MEG実験用LXe scintillation detectorの レーザー逆コンプトンガンマ線を用いた性能評価

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Outline

1. MEG experiment
2. LCS beam test
3. Performance evaluation
4. Summary

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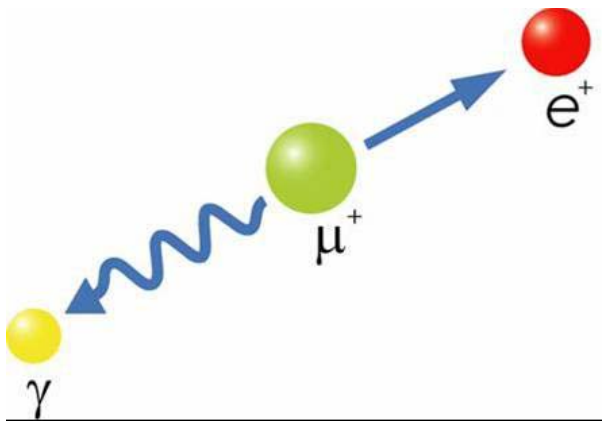
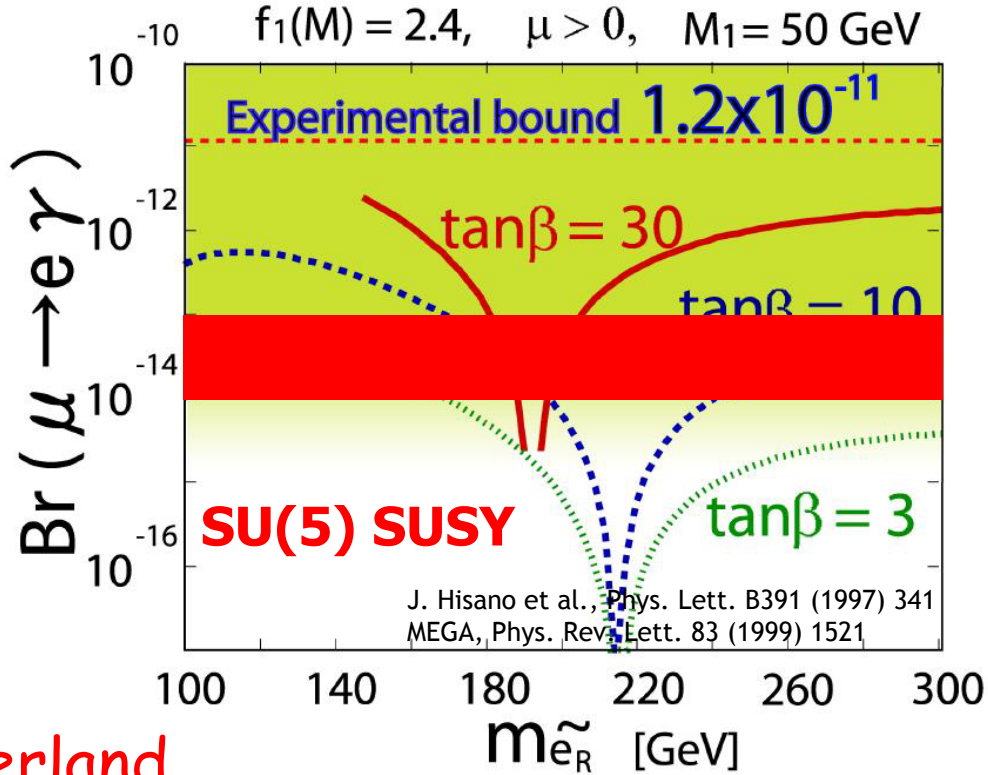
Physics Motivation



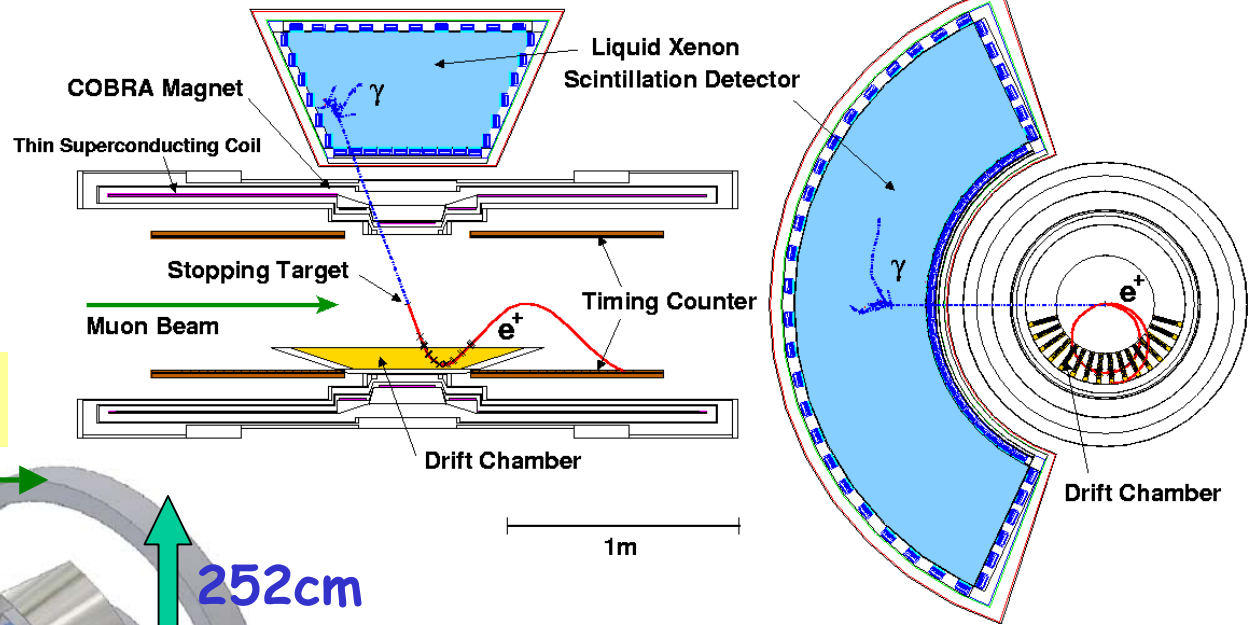
- Clear 2-body kinematics
  - $E_e = E_\gamma = 52.8$ MeV
  - Back to back event
  - Time coincidence

