2 - 18 A Low-energy Platform for Nuclear Astrophysics

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Low energy platform is very important for nuclear astrophysics experiment study[1]. The Institute of Modern Physics (IMP) recently established a low energy experiment terminal for nuclear astrophysics study in Lanzhou, Gansu, China.

The low-energy experiment terminal in IMP is established on the 320 kV HV Platform which is a multi-discipline research platform and has been used for surface and/or ion-atom/molecule studies since 2008[2]. The driver machine of the HV platform is an all-permanent magnet ECR on source[3], which can supply 30 μA proton beam typically.

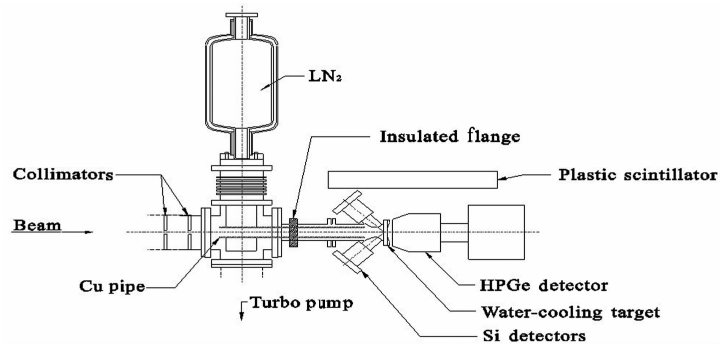

Fig. 1 Schematic diagram of terminal.

The target chamber layout is similar to the one described previously[4] and a schematic diagram is shown in Fig. 1. The chamber can divide into two parts alone the beam line direction. The tail part is insulated from the front part and constitute the Faraday Cup with the target for beam integration. The front part contain two Cu collimators (each of 10 mm diameter) to insure the beam spot completely focused on the target. They are located at a distance of 50 and 100 cm from the target. There is an inline Cu pipe cooled to LN_2 temperature which extended from front part into the tail part and close to the target for minimizing carbon build-up on target surface. This pipe is also insulated from the tail part and a negative voltage is applied to the pipe to suppress secondary electrons from the target. The target is directly water cooling type.

A CLOVER detector is set up at 0° for γ-ray probe. The resolution of the CLOVER is typically 2. 3 keV and relative effciency of about. In order to maximize the effciency, CLOVER can be slide to the target as close as possible. Two Si detectors can be set up at 135° for charged particles probe. A plastic scintillator (length=100 cm, width=50 cm, thickness=5 cm) was placed 10 cm above the CLOVER detector. Coincidence signals of plastic scintillator and CLOVER is used as VETO to reduce the cosmic-ray background.

The energy of the proton beam supplied by the 320 kV HV platform was calibrated using 149 keV resonance in $^{11}B(p,\gamma)^{12}C$. Proton beam energy in the energy range $E_p=100\sim200$ keV (given by accelerator) passed through two collimators and focused on to a thin boron target. The target is 38 $\mu g/cm^2$ thick and produced by sputtering natural boron onto a 0. 2 mm tantalum backing. Beam current is up to 30 μA measured by Faraday cup. First excited state transition peak and its decay peak were observed in the spectrum which is obtained by CLOVER detector. Due to the small energy range of 100 keV, we assumed the angle distribution of capture γ-ray is a constant to the energy. At each energy step the observed yield was corrected for target thickness effects as described in[1]. The plot of relative S-factors is shown in Fig. 2. The present data have been normalized at $E=177$ keV and arbitrarily using $S=100$ keV · b refer to the previous data[5]. The resonance energy derived from the fitting function is 149. 5 keV. It is very consistent with the previous value of 149. 4 keV ($E_p=163$ keV)[5]. The deviate is only 0. 1 keV.

Background at high-energy region ($E_\gamma>2.6$ MeV) is on account of the decay of the radioactive nuclei which due to the muon spallation and of the capture of stopping negative muons[6]. At this energy region

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lead shielding effect decrease and muon veto come into power. We compared background spectrum with and without muon veto and give the result as follows:

Energy region(MeV)	2.6～4.0	4.0～8.0	8.0～12.0	12.0～19.0
Reduction factor	1.39	1.75	2.21	2.84

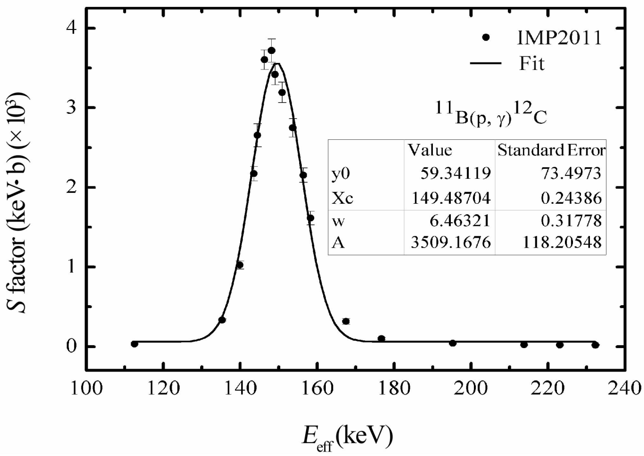

Fig. 2 S-factor of $^{11}B(p,\gamma)^{12}C$.

At present, this new setup is temporarily installed at an experimental terminal for atomic physics research. A new experimental terminal is now being constructed specifically for the low-energy nuclear astrophysics studies. As scheduled, this 320 kV platform will be equipped with a super-conducting ECR source capable of providing much stronger beams, together with a buncher system capable of reducing the background considerably. Thus, a positive shielding can be achieved with the pulsed beams.

References

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