Absolute production cross-section of γ-rays from ^{10}B(p,p$'\gamma$)^{10}B reaction

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Introduction

Light ion induced scattering experiments, both elastic and inelastic, have long been used to study the nuclear structure and the nature of NN interaction within the nuclear medium. The reactions like (p,p$'$) and (p,p$'\gamma$) are specific examples of such experiments. In addition to providing information about the nuclear structure and reaction mechanism, the production cross-section of γ-rays from (p,p$'\gamma$) reactions is important in γ-ray astronomy. This reaction is also of practical importance in material characterisation. Traditionally, the phenomenological analysis of such experimental data is carried out within the Optical Model Potential (OMP) framework. This report presents our studies with proton beam in the energy range 8 to 18 MeV incident on ^{10}B. This work is a continuation of our ongoing program to systematically study a host of light nuclei through (p,p$'$) and (p,p$'\gamma$) reactions [1, 2].

In the present work, we have measured the γ-rays generated from several low-lying states of ^{10}B nucleus and extracted their absolute production cross-sections.

Experimental Details

A 93.5% enriched ^{10}B self-supporting target was mounted on a tantalum ladder. A proton beam of energy 8 to 18 MeV from the BARC-TIFR pelletron facility was bombarded on the target. Three cylindrical 3.5″×6″ $LaBr_3$:Ce and three 4″×4″ NaI:Tl scintillation detectors were used to detect the γ-rays. The detectors were placed at 60°, 90° and 120° on both sides of the beam direction. The distances from the target were adjusted to ensure equal solid angles subtended by the detectors on the target.

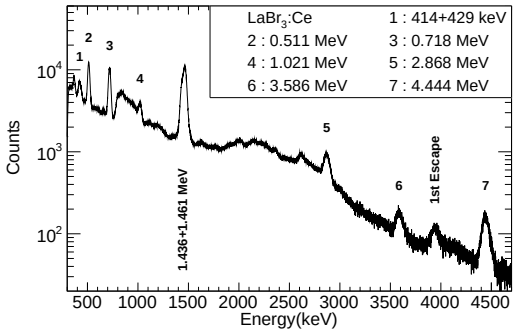

FIG. 1: A typical spectrum of $LaBr_3$:Ce detector acquired during the experiment.

Measurement and Analysis

GEANT4 simulations were carried out to determine the efficiency of the detectors for γ-rays from ^{10}B. Data from standard laboratory γ-ray sources of ^{22}Na, ^{137}Cs, ^{60}Co and Am-Be were used to validate the simulations. Typical spectra obtained from $LaBr_3$:Ce and NaI:Tl detectors during the experiment are presented in Figures 1 and 2, respectively. The peaks seen in the spectra originate from both ^{10}B(p,p$'\gamma$)^{10}B and ^{10}B(p,α)^{7}Be reactions. ^{10}B can capture the incident proton to form ^{11}C which can decay via α-particle emission to ^{7}Be. The formation of ^{7}Be can

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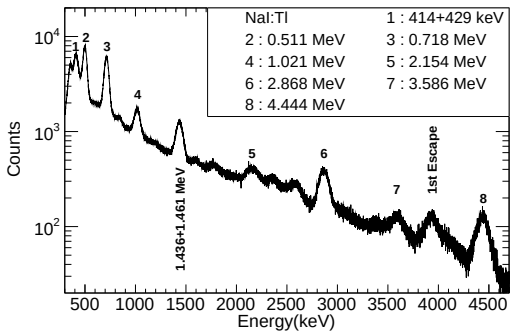

FIG. 2: A typical spectrum of NaI:Tl detector acquired during the experiment.

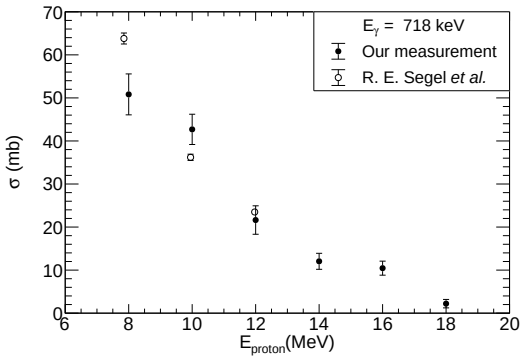

FIG. 3: Absolute production cross-section of 718 keV γ-ray from ^{10}B compared with the data from R. E. Segel *et al.* [3]

be inferred by detecting the 429 keV γ-ray from the first excited state of ^{7}Be. However, a transition with energy 414 keV exists in ^{10}B, which lies very close to the 429 keV γ-ray from ^{7}Be. The NaI:Tl detector, having poor energy resolution as compared to the $LaBr_3$:Ce, could not resolve the two peaks. Fortunately, $LaBr_3$:Ce could sufficiently resolve the two peaks so that a double Gaussian fit can retrieve the counts. One transition of energy 1.436 MeV in the ^{10}B level scheme fully overlaps with the 1.4 MeV internal activity of the $LaBr_3$:Ce detector. Consequently, the data from the $LaBr_3$:Ce detector could not be used to extract the cross-section for 1.436 MeV γ-ray. In this case the data from the NaI:Tl detector was used to extract the cross-section for 1.436 MeV γ-ray after proper background subtraction. We also observed 4.44 MeV γ-ray from the first excited state of ^{12}C. We could estimate the percentage of ^{12}C contamination in the target from the yield of 4.44 MeV γ-rays.

Results and Discussion

We have extracted the cross-sections of 0.414, 0.718, 1.021, 1.436, 2.154, 2.868 and 3.586 MeV γ-rays from ^{10}B(p,p$'\gamma$)^{10}B reaction. Additionally, we could obtain the cross section for 429 keV γ-ray from ^{10}B(p,α)^{7}Be reaction. The full cross-section data set will be presented in the symposium. Figure 3 presents the cross-section of 718 keV γ-ray corresponding to the transition from the first excited state to the ground state of ^{10}B. As of today, only one data set by R. E. Segel *et al.* [3] is available in the literature for ^{10}B(p,p$'\gamma$)^{10}B reaction. The existing data of Segel *et al.* covers beam energy up to 12 MeV. This work extends the data to 18 MeV incident proton energy. A detailed optical model analysis, including channel coupling and the possible role of resonances, are underway.

Acknowledgments

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