# SLAC Summer Institute 2002
# HF @ Tevatron

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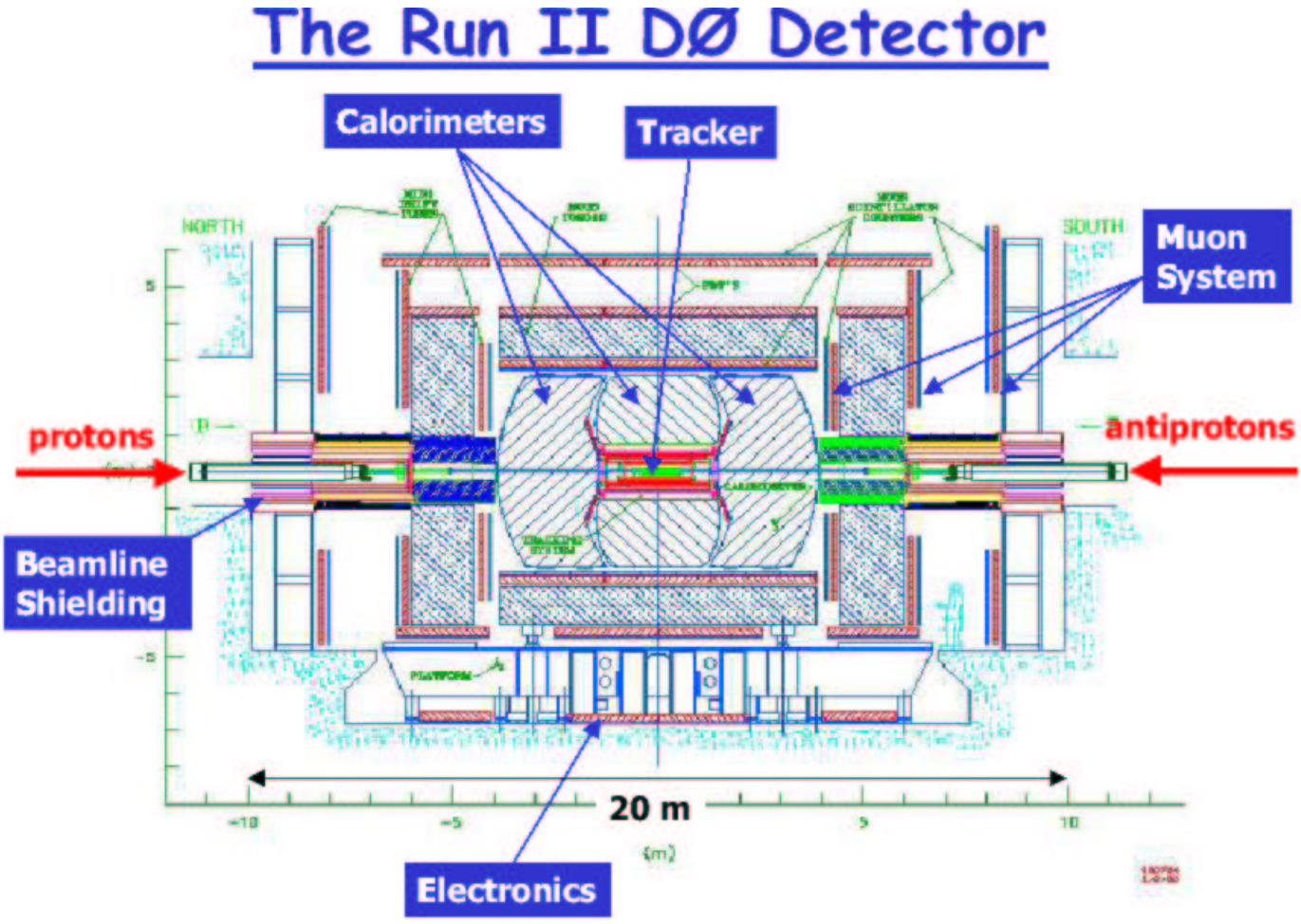
**MIT/CDF**

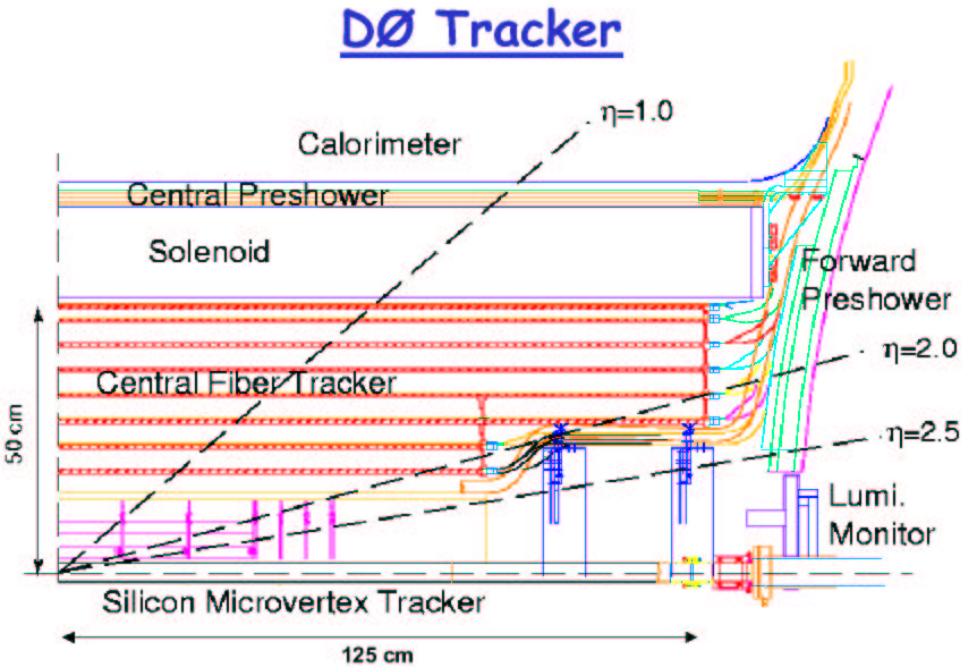
## Overview of Lecture 2

- D0 and CDF Detector Status
- CDF vs BaBelle Today
  - Charm Physics
  - $B \to h^+ h^-$

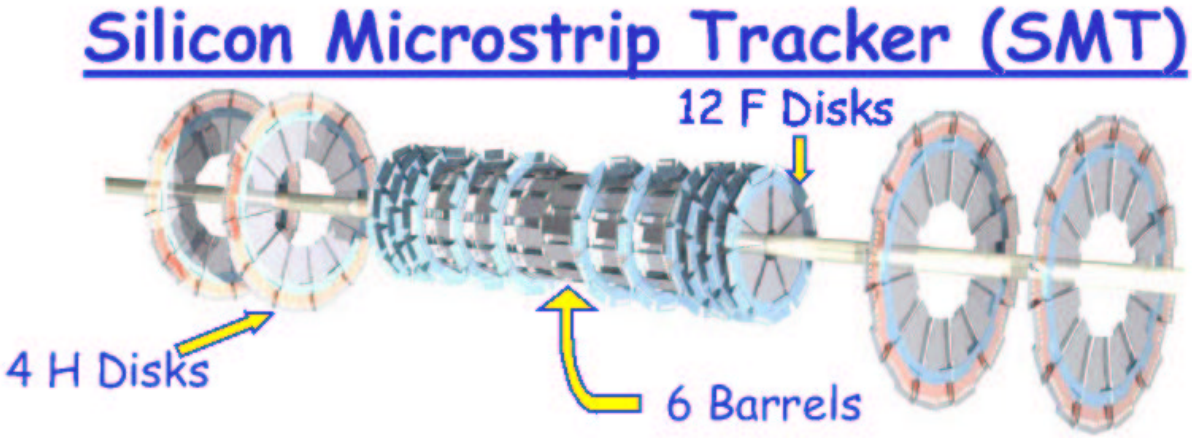
# D0 Detector


The Run II DØ Detector
Calorimeters
Tracker
Muon System
protons
antiprotons
Beamline Shielding
Electronics
20 m
NORTH
SOUTH

