Recent Charm Lifetime and Hadroproduction Results from SELEX

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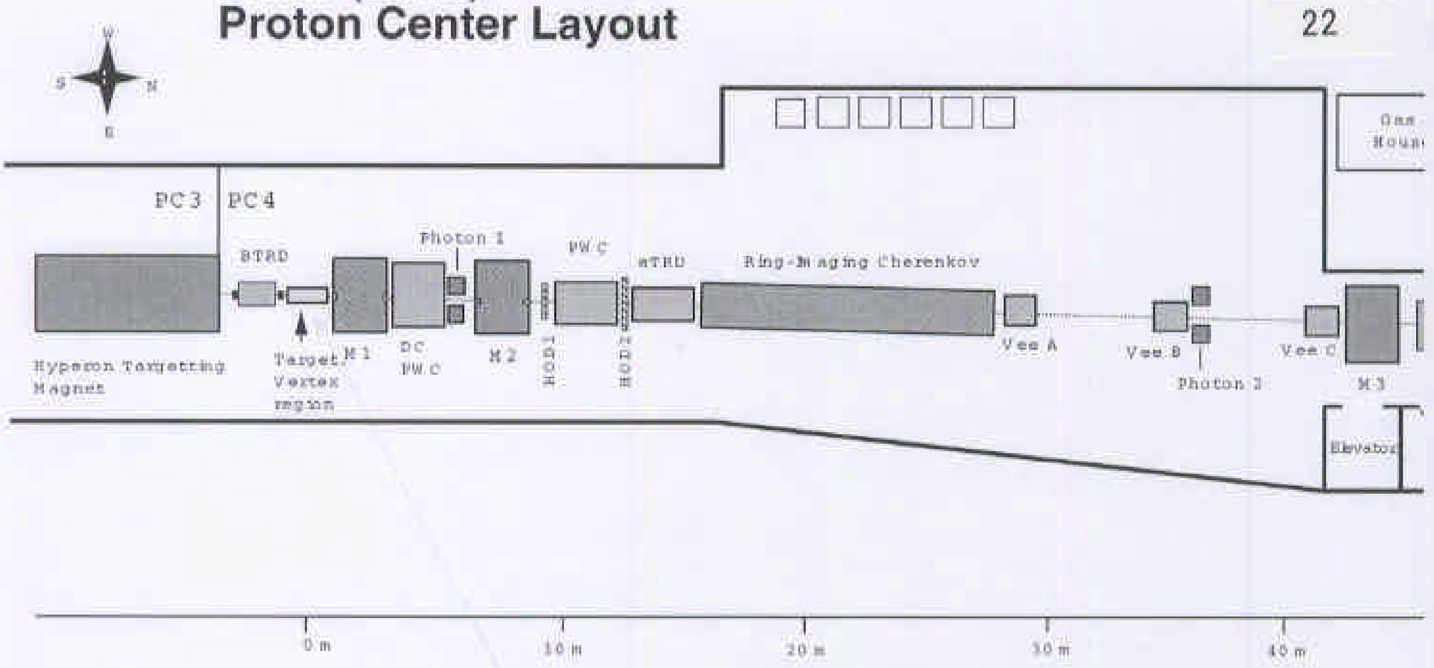
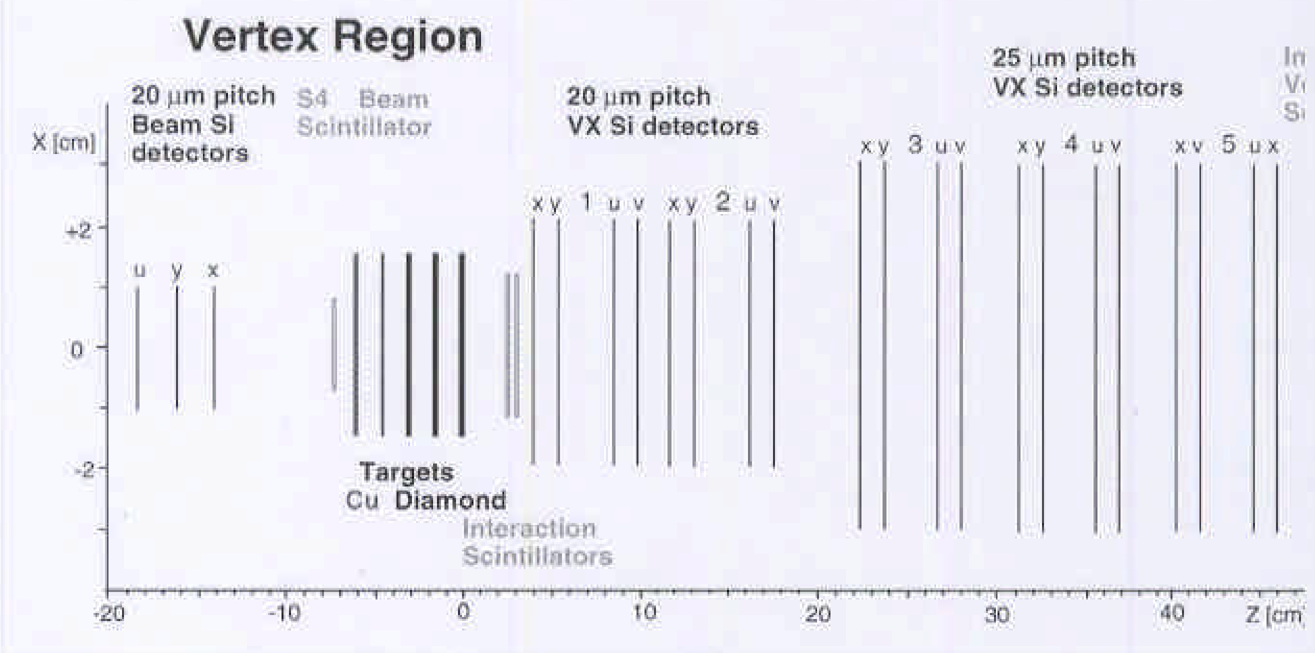
Outline of the talk

