AKPIK 12: AI Topical Day – Heavy-Ion Collisions and QCD Phases (joint session HK/AKPIK)

Time: Thursday 14:00–15:30 Location: HSZ/0105

AKPIK 12.1 Thu 14:00 HSZ/0105

Modelling charged-particle production at LHC energies with deep neural networks — •Maria Calmon Behling for the ALICE Germany-Collaboration — Institut für Kernphysik, Goethe-Universität Frankfurt, Germany

Particle production at the Large Hadron Collider (LHC) is driven by a complex interplay of soft and hard QCD processes. Modelling these interactions across center-of-mass energies and collision systems is still challenging for Monte Carlo event generators. Concise experimental data is indispensable to characterize the final state of a collision. The ALICE experiment with its unique tracking capabilities down to low transverse momenta is perfectly suited to study the bulk particle production in high-energy collisions. During the data taking campaigns of LHC Run 1 and Run 2 (2009 - 2018), a large amount of data were collected of a variety of collision systems at different center-of-mass energies. A recent measurement of charged-particle production covering all of these collision systems provides a comprehensive set of fundamental observables like the charged-particle multiplicity distributions and transverse momentum spectra as well as their correlation.

In this talk, we discuss the possibility of extending this set of discrete experimental data points into unmeasured regions by means of machine learning techniques. Training deep neural networks with ALICE data gives the unique opportunity to measure the evolution of multiplicity dependent charged-particle production across collision system sizes and energies.

Supported by BMBF and the Helmholtz Association.

AKPIK 12.2 Thu 14:15 HSZ/0105

Measurement of the Λ separation energy in hypertriton with ALICE using machine learning techniques — •Regina Michel for the ALICE Germany-Collaboration — GSI Helmholtzzentrum für Schwerionenforschung — Technische Universität Darmstadt

Hypertriton ${}^{3}_{\Lambda}$H is the lightest hypernucleus, consisting of a Λ hyperon, a proton and a neutron. It is structured as a halo nucleus, where the Λ hyperon is very loosely bound to a "deuteron core". Measurements of the Λ separation energy can be used as a test for QCD, for some models of neutron stars and to constrain the possible difference of the lifetimes of ${}^{3}_{\Lambda}$H and Λ. The Λ separation energy can be measured via the invariant mass of the hypertriton decay products. The two-body-decay ${}^{3}_{\Lambda}\mathrm{H} \rightarrow {}^{3}\mathrm{He}+\pi$ is considered. Monte Carlo simulations are conducted to simulate the hypertriton interactions and decays while propagating through the detector. A data sample from Pb-Pb collisions at a center-of-mass energy of $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV recorded with ALICE at the LHC is analyzed using machine learning techniques.

AKPIK 12.3 Thu 14:30 HSZ/0105

Physics performance studies on Ξ^- Baryon at CBM — •Lisa-Katrin Kümmerer[1,2], Andrea Dubla[2], and Ilya Selyuzhenkov[2] for the CBM-Collaboration — [1]Physikalisches Institut, Universität Heidelberg — [2]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt

The Compressed Baryonic Matter (CBM) experiment at FAIR will investigate the QCD phase diagram in the region of high net-baryon densities ($\mu_B > 500$ MeV) in the collision energy range of $\sqrt{s_{NN}} = 2.7 - 4.9$ GeV with high interaction rate, up to 10 MHz, provided by the SIS100 accelerator. The (multi)strange baryons are crucial in determining the chemical freeze-out and its connection to hadronization from deconfined QCD matter.

In this contribution the performance for Ξ^- selection in Au-Au collisions at $\sqrt{s_{NN}} = 4.93$ GeV in the CBM experiment will be presented. The Ξ^- hyperon is reconstructed via the weak decay channel $\Xi^- \rightarrow (\Lambda \rightarrow p\pi^-)\pi^-$ using the Particle-Finder Simple package.

For the reduction of the data size, which is driven by the large combinatorial background, specific skimming pre-selection criteria are optimized in this work. To obtain an optimal and stable separation between signal and background candidates the machine learning tool XGBoost is used. Machine learning allows for efficient, non-linear and multi-dimensional selection criteria to be implemented in a heavy-ion collision environment, enabling to extract and correct the Ξ^- raw yield in different rapidity and transverse momentum intervals.

