Production of neutron-rich isotopes in cold-fragmentation reactions induced by relativistic ^{208}Pb projectiles

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One of the major challenges of nuclear physics is to enlarge the present limits of the chart of the nuclides. The experimental progress during the last decade has allowed to reach the proton drip line up to the charge 80. In contrast, the situation is quite different in the neutron-rich side. The last bound isotope has been observed only up to the charge 10. Fission has been used succesfully to produce medium-mass neutron-rich isotopes [1] while the heavy neutron-rich part remain almost unexplored. However, few years ago, cold-fragmentation reactions induced by relativistic projectiles were proposed as the optimum reaction mechanism to populate the heavy neutron-rich side of the chart of nuclides.

In this paper we report an experiment performed at the GSI fragment separator FRS to produce heavy neutron-rich isotopes close to the neutron shell N = 126 by cold-fragmentation reactions induced by ^{208}Pb projectiles at 1 AGeV impinging a Be target.

The isotopic identification was achieved by measuring both the atomic number and the mass-over-charge ratio A/Z of each nucleus by means of the measurements of the magnetic rigidities, time-of-flight (ToF) and energy loss of each fragment passing through the FRS.

Two position sensitive plastic scintillators placed at the midplane and at the final focal plane of the FRS, provided the ToF and the magnetic rigidity measurements. The ToF calibration was obtained from measurements of the primary beam at several energies by slowing it down with degraders of different thicknesses. The magnetic rigidity was deduced from the magnetic fields of the dipoles and from the horizontal positions measured at the central and final image planes by applying the appropriate ion-optical equations. In order to achieve the required A/Z resolution, higer order corrections had to be applied.

For heavy ions the mass resolution becomes a key problem, since the relative change in magnetic rigidity is close to the intrinsic resolution of the fragment separator. In adition, these heavy ions show a broad ionic charge distribution, affecting separation and identification. The posibility to define the nuclear charge with enough resolution for high charges and to disentangle the different ionic charge states of the nuclei, is achieved by using the so called *degrader energy loss method* [2] which basically takes into account the differences in magnetic rigidity in the two sections of the FRS, as well as a combined measurement of the energy loss in two ionization chambers placed at the exit of the FRS.

Although the data analysis is still in progress in Fig. 1 we report some preliminary results. In this figure we report on a two dimensional cluster plot the nuclear charge as a function of the mass-over-charge ratio of the isotopes measured in two different settings of the FRS optimized to transmit ^{194}W and ^{186}Lu. These measurmentes were obtained in an acquisition time of 2h 41' and 11h 45' respectivelly. The straight lines in the figure correspond to the present limits of the chart of the nuclides. In this measurement, around 30 new isotopes has been identified for the first time. Note that until recently, this region of the nuclear chart was extremely difficult to reach experimentally.

From this work we conclude that cold-fragmentation is a promising reaction mechanism to extent the limits of the chart of nuclides in the region of heavy neutron-rich isotopes, provided that enough primary beam intensities are available. Further investigations of the properties of this heavy neutron-rich isotopes like β half lives are in progress.

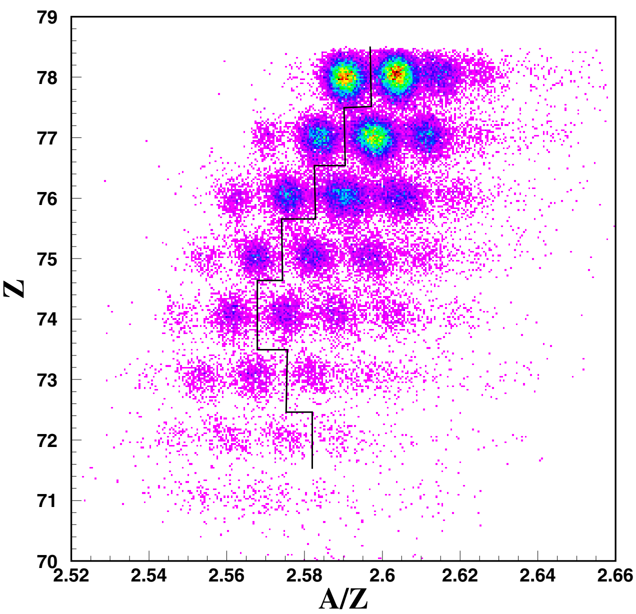

Figure 1: Two dimensional cluster plot of the nuclear charge Z versus the A/Z measured in the reaction $^{208}Pb+Be$ The data corresponds to two settings of the FRS centered in ^{194}W and ^{186}Lu. The straight lines represent the present limits of the chart of nuclides

References

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