Status of experiment NA48:

A precision measurement of ε'/ε in CP violating $K^0 \to 2\pi$ decays

Cagliari-Cambridge-CERN-Dubna-Edinburgh-Ferrara-Florence-Mainz-Orsay-Perugia-Pisa-Saclay-Siegen-Torino-Warsaw-Vienna Collaboration

Proposal 22 July 1990

Approved 28 Nov 1991

Setting-up/data taking 1995/1997–2001

First result published 1999

Final result published 2002

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A precision measurement of direct CP violation in the decay of neutral kaons into two pions

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1997 $\approx$ 0.5 million $K_L \to 2\pi^0$

Result published 1999

1998 $\approx$ 1 million $K_L \to 2\pi^0$

1999 $\approx$ 2 million $K_L \to 2\pi^0$

Beam pipe implosion, drift chambers damaged

2000 $K_L \to 2\pi^0, 3\pi^0$ "dilution" measurement and tests

1998-2000 results published 2001

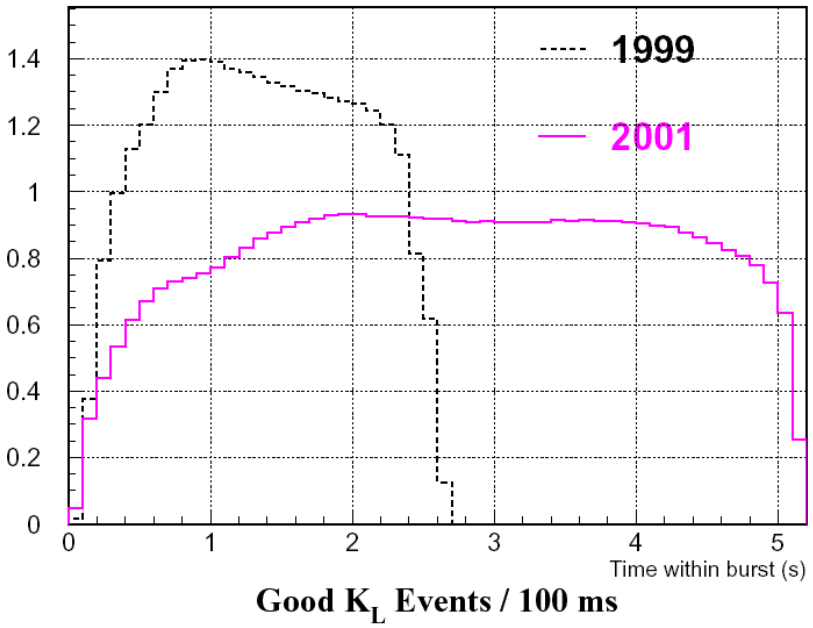
Drift chamber repair

2001 $\approx$ 1.5 million $K_L \to 2\pi^0$ at reduced beam intensity

Final result published 2002

Changed conditions in 2001

	98-99	2001
proton momentum	450 GeV/c	400 GeV/c
SPS cycle time	14.4 s	16.8 s
spill length (effective)	2.4 s (1.7 s)	5.2 s (3.6 s)
duty cycle	0.17	0.31
K_L beam intensity	$\approx 1.5 \times 10^{12}$ ppp	$\approx 2.4 \times 10^{12}$ ppp
K_S beam intensity	$\approx 3 \times 10^{7}$ ppp	$\approx 5 \times 10^{7}$ ppp



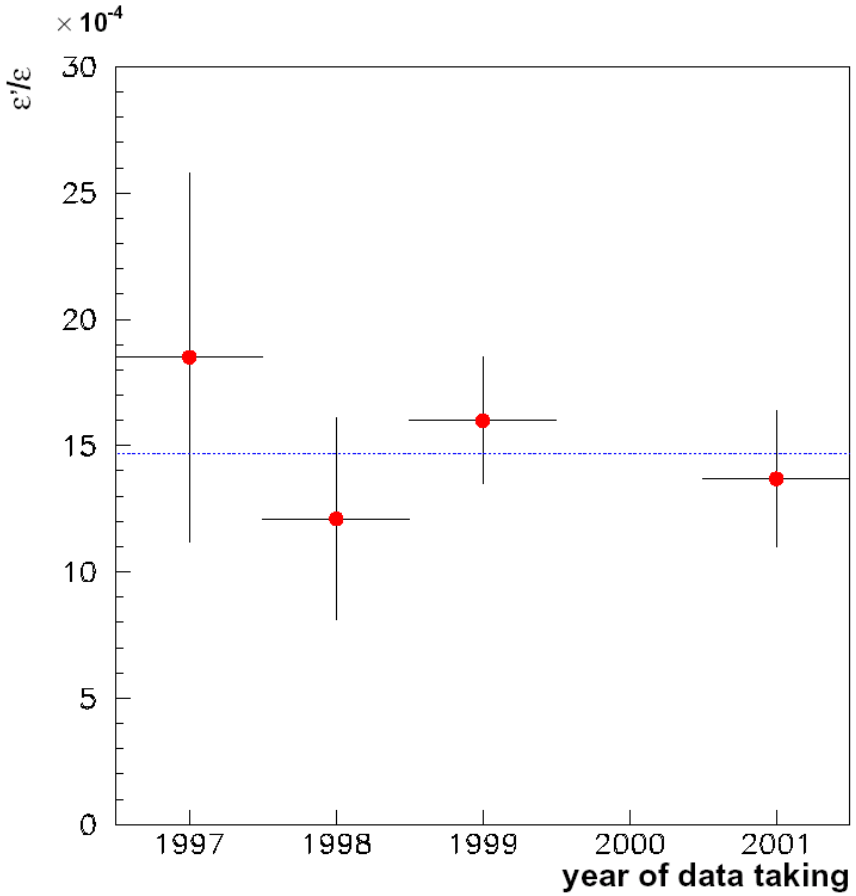
Corrections and systematic uncertainties on R

