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

1. **Analysis and preparation for the two SRC experiments at BM@N**

Author: Timur Atovullaev

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Abstract:

The first (2018) and the second (2022) SRC experiments at JINR took place at the BM@N facility using the liquid hydrogen target and 12C beams of momentum around 46 GeV/c from Nuclotron-NICA. The main goal of the experiments is the study of hard quasi-elastic knockout of a single nucleon in the reaction 12C(p,2p)11B and short-range correlated (SRC) pairs in reactions 12C(p,2p)10B and 12C(p,2p)10Be at large momentum transfer. This talk presents the speaker's contribution to the two SRC experiments at JINR both in hardware and analysis. In particular, charge amplitude calibration and fragment identification for the 2018 experiment; magnetic shielding simulation, silicon detectors (Si) alignment, Si-MWPC tracking, fragment momentum reconstruction, and fragment identification for the 2022 experiment.

2. **SPD detector description and GeoModel**

Author: Aytadzh Allakhverdieva

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Abstract:

The SPD is a planned spin physics experiment at the second interaction point of the NICA collider, which is under construction at JINR. Detector description is an essential component of the SPD offline software. It is used in simulation, reconstruction, and analysis of experimental data. The GeoModel package was chosen for the SPD detector description. The description of a part of the first-stage subsystems will be presented. Additionally, the results of using the detector model in simulations will be demonstrated. The use of the detector model for reconstruction, accessing, and navigating among geometry objects will also be discussed.

3. **Development of a Luminosity Detector for NICA MPD**

Author: Mikhail Buryakov

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Abstract:

A luminosity detector has been developed for the initial commissioning of the NICA collider at JINR, designed to efficiently register events during collisions of light nuclei bunches. Luminosity, a key parameter for particle colliders, is particularly challenging to measure accurately in hadron colliders. The detector supports beam alignment and luminosity monitoring at the MPD interaction point, enabling the control of the transverse beam profile and relative beam positions.

The detector comprises two planes symmetrically positioned 300 cm from the interaction point. Each plane consists of four modules, each containing eight plastic scintillators ($10\times10\times95$ mm^3) with silicon photomultipliers (SiPMs) for readout. Custom electronics based on NINO ASIC were developed. Signals are transmitted to an HPTDC-based DAQ via LVDS cables. Developed and tested the detector demonstrates robust performance for luminosity measurements.

4. **Exploring Exotic and Non-Standard Phenomena in the NOvA Experiment**

Author: Olesia Geitota

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Abstract:

The quantization of electric charge remains an unresolved issue within the Standard Model of the electroweak and strong interactions. Since Millikan's oil drop experiment first demonstrated the discrete nature of electric charge, numerous experiments have refined the definition of unit charge (e) and searched particles with fractional charges. Interest in such particles increased dramatically with the advent of the quark model proposed by Gell- Mann and Zweig in 1964, which successfully explained the deep inelastic scattering experiments of the late 1960s. Although this model is now the cornerstone of the Standard Model, it restricts quarks to baryons and mesons with integer charges, leaving no room for free fractionally charged particles under standard conditions. Decades of searches for long-lived fractionally charged particles (FCPs) have been conducted in various cosmic ray experiments. Previous cosmic ray FCPs searches have relied on underground experiments such as MACRO, Kamiokande-II, and LSD, as well as on space experiments including the Space Shuttle-launched AMS-01, the BESS upper-atmosphere balloon, and the Dark Matter Experiment (DAMPE). Unlike the underground experiments, which require FCPs energies of the order of hundreds of GeV, the orbital searches started with energies of only a few GeV. Despite significant efforts by underground and in-space experiments, no evidence for such particles has been found. However, these searches have established strong flux limits.

5. **3 Flavor Oscillation Analysis of 10 Years of NOvA Data**

Author: Anastasiia Kalitkina

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Abstract:

An accelerator long-baseline neutrino experiment with two detectors, near and far, such as NOvA, can provide precise measurements of neutrino oscillation parameters and shed light on neutrino mass ordering and charge-parity symmetry violation in the lepton sector. NOvA utilizes a muon neutrino or antineutrino beam, provided by the NuMI facility at Fermilab (US), to study two channels in the far detector: muon (anti-)neutrino disappearance and electron (anti-)neutrino appearance. The experiment began collecting data in 2014. Thus, this poster presents the results of the 3-flavor oscillation analysis of 10 years of data, equivalent to 26.6×10^{20} protons-on-target (POT) of neutrino data and 12.5×10^{20} POT of antineutrino data. The analysis has been performed using both

Bayesian and frequentist approaches, yielding results that are consistent with each other and with previous NOvA 3-flavor analysis results. A new world-leading precision for the atmospheric neutrino mass splitting Δm_{32}^2 measured in a single experiment have been achieved by NOvA in this analysis.

