DAΦNE2?

Paolo Franzini

Università di Roma, *La Sapienza*

Alghero, 13 September 2003

OUTLINE

1. WHAT
2. WHEN
3. WHERE
4. WHY
5. HOW
6. KLOE, too

DAΦNE2: what is it

It is a dramatically upgraded DAΦNE, the present machine. It is a new machine with altered geometry but retaining its footprint. It is a DAΦNE capable of

1. Yielding a luminosity of about 5×10^{34}, at 1019.456±0.020 MeV and
2. With a background level preferably lower than the present one now at DAΦNE
3. DAΦNE2 is a machine which could also run up to ∼2 GeV maximum. Performance at 1019.6^{+5}_{-15} MeV must not be compromised.

WHEN, in which time frame?

The project must be completed BEFORE LHC begins its *real physics running*.

This is an excellent and ample time window during which other main projects in the world are:

- TEVATRON. Struggling with bringing up its luminosity. Probably will NOT find the Higgs,
- HERA is winding down its HEP activities, accumulating a large backlog of DIS data that will most likely exhaust their computers and analysis capacities

- B (C) factories are occupied in their microscopic scrutiny of the myriad of B/D decay modes, trying to unravel an unwieldy Gordian knot (bundle?).

That is just the right time for us to bring DAΦNE back to its original goal of measuring all the parameters in the kaon sector, but also beyond it, in its ultimate accuracy, as appropriate for 10 years later.

Remember that while

$$\frac{\Gamma(K_L \to \pi^+\pi^-)}{\Gamma(K_S \to \pi^+\pi^-)} \Bigg/ \frac{\Gamma(K_L \to \pi^0\pi^0)}{\Gamma(K_S \to \pi^0\pi^0)}$$

is well measured, partial widths and amplitude ratios are much more poorly known.

WHERE should it be built?

The site question always comes up. But there is no question: LNF, the high energy laboratory of the INFN!

- Infrastructures are there; from real estate and management to utilities (water? no sewer problem).
- LNF is the only INFN laboratory that has an accelerator division that built a working and productive collider. Furthermore, it's the birthplace of colliders after all.
- Without anyone much noticing, a miracle has occurred in the last dozen of years around LNF.

A new generation of physicists has emerged from the junior staff of LNF and the collaborating institutions (like the travelling minstrels).

They can THINK, DO, ANALYZE, be RESPONSIBLE, on their own AND, even more importantly, work devotedly as a COHERENT team towards a COMMON end.

They are, without any doubt, world class in their skills and motivation, and I'm extremely proud of them. Let's give them an equally worthy instrument to work with!

WHY should it be done?

- It is an IDEAL project for INFN.
- INFN needs a “new” project every 3-5 years to maintain its budget justification.

And it satisfies many relevant points

1. It has a challenging, though yet to be proven feasible design.
2. It is complete and self contained, not a piece of some international humongous project in which INFN functions mainly as a donor.
3. When built, it will have international visibility, as

the present KLOE result are beginning to have. DAΦNE2 certainly would have the UNIQUENESS of being the only BRIGHT phi factory (VEPP-2000's goal luminosity is orders of magnitude lower).

4. The project fits well in the temporal period indicated above including KLOE completing its present physics program and preparing a realistic machine and detector design

5. The upgraded KLOE would still have the largest chamber, the fastest calorimeter, plus more tracking close to the interaction point and a good Q-cal.

Why: PHYSICS!!!

The original KLOE proposal was centered around proving the existence or otherwise of direct $\not{C}\not{P}$. While we proposed to do this by measuring the four rates

$$\Gamma(K_{S,\,L} \to \pi^+\pi^-, \pi^0\pi^0)$$

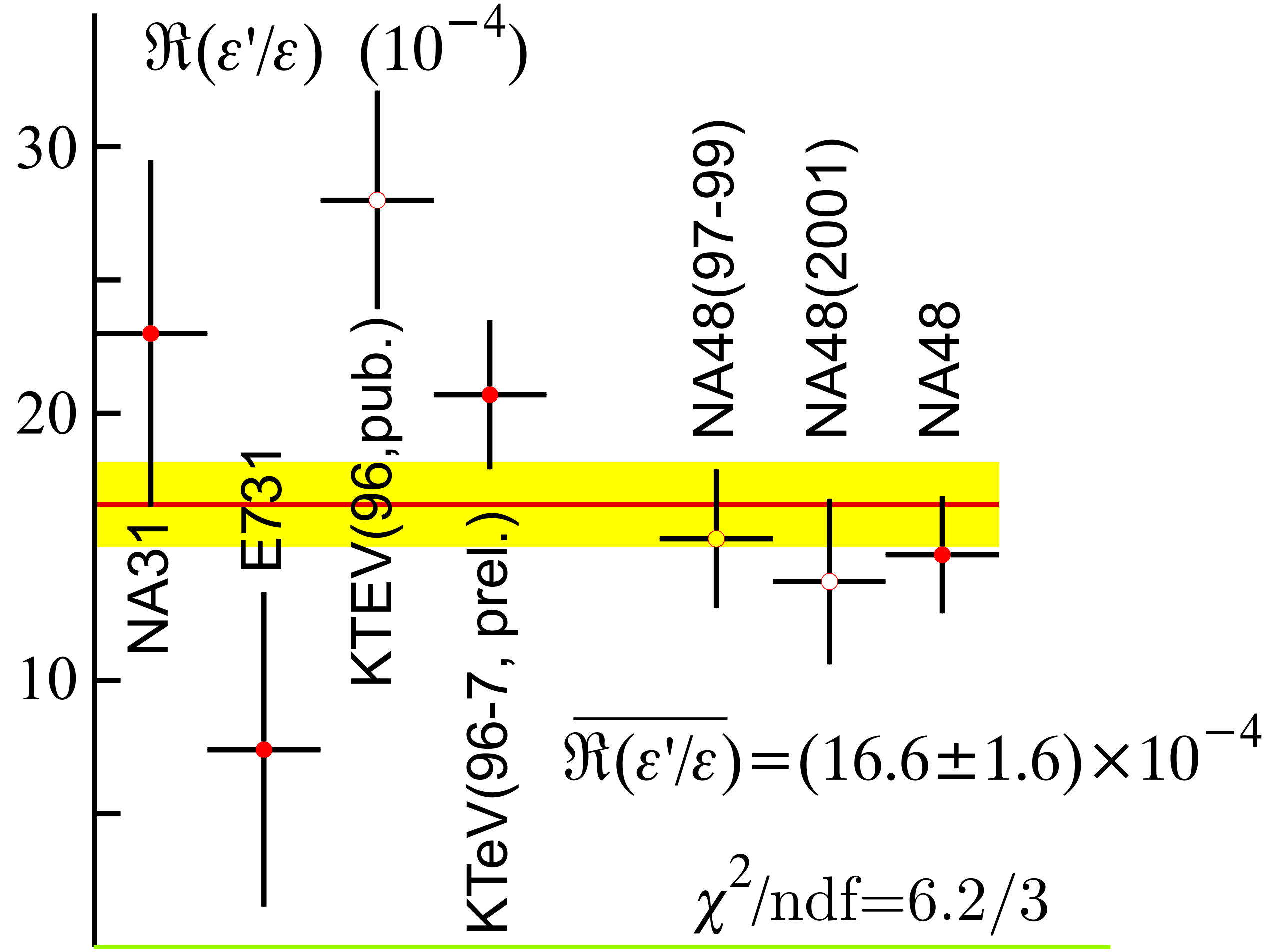
we did emphasize the uniqueness of a ϕ–factory in providing interferometry, thus allowing the measuring of phase and magnitude of the amplitude ratios

