Recent Semileptonic Physics Results from the FOCUS/E831 Experiments

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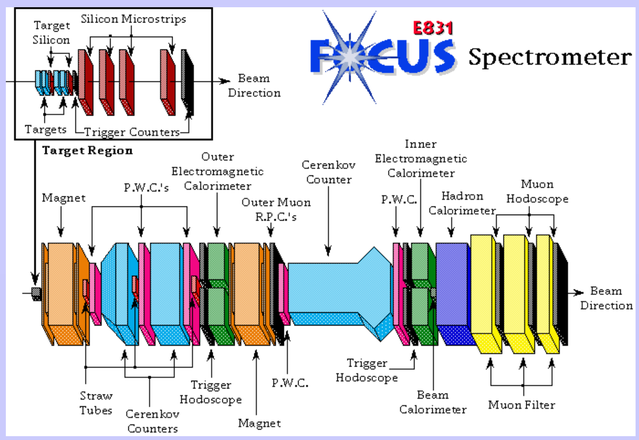
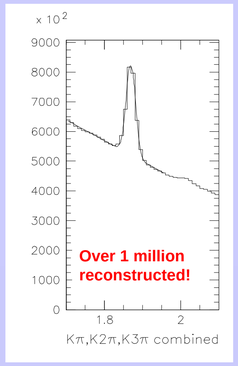
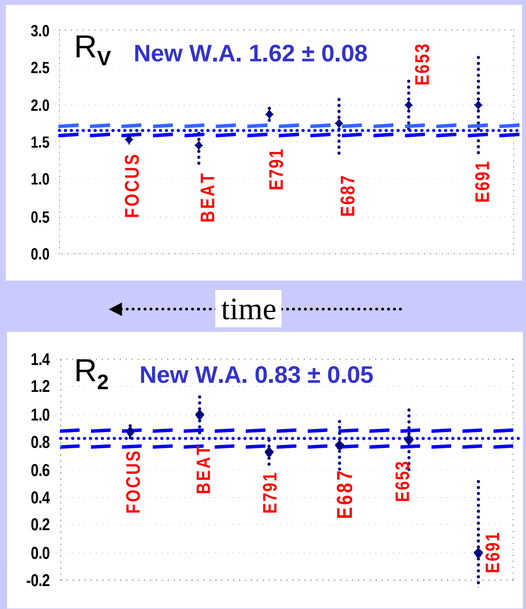
The FOCUS Spectrometer





- **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.**

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



New FOCUS Results:

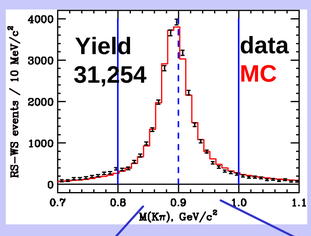
$R_V = 1.504 \pm 0.057 \pm 0.039$

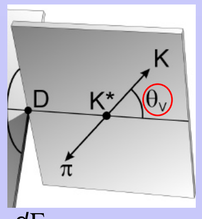
$R_2 = 0.875 \pm 0.049 \pm 0.064$

- **The experimental R_V value is getting smaller with the passing years. The new Focus Value is 2.9 s below E791. We were consistent before charm background correction.**
- **Apart from E691 the R_2 values have been pretty consistent.**

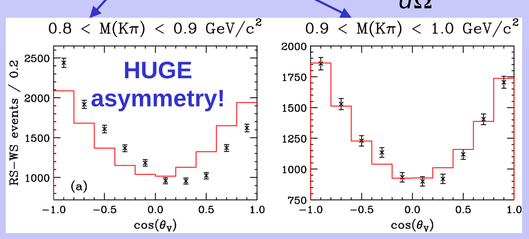
Latest form factor calculation by Damir Becirevic (ICHEP02)
R_V = 1.55 ± 0.11
which is remarkably close to
R_V = 1.504 ± 0.069 (FOCUS)

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





$$\frac{d\Gamma}{d\Omega} \propto 1 + a\cos^2 q_V$$



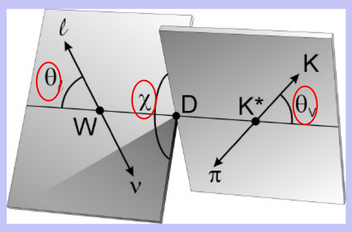
- The $K^-\pi^+$ lineshape looks like 100% K*(890) in our sample, as has been seen for the last 20 years.
- However, we found an forward-backward asymmetry in $\cos\theta_V$ below the K* pole, while almost none above the pole. → QM interference?

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_0.
- 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:

- $M_{K\pi}$
- M_W^2 ◦ q^2 ◦ t



$$|M|^2 \propto (t - m_m^2)\left|\frac{(1+\cos q_l)}{2}\frac{\sin q_V}{\sqrt{2}}e^{ic}BH_+ + \frac{(1-\cos q_l)}{2}\frac{-\sin q_V}{\sqrt{2}}e^{-ic}BH_- + \frac{-\sin q_l}{\sqrt{2}}(\cos q_V B + Ae^{id})H_0\right|^2$$

