Engineering run of the E391a

KEK-PS E391a experiment aims to search for a flavor changing neutral current (FCNC) process, $K_L \rightarrow \pi^0\nu\nu$ decay, which is one of the main decay modes for the CP violation study and very sensitive to new physics beyond the standard model. In spite of the strong interest due to theoretical cleanness, it had been considered impossible to detect the decay experimentally due to extremely small branching fraction and weak kinematical tools for background rejection. Owing to ardent efforts during last decade, it becomes realizable and the E391a is the first dedicate experiment for the decay.

The E391a experiment is in a stage of detector construction for data taking scheduled on February 2004 for 4 months. Figure 1 shows schematic view of the detector setup being prepared and a part of detector component, downstream section, was fabricated on the last summer. During 120 shifts on November to December 2002, we have tested the new built detector setup using neutral beam. A main purpose of the beam test, which we call engineering run, is a calibration of the electromagnetic calorimeter consisting of 576 CsI crystals and two different types of sampling sandwich counters. A overall check of electronics system is another purpose because we will use a hit pattern of the CsI crystals for trigger in the final data taking and 70% of readout channels are concentrated on this downstream section.

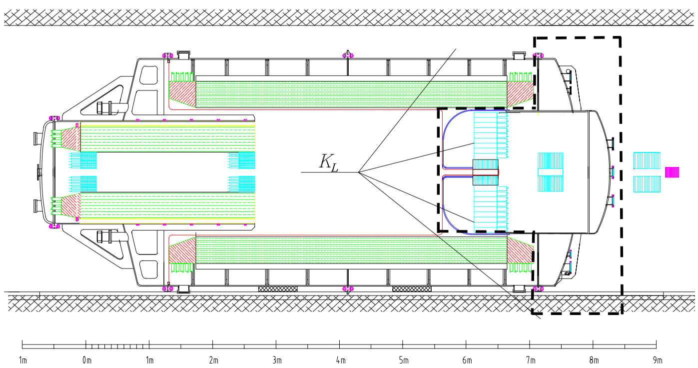

Figure 1. E391a detector setup (up) and a photo after completing fabrication of the downstream section (right). The detector components used at the engineering run is indicated as a marked area by dotted line in the detector setup.

Under the tight schedule and limited experimental condition, we tried to use muon and neutral beam for the calibration of calorimeter instead of usual electron beam. As a first step, we obtained the calibration constant for all CsI crystals by using cosmic rays. During the engineering run, we collected data both for the cosmic ray muon and punch-through muon simultaneously for a crosscheck. The punch-through muon, which comes from the upstream part of the beamline and penetrates through the shield, is in parallel to the beam axis and passes through 4 times longer than cosmic ray does in the CsI crystals.

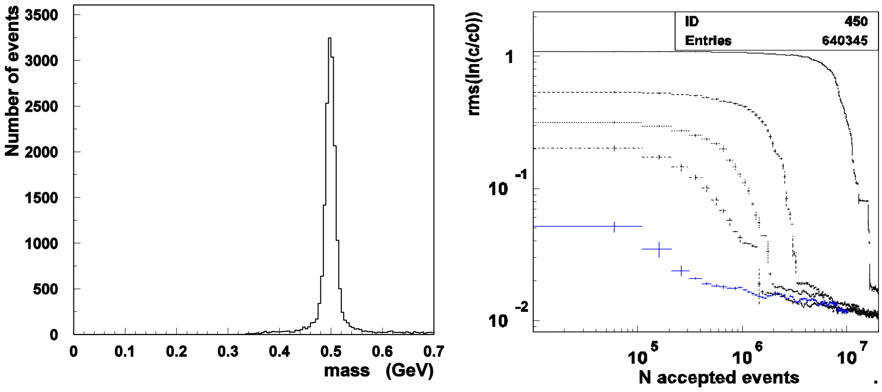

Figure 2. Invariant mass of 6 gammas (left) and a Monte Carlo results showing relationship between number of Kπ3 events and accuracy of the calibration. For the 2% of accuracy, we need 500 thousands of data sample (right).

In the next step, we used gammas from various K_L decays. Figure 2 shows invariant mass distribution of a 6 gamma event samples. The Kπ3 decay ($K_L \rightarrow \pi^0\pi^0\pi^0$) is clearly seen at the proper mass value with low background level. Based on a Monte Carlo study, we found that the present calibration using muons corresponds to a 4% of accuracy and 500 thousands of Kπ3 decays are required to reach less than 2% of accuracy. A million of Kπ3 events that we collected during the engineering run ensure us to achieve our goal of the calibration.

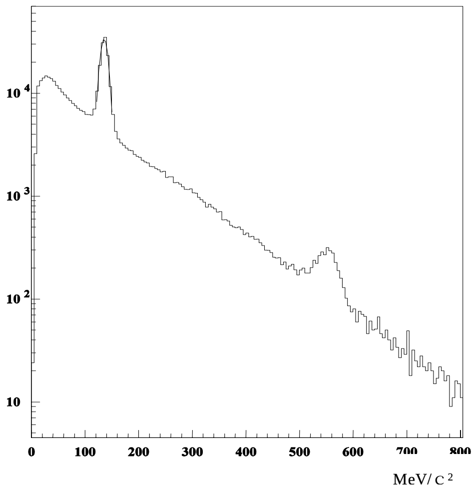

Figure 3. Invariant mass of two gammas assuming that they are produced at the target.

We tried another method for the calibration. By putting a small aluminum target in the beam line, π^0 is produced by interaction with neutrons in the neutral beam. This method is not only a redundant to the K_L decay method but also an attractive approach to use known vertex position for the gammas. We collected two millions of π^0 for two different positions of the target. Clean mass peaks of π^0 and η are observed as shown in Figure 3.

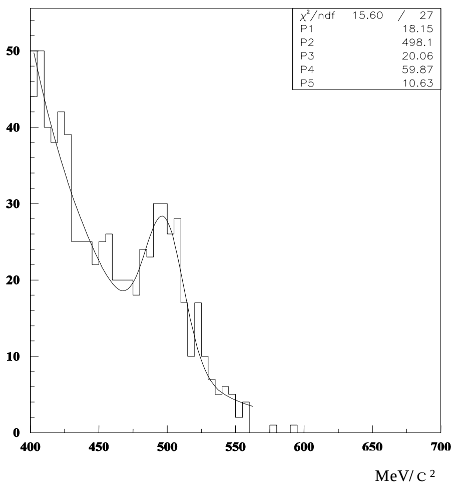

Figure 4. Invariant mass of 4 gammas. A peak indicating Kpi2 decays will become clearer after further calibration.

Finally, we accumulated data for other K_L decay modes as shown in Figure 4. The Kπ2 ($K_L \rightarrow \pi^0\pi^0$) decay is well identified. These other modes are valuable not only for crosscheck of obtained calibration constant but also for further background study.

Judging from the fact that clean peaks of the Kπ3 decay and the π^0-production using the preliminary calibration constant obtained from muons is already observed, further analysis would reach our goal of calibration, less than 2% of accuracy, and valuable softwares will be developed using real data along the analysis. The engineering run can be deserved as a significant step to the success of the E391a.