STUDIES OF Ξ_c^0 PRODUCTION AND DECAY AT *BABAR*

Veronique Ziegler, the University of Iowa
On behalf of the BABAR Collaboration

DPF, Riverside CA, 08-30-2004.

OVERVIEW

- GOAL: Measurement of $\frac{B(\Xi_c^0 \to \Omega^- K^+)}{B(\Xi_c^0 \to \Xi^- \pi^+)}$

- Motivation
- Decay Topologies & Selection Criteria
  [*Inclusion of charge conjugate state implied throughout*]
- Study of Ξ_c^0 Production
- Efficiency Correction
- Result
- Systematic Uncertainties
- Summary and Outlook

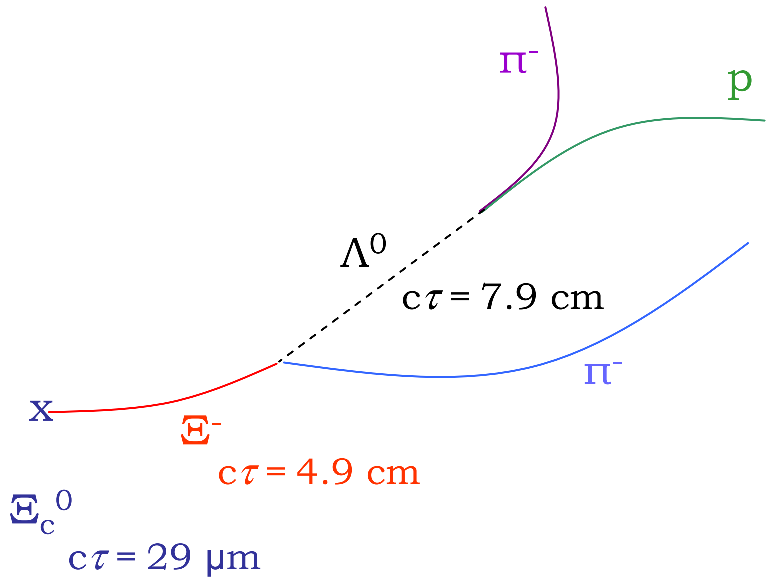
All Results Are *Preliminary*!

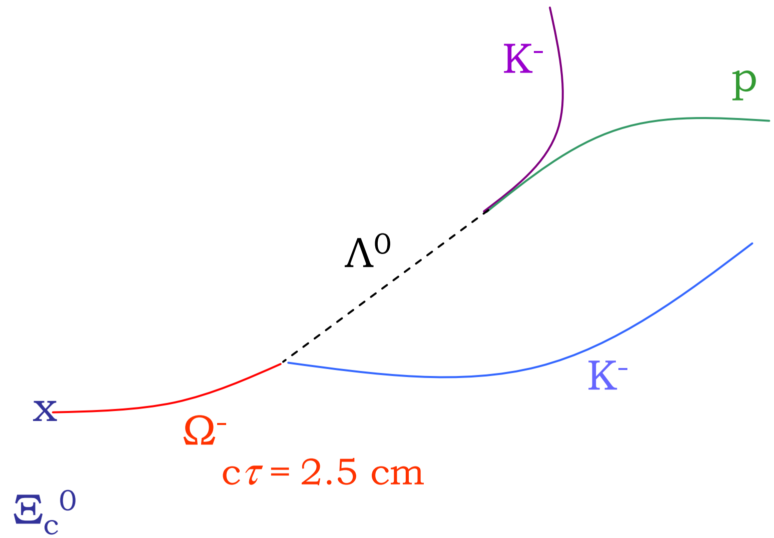
MOTIVATION

- Lots to learn from *charmed baryons*
- Theoretical quark model prediction[1] of $\frac{B(\Xi_c^0 \to \Omega^- K^+)}{B(\Xi_c^0 \to \Xi^- \pi^+)} = 0.32$
- CLEO measurement[2] on 0.5 fb^{-1}: $\frac{B(\Xi_c^0 \to \Omega^- K^+)}{B(\Xi_c^0 \to \Xi^- \pi^+)} = 0.50 \pm 0.21$ (stat.) ± 0.05 (syst.)
- Previous observation[3] for $\Upsilon(4S) \to B\bar{B} \to X + \Xi_c^0 \to \Xi^- \pi^+$, at 3σ level:
  $B(B \to X + \Xi_c^0) \times B(\Xi_c^0 \to \Xi^- \pi^+) = 0.144 \pm 0.048$ (stat.) ± 0.021 (syst.)
- Explore ***charmed baryon*** sector with high luminosity (240 fb^{-1}) at *BABAR*

[1] J.G. Körner, M. Krämer, Z. Phys. C **55**, 659 (1992)
[2] CLEO Collaboration, S. Henderson *et al.*, Phys. Lett. B **283**, 161 (1992)
[3] CLEO Collaboration, B. Barish *et al.*, Phys. Rev. Lett. **79**, 3599 (1997)

Decay Topologies & Selection Criteria





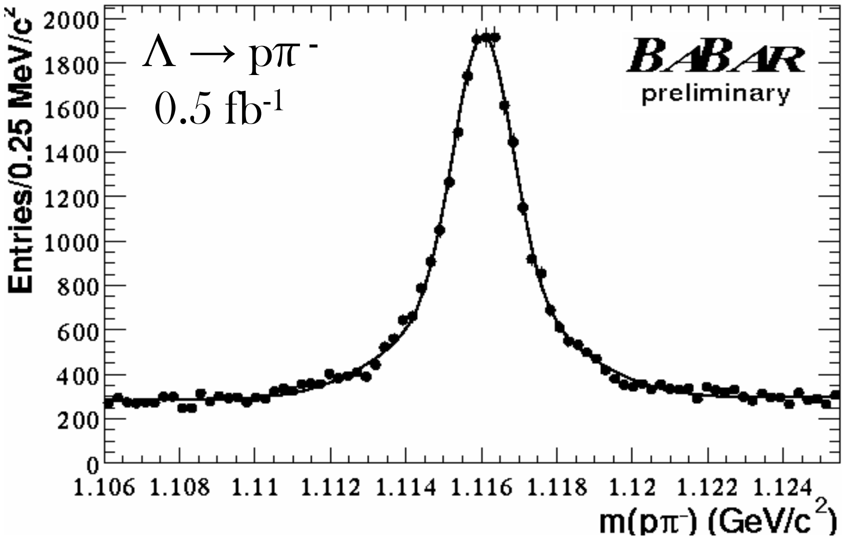
$\Lambda^0 \rightarrow p\pi^-$
- Proton identified using *dE/dx* *& Cherenkov info (DIRC)*
- ~ ±3σ mass window

