AMS with the Gas-Filled Analyzing Magnet System GAMS

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One major problem in AMS is to separate the radioisotope from the disturbing stable isobar, as it is in most cases present as an impurity in the sample. As it was shown in previous work [1,2] isobaric discrimination in a gas filled magnet is a very efficient and sensitive method to detect heavy radioisotopes like ^{59}Ni. In a gas filled region the ions will interact with the gas atoms, loose and capture electrons and an average charge state can be assumed. This charge state depends on their atomic number. Therefore ions with different Z have different magnetic rigidities and one can detect isobars at different positions after magnetic deflection.

In former measurements done in Munich [1] and Argonne [2] spectrographs were used for this purpose. Here, however, the geometry of the magnetic field is not optimized for maximal separation of the disturbing isobar. Due to the long field free drift paths in the gas filled region (more than 50%) the ions loose more energy and get more scattered than necessary. Also the bending angle is not optimized for our intention. Because of the high dispersion, even ions arriving at the same position could have had different path lengths in the gas. This will cause additional energy straggling. For these reasons we have set up GAMS, an AMS system consisting of a 3.5 m time-of-flight path for suppression of isotopic background, a compact 135° magnet (r = 90 cm) and a position sensitive Frisch-grid-ionization-chamber [3,4].

To test the isobaric separation we injected a mixed beam of the stable isotopes ^{58}Ni and ^{58}Fe. With a given difference in magnetic rigidity, i.e. a given distance of the two position peaks, the peak widths had to be minimized. The width is due to two processes: statistics of the charge state fluctuations and small angle scattering after collisions with gas atoms. These two processes depend on the gas pressure in a contrary way, so there should be an optimum pressure. Also different kinds of gases were tested. Using very light gases like hydrogen or helium we got very broad peaks because of the very low charge changing cross sections of these light elements. With heavier gases like argon the small angle scattering dominates the improvement of the statistics due to the large cross sections. Also the energy straggling of the beam is high in this case. The best separation of five times the peak width (FWHM) was achieved with nitrogen at 11 mbar (see fig. 1). This is an improvement of 30% to former measurements with the gas filled Q3D. The energy loss of the 170 MeV ions was in this case of about 45%.

Measuring the Bragg curve with five energy loss sections makes further background suppression possible. The distance of the nickel and the iron peak in the ΔE_3 spectrum e.g. was four times the peak width.

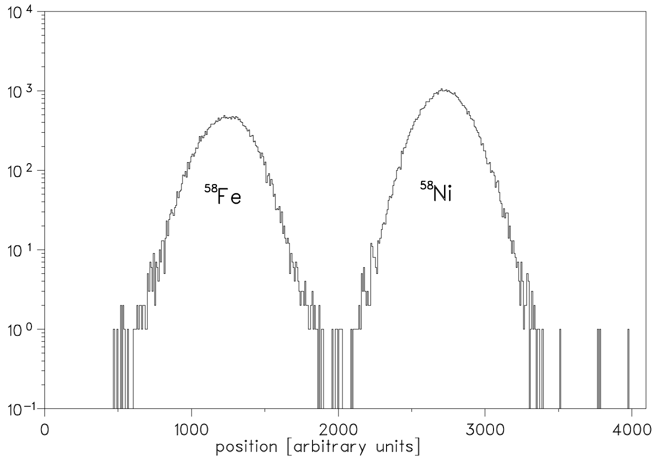

Fig. 1: Separation of the isobars ^{58}Ni and ^{58}Fe in position

The first and third of the energy loss sections are split diagonally to obtain information of position and horizontal angle of the incoming ions. The vertical angle is measured by comparing the time of the ΔE_2 and ΔE_4 signal. The angle measurement is of importance if e.g. a ^{59}Co ion gets Rutherford-scattered on the detector's entrance foil, its path through the detector gets inclined and therefore its energy loss signals becomes very similar to those of an unscattered ^{59}Ni ion. Loosing energy in the scattering process, also its total energy, gets similar to that of a ^{59}Ni ion, which had lost more energy passing the gas magnet. Hence these scattered ions are only to discriminate by measuring their angle.

The disturbing isobar can be bent out of the detector. This allows always an acceptable counting rate in the ionization chamber. Thus ^{60}Fe and ^{53}Mn detection became possible with high sensitivity.

In first tests sensitivities of $^{36}\mathrm{Cl/Cl} \approx 2 \cdot 10^{-15}$, $^{53}\mathrm{Mn/Mn} \approx 5 \cdot 10^{-11}$, $^{59}\mathrm{Ni/Ni} \approx 1 \cdot 10^{-13}$ and $^{60}\mathrm{Fe/Fe} \approx 10^{-14}$ were achieved. The reason for the moderate detection limit in the case of ^{53}Mn was a very high chromium content of 10 ppm in the samples. Nevertheless the ^{53}Mn/Mn ratio was measured in some meteoritic samples because of a typical ^{53}Mn concentration in extraterrestrial samples of one to two orders of magnitude higher.

^{60}Fe measurements are discussed in ref. [5]

References

[1] G. Korschinek et al. Nucl. Instr. and Meth. **B92** (1994) 146
[2] M. Paul et al. Nucl. Instr. and Meth. **B52** (1990) 315
[3] T. Faestermann et al., Jahresbericht 1993, p. 109
[4] T. Faestermann et al., Jahresbericht 1994, p. 254
[5] C. Schmidt et al., this report p. 68