PROCEEDINGS OF SCIENCE

Performance of the KOTO Sampling Calorimeter

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The J-PARC KOTO experiment is searching for the $K_L \to \pi^0 \nu \bar{\nu}$ decay which is sensitive to new physics. A main feature of the signal is that two photons and nothing else are observed in a hermetic detector system. Thus, it is important to detect all decay particles from the K_L decay. A 5.5-m long cylindrical Lead/Scintillator sandwich calorimeter surrounds the K_L decay region to detect extra photons. The detection efficiency of the sampling calorimeter was designed to meet the background elimination capability. We present the performance of the sampling calorimeter using tagged photons from the $K_L \to 3\pi^0$ decay. In particluar, the performance of a new sampling calorimeter installed in 2016 is reported.

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[*] Speaker.

1. KOTO Experiment

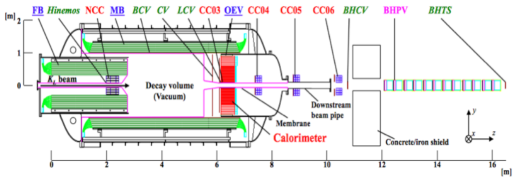


Figure 1: Cut-out-view of the KOTO detector in the physics run in 2015.

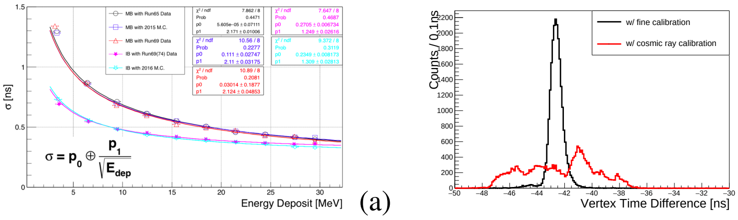
The KOTO experiment [1] is searching for the rare K_L decay $K_L \to \pi^0 \nu \bar{\nu}$ to explore new physics. The Standard Model predicts the branching ratio to be $(3.0 \pm 0.3) \times 10^{-11}$. Because this decay is highly suppressed in the Standard Model, the decay is a good probe to explore new physics. Observables from the $K_L \to \pi^0 \nu \bar{\nu}$ decay are two photons and nothing else. The CsI calorimeter measures the energies and positions of the two photons, and hermetic veto counters ensure that nothing else exists.

2. The Perforamce of The Photon Veto Counter

A photon veto counter called Main Barrel (MB) surrounds the K_L decay region to capture extra photons. It consists of layer of 1 or 2 mm Pb sheet and 5 mm scintillators, and its total thickness is $18.5X_0$. An additional counter called the Inner Barrel (IB) was installed insde the MB to suppress a background from the $K_L \to \pi^0\pi^0$ decay by a factor 3.

The performance of the new counter was measured using tagged photons. We used $K_L \to 3\pi^0$ events with five photons in the CsI calorimeter to reconstruct the energy and direction of a photon going to the barrel region. Using four photons detected in the calorimter, two π^0 are reconstructed to identify the decay vertex of K_L. With the momentum of the fifth photon in the calorimeter and kinematical constraints, the momentum of the sixth photon was reconstructed.

The hit timing of the sixth photon was calculated based on its estimated hit position and the timings of photons in the calorimeter. We evaluated the timing resolution of the barrel counters by comparing the estimated and measured timing differences, as shown in Fig. 2 (a). Fig. 2 (b) shows distributions of the timing differences which means the timing offset of barrel counters. By aligning the timing differences of barrel counters, timing calibration is implemented. Black distribution which is changed from red one presents the result of calibration in FIg. 2 (b)



(a) (b)

Figure 2: (a) Timing resolution of IB and MB. IB provides 1.5 times better timing resolution. (b) Distribution of timing offset of barrel counters. Results of implementation of timing calibration is presented in black distribution which is changed from red distribution.

References

[1] J. K. Ahn et al., (J-PARC KOTO Collaboration), PTEP, 2017, 021C01 (2017).