$$\eta_i = \frac{A(K_L \to i)}{A(K_S \to i)}$$

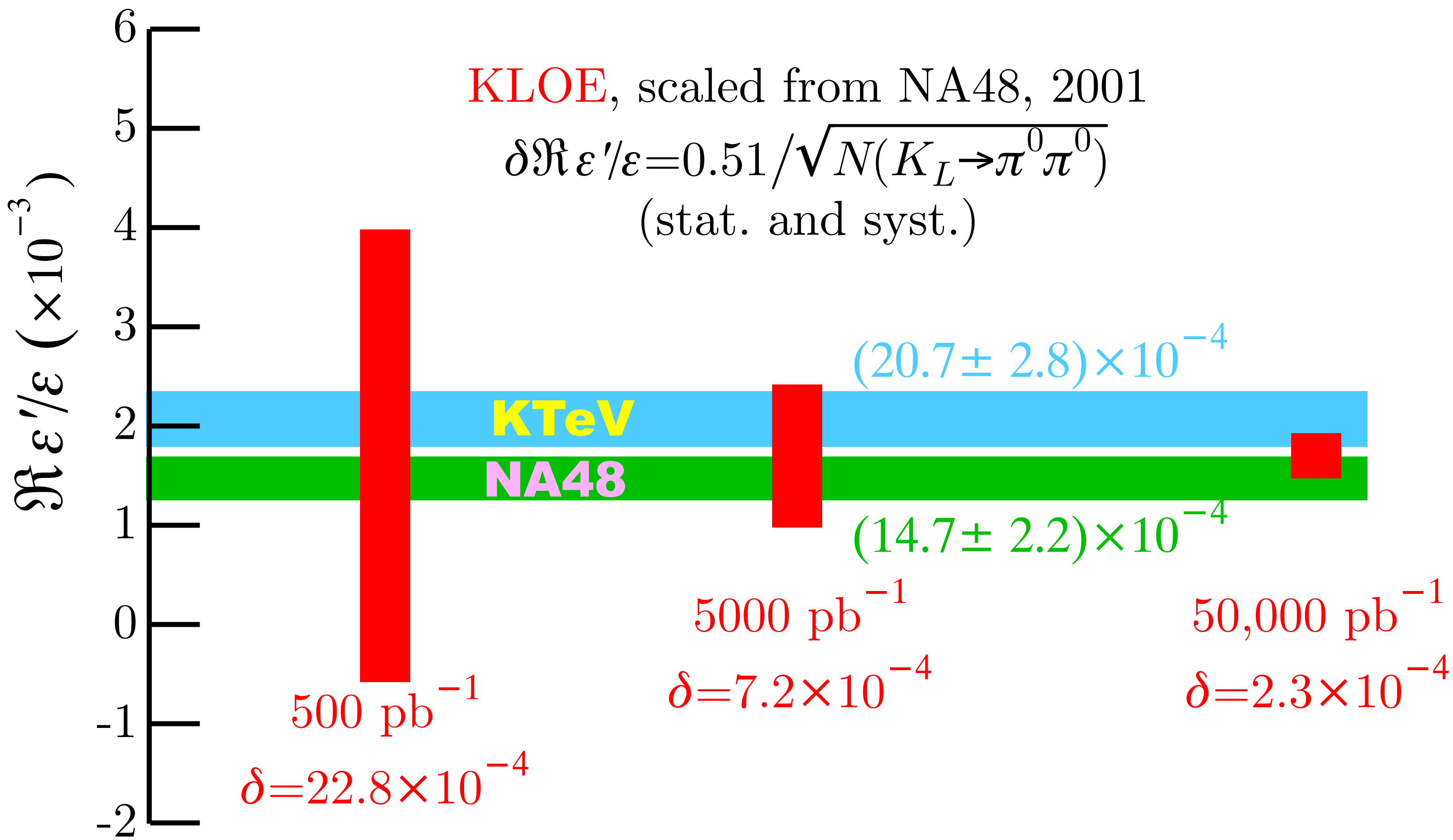
as well as *kinematical* properties such as $\Gamma_{S,\,L}$ and Δm.

Direct $\not{C}\not{P}$ has been proven by NA48 and KTeV, but KLOE has yet not much to say.

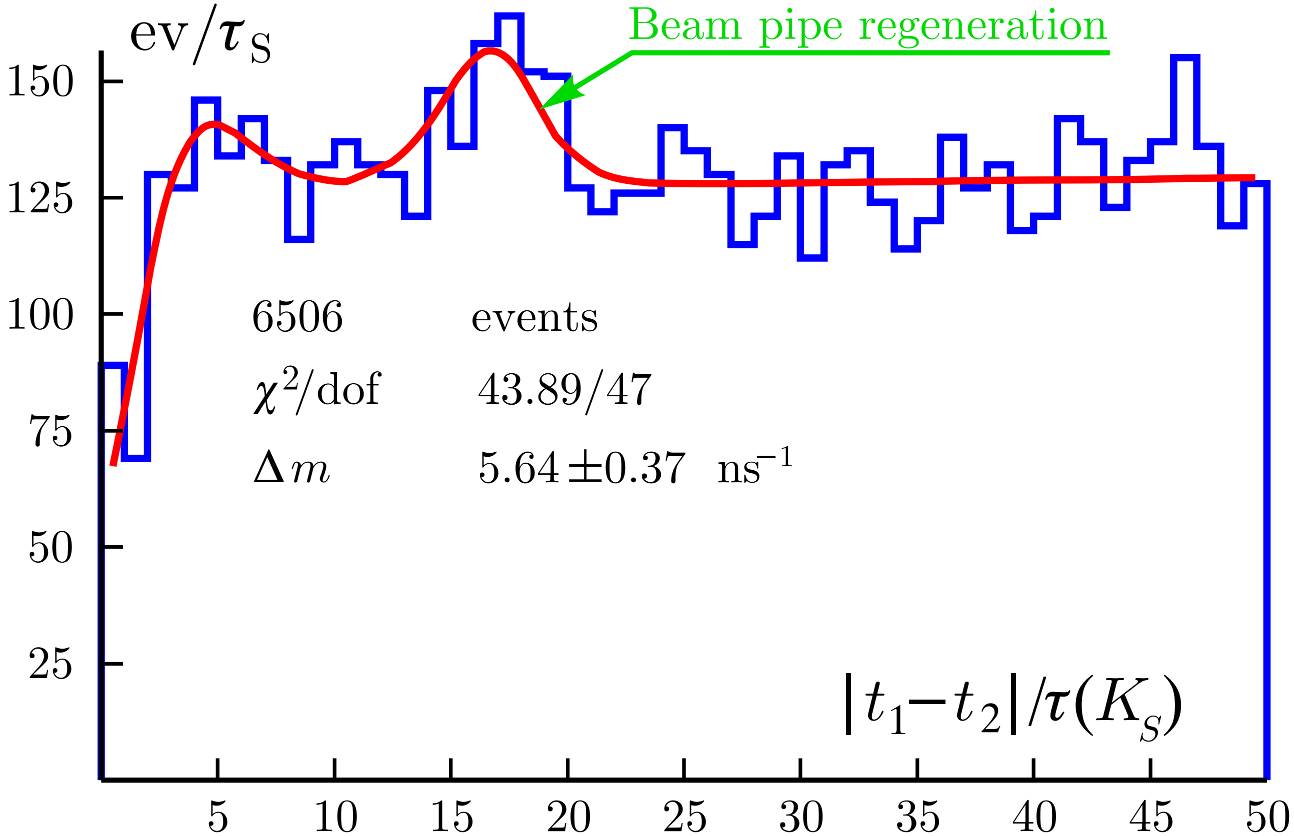
Since there appears to be no way to connect $\Re(\epsilon'/\epsilon)$ and the CKM parameters, there is little reason for spending time and money in trying to perform a third measurement.

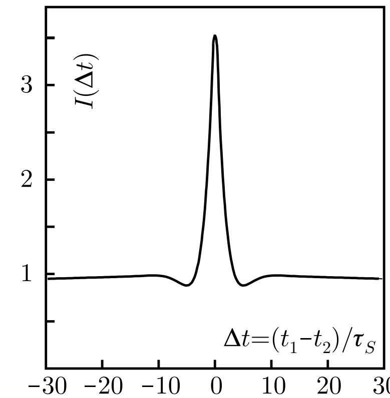


from Lenti, CERN Seminar

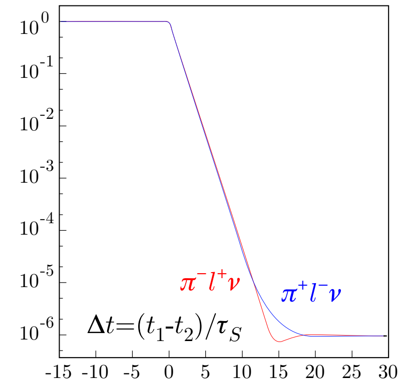


Measuring the η_i parameters (and Γ's and more) remains however a fundamental job to be performed to complete our knowledge of the parameters of the neutral kaon system. And this is already quite a justification for DAΦNE2-KLOE.





$\phi \to K_S K_L$
$\to \pi e^+ \nu$
$+ \pi e^- \nu$



$\phi \to K_S K_L$
$\to \pi^+ \pi^-$
$+ \pi e \nu$

The first example of interference observed in KLOE.

$$e^+e^- \to \phi \to K_S K_L \to \pi^+\pi^- + \pi^+\pi^-$$

$$\Rightarrow \Gamma_S,\ \Gamma_L,\ \Delta m,\ [\Re, \Im(\eta_i,\ \delta \ldots)]$$

$$I(f_1, f_2, \Delta t) = ..2|\eta_1||\eta_2|e^{-\Gamma \Delta t/2} \cos(\Delta m \Delta t + \phi_1 - \phi_2)$$

