Working Group on Flavor Physics

A short summary trying to focus on the shopping list

Fernando Ferroni
Roma “La Sapienza”
& INFN Roma

Thursday, September 11th
Parallel Sessions - Main Room

	Rare Kaon Decays	
09:00	Searches for K-> pi nu nubar at Hadron Machines	D. Jaffe, BNL
	Status of KEK-E391a and Future Prospects on KL ->p0 nn at KEK	Y. Lim, KEK
	Searches for KL ->p0 nn at a F-Factory	F. Bossi, INFN-LNF
10:30	*Coffee Break*	
11:00	KTeV Results on Rare K0 Decays	M. Corcoran, Rice Univ.
	NA48 Results on Rare K0 Decays	A. Ceccucci, CERN
	KLOE Results on Rare K0 Decays	S. Dell'Agnello, INFN-LNF
	Discussion	
13:00	*Lunch*	
	Theoretical Issues in Kaon Physics	
16:30	CP, CPT and Rare Decays	G. D'Ambrosio, INFN-NA
	Quantum Mechanics and Kaon Interferometry	A. Bramon, Univ. Barcelona
	Lattice QCD and Kaon Physics	V. Lubicz, INFN-Roma3
	Discussion	
18:00	*Coffee Break*	
	Charged Kaons and Interferometry	
18:30	Recent Results and Future Perspectives on K+- Decays at Hadron Machines	M. Sozzi, CERN
	Status and Prospects of KLOE on K+-	L. Passalacqua, INFN-LNF
	Interferometry at KLOE: Present and Future	A. Di Domenico, INFN-Roma1
	Discussion	

The wildest dream

	$b \to s$	$b \to d$	$s \to d$
$\Delta F=2$ box	ΔM_{Bs} $A_{CP}(B_s \to \psi\phi)$	ΔM_{Bd} $A_{CP}(B_d \to \psi K)$	ΔM_K, ε_K
$\Delta F=1$ 4−quark box	$B_d \to \phi K$, $B_d \to K\pi$, ...	$B_d \to \pi\pi$, $B_d \to \rho\pi$, ...	ε'/ε, $K \to 3\pi$, ...
gluon penguin	$B_d \to X_s \gamma$, $B_d \to \phi K$, $B_d \to K\pi$, ...	$B_d \to X_d \gamma$, $B_d \to \pi\pi$, ...	ε'/ε, $K_L \to \pi^0 l^+ l^-$, ...
γ penguin	$B_d \to X_s l^+ l^-$, $B_d \to X_s \gamma$ $B_d \to \phi K$, $B_d \to K\pi$, ...	$B_d \to X_d l^+ l^-$, $B_d \to X_d \gamma$ $B_d \to \pi\pi$, ...	ε'/ε, $K_L \to \pi^0 l^+ l^-$, ...
Z^0 penguin	$B_d \to X_s l^+ l^-$, $B_s \to \mu\mu$ $B_d \to \phi K$, $B_d \to K\pi$, ...	$B_d \to X_d l^+ l^-$, $B_d \to \mu\mu$ $B_d \to \pi\pi$, ...	ε'/ε, $K_L \to \pi^0 l^+ l^-$, $K \to \pi\nu\nu$, $K \to \mu\mu$, ...
H^0 penguin	$B_s \to \mu\mu$	$B_d \to \mu\mu$	$K_{L,S} \to \mu\mu$

of Gino Isidori

Even theory has its limitations

decreasing SM contrib. →

decrea-sing SM contrib. ↓

	$b \to s$ $(\sim\lambda^2)$	$b \to d$ $(\sim\lambda^3)$	$s \to d$ $(\sim\lambda^5)$
$\Delta F=2$ box	ΔM_{Bs} $A_{CP}(B_s\to\psi\phi)$	ΔM_{Bd} $A_{CP}(B_d\to\psi K)$	ΔM_K, ε_K
$\Delta F=1$ 4−quark box	$B_d\to\phi K$, $B_d\to K\pi$, ...	$B_d\to\pi\pi$, $B_d\to\rho\pi$, ...	ε'/ε, $K\to 3\pi$, ...
gluon penguin	$B_d\to X_s\gamma$, $B_d\to\phi K$, $B_d\to K\pi$, ...	$B_d\to X_d\gamma$, $B_d\to\pi\pi$, ...	ε'/ε, $K_L\to\pi^0 l^+l^-$, ...
γ penguin	$B_d\to X_s l^+l^-$, $B_d\to X_s\gamma$ $B_d\to\phi K$, $B_d\to K\pi$, ...	$B_d\to X_d l^+l^-$, $B_d\to X_d\gamma$ $B_d\to\pi\pi$, ...	ε'/ε, $K_L\to\pi^0 l^+l^-$, ...
Z^0 penguin	$B_d\to X_s l^+l^-$, $B_s\to\mu\mu$ $B_d\to\phi K$, $B_d\to K\pi$, ...	$B_d\to X_d l^+l^-$, $B_d\to\mu\mu$ $B_d\to\pi\pi$, ...	ε'/ε, $K_L\to\pi^0 l^+l^-$, $K\to\pi\nu\nu$, $K\to\mu\mu$, ...
H^0 penguin	$B_s\to\mu\mu$	$B_d\to\mu\mu$	$K_{L,S}\to\mu\mu$

