Pre-radiator system for $K_L \to \pi^0 \nu\overline{\nu}$ Experiment

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The $K_L \to \pi^0 \nu\overline{\nu}$ decay mode is completely dominated by "direct" CP violation. Since theoretical uncertainties are extremely small, even small deviations from Standard Model predictions or other measurements, *e.g.* in the B sector, will unambiguously signal the presence of new physics. $\mathrm{B}(K_L \to \pi^0 \nu\overline{\nu})$ is expected to lie in the range $(3.1 \pm 1.3) \times 10^{-11}$. The experimental signature for the $K_L \to \pi^0 \nu\overline{\nu}$ decay mode consists of two photons with the invariant mass of a π^0, and nothing else. The experimental challenge arises from the 34% probability that a K_L^0 will emit at least one π^0 in comparison with the expected decay probability for $K_L \to \pi^0 \nu\overline{\nu}$ which is ten orders of magnitude smaller. The most serious source of background arises from the decay $K_L \to \pi^0\pi^0$, which simulates a signal if two photons are undetected.

The KOPIO experiment at Brookhaven National Laboratory, employing a low-energy micro-bunched K_L^0 beam to allow determination of the incident kaon momentum, aims to obtain about 60 events with a signal to background ratio of 2:1. The background suppression is achieved using a combination of hermetic high sensitivity photon vetoing and full reconstruction of each observed photon through measurements of position, angle and energy. Events originating in the two-body decay $K_L^0 \to \pi^0\pi^0$ identify themselves when reconstructed in the K_L^0 center-of-mass system.

Photons from $K_L \to \pi^0 \nu\overline{\nu}$ decay are observed in a two-stage endcap detector comprised of a fine-grained pre-radiator (PR) followed by an 18 radiation length (X_0) electromagnetic calorimeter. The requirements of the PR include a photon angular resolution of approximately 25 mr, a photon conversion efficiency of about 0.7 (2.0 X_0), a position measurement of the shower of 0.45 cm, and a good measurement of the deposited energy since a large fraction of the photon energy will be deposited in the PR. The PR obtains the measurements of the interacting photons from π^0 decay by determining the initial trajectories of the first e^+e^- pairs. The PR with a size of 4 m $\times$ 4 m consists of 64 0.03-X_0-thick layers, each with plastic scintillator, converter and dual coordinate drift chamber. There will be 100K anode wires and 70K cathode strips in total. The anode (cathode) signals are digitized at the chamber by pipeline TDC's (ADC's) after pulse shaping; the cathode read-out requires special care because there will be two pulses with slightly different timings on the same cathode due to the electron-positron pair.

The design concepts have extensively been studied by Monte Carlo calculations for angle and energy resolutions and photon vetoing capabilities. Several prototypes have been built to study the performance of the chamber and scintillator read-out using wave-length-shifting fibers, and to develop front-end electronics and construction techniques.