Future K experiments at the AGS

Organizers: S. Kettell, L. Littenberg, M. Marx

RHIC/AGS Users' Meeting 12 May 2004

A2: Future K Experiments at the AGS

- **When:** 13 May 2004, starting 9am
- **Where:** Hamilton Seminar Room (Chemistry)
- **What:** Scheduled and possible K experiments to be run at the AGS in the next decade
- **What else:** Context for this – current status and future plans for K experiments elsewhere, theoretical perspectives
- **Who:** those working in, or interested in working in this area, those with new ideas…

What’s it all about?

- Great opportunity to economically carry out AGS experiments between RHIC fills
  - One example of DOE doing so
  - NSF getting involved
- Known excellent “targets” in K decay
  - We’ll hear about the two already being exploited
- New ones may emerge
  - [your idea here]
- Need to examine opportunities in light of what is being done (& likely to be done) elsewhere

Agenda

- E949 – S. Kettell
- KTeV – J. Whitmore
- NA48 present – S. Giudici
- Lepton flavor violation (theory) – R. Shrock
- Lepton flavor violation (experiment) – A. Bellavance
- $K \rightarrow \pi\nu\bar{\nu}$ Theory – Y. Grossman
- KLOE – M. Moulsen
- OKA – D. Vavilov
- NA48 future – G. Ruggiero
- K experiments in Japan – T. Komatsubara
- Future Kaon program at FNAL – P. Cooper
- Plans for Ke3 at BNL – J. Comfort
- KOPIO – D. Bryman

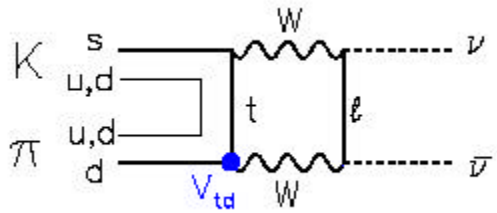
Recent History at AGS

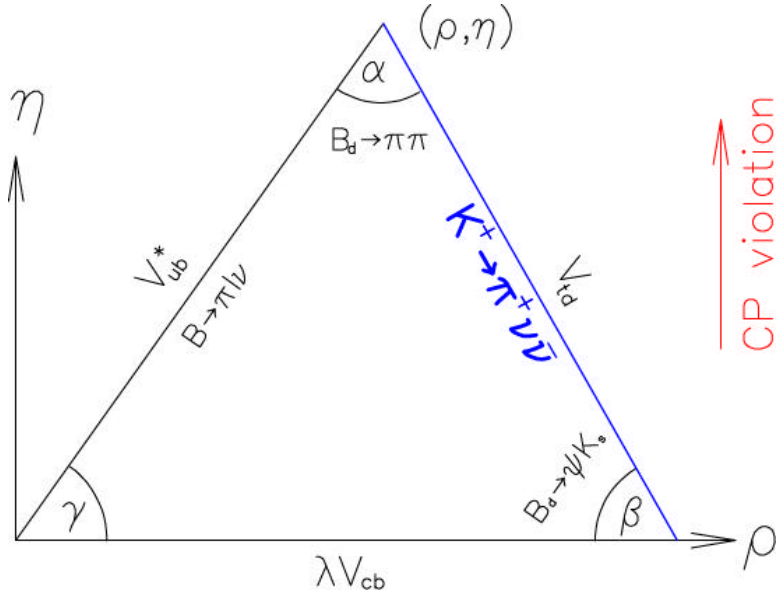
Experiment	Beam	Flux (TP)	s.e.s	result
E787 $K^+ \to \pi^+ \nu\nu$	0.7GeV/c separated	10-30	8×10^{-11}	$1.6^{+1.8}_{-0.8} \times10^{-10}$
E865 $K^+ \to \pi^+ \mu^+ e^-$	~6GeV/c unsepar.	~10	5×10^{-12}	$<1.2\times10^{-11}$
E871 $K_L \to \mu e$	$\langle p_k \rangle$ ~ 4GeV/c	~15	2×10^{-12}	4.7×10^{-12}

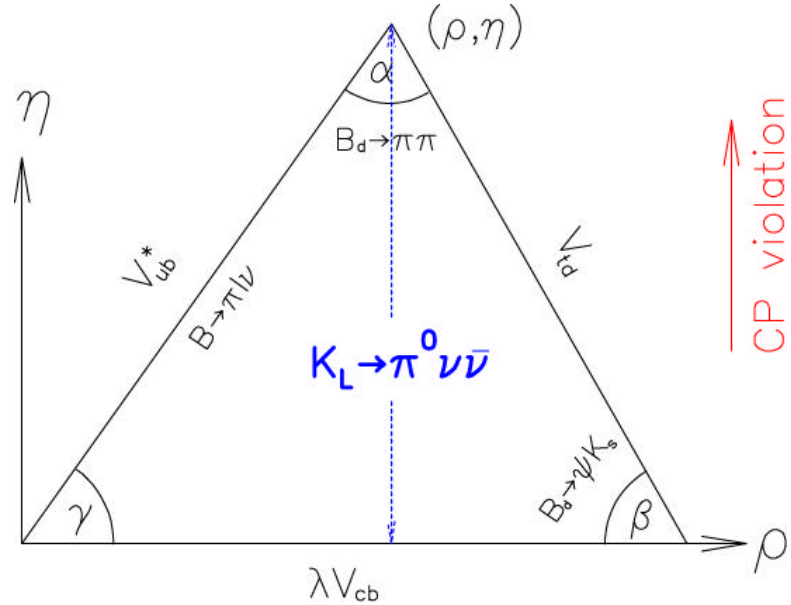
Current/upcoming AGS Exps

Experiment	Beam	Flux (TP)	s.e.s	result
E949 $K^+ \rightarrow \pi^+ \nu\nu$	0.7GeV/c separated	70	$\sim 1.5\times10^{-11}$	$\sim 1.5\times10^{-10}$
KOPIO $K_L \rightarrow \pi^0 \nu\nu$	$\langle p_K \rangle \sim$ 0.6GeV/c μbunched	100	$\sim 7\times10^{-13}$	$\sim 3\times10^{-11}$