- **LFV process**
- **Forbidden in the SM**
- **Sensitive to the new physics**
  SUSY-GUT,
  SUSY-seesaw, etc.
- **Our goal : Br(μ→eγ)>10^{-14} ~ 10^{-13}**
  Present limit < 1.2x10^{-11}
  (MEGA, 1999)



start in 2006 at PSI, Switzerland

MEG Detector



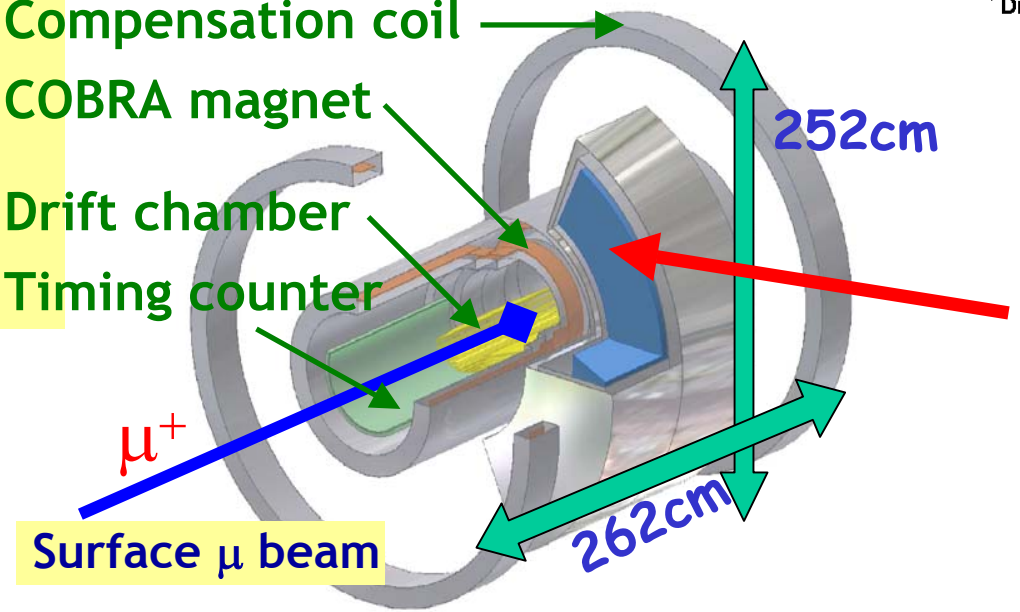
Positron spectrometer

Compensation coil

COBRA magnet

Drift chamber

Timing counter



LXe scintillation detector

is a key detector
in MEG experiment

LXe scintillation detector for the MEG experiment

Liquid Xenon scintillator

- Typically converts gamma-ray to electron at the depth of 2cm to 10cm
- High light yield (75% of NaI)
- Fast decay(45nsec)
- Directly catch scintillation photons
- 828 PMTs、Xenon 800ℓ

Cryostat

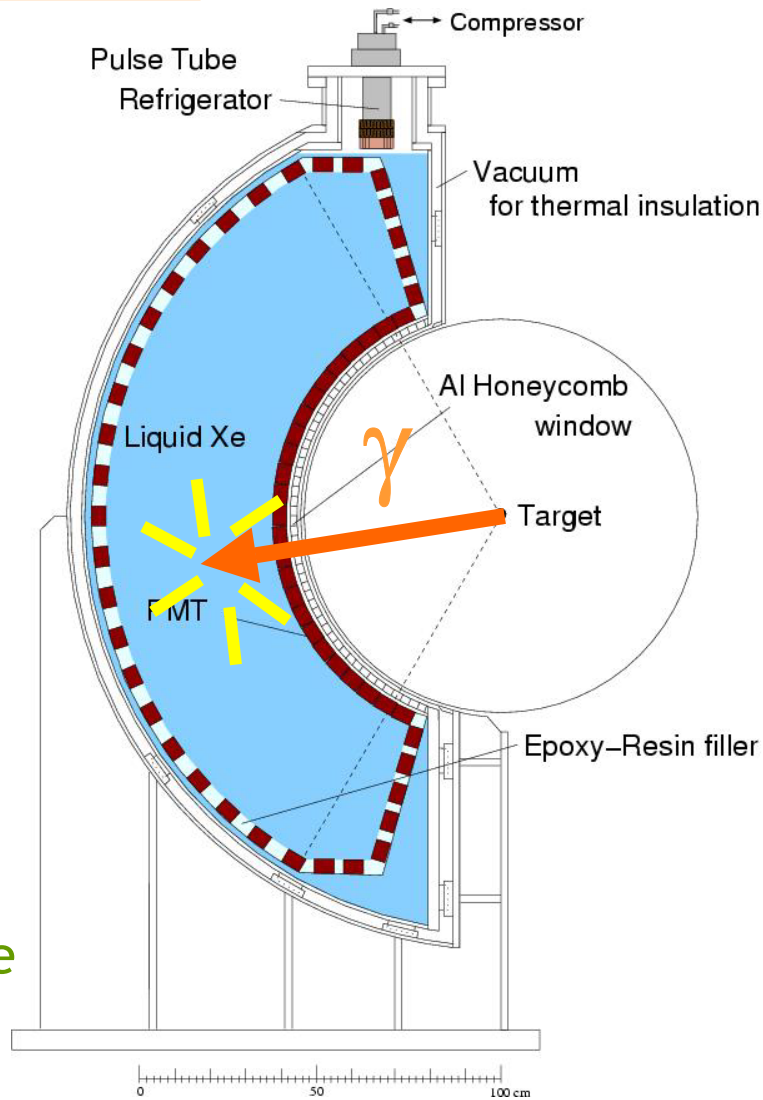
- LXe temp. = 165K (~1atm)
- Pulse tube refrigerator
- Double layer vessel