Theoretical errors $\lesssim 10\%$

by Gino Isidori

And experiments have no less

decreasing SM contrib. →

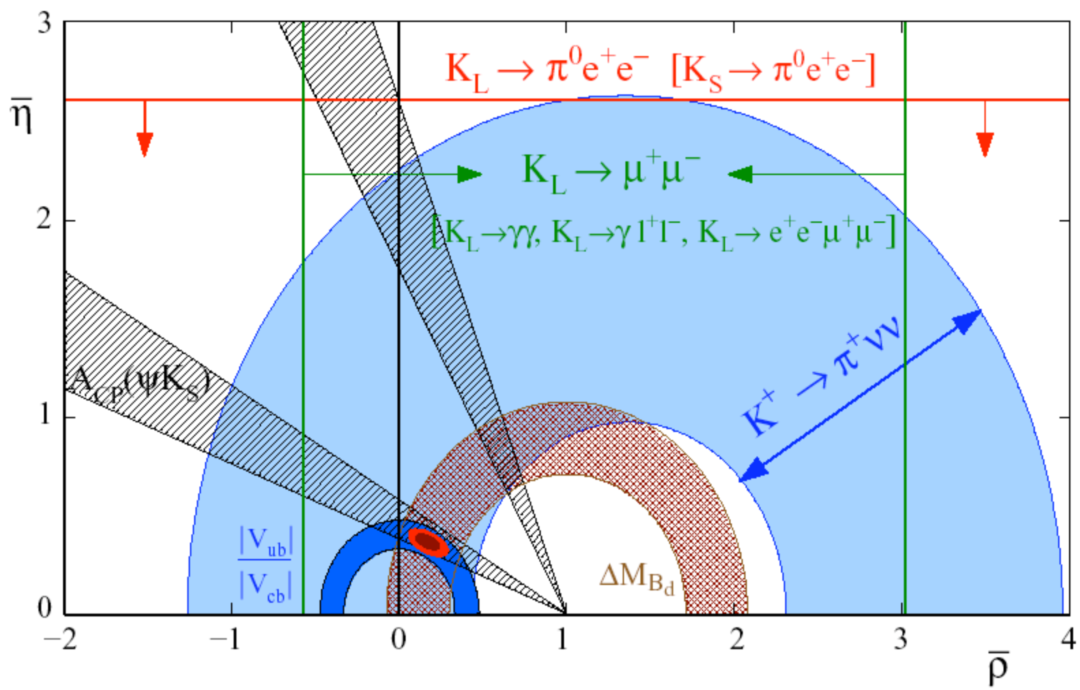
	$b \to s$ $(\sim\lambda^2)$	$b \to d$ $(\sim\lambda^3)$	$s \to d$ $(\sim\lambda^5)$
$\Delta F=2$ box	ΔM_{Bs}, $A_{CP}(B_s \to \psi\phi)$	ΔM_{Bd}, $A_{CP}(B_d \to \psi K)$	ΔM_K, ε_K
$\Delta F=1$ 4–quark box	$B_d \to \phi K$, $B_d \to K\pi$, ...	$B_d \to \pi\pi$, $B_d \to \rho\pi$, ...	ε'/ε, $K \to 3\pi$, ...
gluon penguin	$B_d \to X_s \gamma$, $B_d \to \phi K$, $B_d \to K\pi$, ...	$B_d \to X_d \gamma$, $B_d \to \pi\pi$, ...	ε'/ε, $K_L \to \pi^0 l^+ l^-$, ...
γ penguin	$B_d \to X_s l^+ l^-$, $B_d \to X_s \gamma$, $B_d \to \phi K$, $B_d \to K\pi$, ...	$B_d \to X_d l^+ l^-$, $B_d \to X_d \gamma$, $B_d \to \pi\pi$, ...	ε'/ε, $K_L \to \pi^0 l^+ l^-$, ...
Z^0 penguin	$B_d \to X_s l^+ l^-$, $B_s \to \mu\mu$, $B_d \to \phi K$, $B_d \to K\pi$, ...	$B_d \to X_d l^+ l^-$, $B_d \to \mu\mu$, $B_d \to \pi\pi$, ...	ε'/ε, $K_L \to \pi^0 l^+ l^-$, $K \to \pi\nu\nu$, $K \to \mu\mu$, ...
H^0 penguin	$B_s \to \mu\mu$	$B_d \to \mu\mu$	$K_{L,S} \to \mu\mu$

decrea–sing SM contrib. ↓

(shaded) = exp. error ~ 10% (open) = exp. error ~ 100%

where are we ?

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



$K_L \to \pi^0 \nu \nu$

$K_L \to \pi^0 e^+ e^-$ $[K_S \to \pi^0 e^+ e^-]$

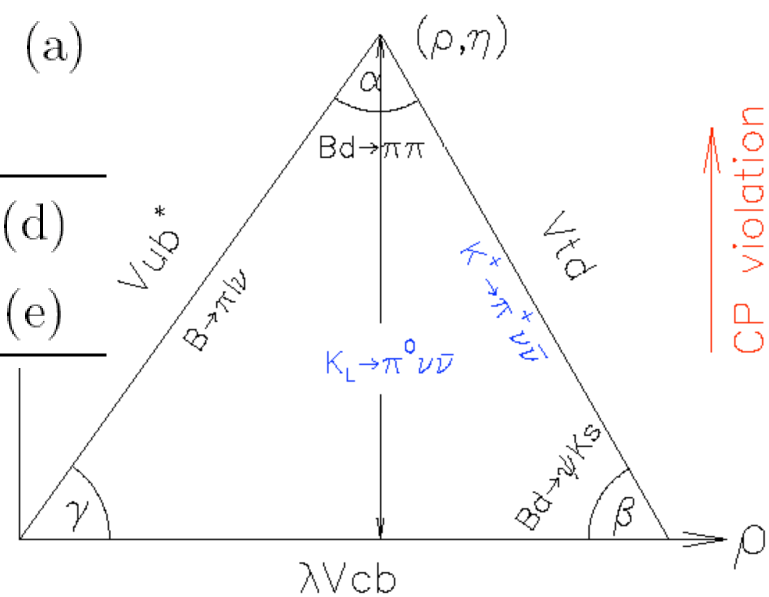
$K \to \pi\nu\bar{\nu}$ at Hadron Machines

