3 - 23 Measurement of ^{19}O+^{12}C Fusion Cross Sections near the Coulomb Barrier Using an Active-target TPC

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The carbon burning is predicted to be responsible for the phenomenon of X-ray super-burst. Stellar model calculations show that the temperature of neutron star crush is not high enough to trigger ignition[1]. It has been suggested that the fusion reaction between light neutron-rich nuclei may provide an additional source of heat[2]. By measuring the fusion cross sections of these nuclei near the Coulomb barrier, we can constrain the theoretical models to provide more reliable extrapolation for astrophysical purpose[3]. Some experiments have shown a fusion enhancement at near and sub-barrier energies for neutron-rich nuclei compared to the stable nuclei in the same isotopic chain[4]. Explaining this phenomenon is a challenge for barrier penetration models, and experimental data of fusion cross sections for an isotopic chain of projectile nuclei are needed for the improvement of theories[5].

Previolls experiments indicated that fusion enhancement is well studied near and below barrier energies[4]. Recently, the fusion of ^{10,14,15}C+^{12}C above barrier energies was studied using a so-called multisampling ionization chamber (MUSIC)[6]. No significant fusion enhancement was observed due to the lack of three-dimensional (3D) traces in MUSIC, measuring the fusion cross sections below 100 mb is challenging[7]. We have developed a 1024-channel three-dimensional time projection chamber called pMATE(prototype Multi-purpose time projection chamber for nuclear Astrophysical and Exotic beam experiments). The TPC gas, served as both the working gas and the target material[8]. The incident particles and reaction products were tracked by the detector, enabling fusion measurements over a wide energy range. The ^{19}O+^{12}C fusion cross sections were measured down to the energy of $E_{\mathrm{c.m.}}$=7.7 MeV[4]. With the pMATE TPC, we expect that the measurement can extend into the lower energy range.

The experiment was conducted at the Radioactive Ion Beam Line in Lanzhou(RIBLL). The ^{19}O secondary beam was produced via the (d,p) reaction by bombarding a liquid-nitrogen cooled D2 gas target with a primary beam of ^{18}O. Figure 1(a) shows that ^{19}O is well separated from ^{18}O using the time-of-flight versus the energy deposited in the first 2 cm of the TPC. To extract fusion cross sections, we used the energy loss (DE/DX) of particle tracks in TPC to distinguish between fusion and elastic events. Figure 1(b) shows an example of tracking reconstruction for a fusion event in our experiment. The 2D plot of range dEdx for single-track events is shown in Fig. 1(c). The fusion evaporation residual (marked by the black solid line) is well separated from the elastic scattering particles. Further analysis of the data is in progress.

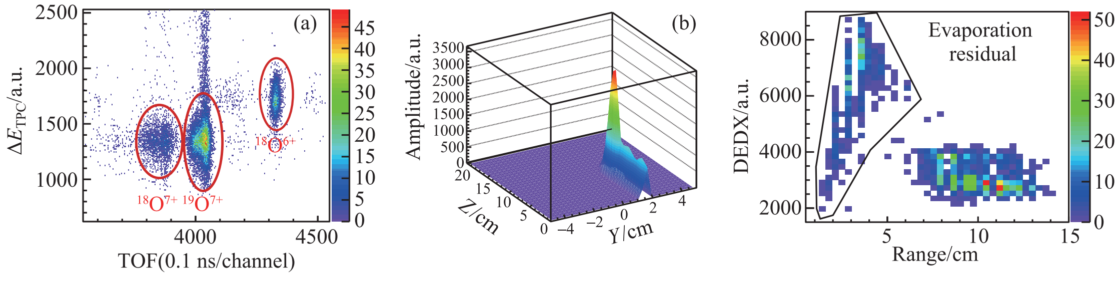

Fig. 1 (color online) (a) Energy loss in TPC versus time-of-flight for ions that inject into TPC, (b) An example of a track reconstruction for one fusion event, (c) Range versus dEdx information of particles which come from events with single track left in TPC. The fusion evaporation residual are surrounded by black solid line.

References

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