
First Observation of the Σ_c^{*+} Baryon; Properties of Σ_c^0 , Σ_c^+ , Σ_c^{++} , and Ω_c^0 Baryons

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CLEO Collaboration



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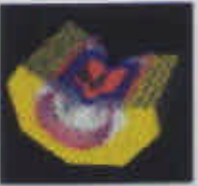


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Talk Overview

All new results are preliminary!

- Charmed-Baryon Spectroscopy
- CLEO Charmed-Baryon Reconstruction Techniques
- Mass and Width Measurements of the Σ_c^0 and Σ_c^{++} Baryons
- Discovery of Σ_c^{*+} and Mass Measurement of the Σ_c^+ Baryon
- First CLEO Observation of the Ω_c^0 Baryon



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The Charmed Baryons

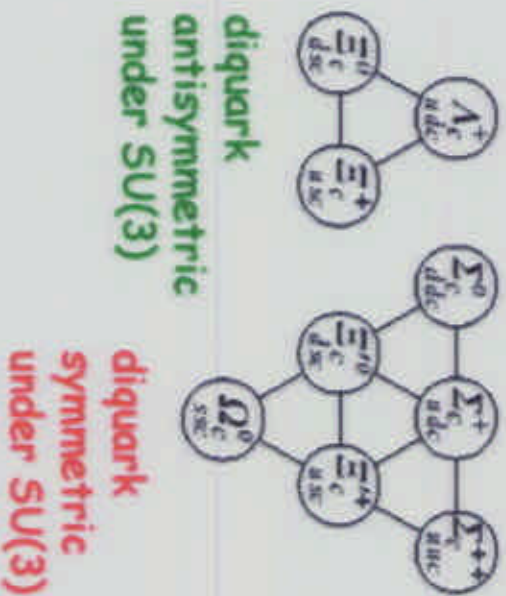
Charmed baryons consist of a heavy c quark and a light diquark

→ Many J^P states

To date, all $L=0$ states seen except

Σ_c^{*+} and Ω_c^{*0}

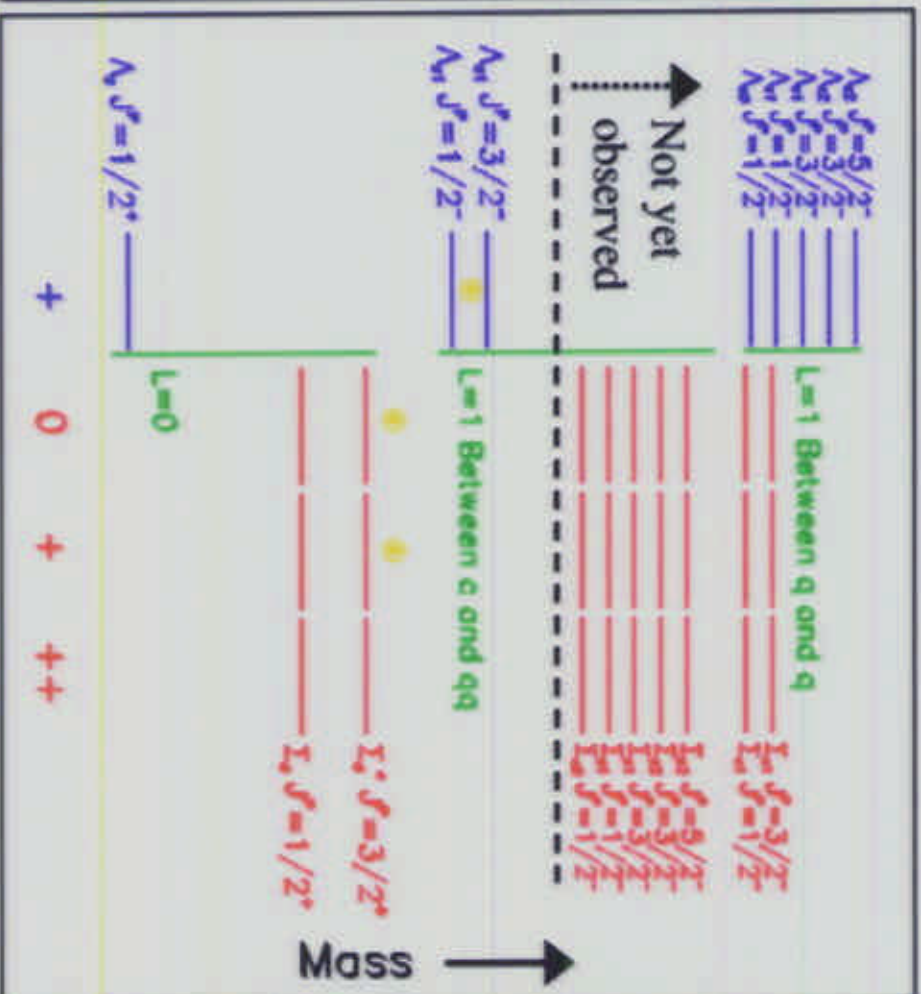
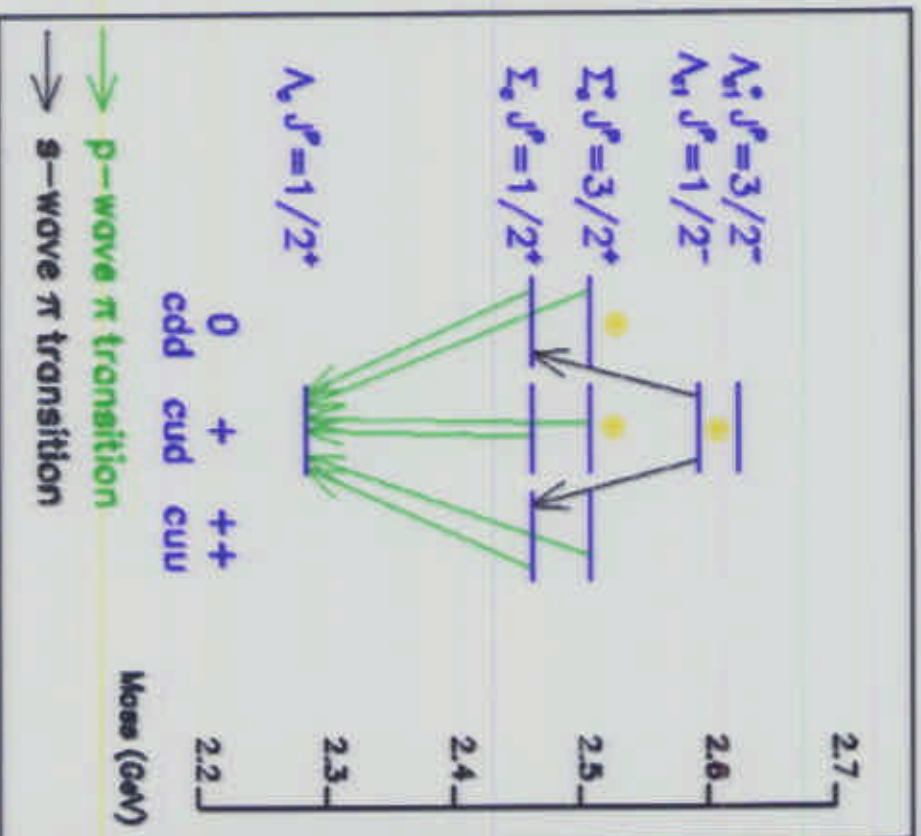
None of the J^P quantum numbers has been measured!





