HELSINKI INSTITUTE OF PHYSICS

Annual Report 2015

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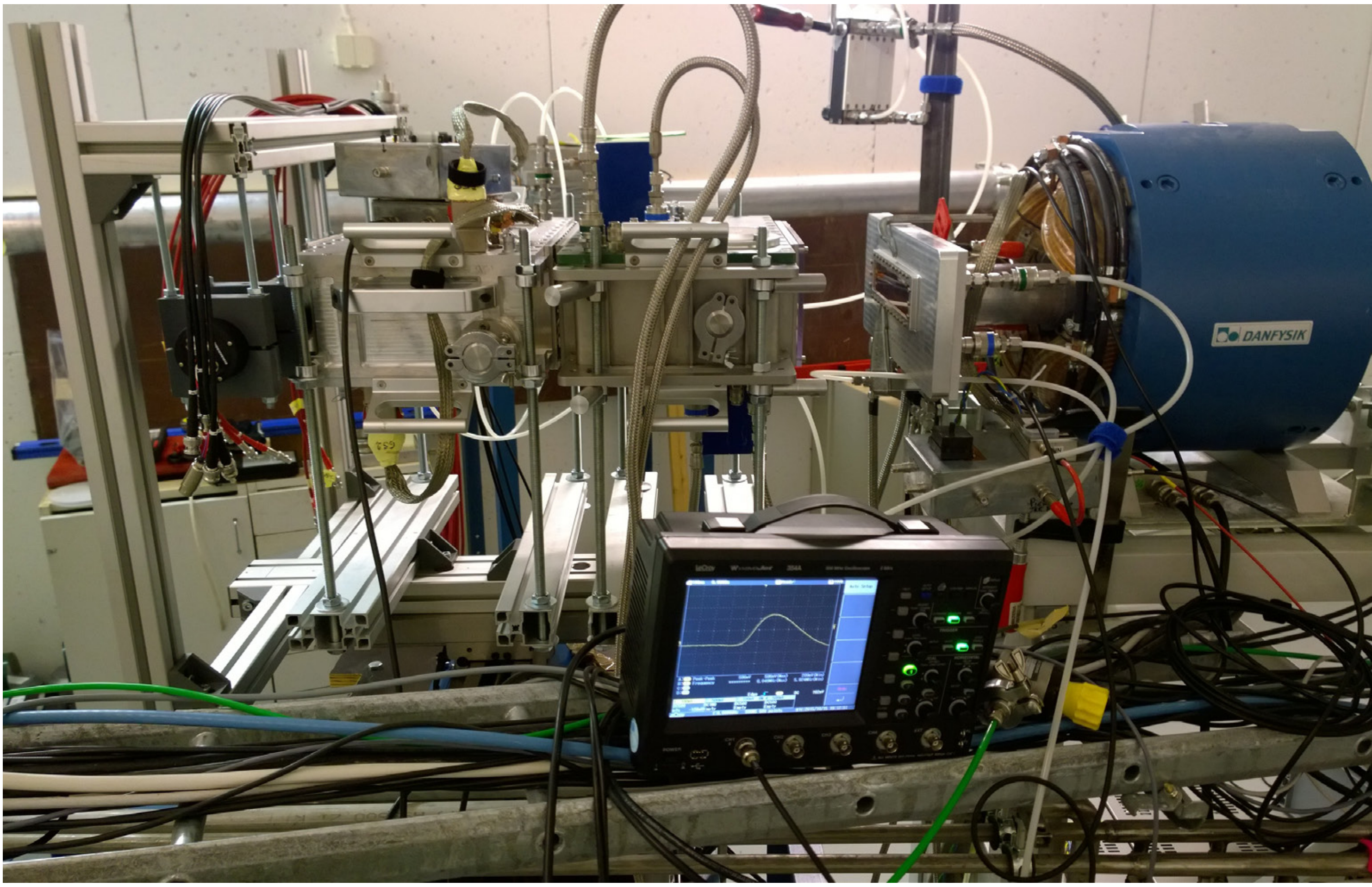

The HGB4 GEM-TPC prototype detector installed in the beam line of the Accelerator Laboratory of the University of Jyväskylä.

Contents

Introduction

Juha Äystö

Research at the Helsinki Institute of Physics (HIP) addresses fundamental science questions from quarks to the Cosmos as well as technologies from semiconductors to accelerators and medical applications and climate research. The research activities of HIP in 2015 have consisted of four main research programmes including a substantial effort on theory, two independent research projects and the Detector Laboratory. Finland's membership of CERN allows an active participation in front-line particle physics experiments. The HIP groups in the CMS, ALICE and TOTEM detector collaborations participate in the data analysis of the runs of the LHC collider, which resumed its operation after a long shutdown in spring 2015 with a full design energy of 13 TeV for pp collisions. Research at CERN's ISOLDE continued with active participation in starting the first experiments with the HIE-ISOLDE facility at record energy. The CLOUD experiment at CERN continued data taking with beams and cosmic radiation in 2015. Scientific output of HIP has been steadily increasing, reaching a level of over 250 peer-reviewed publications in high impact-level journals in 2015.

The Helsinki Institute of Physics 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 is also responsible for co-ordination of the Finnish activities at the new international Facility for Antiproton and Ion Research (FAIR) under construction in Darmstadt, Germany. The University of Helsinki, which is the host organization of HIP, and the Swedish Research Council have formed a consortium "FAIRNORD" for joint representation in the Council of FAIR GmbH.

HIP is operated by the University of Helsinki, Aalto University, the University of Jyväskylä and Lappeenranta and Tampere Universities of Technology. Administratively, since its founding, HIP has been 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, for example, demonstrated by the great interest in CERN shown by Finnish high schools. In 2015 the Institute was able to host 18 science-study visits to CERN by 366 Finnish high school students and 57 + 25 teachers. During 2015, 8 PhD degrees and 17 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 summer 2015, 18 Finnish university students worked at CERN as trainees in HIP research projects.

The research activities of the Helsinki Institute of Physics in 2015 fell into 4 research programmes and 2 special research projects. The research programmes were (1) the Theory Programme, (2) the CMS Programme, (3) the Nuclear Matter Programme and (4) the Technology Programme. The special independent projects in 2015 were the CLOUD project at CERN, which aims at the determination of the role of cosmic radiation in climate warming, and the Planck-Euclid project for the analysis of the cosmic background radiation data from the Planck satellite. In addition, the Detector Laboratory continued as a common infrastructure operating in collaboration with detector construction and the R&D projects of the experimental groups of HIP.

The Theory Programme included five projects: Cosmology of the Early and Late Universe, High Energy Phenomenology in the LHC Era, QCD and Strongly Interacting Gauge Theory, Nuclear Structure for Weak and Astrophysical Processes, and Domain Wall Dynamics. Additionally, Professor Mark Hindmarsh (University of Sussex) continued his five-year part-time visiting professor position in Helsinki, shared by HIP and the Department of Physics.

The CMS Programme included the project for physics analysis and operation of the CMS detector and the project for the CMS tracker upgrade. In 2015 the CMS Programme also carried 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 third two-year (2016-2017) upgrade grant from the Academy of Finland, which will ensure the completion of the Finnish contribution to the inner tracker upgrade. The HIP CMS group has been leading the CMS data preservation and open access project. The highlight of the year was the public release of the CMS data obtained during the first six months at 13 TeV collision energy. The TOTEM project was integrated in the CMS Programme.

The Nuclear Matter Programme included four projects, ISOLDE, ALICE, ALICE-Forward and FAIR. The ALICE groups have focused on the analysis of the ALICE detector data on quark-gluon plasma generated in proton and lead ion collisions. In addition, the ALICE project participates in the GEM readout upgrade of the Time Projection Chamber (TPC) detector for the higher luminosity phase of the LHC with infrastructure funding from the Academy of Finland until 2017. The ALICE project is responsible for the T0/FIT trigger unit.

The Technology Programme was composed of five research projects. The Green Big Data project focused on energy consumption of scientific computing clusters. The Accelerator Technology project included studies of materials for high-gradient accelerating structures and manufacturing aspects of CLIC accelerating components. The Biomedical Imaging project aims to construct a PET demonstrator for medical imaging and pattern recognition. The NINS3 project was started in February with a substantial financial contribution under the FiDiPro funding scheme of TEKES. Peter Dendooven from the University of Groningen was appointed as the first FiDiPro (Finland Distinguished Professor) chair holder at HIP. In September HIP together with CERN and Tampere University of Technology signed a BIC (Business Incubation Center) agreement to assist the creation of start-up companies on CERN-based know-how and technologies.

Dr. Mikko Voutilainen was appointed to a tenure-track Assistant Professor position of experimental particle physics starting November 1, 2015. Juska Pekkanen from the CMS group was awarded the 2015 Fundamental Physics Special Recognition Award by the CMS spokespersons. Dr. Tuomas Lappi of U. Jyväskylä, HIP QCD project leader, was awarded an ERC consolidator grant. Dr. Jaakko Härkönen has been appointed by Xiangtan University (PR China) as an Honorary Professor for the period 2015-2017.

The board of HIP was chaired by Professor Jouko Väänänen, Dean of the Faculty of Science 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 from CERN.

As the past year marked the end of my directorship, I would like to express my deepest thanks to the staff and supporters of HIP. The Institute will be in good hands under the guidance of the new director Professor Paula Eerola whom I wish all the best for guiding HIP through exciting times ahead.

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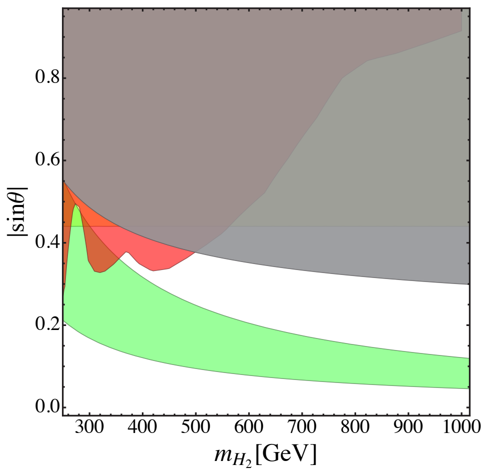
Highlights of Research Results

Theory Programme

In the *Cosmology of the Early and Late Universe* project, we have shown that for a sufficiently high inflationary scale H, space-time curvature can trigger a transition to a negative energy vacuum for a wide range of the curvature coupling ξ: $1 < \xi < 10^5$. Combining this with the lower bound $\xi > 0.1$, imposed by stability during inflation, we find that the minimal scenario of the Standard Model in a background of conventional high-scale inflation constrains the coupling ξ to be close to its conformal value $\xi = 1/6$.

In the *High Energy Phenomenology in the LHC Era* project we have analysed the Higgs portal framework, which generally predicts a new heavy scalar particle in addition to the observed 125 GeV Higgs. We studied the properties of the additional scalar, and in particular pointed out the possibility that it stabilises the Standard Model vacuum. The decay channels of the new scalar include a pair of two 125 GeV Higgses, which may be observed.



A major focus of the *QCD and Strongly Interacting Gauge Theory* project were multiparticle azimuthal correlations caused by colour fields when a high energy nucleus is probed by a dilute projectile. For electron-ion collisions our study connecting this effect to the linearly polarized gluon distribution was published in Physical Review Letters. By including event-by-event fluctuations in our global hydrodynamical model for heavy ion collisions, we were able to put state-of-the art constraints on the temperature dependent quark gluon plasma viscosity.

In the *Nuclear Structure for Weak and Astrophysical Processes* project, a special highlight is the implementation of a CPU friendly computation of the nuclear photo-response. The response of the atomic nucleus to gamma radiation provides crucial information about its structure and the forces acting between constituent nucleons. This response also plays an important role in various astrophysical scenarios. A newly developed method allows efficient computation of the response of the deformed superfluid nucleus, in the framework of microscopic nuclear density functional theory.

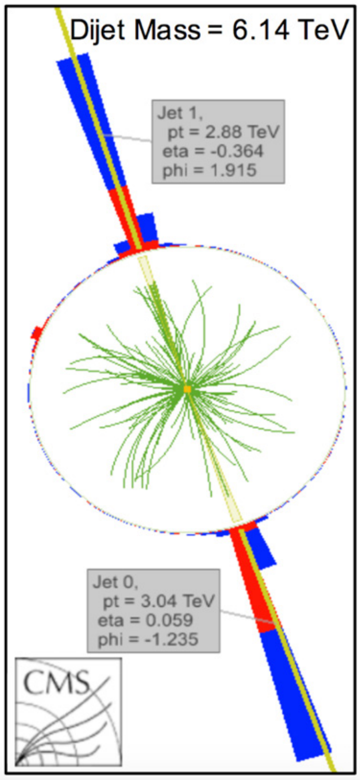
During the second year of the *Domain Wall Dynamics* project we have made significant progress in understanding thermal effects on domain wall dynamics in nanowires, and the importance of Bloch lines within domain walls on the dynamics of the latter. We have also found new equilibrium domain wall structures in wide permalloy strips, consisting of multiple vortices.

CMS Programme

The Compact Muon Solenoid (CMS) experiment is a particle physics experiment at the Large Hadron Collider (LHC) at CERN, Geneva. The first phase of the LHC operation, the so-called Run 1 (2010-2012), culminated in the discovery of a Higgs boson with a mass of about 125 GeV. The LHC

Run 2 was started in spring 2015, with a record centre-of-mass collision energy of 13 TeV. A small excess in the diphoton mass region of about 750 GeV was seen in both the ATLAS and CMS experiments, which raised a lot of public attention. The signals are, however, not statistically significant and more data are needed to clarify the situation. By the end of 2015 the total number of papers submitted for publication by CMS on collision data reached 466.

Researchers in Helsinki contributed in particular to *Higgs analyses, to jet physics, and to B-physics analyses*. The final results on the search for charged Higgs bosons with Run 1 data were completed and accepted for publication in Journal of High Energy Physics. The world's most stringent limits on H^+ production were set for $m_{H^+} < 400$ GeV. The Helsinki researchers contributed to the dijet resonance search using the 13 TeV proton-proton collisions - this was the first public new physics search with the Run 2 data. Helsinki researchers were also behind the measurement of the weak mixing phase ϕ_s in the B_s^0 decay. The results were submitted for publication in Physics Letters B.



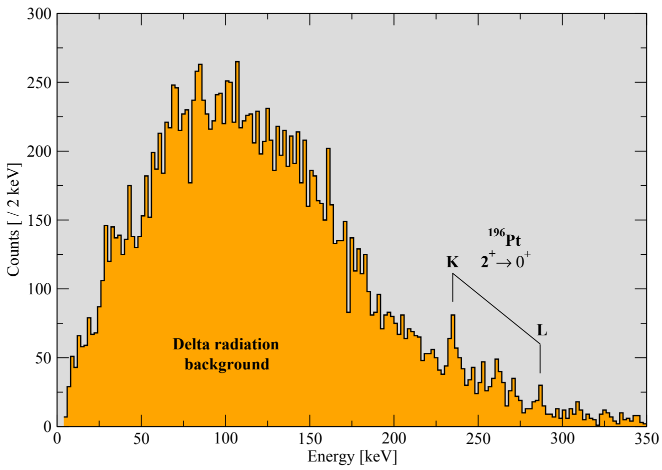
The HIP activities with the CMS pixel detector Phase I upgrade reached their peak intensity in 2015. The HIP commitment was to deliver about 250 of the total 1900 barrel pixel modules by spring 2016. The bare module construction was carried out in co-operation with Advacam Ltd in Micronova, Espoo. The construction proceeded according to schedule, and the produced modules showed good quality and high production yield. The last bare module of the 250 quota was delivered by Advacam in January 2016.

The Finnish group in the TOTEM experiment focused on measuring inelastic and diffractive processes. In October 2015, CMS and TOTEM successfully collected together new Run 2 data at 13 TeV centre-of-mass energy with a special trigger dedicated for exclusive low mass resonance production. A dedicated fill with the Roman Pots closer to the beam was taken for the measurement of the total pp cross-section at 13 TeV. The Helsinki group also actively participated in the TOTEM upgrade developing precise proton time-of-flight measurement using diamond sensors. The first diamond module was installed in the LHC in November 2015, demonstrating the required time resolution in-situ.

M. Voutilainen from the CMS group received the 2015 Wu-Ki Tung Award for Early Career Research on QCD "*For outstanding contributions to the development of innovative techniques for jet energy calibration and the measurement of the inclusive jet cross section at the D-Zero and CMS experiments*". J. Pekkanen was awarded the 2015 Fundamental Physics Special Recognition Award for jet calibration and for his contributions to the dijet resonance search result with 13 TeV data.

Nuclear Matter Programme

Due to the lack of beam time at GSI, the main experimental achievements in low-energy nuclear physics come from the ISOLDE laboratory at CERN. An important milestone at ISOLDE was achieved in October 2015, when a 4.3 MeV/u post-accelerated radioactive beam was delivered for the first time into the MINIBALL set-up. This event was also acknowledged on the CERN main page (https://home.web.cern.ch/about/updates/2015/11/upgraded-nuclear-physics-facility-starts). The SPEDE spectrometer, which has been constructed in the Accelerator Laboratory of the University of Jyväskylä, was transported to ISOLDE in 2015 and successfully commissioned there using the reaction ^{196}Pt(^{133}Cs,^{133}Cs*).



Technology Programme

During 2015 major milestones of the Technology Programme included among others the following.

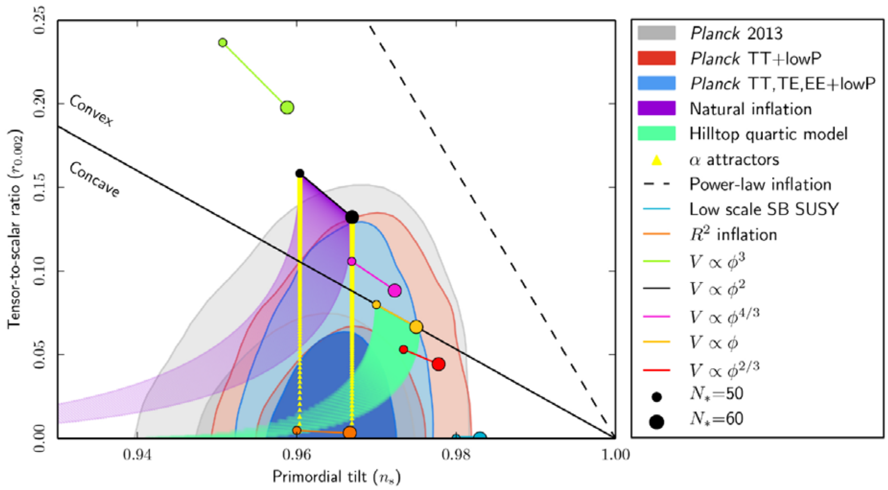
The Accelerator Technology project comprises of theoretical and experimental material research related to high-gradient normal conducting accelerating technology. The work has continued on multiple fronts and new Academy funding has been secured for the project. The focus of the HIP contribution is on two aspects: on understanding the properties of the materials used during accelerator operation and on manufacturing and testing of accelerator components and assemblies.

The Green Big Data project primary aims at developing methods making HEP computing more cost and energy efficient. Other targets are finding industrial applications, supporting students in their MSc and PhD studies, publishing results in high-quality scientific fora, and increasing international research collaboration between Finland, CERN and other partners. Participation in an EU funded research project "Scalable and Secure Infrastructures for Cloud Operations" started in February 2015.

The Biomedical Imaging AvanTomography project aims to construct a PET demonstrator, based on the principle of the Axial PET (AX-PET) project developed by the AX-PET research consortium in CERN. Therefore, the project aims at building an imaging device that provides improved resolution as well as high sensitivity missing in traditional PET-devices. Successful simulations of the device were conducted during 2015.

The Finnish Business Incubation Center of CERN Technologies (FBC) was established in late 2015. FBC supports commercialisation of CERN-related technologies, especially in start-ups and SMEs in Finland. Additionally, the project conducts technology commercialisation and incubation related research.

The NINS3 project commenced in 2015 aims to perform top-level research and development in nationally important topics in nuclear safety, security and safeguards. The project consists of three R&D topics, namely passive tomography of spent nuclear fuel, alpha radiation threat detection and imaging from a distance, and active neutron interrogation of unknown objects.



Planck-Euclid

The second major data release from the Planck mission took place in 2015.

The results are in agreement with the standard 5-parameter cosmological model. No evidence for deviations from this standard model was found and limits to such deviations were tightened. The sum of the three neutrino masses were determined to be less than 0.23 eV, and the amount of primordial gravitational waves was constrained to be less than 11% of the primordial density perturbations.

Theory Programme

Kari Rummukainen,
Theory Programme director

The HIP Theory Programme consists of five fixed term projects: Cosmology of the Early and Late Universe (Syksy Räsänen, University of Helsinki), High Energy Phenomenology in the LHC Era (Aleksi Vuorinen, University of Helsinki), QCD and Strongly Interacting Gauge Theory (Tuomas Lappi, University of Jyväskylä), Nuclear Structure for Weak and Astrophysical Processes (Markus Kortelainen, University of Jyväskylä), and Domain Wall Dynamics (Lasse Laurson, Aalto University). The activity of the projects is distributed in the participating HIP member institutes. In addition, Professor Mark Hindmarsh (University of Sussex) continues his five-year part-time visiting professor position in Helsinki, shared by HIP and the Department of Physics. He is one of the leading authorities in the physics at the intersection of particle physics and cosmology, and his presence significantly enhances research in the Cosmology and High Energy Phenomenology projects.

