# UPDATE ON THE $Re(\epsilon\,'/\epsilon)$ MEASUREMENT FROM NA48

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The NA48 experiment at CERN has been designed to reach an ultimate error of $2 \times 10^{-4}$ on the measurement of the direct CP violation parameter $Re(\epsilon\,'/\epsilon)$ .
The most recent preliminary result from NA48 is $Re(\epsilon\,'/\epsilon) = (12.2 \pm 4.9) \times 10^{-4}$, based on the analysis of the data collected in 1998.

## 1 The NA48 experimental technique

The measurement of the direct CP violation parameter $Re(\epsilon\,'/\epsilon)$ is accomplished in the NA48 experiment by counting the number of events in each of the four decay modes $K_L, K_S \to \pi^0\pi^0, \pi^+\pi^-$ and computing the double ratio $R$:

$$R = \frac{\Gamma(K_L \to \pi^0\pi^0)}{\Gamma(K_S \to \pi^0\pi^0)} \cdot \frac{\Gamma(K_S \to \pi^+\pi^-)}{\Gamma(K_L \to \pi^+\pi^-)} \simeq 1 - 6\, Re(\epsilon\,'/\epsilon)$$

A few million of CP–violating $K_L \to \pi^0\pi^0$ decays, the rarest among the four relevant processes, should be collected to achieve the ultimate precision of $2 \times 10^{-4}$ on the $Re(\epsilon\,'/\epsilon)$ measurement.

The systematics uncertainty is controlled at high accuracy by exploiting cancellations of effects which contribute symmetrically to the different components of the double ratio $R$. Detection efficiencies and rate dependent effects due to beam intensity variations and accidental activity in the detector are minimized by collecting the data simultaneously in the four decay channels.

The $K_S$ and $K_L$ beams are produced concurrently, and coincide in space at the position of the detector. A proton tagger is installed upstream of the $K_S$ target to distinguish $K_S$ from $K_L$. The choice of the production angles makes the $K_L$ and $K_S$ momentum spectra similar in the range 70–170 GeV of accepted kaon energy. Only those decays occurring in the same fiducial volume are used to compute $R$. A counter is installed in the $K_S$ beam line to define the beginning of the decay region, whose length is 3.5 units of $K_S$ lifetime. The longitudinal position distributions of the decay vertex are made equal for $K_L$ and $K_S$ by applying an event–weighting procedure. In this way, the acceptance correction, due to the large difference in average decay leghts, is small, at the price of a 35% loss in event statistics. The definition of the beginning of the fiducial decay region is used to set the neutral energy scale. Background effects are reduced by a suitable detector performance. The $R$ calculation is done in kaon energy bins, in order to be insensitive to beam spectra differences.

Table 1: *Corrections applied to R and systematics uncertainties (1998 data; units* $= 10^{-4}$*).*

| | |
|---|---|
| Mistagging probability | $+1 \pm 8$ |
| Tagging inefficiency | $- \pm 3$ |
| Charged trigger | $-1 \pm 11$ |
| Neutral background | $-7 \pm 2$ |
| Charged background | $+19 \pm 3$ |
| Beam scattering | $-10 \pm 3$ |
| Acceptance | $+31 \pm 9$ |
| Neutral scale | $- \pm 10$ |
| Charged vertex | $+2 \pm 2$ |
| Accidental activity | $+2 \pm 12$ |
| Total correction and systematics on $R$ | $+37 \pm 24$ |

The corrections finally applied to $R$ are due to several systematics effects: $K_S$ and $K_L$ misidentification by proton tagging; trigger inefficiency; background subtraction; acceptance correction; energy scale; accidental activity. Each effect is not larger than a few per mill, as shown in tab. 1 .

## 2 The $Re(\epsilon'/\epsilon)$ analysis in NA48

NA48 has been taking physics data for the $Re(\epsilon'/\epsilon)$ measurement since 1997. The analysis of the data collected in 1997, corresponding to $0.49 \times 10^6$ reconstructed $K_L \to \pi^0\pi^0$, leads to the published result:

$$Re(\epsilon'/\epsilon) = (18.5 \pm 4.5(stat) \pm 5.8(syst)) \times 10^{-4} = (18.5 \pm 7.3) \times 10^{-4}.$$

In the 1998 run, the improvements in charged trigger and data aquisition systems allowed to take data at a beam intensity of $\sim 1.4 \times 10^{12}$ *ppp* on the $K_L$ target. The preliminary result for the duble ratio $R$, based on $1.14 \times 10^6$ reconstructed $K_L \to \pi^0\pi^0$, is: $R = 0.99267 \pm 0.00173(stat.) \pm 0.00238(syst.)$, where the first error is the statistical fluctuation in the event samples and the second error comes from the uncertainties listed in tab. 1 . The preliminary result for the direct CP violating parameter $Re(\epsilon'/\epsilon)$ using 1998 data is:

$$Re(\epsilon'/\epsilon) = (12.2 \pm 2.9(stat) \pm 4.0(syst)) \times 10^{-4} = (12.2 \pm 4.9) \times 10^{-4} .$$

This value, combined with the pubblished 1997 measurement, leads to:

$$Re(\epsilon'/\epsilon) = (14.0 \pm 4.3) \times 10^{-4} .$$

A highly efficent run took place in 1999, with $\sim 2 \times 10^6$ $K_L \to \pi^0\pi^0$ reconstructed events. The data analysis is well advanced.

The present result on $Re(\epsilon'/\epsilon)$ from NA48 confirms the occurrence of direct CP violation in the decays of neutral kaons in two pions. The NA48 data taking for the $Re(\epsilon'/\epsilon)$ physics program will continue until the year 2001.