

Kruger2018: Discovery Physics at the LHC

Monday 03 December 2018 - Friday 07 December 2018

Casa do Sol



Book of Abstracts

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1

LHC flavour anomalies

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After the Higgs search era at the LHC, flavour physics has become one of the most promising windows for studying possible Beyond the Standard Model (BSM) effects. Recently, several anomalies in the B sector have been brought to light and could be seen as hints of BSM physics. We review the status of their theoretical interpretations.

Session 6 / 2

Cornering top-philic dark matter: a comprehensive study from colliders to cosmology

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Studies of dark matter lie at the interface of collider physics, astrophysics and cosmology. Constraining models featuring dark matter candidates entails the capability to provide accurate predictions for large sets of observables and compare them to a wide spectrum of data. We present a framework which, starting from a model Lagrangian, allows one to consistently and systematically make predictions, as well as to confront those predictions with a multitude of experimental results.

As an application, we consider several classes of simplified dark matter models where the dark sector is connected to the Standard Model via couplings to the top quark. We study in detail the complementarity of relic density, direct/indirect detection and collider searches in constraining the model parameter space. Our study goes beyond the tree-level approximation and we show examples of how higher-order corrections can affect the interpretation of the experimental results, both on for cosmological and collider observables.

Parallel 02 / 3

Hydrodynamic flow in small systems?

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The “unreasonable effectiveness” of relativistic fluid dynamics in describing high energy heavy-ion and even proton-proton collisions will be demonstrated and discussed. Several recent ideas of optimizing relativistic fluid dynamics for the specific challenges posed by such collisions will be presented, and some thoughts will be offered why the framework works better than originally expected. I will also address the unresolved question where exactly hydrodynamics breaks down, and why.

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Stepping into the light with High Power Laser and Brilliant Gamma beams at ELI-NP

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In the last decade the “laser world” is experiencing a “revolution” leading to a new paradigm in science and technology. Laser intensities have increased by 6 orders of magnitude in the last few years. The power (1015 Watts) concentrated in these extremely short burst of light (10-15s) are such that the laws of optics change in a fundamental way. This allows to access energy domains which have never been explored before. Based on these premises, the European Strategic Forum for Research Infrastructures (ESFRI) has selected a proposal called the Extreme Light Infrastructure (ELI). The ELI will be built as a network of three complementary pillars in Hungary, Czech Republic and Romania at the frontier of laser technologies, funded by EU regional funds for a total investment of about 1 Billion euros (around 300 Meuros per site) in the time period 2012-2018.

The ELI-NP pillar (NP for nuclear physics) will develop a scientific program using two 10 PW (1015 W) lasers and a Compton back-scattering high-brilliance and intense low-energy gamma beam, a combination of laser and accelerator technology at the frontier of knowledge. The extreme high power density will be used for acceleration of electrons to many tens of GeVs within centimeter distances, which is currently only possible in kilometre-long accelerators. Another exciting perspective is to produce dense bunches of energetic protons and ions resulting from the interaction of high power lasers with gas jets or thin foils of matter. Such power densities are comparable to stellar environment conditions. The new brilliant gamma beam facility at ELI-NP will be used to study key nuclear reactions relevant to nucleosynthesis. One of them is the fusion reaction rate between alpha particles and carbon nuclei to produce oxygen ($4\text{He} + 12\text{C} \rightarrow 16\text{O}$) which lies at the root of life on earth. Multi step reactions, such as fission-fusion, will be used to address questions regarding the formation of heavy elements in the universe. These extreme conditions will also lead to applications in imaging, gamma tomography, in the field of nuclear security regarding the management of sensitive nuclear materials or subjecting materials to intense radiation fields for space mission applications.

These ions can be used to induce secondary reactions on specific materials leading to a new generation of radio isotopes for diagnostics in medicine or to be used for cancer treatment directly.

The present status of the implementation of the ELI-NP facility as well as the new perspectives in Nuclear Physics and Astrophysics and their applications will be described. The impact of this emerging science will be illustrated through specific examples related to health, energy and economical and educational implications of this Large Scale Facility in the host country.

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Constraining new physics with model-dependent collider measurements

Author: Jon Butterworth¹

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I will discuss methods for testing Beyond-the-Standard-Model (BSM) theories using measurements at particle colliders. This exploits the fact that particle-level differential measurements made in fiducial regions of phase-space have a high degree of model-independence. These measurements can therefore be compared to BSM physics implemented in Monte Carlo generators in a very generic way, allowing a wider array of final states to be considered than is typically the case. I will show

applications of the method to generic Dark Matter, light scalar and other simplified extensions of the Standard model, and discuss future prospects.

Session 7 / 6

MAGIC - how Matter's extreme phases can be revealed in Gravitational wave observations and in relativistic heavy Ion Collision experiments

Author: Horst Stoecker¹

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This talk combines a survey of our recent advancements in two rather distinct fields, which reveal - on first sight - a surprising similarity of both, namely relativistic collisions of nuclei and of neutron stars.

Recently, the group at FiAS and at Goethe University discovered that the emitted gravitational waves, as predicted from general relativistic magneto- hydrodynamics from binary neutron star merger - calculations, are extremely sensitive to the appearance of quark matter and the stiffness of the equation of state of QCD Matter in the inner cores of the two colliding Neutron Stars, as also in their gravitational collapse to one black hole. This is a new observable messenger from outer space, which does provide direct signals for the phase structure of strongly interacting QCD matter at high baryon density and high temperature.

Those astrophysically created extremes of thermodynamics do match , to within 20% , the values of temperatures which we find in relativistic hydrodynamics and transport theory of heavy ion collisions at the existing laboratories like LHC, SpS at Cern, RHIC at Brookhaven, and HaDes - SiS18 at GSI and at the NICA and FAIR accelerators under construction, if though at quite different rapidity windows, impact parameters and bombarding energies of the heavy nuclear systems.

