Elastic scattering of ^{12}N at 12 AMeV on ^{12}C

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An elastic scattering measurement of 12 AMeV ^{12}N beam off a ^{12}C target was carried out in March this year at MARS. The experiment is directly related to the peripheral proton-transfer measurement performed last year on a composite melamine target ($C_3H_6N_6$) employing the reaction (^{12}N,^{13}O) at 12 AMeV [1]. The aim of that experiment was to use an indirect method to determine the ANC for the system $^{13}O \rightarrow {}^{12}N + p$. The ANC is extracted from the DWBA analysis of measured angular distributions. For that we need to know the optical potential for both entrance/exit channels of the transfer reaction. When possible, this kind of information can be obtained from elastic scattering measurements. In the case of the (^{12}N,^{13}O) experiment using the melamine target, the elastic channel of interest ^{12}N+^{14}N needs to be disentangled against the ^{12}N+^{12}C and ^{12}N+H elastic channels, due to the presence of C and H-atoms in the melamine target. This is important in order to extract from the data a more certain value for the ANC.

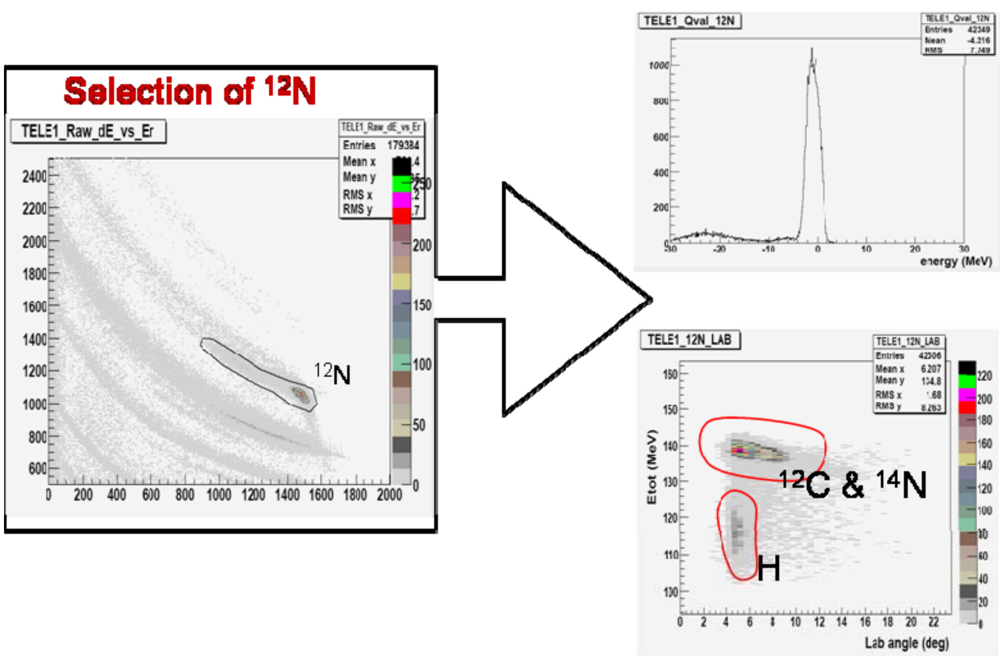

Figure 1. Data analysis of ^{12}N elastic scattering off the melamine target. ΔE-E selection of ^{12}N reaction channels (left). Elastic channel selection by the Q-value = 0 condition (right, top). The three elastic channels separated by their individual kinematics in the E vs. lab angle matrix (right, bottom).

If the elastic scattering of ^{12}N off H in the melamine target can be eliminated by applying proper kinematics cuts in the data analysis, this is not possible for the ^{12}N elastic scattering off ^{12}C nuclei, which can not be separated from the ^{12}N+^{14}N elastic channel, as clearly illustrated in Figure 1.

Calculations for the angular distributions of the elastic channels $^{12}N+^{12}C$ and $^{12}N+^{14}N$, were done with double folded potentials using JLM interaction with the procedure and the average parameters of Refs. [2, 3]: N_v=0.37, N_w=1.0, t_v=1.20 fm, t_w=1.75 fm. They are shown in Figure 2, after being transformed to the laboratory system. From them one can understand to which extent it is important to disentangle the two contributions for a more accurate optical model determination.