- Experimental Overview
- Weak Decays of Charm
  - Motivation
  - SELEX Lifetime Analysis Methods
  - SELEX Results and New World Averages
  - Lifetime Summary
- Hadroproduction of Charm
  - Motivation
  - SELEX Features
  - SELEX Results and World Data Comparisons
  - Hadroproduction Summary

Proton Center Layout





Important Experimental Features

- 600 GeV Negative beam: 50% π / 50% Σ
- 570 GeV Positive beam: 92% protons
- RICH Counter for definite identification of π, K, proton
- precision p resolution ($\Delta p/p \sim 0.5\%$ at 100-300 GeV/c)
- precision vtx resolution (primary: 270 μm; secondary 560 μm)

Charm Lifetime Results

Motivation

Do we know how to calculate the weak decay matrix element for charmed hadrons?

Experimental goal is to delineate lifetime hierarchies for mesons, baryons to:

- test calculation of $1/m_Q$ terms in HQET expansion
- compare strength of W-exchange and -annihilation terms
- compare Pauli suppression mechanisms in different charm hadrons

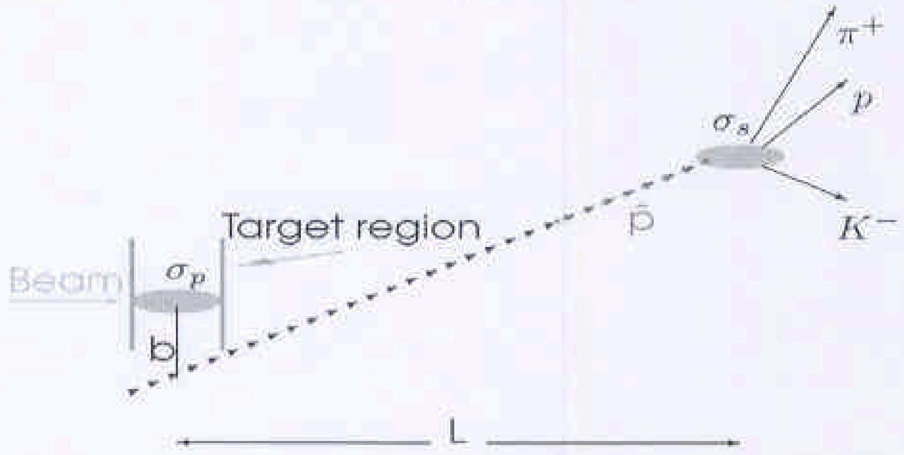
Features of SELEX Lifetime Analysis Method

- apply strong PID requirements to minimize overlapping states
- use real data to establish acceptance correction function
- check systematics by using several decay modes, different production targets
- Use reduced proper time t_R = t $-8\sigma/\beta\gamma$
- $\sigma_{t_R} \sim 20$ fs $\Rightarrow$ use binned likelihood analysis
- Analyze D^0 Lifetime to verify methodology