PMT

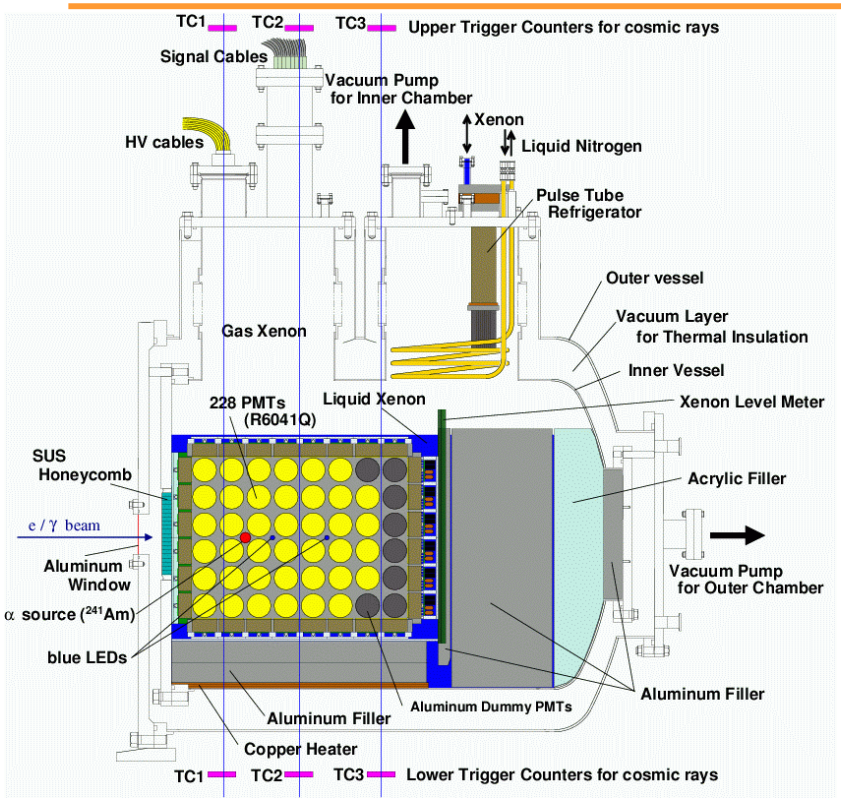
- stable at 165K
- Thickness of 4cm

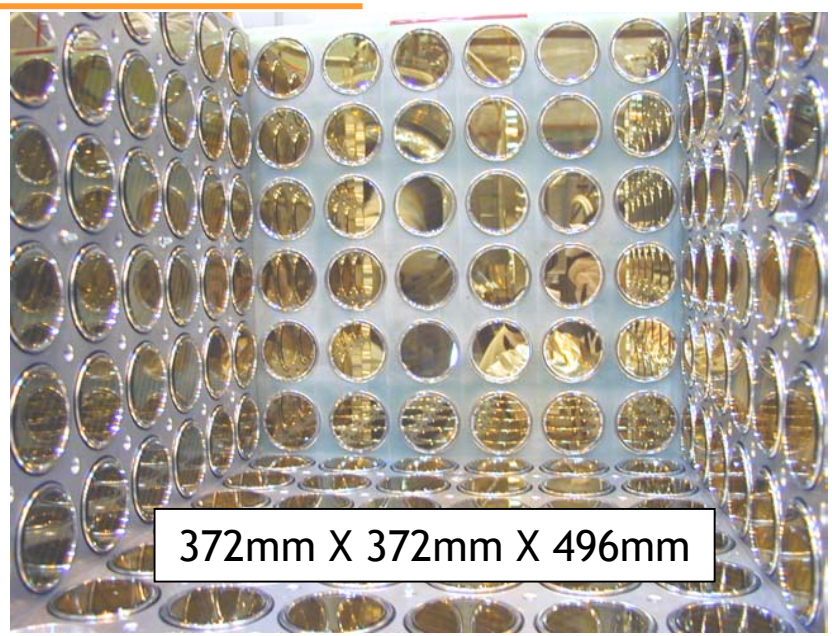
Detector requirement

- Energy: ~2 % (σ)
- Position: 1~2 mm (σ) on incident face



100-liter prototype



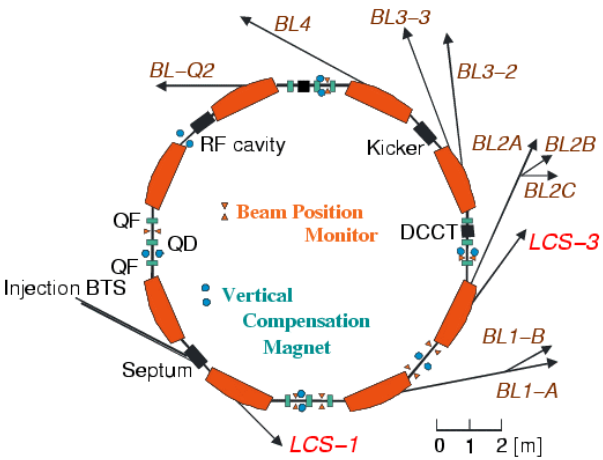


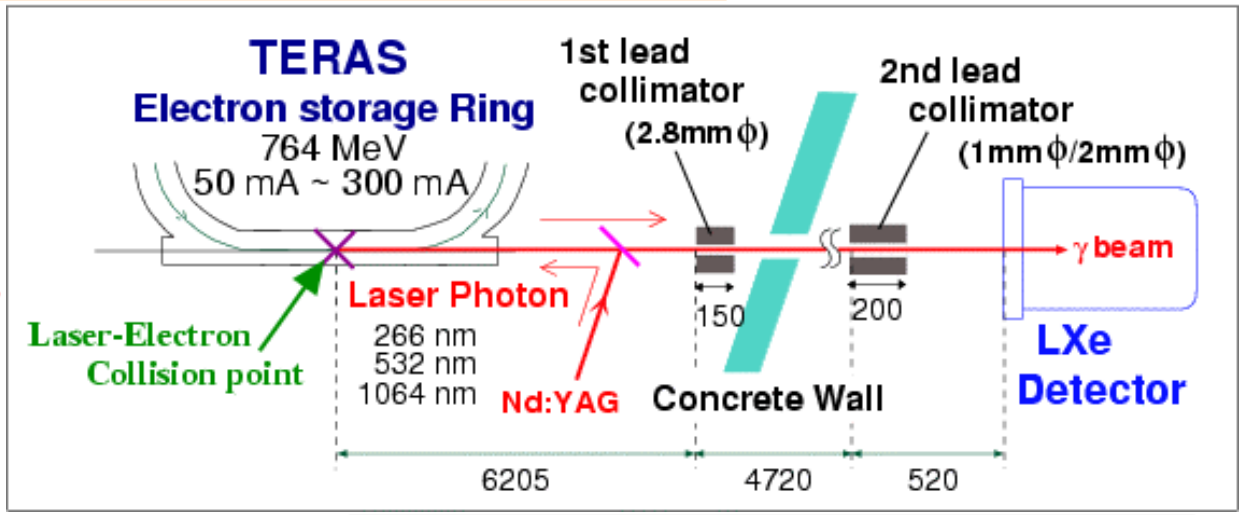
- 68.6-liter active volume
- 228 PMTs

Purpose

- For 10~40 MeV gamma rays
  - Energy resolution
  - Position resolution
- Evaluate performance for 52.8MeV gamma rays

