Offshell-2021 —The virtual HEP conference on Run4@LHC

Report of Contributions

Contribution ID: **1** Type: **Admin**

Introduction (live)

Tuesday, 6 July 2021 14:30 (10 minutes)

Presenter: OFFSHELL ORGANISERS

Session Classification: Unexplored ideas for ALICE, ATLAS, CMS and LHCb

Contribution ID: **2** Type: **Admin**

Introduction (live)

Wednesday, 7 July 2021 00:30 (10 minutes)

Session Classification: Unexplored ideas for ALICE, ATLAS, CMS and LHCb

Contribution ID: **5** Type: **EPJC track**

Prospects of the H->bb coupling measurement at the LHeC with a full detector simulation (live)

Wednesday, 7 July 2021 17:30 (30 minutes)

A Future Large Hadron electron Collider (LHeC) would allow to collide an intense electron beam with a proton or ion beam from the High Luminosity–Large Hadron Collider (HL-LHC). Preliminary studies suggest that not only a rich physics program in the context of deep-inelastic scattering is possible, but also that several high precision Higgs coupling measurements could be performed. In particular, studies suggest uncertainties of 0.8% and 7.4% on the Higgs boson coupling strength to b- and c-quarks respectively. However, these studies are based on fast detector simulations and hence might be subject to several optimistic assumptions. Within this study, we present prospects of the H->bb coupling measurement at the LHeC using the public software infrastructure of the ATLAS Experiment at the LHC for a full detector simulation. This approach does not only consider correctly low-level interactions between the decay particles and the detector material, but also uses state-of-the art reconstruction algorithms. Since the acceptance of the ATLAS detector is somewhat smaller than a potential future LHeC detector, dedicated extrapolation techniques for the reconstruction- and fake-rate efficiencies have been applied and their uncertainties estimated.

Primary authors: BEHERA, SUBHASISH (IIT GUWAHATI); SCHOTT, Matthias (CERN / University of Mainz)

Presenter: SCHOTT, Matthias (CERN / University of Mainz)

Session Classification: Physics at LHC Experiments and Beyond

Contribution ID: **6** Type: **not specified**

Transfer Learning in Deep Neural Networks across LHC Experiments

In recent years, deep learning techniques became highly popular in high energy physics experiments as they deliver very promising results not only in the context of signal classification, but also in the context of object reconstruction. The involved neural network architectures are typically rather complex and require therefore significant resources during the training phase. One possibility to reduce the training time and training resources is the usage of transfer learning techniques. In this work, we present a first study of the possibility to transfer trained networks with experimental data of one LHC experiment to another, focussing on the expected savings in training time as well as the associated effects on its performance. Similarly, we study the possibility to transfer trained networks based on fast simulations to fully simulated data. The latter would allow that scientists outside of the LHC collaborations could develop complex tools, which could easily be adapted and used at the LHC experiments.

Primary authors: BRICKWEDDE, Bernard (Johannes Gutenberg Universitaet Mainz (DE)); SCHOTT, Matthias (CERN / University of Mainz)

Presenter: BRICKWEDDE, Bernard (Johannes Gutenberg Universitaet Mainz (DE))

Session Classification: New Detector and Reconstruction Methodologies, Machine Learning and Computing at HL-LHC

Contribution ID: **7** Type: **EPJC track**

Isospin extrapolation as a method to measure inclusive b->sll decays (recorded)

Thursday, 8 July 2021 03:30 (30 minutes)

Over the last few years, several discrepancies with respect to SM predictions have arisen in studies of exclusive $b \to s\ell^+\ell^-$ decays, where a b-hadron decays into a specific final state. The interpretation for a significant fraction of these discrepancies is clouded by hadronic uncertainties. Inclusive $b \to s\ell^+\ell^-$ decays are regarded to be under better theoretical control, but are less precise experimentally.

Previous measurements of inclusive decays rely on a sum-of-exclusives approach, whereby several specific final states are combined and the result is extrapolated to the full inclusive rate using a hadronisation model. This approach suffers from the systematic uncertainty associated with this extrapolation and is difficult to control. This can be avoided with measurements of fully inclusive decays, whereby only the two leptons are reconstructed. However this approach suffers from large backgrounds.

Here we discuss a new approach to reconstruct inclusive decays involving isospin extrapolation. The idea is to reconstruct a charged kaon and require that it forms a common vertex with the two leptons, resulting in a semi-inclusive $b \to K^+\ell^+\ell^-X$ signature. The presence of the additional kaon allows for greater rejection of background and a well-defined sideband region which can be used to control it.

Measurements of the $b \to K^+\ell^+\ell^-X$ signature require an extrapolation to the fully inclusive rate to account for final states with a K^0 meson. This can be done by assuming using isospin rules for the inclusive decay, which is well established in exclusive B^+ and B^0 $b \to s\ell^+\ell^-$ decays. The extrapolation is expected to provide a complimentary extrapolation to fully inclusive decay rate compared to traditional methods.

The inclusive $b \to s\ell^+\ell^-$ decay rate is approximately one order of magnitude larger than exclusive decays and exists for all b-hadron species. This results in a very large signal yield compared to exclusive measurements which offers potential for very precise measurements in theoretically clean observables, in addition to those affected by hadronic uncertainties. Lepton flavour violation searches and lepton universality tests can be performed on the inclusive decay, where background can be reduced without fear of spoiling the theoretical interpretation. The reconstruction of the kaon also allows for a perfect tagging of the flavour of the b-hadron at decay. This allows for forward-backward asymmetry and CP asymmetry measurements to be performed with similar statistical advantages as for the lepton symmetry tests.

A paper on this would have the following aspects: First by defining the problem and method approach. Then it would detail the main aspects in which background is better controlled with the additional charged kaon. For the theoretically clean observables, discussion on further reducing background and the expected signal yields for the various observables would be estimated. Finally, a discussion on the isospin extrapolation itself will be made. This includes specific issues related to the presence of the diverse admixture of different b-hadron hadron species in the LHC production.

Primary authors: AMHIS, Yasmine Sara (IJCLab (Orsay)); OWEN, Patrick Haworth (Universitaet Zuerich (CH))

Presenter: OWEN, Patrick Haworth (Universitaet Zuerich (CH))

Session Classification: Physics at LHC Experiments and Beyond

Contribution ID: **9** Type: **EPJC track**

Automate Monte Carlo simulation on hardware accelerators for Run4@LHC (recorded)

Friday, 9 July 2021 01:20 (30 minutes)

We propose a new framework for automatic generation of simulated events for particle physics processes in high energy physics applications, for LHC and HL-LHC configurations, with automatic support for hardware accelerators, in particular, graphics processing units (GPU). The project focus on two specific problems: automate the generation of matrix elements and phase space terms for GPU and real-time inference for machine learning tools in order to reduce the computational effort required by the Monte Carlo integrator used by the simulation. From the computational point of view, we show how to extract matrix elements from MG5_aMC@NLO and convert the analytical expressions automatically to multi-threading CPU and GPU code, increasing drastically the number of generated events when compared to the original MC implementation. Furthermore, we investigate the performance of our approach on different clusters configurations, including setups with multi-GPU, and we estimate the efficiency gains when compared to current state of the art implementations.

Primary authors: CARRAZZA, Stefano (CERN); Dr CRUZ MARTÍNEZ, Juan M. (University of Milan); ZARO, Marco (Università degli Studi e INFN Milano (IT)); ROSSI, Marco (CERN)

Presenter: ROSSI, Marco (CERN)

Session Classification: New Detector and Reconstruction Methodologies, Machine Learning and Computing at HL-LHC

Contribution ID: **11** Type: **Poster**

Autoencoder compression for high-energy physics

Data is what drives all research forward, regardless of scientific discipline. At the Large Hadron Collider (LHC) in Switzerland, the data stream of registered events can reach about 60 million megabytes per second, making it physically impossible to save all the produced data with current storage technology. This means that data selection has to be performed at an early stage in the experimental process, often using so-called trigger systems. While these are sophisticated, interesting data may be omitted by accident. This could potentially mean losing out on new discoveries, and thus a risk of not reaching the goal of the LHC in itself.

Data compression techniques can reduce the size of data drastically while giving a sufficiently faithful representation of the uncompressed data. For high-energy physics, using new data-compression techniques as a part of the data selection process would allow for further storage savings without waiting for major technological advancements in storage media, and thus allowing for new scientific discoveries to be made earlier by increasing the amount of data that can be recorded. One of the compression techniques that have been under recent investigation uses autoencoder networks. This is a machine-learning based approach, which utilizes a certain type of neural network known as an autoencoder.

Autoencoders are, in their most basic form, a neural network with multiple layers where the number of inputs is equal to the number of outputs, and the input and target datasets are the same. If the dimension of the hidden layer is (much) smaller than the dimension of the input and output layers, an autoencoder will be tasked with finding an effective representation of the input data, which can then be reconstructed in the output layer. As such, autoencoders are a good candidate for data compression.

In this contribution, autoencoder-based compression will be evaluated, by using the results presented in the thesis "Deep Autoencoders for Compression in High Energy Physics" (https://lup.lub.lu.se/student-papers/search/publication/9004751) by Eric Wulff as a foundation. In addition, we will also present new results and give an outlook in terms of autoencoder compression in the context of future LHC and new colliders.

Primary author: KILDETOFT, Georg Love (Lund University (SE))

Presenter: KILDETOFT, Georg Love (Lund University (SE))

Session Classification: Poster Session

Contribution ID: **12** Type: **EPJC track**

Prospects on searches for baryonic Dark Matter produced in \boldmath b-hadron decays at LHCb (live)

Tuesday, 6 July 2021 16:05 (30 minutes)

A mechanism accommodating baryonic Dark Matter (DM) has been proposed recently [arXiv:2101.02706,arXiv:1810.00880]. This has the advantage of explaining matter-anti-matter imbalance and DM at once, without requiring the proton to be unstable. The DM particles, carrying baryon number, would be produced in b-hadron decays, through a t-channel mediator. In this model, b-hadron branching fractions as high as few per mille are needed both by theoretical and experimental constraints.

