Electron-Capture Delayed Fission of ^{244}Es

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As part of our continuing study of electron-capture delayed fission (ECDF) in the neutron deficient actinides, we measured the delayed fission properties of ^{244}Es. We tried to study this nuclide previously using the $^{233}U(^{15}N,4n)^{244}Es$ reaction, but only saw two delayed fission events during the course of the experiment, indicating that the cross section was on the order of 50 nb. This time we chose the $^{237}Np(^{12}C,5n)^{244}Es$ reaction, which was supposed to have a production cross section on the order of 1 μb.[1] The 88-Inch Cyclotron supplied the 81-MeV (on target) ^{12}C beam.

Reaction products were swept from the target chamber using a He/KCl gas-jet, and were transported via a capillary to our rotating wheel detection system. Collected samples were stepped every 30 seconds between six pairs of solid state particle detectors in order to look for alpha particles and fission fragments.

In order to determine the probability of delayed fission (P_{DF}) one must compare the total number of electron-capture (EC) events to the number of delayed fission events. Even though ^{244}Es has a small alpha branch on the order of 4%, we did not see any alpha particles attributed to ^{244}Es.[2] In order to determine the total number of EC events, we instead measured the alpha decay of ^{244}Cf, its EC daughter. Based on the ^{244}Cf alpha decay we measured a production cross section of 0.5 ± 0.2 μb for ^{244}Es.

A total of 14 coincident fission pairs were detected during the course of the experiment. This resulted in a P_{DF} of $(6.4 \pm 3.8) \times 10^{-4}$, which is consistent with a previously reported value estimated to be on the order of 10^{-4}.[3] The average pre-neutron total kinetic energy (TKE) for fission of ^{244}Cf was 209 ± 15 MeV. Within error, this value agrees with the predictions of 193 MeV and 190 MeV made by Unik and Viola respectively.[4,6] The fission mass-yield distribution is asymmetric as expected for this region.[5] Fig. 1 shows the pre-neutron TKE distribution for the 14 coincident fission events.

Footnotes and References

1. Calculated using the SPIT code. T. Sikkeland, Ark. Fys. **36**, 539 (1967); J. Alonso in *Gmelin Handbook of Inorganic Chemistry*, edited by R. Warncke (Springer-Verlag, New York, 1974), Vol. 7b, p.28.

2. R.B. Firestone, *Table of Isotopes*, 8th ed. (Wiley-Interscience, New Work, 1996).

3. Y.P. Gangrskii et al., Sov. J. Nucl. Phys. **31**(2), 162 (1981).

4. J.P. Unik et al., *Proceedings of the Third International IAEA Symposium on the Physics and Chemistry of Fission*, Rochester, 1973 (IAEA, Vienna, 1974), Vol. II, p. 33.

5. B.D. Wilkins et al., Phys. Rev. C **14**(5), 1832 (1976).

6. V.E. Viola et al., Phys. Rev. C **31**, 1550 (1985).

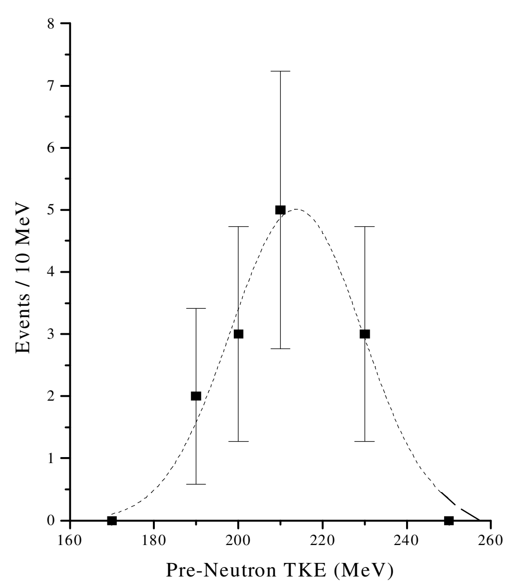

Fig. 1. Pre-neutron TKE distribution for fission of ^{244}Cf.