Improved ^{60}Fe Data from a Ferromanganese Crust

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We have continued our studies on ferromanganese crusts for the detection of supernova induced ^{60}Fe (see [1] and also [2]). As already reported, there are several astrophysical observations which indicate that one or even more supernovae (SNe) occurred rather close to the solar system during the last millions of years. Such information comes from studies of the local interstellar matter [3], analyses of the extreme ultraviolet radiation in the solar vicinity [4], and observations of the composition of cosmic rays [5]. After an explosion, the ejected debris (containing the bulk of ^{60}Fe) can travel 50 pc and even beyond, depending on the density of the interstellar medium. In case of a SN sufficiently close to our solar system, this material can be directly deposited on Earth, leaving an ^{60}Fe signal far above the natural terrestrial level [6,7]. The depth of the signal inside the crust and its intensity yield information on the timing and the distance of this event. The aim of these new measurements was to improve the time resolution of our data as well as to confirm previous measurements. Because of its unique uniformity the crust 237KD from cruise VA13/2 is the best choice to get this information. Hydrogeneous deep-ocean ferromanganese crusts are an ideal reservoir for dating of such a signature. These crusts absorb the elements from the surrounding ocean water and grow accordingly. Our crust originates from the equatorial Pacific at a depth of 4830 m. Its growth rate is about 2.5 mm/Myr based on the dating with the depth profile of incorporated ^{10}Be ($T_{1/2} = 1.5$ Myr) which originates from stratospheric spallation processes [8]. An improved dating of our samples is in progress.

Layers with a thickness of 2 mm were milled of, iron has been chemically extracted, and the ratio of ^{60}Fe/Fe in each layer has been measured by AMS. With the GAMS setup these ratios have been measured with unparalleled sensitivity down to a level of around 10^{-16} [9].

Because of the extremely low ^{60}Fe concentrations these measurements are time consuming. Even in the peak region ^{60}Fe count rates are in the order of one event per hour. The new, improved data are shown in figure 1. A 2 mm profile (wide horizontal error bars) shows a clear peak at 2.8 Myr. Around 2.8 Myr and around 9 Myr we have measured with an improved time resolution (1 mm layers have been taken corresponding to 0.4 Myr each). While the peak at 2.8 Myr could be clearly confirmed, the concentrations measured around 9 Myr are now compatible with our background level of about $2 \cdot 10^{-16}$.

The distance of the SN can be estimated as a few 10 pc (for more details see [2]), which is compatible with expectations: a much smaller distance is very unlikely and should have left additional marks on Earth, whereas for a much larger distance the explosion front would have been stopped by the ISM before it would have reached the Earth.

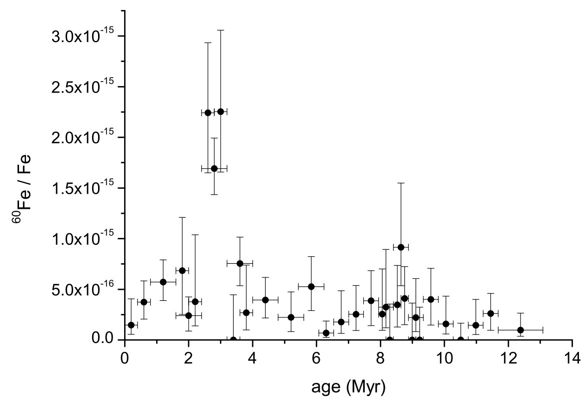

Fig. 1: ^{60}Fe/Fe ratios in the maganese crust versus the age of the layer. Vertical error bars give the statistical error with a CL of 68.3 %, horizontal bars indicate the depth (time) intervals covered by the respective layers.

References

[1] K. Knie *et al.*, Annual report 2002, p. 36
[2] K. Knie *et al.*, Phys. Rev. Lett. **93** (2004) 171103
[3] R.K. Smith, D.P. Cox, ApJS **134** (2001) 283
[4] C.-H. Lyu, F.C. Bruhweiler, ApJ **459** (1996) 216
[5] I.V. Moskalenko et al., ApJ **586** (2003) 1050
[6] B.D. Fields, J. Ellis, New Astronomy **4** (1999) 419
[7] K. Knie *et al.*, Phys. Rev. Lett. **83** (1999) 18
[8] M. Segl *et al.*, Nature **309** (1984) 540
[9] K. Knie *et al.*, NIM **B172** (2000) 717