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The HOLMES experiment

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The detection of neutrino oscillations has proved that neutrinos are massive particles but the assessment of their absolute mass scale is still an oustanding challenge in today particle physics and cosmology.

Beta or electron capture spectrum end-point study is currently the one and only experimental method which can provide a model independent measurement of the absolute scale of neutrino mass. Within this framework the European Research Council has recently funded HOLMES, a new experiment to directly measure the neutrino mass. HOLMES will perform a calorimetric measurement of the energy released in the electron capture decay of 163Ho. This measurement was originally proposed in 1982 by A. De Rujula and M. Lusignoli, but only in the last decade the technological progress in detectors development allowed to design a sensitive experiment.

In a calorimetric measurement the energy released in the decay process is entirely contained into the detector, except for the fraction taken away by the neutrino. This approach eliminates both the problematics connected to the use of an external source and the systematic uncertainties arising from decays on excited final states. The most suitable detectors for this type of measurement are low temperature thermal detectors, where all the energy released into an absorber is converted into a temperature increase that can be measured by a sensitive thermometer directly coupled with the absorber.

HOLMES will deploy a large array of low temperature microcalorimeters with implanted 163Ho nuclei. The resulting mass sensitivity will be as low as 0.4 eV.

HOLMES will be an important step forward in the direct neutrino mass measurement with a calorimetric approach as an alternative to spectrometry. It will also establish the potential of this approach to extend the sensitivity down to 0.1 eV and lower.

In order to reach a sub-eV sensitivity it is necessary to collect statistics higher than 1013 decays. To fulfill this task the best experimental configuration has been defined after

Monte Carlo simulations: in its optimal configuration HOLMES will collect about 3x1013 decays with an instrumental energy resolution of about 1 eV FWHM and a time resolution of about 1 µs. For a total measuring time of 3 years, this requires a total 163Ho activity of about 300 kBq. Deploying an array of 1000 detectors, each pixel must contain an 163Ho activity of about 300 Bq. The total activity is given by about 6.5x1016 163Ho nuclei, or 18 µg.

The detectors for HOLMES have absorbers of Gold and Bismuth coupled to a Transition Edge Sensor (TES). The TES array is read out using microwave multiplexed rf-SQUIDs in combination with a ROACH2 based digital acquisition system. The multiplexed signal acquisition is a crucial feature for the experiment, and extensive research and development activity is in progress in order to maximize the number of multiplexed channels, while preserving the performances of the individual detectors, especially in terms of available signal bandwidth, i.e. time resolution.

The R&D activities necessary to optimize the 163Ho isotope production, the source embedding, the single detector optimization and array engineering, are also in progress and will converge in a preliminary measurement of an array of 16 detectors, identical to the final ones, planned by the end of 2016. This mid-term short measurement will provide precise information on the atomic and nuclear parameter of 163Ho electron capture decay. The final measurement with the full array is expected to start in late 2017.

We outline here the HOLMES project with its technical challenges, and its status and perspectives.

This abstract is presented on behalf of the HOLMES collaboration.