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Measurement of ^{163}Ho electron capture spectrum: detector test

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The determination of the neutrino mass is since many years a very challenging problem. The analysis of the end part of low energy beta decay spectra offers one of the most promising approaches to investigate the neutrino mass. Presently the attention is directed on two isotopes, the ^{3}H for which the KATRIN mass spectrometer has been developed and the ^{187}Re for which an international collaboration called MARE (Micro-calorimeter Array for a Rhenium Experiment) has been installed. For the ^{187}Re low temperature calorimeters based on rhenium energy absorbers (natural rhenium contains 62% ^{187}Re isotope) are used. Both ^{3}H and ^{187}Re are beta- decaying isotopes and from the analysis of the corresponding spectra an upper limit of the electron anti-neutrino can be determined. A parallel experiment that can investigate the mass value of the electron neutrino, is the analysis of low energy electron capture spectra. Presently ^{163}Ho is considered to be the more suitable isotope for this measurement as the total energy available for its decay is about 2.4keV. The use of low temperature micro-calorimeters, where the absorber contains the radioactive source, represents the most promising choice for the ^{163}Ho spectrum measurement. This calorimetric measurement technique (that is the case when all the energy released in the decay minus the energy of the neutrino is measured) allows for obtaining an energy spectrum which is less dependent on theoretical models of the atomic de-excitation. Among energy dispersive detectors, low temperature calorimeters have the highest energy sensitivity. They are usually composed by an energy absorber well thermally connected to a temperature sensor weakly coupled to a thermal bath. When energy E is deposited in the absorber, the temperature of the detector increases as E/C where C is the heat capacity of the detector itself. We develop low temperature metallic magnetic calo-

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rimeters which are based on a paramagnetic sensor positioned in a weak external magnetic field. The change of temperature of the detector leads to a change of magnetization of the sensor which is read out by low noise SQUID magnetometers. The energy resolution we already obtain with magnetic calorimeters is 2.7eV FWHM at 6keV. The pulse rise time of the detector is well below 1μs. These two properties, high energy sensitivity and fast formation of the signal, make magnetic calorimeters suitable for a precise measurement of the ^{163}Ho electron capture spectrum. A high energy resolution spectrum of ^{163}Ho together with precise measurements of the father and daughter atomic masses, which define the total energy available for the decay, will provide a competing and/or complementary measurement of the neutrino mass compared to KATRIN or MARE.

The critical point which still needs to be investigated, before proposing a large scale experiment, is the preparation of the absorber. As mentioned, it is very important that the isotopes are inside the absorber itself and in particular it is needed that in each direction around the source the absorption of the released energy is as close as possible to 100%. Because of this we would like to implant ^{163}Ho ions in the detector absorber-lower part and then cover it with an additional gold layer, which acts as the upper part of the absorber.

Since our aim is to implant the ions in the already micro-structured detector, there are several points which can be investigated with this first ^{163}Ho collection:

-defects generated in the detector structure due to the implantation process

-purity of the beam

-preliminary measurement of the ^{163}Ho electron capture spectrum

We ask for a collection time of about 16 hours (2 shifts) which will allow the preparation of four detectors each with an activity of about 1Bq.

Since the implantation is done directly on the micro-structured detectors, measurements of them can be done a short time after they are back to our institute, after being connected to a SQUID read-out system and cooled-down to 50mK.

In addition we would like to have ^{163}Ho also implanted in a gold foil in small allowed area, which after being covered by sputtering a second gold layer, can be cut in the shape of absorber and glued on top of a detector. This second process will be extremely important in the case that the on chip detectors are damaged by the implantation process. Having these additional absorbers allows us to test:
-the purity of the beam
-a preliminary measurement of the ^{163}Ho electron capture spectrum
We ask then for a second collection step of about 16 hours (2 shifts) in order to have four additional gold absorbers with each 1Bq activity.
The two samples, the detectors on chip and the gold absorber can be mounted on the same sample holder.