Summary of Charm Physics at the Fixed Target Hadron Experiments

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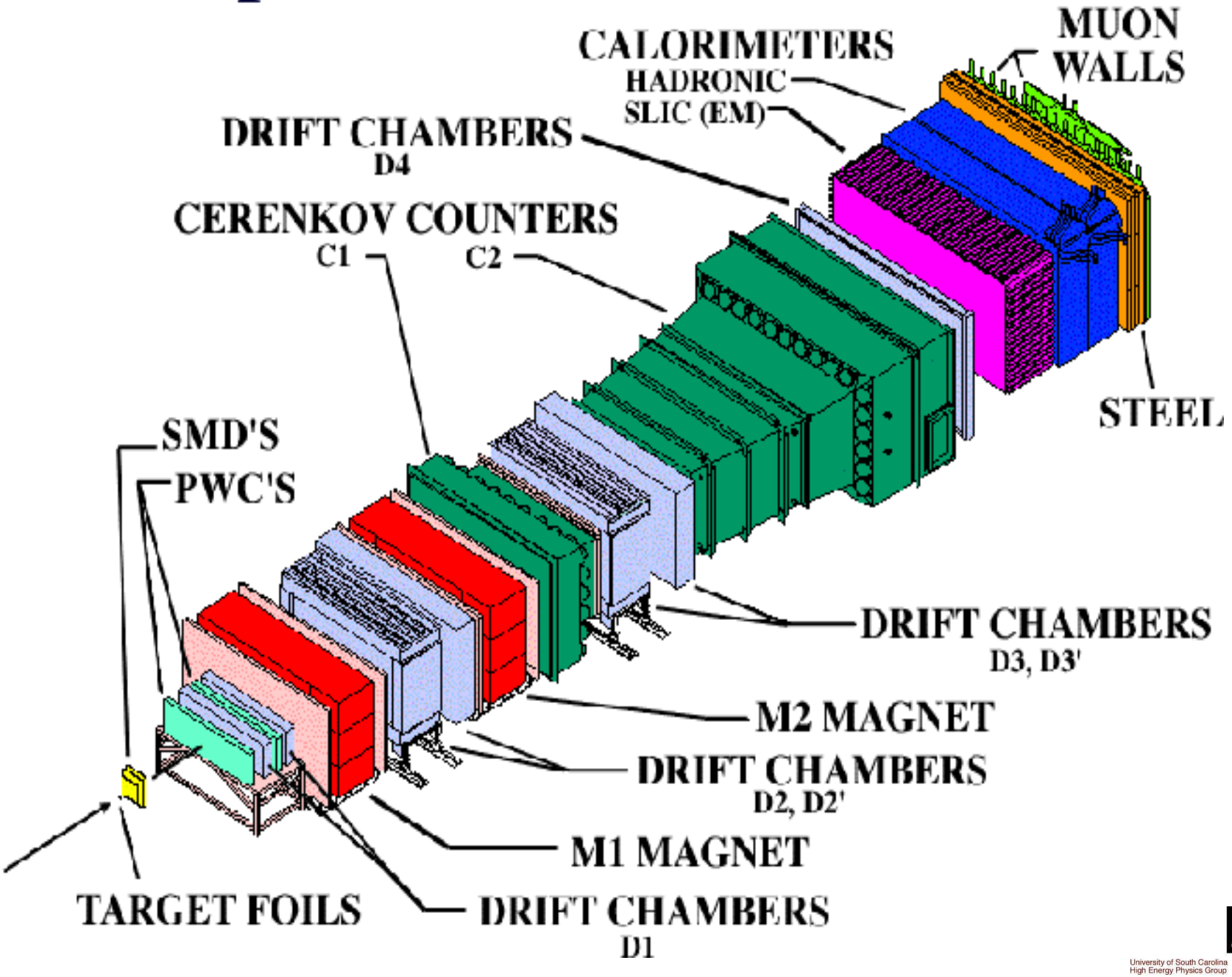
Outline

- *Introduction. Example: E791.*
- D^0-$\bar{D}^0$ mixing
- Searches for CP violation
- Searches for rare decays
- Semileptonic decays
- Baryons
- Dalitz plot based analyses
- Charm production

Introduction

- Fixed target charm experiments considered here are mainly from Fermilab.
- The last of these in their sequences are mainly E791 and FOCUS.
- Other experiments to keep in mind are SELEX etc.
- Most of these experiments ran in the 1990's.
- Data analysis and publications are now essentially complete.

