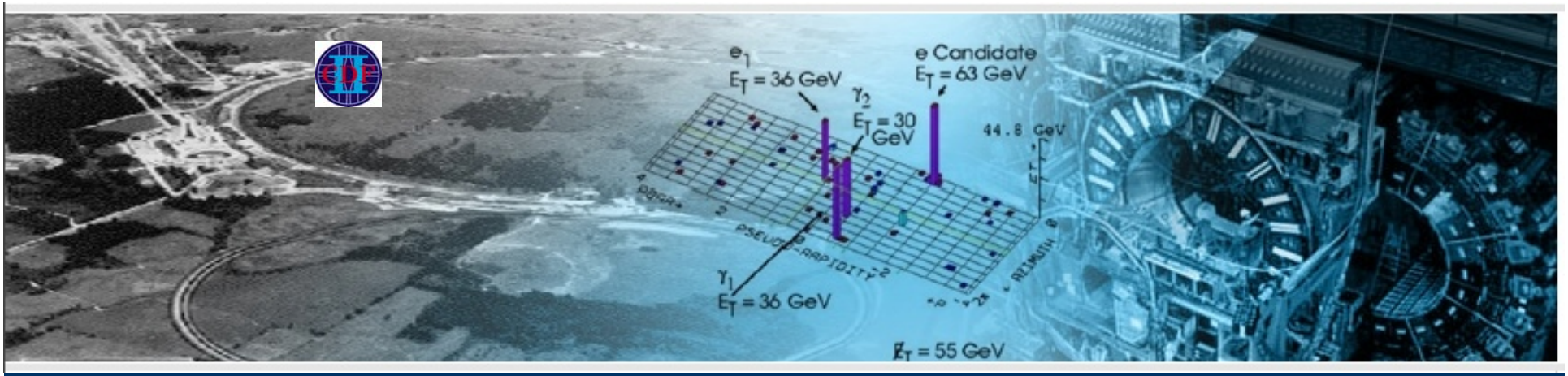
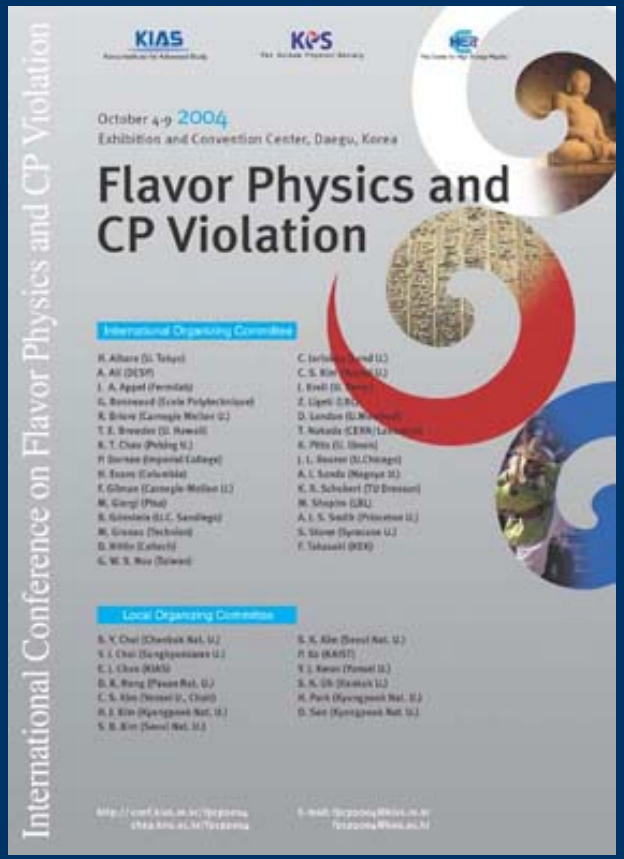




Hot Topics in Flavor Physics at CDF

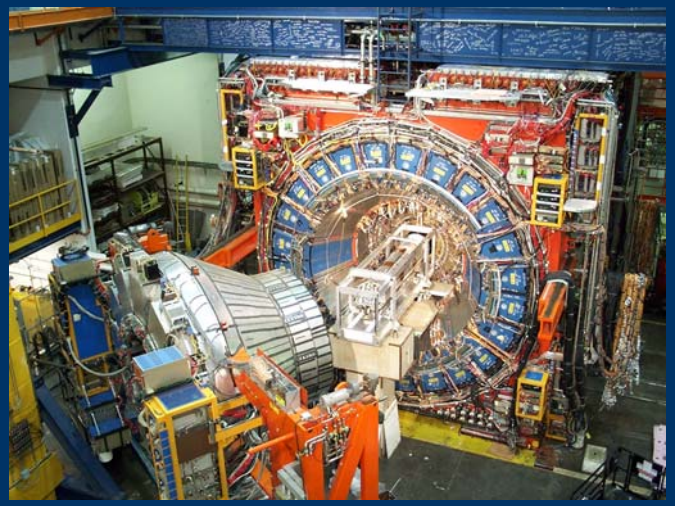
Soon Yung Jun

Carnegie Mellon Univ.

FPCP2004

Daegu, Oct. 4, 2004

Outline



- Tevatron performance and CDF II Detector
- Top, Beauty, Charm and Exotic States

  Top Mass and Production

  No b-(mixing, golden modes) → see S. Menzemer's talks

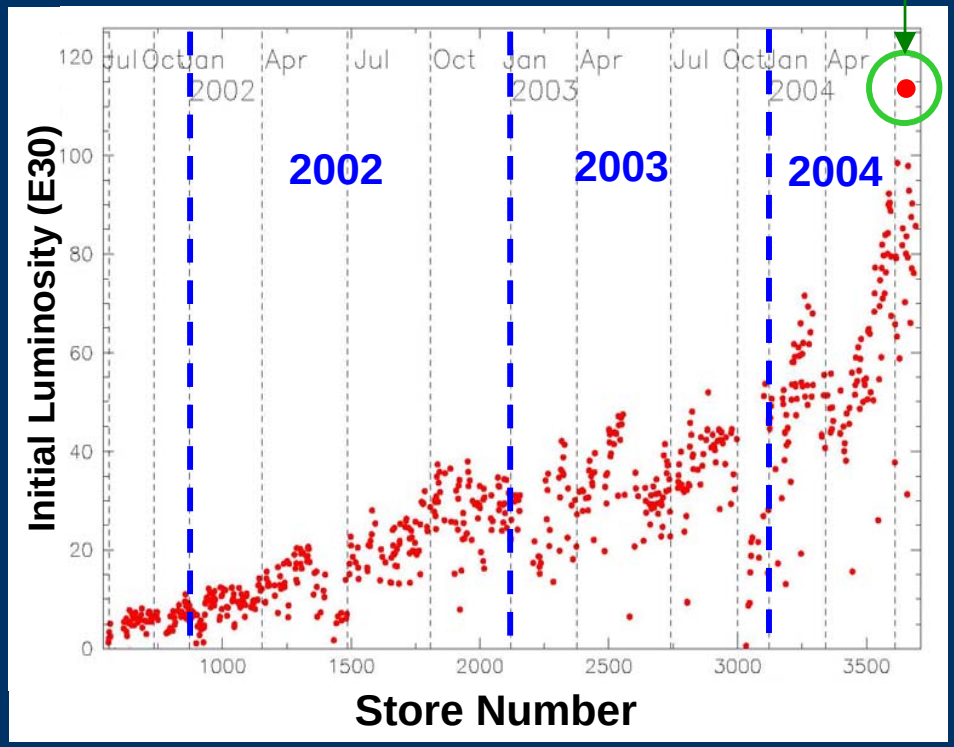
  Charm Production and ~~CP~~ in the c-sector

