Rensselaer

CORNELL UNIVERSITY LEPP
LABORATORY FOR ELEMENTARY-PARTICLE PHYSICS

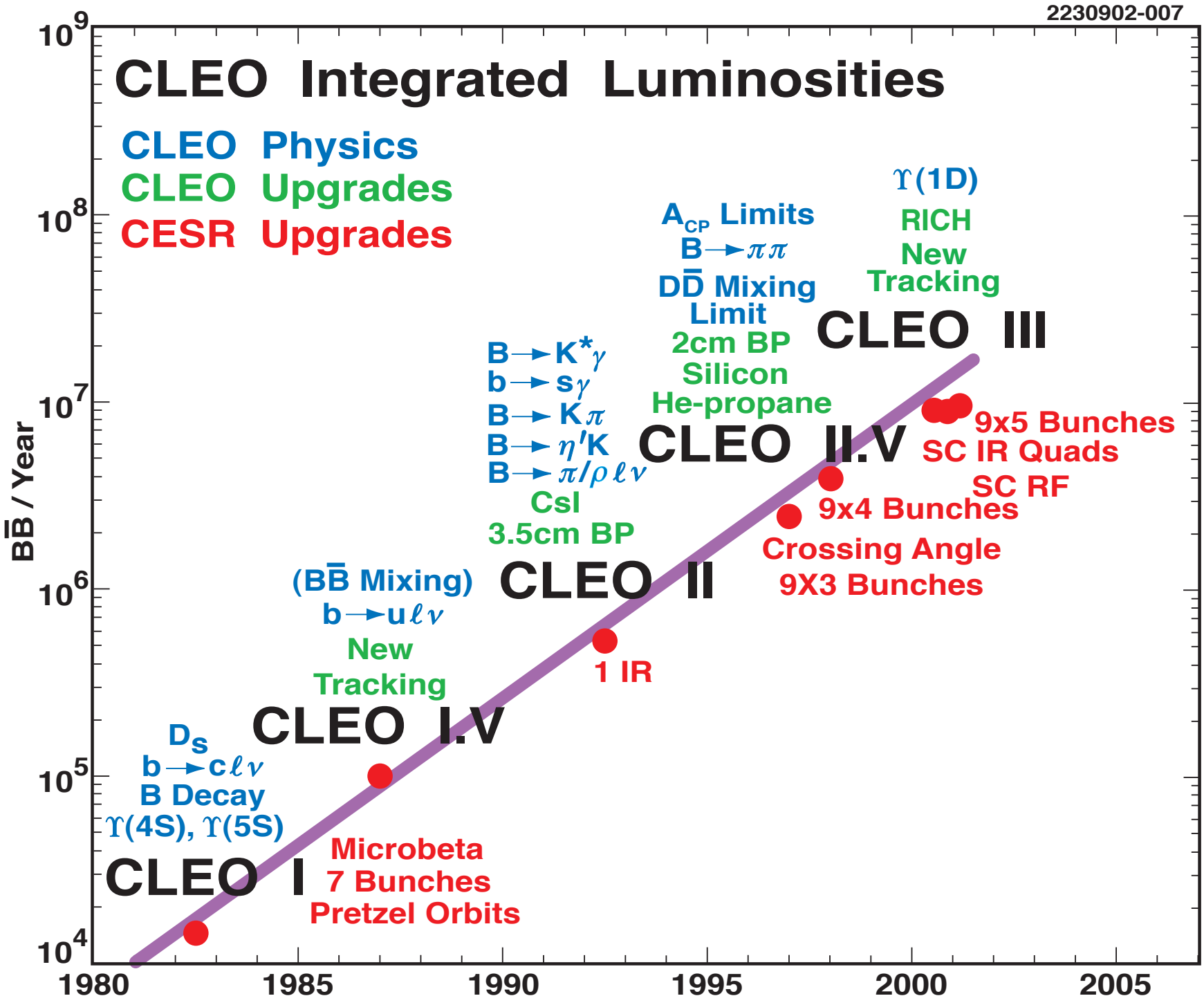
Recent CLEO Charm Meson and Baryon Results

Jim Napolitano (RPI & Cornell)

We will discuss the following results:

1) First Observation of $D^0 \to K^0_S \eta \pi^0$
   Branching Ratio and Dalitz Plot Structure
2) Form factors in $D^0 \to \{\pi^-, K^-\} e^+ \nu$
   First measurement of $D^0 \to \pi^- e^+ \nu_e$ *Form Factor*
3) Measurement of $\Xi_c^0 \to p K^- K^- \pi^+$
   Color-Suppressed Diagrams in Ξ_c^0 *Decay*

2004 Phenomenology Symposium
University of Wisconsin, Madison
26-28 April, 2004


2230902-007
CLEO Integrated Luminosities
CLEO Physics
CLEO Upgrades
CESR Upgrades
$B\bar{B}$ / Year
10^9
10^8
10^7
10^6
10^5
10^4
1980
1985
1990
1995
2000
2005
CLEO I
D_s
$b \to c \ell \nu$
B Decay
$\Upsilon(4S)$, $\Upsilon(5S)$
Microbeta
7 Bunches
Pretzel Orbits
CLEO I.V
$(B\bar{B}$ Mixing)
$b \to u \ell \nu$
New
Tracking
CLEO II
1 IR
$B \to K^* \gamma$
$b \to s \gamma$
$B \to K \pi$
$B \to \eta' K$
$B \to \pi / \rho \ell \nu$
CsI
3.5cm BP
CLEO II.V
A_{CP} Limits
$B \to \pi\pi$
$D\bar{D}$ Mixing
Limit
2cm BP
Silicon
He-propane
9x4 Bunches
Crossing Angle
9X3 Bunches
CLEO III
$\Upsilon(1D)$
RICH
New
Tracking
9x5 Bunches
SC IR Quads
SC RF

1) First Observation of $D^0 \to K^0_S\eta\pi^0$

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

Little is known about D^0 decays including η:

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

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

- $D^0 \to \bar{K}^{\star 0}(892)\eta$
- $D^0 \to K^0_S a^0_0(980)$
- Others?

