and controlling computing clusters.

The second approach, using virtualisation as a platform for physics analysis progressed well.



Virtual machine migration cost when running CMS analysis jobs in the cloud.

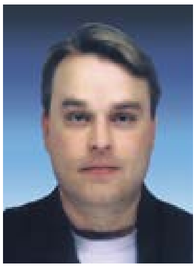
An OpenStack cloud platform was set up for testing purposes and evaluated as a platform to be used in future studies. A prototype of a virtual machine control system was developed for improving the energy efficiency of the OpenStack. The energy overhead of virtual machine migration with the CMSSW software workload was also studied. It was found that virtualisation is a usable technology for both CMS analysis and simulation jobs. The plan is to continue this research and develop an automatic virtual machine control system to save energy in physics computing clusters.

In 2013, the project hosted three summer trainees, and continued active publishing. A PhD degree on virtualisation technologies has progressed well and it will be completed as planned in 2014. The project has a modern and comprehensive test facility for measuring energy efficiency of different computing applications. The test hardware contains over 100 CPU cores, 200 gigabytes of memory, and several terabytes of disk space. The total purchase price of the hardware is over 30 000 euros.

In autumn 2013, the project started collaboration with Aalto University to develop new technologies for energy-efficient big data analysis focusing on CMS computing and in this way prepare new solutions for the future upgrade of the LCH collider at CERN. This collaboration covers all the essential aspects of high-energy physics computing including hardware, software and network technologies.

A delegation from Aalto University visited CERN in November 2013.

The goal for 2014 is to continue research on virtualisation and applying operations management methods for computing centres and cloud computing and also to apply these methods in practice to collaboration with CERN and industry partners with possible external project funding. For research funding two consortium proposals have been submitted to the Academy of Finland in October 2013 and an EU proposal in collaboration with Aalto University is under preparation.



Miika Tuisku, DataGrid project leader

Grid Middleware Development

The EU Framework Programme 7 came to an end in 2013 together with the European Middleware Initiative (EMI) project, where the HIP Technology Programme's DataGrid project had participated for the past three years. The project's EU review in Brussels was a success and encouraging for the project partners. As stated by the EU commission review report: "The EMI technical results are of excellent quality. During its lifetime the EMI consortium brought together the four main European grid middleware development communities and successfully unified them. There is now a single, coherent, European grid middleware community and the synergies which have been uncovered will continue to be exploited beyond the end of the project, along with a valuable set of support tools and processes." Between the new EU commission Framework Programme, Horizon 2020, launched in December 2013 and the deadline of first calls in April 2014, the future role of the HIP Technology Programme is still uncertain.

From the beginning of the EMI project, HIP had the responsibility to manage and co-ordinate the various security working groups that determined the strategic direction of the EMI project Security area. The EMI Security Architecture document has been completed and published by the CERN EU OpenAire project. The Security Token Service (STS) has been completed and the WLCG pilot service has been deployed and is still under evaluation. The Grid components, for which HIP is responsible, have been delivered to the final EMI version, EMI-3. This includes the aforementioned STS, the pseudo-anonymity service and Hydra, the encrypted data storage system. All of these components have been used in a subsequent project external to EMI. This work has been reported in the EMI Collaboration, Exploitation and Sustainability deliverable for the EU commission. HIP Technology Programme personnel were also required at the final EU review of the EMI project. The Security area of the EMI project was favourably mentioned in the EU review report and all its tasks were completed. There was also participation by HIP personnel at the EGI Community Forum in Manchester and the ISGC Conference in Taipei.

Cloud Applications and Industrial Collaboration

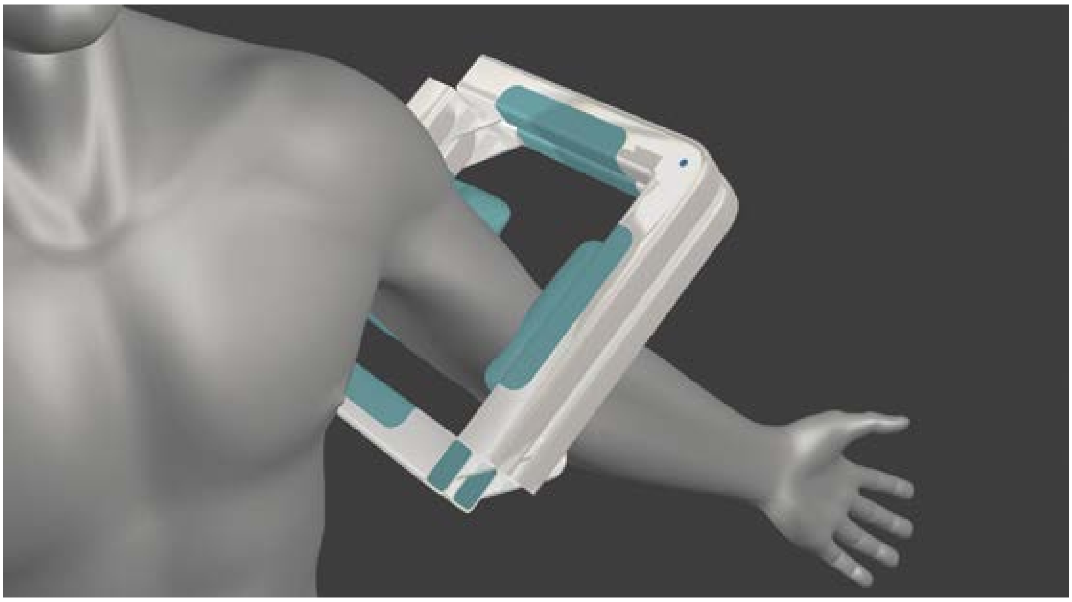
The shift in the focus after a decade of Grid computing research and development is most obvious in the applications domain. Cloud computing is the successor of the Grid computing model, and is in general considered disruptive for current IT industry practices. The main differences with Grid computing are pay-per-use and elastic, on-demand sourcing of ICT capacities. Consequently Scientific computing users do not need capital expenditure (CAPEX) in hardware any longer to secure ICT utilities that can be accounted as Operational expenditures (OPEX) as in software and services.

Fund-raising efforts to continue building the results of the past year's project, Secure InterCloud Exchange (SICX) have not succeeded in 2013. The DataGrid project has nevertheless identified potential collaborators with similar software and ambitions. A PhD study for Aalto University under the title "Reliable and secure cloud storage" is being prepared in the very same research domain. The only externally funded and active effort in the Cloud application area is the ongoing Academy of Finland -funded Data Indirection Infrastructure for Secure HEP Analysis (DII-HEP) project, which is a collaboration between the HIP CMS & TEK Programmes and the Department of Computer Science at the University of Helsinki. The DII-HEP project presented its early results at the CHEP 2013 Conference in Amsterdam.

Ulla Ruotsalainen, PET project leader

AX-PET Collaboration with CERN

At CERN, a new type of a positron emission tomography (PET), Axial PET (AX-PET), has been developed. The AX-PET 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 Wavelength shifter strips are placed orthogonal to them. This structure avoids parallax errors



AX-PET demonstrator.

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 at Tampere University of Technology, we are seeking ways to commercialise a new type of PET scanner using AX-PET 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.

At Tampere University of Technology, we are working on the design of a compact and small-sized AX-PET type demonstrator which can be used for neck, wrist and chest scanning for humans as well as for small animals.

During the year 2013, T. Zedda completed her thesis on the first modular prototype developed in the Department of Signal Processing at Tampere University of Technology, where the first tests characterizing scintillator crystals were conducted. There were also several papers published from CERN on AX-PET type detectors in 2013.

After the first prototype, it was decided that a second prototype should be designed from August 2013 onwards. The work is being done with TEKES-TUTLI funding. The aim is to achieve high resolution and sensitivity in PET measurements via smaller and more accurate electronics circuitry, while keeping the principle of designing a small-sized, portable PET scanner with a modular design. Experiments with a point-like radioactive source are planned to be conducted at Tampere University of Technology during spring 2014.

CLOUD

Markku Kulmala, CLOUD project leader

Background

Atmospheric aerosol particles influence the Earth's radiative balance and therefore the whole climate system. This influence is exerted by two mechanisms. First, aerosol particles can directly reflect or absorb solar radiation. Second, they can act as seeds for cloud condensation and cloud droplet freezing and thereby affect the cloud albedo, extent, precipitation and lifetime. To understand the climate system, it is therefore important to also understand the dynamical behaviour of ambient aerosol particles and cloud droplets, including the formation and growth processes of aerosols, cloud droplet activation and ice nucleation.

The CLOUD (Cosmics Leaving OUtdoor Droplets) experiment at CERN is currently one of the most advanced laboratory set-ups for studying the formation and growth of aerosol particles over a wide range of simulated conditions. Recent upgrades also allow for studying physical processes in clouds, such as cloud droplet activation and ice nucleation. For all the experiments at CLOUD, galactic cosmic rays (GCR) can be simulated, and their influence on physical or chemical processes investigated. A potential effect of GCR on cloud formation or properties is expected by numerous indirect observations and theoretical studies suggesting that GCR may exert a significant influence on the Earth's cloud cover and climate. The main proposed mechanisms are an enhancement of nucleation rates (i.e., the rate of formation of new particles from gas-phase precursors) by ions produced by GCR, and an enhancement of the formation of ice particles due to ionization by GCR. To date, however, the presence or significance of an influence of GCR on any such mechanism has not been experimentally verified. The CLOUD experiment aims at finding pathways of the phenomenon and their significance. Due to its high technical standards, insights are also gained on other details of the investigated processes that are still not well understood, such as nucleation and the initial growth of aerosol particles. The experiment comprises 21 institutes from 9 countries with a strong Finnish contribution.

The CLOUD facility in the T11 area in CERN during the CLOUD8 campaign (Nucleation part) in autumn 2013. The pion/muon beam arrives from the right and hits a hodoscope that monitors the beam intensity before it passes through the chamber. Instruments that were employed on the 16 ports around the chamber are: a modified Chemical Ionization Mass Spectrometer (CIMS) for sub ppt SO_2 measurements, two Diethylene Glycol-based Condensation Particle Counters (DEG-CPC), an Atmospheric Pressure interface Time-Of-Flight mass spectrometer (APi-TOF,), two Chemical ionization APi-TOFs (CI-APi-TOF), a Neutral cluster and Air Ion Spectrometer (ANAIS), two Proton-Transfer-Reaction Time-Of-Flight mass spectrometers (PTR-TOF), water- and butanol-based Condensation Particle Counters (CPC), instruments for gas measurements (SO_2, O_3, H_2O), two Particle Size Magnifiers (PSM), three Scanning Mobility Particle Sizer (SMPS), three Gerdien coupled with three butanol based CPC, and a radial Differential Mobility Analyzer (rDMA) with PSM.

Experiments in 2013

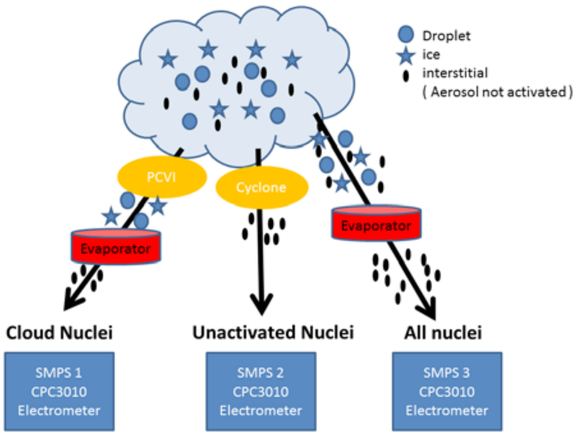
In 2013, the first half of the year was dedicated to workshops, paper writing and instrument development with yet another intensive measurement campaign taking place at the CLOUD chamber at CERN in the autumn: the CLOUD8 campaign from September to December 2013, divided into two parts, nucleation studies and cloud activation studies. Again, a wide variety of instruments was provided by the participating institutes and deployed during these two sets of experiments.

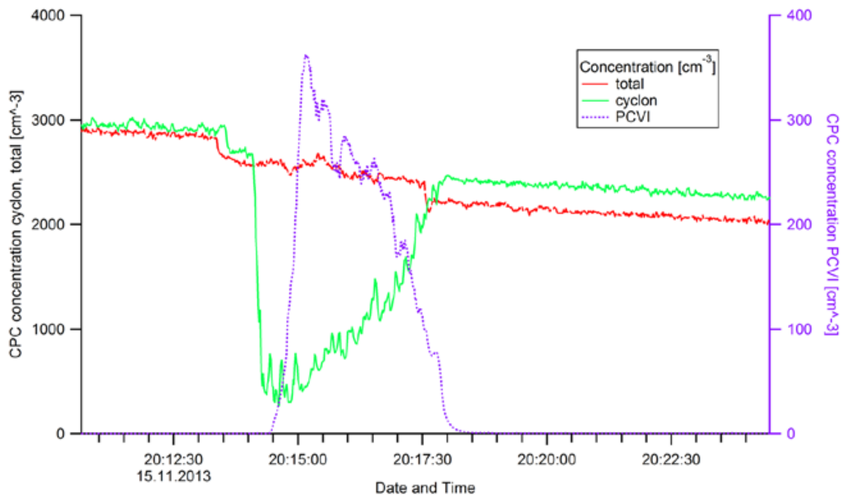
CLOUD8 Cloudy part: The CLOUD chamber was implemented with a better control expansion system that was installed on the top of the chamber. This new system precisely controls the expansion time, from seconds to hours, with the possibility of multistep expansion, allowing cloud formation and controlled evaporation. Cloud seed aerosol particles were generated via the gas phase to particle conversion inside the chamber or directly injected into the chamber by a newly developed sulphuric acid seed particle. The chamber was equipped with an extensive suit of optical detection systems for studying the properties of the cloud droplet population formed inside the chamber upon expansion, such as the SIMONE detector with a polarized laser beam going through the chamber. Two new fast response time temperature strings were installed, one vertically and one horizontally inside the chamber, facing the challenge of going through an electric field. In addition, 3 CCD cameras were also installed at three different levels of the chamber monitoring ice formation on the walls and cloud formation on the beam track of the SIMONE detectors.

- Two PSMs were used in two different operating modes, optimising the information yielded on the size distribution and growth rates of clusters and small particles of sizes between 1 and 3 nm.
- Three identical sets of SMPS, CPC and Gerdien were installed to measure different properties of cloud seeds, looking at different parts of the cloud using three special inlets. They were looking at 1) activated aerosols, 2) non-activated aerosols and 3) total aerosols, see the figure to the left at the top of the next page. The three set-ups have been brought together from the University of Helsinki and PSI, with technology transfer to the University of Helsinki.
- Two switching PSMs with two cut-off sizes were used to look at new particle formation while clouds were evaporating. To deal with the pressure changes of the chamber during expansion they were operated behind an automatic switching valve.
- A special rebuilt pressure resistant and temperature controlled ANAIS monitored ions and neutral clusters during all the processes of the cloud formation and evaporations.
- The APi-TOF was set up to measure alternatively negatively or positively charged ions and ion clusters.

The Finnish team was responsible for the measurement of ions and aerosol particles in the size range 0.8 to 42 nm, deploying an Airborne Neutral cluster and Air Ion Spectrometer (ANAIS). ANAIS was modified according to the prototype set-up tested during CLOUD6 which was exposed to the non-standard conditions present in the chamber (high pressure). This new set-up proved to work very well. The newly developed SMPS, Gerdien and CPC set-ups were for the first time in use during this campaign. Small aerosols were monitored by the two switching PSMs, while charged clusters were monitored by APi-TOF.

CLOUD8 Nucleation part: The CLOUD8 campaign was again a large joint effort at the CLOUD chamber, with a large total number of instruments in use, including for instance





Schematic set-up of CLOUD aerosol instrumentations to study effects of charges on cloud activation. The three set-ups are running in parallel and are simultaneously monitoring the size distribution, total number and charged fraction of a) cloud nuclei (the ones which have been activated into cloud droplets or ice), b) the un-activated nuclei (the ones which did not make it to droplets or ice) and c) all nuclei (activated and un-activated nuclei). By looking at these nuclei properties (size distribution, charged fraction) we gain information on cloud activation processes. Not shown here is the aerosol chemistry composition also measured. The University of Helsinki was responsible for SMPS, electrometers and CPC3010. Prior to the CLOUD campaign a careful inter-comparison and calibration took place at CERN.

Concentration of aerosols behind the three different inlets as shown in the figure to the left (total in red, PCVI, i.e., the activated aerosol in blue, Cyclon, i.e., the non-activated aerosol in green). Before 20:12 local time, the CLOUD chamber is filled with aerosols, without any clouds. The total aerosol concentration is equal to the non-activated aerosol concentration. At 20:13:30 a cloud is activated in the chamber. Therefore the concentration of the activated aerosol increases while the concentration of the non-activated aerosol decreases. Meanwhile, the total concentration decreases slowly due to the expansion. These preliminary results show these prototype inlets and instrumentations operating well.

a total of five dual-stage condensation particle counters, capable of measuring clusters and particles < 2 nm in mobility-equivalent diameter, and a total of five high-resolution Time-Of-Flight mass spectrometers, attempting to determine the abundance, significance, and chemical compositions of vapours, ions, and molecular clusters that form in the initial steps of nucleation.

The Finnish team made a major contribution to CLOUD8 with a total of 14 persons (6 post-docs, 8 PhD students) working on site in CERN during the campaign. The Finnish team was primarily responsible for the measurement of cluster precursors, clusters, small particles, and ions, and brought eleven instruments to CERN: an Airborne Neutral cluster and Air Ion Spectrometer (ANAIS), two Particle Size Magnifiers (PSM), a set-up comprising a radial differential mobility analyser (rDMA) and a PSM, a SMPS, two Gerdiens, two CPCs and two Atmospheric Pressure interface Time-Of-Flight mass spectrometers, one directly connected to the chamber (APi-TOF), one of them equipped with a Chemical Ionization system (CI-APi-TOF):

- Two PSMs were used in two different operating modes, optimising the information yielded on the size distribution and growth rates of clusters, and small particles of sizes between 1 and 3 nm.
- The new rDMA developed in Caltech was coupled with a PSM, used as a counter. The present improved configuration allowed measurements of size distribution of negative ions in the range 1.3–6 nm providing an interesting overlapping with the ANAIS with significantly higher size resolution.
- The ANAIS continued operation with the sample dilution system developed for the earlier campaigns at CLOUD. The ANAIS was also improved to operate at higher pressure and fast pressure change, according to the knowledge gained from the prototype developed for CLOUD6. It was set up inside a temperature-controlled box which was now able to maintain the same temperature as the one inside the CLOUD chamber. We could therefore minimise changes in the ion size distributions and properties due to temperature changes during sampling.