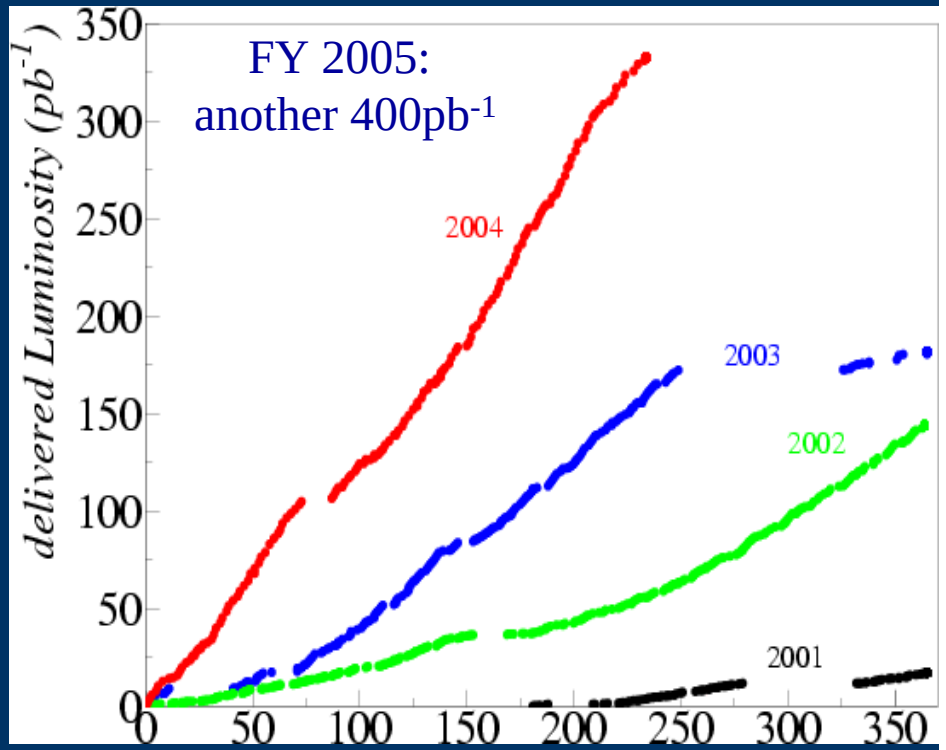
  Pentaquark Search , Properties of X(3872)
- Summary and Outlook

Tevatron Performance

Luminosity, Luminosity and Luminosity!

Record Peak $\mathcal{L}$ = 10.3 x 10^{31} $cm^{-2}sec^{-1}$ on July 16, 2004





Total Delivered: ~600 pb^{-1} → CDF recorded: ~480 pb^{-1}

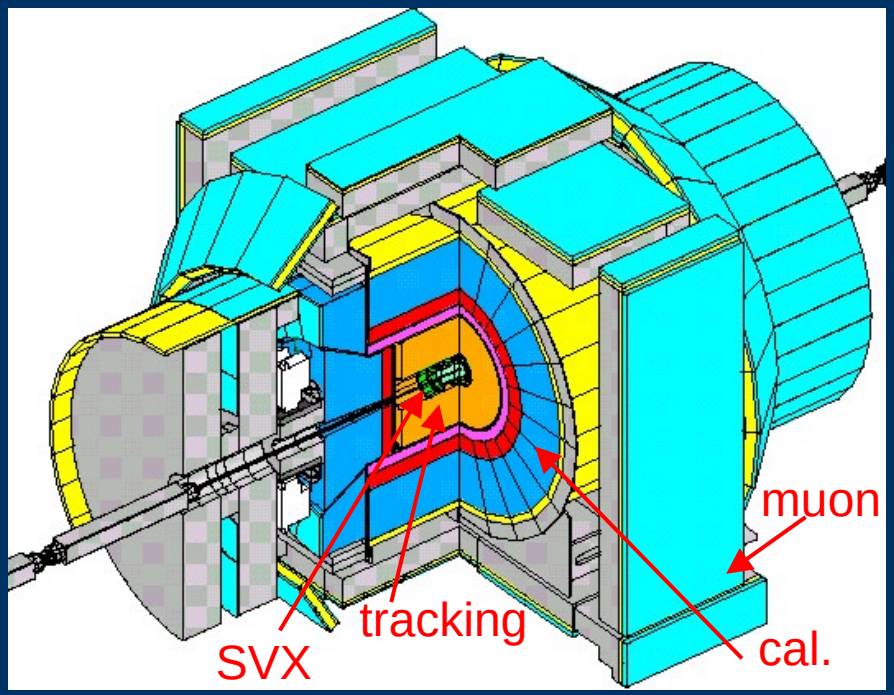
→ @ end of FY09: 4.4 fb^{-1} (baseline) →8.5 fb^{-1} (design)

CDF II detector

New in Run II (precision measurements & search for new physics)

Faster Detector

Faster DAQ



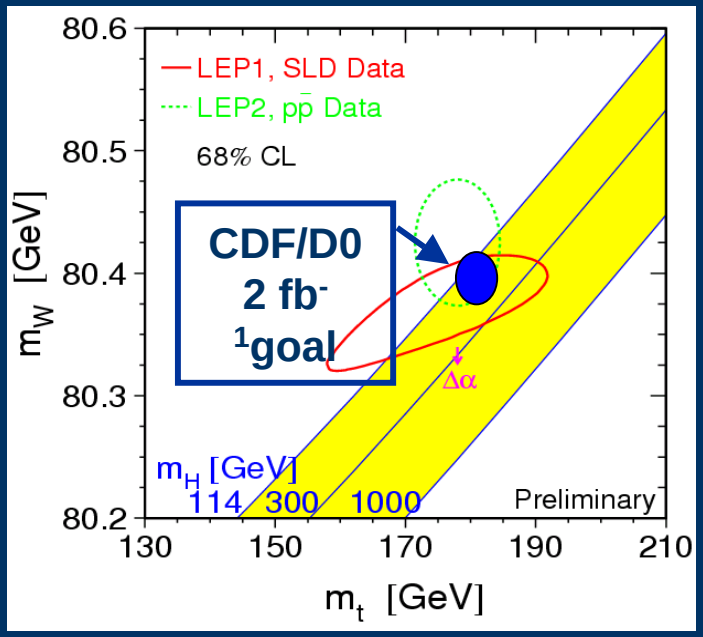
More coverage in SVX, muon detectors, and calorimeters
Trigger (~3M events → write 70 events/s)

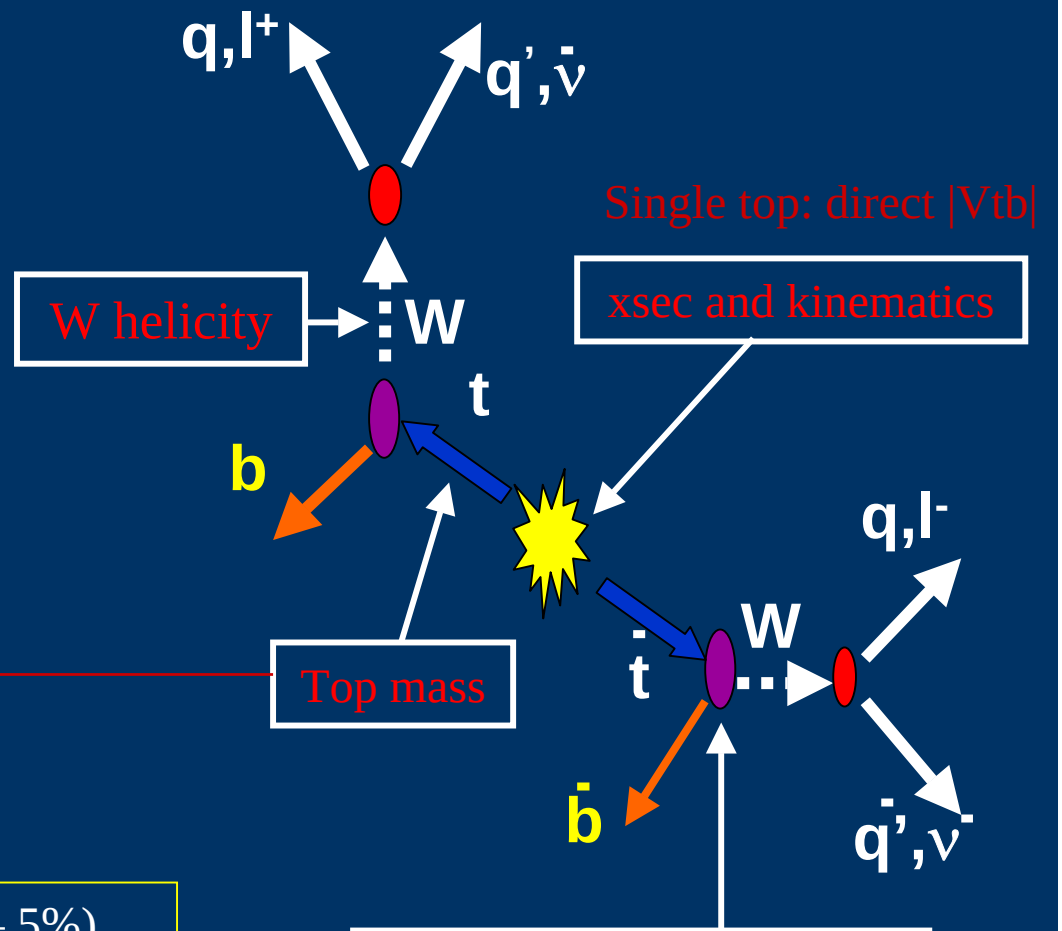
Recent CDF analysis: based on ~200 pb^{-1} (Mar 2002-2003)

