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FOCUS(E831) Collaboration

III International Conference

Hyperons, Charm and Beauty Hadrons

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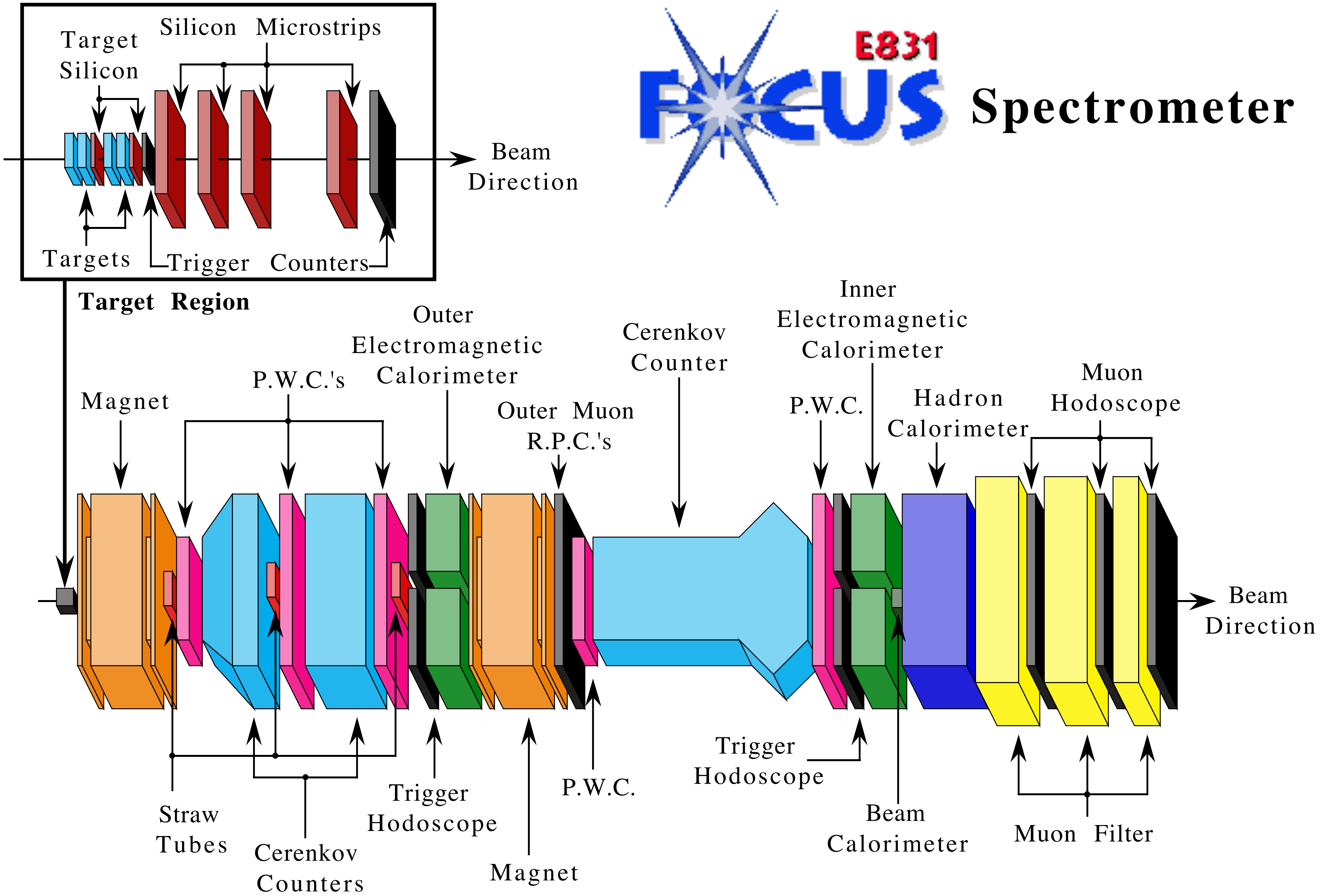
FOCUS Data Set

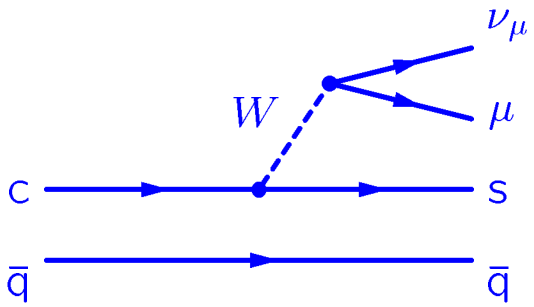
- The goal of FOCUS was to have 1 million fully reconstructed charm decays in the Golden Modes.

- Significant improvements were made to spectrometer:
  - The target was segmented and instrumented with silicon.
  - Straw chambers were added to the central region of the detector.
  - A tie-breaker plane was added to the Outer Electromagnetic Calorimeter.
  - A new lead glass Inner Electromagnetic calorimeter was installed.
  - RPC planes were installed to detect Outer Muons.
  - Proportional tube Inner Muon arrays were replaced by scintillator planes.

- FOCUS achieved and exceeded its original goal. Thanks to detector and software improvements we expect to have very large increases relative to our predecessor E687.


