Run II
First Λ_b Physics Results from the Tevatron

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For the CDF and D0 collaborations

Outline

- Tevatron Status
- CDF and D0
- Charm Physics
- B Physics

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B Physics at Hadron Colliders

Huge production rates: B^+ : 3.6±0.6mb ***(Run I measurement)***

(For p_T ³ 6GeV, |Y|£1)

D^+ : 4.3±0.7mb
D^0 : 9.3±1.1mb

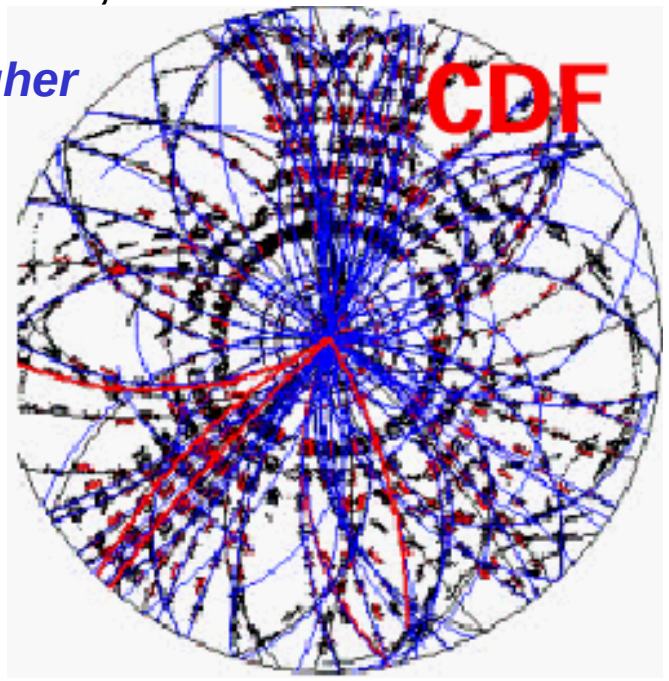
New Run II result!

3 orders of magnitude higher than at e^+e^- ® Y(4S)

Produce all B species: B^0, B^+, B_s, B_c, Λ_b,...

But backgrounds are also 3 orders of magnitude higher

Challenge: **pick the 1 B decay from 10^4 QCD events**



It's all about having a good trigger!

PDG B_s Page

BOTTOM, STRANGE MESONS
$(B = \pm 1, S = \mp 1)$

$B_s^0 = s\bar{b}$, $\overline{B}_s^0 = \bar{s}b$, similarly for B_s^*'s

B_s^0

$I(J^P) = 0(0^-)$

I, J, P need confirmation. Quantum numbers shown are quark-model predictions.

Mass $m_{B_s^0} = 5369.6 \pm 2.4$ MeV

Mean life $\tau = (1.461 \pm 0.057) \times 10^{-12}$ s

$c\tau = 438\ \mu$m

B_s^0-$\overline{B}_s^0$ mixing parameters

$\Delta m_{B_s^0} = m_{B_{sH}^0} - m_{B_{sL}^0} > 13.1 \times 10^{12}\ \hbar\ \text{s}^{-1}$, CL = 95%

$x_s = \Delta m_{B_s^0}/\Gamma_{B_s^0} > 19.0$, CL = 95%

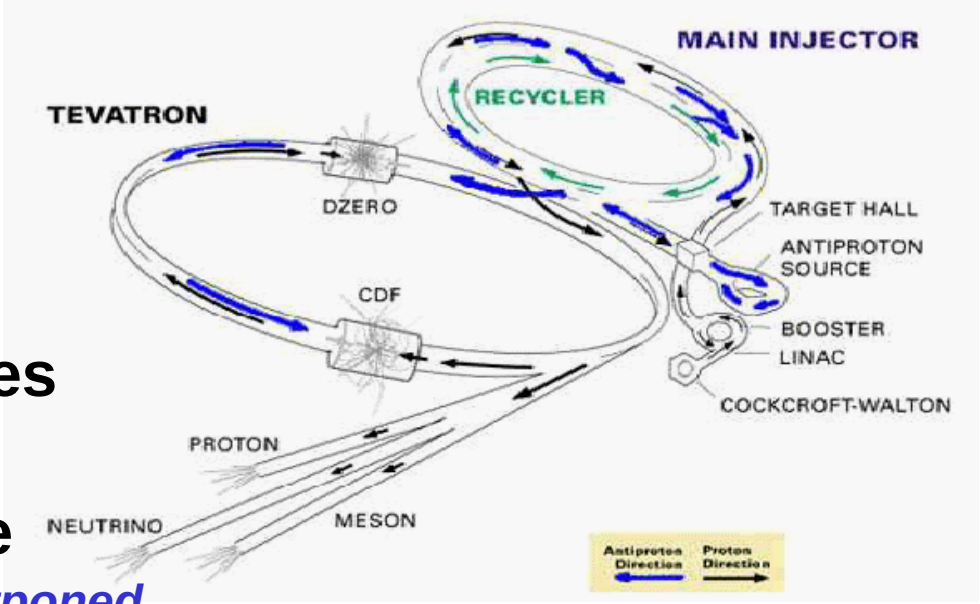
$\chi_s > 0.49862$, CL = 95%

These branching fractions all scale with $B(\bar{b} \to B_s^0)$, the LEP B_s^0 production fraction. The first four were evaluated using $B(\bar{b} \to B_s^0) = (10.7 \pm 1.4)\%$ and the rest assume $B(\bar{b} \to B_s^0) = 12\%$.

The branching fraction $B(B_s^0 \to D_s^- \ell^+ \nu_\ell \text{anything})$ is not a pure measurement since the measured product branching fraction $B(\bar{b} \to B_s^0) \times B(B_s^0 \to D_s^- \ell^+ \nu_\ell \text{anything})$ was used to determine $B(\bar{b} \to B_s^0)$, as described in the note on "Production and Decay of b-Flavored Hadrons."

B_s^0 DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
D_s^- anything		(94 $+30$) %		–
$D_s^- \ell^+ \nu_\ell$ anything	[iii]	(7.9 ± 2.4) %		–
$D_s^- \pi^+$		< 13 %		2321
$D_s^{(*)+} D_s^{(*)-}$		(23 $^{+21}_{-13}$) %		–
$J/\psi(1S)\phi$		(9.3 ± 3.3) $\times 10^{-4}$		1590
$J/\psi(1S)\pi^0$		< 1.2 $\times 10^{-3}$	90%	1788
$J/\psi(1S)\eta$		< 3.8 $\times 10^{-3}$	90%	1735
$\psi(2S)\phi$		seen		1122
$\pi^+\pi^-$		< 1.7 $\times 10^{-4}$	90%	2681
$\pi^0\pi^0$		< 2.1 $\times 10^{-4}$	90%	2681
$\eta\pi^0$		< 1.0 $\times 10^{-3}$	90%	2655
$\eta\eta$		< 1.5 $\times 10^{-3}$	90%	2628
$\rho^0\rho^0$		< 3.20 $\times 10^{-4}$	90%	–
$\phi\rho^0$		< 6.17 $\times 10^{-4}$	90%	–
$\phi\phi$		< 1.183 $\times 10^{-3}$	90%	–
$\pi^+ K^-$		< 2.1 $\times 10^{-4}$	90%	2660
$K^+ K^-$		< 5.9 $\times 10^{-5}$	90%	2639
$K^*(892)^0\rho^0$		< 7.67 $\times 10^{-4}$	90%	–
$\overline{K}^*(892)^0 K^*(892)^0$		< 1.681 $\times 10^{-3}$	90%	–
$\phi K^*(892)^0$		< 1.013 $\times 10^{-3}$	90%	–
$p\overline{p}$		< 5.9 $\times 10^{-5}$	90%	2515
$\gamma\gamma$		< 1.48 $\times 10^{-4}$	90%	2685
$\phi\gamma$		< 7 $\times 10^{-4}$	90%	2588
Lepton Family number (LF) violating modes or $\Delta B = 1$ weak neutral current ($B1$) modes				
$\mu^+\mu^-$	$B1$	< 2.0 $\times 10^{-6}$	90%	2682
e^+e^-	$B1$	< 5.4 $\times 10^{-5}$	90%	2864
$e^\pm\mu^\mp$	LF [ff]	< 6.1 $\times 10^{-6}$	90%	2864
$\phi\nu\overline{\nu}$	$B1$	< 5.4 $\times 10^{-3}$	90%	–

