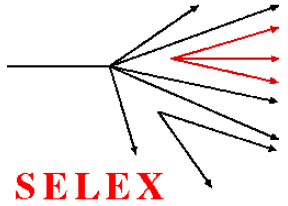


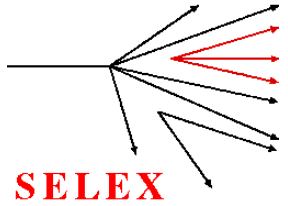
Ξ_c^+ Lifetime Measurement from SELEX (E781) Experiment

Ugur Akgun

for the

SELEX Collaboration

The SELEX (Fermilab E781) Collaboration



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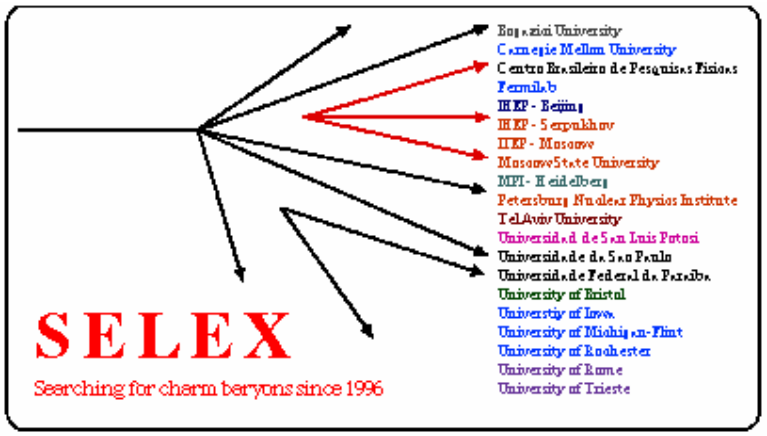
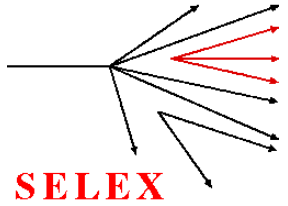
SELEX Experiment at Fermilab





SELEX

"Segmented Large x_F Baryon Spectrometer"

- Unique hadro-production with small p_T ($p_T < 3$ GeV/c) and large x_F ($x_F > 0.1$)
- Typical Lorentz Boost ~ 100
- Took data during the 1996-97 fixed target run at Fermilab
- 1 x 10^9 events with 600 GeV Σ^-, π^- and 540 GeV p beams.
- Charm physics program
  - Production
  - Decay Physics
  - Spectroscopy

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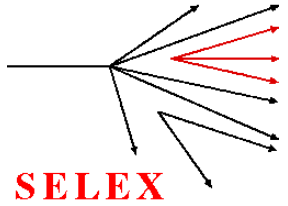
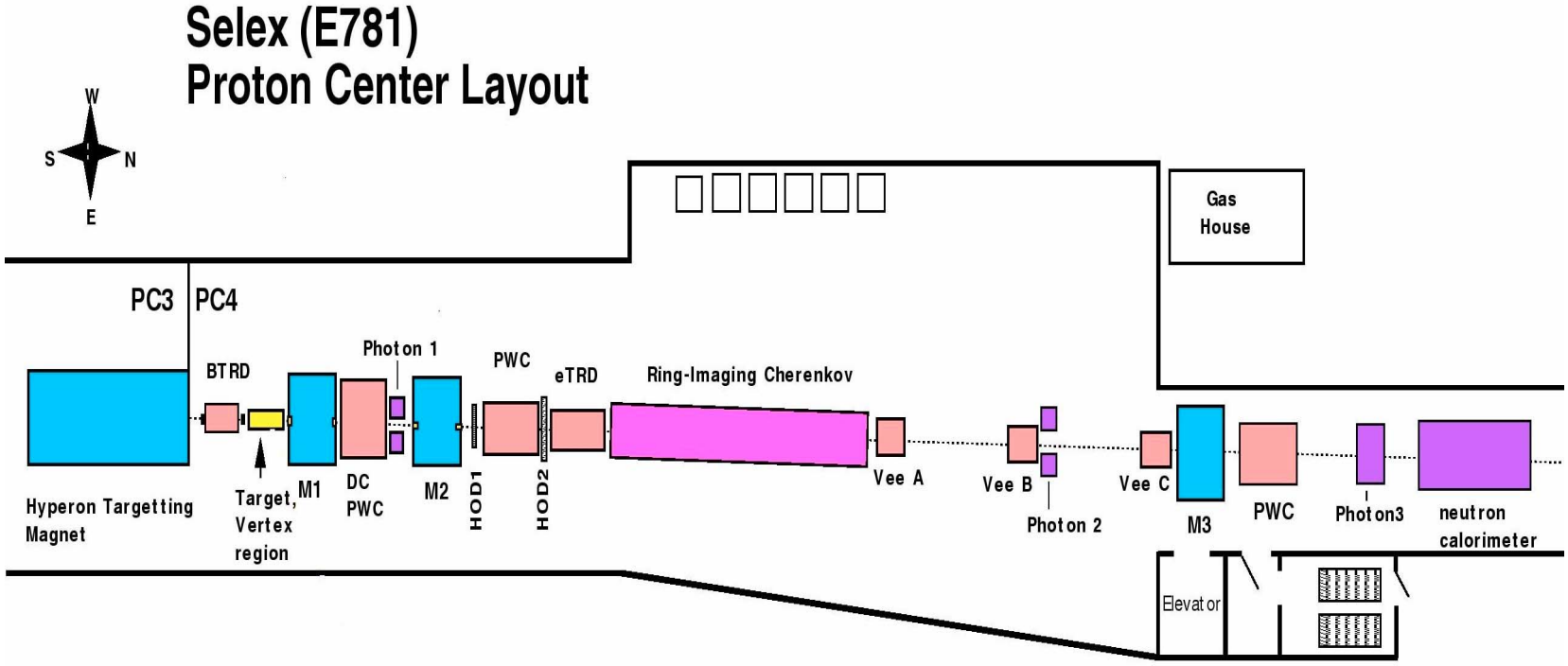
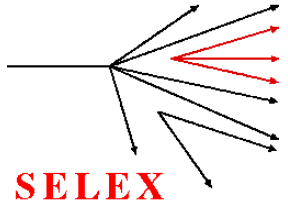
The SELEX Spectrometer