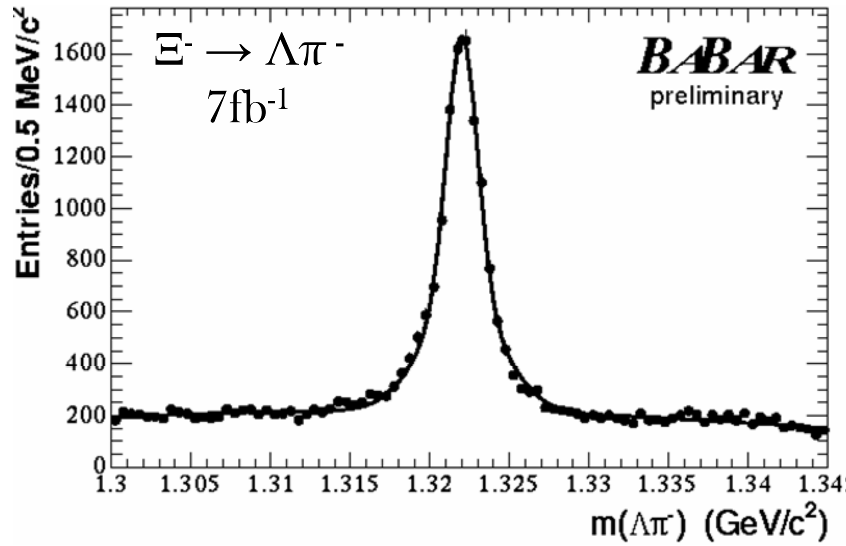
$\Xi^-\pi^+$
- Ξ^-: 1316-1330 MeV/c^2
- $r_\Xi > 2.5$ mm
- $r_\Lambda > r_\Xi$

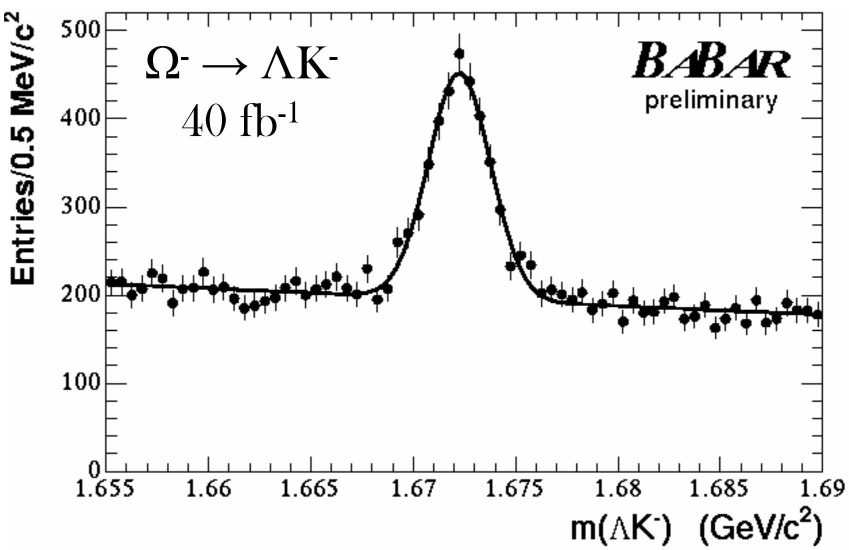
Ω^-K^+
- Ω^-: 1316-1330 MeV/c^2
- $r_\Omega > 1.5$ mm
- *Signed* flight dist. of Λ >3.0 mm
- Kaons identified using *dE/dx* *& Cherenkov info (DIRC)*

r ≡ radius of vertex in transverse plane w.r.t. collision axis

Hyperon Mass Distributions





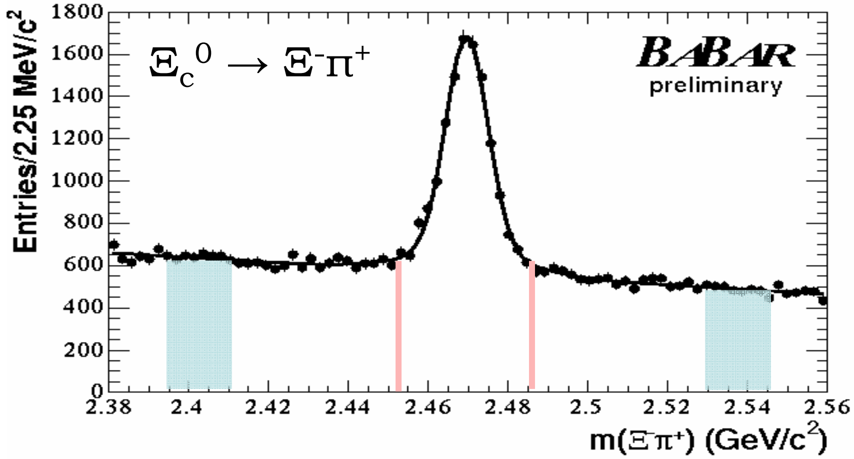


- Full analysis: 116 fb^{-1}
- Optimization of selection criteria:
  - ↳ 20 fb^{-1} ($\Xi^-\pi^+$) & 40 fb^{-1} (Ω^-K^+)
    - ☞ Minimize selection bias

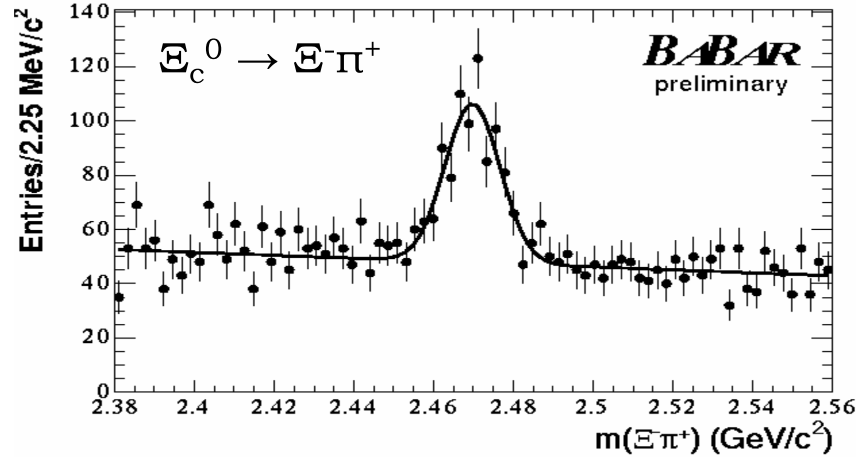
RECONSTRUCTED Ξ_c^0 CANDIDATES

On-Peak Data Sample: Total = 105.4 fb^{-1}
[*At Y(4S)*]

