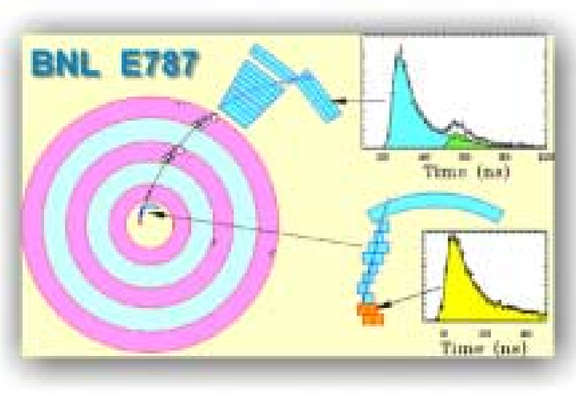


BNL HEP Seminar
June 8, 2000

$K^+ \to \pi^+ \nu \overline{\nu}$: E949/CKM

- Overview of the E787 $K^+ \to \pi^+ \nu \overline{\nu}$ search.
- Status of E949.
- The CKM experiment.
- Conclusions.

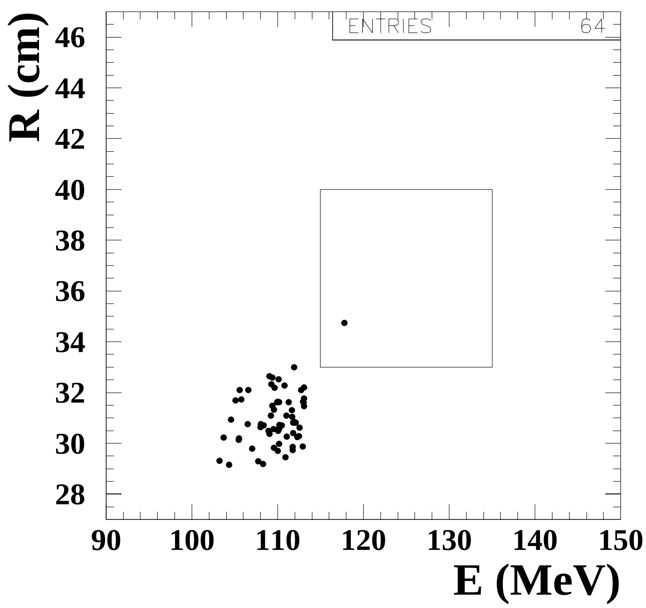
Steve Kettell
Brookhaven National Laboratory

Brookhaven Science Associates
U.S. Department of Energy

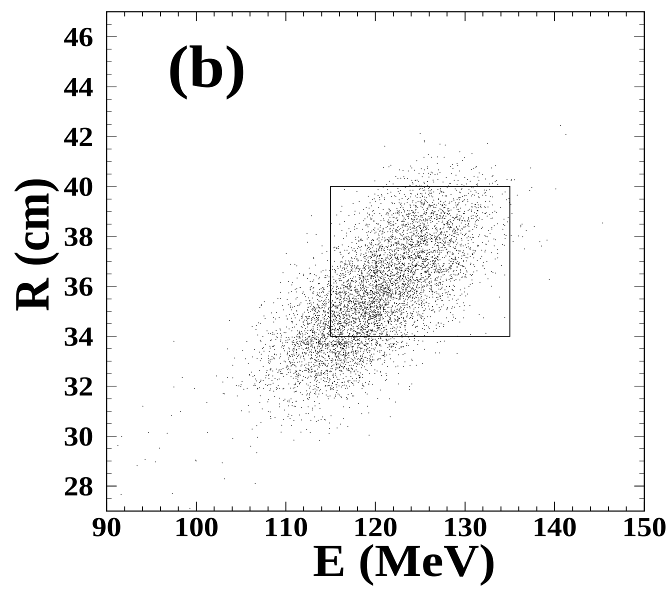
BROOKHAVEN NATIONAL LABORATORY

$K^+ \to \pi^+ \nu \overline{\nu}$ Event

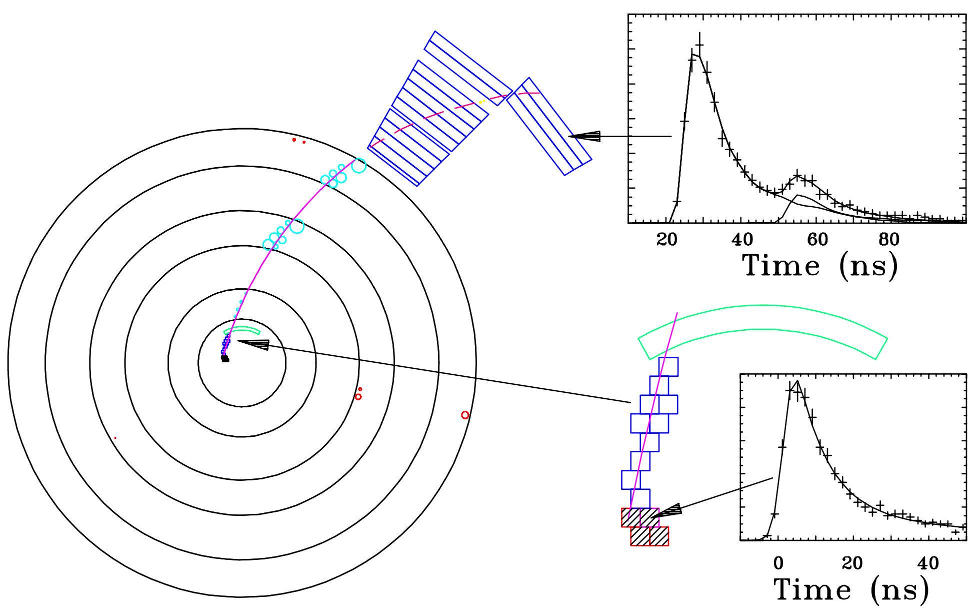
1995–97 Data



Monte Carlo



Event Display

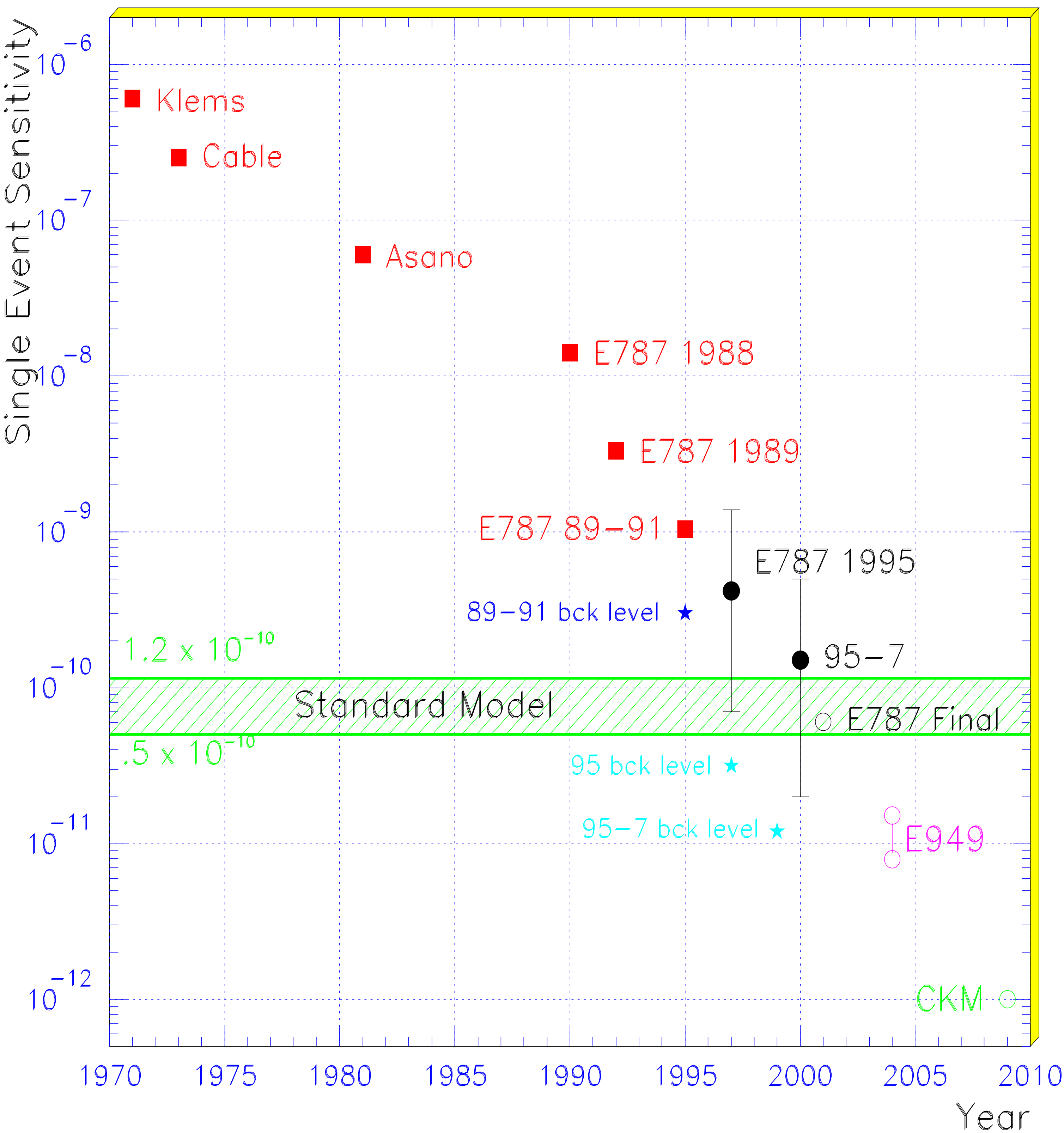


$$\mathbf{BR}(K^+ \to \pi^+ \nu \overline{\nu}\ ) = 1.5^{+3.4}_{-1.2} \times 10^{-10}$$