Already on the menu: $K \to \pi \nu \bar{\nu}$







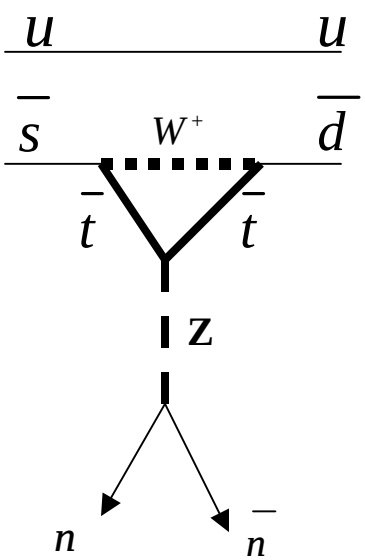
$BR(K^+) \propto |V_{td}|^2$

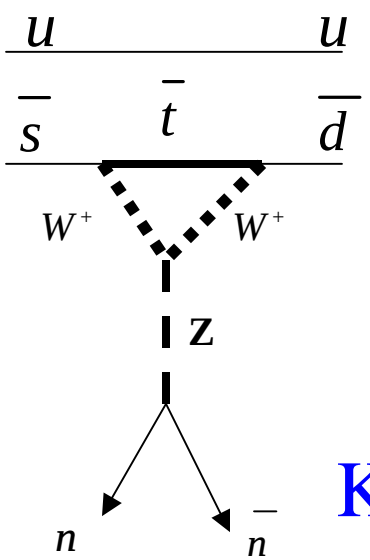
$BR(K_L) \propto (\mathrm{Im}\, V_{td})^2$

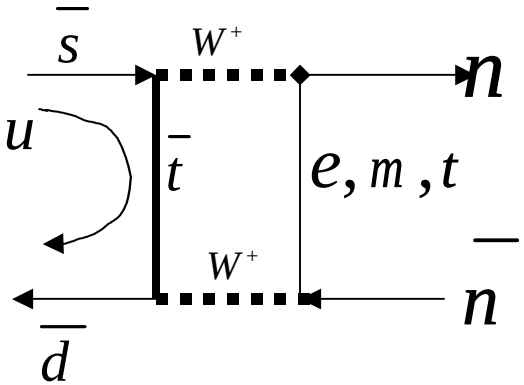
$K \to p n \bar{n}$: Standard Model

Negligible long distance effects. Top quark dominance.

Hadronic matrix elements ($K \to p$) from $K \to p\, e n$.







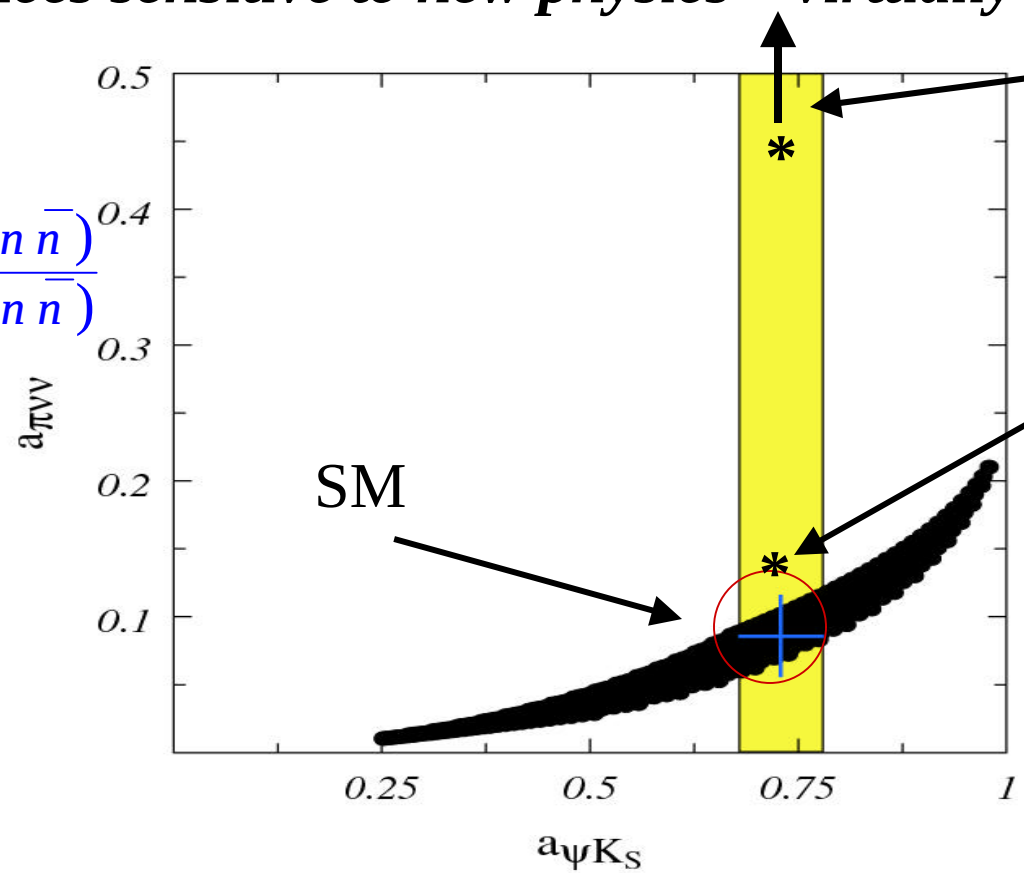
	$K^+ \to p^+ n \bar{n}$	$K_L^0 \to p^0 n \bar{n}$
Branching Ratio (10^{-11})	8.0 ± 1.1	3.2 ± 0.6
Theoretical Uncert. (est.)	7%	2%