The DM particles produced in this model, $\Psi_{(DS)}$ carry baryon number, and have a mass in the range $0.94 < m_{\Psi_{(DS)}} < 4.34$ GeV/c^2, being therefore harder to detect in general missing transverse energy (MET) searches at ATLAS or CMS. However, knowing the position of the production vertex (PV) and the decay vertex of the b-hadron allows a partial reconstruction of the final state and can provide a proxy to MET, hereby referred to as MPT$_B$, opening a window for detection at LHCb. This technique has already proven successful in the analysis of $\Lambda_b \to p\mu\nu_\mu$ decays [arXiv:1504.01568]. Therefore, the study of DM in b decays at LHCb provides unique sensitivity at the LHC, covering the entire parameter space of the model. Sharp kinematic end points are also distinctive signatures of these decays.

In this contribution, we will discuss the LHCb sensitivity to these searches, covering different topologies and giving prospects for Runs 3 and 4 of the LHC. We will give examples of B^0, B^+ and Λ_b decays as well as discussing the advantages and disadvantages compared to other experiments, such as Belle. Notably, the use of Λ_b baryons allows to test the entire mass range for $\Psi_{(DS)}$. For the analysis, the signals and backgrounds will be generated with Pythia [arXiv:1410.3012] and experimental effects will be emulated through a fast simulation [arXiv:2012.02692].

We show here two baseline examples, with topologies that are convenient at LHCb: $B^0 \to \Lambda^* + \Psi_{(DS)}, \Lambda^* \to pK$, and $B^+ \to \Lambda_c^+(2595)\Psi_{(DS)}, \Lambda_c^+(2595) \to \pi^+\pi^-\Lambda_c^+, \Lambda_c^+ \to pK\pi$. In both cases, $\Psi_{(DS)}$ is the dark particle, charged under baryon number. These decay chains are fully reconstructible through charged tracks at LHCb, with the obvious exception of the dark particle, and give access to the $b-$hadron decay points, allowing the determination of MPT$_B$. A simple select and count experiment of the signals and main backgrounds indicates that, in both decays, branching fractions in the $10^{-3} - 10^{-5}$ range should be at reach at LHCb. This result will be tuned once experimental effects are accounted for. Figure 1 shows the distribution of MPT$_B$ for the signal and background in both topologies.

Figure caption: Expected MPT$_B$ distributions at LHCb for the $B^0 \to \Lambda^* + \Psi_{(DS)}$ (left) and $B^+ \to \Lambda_c^+(2595)\Psi_{(DS)}$ (right) decays and corresponding backgrounds. The yields are normalized to 1 fb^{-1} of data and assume pp collisions with $\sqrt{s} = 14$ TeV and signal branching fractions of 10^{-3} and $m(\Psi_{(DS)}) = 2$ GeV/c^2. The distributions are at Pythia level and do not include experimental effects yet, but these will be included by the time of the conference.

Primary authors: BREA RODRIGUEZ, Alexandre (Universidade de Santiago de Compostela (USC), IGFAE); CHOBANOVA, Veronika Georgieva (Universidade de Santiago de Compostela (ES)); CID VIDAL, Xabier (Instituto Galego de Física de Altas Enerxías); LOPEZ SOLINO, Saul (Universidade de

Santiago de Compostela (ES)); MARTINEZ SANTOS, Diego (Universidade de Santiago de Compostela (ES)); MOMBACHER, Titus (Technische Universitaet Dortmund (DE)); Mr RODRIGUEZ FERNANDEZ, Emilio Xose (Instituto Galego de Física de Altas Enerxías, Universidade de Santiago de Compostela); VAZQUEZ SIERRA, Carlos (CERN)

Presenters: MARTINEZ SANTOS, Diego (Universidade de Santiago de Compostela (ES)); VAZQUEZ SIERRA, Carlos (CERN)

Session Classification: Unexplored ideas for ALICE, ATLAS, CMS and LHCb

Contribution ID: **13** Type: **EPJC track**

Fixed Superthin Solid Target and Colliding beams in a single experiment –a novel approach to study the matter under new extreme conditions (live)

Wednesday, 7 July 2021 18:30 (30 minutes)

A novel approach to the experimental and theoretical study of the properties of QCD matter under the new extreme conditions is discussed. Our simulations demonstrate a possibility to reach the initial temperature over 300 MeV and baryonic charge density exceeding the ordinary nuclear density by a factor of three. Such conditions could be realized in the high luminosity (HL) experiments at LHC by means of utilizing scattering of the two colliding beams at the nuclei of a solid target which is fixed at their intersection point.
A new distinctive feature of the proposed experiments is based on the implementation of the superthin solid target operated in the core of colliding beams. This approach is grounded on the successful data-taking process in the LHCb experiment running the colliding and fixed gaseous target modes simultaneously. The thickness of a solid target is assumed to be of the order of the upgraded gaseous target SMOG2 with a storage cell [1].
Assuming the instantaneous luminosity of colliding proton beams at HL LHC of 1036cm−2s−1 and the fixed micropowder jet target of Ni [2] with a thickness of 1016atoms ·cm−2 one can expect the triple nuclear collision rate of 100 s−1. Similar conditions might be realized by inserting into a beam core a superthin graphene target (10-100 atomic layers). We shall present entirely new mechanical construction for handling such target remotely. The third option of the superthin solid target to be discussed is based on 1 μm thick microstrip sensors [3] operated in a beams' halo. Among the advantageous features of superthin and super-light solid micro targets are the orders of magnitude better spatial localization of primary vertices, a large variety of target nuclei, a possibility to run an experiment with a few targets simultaneously, etc.
To simulate the triple nuclear collisions, we employed the UrQMD 3.4 model [4, 5] for the beam center-of-mass collision energies $\sqrt{s}$ = 2.76 TeV. As a result of our modeling, we found that in the most central and simultaneous triple nuclear collisions the initial baryonic charge density is about 3 times higher than the one achieved in the ordinary binary nuclear collisions at this energy. In contrast to the binary nuclear collisions, the high value of baryonic charge density leads to a strong enhancement of proton and Λ-hyperon production at the midrapidity and to a sizable suppression of their antiparticles. A principally new kind of scattering reactions, like a nucleus-fireball interaction, can be studied in such experiments. We argue that at lower energies of collisions the triple nuclear collision method can be of principal importance for locating the (tri)critical endpoint of the QCD phase diagram.
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Primary author: Prof. PUGATCH, Valery (Institute for Nuclear Research, National Academy of Sciences of Ukraine (UA))

Co-authors: Mr VITIUK, Oleksandr (Taras Schevcheno National University of Kyiv); Prof. BUGAEV, Kyrill (Bogolyubov Institute for Theoretical Physics, National Academy of Sciences of Ukraine); Mr DOBISHUK, Vasyl (Institute for Nuclear Research, National Academy of Sciences of Ukraine); Mr SERGIY, Chernyshenko (Institute for Nuclear Research, National Academy of Sciences of Ukraine); Dr GRINYUK, Boris (Bogolyubov Institute for Theoretical Physics, National Academy of Sciences of Ukraine); Mr PANASIUK, Pavlo (Taras Shevchenko National University of Kyiv); Mr YAKOVENKO, Nazar (Taras Shevchenko National University of Kyiv); Mrs ZHEREBTSOVA, Elizaveta (National Research Nuclear University "MEPhI"(Moscow Engineering Physics Institute),); Prof. BLEICHER, Markus (Institute for Theoretical Physics, Goethe University)

Presenter: Prof. BUGAEV, Kyrill (Bogolyubov Institute for Theoretical Physics, National Academy of Sciences of Ukraine)

Session Classification: Physics at LHC Experiments and Beyond

Contribution ID: **14** Type: **EPJC track**

Model Compression and Simplification Pipelines for fast Deep Neural Network inference in FPGAs in HEP (live)

Thursday, 8 July 2021 18:05 (30 minutes)

Co-authors: TORTONESI, Federico (Sapienza Universita e INFN, Roma I (IT)); RUSSO, Graziella (Sapienza Universita e INFN, Roma I (IT)); SABETTA, Luigi (Sapienza Universita e INFN, Roma I (IT)); FRANCESCATO, Simone (Sapienza Universita e INFN, Roma I (IT)); GIAGU, Stefano (Sapienza Universita e INFN, Roma I (IT))

Presenters: RUSSO, Graziella (Sapienza Universita e INFN, Roma I (IT)); SABETTA, Luigi (Sapienza Universita e INFN, Roma I (IT))

Session Classification: New Detector and Reconstruction Methodologies, Machine Learning and Computing at HL-LHC

Contribution ID: **15** Type: **EPJC track**

The next generation techniques for anisotropic flow analyses (live)

Thursday, 8 July 2021 17:35 (30 minutes)

The fundamental theory of strong nuclear force, quantum chromodynamics, predicts the existence of an extreme state of matter dubbed quark–gluon plasma (QGP) under extreme values of temperature and/or baryon density, which are attainable in ultra-relativistic heavy-ion collisions at Large Hadron Collider. Properties of QGP can be inferred via its hydrodynamic response to the anisotropies in the initial state geometry. This phenomenon is known as collective anisotropic flow, and its measurements were crucial in establishing the perfect liquid paradigm about QGP properties.

The most precise anisotropic flow measurements to date are based on the formalism of multivariate cumulants. This approach introduced the flow-specific observables in the field, $v_n\{k\}$, in terms of which most experimental results and theoretical predictions have been reported in flow analyses in the past two decades. However, it was realized recently that the usage of multivariate cumulants in flow analyses is flawed. The non-trivial properties of cumulants are preserved only for the stochastic observables for which the cumulant expansion has been performed directly, and if there are no underlying symmetries due to which some terms in the cumulant expansion are identically zero. Both of these assumptions are violated in the derivation of observables $v_n\{k\}$, which produces non-negligible systematic biases particularly in collisions with a small number of produced particles.

In this work, we attempt for the first time to reconcile the strict mathematical formalism of multivariate cumulants, with the usage of cumulants in anisotropic flow analyses. As a consequence, the outcome of this study will produce the next generation techniques and observables for flow analyses in high-energy nuclear collisions.