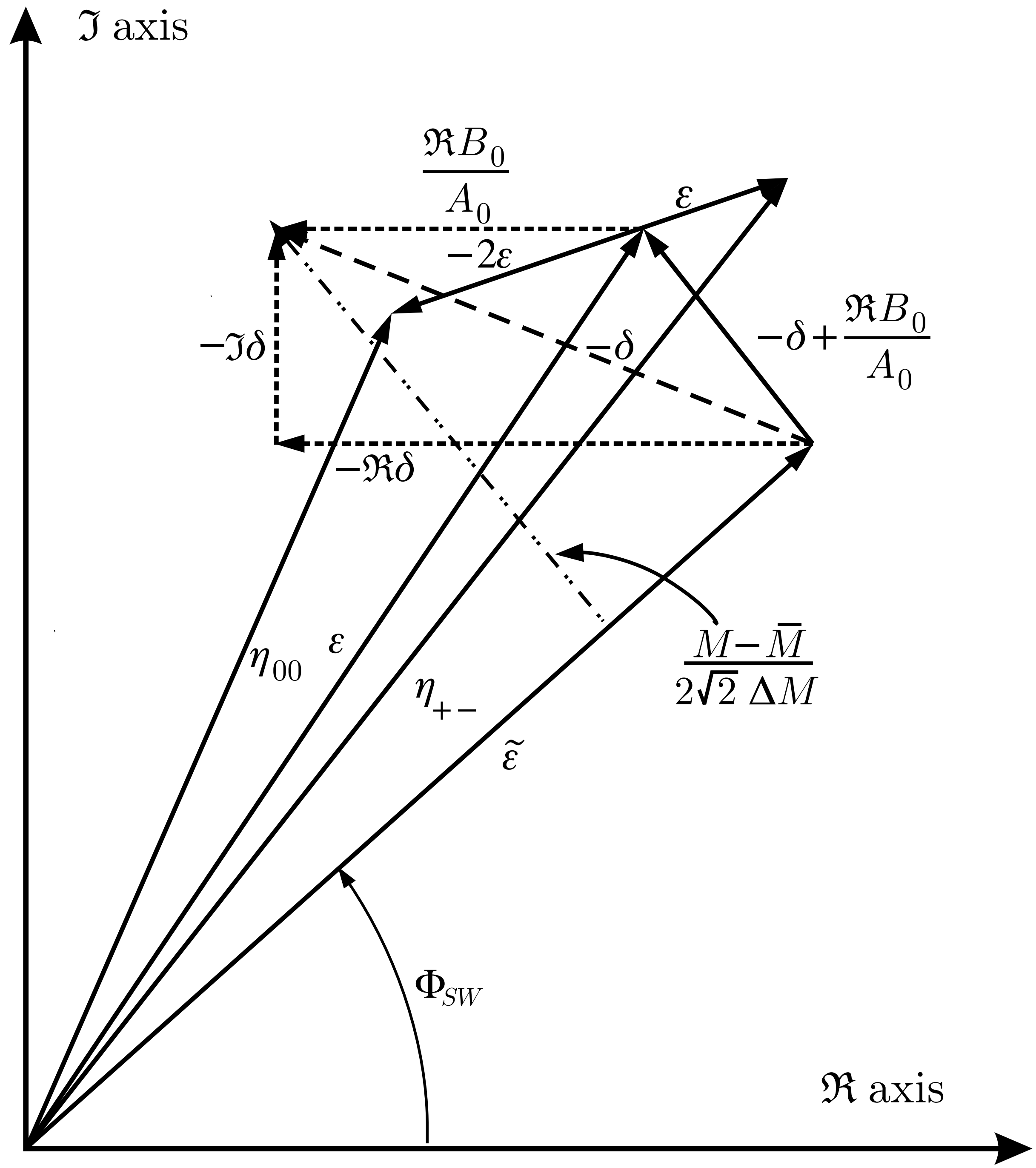
I do not have to remind you that measuring the complex amplitude ratios η_i means measuring $\Re(\epsilon'/\epsilon)$ and much more. From the relations

$$\eta_{\pi^+\pi^-} = \epsilon + \epsilon'$$
$$\eta_{\pi^0\pi^0} = \epsilon - 2\epsilon'$$

(which could be taken as the definition of ϵ and ϵ')

$$\epsilon = (2\eta_{+-} + \eta_{00})/3$$
$$\epsilon' = (2\eta_{+-} - \eta_{00})/3$$

providing much more information than just $\Re(\epsilon'/\epsilon)$, as indicated in figure.



An aside: KLOE, 99-03

In spite of a large amount of frustration, KLOE has made fundamental contributions to:

1. K_S decays, rare and not
2. Scalar mesons
3. $\sigma(e^+e^-\to\pi^+\pi^-)$

A ϕ–factory is unique for K_S study. Only from ϕ-decays we can get pure K_S (and K_L and K^+ and K^-) beams.

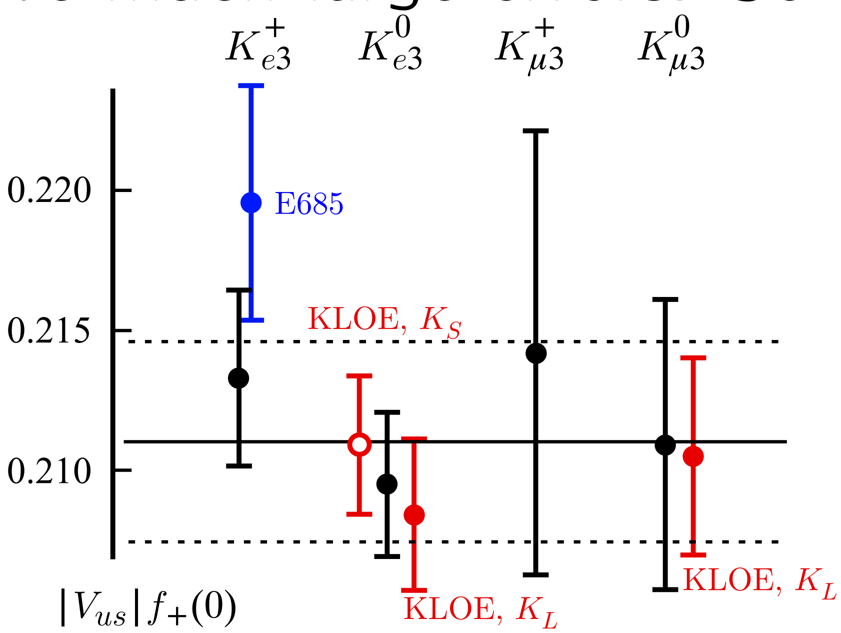
Yields are $\mathcal{O}(10^6)$/pb^{-1} kaons of any kind. After tag and fiducial volume one is left with 10-50% of them. Purity is unsurpassed and (not often appreciated) an absolute count is automatic.

In the 2002-3 edition of PDG KLOE appears for the first time, with 11 entries. All of which are already surpassed by our newer results. By the end of 2003 we will provide the basis for the first improvement, in a long time, >30 years, of the $|V_{us}|$ value.
And, for the first time, our data will allow critical checks of chiral perturbation calculations.

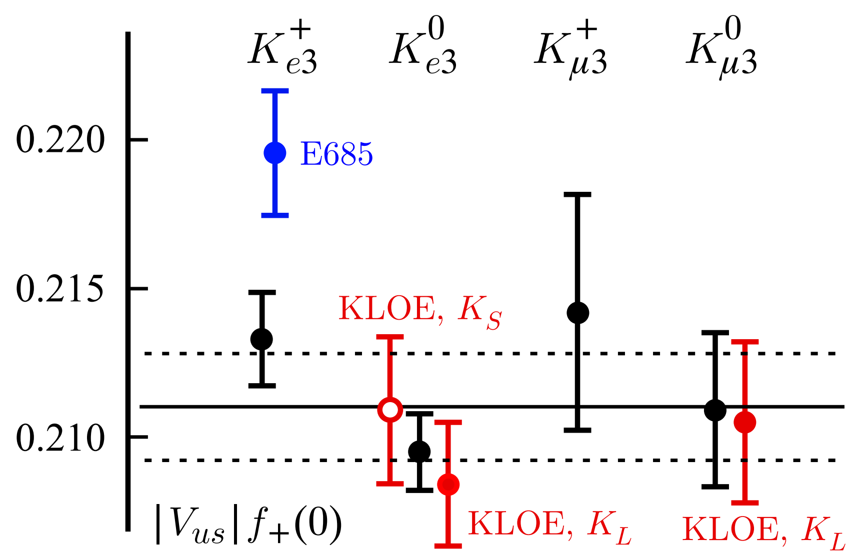
Still the best product of KLOE are all the young people who have had the opportunity to struggle and solve lots of problems to get to final results.

Aside on errors

If you look in PDG for the data used to get $|V_{us}|$ you first realize that they come mostly from 1972 and earlier. One exception is $\tau(K^{\pm})$ which was last measured in 95, with poor agreement between the two result of the same experiment. Given the existing data, I would conclude that the lifetime error is 0.8%, rather then the quoted 0.2%. Second you notice that the error on the branching ratios come from the PDG fit, the actual measurements have much large errors. So things really look more like



than



A problem with the PDG fits (with all fits) is that they give smaller errors and many, large, correlations.

K. Hagiwara *et al.* (Particle Data Group), Phys. Rev. D **66**, 010001 (2002) and 2003 partial update

K_L^0 1965 result in 03 $I(J^P) = \frac{1}{2}(0^-)$

$$x = A(\overline{K}^0 \to \pi^- \ell^+ \nu)/A(K^0 \to \pi^- \ell^+ \nu) = A(\Delta S{=}-\Delta Q)/A(\Delta S{=}\Delta Q)$$

REAL PART OF x

VALUE	*EVTS*	*DOCUMENT ID*	*TECN*	*COMMENT*
$-0.08\,^{+0.16}_{-0.28}$	109	[122] FRANZINI 65	HBC	$\overline{p}p$

Another problem with the PDG fits is that they give very small errors and many, very large, correlations.

