Prototype Window-less Gas-jet Target at VECC

Deepak Pandit[1,2], T. K. Rana[1,2], Surajit Pal[1], Balaram Dey[3], A. K. Sikdar[1,2], Joydip Nandi[1,2], Debasish Mondal[1,2], Saswata Roy[1,2], S. Mukhopadhyay[1,2], Sandipan Dasgupta[4], P. Y. Nabiraj[1,2]

[1]*Variable Energy Cyclotron Centre, 1/AF Bidhan Nagar, Kolkata – 700064, INDIA*
[2]*Homi Bhabha National Institute, Mumbai – 400094, INDIA*
[3]*Department of Physics, Bankura University, Bankura - 722155, INDIA*
[4]*ACD, BARC, Variable Energy Cyclotron Centre, 1/AF Bidhan Nagar, Kolkata – 700064, INDIA*

email:deepak.pandit@vecc.gov.in,

Obtaining nuclear data related to reaction dynamics and structure becomes more challenging when experiments involve accelerated particles interacting with nuclei naturally found in gaseous forms. In some cases, a solid compound containing the nucleus of interest can be produced, such as using hydrides to study reactions involving hydrogen. Alternatively, gas cells with thin windows can be used for noble gases. However, these and other approaches may not always be suitable, as the presence of additional materials in the compound or windows can cause interference. Moreover, accurately measuring reaction cross-sections requires targets that are well-confined, with high density and appropriate thickness to maximize count rates while minimizing energy loss and straggling of the reaction products. A high-density, spatially well-defined gas film serves as an ideal target for low count rate nuclear physics experiments, as it can withstand beam intensities several orders of magnitude higher than a solid target without undergoing alteration. This type of gas target can be created by injecting a supersonic jet into the reaction chamber under vacuum. Thus, gas jets are an optimal solution [1-3].

The schematic diagram of Gas Jet target is shown in Fig 1. The gas jet system consists of four primary components: a nozzle for gas inlet, a skimmer/receiver to efficiently pump out gas from the jet, a differential pumping system to remove any remaining gas, and an effective recirculation and gas cleaning system. In this work, we focus on testing the nozzle and skimmer system. The nozzle delivers the high density and small dimensions required for the jet target. The receiver features a thin-walled, cone-shaped design with smooth surfaces and a knife-edge opening, promoting non-turbulent gas flow. A compact chamber has been designed to house both the nozzle and skimmer, which are detachable for easy assembly and disassembly. The chamber, nozzle and skimmer system are shown in Fig 2.

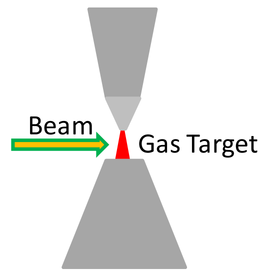

Fig 1: Schematic view of gas jet target.

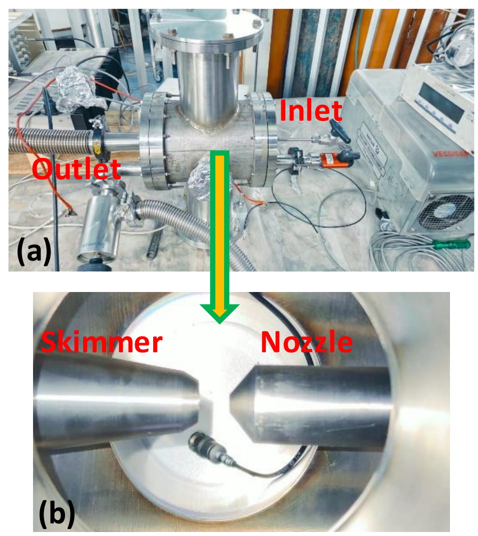

Fig 2: (a) The chamber where the nozzle and skimmer are connected. The skimmer is connected to a roots pump (40 m^3/h). (b) The nozzle and skimmer is displayed where the distance between the tip of the jet nozzle and the lip of the receiver is 1.2 cm.

