Performance of New Sampling Calorimeter in the KOTO Experiment

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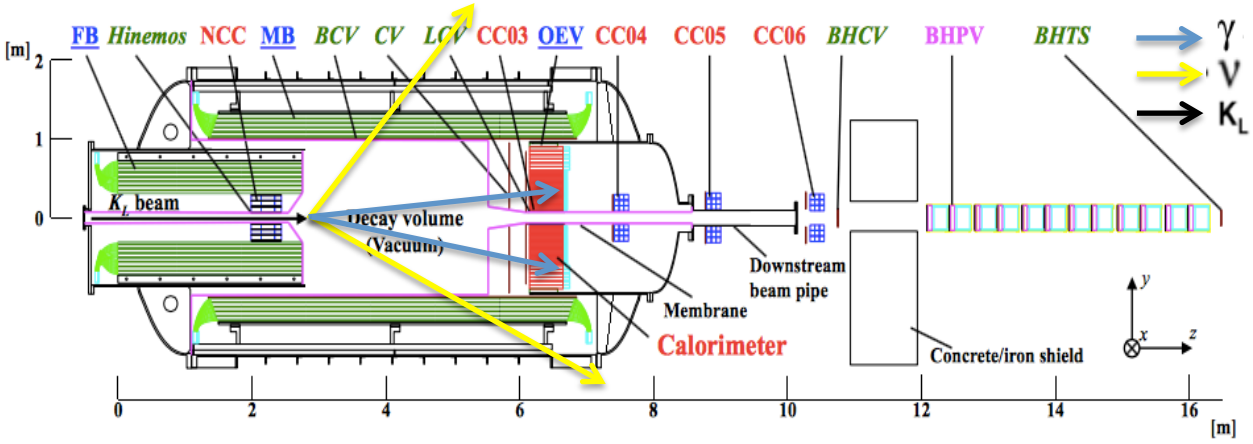
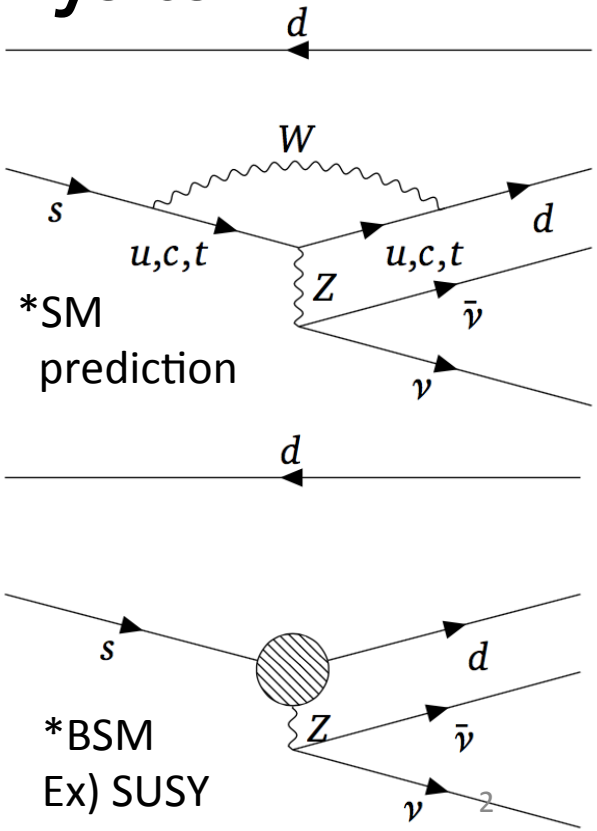
for the KOTO Collaboration 2017 KPS Fall Meeting

J-PARC KOTO Experiment

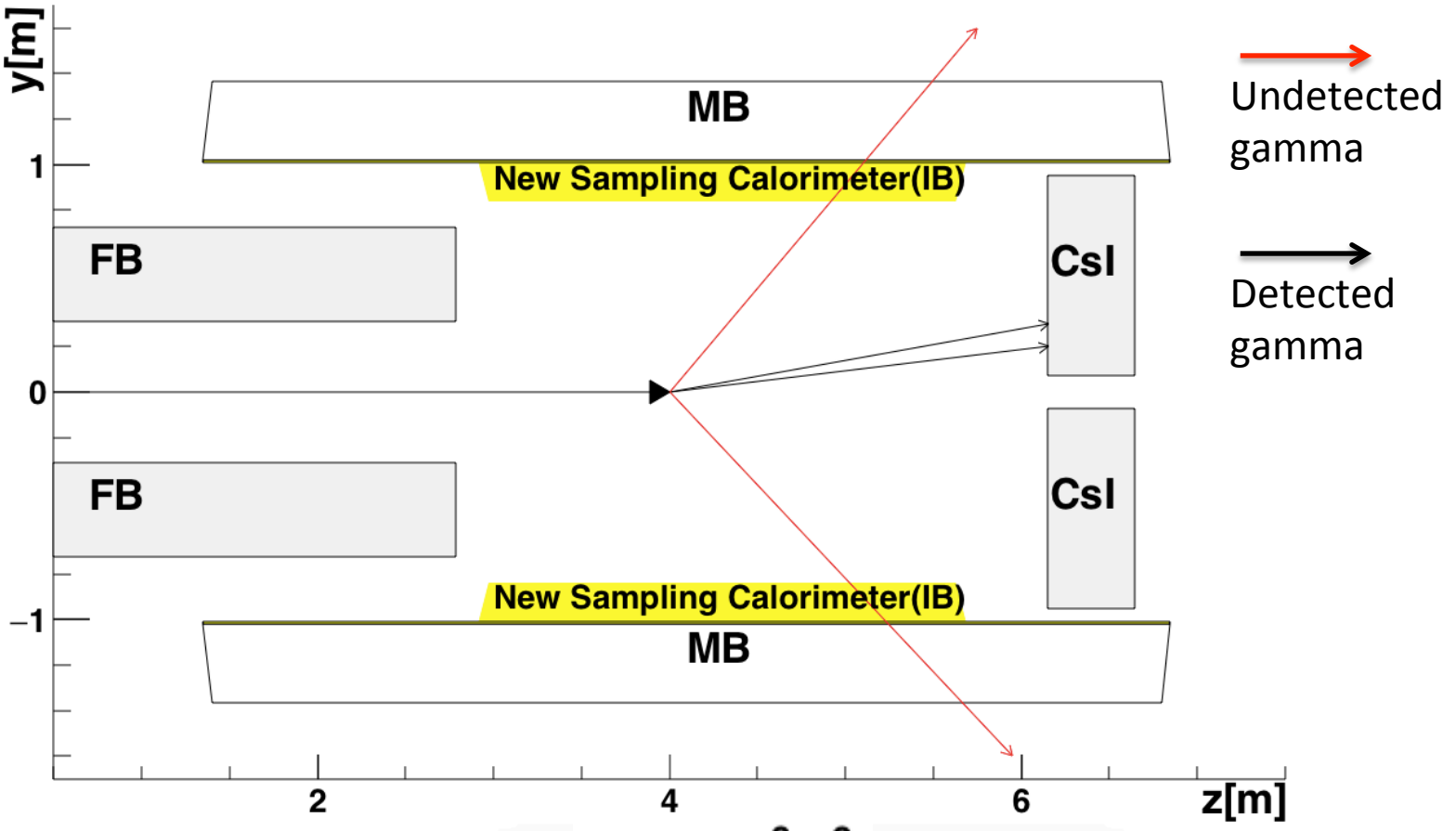
- $Br(K_L \to \pi^0 \nu\bar{\nu}) = (2.8 \pm 0.4) \times 10^{-11}$ predicted by SM
- FCNC process in Standard model (Suppressed)
- Clean mode to explore the New Physics



