POSTER PRESENTATIONS BY YOUNG SCIENTISTS IN THE FIELD OF PARTICLE PHYSICS RESEARCH

1. **Measurements of the Cherenkov light yield in liquid scintillators at the JINR test stand**

   Author: Alexander Antoshkin

   Dzhelepov Laboratory of Nuclear Problems, JINR, Dubna, Russia

   Abstract:

   Various scientific experiments use liquid scintillators like the core sensitive element of their detectors. It is crucial to have a good knowledge of the basic properties of scintillators for precise recovering of the primary particle energy. Cherenkov light component to the liquid scintillators total light yield is one of these properties.

   The special test stand was constructed at JINR to measure the Cherenkov light contribution to the mineral oil based and LAB liquid scintillators total response. The main idea was to measure the light output below and above the Cherenkov light appearance threshold and extract its fraction.

2. **Estimation of the signal of ϕ(1020) detected at the BM@N experiment**

   Author: Ramin Barak

   Veksler and Baldin Laboratory of High Energy Physics, JINR, Dubna, Russia

   Abstract:

   This work is devoted to the search for ϕ(1020) after collisions in the Baryonic Matter at Nuclotron (BM@N) experiment, running at the NICA accelerator complex. Reconstruction efficiency of the ϕ(1020) was derived by employing a phase space analysis of a Monte Carlo data set. This result was then combined with a similar procedure applied to experimental data in order to estimate the number of detected ϕ(1020) in the collision.

3. **VMM3A-based Readout Solution for the SPD Stage-I Straw Tracker**

   Author: Vitalii Bautin

   Veksler and Baldin Laboratory of High Energy Physics, JINR, Dubna, Russia

   Abstract:

   A new front-end electrics solution has been designed for the first stage of SPD-NICA Straw Tracker. To achieve the best performance for the straw tubes, we have developed completely new schematic including differential bufferisation and external ADCs. We managed to utilize the existing VMM3A ASIC originally designed for ATLAS Micromegas detector. That helped us to achieve a low-cost design with a price of ~3-5$ per channel and a power consumption of about 20-30mW per channel. The device is a complete multichannel solution for collection, amplification, and digitization of incoming signals.

4. **Determination of the neutrino mass ordering using atmospheric neutrinos in the JUNO experiment**

Author: Nikita Bessonov

Dzhelepov Laboratory of Nuclear Problems, JINR, Dubna, Russia

Abstract:

The determination of the neutrino mass ordering is one of the key unresolved problems in modern neutrino physics. Due to its large volume, high energy resolution, capability to reconstruct particle tracks, and the possibility to statistically identify the neutrino type, the JUNO experiment has the potential to determine the neutrino mass ordering using atmospheric neutrinos. The goal of this work is to study the sensitivity of the experiment to neutrino oscillation parameters using the GNA software framework. In particular, the sensitivity to mass ordering, the octant of the mixing angle θ_{23}, and the oscillation parameters $\sin^2\theta_{23}$, Δm^2_{32} and δ_{CP} were studied. The work presents the results of calculations of the expected atmospheric neutrino spectra taking into account detector effects, as well as sensitivity results for the oscillation parameters and mass ordering.

5. **Gamma-like event selection at the TAIGA-IACT**

Author: Pavel Bezyazeekov

Dzhelepov Laboratory of Nuclear Problems, JINR, Dubna, Russia

Abstract:

The TAIGA (Tunka Advanced Instrument for Cosmic Ray Physics and Gamma Astronomy) astrophysical complex is located in the Tunka Valley (Republic of Buryatia, Russia), 50 km from Lake Baikal at an altitude of 675 meters above sea level. It is designed for the detection of extensive air showers (EAS) initiated by cosmic rays and high-energy gamma quanta. Currently, the complex includes wide-angle optical detectors Tunka-133 and TAIGA-HiSCORE, scintillation detectors Tunka-Grande and TAIGA-Muon, as well as four Imaging Atmospheric Cherenkov Telescopes (IACTs) of TAIGA-IACT.

One of the key challenges in gamma-ray astronomy observations is the separation of EAS initiated by hadrons from those initiated by gamma quanta, given their intensity ratio reaching approximately 10^5. This study presents a comparative analysis of various approaches for event separation based on IACT-recorded shower images, utilizing both traditional analysis methods and machine learning techniques. An analysis of measurement data from 2020-2023 has been carried out, and the impact of different separation approaches on the observed excess of gamma-like events in the direction corresponding to the gamma quanta source has been evaluated.

