RARE KAON DECAYS FROM NA48

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In an analysis of 1999 and part of 1998 NA48 data 1397 $K_L \to \pi^0\gamma\gamma$ candidates above a background of approximately 30 events have been found. From this a preliminary branching ratio of $\mathrm{BR}(K_L \to \pi^0\gamma\gamma, a_v = -0.45) = (1.51 \pm 0.05_{\mathrm{stat}} \pm 0.20_{\mathrm{sys}}) \cdot 10^{-6}$ has been determined. A clear signal for a diphoton mass $m_{\gamma\gamma} <$ 240 MeV/c^2 has been observed. From a special high intensity K_S run a signal of 149 $K_S \to \gamma\gamma$ events above background has been found, yielding a branching ratio of $\mathrm{BR}(K_S \to \gamma\gamma) = (2.6 \pm 0.4_{\mathrm{stat}} \pm 0.2_{\mathrm{sys}}) \cdot 10^{-6}$.

1 The Decay $K_L \to \pi^0\gamma\gamma$

The decay $K_L \to \pi^0\gamma\gamma$ is of considerable theoretical interest. In the framework of chiral pertubation theory a calculation to the order p^4 predicts[1] a branching ratio of approximately $0.68 \cdot 10^{-6}$. While the first measurements agreed with the theoretical prediction with respect to the invariant diphoton mass spectrum, significantly higher branching ratios were observed by NA31 ($(1.7 \pm 0.3) \cdot 10^{-6}$)[2,3] and E731 ($(1.86 \pm 0.6) \cdot 10^{-6}$)[4].

Consideration of the next to leading order p^6 and vector meson dominance contributions improve the agreement between experiment and theory[5,6]. In case of non-vanishing vector meson exchange the invariant diphoton mass spectrum is significantly enhanced for in the lower mass regions (Fig. 1a).

The $\pi^0\gamma\gamma$ channel and its normalization channel $K_L \to \pi^0\pi^0$ were both triggered by the standard ϵ'/ϵ neutral trigger. Significant background channels are $K_L \to \pi^0\pi^0$ and $K_L \to \pi^0\pi^0\pi^0$ with lost and/or overlapping clusters in the electromagnetic calorimeter. Background from $K_L \to \pi^0\pi^0$ is suppressed by rejecting events with a χ^2 of less than 100 for a $2\pi^0$ hypothesis. $3\pi^0$ events with lost/overlapping photons are rejected by cuts against misreconstructed z-vertices, combinatorial kaon/pion vertex differences, and cluster widths.

From part of 1998 and the full sample of 1999 NA48[7] data 1397 candidates have been found above a very low background of about 30 events. To determine the acceptance, a Monte Carlo simulation with an effective vector coupling of $a_v = -0.45$ has been used to obtain the preliminary branching ratio of $\mathrm{BR}(K_L \to \pi^0\gamma\gamma, a_v = -0.45) = (1.51 \pm 0.05_{\mathrm{stat}} \pm 0.20_{\mathrm{sys}}) \cdot 10^{-6}$. The signal in the invariant mass region below 240 MeV/c^2 gives clear evidence for a contribution beyond the order of p^4 (Figure 1c).

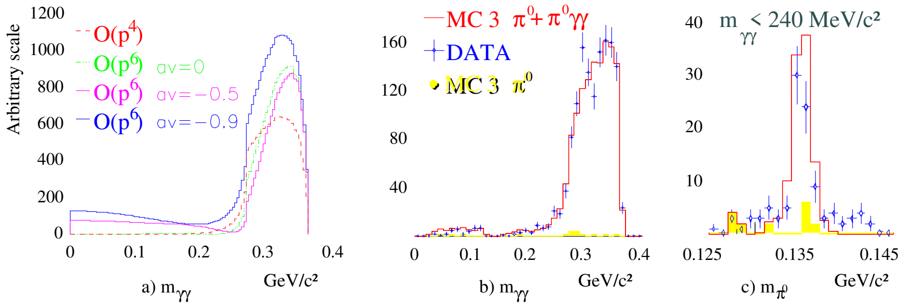

Figure 1. a) Theoretical predictions for the invariant diphoton mass for $K_L \to \pi^0\gamma\gamma$. b) Invariant diphoton mass for $K_L \to \pi^0\gamma\gamma$ candidates. c) Signal for lower diphoton mass region ($m_{\gamma\gamma} < 240$ MeV/c^2).

2 The Decay $K_S \to \gamma\gamma$

Similar to $K_L \to \pi^0\gamma\gamma$, the decay $K_S \to \gamma\gamma$ is important for understanding and testing chiral pertubation theory. A previous measurement by NA31 has found a branching ratio of $(2.4 \pm 0.9) \cdot 10^{-6}$ [8]. Theory predicts a branching ratio of $2.25 \cdot 10^{-6}$ with an error of less than 10% [9].

From a dedicated high intensity K_S run in 1999 a new measurement of the branching ratio with approximately four times the statistics of the NA31 sample is possible. The analysis addresses background from $K_L \to \gamma\gamma$, $K_S \to \pi^0\pi^0$, and $\Lambda \to n\pi^0$. After background subtraction a signal of 149 $K_S \to \gamma\gamma$ candidates remains, giving a branching ratio of $\mathrm{BR}(K_S \to \gamma\gamma) = (2.6 \pm 0.4_{\mathrm{stat}} \pm 0.2_{\mathrm{sys}}) \cdot 10^{-6}$ [10].

References

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