Measurements of production cross sections of neutron-rich nuclides from peripheral collisions of ^{40}Ar (15 MeV/nucleon) projectiles with ^{64}Ni, ^{58}Ni and ^{27}Al targets

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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 simulations indicate that the application of the deep-inelastic transfer mechanism [2,3,4] appears to be a very effective way to obtain rare isotopes at the K150 energies.

Along these lines, aiming at obtaining systematics on production rates, we performed a series of measurements with a 15 MeV/nucleon $^{40}Ar^{9+}$ beam stricking targets of ^{64}Ni, ^{58}Ni and ^{27}Al. The projectile fragments were collected and identified using the MARS recoil separator applying the techniques developed and documented in [2,3]. The Ar beam was send on the primary target location of MARS with an inclination of 4^{o}. After interaction with the target, the fragments traversed a PPAC at the intermediate

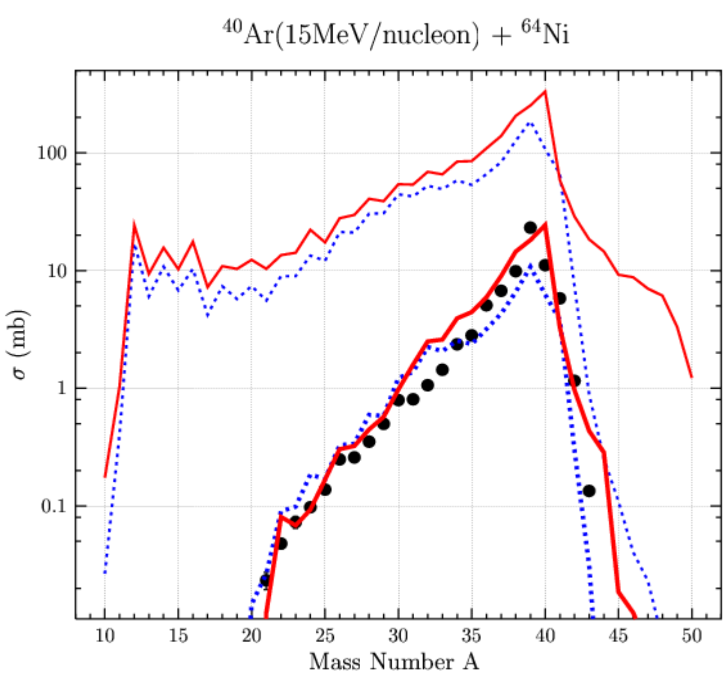

FIG. 1. Isobaric yield distributions from the reaction ^{40}Ar (15 MV/nucleon) +^{64}Ni. The data are given by the solid points. The upper set of lines shows the simulations obtained with the codes DIT [5] (dotted line) and CoMD [6] (full line) followed by the de-excitation code GEMINI [7]. The lower set of lines corresponds to the same calculations which have been filtered by the angular acceptance of the spectrometer.

image location (for position/Brho measurement and START time information) and then they were focused at the end of the device passing through a second PPAC (for image size monitoring and STOP time information). Finally the fragments were collected in a 5x5 cm^2 ΔE-E Si detector telescope (60 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]).