E-791 Spectrometer



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E791:
An example of a Fixed Target Experiment

- The Tevatron delivered a proton beam spill over 23 seconds, at a rep rate of roughly a minute.
- This generated a secondary π^- beam of intensity roughly 2MHz.
- The target consisted of 5 foils:
  - A 0.5 mm Pt target and
  - Four 1.6 mm C (diamond) targets
- The total thickness was 1.9% pion interaction lengths, leading to a ~ 40 KHz interaction rate.
- The trigger rate was ~ 9 KHz, with a ~ 2.5 GeV E_T trigger.
- Events acquired by the DA system were ~ 2.5 KB in length.

Charm rates at E791

- A total of 2 x 10^{10} events were recorded.
- This is 50 Terabytes of data.
- In 1991 50 TB was a BIG deal!

- Due to poor reconstruction efficiency (~ 10%) and a ~ 10^{-3} charm production fraction, only ~ 2 x 10^{6} charm particles are reconstructable.
- Some of the efficiency loss is due to the forward nature of the detector, while some is due to tight vertex separation cuts required to reduce the large backgrounds.

- After factoring in Branching Fractions, the reconstructed sample of, e.g., $D^{*\pm} \rightarrow D^0 \pi^{\pm}$, $D^0 \rightarrow K\pi^{\pm}$, is only ~ 2 x 10^{4}
- Due to background, this is equivalent to 10^{4} events (100 σ).

