Due to the worldwide pandemic, the 56th meeting of the Programme Advisory Committee for Particle Physics was held via videoconference with a reduced agenda.

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 130th session of the JINR Scientific Council (September 2021) relevant to the PAC for Particle Physics and the decisions of the Committee of Plenipotentiaries of the Governments of the JINR Member States (November 2021). The Scientific Council supported all the recommendations of the PAC on the evaluation of new projects and on the continuation of the ongoing projects in particle physics within their suggested timescales, as outlined in the PAC's recommendations.

II. Reports on the ongoing projects with an emphasis on the effect of the pandemic

The PAC heard the progress report on the realization of the Nuclotron-NICA project presented by A. Sidorin. The PAC notes with satisfaction that the booster synchrotron systems were brought up to the design parameters, that an iron beam was accelerated for the first time to the 578 MeV/nucleon design energy, and that electron cooling of a heavy-ion beam was first-ever achieved in Russia in the NICA Booster. JINR and the Budker Institute of Nuclear Physics successfully completed the development of the beam extraction and transport channel systems from the Booster to the Nuclotron. The PAC acknowledges the start of operation of the SOCHI station equipment — an important component of the NICA applied research and innovations programme — designed for irradiating microchips using ion beams extracted from the HILAC. The PAC congratulates the NICA team on the installation of the first superconducting magnet in the collider tunnel, a very significant milestone marking the beginning of the collider assembly and the preparations for the machine commissioning.

The PAC takes note of the progress report on the infrastructure developments at VBLHEP including the Nuclotron facility presented by N. Agapov. The Committee notes with satisfaction that, despite the problems caused by the pandemic, the reconstruction of the power grids has continued and the clearance to operate eleven 6kV modernized substations of total capacity up to 33.6 MW has been granted. The PAC also notes that new cryogenic

equipment has been installed at the central compressor station of Building 1B including a helium liquefier of a capacity of more than 1000 litres per hour, a helium refrigerator for cooling the Booster of 2000 W capacity at a temperature of 4.5 K, four compressed helium purification units, a nitrogen liquefier of 1300 kg/h capacity, and a nitrogen vapour recondenser from Booster screens of 500 kg/h capacity. The large-scale cryogenics equipment located outdoors — a 40 m^3 container for liquid helium and 1000 m^3 gas tanks for gaseous helium and nitrogen — is ready for operation.

The PAC takes note of the report on the realization of the MPD project presented by A. Kisiel. The production of all components of the MPD first-stage detector configuration is progressing well. The commissioning of the time-projection chamber and time-of-flight system with their readout electronics are on track to be completed within 2022. 800 modules of the electromagnetic calorimeter will be produced in Russia and another 800 will be made in China also by the end of the current year. This represents 16 ECal sectors out of the 25 needed for the full azimuthal coverage. The PAC notes the key role of the ECal in the MPD physics programme and urges the MPD team and the JINR management to develop a plan ensuring that the remaining 9 ECal sectors are manufactured as soon as possible. The PAC congratulates the team on launching the tests of the large superconducting solenoid of MPD.

The PAC appreciates the progress in the realization of the BM@N project presented by M. Kapishin. The team is focused on preparing the detectors for the forthcoming runs of the BM@N facility with heavy-ion beams scheduled for 2022: Silicon Beam Tracker detectors and beam profilers are being manufactured. The GEM detectors for the central tracking system have already been tested and their installation is scheduled for spring 2022. The T0 trigger and trigger detectors for the time-of-flight system are expected to be ready by the same time, as well as the target station and the carbon fibre vacuum tube inside BM@N. The new ZDC forward hadron calorimeter is already installed at BM@N. The PAC notes the successful implementation of its longstanding recommendation of having a vacuum beam line in front of BM@N in order to reduce the otherwise huge background.

III. Report of the SPD Detector Advisory Committee

Following the presentation of the conceptual design report of the SPD (Spin Physics Detector) experiment aimed at a comprehensive study of the proton and deuteron spin structure, made at the 54th meeting of the PAC, the PAC recommended establishing an advisory committee to evaluate the SPD CDR and its subsequent evolution into a TDR. The international Detector Advisory Committee (SPD DAC) was formed in April 2021. The Committee is chaired by A. Bressan (University of Trieste, Italy) and includes P. Di Nezza

(National Institute for Nuclear Physics, Frascati, Italy) and a member of the PAC P. Hristov (CERN, Switzerland).

The PAC notes with interest the evaluation report presented by A. Bressan on behalf of the SPD DAC. The Committee held several meetings with the SPD team and asked several questions concerning the SPD detector concept. In addition to that, issues related to the NICA complex infrastructure for polarized beams and possible interactions between the SPD and MPD experiments were discussed in depth. The answers to the DAC's questions were satisfactory and the presentations during the joint meetings were well received by the committee. The DAC particularly appreciated the improvements in the SPD conceptual design with respect to the original CDR, namely changing the magnet location to be outside the ECAL, the possible use of a full MAPS inner tracker, and the clarifications on the straw detectors and the ZDC. On the basis of all that, and following the recommendation of the DAC, the PAC approves the SPD CDR and asks the SPD team to move forward to the TDR preparation. The PAC appreciates the important role of the DAC in the SPD project evaluation and requests periodic DAC reports.

