ISOLDE and Neutron Time-of-flight experiments Committee

CERN Geneva

Letter of intent to the ISOLDE and Neutron Time-of-flight experiments Committee (INTC):

Collection of Rb-83 at low implantation energy for KATRIN

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KATRIN, the KArlsruhe TRItium Neutrino experiment (CERN recognized experiment RE 14) aims to measure the neutrino mass by spectroscopy of the tritium beta spectrum at the endpoint by means of a Magnetic Adiabatic Collimation combined with an Electrostatic filter (MAC-E-filter)

To achieve the anticipated sensitivity of 200 meV/c² (90% C.L.) it is mandatory to reproduce and stabilize the filter potential of 18.6 kV within +/-60 mV over a period of several years. Additionally to conventional electronics this shall be accomplished with the help of a nuclear standard. An appropriate isotope appears to be $^{83\text{m}}\text{Kr}$, a short lived daughter ($T_{1/2} \approx 110$ min) of $^{83}\text{Rb}$ ($T_{1/2} \approx 86$, 2 d). The 32.2 keV isomeric transition in $^{83\text{m}}\text{Kr}$ is highly converted, so that monoenergetic electrons of 17.8 keV (K-32) are emitted, which is close enough to the Tritium endpoint of 18.6 keV. It is also very important, that the natural line width is only 2.8 eV. We need to have a source were the generator isotope $^{83}\text{Rb}$ is embedded and the noble gas krypton is retained sufficiently, but the conversion electrons (at least a significant fraction) get out without energy loss. Also the source should have a chemically inert and robust surface. Especially the work function for electron emission should not change in time.
The technology of production of various radioactive rubidium isotopes by irradiation of krypton gas targets is quite evolved. For the first feasibility studies solid rubidium sources were made by vacuum evaporation of submono-layers of $^{83}$Rb onto various substrates. Evidently, due to contaminations by traces of mainly carbon, oxygen and hydrogen, variations from source to source in the subelectronvolt level were observed on the K-32 and other conversion electron lines. Moreover the long term stability needs to be improved.

A first explorative implantation at ISOLDE into a platinum foil has already been performed. As expected, the number of so called “zero-loss-electrons” is quite small, because the implantation energy was 30 keV. (Figure 1, filter spectra of solid rubidium sources). This should be improved at lower energies. To achieve this, we would provide an electrode system for the collection chamber to decelerate the beam further to about 10 keV at impact onto the surface. This should be close to a proper compromise between Kr-retention and number of “zero-loss” electrons. The setup sketched in Fig. 2 was tested down to an energy of 0.5 keV.
Also the choice of substrate may leave opportunities for improvement, because the catalytic impact of platinum on hydrogen compounds might not be anticipated. Therefore we ask for two collections on two different targets, namely gold and HOPG (highly oriented pyrolytic graphite) at the next possible Rb-beam time. Each source should have an activity of up to 5 MBq. To monitor the HV-System of the KATRIN-setup, we would need one Rb-83 source roughly every half a year. Depending on the producible activity an annual replacement of the source might be sufficient also.

Fig. 2 sketch of the retarding electrodes. The incident ions are guided by the ground electrode into the catcher at high voltage. So that the deceleration takes place only just before the impact and therefore, the spreading of the beam stays within acceptable limits.