J-PARC KOTO실험 샘플링 칼로리미터의 성능 평가

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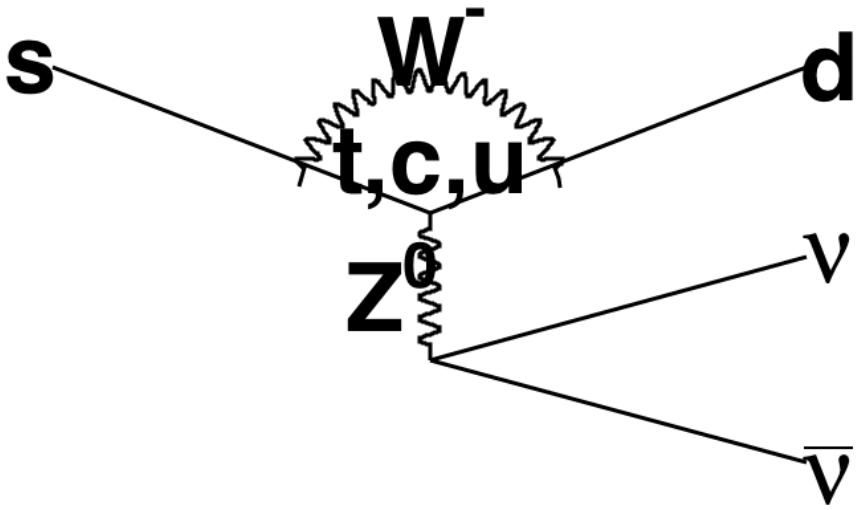
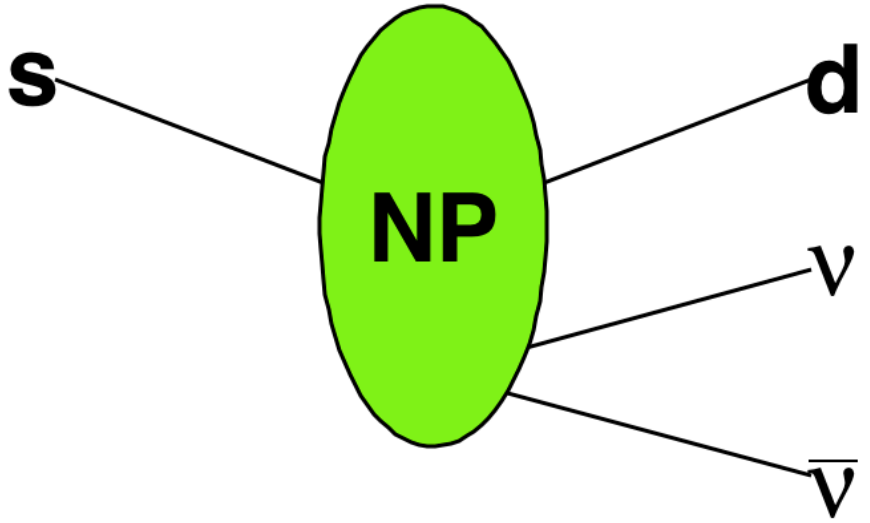
For the KOTO Collaboration
2016 fall KPS

$K_L \to \pi^0 \nu\bar{\nu}$ decay

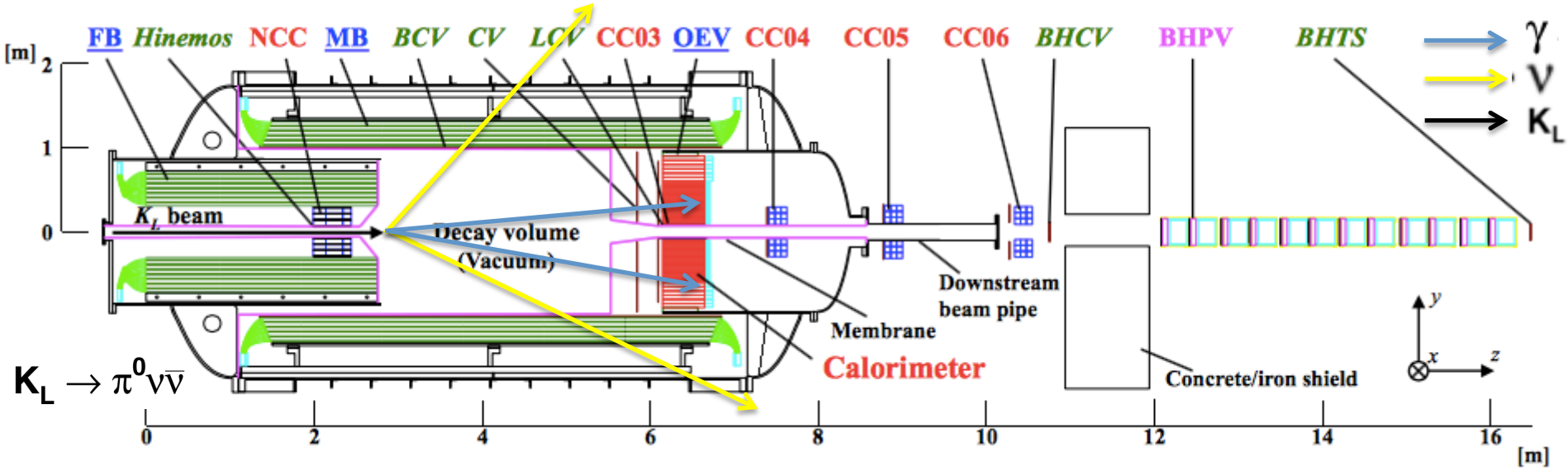
- FCNC process in Standard model
- $Br(K_L \to \pi^0 \nu\bar{\nu}) = (2.8 \pm 0.4) \times 10^{-11}$ predicted by SM
- Clean mode to explore New Physics