K. Hagiwara *et al.* (Particle Data Group), Phys. Rev. D **66**, 010001 (2002) and 2003 partial update

K^0_L 1965 result in 03 $I(J^P) = \frac{1}{2}(0^-)$

$$x = A(\overline{K}^0 \to \pi^- \ell^+ \nu)/A(K^0 \to \pi^- \ell^+ \nu) = A(\Delta S{=}-\Delta Q)/A(\Delta S{=}\Delta Q)$$

REAL PART OF x

VALUE	*EVTS*	*DOCUMENT ID*	*TECN*	*COMMENT*
$-0.08^{+0.16}_{-0.28}$	109	[122] FRANZINI 65	HBC	$\overline{p}p$

CP-Lear (90's) with 640,000 events gave $\Re x = -0.0018 \pm 0.006$ or $\Re x < 1.2\%$ at 95% CL. Same idea.

Another problem with the PDG fits is that they give very small errors and many, very large, correlations.

K. Hagiwara *et al.* (Particle Data Group), Phys. Rev. D **66**, 010001 (2002) and 2003 partial update

K_L^0 1965 result in 03 $I(J^P) = \frac{1}{2}(0^-)$

$$x = A(\overline{K}^0 \to \pi^- \ell^+ \nu)/A(K^0 \to \pi^- \ell^+ \nu) = A(\Delta S{=}{-}\Delta Q)/A(\Delta S{=}\Delta Q)$$

REAL PART OF x

VALUE	*EVTS*	*DOCUMENT ID*	*TECN*	*COMMENT*
$-0.08\ ^{+0.16}_{-0.28}$	109	[122] FRANZINI 65	HBC	$\overline{p}p$

CP-Lear (90's) with 640,000 events gave
$\Re x = -0.0018 \pm 0.006$ or $\Re x < 1.2\%$ at 95% CL. Same idea.

KLOE 2002: 7,700 K_{Se3} decays (170 pb^{-1}),
$\Re x = 0.003 \pm 0.0065$, or $\Re x < 1.3\%$. All 02 data: 0.5%
– A better idea.

Uniqueness of a ϕ–factory
KLOE results

Purity - 1	$\sigma(e^+e^-\to\phi)\gg$cont., $\gg$Bhabha, large θ.
Purity - 2	$\psi(0) = (K_S K_L - K_L K_S)/\sqrt{2}$. – $K^\pm$!!

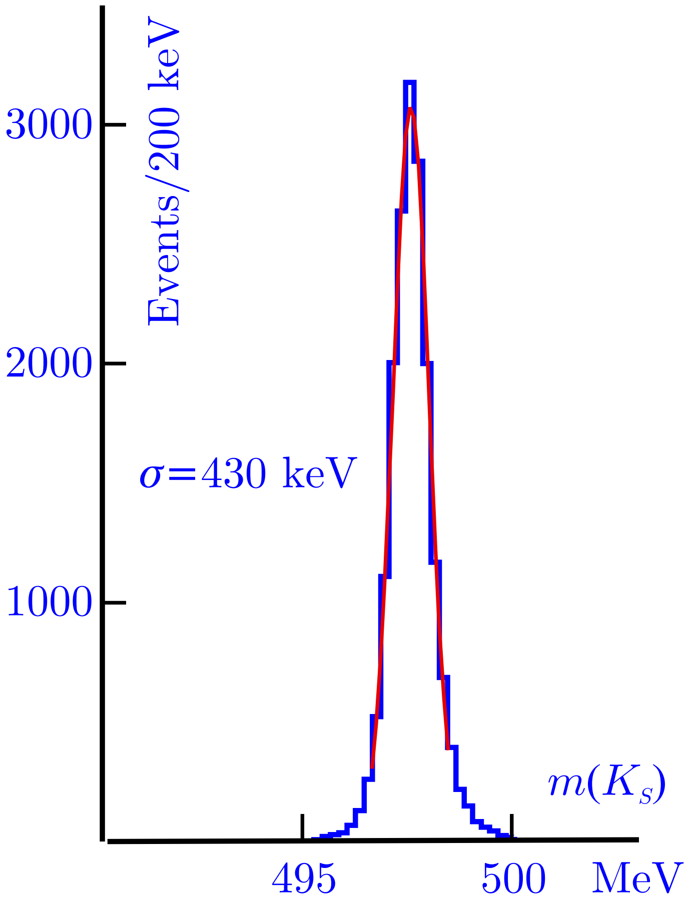
Yield

K^+K^-	50%
$K_S K_L$	34%
$\rho\pi$	15%

$\delta p/p$	0.5%, from machine δE
$\beta(K^0)$	$\sim$0.2; $\delta\beta/\beta\sim$0.5%, from machine δE

this is tex

KLOE Results: Masses



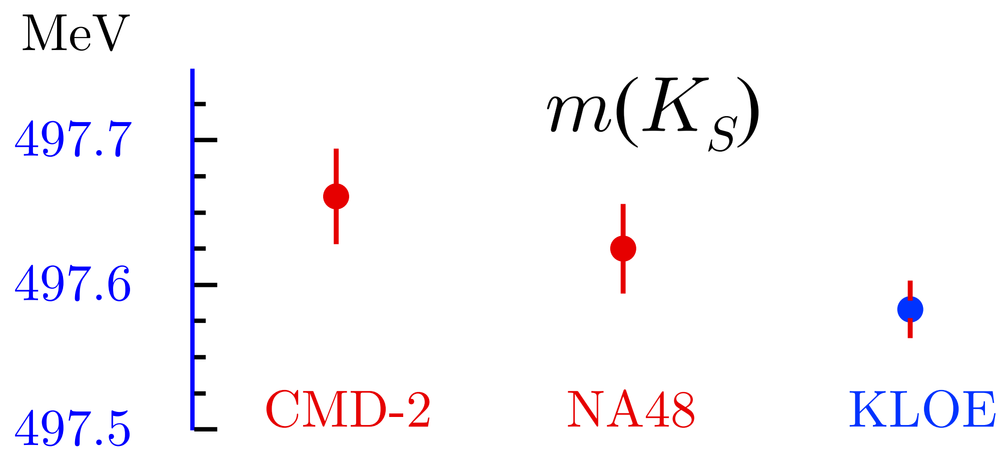
$m(\phi) - 2m(K_S) = 26$ MeV

$(1/2m(\phi))^2 \cong m^2(K_S) + p^2_{K_S}$

$\delta M_{KLOE} \sim 270$ keV

$\delta M_{DA\Phi NE} \sim 220$ keV

$\delta M_{RadCor} \sim 20$ keV

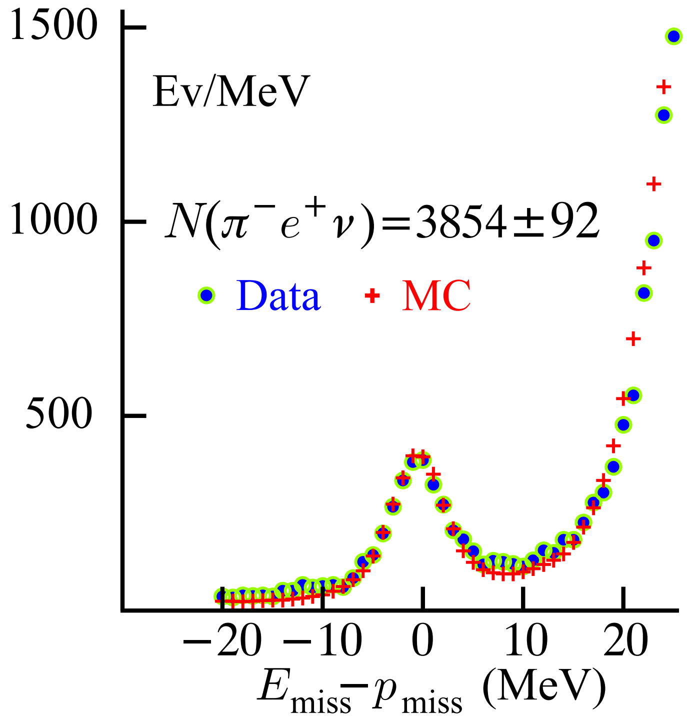


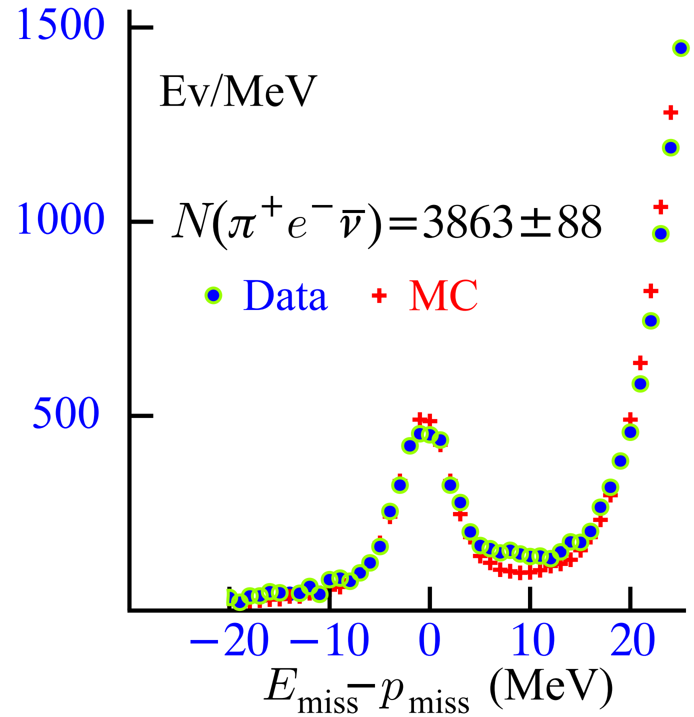
$$m(K_S) = 497.583 \pm 0.005 \pm 0.020 \text{ MeV}$$

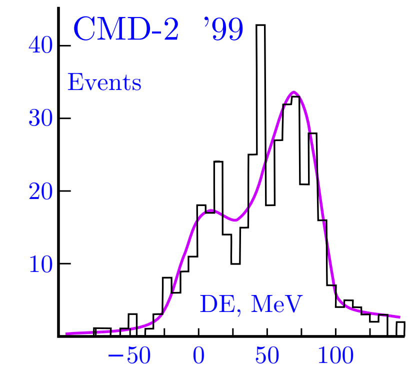
Who is right? Are QED rad corr site dependent?

