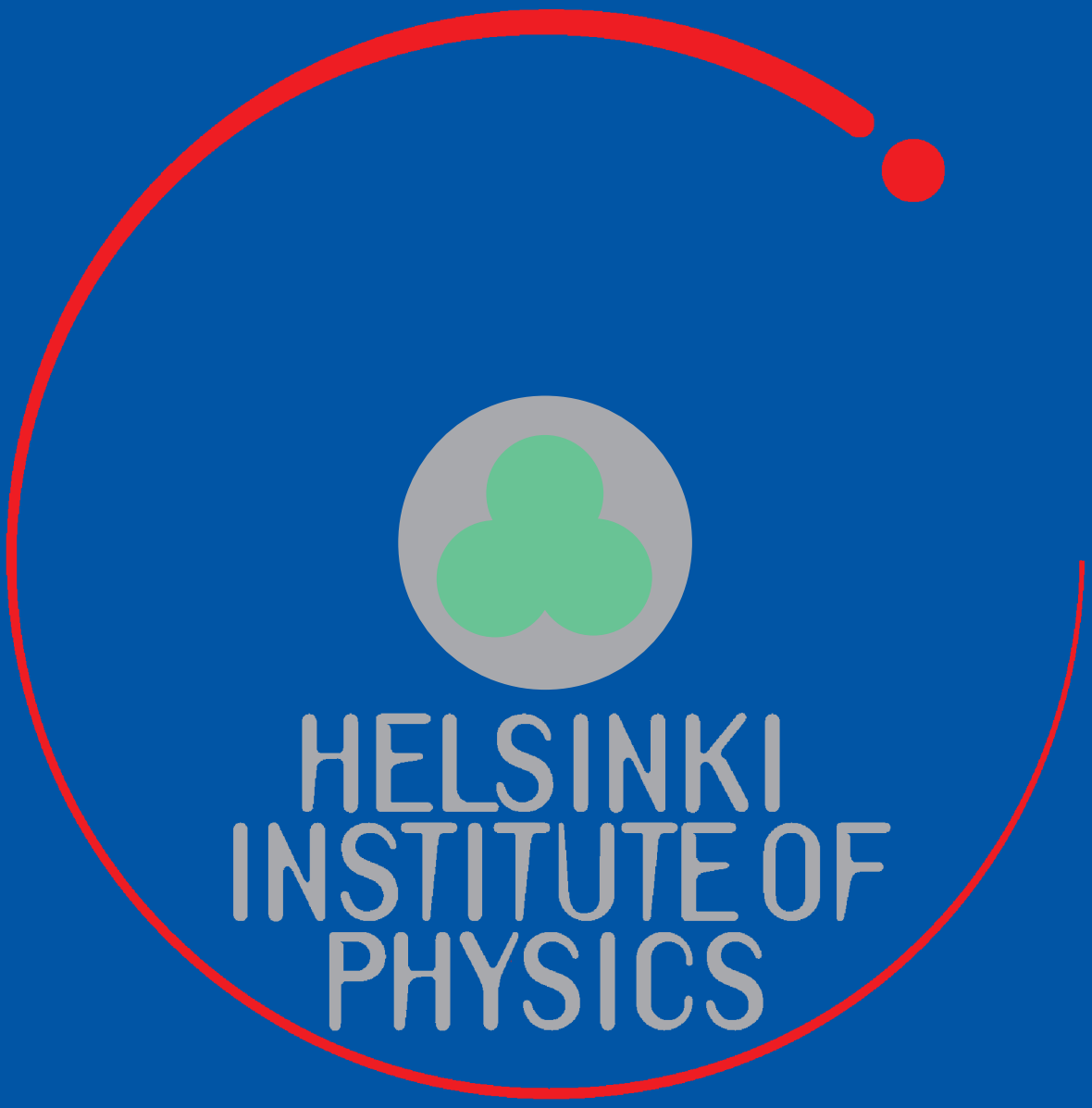
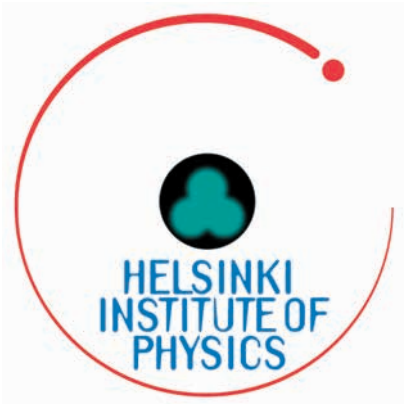


HELSINKI INSTITUTE OF PHYSICS

Annual Report 2017



Annual Report 2017

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The FAIR Groundbreaking event on July 4th, 2017. HIP Director, Professor Paula Eerola on the left. (*Courtesy of G. Otto for FAIR/GSI.*)

Annual Report 2017 Helsinki Institute of Physics

Contents

Preface

Paula Eerola

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, medical applications, and climate research. HIP is operated by the University of Helsinki, Aalto University, the University of Jyväskylä, Lappeenranta University of Technology and Tampere University of Technology. The Institute has, since 1997, had a national mandate from the Finnish Ministry of Education and Culture to co-ordinate the collaboration between CERN and Finland. HIP is also responsible for co-ordination of the Finnish activities at the planned international Facility for Antiproton and Ion Research (FAIR) in Darmstadt, Germany.

The research activities of HIP in 2017 consisted of four main research programmes: the Theory Programme; the CMS Programme including the CMS and TOTEM experiments; the Nuclear Matter Programme including involvements in the ALICE experiment, ISOLDE, and the FAIR facility; and the Technology Programme, with five applied research projects. In addition, there were three independent research projects: Planck-Euclid, CLOUD, and Education and Open Data. The Detector Laboratory served as a general facility for the Institute.

The year 2017 was a busy year. The Large Hadron Collider (LHC) at CERN reached new records both in terms of data quantity and collision intensity. The research efforts produced a wealth of scientific papers and theses, and new sets of instrumentation were successfully installed. A major milestone for FAIR was reached in July 2017, when the FAIR site construction was started with the Groundbreaking ceremony.

Finnish high energy physics was evaluated by two different committees: by HIP's own Scientific Advisory Board, and also by the European Committee for Future Accelerators (ECFA), which paid a visit to Finland in May. Both committees highlighted the benefits of the Finnish model of national co-ordination by HIP that serves as a model for other CERN member states. The extensive school activities were another success story. Other success stories were the local CMS and TOTEM co-operation, commitments to CMS and ALICE Phase 1 upgrades, theory activities, and the synergies of nuclear physics at CERN, at FAIR and in the Jyväskylä Accelerator Laboratory.

We were particularly busy with improving Finnish industry and business contacts with CERN. In April we organised, together with CERN, the CERN Roadshow in Finland. The event, which took place at the Aalto Design Factory, brought together experts from CERN and Finnish companies, career services and public stakeholders. The overarching theme of the event was "CERN is a Finnish laboratory". The event was attended by about 150 participants. In November we organised, together with the Finnish Embassy in Geneva and the Finnish Commerce Guild in Geneva, a Finland at CERN -event, showcasing Finnish inventive expertise with a programme consisting of inspirational speakers and workshops. The main event, celebrating also the centenary anniversary of Finland, attracted about 100 participants to the CERN Globe.

Professor Markku Kulmala, the HIP CLOUD project leader, was nominated Academician of Science. At the University of Helsinki Kenneth Österberg, the HIP CMS Programme leader, was promoted to a professor position, and Aleksi Vuorinen, the HIP High Energy Phenomenology project leader, was nominated to the post of tenure-track professor. Matias Säppi from Aleksi Vuorinen's project was awarded a Finnish Physical Society Master's Thesis Award. Panja-Riina Luukka, project leader of the HIP CMS Upgrade project, was elected the CMS Tracker Institution Board Chair.

For the year 2018 there will be changes in the HIP operations: HIP will get a new director, Professor Katri Huitu, when I begin my tenure as Dean of the Faculty of Science at the University of Helsinki. I wish to congratulate Katri, and also HIP for a good choice – HIP will be in safe hands. Professor Filip Tuomisto from Aalto University will take over as head of the Technology Programme. On the administrative side Tuulikki Laurila will be on leave of absence during part of 2018, and Johanna Hyytiäinen will substitute her. HIP is a mature institute with high-quality activities and a solid organisation, and I am sure that in the future, HIP will achieve better results than ever.

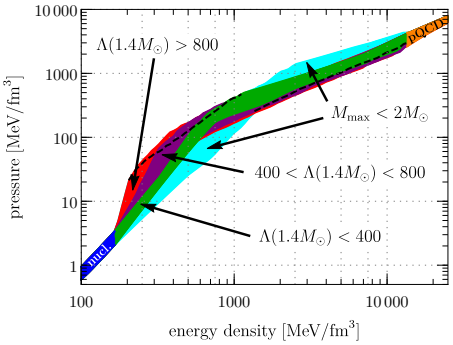
HELSINKI INSTITUTE OF PHYSICS

Highlights of Research Results

Theory Programme

In the *Cosmology of the Early and Late Universe project* one of the highlight topics was the role of the Higgs field during inflation. We showed that a light spectator Higgs field is decoupled from metric fluctuations during inflation, which allows a consistent study of electroweak vacuum stability. Vacuum stability was also studied in Higgs inflation and under non-minimal Higgs-gravity interactions.

In the *High Energy Phenomenology in the LHC Era project* a notable achievement was the state of the art determination of the ultradense matter Equation of State, utilising the LIGO and Virgo observation of gravitational waves from the collision of two neutron stars. The gravitational wave signal is used to pin down the neutron star deformability, which strongly constrains the Equation of State.

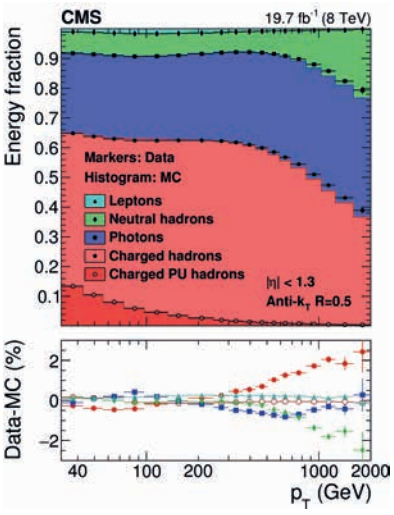


In the *QCD and Strongly Interacting Gauge Theory project* we made major steps forward in understanding processes where a dilute projectile probes the large colour field of a high energy nucleus. This includes calculations of isolated photon and Drell-Yan lepton pairs at leading order, and a new formalism of deep inelastic scattering cross sections and forward particle production in proton-nucleus collisions at next-to-leading order in the weak coupling expansion.

A highlight in the *Nuclear Structure for Weak and Astrophysical Processes project* was the development of a new computational method based on an energy density functional (EDF). The method is applicable for beyond mean-field, symmetry restored multi-reference (MR) calculations. Unlike most of the present EDFs, the developed finite range pseudopotential based EDF is free from divergences at the MR-EDF level.

In the *Domain Wall Dynamics project* the highlights include the study of the fast magnetic vortex wall motion in wide permalloy nanostrips. We find a high-velocity plateau in the velocity vs. applied field curve, originating from localised dynamics of the vortex core in the vicinity of one of the edges of the strip, taking place via repeated double switching of the polarity of the DW vortex core.

CMS Programme



The Compact Muon Solenoid (CMS) is a general purpose experiment at CERN's Large Hadron Collider (LHC). The climax of LHC Run 1 (2010–2012) was the discovery of a Higgs boson. The LHC Run 2 (2015–2018) continued in 2017 with a record luminosity of 51 fb^{-1} making the total recorded luminosity at 13 TeV so far to be 90 fb^{-1}. By the end of 2017, the total number of published CMS physics papers was 611.

HIP participated in detector operations (tracker alignment, jet energy corrections and L1 trigger) and developed deep learning applications. HIP researchers contributed especially to *Higgs and jet physics with the B physics effort finishing*. The highlights included the publication of legacy papers on the Particle Flow and Run 1 Jet Energy Scale and constraints on dark matter with dijet resonances. The group organised the 4th JetMET Workshop "Physics at 100 fb^{-1}" in Helsinki. M. Voutilainen received a 4-year Academy of Finland project grant.

The 2017 milestone for the HIP CMS Upgrade group was the successful installation and commissioning of *the upgraded pixel detector*. HIP delivered 250 flip-chip bonded detector modules to the third layer of the central barrel pixel detector. The group continued R&D on novel detector and interconnection technologies for the CMS Phase 2 Upgrade.

The HIP TOTEM group contributed to the timing detectors of *the CMS-TOTEM precision proton spectrometer (CT-PPS)*. Currently CT-PPS has collected 55 fb^{-1}, the largest diffractive data set ever. TOTEM published total cross-section and ρ parameter measurements at 13 TeV with significant HIP involvement. The measurements cannot be described by conventional models, indicating *the t-channel exchange of a colourless three-gluon bound state*.

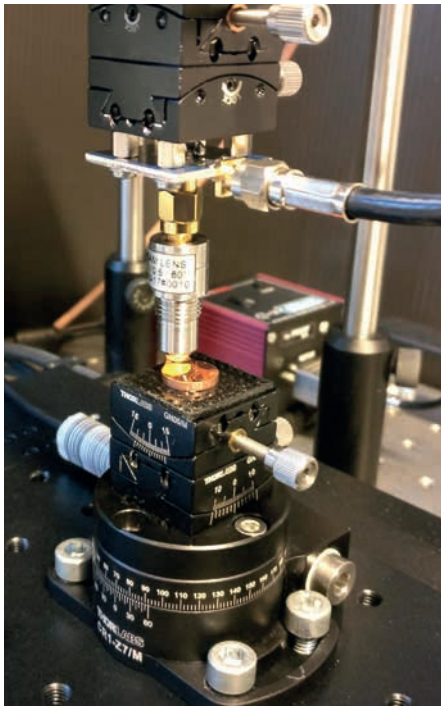
M. Voutilainen and M. Berretti received the CMS Young Researcher Prize and CMS Detector Award, respectively, and P.-R. Luukka was elected the new CMS Tracker Institution Board Chair.

Nuclear Matter Programme

The highlights of the scientific programme of ALICE are the detailed study of higher order flow correlations and quantifying the non-linear hydrodynamic response of their correlations.

At ISOLDE, two important milestones were reached when the beamline for the ISOLDE Solenoidal Spectrometer (ISS) was commissioned and the third step of the HIE-ISOLDE upgrade was finished. The latter allowed a full campaign of experiments with higher energies. The ISS is one of the key instruments in the SISIN project funded by the Academy of Finland (PI J. Pakarinen) aiming for unambiguous determination of the structure of intruder states in the neutron-deficient Pb region.

At FAIR, significant steps forward were taken when civil construction of the FAIR accelerator facility started and Phase-0 beam times for 2018–2019 were selected allowing continuous science progress in parallel with civil construction.



Technology Programme

In the *Accelerator Technology project*, the highlight of the research carried out by the Materials for Accelerator Technology (MAT) group in 2017 is the development of a new hybrid model, which concurrently combines the Laplace solver based on a flexible mesh with finite elements and discrete atomic dynamics in one simulation run. The Module, Structures and Manufacturing (MSM) group has developed a Scanning Acoustic Microscope (SAM) which is an advanced method to measure the mechanical properties of a sample surface. The resolution can exceed 5 μm with focused 250 MHz ultrasound.

Concerning computing performance, the *Green Big Data project* has focused on optimising energy consumption of scientific computing clusters used for HEP computing related to CERN experiments. In 2017 we, e.g., proposed the idea of performing distributed computing in homes to consume the extra electricity generated in homes with solar or other renewable means.

During 2017 several prototype detectors, including CdTe and pixel Si detectors, were tested on a CMS readout chip in the *Radiation Metrology for Applications project*. Development and validation of Monte Carlo models for dosimetric characterization of test beams were also initiated.

In the *Finnish Business Incubation Center of CERN Technologies (BIC) project*, the first incubation case was taken to BIC, namely Advacam Oy in 2017. Additionally, the societal impact of big science studies was also an on-going activity of the project.

The *Novel Instrumentation for Nuclear Safety, Security and Safeguards (NINS3) project*, in collaboration with STUK, IAEA and EURATOM, used the upgraded PGET (Passive Gamma Emission Tomography) instrument in two successful measurement campaigns at the Loviisa and Olkiluoto nuclear power plants in Finland. Research on improving the image reconstruction process is on-going.

Theory Programme

The HIP Theory Programme consists of five fixed term projects: Cosmology of the Early and Late Universe (leader Syksy Räsänen, University of Helsinki), High Energy Phenomenology in the LHC Era (leader Aleksi Vuorinen, University of Helsinki), QCD and Strongly Interacting Gauge Theory (leader Tuomas Lappi, University of Jyväskylä), Nuclear Structure for Weak and Astrophysical Processes (leader Markus Kortelainen, University of Jyväskylä), and Domain Wall Dynamics (leader Lasse Laurson, Aalto University). In addition, Professor Mark Hindmarsh (Sussex University) continues as Visiting Professor in Helsinki, a position shared by HIP and the Department of Physics.

Kari Rummukainen,
Theory Programme director

Cosmology of the Early and Late Universe

Inflation and LHC cosmology, gravitational waves: During 2017, we continued probing the role of the Higgs field during inflation. We studied the difference in the predictions of Higgs inflation between the metric and Palatini formulations of gravity. We also showed that a light spectator Higgs field is decoupled from metric fluctuations during inflation, which allows a consistent study of electroweak vacuum stability in the Jordan frame. We studied electroweak vacuum stability during and after inflation in the presence of Higgs-inflaton and non-minimal Higgs-gravity interactions. We showed that the Higgs-inflaton trilinear interaction can lead to satisfactory reheating and interesting LHC phenomenology.

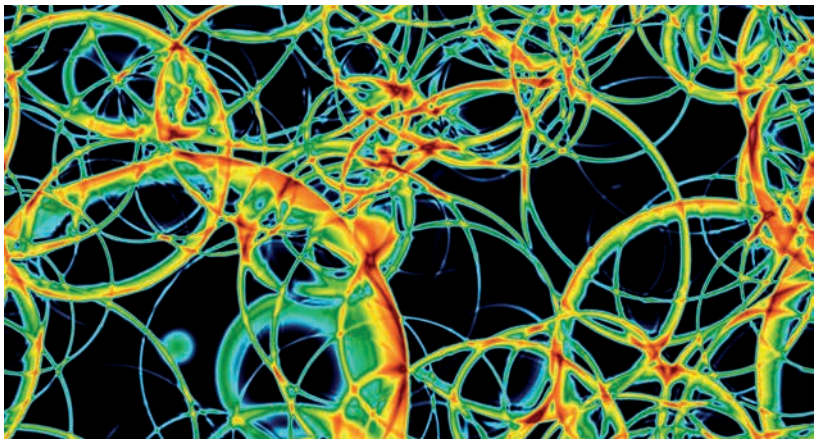
We studied how to determine the scale of inflation in models where dark matter is a feebly interacting scalar. We proposed a simple UV-complete model with dark matter and a promising discovery potential at the LHC, where the dark sector induces a successful electroweak baryogenesis via a CP portal interaction.

During the year, we put new constraints on inflationary scalar field magnetogenesis. We investigated the CMB μ distortion in models with uncorrelated sources which contribute to primordial perturbations and showed that it can help break degeneracies of curvaton parameters.

We presented gravitational wave power spectra from large-scale numerical simulations of a first order thermal phase transition in the early universe and showed that a LISA-like mission has the sensitivity to detect a gravitational wave signal from a wide range of theories extending the Standard Model. We summarised the current understanding of the physics of gravitational wave production from a first-order phase transition, and its connection to underlying particle physics models. For the first time we simulated gravitational wave production from a non-Abelian gauge field.

Late universe inhomogeneities: We studied backreaction predictions and constraints from data on consistency conditions of the FRW

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



A slice through a three-dimensional early universe simulation of bubble collisions that produce gravitational waves.

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

metric. We also modelled backreaction with an ensemble of ellipsoidal structures.

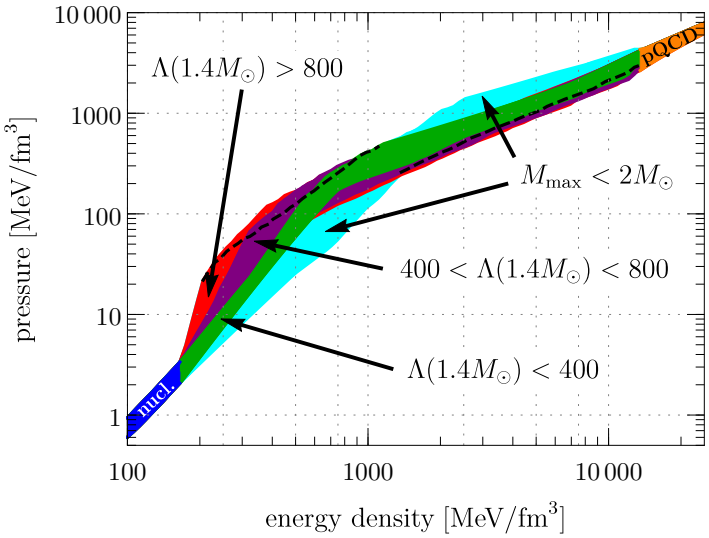
Observational cosmology: We took part in writing the survey requirements and mission design document of the CORE CMB polarization experiment proposed to ESA in answer to the M5 call for a medium-sized mission.