Cosmology of the Early and Late Universe

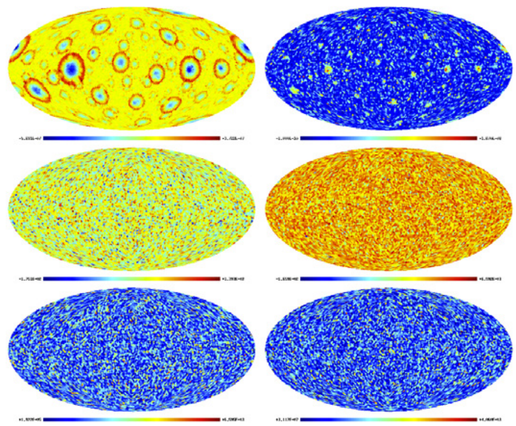
Syksy Räsänen,
Cosmology of the Early and Late Universe
project leader

Inflation: S. Nurmi and T. Tenkanen, in part in collaboration with K. Tuominen, studied a scenario where dark matter relic density is generated non-thermally in the early universe, in which case the dark matter abundance and inflationary dynamics can be intimately related. S. Nurmi and collaborators also investigated the post-inflationary resonant decay of the primordial Higgs condensate into weak gauge bosons with particular focus on non-Abelian interactions. Additionally, S. Nurmi and collaborators studied the evolution of scalar fields during inflation both with and without a non-minimal coupling to gravity. They derived novel constraints on the Standard Model and its extensions from vacuum stability and from limits to isocurvature perturbations created during the decay of scalar condensates. In particular they constrained scalar DM models with weakly coupled hidden sectors.

Dark Matter, baryogenesis and quantum transport: K. Kainulainen and J. Virkajärvi studied, in collaboration with K. Tuominen, dark matter models in the context of technicolour and models with extended scalar sectors. The work includes particle phenomenology as well as model building efforts to achieve, for example, coupling constant unification. They also studied the properties of the finite-temperature electroweak phase transition in extensions of the Standard Model and tested them for successful baryogenesis.

Inhomogenous cosmology: S. Räsänen, as part of a collaboration led by T. Buchert, responded to claims that the backreaction question has been settled and clarified what is known and what remains unclear. M. Lavinto and S. Räsänen analysed anisotropies in the CMB temperature, distance and gravitational lensing using Swiss Cheese models, in particular studying the question of whether the area of the surface of constant redshift is affected by structures. S. Räsänen, in collaboration with J. Väliviita and V. Kosonen, tested the temperature-redshift relation and the duality between angular diameter and luminosity distance using CMB anisotropies. F. Montanari and collaborators analysed all leading contributions to the tree-level galaxy bispectrum, showing that usually neglected lensing-like terms can be relevant for future large-scale surveys such as Euclid and SKA, allowing in principle new constraints on modified gravity.

Modified gravity: H. Nyrhinen and T. Koivisto studied a system of a black hole and surrounding matter in disformally coupled scalar-tensor



Sky maps of the anisotropy in temperature (top) and distance (middle), as well as gravitational lensing (bottom), of the CMB caused by different Swiss Cheese models of structure.

theories of gravity and showed that the disformal coupling can lead to the black hole developing scalar hair. E. Palmgren, in collaboration with J. Väliviita, studied how to distinguish interacting dark energy using CMB, lensing, and baryon acoustic oscillation data.

Aleksi Vuorinen, High Energy Phenomenology in the LHC Era project leader

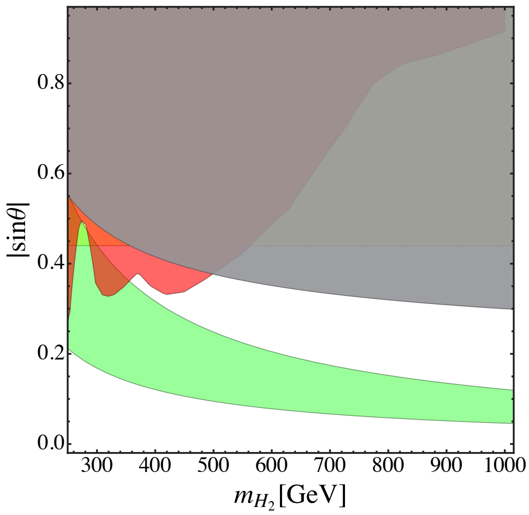
High Energy Phenomenology in the LHC Era

The year 2015 was a very exciting one for high energy physics: the upgraded LIGO experiment was expected to finally observe gravitational waves, and the year ended with the CERN announcement of intriguing hints towards a possible resonance at around 750 GeV, seen in the diphoton channel of pp collisions. Indeed, in February 2016 the LIGO collaboration reported the landmark observation of gravitational waves from a black hole binary merger. Together with the possible confirmation of the 750 GeV resonance, it is safe to say that these discoveries would impact the main directions of theoretical high-energy physics research for the coming years and decades.

For the HIP Theory project on High Energy Phenomenology, the year 2015 witnessed a continuation of several projects initiated during the first year of the project. A significant amount of work was carried out on two major fronts: Beyond the Standard Model (BSM) phenomenology and the physics of strongly coupled gauge theories, in particular QCD. On the first front, the main topics of study included the prospects of baryogenesis in different BSM models, the stability of the Standard Model vacuum, Higgs inflation, dark matter, and the properties of quasi-conformal gauge field theories. In the latter field, we, on the other hand, concentrated on several aspects of holographic dynamics, ranging from thermalization of heavy ion collisions to the properties of selected condensed matter systems, as well as on determining the equation of state of deconfined quark matter using perturbation theory. In what follows, we give brief accounts of three representative highlight results published during 2015.

In the paper "A second Higgs from the Higgs portal", published in JHEP, C. Gross, A. Falkowski and O. Lebedev analysed the Higgs portal framework, which generally predicts the existence of two scalar particles, the lighter of which is identified as the 125 GeV state observed at the LHC. The properties and physical characteristics of the additional scalar were studied as a function of its parameters, and in particular the prospect of it stabilising the Standard Model vacuum was pointed out. A possible decay pattern of the new scalar into a pair of two 125 GeV Higgses, and its subsequent observation, was also studied.

In "A minimal model for SU(N) vector dark matter", published in JHEP, S. Di Chiara and K. Tuominen proposed an extension to the Standard Model that involves a hidden sector composed of a new scalar, singlet under all SM gauge symmetries and only coupled to the SM fields via a Higgs portal. The new sector is assumed to be classically conformal and to possess a new SU(N) gauge symmetry, while the electroweak symmetry breaking results in massive vector particles that can serve as realistic dark matter candidates. After a thorough scan of the parameter space of the model, the authors concluded that



Exclusion plots for the parameter space of the Higgs portal model studied by Falkowski, Gross and Lebedev. The x-axis is the mass of the new scalar, while the y-axis parameterises the mixing of this state with the Standard Model Higgs. The green colour marks the preferred region, where the scalar potential is stable up to the Planck scale.

N = 2, 3 would be the most natural candidates, and made a firm prediction about the discovery of a heavy Higgs-like particle by the end of Run 2 of the LHC.

In the article "Finite coupling corrections to holographic predictions for hot QCD", published in JHEP, A. Vuorinen and collaborators studied the AdS/CFT correspondence beyond the usual infinite 't Hooft coupling limit. Inspecting the properties of N = 4 Super Yang-Mills theory at finite temperature, they developed a new resummation scheme for higher order corrections in an expansion in inverse powers of the coupling λ. This was seen to considerably improve the convergence of the expansion, enabling the use of holographic results at couplings of phenomenological relevance for heavy ion collisions. This is an important observation considering that the most important factor limiting the use of holographic results in many areas of physics is their restriction to unphysically large couplings.

QCD and Strongly Interacting Gauge Theory

Tuomas Lappi,
QCD and Strongly Interacting Gauge Theory project leader

Our work revolves around different aspects of QCD at high energies and densities. In addition to the phenomenology of high energy nuclear collisions at the LHC and RHIC, we are strongly involved with physics studies for planned next generation DIS experiments. We use QCD renormalization group equations (BK, DGLAP, ...) derived in the weak coupling limit to understand the energy and virtuality dependence of the partonic structure of hadrons and nuclei. An important specialty of our group is using this information to understand and model the initial stages of an ultrarelativistic heavy ion collision and the formation of a thermalized quark gluon plasma. The subsequent evolution of this plasma can then be modelled using relativistic hydrodynamics.

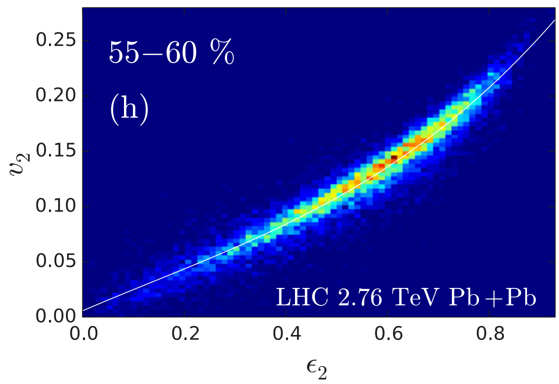
The DGLAP equations describe the scale dependence of parton distributions (PDFs) inside a proton or nucleus required in computing hard-scattering cross sections. Our EPS09 nuclear parton distribution functions (nPDF) are currently the world standard and in 2015 we have actively studied the constraints the new LHC proton-lead data can offer. In addition, our work on the top-quark production showed that while they have still never been observed in nuclear collisions such measurements look feasible at the LHC. The BK evolution equation, in turn, describes the energy dependence of operators needed for calculating QCD scattering cross sections at high energy. We were the first group in the world to be able to achieve a numerical solution of the next-to-leading order BK equation. We also successfully applied our leading order BK-evolved dipole cross section parameterisations to computing production cross sections for J/ψ mesons at forward rapidities in proton-nucleus collisions. This work largely solved the puzzle of a surprisingly large nuclear suppression in this cross section in earlier calculations in the same framework.

Our group uses two complementary QCD approaches to describe the formation of quark gluon plasma in the initial stages of a heavy ion

Markus Kortelainen, Nuclear Structure for Weak and Astrophysical Processes project leader

collision. In the Colour Glass Condensate picture the dense system of brehmsstrahlung gluons inside a high energy nucleus is described as a classical gluon field. One possible experimental signature of the structure of these colour fields are multiparticle azimuthal correlations in the collision of a small projectile off the dense colour field target. In 2015 we solidified the theoretical description of this mechanism and clarified the differences between related classical field calculations of these correlations. In a paper in Physical Review Letters we also related a similar azimuthal anisotropy in deep inelastic scattering to the linearly polarised gluon distribution.

We also model the initial stages of heavy ion collisions starting from perturbative quark and gluon scattering, supplemented with a saturation conjecture to control multiparticle production. This is the model currently implemented as the initial condition to our hydrodynamical studies of heavy ion collisions. We now successfully incorporated the fluctuating transverse geometry of the nucleons in the incoming nuclei in this pQCD + saturation framework. This enabled us to perform a systematic hydrodynamical study of multiplicities, particle spectra, azimuthal anisotropies and their correlations in high energy nucleus-nucleus collisions at LHC and RHIC energies. This event-by-event study represents the state of the art in the field in terms of extensively using available experimental data to constrain the temperature dependent quark gluon plasma viscosity. Our predictions also fared very well in comparison with the new LHC heavy ion data from the higher collision energy reached late in the year.



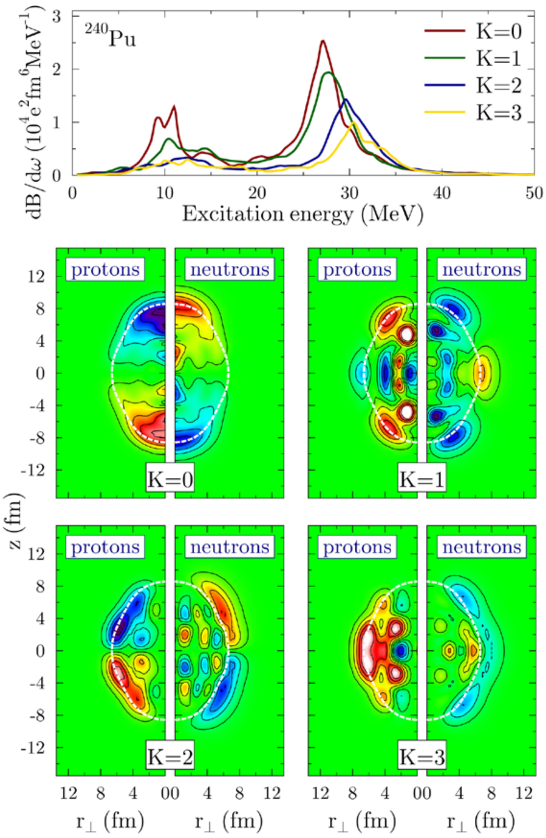
Non-linear correlation between the initial state (spatial) eccentricity and the final state (momentum) anisotropy of produced particles in a non-central LHC heavy ion collision.

Nuclear Structure for Weak and Astrophysical Processes

The research conducted in the Nuclear Theory project focuses on the low-energy nuclear structure and its applications to weak and astrophysical processes. During the year 2015, the main activities were connected to a linear response formalism, direct detection of dark matter, and properties of the meson-nuclear interaction.

Finite amplitude method developments: The response of the atomic nucleus to external stimulation provides crucial information about its structure and the complex forces acting between constituent nucleons. The linear response is one of the commonly used methods to access these excited modes within the framework of superfluid nuclear density functional theory. Traditionally, the linear response, or quasiparticle random-phase-approximation (QRPA), has been formulated in a matrix form. However, the matrix QRPA becomes computationally very demanding with deformed nuclei, resulting in truncations in the used model space. To circumvent this problem, the finite amplitude method (FAM) solves the QRPA problem iteratively.

In 2015, we continued to develop our FAM-QRPA machinery. Firstly, we developed a method to compute efficiently the QRPA sum rules, with an arbitrary energy weight. With this technique, the QRPA poles are enclosed by an integration contour in a complex-energy plane. Secondly, we expanded our FAM module to handle non-axial multipole modes. This work demonstrated the first practical application of the iterative QRPA method for deformed superfluid nuclei, with an arbitrary multipole transition operator. The method is also very well suited for parallel computing. One of the oncoming applications of this novel FAM-QRPA scheme will address photo-absorption cross sections in the heavy rare-earth nuclei.



Topmost panel: The isovector octupole transition strength function in ^{240}Pu as a function of excitation energy. Lower panels: Induced transition densities at an excitation energy of 11 MeV for various K-modes with axial coordinates r and z. The white dashed line indicates the surface of the nucleus.

Direct WIMP detection rates in ^{83}Kr: Presently, there exists plenty of evidence of the existence of dark matter. One of the candidate constituents for dark matter is the weakly interacting massive particle (WIMP), motivated by various theoretical models going beyond the Standard Model. Currently, there are many experimental set-ups which search for the WIMP signal. In our recent work we analysed the possibility to use ^{83}Kr as a detector material. The nucleus ^{83}Kr would offer strong kinematic advantages over many other nuclei in the inelastic channel, due to its very low-lying excited state. We found that ^{83}Kr would make a feasible detector material, although the nuclear-structure considerations seem to slightly weaken the promise of the nucleus as a WIMP target.

Meson-nuclear interaction: An interesting possibility to decrease optical model η-nuclear inelasticity while still retaining the elementary η-N amplitude was found by treating it explicitly as coupling to the pionic channel far below the η threshold [J. A. Niskanen, PRC 92 (2015) 055205]. The strong transition potential in nuclei causes a larger feedback decreasing the overall inelasticity. Even more importantly, the larger spatial extension of nuclei yields much softer form factors and consequently smaller transition probability into high momentum pionic channels.

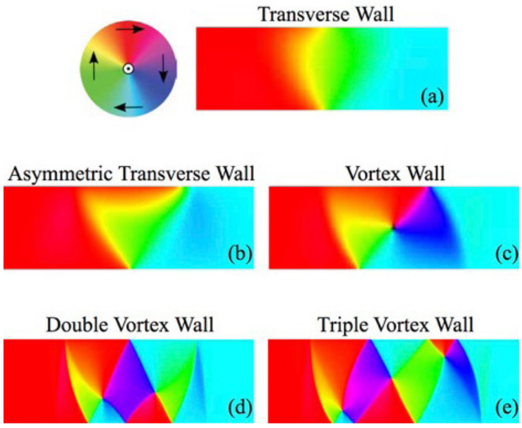
An analogous suppression can be expected also in other similar situations, if the inelasticity arises from coupling to much lighter particles. Such a case could be, e.g., kaonic atoms.

Domain Wall Dynamics

Lasse Laurson, Domain Wall Dynamics project leader

Domain wall dynamics in low-dimensional ferromagnetic structures is an active field of research driven by both numerous promising technological applications as well as fundamental physics interests. During 2015, we have made significant progress in understanding several key issues of domain walls (DWs) and their dynamics in various one- and two-dimensional systems.

Thermal effects on domain wall dynamics: Thermal fluctuations play an important role in the dynamics of DWs, resulting, e.g., in slow creep motion of the DWs; an additional practical issue is that the stochastic component induced by the fluctuations due to a finite temperature may compromise the integrity of data stored, e.g., in racetrack memory devices based on DWs in nanowires. We have shown that when driven with a spin-polarised current via the spin-transfer torque mechanism in finite temperatures, DWs in nanowire geometries experience drift and diffusion components, independent of each other in perfect nanowires without structural disorder or randomness. In real nanowires, things are further complicated by the presence of various forms of quenched disorder (e.g., point defects and grain boundaries)



Equilibrium domain wall structures from micromagnetic simulations of permalloy strips of different widths, with the strip width increasing from (a) to (e). The double and triple vortex walls in (d) and (e), respectively, occur in strips of widths in the range of a few micrometers. *(Phys. Rev. B 91 (2015) 054407)*

interacting with the DWs. We have shown that in nanowire geometries, this interplay leads to creep dynamics with the creep velocity linearly proportional to the driving force, in contrast to the highly non-linear relation encountered for extended DWs.

Domain wall structures in wide permalloy strips: The geometry-dependent equilibrium DW structures in ferromagnetic strips with a low crystalline magnetic anisotropy (such as permalloy strips) are dictated by the balance between shape anisotropy and exchange interactions. In narrow and thin strips, the well-known transverse and vortex DWs are encountered. We have shown that when the lateral strip dimensions are increased beyond the ones of the typical nanostrip geometries, novel equilibrium DW structures consisting of multiple vortices appear. We are currently investigating the properties of the driven dynamics of these new DW types.

Bloch line dynamics within domain walls: When driven with an applied field or spin-polarised current above the so called Walker limit, internal degrees of freedom of the DWs get excited, resulting in an abrupt reduction of their propagation velocity, or the Walker breakdown. In nanowire geometries this takes place via close to uniform precession of the DW internal magnetisation. We have shown that for extended DWs in wide strips, the analogous process consists of spatially non-uniform excitations in the form of nucleation and propagation of Bloch lines along the DW, separating different chiralities of the DW. The Bloch lines are topologically similar to DWs within DWs, and we have also explored their field and current driven dynamics along DWs. Our results show in particular that in contrast to DW dynamics in nanowires, Bloch lines do not experience a Walker breakdown due to topological protection of their internal structure, resulting in stable and fast dynamics which may end up being useful for applications.

CMS Programme

Paula Eerola,
CMS Programme
director

The HIP CMS Programme is responsible for co-ordinating the Finnish participation in the CMS and TOTEM experiments. The Compact Muon Solenoid (CMS) experiment is a particle physics experiment at the Large Hadron Collider (LHC) at CERN, Geneva. The main scientific goals of CMS are detailed investigations of particles and interactions at a new energy regime, understanding the origin of electroweak symmetry breaking (Higgs bosons), and the search for direct or indirect signatures of new physics beyond the Standard Model (SM) of particle physics. The TOTEM experiment is located near the beampipe in immediate connection to CMS. TOTEM is investigating LHC collisions at small scattering angles. The CMS Programme at HIP is divided into four 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, the *CMS Tier-2 Operations project*, and the *TOTEM project*. The Finnish groups in CMS are: HIP (currently 14 authors), the University of Helsinki (3 authors), and Lappeenranta University of Technology (2 authors). In TOTEM there are 9 authors affiliated with HIP, out of which six are also affiliated with the University of Helsinki.

The CMS Experiment Project

Katri Lassila-Perini,
CMS Experiment
project leader

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.

Physics Analysis

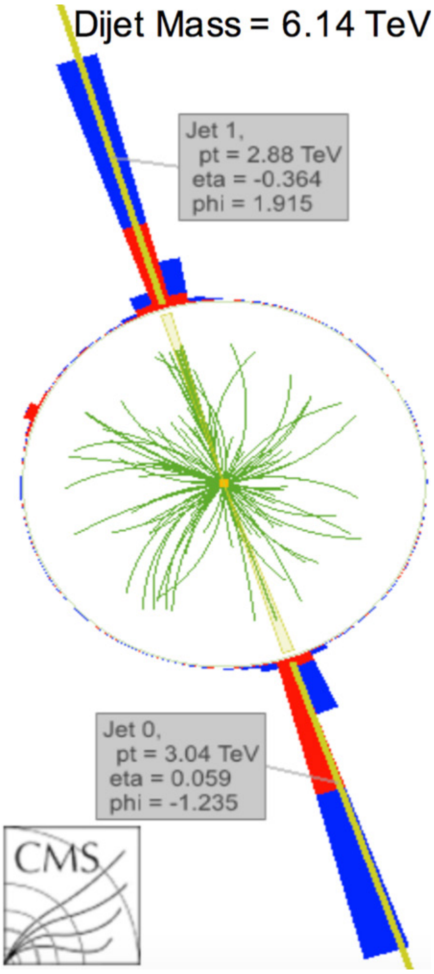
B Physics: In 2015, the HIP group was involved in the weak mixing phase ϕ_s and effective lifetime analyses of the decay channel $B_s \to J/\psi\ \phi$. The ϕ_s phase is interesting since it can indicate contributions from physics beyond the Standard Model. The B_s effective lifetime measurement increases the understanding of the B_s system and gives valuable input for theories such as the heavy-quark expansion model that provide accurate estimates of the ratios of lifetimes for hadrons containing the same heavy quark. A paper on the weak phase measurement was submitted to Physics Letters B and a paper on the B-hadron lifetimes measured in the CMS experiment is expected to be published during 2016.

