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

1. Software development for tracking detectors of the first experimental BM@N run in 2022

Author: Dmitry Baranov
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Abstract:
The next physical runs of the BM@N experiment, planned to be carry out in 2022, require to use of more improved configurations of the experimental setup, rather than in the previous, technical, runs. In order to achieve further progress in the experiment we need to register and process events with higher multiplicity. This inevitably leads to more complicated structure of our detectors - we have to deal with a large number of component parts, such as stations, modules, layers and other elements of the detectors. Because tracking system is one of the main parts of the BM@N setup, a major upgrade primarily affected the detectors of this system, such as Forward Silicon, GEM, and CSC. The primary function of these detectors is to register particle trajectories as a result of the collisions of heavy-ion beams with a fixed target. Success of the future runs will depend directly on the efficiency of the tracking system. The selection of the most appropriate configuration is based on a preliminary analysis of simulated data. That is why development of simulation models for these detectors is a key stage in a general data-processing cycle in the experiment.
The features of the development of program models, including detailed geometry and algorithms for data-simulation and data-reconstruction, for new configurations of the BM@N tracking system in 2022 will be presented in the poster report.

2. Measurement of the gluon fraction and characteristics of quark and gluon jets channel produced in pp interactions at sqrt{S} = 8 and 13 TeV on the CMS detector

Author: Dzmitry Budkouski
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Abstract:
A method for measuring the gluon fraction in a jet sample based on a quark-gluon likelihood discriminator was proposed in the published works of the authors of this report. Measuring the gluon fraction opens the way to measuring the characteristics of quark and gluon jets. The report presents the results of measurements of gluon fraction and mean charged-particle multiplicity in quark and gluon jets with detector CMS in jet samples taken in the semi-leptonic -channel (Run1) and in the gluon enriched “dijets” channel (Run1 and Run2). The problems that have arisen on the way to the implementation of the measurement plan, methods of their solution, preliminary results and short-term plans are described.

3. Central tracking system based on GEM-detectors at the BM@N experiment

Author: Andrei Galavanov
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Abstract:

BM@N (Baryonic Matter at the Nuclotron) is the fixed target experiment aimed to study nuclear matter in the relativistic heavy ion collisions at the Nuclotron accelerator in JINR. Detectors based on Gas Electron multipliers (GEM) have been identified as appropriate for the BM@N tracking system, which is located inside the BM@N analyzing magnet. The stages of the assembly and tests of 7 GEM-detectors at CERN are presented. The stand for long-termed tests was created. Information on the modernization of the gas system is presented: the flow distribution system and the measurements of

oxygen impurity. The influence of the temperature of the gas mixture on the amplitude of the signals in the detector is shown. The information on an independent test of the gas mixing system is provide.

4. Deep learning methods and software for the reconstruction of elementary particle trajectories

Authors: Pavel Goncharov, E. Shchavelev, A. Nikolskaia, E. Rezvaya, D. Rusov, G. Ososkov
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Abstract:

The reconstruction of charged particle trajectories in tracking detectors is a key problem in the analysis of experimental data for high energy and nuclear physics. The amount of data in modern experiments is so large that classical tracking methods, such as the Kalman filter, cannot process them fast enough. In contrast, the recent progress in deep learning opens up an opportunity of applying neural network models to the tracking problem. In our work, three main models applicable to different parts of tracking problems, namely, RDGraphNet as a global tracking method, TrackNETv3 that operates like a trainable Kalman filter, and the LOOT model for primary vertex reconstruction, are proposed. The evaluation results of our models on Monte-Carlo data for the BESIII and BM@N experiments are presented. In addition, a novel library for deep learning tracking that brings together all our elaborations in one place with a unified interface is introduced.

5. Silicon Tracking System of BM@N experiment

Author: Dmitry Dementiev
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Abstract:

In order to study the high-density nuclear equation-of-state in collisions between gold nuclei at Nuclotron beam energies, the existing BM@N experiment at JINR in Dubna has to be substantially upgraded. The measurement of high-multiplicity events at interaction rates up to 5 MHz requires the installation of four new tracking stations equipped with 300 modules with double-sided micro-strip silicon sensors. The results of the simulations and the status of the detector development are presented.