Other: We analysed the consistency of Galileon models with cosmological observations.

We calculated, for the first time with a large-scale numerical simulation, the CMB constraints on the symmetry-breaking scale for global strings and global monopoles. We performed the first numerical simulations of necklaces in a non-Abelian gauge theory, and argued that gravitational wave bounds from millisecond pulsar timing on the string tension in the Nambu-Goto scenario are greatly relaxed.

We investigated cosmic string networks in the Abelian Higgs model using data from large-scale numerical simulations, observing self-similarity of the networks over a wide range of scales, and quantified their energy loss, measured for the first time.

We derived a three-dimensional high-temperature effective field theory for a popular extension of the scalar sector of the Standard Model and determined the viability of a first-order phase transition in the model.



The figure shows the Equation of State of neutron star matter, consistent with all known theoretical limits at low and high density. The magenta region is ruled out by the existence of the heaviest stars observed, while the red and lilac regions are ruled out by the LIGO tidal deformability measurement at 90% and 50% confidence levels, respectively. The figure is taken from *Annala et al., arXiv:1711.02644.*

High Energy Phenomenology in the LHC Era

After a very eventful 2016, the past year witnessed fewer observational surprises in high energy physics. The most significant discovery was without doubt the detection of gravitational waves from the merger of two neutron stars, which was achieved by the LIGO and Virgo Collaborations in August and announced in October. This event marked the dawn of a new era of multimessenger astrophysics, as the observation of gravitational waves was accompanied by that of an electromagnetic counterpart, allowing, e.g., a direct verification of the fact that gravitational and electromagnetic waves propagate at the same velocity. More importantly, it was confirmed that a significant fraction of the observed abundances of heavy elements in our universe has indeed been produced in neutron star collisions, while the measurement of the tidal deformabilities of the two stars involved in the merger provided valuable insights into the collective properties of the matter they contain.

As always, the focus of the theoretical research conducted in the High Energy Phenomenology project closely reflected the experimental advances in the field. This time, we in particular concentrated on the microphysical implications of the neutron star merger measurement and on the strengthening constraints that Large Hadron Collider (LHC) data is placing on Beyond the Standard Model (BSM) physics.

In the preprint *Gravitational-wave constraints on the neutron-star-matter Equation of State*, submitted to the arXiv.org database in November, E. Annala, T. Gorda, A. Kurkela, and A. Vuorinen studied the effects of the recent gravitational wave

measurement on the Equation of State (EoS) of neutron star matter. They constructed the most general EoS for such systems, consistent with all robust theoretical and observational constraints available, by interpolating the function between known low- and high-density limits using a piecewise polytropic form. In the process, it was seen that the tidal deformability measurement of LIGO and Virgo had a dramatic effect on the inferred stellar EoS, reducing its prior uncertainty by almost a factor of two. That is, one single gravitational wave observation produced a qualitative improvement in our understanding of the collective properties of dense QCD matter!

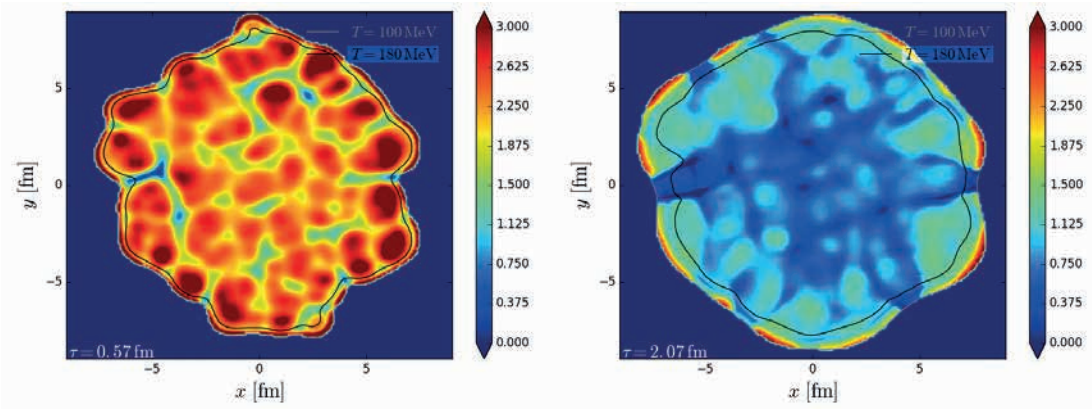
In BSM physics, a lot of attention has recently shifted towards previously less frequently explored models, which however remain feasible despite the LHC not having discovered any species of elementary particles not predicted by the Standard Model. On this front, a particularly promising avenue is the study of models containing so-called Feebly Interacting Massive Particles, or FIMPs, which interact only very weakly with visible sector particles, as these particles constitute one of the prime candidates for dark matter. In the extensive overview article *The Dawn of FIMP Dark Matter: A Review of Models and Constraints*, N. Bernal, M. Heikinheimo, T. Tenkanen, K. Tuominen, and V. Vaskonen reviewed the current status in the field, paying particularly close attention to the observational properties and testability of this class of models.

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 energy and density. In addition to the phenomenology of high energy nuclear collisions at the LHC and RHIC, we are involved with physics studies for planned next generation DIS experiments. We use weak coupling QCD renormalisation group equations to understand the energy and virtuality dependence of the partonic structure of hadrons and nuclei. An important specialty is using this information to understand and model 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 proton or nuclear parton distributions (PDFs) required in computing hard scattering cross sections. In 2017 we studied the physics reach of a future electron-ion collider to further constrain the nuclear PDFs. We also worked to include new LHC data in a future update of our flagship EPPS16 PDF analysis, e.g., from more differential CMS dijet measurements in proton-nucleus collisions and exclusive photon-mediated interactions in nucleus-nucleus collisions. The BK evolution equation, in turn, describes the energy dependence of QCD scattering cross sections at high energy. We



The space-time evolution of the Knudsen number (plasma expansion rate divided by scattering rate), used to chart the validity of the hydrodynamical picture of a heavy ion collision.

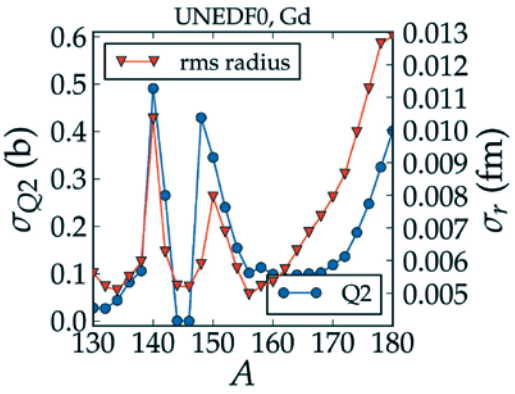
implemented a new next-to-leading order (NLO) BK formalism for calculating deep inelastic scattering cross sections and particle production in forward proton-nucleus collisions. We also calculated isolated photon and Drell-Yan lepton production at forward rapidity in proton-nucleus collisions at leading order.

We use two complementary QCD approaches to describe the formation of quark gluon plasma. In the Colour Glass Condensate picture the early stage of a heavy ion collision is described in terms of a strong classical gluon field. We studied on a real time lattice the evolution of the plasmon mass scale in this highly anisotropic non-equilibrium field configuration. The strong classical gauge fields also exhibit fluctuations in the Chern-Simons fluctuations, which could become manifest as parity violating correlations in the final state. We developed a simple model for evaluating these fluctuations, to provide initial conditions for anomalous hydrodynamics calculations. We also model the initial stages of heavy ion collisions starting from perturbative quark and gluon scattering, and using a saturation conjecture to control multiparticle production. Applying such initial conditions in our event-by-event hydrodynamical studies of heavy ion collisions, we made predictions for xenon-xenon collisions that were then measured at the LHC in 10/2017. We also continued our studies of correlations between different flow harmonics, providing our predictions to the ALICE and STAR Collaborations measuring them at the LHC and RHIC.

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

Nuclear Structure for Weak and Astrophysical Processes

Uncertainty propagation within the UNEDF models: The parameters of the nuclear energy density functionals (EDFs) must be adjusted to experimental data. As a result, they carry uncertainty which then propagates to calculated observables. In our recent work, we quantified statistical uncertainties of binding energies and other bulk properties for all three UNEDF Skyrme EDFs. In addition, the contributions of



Theoretical uncertainty of proton root-mean-square radius and intrinsic quadrupole moment in Gd isotopes with UNEDF0 EDF.

different EDF parameters were studied. Among other important observations, the uncertainties were found to increase rapidly when going towards neutron and proton rich nuclei, and the uncertainties of binding energies decreased notably between the oldest and the latest parameterisation. Information about the EDF parameter uncertainties, and their propagation to calculated quantities, is crucial when assessing the predictive power of the current EDFs, and allows improving development of novel EDFs.

Finite range EDF: Current nuclear EDFs have reached their limits and novel approaches are called for. In addition, most of the present EDFs are unsuitable for full-fledged symmetry-restored beyond mean-field calculations due to ill-defined kernels. We have developed an EDF based on a finite-range pseudopotential, applicable for beyond mean-field calculations. The EDF parameters were adjusted at the spherical Hartree-Fock-Bogoliubov level to a various set of observables. Even though the developed EDF was considered as an initial step towards a more definite novel EDF, it showed promising results. In addition, we also addressed the Landau parameters of pseudopotential based EDFs. This provides a useful and efficient way to constrain the properties of nuclear EDFs.

Collective excitation modes in ^{40}Mg: Collective excitations in a weakly bound neutron rich nucleus can provide insights into the nature of nuclear interactions and the role of the continuum. We investigated dipole modes in

the very neutron rich nucleus of ^{40}Mg by using the linear response theory based finite amplitude method. In this work we used a numerical approach implemented on the coordinate space, to treat the quasiparticle continuum properly. We found that the transition current topologies associated with the low-energy pygmy mode and the giant dipole mode were notably different. The pygmy mode showed collective and compressional character whereas the giant dipole mode showed less collectivity and a more distorted pattern. Also, the energy splitting of the resonances, caused by deformation, did not follow the expected pattern.

Quasibound double Δ system: In one of the last COSY experiments (Jülich) a new resonance at 2380 MeV was found in two pion production. Some optimistic interpretations suggested this to be an exotic six-quark system, a claim partly based on its width being less than twice the decay width of the well known Δ(1232) resonance. However, the paper Phys. Rev. C 95 (2017) 054002 shows that, accounting for kinetic energies implicit in the intermediate wave functions, in NN scattering the effective NΔ and ΔΔ widths are drastically reduced from the free values so that this "dibaryon" could well be a quasibound double Δ system, instead. This interpretation would also naturally explain its manifest decay with two pions.

Domain Wall Dynamics

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 2017, we have made progress in understanding several key issues of domain walls (DWs) and their dynamics in various one- and two-dimensional systems.

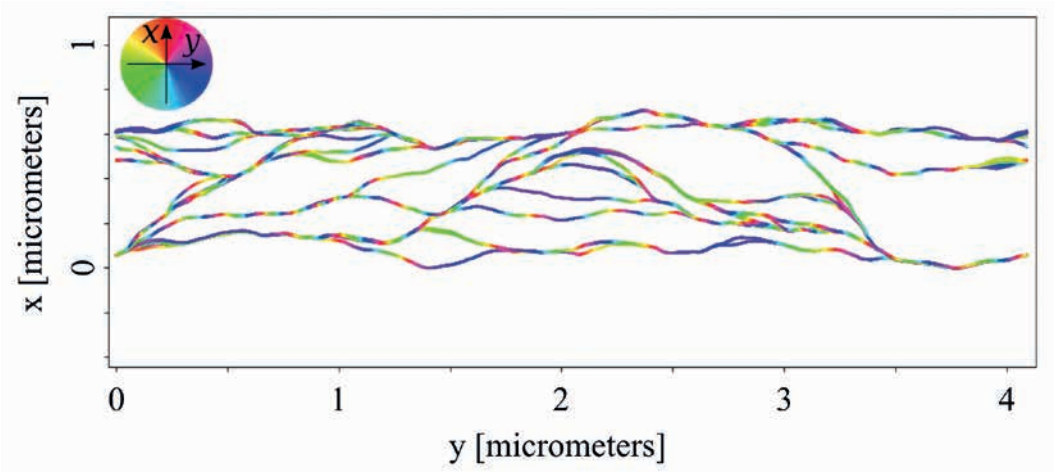
Fast vortex wall motion in wide permalloy strips due to double switching of the vortex core: Vortex DW is one of the DW structures occurring in ferromagnetic nanostrips made of low-anisotropy materials such as permalloy. We have found that in sufficiently wide strips, the typical dynamics where the vortex core of the DW repeatedly travels across the strip width is absent. Instead, one finds a high-velocity plateau in the velocity vs. applied field curve, originating from the localised dynamics of the vortex core in the vicinity of one of the edges of the strip, taking place via repeated double switching of the polarity of the DW vortex core.

Bloch line dynamics within moving domain walls in 3D ferromagnets: We have studied DW dynamics in thick garnet strips, constituting a 3D magnetic system with planar DWs. We found a non-monotonic thickness dependence of the threshold field for the onset of an instability similar to the Walker breakdown in ferromagnetic nanostrips, proceeding via nucleation and propagation of vertical or horizontal Bloch lines within the domain wall. For strips of intermediate thicknesses, the vertical Bloch lines assume a deformed structure due to demagnetising fields at the strip surfaces, breaking the symmetry between the top and bottom faces of the strip, and resulting in circulating Bloch line dynamics along the perimeter of the domain wall.

Bloch lines within extended domain walls in disordered ferromagnetic thin films: Slowly driven extended domain walls in disordered ferromagnets move in bursts with a wide range of sizes, resulting in crackling noise known as the Barkhausen effect. We have studied the internal dynamics of the domain walls during their bursty propagation in thin disordered ferromagnetic films, and have found that a significant fraction of the overall spin rotation corresponds to internal processes within the DWs such as Bloch line nucleation, propagation and annihilation (see the figure on the next page).

Magnetic friction: We have developed a method and an implementation of smooth linear motion in a finite difference-based micromagnetic simulation code, to be used in simulating magnetic friction and other phenomena involving microscale magnets in relative motion. We combine techniques for fast scalar potential calculation and cubic b-spline interpolation, parallelising them on a Graphics Processing Unit (GPU). The implementation also includes the possibility of explicitly simulating eddy currents in the case of conducting magnets. A method paper will be submitted in early 2018.

Lasse Laurson, Domain Wall Dynamics project leader



Examples of consecutive domain wall configurations between bursts of domain wall propagation ("Barkhausen jumps") driven by an applied magnetic field in disordered Pt/Co/Pt thin films as obtained from our GPU-accelerated micromagnetic simulations. The orientation of the in-plane magnetisation within the domain walls separating oppositely magnetised out-of-plane domains is indicated by the different colours, revealing the presence of Bloch lines (localised regions where the domain wall chirality changes) within the domain wall.

CMS Programme

Kenneth Österberg,
CMS Programme director

The HIP CMS programme is responsible for co-ordinating the Finnish participation in the CMS and TOTEM experiments at the Large Hadron Collider (LHC). The Compact Muon Solenoid (CMS) is a general purpose experiment covering detailed investigations of particles and interactions at LHC energies, the origin of electroweak symmetry breaking (Higgs bosons), and the search for signatures of new physics beyond the Standard Model of particle physics. The TOTEM experiment is a dedicated experiment, located at the same LHC interaction point as CMS, focusing on the scattering of particles at small angles ("forward"). The programme is divided into four projects: the CMS experiment, responsible for physics analysis and operations, the CMS upgrade, responsible for the Finnish contribution to the CMS upgrades, the Tier-2 and the TOTEM projects. The Finnish groups in CMS are: HIP (currently 15 authors), the University of Helsinki (4 authors), and Lappeenranta University of Technology (1 author). In TOTEM, there are 10 authors affiliated with HIP, out of which 6 are also affiliated with the University of Helsinki.

CMS Experiment

Introduction

The CMS Experiment project is involved with detector operations on tracker alignment, jet energy corrections and the L1 trigger, and develops deep learning applications in HEP. The physics analyses focus on jet physics and Higgs searches, with the previous B physics effort now finishing. Tens of analyses were published with the 36 fb^{-1} of data recorded in 2016 and calibrated in 2017, and CMS recorded a further 45 fb^{-1} in 2017.

Particular highlights were the publication of legacy papers on Particle Flow and the Run 1 Jet Energy Scale in JINST and the constraints on dark matter with dijet resonances in PLB, with significant HIP contributions. In May, we organised the 4th JetMET Workshop "Physics at 100 fb^{-1}", with 10 invited talks and 46 participants. M. Voutilainen was awarded the CMS Young Researcher Prize and a 4-year Academy of Finland project grant "Top quarks and gluons".

Detector Operations

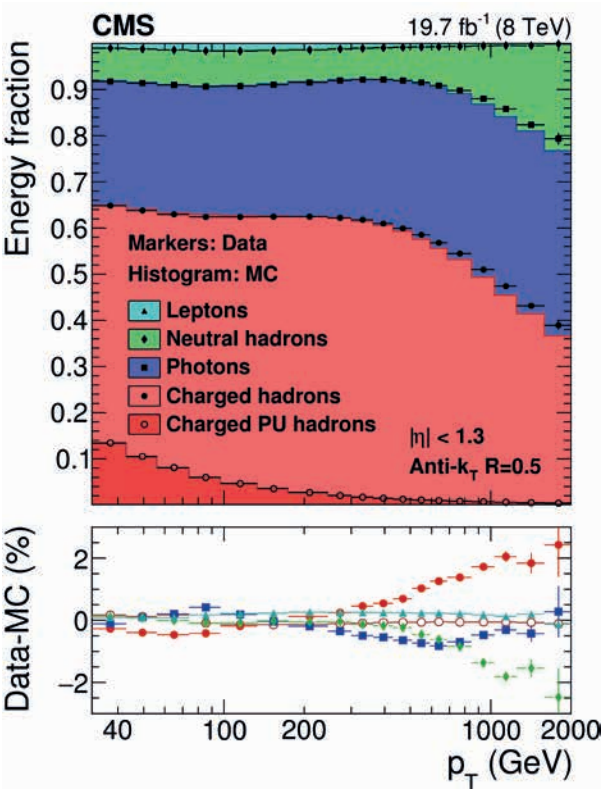
Mikko Voutilainen,
CMS Experiment
project leader

Tracker alignment: HIP continued its long-term involvement in geometrical alignment of the CMS Tracker sensors, a requisite for high-quality physics results. In 2017, T. Lampén performed calculations of the pixel barycenter for the Tracker Alignment group.

Jet energy corrections: Jet energy corrections (JEC) are critical for physics analyses involving jets, which encompasses most CMS analyses. HIP has a long history in the JEC group, and H. Kirschenmann was its co-convener in 2017. M. Voutilainen edited the Run 1 legacy JEC paper published in JINST and performed the JEC global fit on the 2016 data, while H. Siikonen measured the PF jet composition.

L1 trigger: In 2017, HIP took an active role in the L1 Trigger group, as J. Heikkilä and S. Laurila became experts in L1 data certification and were appointed Level-1 Offline Certification Co-Coordinators. This responsibility continues to the end of Run 2.

Deep learning applications: The HIP team (J. Havukainen, K. Kallonen, H. Kirschenmann, T. Lampén) is involved in a number of machine learning projects utilising Deep Neural Networks (DNN), such as improving the true/fake discrimination in central CMS track



The jet energy composition in observed and simulated events as a function of the transverse momentum for the particle-flow reconstruction with the CMS detector. The top panel shows the measured and simulated energy fractions stacked, whereas the bottom panel shows the difference between observed and simulated events. Charged hadrons associated with pile-up vertices are denoted as charged PU hadrons.

reconstruction, refining the event selection in the charged Higgs analysis, and improving JEC and jet flavour identification.

Physics Analysis

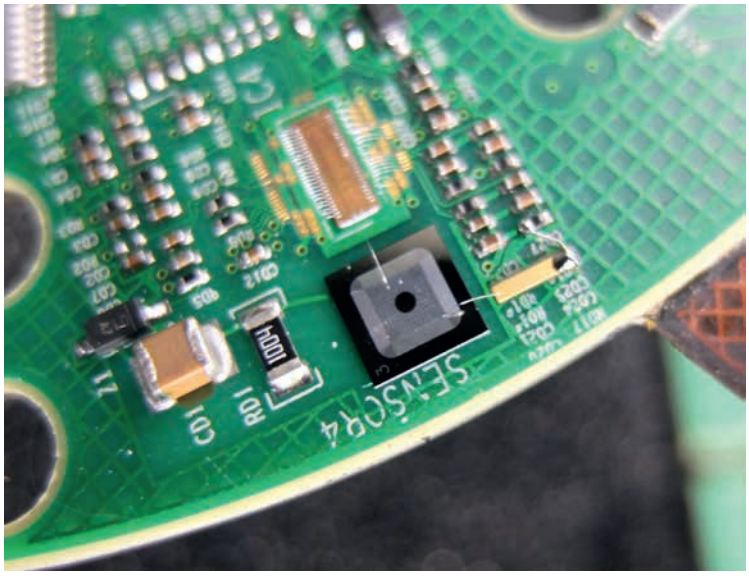
B physics: The B physics team was involved in the effective lifetime analysis of the $B_S \rightarrow J/\psi\,\phi$ decay mode. The effective lifetime result together with other b hadron lifetime results were submitted to the EPJC and T. Järvinen defended his Doctoral thesis on the subject in December. This ends the B physics studies in the HIP CMS group.