Higgs Analysis: The final results on the search for charged Higgs bosons with Run 1 data were completed and accepted as a paper in JHEP. The HIP Higgs group played a leading role in it by analysing the most sensitive decay channel, $H^+ \to \tau\nu$ in the $\tau\tau$ + jets final state, and by statistically combining the results for different decay channels. The world's most stringent limits on H^+ production were set for $m_{H^+} < 400$ GeV. In addition, the group was responsible for the development of the τ + MET trigger and the technique of replacing a μ with a simulated τ (embedding), usable also in other analyses.

Two Master's theses were completed (J. Heikkilä and E. Pekkarinen). The latter work contributed to the H^+ paper and J. Heikkilä's work about a method for testing if the discovered Higgs boson consists of multiple mass-degenerate Higgs bosons was published in EPJC.

Jet Physics: The HIP jet physics group had a central role in the first Run 2 jet analyses. J. Pekkanen acted as lead analyser in the dijet resonance search which submitted the world's first new physics search result with 13 TeV pp

Display of the event with the highest dijet mass (6.14 TeV) found in the analysis of 13 TeV LHC data. The transverse view with respect to the beam axis is shown.



collisions to PRL in December. M. Voutilainen contributed to the first 13 TeV inclusive jet analysis along with measurements at 2.76 and 8 TeV, and published a review article on heavy flavour jets at the LHC in IJMPA. H. Siikonen continued the novel simulation studies on jet flavours in the preparation of a Master's thesis.

Jaakko Härkönen, CMS Upgrade project leader

Jet Energy Corrections

The CMS jet energy corrections group made a major effort in finalising the Run 1 performance paper and in preparing new corrections for the Run 2 detector with substantial changes to the low-level reconstruction software. These were pivotal for the world's most precise top quark mass measurement at 8 TeV and for precise new 13 TeV results. The CMS Jets and Missing ET group responsible for the corrections was co-convened by M. Voutilainen, and M. Voutilainen, J. Pekkanen and H. Siikonen participated in the Run 1 performance paper.

Data Preservation and Open Access

The first public release of the CMS data was evaluated in detail, and the positive feedback resulted in approval of further releases. In parallel, services are being developed for preservation of analysis details with the CERN IT and library groups, raising interest beyond high energy physics. HIP leads a pilot project to bring the scientific data to public use in schools, for which input was collected during the high-school teachers' visit to CERN, and two summer student projects for developing suitable applications got well under way.

Tracker Alignment

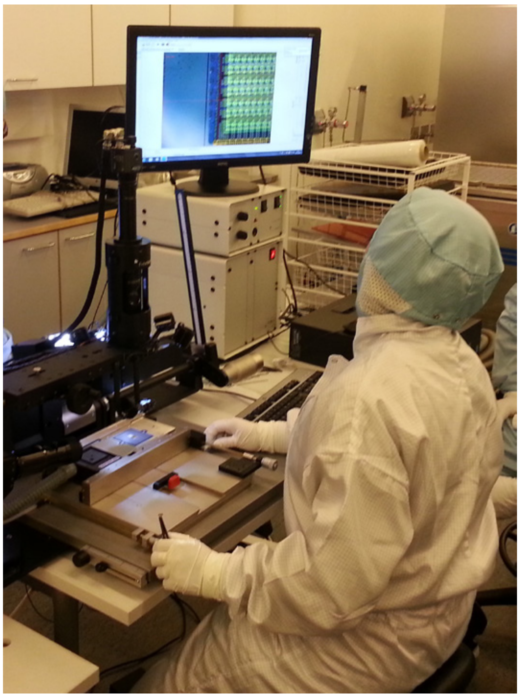
One of the most demanding calibration activities for the CMS Tracker is the geometrical alignment of its 15148 modules with respect to each other. Detector alignment was again one of the essential ingredients for the high-quality physics results of CMS in 2015, since alignment needed to be carried out from scratch after the maintenance interventions. T. Lampén was in charge of maintenance and development of the off-line track-based alignment validation tools, and was co-convener of the CMS Tracker Alignment group in 2015.

The CMS Upgrade Project

Since 2013 the main activity of the HIP CMS Upgrade project has been the Phase I upgrade of the CMS experiment. Our commitment was to deliver 50% of the pixel bare modules on the third layer of the barrel pixel detector, which counts as 250 pixel modules with spares included, from the total of 1900 modules in the whole pixel barrel. This means flip-chip (FC) bonding of 4000 ROCs (CMOS readout ASIC circuit) with more than 4000 individual channels on each ROC into the pixel sensors. The physical size of the module is 2 cm × 8 cm and it consists of 16 ROCs and one sensor. The Phase I Upgrade project was funded by the Academy of Finland and the FC bonding was carried out in co-operation with Advacam Ltd operating in the clean room premises of Micronova Nanofabrication Centre in Espoo. An essential part of this project was the Quality Assurance (QA) of the pixel detector modules right after their FC bonding. The main purpose of the module QA is to reveal possible malfunctioning pixels or entire malfunctioning ROCs before any other parts like mechanical support and interconnection readout electronics are integrated into the module. At this phase a malfunctioning ROC can still be replaced with a new one without sacrificing the whole module.

The bare FC-bonded modules are attached to the mechanical support and the High Density Interconnection (HDI) readout electronics front-end board (full-module) at the CERN-HIP-Taiwan module production centre located at CERN. The last bare module of the 250 quota was delivered by Advacam in January 2016. The Phase I Upgrade project continues with the full-module assembly and the QA testing of the full modules at CERN. These tests include for example thermal cycling and X-ray source calibration. In 2015 the HIP CMS group started an exchange programme with the Finnish School of Watchmaking offering hands-on training periods at the CERN module production centre and later the students will also participate in the final pixel tracker integration activities at the Paul Scherrer Institute (PSI) in Villingen, Switzerland, where the full barrel pixel detector is constructed.

In 2015, we continued our efforts to meet the radiation hardness challenge which will be faced during the upcoming Phase II upgrade of the CMS experiment. A significant increase in the luminosity of the LHC is foreseen in the coming years and, consequently, radiation induced defects will seriously degrade the operation of the silicon sensors, especially in the pixel region. The charge collection distance will degrade to less than the physical segmentation of existing pixel devices, thus resulting in poor particle tracking performance. An obvious approach to maintain sufficiently good spatial resolution is to increase the granularity of the tracking detectors, i.e., scaling down the pixel size. Especially the implementation of Atomic Layer Deposition (ALD) method grown thin films enables new unexplored possibilities to miniaturise the physical segmentation of the future pixel tracking detectors. We have launched a common R&D project with the University of Hamburg and the DESY CMS groups focusing on the development of the future very high granularity pixel detectors. 150 mm diameter p-type Magnetic Czochralski silicon (MCz-Si) wafers are currently being processed at the Micronova facility. The radiation hard MCz-Si is provided by Okmetic Ltd and the manufacturing process includes several ALD grown thin films with special functionality. Another active research topic in 2015 was to incorporate CMS-like readout electronics and data acquisition (DAQ) with high Z-number semiconductors having high spatial and energy



A. Gädda flip-chip bonding a CMS pixel detector in the HIP Detector Laboratory clean room in Kumpula.

resolution in the Radiation Safety, Security and Safeguards (S3) applications.

Lappeenranta (T. Tuuva) has been involved in the CMS Resistive Plate Chambers (RPC) Trigger. Now, Lappeenranta is shifting its focus towards readout electronics for the forward muon detector upgrade, called GE1/1, consisting of large-area GEM detectors. The related readout electronics will be changed to cope with higher readout speed. Lappeenranta is participating in the construction of the readout electronics (VFAT3 readout chip, hybrid and interface bus) in collaboration with CERN and other groups. Funding has been obtained from the Academy of Finland.

Tomas Lindén, Tier-2 Operations project leader

The Tier-2 Operations Project

Grid Computing Activities

In the first year of the LHC Run 2, CMS grid analysis and Monte Carlo production jobs were running on the Finnish CMS Tier-2 site to analyse the new 13 TeV data and to simulate the CMS detector.

HIP was represented in the Nordic e-Infrastructure Collaboration (NeIC) Nordic WLCG (NLCG) steering committee with T. Lindén as chairman until February 2015. The close collaboration between HIP, CSC (IT Center for Science Ltd) and the NeIC Nordic DataGrid Facility (NDGF) resulted in good performance of the CMS computing.

Hardware: The main CPU resource for CMS and ALICE was the 768 core Jade (2009) Linux cluster situated on the CSC premises. Jade was taken out of service at the end of December. The 400 core Linux cluster Korundi (2008) and the 840 core Linux cluster Alcyone (2011) in Kumpula were also used for CMS grid jobs. CMS received a 5.5 M billing unit allocation on the CSC cPouta cloud system in Kajaani and work continued to take this resource into use. The University of Helsinki acquired as part of the Finnish Grid and Cloud Infrastructure Consortium funded by the Academy of Finland a new Linux cluster, Kale. To upgrade the dCache disk system HP Apollo 4510 servers with a total raw capacity of 2176 TB funded by the Academy of Finland were acquired at the end of 2015.

Software: The Advanced Resource Connector (ARC) middleware was upgraded to version 5.x on Jade, Alcyone and Korundi. The dCache and Lustre systems at CSC were very stable in 2015.

The Academy of Finland -funded project concerning cloud computing, "Data Indirection Infrastructure for Secure HEP Data Analysis (DIIHEP)" together with the department of Computer Science at the University of Helsinki studied an OpenStack virtualised environment for CMS-usage. Experiences and results from the OpenStack virtualised ARC cloud service were presented at the 2015 NeIC Conference and at the 21st International Conference on Computing in High Energy and Nuclear Physics CHEP 2015, Okinawa, Japan and published in IEEE Transactions on Services Computing.

Operations: The Finnish CMS Tier-2 resources are operated, maintained and monitored jointly by HIP, CSC and NDGF, which helps to spot problems early with the Site Availability Monitoring jobs. According to the statistics collected with the CMS monitoring tools, the Finnish Tier-2 resources were in "ready" state 71.84% of the time (74.31% in 2014). There were 27 GGUS tickets (18 GGUS and Savannah tickets in total in 2014) issued concerning HIP in 2015.

PhEDEx transferred 419 TB of production data (161 TB in 2014) to HIP and 361 TB of test data (297 TB in 2014) to HIP. From HIP to elsewhere 290 TB of production data (75 TB in 2014) and 211 TB of test data (176 TB in 2014) were shipped. In total 1281 TB of data were transferred with PhEDEx to or from HIP (709 TB in 2014).

A total of 1.341 million CMS grid jobs (1.409 million in 2014) using 26.7 million HS06 CPU hours (32.7 million HS06 CPU hours in 2014) were run with an average CPU efficiency of 68.0% (72.6% in 2014). In addition to this a significant amount of local batch jobs were also run.

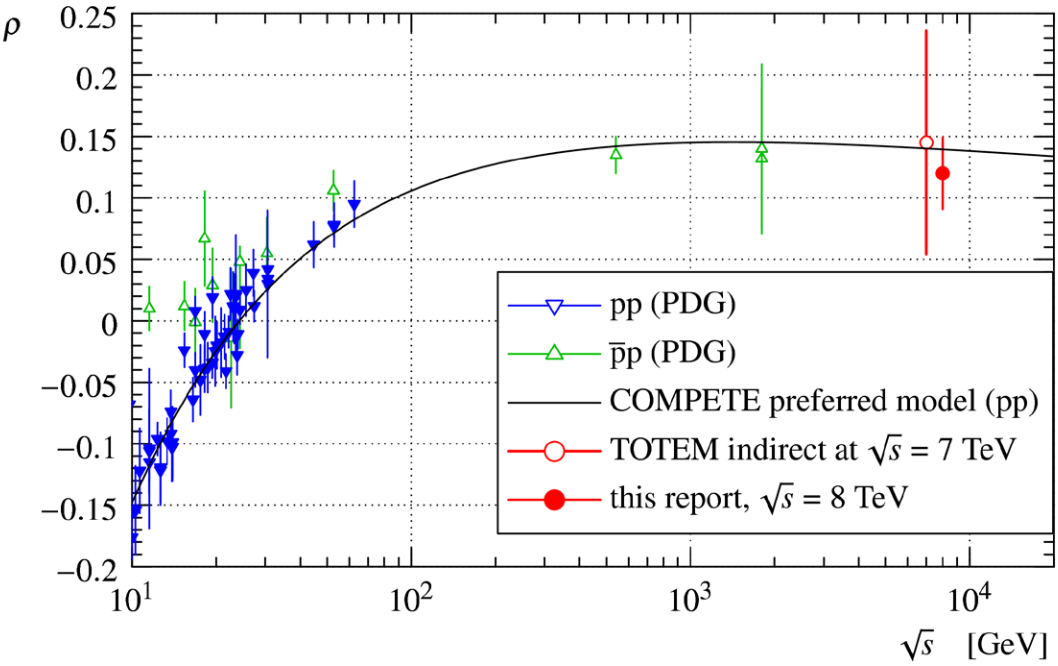
The TOTEM Project

The TOTEM experiment at the Large Hadron Collider (LHC) is currently the leading forward physics experiment. Using LHC Run 1 (2010-12) data, TOTEM has published several important physics measurements, especially the total proton-proton (pp) cross section at $\sqrt{s}$ = 7 and 8 TeV and the differential cross section for elastic pp scattering over a wide t, momentum transfer squared, range. HIP has played a key role in building and operating the GEM detector based T2 telescope, which has contributed significantly to the measurements of the inelastic rate, the forward charged multiplicity and the cross section of several diffractive processes.

In 2015, the TOTEM Helsinki group consisted of two senior scientists, K. Österberg and H. Saarikko, three PhD students T. Naaranoja, F. Oljemark and J. Welti, and one MSc student L. Martikainen. From the HIP Detector Laboratory F. Garcia, J. Heino, R. Lauhakangas and R. Turpeinen contributed to the T2 hardware. K. Österberg continued to co-ordinate the physics analysis of TOTEM as well as being also responsible for the TOTEM side of the common CMS-TOTEM physics analysis work.

In 2015, TOTEM published evidence that the |t| differential cross section of elastic scattering deviates significantly from a pure exponential [Nucl. Phys. B 899 (2015) 527], when ignoring Coulomb interactions, in the so-called diffractive cone region, where hadronic interactions are expected to dominate. In a subsequent paper [http://cds.cern.ch/record/2114603] using very low |t| data, TOTEM shows that the differential elastic cross section is indeed non-purely exponential even when taking Coulomb-hadronic interference effects into account and thus is not described by only one exchange process. Fits with a more complicated polynomial in the exponent describe the data well irrespective

Kenneth Österberg, TOTEM project leader



Energy dependence of the ρ parameter, the ratio between the imaginary and real part of the elastic amplitude at |t| = 0. The blue (green) triangles correspond to proton-(anti)proton measurements listed by the Particle Data Group. The filled (hollow) red circle shows the (in)direct determination by TOTEM at LHC. The black curve gives the preferred proton-proton model by COMPETE *[J. R. Cudell et al., Phys. Rev. Lett. 89 (2002) 201801].*

whether a central or peripheral impact parameter description of elastic scattering is used. At the same time, the ρ parameter was determined directly for the first time at the LHC, see the figure at the bottom of the previous page. Also a new precise total pp cross section measurement at $\sqrt{s}$ = 8 TeV was presented, where for the first time at the LHC no external input was used and Coulomb-hadronic interference effects were explicitly taken into account.

In 2015, LHC Run 2 started at a new record collision energy, 13 TeV. In October, CMS and TOTEM successfully took data together in a special high β^* run with significantly increased luminosity (in total ~ 0.4 pb^{-1}) with a special trigger dedicated for exclusive low mass resonance production allowing an increase in the statistics by about a factor 500 for the glueball candidate study. In addition, this enabled the collection of an unprecedented statistics (> 10^9) of elastic scattering events and thus allowed measurement of the |t| differential cross section up to 3.5 GeV^2 to test a hypothesis involving the contribution from a possible high |t| Odderon. Also a dedicated fill with the Roman Pots closer to the beam was taken for the measurement of the total pp cross section at 13 TeV.

The Helsinki group is focusing on measuring inelastic and diffractive processes. Both an analysis of common CMS-TOTEM data classifying inelastic events into non-diffractive, single and double diffractive using multivariate techniques as well as a measurement of the single diffractive cross section are advancing well. Also the physics reach of missing mass and momentum searches in central diffractive processes in common CMS-TOTEM data taking has been investigated especially for supersymmetric searches. The Helsinki group also actively participated in the TOTEM upgrade developing a precise proton time-of-flight measurement using diamond sensors. The first diamond module was installed into the LHC in November 2015, demonstrating the required time resolution in-situ. Three further modules will be built and installed during the first half of 2016 to be ready for a possible special run in the second half of 2016. The Helsinki contribution to the TOTEM upgrade is covered by 2015-17 infrastructure funding from the Academy of Finland.

Nuclear Matter Programme

Ari Jokinen, Nuclear Matter Programme director

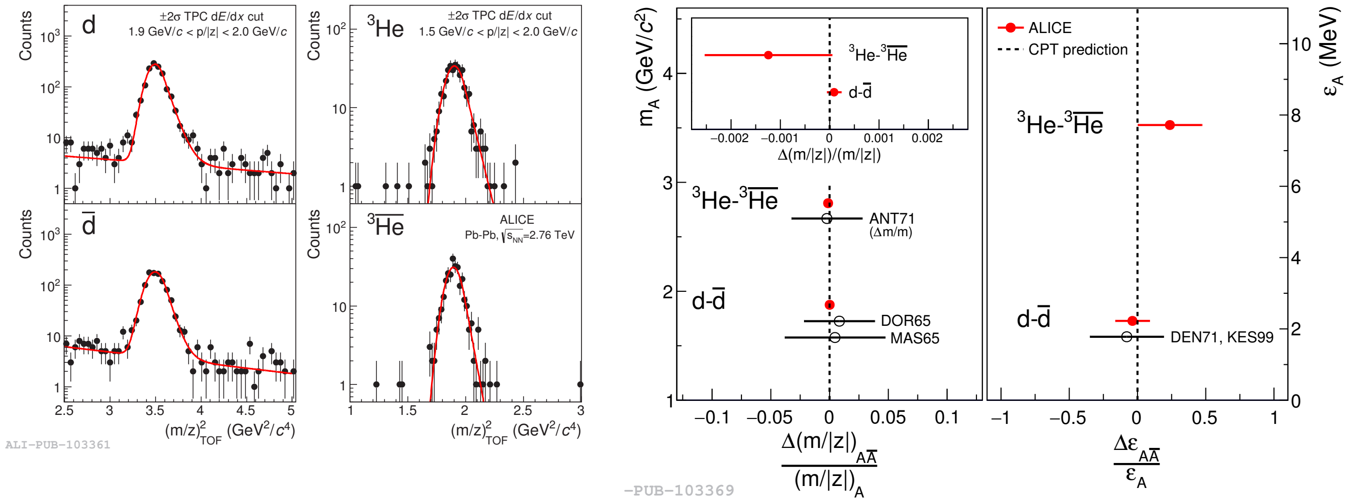
The Nuclear Matter Programme involves the participation of Finnish teams at CERN in studies of two aspects of nuclear and hadronic matter. These are cold exotic matter with the extreme composition of its proton and neutron numbers on the one hand and dense matter created in relativistic heavy ion collisions 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 Academy Researcher Janne Pakarinen (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 Dr. Tuomas Grahn. 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. Since the beginning of 2015, the Nuclear Matter Programme has also included the ALICE-Forward physics project led by Professor Risto Orava.

ALICE

At the beginning of 2015, after a 2-year-long shutdown period, Run 2 started. The LHC delivered proton-proton collisions at 13 TeV, very close to its design value (14 TeV). ALICE collected data during both the proton-proton and the lead-lead collisions (c.m. energy per nucleon 5.02 TeV) campaigns. The contribution of our group includes data analysis, as well as responsibility for the trigger and timing detector T0 and for the single-photon trigger system utilising the electromagnetic calorimeter. We are also deeply involved in the upgrade of the Time Projection Chamber (TPC), and the Fast Interaction Trigger (FIT) system, the successor of the T0 detector. Our main task within the TPC upgrade is to perform quality assurance studies of about 300 m^2 of Gas Electron Multiplier (GEM) foils, which will replace the old TPC readout chambers. This includes optical scanning to map the gain uniformity and leakage current measurements of the newly produced GEM foils. The infrastructure for these large-scale quality assurance tests has already been prepared in the HIP clean room facility and mass production is going to start during the first half of 2016.