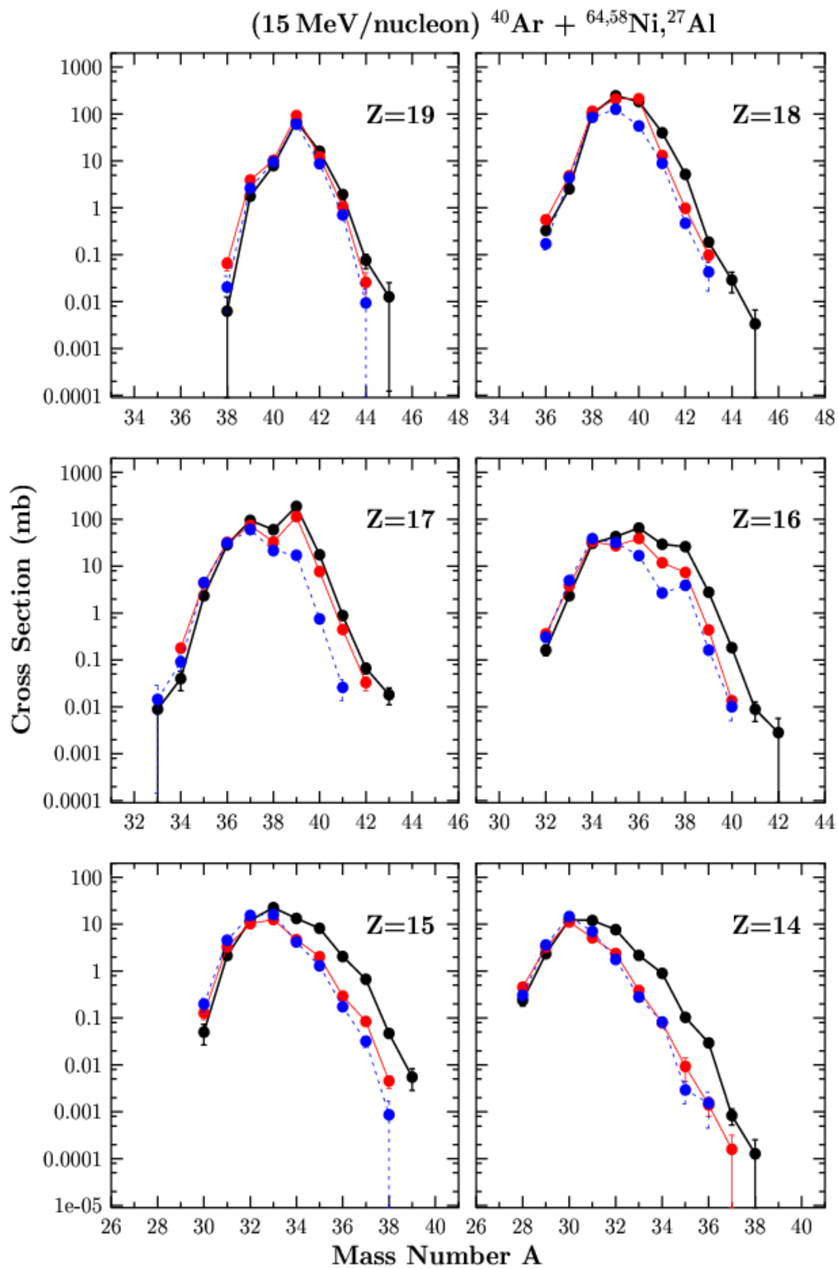

FIG. 2. Cross sections of the isotopes of elements Z=14-19 for the three reactions measured: ^{40}Ar (15 MeV/nucleon) + ^{64}Ni, ^{58}Ni, ^{27}Al represented with black, red and blue points respectively.

Data were obtained in a series of magnetic rigidity settings of the spectrometer to cover the energy and charge state distributions of the fragments. Fig. 1 shows the isobaric yield distributions obtained for the reaction ^{40}Ar+^{64}Ni. The data are given by the solid points. The upper set of lines shows the simulations obtained with the codes DIT [5] (dotted line) and CoMD [6] (full line) followed by the de-excitation code GEMINI [7]. The lower set of lines corresponds to the same calculations which have additionally been filtered by the angular acceptance of the spectrometer. The simulations seem to provide a reasonable description of the data. We used the ratio of the filtered to unfiltered DIT/GEMINI simulations to correct the measured data (obtained in the limited angular acceptance of the spectrometer) and extract total production cross sections for each isotope [2,3].

