Ternary Fission Yields of ^{241}Pu(n_{th},f)

U. Köster, H. Faust [a], G. Fioni [b], T. Friedrichs [a,c], M. Groß, and S. Oberstedt [a]
[a] Institut Laue Langevin, Grenoble [b] CEA Saclay, DSM/DAPNIA/SPHN, Gif-sur-Yvette
[c] TU Braunschweig, Inst. für Metallphysik und Nukl. Festkörperphysik

Ternary fission

Ternary fission was discovered more than 50 years ago [1]. Since then detailed studies of light charged particle accompanied fission were done with different methods (see [2,3] for an overview). Yields and energy distributions of various ternary particles had been measured for several thermal neutron induced fission systems: ^{233}U(n,f), ^{235}U(n,f), ^{239}Pu(n,f) and ^{241}Am(2n,f). However, for other fission systems only scarce data existed which made a systematic study of the dependence of ternary particle yields on the fissility and neutron excess of the compound system difficult. Recently a series of measurements was performed to fill this gap. We studied the system ^{241}Pu(n_{th},f), where formerly only the yields of ^{4}He and ^{3}H were known [4].

LOHENGRIN

The experiments were performed at the recoil separator LOHENGRIN (fig. 1) at the high-flux reactor of the Institut Laue Langevin in Grenoble. Recoiling fission fragments are separated according to their mass over ionic-charge ratio onto a parabola, on which the position is given by their kinetic energy. They are identified in a split-anode ionization chamber.

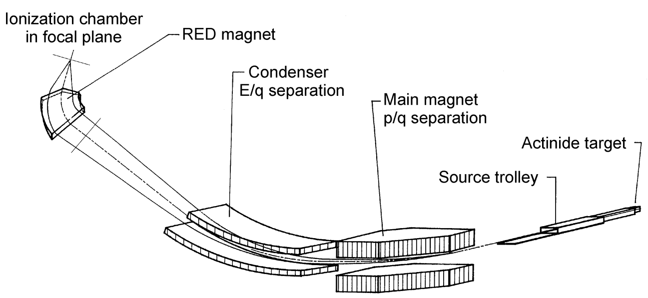

Fig. 1: Arrangement of the recoil separator LOHENGRIN.

Yields

After integration over the distribution of ionic charges and kinetic energies, the yields of 42 nuclides could be determined. For further 17 nuclides upper limits could be deduced, see figure 2.

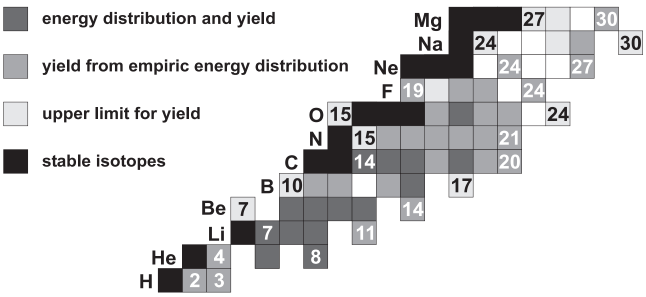

Fig. 2: Overview of the measured ternary particles arranged in form of a nuclide chart. The numbers mark the mass of the lightest and heaviest measured isotope of each element.

The integrated mass yield is shown in figure 3. Binary yields of the light fragment group [5,6] are plotted for comparison. The strong oscillation of the ternary yields can be understood from the fact that most ternary mass yields are dominated by a single isotope. Thus high yields of individual isotopes (^{10}Be, ^{14}C, ...) lead to a significant staggering of the yields.

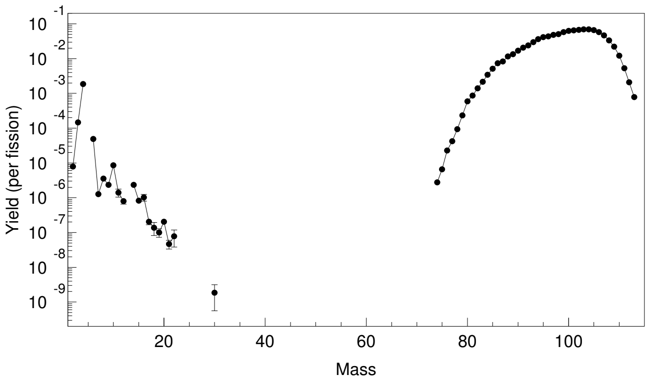

Fig. 3: Absolute mass yields from ^{241}Pu(n_{th},f) (per fission).

Fig. 4 shows that isotopes with large neutron excess can, despite their extremely low yield, be clearly and unambiguously identified in the ΔE-E-scatter plot. Thus also the neutron halo nuclides ^{11}Li, ^{14}Be and ^{19}C could be identified with absolute yields of some 10^{-10}.

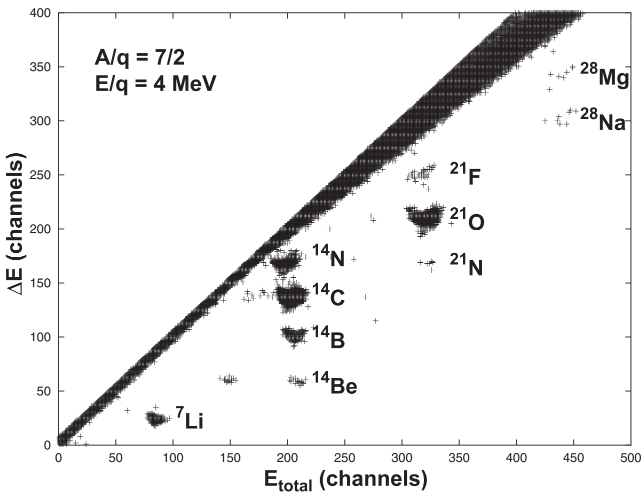

Fig. 4: Identification of ^{14}Be in a ΔE/E scatter plot taken during 19.5 h with the separator set to $A/q = 3.5$ and $E/q = 4$ MeV.

References

[1] T. San-Tsiang *et al.*, C. R. Acad. Sci. **223** (1946) 986
[2] C. Wagemans, ch. 12 in *The Nuclear Fission Process*, ed. by C. Wagemans, CRC Press, Boca Raton, 1991, p. 545.
[3] M. Mutterer and J.P. Theobald, ch. 12 in *Nuclear Decay Modes*, ed. by D.N. Poenaru, IOP, Bristol, 1996, p. 487.
[4] C. Wagemans *et al.*, Phys. Rev. **C33** (1986) 943
[5] Thomas Friedrichs, Ph.D. thesis, TU Braunschweig, 1997
[6] P. Schillebeeckx *et al.*, Nucl. Phys. **A580** (1994) 15