A exp(id) will produce 3 interference terms

where $B \equiv \frac{\sqrt{m_o\Gamma}}{m^2 - m_0^2 + im_0\Gamma}$

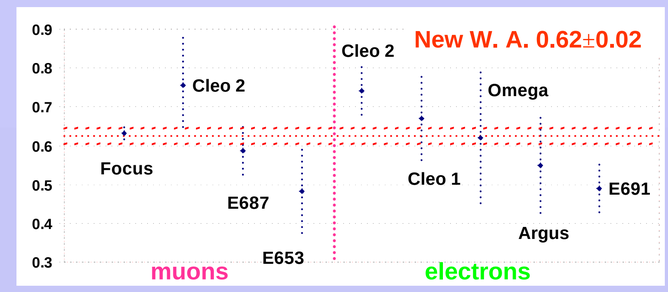
BR ($D^+ \to \bar{K}^{*0}\mu^+\nu$ / $D^+ \to K^-\pi^+\pi^+$)

FOCUS

$$\frac{\Gamma(D^+ \to \overline{K}^{*0}\mu^+\nu)}{\Gamma(D^+ \to K^-\pi^+\pi^+)} = 0.602 \pm 0.010\ (\text{stat}) \pm 0.021\ (\text{sys})$$

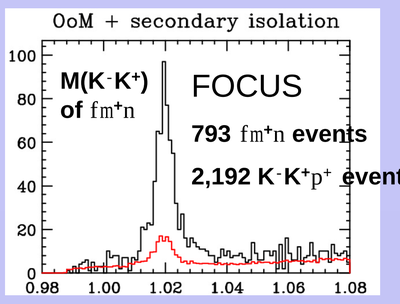
$$f_{K\star} \equiv \frac{\int d\text{LIPS}\ |\mathcal{M}(r_v, r_2, A=0)|^2}{\int d\text{LIPS}\ |\mathcal{M}(r_v, r_2, A=0.36)|^2} = 0.945$$ **correction factor**

- **Based on 11,698 $K^-p^+m^+n$ events and 65,421 $K^-p^+p^+$ 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 s below CLEO and 2.1 s above E691.**



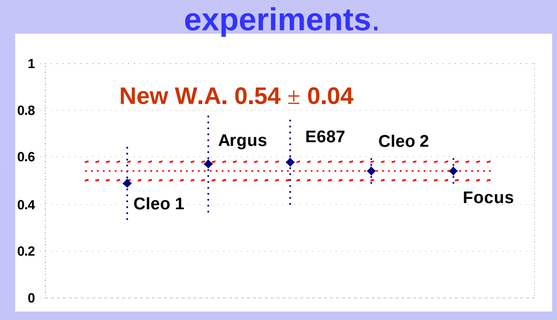
All muon results multiplied by 1.05 to be compared to the electron results.

BR ($D_s^+ \to f\mu^+\nu$ / $D_s^+ \to f\pi^+$)



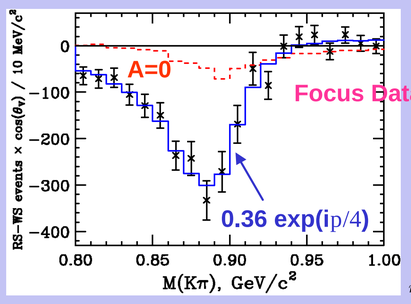
	br	stat	sys	stat+sys
Cleo 1	0.49	0.1	0.12	0.156
Argus	0.57	0.15	0.15	0.212
E687	0.58	0.17	0.07	0.184
Cleo 2	0.54	0.05	0.04	0.064
Focus	0.540	0.033	0.048	0.058

Consistent results between experiments.



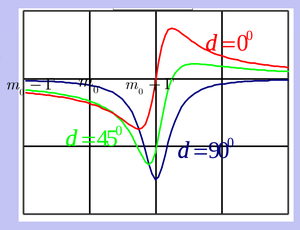
This branching ratio is traditionally used to set the scale for D_s^+ branching fractions by assumptions such as:

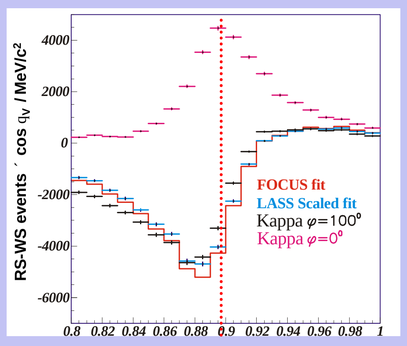
$$\Gamma(fmn) = (0.8 \to 1.0) \times \Gamma(\dot{\bar{K}}^* mn)$$



$\mathrm{Re}(e^{-id} B_{K^*})$

..looks just like the analytic calculation..





Simulation of Various Scenarios

M(Kp), GeV/c², cos q_V weighted

Studies of the acoplanarity-averaged interference

$$+8\cos q_V \sin^2 q_V A\,\mathrm{Re}(e^{-id} B_{K^*})H_0^2$$

- **We extract this interference term by weighting data by $\cos q_V$,**
- **Since all other c-averaged terms in the decay intensity are constant or $\cos^2 q_V$.**
- **For example, shown on the left is the dependence on Kp mass.**
- **A constant 45^0 phase works great...**
- **...other options also possible (details inside the bottom plot.)**
- **Asymmetry expected directly from LASS s-wave K p 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.**

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: $D_s^+ \to fl^+\nu$, $D^+ \to \rho l^+\nu$
- Branching Ratios and Form Factor measurements in other decay modes.
- Rare Decay Channels.

Preliminary $K^{*0}(\to K^-\pi^+)$ lineshape study based on $D^+ \to K^-\pi^+\mu^+\nu$ decays