6. **On the newly formed nuclei at the NICA energies and how to find their origin**

Author: Viktar Kireyeu

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Abstract:

The formation of weakly bound clusters in the hot and dense environment at midrapidity is a surprising phenomenon observed in heavy-ion collisions across a wide range of energies, from a few GeV to several TeV.

Three primary mechanisms have been proposed to explain cluster production: coalescence at kinetic freeze-out, dynamic formation throughout the potential interactions between nucleons, and deuteron production through hadronic reactions.

In our study we identify the experimental observables that can differentiate these production mechanisms by employing the Parton-Hadron-Quantum-Molecular Dynamics (PHQMD) transport approach.

Using three different equations-of-state (EoS) for nuclear matter -- two static EoS('soft' and 'hard') and a momentum-dependent EoS, we also explore the influence of the EoS on collective observables such as directed flow (v1) and elliptic flow (v2) of nucleons and light clusters at GeV beam energies.

The results indicate that the momentum-dependent potential impacts rapidity and transverse momentum spectra differently than flow coefficients, with the best match to HADES and FOPI data on flow coefficients achieved with a momentum-dependent EoS.

Additionally, a scaling behavior of v2 versus pT with atomic number A is observed, suggesting that flow observables can also aid in identifying cluster production mechanisms.

7. **Improving particle identification in the SFGD for ND280 using neural networks.**

Author: Victoria Kiseeva

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Abstract:

The Super-Fine-Grained Detector (SFGD) in the T2K experiment is designed to identify particles such as protons, muons and pions, allowing a deeper understanding of neutrino interaction properties.

Traditionally, Boosted Decision Trees (BDTs) have been used for Particle Identification (PID), but this work aims to improve the efficiency and accuracy of PID by introducing Neural Networks (NNs) as a classification model.

Logistic Regression and Decision Trees are used as baseline models to find opportunities for improvement. In the future, we plan to implement a custom neural network tool, which is currently under development, to improve classification efficiency.

8. **Modelling of light (hyper)nuclei production in heavy-ion collisions at NICA energies based on generator THESEUS**

Author: Marina Kojevnikova

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Abstract:

In this work we studied production of the light-(hyper)nuclei (deuterons, tritons, ^3He, ^4He4, $^3_\Lambda H$ and $^4_\Lambda He$ nuclei) implementing the thermodynamical approach in the updated THESEUS (Three-fluid Hydrodynamics-based Event Simulator Extended by UrQMD final State interaction) generator: THESEUS-v2. In this approach light (hyper)nuclei are treated on the equal basis with hadrons, i.e. using only thermodynamic quantities deduced from simulations within 3FD model (3-Fluid Dynamics). This approach is perfectly suited for heavy-ion collisions at NICA energies.

The afterburner stage in the generator is modeled by UrQMD (Ultra-relativistic Quantum Molecular Dynamics). For light (hyper)nuclei this model does not work, therefore we imitated this afterburner late freeze-out of light nuclei.

The performed modeling confirmed the efficiency of the thermodynamical approach and showed reasonable agreement of the results with the available experimental data of the NA49 and STAR collaborations in the energy range $\sqrt{s_{NN}}$ from 3 to 19.6 GeV and at different centralities. We obtained quite good description of rapidity distributions, p_T- and m_T- spectra, reasonable results on the different particle ratios (d/p, t/p, t/d and tp/d^2) depending on the collision energy, and also to studied the collective flows: directed v_1 and elliptic v_2. We analyzed influence of contributions of unstable states of $^4He*$ nuclei on the yields of deuterons and ^3He, and found the necessity of taking them into account to ^3He yields.

9. **Measurement and control of the Luminosity of the NICA collider**

Author: Genadii Milnov

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Abstract:

Collider experiments have fundamental limitations on the number of interactions at the intersection point. In this way, they differ from experiments with a fixed target, when, within certain limits, the number of interactions (counting rate) can be changed by changing the thickness of the target. The counting rate is proportional to the reaction cross-section and the collider parameter, which is called luminosity and is denoted by $\mathscr{L}$. Along with the maximum attainable energy, luminosity is a key characteristic of the collider. Knowledge of this parameter, which depends on both the energy of the collisions and the type of colliding particles, is necessary already at the experimental planning stage when estimating the speed of the statistics set.