CsI Calorimeter and Hermetic Veto Counters

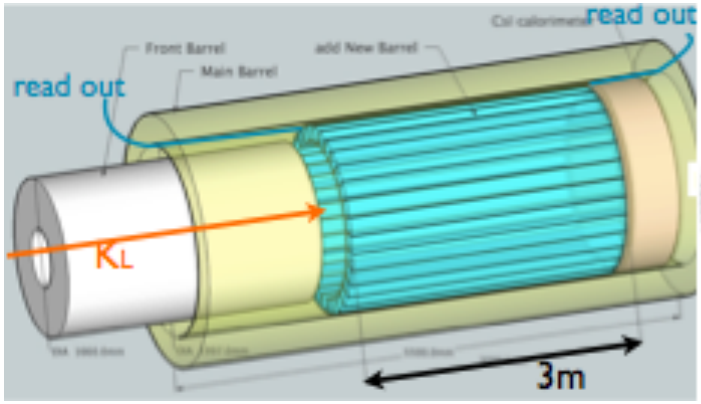


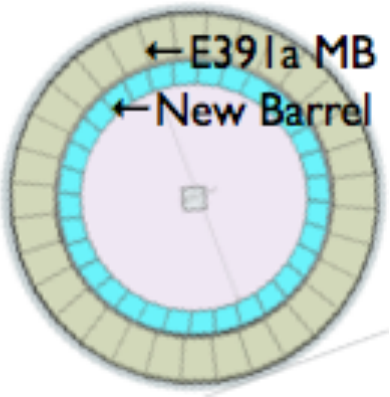
New Pb/Scint Calorimeter

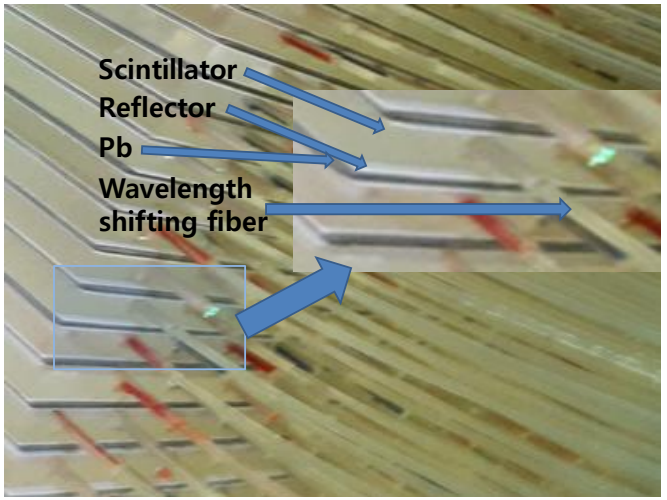


- Due to inefficiency of MB, $K_L \rightarrow \pi^0 \pi^0$ events come into Background
- Better suppression of background events
  - 2.96 +/- 0.2(MB) -> 0.46 +/- 0.02(MB+IB)