The main directions of the physics analysis developed in our group are: (i) Correlations among high-p_T particles to study soft QCD radiation of highly virtual partons propagating through the nuclear medium. The modification of the radiation pattern studied in p-Pb and Pb-Pb with respect to proton-proton collisions (so-called vacuum radiation) can reveal information about cold nuclear matter (p-Pb) and QGP (Pb-Pb). (ii) Azimuthal anisotropy of the bulk particle production in Pb-Pb collisions as a measure of thermalization and collectivity in the early stages of the nuclear collisions. Using various techniques of flow parameters measurement (essentially the *nth*-order Fourier coefficients of the particle distribution in the azimuthal angle) one can access the basic features of the QGP phase such as the rate of thermalization, shear viscosity and initial temperature. These techniques have recently been applied to p-Pb collisions, and even to p-p collisions, where no collective phenomena induced by the QGP phase transition were expected. However, the analysis of the data taken at highest c.m. energies at the LHC shows interesting patterns resembling those observed for Pb-Pb. These observations provide an interesting hint of QGP formation even in small systems like p-Pb or p-p.

Jan Rak, ALICE project leader



Left: Squared mass-over-charge ratio distributions for deuterons (left) and ^{3}He (right) in selected rigidity intervals, top particles and bottom anti-particles. Right: mass-over-charge ratios as compared to previous measurements. With exact CPT invariance both should be zero.

One of the highlights of the scientific programme of ALICE was the precise measurement of the mass difference between light nuclei and anti-nuclei [ALICE Collaboration, Nature Phys. 11 (2015) 811].

Because of the unique capability of ALICE to identify different particle types, we were able to perform extremely precise measurements of the mass differences of deuterons and anti-deuterons, and also helium and anti-helium nuclei. If CPT symmetry, i.e., invariance of physics laws under simultaneous charge conjugation and parity and time reversal, is exact, then the masses of nuclei and anti-nuclei should be the same. This symmetry holds, e.g., in the Standard Model of particle physics. The measurement by ALICE provides a stringent constraint to any effective theory beyond the Standard Model where CPT symmetry is broken.

ISOLDE

Janne Pakarinen, ISOLDE project leader

The ISOLDE 2015 campaign began in mid-April with experiments at the low-energy branch of ISOLDE. The commissioning of the HIE-ISOLDE linear accelerator started in July with stable beams and the first much anticipated radioactive beam was delivered to MINIBALL on October 22nd. After the first step of the HIE-ISOLDE upgrade, the ISOLDE facility can now provide post-accelerated beams with energies up to 4.3 MeV per nucleon. This important milestone marks a new era for nuclear structure studies employing Coulomb excitation and transfer reaction experiments. It was acknowledged on the CERN main page (https://home.web.cern.ch/about/updates/2015/11/upgraded-nuclear-physics-facility-starts). The MINIBALL campaign focused on testing the validity of the nuclear shell model around ^{78}Ni via Coulomb excitation of $^{74-80}$Zn nuclei, and commissioning of the SPEDE spectrometer. ISOLDE also hosted two Finnish students during the summer; L. Martikainen through the CERN summer student programme conducted activities at MINIBALL and M. Mikkola, funded by HIP, worked on the development of the tape station detector measuring the yields of radioactive ions.

The SPEDE Spectrometer

The SPEDE conversion electron spectrometer has been developed by an international collaboration led by Academy Research Fellow J. Pakarinen, who was granted CERN Corresponding Associate for an extended period in 2015. SPEDE allows for the direct measurement of conversion electrons without an electron transport unit in Coulomb excitation experiments.

In the early part of 2015 the SPEDE conversion electron spectrometer completed its final in-beam tests at the Accelerator Laboratory of the University of Jyväskylä using stable beams from the K130 cyclotron. SPEDE then made the journey to ISOLDE to be coupled to the MINIBALL gamma-ray spectrometer to be used with radioactive ion beams at the newly upgraded HIE-ISOLDE. The higher beam energies from HIE-ISOLDE will allow for multi-step Coulomb excitation experiments, underlining the importance of simultaneous in-beam gamma-ray and conversion electron spectroscopy.

SPEDE was installed at the target position of MINIBALL by D. Cox, P. Papadakis and the MINIBALL team. The first commissioning test was performed using the reaction $^{196}Pt(^{133}Cs,^{133}Cs^{*})$. The figure below shows the first measurement of conversion electrons using post-accelerated beams at the HIE-ISOLDE facility. Marked are the K and L conversion peaks from the $2^{+} \rightarrow 0^{+}$ transition in ^{196}Pt.

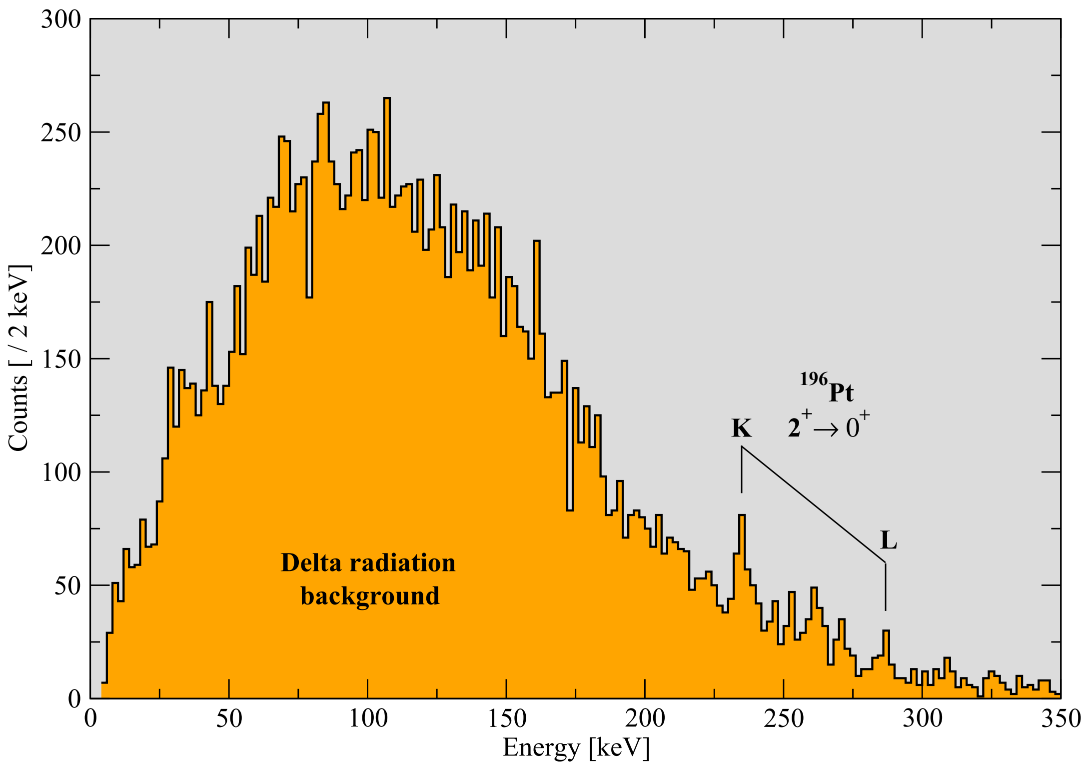
SPEDE returned to Jyväskylä at the very end of 2015 for further development during the first half of 2016 before returning to ISOLDE for an experimental campaign.

FAIR (Facility for Antiproton and Ion Research)

Tuomas Grahn,
FAIR
project leader

With respect to the unique scientific opportunities at the FAIR facility in September the Council confirmed its goal to realise the FAIR project with the scope defined in the Convention (Modularised Start Version, MSV) by 2025. This is an important decision since FAIR has been subject to some delays.

Preparatory work for the FAIR facility has continued in 2015 with developments of in-kind contributions and re-shaping of the physics cases. The Super-FRS Collaboration, that aims to perform experiments using the Super-FRS (Superconducting Fragment Separator) as a separator-spectrometer and support its completion, has played a central role in HIP FAIR research in 2015. The Finnish contribution to FAIR is organised through HIP. Prof. A. Jokinen is the co-spokesperson for the MATS experiment and Dr I. Moore for the LaSpec experiment. Prof. J. Äystö is the chair of the Collaboration Board of the Super-FRS Collaboration.



Particle-gated energy spectrum measured with SPEDE following the $^{196}Pt(^{133}Cs, ^{133}Cs^{*})$ reaction.

Finnish in-kind contributions to FAIR have focused on the construction of the experimental equipment within the NUSTAR Collaboration and Super-FRS. Although the main part of the in-kind contributions is directed to Super-FRS, in 2015 the decision was made to contribute to the NUSTAR experiment. Preparatory work on the work packages of the different instrumentation is on-going. A workshop discussing the FAIR physics cases involving Finnish researchers (NUSTAR, APPA) was held in Jyväskylä in November 2015.

The experiments towards FAIR physics cases have already started at the BigRIPS separator in RIKEN where production tests of heavy (around Z = 82) nuclei have been carried out. The analysis of these data is still at the early stages.

Risto Orava, ALICE-Forward project leader

Super-FRS tracking and diagnostics detectors

The GEM-TPC tracking detector concept was externally evaluated in 2015. The evaluation was carried out by an expert committee and was based on the design report. The valuable feedback was taken into account in the on-going design process.

The in-beam tests of the GEM-TPC detector prototype HGB4 with protons were started at the Accelerator Laboratory of the University of Jyväskylä in 2015 and will carry on in 2016. These tests will help to understand detector stability. The figure below shows the detector installed in the beam line. The GEM-TPC detector is a joint effort by HIP (Dr F. Garcia) and the GSI detector laboratories.

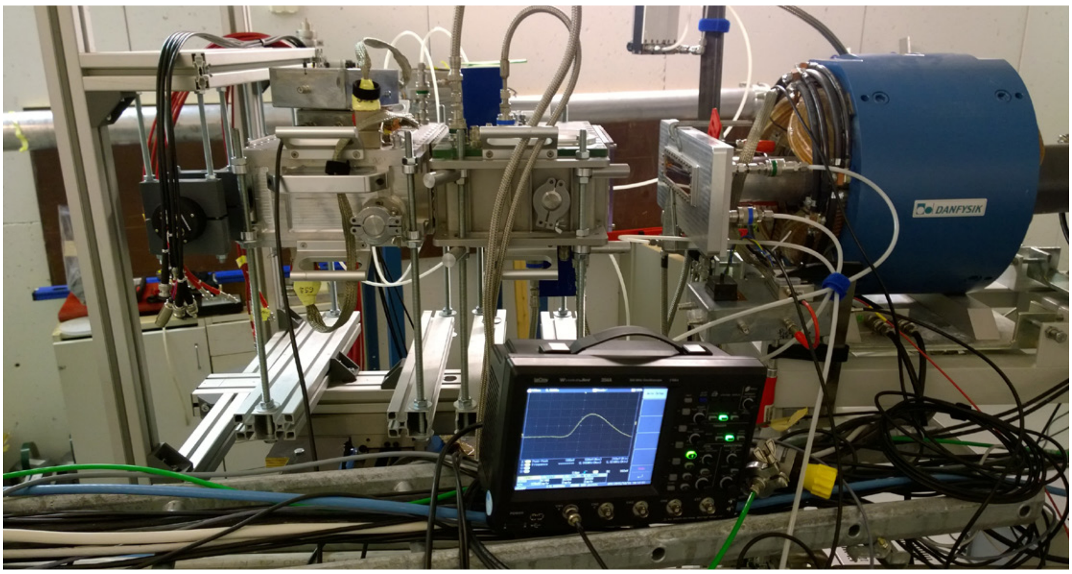
Development work for the MUSIC energy-loss detector needed for the element number Z measurement in Super-FRS kicked off in collaboration with GSI and CEA Saclay. In addition, collaboration with Fermilab was initiated in order to construct prototype SEM-Grid beam profile monitors for Super-FRS.

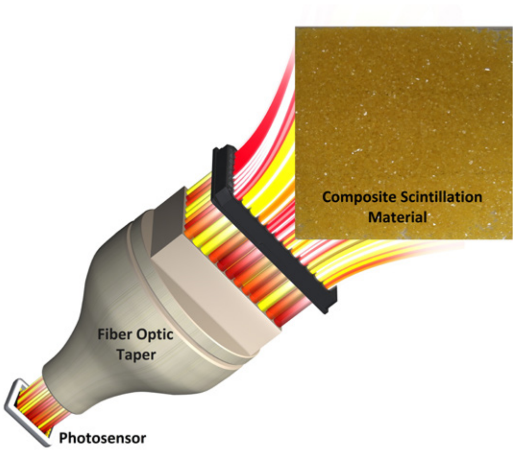
ALICE-Forward

Probing Space-Time in Hadron Interactions at the LHC

Forward Physics in ALICE at the LHC: The Helsinki Forward Physics group concentrates on studies of the space-time structure of high energy hadron collisions. The ALICE experiment at CERN provides an ideal framework for these studies based on the set of central and forward detectors with their excellent tracking, particle identification, rapidity and transverse momentum coverage. Moreover, during the normal high luminosity proton-proton runs at the LHC, ALICE can continue collecting precious forward physics data due to its special optics arrangement while the larger general purpose experiments, ATLAS and CMS, have to cope with large amounts of simultaneous collisions during the

The HGB4 GEM-TPC prototype detector installed in the beam line of the Accelerator Laboratory of the University of Jyväskylä.





CSM based position sensitive detector for AD ALICE modules calibration. *(V. Litichevskyi)*

same bunch cross-overs (pile-up).

On the 17th of August 2015, the ALICE experiment published a precise measurement of the difference between ratios of the mass and electric charge of light nuclei and antinuclei. The result, published in *Nature Physics*, confirms a fundamental symmetry of nature to an unprecedented precision for light nuclei. The measurements are based on the ALICE experiment's abilities to track and identify particles produced in high-energy heavy-ion collisions at the LHC. The new result, which comes exactly 50 years after the discovery of the antideuteron at CERN and in the U.S., improves on existing measurements by a factor of 10–100.

The group has actively developed novel particle detection techniques for the benefit of forward physics studies. Composite Scintillation Material (CSM) technologies were used to facilitate position sensitive minimum ionizing particle (MIP) detection in AD scintillators. The detector configuration includes a CSM element that directly coupled through a light concentrator to a photosensor.

Looking for Magnetic Monopoles and Dark Matter Particles at the LHC - the MoEDAL Experiment at the LHC

The MoEDAL Experiment: The seventh LHC experiment, The Monopole and Exotics Detector at the LHC (MOEDAL) has begun the analysis of its first data collected during the year 2015. The prime motivation of MOEDAL is to search directly for the magnetic monopole - a hypothetical particle with a magnetic charge.

The Helsinki group in MoEDAL concentrates on the potential production processes, Beyond the Standard Model (BSM), of exotic particles, including central exclusive production investigated in ALICE at lower energies.

The technical contributions of the Helsinki group in MoEDAL are based on the use of the optical scanning facility at the Detector Laboratory. In 2016, a feasibility analysis of scanning MoEDAL's plastic Nuclear Track Detector (NTDs) elements is foreseen.

Analysing 2 TeV Proton-Antiproton Collisions - the CDF Experiment at the Fermilab Tevatron

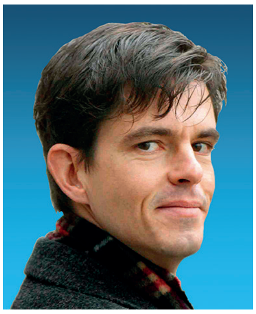
The CDF Experiment: The Helsinki group has continued the physics analysis of the 2 TeV proton-antiproton data collected at the Fermilab Tevatron before autumn 2012. In many respects, this analysis has paved the way for the analysis approaches now used at the CERN LHC.

The Tevatron experiments, CDF and DZero, found evidence for a Higgs boson in 2012, looking at events in which two bottom-flavoured jets recoiled from a vector boson - either Z or a W. The challenge is to see to what extent the observed Higgs boson candidates follow the Standard Model predictions, and whether the Higgses observed at the Tevatron represent a mixture of the same states that were observed at the LHC in 2013.

In 2015, the CDF and DZero experiments combined their results, using the same techniques used in the SM Higgs search combinations. The signal strength of exotic Higgs bosons in the $J^P = 0^-$ and 2^+ states is no more than 0.36 times that predicted for the SM Higgs boson. Given a choice between the SM Higgs boson, which has $J^P = 0^+$, and one of the two exotic models replacing it with the same signal strength, the Tevatron data disfavours the exotic models with a significance of 5.0 standard deviations for 0^- and 4.9 standard deviations for 2^+.

Technology Programme

Saku Mäkinen,
Technology Programme
director



The Technology Programme aims to integrate the projects that have significant technology development, transfer and pre-commercialisation activities of HIP in the same programme. During 2015 the Technology Programme included five research areas supporting the HIP strategy and on-going activities, namely accelerator technology, computing performance and efficiency, medical imaging and pattern recognition, business incubation, and radiation-detection instrumentation.

Markus Aicheler,
Accelerator
Technology
project leader

Flyura Djurabekova,
University Researcher,
SIMAT

Accelerator Technology

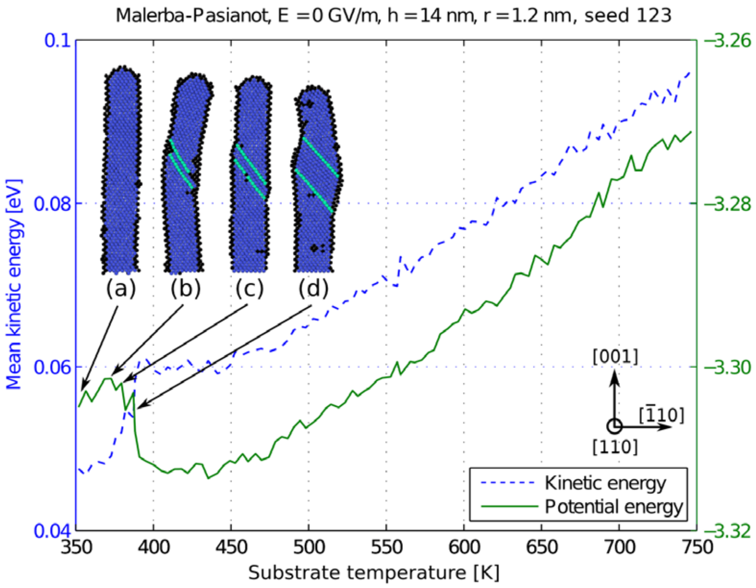
In 2015, the focus of the MAT (Materials for Accelerator Technologies) group was on processes on metal surfaces operated under high electric fields. This interest is motivated by the needs of the Compact LInear Collider (CLIC), one of the major on-going projects at CERN. The MAT group is closely collaborating with Dr. W. Wuensch (CERN), the leader of the CLIC RF structure development group and Dr. S. Calatroni (CERN). The higher the gradient of accelerating *rf* electromagnetic fields, the higher the energy of accelerated particles that can be reached at a reasonable cost. This applies also to the accelerators used in other fields, such as medicine and free electron lasers. Several modern technologies, such as X-ray sources, radio-frequency generating klystrons, particle accelerators, scanning electron microscopes, field emission tip arrays and high-current interrupters, all impose a need for high surface electric fields. Due to the size of the objects, it is becoming more and more difficult to predict, or even analyse the changes happening in the materials subjected to high electric fields.

Within the group we have developed the Kinetic Monte Carlo (KMC) model, Kimocs, of metal surface evolution due to thermal effects as well as electric field effects. The model predicts well the instability of nanowires seen experimentally to fragment at temperatures lower than the melting point of bulk Cu. In our simulations, we confirmed that this process occurs also in nanotips due to enhanced surface diffusion at elevated temperatures.

In 2015, we also added the electric field effects in the model to simulate the influence of a partial charge on surface atoms on the surface diffusion. This model is currently used to reproduce the interesting experiment performed at ETH Zurich by Dr. H. Yanagisawa, with whom we initiated collaboration in 2015. Dr. Yanagisawa observed the growth of a small protrusion at the top a field emitting W tip, which was irradiated by ultrafast femtosecond lasers for a long time. This is a clear evidence of the surface response to high electric fields while the surface was heated for a very short time.

We have also considered the shape memory effect in Cu nanowires as one possible mechanism that prevents high aspect ratio nanosized field electron emitters from being stable at room temperature (see the figure at the top of the next page). We also showed that in the studied tips the stabilising effect of an external applied electric field is an order of magnitude greater than the destabilisation caused by the field emission current.

During the last year we had also a visit of a lecturer from Xi'an Jiaotong University, China, Dr. Z. Wang. His visit was particularly valuable for the group and the project, as his expertise in using the FEM simulations for the plasma-wall interactions allowed us to extend the model to the macroscopic level. This collaboration will be extended in the future for a new potential



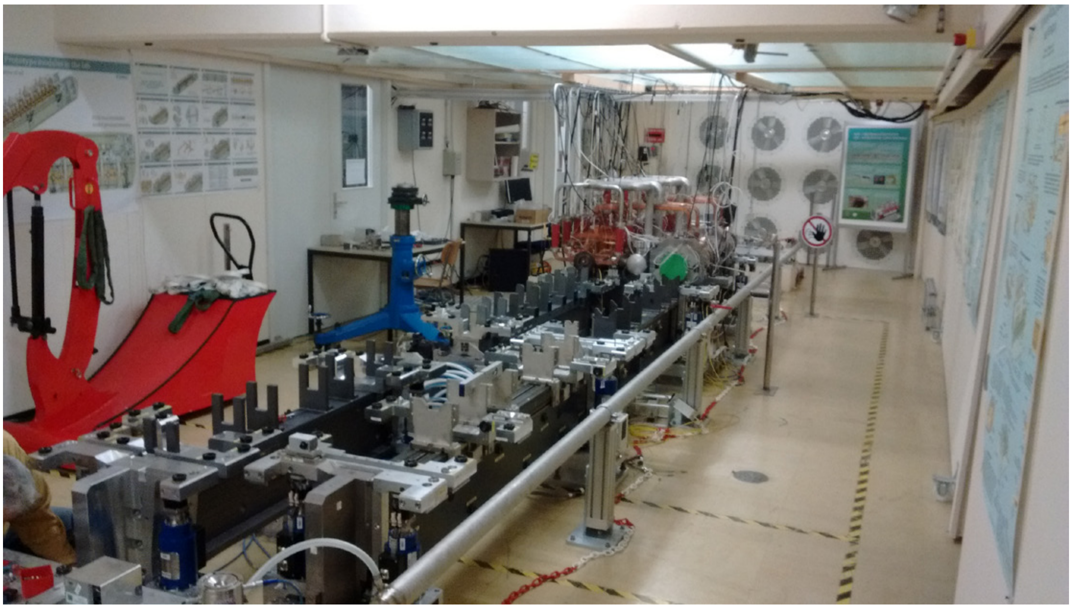
Evolution of a Cu nanotip on the heated copper substrate.

application of our model in the field of vacuum interrupters, which are the main focus of the group at Xi'an Jiaotong University. We have also initiated a study of copper properties during the accelerating structure preparation stage. The high precision assembly of accelerating structures requires a high quality diffusion bonding.

