Programme Advisory Committee for Particle Physics

60th meeting, 17 June 2024

Recommendations

Due to significant air travel difficulties for PAC members, the 60th 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 135th session of the JINR Scientific Council (held in February 2024) relevant to particle physics and the decisions of the JINR Committee of Plenipotentiaries (held in March 2024). The Scientific Council supported all recommendations of the PAC on the evaluation of new projects and the extension of ongoing projects in particle physics within the suggested timescale and ranking, as outlined in the PAC's recommendations.

The PAC welcomes the plans of the Institute's Directorate to ensure full-fledged cooperation of scientists and specialists from the JINR Member States with CERN, as well as the efforts undertaken to establish new scientific connections with Mexico, Brazil, and China.

II. Reports on the Nuclotron-NICA projects

The PAC heard the progress report on the realization of the Nuclotron-NICA project during 2021–2024 presented by A. Sidorin. The Committee appreciates the successful completion of the first stage of the mega-science project NICA: the injection complex of the collider was commissioned, including the heavy ion source KRION-6T, HILAC, Booster, Nuclotron, and beam transfer lines; the program of fundamental and applied research was started at the fixed target facilities. The delay from the initial project schedule resulted mainly from delays in the collider building construction and delivery of the equipment for the beam transport line from the Nuclotron to the collider. Presently, most of the collider equipment is ready for commissioning. The PAC congratulates the NICA team on these achievements.

Recommendation. The launch of the experimental program at the collider is planned for 2025 with a gradual increase in luminosity. The PAC recommends extending the Nuclotron-NICA project until the end of 2027 with ranking A.

The PAC takes note of the report on implementing the MPD project presented by V. Riabov. The production of all components of the MPD first-stage detector is progressing with minimal delays. 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 ready for day 1 of data taking in 2025. At the beginning of 2024, the solenoid was cooled down to 70 K without major problems. Cooling to liquid helium temperature shall start in September 2024. The magnetic field mapping will follow in October for various field configurations using the mapper produced by Novosibirsk INP. Installation of the carbon fiber support frame and detector subsystems is foreseen at the beginning of 2025. The detector should be ready to move to the beam position by July 2025 to meet the NICA accelerator schedule.

The PAC takes note of the progress on the BM@N project presented by M. Kapishin. The BM@N team efforts are focused on calibrating the time-of-flight system and developing methods to determine centrality in the 3.8 A GeV Xe-CsI collisions collected in 2023. The recorded data were reprocessed on the MLIT Tier-1/Tier-2 computers with improved reconstruction and calibration software. The BM@N team presented the status of physics analysis of the production of Λ-hyperons and K^0_s-mesons, and the direct flow of protons in Xe-CsI collisions. The next physics run of the BM@N experiment is planned with a Xe beam at an energy of 2–3 A GeV.

III. Reports on the ongoing projects

The PAC takes note of the status of the SPD project at NICA presented by A. Guskov. The experiment is dedicated to the study of the spin structure of proton and deuteron using high-luminosity collisions of polarized beams. After submitting the Conceptual Design Report, the international SPD collaboration, which currently includes more than 400 scientists from more than 30 research centers, prepared the Technical Design Report for the SPD experiment. As part of the preparation of these reports, R&D on the main subsystems of the experimental setup was carried out, and prototypes of the main elements of the detector were produced. The team is now planning to start building the subsystems of the first phase, which include a muon system, a superconducting solenoid and an associated cryogenic system, a straw-tube-based track detector, a beam-beam collision counter (BBC),

an MCP-based beam collision detector, a Micromegas-based central tracker, a zero-degree calorimeter (ZDC), the end-cap part of an electromagnetic calorimeter, a data acquisition system, a slow control system, a gas distribution system, supporting structures and corresponding IT infrastructure.

The SPD Detector Advisory Committee conducted a thorough review of the updated SPD TDR and held several meetings with the representatives of the SPD collaboration, where questions were asked about the design and readiness of the Collaboration to start implementation of the first phase of the SPD project. Prof. I. Logashenko, Chairman of the SPD DAC, presented the evaluation report of the DAC. The PAC thanks the DAC for this review and emphasizes the importance of regular communication between the SPD Collaboration and this Committee.

Recommendation. The PAC appreciates the achievements of the SPD team in updating the physics program of the experiment and performing numerous R&D's for preparation of the Conceptual and Technical Design Reports of the detector. The PAC recommends extending the SPD project for 5 years until the end of 2029 with ranking A.

The PAC takes note of the status of the NA61/SHINE experiment at the SPS CERN presented by A. Dmitriev. The experimental program includes measurements in heavy-ion, neutrino, and cosmic-ray physics. The PAC notes the new results obtained by the JINR group on the production of charged kaons and small/medium size ions in heavy-ion collisions. The PAC recognizes JINR's contributions to the detector upgrade and its further maintenance, software development, and data analysis.

