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Characterization of first prototypes of thin targets for the NUMEN Experiment

The NUMEN Experiment, at INFN-LNS (Catania), aims to get information on the Nuclear Matrix Elements of the Neutrinoless Double Beta Decay, by measuring Double Charge Exchange (DCE) reactions cross-sections [1]. The energy of the reaction products must be measured with high resolution. To fulfil this requirement, the target must be thin to minimize dispersion and straggling effects on the ejectile energy; the energy resolution is also influenced by the target thickness uniformity. Due to the small thickness, a mechanical support is necessary for the target. On the other hand, to have a large statistics very intense ion beams are required, which release a large amount of heat inside the target. Therefore the isotope will be deposited on a Highly Oriented Pyrolytic Graphite (HOPG) substrate that quickly transfers the heat outside the target system, thanks to its high surface thermal conductivity [2]. The target thickness will be of a few hundreds of nanometer, while the HOPG will be around 2 micrometers thick [3].

Prototypes of Germanium and Tellurium targets have been deposited with Electron Beam Evaporation process, which parameters have been optimized.

In the NUMEN Experiment the reaction final nuclei can be produced in different final states; a good energy resolution is needed to distinguish between the ground state and the first excited states to deduce the related DCE cross-sections. Unfortunately, the deposition technique does not guarantee a perfectly uniform target thickness. Such surface non-uniformity can be qualitatively inspected by Field Emission Scanning Microscopy (FESEM): images of the best Tellurium and Germanium target prototypes will be presented in the talk.

In order to evaluate both thickness and uniformity of the targets, alpha transmission spectroscopy measurements have been performed. The energy distribution shows a peak, which corresponds to the most frequent thickness; the width is related to the thickness spread. An experimental set-up has been designed, using an 241Am alpha-source and a silicon detector to measure the energy of the transmitted alpha particles. Some tests have been made with Rutherford Backscattering (RBS) technique on the same target samples, to evaluate the systematic error of the alpha-measurements.

In order to evaluate the dispersion and straggling effects due to the thickness and non-uniformity on the resolution of the measurements of the DCE products energy, a Montecarlo code has been implemented. The measured parameters of the thickness distribution have been inserted as input data of the simulation, for different values of the relative branching fractions of ground, first and second excited states. The obtained spectra give information about the resolution between two levels. The results are promising and will be shown in the talk.

[1] Cappuzzello F. et al., Eur. Phys. J. A, 54 (2018) 72, https://doi.org/10.1140/epja/i2018-12509-3

[2] V. Capirossi et al., Nucl. Instr, and Meth. in Phys. Res. A, (2018). https://doi.org/10.1016/j.nima.2018.08.081

[3] F. Pinna et al., Design and test of an innovative static thin target for intense ion beams, Il Nuovo Cimento (2019), in press.

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