Status of KLOE-2

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ECFA Meeting

Frascati, June 24, 2010

The pastoral story of DAPHNIS and CHLOE dates back to the II century AD, due to the greek writer Longus. It has been reused since then several times in pictures, poems, ballets…

CHLOE’

N’y a-t-il rien de plus Daphnis,
Que nous tenir entre nos bras
Et nous endormir ainsi?

DAPHNIS

Si, Chloe’. Il y a
La pris de toi
Que je sais maintenant

CHLOE’

N’y a-t-il rien de plus Daphnis,
Que la pris de moi
Que tu as fait?

DAPHNIS

Si, Chloe’. Il y a
Nous tenir entre nos bras
Et nous endormir ainsi

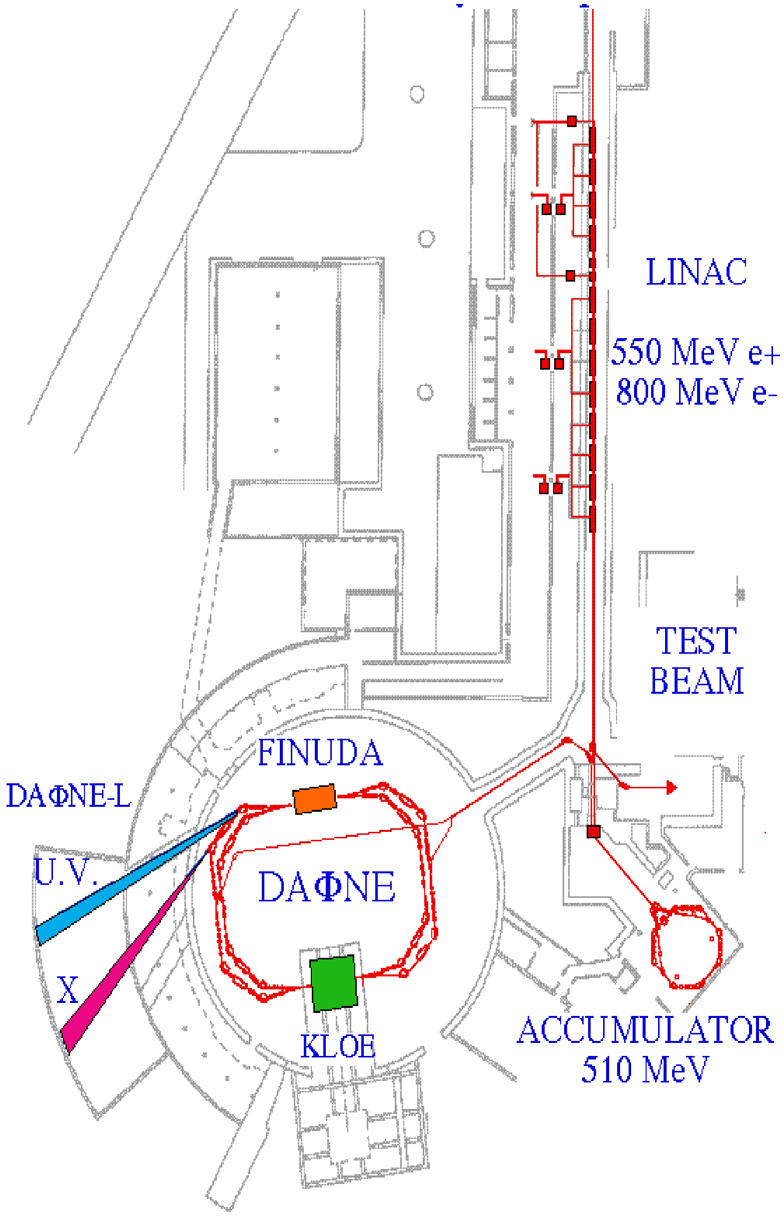
H.P. Roche’ (in Jules et Jim)

DAΦNE is a ~300 m long symmetric e^+e^- machine operating at $E_{c.m.} = 1020$ MeV (Φ resonance peak)

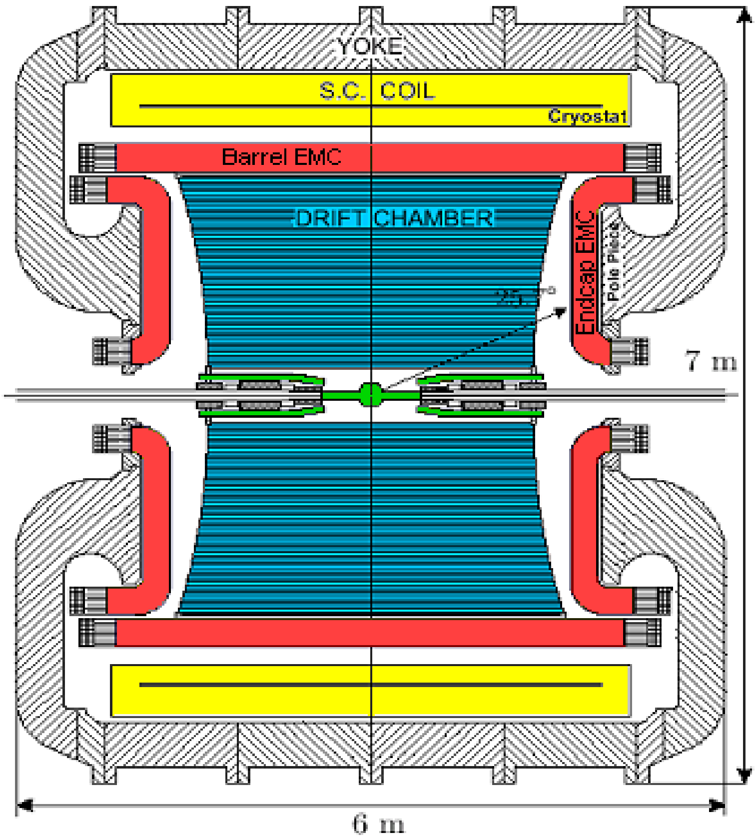
The main event fluxes are:
(in million events/pb^{-1})