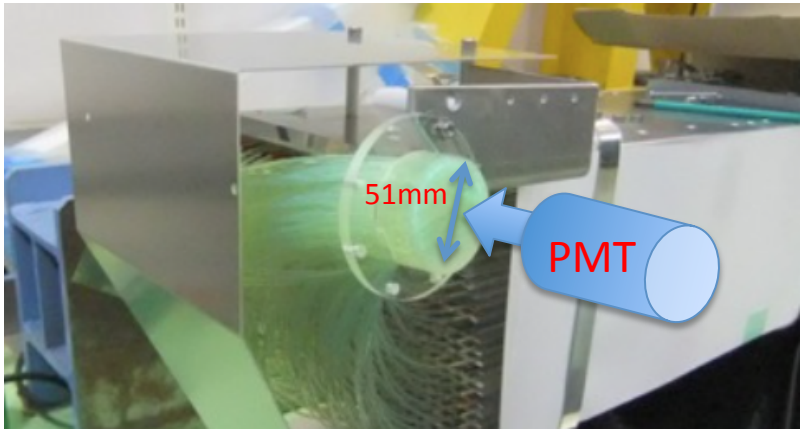
Inner Barrel



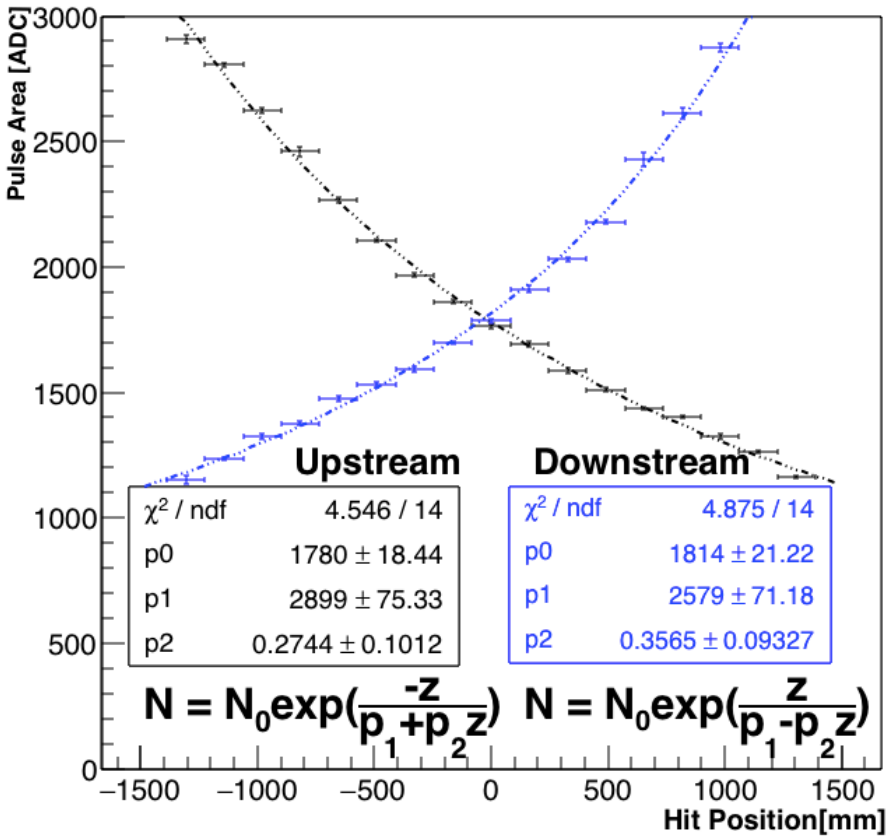


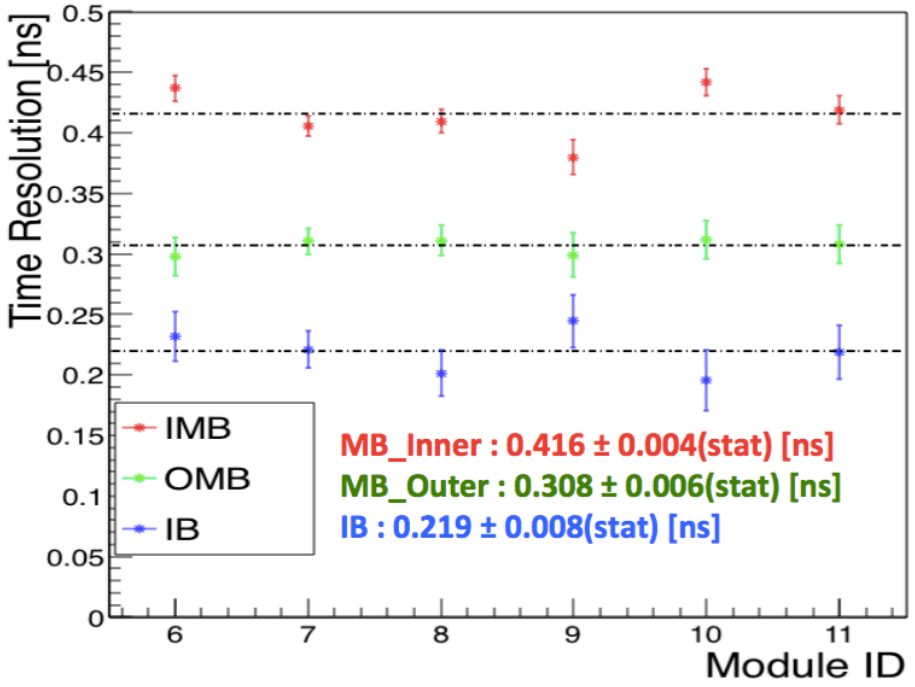


- 25 layers of 1-mm thick Pb sheet and 5-mm thick plastic scintillator
- Add $5X_0$ to $13.5X_0$



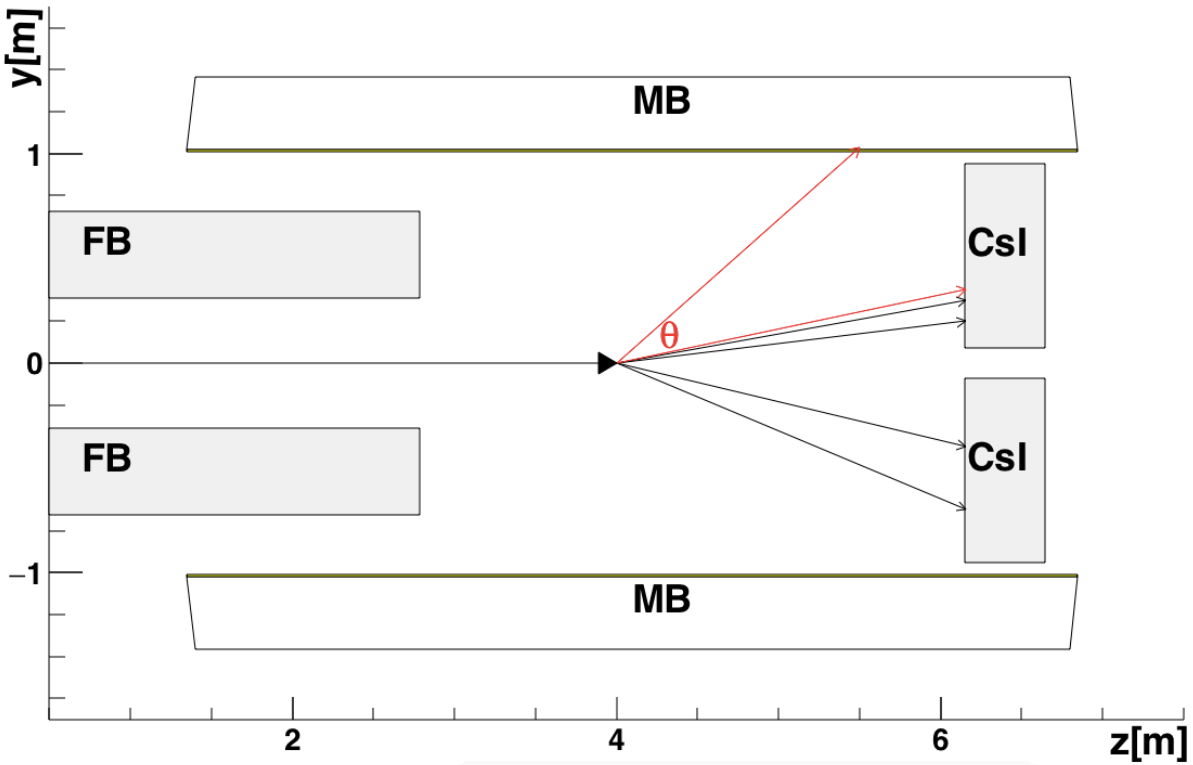
Cosmic Ray Test





- Attenuation curves fitted by two terms.
  - Reconstruction of deposited energy from ADC.
- Superior timing resolution of IB obtained by cosmic-ray.

