Kaons @ LNF

Paolo Franzini

Flavor -kaon!- physics is interesting now and when new physics will show up it will be even more so.

KLOE has acquired full respect and recognition in the world of particle physics.

KLOE must continue to capitalize on its unique skills and opportunities.

OUTLINE

1. Unitarity or Universality
2. Symmetries etc.
3. KLOE, improvements
4. Conclusions

Universality

β-decay,	1900-14-30	$n \longrightarrow pe^- \bar{\nu}$	G_β	G_{ud}
Muon,	1937-40	$\mu \longrightarrow e\nu\bar{\nu}$	G_μ	$G_{\ell\nu_\ell}$
Strangeness,	1946-58	$\Lambda \longrightarrow pe^- \bar{\nu}$	$G_{\Delta S=1}$	G_{us}

1958:

$$G_{ud} \cong G_{\ell\nu_\ell} \neq G_{us}$$

10-12 hyperon β-decays expected, F & G-M, PR **109** 193 (1958), none observed, PR **112** 979 (1958). My name is on the second paper.

Here and in all the following ignore rad corr, symmetry breaking etc.

1963

PHYSICAL REVIEW LETTERS

UNITARY SYMMETRY AND LEPTONIC DECAYS

Nicola Cabibbo
CERN, Geneva, Switzerland
(Received 29 April 1963)

$$G_{ud} = \cos\theta \times G_{\ell\nu_\ell}; \qquad G_{us} = \sin\theta \times G_{\ell\nu_\ell}$$

or

$$G^2_{ud} + G^2_{us} = G^2_{\ell\nu_\ell}$$

a more explicit statement than the $SU(2)_W$ local gauge invariance requirement

$$\sum_i |V_{ui}|^2 = 1$$

which is of course contained in the above.

The requirement that the CKM mixing matrix be unitary has meaning only together with the requirement of a unique Fermi constant G. Said in a different way, the weak charge of quarks and lepton is the same. $(SU(2)_W)$

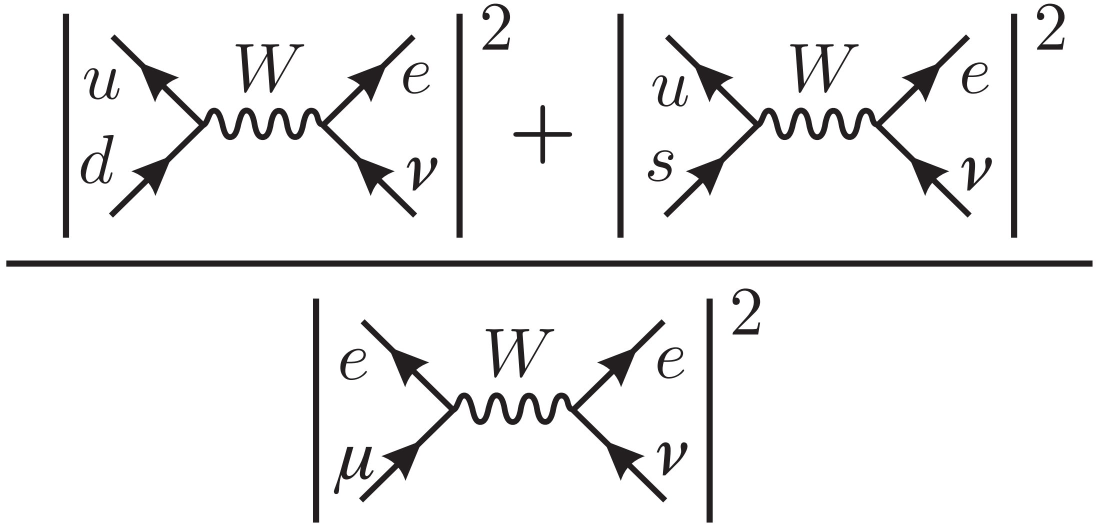
What we measure is in fact G^2_{ud} and G^2_{us}, which is nice.

New physics affects also leptons, thus the muon lifetime depends on more than just G.

$|V_{us}|$

V_{us} and any CKM elements are not measurable. We measure G^2_{ud}, G^2_{us}, G^2_{ub}, G^2_{cb}, G^2_{td} and G^2_{μ}.

