A0428

DEVELOPMENT OF GAMMA-DETECTORS FOR PET WITH POSITION RESOLUTION OF 0.5MM

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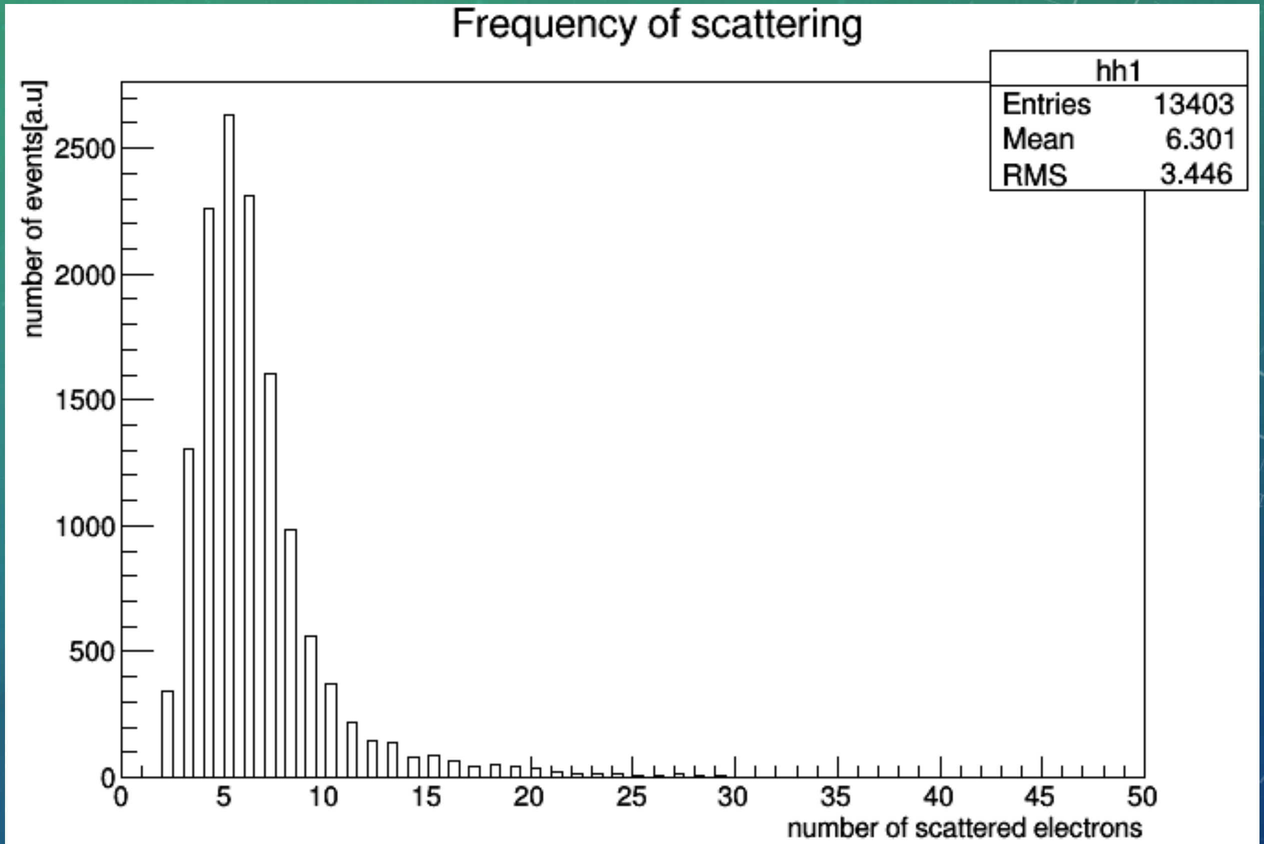
Basic method to improve the position resolution of PET

- In the Positron Emission tomography (PET), positrons and electrons annihilate and pairs of gamma-rays are created. These gamma-rays are caught by the scintillators of the detectors.
- In order to improve the position resolution of PET, scintillation crystals have to be subdivided into small pieces.
- But, the smaller the crystals are made, the more difficult it becomes to ignore the effect of Compton scattering.

- In the PET detectors, Compton scattering typically occur 1～6 times by one annihilation event. (3～8 electrons are scattered including photoelectric absorption)

- It is important to detect where the first scattering position is. (I'll come back to that point later.)



