RARE K^0 DECAYS (PRELIMINARY)

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The preliminary results are obtained in the NA48 experiment at CERN SPS: the first evidence for the decay of $K_S \to \pi^+\pi^-e^+e^-$, an upper limit estimation for $Br(K_S \to \pi^0 e^+e^-)$, and the measurement of the branching ratios of K_S decays into two γ's, and K_L decays into $e^+e^-e^+e^-$, $\pi^0\gamma\gamma$ and $e^+e^-\gamma\gamma$.

1 Experimental Technique

The NA48 detector is designed for the precision measurement of the direct CP violation in the neutral kaon decays. The two beams, K_S and K_L, are produced on two different targets located consequently 6m and 126m upstream of the beginning of the decay region contained in 90m long vacuum tank. The both beams are collimated almost parallel along the OZ axis. The accepted kaon decays corresponds to the beam momentum range from 60 GeV/c^2 to 170 GeV/c^2. The main detector consists of a magnetic spectrometer, a liquid krypton electro-magnetic calorimeter (LKr), an iron-scintillator hadron calorimeter and a muon identification system.

The magnetic spectrometer includes four drift chambers, dipole magnet with momentum kick of 267 MeV/c, and two plastic scintillator hodoscope planes, and provides the mean momentum resolution of $\delta p/p \simeq 0.5 \oplus 0.009(GeV/c)^{-1} \cdot p$.

The LKr has a structure of 13212 square towers of $2 \times 2 cm^2$ cross section and 27 radiation length each, formed by copper-beryllium ribbons and contained into the liquid krypton. The energy resolution is $\sigma(E)/E \simeq 0.100/E \oplus 0.032/\sqrt{E} \oplus 0.005$, where E is in GeV. A decay vertex position (Z coordinate) of a neutral particle with mass M^0 is reconstructed according to an expression $Z_V = Z_{LKr} - \sqrt{\sum_{i,j} \cdot E_i \cdot E_j \cdot r_{ij}^2}/M^0$, where Z_{LKr} is Z-coordinate of the LKr front plane, $E_{i,j}$ is a reconstructed energy of i-,j- clusters, and r_{ij} is a distance between those clusters.

A more complete description of the apparatus can be found elsewhere [1].

Presented results are based on the data recorded in 1997 - 1999 at different trigger and beam intensity conditions.

2 Search for $K_S^0 \to \pi^0 e^+e^-$

A study of $K_S^0 \to \pi^0 e^+e^-$ decay is important for the estimation of indirect CP-violation contribution to the decay $K_L^0 \to \pi^0 e^+e^-$ and test of some models. The predictions of χPT models for this branching ratio are at the level of 10^{-9}, while an experimental limit [2] is $1.1 \cdot 10^{-7}$.

The data recorded during a special high intensity K_S run in 1999 have been used for this measurement. 83960 The decay $K_S \to \pi^0\pi^0_D \to \pi^0 e^+e^-\gamma$ (83960 selected events) was used as a normalisation channel. A comparison of two electron subsystem invariant mass (M_{ee}) spectra obtained for the normalisation channel, with the one predicted [3] for $K_S^0 \to \pi^0 e^+e^-$, is shown in fig. 1. No events have been found in the region of $M_{ee} > 165 MeV/c^2$, where less than 0.3 background events of the normalisation channel are expected. Other possible background is negligible. That allows to calculate a model independent upper limit on $Br(K_S^0 \to \pi^0 e^+e^-, M_{ee} > 165 MeV/c^2)$ as

$$8.3 \cdot 10^{-8}, \quad at \quad 90\% \quad C.L.$$

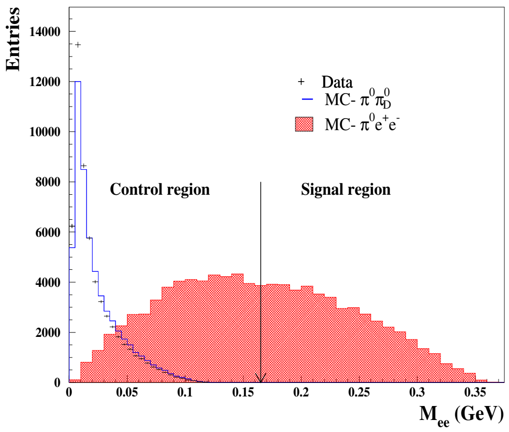

Figure 1. M_{ee} spectra for the signal and background.

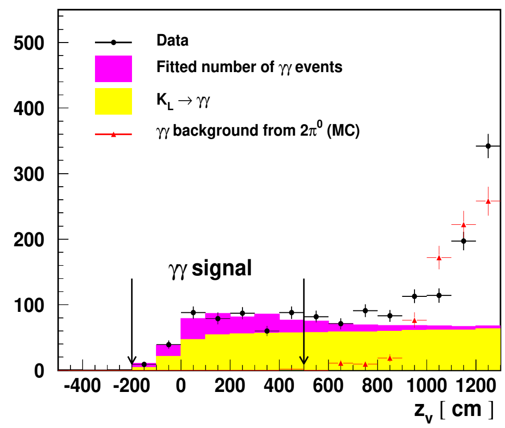

Figure 2. Different contribution to Z_V spectrum.

A limit obtained in the whole kinematic region using M_{ee} spectra of model [3], is:

$$< 1.6 \cdot 10^{-7}.$$

Systematic errors are caused mainly by the difference between the simulated (MC) and experimental spectra (fig. 1), radiative corrections and uncertainties of the LKr cluster energy reconstruction.