In collaboration with the MSM project, we studied the diffusion bonding process via detailed analysis of the diffusion processes in different relevant regions between the disks in CLIC disk stacks. We showed that temperature alone is able to remove the nanosized imperfections during the diffusion bonding process. However, the larger the voids, the higher the temperature required to complete the closure of a void.

The Module, Structures and Manufacturing (MSM) group within the Accelerator Technology project participates mainly in the Compact LInear Collider (CLIC) study. CLIC is developing a 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 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 development of the so-called CLIC module (the smallest modular entity containing all systems of the accelerator). The R&D was done in close collaboration with the CERN CLIC accelerating structures group of Dr. W. Wuensch and the CLIC module team of Dr. S. Döbert (co-led by Dr. M. Aicheler), and several Finnish industrial and academic partners. The project had in 2015 one MSc student (P. Tikka), one researcher (J. Väinölä) and the project leader (Dr. M. Aicheler) at CERN plus two PhD students (A. Meriläinen and R. Montonen) based in Helsinki. The topics covered by the MSM group within the AT project during 2015 included mainly the development of dynamic vacuum and internal shape measurement techniques for RF structures as well as various items related to the CLIC module programme: studies of the thermo-mechanical behaviour of CLIC prototype modules in the lab, data analysis of a fully functional and high power CLIC prototype module in CLEX and design work as well as assembly work for additional lab test modules for more detailed functional studies.

The CLIC module with all the accelerator components and necessary subsystems integrated has to maintain high precision during installation as well as during CLIC operation. The MSM group has supported the exploitation of the first full-scale prototype module (without a



Support structures installed for extension of the test module string with additional Type-0 and Type-1 modules.

beam) in the laboratory (reported earlier) and is currently extending this set-up by another Type-0 and a Type-1 module. This task will be accomplished by early 2016 followed by an extensive measurement campaign.

Green Big Data

Jukka K. Nurminen, Green Big Data project leader

There are several new trends in scientific computing these days: a large part of computing tasks are processed in cloud computing centres using virtualisation technologies; the sizes of the data sets have become extremely large and complex causing challenges for data analysis; and 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 this 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 today.

The Green Big Data project has focused on optimising energy consumption of scientific computing clusters used for HEP computing related to CERN experiments. In 2015, we contributed to this area of research by

- developing tools to visualise energy consumption of scientific software,
- performing fine-grained analysis of the influence of processor architectures on performance and energy-efficiency,
- studying and testing how heterogeneous computer architectures can be applied to HEP computing,
- studying and prototyping solar energy driven computing,
- developing and testing novel workload management methods for computing centres,
- analysing the communication patterns of HEP computing and evaluating the effect of network quality to the computing time and energy efficiency.

The first four topics have been studied in close collaboration with Aalto University and the CMS computing team at CERN while the Department of Operations at the University of Lausanne is a key partner in the fifth one. The last topic is done in an EU-funded research project "Scalable and Secure Infrastructures for Cloud Operations" which started in February 2015.

A Finnish software house, Reaktor, visited CERN in November and gave a presentation on modern software development methods in a CERN IT seminar. In the picture P. Haapio, T. Niemi (HIP), J. Kallunki and J.-M. Liukkonen (left to right).

The personnel of the project included two senior researchers, two PhD students and three summer trainees during the summer. Two MSc theses were completed in the project ("Energy and performance profiling of scientific computing" and "Distributed Computing as a Source of Heat: The Design and Evaluation of a Computerized Heater").

The project has also been looking for ways to create new CERN-related business for the Finnish ICT sector. A concrete outcome of this is an innovative idea that is currently being evaluated by the university innovation services. Furthermore, the project has marketed the opportunities in CERN to Finnish ICT companies. As a result we have had Finnish ICT companies visiting CERN and giving seminar talks about their areas of expertise.

The goal for 2016 is to continue research on heterogeneous and energy-efficient hardware, further develop cloud computing for HEP applications, and apply these methods in practice to collaboration with CERN and industry partners with possible external project funding. The group consisted of the following persons: Prof. J. K. Nurminen, Project leader, K. N. Khan, PhD student, Dr. T. Niemi, Project co-ordinator, J. Kommeri, PhD student, A.-P. Hameri, Senior scientist, Professor at HEC-UNIL., Z. Ou, PostDoc, Aalto University, M. Hirki, MSc dissertation student, Aalto University, S. Heikkilä, Scientist, CERN, J. Strandman and A. Vartiainen.

AvanTomography

The Biomedical Imaging AvanTomography project aims to construct a PET demonstrator, based on the principle of the Axial PET (AX-PET) project developed by the AX-PET research consortium at CERN. The AX-PET design consists of axially oriented scintillating crystals in a staggered grid structure, interleaved by wavelength shifter (WLS) strips. Each crystal and wavelength shifter strip is individually read and processed by multi-pixel photon counters (MPPC). In the AvanTomography project, in addition to this structure, all data is collected and stored in list-mode in a computer. The trans-axial coordinate of the gamma interaction point is acquired from the scintillating crystals, whereas the z-axis is determined by the WLS strips, which collect the light emitted from the crystals.

In conventional PET devices, there is a trade-off between sensitivity and resolution. With the concept of axially oriented crystals and orthogonally placed WLS strips, it is possible to have a good resolution as well as high sensitivity thanks to

Ulla Ruotsalainen, Biomedical Imaging project leader

The partnership agreement for the Finnish Business Incubation Center was signed at CERN. Photo from the left: Head of CERN's Knowledge Transfer Group G. Anelli, CERN's Director General R. Heuer, Finnish Ambassador to Switzerland P. Kairamo, HIP's Director J. Äystö, TUT's President M. Kivikoski and Professor, Director of HIP's Technology Programme S. Mäkinen.

the determination of the exact hit location. It is also possible to solve the so-called parallax error caused by the unknown depth of interaction in the detector crystal. This error can be avoided with the multilayer structure of the axial type PET, and the detectors can be brought near the object which increases the sensitivity of the photon detection.

The AvanTomography project is planned to bring a modular and easily transformable PET scanner structure to the market, allowing it to be used in various applications ranging from the scanning of wrists/arms to scanning small animals. Also the sensitivity of the PET demonstrator can be improved simply by adding more layers of modules to the demonstrator. The AvanTomography project aims to develop a positron emission mammography scanner with axial PET geometry. This scanner is planned to achieve a high sensitivity and resolution which can be used for the early diagnosis of small lesions and early cancer in the cases where mammography can be inconclusive. So far 6 scanner modules have been constructed and tested. Simulations have been conducted to find ways to optimise this design. The scanner structure was characterized using these simulation results. Simulation data were recorded in a realistic List mode format, which is the output data commonly used in commercial PET scanners. Simulated data from phantoms were reconstructed using different reconstruction algorithms.

Saku Mäkinen,
BIC project leader

Finnish Business Incubation Center of CERN Technologies

CERN is establishing an international CERN Business Incubation Network which consists of business incubation centres in each member state. Thus far, the UK, the Netherlands, Austria, France, Spain, Greece, Finland and Norway have established centres to aid commercialisation of CERN-related technologies. The purpose of the network is to enlarge and further improve commercialisation, and therefore, social utilisation, of CERN-related technologies in each member state.

The agreement to establish the FBC (Finnish Business Incubation Center of CERN Technologies), the CERN BIC in Finland, was signed on 16 September 2015 in Geneva by CERN, the Helsinki Institute of Physics (HIP), and Tampere University of Technology. The FBC is operated under the Technology Programme at HIP. The focus is on selecting incubates that exhibit disruptive and business ecosystem changing technologies.

The aim of the Finnish Business Incubation Center of CERN Technologies is to support businesses and entrepreneurs in taking innovative CERN technologies from technical concept to market reality. Specifically, the aim is to find, screen, support and pre-incubate pre-commercialisation and/or the early commercialisation phase of ideas and technologies. The search and screening of ideas is done within the pool of ideas that are eligible if these are

- based on technologies developed at CERN or with direct contribution from CERN,
- companies developing technologies which could also be of interest to CERN,
- any innovative project that could clearly benefit from the support of CERN experts in their core fields of competences.

Initially it is envisioned that for the first 3-year period there would be an open call for proposals. The selection panel will be assessing the proposals according to strict and formally outlined criteria. The selection panel will consist of CERN, HIP/partner universities, and other relevant scientific, industry, venture capital etc. representatives. The objective of this selection process is to find 1–3 high-quality proposals yearly. The Finnish CERN BIC is organised and managed by HIP and operations are carried out together with partner universities and as applicable also the incubation period for accepted proposals will be supported by partner universities as appropriate.

Novel Instrumentation for Nuclear Safety, Security and Safeguards (NINS3) - FiDiPro

Good stewardship of nuclear materials and an adequate response to threats that potentially involve nuclear materials are essential now and far into the future. In order to develop suitable instrumentation for these tasks, a new project on "Novel Instrumentation for Nuclear Safety, Security and Safeguards" (NINS3) was started. The NINS3 project performs R&D on the following important topics:

- passive tomography of spent nuclear fuel,
- alpha radiation threat detection and imaging from a distance,
- active neutron interrogation of unknown objects.

The project links directly to the national reorganisation of radiation protection research, i.e., it is an integral part of the National Radiation Safety Research Programme. The project partners are Helsinki Institute of Physics, the Finnish Radiation and Nuclear Safety Authority STUK, Tampere University of Technology and a consortium of companies in Finland involved in or in need of radiation measurements.

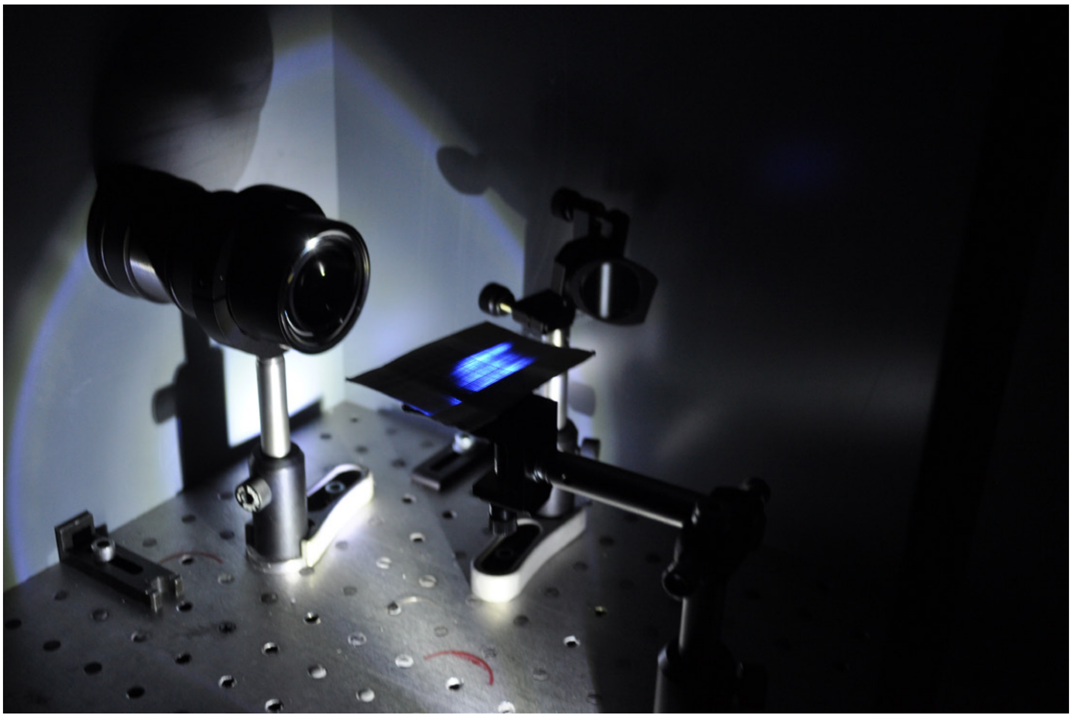
Through the development of new technological concepts, the project will increase the technology readiness level in each of the R&D topics. Finnish industry will be strengthened by transferring the knowledge gained to companies for implementation in new commercial products and services.

The NINS3 project is funded through a FiDiPro - Finland Distinguished Professor - Programme financed by TEKES, the Finnish Funding Agency for Innovation. It is to run from the beginning of 2015 until the end of 2018.

The Passive Gamma-ray Emission Tomography (PGET) prototype previously developed by STUK and Budapest University of Technology and Economics was installed at the Accelerator Laboratory of the University of Helsinki and its data-acquisition system tested. In autumn, the system was shipped abroad for an upgrade of the data-acquisition electronics. During two consultation meetings, each lasting several days, all knowledge on PGET prototype operation of data analysis was transferred from the Budapest colleagues to NINS3 and STUK.

A Monte Carlo simulation framework based on GEANT4 has been set up. For simulations of the tomography of spent nuclear fuel, the framework fully parameterises spent fuel assemblies as well as tomograph detectors. This allows for an efficient optimisation

Peter Dendooven,
NINS3
project leader



Heart of the experimental set-up to study the detection of alpha-radiation-induced fluorescence.

of tomography systems for different fuel assembly types. A second application of the simulation framework is related to the active neutron interrogation of unknown objects. In combination with measurements performed at STUK, new technology, related to both the neutron source and the radiation detectors, for different measurement scenarios, is being investigated.

The work on the detection and imaging of alpha radiation from a distance, performed at Tampere University of Technology, started with repeating earlier passive alpha-radiation-induced fluorescence measurements performed in an air atmosphere. New measurements using gases other than air were performed. Presently, active, i.e., laser-enhanced, alpha-radiation-induced fluorescence is being investigated.

As the NINS3 project aims to develop new technology that is close to or ready for commercialisation, research-to-business activities were initiated right from the start of the project. As a first step, bgator Oy (Tampere, Finland) investigated the market potential of the NINS3 technological topics via a literature research and interviews of a variety of stakeholders. Several central market areas that have been recognised will be given special attention in the next steps of the project.

Detector Laboratory

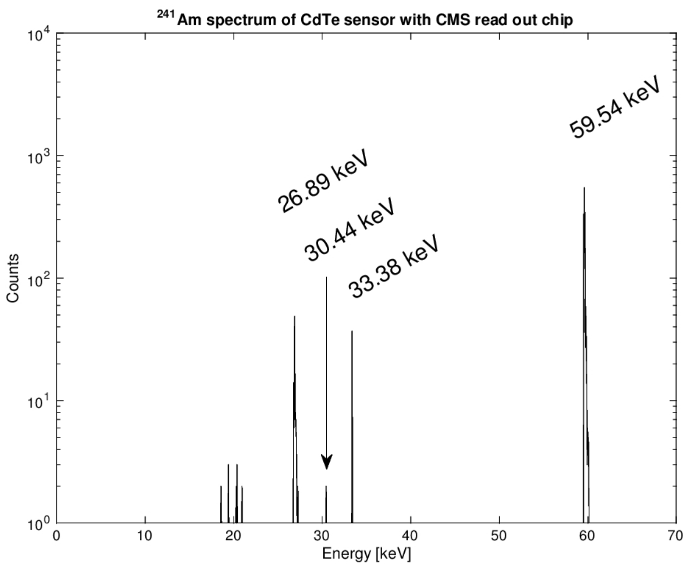
Eija Tuominen, Detector Laboratory coordinator

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 know-how for research projects that develop detector technologies. The Laboratory team has extensive expertise in the modelling, design, construction and testing of semiconductor and gas-filled radiation detectors. In addition, the personnel and scientists working in the Laboratory take the responsibility of educating a new generation of physicists.

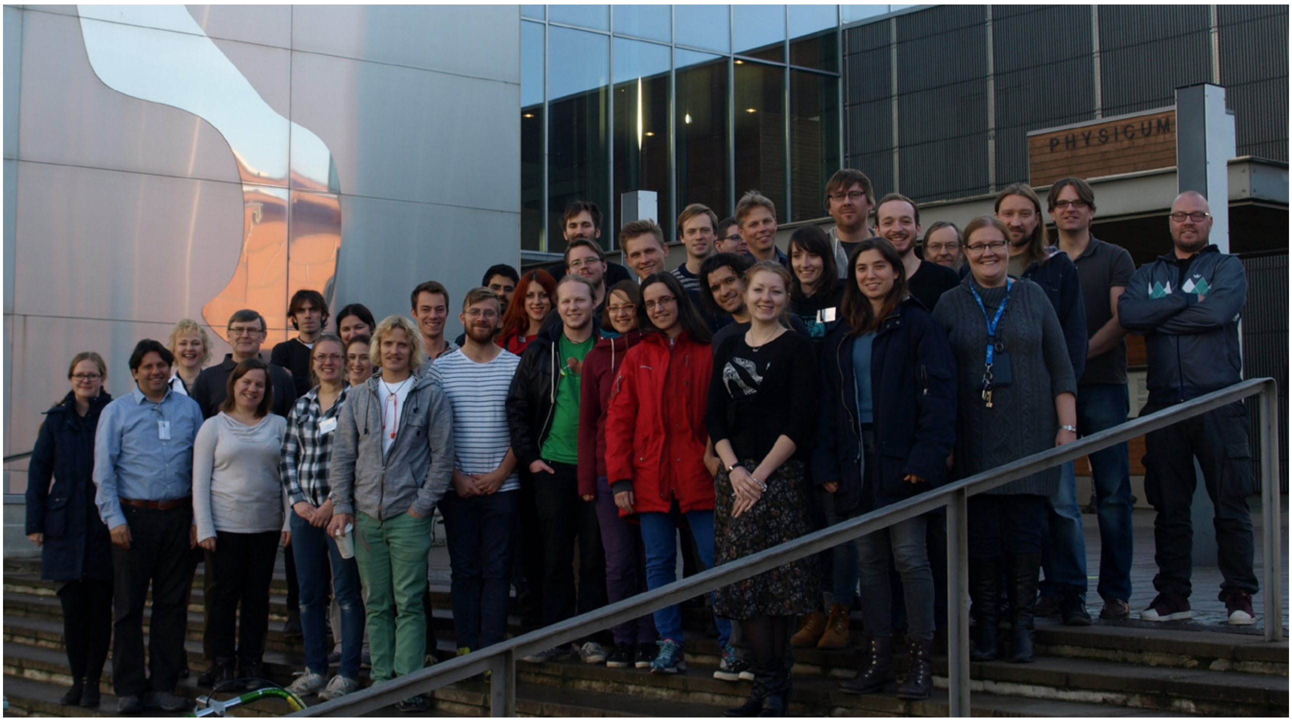
All the projects present in the Detector Laboratory have the objective to provide reliable instruments for large international physics experiments. The Laboratory is specialised in Quality Assurance (QA) of detectors and their components and in detector prototyping. In 2015, the Laboratory hosted several **research** projects participating in the CMS, TOTEM and ALICE experiments at CERN, and the NUSTAR 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 Detector Laboratory supports the instrumentation **activities of HIP experimental projects:** the CMS Upgrade project is in charge of the quality assurance of 250 pixel detector modules for the CERN CMS Tracker Phase I upgrade, to take place in 2016-2017. In addition, the project develops novel detector technologies for the Tracker Phase II upgrade. The FAIR project aims 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 2022. The ALICE project is in charge of the optical and electrical QA of about 400 large-size GEM foils for the CERN ALICE upgrade, to be installed in 2019-2020. The TOTEM project has two activities: the maintenance of the GEM detectors in the TOTEM T2 telescope and the quality assurance of diamond detectors for the TOTEM upgrade. Furthermore, the TEKES FidiPro project develops Novel Instrumentation in Nuclear Safety, Security and Safeguards.

The Detector Laboratory supports several of the research **activities of UH/Physics**, especially in the form of sharing expertise, equipment and infrastructure with various research groups. Its connections with the Division of Particle and AstroPhysics (PAP) are naturally very tight. In addition, the Laboratory collaborates with the Electronics Research Laboratory in the fields of optical imaging and interconnection technologies and with the Accelerator Laboratory in the field of radiation hard semiconductor detectors. Additionally, there are strong connections with the University of Jyväskylä, Department of Physics and with the Aalto University Micronova facility.



Energy spectrum of a CdTe pixel sensor processed at Micronova and measured in the Detector Laboratory clean room with CMS data acquisition software in photon counting mode.



The Detector Laboratory hosted the Nordic research training course in detector technology for particle physics in November 2015.

