Geant4 simulation of two fold clover detector for position resolution calculation

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The simulation of position resolution calculations has been performed for a clover detector with two fold geometry using Geant4. A clover detector along with lead collimator has been created in Geant4 environment to obtain the one to one correspondence between energy deposition and position of interaction. The collected position spectra were fitted with TGo4Fitter libraries of GSI Object Oriented On-line-Offline Go4 software.

1. Introduction

A new generation of detectors is being developed with improved energy resolution and efficiency for γ-ray spectroscopy. The future gamma arrays such as AGATA [1] in Europe and GRETINA [2] in USA involve the high fold segmented germanium detectors. Such detectors will be used with fast digital signal processing and can handle the count rate upto 3MHz for gamma-ray multiplicity equal to one. These detectors will not only give the energy and timing information but also the position information (PI) of the γ-ray interaction based on Pulse Shape Analysis (PSA) technique. The position information can be extracted from core and mirror pulses which resulted after each gamma interaction. Using PI and tracking algorithms [3] the gamma tracks can be reconstructed inside the germanium volume. Gamma tracking is mainly based on Compton Kinematics which gives a unique angle-energy relationship as.

$$E'_\gamma = \frac{E_\gamma}{1+\frac{E_\gamma}{m_o c^2}(1-cos\theta)}$$

where symbols have their usual meanings. Using the above relation it can be shown that the energy resolution of the reconstructed peaks will be directly proportional to the position resolution (θ). Therefore better position determination will give better results for the energy resolution.

In this work we report the first results of simulation of position resolution for a two fold clover detector at TIFR using Geant4 [4] simulation.

2. Simulation Details

A new Geant4 based simulation code has been developed for the simulation of position resolution for a two fold germanium clover detector as given in Ref. [5]. The germanium crystals were created in the simulation with each one having dimensions of 90mm x 90mm with 80mm in depth. The four germanium crystals were placed with a gap of 0.2mm with respect to each other. The whole detector is placed in vaccum of thickness 5.5mm each in x and y direction with 10mm in z direction and is followed by a detector capsule of 1.5mm thick aluminium sheet.

In the code different gamma lines from a radioactive nucleus were implemented from the standard Geant4 radioactivity decay module (v3.3). To increase the overall simulation efficiency the standard G4UserStackingAction class has been implemented in such a way that all the gamma tracks with forward momentum direction with respect to source are processed and rest of them are killed by

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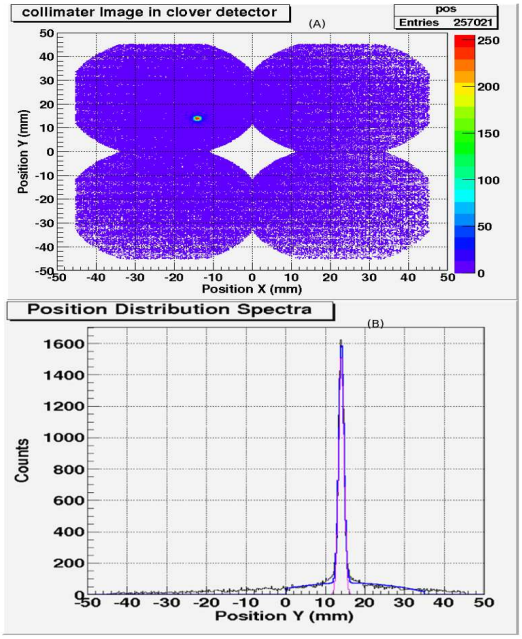

FIG. 1: top panel (A) shows the position spectra of a lead collimator having 1mm diameter (see text) and bottom (B) panel shows the projected spectra of y co-ordinate (see text) with fitted peak shown in pink colour.

G4StackManager. The ROOT [7] based libraries were integrated in the code along with Geant4 libraries. In order to collect the event-by-event information the ROOT libraries were invoked during runtime within the simulation. The collected event mode file is analysed in a separate code in which the GSI Object Oriented On-line-Offline Go4 [6] libraries were invoked. The standard TGo4Fitter libraries have been used to find out the peak position and position resolution (σ) of the projected position spectra. Several calculations have been performed to study the effect of depth and diameter of the collimator hole in the position spectra.

3. Simulation Results

Different combinations of lead block dimension, collimator diameter and distance between collimator and detector (D) have been taken in order to optimise the count rate and

TABLE I: Geometry of Pb blocks with pin hole details

dim. x (mm)	dim. y (mm)	dim. z (mm)	collimator co-ordinates w.r.t. clover center	hole diameter (mm)
77	100	50	(-14,14)	1
77	100	50	(-14,14)	2
28	28	50	(-11,11)	1

TABLE II: Results obtained after fitting with TGo4Fitter library.

D (mm)	Pos. X (mm)	Pos. Y (mm)	σ_x (mm)	σ_y (mm)
0	14.02	14.01	0.67	0.679
0	-14	14	1.35	1.36
100	-25.08	25.06	6.47	6.61

position resolution. The results of the simulation are shown in Table I and II. Total 3 x 10^8 events were processed in each of the sets. It was found that the total simulation time taken by the code is same in all the cases (due to implementation of G4UserStackingAction). Fig 1. shows the lead collimator image corresponding to the first set of values shown in Table I and II.

The theoretical pulse shape calculations are in progress for each position of interaction.

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References

[1] AGATA http://www-win.gsi.de/agata/
[2] GRETINA website http://grfs1.lbl.gov/
[3] I. Piqueras *et.al* Nucl. Instr. and Meth.**A 516**, Issue 1, pp. 122-133 (2004)
[4] Geant4 website http://geant4.cern.ch/
[5] B.S. Nara Singh *et.al* NIM **A 506**, (2003) pp. 238-249
[6] Go4, http://www-linux.gsi.de/ go4.
[7] R. Brun *et.al* NIM **A 389**, (1997) pp. 8186.