- The APi-TOF was set up to measure alternatively negatively or positively charged ions and ion clusters.
- The CI-APi-TOF which was for the first time deployed during CLOUD7 was used also in CLOUD8 and provided precious information on neutral cluster formation. CI-APi-TOF measures the chemical composition of neutral nucleating clusters shedding, at last, light on the mystery of neutral nucleation.
- Two Gerdiens and two CPCs, calibrated during an extensive calibration workshop were set up to measure the charge ratio of particles.
- SMPS was developed in collaboration with PSI to allow fast measurement of particle size distribution.

In previous experiments at CLOUD, prior to 2013, nucleation processes were investigated for the systems of pure sulphuric acid, sulphuric acid + ammonia, sulphuric acid + dimethylamine, and sulphuric acid + oxidation products of pinanediol. The main goal of the CLOUD8, nucleation part, was to answer the question whether or not nucleation can occur only with the oxidation products of organic compounds in the absence of sulphuric acid. This is a very important question as to best of our knowledge sulphuric acid has always been thought to be the driving molecule in different nucleation processes. The CLOUD chamber is the only place in the world where we can perform such an experiment without any trace gases of sulphuric acid (below 1e4 cm-3). Using the extended suite of instruments deployed for CLOUD we are trying to reveal the molecular steps of neutral and charge nucleation pathways of a purely nucleated organic aerosol. Without the beam being available in 2013 a series of experiments have been conducted using natural galactic cosmic rays to explore the effect of ions on organic nucleation and growth processes of oxidation products of α-pinene in the chamber, one of the naturally most abundant monoterpenes, in the absence of, and with a measurable trace amount of sulphuric acid. This was another step towards creating chemical systems in the CLOUD chamber that are capable of nucleation, and at the same time are as relevant as possible to atmospheric nucleation in the boundary layer.

The CLOUD chamber's peripheral equipment was extended and upgraded to allow us to achieve these goals, in particular to allow for an absence of sulphuric acid molecules in the chamber.

Data Analysis, Education and Reporting of Results

A comprehensive data analysis of the data of the last campaign in 2013 is on-going, with a first paper draft already written on the nucleation part of the campaign. The analysis of data from the previous 8 campaigns is still not complete and is continuing as well. Several papers are currently under review, some are about to be submitted and some others have been published such as Almeida et al. (2013) in Nature, or Schobesberger et al. (2013) in PNAS for example.

From February 25th to March 1st 2013 about 30 experts from all around the world were invited to present their work and to listen and comment on the results from CLOUD at the Marie Curie CLOUD-ITN Königstein Conference. The Finnish group including Finnish Marie Curie ITN students presented their results.

In June 2013 two special sections at ICNA (International Conference on Nucleation of atmospheric Aerosol, Boulder USA) were dedicated to CLOUD with more than 30 presentations (talks and posters) related to CLOUD results. Results were shown as well at EGU (Vienna, Austria) and AGU (San Francisco, USA).

Several data analysis workshops took place in 2013 at difference places such as Stockholm University in April, at the Hyytiälä Field Station in August, and at CERN in August involving researchers from most partner institutes. A number of smaller meetings in Helsinki among collaborators were organised by the Helsinki team, aiming at advancing our techniques for analysing the complex data obtained from mass spectrometers, particularly to help us understand the chemical compositions of clusters in the CLOUD chamber.

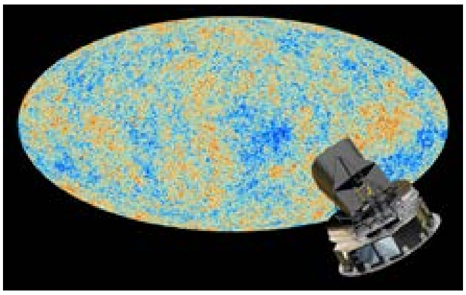
Planck

Hannu Kurki-Suonio,
Planck project leader

Background

The cosmic microwave background (CMB) is radiation coming from the early universe, emitted when the universe was about 400 000 years old. It varies over the sky, reflecting 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 was 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. The Planck mission was extended twice form the original 15 month observation period, so that in the end Planck did science observations for over 4 years, from August 2009 to October 2013. At the end of the mission the satellite was ejected from its orbit around the second Lagrange point of the Sun-Earth system to an independent orbit around the Sun. The results from the first 15 months of data, not including polarization data, were published in 2013.



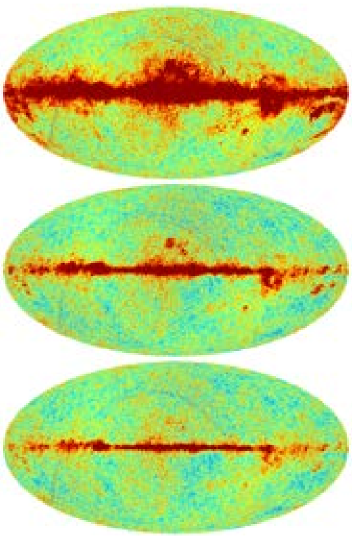
Planck and the Cosmic microwave background. (ESA)

The CMB measurements are contaminated by microwave radiation from our own galaxy and extragalactic objects. To be able to remove this "foreground", the observations were 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).

Data Analysis

The Helsinki group has been responsible for producing the sky maps for the three Low Frequency Instrument (LFI) frequencies (30, 44 and 70 GHz), as well as a number of related tasks, including null tests on the maps, estimation of their residual noise correlations, and producing large Monte Carlo simulations (at CSC - the Finnish IT Centre for Science) of the data. These simulations are needed to support the analysis of flight data. We have also participated in the development of improved calibration methods for LFI.

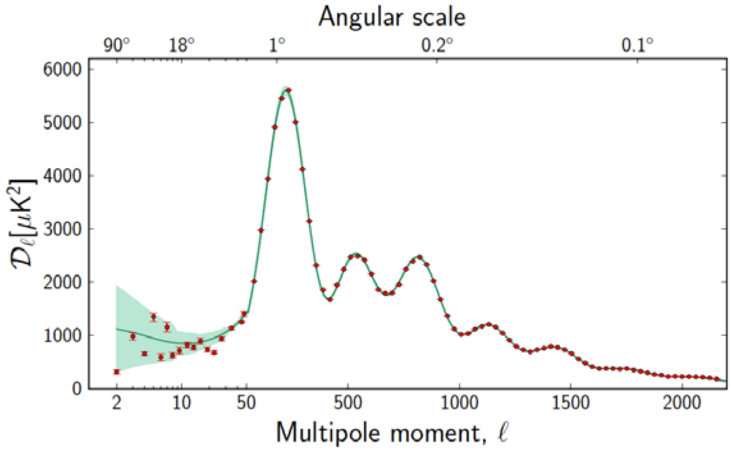
We also participated in the estimation of cosmological parameters and constraints on inflation models from the CMB angular power spectra. In particular, we are responsible for fitting cosmological models with primordial isocurvature (i.e., non-adiabatic) perturbations to Planck data. We are now analysing the full Planck data set for a new data release and results to be published in 2014.



The microwave sky at the three LFI frequencies (30 GHz, 44GHz, and 70 GHz, from top to bottom) in galactic coordinates. The red horizontal band is radiation from the Milky Way.

The Planck 2013 Results

Cosmological results based on the first 15 months of Planck observations were released in March 2013. They include a high-resolution temperature map of the cosmic microwave background (CMB) and its angular power spectrum. The current 5-parameter "standard cosmological model", LambdaCDM, is in remarkable agreement with this data. From Planck data, the values of these parameters were estimated with higher precision than earlier data, in particular that from the WMAP satellite, allows.



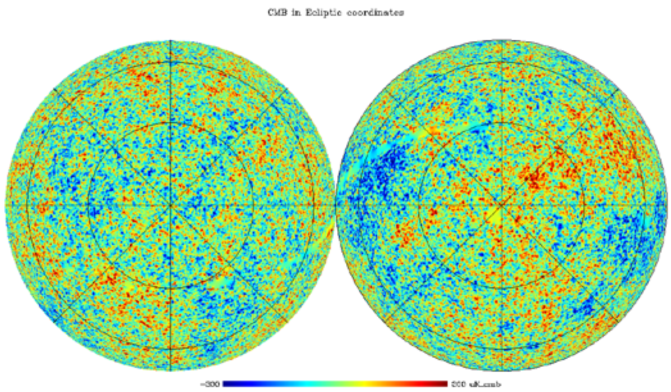
The angular power spectrum of the cosmic microwave background, showing how strong the structure is at each angular scale on the sky. The red dots are the measurements by Planck; the green curve is the prediction of the standard LambdaCDM cosmological model with best-fit values of its parameters. The light green band represents cosmic variance, the expected scatter due to the random nature of the origin of the CMB structure. *(Planck Collaboration, arXiv:1303.5062)*

The Planck values of the cosmological parameters give the composition of the universe as 68.3% dark energy, 26.8% dark matter, and 4.9% ordinary matter and the Hubble constant as H_0 = 67.3±1.2 km/s/Mpc. The spectral index of primordial perturbations was measured as 0.960±0.007, indicating a 5-sigma deviation from scale invariance. The optical depth to the CMB, i.e., the average number of scatterings a CMB photon has experienced between its origin and observation was estimated to be 0.09 [arXiv:1303.5076].

For possible deviations from this standard model, Planck gave new upper limits. The average density of the universe deviates from the critical density, i.e., that corresponding to a flat large-scale geometry, by at most 0.7%. The sum of the masses of the three neutrino species is at most 0.25 eV. The energy density of possible unknown relativistic particles in the early universe is at most that of one neutrino species. The ratio of the power spectrum of possible primordial tensor perturbations (gravitational waves) to that of scalar (density) perturbations is at most 0.12 [arXiv:1303.5076]. The upper limits to possible deviations of primordial density perturbations from adiabaticity, where all energy components vary together, depend on the type of deviation, but for the type of cold dark matter perturbations expected in the curvaton and axion scenarios, the upper bounds are 0.25% and 3.9%, respectively [arXiv:1303.5082]. The limits to the non-linearity parameter, describing possibly deviations of the primordial perturbations from Gaussianity, were tightened to f_{NL} = 2.7±5.8 [arXiv:1303.5084].

A number of features theoretically predicted by the standard cosmological model, but not observed previously, were detected by Planck for the first time: the (non-primordial) non-Gaussianity of the CMB due to the correlation between gravitational lensing of the CMB and its redshift variations (integrated Sachs-Wolfe effect) due to the gravitational effect of matter concentrations by which the CMB radiation has travelled [arXiv:1303.5084]; the correlation between this lensing of the CMB and the cosmic infrared background [arXiv:1303.5078]; and the effect of the motion of the solar system on higher multipoles (than the dipole) of the CMB sky [arXiv:1303.5087].

At the largest scales the CMB temperature variations have some puzzling features, most of them already observed by WMAP and now confirmed by Planck [arXiv:1303.5083]. The most obvious one is that in one hemisphere, mostly north of the ecliptic plane, these variations are weaker than expected and weaker than in the other hemisphere. There is no plausible physical explanation for this. Since the primordial perturbations were produced by quantum fluctuations, this could just be an accidental result from their random nature, but the probability for this appears to be low.



The temperature variation of the cosmic microwave background over the entire celestial sphere, shown in ecliptic coordinates. The Northern hemisphere (north of the orbital plane of the Earth) is on the left, and the southern hemisphere on the right. The "smeared" features on the map are regions where the "foreground" microwave radiation from galaxies was so strong that the CMB could not be properly separated from it: the most obvious ones are the the Milky Way band and the Large Magellanic Cloud near the South Ecliptic Pole.

Administration

Mikko Sainio

The graduate education of physics students continues to be one of the main tasks of the Institute. The past year has seen a major change in the graduate education through the Doctoral Programmes. In the past HIP has collaborated with the Doctoral Programme in Particle and Nuclear Physics (PANU) and the Doctoral Programme in Nanoscience (NGS-NANO) as well as the Doctoral Programme in Concurrent Mechanical Engineering (CME) sponsored by the Ministry of Education and Culture. In 2013 the responsibility of the financing went to the University of Helsinki. This was part of the reform of the graduate education in Finnish universities, which in the University of Helsinki will take full effect from the beginning of 2014. In practice this has meant that the two positions in PANU were supported only for one more year. In addition to the graduate students who are supported by the Doctoral Programmes 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 2009–2013, 46 doctoral degrees and 58 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 Björneborgs Svenska Samskola 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 2013 this programme attracted 366 Finnish students and 61 of their teachers. A related programme has been to bring high school physics teachers to CERN for continuing education courses. In 2013, 49 teachers participated in this programme. These visits have generated considerable coverage in local newspapers all over the country: 22 articles in total in 2013.

The technological and commercial co-operation between Finnish industry and CERN is co-ordinated by HIP in collaboration with Top Science Services LLC, which is the contractor with TEKES, the National Technology Agency of Finland.

Organization and Personnel

Organization

Scientific Advisory Board
Philippe Bloch, Barbara Erazmus, Günther Rosner, Barbro Åsman, Wilfried Buchmüller, Aarne Oja, Wolfram Weise

Board
Johanna Björkroth, Juhani Keinonen, Risto Nieminen, Ilkka Niemelä, Antti Kupiainen, Ulla Ruotsalainen, Kari J. Eskola, Kaisa Miettinen, Veli-Matti Virolainen, Jaakko Härkönen

Steering Group
JÄ, KR, HS, PE, ML, SM, MS, TS

Director
Juha Äystö

Administrative Manager
Mikko Sainio

Theory – Kari Rummukainen
- Laws of Nature and Condensed Particle Matter Phenomenology at the LHC – Kimmo Tuominen
- Cosmophysics – Kimmo Kainulainen
- Low Dimensional Quantum Systems – Ari Harju
- Radiation Damage in Particle Accelerator Materials – Flyura Djurabekova

High Energy Physics – Heimo Saarikko
- Linear Collider Research – Kenneth Österberg
- TOTEM Operation – Risto Orava

CMS – Paula Eerola
- CMS Experiment – Katri Lassila-Perini
- CMS Upgrade – Jaakko Härkönen
- Tier-2 Operations – Tomas Lindén
- Planck – Hannu Kurki-Suonio

Nuclear Matter Physics – Matti Leino
- ALICE – Jan Rak
- ISOLDE – Paul Greenlees
- FAIR – Ari Jokinen

Technology – Saku Mäkinen
- Data Grid – Miika Tuisku
- Green IT – Tapio Niemi
- PET Project – Ulla Ruotsalainen
- CLOUD – Markku Kulmala

The Board: Risto Nieminen, Jaakko Härkönen, Kari J. Eskola, Johanna Björkroth, Juhani Keinonen, Ulla Ruotsalainen and Tuure Tuuva (substitute member).

The Institute Board

Chairman	**Johanna Björkroth**, Vice Rector (University of Helsinki)
Vice Chairman	**Ilkka Niemelä**, Vice Rector (Aalto University)
Members	**Kari J. Eskola**, Professor (University of Jyväskylä)
	Jaakko Härkönen (Chosen by personnel of HIP)
	Juhani Keinonen, Professor (University of Helsinki)
	Antti Kupiainen, Professor (University of Helsinki)
	Kaisa Miettinen, Vice Rector (University of Jyväskylä)
	Risto Nieminen, Professor (Aalto University)
	Ulla Ruotsalainen, Dean (Tampere University of Technology)
	Veli-Matti Virolainen, Vice Rector (Lappeenranta University of Technology)

The Scientific Advisory Board

Chairman Philippe Bloch, Professor (CERN)

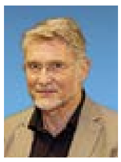
Members:

Wilfried Buchmüller, Professor (DESY)

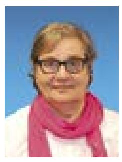
Barbara Erazmus, Professor (CERN and CNRS)

Aarne Oja, Professor (VTT)

Günther Rosner, Professor (FAIR, U. Glasgow)



Wolfram Weise, Professor (ECT*, TU München)



Barbro Åsman, Professor (U. Stockholm)

Personnel

Theory Programme

K. Rummukainen, prof., programme director
M. Hindmarsh, prof., adj. senior scientist
K. Kajantie, prof., adj. senior scientist
M. D'Onofrio, grad. student

Cosmophysics

K. Kainulainen, prof., proj. leader
K. Enqvist, prof., adj. senior scientist
S. Räsänen, adj. senior scientist
J. Virkajärvi, scientist
A. Hektor, adj. scientist
S. Hotchkiss, adj. scientist
M. Karčiauskas, adj. scientist
R. Lerner, adj. scientist
S. Nadathur, adj. scientist
S. Nurmi, adj. scientist
T. Sekiguchi, adj. scientist
S. Flender, grad. student
M. Lavinto, grad. student
T. Meriniemi, grad. student
H. Nyrhinen, grad. student
M. Pääkkönen, grad. student
P. Rahkila, grad. student
S. Rusak, grad. student
P. Wahlman, grad. student

Laws of Nature and Condensed Particle Matter Phenomenology at the LHC

K. Tuominen, docent, proj. leader
K. J. Eskola, prof., adj. senior scientist
P. Hoyer, prof., adj. senior scientist
K. Huitu, prof., adj. senior scientist
J. Maalampi, prof., adj. senior scientist
E. Keski-Vakkuri, adj. senior scientist
M. Antola, scientist
S. Di Chiara, scientist
H. Fukano, scientist
A. Mykkänen, scientist
M. Panero, scientist
H. Paukkunen, scientist
D. Weir, scientist
P. Bandyopadhyay, adj. scientist
T. Lappi, adj. scientist
T. Renk, adj. scientist
J. Alanen, grad. student
T. Alho, grad. student
T. Karavirta, grad. student
A. Keceli, grad. student
L. Leinonen, grad. student
T. Markkanen, grad. student
T. Rantalaiho, grad. student
T. Rüppell, grad. student
J. Suorsa, grad. student
P. Tiitola, grad. student
H. Waltari, grad. student