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Λ_c and Σ_c Spectroscopy





Data Set and CLEO II/II.V Detector

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e^+e^- Collisions near $\Upsilon(4S)$
Resonance (~ 10.5 GeV)

$$\int L dt \approx 14 \text{ fb}^{-1}$$

Charm-quark Production:

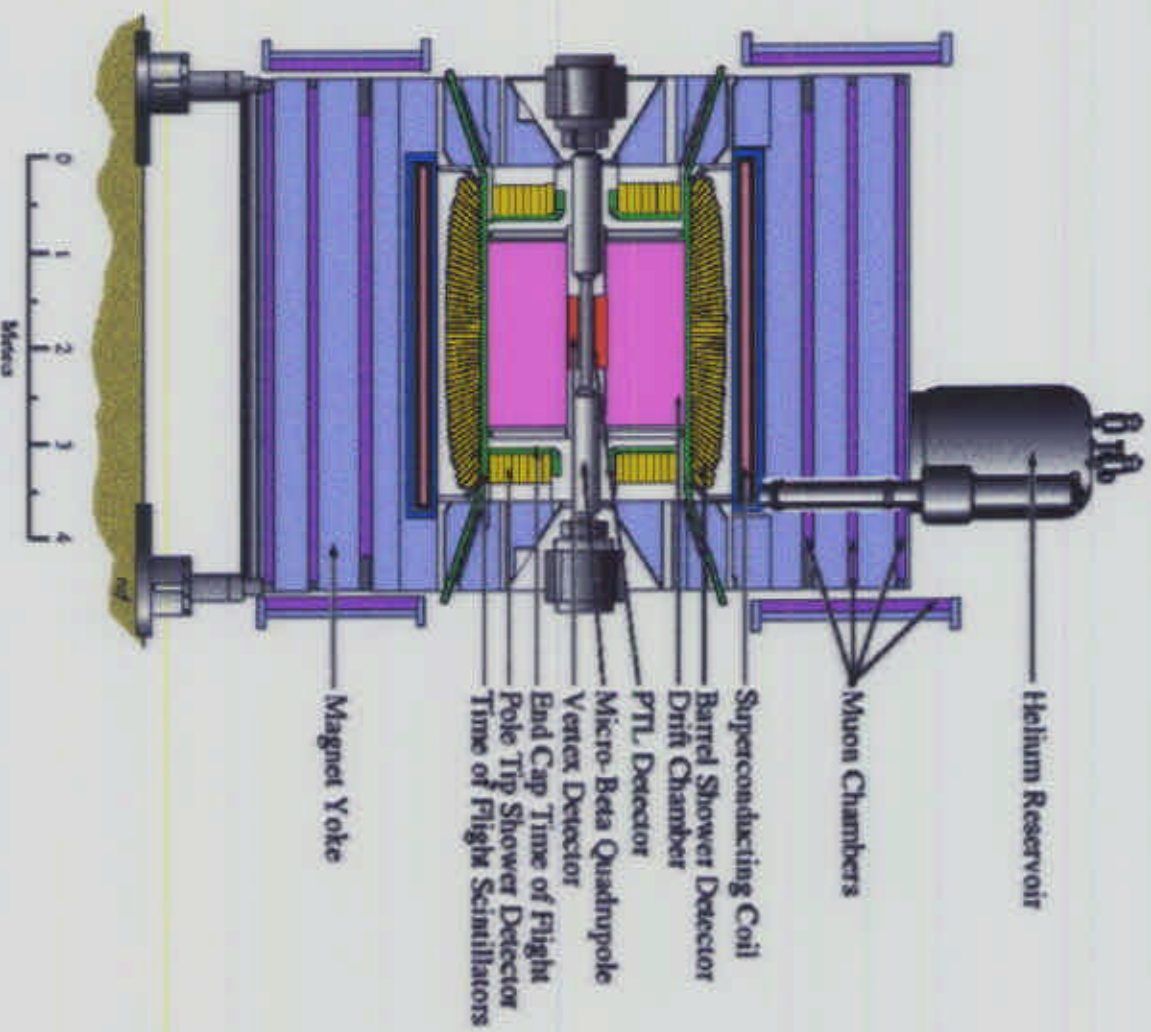
B-meson decays

$e^+e^- \rightarrow c\bar{c}$ jets

Two Configurations:

CLEO II (1989 – 1995)