Top Mass and Production

Top has been hot (heavy & short) since dead sea was sick!

m_t is one of 19 SM parameters
only fermion near EWK scale
constraint to m_H with m_W

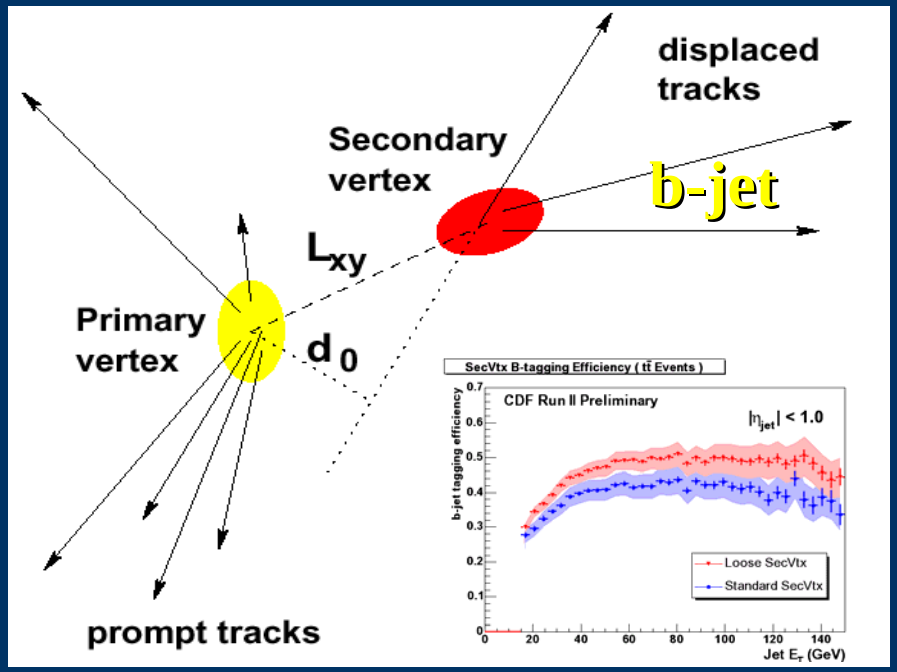




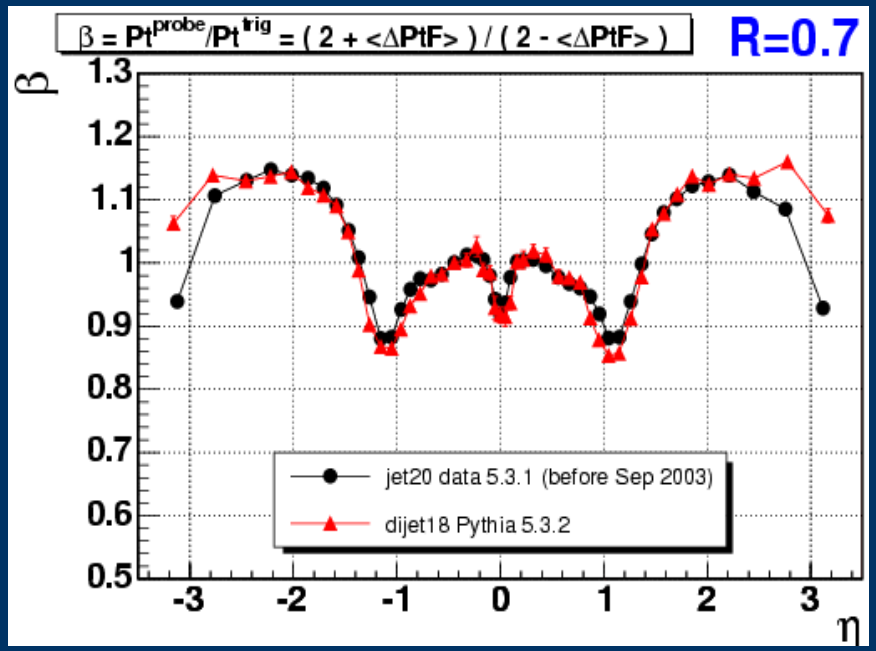
dilepton: both W→ lν (lν lν bb – 5%)
lepton+jets: one W→ lν (lν qq bb - 30%)
all hadronic: both W→ qq (qq qq bb - 44%)

b-jet tagging and Jet energy scale

Displace tracks inside jets



jet-jet balance in Pt



secondary vertex reconstruction

to enhance signal purity

→ optimize efficiency/tag rate

ε (b-tagging | top events) ~ 50%

false tag rate (QCD jets) ~ 0.5%

7-level jet energy corrections

to reduce systematic errors

→ improve simulation

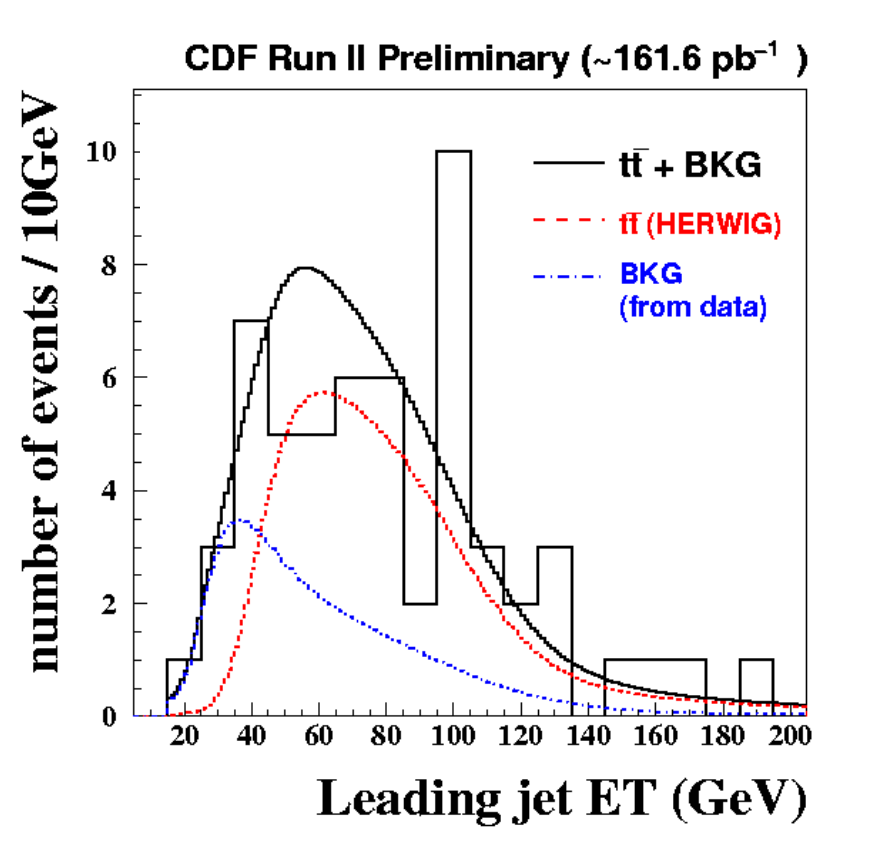
→ understand fragmentation

→ more statistics, better jet resolution and Z → $b\bar{b}$

Production Cross Section

Kinematic Fitting (lepton+jets)

Fit leading jet E_T,
require @ least 1 b-jet tagged



Signal fraction from fitting (0.68+0.14-0.16)

57 events

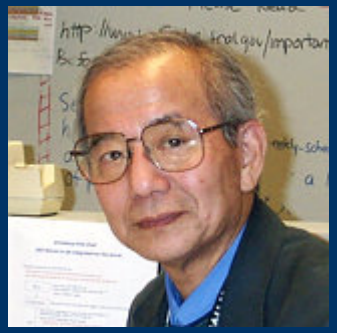
$$\sigma(tt) = \frac{N(W+\geq 3\,jet)\cdot(F\_signal)}{A\cdot\varepsilon\cdot\int Ldt}$$