Buchalla and Buras, Nucl. Phys. ***B548****, 309 (1999); Buras et al.,hep-ph/0402112; Isidori,hep-ph/307014.*

$\mathbf{B} \to y\ K_S$ *and* $\mathbf{K} \to p\ n\ \overline{n}$

Differences sensitive to new physics – virtually free of uncertainties.

$$\frac{\Gamma(\mathbf{K}_L^0 \to p^0 n \overline{n})}{\Gamma(\mathbf{K}^+ \to p^+ n \overline{n})}$$



* "Enhanced" Z^0 Penguins

$\Gamma(K^+)$ x 1; $\Gamma(K_L^0)$ x 12

$\sin(2b_x) = -0.69$

(Buras et al. hep-ph/040211)

* Minimal Flavor Viol.

$\Gamma(K^+)$ x 2; $\Gamma(K_L^0)$ x 4

(Buras hep-ph/0310208)

* Multiple Higgs

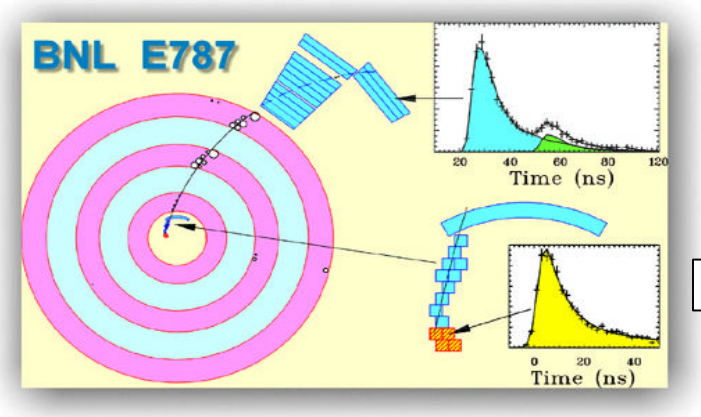
* Extra dimensions

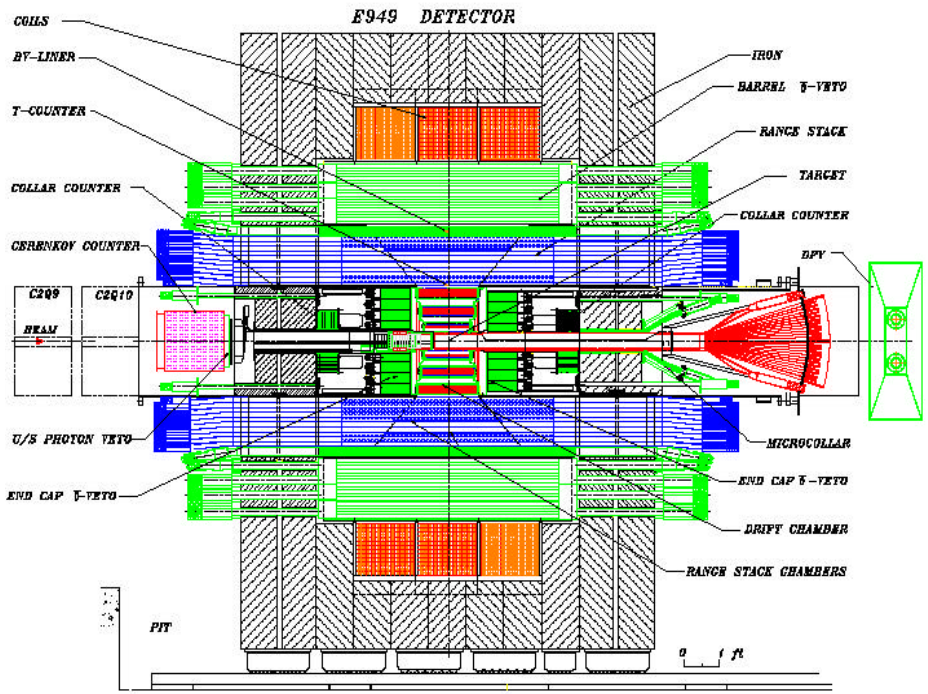
* Low energy SUSY

CP asymmetry in $\mathbf{B} \to y\ K_S$

Nir and Worrah, Phys. Lett. **B423**,319 (1998)

E949 – Measurement of $B(K^+ \rightarrow \pi^+ \nu \bar{\nu})$





$75M Expenditure including $10M Upgrade of E787

Contributing Countries and Institutions:

