Measuring ^{2}H(p,γ)^{3}He cross section at 8 MeV

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Introduction

Radiative capture of a proton on deuteron ^{2}H(p,γ)^{3}He is a reaction of great importance both for nuclear astrophysics and few-body nuclear physics. Our previous work reported cross-sections and astrophysical S-factors for radiative proton capture on deuteron for energies relevant to big-bang nucleosynthesis [1]. This work reports the cross-section of the capture reaction at a higher lab energy of 8 MeV relevant for few-body nuclear physics. The nuclear reaction involving proton and deuteron has the potential to throw light on the nucleon-nucleon interaction and also to look for the three-body force effect. Over the decades, this particular reaction has been studied using both polarised and unpolarised beams of proton [2, 3]. However, notwithstanding the significance of the reaction, there is not much data on the radiative capture cross-section of the proton on deuteron in the 2 to 20 MeV region. We have embarked upon a program to measure the angular distribution and absolute cross-section of the radiative capture γ-rays from 2 to 20 MeV. As a first step, we report our measurement of the cross-section at 8 MeV proton energy.

Experimental Details

The experiment was performed at the BARC-TIFR Pelletron accelerator facility, where a proton beam of energy 8 MeV was incident on a CD_2 target. The thickness of the self-supporting CD_2 target foil was determined by measuring the energy loss of α-particle traversing the foil and was found to be 1.38 mg cm^{-2}. The capture of proton of energy E_{lab} = 8 MeV (E_{CM} = 5.332 MeV) by deutron generates γ-ray of energy 10.826 MeV, given the Q-value of capture reaction is 5.493 MeV. The high energy MeV γ-rays were detected using a large volume 3.5″×6.0″ $LaBr_3$:Ce scintillation detector placed at a distance of 20 cm from the target foil. For background related to the beam hitting the target frame, data was acquired with the beam passing through a blank frame. Data was also acquired for an extended period without a beam to estimate the ambient background around the peak of interest. The total charge incident on the target was measured using a beam current integrator connected to the beam dump.

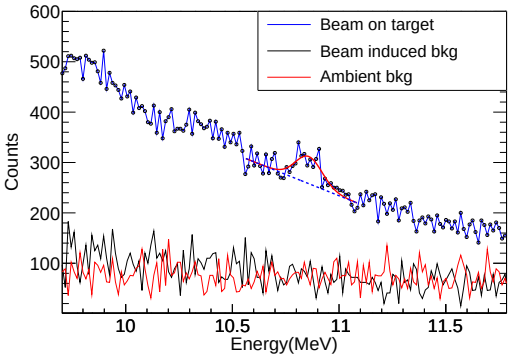

FIG. 1: Spectrum of 10.83 MeV γ-ray acquired in the experiment.

Results and Discussion

Figure 1 presents the spectrum acquired in the experiment, showing a peak at 10.826

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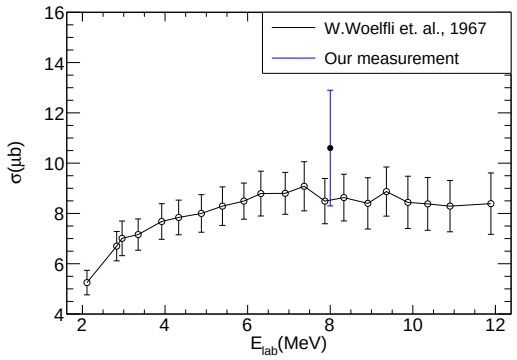

FIG. 2: Our measurement of the cross-section of γ-rays from the capture of the proton on deuteron compared to data available in the literature.

MeV. The peak at 10.826 MeV was fitted with a Gaussian to extract the number of counts under the peak. The counts obtained were corrected for the detector's efficiency, and the cross-section was calculated. Figure 2 presents our measured cross-section of γ-rays compared to the data available in the literature [3]. The error in our measurement is primarily due to the low statistics. The cross-section we extracted is in qualitative agreement with the existing data of Woelfli et al. We plan to repeat the measurements for a longer duration and at other beam energies between 2 to 20 MeV. We also plan to carry out three-body capture calculations to reproduce the data.

Acknowledgments

The authors would like to acknowledge the staff of BARC-TIFR pelletron for providing the beam for the entire duration of the experiment.

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