Jet physics: The CMS SMP-Jets group was co-convened by M. Voutilainen in 2017 and the HIP Jet physics team worked on dijet mass resonances (J. Pekkanen, Doctoral thesis defended in December), top quark mass (H. Siikonen), inclusive jet cross section (L. Martikainen, started in November), gluon identification with DNNs (K. Kallonen) and gluon jet cross section (Ö. Özturk, ERASMUS MSc from U. Marmara, Turkey). The overarching goals were measurements of proton structure, the strong coupling constant α_S and the top quark mass m_t, in exploration of SM vacuum stability and search for new physics. The dijet resonance search published updated limits and constraints on dark matter in PLB, and M. Voutilainen won a 4-year project grant for "Top quarks and gluons". In May the Helsinki JetMET Workshop worked as a catalyst for Deep learning and m_t.

Higgs physics: The search for charged Higgs bosons at 13 TeV centre-of-mass energy continued in 2017. The search was extended

Participants in the 4th JetMET Workshop "Physics at 100 fb^{-1}" organised in Helsinki in May 2017.

to an intermediate mass region, where the mass of the charged Higgs boson is close to the top quark mass. This closes the gap between the 160 and 180 GeV mass regions. The team (S. Lehti, S. Laurila, J. Havukainen and M. Lotti, who completed his MSc thesis and started his PhD studies) continues the analysis with all data recorded in 2016 aiming to have public results in 2018. In addition, the team was responsible for the development of the tau+MET trigger for the 2017 data taking, used in the charged Higgs boson, W' and boosted WH searches. The search for a neutral Higgs boson A → Zh → 2l2τ was started by J. Heikkilä under the supervision of G. Petrucciani (CERN), and in collaboration with U. Wisconsin-Madison and U. Cyprus.



Readout Board for the CMS Beam Luminosity Telescope (BLT) with a silicon diode detector that has been processed in the Micronova clean room facility (Espoo) by the HIP CMS Upgrade group. *(Photo courtesy of Moritz Guthoff/ CERN.)*

CMS Upgrade

The CMS Upgrade project is responsible for the Finnish hardware contribution to the CMS experiment. One of the most important milestones for 2017 was the successful installation and commissioning of the upgraded pixel detector in the beginning of March. The new detector was designed to help with the increasing LHC collision rate and to enhance the particle tracking. In the upgrade the amount of readout channels increased from 65 million to 124 million and the new detector has one additional layer throughout the whole detector. HIP made a significant contribution to the central barrel pixel detector (BPIX) and delivered 250 flip-chip bonded bare detector modules for the third layer (L3) of BPIX together with Advacam Ltd.

In 2017 the CMS Upgrade group has continued the research on novel detector and interconnection technologies aimed for the CMS Phase 2 Upgrade. In 2015 an R&D project together with two other CMS groups (DESY and the University of Hamburg) for novel silicon pixel detectors was launched. The project is benefitting from the Upgrade group's earlier studies on the use of Atomic Layer Deposition (ALD) grown thin films in silicon strip detectors. The objective is to use the ALD thin films as active and passive layers on p-type pixel and strip detectors. In 2017 we were able to process several wafers with these new structures at the Micronova Centre of Micro and Nanotechnology and thus, now the focus of the campaign has shifted towards reliability testing and determining the repeatability of the novel detector designs and structures. This is very critical for devices that have an operation time frame in the scale of 10 years in the very harsh radiation conditions of the High-Luminosity LHC (HL-LHC). HIP has long-term experience in detector design, processing, reliability studies and environmental testing in realistic conditions (e.g., test beams and irradiation studies) and thus, we were also asked to join the CMS MIP Timing Detector group for developing high precision timing detectors for the CMS endcap region.

Panja-Riina Luukka, CMS Upgrade project leader

In 2017, the HIP CMS Upgrade group continued collaboration with the Finnish Radiation and Nuclear Safety Authority (STUK) in the framework of the "Radiation Metrology for Applications" -project. During 2017 several prototype detectors with CMS pixel readout electronics were tested at the radiation metrology laboratory of STUK. On the grounds of the successful tests a common R&D project was initiated together with groups from Aalto University and Lappeenranta University of

Technology. The proposal (MPMIB – Multispectral Photon-counting for Medical Imaging and Beam characterization) received funding in the Academy of Finland RADDESS call for four years starting from 2018. The CMS Upgrade project is a co-ordinator of the research consortium.

The year was also very successful for gaining important positions of responsibility in CMS. In September P.-R. Luukka was nominated co-chair of the CMS Career Committee and in December elected as Chair of the Tracker Institution Board and Tracker Conference Committee.

Lappeenranta activity: The CMS group at Lappeenranta University of Technology (LUT), led by Prof. T. Tuuva, participates in the construction of the electronics and data acquisition system for the CMS GE1/1 station. The GE1/1 using Gas Electron Multiplier (GEM) technology is one of the four new muon detector stations at the CMS forward trigger system, needed due to the increased LHC luminosity after the Long Shutdown 2 (2018–2019). In 2017, the LUT CMS group completed the prototyping phase of the GE1/1 on-detector electronics with GEM electronics boards (GEBs) and VFAT readout hybrids. In addition, the LUT group with its collaborators started the production of 90 wedge-shaped GEBs, i.e., half of the total number of the GEBs to be installed in the CMS GE1/1 muon station.

Tomas Lindén,
Tier-2 Operations
project leader

Tier-2

CMS 13 TeV analysis and simulation jobs were running on the HIP Tier-2 site during the third year of the LHC Run 2 with good performance ensured by the collaboration between HIP, CSC (IT Center for Science Ltd) and the Nordic e-Infrastructure Collaboration (NeIC) Nordic DataGrid Facility (NDGF). T. Lindén represented HIP in the NeIC Nordic LHC Computing Grid steering committee.

CMS jobs were run in Kumpula on the Linux clusters Korundi (400 cores, 2008) and Alcyone (840 cores, 2011). The Korundi cluster was decomissioned on January the 20th 2017. Work continued to take the CMS 5.5 M billing unit allocation on the Kajaani CSC cPouta cloud system into use as well as the University of Helsinki (UH) cluster Kale into CMS use.

The dedicated 10 Gb/s link connecting CSC, Espoo with the Kumpula campus was replaced by using MPLS over the shared UH 20 Gb/s FUNET connection. The dCache services at CSC ran very stably also in 2017.

The collaboration between HIP and the UH Department of Computer Science, started in the cloud computing project Data Indirection Infrastructure for Secure HEP Data Analysis (DIIHEP), continued in 2017.

The Tier-2 resources are operated, maintained and monitored by HIP, CSC and NDGF to spot problems early with Site Availability Monitoring jobs. According to the statistics, the Tier-2 resources were in the "ready" state 81.04% of the time (62.74% in 2016). The "No Info" status was 0.0% (18.49% in 2016). There were 34 GGUS tickets (23 in 2016) concerning HIP.

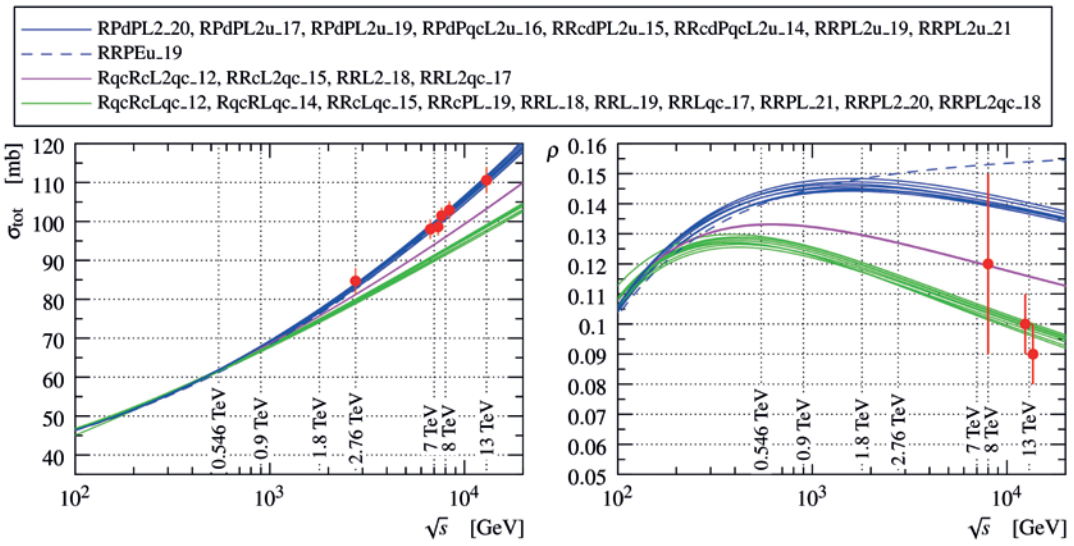
PhEDEx moved 3061 TB of production data (1956 TB in 2016) and 362 TB of test data (400 TB in 2016) to HIP. From HIP to elsewhere 1409 TB of production data (1132 TB in 2016) and 211 TB of test data (216 TB in 2016) were moved. In total PhEDEx moved 5043 TB of data on the WAN (3705 TB in 2016).

A total of 0.65 M CMS grid jobs (0.54 M in 2016) using 13.1 MHS06 CPU hours (23.2 MHS06 CPU hours in 2016) were run with an average CPU efficiency of 70.7% (73.9% in 2016).

Kenneth Österberg,
TOTEM
project leader

TOTEM

The TOTEM project is responsible for the Finnish participation in the TOTEM experiment. The HIP group consisted at the end of 2017 of a professor (K. Österberg), an emeritus professor (H. Saarikko), a senior scientist (F. García), a post-doc (M. Berretti) and two PhD students (T. Naaranoja and F. Oljemark). During the year, one PhD (J. Welti) and one MSc student (L. Martikainen) graduated. Several group members had important responsibilities in TOTEM like physics (K. Österberg) and test beam co-ordination (M. Berretti).



Predictions of the total cross-section and rho parameter from different COMPETE models [*Phys. Rev. Lett. 89 (2002) 201801*] without including t-channel three-gluon exchange for pp interactions. Each model is represented by one line (see legend). The red points represent the reference TOTEM measurements.

TOTEM is the leading forward physics experiment at the LHC focusing mainly on elastic scattering, total cross-section (σ_{tot}) and diffraction. During 2017, TOTEM complemented previous measurements by σ_{tot} measurements at 2.76 and 13 TeV and a precise (±0.01) ρ measurement at 13 TeV, the latter giving a significantly lower value than expected. In fact, the σ_{tot} measurements from 2.76 to 13 TeV and ρ measurement at 13 TeV cannot be described by conventional models (see the figure at the top of the page). Adding t-channel exchange of a colourless three-gluon bound state, previously called the "Odderon", for elastic scattering in both Regge-like and QCD-based models gives a better description of all the measurements (CERN-EP-2017-335). Further precise ρ and differential elastic cross-section measurements over as large √s span as possible are needed to confirm the effects of the Odderon.

Lately the TOTEM physics programme has been extended to exclusive processes through common data taking with the CMS, both for special high β^* runs to access low masses (1–10 GeV) and for standard high luminosity running to access large masses (> 300 GeV), i.e., the CMS-TOTEM precision proton spectrometer (CT-PPS). During 2017, CT-PPS collected ~40 fb^{-1}, constituting together with the ~15 fb^{-1} of 2016 the largest diffractive sample ever collected at a hadron collider. The first physics result, the evidence of proton-tagged semi-exclusive dilepton production at high mass, was made public in 2017.

HIP was responsible for the inelastic rate analysis for the σ_{tot} measurements at both 2.76 (J. Welti) and 13 TeV (P. Helander), and soft diffractive measurements: single diffraction at 7 TeV (F. Oljemark) and soft event classification at 8 TeV (J. Welti). The group (M. Berretti) is also involved in the CMS-TOTEM study of glueball candidates in exclusive processes. Furthermore, HIP (F. García) is active in the design of a new inelastic detector, to be installed for Run 3, for a σ_{tot} measurement at 14 TeV. Finally, HIP actively participates in the Ultra Fast Silicon Detector (UFSD) and diamond based proton time-of-flight (TOF) detector upgrade of both the vertical (special runs) and the horizontal RPs (CT-PPS), covered by infrastructure funding from the Academy of Finland.

M. Berretti leads the tests and assembly of the TOF detectors with further HIP involvement from F. García and R. Turpeinen. T. Naaranoja studies the radiation performance of diamond and together with L. Martikainen made quality assurance tests of diamonds. In 2017, the CT-PPS TOF detectors took data during the complete high luminosity LHC running. Preliminary analysis indicates a time resolution of ~55 ps. For 2018, some planes will be replaced by double diamond planes with improved time resolution. In 2018, the vertical timing upgrade using UFSDs will also be installed.

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. Since the beginning of 2015, the Nuclear Matter Programme has also included the ALICE-Forward physics project. The Nuclear Matter Programme has also continued co-ordinating the Finnish participation in the planning and construction of the FAIR project in Darmstadt. 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.

Jan Rak, ALICE
project leader

ALICE

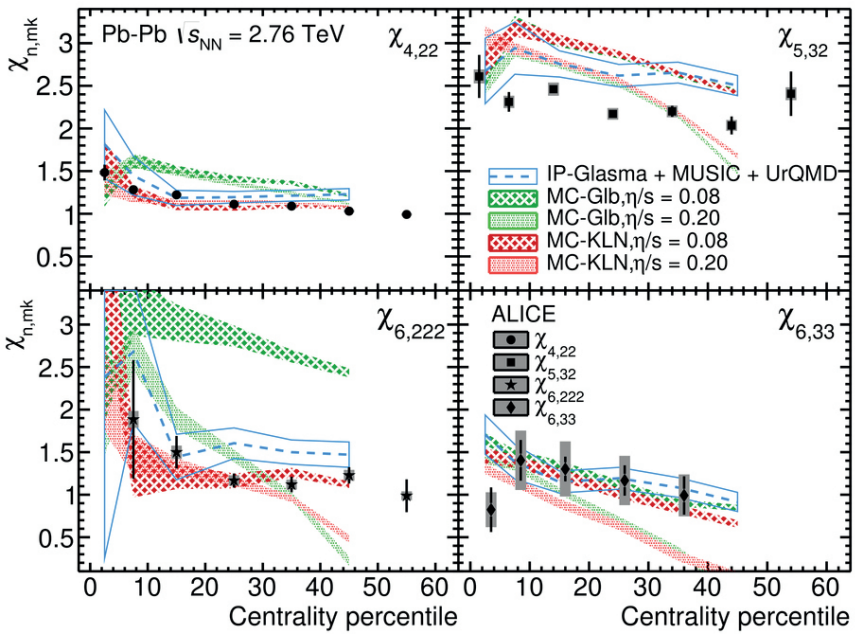
The year 2017 was a very busy and productive year for ALICE and for our team. Throughout most of the running period LHC delivered pp collisions at the centre-of-mass energy of 13 TeV. In the autumn an important test of the stability of the ALICE detectors was performed with LHC producing a particle load equivalent to PbPb collisions at the rate of 50 kHz. This target value corresponds to the conditions approximating LHC performance after the Long Shutdown 2. EMCal, T0 and a prototype of the Fast Interaction Trigger (FIT), that is, the detectors where we contribute the most, took part in the test as well. In October ALICE had a unique chance to register XeXe collisions at $\sqrt{s}$ = 5.44 TeV giving us the opportunity to test the predictive power of hydrodynamics for smaller volumes of quark gluon plasma (QGP). The year ended with a pp reference run at $\sqrt{s}$ = 5 TeV.

The current main directions of the physics analysis performed by our group involve high-p_T triggered correlations and studies of the jet transverse structure. The detailed analysis of pp, pPb and PbPb collisions data provides a deep insight into the QCD radiation processes and their modifications in cold nuclear matter and in QGP. We also study flow patterns via correlations among Fourier coefficients by detailing the azimuthal anisotropies of the final hadron momentum distributions in PbPb collisions.

J. Viinikainen finished his studies on the transverse structure on jets via two-particle correlations in pp and pPb collisions and successfully defended his PhD thesis. D. J. Kim presented studies on flow correlations at two large and highly valued conferences in our field: QM 2017 and Initial Stages 2017. M. Slupecki gave a talk on ALICE Forward Rapidity Upgrades at the 2017 EPS Conference on High Energy Physics. The proceedings papers are now in print.

The work on quality assurance of about 128 m^2 of Gas Electron Multiplier (GEM) foils for the new TPC readout chambers for ALICE is now nearing its completion. The last GEMs should leave the HIP Detector Laboratory during the summer of 2018. At the same time R&D on FIT is gaining full momentum. The FIT detector, replacing the current T0, V0, and FMD, will be a key element for the entire operation of the upgraded ALICE experiment. It will serve as the interaction trigger and luminosity monitor. It will provide the precise event timing, forward multiplicity, centrality, and the interaction plane that are essential for flow measurements. In the preparation for the production stage FIT passed all the required Engineering Design Reviews.

The highlights of the scientific programme



Non-linear flow mode coefficients measured in Pb-Pb collisions are compared to various hydrodynamic calculations.

of ALICE are the detailed study of higher order flow correlations [ALICE Collaboration, arXiv:1709.01127 [nucl-ex]] and quantifying the non-linear hydrodynamic response of their correlations [ALICE Collaboration, Phys. Lett. B 773 (2017) 60].

The different order non-linear mode coefficients show different sensitivities to η/s and the initial conditions. Comparisons to hydrodynamic calculations shown in the figure above suggest that the data are described better by hydrodynamic calculations with smaller η/s providing further constraints on the initial conditions and η/s of the system produced in heavy-ion collisions.

ISOLDE

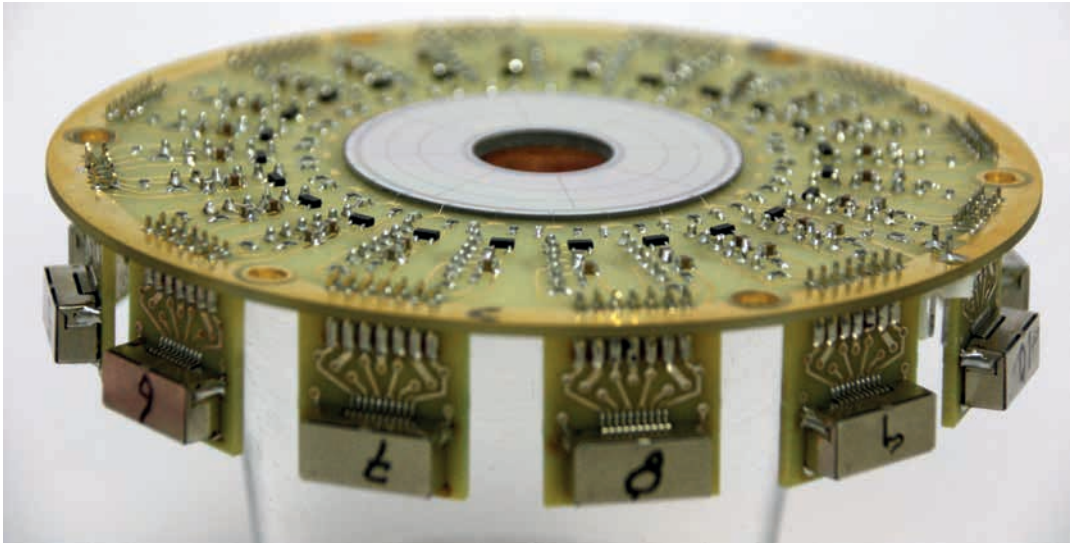
The year 2017 marked the third step (Phase 2A) of the HIE-ISOLDE upgrade. A full campaign of 12 experiments exploiting radioactive ion beams, spanning the chart of nuclei from light ^{9}Li to heavy ^{206}Hg nuclei, was completed. The shell stabilisation of mixed-symmetry states in the N≈80 nuclei, namely ^{140,142}Sm and ^{140}Nd, were probed in a Coulomb excitation experiment at MINIBALL. Another highlight was the study of octupole collectivity in ^{142,144}Ba isotopes. The successful 2017 campaign has demonstrated that HIE-ISOLDE is operating as a reliable and exciting new facility. An experiment at the low-energy branch of ISOLDE explored potential new radionuclides with diagnostic or therapeutic properties, such as ^{155}Tb, underlining the multidisciplinary physics programme conducted at ISOLDE.