Primary author: Mr BILANDZIC, Ante (Technische Universitaet Muenchen (DE))

Presenter: Mr BILANDZIC, Ante (Technische Universitaet Muenchen (DE))

Session Classification: New Detector and Reconstruction Methodologies, Machine Learning and Computing at HL-LHC

Contribution ID: **16** Type: **EPJC track**

Machine learning augmented probes of light Yukawa couplings from Higgs pair production (recorded)

Friday, 9 July 2021 01:50 (30 minutes)

The measurement of the trilinear Higgs self-coupling is among the primary goals of the high-luminosity LHC and is accessible in Higgs pair production. However, this process is also sensitive to other couplings. While most of them can be well-constrained by single-Higgs measurements, this does not hold true for the coupling between the Higgs and light quarks. We show that the Higgs pair production process provides a sensitive probe to these couplings. Making use of interpretable machine learning with boosted decision trees and Shapley values, a measure derived from cooperative game theory, we separate the signal $q\bar{q} \to HH \to b\bar{b}\gamma\gamma$ from the Standard Model HH production and other backgrounds such as HZ, $t\bar{t}H$ and $b\bar{b}\gamma\gamma$. We show that, with the help of the machine learning framework, estimated bounds on light quarks coupling to the Higgs can be significantly improved compared to other probes, *cf.* fig. 1. The introduction of the Shapley values to assess variable importance allows the possibility of using a reduced set of kinematic variables to train the machine learning model. In what would otherwise be a black-box approach of using an over-complete set of kinematic variables, Shapley values tap into kinematic correlation and hence, allow for the selection of a minimal set of important kinematic variables that provide an optimal accuracy of signal vs. background classification.

Furthermore, we explore the potential of disentangling the various new physics operators leading to modifications of the light quark Yukawa coupling and a modified trilinear Higgs self-coupling with the added interpretability of the multivariate analysis using machine learning techniques. Additional kinematics can be further incorporated to help break the degeneracy between the up and down quark operators.

Primary authors: ALASFAR, Lina (Humboldt-Universität zu Berlin); GROEBER, Ramona (Università di Padova and INFN, Sezione di Padova); GROJEAN, Christophe (DESY (Hamburg) and Humboldt University (Berlin)); Dr PAUL, Ayan (DESY, Hamburg and Humboldt Universität zu Berlin); QIAN, Zhuoni (DESY)

Presenter: ALASFAR, Lina (Humboldt-Universität zu Berlin)

Session Classification: New Detector and Reconstruction Methodologies, Machine Learning and Computing at HL-LHC

Contribution ID: **17** Type: **EPJC track**

Probing early-time dynamics with charm balance functions (recorded)

Friday, 9 July 2021 03:05 (30 minutes)

For a long time it was conjectured that the large azimuthal anisotropic flow observed in heavy-ion collisions implied early thermalization. After the discovery of azimuthal anisotropic flow in small systems, where it is unclear if there is time for the system to thermalize, it was realized that one can have hydrodynamization, a phenomena in which flow can build up out-of-equilibrium (chemical and thermal). Recent calculations in kinetic theory supports such a scenario where one starts out with a purely gluonic system and the light quarks first are produced when the system is already flowing. However, this also means that one cannot access early-time dynamics with light quarks.

In this talk we propose to use low p_{T} charm quarks to study the dynamics of the hydrodynamization process. The advantage with charm quarks is that:
- they are dominantly produced early in the collision with rates that should be calculable in pQCD
- they interact with the medium building up some amount of azimuthal anisotropic flow
- they do not thermalize (forget the past) as their final yields would then essentially be zero

We propose to go beyond flow measurements by measuring the balance function of hadrons with (anti)charm. By subtracting charm-charm and anticharm-anticharm correlations from charm-anticharm correlations we want to directly deduce how the charm and anticharm quarks interacts with the system after their production. By measuring the evolution of the charm-anticharm correlation function from small-to-large systems we hope to provide direct experimental insights into the early-time QCD dynamics.

Primary author: CHRISTIANSEN, Peter (Lund University (SE))

Co-authors: SILVERMYR, David (Lund University (SE)); OHLSON, Alice (Lund University (SE)); Dr BASU, Sumit (Lund University (SE))

Presenter: CHRISTIANSEN, Peter (Lund University (SE))

Session Classification: New Detector and Reconstruction Methodologies, Machine Learning and Computing at HL-LHC

Contribution ID: **18** Type: **EPJC track**

An Experiment for Electron-Hadron Scattering at the LHC (live)

Wednesday, 7 July 2021 15:15 (30 minutes)

Primary authors: ARMESTO PEREZ, Nestor (Universidade de Santiago de Compostela (ES)); HOLZER, Bernhard (CERN); KOSTKA, Peter (University of Liverpool (GB)); KLEIN, Max (University of Liverpool (GB)); YAMAZAKI, Yuji (Kobe University (JP)); POLINI, Alessandro (Istituto Nazionale di Fisica Nucleare (INFN))

Presenters: BRITZGER, Daniel (Max-Planck-Institut für Physik München); BRITZGER, Daniel (Deutsches Elektronen-Synchrotron (DE))

Session Classification: Physics at LHC Experiments and Beyond

Contribution ID: **19** Type: **EPJC track**

Probing same-sign WW in hadronic signatures (recorded)

Wednesday, 7 July 2021 01:35 (30 minutes)

The production of two same-sign W bosons in association with two jets via vector boson scattering (VBS), ssWWjj, is a key probe of the mechanism of electroweak symmetry breaking, with the Higgs boson unitarising the process' cross-section. Longitudinal ssWWjj involves the spin-0 modes of the gauge bosons arising from EWSB, and is very sensitive to BSM physics.

With the Run-2 and Run-3 expected datasets, over 500 leptonic ssWWjj events are expected (W -> lv, l=e,mu), of which 35 events have two longitudinally polarised W boson, i.e. sWWjj(LL). More data is expected in Run-4 at the HL-LHC, but will not be sufficient to observe the process using only leptonic decays of the W boson.

The pool of ssWWjj(LL) events can be increased significantly increased by considering events with at least one hadronicically-decaying W (2/3 of W bosons decay hadronically). This is a very challenging final state given the large (by a few orders of magnitude) backgrounds.

We present ideas to systematically study ssWWjj VBS and the main backgrounds in semi-leptonic and hardonic VBS signatures, and, using substructure and jet charge techniques and deep learning, to extract the fraction of ssWWjj(LL) events.

This paper will rely on novel ideas to tackle the problem, and on combining existing tools and techniques in a novel way to probe the ssWWjj VBS signature. No use will be made of LHC experiment's infrastructure or codebases.

Primary author: POTAMIANOS, Karolos (University of Oxford (GB))

Presenter: POTAMIANOS, Karolos (University of Oxford (GB))

Session Classification: Unexplored ideas for ALICE, ATLAS, CMS and LHCb

Contribution ID: **20** Type: **EPJC track**

Measuring Z boson couplings to bottom quarks at the LHC (live)

Primary authors: PANIZZO, Giancarlo (INFN Gruppo collegato di Udine); AMOROSO, Simone (Deutsches Elektronen-Synchrotron (DE)); ZARO, Marco (Università degli Studi e INFN Milano (IT)); PAGANI, Davide (Deutsches Elektronen-Synchrotron (DE))

Presenters: PANIZZO, Giancarlo (INFN Gruppo collegato di Udine); AMOROSO, Simone (Deutsches Elektronen-Synchrotron (DE)); ZARO, Marco (Università degli Studi e INFN Milano (IT)); PAGANI, Davide (Deutsches Elektronen-Synchrotron (DE))

Session Classification: Unexplored ideas for ALICE, ATLAS, CMS and LHCb

Contribution ID: **21** Type: **EPJC track**

Thermodynamics of the 'Little Bang' (live)

Wednesday, 7 July 2021 18:00 (30 minutes)

Observation of the cosmic microwave background radiation (CMBR) by various satellites confirms the Big Bang evolution, inflation and provides important information regarding the early Universe and its evolution with excellent accuracy [1]. In little bangs, the produced fire-ball goes through a rapid evolution from partonic QGP phase to a hadronic phase, and finally freezes out. The physics of heavy-ion collisions at ultra-relativistic energies, popularly known as little bangs, has often been compared to the Big Bang phenomenon of the early Universe [2-3]. Heavy-ion experiments are predominantly sensitive to the conditions that prevail at the later stage of the collision as majority of the particles are emitted near the freeze-out. Thus, a direct and quantitative estimation of the properties of hot and dense matter in the early stages and during each stage of the evolution has not yet been possible.

In heavy-ion collisions, the mean transverse energy p_{T} is a proxy of the temperature and the mean number of charged particles (<N_{ch}>) is a manifestation of energy or entropy density. The major motivation of our study is to generate a map of ϵ and T, similar to the CMBR map, using fluctuation and correlation techniques.

The two-particle p_{T} correlations have been studied for long, and defined in terms of a dimensionless correlation function as a ratio of the differential correlator to the square of the average transverse momentum

$$P_2(\Delta\eta,\Delta\varphi) = \frac{\langle \Delta p_{\mathrm{T}} \Delta p_{\mathrm{T}} \rangle (\Delta\eta,\Delta\varphi)}{\langle p_{\mathrm{T}} \rangle^2} = \frac{1}{\langle p_{\mathrm{T}} \rangle^2} \frac{\int_{p_{\mathrm{T,min}}}^{p_{\mathrm{T,max}}} \rho_2(\mathbf{p}_1,\mathbf{p}_2)\ \Delta p_{\mathrm{T},1}\Delta p_{\mathrm{T},2}\ \ \Delta p_{\mathrm{T},1}\Delta p_{\mathrm{T},2}}{\int_{p_{\mathrm{T,min}}}^{p_{\mathrm{T,max}}} \rho_2(\mathbf{p}_1,\mathbf{p}_2)\ \ \Delta p_{\mathrm{T},1}\mathrm{d}p_{\mathrm{T},2}},$$

where is the inclusive average momentum of produced particles in an event ensemble. Technically, in this type of analysis, integrals of the numerator and denominator of the above expression are first evaluated in four-dimensional space as functions of . The ratio is calculated and subsequently averaged over all coordinates. But when p_{T} is used a proxy to system temperature, it is affected by the radial flow, and falls short to capture the true 'temperature' fluctuation.
To overcome this, we propose a 4-particle p_{T} and number fluctuations where the non-flow effect are suppressed. With this, we can link it to the thermodynamic response functions like specific heat, heat capacity and compressibility. With the advent of high luminosity and high statistics runs in Run3 and Run4 of CERN Large Hadron Collider (LHC), it will be possible to generator 4-particle correlations. The ALICE experiment is expected to take data in LHC Run5 with a completely new detector covering 8 units in rapidity. For these runs, the fluctuation map can be more effective to extract relevant physics towards thermodynamics of hot and dense matter.