Charm Selection Criteria

- vertex-driven with definite RICH identification of p,K required
- signal widths independent of momentum from 80-400 GeV/c
- signals isolated by sideband subtraction, NOT Gaussian fits

Charm Selection



- Good secondary vertex ($\chi^2/dof < 5$)
- Longitudinal separation (L) between the vertices bigger than 8σ ($\sigma^2 = \sigma_p^2 + \sigma_s^2$)
- Charm track points back to primary vertex (pointback $= (\mathrm{b}/\sigma_\mathrm{b})^2 < 12$)
- K, p identified by the RICH: $\mathcal{L}(K),\ \mathcal{L}(p) > \mathcal{L}(\pi)$
- No secondary vertices in material

Figure 1: Schematic of Charm event selection criterion

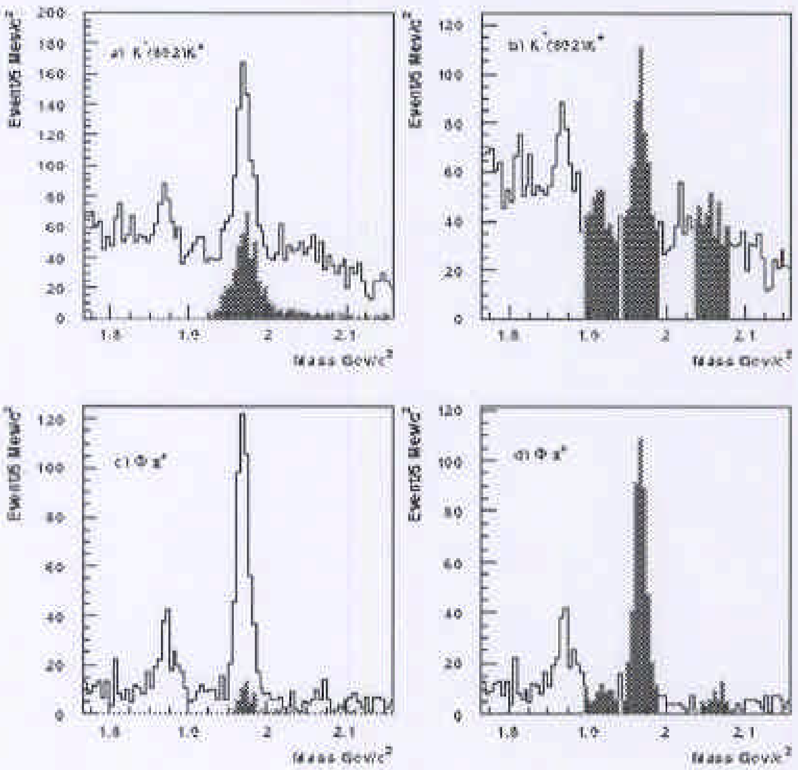
D_s SELECTION

SIGNAL-BCK SEPARATION:

- decay length >8σ , transverse distance > 2.5 its error
- secondary vertex outside any charm target
- decay within fiducial region

D_s SAMPLE: 1024 ± 58

The D^+ ,D^* reflection under the Ds due to π/K misidentification (Fig a,c hatched region) is removed



$D_s \to K^*(892)\ K$	**193 ± 22 events**	**S= 8.3 ± 0.3**
$D_s \to \Phi(1020)\ \pi$	**394 ± 19 events**	**S=19.6 ± 0.5**

