**Muon Ordinary capture for the Nuclear Matrix elemENTs in ββ decays**

**MONUMENT**

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**Abstract**

Search for the neutrinoless double beta decay (0) is one of the priority tasks of the modern physics. Its discovery would play a fundamental role not only for neutrino physics itself, but also for particle physics and cosmology. It would also allow determining the nature of the neutrino (Majorana or Dirac), testing the hierarchy of neutrino masses and possibly finding the effects occurring because of the violation of CP invariance. The discovery of 0 decay could shed light on the reason for the prevalence of matter over antimatter in our Universe. However, to determine the effective mass of the Majorana neutrino from the measured probabilities ​​of 0nbb decay, it is necessary to know the value of the corresponding nuclear matrix element (NME) with sufficient accuracy. Up to date, theoretical NME calculations give results that vary by a factor of 2–3, depending on the shell model used in evaluation. That is why, in recent APPEC recommendations (Astroparticle Physics European Consortium) it was specially recommended to intensify experimental and theoretical efforts, aimed to improve the calculations of NME.

The purpose of this project is carrying out experimental measurements of muon capture at several daughter candidates for 0 decay nuclei. Obtained results would be drastically important for checking the accuracy of theoretical calculations of NME. Our group, together withcolleagues, already applied for the beam time for measurements of ordinary muon capture (OMC) on several isotopes on a meson-factory of the Paul Scherrer Institute (PSI) in Switzerland. This application was reviewed and approved by the PSI User committee in January 2020. The beam time was officially granted in 2020 for a preliminary study of 136Ba (daughter nucleus for 136Xe) with a further measurement program for at least three years. Due to the current situation in the world regarding the COVID-19 coronavirus, the first stage of measurements was postponed from 2020 to October 2021.

The MONUMENT project continues and extends the previous OMC measurement program proposed and implemented under the guidance of JINR employees from 1998 to 2006. Our group has rich experience in the field of high-precision nuclear spectroscopy and its implementation for the study not only rare processes, but also muon capture.

Throughout the period from 2021 to 2023, it is planned to perform OMC measurements for 136Ba isotopes, 76Se and 96Mo. The OMC on 136Ba and 76Se is of particular importance for the planned leading experimental searches for the 0νββ decay of 136Xe – nEXO, KamLAND2-Zen, NEXT, DARWIN, and PandaX-III – and of 76Ge – LEGEND. In addition, we are going to measure and obtain results for OMC in 32S, 40Ca, 56Fe and 100Mo isotopes. These results are important for the experimental verification of theoretical calculations and may also be useful for astrophysics.JINR will play a leading role in the experiment. With the exception of the experimental infrastructure at the accelerator complex, which will be provided by our collaborators, the rest of the project will be led by us. We plan to purchase isotopes for the enriched targets, buyseveral germanium detectors and the necessary electronic equipment. Additionally, the project expenses include cost of travels and work stays at PSI. Overall budget of the project is valued at ~ 378,000 USD for 3 years.

In detail we are going to produce the targets and to construct an active muon filtration system for the experimental data. In 2020, our group prepared a special aluminum frame detector array placement. Preparations for the upcoming measurements in 2021 are in full swing, namely: the creation and testing of solid targets, as well as muon counters for the active muon system.

For June 2021, it is planned to ship part of the measurement setup to Germany. Our members of the project from theTechnische Universität München(TUM) under the leadership of
S. Schonertwill provide part of the germanium detectors and a data acquisition system, which will work in parallel with the exist one. In the future, the entire setup will be assembled and tested in Munich, and then sent to the PSI. Measurements of isotopically enriched 136Ba and 76Se are scheduled for October-November 2021.One of the important parts of preparation for the upcoming measurements is the study of previously accumulated OMC test data in 24Mg in 2019. The time and energy radiation spectra following muon capture in magnesium have been obtained, and the total muon capture rate and the yields of the produced radioisotopes have already been extracted. Based on the obtained results, a publication is being prepared. Data analysis is ongoing.