Production and separation of rare isotope beams at K150 energies (E/A=10-15 MeV/nucleon)

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A substantial part of our recent efforts has been directed in acquiring experience in the production and separation of RIBs in peripheral collisions in the energy range expected from the refurbished K150 cyclotron. The Institute's RIB upgrade plan comprises the implementation of a large-bore superconducting solenoid as a preseparator before a heavy-ion gas stopper [1]. Our recent measurements and calculations indicate that the application of the deep-inelastic transfer mechanism [2,3,4] seems to be a very effective way to obtain rare isotopes at the K150 energies.

Along these lines, we recently performed a preliminary experiment with a 15 MeV/nucleon $^{40}Ar^{9+}$ beam striking a natural Ni (5 mg/cm^2) target. The projectile fragments were collected and identified using the BigSol superconducting solenoid. A schematic diagram of the experimental setup is shown in Fig. 1. The Ar beam, after interaction with the target was collected on an on-axis beam blocker. Behind the beam blocker, a PPAC provided X,Y position measurements and a start signal for the time-of-flight measurement. The fragments were focused at the end of the device ("RIB diagnostics" box in Fig. 1). At the entrance to the box, a circular aperture selected a range of fragment magnetic rigidities. The fragments were then passed through a PPAC providing X,Y position and stop-time information. Finally the fragments were collected in a 5 x 5cm^2 ΔE-E Si detector telescope (50 and 1000 μm thickness). Following standard techniques of Bρ-ΔE-E-TOF (magnetic rigidity, energy-loss, residual energy and time-of-flight, respectively), the atomic number Z, the mass number A, the velocity and the ionic charge of the fragments were obtained on an event-by-event basis (see, e.g [3]).

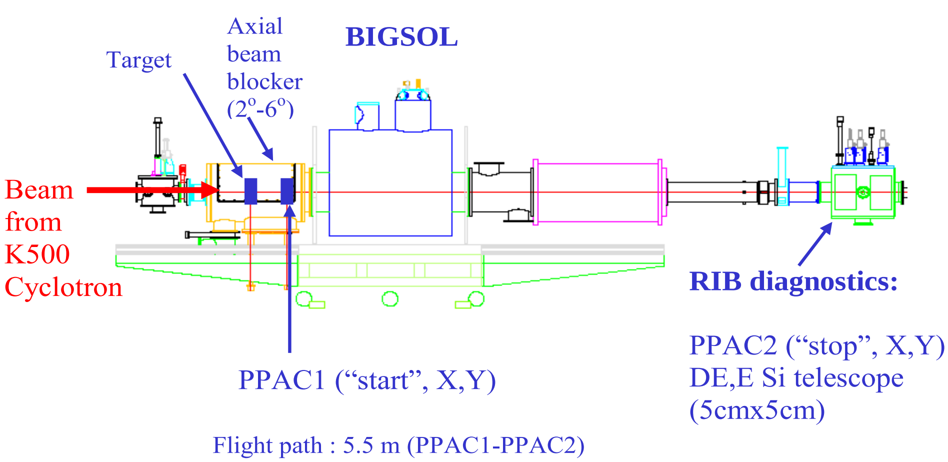

Figure 1. Schematic diagram of BigSol setup and the detector system for RIB production.

Fig. 2 shows a typical on-line ΔE-E spectrum indicating the group of fragments along with intense background of elastics. Fig. 3 shows the corresponding particle identification (Z,A) spectrum after calibration of the on-line measured quantities. Even if the TOF resolution was not fully optimized, the