6. Improvement of track reconstruction algorithm upstream the magnet for SRC at BM@N experiment.

Author: Vasilisa Lenivenko
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Abstract:

The work includes the development of algorithms and reconstruction of tracks in coordinate detectors up to the analyzing magnet, namely: four Multi-Wire Proportional Chambers and three Silicon detectors for a new part of the physics program of the BM@N experiment - studying the properties of short-range-correlations (SRC at BM@N).
Reconstruction of tracks along the beam before and after the target plays a key role in obtaining the first physical results. An article with the first physical results was published in the Nature journal in 2021, events containing one track along the beam after interaction with the target were used for the analysis.
Since then, the reconstruction algorithm has been significantly improved of multi-track events.

7. Magnetic measurements of superconducting magnets of the NICA project and the SiS100 accelerator

Author: Taras Parfylo
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Abstract:

Serial magnetic measurements of superconducting magnets of the NICA project and the SiS100 accelerator began in 2016 and are currently continuing at the Scientific and Experimental Department of Superconducting Magnets and Technologies of the Laboratory of High Energy Physics. The NICA accelerator complex includes two injector chains, existing superconducting synchrotrons – a new Booster and Nuclotron, under construction superconducting Collider. The future SiS100 heavy ion synchrotron is at the heart of the FAIR accelerator facility being created. The accelerators are fitted with Nuclotron-type magnets with a superconducting coil and an iron yoke for shaping the needed magnetic field. Measurement of the magnetic field parameters is necessary for each magnet. The magnetic measurements for the NICA project and the SiS100 accelerator are presented.

8. DIRAC Interware as a service for high-throughput computing at JINR

Authors: Igor Pelevanyuk, V. Korenkov, N. Kutovskiy, V. Mitsyn, D. Podgainy, V. Trofimov, A. Tsaregorodtsev
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Abstract:

The DIRAC Interware is an open-source development platform for the integration of heterogeneous computing and storage resources. The service based on this platform was deployed and configured at MLIT JINR in 2016. JINR has five large computing resources with single access via the DIRAC service, i.e., Tier1, Tier2, the “Govorun” supercomputer, the cloud, and the NICA cluster. In particular, the DIRAC service was used as a tool for the integration of cloud resources of the JINR Member States. The overall performance of the united system is at least three times more efficient compared to the use of any single computing resource. Now it is actively used for the MPD, Baikal-GVD, and BM@N experiments. The total number of completed jobs exceeds 1 million, and the total amount of computing work is around 4.5 million HS06 days. An overview of the system and its performance will be provided. Newly developed tools for system behavior analysis will be described, and the results of their usage will be presented.

9. The software complex for emulation of distributed computing infrastructure for the data processing of the NICA experiments

Authors: Daria Priakhina, V. Korenkov,V. Trofimov, K. Gertsenberger
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Abstract:

One of the uppermost tasks in creating a computing system of the NICA complex is to model of distributed computing infrastructure designed for data processing, both coming from experimental facility and received by event generators in accordance with theoretical concepts for comparison with the expected physical result. A software complex for simulation are developing at the Meshcheryakov Laboratory of Information Technologies. Complex allow to simulate processes of data processing, that come from NICA complex facilities, to find out how the data storage and processing system will work with the available computing power, and to calculate the load on computing farms and communication links with the specified parameters of data flows and tasks.
The software complex consists of a database, a module for setting the simulated structure and equipment configurations, a stable core for the simulation of data transmission and processing, a module for presenting results in the form of graphs. The simulation core is implemented on top of an approach based on the representation of information processes as byte streams.

Currently, work on modeling the computer infrastructure for data processing of the BM@N experiment is in progress. The main goal is proposing some recommendations for organizing data processing with the available allocated resources for the run in 2022 session. The current results of the work are presented. Some recommendations on the organization of the experimental data processing process are provided. Prospects for the development of the software complex are formulated.