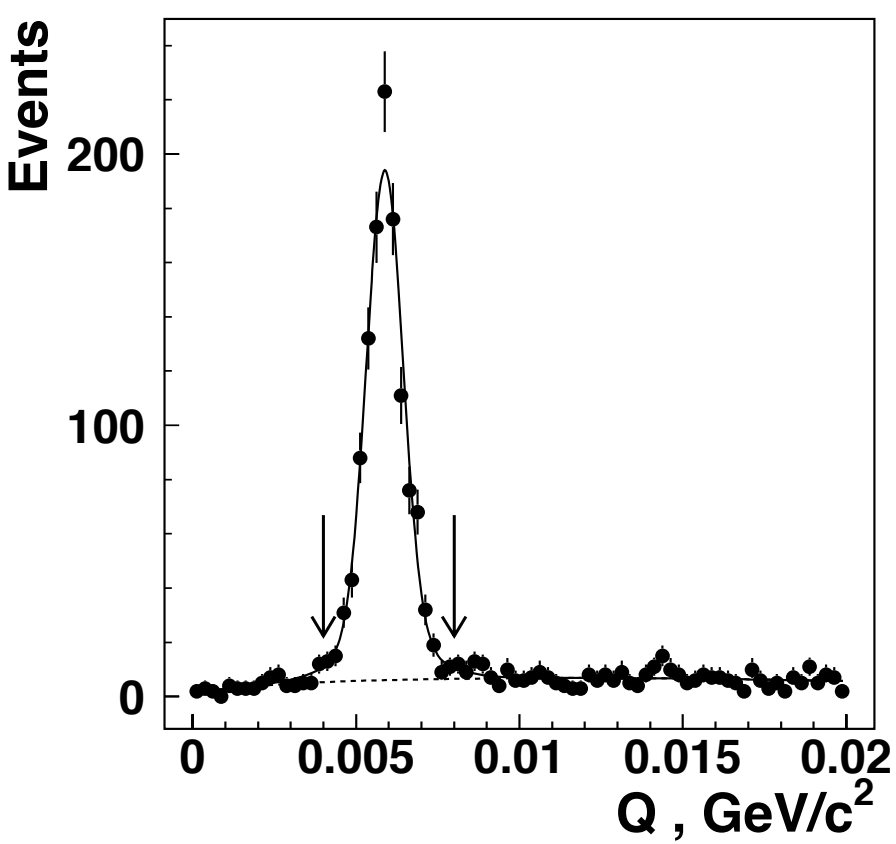
Underlying scalar mesons in D decay are still controversial

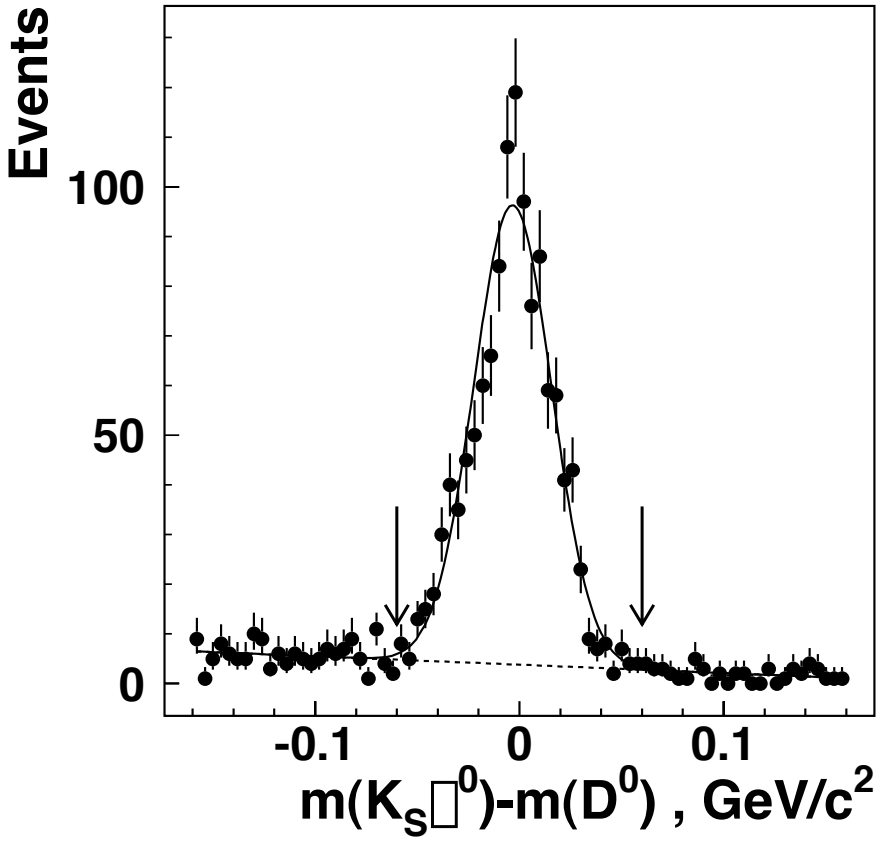
$a_0(980)$, $f_0(980)$, "σ", "κ", ...

Selection of D^0 from $D^{\star+} \to \pi^+_{\rm slow} D^0$

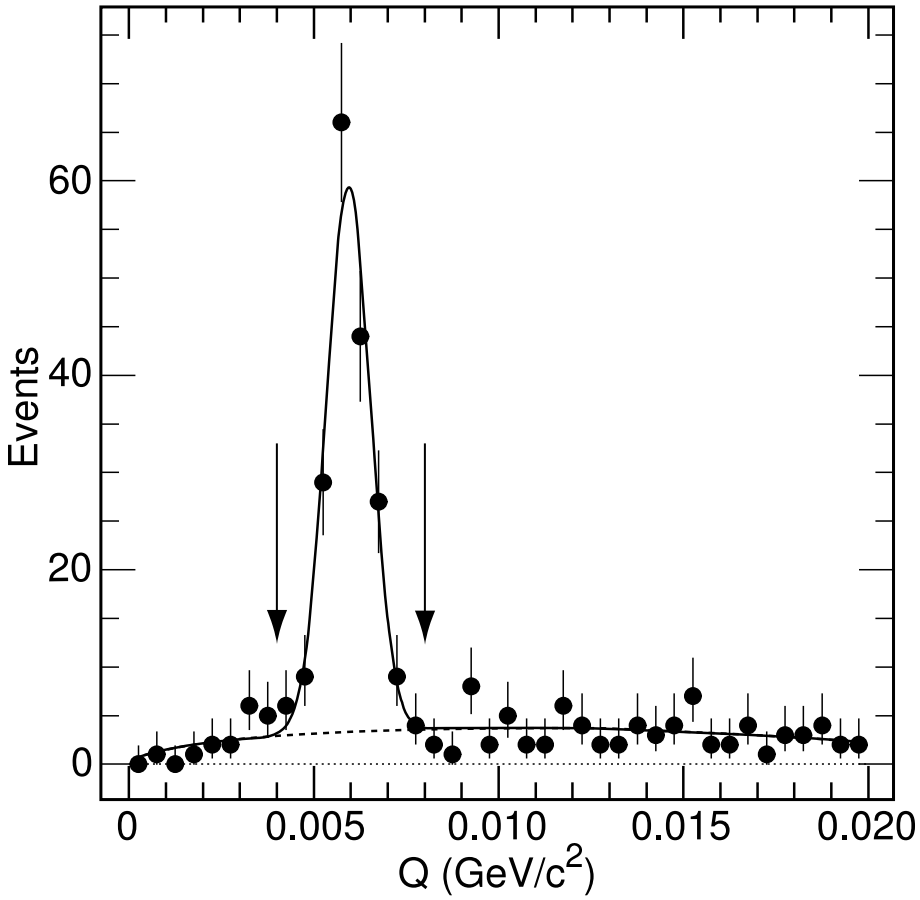
Example: $D^0 \to K^0_S \pi^0$ ("Calibration" mode)