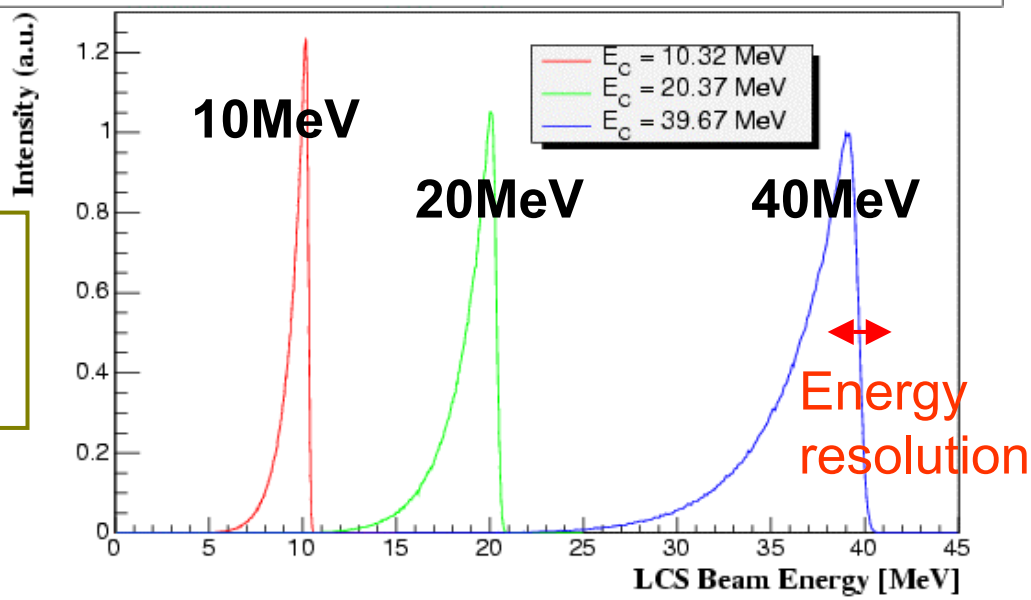
Beam Test @ AIST(former ETL)



