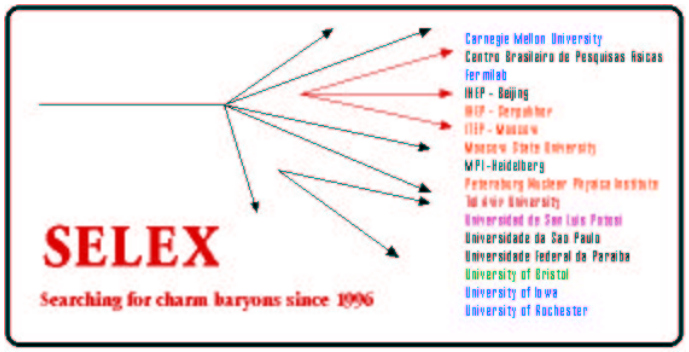

Search for strange and charm Pentaquarks in SELEX

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Outline

- **Introduction – The SELEX Experiment**
- **Search for the $\Theta(1540)$**
- **Search Strategy for charm pentaquark**
- **Summary and Outlook**

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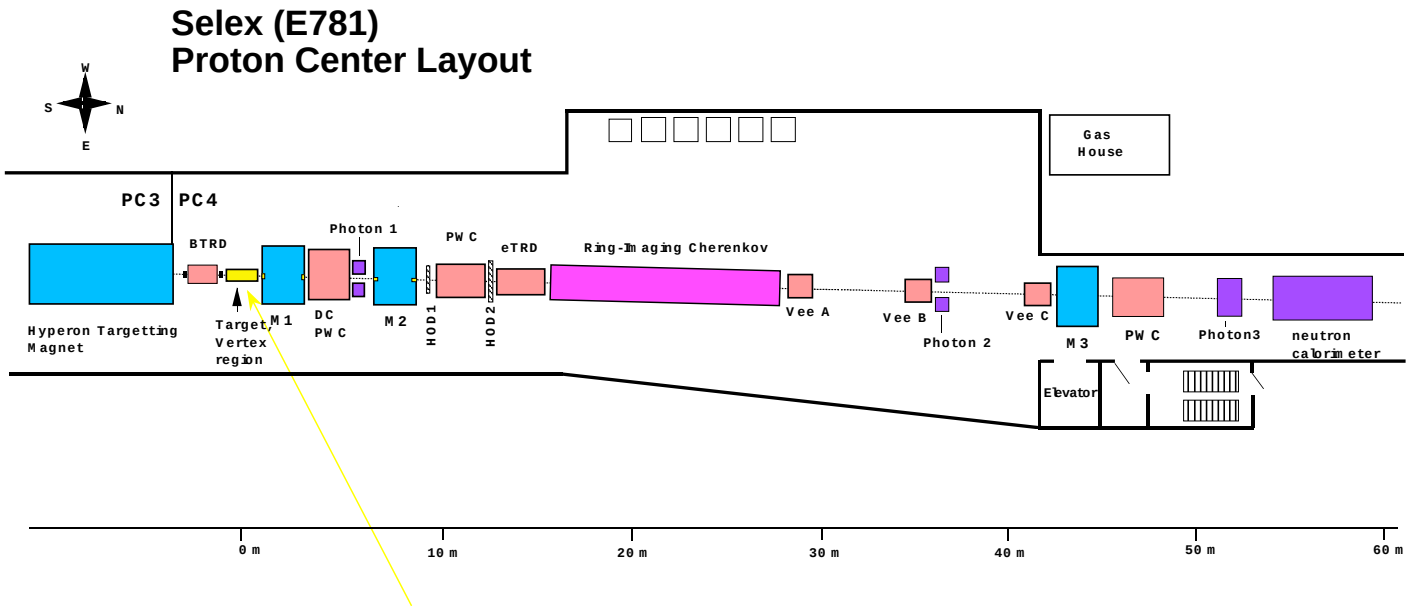
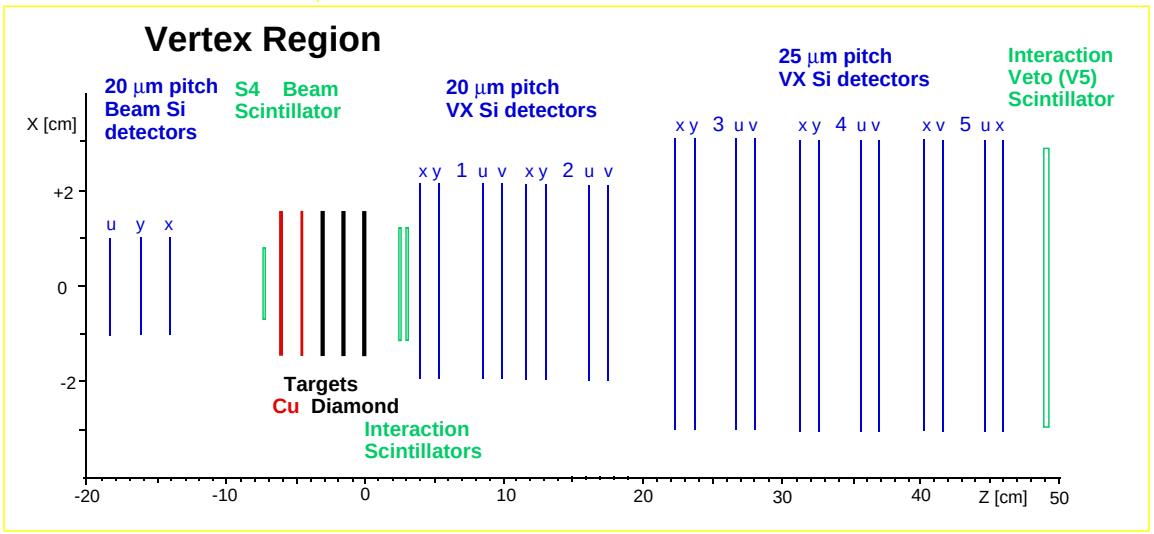
The SELEX Experiment at Fermilab