Low Dimensional Quantum Systems

A. Harju, docent, proj. leader
I. Makkonen, adj. scientist
M. Ervasti, grad. student
T. Hiltunen, grad. student
M. Ijäs, grad. student
T. Siro, grad. student
A. Uppstu, grad. student
J. Ritala, student

Radiation Damage in Particle Accelerator Materials

F. Djurabekova, docent, proj. leader
K. Nordlund, prof., adj. senior scientist
O. Pakarinen, adj. scientist
H. Timko, adj. scientist
K. Avchachov, grad. student
A. Korsbäck, grad. student
A. Leino, grad. student
S. Parviainen, grad. student
A. Pohjonen, grad. student
A. Ruzibaev, grad. student
J. Muszynski, student
R. Ruuth, student
J. Zhao, student

High Energy Physics Programme

H. Saarikko, prof., programme director
H. Niewiadomski, scientist

TOTEM Operation

R. Orava, prof., proj. leader
T. Mäki, scientist
F. García, lab. engineer
T. Aaltonen, grad. student
E. Brücken, grad. student
F. Devoto, grad. student
T. Hildén, grad. student
J. Welti, grad. student
A. Winkler, grad. student
M. Mieskolainen, student

Linear Collider Research

K. Österberg, docent, proj. leader
M. Aicheler, scientist
F. Rossi, scientist
J. Väinölä, researcher
F. Smeds, lab. engineer
R. Montonen, grad. student
F. Oljemark, grad. student
L. Kortelainen, student
V. Mäkinen, student
J. Mäntylä, student
W. Zhou, student

Detector Laboratory

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

CMS Programme

P. Eerola, prof., programme director

CMS Experiment

K. Lassila-Perini, Dr., proj. leader (at CERN)
V. Karimäki, senior scientist
R. Kinnunen, senior scientist
S. Lehti, senior scientist
J. Tuominiemi, adj. senior scientist (at CERN)
M. Kortelainen, scientist
T. Lampén, scientist
L. Wendland, scientist (at CERN)
M. Voutilainen, adj. scientist
G. Fedi, grad. student
T. Järvinen, grad. student
S. Laurila, student
J. Pekkanen, student
S. Richter, student
S. Suoniemi, student

CMS Upgrade

J. Härkönen, Dr., proj. leader
I. Kassamakov, senior scientist
E. Tuominen, senior scientist
P. Luukka, scientist
T. Mäenpää, scientist
E. Tuovinen, scientist
A. Karadzhinova, grad. student
T. Peltola, grad. student
A. Chávez Niemelä, student

Tier-2 Operations

T. Lindén, Dr., proj. leader, grid coordinator
S. Toor, scientist (Uppsala)
O. Kraemer, student

Nuclear Matter Programme

M. Leino, prof., programme director

ALICE

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

ISOLDE

P. Greenlees, prof., proj. leader
R. Julin, prof., adj. senior scientist
I. Moore, adj. senior scientist
J. Pakarinen, adj. scientist
P. Rahkila, adj. grad. student

FAIR

A. Jokinen, prof., proj. leader
E. Tuominen, proj. coordinator
F. García, lab. engineer
K. Rytkönen, lab. engineer
H. Penttilä, adj. scientist
S. Rinta-Antila, adj. scientist

Technology Programme

S. Mäkinen, prof., programme director

DataGrid

M. Tuisku, MSc, proj. leader (at CERN)
J. White, senior scientist (at CERN)
N. Buss, scientist (at CERN)
J. Hahkala, scientist (at CERN)
H. Mikkonen, scientist
C. Lindqvist, student

GreenIT

T. Niemi, Dr., proj. leader (at CERN)
A.-P. Hameri, prof., adj. senior scientist
M. Niinimäki, scientist (at CERN)
J. Kommeri, grad. student (at CERN)

PET Project

U. Ruotsalainen, prof., proj. leader
V. Nuottajärvi, scientist
U. Tuna, grad. student
D. Us, grad. student

CLOUD

M. Kulmala, prof., proj. leader
J. Duplissy, scientist
T. Nieminen, grad. student

Planck

H. Kurki-Suonio, docent, proj. leader
A. Lähteenmäki, adj. senior scientist
J. Väliviita, scientist
T. Poutanen, adj. scientist
M. Savelainen, grad. student
A.-S. Suur-Uski, grad. student
K. Kiiveri, student
V. Lindholm, student
E. Palmgren, student
P. Walia, student

Administration and Support

J. Äystö, prof., director
M. Sainio, docent, adm. manager
T. Sandelin, financial manager
T. Hardén, secretary
T. Heikkilä, secretary
T. Karppinen, secretary (at CERN)
T. Onnela, secretary (at CERN)
A. Heikkilä, tech. coordinator (at CERN)
R. Rinta-Filppula, ped. expert (at CERN)
J. Aaltonen, lab. engineer

Seminars

Seminars held in Helsinki

January 22nd J. Bijnens (Lund, Sweden)
Hadronic light-by-light for the muon anomalous magnetic moment

March 28th P. Yogendran (IISER Mohali, Punjab, India)
Holographic superfluids reprised

April 3rd P. Hoyer (Helsinki)
Forty-five fascinating years of physics

April 9th H. Kurki-Suonio (Helsinki)
Planck results

April 23rd A. Rajantie (Imperial College, UK)
Magnetic monopoles in the cosmos and at the LHC

May 7th K. Ghosh (Oklahoma State Univ., Stillwater, USA)
Top-jets as a probe of constrained minimal supersymmetric standard model with degenerate top squark and lightest supersymmetric particle

May 14th L. Bethke (Imperial College, UK)
Anisotropic gravitational wave background from massless preheating

May 21st S. Caron-Huot (NBI, CPH, Denmark)
When does the gluon reggeize

May 23rd D. Litim (Sussex, UK)
Pulling oneself over the fence: a bootstrap for quantum gravity

May 28th M. Schröck (Graz, Austria)
The effects of Dirac low-mode truncation on the hadron mass spectrum in lattice QCD

May 29th O. Philipsen (Frankfurt, Germany)
Finite density QCD from an effective lattice theory

June 3rd G. Bergner (Frankfurt, Germany)
Supersymmetry on the lattice and simulations of N=1 supersymmetric Yang-Mills theory

June 10th J. Niskanen (Helsinki)
Niskanen's cat

August 6th J. Bekenstein (Jerusalem, Israel)
Black hole thermodynamics - then and now

August 13th J. Rantaharju (Riken AICS, Kobe, Japan)
The gradient flow coupling in Technicolor models

September 3rd O. Lebedev (Helsinki)
The different faces of the Higgs

September 10th S. Hossenfelder (NORDITA, Sweden)
News from quantum gravity phenomenology

September 11th L. Wang (Lancaster, UK)
A new mechanism for curvature perturbations

September 17th A. Vuorinen (Helsinki)
Holographic thermalization at intermediate coupling

September 18th Y. Kuno (Osaka, Japan)
Search for muon to electron conversion at J-PARC - the COMET experiment

October 1st G. Hattacharyya (Saha Institute of Nuclear Physics, Kolkata, India)
Geometrical CP violation and nonstandard Higgs decays

October 11th A. Kurkela (CERN, Switzerland)
Photon production in quark-gluon plasma

October 15th H. Bech Nielsen (NBI, Denmark)
What is so special about the Standard Model? Small representations

October 22nd T. Brauner (Helsinki)
Spontaneous symmetry breaking and Nambu-Goldstone bosons: some news in the old story

October 29th K. Tuominen (Helsinki)
Beyond the Standard Model

October 31st C. Kouvaris (CP3, Odense, Denmark)
The dark side of stars

November 5th A. Ramos (DESY, Germany)
The gradient flow and the determination of alpha_s

November 12th A. Racioppi (NICPB, Tallinn, Estonia)
Towards completing the Standard Model

November 26th T. Markkanen (Helsinki)
Applications of curved space field theory for scalar field models of inflation

December 10th J. Jäykkä (NORDITA, Sweden)
Isospinning hopfions

December 17th R. Foadi (Helsinki)
Composite Higgs scenarios

Visitors

Theory Programme

Cosmophysics

D. Clements (UK) 8.–10.1.
J. Hamann (Switzerland) 12.–13.2.
R. Crittenden (UK) 19.–22.2.
S. Nadathur (UK) 20.2.–1.3.
J. Virkajärvi (Denmark) 4.–5.3.
D. Figueroa (Switzerland) 4.–8.3.
C. Burrage (UK) 5.–8.3.
A. Mozaffari (UK) 9.–12.4.
D. Regan (UK) 9.–12.4.
M. Herranen (Denmark) 20.–25.4.
S. J. Huber (UK) 7.–8.5.
D. Rapetti (UK) 21.–23.5.
J. M. Cline (Canada) 1.–15.6.
T. Takahashi (Japan) 9.–29.9.
A. Golovnev (Russia) 24.10.–6.11.
G. Tasinato (UK) 5.–7.11.
D. Mulryne (UK) 11.–15.11.
S.-Y. Zhou (Italy) 19.–21.11.
J. Wagstaff (Germany) 25.–29.11.

Laws of Nature and Condensed Particle Matter Phenomenology at the LHC

H. Holopainen (Germany) 18.1.
D. Rischke (Germany) 8.–25.2.
P. Huovinen (Germany) 25.2.–1.3.
M. P. Heller (The Netherlands) 4.–8.3.
E. Kiritsis (Greece) 4.–8.3.
M. Krššák (Germany) 4.–8.3.
A. Rebhan (Austria) 4.–8.3.
A. Vuorinen (Germany) 4.–18.3.
K. P. Yogendran (India) 23.–31.3.
D. Regan (UK) 8.–12.4.
A. Vuorinen (Germany) 17.–23.4.
A. Rajantie (UK) 22.–23.4.
K. Ghosh (USA) 25.4.–19.5.
D. Ghosh (India) 6.5.–17.6.
S. J. Huber (UK) 7.–9.5.
L. Bethke (UK) 12.–19.5.
S. Caron-Huot (Denmark) 20.–21.5.
D. Litim (UK) 22.–24.5.
M. Schröck (Austria) 25.–29.5.
O. Philipsen (Germany) 29.–31.5.
G. Bergner (Germany) 30.5–4.6.
J. Rantaharju (Japan) 12.–17.8.
D. Bödeker (Germany) 25.–29.8.
G. Bhattacharyya (India) 9.9.–9.10.
S. Hossenfelder (Sweden) 10.9.
S. Niyogi (India) 15.9.–15.12.
A. Kurkela (Switzerland) 10.–11.10.
M. Raidal (Estonia) 11.–12.10.
S. J. Huber (UK) 29.–31.10.
C. Kouvaris (Denmark) 31.10.–1.11.
A. Ramos (Germany) 4.–7.11.
P. Pandita (India) 4.–21.11.
M. Heikinheimo (Estonia) 11.–13.11.
A. Racioppi (Estonia) 11.–13.11.
F. Sannino (Denmark) 12.–14.11.
Y. Schröder (Germany) 14.–17.11.

Radiation Damage in Particle Accelerator Materials

A. Caro (USA) 9.–15.2.
M. Caro (USA) 9.–15.2.
E. Bringa (Argentina) 19.–22.6.
J. Perkinson (USA) 8.–30.8.
L. Malerba (Belgium) 18.–20.12.

CMS Programme

L. Rolandi (Switzerland) 15.3.
A. Huffmann (UK) 30.9.–2.10.
T. McCauley (USA) 30.9.–2.10.

Planck

M. Reinecke (Germany) 22.–30.4.

Conference participation, Talks and Visits by Personnel

Theory Programme

Cosmophysics

Nordic Winter School on Particle Physics and Cosmology 2013,
2–7 January, Gausdal, Norway (talk by M. Lavinto)

Dark Energy Phenomenology,
7–8 February, Paris, France (talk by S. Flender)

University of the Third Age,
15 February, Lewes, UK (talk by R. Lerner)

Arkadia International Bookshop,
21 February, Helsinki, Finland (talk by R. Lerner)

Arkadia International Bookshop,
13 March, Helsinki, Finland (talk by R. Lerner)

47th ESLAB Symposium: The Universe as Seen by Planck,
2–5 April, ESA/ESTEC, Noordwijk, The Netherlands (talk by S. Hotchkiss)

VIIIth Iberian Cosmology Meeting,
24–26 April, Granada, Spain (talk by M. Karčauskias)

8. Kosmologietag,
25–26 April, Bielefeld, Germany (talk by S. Flender)

Bethe Forum,
13–17 May, Bonn, Germany (talk by K. Enqvist)

Implications of Planck for Fundamental Physics,
28 May, Manchester, UK (R. Lerner)

UK Cosmology Meeting / Lythfest,
29 May, Lancaster, UK (talk by M. Karčauskias, talk by R. Lerner)

Workshop on Cosmological Perturbations post-Planck,
4–7 June, Helsinki, Finland (M. D'Onofrio, K. Enqvist, S. Flender, M. Hindmarsh, S. Hotchkiss, K. Kainulainen, M. Karčauskias, M. Lavinto, talk by R. Lerner, T. Meriniemi, S. Nadathur, talk by S. Nurmi, H. Nyrhinen, S. Räsänen, talk by T. Sekiguchi)

Imperial College,
25–28 July, London, UK (talk by K. Kainulainen)

Mass 2013,
12–14 August, Odense, Denmark (talk by K. Kainulainen)

The 17th International Conference on Particle Physics and Cosmology COSMO 2013,
2–6 September, Cambridge, UK (talk by S. Flender, talk by M. Hindmarsh, S. Hotchkiss)

University of Auckland,
10 September – 19 October, Auckland, New Zealand (talk by S. Hotchkiss)

Arkadia International Bookshop,
12 September, Helsinki, Finland (talk by R. Lerner)

DESY Theory Meeting,
24–27 September, Hamburg, Germany (talk by R. Lerner)

University of Canterbury,
10–12 October, Christchurch, New Zealand (talk by S. Hotchkiss)

Oxford University,
12–16 November, Oxford, UK (talk by S. Hotchkiss)

University of Sussex,
15 November, Brighton, UK (S. Hotchkiss)

Max Planck Institute for Astrophysics,
19 November, Garching, Germany (talk by S. Flender)

Laws of Nature and Condensed Particle Matter Phenomenology at the LHC

Nordic Winter School on Particle Physics and Cosmology 2013,
3–8 January, Gausdal, Norway (K. Rummukainen)

European Particle Physics Strategy Update,
20–26 January, Erice, Italy (talk by K. Huitu)

Indian Institute of Science Education and Research Mohali,
28–30 January, Chandigarh, India (talk by P. Bandyopadhyay)

University of Bergen,
1–2 February, Bergen, Norway (K. Huitu)

Jet Quenching: the Interface between Theory and Experiment,
11–15 February, CERN, Switzerland (I. Helenius)

INT 13–52W Workshop, Nuclear Structure and Dynamics at Short Distances,
11–22 February, Seattle, WA, USA (talk by P. Hoyer)

Institute for Mathematical Sciences,
13–17 February, Chennai, India (talk by P. Bandyopadhyay)

Science and Technology Facilities Council,
18–19 February, Swindon, UK (talk by M. Panero)

Indian Institute of Science Education and Research Thiruvananthapuram,
19 February, Thiruvananthapuram, India (talk by P. Bandyopadhyay)

Indian Institute of Science Education and Research Pune,
20–23 February, Pune, India (talk by P. Bandyopadhyay)

SLAC,
23–28 February, Stanford, CA, USA (talk by P. Hoyer)

HIGGSTOP-2013 Conference,
25–27 February, Goa, India (P. Bandyopadhyay)

Laguna LBNO General Meeting,
25–27 February, DESY, Hamburg, Germany (K. Rummukainen)

Schladming Winter School,
25 February – 1 March, Schladming, Austria (talk by D. Weir)

San Francisco State University,
1 March, San Francisco, CA, USA (talk by P. Hoyer)

LBNL,
3–8 March, Berkeley, CA, USA (talk by P. Hoyer)

HoloGrav 2013 Workshop,
4–8 March, Helsinki, Finland (talk by T. Alho, K. Kajantie, M. Panero, K. Tuominen)

Physics Opportunities at an Electron-Ion Collider,
4–8 March, Valparaiso, Chile (talk by T. Lappi)

Annual Meeting of the Finnish Physical Society,
14–16 March, Espoo, Finland (P. Bandyopadhyay, P. Hoyer, talk by T. Lappi)

University of Southern Denmark,
27–28 March, Odense, Denmark (K. Huitu)

University of Southampton,
1 April – 30 June, Southampton, UK (K. Tuominen)

Workshop on Heavy Quarks and Quarkonia in Thermal QCD,
2–5 April, ECT*, Trento, Italy (talk by M. Panero)

XXI International Workshop on Deep-Inelastic Scattering and Related Subjects,
22–26 April, Marseille, France (talk by H. Paukkunen)

ECT*,
22 April – 13 May, Trento, Italy (P. Hoyer)

Imperial College,
24 April, London, UK (talk by D. Weir)

Workshop on Strongly Interacting Dynamics Beyond the Standard Model and the Higgs Boson,
24–26 April, Edinburgh, UK (talk by K. Rummukainen, talk by K. Tuominen)

Workshop on Proton-Nucleus Collisions at the LHC,
6–10 May, ECT*, Trento, Italy (talk by I. Helenius, talk by P. Hoyer, talk by H. Paukkunen)

Planck 2013 Conference,
19–24 May, Bonn, Germany (S. Di Chiara)

University of Bielefeld,
20–23 May, Bielefeld, Germany (talk by M. Panero)

University of Stavanger,
21–24 May, Stavanger, Norway (talk by D. Weir)

Special Strategy Session,
29–30 May, Brussels, Belgium (K. Huitu)

Workshop on Cosmological Perturbations post-Planck,
4–7 June, Helsinki, Finland (P. Bandyopadhyay, D. Weir)

