PROPOSAL FOR THE GAMMA-RAY POSITION MEASURING SYSTEM USING e+/e- PAIR PRODUCTION EVENTS

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Key words: pair production, position measuring, Geant4

Introduction: In the region of particle beam therapy, to identify dose points, PET detectors or Compton cameras have been studied. However, these systems haven't got competent performance yet. We propose the system which measures pair production events occurred in the system by gamma-rays over 20 MeV come from exposed points. This system can define incidence points and directions.

Methods: This system consist of 20 layers of detectors at 10 mm distances. Each layer is composed of wavelength shifting fibre (WLSF) sheets and a GAGG scintillation board of 1.0 mm thickness. An area of each board is 300*300 mm^2. Sheets are made by ordering WLSF with a diameter of 0.2 mm. The board is sandwiched in sheets, and directions of the sheets are in orthogonal (an illustration is on Fig.1). Gamma-rays which energy is over 7 MeV are more likely to create an e+ / e- pair than being scattered [1]. The light yield at the pair produced layer is unstable, but at following layers, particles consume 1.8 MeV of energy on average. In case, Compton scattering has occurred, the energy loss in following layers are 0.8 MeV in average. Sometimes a pair annihilated gamma-ray loses energy at a former layer, but such energy loss is under 511 keV. Therefore, we can extract pair production events if there are 1.3-2.3 MeV loss of energy at few layers continually.

I have done Monte Carlo simulations by Geant4. First, I shot gamma-rays to the system, then counted events that e+ are found on scintillation boards. I also took data of total energy deposit on scintillation boards, and its positions. If there're some energy deposit over 511 keV, and 1.3-2.3 MeV at following 2 layers, I judged that event as a pair production event. I changed gamma-rays' energy in 10-51 MeV.

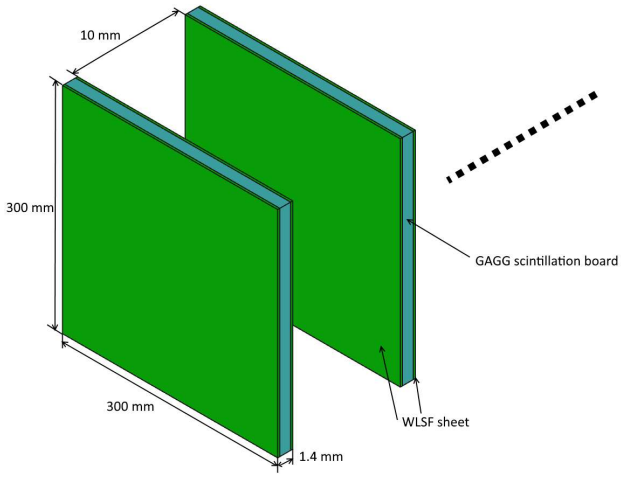

Fig.1 The illustration of our system.

Results: I confirmed that our system can define pair production events over 70% accuracy when gamma-rays' energy are 20 MeV (Fig.2). Now, I'm calculating deviations from gamma-rays' expected trajectories. Moreover, we will soon experience that our detector can distinguish 2 particles passing from 1 particle passing.

Discussion: The ratio of events that is found e+ on scintillation boards are lower than I expected. This ratio may improve by changing thicknesses of scintillation boards.

Cheap and high performance scintillation boards are existing. Therefore, we estimate the cost at very low price.

Conclusion: This system has a potential to be a high resolution gamma-ray position measuring system. It could be useful in many regions of Physics.

References:

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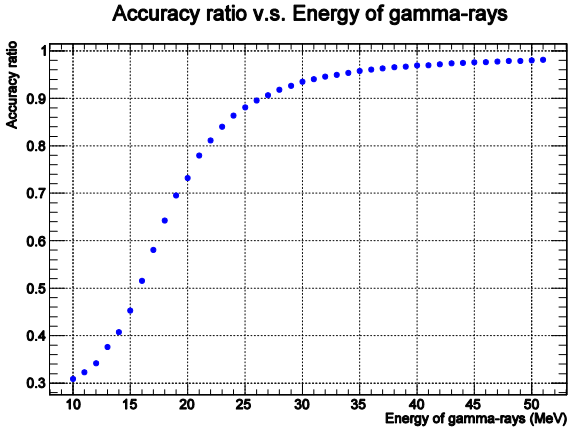

Fig.2 Energy dependency of our system's accuracy ratio that is the ratio of well-judged events to events that are judged as pair production events. When gamma-rays' energy is 20 MeV, over 70% of judges are collect.