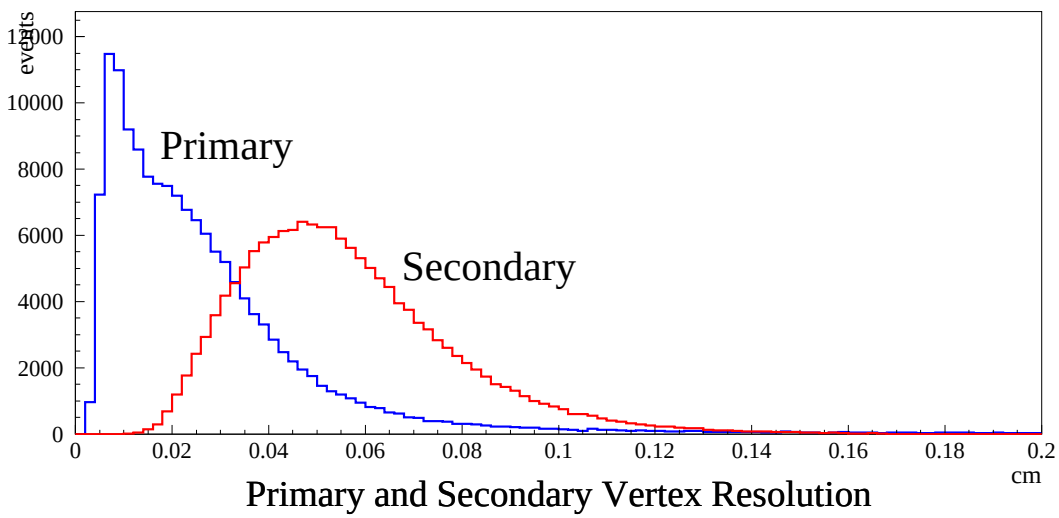


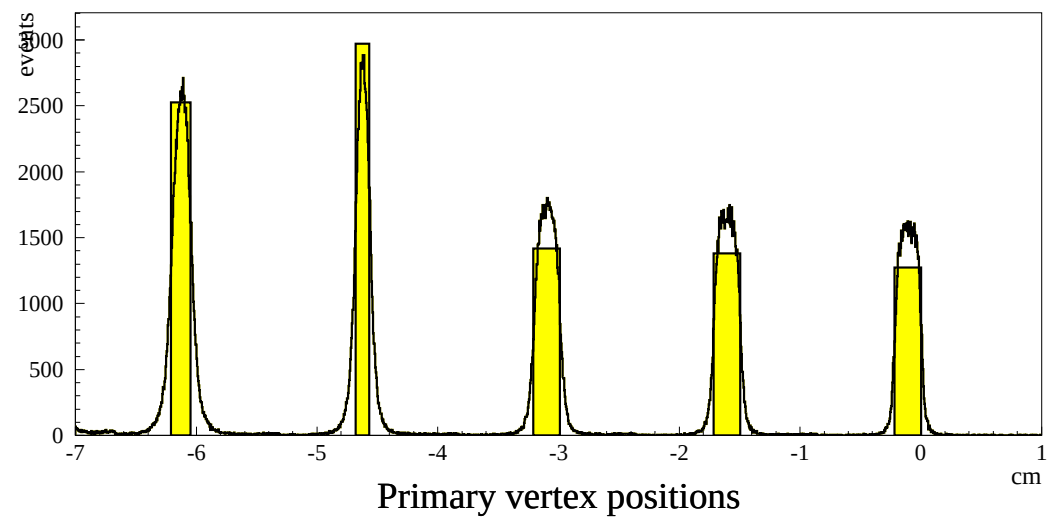


SELEX experiment

- Forward ($x_F > 0.1$) charm production
- Σ^-, π, p beam at 600 GeV/c
- RICH PID above ~ 22 GeV/c
- 20 plane Si-Vertex.
- Data taken 1996/7