US --- BNL, FNAL, University of New Mexico, Stony Brook

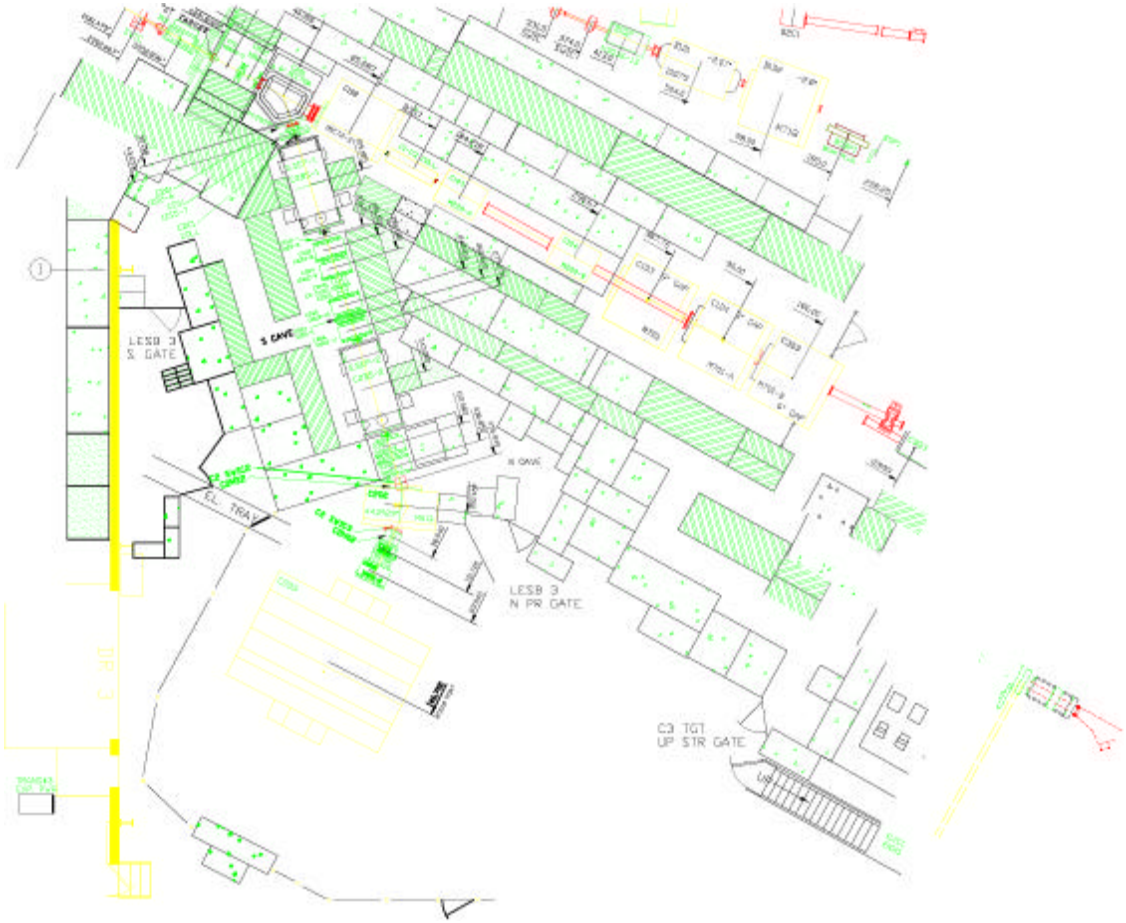
Japan --- Fukui, KEK, Kyoto, National Defense Academy, Osaka, RCNP

Canada --- Alberta, University of British Columbia, TRIUMF

Russia --- IHEP, INR

E949 Beamline

Very pure separated
low energy beam,
600-800 MeV/c
80% K^+
Up to ~25M K^+/pulse
(can stop ~ 25%)