10. Manufacturing serial readout chambers based on MWPC for the MPD TPC detector for NICA project

Author: Aleksander Rybakov
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Abstract:

The Time Projection Chamber (TPC) is the main track detector of the MPD setup. The detector is designed for reconstruction of tracks of charged particles and their identification by dE / dx.
Multi-wire proportional reading chambers (ROC) provide basic information on particle tracks and their properties. To ensure quality performance, they must meet stringent workmanship requirements and long-term stable performance.
At the moment, all the necessary 24 serial ROC chambers have been manufactured and tested, which are ready for installation in the TPC. All manufactured chambers meet the required characteristics, average energy resolution dE / dx = 19%.
The report describes the main stages of manufacturing and testing of manufactured ROC cameras.

11. Drell-Yan Angular Coefficients Measurements with the CMS experiment at the LHC

Author: Vladislav Shalaev
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Abstract:

The Drell-Yan process is extremely important for the physics of hadron colliders. Measuring its characteristics is a critical test of the Standard Model at new energies. In particular, the coefficients of the harmonic polynomials describing the angular distributions of the leptons emission are sensitive to the (V - A) structure of weak interactions and can be indicators of the higher orders effects and QCD twists, as well as the nontrivial QCD vacuum structure, reflected in the correlation of parton spins and their nonzero momentum in the initial state. Modern experimental data at the Large Hadron Collider make it possible to significantly expand the range of the transferred 4-momenta to several TeV, which opens up new possibilities to search for physics beyond the Standard Model.

12. Construction of ARIADNA applied stations based on the NICA accelerator complex

Author: Alexey Slivin
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Abstract:

Within the framework of the NICA project at JINR, the ARIADNA (Applied Research Infrastructure for Advanced Developments at NICA fAcility) applied stations are under construction: ISCRA – Irradiation Setup for Components of Radioelectronic Apparature for microchips with a package for Single Event Effects testing (energy range 150-500 MeV/n); SIMBO – Setup for Investigation of Medical Biological Objects for space radiobiological research and modeling of influence of heavy charged particles on cognitive functions of the primates brain (energy range 500-1000 MeV/n). The mounting of the SOCHI (Station of CHip Irradiation) for decapsulated microchips for SEE testing with low-energy ion beams (3.2 MeV/n) has been completed.

13. Simulation of the elastic scattering processes for the experiments at the Internal target station at the Nuclotron

Author: Arkadiy Terekhin
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Abstract:

The results of the unpolarized and polarized measurements at the Internal target station at the Nuclotron are presented. The simulation of the pd-elastic and pp-elastic scattering for 500 - 1000 MeV proton energy are performed. The results of the first simulation of the pp-, pd and dd-elastic scattering at $\sqrt{s}<27$ GeV a demonstrated.

14. Hit Reconstruction Enhancement in the Cathode Strip Chambers of the CMS Experiment

Authors: Nikolay Voytishin, Vladimir Palichik
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Abstract:

The reconstruction of the charged particle trajectory in the CMS endcap muon system is based on the Cathode Strip Chambers. The reconstruction procedure for these multilayer detectors can be divided into two main parts: reconstruction of hits on a particular layer and segment assembly using reconstructed hits.
There is a growing need to upgrade the hit reconstruction procedure. The reasons for this need are multiple. First of all, the increasing hit rate requires the delimitation of two or more particles that pass very close to each other with greater precision than now. On the other hand, the hardware and electronics upgrade gives us opportunities for better reconstruction, which have not yet been used or reflected in the software.
Proposals for solving these problems, along with the results of comparing the standard and proposed approaches, are presented in the work.

15. Searches for new heavy resonances in the dilepton channel

Author: Ilia Zhizhin
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Abstract:

The search for new heavy resonances in dimuon invariant mass spectra has been performed using data obtained in Run 2 in 2016-2018 in proton-proton collisions at sqrt(s)=13 TeV with the CMS experiment at the LHC. The data correspond to integrated luminosity of 140 fb^(-1). Also, the first results of photon-induced background simulation using the FEWZ Monte-Carlo generator in NLO QCD + EW and NNLO QCD + NLO EW orders are presented.

