Referee's report
on the proposal of the JINR group participation in the COMET experiment

Despite great sucssess of the Standard Model (SM), the quantum gauge field theory with spontaneous breaking of electroweak symmetry, in describing the processes of particle production and decay in terrestrial and space experiments, SM is unable to explain a number of observed phenomena in nature, such as baryon and lepton asymmetries in the Universe, dark energy and dark matter, small cosmological constant, mass and oscillations of neutrinos, etc. All these motivate various searches for physics beyond SM (BSM). Among many possibilities a special attention is paid to the processes wich are forbitten or strongly suppressed in SM. Observation of any of such process would certainly be a sign of a BSM signal.

The processes associated with the flavor violation in the sector of charged leptons (CLFV) have very small rates in SM. From the physics perspectives the study of the process of neutrinoless conversion of muons to electrons $\mu^- \to e^-$ in the presence of a nucleus, where the nucleus is left unchanged, is extremely interesting. Due to GIM suppression in the lepton sector the effect predicted by SM is very small taking into account the neutrino oscillation data. However, the production rate could be enhanced significantly in a number of SM extensions. Processes involving the muon to electron transition are sensitive to a new physics scale of the order of 10^3–10^4 TeV, being significantly larger than scales that can be directly probed at colliders.

The neutrinoless μ-e conversion process, which will be searched for in the COMET experiment, has a very remarkable feature, namely, the energy of the produced electron, being emitted by muon stopped in media, is close to the muon mass, since the muon mass is obviously much larger than both the binding energy of the muon atom and the nuclear recoil energy. This property of the coherent electron production allows to extract the possible signal from various sources of backgrounds with a rather high accuracy. The experiment COMET will be carried out at J-PARC (Japan) using a bunched 8 GeV pulsed proton beam in two phases, Phase-I and Phase-II. The COMET Phase-I aims to achieve a signal sensitivity of 3.1×10^{-15}. The goal of the full experiment is to reach at Phase-II a sensitivity of 2.6×10^{-17}.

The JINR group plays an important and visible role in the COMET experiment. The JINR group participated in R&D and made an important contribution to the creation of three main detector systems: electromagnetic calorimeter (ECAL), straw tracker, Cosmic Ray Veto (CRV). JINR's responsibilities in the COMET experiment include full responsibility for the production of thin-walled straw tubes; full responsibility for the assembly, testing and installation of a full-scale straw tracker for Phase I and upgrades for Phase II; full responsibility for the development and optimization of the crystal calibration method for the phase-I and phase-II calorimeter; full responsibility for the assembly, testing, installation and operation of the calorimeter; full responsibility for crystal certification; primary responsibility for CRV assembly, testing and installation.

My recommendation for the future is to increase the involvement of the JINR group in activities related to physics, signal and background modeling, including detector effects, in order to be ready for data analysis.

The project under consideration on the participation of the JINR group in the COMET experiment is a serious scientific document containing many important details. Plans for 2025-2029 are clearly formulated and realistic. The financial request also seems reasonable. Therefore, I recommend the proposed project for support with the highest priority.

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