(Units = 10^{-4}); errors are pure stat or pure syst		
	2001	98-99
$\pi^+\pi^-$ background	14.2 ± 3.0	16.9 ± 3.0
$\pi^0\pi^0$ background	−5.6 ± 2.0	−5.9 ± 2.0
beam scattering	−8.8 ± 2.0	−9.6 ± 2.0
Tagging inefficiency	± 3.0	± 3.0
Accidental tagging	6.9 ± 2.8	8.3 ± 3.4
$\pi^+\pi^-$ scale	± 2.8	2.0 ± 2.8
$\pi^0\pi^0$ scale	± 5.3	± 5.8
AKS inefficiency	1.2 ± 0.3	1.1 ± 0.4
Acceptance	21.9 ± 3.5	26.7 ± 4.1
	± 4.0	± 4.0
$\pi^+\pi^-$ trigger	5.2 ± 3.6	−3.6 ± 5.2
Accidental activity		
intensity diff.	± 1.1	± 3.0
illumination diff.	± 3.0	± 3.0
K_S in time activity	± 1.0	± 1.0
Total	+35.0 ± 6.5	+35.9 ± 8.1
	± 9.0	± 9.6

$$R = 1 - (1.169 \pm 0.147)\% + (0.350 \pm 0.111)\%$$

First term after 1: effect of the ratio of the 4 numbers;
Second term after 1: corrections.

Re ε'/ε vs run period



The 1997, 98/99 and 2001 results all combined

$$1997\ \mathrm{Re}\,\varepsilon'/\varepsilon = (\ 18.5 \pm 4.5\ (\mathrm{stat.}) \pm 5.8\ (\mathrm{syst.}))\times 10^{-4}$$

$$98/99\ \mathrm{Re}\,\varepsilon'/\varepsilon = (\ 15.0 \pm 1.7\ (\mathrm{stat.}) \pm 2.1\ (\mathrm{syst.}))\times 10^{-4}$$

$$2001\ \mathrm{Re}\,\varepsilon'/\varepsilon = (\ 13.7 \pm 2.7\ (\mathrm{stat.}) \pm 1.5\ (\mathrm{syst.}))\times 10^{-4}$$

$$\mathrm{Average}\quad \mathrm{Re}\,\varepsilon'/\varepsilon = (\ 14.7 \pm 2.2\ )\times 10^{-4}$$

There is a small correlation between the systematic uncertainties which is taken into account in the weighted average.