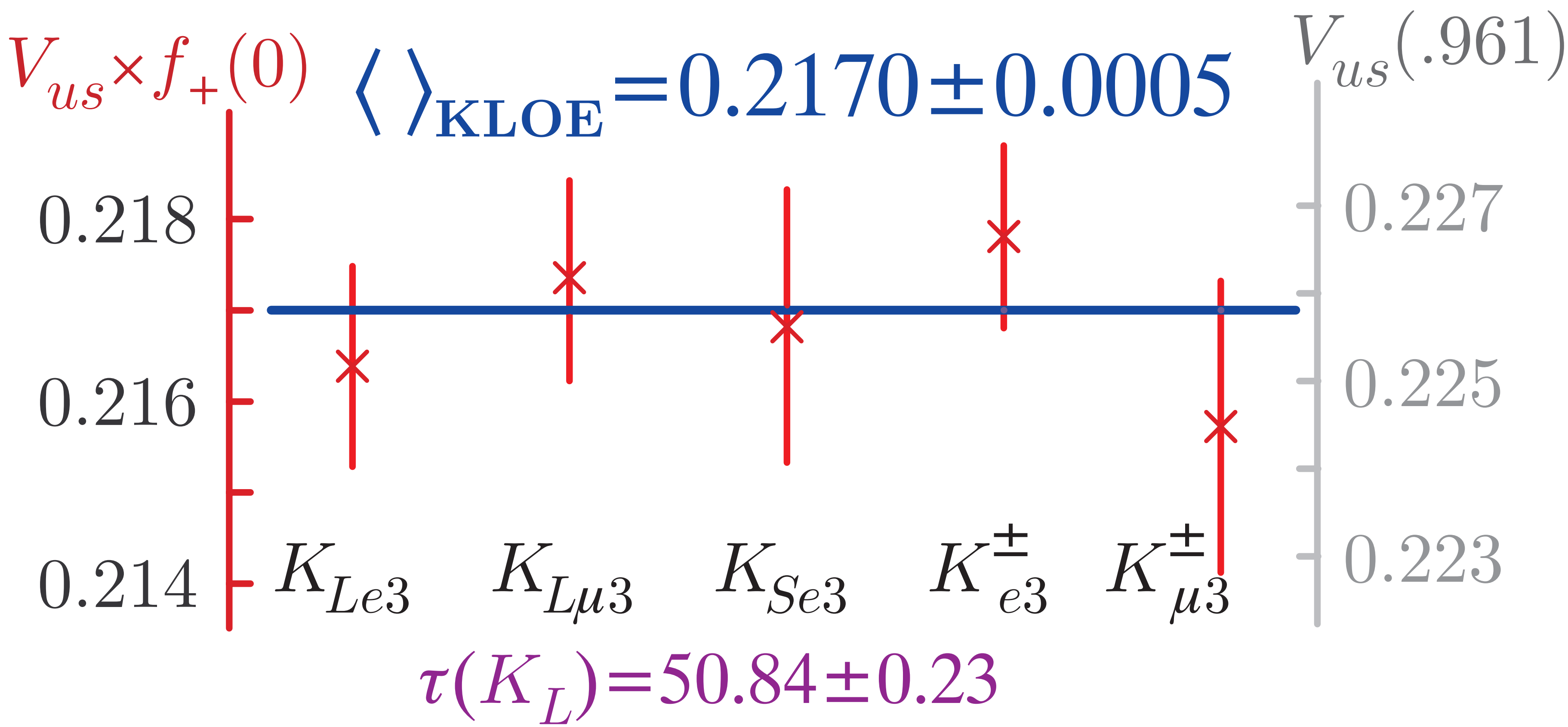
Since $1-|V_{ub}|^2 \sim 0.99998$, a test of unitarity is



$$\Rightarrow |V_{ud}|^2 + |V_{us}|^2 \stackrel{?}{=} 1$$

If we do not find 1.0, we can blame it ALL ON THE MUON or in general on BOTH quarks AND leptons.

