Thin and Thick Target Cross Sections for the Production of ^{53}Mn and ^{60}Fe in Meteorites

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In the last years we have utilized the high sensitivity achievable with our large tandem and the gas-filled analyzing magnet system GAMS [1] to measure the cosmogenic radionuclides ^{53}Mn and ^{60}Fe in meteorites via AMS (accelerator mass spectrometry) [2,3,4,5].

Both radionuclides have a simple target composition in meteorites (iron and nickel for ^{53}Mn, nickel for ^{60}Fe), i.e. their irradiation can be easily deduced from those radionuclide concentrations. Especially ^{53}Mn has a very long half life (3.7 My), thus information can be achieved for time spans $> 10^7$ y.

Unfortunately, there have been no cross section data for the production of ^{53}Mn and ^{60}Fe on nickel, and only poor data for the production of ^{53}Mn on iron. The excitation function for the latter case was already measured and published in the last annual report [6]. In an analogue way the excitation functions for the production of both nuclides with protons on nickel targets were measured by AMS at the GAMS. For the results see tab. 1 and fig. 1.

E [MeV]	Ni(p,x)^{53}Mn σ [mbarn]	Ni(p,x)^{60}Fe σ [μbarn]
33.5	29 ± 3	9.8 ± 1.4
68.1	38 ± 3	23 ± 3
114	56 ± 5	29 ± 3
299	53 ± 6	41 ± 5
781	43 ± 4	76 ± 7
957	48 ± 6	91 ± 11
1190	43 ± 5	84 ± 8
1359	41 ± 5	90 ± 10
2600	27 ± 3	68 ± 7

Table 1: Resulting cross sections for the reactions ^{nat}Ni(p,4pxn)^{53}Mn and ^{nat}Ni(p,3pxn)^{60}Fe.

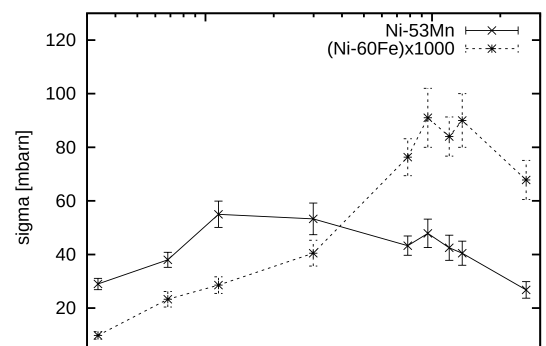

Fig. 1: see table 1

Most cosmogenic ^{53}Mn and ^{60}Fe nuclei, however, are not produced by primary cosmic ray protons, but by secondary protons, and, dominantely, by secondary neutrons. To obtain the production rates in meteoroids, a steel sphere ($r = 10$ cm) has been irradiated isotropically with 1.6 GeV protons to simulate the cosmic ray bombardment of an iron meteorite [7]. In different depths of the sphere nickel and iron target foils were placed. From these foils ^{53}Mn and ^{60}Fe was chemically extracted and measured with AMS. The resulting depth profiles are given in tab. 2 and fig. 2.

d [cm]	Fe(p,x)^{53}Mn	Ni(p,x)^{53}Mn	Ni(p,x)^{60}Fe
0.40	97 ± 14		
0.95		108 ± 7	0.203 ± 0.026
1.92	121 ± 13		
2.50		101 ± 7	0.184 ± 0.026
4.09	126 ± 13		
4.68		101 ± 7	0.226 ± 0.031
5.39	124 ± 19		
6.12	139 ± 20		
7.17		93 ± 11	0.230 ± 0.032
7.50	150 ± 23		
7.96	136 ± 15		
8.04		102 ± 13	0.216 ± 0.027
8.29	131 ± 34		
9.65	151 ± 15		
9.81		105 ± 12	0.256 ± 0.034

Table 2: Production rates for ^{53}Mn and ^{60}Fe in an artificial meteoroid with $r = 10$ cm in 10^{-5} atoms g(target element)$^{-1}$ s^{-1}, normalized to a proton flux of 1 cm^{-2} s^{-1}

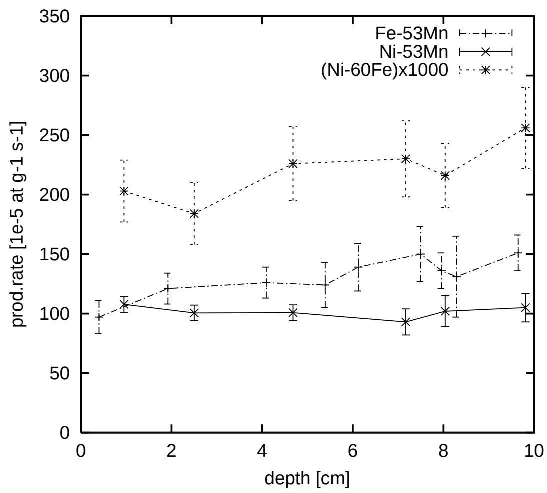

Fig. 2: see table 2

References

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