Simulation study of different geometries for TAGS measurement using BaF_2 detectors.

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Introduction

It is important to know the β-decay strength function accurately both in the basic understanding of the β-decay process, in particular, the Gammow-Teller decay in the vicinity of closed shell nuclei and also in the applied field for the estimation of decay heat. The Total Absorption Gamma Ray Spectroscopy (TAGS) is a very useful tool for the study of β-decays in nuclei, free from pandemonium effects [1 – 4]. In α and γ spectroscopy, information about the level properties is obtained from a direct measurement of decay spectra. For β-decay, this is not the case as the β-decay spectrum is continuous in nature. The information about the decay probability of the β-decay is obtained indirectly from the measurement of the intensity balance of γ-rays from the levels populated in the β-decay transitions. When gamma detector array with HPGe detectors are used for the detection of gamma rays to measure the feeding intensities, there are two main difficulties: low detection efficiency and the fragmentation of gamma intensity. Many weak transitions remain unobserved and, hence, the feeding intensity may be wrongly deduced. For these, much of the β-feeding are not observed and then incorrectly assigned to higher feeding for the low lying levels. This is what termed as Pandemonium effect. The solution to this experimental problem is to adopt a different approach to the measurement using a Total Absorption Gamma Spectrometer which is sensitive to the β-population of the nuclear levels instead of individual gamma rays. In the ideal case, TAGS has detection efficiency of 100%. Instead of having individual gamma peaks, TAGS measures, a sum energy peak corresponding to the total energy of the gamma cascade following the β-decay. This gives direct information about the levels fed in the decay. TAGS are constructed using large scintillator covering 4π of the solid angle around the β-emitting source. Two main criteria for a TAGS set up are the 4π coverage and knowledge of detector response. A few TAGS set up that exist in the world are mostly constructed from large NaI(Tl) detectors because of its high efficiency and low cost.

Construction of a TAGS set up in India is being planned to study the beta decay strength function for physics interest as well as for providing input for the estimation of decay heat of the reactors, particularly for the nuclei for which TAGS measurements are required for the Th/U fuel cycle [5].

We have done simulation work using GEANT-3 for the efficiency and response of a TAGS set up constructed from individual BaF2 detectors with different sizes.

Choice of Geometry

Full 4π coverage was one of the main criteria for the construction of the geometry using the individual BaF2 detectors. We have considered two sets of detectors with same cross sectional area (3.5x3.5 cm^2) but different lengths (5 cm and 35 cm) available at VECC, Kolkata. These detectors have good timing resolution and have already been used in the detection of high energy gamma rays [6]. These BaF2 detectors were arranged to cover maximum of solid angle with minimum loss. Two geometries are being considered (i) a well type and (ii) a box type configuration. These are shown in Fig. 1 constructed from the larger and smaller detectors respectively. In the well type configuration, a 6 x 6 matrix was formed with the detectors in which 4 of them from the middle were pushed back to form a well. The source is placed in the middle of the well and the response was simulated. The well is needed, in the actual experiment, to keep a provision for continuous movement of the nuclei of interest from the production site to the middle of the TAGS set up. Total 36 detectors are needed in this configuration. In the second one, each of the 5 sides of the box configuration contains a wall of 3x3 matrix of BaF2 detectors and there is no wall in the front. In this configuration, a total of 45 detectors are needed.

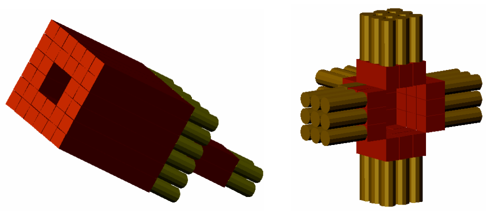

Fig. 1: Well type (left) and box type (right) configurations of TAGS set up using larger and smaller BaF2 detectors respectively.

Results of Simulation

For the simulation, a 2 MeV gamma ray was chosen which is being emitted from the middle of the set up. In Fig. 2, the simulated tracks of 500 gamma rays are shown within the volume of the well type configuration using the larger BaF2 detectors (as shown in Fig. 1 (left)). It shows that almost all of them have deposited full energy within the detector medium and very few excapes out from it.

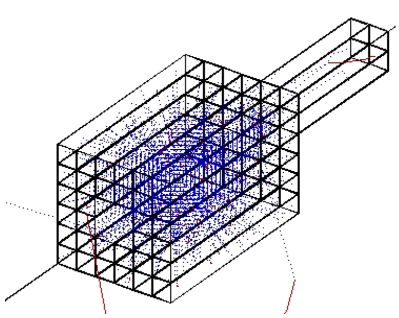

Fig. 2: Simulated tracks of 500 gamma rays (2 MeV each) inside the well type configuration of TAGS set up.

The sum energy spectrum for a 2 MeV incident gamma ray obtained from the simulation in this configuration is shown in Fig. 3. This spectrum is the sum of all the energies deposited in different detectors for each of 100K events. The detector resolution is folded in the simulation. This spectrum clearly shows that we get back the incident energy of the gamma ray in the simulation with a small background mainly contributed by the Compton scattered events. Similar sum energy spectrum will be analysed in a TAGS measurement to get the β-decay scheme and there by the β-feeding intensities.

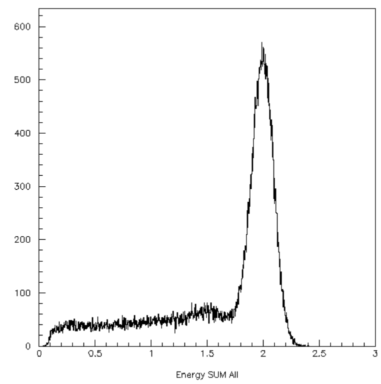

Fig. 3: Sum energy spectrum of a 2 MeV gamma ray in the well type configuration.

Summary

In summary, we are doing simulations for different geometries of a Total Absorption Gamma Spectrometer to be constructed from the BaF2 detectors available at VECC. Two geometries, well type and box type, are being considered. The preliminary results of the simulation give good result for the sum energy. More work is in progress to get response function of the set up and to compare them with experimental data. Detailed of the simulation will be presented in the symposium.

References

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