References:
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Primary authors: Dr BASU, Sumit (Lund University (SE)); Prof. PRUNEAU, Claude Andre (Wayne State University (US)); Dr NAYAK, Tapan (CERN, Geneva and NISER, Bhubaneswar)

Presenters: Dr BASU, Sumit (Lund University (SE)); Dr NAYAK, Tapan (CERN, Geneva and NISER, Bhubaneswar)

Session Classification: Physics at LHC Experiments and Beyond

Contribution ID: **22** Type: **EPJC track**

High P_T Higgs excess as a signal of non-local QFT at the LHC Phase-2 (live)

Thursday, 8 July 2021 03:00 (30 minutes)

Primary authors: PAGANIS, Stathes (National Taiwan University); WU, Hsin-Yeh (National Taiwan University (TW)); SU, Xing-Fu (National Taiwan University (TW)); LI, You-Ying (National Taiwan University (TW)); NIKOLAIDOU, Rosy (Université Paris-Saclay (FR))

Presenter: PAGANIS, Stathes (National Taiwan University)

Session Classification: Physics at LHC Experiments and Beyond

Contribution ID: **23** Type: **Poster**

Artificial Neural Networks on FPGAs for Real-Time Energy Reconstruction of the ATLAS LAr Calorimeters

Within the Phase-II upgrade of the LHC, the readout electronics of the ATLAS LAr Calorimeters is prepared for high luminosity operation expecting a pile-up of up to 200 simultaneous pp interactions. Moreover, the calorimeter signals of up to 25 subsequent collisions are overlapping, which increases the difficulty of energy reconstruction. Real-time processing of digitized pulses sampled at 40 MHz is thus performed using FPGAs.

To cope with the signal pile-up, new machine learning approaches are explored: convolutional and recurrent neural networks outperform the optimal signal filter currently used, both in assignment of the reconstructed energy to the correct bunch crossing and in energy resolution.

Very good agreement between neural network implementations in FPGA and software based calculations is observed. The FPGA resource usage, the latency and the operation frequency are analysed. Latest performance results and experience with prototype implementations will be reported.

Primary authors: AAD, Georges (CPPM, Aix-Marseille Université, CNRS/IN2P3 (FR)); BERTHOLD, Anne-Sophie (Technische Universitaet Dresden (DE)); CALVET, Thomas (CPPM, Aix-Marseille Université, CNRS/IN2P3 (FR)); Mr CHIEDDE, Nemer (Centre National de la Recherche Scientifique (FR)); FORTIN, Etienne Marie (Aix Marseille Univ, CNRS/IN2P3, CPPM, Marseille, France); FRITZSCHE, Nick (Technische Universitaet Dresden (DE)); Mr HENTGES, Rainer (Technische Universitaet Dresden (DE)); LAATU, Lauri Antti Olavi (Centre National de la Recherche Scientifique (FR)); MONNIER, Emmanuel (CPPM, Aix-Marseille Université, CNRS/IN2P3 (FR)); STRAESSNER, Arno (Technische Universitaet Dresden (DE)); VOIGT, Johann Christoph (Technische Universitaet Dresden (DE))

Presenter: VOIGT, Johann Christoph (Technische Universitaet Dresden (DE))

Session Classification: Poster Session

Contribution ID: **25** Type: **Keynote**

Upgrade of the ALICE experiment for LHC Run 4 and beyond (recorded)

Thursday, 8 July 2021 02:15 (45 minutes)

The ALICE experiment is preparing the ITS3, an upgrade of its Inner Tracking System for LHC Run 4. The three innermost layers will be replaced by wafer-scale, truly cylindrical, ultra-thin detector layers, made of Monolithic Active Pixel Sensors. This innovative technology will permit to lower the material budget even further and to improve the tracking and vertexing capabilities. We will present the R&D programme, including the already achieved demonstration of the operability of bent MAPS and future plans.
Moreover, we will present the plans for ALICE 3, a next-generation heavy-ion experiment for LHC Run 5. The idea of this major upgrade is to exploit silicon technologies to build an ultra-thin and fast tracker with unprecedented vertexing capabilities in combination with excellent particle identification from a silicon-based time-of-flight detector in combination with complementary approaches.

Primary author: CARNESECCHI, Francesca (Gangneung-Wonju National University (KR))

Presenter: CARNESECCHI, Francesca (Gangneung-Wonju National University (KR))

Session Classification: Physics at LHC Experiments and Beyond

Contribution ID: **27** Type: **Keynote**

Theory Ideas (live)

Tuesday, 6 July 2021 14:40 (50 minutes)

title to be confirmed

Presenters: REINA, Laura (Florida State University (US)); CRAIG, Nathaniel; CRAIG, Nathaniel (UC Santa Barbara); CRAIG, Nathaniel (Stanford University)

Session Classification: Unexplored ideas for ALICE, ATLAS, CMS and LHCb

Contribution ID: **28** Type: **Admin**

Photo session

Tuesday, 6 July 2021 15:30 (5 minutes)

Session Classification: Unexplored ideas for ALICE, ATLAS, CMS and LHCb

Contribution ID: **31** Type: **Keynote**

Upgrade and physics plans for ATLAS in LHC Run4 (live)

Tuesday, 6 July 2021 16:35 (45 minutes)

The ATLAS experiment has been in successful operation at the Large Hadron Collider (LHC) since 2009, collecting data from proton-proton collisions of up to $\sqrt{s}$ = 13 TeV. It is now gearing up to collect its majority of data at the high luminosity LHC. For this, upgrades are underway to face the challenge of a significant increase in number of interactions per bunch-crossing (pile-up), large detector occupancies and unprecedented collision rates. However, the upgrades will not only allow us to probe the Standard Model with greater precision and comb through finer statistics for new phenomena. It will also be an opportunity to enhance the physics potential of the experiment beyond just increasing the available data sets.
The upgrade will include a replacement of the inner tracker and a new timing detector as well as improvements in trigger acquisition and strategy. This talk will summarise the status and expected performance of these projects followed by how these upgrades are envisaged to boost the physics potential of the experiment for the HL-LHC.

Presenter: ANTEL, Claire (Universite de Geneve (CH))

Session Classification: Unexplored ideas for ALICE, ATLAS, CMS and LHCb

Contribution ID: **32** Type: **EPJC track**

Exploring new possibilities to discover a light pseudo-scalar at LHCb (live)

Wednesday, 7 July 2021 03:20 (30 minutes)

Co-authors: VAZQUEZ SIERRA, Carlos (CERN); BUARQUE FRANZOSI, Diogo (Chalmers University of Technology); FERRETTI, Gabriele (Chalmers University, Gothenburg, Sweden); CACCIAPAGLIA, Giacomo; CACCIAPAGLIA, Giacomo (Centre National de la Recherche Scientifique (FR))

Presenters: FLACKE, Tom (IBS CTPU Daejeon, Korea); CID VIDAL, Xabier (Instituto Galego de Física de Altas Enerxías)

Session Classification: Unexplored ideas for ALICE, ATLAS, CMS and LHCb

Contribution ID: **35** Type: **Keynote**

Theory ideas (live)

Wednesday, 7 July 2021 00:40 (50 minutes)

Co-authors: CRAIG, Nathaniel; CRAIG, Nathaniel (UC Santa Barbara); CRAIG, Nathaniel (Stanford University)

Presenters: CRAIG, Nathaniel; CRAIG, Nathaniel (UC Santa Barbara); CRAIG, Nathaniel (Stanford University); REINA, Laura (Florida State University (US))

Session Classification: Unexplored ideas for ALICE, ATLAS, CMS and LHCb

Contribution ID: **36** Type: **Admin**

Photo session

Wednesday, 7 July 2021 01:30 (5 minutes)

Session Classification: Unexplored ideas for ALICE, ATLAS, CMS and LHCb

Contribution ID: **39** Type: **Keynote**

Upgrade and physics plans for ATLAS in LHC Run4 (recorded)

Wednesday, 7 July 2021 02:35 (45 minutes)

The ATLAS experiment has been in successful operation at the Large Hadron Collider (LHC) since 2009, collecting data from proton-proton collisions of up to $\sqrt{s}$ = 13 TeV. It is now gearing up to collect its majority of data at the high luminosity LHC. For this, upgrades are underway to face the challenge of a significant increase in number of interactions per bunch-crossing (pile-up), large detector occupancies and unprecedented collision rates. However, the upgrades will not only allow us to probe the Standard Model with greater precision and comb through finer statistics for new phenomena. It will also be an opportunity to enhance the physics potential of the experiment beyond just increasing the available data sets.
The upgrade will include a replacement of the inner tracker and a new timing detector as well as improvements in trigger acquisition and strategy. This talk will summarise the status and expected performance of these projects followed by how these upgrades are envisaged to boost the physics potential of the experiment for the HL-LHC.