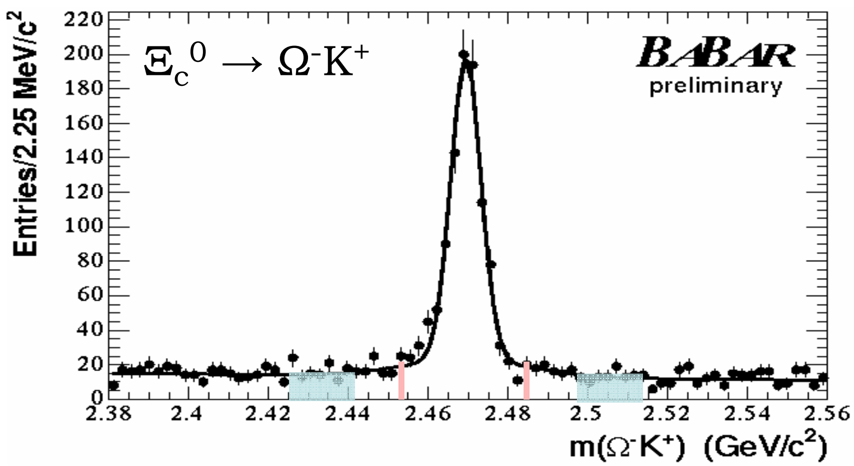
Off-Peak Data Sample: Total = 10.7 fb^{-1}
[*Below Y(4S)*]