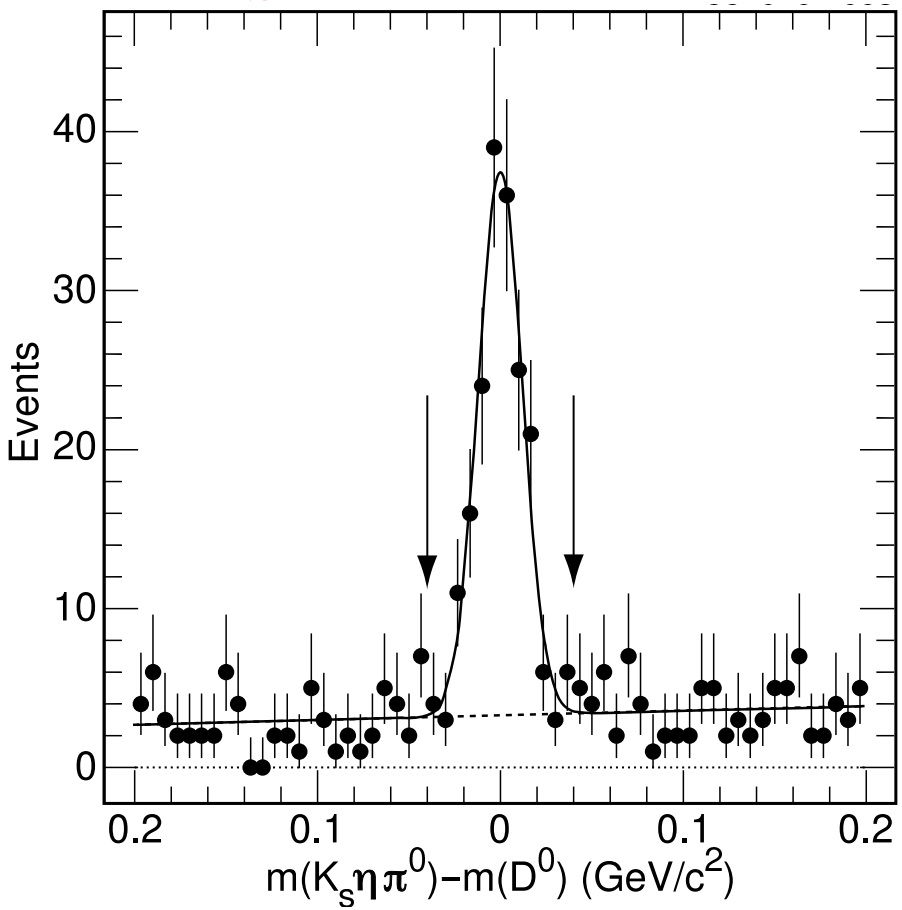
$\Rightarrow$ Use $Q \equiv M(\pi^+_{\rm slow} K_S \pi^0) - M(K_S \pi^0) - m_\pi$





Observation of $D^0 \to K^0_S \eta \pi^0$



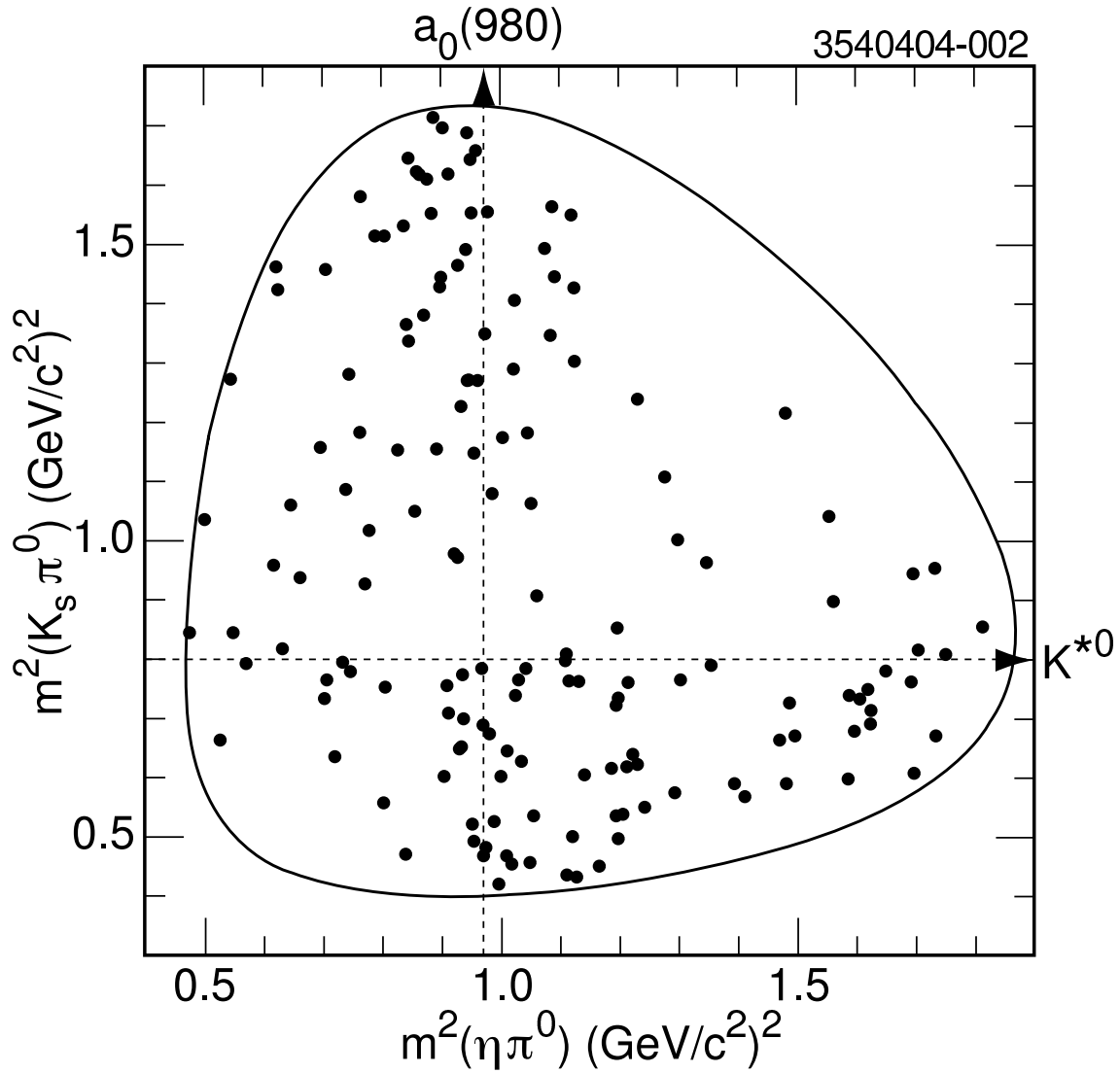


$$\frac{\mathcal{B}(D^0 \to K^0_S \eta \pi^0)}{\mathcal{B}(D^0 \to K^0_S \pi^0)} = 0.46 \pm 0.07 \pm 0.06$$

$$\Rightarrow \mathcal{B}(D^0 \to \bar{K}^0 \eta \pi^0) = (1.05 \pm 0.16 \pm 0.14 \pm 0.10)\%$$