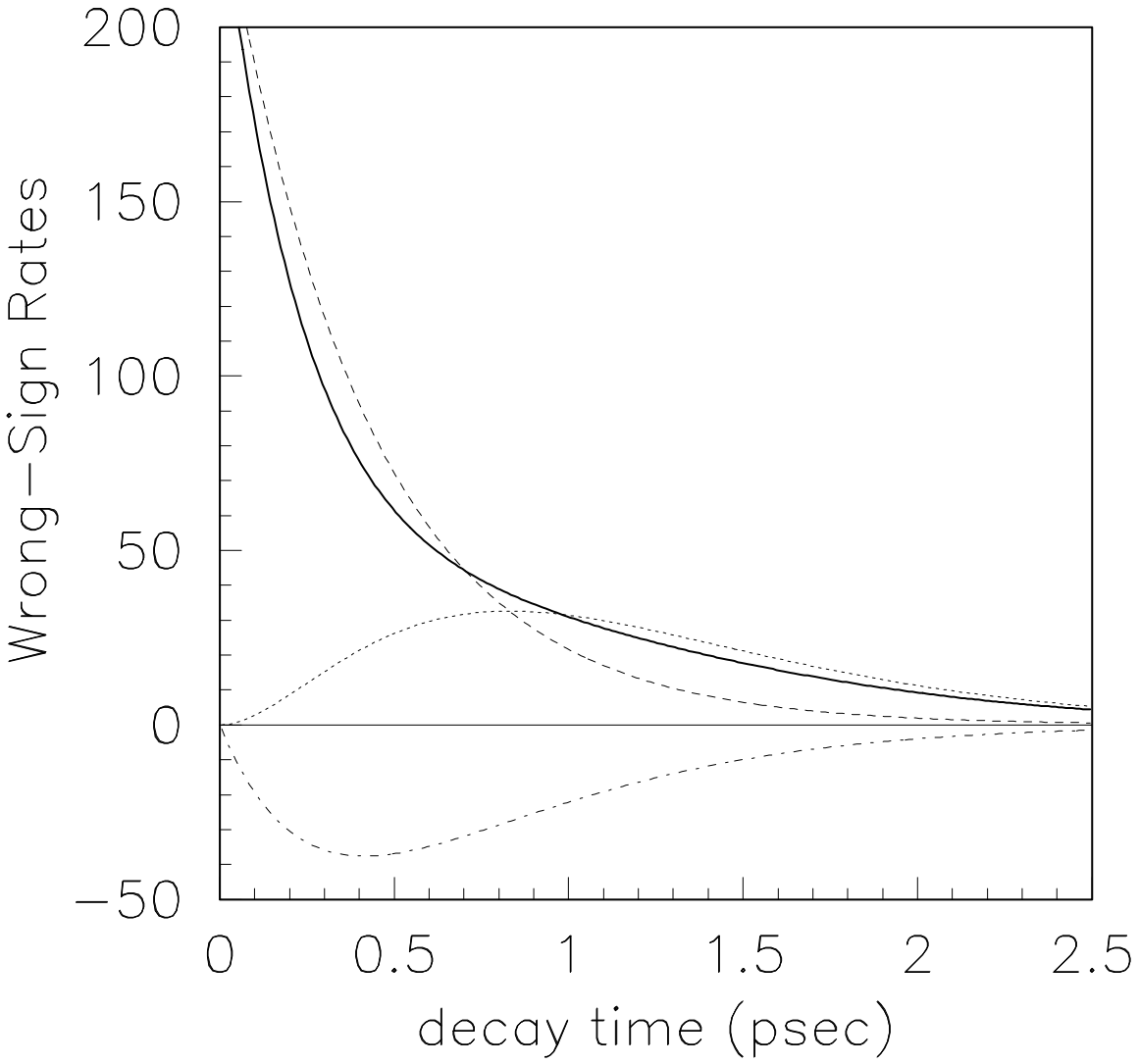
D^0-$\bar{D}^0$ mixing

- In the early days of charm, semileptonic decays were touted as a fertile hunting ground for mixing due to the lack of DCS background.
- An early experiment, E691, reported a mixing rate limit of 0.7% using a measurement based on the rate of like-sign dimuons.
- Another experiment, E615, had even earlier reported that $R_M < 0.56\%$, albeit with certain assumptions about charm production etc.
- Today, measurement of R_M using semileptonic decays continues to be elusive.