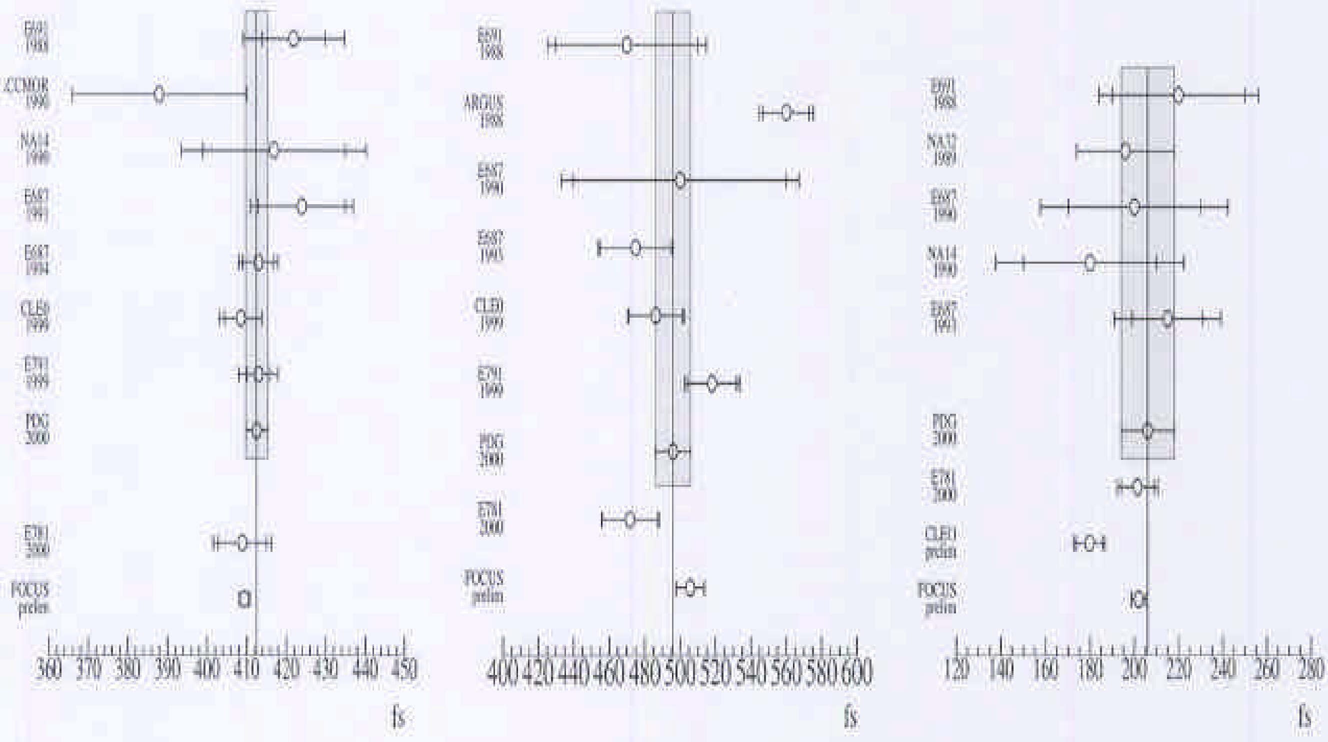
after misidentification subtraction (Fig. b,d)

SELEX Results

- Final results for Λ_c^+, D^0
- Preliminary results for D_s and τ_{D_s}/τ_{D^0}

Charm Hadron	Lifetime (fs)	Stat. Err.	Sys. Err.
$\Lambda_c^+ \to pK^-\pi^+$	201	7.4	5.5
$D^0 \to K\pi$	416	8	-
$D^0 \to K\pi\pi\pi$	402	10.5	-
D^0	409	6	4
$D_s \to \phi\pi$	474	22	-
$D_s \to K^*K$	478	33	-
D_s PRELIMINARY	476	17.5	4.4

Table 1: SELEX Lifetime Results (fs)



D^0 D_s Λ_c

Lifetime Results Summary

- All recent D^0 results agree well
- D_s measurements have not yet converged, but
- all experiments agree that τ_{D_s}/τ_{D^0} is larger than expected