E831
FOCUS Spectrometer
Target Silicon
Silicon Microstrips
Beam Direction
Targets
Trigger Counters
Target Region
Magnet
P.W.C.'s
Outer Electromagnetic Calorimeter
Outer Muon R.P.C.'s
Cerenkov Counter
P.W.C.
Inner Electromagnetic Calorimeter
Hadron Calorimeter
Muon Hodoscope
Beam Direction
Straw Tubes
Cerenkov Counters
Trigger Hodoscope
Magnet
P.W.C.
Trigger Hodoscope
Beam Calorimeter
Muon Filter

Pseudoscalar Semileptonic Decays



- The decay rate expression is:
$$\frac{d\Gamma}{dq^2} = \frac{G_F^2|V_{cq}^2|P^3}{24\pi^3}\{|f_+(q^2)|^2 + m_l^2|f_-(q^2)|^2\}$$
.

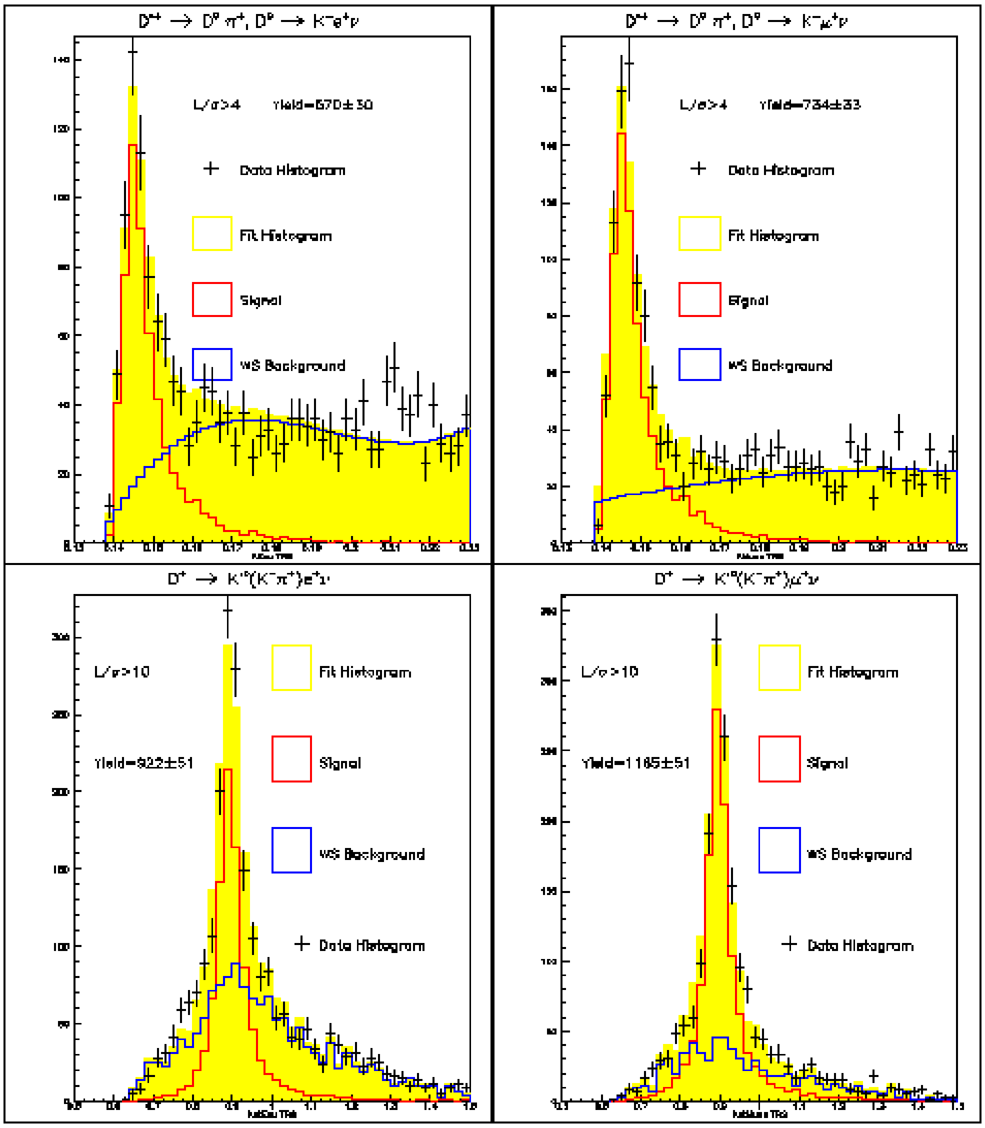
- This should enable us to measure $f_+(0)$ to $\simeq 1\%$ statistical.

- Our $Ke^+\nu$ and $K\mu^+\nu$ samples are of comparable size which should enable us to test lepton universality and measure the $f_-(0)$ form factor.

- The extra reach in q^2 provided by the $\pi l\nu$ mode may enable us to make a better parameterization free measurement of $f_+(q^2.)$

- Measure $|V_{cd}|/|V_{cs}|$ to $\simeq 2.0\% statistical.$

Semileptonic Decays



This analysis, based on 3% of the FOCUS data, shows larger yields than E687.

Vector Semileptonic Decays

- Vector semileptonic decays are described by two axial and one vector form factor.

- Traditionally one measures the ratios $R_v = \frac{V(0)}{A_1(0)}$, and $R_2 = \frac{A_2(0)}{A_1(0)}$.