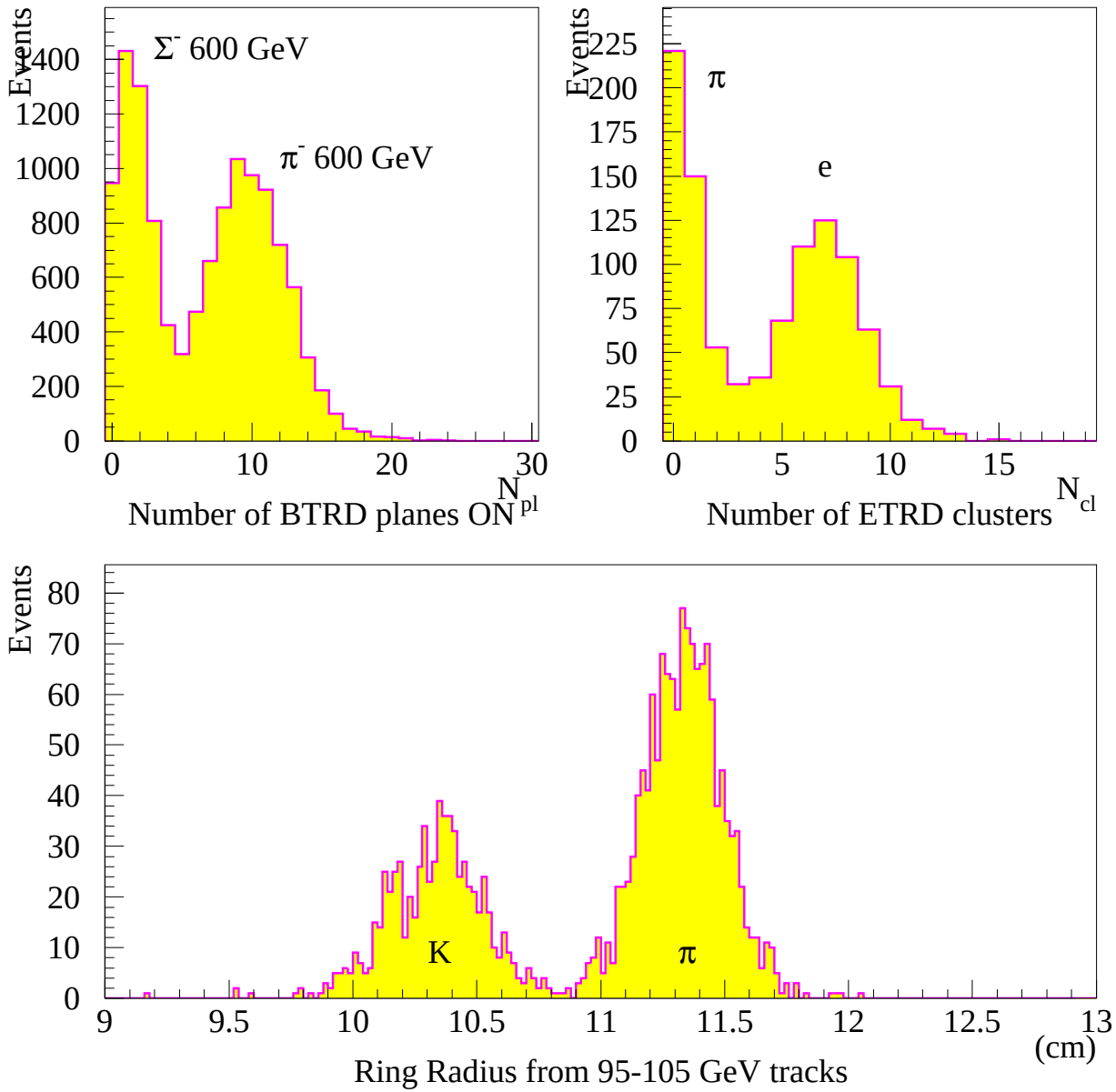
Vertex Spectrometer Performance



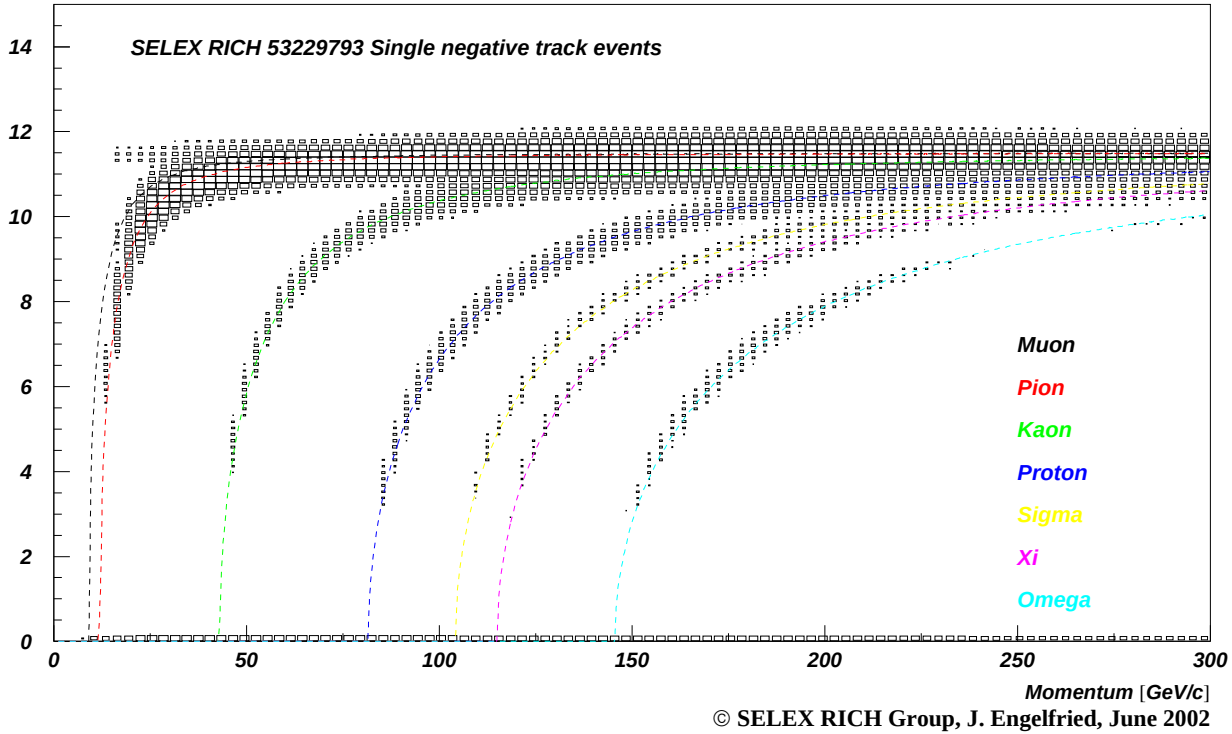


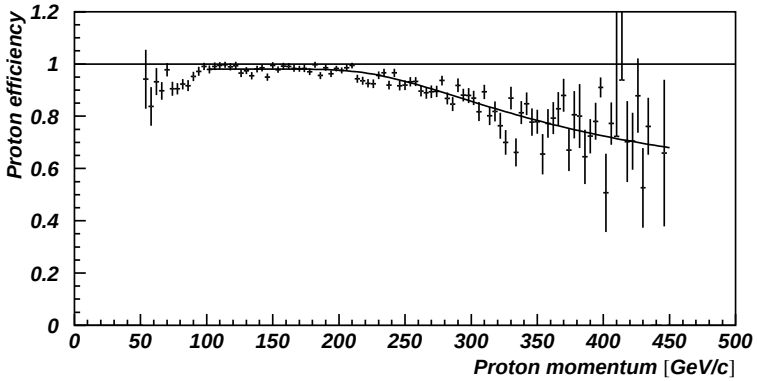
- transverse vtx resolution $8 - 15\,\mu$m
- 20 highly-efficient vertex planes over-determine tracks, reduce tracking confusion in high-multiplicity events
- target foils 0.8-2.2 mm thick with 1.5 cm spacing to localize primary interaction
- Lifetime resolution ~ 20 fs (slightly depending on particle and decay mode)