We demonstrate how the gravitational wave signals from future advanced LIGO-Virgo - to radiowave signals from SKA-events can be combined with the high multiplicity fluctuation - and flow measurements in heavy ion detectors in the lab to pin down the EoS and the phase structure of dense matter.

Parallel 09 / 7

LHCb Upgrade

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During the LHC long shutdown 2, in 2019/2020, the LHCb collaboration is going to perform a major upgrade of the experiment. The upgraded detector is designed to operate at a five times higher instantaneous luminosity than in Run II and can be read out at the full bunch-crossing frequency of the LHC, abolishing the need for a hardware trigger. This talk will present a short overview of the upgrade activities and highlight the physics reach of the upgraded experiment for selected physics topics. In addition, plans for future upgrades will be briefly outlined.

Parallel 02 / 8

Heavy flavour spectroscopy at LHCb (including exotic states)

Author: Nicola Neri¹¹ INFN

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We report on recent heavy flavour spectroscopy results at LHCb. These comprise: the measurement of the branching ratio of the rare $B(s) \rightarrow J/\Psi p \text{ anti-}p$ decay and the precise B_s mass measurement, the search for excited Σ_b states, the production cross-section of Upsilon mesons at $\sqrt{s}=13$ TeV, and a search for tetraquark states in $B^0 \rightarrow \eta_c(1S) K^+\pi^-$ decays.

Parallel 06 / 9

Up- and Down- Quark Masses from QCD Finite Energy Sum Rules

Authors: Alexes Mes¹; CESAREO DOMINGUEZ²; Karl Schilcher³¹ University of Cape Town² UNIVERSITY OF CAPE TOWN³ Johannes Gutenberg-Universitat

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Due to quark-gluon confinement in QCD, the quark masses entering the QCD Lagrangian cannot be measured directly like, for example, the electron or the proton mass. They must be determined either numerically from Lattice QCD, or analytically using QCD sum rules. The latter makes use of the complex squared energy plane, and Cauchy's theorem for the current-current correlator of the axial-vector divergences. This procedure relates a QCD expression containing the quark masses, with a hadronic expression in terms of known hadron masses, couplings, and lifetimes/widths. Thus, the quark masses become a function of known hadronic information.

We determine the up- and down- quark masses from a QCD Finite Energy Sum Rule, using the pseudoscalar correlator to six-loop order in perturbative QCD, with the leading vacuum condensates and higher order quark mass corrections included. We reduce the systematic uncertainties stemming from the hadronic resonance sector by introducing an integration kernel in the Cauchy integral in the complex squared energy plane. Further, we examine the issue of convergence of the perturbative QCD expression of the pseudoscalar-current correlator. Both the Fixed Order Perturbation Theory (FOPT) method and Contour Improved Perturbation Theory (CIPT) method are explored. Our results from the latter exhibit very good convergence and stability in the wide window $s_0 = 1.5 - 4.0 \text{ GeV}^2$, where s_0 is the radius of the integration contour in the complex squared energy s -plane. The results are: $(m_u + m_d)/2 = 4.36 \pm 0.36 \text{ MeV}$ (at a scale $Q = 2 \text{ GeV}$), $m_u(Q = 2 \text{ GeV}) = 2.83 \pm 0.23 \text{ MeV}$, and $m_d(Q = 2 \text{ GeV}) = 5.90 \pm 0.48 \text{ MeV}$.

Poster Session / 10

Fake-Rate Determination for the $t\bar{t}H$ Coupling Measurement with a Signature of Two Same Electric Charge Light Leptons Associated with a Tau Using the ATLAS Detector at the LHC

Author: ATLAS Collaboration^{None}

After the discovery of a Higgs boson, the measurements of its properties are at the forefront of research. The determination of the associated production of a Higgs boson and a pair of top quarks is of particular importance as the $t\bar{t}H$ Yukawa coupling is large and can probe for physics beyond the Standard Model. The analysis is based on data taken by the ATLAS experiment recorded from 13 TeV proton-proton collisions. The $t\bar{t}H$ production was analysed in various final states. The focus of this presentation is on the fake rate determination in the final state with two light leptons of same electric charge and one hadronically decaying tau lepton.

Poster Session / 11

Search for non-resonant Higgs boson pair production

Author: ATLAS Collaboration^{None}

Higgs boson pair production can be used to understand the Higgs boson self-coupling and also serve as a probe for new physics. This poster presents the search for non-resonant Higgs boson pair production in the $b\bar{b}b\bar{b}$, $b\bar{b}t\bar{t}$ and $b\bar{b}\tau\bar{\tau}$ final states using upto 36.1fb^{-1} of proton-proton collisions at $\sqrt{s}=13$ TeV collected by the ATLAS detector. The combination of the three searches is also presented with the final result interpreted in terms of the Higgs boson self-coupling.

Parallel 01 / 12

Dark matter search in events with missing transverse energy and a Higgs boson decaying to two photons with the ATLAS detector

Author: ATLAS Collaboration^{None}

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Data from pp collisions at a center-of-mass energy of 13 TeV, corresponding to an integrated luminosity of 36.1fb^{-1} has been collected with the ATLAS detector in 2015 and 2016. In this search, we look at the Standard Model Higgs boson production in the diphoton channel produced in association with missing transverse energy using three benchmark models. The analysis is performed in several categories based on MET and MET significance. No significant excess over the expected background is observed.

Poster Session / 13

Search for a Heavy Boson in $ZZ\rightarrow 4l$ with the ATLAS Experiment at the LHC

Author: ATLAS Collaboartion^{None}

This poster presents the search for a heavy boson resonance decaying into a pair of Z bosons leading to a $4l$ final state, where l stands for either an electron or a muon. The search uses proton-proton collision (Run-2) data at a centre-of-mass energy of 13 TeV collected with the ATLAS detector during 2015 and 2016 at the LHC. This study aims at answering the important question whether the SM Higgs particle is part of an extended scalar sector – as postulated by various extensions to the SM, which predict additional Higgs-like bosons, motivating searches in an extended range of mass. The results of this study for an hypothetical heavy resonance are presented in the mass range

between 200 GeV and 1200 GeV. We look for an excess in the distribution of the 4l invariant mass, in case there is no significant excess, the results are also interpreted as limits on the production rate of the signal hypothesis obtained from a fit to the mass distribution.

