CDF note 7116

Doubly Cabibbo Suppressed (DCS) $D^0 \to K^+\pi^-$ Signal

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We present plots demonstrating the signal for $D^0 \to K^+\pi^-$ + c.c. decay channel. Assuming no CPV or D-mixing, this mode is the doubly-Cabibbo suppressed decay.

The analysis uses approximately 350 pb^{-1} of integrated luminosity taken by CDF II from through August 2004. The wrong-sign (DCS) signal is 2005 ± 104 (stat.) events. By comparison, the right-sign (Cabibbo favored) decay $D^0 \to K^-\pi^+$ has 495172 ± 907 events. The time-integrated ratio of WS to RS D^0s measured by CDF II is 4.05 ± 0.21 (stat.) ± 0.12 (sys.) $\times 10^{-3}$.

The analysis is leading towards a measurement of D-mixing. That requires a time-dependent analysis, which is beyond the scope of these results.

I. DESCRIPTION

This analysis uses charm mesons to investigate the doubly-Cabibbo suppressed decay $D^0 \rightarrow K^+\pi^-$. It uses approximately 350 pb^{-1} of integrated luminosity, taken by CDF II through August 2004. The hadronic decay trigger, while designed for bottom mesons, is also efficient for charm mesons.

We reconstruct D^0 decaying to a kaon and a pion. An additional pion is attached to form D^* candidates. "Right-sign" (RS) mesons are where both pions from the D^* have the same charge. The Cabibbo favored decay $D^0 \rightarrow K^-\pi^+$ is right-sign. "Wrong-sign" (WS) mesons are where both pions from the D^* have opposite charge. The doubly Cabibbo suppressed decay $D^0 \rightarrow K^+\pi^-$ is wrong-sign.

The soft pion used to form the D^* tags whether the candidate started as a D^0 or a $\bar{D}^0$. dE/dX particle identification is used, but only to improve the signal-to-background, not for tagging.

An investigation of D-mixing requires knowing how the number of RS and WS D^0s change over time. D-mixing is expected to be very small, unlike kaon and bottom meson mixing. Experimental results have set upper limits on mixing parameters. An easier measurement is the time-integrated ratio of WS to RS D^0s. This becomes the DCS/CF ratio, if we make the assumption that there is no CP violation or mixing.

A major source of background is from RS D^0s, where the kaon and pion particle assignments are swapped. This misassigning forms a WS candidate. Events consistent with RS D^0s are excluded from WS plots, and events consistent with WS D^0s are excluded from RS plots.

The signal is fit from getting the D^0 yield as a function of the mass difference ($m_{D^*} - m_{D^0} - m_\pi$). $K\pi$ mass distributions are made in slices of mass difference. The $K\pi$ distribution will have a narrow peak ($\sim$ 9 MeV) for signal, a broad distribution ($\sim$ 70 MeV) for D^0s where the kaon and pion assignments are swapped, and a linear distribution for combinatoric background, where one or both of the high momentum tracks (used to form the D^0 candidate) do not belong to $D^0 \rightarrow K\pi$.

The slices are fit to get the number of D^0s per slice. The plot for the D^0 yield versus mass difference will have a narrow peak for the signal, and a broad distribution due to random pions creating a fake D^* tag.

The plots presented show a clear WS signal from the CDF data being used. The next step (outside the scope of this note) is to measure the time-dependent ratio, to investigate mixing.

II. BLESSED FIGURES

The following pages show the figures that have been blessed for the wrong-sign signal, including a short description.