SM: $\mathrm{BR}(K^+ \to \pi^+ \nu \overline{\nu}\ ) = 0.75 \pm 0.29 \times 10^{-10}$ (from CKM fits)

[1995: PRL **79**, 2204 (1997), 1995–7: PRL **84**, 3768 (2000)]

History of the Search for $K^+ \to \pi^+ \nu \bar{\nu}$



CKM Matrix and CP-Violation

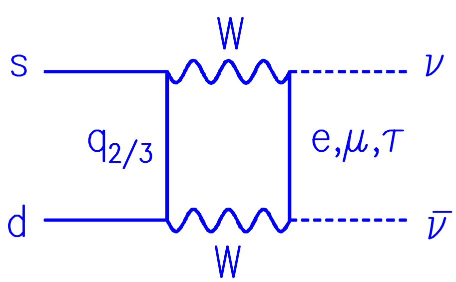
$$V_{\rm CKM} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} \simeq \begin{pmatrix} 1-\lambda^2/2 & \lambda & A\lambda^3(\overline{\rho}-i\overline{\eta}) \\ -\lambda & 1-\lambda^2/2 & A\lambda^2 \\ A\lambda^3(1-\overline{\rho}-i\overline{\eta}) & -A\lambda^2 & 1 \end{pmatrix}$$

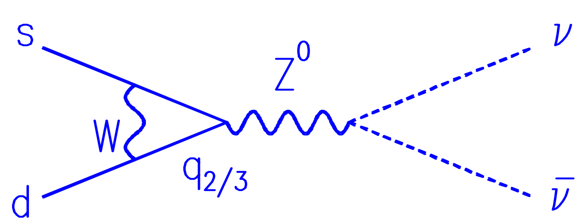
$$\overline{\rho} = \rho(1-\frac{\lambda^2}{2}) \qquad \overline{\eta} = \eta(1-\frac{\lambda^2}{2})$$

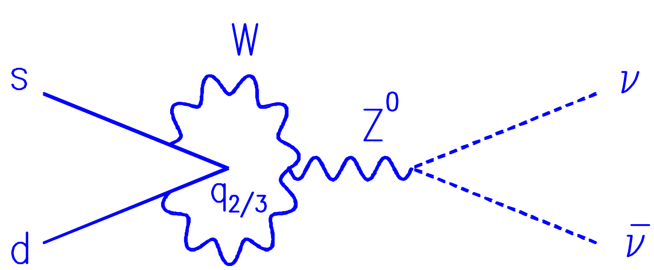
$K\to\pi\nu\overline{\nu}$: The Golden Modes

- $K^+\to\pi^+\nu\overline{\nu}$: measure $|\lambda_t| \equiv |V_{ts}^* V_{td}|$.
- $K_L^\circ\to\pi^\circ\nu\overline{\nu}$: direct CP violating, measure $Im(\lambda_t) = Im(V_{ts}^* V_{td})$.

  This is the best way to measure $Im(\lambda_t)$ and the Jarlskog invariant J_{CP}.

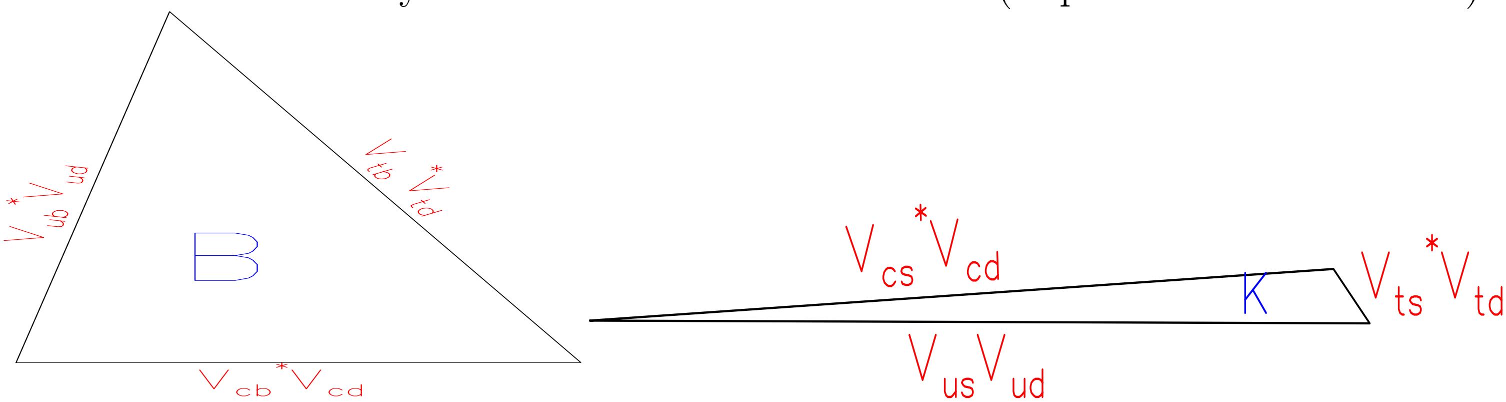




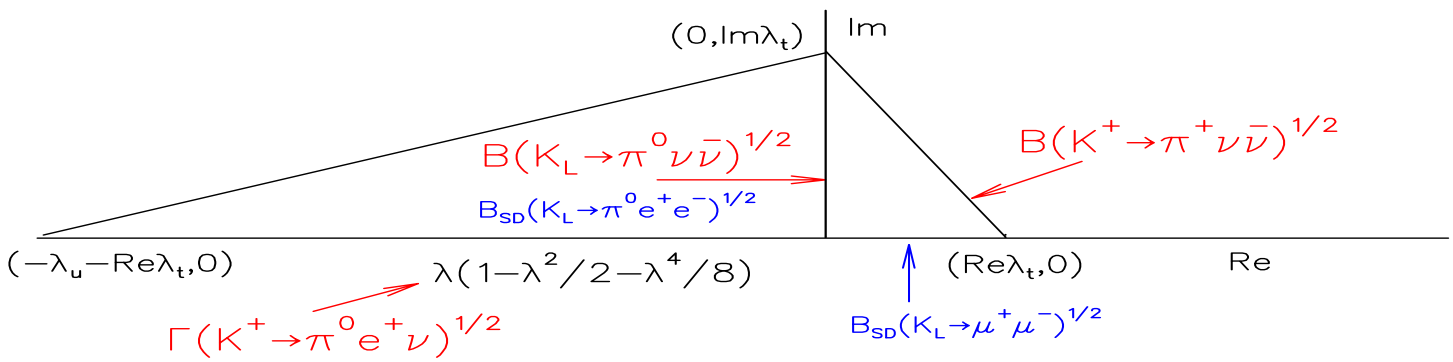


Rare Kaon Decays and the CKM Matrix

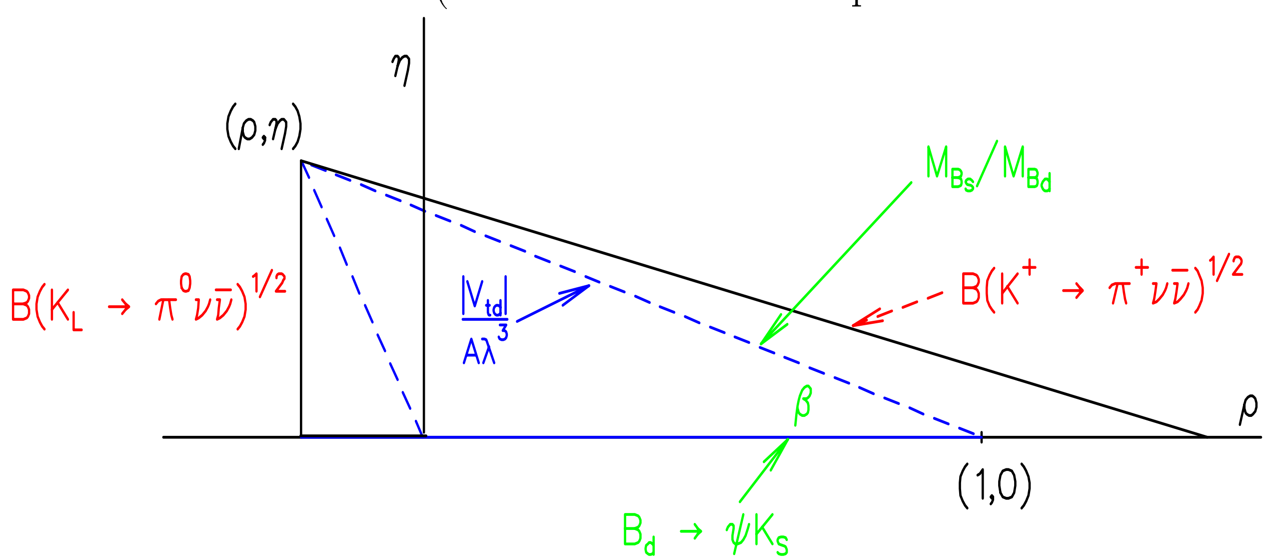
There are six unitarity relations: all should be tested (requires 3 measurements).