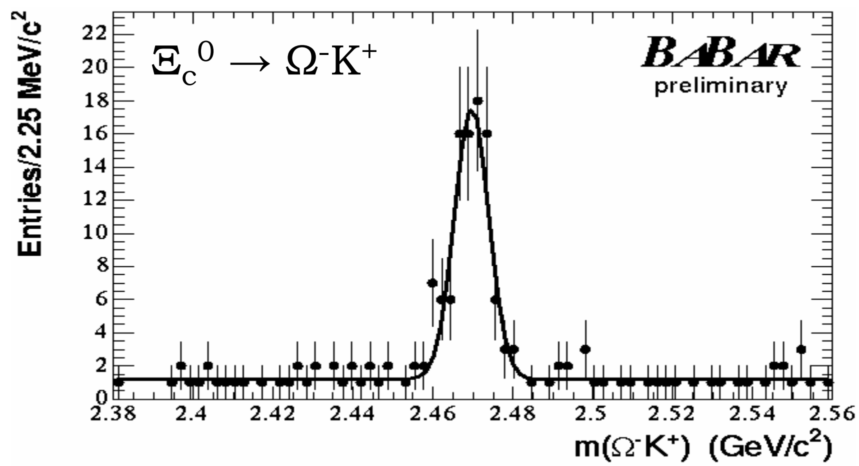
Double Gaussian on Linear Bg



Single Gaussian on Linear Bg



Double Gaussian on Linear Bg

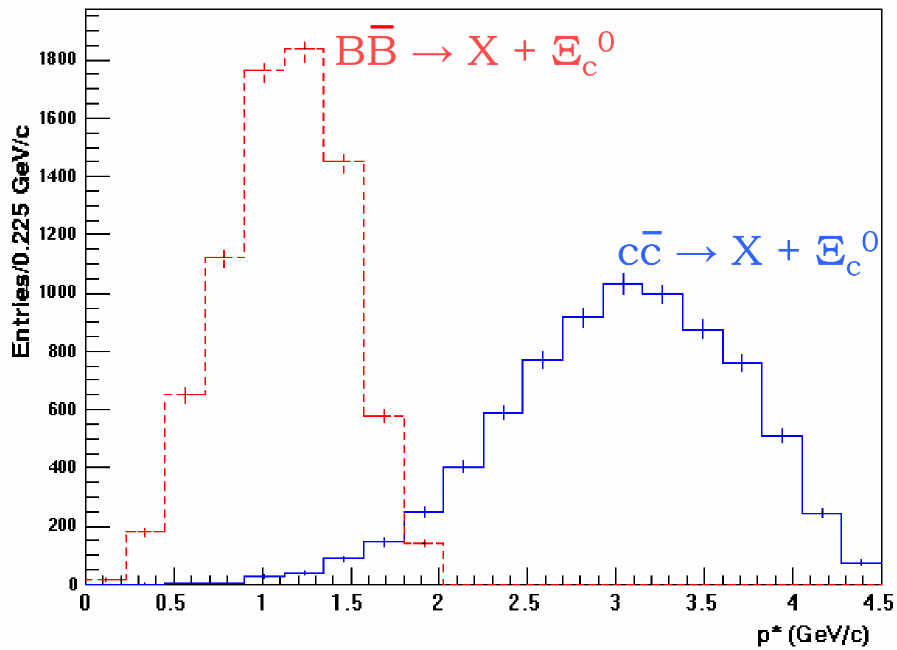


Single Gaussian on Linear Bg

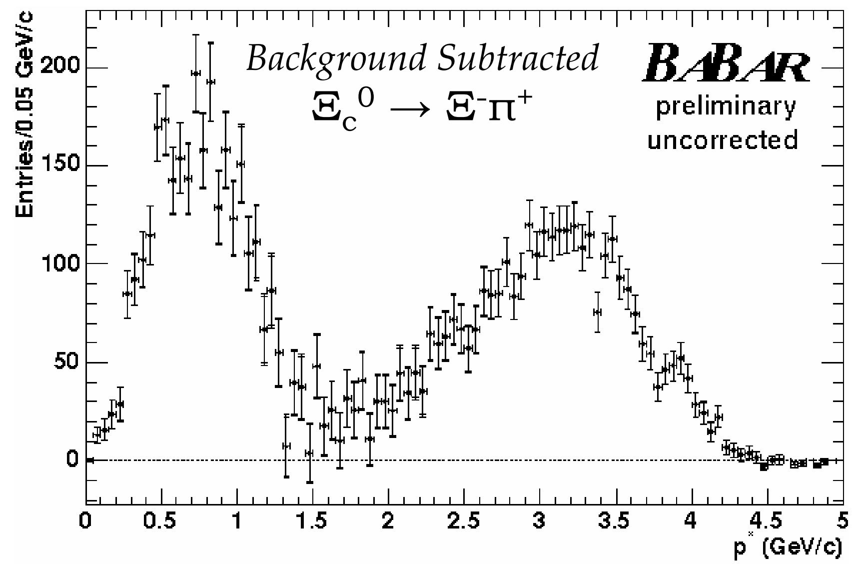
P* DISTRIBUTION OF Ξ_c^0 CANDIDATES

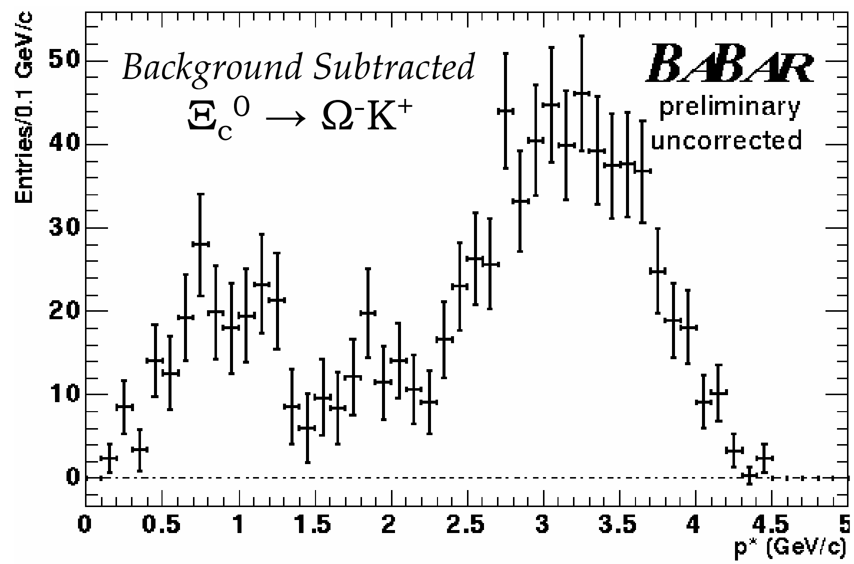
☞ *Investigating the Production of Ξ_c^0's*

SIGNAL MONTE CARLO



ON-PEAK DATA





Events with Ξ_c^0's produced from B decays

Events with Ξ_c^0's produced from $c\bar{c}$ continuum

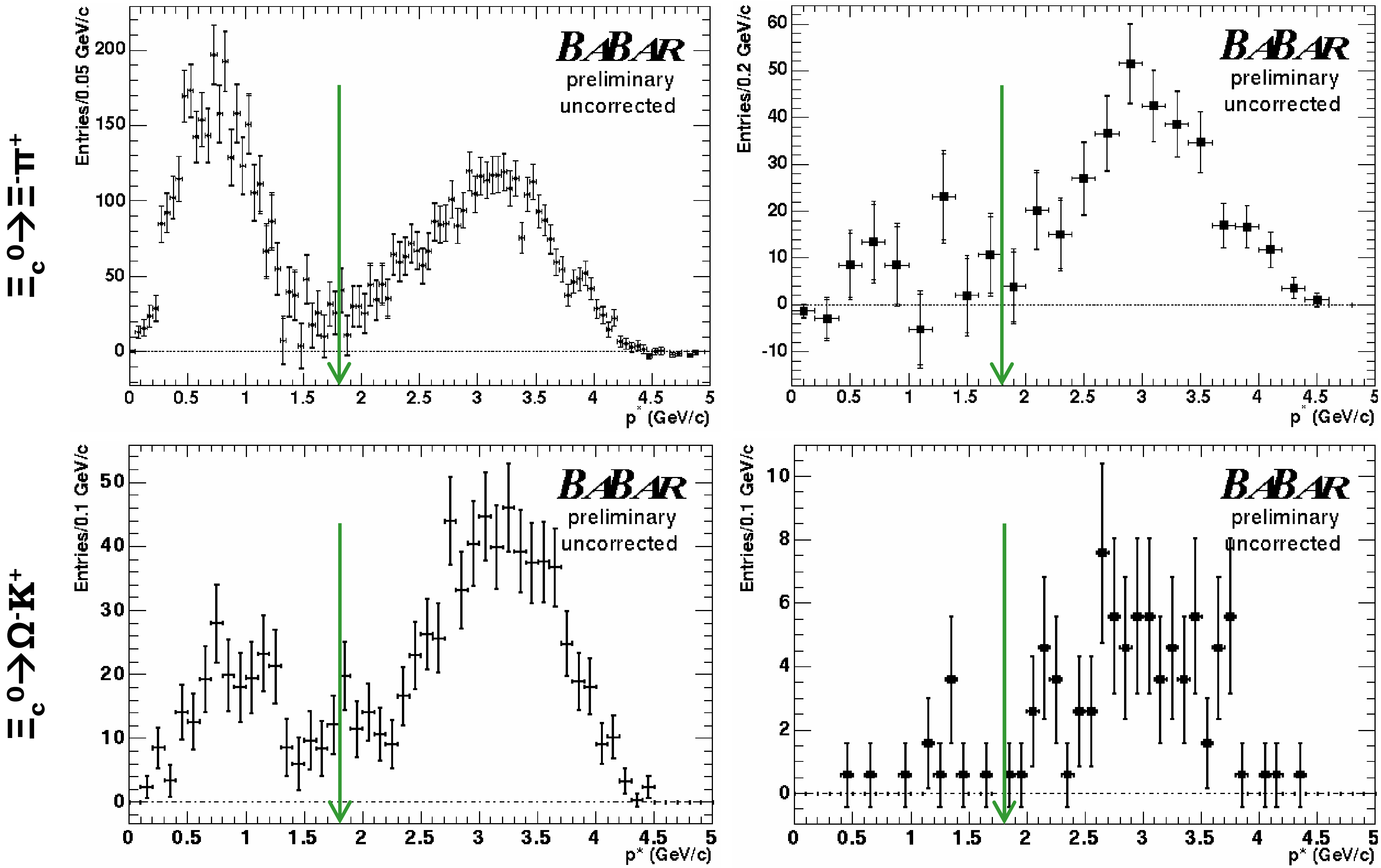
MASS SIDEBAND SUBTRACTED P* DISTRIBUTIONS

On-Peak Data Sample

[At $B\bar{B}$ Production Threshold]

Off-Peak Data Sample

[Below $B\bar{B}$ Production Threshold]

