Programme Advisory Committee for Particle Physics

58th meeting, 21–22 June 2023

Recommendations

Due to the significant air travel difficulties for PAC members, the 58th meeting of the Programme Advisory Committee for Particle Physics was held in a hybrid format via videoconference.

I. Preamble

The Chair of the PAC for Particle Physics, I. Tserruya, presented an overview of the implementation of the recommendations adopted at the previous meeting. JINR Vice-Director V. Kekelidze highlighted the resolution of the 133rd session of the JINR Scientific Council (held in February 2023) relevant to particle physics and the decisions of the JINR Committee of Plenipotentiaries (held in March 2023).

The PAC fully supports the steps taken by the JINR Directorate to increase the participation of Mexican researchers in JINR activities, strengthen cooperation with scientific organizations and universities in China, maintain a high level of cooperation with research organizations from all European countries in order to promote the international status of the Institute and overcome the difficulties of this challenging time.

II. Reports on the NICA projects

The PAC heard the progress report on implementing the Nuclotron-NICA project presented by A. Sidorin. The Committee congratulates the accelerator team for the very successful 4th technical run and thanks the speaker for the detailed analysis of the resources and equipment, including the electron cooling, that were put into operation and improved the performance of the accelerator complex. The PAC notes various delays incurred by the current geopolitical situation, among them the delays in the completion of infrastructure work at the collider building and in the construction of transfer lines from the Nuclotron to the NICA collider. The PAC acknowledges the efforts of the JINR and NICA managements to mitigate these delays and takes note of the resulting revised schedule, which now expects the first beams at the NICA collider in 2025.

The PAC takes note of the progress report on the development of the VBLHEP infrastructure, including the Nuclotron facility, presented by N. Agapov. All the new equipment at the main transformer substation “Dubna” 110/6 kV was installed and put into

operation. As a result, the available power of the substation has been doubled to 40.8 MW, in accordance with the Technical Specifications of PJSC “Rosseti Moscow Region”. The cryogenic subsystems of NICA are now combined into a single complex using cryogenic pipelines, a significant part of which has been tested for leaks and is ready for operation. The installation of engineering and research equipment in the new buildings of the NICA complex – the collider and the new compressor station – is nearing completion.

The PAC takes note of the report on implementing the MPD project presented by V. Ryabov. The production of all components of the MPD first-stage detector is progressing, even though the schedule is delayed due to problems with supplies of many components from European companies, the lack of technical documentation for the delivered components, and the necessity to look for additional qualified manpower. The time-projection chamber, the time-of-flight system and 40 out of 50 half-sectors of the electromagnetic calorimeter remain on track to be installed in 2024. The most critical task is still cooling and current supply of the large superconducting solenoid of MPD. The temporary cryogenic system for the solenoid cooling has been assembled, vacuum tested and operated in manual mode. Cooling to liquid nitrogen and liquid helium temperatures will start in September right after painting the MPD hall. Magnetic field measurements will start in March 2024 and will take three months for different field configurations using the mapper produced by Novosibirsk INP. The PAC congratulates the team on finding viable solutions for the critical issues arising for many aspects of the detector construction, assembly and commissioning.

The PAC appreciates the progress in implementing the BM@N project presented by M. Kapishin. The PAC congratulates the BM@N Collaboration for the first and successful physics run of the BM@N detector in its full configuration with Xe beams of 3.8 AGeV and 3.0 AGeV. The experiment recorded over 550 million Xe+CsI interactions. The identification of Λ-hyperons, K^0_S mesons and charged particles was considerably improved after alignment, calibration of tracking and time-of-flight detectors, and the first data reprocessing. The event centrality was evaluated using the forward hadron calorimeter and the fragment hodoscope. The PAC emphasizes the lack of manpower for ongoing analysis of the recorded data. At the same time, the PAC encourages the BM@N team to concentrate its efforts on getting the first physics results for the Xe run data.

The PAC takes note of the report on preparing the Technical Design Report of the SPD experiment presented by A. Guskov. The layout of the detector has been adopted taking into account new opportunities opened up by the increased permissible load on the floor of the experimental hall. The SPD team is making efforts to find and develop

substitute equipment, components, and technical solutions needed to build the detector. Preparation of documentation for the superconducting SPD solenoid is underway. The PAC reiterates its recommendation to the JINR management on the need to resume the activities of the international SPD Detector Advisory Committee. The PAC encourages the SPD team to proceed with the preparation of the TDR.