$\bar{p}p$ Collisions at the Tevatron



980+980GeV collisions

was 900+900 GeV in RunI

36 p bunches x 36 $\bar{p}$ bunches

396 ns bunch crossing time

132 ns upgrade indefinitely postponed

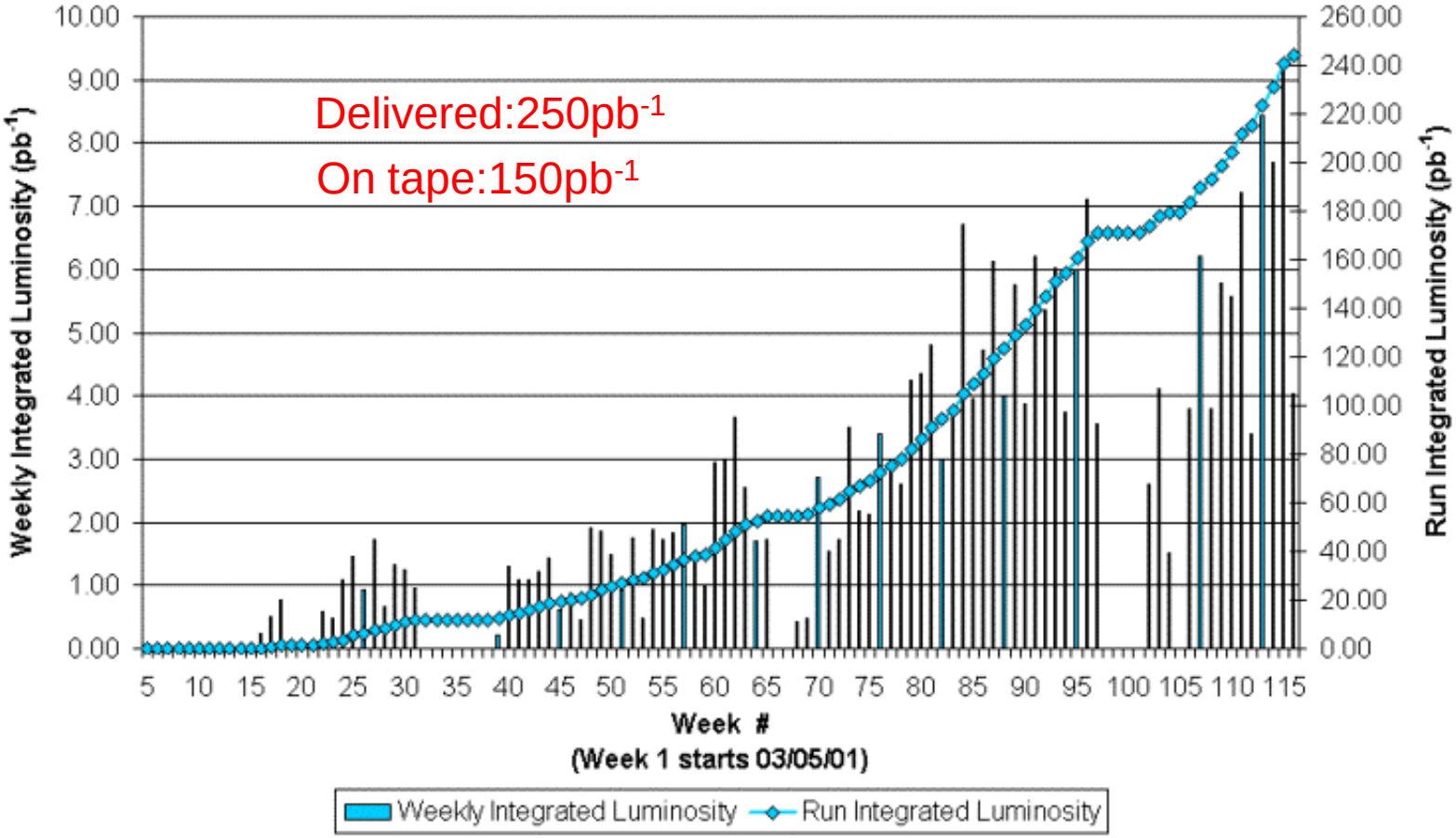
At present luminosities »1 interaction/bunch crossing

Anticipate up to 10 in future

Interaction region:

- **» 30 cm long**
  Need a long silicon detector
- **» 30 mm transverse size**
  Small compared to ct(B) » 450 mm