KOTO experiment

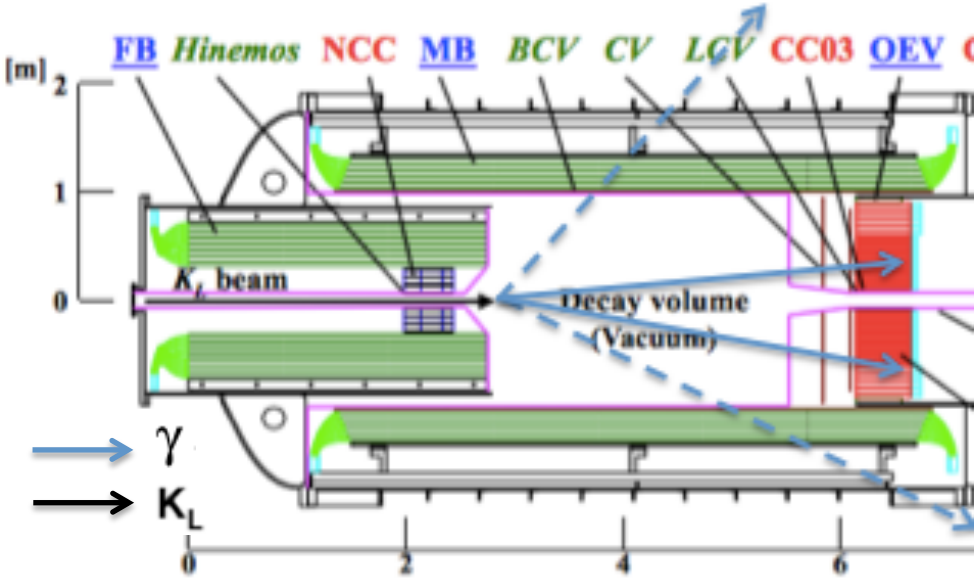
- KL beam line of Hadron Hall at J-PARC

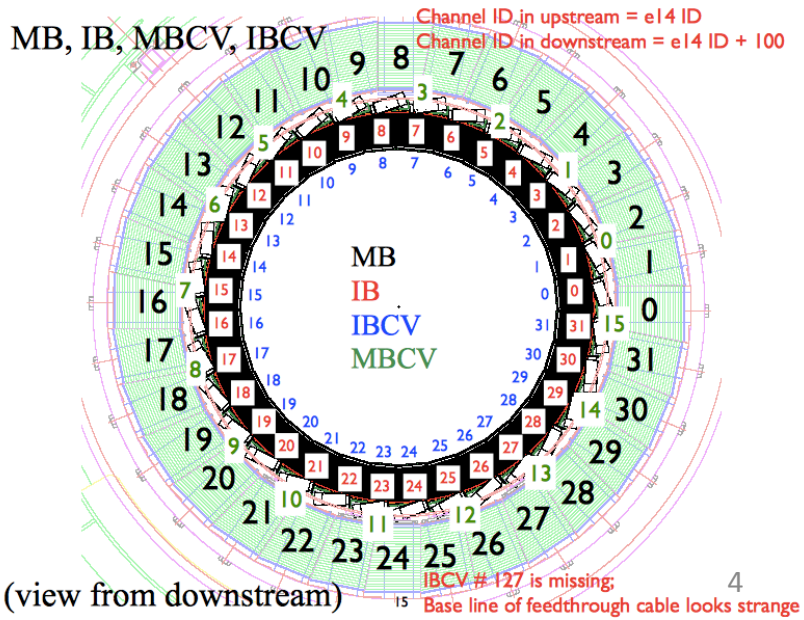


- $\mathbf{K_L \rightarrow \pi^0 \nu\bar{\nu}}$ decay leaves 2ϒ hit only.
- CsI Calorimeter detects 2ϒ
- Hermetic veto counters confirm no additional particles.