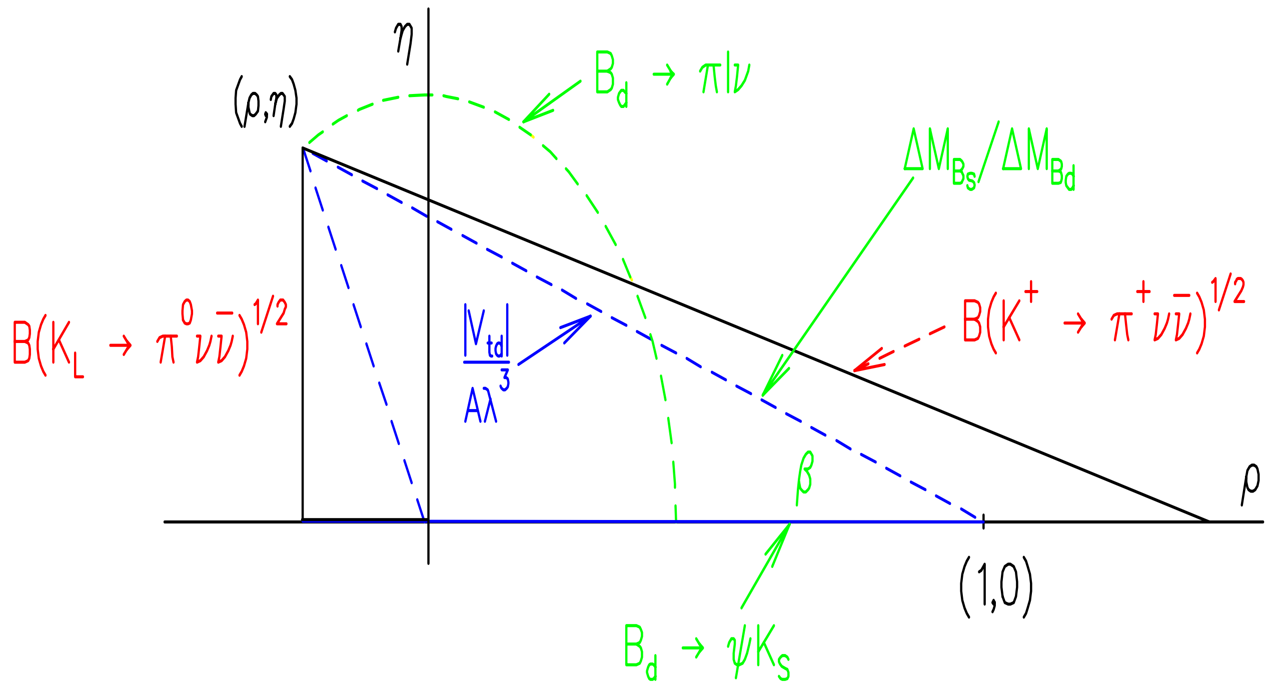
The fundamental measure of CP violation, J_{CP} is related to the area of the triangle and should be measured as well as possible (in as many ways as possible). In the kaon triangle, only two measurements are needed to determine the area: $K^+ \to \pi^\circ e^+ \nu_e$ and $K^\circ_L \to \pi^\circ \nu\overline{\nu}$; and we can completely determine the unitarity triangle with theoretically unambiguous measurements:.



Using only those modes with little or no theoretical ambiguity there are 4 constraints on the two variables (in the conventional representation of the triangle):



$\underline{K \to \pi\nu\overline{\nu}}$



From our current knowledge of the CKM parameters we obtain

$\underline{K^+ \to \pi^+\nu\overline{\nu}}$:

$$\begin{aligned} B(K^+ \to \pi^+\nu\overline{\nu}\ ) &= \frac{\kappa_+\alpha^2 B(K^+ \to \pi^\circ e^+\nu_e\ )}{2\pi^2\sin^4\theta_W|V_{us}|^{\ 2}} \sum_l |X_t V_{ts}^* V_{td}\ + X_c V_{cs}^* V_{cd}\ |^2 \\ &= 8.88\times 10^{-11} A^4[(\overline{\rho}_0 - \overline{\rho})^2 + (\sigma\overline{\eta})^2] \\ &= (0.82 \pm 0.32)\times 10^{-10} \end{aligned}$$

There is also a relation, free of theoretical ambiguity, between $\frac{\Delta M_{B_s}}{\Delta M_{B_d}}$ and $K^+ \to \pi^+\nu\overline{\nu}$:

$\mathrm{B}(K^+ \to \pi^+\nu\overline{\nu}\ ) < 0.4\times 10^{-10}\left[P_{charm} + A^2 X(x_t)\frac{r_{sd}}{\lambda}\sqrt{\frac{\Delta M_d}{\Delta M_s}}\right]^2$ with $r_{sd} = \frac{f_{B_s}\sqrt{B_{B_s}}}{f_{B_d}\sqrt{B_{B_d}}} < 1.4$

$\mathrm{B}(K^+ \to \pi^+\nu\overline{\nu}\ ) < 1.67\times 10^{-10}$

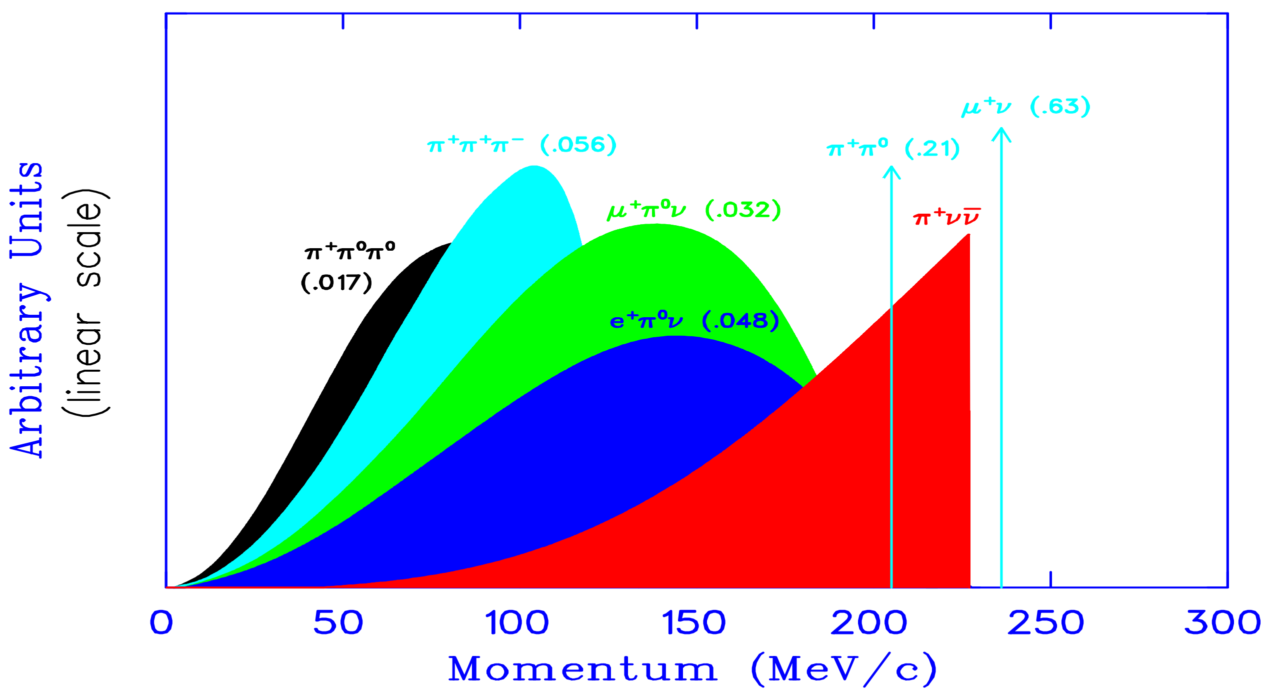
$\underline{K_L^\circ \to \pi^\circ\nu\overline{\nu}}$:

$$\begin{aligned} B(K_L^\circ \to \pi^\circ\nu\overline{\nu}\ ) &= \frac{\tau_{K_L}}{\tau_{K^+}}\frac{\kappa_L\alpha^2 B(K_{e3})}{2\pi^2 sin^4\theta_W|V_{us}|^{\ 2}} \sum_l |Im(V_{ts}^* V_{td})X_t|^2 \\ &= 4.08\times 10^{-10} A^4\eta^2 = 1.56\times 10^{-4}[Im(V_{ts}^* V_{td}\ )]^2 \\ &= (3.1 \pm 1.1)\times 10^{-11} \end{aligned}$$

$K^+ \to \pi^+ \nu \overline{\nu}$ Experimental Strategy

Measure everything possible

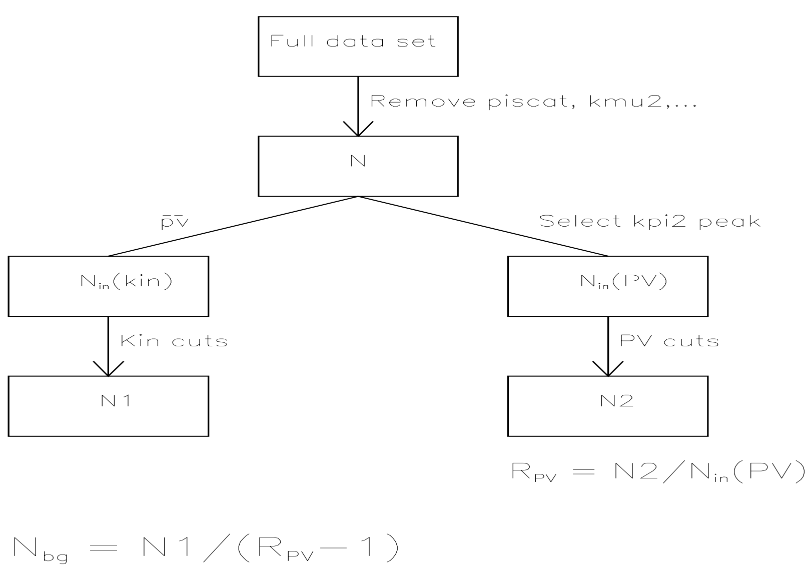
- Positively identify π^+.
- Veto extra particles.
- Measure kinematics with high resolution and redundancy.



