Annual Report 2019

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Publication of J. Tuominiemi's book on 50 years of experimental particle physics in Finland. *Credit: J. Aaltonen, HIP.*

Hannu Koskinen Award to, among others, S. Laurila (HIP) at the Annual Meeting of the Finnish Physical Society. *Credit: B. Reischl, HY/INAR.*

APPEC MoU signing. *Credit: K. Link, APPEC.*

CERN Bootcamp. *Credit: J. Aaltonen, HIP.*

CMS Tracker Week held in Helsinki. *Credit: P. Luukka.*

HIP Town Meeting. *Credit: J. Aaltonen, HIP.*

Christmas Coffee at HIP. *Credit: J. Aaltonen, HIP.*

CONTENTS

KATRI HUITU
Helsinki Institute of Physics director

PREFACE

The Helsinki Institute of Physics (HIP) is a joint research institute of the Universities of Helsinki, Jyväskylä and Tampere, Aalto University, and Lappeenranta-Lahti University of Technology LUT. The Finnish Radiation and Nuclear Safety Authority is an interim member of HIP during 2018-2022. The University of Helsinki is the host organisation of HIP. HIP addresses fundamental science questions from quarks to the Cosmos as well as technologies from semiconductors to medical applications and climate research. It serves as a national institute for Finnish physics and related technology research and development at international accelerator laboratories. By mandate of the Finnish Ministry of Education and Culture, HIP is responsible for the Finnish research collaboration with the European Organization for Nuclear Research CERN and the Facility for Antiproton and Ion Research FAIR GmbH, which is under construction at the GSI Accelerator Laboratory in Darmstadt.

In 2019, the research activities of HIP consisted of four 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 seven applied research projects. In addition, there were three independent research projects: CLOUD, Education and Open Data, and Planck-Euclid. The Detector Laboratory served as a general facility for the Institute.

The Scientific Advisory Board (SAB) made its annual visit in August 2019, and reported that the HIP scientific activity was good. The SAB was pleased to see that the ALICE, CMS, and TOTEM upgrades, as well as the FAIR construction, had received Research Infrastructure Funding from the Academy of Finland. As recommended in 2018 by the SAB, HIP became Finland's representative in the Astroparticle Physics European Consortium from the beginning of 2019.

A research assessment of the University of Helsinki took place during 2018-2019, and the results were published in September 2019. In the assessment, HIP formed one unit together with the Department of Physics. The unit received the highest grade in all the themes of the assessment, namely scientific quality, societal impact, research environment, and unit viability.

This was the last year of the six-year theory projects. As a result of the successful six years, achieved scientific merits include two ERC grants, and several persons in the projects have been appointed to positions in academia or have found a career in the private sector. The call for new theory projects produced 27 applications, out of which four were selected as starting or continuing projects. The application round was exceptional since two of the earlier projects will continue for another three years. This way, in the future the application rounds for theory projects will be every three years.

The LHC experiments - ALICE, CMS, and TOTEM - have been analysing data from Run 2 and at the same time upgrading their detectors during the Long Shutdown 2. Run 3 will begin in 2021. Concerning FAIR, Phase-0 experiments have started, and several in-kind projects are in progress.

The Technology Programme contained seven projects. Industry activation is one of the areas, where much work has been done this year. Connected to activities at CERN, four co-creation projects began that were partly funded by Business Finland. The activities with the Finnish Radiation and Nuclear Safety Authority led to the second prize in the International Atomic Energy Association IAEA challenge competition. In the award-winning research team, in addition to Peter Dendooven's research group, Samuli Siltanen's group was also strongly involved.

The former long-time HIP Theory Programme Director, and before that the Cosmology project leader, Professor Kari Enqvist retired in 2019.

The Director of the Theory Programme, Professor Kari Rummukainen started as an Academy Professor at the beginning of the year; the Director of the Technology Programme, Professor Filip Tuomisto moved from Aalto University to the University of Helsinki in August. The project leader of the CMS Upgrade project, Panja Luukka, started as a Professor at LUT University in August. The project leader of the Materials for Accelerator Technology -project Flyura Djurabekova started as a Professor at the University of Helsinki; David Weir from the High Energy Phenomenology project was appointed to a tenure track Professor position at the University of Helsinki. Former HIP FiDiPro Professor Peter Dendooven started as a visiting Professor at HIP for three years.

The personnel have participated in organising a large number of events. These include the annual Physics Days with a HIP-led organising committee, and in October a HIP Town Meeting, the first of its kind, where the activities and future strategy of HIP were widely described for personnel and others with interest in the Institute.

Another important occasion was at the beginning of the year, when Jorma Tuominiemi's book on 50 years of experimental particle physics in Finland, Kuplakammiofysiikasta Higgsin bosoniin, was published.

The HIP YPA team has continued excellent professional work both in Helsinki and at CERN. In the team, the HR co-ordinator changed when Tuire Savolainen moved to another department in Kumpula, and Elise Veranen began taking care of HIP-related HR.

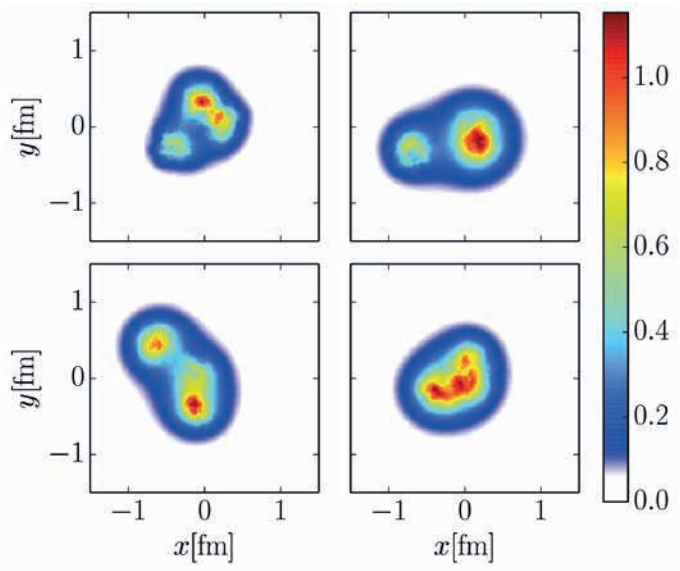
HIGHLIGHTS OF RESEARCH RESULTS

Theory Programme

The HIP Theory Programme conducts research on a broad range of physical topics under five research projects: Nuclear Structure for Weak and Astrophysical Processes; QCD and Strongly Interacting Gauge Theory; Cosmology of the Early and Late Universe; Domain Wall Dynamics; and High Energy Phenomenology in the LHC Era. Below we pick two highlights from the research:

In a recent Nature review article, "Imaging the nucleus with high-energy photons", S. R. Klein and H. Mäntysaari explored recent progress in measurements of photon-mediated exclusive processes. These processes can be used to probe both the average and fluctuations in how quarks and gluons are distributed spatially inside the proton and in heavy nuclei.

Members of the High Energy Phenomenology project, N. Jokela and A. Vuorinen, joined forces with scientists from Harvard University to conduct the first-ever systematic study of the neutron star matter Equation of State (EoS) at non-zero temperature, obtained by combining several viable model calculations for nuclear matter with a state-of-the-art description of quark matter through a bottom-up holographic model V-QCD. The main results of the study will be very useful in relativistic hydrodynamic simulations of neutron star mergers, necessary for the calculation of the gravitational wave signal observed at LIGO and Virgo gravitational wave detectors.



[Nature Rev. Phys. 1 (2019) 662] (reprinted from Phys. Rev. D 94 (2016) 034042, © American Physical Society)

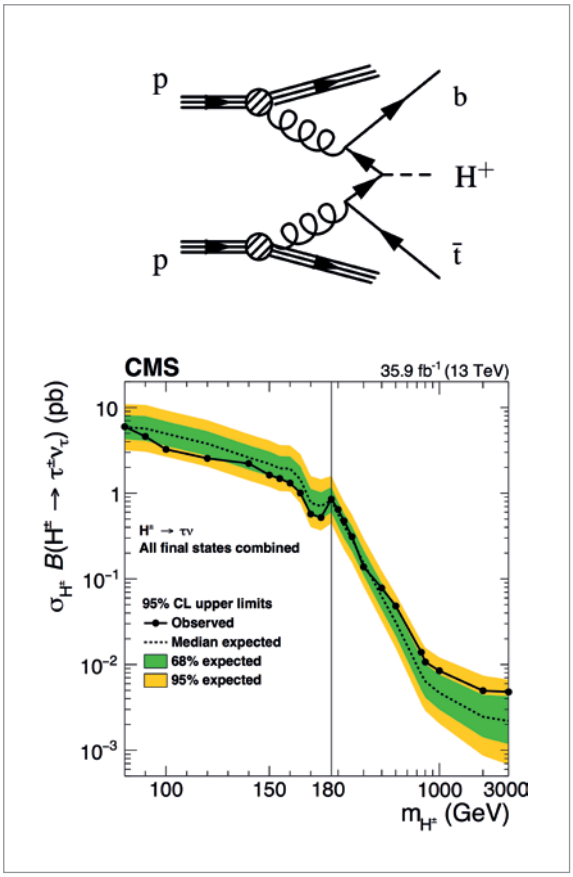
CMS Programme

The Compact Muon Solenoid (CMS) is a general-purpose experiment at CERN's Large Hadron Collider (LHC). Overall, CMS highlights included new measurements of the Higgs boson mass and third-generation fermion couplings (ttH, H → bb/$\tau\tau$), and upper limits of second-generation fermion couplings (H → $\mu\mu$/cc).

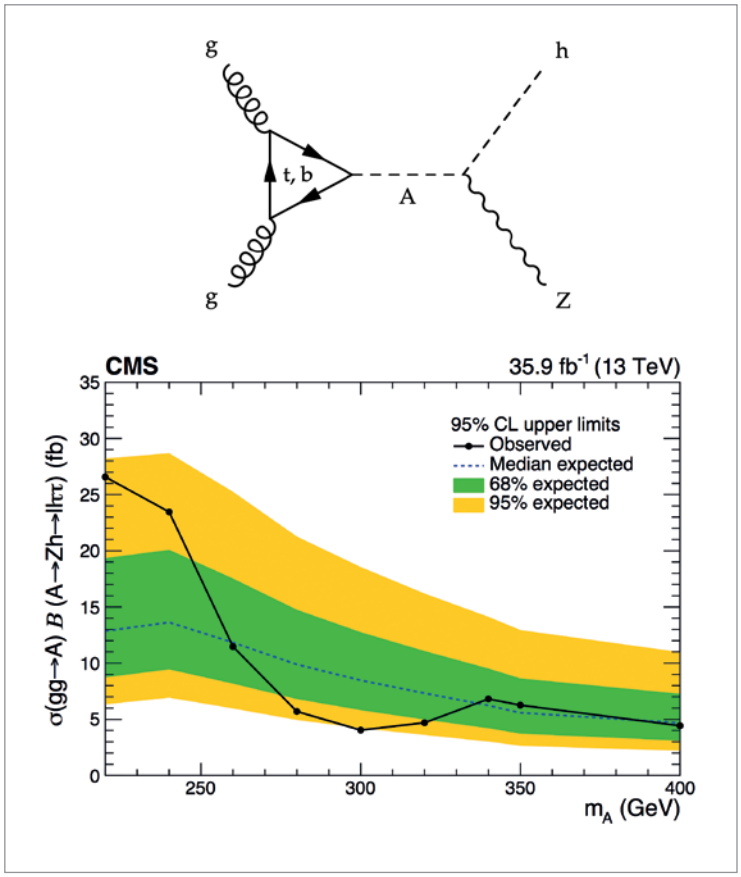
HIP contributed to *new physics searches* (Higgs bosons and supersymmetry) *and precision physics with jets* (the top quark mass and the strong coupling constant). Highlights included new limits on both charged and neutral heavy Higgs searches, with related PhD theses successfully defended by S. Laurila and J. Heikkilä. T. Lampén led the local organisation of the 2019 Physics Days and was appointed co-convener of the alignment, calibration, and database group in charge of the full Run 2 data-set re-reconstruction.

For the refurbishment of the innermost layer of the CMS pixel detector, HIP is doing the quality assurance of the flip-chip bonded modules. The Academy of Finland granted funds for the CMS end-cap timing layer ("MTD-ETL") and TOTEM new T2 constructions, as well as the CMS forward proton detector ("PPS") and HIP Tier-2 storage system upgrades. P. Luukka was appointed CMS Collaboration Board Secretary and Professor at Lappeenranta-Lahti University of Technology. L. Forthomme received the CMS Achievement Award "for his outstanding contribution to the PPS software development".

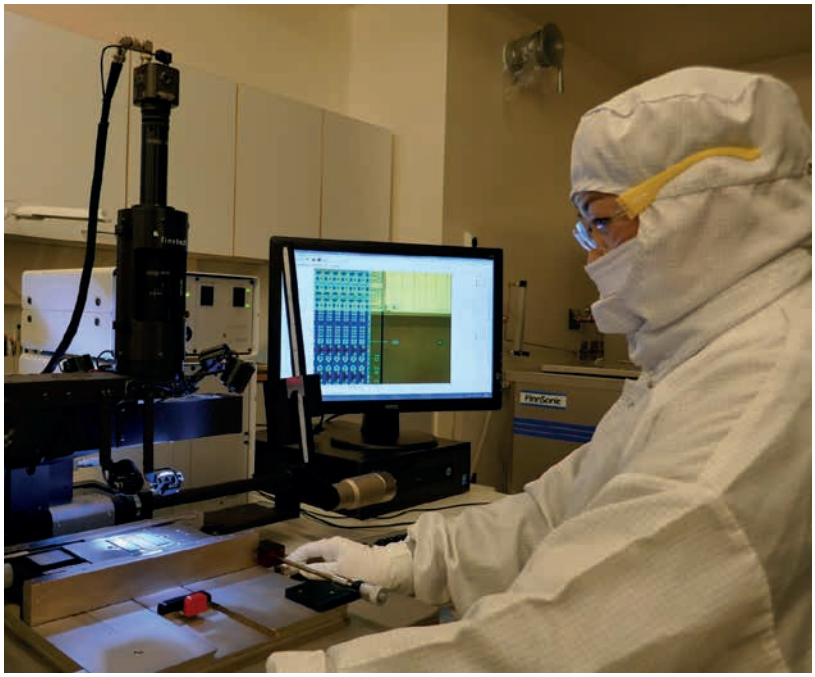
TOTEM is a forward physics experiment at the LHC. The 2019 highlights included the publication of the 13 TeV total cross section and ρ measurement papers along with EPJC featuring the 13 TeV elastic differential cross section ($d\sigma_{el}/dt$) measurement on the cover of its October issue. EPJC also accepted the 2.76 TeV $d\sigma_{el}/dt$ paper. These papers provide evidence for a C-odd colourless three-gluon compound state, the "Odderon".



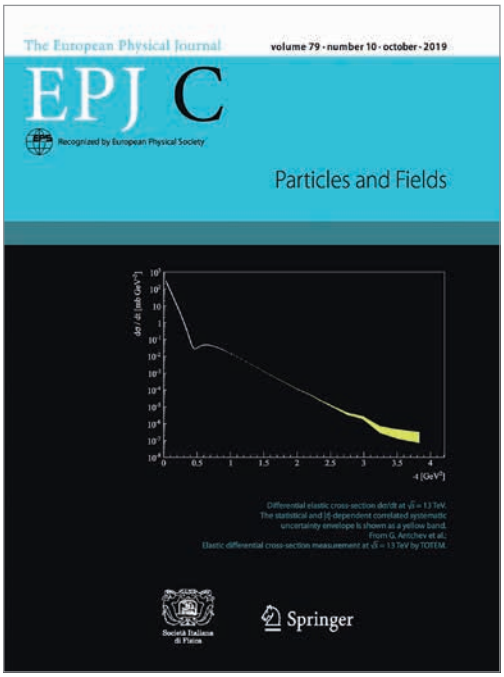
[J. High Energy Phys. 07 (2019) 142, https://doi.org/10.1007/JHEP07(2019)142] © 2020 Springer Nature Switzerland AG



© CMS Collaboration, CERN



Credit: J. Ott.



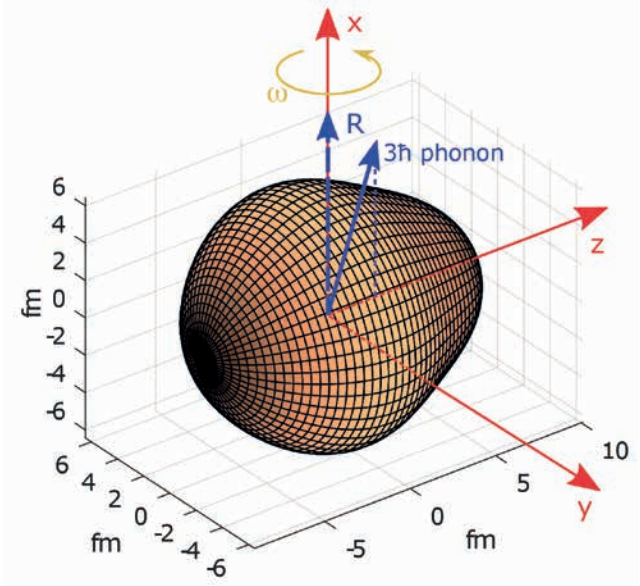
[The European Physical Journal C Volume 79 / No 10 (October 2019)] with kind permission of The European Physical Journal (EPJ)

Nuclear Matter Programme

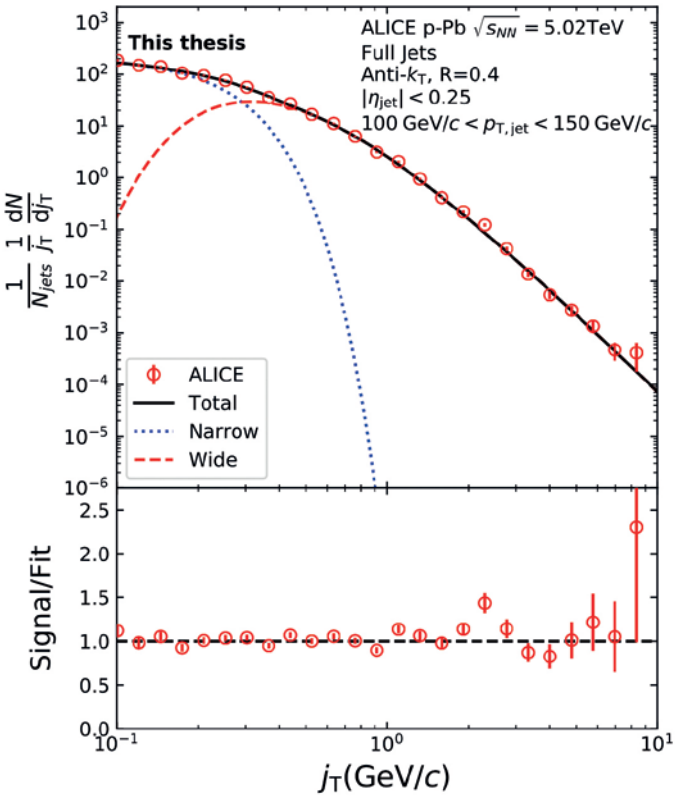
In the ALICE project, the Finnish team took responsibilities for the System Run Coordination and Analysis Framework (M. Slupecki) and for the Detector Control System (H. Rytkönen) in the FIT detector, and W. Trzaska was nominated as permanent ex-officio member of the ALICE Management Board. T. Snellman defended his PhD thesis in June 2019 on jet fragmentation transverse momentum in proton-lead collisions. His results provided constraints to models expecting significant cold nuclear matter effects.

The main ISOLDE highlight was a discovery that will help with the search for electric dipole moments (EDM) in atoms and could contribute to new theories of particle physics, such as supersymmetry. A MINIBALL experiment showed that the radon isotopes ^{224}Rn and ^{226}Rn vibrate between a pear shape and its mirror image but do not possess static pear-shapes in their ground states. In a paper published in Nature Communications, it is concluded that radon atoms provide less favourable conditions for the enhancement of a measurable atomic EDM than radium [*P. A. Butler et al., Nature Commun. 10 (2019) 2473*].

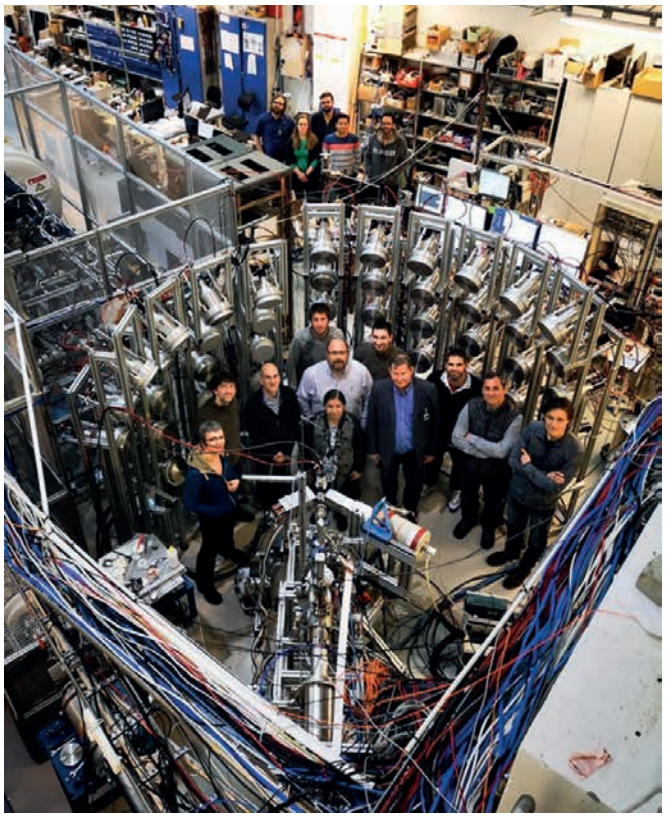
The FAIR Phase-0 experimental programme commenced in 2019 and is set to continue until the full completion of FAIR in 2025. Several new in-kind contracts between Finland and FAIR were signed and MUSIC energy-loss detector design passed its conceptual design phase. The MONSTER neutron detectors were successfully exploited in an experiment studying the short-lived nucleus ^{85}As at the Accelerator Laboratory of the University of Jyväskylä.