- Five-Stage Spectrometer: Beam, Vertex, M1, M2, M3
- Each Spectrometer, except Vertex, includes one bending magnet and associated detectors.

The SELEX Spectrometer

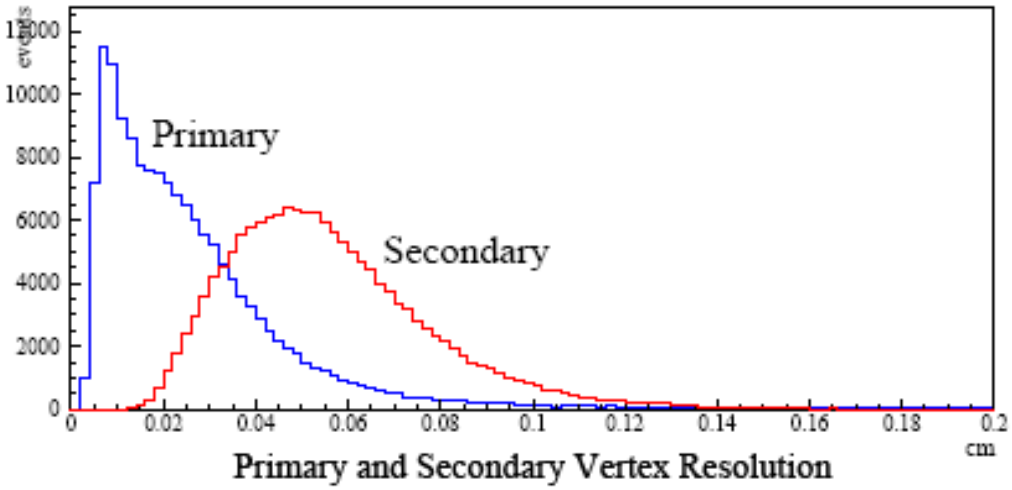


- Segmented charm targets (2 Cu and 3 C), with combined interaction length of 4.3%, and target spacing 1.5 cm.
- High precision, 20 plane silicon, vertex detector σ_{prim}: 270 μm, σ_{sec}: 550 μm
- Particle identification: 2σ K/π separation up to 165 GeV/c
  - Beam TRD and Electron TRD
  - Ring Imaging Cerenkov Detector
  - Lead Glass Photon Detectors
- Analyzing magnets (M1-M2-M3)
- Downstream tracking $\Delta p/p \sim 0.5\%$ for 100 GeV
  - 18 large silicon planes ($\sigma \sim 8\mu m$)
  - 26 PWC and 3 x 24 VDC

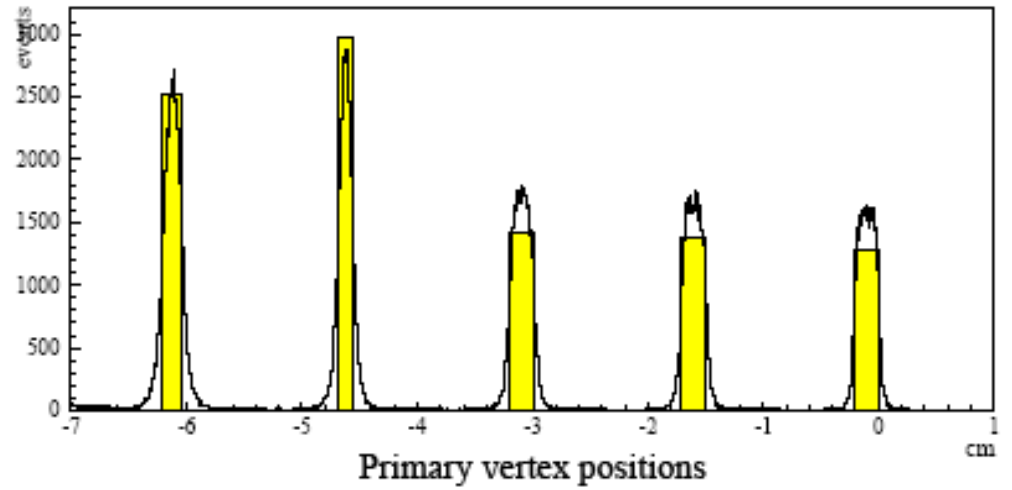
Vertex Spectrometer Performance

SELEX

- Transverse vertex resolution 8-15 μm
- 20 highly-efficient vertex planes determine tracks, reduce tracking confusion in high-multiplicity events
- Target foils 0.8-2.2 mm thick with 1.5 cm spacing to localize primary interaction
- Average proper-time resolution ~20 fs for charm decays