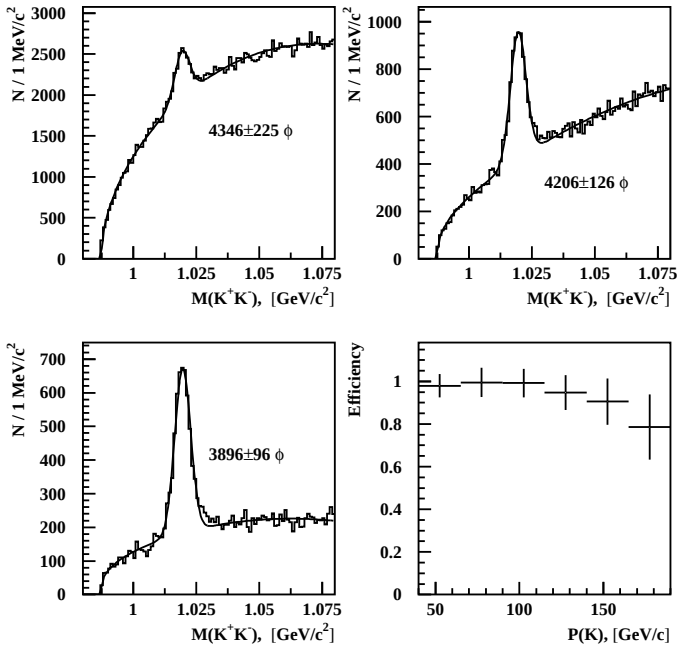
SELEX Particle ID detectors



Ring Imaging Cherenkov Counter Performance







Online Filter

Filter is Online Program which select events that have evidence for a secondary vertex.

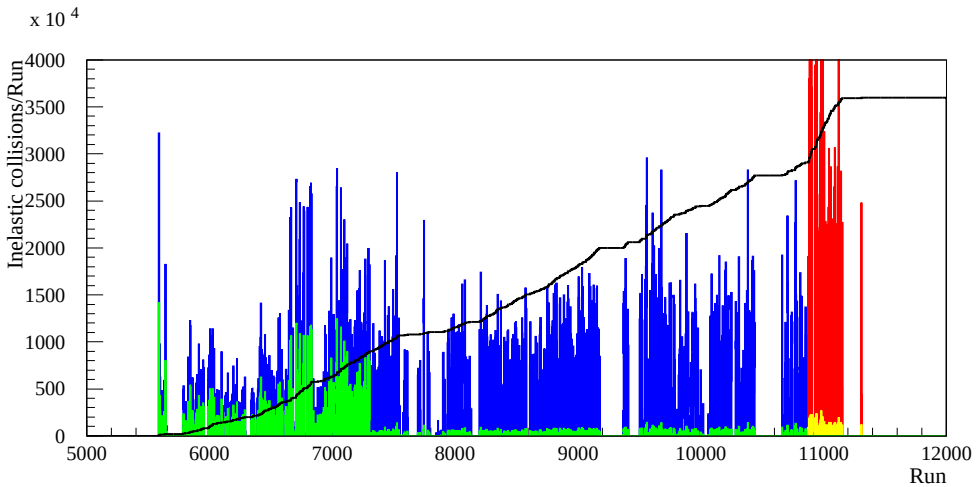
- **Algorithm:**
  - **Start from downstream tracking to find high-momentum ($p > 20\,\mathrm{GeV}/c$) tracks in PWCs**
  - **extrapolate tracks back to vertex silicon within the roads predicted by downstream tracking**
  - **Rejext events if tracks form just a primary vertex**
- **Charm efficiency about 50 %, Rejection 8**
- **4 times more charm per tape, 8 times faster to process.**

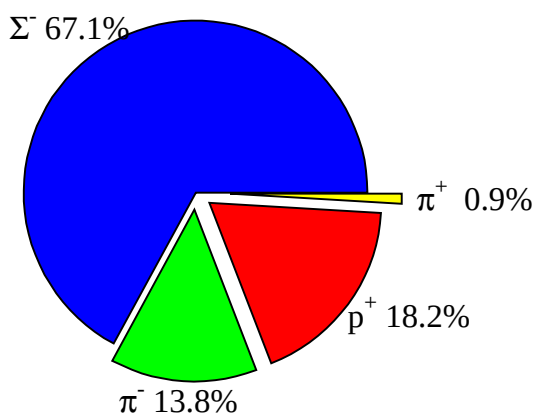
Selex publications

1. Observation of the Cabibbo-suppressed decay $\Xi_c^+ \to pK^-\pi^+$. Phys. Rev. Letter 84 (2000) 1857-1861.
2. Total Cross Section Measurements with π^-, Σ^- and Protons on Nuclei and Nucleons around 600 GeV/c. Nucl. Phys. B 579 (2000) 277-312.
3. Measurement of the Σ^- Charge Radius by Σ^-–Electron Elastic Scattering. Physics Letters B522 (2001) 233-239.
4. Precision measurements of the Λ_c^+ and D^0 lifetimes. Phys. Rev. Letter 86 (2001) 5243-5246.
5. Radiative decay width of the $a_2(1320)^-$ meson. Physics Letters B521 (2001) 171-180.
6. Measurement of the D_s lifetime. Physics Letters B523 (2001) 22-28.
7. Hadronic Production of Λ_c from 600 GeV/c π^-, Σ^- and p beams. Physics Letters B528 (2002), 49-57.
8. First Measurement of $\pi^- e \to \pi^- e\gamma$ Pion Virtual Compton Scattering. Phys. Rev. C 66, 034613 (2002).
9. First Observation of the Doubly Charmed Baryon Ξ_{cc}^+. Phys. Rev. Letters 89 112001 (2002).
10. Production Asymmetry for D_s for 600 GeV/c Σ^- and π^- beam. Physics Letters B558 (2003) 34-40.
11. Upper limit on the decay $\Sigma(1385)^- \to \Sigma^-\gamma$ and cross section for $\gamma\Sigma^- \to \Lambda\pi^-$. Physics Letters B590, 161-169 (2004).
12. Polarization of Σ^+ Hyperons produced by 800 GeV/c Protons on Cu and Be. Submitted to PRD.
13. Confirmation of the Double Charm Baryon Ξ_{cc}^+ via its Decay to pD^+K^-. Submitted to PRL, hep-ex/0406033.
14. First Observation of a Narrow Charm-Strange Meson $D_{sJ}^+ \to D_s^+\eta$ and D^0K^+. Submitted to PRL, hep-ex/0406045.