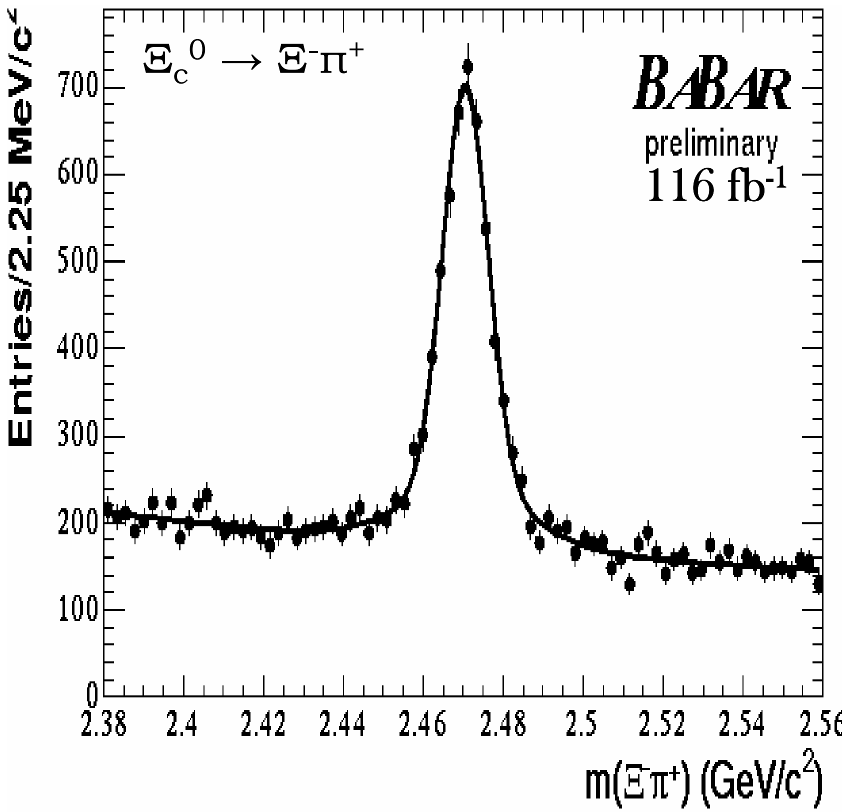


Evidence of Ξ_c^0 Production from B Decays

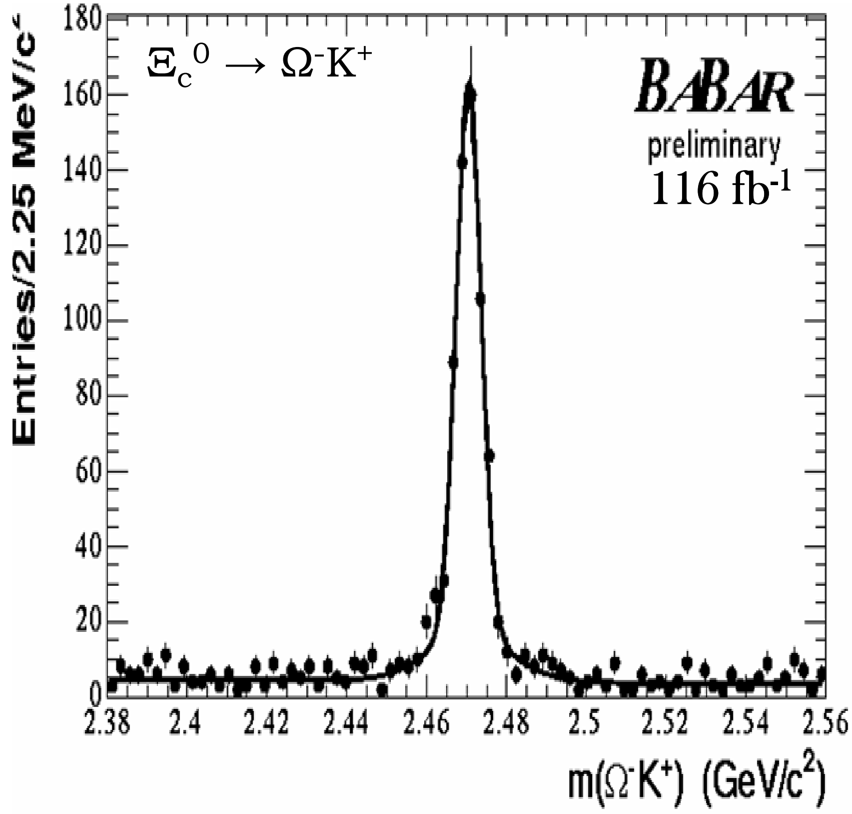
No B Production

ON&OFF-PEAK MASS SPECTRA FOR Ξ_c^0 CANDIDATES

❋ p*>1.8 GeV/c ⇨ *Clean* Ξ_c^0 Signal



Double Gaussian on Linear Bg



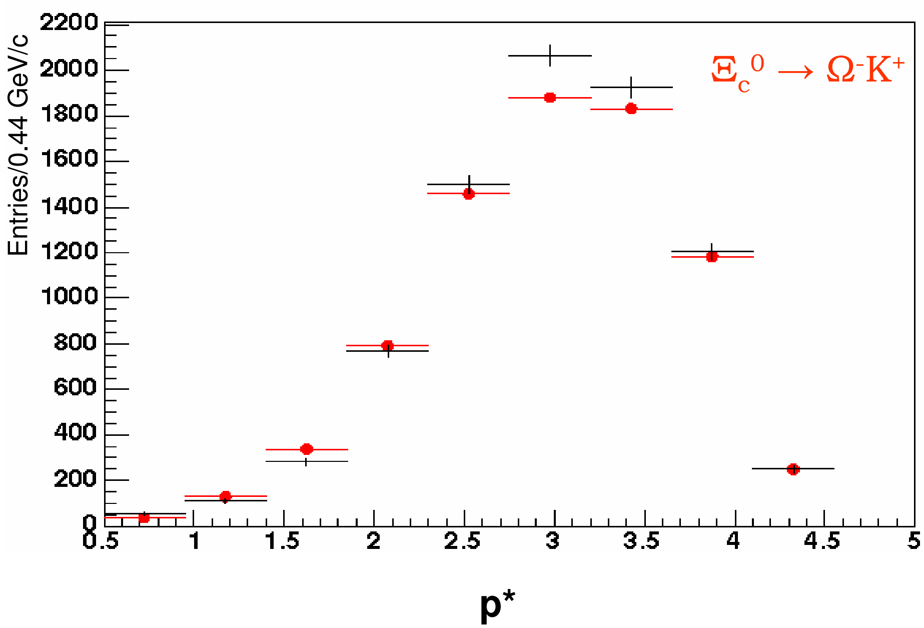
Double Gaussian on Linear Bg

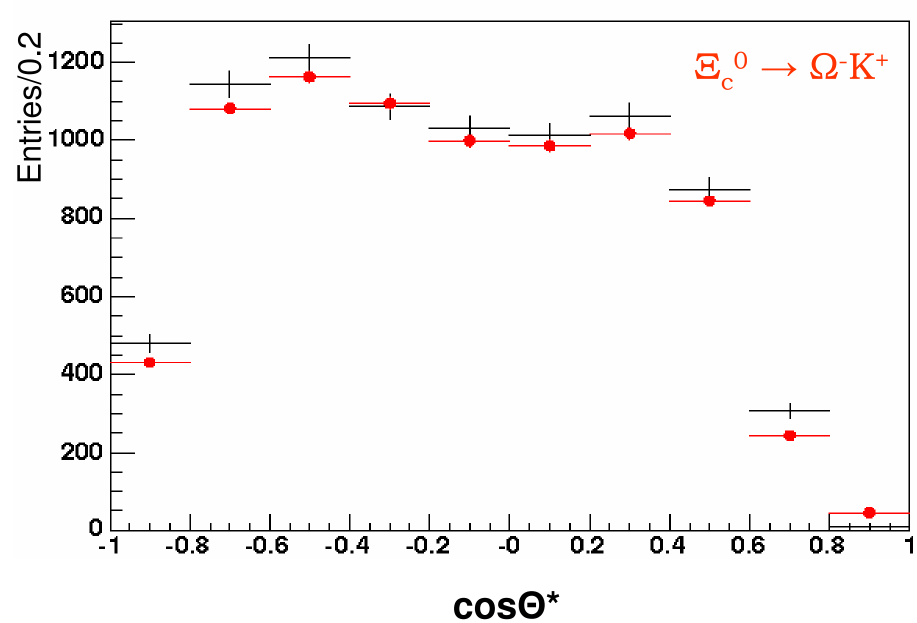
TWO-DIMENSIONAL EFFICIENCY PARAMETERIZATION

$\mathcal{E}ff(p^*, \cos^*\Theta)$ = 15 Parameter function of the form:

Quadratic(p^*) $\otimes$ Quartic($\cos\Theta^*$)

$e^+e^- \rightarrow c\bar{c} \rightarrow X + \Xi_c^0$





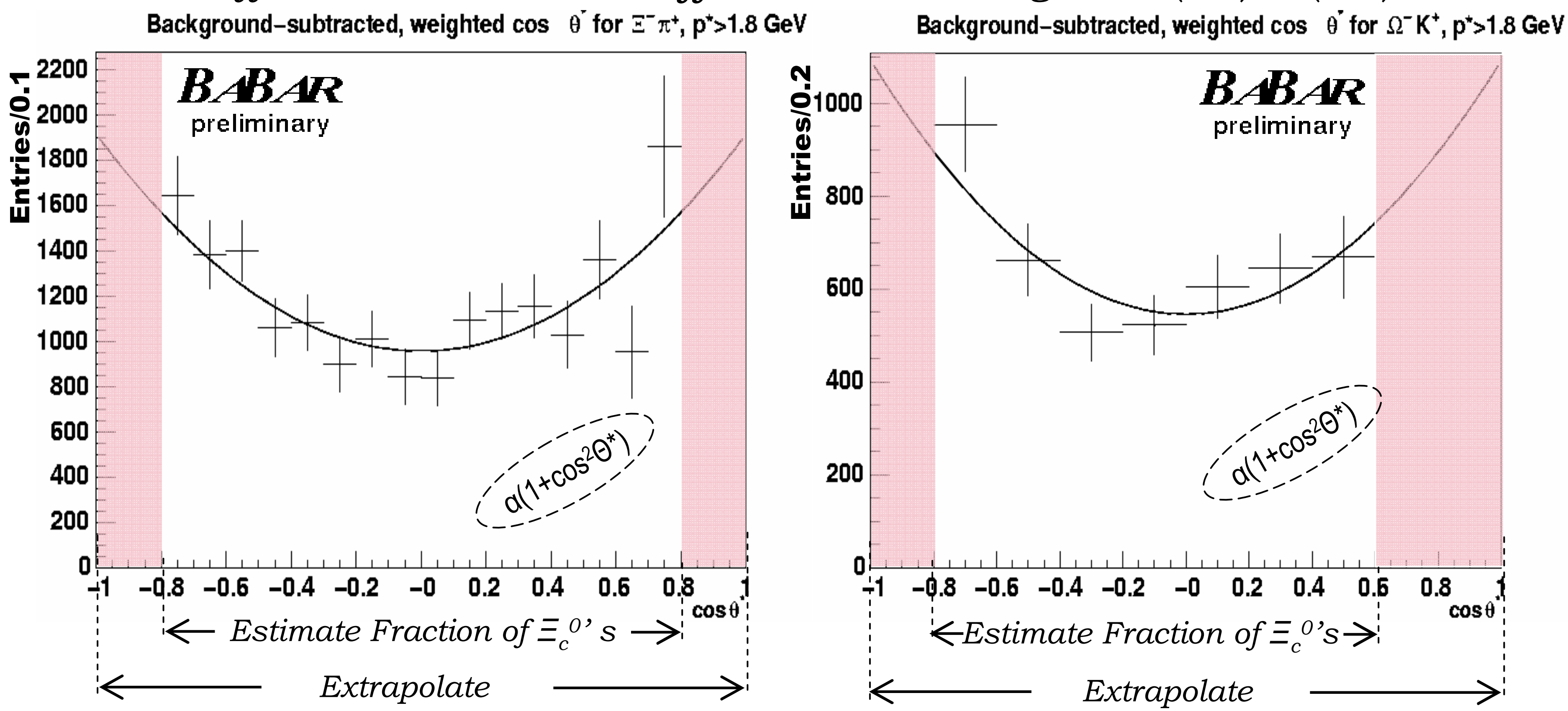
(—●—) Generated x $\mathcal{E}ff(p^*, \cos\Theta^*)$

(—|—) Reconstructed M.C.

Acceptance Correction for Ξ_c^0 Candidates

Ξ_c^0 Candidates → Weighted by $1/\mathcal{E}ff\,(p^*, \cos\Theta^*)$

✵ *Different* kinematics ⇨ *different* $\cos\Theta^*$ ranges for $(\Xi\pi)$ & (ΩK)



Obtain the Total Number of Efficiency Corrected Signal Events for $-1<\cos\Theta^*<1$

$$\frac{B(\Xi_c^0 \rightarrow \Omega^- K^+)}{B(\Xi_c^0 \rightarrow \Xi^- \pi^+)} = 0.296 \pm 0.018\ (\text{stat.})$$

CROSS-CHECKS & SYSTEMATIC UNCERTAINTIES

Cross-checks:

☞ Calculate ratio from off-peak data only
↳ ***consistent*** with main result

☞ Divide the data into 3 p* ranges and calculate the ratio for each range
↳ ***consistent*** with being independent of p* within statistical uncertainties

Systematic uncertainties:

Source	**Uncertainty**
Fits to mass spectrum	**0.019**
cosΘ* Distribution	**0.016**
Efficiency	**0.015**
Limited Monte Carlo Statistics	0.004
Multiple candidates	0.004
Charge asymmetry	0.001
Particle ID	0.006
Omega$^-$ branching fraction	0.003
Total systematic uncertainty	**0.030**

SUMMARY

- We observe Ξ_c^0 production in continuum $c\bar{c}$ events and for **$\Upsilon(4S) \rightarrow B\bar{B} \rightarrow \Xi_c^0 + X$**, using the *BABAR* detector at SLAC
- **We report a first observation of $B \rightarrow X + \Xi_c^0 \rightarrow \Omega^- K^+$**
- We present a *significant* improvement on the existing[1] PDG value [0.50 ± 0.21(stat) ± 0.05(syst)]:

$$\frac{B(\Xi_c^0 \rightarrow \Omega^- K^+)}{B(\Xi_c^0 \rightarrow \Xi^- \pi^+)} = 0.296 \pm 0.018\ (\text{stat.}) \pm 0.030\ (\text{syst.})$$

where the theoretical prediction[2] is 0.32

- **hep-ex/0408056**

[1] CLEO Collaboration, S. Henderson *et al.*, Phys. Lett. B **283**, 161 (1992)
[2] J.G. Körner, M. Krämer, Z. Phys. C **55**, 659 (1992)

OUTLOOK

- Study of Ξ_c^0 production from B decays in the $\Omega^- K^+$ and $\Xi^- \pi^+$ final states
- Study of other charmed baryons
- Measure the inclusive production of Ω^- from B decays
- Do the analyses on 240 fb^{-1} now available at *BABAR*

BACKUP SLIDES

➢Used region of phase space with *well-defined* efficiency.

↳To examine the stability of the result → vary the range of cosΘ*

Range	Fitted yield in range	Fraction of $(1+\cos^2\theta^*)$ in range	Total yield
$(-0.90, +0.80)$	21443 ± 415	79.3%	27040 ± 523
$(-0.80, +0.80)$	19375 ± 393	72.8%	26621 ± 540
$(-0.70, +0.80)$	17733 ± 378	66.9%	26507 ± 565
$(-0.80, +0.60)$	16543 ± 330	64.6%	25608 ± 511
$(-0.80, +0.70)$	17434 ± 341	66.9%	26060 ± 510
$(-0.80, +0.90)$	20931 ± 588	79.3%	26395 ± 742
$(-0.80, +0.00)$	9599 ± 240	36.4%	26371 ± 659
$(-0.00, +0.80)$	9977 ± 317	36.4%	27409 ± 871

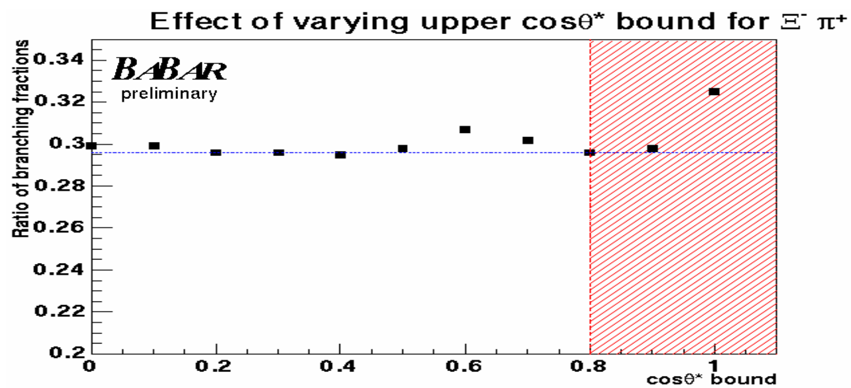
The effect of varying the $\cos\theta^*$ range for $\Xi^-\pi^+$.

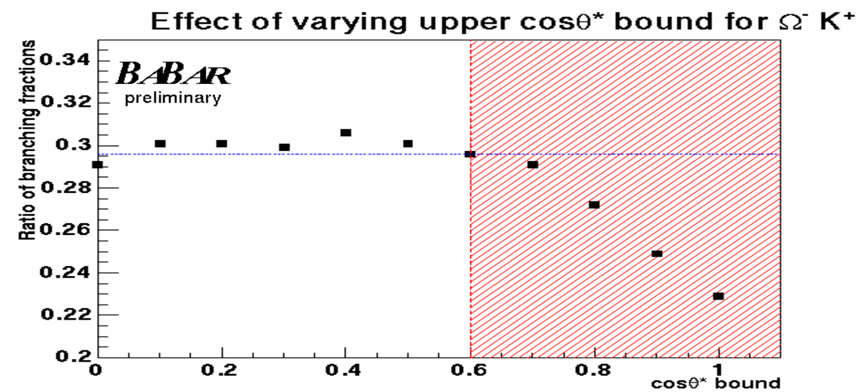
Range	Fitted yield in range	Fraction of $(1+\cos^2\theta^*)$ in range	Total yield
$(-0.60, +0.60)$	3784 ± 162	50.4%	7508 ± 321
$(-0.70, +0.60)$	4127 ± 169	55.7%	7409 ± 296
$(-0.80, +0.60)$	4866 ± 283	61.6%	7874 ± 458
$(-0.80, +0.65)$	5027 ± 197	64.2%	7830 ± 307
$(-0.80, +0.50)$	4544 ± 173	56.7%	8014 ± 305
$(-0.80, +0.00)$	2816 ± 138	36.4%	7736 ± 379
$(-0.00, +0.60)$	1938 ± 175	25.2%	7690 ± 694

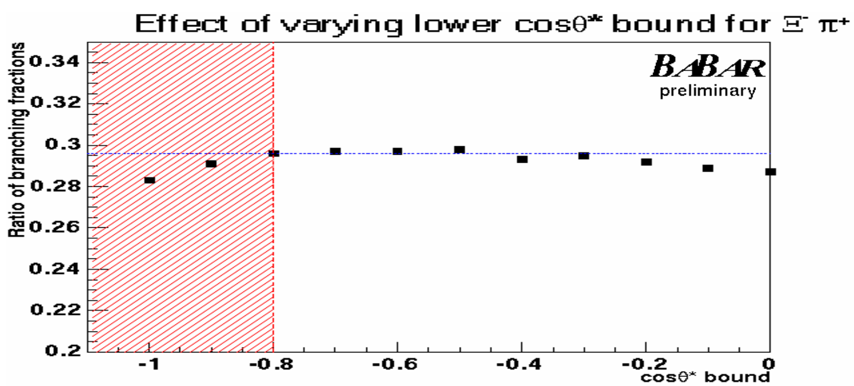
The effect of varying the $\cos\theta^*$ range for $\Omega^-\mathrm{K}^+$.

