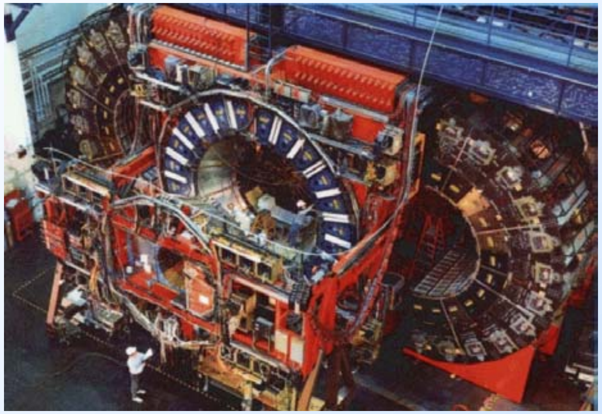
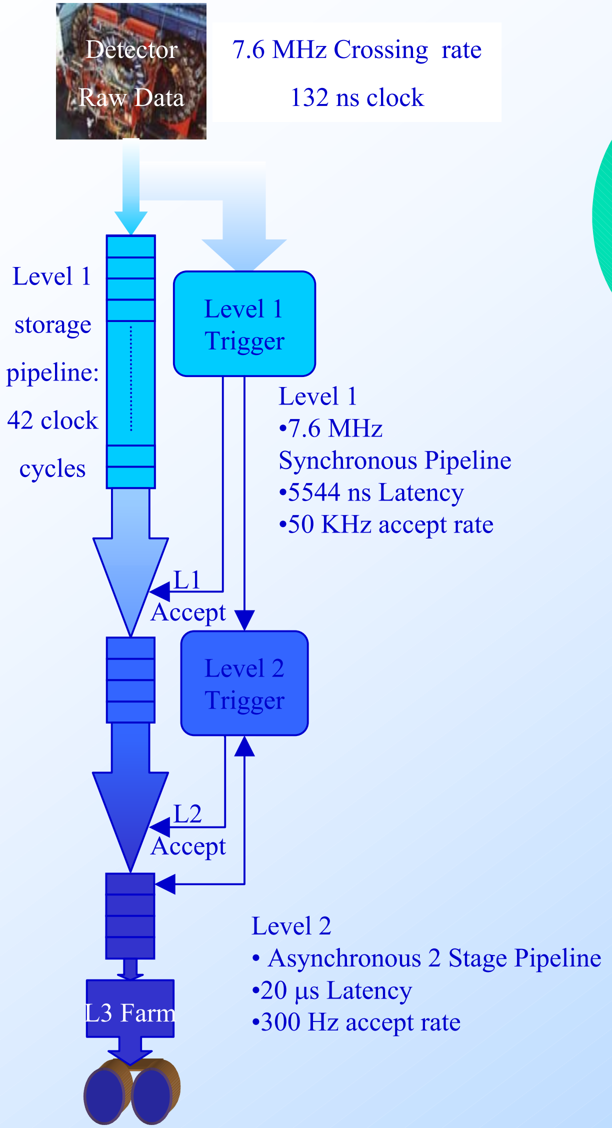


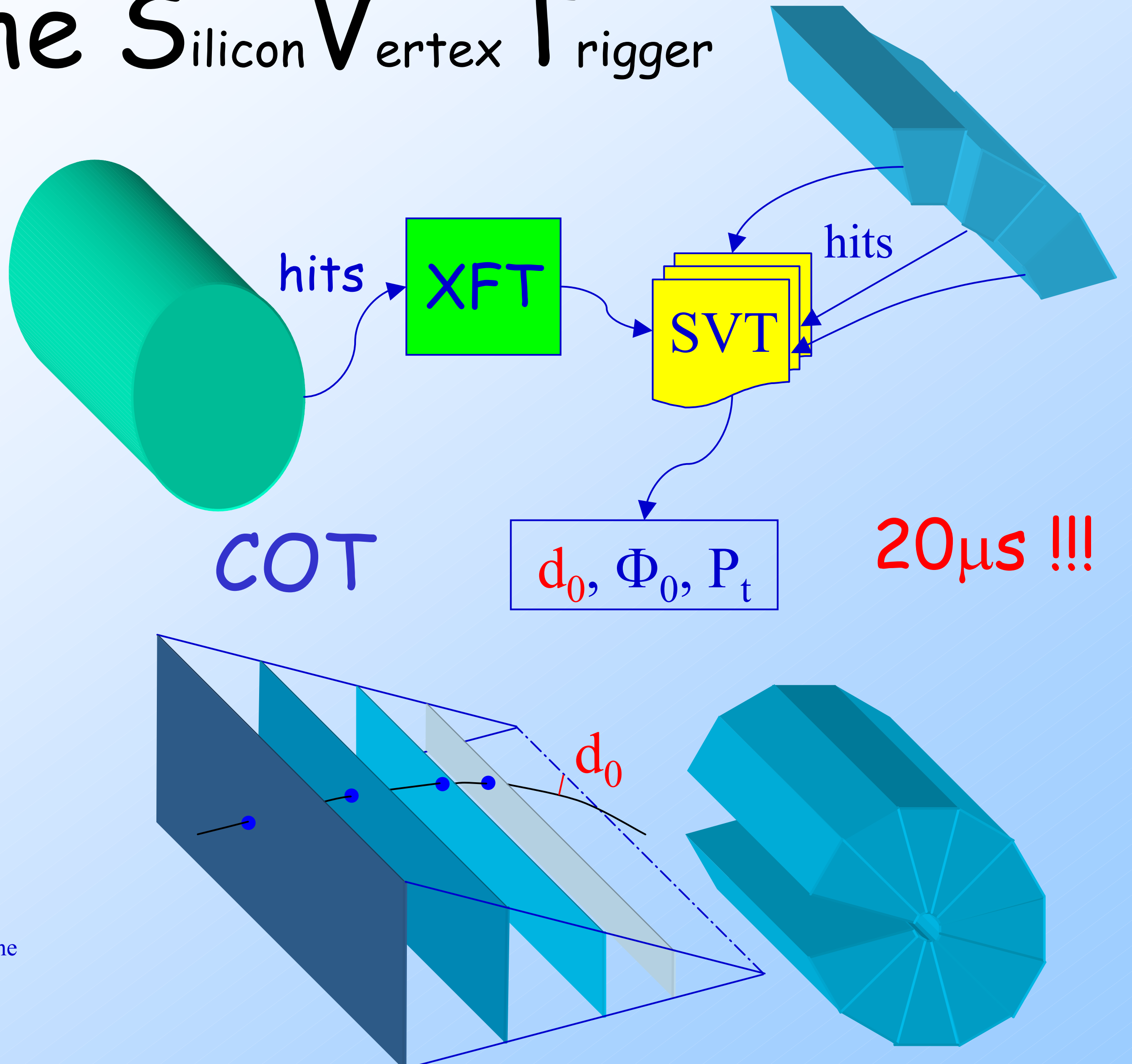
First CDF II Heavy Flavor Results Using the Silicon Vertex Trigger