Knowledge of the magnitude of the absolute luminosity is necessary for carrying out difference measurements, such as obtaining information about neutron-neutron scattering from data on proton-proton and deuteron-deuteron scattering. The magnitude of the absolute luminosity is necessary when comparing experimental results with models for Au+Au scattering without using normalization constants.

The detector proposed for measuring absolute luminosity ("luminosity detector") is based on the topology of heavy ion collisions. A feature of such collisions is that a large number of nucleons from colliding nuclei (spectator nucleons) move in the direction close to each of the beams. Based on this, a detector consisting of two "arms" was proposed to determine the absolute luminosity at the points of convergence of the NICA collider beams. The "shoulders" are symmetrically positioned on both sides of the interaction point at a distance of 300 cm. In turn, each "shoulder" consists of four planes containing eight strips of plastic scintillator in the form of a parallelepiped measuring 1x1x10 $см^3$. The planes are located around the ion conductor, which is a tube with a diameter of 13 cm.

At this stage, a detector based on a fast plastic scintillator is being created. To effectively isolate useful events from scattering on the residual gas and determine the position of the interaction vertex in the event, the time resolution of each of the arms should be at least 0.16 - 0.2 nanoseconds. Before launching into production, R&D studies were conducted, including the time characteristics of scintillation bands with signal removal using silicon photomultipliers (SiPM). Finally, the "luminosity detector" will consist of strips of a plastic scintillator (based on polystyrene), viewed from two sides by HAMAMATSU S14160-6050HS silicon photomultipliers. To increase light collection, scintillators are wrapped in reflective material (Al Mylar). The scintillation strips will be covered with black paper to insulate them from light.

As part of the work on preparing the "luminosity detector" for use, it was performed:

1. Twelve detector modules with new front-end electronics are assembled (with lower power consumption than in the first version);

2. A farm has been designed and manufactured to fix the detector arm. A module movement system has been developed and assembled;

3. A stand has been created for debugging and testing modules on cosmic radiation;

4. On the basis of detectors and a fixing truss, a stand has been assembled (building 3, room213) to test the movement system of the luminosity detector modules;

5. A test session was successfully conducted on the derived CERN SPS beam to optimize the reading channels;

6. According to the results of beam tests, a time resolution of ~ 64 ps was obtained with an efficiency of 99%;

7. A task has been prepared for the integration of a luminosity detector into a multi-purpose MPD detector.

10. **Wire techniques application for magnetic axis measurement of NICA Collider quadrupoles**

Author: Ilya Nikolajchuk

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Abstract:

Wire techniques are precise methods for main magnetic field parameters measurement of accelerators magnets. Vibrating wire method was used for magnetic axis position determine of NICA Collider quadrupoles (JINR, Dubna). Measurement results are used for correct magnets alignment at accelerator ring. Main results of carried out measurement and studies are presented. Closed orbit modelling shows emphasize practical value of obtained measurement data for magnets alignment.

11. **Development of a position-sensitive detector system using the CAEN Front-End Readout System DT5202**

Author: Sergey Romakhov

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Abstract:

A position-sensitive detector based on a scintillator with light-guiding fiber strips and SiPM readout is presented. The detector reconstructs particle coordinates by analyzing amplitude signals from multiple channels, where the particle's position is estimated using a weighted signal approach. The CAEN FERS DT5202 front-end electronics ensure precise signal acquisition and processing. Such detectors are well-suited for building position-sensitive muon telescopes and addressing various other applications, including particle tracking and beam diagnostics. This poster illustrates the detector design, raw and normalized data processing in CERN ROOT, and coordinate reconstruction, supported by graphical results.

12. **Measurement of the Drell-Yan Angular Coefficients in pp collisions at $\sqrt{s} = 13$ TeV as a function of transverse momentum and rapidity**

Author: Vladislav Shalev

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Abstract:

The poster reports a measurement of the eight angular polarization coefficients, $A_0 - A_7$, in the Drell-Yan process using the muon channel. The analysis is based on proton-proton collision data collected by the CMS detector at the LHC at a center-of-mass energy of $\sqrt{s} = 13$ TeV, corresponding to an integrated luminosity of \$140.1\fbinv\$. The coefficients are determined double differentially in eight intervals of transverse momentum and two intervals of rapidity of the muon pair. The results are presented for the \$\PGm\PGm\$ invariant mass range \$81<m\$\$_{\PGm\PGm}\$\$<101\$ GeV/\$c^2\$ and are compared to theoretical predictions from Monte Carlo simulations incorporating next-to-next-to-leading order perturbative Quantum Chromodynamics and next-to-leading order electroweak corrections.