Tevatron Integrated Luminosity

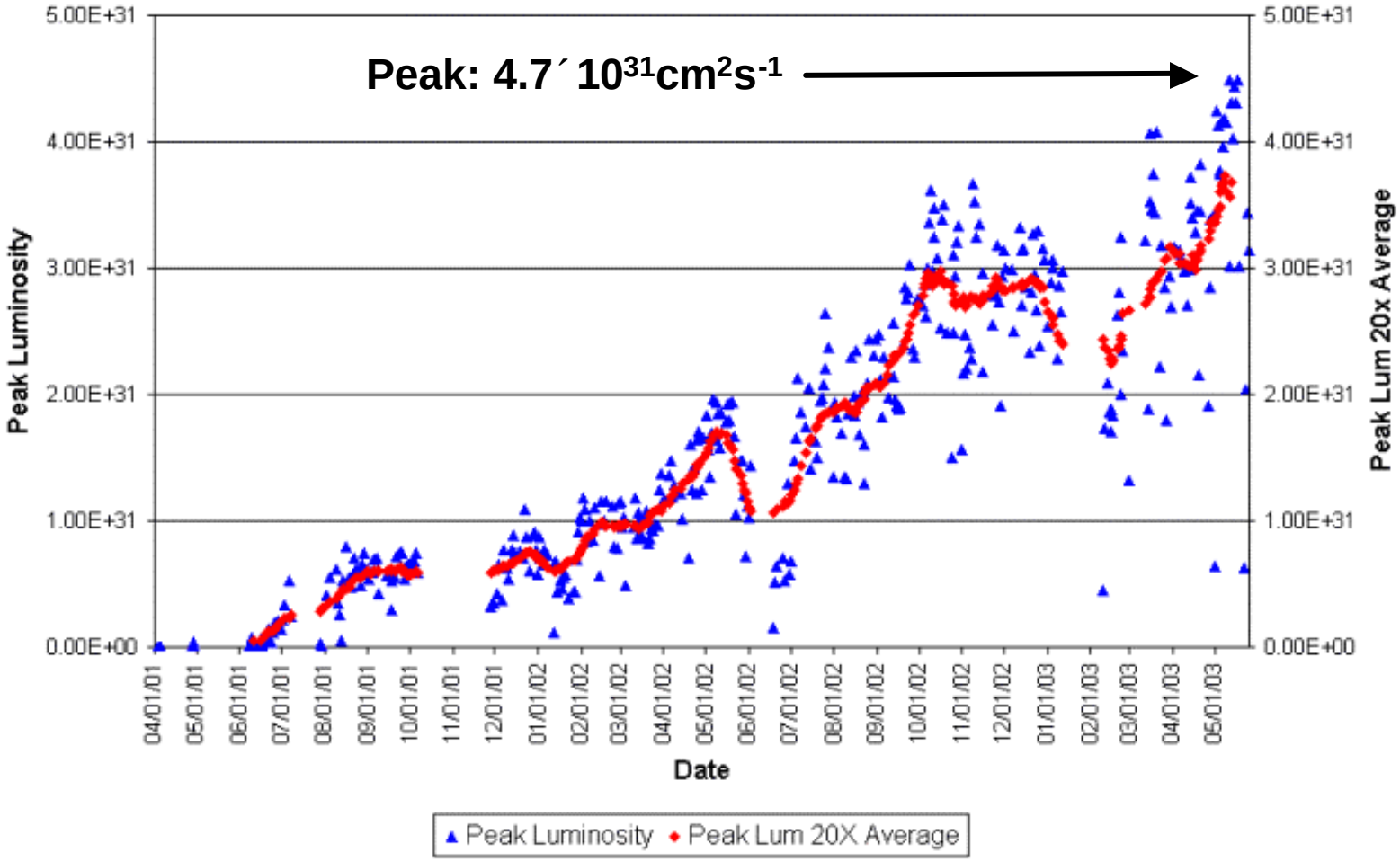


Present analyses use »70pb^{-1}

Compare to 110pb^{-1} in Run I

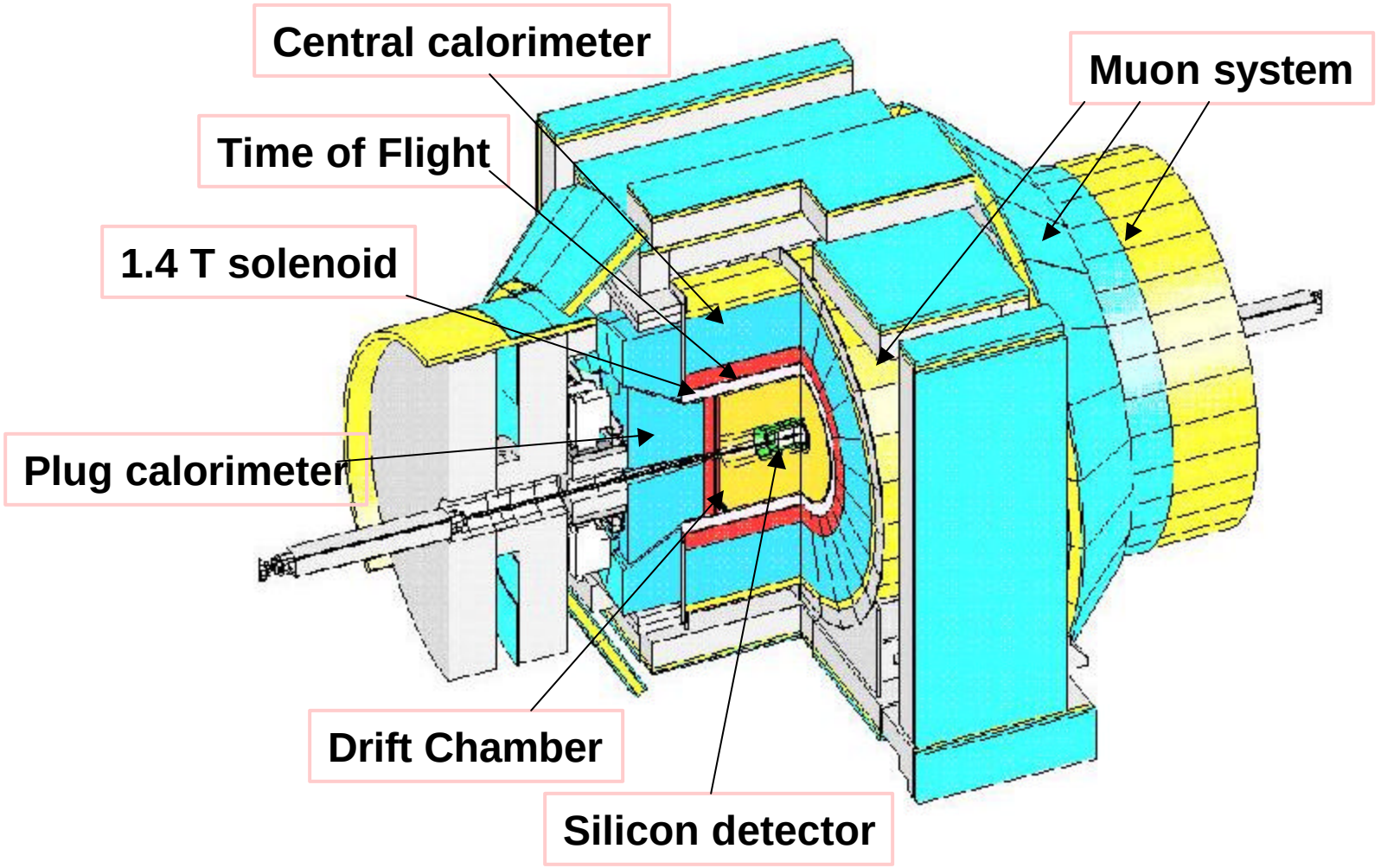
Efficiency typically 85-95%

Tevatron Performance
Instantaneous Luminosity



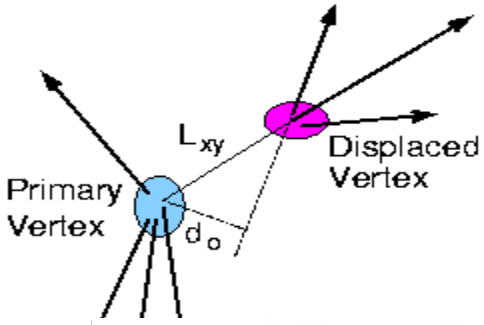
Still factor 2 below nominal

The CDFII Detector

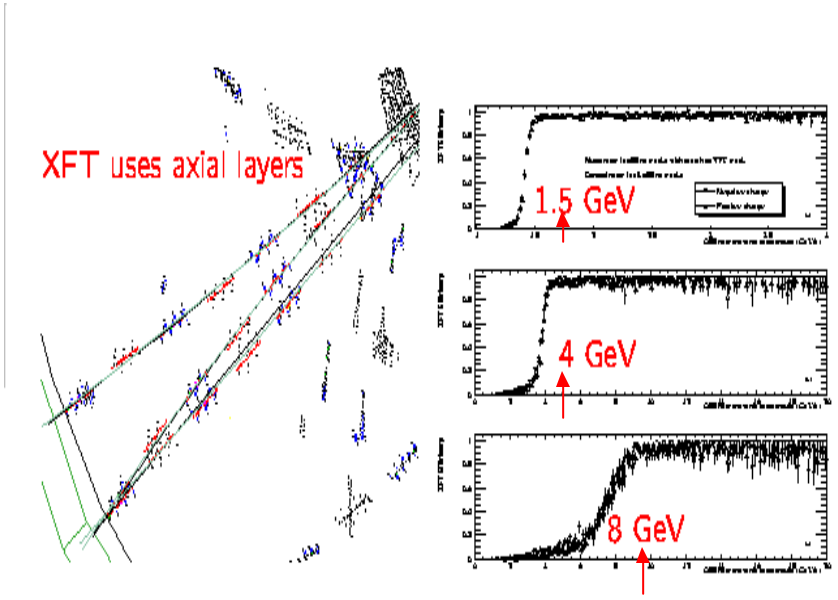


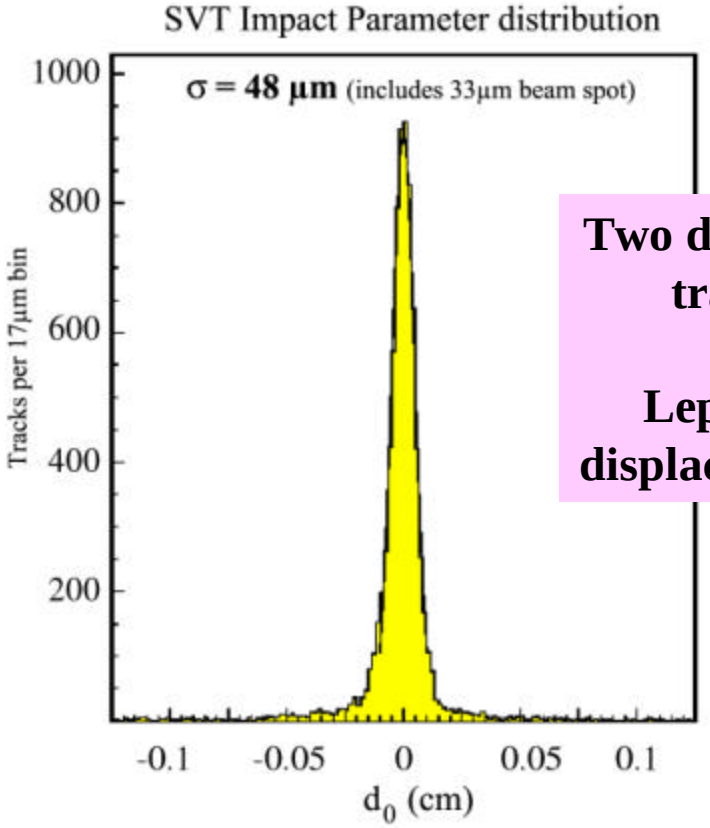
Track and Vertex Triggers

XFT:
uses COT axial to find high pT tracks at L1



SVT:
uses L1 XFT and SVXII





Two displaced tracks

Lepton + displaced track

$\Delta p_T / p_T = 1.65\% \; p_T \; (\mathrm{GeV}/c)$

B Yield Improvement

Tevatron luminosity is below design.

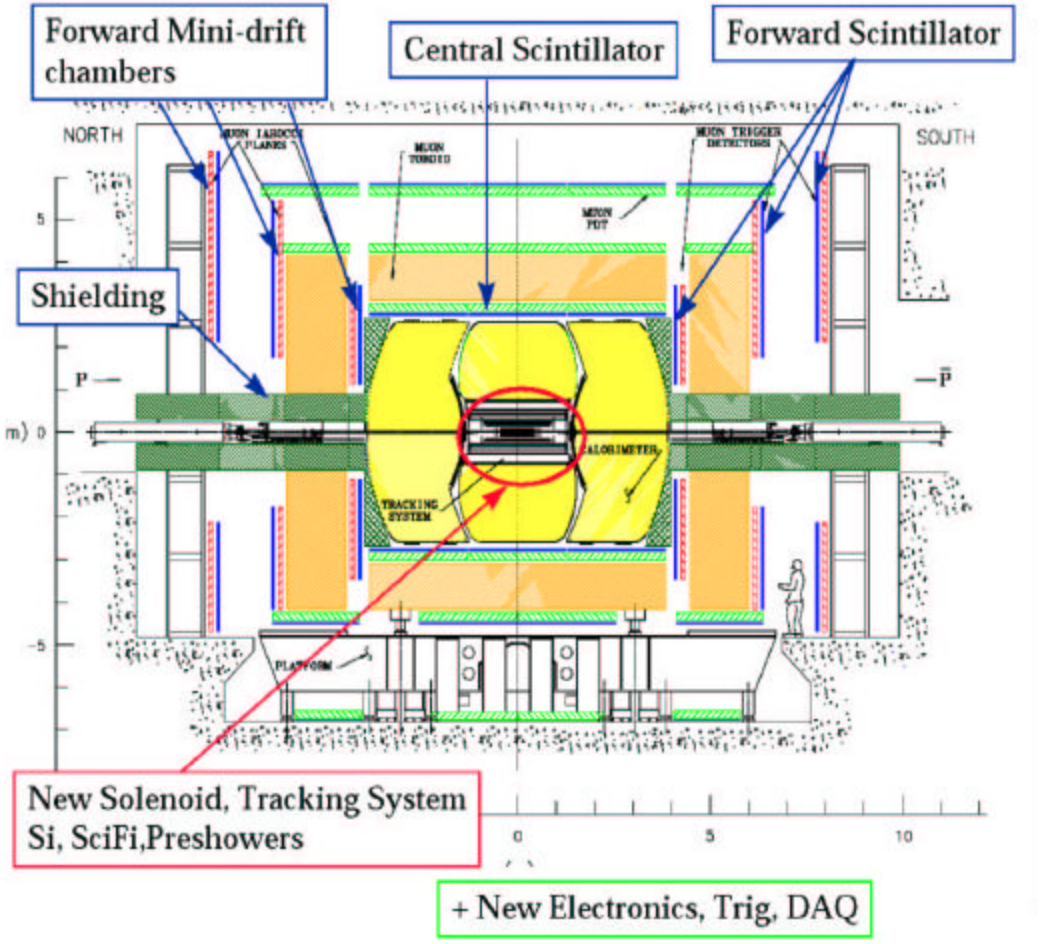
Þ There is available trigger bandwidth.

Improve B yields by

1. **Improvements in silicon coverage**
2. **SVT - require 4 of 5 layers (presently 4 of 4)**
3. **Dynamic prescaling**
4. **Confirm track d_0 in Level 3 trigger**
5. **Tighten fast track processor requirements**

Expect a factor of ~2 improvement in yield. However, as luminosity increases, this will have to be scaled back.