Structure of the detectors

- plate-like GAGG scintillators (34 mm ×34 mm × thickness of 3 mm)

  GAGG scintillator ・・・ $Gd_3 Al_2 Ga_3 O_{12}$ (Ce)

- Position detection of scattering

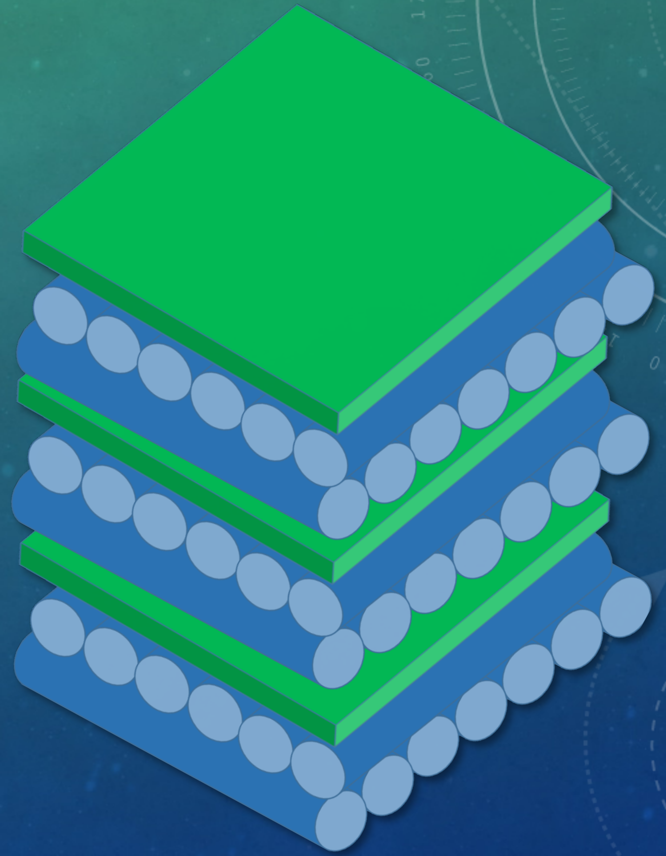
  →WLS fibers (top and bottom surfaces of the scintillators, 0.2 mm in diameter)

  (WLS fiber ・・・ wavelength shifting fiber)

- Detection of energy deposit

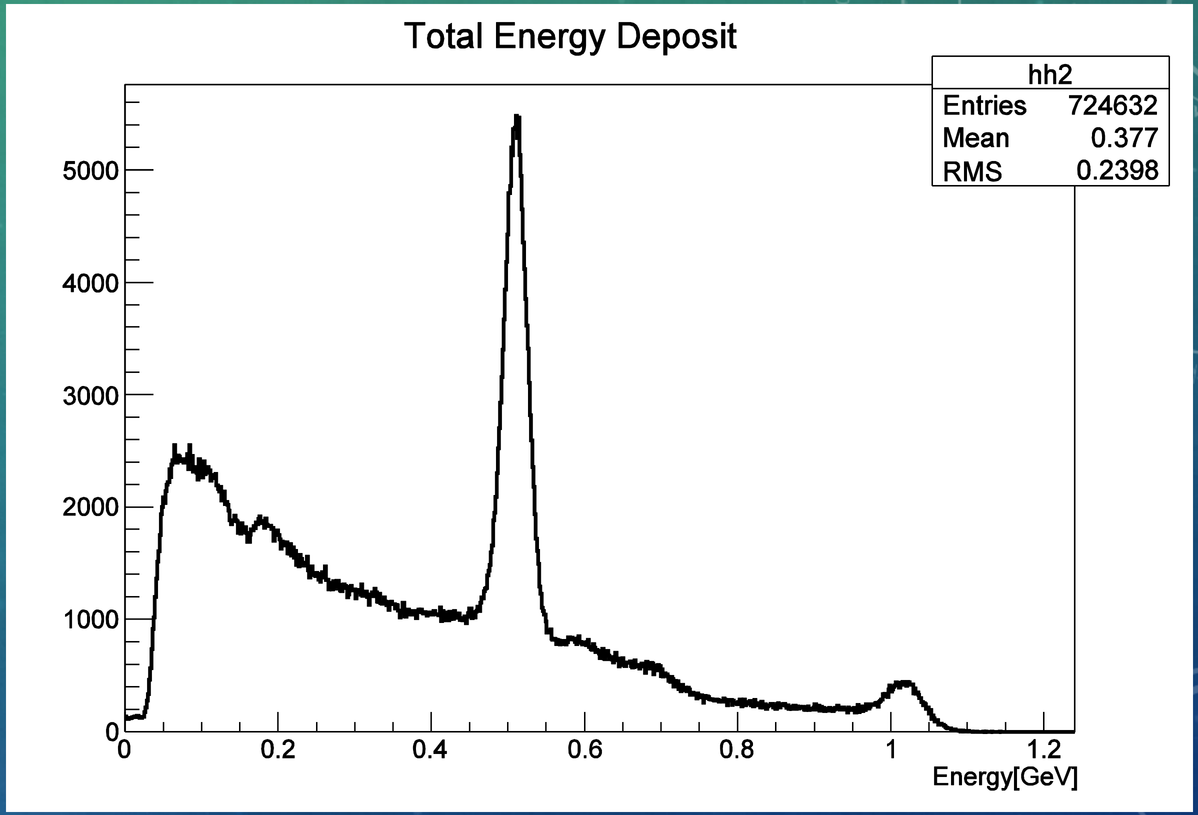
  →SiPM modules (lateral side of the scintillators, 3 mm ×3 mm)