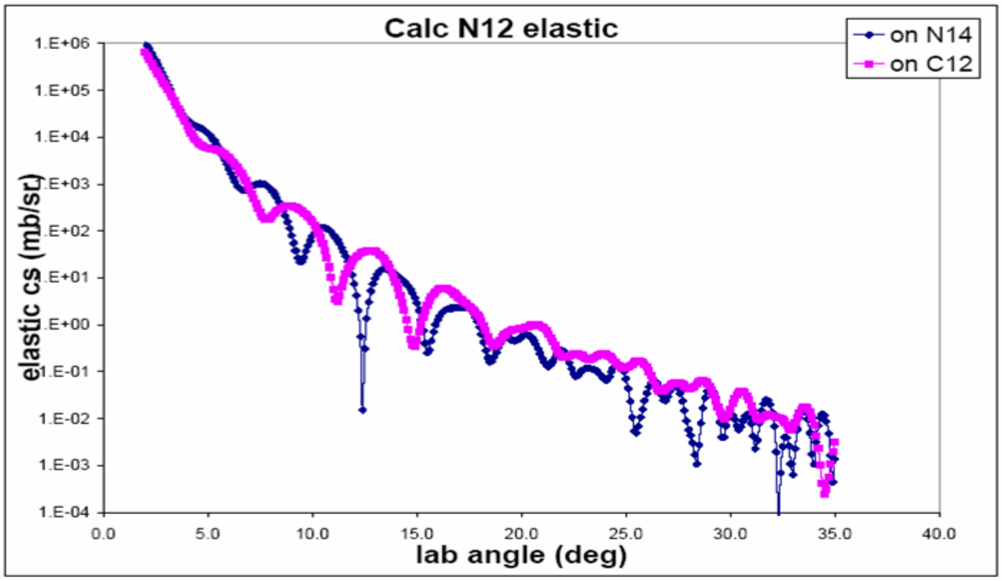

Figure 2. Calculated angular cross section distributions for the two elastic scattering channels ^{12}N off ^{12}C (magenta) and ^{12}N off ^{14}N (dark blue).

Because at the end we are interested in subtracting the differential cross section of $^{12}N+^{12}C$ elastic data from the melamine elastic data, the measurement of ^{12}N elastic scattering off ^{12}C target had to be performed under similar conditions. Hence, a ^{12}C primary beam at 23 AMeV impinging on a LN_2-cooled H_2 gas cell was used to produce the radioactive ^{12}N beam. This time the gas cell havar entrance/exit windows were both made with a thickness of 13 μm.

Therefore, the gas cell was operated at a pressure of ~1.6 atm and the secondary beam was degraded by the same 250-μm-thick Al foil positioned behind the gas cell. The reaction ^{12}C-target employed had a thickness of 2 mg/cm^2. The ^{12}N was produced at a rate of $0.6 \div 1 \times 10^5$ pps. Since this time the aim of the experiment was to get good quality elastic scattering data, to improve the angular definition of the secondary ^{12}N beam on target the slits situated behind the last pair of dipoles of MARS were closed to L/R=±1.0 cm from the beginning of the measurement. MARS D3 dipole had an inclination angle of 5°.

The identification of the reaction channels are shown in Figure 3 with emphasis on ^{12}N reaction channels along with the position distribution in the four ΔE-E telescopes used as detection system.

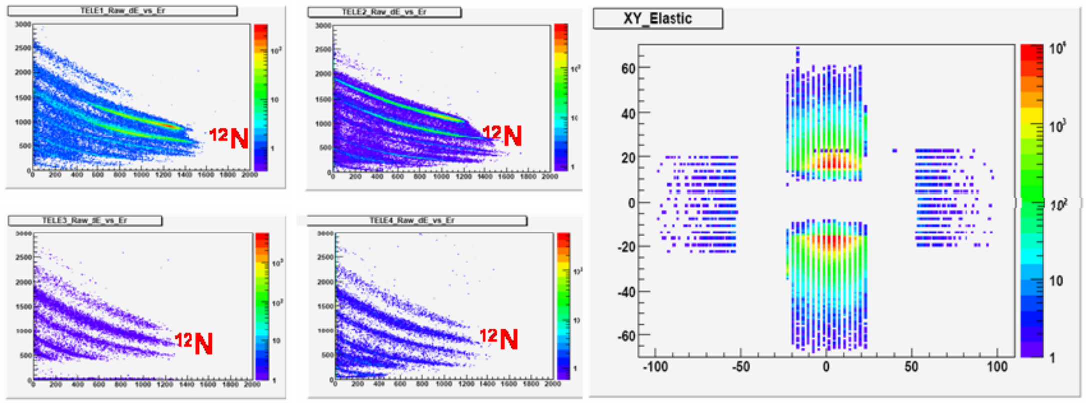

Figure 3. ΔE-E reaction channel identification (right) and the elastic scattering position distribution (left).

Data analysis for this measurement is currently in progress. Once completed, it will enable us to use its results as an input for data analysis on (^{12}N,^{13}O) to extract more accurately the ANC for the system ^{13}O $\rightarrow$ ^{12}N + p, and from it to be able to evaluate the reaction cross section of radiative proton capture ^{12}N(p,γ)^{13}O. The reaction is relevant to the evolution of the Pop III supermassive stars with low metallicity [1].

[1] A. Banu *et al.*, *Progress in Research*, cyclotron Institute, Texas A&M University (2006-2007), p. I-XX

[2] L. Trache *et al.*, Phys. Rev. C **61**, 024612 (2000).

[3] F. Carstoiu *et al.*, Phys. Rev. C **70**, 054610 (2004).