- Suppress background by 10^{11}: B/S(SM) < 0.1
- Reliably **measure** background from data.

Analysis overview

- Blind analysis
  - Signal region is hidden (by inverting cuts) while cuts are developed and background levels estimated
  - In addition, blind analysis for background estimation.
    - Eliminate low statistics bias.
    - A fraction ($\sim 1/3$) of the data is used to set the cuts; actual cut performance is measured on the remaining data.
- "Bifurcated" analysis
  - A priori identification of background sources
  - Same dataset for background studies and signal search
  - Two independent cuts with high rejection for each background
  - Measurement of background in the signal region at $\mathcal{O}(10^{-3}\text{–}10^{-2})$ events
- Correlation studies
- Prediction of background levels around signal region (with confirmation)
- Background likelihood analysis (using predetermined likelihood functions) in the signal region for assessing candidate events.



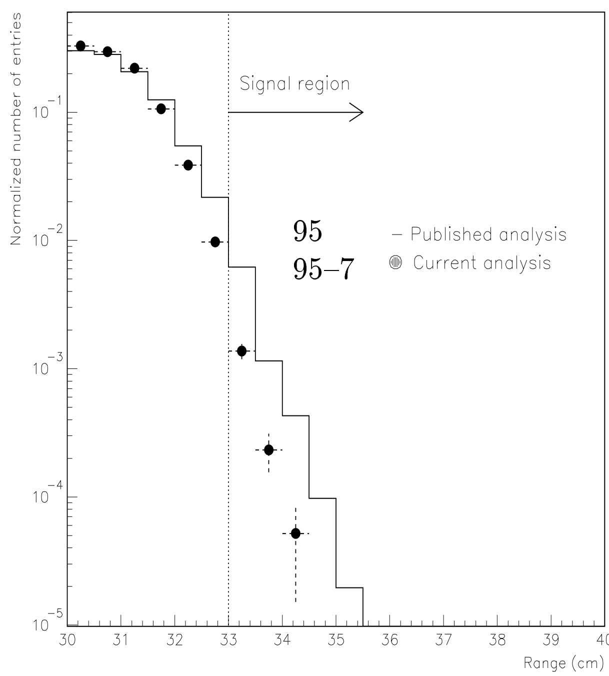
Analysis of 1995-7 dataset

Goals:

- Increase rejection by a factor of 3 to maintain same background level as 1995 (background level to 10% of SM signal)
- Maintain (or increase) acceptance
- Increase background samples (beyond increase in sensitivity)
- Further test understanding of the backgrounds

Improvements: (e.g. — kinematic rejection of $K^+ \to \pi^+ \pi^\circ$)

- π^+ kinematic quantities (R, E, & P) are used to reject $K_{\pi 2}$ background events.
- Reconstruction improvements led to a significant increase in rejection.
- Further rejection can be achieved without much loss of acceptance, particularly for the range cut.



Range (cm)

Background

	1995	1996-7	Total
$K^+ \to \pi^+ \pi^\circ$	0.015	0.006	0.021 ± 0.005
$K^+ \to \mu^+ \nu_\mu$	0.008	0.021	0.028 ± 0.010
1-beam	0.0026	0.0015	0.004 ± 0.003
2-beam	0.015	0.0005	0.016 ± 0.015
CEX	0.0045	0.005	0.010 ± 0.007
Total			0.08 ± 0.02

Background level is now 1.2×10^{-11} !

Acceptance

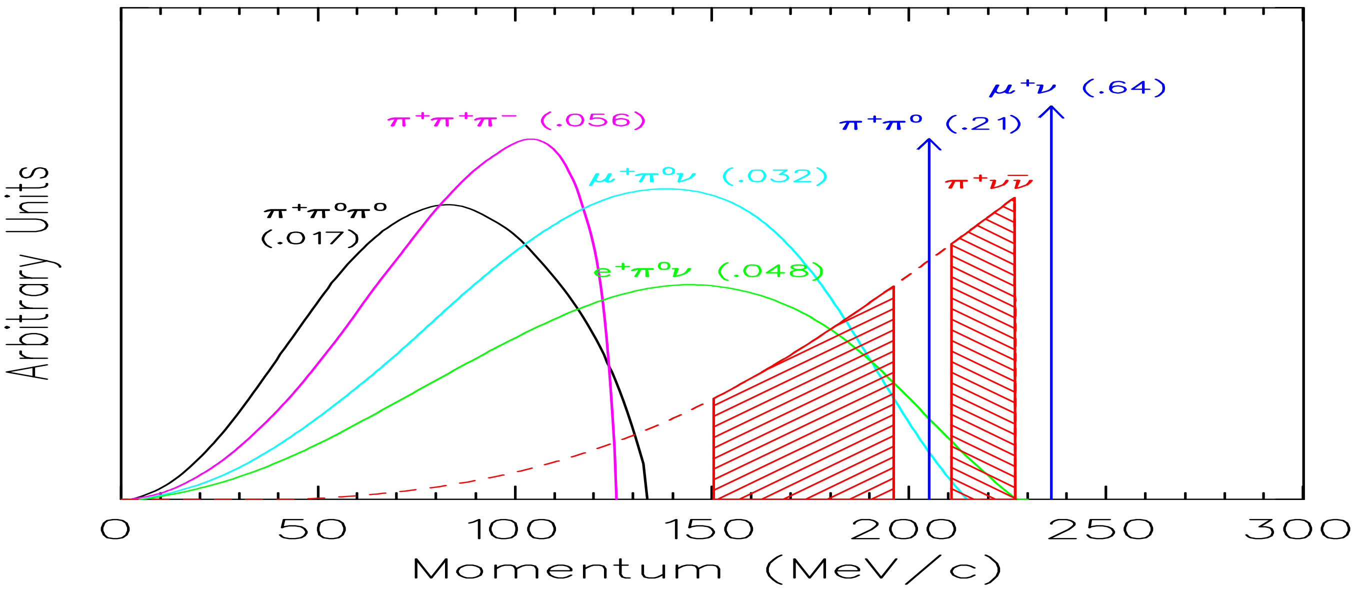
	1995-7
K^+ stop efficiency	$0.704 \pm 0.004^{stat} \pm 0.009^{syst}$
K^+ decay after 2 ns	0.850 ± 0.001
$K^+ \to \pi^+ \nu \overline{\nu}$ phase space	$0.155 \pm 0.001^{stat} \pm 0.001^{syst}$
Solid angle acceptance	0.407 ± 0.001
π^+ nucl. int., decay-in-flight	0.513 ± 0.005^{stat}
Reconstruction efficiency	0.959 ± 0.001
Other kinematic constraints	$0.665 \pm 0.007^{stat} \pm 0.020^{syst}$
$\pi - \mu - e$ decay acceptance	$0.306 \pm 0.005^{stat} \pm 0.004^{syst}$
Beam and target analysis	0.699 ± 0.001
Accidental loss	0.785 ± 0.002
Total acceptance	$[0.208 \pm 0.005^{stat} \pm 0.021^{syst}]$%

$$\mathrm{BR}(K^+ \to \pi^+ \nu \overline{\nu}) = 1.5^{+3.4}_{-1.2} \times 10^{-10}$$ [PRL **84**, 3768 (2000)]

