Study of ^{8}B + ^{40}Ar fusion reaction using TexAT

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The study of fusion reactions induced by light exotic radioactive beams is a powerful tool to understand a variety of interesting and new dynamic effects present in weakly-bound systems. For instance, the low-binding energy and strong cluster configurations in exotic nuclei would produce a decoupling between the valence particle and the core nucleus, which give rise to an increase of the breakup and/or transfer probability in total reaction cross section. However, still it is a question whether fusion in the Coulomb barrier energy region of halo nuclei such as ^{6}He (two-neutron halo nucleus) or ^{8}B (one-proton halo nucleus) is enhanced owing to the extended nuclear-matter distribution, or hindered due to the fact that such nuclei break into two or more fragments. However, the influence of the breakup in the elastic and fusion processes induced by exotic nuclei is not well known and challenging to study in both theory and experiment. Thus, the study of heavy ion fusion has been a subject of renewed interest in our community [1].

The study of ^{8}B fusion reaction on ^{40}Ar has been performed at the Cyclotron Institute of the Texas A\&M University. A primary beam of ^{6}Li was used to create the ^{8}B beam through the two proton pickup reaction (^{3}He,*n*) and a 97% pure ^{8}B beam at energies of 40 MeV and 48 MeV was produced by the recoil separator MARS. This was the first fusion experiment using the recently developed active target, TexAT. The beam was impinged on the ^{40}Ar gas target in the scattering chamber filled with an Ar:CH_4 95:5 (P5) gas mixture at a gas pressure ranging from 150 Torr to 210 Torr. The gas pressure was adjusted for the unreacted ^{8}B beam barely make it to the downstream silicon detector resulting in the fusion product not making any trigger on the silicon detector. Then, the trigger of the silicon detector was used to veto all events of unreacted beam and elastic scattering at small angles, and only fusion-like events could be recorded in data. Fig. 1(a) shows a typical fusion event observed on the Micromegas. As the beam particle loses its kinetic energy in the gas, the beam energy of the fusion reaction is determined by the vertex point where the reaction happened and this provides us the possibility to investigate fusion reactions in a wide range of center-of-mass energies around the Coulomb barrier (V_C = 16.4 MeV). The resulting compound nucleus and the respective fission fragments produce a higher energy loss (in comparison to the unreacted beam) in the gas and stops in only few millimeters of the active area of the Micromegas. Therefore, a large energy loss signal is observed at the edge of the ion range spectra, as seen in Fig. 1(b).