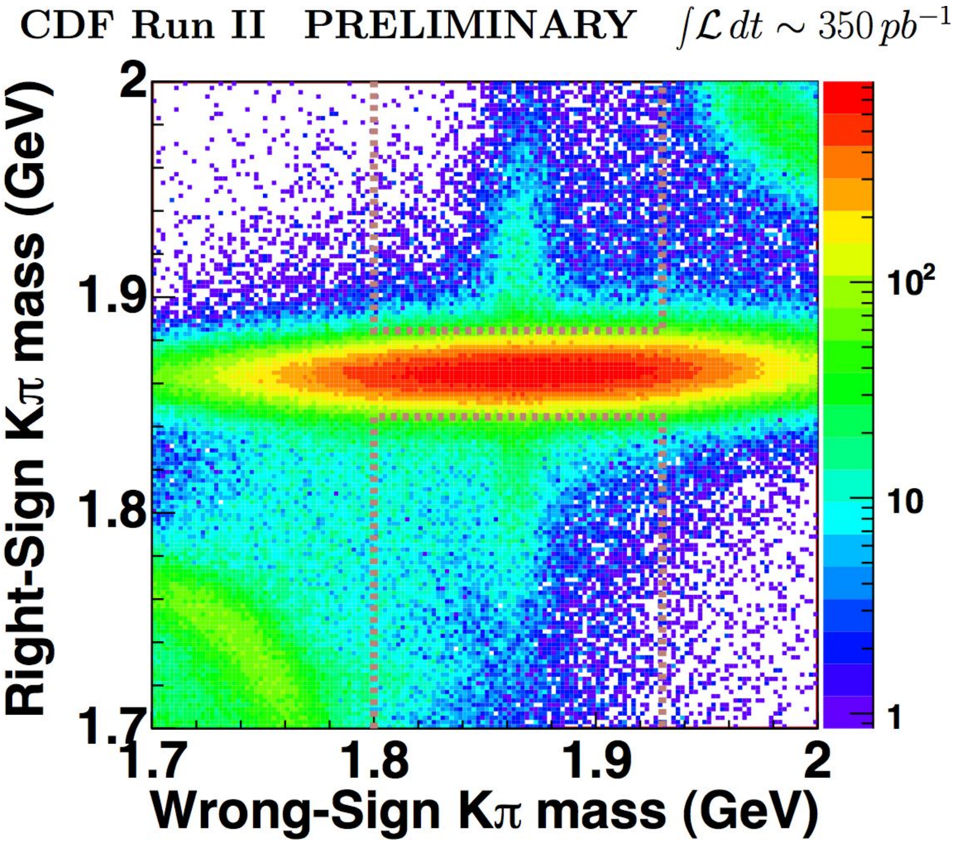

FIG. 1: $K\pi$ events plotted with both RS and WS mass interpretations.

The PDG mass for the D^0 is 1.8645 GeV. A cut requiring a good (WS) D* tag is used to reduce background. The bins are 3 MeV wide, along each axis. The regions enclosed by the dashed brown boxes are used to get the WS signal. The mass window (along the x-axis) is narrowed to prevent contamination from $D^0 \to KK, \pi\pi$ events that populate the upper right and lower left corners. The middle region is excluded to reduce background from RS D^0s.