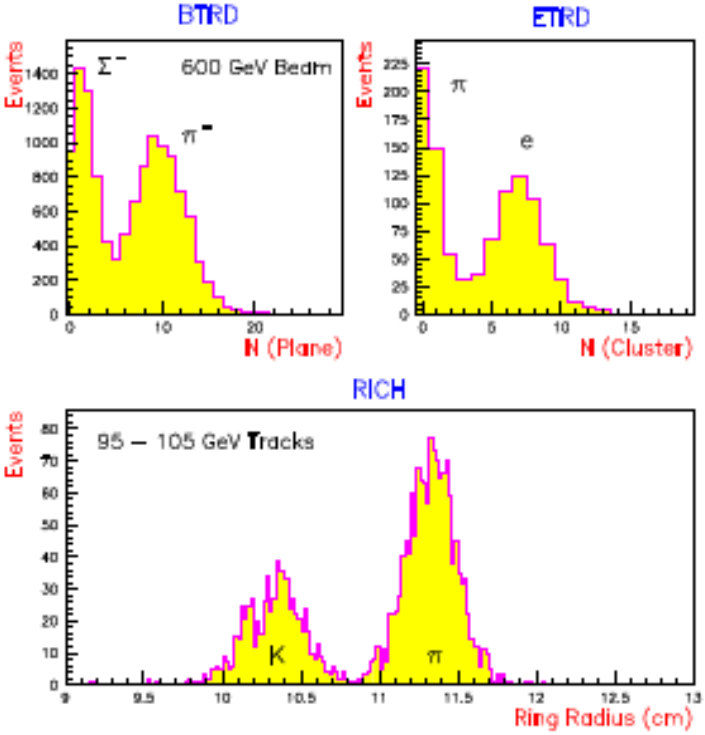


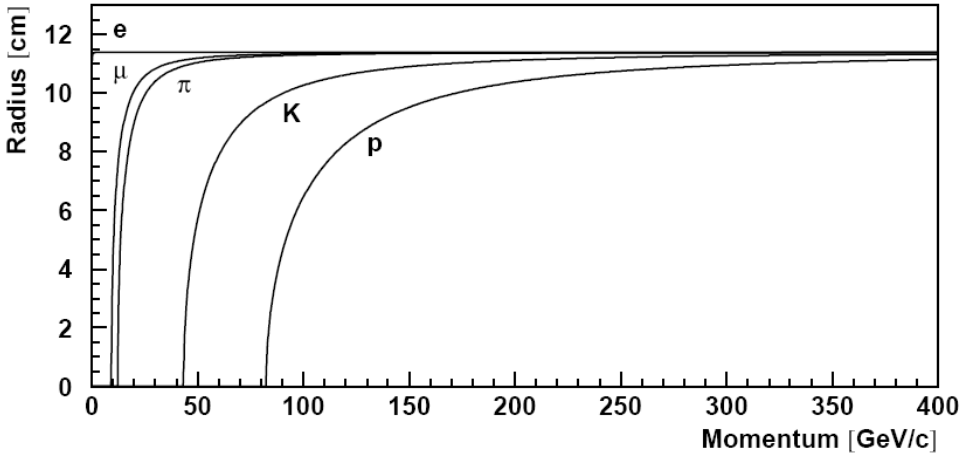
Primary and Secondary Vertex Resolution



Primary vertex positions

Charged Particle Identification





RICH

- Ring Radius = 1.56 mm
- 2σ K/π separation up to 165 GeV
- Pion mis-identification rate ~ 4%