$K_L \to \pi^0\pi^0\pi^0$ Reconstruction Using 5γ on CsI and 1γ on Barrel



$$E_6 = \frac{M_\pi^2}{2E_5(1-\cos\theta)}$$

$$M_{K_L}^2 = \left(\sum_{i=1}^{6} E_i\right)^2 - \left(\sum_{i=1}^{6} \vec{p}_i\right)^2$$

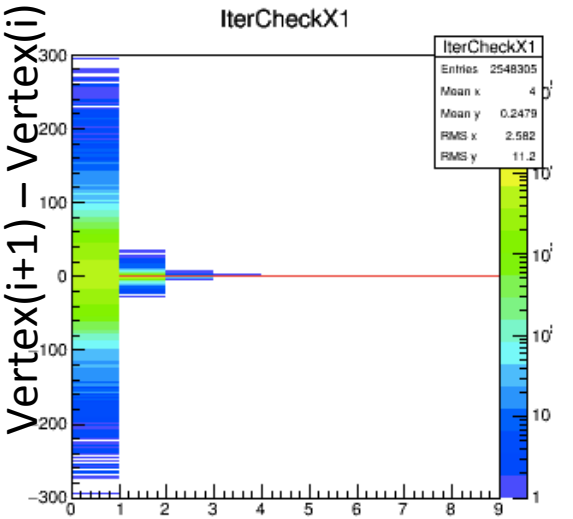
- $K_L \to \pi^0\pi^0\pi^0$ decay samples with 5γs on CsI and 1γ on Barrel
- Reconstruction of $2\pi^0$ from 4γs on CsI
- 1γ Reconstruction from hit information of Barrel (timing and Module ID)
- Reconstruction of the third π^0 from 1γ on CsI and 1γ on Barrel

Reconstruction of Vertex X, Y

Vertex X,Y from C.O.E.

Reconstruction of Energy of incident gamma

Iteration (10 times)



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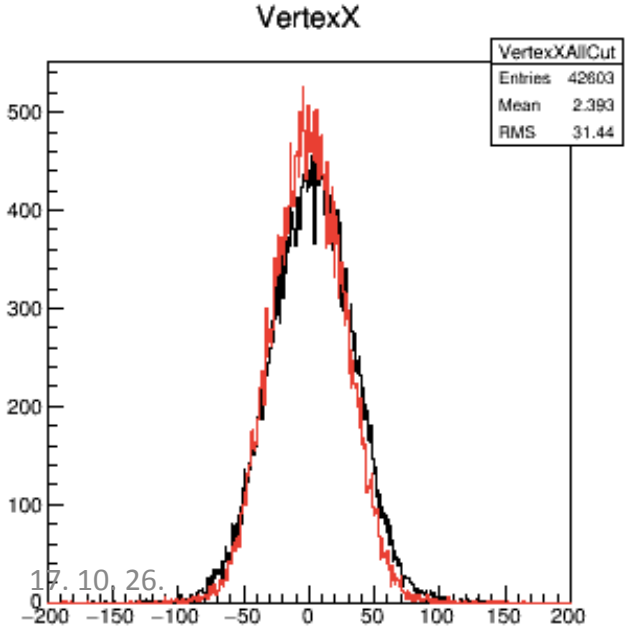
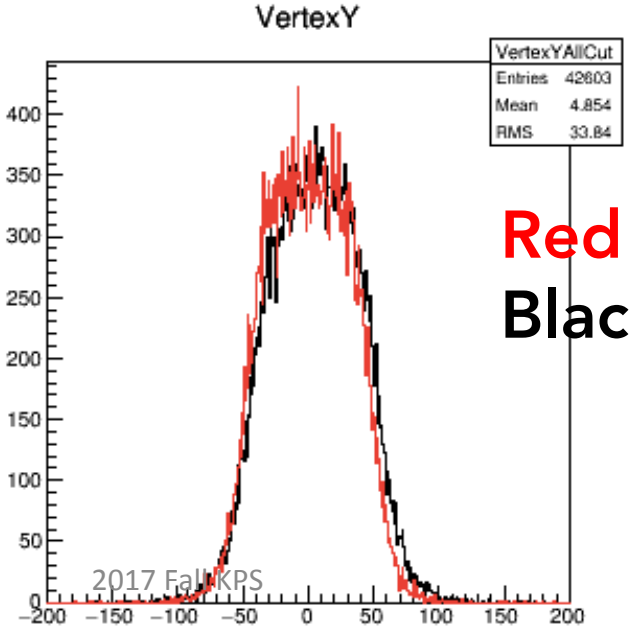
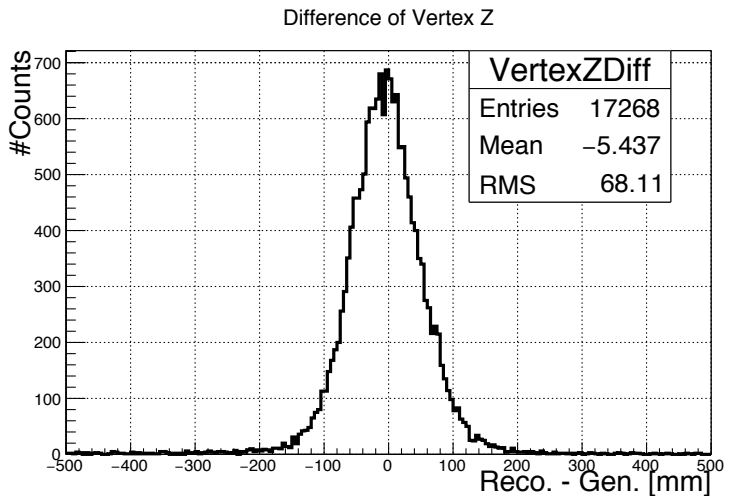


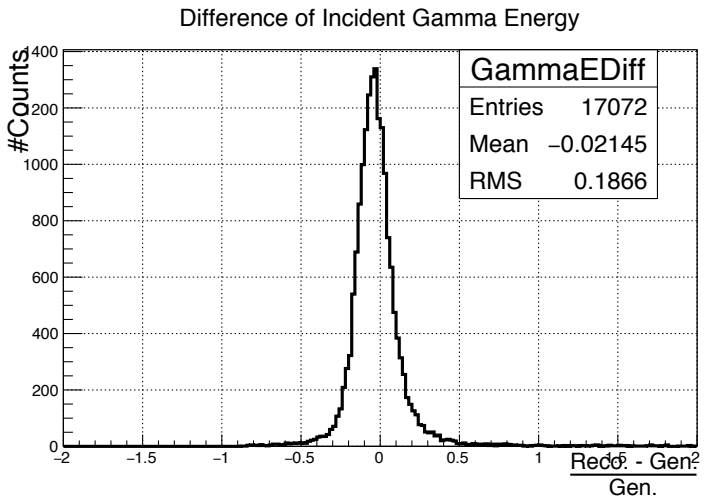


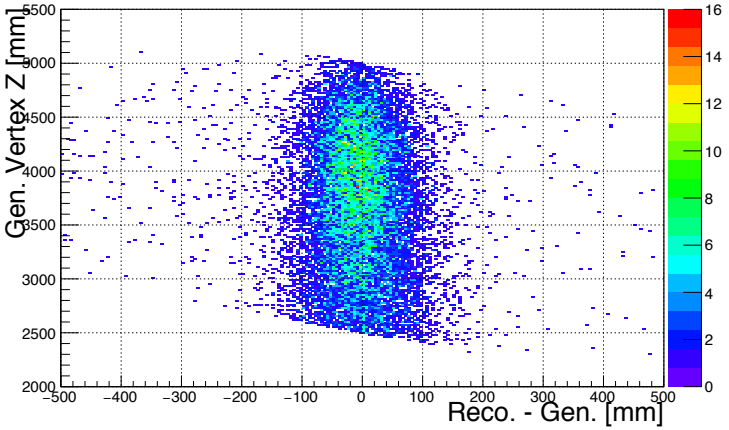
Red : M.C.

