Referee report on the project
“Study of neutrino oscillations in the JUNO experiment (participation of JINR)”

Neutrino physics is generally considered as one of the most promising researches, where New Physics can be finally discovered. Undoubted experimental evidences for neutrino oscillations have clearly proven very small but non-zero masses of neutrinos. Thus for the Standard model where neutrinos appears as massless particles an extension is required. Depending from an extension model there are a lot of interesting physics beyond the Standard Model, and neutrino oscillations are only first discovered manifestation of that. Now, detailed study of the neutrino oscillation phenomenon is very intriguing, as it can lead for example to discovery of a difference between neutrino and antineutrino oscillation parameters (CP-violating phase), which will be trandemious importance for our understanding of Nature and why our Universe is that we observed.

Recently physics make a breakthrough with experimental determination of all neutrino mixing angles and mass differences. Surprisingly and without a reasonable theoretical explanation all mixing angles appear to be large. Some other questions remained not answered, as what is neutrino mass hierarchy, if there is a CP-violation in the neutrino sector, etc. One of the mixing angles, the θ_{23}, is not known as precise as others. There is also a question about existence of sterile neutrinos and their possible admixture with known neutrino types. One of those important questions, the mass ordering (MO) determination, will be experimentally addressed by large scale project named JUNO (Jiangmen Underground Neutrino Observatory).

The JUNO experiment in China, which will be soon enter in the commissioning phase after all the constructions will be completed, is going to detect neutrinos emitting by nuclear reactors located at a distance of 53 km from the large liquid scintillator detector. The reactor approach expect to provide most precise MO measurements, information that will be an important significance for the accelerator based neutrino experiments (i.e. DUNE, T2HK) targeting simultaneously the MO, δCP and θ_{23}.

Staring with participation in preceding DayaBay experiment and first experimental measurement of θ_{13}, the JINR group is continue to contribute significantly to the detector construction and physics analysis preparation of the experimental program which is now evolved in the JUNO experiment. The contribution includes: R&D and production of the power supply units for photomultipliers of the JUNO detector and SiPMs of the JUNO satellite TAO

(The Taishan Antineutrino Observatory) detector; R&D and production of the magnetic field shields for the large PMs of the OSIRIS detector which is an important subsystem of the liquid scintillator fillling chain of the JUNO main detector; mass testing of PMs. The JINR computing handles a significant part of JUNO's distributed jobs. The JINR group participates in the neutrino oscillation analysis, sensitivity estimation and event reconstruction. The JINR yield in the JUNO experiment is highly visible and well known. The reviewed project prolongation document gives an overview of the JUNO experiment with description of JINR group contribution provided in details.

JUNO is planning to start data taking in 2024 and achieve the nominal goal of MO determination at the level of above 3σ in six years. It also is going to measure both the mass squared differences and solar oscillation amplitude at a precision of ~0.5%. JUNO's program includes a wide range of other physics goals, such as searches for physics beyond the Standard Model, proton decay, detection of Supernova neutrinos, and study on a new level of geo-, atmospheric, and solar neutrinos.

In summary, the project "Study of neutrino oscillations in the JUNO experiment (participation of JINR)" is very well advanced, it utilizing modern approaches to measure neutrino fundamental parameters. JINR contributions to the project include detector construction and physics analysis, which are well-justified and make JINR participation in the experiment important and visible. The JINR JUNO scientific team, the requested resources, are adequate and even moderate for the project goals. It can be noted with pleasure that the project attracts many young researches. Certainly, I strongly support approving the extension of the project at JINR with a highest priority for the requested period.

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