Scattering process of $^{11}$Be from $^{209}$Bi at Coulomb barrier energies


$^1$ Gesellschaft für Schwerionenforschung (GSI), D-64291 Darmstadt, Germany
$^2$ University of Padova and INFN, I-35131 Padova, Italy
$^3$ University of Napoli and INFN, I-80126 Napoli, Italy
$^4$ University of Milano and INFN, I-20133 Milano, Italy
$^5$ INFN Laboratori Nazionali di Legnaro, I-35020 Legnaro (PD), Italy
$^6$ Institute of Particle and Nuclear Studies (KEK), 205-0801 Tsukuba-shi, Japan
$^7$ The Institute of Physical and Chemical Research (RIKEN), 351-0198 Wako-shi, Japan
$^8$ University of Udine and INFN, I-33100, Udine, Italy

In our experiment we studied the scattering process of $^{11}$Be from $^{209}$Bi. The $^{11}$Be secondary beam ($S_n = 0.504$ MeV) was obtained via fragmentation of a high energy $^{13}$C primary beam impinging on a thick Be target at 100 A-MeV. The reaction products were separated with the RIPS facility at RIKEN and heavy reduced in energy by means of an aluminum degrader. The outcoming $^{11}$Be beam had a Lorentzian shape centered at 43 MeV with a FWHM of 15 MeV, an overall intensity of $10^5$ pps and a beam size at the target position of 27 mm (x axis) $\times$ 19 mm (y axis). The measurement of the scattering process with such a poor emittance and low intensity secondary beam was possible by tracking the incident beam with position sensitive detectors and by detecting the scattered particles with the high granularity EXODET array [1], which subtends $\sim 2\pi$ sr and allows for a position resolution of $\sim 1^\circ$.

The scattering angular distributions were evaluated for 2-MeV energy bins in the energy range between 40 and 48 MeV and they turned out to be rather similar to those obtained for $^9$Be ($S_n = 1.554$ MeV) nuclei interacting with a $^{209}$Bi target. This similarity, also observed for the fusion cross sections of both systems [2], suggests moderate effects due to the low binding energy on the reaction dynamics at Coulomb barrier energies. A further comparison shows that for system $^{11}$Be + $^{209}$Bi the reaction cross section is much larger than the fusion one. Since in this energy range a few processes (namely fusion, inelastic excitations, breakup processes) are expected to exhaust the whole reaction cross section, this discrepancy could by solved by a strong breakup channel $^{11}$Be $\rightarrow$ $^{10}$Be + n. The deduced reaction cross section were also compared with those obtained for other weakly bound projectiles ($^9$Be, $^6$Li and $^6$He) interacting with high-Z target ($^{208}$Pb and $^{209}$Bi), see Fig. 1. Among all of them, $^6$He exhibits the highest “reactivity” at Coulomb barrier energies, even if its binding energy ($S_{2n} = 0.972$ MeV) is larger than for $^{11}$Be. Theoretical analyses are going on to investigate the origin of this unexpected behavior.

![Figure 1: Reaction cross sections for five similar mass systems at Coulomb barrier energies. Data are been divided by $R^2$, with $R$ sum of the projectile and target radii, and plotted vs. $E_{cm}/V_C$.](image-url)