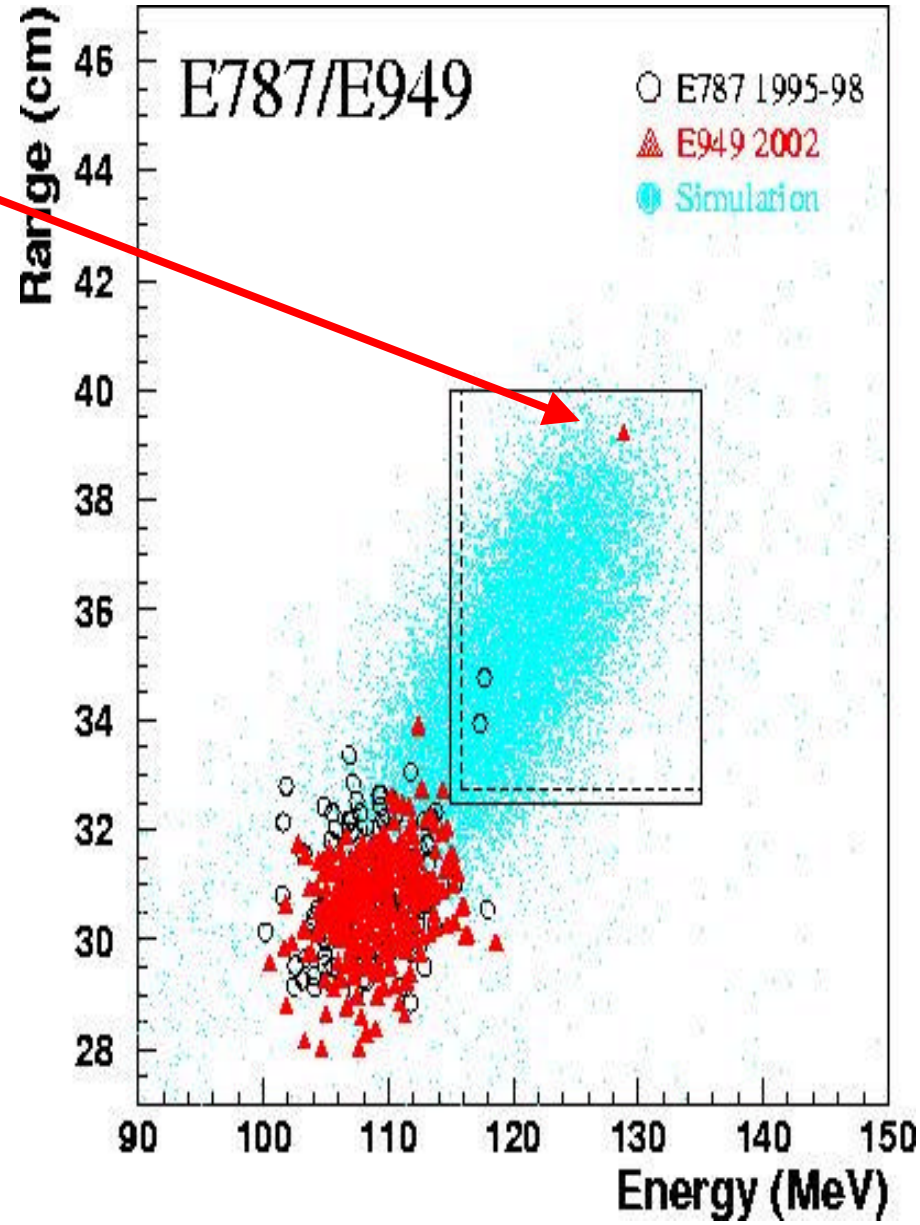
E949 Results

- E949 has observed a **3rd** $K^+ \rightarrow \pi^+ \nu\bar{\nu}$ event:

$$\mathbf{B(K^+ \rightarrow \pi^+ \nu\bar{\nu}) = 1.47^{+1.30}_{-0.89} \times 10^{-10}}$$

(SM: 0.8 $\times 10^{-10}$)

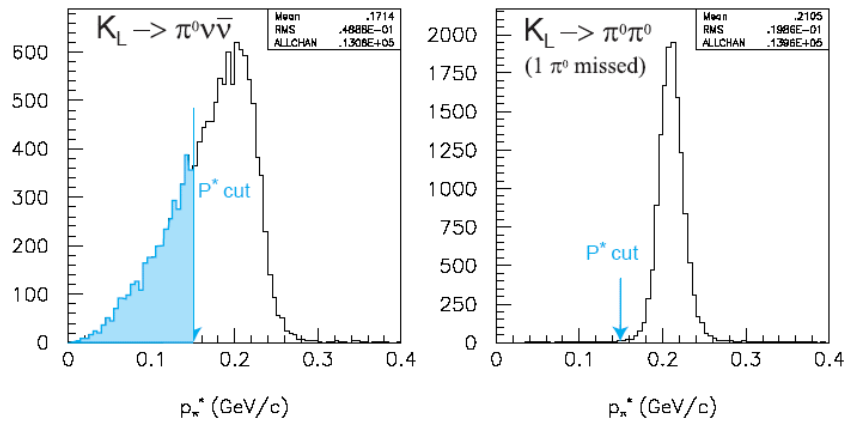
  - $0.006 < |V_{td}| < 0.027$
  - $-0.77\times10^{-3} < Re\lambda_t < 1.06\times10^{-3}$
  - $0.23\times10^{-3} < |\lambda_t| < 1.06\times10^{-3}$
  - $|Im\lambda_t| < 0.89\times10^{-3}$
- Submitted to PRL

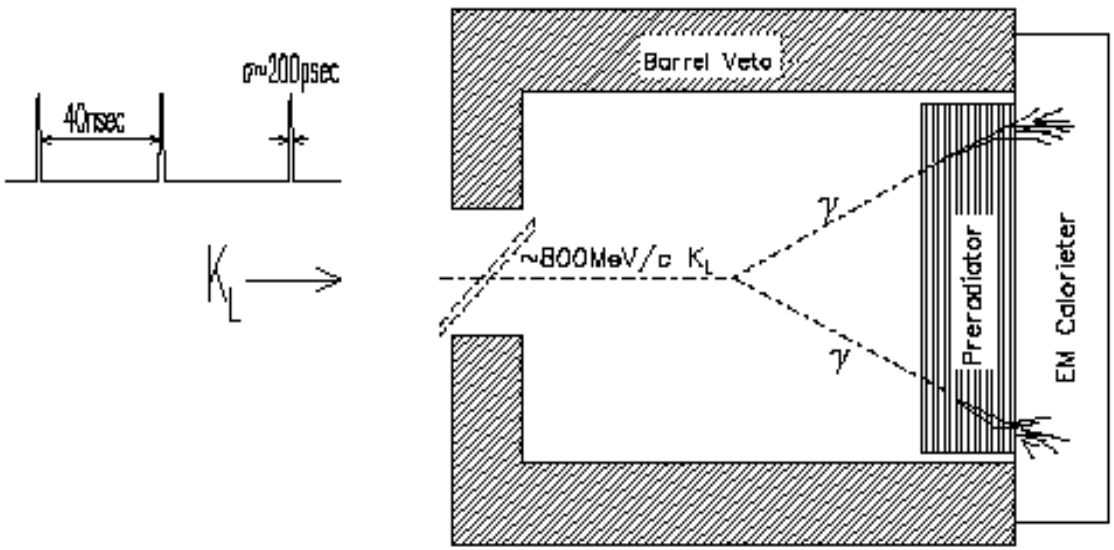


KOPIO: Measurement of $K_L^0 \to \pi^0 \nu \bar{\nu}$

CONCEPTS

- Measure as much as possible:
  Energy, position and $ANGLE$ of each photon.
- Work in the C.M. system :
  Use TOF to get the K_L^0 momentum.
- Maximize Photon Veto Efficiency
- Maximize Intensity of Microbunched Beam