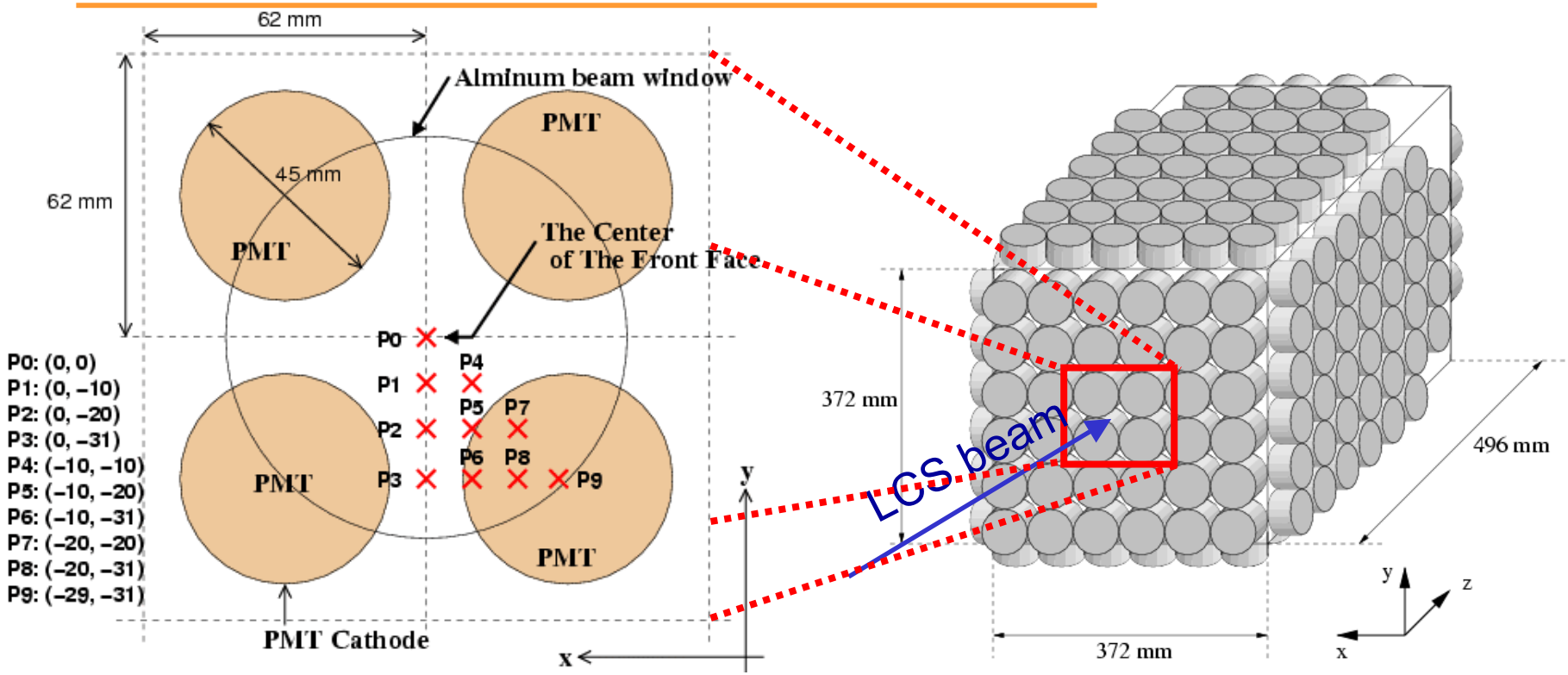


Incident γ-rays

- 10,20,40-MeV Compton edge
- 1 mm-ϕ collimation

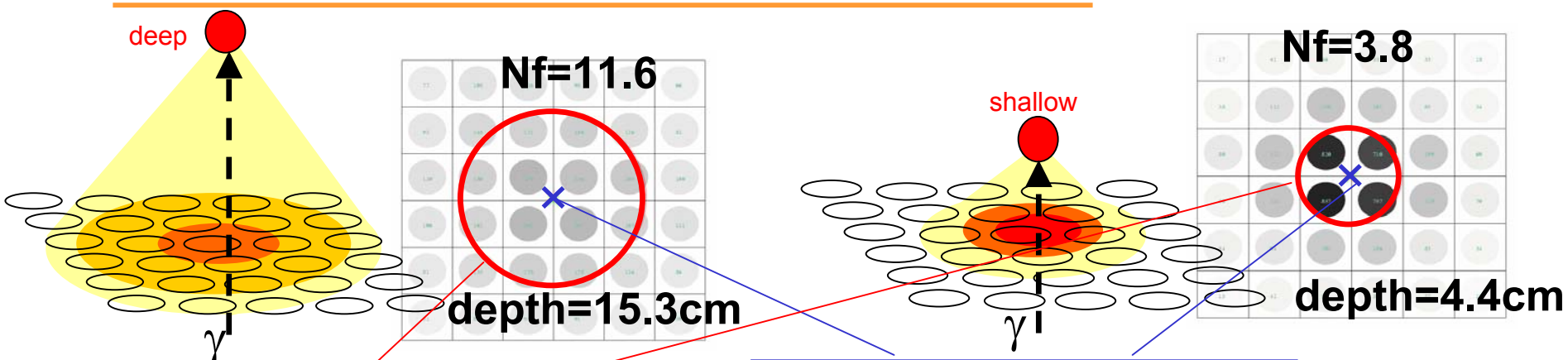


Incident position



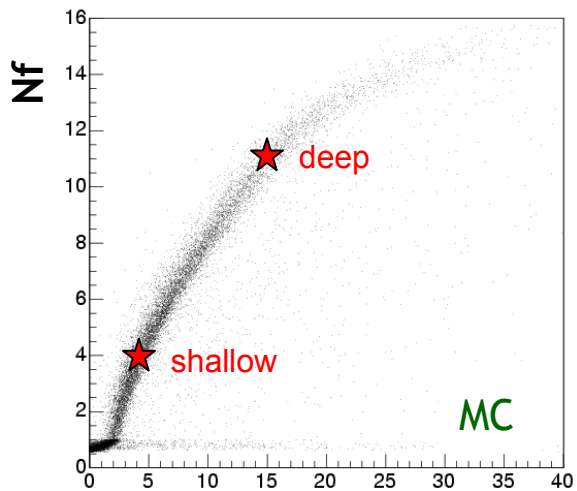
γ-ray Energy at Compton edge	Impinging position
10 MeV	P0 and P9
20 MeV	P0 and P9
40 MeV	P0 ∼ P9

Vertex Reconstruction



Reconstructed (x,y)

