AMS with Actinides

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Recently, we have focused our investigations on the development of an AMS method for the detection of actinides, as the setup of the Munich tandem laboratory shows ideal conditions for this aim.

Beside our strong astrophysical interest in detecting actinides, AMS is also believed to be a very sensitive tool in environmental research, which cannot be reached by other methods, e.g. the sensitivity of measuring actinides with AMS is at least three orders of magnitude lower than that practicable by alpha spectrometry.

AMS with actinides differs from standard AMS, where a concentration of a long living isotope in a matrix of a stable isotop of the same element is measured. Since actinides have no stable isotopes a radioactive tracer isotope has to be added before the chemical sample preparation to check the efficiencies of chemistry and ion source. On the other hand actinides can be highly enriched, while in standard AMS there are limitations due to the stable isotopes. This can cause high sample amounts, which have to be introduced into the ion source.

For measuring actinides with AMS, a new dedicated ionisation chamber was constructed and the first tests show promising results.

In cooperation with the Radiochemisches Institut der Technischen Universtiät München, chemically variing types of plutonium samples were investigated with regard to their use in the Cs-sputter ion source. An aim is to use very small amounts of matrices in order to have an easy applicable preparation method and to get high yields of plutonium out of the source.

General setup

For actinide measurements with AMS, the $-10°$ beamline at the Tandem laboratory is used. On the low-energy side, negative PuO^- molecules are produced in a Cs-sputter ion source in sputter cathodes containing Pu in an ironoxid matrix. The Pu nuclides are accelerated as Pu^{11+} at a terminal voltage of about 12.5 MV.

One of the great benefits of the Munich Tandem setup is an analyzing magnet of high magnetic rigidity after the tandem, which allows to bend even actinides at high terminal voltages and therefore achieving a good energy resolution in the detector. For detecting actinides, a combination of Time-Of-Flight and $\Delta E/E_{rest}$ telelscope, consisting of an ionisation chamber with two energy loss sections and depletion layer counter, has been chosen.

First results

The sputter cathodes (test samples and standards) were made of ^{239}Pu in an iron matrix solved in concentrated HF. For a test of total Pu yields, a small amount of 7×10^7 Atoms ^{239}Pu has been used. During the AMS measurement about 4700 events were counted totally, i.e. the detection limit is about 15000 atoms of ^{239}Pu.

In addition, background measurements have been performed with blank samples, made of purified iron oxide powder. The background was found to be less than 2×10^{-15} Pu/Fe depending on the Pu-isotope. A TOF/E_{rest} spectrum of a measurement of a ^{239}Pu-standard is shown in fig. 1.

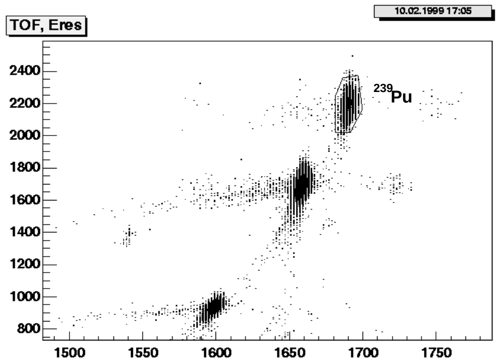

Fig. 1: TOF/E_{rest} spectrum of a ^{239}Pu-standard

New detector

The new ionization chamber, divided in two energy loss sections, has a total detection length of about 160 mm and ends with a surface barrier counter. The length was chosen with respect to the high stopping power of actinides. Due to the length it will be possible to choose a low gas pressure of about 10 mbar and hence to be able to use a thin entrance foil of about 100 μg/cm^2 in order to keep energy loss and straggling low. The anode is divided in two symetrical sections, so the field lines are perpendicular to the anode at the division line. This simple construction allows to waive potential forming components, like potential rings. A drawing of the new detector is shown in fig. 1.

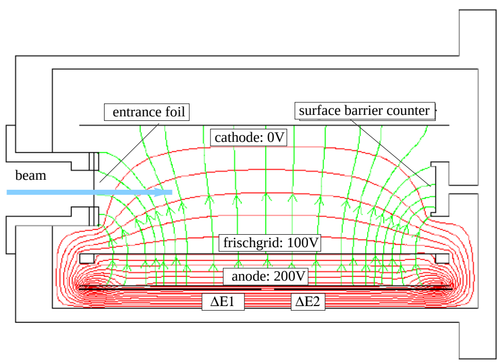

Fig. 2: Drawing of the new combinated ionisation chamber/surface barrier counter with potential lines and electrical field. Distance between entrance foil and surface barrier counter: 160mm