Providing **education** in the instrumentation of physics is of outmost importance in the Detector Laboratory. The scientists working in the Laboratory lecture courses about semiconductor physics and detector technologies. Research-based hands-on exercises and special assignments are organised in the Laboratory. In addition, doctoral and Master's students are supervised in their dissertation works. In 2015, the major educational effort for the whole team was to organise a one-week laboratory course on detector technologies for 20 Nordic post-graduate students in close collaboration with PAPU, the University of Uppsala Sweden and the Niels Bohr Institute Denmark.

In the Detector Laboratory, special effort is devoted to developing methods of **societal interaction** to ignite interest in physics among young people. One of the key outreach activities of the Laboratory is to demonstrate the instrumentation of particle physics for the high-school students participating in the HIP visitor programme at CERN. In addition, the Laboratory takes part in the outreach efforts organised by UH/Physics, e.g., CERN Master Class and "Science Bazaar". Furthermore, three secondary school TET-trainees and two trainees from the Finnish School of Watchmaking worked in the Laboratory.

CLOUD

Markku Kulmala, CLOUD project leader

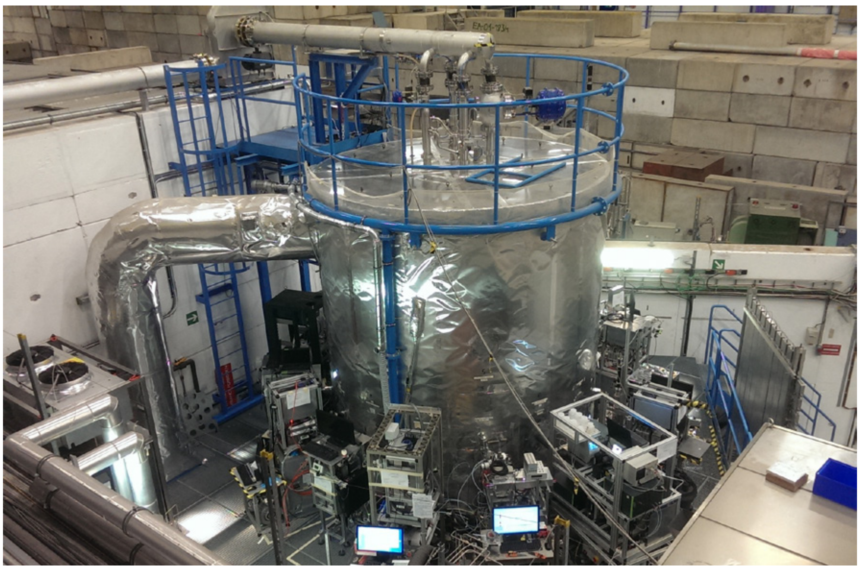
Background

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 atmospheric aerosol particles over a wide range of simulated conditions. 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 also to 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.

Numerous indirect observations and theoretical studies suggest that galactic cosmic rays GCR may exert a significant influence on the Earth's cloud cover and climate. At CLOUD, different levels of GCR can be simulated to investigate experimentally their influence on physical or chemical atmospheric processes. 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. The CLOUD experiment aims to find pathways for the phenomena and their significance. The experiment is being undertaken by 21 institutes with a strong Finnish contribution (the University of Helsinki, the University of Eastern Finland and the Finnish Meteorological Institute).

Experiments in 2015: the CLOUD10 Experiment

During September to December 2015, an intensive measurement campaign, CLOUD10, was organised at the CLOUD chamber. The Finnish team made a major contribution, with a total of 20 persons working on site during the campaign, while the rest of the Helsinki team provided daily remote technical and data analysis support. The main research topic of the campaign was to simulate atmospheric aerosol particle formation relevant to the boreal forest environment in Hyytiälä, where the University of Helsinki SMEAR II research station is located. There, the atmosphere-ecosystem interactions are continuously measured, providing a unique dataset against which chamber experiments such as CLOUD can be compared.



The CLOUD facility in the T11 area at CERN during the CLOUD10 campaign in autumn 2015. The pion/muon beam arrives from the right and hits a hodoscope that monitors the beam intensity before it passes through the chamber to the left. Instruments were employed on the 16 ports around the chamber.

Other research topics also investigated in the CLOUD10 campaign were:

- temperature dependence of the particle formation rate for a variety of organic precursors,
- the first experiments simulating aerosol particle formation in the Amazon and in urban environments.

The CLOUD chamber apparatus was implemented with two new light systems to enhance OH production and NO production, respectively: the excimer laser and the UVa system. A wide variety of instruments was provided by the participating institutes and deployed during this experiment. The Finnish team was responsible for several instruments such as a NAIS, PSM, CPCs, CIC, a new extra-sensitive NO monitor system, an APi-ToF and two CI-TOF-MS.

Data Analysis, Education and Reporting of Results

A comprehensive analysis of the data collected during the CLOUD7–10 campaigns is ongoing within the working groups. Several papers are currently under open review (Ignatius (ACPD), Hoyle (ACPD), Nichman (ACPD), Järvinen (ACPD)), some are about to be submitted and some other have been published (such as Kim (ACP), Kürten et al. (ACP), Wimmer et al. (AMT), Franchin et al. (ACP), Schobesberger et al. (ACP) and Duplissy et al. (JGR)).

Several CLOUD workshops were organised: at Hyytiälä (CLOUD10 preparation workshop), at PSI (CLOUD9 data workshop) and CERN (CLOUD10 first evaluation). Biweekly virtual meetings were organised within the different CLOUD working groups. Results were presented at different international conferences such as EAC (Milan, Italy) and AGU (San Francisco, USA). The 3rd CLOUD-TRAIN workshop took place in June 2015 in Cascais, Portugal, with the participation of the Helsinki PhD students.

Planck-Euclid

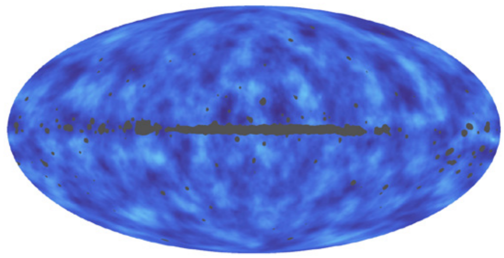
Hannu Kurki-Suonio, Planck-Euclid project leader

Planck

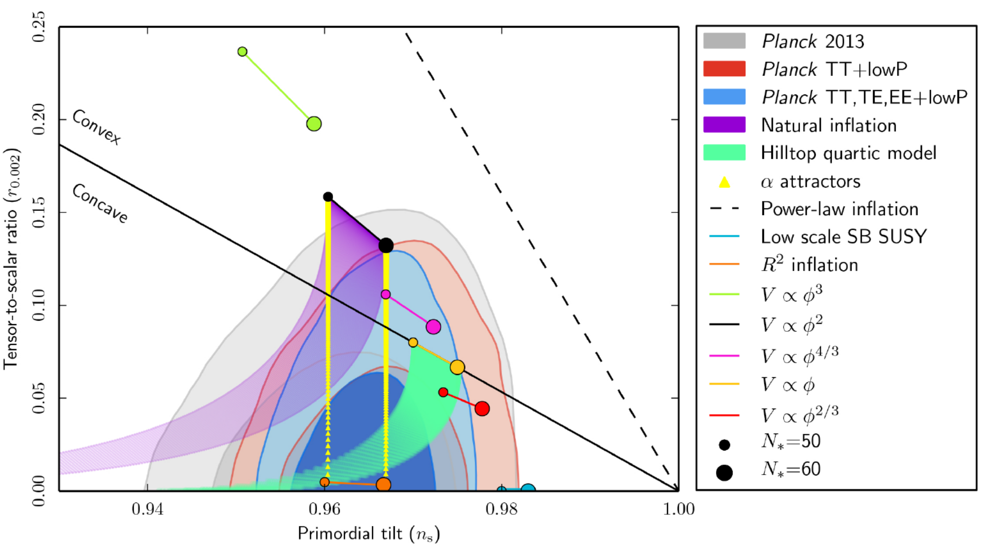
The Planck satellite was launched in 2009, and made observations until 2013. The main purpose of the mission was to measure the cosmic microwave background (CMB) with unprecedented accuracy, and use this to determine the properties of the universe. Planck carried two instruments, the Low Frequency Instrument (LFI) and the High Frequency Instrument (HFI). Data analysis will continue until 2016.

The Helsinki group was responsible for producing the sky maps for the three LFI frequencies (30, 44 and 70 GHz) as well as for a number of related tasks. We developed improved calibration and beam deconvolution methods for LFI, and fitted cosmological models of primordial isocurvature perturbations to Planck data.

In 2015, the Planck Collaboration completed the analysis for the second data release, which is now available at the Planck Legacy Archive, and 28 "Planck 2015 results" publications (http://www.cosmos.esa.int/web/planck). The results are in agreement with the 5-parameter LambdaCDM model: the main components of the universe are dark energy, cold dark matter (CDM), and ordinary matter, and the primordial perturbations responsible for the origin of structure were Gaussian and almost, but not quite, scale invariant, as predicted by the simplest cosmological inflation models. The values of these parameters were determined with greater accuracy: dark energy makes up 69.2 ± 1.2%, cold dark matter 26.0 ± 1.2% and ordinary matter 4.8 ± 0.2% of the total. The universe expands at a rate of 67.8 ± 0.9 km/s/Mpc. The primordial perturbations deviate from scale invariance by -3.2 ± 0.6%, indicating that perturbations were slightly stronger at larger distance scales. From the fraction of CMB photons that were observed to be scattered by interstellar free electrons, 6.6 ± 1.6%, it was determined that the first stars were formed 550 million years after the big bang. This was a revision upwards from the earlier determination by the NASA WMAP satellite.



The gravitational effect of mass concentrations in the universe bends the path of the CMB photons. The resulting distortion of the CMB map was used to determine the matter distribution in the universe, over the whole sky, projected along the line of sight. In this figure lighter colour corresponds to more matter (mostly CDM). Dark grey corresponds to directions obscured by the Milky Way. *[Planck Collaboration: Planck 2015 results. I. Overview of products and scientific results. arXiv:1502.01582v2, submitted to Astronomy & Astrophysics]*



Planck constraints on the spectral index (horizontal axis) and primordial gravitational waves (vertical axis) compared to predictions of several cosmological inflation models. The structure in our universe is thought to originate from quantum fluctuations during cosmological inflation in the early universe. Planck results rule out many such models, but other inflation models fit these results. The region allowed by Planck is shown in blue, dark blue is the 68% confidence region and light blue the 95% confidence region. *[Planck Collaboration: Planck 2015 results. XX. Constraints on inflation. arXiv:1502.02114v1, submitted to Astronomy & Astrophysics]*

Euclid

The next cosmology space mission after Planck will be Euclid. It will be launched in December 2020. Euclid will address some of the main open questions in cosmology, in particular the cause of the accelerated expansion of the universe: Is it due to a mysterious "dark energy" permeating the universe, does the law of gravity deviate from general relativity at cosmological distance scales, or is there yet another explanation, possibly related to poorly understood effects of inhomogeneities on observations?

Over the course of 6 years Euclid will photograph over one third of the sky in the visible and near infrared, obtaining images of over a billion galaxies and spectra of tens of millions of galaxies. Based on this data, the Euclid Consortium will determine the 3-dimensional distribution of galaxies and dark matter in the universe. Euclid will observe the last three quarters - about 10 billion years - of the history of the universe; complementing Planck, whose cosmological measurements are mainly from the 400,000-year-old early universe. We are participating in the development of data analysis methods for Euclid and will eventually analyse some of the data. We operate one of the nine Euclid Science Data Centers, SDC-Finland, located at the Kajaani facility of CSC - IT Center for Science.

Administration

Mikko Sainio

The graduate education of physics students continues to be one of the main tasks of the Institute. The last couple of years have seen a major change in graduate education at the University of Helsinki. Four graduate schools, including the Doctoral School in Natural Sciences (http://www.helsinki.fi/doctoral-schools/natural-sciences/index.html), started their operations at the beginning of 2014. The HIP graduate students who take their degree at the University of Helsinki belong to the Doctoral programme in particle physics and universe sciences PAPU (http://blogs.helsinki.fi/papu-dp/) or the Doctoral programme in materials research and nanosciences MATRENA (http://blogs.helsinki.fi/matrena-dp/). Graduate education in other partner universities is organised in a similar manner as the Graduate Schools. In addition to the graduate students who are supported by the Doctoral programmes or by the Institute, a fair number of undergraduate students join the research groups and complete their Masters' theses work at the Institute. Many of these students continue 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 2011-2015, 46 doctoral degrees and 71 Masters' degrees have been earned in HIP research projects.

The National Board of Education (Opetushallitus) has continued its collaboration with HIP and the Jyväskylä Educational Consortium in the CERN science learning 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 2015 this programme attracted 366 Finnish students and 57 of their teachers. A related programme has been operated to bring high school physics teachers to CERN for continuing education courses. In 2015, 25 teachers participated in this programme. These visits have generated considerable coverage in blogs and local newspapers all over the country: 15 newspaper articles in total in 2015.

On September 15, 2015, HIP signed together with CERN and Tampere University of Technology a contract on a "Business Incubation Center" which aims to support new business innovations in the fields of CERN technologies.

Organization and Personnel

Organization

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

Board
Jouko Väänänen, Rauno Julin, Mikko Ritala, Risto Nieminen, Hannu Koskinen, Ulla Ruotsalainen, Kari J. Eskola, Tuija Pulkkinen, Kenneth Österberg, Jari Hämäläinen

Steering Group
JÄ, KR, PE, AJ, SM, MS, TS

Director
Juha Äystö

Administrative Manager
Mikko Sainio

Theory
Kari Rummukainen

- **Cosmology of the Early and Late Universe** – Syksy Räsänen
- **High Energy Phenomenology in the LHC Era** – Aleksi Vuorinen
- **QCD and Strongly Interacting Gauge Theory** – Tuomas Lappi
- **Nuclear Structure for Weak and Astrophysical Processes** – Markus Kortelainen
- **Domain Wall Dynamics** – Lasse Laurson

CMS
Paula Eerola

- **CMS Experiment** – Katri Lassila-Perini
- **CMS Upgrade** – Jaakko Härkönen
- **Tier-2 Operations** – Tomas Lindén
- **TOTEM** – Kenneth Österberg

Nuclear Matter
Ari Jokinen

- **ALICE** – Jan Rak
- **ISOLDE** – Janne Pakarinen
- **FAIR** – Tuomas Grahn
- **ALICE-Forward** – Risto Orava

Detector Laboratory
Eija Tuominen

Technology
Saku Mäkinen

- **Accelerator Technology** – Markus Aicheler, Flyura Djurabekova
- **Green Big Data** – Jukka K. Nurminen
- **Biomedical Imaging** – Ulla Ruotsalainen
- **BIC** – Saku Mäkinen
- **NINS3** – Peter Dendooven

Planck-Euclid
Hannu Kurki-Suonio

CLOUD
Markku Kulmala

The Institute Board

Chairman	**Jouko Väänänen**, Dean (University of Helsinki)
Vice Chairman	**Risto Nieminen**, Dean (Aalto University)
Members	**Kari J. Eskola**, Professor (University of Jyväskylä) **Jari Hämäläinen**, Vice Rector (Lappeenranta University of Technology) **Rauno Julin**, Professor (University of Jyväskylä) **Hannu Koskinen**, Professor (University of Helsinki) **Tuija Pulkkinen**, Vice Rector (Aalto University) **Mikko Ritala**, Professor (University of Helsinki) **Ulla Ruotsalainen**, Vice Rector (Tampere University of Technology) **Kenneth Österberg** (Chosen by personnel of HIP)

The Board: Jari Hämäläinen, Kenneth Österberg, Jouko Väänänen, Hannu Koskinen, Mikko Ritala, Tuija Pulkkinen, Risto Nieminen, Ulla Ruotsalainen, Kari J. Eskola.

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 (U. Glasgow)

Wolfram Weise, Professor (ECT*, TU München)

Barbro Åsman, Professor (U. Stockholm)

Personnel

Theory Programme

K. Rummukainen, prof., programme director
M. Laine, prof., senior scientist
M. Hindmarsh, prof., adj. senior scientist
K. Kajantie, prof., adj. senior scientist
A. Krasheninnikov, adj. senior scientist

Cosmology of the Early and Late Universe

S. Räsänen, docent, proj. leader
K. Enqvist, prof., adj. senior scientist
K. Kainulainen, prof., adj. senior scientist
F. Montanari, scientist
S. Nadathur, scientist
S. Rusak, scientist
T. Sekiguchi, scientist
J. Virkajärvi, scientist
S. Nurmi, adj. scientist
T. Alanne, grad. student
V.-M. Enckell, grad. student
A. Hämäläinen, grad. student
H. Jukkala, grad. student
K. Kettula, grad. student
M. Lavinto, grad. student
H. Nyrhinen, grad. student
T. Tenkanen, grad. student
V. Vaskonen, grad. student
P. Wahlman, grad. student
E. Tomberg, student

High Energy Phenomenology in the LHC Era

A. Vuorinen, docent, proj. leader
P. Hoyer, prof., adj. senior scientist
K. Huitu, prof., adj. senior scientist
O. Lebedev, prof., adj. senior scientist
E. Keski-Vakkuri, adj. senior scientist
K. Tuominen, docent, adj. senior scientist
T. Brauner, scientist
M. D'Onofrio, scientist
O. Taanila, scientist
T. Zingg, scientist
A. Amato, adj. scientist
S. Di Chiara, adj. scientist
I. Ghişoiu, adj. scientist
C. Gross, adj. scientist
N. Jokela, adj. scientist
V. Keus, adj. scientist
J. Järvelä, grad. student
A. Keçeli, grad. student
A. Pönni, grad. student
J. Remes, grad. student
T. Tenkanen, grad. student
P. Tiitola, grad. student
S. Tähtinen, grad. student
H. Waltari, grad. student

QCD and Strongly Interacting Gauge Theory

T. Lappi, docent, proj. leader
K. J. Eskola, prof., adj. senior scientist
H. Paukkunen, scientist
Y. Zhu, scientist
H. Mäntysaari, grad. student
J. Peuron, grad. student
T. Rantalaiho, grad. student
J. Suorsa, grad. student

Nuclear Structure for Weak and Astrophysical Processes

M. Kortelainen, Dr., proj. leader
J. Dobaczewski, prof., adj. senior scientist
W. Satuła, prof., adj. senior scientist
J. Niskanen, docent, adj. senior scientist
T. Oishi, scientist
T. Haverinen, grad. student
J. Liimatainen, student

Domain Wall Dynamics

L. Laurson, Dr., proj. leader
V. Estévez Nuño, scientist
T. Herranen, grad. student

CMS Programme

P. Eerola, prof., programme director

CMS Experiment

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

CMS Upgrade

J. Härkönen, Dr., proj. leader
I. Kassamakov, senior scientist
P.-R. Luukka, senior scientist
E. Tuominen, senior scientist
T. Mäenpää, scientist
E. Tuovinen, scientist
T. Arsenovich, grad. student
A. Gädda, grad. student
A. Karadzhinova, grad. student
T. Peltola, grad. student
A. Winkler, grad. student
J. Juvelainen, trainee

Tier-2 Operations

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

TOTEM

K. Österberg, docent, proj. leader
H. Saarikko, prof., adj. senior scientist
T. Naaranoja, grad. student
F. Oljemark, grad. student
J. Welti, grad. student
L. Martikainen, student

Nuclear Matter Programme

A. Jokinen, prof., programme director

ALICE

J. Rak, prof., proj. leader
D. J. Kim, senior scientist
S. S. Räsänen, senior scientist
E. Brücken, scientist
T. Hildén, scientist
B. Chang, grad. student
T. Snellman, grad. student
M. Vargyas, grad. student
J. Viinikainen, grad. student

ISOLDE

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

FAIR

T. Grahn, Dr., proj. leader
E. Tuominen, proj. coordinator
F. García, lab. engineer
K. Rytkönen, lab. engineer
H. Penttilä, adj. scientist
S. Rinta-Antila, adj. scientist

ALICE-Forward

R. Orava, prof., proj. leader
V. Litichevskyi, scientist
M. Mieskolainen, grad. student

Technology Programme

S. Mäkinen, prof., programme director
F. Laurila, student

Accelerator Technology

M. Aicheler, Dr., proj. leader
F. Djurabekova, docent, senior scientist
K. Nordlund, prof., adj. senior scientist
V. Jansson, scientist
S. Parviainen, scientist
V. Zadin, adj. scientist
K. Avchachov, grad. student
E. Baibuz, grad. student
A. Korsbäck, grad. student
A. Leino, grad. student
A. Meriläinen, grad. student
R. Montonen, grad. student
M. Parekh, grad. student
A. Ruzibaev, grad. student
M. Veske, grad. student
S. Vigonski, grad. student
J. Väinölä, grad. student
R. Rajamäki, student

Green Big Data

J. K. Nurminen, prof., proj. leader
A.-P. Hameri, prof., senior scientist
T. Niemi, senior scientist (at CERN)
K. Khan, grad. student
J. Kommeri, grad. student
J. Strandman, grad. student
J. Eskonen, student
M. Hirki, student
A. Vartiainen, student

Biomedical Imaging

U. Ruotsalainen, prof., proj. leader
S. Ylipää, grad. student

Finnish Business Incubation Center of CERN Technology (BIC)

S. Mäkinen, prof., proj. leader
P. Kauttu, grad. student

Novel Instrumentation for Nuclear Safety, Security and Safeguards (NINS3)

P. Dendooven, prof., proj. leader
C. Bélanger-Champagne, scientist
P. Peura, scientist
T. Kerst, grad. student

Detector Laboratory

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

CLOUD

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

Planck-Euclid

H. Kurki-Suonio, docent, proj. leader
C. Kirkpatrick, scientist
M. Savelainen, adj. scientist
J. Väliviita, adj. scientist
E. Palmgren, grad. student
A.-S. Suur-Uski, grad. student
K. Kiiveri, student
V. Lindholm, 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 20th A. Ramallo (Santiago de Compostela, Spain)
Cold holographic matter

February 3rd S. Heinemeyer (Santander, Spain)
Higgs and supersymmetry

February 4th K. Freese (NORDITA, Stockholm, Sweden)
The dark side of the Universe

February 5th J. Pinfold (Edmonton, Canada)
The MoEDAL experiment at the LHC - a new light on the high energy frontier

February 10th K. Kajantie (Helsinki)
Phases and phase transitions of hot QCD with lots of massless quarks

February 17th J. Reuter (DESY, Germany)
Electroweak vector boson scattering at the LHC after the Higgs discovery

February 18th T. Alho (Reykjavik, Iceland)
Finite temperature monopole correlations in holographically flavored liquids

March 4th M. Kalliokoski (CERN, Switzerland)
Beam loss monitoring and machine protection of the LHC for Run 2

March 10th O. Taanila (NIKHEF, The Netherlands)
Analytical models of holographic thermalization

March 20th M. Långvik (Marseille, France)
Applications of conformal SU(2,2) transformations to spinfoams and spin-networks

March 26th L. Jenkovszky (Bogolyubov Institute for Theoretical Physics, National Ac. Sc. of Ukraine, Ukraine)
Regge factorization and diffraction dissociation at the LHC

April 7th A. Rebhan (Vienna, Austria)
Top-down holographic glueballs and their decay patterns

April 16th G. Cacciapaglia (IPN, Lyon, France)
Unveiling the dynamics behind a composite Higgs

April 23rd J. Louko (Nottingham, UK)
Did the chicken survive the firewall?