III. Reports on the scientific results obtained by JINR groups in the LHC experiments

The PAC takes note of the report by B. Batyunya on the new results obtained by the JINR team in the ALICE experiment on femtoscopic di-kaon correlations in p-Pb interactions and in ultra-peripheral Pb-Pb collisions (UPC) at an energy of 5.02 TeV. An updated 3D analysis of femtoscopic correlations showed that the kaon emission times are the same in p-Pb and Pb-Pb collisions at the same charged particle multiplicities. The new UPC analysis showed that the best description of the invariant mass spectrum of four pions corresponds to the sum of the spectra of the two resonances $\rho^0(1450)$ and $\rho^0(1700)$. These results were approved for publication by the ALICE Collaboration. In addition, the team continued to be involved in the maintenance of the GRID-ALICE analysis at JINR.

The PAC takes note of the new results and current activities in the ATLAS experiment presented by T. Lyubushkina. Topics under study in JINR include the applicability of the Standard Model (SM) and verification of its predictions, the search for additional exotic bosons in two-jet processes, the search for long-lived supersymmetry and supersymmetric charged Higgs bosons. With significant participation of the JINR group, new results have been obtained in the study of SM processes and the Higgs boson. The limits for physics beyond the Standard Model have also been updated. The PAC notes the significant contribution made by the group within the ATLAS upgrade programme to the production and assembly of all 32 Micromegas quadruplets for the New Small Wheel, which are partially included in the trigger system. During the first half of 2023, the JINR group significantly contributed to three ATLAS journal publications and presented ATLAS's results in two international conferences.

The PAC takes note of the new results and current activities of the JINR group in the CMS experiment presented by V. Karjavin. The Committee acknowledges the successful participation of the JINR group in the physics analysis of the LHC Run2 and Run3 data, and in launching the CMS detector during the Run3 data collection period in 2023. The JINR group continues its involvement in the search for signals of physics beyond the Standard Model, such as extra gauge bosons, excited graviton states, and dark matter

mediators, with the Run3 data. An effective quark-gluon discriminator was developed to measure the fraction of the gluon jet, which was found to be smaller than in the existing Monte Carlo models by 10–20 %. JINR specialists make a significant contribution to ensuring the reliable and uninterrupted operation of the CMS Tier-1 centre at JINR. The PAC notes the active participation of the JINR group in the construction of the high-granularity calorimeter HGCal and the upgrade of the forward muon station ME1/1 within the framework of JINR's obligations in the CMS upgrade project for the operation in high luminosity conditions at the HL-LHC.

IV. Reports on the ongoing projects

The PAC takes note of the status of the NA64 experiment presented by D. Peshekhonov. By 2022, NA64, one of the leading experiments searching for new physics below the electroweak scale, has accumulated a milestone number of $\sim 10^{12}$ electrons on target. The ongoing analyses are focused on improving the sensitivity in the search for axion-like particles, a new Z′ gauge boson, and also additional violation of the U(1) gauge $L_\mu - L_\tau$ symmetry. The search for inelastic dark matter and the generic X (17 MeV) boson will continue as well. The pilot run with a high-intensity 160 GeV muon beam demonstrated the possibility of collecting 10^{11} MOT before the Long Shutdown in 2026.

Recommendation. The PAC appreciates the involvement of the JINR team in the project, its theoretical motivation, its responsibilities in the detector operation, the development and support of the straw tracker, the DAQ operation, and the data taking and analysis. The PAC supports further participation of the JINR team in the NA64 experiment and recommends its continuation for the period from January 2024 to June 2026 with ranking A.

The PAC takes note of the report on preparing the SCAN-3 experiment presented by S. Afanasiev. The project is aimed at studying highly excited nuclear matter formed in dA interactions. This state of matter is studied by observing the decay of the excited nucleus into a pair of energetic particles emitted at an angle close to 180^0 and with an energy resolution of 4–5 MeV. The physics programme includes the study of the η- and Δ–nuclei formation and the determination of binding energies and widths of quasi-bound states.

Recommendation. The PAC feels that a firm recommendation cannot be made at this time. As a project approved in 2019 and seeking extension, the PAC requests the JINR team to return to it at the next session of the PAC with a clear proposal and a clear

presentation outlining the original goals of the project in 2019, the achievements over the past four years, and its plans for the requested extension period.

