First Observation of the $D_{sJ}(2632)$ Meson

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for the SELEX Collaboration

The SELEX Collaboration has announced the first observation of a massive, narrow resonance in the charm-strange system. Seen both in $D_S\eta$ and D^0K^+ final states, the meson is unusual both in that it is very narrow despite being far above the strong decay threshold and also in that the the $\Gamma(D^0K^+)/\Gamma(D_S^+\eta) = 0.14 \pm 0.06$. Production is also unusual, with a large asymmetry favoring D_{sJ}^- over D_{sJ}^+ production from the Σ^- beam.

Keywords: First Observation; Heavy narrow state; SELEX

1. Introduction

The SELEX Collaboration has reported the first observation of another massive, narrow resonance in the charm-strange system. [1] The state is seen in two decay modes: $D_S\eta$ and D^0K^+. The data are shown in Fig. 1. The details of the original analysis are given in Ref.1. The background calculation for the $D_S\eta$ channel has been improved in this paper and will appear in the revised version of Ref.1.

The original background, based on mixing a D_S meson from one event with an η candidate from another, was statistics-limited. We increased the sample by mixing 25 η candidates with each D_S meson, then rescaling the resulting distribution by 1/25. The result is shown in Fig. 1 by the light shading. It describes everything over a wide mass range ... except the signal peak. The inset at left in Fig. 1 shows the result of subtracting the combinatoric background from the real data. The fit function is a Gaussian whose width is fixed from Monte Carlo simulation with no background term. The peak mass difference is 666.7 ± 3.3 MeV/c^2 and the resonance mass is 2635.4 ± 3.3 MeV/c^2. The fit probability is 31%. The peak's significance from counting statistics is 6.3σ. We also calculated the Poisson fluctuation probability for a background of 54 events to fluctuate up to a total of 101 events to be 3×10^{-7}. Putting in the detection efficiencies from simulation, we calculate that 55% of the SELEX D_S events from the Σ^- beam come from $D_{sJ}(2632)$ production.

The $D_{sJ}(2632)$ mass is well above threshold for the D^0K^+ channel. The SELEX D^0K^+ mass spectrum shown in Fig. 1 shows the well-known $D_{sJ}(2573)$ with a mass and width consistent with the PDG and another narrow peak at 2632 MeV/c^2. Combinatoric background, measured by the D^0K^- wrong-sign mass spectrum, is flat and featureless. The narrow peak's mass (2631.5 ± 1.9 MeV/c^2) agrees well with the peak seen in the $D_S\eta$ channel. Its width is consistent with experimental

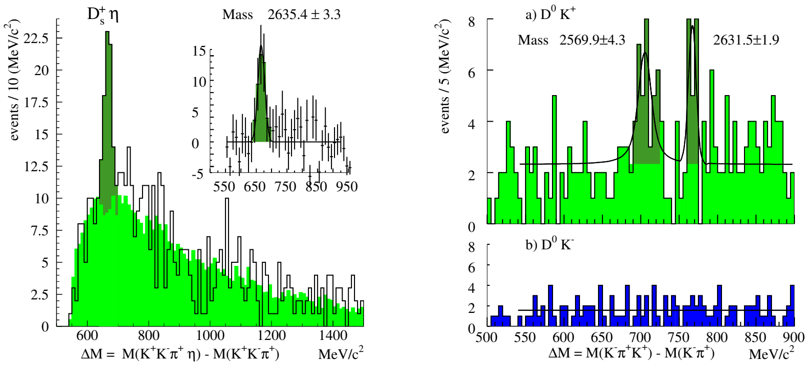

Fig. 1. left: mass distribution for $\mathrm{D_S}\eta$; right: mass distribution for $\mathrm{D^0K^+}$, showing the known $\mathrm{D_{sJ}}(2573)$ and the new state in the top plot and the wrong-sign combinatoric background below.

resolution (5 MeV/c^2). The Breit-Wigner width $\Gamma < 17$ MeV/c^2 at 90% confidence level. The fluctuation probability that a constant background can explain the peak is 10^{-4}. The relative branching ratio $\Gamma(\mathrm{D^0K^+})/\Gamma(\mathrm{D_S^+}\eta) = 0.14 \pm 0.06$ strongly favors the $\mathrm{D_S}\eta$ mode, a very surprising result.

2. Possible Interpretation

At the summer conferences, CLEO and BaBar have announced that their searches see no evidence for production of the $\mathrm{D_{sJ}}(2632)$ in e^+e^- collisions at 10.58 GeV CM energy. The FOCUS photoproduction experiment has commented privately that they do not see this state in 180 GeV γN collisions. Can we understand this?

The usual treatment of hadron production in e^+e^- collisions involves fragmentation. There is fundamental symmetry between particle and antiparticle in such processes. In the SELEX data from the 600 GeV Σ^- beam, there is a striking asymmetry in $\mathrm{D_S}$ production: $\mathrm{D_S^-}/\mathrm{D_S^+} \sim 3$. Also, in CLEO data with a stiff $\mathrm{D_S^*}$ ($\mathrm{p} > 3.5$GeV/c) the fraction of all $\mathrm{D_S}$ production that comes through these $\mathrm{D_S^*}(2112)$ states is $0.59 \pm 0.03 \pm 0.01$ [2]. For these SELEX data the equivalent ratio is 0.24 ± 0.06. These results do not agree at all. However, if we remove the 55% of the $\mathrm{D_S}$ mesons that come from the $\mathrm{D_{sJ}}(2632)$, then the SELEX fraction becomes 0.53 ± 0.13, consistent with the CLEO fragmentation result. This suggests that there may be two production mechanisms for $\mathrm{D_S}$ mesons in the SELEX data: a fragmentation part like in e^+e^- data and a second part responsible for $\mathrm{D_{sJ}}(2632)$ production with a large production asymmetry. In this picture a verification of the $\mathrm{D_{sJ}}(2632)$ is likely to require further studies in hadronic collisions.

References

1. hep-ex/0406045 (submitted to Phys. Rev. Lett.)
2. D. Besson, *et al.*, *Phys. Rev.* **D68**, 032002 (2003)