New Pb/Scint Calorimeter

- Better suppression of background events associated with $K_L \rightarrow 2\pi^0$ decay
- Better timing resolution for rejecting back-splash events

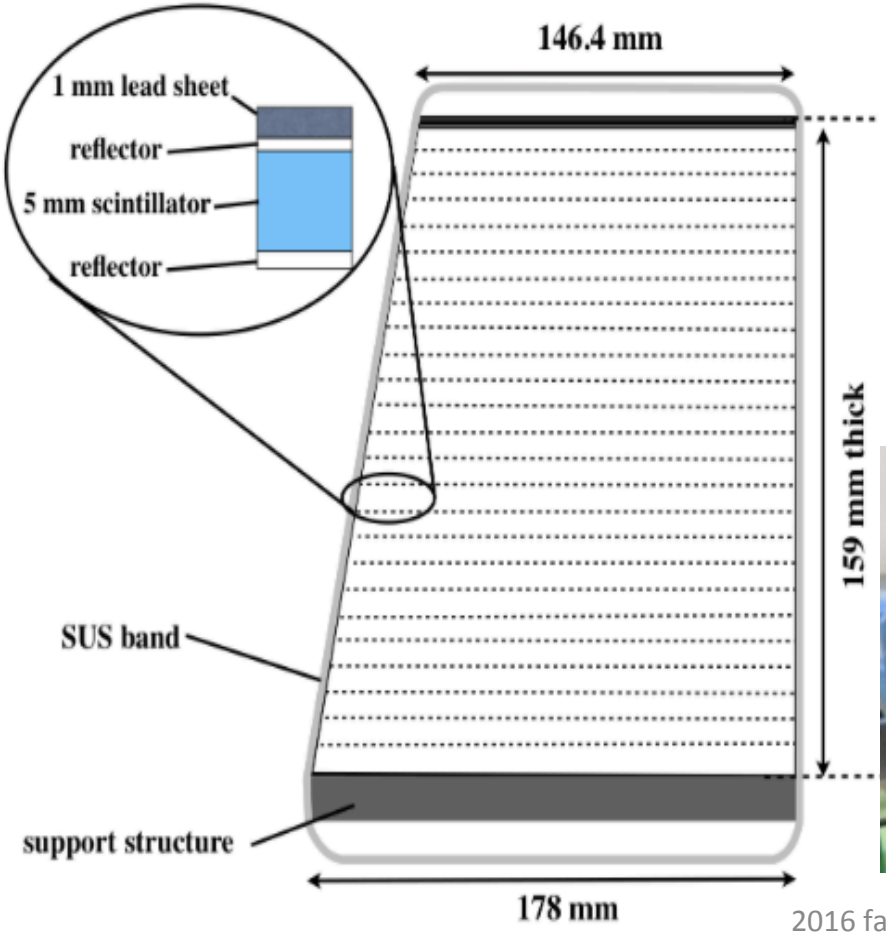


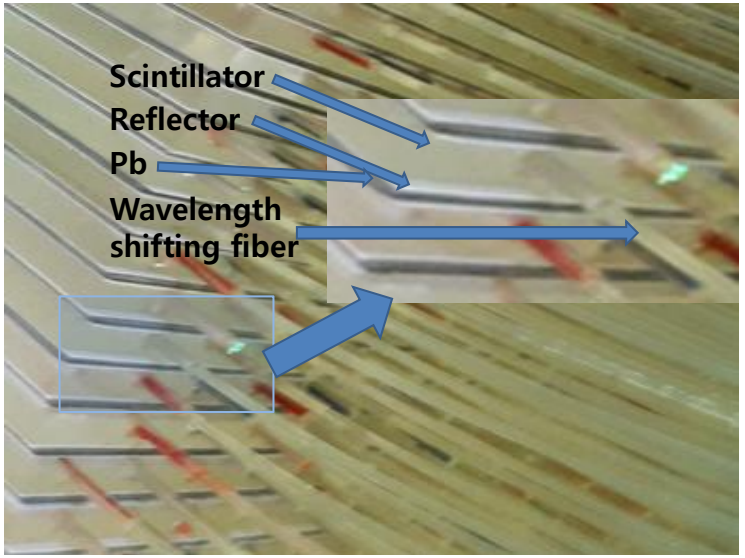


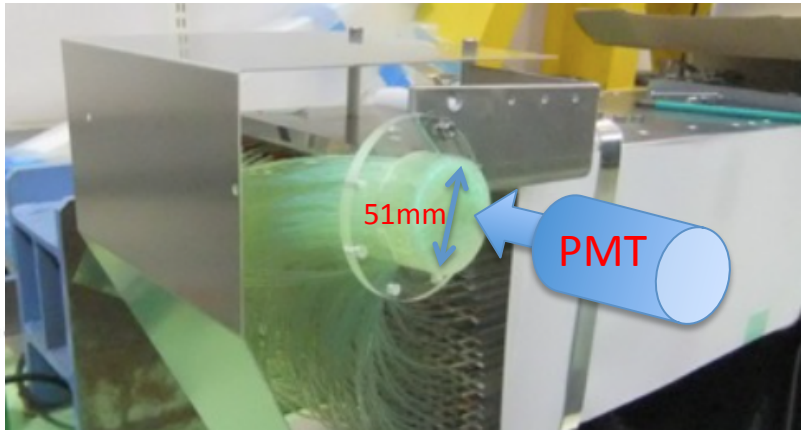
Not detected 2γ (inefficiency of barrel)