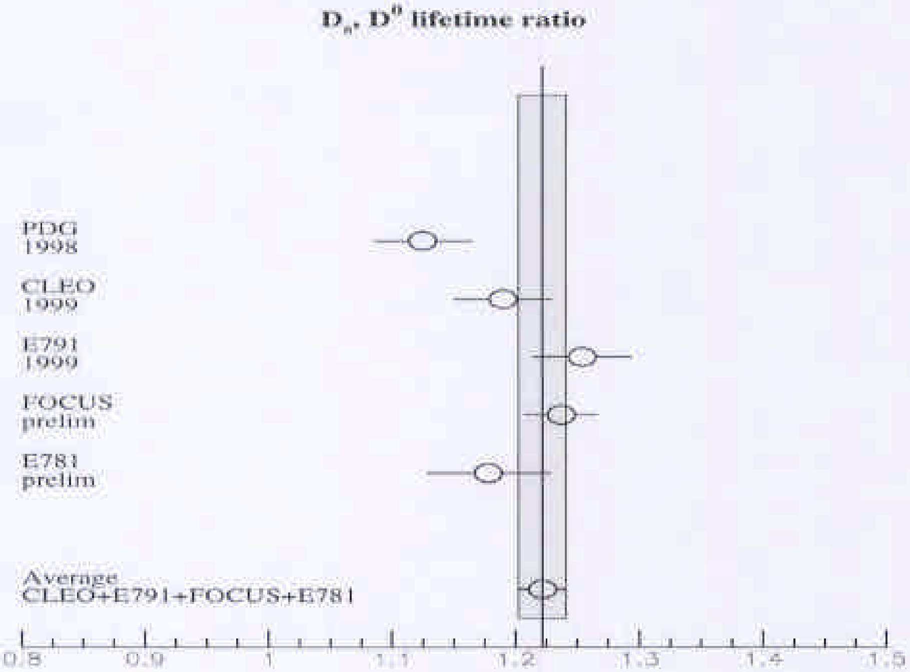


Figure 2: Recent D_s / D^0 Lifetime Ratio Results

Complete grasp of the meson hierarchy is perhaps further away than had been thought.

Λ_c results from the fixed target experiments have converged nicely.

Now we need to improve the csq baryon lifetimes.

Recent SELEX Charm Hadroproduction Results

Charm hadroproduction is major challenge to factorized pQCD analysis

- quark-level QCD process is charm/anticharm symmetric
- hadronization depends on local color field environment
- experiments observe significant production asymmetries in SOME cases

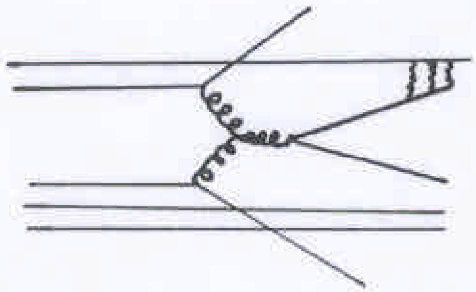
Until SELEX high-statistics charm hadroproduction used π^- beam

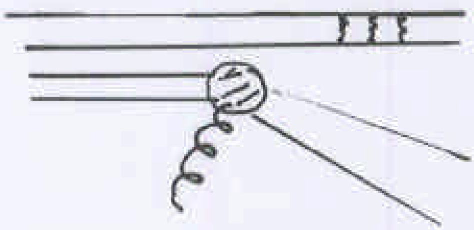
SELEX compares π^-, Σ^-, and proton production in same apparatus

Clear systematic differences between pion and baryon beams emerge

Possible Phenomenology

Two classes of models for asymmetries: color-drag (leading particle effect) and intrinsic charm





Predictions differ:

- color-drag effects are more pronounced at high x_F and don't depend on p_T
- intrinsic charm effects occur at low p_T, become apparent at large x_F