# D0 Tracking System




8x2 fibers
100μm pe
doublet



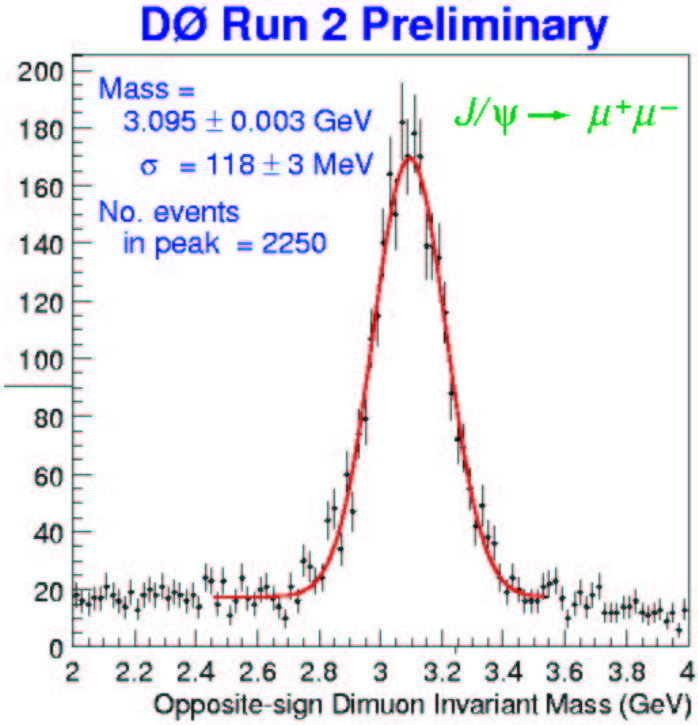
# D0 Trigger Status

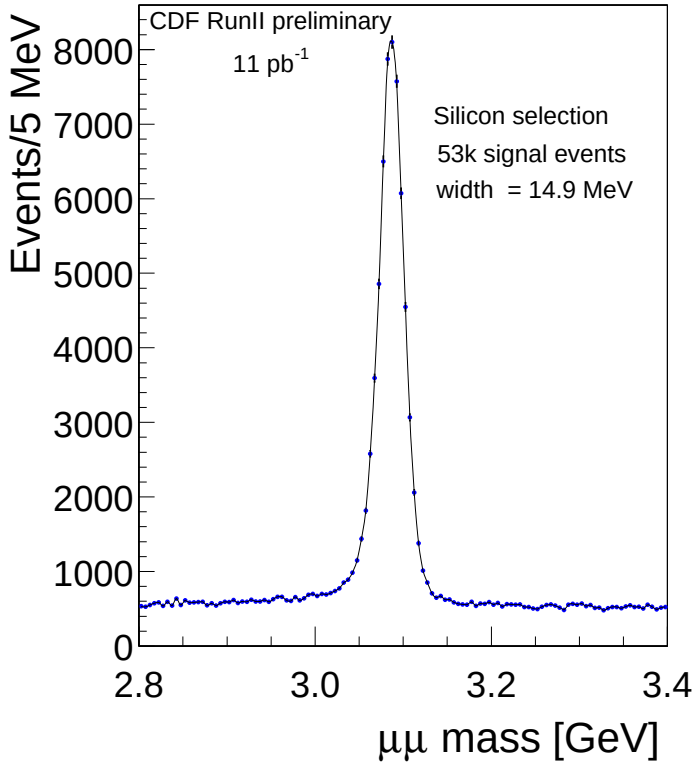

## Plan to Trigger on:

- $J/\psi \to \mu^+\mu^-$
- $J/\psi \to e^+e^-$
- single lepton

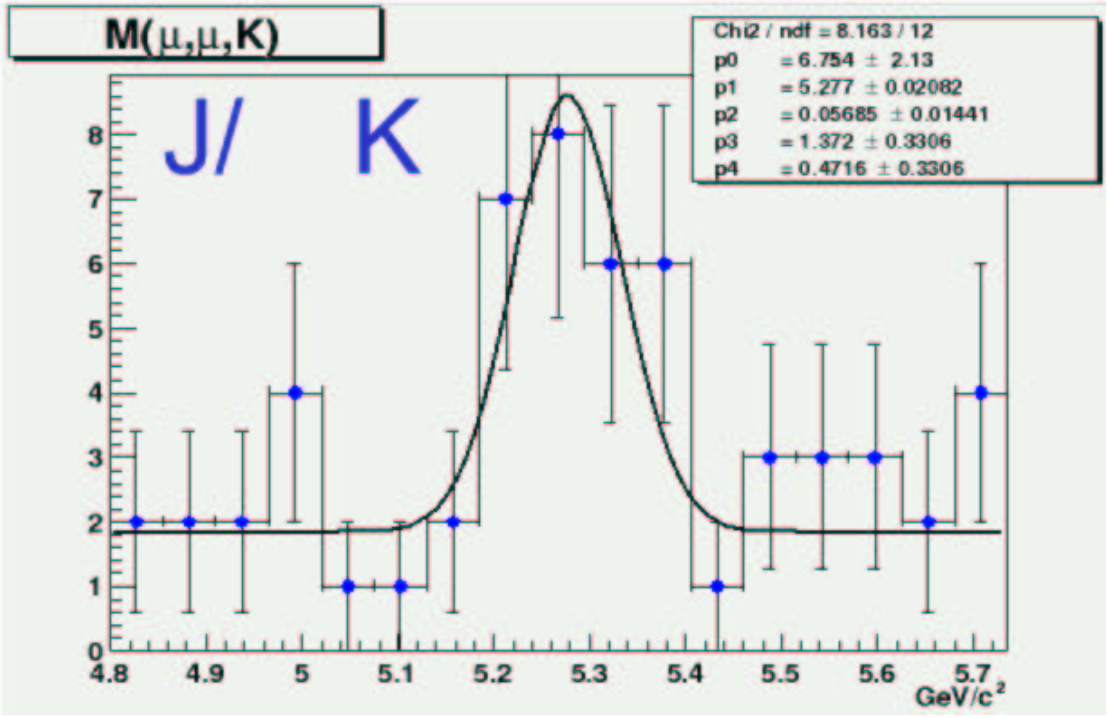
# D0/CDF — Comparison of Status

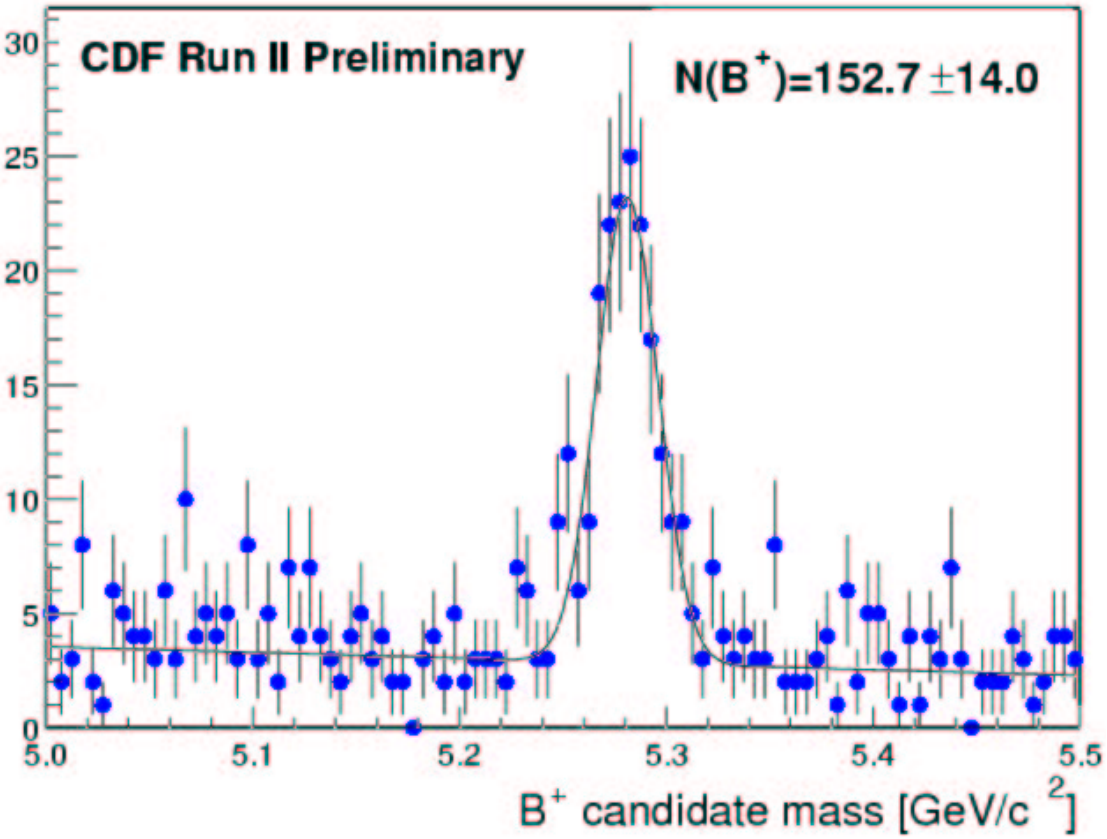
# $J/\psi$ Sample


DØ Run 2 Preliminary
Mass =
3.095 ± 0.003 GeV
σ = 118 ± 3 MeV
No. events
in peak = 2250
J/ψ → μ+μ−
Opposite-sign Dimuon Invariant Mass (GeV)

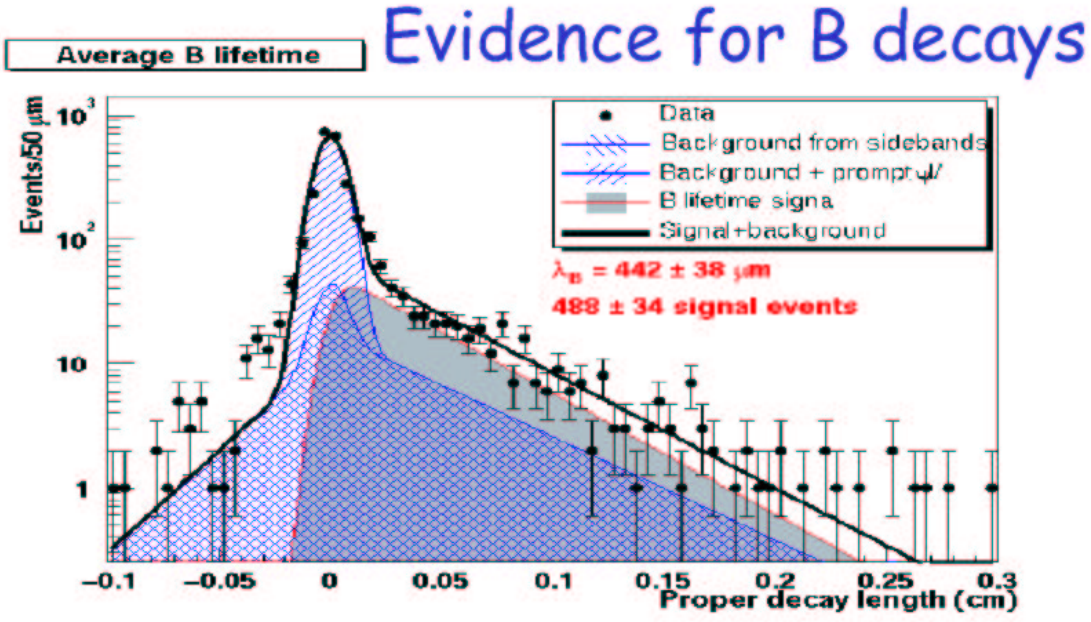

CDF RunII preliminary
11 pb-1
Silicon selection
53k signal events
width = 14.9 MeV
Events/5 MeV
μμ mass [GeV]

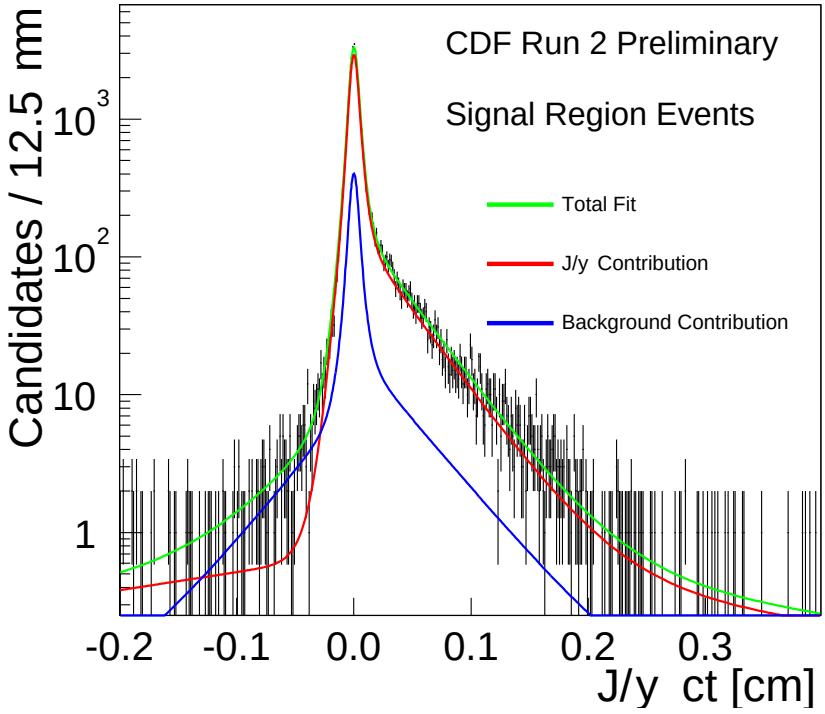
# $B^+ \to J/\psi K^+$


M(μ,μ,K)
J/ K
Chi2 / ndf = 8.163 / 12
p0 = 6.754 ± 2.13
p1 = 5.277 ± 0.02082
p2 = 0.05685 ± 0.01441
p3 = 1.372 ± 0.3306
p4 = 0.4716 ± 0.3306
GeV/c²


CDF Run II Preliminary
N(B⁺)=152.7 ±14.0
B⁺ candidate mass [GeV/c²]

