

Absolute cross-section of γ -rays from $^{11}\text{B}(p,p'\gamma)^{11}\text{B}$ reaction

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Introduction

Inelastic scattering experiments play a significant role in the study of nucleon-nucleus (NA) interaction. These many-body NA interactions can be accurately described for heavy target nuclei and high incident nucleon energy. However, for light target nuclei ($A < 40$) and low energy projectiles (< 40 MeV), the nuclear structure effects become much more pronounced and rapid variations in cross-section are observed. This poses a challenge for the theoretical models in explaining the reaction cross-section data accurately. Several factors contribute to the complexity of the problem, such as nuclear deformations, coupling of states, compound nuclear resonances, etc. Moreover, there is a dearth of data for the cross-section of γ -rays from such inelastic scattering reactions. Such cross-section data is important for γ -ray astronomy and material composition analysis.

Motivated by above-mentioned points, we have performed a series of proton inelastic scattering experiments, namely, $^{12}\text{C}(p,p'\gamma)^{12}\text{C}$, $^{16}\text{O}(p,p'\gamma)^{16}\text{O}$ and $^{10}\text{B}(p,p'\gamma)^{10}\text{B}$ [1–3]. We also attempted to develop a detailed theoretical model based on Optical Model Potential(OMP) formalism to reproduce the finer structures in the cross-section data for $^{16}\text{O}(p,p'\gamma)^{16}\text{O}$ reaction [1]. As a next step of our ongoing investigation, we wanted to measure the γ -ray cross-section for ^{11}B . In this paper, we report our measurements of the absolute cross-section of γ -rays from $^{11}\text{B}(p,p'\gamma)^{11}\text{B}$

reaction. To the best of our knowledge, this is the first report of the cross-section of γ -rays from ^{11}B in this energy region. It is expected that an in-depth analysis and comparison of the cross sections from $^{10,11}\text{B}$ with magic nuclei like ^{16}O will provide greater insights into the structures of these nuclei and the reaction dynamics. The knowledge so obtained may provide necessary inputs for developing a more realistic optical model analysis framework.

Experimental Details

The experiment was performed using proton beams from the BARC-TIFR Pelletron accelerator facility. A 95% enriched, self-supporting ^{11}B target having thickness $211 \mu\text{g cm}^{-2}$ was used for the experiment. The target foil was bombarded with 13 proton energies from 8 to 20 MeV. The γ -rays produced from the target were detected using a large volume $3.5'' \times 6.0''$ LaBr₃:Ce detector. The angular distribution of γ -rays was measured at 8 and 12 MeV at nine different angles. The total charge incident on the target was measured using a current integrator connected to the Faraday cup at the beam dump.

Data Analysis

The bombardment of protons on ^{11}B target produced several high energy γ -rays. Many photo peaks overlapped with the escape peaks of the γ -rays. This makes identifying and extracting accurate counts under the photo peaks a difficult task. In order to circumvent this difficulty, a realistic Compton background due to all the γ -rays, along with the escape peaks, was generated using the GEANT4 toolkit.

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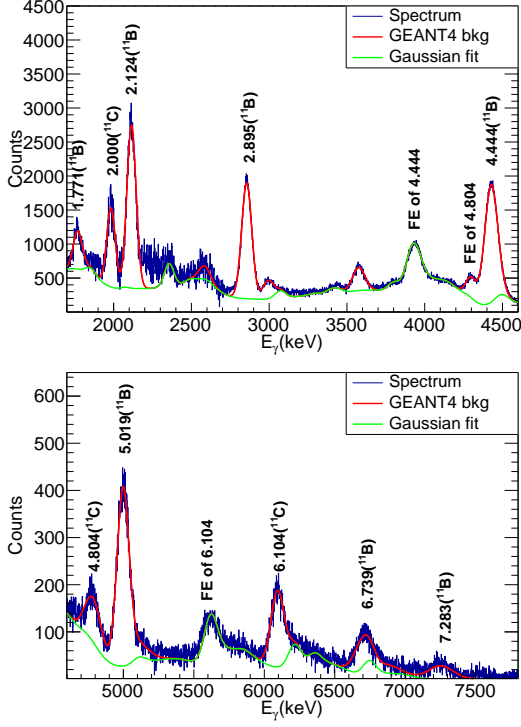


FIG. 1: A typical spectrum of γ -rays acquired during the experiment for 8.5 MeV protons. The upper panel presents the transitions up to 4.5 MeV and the lower panel presents the transitions above 4.5 MeV.

Figure 1 presents a typical spectrum (blue), the GEANT4 generated Compton background (green) and the photopeaks fitted with Gaussian (red). The counts under the photopeaks were corrected for the efficiency of the detector and the cross-section was determined for all the beam energies.

Results and Discussion

Figure 2 presents the cross-section of γ -rays from the first two excited states of ^{11}B . Cross-sections have been determined for several other γ -rays from ^{11}B which will be presented at the conference. To the best of our knowledge, this is the first report of the cross-section of γ -rays from ^{11}B . Rapid variations in the cross-section are observed below 12 MeV proton energy.

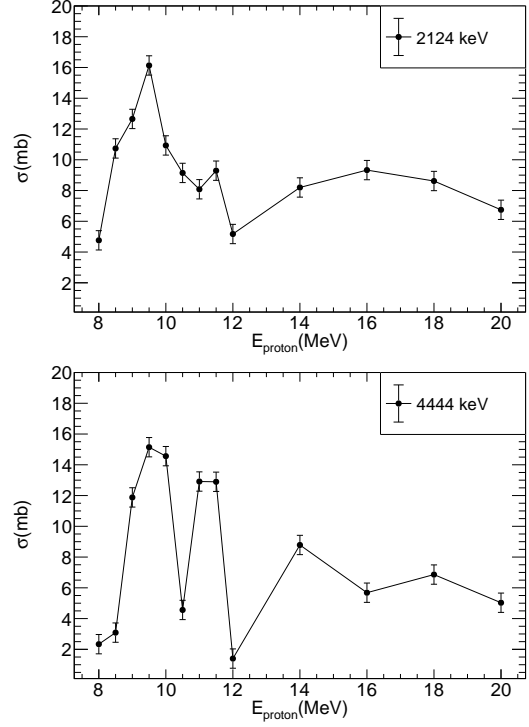


FIG. 2: Absolute cross-section of γ -rays from ^{11}B

This aligns with our previous measurements as described in the introduction [1]. Work is in progress to develop a theoretical model based on an optical model potential formalism to reproduce the cross-section data.

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References

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