Study of Particle ID in Liquid Scintillator using Imaging Detector

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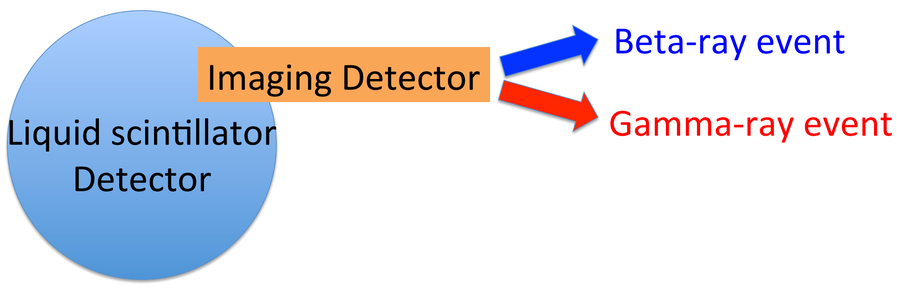
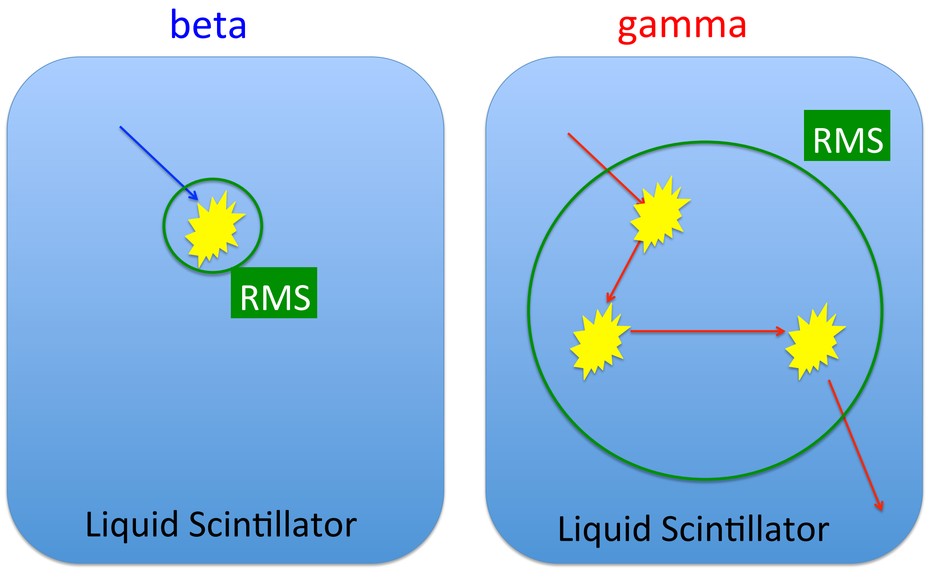
Motivation

Motivation of particle identification in liquid scintillator

- Background reduction
- Detection efficiency improvement

Particle identification with imaging detector is the new method as the improvement of detector. It makes to distinguish beta-ray and gamma-ray possible!



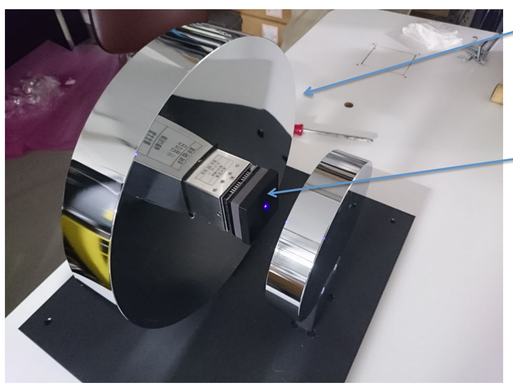


There is difference of the light emission in liquid scintillator…
β : captured soon
γ : causes compton scattering

The positions of light emitted is one of the parameter for particle identification!

Imaging Detector

Imaging detector prototype



Optic

Keigo's poster mentions status of optic.

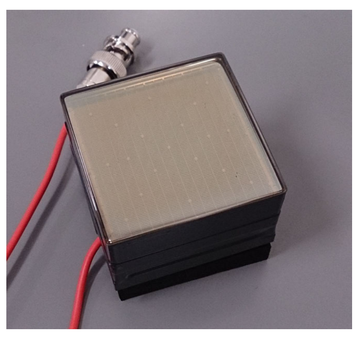
Multi Pixel Photon Detector

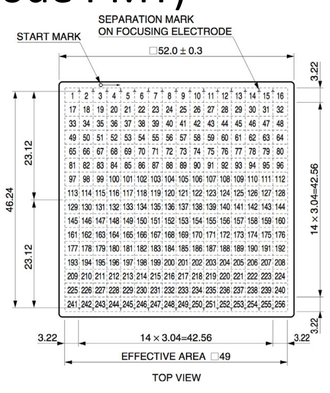
Requirement

- 1p.e. sensitivity
- Low darkrate
- Ease of expansion

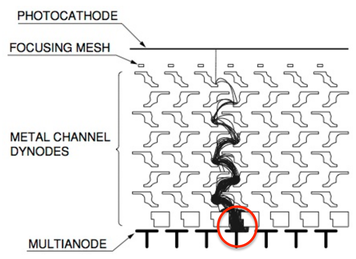
The first candidate is…

MAPMT (Multi Anode PMT)