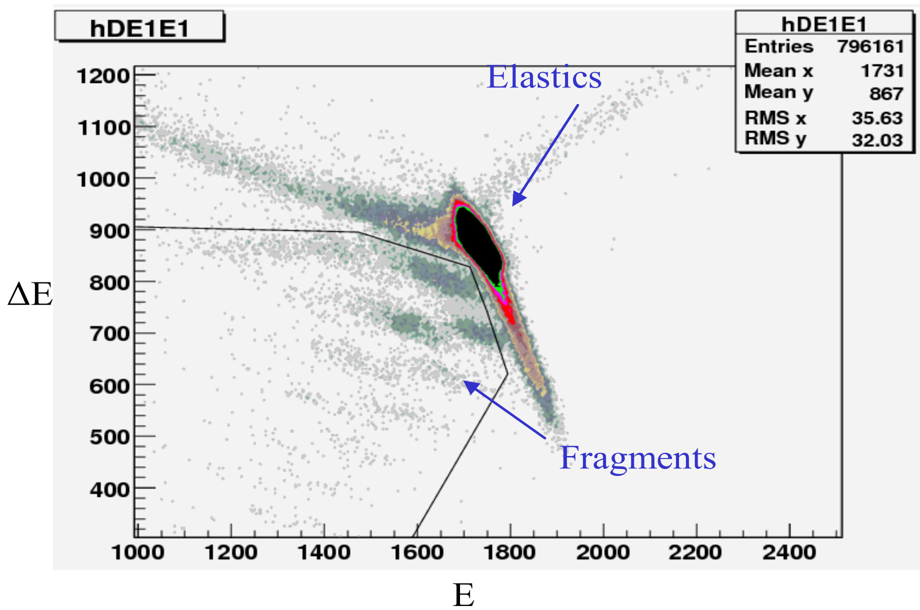

Figure 3. Example of an on-line ΔE-E plot showing a group of projectile fragments from ^{40}Ar(15MeV/nucleon) + ^{nat}Ni, along with elastically scattered beam.

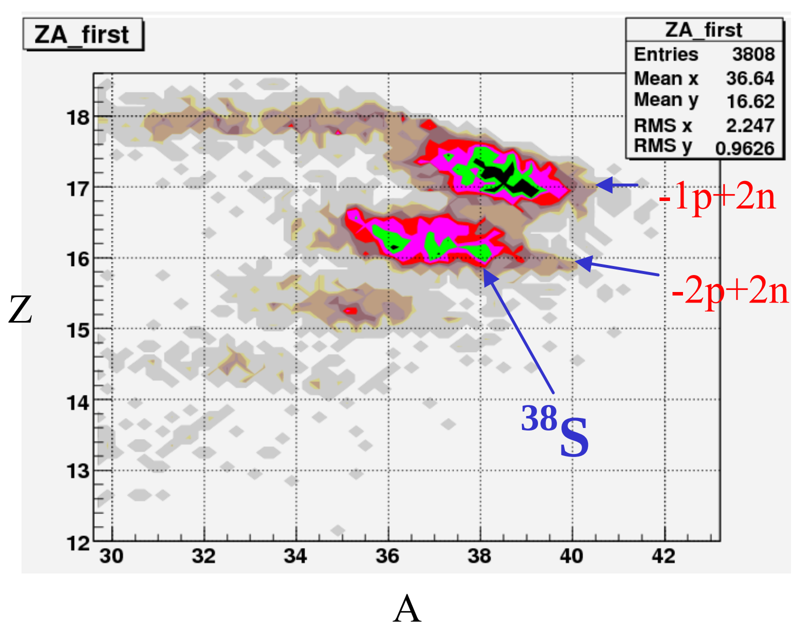

Figure 2. Particle identification (Z vs A) plot of the group of fragments shown in Fig. 1. The magnetic rigidity of this run was Bρ = 1.28 Tesla-meter (corresponding to a 84.1 A current in the BigSol magnet). A narrow angular acceptance of 3.0-3.5 degrees was selected for this run.

mass of the fragments was obtained with a resolution of approximately 1.2 units (FWHM). The figure shows that along with proton-removal products (e.g. ^{38}S), neutron-pickup products are produced in substantial yields, as expected from a deep-inelastic transfer mechanism at these energies. Using the reaction simulation procedure described in our previous works [2,3,4] and filtering the events through BigSol (and the subsequent experimental apparatus) using the beam-optics code RAYTRACE, we found that that the yields of the observed neutron-rich products are in overall agreement with the model expectations. We plan to extend the RIB production tests in the near future and investigate ways to separate the RIB mixtures from the elastically scattered beam using, e.g., a degrader after the target or an iris-like aperture at the diagnostic chamber.

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[3] G. A. Souliotis *et al.*, Nucl. Instrum. Methods Phys. Res. **B204**, 166 (2003).
[4] M. Veselsky, and G. A. Souliotis, Nucl.Phys. **A765**, 252 (2006).