New Pb/Scint Calorimeter

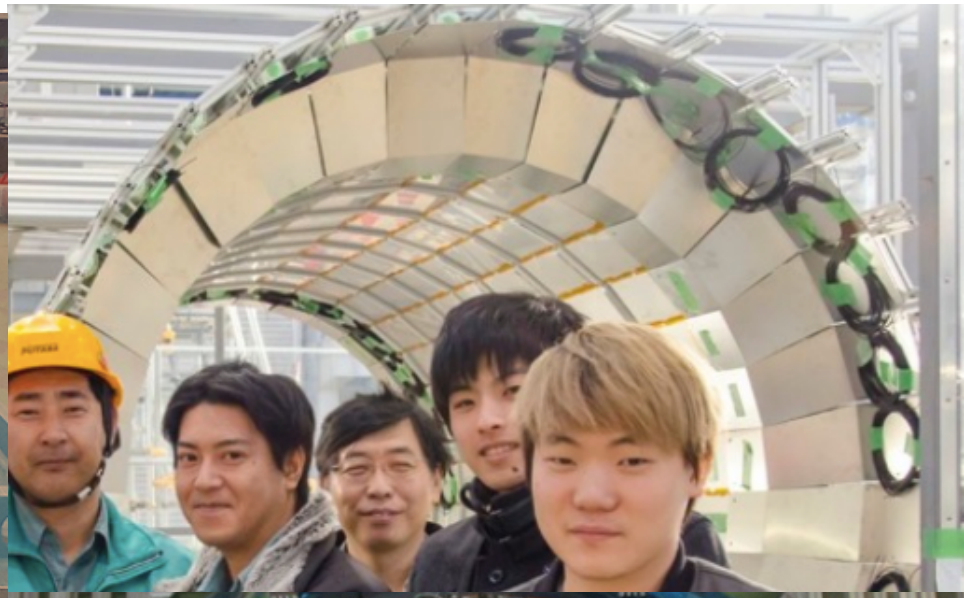
- 25 layers of 1-mm thick Pb sheet and 5-mm thick plastic scintillator