E787 Summary

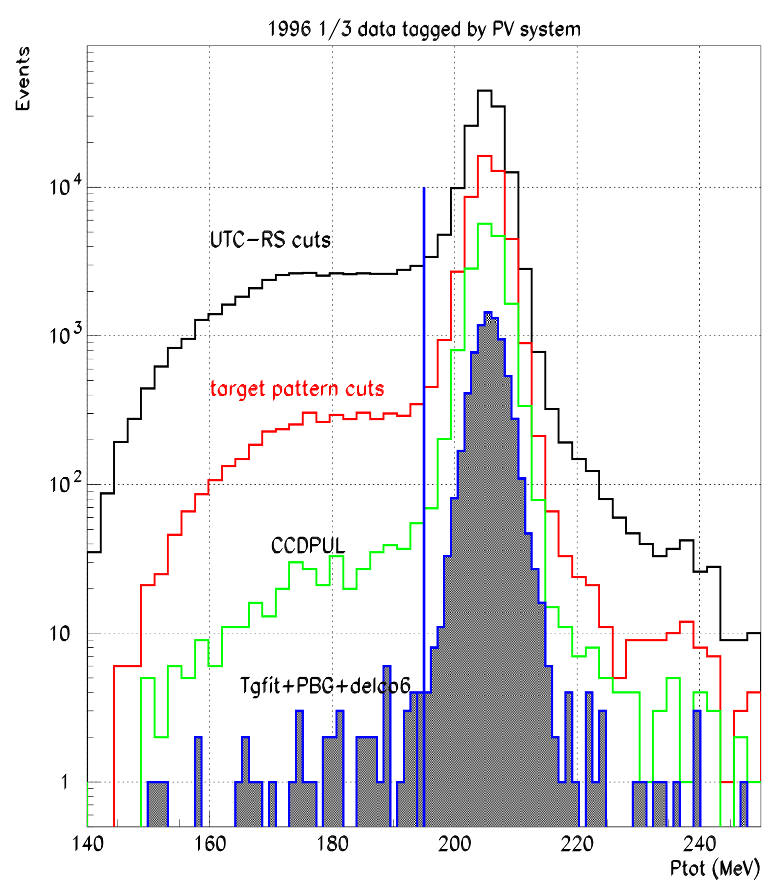
- Detector and Beam upgrade in 1992–3.
- 1995 — first physics run (PRL **79**, 2204, 1997)
  - 23 week run with 17 weeks of $K^+ \to \pi^+ \nu\overline{\nu}$ data
  - sensitivity = 4.2×10^{-10} (background level = 3.4×10^{-11})
- 1996 — shorter run.
  - 16 week run with 13 weeks of $K^+ \to \pi^+ \nu\overline{\nu}$ data
  - increased trigger eff., improved acceptance at lower momentum
- 1997 — very short run.
  - 9 week run with 8 weeks of $K^+ \to \pi^+ \nu\overline{\nu}$ data
  - lower momentum, reduced deadtime
- 1995–97 — (PRL **84**, 3768, 2000)
  - sensitivity = 1.5×10^{-10} (background level = 1.2×10^{-11})
- 1998 — combine FY98 and FY99 into one good final run.
  - 26 week run with ∼22 weeks of $K^+ \to \pi^+ \nu\overline{\nu}$ data
  - higher duty factor, long run (not as long or as many protons as hoped)
  - Analysis should finish in 2000 (sensitivity ∼ SM).
- $K^+ \to \pi^+ \nu\overline{\nu}$ below $K^+ \to \pi^+ \pi^\circ$
  - Significant progress on analysis of 1996 data.
  - Demonstration for E949.
- $K^+ \to \pi^+ \pi^\circ \gamma$ (DE), $K^+ \to \mu^+ \nu_\mu \gamma$ (SD$^+$), $K^+ \to \pi^+ \gamma\gamma$, $K^+ \to \pi^+ \mu^+ \mu^-$

$K^+ \to \pi^+ \nu \bar{\nu}$ below the $K^+ \to \pi^+ \pi^\circ$ peak



Improvements

- Improved track finding and double-pulse fitting in target.
- Better photon veto.



- Phase space larger than above $K_{\pi 2}$.
- Less π^+ absorption losses.
- Possibility of $\times 3$ more acceptance.
- $K^+ \to \pi^+ \nu \bar{\nu}$ spectral shape.
- Reject $K_{\pi 2}$ with π^+ interaction.

- Good progress on 1996 analysis.
- Room for improvement.
- 1995–8(est.): SES$\sim$0.3$\times$SM, B<1.
- E949 will reduce background >2$\times$.

E787 Results

Mode	Result	Gain	Comments
$K^+ \to \pi^+ \nu\bar{\nu}$	$\left(1.5^{+3.4}_{-1.2}\right) \times 10^{-10}$	900	constrains new physics, $\|V_{td}\|$ **Discovery!** (1 clean event)
$K^+ \to \pi^+ \mu\mu$	$(5.0 \pm 1.0) \times 10^{-8}$	4500	χPT study **Discovery!** (~ 200 events)
$K^+ \to \pi^+ \gamma\gamma$	$(1.1 \pm 0.3) \times 10^{-6}$	100	χPT study **Discovery!** (~ 30 events)
$K^+ \to \mu^+ \nu\gamma$	$(1.33 \pm 0.22) \times 10^{-5}$	1000	χPT study **Discovery!** (~ 900 SD$^+$ events)
$K^+ \to \pi^+ \pi^0 \gamma$	$(4.72 \pm 0.82) \times 10^{-6}$	8	χPT study BR$_{DE}$ is $4\times$ smaller
$K^+ \to \pi^+ \pi^\circ \nu\bar{\nu}$	$< 4.3 \times 10^{-5}$	23000	new physics search (SM$\sim 10^{-14}$) Preliminary!
$K^+ \to \pi^+ X^0$	$< 1.1 \times 10^{-10}$	400	new particle search
$K^+ \to \mu^+ \nu\mu\mu$	$< 4.1 \times 10^{-7}$	$2.4M$	Higgs hunting ground
$K^+ \to e^+ \nu\mu\mu$	$< 5 \times 10^{-7}$	$2.0M$	χPT study
$\pi^0 \to \nu\bar{\nu}$	$< 8 \times 10^{-7}$	10	+new particle search
$\pi^0 \to \gamma X^0$	$< 5.3 \times 10^{-4}$	1900	New light vectors
$K^+ \to \pi^+ \nu\bar{\nu}\,(2)$	ongoing		search below $K^+ \to \pi^+ \pi^\circ$
$K^+ \to \pi^\circ \mu^+ \nu_\mu \gamma$	ongoing		χPT study; never observed
$K^+ \to \pi^+ \gamma$	ongoing		Exotic Search

E949 Status

Proposal

- Solid projection of sensitivity gain from E787 (6–10 SM events)
- Background ∼10% of SM signal. Measured by E787.

The proposed experiment will provide critical input determining the unitarity triangle and testing the Standard Model hypothesis for the source of CP-violation. Comparisons between measurements such as this and those in the B system will provide the best overall test of the Standard Model picture and have the potential to reveal new physics — BNL HENP PAC 10/12/98

Status

- Approved (BNL 10/98; DOE 8/99)
- E949 has assured substantial BNL HEP funding through FY03.
  - First AGS2000 experiment approved (precedent setting).
  - Key part of HEP bridge: g-2 → E949 → RSVP
  - Critical to suceed.
- Construction underway (close det. 8/00; cosmic 1/01; pulse-on-dem. 2/01)
- Run during FY01–03 RHIC runs. (start 5/01)

Key Items

- Critical that RHIC reaches lifetimes of 10–20 hours 'soon'.
- Need to establish ability to switch from Au to 65 Tp (p^+) 'quickly'.
- Finish detector and LESB3 upgrades and debugging rapidly.
- Establish and minimize $K^+ \to \pi^+ \nu \overline{\nu}$ (2) background.
- Verify rate dependence of acceptance.
- DOE: Collaboration between BNL and FNAL on E949/CKM 'important' to E949 approval.