[Nature Commun. 10 (2019) 2473]



Credit: W. H. Trzaska



Credit: H. Penttilä

Technology Programme

The Technology Programme aims to integrate HIP projects that have significant technology development, transfer, and pre-commercialisation activities into the same programme. In addition, the research activities performed within the programme are designed to seek synergies with big science initiatives at large. The programme is structured into three thematic areas - systems, materials, and technology - each consisting of several small projects. Several projects have been successful in raising external funding for the R&D work, thus strengthening the impact of the programme.

Within the detector system development activities, a proof-of-concept 3-detector coincidence setup for positron lifetime spectroscopy in radioactive materials has been designed, constructed, and tested, and one has now been commissioned at the JRC nuclear facility in Karlsruhe. A laboratory-scale X-ray absorption spectroscopy device has been developed with a design allowing coupling with accelerators.

The materials projects have generated significant breakthroughs in understanding the effect of electric fields on the migration barrier for biased diffusion on Cu surfaces. In addition, the effect of C interstitials on the radiation damage build-up in high entropy alloys (FeNiCoCrMn) has been elucidated.

An important highlight of the technology development is the finalisation of a PNAR (Passive Neutron Albedo Reactivity) instrument to measure fuel assembly neutron multiplication; this was finalised in close collaboration with STUK, including advanced image reconstruction algorithms. CERN-related co-creation projects, funded by Business Finland were wrapped up and several co-innovation project proposals were set up.

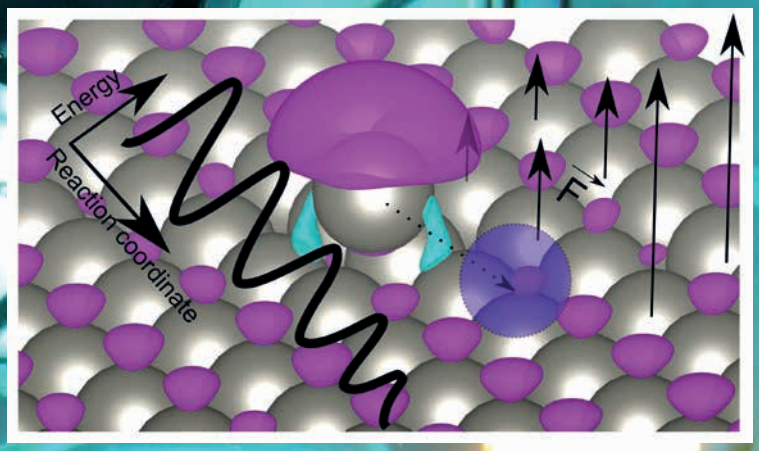


Illustration by E. Baibuz

Picture: TVO

THEORY PROGRAMME

The HIP Theory Programme is responsible for running a broad theoretical physics research programme, supporting research at HIP and at member universities. In 2019, the programme consisted of five fixed-term research 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, Tampere University). The final year of the project period was 2019, and 2020 will see a renewed project structure.

KARI RUMMUKAINEN
Theory Programme director

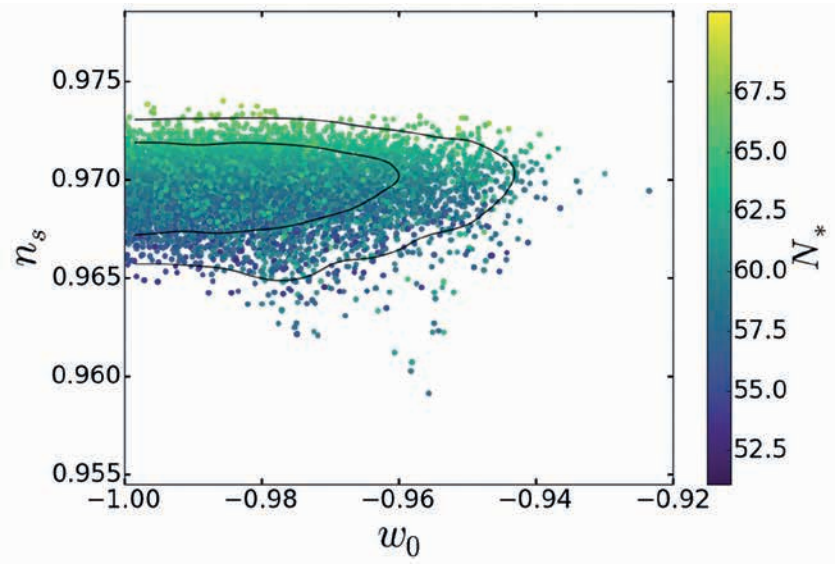
SYKSY RÄSÄNEN
Cosmology of the Early and Late Universe project leader

Cosmology of the Early and Late Universe

The cause of late-time accelerated expansion and the nature of early universe inflation are among the most prominent questions in cosmology. Another topical field is cosmology related to electroweak physics, probed on earth at the LHC, and to be probed on the sky by the LISA mission due to be launched in 2034. We have studied a range of issues in these fields, with a clear connection to observations. I will mention some examples.

One interesting link between particle physics and cosmology is the possibility that the Standard Model Higgs drives inflation. We studied this model in the teleparallel formulation of general relativity for the first time, showing that the gravitational wave (GW) amplitude can be large. We also showed that in the Palatini formulation the Higgs field breaks up rapidly after inflation.

We studied quintessential inflation, which ties together accelerated expansion at early and late times, and which can involve the generation of topological defects and GWs.

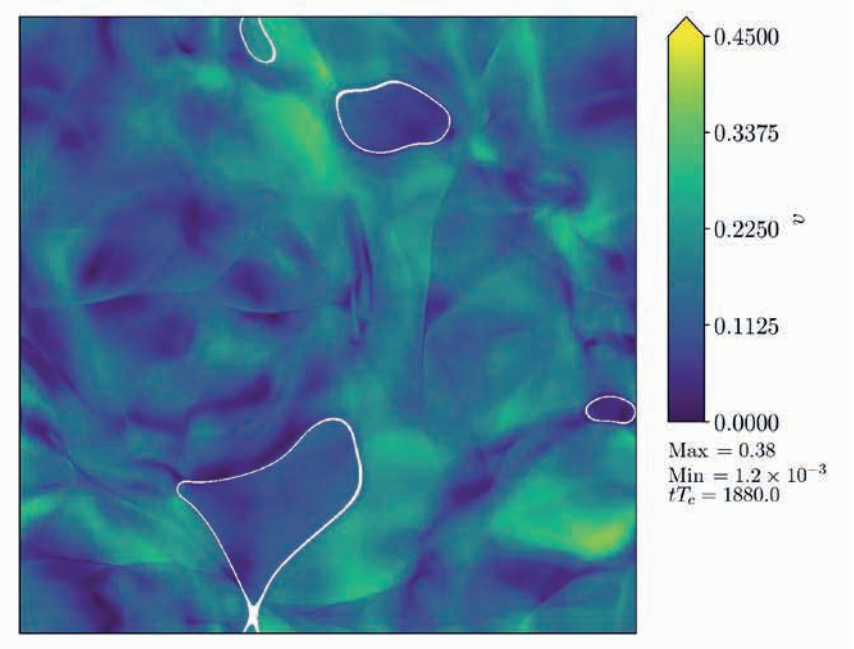


Correlation between the spectral index of inflationary scalar perturbations and the dark energy equation of state in a model of quintessential inflation based on scale invariance.
[Phys. Rev. D 99 (2019) 063512]

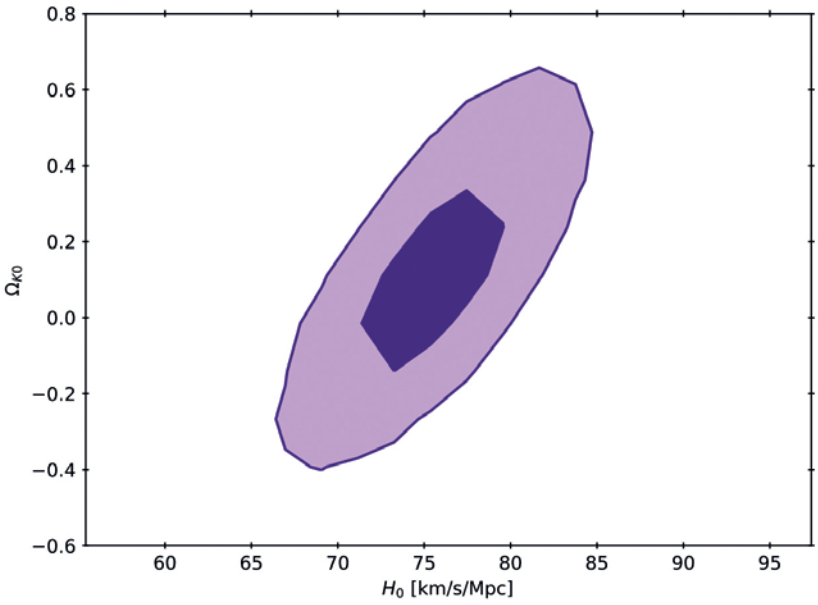
We showed that spectator fields during inflation can generate oscillatory features in the cosmic microwave background, which had been suggested as a smoking gun for alternatives to inflation. We also studied the possibility that the field driving inflation is dark matter, and the gravitational production of inert scalars as dark matter.

One strong topic has been first-order phase transitions in the early universe. If there is an electroweak phase transition, the resulting GWs may be detected by LISA. We did ground-breaking work, including the first 3D simulations of strong first-order transitions, the first end-to-end non-perturbative study of a first-order electroweak transition, and a method for calculating the GWs from thermodynamic parameters, without simulations. We showed that if there are two Higgs doublets with large couplings, strong phase transitions cannot be reliably studied with any current method. We also contributed to the LISA consortium's survey of GW generation from phase transitions by developing the online tool PTPlot.

We continued studying various effects related to cosmological inhomogeneities that link the expansion rate and light propagation. Close to observations, we made the first model-independent measurement of spatial curvature and the Hubble constant based on strong lensing time delay and supernova luminosity. We also contributed to a White Paper for the Astro2020 Decadal Survey on how upcoming observations will shed light on the link between primordial black holes and dark matter.



Fluid speed in a slice through 3D simulation of cosmic fluid following bubble collisions in a first-order phase transition. Bubble walls are shown in white. Both shocks and vorticity are visible. *Credit: M. Hindmarsh.*



Correlation of the Hubble constant (present expansion rate) and the spatial curvature of the universe as determined from strong lensing time delay of quasars combined with the luminosity of type Ia supernovae.
[Phys. Rev. Lett. 123 (2019) 231101] © American Physical Society.

ALEKSI VUORINEN
High Energy Phenomenology in the LHC Era project leader

High Energy Phenomenology in the LHC Era

The year 2019 witnessed the continuation and completion of many projects initiated during the course of the High Energy Phenomenology project. Aiming to perform research on a broad spectrum of topics in modern high energy physics, we studied, e.g., the holographic description of dense quark matter, a model-independent description of neutron star interiors, high-order perturbative calculations in QCD and the Electroweak theory, as well as the non-perturbative dynamics of gauge field theories. With the LHC currently shut down, most new observational advances reported during the year originated from complementary smaller-scale collaborations, including, e.g., a multitude of gravitational wave observations from LIGO and Virgo, which were turned on in the spring of 2019. These advances were reflected in the choice of research topics within the HEP project.

Within lattice field theory, K. Rummukainen, K. Tuominen and collaborators derived a milestone result in an attempt to determine the fate of non-asymptotically-free gauge theories in the ultraviolet limit. By considering SU(2) gauge theory with 24 and 48 Dirac fermions on the lattice, the authors were able to show that the so-called gradient flow method can be successfully implemented and applied to the determination of the renormalized running coupling even when asymptotic freedom is lost. The results of the paper point towards the existence of a physical cut-off in the UV, thereby implying that a larger number of flavours might be needed to achieve a so-called "*interacting safe fixed point*" in the theory.

Within studies of strongly coupled quark matter using the gauge/gravity duality, N. Jokela and A. Vuorinen teamed up with P. Chesler and A. Loeb from Harvard University to conduct the first-ever systematic study of the neutron star matter Equation of State (EoS) at non-zero temperature, obtained by combining several viable model calculations for nuclear matter with a state-of-the-art description of quark matter through the bottom-up holographic model V-QCD. Carefully taking into account all observational constraints, it was discovered that the EoS is heavily constrained and that even quantitative details of the QCD phase diagram, such as the location of the deconfinement transition and its order, can be relatively accurately predicted. It is anticipated that the main results of the study will become widely used in relativistic hydrodynamic simulations of neutron star mergers, which play a crucial role in the eventual analysis of postmerger GW signals to be recorded by LIGO and Virgo.

QCD and Strongly Interacting Gauge Theory

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 colliders such as the EIC and FCC. We use weak coupling QCD renormalization group equations to understand the partonic structure of hadrons and nuclei. We then use this information to understand and model the formation of a thermalized quark gluon plasma in heavy ion collisions and model its subsequent evolution using relativistic hydrodynamics.

The DGLAP equations describe the scale dependence of proton and nuclear parton distributions (PDFs). In 2019, using our PDF reweighting procedure we charted the impact of the CMS dijet and LHCb D-meson data on nuclear gluon distributions in global PDF fits. We also launched NNLO PDF studies and further addressed heavy-quark observables such as double D-meson production at the LHC. The BK and JIMWLK evolution equations, in turn, describe the energy dependence of QCD cross sections at high energy. We continued developing the BK formalism for deep inelastic scattering cross sections to next-to-leading order in perturbation theory, working towards a fit of HERA data and the inclusion of heavy quarks. We have also studied many aspects of ultraperipheral photon-mediated processes at the LHC, both in order to eventually include them in PDF fits, and to explore the transverse spatial distribution of gluons inside nucleons and nuclei. We also participated in the PYTHIA 8 developments in modelling hard diffractive photoproduction events.

To describe the formation of quark gluon plasma, we use two complementary QCD approaches. 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 have continued to study the dynamics of the infrared sector of overoccupied gluonic systems far from equilibrium, in particular discovering a new self-similar cascade behaviour in two-dimensional systems that are close to what is found in the initial stages of heavy ion collisions. We also model the initial stages of heavy ion collisions starting from perturbative quark and gluon scattering, and use a saturation conjecture to control multiparticle production. These initial conditions are then used in our event-by-event hydrodynamical studies of heavy ion collisions. In the past year, we derived new equations of motion for relativistic magnetohydrodynamics to describe the effect of the strong magnetic fields present in heavy ion collisions.

TUOMAS LAPPI
QCD and Strongly Interacting Gauge Theory project leader

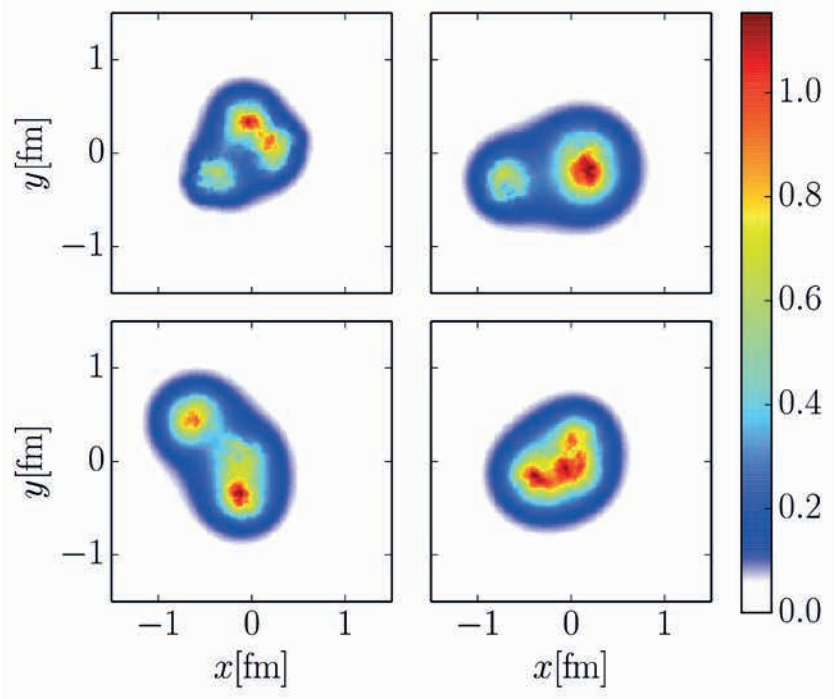


Illustration of the density fluctuations of gluons in the transverse plane of the proton, extracted from exclusive vector meson production cross sections. *[Nature Rev. Phys. 1 (2019) 662] (reprinted from Phys. Rev. D 94 (2016) 034042, © American Physical Society).*

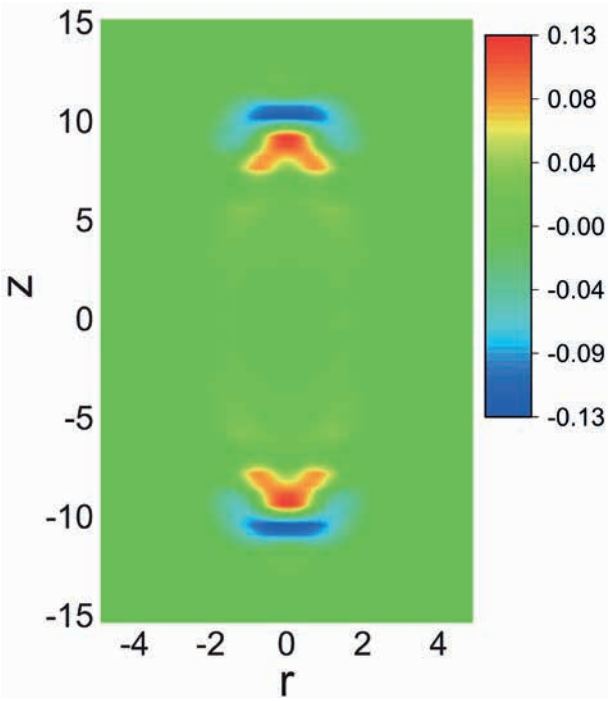
MARKUS KORTELAINEN
Nuclear Structure for Weak and Astrophysical Processes project leader

Nuclear Structure for Weak and Astrophysical Processes

Isobaric multiplet mass equation: The strong nucleon force approximately follows isospin symmetry. This means that the strength of the interaction is roughly similar between different nucleon species. There is, however, a small isospin symmetry breaking term in the strong force. Naturally, the Coulomb interaction provides another source of isospin symmetry breaking. The impact of isospin symmetry breaking can be seen in the energies of states along the same isobar. Due to broken isospin symmetry, the isobaric analog states no longer have the same energy. We have demonstrated that these energy differences can be explained well by introducing isospin symmetry breaking forces.

Symmetry restoration and proton-neutron pairing: One of the key questions in nuclear structure physics is whether proton-neutron (pn) pairs form a pairing condensate in nuclei, as like-particles do. In the mean-field formalism, to account for pn pairing, the most general quasiparticle vacuum state has to be used, which breaks particle-number, spin, and isospin symmetries. To properly handle the effects of the pn pairing condensate, all these broken symmetries should be restored. We have demonstrated that this kind of symmetry restoration allows a theoretical model to describe any kind of mixture of pairing condensate ranging from pn condensates to like-particle condensates.

Small-amplitude collective modes of a finite-size unitary Fermi gas in deformed traps: Studies of strongly interacting ultracold atomic gases have interdisciplinary interests in the quantum many-body systems, such as in condensed matter, nuclear physics, and neutron stars. The collective oscillation frequencies and damping rates of cold Fermi gases can be measured, which provides a good testing ground for various aspects of many-body theories. We have investigated collective breathing modes of a unitary Fermi gas in a deformed trapping potential. These modes were computed by using superfluid linear response theory. When going from a spherical trapping potential towards a more elongated potential, a large shift in the resonance frequency was seen. Also, at the limit of large particle number, a connection to the hydrodynamical result could be established.



Spatial distribution of the transition density for a system of 200 particles in an elongated trapping potential. *[Phys. Rev. A 100 (2019) 053613]*

Domain Wall Dynamics

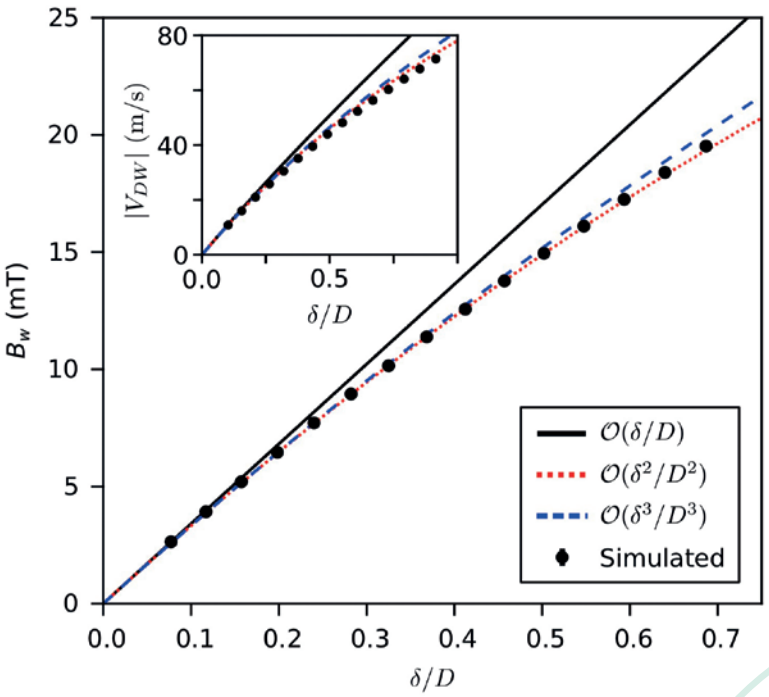
Domain wall dynamics in low-dimensional ferromagnetic structures is an active field of research driven by both numerous promising technological applications as well as fundamental physics interests. 2019 marked the final year of the project, and several papers were published on a variety of problems, including a PRL on Barkhausen noise due to precessional domain wall motion. In addition, I. Rissanen defended his PhD thesis in October 2019, resulting in the second doctoral degree of the project.

Demagnetizing energy of thin film domain walls: Due to its non-local nature, calculating the demagnetizing field remains one of the biggest challenges in understanding domain structures in ferromagnetic materials. We computed analytically the demagnetizing energy of a straight domain wall described by the classical tanh magnetization profile in a thin film with perpendicular magnetic anisotropy. We then used our expression for the demagnetizing energy to derive accurate expressions for important properties of the domain wall such as the domain wall width and the Walker breakdown field.