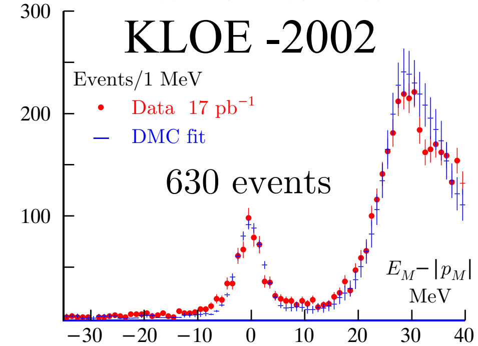
Momentum scale + accuracy. RADIATIVE corrections

KLOE Results: K_S-semileptonic









$$\mathrm{BR}(K_S \to \pi e \nu) = (6.9 \pm 0.15) \times 10^{-4};\ \delta\Gamma/\Gamma = 2.2\%$$

$$\mathcal{A}_S^e = (19 \pm 18) \times 10^{-3}$$

$$K_L:\ \delta\Gamma/\Gamma = 1\%,\ \delta\mathcal{A}_L^e = 7.4 \times 10^{-5}$$

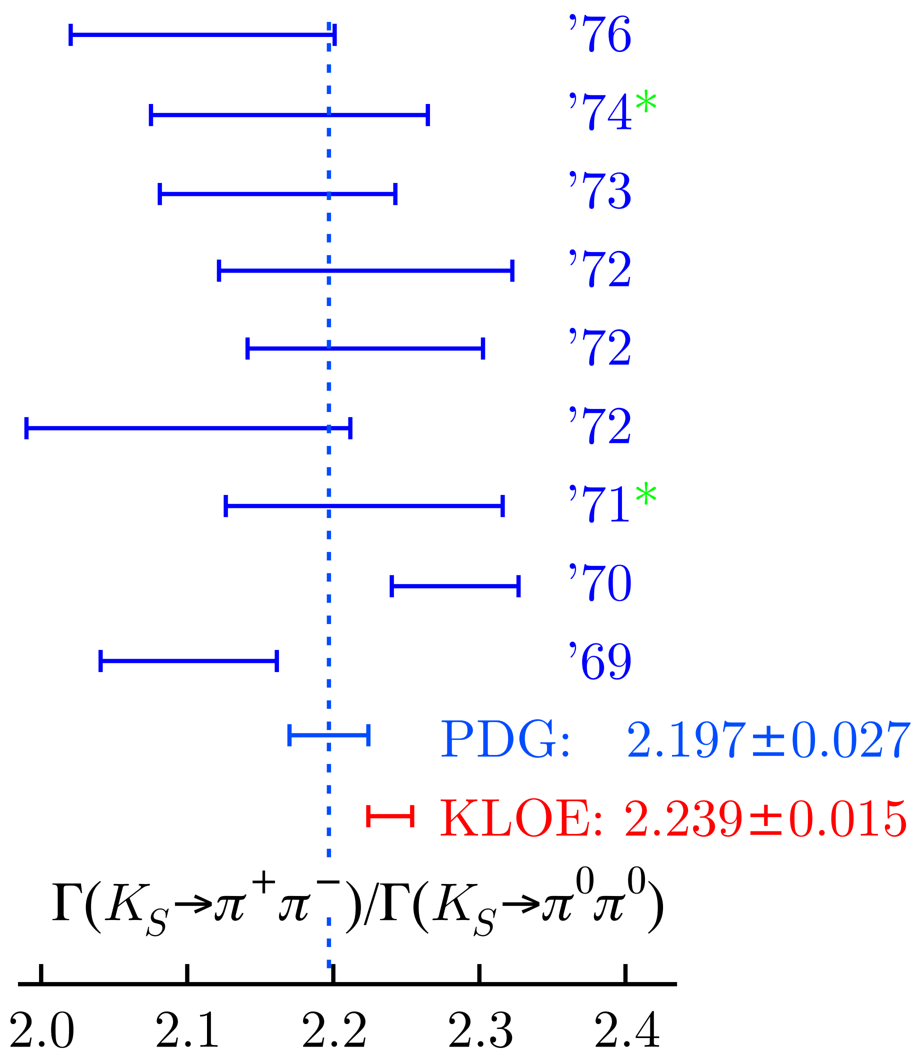
Tagging, particle ID

KLOE Results: $K_S \to \pi^+\pi^-(\gamma)/K_S \to \pi^0\pi^0$

Trigger eff $>$96.5%
Overall accept. $\sim$57%
ALL FROM DATA
$R = 2.239 \pm 0.003$(stat.) $\pm$ 0.015(syst.)
KLOE includes all $K_S \to \pi^+\pi^-\gamma$, others inc. unknown fraction.

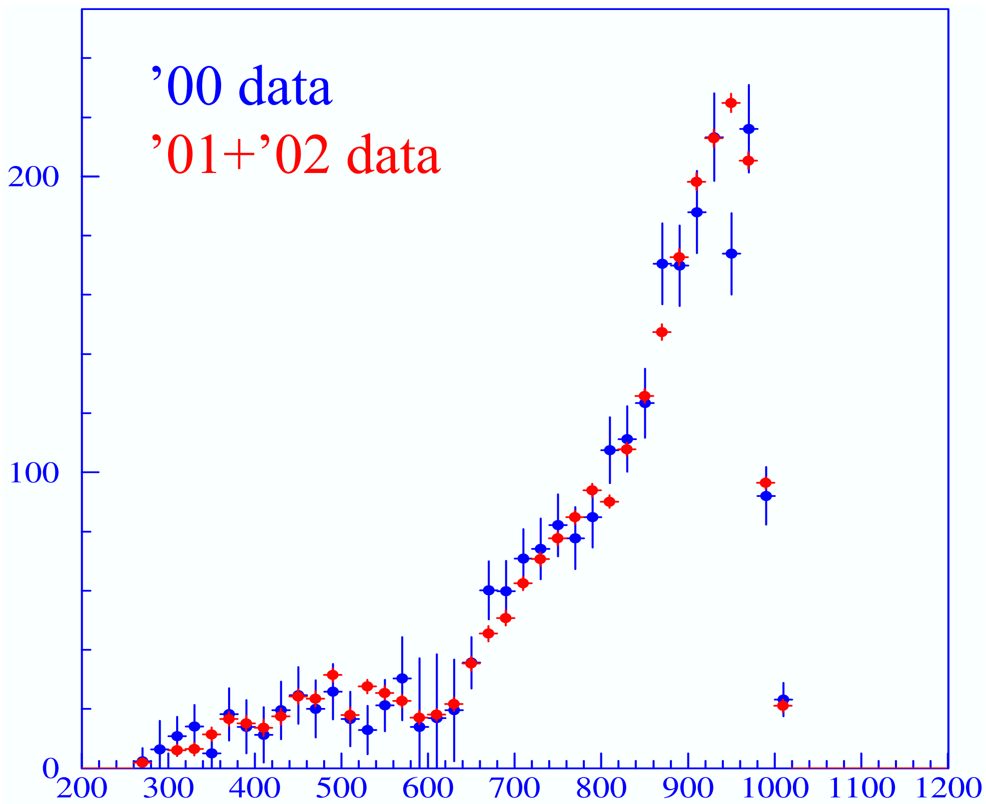
$\delta R/R = 0.1\%$ contributes 1.6×10^{-4} to error on $\Re(\epsilon'/\epsilon)$.
Coming soon