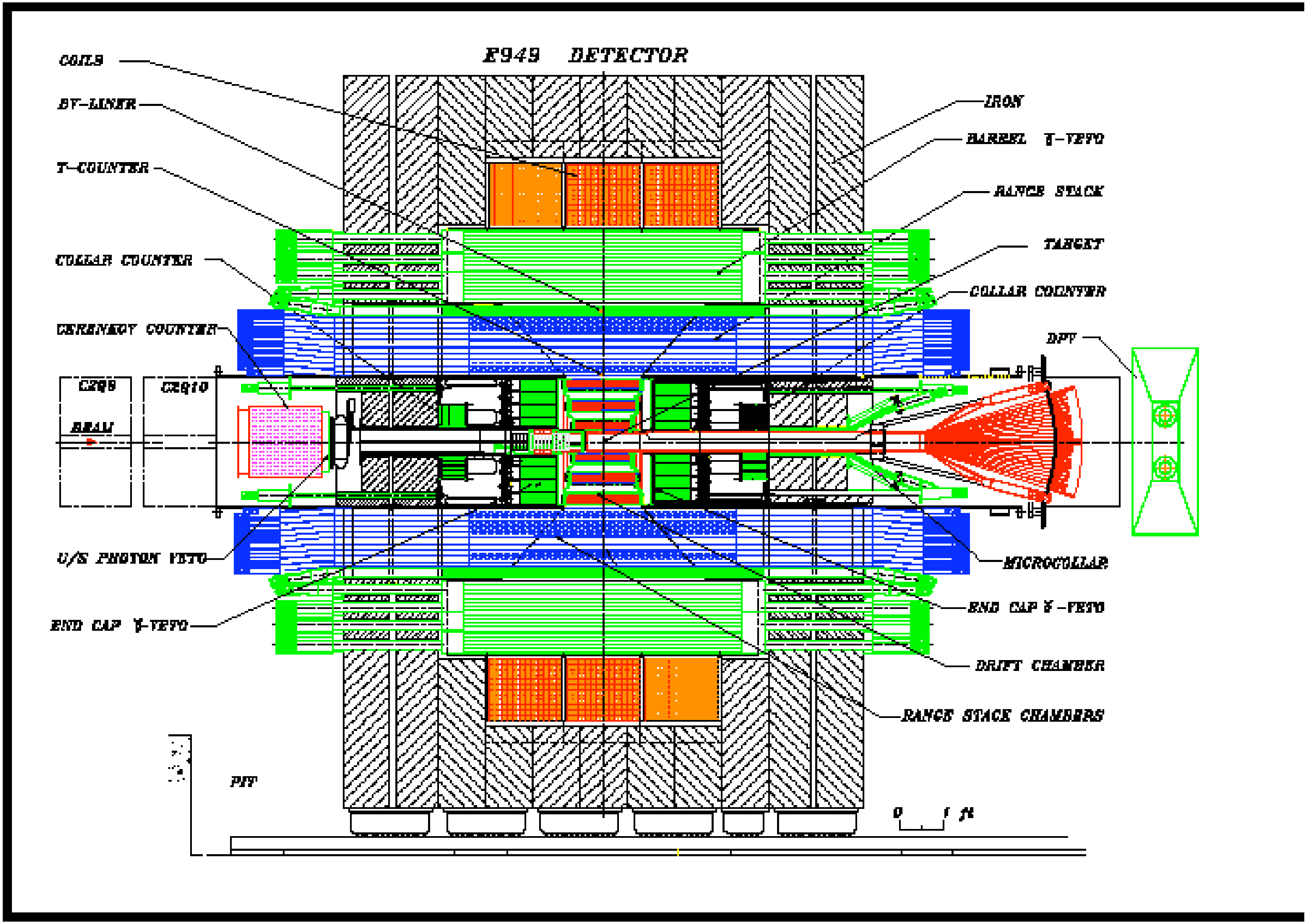
David E. Jaffe, BNL

Overview

Expt	Mode	Results or Goal
E787	$K^+ \to \pi^+\nu\bar{\nu}$	Completed. 2 candidates.
E949	$K^+ \to \pi^+\nu\bar{\nu}$	1/5 completed. $\mathcal{O}(10)$ SM events

	$\mathcal{B}(K^+ \to \pi^+\nu\bar{\nu})$
Measurement	$(1.57^{+1.75}_{-0.82}) \times 10^{-10}$ (a)
Expectation	$(0.7 \pm 0.2) \times 10^{-10}$ (d)
	$(0.7 \pm 0.1) \times 10^{-10}$ (e)




E949 DETECTOR
COILS
BV-LINER
T-COUNTER
COLLAR COUNTER
CERENKOV COUNTER
CZQ9
CZQ10
BEAM
U/S PHOTON VETO
END CAP γ-VETO
IRON
BARREL γ-VETO
RANGE STACK
TARGET
COLLAR COUNTER
DPV
MICROCOLLAR
END CAP γ -VETO
DRIFT CHAMBER
RANGE STACK CHAMBERS
PIT
0 1 ft

E949 status

Upgrades to E787:

Improved photon veto hermeticity

Improved tracking resolution

Higher rate and duty factor

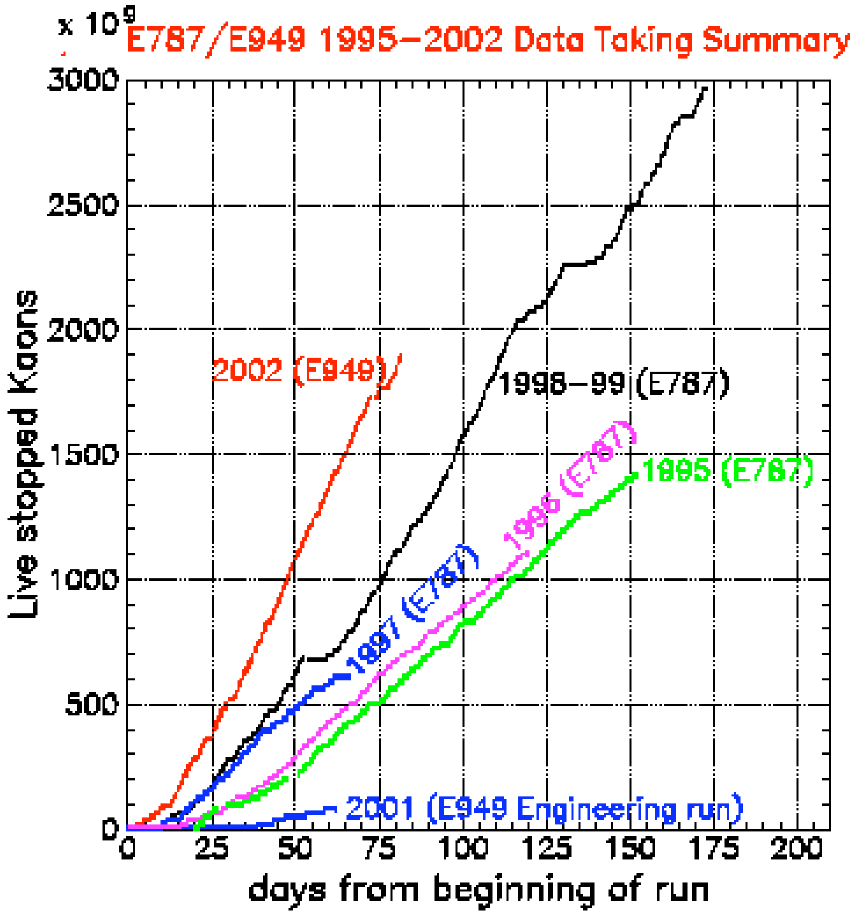
2002 run$\leq$ E787 sensitivity,

$\sim 20\%$ of E949 sensitivity goal of $< 10^{-11}$.

pnn1 results: fall 2003.

