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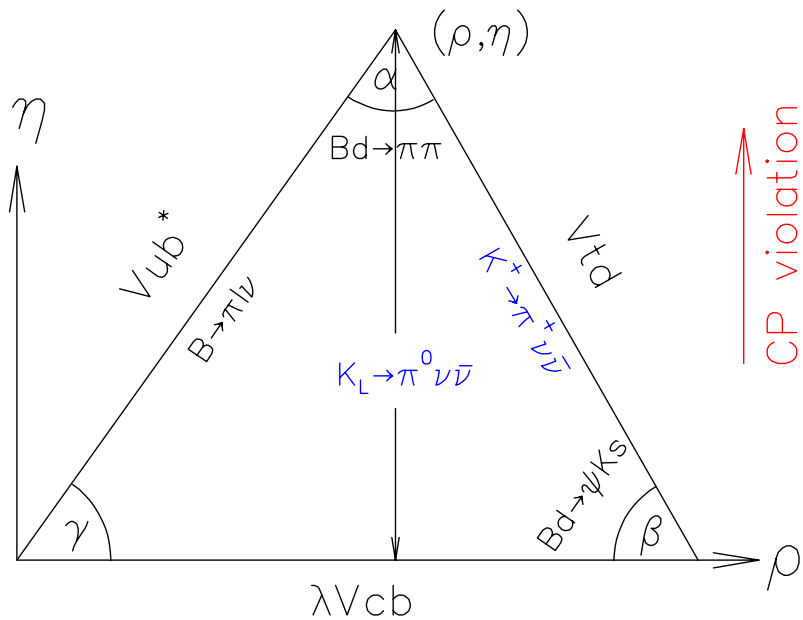
HEPAP

BNL E949 Measurement of $K^+ \to \pi^+ \nu \bar{\nu}$

Douglas Bryman
University of British Columbia

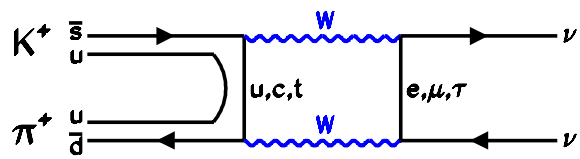
STANDARD MODEL CP VIOLATION

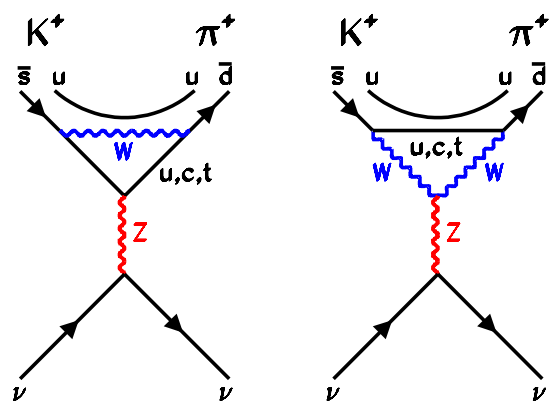


FOUR "SUPER-CLEAN" K AND B MEASUREMENTS WILL TEST THE SM CP-VIOLATION PICTURE

$K^+ \to \pi^+ \nu\bar{\nu}$	**E949** (BNL), CKM (FNAL)
$K_L^0 \to \pi^0 \nu\bar{\nu}$	KOPIO (BNL)
$B_d \to \Psi K_s$	BABAR, BELLE, CDF, LHC-B
$\frac{x_s}{x_d} = \frac{B_s - \overline{B_s}}{B_d - \overline{B_d}}$	CDF, LHC-B, BTEV

