New Photon Detector

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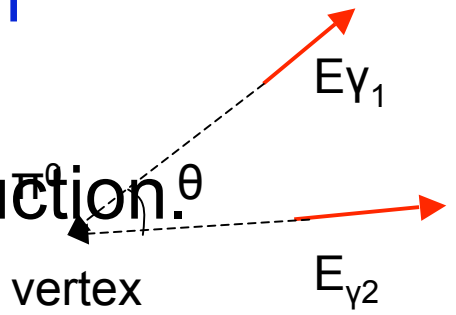
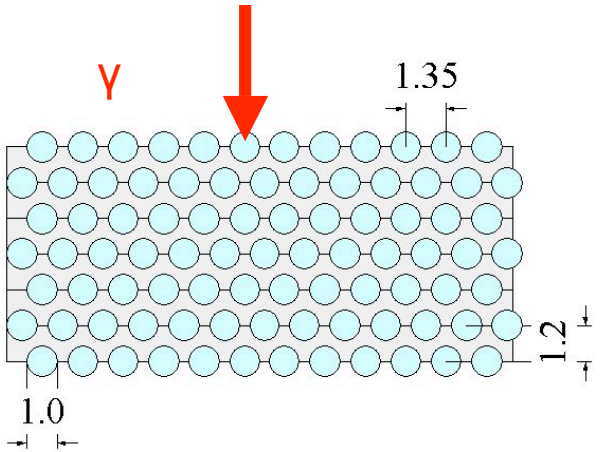
Introduction

- Standard Photon Detector - CsI crystals measures Energy and Position of photons.
- Our interest is additional Direction measurement.
- Direct Vertex and Mass reconstruction.
  $M_{\gamma\gamma}^2 = E_{\gamma 1}E_{\gamma 2}(1 - \cos\theta)$
  Strong confidence on $\pi^0 \rightarrow \gamma\gamma$
  from $K^0_L \rightarrow \pi^0\nu\nu$ decay.
- This talk will be R&D of Photon Detector.



Photon Detector

- SPA-CAL is consisted of Scintillating fibers and lead radiator



grooved lead plate 0.5mmt

Scinti fiber 1 mmΦ

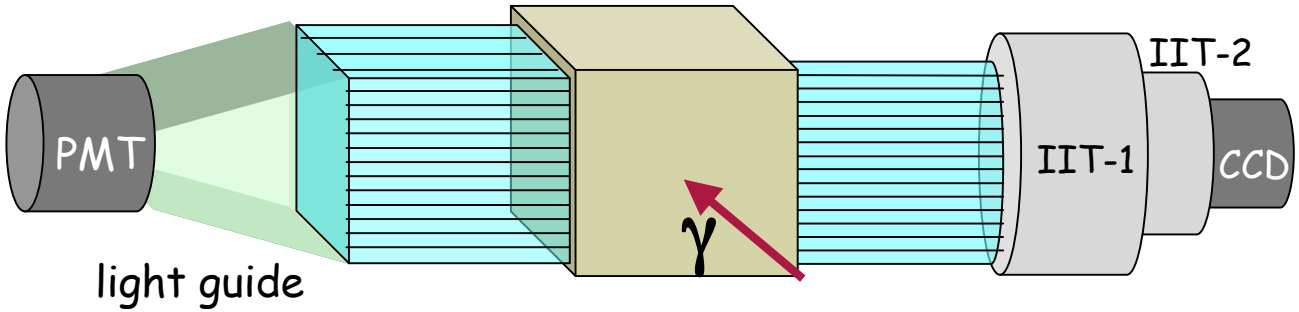
Individual fiber readout gives

Photon energy, position and direction.

Prototype Detector

10 cm x 10 cm x 9.7 cm($6X_0$)

75 cm long x 75 fibers x76 layers(5850 fibers)