# Inclusive Lifetime

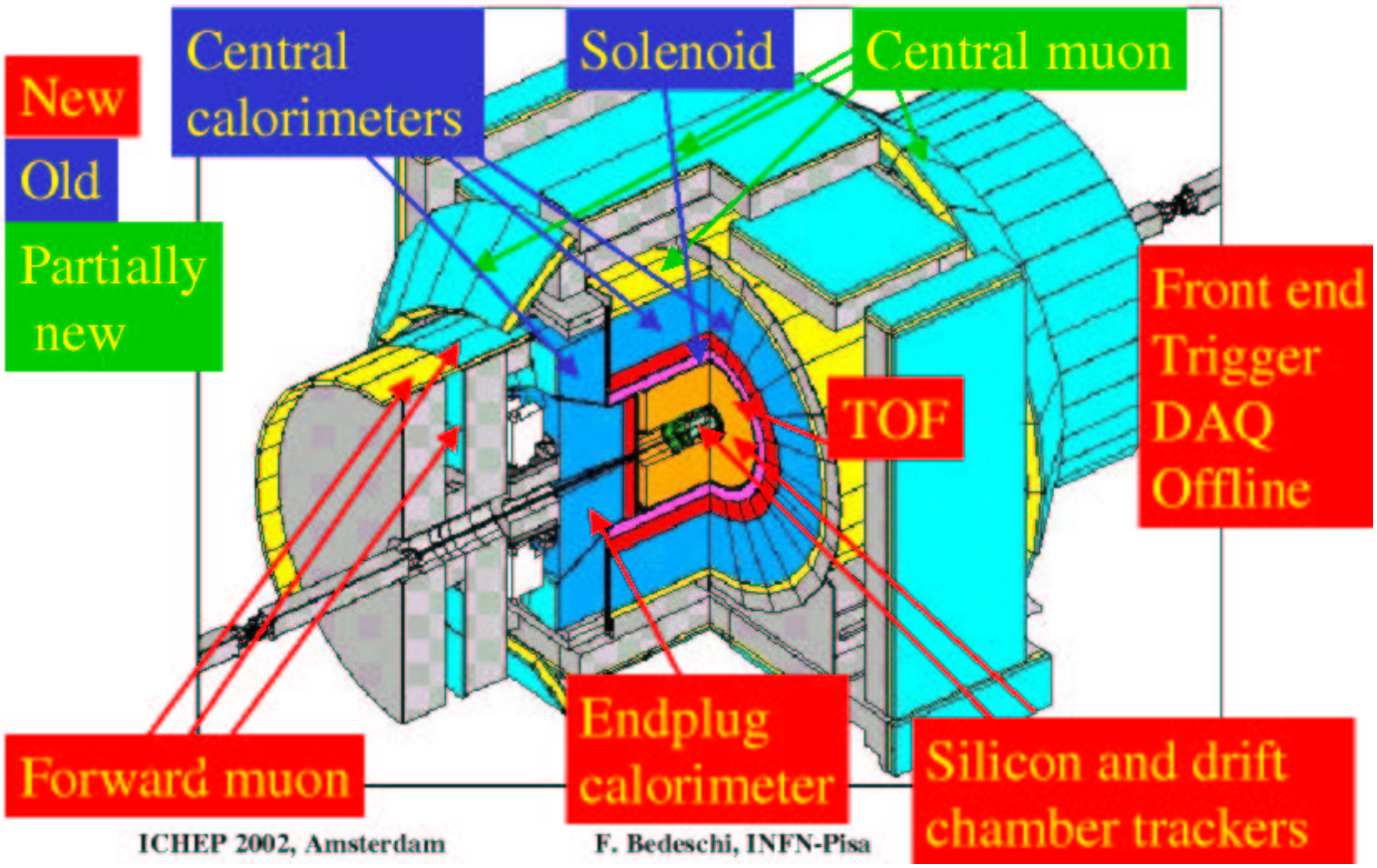



CDF measurement: $c\tau = 458 \pm 10 \pm 11 \mu$m

# CDF Detector Details

# CDF Detector

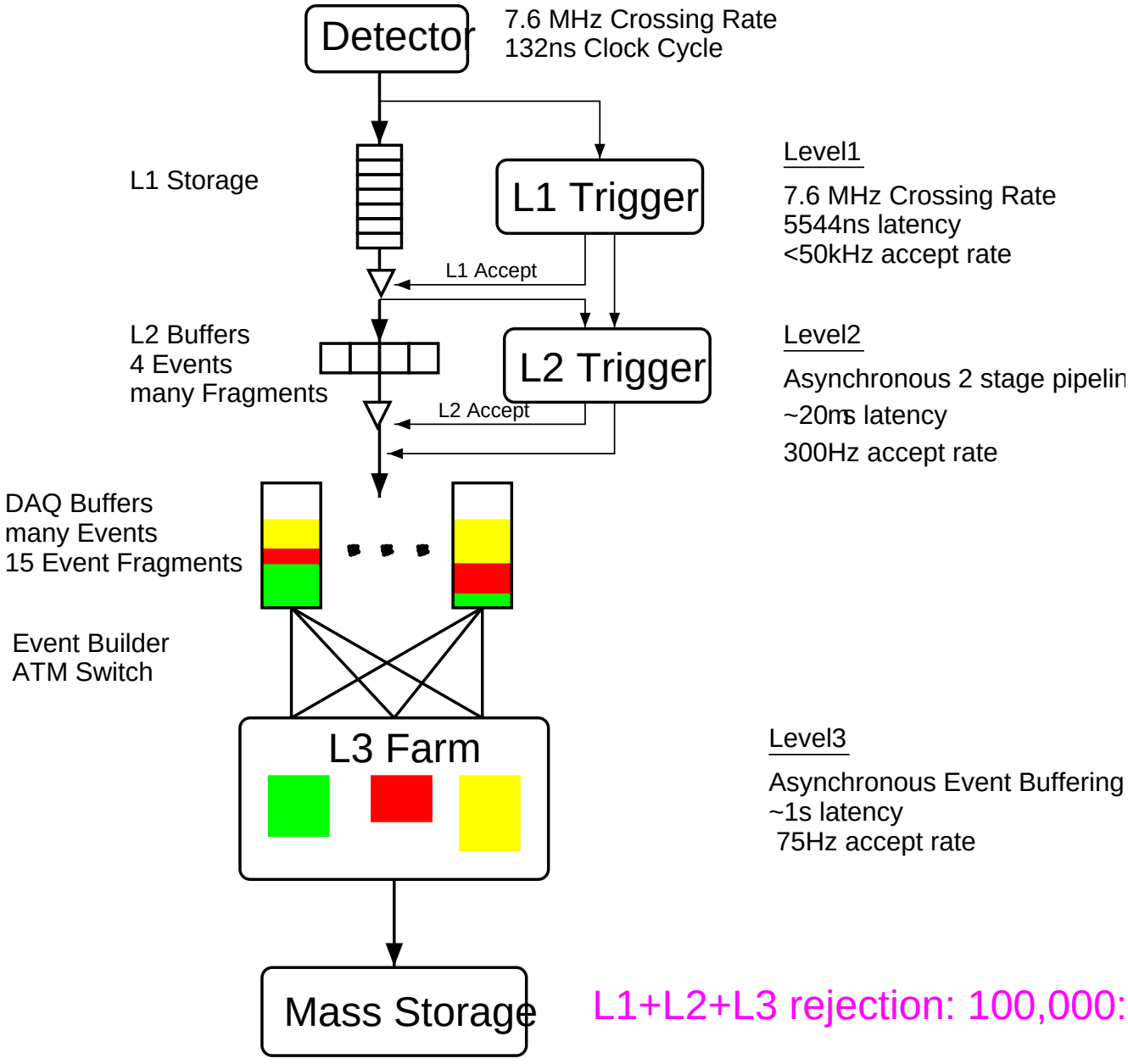


# CDF: What's new in Run II(a) ?

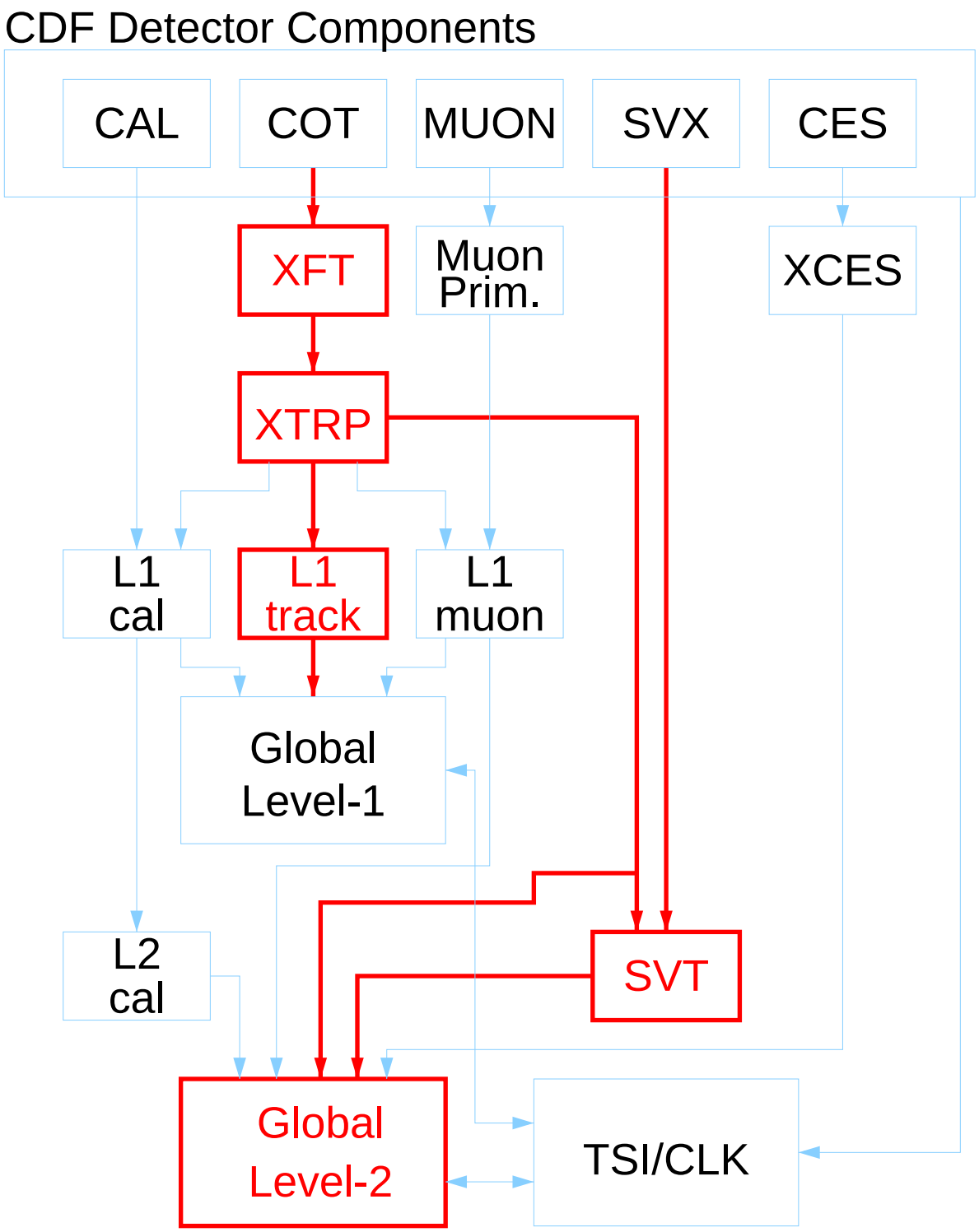
- 10% increase in $\sqrt{s}$
- $\times 20$ increase in luminosity
- radically new Trigger
  - $\times 50$ increase in $J/\psi$ yield
  - $\times 10^4 - 10^5$ increase in hadronic heavy flavor yield

# CDF Trigger and DAQ Overview

## Dataflow of CDF "Deadtimeless" Trigger and DAQ



# CDF Run II Trigger System



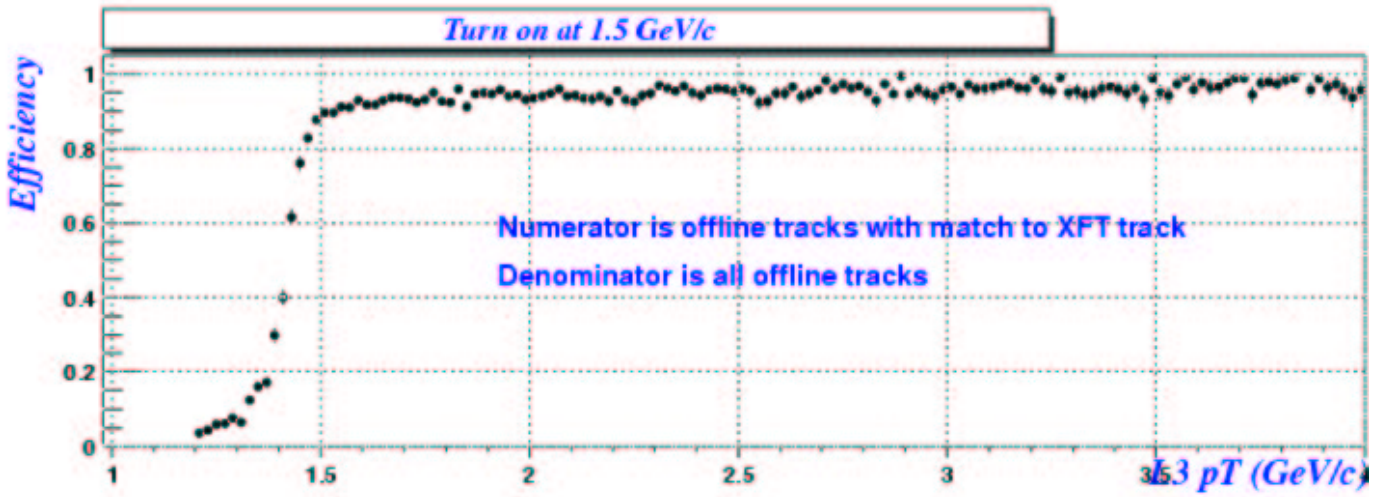
# CDF Run II Hadronic $b$ Trigger

Level1: crude r-$\phi$ tracking, COT only

- 2 opp. charge tracks with $p_T > 2$GeV
- sum $p_T$ of 2 tracks $> 5.5$GeV
- $\Delta\phi < 135°$