The HIP contribution in the MINIBALL campaign included a summer student project, in which E. Giannopoulos performed a detailed study of the γ-ray detection efficiency of the MINIBALL array in energies ranging up to 6 MeV. In another summer student project, A. Töysä simulated changes in the electron distribution and population of a radioactive atom in the COLLAPS beamline at ISOLDE. It is also noteworthy that J. Ojala finished his Master's thesis "*Testing of the SPEDE Conversion Electron Spectrometer at ISOLDE*" early in 2017.

New Instruments and Projects

The commissioning of the XT02 beamline hosting the ISOLDE Solenoidal Spectrometer (ISS) marked an important milestone on the way towards high precision transfer reaction experiments with radioactive beams. ISS will provide a complementary technique to investigate single-particle orbitals involved in particle

Janne Pakarinen, ISOLDE project leader



The silicon detector and related front-end electronics of the SPEDE spectrometer developed in close collaboration between the University of Jyväskylä and the University of Liverpool. SPEDE will be used in studies of exotic nuclei at ISOLDE, CERN.

Tuomas Grahn,
FAIR project leader

excitations resulting from nucleon transfer. The first experiments with ISS are planned for 2018. It will be one of the key instruments in the SISIN project which was funded by the Academy of Finland in the 2016 call (PI J. Pakarinen). SISIN is aiming for unambiguous determination of the structure of intruder states in the neutron-deficient Pb region.

Parts of the SPEDE spectrometer have been redesigned to allow combining SPEDE with the ISOLDE Decay Station. SPEDE will be used to investigate the low-lying excited states in ^{182,184,186}Hg populated through β decay of ^{182,184,186}Tl. While the experiment will assess the structure of low-lying states, it will also provide essential information for the planned Coulomb excitation experiments at HIE-ISOLDE.

FAIR (Facility for Antiproton and Ion Research in Europe GmbH) Operations

Civil construction of the FAIR accelerator facility started in March 2017, first by linking the existing accelerator systems of GSI Helmholtzzentrum für Schwerionenforschung (GSI) to the new FAIR

The FAIR Groundbreaking event on July 4th, 2017. HIP Director, Professor Paula Eerola on the left. (*Courtesy of G. Otto for FAIR/GSI.*)

facility. The Groundbreaking ceremony was held in July 2017, which marked the beginning of construction of the SIS100 ring accelerator. By the end of 2017 the civil construction of SIS100 was well under way.

FAIR Phase-0 Scientific Programme

The FAIR General Programme Advisory Committee (G-PAC) announced the call for proposals for the FAIR Phase-0 experiments in spring 2017. A total of 93 proposals with 153 days of beamtime were approved to be carried out in 2018–2019. Prof. P. T. Greenlees (University of Jyväskylä) is a member of G-PAC.

The FAIR Phase-0 experiments will be carried out using the upgraded GSI accelerators and FAIR equipment. Finnish researchers are well represented in the experiments that will begin in 2018, and focus on the structure of the nuclei of the r-process (nucleosynthesis that produces heavy elements) peak near the neutron number N=126, and on the N=Z nuclei with Z<50. Finland, with 0.5% share of FAIR, has researchers participating in 2% of the G-PAC approved beamtime days. For instance, in one of the experiments a co-spokesperson is from the University of Jyväskylä (Dr. T. Grahn). The studies will be carried out in the DESPEC and Super-FRS Experiment sub-collaborations of NUSTAR. Furthermore, work continued within NUSTAR to define the Day-1 configuration of experiments that are planned to be fully funded by 2025.

Super-FRS Tracking and Diagnostics Detectors

The major Finnish contributions to the Super-FRS separator-spectrometer of FAIR are the beam tracking and diagnostics detectors and their mechanical solutions. These include the GEM-TPC beam position detectors (developed by HIP in collaboration with GSI), the MUSIC energy-loss detectors for Z identification and the SEM-Grid beam profile detectors.

It is planned that HIP will collaborate with Fermilab in delivery of the SEM-Grid detectors. Therefore, standard Fermilab SEM-Grid detectors that have only been used with protons were tested with heavy ions at the Accelerator Laboratory of the University of Jyväskylä.

The in-kind contract for the MUSIC detectors was signed in December 2017, being the first such contract for Finland. The four detectors will be built together with GSI and mechanical supporting structures will be designed at the University of Jyväskylä.

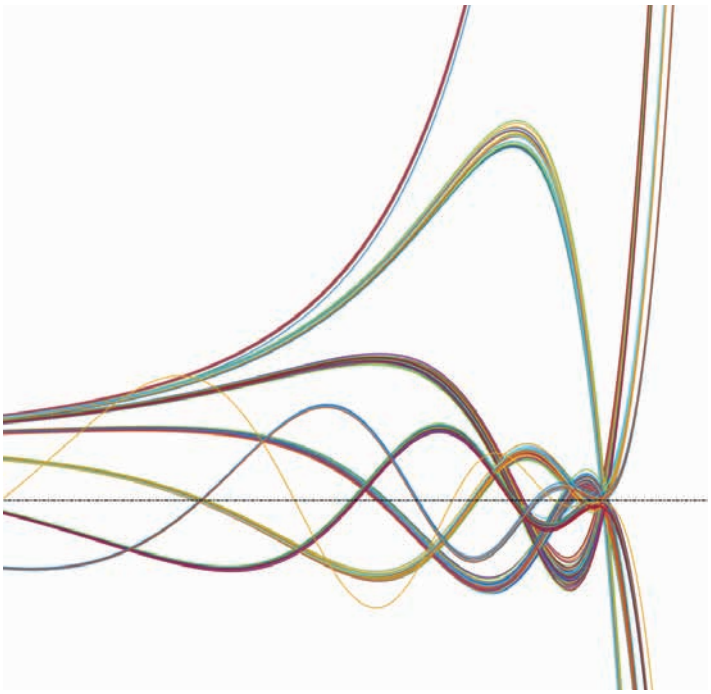
The GEM-TPC detector investigations concentrated on data analysis of the earlier test experiments and on the optimisation of the timing performance.

The first signed FAIR in-kind contract for Finland. From left to right: Jörg Blaurock (FAIR), Ursula Weyrich (FAIR), Paula Eerola, and Niklas Ottosson (VR Sweden). *(Photo: T. Hahn, FAIR.)*

Forward Physics in ALICE at the LHC

ALICE provides an ideal framework for studies of the space-time structure of high energy hadron collisions, based on the set of central and forward detectors with their excellent tracking, particle identification, rapidity and transverse momentum coverage. Also, during normal high luminosity pp runs, 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

Risto Orava, ALICE-Forward project leader



Combinatorial oscillations (*M. Mieskolainen, WE-Heraeus QCD School, Bad Honnef, Germany, September 2017*).

with large amounts of simultaneous collisions during the same bunch cross-overs (pile-up). In 2017, publications on inclusive diffractive cross sections, glueball analysis and partial wave analysis were completed, and several major conference presentations were given. By the end of 2017, ALICE had collected about 5.4 pb^{-1} of pp Double Gap events for the analysis of glueballs and exotic central states.

M. Mieskolainen developed a new Monte Carlo event generator approach for exclusive central diffraction at the LHC. The generator, targeted for glueball analyses and currently under beta testing for a first public release, incorporates differential absorption (screening loop) calculations together with a parameterised set of processes and amplitudes. He also introduced the first *Deep Learning* based analysis algorithm for high energy diffraction, and constructed a new algorithm for inverting non-linear autoconvolution type integral equations using FFT and Efron's bootstrap random sampling based uncertainty estimation. He continued to build up novel incidence algebra (Möbius functions) based combinatorial structures for high energy diffraction. This work was presented in the WE-Heraeus QCD School in September. M. Mieskolainen also continued his analysis of inclusive and exclusive diffraction in ALICE. For the exclusive processes, a new Expectation Maximization (EM) iteration based probabilistic particle and decay channel identification algorithm was constructed. A reference C++ implementation is now available. The basic motivation behind the analyses, novel physics tools and mathematical approaches by M. Mieskolainen is to learn more about asymptotic high energy QCD in the non-perturbative domain.

Using the LHC Ring for Tagging Forward Physics Events

As a proposal for using the LHC ring in forward physics event tagging was completed, several major conference presentations were given in 2017. The proposal aims at configuring a new physics search facility based on the existing instrumentation of the LHC ring and the LHC experiments. This novel approach uses the LHC Beam Loss Monitoring (BLM) and other LHC beam instrumentation devices for tagging the new physics event candidates in a model independent way.

Several physics processes, based mainly on Central Exclusive Production (CEP) are studied. The CEP processes provide an ideal test ground for the proposal, with a pair of coincident final state protons – exiting the LHC beam vacuum chamber – being used to tag the event candidates. The fractional momenta of the final state protons are directly related to the invariant mass of the centrally produced system.

Forward Detector R&D

The group has participated in the development of novel particle detection techniques aimed at forward physics studies in ALICE (AD and FIT projects).

The Helsinki group is also involved in the CERN experiment MoEDAL, searching for magnetic monopoles, and the CDF experiment at the Fermilab Tevatron.

Technology Programme

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 2017 the Technology Programme included research areas supporting the HIP strategy and on-going activities, namely accelerator technology, computing performance and efficiency, business incubation, and radiation-detection instrumentation.

Saku Mäkinen,
Technology Programme
director

Accelerator Technology (MAT/MSM)

Markus Aicheler,
Accelerator
Technology
project leader

Flyura Djurabekova,
University Researcher,
SIMAT

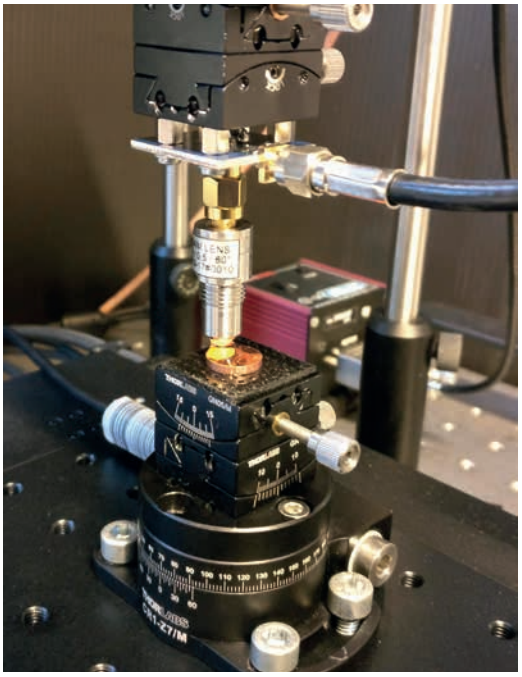
The MAT group – Materials for Accelerator Technology – is part of the Accelerator Technology project. In the group, we develop computer simulation models to describe the behaviour of different materials in extreme environments. The focus of the group is the understanding of breakdown phenomena near metal surfaces under high electric and high-gradient electromagnetic fields on the fundamental level to enable the design of an efficient RF accelerating structure for the Compact LInear Collider (CLIC) study at CERN. We have developed a multiscale model to span from the electronic properties of metal surfaces, using density functional theory methods, to the microscopic mechanical behaviour of surfaces in response to cyclic tensile stress loads due to the interaction between an electric field and a charged metal surface, using atomistic simulations methods combined with continuous electrodynamic models. The highlight of the research carried out in 2017 is the development of a new hybrid model, which concurrently combines the Laplace solver based on a flexible mesh with finite elements and discrete atomic dynamics in one simulation run. We also started experimental research into the behaviour of vacuum breakdown rates depending on materials properties. In our research we collaborate closely with Dr. W. Wünsch (CERN), Prof. Y. Ashkenazy (Hebrew University of Jerusalem, Israel), Dr. V. Zadin (Tartu University) and Dr. Zh. Wang (Xi'an Jiaotong University). The group consists of the group leader (Dr. F. Djurabekova), two postdoctoral researchers (Dr. V. Jansson and Dr. A. Kyritsakis) and four graduate students (E. Baibuz, M. Veske, A. Saressalo and J. Lahtinen).

The Module, Structures and Manufacturing (MSM) group within the Accelerator Technology project collaborates strongly with various groups and projects at CERN and with FAIR: e.g., the Compact LInear Collider (CLIC) study at CERN is developing 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. The CLIC study has entered a new phase of technical development and optimisation that will lead to a Technical Implementation Plan by 2019.

The focus of the HIP contribution is on a) R&D for the manufacturing of CLIC RF structures and the re-engineering of the so called CLIC module (the smallest modular entity containing all sub-systems of the accelerator); b) ramping up R&D activity related to Beam Instrumentation in close collaboration with the BI group at CERN leading to a future PhD thesis; c) taking part in CompactLight (an EU project on the design of future normal conducting FELs).

The work is executed in close collaboration with the CERN CLIC accelerating structures group of Dr. W. Wünsch and the CLIC module team of Dr. S. Döbert (co-led by Dr. M. Aicheler), and several Finnish industrial and academic partners. In 2017 the project had one MSc student (A. Moilanen), one

Jukka K. Nurminen, Green Big Data project leader



Scanning Acoustic Microscope measurement of a copper disc. The Scanning Acoustic Microscope (SAM) is an advanced method to measure the mechanical properties of a sample surface. The resolution can exceed 5 µm with focused 250 MHz ultrasound. To increase the signal-to-noise ration we use pulse compression. Echo amplitudes are related to the mechanical properties and the time-of-flight is related to the topology of the sample. In the picture our SAM measures a copper sample from the DC spark gap. *(Courtesy of Dr. Markus Aicheler.)*

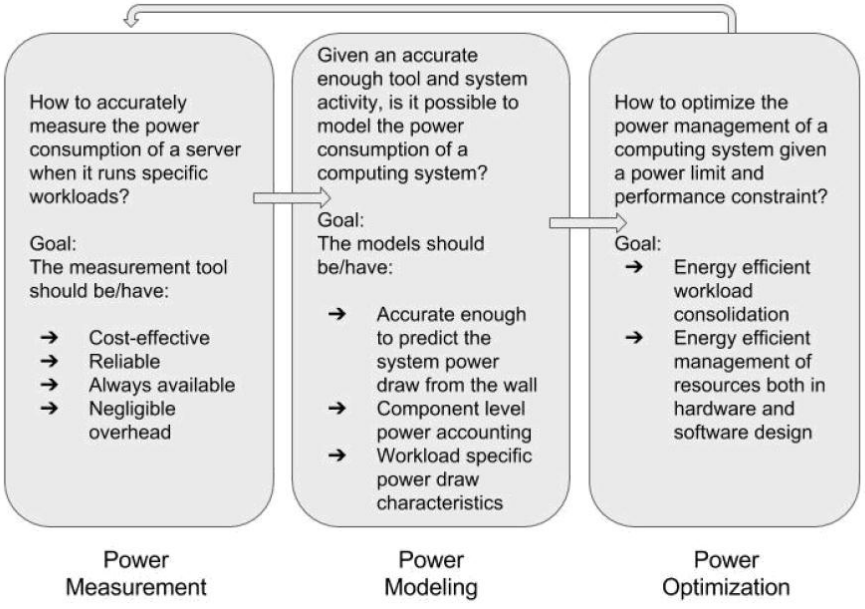
researcher (J. Väinölä), and the project leader (Dr. M. Aicheler) at CERN plus two PhD students (A. Meriläinen and R. Montonen) and one MSc student (A. Holmström) based in Helsinki.

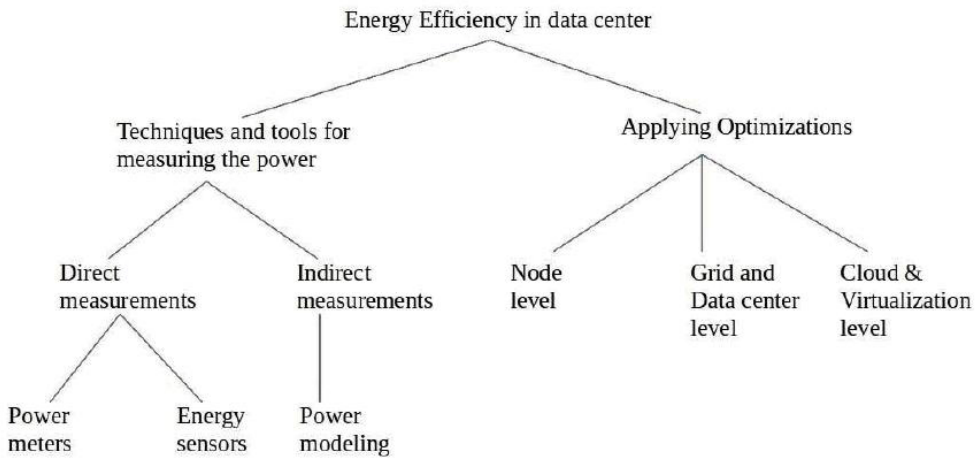
More details can be found under: http://research.hip.fi/hwp/acctech/accelerator-technology

Green Big Data

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 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 the CERN LHC experiments will be ten times higher in 2020 than today.

Research methodology.





Different approaches to improve the energy efficiency of computing nodes.

The Green Big Data project has focused on optimising the energy consumption of scientific computing clusters used for HEP computing related to CERN experiments. In 2017, we contributed to this area of research by

- developing models for estimating and controlling HPC energy-consumption,
- performing data-analysis of data centre logs and power traces with machine learning techniques using both CERN and CSC data,
- studying RAPL technology from Intel as a software only approach to derive estimates for both computer and job-specific energy spending,
- contributing to the *Scalable and Secure Infrastructures for Cloud Operations* Horizon 2020 project by leading the *High energy physics data processing* scenario.

Work on these items has continued in collaboration with Aalto University.

The personnel of the project included three part-time senior researchers and one full-time PhD student.

Because this is the final project year we have focused activities on finalising our work:

- K. Khan's Doctoral thesis on *Energy Measurement and Modeling in High Performance Computing with Intel's RAP* will enter preliminary examination at the end of the year.
- We have published journal papers summarising the findings of earlier papers and our experiences on this theme.

More details can be found on the project home page: https://twiki.cern.ch/twiki/bin/view/Main/GreenBigData

Radiation Metrology for Applications

Teemu Siiskonen, Radiation Metrology for Applications project leader

The safety and efficacy in medical x-ray imaging and radiotherapy requires accurate and reliable radiation beam characterization combined with methods to assess the patient exposure. In medical imaging, detectors with high quantum efficiency, energy resolving capabilities and good image quality are desirable to reduce patient exposure. In radiotherapy the introduction of flattening filter free (FFF) and small diameter beams result in dose gradients that have become so steep and localised that small scale measurements are urgently needed, including two- and three-dimensional maps of the dose distribution. Therefore, new measurement methods are needed to bridge the gap between the current laboratory reference conditions and modern radiotherapy beam dosimetry. In this context, an R&D project was initiated for new ionizing radiation detector technologies in medical applications. The project, whose

partners are the Helsinki Institute of Physics, Aalto University, Lappeenranta University of Technology and the Finnish Radiation and Nuclear Safety Authority (STUK), will receive funding from the Academy of Finland starting in 2018 (MPMIB – Multispectral Photon counting for Medical Imaging and Beam characterization). The team consists of 4 senior researchers and 5 post-docs and PhD students.

During 2017 several prototype detectors, including CdTe and pixel Si detectors, on a CMS readout chip were tested at the Radiation Metrology Laboratory of STUK. The tests concentrated on the dose and dose rate linearity of the detectors in both photon and neutron beams and also their ability to handle the very high dose rates encountered in radiotherapy applications and also to assess the pixel-by-pixel spectral acquisition capabilities of Si detectors. Development and validation of Monte Carlo models for dosimetric characterization of test beams were also initiated. Construction of large area pixelised detectors and their readouts, the development of data processing algorithms and further detector tests will continue in the abovementioned MPMIB project.

Saku Mäkinen,
BIC project leader

Peter Dendooven,
NINS3
project leader

Finnish Business Incubation Center of CERN Technologies

The CERN Business Incubation Network aims to improve commercialisation, and therefore, the social utilisation of CERN-related technologies in each member state. The FBC (Finnish Business Incubation Center of CERN Technologies), the CERN BIC in Finland, was established in 2015. The FBC is operated under the Technology Programme at HIP. The focus of the FBC is to be very selective in its search for incubatees, the FBC only selects ideas, innovations, or incubatees that exhibit disruptive and business ecosystem changing technologies. During 2017 multiple screening cases were conducted and the first one was adopted as an incubatee of the FBC, namely Advacam Oy.

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.

During 2017 the project was extended for an additional 3 years. The organisation of FBC will also be changed in 2018. The main change of organising is to build shared operations in each partner university of HIP. This brings the operations closer to the universities' activities locally. *FBC website: http://www.hip.fi/bic*

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

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 this context, the "Novel instrumentation for Nuclear Safety, Security and Safeguards" (NINS3) project performs R&D on passive tomography of spent nuclear fuel, alpha radiation threat detection and imaging from a distance, and active neutron interrogation of unknown objects. The project is an integral part of the National Radiation Safety Research Programme. The project partners are the 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.