Not optimal in 2002:

1. Spill duty factor.
2. Proton beam momentum.
3. K/π electrostatic separators.

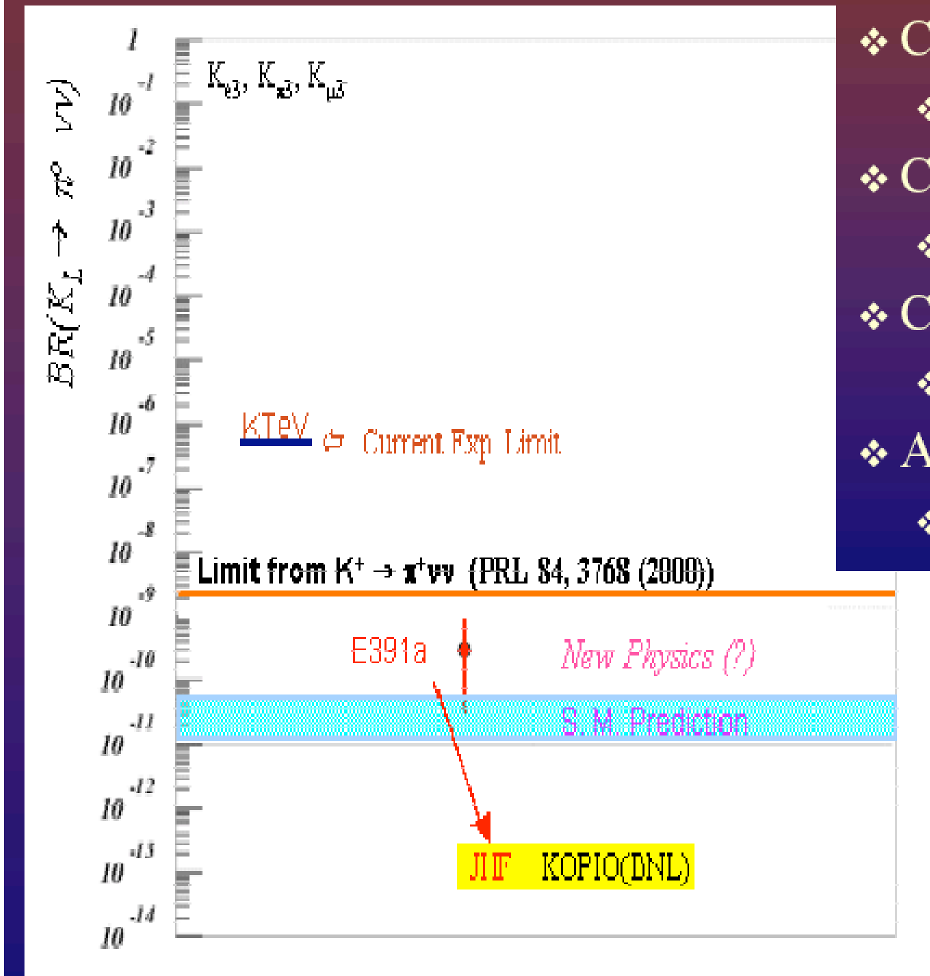


Clouds on future: cross the fingers

Status of KEK-E391a and Future Prospects on $K_L \rightarrow \pi^0 \nu\bar{\nu}$ at KEK

GeiYoub Lim

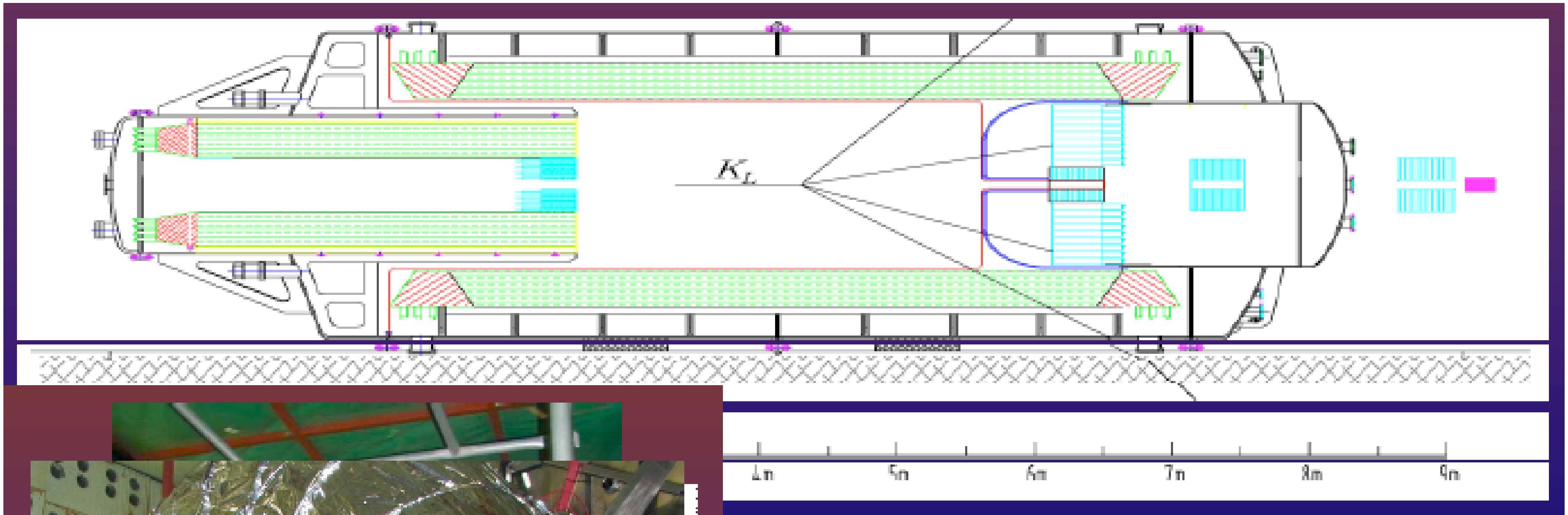
IPNS, KEK

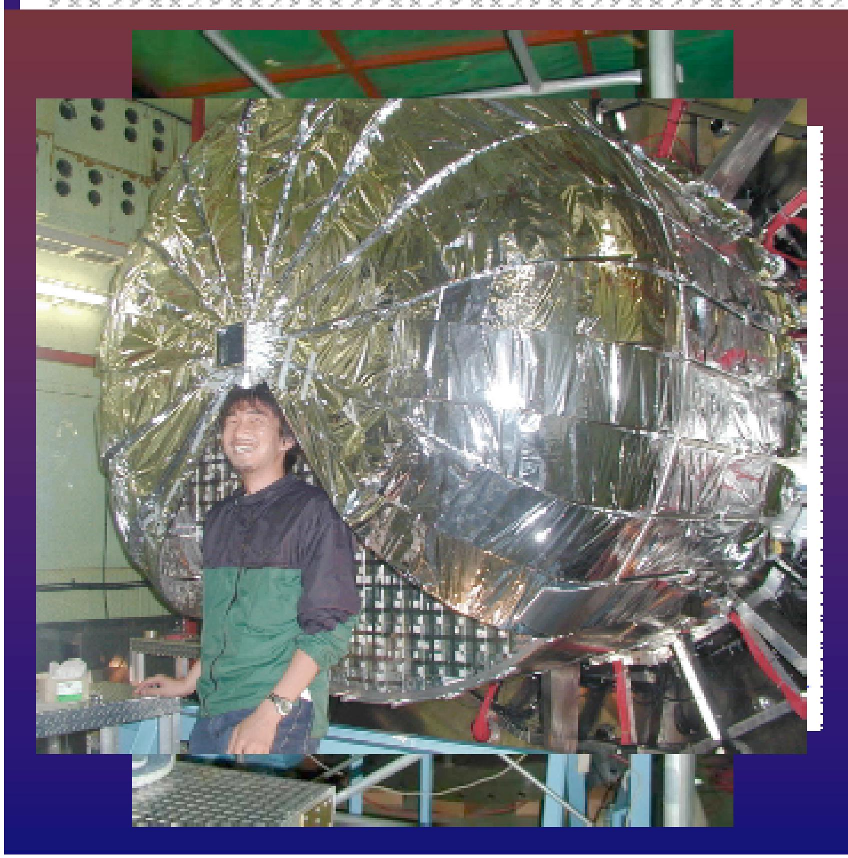


What shall we do ?