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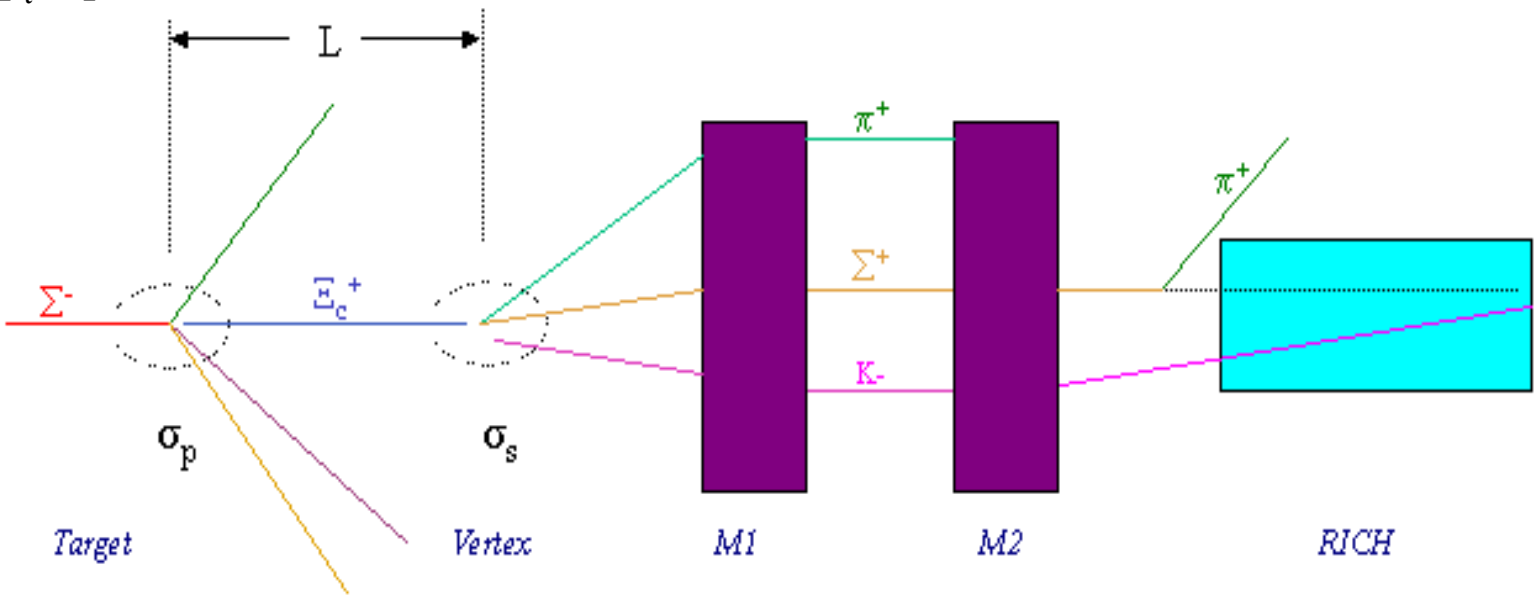
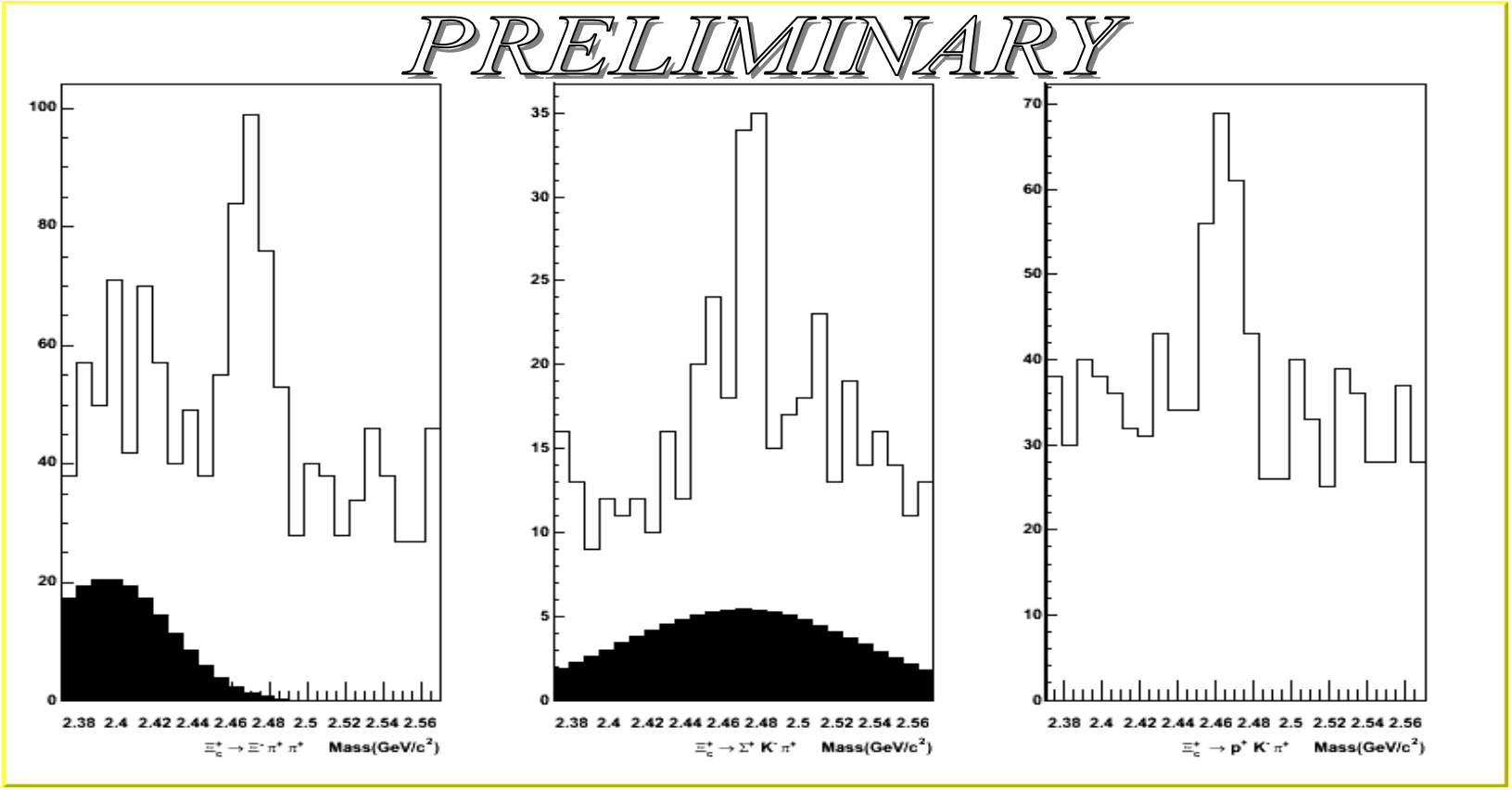
Event Selection Criteria

- 3D decay vertex must lies outside target material
- RICH identification probability on decay products
- Decay vertex separation significance (L/σ): L is the distance between the primary and the secondary vertices and $\sigma_L = (\sigma_{prim}^2 + \sigma_{sec}^2)^{1/2}$
- Charm vector points back to primary (b/σ_{prim}): Impact parameter of the extrapolated track with respect to the primary vertex divided by σ_{prim}
- 2nd largest miss significance among decay tracks
- Σp_t^2, pion momentum cuts.