CERN,
8–18 June, Geneva, Swizerland (K. Kajantie)

Imperial College,
10–14 June, London, UK (talk by D. Weir)

Conference on High Energy, High Density and Hot QCD (h3QCD),
17–21 June, ECT*, Trento, Italy (talk by T. Lappi)

Workshop on Cosmology and Fundamental Physics with Planck,
20–26 June, CERN, Switzerland (M. D'Onofrio)

ECT*,
20 June – 6 July, Trento, Italy (P. Hoyer)

High Energy Physics and Quantum Field Theory (QFTHEP 2013),
23–29 June, St. Petersburg, Russia (talk by S. Di Chiara)

University of Pisa,
24–27 June, Pisa, Italy (talk by M. Panero)

Jet Workshop 2013,
1–4 July, Paris, France (talk by T. Renk)

Workshop on Flavor Structure of the Nucleon Sea,
1–5 July, ECT*, Trento, Italy (talk by P. Hoyer)

The 2013 European Physical Society Conference on High Energy Physics,
18–24 July, Stockholm, Sweden (talk by T. Lappi, talk by M. Panero)

EPS HEP, Beyond the LHC -Workshop,
21–27 July, Stockholm, Sweden (talk by K. Huitu)

Strangeness in Quark Matter (SQM) 2013,
22–27 July, Birmingham, UK (talk by T. Renk)

Meeting on QCD Phase Diagram & Holography,
27–28 July, Frankfurt, Germany (talk by T. Alho, talk by M. Panero)

Indian Institute of Science Bengaluru,
28 July – 1 August, Bengaluru, India (talk by P. Bandyopadhyay)

Conference on Gauge/Gravity Duality 2013,
29 July – 2 August, Munich, Germany (talk by T. Alho, K. Kajantie)

The 31st International Symposium on Lattice Field Theory, Lattice 2013,
29 July – 3 August, Mainz, Germany (talk by M. Panero, talk by K. Rummukainen, talk by J. Suorsa, talk by D. Weir)

Physical Research Institute Ahmedabad,
1 August, Ahmedabad, India (talk by P. Bandyopadhyay)

Indian Institute of Technology Gandhinagar,
3–5 August, Gandhinagar, India (talk by P. Bandyopadhyay)

Workshop on Extreme QCD 13,
5–7 August, Bern, Switzerland (talk by K. Rummukainen)

Workshop on Origin of Mass 2013,
11–16 August, Odense, Denmark (talk by M. Panero, K. Tuominen)

2nd Workshop on Jet Modification in the RHIC and LHC Era,
20–22 August, Detroit, MI, USA (talk by T. Renk)

RHIC Strategy Meeting,
24–25 August, Detroit, MI, USA (talk by T. Renk)

SUSY 2013 Conference,
25–31 August, ICTP, Trieste, Italy (talk by P. Bandyopadhyay)

International Conference on New Frontiers in Physics (ICNFP 2013),
28 August – 4 September, Chania, Greece (talk by S. Di Chiara)

Physics Opportunities at an ElecTron-Ion Collider Workshop,
2–5 September, Jyväskylä, Finland (talk by I. Helenius, talk by H. Paukkunen, talk by A. Vuorinen)

The 17th International Conference on Particle Physics and Cosmology COSMO 2013,
2–6 September, Cambridge, UK (talk by M. D'Onofrio, talk by D. Weir)

Swedish Research Council Panel Meeting,
5-6 September, Stockholm, Sweden (K. Huitu)

International Conference on the Initial Stages in High-Energy Nuclear Collisions,
8–14 September, Illa da Toxa, Spain (talk by H. Paukkunen)

EDS Blois 2013: The 15th Conference on Elastic and Diffractive Scattering,
9–13 September, Saariselkä, Finland (K. Huitu, talk by T. Lappi)

Meeting: Third Annual Dirac Day,
23 September, Leicester, UK (talk by D. Weir)

CERN,
23–27 September, Geneva, Switzerland (M. D'Onofrio)

DESY Theory Workshop 2013: Nonperturbative QFT: Methods and Applications,
24–27 September, Hamburg, Germany (talk by K. Rummukainen)

NORDITA Board Meeting,
26–27 September, Stockholm, Sweden (K. Huitu)

University of Edinburgh,
30 September – 4 October, Edinburgh, UK (talk by P. Hoyer)

Workshop on Heavy Flavor Correlations in Nuclear Collisions,
2–4 October, Bergen, Norway (talk by T. Renk)

NORDITA,
14–15 October, Stockholm, Sweden (talk by K. Kajantie)

QCD Frontier 2013,
21–22 October, Newport News, VA, USA (talk by H. Paukkunen)

Subatech,
21–23 October, Nantes, France (P. Hoyer)

Syracuse University,
21–23 October, Syracuse, NY, USA (talk by D. Weir)

Workshop on Saturation Signals,
23–24 October, Utrecht, The Netherlands (talk by I. Helenius)

Particle Physics Day 2013,
24 October, Helsinki, Finland (talk by P. Bandyopadhyay)

IPhT in Saclay,
24–25 October, Paris, France (talk by P. Hoyer)

Washington University,
24–25 October, St. Louis, MO, USA (talk by D. Weir)

Hard Probes 2013 Summer School,
30 October – 3 November, Cape Town, South Africa (I. Helenius, talk by T. Lappi)

Hard Probes 2013,
4–8 November, Stellenbosch, South Africa (talk by P. Bandyopadhyay)

DESY,
10–13 November, Hamburg, Germany (talk by P. Bandyopadhyay)

2nd Workshop on Probing Strangeness in Hard Processes,
11–13 November, Frascati, Italy (talk by P. Hoyer)

Karlsruhe Institute of Technology,
13–16 November, Karlsruhe, Germany (talk by P. Bandyopadhyay)

CERN,
14–15 November, Geneva, Switzerland (M. D'Onofrio)

MIT,
15 November, Boston, MA, USA (T. Alho)

University of Sussex,
18–19 November, Sussex, UK (talk by D. Weir)

Stony Brook University,
18–20 November, Stony Brook, NY, USA (talk by T. Alho)

New Frontiers in QCD 2013,
18 November – 20 December, Kyoto, Japan (talk by T. Lappi, talk by T. Renk)

Queen Mary University of London,
20 November, London, UK (talk by D. Weir)

6th Odense Winter School on Theoretical Physics 2013,
20–21 November, Odense, Denmark (P. Hoyer, talk by K. Kajantie, K. Tuominen)

Brookhaven National Laboratory,
20–22 November, Brookhaven, NY, USA (talk by T. Alho)

University of Illinois at Chicago,
25 November, Chicago, IL, USA (talk by T. Alho)

CSC Autumn School in Computational Physics 2013,
25–26 November, London, UK (talk by K. Rummukainen)

NORDITA,
25–26 November, Stockholm, Sweden (talk by D. Weir)

University of Jyväskylä,
26 November, Jyväskylä, Finland (talk by P. Bandyopadhyay)

CP3 Institute,
6–13 December, Odense, Denmark (talk by T. Alho)

CCTP, University of Crete,
9–13 December, Heraklion, Crete (talk by P. Hoyer)

Low Dimensional Quantum Systems

13th International Workshop on Slow Positron Beam Techniques and Applications (SLOPOS13),
15–20 September, Garching, Germany (invited talk by I. Makkonen)

Radiation Damage in Particle Accelerator Materials

CLIC Workshop at CERN,
28 January – 1 February, Geneva, Switzerland (F. Djurabekova)

"Towards Reality in Nanoscale Materials VI" Workshop,
10–13 February, Levi, Finland (talk by F. Djurabekova)

SCKCEN,
22–26 February, Mol, Belgium (F. Djurabekova)

Collaboration Meeting at CERN,
9–11 March, Geneva, Switzerland (F. Djurabekova, K. Nordlund)

Annual Meeting of the Finnish Physical Society,
14–16 March, Espoo, Finland (F. Djurabekova, A. Leino, talk by S. Parviainen)

EMRS Conference,
26–30 May, Strasbourg, France (F. Djurabekova, K. Nordlund, S. Parviainen)

High Gradient and Breakdown Workshop,
2–7 June, Trieste, Italy (talk by F. Djurabekova, K. Nordlund)

17th International Conference on Radiation Effects in Insulators (REI-17),
30 June – 5 July, Helsinki, Finland (organiser F. Djurabekova, talk by A. Leino, organiser K. Nordlund, talk by O. Pakarinen)

ISI Conference,
21–25 August, Yaroslavl, Russia (invited talk by F. Djurabekova, K. Nordlund)

CERN Collaboration,
7–10 September, Geneva, Switzerland (K. Nordlund)

SMMIB,
15–21 September, Kusadasi, Turkey (talk by F. Djurabekova, talk by K. Nordlund)

OIST/Kyoto University Collaboration Visit,
11–19 October, Okinawa/Kyoto, Japan (F. Djurabekova)

Nanoscience Days 2013 and Meeting of The National Graduate School in Nanoscience,
23–25 October, Jyväskylä, Finland (A. Leino)

4th International Workshop on Mechanisms of Vacuum Arcs (MeVARC-4),
5–9 November, Chamonix, France (talk by F. Djurabekova, talk by A. Korsbäck, K. Nordlund, talk by S. Parviainen)

De Finlandssvenska Fysik- och Kemidagarna,
22–24 November, Helsinki, Finland - Stockholm, Sweden (talk by S. Parviainen)

8th International Linear Accelerator School, training,
4–16 December, Antalya, Turkey (A. Korsbäck)

ORNL Participation in Red Team to support the proposal to USA Department of Energy,
10–16 December, Knoxville, TN, USA (F. Djurabekova)

High Energy Physics Programme

Linear Collider Research

CLIC Workshop 2013,
28 January – 1 February, CERN, Geneva, Switzerland (R. Montonen, J. Väinölä, talks by M. Aicheler, F. Smeds, and K. Österberg)

Results and Prospects of Forward Physics at the LHC,
11–12 February, CERN, Geneva, Switzerland (talk by K. Österberg)

Tarkmet Oy and Mectalent Oy,
21–22 February, Vaasa and Oulu, Finland (M. Aicheler)

LHC Committee Meeting,
13 March, CERN, Geneva, Switzerland (F. Oljemark)

The Annual Meeting of the Finnish Physical Society,
14–16 March, Espoo, Finland (R. Montonen, F. Oljemark, talks by A. Meriläinen and J. Welti)

Protoshop Oy, Aalto University and Mikes,
27–28 May, Espoo, Finland (M. Aicheler, K. Österberg)

International Workshop on Breakdown Science and High Gradient Technology (HG2013),
3–6 June, Trieste, Italy (talk by M. Aicheler)

EuCARD Annual Meeting (EuCARD'13),
10–14 June, CERN, Geneva, Switzerland (K. Österberg)

Doctoral Program in Concurrent Mechanical Engineering (DPCME) - Spring Seminar,
11–16 June, Obergurgl, Austria (talk by R. Montonen)

2013 European Physical Society Conference on High Energy Physics (EPSHEP 2013),
18–24 July, Stockholm, Sweden (talk by K. Österberg)

Aalto University,
7–8 August, Espoo, Finland (M. Aicheler, K. Österberg)

HIP Scientific Advisory Board,
28–29 August, Helsinki, Finland (talk by K. Österberg)

4th Workshop on Physics Opportunities at an Electron-Ion Collider (POETIC IV),
2–5 September, Jyväskylä, Finland (talk by K. Österberg)

EDS Blois 2013,
9–13 September, Saariselkä, Finland (J. Welti, talks by F. Oljemark and K. Österberg)

5th International Conference on Structural Analysis of Advanced Materials (ICSAAM 2013),
23–26 September, Kos, Greece (F. Smeds)

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

4th International Workshop on Mechanisms of Vacuum Arcs (MeVArc 2013),
4–7 November, Chamonix, France (M. Aicheler)

CLIC Two-Beam Module Lab Program Review,
6 November, CERN, Geneva, Switzerland (talk by F. Rossi)

III Workshop on QCD and Diffraction at the LHC,
18–20 November, Cracow, Poland (talk by K. Österberg)

8th International Accelerator School for Linear Colliders,
4–15 December, Antalya, Turkey (M. Aicheler)

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

CLIC Module Working Group Meetings,
CERN, Geneva, Switzerland (talks by L. Kortelainen and F. Rossi)

CLIC RF Structure Development Meetings,
CERN, Geneva, Switzerland (talk by R. Montonen)

CLIC RF Structure Production Meetings,
CERN, Geneva, Switzerland (talks by M. Aicheler, L. Kortelainen, R. Montonen, F. Rossi, F. Smeds and J. Väinölä)

CMS-TOTEM Combined Analysis and Approval Meetings,
CERN, Geneva, Switzerland (co-organised by K. Österberg)

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

TIARA PP WP3 Meetings,
CERN, Geneva, Switzerland (J. Väinölä)

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

TOTEM Physics and Analysis Meetings,
CERN, Geneva, Switzerland (talks by F. Oljemark, J. Welti, and K. Österberg, co-organised by K. Österberg)

CMS Programme

Workshop on Silicon Strip Sensors for the CMS Phase II Upgrade,
21–22 January, CERN, Geneva, Switzerland (talk by T. Mäenpää)

Annual Meeting of the Finnish Physical Society,
14–16 March, Espoo, Finland (P. Eerola, G. Fedi, talk by T. Järvinen, A. Karadzhinova, R. Kinnunen, M. Kortelainen, T. Lampén, T. Lindén, T. Mäenpää, talk by L. Wendland)

Alumni Evening of the Faculty of Science, University of Helsinki,
21 March, Helsinki, Finland (talk by M. Kortelainen)

2nd RD50 Simulation Working Group Meeting,
27 March, CERN, Geneva, Switzerland (talk by T. Peltola)

MAOL Annual Meeting,
20 April, Helsinki, Finland (talk by P. Eerola)

Nordic e-Infrastructure Collaboration: Lessons, Opportunities and Future Directions,
15–16 May, Trondheim, Norway (T. Lindén, S. Toor)

The 15th International Workshop on Advanced Computing and Analysis Techniques in Physics Research (ACAT2013),
16–21 May, Beijing, China (talk by T. Lampén)

Workshop on the Future of Big Data Management,
27–28 May, London, UK (K. Lassila-Perini)

22nd RD50 Workshop,
3–5 June, Albuquerque, NM, USA (talk by T. Peltola)

114th LHCC Meeting,
12–13 June, CERN, Geneva, Switzerland (talk by J. Härkönen)

Nordic Physics Days,
12–14 June, Lund, Sweden (P. Eerola)

The 2013 European Physical Society Conference on High Energy Physics,
18–24 July, Stockholm, Sweden (P. Eerola, member of the International organising committee)

CMS Tracker Week, Tracker Phase 2 Sensors Meeting,
26–30 August, CERN, Geneva, Switzerland (talk by T. Peltola)

175th Anniversary Symposium "Randomness and Order in the Exact Sciences", the Finnish Society of Sciences and Letters,
2–4 September, Helsinki, Finland (invited talk by P. Eerola)

24th Micromechanics and Microsystems Europe Conference 2013,
3–5 September, Espoo, Finland (talk by A. Karadzhinova)

Meeting of the Finnish Society of Sciences and Letters,
16 September, Helsinki, Finland (talk by P. Eerola)

Järvenpää Library,
19 September, Järvenpää, Finland (lecture by S. Lehti)

CMS Pixel Phase 1 Upgrade Workshop,
29 September – 3 October, Giardini-Naxos, Italy (talk by J. Härkönen)

NuStar Week 2013,
7–11 October, Helsinki, Finland (talk by J. Härkönen)

20th International Conference on Computing in High Energy and Nuclear Physics (CHEP),
14–18 October, Amsterdam, The Netherlands (K. Lassila-Perini, T. Lindén, S. Toor)

Particle Physics Day,
24 October, Helsinki, Finland (P. Eerola, invited talk by J. Tuominiemi, talks by G. Fedi, J. Härkönen, S. Laurila, and M. Voutilainen)

PV 2013 Ensuring Long-Term Preservation and Adding Value to Scientific and Technical Data,
4–6 November, Frascati, Italy (talk by K. Lassila-Perini)

Worldwide Large Hadron Collider Computing Grid Collaboration Workshop,
11–12 November, Copenhagen, Denmark (T. Lindén)

23rd RD50 Workshop,
13–15 November, CERN, Geneva, Switzerland (talk by T. Peltola)

Karhulan lukio,
19 November, Kotka, Finland (lecture by J. Tuominiemi)

URSA,
19 November, Helsinki, Finland (talk by S. Lehti)

CMS Phase 2 Pixel Sensor Review,
20 November, CERN, Geneva, Switzerland (talk by J. Härkönen)

19th International Symposium on Particles, Strings and Cosmology (PASCOS),
20–26 November, Taipei, Taiwan (talk by M. Voutilainen)

De Finlandssvenska Fysik- och Kemidagarna,
22–24 November, Helsinki, Finland - Stockholm, Sweden (talk by T. Lindén)

University of Jyväskylä Physics Colloquium,
13 December, Jyväskylä, Finland (talk by J. Härkönen)

Micronova ALD Seminar,
17 December, Espoo, Finland (talk by J. Härkönen)

Nuclear Matter Programme

ALICE

CERN,
15–22 October, Geneva, Switzerland (E. Brücken)

ISOLDE

Heavy Ion Accelerator Symposium on Fundamental and Applied Science - 2013,
8–12 April, Manning Clarke Centre, Australian National University, Canberra, Australia (talk by J. Pakarinen)

Shape Coexistence Across the Chart of the Nuclides,
15–16 April, University of York, UK (talk by J. Pakarinen)

EURISOL Topical Meeting - "Going to the Limits of Mass, Spin and Isospin with Heavy Radioactive Ion Beams",
1–3 July, Crakow, Poland (invited talk by J. Pakarinen)

ISTROS 2013 - Isospin, Structure, Reactions and Energy of Symmetry,
23–27 September, Casta-Papiernicka, Slovakia (invited talk by J. Pakarinen)

FAIR

University of Jyväskylä,
20 August, Jyväskylä, Finland (talk by E. Brücken)

Technology Programme

Helix Nebula - The Science Cloud, Results & Engagement,
16 January, Frascati, Italy (talk by H. Mikkonen and J. White)