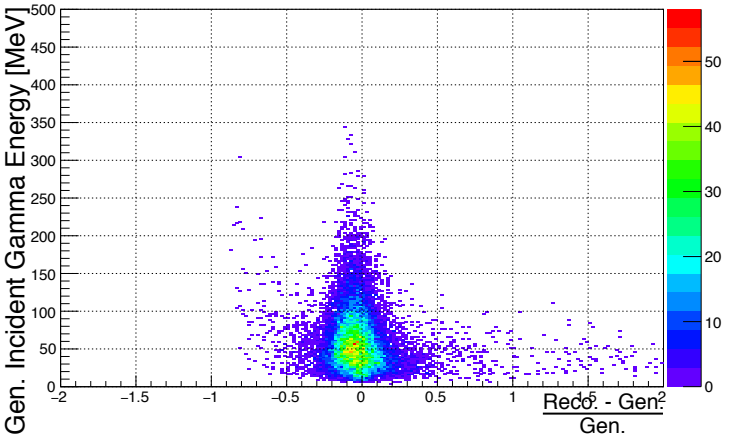
Black : Data(Run62)

Reconstruction Quality



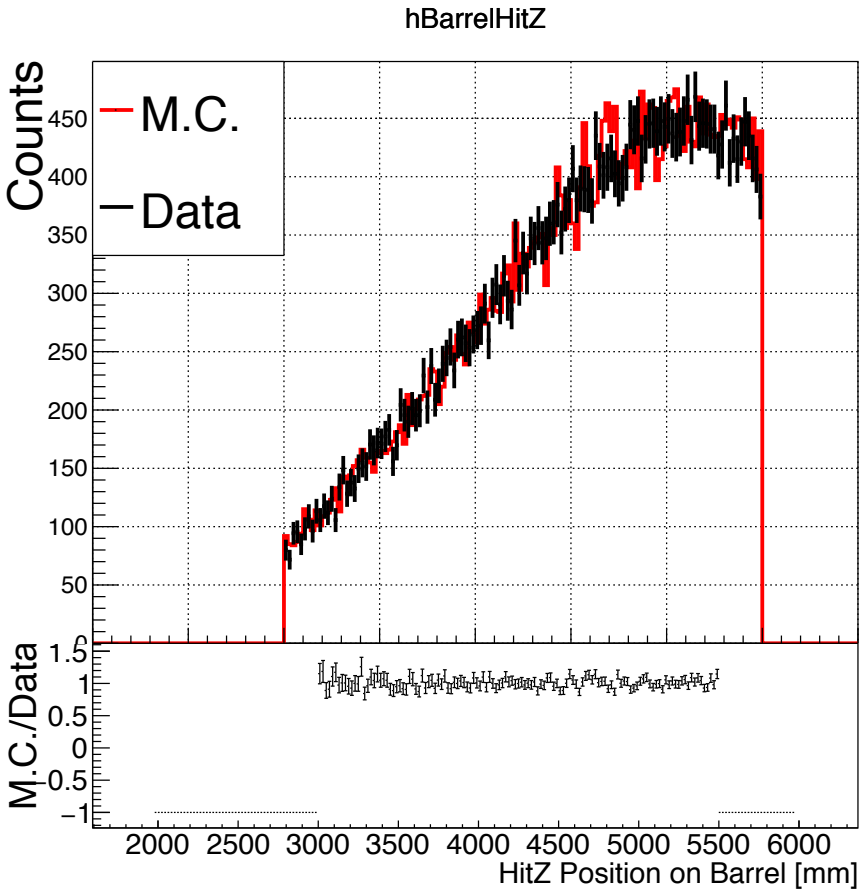


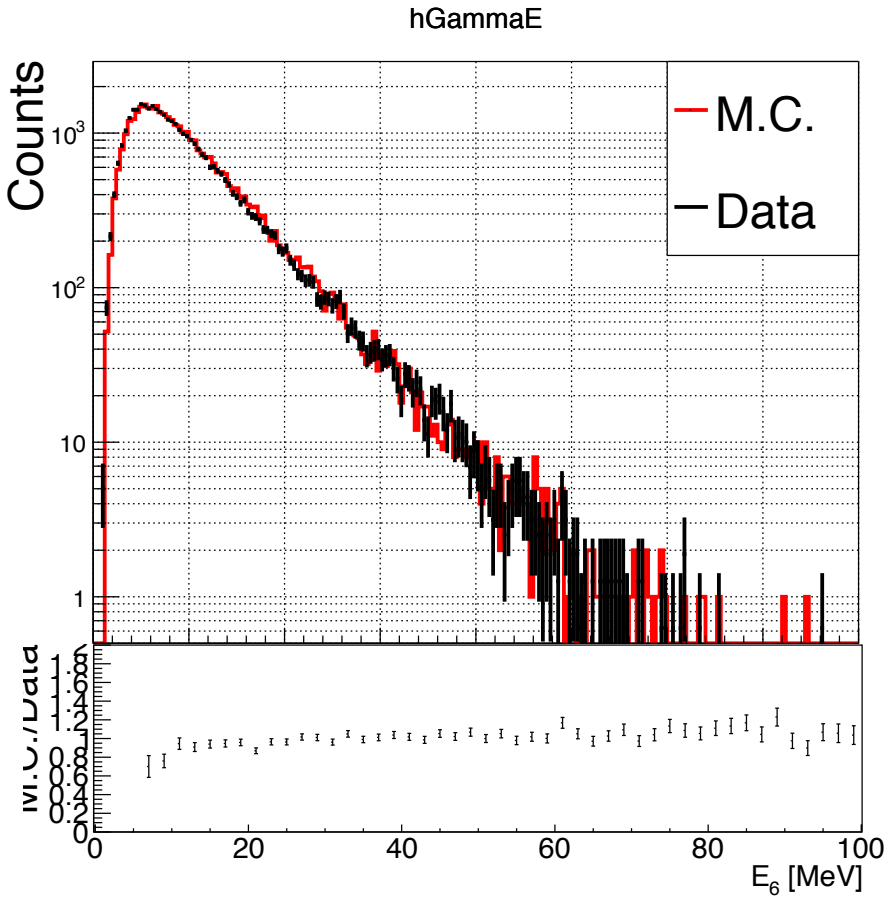




$\mathbf{K_L \to \pi^0\pi^0\pi^0}$ **Monte Carlo Generation**

Response Comparison





- Good agreement between M.C. and Data

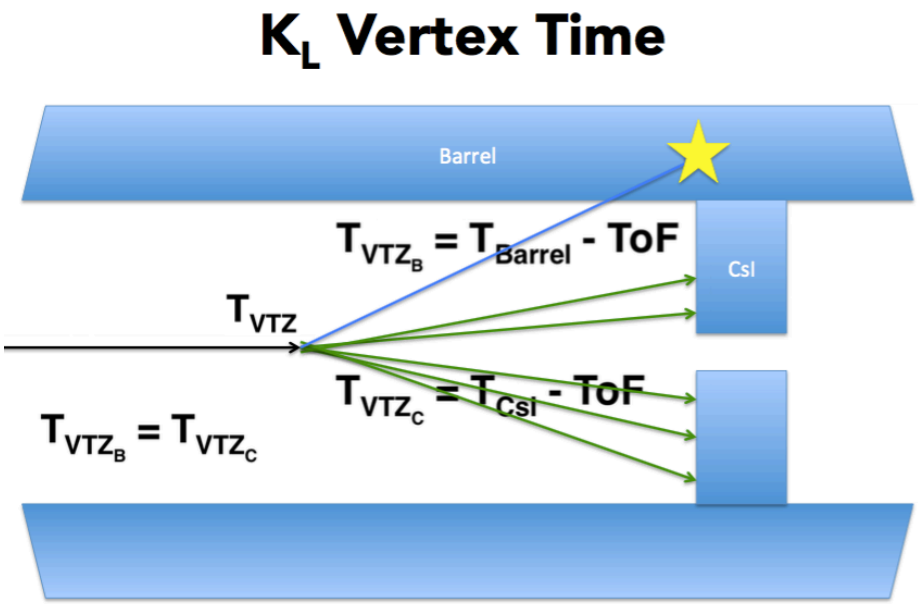
Reconstruction Results

