Measurement of $^{121}Sb(n,\gamma)^{122}Sb$ reaction cross sections within 1.6-3.1 MeV neutron energy range

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Introduction

Neutron-induced reaction cross sections are useful in understanding nuclear heating, induced radioactivity, nuclear transmutation rates, and radiation damage to structural materials caused by gas formation on the first wall of the materials [1–6]. Nuclear data which includes neutron elastic and inelastic scattering cross sections on important structural and coolant materials is important for the next generation nuclear facilities [7–9].
Excitation functions were measured for $^{121}Sb(n,\gamma)^{122}Sb$ and $^{123}Sb(n,\gamma)^{124}Sb$ reactions using natural sample of antimony in the neutron energy range 1.6-3.1 MeV. Here, we are going to present only $^{121}Sb(n,\gamma)^{122}Sb$ reaction cross section and the corresponding were compared with the experimental data from EXFOR and as well as TALYS-1.9, ENDF/B-VIII.0 and JEFF-3.1/A. The main objective of this experiment was to obtain the cross section data at low energies for $^{121}Sb(n,\gamma)^{122}Sb$ reaction associated with covariance analysis.

Experimental Details

The experiment was carried out at the 6 MV Folded Tandem Ion Accelerator (FOTIA) facility, BARC, Mumbai. In the experiment, the proton having energies 3.6, 4.6 and 5.0 MeV were bombarded on a natural lithium target for neutron production purpose. EPEN code was used for the simulation of neutron flux. This code has been designed for the proton energy from the reaction threshold to 7.0 MeV. Since the incident proton energies were higher than the threshold energy (2.37 MeV) of the first excited state of ^{7}Be, and the low energy neutron production yield (n_1) will contribute to the ground state neutron (n_0) production yield. Since the contribution of other reaction channel is negligible and the contribution of neutron state (n_1) is less than 10%. So, the main contribution of neutron production yield comes from (n_0). The neutron flux energy spectra for (p,n_0) and (p,n_1) obtained from EPEN code for the three energies 1.66, 2.65 and 3.05 MeV are presented in Fig. 1.

Result and Discussion

In the present work, efficiency calibration [10, 11] of the HPGe detector for different gamma ray energies has been carried out using a standard ^{152}Eu point source. The geometry dependent efficiency (ϵ_p) of the point source for source-detector at a distance of 80 cm was estimated using the following equation:

$$\epsilon_p = \frac{CK_c}{A_o I_\gamma \Delta t e^{-\lambda t}} \quad (1)$$

In the above equation, A_0 is the known activity of ^{152}Eu (A_0 = 6659 Bq as on 01 Oct 1999) point source. The measured efficiency and the fitted efficiency curve are plotted in Fig. 2.

Production of ^{122}Sb radionuclide

The measurement of the reaction cross-section of the E_γ = 564.24 keV of ^{122}Sb ($t_{1/2} = 65.28h$) with intensity I_γ = 70.68 % was done after the cooling of 7200 second. The nuclear reaction cross sections were calculated

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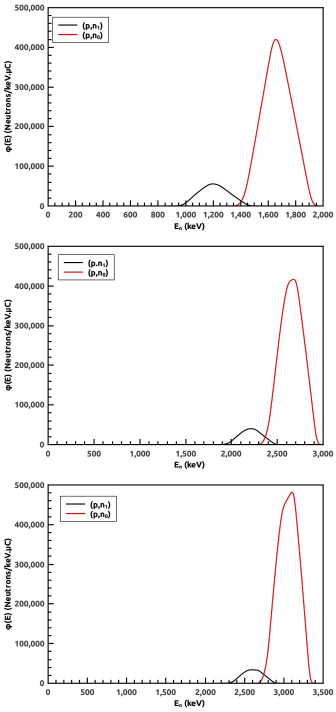

FIG. 1: Neutron flux energy spectra obtained from EPEN at E_p = 3.6, 4.6 and 5.0 MeV

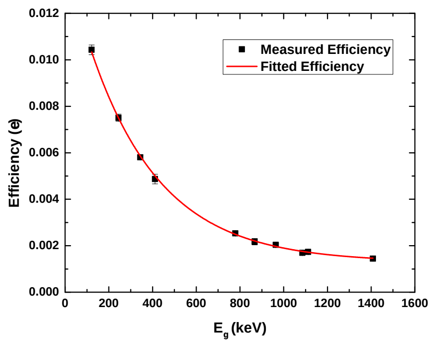

FIG. 2: Efficiency calibration curve of the HPGe detector calibrated at a distance of 80 cm from the source.

using the following activation formula:

$$\sigma_s = \sigma_m \eta \frac{A_s \lambda_s a_m N_m I_m f_m}{A_m \lambda_m a_s N_s I_s f_s} \frac{N_{corr(s)} C_{attn(s)}}{N_{corr(m)} C_{attn(s)}} \quad (2)$$

Fig. 3 shows the excitation function of $^{121}Sb(n,x)^{122}Sb$ reaction at the neutron energies 1.66, 2.65 and 3.05 MeV, obtained in this study and compared with the existing experimental data and the evaluated data. The necessary corrections resulting from the low-energy background neutron contribution and gamma ray self attenuation are considered in the present study. The details of the data analysis of the reaction cross sections and uncertainty quantification will be presented during the conference.

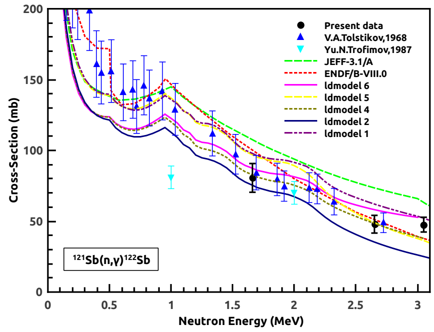

FIG. 3: Excitation function of $^{121}Sb(n,x)^{122}Sb$ reaction with literature data and the calculated values from TALYS-1.9 and also with ENDF/B-VIII.0 and JEFF-3.1/A.

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