SELEX Measurements for Λ_c, D_s and D_0

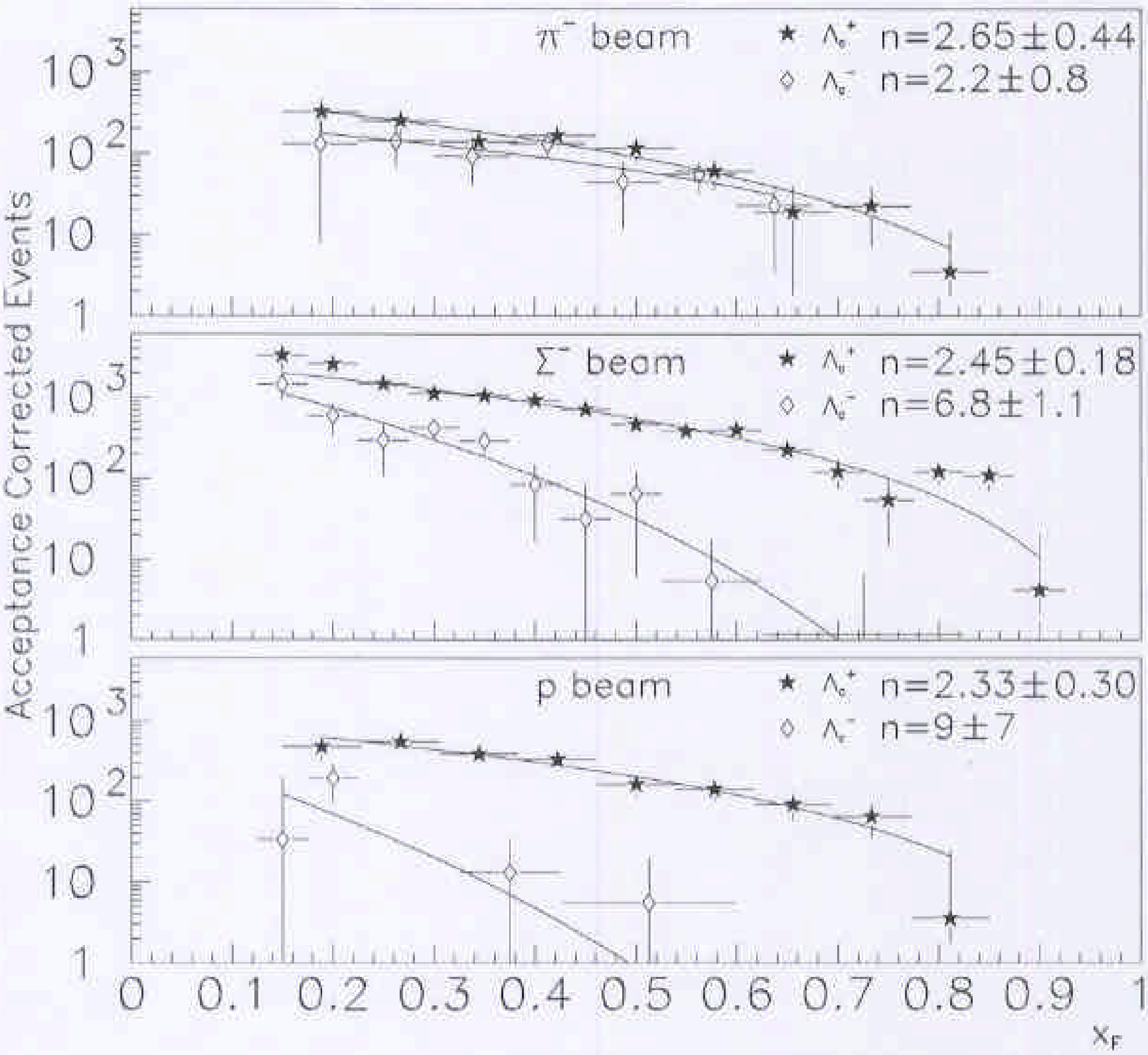


Figure 3: SELEX Λ_c^+ and $\overline{\Lambda_c}$ Results

Λ_c production is very hard for all beam particles

Striking contrasts in production of antibaryons between pi beam (valence antiquark) and baryon beams (no valence antiquark).

Large-x_F structure in Σ^- data suggests Pythia-style color-drag

What happens in p_T?

