

Review of NA61/SHINE project: Proposal for Extension of JINR Participation in 2025-2029

The JINR team of NA62/SHINE experiment proposes extension of the project in 2025-2029. The authors provided extensive description of the physics program, achieved results and the plans for the new period. These plans belong to two groups containing several subjects each

- Investigation of the strong interactions
 - study the properties of the onsets of deconfinement and fireball
 - search for the critical point of strong interacting matter
 - direct measurements of open charm.
- Neutrino and cosmic ray physics
 - measurement for the J-RAPC (T2K) and Fermilab (NuMI and DUNE) neutrino experiments
 - measurements of nuclear fragmentation cross sections and hadron production to improve air shower simulations and understand the cosmic ray propagation in Galaxy

I appreciate very much the detailed discussion of the recent NA61 physics results, where some long-standing questions like the existence of “horn” structure and the search for critical point were clarified. In most of the studied collision systems no evidence for any of these effects was found, however unexpected collision energy and systems size dependences for small/medium size ions together with anomal excess of K^\pm/K_s^0 were measured.

NA61/SHINE studies of the collisions between different beams (π , K, p) and targets at different energies will help to reduce the uncertainties of final results in neutrino experiments. The cosmic-ray program provided unique results which cannot be described by the existing models. These measurements are needed to interpret high precision data on cosmic rays.

The NA61 detector was upgraded in 2021 with new Vertex Detector, replaced TPC readout electronics, new trigger and data acquisition systems, modernised Projectile Spectator Detector, and additional TOF detectors for particle identification at mid-rapidity. Afterwards the JINR group installed the left TOF arm, which was fully integrated and participated in the 2023 data taking. The right TOF arm is going to be installed in 2024, completing the full acceptance coverage.

The JINR group contributions and responsibilities are:

- Construction of the TOF system based on MRPC.
- TOF-L and overall facility maintenance during data taking.
- TOF-R commissioning.
- Participation in trigger R&D.
- Reconstruction chain in the SHINE framework.
- Data analysis.

The JINR group plans to work on the following subjects:

Hardware & data taking:

- ToF-L and overall facility maintenance during data taking
- ToF-R commissioning
- Participation in trigger R&D

Software:

- Service and further development of calibration software
- Reconstruction chain in the SHINE framework

Data analysis (the same topics were part of the 2021 list):

- Study of light nucleus formation (d, t, ^3He , ..) in nucleus-nucleus interactions
- Study of hyperon and hyper-nuclei production in Be + Be, Ar + Sc, Xe + La, Pb + Pb collisions
- Analysis of anti-matter production in relativistic interactions
- Participation in the study of open charm production in heavy ion collisions
- Measurement of hadron production for neutrino and cosmic ray physics
- Further development of theory models for better understanding the collected data

The JINR group of NA61 is very balanced. It consists of 36% young and 64% experienced physicists. They published 26 papers during the last three years, defended 2 PhD thesis, 2 PhD and 1 DSc thesis are under way. At the same time, one third of the group members are listed at 10% participation, which in my opinion is inefficient.

The requested resources are relatively modest and justified. I would still encourage additional information about the requested materials. I also observe that for example there is no request for CPU and disk resources, while the reconstruction chain is one of the group responsibilities, and the analysis certainly needs computing resources. This point needs clarification.

The reviews of the referees A.A.Baldin and S.G.Bondarenko are positive and support the requested extension. They underline the quality of the physics program, the successful upgrade, the substantial contribution of the JINR group, the interesting results and the training value of the NA61 analysis. The referees point out the synergy between NA61 and NICA projects. They also indicate that the required resources are modest and fully justified.

I completely agree with the opinion of both referees and propose to extend the JINR participation in the NA61/SHINE experiment in 2025-2029.

As a final note I would mention that the main uncertainty for the project comes from the extension of the International Collaboration Agreement between CERN and JINR. Hopefully the situation will become clear in the coming weeks.

Peter Hristov, 15/06/2024