Presenter: ANTEL, Claire (Universite de Geneve (CH))

Session Classification: Unexplored ideas for ALICE, ATLAS, CMS and LHCb

Contribution ID: **43** Type: **Keynote**

LHCb as a 4D precision detector in Upgrade II (live)

Wednesday, 7 July 2021 14:30 (45 minutes)

Presenter: KEIZER, Floris (CERN)

Session Classification: Physics at LHC Experiments and Beyond

Contribution ID: **51** Type: **Keynote**

LHCb as a 4D precision detector in Upgrade II (recorded)

Thursday, 8 July 2021 00:30 (45 minutes)

Presenter: KEIZER, Floris (CERN)

Session Classification: Physics at LHC Experiments and Beyond

Contribution ID: **59** Type: **Keynote**

Experiment Keynote talk (live)

Thursday, 8 July 2021 14:30 (50 minutes)

Presenter: ELSEN, Eckhard (Deutsches Elektronen-Synchrotron (DE))

Session Classification: New Detector and Reconstruction Methodologies, Machine Learning and Computing at HL-LHC

Contribution ID: **62** Type: **Keynote**

Physics by CMS during HL-LHC (live)

Thursday, 8 July 2021 16:20 (45 minutes)

Presenters: HEINTZ, Ulrich (Unknown); HEINTZ, Ulrich (Brown University (US))

Session Classification: New Detector and Reconstruction Methodologies, Machine Learning and Computing at HL-LHC

Contribution ID: **67** Type: **Keynote**

Experiment keynote talk (recorded)

Friday, 9 July 2021 00:30 (50 minutes)

Presenter: ELSEN, Eckhard (Deutsches Elektronen-Synchrotron (DE))

Session Classification: New Detector and Reconstruction Methodologies, Machine Learning and Computing at HL-LHC

Contribution ID: **70** Type: **Keynote**

Physics by CMS during HL-LHC (recorded)

Friday, 9 July 2021 02:20 (45 minutes)

Presenters: HEINTZ, Ulrich (Unknown); HEINTZ, Ulrich (Brown University (US))

Session Classification: New Detector and Reconstruction Methodologies, Machine Learning and Computing at HL-LHC

Contribution ID: **75** Type: **EPJC track**

High P_T Higgs excess as a signal of non-local QFT at the LHC Phase-2 (live)

Wednesday, 7 July 2021 15:45 (30 minutes)

Primary authors: WU, Hsin-Yeh (National Taiwan University (TW)); NIKOLAIDOU, Rosy (Université Paris-Saclay (FR)); Prof. PAGANIS, Stathes (National Taiwan University); SU, Xing-Fu (National Taiwan University (TW)); LI, You-Ying (National Taiwan University (TW))

Presenter: Prof. PAGANIS, Stathes (National Taiwan University)

Session Classification: Physics at LHC Experiments and Beyond

Contribution ID: **76** Type: **EPJC track**

An Experiment for Electron-Hadron Scattering at the LHC (live)

Thursday, 8 July 2021 01:15 (30 minutes)

Presenters: HOLZER, Bernhard (CERN); KLEIN, Max (University of Liverpool (GB)); ARMESTO PEREZ, Nestor (Universidade de Santiago de Compostela (ES)); KOSTKA, Peter (University of Liverpool (GB)); YAMAZAKI, Yuji (Kobe University (JP))

Session Classification: Physics at LHC Experiments and Beyond

Contribution ID: **78** Type: **EPJC track**

Measuring □ boson couplings to bottom quarks at the LHC

Presenters: PAGANI, Davide (Deutsches Elektronen-Synchrotron (DE)); PANIZZO, Giancarlo (INFN Gruppo collegato di Udine); ZARO, Marco (Università degli Studi e INFN Milano (IT)); AMOROSO, Simone (Deutsches Elektronen-Synchrotron (DE))

Session Classification: Unexplored ideas for ALICE, ATLAS, CMS and LHCb

Contribution ID: **82** Type: **EPJC track**

Model Compression and Simplification Pipelines for fast Deep Neural Network inference in FPGAs in HEP (live)

Thursday, 8 July 2021 01:45 (30 minutes)

Co-authors: TORTONESI, Federico (Sapienza Universita e INFN, Roma I (IT)); FRANCESCATO, Simone (Sapienza Universita e INFN, Roma I (IT)); GIAGU, Stefano (Sapienza Universita e INFN, Roma I (IT)); SABETTA, Luigi (Sapienza Universita e INFN, Roma I (IT))

Presenters: SABETTA, Luigi (Sapienza Universita e INFN, Roma I (IT)); RUSSO, Graziella (Sapienza Universita e INFN, Roma I (IT))

Session Classification: Physics at LHC Experiments and Beyond

Contribution ID: **83** Type: **Keynote**

Upgrade of the ALICE experiment for LHC Run 4 and beyond (live)

Wednesday, 7 July 2021 16:15 (45 minutes)

The ALICE experiment is preparing the ITS3, an upgrade of its Inner Tracking System for LHC Run 4. The three innermost layers will be replaced by wafer-scale, truly cylindrical, ultra-thin detector layers, made of Monolithic Active Pixel Sensors. This innovative technology will permit to lower the material budget even further and to improve the tracking and vertexing capabilities. We will present the R&D programme, including the already achieved demonstration of the operability of bent MAPS and future plans.
Moreover, we will present the plans for ALICE 3, a next-generation heavy-ion experiment for LHC Run 5. The idea of this major upgrade is to exploit silicon technologies to build an ultra-thin and fast tracker with unprecedented vertexing capabilities in combination with excellent particle identification from a silicon-based time-of-flight detector in combination with complementary approaches.

Primary author: CARNESECCHI, Francesca (Gangneung-Wonju National University (KR))

Presenter: CARNESECCHI, Francesca (Gangneung-Wonju National University (KR))

Session Classification: Physics at LHC Experiments and Beyond

Contribution ID: **84** Type: **EPJC track**

Prospects of the H->bb coupling measurement at the LHeC with a full detector simulation (live)

Thursday, 8 July 2021 04:00 (30 minutes)

A Future Large Hadron electron Collider (LHeC) would allow to collide an intense electron beam with a proton or ion beam from the High Luminosity–Large Hadron Collider (HL-LHC). Preliminary studies suggest that not only a rich physics program in the context of deep-inelastic scattering is possible, but also that several high precision Higgs coupling measurements could be performed. In particular, studies suggest uncertainties of 0.8% and 7.4% on the Higgs boson coupling strength to b- and c-quarks respectively. However, these studies are based on fast detector simulations and hence might be subject to several optimistic assumptions. Within this study, we present prospects of the H->bb coupling measurement at the LHeC using the public software infrastructure of the ATLAS Experiment at the LHC for a full detector simulation. This approach does not only consider correctly low-level interactions between the decay particles and the detector material, but also uses state-of-the art reconstruction algorithms. Since the acceptance of the ATLAS detector is somewhat smaller than a potential future LHeC detector, dedicated extrapolation techniques for the reconstruction- and fake-rate efficiencies have been applied and their uncertainties estimated.

Primary authors: BEHERA, SUBHASISH (IIT GUWAHATI); SCHOTT, Matthias (CERN / University of Mainz)

Presenter: BEHERA, SUBHASISH (IIT GUWAHATI)

Session Classification: Physics at LHC Experiments and Beyond

Contribution ID: **85** Type: **EPJC track**

Isospin extrapolation as a method to measure inclusive b->sll decays (live)

Wednesday, 7 July 2021 17:00 (30 minutes)

Over the last few years, several discrepancies with respect to SM predictions have arisen in studies of exclusive $b \to s\ell^+\ell^-$ decays, where a b-hadron decays into a specific final state. The interpretation for a significant fraction of these discrepancies is clouded by hadronic uncertainties. Inclusive $b \to s\ell^+\ell^-$ decays are regarded to be under better theoretical control, but are less precise experimentally.

Previous measurements of inclusive decays rely on a sum-of-exclusives approach, whereby several specific final states are combined and the result is extrapolated to the full inclusive rate using a hadronisation model. This approach suffers from the systematic uncertainty associated with this extrapolation and is difficult to control. This can be avoided with measurements of fully inclusive decays, whereby only the two leptons are reconstructed. However this approach suffers from large backgrounds.

Here we discuss a new approach to reconstruct inclusive decays involving isospin extrapolation. The idea is to reconstruct a charged kaon and require that it forms a common vertex with the two leptons, resulting in a semi-inclusive $b \to K^+\ell^+\ell^-X$ signature. The presence of the additional kaon allows for greater rejection of background and a well-defined sideband region which can be used to control it.

Measurements of the $b \to K^+\ell^+\ell^-X$ signature require an extrapolation to the fully inclusive rate to account for final states with a K^0 meson. This can be done by assuming using isospin rules for the inclusive decay, which is well established in exclusive B^+ and B^0 $b \to s\ell^+\ell^-$ decays. The extrapolation is expected to provide a complimentary extrapolation to fully inclusive decay rate compared to traditional methods.

The inclusive $b \to s\ell^+\ell^-$ decay rate is approximately one order of magnitude larger than exclusive decays and exists for all b-hadron species. This results in a very large signal yield compared to exclusive measurements which offers potential for very precise measurements in theoretically clean observables, in addition to those affected by hadronic uncertainties. Lepton flavour violation searches and lepton universality tests can be performed on the inclusive decay, where background can be reduced without fear of spoiling the theoretical interpretation. The reconstruction of the kaon also allows for a perfect tagging of the flavour of the b-hadron at decay. This allows for forward-backward asymmetry and CP asymmetry measurements to be performed with similar statistical advantages as for the lepton symmetry tests.

A paper on this would have the following aspects: First by defining the problem and method approach. Then it would detail the main aspects in which background is better controlled with the additional charged kaon. For the theoretically clean observables, discussion on further reducing background and the expected signal yields for the various observables would be estimated. Finally, a discussion on the isospin extrapolation itself will be made. This includes specific issues related to the presence of the diverse admixture of different b-hadron hadron species in the LHC production.

Primary authors: AMHIS, Yasmine Sara (IJCLab (Orsay)); OWEN, Patrick Haworth (Universitaet Zuerich (CH))

Presenter: OWEN, Patrick Haworth (Universitaet Zuerich (CH))

Session Classification: Physics at LHC Experiments and Beyond

Contribution ID: **86** Type: **EPJC track**

Automate Monte Carlo simulation on hardware accelerators for Run4@LHC (live)

Thursday, 8 July 2021 15:50 (30 minutes)

We propose a new framework for automatic generation of simulated events for particle physics processes in high energy physics applications, for LHC and HL-LHC configurations, with automatic support for hardware accelerators, in particular, graphics processing units (GPU). The project focus on two specific problems: automate the generation of matrix elements and phase space terms for GPU and real-time inference for machine learning tools in order to reduce the computational effort required by the Monte Carlo integrator used by the simulation. From the computational point of view, we show how to extract matrix elements from MG5_aMC@NLO and convert the analytical expressions automatically to multi-threading CPU and GPU code, increasing drastically the number of generated events when compared to the original MC implementation. Furthermore, we investigate the performance of our approach on different clusters configurations, including setups with multi-GPU, and we estimate the efficiency gains when compared to current state of the art implementations.