Based on the work of the NINS3 project, HIP

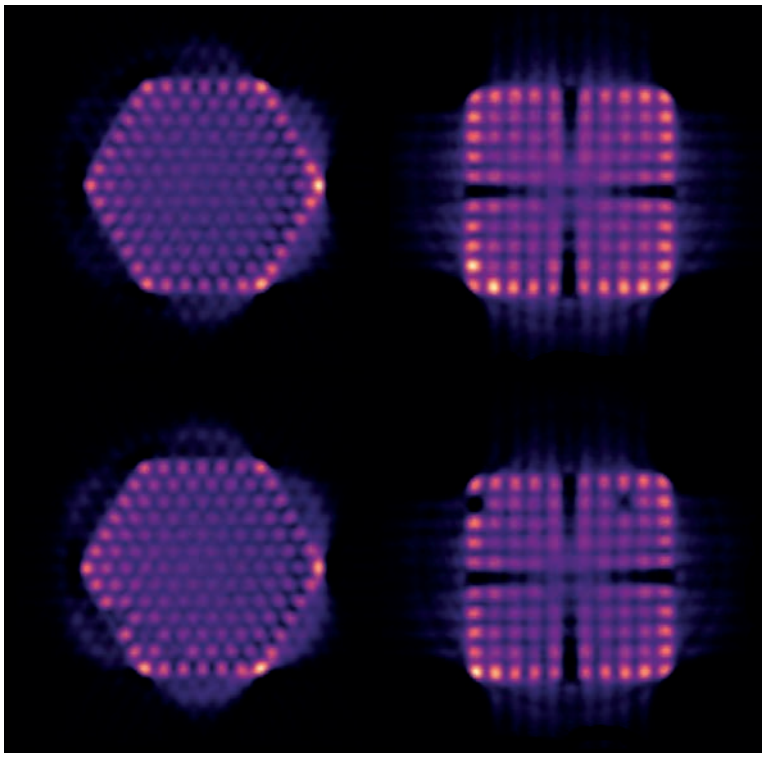
has been accepted as a member of ESARDA, the European Safeguards Research and Development Association. C. Bélanger-Champagne has joined the ESARDA Non-Destructive Assay (NDA) Working Group.

In collaboration with STUK, IAEA and EURATOM, the upgraded PGET (Passive Gamma Emission Tomography) instrument was used in two successful measurement campaigns at the Loviisa and Olkiluoto nuclear power plants in Finland. Research on improving the image reconstruction process is on-going.

The activities related to the NDA of spent nuclear fuel have been expanded. Following a recommendation from the ASTOR NDA Verification Focus Group installed by IAEA, we have used Monte Carlo simulations to develop the PNAR (Passive Neutron Albedo Reactivity) capability to measure fuel assembly neutron multiplication. This work is performed in close collaboration with STUK and S. Tobin (on leave from Los Alamos National Laboratory).

The design of a novel instrument for active neutron interrogation of artillery shells was finalised. A device based on this design is being set up by JHV Physics Oy. We have purchased a germanium gamma ray imaging device (GeGI) from PHDS Co. to add imaging capability to active neutron interrogation of various types of objects. A market survey related to combining active neutron interrogation systems with high energy gamma ray imaging instruments was conducted via an MSc research project at Tampere University of Technology.

Using a new set-up to investigate alpha-particle-induced radioluminescence, the efficacy of detecting solar blind radioluminescence in situations where the gas environment can be controlled has been demonstrated. A large body of data was gathered on the dynamic nature of nitric oxide (NO) radioluminescence in the UV spectral region, enabling us to refine the theoretical model that was put forward earlier. The dependence of NO radioluminescence on environmental gases has been studied and a maximum possible enhancement of emitted light by means of gas manipulation has been found. NO radioluminescence can be up to 50 times as strong as that of N_2.



Passive gamma emission tomography images of spent nuclear fuel assemblies at the Finnish nuclear power plants. In the bottom row, missing fuel pins can clearly be identified.

Detector Laboratory

Eija Tuominen,
Detector Laboratory
coordinator

The Helsinki Detector Laboratory is a national permanent 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), especially the UH Division of Particle and Astrophysics (PAP). The Laboratory provides premises, equipment, know-how and technical support 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 Laboratory team is active in education and outreach. Its activities are co-ordinated and priorities set by the Detector Laboratory Steering Board.

All the Detector Laboratory projects have the objective of providing reliable instruments for large **international physics experiments**. The Laboratory is specialised in the quality assurance of detectors and their components and in detector prototyping. In 2017, the Laboratory hosted the activities of experimental projects participating in the instrumentation of the CMS, TOTEM and ALICE experiments at CERN, and the NUSTAR experiment at FAIR. In addition, the Laboratory hosted several projects funded by the Academy of Finland and TEKES. Furthermore, new detector technologies were developed in the framework of the CERN CMS, RD50 and RD51 collaborations.

Quality assurance of CERN ALICE GEM production foils taking place in the Detector Laboratory clean room.

Detector technologies were presented at the International Researchers' Night.

The Detector Laboratory has a wide network of **national collaboration**, especially in the form of sharing expertise, equipment and infrastructure. The Laboratory collaborates with the UH Electronics Research Laboratory in the field of optical imaging and interconnection technologies and with the UH Accelerator Laboratory in the field of radiation hard semiconductor detectors. Collaboration is active also with the University of Jyväskylä, Department of Physics; Lappeenranta University of Technology, School of Engineering Science; Aalto University, Micronova facility; and the Finnish Radiation and Nuclear Safety Authority (STUK). Furthermore, in 2017 the Laboratory hosted a project financed by the Finnish Funding Agency for Innovation (TEKES) for the development of black silicon photodiodes with the Aalto University Department of Micro and Nanosciences.

Providing **education** in the instrumentation of physics is of outmost importance to the Detector Laboratory. In the framework of the Master's Programme for Particle Physics and Astrophysical Sciences (ParAs), the Laboratory offers lecture courses about semiconductor physics and detector technologies as well as research-based hands-on exercises and special assignments. In addition, the Laboratory supervises the dissertation work of Doctoral and Master's students, especially in the framework of the Doctoral Programme in Particle Physics and Universe Sciences (PAPU).

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 groups of visiting high-school students, totalling about 200 persons in 2017. In addition, in 2017, the Laboratory took an active part in outreach efforts, e.g., CERN Master Class, "Koekampus", "Science Bazaar", EU Researchers' Night and the Bring-Your-Child-to-Work -event. Furthermore, two secondary school TET-trainees and a trainee from the Finnish School of Watchmaking did their practice work at the Laboratory.

CLOUD

Markku Kulmala,
CLOUD
project leader

Background

The CLOUD (Cosmics Leaving OUtdoor Droplets) experiment at CERN is one of the most advanced laboratory set-ups for studying the formation and growth of atmospheric aerosol particles, which influence the Earth's radiative balance and therefore the whole climate system. This is caused by two mechanisms. First, aerosol particles can directly reflect or absorb solar radiation. Second, they can act as seeds for the formation of cloud droplets or ice crystals and thereby affect clouds' albedo, lifetime as well as precipitation. Measuring the underlying microphysics in controlled laboratory conditions is important for understanding the dynamical behaviour of ambient aerosol particles and cloud droplets, including the formation and growth processes of aerosols, cloud droplet activation and ice nucleation.

Indirect observations and theoretical studies have suggested that galactic cosmic rays (GCR) may influence the Earth's cloud cover and climate. The main proposed mechanisms are enhancement of nucleation rates (i.e., the rate of formation of new particles from gas-phase precursors) or the formation of ice particles due to ionization by GCR. The CLOUD experiment aims to find possible pathways for this phenomenon and evaluate their significance. By using the CERN proton synchrotron (PS), different levels of GCR can be simulated to investigate their influence on atmospheric processes.

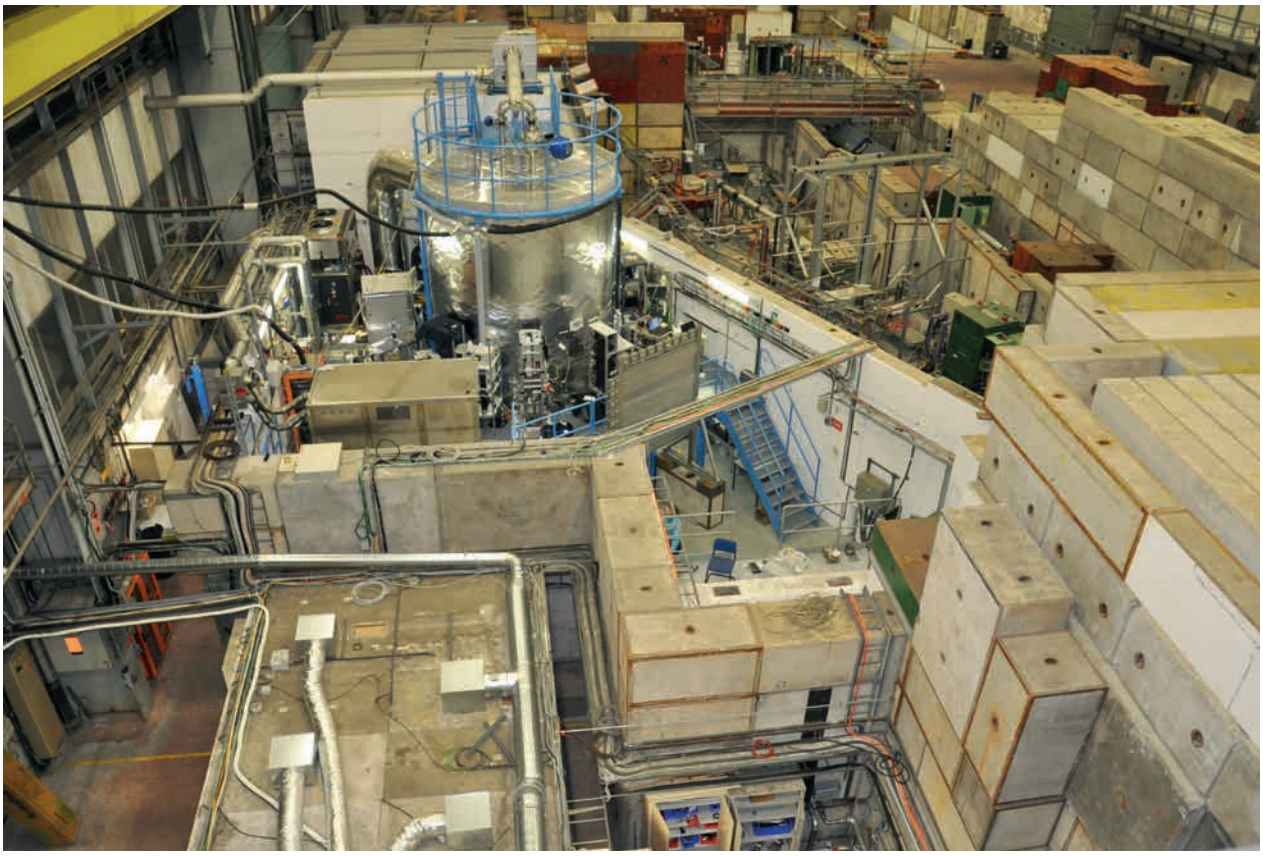
The CLOUD Collaboration comprises 21 institutes, with a strong Finnish contribution (the University of Helsinki, the Helsinki Institute of Physics, the University of Eastern Finland and the Finnish Meteorological Institute).

Experiments in 2017: The CLOUD12 Campaign

During autumn 2017, a 10-week intensive measurement campaign, CLOUD12, was organised to simulate particle formation in conditions relevant to the marine atmosphere, boreal forest, semi-urban and urban environments. The Finnish team made a major contribution, with a total of 15 persons working on site during the campaign, while the rest of the Helsinki team provided daily remote technical and data analysis support. The team was responsible for several important instruments such as particle counters and mass spectrometers.

Data Analysis, Education and Reporting of Results

The analysis of the data collected during the CLOUD7–12 campaigns is continuously on-going within the institutes and cross-institute working groups. Regular CLOUD workshops (Bad Zurzach, Switzerland and Vienna, Austria) are organised to support the analysis. We published 6 peer reviewed papers within CLOUD, which are summarised briefly here. For organic dominated chemical system, Wagner et al. (2017) investigated the role of ions in new particle formation in the CLOUD chamber, while Frege et al. (2018) studied the influence of temperature on the composition of ions. For a sulphuric acid system, Tsagkogeorgas et al. (2017) studied the dependence on humidity in the evaporation of particles, while Määttänen et al. (2018) developed a parameterisation of their formation, which can be used in global modelling. Gordon et al. (2017) implemented our findings in a global model to compare new particle formation in the present-day and preindustrial atmospheres. Finally, Nichman et al. (2017) reported the performance of a new device to study the asphericity of small ice particles in the CLOUD chamber. In 2017 we were granted a third round of MSCA ITN funding, CLOUD-MOTION, providing a third generation of PhD students (two at the University of Helsinki) to work on CLOUD.



The CLOUD experiment, surrounded by detectors brought by the participating institutes.

Planck-Euclid

Hannu Kurki-Suonio, Planck-Euclid project leader

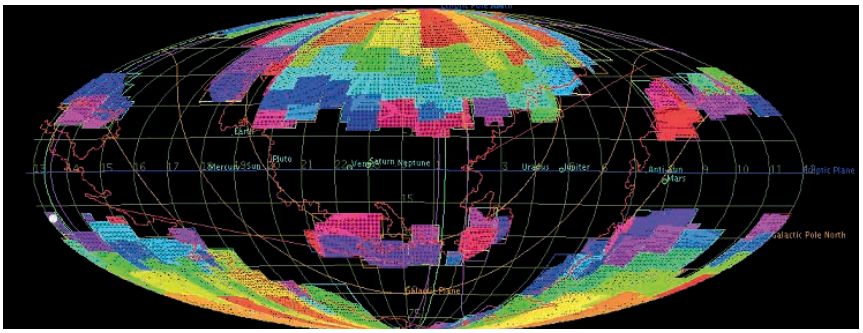
Planck and Euclid are the two cosmology missions of the European Space Agency. Planck measured the cosmic microwave background (CMB) with unprecedented accuracy to determine the properties of the universe. Euclid will study the "Dark Energy Question" – why is the expansion of the universe accelerating? – surveying over one third of the sky obtaining images of over a billion galaxies and the spectra of tens of millions of galaxies. The Euclid Consortium will determine the 3-dimensional distribution of galaxies and dark matter in the universe, compare their statistics to cosmological models and thus constrain the law of gravity and the dark energy equation of state. Euclid and Planck complement each other in improving our understanding of the universe, its structure, composition, origin, and governing forces; Planck concentrating on the early universe and Euclid on its later evolution. Planck made observations from 2009 to 2013; Euclid will be launched in 2021 and the nominal mission will take 6 years.

Planck

In 2017 we kept reanalysing Planck data. The final release of the Planck data and results is now scheduled in early 2018. We produced a new set of window functions for Planck LFI beams. Together with the US Planck team we produced FFP10, the tenth full-focal-plane simulation of Planck data, with 1000 realisations of LFI data and 300 realisations of HFI data, using supercomputers at CSC (Finland) and NERSC (USA). This set of simulations was used by us and other Planck teams to support the data analysis. We have fitted the parameters of cosmological models with primordial isocurvature perturbations to Planck data in preparation for the 2018 Planck Inflation paper. We also participated in an international simulation and analysis effort (Exploring Cosmic Origins with CORE) for a future polarization-optimised CMB satellite, which led to 10 submitted papers to be published in 2018. The related satellite proposal, CORE, to the European Space Agency was not selected for the M5 launch; discussions for preparing a new proposal have begun.

Euclid

We operate one of the nine Euclid Science Data Centers, SDC-FI. It runs on virtual machines at the CSC Kajaani Data Center. In 2017 the capacity of SDC-FI was increased to 640 virtual CPUs (400 physical cores) and 82 TB of storage. We participated in the Euclid SDC Science Challenge 3, where simulated data corresponding to nine Euclid fields (5 square degrees) was analysed all the way to merging the data products from the different instruments, and in Infrastructure Challenge 7. We have the main responsibility in Euclid for validating the code to estimate the galaxy 2-point correlation function (2PCF), and this task has occupied most of the SDC-FI computing capacity. We have introduced several improvements in the 2PCF algorithm and its implementation.



The planned Euclid sky survey in ecliptic coordinates. Different colours indicate regions of the sky to be surveyed during different six-month periods.
(Credit: ESA / Euclid Consortium.)

Education and Open Data

Education and Open Data is a new project in HIP established in 2017, and it is a continuation of the activities which HIP has devolved with great success earlier: the programme of high-school/teachers visits to CERN and the data preservation and open access to CMS data. The project is led by K. Lassila-Perini, who also acts as the Data preservation and Open Access co-ordinator of the CMS experiment.

Katri Lassila-Perini, Education and Open Data project leader

High School Visits

In 2017, 18 high-school groups from Finland, with a total of 364 students and 60 teachers, attended a three-day visit to CERN. The visits are preceded by an extensive study period in the visitors' own schools, preparing students for an intensive lecture and visit programme at CERN. The visit programme is partly subventioned by the Finnish National Agency for Education, and the applications and selection of groups is co-ordinated by the national CERN high-school network. A one-week course for teachers was organised at CERN in June, 2017. The feedback from these visits is overwhelmingly positive, the students greatly appreciate the direct contact with the researchers and their enthusiasm, and the visits encourage the students to join various scientific branches for their further studies.

Open Data Training

A new activity, a two-day course for the use of open data in schools was organised in the Viikki Teacher Training School of the University of Helsinki in March 2017, it was inspired by discussions with the teachers during the teacher's course at CERN in 2016 and the developments in the open data domain. The goal for the participants was to get to know CMS Open Data and prepare their own teaching material using it. The course was attended by 34 teachers and teacher students and the feedback was very encouraging. The material was prepared by P. Rikkilä, a HIP summer student in 2016 now preparing his Master's Thesis at the University of Jyväskylä. Two HIP summer students and one CERN summer student worked in the project at CERN during summer 2017, and developed further material for educational use of the CMS Open Data. The use of the material could be piloted in the Open Data working groups during the CERN three-week teacher programme and the international two-week summer camp for high-school students. A teaching module for a high-school and a secondary school course is now being developed and piloted in a real teaching situation in a school by P. Veteli, who is preparing his Master's Thesis at the University of Helsinki.

Open Data Release

The CMS experiment made the third public release of research data in December 2017, consisting of data collected in 2012 and simulations, a total of 1 PB. The published data contributed to the Higgs boson discovery in 2012, and a detailed analysis example for the Higgs boson decaying into a four lepton final state is included in the release. A major step towards the long-term re-usability of the data was demonstrated by HIP trainee P. Niemi from Lapland University of Applied Sciences showing that it is possible to reprocess the original raw data to the format appropriate for the analysis only using tools available publicly. The example is included in the release. In parallel with the release, the CERN Open Data portal went through a major upgrade for the underlying structure and the user interface, and now offers detailed guidance for different users. Training sessions co-ordinated through the HIP Education and Open Data project gave valuable input to the new guide for educational use of the CMS Open Data on the Open Data portal.

Joint Activities

Antti Väihkönen,
Research coordinator

HIP is a joint institute of five universities. Its host, the University of Helsinki, continued reforms in 2017 with the renewal of the Regulations of the University. The Big Wheel education reform was implemented further and the University was preparing for the new internal structure of the faculties to come into force at the beginning of 2018. A search for a new director for HIP was carried out when the director, Professor Paula Eerola, was appointed Dean of the Faculty of Science starting at the beginning of 2018.

The doctoral education of physics students continues to be one of the main tasks of the Institute. The HIP doctoral students who take their degrees at the University of Helsinki belong to the Doctoral Programme in Particle Physics and Universe Sciences, PAPU, or the Doctoral Programme in Materials Research and Nanosciences, MATRENA. In addition to the doctoral students, a fair number of undergraduate students join the research groups and complete their Masters' theses work at the Institute. Many of them continue as doctoral students in the Institute projects. In 2017 the traditional CERN summer student programme included positions at ESRF in Grenoble, in a regular way after piloting the previous year. During the period 2013–2017, 41 doctoral degrees and 68 Masters' degrees have been earned in HIP research projects.