Three Decay Channels

SELEX

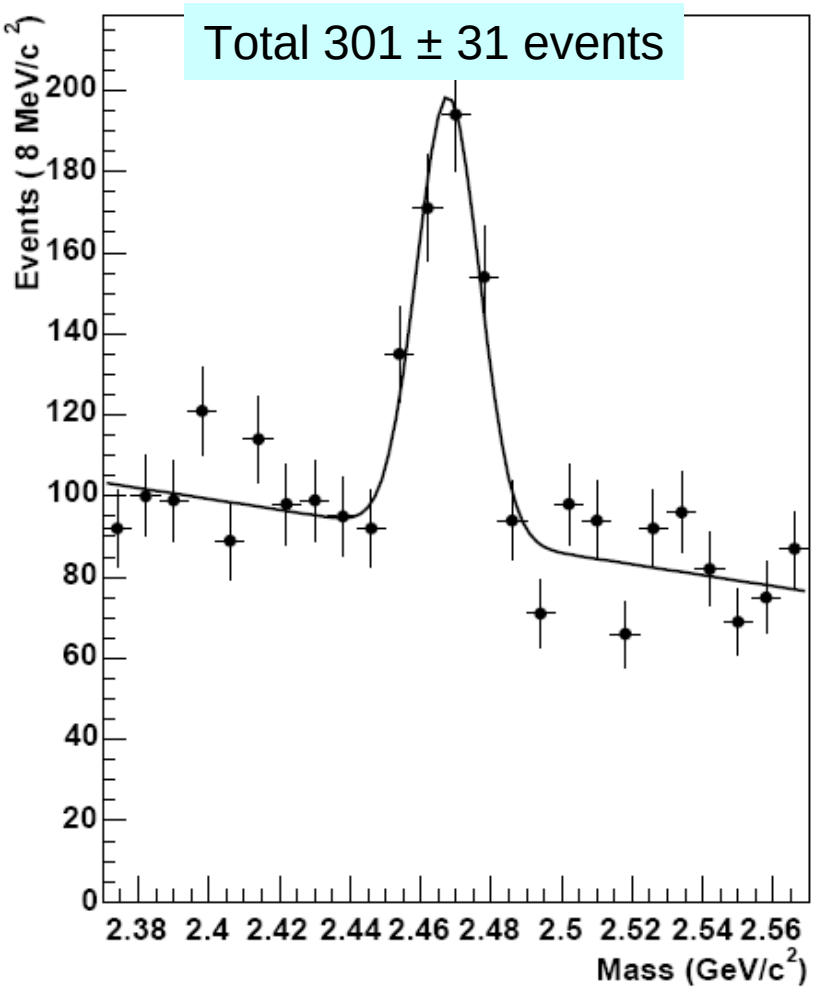


$\Xi_c^+ \rightarrow \Xi^- \pi^+ \pi^+$ 157 ± 21 events

$\Xi_c^+ \rightarrow \Sigma^+ k^- \pi^+$ 46 ± 11 events

$\Xi_c^+ \rightarrow p^+ k^- \pi^+$ 98 ± 17 events

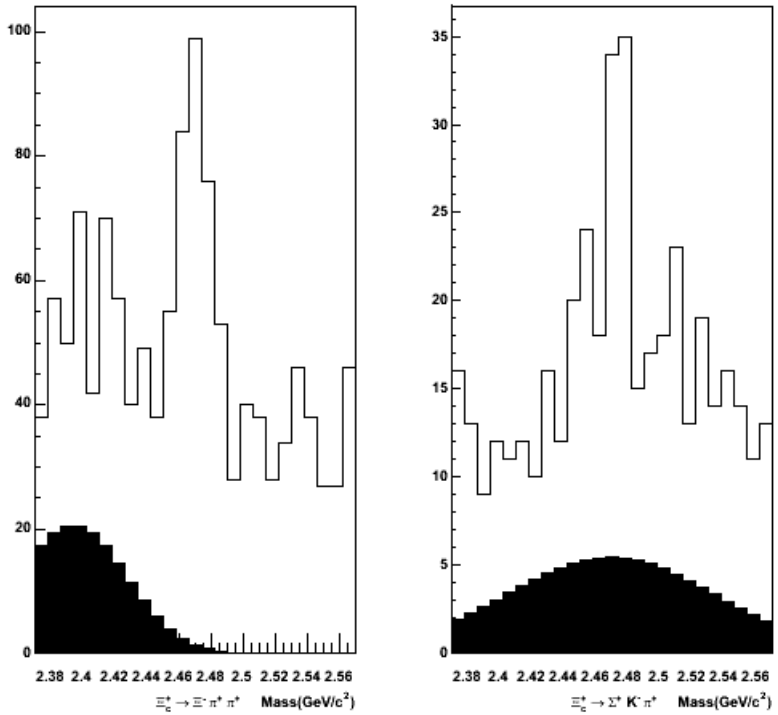
Total Signal



Decay Channel	Number of Events
$\Xi_c^+ \rightarrow \Xi^- \pi^+ \pi^+$	157±21
$\Xi_c^+ \rightarrow p^+ k^- \pi^+$	98±17
$\Xi_c^+ \rightarrow \Sigma^+ k^- \pi^+$	46±11
Total	301±31