DØ Run II Detector



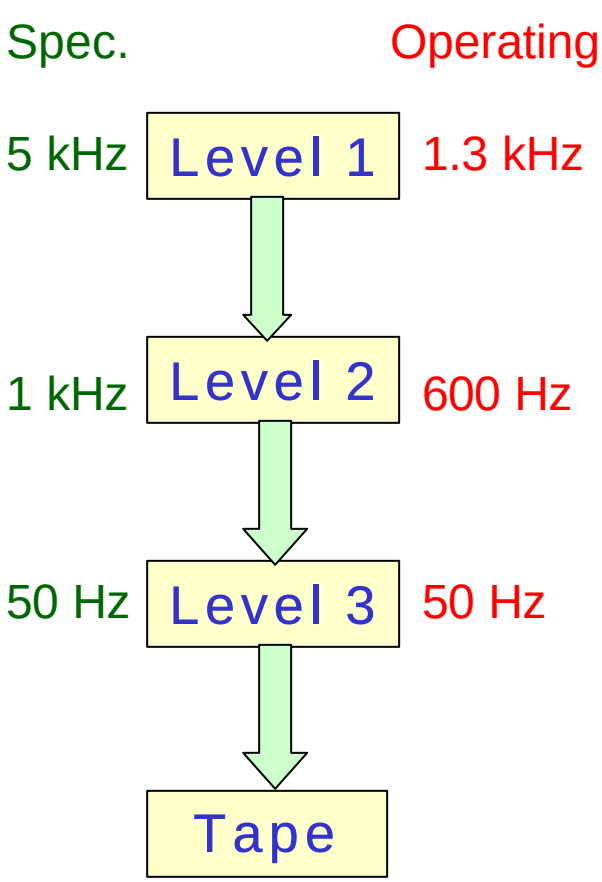
Retained from Run I

LrAr Calorimeter
Central muon detector
Muon Toroid

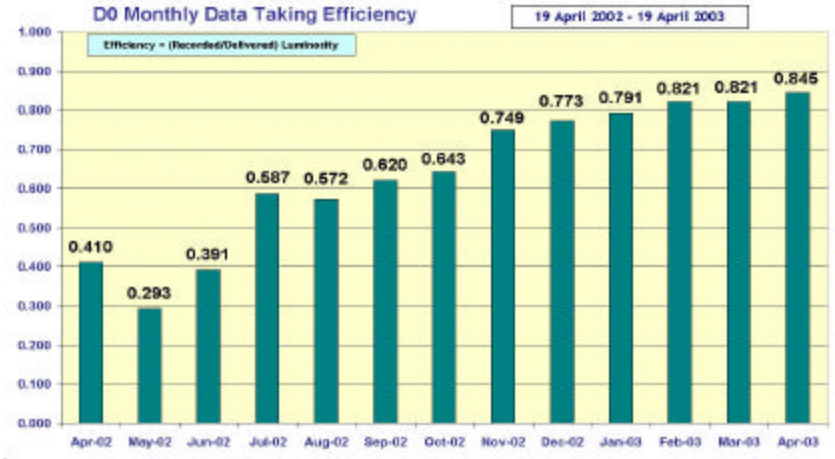
New for Run II

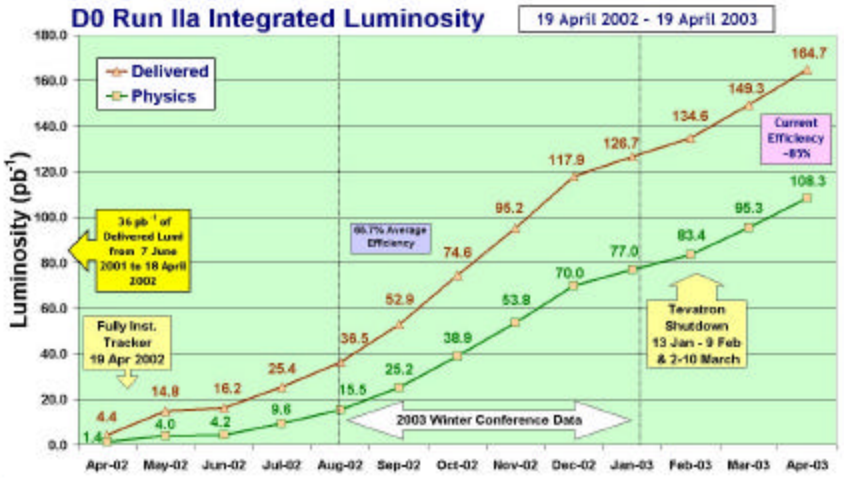
Magnetic tracker
2 Tesla solenoid
Silicon microvertex tracker
Scintillating fiber tracker
Preshower detectors
Forward muon detector
Forward proton detector
Front-end electronics
Trigger and DAQ

Trigger and DAQ



Tracker and silicon-based triggers integration underway

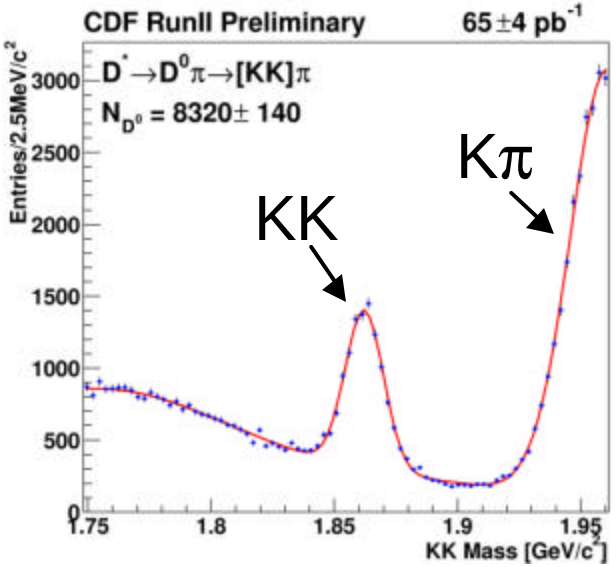


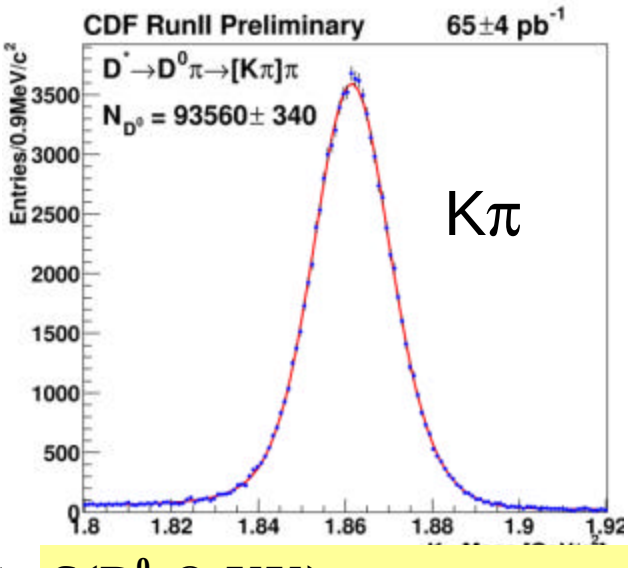


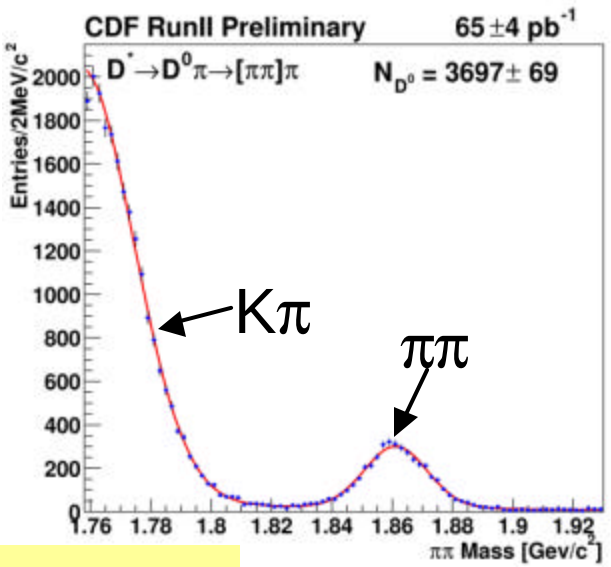
DAQ efficiency improved significantly, running routinely at ~85% now...

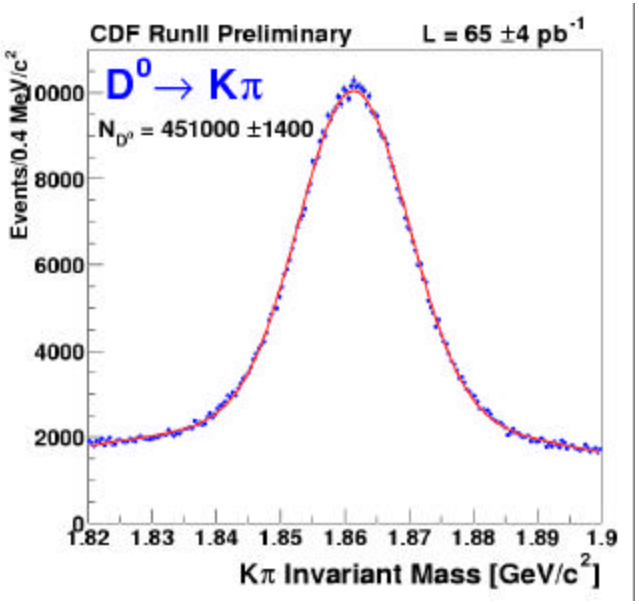
Charm Yields

See Gianluigi Boca's talk on Wednesday evening.









$$\frac{\Gamma(D^0 \to KK)}{\Gamma(D^0 \to K\pi)} = (9.38 \pm 0.18 \pm 0.10)\%$$

$$\frac{\Gamma(D^0 \to pp)}{\Gamma(D^0 \to K\pi)} = (3.686 \pm 0.076 \pm 0.036)\%$$

New Run II results!