$\rightarrow \sim 60\%$ **of L1 bandwidth**

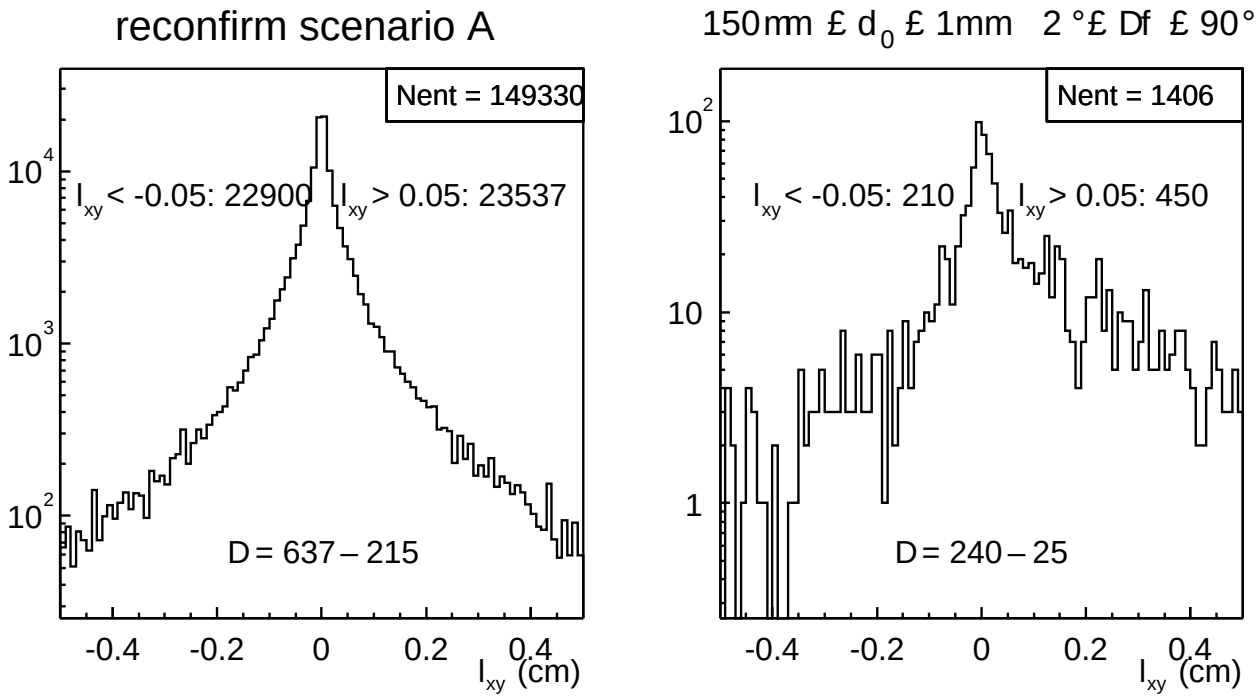
## XFT turn on curve



# Level2 Hadronic $b$ Trigger

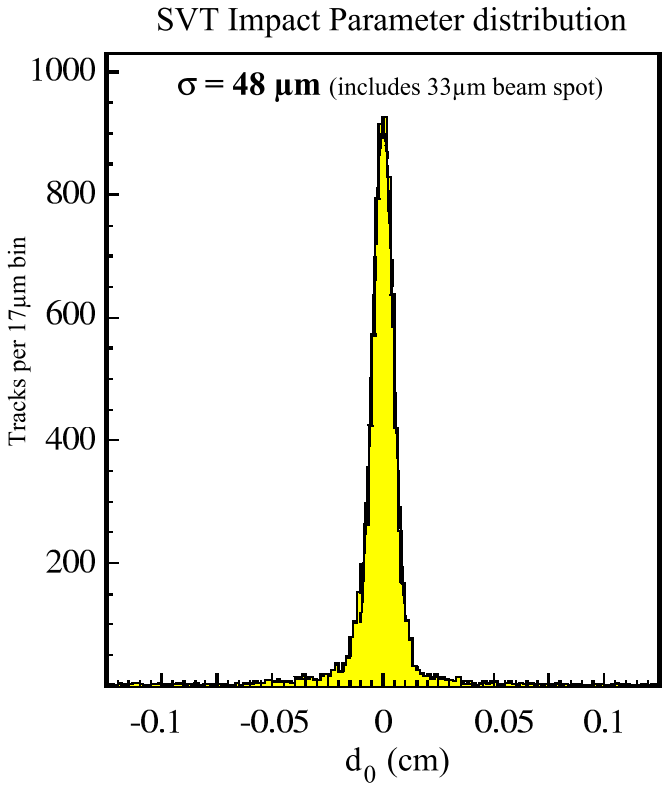
- repeat L1 but with better tracking resolution
- impact parameter of tracks within 100$\mu$m - 1.0mm
- cuts on $\Delta\phi, d0, \vec{p_t}\vec{x_v}$ of track-pair

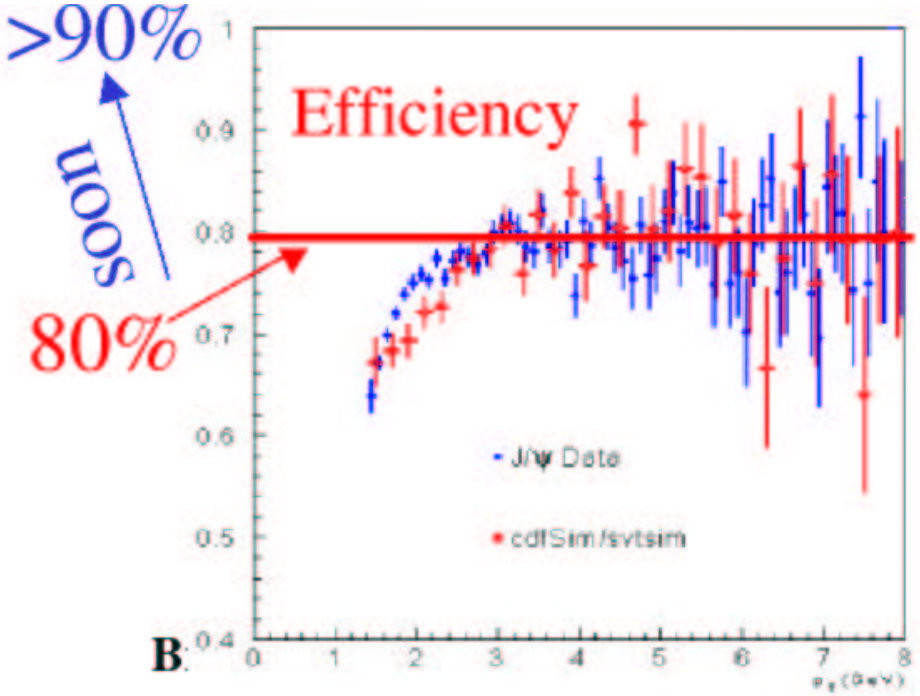
$\rightarrow \sim 20 - 30\%$ of L2 bandwidth




Lxy = flight distance in x–y plane,
projected onto 3–momentum.

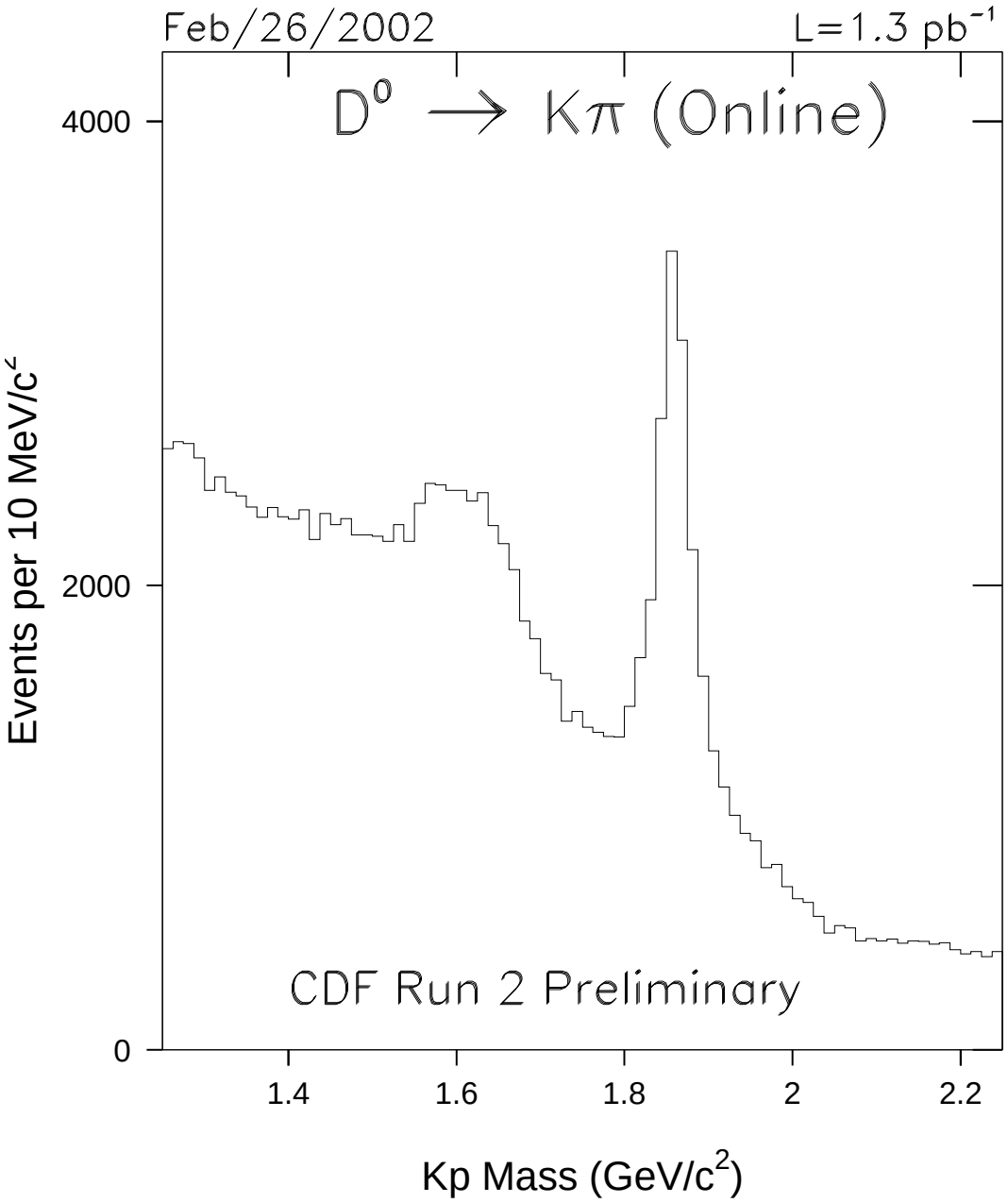
# Performance of Level2 Hadronic Trigger