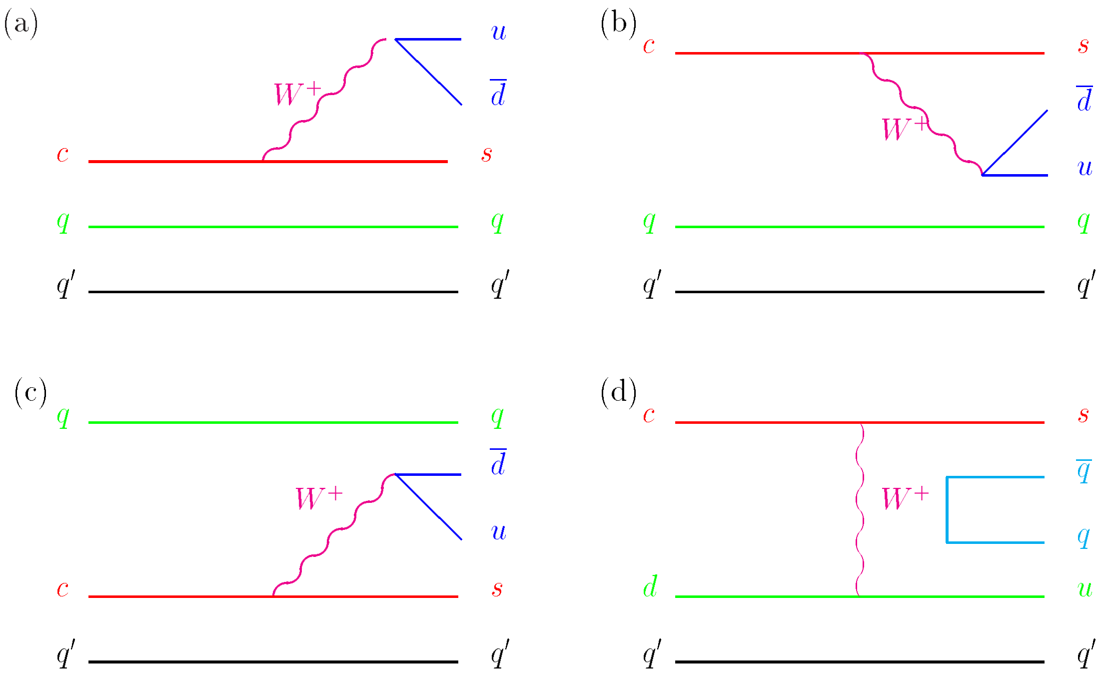
- FOCUS anticipates being able to measure R_2 and R_v to better than 5% for the K^* mode, and better than 10% for the ϕ mode.

- E687 reported the first statistically significant observation of the decay $D \to \rho^0 l\nu$ with a yield of 39±9 events. Given the large increase in statistics already observed in other modes the prospects for greatly increasing the statistics are good. We anticipate measuring the branching ratio w.r.t. $D \to K^{*0} l\nu$ and the form factors for this decay.

- We also intend to study $D \to \eta l\nu$, and charm baryon semileptonic decays such as $\Lambda_c \to \Lambda l\nu$ and $\Xi_c \to X l\nu$.

Mode	$Kl\nu$	$\pi l\nu$	$K^{*0}l\nu$	$\phi l\nu$
E687	$\simeq 1250$	$\simeq 78$	$\simeq 875$	$\simeq 120$
FOCUS	$\simeq 30K$	$\simeq 5K$	$\simeq 50K$	$\simeq 10K$

Mode	Experiment	R_2	R_v
$K^{*0}l\nu$	E791	$0.72 \pm 0.08 \pm 0.09$	$1.84 \pm 0.11 \pm 0.08$
$K^{*0}l\nu$	E687	$0.78 \pm 0.18 \pm 0.10$	$1.74 \pm 0.27 \pm 0.28$
$\phi l\nu$	CLE2	$1.0 \pm 0.3 \pm 0.2$	$0.9 \pm 0.6 \pm 0.3$
$\phi l\nu$	E687	$1.0 \pm 0.5 \pm 0.1$	$1.8 \pm 0.8 \pm 0.2$



State	External Spectator	Exch.	Const. Int. Spect.	Dest. Int. Spect.
Λ_c^+	Γ_{Spec}	$+\ \Gamma_{Exc}$		- Γ^-_{Int}
Ξ_c^+	Γ_{Spec}		$+\Gamma^+_{Int.}$	- Γ^-_{Int}
Ξ_c^0	Γ_{Spec}	$+\ \Gamma_{Exc}$	$+\Gamma^+_{Int.}$	
Ω_c^0	Γ_{Spec}		$+\ \frac{10}{3} \times \Gamma^+_{Int.}$	

Charm Baryons

- There are three hadronic-spectator and one W exchange diagram which contribute significantly to the rate.
- Interference effects and the fact that the W exchange is not helicity suppressed are used to predict the hierarchy of lifetimes.
- Is $\tau(\Omega_c^0) < \tau(\Xi_c^0) < \tau(\Lambda_c^+) < \tau(\Xi_c^+)$?
- E687 measured the lifetimes of the $\Lambda_c, \Xi_c^+, \Xi_c^0$ and the Ω_c.
- Early indications are that we will have $\geq 20K$ $\Lambda_c^+ \to pK^-\pi^+$ decays.