Poster Session / 14

Search for a Higgs boson decaying through Z_{dark} to 4 leptons

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Abstract will be provided when poster is accepted. A potential presenter is Diallo Boye

Poster Session / 15

Search for diboson resonances in the $lvll$ final state

Author: ATLAS Collaboration^{None}

Abstract will be provided when the poster is accepted. A potential presenter is Salah-eddine Dahbi

Parallel 03 / 16

Boosted object tagging in ATLAS and CMS

Authors: ATLAS Collaboration^{None}; Pierre-Antoine Delsart¹

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At the energies of the Large Hadron Collider vector bosons, higgs bosons and top quarks are often produced with momenta significantly higher than their rest mass. This means that if they decay hadronically their decay products are boosted such that they fall in a small area in η - ϕ . The identification of these interesting objects over the large backgrounds of jets from QCD processes poses an interesting reconstruction challenge. An efficient way to reconstruct these is to use large-radius jets. As well as the mass of the large-radius jet, sub-structure variables that attempt to separate the hard multi-prong structure of these interesting jets from the QCD radiation pattern are used. Recently, machine learning techniques have been employed to fully exploit the correlations in these variables and the detector's capabilities. Measuring the efficiency of identifying these objects in data and the background rejection that can be achieved has been a primary focus such that these complicated taggers can be used in analyses. Finally the sensitivity of these tagging techniques to pile-up – additional simultaneous collisions with the collisions of interest – will be shown along with the various methods used to mitigate such effects.

Session 5 / 17

Constraints on SM Physics from Colliders

Authors: Kristof Schmieden¹; ATLAS Collaboration^{None}¹ *CERN***Corresponding Author:** kristof.schmieden@cern.ch

Effective field theories provide an elegant approach to study possible new physics scenarios, by comparing precision measurements with Standard Model predictions. The latest results on multi-boson processes at the LHC, which are sensitive to anomalous gauge couplings and thus can be used to constrain EFT operators, will be presented. The consistency of the Standard Model can also be tested by a global electroweak fit to precision observables in the electroweak sector. We will present here the precision measurement of the W boson mass as well as the new results on the determination of the electroweak mixing angle and the top quark mass.

Parallel 01 / 18

Diboson measurements from ATLAS and CMS

Authors: ATLAS Collaboration^{None}; Benjamin Freund¹¹ *Université de Montréal***Corresponding Author:** benjamin.freund@cern.ch

The gauge structure of the electroweak sector can be tested by studying diboson final states in proton-proton collisions, involving triple and quadratic gauge couplings. In this talk, we will first review the latest precision measurements of diboson final states at a center of mass energy of 13 TeV as well as their interpretation in the view of effective field theories. Moreover, we will discuss the first observation of vector boson scattering events with WW and WZ final states by the ATLAS and CMS collaborations. Special focus will be drawn on the comparison to various theory predictions on the fiducial cross-sections of these processes.

Parallel 09 / 19

HL-LHC prospects from ATLAS and CMS

Author: Catrin Bernius¹¹ *Catrin.Bernius@cern.ch*

The Large Hadron Collider (LHC) has been successfully delivering proton-proton collision data at the unprecedented center of mass energy of 13 TeV. An upgrade is planned to increase the instantaneous luminosity delivered by LHC in what is called HL-LHC, aiming to deliver a total of about 3000/fb of data per experiment. To cope with the expected data-taking conditions ATLAS is planning major upgrades of the detector. Additionally, ATLAS and CMS are preparing inputs to a CERN Yellow Report that aims to summarize the physics reach for HL-LHC and to be submitted as input to the European Strategy before the end of 2018. In this contribution we focus on the physics reach expected for a wide range of measurements and searches at the HL-LHC for the ATLAS and CMS experiments, including Higgs coupling, di-Higgs boson production sensitivity, Vector Boson Scattering prospects as well as discovery potential for electroweak SUSY and other exotic benchmark scenarios.

Parallel 03 / 20

Heavy neutrino searches at ATLAS and CMS

Authors: debarati roy¹; ATLAS Collaboration^{None}¹ *PostDoc***Corresponding Author:** debarati.roy@cern.ch

Multiple theories beyond the Standard Model predict the existence of heavy neutrinos in order to explain the light neutrino masses, such as the Type I seesaw mechanism, which introduces new heavy neutrino states without additional vector bosons, or the Type III seesaw mechanism which introduces additional heavy lepton triplets. Left-right symmetric models, which restore parity symmetry in weak interactions at a higher energy scale, also predict heavy neutrinos, along with right-handed counterparts to the weak gauge bosons. Searches for such heavy Majorana or Dirac neutrinos with the ATLAS and CMS detectors will be presented using proton-proton data from the LHC at a center-of-mass energy of 13 TeV.

Parallel 07 / 21

Observation of Higgs in bb channel from ATLAS and CMS

Authors: ATLAS Collaboration^{None}; Camilla Vittori^{None}

Measurements of Higgs boson decays to fermions are important to understand the mass generation of fermions. In the Standard Model, the $H \rightarrow b\bar{b}$ decay is expected to account for almost 60% of the Higgs branching fraction, but experimentally it is difficult to observe because of overwhelming backgrounds from Standard Model processes. For this reason, the search for the $H \rightarrow b\bar{b}$ decay is performed exploiting the more distinct signature of Higgs boson production in association with a leptonically decaying vector boson (V). This talk describes the search for the $VH \rightarrow b\bar{b}$ process using pp collision data taken at 13 TeV, and presents also the results from the combination with the search for $H \rightarrow b\bar{b}$ using other production processes and center-of-mass energies, leading to the observation of the $H \rightarrow b\bar{b}$ decay.