16. Charmonium study at BESIII

Author: Olga Bakina
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Abstract:

The poster presents the preliminary results on the study of inclusive prompt J/psi production and J/psi decay to phi eta obtained by the BESIII-JINR group.

17. Production of J/ψ pairs in pion-nucleon scattering at COMPASS

Author: Andrei Gridin
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Abstract:

During the past 40 years, the production of pairs of J/psi mesons in high-energy hadron collisions has been studied by several experiments. The currently available statistics of J/psi pair events is very limited and mostly obtained at high √s energies where single and double parton scattering mechanisms are dominant.
The single parton scattering plays an important role at low √s, but the double J/psi production process can also be related to the hypothesis of the intrinsic charm of hadrons and the exotic tetraquark states that decay to J/psi pair. The first evidence of such tetraquark states have recently been observed by the LHCb experiment.

The COMPASS experiment at CERN uses a 190 GeV/c negative pion beam scattering off different nuclear targets to study dimuon pair production. For today COMPASS is the only experiment that can search for J/psi pairs at low √s energies and evaluate the contribution of different production mechanisms.

18. Study of the Bc+ → J/ψ Ds+ and Bc+ → J/ψ Ds∗+ decays in pp collisions at s√=13 TeV with the ATLAS detector

Author: Tatiana Lyubushkina
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Abstract:

A study of the $B_c^+ \to J/\psi\, D_s^+$ and $B_c^+ \to J/\psi\, D_s^{*+}$ decays using 139 fb^{-1} of integrated luminosity collected with the ATLAS detector from √s=13 TeV pp collisions at the LHC is presented. The ratios of the branching fractions of the two decays to the branching fraction of $B_c^+ \to J/\psi\, \pi^+$ decay channel are measured: $B(B_c^+ \to J/\psi\, D_s^+)/B(B_c^+ \to J/\psi\, \pi^+)=2.76\pm0.47$, $B(B_c^+ \to J/\psi\, D_s^{*+})/B(B_c^+ \to J/\psi\, \pi^+)=5.33\pm0.96$. The ratio between the branching fractions of the two decays is found to be $B(B_c^+ \to J/\psi\, D_s^{*+})/B(B_c^+ \to J/\psi\, D_s^+)=1.93\pm0.26$. For the $B_c^+ \to J/\psi\, D_s^{*+}$ decay, the transverse polarization fraction, $\Gamma^{\pm\pm}/\Gamma$, is measured to be 0.70±0.11. Here the uncertainty is a quadratic sum of statistical and systematic contributions. The precision of the measurements exceeds that of all previous studies of these decays. A comparison with available theoretical predictions for the measured quantities is presented.

19. LM2 Micromegas chamber production and test for the NSW

Author: Irakli Minashvili
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Abstract:

The upgrade of the Large Hadron Collider (LHC) to the High Luminosity LHC (HL-LHC) is required to probe the physics beyond Standard Model. After the ongoing long shutdown (LS2), the accelerator luminosity will be increased 2 to 3 times as compared to designed luminosity value i.e. $1 \times 10^{34}\ cm^{-2}s^{-1}$. To meet the requirements of the higher rates environment of HL-LHC era, the muon system of the ATLAS detector needs to be upgraded. Therefore, the End-Cap Inner Wheel (Small Wheel) comprised of Cathode Strip Chambers (CSC) and monitored Drift Tubes (MDT) chambers will be replaced by the New Small Wheel (NSW). The NSW will be constituted of Micromegas detectors as a primary tracking detector and small-strip Thin Gap Chambers (sTGC) for triggering. Totally 256 modules, about $3m^2$ each, will be installed in two wheels, 16 sectors per wheel covering a total area of ~ 1200 m^2 . Totally 70 RO panel and 33 LM2 Micromegas modules were produced and tested in the DLNP

JINR. The paper gives an overview of the Micromegas chambers for the ATLAS detector upgrade characteristic and production details.

