AMS with ^{60}Fe

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The longlived radioisotope ^{60}Fe has previously been used as an AMS isotope only at the Argonne National Laboratory, where the halflife of 1.5 Myr has been measured [1]. However a number of important applications in different fields of research are conceivable. Examples are:

Astrophysics: The concentration of ^{60}Fe in meteorites, produced by cosmic ray induced spallation of Ni isotopes, could together with concentrations of other radioisotopes, yield information on the history of these meteorites and on spectrum and constance of cosmic radiation.

Nuclear physics: With the detection of ^{60}Fe in fission fragments the yield of A=60 in neutron induced fission could be measured, thus extending the known yield curves, with several orders of magnitude more sensitivity, to the asymmetric side.

Medicine: With ^{60}Fe the iron metabolism in men could be investigated with negligible dose, and double tracer measurements with ^{55}Fe, also detectable by AMS [2], are a promising possibility.

For all these applications a detection limit of less than ^{60}Fe/Fe=10^{-13} is necessary. As will be shown, we were able to reach this level of sensitivity using the detection system GAMS [3].

In order to perform quantitative measurements, we produced a calibration standard with known ^{60}Fe concentration. The usual (n,γ) reaction is not possible in this case, because ^{59}Fe is not stable. Therefore we used the ^{48}Ca(^{18}O,α2n)^{60}Fe compound reaction. A 55 MeV ^{18}O beam bombarded a 1.4 mg/cm^2 thick ^{48}Ca target, enriched to 70%, that was mounted in front of an iron foil. The recoil nuclei were implanted into this foil. With a Ge detector in-beam gamma rays were measured. From the total number of counts for the 1291 keV $4^+ \to 2^+$ and 824 keV $2^+ \to 0^+$ transitions in ^{60}Fe we could calculate the total number of ^{60}Fe nuclei produced and their concentration in the Fe foil as $(8.8 \pm 0.6) \cdot 10^{-12}$. In order to homogenize this foil we dissolved it in HCl and precipitated $Fe(OH)_3$ with ammonia. This served as sputter target. We determined also the cross section for this evaporation channel as 14 ± 1 mb.

For the AMS measurement we extracted ^{60}Fe^{16}O$^-$ molecular ions from the sputter source, because their yield is similar as for NiO$^-$, whereas for atomic ions the isobar ^{60}Ni$^-$ has about 20 times higher yield than ^{60}Fe$^-$. The ions were accelerated to 150 MeV and the 11^+ charge state was selected with the analyzing magnet and transported to the GAMS system. In the gas filled magnet the isobars were spatially separated. Their position, angle, total energy and several energy losses were measured in the ionization chamber behind the magnet. Fig. 1 and 2 show two-dimensional spectra, as a function of position and total energy, for our calibration sample and for a meteoritic sample. Both spectra are obtained without setting conditions on energy losses or time of flight. The dominant intensity comes from ^{76}Se at small energy, not suppressed by the injection magnet, and from ^{60}Ni, visible on the side of the detector. Its intensity in the detector was cut down by a factor of 100 by deflecting it with the magnet. Even without conditions ^{60}Fe from the calibration sample is clearly visible in Fig.1. By setting conditions on all measured parameters the other components in the spectra are completely eliminated, but the ^{60}Fe are reduced only by 20%. In the spectrum for the meteoritic sample one event fulfills all conditions. If this event is a true ^{60}Fe event, the concentration in this meteorite is ^{60}Fe/Fe= $1.2 \cdot 10^{-14}$. In a spectrum of a blank sample we observed no event with about the same sensitivity.

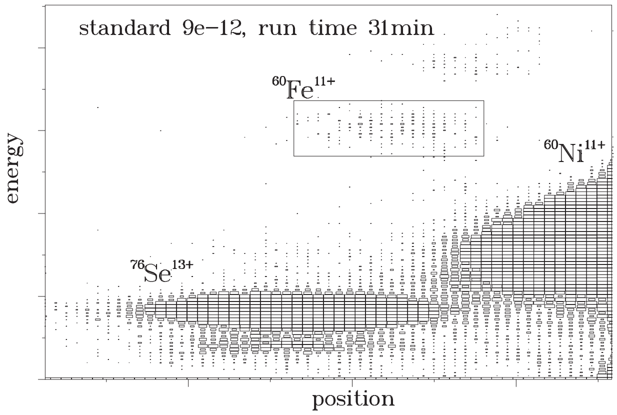

Fig. 1: Position versus total energy for the calibration sample. No conditions on other parameters. From the 241 events in the range for ^{60}Fe, 196 survive, if the proper conditions on other parameters are set, whereas all background events are eliminated.

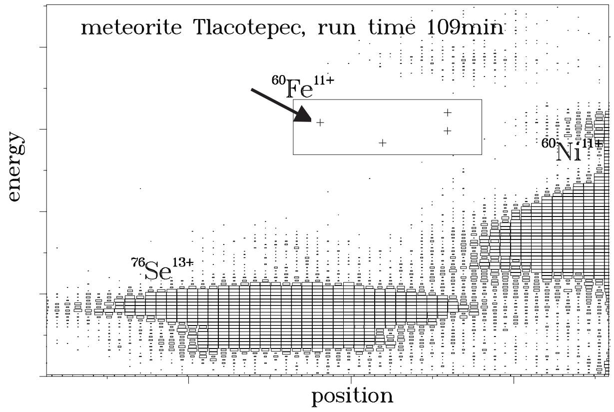

Fig. 2: Same as Fig.1 for a sample from the meteorite Tlacotepec. Of the four events in the ^{60}Fe range (intensified by +) only one (marked by the arrow) remains after setting the conditions. This corresponds to a concentration of $1.2 \cdot 10^{-14}$.

References

[1] W. Kutschera et al., Nucl. Instr. and Meth. **B5** (1984) 430
[2] G. Korschinek et al., Nucl. Instr. and Meth. **B52** (1990) 498
[3] K. Knie et al., Jahresbericht 1995