IIT+CCD system

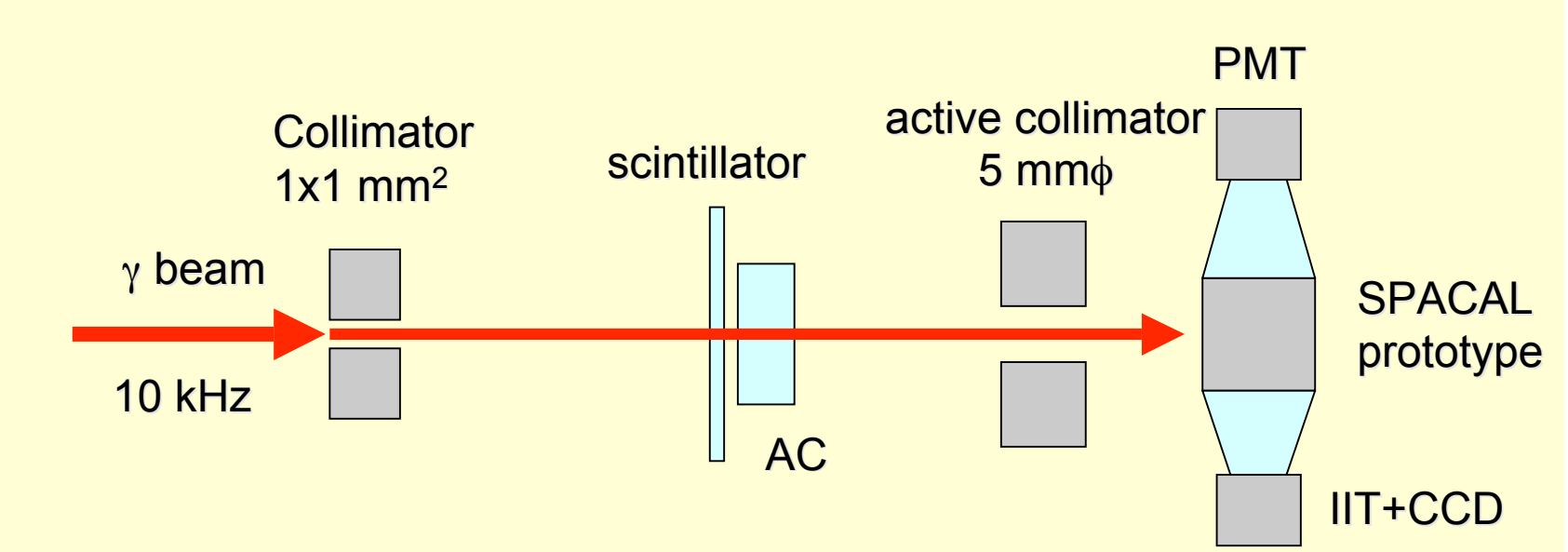
IIT gain x10^6 gate width 100 μs

CCD 768(H)x 494(V), readout 30 flames /sec

Setup of the beam test

- Photon beam @ SPring-8
  - **E_γ : 1.5 ~ 3.0 GeV** tagged photons
- Collimator (1 mm^2 hole)
  - avoiding the image overlap

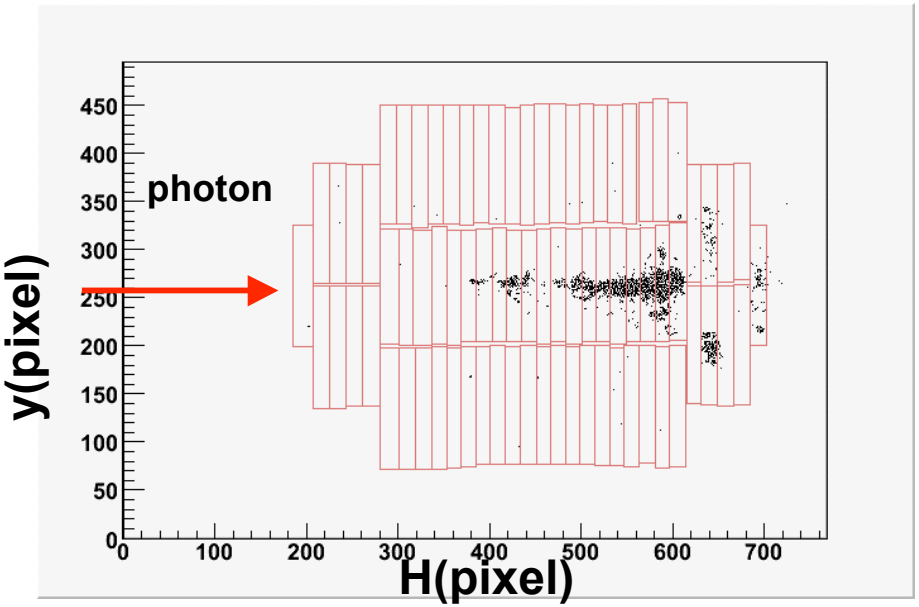
- Trigger
  - self trigger (E_γ > 300 MeV)
  - rate: 16 Hz