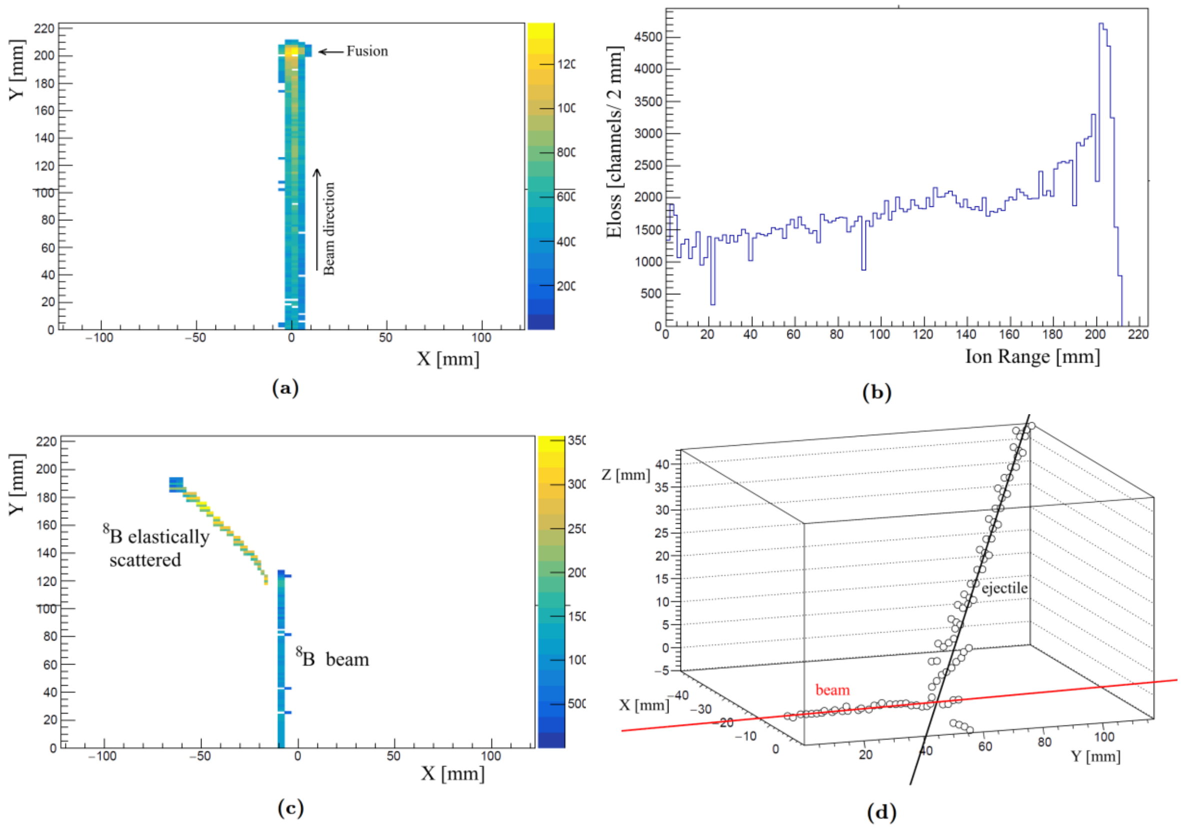

FIG. 1, (a) Fusion event detected on the Micro Megas plane. (b) Ionization ion range of a fusion event. (c) Elastic scattering event. (d) 3 dimensional reconstruction of an elastic scattering event.

In order to fully determine the fusion events from other reaction channels, e.g. elastic scattering (see Fig. 1(c)), it is necessary to have a good method to identify hit patterns. In the present analysis, the RANSAC (random sample consensus) [2] algorithm has been implemented to identify and fit the particle tracks in the 3-dimensional space. The same routine has been successfully used in the analysis of other active target experiments such as AT-TPC and ACTAR. Fig. 1(d) shows a scattering event that was fitted with RANSAC. The next step is to apply the routines to identify all the fusion-fission events measured in the ^{8}B + ^{40}Ar experiment.

Fig. 2 shows a preliminary fusion excitation function from the data taken for two hours of beam time. While the analysis was performed by inspecting event-by-event basis, we are working on developing a tool for the identification of fusion events as mentioned earlier.

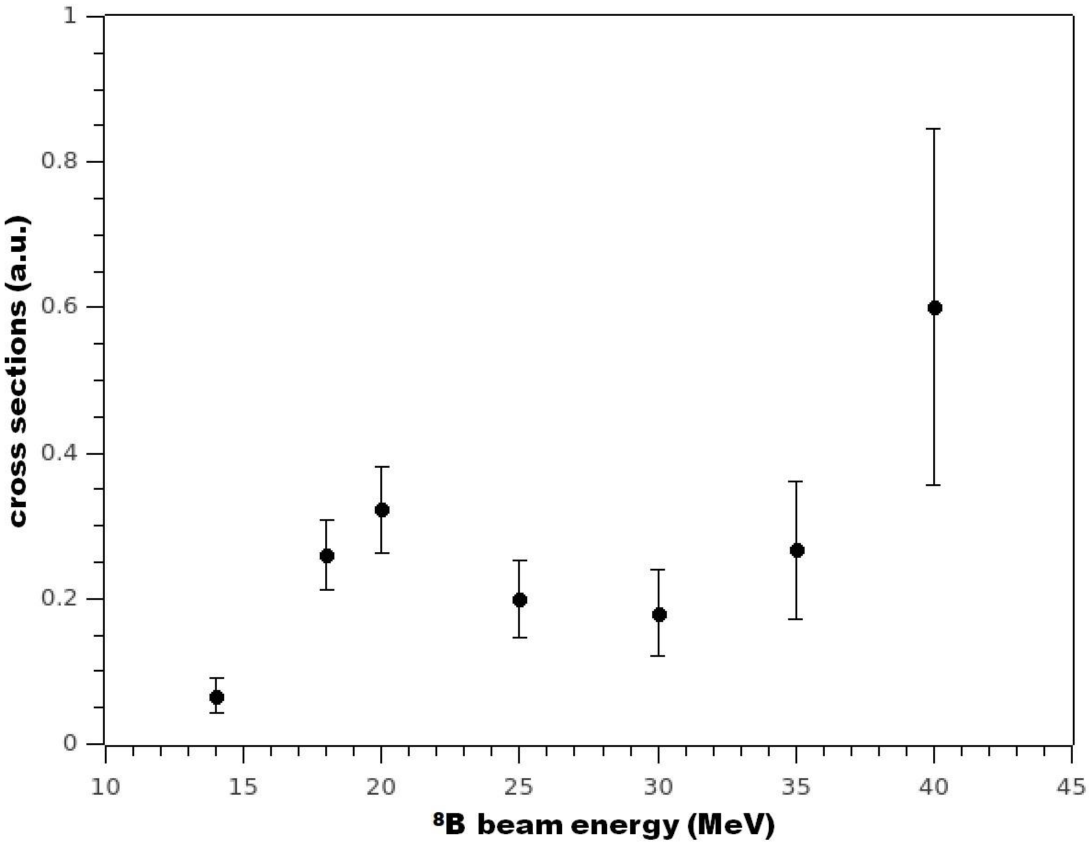

FIG. 2. Preliminary fusion excitation function.

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[2] Y. Ayyad *et al.*, Nucl. Instrum. Methods Phys. Res**.** **A880**, 166 (2018).