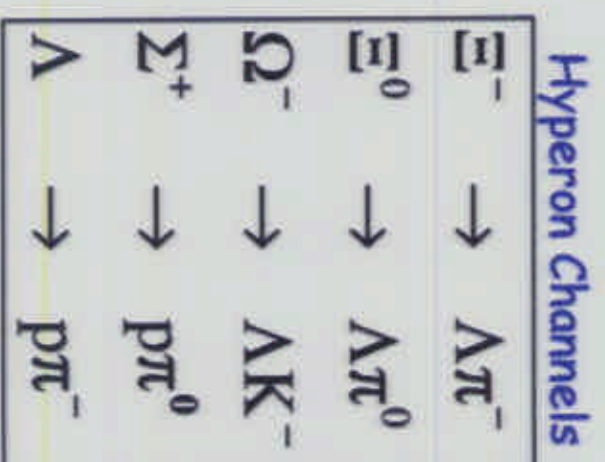
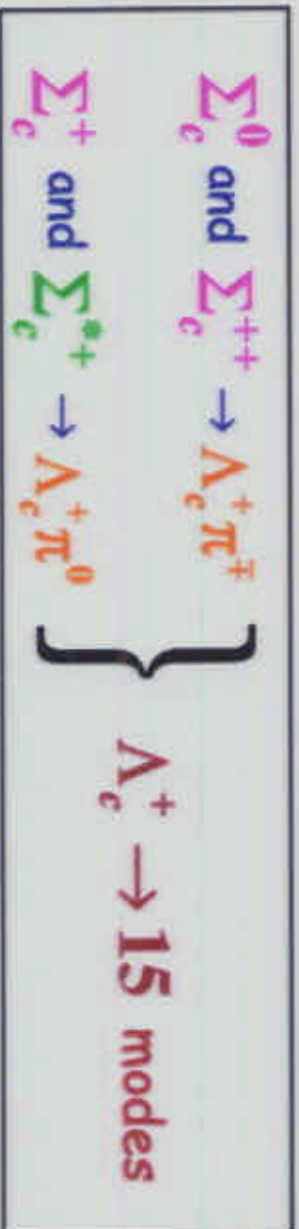
CLEO II.V (1996 – 1999)





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Reconstructed Candidate Modes





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Event Selection and Background Suppression Principles

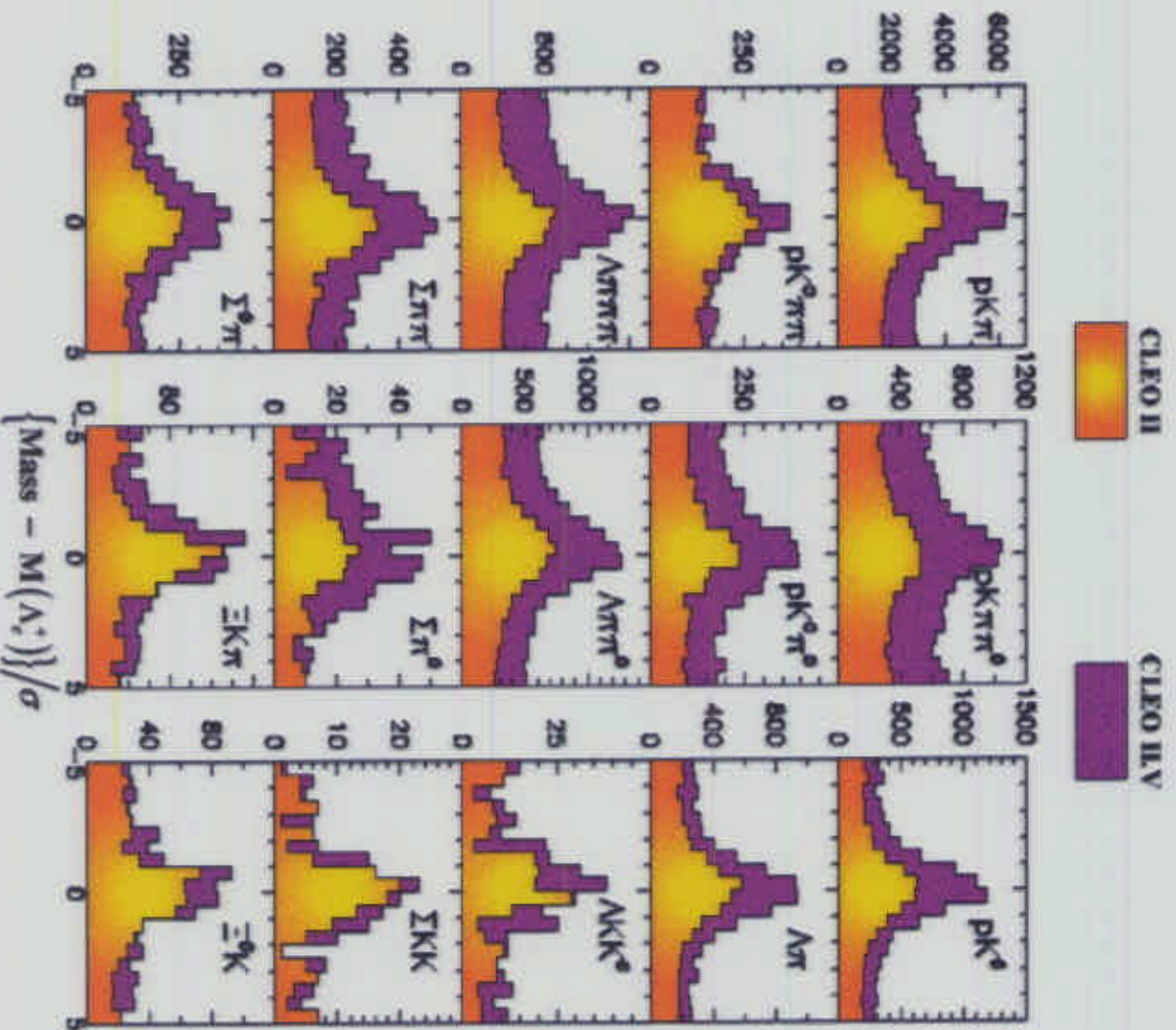
- ◆ π^0 candidates are reconstructed in the **CSI calorimeter barrel region**
- ◆ **p, K^+ , π^+** candidates are identified using **time-of-flight** and **dE/dx info**
- ◆ **Displaced vertices** are used to identify $\Lambda, \Sigma^+, \Xi^-, \Xi^0, \Omega^-$ candidates
- ◆ **Scaled Momentum criterion**: $x_p > 0.5$ or 0.6 , where $x_p \equiv p/p_{\max}$
and $p_{\max} \equiv \sqrt{E_{\text{beam}}^2 - M_{\text{cand}}^2}$
 - reduces **combinatorial background**
 - **Note**: charmed baryons with **B-meson parents** have $x_p < 0.4$