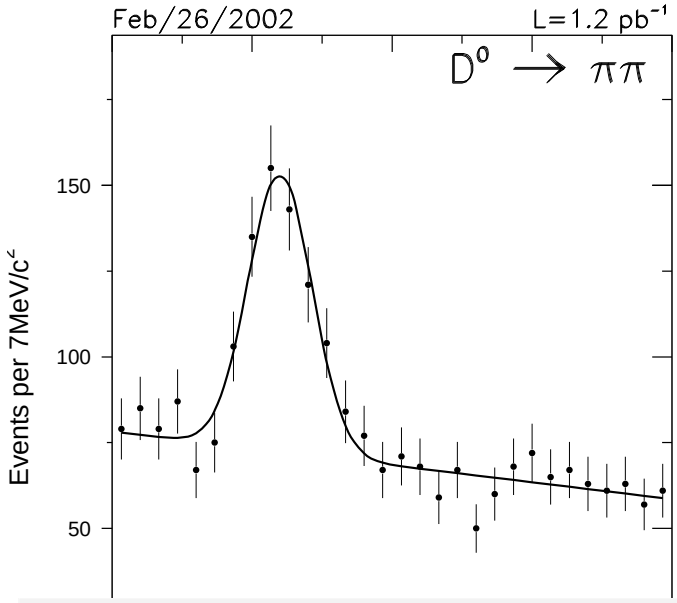

Impact parameter resolution = 35$\mu$m

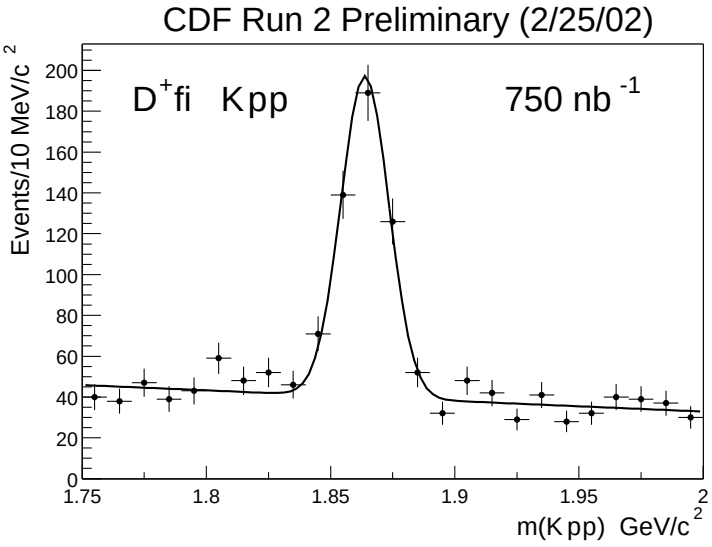
# $D^0$ as seen by L2 Trigger

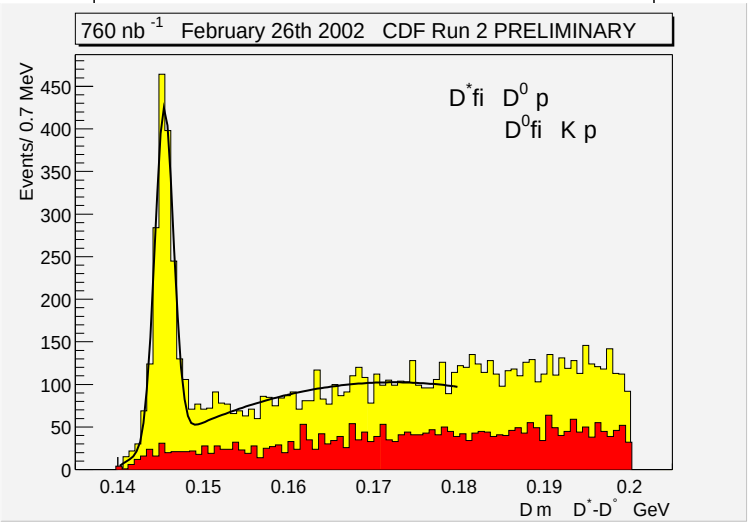


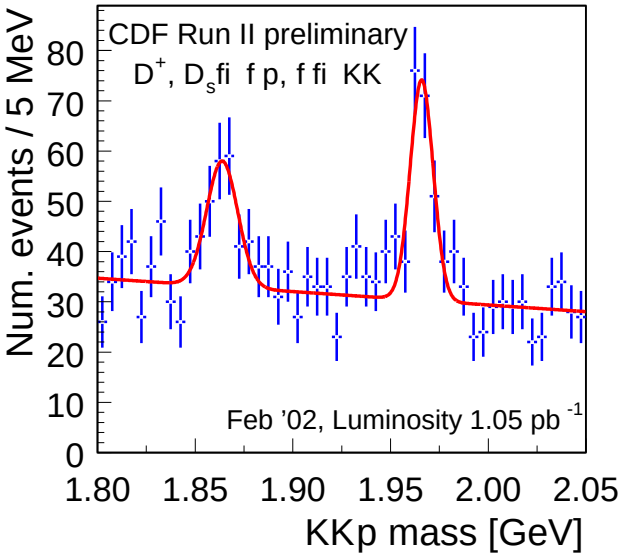

$\sim 10,000\ D^0 \to K^-\pi^+$ per $pb^{-1}$ ...
... or $\sim$ 1Hz @ design lumi!!!

# Charm @ CDF




This is 3 hours of running @ design lumi !!!

# Level3 Hadronic Trigger

## Expected Composition:

- $\sim$ 100nb $b\bar{b}$ trigger crossection for Level2 (Pythia MC)
- $\sim$ 100nb $c\bar{c}$ trigger crossection for Level2 (Pythia MC)
- $\sim$ 560nb hadronic trigger crossection for Level2 (Run I data)
- $<$ 20Hz output to storage for hadronic trigger

At Run2a design Luminosity ($10^{32}/cm^2sec$)...
... we may be throwing away c's & b's in Level3!!!

Full silicon reconstruction @ L3
$\Rightarrow$ Physics Analysis selection @ L3

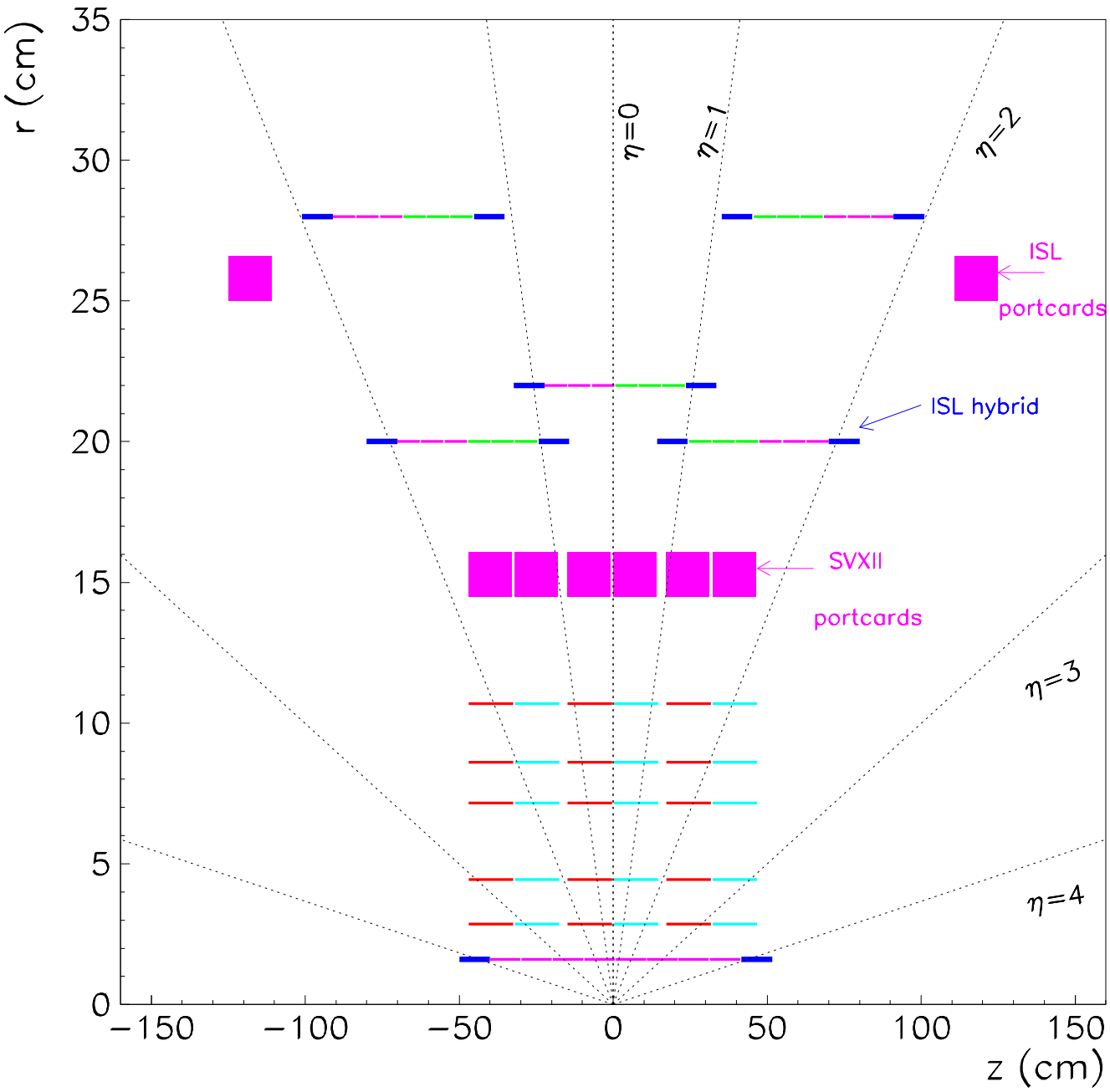
# Hadronic Trigger Summary

| *cut* | $eff.\ B \to \pi^+\pi^-$ | *eff. bkg* | *ratio* |
|---|---|---|---|
| $p_t > 2GeV$ | 0.12 | 0.025 | 5 |
| *opp. charge* | 1 | 0.64 | 1.6 |
| $\Delta\phi$ | 0.7 | 0.6 | 1.2 |
| | | | |
| *d0 cut* | 0.18 | $1.5 \times 10^{-3}$ | 120 |

