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Charm Meson Decays to $K_S K_S X$ at FOCUS

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Using data from the FOCUS experiment, we report on the decay of D mesons into states containing more than one K_S^0. We present evidence for two new Cabibbo favored decay modes, $D^0 \to K_S^0 K_S^0 K^- \pi^+$ and $D^0 \to K_S^0 K_S^0 K^+ \pi^-$ and measure their combined branching fraction relative to $D^0 \to \overline{K^0}\pi^+\pi^-$. We also report new measurements of $\frac{\Gamma(D^0 \to K_S K_S \pi^+\pi^-)}{\Gamma(D^0 \to \overline{K^0}\pi^+\pi^-)}$, $\frac{\Gamma(D^0 \to K_S K_S K_S)}{\Gamma(D^0 \to \overline{K^0}\pi^+\pi^-)}$, $\frac{\Gamma(D^0 \to K^0 \overline{K^0})}{\Gamma(D^0 \to \overline{K^0}\pi^+\pi^-)}$, and $\frac{\Gamma(D^+ \to \overline{K^0}\,\overline{K^0} K^+)}{\Gamma(D^+ \to \overline{K^0}\pi^+\pi^-\pi^+)}$.

1. Introduction

The FOCUS two magnet forward spectrometer [1] has excellent silicon strip vertexing detectors [2], three multicell Čerenkov detectors [3] for charged particle identification, and three meters of decay length where vees can be reconstructed. A detailed description of individual K_S^0 reconstruction can be found in reference [4].

2. Evidence for $D^0 \to K_S K_S K^\pm \pi^\mp$

The first evidence for $D^0 \to K_S K_S K^\pm \pi^\mp$ is presented in Fig. 1. There are 57 $\pm$ 10 events in the signal at a significance of separation between the production and decay vertices greater than four (L/$\sigma_L > 4$). While the decay modes $D^0 \to \overline{K^0}\,\overline{K^0} K^+ \pi^-$, $D^0 \to \overline{K^0} K^0 K^- \pi^+$, and $D^0 \to \overline{K^0} K^0 K^+ \pi^-$ can result in the final state $K_S K_S K^\pm \pi^\mp$, the decay mode $D^0 \to \overline{K^0} K^0 K^+ \pi^-$ is doubly Cabibbo suppressed and we assume this mode is small compared to the other two Cabibbo favored modes. We have used the soft pion tag from the D^{*+} to show weak evidence for both Cabibbo favored channels (7.2±3.4 events and 6.8±2.9 events).

3. The $D^0 \to K_S^0 K_S^0 \pi^+ \pi^-$ Decay Mode

This channel is Cabibbo-suppressed and was first observed by the ARGUS Collaboration [5]. It has a larger background than the $D^0 \to K_S K_S K^+ \pi^-$ channel due to more phase space and two pions. We eliminate dipion combinations which are consistent with the K^0 mass and we increase the L/σ_L cut to greater than six to improve the signal to noise. The $K_S^0 K_S^0 \pi^+ \pi^-$ invariant mass is presented in Fig. 1. The fit to the figure returns 113±21 events.

*on behalf of the FOCUS Collaboration (http://www-focus.fnal.gov/)

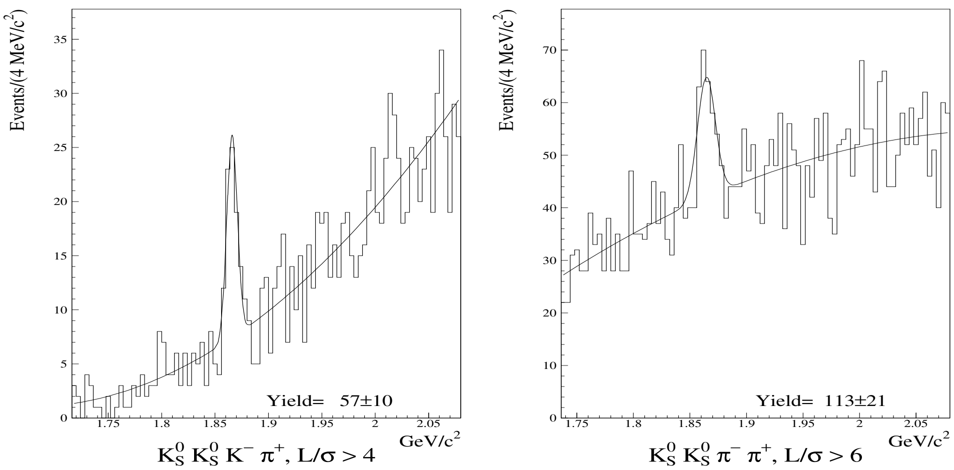

Fig. 1. Invariant mass distributions for $D^0 \to K_S K_S K^{\pm}\pi^{\mp}$ and for $D^0 \to K_S K_S \pi^{\pm}\pi^{\mp}$.