20. 3D visualization of radiotracers for SPECT imaging using a Timepix detector with a coded aperture

Author: Vladislav Rozhkov
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Abstract:

The poster presents a scanner for visualizing gamma sources, built on the Timepix detector with a CdTe sensor, using MURA type coded apertures as a collimator. The characteristics of this system are given and the algorithms for preprocessing the obtained images are discussed in detail.

21. Design and simulation of an s-band RF photogun for generation of twisted electrons

Author: Yana Samofalova
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Abstract:

A source of high energy electrons carrying orbital angular momentum is being designed at DLNP. The key component of the source is a new 1.5-cell 2.856 GHz S-band RF photogun. The general design and simulation of the photogun is presented. The electrodynamic parameters are determined and the accelerating field distribution is calculated. The particle dynamics is simulated and analyzed to obtain the required beam properties.

22. Light Detection System of the DUNE Near Detector LAr TPC

Author: Alexandr Selyunin
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Abstract:

The Deep Underground Neutrino Experiment (DUNE) is an under-construction international long-base accelerator neutrino experiment hosted in the US. DUNE will consist of two neutrino detectors - Near and Far. The Near Detector (ND) will be instrumented with Liquid Argon TPC likewise the Far Detector. Neutrino interactions produce a scintillation light in the TPC volume that is registered by the Light Detection System (LDS). The LDS provides a fast trigger for the Charge Detection System and is based on the dielectric light traps read out by the silicon photomultipliers. Two approaches of light detection are employed in the ND-LAr TPC – ArCLight and Light Collection Module (LCM). The first prototype of ND-LAr TPC, the so-called Module-0, was tested with cosmic rays at the University of Bern. Module-0 included both, ArCLight and LCM light detectors. The performance of the Light Detection System prototype is presented by the results of the Module-0 test.

23. Mass tests of silicon photodetector (SiPM) arrays for the TAO experiment

Author: Vladislav Sharov
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Abstract:

Taishan Antineutrino Observatory (TAO) is a satellite experiment of the JUNO neutrino experiment that aims to measure the mass hierarchy and other neutrino oscillation parameters with unprecedented precision ~3% MeV. In order to achieve such a resolution, it is necessary to accurately measure the

energy spectrum of the primary flux of reactor antineutrinos near the reactor. This problem is supposed to be solved using the detector of the TAO experiment, which is a spherical volume filled with a liquid scintillator and surrounded by ~10^5 SiPMs, grouped into arrays in the amount of 4100 pcs. SiPMs will be used to detect light emitted as a result of the interaction of decay products of reactor antineutrinos with a detector scintillator.
According to the conditions of the TAO experiment, the energy resolution of the detector itself must be at least ~2% MeV of the energy release, to achieve which it is necessary to carefully study and certify the characteristics of all SiPMs arrays.
For this purpose, the DLNP group developed a stand and a methodology for studying the characteristics of SiPMs arrays, which makes it possible to determine the main parameters (photon detection efficiency, gain, cross-currents, noise, etc.). Also, to power a large number of SiPMs, we, together with the Marathon company, developed a multi-channel power supply.

24. Calculation of neutrino oscillation probabilities in the Earth using Magnus expansion

Author: Arina Shaidurova
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Abstract:

Propagation of neutrinos produced in the atmosphere through the Earth has a noticeable effect of neutrino flavor oscillations. The multipurpose experiment JUNO will also observe atmospheric neutrinos. Measurement of oscillation parameters with atmospheric neutrinos requires calculation of oscillation probabilities with realistic matter density distribution of the Earth.
The authors have developed a program for calculating probabilities of atmospheric neutrino oscillations within the GNA software. The evolution equation for the flavor neutrino state is solved using the Magnus expansions method. This method preserves the norm of the solution at each integration step in any order of approximation and combines computational efficiency with high precision.
The results of the program for different neutrino oscillation channels are presented, as well as an estimation of the computational performance for different energy ranges.