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15 Λ_c^+ Modes

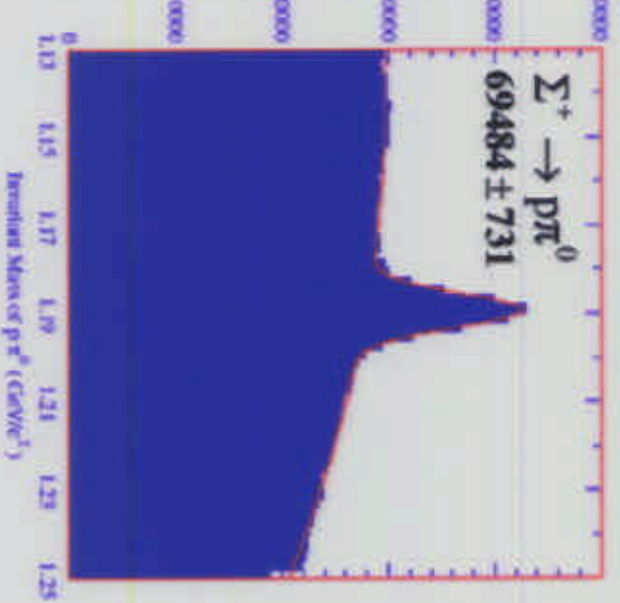
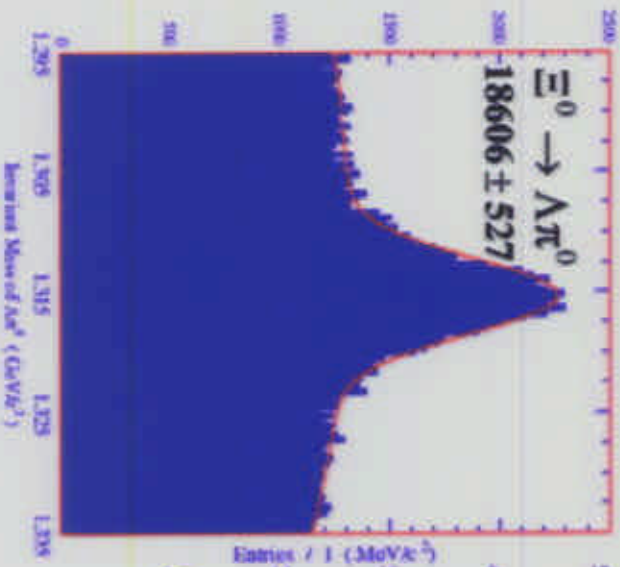
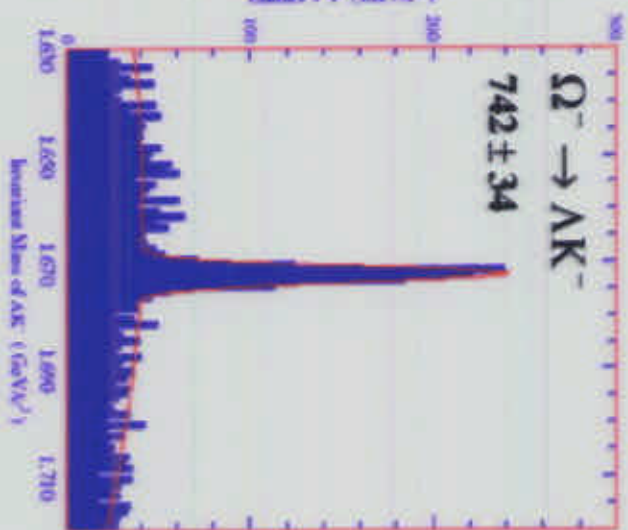
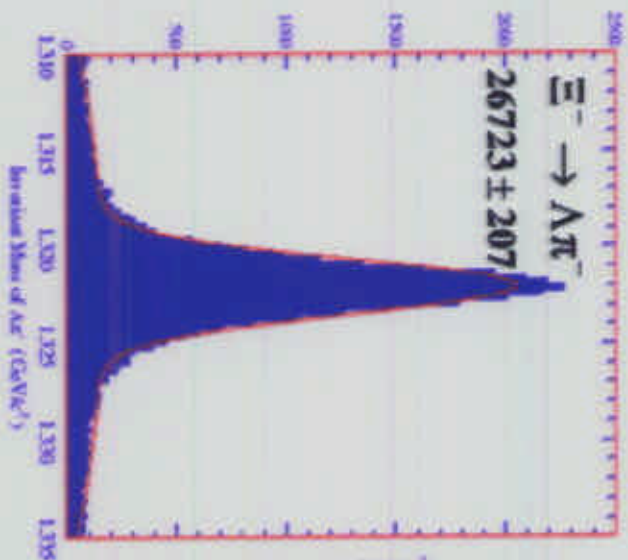
- $X_p > 0.5$
- Signal region: $\pm 1.6\sigma$
- Yield $\sim 58\,000$ candidates
- S:N $\sim 1 : 1.2$