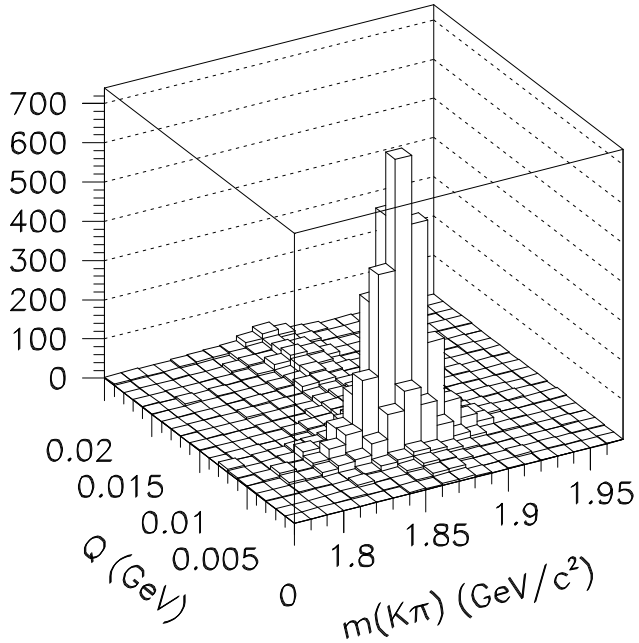
Mixing results from E791

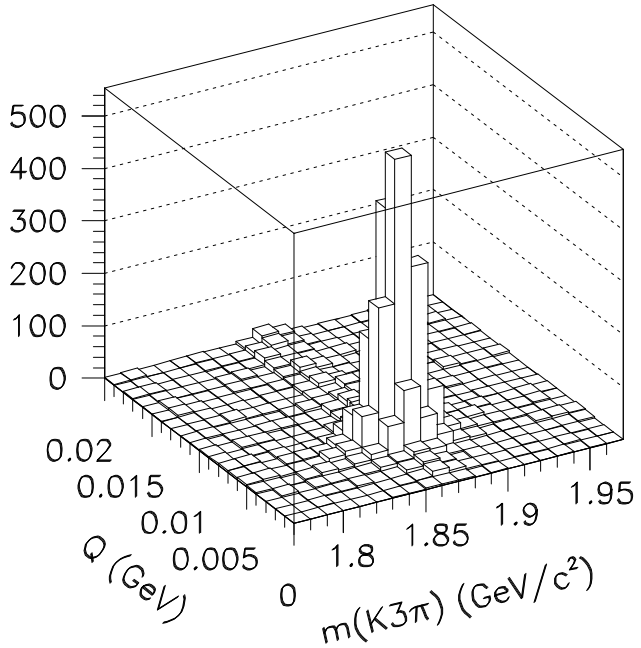
- Based on the sample of ~ 100σ D* decays, we utilized the Kπ decay mode.
- [We learned the D* trick of cleaning up events from Mike Witherell; later I learned of its origins from Val Fitch.]