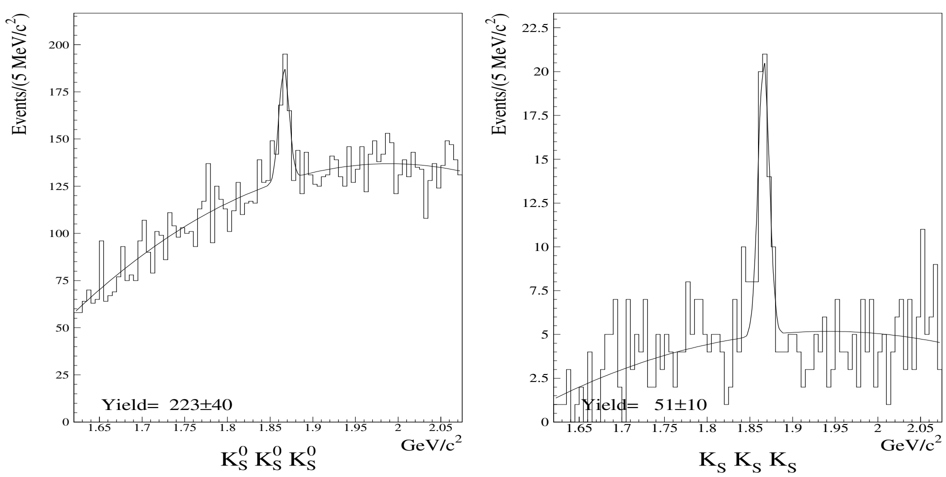

Fig. 2. Invariant mass plots of $D^0 \to K_S K_S K_S$ with and without a D^{*+} soft pion tag.

4. The $D^0 \to K_S^0 K_S^0 K_S^0$ Decay Mode

Due to the limited phase space and the need to identify three K_S^0 candidates, a $D^0 \to K_S^0 K_S^0 K_S^0$ decay mode can be observed without the need for a D^{*+} tag or a L/σ_L cut. In Fig. 2 we present the invariant mass of $K_S K_S K_S$ candidates.

5. A first look at $D^+ \to \overline{K^0 K^0} K^+$ Decay Mode.

There are two reports of this decay mode, one by the CLEO Collaboration found a branching ratio of 3.7±0.8% [6] and the other by the ARGUS Collaboration found

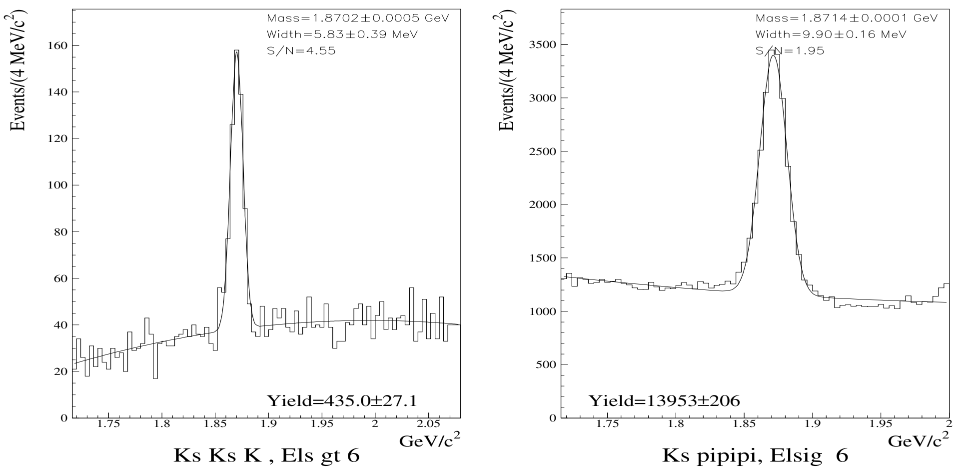

Fig. 3. The invariant mass plots for $D^+ \rightarrow \overline{K^0 K^0} K^+$ and $D^+ \rightarrow K_S \pi^+ \pi^- \pi^+$.

1.54±0.44% [5]. The FOCUS plot together with the normalizing decay mode is shown in Fig. 3. The FOCUS result is more consistent with the ARGUS result.

6. Summary

We summarize our branching ratios and compare them in Table 1 to Particle Data Group world averages where available [7].

Table 1

Decay Mode	Branching Ratio	PDG 2004
$\frac{\Gamma(D^0 \rightarrow K_S K_S K^\pm \pi^\mp)}{\Gamma(D^0 \rightarrow \overline{K}^0 \pi^+ \pi^-)}$	1.06±0.19 %	-
$\frac{\Gamma(D^0 \rightarrow K_S K_S \pi^+ \pi^-)}{\Gamma(D^0 \rightarrow \overline{K}^0 \pi^+ \pi^-)}$	2.08±0.35 %	3.1±1.0 %
$\frac{\Gamma(D^0 \rightarrow K_S K_S K_S)}{\Gamma(D^0 \rightarrow \overline{K}^0 \pi^+ \pi^-)}$	1.79±0.27 %	1.54±0.25 %
$\frac{\Gamma(D^0 \rightarrow K^0 \overline{K}^0)}{\Gamma(D^0 \rightarrow \overline{K}^0 \pi^+ \pi^-)}$	1.44±0.32 %	1.20±0.33 %
$\frac{\Gamma(D^+ \rightarrow \overline{K}^0 \overline{K}^0 K^+)}{\Gamma(D^+ \rightarrow \overline{K}^0 \pi^+ \pi^- \pi^+)}$	0.206 ± 0.013	

References

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