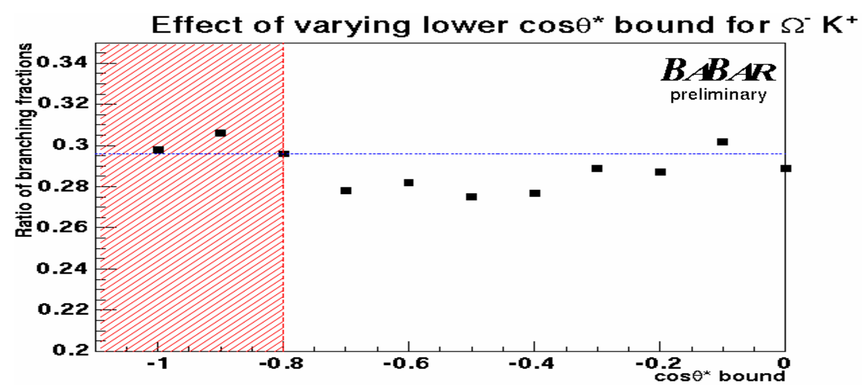
No systematic trend

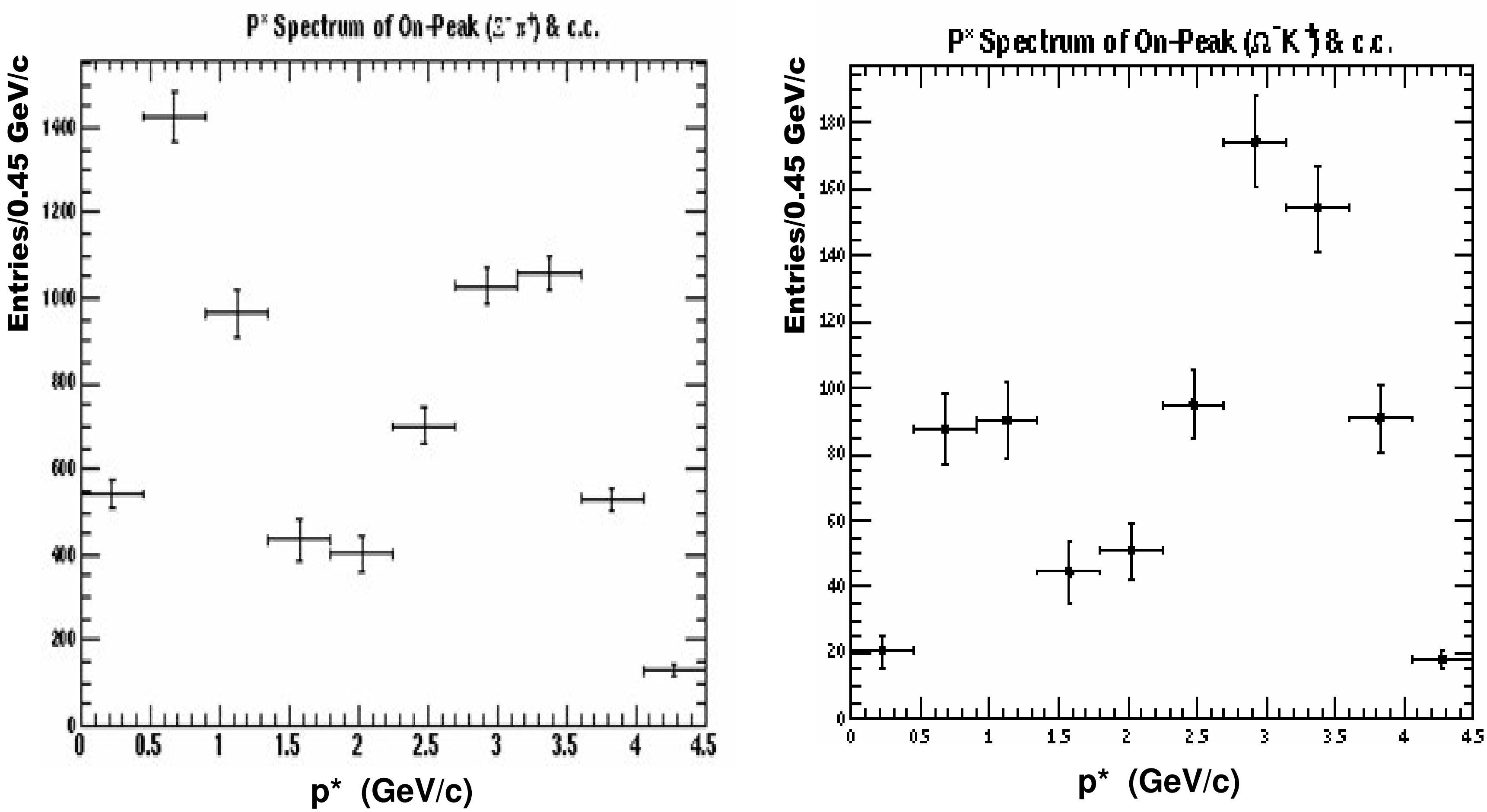
↳ Extrapolation *sound*!


Effect of varying upper cosθ* bound for Ξ⁻ π⁺
BABAR
preliminary
Ratio of branching fractions
0.34
0.32
0.3
0.28
0.26
0.24
0.22
0.2
0
0.2
0.4
0.6
0.8
1
cosθ* bound


Effect of varying upper cosθ* bound for Ω⁻ K⁺
BABAR
preliminary
Ratio of branching fractions
0.34
0.32
0.3
0.28
0.26
0.24
0.22
0.2
0
0.2
0.4
0.6
0.8
1
cosθ* bound


Effect of varying lower cosθ* bound for Ξ⁻ π⁺
BABAR
preliminary
Ratio of branching fractions
0.34
0.32
0.3
0.28
0.26
0.24
0.22
0.2
-1
-0.8
-0.6
-0.4
-0.2
0
cosθ* bound


Effect of varying lower cosθ* bound for Ω⁻ K⁺
BABAR
preliminary
Ratio of branching fractions
0.34
0.32
0.3
0.28
0.26
0.24
0.22
0.2
-1
-0.8
-0.6
-0.4
-0.2
0
cosθ* bound



p^* distribution from Ξ_c^0 decays from on-peak data, obtained from making ten slices in p* from 0 – 4.5 GeV/c, i.e., 0.45 GeV/c each, and fitting the reconstructed Ξ_c^0 mass spectrum in each bin with a signal Gaussian shape on a linear background. The fitted number of signal events is plotted from each slice for (a) $\Xi^-\pi^+$ mode (b) Ω^-K^+ mode.