(10.8±0.5)%

PDG

(3.8±0.2)%

$$A_{CP} = \frac{\Gamma(D^0 \to pp) - \Gamma(\bar{D}^0 \to pp)}{\Gamma(D^0 \to pp) + \Gamma(\bar{D}^0 \to pp)}$$

$$A_{CP}^{KK} = (2.0 \pm 1.7 \pm 0.6)\%$$

$$A_{CP}^{pp} = (3.0 \pm 1.9 \pm 0.6)\%$$

New Run II results!

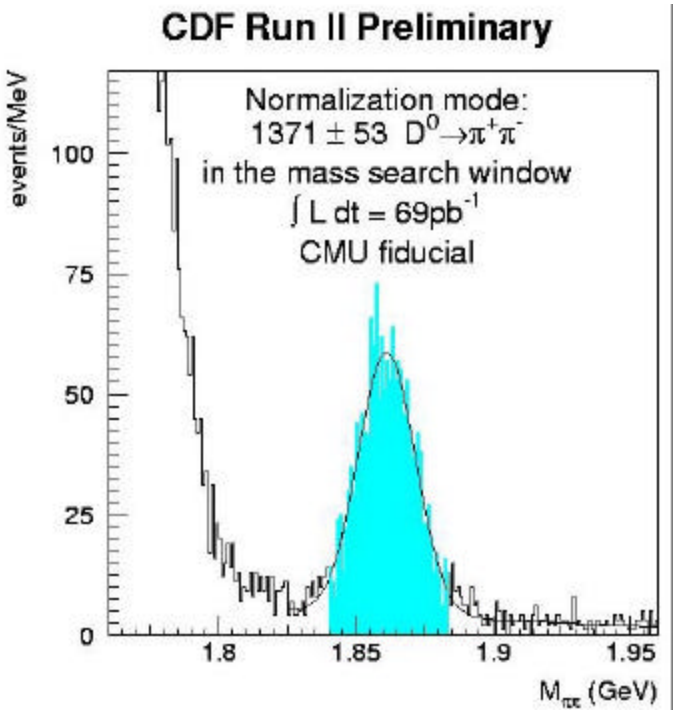
PDG

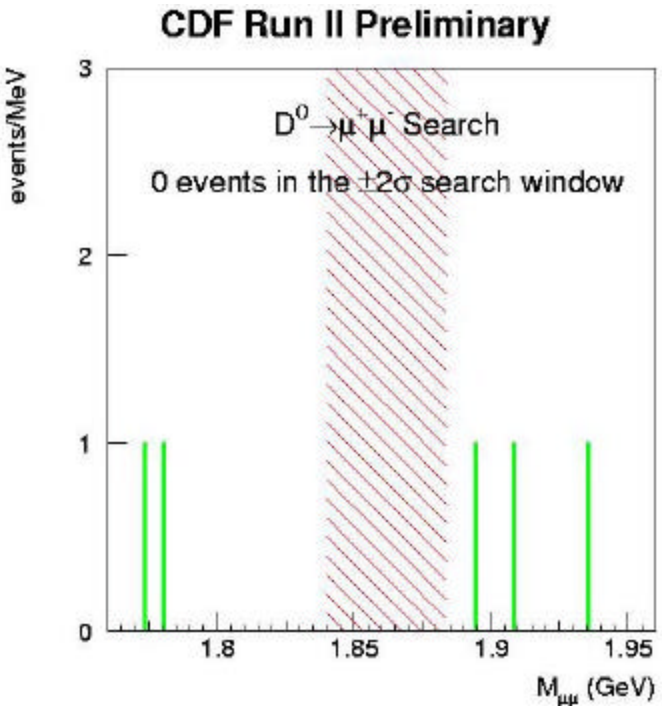
(0.5±1.6)%

(2.1 ± 2.6)%

$D^0 \to \mu^+\mu^-$

See Will John's talk on Wednesday evening.





Rare decays: $D^0 \to \mu\mu$ <2.4´10^{-6}

New Run II result!

PDG: < 4.1x10^{-6}

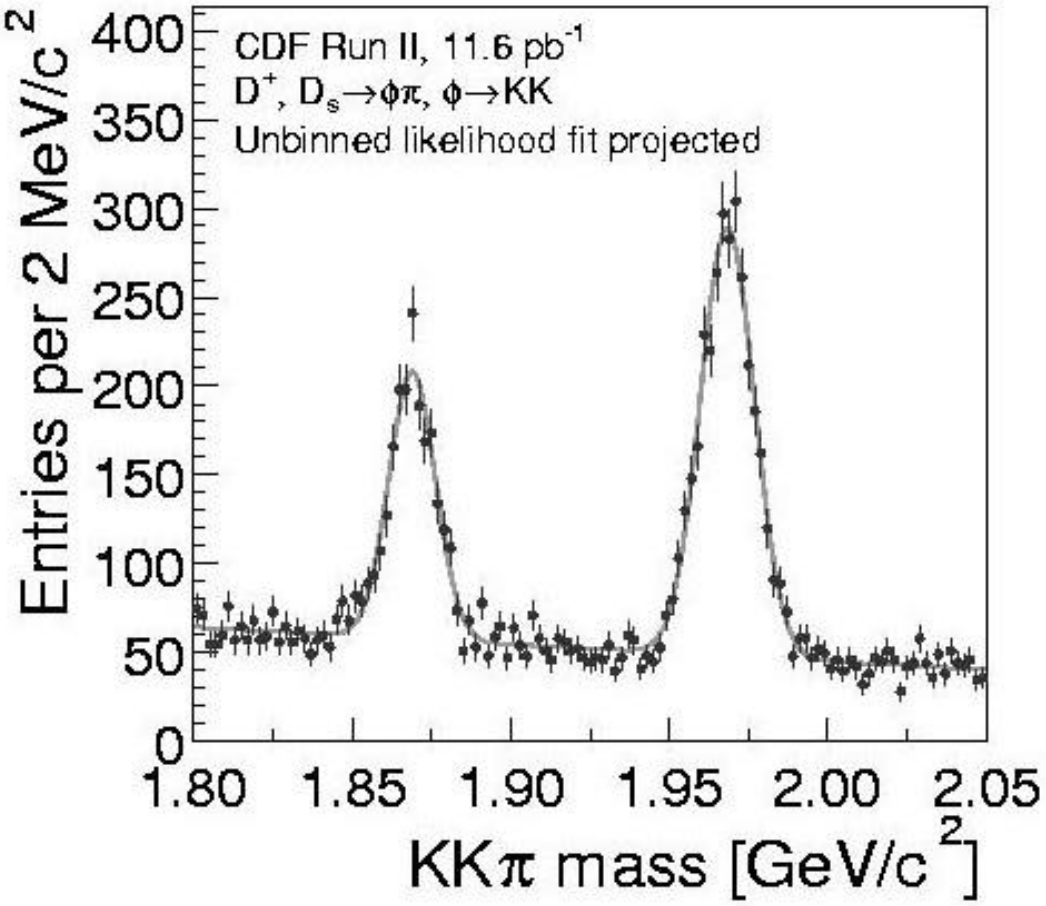
$m(D_s) - m(D^+)$

$m(D_s) - m(D^+)$ =
$99.41 \pm 0.38 \pm 0.21$ GeV/c^2

New Run II result!

PDG: 99.2 ± 0.5 GeV/c^2

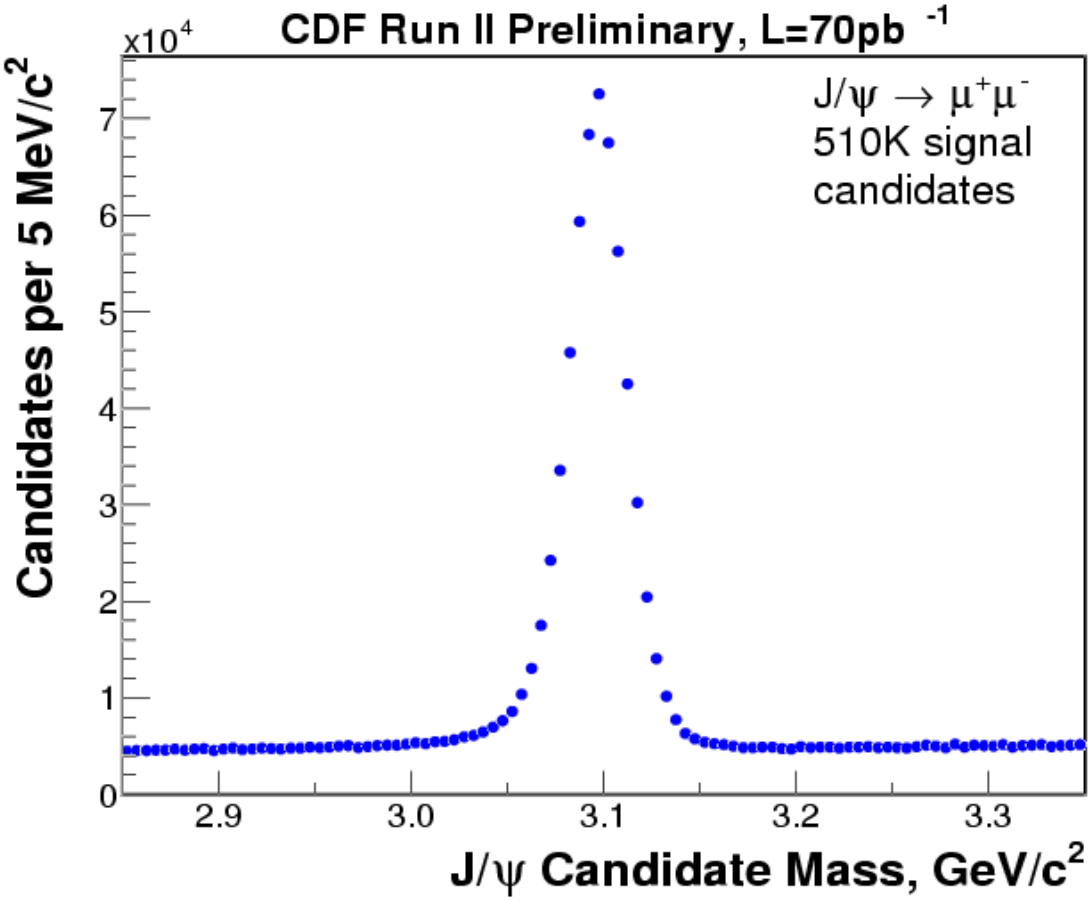
Shows typical mass resolutions of 10-20 MeV/c^2