The PAC takes note of the activities of the JINR group in the BESIII experiment presented by I. Denisenko. The BESIII experiment at IHEP (Beijing, China) is primarily aimed at studying the spectroscopy of light hadrons and charmonia, open charm physics, and the physics of the τ-lepton. The JINR group has produced high-quality physics results in the fields of light hadron spectroscopy, the search for glueball states, inclusive charmonia production and decay properties of charmonia states that led to several publications and several theses. The group is the leading software developer in the BESIII collaboration, working on distributed computing and the development of machine learning algorithms for event reconstruction.

Recommendation. The PAC appreciates the important contributions of the JINR group, and in particular the plans to continue the study of charmed quarks in the future SPD experiment at NICA. The PAC recommends that JINR continue its participation in the BESIII project for the period from January 2024 to June 2028 with ranking A.

The PAC takes note of the report presented by A. Borodin on JINR's participation in the TAIGA experiment. The JINR group plays an important role in the TAIGA collaboration for the development and production of Imaging Atmospheric Cherenkov Telescopes (IACT). The mechanical structures of four IACTs involved in the collection of experimental data have been constructed. JINR has developed a technique for manufacturing focusing mirrors for the telescopes. Since the last presentation at the PAC, JINR's participation in data analysis has been strengthened by attracting young researchers. They made a visible contribution to the Monte Carlo simulation of the telescopes and the software development for off-line analysis.

Recommendation. The PAC encourages the JINR TAIGA team to collaborate with the JINR BAIKAL team in the data analysis, in particular in the search for events with similar and complementary characteristics. The PAC recommends that JINR continue its participation in the TAIGA project for the period from January 2024 to January 2029 with ranking A.

The PAC takes note of the report on the status of JINR team's involvement in the preparation of the JUNO experiment presented by D. Naumov. The JUNO experiment is focused on determining the neutrino mass ordering with the goal to reach a significance of at least three to four standard deviations after six years of data collection. JUNO aims at providing the most precise measurements of 3 neutrino oscillation parameters (Δm^2_{31}, Δm^2_{21}, $\sin^2 2\theta_{12}$) reaching a precision of 0.2–0.5 %. The JINR team is highly recognized

within the collaboration, making substantial contributions to hardware, including the production of more than 20 thousand high-voltage units for all JUNO's PMTs, the construction of the top tracker detector, purchasing SiPMT for the TAO detector. The team also contributes to the development of software for simulation, reconstruction, and data analysis, and to the extensive tests of the PMTs. The JINR team plays a visible role in the management of the JUNO collaboration, including the positions in the Executive Board, the Speakers Committee and the Publication Committee. They also serve as T2 and T3 level managers.

Recommendation. The PAC appreciates the important contributions and the visible participation of the JINR team in the JUNO reactor neutrino experiment, which is at the commissioning stage, and recommends that JINR continue its participation in JUNO for the period from January 2024 to January 2027 with ranking A.

The PAC heard the report on JINR's participation in the current accelerator neutrino NOvA experiment and in the preparation of the new generation DUNE experiment presented by L. Kolupaeva. The JINR group has made significant contributions to the NOvA experiment, including the test benches for scintillators and electronics built at JINR, the realization of the Remote Operation Center (ROC-Dubna), and computer infrastructure based on grid and cloud technologies. The latter are used by JINR staff for the analysis of neutrino oscillations, the study of supernovae and atmospheric neutrinos, the search for the Dirac monopole, and more. Members of the JINR team hold prominent positions in the NOvA collaboration, coordinating the processing of experimental data and analysis of exotic channels. They also provide expertise in supernova triggering, DAQ and ROC operation. Taking into account the plans for the NOvA operation until the end of 2026, world record sensitivities are expected in determining the neutrino mass hierarchy and the CP violation phase.

The JINR group also presented its plans towards the next generation DUNE project. The group could make a significant contribution to the construction of the Near Detector, including a light collection system in liquid argon, a tube-based tracking system, as well as data analysis algorithms and methods.

Recommendation. The PAC appreciates the important scientific missions of the NoVA and DUNE experiments, and the strength of the JINR team participating in these two projects. The PAC recommends the continuation of JINR's participation in the NOvA experiment and supports the preparation work for the DUNE project for the period from January 2024 to January 2027 with ranking A.