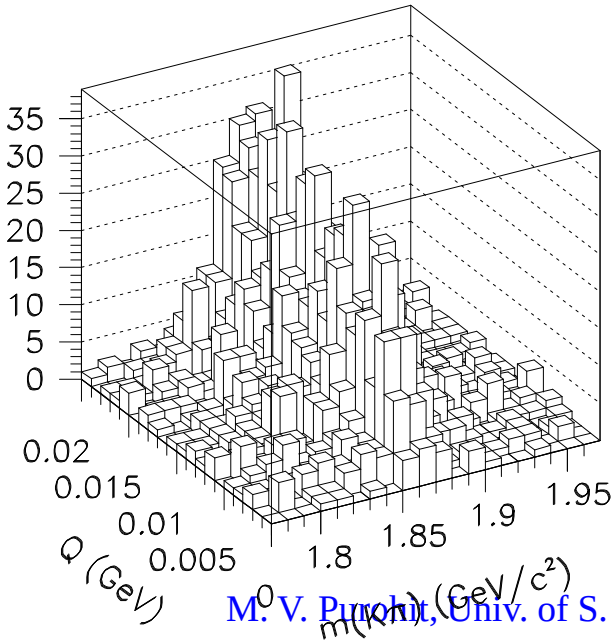
E791 Hadronic Mixing

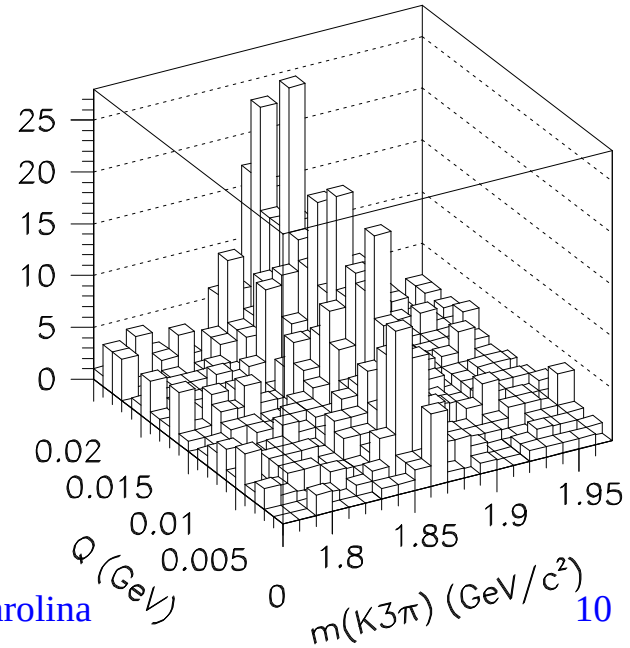


E791 Hadronic Mixing: Data









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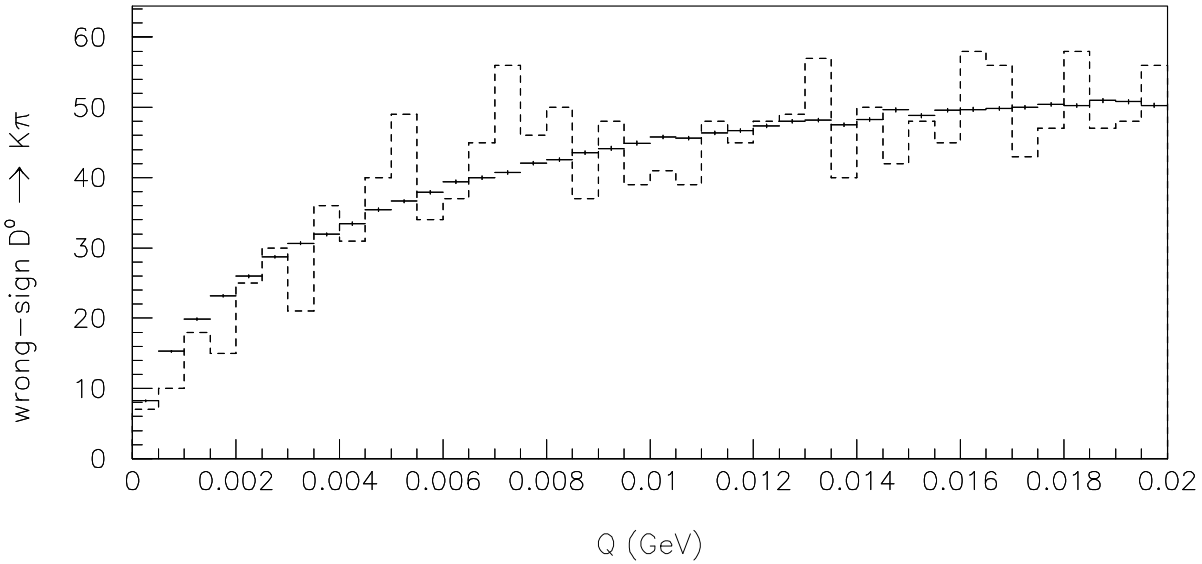
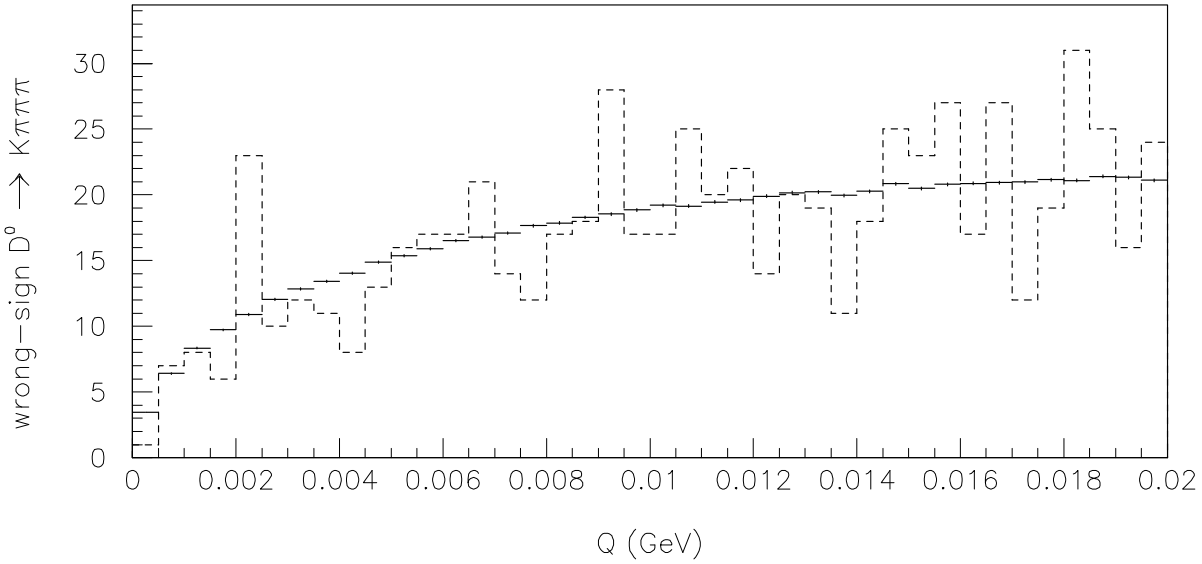
E791 Hadronic Mixing: Data