Dalitz Plot for $D^0 \to K^0_S \eta \pi^0$

Tighter cuts than for branching ratio measurement



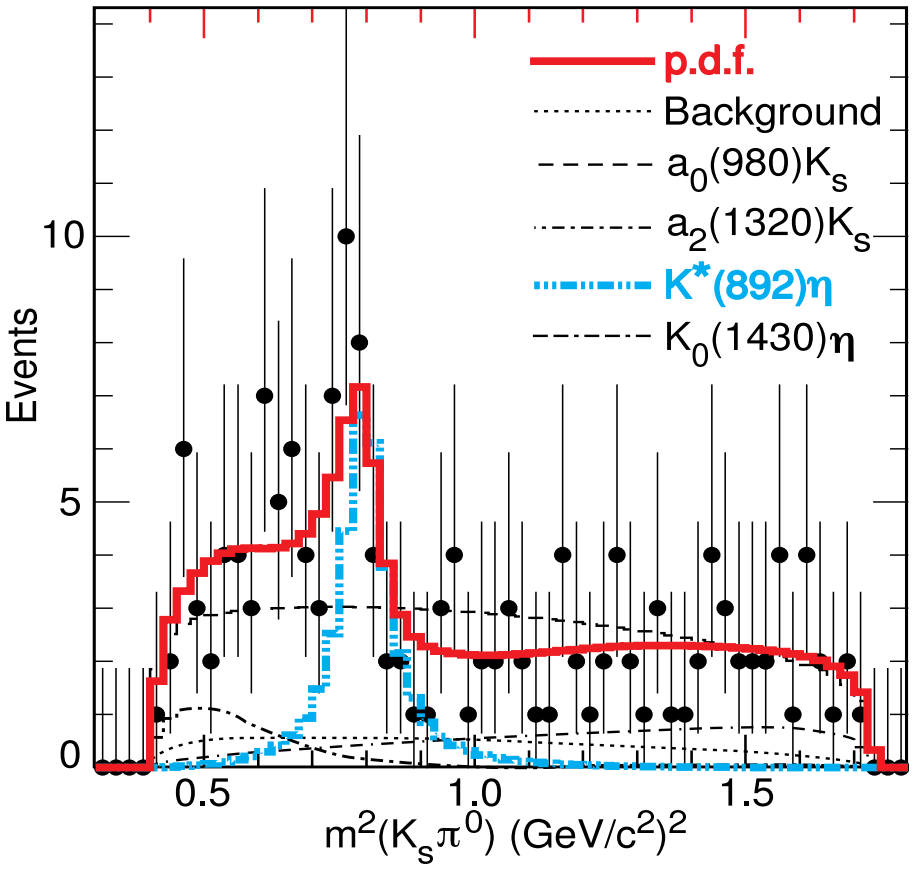
Substructure is dominated by $K^\star(892)$ and $a_0(980)$

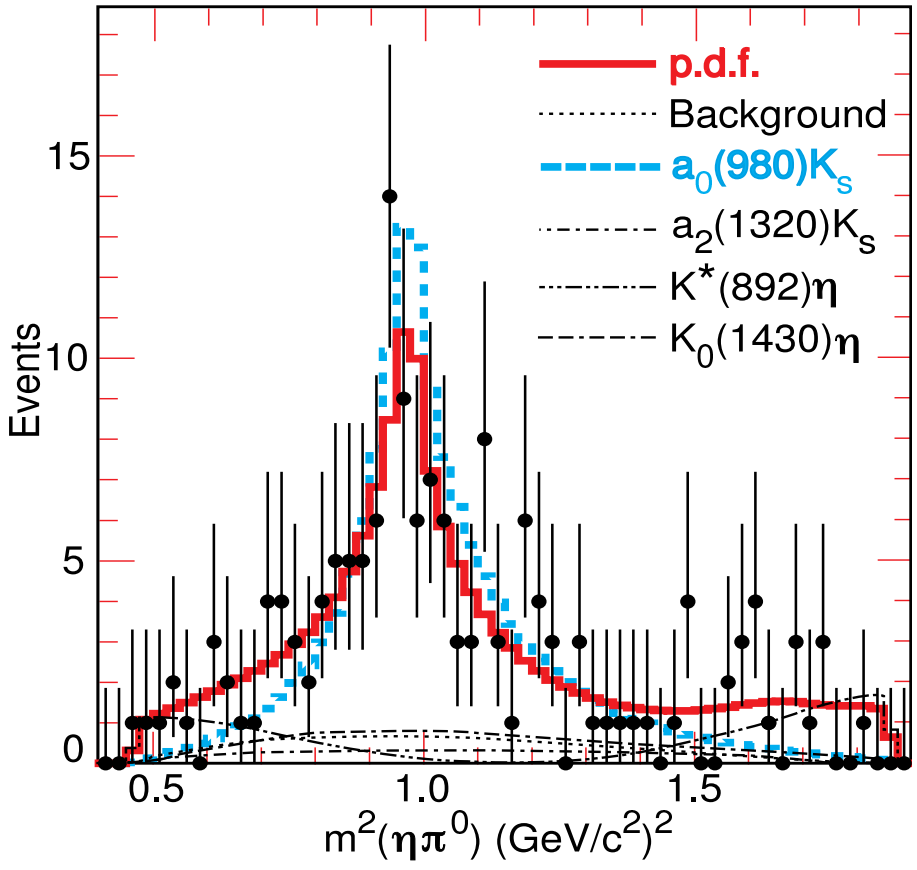
Interference!

- **Deficit in center**
- **$a_0(980)$ asymmetry**
- **Shift(?) in $K^\star(892)$**

Fit Dalitz Plot for Amplitudes

Unbinned maximum likelihood fit to Breit-Wigner shapes

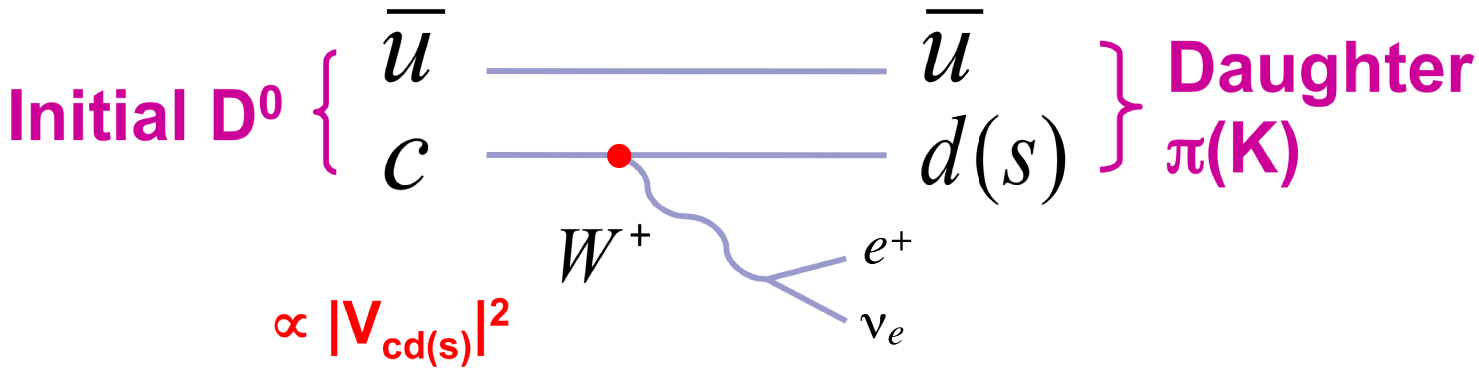




$$\mathcal{FF}(D^0 \to K^\star(892)\eta) = 0.293 \pm 0.062 \pm 0.029 \pm 0.019$$
$$\mathcal{FF}(D^0 \to a_0(980)K_S) = 1.19 \pm 0.09 \pm 0.20 \pm 0.16$$
$$\mathcal{FF}(D^0 \to \text{Other}) = 0.246 \pm 0.092 \pm 0.025 \pm 0.087$$

2) Form Factors in $D^0 \to \{\pi^-, K^-\} e^+ \nu$

New CLEO-III analysis to be published soon.