## Selection of other B decays

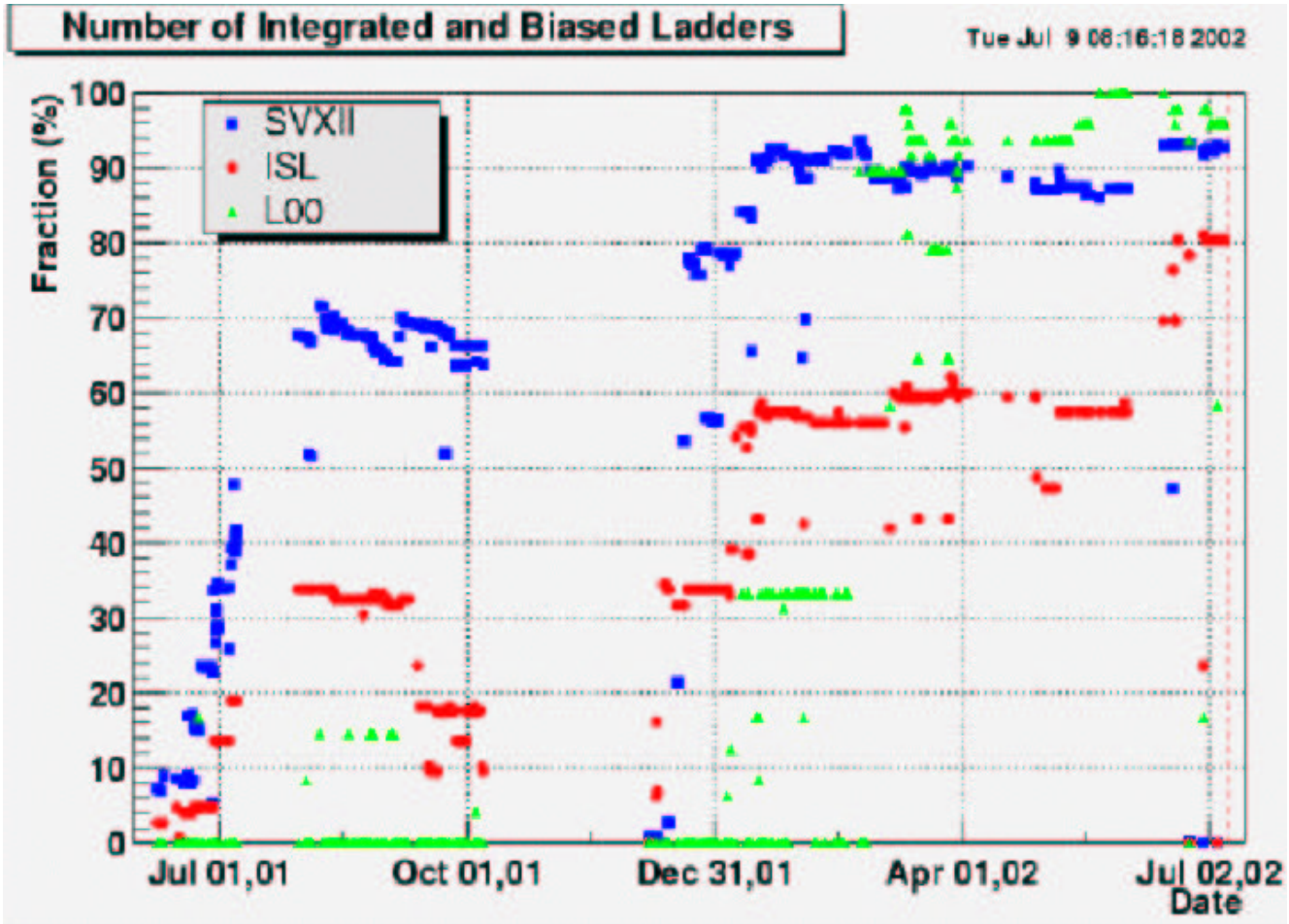
| | | |
|---|---|---|
| $\pi^+\pi^-$ | $\sim$ | 1% |
| $\rho^0\pi^+$ | $\sim$ | 0.4% |
| $K^{*+}\pi^-$ | $\sim$ | 0.2% |
| $\phi K_s$ | $\sim$ | 0.1% |
| | | |
| *generic* | $\sim$ | 0.1% |