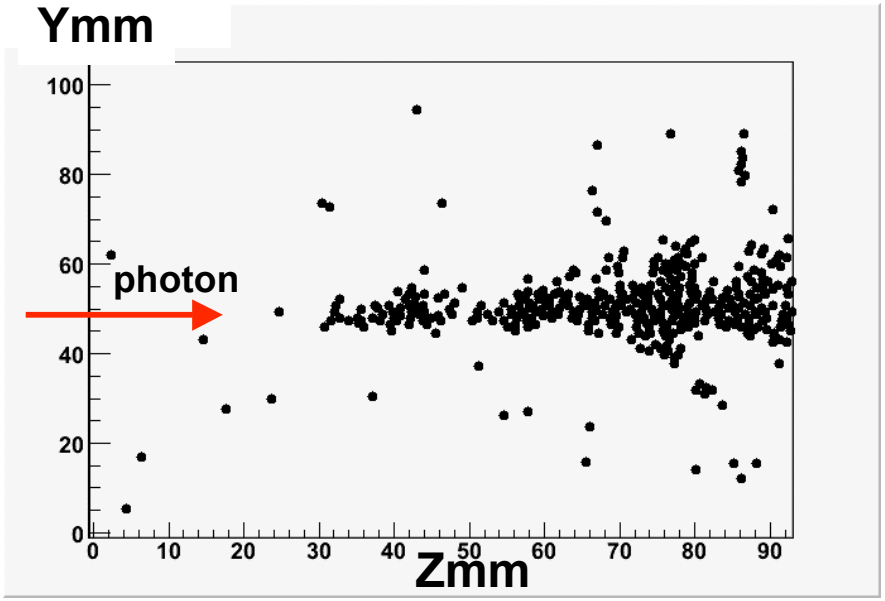


TOP VIEW

Transform from CCD coordinate to Detector coordinate

CCD picture

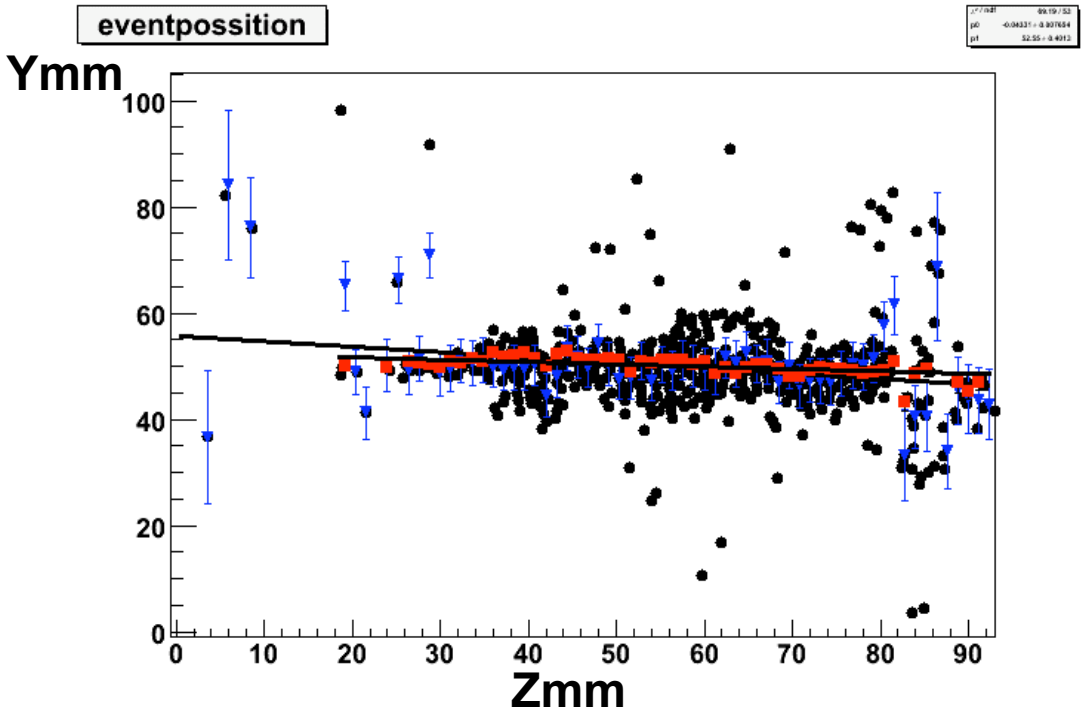




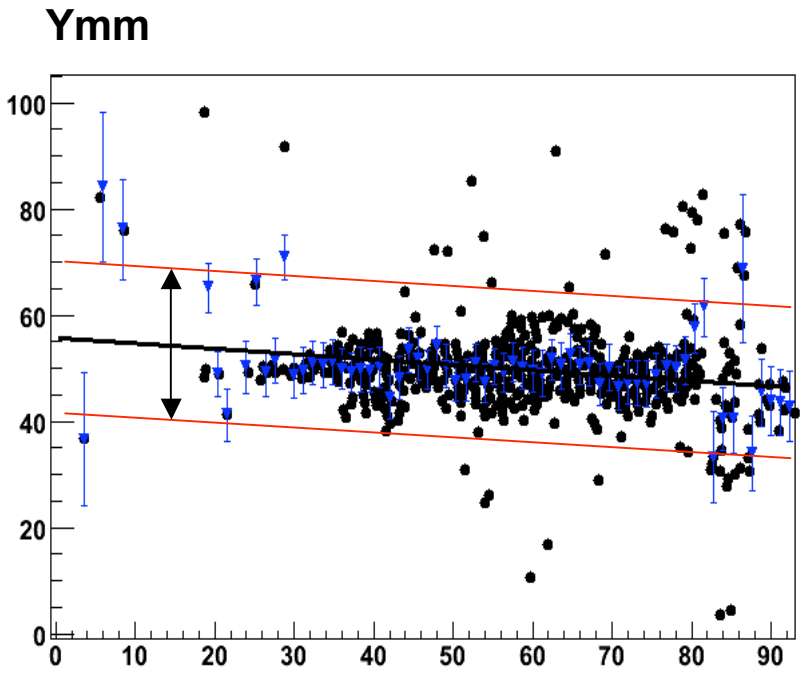
