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

Patrizia CENCI
Istituto Nazionale di Fisica Nucleare, Perugia, Italy.

The NA48 experiment at CERN has been designed to reach an ultimate error of 2×10^{-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, are collected to achieve the ultimate precision of 2×10^{-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 $\mathrm{K_S}$ and $\mathrm{K_L}$ beams are produced concurrently, and coincide in space at the position of the detector. A proton tagger is installed upstream of the $\mathrm{K_S}$ target to distinguish $\mathrm{K_S}$ from $\mathrm{K_L}$. The choice of the production angles makes the $\mathrm{K_L}$ and $\mathrm{K_S}$ 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 $\mathrm{K_S}$ beam line to define the beginning of the decay region, whose length is 3.5 units of $\mathrm{K_S}$ lifetime. The longitudinal position distributions of the decay vertex are made equal for $\mathrm{K_L}$ and $\mathrm{K_S}$ 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 ± 11
Neutral background	-7 ± 2
Charged background	$+19 \pm 3$
Beam scattering	-10 ± 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: $\mathrm{K_S}$ and $\mathrm{K_L}$ 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 0.49×10^6 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 $\mathrm{K_L}$ target. The preliminary result for the duble ratio R, based on 1.14×10^6 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.