Results from J/ψ Trigger

510K J/ψ → μμ

Measure J/ψ's down to p_T=0



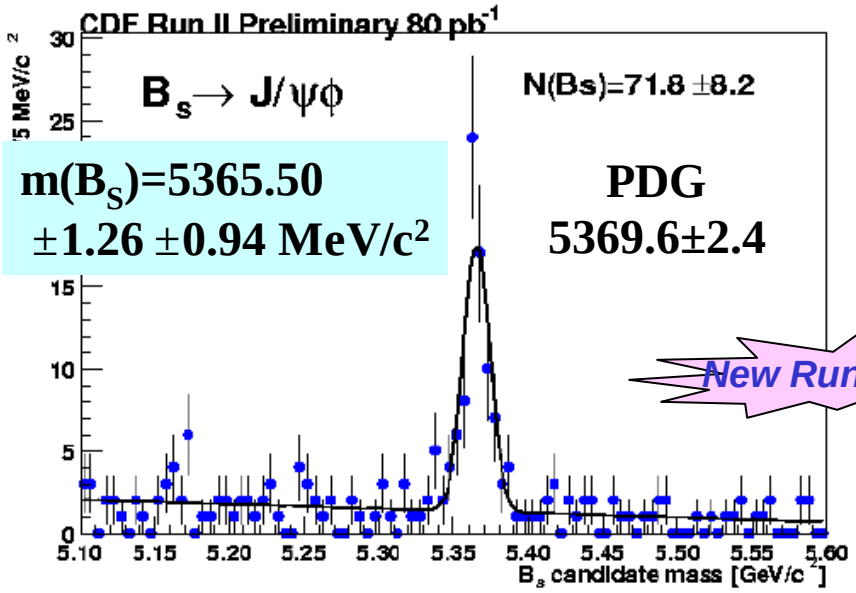
(For |h|£0.6, all p_T)

$$\sigma(J/\psi)\times B(J/\psi\to\mu\mu) = 240 \pm 1^{+35}_{-28}\,\text{nb}$$

New Run II result!

Results from J/ψ Trigger II

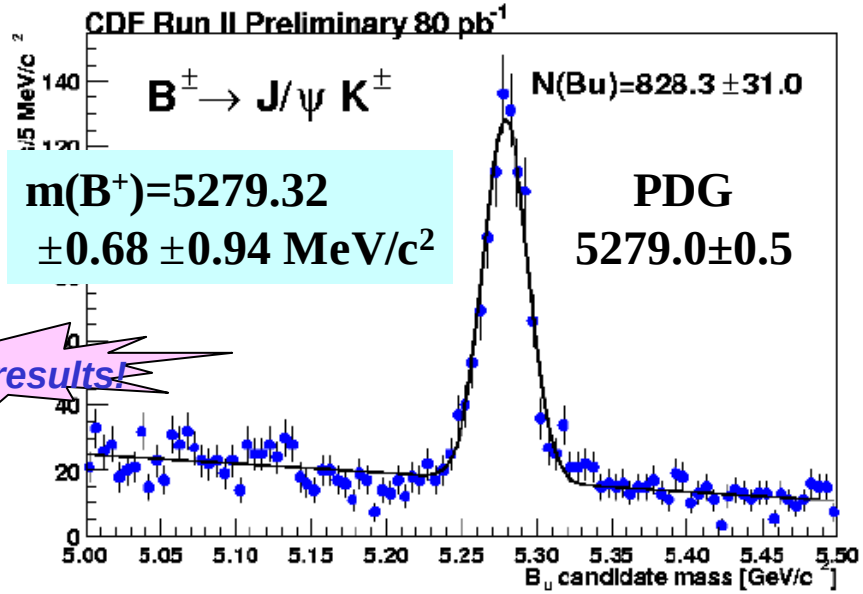
Yield/Lum »70% higher than Run 1



$m(B_S)$=5365.50 ±1.26 ±0.94 MeV/c^2

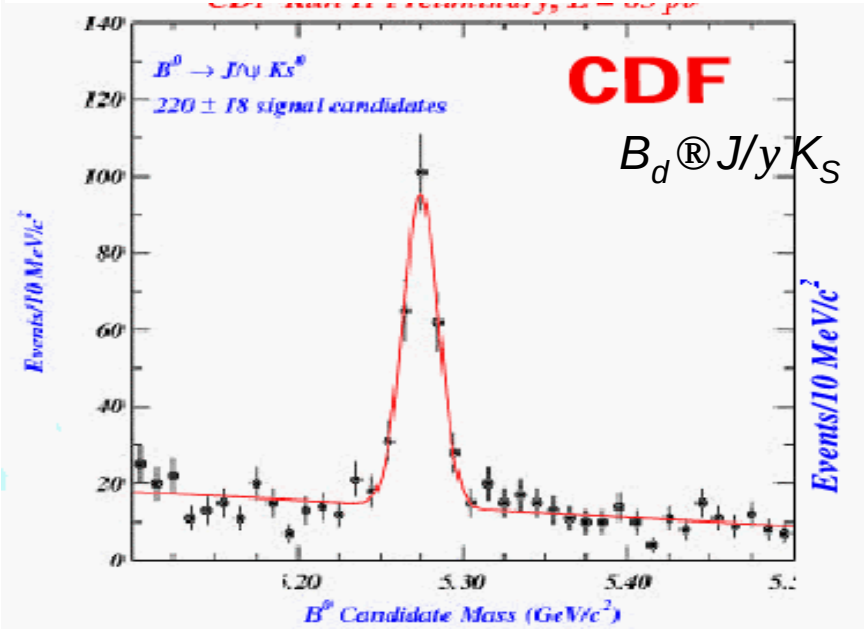
PDG 5369.6±2.4

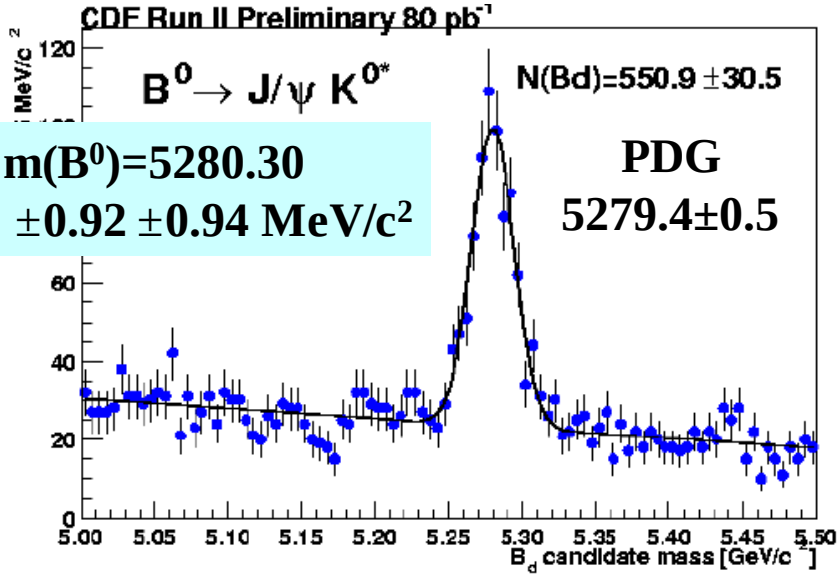
New Run II results!



