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Colloquia: COMEX7

^{8}B reaction dynamics researched at HIE-ISOLDE

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Summary. — For the first time a measurement of $^{8}\mathrm{B} + {}^{64}\mathrm{Zn}$ reaction has been performed at HIE-ISOLDE at CERN at energies around the Coulomb barrier, to understand how the debated halo structure of the light nucleus can affect reaction dynamics.

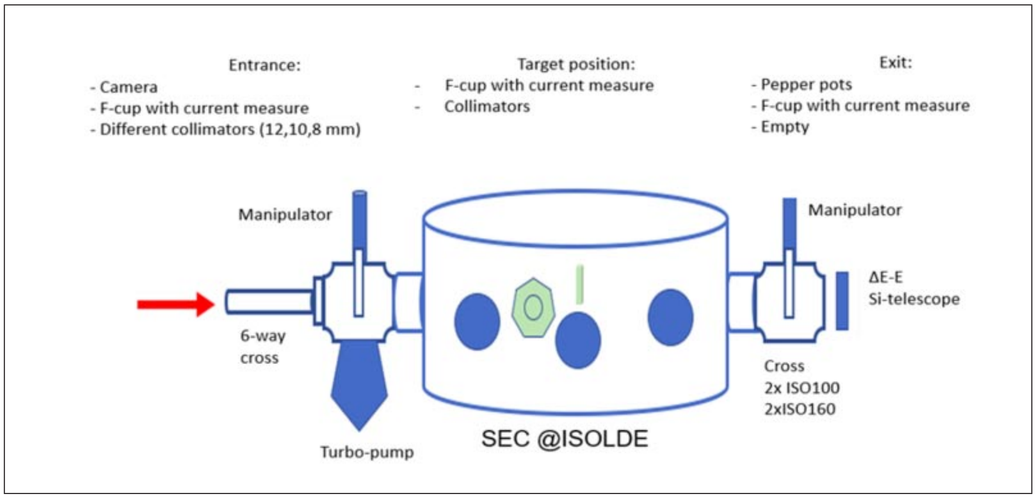

Fig. 1. – Sketch of the diagnostics apparatuses mounted on SEC for this experimental run.

1. – Introduction

^{8}B is the best candidate to be a proton halo nucleus, thanks to its very low energy required (0.138 MeV) to break-up in ^{7}Be+p.

Investigations made so far [1-3] seems to suggest that ^{8}B behaviour mimics the neutron halo nuclei in its increased reaction cross section σ_r. Those experiments used ^{8}B in-flight beams, which implied some limitation on beam purity and energy and angular spread, mainly. For this reason, we decided to explore the ^{8}B reaction dynamics in the only RIB facility in the world that can provide a post-accelerated isol ^{8}B beam, namely HIE-ISOLDE, at CERN.

2. – Experimental setup

Experiment has been performed in 2018 at HIE-ISOLDE. The aim was to measure the ^{8}B+^{64}Zn high-resolution elastic scattering angular distributions in a very wide angular range and the ^{8}B breakup. From the elastic scattering angular distribution the total reaction cross-section can be obtained. The multipurpose scattering chamber SEC (Scattering Experiments Chamber) was used and equipped with additional diagnostics for the desired goals. In fig. 1 sketch of the chamber and diagnostic apparatuses mounted is presented.

A first block of tools was mounted on an actuator at the entrance of SEC, in particular a Faraday cup for the current measurement and collimators. Moreover, a beam camera was mounted to look at the beam profile on a quartz. In this way, a careful beam tuning with the stable ^{12}C beam (shown in fig. 2) could be provided, so that the incoming RIB could also be optimizated upon its entrance in SEC, despite of its very low intensity.

The chamber center was equipped with a moving target holder, which also had a Faraday cup and collimators. Its movement could be driven by remote. Finally, at the end of the beam path in SEC, another vertical rod was positioned, with pepper-pots, Faraday cup and an empty frame. The latter was used to let the beam finish its path

Fig. 2. – ^{12}C calibration beam profile, captured by the beam camera posed at the entrance of SEC.

onto a two-stages silicon telescope (ΔE and E were point-like detectors of 15 and 700 μm, respectively), who has turned to be crucial to verify the RIB purity, as it can be seen in fig. 3, where the only ^{8}B locus is visible.

The ^{8}B produced has been charge-breeded and then post-accelerated by the Linac to E_{lab}=4.5 MeV/u. During the experiment, because of the ion source complex contaminations of $^{96}Mo^{2+}$ that prevented the possibility of cooling and bunching the beam in the REXTRAP, the ^{8}B beam was delivered with an intensity of only 400 pps. A ^{64}Zn target of 1 mg/cm2 (produced at LNS) was used, properly chosen because of the systematic studies performed whith such a target, having already been used for halo and weakly-bound beams experiments [4, 5].

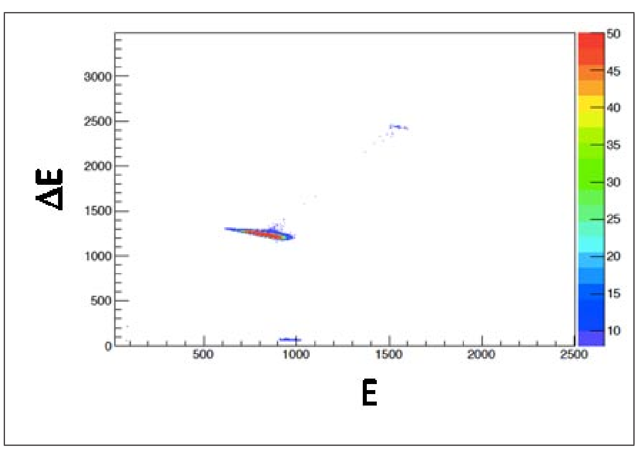

Fig. 3. – ^{8}B observed in the silicon telescope placed at 0°.

Inside SEC, the GLORIA detection system [6] was used to collect reaction events. It is made by 6 telescopes of Doble Sided Silicon Strip detectors, with the ΔE stage 40 μm thick and the E stage of 1000 μm. Telescopes at forward angles had also a third stage (pads, without strips segmentation) as thick as the E stages. Five of the telescopes were placed 65 mm distant from the target, which was tilted at 30° with respect to the beam axis, while the sixt has been put farer (115 mm from the target) in this run, to collect events down to θ=8.5°.

3. – Results and perspectives

Results are described in [7]. Scattering is measured and the Coulomb-nuclear interference region is mapped attentively. Small effects of coupling to the continuum are evident and its reaction cross-section σ_R is comparable to the one of ordinary weakly bound nuclei on the same target. This different behaviour with respect to n-halo nuclei is also reported in [8], where the measurement is performed at higher energies.

Dominance of elastic and non-elastic breakup at small and larger angles, respectively, emerges from the inclusive angular and energy ^{7}Be distributions obtained. The breakup cross section σ_{bu} is such that $\sigma_{bu}/\sigma_R \sim$20-25%, again unlike n-halo nuclei.

The case of post-acceleration effect was evaluated, at first using a semi-classical approach. However, continuum discretised coupled channel (CDCC) calculations have shown that a number of different multipolarities contribute to the excitation of ^{8}B leading to breakup. Therefore, the simple semiclassic approach does not provide indications about post acceleration in the present case. In [9], where exclusive breakup was measured, near target breakup has been determined to dominate.

Considering these results, still some question is open. Hopefully, an isol beam non inclusive breakup measurement could confirm the results in [9] and definetely help in the understanding of the many processes intervening in the ^{8}B and, generally, in proton-halo nuclei dynamics.

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