A. Cerri

ICHEP 2002

The Silicon Vertex Trigger



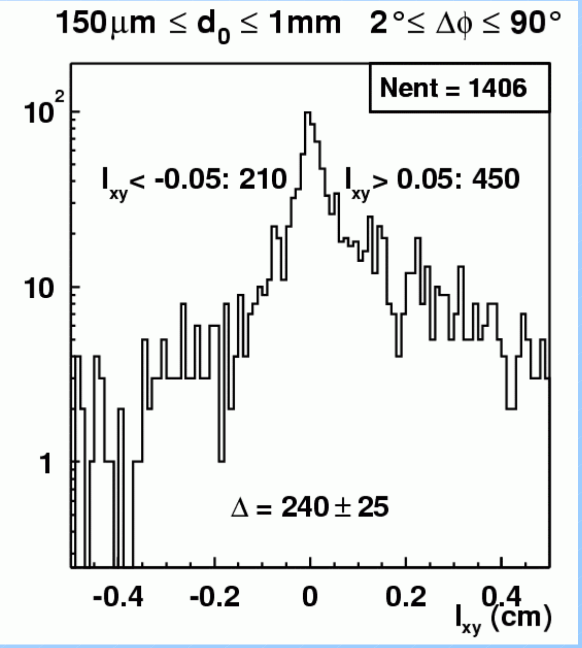


A. Cerri, LBNL

The Two Track Trigger

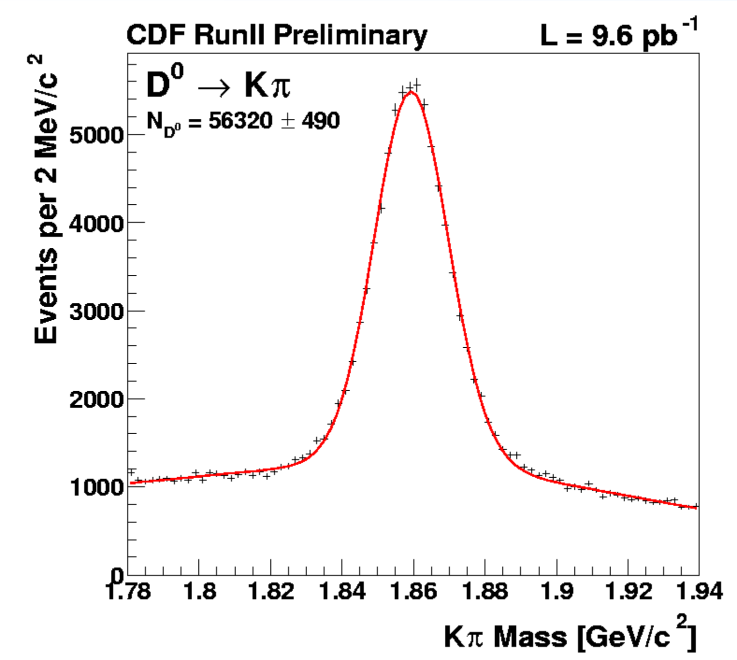
is just a selection based on the SiliconVertexTrigger…

- Why so much emphasis on tracking at trigger level?
  - B physics at hadron colliders has two main features:
    - ❶ Large cross section O(0.1 mb !!!)
    - ❷ Huge background O(0.05 b !!!)
  - So far CDF has only one cure: require leptons
  - There comes the challenge: tracking at trigger level with sufficient resolution!

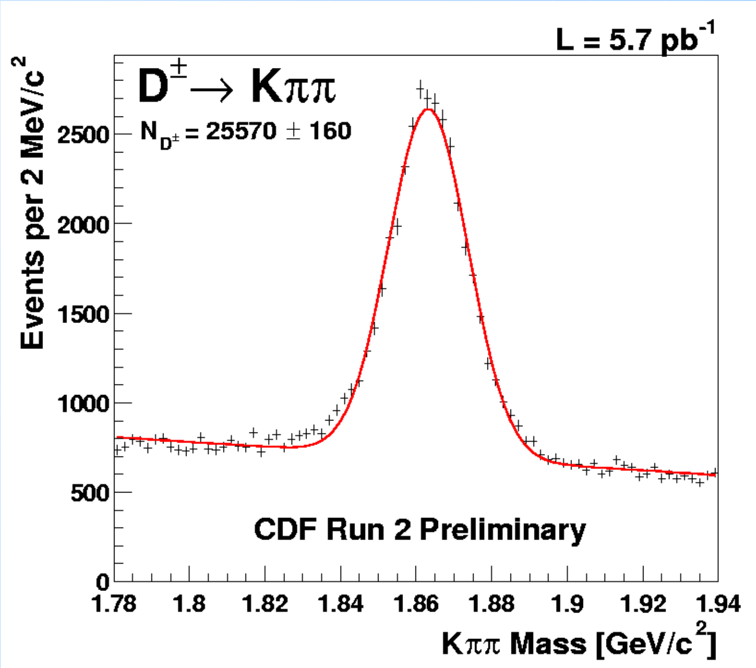


The TTT is the first case in which CDF investigates low Pt B physics without explicitly requiring leptons

First HF signals…



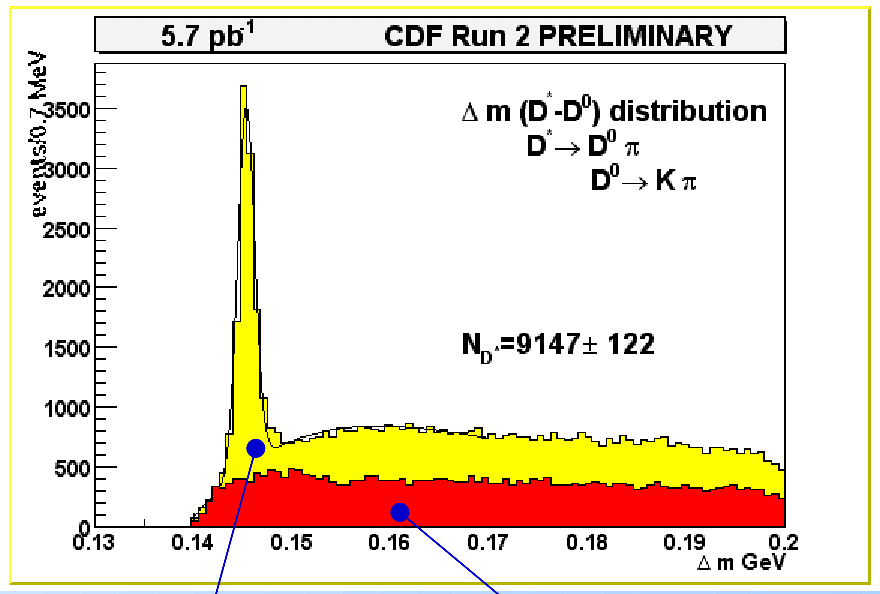
- Offline confirmation of TTT cuts
- $\Delta z(K\text{-}\pi) < 5$cm
- $L_{xy}(D) > 500$ um
- $d_0(K)*d_0(\pi) \leq 0$
- $P_T(D) > 5.5$ GeV/c