Charm Topics Non-Charm Topics

SELEX Beam and Data Taking





Total 15.2 Billion interactions

- **Most data taken with Σ^- beam (BTRD in trigger)**
- **Also data with π^-, p, and π^+**
- **For every single event we identify the beam particle.**

- **15 Billion Interaction**
- **1 Billion events written to tape**

SELEX Offline Analysis

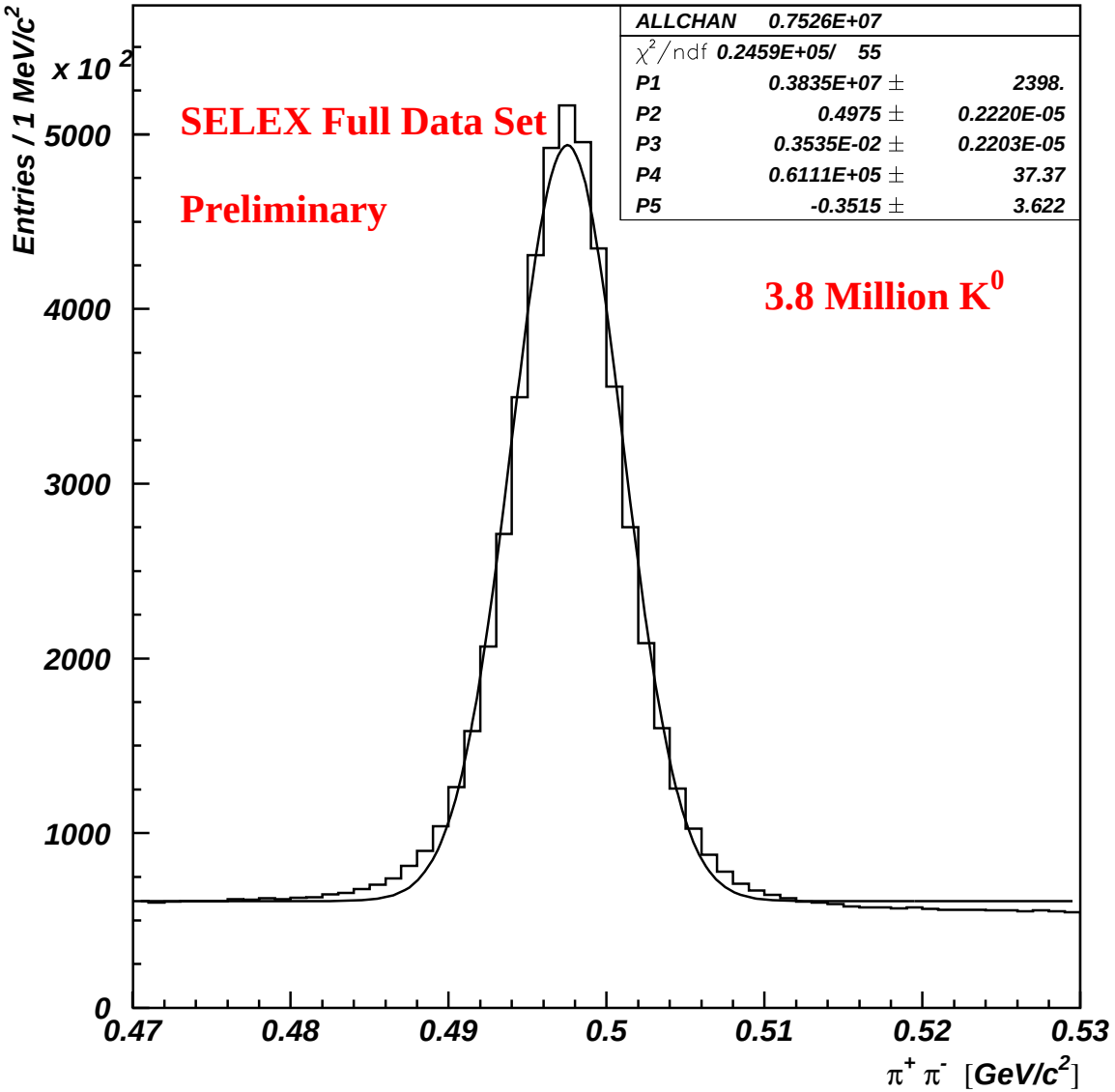
- **Software Package (unpack, tracking, particle id, photons,vertexing)**
- **Table-Driven package reconstructs candidates, writes DST**

- **Analyse 1 Billion events takes ∼6 months on computer farm**
- **We did it two times. . . (1998, 2001)**