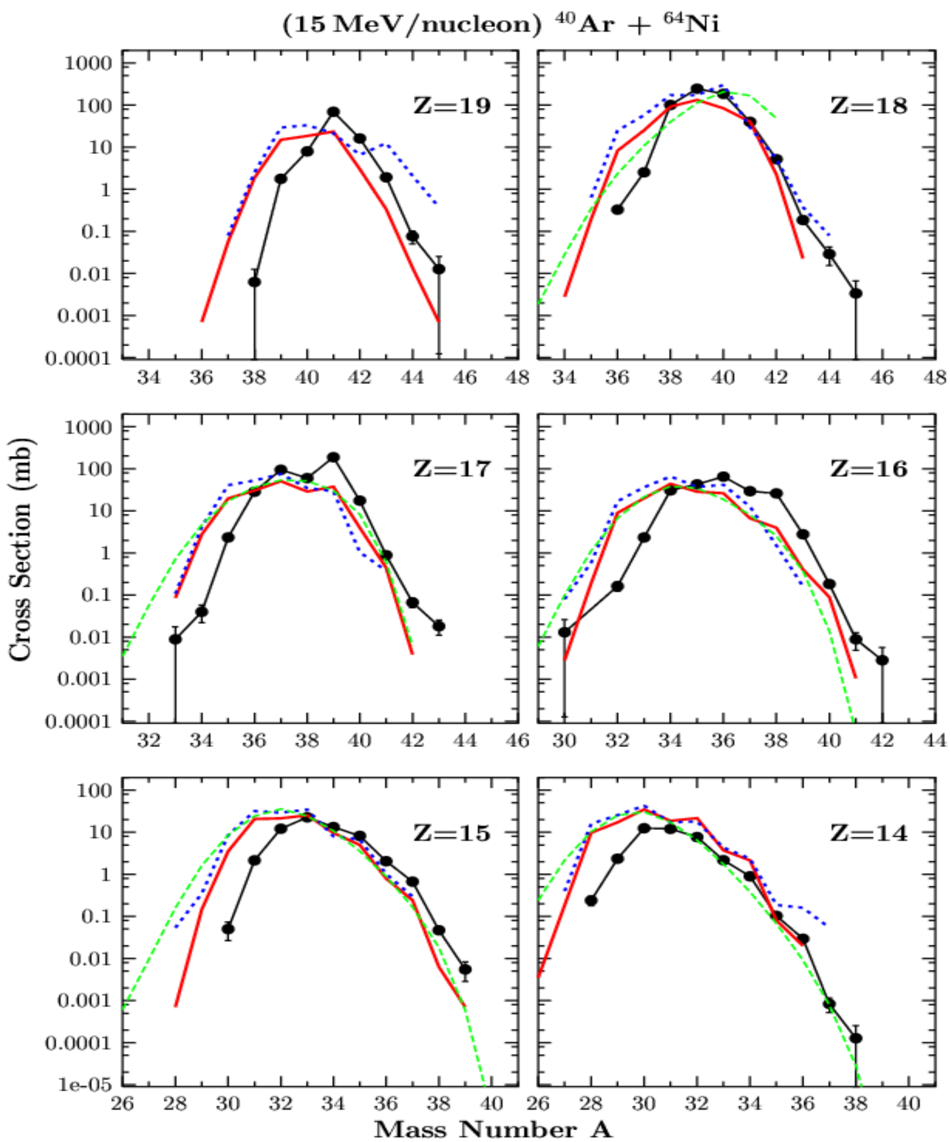

FIG. 3. Cross sections of the isotopes of elements Z=14-19 from the reaction ^{40}Ar (15 MeV/nucleon) + ^{64}Ni (black points). The red (full) line corresponds to the CoMD/GEMINI [6,7] calculation, whereas the blue (dotted) line corresponds to the DIT/GEMINI [5,7] calculation. The green (dashed) line shows the expectation of the EPAX parametrization [8].

Fig. 2 shows the cross sections of the isotopes of elements Z=14-19 for the three reactions measured: ^{40}Ar (15 MeV/nucleon) + ^{64}Ni,^{58}Ni, ^{27}Al, represented with black, red and blue points respectively. Fig. 3 shows the cross sections of the isotopes of elements Z=14-19 from the reaction ^{40}Ar (15 MeV/nucleon) + ^{64}Ni (black points). The red (full) line corresponds to the CoMD/GEMINI calculation, whereas the blue (dotted) line corresponds to the DIT/GEMINI calculation. Finally the green (dashed) line shows the expectation of the EPAX parametrization for high-energy fragmentation [8]. Figs. 2 and 3 show that along with proton-removal products, neutron-pickup products are produced in substantial yields, as expected from a deep-inelastic transfer mechanism at these energies [2,3,4]. From the present data we observe that very neutron-rich products are most abundantly produced, as expected, by the most neutron-rich ^{64}Ni target. Finally, both the standard DIT and the CoMD calculations seem to underestimate the most neutron-rich products.

We are currently working on detailed simulations of the cross sections using the improved version of the DIT model approach [4], as well as the CoMD code with careful description of the ground states of the nuclei involved in the reactions. On the experimental front, we are in the process of data analysis of a similar set of projectile-like fragments from a ^{86}Kr (15 MeV/nucleon) with heavy targets

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