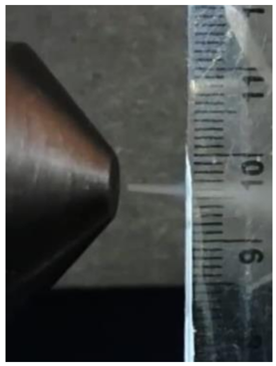

Fig. 3. The profile of the jet from the nozzle. Smoke was injected at 2 atm pressure at input of the nozzle in air. Minimum division on the scale is 1 mm.

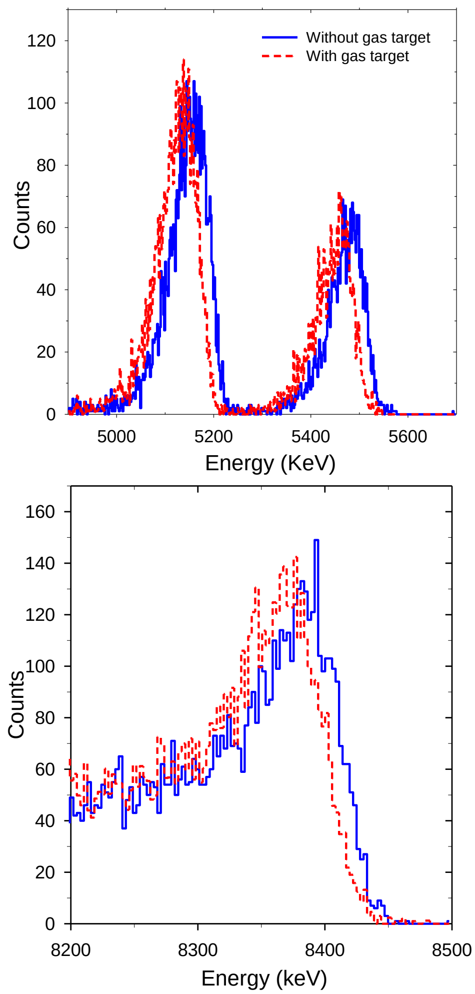

Fig. 4. Demonstration of energy loss measurement with the silicon surface barrier detector and Am-Pu (upper) and ^{229}Th (lower) alpha source. The blue solid line (right one) is alpha energy spectrum with no jet while the red dotted line (left one) with gas jet (air).

The minimum internal diameter of the nozzle was 1 mm as obtained from simulation [4]. The profile of the jet from the nozzle is displayed in Fig.3. The receiver had an opening diameter 14 mm. For our first experiment air was used, we simply opened the valve of our nozzle, with vacuum inside the chamber, to admit air at atmospheric pressure (1 atm). The gas jet comes out of the nozzle and is immediately caught by the receiver connected to a roots pump (40 m^3/h).

To measure the target thickness of the gas jet, Am-Pu and ^{229}Th alpha sources and a 500 µm silicon surface barrier detector was used. Aluminum collimators with a 2 mm diameter were placed to collimate both the source and the detector. The detector and source were positioned face-to-face, 3 cm apart, and perpendicular to the jet direction (0.8 cm from the nozzle tip). Initially, the alpha spectrum was recorded in a vacuum with the nozzle valve closed. Then, the nozzle valve was opened to allow air to enter the chamber at 1 atm. The equilibrium pressure in the chamber was 9 x10^{-1} mbar (due to the small roots pump at the skimmer). Figure 4 shows the alpha spectrum for without the jet target (blue solid line) and with the jet target (red dotted line). The peak shift of ~ 21 keV and 14 keV is observed at 5.486 and 8.38 MeV, respectively. This corresponds to target thickness of ~ 30 µg/cm^2 and areal density 1.23 x 10^{18} atoms/cm^2.

Efforts are underway to connect the skimmer to a larger roots pump and to supply the inlet with pure gas at a higher input pressure. The results will be presented at the symposium.

Acknowledgement

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