$K \to \pi\nu\bar{\nu}$ in the Standard Model



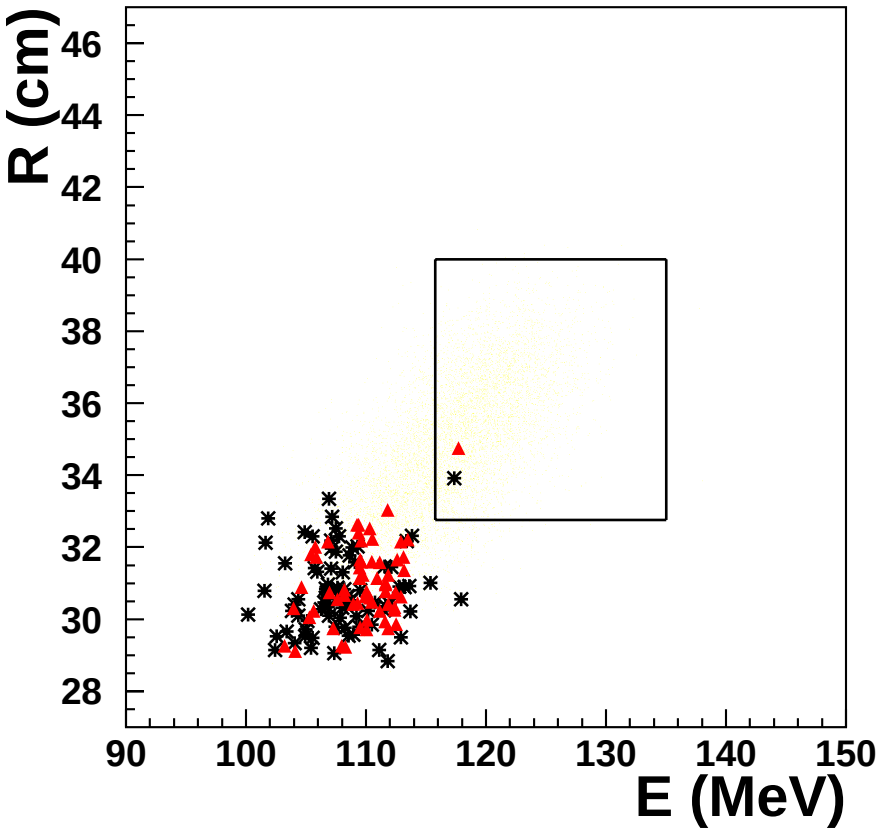


	$K^+ \to \pi^+\nu\bar{\nu}$	$K_L^0 \to \pi^0\nu\bar{\nu}$
Top Quark Dependence	$\lvert\lambda_t\rvert = \lvert V_{ts}^* V_{td}\rvert$	Im(λ_t)=Im$(V_{ts}^* V_{td})$
SM BR (10^{-11})	7.2 ± 2.1	2.6 ± 1.2
Est. Theory Uncertainty	7% (charm)	2%

- Negligible long distance effects (10^{-13}).
- Hadronic matrix elements from isospin analog $K^+ \to \pi^0 e^+ \nu_e$.

NEW RESULTS on $K^+ \to \pi^+ \nu \bar{\nu}$

- E787 PRL 2002: Two $K^+ \to \pi^+ \nu \bar{\nu}$ events seen
- Background level 0.15 events
- B($K^+ \to \pi^+ \nu \bar{\nu}$)= $1.57^{+1.75}_{-0.82} \times 10^{-10}$
  (SM:$0.72 \pm 0.21 \times 10^{-10}$)
- E949 GOAL: sensitivity of 10^{-11}



D'Ambrosio and Isidori, 2002
hep-ph/0112135

Impact of E787 and E949 on Flavor Physics

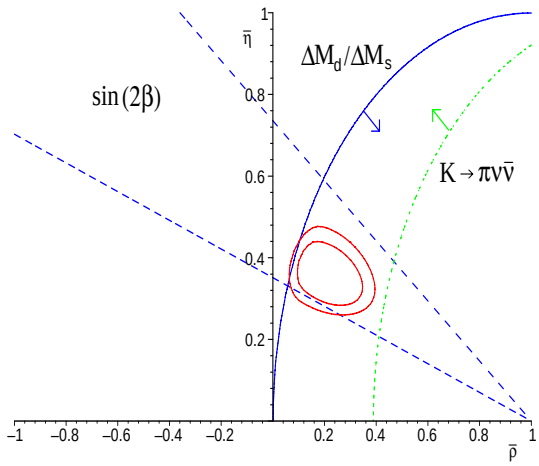


Figure 2: Allowed region in the $\bar{\rho} - \bar{\eta}$ plane using only theoretically *clean* observables: 90% C.L. interval imposed by $\sin(2\beta)$ (dashed); 90% C.L. limit from the upper bound on $\Delta M_{B_d}/\Delta M_{B_s}$ (full); 90% C.L. limit from the lower bound on $\mathcal{B}(K^+ \to \pi^+\nu\bar{\nu})$ (dotted). For comparison the 68% and 90% C.L. ellipses from the global fit in Fig. 1 are also shown.