Parallel 07 / 22

Results on ttH by CMS and ATLAS

Authors: ATLAS Collaboration^{None}; Djamel BOUMEDIENE¹¹ *CNRS***Corresponding Author:** djamel.boumediene@cern.ch

The measurement of the production of the Higgs boson in association with a pair of top-anti-top quarks directly probes the coupling of the top quark, the heaviest known particle, to the Higgs boson. Measurements are performed in different Higgs boson decay channels, including Higgs boson decays to a pair of photons, to multilepton final states, including $ZZ^* \rightarrow 4l$, and to a pair of b-quarks. The challenges range from analyzing final states with very small branching ratios to understanding the backgrounds for very complex final states. This talk presents the different analyses based on pp collision data collected at 13 TeV, as well as their combined results, leading to the observation of the ttH production process.

Session 4 / 23**Summary of BSM Searches at the LHC****Authors:** ATLAS Collaboration^{None}; Kathleen Whalen^{None}

Despite the successes of the Standard Model, there remain a number of unanswered questions about the nature of the universe, including what are dark matter and dark energy, why is gravity so weak, what is the origin of the matter/anti-matter asymmetry of the universe, and why does the Higgs boson have its particular mass. ATLAS and CMS conduct extensive search programs for proposed extensions to the Standard Model that might help to answer some of these questions, and others. While some of these new physics models would appear in traditional searches for resonances or as excesses of events with large missing transverse momentum, a growing number of them exploit unconventional detector signatures like disappearing tracks, displaced vertices, and tracks with large energy loss. This talk presents the latest results from the search program, using Run 2 data from the LHC.

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Results on heavy ion physics at LHCb**Author:** Giacomo Graziani¹¹ INFN, Sezione di Firenze**Corresponding Author:** graziani@fi.infn.it

In the last years the LHCb experiment established itself as an important contributor to heavy ion physics by exploiting some of its specific features. Production of particles, notably heavy flavour states, can be studied in p-p, p-Pb and Pb-Pb collisions at LHC energies in the forward rapidity region (pseudorapidity between 2 and 5), providing measurements which are highly complementary to the other LHC experiments. Moreover, owing to its forward geometry, the detector is also well suited to study fixed-target collisions, obtained by impinging the LHC beams on gas targets with different mass numbers. This configuration allows to study pA collisions at the relatively unexplored scale of $\sqrt{s_{NN}} \sim 100$ GeV, and can also provide valuable inputs to cosmic ray physics.

An overview of the unique measurements obtained so far by the LHCb ion program will be given, with emphasis on the most recent results. In particular, the first results obtained in the fixed-target configuration will be

presented: the first measurement of antiproton production in proton-helium collisions, which is an input for the modelling of the expected antiproton flux in cosmic rays, and the first measurement of charm production in pHe and pAr collisions at the LHC, providing unprecedented access to the charm nPDF at large x.

Parallel 07 / 25**Di-Higgs searches at CMS and ATLAS****Author:** Mario Pelliccioni¹¹ Istituto Nazionale di Fisica Nucleare**Corresponding Author:** pellicci@to.infn.it

The search for events where two Higgs bosons have been produced is a fundamental step in understanding the SM electroweak symmetry breaking. It can also be a powerful tool to investigate the existence of massive bosons that decay via two Higgs particles. This topic is of particular interest for the high luminosity LHC program. In this presentation I will show the recent studies by ATLAS

and CMS that search for the production of either two resonant or non-resonant Higgs bosons, and I will discuss the future perspectives of this research program.

Parallel 04 / 26

Heavy-Ion results from the HADES experiment

Author: Celso Franco¹

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The HADES experiment at GSI was designed to investigate the properties of hadrons inside dense nuclear matter. The latter is created by heavy-ion collisions at energies of 1--2 AGeV. Currently, HADES is the only running experiment that studies the region in the QCD phase diagram of very high net-baryon densities and moderate temperatures. The created state of matter, in fact, resembles matter created during merger of neutron stars with particular configuration. While the gravitational waves emitted by such events are expected to tightly constrain the equation of state of nuclear matter, HADES has the potential of providing a deeper understanding about the microscopic properties of such matter due to an improved modeling of heavy heavy-ion collisions. One of the goals is to improve the knowledge about the generation of hadronic masses. At three times normal nuclear matter density the quark antiquark condensates, which are an order parameter of chiral symmetry restoration, are partially depleted and, therefore, HADES is able to provide crucial information by investigating the in-medium properties of hadrons. One of the best probes that one can use to investigate a strongly interacting baryon-rich medium are the dileptons emerging from virtual photon decays. Since electromagnetic probes decouple from the dense interaction region once they are produced, their phase space distributions carry information about the temperature and structure of the dense QCD medium. Hadrons carrying strangeness are valuable messengers as well, because at 1--2 AGeV their production threshold is above the energy available in a single N+N collision. This means that additional energy is provided by the medium and, therefore, strange hadrons are also good probes of the in-medium properties. Both the dilepton and strangeness results from the HADES Au+Au data at 1.23 AGeV will be presented.

Parallel 02 / 27

Geometrically Driven Phase Transition in Finite Size (Casimir like) Systems

Authors: Sylvain Mogliacci¹; Isobel Kolbe²; William Horowitz²

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Following the recent development of a finite size thermal field theoretic formalism, meant to probe small size corrections to the Quark-Gluon Plasma (QGP) thermal properties, we investigate such thermal "Casimir" (geometrically confined) systems, in the thermodynamic limit, when isolated. We find and present in detail the characteristic behavior of a second order phase transition (unusually) – driven by the size of the system – with a divergent isoenergetic compressibility, calculated from first principles, at a critical length $L_c \sim 1/T$. Finally, we comment on the relevance of these findings for the subsequent phenomenology of QGPs, such as those created in modern Heavy Ion Collisions (HIC), with respect to future calculations and interpretations of physical observables characterizing the presence of a QGP in HIC.