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

The PAC takes note of the report presented by E. Rogochaya on the results obtained by the JINR group in the ALICE experiment. The group's work on data analysis was mainly focused on femtoscopic correlations of pairs of charged kaons in peripheral and central Pb-Pb interactions at 5.02 A TeV c.m. energies and the production of vector mesons in ultraperipheral (UPC) Pb-Pb collisions. In 1D and 3D analyses of the kaon femtoscopic correlations, the dependencies of the kaon source radii on the event multiplicity and transverse momenta of the pairs were studied. It was first-ever shown that the time of kaon emission decreases threefold in the peripheral Pb-Pb interactions compared to the central ones. Possible formation of a single-state ρ(1450) and a single-state ρ(1450) with a heavier-state ρ(1700) was studied in the UPC events with coherent photoproduction of four pions. In addition, the team continued to participate in the maintenance and development of the GRID-ALICE analysis at JINR. The PAC appreciates the progress on the PHOS spectrometer upgrade with a new readout scheme with a very good time resolution of 100ps.

The PAC takes note of the new results and current activities of the JINR group participating in the ATLAS experiment presented by E. Khramov. The topics under study include the applicability of the Standard Model (SM) and verification of its predictions, searches for additional exotic bosons in two-jet processes, searches for the manifestation of

long-lived supersymmetry and supersymmetric charged Higgs bosons. The JINR group members contributed to the update of upper limits for physics beyond the SM (BSM) processes, as well as to the study of SM Higgs boson production. In particular, the production of a Higgs boson in association with a W or Z boson was established with observed (expected) significances of 4.0 (4.1) and 5.3 (5.1) standard deviations, respectively, and masses of BSM R-hadrons up to 1.4 TeV were excluded for gluino lifetimes from 10^{-5} s to 10^{3} s. The PAC acknowledges the significant contribution made by the group within the ATLAS upgrade programme, in particular, to the production and assembly of all thirty-two Micromegas large quadruplets for the New Small Wheels. The JINR group also continues its successful participation in the ATLAS detector maintenance and development of software programmes.

The PAC takes note of the report presented by V. Karjavin on the results obtained by the JINR group participating in the CMS experiment. Based on the full statistics of Run-2 of 140 fb^{-1}, the JINR group set upper limits on the ratio $(\sigma \cdot B)_{Z'} / (\sigma \cdot B)_{Z^0}$ of the product of the production cross section and the branching ratio in a dilepton channel of a new resonance with an intrinsic width of up to 10%, to that of the SM Z^0 boson, at a 95% confidence level. The limits are interpreted in the context of the sequential SM (SSM) and a superstring-inspired model that predict spin-1 resonances. Lower mass limits of 5.15 (4.56) TeV are set in the Z'_{SSM} (Z'_{ψ}) models. For the spin-1 resonances, the exclusion limits are set in the mass plane of mediator and DM particles. For large values of m_{DM}, mediator masses below 1.92 (4.64) TeV are excluded from the model where the mediator is a vector (axial vector) with small (large) coupling to leptons. For m_{DM}=0, these limits are reduced to 1.04 and 3.41 TeV, respectively. As part of the CMS detector upgrade for HL-LHC, the group is participating in the development of the high granularity calorimeter (HGCal) and modernization of the ME1/1 front muon station.

The PAC notes with satisfaction the growing visibility and the increased involvement in physics analyses of the three JINR teams participating in the LHC experiments.

V. Presentations by young scientists

The PAC reviewed 28 posters presented in Zoom breakout room mode by young scientists from VBLHEP, MLIT, and DLNP. The PAC was very pleased with the overall good quality of the reports. The Committee selected two reports: “Deep learning methods and software for the reconstruction of elementary particle trajectories” made by P. Goncharov and “Construction of ARIADNA applied stations based on the NICA accelerator complex”

made by A. Slivin, both to be presented at the next session of the Scientific Council in February 2022.

VI. Next meeting of the PAC

The next meeting of the PAC for Particle Physics is scheduled for 20–21 June 2022.

The preliminary agenda for the next meeting includes:

– follow-up to the to-do list from this PAC meeting;
– discussion of the research programme in the field of particle physics for the next JINR Seven-Year Development Plan (2024–2030);
– status report on the Nuclotron-NICA project;
– status report on the infrastructure issues including Nuclotron;
– report from the coordinator of the experimental programme with Nuclotron beams;
– status report on the MPD project including simulation results;
– report on the BM@N project including simulation and physics results;
– report on the preparation of the SPD TDR;
– progress reports on JINR's participation in the LHC experiments;
– consideration of new projects;
– final reports and recommendations on the projects to be completed in 2022;
– posters from young physicists.

I. Tserruya

Chair of the PAC
for Particle Physics

A. Cheplakov

Scientific Secretary of the PAC
for Particle Physics