  (SiPM ・・・ Silicon Photomultiplier ※not drawn in this picture)

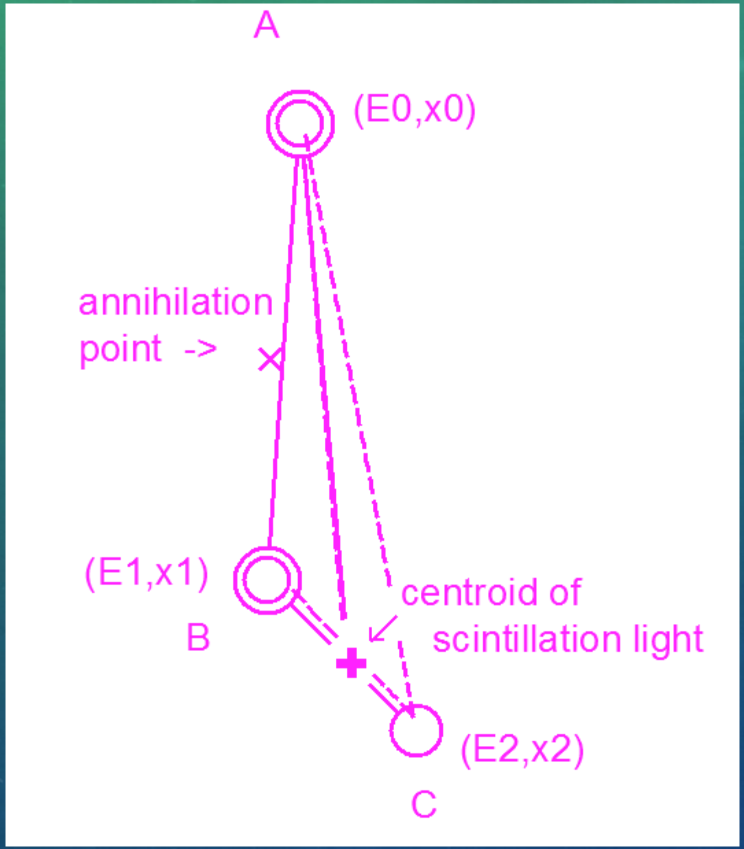


Energy deposit in the detectors

- In approximately 4% of the whole e^+-e^- annihilation events, the two gamma rays directly come into the detectors without being scattered in the patients' bodies.
- Even if the total energy deposit is high, there remains the possibility of Compton scattering in the detectors.



Analysis for Compton scattering events



- Example : when the Compton scattering occurred one time

∠ABC and ∠ACB are compared with the energy deposit E0, E1 and E2 and then it is determined which is the first scattering point, B or C.

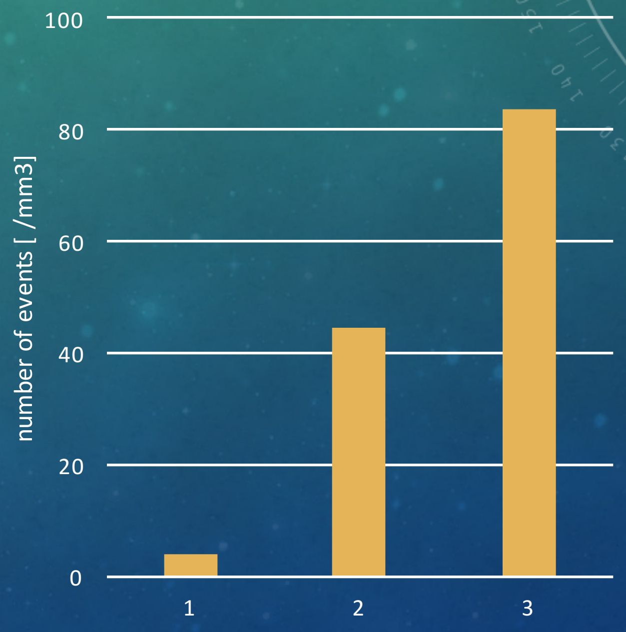
Conventionally, the centroid has been used as the data. It's off the correct position.

Analysis for Compton scattering events

- As a result of the simulation, in approximately 73% of Compton scattering events, the first scattering positions are correctly determined by calculating the energy discrepancy.

The number of events for cancer detection

- 1: Only photoelectric absorption events
- 2,3: number of events in which first scattering positions are correctly (less than 0.1 mm error) determined
- 2: by estimation of the centroid of scintillation lights
- 3: by calculating the energy discrepancy



Conclusion

- If Compton scattering events are used as data for PET analysis, the data quantity is more than ten times as many as that of photoelectric absorption events.
- If the energy discrepancy is calculated using the data of SiPM, the position accuracy improves compared with using the centroid of scintillation lights.

Thank you for listening!