$m(B^+)$=5279.32 ±0.68 ±0.94 MeV/c^2

PDG 5279.0±0.5



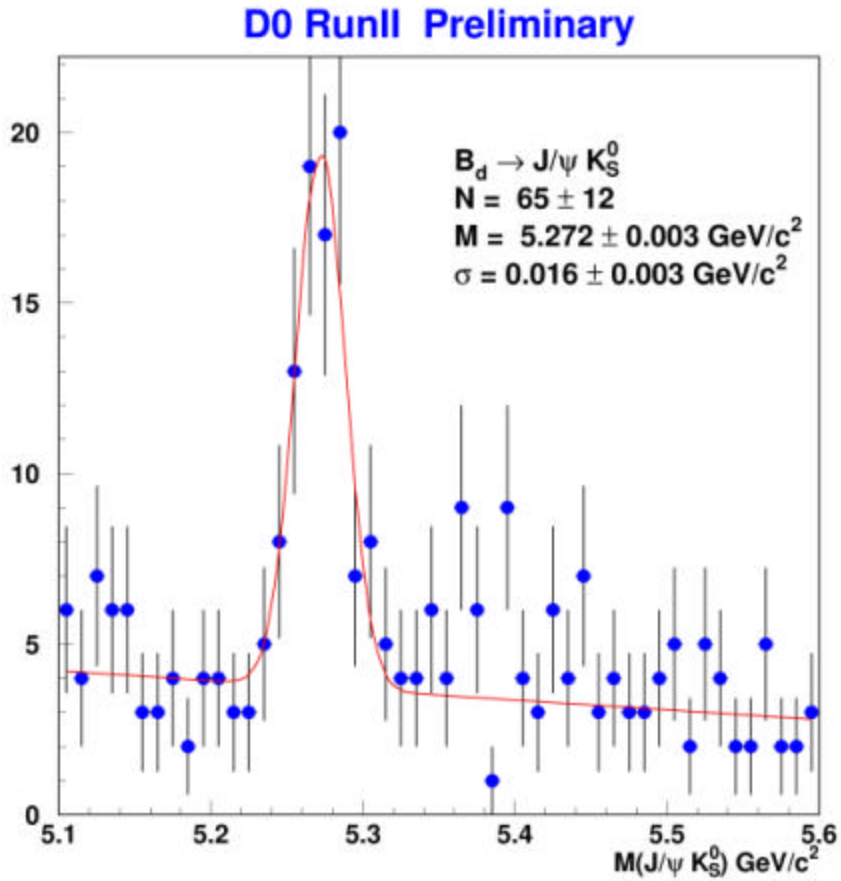


$m(B^0)$=5280.30 ±0.92 ±0.94 MeV/c^2

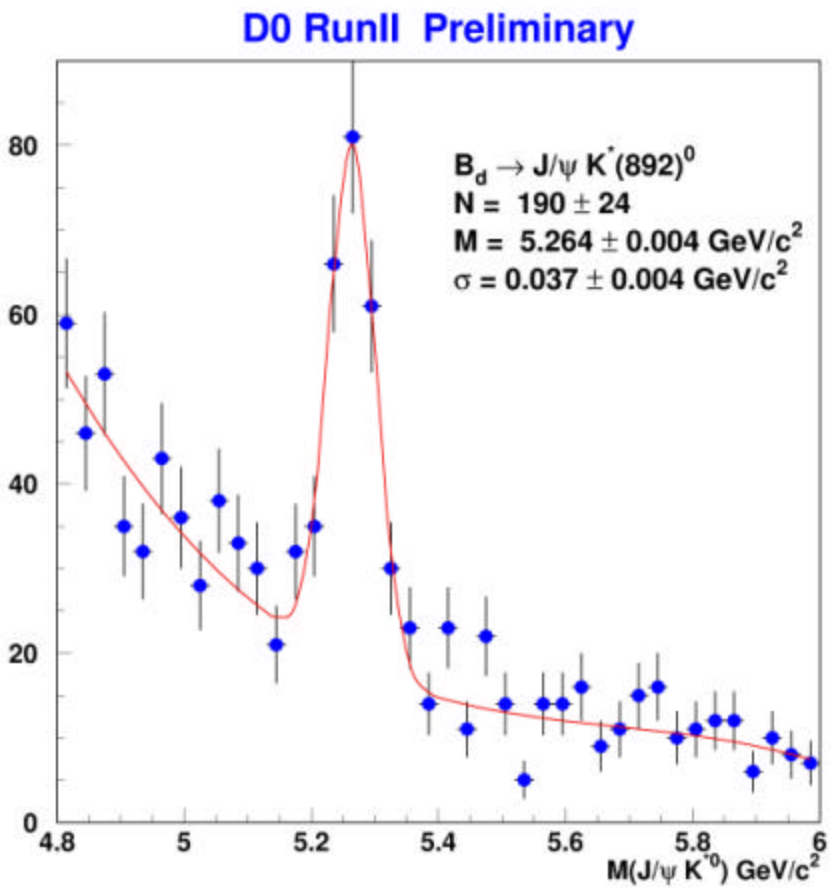
PDG 5279.4±0.5

Results from J/ψ Trigger III

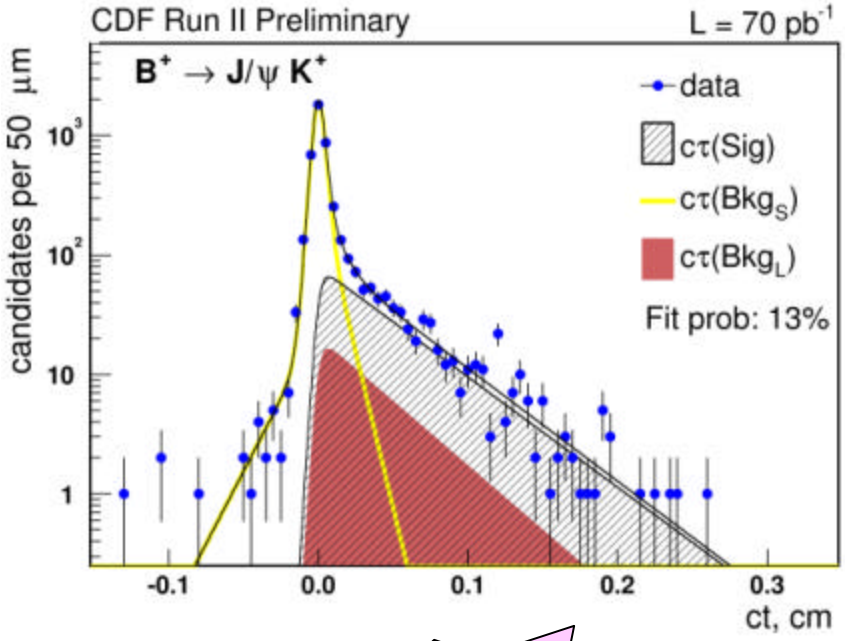
B_d ® J/ψ K_s



B_d ® J/ψ K^{*0}



New Lifetime Measurements



New Run II result!

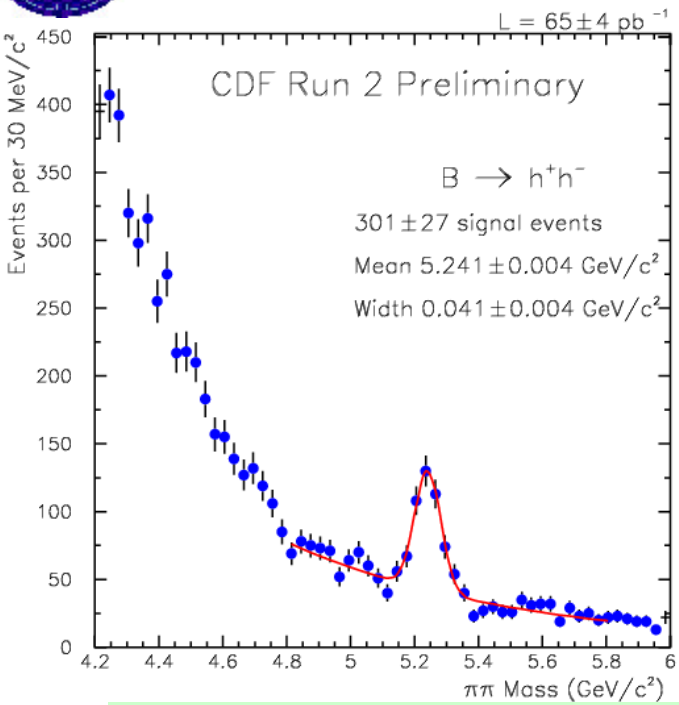
See Vivek Jain's talk on Wednesday morning.

Resolution is ~40 μm.

Should improve by a factor of ~2 when inner most silicon layer is included (important for B_S mixing analysis).

	PDG
$\tau(B^+)=1.57\pm0.07\pm0.02$ ps	**1.674 ± 0.018 ps**
$\tau(B^0)=1.42\pm0.09\pm0.02$ ps	**1.542 ± 0.016 ps**
$\tau(B_s)=1.25\pm0.20\pm0.02$ ps	**1.461 ± 0.057 ps**

Hadronic B Yields



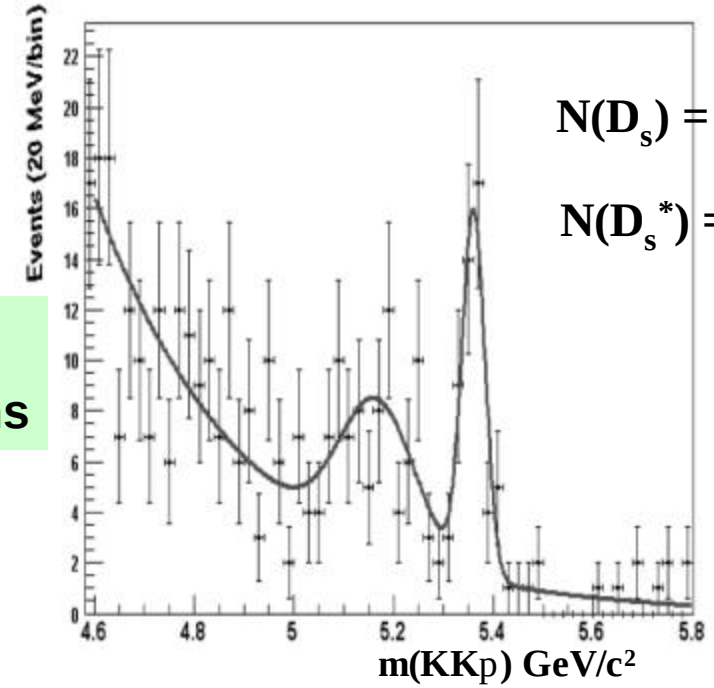
See Mat Martin's talk on Wednesday morning.