A: ttbar acceptance ε: eff. for ttbar
ε : 4.02 +-0.03(stat.) +-0.45(sys) %

m_t = 175 GeV/c^2

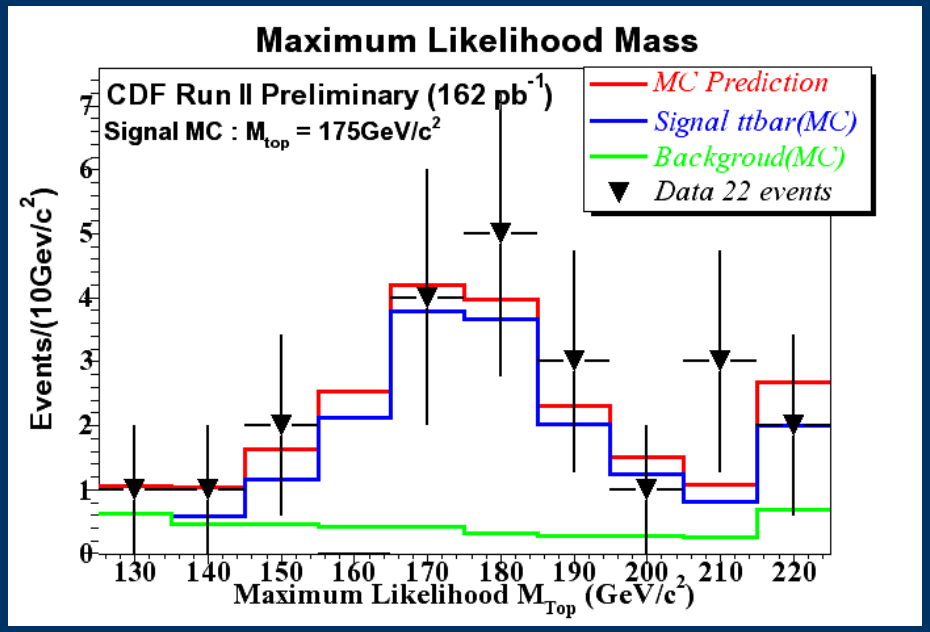
σ_{tt} = 6.0 ± 1.6 (stat) ± 1.2 (sys) pb

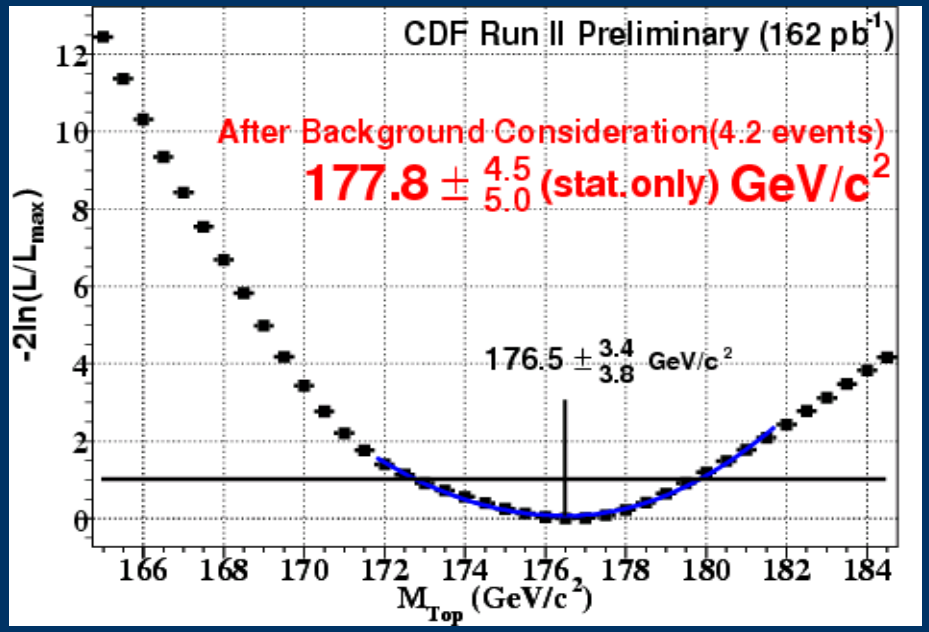
Top Mass



In 1988, Kuni Kondo said, "use Dynamic Likelihood Method"

$$L^i(M_{top}) = \sum_{I_t}\sum_{I_s}\int \frac{2\pi^4}{Flux} F(z_a, z_b, p_T)\,|M|^2\,\delta(s_w - (\ell+\nu)^2)\,w(I_t, \mathbf{x}\,|\,\mathbf{y}; M_{top})\,d\mathbf{x}\,ds_w$$



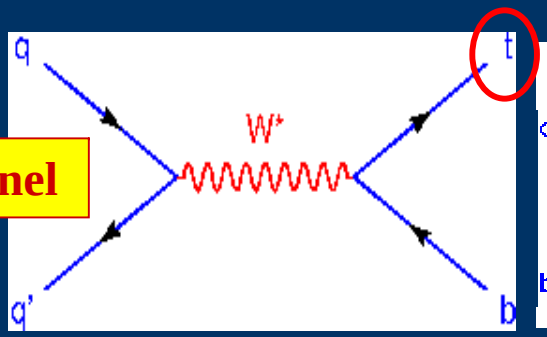


22 $t\bar{t}$ (lepton+jets) events ≥ **1 b-tag**: 12 combinations with weighted by diff. cross section

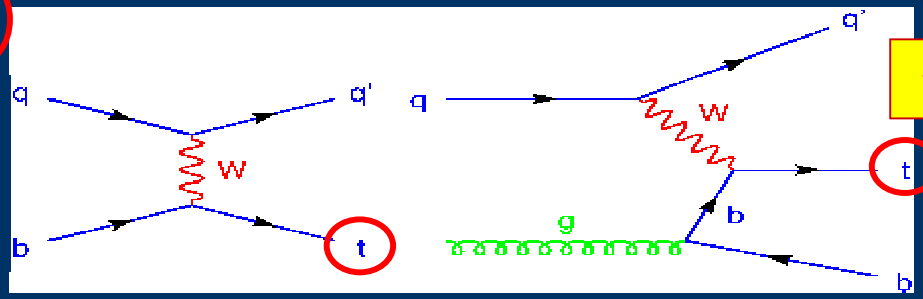
$$\mathbf{m_{top} = 177.8\ ^{+4.5}_{-5.0}(stat) \pm 6.2\ (sys)\ GeV/c^2}$$

Single Top Search

Direct measurement of V_{tb} and sensitive to new physics

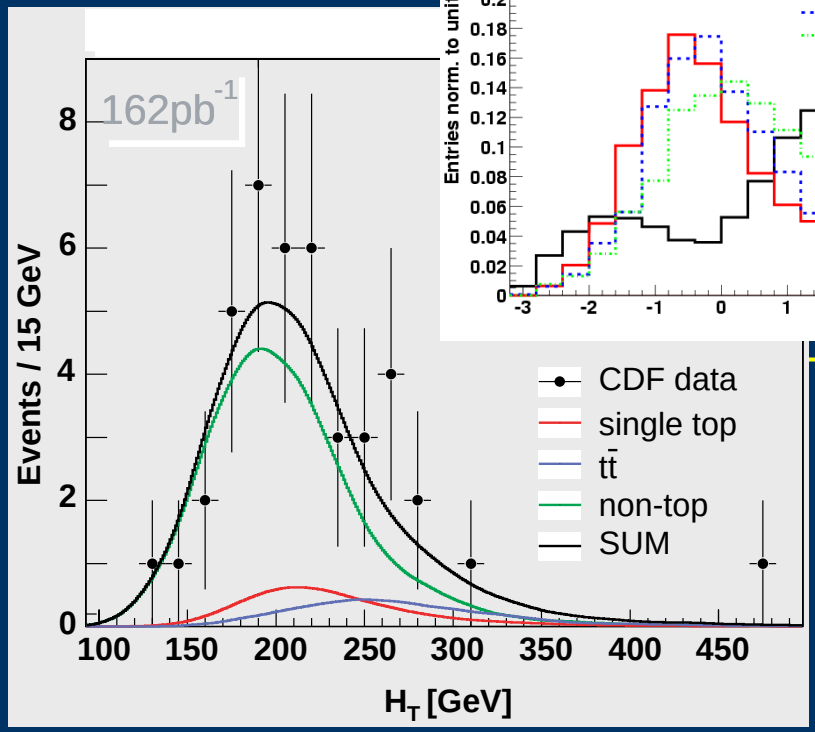


s-channel



t-channel

W+2jets (1 b-tag)



likelihood fit

Q(lep)*η(light jet) (t-ch)

fit to H_T (t+s ch)

Upper limit 95% C.L.

