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RELEVANT RESULTS FROM THE NA48 EXPERIMENT

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ABSTRACT

We report relevant results from NA48 experiment at CERN SPS. NA48 was proposed in 1990 [1] to study direct CP violation in $K^0 \to \pi\pi$ to a level of accuracy sufficient to resolve the inconclusive status left by the previous measurements performed by NA31 [2] and E731 [3]. In 2002 NA48 published the final result [4]. Small modification to the experimental setup have allowed NA48 to go forward with an extensive investigation of K^0 rare decays and hyperon decays. Some results are already available and reported here together with the final CP violation measurement.

1 The measurement of $Re(\epsilon'/\epsilon)$

It is well known that the decay of $K^0/\overline{K^0}$ into two pions violates CP. Such a violation can have two contributions: one, indirect, associated to $K^0/\overline{K^0}$ mixing and another, direct, coming from the decay amplitude. The amount of direct CP violation in this decay is parametrized by the parameter $Re(\epsilon'/\epsilon)$, which can be computed in the framework of the standard electro-weak-model, albeit with large theoretical uncertainties. Typical theoretical predictions of $Re(\epsilon'/\epsilon)$ varies from few 10^{-4} to about 2×10^{-3}, even though with large exceptions.
$Re(\epsilon'/\epsilon)$ is connected to the double ratio of decay rates according to the following formula:

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

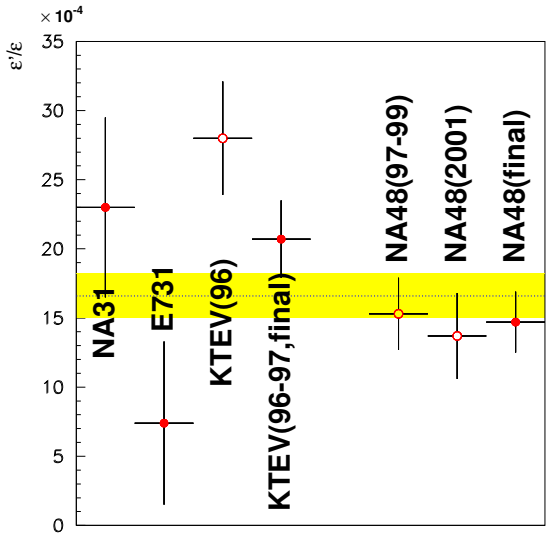

Figure 1: *World measurements of* $Re(\epsilon'/\epsilon)$

In order to exploit the cancellation in the double ratio of systematic uncertainties, the experimental apparatus consists of two concurrent and almost co-linear beams, one providing the experiment with K_L decays and the other one with K_S decays and the K^0 to $\pi\pi$ decays are reconstructed in the same decay region. A tagging station is devoted to identify the K^0 decay as a K_S or a K_L decay. In 2002 NA48 has published [4] the final result of the measurement:

$$Re(\epsilon'/\epsilon) = (15.3 \pm 2.6) \times 10^{-4} \tag{2}$$

It is the most precise measurement ever done as shown in Fig.1. The world average value is also reported together with the uncertainty (yellow band).

2 Selected items about rare decays

The radiative kaon decays are ideally suited to test the validity of the Chiral Perturbation Theory (χPhT). The processes may be described in a perturbative expansion of momenta: $\mathcal{O}(p^2), \mathcal{O}(p^4)$. Examples of this type are $K_S \to \gamma\gamma$ and $K_L \to \pi^0\gamma\gamma$. In both cases there is no contribution from the $\mathcal{O}(p^2)$ term, while the $\mathcal{O}(p^4)$ contribution is predicted to better than 5% by χPhT. NA48 has measured [5],[6]:

$$BR(K_S \to \gamma\gamma) = (2.78 \pm 0.06_{stat} \pm 0.02_{MCstat} \pm 0.04_{syst}) \times 10^{-6} \tag{3}$$

$$BR(K_L \to \pi^0\gamma\gamma) = (1.36 \pm 0.03_{stat} \pm 0.03_{syst} \pm 0.03_{norm}) \times 10^{-6} \quad (4)$$

The value of $BR(K_S \to \gamma\gamma)$ deviates from $\mathcal{O}(p^4)$ prediction and indicates a large $\mathcal{O}(p^6)$ contribution. The $\mathcal{O}(p^4)$ contribution to $K_L \to \pi^0\gamma\gamma$ turns out to be also an underestimation of the decay rate. Anyway at $\mathcal{O}(p^6)$ the rate may be reproduced by adding a contribution from the VDM mechanism, via the coupling constant a_v that NA48 has measured to be:

$$a_v = -0.46 \pm 0.03_{stat} \pm 0.04_{syst} \quad (5)$$

3 Hyperon decays in NA48

The target used for the production of K^0s is also a huge source of hyperons. By using the small fraction of hyperons that passed the standard triggers in the previous years, the NA48 collaboration has already published results on hyperon physics [7]:

$$m(\Xi^0) = [1314.82 \pm 0.06(stat.) \pm 0.20(syst.)]MeV/c^2 \quad (6)$$

$$BR(\Xi^0 \to \Lambda\gamma) = [1.90 \pm 0.34(stat.) \pm 0.19(syst.)] \times 10^{-3} \quad (7)$$

$$BR(\Xi^0 \to \Sigma^0\gamma) = [3.14 \pm 0.76(stat.) \pm 0.32(syst.)] \times 10^{-3} \quad (8)$$

In the 2002 special triggers have been dedicated to hyperon decays and NA48 claims main achievements to:

1. study form factors and flavor symmetry violations in the Ξ^0 decays;
2. give an alternative measurement of V_{us} (CKM parameter) using Ξ^0 (and Λ) beta decay instead of kaon beta decays.

References

1. NA48 Collaboration (A. Lay *et al.*) CERN-SPSC-90-22.
2. NA48 Collaboration (G.D. Barr *et al.*) Phys. Lett. B **317**, 233-242 (1993).
3. NA48 Collaboration (L.K. Gibbons *et al.*) Phys. Rev. D **55**, 6625-6715 (1997).
4. NA48 Collaboration (J.R. Batley *et al.*) Phys. Lett. B **544**, 97-112 (2002).
5. NA48 Collaboration (A. Lay *et al.*) Phys. Lett. B **551**, 7-15 (2003).
6. NA48 Collaboration (A. Lay *et al.*) CERN-EP/2002-030, hep-ex/0205010.
7. NA48 Collaboration (A. Lay *et al.*) Eur. Phys. J. C **12**, 69-76 (2000).