Possible AGS Operations Plan - FY00-06

Running
If approved/funded
Construction/upgrades
Commissioning/tests

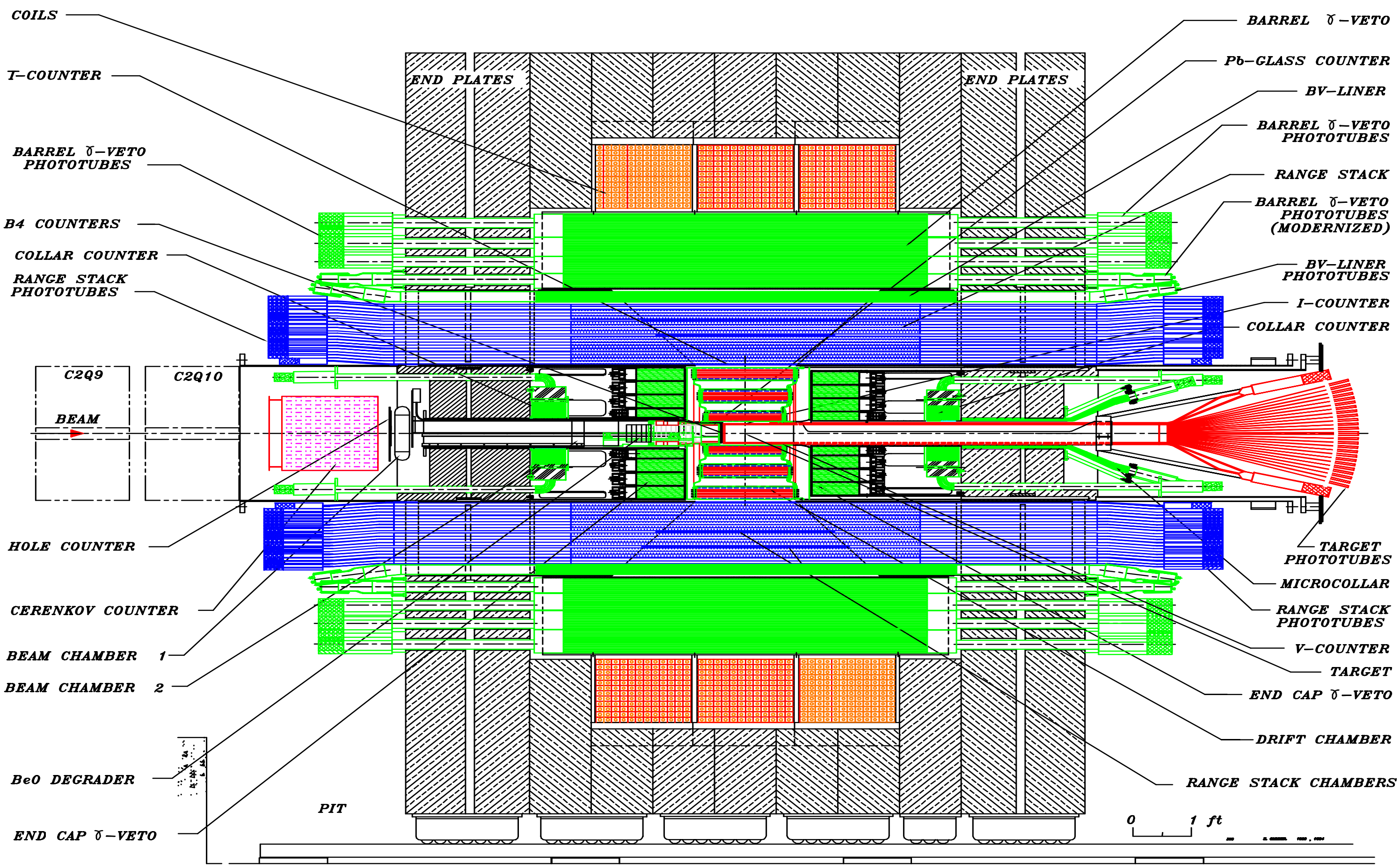
2/10/00

Program Element	Experiment	FY00	FY01	FY02	FY03	FY04	FY05	FY06
RHIC Operation								
AGS SEB Operations								
♦ E949[Bryman,Kettell,Sugimoto]	$K^+ \to \pi^+ \nu\bar{\nu}$							
♦ E926 [Bryman,Littenberg,Zeller]	$K^0 \to \pi^0 \nu\bar{\nu}$	----	R&D-----					
♦ E940 [Molzon]	$\mu^- N \to e^- N$	----	R&D-----					
♦ Test Runs [R&D for E926/E940]								
♦ * E930[Tamura]	Hypernuclear γ's							
♦ * E931[Dehnhard,Hungerford,Zeps]	ΔI=1/2 Rule							
♦ * E927[Nefkens]	K_{e3}							
AGS FEB Operations								
♦ E821 [Hughes,Morse,Roberts]	μ g-2							
♦ #E933[Hartouni,Morse]	p							
♦ #E938[Hastings]	SNS							
♦ E951[McDonald]	μμ collider							
Radiobiology								
♦ AGS								
♦ BAF								

* Medium Energy Experiments

\# DOE DP and BES experiments

E949: $K^+ \to \pi^+ \nu \overline{\nu}$



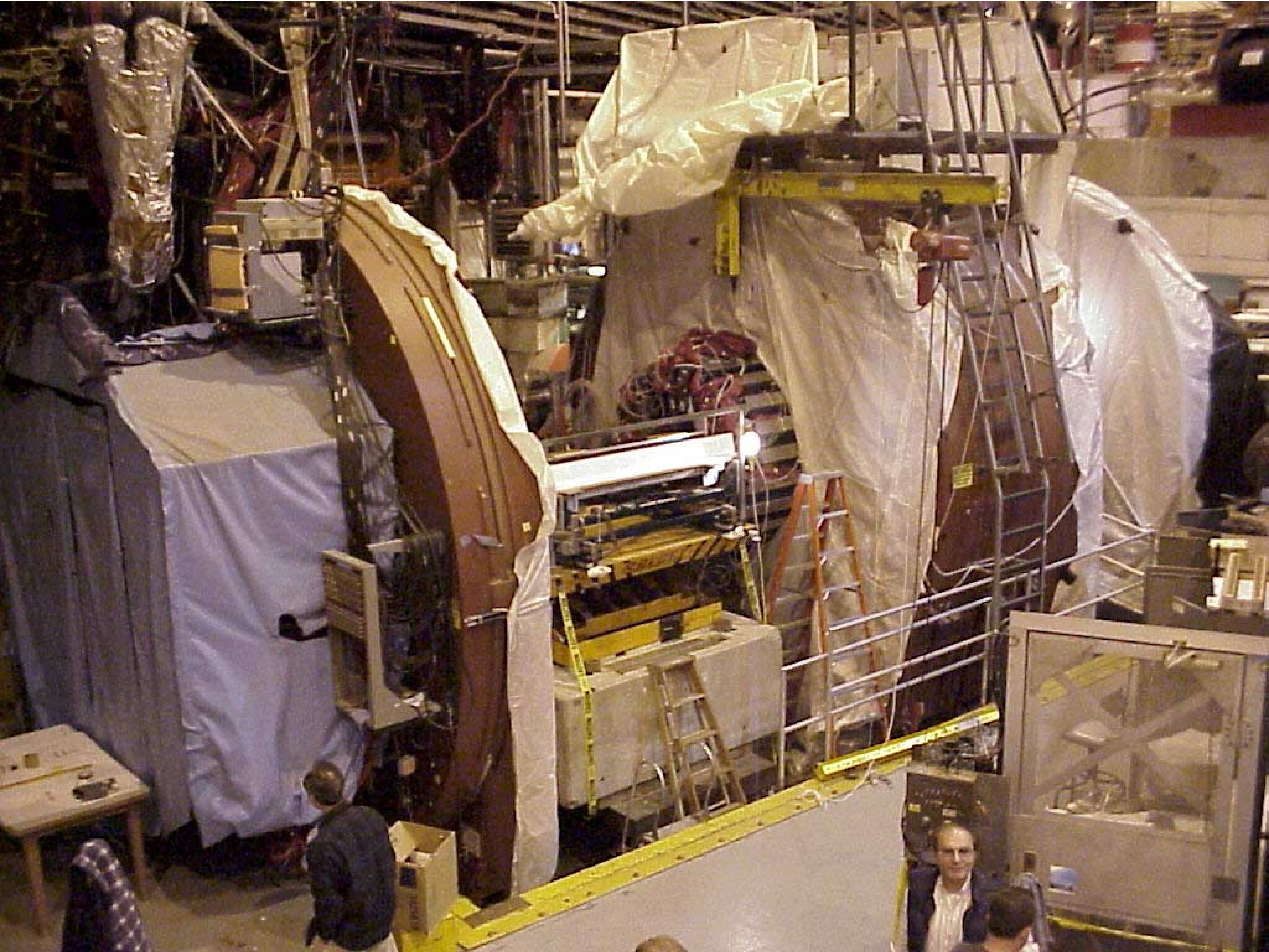
Alberta/BNL/FNAL/Fukui/IHEP/INR/KEK
Kyoto/UNM/Osaka/TRIUMF/Yeshiva

Sensitivity Improvement compared to E787 (1995):

- Increased spill length (×1.56)
- Lower Momentum (×1.38)
- Increased efficiency (trigger,DAQ,analysis) (×3.2)
  - Increase acceptance below $K_{\pi 2}$ peak [×2]
  - Re-optimize analysis for higher rates [×2]
- Total gain of ×14 (per hour of running)

E949 Upgrades

- Photon Veto (access low p_π phase space)
  - Barrel Veto Liner (additional 2.3 $X_\circ$)
  - Live degrader upgrade
  - Additional upstream vetoes
  - Thicken collar counter
  - Downstream veto
- UTC (tracking efficiency increase)
- Range stack upgrades
  - Replace T-counters (better trigger, tracking efficiency)
  - Replace Layer 2-5 (better dE/dx resolution, timing)
  - Repair dead RSSCs (better tracking efficiency)
- Trigger upgrade (reduce deadtime and improve rejection)
- DAQ upgrade (reduce deadtime, increase rate capability)
- Monitor system (improve reliability and energy resolution)
- Beam counter upgrade (increase background rejection)
- Other electronics (increase background rejection and efficiency)



E949

An experiment to measure the branching ratio $B(K^+ \to \pi^+ \nu \bar{\nu})$

B. Bassalleck[10], E.W. Blackmore[12], D.A. Bryman[2,12]a, S. Chen[12], I-H. Chiang[3], P.S. Cooper[4], M.V. Diwan[3], D.E. Fields[10], J.S. Frank[3], T. Fujiwara[9], J.S. Haggerty[3], M.P. Grigoriev[7] T. Inagaki[8], A.P. Ivashkin[7], S. Kabe[8], S.H. Kettell[3]a, M.M. Khabibullin[7], A.N. Khotjantsev[7], P. Kitching[1], M. Kobayashi[8], T.K. Komatsubara[8], A. Konaka[12], A. Kozjevnikov[6], Y.G. Kudenko[7], Y. Kuno[8], L. Landsberg[6], K.K. Li[3], X. Li[2], L.S. Littenberg[3], J. Lowe[10], J.A. Macdonald[12], J. Mildenberger[12], O.V. Mineev[7], M. Miyajima[5], V. Mukhin[6], N. Muramatsu[8], T. Nakano[11], J. Nishide[5], M. Nomachi[11], T. Nomura[9], T. Numao[12], V. Obraztsov[6], K. Omata[8], S. Petrenko[6], M. Pommot-Maia[13], J.-M. Poutissou[12], R. Poutissou[12], E. Ramberg[4], G. Redlinger[3], V. Rykalin[6], T. Sato[8], K. Shimada[5], T. Shinkawa[8], T. Shimoyama[5], R.C. Strand[3], S. Sugimoto[8]a, Y. Tamagawa[5], T.L. Thomas[10], T. Toshinao[8], R.S. Tschirhart[4], V. Victorov[6], Y. Yoshimura[8] and T. Yoshioka[8].

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[10]University of New Mexico, Albuquerque, NM 87131, United States
[11]Research Center for Nuclear Physics, Osaka University, Mihogaoka, Ibaraki, Osaka 567-0047, Japan
[12]TRIUMF, 4004 Wesbrook Mall, Vancouver, B.C. V6T 2A3, Canada
[13]Yeshiva University, 245 Lexington Ave, New York, NY 10016

beam: LESB3, low energy (600-800 MeV/c) separated K^+ beam. The beam conditions are expected to be a 730 MeV/c K^+ beam with a K^+/π^+ ratio of >3:1 with 65 Tp on the C-target. The expected spill length is ∼4.1 sec and a Duty Factor of 64%.

detector: Solenoidal magnetic spectrometer, with 4π calorimetric detection of all decay products except neutrinos.

hours: Request 6,000 hours. This should represent 2 years of running in the RHIC era. Expect to be ready for data collection during the fall of 2000.