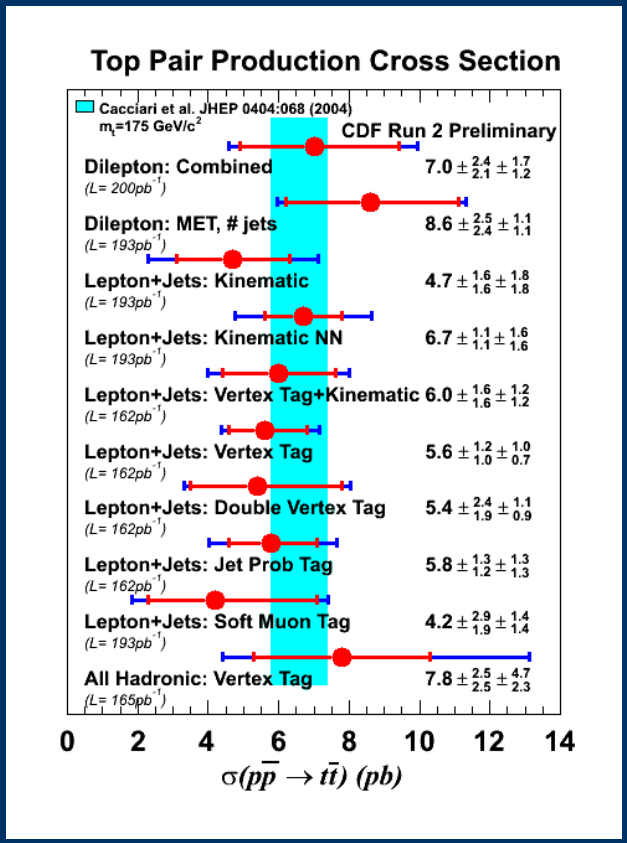
t-ch < **10.1** pb

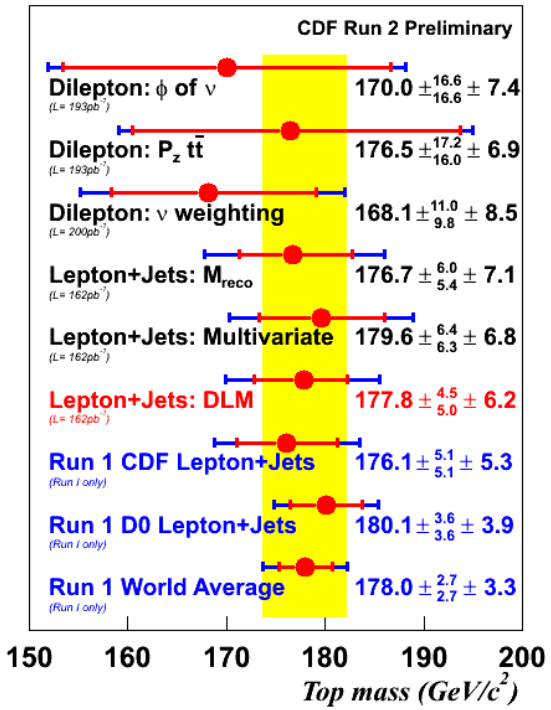
s-ch < **13.6** pb

comb < **17.8** pb

Summary: CDF Top

tt Cross Section	Top Mass	Other Analysis





Single top

Search for t'

W helicity

Top quark spin

H^+ from top decay

Rare decays (t→Zc)

Br (Wb)/(Wq)

(dilepton)/(lepton+jet)

tau-dilepton

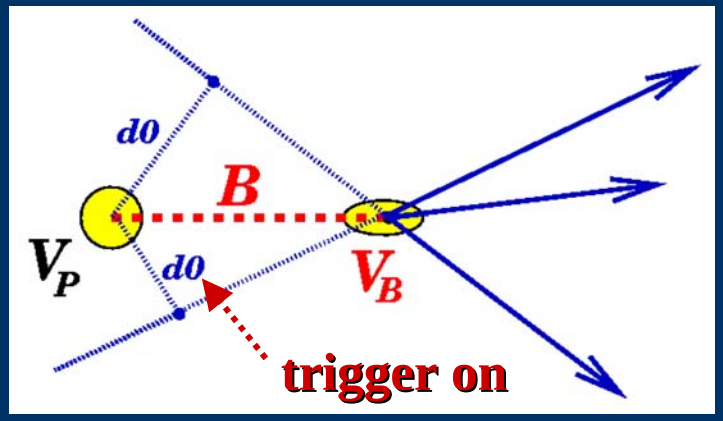
X → ttbar

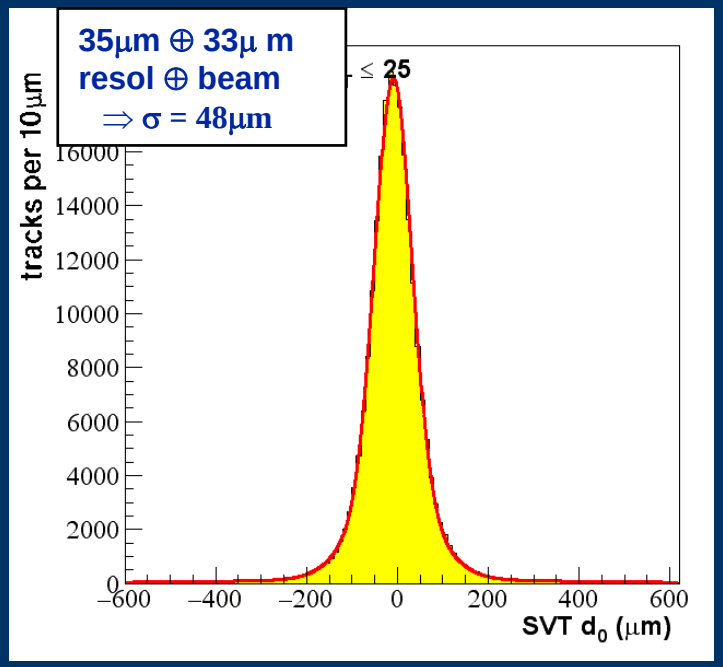
Rich top signal today, a window to new physics and its background tomorrow.

B Physics @CDF

B-physics = Trigger + Tracking + (flavor tagging)

- **Silicon Vertex Tracker using SVX impact parameter d_0**





- Two SVT Track (hadronic)
- SVT + lepton (semileptonic)
- Di-Lepton (J/ψ)

- **This talk will NOT cover**

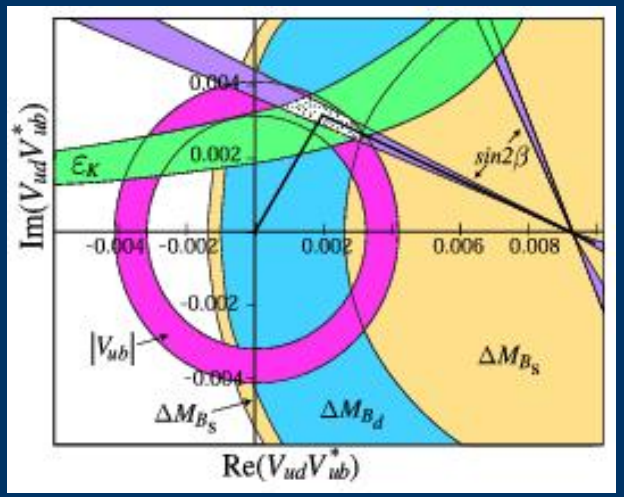
B_s Mixing

$B_s \rightarrow J/\Psi\ \phi$

$B_s \rightarrow \phi\phi$

$B \rightarrow hh$

$B \rightarrow \mu\mu$



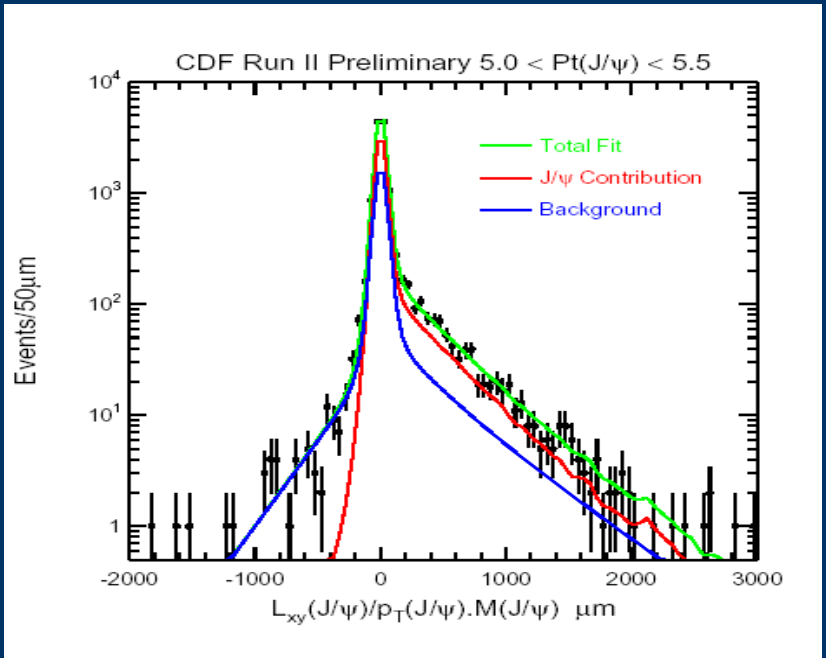
See S. Menzemer's Bs mixing & B-physics from Tevatron

