reconstructed. After the geometry efficiency correction, the normalized center of mass cross section of $^{16}O(p, \alpha)^{13}N$ for E_{cm} <6.7 MeV is presented in Fig. 2. A very good agreement was found for our result and that of Nero[5]. For the lack of statistics, few events were observed around E_{cm}=5.96 MeV, corresponding to the ^{17}F (E_x=6.56 MeV). The $(CH_2)_n$ target used in the current experiment limited the beam intensity and introduced background due to the carbon in the target. To improve the statistics, we are developing a pure hydrogen target and hope to achieve more statistics at the resonance at E_{cm}=5.96 MeV.

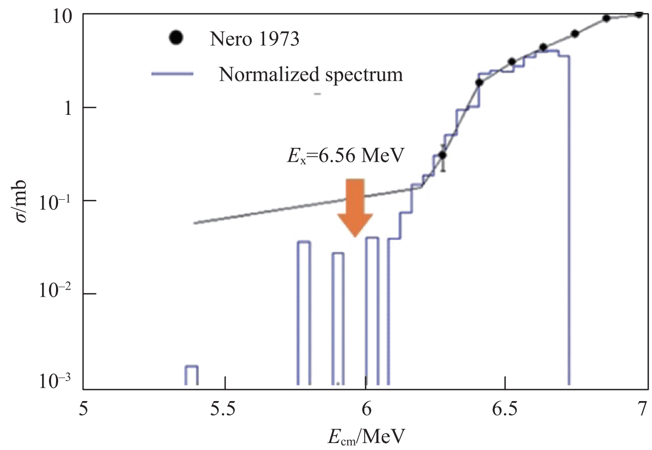

Fig. 2 (color online) The $^{16}O(p, \alpha)^{13}N$ reaction cross section as a function of center of mass energy. The solid circles are the experimental data from Nero[5]. The histogram is the normalized cross section from present experiment. The arrow indicates the expected resonance of E_x = 6.56 MeV of ^{17}F.

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2 - 17 Method for Determination of Deuterium Impurity in Helium Beam*

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JUNA (Jinping Underground laboratory for Nuclear Astrophysics) is planing to measure the $^{13}C(\alpha, n)^{16}O$ and some other important reactions at or close to stellar energies using intense helium beam out of an ECR driven accelerator in Jinping Underground laboratory[1]. Deuterium impurity in ion source will produces significant amount of neutrons, limiting the background level. To control the deterium impurity, we have developed a method to measure the deuterium impurity within Helium beam using the d(d,p)t reaction.

A test experiment has been done by using the 320 kV HV platform at IMP He^{2+} beam was produced by an ECR source and post-acclerated to 275 keV/q after it was filtered by a 90 ° magnet. The beam bombarded a deterium implantation target with a titanium substrate. The atom density of its effective layer is 1.98×10^{19} atoms/cm^2 and the ratio of D/Ti is 1.5. The protons produced by the d(d,p)T reaction was detected by a 300 μm thick silicon detector located at 135°. The distance between the detector and the target is 20 cm and a aluminium foil with thickness of 7 μm was placed before the silicon detector to stop the scattered He^{2+} particles. The reaction chamber was electrically isolated from the beam line and the incident total charge was recorded with a beam current integrator.

Hydrogen gas was fed into the ECR source first to get a weak D^+ beam for the energy calibration of the silicon detector. Taking the advatange of the similar A/q ratio, H_2^+ beam was tuned to the target as a pilot beam and the proton from d(d,p)t was clearly observed and shown in Fig. 1(a). After the calibration, hydrogen gas was shut off and replaced with hellium and the proton spectrum is shown as Fig. 1(b).

