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

1. A study of the correlation between the kinetic energy of a track and its energy response in the ZDC for run7 on the BM@N experiment.

Author: **Alishina Ksenia**
Veksler and Baldin Laboratory of High Energy Physics, JINR, Dubna, Russia
Abstract:

BM@N (Baryonic Matter at Nuclotron) is the first fixed-target experiment at the ion – accelerating complex Nuclotron/NICA at JINR (Dubna, Russia). At Nuclotron energies up 2 to 4.5 GeV, the nucleon density of the fireball formed heavy nucleus collision is 3 to 4 times higher than the saturation density. These energies are high enough to study strange mesons and multistrange hyperons produced in nucleus-nucleus collisions close to the kinematic threshold.

The Run7 data set was collected in March 2018. Based on the data obtained, the differential cross sections of inelastic interactions of argon ions, in the range of kinetic energies of 2.3-3.5 GeV, with target nuclei of various materials: C, Al, Cu, Pb, Sn are planned to be measured.

Results obtained so far are presented on the analysis of the correlation between the expected kinetic energy of tracks extrapolated from the TOF700 (Time-of-Flight system) to the ZDC (Zero Degree Calorimeter) and its energy response to the ZDC. This is an important step for estimating event centrality.

2. Slow magnetic monopoles search in NOvA

Author: **Antoshkin Alexander**
Dzhelepov Laboratory of Nuclear Problems, JINR, Dubna, Russia
Abstract:

The NOvA far detector (FD) is well suited for finding exotic particles due to its specific technical features. With a surface area of 4,000 m^2 and a location near the earth's surface, the 14 kt FD provides unique sensitivity to potential low-mass magnetic monopoles at subluminal velocities ($v < c/100$). As a whole, slow monopole analysis can lead to a discovery, or it can limit the existence of such monopoles in a wide range of parameters, previously unreachable in other experiments (MACRO, SLIM, IceCube).

3. Optical simulation of PMT

Author: **Antoshkina Tatiana**
Dzhelepov Laboratory of Nuclear Problems, JINR, Dubna, Russia
Abstract:

PMTs are widely used in different areas of physics, especially in neutrino experiments that use a great amount of PMTs, both large and small, in order to determine the neutrino hierarchy and oscillation parameters through achieving excellent energy resolution. PMTs do collect the light from the detector and convert it into the electric signal. The quality of such converting depends on so-called PDE (photo-detection efficiency) that is connected with quantum efficiency (the property of the photocathode layer inside each PMT). The main goal is to describe optical processes (principally light absorption) inside the photocathode theoretically because the PMT optical model is a very important ingredient of the energy reconstruction procedure.

4. Coherent radiation of relativistic charged particles from dielectric target and applications for beam diagnostics

Author: **Bleko Veronika**
Veksler and Baldin Laboratory of High Energy Physics, JINR, Dubna, Russia
Abstract:

One of the major challenges faced when launching and operating particle accelerators is meeting the requirement of on-line beam position monitoring. A possible solution to this problem is the use of different types of polarization radiation: diffraction radiation, transition radiation, Cherenkov radiation and Smith-Purcell radiation. The unique properties of radiation and the relatively simple realization of the occurrence conditions open up wide possibilities for the creation of new beam diagnostic method and sources of electromagnetic radiation in different spectral ranges. The purpose of the research is the theoretical and experimental study of the properties of radiation generated by the interaction of relativistic charged particles with the functional targets. This research is important both for deeper understanding of the nature of electromagnetic interactions and development of advanced diagnostic tools for accelerated beams of charged particles.

5. Study of anomalous events in TUS experiment

Author: **Blinov Alexander**
Dzhelepov Laboratory of Nuclear Problems, JINR, Dubna, Russia

Abstract:

The main goal of the TUS experiment was to search for and study extremely high-energy cosmic rays with energies E > 70 EeV. The TUS detector registered a number of unusual events, the origin of which is unclear. The analysis of not similar to EAS and unique anomalous events is the subject of the study presented in this work.

6. JUNO Neutrino Mass Ordering Sensitivity with Subdetectors

Author: **Dolzhikov Dmitriy**
Dzhelepov Laboratory of Nuclear Problems, JINR, Dubna, Russia

Abstract:

The Jiangmen Underground Neutrino Observatory (JUNO) is a multi-purpose 20~kton liquid scintillator detector under construction at 700~m underground in the south of China. One of the main goals of the experiment is to determine Neutrino Mass Ordering (NMO). It was shown that JUNO sensitivity to NMO depends on a choice of fiducial volume cut due to the spatial non-uniformity of the detector characteristics. For example, a bigger cut leads to more statistics, but worse energy resolution and higher accidental background. Instead of choosing a specific fiducial volume, the entire detector volume may be divided into a few virtual subdetectors. Taking into account the characteristics of each subdetector, one can perform simultaneous data analysis for each subdetector. Such approach may lead to better sensitivity to NMO. The current status of developing the subdetector approach will be presented in this poster.

