Referee's report
on the JINR participation in the
Project :
Search for new physics in the charged lepton sector.
COMET experiment.

The Standard Model (SM), quantum gauge field theory with spontaneous breaking of electroweak symmetry, reached its logical conclusion with the discovery of the Higgs boson at the LHC. The SM was completed in the sense that all the predicted particles have been found and all the interaction structures have been fixed.The successes of the SM in describing the processes of particle production and decay in terrestrial and space experiments are well known. However, the 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. The search for any possible manifestations of physics beyond the Standard Model (BSM) is of great importance. Not yet observed rare processes with very low probabilities, predicted by the SM, are of particular interest, since any observation of them will be a BSM signal.

The processes associated with the flavor violation of the 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 (of the order of 10^{-54}) taking into account the neutrino oscillation data. However, the production rate could be enhanced significantly in a number of SM extensions such as SUSY models, models with extra space-time dimensions, grand unified models etc. Processes involving the muon-electron transition, which is a powerful tool for studying BSM physics, are sensitive to new effective physical mass scales of 10^3–10^4 TeV, 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 will be carried out using a two-staged approach, Phase-I and Phase-II. The COMET Phase-I aims to achieve a signal sensitivity of 3.1×10^{-15} , roughly a factor 100 better than the current experimental limit. The goal of the full experiment is to reach at Phase-II a sensitivity of 2.6×10^{-17}.

The contribution of the JINR team to COMET consists in participation in the R&D and production of three main detector systems of the experiment: the electromagnetic calorimeter (ECAL), the straw tracker, the Cosmic Ray Veto (CRV). The JINR group is fully responsible for manufacturing of all straw tubes based on JINR experience obtained in participation at the NA62 experiment at CERN. The JINR-COMET group created a special laboratory (Clean Room) to develop and produce unique straw tubes with new parameters using ultrasonic welding technology in an agreement with requirements from Japanese side. Within the Phase-I 2700 fullsize straw tubes have been produced, after testing and checking according to quality standard all tubes were sent to Japan at KEK and from there to J-PARC. At the J-PARC started a regular checking process of the straw tube conditions. One should mention that the crystals used have been thoroughly investigated in DLNP JINR. Also one should stress JINR contribution to the problem of backgound redution. Muons from cosmic rays mimic the 105 MeV conversion electrons, this is a major background. JINR group contributes significantly to the Cosmic-Ray Veto (CRV) system which is needed to suppress the cosmic muons.

All the results and achievements by JINR in the international COMET experiment show a strong role and visibility the JINR group has in the COMET Collaboration.

The only recommendation from my side is that the JINR group should intensify its participation in the activities of groups of physicists, pay more attention to modeling and studying background processes, as well as the signal process, including BSM expectations.

The project “Search for new physics in the sector of charged leptons” (the Project COMET) is very interesting and perspective from the point of view of physics. The JINR group has the necessary experience and made a significant contribution despite difficulties related to the pandemic. The financial request looks reasonable. Therefore, I recommend the proposed project for a support with the first priority.

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