Primary authors: CARRAZZA, Stefano (CERN); Dr CRUZ MARTÍNEZ, Juan M. (University of Milan); ZARO, Marco (Università degli Studi e INFN Milano (IT)); ROSSI, Marco (CERN)

Presenter: ROSSI, Marco (CERN)

Session Classification: New Detector and Reconstruction Methodologies, Machine Learning and Computing at HL-LHC

Contribution ID: **87** Type: **EPJC track**

Exploring new possibilities to discover a light pseudo-scalar at LHCb (live)

Tuesday, 6 July 2021 17:20 (30 minutes)

Co-authors: VAZQUEZ SIERRA, Carlos (CERN); BUARQUE FRANZOSI, Diogo (Chalmers University of Technology); CACCIAPAGLIA, Giacomo (Centre National de la Recherche Scientifique (FR)); CACCIAPAGLIA, Giacomo

Presenters: FERRETTI, Gabriele (Chalmers University, Gothenburg, Sweden); FLACKE, Tom (IBS CTPU Daejeon, Korea); CID VIDAL, Xabier (Instituto Galego de Física de Altas Enerxías)

Session Classification: Unexplored ideas for ALICE, ATLAS, CMS and LHCb

Contribution ID: **88** Type: **EPJC track**

Prospects on searches for baryonic Dark Matter produced in \boldmath b-hadron decays at LHCb (live)

Wednesday, 7 July 2021 02:05 (30 minutes)

A mechanism accommodating baryonic Dark Matter (DM) has been proposed recently [arXiv:2101.02706,arXiv:1810.00880]. This has the advantage of explaining matter-anti-matter imbalance and DM at once, without requiring the proton to be unstable. The DM particles, carrying baryon number, would be produced in b-hadron decays, through a t-channel mediator. In this model, b-hadron branching fractions as high as few per mille are needed both by theoretical and experimental constraints.

The DM particles produced in this model, $\Psi_{(DS)}$ carry baryon number, and have a mass in the range $0.94 < m_{\Psi_{(DS)}} < 4.34$ GeV/c^2, being therefore harder to detect in general missing transverse energy (MET) searches at ATLAS or CMS. However, knowing the position of the production vertex (PV) and the decay vertex of the b-hadron allows a partial reconstruction of the final state and can provide a proxy to MET, hereby referred to as MPT$_B$, opening a window for detection at LHCb. This technique has already proven successful in the analysis of $\Lambda_b \to p\mu\nu_\mu$ decays [arXiv:1504.01568]. Therefore, the study of DM in b decays at LHCb provides unique sensitivity at the LHC, covering the entire parameter space of the model. Sharp kinematic end points are also distinctive signatures of these decays.

In this contribution, we will discuss the LHCb sensitivity to these searches, covering different topologies and giving prospects for Runs 3 and 4 of the LHC. We will give examples of B^0, B^+ and Λ_b decays as well as discussing the advantages and disadvantages compared to other experiments, such as Belle. Notably, the use of Λ_b baryons allows to test the entire mass range for $\Psi_{(DS)}$. For the analysis, the signals and backgrounds will be generated with Pythia [arXiv:1410.3012] and experimental effects will be emulated through a fast simulation [arXiv:2012.02692].

We show here two baseline examples, with topologies that are convenient at LHCb: $B^0 \to \Lambda^* + \Psi_{(DS)}, \Lambda^* \to pK$, and $B^+ \to \Lambda_c^+(2595)\Psi_{(DS)}, \Lambda_c^+(2595) \to \pi^+\pi^-\Lambda_c^+, \Lambda_c^+ \to pK\pi$. In both cases, $\Psi_{(DS)}$ is the dark particle, charged under baryon number. These decay chains are fully reconstructible through charged tracks at LHCb, with the obvious exception of the dark particle, and give access to the $b-$hadron decay points, allowing the determination of MPT$_B$. A simple select and count experiment of the signals and main backgrounds indicates that, in both decays, branching fractions in the $10^{-3} - 10^{-5}$ range should be at reach at LHCb. This result will be tuned once experimental effects are accounted for. Figure 1 shows the distribution of MPT$_B$ for the signal and background in both topologies.

Figure caption: Expected MPT$_B$ distributions at LHCb for the $B^0 \to \Lambda^* + \Psi_{(DS)}$ (left) and $B^+ \to \Lambda_c^+(2595)\Psi_{(DS)}$ (right) decays and corresponding backgrounds. The yields are normalized to 1 fb^{-1} of data and assume pp collisions with $\sqrt{s} = 14$ TeV and signal branching fractions of 10^{-3} and $m(\Psi_{(DS)}) = 2$ GeV/c^2. The distributions are at Pythia level and do not include experimental effects yet, but these will be included by the time of the conference.

Primary authors: BREA RODRIGUEZ, Alexandre (Universidade de Santiago de Compostela (USC), IGFAE); CHOBANOVA, Veronika Georgieva (Universidade de Santiago de Compostela (ES)); CID VIDAL, Xabier (Instituto Galego de Física de Altas Enerxías); LOPEZ SOLINO, Saul (Universidade de

Santiago de Compostela (ES)); MARTINEZ SANTOS, Diego (Universidade de Santiago de Compostela (ES)); MOMBACHER, Titus (Technische Universitaet Dortmund (DE)); Mr RODRIGUEZ FERNANDEZ, Emilio Xose (Instituto Galego de Física de Altas Enerxías, Universidade de Santiago de Compostela); VAZQUEZ SIERRA, Carlos (CERN)

Presenters: MARTINEZ SANTOS, Diego (Universidade de Santiago de Compostela (ES)); VAZQUEZ SIERRA, Carlos (CERN)

Session Classification: Unexplored ideas for ALICE, ATLAS, CMS and LHCb

Contribution ID: **89** Type: **EPJC track**

Fixed Superthin Solid Target and Colliding beams in a single experiment –a novel approach to study the matter under new extreme conditions (recorded)

Thursday, 8 July 2021 04:30 (30 minutes)

A novel approach to the experimental and theoretical study of the properties of QCD matter under the new extreme conditions is discussed. Our simulations demonstrate a possibility to reach the initial temperature over 300 MeV and baryonic charge density exceeding the ordinary nuclear density by a factor of three. Such conditions could be realized in the high luminosity (HL) experiments at LHC by means of utilizing scattering of the two colliding beams at the nuclei of a solid target which is fixed at their intersection point.
A new distinctive feature of the proposed experiments is based on the implementation of the superthin solid target operated in the core of colliding beams. This approach is grounded on the successful data-taking process in the LHCb experiment running the colliding and fixed gaseous target modes simultaneously. The thickness of a solid target is assumed to be of the order of the upgraded gaseous target SMOG2 with a storage cell [1].
Assuming the instantaneous luminosity of colliding proton beams at HL LHC of 1036cm−2s−1 and the fixed micropowder jet target of Ni [2] with a thickness of 1016atoms ·cm−2 one can expect the triple nuclear collision rate of 100 s−1. Similar conditions might be realized by inserting into a beam core a superthin graphene target (10-100 atomic layers). We shall present entirely new mechanical construction for handling such target remotely. The third option of the superthin solid target to be discussed is based on 1 μm thick microstrip sensors [3] operated in a beams' halo. Among the advantageous features of superthin and super-light solid micro targets are the orders of magnitude better spatial localization of primary vertices, a large variety of target nuclei, a possibility to run an experiment with a few targets simultaneously, etc.
To simulate the triple nuclear collisions, we employed the UrQMD 3.4 model [4, 5] for the beam center-of-mass collision energies $\sqrt{s}$ = 2.76 TeV. As a result of our modeling, we found that in the most central and simultaneous triple nuclear collisions the initial baryonic charge density is about 3 times higher than the one achieved in the ordinary binary nuclear collisions at this energy. In contrast to the binary nuclear collisions, the high value of baryonic charge density leads to a strong enhancement of proton and Λ-hyperon production at the midrapidity and to a sizable suppression of their antiparticles. A principally new kind of scattering reactions, like a nucleus-fireball interaction, can be studied in such experiments. We argue that at lower energies of collisions the triple nuclear collision method can be of principal importance for locating the (tri)critical endpoint of the QCD phase diagram.
References:
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[2] V. Pugatch et al., The 13th International Conference on Cyclotrons and their Applications: Proceedings, Vancouver, BC, Canada. p. 297.
[3] V. Pugatch, International Conference "CERN-Ukraine co-operation: current state and prospects "Kharkiv. 15-May-2018; LHCb-TALK-2018-557.
[4] S.A. Bass et al., Prog. Part. Nucl. Phys. 41 (1998), 225-370.
[5] M. Bleicher et al., J. Phys. G 25 (1999), 1859-1896.

Primary author: Prof. PUGATCH, Valery (Institute for Nuclear Research, National Academy of Sciences of Ukraine (UA))

Co-authors: Mr VITIUK, Oleksandr (Taras Schevcheno National University of Kyiv); Prof. BUGAEV, Kyrill (Bogolyubov Institute for Theoretical Physics, National Academy of Sciences of Ukraine); Mr DOBISHUK, Vasyl (Institute for Nuclear Research, National Academy of Sciences of Ukraine); Mr SERGIY, Chernyshenko (Institute for Nuclear Research, National Academy of Sciences of Ukraine); Dr GRINYUK, Boris (Bogolyubov Institute for Theoretical Physics, National Academy of Sciences of Ukraine); Mr PANASIUK, Pavlo (Taras Shevchenko National University of Kyiv); Mr YAKOVENKO, Nazar (Taras Shevchenko National University of Kyiv); Mrs ZHEREBTSOVA, Elizaveta (National Research Nuclear University "MEPhI"(Moscow Engineering Physics Institute),); Prof. BLEICHER, Markus (Institute for Theoretical Physics, Goethe University)

Presenter: Prof. BUGAEV, Kyrill (Bogolyubov Institute for Theoretical Physics, National Academy of Sciences of Ukraine)

Session Classification: Physics at LHC Experiments and Beyond

Contribution ID: **90** Type: **EPJC track**

The next generation techniques for anisotropic flow analyses (recorded)

Friday, 9 July 2021 03:35 (30 minutes)

The fundamental theory of strong nuclear force, quantum chromodynamics, predicts the existence of an extreme state of matter dubbed quark–gluon plasma (QGP) under extreme values of temperature and/or baryon density, which are attainable in ultra-relativistic heavy-ion collisions at Large Hadron Collider. Properties of QGP can be inferred via its hydrodynamic response to the anisotropies in the initial state geometry. This phenomenon is known as collective anisotropic flow, and its measurements were crucial in establishing the perfect liquid paradigm about QGP properties.