- K^+K^- : 1.5
- ρπ : 0.5
- $K_S K_L$: 1.
- ηγ : 0.04

Moreover, one has to consider also $\mu^+\mu^-(\gamma)$, $\pi^+\pi^-(\gamma)$, $e^+e^-(\gamma)$ final states (Bhabha rate ~5 Mevents/pb^{-1}, depending on acceptance cuts)



Built in the late 90's, KLOE is a multi purpose apparatus, optimised to maximise the detection efficiency for K_L decays



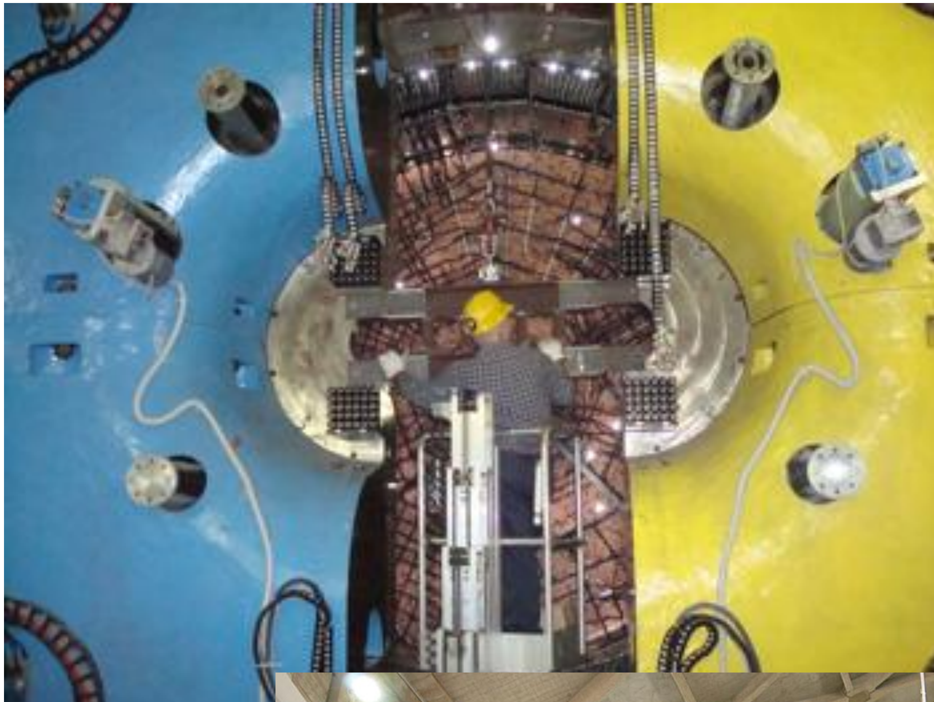
❖ **Superconducting coil** B = 0.52 T

❖ **Be beam pipe** (0.5 mm thick), spherical 10 cm radius

❖ **Electromagnetic calorimeter**
Lead/scintillating fibers (1 mm ∅) 4880 PMT's, 15 X_0

❖ **Drift chamber**
(4 m ∅ × 3.3 m) 90% He + 10% IsoB, CF frame, 12582 stereo, single sense wire, "almost squared" cells

❖ **Quadrupole calorimeter**

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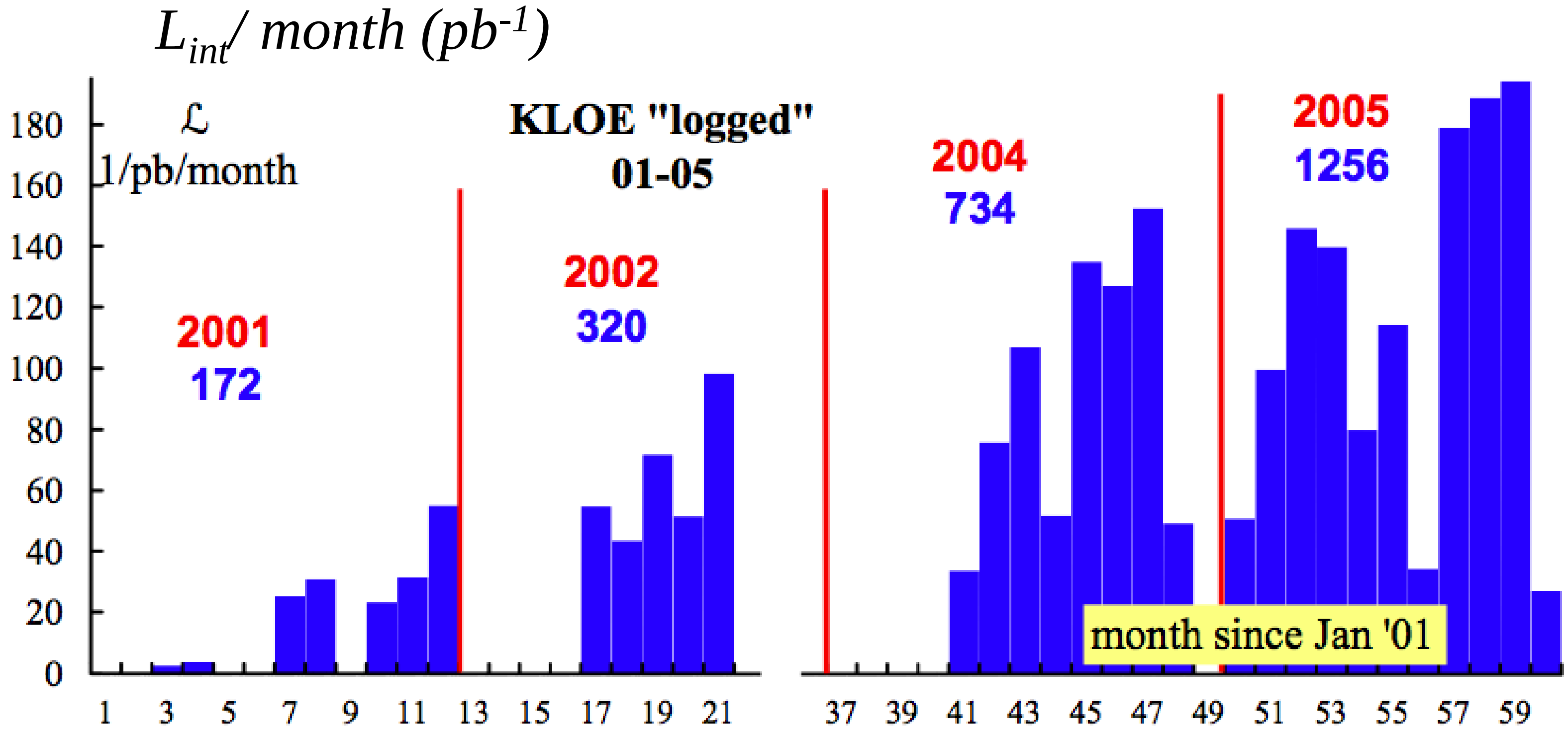
Between years 2000 and 2006 DAΦNE has delivered to KLOE 2.5 fb^{-1} of data at the Φ(1020) peak plus additional 250 pb^{-1} off-peak