CloudScape V,
27–28 February, Brussels, Belgium (talk by M. Tuisku)

CERN Computing Seminar: Crushing Data Silos with ownCloud,
14 March, Geneva, Switzerland (talk by M. Tuisku)

International Symposium on Grids & Clouds (ISGC) 2013,
17–22 March, Taipei, Taiwan (talk by J. White)

EGI Community Forum,
8–12 April, Manchester, UK (talk by J. White)

EMI SciencePAD/MEDIA Meeting,
22 April, Rome, Italy (talk by J. White)

EMI EU Final Review,
11 June, Brussels, Belgium (talk by J. White)

15th International Conference on Data Warehousing and Knowledge Discovery - DaWaK 2013,
26–29 August, Prague, Czech Republic (talk by T. Niemi and M. Niinimäki)

The International Computer Science and Engineering Conference,
4–6 September, Bangkok, Thailand (talk by T. Niemi and M. Niinimäki)

Open Knowledge Foundation Conference,
16–18 September, Geneva, Switzerland (talk by M. Tuisku)

19th International Conference on Information and Software Technologies (ICIST 2013),
10–11 October, Kaunas, Lithuania (talk by T. Niemi and M. Niinimäki)

2nd Workshop on Energy for Sustainable Science at Research Infrastructures,
23–25 October, CERN, Geneva, Switzerland (talk by J. Kommeri)

Valtakunnalliset virtuaaliopetuksen teemapäivät,
2–3 December, Helsinki, Finland (invited talk by M. Tuisku)

Planck

Euclid SWG-OU Garage Days,
28–29 January, London, UK (H. Kurki-Suonio)

Euclid SGS System Team Meeting,
30 January, London, UK (H. Kurki-Suonio)

LFI Core Team Meeting 31,
18–19 February, Bologna, Italy (H. Kurki-Suonio, M. Savelainen, A.-S. Suur-Uski)

47th ESLAB Symposium: The Universe as Seen by Planck,
2–5 April, ESA/ESTEC, Noordwijk, The Netherlands (H. Kurki-Suonio, M. Savelainen, talk by A.-S. Suur-Uski, talk by J. Väiviita)

University of Jyväskylä,
26 April, Jyväskylä, Finland (invited talk by H. Kurki-Suonio)

Euclid Consortium Meeting,
13-15 May, Leiden, The Netherlands (H. Kurki-Suonio, J. Väiviita)

Workshop on Cosmological Perturbations post-Planck,
4 June, Helsinki, Finland (invited talk by H. Kurki-Suonio, M. Savelainen, A.-S. Suur-Uski, J. Väiviita)

LFI Core Team Meeting 32,
5–6 June, Bologna, Italy (K. Kiiveri, H. Kurki-Suonio, A.-S. Suur-Uski)

European Week of Astronomy and Space Science,
8–9 July, Turku, Finland (invited talk by H. Kurki-Suonio, M. Savelainen)

Planck Working Group 3 (CTP) Meeting,
15–16 July, Cambridge, UK (V. Lindholm)

International Conference on Parallel Computing ParCo 2013,
10–13 September, Munich, Germany (invited talk by H. Kurki-Suonio)

LFI Core Team Meeting 33,
16–17 September, Bologna, Italy (V. Lindholm, invited talk by A.-S. Suur-Uski)

Euclid Consortium Board Meeting,
19 September, London, UK (H. Kurki-Suonio)

Planck 2014 Papers Meeting,
24–25 September, Cambridge, UK (invited talk by H. Kurki-Suonio)

Planck Working Group 3 (CTP) Meeting,
30 September – 1 October, Lillehammer, Norway (A.-S. Suur-Uski)

LFI Core Team Meeting 34,
4–5 November, Bologna, Italy (K. Kiiveri, invited talk by H. Kurki-Suonio)

Joint Core Team Meeting,
6–8 November, Bologna, Italy (K. Kiiveri, invited talk by H. Kurki-Suonio, M. Savelainen, talk by A.-S. Suur-Uski, talk by J. Väiviita)

Euclid Data Model Workshop,
13–14 November, Toulouse, France (H. Kurki-Suonio, V. Lindholm)

Administration and Support

IPPOG Meeting,
4–6 April, Fermilab, Batavia, IL, USA (invited talk by R. Rinta-Filppula)

Scandinavian Teachers Programme Review,
19–20 June, CERN, Geneva, Switzerland (invited talk by R. Rinta-Filppula)

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

IPPOG Meeting,
15–16 November, CERN, Geneva, Switzerland (R. Rinta-Filppula)

Publications

Theory Programme

Cosmophysics

C. Boehm and S. Räsänen,
Violation of the FRW consistency condition as a signature of backreaction,
J. Cosmol. Astropart. Phys. 09 (2013) 003

J. C. Bueno Sánchez and K. Enqvist,
On the fate of coupled flat directions during inflation,
J. Cosmol. Astropart. Phys. 03 (2013) 029

C. T. Byrnes, S. Nurmi, G. Tasinato, and D. Wands,
Implications of the Planck bispectrum constraints for the primordial trispectrum,
Europhys. Lett. 103 (2013) 19001

J. M. Cline and K. Kainulainen,
Electroweak baryogenesis and dark matter from a singlet Higgs,
J. Cosmol. Astropart. Phys. 01 (2013) 012

J. M. Cline and K. Kainulainen,
Improved electroweak phase transition with subdominant inert doublet dark matter,
Phys. Rev. D 87 (2013) 071701(R)

J. M. Cline, P. Scott, K. Kainulainen, and C. Weniger,
Update on scalar singlet dark matter,
Phys. Rev. D 88 (2013) 055025

K. Enqvist, D. G. Figueroa, and R. N. Lerner,
Curvaton decay by resonant production of the Standard Model higgs,
J. Cosmol. Astropart. Phys. 01 (2013) 040

K. Enqvist, R. N. Lerner, and S. Rusak,
Reheating dynamics affects non-perturbative decay of spectator fields,
J. Cosmol. Astropart. Phys. 11 (2013) 034

K. Enqvist, T. Meriniemi, and S. Nurmi,
Generation of the Higgs condensate and its decay after inflation,
J. Cosmol. Astropart. Phys. 10 (2013) 057

K. Enqvist, H. J. Nyrhinen, and T. Koivisto,
Binary systems in Palatini *f(R)* gravity,
Phys. Rev. D 88 (2013) 104008

K. Enqvist and S. Rusak,
Modulated preheating and isocurvature perturbations,
J. Cosmol. Astropart. Phys. 03 (2013) 017

K. Enqvist and T. Takahashi,
Mixed inflaton and spectator field models after Planck,
J. Cosmol. Astropart. Phys. 10 (2013) 034

D. G. Figueroa, M. Hindmarsh, and J. Urrestilla,
Exact scale-invariant background of gravitational waves from cosmic defects,
Phys. Rev. Lett. 110 (2013) 101302

D. G. Figueroa and T. Meriniemi,
Stochastic background of gravitational waves from fermions - Theory and applications,
J. High Energy Phys. 10 (2013) 101

S. Flender and S. Hotchkiss,
The small scale power asymmetry in the cosmic microwave background,
J. Cosmol. Astropart. Phys. 09 (2013) 033

S. Flender, S. Hotchkiss, and S. Nadathur,
The stacked ISW signal of rare superstructures in ΛCDM,
J. Cosmol. Astropart. Phys. 02 (2013) 013

I. Harrison and S. Hotchkiss,
A consistent approach to falsifying ΛCDM with rare galaxy clusters,
J. Cosmol. Astropart. Phys. 07 (2013) 022

A. Hektor, M. Raidal, and E. Tempel,
Evidence for indirect detection of dark matter from galaxy clusters in *Fermi* γ-ray data,
Astrophys. J. Lett. 762 (2013) L22

A. Hektor, M. Raidal, and E. Tempel,
Fermi-LAT gamma-ray signal from Earth limb, systematic detector effects and their implications for the 130 GeV gamma-ray excess,
Eur. Phys. J. C 73 (2013) 2578

M. Hindmarsh and D. R. T. Jones,
Consistent cosmology with Higgs thermal inflation in a minimal extension of the MSSM,
J. Cosmol. Astropart. Phys. 03 (2013) 021

K. Kainulainen, K. Tuominen, and J. Virkajärvi,
Dark matter from unification,
J. Cosmol. Astropart. Phys. 10 (2013) 036

M. Lavinto, S. Räsänen, and S. J. Szybka,
Average expansion rate and light propagation in a cosmological Tardis spacetime,
J. Cosmol. Astropart. Phys. 12 (2013) 051

D. H. Lyth and M. Karčiauskas,
The statistically anisotropic curvature perturbation generated by $f^2(\phi)F_{\mu\nu}F^{\mu\nu}$,
J. Cosmol. Astropart. Phys. 05 (2013) 011

T. Markkanen and A. Tranberg,
A simple method for one-loop renormalization in curved space-time,
J. Cosmol. Astropart. Phys. 08 (2013) 045

V. Marra, M. Pääkkönen, and W. Valkenburg,
Uncertainty on *w* from large-scale structure,
Mon. Not. R. Astron. Soc. 431 (2013) 1891

S. Nurmi, C. T. Byrnes, and G. Tasinato,
A non-Gaussian landscape,
J. Cosmol. Astropart. Phys. 06 (2013) 004

Laws of Nature and Condensed Particle Matter Phenomenology at the LHC

K. J. Eskola in J. L. Albacete et al.,
Predictions for p+Pb collisions at $\sqrt{s_{NN}}$ = 5 TeV,
Int. J. Mod. Phys. E 22 (2013) 1330007

T. Alho, N. Evans, and K. Tuominen,
Dynamic AdS/QCD and the spectrum of walking gauge theories,
Phys. Rev. D 88 (2013) 105016

T. Alho, M. Järvinen, K. Kajantie, E. Kiritsis, and K. Tuominen,
On finite-temperature holographic QCD in the Veneziano limit,
J. High Energy Phys. 01 (2013) 093

O. Antipin, F. Sannino, and K. Tuominen,
The mirage of the Fermi scale,
Mod. Phys. Lett. A 28 (2013) 1350140

V. Balasubramanian, A. Bernamonti, J. de Boer, B. Craps, L. Franti, F. Galli, E. Keski-Vakkuri, B. Müller, and A. Schäfer,
Inhomogeneous holographic thermalization,
J. High Energy Phys. 10 (2013) 082

V. Balasubramanian, A. Bernamonti, J. de Boer, B. Craps, L. Franti, F. Galli, E. Keski-Vakkuri, B. Müller, and A. Schäfer,
Inhomogeneous thermalization in strongly coupled field theories,
Phys. Rev. Lett. 111 (2013) 231602

G. Bali, F. Bursa, L. Castagnini, S. Collins, L. Del Debbio, B. Lucini, and M. Panero,
Mesons in large-*N* QCD,
J. High Energy Phys. 06 (2013) 071

P. Bandyopadhyay, E. J. Chun, H. Okada, and J.-C. Park,
Higgs signatures in inverse seesaw model at the LHC,
J. High Energy Phys. 01 (2013) 079

P. Bandyopadhyay and K. Huitu,
Production of two higgses at the Large Hadron Collider in CP-violating MSSM,
J. High Energy Phys. 11 (2013) 058

P. Bandyopadhyay, K. Huitu, and A. Sabanci,
Status of $Y = 0$ triplet Higgs with supersymmetry in the light of ~ 125 GeV Higgs discovery,
J. High Energy Phys. 10 (2013) 091

R. Chatterjee, H. Holopainen, I. Helenius, T. Renk, and K. J. Eskola,
Elliptic flow of thermal photons from an event-by-event hydrodynamic model,
Phys. Rev. C 88 (2013) 034901

R. Chatterjee, H. Holopainen, T. Renk, and K. J. Eskola,
Centrality and initial formation time dependence of the emission of thermal photons from fluctuating initial conditions at RHIC and LHC,
Nucl. Phys. A 910 (2013) 207

D. D. Dietrich, P. Hoyer, and M. Järvinen,
Towards a Born term for hadrons,
Phys. Rev. D 87 (2013) 065021

K. J. Eskola,
Global analysis of nuclear PDFs - latest developments,
Nucl. Phys. A 910 (2013) 163

K. J. Eskola, H. Paukkunen, and C. A. Salgado,
A perturbative QCD study of dijets in p+Pb collisions at the LHC,
J. High Energy Phys. 10 (2013) 213

N. Evans and K. Tuominen,
Holographic modelling of a light technidilaton,
Phys. Rev. D 87 (2013) 086003

L. Franti,
On the rotational dynamics of the rattleback,
Cent. Eur. J. Phys. 11 (2013) 162

H. S. Fukano and K. Tuominen,
126 GeV Higgs boson in the top-seesaw model,
J. High Energy Phys. 09 (2013) 021

K. Ghosh, K. Huitu, J. Laamanen, and L. Leinonen,
Top quark jets as a probe of the constrained minimal supersymmetric standard model with a degenerate top squark and lightest supersymmetric particle,
Phys. Rev. Lett. 110 (2013) 141801

M. Heikinheimo, A. Racioppi, M. Raidal, C. Spethmann, and K. Tuominen,
Dark Supersymmetry,
Nucl. Phys. B 876 (2013) 201

I. Helenius, K. J. Eskola, H. Honkanen, and C. A. Salgado,
Modeling the impact parameter dependence of the nPDFs with EKS98 and EPS09 global fits,
Nucl. Phys. A 910 (2013) 510

I. Helenius, K. J. Eskola, and H. Paukkunen,
Centrality dependence of inclusive prompt photon production in d+Au, Au+Au, p+Pb, and Pb+Pb collisions,
J. High Energy Phys. 05 (2013) 030

M. Hindmarsh and D. R. T. Jones,
Strictly anomaly mediated supersymmetry breaking,
Phys. Rev. D 87 (2013) 075022

M. Laine, G. Nardini, and K. Rummukainen,
Lattice study of an electroweak phase transition at $m_h \simeq 126$ GeV,
J. Cosmol. Astropart. Phys. 01 (2013) 011

T. Lappi,
Multigluon correlations in JIMWLK,
Nucl. Phys. A 910 (2013) 518

T. Lappi and H. Mäntysaari,
On the running coupling in the JIMWLK equation,
Eur. Phys. J. C 73 (2013) 2307

T. Lappi and H. Mäntysaari,
Forward dihadron correlations in deuteron-gold collisions with a Gaussian approximation of JIMWLK,
Nucl. Phys. A 908 (2013) 51

T. Lappi and H. Mäntysaari,
Forward dihadron correlations in the Gaussian approximation of JIMWLK,
Nucl. Phys. A 910 (2013) 498

T. Lappi and H. Mäntysaari,
J/Ψ production in ultraperipheral Pb+Pb and p+Pb collisions at energies available at the CERN Large Hadron Collider,
Phys. Rev. C 87 (2013) 032201(R)

T. Lappi and H. Mäntysaari,
Single inclusive particle production at high energy from HERA data to proton-nucleus collisions,
Phys. Rev. D 88 (2013) 114020

B. Lucini and M. Panero,
SU(N) gauge theories at large N,
Phys. Rep. 526 (2013) 93

S. Mogliacci, J. O. Andersen, M. Strickland, N. Su, and A. Vuorinen,
Equation of state of hot and dense QCD: resummed perturbation theory confronts lattice data,
J. High Energy Phys. 12 (2013) 055

R. Paatelainen, K. J. Eskola, H. Holopainen, and K. Tuominen,
Multiplicities and P_T spectra in ultrarelativistic heavy ion collisions from a next-to-leading order improved perturbative QCD + saturation + hydrodynamics model,
Phys. Rev. C 87 (2013) 044904

H. Paukkunen and C. A. Salgado,
Agreement of neutrino deep inelastic scattering data with global fits of parton distributions,
Phys. Rev. Lett. 110 (2013) 212301

T. Renk,
Modelling jet quenching,
Nucl. Phys. A 910 (2013) 43

T. Renk,
Theoretical assessment of jet-hadron correlations,
Phys. Rev. C 87 (2013) 024905

T. Renk,
Jet-mass dependence of the in-medium shower modification,
Phys. Rev. C 87 (2013) 037901

T. Renk,
Physics probed by the P_T dependence of the nuclear suppression factor,
Phys. Rev. C 88 (2013) 014905

T. Renk,
Photon emission from a medium-modified shower evolution,
Phys. Rev. C 88 (2013) 034902

T. Renk,
Space-time structure of the energy deposition into the bulk medium due to jet quenching,
Phys. Rev. C 88 (2013) 044905

T. Renk,
Biased showers: A common conceptual framework for the interpretation of high-P_T observables in heavy-ion collisions,
Phys. Rev. C 88 (2013) 054902

K. Tuominen,
Finite temperature phase diagrams of gauge theories,
Phys. Rev. D 87 (2013) 105014

D. J. Weir, R. Monaco, V. P. Koshelets, J. Mygind, and R. J. Rivers,
Gaussianity revisited: exploring the Kibble-Zurek mechanism with superconducting rings,
J. Phys.: Condens. Matter 25 (2013) 404207

D. J. Weir, R. Monaco, and R. J. Rivers,
Defect formation in superconducting rings: external fields and finite-size effects,
J. Low Temp. Phys. 171 (2013) 788

Low Dimensional Quantum Systems

Z. Fan, T. Siro, and A. Harju,
Accelerated molecular dynamics force evaluation on graphics processing units for thermal conductivity calculations,
Comput. Phys. Comm. 184 (2013) 1414

T. Hiltunen, J. Ritala, T. Siro, and A. Harju,
Non-adiabatic charge state transitions in singlet-triplet qubits,
New J. Phys. 15 (2013) 103015

M. Ijäs, M. Ervasti, A. Uppstu, P. Liljeroth, J. van der Lit, I. Swart, and A. Harju,
Electronic states in finite graphene nanoribbons: Effect of charging and defects,
Phys. Rev. B 88 (2013) 075429

M. Ijäs, P. Havu, and A. Harju,
Interaction of chlorine with Stone-Wales defects in graphene and carbon nanotubes and thermodynamical prospects of chlorine-induced nanotube unzipping,
Phys. Rev. B 87 (2013) 205430