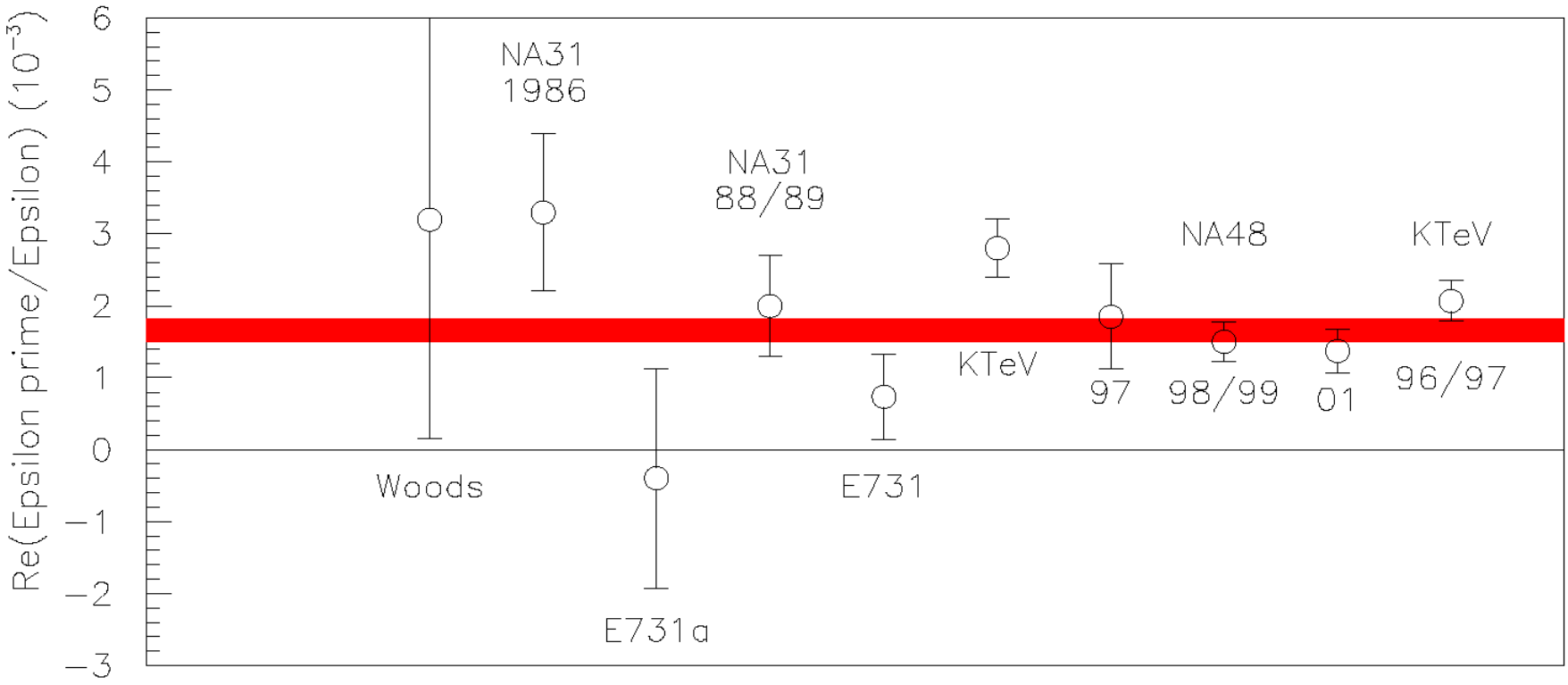
New proposal:

1. At least 10× the statistics of present experiments
2. Reduction of systematic uncertainties by a factor 3

Principal elements:

1. Concurrent detection of all 4 decay modes in the same detector
2. Tagging of K_S and K_L: coll. beams
3. Fast LKr calorimeter 2.4 m ϕ for photon detection
4. Magnet spectrometer for $\pi^+\pi^-$ to reduce background to 10^{-3} level
5. New method of analysis to reduce systematic error $K_L : K_S$ weighting

Summary of Re ε'/ε measurements



The red band corresponds to the average of the experimental values. The earlier NA31-1986 and E731a values are included in the final NA31 an E731 values, respectively. The 1997 KTeV result has been revised and is included in the 96/97 result.

World average 2002

after 5 (3) years of data taking by NA48 and KTeV:

$$\mathrm{Re}\,\varepsilon'/\varepsilon = (17 \pm 2) \times 10^{-4}$$

This implies direct CP violation in $K^0 \to 2\pi$ decays:

$$\frac{\Gamma(K^0 \to \pi^+\pi^-) - \Gamma(\overline{K}^0 \to \pi^+\pi^-)}{\Gamma(K^0 \to \pi^+\pi^-) + \Gamma(\overline{K}^0 \to \pi^+\pi^-)} = 2\,\mathrm{Re}\,\epsilon' = +(5.5 \pm 1) \times 10^{-6}$$

$$\frac{\Gamma(K^0 \to 2\pi^0) - \Gamma(\overline{K}^0 \to 2\pi^0)}{\Gamma(K^0 \to 2\pi^0) + \Gamma(\overline{K}^0 \to 2\pi^0)} = -4\,\mathrm{Re}\,\epsilon' = -(11 \pm 1) \times 10^{-6}$$

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Rare K_L decay results published recently and work in progress

K_S life time, K^0 and η masses

$K_L \to \pi^0\gamma\gamma$ branching ratio

$K_L \to 3\pi^0$ Dalitz plot (form factor)

$K_S, K_L \to \pi^+\pi^- e^+ e^-$ decay asymmetries

$K_L \to 2\gamma$ braching ratio

$K_L \to \pi^0\pi^0\gamma$ branching ratio

$K_L \to \pi^0\pi^0\gamma\gamma$

$K_L \to \pi e\nu$ form factor

$K_L \to \pi\mu\nu$ form factors

$K_L \to \pi e\nu, \pi\mu\nu$ charge asymmetries

$K_L \to \pi^\pm\pi^0 e^\mp\nu$ Dalitz plot

$K_L \to e^+e^-\gamma$ rate and form factor

$K_L \to e^+e^-\gamma\gamma$ rate

$K_L \to \mu^+\mu^-\gamma$ rate