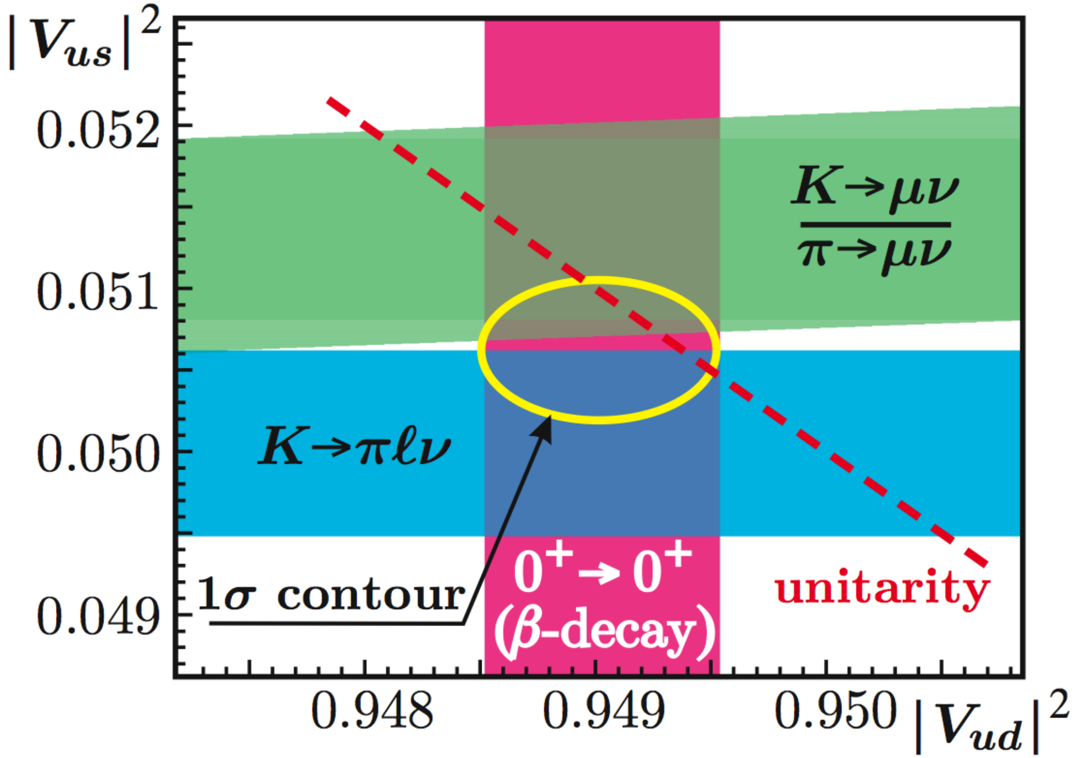
Best day: 10 pb^{-1}

Best month: 194 pb^{-1}

Using these data, KLOE has published about 50 physics papers, addressing several fundamental topics in the fields of flavour and hadronic physics. Among our results one can list:

- The complete set of measurement of neutral and charged kaon decay parameters to allow the precision measurement of V_{us} setting the best unitarity limit on the CKM matrix
- A precise determination of the hadronic contribution to the g-2 of the muon
- The best limit published so far on LFV in K_{e2} decays
- The most detailed studies on the nature of scalar mesons
- The measurement of some of the rarest branching ratios of the K_s and η mesons

