# KOPIO RSVP

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


Presented at the
SLAC Summer Institute 2004
by
Athanasios Hatzikoutelis, Virginia Tech, Blacksburg VA
Ilektra A. Christidi, SUNY at Stony Brook, NY

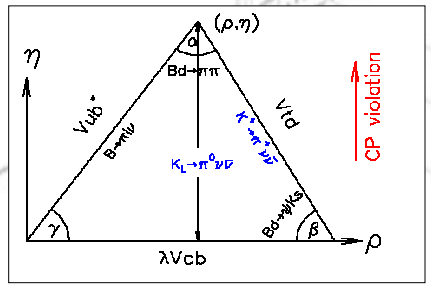

## Motivation

The "Golden" mode of decay for the $K_L^0$ is unique among potential SM observables. It is driven by direct CP violation due to the CP properties of the $K_l^0$ , $\pi^0$ and the relevant neutral transition current. To facilitate the SM prediction of the branching ratio (BR) of the decay and exhibit its relation to other measurements, Wolfenstein parameterization ($\lambda$,A,$\rho$,$\eta$) of the CKM matrix is employed. In this representation,

$$BR = 1.8 \cdot 10^{-10}\, \eta^2 A^4 X^2(m_t^2/M_W^2)$$

$$\cong (3.1 \pm 1.3) 10^{-11}$$

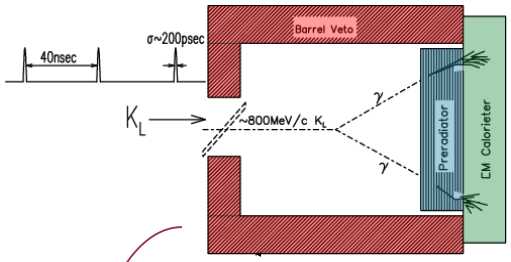
A clean measure of the height of the unitarity triangle is provided by the BR. All other parameters being known implies that the relative error in $\eta$ is half that on the BR.

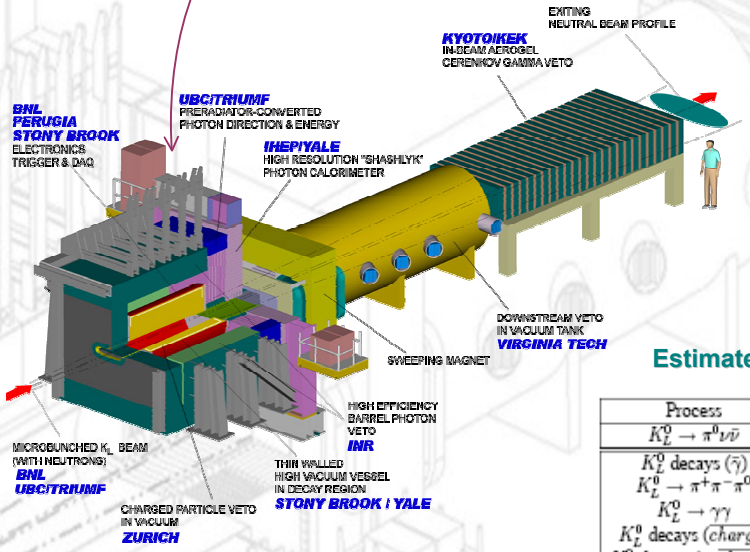



| | | | |
|---|---|---|---|
| $K_L^0 \to \pi^0 \nu\bar{\nu}$ | $\mathrm{Im}(V_{ts}^* V_{td})$ | KOPIO | $2A_\square = \left\|\mathrm{Im} V_{ts}^* V_{td}\right\| \lambda\left(1-\frac{\lambda^2}{2}\right)$ "Jarlskog invariant" $\|J_{cp}\|$ |
| $K^+ \to \pi^+ \nu\bar{\nu}$ | $\|V_{ts}^* V_{td}\|$ | E949 | |

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

The Standard Model level, with a single event sensitivity of below $10^{-12}$.



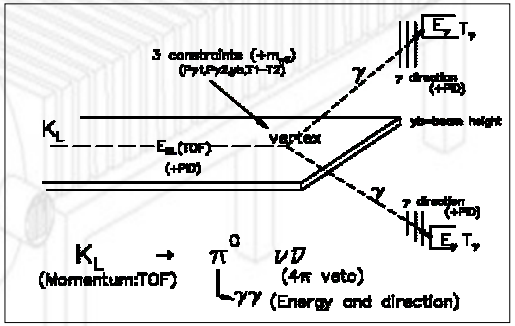




## May 2004 beam extinction test

Using a 4.5 MHz cavity for beam extraction from the AGS, a microbunch width of 3ns and an interbunch extinction (number of events between microbunches relative to the microbunch) of ~$10^{-5}$ was observed. The p-bars and $\pi$'s in the beam were electrostatically separated and the residual $\pi$'s suppressed by TOF cuts. Two small scintillators were used to trigger and measure the timing of the microbunched beam, and a 3x3 prototype shashlyk calorimeter was used for the energy measurement. The extinction result is better than what was predicted by

**Measuring :**

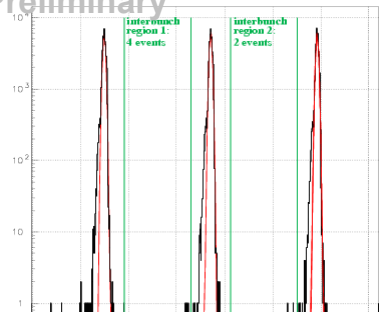
- Time of flight of the $K_L$ to allow kinematic selection to reject backgrounds.
- The converted $\gamma$ direction.
- The $\gamma$ energies with high precision.
- All other detectable particles that are emitted in the decay in order to veto the events




## Estimated event levels for signal and backgrounds :

| Process | Modes | Main source | Events |
|---|---|---|---|
| $K_L^0 \to \pi^0 \nu\bar{\nu}$ | | | 41 |
| $K_L^0$ decays $(\bar{\gamma})$ | $\pi^0\pi^0,\pi^0\pi^0\pi^0,\pi^0\gamma\gamma$ | $\pi^0\pi^0$ | 12.8 |
| $K_L^0 \to \pi^+\pi^-\pi^0$ | | | 0.65 |
| $K_L^0 \to \gamma\gamma$ | | | 0.02 |
| $K_L^0$ decays $(\overline{charge})$ | $\pi^\pm e^\mp\nu, \pi^\pm\mu^\mp\nu, \pi^+\pi^-$ | $\pi^-e^+\nu$ | 0.02 |
| $K_L^0$ decays $(\bar{\gamma}, \overline{charge})$ | $\pi^\pm l^\mp\nu\gamma, \pi^\pm l^\mp\nu\pi^0, \pi^+\pi^-\gamma$ | $\pi^-e^+\nu\gamma$ | 4.4 |
| Other particle decays | $\Lambda \to \pi^0 n, K^- \to \pi^-\pi^0, \Sigma^+ \to \pi^0 p$ | $\Lambda \to \pi^0 n$ | 0.01 |
| Interactions | n, $K_L^0$, $\gamma$ | $n \to \pi^0$ | 0.2 |
| Accidentals | n, $K_L^0$, $\gamma$ | n, $K_L^0$, $\gamma$ | 0.8 |
| Total Background | | | 18.9 |

Preliminary




**Current Status and Schedule**

- Technologies have matured in an R&D phase for 3 years.
- Receiving $2.5M this year for "advanced planning".
- Integration and configuration control initialized.
- Re-baselining of the detector is in process with the review set in early 2005.
- RSVP construction starts in FY05 as requested in the NSF budget