Recent Semileptonic Physics Results from the FOCUS/E831 Experiments

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The FOCUS Spectrometer

- 1996-1997 Fixed Target Run at Fermilab.
- Successor to E687. Designed to study charm particles produced by ~180 GeV photons using a fixed target spectrometer.
- Member groups from USA, Italy, Brazil, Mexico, Korea.

The New S-Wave Interference in $D^+ \rightarrow K^-\pi^+\mu^+\nu$ Decays

- The $K^-\pi^+$ lineshape looks like 100% $K^*(890)$ in our sample, as has been seen for the last 20 years.
- However, we found an forward-backward asymmetry in cos$\theta$, below the $K^*$ pole, while almost none above the pole. → QM interference?

Adding an S-wave interference

- We tried a simple approach; adding a new constant amplitude $A \exp(i\delta)$ in the place where the $K^*$ couples to an $m=0$ $W^-$ with amplitude $H_1$.
- This assumes the $q^2$ dependence of the anomaly S-wave coupling is the same as the $K^*$ (could be challenged).

A 4-body decay requires 5 kinematic variables:
- $M_{Z^0}$
- $M_{\pi^+\mu^+\nu}$
- $q^2 = q^2 + q_{\mu}^2$
- $A \exp(i\delta)$
- $H_1$

A $\exp(i\delta)$ will produce 3 interference terms:

Studies of the acoplanarity-averaged interference

$+8 \cos \theta_3 \sin^2 \theta_3 A \Re(e^{-i\theta_3} B_{\nu}^2) B_{\nu}^2$ B_{\nu}^2$

- We extract this interference term by weighting data by cos$\theta$, Since all other $q^2$-averaged terms in the decay intensity are constant or cos$\theta$.$\nu$.
- For example, shown on the left is the dependence on $K^*$ mass.
- A constant $\theta^3$ phase works great...
- Other options also possible (details inside the bottom plot.)
- Asymmetry expected directly from LASS s-wave $K^+$ phase shift analysis gives a comparable result.
- A Kappa S-wave needs a 100 degree phase shift of its BW relative to the $K^*$ BW.

Form Factors of $D^+$ → $K^-\pi^+\mu^+\nu$

New FOCUS Results:

- $R_V = 1.504 \pm 0.057 \pm 0.039$
- $R_S = 0.875 \pm 0.049 \pm 0.064$
- The experimental $R_V$ value is getting smaller with the passing years. The new FOCUS Value is 2.5% below E791. We were consistent before charm background correction.
- Apart from E691 the $R_V$ values have been pretty consistent.

Latest form factor calculation by Damir Bacirevic (ICHEP02)

- $R_V = 1.55 \pm 0.11$
- which is remarkably close to $R_V = 1.555 \pm 0.065$ (FOCUS)

BR ($D^+ \rightarrow K^*\mu^+\nu$ / $D^+ \rightarrow K^-\pi^+$)

FOCUS

$\Gamma(D^+ \rightarrow K^*\mu^+\nu) / \Gamma(D^+ \rightarrow K^-\pi^+\nu) = 0.602 \pm 0.010\,\text{(stat)} \pm 0.021\,\text{(sys)}$

- Based on 11,698 $K^*\mu^+\nu$ events and 65,421 $K^-\pi^+$ events
- Correction factor applied to subtract S-wave interference contribution.
- Our number, the only one to consider an S-wave contribution explicitly, is 1.6 to below CLEO and 2.1$

- $K^*$ events

BR ($D_s^+ \rightarrow \phi\mu^+\nu / D_s^+ \rightarrow \phi \pi^+$)

FOCUS

$\Gamma(D_s^+ \rightarrow \phi\mu^+\nu / D_s^+ \rightarrow \phi \pi^+) = 0.54 \pm 0.04$

- Consistent results between experiments.

Future

- Both muon and electron channels of the semileptonic decays are being exploited.
- Our preliminary result on the $K^*$ lineshape is clean and competitive, and consistent with the S-wave analysis shown on the left column.
- Search for S-wave interference phenomena in other semileptonic channels: $D^+_s \rightarrow \phi\nu$, $D^+ \rightarrow \rho\nu$
- Branching Ratios and Form Factor measurements in other decay modes.
- Rare Decay Channels.