The most precise anisotropic flow measurements to date are based on the formalism of multivariate cumulants. This approach introduced the flow-specific observables in the field, $v_n\{k\}$, in terms of which most experimental results and theoretical predictions have been reported in flow analyses in the past two decades. However, it was realized recently that the usage of multivariate cumulants in flow analyses is flawed. The non-trivial properties of cumulants are preserved only for the stochastic observables for which the cumulant expansion has been performed directly, and if there are no underlying symmetries due to which some terms in the cumulant expansion are identically zero. Both of these assumptions are violated in the derivation of observables $v_n\{k\}$, which produces non-negligible systematic biases particularly in collisions with a small number of produced particles.

In this work, we attempt for the first time to reconcile the strict mathematical formalism of multivariate cumulants, with the usage of cumulants in anisotropic flow analyses. As a consequence, the outcome of this study will produce the next generation techniques and observables for flow analyses in high-energy nuclear collisions.

Primary author: Mr BILANDZIC, Ante (Technische Universitaet Muenchen (DE))

Presenter: Mr BILANDZIC, Ante (Technische Universitaet Muenchen (DE))

Session Classification: New Detector and Reconstruction Methodologies, Machine Learning and Computing at HL-LHC

Contribution ID: **91** Type: **EPJC track**

Machine learning augmented probes of light Yukawa couplings from Higgs pair production (live)

Thursday, 8 July 2021 15:20 (30 minutes)

The measurement of the trilinear Higgs self-coupling is among the primary goals of the high-luminosity LHC and is accessible in Higgs pair production. However, this process is also sensitive to other couplings. While most of them can be well-constrained by single-Higgs measurements, this does not hold true for the coupling between the Higgs and light quarks. We show that the Higgs pair production process provides a sensitive probe to these couplings. Making use of interpretable machine learning with boosted decision trees and Shapley values, a measure derived from cooperative game theory, we separate the signal $q\bar{q} \to HH \to b\bar{b}\gamma\gamma$ from the Standard Model HH production and other backgrounds such as HZ, $t\bar{t}H$ and $b\bar{b}\gamma\gamma$. We show that, with the help of the machine learning framework, estimated bounds on light quarks coupling to the Higgs can be significantly improved compared to other probes, *cf.* fig. 1. The introduction of the Shapley values to assess variable importance allows the possibility of using a reduced set of kinematic variables to train the machine learning model. In what would otherwise be a black-box approach of using an over-complete set of kinematic variables, Shapley values tap into kinematic correlation and hence, allow for the selection of a minimal set of important kinematic variables that provide an optimal accuracy of signal vs. background classification.

Furthermore, we explore the potential of disentangling the various new physics operators leading to modifications of the light quark Yukawa coupling and a modified trilinear Higgs self-coupling with the added interpretability of the multivariate analysis using machine learning techniques. Additional kinematics can be further incorporated to help break the degeneracy between the up and down quark operators.

Primary authors: ALASFAR, Lina (Humboldt-Universität zu Berlin); GROEBER, Ramona (Università di Padova and INFN, Sezione di Padova); GROJEAN, Christophe (DESY (Hamburg) and Humboldt University (Berlin)); Dr PAUL, Ayan (DESY, Hamburg and Humboldt Universität zu Berlin); QIAN, Zhuoni (DESY)

Presenter: ALASFAR, Lina (Humboldt-Universität zu Berlin)

Session Classification: New Detector and Reconstruction Methodologies, Machine Learning and Computing at HL-LHC

Contribution ID: **92** Type: **EPJC track**

Probing early-time dynamics with charm balance functions (live)

Thursday, 8 July 2021 17:05 (30 minutes)

For a long time it was conjectured that the large azimuthal anisotropic flow observed in heavy-ion collisions implied early thermalization. After the discovery of azimuthal anisotropic flow in small systems, where it is unclear if there is time for the system to thermalize, it was realized that one can have hydrodynamization, a phenomena in which flow can build up out-of-equilibrium (chemical and thermal). Recent calculations in kinetic theory supports such a scenario where one starts out with a purely gluonic system and the light quarks first are produced when the system is already flowing. However, this also means that one cannot access early-time dynamics with light quarks.

In this talk we propose to use low p_{T} charm quarks to study the dynamics of the hydrodynamization process. The advantage with charm quarks is that:
- they are dominantly produced early in the collision with rates that should be calculable in pQCD
- they interact with the medium building up some amount of azimuthal anisotropic flow
- they do not thermalize (forget the past) as their final yields would then essentially be zero

We propose to go beyond flow measurements by measuring the balance function of hadrons with (anti)charm. By subtracting charm-charm and anticharm-anticharm correlations from charm-anticharm correlations we want to directly deduce how the charm and anticharm quarks interacts with the system after their production. By measuring the evolution of the charm-anticharm correlation function from small-to-large systems we hope to provide direct experimental insights into the early-time QCD dynamics.

Primary author: CHRISTIANSEN, Peter (Lund University (SE))

Co-authors: SILVERMYR, David (Lund University (SE)); OHLSON, Alice (Lund University (SE)); Dr BASU, Sumit (Lund University (SE))

Presenter: CHRISTIANSEN, Peter (Lund University (SE))

Session Classification: New Detector and Reconstruction Methodologies, Machine Learning and Computing at HL-LHC

Contribution ID: **93** Type: **EPJC track**

Probing same-sign WW in hadronic signatures (live)

Tuesday, 6 July 2021 15:35 (30 minutes)

The production of two same-sign W bosons in association with two jets via vector boson scattering (VBS), ssWWjj, is a key probe of the mechanism of electroweak symmetry breaking, with the Higgs boson unitarising the process' cross-section. Longitudinal ssWWjj involves the spin-0 modes of the gauge bosons arising from EWSB, and is very sensitive to BSM physics.

With the Run-2 and Run-3 expected datasets, over 500 leptonic ssWWjj events are expected (W -> lv, l=e,mu), of which 35 events have two longitudinally polarised W boson, i.e. sWWjj(LL). More data is expected in Run-4 at the HL-LHC, but will not be sufficient to observe the process using only leptonic decays of the W boson.

The pool of ssWWjj(LL) events can be increased significantly increased by considering events with at least one hadronicically-decaying W (2/3 of W bosons decay hadronically). This is a very challenging final state given the large (by a few orders of magnitude) backgrounds.

We present ideas to systematically study ssWWjj VBS and the main backgrounds in semi-leptonic and hardonic VBS signatures, and, using substructure and jet charge techniques and deep learning, to extract the fraction of ssWWjj(LL) events.

This paper will rely on novel ideas to tackle the problem, and on combining existing tools and techniques in a novel way to probe the ssWWjj VBS signature. No use will be made of LHC experiment's infrastructure or codebases.

Primary author: POTAMIANOS, Karolos (University of Oxford (GB))

Presenter: POTAMIANOS, Karolos (University of Oxford (GB))

Session Classification: Unexplored ideas for ALICE, ATLAS, CMS and LHCb

Contribution ID: **94** Type: **EPJC track**

Thermodynamics of the 'Little Bang' (recorded)

Friday, 9 July 2021 04:05 (30 minutes)

Observation of the cosmic microwave background radiation (CMBR) by various satellites confirms the Big Bang evolution, inflation and provides important information regarding the early Universe and its evolution with excellent accuracy [1]. In little bangs, the produced fire-ball goes through a rapid evolution from partonic QGP phase to a hadronic phase, and finally freezes out. The physics of heavy-ion collisions at ultra-relativistic energies, popularly known as little bangs, has often been compared to the Big Bang phenomenon of the early Universe [2-3]. Heavy-ion experiments are predominantly sensitive to the conditions that prevail at the later stage of the collision as majority of the particles are emitted near the freeze-out. Thus, a direct and quantitative estimation of the properties of hot and dense matter in the early stages and during each stage of the evolution has not yet been possible.

In heavy-ion collisions, the mean transverse energy p_{T} is a proxy of the temperature and the mean number of charged particles (<N_{ch}>) is a manifestation of energy or entropy density. The major motivation of our study is to generate a map of ϵ and T, similar to the CMBR map, using fluctuation and correlation techniques.

The two-particle p_{T} correlations have been studied for long, and defined in terms of a dimensionless correlation function as a ratio of the differential correlator to the square of the average transverse momentum

$$P_2(\Delta\eta,\Delta\varphi)=\frac{\langle\Delta p_{\mathrm{T}}\Delta p_{\mathrm{T}}\rangle(\Delta\eta,\Delta\varphi)}{\langle p_{\mathrm{T}}\rangle^2}=\frac{1}{\langle p_{\mathrm{T}}\rangle^2}\frac{\int_{p_{\mathrm{T,min}}}^{p_{\mathrm{T,max}}}\rho_2(\mathbf{p}_1,\mathbf{p}_2)\ \Delta p_{\mathrm{T},1}\Delta p_{\mathrm{T},2}\ \ \Delta p_{\mathrm{T},1}\Delta p_{\mathrm{T},2}}{\int_{p_{\mathrm{T,min}}}^{p_{\mathrm{T,max}}}\rho_2(\mathbf{p}_1,\mathbf{p}_2)\ \ \Delta p_{\mathrm{T},1}\mathrm{d}p_{\mathrm{T},2}},$$

where is the inclusive average momentum of produced particles in an event ensemble. Technically, in this type of analysis, integrals of the numerator and denominator of the above expression are first evaluated in four-dimensional space as functions of . The ratio is calculated and subsequently averaged over all coordinates. But when p_{T} is used a proxy to system temperature, it is affected by the radial flow, and falls short to capture the true 'temperature' fluctuation.
To overcome this, we propose a 4-particle p_{T} and number fluctuations where the non-flow effect are suppressed. With this, we can link it to the thermodynamic response functions like specific heat, heat capacity and compressibility. With the advent of high luminosity and high statistics runs in Run3 and Run4 of CERN Large Hadron Collider (LHC), it will be possible to generator 4-particle correlations. The ALICE experiment is expected to take data in LHC Run5 with a completely new detector covering 8 units in rapidity. For these runs, the fluctuation map can be more effective to extract relevant physics towards thermodynamics of hot and dense matter.