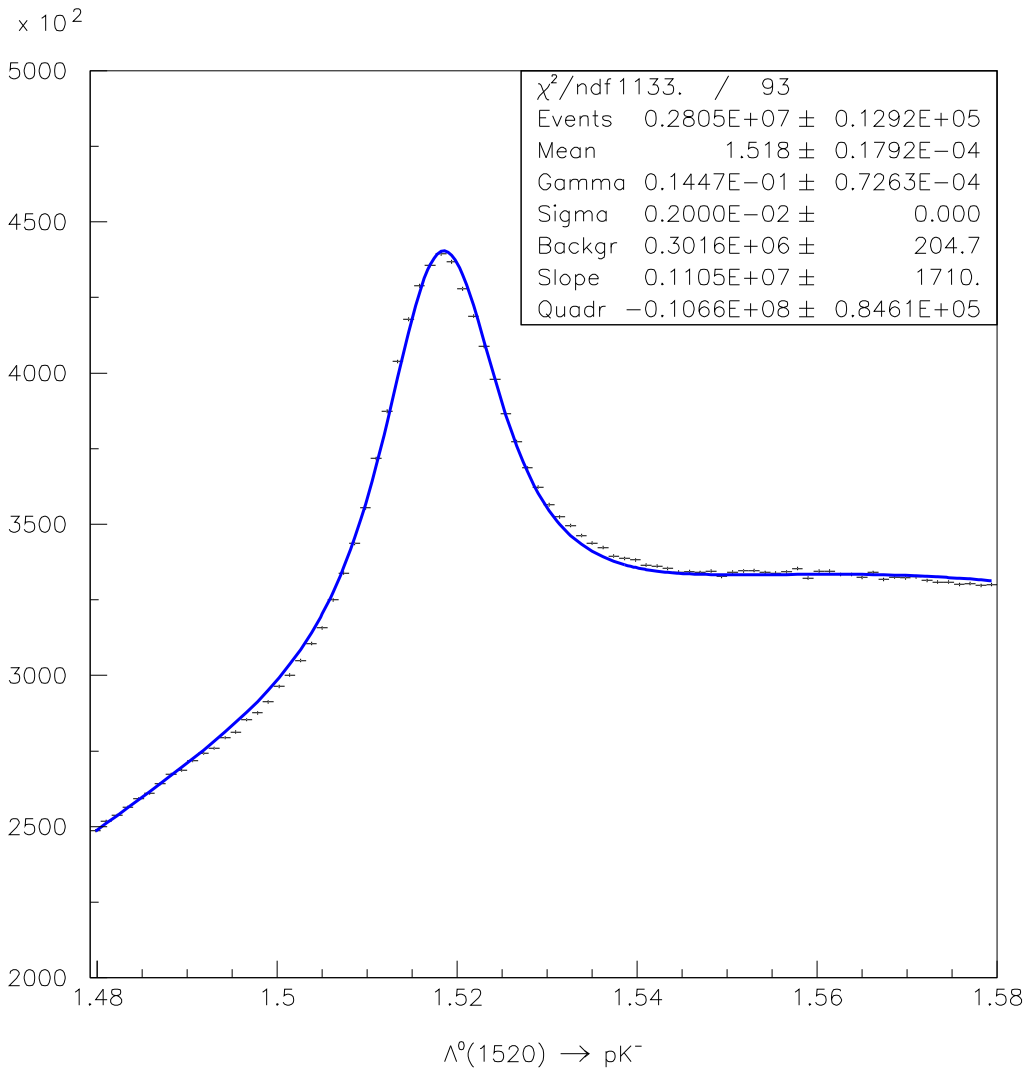
- **Physics Analysis: Analyse DST with fortran and/or convert to ntuples**
- **For special topics not previously forseen and/or when more information needed: Strip files with full events**

- **For $\Theta(1540)$: Run over full event, strip selected K^0 and Λ^0.**
- **ALL cuts defined by previous analyzes! (partid, vertexing, etc)**

SELEX K^0 Sample



SELEX Λ(1520) Sample



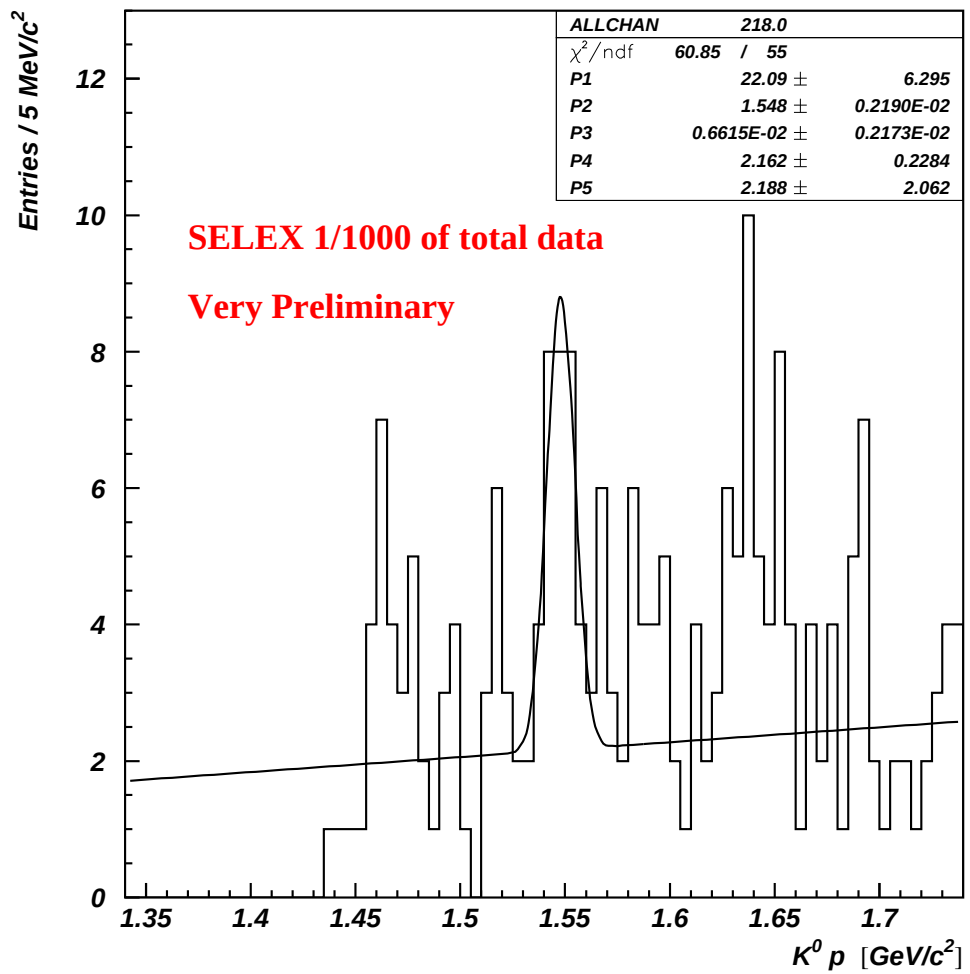
2.8 Million $\Lambda(1520) \rightarrow pK^-$