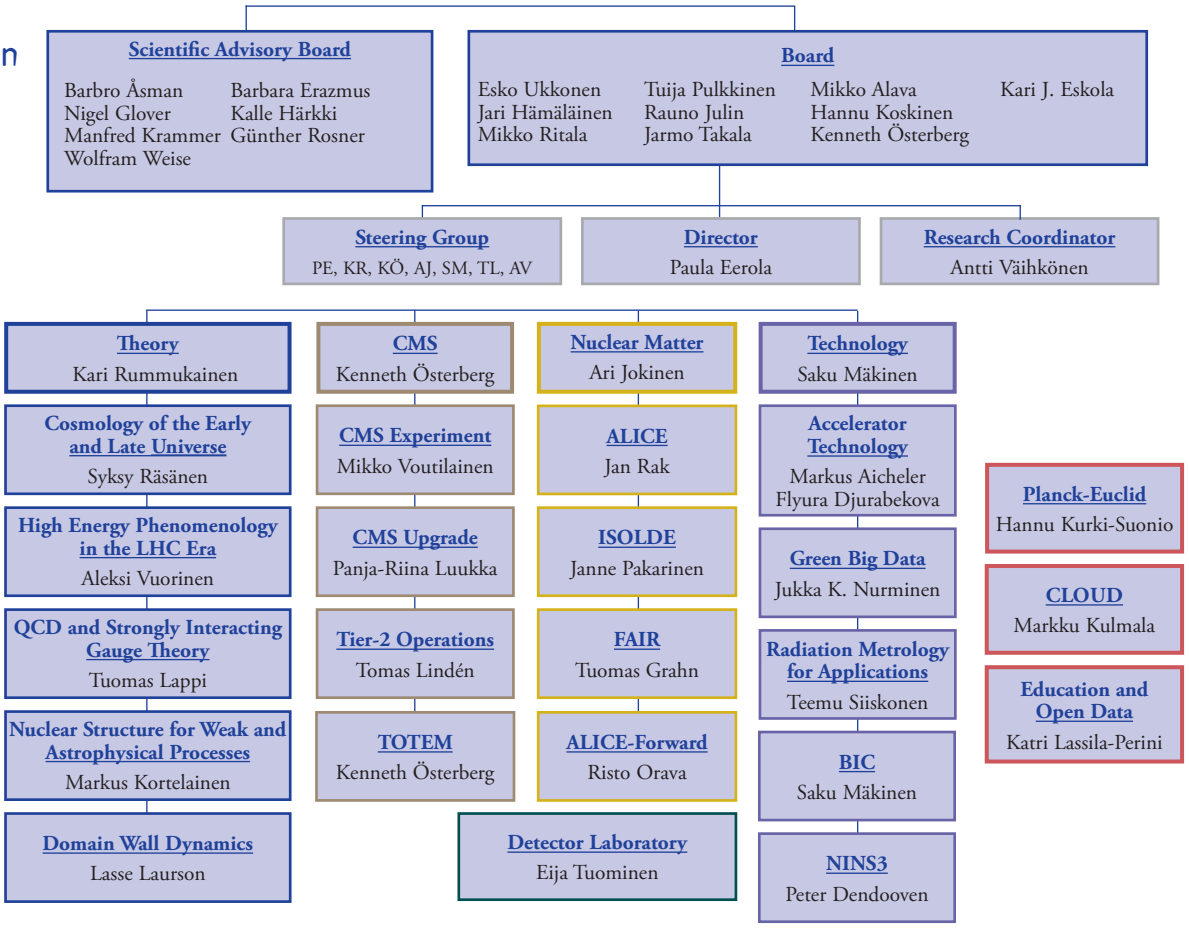
HIP made a major effort in raising awareness of CERN business, job and educational opportunities during 2017. In close collaboration with CERN and other actors HIP organised a one-day event *CERN Roadshow in Finland* at the Aalto Design Factory in April and a three-day event *Finland at CERN* in Geneva in November. The latter event was part of the Suomi Finland 100 programme celebrating the centenary of Finland's independence.

Industrial activation was also continued within the HIP Technology Programme and the Business Incubation Center, which aims to support new business innovations in the fields of CERN technologies. The first incubation agreement was signed between HIP and Advacam Oy.

The research collaboration with the Finnish National Radiation and Nuclear Safety Authority (STUK) was strengthened by the Radiation Metrology for Applications project, which started at the beginning of 2017.

Organization and Personnel

Organization



The Institute Board

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Manfred Krammer, Department Head, Dr. (CERN)

Günther Rosner, Professor (U. Glasgow)

Wolfram Weise, Professor (TU München)

Personnel

Theory Programme

K. Rummukainen, prof., programme director

Cosmology of the Early and Late Universe

S. Räsänen, docent, proj. leader
K. Enqvist, prof., adj. senior scientist
A. Finoguenov, prof., adj. senior scientist
M. Hindmarsh, prof., adj. senior scientist
K. Kainulainen, prof., adj. senior scientist
F. Montanari, scientist
D. Weir, adj. scientist
V.-M. Enckell, grad. student
H. Jukkala, grad. student
H. Nyrhinen, grad. student
J.-M. Ojanperä, grad. student
P. M. Rahkila, grad. student
E. Tomberg, grad. student
V. Vaskonen, grad. student
P. Wahlman, grad. student

High Energy Phenomenology in the LHC Era

A. Vuorinen, ass. prof., proj. leader
K. Huitu, prof., adj. senior scientist
K. Kajantie, prof., adj. senior scientist
O. Lebedev, prof., adj. senior scientist
E. Keski-Vakkuri, adj. senior scientist
M. Sainio, adj. senior scientist
K. Tuominen, adj. senior scientist
M. Heikinheimo, scientist
A. Meroni, scientist
T. Rindlisbacher, scientist
B. DiNunno, adj. scientist
T. Gorda, adj. scientist
C. Gross, adj. scientist
N. Jokela, adj. scientist
V. Keränen, adj, scientist
V. Keus, adj. scientist
E. Annala, grad. student
N. Koivunen, grad. student
A. Pönni, grad. student
J. Remes, grad. student
M. Säppi, grad. student
T. Tenkanen, grad. student
S. Tähtinen, grad. student
M. Zatta, grad. student

QCD and Strongly Interacting Gauge Theory

T. Lappi, docent, proj. leader
K. J. Eskola, prof., adj. senior scientist
V. Guzey, scientist
H. Paukkunen, scientist
Y. Zhu, scientist
B. Ducloué, adj. scientist
M. Kuha, grad. student
P. Paakkinen, grad. student
J. Peuron, grad. student
A. Ramnath, grad. student
A. Rantalaiho, 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. Toivanen, senior scientist
K. Bennaceur, adj. senior scientist
J. Niskanen, adj. senior scientist
K. Petrik, scientist
T. Haverinen, grad. student

Domain Wall Dynamics

L. Laurson, Dr., proj. leader
T. Herranen, grad. student
I. Rissanen, grad. student

CMS Programme

K. Österberg, prof., programme director

CMS Experiment

M. Voutilainen, ass. prof., proj. leader
P. Eerola, prof., senior scientist
T. Lampén, senior scientist
K. Lassila-Perini, senior scientist (at CERN)
S. Lehti, senior scientist
J. Tuominiemi, adj. senior scientist
H. Kirschenmann, scientist
M. Kortelainen, scientist
T. Lindén, lab. engineer
J. Heikkilä, grad. student
T. Järvinen, grad. student
S. Laurila, grad. student
M. Lotti, grad. student
J. Pekkanen, grad. student
H. Siikonen, grad. student
J. Havukainen, student
K. Kallonen, student

CMS Upgrade

P.-R. Luukka, Dr., proj. leader
E. Tuominen, senior scientist
I. Kassamakov, adj. senior scientist
T. Arsenovich, grad. student
M. Golovleva, grad. student
A. Gädda, grad. student
T. Hakkarainen, grad. student
A. Karadzhinova, grad. student
L. Martikainen, grad. student
J. Ott, grad. student
V. Pyykkönen, grad. student
A. Winkler, grad. student

Tier-2 Operations

T. Lindén, Dr., proj. leader, grid coordinator

TOTEM

K. Österberg, prof., proj. leader
H. Saarikko, prof. emeritus, adj. senior scientist
M. Berretti, scientist
T. Naaranoja, grad. student
F. Oljemark, grad. 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
P. Greenlees, prof., adj. senior scientist
A. Jokinen, prof., adj. senior scientist
I. Moore, prof., adj. senior scientist
T. Grahn, adj. senior scientist
K. Helariutta, adj. senior scientist
D. Cox, adj. scientist
U. Jakobsson, adj. scientist
P. Papadakis, adj. scientist
P. Rahkila, adj. scientist
P. Ruotsalainen, adj. scientist
J. Konki, adj. grad. student
J. Ojala, adj. grad. student

FAIR

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E. Tuominen, docent, proj. coordinator
J. Äystö, prof., director emeritus, adj. senior scientist
A. Jokinen, prof., adj. scientist
I. Moore, prof., adj. scientist
H. Penttilä, adj. senior scientist
S. Rinta-Antila, adj. senior scientist
C. Scholey, adj. senior scientist
F. García, lab. engineer

ALICE-Forward

R. Orava, prof., proj. leader
M. Mieskolainen, grad. student

Technology Programme

S. Mäkinen, prof., programme director

Accelerator Technology

M. Aicheler, Dr., proj. leader
F. Djurabekova, senior scientist
E. Hæggström, prof., adj. senior scientist
K. Nordlund, prof., adj. senior scientist
K. Österberg, prof., adj. senior scientist
T. Ahlgren, adj. senior scientist
I. Kassamakov, adj. senior scientist
A. Kuronen, adj. senior scientist
V. Jansson, scientist
A. Kyritsakis, scientist
V. Zadin, adj. scientist
E. Baibuz, grad. student
A. Meriläinen, grad. student
R. Montonen, grad. student
A. Saressalo, grad. student
H. Vázquez Muíños, grad. student
M. Veske, grad. student
J. Väinölä, grad. student (at CERN)
A. Xydou, grad. student (at CERN)
A. Holmström, student
J. Lahtinen, student

Green Big Data

J. K. Nurminen, prof., proj. leader
A.-P. Hameri, prof., senior scientist
T. Niemi, senior scientist (at CERN)
S. Heikkilä, scientist (at CERN)
K. Khan, grad. student

Radiation Metrology for Applications

T. Siiskonen, Dr., proj. leader (at STUK)
J. Tikkanen, grad. student (at STUK)

Finnish Business Incubation Center of CERN Technologies (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
V. Litichevskyi, scientist
P. Peura, scientist
T. Kerst, grad. student

Detector Laboratory

E. Tuominen, senior engineer, lab. coordinator
M. Juntunen, research coordinator
I. Hietanen, senior scientist
T. Hildén, scientist
N. Lebedeva, scientist
F. García, lab. engineer
J. Heino, lab. engineer
P. Koponen, lab. engineer
E. Kangasaho, lab. technician
R. Turpeinen, lab. technician

CLOUD

M. Kulmala, prof., Academician, proj. leader
J. Duplissy, scientist

Planck-Euclid

H. Kurki-Suonio, docent, proj. leader
V. Allevato, scientist
E. Keihänen, scientist
A.-S. Suur-Uski, scientist
J. Väliviita, scientist
C. Kirkpatrick, adj. scientist
M. Savelainen, adj. scientist
K. Kiiveri, grad. student
V. Lindholm, grad. student
A. Viitanen, grad. student

Education and Open Data

K. Lassila-Perini, Dr., proj. leader (at CERN)
P. Veteli, research assistant
P. Rikkilä, student

Administration and Support

P. Eerola, prof., director
A. Väihkönen, research coordinator
J. Aaltonen, lab. engineer

University Services administration team including:
T. Laurila, admin. manager
H. Kinnunen, controller
T. Hardén, service coordinator
T. Savolainen, HR coordinator
T. Heikkilä, secretary
T. Karppinen, secretary (at CERN)
T. Onnela, secretary (at CERN)

Seminars

Seminars held in Helsinki

9th January A. De Roeck (CERN)
Searching for exotic long lived particles with dedicated experiments at the LHC

10th January T. Ojanen (Aalto)
Topological matter for pedestrians

16th January M. Lippert (Long Island University)
Shining light on quantum gravity with pulsar-black hole binaries

9th February T. Alho (Reykjavik)
Monopole correlation functions and holographic phases of matter in 2+1 dimensions

14th February B. Goutéraux (NORDITA)
Bad metals from density waves

21st February A. Mazumdar (Lancaster)
Infinite derivative ghost free and singularity free theory of gravity

23rd February J. Louko (Nottingham)
Waiting for Unruh

27th February N. Brambilla (TU München)
Quarkonium with effective field theories

28th February A. Vairo (TU München)
Heavy Majorana neutrino production and decay in the hot early universe

14th March N. Haque (Giessen)
Resummed QCD thermodynamics at finite temperature and chemical potential

16th March R. Paatelainen (Jyväskylä)
Towards higher order accuracy in LCPT

21st March B. Oblak (ETH, Zürich)
BMS particles in three dimensions

28th March B. DiNunno (Austin)
Relaxation of non-local probes in AdS/CFT

27th April J. Andersen (Trondheim)
QCD in strong magnetic fields

2nd May G. Dvali (LMU Munich)
The secret quantum life of black holes

4th May H. Paukkunen (Jyväskylä)
Nuclear PDFs today

9th May J. Olsen (Princeton, CERN)
Exploring the energy frontier: LHC at 13 TeV

11th May A. Pönni (Helsinki)
Holographic entanglement flows

12th May P. Harris (CERN)
Understanding the minutiae of the standard model with dark matter

16th May M. Valtonen (Turku)
Post-Newtonian components of a gravitational wave

16th May A. Rothkopf (Heidelberg)
Improved real-time dynamics of thermal fields from lattice simulations

30th May T. Dorigo (Padova)
Controversial phenomena in collider data and the five sigma criterion in HEP

30th May O. Henriksson (Boulder)
Holographic studies of ABJM theory at finite density

31st May M. Panero (Torino)
Non-equilibrium theorems from statistical mechanics and their applications in lattice QCD

1st June M. Khouchen (Brno)
Fundamental strings and D1 branes on deformed AdS3 x S3 background

6th June D. Fernández (Reykjavik)
Entanglement entropy at non-equilibrium in holography

8th June M. Kaya (Marmara)
Jet measurements at CMS

9th June D. Rodríguez (Oviedo)
Stiff phases in holography

14th June K. Yagi (Princeton)
Probing fundamental physics with gravitational waves from compact binary coalescences

15th June T. Zingg (NORDITA)
Holographic renormalization via background subtraction

8th August J.-P. Blaizot (Saclay)
Bose-Einstein condensation in unusual circumstances

15th August M. Krššák (Tartu)
Modified teleparallel theories

22nd August V. Tarasov (Moscow State University)
Physics on fractals: approaches and problems

29th August S. Rusak (NORDITA)
Inflation, Higgs and EW vacuum stability

19th September P. Di Vecchia (NORDITA)
Universal soft behavior of massless particles and the tale of two dilatons

26th September O. Gould (Imperial College, London)
Magnetic monopole creation

10th October T. Brauner (Stavanger)
Nuclear matter without nucleons and Bose-Einstein condensation in strong magnetic fields

12th October H. Patel (UMass Amherst)
Automated calculation of one loop integrals with Package-X and CollierLink

17th October C. Carlson (College of William and Mary, Virginia)
Proton radius problem review

20th October Particle Physics Day
T. Lappi (Jyväskylä):
QCD theory overview
D. J. Kim (Jyväskylä):
ALICE experimental overview
P. Paakkinen (Jyväskylä):
EPPS16 – First nuclear PDFs to include LHC data
H. J. Hänninen (HIP):
Deep inelastic scattering in the dipole picture at next-to-leading order
J. Parkkila (Jyväskylä):
Linear and non-linear flow mode in 5 TeV Pb-Pb
V. Keus (Helsinki):
Particle cosmology theory overview
H. Kirschenmann (HIP):
CMS+TOTEM experimental overview
T. V. I. Tenkanen (Helsinki, HIP):
Non-perturbative study of electroweak phase transition in BSM models
M. Lotti (HIP):
Search for charged Higgs bosons in the CMS experiment
N. Jokela (Helsinki, HIP):
Holography theory overview talk
K. K. Loo (Jyväskylä):
Neutrino physics experimental overview
T. J. Kärkkäinen (HIP):
Constraints to Triplet Higgs model from oscillation experiments
S. Vihonen (Jyväskylä):
Neutrino oscillations in BSM physics

24th October J. Kozaczuk (UMass Amherst)
Dark photons from nuclear transitions

26th October A. Smilga (Nantes)
Ultraviolet behaviour of nonrenormalizable supersymmetric theories

7th November E. Kilpua and M. Palmroth (Helsinki)
Experimental dialogue talk on space physics and space weather

16th November S. Mondal (Helsinki)
The various aspects and future prospects of heavy neutrino search

23rd November S.-J. Wang (Beijing)
The gravitational waves from the first-order phase transition with a dimension-six operator

28th November A. Kupiainen (Helsinki)
Proof of the DOZZ formula

30th November X. Chu (Vienna)
Dark matter indirect signals with a long-lived mediator

4th December C. Young (CERN/ATLAS)
Particle flow reconstruction in ATLAS for jets and MET

14th December S. Huber (Sussex)
Baryons and gravitational waves from the electroweak phase transition?

Visitors

Theory Programme

Cosmology of the Early and Late Universe

M. Rinaldi (Italy) 23.–27.1.
T. Takahashi (Japan) 24.–31.1., 18.–2.11.
G. Ballesteros (France) 30.1.–3.2.
V. Keus (Finland) 1.–2.2.
A. Mazumdar (UK) 21.–22.2.
R. Durrer (Switzerland) 22.–23.2.
A. Barreira (Germany) 28.2.–3.3.
T. Tenkanen (UK) 3.–10.3.
J. Beltrán (France) 14.–16.3.
T. Tram (Denmark) 27.–30.3.
J. Chluba (UK) 4.–7.4.
F. Montanari (Finland) 6.–7.4.
V. Poulin (France) 11.–13.4.
C. Byrnes (UK) 24.–28.4.
S. Galli (France) 2.–4.5.
D. Cutting (UK) 9.–26.5.
S. Camera (Italy) 19.–25.5.
T. Markkanen (UK) 23.–26.5.
D. Marsh (UK) 29.5.–1.6.
Q. Shafi (USA) 3.–7.6.
T. Prokopec (The Netherlands) 13.–16.6.
R. Caldwell (USA) 29.6.
S. Hotchkiss (New Zealand) 11.–14.7.
K. Tuominen (Finland) 6.–8.9.
O. Gould (UK) 25.–27.9.
T. Moroi (Japan) 28.–30.9.
H. H. Patel (USA) 1.–14.10.
K. Kohri (Japan/UK) 3.–5.10.
T. Toma (Germany) 15.–22.10.
J. Kozaczuk (USA) 23.–25.10.
J. Vieira (UK) 24.–26.10.
K. Dolag (Germany) 8.–9.11.
G. Fanizza (Switzerland) 12.–18.11.
J. Cline (Sweden/Canada) 16.–22.11.
S.-J. Wang (China) 20.11.–1.12.
F. Kahlhoefer (Germany) 28.11.–3.12.
N. Tamanini (Germany) 29.11.–1.12.

High Energy Phenomenology in the LHC Era

T. Ojanen (Finland) 10.1.
M. Lippert (USA) 14.–17.1.
T. Alho (Iceland) 8.–10.2.
B. Gouteraux (Sweden) 12.–14.2.
N. Brambilla (Germany) 27.2.
A. Vairo (Germany) 27.2.
N. Haque (Germany) 13.–15.3.
R. Paatelainen (Finland) 15.–17.3.
B. Oblak (Switzerland) 19.–26.3.
B. DiNunno (USA) 27.–30.3.
D. Rodriguez (Spain) 1.4.–30.6.
J. Andersen (Norway) 27.–28.4.
H. Paukkunen (Finland) 4.5.
A. Rothkopf (Germany) 15.–17.5.
O. Henriksson (USA) 29.5.–1.6.
M. Panero (Italy) 30.5.–2.6.
D. Fernandez (Iceland) 5.–7.6.
T. Zingg (Sweden) 12.–16.6.
K. Yagi (USA) 12.–18.6.
J.-P. Blaizot (France) 7.–9.8.
M. Krššák (Estonia) 14.–15.8.
P. Di Vecchia (Denmark) 18.–19.9.
O. Gould (UK) 25.–28.9.
H. H. Patel (USA) 1.–14.10.
T. Brauner (Norway) 9.–11.10.
J. Kozaczuk (USA) 23.–27.10.
S. Huber (UK) 13.–15.12.

QCD and Strongly Interacting Gauge Theory

H. Niemi (Germany) 5.1., 18.–26.4., 28.8.–1.9.
P. Huovinen (Poland) 9.–13.1., 5.–9.6.
D. Rischke (Germany) 23.2.–1.3.
I. Helenius (Germany) 27.–31.3., 22.6., 11.–24.8., 18.–22.12.
D. Müller (Austria) 1.5.–31.7.
H. Mäntysaari (USA) 15.–19.5.
J.-P. Blaizot (France) 9.–12.8.
A. Vuorinen (Finland) 13.10.
R. Paatelainen (Finland) 21.–22.11.

Domain Wall Dynamics

M. C. Miguel (Spain) 14.–16.2.
E. Ferrero (Italy) 6.–9.3.

CMS Programme

S. Ericksson (UK) 3.5.
P. Pusa (UK) 3.5.
A. Kardzhinova-Ferrer (Croatia) 7.–10.5.
T. Dorigo (Italy) 29.–30.5.
M. Backhaus (Switzerland) 5.–7.10.
A. Starodumov (Croatia) 5.–7.10.
P. Newman (UK) 3.11.
C. Young (Switzerland) 5.12.
U. Egede (UK) 18.12.

Nuclear Matter Programme

FAIR

H. Heggen (Germany) 18.–21.4.
N. Kurz (Germany) 18.–21.4.

ALICE–Forward

A. De Roeck (Switzerland) 8.–10.1.

Technology Programme

Accelerator Technology

K. Eimre (Estonia) 30.6.–3.7.
D. Rivoiron (Switzerland) 4.–6.7.
H. Gerster (Switzerland) 4.–7.7.
H. Schmickler (Switzerland) 4.–7.7.