April 28th D. Sokolowska (Warsaw, Poland)
Dark matter in multi-scalar extensions of the Standard Model with discrete symmetries

May 12th H.-P. Nilles (Bonn, Germany)
Unification of fundamental interactions

May 19th Y. Bea (Santiago de Compostela, Spain)
Massive study of magnetized unquenched ABJM

June 2nd S. Pokorski (Warsaw, Poland)
Looking for hidden supersymmetry

June 9th H. Meyer (Mainz, Germany)
Real-time phenomena in finite-temperature QCD

June 11th C. Hoyos (Oviedo, Spain)
Ward identities and transport in 2+1 dimensions

August 18th J. Bekenstein (Hebrew University of Jerusalem, Israel)
Playing with quantum gravity on the tabletop

September 8th R. Fleischer (NIKHEF, The Netherlands)
In pursuit of new physics with B decays: theoretical status and prospects

September 10th A. Kurkela (CERN, Switzerland)
Hydrodynamisation in high energy nuclear collisions from QCD Lagrangian?

September 10th Y. C. Ong (NORDITA, Stockholm, Sweden)
Hawking evaporation time scale of black holes in Anti-de Sitter spacetime

September 29th J. M. No (Sussex, UK)
Probing the electroweak phase transition at LHC and beyond

October 6th J. Rantaharju (Odense, Denmark)
Lattice four-fermion interactions for beyond Standard Model physics

October 13th A. Cabo (La Habana, Cuba)
Is a generalized NJL model the effective action of massless QCD?

October 15th T. Alanne (CP3-Origins, Odense, Denmark)
Elementary Goldstone Higgs and raising the fundamental scale

October 20th T. Alho (Reykjavik, Iceland)
Geometric Algebra: a coordinate free formalism for inner product spaces

October 22nd T. Alho (Reykjavik, Iceland)
Geometric Algebra: a coordinate free formalism for inner product spaces (cont.)

October 27th A. Merle (MPI, Munich, Germany)
Sterile neutrino dark matter: from particle to astrophysics and back

November 3rd L. Bryngemark (Lund, Sweden)
Search for physics beyond the Standard Model using dijet distributions in ATLAS

November 5th D. Daverio (Geneva, Switzerland)
Large scale structure formation within a general relativistic framework

November 10th D. Salek (Amsterdam, The Netherlands)
Dark matter (and dark mediators) at the LHC

November 12th J. Park (Energy Matter Conversion Corporation, San Diego, USA)
Polywell fusion - electric fusion in a magnetic cusp

November 17th G. Itsios (Santiago de Compostela, Spain)
Exploring cold holographic matter

November 19th J. Nättilä (Tuorla, Turku)
Equation of state for the dense matter inside neutron stars using thermonuclear explosions

November 24th J. Ghiglieri (Bern, Switzerland)
Gravitational wave background from Standard Model physics

November 26th A. de Roeck (CERN, Switzerland)
The Large Hadron Collider: the present and the future

December 1st H. Weigert (Cape Town, South Africa)
QCD at small high energies: Wilson line correlators in the Color Glass Condensate and beyond

December 10th D. Milstead (Stockholm, Sweden)
A new high precision search for neutron-antineutron oscillations at the ESS

December 17th M. Krššák (Sao Paulo, Brazil)
Teleparallel gravity and the role of inertia in theories of gravity

December 18th V. Keränen (Oxford, UK)
Thermalization in the AdS/CFT duality

Visitors

Theory Programme

Cosmology of the Early and Late Universe

D. Mulryne (UK) 19.-30.1.
E. Majerotto (Spain) 28.-30.1.
P. Fleury (France) 3.-5.2.
F. Montanari (Switzerland) 9.-13.2.
J. Yokoyama (Japan) 11.-13.2.
F. Miniati (Switzerland) 23.-27.2.
D. Alonso (UK) 2.-5.3.
T. Takahashi (Japan) 23.-27.3.
S. M. Koksbang (Denmark) 14.-15.4.
O. Novikov (Russia) 16.4.
J. Louko (UK) 17.-26.4.
C. Caprini (France) 5.-7.5.
A. Mirizzi (Italy) 8.6.
N. Nunes (Portugal) 8.-12.6.
F. Ferrer (USA) 15.-19.6.
M. Kawasaki (Japan) 7.-15.7.
T. Markkanen (UK) 26.-28.8.
A. Kovacs (Spain) 22.-25.9.
M. Laine (Switzerland) 14.-15.10.
M. Joyce (France) 3.-5.11.
L. Krauss (USA) 12.-13.11.
B. Bassett (South Africa) 25.-28.11.
K. C. Chan (Spain) 30.11.-4.12., 9.12.
J. M. Cline (Canada) 2.-5.12.

High Energy Phenomenology in the LHC Era

A. V. Ramallo (Spain) 18.-24.1.
S. Heinemeyer (Spain) 2.-4.2.
T. Alho (Iceland) 16.-20.2., 18.-23.10.
O. Taanila (The Netherlands) 9.-13.3.
A. Rebhan (Austria) 6.-10.4.
G. Cacciapaglia (France) 15.-19.4.
J. Louko (UK) 22.-24.4.
D. Sokolowska (Poland) 27.-29.4.
Y. Bea (Spain) 11.-22.5.
H.-P. Nilles (Germany) 12.-13.5.
M. Ihl (Portugal) 17.-24.5.
S. Pokorski (Poland) 1.-3.6.
H. Mayer (Germany) 8.-10.6.
C. Hoyos (Spain) 8.-12.6.
R. Fleischer (The Netherlands) 7.-9.9.
A. Kurkela (Switzerland) 10.-11.9.
J. No (UK) 28.-30.9.
J. Rantaharju (Denmark) 5.-9.10.
T. Alanne (Denmark) 14.-16.10.
G. Itsios (Spain) 16.-23.11.
J. Nättilä (Finland) 18.-20.11.
H. Weigert (South Africa) 22.11.-7.12.
J. Ghiglieri (Switzerland) 23.-27.11.
C. Spethmann (Estonia) 8.-11.12.
M. Krššák (Brazil) 16.-18.12.
V. Keränen (UK) 18.12.

QCD and Strongly Interacting Gauge Theory

R. Paatelainen (Spain) 5.-9.1.
P. Huovinen (Germany) 12.-13.1.
D. Rischke (Germany) 14.-25.2.
J. Jalilian-Marian (USA) 10.-13.6.
I. Helenius (Sweden) 11.6., 4.12.
J. Auvinen (USA) 23.6.
H. Weigert (South Africa) 12.8.
S. Schlichting (USA) 14.-19.12.

Nuclear Structure for Weak and Astrophysical Processes

N. Hinohara (USA/Japan) 15.-27.3.
M. Konieczka (Poland) 22.8.-13.9.

CMS Programme

J. Park (USA) 12.-14.11.
A. Abhishek (India) 4.12.2015-21.4.2016

Nuclear Matter Programme

ALICE

P. Gasik (Germany) 23.-26.11.
M. Ball (Germany) 23.-27.11.
V. Ratza (Germany) 23.-27.11.

ALICE-Forward

J. Pinfold (Canada) 2.-5.2.
L. Jenkovszky (Ukraine) 25.-27.3.
A. De Roeck (Switzerland) 25.-27.11.

Technology Programme

Accelerator Technology

Z. Wang (China) 1.9.2014-15.10.2015
K. Kupka (Germany) 7.1.-7.2.
C. Trautmann (Germany) 17.-19.3.

Planck-Euclid

M. Reinecke (Germany) 19.-23.1.
D. Tavagnacco (Italy) 23.-26.3.
R. Keskitalo (USA) 3.7.

Conference participation, Talks and Visits by Personnel

Theory Programme

Cosmology of the Early and Late Universe

Nordic Winter School on Cosmology and Particle Physics,
2-7 January, Svingvoll, Norway (talk by T. Tenkanen, talk by V. Vaskonen)

Beyond LCDM Conference,
7-11 January, Oslo, Norway (talk by M. Lavinto, S. Räsänen)

Extended Theories of Gravity,
4-13 March, NORDITA, Stockholm, Sweden (T. Koivisto, talk by H. Nyrhinen)

Annual Meeting of the Finnish Physical Society,
17-19 March, Helsinki, Finland (talk by T. Tenkanen)

Kosmologietag Workshop,
6-8 May, Bielefeld, Germany (talk by T. Tenkanen)

Origin of Mass,
11-22 May, Odense, Denmark (talk by K. Kainulainen)

Neutrinos and Dark Matter in Nuclear Physics,
1-5 June, Jyväskylä, Finland (talk by K. Kainulainen)

Spacetime Odyssey Continues,
1-5 June, NORDITA, Copenhagen, Denmark (talk by K. Kainulainen)

One Hundred Years of Strong Gravity,
8-16 June, Instituto Superior Tecnico, Lisbon, Portugal (talk by H. Nyrhinen)

University of Jyväskylä,
17-18 June, Jyväskylä, Finland (T. Tenkanen)

University of Jyväskylä,
10-12 August, Jyväskylä, Finland (T. Tenkanen)

Current Themes in High Energy Physics and Cosmology,
17-21 August, Niels Bohr Institute, Copenhagen, Denmark (K. Kainulainen)

Calliolab DM & HIP Meeting,
2 September, University of Helsinki, Helsinki, Finland (talk by J. Virkajärvi)

COSMO'15 Conference,
7-11 September, Warsaw, Poland (talk by V.-M. Enckell, talk by S. Nurmi, talk by T. Tenkanen)

Particle Physics and Cosmology Meeting Workshop,
17-18 September, Tampere, Finland (talk by V.-M. Enckell, H. Jukkala, K. Kainulainen, talk by M. Lavinto, S. Nurmi, talk by H. Nyrhinen, S. Räsänen, talk by T. Tenkanen, talk by V. Vaskonen, J. Virkajärvi)

DESY Theory Workshop 2015: Physics at the LHC and Beyond,
29 September - 2 October, Hamburg, Germany (talk by T. Tenkanen, talk by V. Vaskonen)

University of Nottingham,
12-14 October, Nottingham, UK (talk by H. Nyrhinen)

University of Stavanger,
15 October - 10 November, Stavanger, Norway (talk by T. Tenkanen)

Imperial College London,
2-3 November, London, UK (talk by T. Tenkanen)

Queen Mary University of London,
4-5 November, London, UK (talk by T. Tenkanen)

King's College London,
6 November, London, UK (talk by T. Tenkanen)

University of Sussex,
9-10 November, Brighton, UK (talk by T. Tenkanen)

ICG Portsmouth,
11 November, Portsmouth, UK (talk by T. Tenkanen)

NORDITA,
16-17 November, Stockholm, Sweden (talk by T. Tenkanen)

CP3 Origins,
18-20 November, Odense, Denmark (T. Tenkanen)

NORDITA,
18 November - 9 December, Stockholm, Sweden (H. Nyrhinen)

University of Münster,
19 November, Münster, Germany (talk by T. Tenkanen)

University of Bielefeld,
20 November, Bielefeld, Germany (talk by T. Tenkanen)

University of Heidelberg,
21-23 November, Heidelberg, Germany (talk by T. Tenkanen)

Particle Physics Day 2015,
30 November, Helsinki, Finland (talk by T. Tenkanen)

University of California,
30 November - 4 December, Los Angeles, CA, USA (talk by T. Tenkanen)

Stanford University,
7-11 December, Palo Alto, CA, USA (talk by T. Tenkanen)

CP3 Origins,
8-9 December, Odense, Denmark (talk by S. Räsänen)

NORDITA,
10-14 December, Copenhagen, Denmark (talk by S. Räsänen)

28th Texas Symposium on Relativistic Astrophysics,
13-18 December, Geneva, Switzerland (talk by F. Montanari)

Dark Cosmology Centre,
14 December, Copenhagen, Denmark (talk by S. Räsänen)

Dark Matter - Cairo Workshop,
14-17 December, Cairo, Egypt (talk by V. Vaskonen)

University of California,
14-18 December, Berkeley, CA, USA (T. Tenkanen)

High Energy Phenomenology in the LHC Era

NIKHEF,
27-29 January, Amsterdam, The Netherlands (talk by A. Vuorinen)

Oxford University,
22-24 February, Oxford, UK (talk by A. Vuorinen)

University of Sussex,
25-26 February, Brighton, UK (talk by A. Vuorinen)

Origin of Mass and Strong Coupling Gauge Theories (SCGT15),
3-6 March, Nagoya, Japan (talk by K. Tuominen)

Gauge/Gravity Duality 2015,
13-17 April, Florence, Italy (talk by N. Jokela)

Holographic Methods for Strongly Coupled Systems,
13-24 April, Florence, Italy (N. Jokela)

Holographic Methods for Strongly Coupled Systems,
13 April - 1 May, Florence, Italy (talk by T. Zingg)

sQGP and Extreme QCD,
11-18 May, KITPC, Beijing, China (talks by A. Vuorinen)

International Workshop on Condensed Matter Physics & AdS/CFT,
25-29 May, Kavli IPMU, Kashiwa Campus, University of Tokyo, Japan (talk by T. Zingg)

Iberian Strings 2015,
27-29 May, Salamanca, Spain (talk by J. Järvelä)

Annual Meeting of NewComStar COST Action,
16-18 June, Budapest, Hungary (talk by A. Vuorinen)

The Neutron Star Radius, And All That Jazz,
19 June - 2 July, McGill University, Montreal, Canada (talk by A. Vuorinen)

Strings 2015,
22-26 June, Bengaluru, India (N. Jokela)

Lattice Gauge Theory Simulations Beyond the Standard Model of Particle Physics,
22-26 June, Tel Aviv, Israel (talk by K. Tuominen)

Equilibration Mechanisms in Weakly and Strongly Coupled Quantum Field Theory,
3-22 August, Seattle, WA, USA (J. Järvelä, A. Pönni, A. Vuorinen, organiser)

APCTP Focus Program: Holography and its Applications,
6-14 August, Pohang, South Korea (talk by K. Tuominen)

27th International Symposium on Lepton Photon Interactions,
17-21 August, Ljubljana, Slovenia (talk by A. Vuorinen)

Mathematica Summer School on Theoretical Physics,
24-29 August, Waterloo, Canada (A. Pönni)

TH Division, CERN,
14-17 September, Geneva, Switzerland (A. Vuorinen)

Cosmology and Particle Physics Meeting,
17-18 September, Tampere, Finland (talk by A. Pönni)

International Workshop on Holography and Condensed Matter,
23-26 September, Perugia, Italy (talk by N. Jokela)

Applications of Gauge/Gravity Duality 2015,
21-23 October, Chalmers University of Technology, Gothenburg, Sweden (talk by N. Jokela, talk by T. Zingg)

Holography: Entangled, Applied and Generalized,
26-30 October, Copenhagen, Denmark (A. Pönni)

QCD and Strongly Interacting Gauge Theory

Nordic Winter School on Cosmology and Particle Physics,
2-7 January, Gausdal, Norway (J. Peuron)

NORDITA Winter School 2015 on Theoretical Particle Physics,
7-16 January, Stockholm, Sweden (J. Peuron)

Advanced Threading and Optimization,
24-26 February, CSC, Espoo, Finland (J. Peuron)

Annual Meeting of the Finnish Physical Society,
17-19 March, Helsinki, Finland (talk by K. J. Eskola, T. Lappi)

Brookhaven National Laboratory,
21-25 April, Upton, NY, USA (T. Lappi)

DIS 2015 XXIII International Workshop on Deep-Inelastic Scattering and Related Subjects,
27 April - 1 May, Dallas, TX, USA (invited talk by T. Lappi)

Brookhaven National Laboratory,
3-14 May, Upton, NY, USA (T. Lappi)

CERN,
1-6 June, Geneva, Switzerland (J. Peuron)

Brookhaven National Laboratory,
16-27 June, Upton, NY, USA (T. Lappi)

Hard Probes 2015,
29 June - 3 July, Montreal, Canada (talk by K. J. Eskola, invited talk by T. Lappi, H. Mäntysaari)

Equilibration Mechanisms in Weakly and Strongly Coupled Quantum Field Theory,
24-29 August, Seattle, WA, USA (talk by T. Lappi, J. Peuron)

Quark Matter 2015,
27 September - 3 October, Kobe, Japan (talk by T. Lappi)

New Progress in Heavy Ion Collision: What is Hot in the QGP,
5-9 October, Wuhan, China (invited talk by T. Lappi)

Introduction to Parallel Programming,
20-22 October, CSC, Espoo, Finland (J. Peuron)

Universidad de Santiago de Compostela,
21-23 October, Santiago de Compostela, Spain (H. Paukkunen)

PDF4LHC Meeting,
27 October, CERN, Geneva, Switzerland (invited talk by H. Paukkunen)

Particle Physics Day 2015,
30 October, Helsinki, Finland (K. J. Eskola, T. Lappi, talk by J. Peuron, talk by Y. Zhu)

Zimanyi Winter School on Heavy Ion Physics,
7-11 December, Budapest, Hungary (invited talk by T. Lappi)

Introduction to Accelerators,
8-10 December, CSC, Espoo, Finland (J. Peuron)

Nuclear Structure for Weak and Astrophysical Processes

13th Nordic Meeting on Nuclear Physics,
13-17 April, Saariselkä, Finland (talk by T. Oishi)

Nuclear Structure and Dynamics III,
14-19 June, Portoroz, Slovenia (talk by M. Kortelainen)

The Future of Multireference Density Functional Theory Workshop,
25-26 June, University of Warsaw, Warsaw, Poland (talk by M. Kortelainen, talk by T. Oishi)

The 5th International Conference on Proton-Emitting Nuclei (PROCON2015),
6-10 July, Institute of Modern Physics, Chinese Academy of Science, Lanzhou, China (talk by T. Oishi)

NORDITA Master Class in Physics 2015,
8-14 August, Ishøj, Denmark (T. Haverinen)

Information and Statistics in Nuclear Experiment and Theory ISNET-3,
16-20 November, ECT*, Trento, Italy (talk by T. Haverinen, talk by M. Kortelainen)

Collaboration Meeting,
1-4 December, IPNL, Lyon, France (talk by T. Haverinen, talk by M. Kortelainen, talk by T. Oishi)

Domain Wall Dynamics

Workshop on Complex Systems,
15 January, Università degli Studi di Milano, Milan, Italy (invited talk by L. Laurson)

Workshop on Avalanche Shapes,
2-4 March, Courmayeur, Italy (L. Laurson, organiser)

Annual Meeting of the Finnish Physical Society,
17-19 March, Helsinki, Finland (L. Laurson, session chairman)

Ghent University,
8-10 June, Ghent, Belgium (L. Laurson)

Recent Trends in Nanomagnetism, Spintronics and their Applications (RTNSA 2015),
30 June - 3 July, Ordizia, Spain (talk by V. Estévez)

International Conference on Magnetism,
5-10 July, Barcelona, Spain (V. Estévez, T. Herranen)

CNRS, École Normale Supérieure de Lyon,
9 October - 7 November, Lyon, France (L. Laurson)

CMS Programme

CMS Data Analysis School,
19-23 January, Bari, Italy (J. Pekkanen)

Medical Imaging, Dosimetry and Hadron Therapy - Semiconductor Radiation Detectors Point of View,
23 January, Jyväskylä, Finland (talk by J. Härkönen)

Studia Generalia,
5 February, Helsinki, Finland (talk by L. Wendland)

Finnish Society for Natural Philosophy,
17 February, Helsinki, Finland (talk by T. Peltola)

10th Anniversary "Trento" Workshop on Advanced Silicon Detectors,
17-19 February, Trento, Italy (talk by J. Härkönen)

Higgs Workshop,
27 February, CERN, Switzerland (talk by L. Wendland)

The Finnish Society for Futures Studies Seminar,
10 March, Helsinki, Finland (talk by T. Lindén)

Tekniska Föreningen i Finland (TFiF) Seminar on Nuclear Energy,
12 March, Helsinki, Finland (talk by T. Lindén)