First Try: SELEX 1 Million Event Sample

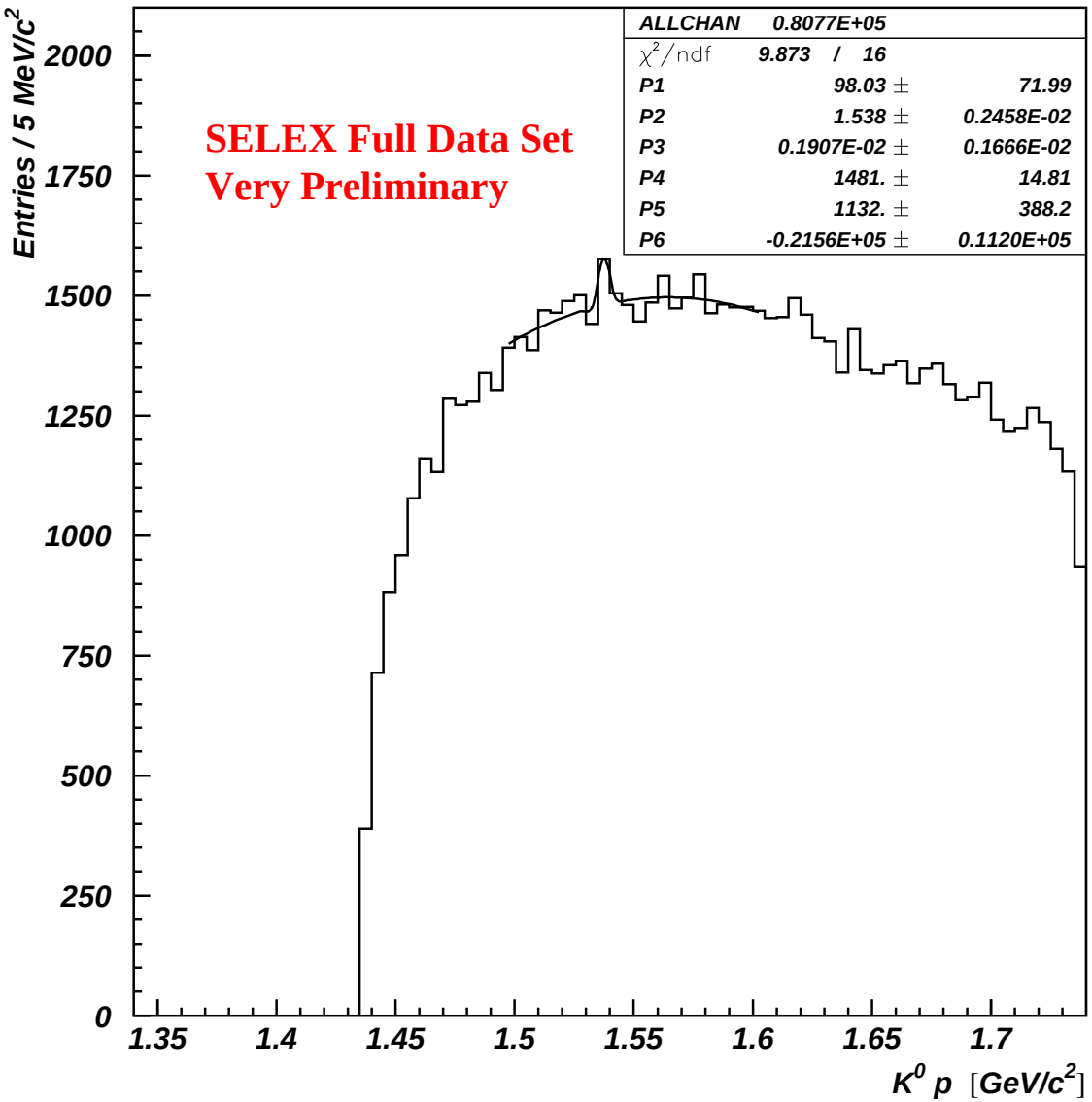
- To test software:
  Run over 1/1000 of full data sample
- Reconstruct $K^0 \to \pi^+\pi^-$,
  Decay Vertex in first few cm
- Add track from primary vertex
- for $\Theta(1540)$: RICH Identified Proton

- Peak with 22.4 ± 6 events,
  at $1548 \pm 2\,\mathrm{MeV}/c^2$

- THIS IS GREAT! WE WILL HAVE 22000 $\Theta(1540)$!!??!!