Bursty magnetic friction between polycrystalline thin films with domain walls: Two magnets in relative motion interact through their dipolar fields, making individual magnetic moments dynamically adapt to the changes in the energy landscape and bringing about collective magnetization dynamics. Some of the energy of the system is irrevocably lost through various coupling mechanisms between the spin degrees of freedom and those of the underlying lattice, resulting in magnetic friction. We used micromagnetic simulations to study statistical properties of bursty magnetic friction in a system of two thin ferromagnetic films with quenched disorder mimicking a polycrystalline structure.

Barkhausen noise from precessional domain wall motion: The jerky dynamics of domain walls driven by applied magnetic fields in disordered ferromagnets - the Barkhausen effect - is a paradigmatic example of crackling noise. In our paper published in PRL, we studied Barkhausen noise in disordered Pt/Co/Pt thin films due to precessional motion of domain walls using full micromagnetic simulations, allowing for a detailed description of the domain wall internal structure. In this regime, the domain walls contain topological defects known as Bloch lines, which repeatedly nucleate, propagate, and annihilate within the domain wall during the Barkhausen jumps.

LASSE LAURSON
Domain Wall Dynamics project leader



The numerical Walker breakdown field B_w as a function of δ/D, i.e., film thickness divided by the domain wall width (points), compared to our analytical prediction including first-, second-, and third-order terms (lines). Inset: The numerical Walker breakdown velocity V_w (points) compared to our analytical predictions (lines). *[Phys. Rev. B 100 (2019) 094440]*

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 precision measurements of particles and interactions, the origin of electroweak symmetry breaking (Higgs bosons), and the search for signatures of new physics. TOTEM is a dedicated forward physics experiment, located at the same LHC interaction point as CMS, focusing on elastic scattering, total cross section, and diffractive and exclusive processes. The programme is divided into four projects: the CMS Experiment project, responsible for physics analysis and operations; the CMS Upgrade project, responsible for the detector upgrade contributions; the Tier-2 Operations poject; and the TOTEM project. The Finnish groups in CMS are: HIP (currently 15 authors), the Department of Physics at the University of Helsinki (5 authors), and Lappeenranta-Lahti University of Technology (2 authors). TOTEM currently has 8 HIP authors, out of which 6 are also affiliated with the Department of Physics at the University of Helsinki.

MIKKO VOUTILAINEN
CMS Experiment project leader

CMS Experiment

Introduction and Highlights

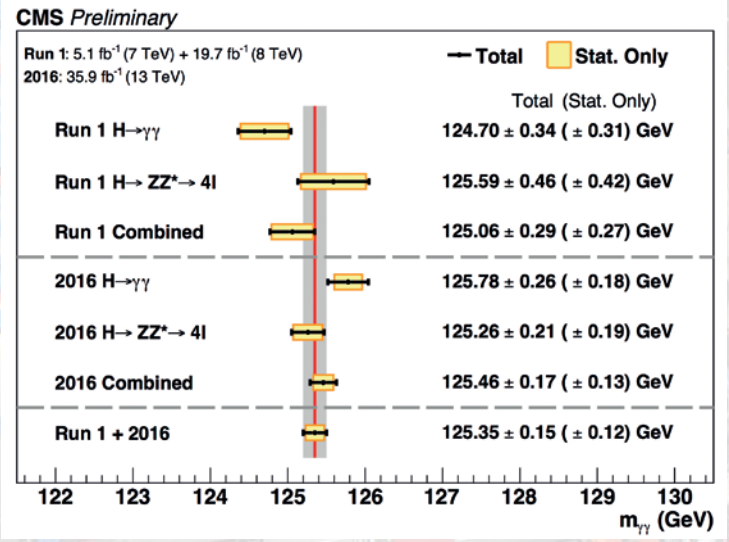
The Large Hadron Collider (LHC) is in a unique position to explore the electroweak symmetry breaking and the origins of the universe. The CMS experiment project is focused on analysis of the LHC data, both for new physics searches (heavy Higgs bosons and supersymmetry) and for precision measurements with jets (the top quark mass m_t and the strong coupling constant α_s). These are supported by a strong involvement in detector operations on jet energy corrections (JEC), in the Level-1 trigger (L1T), and in the alignment, calibration and database (AlCaDB) group. We also develop deep machine learning (ML) applications in HEP.

In 2019, the focus was on the calibration of the full Run 2 data set of 136 fb^{-1} and the publication of searches with a partial 2016 data set of 36 fb^{-1}. Both charged and neutral heavy Higgs searches published new strong limits, with S. Laurila (now at CERN) and J. Heikkilä (now at U. Zurich) successfully defending their PhD theses. The precision measurements on jets focused on reducing systematic uncertainties, with one completed MSc thesis on gluon jet identification by K. Kallonen (now a HIP PhD student), another on a re-analysis of the D0 top quark mass measurement by T. Mäkelä (now at DESY) and one in preparation on the b-jet energy scale by M. Myllymäki.

HIP continued its strong scientific leadership at CMS: T. Lampén convened the AlCaDB group responsible for the legacy re-reconstruction of the Run 2 data; M. Voutilainen convened the TOP Mass & Properties group; and H. Kirschenmann convened the SMP Hadronic Final States group. Overall, CMS highlights included new measurements of the Higgs boson mass and couplings to third-generation fermions (ttH, H → bb and H → $\tau\tau$), and new upper limits on the couplings to second-generation fermions (H → $\mu\mu$, H → cc).

Detector Operations

The detector operations contribution focused on the legacy re-reconstruction of the 2017 (ready), the 2018 (on-going) and the 2016 (ready in spring) data to obtain optimal precision for the Run 2 physics analyses. The JEC team with five contributors from HIP provided calibrations for the 2018 data and focused on improving systematic uncertainties. In the L1T group, M. Lotti took over the on-going HIP activities. On the ML front, J. Havukainen created a streamlined track quality estimation for Run 3 and K. Kallonen took over the data and simulation scale factors for the gluon jet identification.



A summary of the individual and combined CMS Higgs boson mass measurements in the diphoton and four lepton decay channels. Statistical (wider, yellow-shaded bands), and total (black error bars) uncertainties are given. The (red) vertical line and corresponding (grey) shaded column indicate the central value and the total uncertainty of the combined measurement, respectively. © *CMS Collaboration, CERN.*

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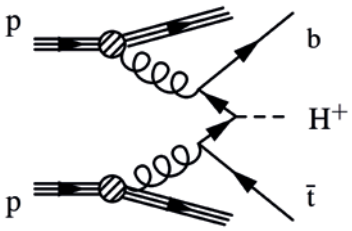
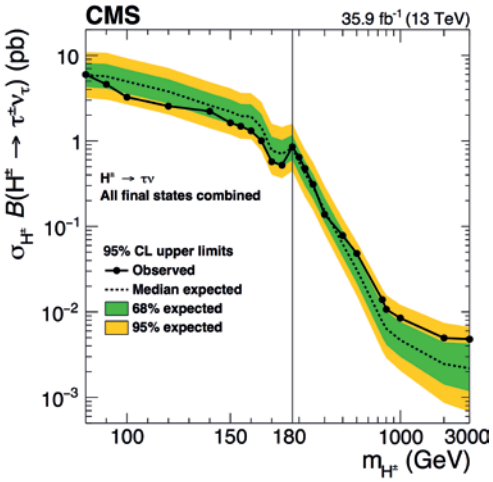
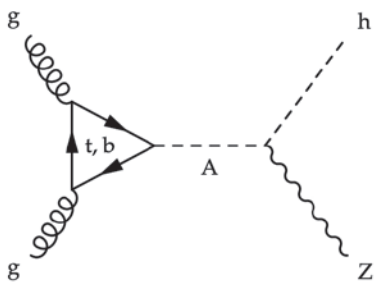
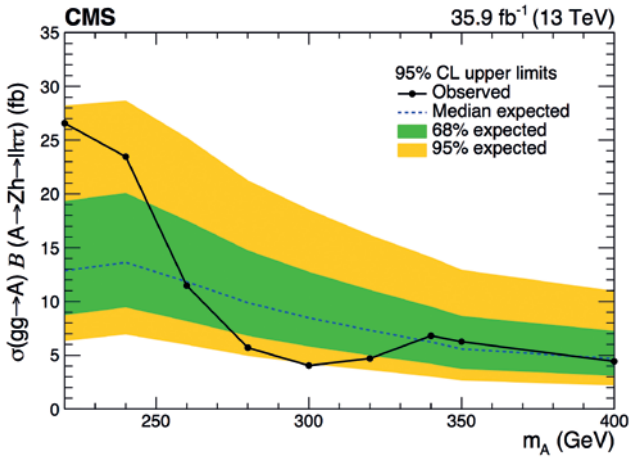


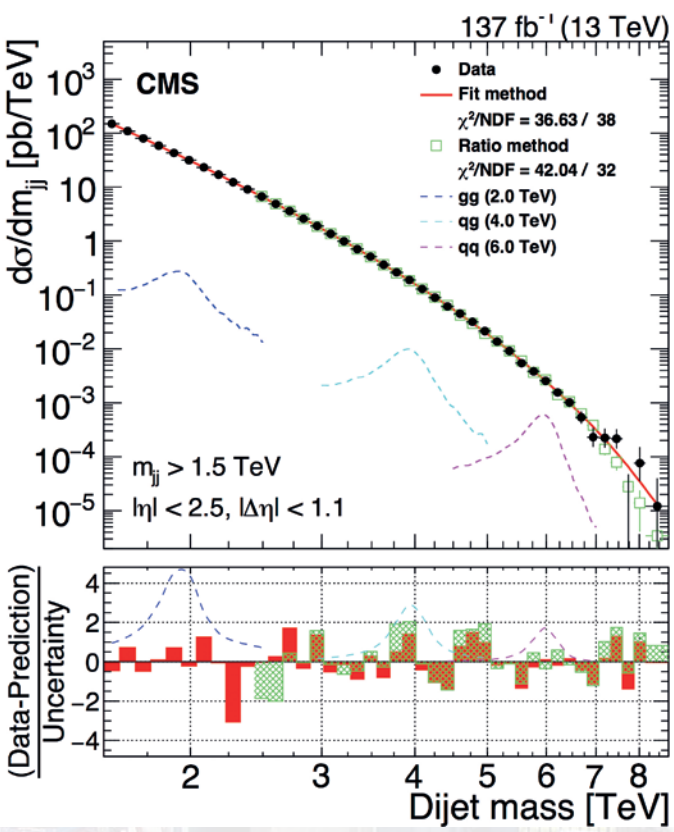


CMS charged Higgs boson search. Left: production diagram and right: the observed (solid line) and expected (dashed line) exclusion limit on the product of the charged Higgs boson production cross section and the branching ratio to tau and its neutrino as a function of the charged Higgs boson mass. The green (yellow) bands represent one (two) standard deviations from the expected limit. *[J. High Energy Phys. 07 (2019) 142, https://doi.org/10.1007/JHEP07(2019)142] © 2020 Springer Nature Switzerland AG.*





CMS pseudoscalar neutral Higgs boson search. Left: production diagram and right: the observed (solid line) and expected (dashed line) exclusion limits on the product of the pseudoscalar Higgs boson production cross section and branching ratio to a leptonically decaying Z and a Higgs decaying to a tau pair as a function of the pseudoscalar Higgs boson mass. The green (yellow) bands represent one (two) standard deviations from the expected limit. © *CMS Collaboration, CERN.*



CMS dijet resonance search: dijet mass spectrum in the signal region (points) compared to a background parametrisation (solid line) and prediction from a control region (green squares). The lower panel shows the difference between the data and the parametrisation (red, solid), and the data and the prediction from the control region (green, hatched), divided by the statistical uncertainty in the data. Predicted signals from narrow gluon-gluon, quark-gluon, and quark-quark resonances are shown (dashed lines) with cross sections equal to the observed upper limits. © *CMS Collaboration, CERN.*

Precision Measurements

We participated in precision measurements of the top quark mass, the inclusive jet cross section and the gluon jet cross section. The overall goals are measurements of the proton structure, the strong coupling constant α_s and the top quark mass m_t, in exploration of Standard Model (SM) vacuum stability and physics up to the Planck scale. In 2019, the first internal analyses were performed on the full Run 2 data set, with focus on substantially reducing systematic uncertainties compared to Run 1.

New Physics Searches

We published results on searches of charged ($H^\pm \to \tau^\pm \nu$) and neutral ($A \to Z(\to \ell\ell)\, H(\to \tau\tau)$) heavy Higgs bosons using data collected in 2016, as well as continued the $H^\pm$ search with the full Run 2 data and in the new $WH^\pm$ final state, which accesses parameter space parts that are so far poorly constrained by other searches. We also participated in the gluino ($\tilde{g}$) pair production search with $\tilde{g} \to tt$ decay in the most sensitive one-lepton final state, using advanced ML techniques. These channels allow exploration of the electroweak symmetry breaking regime, in search for physics beyond the Standard Model and potential candidates for dark matter.

CMS Upgrade

The instantaneous luminosity of the LHC is gradually raised during its operational time to enhance the sensitivity of the experiments to very rare events and to allow high precision measurements of the known processes, like the Higgs boson properties. The most extensive LHC upgrade will take place during the years 2025-2027, the so-called High Luminosity LHC (HL-LHC), resulting in a ten-fold increase in the data rate. However, the high instantaneous luminosity also poses significant challenges to the detector systems. Consequently, the CMS experiment needs to be upgraded several times to meet the goals set for high-quality physics data taking.

In 2019-2020, the pixel detector will go through an intermediate upgrade to improve its performance for Run 3 starting in spring 2021. In this upgrade, the innermost layer of the pixel detector will be replaced with modules carrying an upgraded readout chip. The flip-chip bonding of the 150 detector modules started in summer 2019 at Advacam Oy in Finland, and the HIP CMS Upgrade group is responsible for the initial quality assurance of these modules before their integration with the support mechanics and readout electronics.

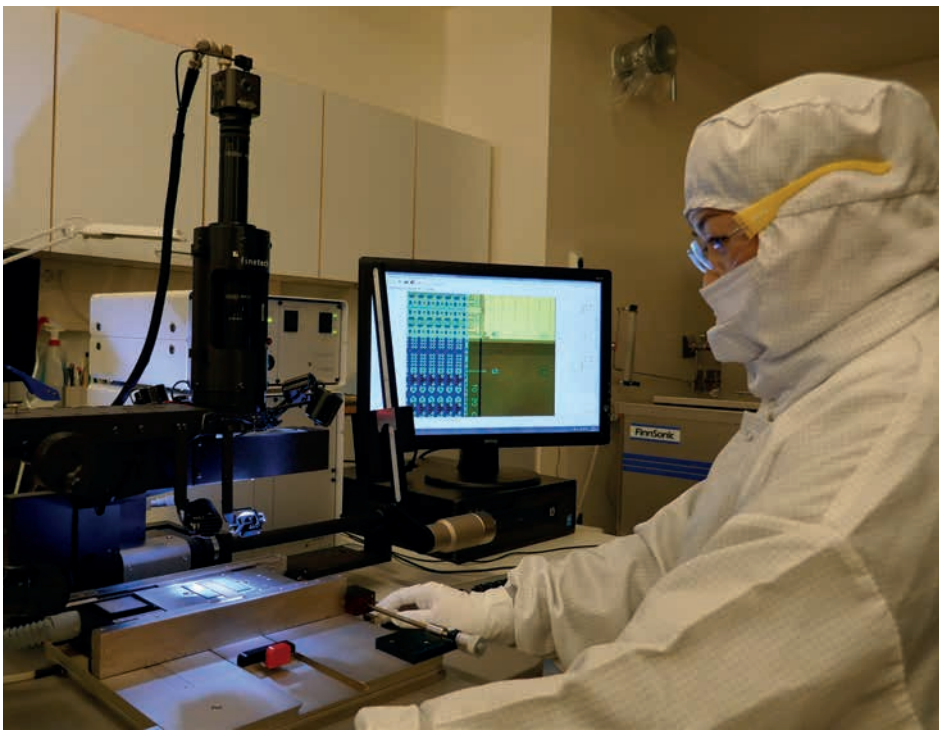
The most comprehensive upgrade of CMS, the Phase-2 upgrade, will happen during the Long Shutdown 3 (LS3) in 2025-2027. In this upgrade, Finland will participate in the upgrade of the Tracker pixel detector and in the building of the new Minimum Ionizing Particle Timing Detector Endcap Timing Layer (MTD-ETL). In 2019, the CMS Upgrade team has actively participated in the evaluation of the prototype sensors for the MTD-ETL.

In 2019, the group also continued the collaboration with the Finnish Radiation and Nuclear Safety Authority (STUK), Aalto University, and Lappeenranta-Lahti University of Technology (LUT) in developing a multispectral imaging detector for medical imaging and beam characterization within an Academy of Finland funded project.

In September 2019, P. Luukka was appointed CMS Collaboration Board Secretary (L0 position) and is currently a member of the CMS Management team. In addition, P. Luukka continued until the end of 2019 as the CMS Tracker Institution Board and Conference Committee Chair. In 2019, P. Luukka was also appointed Professor of Physics at LUT, thus strengthening the CMS team at LUT. The first part of the Academy of Finland funding for the MTD-ETL construction was also granted in January 2019.

PANJA-RIINA LUUKKA
CMS Upgrade project leader

The LUT CMS group, led by Professor T. Tuuva, has continued their participation 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 for Run 3 and beyond.



A. Gädda reworking a CMS pixel module with the Kumpula Detector Laboratory flip-chip bonder. *Credit: J. Ott.*

TOMAS LINDÉN
Tier-2 Operations project leader

Tier-2 Operations

CMS analysis and simulation jobs were running on the HIP Tier-2 site during the Long Shutdown 2 with good availability 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 represents HIP in the NeIC Nordic LHC Computing Grid steering committee. F. Kivelä made his civil service in the Tier-2 project.

CMS jobs were run on the Linux clusters Kale (2720 cores) and Alcyone (840 cores). The dCache services at CSC run very stably. The speed of the HIP WAN connection increased to 40 Gb/s. As a test, CMS jobs were also run on ARM boards using Singularity and CVMFS and the energy consumption was measured. This collaboration between HIP and the UH Department of Computer Science was presented as a poster at the CHEP 2019 Conference.

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 84.9% of the time (76.5% in 2018). There were 17 GGUS tickets (26 in 2018) concerning HIP. The funding to upgrade the storage system in 2020-2021 was approved by the Academy of Finland.

PhEDEx moved 9697 TB of production data (5294 in 2018) and 183 TB of test data (167 in 2018) to HIP; and 2479 TB of production data (2081 in 2018) and 164 TB of test data (168 in 2018) were moved from HIP to elsewhere. In total, HIPs PhEDEx moved 12522 TB of data (7710 in 2018). A total of 1.12 M CMS grid jobs (0.83 in 2018) using 27.0 MHS06 CPU hours (14.2 in 2018) were run with an average CPU efficiency of 49.8% (52.2% in 2018).

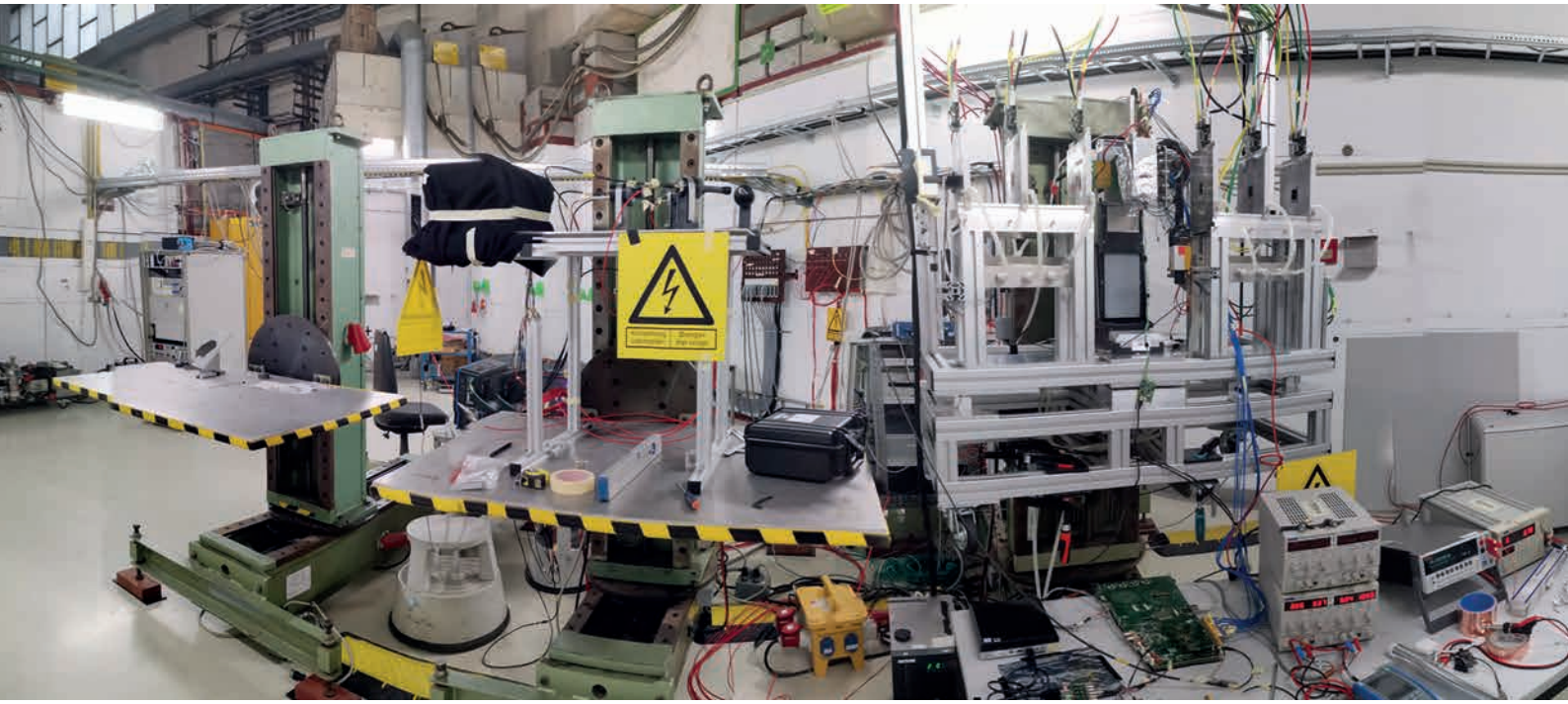
KENNETH ÖSTERBERG
TOTEM project leader

TOTEM

The TOTEM project is responsible for the Finnish CMS and TOTEM forward physics contributions. In 2019, the group consisted of Professor K. Österberg, Professor Emeritus H. Saarikko, scientist F. Garcia, post-doc L. Forthomme, and PhD students T. Naaranoja and F. Oljemark. The focus was on physics analysis and publications, Run 3 upgrade preparations, and calibrations and software for the legacy reconstruction of the CMS Run 2 data. The group members co-ordinated the TOTEM physics (K. Österberg) and CMS PPS test beam (F. Garcia) activities.