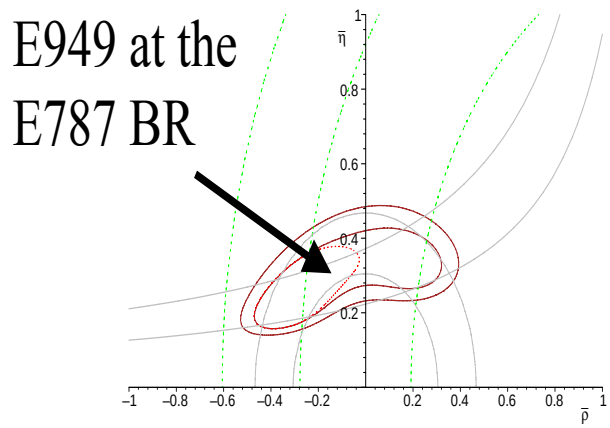
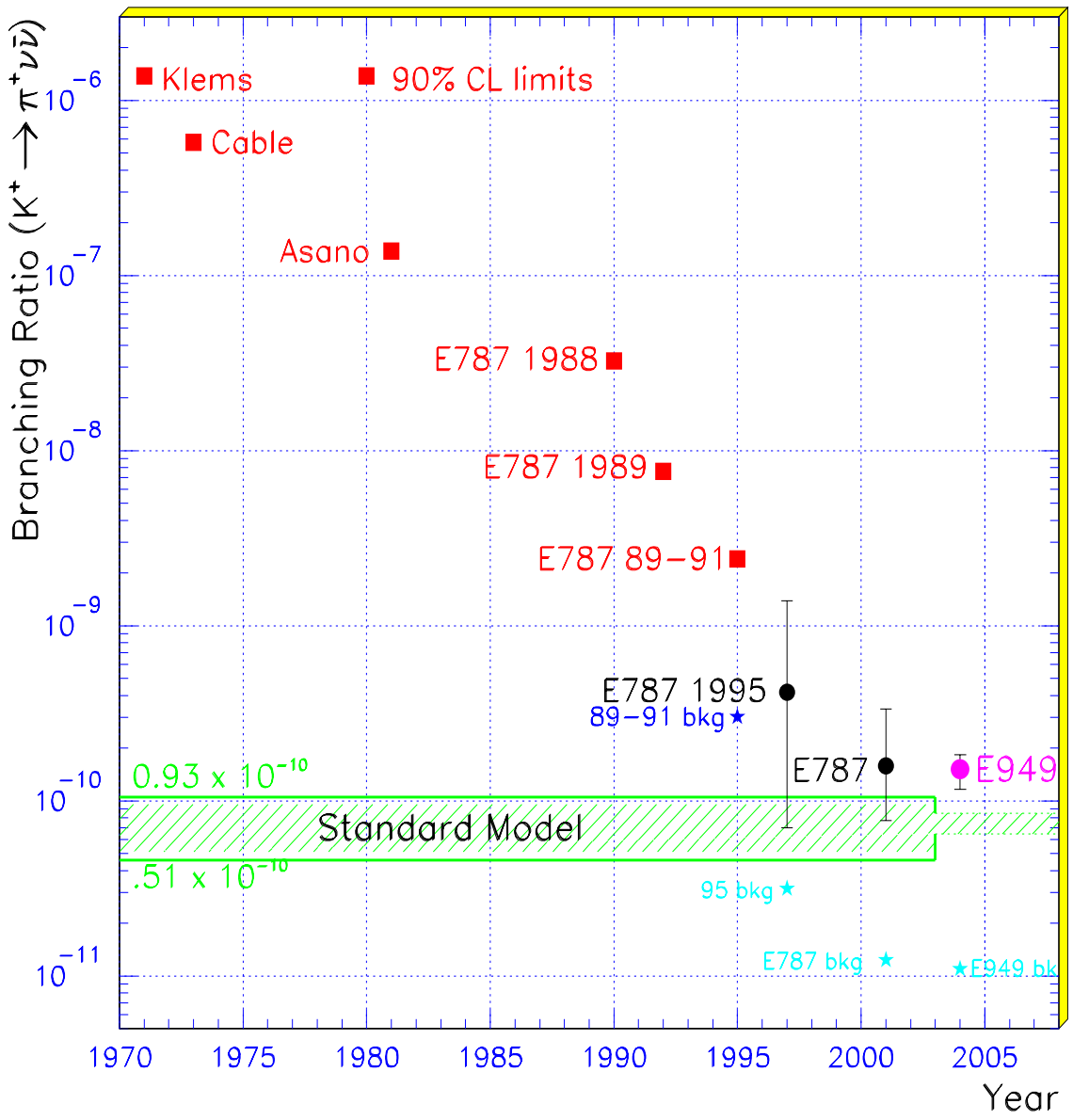


Figure 3: Allowed region in the $\bar{\rho} - \bar{\eta}$ plane with the inclusion of $\mathcal{B}(K^+ \to \pi^+\nu\bar{\nu})$ and without B_d–$\bar{B}_d$ data. The two external contours denotes 68% and 90% confidence intervals; the inner (dotted) one is the 68% confidence interval under the assumption that experimental error in (1) is reduced by a factor two.