7. Beam lines development and construction at NICA. SOCHI beam line physical start-up

Author: **Filatov Georgy**
Veksler and Baldin Laboratory of High Energy Physics, JINR, Dubna, Russia

Abstract:

As part of the NICA project, an Innovation Block focusing on applied research is being set up. That requires beam shaping and transport from the accelerators to the target stations for applied research. To do this, new beam lines are being calculated and built with the engineering infrastructure (including stations, biological shielding and engineering lines). The NICA accelerator complex includes the HILAC (Heavy Ion Linear Accelerator) and the Nuclotron (superconducting synchrotron), on which the channels for applied research are based. The technical highlights of the beam lines and the SOCHI beam run results are given in this work.

8. The NA64μ experiment at the CERN SPS

Author: **Gertsenberger Svetlana**
Veksler and Baldin Laboratory of High Energy Physics, JINR, Dubna, Russia

Abstract:

The NA64 experiment is a fix-target experiment at the CERN SPS combining the active beam dump and missing energy techniques to search for rare events by colliding 100-150 GeV energy electron or muon beams onto an active target. The article presents the muon part of the NA64μ experiment. The experiment looks for a light Zμ vector boson produced in the bremsstrahlung reaction $\mu Z \rightarrow \mu Z Z_\mu$ and coupled to the second and third lepton generations through the $L_\mu - L_\tau$ current. The existence of this boson could explain the (g-2) muon anomaly. A method of the searching for Z_μ, the setup and sensitivity of the experiment are represented in this poster. The results and future plans are also given.

9. Electron neutrino energy estimators for the NOvA 3 Flavor Analysis

Author: **Kalitkina Anastasiia**
Dzhelepov Laboratory of Nuclear Problems, JINR, Dubna, Russia

Abstract:

NOvA is a long baseline neutrino experiment with a main goal of measuring neutrino oscillation parameters by observing electron neutrino appearance and muon neutrino disappearance. NOvA uses the NuMI beamline located at Fermilab and two functionally identical detectors, the distance between which is 810 km. Precise measurements of the oscillation parameters require a set of selection algorithms and cuts in order to separate charged current electron and muon neutrino events from their corresponding backgrounds, as well as energy estimators with good resolution to accurately measure the neutrino energy spectra. This poster will discuss future improvements to the electron neutrino energy estimation algorithm, with particular focus given to advances in machine learning techniques.

10. East-west asymmetry effect in atmospheric muon flux in the Far Detector of NOvA

Author: **Petrova Olga**
Dzhelepov Laboratory of Nuclear Problems, JINR, Dubna, Russia

Abstract:

In the Far Detector of the NOvA experiment we can measure atmospheric muon flux and the so-called east-west effect of the geomagnetic field in it. But this measurement is entangled with the flux asymmetry caused by absorption in the Far Detector overburden and in the surrounding rock. Also atmospheric muon track reconstruction efficiency should be taken into account.The poster presents some intermediate results of the east-west effect analysis in the NOvA experiment.

11. KRION-6T ion source electronics development

Author: **Ponkin Dmitriy**
Veksler and Baldin Laboratory of High Energy Physics, JINR, Dubna, Russia

Abstract:

The cycle of works is devoted to the development of new electronics and technical systems development for the electron string ion source (ESIS) KRION-6T designed at VBLHEP JINR. The KRION-6T ion source is a pulsed cryogenic superconducting ionizer of heavy elements atoms, which makes it possible to obtain beams of highly charged particles. The source was designed, developed and used at the test facility and in the accelerator runs of the HILAC, Booster and Nuclotron as a prototype of source of heavy ions for the NICA/MPD complex.

In the period from 2012 to the present both the author personally and with his significant contribution a number of electronic systems and special programs for ensuring the operation of sources of highly charged ions of the KRION type: KRION-2, KRION-6T, KRION-T developed and put into operation.