Baryon	Lifetime (ps)	Experiment
Ξ_c^+	$0.35^{+0.11}_{-0.08} \pm 0.02$	E687
Λ_c^+	$0.215 \pm 0.016 \pm 0.008$	E687
Ξ_c^0	$0.101^{+.025}_{-0.017} \pm 0.005$	E687
Ω_c^0	$0.086^{+0.027}_{-0.020} \pm 0.028$	E687
Ω_c^0	$0.055^{+0.013+0.018}_{-0.011-0.023}$	WA89

Charm Baryons

- Study the Λ_c^{*+}(2593 and Λ_c^{*}(2593 in the mode $\Lambda_c^{*+} \to \Lambda_c^+\pi^+\pi^-$. The accompanying plot is from $\simeq$ 20% of our data.

- Study $\Sigma_c^{++} \to \Lambda_c^+\pi^+$, $\Sigma_c^0 \to \Lambda_c^+\pi^-$ and $\Sigma_c^+ \to \Lambda_c^+\pi^0$.

- E687 published 68.8 ± 11.0 Σ_c^0 and 55.8 ± 10.2 Σ_c^+ events. We already see $\simeq$ 4 times as much yield in 20% of FOCUS data.

- We also observe the decays $\Xi_c^+ \to \Xi^-\pi^+\pi^+$, $\Lambda_c^+ \to \Xi^- K^+\pi^+$, and $\Xi_c^0 \to \Xi^-\pi^+$.

- We will be in a position to make better measurements of known excited baryons such as Ξ_c^{*+} and of the Ω_c^0.

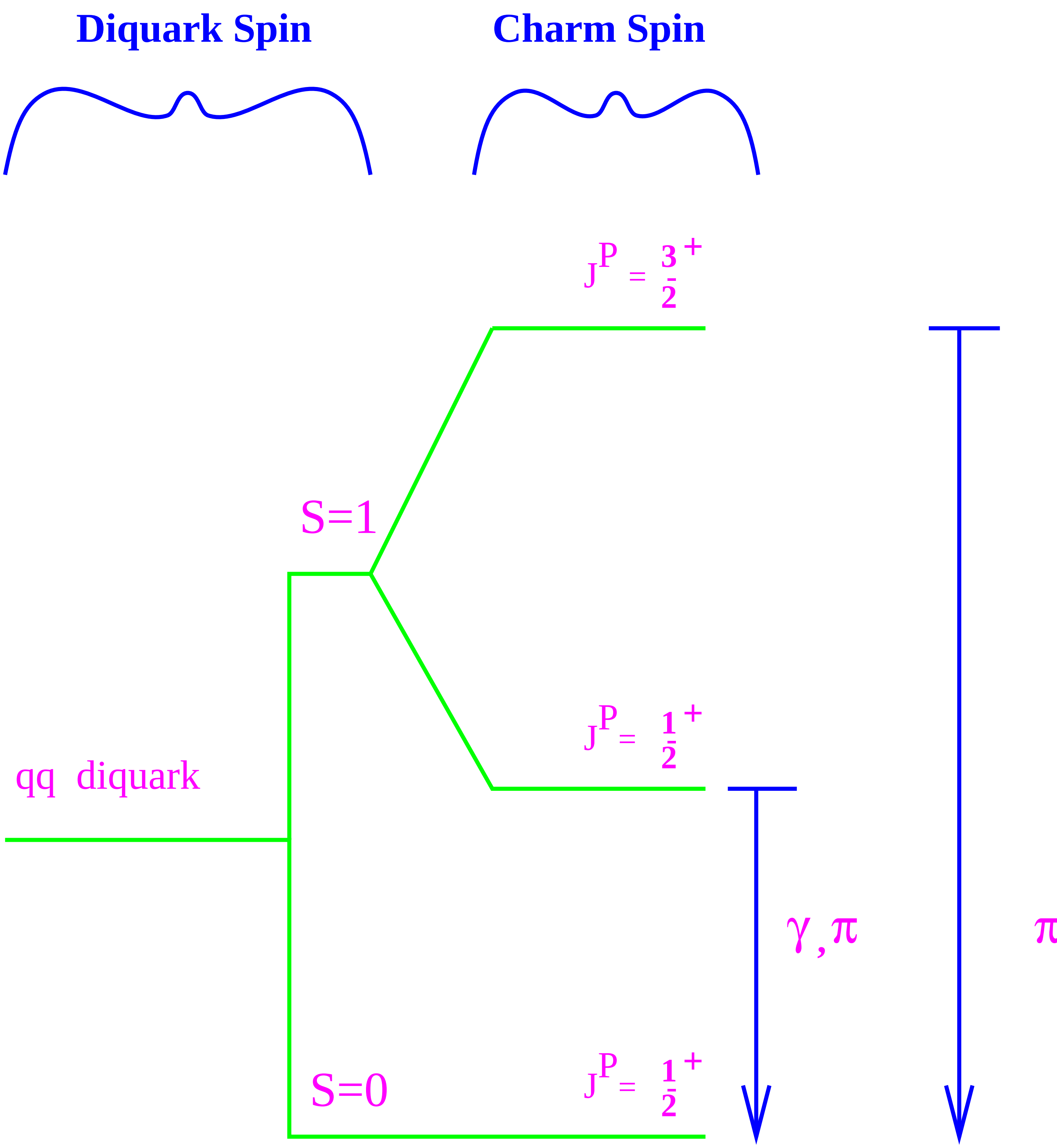
- We will search for doubly charmed baryons.

Conclusions

- Our first look at the FOCUS data sample has been very encouraging.

- We expect to be in a position to improve many important measurements over their present values.

- With such large samples we are optimistic about the possibility of discovering new decay modes and states.