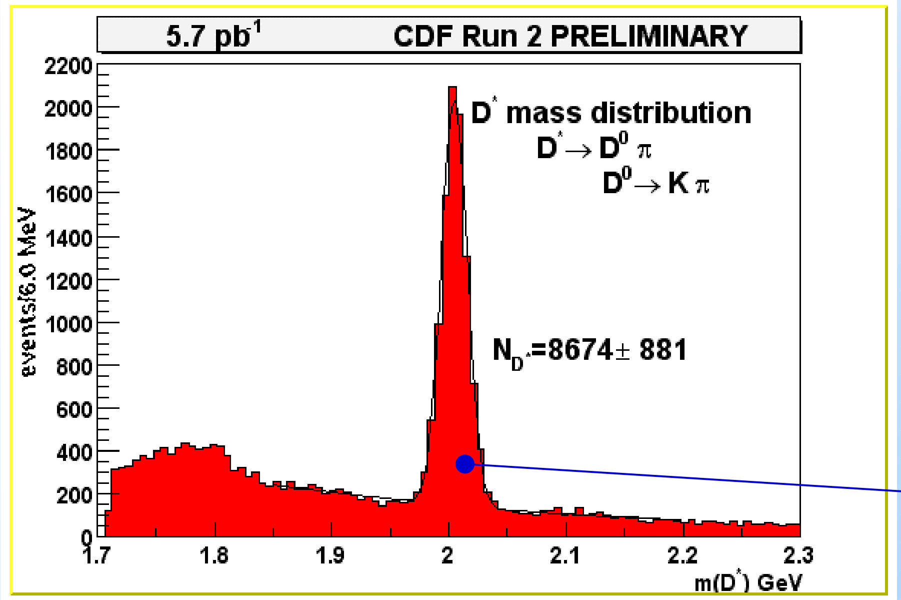


- Offline confirmation of TTT cuts
- $\Delta z(K\text{-}\pi_1, K\text{-}\pi_2, \pi_1\text{-}\pi_2) < 5$cm
- $L_{xy}(D^+) > 800$ um
- $\chi^2_{xy} < 30$
- $P_T(D^+) > 6$ GeV/c

…something even cleaner

- Offline confirmation of TTT cuts
- $\Delta z(K-\pi, K-\pi_s, \pi-\pi_s) < 4cm$
- $m(D^0) \in [1.56, 2.16]$ MeV
- $Q(K)*Q(\pi)<0$ $Q(K)*Q(\pi_s)<0$
- $\Delta R(D^0-\pi_s)<0.2$





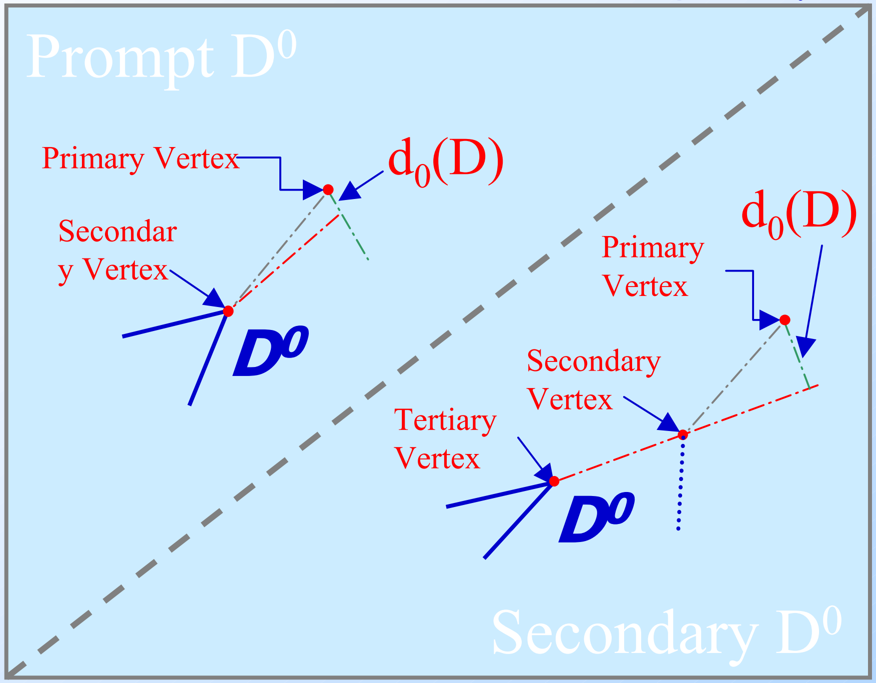
$|m(D^0)-m(D^0\ PDG)| \in [0.25, 0.3]$ GeV

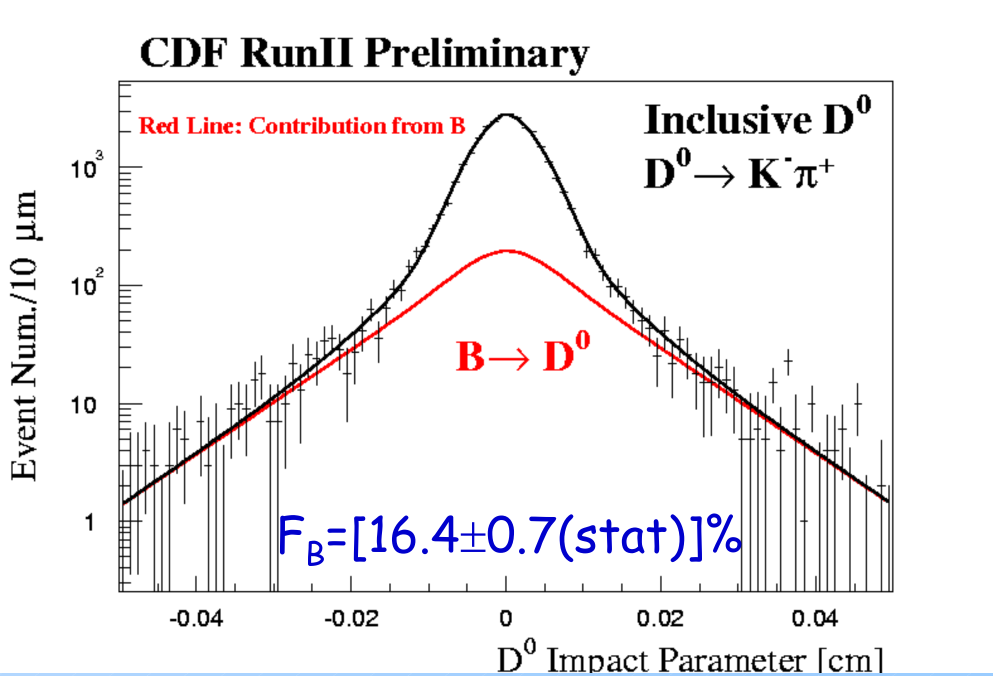
$|m(D^0)-m(D^0\ PDG)|<0.1$

$|m(D^*)-m(D^0)-0.1455|<3$ MeV

Is the Tevatron/CDF a charm factory?!??