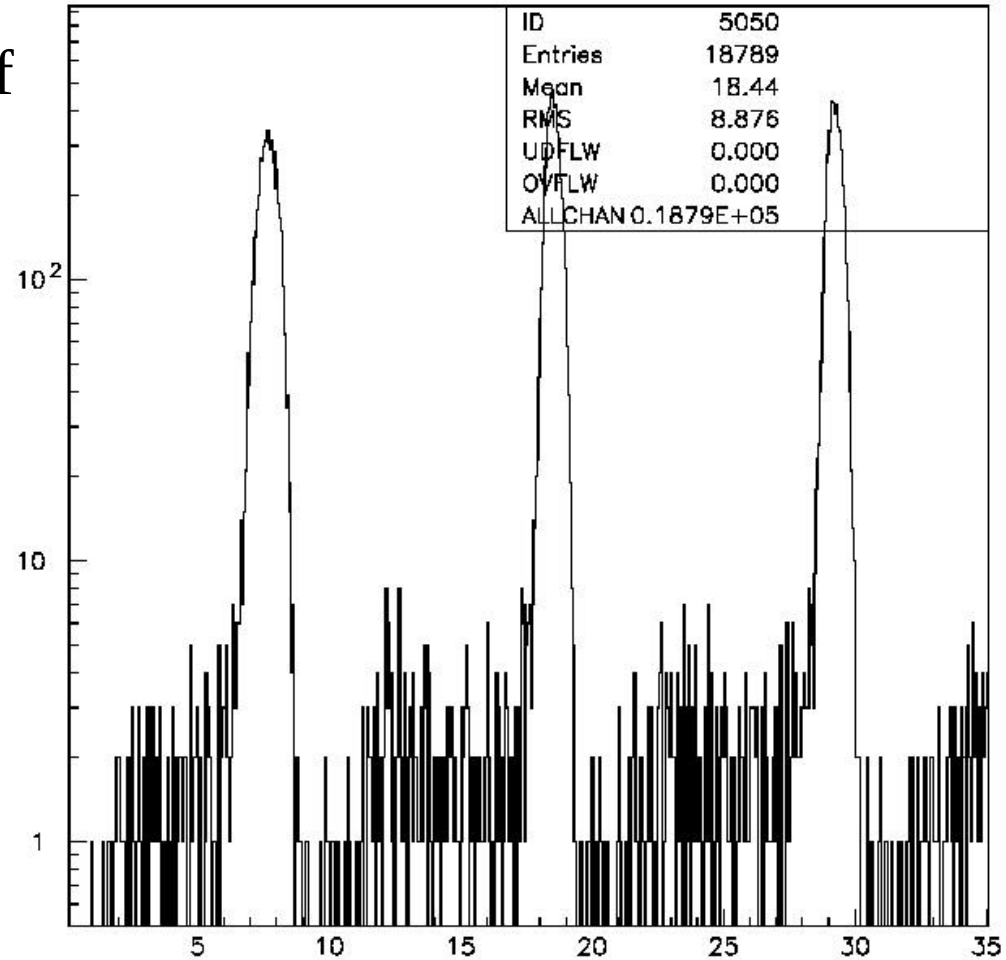
Aim:
>40 events
With S:B>2:1

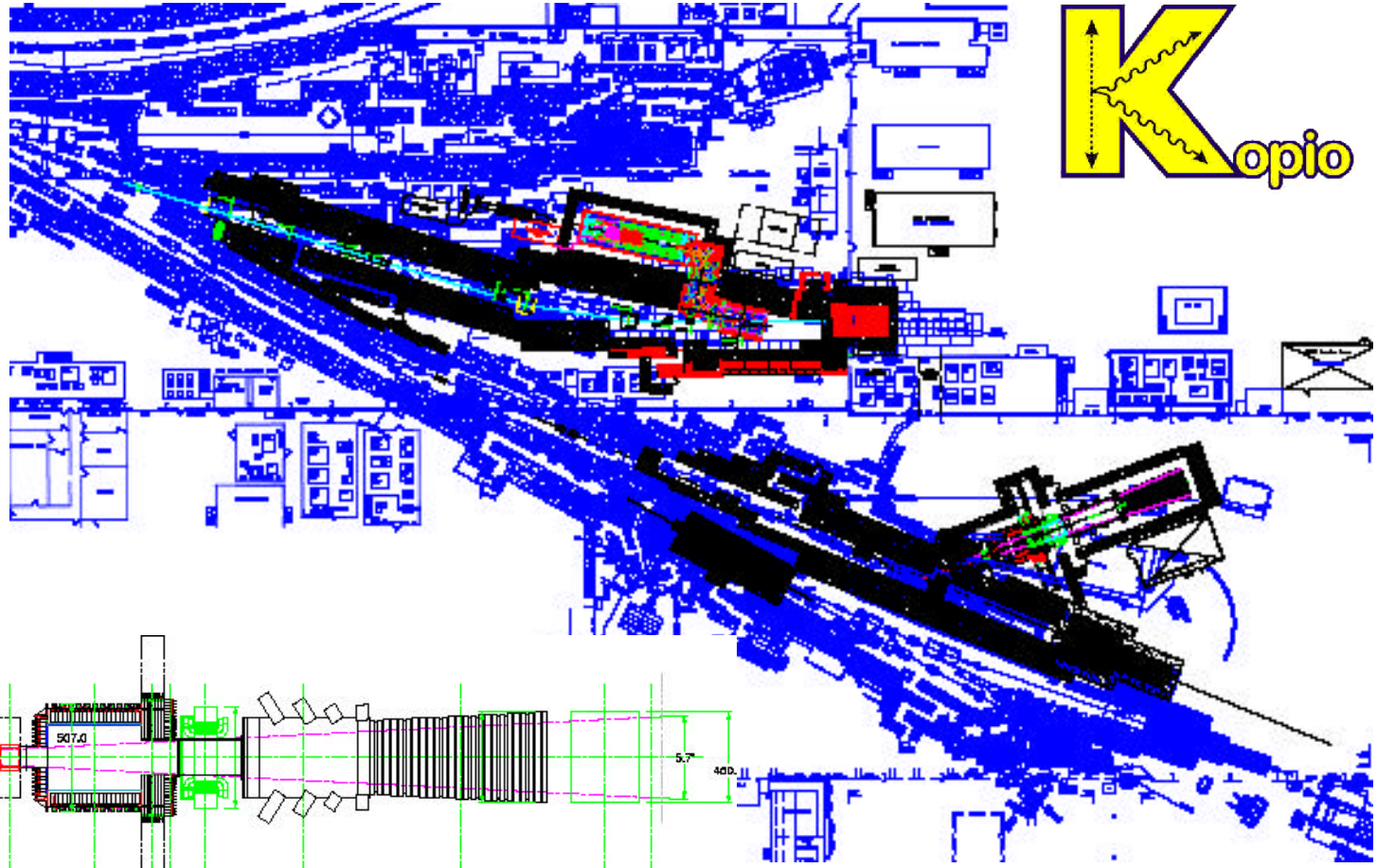
Microbunched Beam

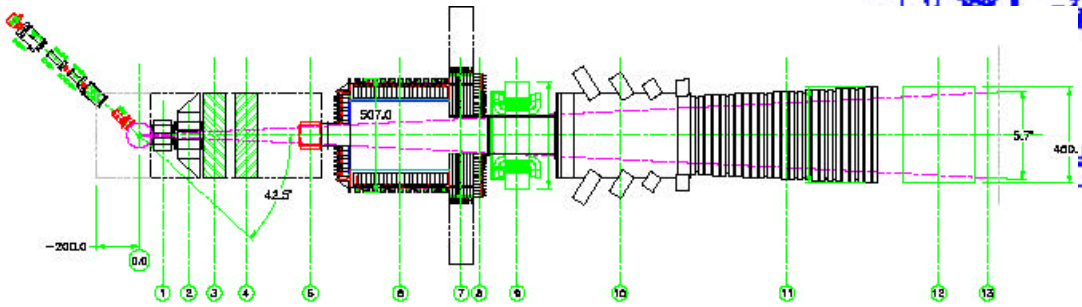
KOPIO needs bunches of 200-300ps every 40 ns, extinction <10^{-3} between

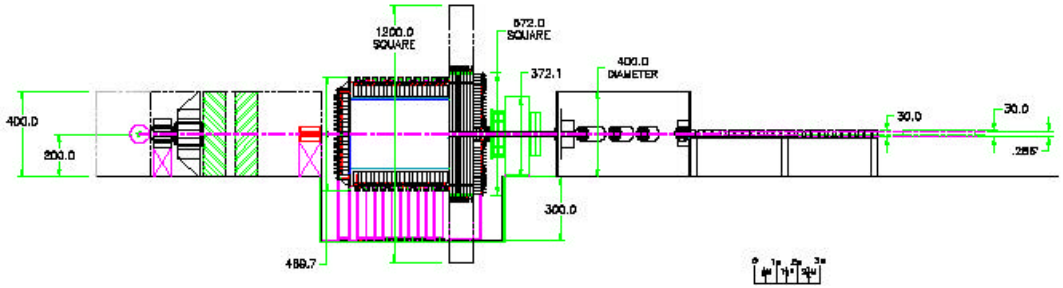
Bunch width achieved, working on extinction