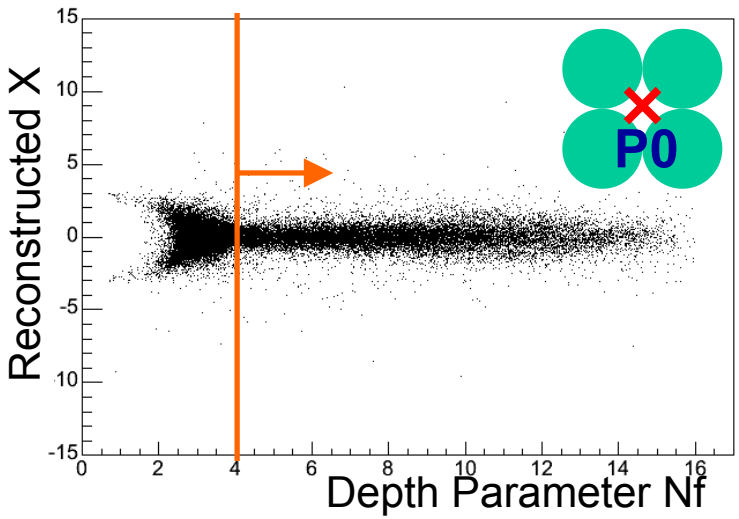
(Sum of front outputs) / 2

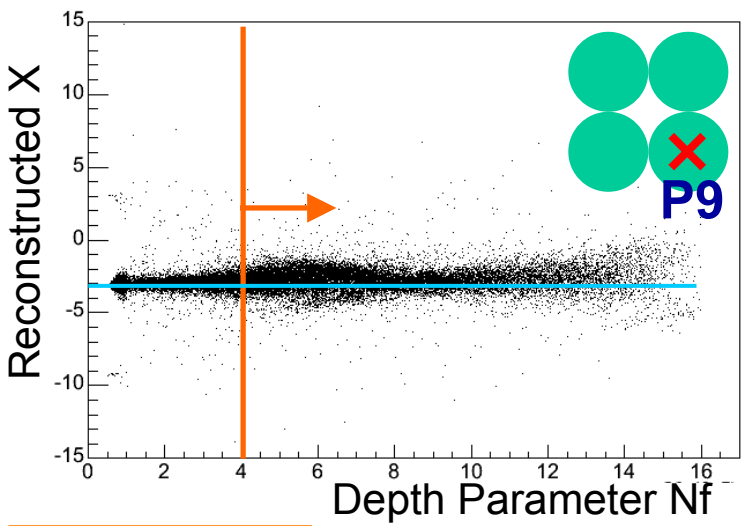


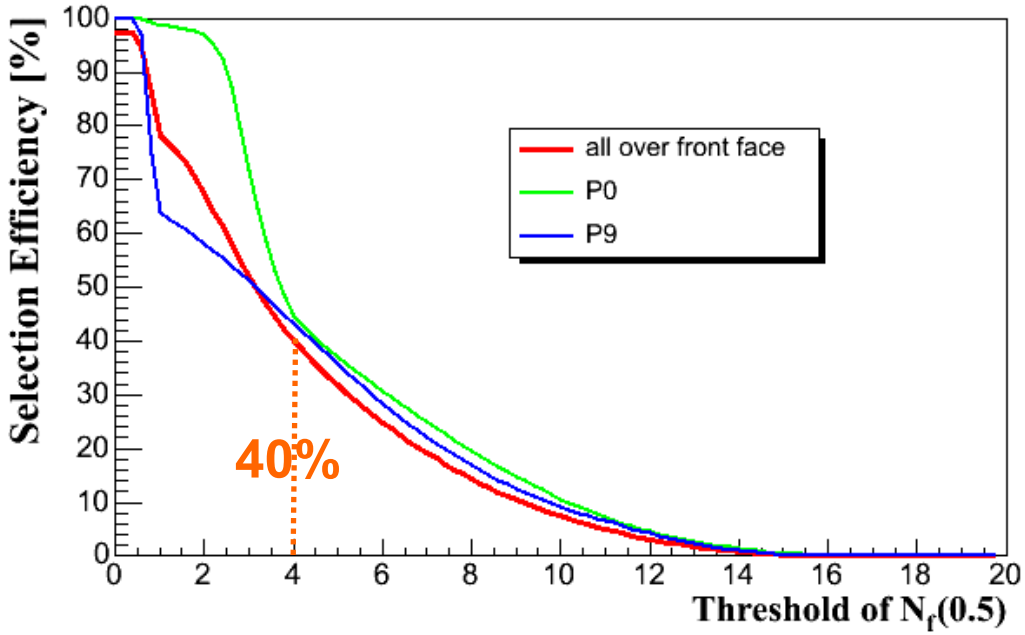
Depth ~ spread of distribution

Depth parameter
Nf: # of PMTs in red circle

Position Resolution







for events s.t. Nf > 4

fitting with 2-D double Gaussian

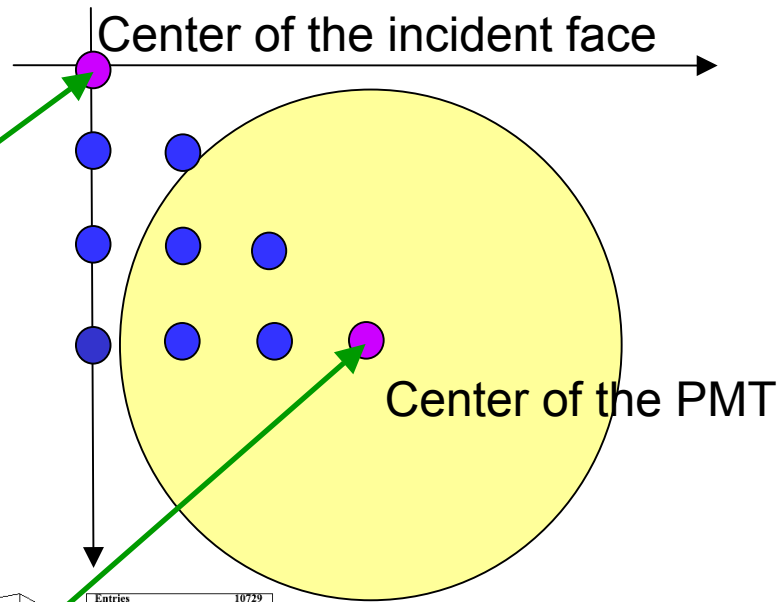
F(x,y) = a(narrow Gaussian)
+ (1-a)(broad Gaussian),

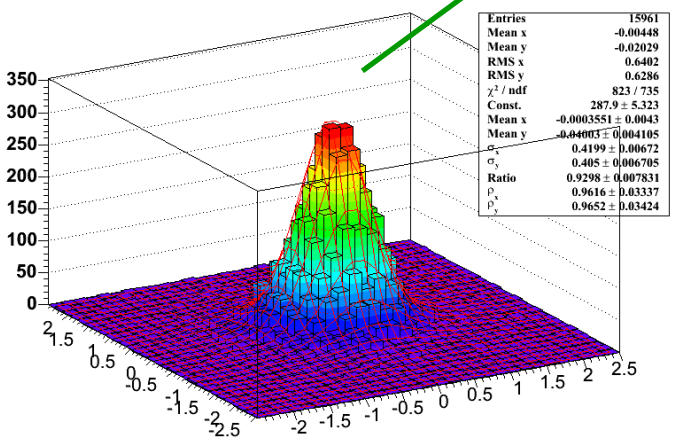
a: ratio

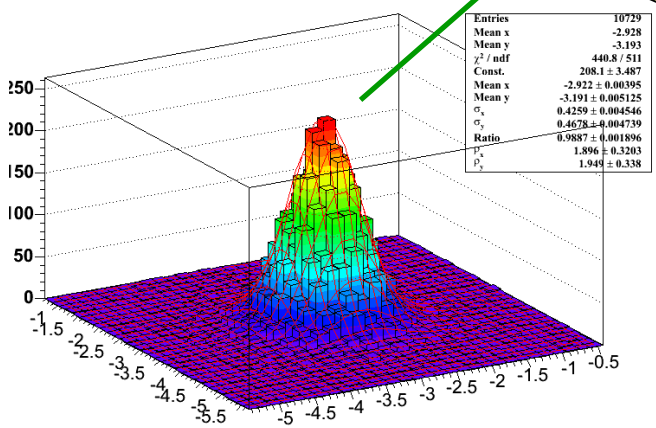
Position Resolution (P0-P9)

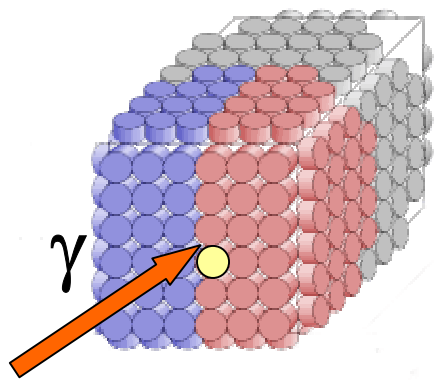
4.2 mm 4.1 mm			
3.8 mm 4.1 mm	4.0 mm 4.0 mm		
3.7 mm 4.1 mm	3.9 mm 4.1 mm	4.2 mm 4.3 mm	
3.8 mm 4.6 mm	4.1 mm 4.7 mm	4.3 mm 4.8 mm	4.3 mm 4.7 mm