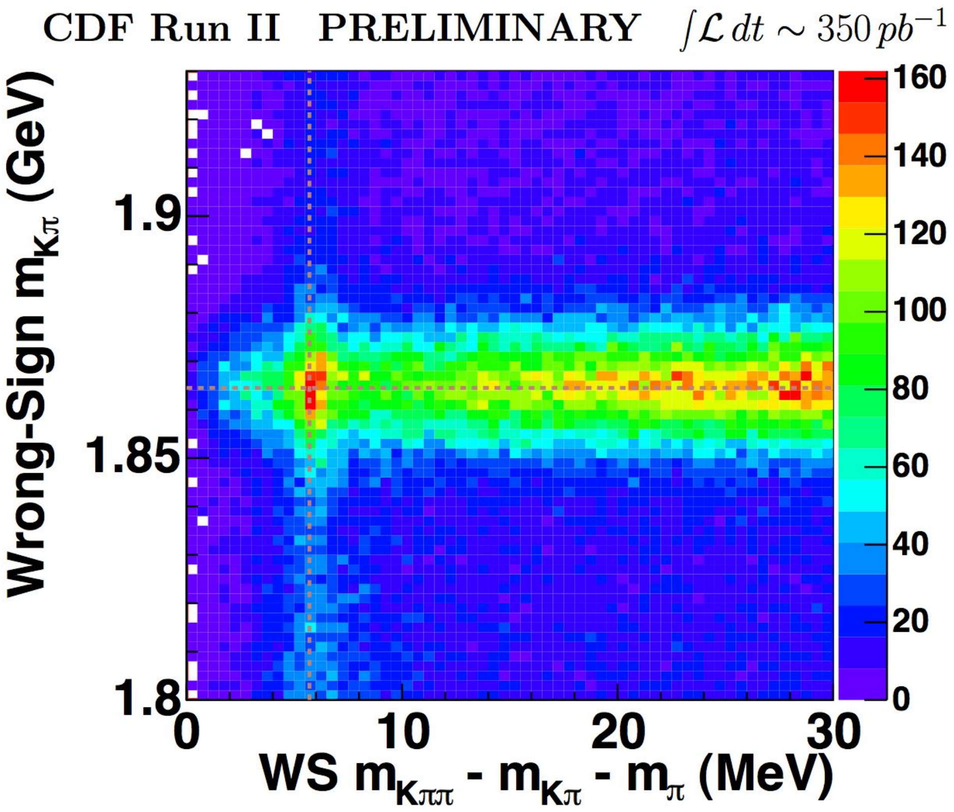

FIG. 2: WS $K\pi$ mass versus D^* Mass Difference

The PDG values for the D^0 and D^* are shown by the dashed lines. The $K\pi$ axis is in 2 MeV bins, the mass difference ($m_{K\pi\pi^*} - m_{K\pi} - m_\pi$) axis is 0.5 MeV bins. Events consistent with RS D^0s have been excluded. The background in the horizontal band are from real D^0s that are falsely tagged as WS D^*s due to an unassociated pion track being attached. The background in the vertical band are from real D^*s, where the D^0 does not decay to a kaon and a pion.

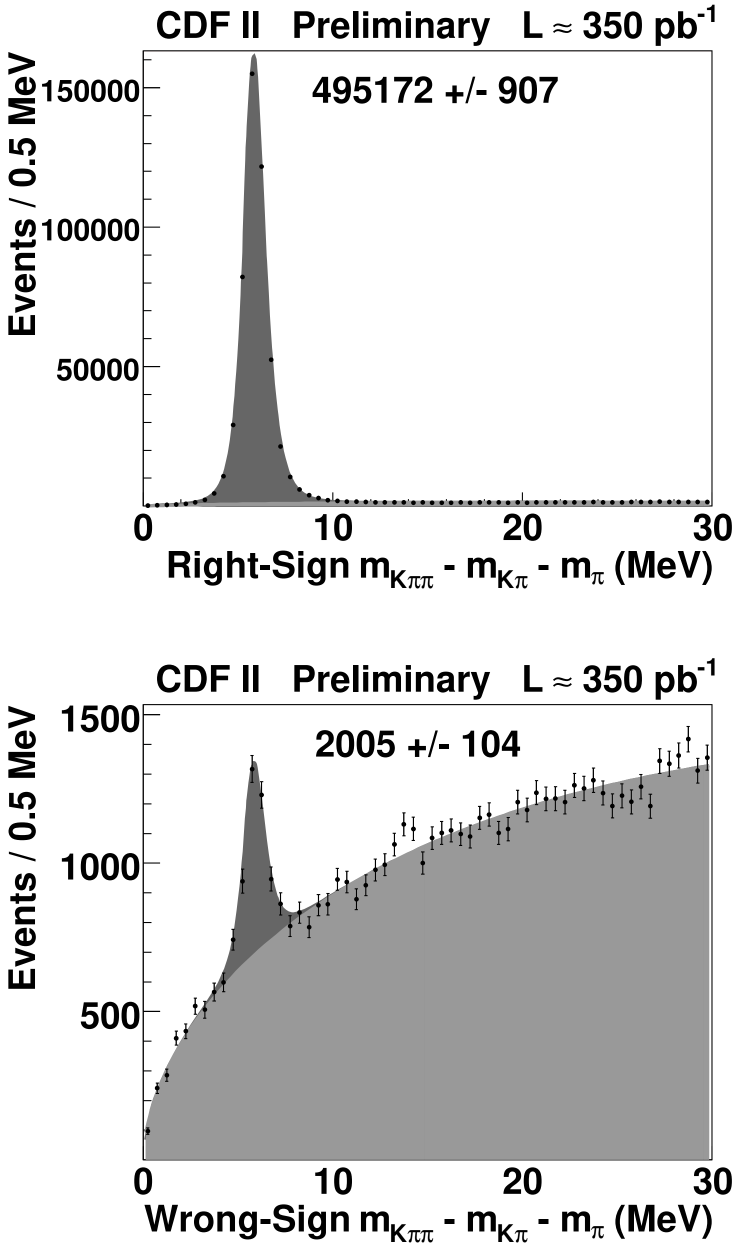

FIG. 3: D* yields for RS and WS events

The data is divided into slices of mass difference. For each slice, the $K\pi$ distribution is fit. The fit signal will give the number of real, correctly reconstructed D^0s. The signal yield for each slice is then plotted as a function of mass difference, with the error bars taken from the signal uncertainty of each slice. This leaves two possibilities: a real D^* (signal), or a D^0 with a fake tag (background). In the plots, dark grey is the signal fit, light grey is the background.