In 2019, TOTEM published the 13 TeV total cross section (σ_{tot}) and ρ measurements along with the 13 TeV elastic differential cross section ($d\sigma_{el}/dt$). Moreover, the 2.76 TeV $d\sigma_{el}/dt$ paper was accepted for publication. The sum of the four publications is evidence for t-channel exchange of a C-odd colourless three-gluon compound state, the so-called Odderon, in elastic scattering both via a decrease in the ρ value and a persistency of the $d\sigma_{el}/dt$ diffractive minimum at LHC energies.

Concerning TOTEM, HIP was actively involved in single diffractive (F. Oljemark) as well as Odderon and glueball studies (K. Österberg). Regarding PPS, L. Forthomme played a key role in the 2016 data-based exclusive diphoton analysis and studies of low-mass supersymmetry searches, where an initial aim is to develop a dedicated high-level trigger to increase the CMS sensitivity to such searches in Run 3.



The CMS PPS and TOTEM test beam setup at DESY, Hamburg. From the left: plastic scintillators, quartz and sapphire bars, silicon pixel tracker with diamond detectors under test in the middle and the electron beam with its collimation system. *Credit: F. Garcia.*

Another focus area was Run 3 detector upgrade prototype and Run 2 sensor performance studies using both LHC data and tests with particle beams at DESY (L. Forthomme, F. Garcia, R. Turpeinen). Especially the tests at DESY contributed to an increased understanding of the PPS diamond sensor performance. In addition, T. Naaranoja continued her studies of the diamond radiation hardness.

For the Run 3 PPS time-of-flight (TOF) detector, HIP plays a key role in the diamond sensor purchase, metallization, and quality assurance (K. Österberg, the HIP CMS Upgrade group) as well as for the timing detector software (L. Forthomme). F. Garcia is responsible for the scintillator production for the new TOTEM T2 detector, to be installed for Run 3, for a σ_{tot} measurement at 14 TeV in a dedicated special run. In 2019, the Technical Design Report of the new T2 was approved. In addition, the funding for the HIP contributions to the PPS TOF and the new T2 detector constructions were approved by the Academy of Finland. In view of the longer-term future, an expression-of-interest for an HL-LHC PPS was submitted for CMS internal review. ●

L. Forthomme from HIP receiving his CMS achievement award "for his outstanding contribution to the PPS software development" from the CMS spokesperson R. Carlin and the CMS collaboration board chair H. Prosper. © *CERN.*

NUCLEAR MATTER PROGRAMME

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. Exotic nuclei are studied at the ISOLDE facility while the study of quark gluon plasma and related phenomena takes place at ALICE. 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.

ARI JOKINEN
Nuclear Matter Programme director

SAMI RÄSÄNEN
ALICE project leader

ALICE

A Large Ion Collider Experiment - ALICE - is the dedicated heavy ion measurement at the LHC, designed to study the properties of the quark gluon plasma. ALICE has excellent particle identification and low momentum tracking capabilities that allow, for example, heavy flavour measurements down to very low momenta. One example of the performance of the ALICE detector is the 2019 measurement for the life-time of the hypertriton, the most precise result in the world so far.

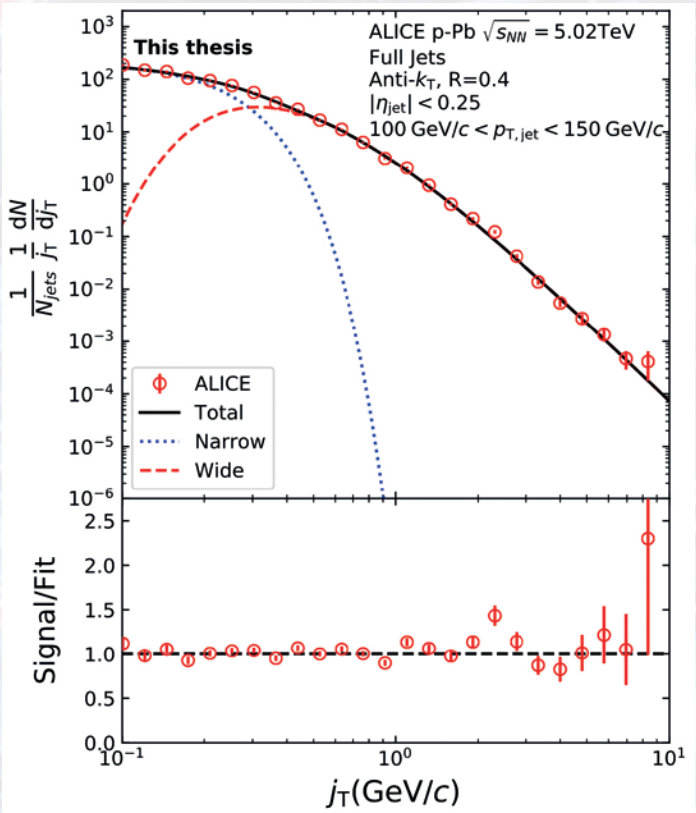
CERN accelerators are currently undergoing a major performance upgrade. To cope with the increased luminosity and collision rate during the upcoming LHC Run 3 and 4, ALICE is replacing and modernising its infrastructure. During the March 2019 Fest Colloquium, ALICE celebrated the achievements of the retiring subsystems, including the timing detector T0. The success of the T0 project led the way to the design and approval of the new Fast Interaction Trigger (FIT) detector. Starting from LHC Run 3, FIT will provide the fast trigger, luminosity, centrality, and event plane measurements for heavy ion collisions. In 2019, the functionality of FIT was further enlarged by the addition of the Forward Diffractive Detector, the successor of the ALICE AD detector from Run 2. In recognition of the importance of the detector for the operation of ALICE, FIT project leader (W. H. Trzaska) became a permanent ex-officio member of

The ALICE Finland team in June 2019 celebrating the PhD of T. Snellman. *Credit: W. H. Trzaska.*

the Management Board representing all Forward detectors. During 2019, the FIT detector entered the final production phase and our group took additional responsibilities for the System Run Coordination and Analysis Framework (M. Slupecki), and also for the Detector Control System (H. Rytkönen).

In the physics data analysis, our group remained focused on jet analysis and collective flow including measurement of the higher-order harmonics, where a hint of a deviation from the trend set by viscous damping was seen. In some models, this is related to an acoustic peak. In June 2019, T. Snellman defended his PhD thesis on jet fragmentation transverse momentum measurements in proton-proton and proton-lead collisions. The results were found to be similar for both systems giving stringent constraints to models expecting significant broadening of jets in cold nuclear matter. O. Saarimäki's analysis on dijet mass continues our involvement in jets.

Our conference highlights include a plenary talk at VCI 2019 (W. H. Trzaska) as well as one talk (J. Parkkila) and two posters (O. Saarimäki, D. J. Kim) at Quark Matter 2019.



Jet fragmentation transverse momentum distribution in proton-lead collisions, after the background subtraction, together with two-component model fit. *Credit: W. H. Trzaska.*

JANNE PAKARINEN
ISOLDE
project leader

ISOLDE

Due to the CERN second Long Shutdown, the year 2019 was mainly focused on analysis of earlier data obtained at ISOLDE.

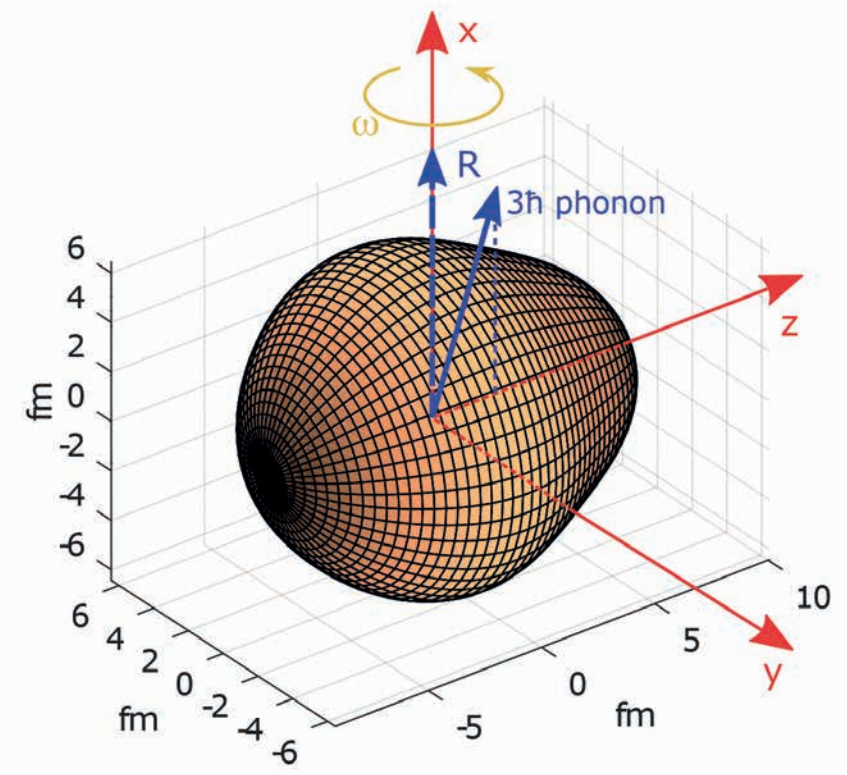
The main highlight of 2019 was a discovery that will help with the search for electric dipole moments (EDM) in atoms and could contribute to new theories of particle physics, such as supersymmetry. Short-lived isotopes of both radon and radium have both been identified as potential candidates for measuring EDMs in atoms. HIP affiliated researchers J. Ojala and V. Virtanen joined an international team lead by P. Butler from the University of Liverpool, UK that exploited the ISOLDE facility at CERN to accelerate beams of radioactive radon ions and were able to measure the properties of rotating radon nuclei. The experiments showed that the radon isotopes ^{224}Rn and ^{226}Rn vibrate between a pear shape and its mirror image but do not possess static pear-shapes in their ground states. This behaviour is quite different from their neighbouring radium isotopes that are permanently deformed into the shape of a pear. In a paper published in Nature Communications, they conclude for the first time that radon atoms provide less favourable conditions for the enhancement of a measurable atomic EDM than radium.

In the low-energy branch of the ISOLDE facility, contributions to the laser spectroscopy programme with the CRIS experiment were made. In just the last two years, particular highlights were the study of tin isotopes up to ^{104}Sn, and studies of the rich isomerism in the indium isotopic chain. As a world-first, optical spectroscopy on radioactive radium-fluoride molecules was performed. Besides the technical novelty of these experiments, they also provided the first spectroscopic information on a molecule that may one day provide extremely sensitive tests for physics beyond the Standard Model.

During the HIP funded summer training, M. Kivekäs worked with perturbed angular correlations experiments with short-lived isotopes. That included mechanical design, programming automation software, and development of the new implantation station. After successfully defending his PhD thesis at JYFL, M. Vilen started as a CERN Applied Fellow at ISOLDE, developing a new MR-TOF device for radioactive species.

Future plans

The ISOLDE users community has been steadily growing in the last 15 years and the demand for beam time outnumbers the current production capabilities. Thus, the ISOLDE Collaboration has initiated the EPIC project (Exploiting the Potential of ISOLDE at CERN) to take full advantage of the recent upgrades at CERN, driven by the LHC Injectors Upgrade. ●



Cartoon illustrating how the octupole phonon vector aligns with the rotation (R) vector. *[Nature Commun. 10 (2019) 2473]*

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

In 2019, the HIP FAIR project operated with two main goals, realisation of the Finnish FAIR in-kind contributions to accelerators and experiments, and also to advance the science programme of the NUSTAR experiment at FAIR. Both of these goals were achieved as three new in-kind delivery contracts were signed, and the FAIR Phase-0 experimental programme exploiting the existing GSI accelerators (UNILAC and SIS18) started. Civil construction of FAIR in Darmstadt is on schedule. The SIS100 synchrotron tunnel construction is the most visible civil construction development.

Experiment with the MONSTER Neutron Detectors

The MONSTER (Modular Neutron Spectrometer) neutron detectors were successfully tested and exploited in an experiment studying the short-lived nucleus ^{85}As at the Accelerator Laboratory of the University of Jyväskylä as a part of the FAIR Phase-0 experimental campaign.

The beta decay of ^{85}As is followed by the emission of neutrons, a phenomenon called "*beta-delayed neutron decay*". Such neutrons were used to test and characterize the performance of MONSTER, which is one of the most precise instruments to measure the energies of beta-delayed neutrons.

Studies of beta-delayed neutron emission in nuclei far from stability are one of the goals of the NUSTAR experiment of FAIR. The knowledge of the beta-decay properties contributes not only to the understanding of nuclear structure, but is also essential in the understanding of the astrophysical heavy-element nucleosynthesis and for more accurate simulations of nuclear reactors. Eight MONSTER detector modules are provided in-kind to FAIR by Finland.

FAIR Accelerator Components

Some of the main in-kind contributions from Finland are the beam diagnostic and identification detectors that are needed for the Superconducting Fragment Separator (Super-FRS), including mechanical devices and particle detectors. The MUSIC energy-loss detector passed its conceptual design phase and the GEM-TPC tracking detector prototype was tested with future readout electronics. The in-kind contract for the delivery of SEM-grid beam-profile detectors for the Super-FRS was signed and Fermi National Accelerator Laboratory delivered the prototype SEM-grid detectors. Mass production is planned to begin in 2020.

The in-kind contract for the beam insertion devices for the 32 detector stations was signed and development started. Another signed in-kind contract dealt with the safety transport container of radioactive Super-FRS beam-line components.

TUOMAS GRAHN
FAIR
project leader

The SIS100 synchrotron tunnel under construction in November 2019. *Credit: T. Grahn.*

TECHNOLOGY PROGRAMME

The Technology Programme aims to integrate HIP projects that have significant technology development, transfer, and pre-commercialisation activities into the same programme. In addition, the research activities performed within the programme are designed to seek synergies with big science initiatives at large. The programme is structured into three thematic areas - systems, materials, and technology - each consisting of several small projects. Several projects have been successful in raising external funding for the R&D work, thus strengthening the impact of the programme.

FILIP TUOMISTO
Technology Programme director

Systems

MARKUS AICHELER
Accelerator Technology: Module, Structures and Manufacturing (MSM) project leader

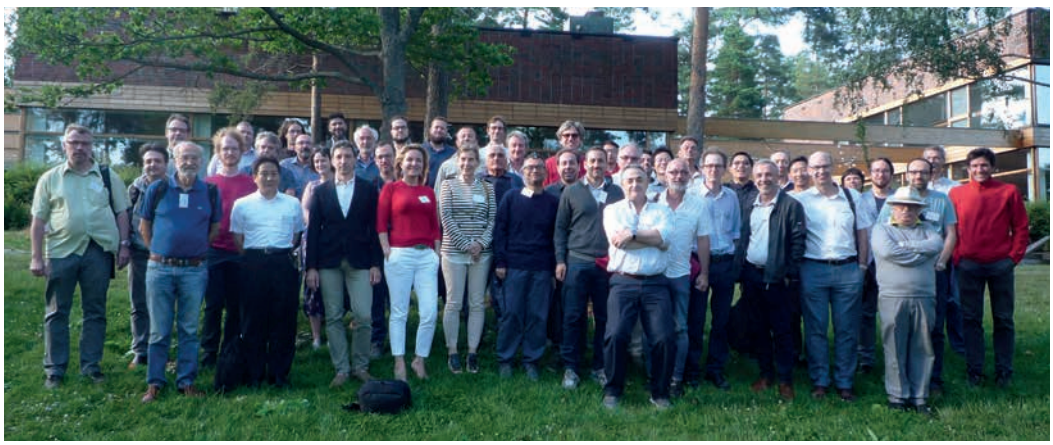
Accelerator Technology: Module, Structures and Manufacturing (MSM)

The Accelerator Technology: Module, Structures and Manufacturing (MSM) project collaborates strongly with various groups and projects at CERN, e.g., with the Compact LInear Collider (CLIC) study at CERN that is developing a two-beam technology for a future multi-TeV electron positron collider, as well as with the Beam Instrumentation Group.

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) an R&D activity on a cooling system for Beam Instrumentation in close collaboration with the BI group at CERN; c) taking part in CompactLight (an EU project on the design of future normal conducting FELs); and d) executing the Business Finland funded co-creation project "Advanced Materials and Mechanics for Detectors and Accelerators" (AMMDA), leading to a submission of a co-innovation proposal.

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 2019, the project had one researcher (J. Väinölä) and the project leader (Dr. M. Aicheler) at CERN, plus three PhD students (A. Meriläinen, R. Montonen and A. Holmström) based in Helsinki.

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



Group picture of the CompactLight project members at the midterm review of the project at hotel Rantapuisto in June 2019. *Credit: CompactLight Project.*

Diagnostics: Novel Gamma-Ray Spectroscopy for Radioactive Materials Testing (GAMMA)

Securing sufficient and environmentally sustainable electricity production is one of the main challenges for the future. Among electricity sources, fission and fusion reactors do not suffer from intermittencies observed in solar or wind resources and allow an efficient and flexible basis for the highly demanding electricity network, especially around big cities and industries. However, they require materials that resist extreme radiation environments.

Maintaining those material properties is only possible by perfectly harnessing their behaviour at both microscopic and macroscopic scales. In addition, by developing new materials with finely tuned properties, including improved radiation resistance and easy reprocessing, reduced amounts of resources and nuclear waste to manage will be required.

Tailoring material properties relies specifically on specially designed atomic structure allowing accumulation of defects under irradiation without loss of performance. An efficient way to characterize those microscopic properties is via X-ray Absorption Spectroscopy (XAS) and Positron Annihilation Lifetime Spectroscopy (PALS). Well established in material studies, those non-destructive and complementary characterization techniques are not usually applied to highly radioactive materials due to scarce access to the dedicated facilities, and the high cost and technical limitation arising when dealing with strongly radioactive materials. Thanks to recent technological developments in radiation detection and X-ray optics, the GAMMA project is developing new XAS and PALS devices that allow studying highly radioactive materials at the laboratory scale, unlocking access to their microscopic structure behaviour. ●

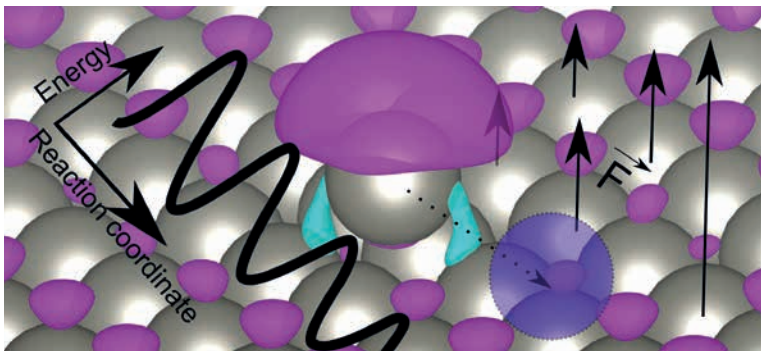
Materials

Materials for Accelerator Technology (MAT)

Within the project Materials for Accelerator Technology (MAT) we deal with processes on metal surfaces working in the extreme conditions of particle accelerators. The reasons for why ultra-high vacuum insulation near metal surfaces working under high electric and electromagnetic fields repeatedly breaks down, even after the surface reaches a stable performance, are not yet understood. A complex phenomenon involves processes on different time and length scales and requires knowledge of different fields: from atomic to surface and plasma physics. In our group, we collaborate with the R&D group led by Dr. W. Wünsch, who designs accelerating structures for the linear particle accelerator CLIC, which was selected as one of the strategic projects at CERN. The structures are developed to withstand high-gradient electromagnetic fields. Frequent sparks near the surface disturb bunches of accelerated particles reducing luminosity and increasing power consumption. In our group, we develop multiscale computer simulation models to describe behaviour of metals under high electric fields. In 2019, the highlight of the work related the quantum-mechanical understanding of the effect of surface defects on the work function, and the building of a theory explaining the effect of an electric field on the migration barrier for biased diffusion on Cu surfaces. We performed a number of experiments, revealing the processes near the anode surface with a nanoscale resolution. We also confirmed the correlation of the distribution of breakdown spots with microstructure of the electrodes: in Cu samples with large grains, the breakdowns are located within a single grain, while in the samples with smaller grains, the breakdown spots are more random. ●

RENÉ BÈS
GAMMA project leader

FLYURA DJURABEKOVA
Materials for Accelerator Technology (MAT) project leader



Three-dimensional illustration of the effect of an electric field on migration barriers of an adatom on the (110) W surface. The grey balls are the W atoms with the charge distribution due to the applied field shown in purple. The semi-transparent blue colour indicates the final position of the adatom after the transition. The directions and lengths of the arrows represent the direction and magnitude of the electric field near the adatom. The black curve shows the variation of the energy landscape along the transition direction. *Illustration by E. Baibuz.*

ILJA MAKKONEN
Materials for Big Science Installations (BIGS) project leader

Credit: I. Makkonen

Materials for Big Science Installations (BIGS)

The development and characterization of new materials for extreme environments is at the core of the technological needs of Big Science. Choosing and developing materials for next-generation facilities is critical for cost and environmental efficiency. This HIP Technology project focuses on two classes of materials, the high-entropy alloys (HEAs), a novel materials class, that can be tailored to suit multiple potential applications, and tungsten, an important plasma-facing material to be used in future fusion reactors.

HEAs are a relatively new class of metallic alloys that contain five or more elements in nearly equivalent ratios. HEAs differ significantly from conventional metallic alloys, such as steel-based Fe-C alloys, cupronickels, and bronze, where there are one or two main elements with other alloying elements clearly in the minority. Global interest towards HEAs is due to the exceptional properties of these alloys, such as unique corrosion or abrasion resistance, radiation hardness, or performance at extreme (either low or high) temperatures. Even though the HEAs are a hot topic globally, a fundamental understanding of these types of materials from the atomic scale to macroscale is currently missing from the scientific literature.