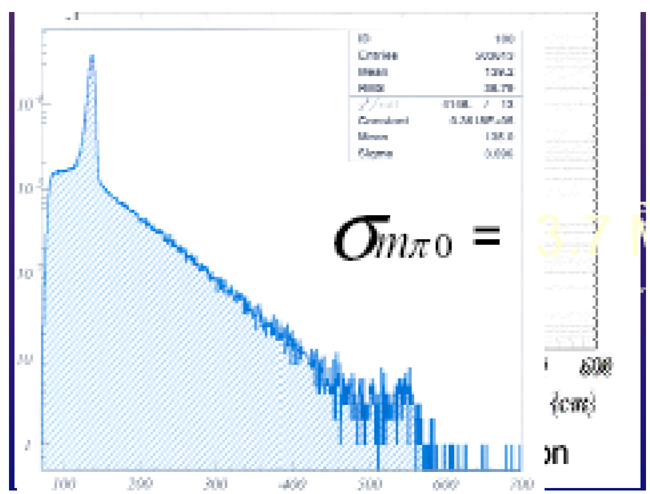
- Clear single π^0
  - $\pi^0 \rightarrow \gamma\gamma$ for high sensitive measurement
- Confirm no other accompanying particle
  - Perfect veto system
- Complete understand of background
  - Based on data with help of M.C.
- A huge amount K_L decays
  - High intensity K_L beam line, Large acceptance

E391a detector





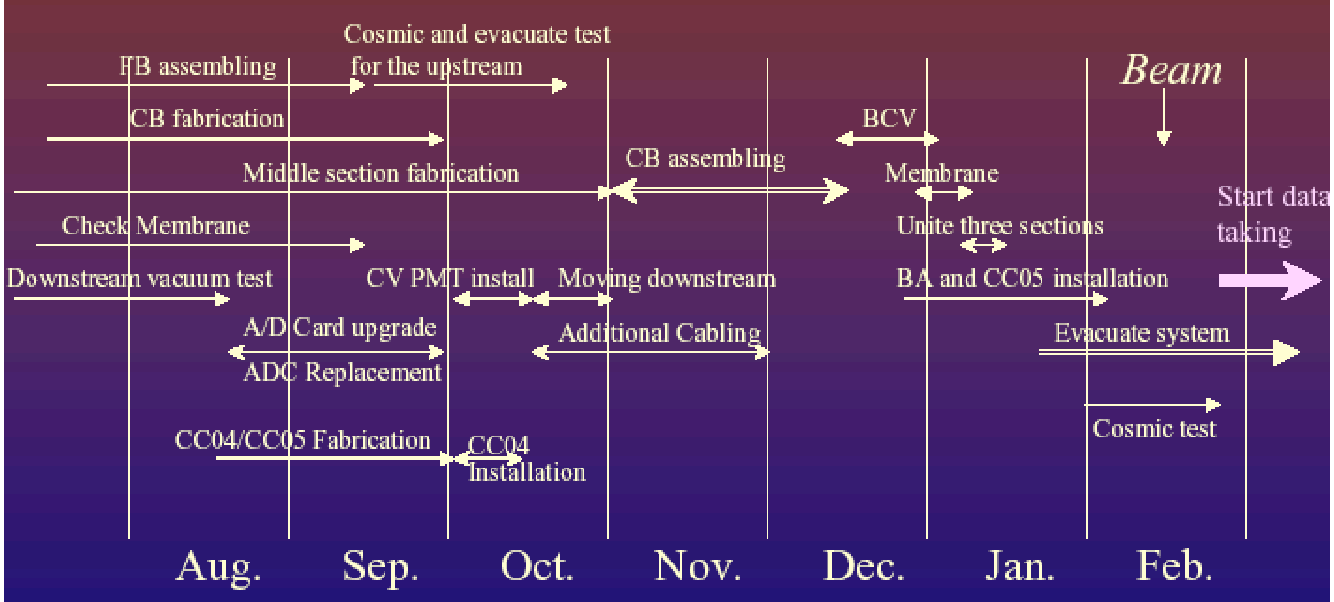
Engineering run



Summary

- KEK-PS E391a
  - The first dedicated experiment for the $K_L \to \pi^0 \nu\nu$
  - Detector is constructed on schedule for Feb. 2004
  - Aiming to $3X10^{-10}$ S.E.S.
  - Significant step to the precise measurement

Schedule



Rare K_L Decays
Recent Results from KTeV

Marj Corcoran

Rice University
for the KTeV collaboration

- Best limits on modes with possible direct **CP**-violating contributions
  - $K_L \to \pi^0 ee$
  - $K_L \to \pi^0 \mu\mu$
  - $K_L \to \pi^0 \nu\nu$