Diquark Spin
Charm Spin
$J^P = \frac{3}{2}^+$
S=1
$J^P = \frac{1}{2}^+$
qq diquark
γ, π
π
S=0
$J^P = \frac{1}{2}^+$

Charm Baryon Spectroscopy

$J^P = \frac{1}{2}^+$

S=2 Ω_c^0

S=1 $\Xi_c^0 (\Xi_c^{\prime 0})$ $\Xi_c^+ (\Xi_c^{\prime +})$

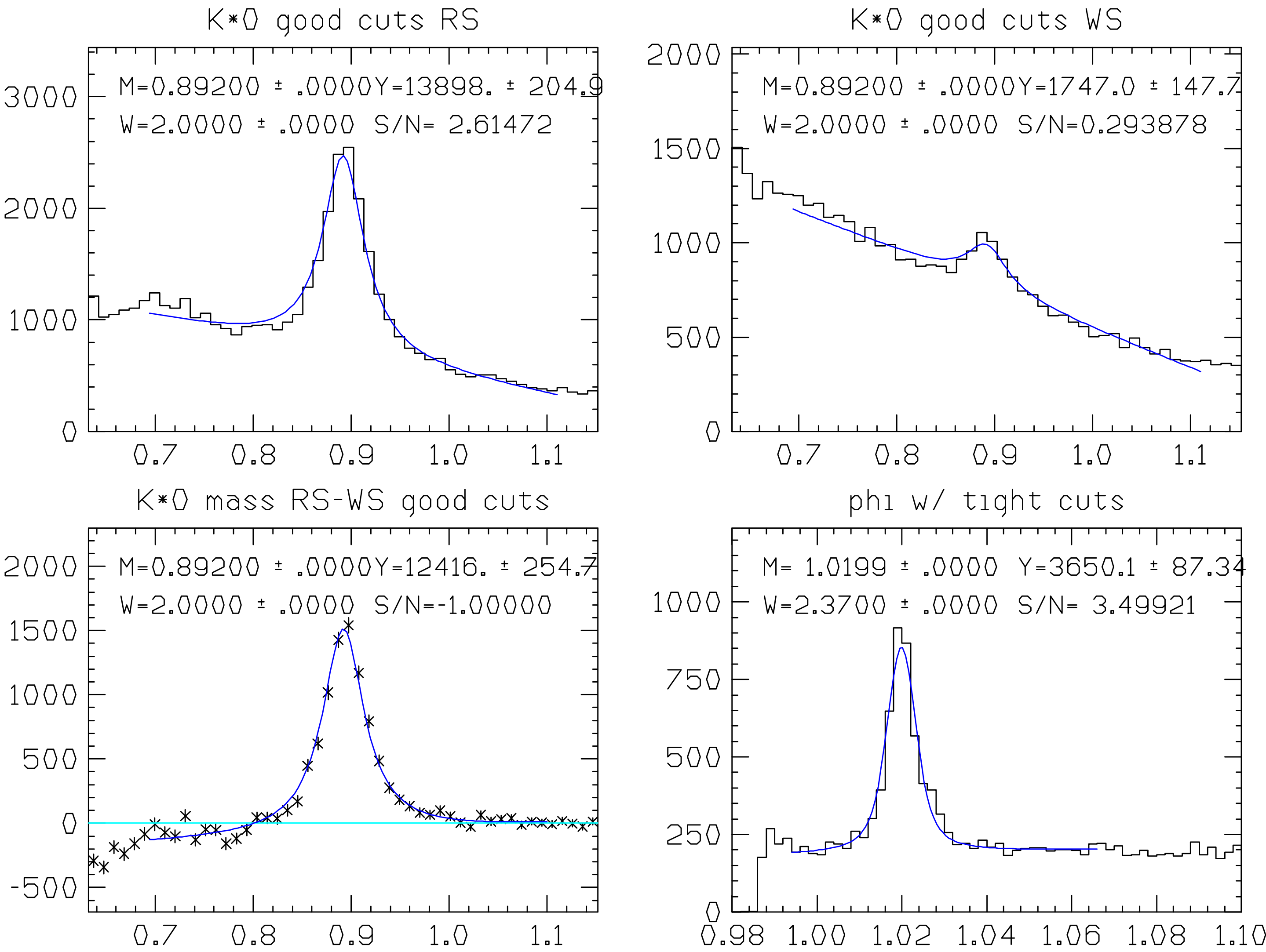
S=0 Σ_c^0 Σ_c^+, Λ_c^+ Σ_c^{++}

$J^P = \frac{3}{2}^+$

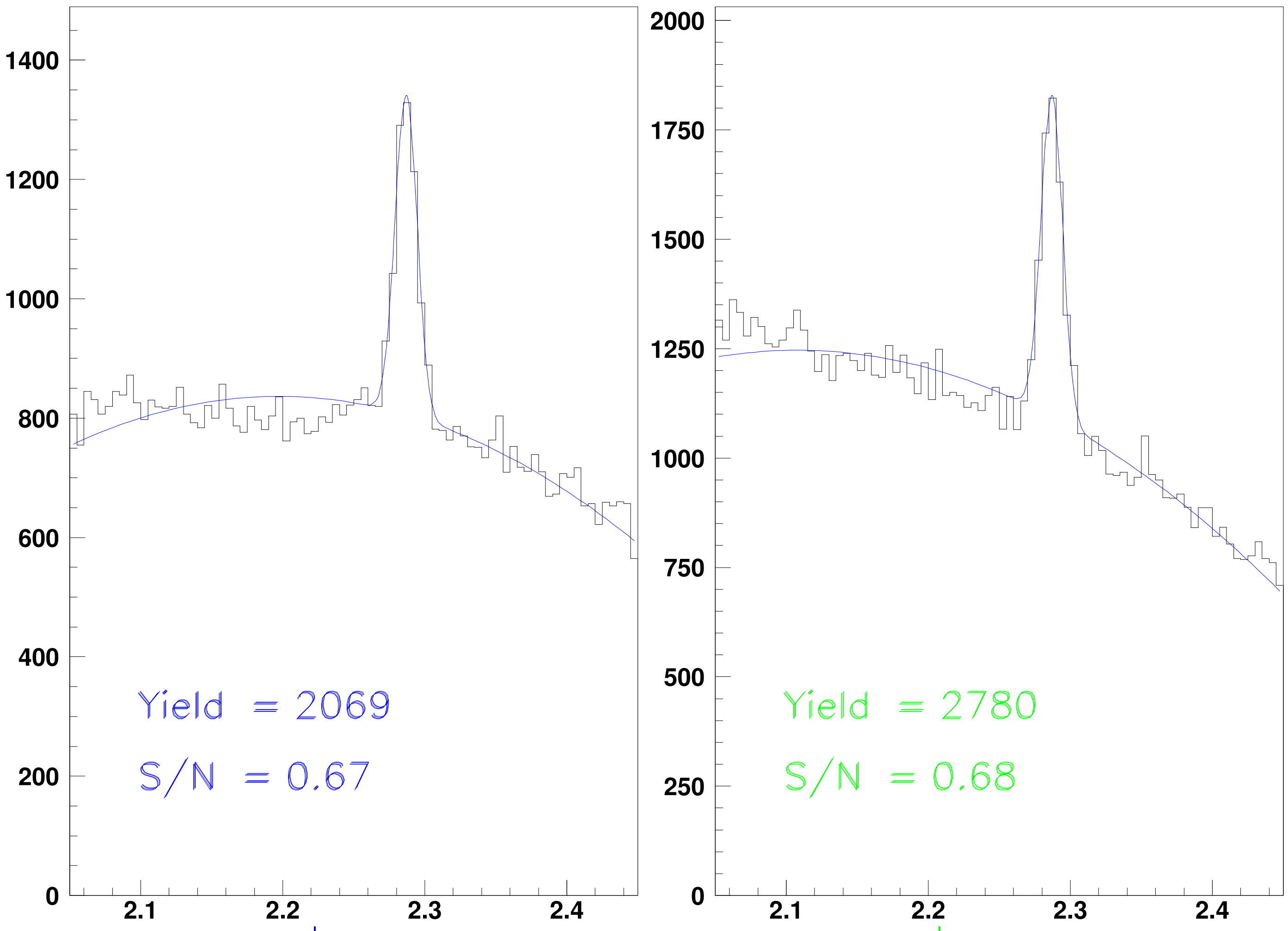
S=2 Ω_c^{*0}

S=1 Ξ_c^{*0} Ξ_c^{*+}