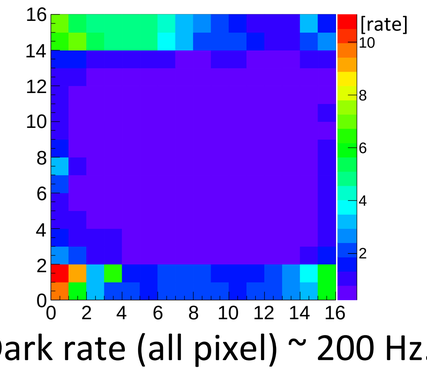


Electrode structure and electron trajectories



Multi Anode PMT informed us photon hit position as a pixel.

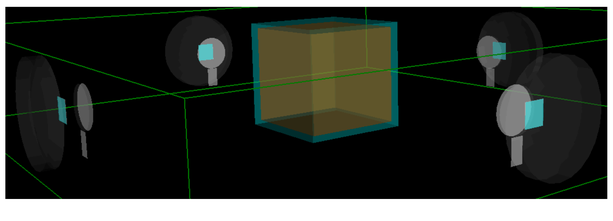
Dark rate measurement



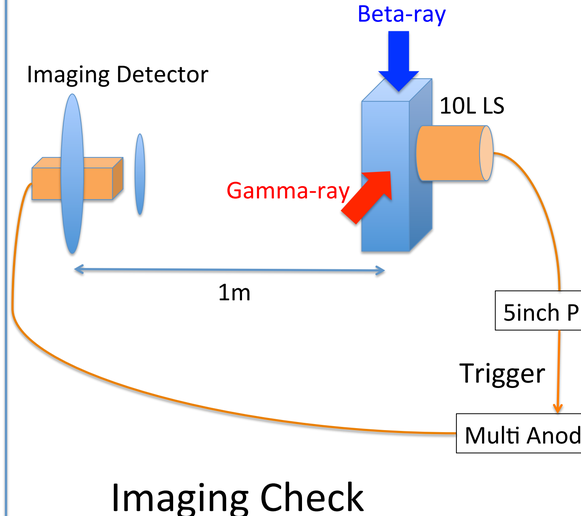
Dark rate (all pixel) ~ 200 Hz.
Accidental hit rate became 0.0002.
It is enough to use as a photon detector.

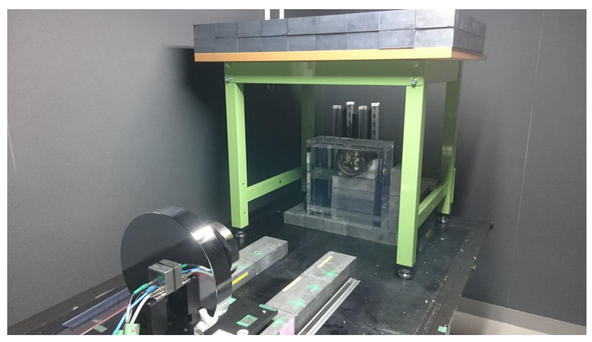
Expansion

Data Processor (VME module for multi anode PMT) can control some MAPMTs in parallel. It makes easy to develop multi imaging detector.



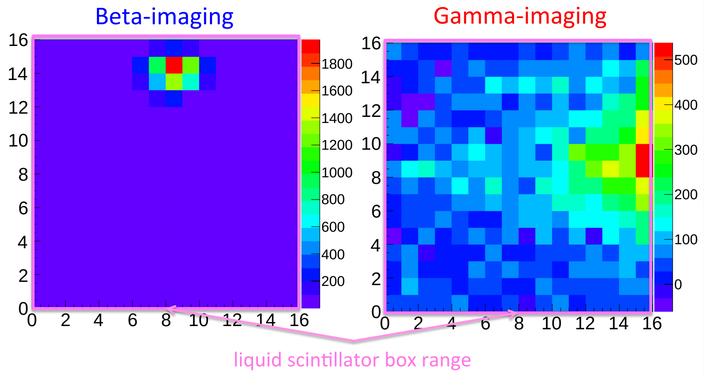
Setup for demonstration



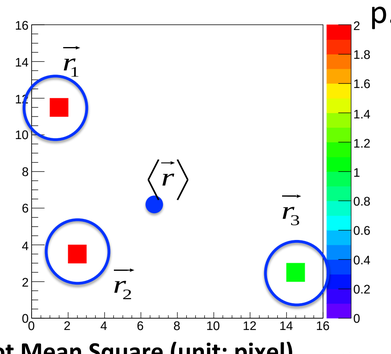


Imaging Check

Histograms show the hit count about all taken photo.
It means success of beta-ray and gamma-ray imaging statistically.
I must analyze taken photos one by one about its RMS.