There are two main aspects in the project's research at the University of Helsinki: experimental characterization using especially the positron annihilation technique; and first-principles calculations of the metals and metallic alloys, as well as defects and defect clusters inside. In 2019, the main focus of the project was on the experimental defect studies of irradiation-induced defects in a prototypical HEA alloy, the so-called Cantor alloy (FeCrMnNiCo).

Technology

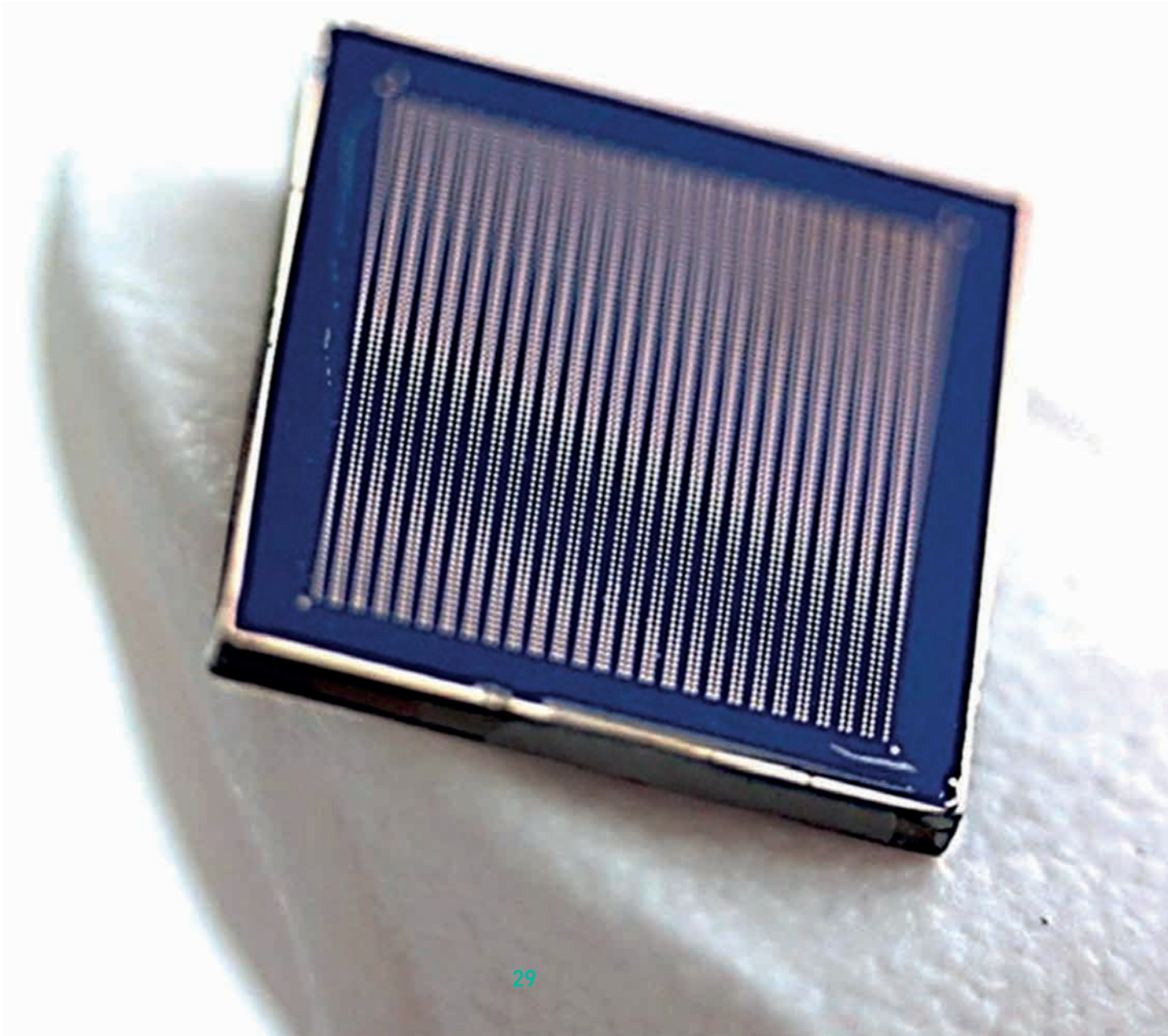
Radiation Metrology for Applications (RADMET)

The increasing frequency of computed tomography (CT) medical imaging calls for efficient patient exposure optimisation. This optimisation aims at the lowest patient dose possible, with the constraint that the required diagnostic information must be obtained from the acquired CT image.

Novel detectors that can detect single photons and their energies have been developed and tested. These detectors include different scintillator materials combined with Si photodiode arrays and pixel detectors as well as CdTe pixel detectors. The detectors are read using the technology developed for the CMS experiment at CERN. Together with advanced data processing and image reconstruction algorithms developed in the project high detection efficiency, excellent image quality and lower patient doses are achievable. Further applications can be found in Boron Neutron Capture Therapy (BNCT). The detectors can be used to detect particle radiation (e.g., alpha particles, electrons or protons) as well, widening the range of applications where these detectors can be used.

The project partners are the Helsinki Institute of Physics, Aalto University, Lappeenranta-Lahti University of Technology, and the Finnish Radiation and Nuclear Safety Authority STUK. The project receives funding from the Academy of Finland (RADDESS program).

TEEMU SIISKONEN
Radiation Metrology for Applications (RADMET) project leader



A. Gädda.

PETER DENDOOVEN
Radiation Safety Research & Development (RADAR) project leader

Radiation Safety Research & Development (RADAR)

The project "RADiation sAfety Research & development" (RADAR) was started and has encompassed the final months of the NINS3 project, the start-up of the GOSSER II project and the DEFACTO project.

GOSSER II (Geological Safeguards and Security R&D Project, 2019-2022, co-ordinated by the Finnish Radiation and Nuclear Safety Authority STUK) aims to create a safeguards approach for spent nuclear fuel disposal in a geologic repository.

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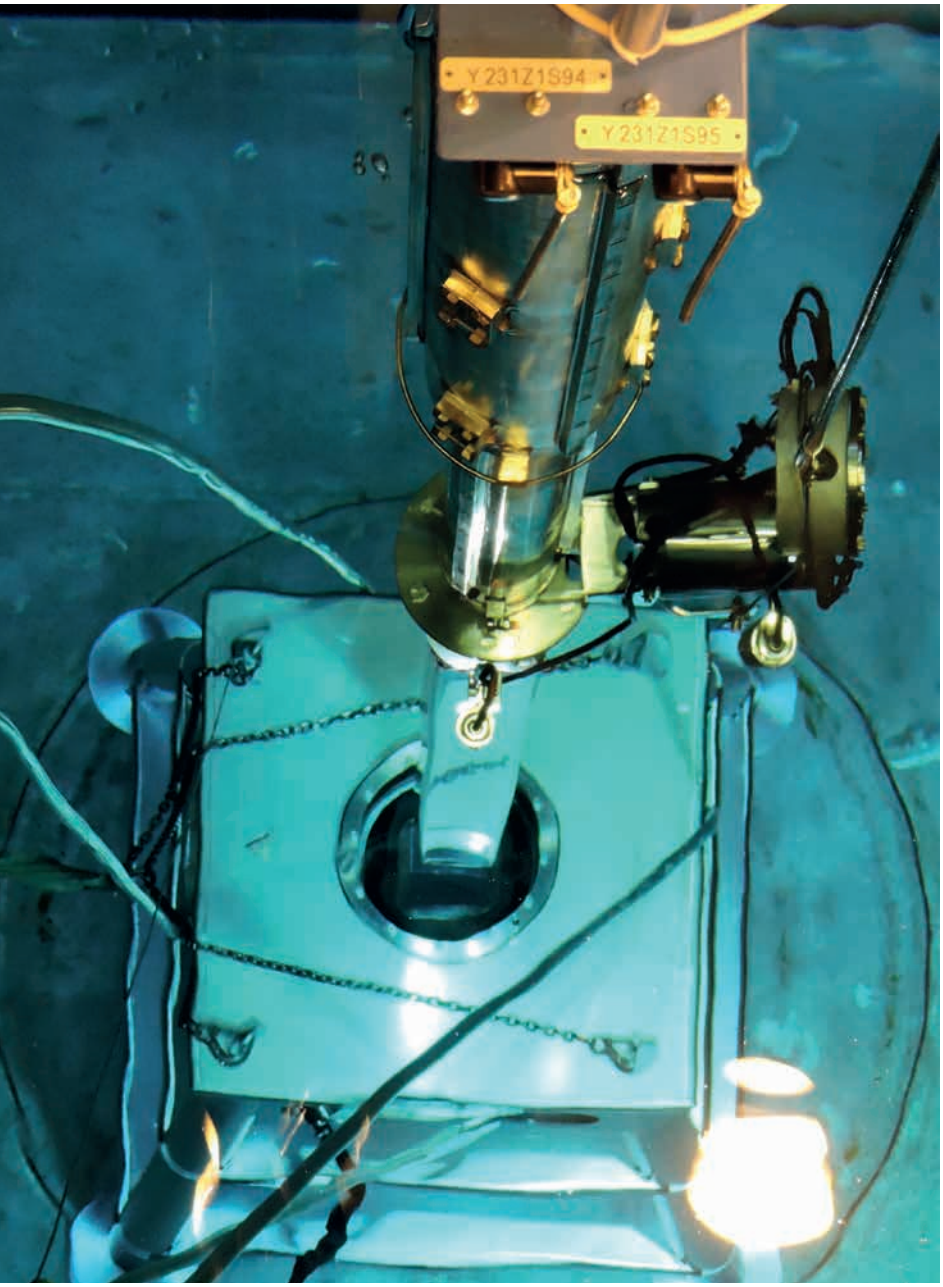


The GOSSER II activities at HIP continue work performed under NINS3. Developing image reconstruction for passive gamma emission tomography (PGET) of spent fuel has continued in collaboration with mathematicians from the University of Helsinki and Lappeenranta-Lahti University of Technology. We participated in the IAEA Tomography Reconstruction and Analysis Challenge, winning 2nd prize! The joint HIP-STUK construction of the PNAR (Passive Neutron Albedo Reactivity) prototype device was completed. During a first test at an interim fuel storage facility, the PNAR and PGET devices were installed on top of each other such that the same fuel assembly could be measured by both devices simultaneously.

In the STUK-HIP joint project, DEFACTO (Detector for fallout and air concentration monitoring), new early warning detectors for improved emergency management are being developed. The detectors aim to improve upon the present ones by distinguishing airborne radioactivity, fallout components, and radioactive contamination of the detector box. We demonstrated that airborne radioactivity can be distinguished from fallout with a phoswich detector consisting of two scintillator crystals and a passive gamma shield. Different methods to measure detector box surface contamination have been tested at the HIP Detector Laboratory.

A spent fuel assembly being lowered into the PGET + PNAR device. The device sits 15 metres underwater at the bottom of the spent fuel pool. *(Picture: TVO)*

Finnish Business Incubation Center of CERN Technologies (BIC)

The CERN Business Incubation Network aims to improve commercialisation, and therefore, 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.

During 2019, the opportunities to organise FBC operations have been discussed with multiple partners nationally and the organising of activities have established a network type of governance for FBC. The first institution to get involved in this is Tamlink Oy and negotiations have been initiated with HIP and CERN on these matters.

The project as part of the Technology Programme has also supported a number of other R&D&I activities nationally. During 2019, these activities have included, for example, support for Business Finland applications in partner universities, Challenge Based Innovation programmes, and industrial partner engagements.

SAKU MÄKINEN
BIC project leader

OTHER PROJECTS

MARKKU KULMALA
CLOUD
project leader

CLOUD

Background

Indirect observations and theoretical studies have suggested that galactic cosmic rays (GCR) may have influenced the Earth's cloud cover and climate, possibly by affecting aerosol-particle properties. These tiny particles, floating in the atmosphere, influence the Earth's climate system via two mechanisms. First, they can directly reflect or absorb solar radiation, and second, they can act as seeds for the formation of cloud droplets or ice crystals and thereby affect the lifetime and precipitation of clouds. Measuring the underlying microphysics in controlled laboratory conditions is a key to understanding the dynamical behaviour of aerosol particles and cloud droplets, including the formation and growth processes of aerosols particles, cloud droplet activation, and ice nucleation. The CLOUD (Cosmics Leaving OUtdoor Droplets) experiment at CERN is one of the most advanced laboratory setups for studying these processes. The experiment aims to find the possible pathways of these phenomena and to evaluate their significance in the atmosphere, for example by using the CERN proton synchrotron to vary levels of GCR in the CLOUD experiment.

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).

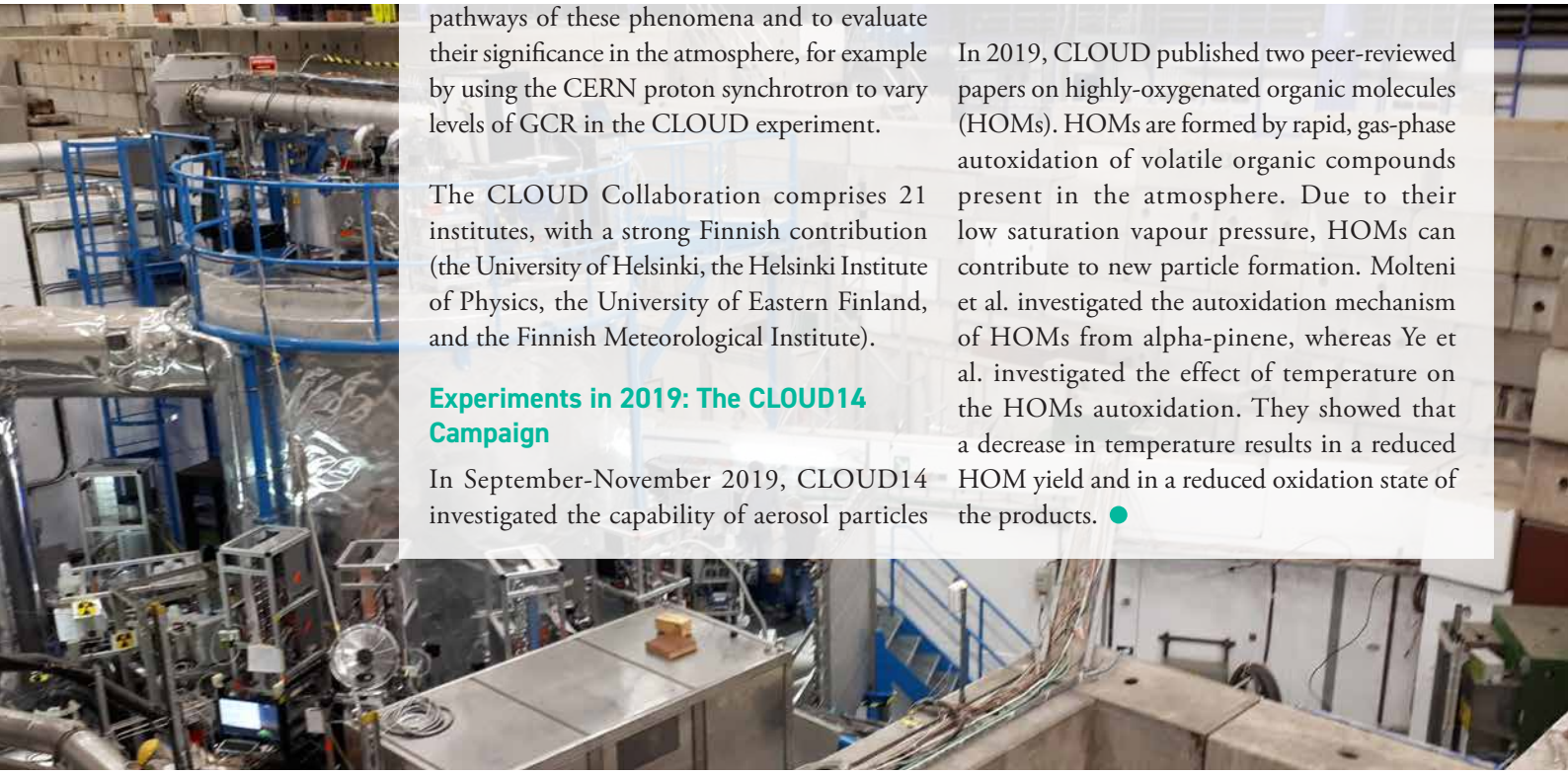
Experiments in 2019: The CLOUD14 Campaign

In September-November 2019, CLOUD14 investigated the capability of aerosol particles to act as ice nuclei. The studied particles were formed in conditions relevant to the marine atmosphere, boreal forest, semi-urban, and urban environments. The Finnish team made an important contribution by operating instruments such as an ice particle chamber, particle counters, and mass spectrometers, and participated in planning and conducting the experiments.

Data Analysis, Education, and Reporting of Results

Our two CLOUD students (CLOUD MSCA ITN funding) are conducting their PhD research in the Doctoral Programme of Atmospheric Sciences at the University of Helsinki. They follow international training organised by the CLOUD-MOTION project. Three PhD students who were involved in the CLOUD experiment graduated in 2019. In 2019, two CLOUD workshops (in Wengen, Switzerland and Stockholm, Sweden) were organised to support the analysis and a collaboration meeting took place at CERN in October.

In 2019, CLOUD published two peer-reviewed papers on highly-oxygenated organic molecules (HOMs). HOMs are formed by rapid, gas-phase autoxidation of volatile organic compounds present in the atmosphere. Due to their low saturation vapour pressure, HOMs can contribute to new particle formation. Molteni et al. investigated the autoxidation mechanism of HOMs from alpha-pinene, whereas Ye et al. investigated the effect of temperature on the HOMs autoxidation. They showed that a decrease in temperature results in a reduced HOM yield and in a reduced oxidation state of the products.

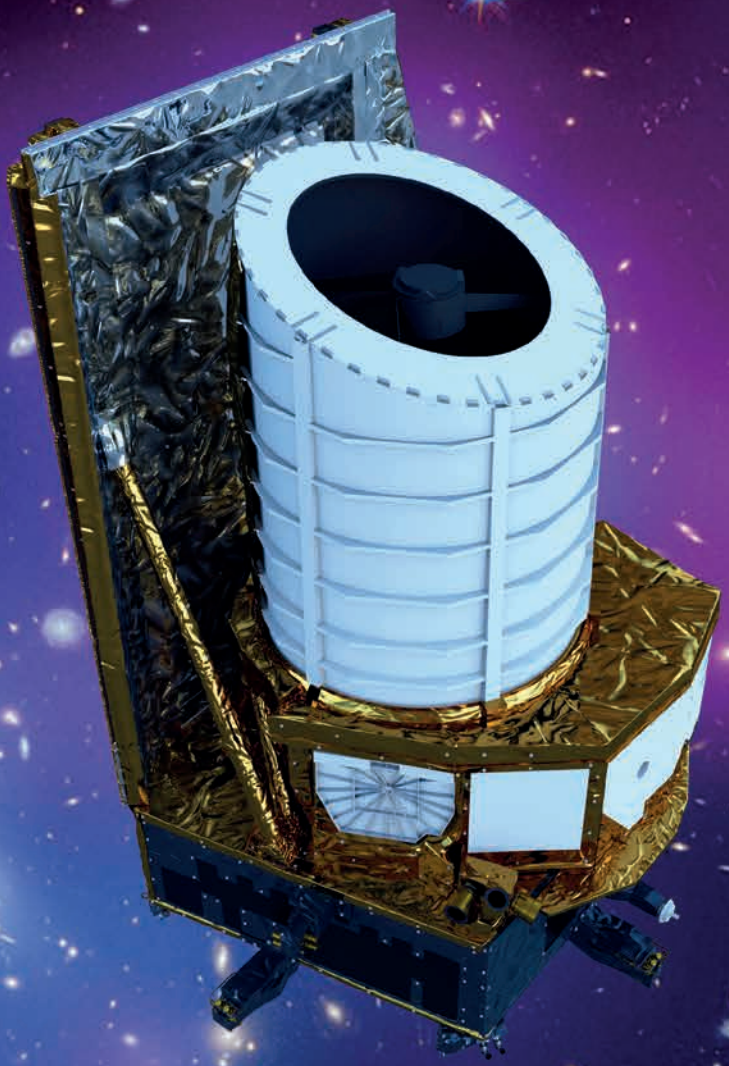


The CLOUD experiment, surrounded by detectors brought by the participating institutes. *Credit: J. Duplissy.*

HANNU KURKI-SUONIO
Planck-Euclid project leader

Planck-Euclid

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 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 concentrates on the early universe and Euclid on its later evolution. Planck made observations from 2009 to 2013; Euclid will be launched in 2022 and will make observations for 6 years.



Artist's impression of the Euclid spacecraft.
Credit: ESA/ATG medialab (spacecraft); NASA, ESA, CXC, C. Ma, H. Ebeling and E. Barrett (University of Hawaii/IfA), et al. and STScI (background).

The participants of the Euclid Consortium Meeting 2019 gathered in front of the Finlandia Hall. *Credit: Atte Mäläskä / Tailorframe Oy.*

Planck

The final Planck results were mostly released in 2018. The release was completed in 2019 with three additional publications (on primordial non-Gaussianity, on isotropy and statistics of the CMB, and on the CMB power spectrum and the Planck likelihood code) and the Planck likelihood code was added to the Planck Legacy Archive, where it is openly available to everybody. The likelihood code allows anyone to compare her/his favourite cosmological model to Planck data, and fit the parameters of the model to the data. Planck results remain in agreement with the standard model of cosmology, the LambdaCDM model. The Planck project is essentially over now, except that two of the Planck publications are still under peer review. All 12 final-release publications will be published together once these two have passed review.

Euclid

The Euclid satellite is nearing completion. The two instruments, NISP (Near Infrared Spectrometer and Photometer) and VIS (imager at visible wavelengths), were completed in 2019, and the first test images were taken with them in the laboratory. The instruments will be delivered for integration to the satellite payload in 2020. The projected launch date remains in June 2022, with somewhat less margin in the schedule than a year ago. We organised the annual Euclid Consortium Meeting, which in 2019 was held in the Finlandia Hall in Helsinki. This 5-day conference had 408 participants.