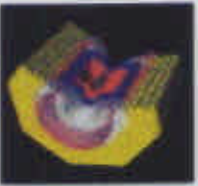




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Inclusive Hyperon Samples

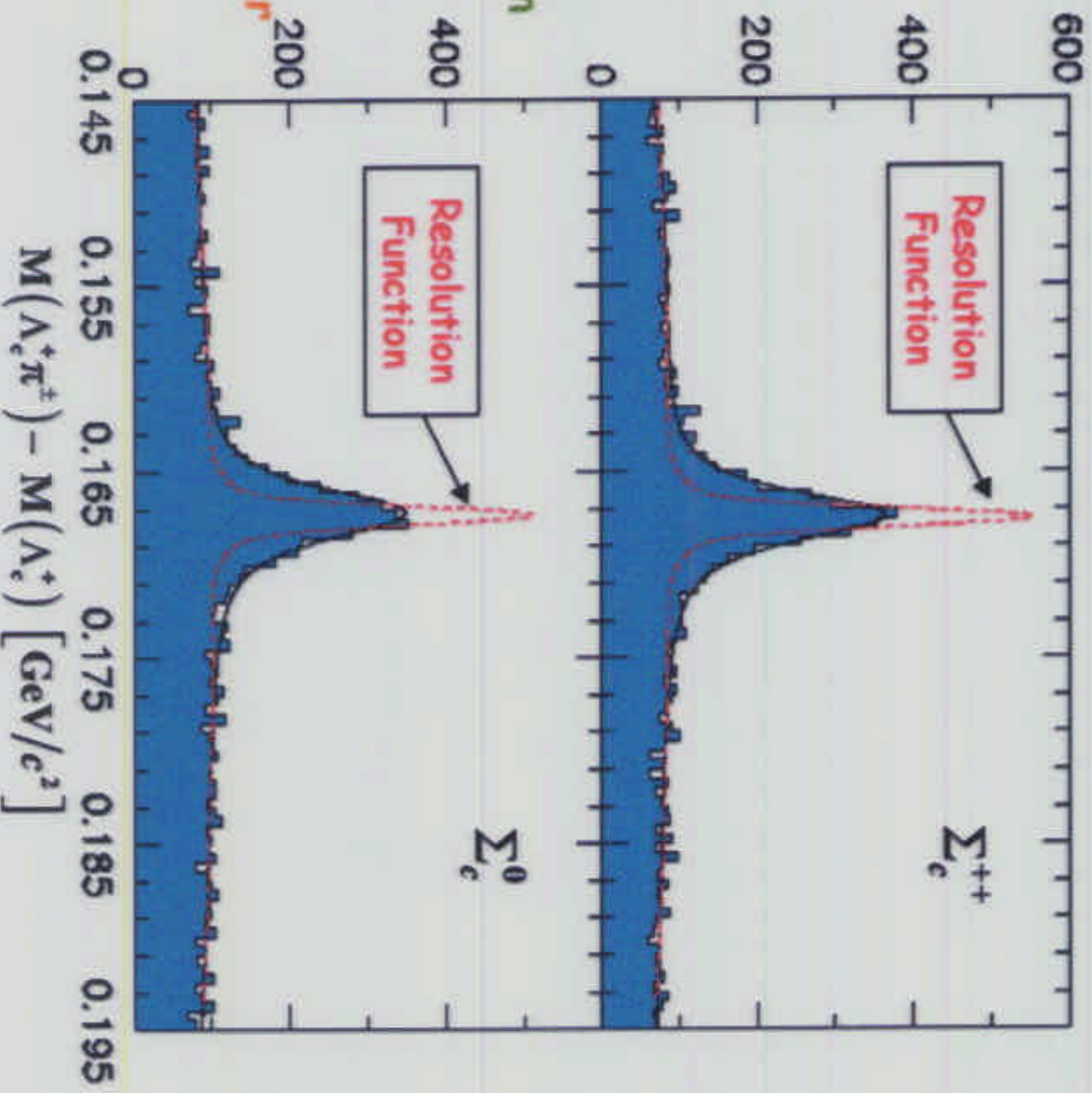




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Σ_c^{++} and Σ_c^0 Mass and Width Fits

- **Double-Gaussian resolution function** ($\sigma \sim 0.6 \text{ MeV}/c^2$)
- **Yields: ~ 2000 events**
- **Fit to p -wave Breit-Wigner convolved with resolution function**
- $X_p > 0.5$





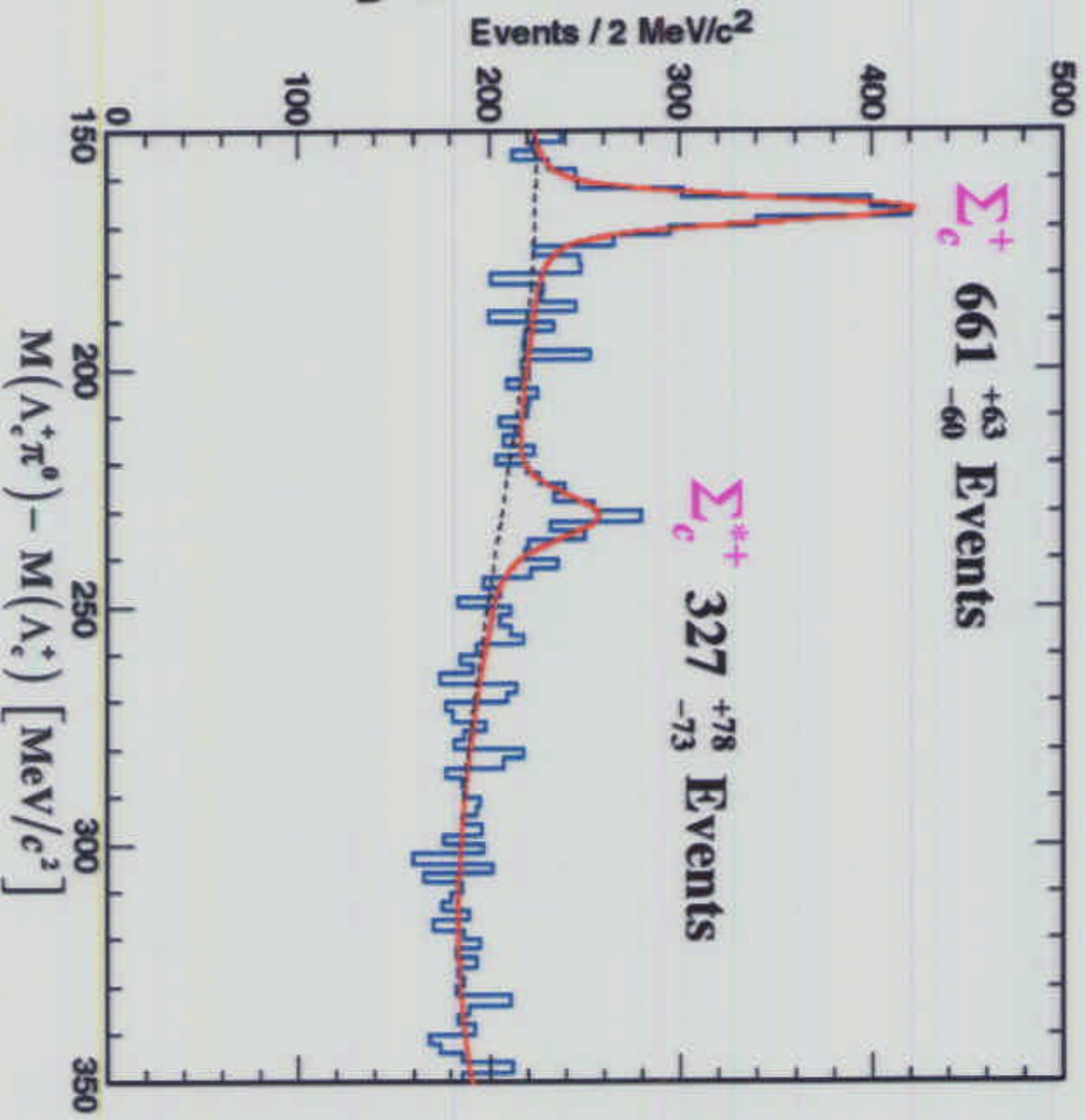
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Σ_c^+ and Σ_c^{*+} Yields