Abstract

A new, more precise measurement of the $K^+ \to \pi^+ \nu \bar{\nu}$ branching ratio is proposed. Improvements to the E787 apparatus and running mode will be made to reach a sensitivity of $(8\text{–}15) \times 10^{-12}$, an order of magnitude below the Standard Model prediction. This will result in a determination of $|V_{td}|$ to better than 30%.

[a]spokespersons:
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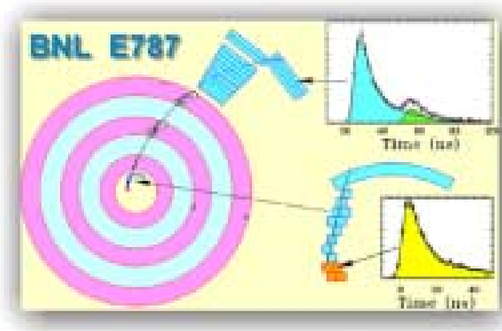
Steve Kettell, kettell@bnl.gov, (631)344-5323; and
Shojiro Sugimoto, shojiro.sugimoto@kek.jp, (+81)424-69-9548.



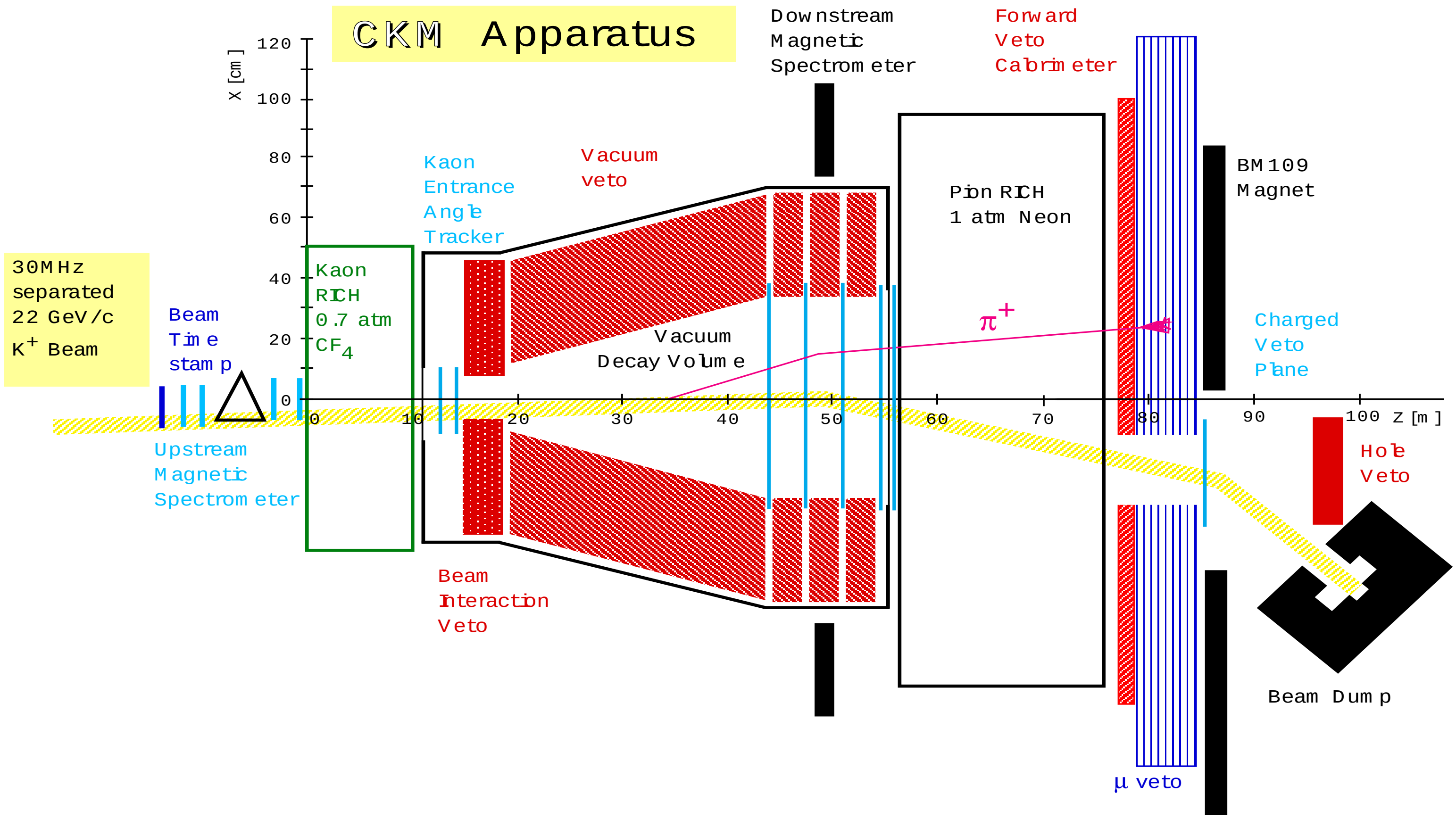
$K^+ \to \pi^+ \nu \overline{\nu}$: E949 & CKM

... the two experiments are stages of a program for studying $K^+ \to \pi^+ \nu \overline{\nu}$, which will eventually reach a sensitivity comparable to the theoretical accuracy at which this process can be calculated in the Standard Model. Stage one would be E949, which seeks to reach a sensitivity of $\sim 10^{-11}$ and stage two would be CKM, which seeks to reach a sensitivity an order of magnitude beyond this level.

- Collaboration begun in summer of 1999
- E949 approved 8/99
- plans for integration of FNAL TDC's into E949 underway (2/00)
- system tests planned for 9/00
- BNL represented at CKM collaboration meeting 9/99
- BNL active in biweekly CKM video meetings
- BNL contribution to PV system under development

- E949
  - FNAL TDC's to instrument the range stack
  - manpower/expertise
- CKM
  - BNL is collaborating on the Photon Veto
  - manpower/expertise

CKM (FNAL E905): $K^+ \to \pi^+ \nu\overline{\nu}$

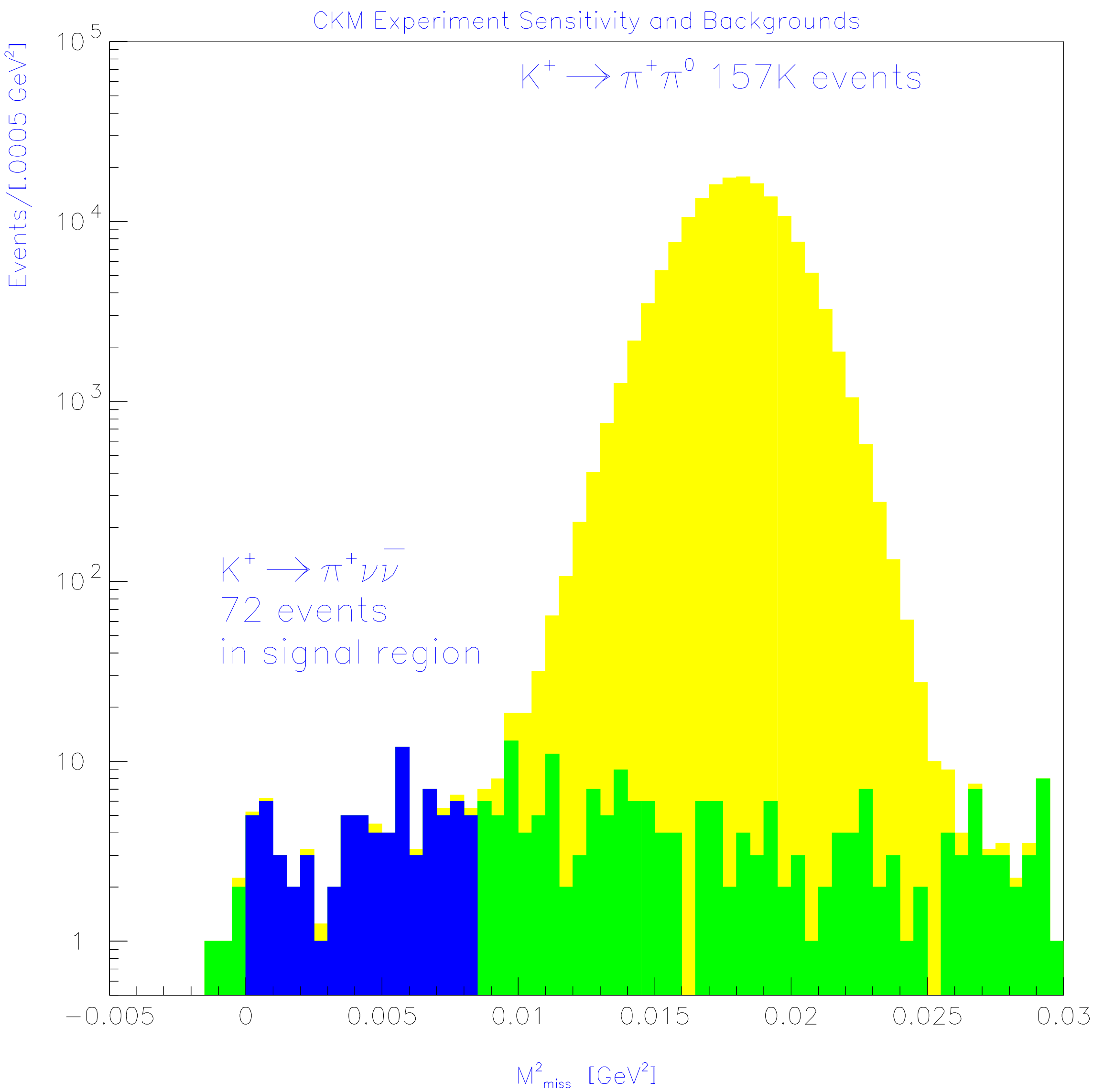


BNL/FNAL/IHEP/Michigan/Texas/UASLP/Virginia

- Goal: ∼100 $K^+ \to \pi^+ \nu\overline{\nu}$ events, determine $|V_{td}|$ to ∼ 10%.
- Decay in flight with a separated 22 Gev/c K$^+$ beam (K/π= 2:1).
- Redundant kinematics: velocity (RICH's) and momentum (straws in vacuum) spectrometers.
- Hermetic photon veto, good μ-rejection.