References:

1. E. Komatsu and C. L. Bennett (WMAP science team)arXiv:1404.5415 [astro-ph.CO].

2. W. Florkowski, Phenomenology of Ultra-relativistic Heavy-ion Collisions, World Scientific, 2010.

3. U. Heinz, J. Phys.: Conf. Ser.455, 012044 (2013).

Primary authors: Dr BASU, Sumit (Lund University (SE)); Prof. PRUNEAU, Claude Andre (Wayne State University (US)); Dr NAYAK, Tapan (CERN, Geneva and NISER, Bhubaneswar)

Presenter: Dr BASU, Sumit (Lund University (SE))

Session Classification: New Detector and Reconstruction Methodologies, Machine Learning and Computing at HL-LHC

Contribution ID: **95** Type: **Poster**

The ATLAS Muon RPC system upgrade for the High Luminosity LHC

The present Resistive Plate Chambers (RPC)trigger system in the ATLAS muon barrel was designed according to a reference luminosity of 10ˆ34 cm-2 s-1 with a safety factor of 5, with respect to the simulated background rates, corresponding to about 300 fb-1 integrated luminosity. HL-LHC will reach a 7.5 times higher luminosity, and correspondingly higher rate, an expected integrated luminosity of 5000 fb-1 and a total duration extended until at least 2040, largely increasing the detector performance and longevity required. Moreover, the present muon barrel trigger acceptance is just above 70%, due to the presence of the barrel toroid support structures.
The ATLAS muon Collaboration approved a major RPC upgrade plan, involving both detector and trigger-readout electronics, to guarantee the performance required by the physics program for the 20 years scheduled. This plan pivots on installing a layer of 272 new generation RPCs in the inner barrel (BI), to increase the redundancy, the selectivity, and provide almost full acceptance. The first 10% of the system, corresponding to the edges of the inner barrel even sectors (BIS78), is being installed as pilot of the phase-2 project. To match the performance requirements, the new RPCs will have a different structure, materials and a high performance front-end electronics. The new BI chambers and readout electronics, will substantially increase the redundancy and flexibility of the trigger algorithm, increasing its selectivity and efficiency and at the same time lowering the performance demand on the legacy RPCs, extending thus their longevity to match the HL-LHC target. A report on the upgrade project will be presented.

Presenter: XIE, Xiangyu (University of Science and Technology of China (CN))

Session Classification: Poster Session

Contribution ID: **96** Type: **Poster**

Development of the ATLAS Liquid Argon Calorimeter Readout Electronics for the HL-LHC

To meet new TDAQ buffering requirements and withstand the high expected radiation doses at the high-luminosity LHC, the ATLAS Liquid Argon Calorimeter readout electronics will be upgraded. Developments of low-power preamplifiers and shapers to meet low noise and excellent linearity requirements are ongoing in 130nm CMOS technology. In order to digitize the analogue signals on two gains after shaping, a radiation-hard, low-power 40 MHz 14-bit ADCs is developed in 65 nm CMOS. The signals will be sent at 40 MHz to the off-detector electronics, where FPGAs connected through high-speed links will perform energy and time reconstruction through the application of corrections and digital filtering. The data-processing, control and timing functions will be realized by dedicated boards connected through ATCA crates. Results of tests of prototypes of front-end components will be presented, along with design studies on the performance of the off-detector readout system.

Session Classification: Poster Session

Contribution ID: **98** Type: **Poster**

Nanosecond machine learning with BDT for high energy physics

We present a novel implementation of classification using boosted decision trees (BDT) on field programmable gate arrays (FPGA). Two example problems are presented, in the binary classification of electrons vs. photons and in the selection of vector boson fusion-produced Higgs bosons vs. the rejection of the multijet processes. The firmware implementation of binary classification requiring 100 training trees with a maximum depth of 4 using four input variables gives a latency value of about 10ns. Implementations of machine learning algorithms such as BDT will enable the level-1 trigger systems of the Run 4 LHC to be more sensitive to new physics. The work is described in [2104.03408].

Primary author: CARLSON, Ben (University of Pittsburgh)

Presenter: CARLSON, Ben (University of Pittsburgh)

Session Classification: Poster Session

Contribution ID: **99** Type: **Poster**

The superthin fixed target for the LHCb experiment in Run4

Fixed target studies at the LHC energies (SNN about 80-120 GeV) are considered as a powerful tool for exploring QCD phase diagram in a weakly known domain of densities and temperatures with variety of possible peculiarities in the EOS in entrance and exit channels in high energy heavy ions collisions. The LHCb Collaboration having implemented the SMOG2 gaseous setup with a unique feature of data taking in colliding and fixed target mode, simultaneously, plans to contribute here during Run3.
The future HL-LHC experiments in Run4 aim to take data at the essentially higher instantaneous luminosity of up to 10ˆ36 cmˆ(-2)/s. Focusing for that purpose the colliding beams in the interaction region to a spot of a few μmˆ2 implies rather strict requirements to a fixed target setup which stem out of the LHC beam intensity, stored energy and superconductive magnets quench criticality, long term integrity of radiation load on detectors, impact of vibrations on the interaction rate stability etc.
In this presentation we discuss the design of the fixed target setup based on the superthin solid targets being operated in a halo of the circulating beams. Details will be provided on the two-fold benefits of the Implementation of a fixed solid target mode.
From the physical point of view, it will extend tremendously the range of nuclei opening unexplored domain of studies on a role of ground state nuclei properties (Isospin, spin, parity, deformation, shells, neutron halo, etc.,). A-A collisions in fixed target mode generate conditions between those achieved at the SPS and those probed at RHIC. LHCb measurements in fixed target and in colliding beam mode will bridge the gap between the SPS and the LHC in a single experiment.
Another advantageous feature of a superthin fixed solid target mode stems out of its principle of construction and operation. Metal micro wire is moved in/out of the circulating beam halo to provide stable Interaction rate. The design of the experimental setup based on the 1-2 μm thick metal wires (KINR production) and MEMS (Micro Electronics Micromechanichal Systems) actuators for their movement at 3-5 sigma from the beam axis with a few nanometer step accuracy will be presented.
The results of Monte Carlo simulations are discussed for positioning of the target at the LHCb IP8 region (Z = 0 cm) as well as at the Z = - 50 cm inside the Vertex Locator (VeLo). One of the peculiarities is that instead of ˜ 30 cm long interaction region one gets really interaction point –1 μm long, only. This may lead to new ideas on how it could be explored for physics analysis (reduction of background, improvement of accuracy in vertex reconstruction, etc.). Steering of the target will be provided by the specialized system RMS-R4 operating its radiation hard metal-foil detectors for monitoring of the LHCb instantaneous luminosity.

Primary authors: CHERNYSHENKO, Serhii (National Academy of Sciences of Ukraine (UA)); PUGATCH, Valery (Institute for Nuclear Research NAS); DOBISHUK, Vasyl (National Academy of Sciences of Ukraine (UA))

Presenter: CHERNYSHENKO, Serhii (National Academy of Sciences of Ukraine (UA))

Session Classification: Poster Session

Contribution ID: **100** Type: **Poster**

Probing anomalous hZZ couplings using Higgs production in electron-proton collisions

We probe anomalous HZZ coupling through single Higgs boson production at the Large Hadron electron collider with 60 GeV (7 TeV) of electron (proton) energy. The sensitivity of CP-even and odd anomalous couplings are measured through azimuthal angle difference between scattered electron and forward jets along with cross section as a function of luminosity. Comparative studies for HWW anomalous couplings are also performed.

Primary authors: Dr SHIVAJI, Ambresh (IISER Mohali, India); Dr KUMAR, Mukesh (University of theWitwatersrand, Johannesburg); SHARMA, PRAMOD (IISER Mohali)

Presenter: SHARMA, PRAMOD (IISER Mohali)

Session Classification: Poster Session

Contribution ID: **101** Type: **Poster**

Measuring CP nature of tau−lepton Yukawa coupling at the $e^{-}p$ collider

We study the prospect of determining the CP violating phase in τ−lepton Yukawa coupling at the $e^{-}p$ Collider (LHeC). The beam energy that we have considered for the electron and proton is 150 GeV and 7 TeV respectively. The Higgs is produced through charged current as well as neutral neutral current process with a focus on the earlier because of the higher cross section. We have analyzed interesting CP odd observables utilizing the dominant tau lepton decay channel. The CP violating phase is estimated using chi square corresponding to the T-odd observables and found very promising results.

Primary authors: Dr SWAIN, Abhaya Kumar (Physical Research Laboratory); Prof. GOYAL, Ashok (University of Delhi, India.); Prof. DUTTA, Sukanta (University of Delhi, India.); Dr THAKOOR, Mukesh Kumar (School of Physics and Institute for Collider Particle Physics, University of the Witwatersrand, Johannesburg, Wits 2050, South Africa.)

Presenter: Dr SWAIN, Abhaya Kumar (Physical Research Laboratory)

Session Classification: Poster Session

Contribution ID: **102** Type: **not specified**

Farewell

Thursday, 8 July 2021 18:35 (3 minutes)

Session Classification: New Detector and Reconstruction Methodologies, Machine Learning and Computing at HL-LHC