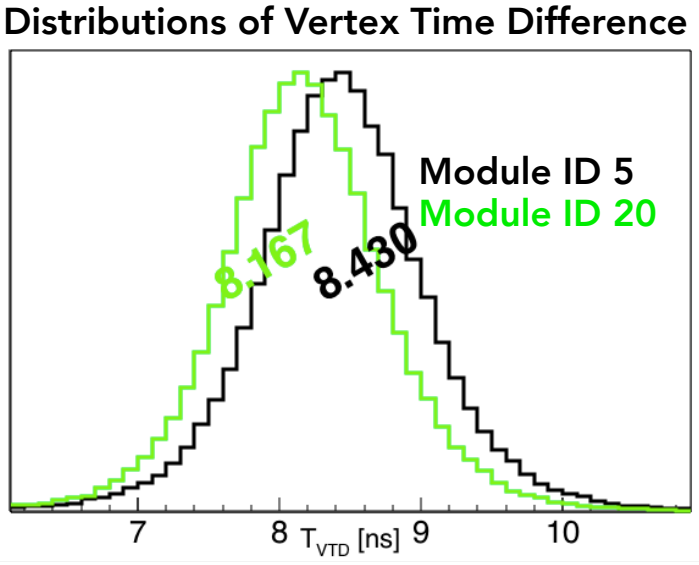
Background	Probability
Dalitz Decay of pion	5.25×10^{-6}
Ineff. of other Det.	1.87×10^{-3}
Fusion	5.25×10^{-6}

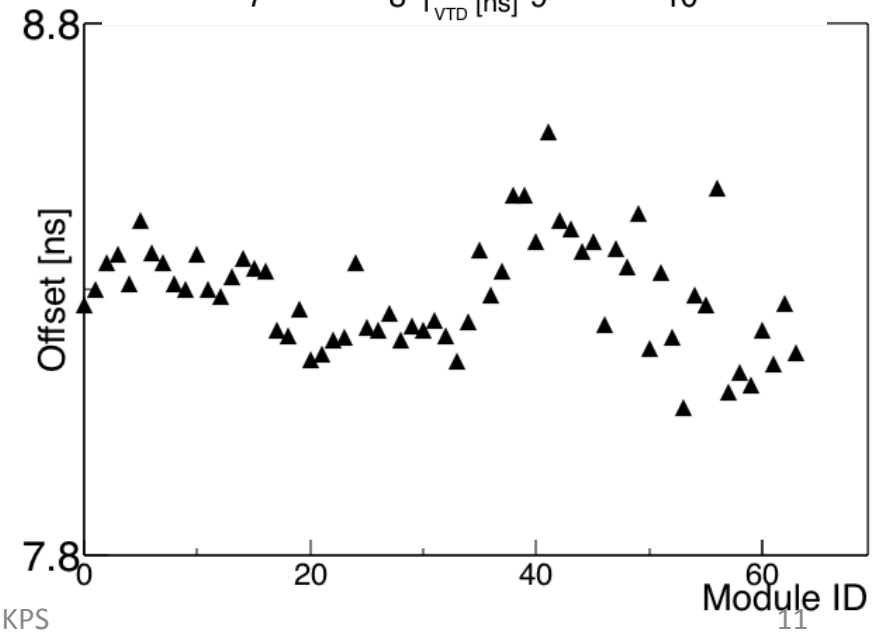
Detector	Probability
CsI	1.04×10^{-3}
FB	5.70×10^{-4}
Beam Pipe	8.14×10^{-5}
BHPV	1.71×10^{-4}

- Mis-reconstruction due to inefficiency of other detectors.
- Gamma selection with 99.7% accuracy.