We operate one of the nine Euclid Science Data Centers, SDC-FI, which will eventually analyse Euclid data. It runs on virtual machines at the CSC Kajaani Data Center. We participated in the Euclid SDC Science Challenge 4/5/6, where the current version of the Euclid data analysis pipeline was tested. We participate in the development of the code to produce simulated NISP data. We have the main responsibility in Euclid for validating the code to estimate the 2-point correlation function (2PCF) of the galaxy distribution, one of the main cosmology products of Euclid, and this task has occupied most of the SDC-FI computing capacity. In 2019, we also started participating in the development of the code and were able to make the code faster by an order of magnitude. ●

Education and Open Data

The Education and Open Data project covers and connects two activities: the Finnish high-school visit programme at 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.

High School Visits

In 2019, 19 high-school groups from Finland, with a total of 386 students and 56 teachers, attended a three-day visit to CERN. The visits are preceded by extensive studies in schools, preparing for an intensive lecture and visit programme at CERN. The programme is partly subsidised by the Finnish National Agency for Education, and co-ordinated by the national CERN high-school network. A two-day course for rectors and study counsellors with 14 participants was organised at CERN in 2019. The feedback from these visits is excellent, the direct contact with the researchers and their enthusiasm is greatly appreciated, and the visits encourage students to join various scientific branches.

Open Data Training

A two-day course for the use of open data in schools, with the goal of becoming familiar with CMS Open Data and preparing teaching material using them, was organised at Lapland University of Applied Sciences in Rovaniemi in April 2019, after earlier successful trainings in 2017 and 2018. The course was attended by 24 teachers at different levels of education and the feedback was very encouraging. In particular, the ease of use of the suggested material in the form of "jupyter notebooks" was appreciated, and the possibility to extend and adapt the material for their own curriculum and to other topics. The courseware is based on the work of HIP summer students since 2016, further extended by two summer students in 2019. The material is in use in the CERN teacher programmes. Use of open data in a real teaching situation is also piloted by P. Veteli, preparing his Master's Thesis at the University of Helsinki. ●

KATRI LASSILA-PERINI
Education and Open Data project leader

CMS Data Preservation and Open Data Releases

The CMS Data Preservation and Open Access group manages the actions needed for data and knowledge preservation of the experiment. Data is regularly released for public use, and the latest release in July 2019 included examples and specially prepared samples for machine learning, with a contribution for jet studies from the HIP CMS group. This latest release also brings all collision data from 2010 to the public domain, as stated in the CMS data policy. The CMS Open Data are increasingly in use, for scientific studies and in education, and in 2019 also in the Particle Physics course at the University of Helsinki.

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DETECTOR LABORATORY

EIJA TUOMINEN
Detector Laboratory chief engineer

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 at the University of Helsinki (UH). The Laboratory provides premises, equipment, expertise, and technical support for research projects that develop detector technologies. The Laboratory team has extensive expertise in modelling, design, construction and testing of radiation detectors.

The Detector Laboratory provides 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 2019, the Laboratory provided instrumentation for the CMS and TOTEM experiments at CERN and for the NUSTAR experiment at FAIR. In addition, projects of radiation safety by the Finnish Radiation and Nuclear Safety Authority STUK and projects of medical imaging funded by the Academy of Finland were present in the Laboratory.

The Second Nordic Conference for Diversity in Physics was organised in Helsinki in November 2019.

The Detector Laboratory has a wide network of **national collaborations**, especially in the form of sharing expertise, equipment, and infrastructure. The Laboratory collaborates actively with the laboratories of the UH Faculty of Science, as well as with the instrumentation laboratories and physics departments at other Finnish universities. Collaboration is especially strong with the Aalto University Nanofabrication Centre. In addition, the Laboratory collaborates with Finnish industry, especially with small and medium size companies and start-ups.

Providing **education** in instrumentation of physics is of utmost importance to the Detector Laboratory. In the framework of the Master's Programme for Particle Physics and Astrophysical Sciences (PARAS), the Laboratory offers four courses of instrumentation, including hands-on laboratory exercises. The Laboratory staff also supervise doctoral and master students in their thesis works, especially in the framework of the Doctoral Programme in Particle Physics and Universe Sciences (PAPU).

Special effort is devoted to **societal interaction** to ignite interest in physics among children and youth. About 200 high-school students visited the Laboratory in 2019. In addition, the Laboratory was active in public outreach events, e.g., EU Researchers' Night, UH Think Corner "Smart as Hel", and Bring-Your-Child-to-Work. Furthermore, four secondary school students practiced in the Laboratory in 2019. The Laboratory team is also active in promoting wellbeing and diversity, e.g., in the organisation of the Nordic Conference for Diversity in Physics.

Children learn by playing at Kumpula Bring-Your-Child-to-Work Day.
Credit: J. Aaltonen, HIP.

At the UH Think Corner Tinkering Event children learn to transfer electricity to light.
Credit: J. Aaltonen, HIP.

JOINT ACTIVITIES

© Linda Tammisto, University of Helsinki

ANTTI VÄIHKÖNEN
Research coordinator

HIP is a joint institute of five universities. The Finnish Radiation and Nuclear Safety Authority (STUK) is an interim member of HIP since 2018 and, during 2019, a continuation of the membership for 2020-2022 was prepared. The HIP Regulations were slightly revised in the process.

After many changes in the administrative environment of HIP in previous years, 2019 was more stable. The biggest changes were in Tampere where two universities and one university of applied sciences merged, and the Tampere University of Technology changed its name to Tampere University. Lappeenranta University of Technology included Lahti in its name but will use a shorter unofficial name, LUT University.

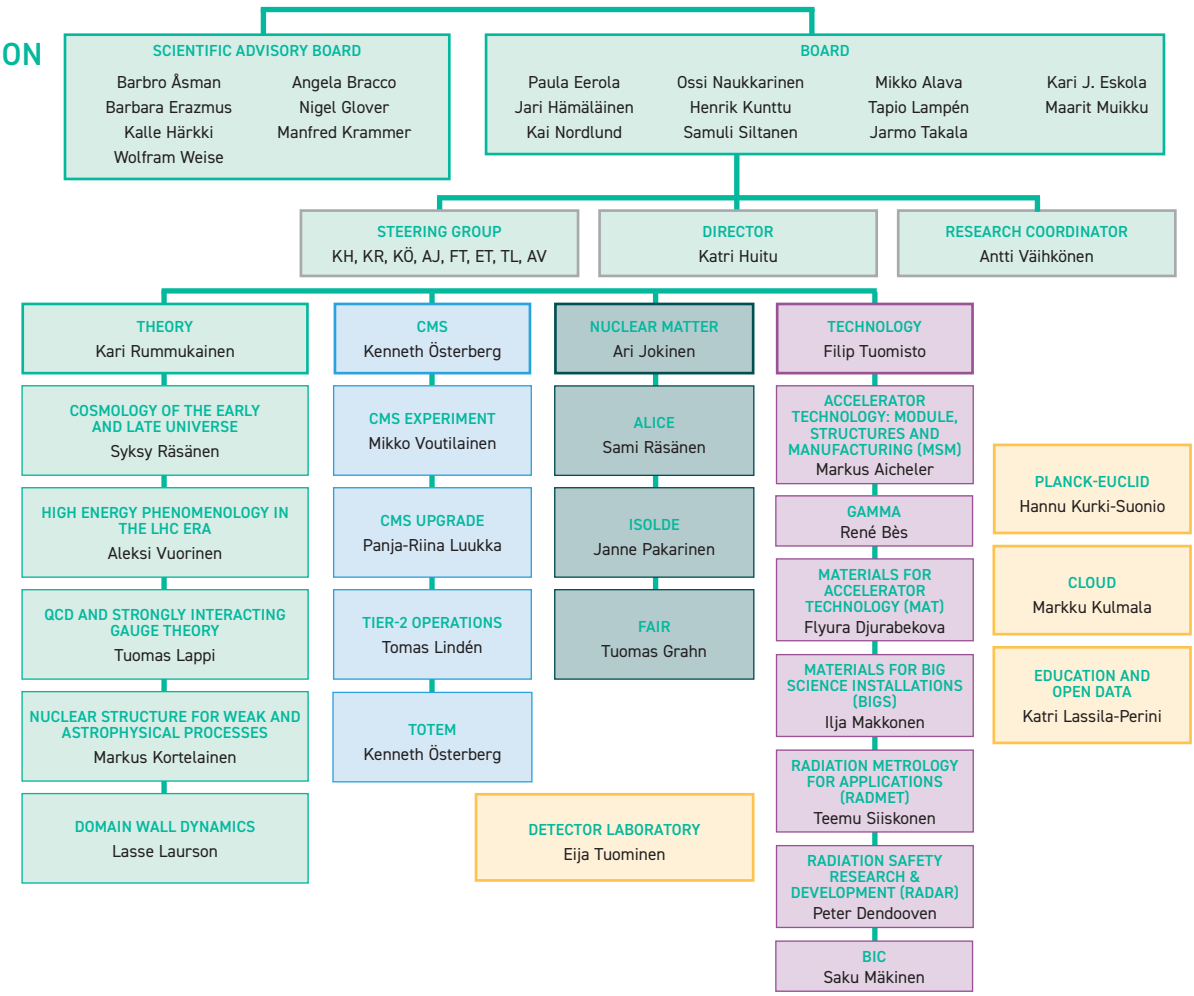
The publication output of HIP continued very strongly with about 300 peer reviewed publications in 2019. The scientific production of HIP is generally of high quality as was stated by the Scientific Advisory Board. A research evaluation of the University of Helsinki was conducted in 2019, and the Helsinki part of HIP was evaluated together with the Department of Physics. The combination received the highest grade, *excellent*, in all categories.

The doctoral education of physics students continues to be one of the main tasks of the Institute. In addition, a fair number of undergraduate students have joined the research groups and are completing their Master's theses at the Institute. Many of them are continuing as doctoral students in Institute projects. In 2019, the CERN summer student programme continued with positions at ESRF in Grenoble, as has become tradition. During the period 2015-2019, 47 doctoral degrees and 57 Master's degrees have been earned in HIP research projects.

The effort to enhance HIP community awareness both within and outside HIP continued. After the CMS and Technology Programmes' internal programme meetings in late 2018, the Theory Programme and the Nuclear Matter Programme had their meetings in early 2019. The HIP Steering group visited Tampere University in the spring. The first HIP Town Meeting took place in Helsinki in October 2019. The HIP Blog, https://blog.hip.fi/, kept a steady pace of posts and has definitely claimed its place.

ORGANIZATION AND PERSONNEL

ORGANIZATION



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D. Weir, adj. scientist
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V.-M. Enckell, grad. student
H. Jukkala, grad. student
O. Koskivaara, grad. student
L. Laulumaa, grad. student
J. Leskinen, grad. student
J.-M. Ojanperä, grad. student
S. Raatikainen, grad. student
P. M. Rahkila, grad. student
L. Tenhu, grad. student
E. Tomberg, grad. student
N. Venkatesan, grad. student
P. Wahlman, grad. student

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J. Tarrio, scientist
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N. Jokela, adj. scientist
V. Keus, adj. scientist
R. Paatelainen, adj. scientist
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T. Kärkkäinen, grad. student
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J. Österman, grad. student

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J. Suorsa, grad. student

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W. Satuła, prof., adj. senior scientist
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J. Niskanen, adj. senior scientist
T. Haverinen, grad. student

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I. Rissanen, grad. student

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K. Lassila-Perini, senior scientist (at CERN)
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M. Kortelainen, scientist
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J. Heikkilä, grad. student
K. Kallonen, grad. student
S. Laurila, grad. student
M. Lotti, grad. student
H. Siikonen, grad. student

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V. Liticheskyi, scientist
S. Barthuar, grad. student
M. Golovleva, grad. student
A. Gädda, grad. student
S. Kirschenmann, grad. student
L. Martikainen, grad. student
J. Ott, grad. student
V. Pyykkönen, grad. student
J. Tikkanen, grad. student

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TOTEM

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F. García, lab. engineer
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K. Österberg, prof., adj. senior scientist
I. Kassamakov, adj. senior scientist
A. Meriläinen, grad. student
R. Montonen, grad. student
A. Solodko, grad. student (at CERN)
J. Väinölä, grad. student (at CERN)
A. Holmström, student

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J. Slotte, scientist
A. Vancraeyenest, scientist
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Radiation Metrology for Applications (RADMET)
T. Siiskonen, Dr., proj. leader (at STUK)
J. Tikkanen, grad. student

Radiation Safety Research & Development (RADAR)
P. Dendooven, prof., proj. leader
P. Holm, scientist (at STUK)
S. Ihantola, scientist (at STUK)
K. Peräjärvi, scientist (at STUK)
R. Backholm, grad. student
V. Berlea, grad. student
T. Kerst, grad. student

Finnish Business Incubation Center of CERN Technologies (BIC)
S. Mäkinen, prof., proj. leader
P. Kauttu, grad. student

Other projects

CLOUD

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

Planck-Euclid

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

Education and Open Data

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

Detector Laboratory

E. Tuominen, chief engineer
I. Kassamakov, docent, lab. engineer
F. García, lab. engineer
J. Heino, lab. engineer
P. Koponen, lab. engineer
R. Turpeinen, lab. technician

Administration and Support

K. Huitu, 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
E. Veranen, HR coordinator
T. Heikkilä, secretary
T. Karppinen, secretary (at CERN)
T. Onnela, secretary (at CERN)

HIP SEMINARS

7 February L. Bergström (Stockholm)
Primordial black holes as dark matter?

12 February U. Gran (Gothenburg)
Dynamical symmetry enhancement near black hole horizons

14 February J. Stahov (Tuzla)
The single energy partial wave analysis of scattering data with analyticity constraints

12 March M. Baggioli (Madrid)
Holographic viscoelastic phases of matter: from fluids to solids and more

19 March C. Das (JINR)
Octant of θ23 in neutrino mixing and beyond the Standard Model

25 April V. Vaskonen (King's College)
Primordial black holes in the light of LIGO observations

30 April C. Hoyos (Oviedo)
Effective long distance q-qbar potential in holographic RG flows

7 May T. Mäkelä (HIP, Helsinki)
Flavour-dependent jet energy corrections and top quark mass

14 May P. Auclair (Paris)
The stochastic background of gravitational waves from cosmic strings

24 May F. Wilczek (MIT and Stockholm)
Axion plasmon converter

13 June S. Schuster (Wellington University)
Sparsity - quantifying the difference between Hawking radiation and black body radiation

25 June N. Koivunen (Helsinki)
Froggatt-Nielsen mechanism in 331-models

27 June S. Dutta (IISER Bhopal India)
Towards phase space description of Chern-Simons matter theories on generic three manifolds

27 June F. Reindl (HEPHY and TU Vienna)
The COSINUS experiment - cryogenic NaI detectors for direct dark matter search

28 June E. Gabrielli (Trieste)
Searching for the dark sector

30 July S. Brodsky (SLAC)
Meson/baryon/tetraquark supersymmetry from superconformal algebra and light-front holography

6 August J. Sonnenschein (Tel Aviv)
Recent result of the HISH (holography inspired stringy hadron) model

13 August P. Schicho (Bern)
3-loop gauge coupling in hot QCD

20 August H. Mehdipour (Islamic Azan University, Lahijan branch)
Noncommutative Hayward black holes

27 August T. Tenkanen (Johns Hopkins University)
Spectator dark matter

27 August T. Naaranoja (Helsinki)
Diamond time-of-flight detectors and their radiation tolerance

10 September J. Subils (Barcelona)
Mass gap without confinement

1 October G. White (Triumf, Canada)
Electroweak baryogenesis, experimental status, progress and extensions

17 October B. Murray (Warwick, CERN)
Probing the origin and future of the universe

22 October S. Rai (Harish-Chandra Research Institute)
Some non-standard signals for vector-like quarks at LHC

24 October J. F. Pedraza (London)
Constraining higher order gravities with subregion duality

29 October K. Kannike (Tartu)
Scalar singlet dark matter with and without Z3 symmetry

6 November V. Puletti (Reykjavik)
Entanglement measures in generalised quantum Lifshitz models

12 November O. Henriksson (Helsinki)
Finite density gauge theories and brane instabilities

13 November H. Banerjee (Kolkata)
Nondecoupling supersymmetry and an Lμ-Lτ gauge boson at Belle-II

19 November V. Leino (Munich)
Lattice constraints to heavy quark diffusion coefficent

26 November K. Mkrtchyan (Pisa)
The problem of interacting Lagrangian for higher-spin gravity and the progress in three dimensions

28 November J. van de Vis (DESY)
Reheating after multifield inflation with nonminimal couplings

3 December A. Roper-Pol (Colorado)
Gravitational wave production from MHD turbulence in the early-universe

5 December A. Schmitt (Southampton)
Dense quark and nuclear matter from holography

12 December J. Mas (Santiago de Compostela)
Periodically driven AdS/CFT

19 December W. van der Schee (CERN)
Gravitational waves from holographic neutron star mergers

VISITORS

Theory Programme

Cosmology of the Early and Late Universe

A. Atreya (India) 20.-22.1.
W. Porod (Germany) 7.3.-12.4.
C. Pitrou (France) 13.3.
A. Büchner (Germany) 31.3.-5.4.
H. Hinrichsen (Germany) 31.3.-5.4.
W. Kinney (Sweden, USA) 1.-5.4.
K. Tuominen (Finland) 8.4.-10.5., 3.-7.7.
T. Collett (UK) 16.-18.4.
V. Vaaskonen (UK) 23.-24.4.
K. Ala-Mattinen (Finland) 6.-10.5., 3.-7.7.
J. M. Cline (Canada) 1.-15.6., 3.-7.7.
R. Ares (UK) 3.-7.7.
D. Cutting (UK) 3.-7.7.
J. R. Espinosa (Spain) 3.-7.7.
D. G. Figueroa (Switzerland) 3.-7.7.
C. Gowling (UK) 3.-7.7.
S. Kasuya (Japan) 3.-7.7.
M. Kawasaki (Japan) 3.-7.7.
V. Keus (Finland) 3.-7.7.
T. Markkanen (UK) 3.-7.7., 18.-22.11.
D. Mulryne (UK) 3.-7.7.
H. B. Nezhad (Iran) 3.-7.7.
L. Niemi (Finland) 3.-7.7.
G. Rigopoulos (UK) 3.-7.7.
T. Sekiguchi (Japan) 3.-7.7.
T. Takahashi (Japan) 3.-7.7.
T. Tenkanen (USA) 3.-7.7.
V. Vennin (France) 3.-7.7.
G. White (Canada) 30.9.-2.10.
J. van de Vis (Germany) 26.-29.11.
A. Roper-Pol (USA) 2.-3.12.
S. Cebrián Guajardo (Spain) 3.-5.12.
S. Huber (UK) 9.-12.12.
H. M. Lee (Switzerland, South Korea) 15.-18.12.

High Energy Phenomenology in the LHC Era

M. Järvinen (the Netherlands) 4.1., 18.-26.6., 28.7.-18.8., 7.-10.9., 19.-31.12.
B. Craps (Belgium) 9.-11.1.
S. Kawai (South Korea) 6.2.-1.3., 6.-31.8.
U. Gran (Sweden) 11.-12.2.
M. Baggioli (Spain) 12.-16.3.
C. Hoyos (Spain) 29.4.-4.5.
A. Ramallo (Spain) 12.-18.5.
M. Rahimi (Iran) 10.6.-4.12.
S. Dutta (India) 27.-28.6.
H. Mehdipour (Iran) 12.8.-11.9.
J. Subils (Spain) 12.8.-12.11.
P. Benincasa (Denmark) 9.-11.10.
J. Pedraza (UK) 22.-25.10.
V. Puletti (Iceland) 6.-7.11.
A. Schmitt (UK) 4.-7.12.
J. Mas (Spain) 11.-14.12.
R. Paatelainen (Switzerland) 19.-20.12.
W. van der Schee (Switzerland) 19.-20.12.

QCD and Strongly Interacting Gauge Theory

R. Paatelainen (Switzerland) 2.-3.1., 27.-31.5., 12.-21.8.
J. Peuron (Italy) 11.-22.2., 12.8.-2.9., 20.12.
E. Molnar (Germany) 19.-26.2.
D. Rischke (Germany) 20.-27.2.
M. Walt (Germany) 13.-17.5.
P. Huovinen (Serbia) 27.5.-21.6.
K. Boguslavski (Austria) 21.-31.8.
K. Kajantie (Finland) 3.-4.9.
J. Rojo (the Netherlands) 5.-7.9.
M. Li (USA) 21.-28.9.
J. Fotakis (Germany) 24.9.-15.10.

CMS Programme

L. Forthomme (Switzerland) 20.2.-9.3., 4.-23.11.
F. Canelli (Switzerland) 6.-7.3.
K. Ozdemir (Turkey) 30.3.-7.4.
B. Schillinger (Germany) 1.6.-31.12.
O. Atakisi (Turkey) 17.6.-31.8.
N. Tsarigradski (Germany) 16.7.-15.10.
B. Murray (UK) 16.-19.10.
A. Read (Norway) 21.-23.11.

Nuclear Matter Programme

ALICE

J. Nagle (USA) 17.-23.6.

Technology Programme

Materials

Materials for Accelerator Technology (MAT)

D. Ivekovic (Croatia) 13.-26.1., 6.-13.4.
M. Karlusic (Croatia) 13.-26.1., 6.-13.4.
J. Hanzek (Croatia) 7.-20.7., 13.-25.10.
M. Sequeira (Portugal) 1.-21.10.