S=0 Σ_c^{*0} Σ_c^{*+} Σ_c^{*++}

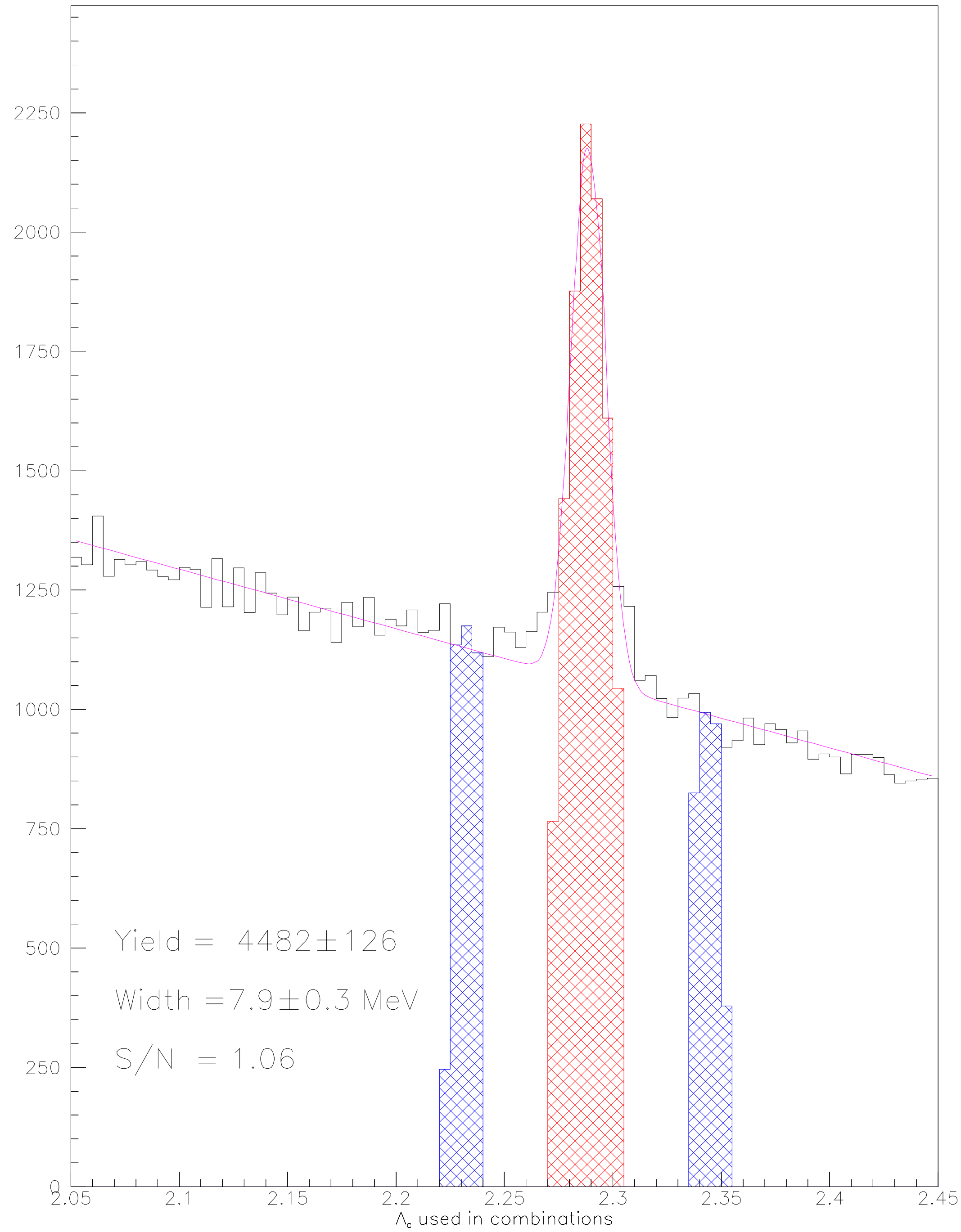


K*0 good cuts RS
M=0.89200 ± .0000Y=13898. ± 204.9
W=2.0000 ± .0000 S/N= 2.61472
K*0 good cuts WS
M=0.89200 ± .0000Y=1747.0 ± 147.7
W=2.0000 ± .0000 S/N=0.293878
K*0 mass RS-WS good cuts
M=0.89200 ± .0000Y=12416. ± 254.7
W=2.0000 ± .0000 S/N=-1.00000
phi w/ tight cuts
M= 1.0199 ± .0000 Y=3650.1 ± 87.34
W=2.3700 ± .0000 S/N= 3.49921