P. Järvinen, S. K. Hämäläinen, K. Banerjee, P Häkkinen, M. Ijäs, A. Harju, and P. Liljeroth,
Molecular self-assembly on graphene on SiO_2 and h-BN substrates,
Nano Lett. 13 (2013) 3199

N. B. Kopnin, M. Ijäs, A. Harju, and T. T. Heikkilä,
High-temperature surface superconductivity in rhombohedral graphite,
Phys. Rev. B 87 (2013) 140503(R)

A. Odriazola, M. M. Ervasti, I. Makkonen, A. Delgado, A. González, E. Räsänen, and A. Harju,
Scaling in the correlation energies of two-dimensional artificial atoms,
J. Phys.: Condens. Matter 25 (2013) 505504

E. Räsänen, S. Pittalis, G. Bekçioğlu, and I. Makkonen,
Large two-dimensional electronic systems: Self-consistent energies and densities at low cost,
Phys. Rev. B 87 (2013) 035144

F. Tuomisto and I. Makkonen,
Defect identification in semiconductors with positron annihilation: Experiment and theory,
Rev. Mod. Phys. 85 (2013) 1583

J. van der Lit, M. P. Boneschanscher, D. Vanmaekelbergh, M. Ijäs, A. Uppstu, M. Ervasti, A. Harju, P. Liljeroth, and I. Swart,
Suppression of electron-vibron coupling in graphene nanoribbons contacted via a single atom,
Nat. Commun. 4 (2013) 2023

Radiation Damage in Particle Accelerator Materials

B. Afra, M. D. Rodriguez, C. Trautmann, O. H. Pakarinen, F. Djurabekova, K. Nordlund, T. Bierschenk, R. Giulian, M. C. Ridgway, G. Rizza, N. Kirby, M. Toulemonde, and P. Kluth,
SAXS investigations of the morphology of swift heavy ion tracks in α-quartz,
J. Phys.: Condens. Matter 25 (2013) 045006

K. A. Avchaciov, Y. Ritter, F. Djurabekova, K. Nordlund, and K. Albe,
Controlled softening of $Cu_{64}Zr_{36}$ metallic glass by ion irradiation,
Appl. Phys. Lett. 102 (2013) 181910

M. Backman, M. Toulemonde, O. H. Pakarinen, N. Juslin, F. Djurabekova, K. Nordlund, A. Debelle, and W. J. Weber,
Molecular dynamics simulations of swift heavy ion induced defect recovery in SiC,
Comput. Mat. Sci. 67 (2013) 261

T. Bierschenk, R. Giulian, B. Afra, M. D. Rodriguez, D. Schauries, S. Mudie, O. H. Pakarinen, F. Djurabekova, K. Nordlund, O. Osmani, N. Medvedev, B. Rethfeld, M. C. Ridgway, and P. Kluth,
Latent ion tracks in amorphous silicon,
Phys. Rev. B 88 (2013) 174111

L. Bukonte, F. Djurabekova, J. Samela, K. Nordlund, S. A. Norris, and M. J. Aziz,
Comparison of molecular dynamics and binary collision approximation simulations for atom displacement analysis,
Nucl. Instr. Meth. B 297 (2013) 23

C. Cassidy, V. Singh, P. Grammatikopoulos, F. Djurabekova, K. Nordlund, and M. Sowwan,
Inoculation of silicon nanoparticles with silver atoms,
Sci. Rep. 3 (2013) 3083

F. Djurabekova, K. B. Ashurov, S. E. Maksimov, N. N. Turaeva, and B. L. Oksengendler,
Fundamental processes of radiation modification of semiconductor nanostructures,
Phys. Status Solidi C 10 (2013) 685

L. Pizzagalli, J. Godet, J. Guénolé, S. Brochard, E. Holmstrom, K. Nordlund, and T. Albaret,
A new parametrization of the Stillinger-Weber potential for an improved description of defects and plasticity of silicon,
J. Phys.: Condens. Matter 25 (2013) 055801

A. S. Pohjonen, S. Parviainen, T. Muranaka, and F. Djurabekova,
Dislocation nucleation on a near surface void leading to surface protrusion growth under an external electric field,
J. Appl. Phys. 114 (2013) 033519

M. C. Ridgway, T. Bierschenk, R. Giulian, B. Afra, M. D. Rodriguez, L. L. Araujo, A. P. Byrne, N. Kirby, O. H. Pakarinen, F. Djurabekova, K. Nordlund, M. Schleberger, O. Osmani, N. Medvedev, B. Rethfeld, and P. Kluth,
Tracks and voids in amorphous Ge induced by swift heavy-ion irradiation,
Phys. Rev. Lett. 110 (2013) 245502

D. Schauries, M. Lang, O. H. Pakarinen, S. Botis, B. Afra, M. D. Rodriguez, F. Djurabekova, K. Nordlund, D. Severin, M. Bender, W. X. Li, C. Trautmann, R. C. Ewing, N. Kirby, and P. Kluth,
Temperature dependence of ion track formation in quartz and apatite,
J. Appl. Cryst. 46 (2013) 1558

High Energy Physics Programme

TOTEM Operation

T. Aaltonen et al.,
Operational experience, improvements, and performance of the CDF Run II silicon vertex detector,
Nucl. Instr. Meth. A 729 (2013) 153

(T. Aaltonen, E. Brucken, F. Devoto, P. Mehtala, and R. Orava in T. Aaltonen et al. (CDF Collaboration))

T. Aaltonen et al.,
Search for the Higgs boson in the all-hadronic final state using the full CDF data set,
J. High Energy Phys. 02 (2013) 004

T. Aaltonen et al.,
Measurement of the B_c^- meson lifetime in the decay $B_c^- \to J/\psi\pi^-$,
Phys. Rev. D 87 (2013) 011101(R)

T. Aaltonen et al.,
Measurement of *W*-boson polarization in top-quark decay using the full CDF Run II data set,
Phys. Rev. D 87 (2013) 031104(R)

T. Aaltonen et al.,
Updated search for the standard model Higgs boson in events with jets and missing transverse energy using the full CDF data set,
Phys. Rev. D 87 (2013) 052008

T. Aaltonen et al.,
Measurement of the mass difference between top and antitop quarks,
Phys. Rev. D 87 (2013) 052013

T. Aaltonen et al.,
Search for $B_s^0 \to \mu^+\mu^-$ and $B^0 \to \mu^+\mu^-$ decays with the full CDF Run II data set,
Phys. Rev. D 87 (2013) 072003

T. Aaltonen et al.,
Measurement of the top quark forward-backward production asymmetry and its dependence on event kinematic properties,
Phys. Rev. D 87 (2013) 092002

T. Aaltonen et al.,
Measurement of $R = B(t \to Wb)/B(t \to Wq)$ in top-quark-pair decays using lepton+jets events and the full CDF run II dataset,
Phys. Rev. D 87 (2013) 111101(R)

T. Aaltonen et al.,
Top-quark mass measurement in events with jets and missing transverse energy using the full CDF data set,
Phys. Rev. D 88 (2013) 011101(R)

T. Aaltonen et al.,
Signature-based search for delayed photons in exclusive photon plus missing transverse energy events from $p\bar{p}$ collisions with $\sqrt{s}$ = 1.96 TeV,
Phys. Rev. D 88 (2013) 031103(R)

T. Aaltonen et al.,
Exclusion of exotic top-like quarks with -4/3 electric charge using jet-charge tagging in single-lepton $t\bar{t}$ events at CDF,
Phys. Rev. D 88 (2013) 032003

T. Aaltonen et al.,
Searches for the Higgs boson decaying to $W^+W^- \to \ell^+\nu\ell^-\bar{\nu}$ with the CDF II detector,
Phys. Rev. D 88 (2013) 052012

T. Aaltonen et al.,
Combination of searches for the Higgs boson using the full CDF data set,
Phys. Rev. D 88 (2013) 052013

T. Aaltonen et al.,
Higgs boson studies at the Tevatron,
Phys. Rev. D 88 (2013) 052014

T. Aaltonen et al.,
Combination of CDF and D0 *W*-Boson mass measurements,
Phys. Rev. D 88 (2013) 052018

T. Aaltonen et al.,
Evidence for a bottom baryon resonance Λ_b^{*0} in CDF data,
Phys. Rev. D 88 (2013) 071101(R)

T. Aaltonen et al.,
Indirect measurement of $\sin^2\theta_W$ (M_W) using e^+e^- pairs in the *Z*-boson region with $p\bar{p}$ collisions at a center-of-momentum energy of 1.96 TeV,
Phys. Rev. D 88 (2013) 072002

T. Aaltonen et al.,
Measurement of the leptonic asymmetry in $t\bar{t}$ events produced in $p\bar{p}$ collisions at $\sqrt{s}$ = 1.96 TeV,
Phys. Rev. D 88 (2013) 072003

T. Aaltonen et al.,
Measurement of the top-quark pair-production cross section in events with two leptons and bottom-quark jets using the full CDF data set,
Phys. Rev. D 88 (2013) 091103(R)

T. Aaltonen et al.,
Search for the production of *ZW* and *ZZ* boson pairs decaying into charged leptons and jets in $p\bar{p}$ collisions at $\sqrt{s}$ = 1.96 TeV,
Phys. Rev. D 88 (2013) 092002

T. Aaltonen et al.,
Search for a dijet resonance in events with jets and missing transverse energy in $p\bar{p}$ collisions at $\sqrt{s}$ = 1.96 TeV,
Phys. Rev. D 88 (2013) 092004

T. Aaltonen et al.,
Production of K_S^0, $K^{*\pm}$(892) and ϕ^0(1020) in minimum bias events and K_S^0 and Λ^0 in jets in $p\bar{p}$ collisions at $\sqrt{s}$ = 1.96 TeV,
Phys. Rev. D 88 (2013) 092005

T. Aaltonen et al.,
Observation of the production of a *W* boson in association with a single charm quark,
Phys. Rev. Lett. 110 (2013) 071801

T. Aaltonen et al.,
Measurement of the cross section for prompt isolated diphoton production using the full CDF Run II data sample,
Phys. Rev. Lett. 110 (2013) 101801

T. Aaltonen et al.,
Search for a two-Higgs-boson doublet using a simplified model in $p\bar{p}$ collisions at $\sqrt{s}$ = 1.96 TeV,
Phys. Rev. Lett. 110 (2013) 121801

T. Aaltonen et al.,
Search for resonant top-antitop production in the lepton plus jets decay mode using the full CDF data set,
Phys. Rev. Lett. 110 (2013) 121802

T. Aaltonen et al.,
Search for supersymmetry with like-sign lepton-tau events at CDF,
Phys. Rev. Lett. 110 (2013) 201802

T. Aaltonen et al.,
Search for pair production of strongly interacting particles decaying to pairs of jets in $p\bar{p}$ collisions at $\sqrt{s}$ = 1.96 TeV,
Phys. Rev. Lett. 111 (2013) 031802

T. Aaltonen et al.,
Measurement of the cross section for direct-photon production in association with a heavy quark in $p\bar{p}$ collisions at $\sqrt{s}$ = 1.96 TeV,
Phys. Rev. Lett. 111 (2013) 042003

T. Aaltonen et al.,
Measurement of the differential cross section $d\sigma/d(\cos\theta_t)$ for top-quark pair production in $p\bar{p}$ collisions at $\sqrt{s}$ = 1.96 TeV,
Phys. Rev. Lett. 111 (2013) 182002

T. Aaltonen et al.,
Direct measurement of the total decay width of the top quark,
Phys. Rev. Lett. 111 (2013) 202001

T. Aaltonen et al.,
Observation of D^0-$\bar{D}^0$ mixing using the CDF II detector,
Phys. Rev. Lett. 111 (2013) 231802

T. Aaltonen et al.,
***W*-boson polarization measurement in the $t\bar{t}$ dilepton channel using the CDF II detector**,
Phys. Lett. B 722 (2013) 48

(E. Brücken, J. Heino, J. Kalliopuska, K. Kurvinen, R. Lauhakangas, T. Luntama, F. Oljemark, R. Orava, K. Österberg, and H. Saarikko in E. Alagoz et al.)

E. Alagoz et al.,
Performance of almost edgeless silicon detectors in CTS and 3D-planar technologies,
J. Instr. 8 (2013) P06009

(E. Brücken, F. Garcia, J. Heino, T. Hilden, K. Kurvinen, R. Lauhakangas, T. Mäki, F. Oljemark, R. Orava, K. Österberg, H. Saarikko, and J. Welti in G. Antchev et al. (TOTEM Collaboration))

G. Antchev et al.,
Measurement of proton-proton elastic scattering and total cross-section at $\sqrt{s}$ = 7 TeV,
Europhys. Lett. 101 (2013) 21002

G. Antchev et al.,
Measurement of proton-proton inelastic scattering cross-section at $\sqrt{s}$ = 7 TeV,
Europhys. Lett. 101 (2013) 21003

G. Antchev et al.,
Luminosity-independent measurements of total, elastic and inelastic cross-sections at $\sqrt{s}$ = 7 TeV,
Europhys. Lett. 101 (2013) 21004

G. Antchev et al.,
Luminosity-independent measurement of the proton-proton total cross section at $\sqrt{s}$ = 8 TeV,
Phys. Rev. Lett. 111 (2013) 012001

G. Antchev et al.,
Double diffractive cross-section measurement in the forward region at the LHC,
Phys. Rev. Lett. 111 (2013) 262001

(E. Brücken, F. Garcia, J. Heino, T. Hilden, R. Lauhakangas, T. Mäki, F. Oljemark, R. Orava, K. Österberg, H. Saarikko, and J. Welti in G. Antchev et al. (TOTEM Collaboration))

G. Antchev et al.,
Performance of the TOTEM detectors at the LHC,
Int. J. Mod. Phys. A 28 (2013) 1330046

Linear Collider Research

(A. Kiiskinen, R. Orava, K. Osterberg, and L. Salmi in J. Abdallah et al. (DELPHI Collaboration))

J. Abdallah et al.,
Search for charged Higgs bosons: combined results using LEP data,
Eur. Phys. J. C 73 (2013) 2463

(A. Kiiskinen, R. Orava, K. Osterberg, and L. Salmi in S. Schael et al. (DELPHI Collaboration))

S. Schael et al.,
Electroweak measurements in electron-positron collisions at W-boson-pair energies at LEP,
Phys. Rep. 532 (2013) 119

Detector Laboratory

M. Castellote, R. H. Leeney, G. O'Corry-Crowe, R. Lauhakangas, K. M. Kovacs, W. Lucey, V. Krasnova, C. Lydersen, K. M. Stafford, and R. Belikov,
Monitoring white whales (*Delphinapterus leucas*) with echolocation loggers,
Polar Biol. 36 (2013) 493

K. Hanhijarvi, I. Kassamakov, J. Aaltonen, V. Heikkinen, L. Sainiemi, S. Franssila, and E. Haeggstrom,
Through-silicon stroboscopic characterization of an oscillating MEMS thermal actuator using supercontinuum interferometry,
IEEE - ASME Transactions on Mechatronics 18 (2013) 1418

V. Heikkinen, I. V. Kassamakov, T. Paulin, A. Nolvi, and E. Hæggström,
Stroboscopic scanning white light interferometry at 2.7 MHz with 1.6 µm coherence length using a non-phosphor LED source,
Opt. Express 21 (2013) 5247

I. Kassamakov, K. Grigoras, V. Heikkinen, K. Hanhijarvi, J. Aaltonen, S. Franssila, and E. Haeggstrom,
Nondestructive inspection of buried channels and cavities in silicon,
J. Microelectromech. Syst. 22 (2013) 438

H. Seppänen, T. Rauhala, S. Kiprich, J. Ukkonen, M. Simonsson, R. Kurppa, P. Janhunen, and E. Hæggström,
One kilometer (1 km) electric solar wind sail tether produced automatically,
Rev. Sci. Instrum. 84 (2013) 095102

CMS Programme

(V. Azzolini, P. Eerola, G. Fedi, M. Voutilainen, J. Härkönen, A. Heikkinen, V. Karimäki, R. Kinnunen, M. J. Kortelainen, T. Lampén, K. Lassila-Perini, S. Lehti, T. Lindén, P. Luukka, T. Mäenpää, T. Peltola, E. Tuominen, J. Tuominiemi, E. Tuovinen, D. Ungaro, and L. Wendland with the CMS Collaboration (S. Chatrchyan et al.))

CMS Collaboration,
Measurement of the elliptic anisotropy of charged particles produced in PbPb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV,
Phys. Rev. C 87 (2013) 014902

CMS Collaboration,
Forward-backward asymmetry of Drell-Yan lepton pairs in pp collisions at $\sqrt{s}$ = 7 TeV,
Phys. Lett. B 718 (2013) 752

CMS Collaboration,
Studies of jet quenching using isolated-photon + jet correlations in PbPb and pp collisions at $\sqrt{s_{NN}}$ = 2.76 TeV,
Phys. Lett. B 718 (2013) 773

CMS Collaboration,
Search for new physics in events with opposite-sign leptons, jets, and missing transverse energy in pp collisions at $\sqrt{s}$ = 7 TeV,
Phys. Lett. B 718 (2013) 815

CMS Collaboration,
Search for a W' boson decaying to a bottom quark and a top quark in pp collisions at $\sqrt{s}$ = 7 TeV,
Phys. Lett. B 718 (2013) 1229

(P. Eerola, G. Fedi, M. Voutilainen, J. Härkönen, A. Heikkinen, V. Karimäki, R. Kinnunen, M. J. Kortelainen, T. Lampén, K. Lassila-Perini, S. Lehti, T. Lindén, P. Luukka, T. Mäenpää, T. Peltola, E. Tuominen, J. Tuominiemi, E. Tuovinen, D. Ungaro, and L. Wendland with the CMS Collaboration (S. Chatrchyan et al.))