CONFERENCE PARTICIPATION, TALKS AND VISITS BY PERSONNEL

Theory Programme

Cosmology of the Early and Late Universe

University of Stavanger,
7-8 January, Stavanger, Norway (talk by D. Weir)

6th LISA Cosmology Working Group Workshop,
14-18 January, Madrid, Spain (J. Dahl, talk by M. Hindmarsh, K. Rummukainen, talk by D. Weir)

CERN-TH Institute "Scale Symmetry in Particle Physics and Cosmology",
28 January - 1 February, Geneva, Switzerland (talk by J. Rubio)

University of the Basque Country,
18-22 February, 21-27 March, 27-30 June, 24-31 July, 23-30 November, Bilbao, Spain (A. Lopez-Eiguren)

King's College London,
27 February, London, UK (talk by S. Räsänen)

Imperial College London,
1 March, London, UK (talk by S. Räsänen)

University of Manchester,
7 March, Manchester, UK (talk by S. Räsänen)

University of Sussex,
18-19 March, Sussex, UK (talk by D. Weir)

IberiCOS 2019,
15-17 April, Bilbao, Spain (talk by A. Lopez-Eiguren, talk by J. Rubio)

University of Plymouth Centre for Mathematical Sciences,
30 April - 1 May, Plymouth, UK (talk by O. Gould)

University of Nottingham,
8-10 May, Nottingham, UK (talk by O. Gould)

CERN,
16-20 May, Geneva, Switzerland (K. Kainulainen)

7th RISE Collaboration Workshop: NonMinimalHiggs,
27-29 May, Helsinki, Finland (O. Gould, talk by M. Hindmarsh, talk by K. Kainulainen, talk by S. Nurmi, talk by S. Räsänen, talk by E. Tomberg)

PHOTON 2019,
3-7 June, Frascati, Italy (talk by O. Gould)

Workshop: Inflation and the Dark Sector - Current Challenges and Future Perspectives,
3-7 June, Jyväskylä, Finland (talk by O. Gould, talk by M. Hindmarsh, K. Kainulainen, O. Koskivaara, L. Laulumaa, J. Leskinen, talk by A. Lopez-Eiguren, S. Nurmi, talk by J. Rubio, talk by S. Räsänen, L. Tenhu, talk by E. Tomberg, N. Venkatesan, talk by D. Weir)

ITP Heidelberg University,
10-14 June, Heidelberg, Germany (talk by J. Rubio)

Conference on Geometric Foundations of Gravity,
17-21 June, Tartu, Estonia (S. Raatikainen, talk by S. Räsänen)

PASCOS 2019,
1-5 July, Manchester, UK (talk by J. Rubio)

Inhomogeneous Cosmologies IV,
14-19 July, Torun, Poland (talk by S. M. Koksbang)

CERN,
1 August - 31 December, Geneva, Switzerland (K. Kainulainen)

NORDITA Program, Gravitational Waves from the Early Universe,
26 August - 20 September, Stockholm, Sweden (talk by O. Gould, organised and talks by M. Hindmarsh, A. Lopez-Eiguren, talk by K. Rummukainen, talk by D. Weir)

Corfu Summer Institute 2019,
31 August - 11 September, Corfu, Greece (talk by J. Rubio)

Cosmo19,
2-6 September, Aachen, Germany (M. Hindmarsh, A. Lopez-Eiguren, L. Tenhu, N. Venkatesan)

Quantum Gravity and Matter,
9-13 September, Heidelberg, Germany (talk by J. Rubio)

Dirac Day,
12 September, Leicester, UK (talk by A. Lopez-Eiguren)

KTH-Project Evaluation Committee Meeting,
15-17 September, Stockholm, Sweden (K. Kainulainen)

CERN,
18-26 September, Geneva, Switzerland (L. Laulumaa, S. Nurmi)

7th LISA Cosmology Working Group Workshop,
23-27 September, Padova, Italy (J. Dahl, O. Gould, talk by M. Hindmarsh, K. Rummukainen, D. Weir)

Laboratory of High Energy and Computational Physics (HEPC),
25-29 September, Tallinn, Estonia (lectures by S. Räsänen)

Brda 2019: Selected Topics in High Energy Physics, Astrophysics, and Cosmology,
9-11 October, Goriška Brda, Slovenia (talk by L. Niemi, talk by D. Weir)

Workshop on High Frequency Gravitational Waves,
14-17 October, Trieste, Italy (talk by M. Hindmarsh)

CERN,
20-26 October, Geneva, Switzerland (H. Jukkala)

University of Salamanca,
21-25 October, Salamanca, Spain (talk by J. Rubio)

Queen Mary University of London,
23-24 October, London, UK (talk by E. Tomberg)

Imperial College London,
25 October, London, UK (talk by E. Tomberg)

University of Sussex,
28-29 October, Falmer, UK (talk by E. Tomberg)

University of Portsmouth,
30 October, Portsmouth, UK (talk by E. Tomberg)

University of Oxford,
31 October, Oxford, UK (talk by E. Tomberg)

Meeting on Particle Cosmology,
31 October - 1 November, Tampere, Finland (talk by O. Gould, talk by S. M. Koksbang, talk by L. Laulumaa, talk by A. Lopez-Eiguren, S. Nurmi, talk by J. Rubio, S. Räsänen, talk by L. Tenhu, talk by N. Venkatesan)

University of Manchester,
1 November, Manchester, UK (talk by E. Tomberg)

Second Conference of the Nordic Network for Diversity in Physics NORNDiP,
4-5 November, Helsinki, Finland (O. Gould, talk by S. M. Koksbang, S. Räsänen)

Particle Physics Day 2019,
7 November, Helsinki, Finland (talk by S. Räsänen, N. Venkatesan)

Nordic Winter School in Theoretical Physics,
12-15 November, Odense, Denmark (lectures by K. Kainulainen, talk by N. Venkatesan)

Meeting of Groupe de Recherche "Ondes gravitationelles",
13 November, Paris, France (talk by M. Hindmarsh)

CERN,
24-30 November, Geneva, Switzerland (O. Koskivaara)

University of Tartu,
3 December, Tartu, Estonia (talk by S. Raatikainen)

King's College London,
4-5 December, London, UK (talk by D. Weir)

University of Liverpool,
11-12 December, Liverpool, UK (talk by D. Weir)

30th Texas Symposium on Relativistic Astrophysics,
15-20 December, Portsmouth, UK (talk by E. Tomberg)

High Energy Phenomenology in the LHC Era

Iberian Strings 2019 Workshop,
23-25 January, Barcelona, Spain (invited talk by J. Tarrio)

Freie Universität Berlin,
11 February, Berlin, Germany (invited talk by A. Vuorinen)

INTEGRAL Workshop,
12-13 February, Geneva, Switzerland (invited talk by A. Vuorinen)

CERN,
5-29 March, Geneva, Switzerland (S. Säppi)

CERN,
11-23 March, Geneva, Switzerland (A. Vuorinen)

University of Genoa,
19 March, Genoa, Italy (invited seminar by J. Tarrio)

PHAROS Conference 2019: The Multi-Messenger Physics and Astrophysics of Neutron Stars,
22-26 April, Platja d'Aro, Spain (N. Jokela)

Research visit,
27-31 May, Utrecht, the Netherlands (N. Jokela)

Strangeness in Quark Matter Conference,
8-16 June, Bari, Italy (N. Jokela)

XQCD 2019 Conference,
23-28 June, Tokyo, Japan (S. Säppi)

Holographic QCD Workshop,
22-26 July, NORDITA, Sweden (invited talk by N. Jokela, invited talk by A. Vuorinen)

University of Oviedo,
1 September - 30 November, Oviedo, Spain (J. Tarrio)

Challenges in Theoretical High-Energy Physics Workshop,
23-27 September, NORDITA, Sweden (invited talk by N. Jokela)

Quo Vadis, QCD Theory? Workshop,
2-4 October, Stavanger, Norway (invited talk by A. Vuorinen)

UCT School on High-Energy Physics 2019,
18-22 November, Cape Town, South Africa (invited lectures by S. Säppi)

Holography, Neutron Stars and Gravitational Waves Workshop,
25-29 November, Paris, France (invited talk by N. Jokela)

QCD and Strongly Interacting Gauge Theory

XXV Cracow EPIPHANY Conference on Advances in Heavy Ion Physics,
8-11 January, Cracow, Poland (invited talk by T. Lappi)

University of Santigo de Compostela,
14-18 January, Santiago de Compostela, Spain (seminar by M. Mace)

Tübingen University,
29 January - 1 February, Tübingen, Germany (seminar by I. Helenius)

CERN,
11-14 February, Geneva, Switzerland (seminar by M. Mace)

Rivet ep Preservation Meeting,
18-20 February, DESY, Hamburg, Germany (invited talk by I. Helenius)

COST Workshop on Interplay of Hard and Soft QCD Probes for Collectivity in Heavy-Ion Collisions,
25 February - 1 March, Lund, Sweden (invited talk by I. Helenius)

Physics Days 2019,
5-7 March, Helsinki, Finland (talk by I. Helenius, T. Löytäinen)

Workshop on Collectivity in Small Systems,
14-16 March, Houston, TX, USA (T. Lappi, invited talk by M. Mace)

TU Wien,
20-23 March, Vienna, Austria (seminar by T. Lappi)

SUBATECH,
25 March, Nantes, France (seminar by G. Beuf)

27th Workshop on Deep-Inelastic Scattering and Related Subjects (DIS2019),
8-12 April, Turin, Italy (talks by G. Beuf, talk by H. Mäntysaari, talks by H. Paukkunen, talk by A. Ramnath)

PYTHIA Workshop 2019,
8-12 April, Melbourne, Australia (invited talk by I. Helenius)

FIAS,
15-26 April, Frankfurt am Main, Germany (G. Inghirami)

NCBJ,
22 April - 5 May, Warsaw, Poland (G. Beuf)

J.W. Goethe University,
24 April - 2 May, Frankfurt am Main, Germany (G. Inghirami)

Origins of Correlations in High Energy Collisions Workshop,
29 April - 24 May, Seattle, WA, USA (talk by T. Lappi, talk by M. Mace, talk by H. Mäntysaari)

Strong Interactions beyond Simple Factorization: Collectivity at High Energy from Initial to Final State,
27 May - 5 June, Storrs, CT, USA (S. Demirci)

QCD Master Class,
9-22 June, Saint-Jacut-de-la-Mer, France (S. Demirci)

5th International Conference on the Initial Stages in High-Energy Nuclear Collisions (IS2019),
24-28 June, New York, NY, USA (T. Lappi, invited talk by M. Mace, invited talk by H. Mäntysaari)

Bielefeld University,
15-27 July, Bielefeld, Germany (S. Demirci)

2019 CTEQ School on QCD and Electroweak Phenomenology,
16-26 July, Pittsburgh, PA, USA (M. Kuha, T. Löytäinen)

EIC User Group Meeting 2019,
22-26 July, Paris, France (invited talk by I. Helenius, invited talk by T. Lappi)

NCBJ,
22-26 July, Warsaw, Poland (seminar by G. Beuf)

3rd International Workshop on QCD Challenges from pp to AA,
19-23 August, Lund, Sweden (invited talk by M. Mace)

Low-x 2019,
26-31 August, Nicosia, Cyprus (talk by Y. Mulian, talk by A. Ramnath)

BNL,
29 August - 2 October, Upton, NY, USA (seminar by H. Mäntysaari)

Towards Accuracy at Small x Workshop,
10-13 September, Edinburgh, UK (talk by Y. Mulian)

Light-Cone 2019,
16-20 September, Palaiseau, France (talk by G. Beuf)

POETIC 2019,
16-21 September, Berkeley, CA, USA (talk by A. Ramnath)

University of Florence,
16-27 September, Florence, Italy (G. Inghirami)

BNL,
23-27 September, Upton, NY, USA (seminar by A. Ramnath)

Workshop on Physics and Detector Requirements at Zero-Degree of Colliders,
24-26 September, Stony Brook, NY, USA (invited talk by H. Mäntysaari)

Quo Vadis QCD Theory? Workshop,
30 September - 3 October, Stavanger, Norway (invited talk by T. Lappi)

INT,
30 September - 4 October, Seattle, WA, USA (seminar by A. Ramnath)

EINN2019,
27 October - 2 November, Paphos, Cyprus (invited talk by T. Lappi)

Implications of LHCb Measurements and Future Prospects,
16-18 November, CERN, Geneva, Switzerland (invited talk by H. Mäntysaari)

15th Vienna Central European Seminar on Particle Physics and Quantum Field Theory,
28-29 November, Vienna, Austria (invited talk by T. Lappi)

Zimányi School 2019,
2-6 December, Budapest, Hungary (talk by T. Lappi, invited talk by H. Mäntysaari)

Nuclear Structure for Weak and Astrophysical Processes

Workshop on Novel Approaches for the Description of Heavy Nuclei,
18-20 March, Lund, Sweden (talk by T. Haverinen, talk by M. Kortelainen)

University of Lyon,
12-18 May, Lyon, France (T. Haverinen)

Symposium "Challenges in Theory of Heavy Nuclei",
17-20 July, York, UK (talk by M. Kortelainen)

Workshop on the Nuclear Octupole Degree of Freedom,
25-26 July, Paisley, UK (talk by M. Kortelainen)

International Nuclear Physics Conference,
29 July - 2 August, Glasgow, UK (talk by M. Kortelainen)

Domain Wall Dynamics

Workshop "Avalanche Dynamics and Precursors of Catastrophic Events",
4-8 February, Les Houches, France (organised by L. Laurson, P. Murray)

University of Erlangen-Nuremberg,
24-26 April, Fürth, Germany (invited talk by L. Laurson)

EarthFlows Seminar, University of Oslo,
19-20 June, Oslo, Norway (invited talk by L. Laurson)

CMS Programme

CMS Experiment

Nordic Winter School in Particle Physics,
2-7 January, Skeikampen, Norway (talk by S. Laurila, M. Lotti)

SMP-HAD Workshop,
14-15 January, CERN, Geneva, Switzerland (H. Kirschenmann, talk by L. Martikainen)

CMS Week,
4-8 February, CERN, Geneva, Switzerland (H. Kirschenmann, M. Lotti, J. Tuominiemi)

VBSCan In-Person Meeting in 2nd Grant Period,
10-12 February, Ljubljana, Slovakia (M. Voutilainen)

VBSCan@Ljubljana Training Event,
12-15 February, Ljubljana, Slovakia (K. Kallonen)

PARTICLEFACE 2019 Meeting,
25 February - 1 March, Coimbra, Portugal (M. Voutilainen)

Physics Days 2019,
5-7 March, Helsinki, Finland (talk by K. Kallonen, M. Kim, organising committee chair T. Lampén, talk by S. Laurila, talk by T. Mäkelä)

54th Rencontres de Moriond - Electroweak Interactions and Unified Theories,
16-23 March, La Thuile, Italy (talk by J. Heikkilä)

International School of Trigger and Data Acquisition,
3-12 April, Royal Holloway, University of London, UK (S. Laurila, L. Martikainen)

CMS Week,
8-12 April, CERN, Geneva, Switzerland (M. Kim, J. Tuominiemi, M. Voutilainen)

JETMET Workshop,
15-17 April, CERN, Geneva, Switzerland (talk by H. Kirschenmann)

LHCP,
20-25 May, Puebla, Mexico (talk by H. Kirschenmann)

CERN Bootcamp,
3-7 June, CERN, Geneva, Switzerland (T. Lampén)

3rd International Turkey-Iran Joint Conference on LHC Physics,
11-14 June, Istanbul, Turkey (invited talk by M. Voutilainen)

CMS Week,
24-28 June, CERN, Geneva, Switzerland (H. Kirschenmann)

VBSCan Mid-Term Scientific Meeting,
2-4 July, Istanbul, Turkey (T. Lampén)

EPS-HEP 2019 Conference,
10-17 July, Ghent, Belgium (session chaired by M. Voutilainen)

CTEQ School on QCD and Electroweak Phenomenology,
16-26 July, University of Pittsburgh, PA, USA (L. Martikainen)

BOOST 2019 Workshop,
21-26 July, MIT, Cambridge, Massachusetts, MA, USA (K. Kallonen, talk by H. Kirschenmann)

13th MCnet Summer School,
29 July - 2 August, Windsor, UK (L. Martikainen)

European School of High-Energy Physics,
4-17 September, St. Petersburg, Russia (L. Martikainen)

CERN School of Computing 2019,
15-28 September, Cluj-Napoca, Romania (K. Kallonen)

University of Cyprus,
22-29 September, Nicosia, Cyprus (talk by S. Lehti, talk by M. Lotti)

CMS Week,
23-27 September, CERN, Geneva, Switzerland (J. Tuominiemi)

Particle Physics Day 2019,
7 November, Helsinki, Finland (talk by S. Lehti)

Plenary ECFA,
12-16 November, CERN, Geneva, Switzerland (J. Heikkilä, M. Voutilainen)

CMS Top Group Workshop 2019,
19-22 November, DESY, Hamburg, Germany (session chaired by and talk by M. Voutilainen)

IPPOG Collaboration Meeting,
28-30 November, CERN, Geneva, Switzerland (S. Lehti)

VBSCan: BSM Models in Vector Boson Scattering Processes,
4-5 December, Lisbon, Portugal (H. Kirschenmann)

CMS Upgrade

Karlsruhe Institute of Technology,
21-26 January, Karlsruhe, Germany (J. Ott)

Fermilab National Accelerator Laboratory,
3-17 February, Batavia, IL, USA (J. Ott)

15th Vienna Conference on Instrumentation,
18-22 February, Vienna, Austria (J. Ott)

Physics Days 2019,
5-7 March, Helsinki, Finland (E. Brücken, A. Gädda, S. Kirschenmann, V. Litichevskyi, talk by J. Ott, organising committee vice-chair E. Tuominen)

17th IPPOG Meeting,
23-25 May, GSI, Darmstadt, Germany (J. Ott)

33rd RD50 Workshop,
12-14 June, Lancaster, UK (talk by S. Bharthuar)

CMS Week,
24-28 June, CERN, Geneva, Switzerland (chair P. Luukka, J. Ott)

21st International Workshop on Imaging Radiation Detectors,
7-12 July, Kolympari, Crete, Greece (talk by E. Brücken)

CMS Tracker Week,
15-19 July, Helsinki, Finland (S. Bharthuar, organising committee secretary E. Brücken, A. Gädda, S. Kirschenmann, V. Litichevskyi, organising committee chair P. Luukka, J. Ott)

Niels Bohr Summer School on Therapeutic and Diagnostic Medical Physics,
19-23 August, Copenhagen, Denmark (S. Kirschenmann)

HIP Scientific Advisory Board Meeting,
28-29 August, Helsinki, Finland (talk by P. Luukka)

CERN School of Computing 2019,
15-28 September, Cluj-Napoca, Romania
(S. Kirschenmann)

18th Conference Gettering and Defect Engineering in Semiconductor Technology (GADEST),
22-27 September, Zeuthen, Germany (talk by J. Ott)

VERTEX 2019 (28th International Workshop on Vertex Detectors),
12-18 October, Dubrovnik, Croatia (talk by P. Luukka, talk by J. Ott)

NUSPRASEN Workshop on Nuclear Science Applications,
25-27 November, Helsinki, Finland (E. Brücken, S. Kirschenmann, V. Litichevskyi)

12th International Hiroshima Symposium on the Development and Application of Semiconductor Tracking Detectors (HSTD12),
14-18 December, Hiroshima, Japan (talk by S. Bharthuar, talk by A. Gädda)

Tier-2 Operations

Physics Days 2019,
5-7 March, Helsinki, Finland (T. Lindén)

HEPiX Spring 2019 Workshop,
25-29 March, University of California in San Diego, CA, USA (T. Lindén)

EMC2, TAE Technologies, Lockheed Martin,
26 March - 2 April, California, USA (T. Lindén)

FUNET Technical Days,
28-29 May, Helsinki, Finland (T. Lindén)

NorduGrid 2019 Conference,
11-14 June, Lund, Sweden (T. Lindén)

HIP Scientific Advisory Board Meeting,
28-29 August, Helsinki, Finland (talk by T. Lindén)

Nuclear Science and Technology Symposium 2019,
30-31 October, Helsinki, Finland (talk by T. Lindén)

Joint WLCG & HSF Workshop 2019,
2-3 November, Adelaide, Australia (T. Lindén)

24th International Conference on Computing in High Energy and Nuclear Physics,
4-8 November, Adelaide, Australia (T. Lindén)

De Finlandssvenska Fysik- och Kemidagarna,
15-17 November, Helsinki-Stockholm-Helsinki ferry (T. Lindén)

TOTEM

7th Beam Telescope and Test Beams Workshop,
14-18 January, CERN, Geneva, Switzerland (F. Garcia, talk by T. Naaranoja)

CLIC Workshop 2019,
21-25 January, CERN, Geneva, Switzerland (K. Österberg)

PPS and TOTEM Upgrade Meeting,
22-23 January, CERN, Geneva, Switzerland
(L. Forthomme, talk by F. Garcia, talk by T. Naaranoja, K. Österberg)

RD51 Mini-Week,
4-7 February, CERN, Geneva, Switzerland (F. Garcia)

TOTEM Collaboration and LHCC Referees Meeting,
25-28 February, CERN, Geneva, Switzerland (talk by L. Forthomme, talks and chairing by K. Österberg)

Physics Days 2019,
5-7 March, Helsinki, Finland (L. Forthomme, T. Naaranoja, F. Oljemark, talk by K. Österberg)

Hasselt Diamond Workshop 2019 - SBDD XXIV,
13-15 March, Hasselt, Belgium (T. Naaranoja)

CERN,
1-10 April, Geneva, Switzerland (F. Garcia)

LHC RRB Meeting,
14-17 April, Geneva, Switzerland (K. Österberg)

DESY,
7-13 May, Hamburg, Germany (L. Forthomme, F. Garcia)

TOTEM Collaboration and LHCC Referees Meeting,
3-6 June, CERN, Geneva, Switzerland (talk by L. Forthomme, talks and chairing by K. Österberg)

GSI,
3-14 June, Darmstadt, Germany (F. Garcia)

LHCC Open Session,
5 June, CERN, Geneva, Switzerland (talk by L. Forthomme)

De Beers Diamond Conference,
8-10 July, Warwick, UK (T. Naaranoja)

EPS-HEP 2019 Conference,
10-17 July, Ghent, Belgium (talk by L. Forthomme)

CERN,
20-30 August, Geneva, Switzerland (F. Garcia)

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

International Conference on Diamond and Carbon Materials 2019 (DCM 2019),
8-12 September, Sevilla, Spain (T. Naaranoja)

TOTEM Collaboration and LHCC Referees Meeting,
9-12 September, CERN, Geneva, Switzerland (talk by L. Forthomme, F. Garcia, talks and chairing by K. Österberg)

DESY,
22-30 September, Hamburg, Germany (L. Forthomme, F. Garcia)

HIP Town Meeting,
3 October, Helsinki, Finland (invited talk by K. Österberg)

2019 IEEE Nuclear Science Symposium (NSS) and Medical Imaging Conference (MIC),
26 October - 2 November, Manchester, UK (F. Garcia)

LHC RRB Meeting,
28-30 October, Geneva, Switzerland (K. Österberg)