transform

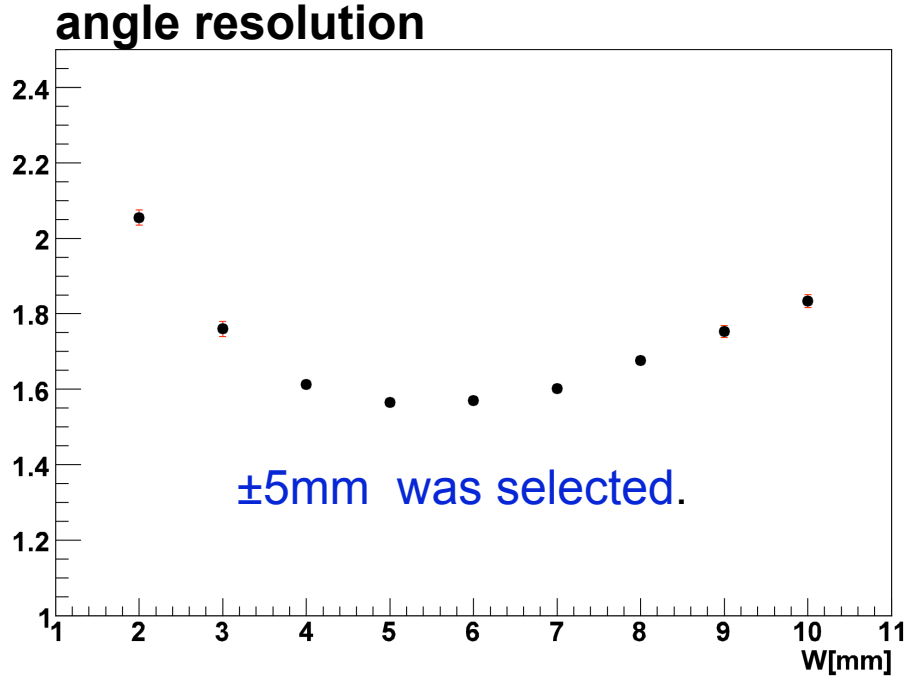
Tracking method

- Take mean of hit points at each layer.
- Linear fit of all means.
- Remove hits outside of road.
- Find vertex.
- Linear fit inside the road.