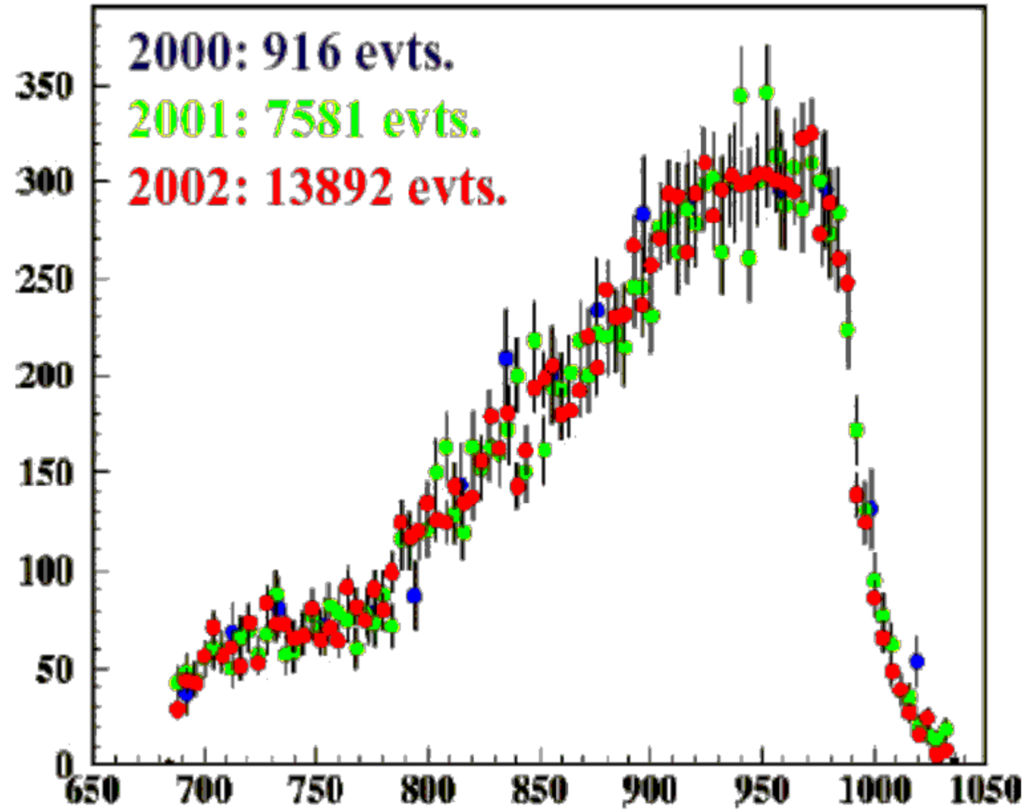
Do not take seriously PDG!



this is tex

KLOE Results: Scalars



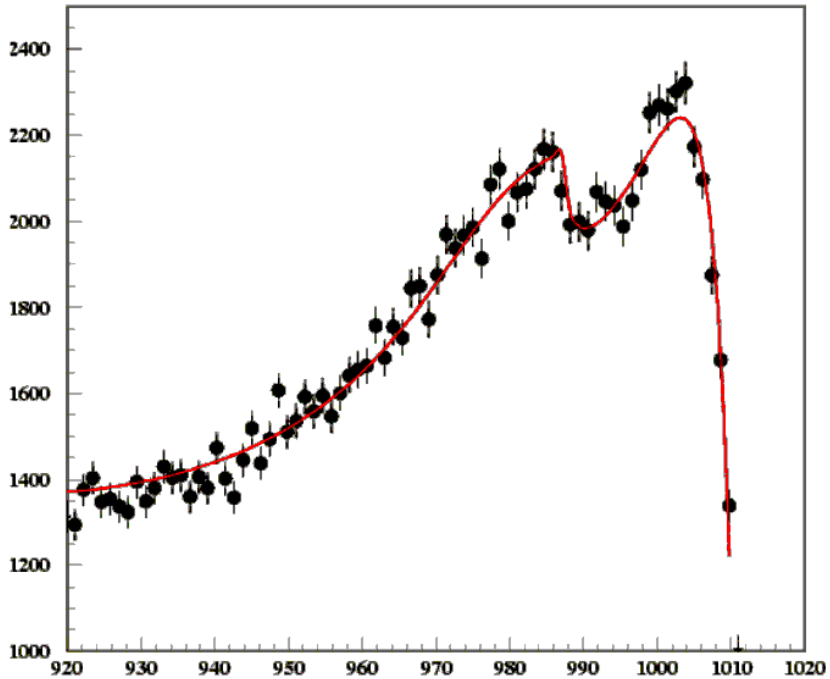


$$\mathrm{BR}(\phi\to\pi^0\pi^0\gamma)=(1.09\pm0.06)\times10^{-4}$$

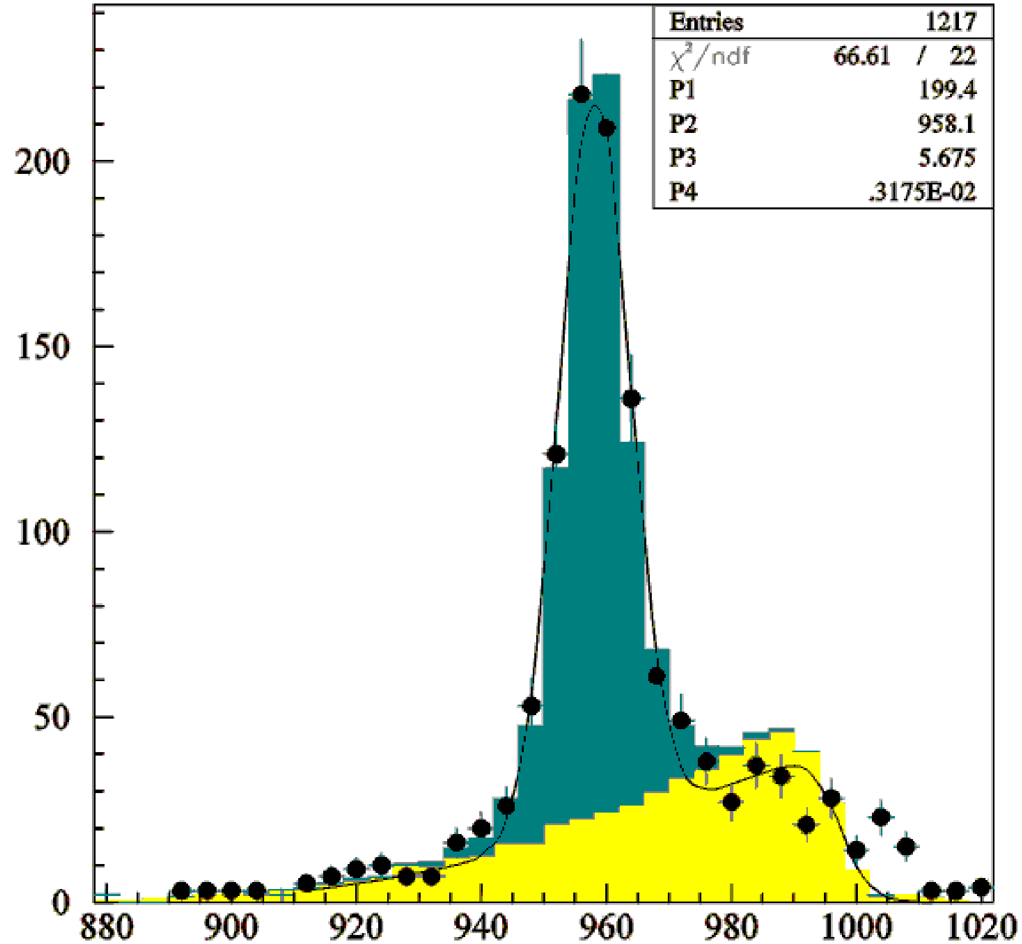
$$\mathrm{BR}(\phi\to\eta\pi^0\gamma)=(0.85\pm0.08)\times10^{-4}$$

First clean look at structure of scalars

KLOE Results: Pseudoscalars



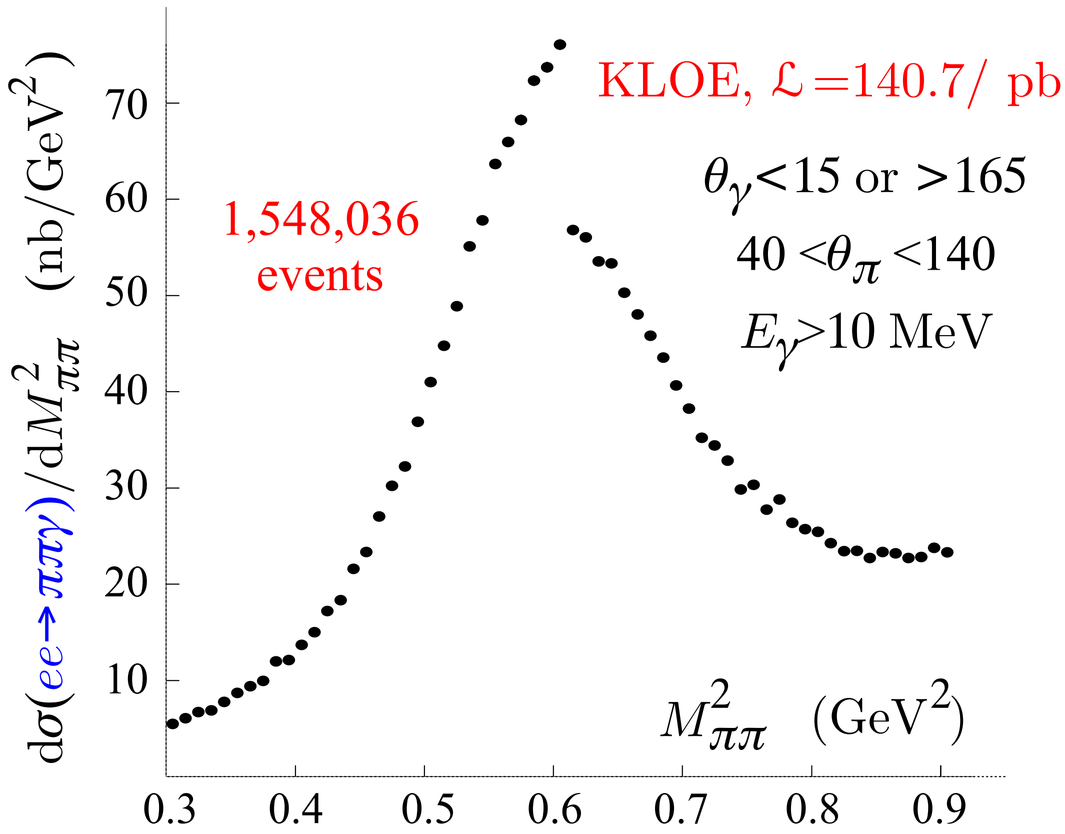
First evidence for
$\phi \to f_0\gamma \to \pi^+\pi^-\gamma$
really $f_0 \to \pi^+\pi^-$