Particle Physics Day 2019,
7 November, Helsinki, Finland (talk by L. Forthomme, talk by K. Österberg)

TOTEM Collaboration and LHCC Referees Meeting,
18-21 November, CERN, Geneva, Switzerland (talk by L. Forthomme, talk by F. Garcia, talks and chairing by K. Österberg)

Nuclear Matter Programme

ALICE

CERN,
20-25 January, 24-29 March, 15-18 April, 25-30 August, 28-31 October, 24-29 November, Geneva, Switzerland (S. Räsänen)

CERN,
26 January - 7 February, 4-8 November, Geneva, Switzerland (H. Rytkönen)

CERN,
26 January - 11 February, 20 February - 2 March, 24 April - 30 June, Geneva, Switzerland (M. Slupecki)

CERN,
28 January - 2 February, 24-29 March, 10-18 April, 6-10 May, 24-28 June, 14-21 July, 25-30 August, 28-31 October, 24-29 November, Geneva, Switzerland (W. Trzaska)

Vienna Conference on Instrumentation (VCI2019),
18-23 February, Vienna, Austria (plenary talk by W. Trzaska)

Yonsei University,
21-30 May, Seoul, South Korea (D. J. Kim)

XIV Workshop on Particle Correlations and Femtoscopy (WPCF2019),
3-8 June, Dubna, Russia (talk by D. J. Kim)

Initial Stages (IS2019),
24-28 June, BNL, Upton, NY, USA (J. Parkkila)

ALICE Physics Week,
21-26 July, Prague, Czech Republic (S. Räsänen, talk by O. Saarimäki)

CERN,
23 July - 4 August, Geneva, Switzerland (D. J. Kim)

Quark Matter 2019 Conference,
4-9 November, Wuhan, China (talk by D. J. Kim, O. Saarimäki)

ISOLDE

International Conference on Hyperfine Interactions and Their Applications,
10-15 February, Goa, India (talk by R. de Groote)

Nuclear Matter Workshop,
22 February, Jyväskylä, Finland (talk by W. Gins, talk by T. Grahn, P. Greenlees, A. Jokinen, J. Ojala, talk by J. Pakarinen)

84th ISOLDE Collaboration Committee Meeting,
19 March, CERN, Geneva, Switzerland (J. Pakarinen)

Physics between Lead and Uranium: in Preparation of New Experimental Campaigns at ISOLDE,
16-18 April, Leuven, Belgium (talk by T. Grahn, J. Pakarinen)

85th ISOLDE Collaboration Committee Meeting,
1 July, CERN, Geneva, Switzerland (J. Pakarinen)

INTC Meeting,
2-3 July, CERN, Geneva, Switzerland (I. Moore)

ISS - ISOLDE Solenoidal Spectrometer Workshop,
27-28 August, Liverpool, UK (A. Illana, J. Pakarinen)

HIP Town Meeting,
3 October, Helsinki, Finland (T. Grahn, K. Helariutta, talk by A. Jokinen, J. Pakarinen)

86th ISOLDE Collaboration Committee Meeting,
5 November, CERN, Geneva, Switzerland (J. Pakarinen)

INTC Meeting,
6-7 November, CERN, Geneva, Switzerland (A. Illana, I. Moore, J. Pakarinen)

Marie Curie ITN Kick-Off Meeting: Laser Ionization and Spectroscopy of Actinide Elements,
2 December, CERN, Geneva, Switzerland (I. Moore)

ISOLDE EPIC Workshop 2019,
3-4 December, CERN, Geneva, Switzerland (J. Pakarinen)

MINIBALL Steering Committee Meeting,
4 December, CERN, Geneva, Switzerland (J. Pakarinen)

ISOLDE Workshop and Users Meeting 2019,
5-6 December, CERN, Geneva, Switzerland (J. Ojala, J. Pakarinen)

FAIR

NUSTAR Annual Meeting 2019,
25 February - 1 March, Darmstadt, Germany (T. Grahn, A. Jokinen, A. Kankainen, M. Luoma, I. Moore, J. Äystö)

5th International Workshop on In-Kind Best Practice IKBest5,
8-10 April, Helsinki, Finland (T. Grahn, A. Jokinen, M. Sainio)

Super-FRS Experiment Collaboration Meeting,
17-19 June, Walldorf, Germany (talk by T. Grahn, A. Jokinen, J. Äystö)

6th International FAIR School,
7-14 September, Castiglione della Pescaia, Italy (M. Luoma)

NUSTAR Week 2019,
23-27 September, Gif-sur-Yvette, France (talk by T. Grahn, M. Luoma, J. Äystö)

FRS Ion Catcher Collaboration Meeting,
24 October, Giessen, Germany (A. Kankainen, I. Moore, talk by M. Reponen)

Technology Programme

Materials

Materials for Accelerator Technology (MAT)

Workshop on High Voltage in Vacuum,
7-9 January, Philips, Hamburg, Germany (invited talk by F. Djurabekova, invited talk by A. Kyritsakis)

CLIC Workshop,
21-25 January, CERN, Geneva, Switzerland (F. Djurabekova)

COST Action Meeting,
4-5 March, Porto, Portugal (F. Djurabekova)

Physics Days 2019,
5-7 March, Helsinki, Finland (F. Djurabekova, talk by J. Kimari, talk by A. Saressalo)

CERN,
5-10 May, Geneva, Switzerland (invited seminar by A. Kyritsakis)

High Gradient Workshop,
10-14 June, Chamonix, France (F. Djurabekova, talk by A. Kyritsakis, A. Saressalo)

Technical University of Lisbon,
17-19 June, Lisbon, Portugal (invited seminar by F. Djurabekova)

International Vacuum Nanoelectronics Conference (IVNC),
22-26 July, Cincinatti, OH, USA (invited talk and talk by A. Kyritsakis)

International Conference "Radiation Effects in Insulators",
18-24 August, Astana, Kazakhstan (talk by F. Djurabekova, H. Vázquez Muíños)

Panel Meeting organised by Vetenskapsrådet,
12-13 September, Stockholm, Sweden (F. Djurabekova)

International Workshop "Mechanisms of Vacuum Arcing",
15-20 September, Padova, Italy (talk by E. Baibuz, talk by F. Djurabekova, talk by J. Kimari, talk by A. Kyritsakis)

Summer School organised by COST Action TUMIEE "Towards Understanding and Modelling Intense Electronic Excitations",
22-24 September, Rethymno, Greece (invited lecture by F. Djurabekova)

Meeting "AI Day",
26 November, Espoo, Finland (J. Kimari)

MRS Fall Meeting,
30 November - 7 December, Boston, MA, USA (talk by J. Kimari)

Materials for Big Science Installations (BIGS)

Physics Days 2019,
5-7 March, Helsinki, Finland (E. Lu, I. Makkonen, K. Simula)

15th International Workshop on Slow Positron Beam Techniques & Applications (SLOPOS-15),
2-9 September, Prague, Czech Republic (talk by E. Lu, K. Simula)

Technology

RADAR

Physics Days 2019,
5-7 March, Helsinki, Finland (talk by S. Ihantola)

41st ESARDA Safeguards Symposium 2019,
13-16 May, Stresa, Italy (talk by P. Dendooven)

G4FUN Kick-Off Meeting (Geant4 Users Group, Finland),
4 June, Helsinki, Finland (talk by S. Ihantola)

NSFF (Nordic Society for Radiation Protection) Conference,
10-14 June, Helsinki, Finland (talk by S. Ihantola)

IEEE Nuclear Science Symposium and Medical Imaging Conference (NSS-MIC),
28 October - 2 November, Manchester, UK (talk by R. Backholm, P. Dendooven)

NUSPRASEN Workshop on Nuclear Science Applications,
25-27 November, Helsinki, Finland (P. Dendooven)

Other projects

Planck-Euclid

Euclid Consortium Board Meeting,
28-29 January, Leiden, the Netherlands (talk by H. Kurki-Suonio)

Euclid OU-SHE-LE3 Meeting,
28-31 January, Nice, France (talk by E. Keihänen, H. Kurki-Suonio, talk by A. Viitanen)

BeyondPlanck 3rd Consortium Meeting,
11-15 February, Athens, Greece (talk by E. Keihänen, talk by A.-S. Suur-Uski)

Concordances and Challenges in Cosmology after Planck,
18-22 February, Sexten, Italy (invited talk by J. Väliviita)

Scuola Normale Superiore,
20 February - 1 March, 9-18 April, 24 November - 8 December, Pisa, Italy (A. Viitanen)

OU-SIM Refactoring / Cycle 9 Meeting,
26-28 February, Paris, France (K. Kiiveri, talk by C. Kirkpatrick)

Euclid Science Challenge 4/5/6 Meeting,
5-8 March, Paris, France (H. Kurki-Suonio, V. Lindholm, S. Tuominen)

Euclid SDC-FR Review,
24-29 March, Toulouse, France (H. Kurki-Suonio)

BeyondPlanck Review,
28 March, Brussels, Belgium (talk by A.-S. Suur-Uski)

University of Oslo,
6-8 May, Oslo, Norway (E. Keihänen, A.-S. Suur-Uski)

SPIDERS Meeting,
19-22 May, Toulouse, France (talk by K. Kiiveri)

IRAP,
20-24 May, Toulouse, France (C. Kirkpatrick)

LAM,
22 May, Marseille, France (K. Kiiveri)

Supermassive Black Holes Environment and Evolution,
19-22 June, Corfu, Greece (talk by A. Viitanen)

BeyondPlanck 4th Consortium Meeting,
16-20 September, Milan, Italy (talk by E. Keihänen, A.-S. Suur-Uski)

Euclid Science Challenge 4/5/6 Meeting,
17-18 September, Edinburgh, UK (V. Lindholm)

Euclid Developer's Worlshop 6,
15-18 October, Madrid, Spain (G. Gozaliasl, K. Kiiveri)

Accretion History of AGNs Workshop,
17-19 October, Miami, FL, USA (talk by A. Viitanen)

IFPU,
20-24 October, Trieste, Italy (E. Keihänen)

Euclid Consortium Board Meeting,
22-23 October, Paris, France (H. Kurki-Suonio)

Finnish Cosmophysics Meeting,
31 October - 1 November, Tampere, Finland
(H. Kurki-Suonio, talk by A.-S. Suur-Uski)

Euclid Science Challenge 7 Kick-Off Meeting,
4-5 December, Paris, France (H. Kurki-Suonio,
V. Lindholm)

Detector Laboratory

Physics Days 2019,
5-7 March, Helsinki, Finland (J. Heino, P. Koponen,
E. Tuominen, R. Turpeinen)

Forum för Genusvetenskap och Jämställdhet,
8 March, Linköping, Sweden (talk by E. Tuominen)

5th International Workshop on In-Kind Best Practice IKBest5,
8-10 April, Helsinki, Finland (talk by E. Tuominen)

Ruđer Bošković Institute RBI,
2-7 May, Zagreb, Croatia (E. Tuominen)

Deutsches Elektronen-Synchrotron DESY,
7-13 May, Hamburg, Germany (R. Turpeinen)

European Nanofabrication Research Infrastructure Symposium ENRIS 2019,
16-18 June, Enschede, the Netherlands (E. Tuominen)

21st International Workshop on Radiation Imaging Detectors iWoRiD 2019,
7-12 July, Crete, Greece (J. Heino)

General Assembly Meeting of the Gender Equality Network in Physics in the European Research Area GENERA,
18-19 September, DESY, Hamburg, Germany (talk by
E. Tuominen)

Deutsches Elektronen-Synchrotron DESY,
20-25 September, Hamburg, Germany (R. Turpeinen)

Second Conference of the Nordic Network for Diversity in Physics NORNDiP,
4-5 November, Helsinki, Finland (talk by E. Tuominen)

PUBLICATIONS

Theory Programme

Cosmology of the Early and Late Universe

A. López-Eiguren in A. Achúcarro et al.,
Cosmological evolution of semilocal string networks,
Phil. Trans. R. Soc. A 377 (2019) 20190004

J. P. Beltrán Almeida, N. Bernal, J. Rubio, and T. Tenkanen,
Hidden inflaton dark matter,
J. Cosmol. Astropart. Phys. 03 (2019) 012

D. Bettoni, G. Domènech, and J. Rubio,
Gravitational waves from global cosmic strings in quintessential inflation,
J. Cosmol. Astropart. Phys. 02 (2019) 034

J. Rubio in S. Casas et al.,
Scale-invariant alternatives to general relativity. III. The inflation-dark energy connection,
Phys. Rev. D 99 (2019) 063512

T. Collett, F. Montanari, and S. Räsänen,
Model-independent determination of H_0 and Ω_{K0} from strong lensing and type Ia supernovae,
Phys. Rev. Lett. 123 (2019) 231101

F. Montanari in E. Di Dio et al.,
The full-sky angular bispectrum in redshift space,
J. Cosmol. Astropart. Phys. 04 (2019) 053

G. Domènech, J. Rubio, and J. Wons,
Mimicking features in alternatives to inflation with interacting spectator fields,
Phys. Lett. B 790 (2019) 263

Y. Ema, M. Karčiauskas, O. Lebedev, S. Rusak, and M. Zatta,
Higgs-inflaton mixing and vacuum stability,
Phys. Lett. B 789 (2019) 373

V.-M. Enckell, K. Enqvist, S. Räsänen, and L.-P. Wahlman,
Inflation with R^2 term in the Palatini formulation,
J. Cosmol. Astropart. Phys. 02 (2019) 022

M. Fairbairn, K. Kainulainen, T. Markkanen, and S. Nurmi,
Despicable dark relics: generated by gravity with unconstrained masses,
J. Cosmol. Astropart. Phys. 04 (2019) 005

M. Hindmarsh and M. Hijazi,
Gravitational waves from first order cosmological phase transitions in the Sound Shell Model,
J. Cosmol. Astropart. Phys. 12 (2019) 062

M. Hindmarsh et al.,
Type I Abelian Higgs strings: Evolution and cosmic microwave background constraints,
Phys. Rev. D 99 (2019) 083522

D. Iosifidis and T. Koivisto,
Scale transformations in metric-affine geometry,
Universe (Wszechswiat) 5 (2019) 82

T. Koivisto and G. Tsimperis,
The spectrum of teleparallel gravity,
Universe (Wszechswiat) 5 (2019) 80

S. M. Koksbang,
Towards statistically homogeneous and isotropic perfect fluid universes with cosmic backreaction,
Class. Quantum Grav. 36 (2019) 185004

S. M. Koksbang,
Another look at redshift drift and the backreaction conjecture,
J. Cosmol. Astropart. Phys. 10 (2019) 036

S. M. Koksbang,
Light path averages in spacetimes with nonvanishing average spatial curvature,
Phys. Rev. D 100 (2019) 063533

S. M. Koksbang and C. Clarkson,
Accurately computing weak lensing convergence,
Mon. Not. R. Astron. Soc. Lett. 486 (2019) L41

S. Raatikainen and S. Räsänen,
Higgs inflation and teleparallel gravity,
J. Cosmol. Astropart. Phys. 12 (2019) 021

J. Rubio and E. S. Tomberg,
Preheating in Palatini Higgs inflation,
J. Cosmol. Astropart. Phys. 04 (2019) 021

S. Räsänen and E. Tomberg,
Planck scale black hole dark matter from Higgs inflation,
J. Cosmol. Astropart. Phys. 01 (2019) 038

J. Rubio in S. Savastano et al.,
Primordial dark matter halos from fifth forces,
Phys. Rev. D 100 (2019) 083518

High Energy Phenomenology in the LHC Era

T. Alanne, M. Heikinheimo, V. Keus, N. Koivunen, and K. Tuominen,
Direct and indirect probes of Goldstone dark matter,
Phys. Rev. D 99 (2019) 075028

V. Balasubramanian, N. Jokela, A. Pönni, and A. V. Ramallo,
Information flows in strongly coupled ABJM theory,
J. High Energy Phys. 01 (2019) 232

K. Huitu, S. Mondal, and H. Waltari in A. Chatterjee et al.,
Multileptonic signals of co-annihilating left-right supersymmetric dark matter,
Phys. Rev. D 99 (2019) 035017

P. M. Chesler, N. Jokela, A. Loeb, and A. Vuorinen,
Finite-temperature equations of state for neutron star mergers,
Phys. Rev. D 100 (2019) 066027

J. de Boer, J. Järvelä, and E. Keski-Vakkuri,
Aspects of capacity of entanglement,
Phys. Rev. D 99 (2019) 066012

J. Tarrío in A. F. Faedo et al.,
Spectrum of a supersymmetric color superconductor,
J. High Energy Phys. 11 (2019) 020

M. Frank, K. Huitu, and S. Mondal,
Dark matter and collider signals in supersymmetric $U(1)'$ models with nonuniversal Z' couplings,
Phys. Rev. D 100 (2019) 115018

D. K. Ghosh, K. Huitu, S. Mondal, and M. Mitra,
Same-sign trilepton signal for stop quark in the presence of sneutrino dark matter,
Phys. Rev. D 99 (2019) 075014

T. Gorda, A. Helset, L. Niemi, T. V. I. Tenkanen, and D. J. Weir,
Three-dimensional effective theories for the two Higgs doublet model at high temperature,
J. High Energy Phys. 02 (2019) 081

O. Gould, D. L.-J. Ho, and A. Rajantie,
Towards Schwinger production of magnetic monopoles in heavy-ion collisions,
Phys. Rev. D 100 (2019) 015041

O. Gould, J. Kozaczuk, L. Niemi, M. J. Ramsey-Musolf, T. V. I. Tenkanen, and J. Weir,
Nonperturbative analysis of the gravitational waves from a first-order electroweak phase transition,
Phys. Rev. D 100 (2019) 115024

O. Gould, S. Mangles, A. Rajantie, S. Rose, and C. Xie,
Observing thermal Schwinger pair production,
Phys. Rev. A 99 (2019) 052120

N. Jokela in U. Gran et al.,
Holographic fundamental matter in multilayered media,
J. High Energy Phys. 12 (2019) 038

A. Guarino, J. Tarrío, and O. Varela,
Halving ISO(7) supergravity,
J. High Energy Phys. 11 (2019) 143

M. Heikinheimo, K. Huitu, V. Keus, and N. Koivunen,
Cosmological constraints on light flavons,
J. High Energy Phys. 06 (2019) 065

M. Heikinheimo, K. Nordlund, K. Tuominen, and N. Mirabolfathi,
Velocity-dependent dark matter interactions in single-electron resolution semiconductor detectors with directional sensitivity,
Phys. Rev. D 99 (2019) 103018

O. Henriksson, C. Hoyos, and N. Jokela,
Novel color superconducting phases of $N = 4$ super Yang-Mills at strong coupling,
J. High Energy Phys. 09 (2019) 088

S. Hossenfelder and T. Zingg,
Analog models for holographic transport,
Phys. Rev. D 100 (2019) 056015

K. Huitu and N. Koivunen,
Suppression of scalar mediated FCNCs in a $SU(3) \times SU(3)_f \times U(1)_x$ -model,
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K. Huitu, N. Koivunen, O. Lebedev, S. Mondal, and T. Toma,
Probing pseudo-Goldstone dark matter at the LHC,
Phys. Rev. D 100 (2019) 015009

T. Ishii, M. Järvinen, and G. Nijs,
Cool baryon and quark matter in holographic QCD,
J. High Energy Phys. 07 (2019) 003

G. Itsios, N. Jokela, J. Järvelä, and A. V. Ramallo,
Low-energy modes in anisotropic holographic fluids,
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Phys. Rev. D 99 (2019) 116003

N. Jokela, J. M. Penín, A. V. Ramallo, and D. Zoakos,
Gravity dual of a multilayer system,
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N. Jokela and A. Pönni,
Notes on entanglement wedge cross sections,
J. High Energy Phys. 07 (2019) 087

V. Keus, L. Niemi, and K. Rummukainen in K. Kainulainen et al.,
On the validity of perturbative studies of the electroweak phase transition in the Two Higgs Doublet model,
J. High Energy Phys. 06 (2019) 075

K. Kajantie, L. D. McLerran, and R. Paatelainen,
Gluon radiation from a classical point particle,
Phys. Rev. D 100 (2019) 054011

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Long-lived triplinos and displaced lepton signals at the LHC,
Eur. Phys. J. C 79 (2019) 345

L. Niemi, T. V. I. Tenkanen, and D. J. Weir in L. Niemi et al.,
Electroweak phase transition in the real triplet extension of the SM: Dimensional reduction,
Phys. Rev. D 100 (2019) 035002

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Thermal free energy of large N_f QED in 2+1 dimensions from weak to strong coupling,
Phys. Rev. D 100 (2019) 073009

A. Vuorinen,
Neutron stars and stellar mergers as a laboratory for dense QCD matter,
Nucl. Phys. A 982 (2019) 36

QCD and Strongly Interacting Gauge Theory

J. L. Albacete, H. Niemi, H. Petersen, and A. Soto-Ontoso,
Correlated gluonic hot spots meet symmetric cumulants data at LHC energies,
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K. Boguslavski, A. Kurkela, T. Lappi, and J. Peuron,
Spectral function for overoccupied gluondynamics from classical lattice simulations,
Acta Phys. Pol. B 50 (2019) 1105

K. Boguslavski, A. Kurkela, T. Lappi, and J. Peuron,
Highly occupied gauge theories in 2+1 dimensions: A self-similar attractor,
Phys. Rev. D 100 (2019) 094022

G. S. Denicol, E. Molnár, H. Niemi, and D. H. Rischke,
Resistive dissipative magnetohydrodynamics from the Boltzmann-Vlasov equation,
Phys. Rev. D 99 (2019) 056017

B. Ducloué, E. Iancu, T. Lappi, A. H. Mueller, G. Soyez, D. N. Triantafyllopoulos, and Y. Zhu,
On the use of a running coupling in the calculation of forward hadron production at next-to-leading order,
Nucl. Phys. A 982 (2019) 271

B. Ducloué, T. Lappi, and H. Mäntysaari,
Forward rapidity isolated photon production in proton-nucleus collisions,
Nucl. Phys. A 982 (2019) 267

K. J. Eskola, P. Paakkinen, and H. Paukkunen,
Non-quadratic improved Hessian PDF reweighting and application to CMS dijet measurements at 5.02 TeV,
Eur. Phys. J. C 79 (2019) 511

V. Guzey,
Dijet photoproduction in ultraperipheral collisions at the LHC and nuclear PDFs at small x,
Phys. Part. Nuclei Lett. 16 (2019) 498

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