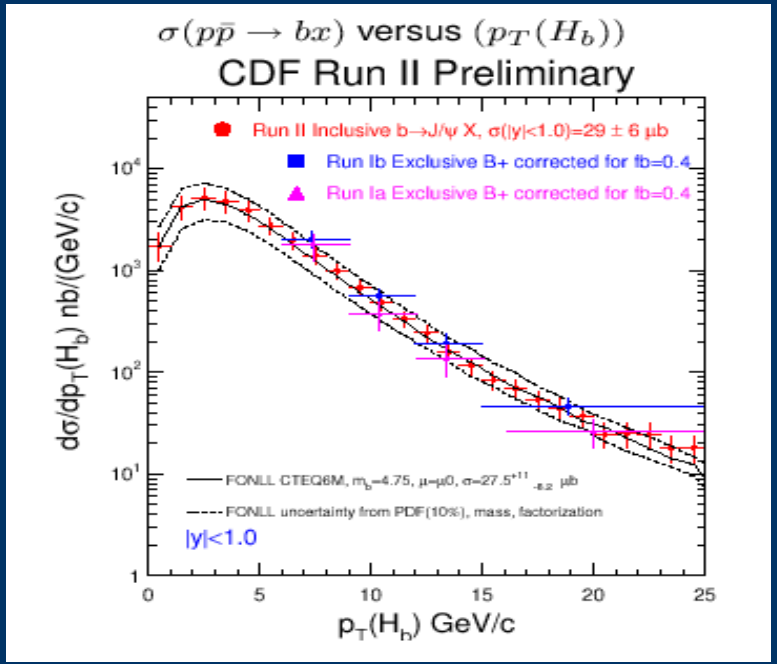
Inclusive B Cross Section

RunI b-cross section ~ 3x higher than theory

Unbinned maximum likelihood fit $L_{xy}(J/\psi)$ to extract the b fraction

Theory: Next-to-Leading-log resummations, non perturbative fragmentation function from LEP, new factorization schemes…





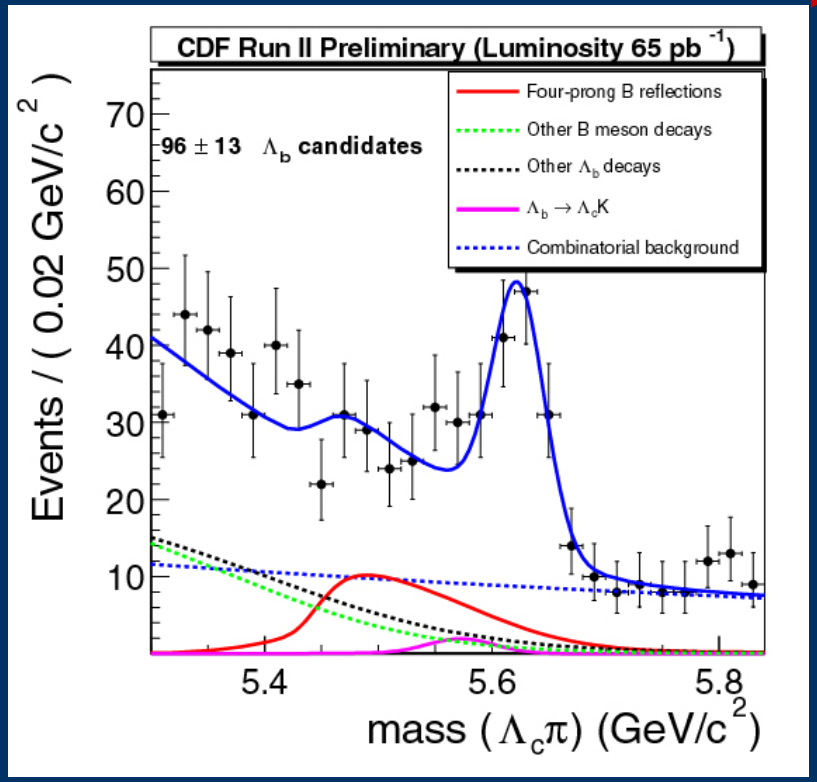
$$\sigma(p\bar{p} \rightarrow bX)|_{|y|<1.0} = (29.4 \pm 0.6(stat) \pm 6.2(sys))\ \mu b$$

$$\textbf{FONLL}\ \sigma(p\bar{p} \rightarrow bX)|_{|y|<1.0} = (27.5^{+11}_{-8.2})\ \mu b$$