50th Rencontres de Moriond EW,
14-21 March, La Thuile, Italy (plenary talk by M. Voutilainen)

Annual Meeting of the Finnish Physical Society,
17-19 March, Helsinki, Finland (talk by J. Heikkilä, talk by T. Järvinen, T. Lindén, talk by J. Pekkanen, talk by T. Peltola, L. Wendland)

CERN Colloquium,
26 March, Geneva, Switzerland (talk by T. Lindén)

2015 WLCG Collaboration Workshop,
11-12 April, Okinawa, Japan (T. Lindén)

21st International Conference on Computing in High Energy and Nuclear Physics (CHEP),
13-17 April, Okinawa, Japan (T. Lindén)

CMS Week,
4-8 May, CERN, Switzerland (talk by M. Voutilainen)

Nordic e-Infrastructure Collaboration Conference 2015,
5-8 May, Espoo, Finland (T. Lindén, talk by S. Toor)

DASPOS HEP Data Model Workshop,
18-20 May, University of Notre Dame, South Bend, IN, USA (K. Lassila-Perini)

RD39 Status Report, 122nd LHCC Open Session,
3-4 June, CERN, Switzerland (talk by J. Härkönen)

The 24th International Workshop on Vertex Detectors,
4 June, Santa Fe, NM, USA (talk by T. Peltola)

DPHEP Collaboration Workshop,
8-10 June, CERN, Switzerland (talk by K. Lassila-Perini)

CMS Phase I Pixel Upgrade Workshop,
8-10 June, Visegrad, Hungary (talk by P. Luukka)

26th RD50 Workshop,
22-24 June, Santander, Spain (talk by T. Peltola and E. Tuovinen)

CMS Physics Week,
22-25 June, CERN, Switzerland (talk by K. Lassila-Perini, M. Voutilainen)

EDS Blois,
28 June - 5 July, Borgo, Corsica, France (M. Voutilainen, session co-chair)

JetMET Workshop,
7-10 July, Lyon, France (M. Voutilainen, organiser)

The 2015 Europhysics Conference on High Energy Physics,
22-28 July, Vienna, Austria (talk by P. Eerola)

Kafkas University,
16-19 September, Kars, Turkey (M. Voutilainen)

10th international "Hiroshima" Symposium on Development and Application of Semiconductor Tracking Detectors,
25 September, Xi'an, China (talk by J. Härkönen)

CMS Week,
19-23 October, CERN, Switzerland (M. Voutilainen)

2015 Functional Materials Technology and Industry Forum,
20 October, Xiangtan, China (talk by J. Härkönen)

Research Training Course in Detector Technology for Particle Physics,
26 October - 6 November, Copenhagen, Denmark and Helsinki, Finland (J. Pekkanen)

De Finlandssvenska Fysik- och Kemidagarna,
13-15 November, Helsinki, Finland - Stockholm, Sweden (T. Lindén)

CMS Physics Week,
7-11 December, CERN, Switzerland (talk by K. Lassila-Perini, talk by T. Lindén, talk by M. Voutilainen)

Higgs to Taus Workshop,
18 December, CERN, Switzerland (talk by L. Wendland)

TOTEM

European School in Instrumentation for Particle and Astroparticle Physics (ESIPAP) 2015,
26 January - 21 March, Archamps, France (T. Naaranoja)

Annual Meeting of the Finnish Physical Society,
17-19 March, Helsinki, Finland (F. Oljemark, J. Welti, K. Österberg)

Tuscany TOTEM Collaboration Meeting,
12-18 April, Caprese Michelangelo, Italy (F. Garcia, talks by T. Naaranoja and K. Österberg)

Third Annual Conference on LHC Physics (LHCP 2015),
31 August - 5 September, St. Petersburg, Russia
(talks by H. Saarikko and K. Österberg)

LHC Working Group on Forward Physics and Diffraction,
27-28 October, CERN, Geneva, Switzerland
(talk by K. Österberg)

CERN,
29 October - 12 December, Geneva, Switzerland
(F. Oljemark)

Particle Physics Day 2015,
30 October, Helsinki, Finland (talk by K. Österberg)

De Finlandssvenska Fysik- och Kemidagarna,
13-15 November, Helsinki, Finland - Stockholm, Sweden
(talk by K. Österberg)

LHC Minimum Bias and Underlying Event Working Group,
19 November, CERN, Geneva, Switzerland
(talk by K. Österberg)

PAPU Day 2015,
2 December, Helsinki, Finland
(talks T. Naaranoja and J. Welti)

LHC RRB Meetings,
CERN, Geneva, Switzerland (K. Österberg)

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

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

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

CMS-TOTEM Combined Analysis Meetings,
CERN, Geneva, Switzerland (talks by J. Welti, co-organised by K. Österberg)

Nuclear Matter Programme

ALICE

School of ROC,
23-27 March, Munich, Germany (E. Brücken, T. Hildén)

4th International Conference on Micro-Pattern Gaseous Detectors,
12-15 October, Trieste, Italy (E. Brücken, T. Hildén)

RD51 Collaboration Meeting,
16-17 October, Trieste, Italy (talk by E. Brücken)

ISOLDE

13th Nordic Meeting on Nuclear Physics,
13-17 April, Saariselkä, Finland (talk by J. Pakarinen, talk by P. Papadakis)

TSR@ISOLDE Workshop,
27-28 April, Geneva, Switzerland (T. Grahn, J. Pakarinen)

ISTROS 2015 Conference,
1-6 May, Častá-Papiernička, Slovakia (talk by J. Pakarinen)

ISOLDE Seminar,
17 June, Geneva, Switzerland (talk by J. Pakarinen)

CERN Corresponding Associate,
1 July - 31 December, Geneva, Switzerland (J. Pakarinen)

Reflections on the Atomic Nucleus Conference,
28-30 July, Liverpool, UK (talk by J. Pakarinen)

Physics Division Seminar,
14 September, Argonne, IL, USA (talk by T. Grahn)

HELIOS@ISOLDE Meeting,
29 September, Daresbury, UK (J. Pakarinen)

MINIBALL Workshop,
1 December, Geneva, Switzerland (J. Pakarinen)

ISOLDE Workshop,
2-4 December, Geneva, Switzerland (talk by J. Pakarinen)

FAIR

Annual Meeting of the Finnish Physical Society,
17-19 March, Helsinki, Finland (talk by T. Grahn)

13th Nordic Meeting on Nuclear Physics,
13-17 April, Saariselkä, Finland (talk by T. Grahn)

Super-FRS Collaboration Meeting,
22-24 April, Walldorf, Germany (talk by T. Grahn)

ISTROS 2015 Conference,
1-6 May, Častá-Papiernička, Slovakia (talk by T. Grahn)

RIPS25 Symposium,
6-7 December, Shonan, Japan (T. Grahn)

ALICE-Forward

Ukrainian Academy of Sciences,
27-30 May, Kiev, Ukraine (invited lecture by R. Orava)

WE Hereaus School on Diffractive and Electromagnetic Processes at High Energies,
17-20 August, Bad Honnef, Germany (talk by M. Mieskolainen, invited lectures by R. Orava)

AD ALICE Collaboration Meetings,
15-25 October, CERN, Geneva, Switzerland
(invited seminars by V. Litichevskyi)

XV Mexican Workshop on Particles and Fields,
8 December, Mazatlan, Sinaloa, Mexico
(invited plenary presentation by R. Orava)

BUAP,
11 December, Mexico City (Puebla), Mexico
(invited seminar by R. Orava)

FIT Collaboration Meeting,
17 December, CERN, Geneva, Switzerland
(invited seminar by V. Litichevskyi)

ALICE Diffractive PWG Meetings,
CERN, Geneva, Switzerland (presentations by M. Mieskolainen)

ALICE AD, FIT and Diffractive PWG Meetings,
CERN, Geneva, Switzerland (presentations by R. Orava)

MoEDAL Collaboration Meetings,
CERN Geneva, Switzerland (presentations by R. Orava)

Technology Programme

Accelerator Technology

CLIC Annual Meeting,
25-31 January, CERN, Geneva, Switzerland
(E. Baibuz, F. Djurabekova, talk by V. Jansson, K. Nordlund, S. Parviainen)

CLIC Workshop 2015,
26-30 January, CERN, Geneva, Switzerland
(M. Aicheler, talk by A. Meriläinen, talk by R. Montonen, J. Väinölä, K. Österberg)

TRNM Workshop,
7-11 February, Levi, Finland (F. Djurabekova)

Brokerage Event for ICT25 Call Organized by EU Commission,
17-19 February, Brussels, Belgium (F. Djurabekova)

Annual Meeting of the Finnish Physical Society,
17-19 March, Helsinki, Finland (E. Baibuz, talk by V. Jansson, A. Meriläinen, R. Montonen, S. Parviainen, M. Veske, S. Vigonski)

Meeting with Y. Ashkenazi Group,
22-24 March, CERN, Geneva, Switzerland
(talk by F. Djurabekova, M. Veske, S. Vigonski)

OECD-NEA 11th WPMM Extended Meeting,
4-6 May, Paris, France (invited talk by F. Djurabekova)

International Conference on Swift Heavy Ions in Matter (SHIM),
18-21 May, Darmstadt, Germany
(F. Djurabekova, A. Leino, K. Nordlund)

DPCME Spring Seminar 2015,
22 May - 1 June, Brisbane, Australia (talk by R. Montonen)

International Workshop on Breakdown Science and High Gradient Technology (HG2015),
16-19 June, Beijing, China (talk by V. Jansson, M. Veske)

SPIE Optical Metrology 2015,
22-25 June, Munich, Germany (R. Montonen)

International Workshop Nanopartening-2015,
12-15 July, Krakow, Poland (F. Djurabekova)

International Nanoelectronics Conference (IVNC-28),
13-17 July, Guangzhou, China (talk by E. Baibuz, S. Parviainen)

International Conference on Defects in Semiconductors (ICDS),
28-31 July, Espoo, Finland (F. Djurabekova)

International Conference on Ion Solid Interactions (ISI),
20-24 August, Moscow, Russia (F. Djurabekova, international committee member)

International Workshop "Mechanisms of Vacuum Arcs" (MeVARC-5),
1-5 September, Saariselkä, Finland (talk by E. Baibuz, talk by F. Djurabekova, talk by V. Jansson, talk by A. Meriläinen, K. Nordlund, M. Parekh, talk by S. Parviainen, talk by M. Veske, talk by S. Vigonski, talk by V. Zadin)

E-MRS 2015 Fall Meeting,
15-18 September, Warsaw, Poland
(talk by V. Jansson, talk by M. Veske, talks by V. Zadin)

Festschrift Conference REM-8 for Peter Sigmund,
20-23 September, Kerteminde, Denmark (F. Djurabekova)

MEXAT Atom Probe Workshop,
12-16 October, Roen, France (invited talk by S. Parviainen)

International School on Simulation of Ion Beam Irradiation and its Effects,
24-25 October, Jaipur, India (invited lecture by F. Djurabekova)

International Conference on Radiation Effects in Insulators (REI-18),
26-31 October, Jaipur, India (talk by F. Djurabekova, talk by A. Leino)

Ninth International Accelerator School for Linear Colliders,
26 October - 6 November, Whistler, British Columbia, Canada (M. Aicheler)

Particle Physics Day 2015,
30 October, Helsinki, Finland (talk by V. Jansson)

University of Kassel,
2-8 November, Kassel, Germany (R. Montonen)

De Finlandssvenska Fysik- och Kemidagarna,
13-15 November, Helsinki, Finland - Stockholm, Sweden (V. Jansson, S. Parviainen)

FAIR Meeting,
26 November, Jyväskylä, Finland (talk by F. Djurabekova)

PAPU Day 2015,
10 December, Helsinki, Finland (talk by R. Montonen)

Novel Instrumentation for Nuclear Safety, Security and Safeguards (NINS3)

13th Nordic Meeting on Nuclear Physics,
13-17 April, Saariselkä, Finland (invited talk by P. Dendooven)

Northern Optics & Photonics 2015,
1-6 June, Rauha, Finland (T. Kerst)

The Millennium Technology Prize Event: Panel Discussion on "Sensory and Imaging Technology in Science, Health and Security",
30 June, CERN, Geneva, Switzerland
(invited talk and panel discussion by P. Dendooven)

34th Mazurian Lakes Conference on Physics,
6-13 September, Piaski, Poland
(invited talk by P. Dendooven)

UGET Phase1 Review Meeting,
29-30 September, Vienna, Austria (P. Peura)

Budapest University of Technology and Economics,
8-12 October, Budapest, Hungary
(C. Bélanger-Champagne, P. Dendooven)

CANBERRA BeNeLux & Scandinavia Users' Group Meeting,
13-15 October, Helsinki, Finland (C. Bélanger-Champagne, P. Dendooven, T. Kerst, P. Peura)

Symposium on the Future Prospects for Photonics,
5-6 November, Tampere, Finland (T. Kerst)

MATINE Research Seminar,
18 November, Helsinki, Finland (P. Peura)

Helsinki University,
8 December, Helsinki, Finland (T. Kerst)

Planck-Euclid

Beyond LambdaCDM Conference,
13-17 January, Oslo, Norway (J. Väliviita)

Euclid Garage Days,
10-14 February, Barcelona, Spain (C. Kirkpatrick, H. Kurki-Suonio)

Planck LFI Core Team Meeting,
11-13 February, Bologna, Italy (A.-S. Suur-Uski)

Euclid Consortium Board Meeting,
27 February, Paris, France (H. Kurki-Suonio)

Euclid SGS System Team Meeting,
17-19 March, Paris, France (C. Kirkpatrick, H. Kurki-Suonio, V. Lindholm)

Euclid OU-SIM Meeting,
16-17 April, Barcelona, Spain (C. Kirkpatrick, H. Kurki-Suonio)

Planck LFI Core Team Meeting,
11-12 May, Bologna, Italy (talk by K. Kiiveri, H. Kurki-Suonio, A.-S. Suur-Uski)

Euclid Consortium Meeting,
7-12 June, Lausanne, Switzerland (C. Kirkpatrick, H. Kurki-Suonio, J. Väliviita)

Nordic Optical Telescope, Instituto de Canarias,
5-8 September, La Palma, Spain (C. Kirkpatrick)

COSMO-15,
7-11 September, Warsaw, Poland (talk by E. Palmgren)

Planck LFI Core Team Meeting,
17-18 September, Bologna, Italy (K. Kiiveri, talk by H. Kurki-Suonio, E. Palmgren)

Euclid Consortium Board Meeting,
24-25 September, Oslo, Norway (H. Kurki-Suonio)

Euclid Garage Days,
7-9 October, Munich, Germany (H. Kurki-Suonio)

Euclid Developers Workshop,
20-23 October, Geneva, Switzerland (C. Kirkpatrick, H. Kurki-Suonio)

Planck LFI Core Team Meeting,
18-19 November, Bologna, Italy (A.-S. Suur-Uski)

Nordic Optical Telescope, Instituto de Canarias,
6-10 December, La Palma, Spain (C. Kirkpatrick)

Euclid Consortium Board Meeting,
11 December, Paris, France (H. Kurki-Suonio)

Euclid SGS System Team Meeting,
15-16 December, Edinburgh, UK (C. Kirkpatrick)

Publications

Theory Programme

Cosmology of the Early and Late Universe

S. Räsänen in T. Buchert et al.,
Is there proof that backreaction of inhomogeneities is irrelevant in cosmology?,
Class. Quantum Grav. 32 (2015) 215021

K. Enqvist, D. J. Mulryne, and S. Nurmi,
Resolving primordial physics through correlated signatures,
J. Cosmol. Astropart. Phys. 05 (2015) 010

K. Enqvist, S. Nadathur, T. Sekiguchi, and T. Takahashi,
Decaying dark matter and the tension in σ_8,
J. Cosmol. Astropart. Phys. 09 (2015) 067

A. Golovnev, M. Karčiauskas, and H. J. Nyrhinen,
ADM analysis of gravity models within the framework of bimetric variational formalism,
J. Cosmol. Astropart. Phys. 05 (2015) 021

M. Herranen, T. Markkanen, S. Nurmi, and A. Rajantie,
Spacetime curvature and Higgs stability after inflation,
Phys. Rev. Lett. 115 (2015) 241301

M. Hindmarsh, S. J. Huber, K. Rummukainen, and D. J. Weir,
Numerical simulations of acoustically generated gravitational waves at a first order phase transition,
Phys. Rev. D 92 (2015) 123009

K. Horiguchi, K. Ichiki, T. Sekiguchi, and N. Sugiyama,
Primordial magnetic fields from self-ordering scalar fields,
J. Cosmol. Astropart. Phys. 04 (2015) 007

S. Hotchkiss, S. Nadathur, S. Gottlöber, I. T. Iliev, A. Knebe, W. A. Watson, and G. Yepes,
The Jubilee ISW Project - II. Observed and simulated imprints of voids and superclusters on the cosmic microwave background,
Mon. Not. R. Astron. Soc. 446 (2015) 1321

K. Kainulainen, K. Tuominen, and J. Virkajärvi,
A model for dark matter, naturalness and a complete gauge unification,
J. Cosmol. Astropart. Phys. 07 (2015) 034

M. Kawasaki, K. Saikawa, and T. Sekiguchi,
Axion dark matter from topological defects,
Phys. Rev. D 91 (2015) 065014

K. Kettula et al.,
CFHTLenS: weak lensing calibrated scaling relations for low-mass clusters of galaxies,
Mon. Not. R. Astron. Soc. 451 (2015) 1460

M. Lavinto and S. Räsänen,
CMB seen through random Swiss Cheese,
J. Cosmol. Astropart. Phys. 10 (2015) 057

T. Markkanen,
Curvature induced running of the cosmological constant,
Phys. Rev. D 91 (2015) 124011

T. Markkanen, S. Räsänen, and P. Wahlman,
Inflation without quantum gravity,
Phys. Rev. D 91 (2015) 084064

K. Kettula in M. Mirkazemi et al.,
Brightest X-ray clusters of galaxies in the CFHTLS wide field: catalog and optical mass estimator,
Astrophys. J. 799 (2015) 60

H. F. S. Mota and M. Hindmarsh,
Big-bang nucleosynthesis and gamma-ray constraints on cosmic strings with a large Higgs condensate,
Phys. Rev. D 91 (2015) 043001

S. Nadathur and S. Hotchkiss,
The nature of voids - II. Tracing underdensities with biased galaxies,
Mon. Not. R. Astron. Soc. 454 (2015) 889

S. Nadathur and S. Hotchkiss,
The nature of voids - I. Watershed void finders and their connection with theoretical models,
Mon. Not. R. Astron. Soc. 454 (2015) 2228

S. Nadathur, S. Hotchkiss, J. M. Diego, I. T. Iliev, S. Gottlöber, W. A. Watson, and G. Yepes,
Self-similarity and universality of void density profiles in simulation and SDSS data,
Mon. Not. R. Astron. Soc. 449 (2015) 3997

S. Nurmi, T. Tenkanen, and K. Tuominen,
Inflationary imprints on dark matter,
J. Cosmol. Astropart. Phys. 11 (2015) 001

A. Ota, T. Sekiguchi, Y. Tada, and S. Yokoyama,
Anisotropic CMB distortions from non-Gaussian isocurvature perturbations,
J. Cosmol. Astropart. Phys. 03 (2015) 013

D. Regan and M. Hindmarsh,
The bispectrum of matter perturbations from cosmic strings,
J. Cosmol. Astropart. Phys. 03 (2015) 008

D. Regan and M. Hindmarsh,
The bispectrum of cosmic string temperature fluctuations including recombination effects,
J. Cosmol. Astropart. Phys. 10 (2015) 030

S. Räsänen, K. Bolejko, and A. Finoguenov,
New test of the Friedmann-Lemaître-Robertson-Walker metric using the distance sum rule,
Phys. Rev. Lett. 115 (2015) 101301

J. Väliviita and E. Palmgren,
Distinguishing interacting dark energy from wCDM with CMB, lensing, and baryon acoustic oscillation data,
J. Cosmol. Astropart. Phys. 07 (2015) 015

High Energy Phenomenology in the LHC Era

G. Aarts, C. Allton, A. Amato, P. Giudice, S. Hands, and J.-I. Skullerud,
Electrical conductivity and charge diffusion in thermal QCD from the lattice,
J. High Energy Phys. 02 (2015) 186

T. Alanne, H. Gertov, F. Sannino, and K. Tuominen,
Elementary Goldstone Higgs boson and dark matter,
Phys. Rev. D 91 (2015) 095021

T. Alho, M. Järvinen, K. Kajantie, E. Kiritsis, and K. Tuominen,
Quantum and stringy corrections to the equation of state of holographic QCD matter and the nature of the chiral transition,
Phys. Rev. D 91 (2015) 055017

A. Amato, P. Giudice, and S. Hands,
Hadron wave functions as a probe of a two-color baryonic medium,
Eur. Phys. J. A 51 (2015) 39

M. Antola, S. Di Chiara, and K. Tuominen,
Ultraviolet complete technicolor and Higgs physics at LHC,
Nucl. Phys. B 899 (2015) 55

P. Bandyopadhyay and E. J. Chun,
Lepton flavour violating signature in supersymmetric U(1)' seesaw models at the LHC,
J. High Energy Phys. 05 (2015) 045

P. Bandyopadhyay, K. Huitu, and A. S. Keçeli,
Multi-lepton signatures of the triplet like charged Higgs at the LHC,
J. High Energy Phys. 05 (2015) 026

Y. Bea, N. Jokela, M. Lippert, A. V. Ramallo, and D. Zoakos,
Flux and Hall states in ABJM with dynamical flavors,
J. High Energy Phys. 03 (2015) 009

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