Production of heavy neutron-rich nuclei "south" of lead

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The properties of nuclei along the N = 126 neutron shell, "south" of lead are extremely interesting for the production of heavy elements in stellar nucleosynthesis through the r-process. Nuclei in this region have been produced using a 1 A GeV ^{208}Pb beam by cold projectile-fragmentation reactions in a beryllium target, where mostly protons are abraded from the projectile, while the excitation energy induced is low, partly even below the particle evaporation threshold. Neutron-rich projectile residues were analysed by the magnetic spectrometer FRS and identified in mass and atomic number, see Fig. 1.

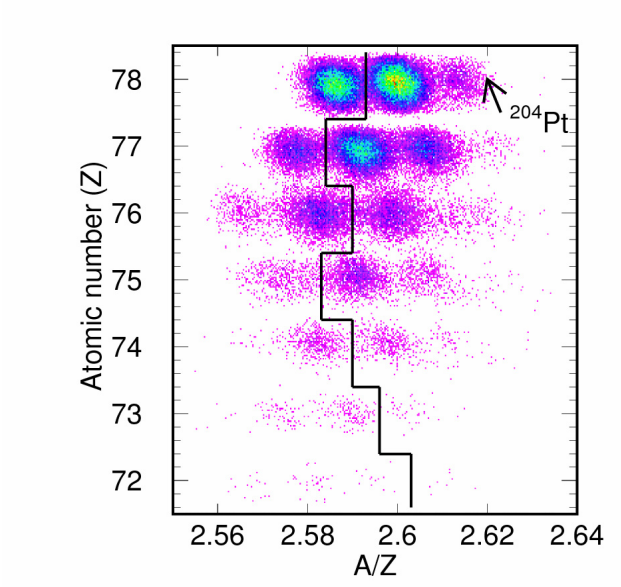

Figure 1: Identification matrix showing part of the most neutron.-rich nuclei produced in this experiment. The black lines represent the present limits of known nuclei.

The production cross sections of more than 190 neutron-rich isotopes of elements from lead down to ytterbium were measured with an uncertainty around 15%. 25 of those have been produced and identified for the first time.

Fig. 2 shows the isotopic distributions for some selected elements in comparison with different model calculations. The semi-empirical formula EPAX v.2 [1] in general fails in the description of the data; in particular the most neutron-rich nuclei are considerably overestimated. Much better agreement is found for the COFRA code [2], which is an analytical formulation of the abrasion-ablation model [3]. The good description of the data confirms that that reaction channels leading to the production of the most neutron-rich nuclei are due to large fluctuations in both the N/Z and the excitation energy of the pre-fragment.

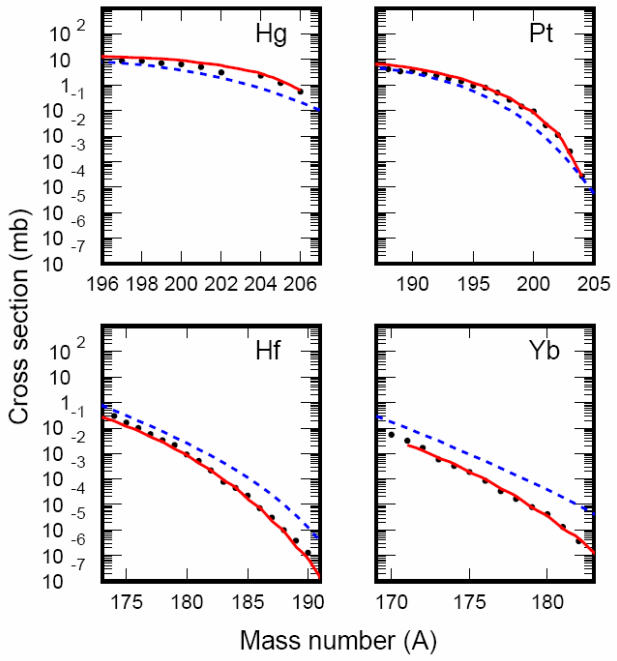

Figure 2: Isotopic production cross sections of some selected residual elements measured in this experiment compared to two model calculations, EPAX [1] (dahsed line) and COFRA [2] (solid line).

Our experiment has proven that cold fragmentation is a suitable reaction mechanism for the production of extremely neutron-rich nuclei, which are too heavy to be produced as fission fragments. This opens a way for investigating the properties of heavy nuclei close to the r-process path.

References

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