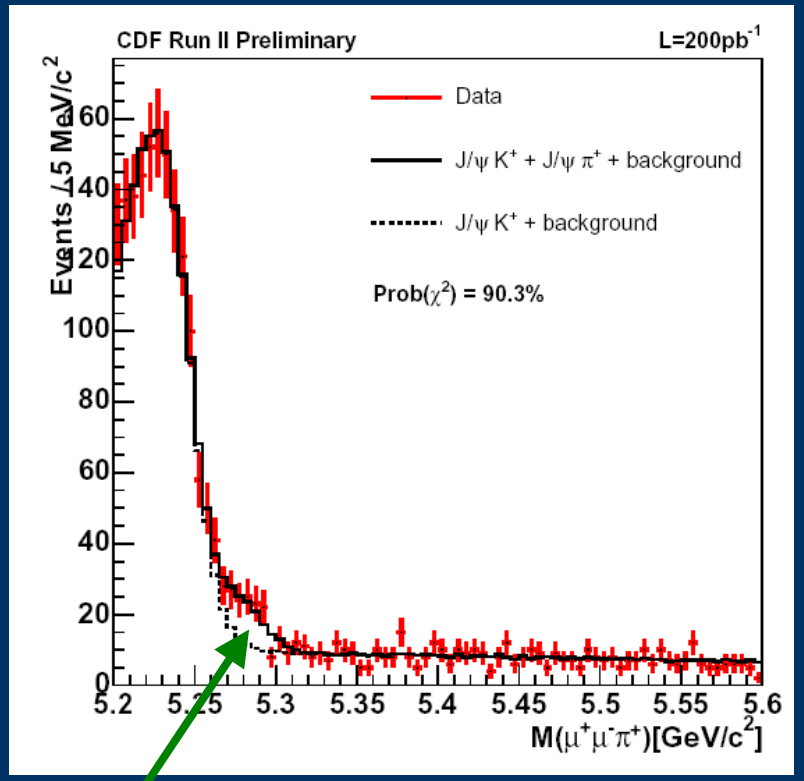
Branching Ratio

B baryon decays: $\Lambda_b \rightarrow \pi \Lambda_c (\rightarrow pK\pi)$

Cabibbo-suppressed $B^+ \rightarrow J/\psi K^+$



use dE/dx

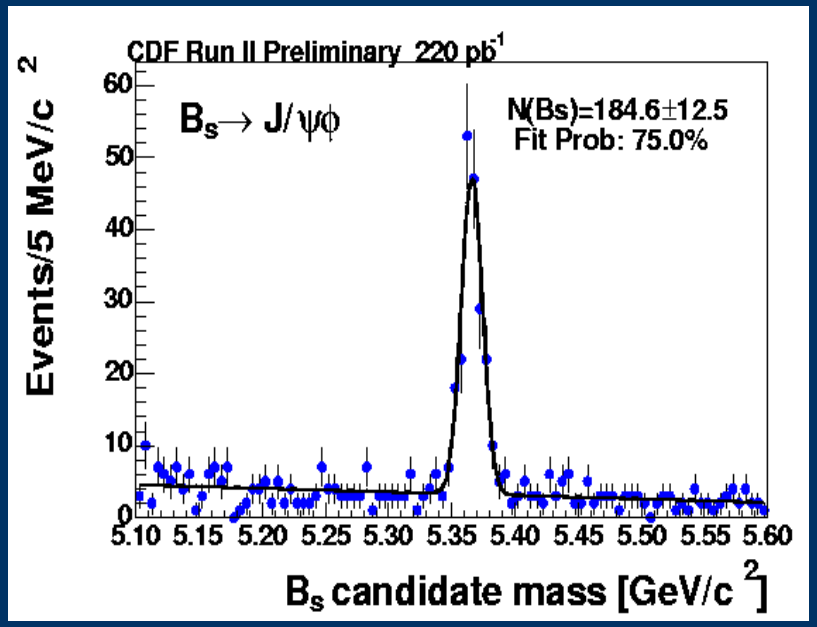


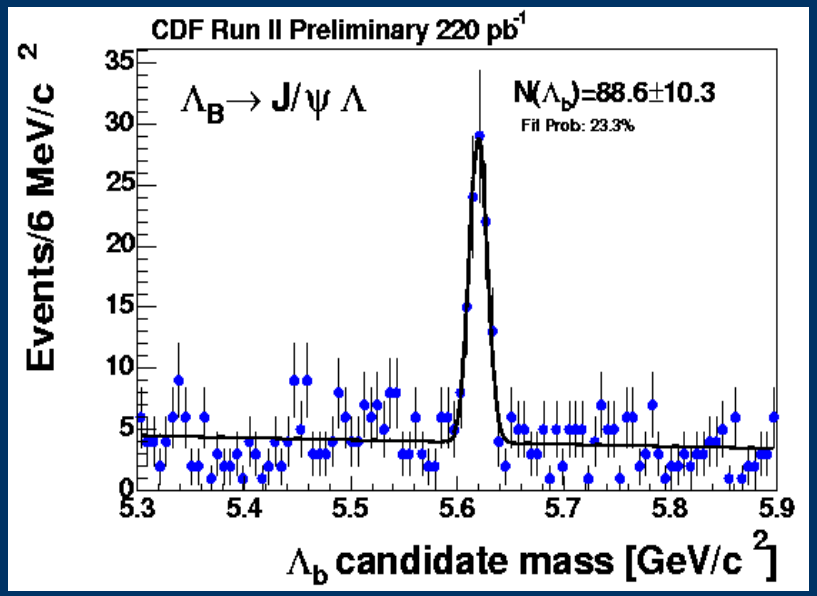
Measure $\dfrac{\sigma_b \times f_{baryon} \times BR(\Lambda_b \rightarrow \Lambda^+_c \pi^-)}{\sigma_b \times f_d \times BR(B^0 \rightarrow D^- \pi^+)}$

$$\frac{Br(B^+ \rightarrow J/\psi \pi^+)}{Br(B^+ \rightarrow J/\psi K^+)} = (4.5 \pm 0.8(stat.) \pm 0.3(syst.))\%$$

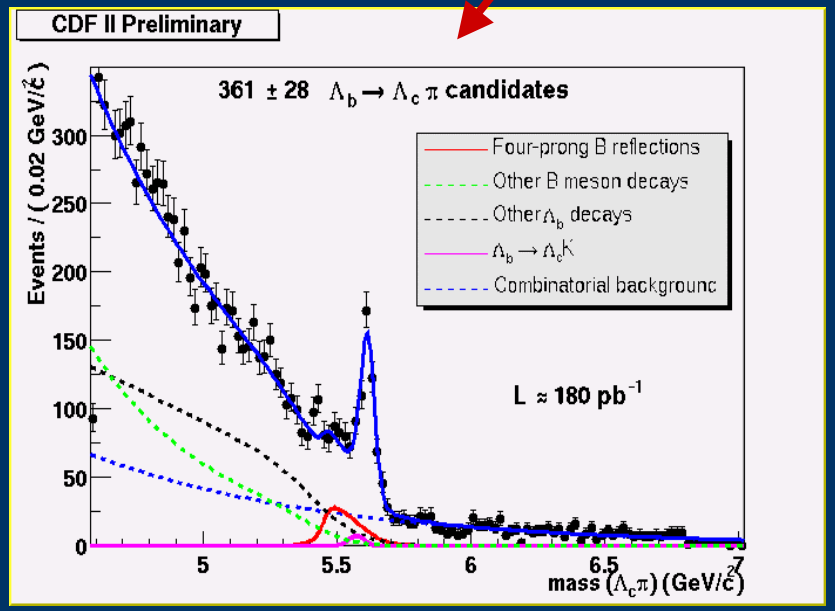
$BR(\Lambda_b \rightarrow \Lambda_c \pi^{\pm}) = (6.0 \pm 1.0(stat) \pm 0.8(sys) \pm 2.1(BR)) \times 10^{-3}$

Mass: B_s and Λ_b





- **Exclusive J/ψ X channels**
- **Exclusive $\Lambda_b \rightarrow \Lambda_c \pi$**

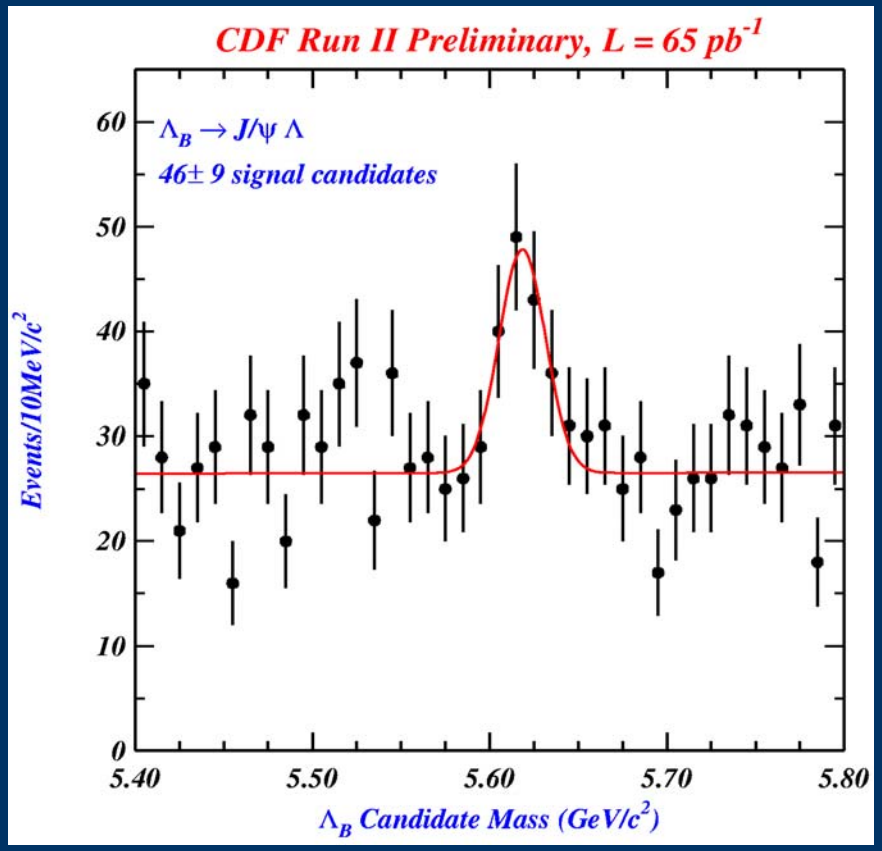


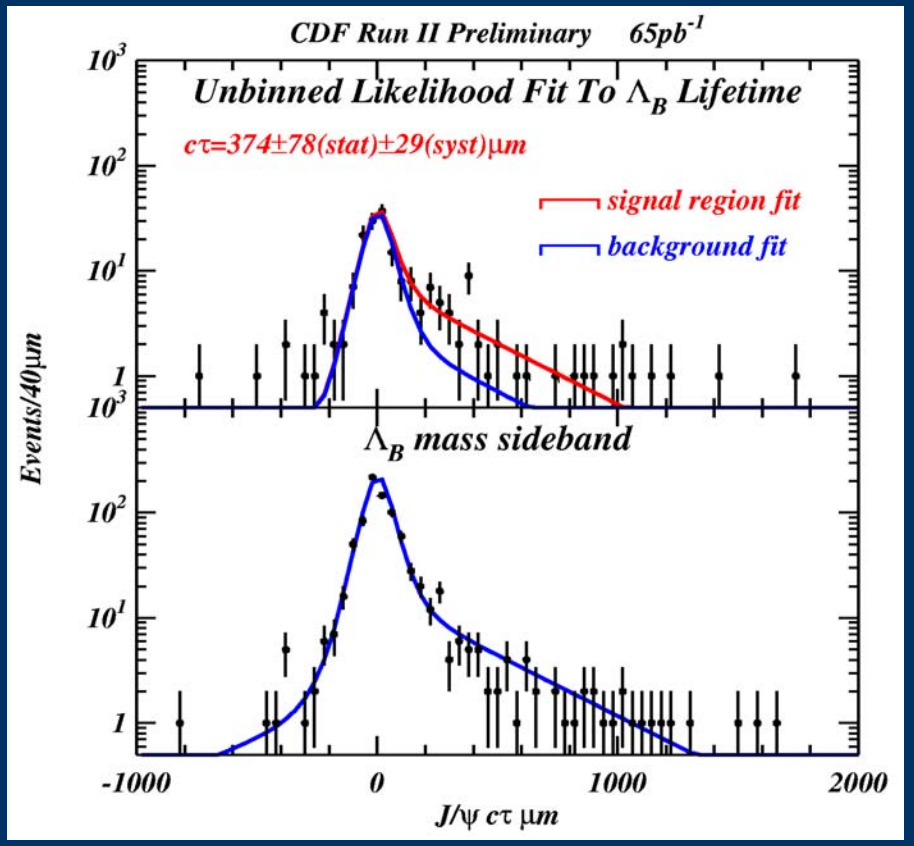
	CDF preliminary	PDG value
B_s	5366.01 ± 0.73 ± 0.30	**5369.6 ± 2.4**
Λ_b	5619.7 ± 1.2 ± 1.2	**5624 ± 9**