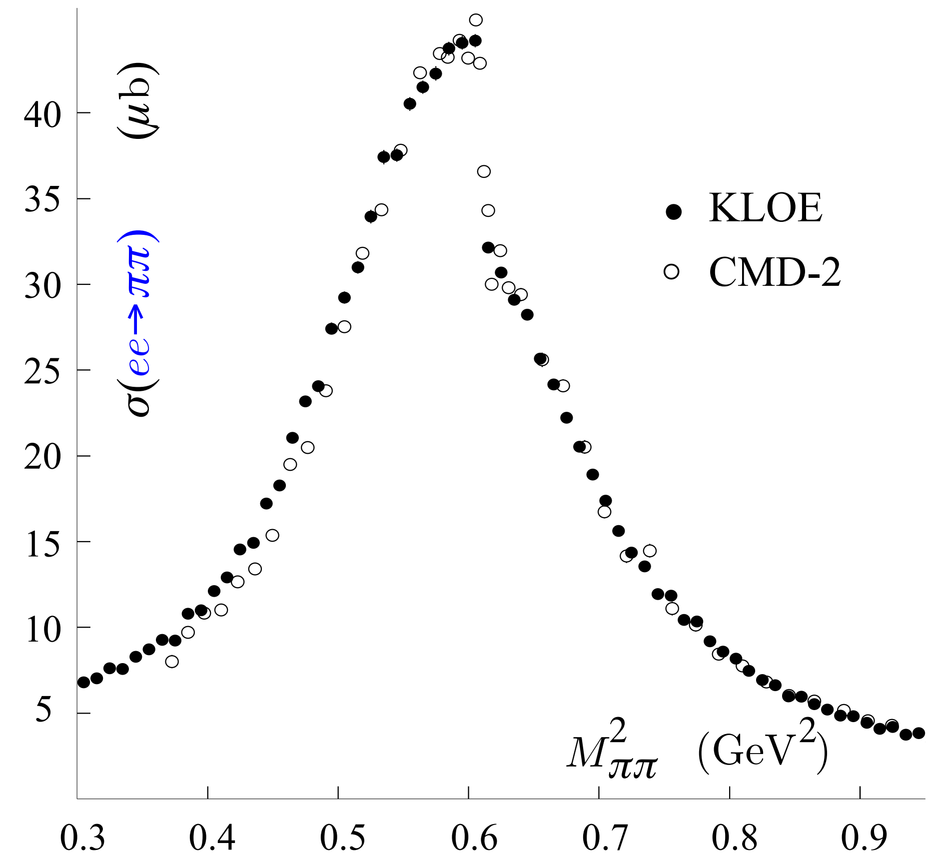


BR($\phi \to \eta'\gamma$)$=6.10 \pm 0.7 \times 10^{-5}$

Mixing, gluon contents

KLOE Results: $\sigma(e^+e^-\to\pi^+\pi^-)$





ISR instead of scan, radiative corrections

All of the above was just to prove that

1. A ϕ–factory is a good source of physics, even with low $\mathcal{L}$ and very large background
2. DAΦNE, with KLOE, has been a valuable venture, producing many highly skilled young people
3. LNF and INFN have profited from it and, for another couple of years will continue to do so, in a world which is becoming less and less sympathetic to research in fields remote from everyday connections. Which should never be a consideration. . .

But the end is close, very close. We should find a way to go further.

A ϕ–factory provides
pure, monochromatic,
low β
K_S (. . .) beam
with absolute count

IF ONE CAN DO
EXCEPTIONAL PHYSICS
WITH THE ABOVE
BOUNDARY CONDITIONS
WE SHOULD HAVE A NEW
DAΦNE

And that is what we have to ask

$K_L \to \pi^0 \nu\bar{\nu}$ cannot be measured

It has been said so often:

$$\Im V_{td} V_{ts}^* = A^2 \lambda^5 \eta = 25.6 \sqrt{\mathrm{BR}(K_L \to \pi^0 \nu\bar{\nu})}$$

$$\mathrm{BR}(K_L \to \pi^0 \nu\bar{\nu}) = 3 \times 10^{-11}$$

10 eV/3×10^{-11}=3.3×10^{11} K's. @1% dec/ϕ, need $100 \times 3.3 \times 10^{11}$=$3.3 \times 10^{13}$ ϕ's or 1.1×10^{13} μb^{-1}. In one year, need $\mathcal{L}$=10^6 μb^{-1}/s or $\mathcal{L}$=1×10^{36} cm^{-2} s^{-1}. For one hundred events, $\mathcal{L}$=1×10^{37} cm^{-2} s^{-1} or 10 year running.

$$J_{12} = \frac{h = A^2\lambda^5\eta\ (\times 10)}{\lambda(1-\lambda^2/2)}$$

To get η need λ and A!

$\delta(A^2\lambda^5)/(A^2\lambda^5) \sim 5.6\%$, K. Schubert, LP03. Optimistic?

What can be done?

While $\mathcal{L}$=1000 nb^{-1}/s is out, $\mathcal{L}$=50 nb^{-1}/s is conceivable. It is a pity that a series of circumstances did not allow DAΦNE to resume running, after the major improvements of Jan-June.

With 50 nb^{-1}/s, the K_S yield is 5×10^{11} per year. Many things become interesting. In the SM $K_S \to \pi^0\pi^0\pi^0$, $\to \pi^0 e^{\pm}\nu$ or the semileptonic asymmetry are trivially calculable from K_L BR's and ϵ:

1. BR($K_S \to \pi^0\pi^0\pi^0$)=1.9 × 10^{-9} (±2.4%)
2. BR($K_S \to \pi^{\pm} e^{\mp}\nu$)=6.7 × 10^{-4} (±1.5%)
3. $\mathcal{A}_S^{\ell}$=2$\Re\epsilon$=3.323 × 10^{-3} (±1.7%)

...

When something is so precisely predicted, it sort becomes a must to measure it. Ignoring the usual comment of how much discovery range is possible...

The above ideal ϕ–factory with the given BR's means

$$N(K_S \to \pi^0\pi^0\pi^0) \quad 950/\text{y}$$
$$N(K_S \to \pi^\pm e^\mp \nu) \quad 3.3 \times 10^8/\text{y}$$

Not all decays can be collected, but at least all K_S's decay in the detector.

For comparison, NA48 collected 5×10^6 $K_L \to \pi^0\pi^0$ decays between 1997 and 2001, the original proposal having been submitted in 1990.

They also measured several other BRs:

Outline

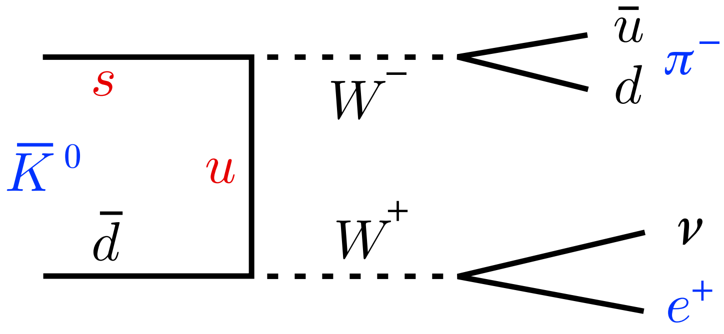
- $K_S \to \pi^0 ee$
- $K_{L,S} \to \pi\pi ee$
- $K_{S,L} \to \gamma\gamma$
- $K_{S,L} \to \pi^0\gamma\gamma$

September 11, 2003 **A. Ceccucci, Alghero**

Really very nice. Good for KLOE at DAΦNE2

What can we probe about the standard model?

Some things are almost trivial: $\Delta S = \Delta Q$.



$x = A(K^0 \to e^+)/A(\overline{K^0} \to e^+) \sim Gm^2 \sim 10^{-6 \cdot\cdot -7}$. Or from compositeness, $x = 10^{-10} \times (1 \text{ GeV}/\Lambda)^6$, or. . . . But no loops, no SS. There are in general two x's: x^+, x^-.

Must do better.