V_{us} determination and CKM unitarity



Fit on

V_{us} *from* K_{l3}

V_{us}/V_{ud} *from* $K_{\mu 2}/\pi_{\mu 2}$

V_{ud} *from* $0^+ \to 0^+$ β decays

$$|V_{us}| = 0.2249 \pm 0.0010$$

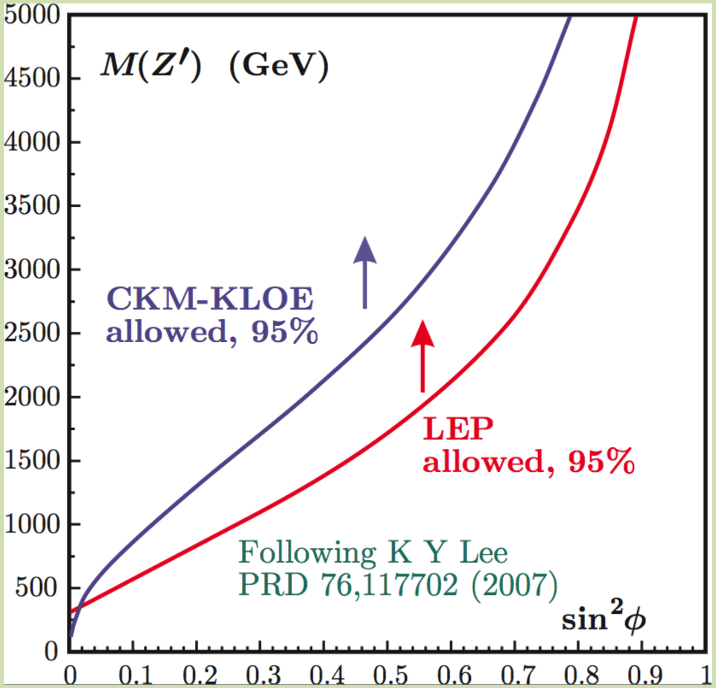
$$|V_{ud}| = 0.97418 \pm 0.00026$$

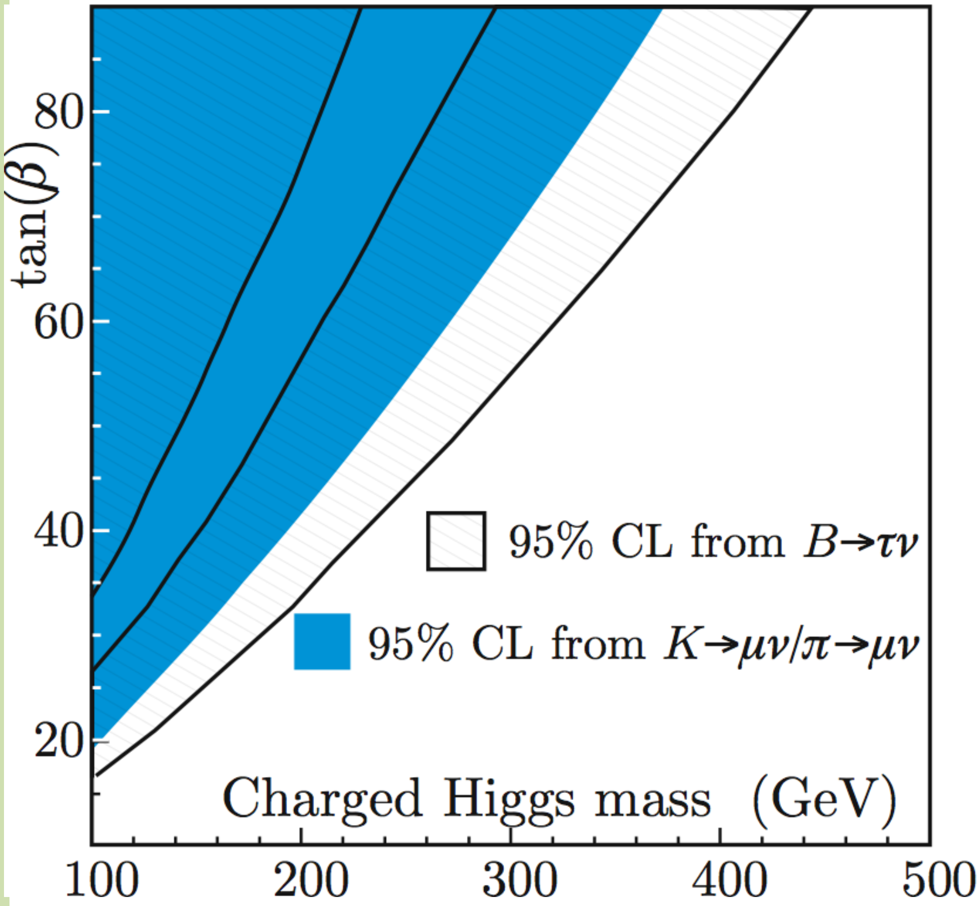
$$1 - |V_{us}|^2 - |V_{ud}|^2 = 0.0004 \pm 0.0007$$