# CDF — The SVX Experiment

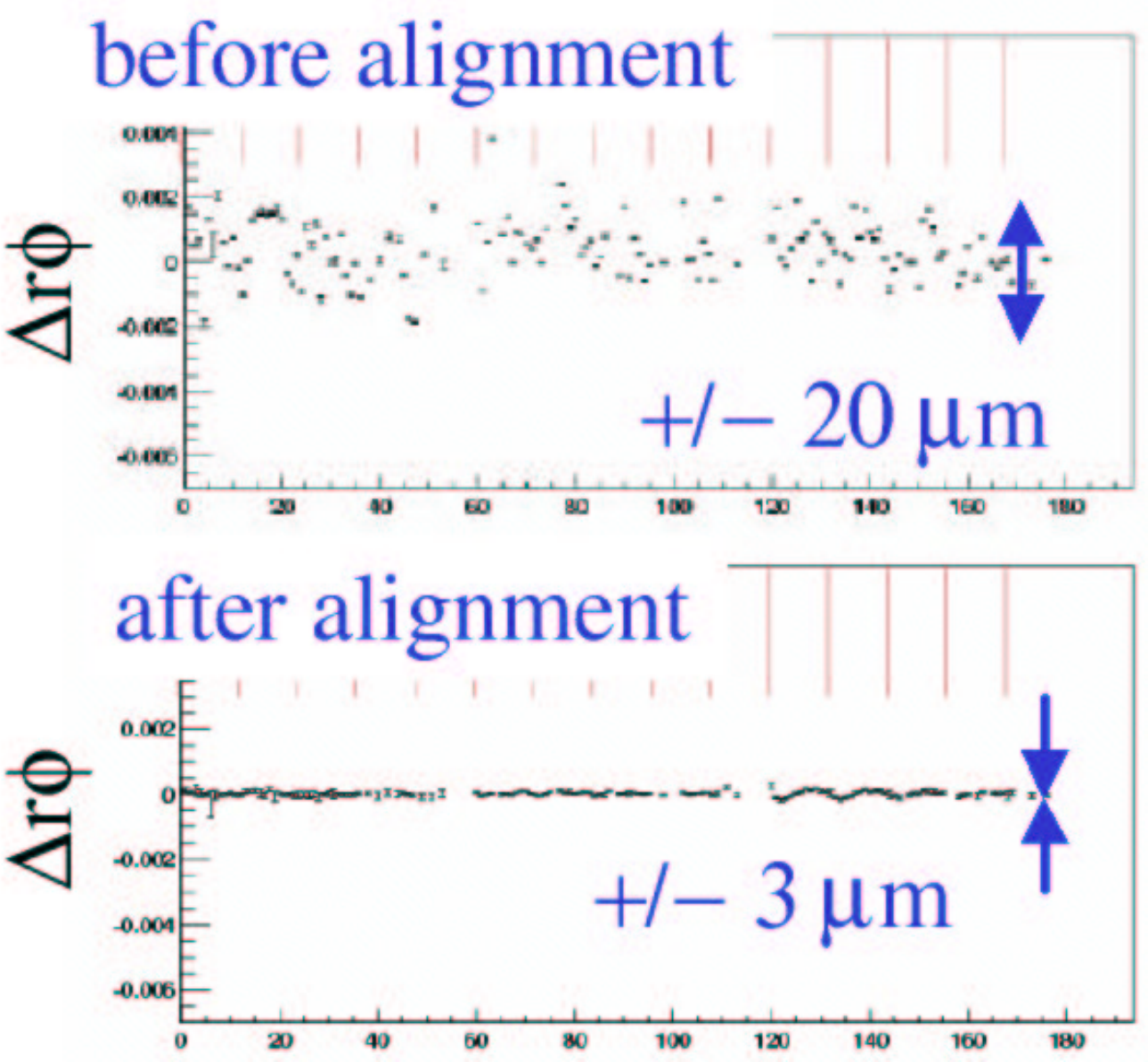



8 silicon & 96 drift chamber layers

# Sili Detector Commissioning



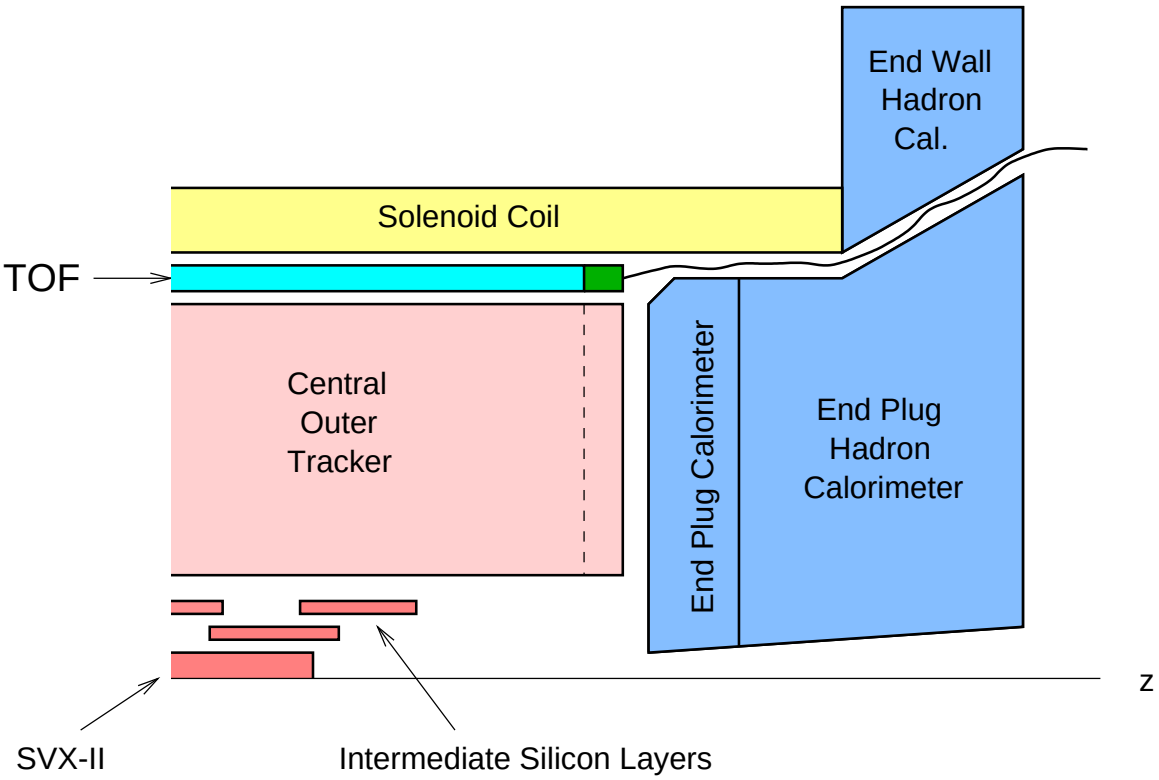
# Alignment

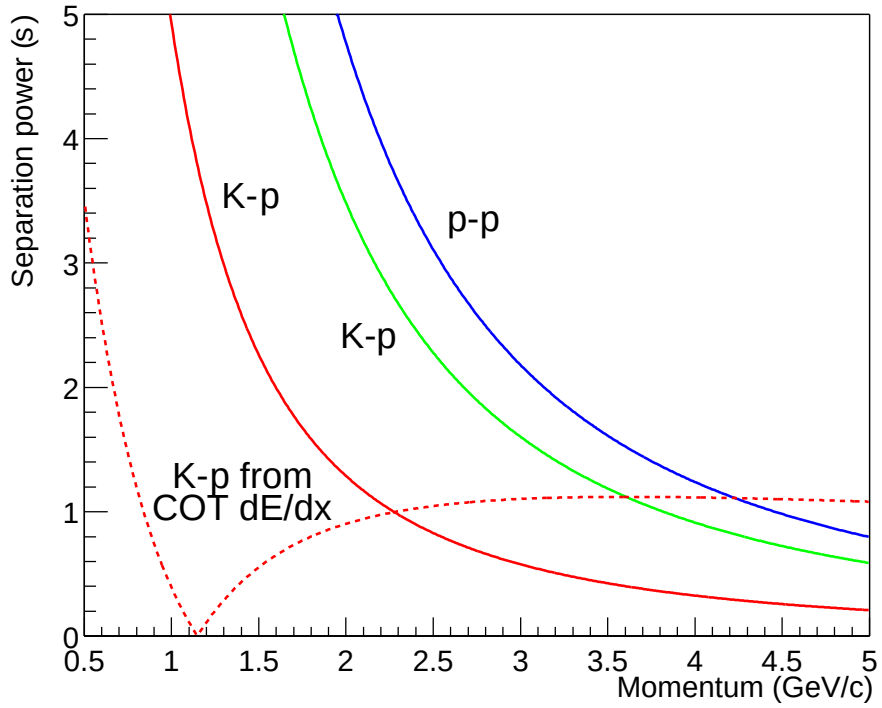



## Remaining Tracking Issues

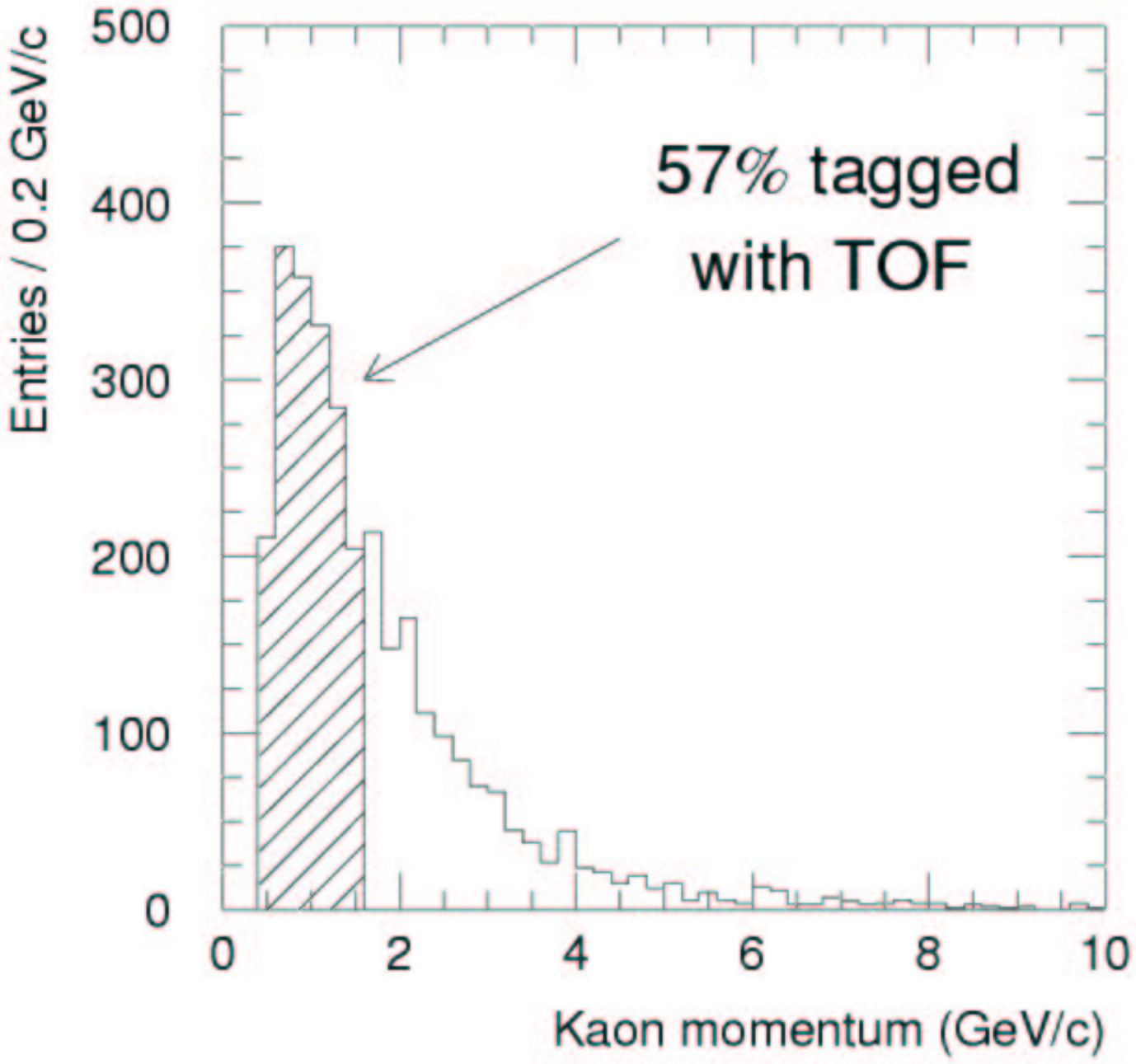
- z-alignment
- 3D tracking
- incl. of L00
- silicon standalone tracking

# CDF Time of Flight System

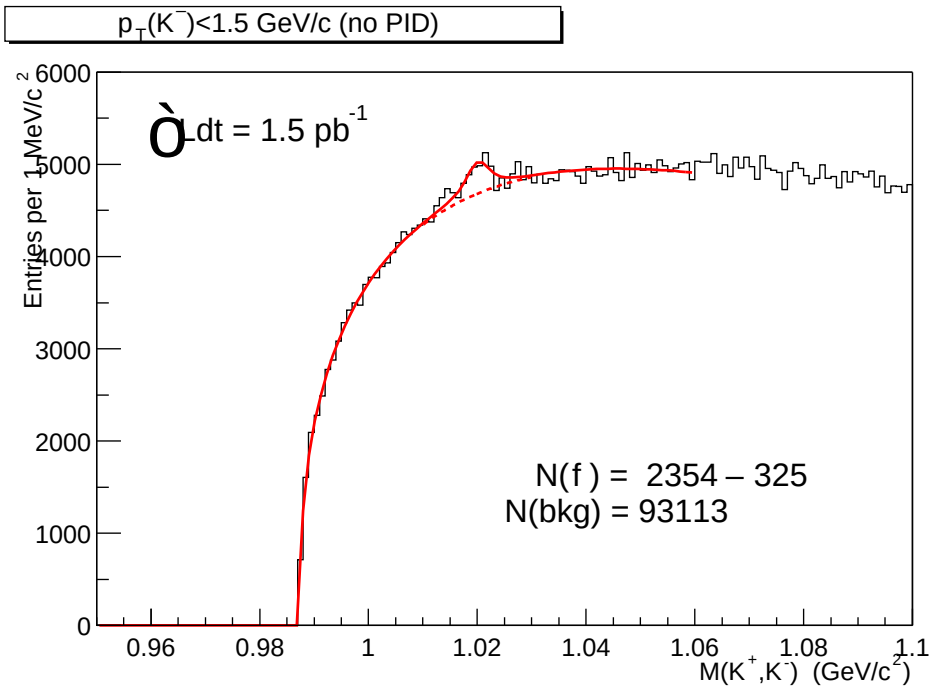


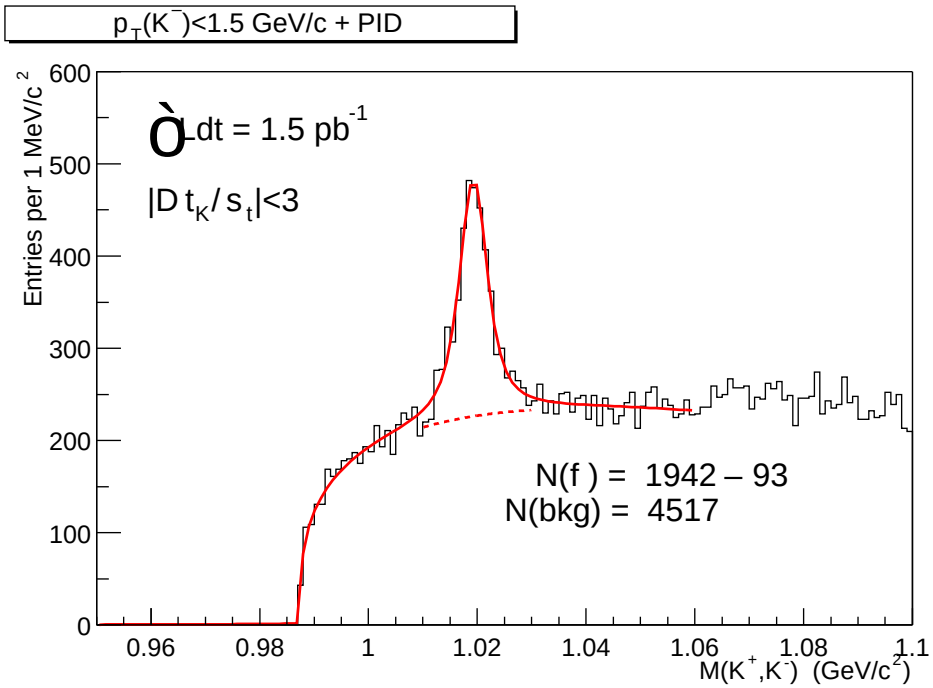



# Opposite side Kaons in MC



# $\phi \to K^+K^-$ with/without TOF




×20 bkg reduction @ 80% eff.

# "Normalizing" BaBelle and CDF

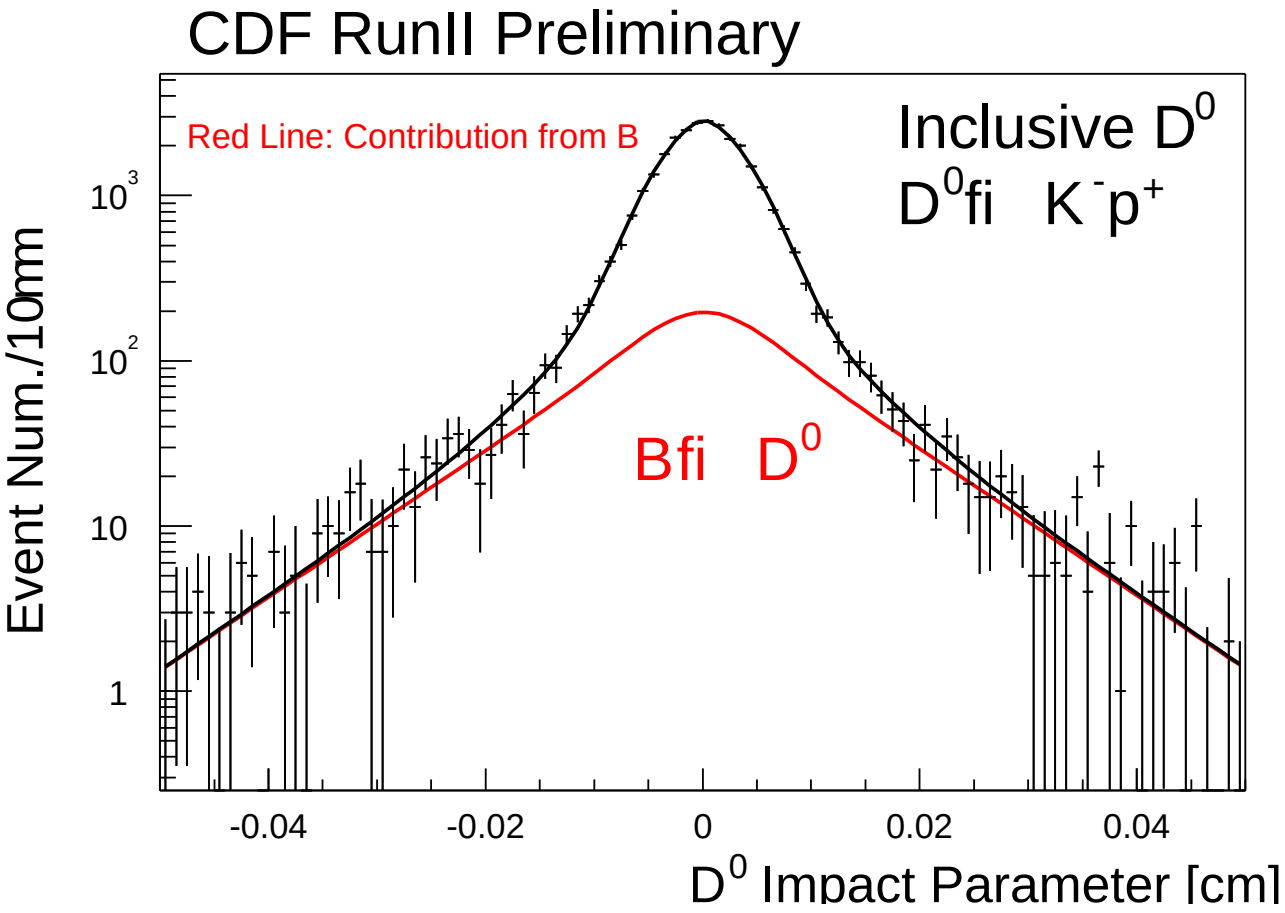
- $D^{*+} \to D^0\pi^+ \to K^-\pi^+\pi^+$
- $D^0 \to h^+h^-$
- $B^0 \to h^+h^-$

# Goals of CDF Charm Program

- $\Delta\Gamma \rightarrow$ no $D^*$ tag
- rare and forbidden $D$ decays $\rightarrow$ no $D^*$ tag
- CP violation in $D^0 \rightarrow h^+h^-$ $\rightarrow$ requires $D^*$ tag