- Mass Fits to p -wave Breit-Wigner convolved with resolution function

$$\bullet X_p > 0.6$$

- First observation of Σ_c^{*+} resonance



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Theoretical Predictions for $\Gamma(\Sigma_c^0, \Sigma_c^{++})$

J. L. Rosner, Phys. Rev. D. 52, 6461 (1995) 1.32 ± 0.04 MeV

D. Perjoi & T.-M. Yan, Phys. Rev. D 56, 5483 (1997) ~ 2 MeV

S. Tafiq, P.S. O'Donnell, & J.G. Körner, Phys. Rev. D 58, 054010 (1998) ~ 1.6 MeV

M.A. Ivanov, J.G. Körner, V.E. Lyubovitskij, & A.G. Rusetsky, Phys. Lett. B 442, 435 (1998) ~ 2.75 MeV

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Page 12a



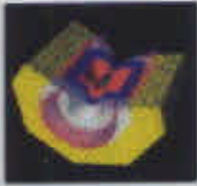
CLEO Σ_c Mass and Width Measurements

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Observable \ Isospin	$\Sigma_c^{(*)0}$	$\Sigma_c^{(*)+}$	$\Sigma_c^{(*)++}$	
$J^P = \frac{1}{2}^+$	$M(\Sigma_c) - M(\Lambda_c^+)$	$167.2 \pm 0.1 \pm 0.2$	$166.4 \pm 0.2 \pm 0.3$	$167.4 \pm 0.1 \pm 0.2$
	$\Gamma(\Sigma_c)$	$2.4 \pm 0.2 \pm 0.4$	< 4.6 (90% CL)	$2.5 \pm 0.2 \pm 0.4$
$J^P = \frac{3}{2}^+$	$M(\Sigma_c^*) - M(\Lambda_c^+)$	$232.6 \pm 1.0 \pm 0.8$	$231.0 \pm 1.1 \pm 2.0$	$234.5 \pm 1.1 \pm 0.8$
	$\Gamma(\Sigma_c^*)$	$13.0^{+3.7}_{-3.0} \pm 4.0$	< 17 (90% CL)	$17.9^{+3.8}_{-3.2} \pm 4.0$

- PRELIMINARY CLEO results
- G. Brandenburg *et al.* (CLEO), Phys. Rev. Lett. 78, 2304 (1997)

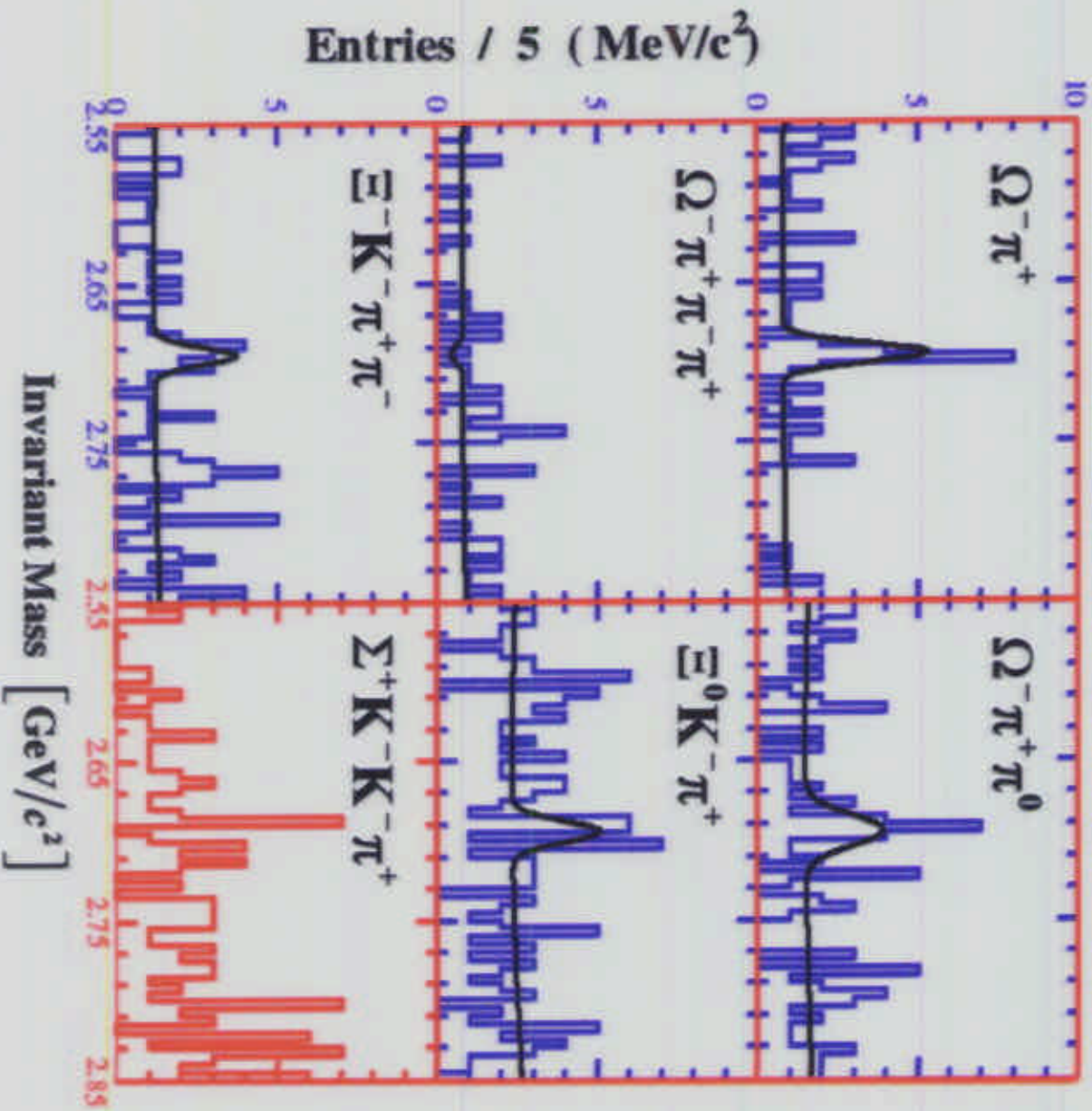
All quantities are in MeV/ c^2
 First uncertainties are statistical; second are systematic.