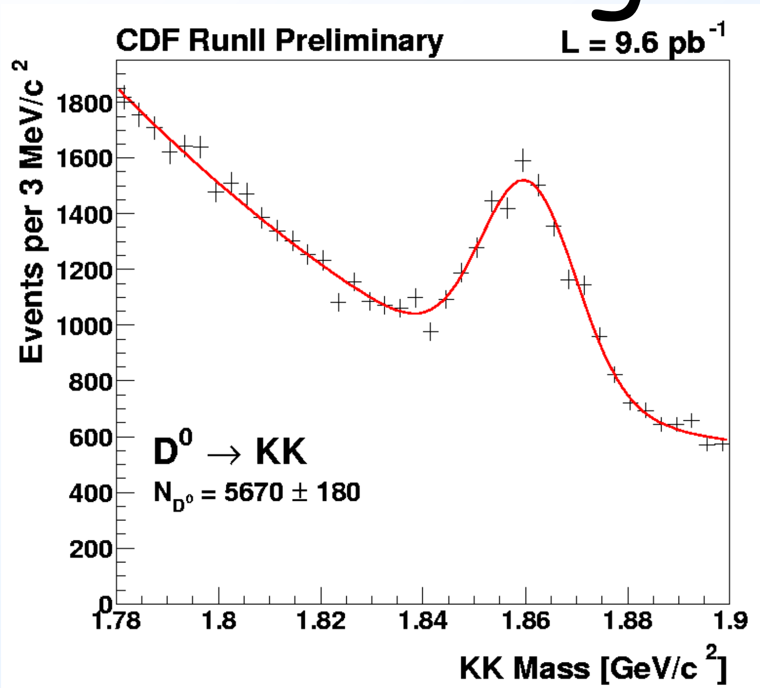
- Get a clean charm sample
- $d_0(D)$ distributed differently for prompt/non prompt
- Careful modeling exploiting K^0 and analytic models

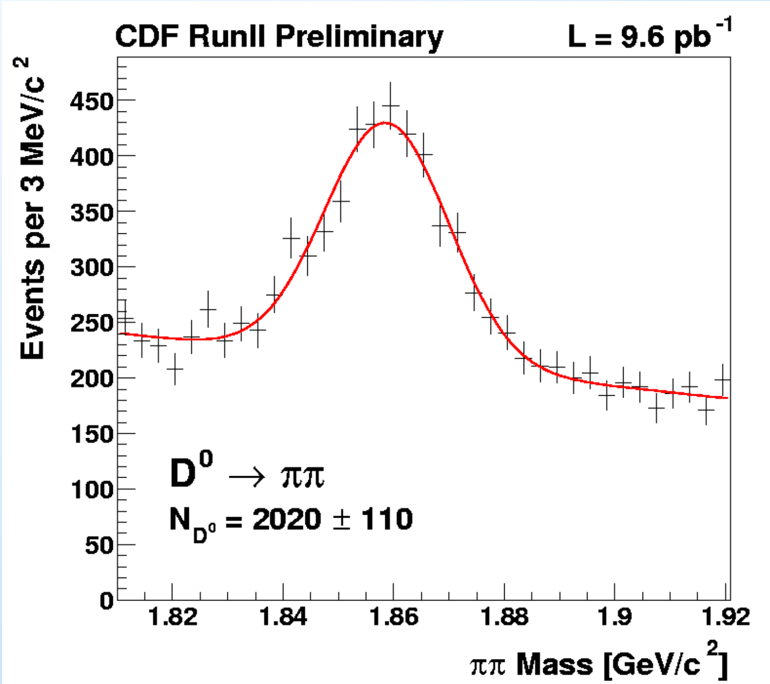




There's Plenty of Prompt Charm!

CP eigenstates...





With a selection very close to the $K\pi$ signal we see D^0 decays to CP eigenstates, with incredible yields!

$\Gamma(D^0 \rightarrow \pi\pi)/\Gamma(D^0 \rightarrow K\pi)$

$\Gamma(D^0 \rightarrow KK)/\Gamma(D^0 \rightarrow K\pi)$

are already accessible with good statistical accuracy and reasonable systematics!!!

KK/ππ/Kπ relative BR

- Is a good benchmark
- PDG measurements have errors close compared to our current statistics
- Systematics is reasonable because Kπ/ππ/KK share:
  - Selection
  - ≈Kinematics
  - Mass

$$\frac{\Gamma\left(D^0 \to K^+K^-\right)}{\Gamma\left(D^0 \to K\pi\right)} = \left[11.18 \pm 0.48(stat) \pm 0.98(syst)\right]\%$$

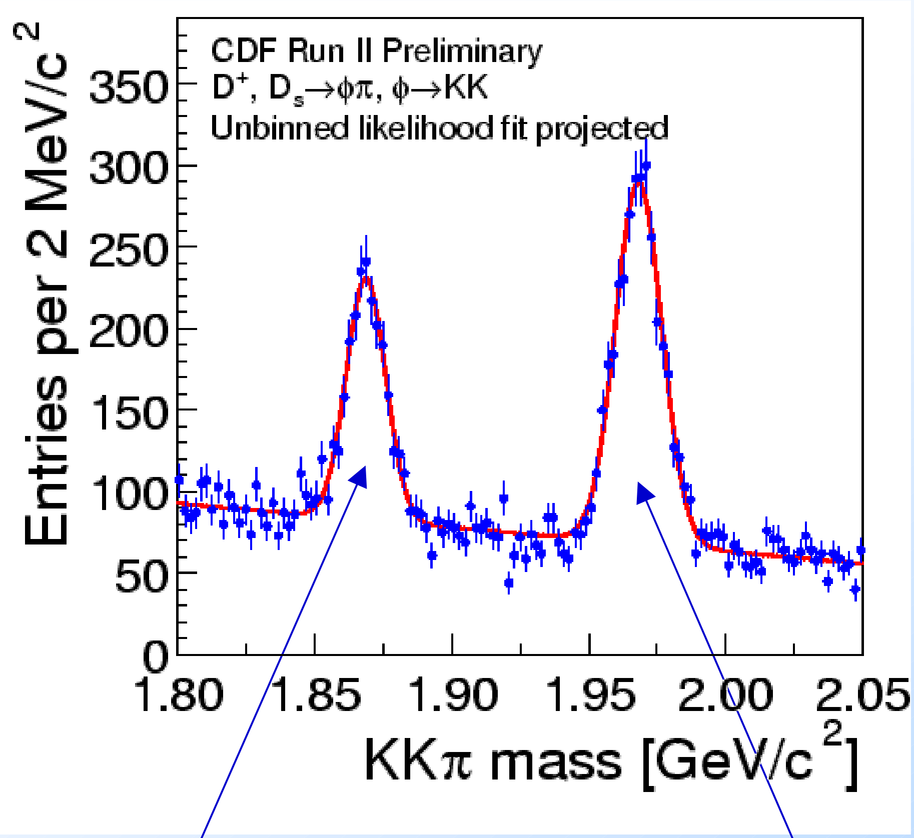
$$PDG = \left[10.83 \pm 0.26\right]\%$$

$$\frac{\Gamma\left(D^0 \to \pi^+\pi^-\right)}{\Gamma\left(D^0 \to K\pi\right)} = \left[3.37 \pm 0.20(stat) \pm 0.16(syst)\right]\%$$

$$PDG = \left[3.76 \pm 0.17\right]\%$$

Effect	KK/ Kπ Syst. Error [%]	ππ/ Kπ Syst. Error [%]
Background Model (POLY2, POLY3, EXP)	7.9	1.4
Reflected Peak Model (σ ratio ±1σ, free σ)	1.3	1.3
Lifetime Difference (average from PDG)	2.2	2.2
DCS decays (from PDG)	0.4	0.4
Tracking	0.4	1.7
Trigger Simulation (parametr. Vs GEANT)	1.9	2.5
Mean Z (±1.5cm)	0.7	0.5
Material Description	0.5	0.5
Input Spectra (realistic Vs flat)	1.8	1.8
b/c ratio	1.1	-
Total	8.8	4.6

And something *strange* !