PRELIMINARY

Possible Reflection From Λ_c^+

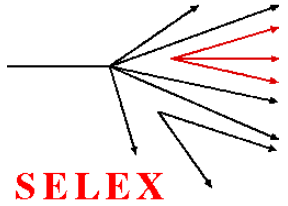


PRELIMINARY

Possible Reflection from Λ_c^+ :

- $\Lambda_c^+ \rightarrow \Sigma^- \pi^+ \pi^+$ $\quad$ $\Lambda_c^+ \rightarrow \Sigma^+ \pi^- \pi^+$
- Σ^- misidentified as Ξ^- or π^- as K^-
- Assumed 100% misidentification.
- The shapes are determined by Monte Carlo simulations
- The areas are normalized to the observed number of signal events in Λ_c^+ data

Lifetime Technique



We used binned maximum likelihood fitting technique to determine the lifetime. This fit was applied to a reduced proper time distribution;

$$t' = t - t_{min} = \frac{L - N\sigma_L}{\beta\gamma c}$$

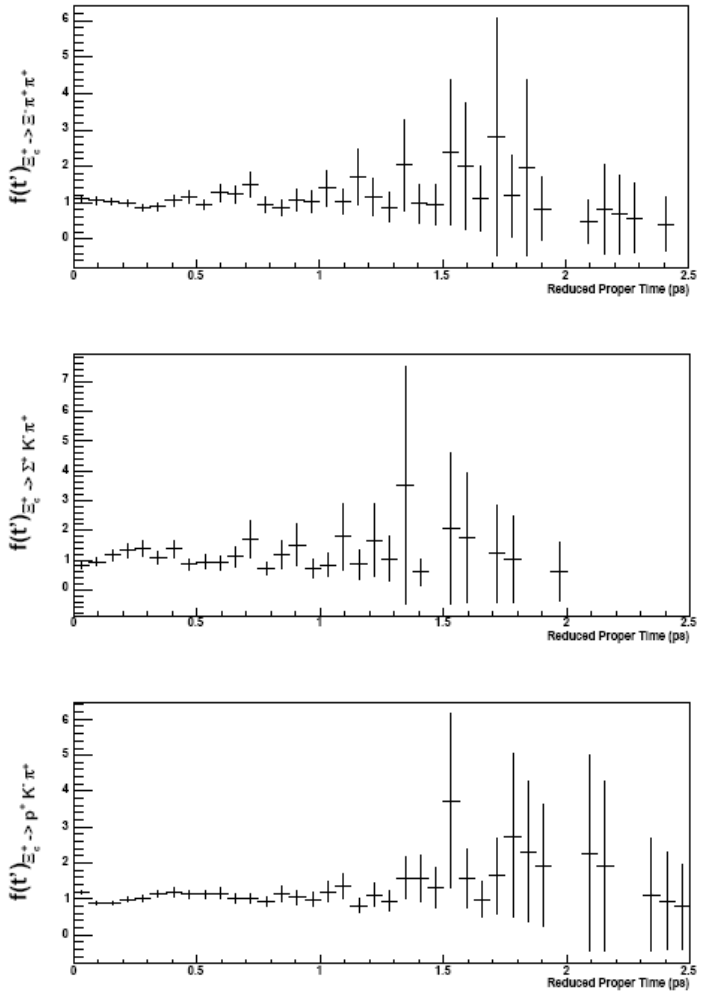
Where N is the significance of the detachment cut.
The probability density function is defined as;

$$P(\tau_{\Xi_c^+}, \tau_{Bckg}, \alpha, \beta, t') = N_s(((1-\beta) - A)\frac{e^{-t'/\tau_{\Xi_c^+}}}{\tau_{\Xi_c^+}} f(t') + \beta B(t') + A\frac{e^{-t'/\tau_{\Lambda_c^+}}}{\tau_{\Lambda_c^+}})$$

Where,

$$B(t') = e^{-t'/\tau_{Bckg}}\frac{\alpha}{\tau_{Bckg}} + (1-\alpha)\frac{C}{t'_{max}}$$

Correction Function

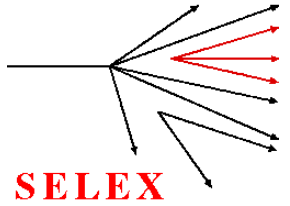


- The correction function is obtained from bin by bin ratio of MC events' reduced proper time distributions before and after the reconstruction code.