Parallel 07 / 28

Results on Top Physics by ATLAS, CMS and LHCb

Author: James Keaveney¹

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Recent results on top quark physics from ATLAS, CMS and LHCb will be presented. Results will include measurements of inclusive and differential cross sections of top pair and single top production, searches for rare process involving top quarks, and measurements of assorted top quark properties including the top mass and top pair spin correlation. The latest constraints on Effective Field Theories of new physics using top quark data will also be discussed.

Session 8 / 29

Collider constraints on Dark Matter, Dark Energy and Cosmology

Author: Francesco Pandolfi¹

¹ *Università di Roma I e Sezione dell'INFN in Roma*

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The talk will present the most up-to-date measurements obtained by the ATLAS and CMS experiments at the CERN LHC related to the searches for dark matter and dark energy and the constraints provided on these quantities

Parallel 03 / 30

Searches in multilepton final states by CMS and ATLAS

Author: YoungDo Ho¹

¹ *Kyungpook National University in Daegu, Korea, Republic Of*

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The talk will present a review of the most recent results obtained by the ATLAS and CMS experiments at the CERN LHC on the searches for New Physics using multi-lepton final states.

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Jet substructure measurements by CMS and ATLAS

Author: Collaboration CMS^{None}

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The talk will present the most recent results obtained by the ATLAS and CMS experiments at the CERN LHC using jet substructures both in the context of standard model measurements and searches for new physics

Parallel 08 / 32

Investigation of collectivity in small collision systems with ALICE

Author: Katarina Gajdosova^{None}

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Interactions of proton-proton and proton-lead were not expected to form a deconfined hot and dense matter, called the Quark-Gluon Plasma (QGP). However, these small collision systems with high multiplicities revealed signs of collectivity, which are understood as a signature of the QGP emergence in heavy-ion collisions. An excellent tool to probe the presence of collectivity is the anisotropic flow measured with two- and multi-particle cumulants.

In this talk, we will present the first measurement of flow coefficients and their magnitude correlations using Symmetric Cumulants for charged particles in pp collisions at $\sqrt{s} = 13$ TeV, p-Pb at $\sqrt{s_{NN}} = 5.02$ TeV, Xe-Xe at $\sqrt{s_{NN}} = 5.44$ TeV and Pb-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV, collected at the LHC Run2 program. In addition, the flow coefficients of identified particles in p-Pb collisions will be presented. Such broad spectrum of colliding systems with different energies and wide range of multiplicity allows for detailed investigation of their collision dynamics. Non-flow effects, which are azimuthal correlations not originating from a common symmetry plane, are suppressed with the pseudorapidity separation and the subtraction method. Both methods are particularly important for studies of collectivity in small systems. The results are compared to various theoretical models, providing an important insight into initial conditions and into the nature of collective phenomena in different collision systems.

Session 8 / 33

CP violation in heavy-flavour hadrons at LHCb

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We report on recent CP violation measurements of charm and beauty hadrons at LHCb. Measurements of CP asymmetries in D mesons, B mesons and b -baryons will be discussed.

Parallel 04 / 34

Heavy ion results by ATLAS and CMS

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The heavy-ion programmes in the ATLAS and CMS experiments at the Large Hadron Collider aim to probe and characterise properties of the quark-gluon plasma created in relativistic Pb-Pb collisions. Smaller collision systems involving nuclei and protons are used to distinguish between initial and final-state effects. The heavy-ion experiments explored the onset of collectivity in small systems via azimuthal correlations in p-Pb collisions, energy loss of high momentum partons via measurements of photon-tagged jets, jet shapes, heavy-flavour jets, and reconstruction of heavy-flavour hadrons. Results on hot and cold nuclear effects on charmonia and bottomonia via measurements in p-Pb and Pb-Pb are also studied. Measurements of W bosons and top quark production in p-Pb collisions will be presented.

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Revisiting the high-scale validity of Type-II seesaw model with novel LHC signature

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The Type-II seesaw model is a well-motivated new physics scenario to address the origin of the neutrino mass issue. We show that this model can easily accommodate an absolutely stable vacuum until the Planck scale, however with strong limit on the exotic scalar masses and the corresponding mixing angle. We examine the model prediction at the current and future high luminosity run of the Large Hadron Collider (LHC) for the scalar masses and mixing angles fixed at such high-scale valid region. Specifically, we devise the associated and pair production of the charged scalars as a new probe of the model at the LHC. We show that for a particular signal process the model can be tested with 5σ signal significance even at the present run of the LHC.

Session 6 / 36

Dark matter, collider searches and the early Universe

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Energy and multiplicity dependence of resonance production in small collision systems with ALICE at the LHC

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At ultrarelativistic energies the study of hadronic resonances plays an important role both in pp and in heavy-ion collisions as it provides information about strangeness production and the hadronic phase of the system. Measurements in pp and p-Pb collisions at various energies constitute a baseline for studies in heavy-ion collisions and provide constraints for tuning QCD-inspired event generators. Furthermore high multiplicity pp collisions, where the density and the volume of the system are expected to be larger compared to minimum bias pp collisions can help in the search for the onset of collective phenomena.

New results on energy and charged particle multiplicity dependence of resonance production (in particular $K^*(892)^0$, $K^*(892)^\pm$, $\phi(1020)$) in small collision systems with ALICE at the LHC will be presented. Comparison with model predictions will also be shown.