Remove noise by roading

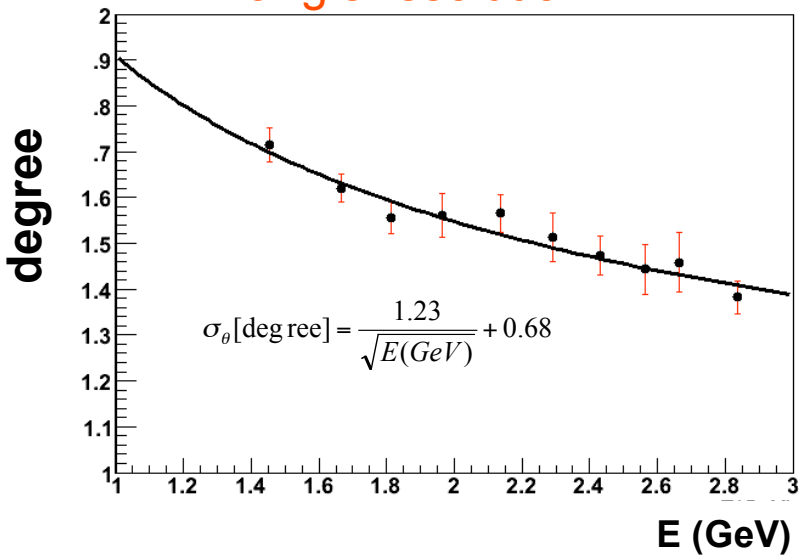




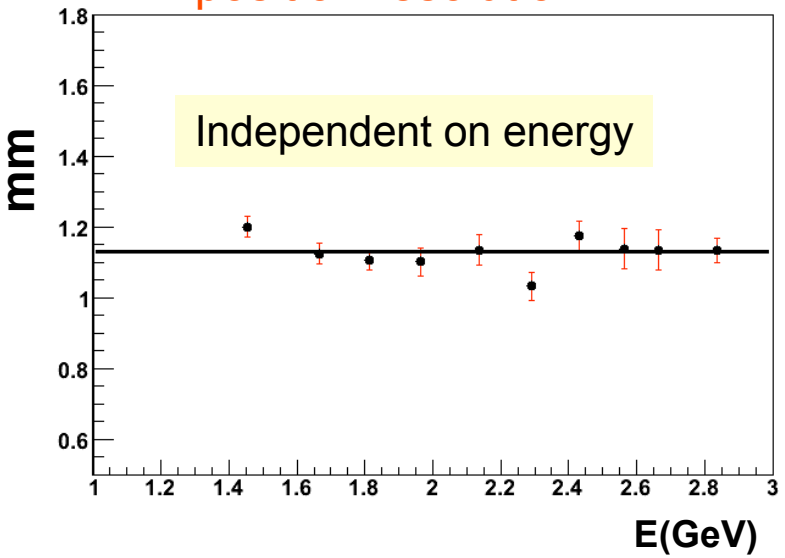
Tracking Results

Energy dependence of resolutions

angle resolution



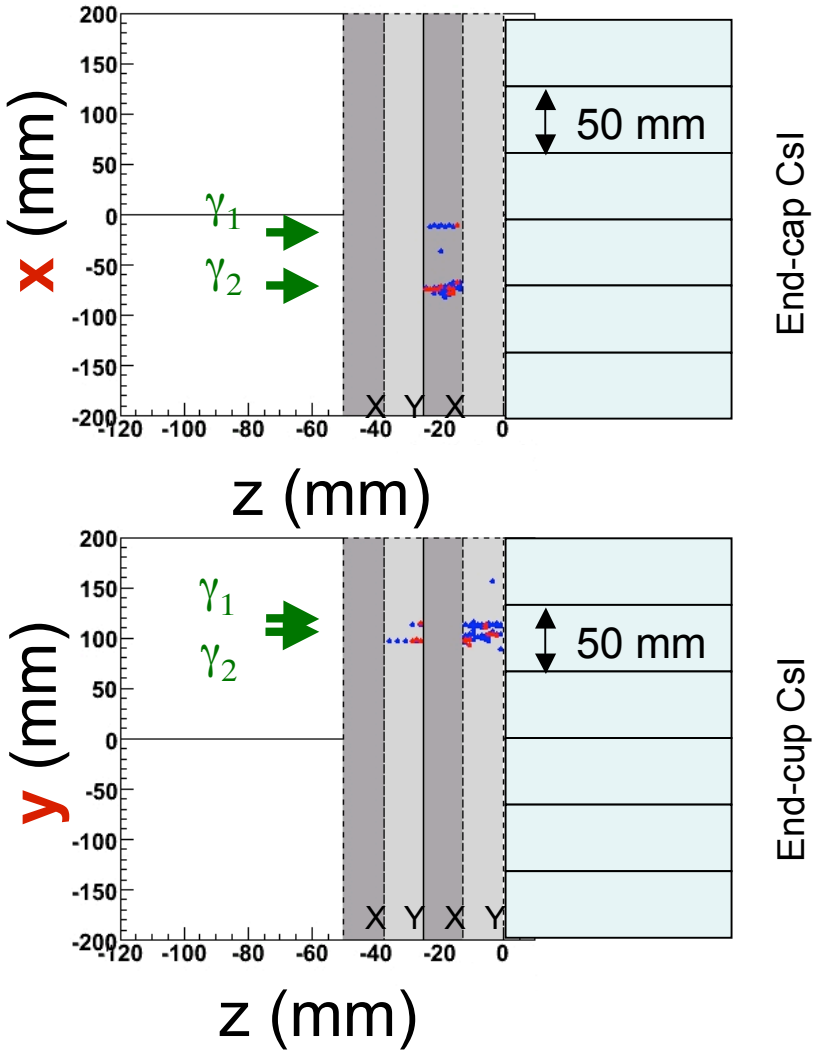
position resolution



$\sigma m\pi^0$ = 30 MeV for $P\pi^0$ = 2 GeV

Pre-shower for CsI calorimeter

Fiber-hit distribution



MC Demonstration
(simple XYXY configuration)

2 photons
$E\gamma_1 = E\gamma_2 = 0.3$ GeV
$R_{12} = 65$ mm

Conversion efficiency
~ 90 % with 3.2 X_0
=5 cm thickness **Compact**

Energy resolution
$\sigma_E/E = 2$ % for E_γ=1 GeV
(1.5 % for CsI only)

Photon separation efficiency
~100 % for >20 mm distance
E_γ >0.1 GeV

Summary

- Prototype SPA-CAL was built.