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Ω_c^0 Search Modes

$X_p > 0.5$ or 0.6



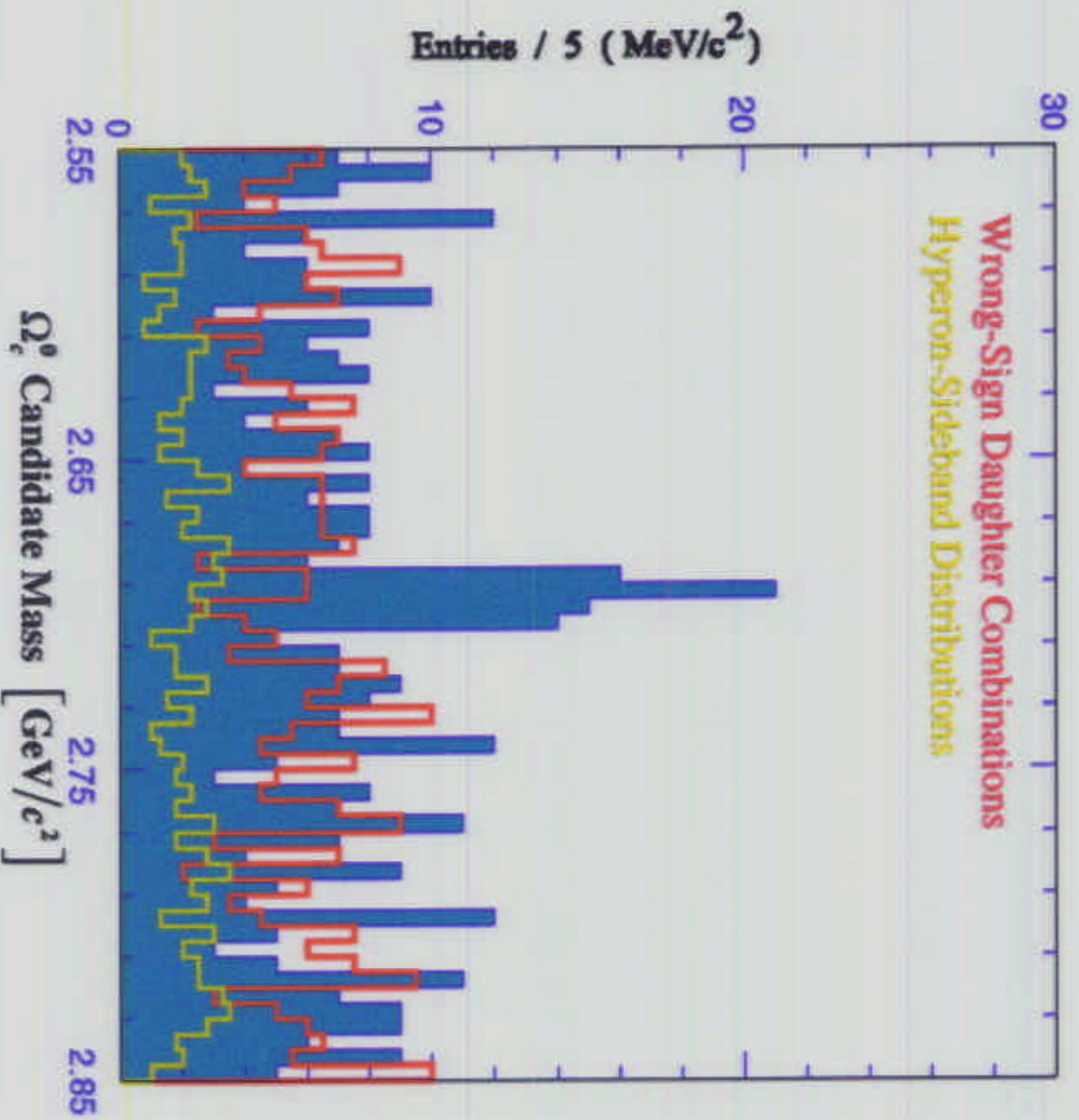


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Sum of 5 Ω_c^0
Search Modes

Total Fitted Yield:

40.4 ± 9.0 (stat.)
candidates



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14



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Summary of Preliminary Ω_c^0 Results