Parallel 05 / 38

Stealth SUSY search with a large-radius jet containing a photon

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The LHC has collected data for more than eight years, but no clear signal for new physics has emerged so far. This is surprising because there is overwhelming evidence that the Standard Model must be extended. One such extension is SUSY. Here, new scalar and fermions at the TeV scale are predicted but the null results at the LHC have ruled out large region of its parameter space. However, many searches assume that large missing transverse energy is present in the signal. In the so-called stealth SUSY scenarios, new light almost degenerate fermion/boson pairs with weak scale supersymmetric masses are introduced which result in significantly reduced missing transverse energy. In this talk we want to investigate the discovery potential of such stealth SUSY models at the LHC. We reconstruct the decay products by using a large-radius jet containing a high transverse momentum photon, which has not been used in experiments so far. Requirements on the event topology, and use of substructure variables result in orders of less background than signal.

Session 09 / 39

Highlights of the production of (Anti-)(Hyper-)Nuclei and Exotica with ALICE at the LHC

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The high collision energies reached at the Large Hadron Collider (LHC) at CERN in proton-proton, proton-lead and, in particular, lead-lead collisions, lead to significant production rates of fragile objects, i.e. objects whose binding energies are small compared to the average kinetic energy of the particles produced in the system. Such objects are, for instance, light (anti-)nuclei and (anti-)hypernuclei. The most extreme example here is the hypertriton, a bound state of a proton, a neutron and a lambda, where the separation energy of the lambda is only around 130

keV. These states, from the anti-deuteron up to the anti-alpha nuclei, are nevertheless created and observed in heavy-ion collisions at the LHC.

Their production yields can even be well described in a statistical-thermal model approach with only three parameters, namely chemical freeze-out temperature T_{ch} , volume V and baryo-chemical potential μ_B . The latter is close to zero at LHC, which means the ratio of anti-baryons to baryons is close to unity and in continuation also anti-nuclei and nuclei of the same type are produced in equal amounts. T_{ch} at the LHC is extracted to be 156 MeV, which is a factor 1000 above the binding energy of the lambda to the deuteron inside the hypertriton.

In addition, the thermal model can be used to make predictions for the production of other fragile objects, such as bound states of hyperons and nucleons, or hyperonhyperon bound states. The data collected at LHC can be used to test the existence of these bound states.

Poster Session / 40

A Characterisation and Reconstruction of Radial Strip Sensors in Preparation for a Higher Radiation Environment in the ATLAS Detector at CERN

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The upgrade of the Large Hadron Collider (LHC) to the high luminosity LHC (HL-LHC) will result in far more collisions occurring per particle bunch crossing, in turn producing more particles per second. Consequently, the current detectors will need to be upgraded to accommodate for the large increase in radiation and data acquisition as well as a need to improve the tracking efficiency for the increased occupancy environment. One of the main upgrades to the ATLAS detector is the complete overhaul of the inner detector (ID) by replacing it with an all silicon Inner Tracker (ITk). A simulation of the ITk will also be required for performance simulations as well as for testing sample sensors in testbeams. The current testbeam simulation and reconstruction software are written completely using Cartesian definitions. However, some of the geometries in the ITk have radial definitions. In particular, the geometry of the R0 sensor in the strip end-cap is in need of a radial description. Presented is the work behind characterising a radial geometry for the R0 sensor in these testbeam software. The simulated data was reconstructed and analysed with post-reconstruction software and then compared to the reconstructed and analysed data from the EUDET testbeam telescope at DESY, Hamburg.

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New physics at the EW scale and the production of multiple leptons at the LHC

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A number of features of the Run 1 data impelled us to hypothesize the existence of a heavy boson with a mass around 270 GeV that decays predominantly into Sh , where h is the SM Higgs boson and S is an additional boson. A number of predictions are made. This includes the anomalous production of opposite sign di-leptons, same sign di-leptons, three and more leptons. These multi-lepton final states appear with and without b -tagged jets. Run 2 data with multi-leptons is compared to these predictions. A large discrepancy between the data and SM MCs is observed cannot be resolved with available tools. These results are interpreted in terms of $H \rightarrow Sh$ produced via gluon-gluon fusion and in association with top quarks. The compatibility of the results with the current Higgs boson data is discussed.

Parallel 04 / 42

Strongly Coupled $\Upsilon(1S)$ Suppression in $\sqrt{s_{NN}} = 2.76$ TeV Pb+Pb Collisions

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In a revolutionary paper, Matsui and Satz proposed using the suppression of quarkonia as a smoking gun signature of deconfinement in relativistic heavy ion collisions. The stunning success of using strong-coupling, AdS/CFT techniques to predict the viscosity to entropy density ratio extracted from RHIC and LHC heavy ion collision data using sophisticated 3+1D relativistic viscous hydrodynamics has prompted further investigation into the physics of a strongly-coupled plasma. We compute, for the first time, the suppression of bottomonia in a strongly coupled QGP, and compare the results to those from a weakly coupled QGP and to data. The complex binding energies which inform the thermal width and hence the R_{AA} of $\Upsilon(1S)$ are determined using imaginary time techniques. Further, we discuss the validity of this methodology which solves for strongly coupled binding energies using static $q\bar{q}$ potential models from AdS/CFT by comparing to independent results.

Parallel 02 / 43

Small system corrections to thermal field theory and pQCD energy loss

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The ominous absence of partonic energy loss in small colliding systems is forcing the heavy-ion community to sharpen its theoretical tools. In particular, all the main forms of pQCD energy loss depend on the assumption that the brick of QGP is large, but it is clear that any droplet of QGP that may be created in high multiplicity $p/d + A$ or peripheral AA collisions cannot be much larger than the mean free path, $\lambda_{m,fp}^{QCD} \sim 1$ fm. We present an illuminating and exhaustive numerical analysis of the recent extension of DGLV energy loss to all separation distances, and show a need for stronger theoretical control over the nature of the medium at early times and short separation distances. Prompted by this demand for an understanding of the small system corrections to medium properties

that are traditionally computed in an infinite medium, we then present a thermal field theoretical calculation of the thermodynamic properties of a toy model. We consider a single, massless, scalar field and impose Dirichlet boundary conditions in order to investigate the qualitative effect of a boundary on the properties of the medium, finding significant deviations from the standard Stefan-Boltzmann results, even at relatively large L .