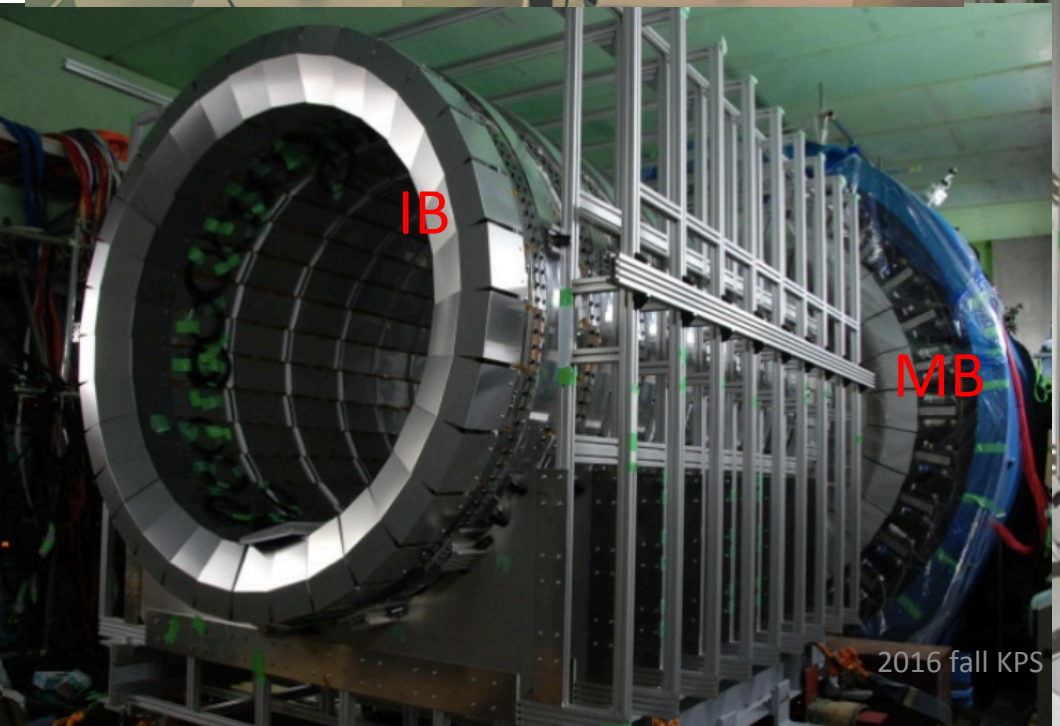




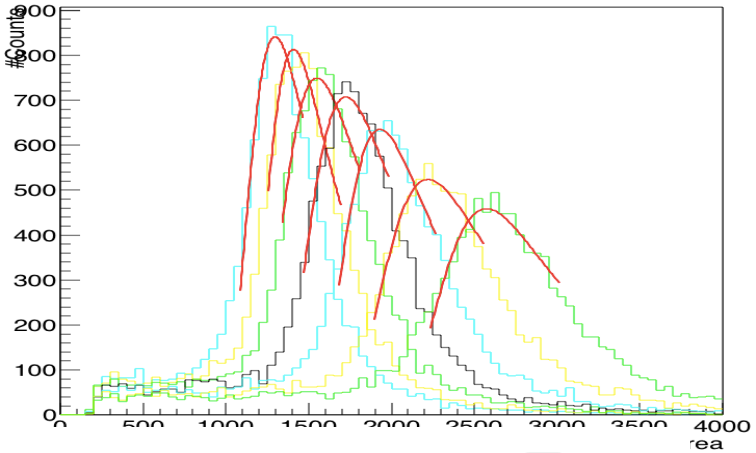


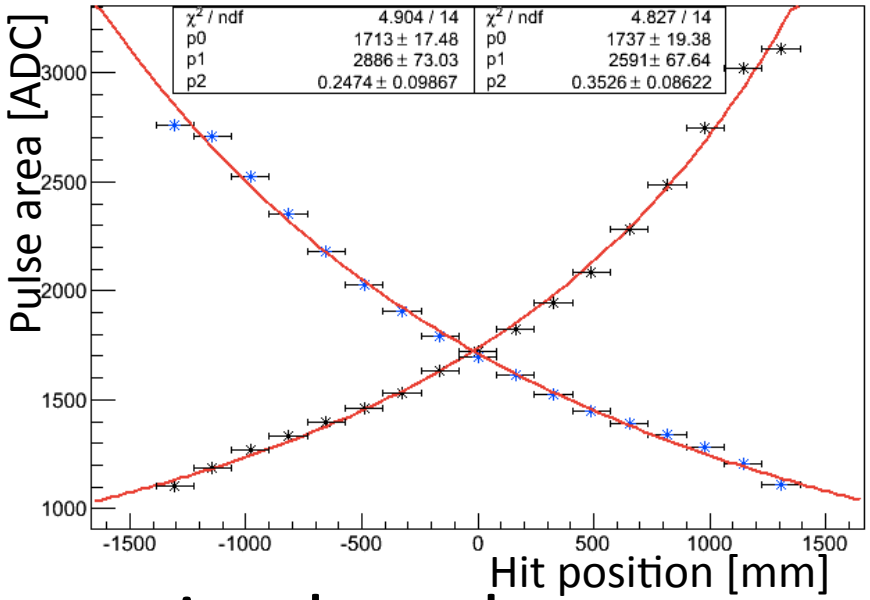
Assembly of Inner Barrel



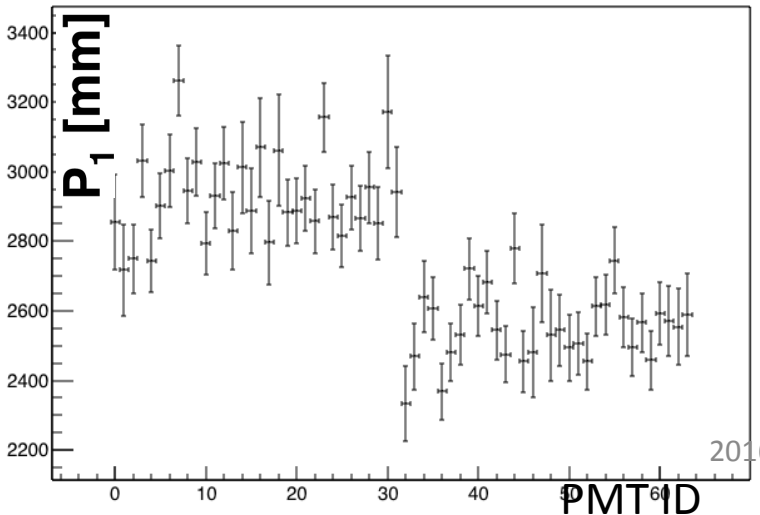


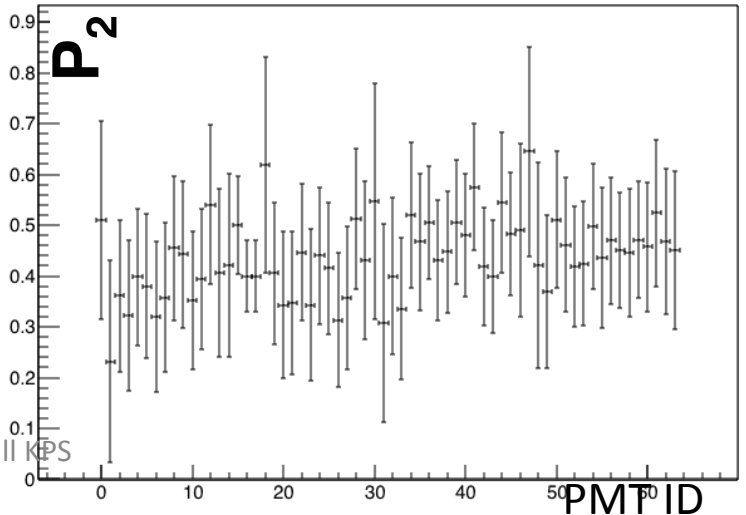