CKM (FNAL E905): $K^+ \to \pi^+ \nu \overline{\nu}$

- Proposal submitted 4/15/98.
- Approved R&D project (11/11/98).
- Plan for full technical proposal 4/01.
- Collect ∼100 events in two years by ∼2008
- Determine $|V_{td}|$ to ∼10%.



Charged Kaons at the Main Injector

March 10, 2000

A Proposal for a Precision Measurement of the Decay $K^+ \to \pi^+ \nu \overline{\nu}$ and Other Rare K^+ Processes at Fermilab Using the Main Injector

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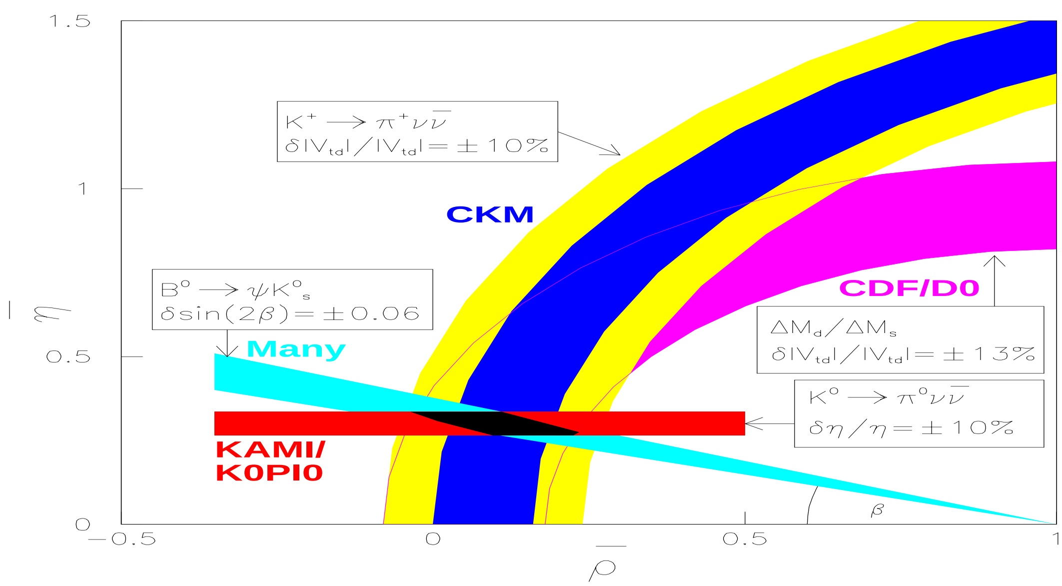
Future Kaon contribution to the CKM Matrix

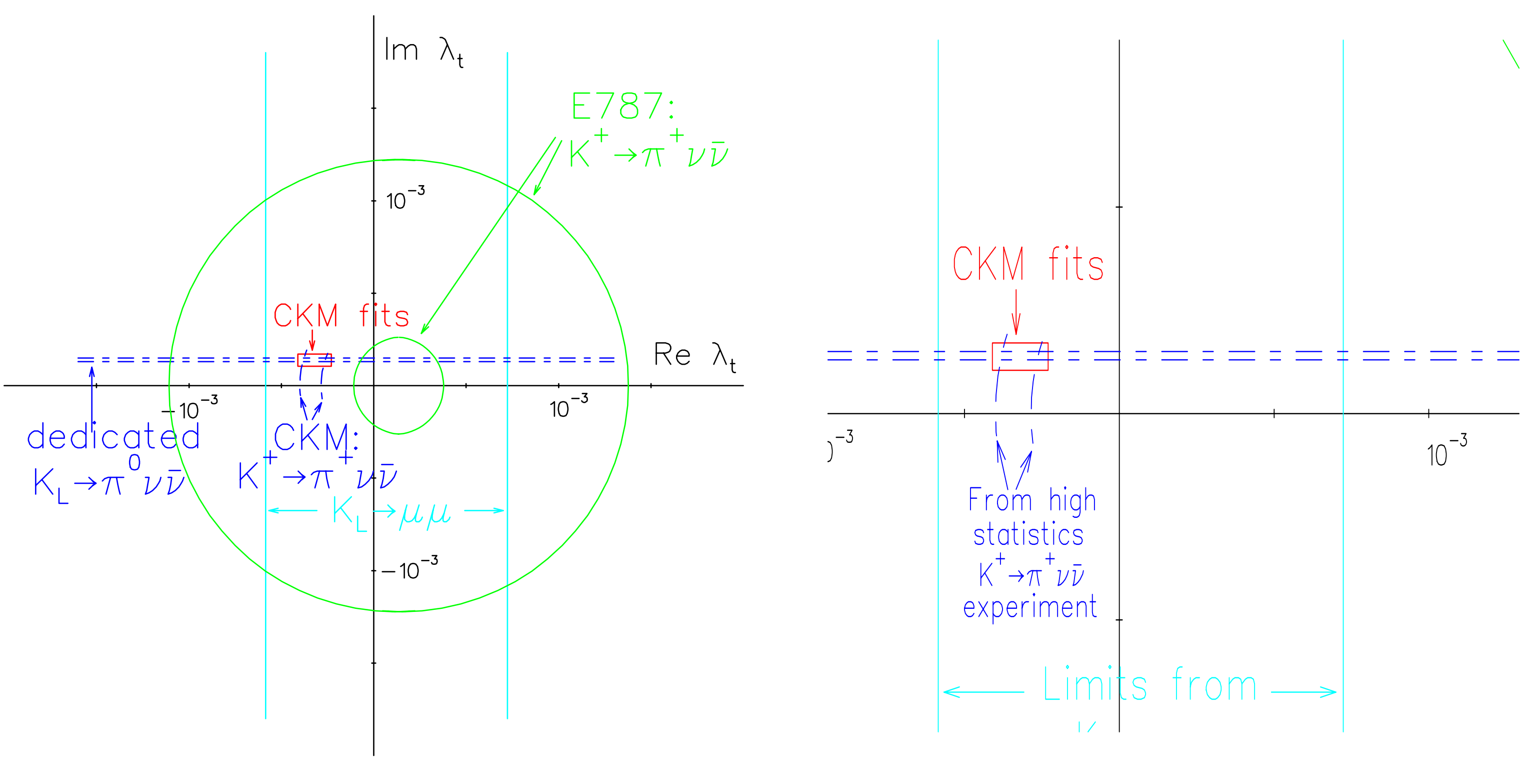
Measurements and tests of the Standard Model:

- Determine $Im(\lambda_t)$ and J_{CP} to 7–8% (now 22% and ~40%)
- Overconstrain the angle β from $B_d^\circ \to \psi K_S^\circ$ and $K_L^\circ \to \pi^\circ \nu\overline{\nu}$ / $K^+ \to \pi^+ \nu\overline{\nu}$
- Overconstrain $|V_{td}|$ from $\Delta M_{B_s}/\Delta M_{B_d}$ and $K^+ \to \pi^+ \nu\overline{\nu}$

Future contraints on $\overline{\rho}$ and $\overline{\eta}$



Expressed in terms of λ_t:



Conclusions

- The AGS HEP program is alive and well.
  - DOE has a funding committment to E949 through FY03.
  - E949 will provide a bridge to RSVP (if RSVP is funded).
- The study of Rare Symmetry Violating processes is alive and well.
  - $K \to \pi\nu\overline{\nu}$ is recognized to provide important input to understanding quark mixing and CP-violation
  - E949 will observe 6–10 SM events
[12–20 if BR($K^+ \to \pi^+\nu\overline{\nu}$)=1.67×10^{-10}]
  - KOPIO/CKM (along with $B_d^\circ \to \psi K_S^\circ$) should provide quantitative tests of the SM picture of CP-violation.
- The BNL Physics Department is well positioned to make a big impact through E949, KOPIO and CKM.
  - Recognized leaders in $K^+ \to \pi^+\nu\overline{\nu}$, which is generally agreed as critical to understanding quark mixing and CP-violation.
  - E949 will proceed (and may find a significant and suprizing result...) and will contribute to the big picture of CP-violation.
  - Major players in $K_L^\circ \to \pi^\circ\nu\overline{\nu}$, which is the gold standard, with a solid experiment, that may be funded and may run at BNL.
  - Welcomed in CKM, with plenty of opportunity to contribute to what could be the definitive $K^+ \to \pi^+\nu\overline{\nu}$ experiment.
  - It is an ambitious program! and we could use help.