Towards a FT Charm Chapter

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Motivation for a New Charm Expt.

Large *D*0 mixing (~1%) now observed at BaBar, Belle, and CDF

Exciting prospects for new physics sensitivity:

- CP violation in mixing would be direct evidence of new physics
- Mixing param's *x* or *y* larger than SM predictions, or $x >> y$
- CP violation in either |q/p| or its phase (|q/p|, ϕ not equal 1, 0)

Tevatron fixed-target charm experiment could give 10x sensitivity of the current generation of *B*-factory exp'ts.

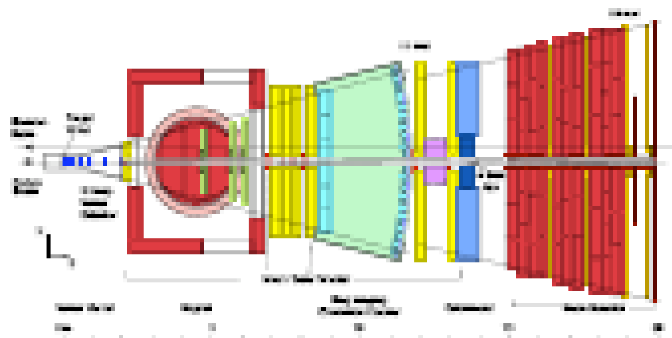
- Scaled from HERA-B, 64K tagged DCS decays reconstructed/yr
- Scaled from E791/FOCUS, 69K tagged DCS decays/yr
- Possible with modern rad-hard track'g, trigger, and comput'g

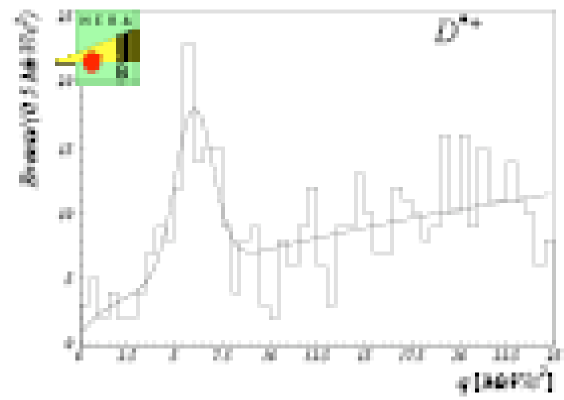
FT charm experiment – could be a major component of a Tevatron slow-spill program

FNAL experiment: yield estimate #1

Scale from HERA-B: 61.3 ± 13 D*-tagged CF $D^0 \to K^-\pi^+$ in 182 x 10^6 hadronic interactions. Multiplying this rate by $\Gamma(D^0 \to K^+\pi^-)/\Gamma(D^0 \to K^-\pi^+)$=0.377% gives a fractional rate (including (loose) trigger + reconstruction efficiencies) of 1.3 x 10^{-8} (Reference: I. Abt et al., Eur. Phys. Jour. C52, 531, 2007)

proton beam,
p = 920 GeV/c





One year of running, assuming 7 MHz interaction rate and trigger efficiency of 50% relative to that of HERA-B:

$$(7\ \text{MHz})(1.4 \times 10^7\ \text{s})(1.3 \times 10^{-8})(0.5) = 64000\ \text{D*-tagged}\ D^0 \to K^+\pi^-$$

⇒ **192000 in 3 years of running**

FNAL experiment: yield estimate #2

Scale from E791: 35 D-tagged DCS $D^0 \rightarrow K^+\pi^-$ in 5 x 10^{10} hadronic interactions. This gives a fractional rate (including (loose) trigger + reconstruction efficiencies) of 7 x 10^{-10}* (Reference: E. Aitala et al., PRD 57, 13, 1998)

