Investigation of proton elastic scattering on ^{70}Zn in inverse kinematics using a stored ESR beam interacting with an internal CH_4 target

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The investigation of light-ion induced direct reactions in inverse kinematics, using stored and cooled radioactive beams, interacting with internal H, He, etc. gas-jet targets, bears a large potential for nuclear structure and astrophysics studies on exotic nuclei. In particular, this technique enables, as compared to investigations at external targets, high resolution measurements down to very low momentum transfer. It also provides in many cases a gain in luminosity from accumulation and recirculation of the radioactive beams [1]. Consequently an extended research project was recently proposed to the FAIR-PAC by the EXL collaboration (EXotic nuclei studied in Light-ion induced reactions at the NESR storage ring) [2]. In order to explore the experimental conditions for measurements planned at FAIR, performance tests with a prototype detector setup, installed at the internal target of the ESR have been recently performed with stored stable beams.

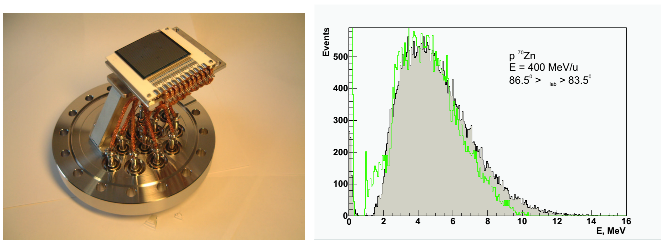

Figure 1: Left side - UHV compartible Si-strip detector for recoil protons; right side - comparison of the experimental energy spectrum obtained from detector-group 2 (green histogram) and the result of a Monte Carlo simulation (filled gray histogram).

The experimental setup consisted of a 40 x 40 mm^2 Si-strip detector (Fig. 1, left), mounted on the 90^0 flansch of the existing ESR vacuum chamber surrounding the internal target, which was supposed to measure the target-like recoil particles from the interaction of the circulating beam with the internal target in a single mode, or, alternatively, in coincidence with the scattered beam particles, detected in a standard scintillation detector located downstream from the target after the first dipole magnet. The Si detector, provided by MICRON, was specially designed to meet the strict UHV conditions required at the ESR. The 1 mm thick Si wafer is mounted on a ceramic support structure, and the connectors including the readout scheme (collective readout by charge division of 5 groups of 8 channels each) have been made without soldering, thus allowing baking of the detector up to 200^0 C. The excellent detector performance (energy resolution of ΔE = 40 keV for 5 MeV α-particles, and position resolution of Δx = 1 mm) was maintained after several baking cycles. UHV capable cables with glass pearls for providing isolation from the shielding were used, and a 1 μm thick Ni foil was mounted in front of the detector to suppress δ-electrons. The detector was mounted at a distance of 16 cm from the gas-jet target, thus covering an angular range $89^0 \geq \theta_{lab} \geq 74^0$.

In a first test experiment data were taken with a 400 MeV/u ^{70}Zn beam, interacting with a CH_4 gas-jet target. The average luminosity was estimated to be of the order of 10^{27}cm^{-2}s^{-1}. An energy spectrum obtained in coincidence with the scattered projectiles from the detector-group 2 ($86.5^0 \geq \theta_{lab} \geq 83.5^0$), is displayed in Fig. 1, right. The good agreement with the result of a Monte Carlo Simulation for ^{70}Zn proton scattering demonstrates that the measured spectra are well understood, and that background reactions are well discriminated by the coincidence requirement.

The differential cross section dσ/dt, extracted from the present data is displayed in Fig. 2. The solid line represents a Glauber calculation assuming a Gaussian-like matter distribution for ^{70}Zn. The results are interpreted as follows: for the data taken without coincidence condition (red dots), a good agreement with the predicted cross section is obtained for $t \leq 0.025$ (GeV/c)^2, whereas for higher momentum transfer the measured cross section is enhanced, most probably due to a considerable background contribution from ^{70}Zn + ^{12}C reactions. For the data taken in coincidence with the scattered projectiles (blue dots), the data for $t \geq 0.025$ (GeV/c)^2 are in excellent agreement with the predicted t-dependence of the cross section, thus demonstrating that the coincidence condition provides an efficient discrimination against background. For the low momentum transfer region the measured cross section in the coincidence mode is drastically reduced, most probably due to the lack in coincidence capability of the scintillation detector for very small momentum transfer.

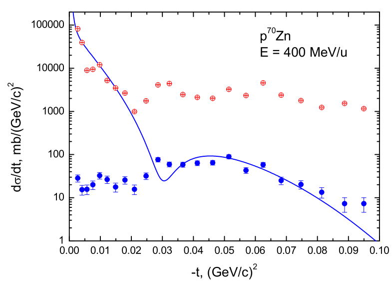

Figure 2: p^{70}Zn elastic scattering differential cross section versus the four momentum transfer squared -t (for discussions see test).

References

[1] P. Egelhof et al., Physica Scripta, **T104**, (2003) 151.
[2] The EXL collaboration, GSI Annual Report 2004.