Recommendation. The PAC recognizes the relevance of NA61/SHINE to the NICA project and the benefit of training young researchers in the framework of the NA61/SHINE experiment. The PAC encourages the JINR team to gradually shift its focus to the in-house flagship projects. The PAC recommends extending the participation of the JINR group in the NA61/SHINE experiment for 2 years until the end of 2026 with ranking B.

The PAC takes note of the report on JINR's participation in the NA62 experiment at the SPS CERN presented by D. Madigozhin. The goal of the experiment is to measure the very rare decay $K^+ \to \pi^+ \nu\nu$ with an accuracy of about 10%, perform a number of additional studies of rare kaon decays to test the Standard Model, and refine the parameters of chiral perturbation theory. The JINR group made significant contributions to the development, production and maintenance of the NA62 magnetic spectrometer, software development,

data collection and analysis, as well as the elaboration of the NA62 scientific program. The PAC welcomes the publication of an interim result on the probability of the $K^+ \to \pi^+ \nu\nu$ decay with an accuracy of about 40%, based on the data recorded in 2016–2018. The PAC appreciates the publication of the results of the search for a number of decays forbidden within the Standard Model, precision measurements of the characteristics of the decays $K^+ \to \pi^+\mu^+\mu^-$, $K^+ \to \pi^+\gamma\gamma$ and $K^+ \to \pi^0 e^+ \nu\gamma$, as well as the results of the analysis of a previously unobserved rare decay $K_{\mu 4}{}^{00}$.

Recommendation. The PAC appreciates the achievements of the JINR team participating in the NA62 experiment and notes that the completion of NA62 data taking is expected in 2025. The completion of its analysis and preparation of publications will take several years more. The PAC recommends continuing the participation of the JINR group in the NA62 experiment for 3 years until the end of 2027 with ranking A.

The PAC takes note of the results obtained by the JINR group in the STAR experiment at the RHIC collider presented by A. Aparin. The dependence of femtoscopic parameters on the energies and centrality of nuclear collisions was studied for energies $\sqrt{s_{NN}}$ = 3.0–7.7 GeV. New results were obtained on the nuclear modification factor in the region of high transverse momenta. In the region of low transverse momenta, spectra of $K_S{}^0$ mesons were obtained for the first time based on statistics of about 500 million events obtained with new detectors (iTPC, EPD). The JINR group participated in two runs with the STAR detector acceptance extended to the region of forward pseudo-rapidities. Data were collected for the implementation of the Hot QCD program in Au+Au collisions at an energy of 200 GeV and the Cold QCD program with transversely polarized protons at 510 GeV. In the next years, processing of the data from the beam energy scan will continue with an emphasis on the overlapping energy region of the RHIC and NICA colliders in order to search for signatures of phase transitions and study the phase diagram of nuclear matter.

Recommendation. The PAC appreciates the results presented by young scientists and students at international conferences. The experience they gained from the STAR experiment will be useful in carrying out experiments at NICA. The PAC encourages the JINR STAR team to gradually shift its focus to the NICA experiments and recommends extending the JINR participation in the STAR experiment for 2 years until the end of 2026 with ranking B.

The PAC takes note of the report on the participation of the JINR group in the COMET project at J-PARC presented by Z. Tsamalaidze. The experiment is aimed at exploring physics beyond the Standard Model by searching for a possible charged lepton flavor violation (CLFV) through the neutrinoless process of muon-to-electron transition. In 2023–2024, the JINR team made a significant contribution to the development and production of several subdetectors of the COMET detector. In particular, progress was made in developing a technique for making straw tubes with parameters superior to those available so far. In addition, collaboration members from JINR took part in the assembly and testing of the first station of the straw tracker in J-PARC. Important work was done to produce the final prototype of the straw tracker, to model and optimize the calorimeter. The R&D work for the construction of the Cosmic Veto Counter was completed, the proposed design of the detector was approved, and a first module was produced.

Recommendation. The PAC notes with satisfaction the important role that the JINR group is playing in the development and construction of the main subdetector systems of the COMET facility. The PAC also appreciates the participation of representatives of the JINR group in the management structures of the COMET collaboration. The PAC recommends continuing participation of the JINR group in the COMET experiment for 5 years until the end of 2029 with ranking A.

IV. Proposal of new projects

The PAC heard the proposal to open a new project, “Development of a particle registration technique in future experiments with the participation of JINR,” presented by Yu. Davydov. The project is aimed at R&D for new detectors and novel methods for processing and analyzing experimental data, taking into account modern trends in achieving maximum energies and intensities of particle beams. The project is focused on serving future experiments with colliding beams at NICA and the Super Charm-Tau Factory (SCT) in Russia, the Super Tau-Charm Facility (STCF) and the Circular Electron Positron Collider (CEPC) in China, as well as fixed target experiments at accelerators with intermediate and high beam energies. The PAC notes that the group members have expertise in the use of modeling methods, software development, and implementation of machine learning in data analysis and processing, in the development of various types of detectors and electronics, as well as experience in their implementation and use in large accelerator experiments.