- Offline confirmation of TTT cuts
- $\Delta z(K\text{-}K) < 4$cm
- $m(\phi) \in [1010,1035]$ MeV
- $\Delta z(\phi\text{-}\pi) < 4$cm
- $\chi^2(r\phi) < 7$
- $L_{xy}(D) > 500$ um
- helicity cut $|\cos(\theta^{\phi}_{helicity})| > 0.4$
- keep candidate with largest helicity
- Fit gaussians+linear background

- 1350 ± 60 events
- 7.1 ± 0.4 MeV/c^2
- $S/B \approx 0.76$

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- 2360 ± 70 events
- 8.4 ± 0.2 MeV/c^2
- $S/B \approx 1.4$

Yum…

$\Delta m(D^{+}-D_s)$

- Is a good benchmark
- PDG measurements have errors close compared to our statistics
- Systematics is reasonable because D^{+}/D_s share:
  - Selection
  - Kinematics
  - ≈Mass

$$\Delta m = 99.28 \pm 0.43(stat) \pm 0.27(syst)\, MeV/c^2$$

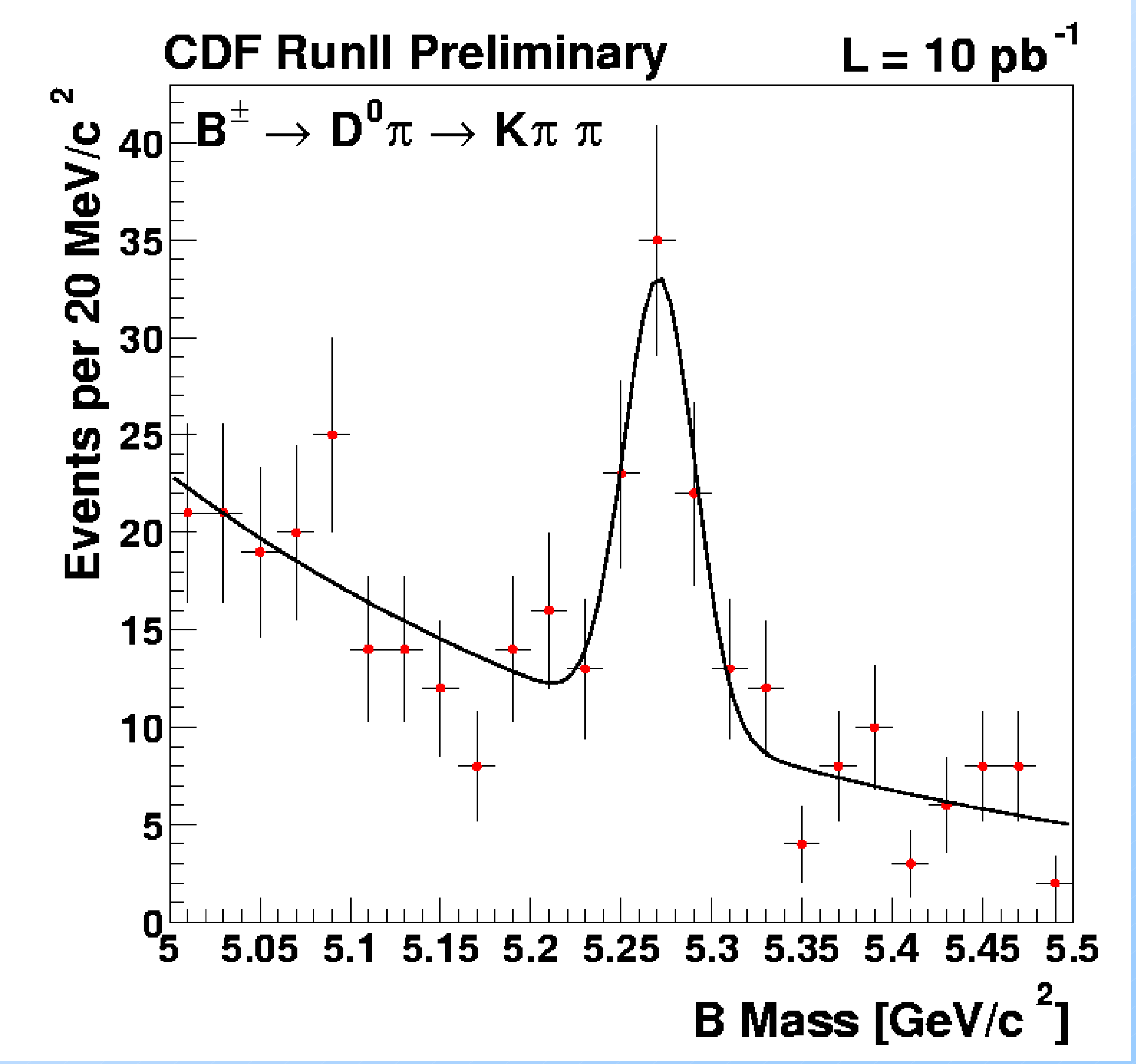
Previous PDG average: 99.2±0.5 MeV/c^2

Systematics

Effect	Syst. Error [MeV/c^2]
χ^2 cut (±1)	0.06
L_{xy} cut(±100 μm)	0.09
$Cos(\theta_{hel})$ cut (±0.05)	0.09
Duplicate removal (on/off)	0.04
COT error scale (on/off)	0.03
False curv. (on/off)	0.055
SVX material (±1σ)	0.015
B field (±1σ)	0.025
Background shape (lin/exp)	0.22
Fitting range (2x)	-
Kinematics (reweight in Pt)	0.004
Total	0.273

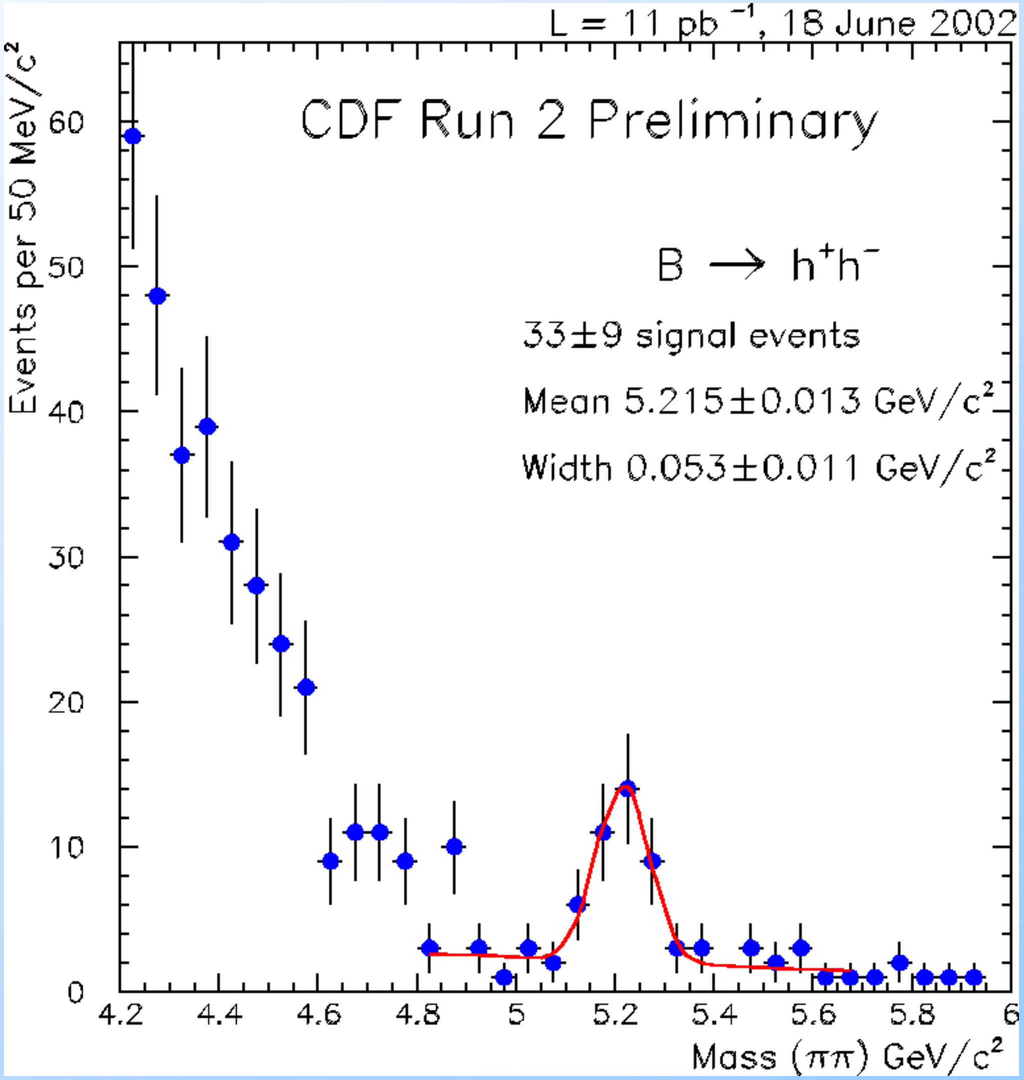
What about Bees? (I)