Session 2 / 44

Summary of results on Standard Model Higgs

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The talk will review the current status of the knowledge of the properties of the Higgs boson within the SM framework, from measurements of the mass to various production mechanisms and decay channels. The talk will include results by both the ATLAS and the CMS experiments at the CERN LHC.

Parallel 01 / 45

Precision electroweak results from ATLAS and CMS

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The large datasets accumulated by the ATLAS and CMS experiments at the CERN LHC allowed to derive very precise measurements of properties of the W and Z bosons and a variety of other electroweak processes. The talk will review the most recent results provided by the two collaborations.

Parallel 10 / 46

Measurement of heavy-flavours as a function of charged-particle multiplicity with ALICE at the LHC

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Heavy flavours (charm and beauty) quarks are produced in the early stages of ultra-relativistic collisions via hard scatterings and are an important tool for studying different aspects of Quantum Chromodynamics (QCD) in hadronic collisions. Charged-particle multiplicity gives information on the global characteristics of the event and can be exploited to investigate the possible influence of

the event hadronic activity on particle production. At LHC energies, the measurement of heavy-flavours as a function of charged-particle multiplicity gives insight into the mechanisms which influence their production in hadronic collisions at these energies and is a tool to test the possible role of multi-parton interactions. In ALICE, heavy-flavour production is measured at central rapidity in the hadronic and electronic decay channels as well as at forward rapidity in the muonic decay channel. Charged-particle multiplicity is measured at central and forward rapidity. We will present the results on heavy-flavour production as a function of charged-particle multiplicity in pp collisions at 7 TeV, 8 TeV and 13 TeV as well as in p-Pb collisions at 5.02 TeV and 8.16 TeV. The results will also be compared to quarkonia measurements as well as theoretical model calculations.

Parallel 05 / 47

Search for chargino-neutralino pairs at LHC using MT2-MAOS reconstruction

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Several studies based upon the MT2-MAOS method [1] have shown the possibility of reconstructing the momenta of invisible particles in events produced at hadron colliders. This has opened an avenue to extract more informations about signals which are studied or searched for in events topologies having some missing transverse momentum (mET).

We present preliminary results of a realistic application of such a method in a simulated search for chargino-neutralino pairs decaying to $W(-\rightarrow l\nu)+h(-\rightarrow b\bar{b})+mET$ at the LHC Run 2.

In particular, we include the impact of the sub-detector finite resolutions, of the pile-up, and of the background surviving the event selection, on the reconstruction of the signal kinematics. We compare these preliminary results with those from the standard analysis techniques currently employed by the ATLAS and CMS for this search channel.

[1] arXiv:0810.4853v3, arXiv:0908.0079, arXiv:0909.4853 [hep-ph]

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Lepton flavor universality in Bc decays to charmonia

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We discuss semileptonic Bc-meson decays into final charmonium states $J\psi$ and η_c within the Standard Model and beyond. We calculate relevant hadronic transition form factors and motivated by the recent measured deviations in $B_c \rightarrow J\psi l \nu$ decay from the SM prediction, we carefully examine possibilities of New Physics in these decays.

Parallel 05 / 49

Some recent developments in the area of jet substructure

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We first report on the detailed study of performance against robustness of two-prong substructure taggers, performed as a part of Les Houches 2017 Standard Model Working group report (arXiv:1803.07977 [hep-ph]). Then recent results on detector level smearing for jet substructure observables will be discussed, where we point out the shortcomings of the usual Delphes based approach, and suggest improvements.

Session 09 / 50

Decoding the nature of Dark Matter

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Determination of the nature of Dark Matter (DM) is one of the most fundamental problems of particle physics and cosmology. If DM is light enough and interacts with Standard Model particles directly or via some mediators with a strength beyond the gravitational one, it can be directly produced at the Large Hadron

Collider or future particle accelerators. The typical signature from DM produced in particles collisions is missing transverse energy, MET, due to the fact that they escape undetected from the experimental apparatus. We have found that different energy dependence of the cross-sections is connected to a different distributions of the invariant mass of the DM pair, and consequently to different MET distributions such that certain DM operators can be distinguished from each other and, through this, it is possible to characterise the spin of DM in some cases. On the other hand DM searches in non-collider experiments - DM direct and indirect detection ones provide independent complimentary potential to probe the nature of DM and DM theory space.

Parallel 01 / 51

Tests of Lepton Flavor Universality at LHCb

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In the Standard Model the three charged leptons are identical copies of each other, apart from mass differences and the electroweak coupling of the gauge bosons to leptons is independent of the lepton flavour. This prediction is called lepton flavour universality (LFU) and is well tested in tree level decays, any violation of LFU would be a clear sign of physics beyond the Standard Model. Experimental tests of LFU in semileptonic decays of b-hadrons or rare b decays are highly sensitive to New Physics particles which preferentially couple to the 2nd and 3rd generations of leptons. Recent results from LHCb on lepton flavour universality in semileptonic $b \rightarrow c\ell\nu$ transitions and rare $b \rightarrow s\ell\ell$ decays are discussed.

Session 7 / 52

Recent ALICE results on jets and photons

Author: Thomas Peitzmann¹¹ *Utrecht University/Nikhef***Corresponding Author:** thomas.peitzmann@cern.ch

The ALICE experiment at the LHC is dedicated to measurements of high-energy nucleus-nucleus collisions to study strongly interacting matter under conditions of extreme density and temperature, where the creation of a quark-gluon plasma state of matter is expected. It also performs measurements in proton-proton and proton-nucleus to provide reference measurement for the understanding of the initial state and possible modifications in cold nuclear matter, as well as to understand the onset of collective phenomena.