Bunching technique could be used in other beams, for other purposes

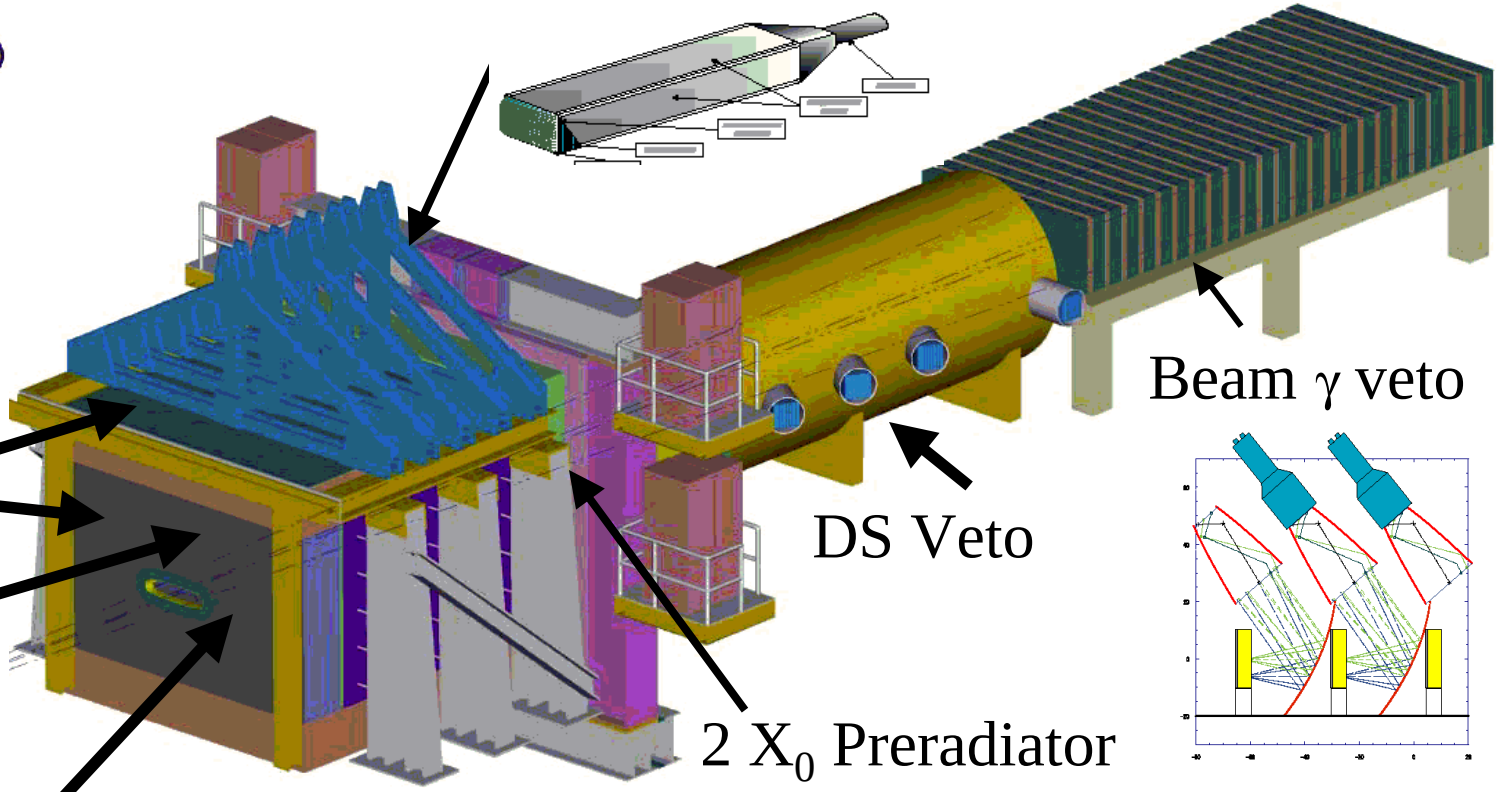





507.0
42.5°
-200.0
0.0
5.7°
400.
1
2
3
4
5
6
7
8
9
10
11
12
13


1200.0
SQUARE
572.0
SQUARE
372.1
400.0
DIAMETER
400.0
200.0
30.0
30.0
.286°
300.0
489.7

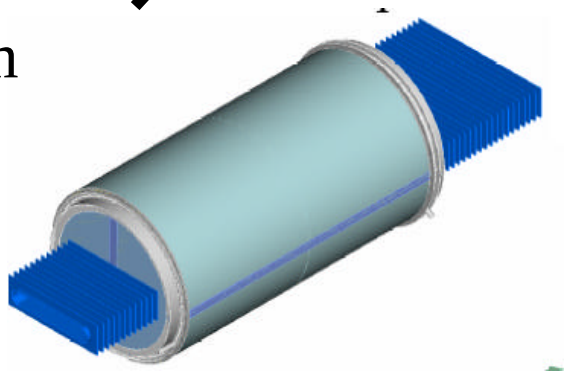
Shashlyk calorimeter



Barrel, US Veto

CP veto

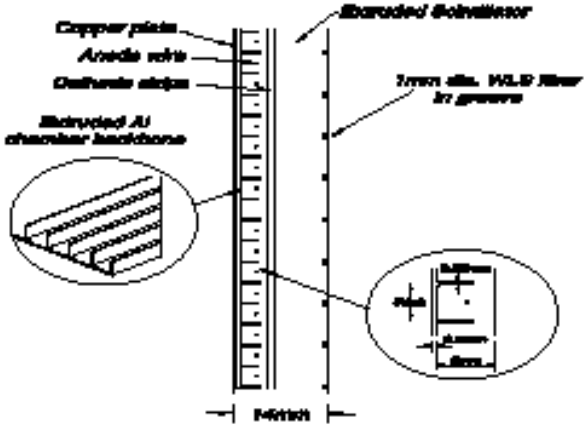
Vacuum tank



DS Veto

Beam γ veto

2 X_0 Preradiator



Other Experiments Discussed for AGS

- Ke3 check of CKM unitarity
  - There's a talk about this tomorrow
- $K^+ \rightarrow \pi^0 \mu^+ \nu_\mu$ polarization (multi-Higgs)
  - Recently done at KEK
- $K^+ \rightarrow \pi^+ \mu^+ \mu^-$ polarization ($|V_{td}|$)
- $K_L \rightarrow \pi^0 \mu^+ \mu^-$ polarization (CP-violation)

Last Thoughts

- Upcoming program supported by NSF
- Additional experiments cheap to run
  - Although proton economics non-trivial
- Smaller scale (sociological advantages)
- Interesting AGS capabilities facilitate new ideas
  - Unprecedented intensities
  - μbunching of various sorts
  - Low energies (can time K's, stop them, stop μ's)
- Workshop will help refine any new ideas
- Near term opportunities
  - Open KOPIO collaboration meeting Friday