12. Simulation of computing infrastructures for the acquisition, storage and processing of data of the NICA experiments

Author: **Priakhina Daria**
Meshcheryakov Laboratory of Information Technologies, JINR, Dubna, Russia
Abstract:

The main task in creating a computing infrastructure of any large-scale experiment is the predictive modeling of data storage and processing centers. A software complex is being developed at the Meshcheryakov Laboratory of Information Technologies; it allows estimating how the data storage and processing infrastructure will work with the available computing resources, and defining the load on computing components and communication links with the specified parameters of data flows and jobs.

The software complex consists of several modules and a database. The database contains information about the architecture of the simulated system, equipment configurations, parameters of data flows and jobs, as well as the obtained simulation results. A user interface has been developed to set input parameters for modeling. The main module of the complex is a stable core for modeling data transmission and processing. A module to present the results is implemented. This module is executed at the end of the simulation and allows one to obtain graphs reflecting various processes in the system.

At present, the software complex is being used for the simulation of computing infrastructures for data acquisition, storage and processing within the NICA experiments. BM@N is the first experiment to test the software complex. The results of modeling the distributed computing infrastructure of the BM@N experiment are obtained and analyzed in order to assess current and future resource requirements for data storage and processing. The work presents the results of modeling the computing infrastructure with the available allocated resources for the BM@N 2022/2023 winter session. Plans for the further upgrade of the software complex to obtain predictive values for the number of necessary resources in the perspective of the development of computing for the BM@N experiment for 2023-2030 are formulated.

13. Intelligent robust control system for elements of the accelerator complex

Author: **Reshetnikov Andrey**
Meshcheryakov Laboratory of Information Technologies, JINR, Dubna, Russia
Abstract:

The poster is devoted to the toolkit description of a software-algorithmic platform of intelligent control (using the example of quantum self-organizing controllers in the control circuit) for the hardware of the current layout of the remote control of the cooling process of a superconducting magnet with a guaranteed achievement of a stable superconductivity zone. At the same time, optimal control quality parameters, such as temperature, nitrogen consumption, speed, the required pressure level and minimal complexity of the control implementation, are provided. A description of the current layout of a remote control system with built-in self-organizing quantum regulators is presented. The selected structure of the intelligent control system is considered and justified by the example of nitrogen consumption; the operability and efficiency of the developed intelligent control system based on quantum soft computing technologies are experimentally demonstrated.

14. Light readout system for the Liquid Argon TPC of the DUNE ND

Author: **Sharov Vladislav**
Dzhelepov Laboratory of Nuclear Problems, JINR, Dubna, Russia
Abstract:

A modular liquid-argon (LAr) TPC with pixelated charge readout is considered as a part of the near detector for the DUNE experiment. Such the TPC is developing by ArgonCube collaboration. To provide a trigger for the neutrino event the LAr scintillation light detection is proposed. The light is a vacuum ultraviolet with 128 nm wavelength, thus, it is a challenge to register it. The main requirements imposed on the light detection system are: a good performance at cryogenic temperatures, nonconductive materials, compact dimensions, detection

efficiency at a level of percent. A light collection module (LCM) as a one candidate for the system is developed at JINR (Dubna, Russia). Second candidate is ArCLight which was developed at University of Bern. Also, a full readout chain for the Light Readout System (LRS) is being developed at JINR that contains the front-end electronics, SiPMs power supply, ADC, cold PCB. The ArgonCube 2x2 program is currently ongoing to verify the performances of the subsystems of the TPC including LRS. So far, 3 TPC modules have been tested in the Bern University cryogenic laboratory using cosmic muons. These studies have shown a good performance of the LRS subsystem. Further tests at Fermilab of all 4 TPC modules (2x2 setup) are going to verify the LRS performance using neutrino beam.

15. Drift Chambers Detector in the SRC setup at BM@N

Author: **Voytishin Nikolay**
Meshcheryakov Laboratory of Information Technologies, JINR, Dubna, Russia
Abstract:

BM@N (Baryonic Matter at Nuclotron) is the first functioning experiment of the NICA-Nuclotron-M accelerator complex, one of the main goals of which is to study the properties of hadrons and the formation of (multi) -strange hyperons on the threshold of the birth of hypernuclei.

During the spring session of the Nuclotron operation in 2022, a data acquisition run took place as part of the SRC at BM@N (Short Range Correlations) physics program. A substantial part of the nucleons in the nucleus belongs to strongly interacting short-lived pairs, called SRC pairs. The nucleons in these pairs have a high absolute and low momentum of the center of mass (relative to the Fermi momentum). Traditionally, the properties of SRC pairs are studied using hard scattering reactions when the nucleus interacts with one nucleon. In the BM@N experiment, inverse kinematics was used: the carbon nucleus hits a fixed target. This program involves the use of light carbon ions and a unique liquid hydrogen target.