3 Study of $K_S \to \pi^+\pi^-e^+e^-$ Decays

Study of this decay is important for the estimation of CP-conserving contribution to the $K_L \to \pi^+\pi^-e^+e^-$ decay. A measurement of an asymmetry $A = cos\phi \cdot sin\phi$ (here ϕ is an angle between two planes, one defined by 2 pions and another - by two electrons, both at the kaon CM system) could check the CP-conservation in this decay.

The data for the present measurement has been recorded in 1998. An acceptance was calculated according to the model [4]. There have been reconstructed 52 events of $K_S \to \pi^+\pi^-e^+e^-$ decay and 89 events of the decay $K_L \to \pi^+\pi^-\pi^0_D \to \pi^+\pi^-e^+e^-(\gamma)$ which is used as a normalisation channel. The major background is expected from this channel, and is less than one. The radiative corrections, LKr cluster reconstruction, and MC deviation from the experimental spectra have been considered as the major sources of the systematic. The asymmetry A has been found to be consistent with zero. The obtained $Br(K_S \to \pi^+\pi^-e^+e^-)$ is:

$$(5.1 \pm 0.9_{tat} \pm 0.3_{syst}) \cdot 10^{-5}.$$

4 Measurement of $Br(K_S \to \gamma\gamma)$

This measurement could be a critical test of χPT models, because no short distance effects are contributed to the relevant calculations.

The data recorded during the high intensity run ($6 \cdot 10^9$ ppp on K_S target) in 1999 has been used. The events have been selected having only 2 LKr clusters with an energy $3 < E_{cl} < 100GeV$. To extract $K_S \to \gamma\gamma$ decays a Z_V distribution for the selected events (fig. 2) has been analysed. The major contribution to this spectrum came from $K_L \to 2\gamma$ (which number has been estimated as 294 events) and $K_S \to 2\pi^0 \to 2\gamma(2\gamma)$ decays. The latter one is used as a normalisation channel with the Z_V spectrum obtained by the MC. A signal region was chosen in the restricted Z_V interval which is close to the end of the K_S final collimator. The result of

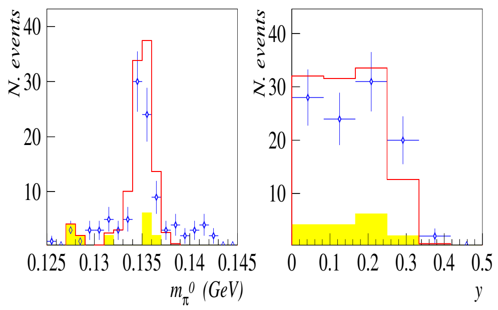

Figure 3. Two γ invariant mass and y spectra.

148 $K_S \to \gamma\gamma$ decays has been obtained using the maximum likelihood method (binned over energy and Z_V) to fit to the Z_V distribution, which leads to:

$$Br(K_S \to 2\gamma) = (2.6 \pm 0.4_{stat} \pm 0.2_{syst}) \cdot 10^{-6}.$$

5 Study [a] of $K_L \to e^+e^-e^+e^-$

The obtained branching ratio is based on 132 reconstructed events:

$$(3.67 \pm 0.32_{stat} \pm 0.23_{syst} \pm 0.08_{norm}) \cdot 10^{-8}.$$

It has been observed 19 events of the $K_L \to \mu^+\mu^-e^+e^-$ decay.

6 Study of $K_L \to \pi^0 2\gamma$ Decays

The measurement of $Br(K_L \to \pi^0\gamma\gamma)$ allows to test χPT calculations of the order of p^6 taking into account the vector meson exchange mechanism, and estimate a CP-conserving intermediate state in $K_L \to \pi^0 e^+e^-$ decay. The p^4 order diagrams can not describe neither a tail in the two gamma invariant mass ($M_{\gamma\gamma}$) distribution at the low masses ($< 240 MeV/c^2$), nor the spectrum of photon energy ($y = |E_1^* - E_2^*|/M_K$) in the kaon CM system.

[a] More detail analysis is presented in the contributed paper No. 229.

A part of the data recorded in 1998 and data of 1999 runs have been used for this analysis. In total 1397 $K_L \to \pi^0\gamma\gamma$ decays have been selected, 30 of which were estimated as the background ones. An effective vector coupling constant $a_v = -0.45$ has been used in the MC efficiency calculations. That has led to the reasonable agreement between the experiment and MC in $M(\pi^0 \to 2\gamma)$ and y spectra at $M_{\gamma\gamma} < 240 Me4V/c^2$ (fig. 3). The corresponding branching ratio (at $a_v = -0.45$) has been evaluated as:

$$(1.51 \pm 0.05_{stat} \pm 0.20_{syst}) \cdot 10^{-6}.$$

7 Study of $K_L \to e^+e^-2\gamma$

This study is important for the estimation of the background in searching for a CP-violating $K_L \to \pi^0 e^+e^-$ decay.

It have been selected 492 events of $K_L \to e^+e^-\gamma\gamma$ decay, and 29879 events of $K_L \to e^+e^-\gamma$ decay used as a normalisation channel, among the data recorded in 1997 and 1998 runs. The major background contribution was estimated to be from $K_s \to \pi^0\pi^0_D \to \pi^0 e^+e^-(\gamma)$ (3.8 ev.), $K_L \to e^+e^-\gamma + (\gamma)_{bremss.}$ (9.9 ev.) and $K_L \to$ *all others* (11.4 ev.). Systematic sources related to an uncertainty in α_{K^*}, the external bremsstrahlung and applied cut variations, have been taken into account. The obtained branching ratio at $E^*_\gamma > 5MeV$, is:

$$(6.32 \pm 0.31_{stat} \pm 0.20_{sys} \pm 0.29_{norm}) \cdot 10^{-7}$$

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References

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