Prospects for Measuring $K \to \pi\nu\bar{\nu}$ at Fermilab Project X

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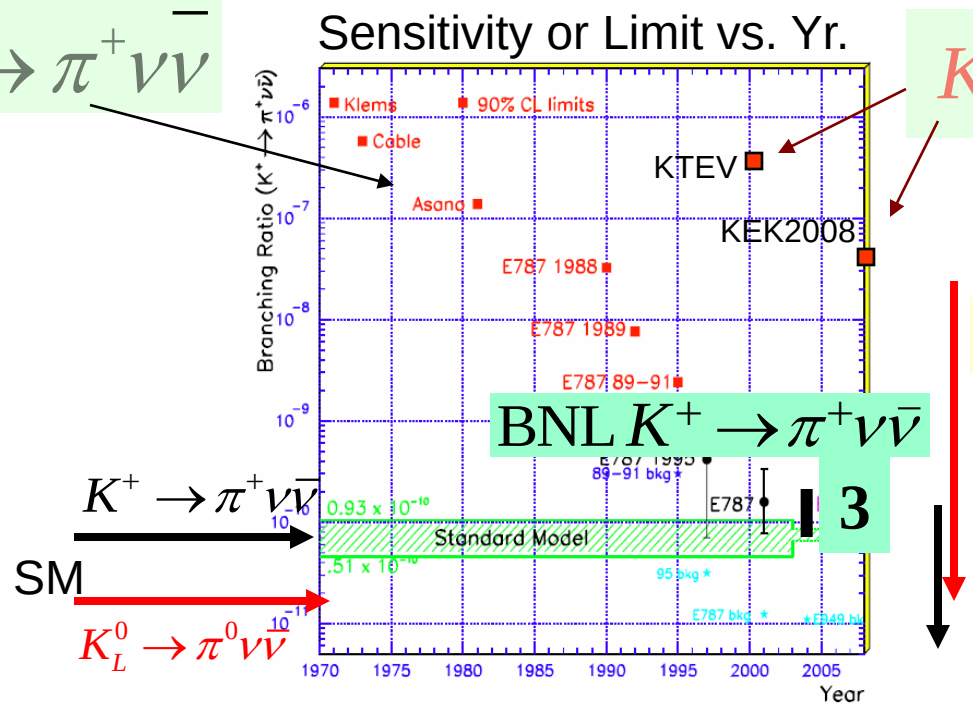
$K \to \pi\nu\bar{\nu}$ Experiments

$K^+ \to \pi^+\nu\bar{\nu}$



$K^+ \to \pi^+\nu\bar{\nu}$

SM

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

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

CERN NA62?

J-PARC?

Project-X?

1000???

High duty factor; Long running.

$\mathrm{Br}(K^+ \to \pi^+\nu\bar{\nu})_{\mathrm{SM}} < (8.22 \pm 0.84)\ \mathrm{x}10^{-11}$

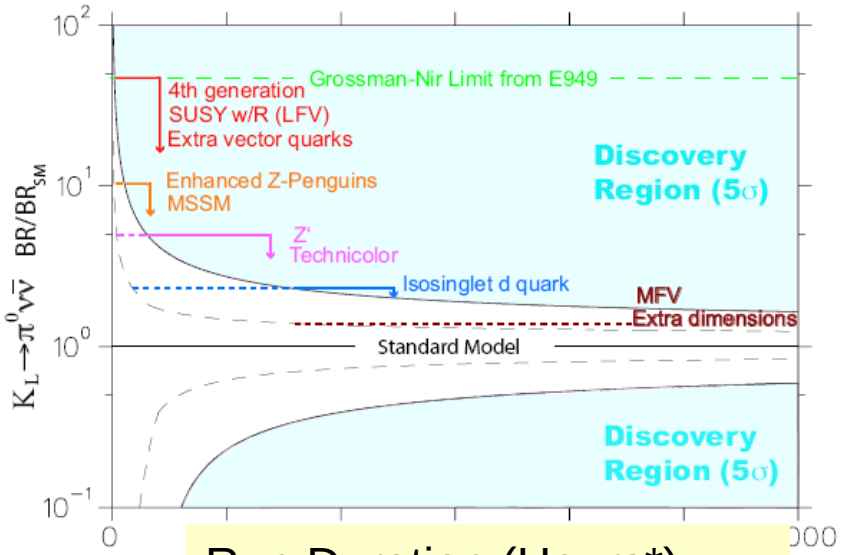
$\mathrm{Br}(K_L^0 \to \pi^0\nu\bar{\nu})_{\mathrm{SM}} < (2.76 \pm 0.40)\ \mathrm{x}10^{-11}$