D^0-$\bar{D}^0$ mixing : Results

- Various results were obtained by E791, under various assumptions about interference:
  - R_M < ~ 0.4% - 1.0%, for the Kπ case
  - The semileptonic result was R_M < ~ 0.7%
- Results from FOCUS were similar. In the Kπ case, they performed various fits to the data and found that R_M < ~ 0.63%

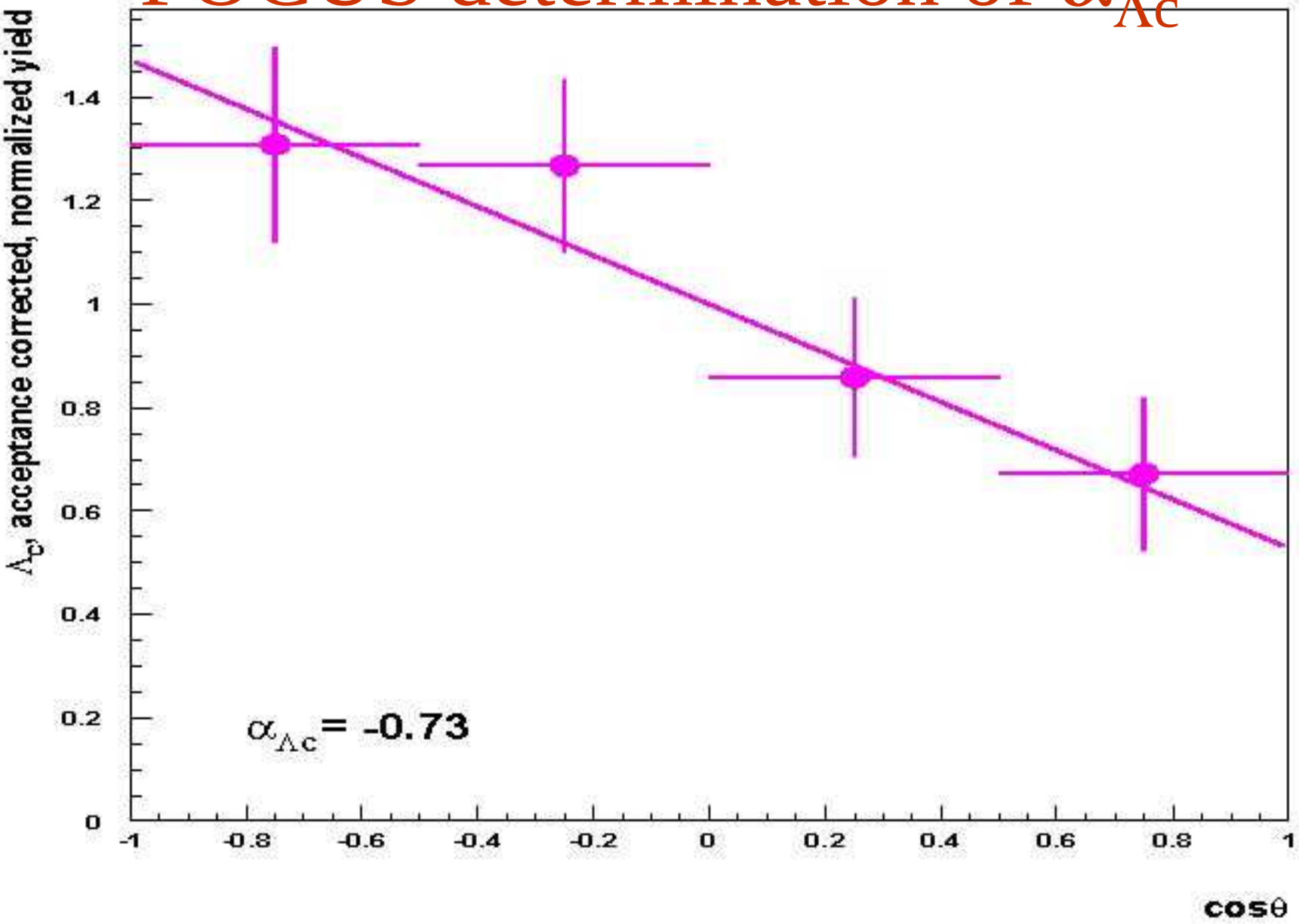
The beginnings of lifetime difference measurements