- Each decay channel has its own correction function

PRELIMINARY

Systematic Error Calculation



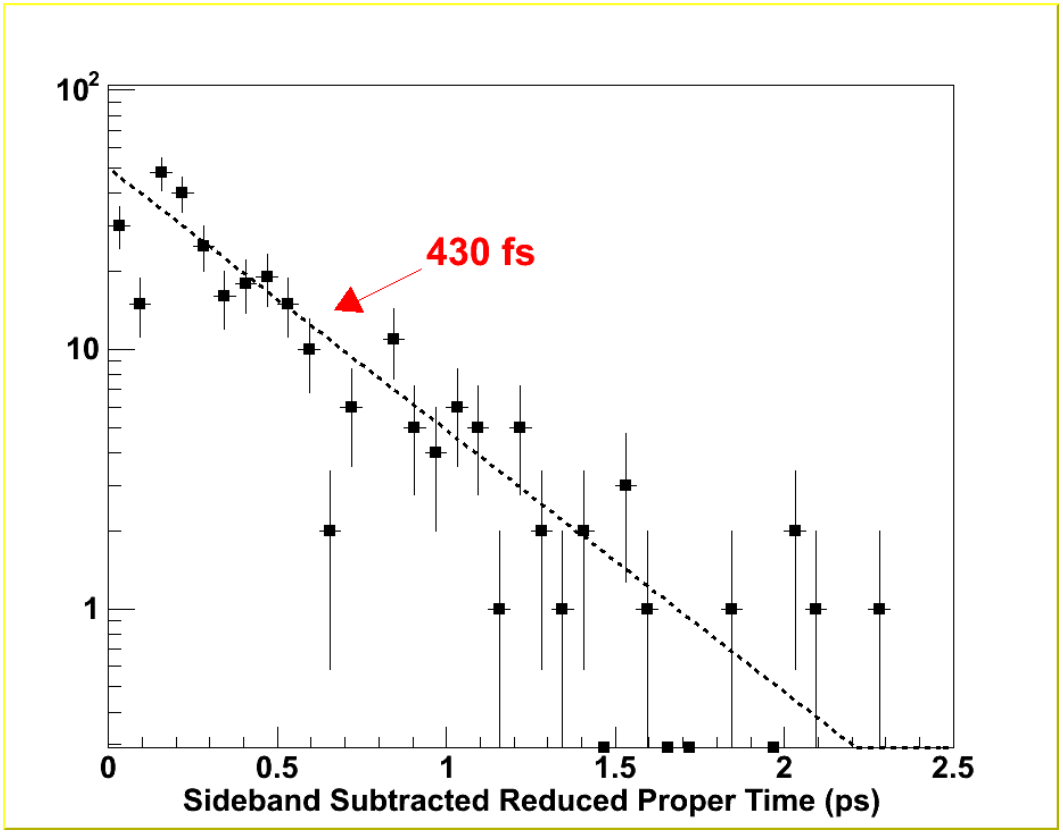
Sideband selection to parametrize the background	**< 1 fs**
Reduced proper time bin size	**4 fs**
Fitting the correction function	**4 fs**
xF power selection for the MC set	**7 fs**
Reduced proper time max value	**1.5 fs**
Total	**9 fs**

PRELIMINARY

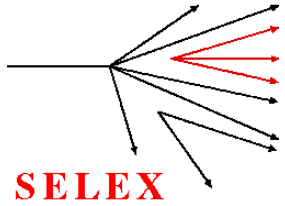
Results

We have measured the Ξ_c^+ lifetime
430 ± 22 (stat) ± 9 (sys) fs

Decay Channel	Events	Lifetime (fs)
$\Xi_c^+ \rightarrow \Xi^- \pi^+ \pi^+$	157 ± 21	420 ± 28
$\Xi_c^+ \rightarrow p^+ k^- \pi^+$	98 ± 17	429 ± 39
$\Xi_c^+ \rightarrow \Sigma^+ k^- \pi^+$	46 ± 11	465 ± 76
Total	301 ± 31	430 ± 22

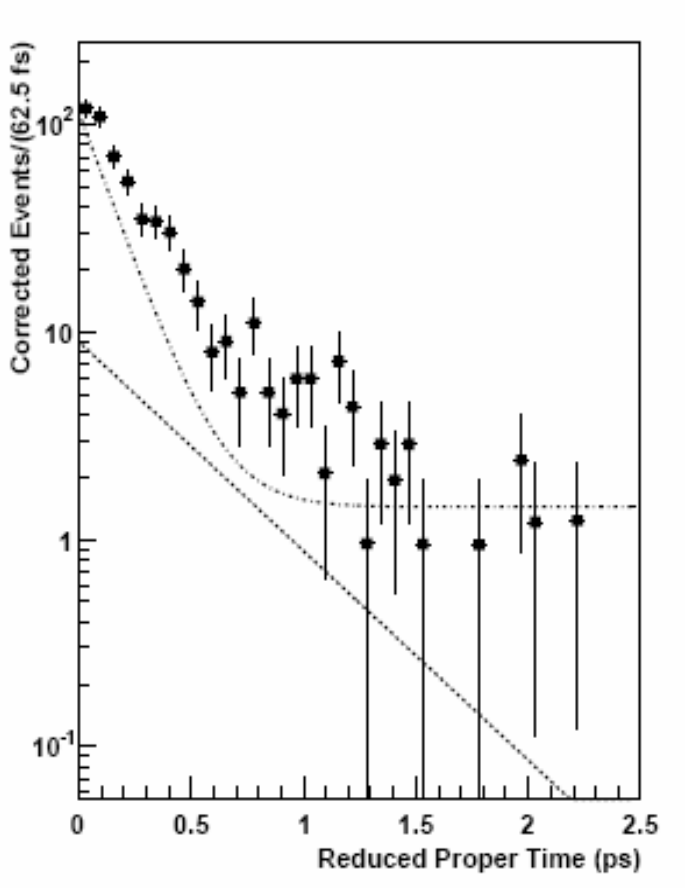


PRELIMINARY

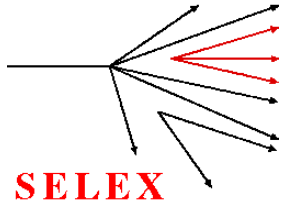


Backup Slides

Maximum Likelihood Fit



SELEX Discovery Papers



Observation of the Cabibbo–suppressed decay $\Xi_c^+ \to pK^-\pi^+$

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(September 25, 2002)