- Offline confirmation of TTT cuts
- $M(D^0)$ within 4σ
- Δz(tracks) < 5 cm
- $0 < L_{xy}(D) < 4$ mm
- $\Delta\varphi(D-\pi) < 2$ rad
- $d(\pi)*d(D) < 0$
- $|d(B)| < 100\mu m$
- $P_t(B) > 5.5$ GeV



What about Bees? (II)

- Offline confirmation of TTT cuts
- Lxy > 0.05
- |eta(B)| < 1
- |d(π)| > 0.02
- |d(B)| < 0.075
- Isolation: $\frac{P_t(B)}{\sum_{\Delta R(B-X)<0.5} P_t(X)} > 0.5$



Comments on Yields

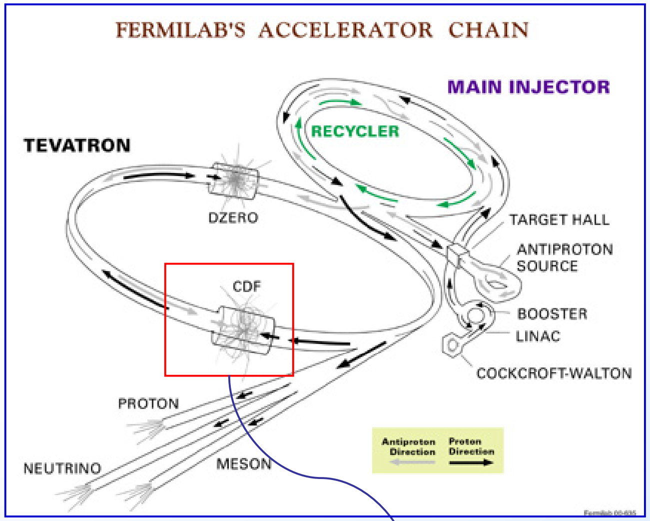
- Signals based on ≈10pb^{-1} out of 2fb^{-1} to come…
- The data sample comes from commissioning with:
  - partial Si coverage
  - Non optimized trigger
  - Reliably understand these differences in simulation
- Expect ≥x3 improvement in TTT B physics yields
- Additional improvements in offline efficiency expected

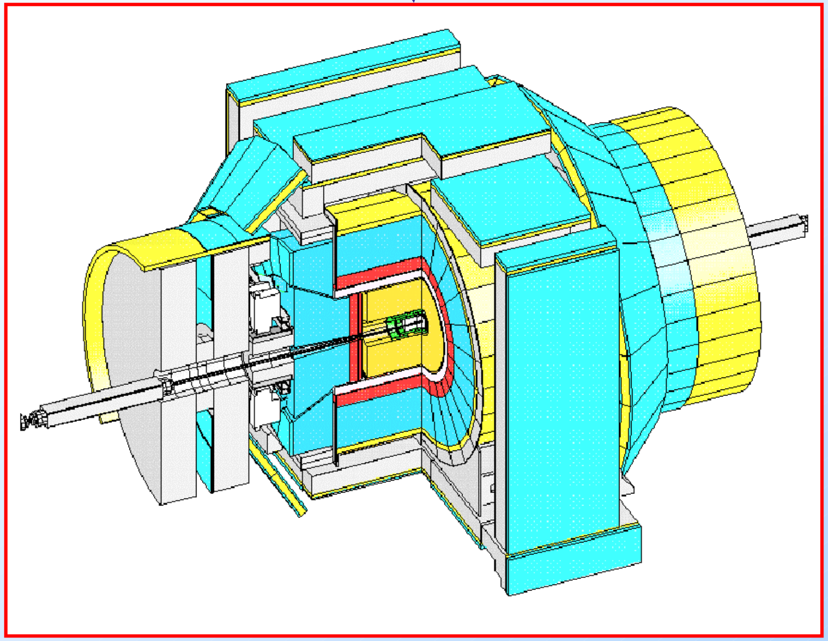
Conclusions...

- Plenty of Charm!
  - Good benchmark for two body charmless B decays:
    - Energy scale, PID and dE/dx
  - By themselves:
    - Large statistics ➡ "world class" charm physics:
      - $\Delta m(D_s - D^+)$
      - $\{\Gamma(D0 \rightarrow \pi\pi), \Gamma(D0 \rightarrow KK)\} / \Gamma(D0 \rightarrow K\pi)$
    - These are good physics benchmarks of what we will be able to do with the full statistics!
- Charmed/uncharmed B are showing up!
  - First observation of fully hadronic B (hh, $D^0\pi$)
  - Background rates compatible with predictions
  - Yields fully understood
  - Now the fun begins!!!

Backup Slides

CDF II





- Renewed detector & Accelerator chain:
  - Higher Luminosity ➡ higher event rate
  - →Detector changes/improvements:
    - →DAQ redesign
    - →Improved performance:
    - ➢Detector Coverage
    - ➢Tracking Quality

Two Paths...

PiPi

- L1:
  - Two XFT tracks
  - $P_{t1}>2$ GeV $P_{t1}+P_{t2}>5.5$ GeV
  - $\Delta\phi<135°$
- L2:
  - $d_0>100$ μm for both tracks
  - Validation of L1 cuts and $\Delta\phi>20°$
  - $P_t \cdot X_v>0$
  - $d_0(B)<140$ μm

