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Performance test of a prototype barrel calorimeter for E391a

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As a prototype of the barrel γ veto detector for the $K_L \to \pi^0 \nu \bar{\nu}$ experiment (E391a), a lead/scintillator sampling calorimeter consisting of 86 layers of Pb/Plastic (1mm/5mm thickness) with a 1 m length was fabricated. Plastic scintillators were made of MS resin (including PPO 1% and POPOP 0.02%) by an extrusion method. A sheet of TiO_2PET(E60L) was used as a reflector wrapping the scintillator. For readout of scintillation light, WLS fibers (BCF–91A) were buried in grooves of the scintillator plate with a 10mm spacing. Light signals were read out from both sides of the WLS fibers with 16 PMTs (2" diameter).

The performance test was made at the T1 beam line using $e^{\pm}$, $\pi^{\pm}$ and p with momenta between 0.4 and 1.5 GeV/c. In the off-line analysis, a gain of each PMT for a given deposit energy was calibrated for π^- passing through the calorimeter, where the energy deposit in each scintillator layer was calculated by GEANT4 simulations. For electrons, the energy response of the detector showed a good linearity, and the energy resolution was $\sigma/E\,(GeV) \approx 5.3\% \big/ \sqrt{E\,(GeV)}$ (including a spread of the beam momentum). The photoelectron number was measured to be $N_{pe} = 5.7$/MeV when the beam hit the center of the module. This corresponds to the photoelectron number of 18.8 per 1-MeV energy deposit in the scintillator. A uniformity of the detector response and the light attenuation length in the WLS fibers were studied using hadron beams. When these numbers obtained by the 1 m module are extrapolated to the 5.5 m module, the minimum photoelectron number is estimated to be 7–8 per 1-MeV energy deposit. This value is large enough to assure the good photon veto efficiency to suppress backgrounds in the decay measurement.

Fig1. A Pb/Plastic sandwich before wrapping with a sheet of TiO_2PET.

Fig2. Side view of the 1m prototype module.