Referee report on the project

**Study of Neutrino Oscillations in NOvA experiment**

**(JINR participation)**

The current proposal is an extension of the JINR project NOvA first approved in 2014. The proposal presents the results obtained in the previous period, the future plans in NOvA, and preparations for a new neutrino experiment, DUNE.

NOvA is a long baseline off-axis neutrino experiment studying neutrino oscillations in the beam from the Fermilab accelerator complex. The Near and Far detectors of the experiment placed 810 km away use the same technology: both are liquid scintillator calorimeters composed of PVC cells allowing tracking.

In the past period of the project, the JINR group has made a significant contribution to the NOvA results. The Remote Operation Center (ROC) developed in JINR in 2015, the first of non-US ROCs, provides possibility for the JINR scientists to be involved directly in the process of measurements. This is especially important for young scientists and students who can acquire a unique experience of participation in real-time experiment.

The JINR physicists participate in different physics analyses of the NOvA data. This includes not only neutrino oscillation analysis, which was the primary goal of the experiment, but a number of others: search for supernova signal, search for magnetic monopole, different aspects of cosmic muon physics. All analyses will continue in the extension period. Considerable work has been done also for updating Monte-Carlo code for neutrino interactions.

Such large-scale neutrino experiments like NoVA and DUNE require an adequate powerful computing infrastructure. In order to contribute to the international collaboration computing resources, the facilities of the Laboratory of Information Technology have been extended for using by NOvA/DUNE. These resources are accessible not only to JINR scientists but also to other NOvA collaborators via the Open Science Grid.

Essential results were obtained in hardware. With electronic test-bench arranged in JINR, a better understanding of the detector performance was reached. In particular, cross-talks between the channels and shaping parameters were determined, response to particles of different ionization losses measured. All these parameters are important in the NOvA detector simulation.

After NOvA, the neutrino beam of Fermilab will be employed by DUNE, the next generation accelerator long baseline neutrino experiment. The core component of the neutrino detection system of the Near Detector of DUNE will be a modular structure liquid argon TPC, dubbed ArgonCube. The JINR group is going to contribute to the DUNE Near Detector from the very beginning, developing the light collection system aimed at fast timing from prompt scintillations. In the ArgonCube collaboration, JINR has already taken responsibility to provide and produce the complete light readout system including the light collection modules, electronics, DAQ and Slow Control. For this purpose, a cryogenic test bench was constructed in DLNP JINR, which allowed numerous tests of the light readout system. Within the current project, JINR is planning to provide the whole light collection system for the TPC demonstrator module and to prepare a prototype of the full-scale module.

The JINR NOvA team is well balanced including senior scientists, junior scientists and students, with a nice average age of about 35 and a total FTE of 21.2. The role of each participant is clearly defined in the project.

A big activity of the team members is well seen in the extensive list of conference reports and seminars. Concerning presentation of the material in the project, I would advise to emphasize the most meaningful ones – now they are smeared over the whole text.

Summarizing, through this project JINR participates in one of the most advanced international neutrino experiments, providing significant contributions in all its aspects: physics analysis, instrumentation and computing. Support of continuation of this activity would be a reasonable decision.

The requested resources seem adequate for this large-scale participation in NOvA/DUNE.

I recommend approving the project extension with the highest priority.

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