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

S. Tobin (USA) 9.–23.4., 26.–30.6., 4.–15.9.

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 (E. Tomberg)

Sultan Qaboos University, Oman Astronomical Society,
3–15 January, Muscat, Oman (invited colloquium talk by M. Hindmarsh, invited talk by M. Hindmarsh)

Oslo University,
3 February, Oslo, Norway (colloquium talk by K. Kainulainen)

University of Lisbon,
12–17 February, Lisbon, Portugal (invited colloquium talk by M. Hindmarsh)

Workshop: GR Effects in Cosmological Surveys,
13–18 February, Cape Town, South Africa (talk by F. Montanari)

Annual Meeting of the Finnish Physical Society,
22–24 March, Helsinki, Finland (K. Kainulainen, F. Montanari, S. Räsänen, E. Tomberg)

Higgs Cosmology. The Royal Society Theo Murphy Meeting,
27–28 March, Chicheley, UK (talk by K. Enqvist, K. Kainulainen, talk by D. Weir)

University of Massachusetts Amherst,
29 March – 11 April, Amherst, MA, USA (D. Weir)

Amherst Center for Fundamental Interactions Workshop "Making the Electroweak Phase Transition (Theoretically) Strong",
6–8 April, Amherst, MA, USA (talk by D. Weir)

CERN,
9–22 April, Geneva, Switzerland (K. Kainulainen)

University of Würzburg,
3–6 May, Würzburg, Germany (talk by K. Kainulainen)

7th Iberian Gravitational Wave Meeting,
15–17 May, Bilbao, Spain (talk by D. Weir)

OliveFest,
17–19 May, Minneapolis, MN, USA (talk by K. Kainulainen)

Spring School on Numerical Relativity and Gravitational Wave Physics,
18–22 May, Beijing, China (lectures by D. Weir)

Astronomical Observatory of Trieste and SISSA,
25–31 May, Trieste, Italy (talk by F. Montanari)

School on Gravitational Waves for Cosmology and Astrophysics,
28 May – 4 June, Benasque, Spain (invited lectures by M. Hindmarsh)

Euclid Consortium General Meeting,
5–8 June, London, UK (F. Montanari)

University of Sussex,
19–30 June, Sussex, UK (D. Weir)

Inhomogeneous Cosmologies Workshop,
2–7 July, Torun, Poland (talk by S. Räsänen)

Advances in Theoretical Cosmology in Light of Data,
3–7 July, NORDITA, Stockholm, Sweden (talk by D. Weir)

Practitioners' Workshop on Relativistic Effects in Large Scale Structure,
5–7 July, Zurich, Switzerland (talk by F. Montanari)

University of Sussex,
10–21 July, Sussex, UK (D. Weir)

Advances in Theoretical Cosmology in Light of Data,
17–21 July, NORDITA, Stockholm, Sweden (talks by S. Räsänen and E. Tomberg)

Cosmo 17,
18 August – 1 September, Paris, France (talk by D. Weir)

4th LISA Cosmology Working Group Workshop,
15–20 October, Mainz, Germany (talk by M. Hindmarsh, D. Weir)

London Relativity Seminar,
18 October, London, UK (talk by S. Räsänen)

Oxford Theoretical Particle Physics Seminar,
19 October, Oxford, UK (talk by S. Räsänen)

Sussex Cosmology Monday Meeting,
23 October, Brighton, UK (talk by S. Räsänen)

ICQ Colloquium,
26 October, Portsmouth, UK (talk by S. Räsänen)

Max Planck Institute for Physics,
6–8 November, Munich, Germany (invited colloquium talk by M. Hindmarsh)

IFAE Seminar,
10 November, Barcelona, Spain (talk by S. Räsänen)

University of the Basque Country,
17–21 November, Bilbao, Spain (talk by M. Hindmarsh)

University of Helsinki,
7–13 December, Helsinki, Finland (K. Kainulainen)

High Energy Phenomenology in the LHC Era

Quark Matter 2017,
5–11 February, Chicago, IL, USA (T. Gorda)

QCD at Finite Temperature and Heavy Ion Collisions,
12–15 February, BNL, Upton, NY, USA (talk by A. Vuorinen)

Harvard University,
16–18 February, Cambridge, MA, USA (A. Vuorinen)

Micro-Workshop on Analytic Properties of Thermal Correlators at Weak and Strong Coupling,
5–8 March, Oxford, UK (talk by A. Vuorinen)

Annual Meeting of the Finnish Physical Society,
22–24 March, Helsinki, Finland (M. Säppi, A. Vuorinen)

Annual NewCompStar COST Action Workshop,
28–31 March, Warsow, Poland (talk by A. Vuorinen)

CERN,
30 April – 20 May, Geneva, Switzerland (T. Gorda)

Origin of Mass 2017,
1–4 May, Odense, Denmark (talk by M. Heikinheimo)

Summer School in Particle Physics,
15–19 May, Helsinki, Finland (lecture by N. Jokela, organiser A. Vuorinen)

ENS,
21–24 May, Paris, France (N. Jokela)

Pre-Strings 2017: Advanced Strings School,
19–24 June, Haifa, Israel (N. Jokela)

Strings 2017,
25 June – 1 July, Tel Aviv, Israel (N. Jokela)

Extreme QCD Workshop,
26–28 June, Pisa, Italy (IAS member A. Vuorinen)

EPS Plasma Physics Conference,
26–30 June, Belfast, Northern Ireland, UK (talk by M. Heikinheimo)

Summer School on EFT In Particle Physics and Cosmology,
3–28 July, Les Houches, France (M. Säppi)

EPS-HEP Conference,
5–9 July, Venice, Italy (convener A. Vuorinen)

Canterbury Tales of Hot QFTs in the LHC Era,
10–15 July, Oxford University, Oxford, UK (talk by A. Vuorinen)

NewCompStar School 2017,
11–15 September, Sofia, Bulgaria (E. Annala)

DESY,
14–16 September, Hamburg, Germany (invited seminar by A. Vuorinen)

TU Munich,
17–19 September, Munich, Germany (invited seminar by A. Vuorinen)

Tartu-Tuorla Cosmology Meeting 2017,
26–29 September, Tartu, Estonia (M. Heikinheimo)

Workshop on Many-Body Quantum Chaos, Bad Metals and Holography,
4–6 October, Stockholm, Sweden (plenary talk by N. Jokela)

University of Jyväskylä,
12–13 October, Jyväskylä, Finland (invited colloquium talk by A. Vuorinen)

APC,
18–20 October, Paris, France (invited seminar by N. Jokela)

Tuorla Observatory,
19 October, Turku, Finland (invited seminar by A. Vuorinen)

Particle Physics Day 2017,
20 October, Helsinki, Finland (talk by N. Jokela, organiser A. Vuorinen)

TU Darmstadt,
26–27 October, Darmstadt, Germany (invited seminar by A. Vuorinen)

Institute for Nuclear Theory & University of Colorado Boulder,
11–25 November, Seattle, WA & Boulder, CO, USA (invited seminars by T. Gorda)

COST CA16214 Management Committee Meeting,
22 November, Brussels, Belgium (N. Jokela)

Workshop on Holographic Dense QCD and Neutron Stars,
23–25 November, Paris, France (talk by E. Annala, organiser N. Jokela, talk by J. Remes)

QCD and Strongly Interacting Gauge Theory

BNL,
12–13 January, Upton, NY, USA (seminar by J. Peuron)

Quark Matter 2017,
5–11 February, Chicago, IL, USA (talk by K. J. Eskola, T. Lappi, P. Paakkinen, invited talk by H. Paukkunen, J. Peuron)

Probing QCD in Photon-Nucleus Interactions at RHIC and LHC: the Path to EIC,
13–17 February, Seattle, WA, USA (T. Lappi)

CERN,
20 February – 17 March, Geneva, Switzerland (seminar by J. Peuron)

University of Helsinki,
3 April, Helsinki, Finland (seminar by H. Paukkunen)

DIS 2017 XXV International Workshop on Deep-Inelastic Scattering and Related Subjects,
3–7 April, Birmingham, UK (talks by B. Ducloué, P. Paakkinen, and H. Paukkunen)

CERN,
24 April – 19 May, Geneva, Switzerland (J. Peuron)

Saturation: Recent Developments, New Ideas and Measurements,
26–28 April, Birmingham, UK (T. Lappi)

CERN,
9–12 May, Geneva, Switzerland (T. Lappi)

Lattice 2017,
18–24 June, Granada, Spain (talk by J. Peuron)

QCD Master Class 2017,
18–24 June, Saint-Jacut-de-la-Mer, France (A. Ramnath)

Synergies of pp and pA Collisions with an Electron-Ion Collider,
26–28 June, BNL, Upton, NY, USA (talk by B. Ducloué)

Summer School on Methods of Effective Field Theory & Lattice Field Theory,
26 June – 7 August, Munich, Germany (talk by J. Peuron, Y. Zhu)

The Electron Ion Collider User Group Meeting,
18–22 July, Trieste, Italy (invited talk by T. Lappi)

The European Physical Society Conference on High Energy Physics (EPS-HEP),
5–12 August, Venice, Italy (talk by P. Paakkinen)

LHeC and FCC-eh Workshop,
11–13 September, CERN, Geneva, Switzerland (talk by V. Guzey)

LFC17: Old and New Strong Interactions from LHC to Future Colliders,
11–15 September, Trento, Italy (invited talk by P. Paakkinen)

The 4th International Conference on the Initial Stages in High-Energy Nuclear Collisions,
18–22 September, Cracow, Poland (K. J. Eskola, talk by T. Lappi, invited talk by H. Paukkunen, J. Peuron, A. Ramnath)

12th International Workshop on High-pT Physics in the RHIC/LHC Era,
2–5 October, Bergen, Norway (talk by P. Paakkinen)

CERN,
16 October – 15 December, Geneva, Switzerland (J. Peuron)

Implications of LHCb Measurements and Future Prospects,
8–10 November, Geneva, Switzerland (talk by H. Paukkunen)

Zimányi School '17,
4–8 December, Budapest, Hungary (talk by T. Lappi)

Nuclear Structure for Weak and Astrophysical Processes

Probing Fundamental Interactions by Low Energy Excitations – Advances in Theoretical Nuclear Physics,
5–9 June, Stockholm, Sweden (invited talk by M. Kortelainen)

ECT* Doctoral Training Programme, Microscopic Theories of Nuclear Structure, Dynamics and Electroweak Currents,
12–30 June, Trento, Italy (talk by T. Haverinen)

2017 TALENT Course at the ECT*,
3–21 July, Trento, Italy (T. Haverinen)

IPNL, UCB Lyon 1,
15 September – 30 November, Lyon, France (T. Haverinen)

Bridging Nuclear Ab-Initio and Energy-Density-Functional Theories,
2–6 October, Orsay, France (invited talk by M. Kortelainen)

Information and Statistics in Nuclear Experiment and Theory ISNET-5,
6–9 November, York, UK (invited talk by M. Kortelainen)

The Many Shapes of Nuclear Structure,
20–21 November, Lyon, France (invited talk by M. Kortelainen)

Forschungszentrum Jülich,
7–24 December, Jülich, Germany (J. Niskanen)

FiDiPro Winter Symposium on Nuclear Structure Physics,
12–15 December, Jyväskylä, Finland (invited talk by T. Haverinen, invited talk by M. Kortelainen, J. Toivanen)

Domain Wall Dynamics

CECAM Workshop Challenges in Crystal Plasticity: From Discrete Dislocations to Continuum Models,
27 February – 1 March, Lugano, Switzerland (organiser L. Laurson)

University of Groningen, Zernike Institute for Advanced Materials Micromechanics,
13–14 June, Groningen, The Netherlands (talk by L. Laurson)

Trends in Nanotribology 2017 (TiN 2017),
25–30 June, Trieste, Italy (invited talk by L. Laurson, I. Rissanen)

62nd Annual Conference on Magnetism and Magnetic Materials (MMM 2017),
6–11 November, Pittsburgh, PA, USA (I. Rissanen)

CMS Programme

CMS Experiment

Nordic Winter School on Cosmology and Particle Physics,
2–7 January, Svingvoll, Norway (J. Havukainen, talk by S. Laurila)

CMSDAS@LPC,
7–15 January, Fermi National Accelerator Laboratory, Batavia, IL, USA (H. Siikonen)

CMS SMP-J Workshop,
25–26 January, CERN, Geneva, Switzerland (co-convener M. Voutilainen)

CMS Week,
6–10 February, CERN, Geneva, Switzerland (talk by K. Lassila-Perini, J. Tuominiemi)

Les Rencontres de Physique de la Vallée d'Aoste,
5–11 March, La Thuile, Italy (J. Pekkanen)

CLIC Workshop 2017,
6–10 March, CERN, Geneva, Switzerland (talk by H. Kirschenmann)

52nd Rencontres de Moriond – Electroweak Interactions and Unified Theories,
18–25 March, La Thuile, Italy (talk by J. Pekkanen)

Inter-Experimental LHC Machine Learning Working Group Workshop,
20–22 March, CERN, Geneva, Switzerland (J. Havukainen)

Annual Meeting of the Finnish Physical Society,
22–24 March, Helsinki, Finland (talk by H. Siikonen, J. Tuominiemi, M. Voutilainen)

CA1608 COST Action Management Committee Meeting,
30 March, Brussels, Belgium (M. Voutilainen)

CMS Week,
3–7 April, CERN, Geneva, Switzerland (talk by K. Lassila-Perini, J. Tuominiemi, M. Voutilainen)

CMS SUSY Workshop 2017,
10–12 April, Ghent, Belgium (H. Kirschenmann)

Standard Model at the LHC 2017 (SM@LHC2017),
2–5 May, Amsterdam, The Netherlands (session chair M. Voutilainen)

SMARTHEP H2020 Application Kick-Off Workshop,
3–5 May, Lund, Sweden (talk by J. Havukainen)

Helsinki JetMET Workshop: Physics at 100 fb^{-1},
10–12 May, Helsinki, Finland (co-organised and talk by J. Havukainen, J. Heikkilä, co-chaired and talk by H. Kirschenmann, T. Lampén, S. Laurila, J. Pekkanen, H. Siikonen, J. Tuominiemi, co-chaired by M. Voutilainen)

LHCP2017, The Fifth Annual Conference of Large Hadron Collider Physics,
15–20 May, Shanghai, China (session convener K. Lassila-Perini)

Thematic CERN School of Computing,
4–10 June, Split, Croatia (H. Siikonen)

CMS Week,
19–23 June, CERN, Geneva, Switzerland (talk by K. Lassila-Perini, talk by M. Voutilainen)

VBSCan Kickoff Meeting,
28–30 June, Split, Croatia (M. Voutilainen)

CMS Machine Learning Workshop,
5–6 July, CERN, Geneva, Switzerland (talk by J. Havukainen)

The 13th Workshop of the LHC Higgs Cross Section Working Group,
13–14 July, CERN, Geneva, Switzerland (S. Lehti)

International Conference of Physics Students 2017,
7–14 August, Turin, Italy (talk by J. Havukainen)

Charged Higgs Workshop,
28–29 August, Puebla, Mexico (talk by S. Lehti)

CERN-Fermilab Hadron Collider Physics Summer School,
28 August – 6 September, CERN, Geneva, Switzerland (J. Pekkanen)

HIP SAB Meeting,
29–30 August, Helsinki, Finland (talk by T. Lampén, talk by K. Lassila-Perini)

CMS Physics Object School,
3–9 September, Bari, Italy (J. Havukainen, M. Lotti)

The 2017 European School of High-Energy Physics,
6–19 September, Evora, Portugal (J. Heikkilä)

CMS Week in Rio de Janeiro,
25–29 September, Rio de Janeiro, Brazil (S. Laurila, talk by J. Pekkanen)

Particle Physics Day 2017,
20 October, Helsinki, Finland (P. Eerola, T. Järvinen, K. Kallonen, talk by H. Kirschenmann, T. Lampén, S. Laurila, talk by M. Lotti, J. Tuominiemi, co-organised by M. Voutilainen)

University of Uppsala,
26 October, Uppsala, Sweden (M. Voutilainen)

Fall17 Offline and Computing Week,
13–15 November, CERN, Geneva, Switzerland (talk by J. Havukainen)

Top! Hammertime (a CMS Top Quark Workshop),
14–15 November, CERN, Geneva, Switzerland (talk by M. Voutilainen)

CMS Exotica Workshop 2017,
30 November – 2 December, Brussels, Belgium (J. Heikkilä)

SMARTHEP H2020 Application Writing Workshop,
1–2 December, Lund, Sweden (H. Kirschenmann)

CMS Week,
4–8 December, CERN, Geneva, Switzerland (talk by K. Lassila-Perini, J. Tuominiemi, M. Voutilainen)

SUSY 2017,
11–15 December, Mumbai, India (talk by H. Kirschenmann)

AI Day,
13 December, Espoo, Finland (J. Havukainen, K. Kallonen)

University of Lund,
14–15 December, Lund, Sweden (talk by M. Voutilainen)

CMS Upgrade

European School of Instrumentation in Particle and Astroparticle Physics 2017 (ESIPAP 2017),
23 January – 17 March, Archamps, France (T. Arsenovich, J. Ott)

12th "Trento" Workshop on Advanced Silicon Radiation Detectors,
20–22 February, Trento, Italy (P. Luukka)

CMS Tracker Phase-2 Upgrade Week,
6–10 March, CERN, Geneva, Switzerland (P. Luukka)

Annual Meeting of the Finnish Physical Society,
22–24 March, Helsinki, Finland (talk by P. Luukka)

CERN Roadshow in Finland,
6–7 April, Espoo, Finland (co-organiser P. Luukka)

CERN,
9–13 April, Geneva, Switzerland (P. Luukka)

13th IPPOG Meeting,
19–22 April, Lisbon, Portugal (P. Luukka)

Anti-Hydrogene Workshop,
3 May, Helsinki, Finland (A. Gädda, talk by P. Luukka, J. Ott, E. Tuominen, talk by A. Winkler)

CMS Tracker Week,
14–19 May, CERN, Geneva, Switzerland (P. Luukka)

CERN,
19–23 May, Geneva, Switzerland (L. Martikainen)

30th RD50 Workshop,
5–7 June, Cracow, Poland (talk by J. Ott, E. Tuominen)

CMS Week,
19–23 June, CERN, Geneva, Switzerland (P. Luukka)

CMS Tracker Week,
17–21 July, CERN, Geneva, Switzerland (P. Luukka, J. Tuominiemi)

Albert-Ludwigs-Universität,
24 July – 3 August, Freiburg, Germany (J. Ott)

HIP SAB Meeting,
29–30 August, Helsinki, Finland (talk by P. Luukka)

11th International Conference on Position Sensitive Detectors,
3–8 September, Milton Keynes, UK (talk by A. Gädda)

CERN,
19 September – 12 October, Geneva, Switzerland (L. Martikainen)

Fermi National Accelerator Laboratory,
23–29 September, Batavia, IL, USA (P. Luukka)

CMS Tracker Week,
23–27 October, CERN, Geneva, Switzerland (M. Golovleva, P. Luukka)

CMS MIP Timing Detector Meeting,
30–31 October, CERN, Geneva, Switzerland (J. Ott)

14th IPPOG Meeting,
2–4 November, CERN, Geneva, Switzerland (P. Luukka)

ALICE, ATLAS, CMS and LHCb Career Networking Event,
13 November, CERN, Geneva, Switzerland (chair P. Luukka)

9th Young Researchers' BNCT Meeting,
13–15 November, Kyoto, Japan (chair A. Winkler)

31th RD50 Workshop,
20–22 November, CERN, Geneva, Switzerland (T. Arsenovich, J. Ott)

Ruđer Bošković Institute,
27 November – 1 December, Zagreb, Croatia (A. Winkler)

CMS Week,
4–8 December, CERN, Geneva, Switzerland (chair and talk by P. Luukka)

CMS Tracker Phase-2 Upgrade Week,
11–15 December, CERN, Geneva, Switzerland (P. Luukka)

11th International "Hiroshima" Symposium on the Development and Application of Semiconductor Tracking Detectors,
11–15 December, Okinawa, Japan (A. Gädda, talk by A. Winkler)

Fermi National Accelerator Laboratory,
28 December – 10 January, Batavia, IL, USA (L. Martikainen, J. Ott)

Tier-2 Operations

Annual Meeting of the Finnish Physical Society,
22–24 March, Helsinki, Finland (T. Lindén)

Helsinki JetMET Workshop: Physics at 100 fb^{-1},
10–12 May, Helsinki, Finland (T. Lindén)

NeIC2017,
29 May – 1 June, Umeå, Sweden (T. Lindén)

NorduGrid 2017,
28–30 June, Tromsø, Norway (T. Lindén)

Fall17 Offline and Computing Week,
13–15 November, CERN, Geneva, Switzerland (T. Lindén)

De Finlandssvenska Fysik- och Kemidagarna,
17–19 November, Helsinki, Finland – Stockholm, Sweden (T. Lindén)