High sensitivity experiments would expand the $K \to \pi\nu\bar{\nu}$ discovery potential.

$K_L^0 \to \pi^0\nu\bar{\nu}\,(BR/BR_{SM})$ *vs.* Events Observed

Experiment Sensitivity for SM Events

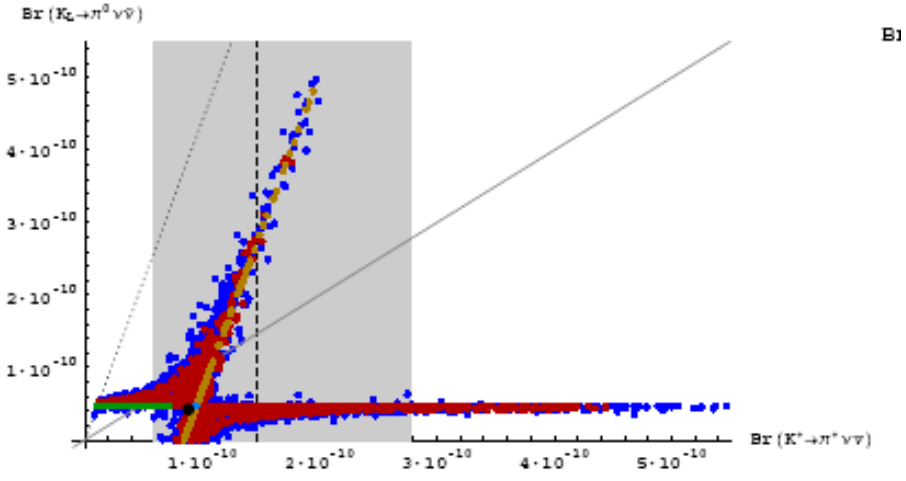
O(100) ⟶ O(1000)



New Physics Example:

$K_L^0 \to \pi^0\nu\bar{\nu}$ *vs.* $K^+ \to \pi^+\nu\bar{\nu}$

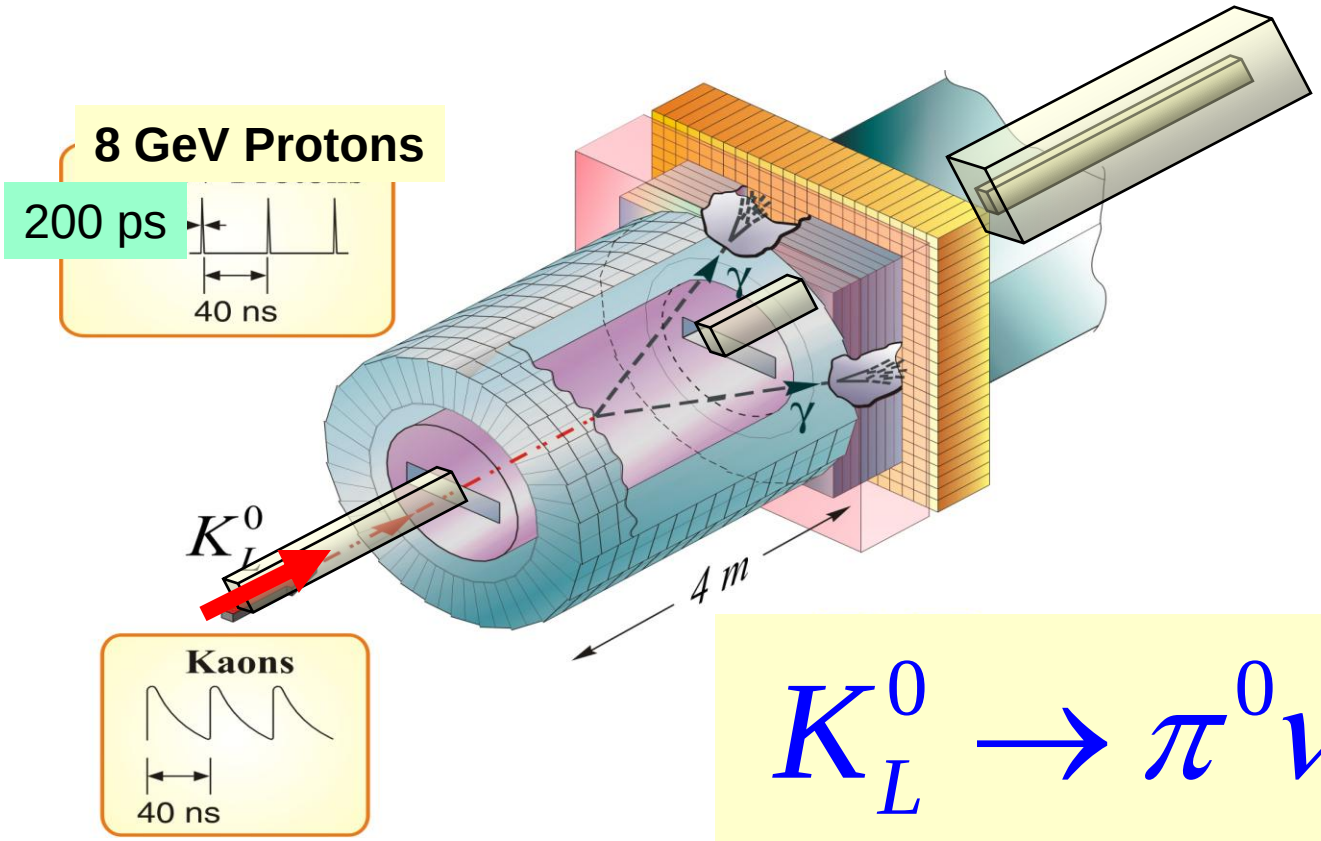
Littlest Higgs Model with T-parity



M. Blanke, *et al.*,arXiv:hep-ph/0610298.

*AGS

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



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

- Use TOF to work in the K_L^0 c.m. system
- Identify main 2-body background $K_L^0 \to \pi^0\pi^0$
- Reconstruct $\pi^0 \to \gamma\gamma$ decays with pointing calorimeter
- 4π solid angle photon and charged particle vetos

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

High intensity of Project X is ideal for the TOF-based K_L experiment.

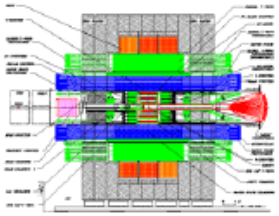
- Small aperture, symmetric beam - makes for simpler, higher acceptance detector
- Exploit advances in instrumentation

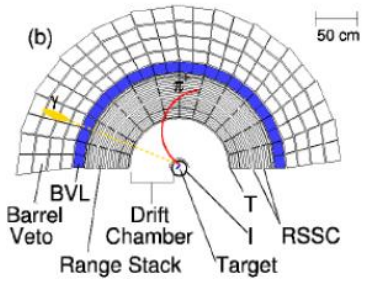
- 300 events/year at 1st stage of Project X;

  3% precision possible after 5 years.
- 5 times higher intensity could be used to get ~900 events/year