6. **Sensitivity Study for q = 1/3e Lightly Ionizing Particles in the NOvA Far Detector**

Author: Olesia Geitota

Dzhelepov Laboratory of Nuclear Problems, JINR, Dubna, Russia

Abstract:

The quantization of electric charge remains an unresolved issue within the Standard Model of the electroweak and strong interactions. We present a sensitivity study for detecting particles with fractional charge q = 1/3e in the NOvA Far Detector, a 14-kton, highly segmented (4×6 cm2) liquid scintillator detector exposed to atmospheric muons at the surface. To simulate Lightly Ionizing Particles (LIPs) in Far Detector we take as a basis muon particles with modified charge, so LIP's weakly ionize the environment. Using NOvA's fine granularity and precise calorimetry, we evaluate the detector's capability to identify the distinctive dE/dx signature of the LIPs, which should deposit much lower ionization of minimum-ionizing muons (~2 MeV cm2/g). Using cosmic muon data, advanced modeling tools and state-of-the-art analysis techniques, this study aims to contribute to the global effort to detect evidence of LIPs and constrain the physics of BSMs.

7. **Neutron Radiation Effects on the Reliability of the Cyclone V FPGA Development Board**

Author: Youmna Ghoneim

Veksler and Baldin Laboratory of High Energy Physics, JINR, Dubna, Russia

Abstract:

The Time Projection Chamber (TPC) serves as the primary tracking system for the Multi-Purpose Detector (MPD). It incorporates approximately 1500 Cyclone V FPGAs, which operate under radiation-prone environments. To investigate their performance under such conditions, we used the DE0-Nano SoC Development Board — equipped with a Cyclone V FPGA — as it closely resembles the electronic configuration of the MPD’s TPC.

This board was exposed to neutron radiation at the JINR FRANK and Neutron Laboratories, with experiments conducted remotely using QUARTUS FPGA firmware developed in Verilog HDL. Our investigation focused on monitoring the board’s operational status and evaluating the stability of data transmission during irradiation.

Radiation exposure does not always cause physical damage to electronics but can significantly degrade firmware efficiency and disrupt data transmission. One of the critical concerns is radiation-induced instability in the FPGA's power supply module, which may lead to unreliable performance, logic faults, or even hardware failure. Furthermore, compromised power or memory integrity can reduce the performance of the embedded ARM processor, rendering the board unsuitable for demanding applications.

To mitigate these effects, we applied various shielding materials — paraffin, borated polyethylene, and cadmium sheets — around the development board, USB connectors, Micro-USB, and Ethernet interfaces, ensuring that only the FPGA processor itself was directly exposed to neutron radiation.

Post-irradiation, we assessed the performance of the Cyclone V FPGA and evaluated the power efficiency of the board via USB input connectors, noting significant degradation due to radiation exposure. Additionally, we placed silicon sensors over the FPGA processor during irradiation to estimate neutron fluence through measurements of increased leakage current — an indicator of radiation-induced damage in silicon.

8. **Fluxes of atmospheric muons and neutrinos and their characteristics in the range of 100 GeV-10 PeV**

Author: Anna Gridina

Dzhelepov Laboratory of Nuclear Problems, JINR, Dubna, Russia

Abstract:

Neutrino and muon fluxes in the range from 100 GeV to 10 PeV are generated in weak decays of mesons and baryons formed because of the interaction of cosmic rays with the Earth's atmosphere. Comparison of the calculated spectra of atmospheric muons and neutrinos with experimental data allows one to obtain information on the details of the development of a cascade shower, makes it possible to study the parameters of primary cosmic rays, as well as the contributions of various decay modes of unstable hadrons. The report presents the results of calculating the spectral and zenith-angular characteristics of atmospheric muon and neutrino fluxes for a few models of hadron-nucleus interactions and models of the energy spectrum and elemental composition of primary cosmic rays, performed within the framework of a single computational scheme. A comparison of the calculated characteristics with the results of measurements on the IceCube and ANTARES neutrino telescopes is given.

9. **Offline data processing system for the SPD experiment**

Author: Alexey Konak

Meshcheryakov Laboratory of Information Technologies

Abstract:

The SPD (Spin Physics Detector) facility at the NICA accelerator complex at JINR is under construction. In addition to the physics facility itself, the software for the future experiment is also being developed. There is already a constant demand for sufficiently large-scale data productions to simulate physical processes in a future experiment. To facilitate their implementation, MLIT staff are developing a set of systems and services that allow for the orderly storage and processing of experimental data both on JINR resources and on the resources of the institutes that are members of the SPD collaboration. The presented systems and services are in trial operation. Over the past six months, the system has modeled more than 1 billion physical events for the benefit of the physical experiment groups and obtained more than 200 TB of data.