For $q^\mu \equiv p^\mu(W^+)$ have $\dfrac{d\Gamma}{dq^2} = \dfrac{G^2}{24\pi^3} |V_{cq}|^2 \, p^3 \, |\mathcal{F}(q^2)|^2$

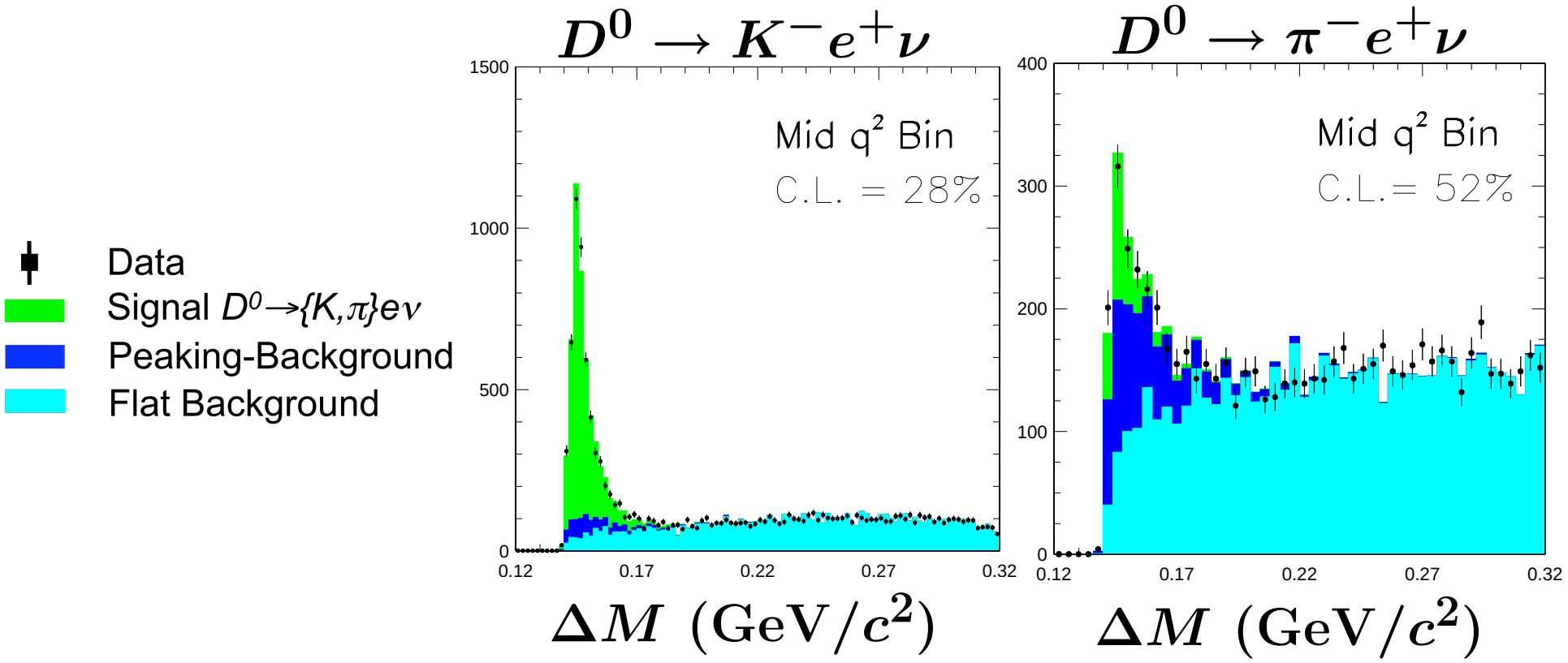
Note: First measurement of $D \to \pi e \nu$ form factor shape!

Plus: New result for $\mathcal{B}(D^0 \to \pi e \nu)/\mathcal{B}(D^0 \to K e \nu)$

Signal and Background in CLEO-III

Reconstruct D^0 using $p_\nu = p_{\rm missing}$ and subject to the constraint that $M(\{K^-, \pi^-\}e^+\nu) = M(D^0)$.

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

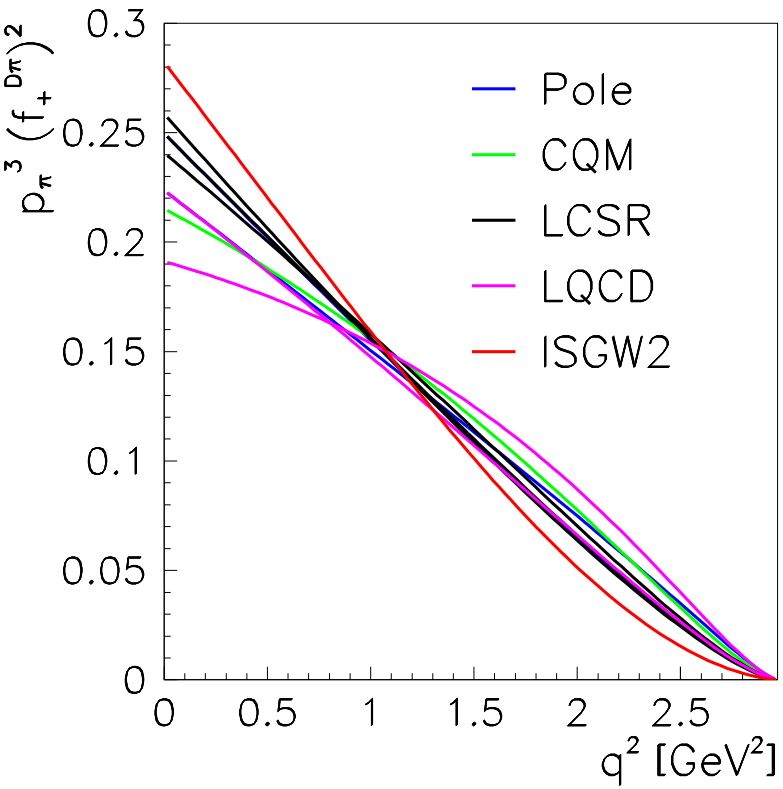


$\Rightarrow$ The challenge for $D \to \pi e\nu$ is significant!