Vertex Time Difference

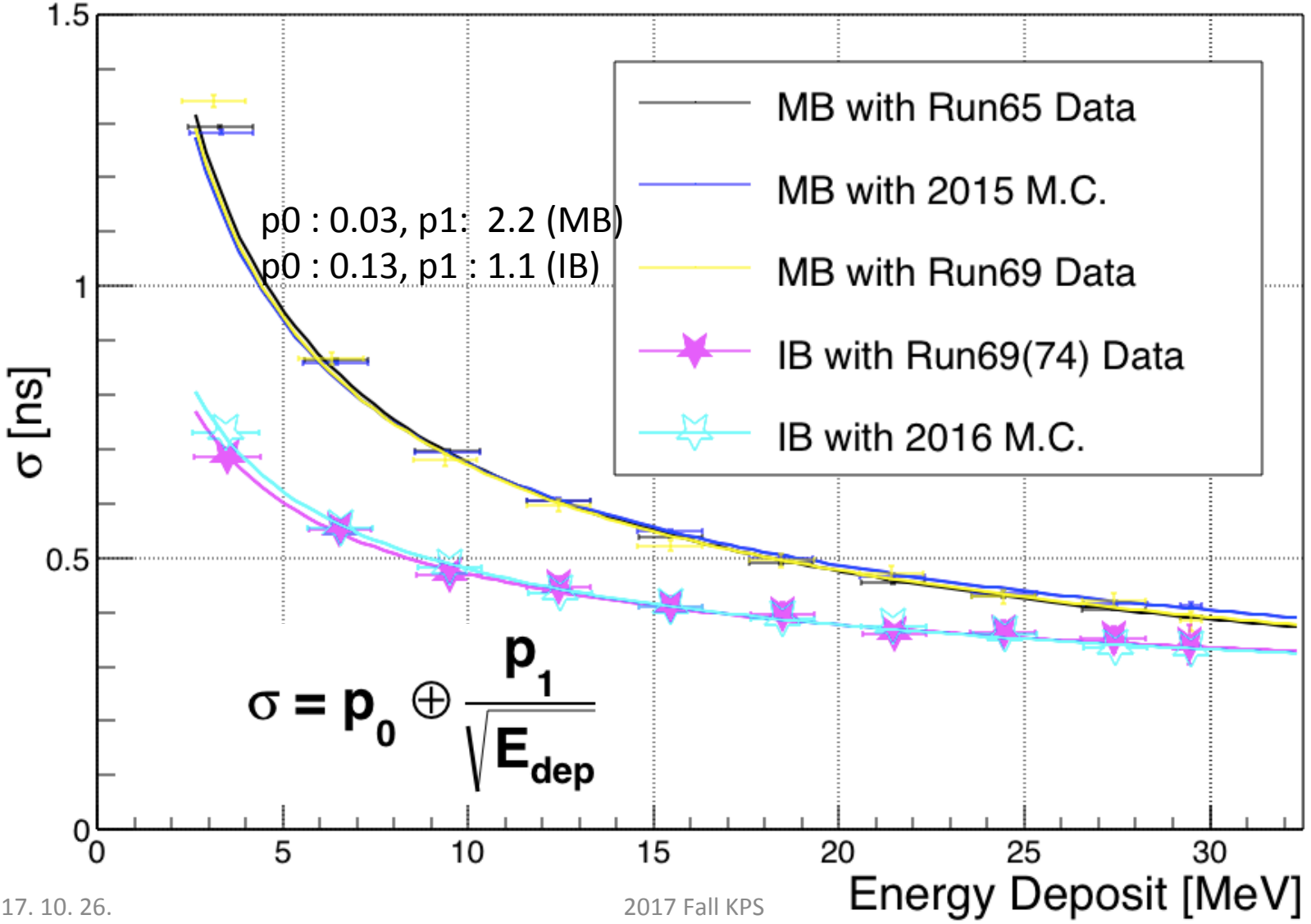




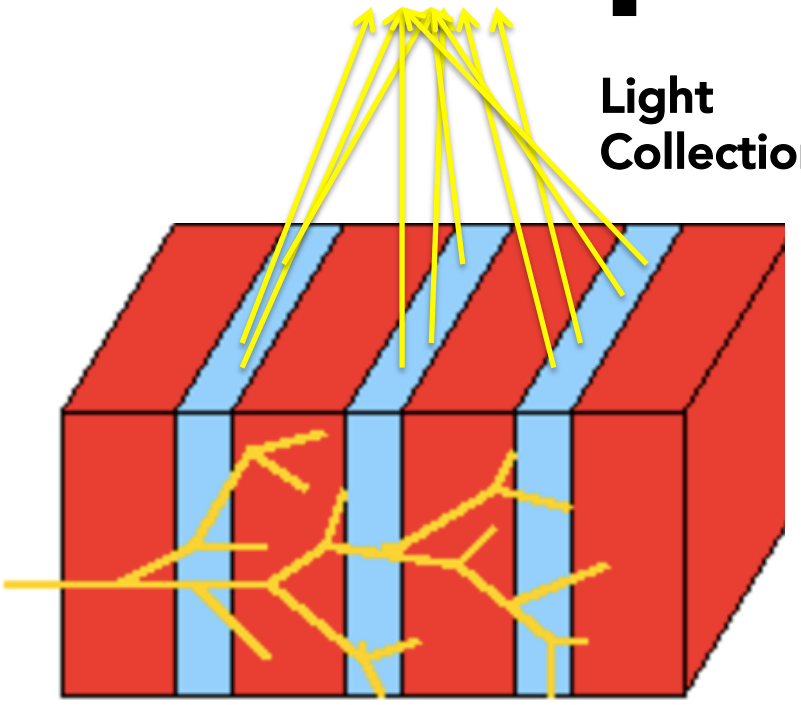


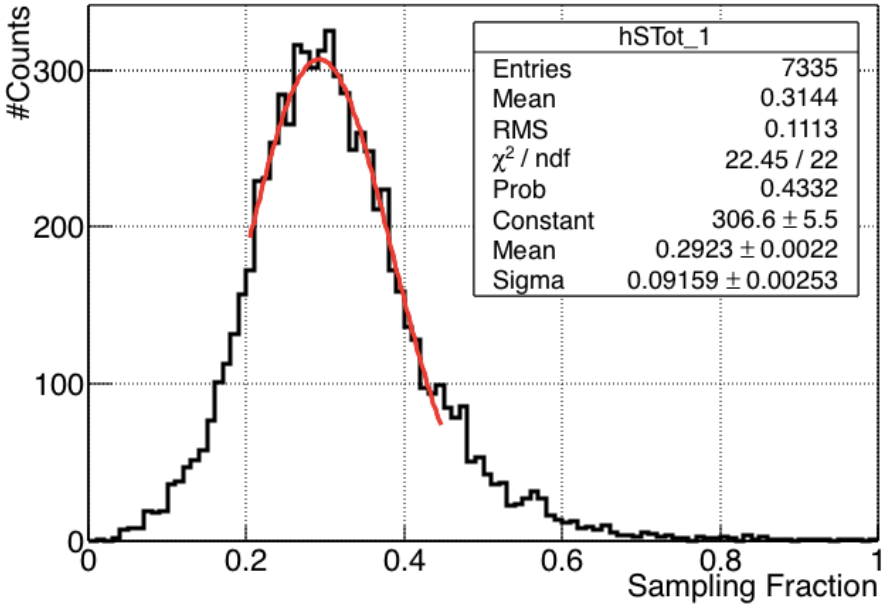
- Vertex Time Reconstruction with
  - Barrel
  - CsI Calorimeter
- Vertex Tine Difference
  - Invariant