Attenuation of Scintillation light



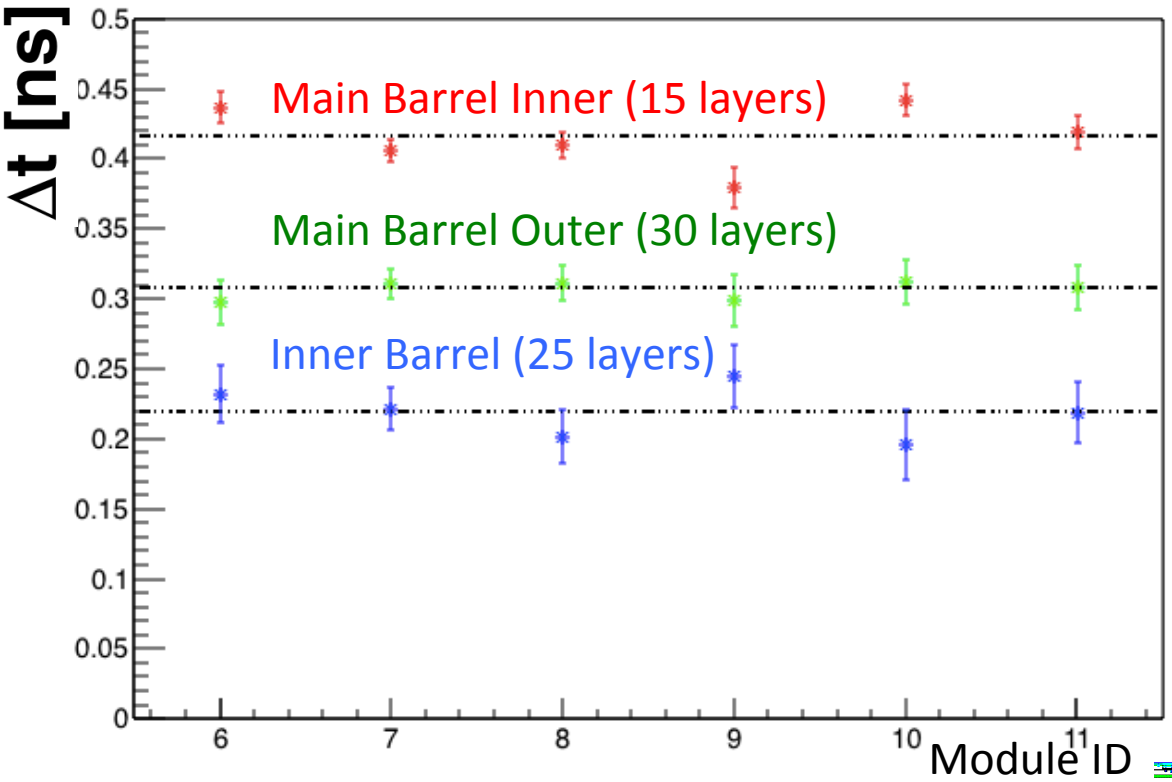


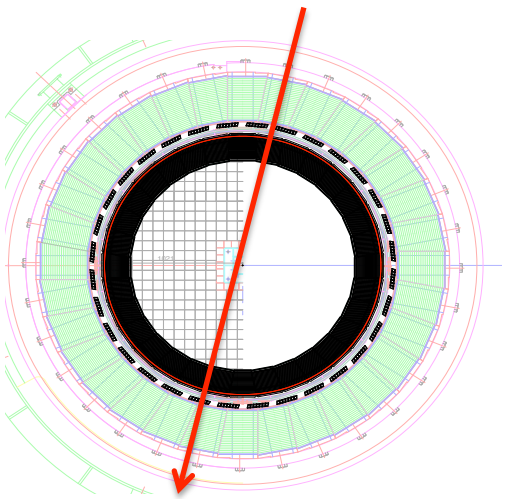
- $N = N_0 \exp\left(\frac{-z}{p_1 + p_2 z}\right)$
- Linear term in the attenuation length describes the wave-length dependence.