The PAC heard the report on the project “Multifunctional Information and Computing Complex (MICC)” presented by V. Korenkov. The PAC highly appreciates the efforts aimed at providing modern computing facilities on the basis of MICC to the JINR scientists. MICC LRIP (Large Research Infrastructure Project) will provide full support for the operation of all MICC hardware and software components. These include the Tier1 and Tier2 grid sites, cloud infrastructure, hyperconverged supercomputer “Govorun”, multi-layer data storage system, network infrastructure, power supply and climate control systems. Upgrade and reconstruction of these components will be carried out in accordance with new trends in the development of IT technologies and user requirements.

Recommendation. The PAC recognizes the decisive role of MICC in the scientific research and the needs of modern computing power and data storage systems. The PAC recommends extending the project “Multifunctional Information and Computing Complex” for the period from January 2024 to January 2031 with ranking A.

V. Proposals of new projects

The PAC heard the proposal to open a new project “Mathematical methods, algorithms and software for modeling physical processes and experimental facilities, processing and analyzing experimental data” presented by S. Shmatov. The project is aimed at developing general mathematical methods and software with the widespread use of artificial intelligence and machine learning techniques for modeling physical processes and experimental facilities, processing and analyzing experimental data in close cooperation with the users, including, first of all, the experiments of the JINR flagship project NICA and the JINR neutrino programme. Cooperation will also be continued on experiments at the world’s accelerator centers (CERN, BNL, etc.), experiments in the field of neutrino physics and astrophysical experiments, and radiobiological research programmes.

Recommendation. The PAC notes the ever-growing role that software, algorithms, machine learning techniques, and computational physics play in modern science, including high-energy physics, nuclear physics, and related fields. The PAC recommends opening the project in 2024 for the period from January 2024 to January 2027 with ranking A.

The PAC takes note of the new project for the participation of the JINR group in the fixed target AMBER experiment at the CERN SPS presented by A. Guskov. The experiment is dedicated to the study of the internal structure and properties of hadrons. The first stage will include precision measurement of the electromagnetic radius of the proton, the study of the partonic structure of charged pions in the Drell–Yan and charmonia

production processes, and measurement of the yield of antiprotons in p-He collisions. The AMBER project is approved at CERN and is currently performing a test run. The basis of the AMBER facility is the upgraded COMPASS spectrometer. The JINR team will maintain the operation and upgrade of the electronics of existing detectors, including electromagnetic and hadron calorimeters, and the wide-aperture muon system. Micromegas-based trackers will also be developed by the JINR team.

Recommendation. Taking into account the synergy between the rich physics programmes of the AMBER and NICA SPD experiments, including the benefit of training young researchers in the AMBER experiment while the SPD is under construction, the PAC recommends the participation of the JINR team in the AMBER experiment for the period from January 2024 to June 2026 with ranking A.

VI. New structure of research themes at BLTP

The PAC takes note of the report on the themes “Fundamental Interactions of Fields and Particles”, “Modern Mathematical Physics: Gravity, Supersymmetry and Strings”, “Dubna International Advanced School of Theoretical Physics (DIAS-TH)” and the proposal for a new structure of research themes and projects in BLTP presented by D. Kazakov. The BLTP’s research focuses mainly on elementary particle physics and modern mathematical physics. BLTP also leads successful educational programmes for young scientists and students from the JINR Member States and other countries.

Recommendation. The PAC supports the continuation of scientific research in the presented directions within the new structure of themes and projects in the fields of elementary particle physics, fundamental interactions, modern mathematical physics, and educational activities in modern theoretical physics as outlined in the presentation of D. Kazakov.

VII. Presentations by young scientists

The PAC reviewed 13 reports presented at the poster session by young scientists from VBLHEP, BLTP, and DLNP. The Committee selected the report “The correction system of the NICA Booster guiding magnetic field” made by M. Shandov to be presented at the next session of the Scientific Council in September 2023.

VIII. Next meeting of the PAC

The next meeting of the PAC for Particle Physics is scheduled for 22–23 January 2024.

The preliminary agenda for the next meeting includes:

– status report on the Nuclotron-NICA project;
– status report on the infrastructure issues including the Nuclotron;
– report from the coordinator of the experimental programme with the Nuclotron beams;
– status report on the MPD project including simulation results;
– report on the BM@N project including physics results, in particular from the Xe run;
– report on the preparation of the TDR for the SPD detector;
– progress reports on JINR's participation in the LHC experiments;
– consideration of new projects;
– final reports and recommendations for the projects to be completed in 2024;
– posters from young physicists.

I. Tserruya

Chair of the PAC
for Particle Physics

A. Cheplakov

Scientific Secretary of the PAC
for Particle Physics