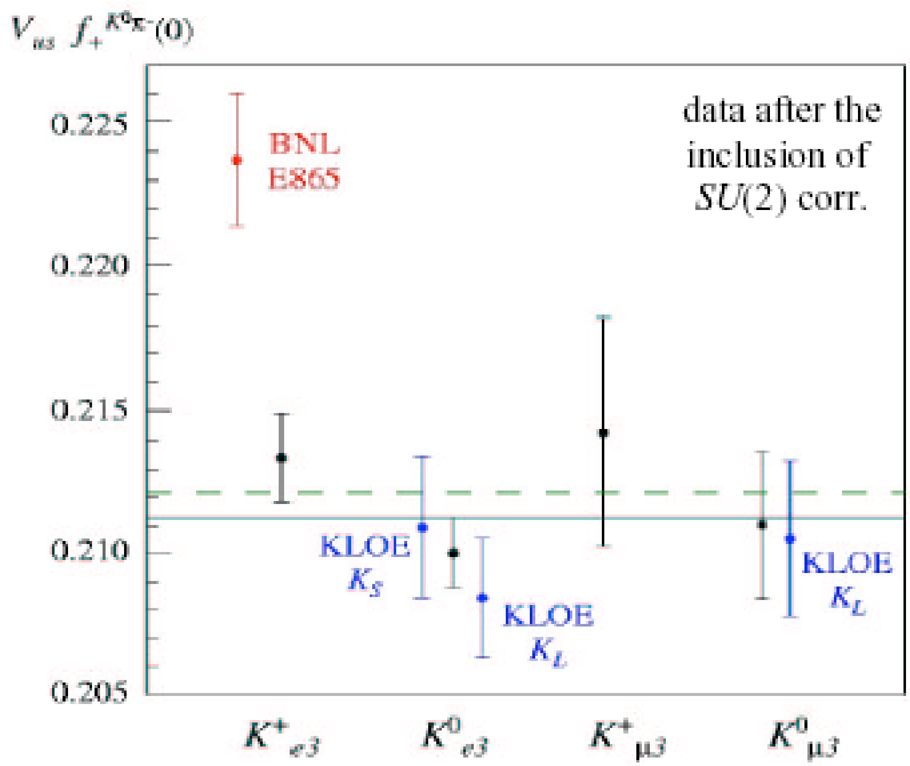
Experiment: $K_L \to \pi^0 ee$ ($\mu\mu$)

E799-II (KTeV)

Mode	Upper Limit 90% CL	Ref.
$K_L \to \pi^0 ee$	$< 5.1 \times 10^{-10}$	PRL86 (2001) 97 data
	$< 2.8 \times 10^{-10}$	Preliminary 97+99
$K_L \to \pi^0 \mu\mu$	$< 3.8 \times 10^{-10}$	PRL84 (2000)

A tiny (!!??) factor 10 away

BTW looking at very rare we shall not overlook some duty we have



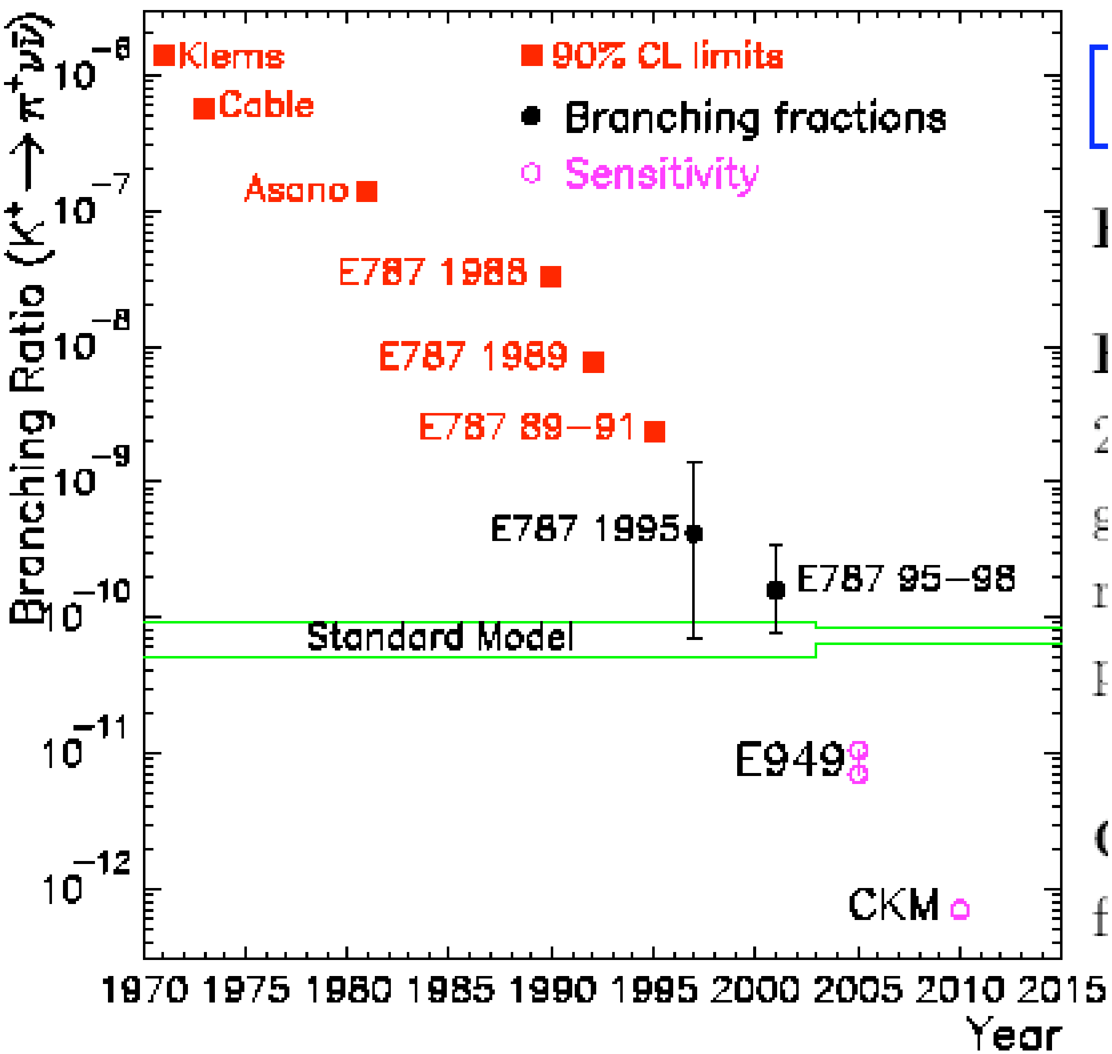
The present situation
is rather confused
[large SU(2) breaking=
wrong th. corrections,
or bad data?]...

...but in a short–time,
[with the help of KLOE
data on both modes],
we shoud be able
to clarify it.