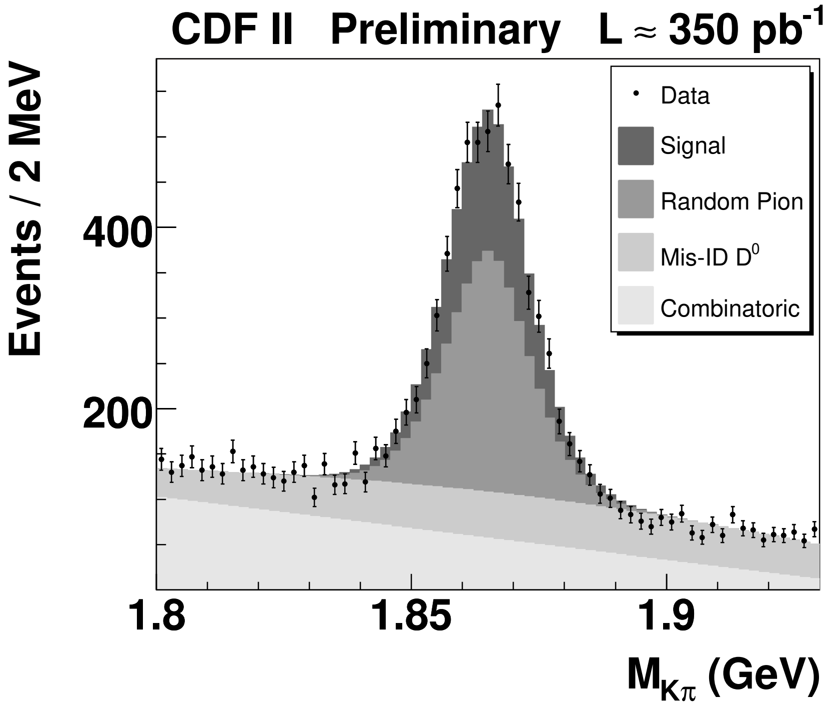

FIG. 4: WS $K\Pi$ Mass with Fit Projections

The distribution of WS $m_{K\pi}$ with the D^* mass difference required to be between 5-7 MeV. The data are the points with error bars. The results of the yield technique fit are projected onto this histogram. The projections are WS D^0 signal, D^0s with a fake D^* tag (random pion), RS D^*s with the kaon and pion assignments swapped (mis-ID D^0), and other backgrounds where either or both of the high-momentum tracks do not belong to $D^0 \to K\pi$ (combinatoric).

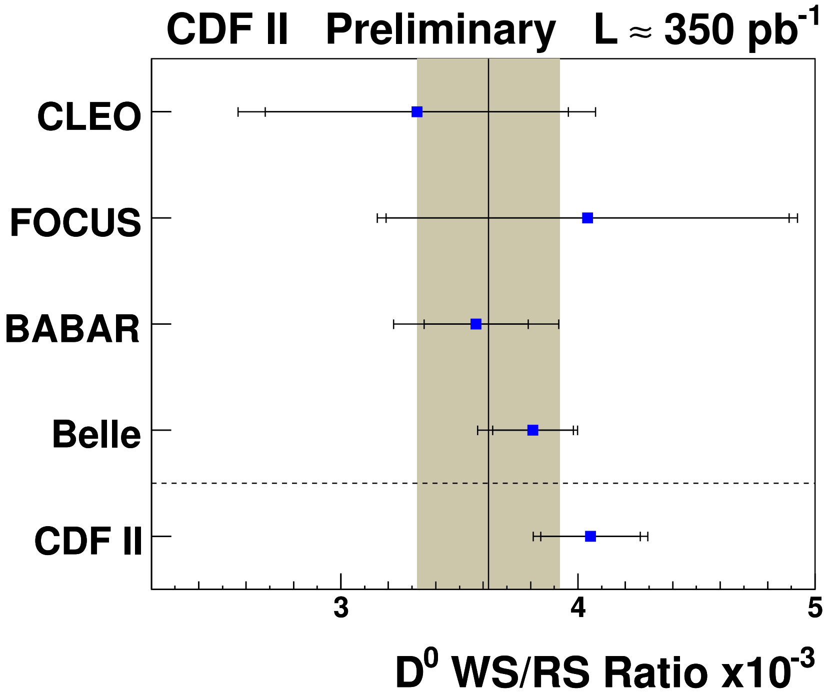

FIG. 5: WS/RS D^0 Ratio by Experiment

The time-integrated ratio of WS to RS D^0s by experiment. The inner error bars are statistical errors, the outer bars are statistical and systematic added in quadrature. The grey region is the PDG 2004 value, based on the decay fractions of the CF and DCS decay modes. The DCS decay fraction does not include the Belle 2004 result (but does include the E791 measurement, not included in this figure). The CDF II result has not been added to the PDG value.