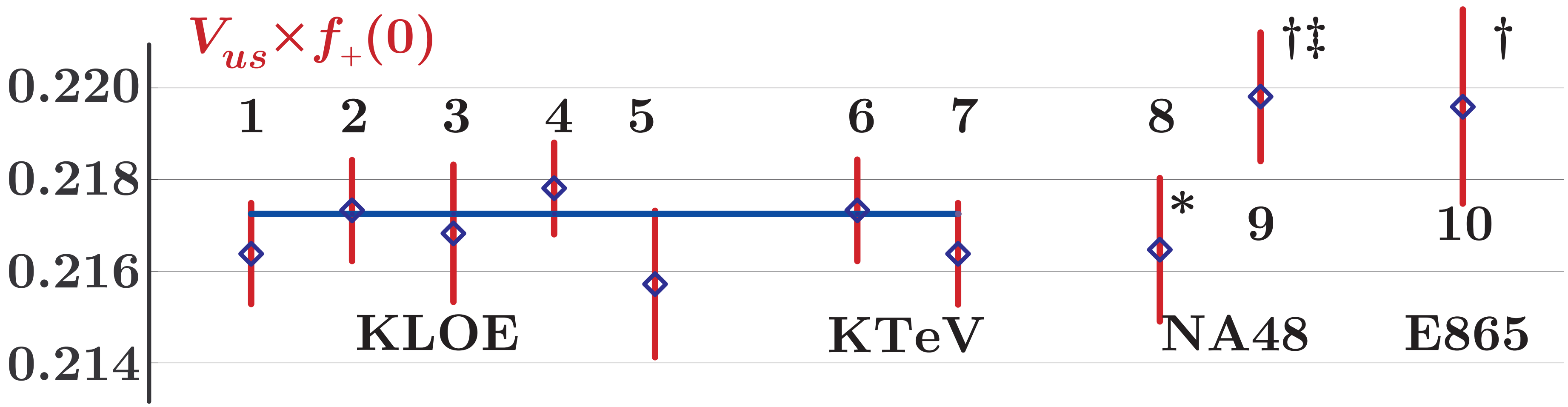
KLOE



$$\chi^2/\text{dof}=1.9/4$$

A PDG fanatic should rescale error by $\times 0.7$!

World average



Fit to points 1-7: $V_{us} \times f_+(0) = 0.21723 \pm 0.00045$, $\chi 2/\mathrm{dof} = 2.79/6$

correlations included

NOTES: 1, 6, 8 K_{Le3}; 2, 7 $K_{L\mu 3}$; 3 K_{Se3}; 4, 9, 10 K^+_{e3};5 K^-_{e3}

1, 2, 6, 7, 8 are correlatade through $\tau(K_L)$ (KLOE)

this is not important for 4, 5, 9 and 10

*) 8 uses KTeV BR($K_L \to 3\pi^0$)

†) 9 and 10 use PDG '02 and '04 normalization

‡) 9 is unpublished

this is tex

Measurements of the kaon partial rates, *i.e.* branching ratios and lifetimes provide at present by far the most accurate test of Universality.

$$|V_{ud}|^2 + |V_{us}|^2 + |V_{ub}|^2 = 0.9998 \pm 0.0011$$

the error being dominated by em, $SU(2)$ and $SU(3)$ corrections. (8 out of 11 is due to $\delta f(0)$ from Leutwyler and Ross).

How far from 1.0 could we be today? As much as a 3σ discrepancy if you take new extreme values of $|V_{ud}|$ and $f(0)$=0.98.

New physics? Change G_μ by 2/1166, which could be due to processes at a 2 TeV scale, or $\delta G_\mu^2/G_\mu^2 \sim 0.4\%$. At the limit of visibility in $|V_{us}|$. The same scale would give the present muon anomaly discrepancy.

The present KLOE achievements beg for 20-50 fb^{-1} of data to push the accuracy of "V_{us}" measurements.

In some sense the $\pi\nu\nu$ studies are more limited and would in any case be much more conclusive together with the above measurements. Need λ!

$f(0)$ will come and don't forget $K \to \mu\nu$ and f_π/f_K.

this is tex

K_S-semileptonic decays

KLOE at DAΦNE has proven its excellent ability.

Still of very great interest:

- $|V_{us}|$
- $\Delta S = \Delta Q$
- TCP
- $\Re$ and $\Im$ of amplitudes

K_L, $K^{\pm}$ lifetimes

$f_+(t)$ and $f_0(t)$ parameters

$K_L, K_S \to \gamma\gamma$

$K_S \to \pi^0\pi^0\pi^0$

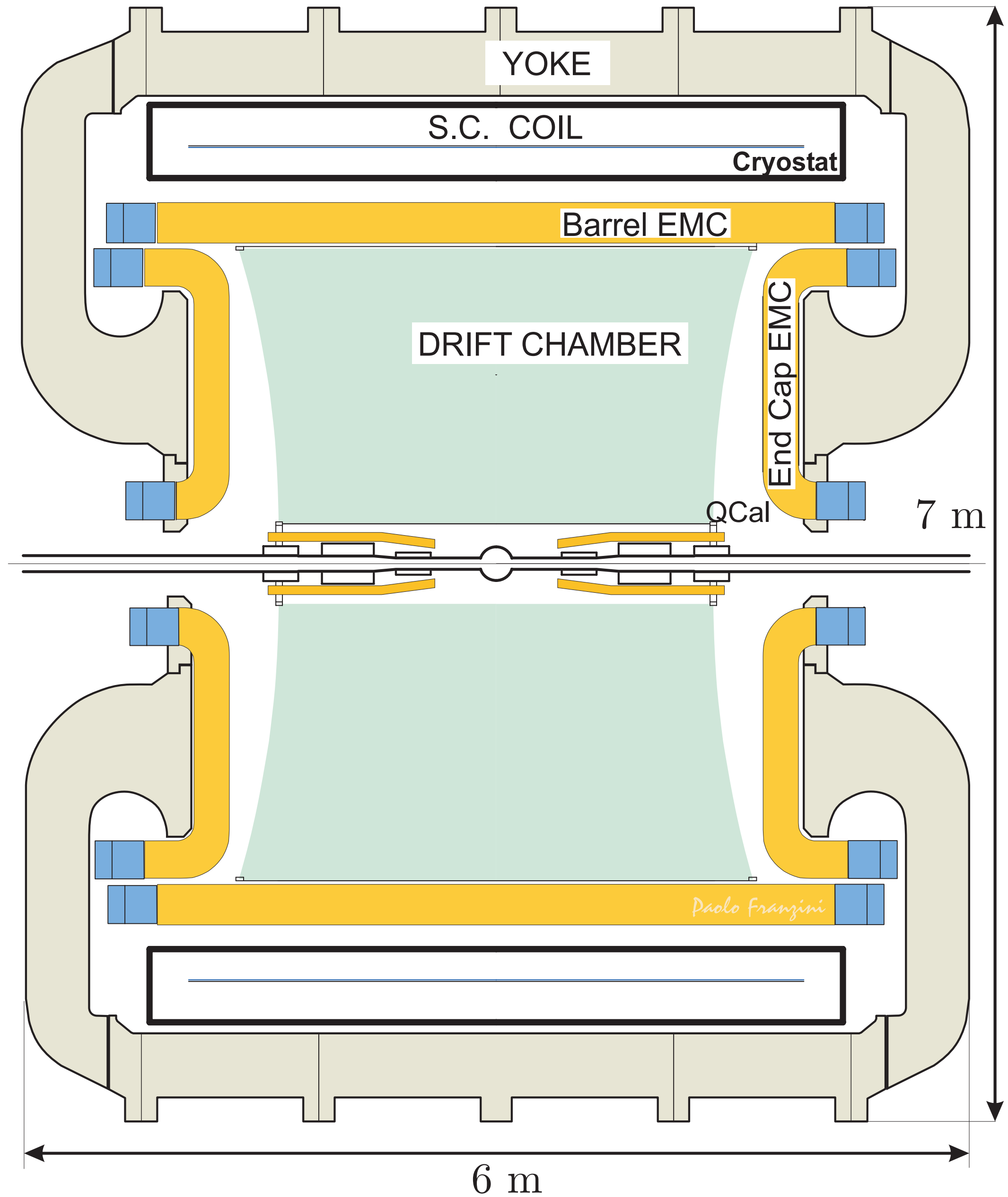
$K_S, K_L \to \pi^0$+lepton pair

this
is
tex

Interferometry

- Improve on $\not{C}\not{P}$
- Measure all kaon parameters
- Quantum mechanical coherence

KLOE


YOKE
S.C. COIL
Cryostat
Barrel EMC
DRIFT CHAMBER
End Cap EMC
QCal
7 m
6 m
Paolo Franzini

Wish list for KLOE

1. Particle ID
2. Vertex Detector
3. Time of Flight
4. New Chamber
5. New Calorimeter
6. Q-cal

Particle ID

At our energies hard.

$\frac{dE}{dx}$ not effective, terrible overhead on cpu time

Make timing more effective, lower field? $\Rightarrow$

Loss in momentum resolution?

Increase in bckgnd?

Vertex Detector

There are two possibilities (more?):

GEM

TPC

Need measuring fluxes of low energy photon and electrons near the beam pipe

Time of flight

Improve time resolution:

Better phototubes (?)

More scintillator=new cal $\Rrightarrow$ €€

RPC-multilayer=space $\Rrightarrow$ new DC $\Rrightarrow$ €€, time

New Chamber

Reduce radius, 1.5-1.8 vs 2.0 m (loss of K_L path)

1:1 Sense to field wire ratio

No Ag coating on Al wires

$\Rrightarrow$ €€, time

New Calorimeter

More scintillator, $\times 2$

More read-out layers $\times 1.5$

$\Rrightarrow$ Improve timing, energy res., particle ID

$\Rrightarrow$ €€, time

Q-cal

Is it useful now?

Some work to be started soon, fall '05 – winter '06

LNF OWES KLOE

AND WE OWE IT TO LNF