Recommendation. The PAC supports the proposal for the opening of the new project, “Development of a particle registration technique in future experiments with the participation of JINR.” However, the PAC considers that the program presented is too general. The PAC encourages the team to prepare a more elaborate program outlining the specific goals and objectives of the project and to submit it to the PAC in one year. Consequently, the PAC recommends now opening the new project for one year with ranking A.

V. Reports on research results obtained by JINR groups in the LHC experiments

The PAC takes note of the report by B. Batyunya on new results obtained by the JINR group in the ALICE collaboration on femtoscopic correlations of non-identical charged kaons in p-Pb interactions at 5.02 TeV and on ultra-peripheral Pb-Pb collisions (UPC) at the same energy. The source radii of emission of non-identical kaons were found to be different from those of identical kaons. The disagreement with previously published results for Pb-Pb collisions is under discussion. The masses and widths of the ρ^0 meson states in 4-pion UPC events agree with the PDG values for the $\rho^0(1450)$ and $\rho^0(1700)$ resonances. The JINR group participates in maintaining the GRID-ALICE system at JINR. The PAC notes new results on signal energy resolution (~1%) and time resolution (up to 100 ps) of the detectors and electronics obtained for the PHOS spectrometer. The new data analysis software proposed by the group members for the current PHOS version makes it possible to reduce the time resolution of the spectrometer by a factor of 3–4.

The PAC takes note of the new results and current activities of the JINR group in the ATLAS experiment presented by I. Yeletskikh. The physics analysis program at JINR covers the verification of Standard Model (SM) predictions, Higgs physics, searches beyond the Standard Model (BSM), physics of B-hadrons and light states. New mass and cross-section limits were obtained in the search for quantum black holes in lepton plus jets final states, with leading contribution of the JINR team. Ongoing studies of the B^*_c meson properties and measurements of the spectra of Z_c tetraquarks are fully covered by JINR physicists. The PAC notes the contribution made by the JINR group to the ATLAS software development, detector simulation support and detector maintenance, as well as to the ATLAS upgrade program. JINR physicists made a significant contribution to the Event Picking Service, simulation of the Tile Calorimeter on the test beam, and theoretical support for gluon TMD measurements at ATLAS. During the first half of 2024, the JINR group contributed to 4 journal publications related to physics at ATLAS.

The PAC heard the report on the participation of the JINR group in the CMS experiment presented by V. Karjavin. The Committee notes the significant contribution made by JINR physicists to studies of high-energy lepton production based on the available RUN3 data and complete statistics of the RUN2 period. The JINR group continues the search for candidates for non-baryonic dark matter, processes with violation of the lepton number, and extended Higgs models. The fractions of quark and gluon (q/g) jets in the samples of inclusive jets were measured as a function of the transverse momentum of the jet in the region 60–1800 GeV for the CMS RUN2 data and compared with PYTHIA8. Work is underway to adjust the hadronization model for measuring the q/g fractions. The PAC acknowledges the contribution of the JINR group in the maintenance of the ME1/1 forward muon station and the hadron calorimeter HCAL. In the framework of the Phase-2 CMS upgrade, the JINR group is making significant progress in creating a test setup for the high-granularity calorimeter HGCal, as well as in the modernization of the forward muon station ME1/1. The PAC highly appreciates the provision and maintenance of reliable and uninterrupted operation of the Tier-1 and Tier-2 centers of the JINR Multifunctional Information and Computing Complex for distributed processing of the CMS data. The PAC is pleased to note the significant contribution of young scientists from the JINR-CMS group to the preparation of a large number of scientific publications and presentations at international conferences.

VI. Presentations by young scientists

The PAC heard with interest 5 reports by young scientists from DLNP and VBLHEP at the poster session. The Committee selected the report “Study of Λ-hyperon production in carbon collisions with solid targets in BM@N experiment” made by K. Alishina to be presented at the next session of the Scientific Council in September 2024.

VII. Next meeting of the PAC

The next meeting of the PAC for Particle Physics is scheduled for 20–21 January 2025. The preliminary agenda for the next meeting includes:

- status report on the Nuclotron-NICA project,
- report from the coordinator of the experimental program with the Nuclotron beams,
- status report on the MPD project including simulation results,
- report on the BM@N project including physics results for the Xe run,
- progress report from the SPD project,

- 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 2025,
- posters from young physicists.

I. Tserruya

Chair of the PAC
for Particle Physics

A. Cheplakov

Scientific Secretary of the PAC
for Particle Physics