CMS Collaboration,
Measurement of the sum of WW and WZ production with W+dijet events in pp collisions at $\sqrt{s}$ = 7 TeV,
Eur. Phys. J. C 73 (2013) 2283

CMS Collaboration,
Measurement of differential top-quark-pair production cross sections in pp collisions at $\sqrt{s}$ = 7 TeV,
Eur. Phys. J. C 73 (2013) 2339

CMS Collaboration,
Measurement of the $t\bar{t}$ production cross section in the τ + jets channel in pp collisions at $\sqrt{s}$ = 7 TeV,
Eur. Phys. J. C 73 (2013) 2386

CMS Collaboration,
Search for supersymmetry in pp collisions at $\sqrt{s}$ = 7 TeV in events with a single lepton, jets, and missing transverse momentum,
Eur. Phys. J. C 73 (2013) 2404

CMS Collaboration,
Search for physics beyond the standard model in events with τ leptons, jets, and large transverse momentum imbalance in pp collisions at $\sqrt{s}$ = 7 TeV,
Eur. Phys. J. C 73 (2013) 2493

CMS Collaboration,
Search for narrow resonances and quantum black holes in inclusive and b-tagged dijet mass spectra from pp collisions at $\sqrt{s}$ = 7 TeV,
J. High Energy Phys. 01 (2013) 013

CMS Collaboration,
Measurement of the ZZ production cross section and search for anomalous couplings in $2\ell 2\ell'$ final states in pp collisions at $\sqrt{s}$ = 7 TeV,
J. High Energy Phys. 01 (2013) 063

CMS Collaboration,
Search for supersymmetry in final states with missing transverse energy and 0, 1, 2, or ≥ 3 b-quark jets in 7 TeV pp collisions using the variable α_T,
J. High Energy Phys. 01 (2013) 077

CMS Collaboration,
Search for heavy quarks decaying into a top quark and a W or Z boson using lepton + jets events in pp collisions at $\sqrt{s}$ = 7 TeV,
J. High Energy Phys. 01 (2013) 154

CMS Collaboration,
Search for exotic resonances decaying into WZ/ZZ in pp collisions at $\sqrt{s}$ = 7 TeV,
J. High Energy Phys. 02 (2013) 036

CMS Collaboration,
Search in leptonic channels for heavy resonances decaying to long-lived neutral particles,
J. High Energy Phys. 02 (2013) 085

CMS Collaboration,
Search for new physics in events with same-sign dileptons and b jets in pp collisions at $\sqrt{s}$ = 8 TeV,
J. High Energy Phys. 03 (2013) 037

CMS Collaboration,
Search for new physics in events with photons, jets, and missing transverse energy in pp collisions at $\sqrt{s}$ = 7 TeV,
J. High Energy Phys. 03 (2013) 111

CMS Collaboration,
Study of the underlying event at forward rapidity in pp collisions at $\sqrt{s}$ = 0.9, 2.76, and 7 TeV,
J. High Energy Phys. 04 (2013) 072

CMS Collaboration,
Measurement of the X(3872) production cross section via decays to $J/\psi\pi^+\pi^-$ in pp collisions at $\sqrt{s}$ = 7 TeV,
J. High Energy Phys. 04 (2013) 154

CMS Collaboration,
Measurement of the $t\bar{t}$ production cross section in the all-jet final state in pp collisions at $\sqrt{s}$ = 7 TeV,
J. High Energy Phys. 05 (2013) 065

CMS Collaboration,
Studies of jet mass in dijet and W/Z + jet events,
J. High Energy Phys. 05 (2013) 090

CMS Collaboration,
Identification of b-quark jets with the CMS experiment,
J. Instr. 8 (2013) P04013

CMS Collaboration,
The performance of the CMS muon detector in proton-proton collisions at $\sqrt{s}$ = 7 TeV at the LHC,
J. Instr. 8 (2013) P11002

CMS Collaboration,
Observation of a diffractive contribution to dijet production in proton-proton collisions at $\sqrt{s}$ = 7 TeV,
Phys. Rev. D 87 (2013) 012006

CMS Collaboration,
Search for contact interactions in $\mu^+\mu^-$ events in pp collisions at $\sqrt{s}$ = 7 TeV,
Phys. Rev. D 87 (2013) 032001

CMS Collaboration,
Search for supersymmetry in final states with a single lepton, b-quark jets, and missing transverse energy in proton-proton collisions at $\sqrt{s}$ = 7 TeV,
Phys. Rev. D 87 (2013) 052006

CMS Collaboration,
Search for contact interactions using the inclusive jet p_T spectrum in pp collisions at $\sqrt{s}$ = 7 TeV,
Phys. Rev. D 87 (2013) 052017

CMS Collaboration,
Search for supersymmetry in events with opposite-sign dileptons and missing transverse energy using an artificial neural network,
Phys. Rev. D 87 (2013) 072001

CMS Collaboration,
Search for Z' resonances decaying to $t\bar{t}$ in dilepton + jets final states in pp collisions at $\sqrt{s}$ = 7 TeV,
Phys. Rev. D 87 (2013) 072002

CMS Collaboration,
Search for new physics in final states with a lepton and missing transverse energy in pp collisions at the LHC,
Phys. Rev. D 87 (2013) 072005

CMS Collaboration,
Search for fractionally charged particles in pp collisions at $\sqrt{s}$ = 7 TeV,
Phys. Rev. D 87 (2013) 092008

CMS Collaboration,
Measurements of differential jet cross sections in proton-proton collisions at $\sqrt{s}$ = 7 TeV with the CMS detector,
Phys. Rev. D 87 (2013) 112002

CMS Collaboration,
Search for narrow resonances using the dijet mass spectrum in pp collisions at $\sqrt{s}$ = 8 TeV,
Phys. Rev. D 87 (2013) 114015

CMS Collaboration,
Interpretation of searches for supersymmetry with simplified models,
Phys. Rev. D 88 (2013) 052017

CMS Collaboration,
Evidence for associated production of a single top quark and W boson in pp collisions at $\sqrt{s}$ = 7 TeV,
Phys. Rev. Lett. 110 (2013) 022003

CMS Collaboration,
Search for pair production of third-generation leptoquarks and top squarks in pp collisions at $\sqrt{s}$ = 7 TeV,
Phys. Rev. Lett. 110 (2013) 081801

CMS Collaboration,
Measurement of the $\Upsilon(1S)$, $\Upsilon(2S)$, and $\Upsilon(3S)$ polarizations in pp collisions at $\sqrt{s}$ = 7 TeV,
Phys. Rev. Lett. 110 (2013) 081802

CMS Collaboration,
Study of the mass and spin-parity of the Higgs boson candidate via its decays to Z boson pairs,
Phys. Rev. Lett. 110 (2013) 081803

CMS Collaboration,
Search for pair-produced dijet resonances in four-jet final states in pp collisions at $\sqrt{s}$ = 7 TeV,
Phys. Rev. Lett. 110 (2013) 141802

CMS Collaboration,
Measurement of associated production of vector bosons and top quark-antiquark pairs in pp collisions at $\sqrt{s}$ = 7 TeV,
Phys. Rev. Lett. 110 (2013) 172002

CMS Collaboration,
Inclusive search for supersymmetry using razor variables in pp collisions at $\sqrt{s}$ = 7 TeV,
Phys. Rev. Lett. 111 (2013) 081802

CMS Collaboration,
Observation of long-range, near-side angular correlations in pPb collisions at the LHC,
Phys. Lett. B 718 (2013) 795

CMS Collaboration,
Search for a narrow, spin-2 resonance decaying to a pair of Z bosons in the $q\bar{q}\ell^+\ell^-$ final state,
Phys. Lett. B 718 (2013) 1208

CMS Collaboration,
Search for flavor changing neutral currents in top quark decays in pp collisions at 7 TeV,
Phys. Lett. B 718 (2013) 1252

CMS Collaboration,
Search for supersymmetry in events with photons and low missing transverse energy in pp collisions at $\sqrt{s}$ = 7 TeV,
Phys. Lett. B 719 (2013) 42

CMS Collaboration,
Search for heavy narrow dilepton resonances in pp collisions at $\sqrt{s}$ = 7 TeV and $\sqrt{s}$ = 8 TeV,
Phys. Lett. B 720 (2013) 63

CMS Collaboration,
Measurement of the $t\bar{t}$ production cross section in pp collisions at $\sqrt{s}$ = 7 TeV with lepton + jets final states,
Phys. Lett. B 720 (2013) 83

CMS Collaboration,
Search for excited leptons in pp collisions at $\sqrt{s}$ = 7 TeV,
Phys. Lett. B 720 (2013) 309

CMS Collaboration,
Measurement of the W^+W^- and ZZ production cross sections in pp collisions at $\sqrt{s}$ = 8 TeV,
Phys. Lett. B 721 (2013) 190

CMS Collaboration,
Measurement of the inelastic proton-proton cross section at $\sqrt{s}$ = 7 TeV,
Phys. Lett. B 722 (2013) 5

CMS Collaboration,
Search for anomalous production of highly boosted Z bosons decaying to $\mu^+\mu^-$ in proton-proton collisions at $\sqrt{s}$ = 7 TeV,
Phys. Lett. B 722 (2013) 28

CMS Collaboration,
Search for a Higgs boson decaying into a b-quark pair and produced in association with b quarks in proton-proton collisions at 7 TeV,
Phys. Lett. B 722 (2013) 207

CMS Collaboration,
Event shapes and azimuthal correlations in Z + jets events in pp collisions at $\sqrt{s}$ = 7 TeV,
Phys. Lett. B 722 (2013) 238

CMS Collaboration,
Search for long-lived particles in events with photons and missing energy in proton-proton collisions at $\sqrt{s}$ = 7 TeV,
Phys. Lett. B 722 (2013) 273

CMS Collaboration,
Search for heavy resonances in the W/Z-tagged dijet mass spectrum in pp collisions at $\sqrt{s}$ = 7 TeV,
Phys. Lett. B 723 (2013) 280

CMS Collaboration,
Searches for Higgs bosons in pp collisions at $\sqrt{s}$ = 7 and 8 TeV in the context of four-generation and fermiophobic models,
Phys. Lett. B 725 (2013) 36

CMS Collaboration,
Search for a non-standard-model Higgs boson decaying to a pair of new light bosons in four-muon final states,
Phys. Lett. B 726 (2013) 564

CMS Collaboration,
Measurement of the Υ(1S), Υ(2S), and Υ(3S) cross sections in pp collisions at $\sqrt{s}$ = 7 TeV,
Phys. Lett. B 727 (2013) 101

(P. Eerola, G. Fedi, M. Voutilainen, J. Härkönen, V. Karimäki, R. Kinnunen, M. J. Kortelainen, T. Lampén, K. Lassila-Perini, S. Lehti, T. Lindén, P. Luukka, T. Mäenpää, T. Peltola, E. Tuominen, J. Tuominiemi, E. Tuovinen, and L. Wendland with the CMS Collaboration (S. Chatrchyan et al.))

CMS Collaboration,
Search for a standard-model-like Higgs boson with a mass in the range 145 to 1000 GeV at the LHC,
Eur. Phys. J. C 73 (2013) 2469

CMS Collaboration,
Measurement of masses in the $t\bar{t}$ system by kinematic endpoints in pp collisions at $\sqrt{s}$ = 7 TeV,
Eur. Phys. J. C 73 (2013) 2494

CMS Collaboration,
Search for supersymmetry in hadronic final states with missing transverse energy using the variables α_T and b-quark multiplicity in pp collisions at $\sqrt{s}$ = 8 TeV,
Eur. Phys. J. C 73 (2013) 2568

CMS Collaboration,
Measurement of the W^+W^- cross section in pp collisions at $\sqrt{s}$ = 7 TeV and limits on anomalous WWγ and WWZ couplings,
Eur. Phys. J. C 73 (2013) 2610

CMS Collaboration,
Jet and underlying event properties as a function of charged-particle multiplicity in proton-proton collisions at $\sqrt{s}$ = 7 TeV,
Eur. Phys. J. C 73 (2013) 2674

CMS Collaboration,
Search for top-squark pair production in the single-lepton final state in pp collisions at $\sqrt{s}$ = 8 TeV,
Eur. Phys. J. C 73 (2013) 2677

CMS Collaboration,
Search for the standard model Higgs boson produced in association with a top-quark pair in pp collisions at the LHC,
J. High Energy Phys. 05 (2013) 145

CMS Collaboration,
Observation of a new boson with mass near 125 GeV in pp collisions at $\sqrt{s}$ = 7 and 8 TeV,
J. High Energy Phys. 06 (2013) 081

CMS Collaboration,
Study of exclusive two-photon production of W^+W^- in pp collisions at $\sqrt{s}$ = 7 TeV and constraints on anomalous quartic gauge couplings,
J. High Energy Phys. 07 (2013) 116

CMS Collaboration,
Searches for long-lived charged particles in pp collisions at $\sqrt{s}$ = 7 and 8 TeV,
J. High Energy Phys. 07 (2013) 122

CMS Collaboration,
Measurement of the Λ_b^0 lifetime in pp collisions at $\sqrt{s}$ = 7 TeV,
J. High Energy Phys. 07 (2013) 163

CMS Collaboration,
Search for microscopic black holes in pp collisions at $\sqrt{s}$ = 8 TeV,
J. High Energy Phys. 07 (2013) 178

CMS Collaboration,
Measurement of the hadronic activity in events with a Z and two jets and extraction of the cross section for the electroweak production of a Z with two jets in pp collisions at $\sqrt{s}$ = 7 TeV,
J. High Energy Phys. 10 (2013) 062

CMS Collaboration,
Measurement of the production cross section for $Z\gamma \to \nu\bar{\nu}\gamma$ in pp collisions at $\sqrt{s}$ = 7 TeV and limits on ZZγ and Zγγ triple gauge boson couplings,
J. High Energy Phys. 10 (2013) 164

CMS Collaboration,
Measurement of the W-boson helicity in top-quark decays from $t\bar{t}$ production in lepton+jets events in pp collisions at $\sqrt{s}$ = 7 TeV,
J. High Energy Phys. 10 (2013) 167

CMS Collaboration,
Measurement of the differential and double-differential Drell-Yan cross sections in proton-proton collisions at $\sqrt{s}$ = 7 TeV,
J. High Energy Phys. 12 (2013) 030

CMS Collaboration,
Measurement of the cross section and angular correlations for associated production of a Z boson with b hadrons in pp collisions at $\sqrt{s}$ = 7 TeV,
J. High Energy Phys. 12 (2013) 039

CMS Collaboration,
Energy calibration and resolution of the CMS electromagnetic calorimeter in pp collisions at $\sqrt{s}$ = 7 TeV at the LHC,
J. Instr. 8 (2013) P09009

CMS Collaboration,
Measurement of neutral strange particle production in the underlying event in proton-proton collisions at $\sqrt{s}$ = 7 TeV,
Phys. Rev. D 88 (2013) 052001

CMS Collaboration,
Rapidity distributions in exclusive Z + jet and γ + jet events in pp collisions at $\sqrt{s}$ = 7 TeV,
Phys. Rev. D 88 (2013) 112009

CMS Collaboration,
Measurement of the $B_s^0 \to \mu^+\mu^-$ branching fraction and search for $B^0 \to \mu^+\mu^-$ with the CMS experiment,
Phys. Rev. Lett. 111 (2013) 101804

CMS Collaboration,
Searches for new physics using the $t\bar{t}$ invariant mass distribution in pp collisions at $\sqrt{s}$ = 8 TeV,
Phys. Rev. Lett. 111 (2013) 211804

CMS Collaboration,
Search for top squarks in *R*-parity-violating supersymmetry using three or more leptons and *b*-tagged jets,
Phys. Rev. Lett. 111 (2013) 221801

CMS Collaboration,
Multiplicity and transverse momentum dependence of two- and four-particle correlations in pPb and PbPb collisions,
Phys. Lett. B 724 (2013) 213

CMS Collaboration,
Search for gluino mediated bottom- and top-squark production in multijet final states in pp collisions at 8 TeV,
Phys. Lett. B 725 (2013) 243

CMS Collaboration,
Search for a Higgs boson decaying into a Z and a photon in pp collisions at $\sqrt{s}$ = 7 and 8 TeV,
Phys. Lett. B 726 (2013) 587

CMS Collaboration,
Search for a new bottomonium state decaying to $\Upsilon(1S)\pi^+\pi^-$ in pp collisions at $\sqrt{s}$ = 8 TeV,
Phys. Lett. B 727 (2013) 57

CMS Collaboration,
Angular analysis and branching fraction measurement of the decay $B^0 \to K^{*0}\mu^+\mu^-$,
Phys. Lett. B 727 (2013) 77

CMS Collaboration,
Measurement of the prompt J/ψ and ψ(2S) polarizations in pp collisions at $\sqrt{s}$ = 7 TeV,
Phys. Lett. B 727 (2013) 381

E. Verbitskaya, V. Eremin, A. Zabrodskii, Z. Li, and P. Luukka,
Restriction on the gain in collected charge due to carrier avalanche multiplication in heavily irradiated Si strip detectors,
Nucl. Instr. Meth. A 730 (2013) 66

Nuclear Matter Programme

ALICE

(J. Äystö, B. Chang, D. J. Kim, J. Kral, F. Krizek, J. Rak, and S. S. Räsänen in E. Abbas et al. (ALICE Collaboration))

E. Abbas et al.,
Mid-rapidity anti-baryon to baryon ratios in pp collisions at $\sqrt{s}$ = 0.9, 2.76 and 7 TeV measured by ALICE,
Eur. Phys. J. C 73 (2013) 2496

E. Abbas et al.,
Charmonium and e^+e^- pair photoproduction at mid-rapidity in ultra-peripheral Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV,
Eur. Phys. J. C 73 (2013) 2617

E. Abbas et al.,
Performance of the ALICE VZERO system,
J. Instr. 8 (2013) P10016

E. Abbas et al.,
Centrality dependence of the pseudorapidity density distribution for charged particles in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV,
Phys. Lett. B 726 (2013) 610

(J. Äystö, B. Chang, D. J. Kim, J. Kral, F. Krizek, N. Novitzky, J. Rak, and S. S. Räsänen in B. Abelev et al. (ALICE Collaboration))

B. Abelev et al.,
Measurement of inelastic, single- and double-diffraction cross sections in proton-proton collisions at the LHC with ALICE,
Eur. Phys. J. C 73 (2013) 2456

B. Abelev et al.,
Charged kaon femtoscopic correlations in pp collisions at $\sqrt{s}$ = 7 TeV,
Phys. Rev. D 87 (2013) 052016