was 0.0031 ± 0.0015 in PDG04

Constraints on New Physics

Tree level breaking of unitarity in models with non-universal gauge interaction



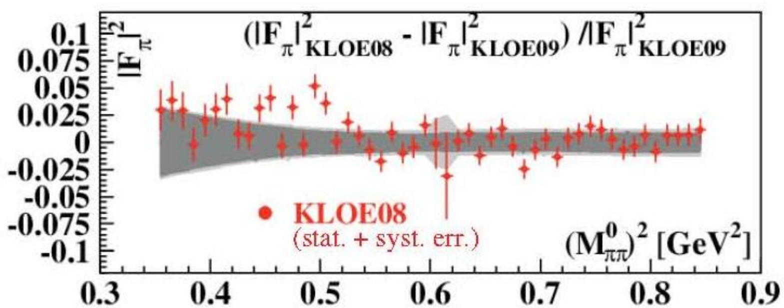


Hadronic contribution to muon g-2

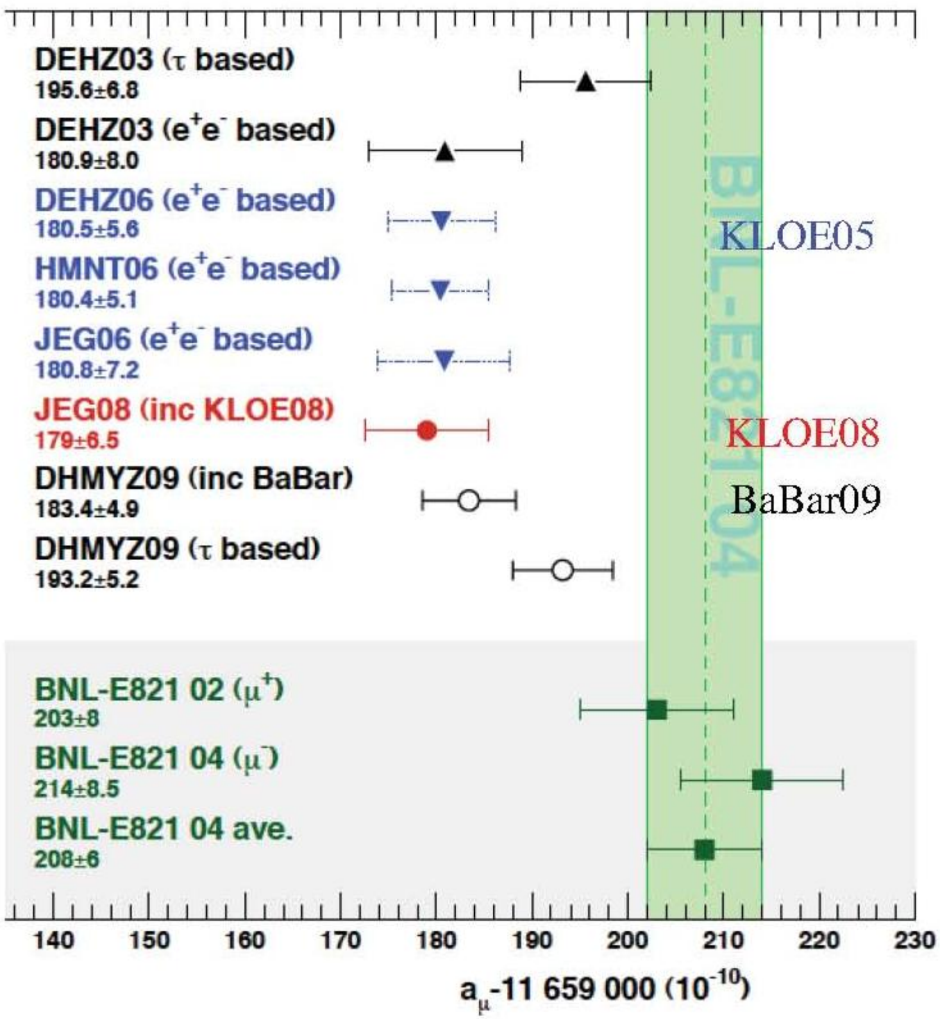
Discrepancy between a_μ^{SM} and a_μ^{EXP} at 3.2σ level

New KLOE analysis , with different selection criteria confirms KLOE08

Fractional difference:



band: KLOE09 error



Since early 2004, a lively discussion has started in the laboratory about the feasibility and the possible physics reach of a further KLOE run collecting data at a higher luminosity machine

In 2006 a first Expression of Interest of the the newly born KLOE-2 Collaboration was put forward:
http://lnf.infn.it/lnfadmin/direzione/roadmap/LoIKLOE.pdf

During 2008 the DAΦNE team (with the collaboration also of a few KLOE-2 members) has proven the feasibility of having a machine able to provide 4-5 fb^{-1} per year at the Φ peak

Following this extraordinary result, the laboratory has allowed us to roll back the detector on the beam line, for a new data taking campaing which is starting these days

There is quite a number of physics channels which can profit of the increased statistics expected from the forecoming run

Since, however, most of them involve decay processes at or very close the interaction point, we have also proposed a program for upgrading the detector aimed at *improving its charged vertex efficiency near the IP and its acceptance for photons emitted at low polar angles*

The new subdetectors are being presently built and will be ready for installation by the fall of 2011 (*step-1* phase, in the KLOE-2 jargoon). The run starting these days (*step-0* phase) has the multiple purpose of improving our understanding of the machine conditions, of increasing at best the statistical sample for some rare or forbidden decays analysis, and of exploiting the performance of the newly installed $\gamma\gamma$ detectors

Two photon physics at DAΦNE can be very useful to improve our knowledge on the nature of the scalar particles. However the need of fighting against copious backgrounds from some main Φ decay channels impose us the installation of dedicated detectors to tag the presence of the scattered leptons, peculiar to these reactions

Two different pairs of detectors have been designed and built for the purpose. The Low Energy Tagger, a crystal calorimeter, to be placed inside KLOE at 1.5 m from the IP. The High Energy Tagger, a scintillator hodoscope to be inserted at 11 m from the IP, just after the first bending dipoles

Both LET and HET have been installed and are ready for the first test run in the forecoming weeks



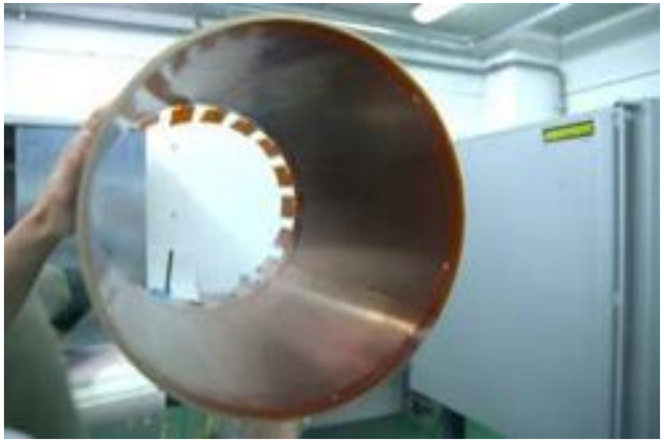

The "core" project of the step-1 phase is the construction and insertion of a new Inner Tracker (IT) detector