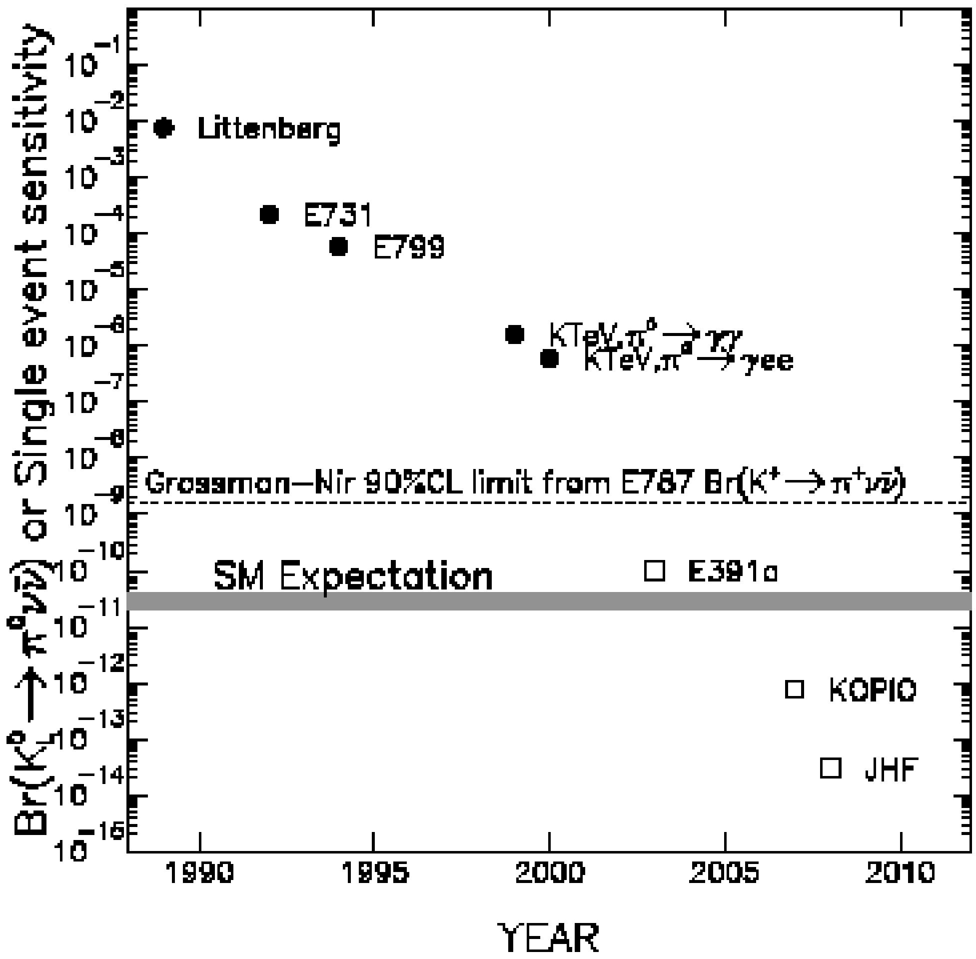
⬇

uncertainty dominated
by the th. error on *f(0)*?

Future (semi-solid or rather liquid) in $K^+ \to \pi^+ \nu \bar{\nu}$



Future (same state of condensation) in $K_L^0 \to \pi^0 \nu \bar{\nu}$



Future (gaseous) in

$K_L \to \pi^0 ee(\mu\mu)$ Perspectives

Admittedly aggressive Road Map

- Detector $\sigma(\gamma\gamma)$ ×2
  - Very ambitious, KTeV/NA48 already state of the art
- K_S-K_L time dependent interference ×2
  - Position experiment between 9 and 16 K_S lifetimes (hep-ph/0107046)
- K_S-K_L time independent interference ×3
  - Assume constructive interference (theoretically preferred)
- Data Taking ×5
  - Run in "factory mode". After all E799-II run only for a few months to collect ~7 × 10^{11} K_L decays
- Beam intensity ×4
  - Need ~10^{12} protons/sec, slowly extracted, high energy, DC
- Tot ~ ×240 → sens~ ×15
  - close the gap between current upper limit and SM
- Where? When?

NA48/3 ??

- CERN is currently the only place where high energy kaon beams could be employed

Future (unkwnown state of matter)

$K_L \Rightarrow \pi^0 \nu\bar{\nu}$ at a Φ factory?

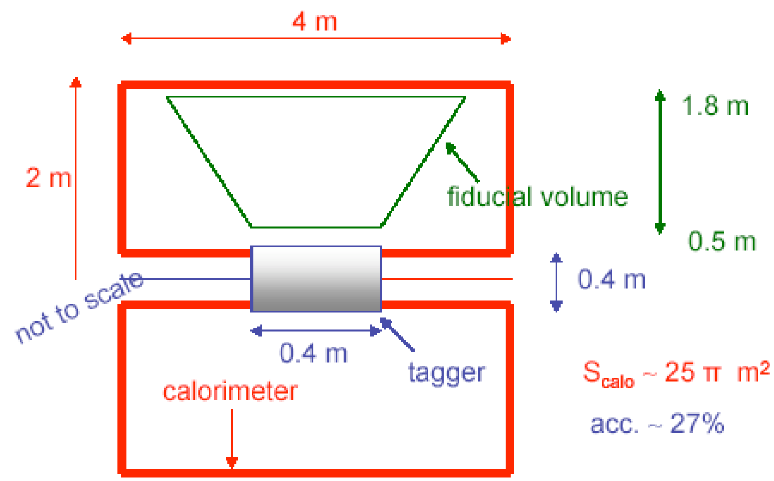
F. Bossi
LNF-INFN

Production rate: 10^6 K_S-K_L pairs / pb^{-1}

1 year @ 10^{35} $cm^{-2}s^{-1}$: 10^{12} K_L produced

observed decays: 30 * ε_{tot} / year (SM)

must be $\varepsilon_{tot} \geq\sim 10\%$



The search for $K_L \rightarrow \pi^0 \nu\nu$ is probably the most exciting goal and solid motivation for the high luminosity option of DAΦNE 2 (*see Gino's talk yesterday*)

It requires however luminosities of order ***10^{35}*** $cm^{-2}s^{-1}$

Future (unkwnown state of matter)

1 year @ 10^{32} = 1 $fb^{-1} \approx 3\ 10^9\ \Phi \approx 3\ 10^9\ K^{\pm}$

→ Allows few per mil measurement of O(1%) BRs
V_{us} @ / below 1% (theor. error…?)
$\delta_g(K^{\pm} \to \pi^{\pm} 2\pi^0)$ below 1 %

1 year @ $5 \cdot 10^{33}$ = 50 $fb^{-1} \approx 1.5\ 10^{11}\ \Phi \approx 1.5\ 10^{11}\ K^{\pm}$

→ $\approx$ 2 10^6 $K^{\pm} \to e^{\pm}\nu$ <u>produced</u>
$\approx$ 15 $K^{\pm} \to \pi^{\pm}\nu\nu$ <u>produced</u>