10. **Analysis of the Drell-Yan process based on RUN2 open data from the CMS experiment**

    Author: YuriI Korsakov

    Meshcheryakov Laboratory of Information Technologies

    Abstract:

    In this work, the results of the analysis of the Drell-Yan process using open CMS data from 2015 are presented. The dataset corresponds to an integrated luminosity of 2.64 fb^{-1} at a center-of-mass energy of 13 TeV. The differential cross section of the Drell-Yan process and the kinematic properties of the muon pair were calculated.

11. **Directed flow of protons in Xe+CsI collisions at the beam energy of 3.8A GeV with the BM@N experiment**

    Author: Mikhail Mamaev

    Veksler and Baldin Laboratory of High Energy Physics, JINR, Dubna, Russia

    Abstract:

    In heavy-ion collisions at beam energies of several GeV per nucleon, hot and dense strongly interacting matter is formed—a state of matter akin to that found in astrophysical environments such as neutron star interiors and neutron star mergers. Collective flow, particularly the directed flow of particles produced in these collisions, serves as a sensitive probe of the properties of this extreme matter. We present the first measurements of proton directed flow in Xe+CsI collisions at 3.8A GeV, obtained by the BM@N experiment during its 2023 data-taking campaign. The results show good agreement with existing world data, confirming the consistency of our measurements with previous experimental findings. Additionally, we compare our data with theoretical predictions from the Jet-AA-Model, providing new insights into the dynamics of nuclear matter under extreme conditions.

12. **Investigation of Alpha Particle Emission in Nuclear Track Emulsion Irradiated by Relativistic Muons**

    Author: Natarajan Marimuthu

    Veksler and Baldin Laboratory of High Energy Physics, JINR, Dubna, Russia

    Abstract:

    Fragmentation of atomic nuclei was first identified in nuclear photographic emulsion layers exposed to cosmic ray irradiation. The exposure of nuclear track emulsion (NTE) layers to relativistic muons provides a unique opportunity to investigate nuclear multifragmentation processes induced by a purely electromagnetic probe. As part of the BECQUEREL experiment, NTE detectors were exposed to a relativistic muon beam to investigate muon-induced nuclear interactions. The primary objective was to identify and precisely measure short-range alpha particle tracks resulting from these interactions. Such tracks are produced through the 3α disintegration of carbon nuclei via the reaction $\mu + {}^{12}C \rightarrow \mu' + 3\alpha$, initiated by relativistic muons. SRIM simulations were used to

calculate the energy loss of alpha particles in NTE, enabling accurate reconstruction of their kinetic energies. Track geometry analysis allowed for precise determination of the emission angles of the alpha particles. This approach also facilitated the extraction of invariant mass spectra for various alpha particle combinations. The results were compared with those from organic scintillators used in studies of 3α fragmentation of 12C nuclei. This comparison provides further insight into the mechanisms of muon-induced interactions across different detection media.

13. **Separation of particle trajectories by beam collision events accumulated in a single time slice in the SPD detector at the NICA accelerator using graph neural networks**

Author: Saveliy Omelyanchuk

Meshcheryakov Laboratory of Information Technologies

Abstract:

This work is devoted to the development of deep learning methods for the classification of elementary particle tracks. The paper explores the architecture of a graph neural network (GNN) for track classification by events in each time slice in the SPD experiment. A new approach to track sorting is presented, along with an investigation of learning dynamics and model testing under various conditions. The model is implemented and trained using modern deep learning tools that enable parallel tensor computations.

14. **Performance study of the MPD fixed-target setup for anisotropic flow measurements at NICA**

Author: Petr Parfenov

Veksler and Baldin Laboratory of High Energy Physics, JINR, Dubna, Russia

Abstract:

A primary objective of the beam energy scan program at the Nuclotron-NICA facility is to investigate the properties of dense baryonic matter through relativistic heavy-ion collisions in the energy range √sNN=2–5 GeV. These studies aim to constrain the equation of state (EoS) and probe potential phase transitions in high-baryon-density matter. We present a systematic performance study of the Multi-Purpose Detector (MPD) in its fixed-target configuration (MPD-FXT) for measuring differential anisotropic flow of identified charged hadrons at a beam energy of T=2.5A GeV (√sNN=2.87 GeV), utilizing both symmetric (Xe+Xe) and asymmetric (Xe+W) collision systems. The analysis employs comprehensive simulations incorporating full detector response and event reconstruction procedures specific to the NICA experimental environment.