Some are deeper: is the quark mixing matrix unitary? Remember however how strong are the constraints from ΔM_K and $\text{BR}(K_L \to \mu\mu)$

CKM

$|V_{ud}| = 0.9737 \pm 0.0007$

$\lambda = 0.2235 \pm 0.0033$ (± 1.5 %)	scandalous
$A\lambda^2 = 0.0415 \pm 0.0011$ (± 2.7 %)	optimist
$A\lambda^3\sqrt{\rho^2 + \eta^2} = 0.0038 \pm 0.0004$ (± 10 %)	same
$\mathrm{atan}(\eta/\rho) = (58 \pm 19)^\circ$ (± 5 % of 360°)	needs work

$$|V_{ud}|^2 + |V_{us}|^2 + |V_{ub}|^2 = 0.9969 \pm 0.0017 \quad -1.8\,\sigma$$

$$|V_{cd}|^2 + |V_{cs}|^2 + |V_{cb}|^2 = 1.042 \pm 0.029 \quad +1.5\,\sigma$$

$$|V_{ud}V_{cd}| - |V_{us}V_{cs}| \pm |V_{ub}V_{cb}| = -0.002 \pm 0.016 \quad 0.1\,\sigma$$

12 Aug 2003 K. R. Schubert (TU Dresden), Lepton Photon 2003

Measuring angles and/or η is a hard way to go about it. Still it is important. And do not forget that $K_L \to \pi^0 \nu\bar{\nu}$ measures $A^2\lambda^5\eta$, not η. In some sense this mode has lost some luster today, at least wrt to measuring η.

But we must check "J" everywhere we can and what if Belle is right?

Measuring BR($K^+ \to \pi^+\nu\bar{\nu}$ and $K_L \to \pi^0 \nu\bar{\nu}$) is not a job for the next ϕ–factory. $K^+ \to \pi^+\nu\bar{\nu}$ after adiabatic improvements?

So somebody else must do it or maybe DAΦNE3.

Remember that it took 40 years to get from the discovery of $\not{C}\not{P}$ to the present firm value for $\Re(\epsilon'/\epsilon)$.

And if you really ask who did it was NA48-KTeV – but – after the experience of NA31-E731. So it took 20 years!

The same was true about $K^+ \to \pi^+ \nu\bar{\nu}$

Also, direct $\not{C}\not{P}$ can be searched for in $K^\pm$decays. The NA48/2 effort could continue at a new ϕ–factory, possibly reaching better sensitivity.

Remember $A_g \sim 10^{-6}$ and $A_\Gamma \sim 10^{-8}$ and not even the authors, GGG, like the SS enhancement via a CMO (*possible only if. . . several conditions. . . conspire*) they propose.

Still we can look for other justifications.

In 1957-64 we saw the demise of P, C and CP what about CPT? This is a most important reason for studying K_S decays. Let me notice right away that we must aim for $\mathcal{O}(10^{-5})$ sensitivity or 10^9 semileptonic K_S decays.

CPT. The kaon system does provide the strongest upper bound on $\Delta M/\langle M\rangle$ for CPT conjugate states. Of course since we do not really know what to expect, we do not know when we have achieved a significant –null– result.

An argument made in the past is that one should compare the dimensionless ratio $\Delta M_K/M_K$ with another dimensionless ratio M_K/M_{Plank}=0.5/1.2 $\times$ $10^{19}$$\sim$4 $\times$ 10^{-20}. There one might contemplate loss of QM coherence or non flat space, thus losing the bases for the Pauli-Lüders theorem.

So we should aim for $\Delta M_K \sim 2\times 10^{-11}$ eV.

Without assuming CPT invariance, to l.o. in "ϵ":

$$|\,K_S\,\rangle = [(1+\epsilon_S)|\,K^0\,\rangle + (1-\epsilon_S)|\,\overline{K^0}\,\rangle]/\sqrt{2}$$
$$|\,K_L\,\rangle = [(1+\epsilon_L)|\,K^0\,\rangle + (1-\epsilon_L)|\,\overline{K^0}\,\rangle]/\sqrt{2}$$

Define $\tilde{\epsilon}$ and δ through the identities

$$\epsilon_S \equiv \tilde{\epsilon} + \delta \qquad \epsilon_L \equiv \tilde{\epsilon} - \delta.$$

Using unitarity, $\mathcal{A}^e_L$, etc. and assuming no $\not{C}\not{P}\not{T}$ in the decay amplitudes leads to limits on δ and

$$\frac{|M(K^0) - M(\overline{K^0})|}{\langle M \rangle} = \frac{\Delta M}{M} = (2 \pm 9) \times 10^{-19}$$

2 ± 4

Without any assumption about $\not{C}\not{P}\not{T}$ or $\Gamma(K^0) = \Gamma(\overline{K^0})$, the result is considerably weaker, ~few×10^{-18}.

From

$$|M(K^0) - M(\overline{K^0})| = |\Gamma_S - \Gamma_L|\,|\Re\delta \tan\phi_{SW} - \Im\delta|$$

one needs measuring δ to $2/3\times10^{-5}$.

In general, but with $\Delta S = \Delta Q$, $\Re\delta = (\mathcal{A}^e_L - \mathcal{A}^e_S)/4$. Thus need $\mathcal{A}$ to ~3×10^{-5} or 10^9 events.

KLOE at DAΦNE2

- $\Delta S = \Delta Q$, use charge exchange, $K^+ \Rightarrow K^0$, $K^- \Rightarrow \overline{K}^0$ to tag strangeness.
- Use interference to measure $\Re\eta_{+-} \ldots . \Im\eta_{00}$, $\Im\delta$
- K_S, and K_L, leptonic asymmetry$\rightarrow\Re\delta$
- Push all modes to the limit, $\sim 10^{-11}$

It is a long program, especially since the overall efficiency is not 1, but it is not 0.01 either.

We should think in terms of a decade of continuous access, just like NA48 wishes.

HOW should it be built?

- Machine: upgrade present machine, improve IR
- KLOE: upgrade emcal and chamber, instrument IR

Is KLOE OK? Its mission was $\Re(\epsilon'/\epsilon)$ which needs many $K_L \to \pi^+\pi^-$ and $K_L \to \pi^0\pi^0$ decays. Hence a large detector. If you can afford it, larger is better, mostly.

But now we are talking of K_S decays, with a mean decay path of 5.6 mm. We could reduce the outer chamber radius (good for $K^\pm$), still the best chamber around, and add to the calorimeter, gaining energy resolution and timing accuracy.

A new chamber could have $(1.5/2)^2 \sim 1/2$ or 50% less wires, but more sense wires in a 1:1 sense to field ratio. A vertex chamber would help a lot.

Also a better Q-cal!!. Pt-Si is best but W-Si will do.

Finally, luminosity must come together with low background, less than now, absolute, not bckgnd to lumi ratio!

Luckily higher $\mathcal{L}$ and lower background are not mutually exclusive

CONCLUSIONS

KLOE still hopes to collect $\int \mathcal{L}\mathrm{d}t >$1 fb^{-1} in 2004, to complete the first phase of a successful program.

Beyond that, the DAΦNE2 collider discussed could give a $\times$100 increase in $\mathcal{L}$. At lower $\mathcal{L}$, variable energy allows many other programs as discussed. This guarantees very exciting physics, to be well underway before the end of this decade.

The SM fares extremely well at LEP, SLAC, the Tevatron and even at BNL $(g-2)$, but we do not know about $\Delta S = \Delta Q$, CKM unitarity, $CPT\ldots$

We need DAΦNE2!!!

We need DAΦNE2!!!

We need DAΦNE2!!!

We need DAΦNE2!!!

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

	loss	tot loss
$K_S K_L/\phi$	0.34	0.3400
decay	0.25	0.0850
K_L tag	0.50	0.0425
Fid. cuts	0.25	0.0106

see, $<1\%$!!!! – – as in transp. no. 21

$\mathcal{L}$	50,000, μb^{-1}/s
$\int_{1y}\mathcal{L}$	5×10^{11}, μb^{-1}
K_S sl	3.5×10^{8}
$\delta\mathcal{A}$	5.3×10^{-5}
$\delta\delta$	1.3×10^{-5}
ΔM	4×10^{-11} eV
$\Delta M/M$	8×10^{-20}

Mnemonic help for $e^+e^-\to\phi\to KK$

$N(K_S)=N(K_L)=N(K^+)\sim N(K^-)=\int\mathcal{L}$ in μb^{-1}

From Gino Isidori

Highlights of the kaon–physics program @ Φ–factory vs. luminosity:

10^0 fb^{-1} [≈ 10^9 $K\bar{K}$]

≈ KLOE now

- V_{us} from K_{l3} @ 10^{-3} (CKM);
- rare K_S decays down to BR~10^{-8} (CHPT/CPT);
- 10^{-2} bounds on $K_S \to \pi l \nu$ charge asym. (CPT)

⋮

10^1 fb^{-1} [≈ 10^{10} $K\bar{K}$]

original KLOE program

- Re(ε'/ε) @ 10^{-4} (direct CPV);
- $K_{L,S}$ interf. ⇒ Im(ε'/ε) @ 10^{-2} (CPT);
- ππ phases from K_{l4} @ % level (QCD vacuum)

⋮

10^2 fb^{-1} [≈ 10^{11} $K\bar{K}$]

- CPT tests @ uprecedented level of precision via rare K_S & $K_{L,S}$ interferences;
- search for exotic direct CPV in $K^{\pm}$ asym. and rare K_L decays

⋮

10^3 fb^{-1} [≈ 10^{12} $K\bar{K}$]

frontier of flavor physics

- sensitivity to $K_L \to \pi^0 \nu\nu$ (& $K_L \to \pi^0 ee$) at the SM level:

region of high discovery potential for non–standard sources of CPV via new tests of the CKM mech. in the kaon system

⇒very interesting also in a long–term perspective⇐

10^4 fb^{-1}

From Gino Isidori

- Conclusions

BUT SCALE OFF BY 10

I'm strongly in favor of the high–luminosity option!

and if the option is realistic

I'm ready to defend it...