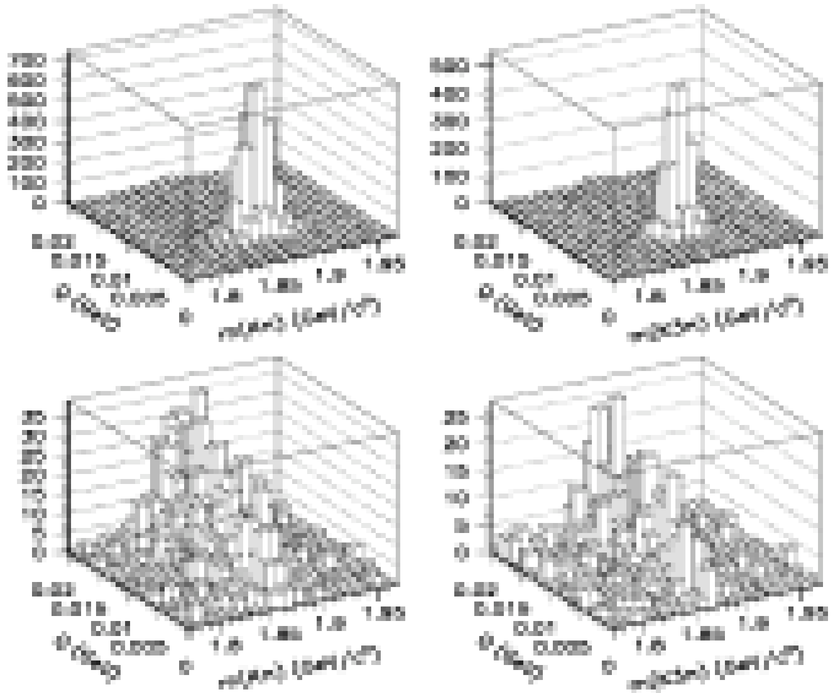
π^- beam,
p = 500 GeV/c

CF $D \rightarrow K^-\pi$

CF $D \rightarrow K^-\pi\pi$

DCS $D \rightarrow K^+\pi$

DCS $D \rightarrow K^+\pi\pi$



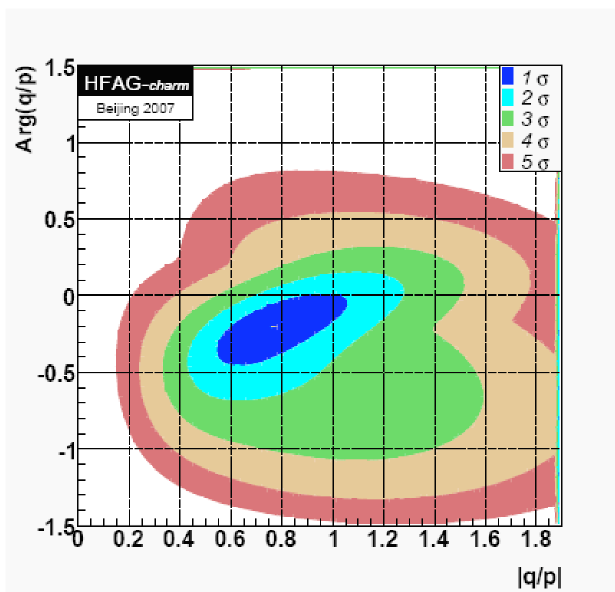
One year of running, assuming 7 MHz interaction rate and the same trigger+reconstruction efficiency as E791:

(7 MHz)(1.4 x 10^7 s)(7 x 10^{-10}) = 69000 D*-tagged $D^0 \rightarrow K^+\pi^-$

$\Rightarrow$ **207000 in 3 years of running**

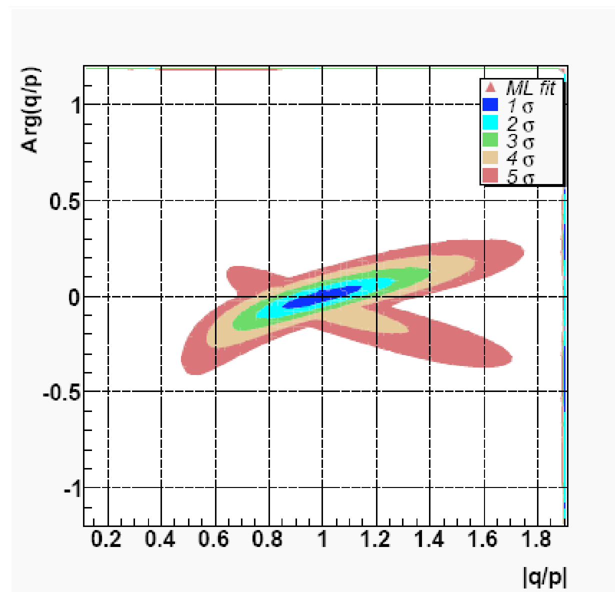
Charm Mixing and *CP* Violation Program at the Tevatron

230K DCS decays reconstructed in 3-4 yr run
Plots of CP V parameters: ϕ vs $|q/p|$



Current Measurements

(HFAG)



Same central values, scaled

uncertainties for 3-4 yr run

(scaled y_{CP} and Belle $D^0 \rightarrow K^+\pi^-$)

Why LHCb can't do these measurements?

The short answer is:

A charm experiment at LHC? Yes, perhaps, but there are nontrivial uncertainties regarding triggering, backgrounds, etc.

In a global sense, one does not want to do a energies; the Tevatron energy is about right.

One does not want to take D*'s only from B decays; prompt D*'s are desired.

The LHCb lifetime distribution will contain both prompt and B-daughter D*'s with different lifetime functions.

Super B-Factories

Proposals for a Super B-factory talk about as much as ten times our Tevatron estimates.

So, if a B-factory were approved quickly, the Tevatron FT idea will not have traction.

It's not clear what can happen to push a B-factory soon.

Charm Chapter Outline

Introduction
- Motivation

Brief overview of technologies leading to new opportunities.
- Silicon pixels (vertexing)
- Triggering (decay vertices, impact parameters)
- RICH detectors (pi/*K* separation)

List of the physics examples in the sub-chapters to follow:
- CP violation in D mixing
- Direct *CPV* searches
- Rare and forbidden charm decays
- Spectroscopy via Dalitz-plot analyses
- Spectroscopy via production (e.g., double charm baryons)
- Others?

Summary

In brief, we write this chapter to keep the possibility of a fixed-target charm experiment at the Tevatron a viable option for Fermilab (and the US HEP program), to be decided upon once there is a clearer picture of available funding, manpower, and feasibility of the current roadmap.

Where Are We?

We have drafted an introduction and the previous outline, sent it to some of the leaders in charm physics last week, and already have five responses.

We will work towards a document with those who express interest.