This talk will present recent results of the ALICE experiment on hard (high Q^2) and electromagnetic probes. More specifically, the jet yield, hadron-jet correlations, and the shape and substructure of jets in pp and Pb-Pb will be discussed. Furthermore, the measurement of the direct photon yield in pp and p-A collisions and the final results of direct photon elliptic flow in Pb-Pb collisions at 2.76 TeV will be presented. These observables yield information on in-medium parton-energy loss and parton shower modifications, and on thermal electromagnetic radiation, and by this constrain the dynamics of the system and its transport properties.

Parallel 10 / 53

Heavy hadron production and quarkonia

Author: Siim Tolk¹¹ *CERN***Corresponding Author:** siim.tolk@cern.ch

The LHCb detector covers a unique forward rapidity region with exceptional reach to also small transverse momenta. In this talk we will discuss a selection of the latest results from LHCb on heavy hadron and quarkonia production.

Session 10 / 54

Recent ALICE results on open heavy-flavour and quarkonium production

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Recent ALICE results on open heavy-flavour and quarkonia production
Grazia Luparello for the ALICE Collaboration
(INFN Trieste)

The ALICE experiment is designed to study the hot and dense medium, the Quark-Gluon Plasma (QGP), produced in ultra-relativistic heavy-ion collisions at the LHC.

Due to their large masses, heavy quarks (charm and beauty) are produced in the early stages of the heavy-ion collisions, through hard-parton scatterings, and their abundances are preserved throughout the subsequent evolution of the medium. Therefore they represent ideal probes for characterising

the QGP and for studying its transport properties.

In particular, the measurement of the production of open heavy-flavour hadrons in nucleus-nucleus collisions can give insight in the mechanisms of in-medium energy loss, propagation and hadronisation of heavy quarks.

The sequential suppression of the quarkonium states by colour screening was initially proposed as a signature of QGP formation. However, results on charmonium suppression in Pb-Pb collisions at the LHC seem to indicate that additional mechanisms, such as the (re)combination of charm and anti-charm quarks, play a role, leading to a more complex picture of the quarkonium melting in the QGP.

The ALICE experiment is well suited for measuring of both open heavy-flavour hadrons and quarkonia at mid and forward rapidities, exploiting several different experimental techniques.

This talk will present a review of the ALICE results on open heavy-flavour and quarkonium production with a particular focus on the studies in Pb-Pb collisions at $\sqrt{(s_{NN})} = 5.02$ TeV.

Parallel 09 / 55

Belle II Experiment status and physics prospects

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The Belle II experiment is a substantial upgrade of the Belle detector and has recently successfully started operation at the SuperKEKB energy-asymmetric e^+e^- collider, with the first collisions in April 2018. The design luminosity is $8 \times 10^{35} \text{ cm}^{-2}\text{s}^{-1}$ and the Belle II experiment aims to record 50 ab^{-1} of data, a factor of 50 more than the Belle experiment. This large data set will be accumulated with low backgrounds and high trigger efficiencies in a clean e^+e^- environment; it will allow to probe New Physics scales that are well beyond the reach of direct production at the LHC and will complement the searches through indirect effects that are currently ongoing or planned.

This data set offers also the possibility to search for a large variety of dark sector particles in the GeV mass range complementary to LHC and dedicated low energy experiments. These searches will profit both from the size of the Belle II data, and from specifically designed triggers for the early running of Belle II.

This talk will review the detector upgrade, present results obtained from the first collision data analysis and prospects for the next phase of data taking that will start in early 2019; I will then focus on the planned searches, and the discovery potential of the first data.

Parallel 06 / 56

Unification of gauge and Yukawa couplings

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The unification of gauge and top Yukawa couplings is an attractive feature of gauge-Higgs unification models in extra-dimensions. This feature is usually considered difficult to obtain based on simple group theory analyses. We consider a minimal toy model including the renormalisation group running at one loop. The gauge couplings unify asymptotically at high energies, and we discuss presence of an UV fixed point. The problem of the Higgs mass generation by the Coleman-Weinberg effective potential is also discussed.

Parallel 06 / 57

Composite models on a safe road to the Planck scale

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We will introduce a new paradigm that allows to define composite models that feature an interacting fixed point in the UV (asymptotic safety). This is based on large Nf resummation techniques. I will describe an example that features a composite Higgs and Dark Matter at low energies, and that allows to generate flavour physics dynamically via partial compositeness.

Session 11 / 58

Probing beyond the Standard Model with Flavour Physics

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The persistent flavour anomalies in semileptonic and rare leptonic decays of B mesons are among the most compelling hints of physics beyond the Standard Model (SM). Particular exciting in this context are the hints for violations of lepton-flavour universality. The status of these anomalies will be reviewed and their implications for physics beyond the SM will be discussed.”

Opening Session / 59

Large Scale Facilities in Nuclear Physics

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Opening Session / 60

Welcome and introduction

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Opening Session / 61

Overview Talk

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Session 2 / 62

Results on Heavy Ion Physics at LHCb

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Session 4 / 63

The Physics of a Trillion degrees

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A microsecond after the Big Bang, all of space existed at a trillion degrees, one hundred thousand times hotter than the center of the sun. 13.8 billion years later, massive collaborations of thousands of scientists recreate these conditions of the early universe thousands of times a second in one of the most expensive and complicated science experiments ever attempted. In this talk I provide a general introduction to the physics explored in these Little Bangs, ephemeral fireballs that—during their lifetimes of less than a billionth of a trillionth of a second—are droplets of the hottest, most perfect fluid in the universe.

Session 5 / 64

Constraining new physics with model-dependent collider measurements

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Parallel 08 / 65

Quarkonium results in pp and p–Pb collisions from ALICE at the LHC

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Parallel 08 / 66

A Comparison of p-p, p-Pb, Pb-Pb Collisions in the Thermal Model: Multiplicity Dependence of Thermal Parameters

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Parallel 10 / 67

LHC phase one ALICE upgrades: the inner tracker silicon pixel detector

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Session 11 / 68

iThemba LABS student prize winner talk

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Closing Remarks

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iThemba LABS student runner up talk