Compact High Field System for $K^+ \to \pi^+ \nu\bar{\nu}$

Improvement of techniques developed at BNL E787/949





- Low P_K ~400 MeV/c for high stopping efficiency
- Sci-Fi target and range stack for high rate

$\pi \to \mu \to e$ measurements

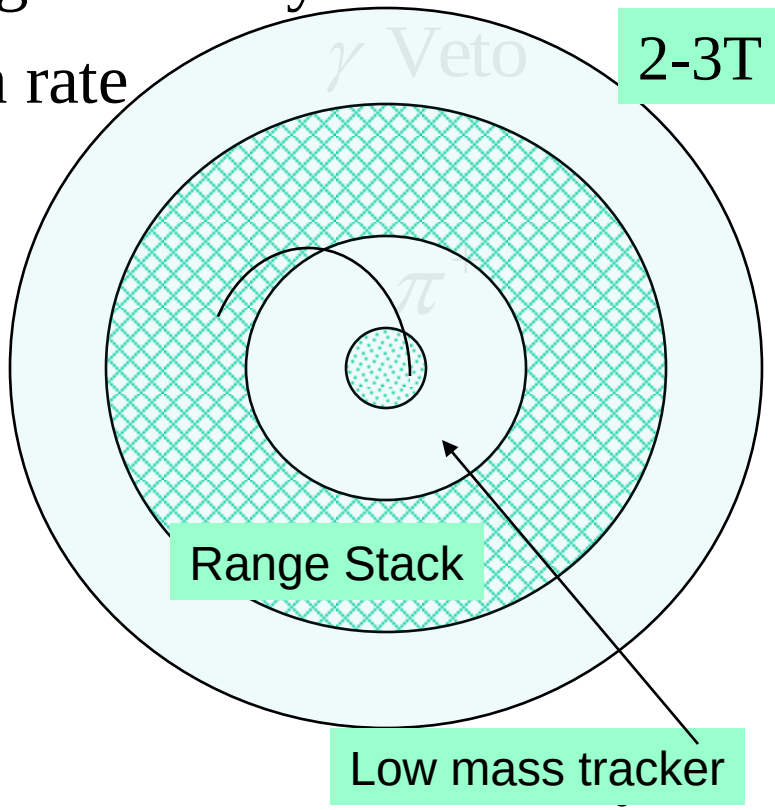
- High acceptance and precise

momentum measurement to suppress

$K^+ \to \pi^+\pi^0, K^+ \to \mu^+\nu$ backgrounds

- "Ideal" homogeneous photon veto

e.g. LXe 20 X_0



$K^+ \to \pi^+ \nu\bar{\nu}$	FNAL "Booster" (20 kW)	FNAL Project-X	FNAL Project-X Upgrade
Events/yr*	40	250	1500
Events/5yr	200	1300	7400
Precision**	**8**	**3**	**1.5**

***Estimates based on extrapolation of BNL E949.*

*** Includes separate estimates of backgrounds in Regions I (10%) and 2(75%)*.

Kaon Experiment Issues

- Details of scheme for delivering ~100% duty factor.
- Uncertainties in K production cross-sections at 8 GeV.
- Dual targeting for charged and neutral experiments appears feasible but needs examination.
- Some detector technology R&D would be valuable.
- Further development of CKM parameters (from theory and B physics) needed for 3% measurements.

Project X Kaon Working Group Conclusions:

- Precise measurements of $K^+ \to \pi^+ \nu\bar{\nu}$ and $K_L^0 \to \pi^0 \nu\bar{\nu}$ are highly motivated by exploration of high mass scale physics.
- Both $K^+ \to \pi^+ \nu\bar{\nu}$ and $K_L^0 \to \pi^0 \nu\bar{\nu}$ experiments appear feasible collecting O(1000) events at the SM levels.

World leading experiments could begin at low 8-GeV beam power (20 kW) and transition to the high power Project-X era.