B. Abelev et al.,
Charge separation relative to the reaction plane in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV,
Phys. Rev. Lett. 110 (2013) 012301

B. Abelev et al.,
Pseudorapidity density of charged particles in p+Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV,
Phys. Rev. Lett. 110 (2013) 032301

B. Abelev et al.,
Transverse momentum distribution and nuclear modification factor of charged particles in p+Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV,
Phys. Rev. Lett. 110 (2013) 082302

B. Abelev et al.,
Net-charge fluctuations in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV,
Phys. Rev. Lett. 110 (2013) 152301

B. Abelev et al.,
Coherent J/ψ photoproduction in ultra-peripheral Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV,
Phys. Lett. B 718 (2013) 1273

B. Abelev et al.,
Anisotropic flow of charged hadrons, pions and (anti-)protons measured at high transverse momentum in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV,
Phys. Lett. B 719 (2013) 18

B. Abelev et al.,
Long-range angular correlations on the near and away side in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV,
Phys. Lett. B 719 (2013) 29

B. Abelev et al.,
Centrality dependence of charged particle production at large transverse momentum in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV,
Phys. Lett. B 720 (2013) 52

B. Abelev et al.,
Measurement of electrons from beauty hadron decays in pp collisions at $\sqrt{s}$ = 7 TeV,
Phys. Lett. B 721 (2013) 13

B. Abelev et al.,
Measurement of the inclusive differential jet cross section for pp collisions at $\sqrt{s}$ = 2.76 TeV,
Phys. Lett. B 722 (2013) 262

B. Abelev et al.,
Charge correlations using the balance function in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV,
Phys. Lett. B 723 (2013) 267

(J. Äystö, B. Chang, D. J. Kim, J. Kral, F. Krizek, J. Rak, and S. S. Räsänen in B. Abelev et al. (ALICE Collaboration))

B. Abelev et al.,
Multiplicity dependence of two-particle azimuthal correlations in pp collisions at the LHC,
J. High Energy Phys. 09 (2013) 049

B. Abelev et al.,
Centrality determination of Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV with ALICE,
Phys. Rev. C 88 (2013) 044909

B. Abelev et al.,
Centrality dependence of π, *K*, and p production in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV,
Phys. Rev. C 88 (2013) 044910

B. Abelev et al.,
***D* meson elliptic flow in noncentral Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV,**
Phys. Rev. Lett. 111 (2013) 102301

B. Abelev et al.,
***J/ψ* elliptic flow in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV,**
Phys. Rev. Lett. 111 (2013) 162301

B. Abelev et al.,
Directed flow of charged particles at midrapidity relative to the spectator plane in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV,
Phys. Rev. Lett. 111 (2013) 232302

(F. Krizek and S. S. Räsänen in B. Abelev et al. (ALICE Collaboration))

B. Abelev et al.,
Energy dependence of the transverse momentum distributions of charged particles in pp collisions measured by ALICE,
Eur. Phys. J. C 73 (2013) 2662

B. Abelev et al.,
K_S^0 and Λ production in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV,
Phys. Rev. Lett. 111 (2013) 222301

B. Abelev et al.,
Long-range angular correlations of π, K and p in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV,
Phys. Lett. B 726 (2013) 164

B. Abelev et al.,
Multiplicity dependence of the average transverse momentum in pp, p-Pb, and Pb-Pb collisions at the LHC,
Phys. Lett. B 727 (2013) 371

(D. J. Kim, F. Krizek, N. Novitzky, and J. Rak in A. Adare et al. (PHENIX Collaboration))

A. Adare et al.,
Medium modification of jet fragmentation in Au + Au collisions at $\sqrt{s_{NN}}$ = 200 GeV measured in direct photon-hadron correlations,
Phys. Rev. Lett. 111 (2013) 032301

(D. J. Kim and J. Rak in A. Adare et al. (PHENIX Collaboration))

A. Adare et al.,
Transverse-momentum dependence of the J/ψ nuclear modification in d +Au collisions at $\sqrt{s_{NN}}$ = 200 GeV,
Phys. Rev. C 87 (2013) 034904

A. Adare et al.,
Neutral pion production with respect to centrality and reaction plane in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV,
Phys. Rev. C 87 (2013) 034911

A. Adare et al.,
$\Upsilon(1S+2S+3S)$ production in d +Au and p+p collisions at $\sqrt{s_{NN}}$ = 200 GeV and cold-nuclear-matter effects,
Phys. Rev. C 87 (2013) 044909

A. Adare et al.,
Direct photon production in d +Au collisions at $\sqrt{s_{NN}}$ = 200 GeV,
Phys. Rev. C 87 (2013) 054907

A. Adare et al.,
Spectra and ratios of identified particles in Au+Au and d +Au collisions at $\sqrt{s_{NN}}$ = 200 GeV,
Phys. Rev. C 88 (2013) 024906

A. Adare et al.,
Azimuthal anisotropy of π^0 and η mesons in Au + Au collisions at $\sqrt{s_{NN}}$ = 200 GeV,
Phys. Rev. C 88 (2013) 064910

A. Adare et al.,
Double-spin asymmetry of electrons from heavy-flavor decays in p + p collisions at $\sqrt{s}$ = 200 GeV,
Phys. Rev. D 87 (2013) 012011

A. Adare et al.,
Nuclear modification of ψ', χ_c, and J/ψ production in d +Au collisions at $\sqrt{s_{NN}}$ = 200 GeV,
Phys. Rev. Lett. 111 (2013) 202301

A. Adare et al.,
Quadrupole anisotropy in dihadron azimuthal correlations in central d +Au collisions at $\sqrt{s_{NN}}$ = 200 GeV,
Phys. Rev. Lett. 111 (2013) 212301

ISOLDE

J. Pakarinen in L. P. Gaffney et al.,
Studies of pear-shaped nuclei using accelerated radioactive beams,
Nature 497 (2013) 199

J. Pakarinen in J. G. Johansen et al.,
Experimental study of bound states in ^{12}Be through low-energy ^{11}Be (d, p)-transfer reactions,
Phys. Rev. C 88 (2013) 044619

J. Pakarinen in N. Warr et al.,
The Miniball spectrometer,
Eur. Phys. J. A 49 (2013) 40

Technology Programme

T. Niemi and M. Niinimaki,
Data integration for phone users' mobility analysis,
2013 International Computer Science and Engineering Conference (ICSEC), Bangkok, Thailand, 4–6 September (2013) 120

P. Thanisch, T. Niemi, J. Nummenmaa, Z. Zhang, M. Niinimäki, and P. Saariluoma,
Incompleteness in conceptual data modeling,
Communications in Computer and Information Science 403 (2013) 159

P. Thanisch, J. Nummenmaa, T. Niemi, and M. Niinimäki,
Cell-at-a-time approach to lazy evaluation of dimensional aggregations,
Lecture Notes in Computer Science 8057 (2013) 349

S. Toor, L. Osmani, P. Eerola, O. Kraemer, T. Lindén, S. Tarkoma, and J. White,
A scalable infrastructure for CMS data analysis based on OpenStack Cloud and Gluster file system,
International Conference on Computing in High Energy and Nuclear Physics (CHEP) 2013, Amsterdam, The Netherlands, October, 2013 (2013)

CLOUD

T. Nieminen M. Sipilä, and M. Kulmala in J. Almeida et al.,
Molecular understanding of sulphuric acid-amine particle nucleation in the atmosphere,
Nature 502 (2013) 359

T. Nieminen in S. A. Häkkinen et al.,
Semi-empirical parameterization of size-dependent atmospheric nanoparticle growth in continental environments,
Atmos. Chem. Phys. 13 (2013) 7665

T. Nieminen in M. K. Kajos et al.,
Terpenoid emissions from fully grown east Siberian *Larix cajanderi* trees,
Biogeosciences 10 (2013) 4705

M. Sipilä in H. Keskinen et al.,
Evolution of particle composition in CLOUD nucleation experiments,
Atmos. Chem. Phys. 13 (2013) 5587

A.-J. Kieloaho, H. Hellén, H. Hakola, H. E. Manninen, T. Nieminen, M. Kulmala, and M. Pihlatie,
Gas-phase alkylamines in a boreal Scots pine forest air,
Atmos. Environ. 80 (2013) 369

T. Nieminen in M. Kulmala et al.,
Direct observations of atmospheric aerosol nucleation,
Science 339 (2013) 943

T. Nieminen and J. Duplissy in S. Schobesberger et al.,
Molecular understanding of atmospheric particle formation from sulfuric acid and large oxidized organic molecules,
PNAS, Proc. Natl. Acad. Sci. U.S.A. 110 (2013) 17223

T. Nieminen in R. Väänänen et al.,
Analysis of particle size distribution changes between three measurement sites in northern Scandinavia,
Atmos. Chem. Phys. 13 (2013) 11887

Planck

(H. Kurki-Suonio, A. Lähteenmäki, T. Poutanen, and A.-S. Suur-Uski in Planck Collaboration)

Planck Collaboration,
***Planck* intermediate results V. Pressure profiles of galaxy clusters from the Sunyaev-Zeldovich effect,**
Astron. Astrophys. 550 (2013) A131

Planck Collaboration,
***Planck* intermediate results VI. The dynamical structure of PLCKG214.6+37.0, a *Planck* discovered triple system of galaxy clusters,**
Astron. Astrophys. 550 (2013) A132

Planck Collaboration,
***Planck* intermediate results VII. Statistical properties of infrared and radio extragalactic sources from the *Planck* Early Release Compact Source Catalogue at frequencies between 100 and 857 GHz,**
Astron. Astrophys. 550 (2013) A133

Planck Collaboration,
***Planck* intermediate results IX. Detection of the Galactic haze with Planck,**
Astron. Astrophys. 554 (2013) A139

Planck Collaboration,
***Planck* intermediate results X. Physics of the hot gas in the Coma cluster,**
Astron. Astrophys. 554 (2013) A140

Planck Collaboration,
***Planck* intermediate results XI. The gas content of dark matter halos: the Sunyaev-Zeldovich-stellar mass relation for locally brightest galaxies,**
Astron. Astrophys. 557 (2013) A52

Planck Collaboration,
***Planck* intermediate results XII. Diffuse Galactic components in the Gould Belt system,**
Astron. Astrophys. 557 (2013) A53

(H. Kurki-Suonio, T. Poutanen, and A.-S. Suur-Uski in Planck Collaboration)

Planck Collaboration,
***Planck* intermediate results III. The relation between galaxy cluster mass and Sunyaev-Zeldovich signal,**
Astron. Astrophys. 550 (2013) A129

Planck Collaboration,
***Planck* intermediate results IV. The *XMM-Newton* validation programme for new *Planck* galaxy clusters,**
Astron. Astrophys. 550 (2013) A130

Planck Collaboration,
***Planck* intermediate results VIII. Filaments between interacting clusters,**
Astron. Astrophys. 550 (2013) A134

(H. Kurki-Suonio, T. Poutanen, and A.-S. Suur-Uski in Planck and AMI Collaborations)

Planck and AMI Collaborations,
***Planck* intermediate results II. Comparison of Sunyaev-Zeldovich measurements from *Planck* and from the Arcminute Microkelvin Imager for 11 galaxy clusters,**
Astron. Astrophys. 550 (2013) A128

M. Savelainen, J. Väliviita, P. Walia, S. Rusak, and H. Kurki-Suonio,
Constraints on neutrino density and velocity isocurvature modes from WMAP-9 data,
Phys. Rev. D 88 (2013) 063010

Preprints

HIP preprint series

G. S. Bali, F. Bursa, L. Castagnini, S. Collins, L. Del Debbio, B. Lucini, and M. Panero,
Mesons in Large-N QCD,
HIP-2013-01-TH

S. Nurmi, C. T. Byrnes, and G. Tasinato,
A Non-Gaussian Landscape,
HIP-2013-02-TH

K. Kajantie, M. Krššák, and A. Vuorinen,
Energy Momentum Tensor Correlators in Hot Yang-Mills Theory: Holography Confronts Lattice and Perturbation Theory,
HIP-2013-03-TH

G. S. Bali, L. Castagnini, S. Collins, F. Bursa, L. Del Debbio, B. Lucini, and M. Panero,
The Meson Spectrum in Large-N QCD,
HIP-2013-04-TH

D. J. Weir, R. Monaco, V. P. Koshelets, J. Mygind, and R. J. Rivers,
Gaussianity Revisited: Exploring the Kibble-Zurek Mechanism with Superconducting Rings,
HIP-2013-05-TH

T. Markkanen and A. Tranberg,
A Simple Method for One-Loop Renormalization in Curved Space-Time,
HIP-2013-06-TH

M. Hindmarsh, S. J. Huber, K. Rummukainen, and D. J. Weir,
Gravitational Waves from the Sound of a First Order Phase Transition,
HIP-2013-07-TH

C. Boehm and S. Räsänen,
Violation of the FRW Consistency Condition as a Signature of Backreaction,
HIP-2013-08-TH

P. Bandyopadhyay, K. Huitu, and A. Sabanci,
Status of $Y = 0$ Triplet Higgs with Supersymmetry in the Light of ~ 125 GeV Higgs Discovery,
HIP-2013-09A-TH

K. Enqvist, T. Meriniemi, and S. Nurmi,
Generation of the Higgs Condensate and Its Decay after Inflation,
HIP-2013-09B-TH

K. Enqvist, T. Koivisto, and H. J. Nyrhinen,
Binary Systems in Palatini-$f(R)$ Gravity,
HIP-2013-10A-TH

D. G. Figueroa and T. Meriniemi,
Stochastic Background of Gravitational Waves from Fermions - Theory and Applications,
HIP-2013-10B-TH

V. Balasubramanian, A. Bernamonti, J. de Boer, B. Craps, L. Franti, F. Galli, E. Keski-Vakkuri, B. Müller, and A. Schäfer,
Inhomogeneous Thermalization in Strongly Coupled Field Theories,
HIP-2013-11A-TH

K. Enqvist, R. N. Lerner, and S. Rusak,
Reheating Dynamics Affects Non-Perturbative Decay of Spectator Fields,
HIP-2013-11B-TH

M. Panero, K. Rummukainen, and A. Schäfer,
A Lattice Study of the Jet Quenching Parameter,
HIP-2013-12-TH

M. Savelainen, J. Väliviita, P. Walia, S. Rusak, and H. Kurki-Suonio,
Constraints on Neutrino Density and Velocity Isocurvature Modes from WMAP-9 Data,
HIP-2013-13-TH

V. Balasubramanian, A. Bernamonti, J. de Boer, B. Craps, L. Franti, F. Galli, E. Keski-Vakkuri, B. Müller, and A. Schäfer,
Inhomogeneous Holographic Thermalization,
HIP-2013-14-TH

M. Lavinto, S. Räsänen, and S. J. Szybka,
Average Expansion Rate and Light Propagation in a Cosmological Tardis Spacetime,
HIP-2013-15-TH

M. Panero, K. Rummukainen, and A. Schäfer,
Momentum Broadening of Partons on the Light Cone from the Lattice,
HIP-2013-16-TH

M. Panero, K. Rummukainen, and A. Schäfer,
Jet Quenching in a Strongly Interacting Plasma - A Lattice Approach,
HIP-2013-17-TH

B. Lucini and M. Panero,
Introductory Lectures to Large-N QCD Phenomenology and Lattice Results,
HIP-2013-18-TH

H. Nishimura, S. Stricker, O. Taanila, and A. Vuorinen,
Gravitational Collapse in AdS Space and Thermalization at Strong Coupling,
HIP-2013-19-TH

T. Alho, M. Järvinen, K. Kajantie, E. Kiritsis, C. Rosen, and K. Tuominen,
A Holographic Model for QCD in the Veneziano Limit at Finite Temperature and Density,
HIP-2013-20-TH

K. Enqvist, R. N. Lerner, and T. Takahashi,
The Minimal Curvaton-Higgs Model,
HIP-2013-21-TH

A. Tranberg and D. J. Weir,
On the Quantum Stability of Q-balls,
HIP-2013-22-TH

D. J. Weir, S. Catterall, and D. Mehta,
Eigenvalue Spectrum of Lattice N=4 Super Yang-Mills,
HIP-2013-23-TH

S. Mogliacci,
Kurtoses and High Order Cumulants: Insights from Resummed Perturbation Theory,
HIP-2013-24-TH

J. M. Suorsa, T. Rantalaiho, K. Rummukainen, K. Splittorff, and D. J. Weir,
Investigating the Sharpe-Singleton Scenario on the Lattice by Direct Eigenvalue Computation,
HIP-2013-25-TH

T. Sekiguchi, H. Tashiro, J. Silk, and N. Sugiyama,
Cosmological Signatures of Tilted Isocurvature Perturbations: Reionization and 21cm Fluctuations,
HIP-2013-26-TH

E. S. Fraga, A. Kurkela, and A. Vuorinen,
Interacting Quark Matter Equation of State for Compact Stars,
HIP-2013-27-TH

J. A. Niskanen,
Low-Energy η-Nuclear Scattering Parametres *vs.* Binding Properties in Light Nuclei,
HIP-2013-28A/TH

S. Räsänen,
A Covariant Treatment of Cosmic Parallax,
HIP-2013-28B/TH

HIP internal reports

T. Rüppell,
Aspects of Symmetry Breaking in Supersymmetric Models,
HIP-2013-01 (Doctoral thesis)

CERN CLIC Notes

F. Rossi, R. Modello, G. Riddone, K. Österberg, I. Kossyvakis, D. Gudkov, and A. Samoshkine,
Study of the Thermo-Mechanical Behavior of the CLIC Two-Beam Modules,
CLIC-Note-1001

Edited by Christina Helminen

Layout Mari Lindgren
Printed by Unigrafia

HELSINKI INSTITUTE OF PHYSICS

Helsinki office
P.O. Box 64 (Gustaf Hällströmin katu 2)
FIN-00014 University of Helsinki, Finland
tfn +358-9-191 50521
fax +358-9-191 50522
http://www.hip.fi/

CERN office
CERN/PH
CH-1211 Geneva 23, Switzerland
tfn +41-22-76 73027
fax/PH +41-22-76 73600