Referee report on the project

Study of Neutrino Oscillations in NOvA experiment
(JINR participation)

NOvA is a new generation long-base neutrino experiment studying oscillations of muon-flavor to electron-flavor neutrinos. The experiment addresses fundamental questions of neutrino physics – the neutrino mass hierarchy, CP violation in the leptonic sector and parameters of the neutrino mixing matrix.

NOvA uses neutrino (antineutrino) beam from Fermilab and comprises two detectors: a Near Detector directly at the FNAL site and a Far Detector placed 810 km away in Minnesota. Both detectors are positioned at *off-axis* location, 14 mrad to the Fermilab neutrino channel. This allows, by the price of intensity loss, to obtain rather narrow energy spectrum of neutrino centered around 2 GeV. Each of the two detectors represents a large-volume liquid scintillator tracking calorimeter. Using of the same technology in Near and Far Detectors reduces systematics coming, in particular, from uncertainties in the neutrino flux, cross sections, efficiencies etc.

The current proposal is extension of the JINR project NOvA first approved in 2014. Since then the JINR group attained a big progress and significantly contributed to NOvA results. It participated in different aspects of the experiment: data analysis, simulations, data taking and hardware studies.

According to initial plan of the project, there was developed in JINR the Remote Operation Center (ROC) that started operation in 2015 and became the first non-USA ROC. It receives the data from NOvA in on-line regime and allows full monitoring and control of ND and FD detectors. Due to creation of the ROC, the JINR physicists received possibility to participate in data taking directly from Dubna, without necessity to visit FNAL.

JINR participated also in study of electronics and other hardware components of the NOvA setup. Response to large or long signals, cross-talk and shaping parameters have been investigated using a test bench. Some of the results were adopted by the NOvA collaboration as a useful way to improve performance of the apparatus.

A big job has been done in the field of computing infrastructure and corresponding software development. The Tier-2 cluster of the Laboratory of Information Technology and the JINR Cloud were set up for the NOvA experimental data acquisition, physics analysis and simulations.

Data analysis included several directions. This was Monte-Carlo simulation, tuning of the neutrino cuts, analysis of neutrino oscillations, search for ways to optimize such analysis. Theorists from BLTP developed a phenomenological method for high-accuracy calculation of the neutrino-nucleus cross sections for all nuclear targets.

Apart from pure neutrino physics, the research covered also other areas. First, detection of Supernova neutrino signal was considered very thoroughly. Detection of magnetic monopole was studied, too, and the slow monopole trigger was implemented in 2015. Finally, the possibilities of NOvA as a cosmic-ray telescope were estimated including, in particular, east-west asymmetry and detection of very high energy cosmic rays (>100 GeV).

Summarizing, the past period of the JINR project NOvA was very productive in physics results, in developing the computing infrastructure and hardware, and provided a basis for further successful participation in the NOvA experiment. It is important that there are many young people among the JINR-NOvA team.

The physics content of the project is of high quality in no doubt. From imperfections of the text, I could mention excessive details of the used analysis algorithms. Besides, though description of the Supernova neutrino signal detection takes several pages, nothing is written about the physics conclusions in case such signal is detected. Nevertheless, these small drawbacks disappear in view of high merits of the project and considerable achieved results.

The NOvA experiment is currently one of the most important neutrino experiments. JINR can make significant scientific contribution to expected physics results of this high-class experiment.

The requested resources seem to be quite reasonable.

I recommend to approve extension of the project to 2018-2020 with a highest priority.

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