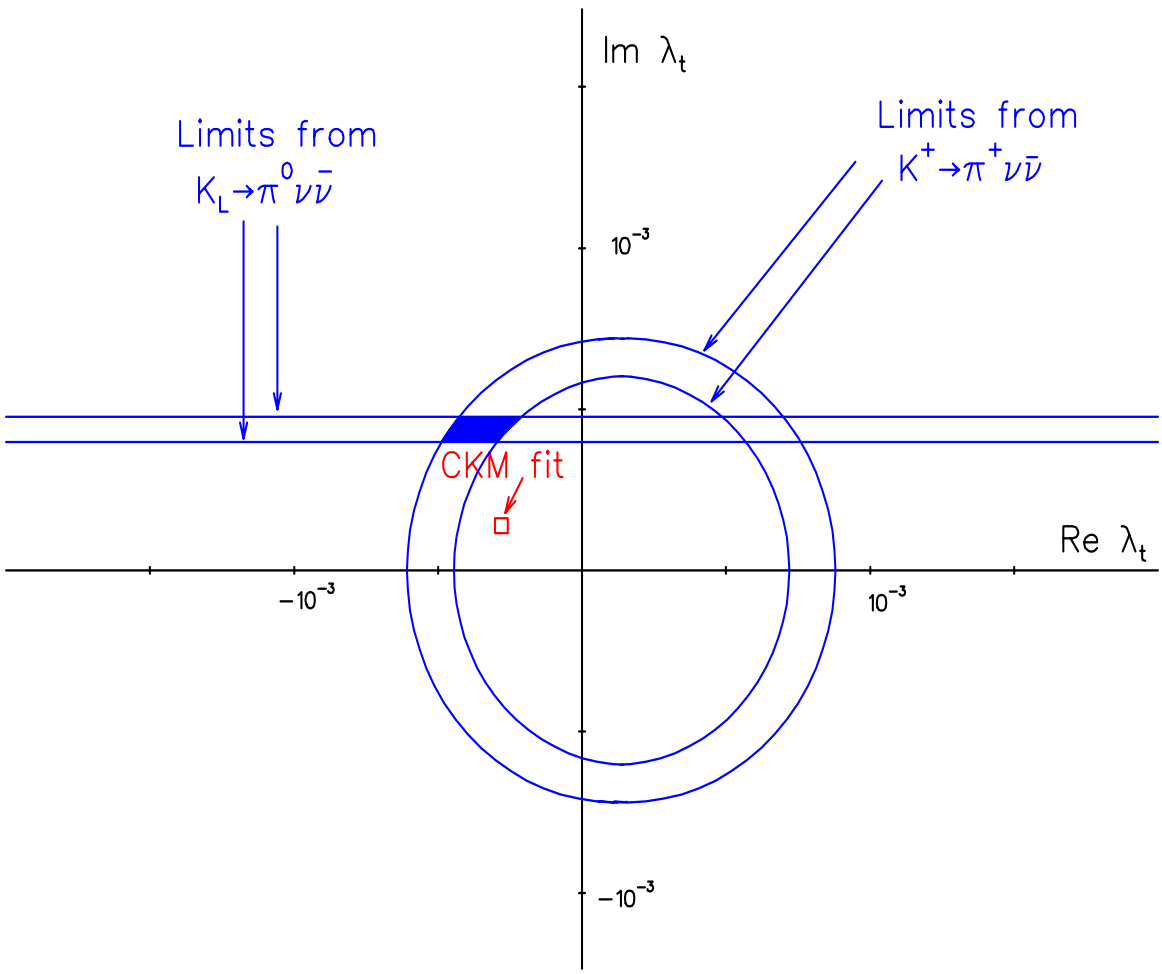
E787 and other clean observables (90% CL)

Possible E949 result favoring Non-SM

History of $K^+ \to \pi^+ \nu\bar{\nu}$ Measurements



Future Constraints on $\lambda_t = V_{ts}^* V_{td}$



E787 To E949 Transition

- E787: A major investment of human and financial resources by the DOE, and agencies of Canada and Japan.
- Successful completion of E949, a high priority for DOE DHEP (subject to adequate appropriations).
- Substantial funding provided by Canada, Japan, Russia, and DOE to upgrade the detector
- Transfer of knowledge from the AGS rare K decay program to FNAL MI group planning CKM
- Continuity of AGS expertise for NSF-funded RSVP program including KOPIO.

E949 Collaboration

63 Researchers (5 R.A.s and 11 Grad Students.)

$8M E949 upgrade (Canada, Japan : $6M)

- CANADA *$2M (NSERC/NRC)*
  Univ. Alberta, Univ. British Columbia, TRIUMF

- Japan *$4M (US-Japan Fund)*
  Fukui Univ., JAERI, KEK, Kyoto Univ., Osaka Univ., NDAJ, RCNP (Osaka), Univ. Tokyo

- US *$2M (DOE)*
  BNL, FNAL, Univ. New Mexico

- Russia
  INR (Moscow), IHEP (Protvino)

What can HEPAP do?

- Affirm the physics case for the E949 measurement of $K^+ \to \pi^+ \nu \bar{\nu}$.
- Recommend that E949 be completed.