$D^0 \to \pi^- e^+ \nu_e$ Normalized q^2 Distribution

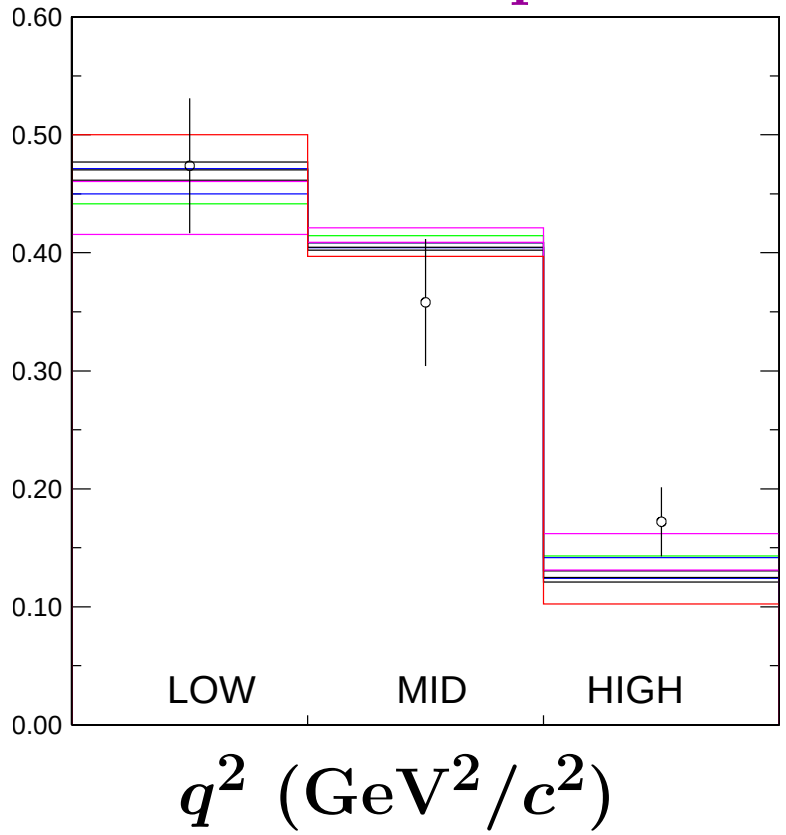
Preliminary! Paper will be submitted shortly.

Form factor models



Binned data points

$$\frac{1}{\Gamma}\frac{d\Gamma}{dq^2} \times \text{Effic.}$$

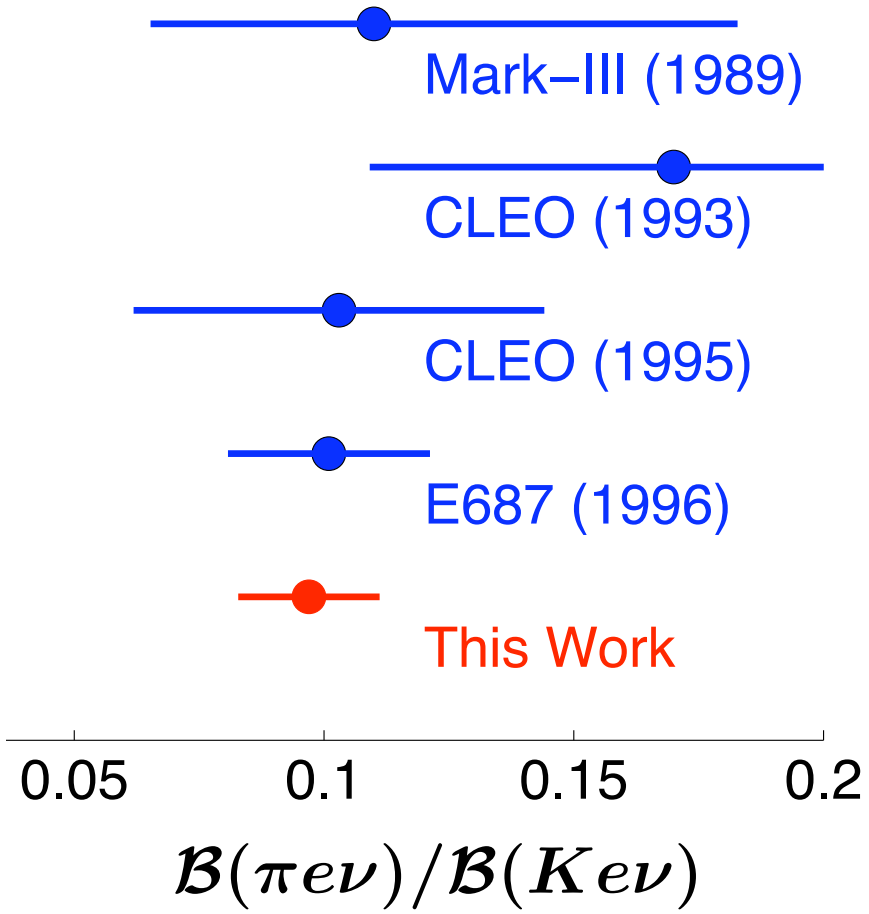


Results are consistent with form factor models, but not quite enough sensitivity to distinguish them.

Relative Semileptonic Branching Ratio

Preliminary! Paper will be submitted shortly.

We find $$\frac{\mathcal{B}(D^0 \to \pi e \nu)}{\mathcal{B}(D^0 \to K e \nu)} = 0.097 \pm 0.010 \pm 0.010$$

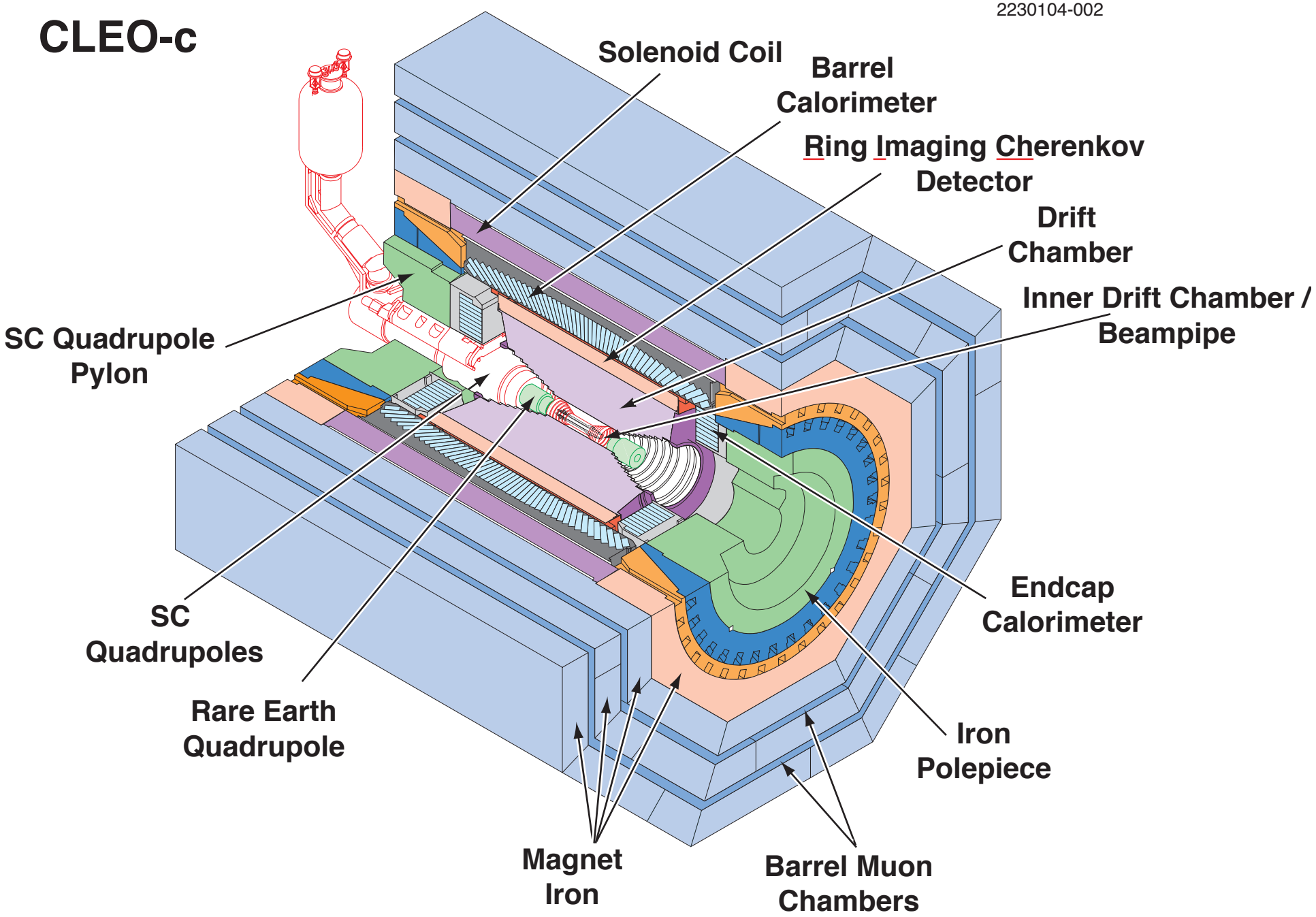


Systematic error dominated by three sources:

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

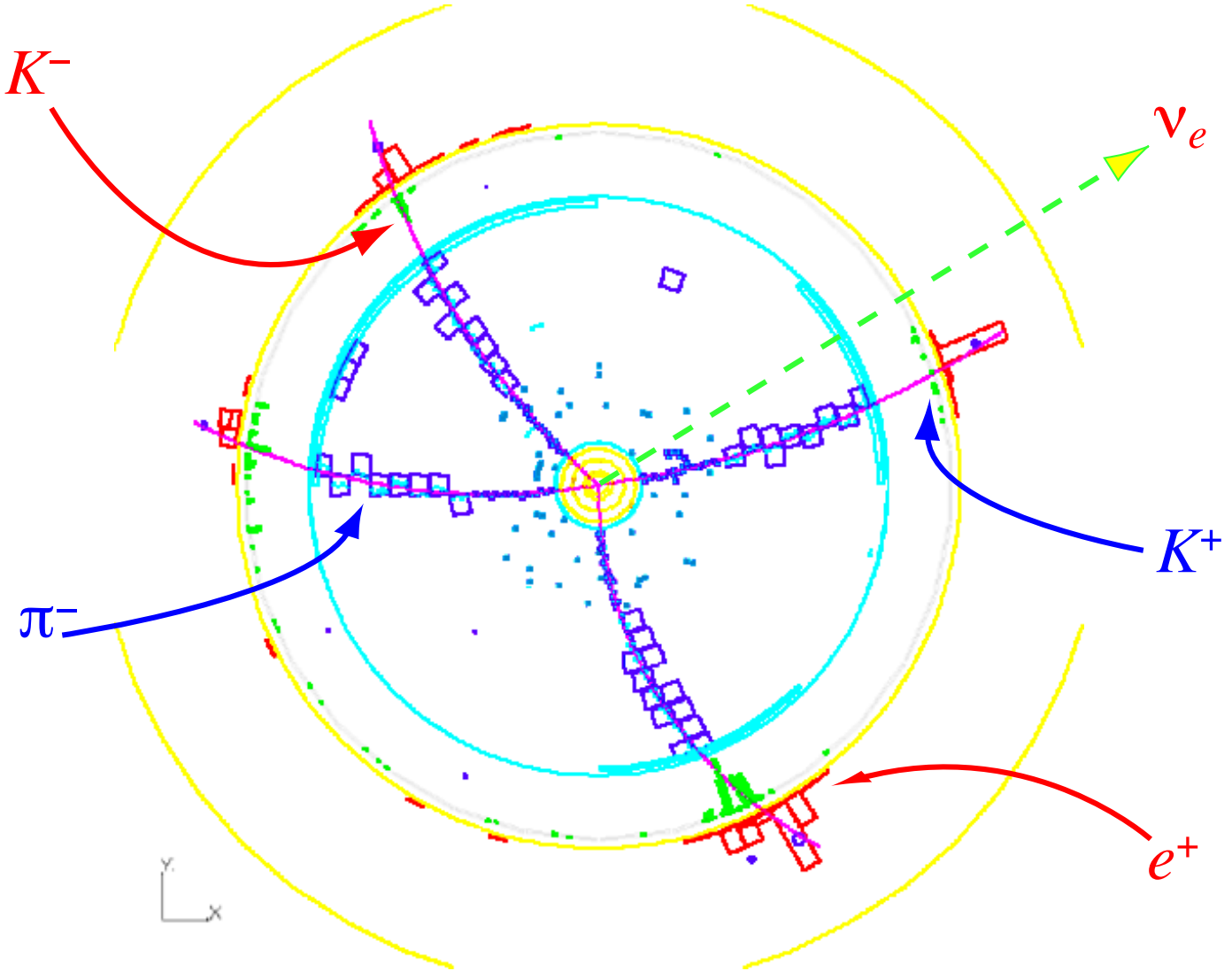
2) Misidentification of kaons as pions ($\sim 4\%$)

3) Uncertainty in background branching fractions ($\sim 4\%$)


CLEO-c
2230104-002
Solenoid Coil
Barrel Calorimeter
Ring Imaging Cherenkov Detector
Drift Chamber
Inner Drift Chamber / Beampipe
SC Quadrupole Pylon
SC Quadrupoles
Rare Earth Quadrupole
Endcap Calorimeter
Iron Polepiece
Magnet Iron
Barrel Muon Chambers

CLEO-c event: $e^+e^- \to \psi''(3770) \to D^0\bar{D}^0$

$D^0 \to K^-e^+\nu_e$ $\quad$ $\bar{D}^0 \to K^+\pi^-$



3) Measurement of $\Xi_c^0 \to pK^-K^-\pi^+$

I. Danko *et al.*, Phys. Rev. D 69, 052004 (2004)

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

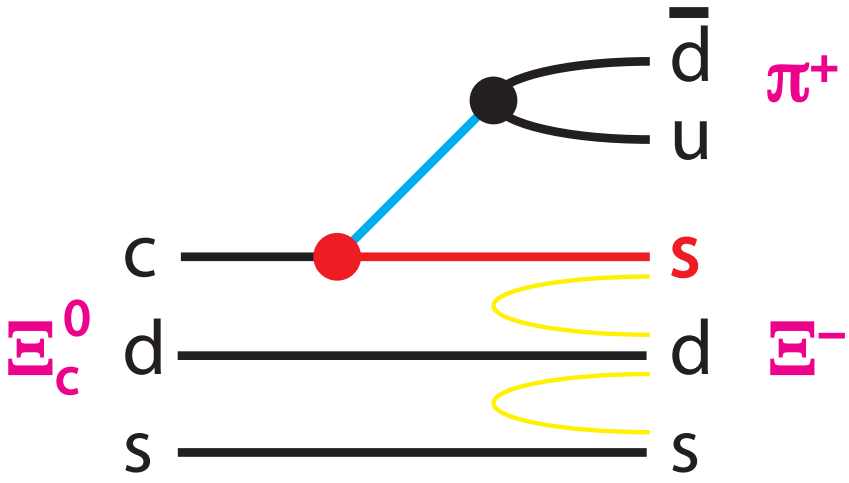
Measured $\Xi_c^0 \to pK^-K^-\pi^+$ rate relative to $\Xi_c^0 \to \Xi^-\pi^+$

Needs extensive p, K, π particle identification made possible by RICH in CLEO-III

Only previous result: ACCMOR 1990 (four events, all $\bar{K}^\star$)

