The Excitation Function for the Production of ^{53}Mn via the Spallation Reaction ^{nat}Pb + p

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Excitation functions from proton-irradiated targets are interesting for many cases, e.g. understanding of production yields by cosmic rays in extraterrestrial matter, but also for the long-term waste management of accelerator exposed materials. Isotopes with half-lives of hundred-thousand to some million of years are likely to be produced in this nuclear reaction. Those are for instance ^{59}Ni and ^{53}Mn. Moreover, several α-emitting rare earth elements (REE) like ^{148}Gd ($T_{1/2}$= 74.6 a), ^{154}Dy ($T_{1/2}$ = 3.0 $\cdot 10^6$ a) or ^{146}Sm ($T_{1/2}$ = 1.03 $\cdot 10^8$ a) are of special interest because their α-radiation may cause serious dose limit problems for the final disposal. The irradiations were performed at the SATURNE synchrotron in Saclay with proton energies up to 2.7 GeV. The produced radionuclides were then chemically extracted. Special attention had to be paid to the quantitative chemical separation of the stable isobaric isotopes, which might interfere with the AMS measurement. This means that ^{53}Mn had to be separated from stable ^{53}Cr and ^{59}Ni from stable ^{59}Co.

The irradiated Pb targets (ca 125 mg/cm^2) were dissolved in 7 M HNO_3. After removing ^{10}Be, ^{26}Al, ^{129}I, ^{36}Cl, ^{60}Fe and ^{99}Tc a 6 molar M HCl solution was obtained, which contained the remaining interesting isotopes, ^{53}Mn, ^{59}Ni and the rare earth elements. 5 mg Mn, 5mg Ni and 1 mg of La were added as carrier material, the solution was evaporated to dryness and the residue was dissolved in 0.1 M HNO_3. Lanthanum carrying all lanthanides was precipitated as fluoride using 1 M HF. The lanthanides can be separated from each other by dissolving the fluorides in boric acid, adsorption of the Ln^{3+} cations onto an ion exchanger (DOWEX50x8) and following subsequent elution. The details of this separation procedure as well as the results of the α-measurements will be described elsewhere. Mn was then precipitated by using a mixture of H_2O_2 and NH_3. The $MnO(OH)_2$ was washed twice with bi-distilled water and dried at 80°C. ^{53}Cr as the isobaric isotope to ^{53}Mn is known to form anions in basic oxidizing medium and, additionally, a peroxide complex can be formed. By this method, chromium is separated completely from the Mn fraction. Ni remains in the solution as ammonium complex $Ni(NH_3)_4{}^{2+}$ under these conditions and can be precipitated as insoluble complex with dimethylglyoxime (DMG). The stable ^{59}Co-isobar does not form such insoluble complexes.

The AMS measurements were carried out at our AMS set up GAMS. In Fig.1 the dependence of the cross sections for the production of ^{53}Mn in lead targets on the proton energy is shown.

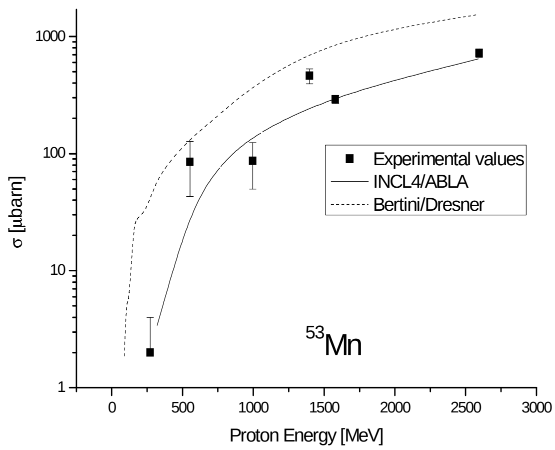

Fig. 1: Cross sections for the production of ^{53}Mn in the reaction ^{nat}Pb +p as a function of the proton energy

Comparing these results with those obtained by theoretical predictions, the values fit well. It can also be seen, that the new developed INCL4/ABLA code gives a better agreement with the experimental values. These results strengthen the knowledge on the residue nuclide production of very long-lived isotopes by spallation and are, therefore, of great importance to evaluate the risk of long-term storage of accelerator waste resulting from accelerator exposed materials. But they are also of importance for understanding the production of long-lived radionuclides due to cosmic rays in extraterrestrial matter.