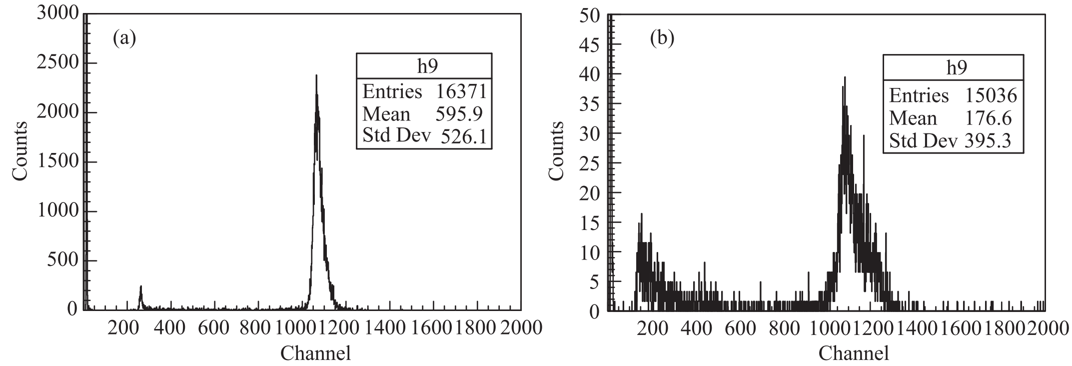

Fig. 1 (a) A sample of observed proton spectrum by using the H_2^+ beam. (b) A sample of observed proton spectrum by using the He^{2+} beam. The total charge of each of them is 1 Coulomb and the proton counts are 103969(1107) and 3444(75).

The observed proton yield was $1.04(1)\times10^5$ cnt/Coulomb using H_2^+ beam and $3.44(8)\times10^3$ cnt/Coulomb using He^{2+} beam. The total number of the incident D^+ is determined by

$$D=\frac{Y}{4\pi\frac{d\sigma}{d\Omega}N_s} ,$$

in which Y is the number of proton recorded by silicon detector, N_s is the areal density of the deuterium in the target, $\frac{d\sigma}{d\Omega}$ is the differential cross section at the 135° in the frame of laboratory. Considering the energy loss of the beam in the target, we chose Geant4 toolkit to calculate the proton production yield and we got the $D^+/He^{2+}=2.7(0.2)\times10^{-5}$ by comparing the simulation result (Fig. 2(a)) with experimental data (Fig. 1(b)).

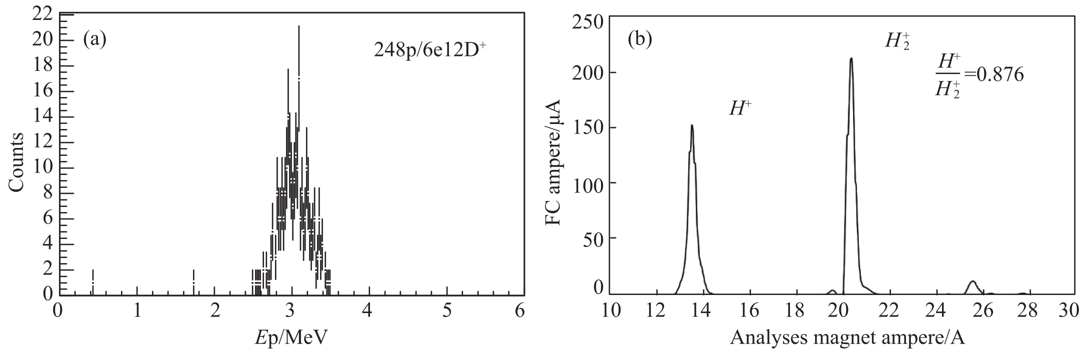

Fig. 2 (a) Geant4 simulation result of proton peak using D^+ beam (b) Distribution of ion beams out of the ECR sour using H_2 working gas.

There is another way to estimate the D^+ impurity of He^{2+}, which uses H_2^+ beam as a calibrator. Fig. 2(b) shows the distribution of ion beams out of ECR source when H_2 was the work gas in ECR source. By integrating H^+ and H_2^+ peaks, we obtain the ratio of $H^+/H_2^+ = 0.876$. The natural abundance of deuterium is 1.15×10^{-4}, by assuming it is the same as the ratio of D^+/H^+ in ion source, the ratio of D^+/H_2^+ will be 1.01×10^{-4}. By comparing the difference of the proton spectra in Fig. 1, the ratio of $D^+/He^{2+}=6.7(0.1)\times10^{-6}$. This result is about 1/4 of the one obtained with the first method. Since GEANT4 simulation and the target condition were not validated by independent measurement, the result with the second method is more reliable.

Reference

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