- The detector was read with IIT+CCD(slow)
  and tested at Spring 8.
- Test beam result

$$\sigma_\theta(\mathrm{degree}) = 1.23/\sqrt{E(GeV)} + 0.68$$

$$\sigma_x(mm) = 1.2$$

⟶ σmπ^0 = 30 MeV for Pπ^0 = 2 GeV

reduce odd pair background.

- Simulation result on
  Pre-shower(3.2X_0) for CsI calorimeter

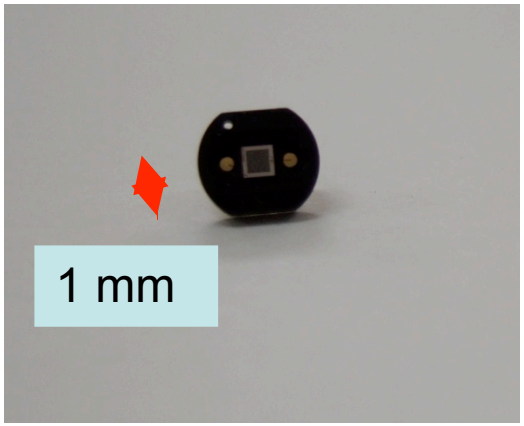
  σ_E/E = 2% at 1 GeV

  two photons can be separated
  if distance > 20 mm and Eγ> 0.1 GeV.

reduce fusion background.

Silicon Photomultiplier for photo senser(fast)

- MPPC(Multi-Pixel Photon Counter)
  Geiger mode Avalanche Photo Diode
  gain ～$1x10^6$
  QE ～30% (max at 400 nm)
  active area 1 mm x 1mm (400 pixels)
  pulse width ～10 ns
  Can be use as fast device
  for fiber readout .



MPPC(Hamamatsu)