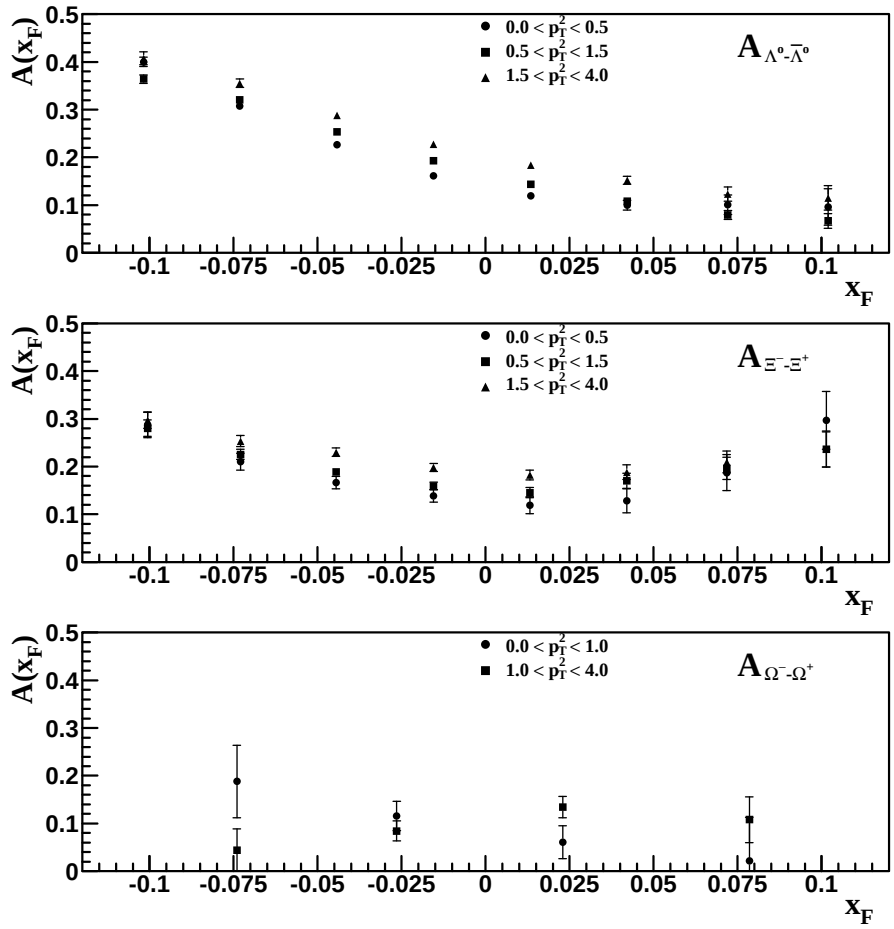
- Today the B factories routinely measure lifetimes in the K^+K^- and $\pi^+\pi^-$ modes and compare them to the lifetime in the $K\pi$ mode.
- There was a time when we marveled that B factories might ever measure the lifetime (given their relatively poor lifetime resolution).
- The first such measurements and their consequences for *y* were made by Fixed target experiments.

Baryons

- Examples of analyses include
  - Charge asymmetries in the production of Hyperons
  - Λ_c^+ resonant decay analysis into pKπ,
    Search for CPV
  - Λ_c^+ decay asymmetry parameter ($\rightarrow \Lambda\pi^+$),
    Search for CPV

FOCUS determination of $\alpha_{\Lambda c}$

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0.5 < p_T^2 < 1.5
1.5 < p_T^2 < 4.0
A_Λ°-Λ̄°
x_F
A(x_F)
0.0 < p_T^2 < 0.5
0.5 < p_T^2 < 1.5
1.5 < p_T^2 < 4.0
A_Ξ⁻-Ξ⁺
x_F
A(x_F)
0.0 < p_T^2 < 1.0
1.0 < p_T^2 < 4.0
A_Ω⁻-Ω⁺
x_F

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STACK:

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