High Mass

Two Body

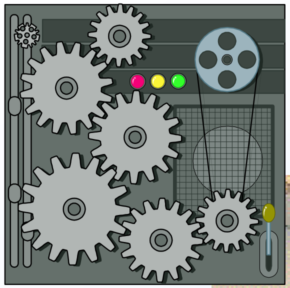
DsPi

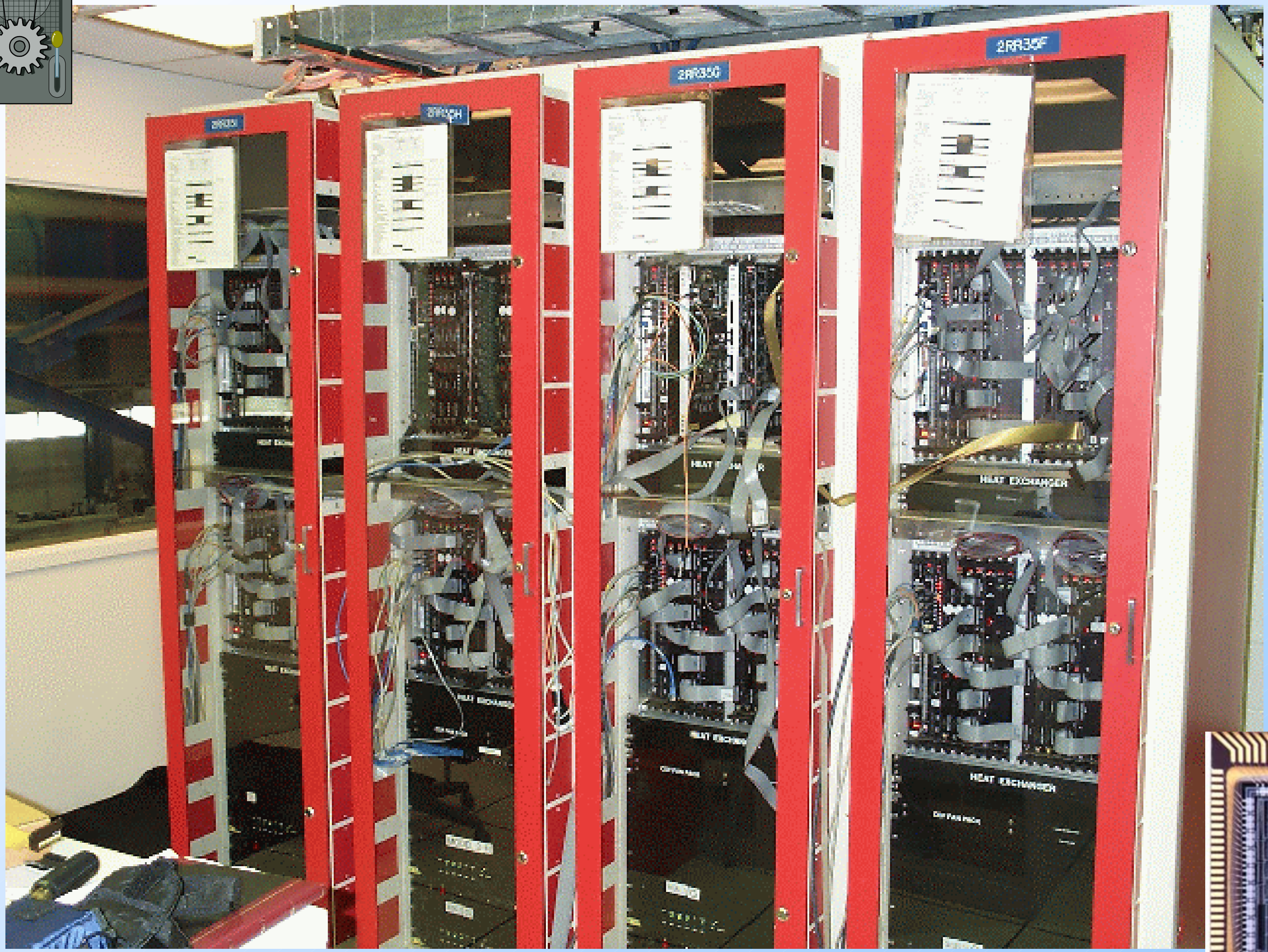
- L1:
  - Two XFT tracks
  - $P_{t1}>2$ GeV $P_{t1}+P_{t2}>5.5$ GeV
  - $\Delta\phi<135°$
- L2:
  - $d_0>120$ μm for both tracks
  - Validation of L1 cuts and $\Delta\phi>2°$
  - $P_t \cdot X_v>0$
  - ~~$d_0(B)<140$ μm~~

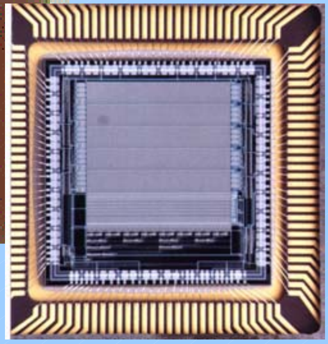
Low Mass

Many Body

How does it look like?

