Direct Reactions with Light Neutron-Rich Nuclei*

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Quasi free (p,2p) and (p,pn) knockout reactions with radioactive beams in inverse kinematics allow us to obtain spectroscopic information about valence and deeply bound single-particle states and to study their evolution over a large variation in isospin. Recent studies have shown that the occupancies of loosely bound valence nucleons in neutron- or proton-rich nuclei have a spectroscopic factor close to unity, whereas single-particle strength for deeply bound nucleons is suppressed in isospin asymmetric systems compared to the predictions of the many-body shell model [1]. Further experimental and theoretical studies are needed for a qualitative and quantitative understanding.

For this aim a series of measurements have been performed on the complete oxygen isotopic chain using the existing experimental setup LAND/R3B at GSI (Cave C). In the experiment S393 the primary beam ^{40}Ar with an energy of 600 AMeV is fragmented into the exotic ions on a beryllium target using the Fragment Separator FRS.

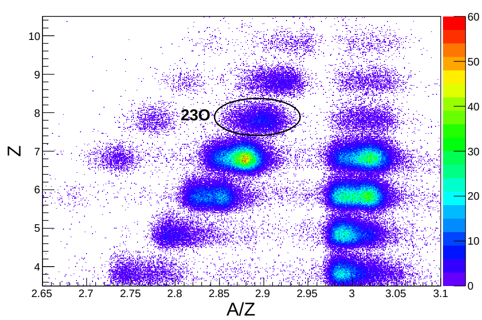

Figure 1: Identification plot of the incoming ions with the graphical cut around the ^{23}O.

The charge Z and mass A of the projectiles hitting the target in Cave C are determined from energy-loss and time-of-flight measurements using silicon PIN diodes and plastic scintillators before the target. Figure 1 depicts charge of ions versus A/Z ratio for a run optimized for transportation of ions with $\sim$ A/Z=3. One can identify here the isotopes from helium up to fluorine.

In order to reconstruct the reaction channel of interest the outgoing fragments are detected and tracked by using silicon strip detectors (SSD), the dipole magnet ALADIN, fibre detectors and Time of Flight Wall detector (TFW), which are located downstream of the target. Two SSDs are located after the target and offer a good charge resolution.

Figure 2 shows the reconstructed fragment-mass distribution for the incoming beam ^{23}O on the target CH_2 by applying a cut on outgoing Oxygen ions (Z=8). Additionally it is required that the cyrstal ball detector (XB), which surrounds the target area and consists of 162 NaI(Tl) crystals, detects at least one high energetic nucleon (neutron).

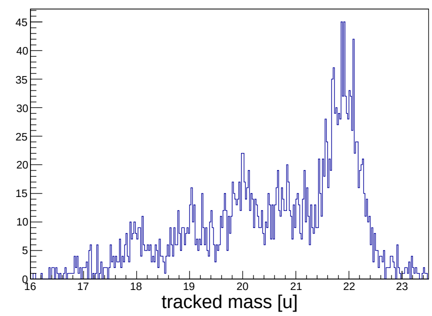

Figure 2: Tracked mass of the outgoing Oxygen fragments after one neutron removing from the projectile ^{23}O.

An indication of the quasi free knockout reactions is the angular correlation between the knocked-out nucleon from the projectile and the protons from the CH_2 target. Figure 3 presents the polar (left) and the azimuthal (right) correlation of proton and neutron of the investigated reaction channel ^{23}O(p,pn)^{22}O. Due to the momentum conservation proton and neutron show opposite azimuthal angels, while they are scattered within a polar angle $0° < \theta < 90°$ by sharing the beam energie of $\sim$ 500 MeV. Background, including reactions induced by the carbon in the target, have been subtracted using measurements with empty and carbon target.

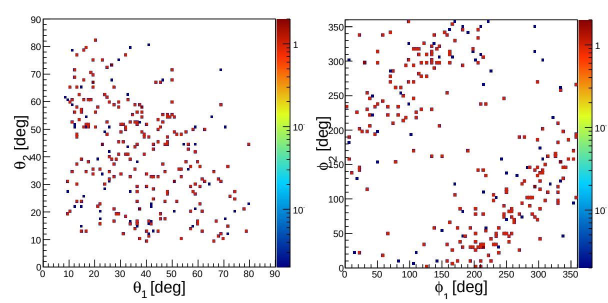

Figure 3: Angular correlations of protons from the CH_2 target and neutrons from the projectile ^{23}O. Left: polar-angle correlations; right: azimuthal-angle correlations.

References

[1] A. Gade et al., Phys. Rev. C77 (2008) 044306.

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