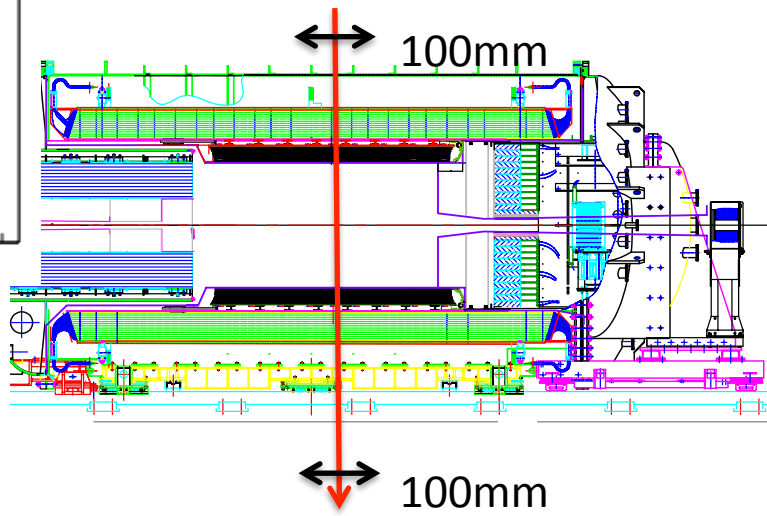




Time resolution of Inner Barrel



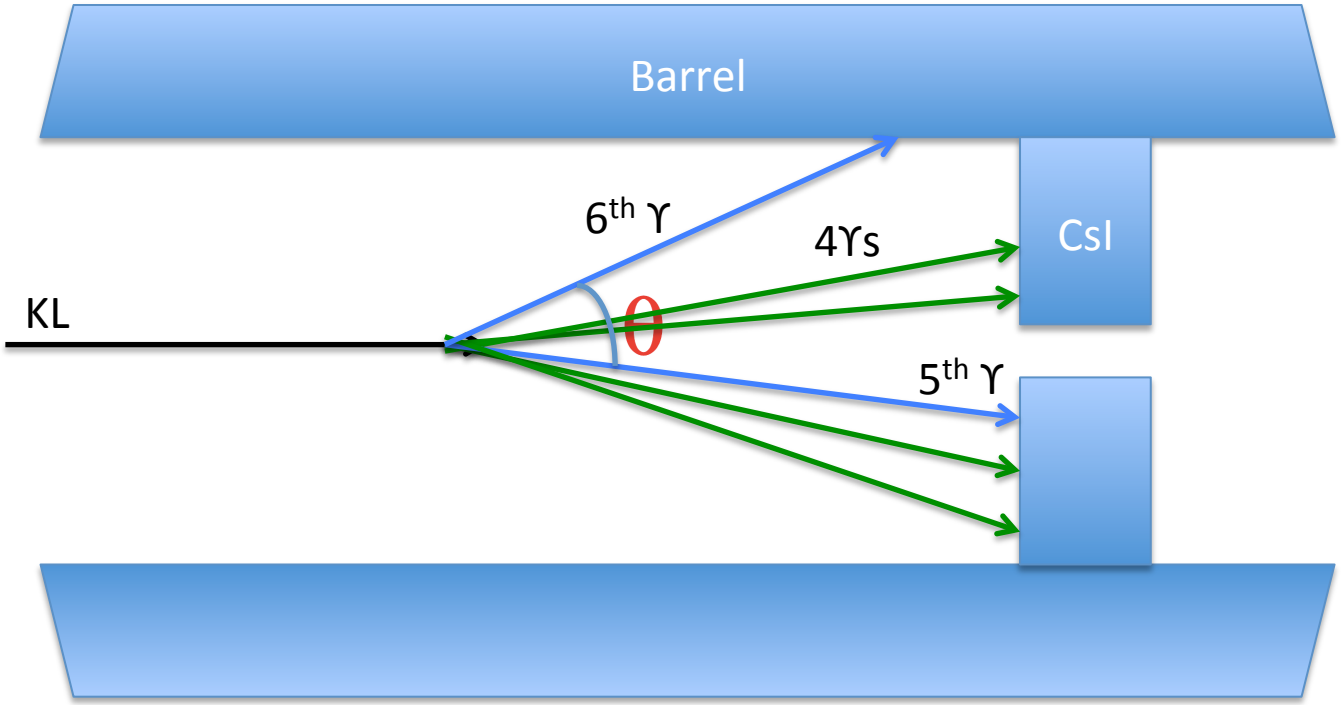




Selected cosmic ray track

- Time resolution of IB was found to be superior to those of Main Barrels using cosmic-ray data
- $\Delta t_{IB} = 219 \pm 8$ ps while $\Delta t_{MBOut} = 308 \pm 6$ ps and $\Delta t_{MBIn} = 416 \pm 4$ ps