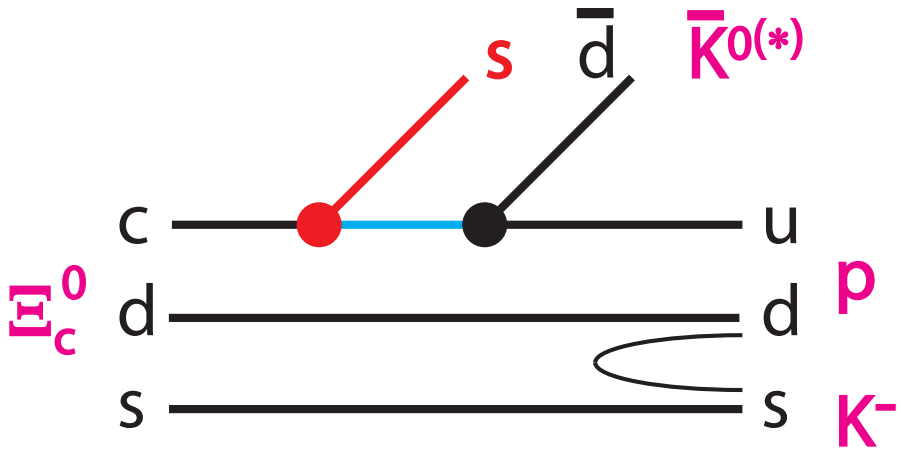
Final State Particles and Weak Decay Diagrams

External W^+



$\ldots$or $sds \to K^- p K^-$, etc

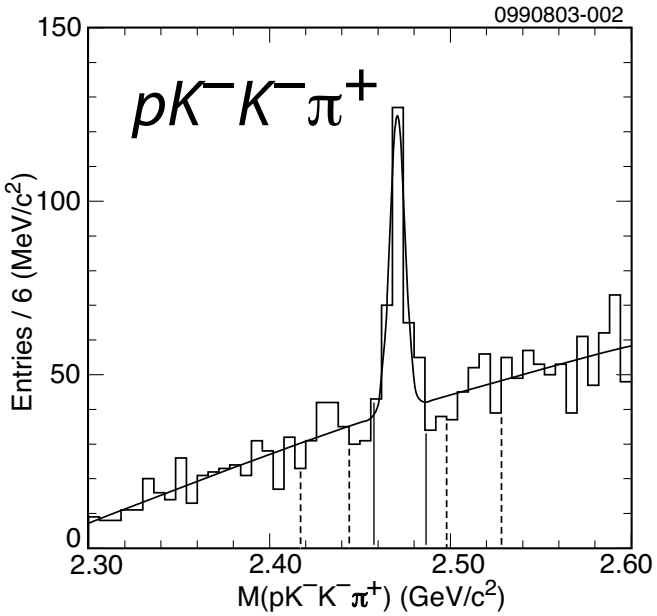
Internal W^+

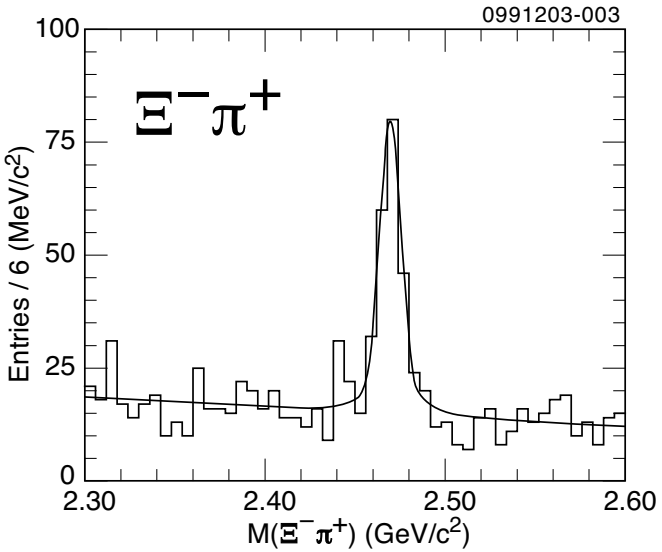


$\Rightarrow$ Absence of a π^+ (or K^+) implies that the decay proceeds through an internal W^+ line, and these should be color-suppressed.

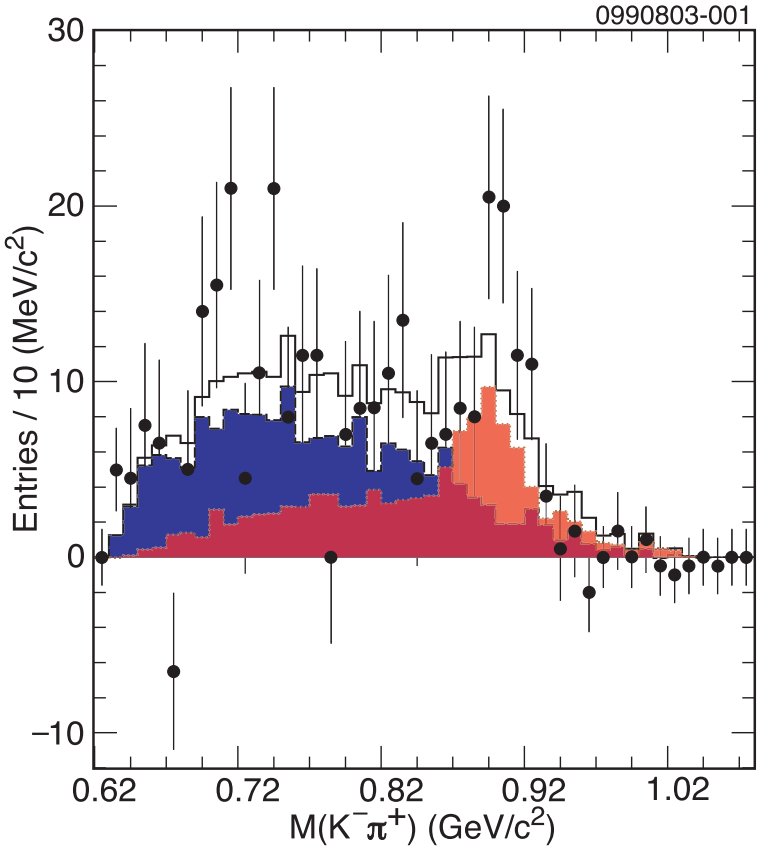
Results: Ξ_c^0 Decay

Ξ_c^0 Decay modes





$K^-\pi^+$ *mass:*



$$\mathcal{B}(\Xi_c^0 \to pK^-K^-\pi^+)/\mathcal{B}(\Xi_c^0 \to \Xi^-\pi^+) = 0.35 \pm 0.06 \pm 0.03$$

$$\mathcal{B}(\Xi_c^0 \to pK^-K^-\pi^+; \text{No } \bar{K}^\star)/\mathcal{B}(\Xi_c^0 \to \Xi^-\pi^+) = 0.21 \pm 0.04 \pm 0.02$$

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
  - $D^0 \to K^0_S \eta \pi^0$ including $D^0 \to K^0_S a_0(980)$
  - Form factor shape for $D^0 \to \pi^- e \nu$
  - $\Xi_c^0 \to p K^- K^- \pi^+$; No $\bar{K}^\star$

- Stay tuned for new charm results from CLEO-c

  See also Alex Smith, this conference.