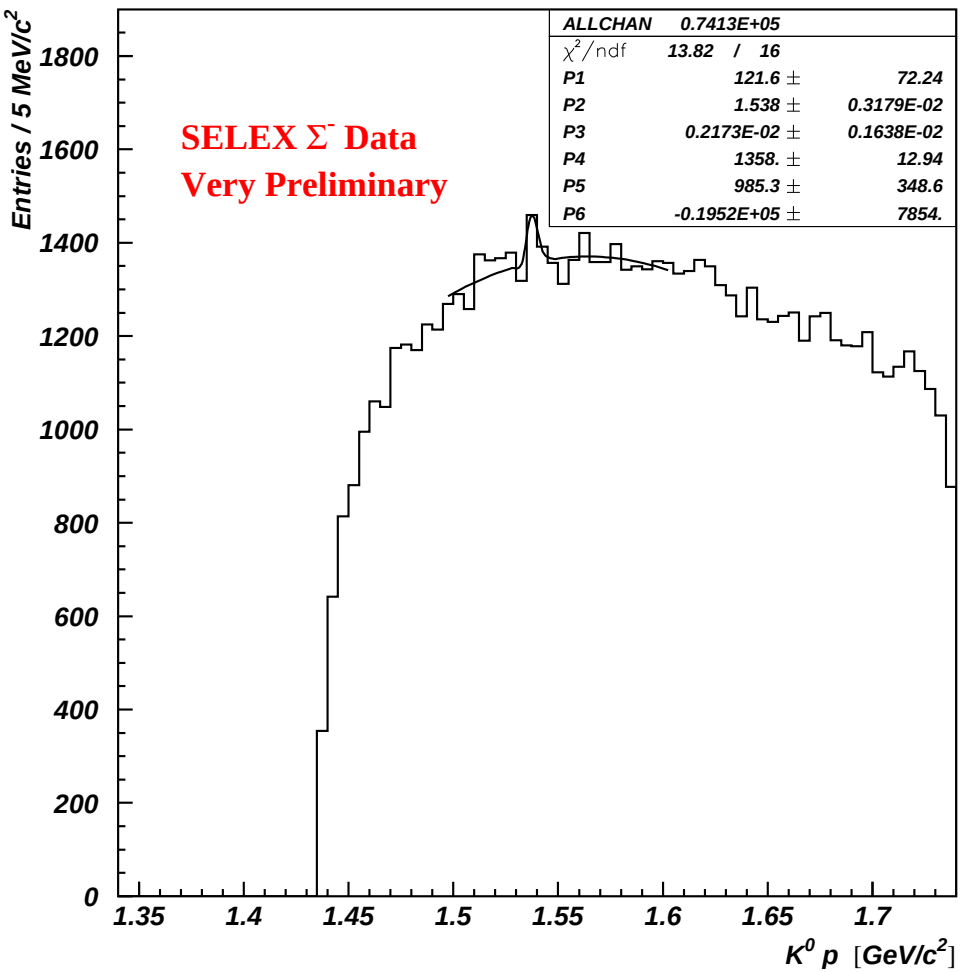


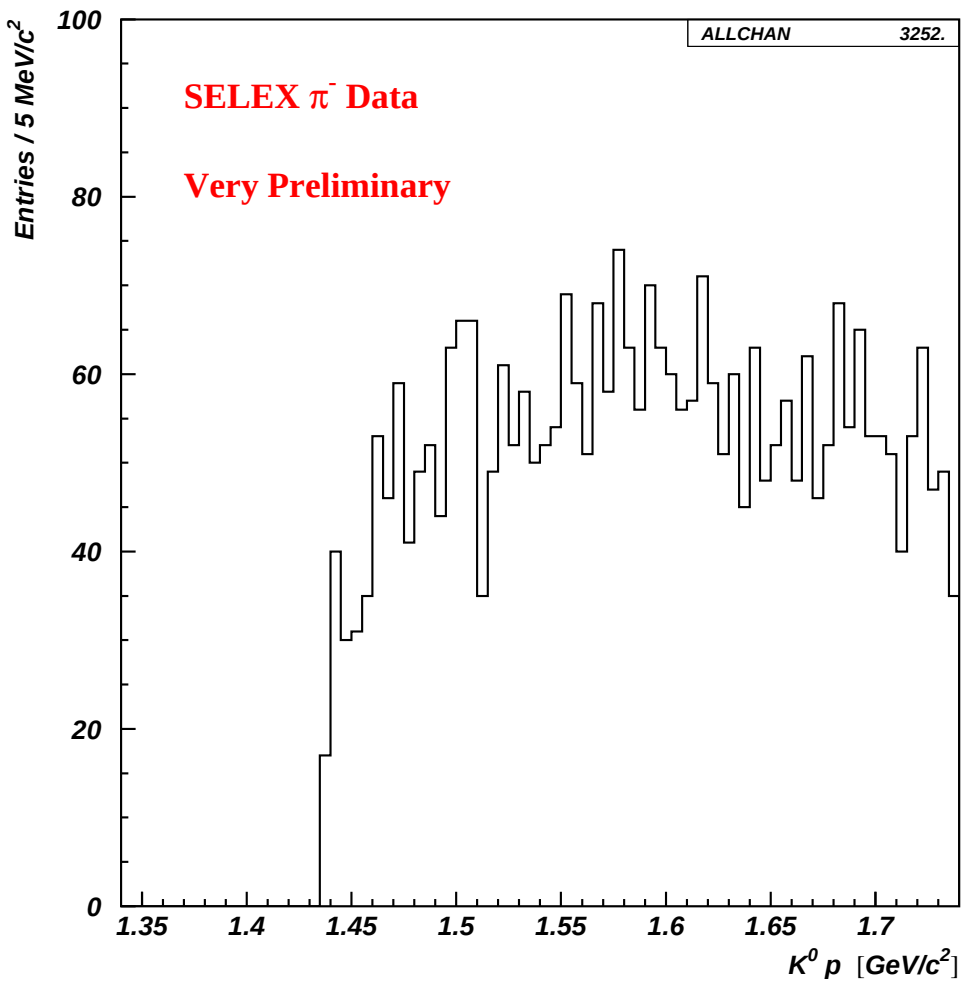
SELEX Full data Sample



Fit says 98 ± 72 Events: NOTHING!! NO Θ(1540)

Separation for Beam Particles





Search Strategy for Charm Pentaquarks

- **Below Strong Threshold: $\Theta_c^0 \longrightarrow pK^+\pi^-\pi^-$**
- **To make sure there is no problem in analysis:**
  - **Also look for Antiparticle: $\overline{\Theta_c^0} \longrightarrow \bar{p}K^-\pi^+\pi^+$**
  - **Also look for Isospin Mulitplets: $\Theta_c^+ \longrightarrow pK^+\pi^-$, etc.**
  - **Also look for Wrong-Sign Combinations: $\Theta_c \longrightarrow pK^-\pi^+\pi^-$, etc.**
  - **Don't believe the predictions: Select wide mass range**
  - **Binning: Select bin size according to experimental resolution (MC)**

- **With this, you look at a lot of histograms with a lot of bins.**
- **$3 - 4\,\sigma$ fluctuations HAVE to show up.**

- **Above Threshold: $\overline{D^0}p\pi^-$ (H1)**
- **Same strategy – and same problems – as above.**

- **In SELEX we tried all of them – with no conclusive results yet**

Summary and Outlook

- **SELEX searched for Strange and Charm Pentaquark States**
- **Interesting fluctuation in 1/1000 of full data set in pK^0**
- **No signal for $\Theta(1540)$ in SELEX data**
- **Charm Pentaquark search still not conclusive**