TOTEM

CMS FSQ Workshop,
22–23 January, CERN, Geneva, Switzerland (talk by M. Berretti)

RD51 Mini Week,
20–23 February, CERN, Geneva, Switzerland (talk by M. Berretti)

TOTEM Collaboration Meeting, LHCC Referees and Student Poster Session,
20–23 February, CERN, Geneva, Switzerland (talk by M. Berretti, T. Naaranoja, talk by K. Österberg)

NBI, University of Copenhagen,
24 February, Copenhagen, Denmark (K. Österberg)

CLIC Workshop 2017,
6–10 March, CERN, Geneva, Switzerland (K. Österberg)

LHC WG on Forward Physics and Diffraction,
21–22 March, CERN, Geneva, Switzerland (invited talk by K. Österberg)

Annual Meeting of the Finnish Physical Society,
22–24 March, Helsinki, Finland (M. Berretti, T. Naaranoja, K. Österberg)

DIS 2017 XXV International Workshop on Deep-Inelastic Scattering and Related Subjects,
3–7 April, Birmingham, UK (invited plenary talk by K. Österberg)

Vetenskapsrådet Infrastructure Panel,
19–20 April, Stockholm, Sweden (K. Österberg)

CAS Programme Committee Meeting and LHCC Referees Session,
8–11 May, CERN, Geneva, Switzerland (K. Österberg)

LHCP2017,
14–20 May, Shanghai, China (two invited talks by M. Berretti)

CERN,
19–23 May, Geneva, Switzerland (T. Naaranoja)

Hadron Physics and Non Perturbative QCD 2017,
22–24 May, Cuneo, Italy (talk by M. Berretti)

TOTEM Collaboration Meeting,
5–10 June, Malaucene, France (talk by M. Berretti, talk by T. Naaranoja, talk by K. Österberg)

HIP SAB Meeting,
29–30 August, Helsinki, Finland (talk by K. Österberg)

TOTEM Collaboration Meeting and LHCC Referees Session,
11–14 September, CERN, Geneva, Switzerland (talk by M. Berretti, talk by T. Naaranoja, talk by F. Oljemark, talk by K. Österberg)

CERN,
19 September – 12 October, Geneva, Switzerland (T. Naaranoja)

LHC RRB Meeting,
23–25 October, CERN, Geneva, Switzerland (K. Österberg)

6th ADAMAS Workshop,
27–28 November, Zagreb, Croatia (talk by T. Naaranoja)

TOTEM Collaboration Meeting, LHCC Referees and Open Session,
28 November – 1 December, CERN, Geneva, Switzerland (talk by M. Berretti, talk by T. Naaranoja, invited talk and talk by K. Österberg)

Nuclear Matter Programme

ALICE

MPGD2017, 5th International Conference on Micro-Pattern Gas Detectors,
22–26 May, Philadelphia, PA, USA (E. Brücken, talk by T. Hildén)

ALICE TPC Upgrade Meeting,
28–30 August, Geneva, Switzerland (talk by E. Brücken)

ALICE TPC Upgrade Meeting,
14–18 November, Geneva, Switzerland (talk by T. Hildén)

ISOLDE

Physical Pharmacology Symposium,
9 February, Turku, Finland (U. Jakobsson)

MINIBALL Workshop,
9–10 May, York, UK (talk by D. Cox, J. Pakarinen)

International Symposium on Radiopharmaceutical Sciences,
15–19 May, Dresden, Germany (U. Jakobsson)

International PET Symposium,
27–29 May, Turku, Finland (talk by U. Jakobsson)

CERN,
17–23 July, Geneva, Switzerland (J. Pakarinen)

CERN,
4–7 September, Geneva, Switzerland (K. Helariutta, U. Jakobsson)

CERN,
17–23 October, Geneva, Switzerland (J. Ojala)

ESNT Workshop 2017,
22–27 October, CEA-SACLAY, Paris, France (talk by J. Pakarinen)

ISOLDE Collaboration Committee Meeting,
7 November, CERN, Geneva, Switzerland (J. Pakarinen)

ISOLDE Users Meeting,
4–5 December, CERN, Geneva, Switzerland (J. Pakarinen)

FiDiPro Winter Symposium on Nuclear Structure Physics,
12–15 December, Jyväskylä, Finland (talk by J. Pakarinen)

FAIR

NUSTAR Annual Meeting 2017,
27 February – 2 March, Darmstadt, Germany (talk by F. García)

Advances in Radioactive Isotope Science,
28 May – 2 June, Keystone, CO, USA (T. Grahn)

FiDiPro Winter Symposium on Nuclear Structure Physics,
12–15 December, Jyäskylä, Finland (talk by T. Grahn)

ALICE-Forward

ALICE Week,
3–8 March, CERN, Geneva, Switzerland (contribution by R. Orava)

XSCRC2017: Cross Sections for Cosmic Rays @ CERN,
31 March, Geneva, Switzerland (invited plenary presentation by R. Orava)

ALICE Week,
1–6 May, CERN, Geneva, Switzerland (contribution by R. Orava)

CERN,
22 May – 15 December, Geneva, Switzerland (R. Orava)

PHOTON 2017: 2017 International Conference on the Structure and the Interactions of the Photon, including the 22th International Workshop on Photon-Photon Collisions, and the International Workshop on High Energy Photon Colliders,
23–27 May, CERN, Geneva, Switzerland
(invited plenary presentation by R. Orava)

ALICE Week,
29 May – 3 June, CERN, Geneva, Switzerland
(contribution by R. Orava)

Low-x 17,
12–18 June, Bari, Italy (talk by M. Mieskolainen, invited plenary presentation by R. Orava)

ALICE Week,
24–29 July, CERN, Geneva, Switzerland (talk by M. Mieskolainen, contribution by R. Orava)

HIP Scientific Advisory Board (SAB) Review,
29 August, Helsinki, Finland (contribution by R. Orava)

WE-Heraeus QCD School,
23–30 September, Bad Honnef, Germany (talk by M. Mieskolainen)

ALICE Week,
25–30 September, CERN, Geneva, Switzerland
(contribution by R. Orava)

ALICE Week,
4–9 December, CERN, Geneva, Switzerland
(contribution by R. Orava)

LHC Working Group on Forward Physics and Diffraction,
7–8 December, CERN, Geneva, Switzerland (invited plenary presentation by R. Orava)

Technology Programme

Accelerator Technology

Towards Reality in Nanoscale Materials IX,
13–16 February, Levi, Finland (E. Baibuz, talk by F. Djurabekova, A. Kyritsakis, talk by H. Vázquez Muíños)

146th Annual Meeting of The Mineral, Metals & Materials Society,
26 February – 3 March, San Diego, CA, USA
(invited talk by F. Djurabekova)

CLIC Workshop 2017,
6–10 March, CERN, Geneva, Switzerland (talk by F. Djurabekova)

6th International Workshop on Mechanics of Vacuum Arcs (MeVArc 2017),
19–23 March, Jerusalem, Israel (M. Aicheler, talk by F. Djurabekova, talk by V. Jansson, A. Saressalo, talk by M. Veske)

Annual Meeting of the Finnish Physical Society,
22–24 March, Helsinki, Finland (talk by E. Baibuz, talk by J. Lahtinen, H. Vázquez Muíños)

Uppsala University,
22 May, Uppsala, Sweden (talk by F. Djurabekova, A. Kyritsakis, A. Saressalo)

International Workshop on Field Emission and Evaporation from Non-Metallic Needles,
8–9 June, Rouen, France (invited talk by A. Kyritsakis)

International Workshop on Breakdown Science and High Gradient Technology,
13–16 June, Valencia, Spain (talk by F. Djurabekova)

Nanoscale Pattern Formation at Surfaces and Formation of 3D Nanostructures,
26–30 June, Helsinki, Finland (E. Baibuz, chair F. Djurabekova, talk by V. Jansson, talk by H. Vázquez Muíños)

19th International Conference of Radiation Effects in Insulators,
2–7 July, Versailles, France (talk by F. Djurabekova, talk by H. Vázquez Muíños)

International Conference on Surface Modifcation of Materials by Ion Beams (SMMIB-2017),
9–14 July, Lisbon, Portugal (invited talk by F. Djurabekova)

International Vacuum Nanoelectronics Conference,
10–14 July, Regensburg, Germany (talk by V. Jansson, talk by A. Kyritsakis)

International School on Ion-Surface Interaction,
19–20 August, Moscow, Russia (invited talk by F. Djurabekova)

Ion-Surface Interactions,
21–25 August, Moscow, Russia (invited talk by F. Djurabekova)

2017 Young Researchers in Vacuum Micro-, Nanoelectronics,
5–6 October, St. Petersburg, Russia (invited talk by F. Djurabekova)

Mini MeVArc,
17–19 October, Tartu, Estonia (talk by E. Baibuz, talk by F. Djurabekova, talk by V. Jansson, talk by J. Lahtinen, talk by A. Saressalo, talk by M. Veske, talk by S. Vigonski)

De Finlandssvenska Fysik- och Kemidagarna,
17–19 November, Helsinki, Finland – Stockholm, Sweden (V. Jansson)

Panel Meeting New Nuclear Technology,
20–21 November, Stockholm, Sweden (F. Djurabekova)

Fall Meeting Materials Research Society: Symposium NM05: Nanomaterials, Nanoparticles and Nanostructures Produced by Plasmas – Synthesis, Characterization and Applications,
26–30 November, Boston, MA, USA (invited talk by F. Djurabekova)

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

Annual Meeting of the Finnish Physical Society,
22–24 March, Helsinki, Finland (P. Dendooven, T. Kerst)

CERN Roadshow,
6 April, Otaniemi, Finland (P. Dendooven)

ESARDA Symposium 2017,
15–18 May, Düsseldorf, Germany (C. Bélanger-Champagne, talk by P. Dendooven, P. Peura)

GET Workshop, IAEA,
29–31 May, Vienna, Austria (C. Bélanger-Champagne, P. Dendooven, P. Peura)

CLEO Europe,
24–29 June, Munich, Germany (talk by T. Kerst)

Physics Colloquium,
8 September, Jyväskylä, Finland (talk by P. Dendooven)

Course/Topical Day "Nuclear Data and Decay Heat",
25–26 October, Mol, Belgium (C. Bélanger-Champagne)

Nordic Society 2017 – Seminar on Non-Proliferation Issues,
7–8 November, Sigtuna, Sweden
(talk by C. Bélanger-Champagne, P. Dendooven)

Physics Colloquium,
16 November, Groningen, The Netherlands (talk by P. Dendooven)

ESARDA WG Meetings,
20–21 November, Ispra, Italy
(talk by C. Bélanger-Champagne)

Symposium on Future Prospects for Photonics on Mid-Infrafred Light Sources and Applications,
13–14 December, Tampere, Finland (T. Kerst)

Detector Laboratory

CERN,
13–18 February, Geneva, Switzerland
(F. García, R. Turpeinen)

Physikalisch-Technische Bundesanstalt,
14 February, Berlin, Germany (M. Juntunen)

TOTEM Collaboration Meeting, LHCC Referees and Student Poster Session,
20–23 February, CERN, Geneva, Switzerland (F. García)

ECR 2017, European Congress of Radiology,
1–5 March, Vienna, Austria (talk by M. Juntunen)

CERN,
6–22 March, Geneva, Switzerland (F. García)

CERN,
6–25 March, Geneva, Switzerland (R. Turpeinen)

CERN CMS Project Meeting,
12–16 March, Geneva, Switzerland (T. Hakkarainen)

Annual Meeting of the Finnish Physical Society,
22–24 March, Helsinki, Finland (talk by E. Tuominen)

SPIE Optics & Optoelectronics,
24–28 April, Prague, Czech Republic (talk by M. Juntunen, E. Tuominen)

1st European Nanofabrication Research Infrastructure Symposium – ENRIS 2017,
8–9 May, Trondheim, Norway (E. Tuominen)

SPIE Microtechonologies,
8–10 May, Barcelona, Spain (talk by M. Juntunen)

MPGD2017, 5th International Conference on Micro-Pattern Gas Detectors,
22–26 May, Philadelphia, PA, USA (J. Heino)

CERN RD50 Workshop Radiation Hard Semiconductor Devices for Very High Luminosity Colliders,
5–7 June, Cracow, Poland (E. Tuominen)

TOTEM Collaboration Meeting,
5–10 June, Malaucene, France (F. García)

SPIE Security & Defence,
12–13 September, Warsaw, Poland (talk by M. Juntunen)

EMG Automation GmbH,
18 September, Lübeck, Germany (M. Juntunen)

RD51 Collaboration Meeting,
25 September – 3 October, CERN, Geneva, Switzerland
(F. García)

Finland at CERN – What Can Finland Do for Science,
1–3 November, Geneva, Switzerland (talk by E.Tuominen)

CERN,
15–21 November, Geneva, Switzerland
(F. García, R. Turpeinen)

CERN,
14–22 December, Geneva, Switzerland
(F. García, R. Turpeinen)

CLOUD

ICNAA2017,
25–30 June, Helsinki, Finland (talk by J. Duplissy)

Finnish Centre of Excellence Annual Seminar,
4–6 October, Helsinki, Finland (talk by J. Duplissy)

Planck-Euclid

Euclid PAQA Workshop,
11–13 January, Paris, France (E. Keihänen)

SDSS IV SPIDERS Team Meeting,
17–18 January, Munich, Germany (C. Kirkpatrick)

Euclid Consortium Board Meeting,
31 January – 1 February, Heidelberg, Germany
(H. Kurki-Suonio)

Euclid OU-SIM Cycle 2/3 Meeting,
2–3 February, Barcelona, Spain (E. Keihänen, C. Kirkpatrick)

Euclid LE3 and System Team Meeting,
22–24 February, London, UK (V. Allevato, H. Kurki-Suonio, V. Lindholm)

W. M. Keck Observatory,
26–28 February, Kamuela, HI, USA (C. Kirkpatrick)

Institute for Astronomy,
1–7 March, Honolulu, HI, USA (C. Kirkpatrick)

Euclid OU-SIM Cycle 3/4 Meeting,
3–5 April, Toulouse, France (E. Keihänen, C. Kirkpatrick)

IAC,
24–27 April, La Palma, Spain (C. Kirkpatrick)

Euclid Theory Working Group Meeting,
2–3 May, Heidelberg, Germany (J. Väliviita)

Euclid Inter Science Taskforce Meeting,
4–5 May, Heidelberg, Germany (J. Väliviita)

Euclid Consortium Meeting,
5–9 June, London, UK (talk by V. Allevato, E. Keihänen, K. Kiiveri, C. Kirkpatrick, V. Lindholm, talk by J. Väliviita)

Euclid Galaxy Clustering under Science Performance Review,
3–8 July, Sexten, Italy (talk by V. Allevato, talk by V. Lindholm)

Oslo University,
25–27 September, Oslo, Norway (E. Keihänen)

SPIDER/CODEX Meeting,
9–12 October, Garching, Germany (C. Kirkpatrick)

Euclid Developers Workshop,
9–13 October, Trieste, Italy (K. Kiiveri, H. Kurki-Suonio, A. Viitanen)

Euclid OU-SIM Cycle 4/5 Meeting,
19–20 October, Marseille, France (C. Kirkpatrick)

XMM-Newton OTAC Meeting,
6–7 November, Milan, Italy (C. Kirkpatrick)

Euclid Science Challenge 3 Final Meeting,
13–15 December, Paris, France (talk by V. Lindholm)

Publications

Theory Programme

Cosmology of the Early and Late Universe

J. M. Cline, K. Kainulainen, and D. Tucker-Smith,
Electroweak baryogenesis from a dark sector,
Phys. Rev. D 95 (2017) 115006

M. Hindmarsh, S. J. Huber, K. Rummukainen, and D. J. Weir,
Shape of the acoustic gravitational wave power spectrum from a first order phase transition,
Phys. Rev. D 96 (2017) 103520

M. Hindmarsh, J. Lizarraga, J. Urrestilla, D. Daverio, and M. Kunz,
Scaling from gauge and scalar radiation in Abelian-Higgs string networks,
Phys. Rev. D 96 (2017) 023525

M. Hindmarsh, K. Rummukainen, and D. J. Weir,
Numerical simulations of necklaces in SU(2) gauge-Higgs field theory,
Phys. Rev. D 95 (2017) 063520

K. Kainulainen, J. Leskinen, S. Nurmi, and T. Takahashi,
CMB spectral distortions in generic two-field models,
J. Cosmol. Astropart. Phys. 11 (2017) 002

T. S. Koivisto and H. J. Nyrhinen,
Stability of disformally coupled accretion disks,
Phys. Scr. 92 (2017) 105301

A. Lopez-Eiguren, J. Lizarraga, M. Hindmarsh, and J. Urrestilla,
Cosmic microwave background constraints for global strings and global monopoles,
J. Cosmol. Astropart. Phys. 07 (2017) 026

T. Markkanen, S. Nurmi, S. Räsänen, and V. Vennin,
Narrowing the window of inflationary magnetogenesis,
J. Cosmol. Astropart. Phys. 06 (2017) 035

F. Montanari and S. Räsänen,
Backreaction and FRW consistency conditions,
J. Cosmol. Astropart. Phys. 11 (2017) 032

F. Montanari and S. Räsänen,
Evaluating backreaction with the ellipsoidal collapse model,
J. Cosmol. Astropart. Phys. 12 (2017) 008

F. Montanari in J. Renk et al.,
Galileon gravity in light of ISW, CMB, BAO and H_0 data,
J. Cosmol. Astropart. Phys. 10 (2017) 020

S. Räsänen and P. Wahlman,
Higgs inflation with loop corrections in the Palatini formulation,
J. Cosmol. Astropart. Phys. 11 (2017) 047

High Energy Phenomenology in the LHC Era

K. Huitu in A. G. Akeroyd et al.,
Prospects for charged Higgs searches at the LHC,
Eur. Phys. J. C 77 (2017) 276

T. Alanne, A. Meroni, and K. Tuominen,
Neutrino mass generation and leptogenesis via pseudo-Nambu-Goldstone Higgs portal,
Phys. Rev. D 96 (2017) 095015

T. Alanne, F. Sannino, T. Tenkanen, and K. Tuominen,
Inflation and pseudo-Goldstone Higgs boson,
Phys. Rev. D 95 (2017) 035004

C. Gross and O. Lebedev in G. Arcadia et al.,
Evading direct dark matter detection in Higgs portal models,
Phys. Lett. B 769 (2017) 129

N. Bernal, M. Heikinheimo, T. Tenkanen, K. Tuominen, and V. Vaskonen,
The dawn of FIMP Dark Matter: A review of models and constraints,
Int. J. Mod. Phys. A 32 (2017) 1730023

S. Biswas, E. Gabrielli, M. Heikinheimo, and B. Mele,
Dark-photon searches via *ZH* production at e^+e^- colliders,
Phys. Rev. D 96 (2017) 055012

T. Brauner, T. V. I. Tenkanen, A. Tranberg, A. Vuorinen, and D. J. Weir,
Dimensional reduction of the Standard Model coupled to a new singlet scalar field,
J. High Energy Phys. 03 (2017) 007

S. Di Chiara, M. Heikinheimo, and K. Tuominen,
Vector resonances at LHC Run II in composite 2HDM,
J. High Energy Phys. 03 (2017) 009

B. S. DiNunno, S. Grozdanov, J. F. Pedraza, and S. Young,
Holographic constraints on Bjorken hydrodynamics at finite coupling,
J. High Energy Phys. 10 (2017) 110

C. Ecker, C. Hoyos, N. Jokela, D. Rodríguez Fernández, and A. Vuorinen,
Stiff phases in strongly coupled gauge theories with holographic duals,
J. High Energy Phys. 11 (2017) 031

Y. Ema, M. Karčiauskas, O. Lebedev, and M. Zatta,
Early Universe Higgs dynamics in the presence of the Higgs-inflaton and non-minimal Higgs-gravity couplings,
J. Cosmol. Astropart. Phys. 06 (2017) 054

K. Huitu and H. Waltari in M. Frank et al.,
Resonant slepton production and right sneutrino dark matter in left-right supersymmetry,
J. High Energy Phys. 05 (2017) 015

I. Ghişoiu, T. Gorda, A. Kurkela, P. Romatschke, M. Säppi, and A. Vuorinen,
On high-order perturbative calculations at finite density,
Nucl. Phys. B 915 (2017) 102

C. Gross, O. Lebedev, and J. M. No,
Drell-Yan constraints on new electroweak states: LHC as a $pp \to \ell^+\ell^-$ precision machine,
Mod. Phys. Lett. A 32 (2017) 1750094

C. Gross, O. Lebedev, and T. Toma,
Cancellation mechanism for dark-matter-nucleon interaction,
Phys. Rev. Lett. 119 (2017) 191801

M. Heikinheimo, K. Kannike, F. Lyonnet, M. Raidal, K. Tuominen, and H. Veermäe,
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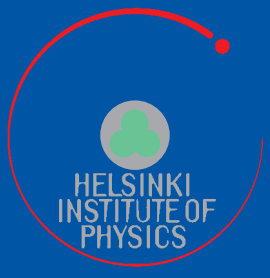

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