15. **Dilepton Measurements in the MPD Experiment at NICA**

Author: Sudhir Pandurang Rode

Veksler and Baldin Laboratory of High Energy Physics, JINR, Dubna, Russia

Abstract:

The Multi-Purpose Detector (MPD) experiment is a flagship heavy-ion research project at the NICA accelerator complex in JINR, scheduled for commissioning in 2026. The experiment will operate at center-of-mass energies of √sNN = 4–11 GeV (collider mode) and √sNN = 2.4–3.5 GeV (fixed-target mode) and explore the high net-baryon density region of the QCD phase diagram. Dilepton measurements in heavy-ion collisions serve as a powerful probe of the hot and dense nuclear medium, providing information about the initial temperature as well as chiral symmetry restoration and fireball lifetime.

The MPD experiment is uniquely equipped for the measurements of dileptons. It offers excellent track reconstruction by the Time Projection Chamber (TPC) and in addition, electron identification along with superior electron-hadron separation with help of Time-Of-Flight (TOF) and Electromagnetic Calorimeter (ECal) subsystems. In this poster presentation, the prospects and the detector performance for the electron identification and dilepton measurements together with Key physics feasibility studies demonstrating capabilities of MPD experiment will be presented.

16. **The SPD Online Filter middleware**

Author: Leonid Romanychev

Meshcheryakov Laboratory of Information Technologies

Abstract:

«SPD Online Filter» is a hardware-software system designed for multi-stage, high-throughput processing of data from the SPD detector. Its main task is the primary processing of data, in order to reduce its volume for long-term storage and subsequent full processing. The «SPD Online Filter» comprises a dedicated compute cluster, a middleware software, and a set of application-level services. The middleware layer consists of three microservice-based systems that communicate via lightweight API gateways for request routing and a message broker to decouple producers and consumers. Together, they form a configurable, fault-tolerant, and scalable data-processing pipeline.

This poster illustrates the architecture of the overall system and its constituent subsystems, demonstrates the coordinated interaction among components, and shows how they work together to deliver reliable, scalable, real-time processing of raw detector data to meet the SPD experiment's requirements.

17. **Search for dark matter particles predicted by the scalar portal model with a two-doublet expansion of Higgs sector and one extra singlet**

Author: Kirill Slizhevskii

Meshcheryakov Laboratory of Information Technologies

Abstract:

The CMS experiment at the LHC investigates the possibility of physics beyond the Standard Model. To search for candidates for dark matter (DM) particles, Z boson events with large missing transverse momentum in the final state are used. The analysis is based on data at the center-of-mass energy of 13 TeV collected during of the LHC's second operating period RUN2 detector operation, which corresponds to an integrated luminosity of 137 fb^{-1}. The results of the analysis used to constrain the parameters of simplified DM models with vector, axial-vector, scalar, pseudoscalar mediators and a two-doublet Higgs model (2HDM+a) with an additional pseudoscalar mediator. We present a simulation of signal processes for 2HDM+S/a, performed using the MadGraph5 and Pythia8 generators, which are used in the analysis of the LHC's third operating period RUN3 with an energy of 13.6 TeV.

18. **Graph neural network with attention and two-stage aggregation for particle track reconstruction in the TPC MPD of NICA complex**

Author: Yauheni Talochka

Meshcheryakov Laboratory of Information Technologies

Abstract:

One of the main challenges for the TPC MPD at the NICA accelerator complex, under the extremely high interaction frequency reaching megahertz levels, which significantly increases the volume of data recorded by detectors, is the reconstruction of particle tracks. We present a Graph Neural Network with an attention mechanism and two-stage aggregation for particle track reconstruction in the TPC MPD of the NICA. A dataset of 1000 Au-Au collision events generated with MPDRoot was utilized to train the GNN model. We demonstrate that the introduction of the attention mechanism and two-stage aggregation allows improving the performance of the GNN in edge classification, achieving 96.2% accuracy and 92.6% in both purity and efficiency. Meanwhile, the track reconstruction efficiency was evaluated to be greater than 90% for track integrities below 80%, but it drops sharply to 48% for higher integrity thresholds.

