Recent CLEO Charm Meson and Baryon Results

Jim Napolitano (RPI & Cornell)

We will discuss the following results:

1) First Observation of $D^0 \rightarrow K^0_S \eta \pi^0$
   Branching Ratio and Dalitz Plot Structure

2) Form factors in $D^0 \rightarrow \{\pi^-, K^-\}e^+\nu$
   First measurement of $D^0 \rightarrow \pi^-e^+\nu_e$ Form Factor

3) Measurement of $\Xi^0_c \rightarrow pK^-K^-\pi^+$
   Color-Suppressed Diagrams in $\Xi^0_c$ Decay

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1) First Observation of $D^0 \rightarrow K_S^0 \eta \pi^0$

CLEO-II.V analysis to be submitted to Phys.Rev.Lett.

Little is known about $D^0$ decays including $\eta$:

PDG 2002: $\mathcal{B}(D^0 \rightarrow \eta X) < 13\%$ @90\% CL

$K_S^0 \eta \pi^0$ is a $CP = +1$ eigenstate with potential resonant substructures. For example:

- $D^0 \rightarrow \bar{K}^* (892) \eta$
- $D^0 \rightarrow K_S^0 a_0^0 (980)$
- Others?

Underlying scalar mesons in $D$ decay are still controversial

$a_0 (980), f_0 (980), "\sigma", "\kappa", \ldots$
Selection of $D^0$ from $D^{*+} \rightarrow \pi^+ D^0$

Example: $D^0 \rightarrow K^0_S \pi^0$ ("Calibration" mode)

$$\Rightarrow \text{Use } Q \equiv M(\pi^+_{\text{slow}} K_S \pi^0) - M(K_S \pi^0) - m_\pi$$
Observation of $D^0 \to K^0_S\eta\pi^0$

\[
\frac{\mathcal{B}(D^0 \to K^0_S\eta\pi^0)}{\mathcal{B}(D^0 \to K^0_S\pi^0)} = 0.46 \pm 0.07 \pm 0.06
\]

\[\Rightarrow \mathcal{B}(D^0 \to \bar{K}^0\eta\pi^0) = (1.05 \pm 0.16 \pm 0.14 \pm 0.10)\%
\]
Dalitz Plot for $D^0 \rightarrow K_S^0 \eta \pi^0$

Tighter cuts than for branching ratio measurement

Substructure is dominated by $K^*(892)$ and $a_0(980)$

Interference!
- Deficit in center
- $a_0(980)$ asymmetry
- Shift(?) in $K^*(892)$
Fit Dalitz Plot for Amplitudes

Unbinned maximum likelihood fit to Breit-Wigner shapes

\[ \mathcal{F}\mathcal{F}(D^0 \rightarrow K^*(892)\eta) = 0.293 \pm 0.062 \pm 0.029 \pm 0.019 \]
\[ \mathcal{F}\mathcal{F}(D^0 \rightarrow a_0(980)K_S) = 1.19 \pm 0.09 \pm 0.20 \pm 0.16 \]
\[ \mathcal{F}\mathcal{F}(D^0 \rightarrow \text{Other}) = 0.246 \pm 0.092 \pm 0.025 \pm 0.087 \]
2) Form Factors in $D^0 \rightarrow \{\pi^-, K^-\}e^+\nu$

New CLEO-III analysis to be published soon.

For $q^\mu \equiv p^\mu(W^+)$ have

$$\frac{d\Gamma}{dq^2} = \frac{G^2}{24\pi^3} |V_{cq}|^2 p^3 |\mathcal{F}(q^2)|^2$$

Note: First measurement of $D \rightarrow \pi\nu$ form factor shape!

Plus: New result for $\mathcal{B}(D^0 \rightarrow \pi\nu) / \mathcal{B}(D^0 \rightarrow K\nu)$
Reconstruct $D^0$ using $p_{\nu} = p_{\text{missing}}$ and subject to the constraint that $M(\{K^-, \pi^-\}e^+\nu) = M(D^0)$.

Use $\Delta M \equiv M(\pi_{\text{slow}}D) - M(D)$

$\Rightarrow$ The challenge for $D \rightarrow \pi e\nu$ is significant!
$D^0 \rightarrow \pi^- e^+ \nu_e$ Normalized $q^2$ Distribution

*Preliminary! Paper will be submitted shortly.*

**Form factor models**

Results are consistent with form factor models, but not quite enough sensitivity to distinguish them.
We find \[
\frac{\mathcal{B}(D^0 \rightarrow \pi e\nu)}{\mathcal{B}(D^0 \rightarrow K e\nu)} = 0.097 \pm 0.010 \pm 0.010
\]

Systematic error dominated by three sources:

1) Neutrino reconstruction simulation (\(\sim 3\%\))

2) Misidentification of kaons as pions (\(\sim 4\%\))

3) Uncertainty in background branching fractions (\(\sim 4\%\))
CLEO-c event: $e^+e^- \rightarrow \psi''(3770) \rightarrow D^0\bar{D}^0$

$D^0 \rightarrow K^-e^+\nu_e \quad \bar{D}^0 \rightarrow K^+\pi^-$
3) Measurement of $\Xi^0_c \rightarrow pK^-\bar{K}^-(892)^0$  


Physics: The decay $\Xi^0_c \rightarrow pK^-\bar{K}^-(892)^0$ cannot proceed through external $W$ decay, so it is “color suppressed”.  
$\Rightarrow$ Want to separate it from nonresonant four-body decays.

Measured $\Xi^0_c \rightarrow pK^-K^-\pi^+$ rate relative to $\Xi^0_c \rightarrow \Xi^-\pi^+$

Needs extensive $p, K, \pi$ particle identification made possible by RICH in CLEO-III

Only previous result: ACCMOR 1990 (four events, all $\bar{K}^*$)
Final State Particles and Weak Decay Diagrams

**External $W^+$**

...or $sds \rightarrow K^- p K^-$, etc

⇒ Absence of a $\pi^+$ (or $K^+$) implies that the decay proceeds through an internal $W^+$ line, and these should be color-suppressed.
Results: $\Xi^0_c$ Decay

$\Xi^0_c$ Decay modes

$\Xi^0_c \rightarrow pK^-K^-\pi^+$

$K^-\pi^+$ mass:

\[ \mathcal{B}(\Xi^0_c \rightarrow pK^-K^-\pi^+)/\mathcal{B}(\Xi^0_c \rightarrow \Xi^-\pi^+) = 0.35 \pm 0.06 \pm 0.03 \]

\[ \mathcal{B}(\Xi^0_c \rightarrow pK^-K^-\pi^+; \text{No } \bar{K}^*)/\mathcal{B}(\Xi^0_c \rightarrow \Xi^-\pi^+) = 0.21 \pm 0.04 \pm 0.02 \]
Summary

• CLEO still produces results from high energy data sets
  Several publications are on the way.
  See also Vladimir Savinov, this conference.

• Some first observations are presented here
  
  - $D^0 \rightarrow K^0_S \eta \pi^0$ including $D^0 \rightarrow K^0_S a_0(980)$
  - Form factor shape for $D^0 \rightarrow \pi^- e^+\nu$
  - $\Xi^0_c \rightarrow pK^- K^- \pi^+$; No $\bar{K}^*$

• Stay tuned for new charm results from CLEO-c
  See also Alex Smith, this conference.