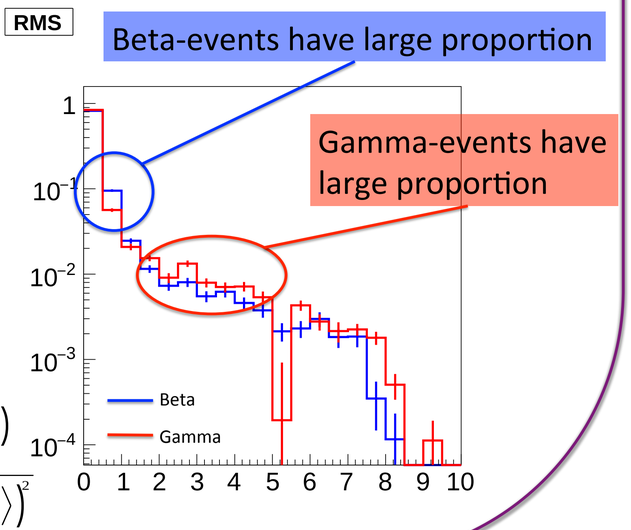
Analysis



Root Mean Square (unit: pixel)
r : hit position
n : p.e. each r
N : sum of p.e.
<r> : center of mass

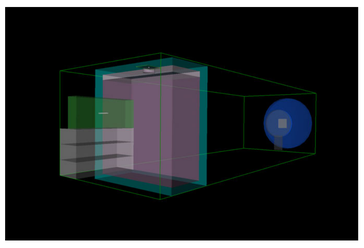
$$\langle \vec{r} \rangle = \frac{1}{N}\sum_i \left(n_i \times \vec{r}_i\right)$$

$$RMS = \sqrt{\frac{1}{N}\sum_i n_i \left(\vec{r}_i - \langle \vec{r} \rangle\right)^2}$$



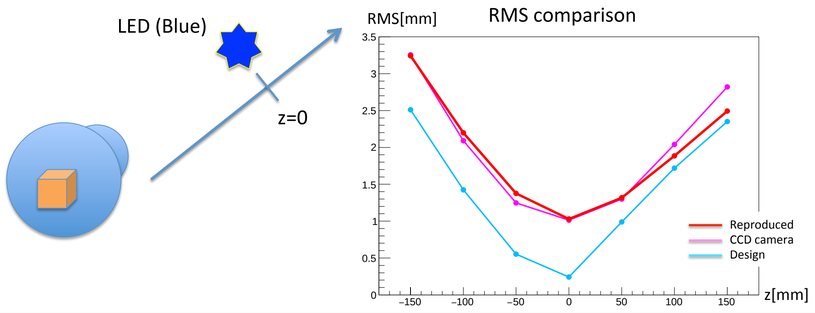
Monte Carlo Simulation

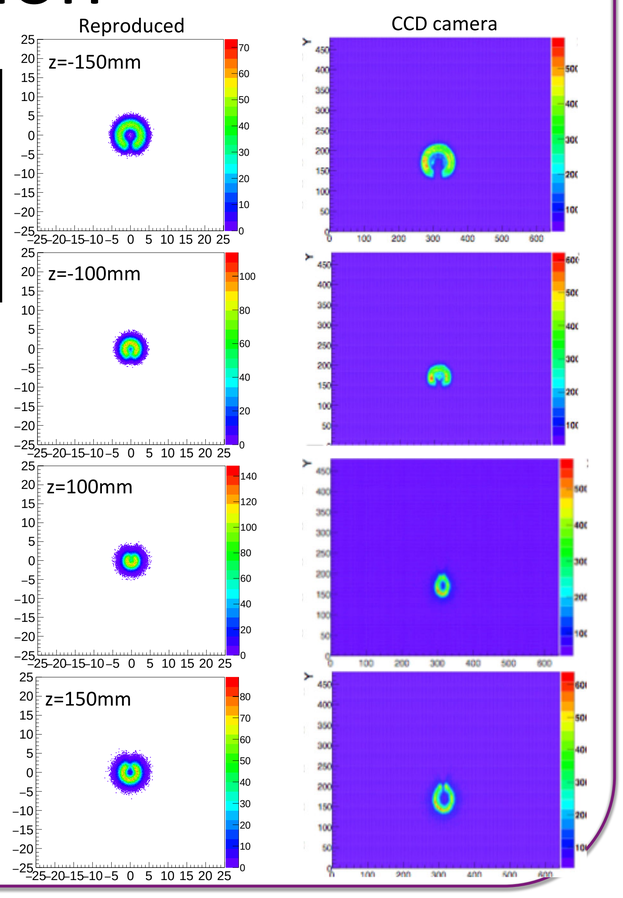
Observation shows slightly positive result. Next, I am verifying the result by Geant4 simulation (Monte Carlo simulation tool).



Reproduced Optic

It is necessary that Optic is reproduced precisely in Monte Carlo simulation. I adopted aberration from LED images taken by CCD camera.





Summary&ToDo

Summary

- Prototype of imaging detector has been made.
- Demonstration for Particle identification has been done.
- Beta-ray and Gamma-ray imaging was successful.
- The difference of RMS histogram was found.

ToDo

- Monte Carlo simulation should be finished.
- In demonstration, There are many background events. I identify background source and evaluate its effect.
- I will suggest more suitable setup for particle identification.