25. Vacuum system of the LINAC-200 accelerator

Author: Dmitry Shokin
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Abstract:

The linear accelerator Linac-200 at JINR is constructed to provide electron test beams with energy up to 200 MeV to carry out particle detector R&D, to perform studies of advanced methods of beam diagnostics, and to work as an irradiation facility for applied research. While the accelerator largely reuses refurbished parts of the MEA accelerator from NIKHEF, the accelerator vacuum system is renovated. In this report, the design and status of new vacuum system will be presented.

26. The Control System of the Linac-200 Electron Accelerator at JINR

Author: Aleksei Trifonov
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Abstract:

The linear accelerator Linac-200 at JINR is constructed to provide electron test beams with energy up to 200 MeV to carry out particle detector R&D, to perform studies of advanced methods of beam diagnostics, and to work as an irradiation facility for applied research. While the accelerator largely reuses refurbished parts of the MEA accelerator from NIKHEF, the accelerator control system is

completely redesigned. A new distributed control system has been developed using the Tango toolkit. The key subsystems of the accelerator (including focusing and steering magnets control, vacuum control system, synchronization system, electron gun control system, precise temperature regulation system) were redesigned or deeply modernized. This report presents the design and the current status of the control system of the Linac-200 machine.

27. The RF system for the linear electron accelerator LINAC-200

***Author*:** Konstantin Yunenko
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Abstract:

The linear accelerator Linac-200 at JINR is being constructed to provide electron test beams with energy up to 200 MeV to carry out particle detector R&D, to perform studies of advanced methods of beam diagnostics, and to work as an irradiation facility for applied research. The design and status of the RF system of the LINAC-200 machine will be presented in the report.

28. Search for sterile neutrino with Daya Bay and TAO detectors

Author: Vitalii Zavadskyi
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Abstract:

Modern neutrino physics keeps a few anomalies that can not be described by the three-neutrino mixing and oscillation framework. Reactor neutrino experiments observed a deficit of the anti-neutrino flux at 2.6σ level with respect to the prediction.
Gallium detectors for solar neutrinos observed a deficit of events from radioactive calibration sources of neutrino (^{37}Ar and ^{51}Cr) at 2.3σ level.
One of the explanation of anomalies could be explained with one or more sterile neutrinos, which interact only gravitationally.
The Daya Bay experiment is sensitive to sterile neutrino parameters mixing angle θ_{14} in a region of $10^{-4} < \Delta m^2_{41} < 10^{-1}$ eV². Since no significant signal was observed, it enables us to exclude a large region of sterile neutrino parameter space.
Experience of work with the Daya Bay experiment enables same analysis with other reactor experiments. The next generation experiment JUNO will use satellite experiment TAO to make precise measurement of antineutrino flux from Taishan Nuclear Power Plant. Close distance to reactor and good energy resolution allow excluding three-neutrino mixing and being sensitive to sterile neutrinos in region $10^{-2} < \Delta m^2_{41} < 10$ eV².
The results of the sensitivity analysis of the Daya Bay and TAO along with a brief overview of the searches done will be presented in this poster.

29. Machine learning for energy reconstruction in JUNO

Author: Arsenii Gavrikov
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Abstract:

The Jiangmen Underground Neutrino Observatory (JUNO) is a neutrino experiment under construction with a broad physical program. The main goals of JUNO are the determination of the neutrino mass ordering and high precision measurement of neutrino oscillation properties. Precise reconstruction of the event energy is crucial for the success of the experiment.

The JUNO detector is equipped with a huge number of photomultiplier tubes (PMTs) of two types: 17 612 large PMTs (20 inches) and 25 600 small PMTs (3 inches). The detector is designed to provide an energy resolution of 3% at 1 MeV.
In this work we study ML approach for energy reconstruction from the signal gathered by the PMT array and present fully connected deep neural network using aggregated features. The dataset for training and testing is generated by the full detector MC method using the official JUNO software.