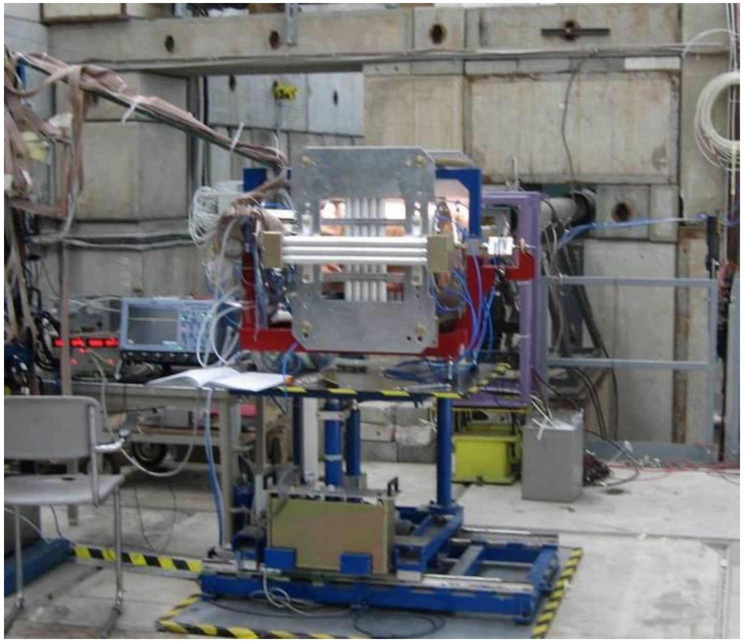
It is based on a well established technology, shaped in a totally innovative geometry, i.e. the *cylindrical GEM* (C-GEM)

This new subdetector allows us to improve our vertex efficiency for charged tracks, while keeping the increase in the material budget at the level of 2% of X_0

# lyers	dx@vtx (mm)	dz@vtx (mm)	dx@pca (mm)	dz@pca (mm)
5	**1.6**	**1.1**	**0.5**	**0.85**
4	**1.7**	**1.18**	**0.5**	**0.85**
NO IT	**4.2**	**3.1**	**1.6**	**2.2**

A small size prototype of the C-GEM has been built and succesfully tested in 2008-2009. After some further R&D work, we are now starting the construction of the final “large size” detector





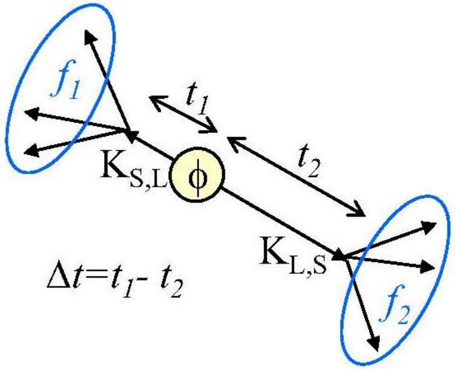
A thorough discussion of the KLOE-2 physics program can be found in *arXiv:1003.3868* which has been accepted for publication on EPJC

- Studies on CPT and QM violation with neutral kaons interferometry
- Tests of Lepton Flavor Violation with K_{e2} decays
- Studies on C, P, CP violation using rare η and K_S decays
- Tests of Chiral Perturbation Theory with η, η' , and K_S decays
- Searches for signals of a Secluded Gauge Symmetry

It can be seen as a “natural” extension of the KLOE program in the field of flavour and hadronic physics, with some additions, such as $\gamma\gamma$ interactions, or searches for new light gauge bosons

The most specific (and intriguing) feature of the neutral kaon system produced in Φ decays is that it is subject to quantum entanglement

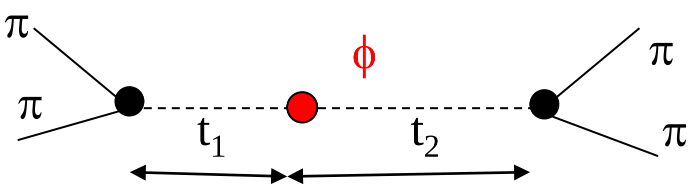
This means that the decay probability of each one of the kaons depends also on what the other particles does, giving rise to a well defined interference term in the decay intensity



$$I(f_1,t_1;f_2,t_2) = C_{12}\{|\eta_1|^2 e^{-\Gamma_L t_1 - \Gamma_S t_2} + |\eta_2|^2 e^{-\Gamma_S t_1 - \Gamma_L t_2} - 2|\eta_1||\eta_2| e^{-(\Gamma_S+\Gamma_L)(t_1+t_2)/2}\cos[\Delta m(t_2 - t_1) + \phi_1 - \phi_2]\}$$