σ x
σ y

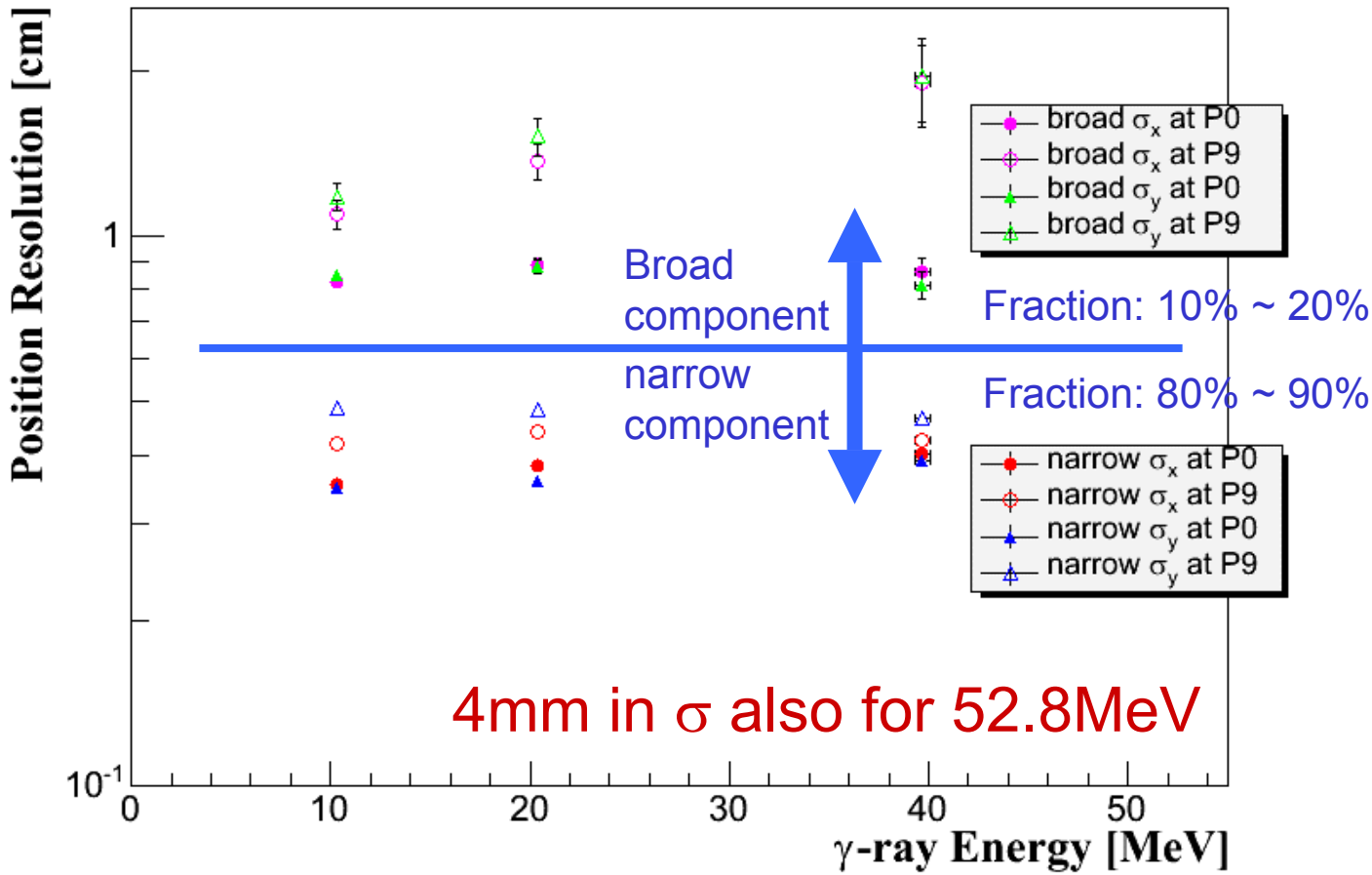








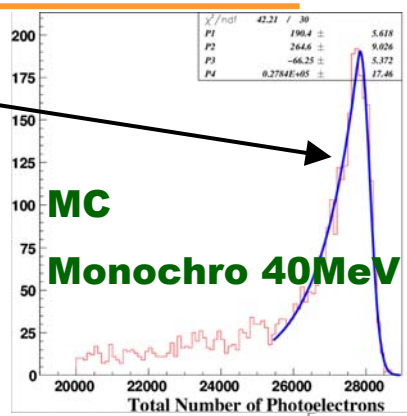
Position Resolution (10-40MeV)

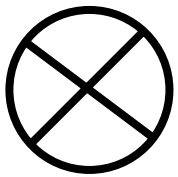


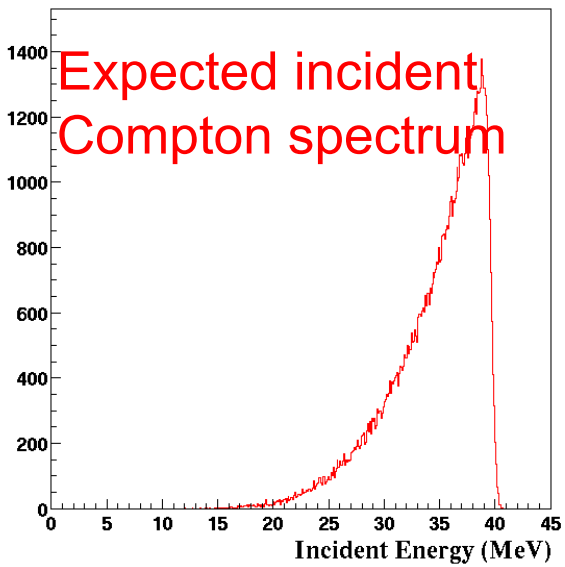
Energy Resolution

Response function

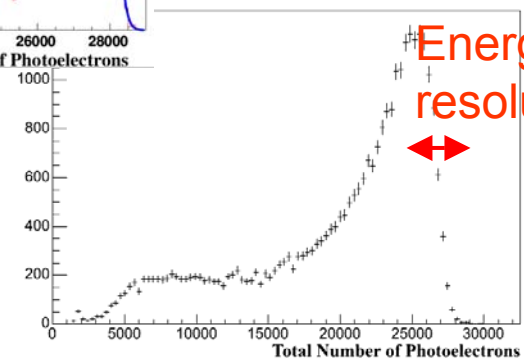
$$h(E) = \begin{cases} \exp\left(\frac{t}{\sigma^2}\left\{\frac{t}{2} - (E-\mu)\right\}\right), & E \le \mu + t, \\ \exp\left\{\frac{(E-\mu)^2}{-2\sigma^2}\right\}, & E > \mu + t \end{cases}$$



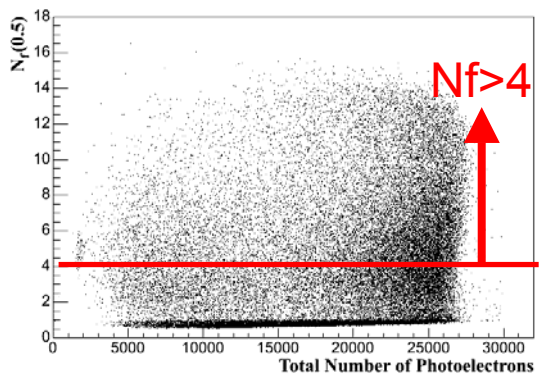




The spectra were fitted with a **convolution** of the response function and incident LCS spectrum.

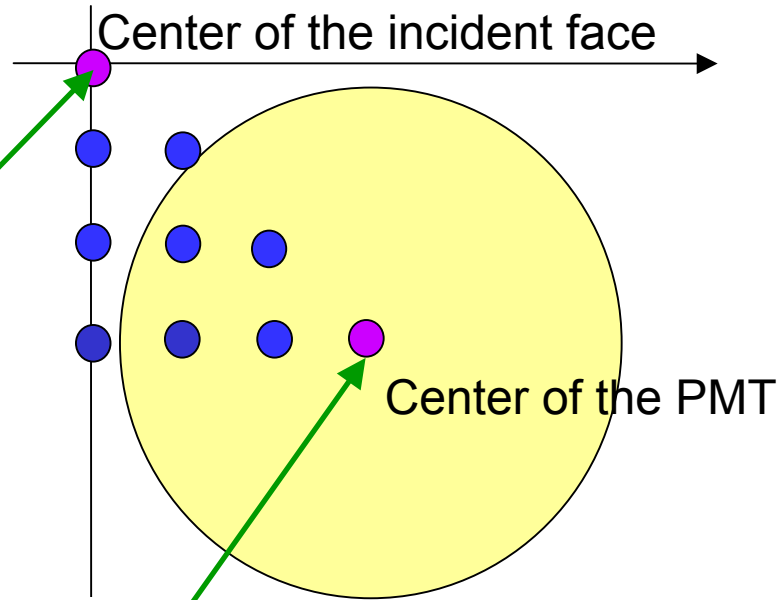


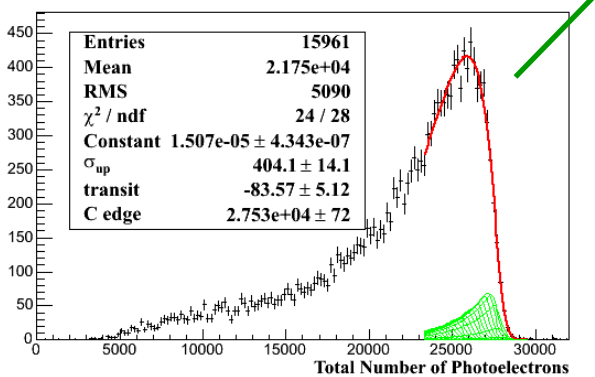
The spectrum has lower tail. In this analysis,the resolution was evaluated by **right part of sigma**.