We report the first observation of the Cabibbo–suppressed charm baryon decay $\Xi_c^+ \to pK^-\pi^+$. We observe 150 ± 22 events for the signal. The data were accumulated using the SELEX spectrometer during the 1996–1997 fixed target run at Fermilab, chiefly from a 600 GeV/c Σ^- beam. The branching fractions of the decay relative to the Cabibbo–favored $\Xi_c^+ \to \Sigma^+K^-\pi^+$ and $\Xi_c^+ \to \Xi^-\pi^+\pi^+$ are measured to be $B(\Xi_c^+ \to pK^-\pi^+)/B(\Xi_c^+ \to \Sigma^+K^-\pi^+) = 0.22 \pm 0.06 \pm 0.03$ and $B(\Xi_c^+ \to pK^-\pi^+)/B(\Xi_c^+ \to \Xi^-\pi^+\pi^+) = 0.20 \pm 0.04 \pm 0.02$, respectively.

First Observation of the Doubly Charmed Baryon Ξ_{cc}^+

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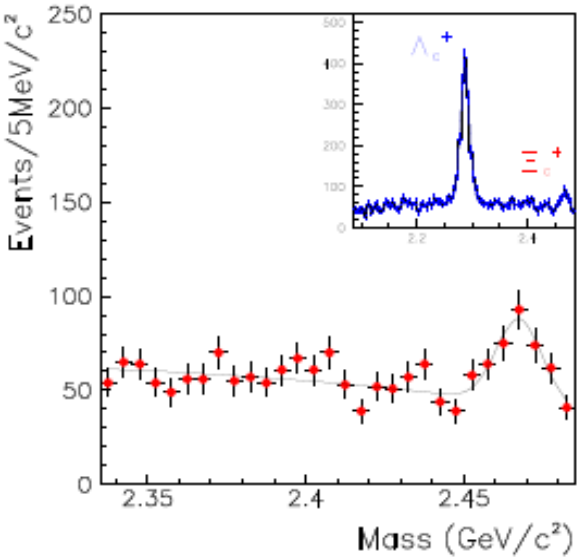
We observe a signal for the doubly charmed baryon Ξ_{cc}^+ in the charged decay mode $\Xi_{cc}^+ \to \Lambda_c^+K^-\pi^+$ in data from SELEX, the charm hadro-production experiment at Fermilab. We observe an excess of 15.9 events over an expected background of 6.1 ± 0.5 events, a statistical significance of 6.3σ. The observed mass of this state is 3519 ± 1 MeV/c^2. The Gaussian mass width of this state is 3 MeV/c^2, consistent with resolution; its lifetime is less than 33 fs at 90% confidence.

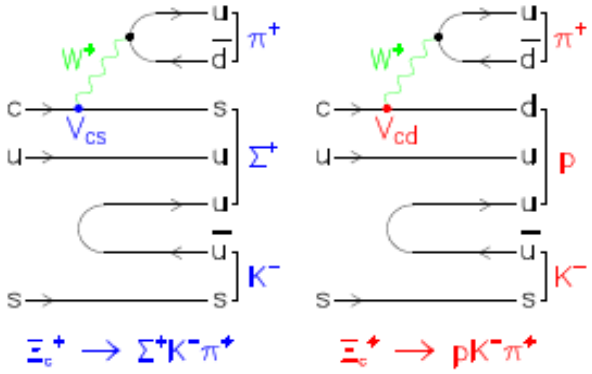
PACS numbers: 14.20.Lq, 13.30.Eg

Observation of $\Xi_c^+ \rightarrow \Xi^-\pi^+\pi^+$ PRL 84, 1857 (2000)

SELEX



- Signal Events $= 150 \pm 22 \pm 5$ @ $M_{\Xi_c^+} = 2467.4 \pm 1.2$ (MeV/c^2)
- Confirmed by FOCUS PL B512, 277 (2001)



$$\Gamma \propto G_F^2 \sum_{q=d,s} |V_{uq}V_{cq}|^2 \mathcal{F}(m_Q)$$

$$\frac{\Gamma_{CS}}{\Gamma_{CF}} \approx \mathcal{O}(\left|\frac{V_{cd}}{V_{cs}}\right|^2 = tan^2\theta_c)$$

$$\frac{\mathcal{B}(\Xi_c^+ \rightarrow pK^-\pi^+)}{\mathcal{B}(\Xi_c^+ \rightarrow \Sigma^+K^-\pi^+)} = 2.1\alpha \times \tan^2\theta_c$$

$$\alpha = 2.0 \pm 0.5 \pm 0.2$$