19. **Nuclear modification factor of inclusive charged particles and strange hadrons in Au+Au collisions with the STAR experiment**

Author: Artem Timofeev

Veksler and Baldin Laboratory of High Energy Physics, JINR, Dubna, Russia

Abstract:

The exploration of the Quantum Chromodynamics (QCD) phase diagram via heavy-ion collisions is central to understanding the transition from hadronic matter to a deconfined quark-gluon plasma (QGP). The nuclear modification factor, particularly R_{CP} , serves as

a key observable for probing parton energy loss and the properties of the created hot and dense medium. Simultaneously, strange hadrons provide unique insights into the QCD transition and chemical freeze-out conditions due to their sensitivity to strangeness enhancement – a proposed signature of QGP formation. The STAR experiment's Beam Energy Scan (BES) program offers a powerful opportunity to study these probes across a broad range of collision energies.

We present measurements from the STAR experiment on the nuclear modification factor (R_{CP}) for inclusive charged particles in Au+Au collisions at BES energies. These results, based on significantly enhanced statistics from BES-II, are compared to model calculations (e.g., URQMD) and earlier BES-I findings to critically evaluate theoretical descriptions of parton energy loss and medium effects at lower collision energies. The behavior of R_{CP} at higher transverse momenta (p_T) is analyzed to investigate potential jet quenching signatures in the BES energy regime.

Additionally, we extend our investigation to the nuclear modification of strange hadrons. The simultaneous study of charged particles and strange hadrons allows for a comprehensive comparison of medium modification effects. Precise measurements of strangeness production and its modification factor provide crucial information on the degree of strangeness enhancement, the dynamics of the hot medium, and the chemical freeze-out parameters, offering deeper insights into the formation and properties of QGP-like matter at the BES energies.

20. **Study of Λ hyperons directed flow in Xe+Cs(I) collisions at E_{kin}=3.8 AGeV with BM@N experiment**

Author: Valerii Troshin

Veksler and Baldin Laboratory of High Energy Physics, JINR, Dubna, Russia

Abstract:

The study of nuclear matter at high baryon densities is one the main goals of beam energy scan programs in relativistic heavy-ion collisions ($\sqrt{s_{NN}}$~2.4–11 GeV), aiming to explore the QCD phase diagram and search for signatures of a first-order phase transition and critical point. Anisotropic flow observables, particularly the directed flow (v_1) of strange hadrons like Λ hyperons, provide crucial insights into the early-stage dynamics and baryon transport, probing both the equation of state and the transition between partonic and hadronic degrees of freedom in dense matter.

We present the first measurements of directed flow for Λ hyperons in Xe+Cs(I) collisions at E_{kin}=3.8 AGeV obtained by the BM@N experiment.

21. **Deuteron directed flow in the recent physical data of Xe+CsI collisions at 3.8A GeV from the BM@N experiment**

Author: Irina Zhavoronkova

Veksler and Baldin Laboratory of High Energy Physics, JINR, Dubna, Russia

Abstract:

Collective flow measurements in heavy-ion collisions provide a powerful tool to study the properties of strongly-interacting matter under extreme conditions. The initial spatial asymmetry of the energy distribution of the colliding nuclei results in the collective anisotropy of the produced particles. The anisotropy formation is governed by the transport properties of the created matter. Hence the collective flow is a suitable observable to constrain the transport coefficients. Besides, the v1 and v2 flow coefficients are sensitive to the EOS, with those of light nuclei being presumably more sensitive than of protons, providing even tighter constraints on EOS. Moreover, studying the light nuclei collective flow can provide insights into their production mechanism in heavy-ion collisions at energies of a few GeV per nucleon. We present the first measurements of deuteron v1 in Xe+CsI collisions at 3.8A GeV, obtained during the BM@N experiment's physics run of 2023. Our results are compared with existing data from other experiments, and we further examine the scaling of directed flow with mass number.

22. **Study of strange particle production in Xe+CsI interactions at $\sqrt{s}$ = 3.26 AGeV at the BM@N experiment**

Author: Roman Zinchenko

Veksler and Baldin Laboratory of High Energy Physics, JINR, Dubna, Russia

Abstract:

Study of the strangeness production is one the main physics topics of heavy-ion experiments. Strange probes provide information about properties of hot and dense nuclear matter produced in high-energy nuclear interactions, in particular, its equation of state.

In December, 2022 - January, 2023 the BM@N experiment conducted its first physics run with full detector configuration. Over 500 million events of Xe+CsI interactions with the Xe beam kinetic energy of 3.8A GeV were recorded. Currently, the collected event statistics is being actively analyzed. Some preliminary results of the physics analysis related to study of the production of K^0_S mesons and Λ hyperons are presented such as lifetime measurements, transverse mass and rapidity spectra.