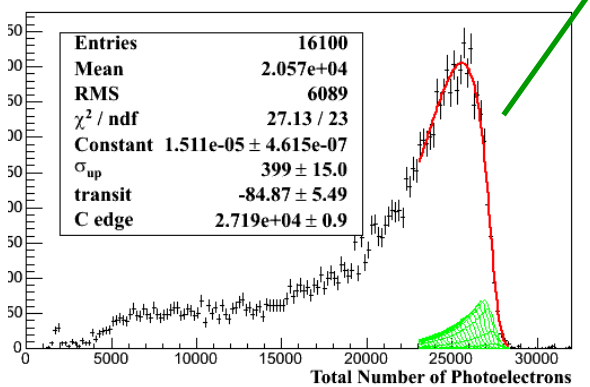


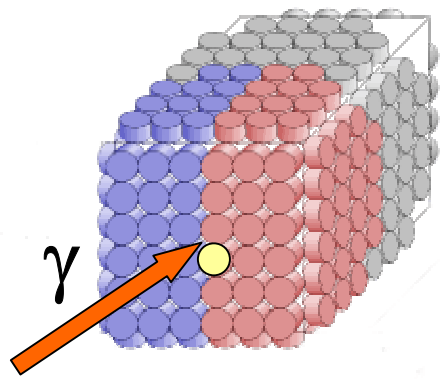
Energy Resolution (P0-P9)

1.5 %				
1.5 %	1.5 %			
1.5 %	1.5 %	1.5 %		
1.4 %	1.4 %	1.5 %	1.5 %	

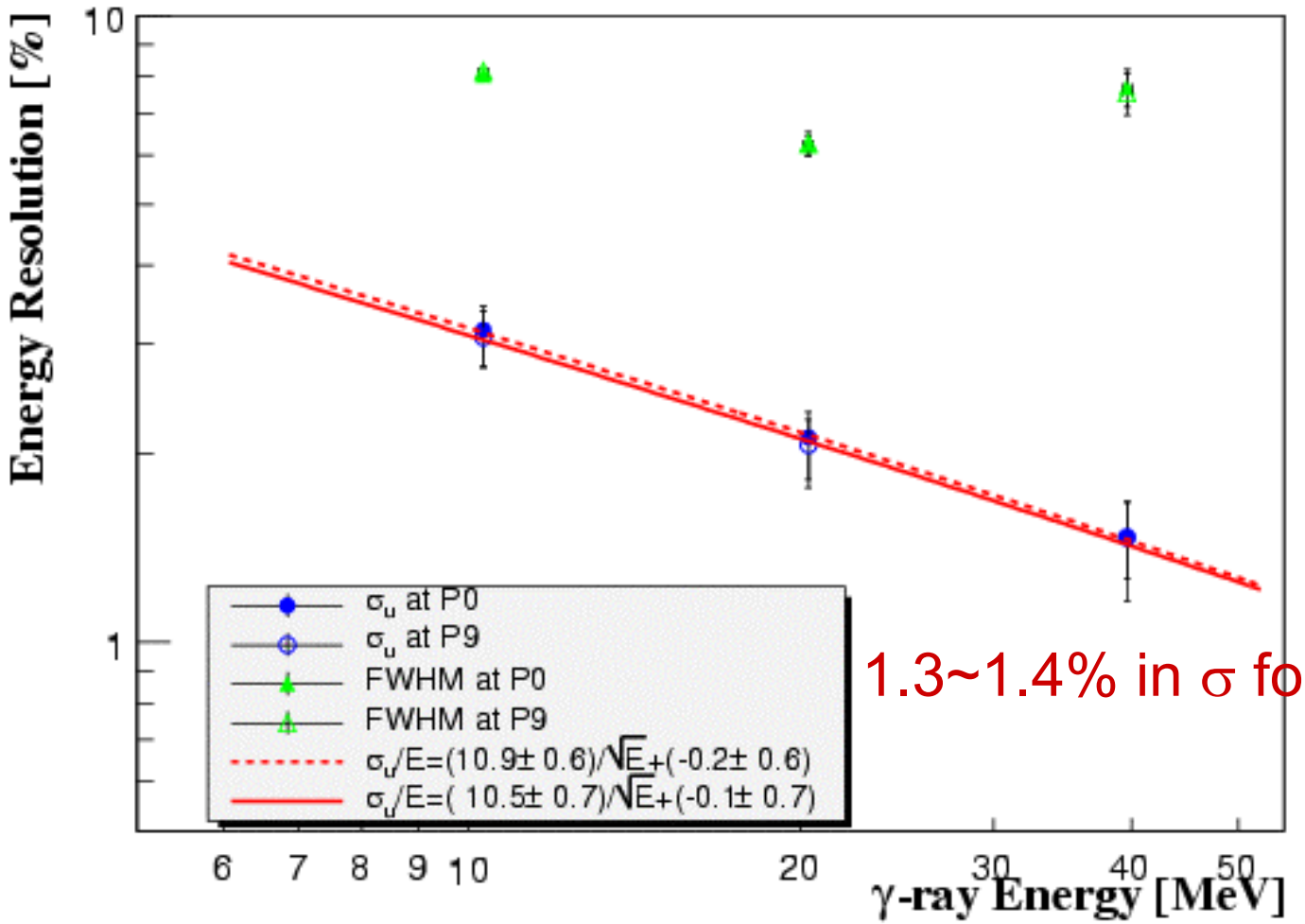








Energy Resolution (10-40MeV)



1.3~1.4% in σ for 52.8MeV

Summary

We evaluated the performance of the prototype LXe detector with laser Compton scattering gamma-rays at AIST.

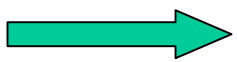
Position resolution(σ)

- Position dependence: ~4 mm (40MeV)
- Energy dependence: ~4mm (10MeV~40MeV)

Energy resolution(σ)

- Position dependence: 1.4~1.5 % (40MeV)
- Energy dependence: 3.2%→1.5% (10MeV→40MeV)

How is energy resolution for monochromatic gamma-rays?



next talk by R.Sawada

End of slides