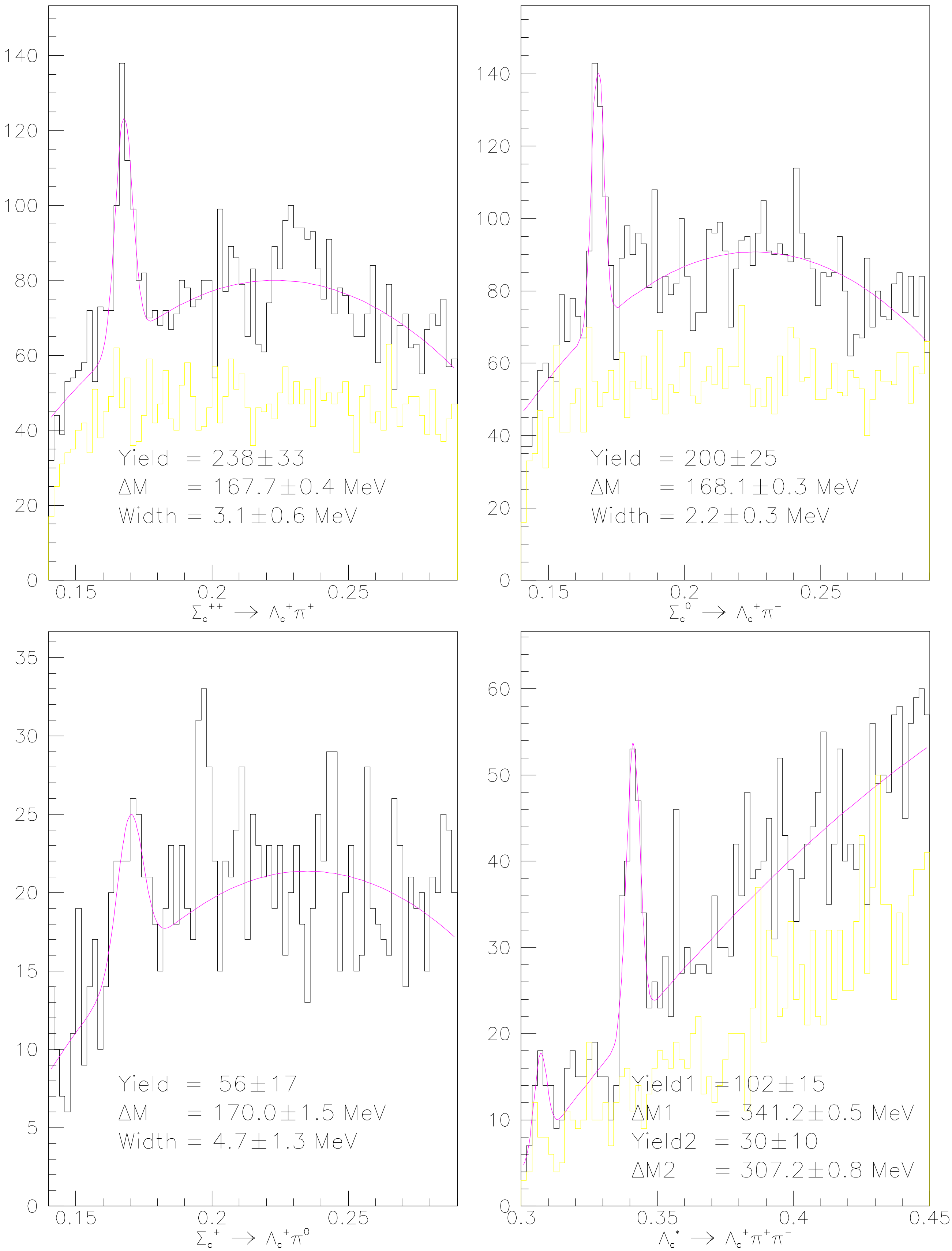


$\Lambda_c^+ \to pK^-\pi^+$, E687 Particle ID

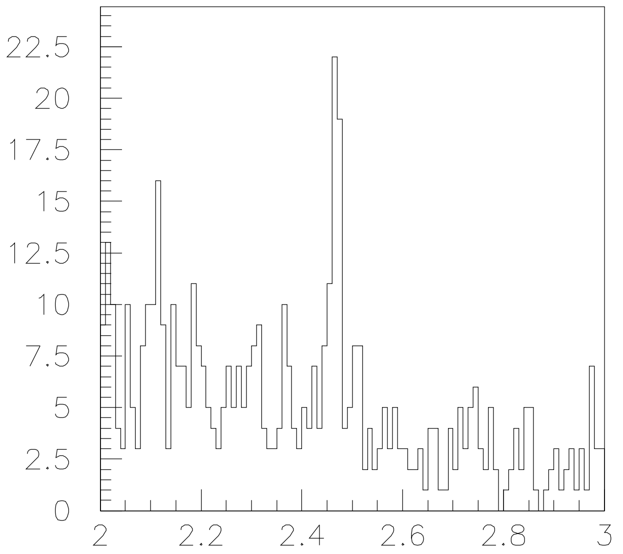
$\Lambda_c^+ \to pK^-\pi^+$, FOCUS Particle ID



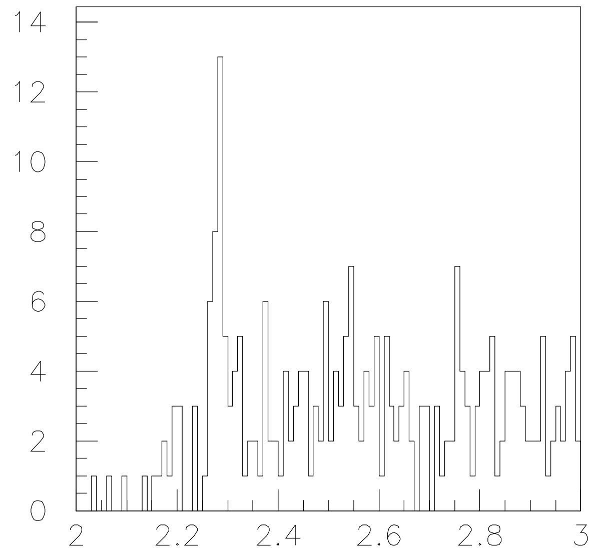
Yield = 4482±126
Width =7.9±0.3 MeV
S/N = 1.06
2250
2000
1750
1500
1250
1000
750
500
250
0
2.05
2.1
2.15
2.2
2.25
2.3
2.35
2.4
2.45
Λ_c used in combinations



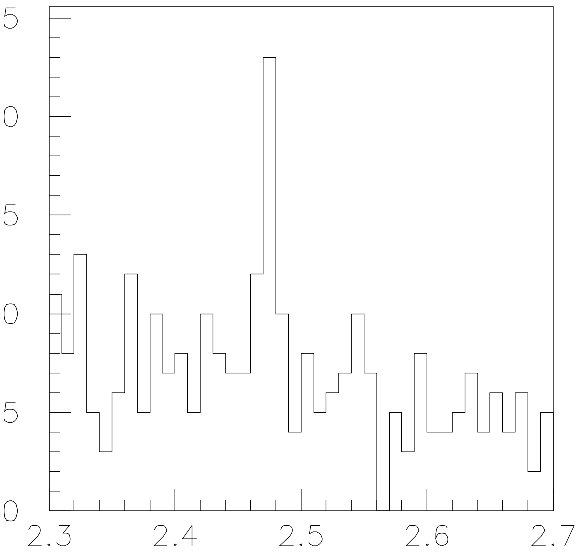
Yield = 238±33
ΔM = 167.7±0.4 MeV
Width = 3.1±0.6 MeV
$\Sigma_c^{++} \to \Lambda_c^+\pi^+$
Yield = 200±25
ΔM = 168.1±0.3 MeV
Width = 2.2±0.3 MeV
$\Sigma_c^{0} \to \Lambda_c^+\pi^-$
Yield = 56±17
ΔM = 170.0±1.5 MeV
Width = 4.7±1.3 MeV
$\Sigma_c^{+} \to \Lambda_c^+\pi^0$
Yield1 = 102±15
ΔM1 = 341.2±0.5 MeV
Yield2 = 30±10
ΔM2 = 307.2±0.8 MeV
$\Lambda_c^{*} \to \Lambda_c^+\pi^+\pi^-$



$\Xi_c^+ \longrightarrow \Xi^- \pi^+ \pi^+$



$\Lambda_c^+ \longrightarrow \Xi^- K^+ \pi^+$



$\Xi_c^0 \longrightarrow \Xi^- \pi^+$