AKPIK 12.4 Thu 14:45 HSZ/0105

Multi-differential Λ Yield Measurement in the CBM Experiment using Machine Learning Techniques — •Axel Puntke[1] and Shahid Khan[2] for the CBM-Collaboration — [1]Institut für Kernphysik, WWU Münster — [2]Eberhard Karls University of Tübingen

The Compressed Baryonic Matter (CBM) experiment at FAIR will investigate the QCD phase diagram at high net-baryon densities (μB > 500 MeV) with heavy-ion collisions in the energy range of $\sqrt{s}_{\mathrm{NN}} = 2.9$-4.9 GeV. Precise determination of dense baryonic matter properties requires multi-differential measurements of strange hadron yields, both for the most copiously produced K^0_s and Λ as well as for rare (multi-)strange hyperons and their antiparticles.

The strange hadrons are reconstructed using methods based on a Kalman Filter algorithm that has been developed for the reconstruction of particles via their weak decay topology. The large combinatorial background needs to be suppressed by applying selection criteria according to the topology of the decay. This selection is optimized by training a boosted decision tree-based machine learning model with simulated data from two event generators, UrQMD and DCM-QGSM-SMM. After the signal has been selected, the yield of the strange hadron is computed.

In this talk, the analysis procedure for the most abundant Λ baryon is presented and the performance of the non-linear multi-parameter selection method is evaluated. A fitting routine is implemented to extract the Λ yield, on which the performance gain of training a separate model for each p_{T}-y interval will be discussed.

AKPIK 12.5 Thu 15:00 HSZ/0105

Full beauty-hadron reconstruction with J/ψ: feasibility study for Run 3 with ALICE — •Guillaume Taillepied for the ALICE Germany-Collaboration — GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany

The study of the production of hidden and open heavy-flavour hadrons in proton-proton (pp) collisions provides an essential test of quantum chromodynamics, involving both the perturbative and non-perturbative regimes. The J/ψ meson allows to study both the charm sector, via the measurement of prompt J/ψ, and the beauty sector through the measurement of the non-prompt component, coming from the decay of beauty hadrons. With the recent upgrades of the ALICE apparatus, the full reconstruction of beauty hadrons in exclusive decay channels containing non-prompt J/ψ mesons is now possible, providing a new way to study beauty physics in hadronic collisions.

In this talk, a feasibility study of the $\mathrm{B}^+ \rightarrow \mathrm{J}/\psi\ \mathrm{K}^+$, $\mathrm{J}/\psi \rightarrow \mathrm{e}^+\mathrm{e}^-$ process in pp collisions at $\sqrt{s} = 13.6$ TeV with ALICE will be presented. The analysis makes use of the KFParticle package for a precise reconstruction of the B^+ and non-prompt J/ψ decay chain. The package also provides important information for the training of a machine learning model, increasing the signal selection efficiency and signal-over-background ratio. Discussions on the perspectives in lead-lead collisions for Run 3, based on the results of this feasibility study, will be shown.

AKPIK 12.6 Thu 15:15 HSZ/0105

Photon reconstruction in the Transition Radiation Detector of ALICE — •Peter Stratmann for the ALICE Germany-Collaboration — Institut für Kernphysik, Wilhelm-Klemm-Str. 9, 48149 Münster

The Transition Radiation Detector (TRD) of the ALICE detector at the Large Hadron Collider has the main purpose of identifying electrons and triggering on electrons and jets. Furthermore, it improves the resolution in track reconstruction at high transverse momenta. The working principle is based on transition radiation, which is produced by charged particles transversing boundaries of material with different dielectric constants.

In a rather new approach, the TRD should be used for measuring the photon production through the detection of conversion electrons. This is facilitated by the large material budget located in front and inside of the TRD. For this purpose, stand-alone tracking independent of the Inner Tracking System and the Time Projection Chamber had already been implemented. So far, this is achieved by a Kalman filter. As a new method, the photons are reconstructed in the TRD using Graph Neural Networks. These have the advantage that they operate well on the high-dimensional and sparse nature presented by the

TRD data. In this talk, we will present the principles of the TRD, the direct photon reconstruction in the stand-alone tracking, and first results obtained with the Graph Neural Network.

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