13. **Free-streaming data acquisition system for the modernized silicon tracking system of the BM@N experiment**

Author: Mikhail Shitenkov

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Abstract:

The results of the development of the high-speed free-streaming data acquisition system to be used for the upgraded silicon tracking system of the BM@N experiment are presented.

The data acquisition system comprises front-end electronics, concentrator unit and the back-end interface for the server node. The front-end electronics for the data readout from CBM/BMN modules are based on the STS-XYTER ASICs. The hardware-software complex based on FPGA provides a 4,8 Gbit/s bidirectional optical link between 48 front-end ASICs equal to 6 144 detector channels, and data processing boards in the server nodes. The data processing boards concentrate and pre-process the data stream and are capable of filtering incoming data according to the BM@N trigger, as well as providing an interface for the configuration and control of the readout electronics. The prototype of the data acquisition system equipped with six CBM/BMN modules was successfully tested with a 1 GeV proton beam at PNPI (Gatchina). It has been demonstrated that free-streaming detector electronics are capable of operating at detector occupancies up to 360 kHz/cm². A free-streaming readout chain can also be operated with a triggered-based event builder system with a maximum trigger rate of 78 kHz. These parameters satisfy the requirements of the BM@N experiment.

14. **Construction of the ISCRA and SIMBO stations for applied research on high-energy ion beams. Radiation hardness testing of microchips by low energy pulsed ion beams at the SOCHI station**

Author: Aleksey Slivin

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Abstract:

The implementation of the NICA (Nuclotron based Ion Collider fAcility) mega-science project at the VBLHEP JINR opens wide opportunities for development of applied research in such areas of science as: radiation hardness testing of semiconductor devices, the challenges for modern medicine and biology, radiation materials science. The ARIADNA (Applied Research Infrastructure for Advanced Developments at NICA fAcility) infrastructure, which is currently being created at VBLHEP, includes the following stations for applied research: the Irradiation Setup for Components of Radioelectronic Apparatus (ISCRA), the Setup for Investigation of Medical Biological Objects (SIMBO); the Station Of CHip Irradiation (SOCHI).

The description and current status of the ISCRA station, the prototype of the detector part of the ISCRA station (DPS-NICA), SIMBO and SOCHI stations are presented.

The poster includes the results of commissioning tests with ionizing radiation source at the ISCRA and SIMBO stations, the results of single event effects (SEE) testing of decapsulated microchips by pulsed heavy ion beams at low energy at the SOCHI station during five beam runs.

15. **The Super-FGD detector as part of the T2K ND280 upgrade.**

Author: Ilya Vasilyev

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Abstract:

The T2K experiment explore the fundamental parameters of neutrinos, such as mass hierarchy, oscillation angles and degree of CP violation. Between 2022 and 2024, the near-field detector ND280 was being upgraded including the installation of a new Super-FGD active target consisting of nearly two million light-isolated scintillation cubes with facet dimensions of 1x1x1 cm, with light captured by WLS fibers in three orthogonal directions. At present, the T2K experiment continues to collect data and the first neutrinos have already been registered by the new detector. The report briefly presents the main stages of the Super-FGD creation and the contribution of the JINR group.

16. **Fast Neutrino Oscillation in Short Baseline Reactor Antineutrino Experiments**

Author: Vitalii Zavadskyi

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Abstract:

Nuclear power plants are actively used to study the properties of neutrinos due to the intense Î½ e flux, which makes possible to accumulate significant statistics. In short baseline experiments, where the distance between the reactor and the detector is less than 100 meters, it is important to take into account the smearing of the oscillation base to avoid overestimating of sensitivity to fast neutrino oscillations.

This work presents the results of accounting for this smearing for a 15 m oscillation baseline and compares them with a point-like model.

17. **Methods and complexes of experimental data processing of the electromagnetic calorimeter (ECal) and the Time-of-Flight detector (TOF) MPD**

Author: Victor Baryshnikov

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Abstract:

The Multipurpose Detector (MPD) is one of the main experimental setups at the NICA accelerator complex of JINR. The electromagnetic calorimeter (ECal) and the Time-of-Flight system (TOF) are important components of MPD and are designed to identify particles by measuring energy and time of flight, respectively. Both detectors are complex multicomponent systems containing readout electronics, which, together with the data acquisition system (DAQ), allows digitizing the electrical signals and record data in binary TLV format.The paper presents the results of the development of methods and complexes for experimental data processing of the electromagnetic calorimeter and a Time-of-Flight detector. The main attention is paid to the reconstruction of TOF and ECal data, calibration and correction methods, and online monitoring of the electromagnetic calorimeter.