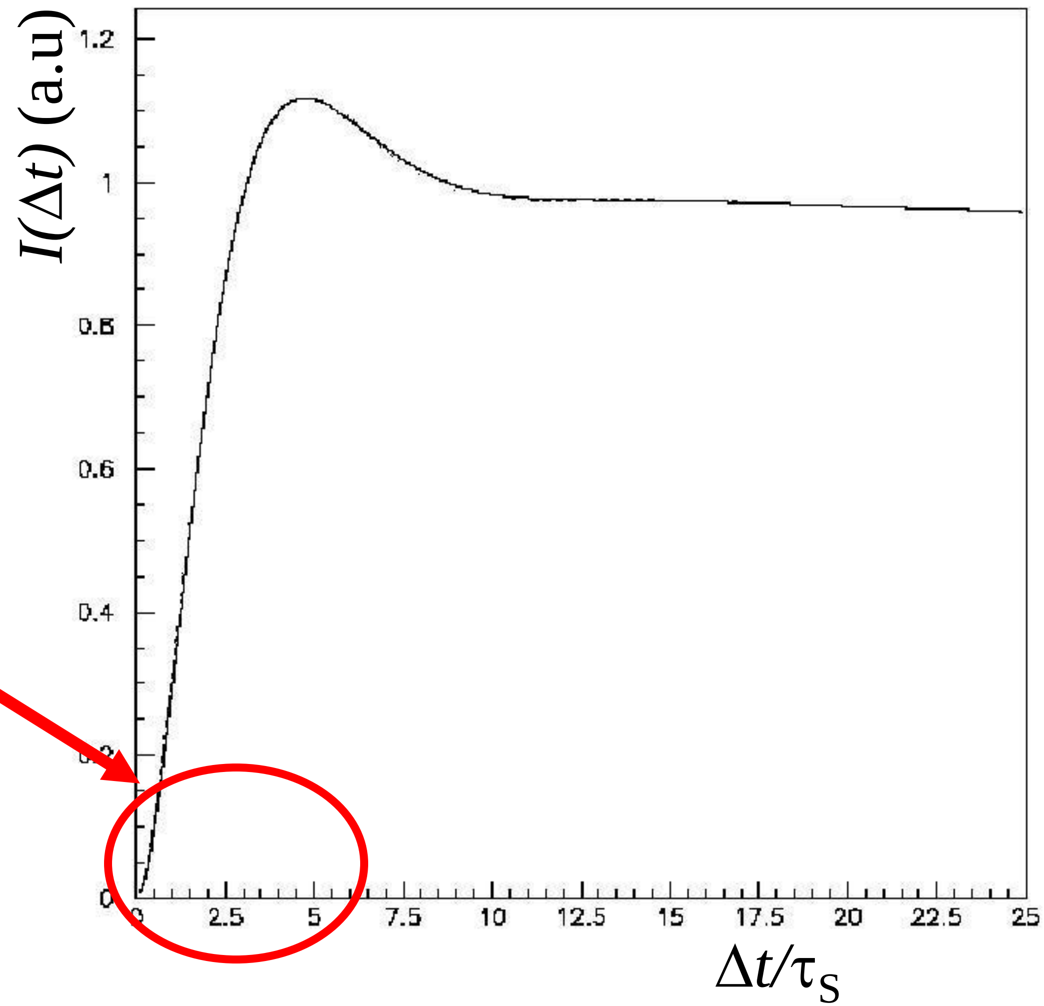
The specific form of the decay intensity depends on the final decay channel. In the case of $4\pi^{\pm}$ it has the form shown in the plot below

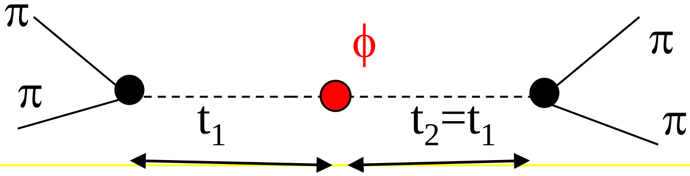
$$\Delta t = |t_1 - t_2|$$



EPR correlation:

no simultaneous decays (Δt=0) in the same final state due to the destructive quantum interference





Hawking suggested that at the microscopic level, in a QG picture, non trivial space-time fluctuation could give rise to decoherence effects, which would necessarily entail CPT violation

This idea has been applied, for instance, in a model by Ellis and collaborators, specifically for the neutral kaon system produced in Φ decays introducing 3 CPTV parameters, α, β and γ, distorting the above mentioned decay intensity. Naively, one expects:

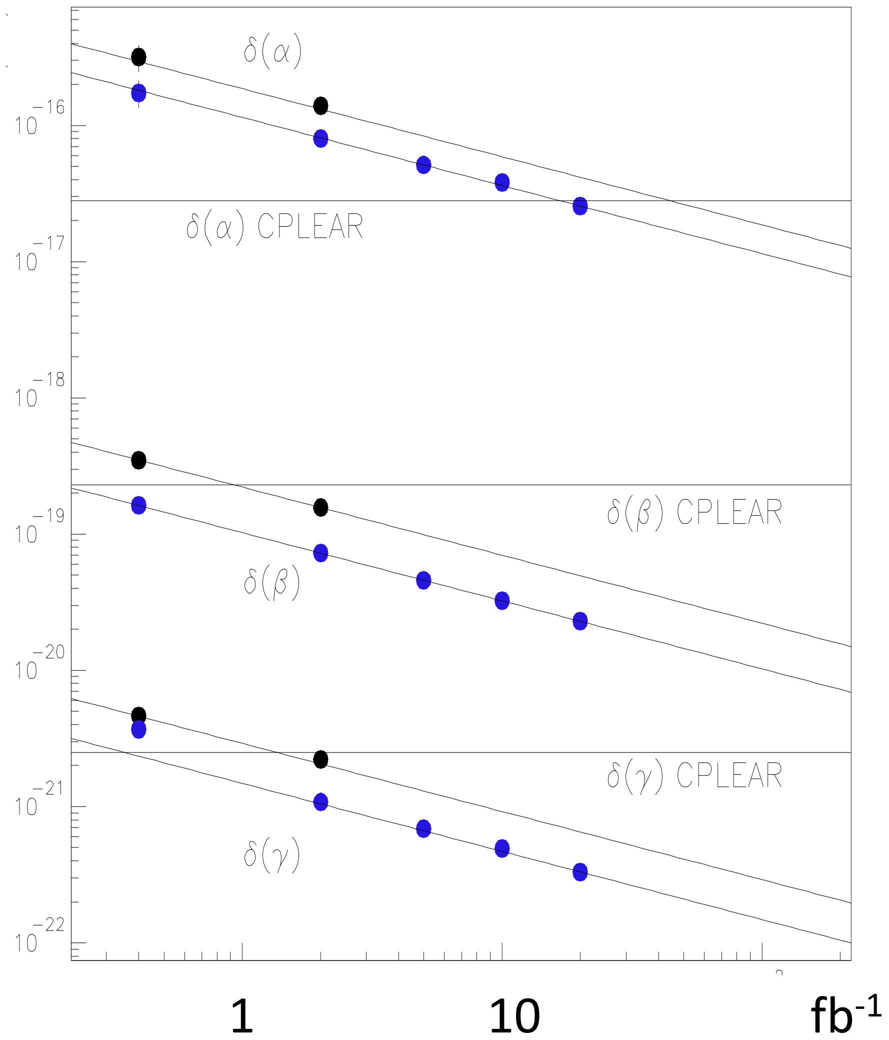
$$\alpha, \beta, \gamma = O\left(\frac{M_K^2}{M_{Plank}} \right) \approx 2 \times 10^{-20} GeV$$

