Construction of the Experimental Facility for Nuclear Astrophysics

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Construction of a low-energy, high current accelerator for the study of fusion reactions has been completed(Fig.1). Higher current is crucial to measure extremely fine cross sectional measurements of the ^{3}He(^{3}He,2p)α reaction at 40 to 50 keV. More than 1 mA of ^{3}He^{1+} and 100 μA of ^{3}He^{2+} at 10 keV potential was obtained so far. The use of a multi-electrode extraction system for the NANOGAN ECR ion source is expected to improve the beam quality and to raise the luminosity for the beam-to-target interaction. The use of higher extraction voltage than the used for traditional ion sources improves the beam optics although there might happen the discharge between these electrodes[1].

Up to now, we successfully transported the analyzed current of ^{3}He^{1+} to the target chamber. With less than 10 watts for RF power and 10 keV ion source potential, the total current was 6.28 mA at the source extraction and 930 μA at the target position after through three collimaters, 35mm, 25mm, 8mm in diameter. We have further investigated the operational conditions in order to get a larger current of ^{3}He^{2+} ions by various ion source operating conditions. The performances will be investigated by higher applying potential to a multi-electrode extraction system, and DC-bias method in better vacuum condition than before.

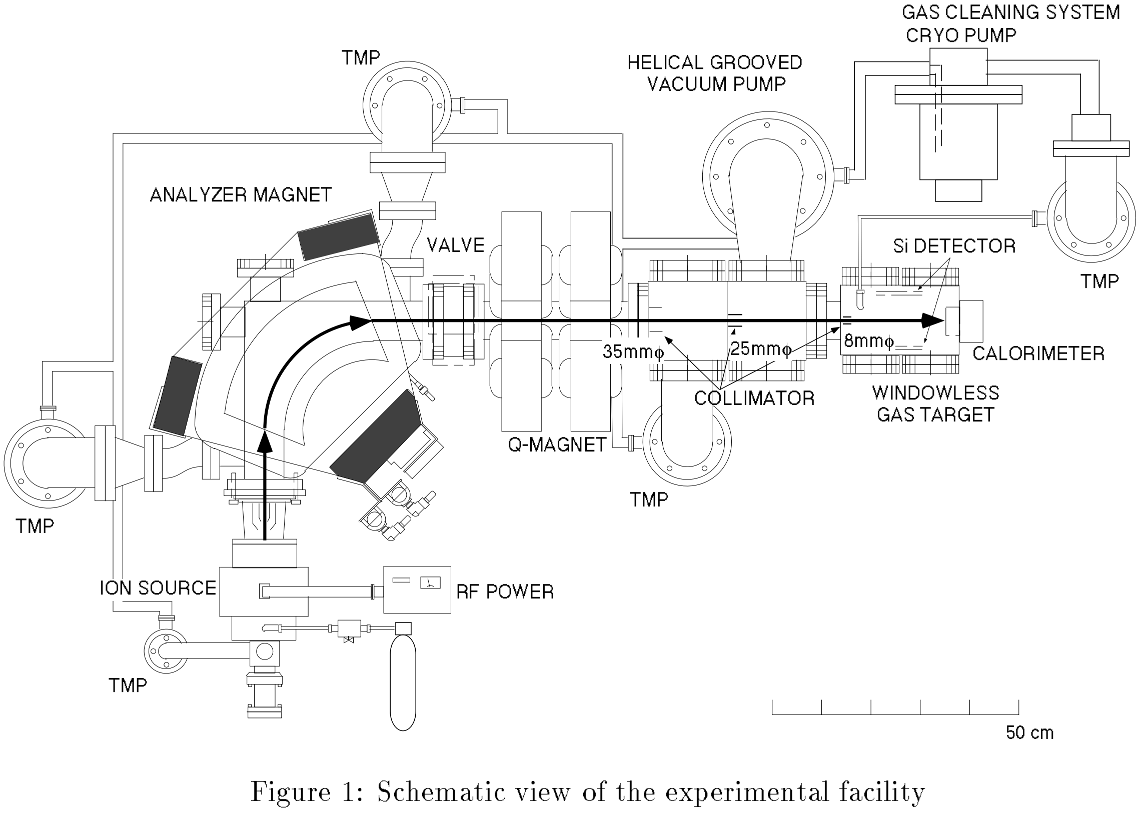
GAS CLEANING SYSTEM
CRYO PUMP
TMP
HELICAL GROOVED VACUUM PUMP
ANALYZER MAGNET
VALVE
Si DETECTOR
TMP
35mmφ
25mmφ
8mmφ
CALORIMETER
COLLIMATOR
WINDOWLESS GAS TARGET
Q-MAGNET
TMP
TMP
ION SOURCE
RF POWER
TMP
50 cm

