GAMMA GATED NEUTRON SPECTRUM FROM Am-Be SOURCE

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Introduction

Am-Be radioactive sources are commonly used in laboratory as easy source for fast neutron generation. It can also be used as a mono energetic 4.4 MeV energy gamma ray source . The α-particle, from Am-241, captured by ^{9}Be nucleus produces neutrons and higher energy gamma rays, via reaction ^{9}Be(α,n)^{12}C. Due to the source composition matrix effects in alpha energy loss, and multiple scattering of neutrons inside the source, the emitted neutrons are having a continuous energy. To understand the exact nature of neutron spectrum, the individual neutron colonies corresponding to residual energy states of ^{12}C has to be correlated through the level scheme of ^{12}C.

With this motivation, the neutron spectrum from a 100mCi Am-Be source has been measured using time of flight(TOF) setup, gating the gamma rays from different decay levels of residual ^{12}C states.

Materials and Methods

A sealed 100mCi neutron source is used for the study. The source was placed inside the target chamber of NAND facility,IUAC, New Delhi[1]. A BaF_2 scintillator was placed inside the target chamber for tagging gammas emerged from the source. One of the neutron detectors of NAND facility, BC501A liquid scintillator of 5”x5” cylindrical cell is chosen as the stop detector for neutrons. The distance between source and neutron detector is 175cm which is the radius of the NAND facility itself. A Time to Amplitude Convertor(TAC) using Ortec-566 TAC module was used to record TOF between gamma tagging detector and neutron detector. A Pulse Shape Discriminator PSD also generated from the delayed output of BC501A detector. The parameters gamma energy E_γ , TAC and PSD were acquired through CAMAC using 4K ADC configured through FREEDOM software. The data were acquired for a total acquisition time of 40 hrs. A 2D plot between TAC and PSD was generated and neutrons were separated. Fig 1 shows a typical 2D histogram of TOF versus PSD with clear separation between neutrons and gamma rays.

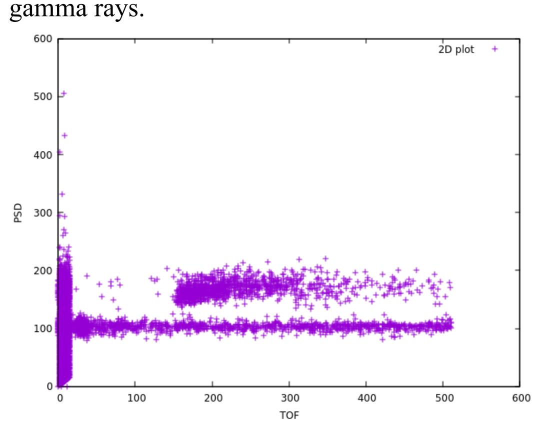

Fig 1 Two dimensional represenation of TOF versus PSD in the neutron detector

The energy calibration of BaF_2 was performed using ^{60}Co and ^{137}Cs sources. The efficiency of BC501A neutron detector has been simulated with monte-carlo code. Further the neutron spectrum corresponding to tagged gamma ray has been generated applying appropriate 1D gates in gamma energy spectrum. The gamma rays corresponding first and second excited state level transitions in ^{12}C are tabulated in table1. Neutron energy spectrum was generated from conversion of neutron time of flight into energy. Thus produced neutron energy spectrum tagged with 4.4 MeV gamma rays is generated which is compared with theoretical spectrum simulated for Am-Be source[2].

γ energy	Decay levels
4.44 MeV	2^+(4.44 MeV) to 0^+(0 MeV)
3.21MeV	0^+(7.65MeV) to 2^+(4.44MeV)

Table. 1 Gamma decay energies and transition levels in ^{12}C

Result and discussion

The neutron energy spectra measured as described above is shown in fig 2. The measured data (preliminary)have not been corrected for neutron detector efficiency. The 4.4 MeV tagged neutron spectra are visible in the energy range of 1.5MeV to 6 MeV beyond which there is no strength. Also presented is the full energy neutron spectra simulated for Am-Be source[2]. Agreement between measured data and simulated data is good between 2.5MeV to 6 MeV. It is to be considered that in simulation, the energy loss of alpha particle is not taken into account and that could be a reason for the shift in peak energy. Two prominent peaks energies corresponding to 2.8 MeV and 4.6 MeV are identified. The neutron colony for energy around 9 MeV corresponding to ground state of ^{12}C could not be measured as there is no gamma produced for tagging. Some of the weak lower energy colonies also could not be identified due to limited neutron flux available for the experiment. The gamma gated measurement made the present result more precise. More detailed analysis is in progress Improvement in measurement is possible with high flux neutron source. Further colonies may be identified on incorporating velocity chopper with high flux source.

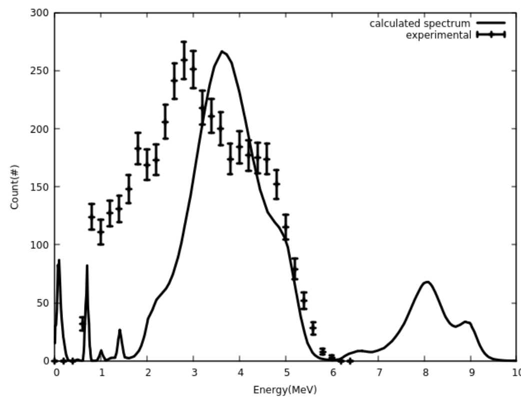

Fig.2 The neutron energy spectrum of Am-Be source measured(preliminary) and simulated[2]

References

[1] P. Sugathan et.al PRAMANA, (2014)Vol.83, No.5, 807-815

[2] A T Fathima shirin shana et al. DAE Symp.Nucl.Phys. 63 (2018) 636-637