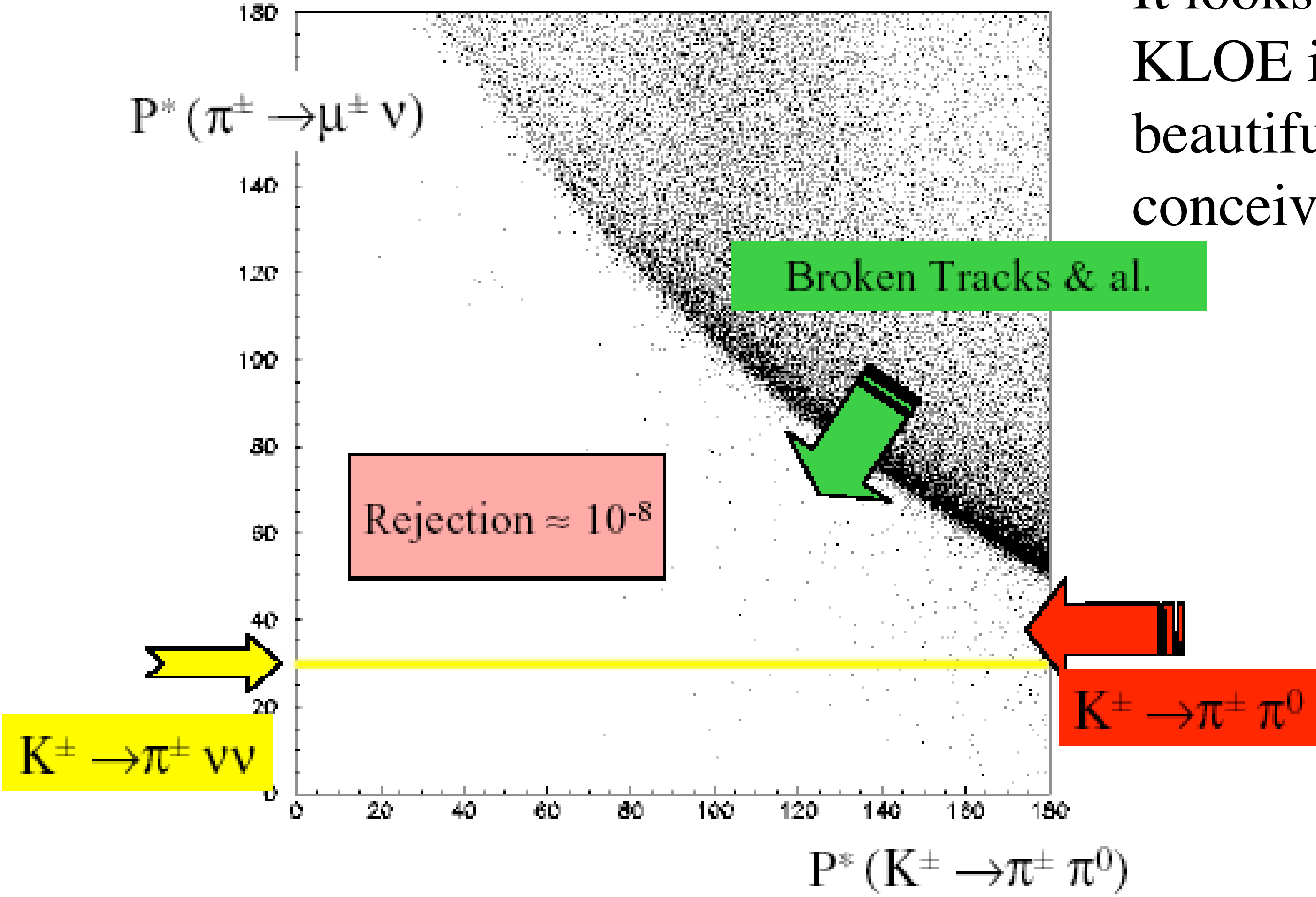
1 year @ 10^{35} = 10^3 $fb^{-1} \approx 3\ 10^{12}\ \Phi \approx 3\ 10^{12}\ K^{\pm}$

→ $\approx$ 300 $K^{\pm} \to \pi^{\pm}\nu\nu$ <u>produced</u>

L. Passalacqua / LNF-INFN
& the KLOE $K^{\pm}$ group.

Future (unkwnown state of matter)

It looks like that KLOE is the most beautiful MC ever conceived



L. Passalacqua / LNF-INFN
& the KLOE K± group.

$$\varepsilon_{START} = (2\varepsilon_a)\cdot 0.85\cdot(2\varepsilon_a)\cdot 0.3 \sim 9\%$$

Conclusions

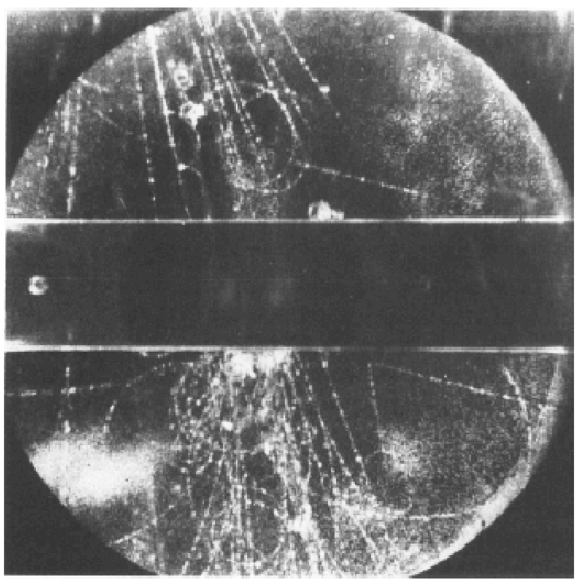
- Great opportunity of comparing things and exchanging idea. Start of an exciting process.
- Thanks to all for their great presentations
- Forgive me those of you I had no time to show your results

- and…….if we

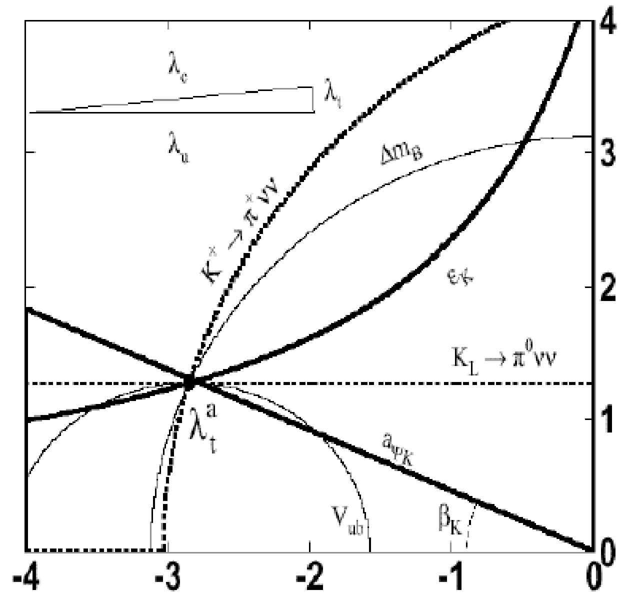
get Jedi Master Joda
to help us

Long live to Kaon Physics

Once upon a time, (neutral) kaons delivered many surprises and precious insight…



CPV



… they are still doing so today, their charged partners can join as well as effective CPV and ChPT probes