Timing Resolution from K_L signal

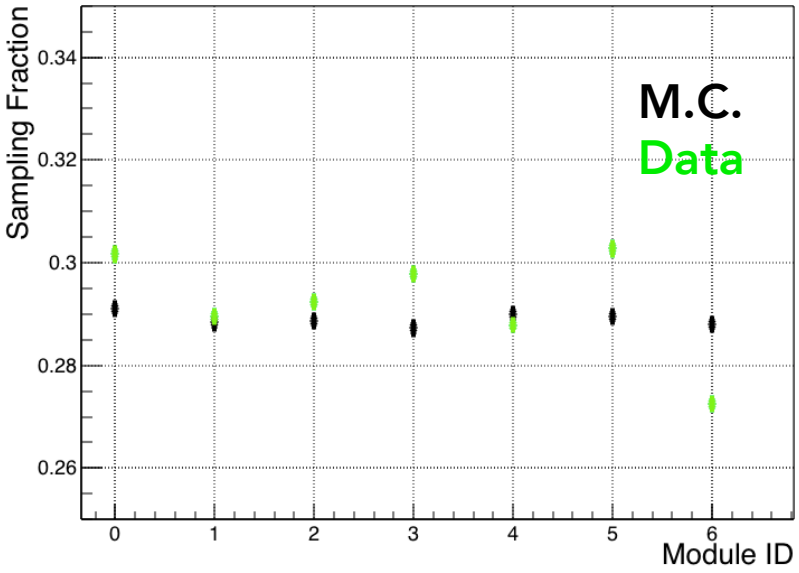


Sampling Fraction

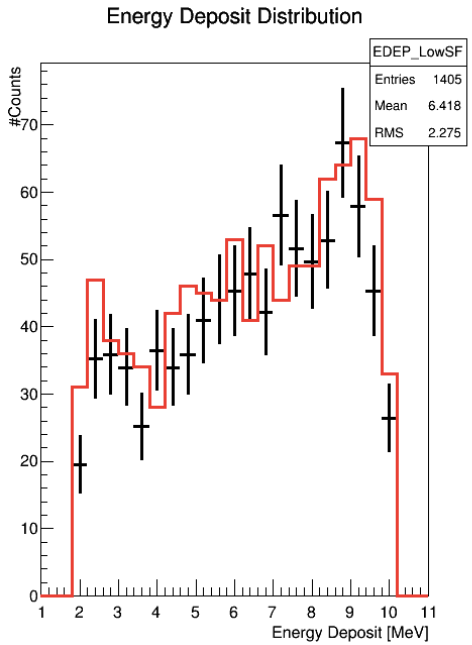


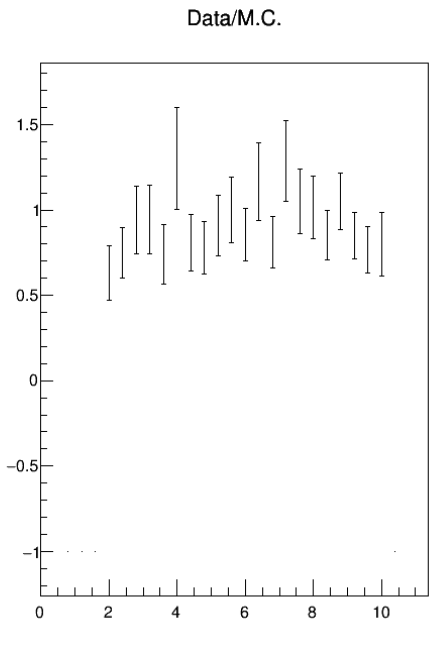


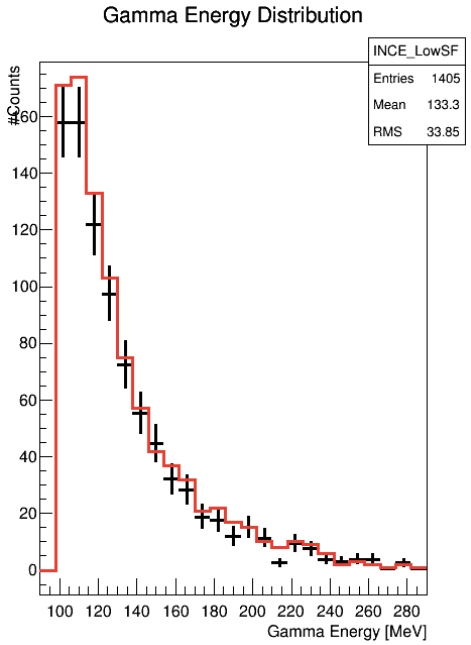
- Sampling Calorimeter collects signal only from Active
  - Plastic scintillator
- Passive induces interaction with high Z number
  - Lead plate

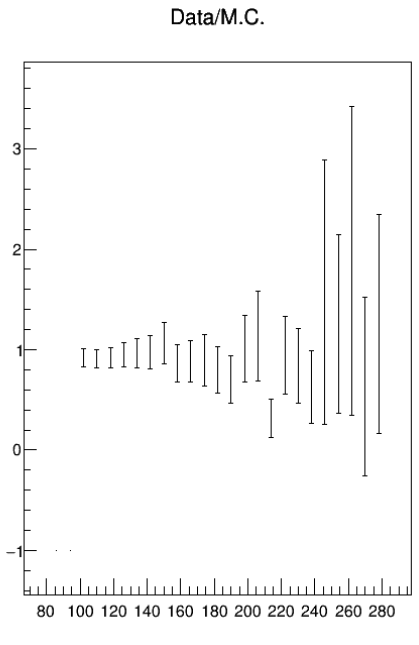


Data/M.C. @ Low S.F.









- Low sampling event selection
  - Gamma Energy > 100 MeV & Deposited Energy < 10 MeV
- Even if in extreme region, agreement between M.C. and Data is shown.

Summary

- Reconstruction of $K_L \to \pi^0\pi^0\pi^0$ is done with 99.7% accuracy.
- Fine time and energy calibration are done with clear gamma selection.
- Timing Resolutions of Barrel Detector are evaluated using K_L signal.
  - p0 : 0.13[ns], p1 : 1.1[ns] for Inner Barrel
  - p0 : 0.03[ns], p1 : 2.2[ns] for Main Barrel
- Sampling Fractions of Barrel Detector are determined.
  - 0.29(IMB), 0.20(OMB), 0.31(IB)
- Deep agreement between M.C. and Data is checked.