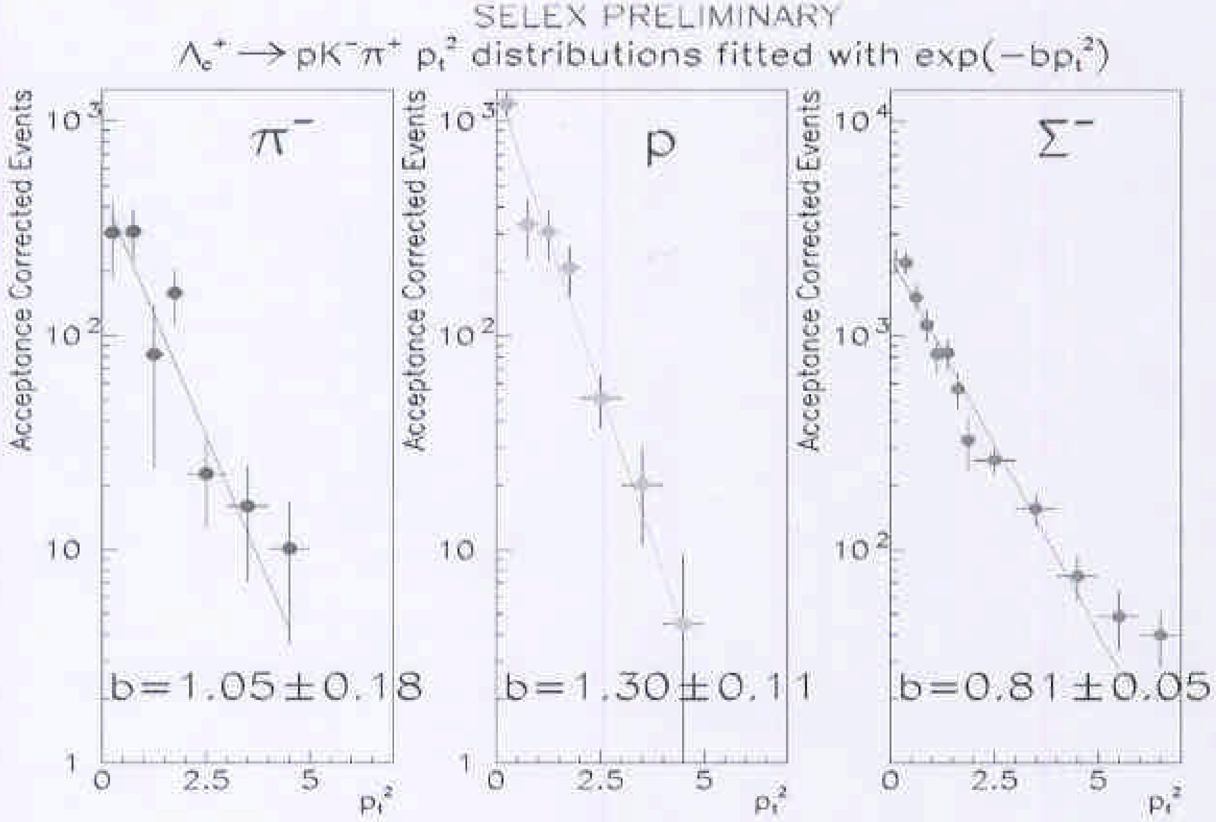


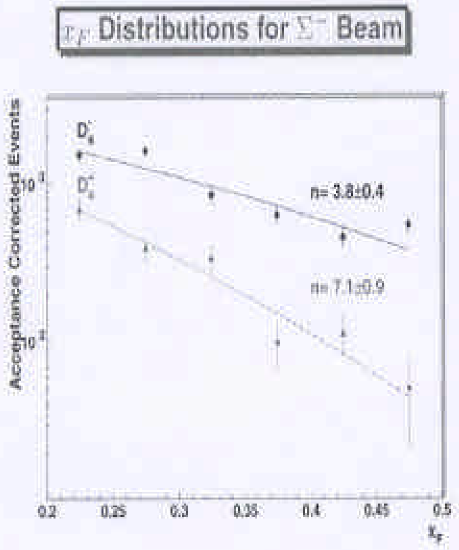
Figure 4: SELEX $\Lambda_c^+ p_T$ distribution

Σ^- production data show expected deviation from Gaussian behaviour slightly earlier than corresponding D^+ spectra from pi beams

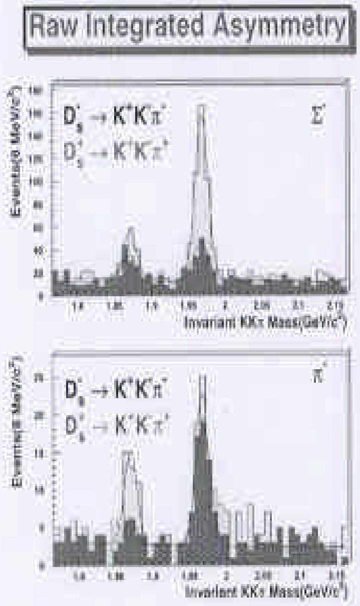
Forward gaussian slope ($p_T^2 \leq 4(GeV/c)^2$) same for all beams

What about meson production by meson and baryon beams?

D_s^+ and D_s^- production should look much different for π^- and Σ^- beams in color-drag model



fit: $(1 - x_F)^n$



$$A \equiv \frac{N_{D_s^-} - N_{D_s^+}}{N_{D_s^-} + N_{D_s^+}}$$

$A(x_f > 0.2) = 0.57 \pm 0.07$ Σ^-
$A(x_f > 0.2) = -0.08 \pm 0.08$ π^-

Figure 5: SELEX D_s x_F Distributions

The effect of the shared valence quark is clearly seen in the Σ^- x_F distributions, but no effect for the π^-.

Similar effects are observed in the other D meson distributions

Hadroproduction Summary at $\sqrt{s} \sim 33.5$ GeV

- charm $d\sigma/dx_F$ shows strong sensitivity to shared valence quark
- little support in SELEX data for intrinsic charm
- comparing different states, different beams in these data will probe further into hadronization systematics