Measurement of Fusion Cross Sections Nearby and Below the Coulomb Barrier for the Reactions $^{32}S + ^{98,100}Mo$, $^{32}S + ^{102}Ru$ with the Q3D ◇

C. Zotti, K. E. G. Löbner, T. Faestermann, P. G. Thirolf, D. Rudolph, D. Gassmann, K. Rudolph, Th. Kerscher, C. Fischbeck, S. Issmer, J. Ott, M. Falch, and D. Habs

1. Motivation

The experiment aims at measuring fusion cross sections for the reactions $^{32}S + ^{98,100}Mo$ and $^{32}S + ^{102}Ru$ with a statistical accuracy better than 1 % in energy steps of 0.5 MeV below the Coulomb barrier in order to determine the barrier distribution. These experimentally determined barrier distributions will be compared to those obtained from CC-FUSB calculations [1,2].

2. Experimental Setup

Separation of the evaporation residues (ERS) from the incoming beam by different magnetic rigidities was performed using the gas filled Q3D spectrograph [3]. A capton foil (30 μg/cm^2) separated the target chamber and the Q3D from the vacuum in the beam tube, causing an energy loss of 0.45 MeV for the projectiles before hitting the target. ERS and projectiles end up with different average charge states and as a consequence the magnetic rigidity $B\rho$ of the ERS is 30 % higher than that of the projectiles [4]. For kinetic energies of the projectiles between 120 MeV and 115.5 MeV transmission of the ERS through the Q3D was optimized at 0.24 mbar N_2 and B = 0.926 T with the beam transmission minimized. Between 115 MeV and 108 MeV the optimum field shifted to 0.931 T. The aperture slits of the Q3D were set to a solid angle of 12 msr. Measuring at 0° with respect to the beam axis comprised an angular region between +3° and -3°. For each energy step data were accumulated at 0° and 6.43°. For normalization and beam position correction two PIN diodes were positioned at the angles of -26.0° and +24.8° with respect to the beam axis. They covered a solid angle of 0.189 msr and counted the Rutherford scattered projectiles. For both monitors and the signals of the ionization chamber a background correction was performed using additional measurements with an empty target frame. A new ionization chamber was designed, constructed, and tested with alpha sources as a focal plane detector of the Q3D. Its task was to detect all the incoming ERS.

3. Measurements with the ionization chamber

Modifications with respect to the description given in [5] were necessary. The position information is extracted by splitting the cathode diagonally. The anode was devided into two segments dE (width: 3.3 cm) and E_{rest} (width:5.5 cm). A pressure of 22 mbar Isobuthane gas (ISB) suitably stopped the ERS and kept the mylar foil of the entrance window intact so that a supporting grid could be avoided. The voltage for the cathode was 0 V, 275 V for the frish grid, 430 V for the anode. They are low enough to avoid gas discharge effects and to guarantee good collection of the charge carriers. Due to losses during the travel through the N_2 gas along the length of the three dipole magnets (800 cm: 12MeV) and the mylar foil (0.9 μm: 3 MeV) the kinetic energy of the ERS is reduced from 30 MeV to 15 MeV at 120 MeV projectile energy. Energy losses within the ISB gas limit the detectable energy to 3.5 MeV for ERS. Each segment has a capacitance of 150 pF with respect to ground, which deteriorates the energy resolution. Calibration of the x-coordinate was carried out by varying the position of an alpha source. The experimental set up was tested with a ^{127}I beam of 35 MeV, which simulates the ERS. Variation of the magnetic field showed a linear dependance of the position with the field strenght. The FWHM of the ^{127}I beam in x-direction resulted to be 52 cm, in total the ^{127}I projectiles cover approximately 109 cm of the aperture window length (170 cm). The FWHM corresponds to $\frac{dB\rho}{B\rho} = 2.7\,\%$. Semiempirical calculations attribute 2.4 % to statistical fluctuations around the average charge state and 0.6 % to multiple small angles scattering in the N_2 gas [6]. The mass distribution of the ERS increases $\frac{dB\rho}{B\rho}$ to 3.5 %. Assuming a Gaussian distribution, over 95 % of the ERS are detected along the length of the aperture window (170 cm). Broadening of the ^{127}I in y-direction is caused by multiple small angles scattering [7].The calculated FWHM of 3.1 cm lies well within the acceptance of the magnetic poles (8.5 cm). Due to focusing effects the same FWHM is expected for the ERS.

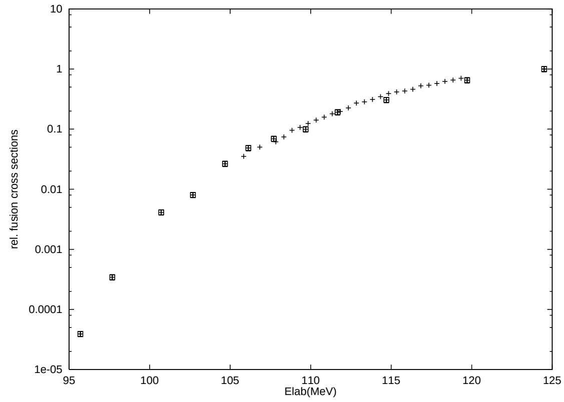

Fig. 1: $\sigma_{fus}/\sigma_{fus}(124.5MeV)$ of $^{32}S + ^{100}Mo$ (crosses) compared to measurements of Pengo *et al.* (squares).

4. Present state of the analysis

For all three reactions there is good agreement between the relative fusion cross sections and cross sections measured at the HF-Spectrometer by Pengo *et al.* [8].

Further analysis is in progress.

References

[1] F. J. Schindler *et al.*, Nucl.Phys **A603** (1996) 77
[2] T. Winkelmann *et al.*, Jahresbericht 1992, p. 15
[3] K. Knie, Ph.D. thesis, TU München, 1996
[4] H. Betz, Reviews of Modern Physics **44** (1972) 465
[5] C. Zotti *et al.*, Jahresbericht 1994, p. 251
[6] P. Armbruster, Nucl. Instr. Meth **I91** (1971) 499
[7] H. A. Bethe *et al.*, Phys. Rev. **89** (1953) 1256
[8] R. Pengo *et al.*, Nucl. Phys. **A411** (1983) 255

◇ This work is supported by the DFG