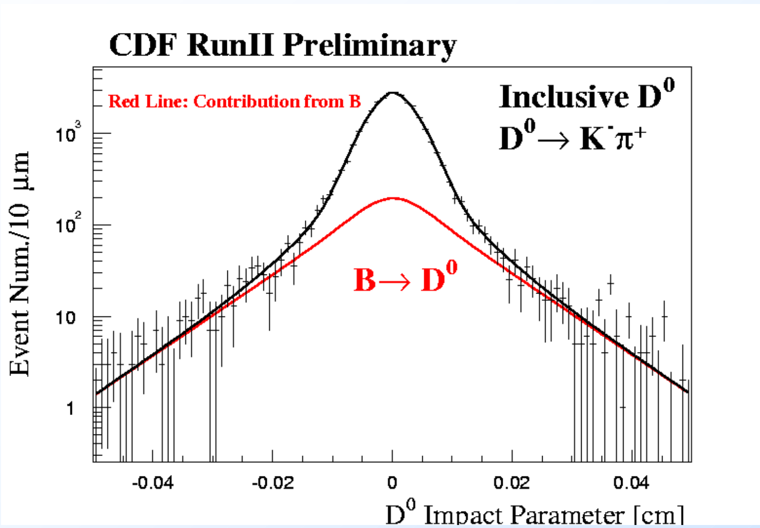




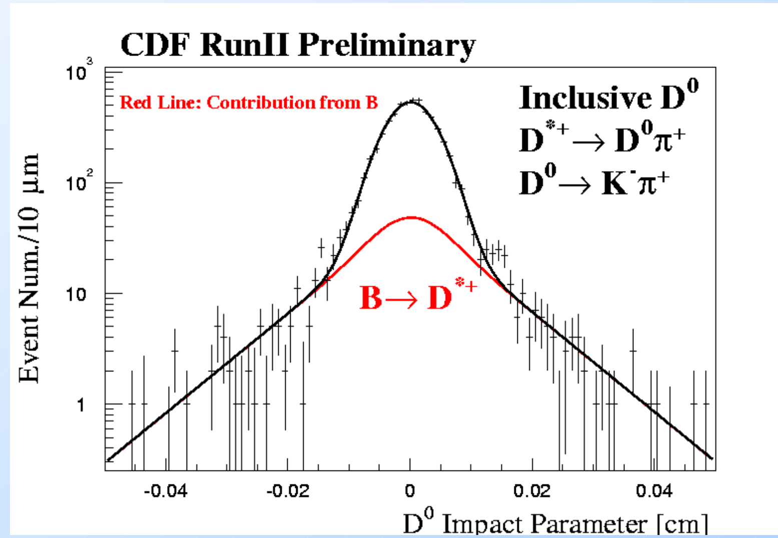


Prompt fractions…

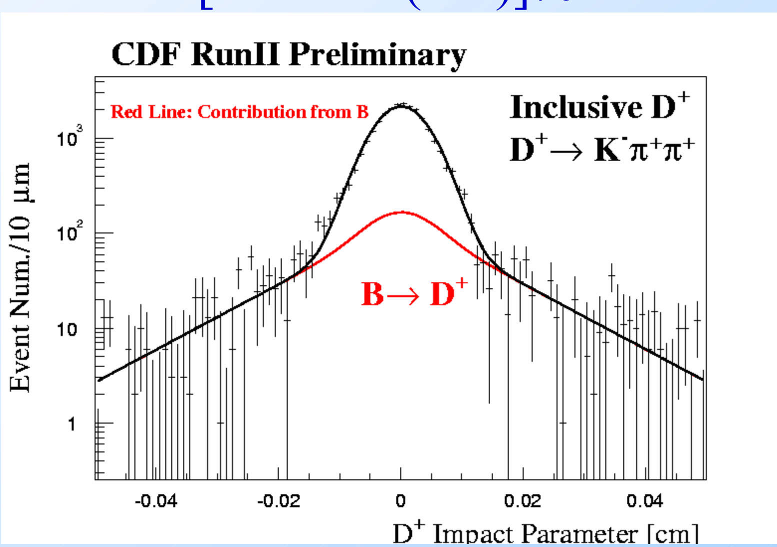
[16.4±0.7(stat)]%



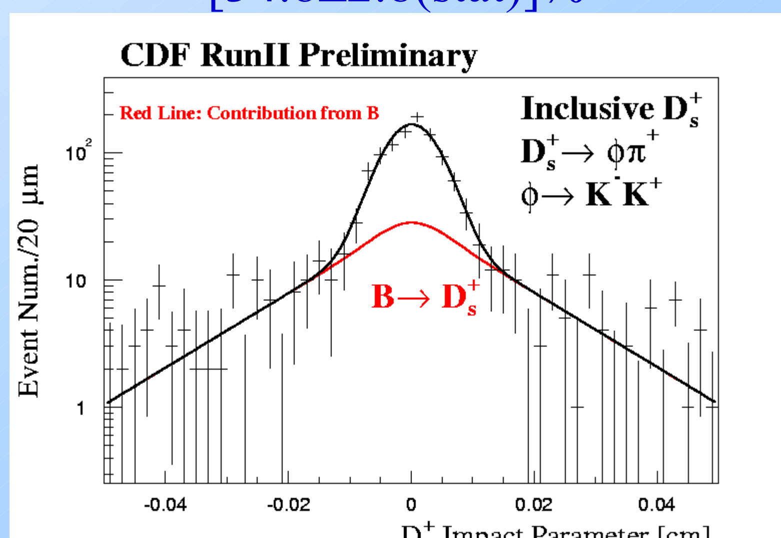
[11.4±1.4(stat)]%



[11.3±0.5(stat)]%

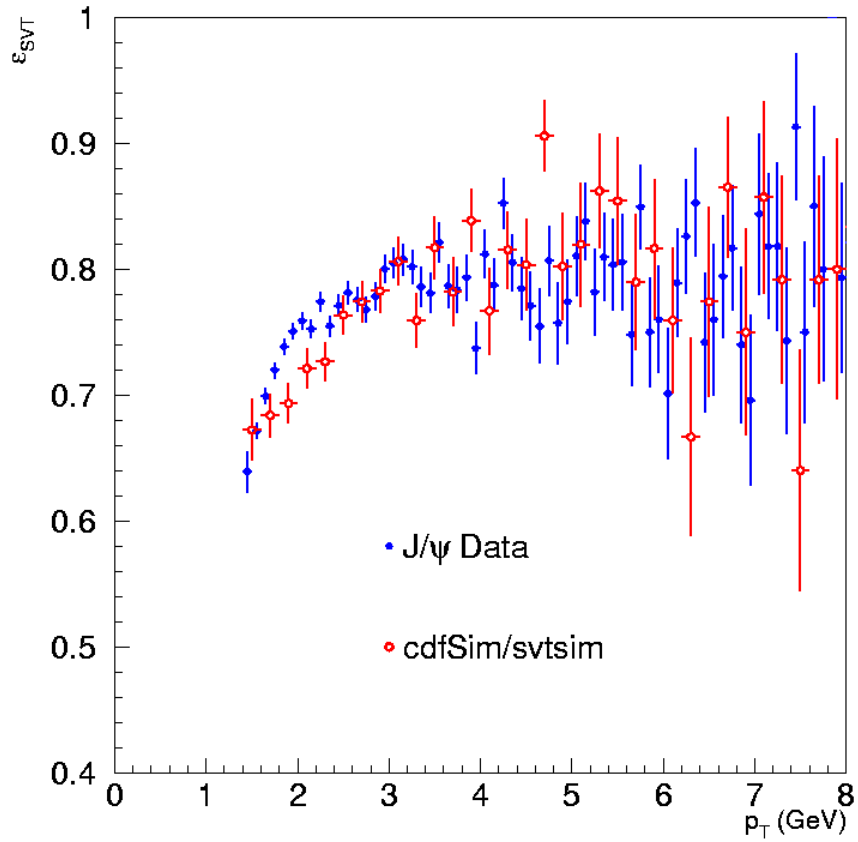


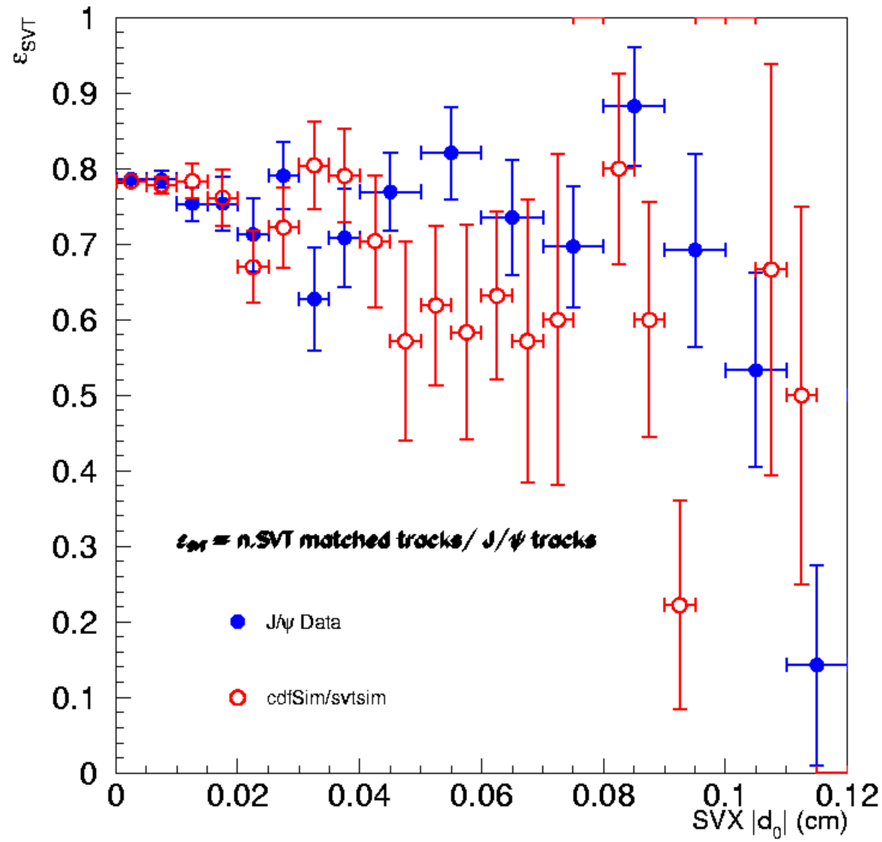
[34.8±2.8(stat)]%



Backup slide I

How well do we know how to model the trigger selection/detector effects?





Backup Slide II

D^+-D_s cuts