KLOE has already measured γ (assuming $\alpha = \beta = 0$) obtaining

$$\gamma = \left(0.7 \pm 1.2_{STAT} \pm 0.3_{SYST}\right) \times 10^{-21}\ \text{GeV}$$

KLOE-2 becomes competive on γ and β with a few fb^{-1} collected, and also on α with $\geq 20\ fb^{-1}$

The use of a inner tracker (blue points in figure) improves on the reachable limits by a factor ~ 3 (note the logarithmic scale!)



The Collaboration has also started studying the possibility of taking data at energies different from the nominal one

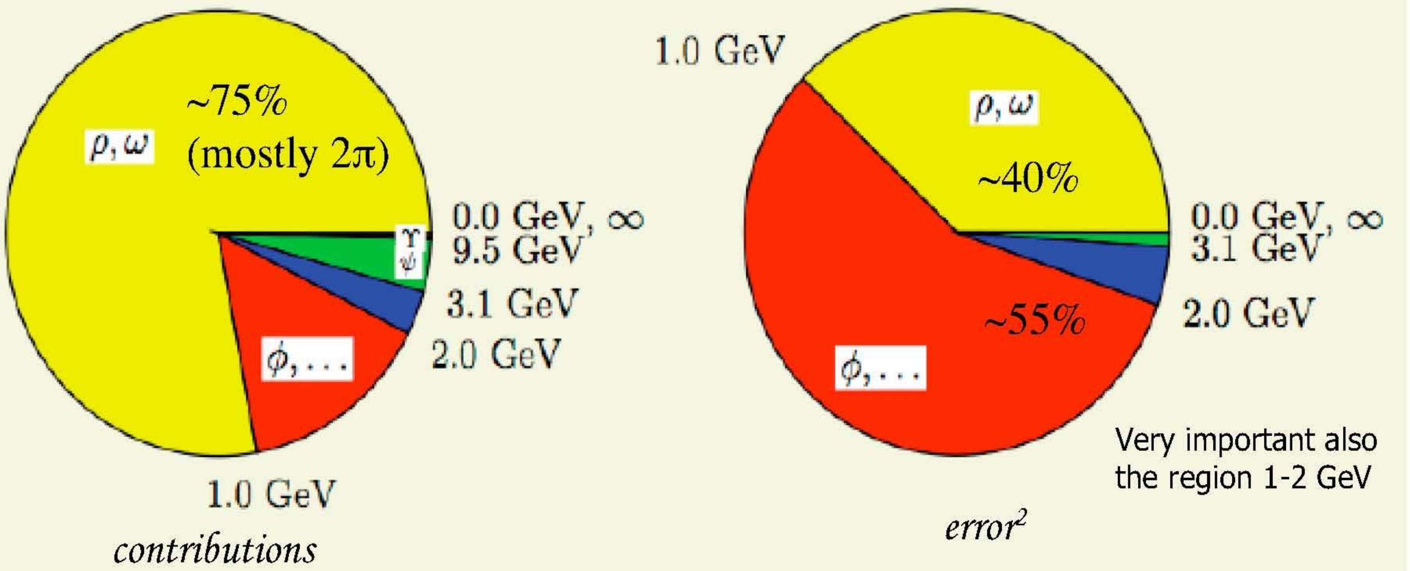
In particular the physics potentials of a possible scan in energy between 1 and 2-2.5 GeV have been studied in detail. It would be fundamental in decreasing the current theoretical error on a_μ and on the value of $\alpha_{e.m.}(M_Z)$, the presently worstly known among the SM parameters

This program as well as a short discussion on the technical requirements to obtain such a machine from the present DAΦNE can be found in *LNF 10/17 (P)*

Dispersion Integral:

Contribution of different energy regions to the dispersion integral and the error to a_μ^{had}

F. Jegerlehner, Talk at PHIPSI08



Experimental errors on σ^{had} translate into theoretical uncertainty of a_μ^{had}!

→ Needs precision measurements!

$\delta a_\mu^{exp} \rightarrow 1.5\ 10^{-10} = 0.2\%$ on a_μ^{HLO}

New g-2 exp.

At present the Collaboration consists of about 80 researchers coming from 12 Intstitutions of 5 different countries

Bari, Cosenza, Cracow, Frascati, Moscow ITEP, Napoli, Roma 1, Roma 2, Roma 3, Tblisi, Uppsala, Warsaw Soltan

We actively partecipate to 2 European Networks: FLAVIANET and PRIMENET

KLOE-2 is an open community: new collaborators and new ideas are always welcome!