Inner Barrel performance test with $\mathbf{K_L \to \pi^0\pi^0\pi^0}$ decays

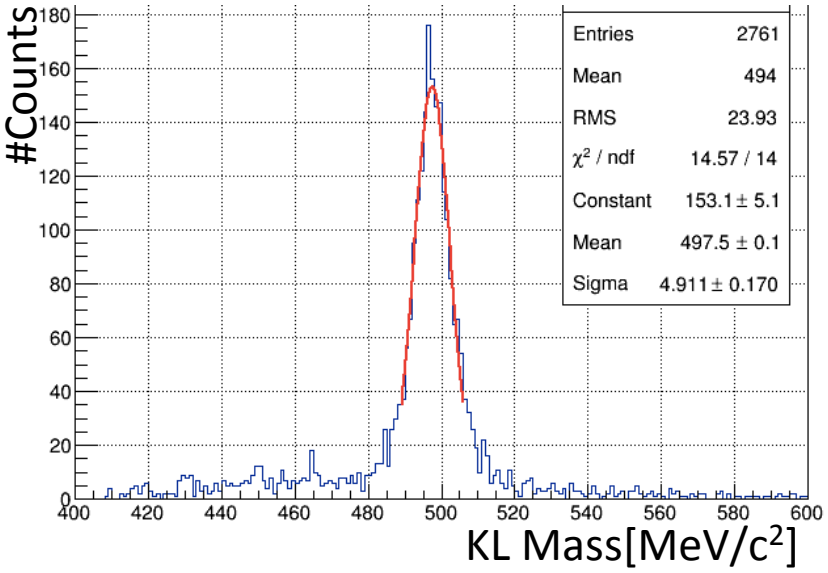


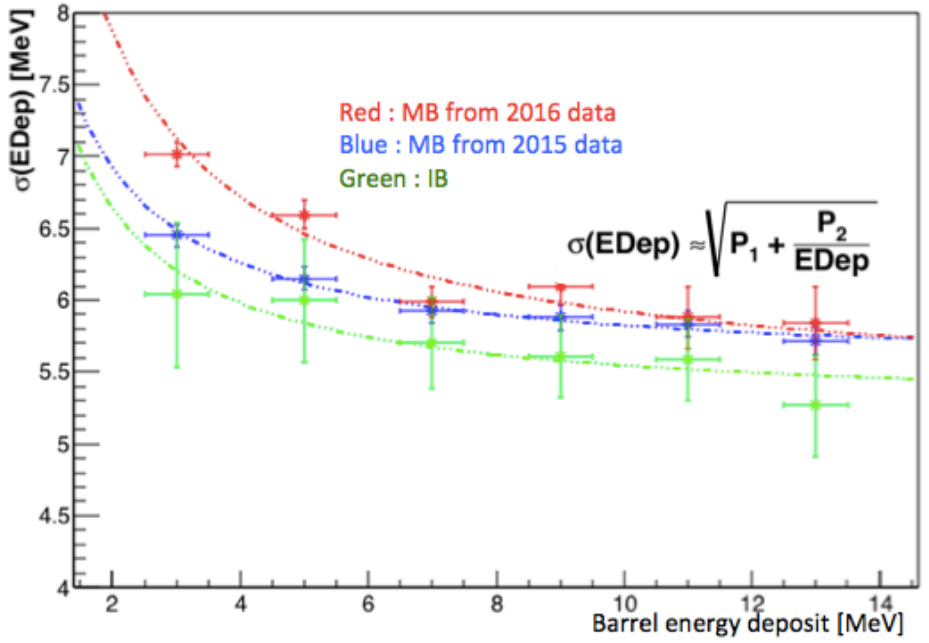
- $\mathbf{K_L \to \pi^0\pi^0\pi^0}$ decay samples with 5ϒs on CsI and 1ϒ on Barrel
- Reconstruction of $2\pi^0$ from 4ϒs on CsI
- 1ϒ Reconstruction from hit information on Barrel (timing and segment ID)
- Reconstruction of the last π^0 from 1ϒ on CsI and 1ϒ on Barrel

KL reconstruction with 5ϒ(CsI) and 1ϒ(Barrel)

$$M_{K_L}^2 = \left(\sum_{i=1}^{6} E_i\right)^2 - \left(\sum_{i=1}^{6} \vec{p}_i\right)^2 \qquad E_6 = \frac{M_\pi^2}{2E_5(1-\cos\theta)}$$

- Timing resolution of Barrel is related to angular resolution in theta and energy resolution in E_6





Summary

- A new Pb/Scintillator calorimeter (Inner Barrel) was operated successfully in the 2016 runs.
- Thanks to Inner Barrel, the timing resolution in Barrel detectors proved to be much improved.
- Further study on the $\mathbf{K_L} \rightarrow \pi^0\pi^0\pi^0$ decay will be performed with ϒ hits on CsI and Barrel