Clean B ® hh signal established

Disentangle B_d ® pp B_d ® Kp

B_s ® KK B_s ® Kp

with kinematics & dE/dx



$N(D_s) = 42 \pm 8$

$N(D_s^*) = 56 \pm 15$

B_s ® D_sp, D_s ® fp :
golden mode for B_s oscillations

Add additional modes

- **B_s ® D_s ppp, D^0Kp**
- **D_s ® K*K, ppp, K_SK**

Need O(10^3) events to observe SM B_s oscillations at 5s

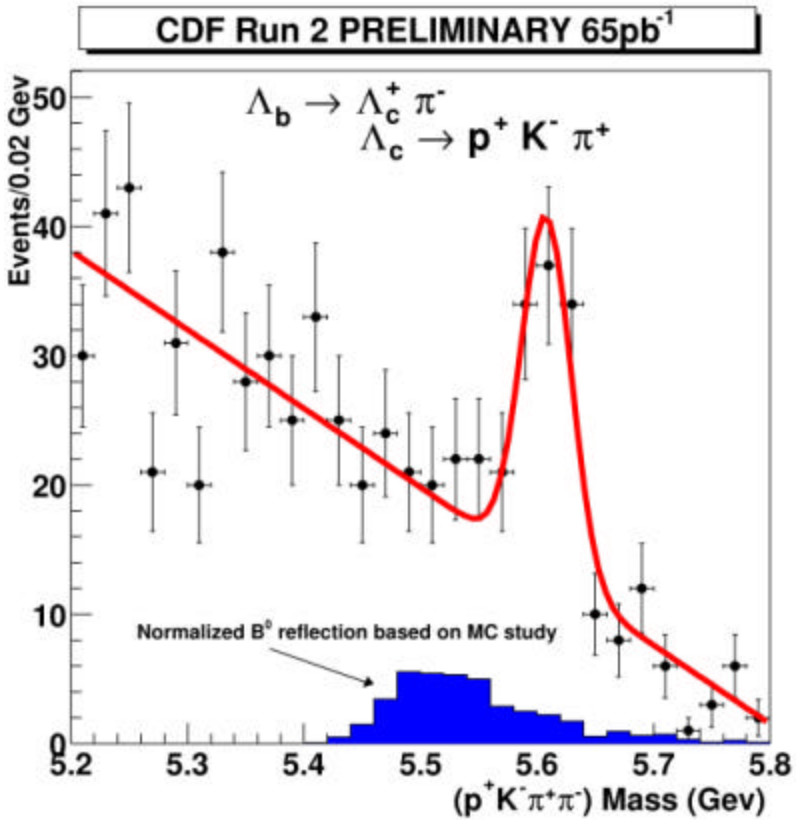
May take a while…

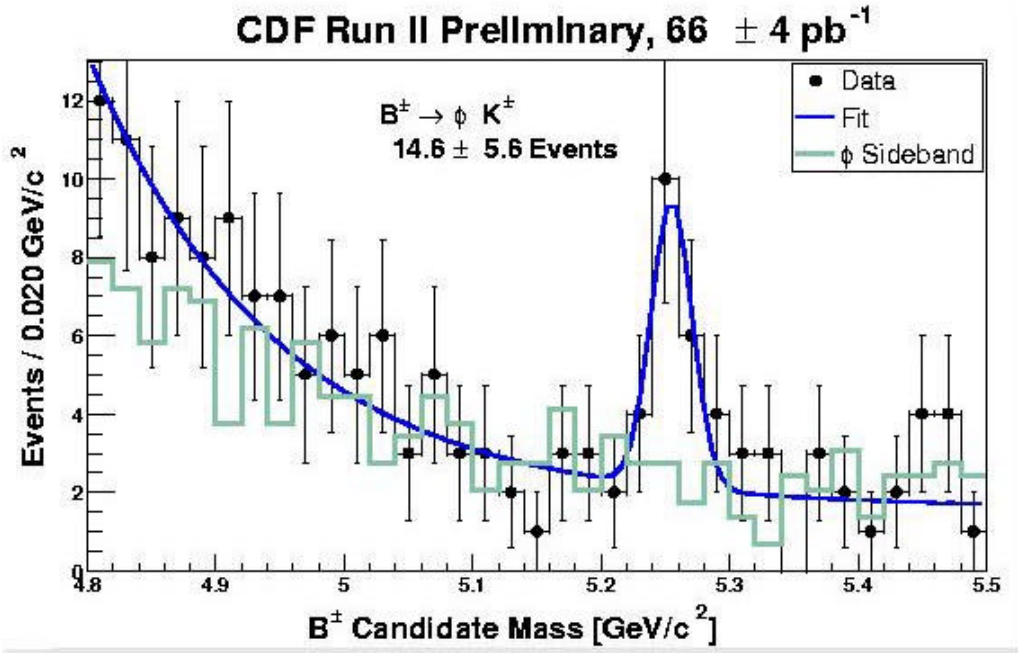
More B Signals

See Mat Martin's talk on Wednesday morning.

$\Lambda_b \to \Lambda_c p$, $\Lambda_c \to p K p$

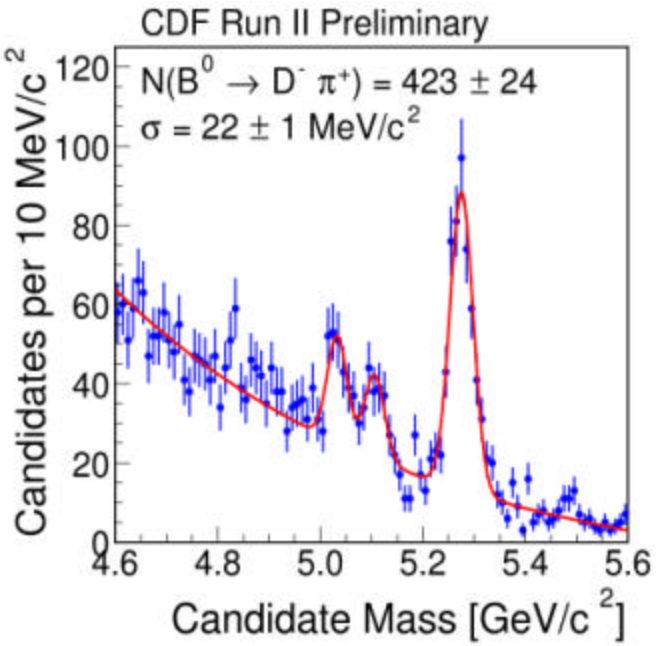
$B^{\pm} \to f K^{\pm}$



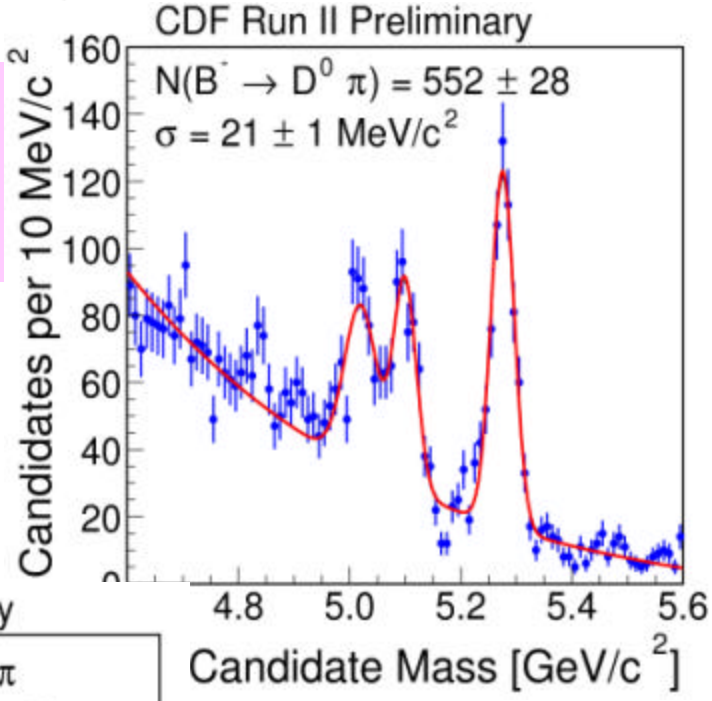


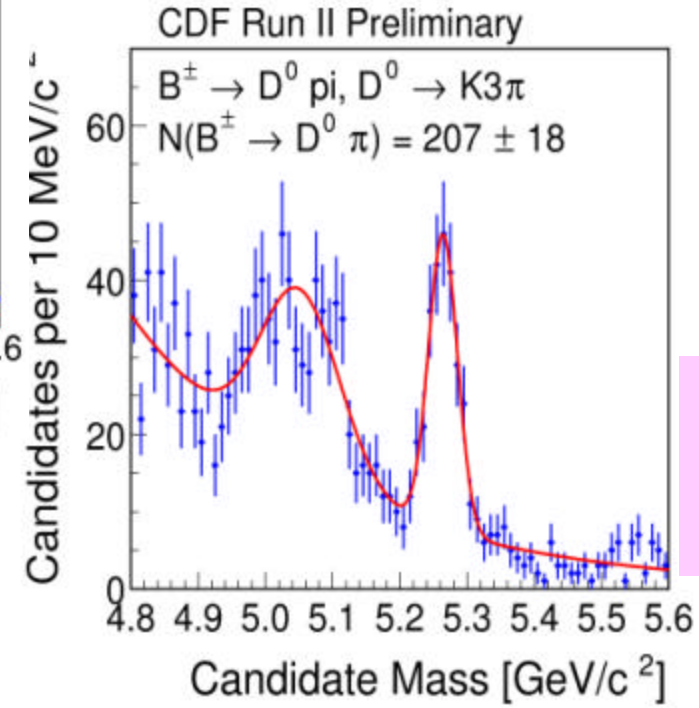
Still More B Signals

$B^0 \to D^0 p$, $D^0 \to K p$



$B^{\pm} \to D^0 p$, $D^0 \to K p$





$B^{\pm} \to D^0 p$, $D^0 \to K p p$

Summary

Run II is underway. Tevatron luminosity is increasing (albeit more slowly than we would like).

D0 and CDF detectors are functioning well and taking data at high efficiency.

Detector upgrades have significantly enhanced the B physics potential of both detectors.

New bottom and charm physics results are coming out.

Stay tuned for more!