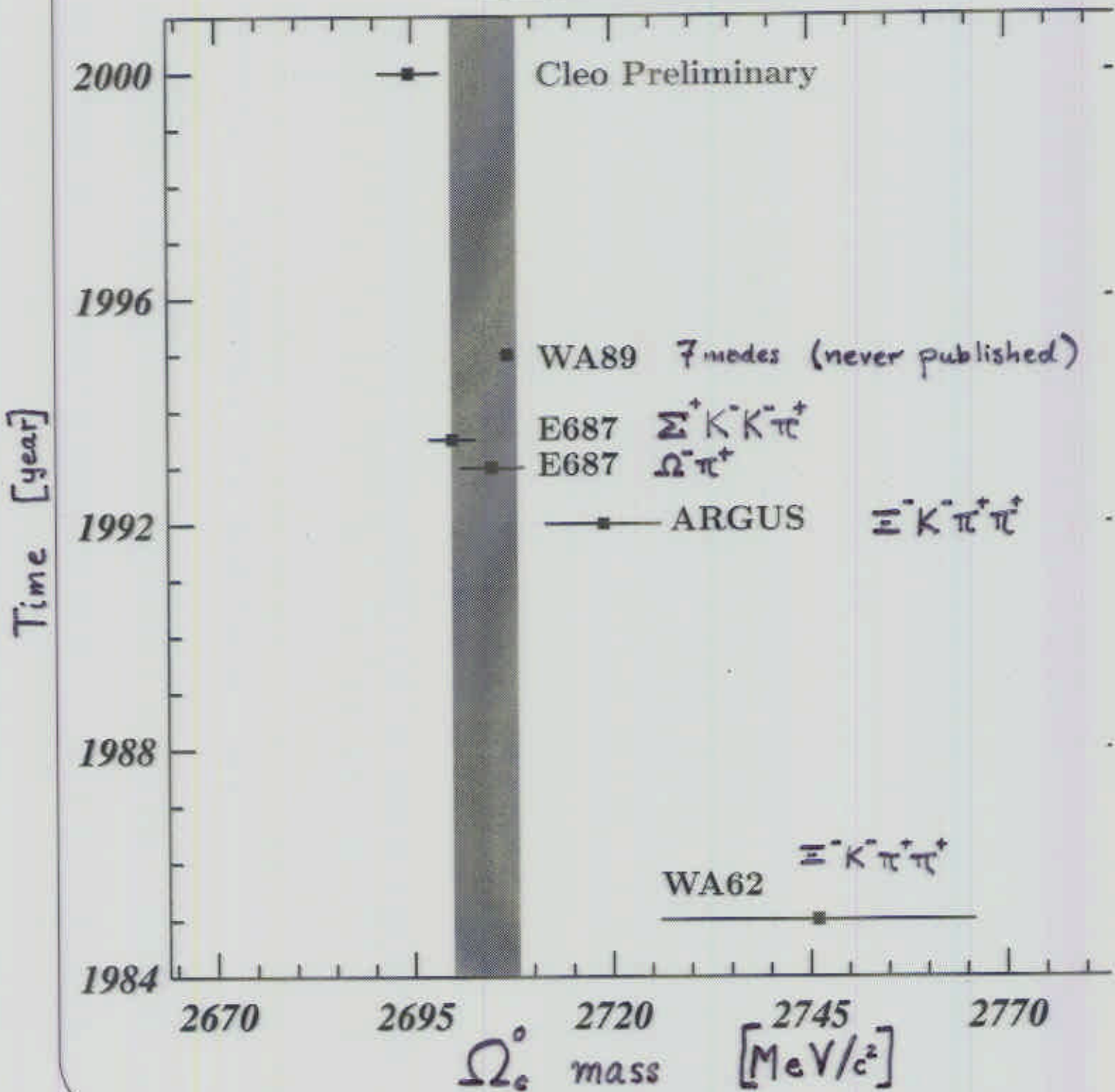
Mode	Fitted Yield	Relative \mathcal{B}	$\sigma \cdot \mathcal{B}$ [fb]
$\Omega^- \pi^+$	13.3 ± 4.1	1.0	$11.3 \pm 3.9 \pm 2.3$
$\Omega^- \pi^+ \pi^0$	11.8 ± 4.9	$4.2 \pm 2.2 \pm 1.2$	$47.6 \pm 18.0 \pm 2.8$
$\Omega^- \pi^+ \pi^+ \pi^-$	-0.9 ± 1.4	< 0.6 (90% CL)	< 5.1 (90% CL)
$\Xi^0 \pi^+ K^-$	9.2 ± 4.9	$4.0 \pm 2.5 \pm 0.6$	$45.1 \pm 23.2 \pm 4.1$
$\Xi^- \pi^+ \pi^+ K^-$	7.0 ± 3.7	$1.6 \pm 1.1 \pm 0.4$	$18.2 \pm 10.6 \pm 3.8$
Combined	40.4 ± 9.0	–	–
$\Sigma^+ K^- K^- \pi^+$	< 9.5 (90% CL)	< 4.8 (90% CL)	< 53.8 (90% CL)

Unbinned maximum likelihood fit mass:

$$M(\Omega_c^0) = 2694.6 \pm 2.6 \text{ (stat.)} \pm 2.4 \text{ (syst.) MeV}/c^2$$

CONCLUSIONS

Mass Measurements





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Conclusions

- ◆ We present the most statistically accurate measurements of the Σ_c^0 , Σ_c^+ , and Σ_c^{*++} masses.
- ◆ We have made preliminary measurements of the Σ_c^0 and Σ_c^{*++} widths.
- ◆ We report the first observation of the Σ_c^{*+} baryon and measure its mass to be

$$M(\Sigma_c^{*+}) - M(\Lambda_c^+) = 231.0 \pm 1.1 \text{ (stat.)} \pm 2.0 \text{ (syst.) MeV}/c^2$$



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Conclusions, cont'd

- ◆ CLEO has now, for the first time, observed a significant number of Ω_c^0 candidates. We present a preliminary mass measurement of

$$M(\Omega_c^0) = 2694.6 \pm 2.6 \text{ (stat.)} \pm 2.4 \text{ (syst.) MeV}/c^2$$

- ◆ Supporting documentation can be found in
 - ◆ hep-ex/0007041
 - ◆ hep-ex/0007047
- ◆ CLEO continues to contribute to knowledge of the charmed baryon sector.