For the mentioned physical run, a complete agreement of the reconstruction of the simulated and physical data in the detector system of the drift chambers was achieved. The reconstruction efficiencies for different types of particles were estimated on different types of data. The preparatory work made it possible to carry out a preliminary analysis of the collected data quickly and with high accuracy.

We present a brief overview of the main SRC detector systems of the experimental configuration and the first results of the track reconstruction and identification of charged particles, which are used to detect SRC pairs and the residual nucleus.

16. Analyzing Power of Quasi-Elastic Proton-Proton Scattering at the Energies from 200 to 650 MeV/nucleon

Author: **Volkov Ivan**
Veksler and Baldin Laboratory of High Energy Physics, JINR, Dubna, Russia
Abstract:

Analyzing power of proton-proton quasi-elastic scattering was obtained at the Nuclotron Internal Target Station using a polarized deuteron beam and a polyethylene target. The selection of useful events was performed using the time and amplitude information from scintillation counters. The asymmetry on hydrogen was obtained using the process of the carbon background subtraction. The obtained analyzing power values are compared with the predictions of the partial-wave analysis SAID at the beam energies of 200, 500, 550, and 650 MeV/nucleon.

17. Vector finder toolkit for the nica/mpd inner tracking system

Author: **Zinchenko Dmitriy**
Veksler and Baldin Laboratory of High Energy Physics, JINR, Dubna, Russia
Abstract:

Although the start-up of the MPD experiment is still ahead, the work on the preparation and physics validation of the future detector upgrade program has already been initiated. As one of the possible MPD upgrade steps, an Inner Tracking System (ITS) based on the next generation silicon pixel detectors is being considered to be installed between the beam pipe and the Time Projection Chamber (TPC). The existing track reconstruction method in MPD is based on Kalman filter in the TPC, and it's simple extension to the ITS is no considered as the most efficient approach. Therefore, another method, based on the "vector finder" approach, was developed, as well as a suitable way to match reconstructed tracks from the TPC and ITS.

Proposed methods were implemented as Vector Finder toolkit and are described in this work. Their performance was tested for primary and secondary track reconstruction in the MPD ITS on Monte-Carlo generated data of nucleus-nucleus collisions. Vector Finder toolkit has also been adapted for BM@N – fixed target experiment at NICA, and it's preliminary performance results on Monte-Carlo simulated data show improvement compared to previously used track reconstruction method.

18. Distributed heterogeneous computing infrastructure for MPD experiment

Author: **Zuev Maxim and Pelevanyuk Igor**
Meshcheryakov Laboratory of Information Technologies, JINR, Dubna, Russia

Abstract:

Since 2016, a distributed heterogeneous computing infrastructure, created using the DIRAC platform, has been being developed at JINR. It is used to process data from JINR experiments. At present, the system combines all MICC resources, the clouds of the JINR Member States, the resources of the National Research Computer Network of Russia and the cluster of the National Autonomous University of Mexico (being part of the MPD collaboration). Using the DIRAC platform makes it possible to get unified access to all integrated computing and storage resources, to carry out performance analysis and account for consumed resources.

This infrastructure is most actively utilized by the MPD collaboration; it is used for mass Monte Carlo data generation for all physical working groups. Since 2019, the MPD collaboration has run 31 data generation campaigns. 1.5 million jobs with a total duration of 1,535 years were completed. In total, 1.3 billion events were generated, 439 million of which were also reconstructed. The total amount of MPD data in the distributed network reached 1.3 PB with a total storage capacity of over 2 PB. Due to the increase in the amount of data required for physics analysis, it is planned to expand the storage by another 1 PB by means of a new ultra-fast storage on the "Govorun" supercomputer.

The main resources involved in mass data generation are as follows: "Govorun" supercomputer, Tier1, Tier2 and EOS storage system. In 2022, with the increase in the amount of data generated, the infrastructure was expanded. In the EOS storage system, the MPD experiment quota was increased by 1 PB. The increase in the number of resources used on the "Govorun" supercomputer was the largest: 32 compute nodes were added, which increased the number of available resources by 2,300 CPU cores, and as a result, over 50 million events were generated in less than a month. The modernized "Govorun" supercomputer plays a key role in the implementation of the program of mass simulation runs of MPD experiment data for the NICA project. At the moment, such tasks can be effectively and massively performed only on the nodes of the "Govorun" supercomputer.