Common Problem: Distinguish prompt from secondary

# Prompt Charm vs Charm from $B$'s




## Fractions of Charm from B

$$D^0 \qquad 16 - 23\%$$

$$D^{*+} \qquad 10 - 20\%$$

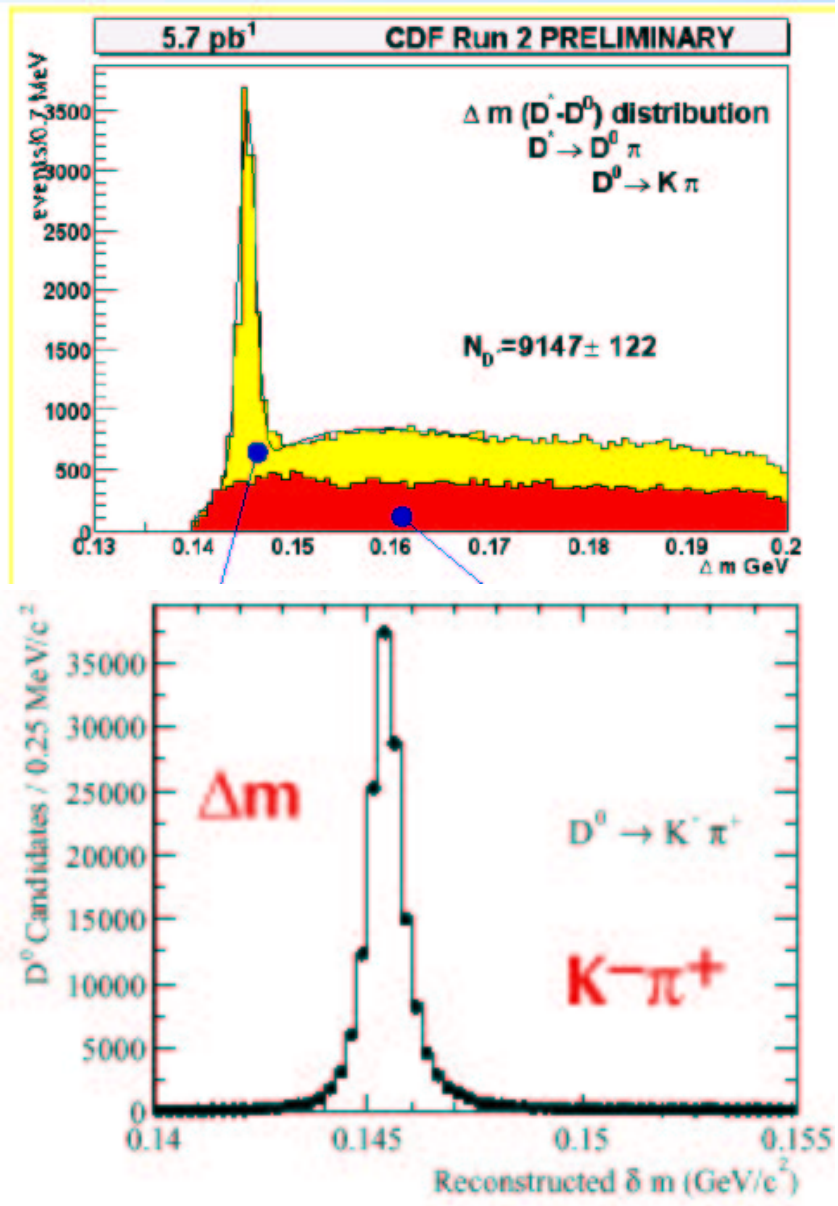
**Range due to "resolution function"**

# Strategy for CDF/BaBelle Normalization

- Compare relative error on yields @ ICHEP2002
- Assume $1/\sqrt{luminosity}$ scaling of error
- Calculate CDF lumi needed to match error for 200fb$^{-1}$ @ BaBelle

**This ignores ongoing improvements @ CDF**

# Expected $D^{*+}$ Yield of CDF and BaBelle



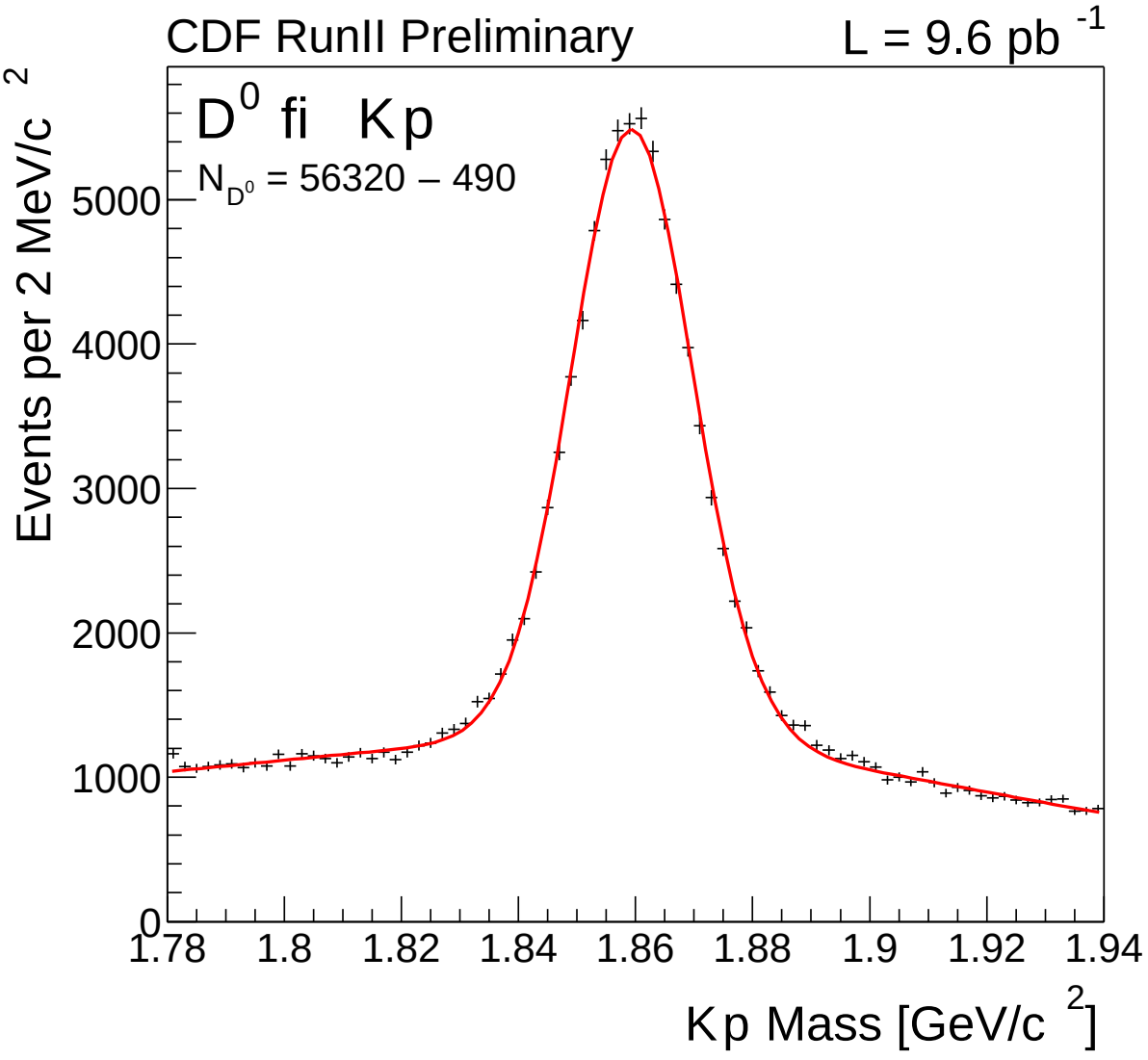

CDF: $122/9147 = 1.3\%$ @ $5.7\text{pb}^{-1}$

BaBar: $1/\sqrt{158,000} = 0.25\%$ @ $58\text{fb}^{-1}$

CDF/BaBar: $(1.3/0.25)^2 = 27$

$\Rightarrow 530 pb^{-1}$ @ CDF $\equiv 200 fb^{-1}$ @ BaBar

# Charm Physics without $D^{*\pm}$ tag



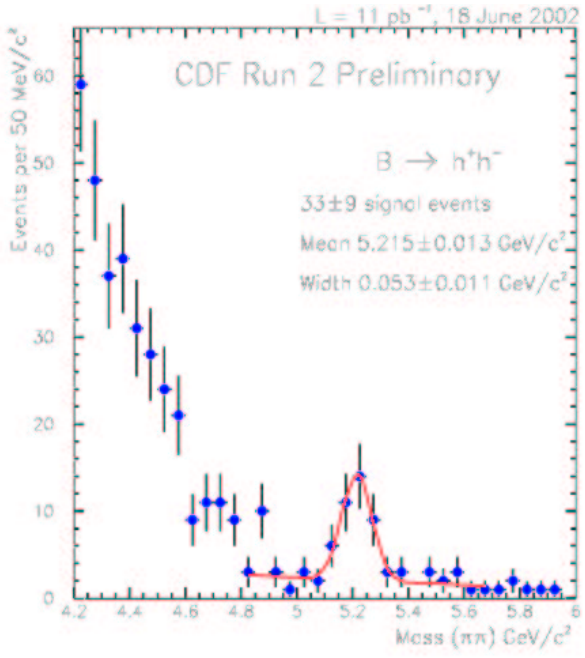

CDF: $490/56320 = 0.9\%$ @ $9.6\text{pb}^{-1}$

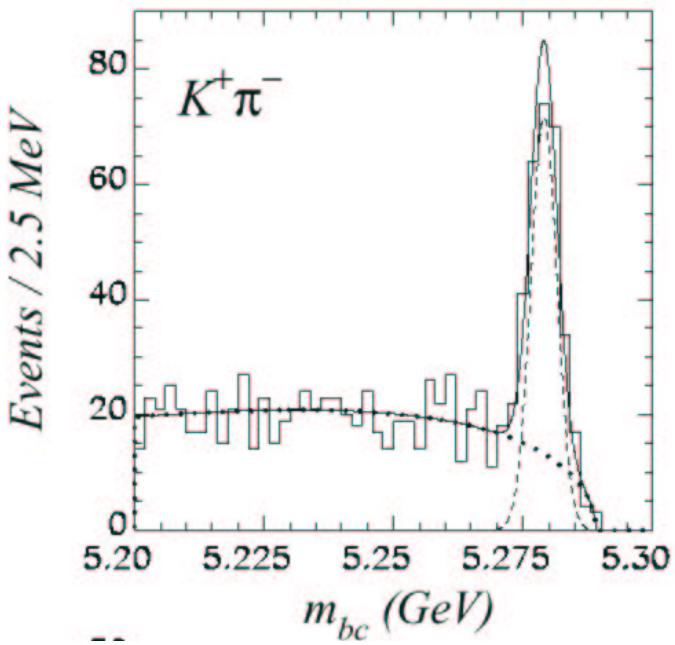
BaBar: $1/\sqrt{158,000} = 0.25\%$ @ $58\text{fb}^{-1}$

CDF/BaBar: $(0.9/0.25)^2 = 12$

$\Rightarrow 400 pb^{-1}$ @ CDF $\equiv 200 fb^{-1}$ @ BaBar

# Expected Yield of CDF and BaBelle for $B \to h^+h^-$




CDF: $33 \pm 9$ events, roughly 18 of which are $B_d \to K\pi$

BaBar: $589 \pm 30$ events @ $88\text{fb}^{-1}$

CDF/BaBar: $18/600 = 3\%$

$\Rightarrow 0.8\text{fb}^{-1}$ @ CDF $\equiv 200\text{fb}^{-1}$ @ BaBar

Note: Given present statistics @ CDF, we look at yields only rather than relative error on yields.

# Expected Improvements @ CDF

- $(0.9/0.8)^2$ increase in silicon coverage
- $(0.9/0.8)^2$ increase in svt pattern coverage
- inclusion of L00
- 3D vertexing
- improved analysis techniques

# CDF Status Summary

- hadronic trigger works.
- bkg's quite manageable.
- TOF works ...
- ... but flavor tagging has barely begun.
- Serious delays in Tevatron Lumi ...
- ... as well as CDF commissioning.
- Nevertheless excellent prospects for Summer 2003