Figure 1: Schematic view of the experimental facility

^{3}He(^{3}He,2p)α(Q=12.86MeV) reaction is identified to measure the proton energy($E_p = 0 \sim 10.7$MeV) by ΔE-E counter telescope placed at the gas target(Fig. 2). The proton from ^{3}He(d,p)α(Q=18.4 MeV) reaction which caused by deuterium contamination in the target gas or ion beam (as HD$^+$ molecule), cosmic-ray and electric noise will contribute as the background events. Because the cross section is 6$\sim$8 orders of magnitude larger than ^{3}He(^{3}He,2p)α reaction[2], ^{3}He(d,p)α is the most serious background origin in the interesting energy region. The counter telescope is required to be able to distinguish these two reactions. Because the thickness of E counter is chosen as 1500μm to stop the proton from ^{3}He(d,p)α reaction(E_p=14.7MeV), these two events will be distinguished clearly. The thickness of ΔE counter is 140μm and both counters have large active area of 2500mm^2. In front of ΔE counter, Mylar foil which thickness is 20μm is arranged to stop α particle from both reactions and elastic ^{3}He.

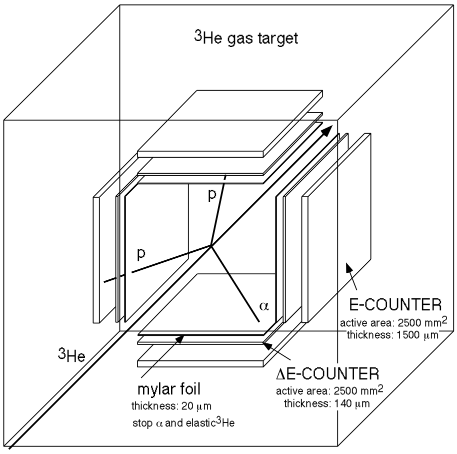

Figure 2: Schematic view of ΔE-E counter telescope

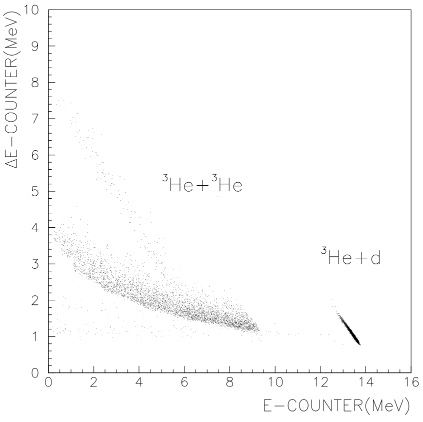

Figure 3: The result of Monte Carlo simulation

Fig.3 shows the result of Monte Carlo simulation(GEANT3) for ^{3}He(^{3}He,2p)α and ^{3}He(d,p)α reaction. It was turned out that we can almost clearly distinguish the both events. But we found ^{3}He(d,p)α events in the window of $1< \Delta E<1.5$MeV and $0<E<14$MeV. These events were caused by escaping of proton from the edge of E counter. The contribution of these events to ^{3}He(^{3}He,2p)α events given by Monte Carlo simulation, is 0.5%. The deuterium contamination of target gas and ion beam is required to the order of ppb in order to make the contribution negligible. But it is difficult to reduce the contamination to the order immediately, we will additionally require proton-proton coincidence for ^{3}He(^{3}He,2p)α events. To get higher detection efficiency, we will accept not only the event that both protons from ^{3}He(^{3}He,2p)α reaction stop in E counter but also the event that either proton stops in E counter and the other proton stops ΔE counter. The acceptable energy region will be chosen as $\Delta E>1$ MeV and $E>1$ MeV to reject cosmic-ray and electric noise background events. The total detection efficiency will be about 10%, and count rates will be about 2 counts/day for $\sigma \sim$ pico barn. In the future it will be hoped that deuterium contamination will be improve down to ppb order and ^{3}He(^{3}He,2p)α event will be identified from the energy of either proton in order to get higher detection efficiency($\sim$ 40%).

References

[1] T. Itahashi *et al.*, Review of Scientific Instruments **69** (1998) 168.
[2] M. Junker *et al.*, Phys. Rev. **C57** (1998) 2700.