B-baryon Lifetime

The first measurement of Λ_b Lifetime in a fully reconstructed mode

cf: $\Lambda_B \to \Lambda_c l\nu\ (\Lambda_c \to pK\pi)$ $\tau = 1.33 \pm 0.15 \pm 0.07$ ps (Run I CDF)





$\mathcal{L}$ = 65 pb^{-1} → $\tau(\Lambda_B) = 1.25 \pm 0.26$ (stat.) ± 0.10 (syst.) ps

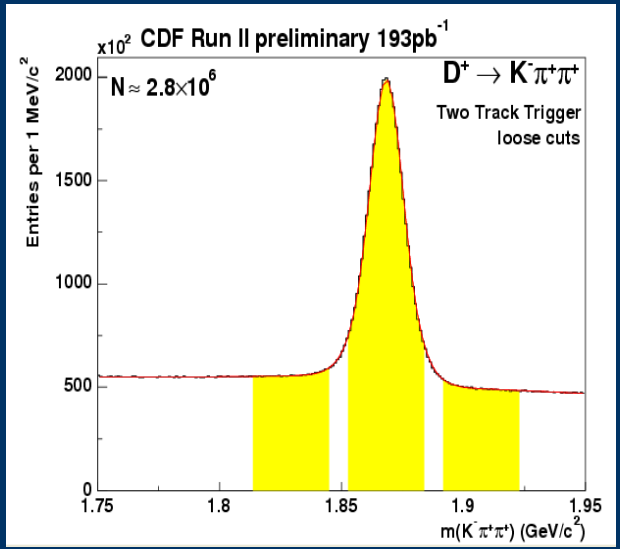
Charm Physics at CDF

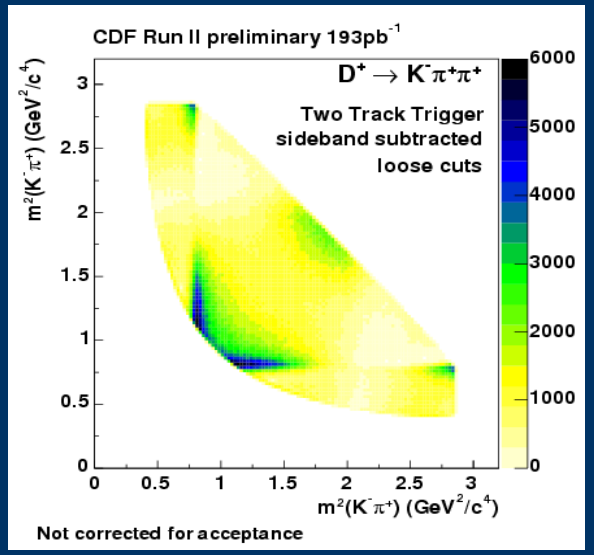
Have you drowned by copious charm?

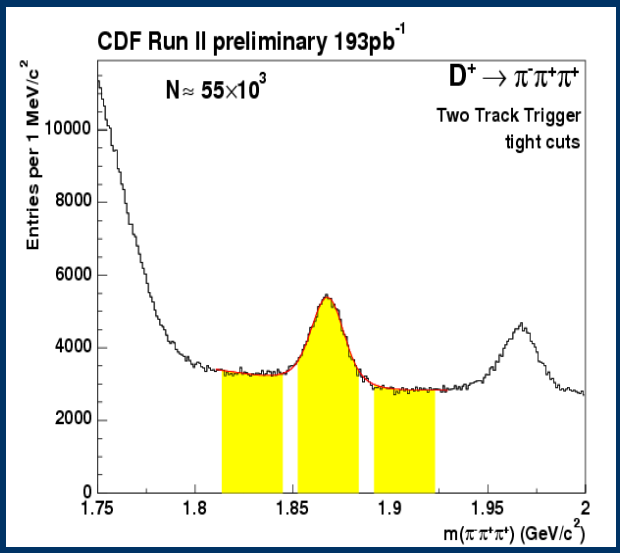
Integrated prompt charm cross section ($|\eta|< 1$)

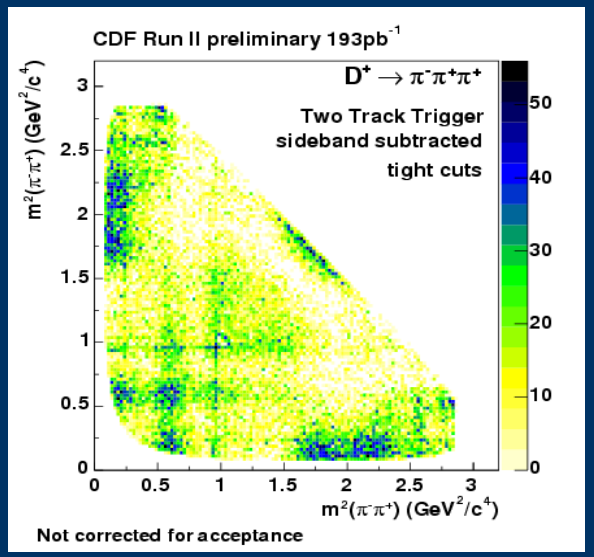
	P_t thr. GeV/c	σ μb
D^0	5.5	13.3±0.2±0.5
D^{*+}	6.0	5.2±0.1±0.8
D^+	6.0	4.3±0.1±0.7
D_s	8.0	0.75±0.05±0.22

- Large statistics → Detailed features
- D^+ Dalitz properties
- *Br*($D^+ \rightarrow \pi^+\pi^-\pi^+$)

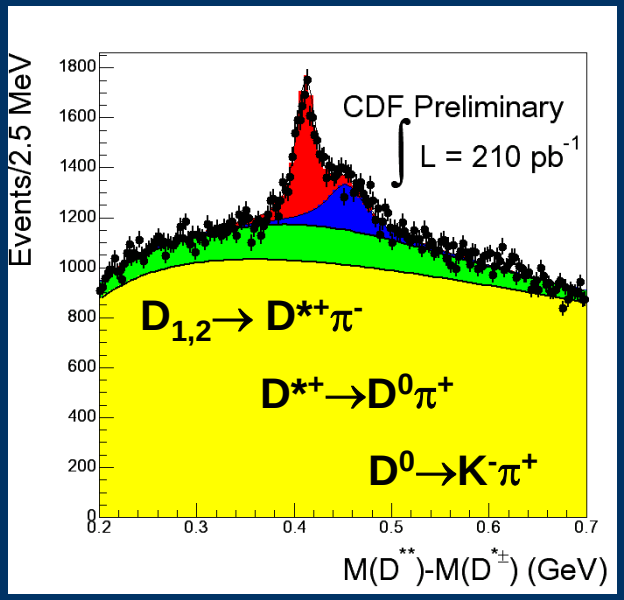


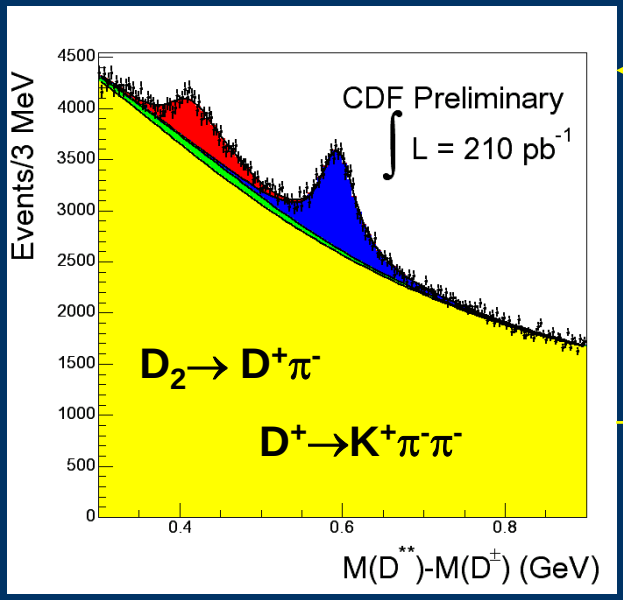






D** Properties and moment analysis





Prompt D_1, D_2

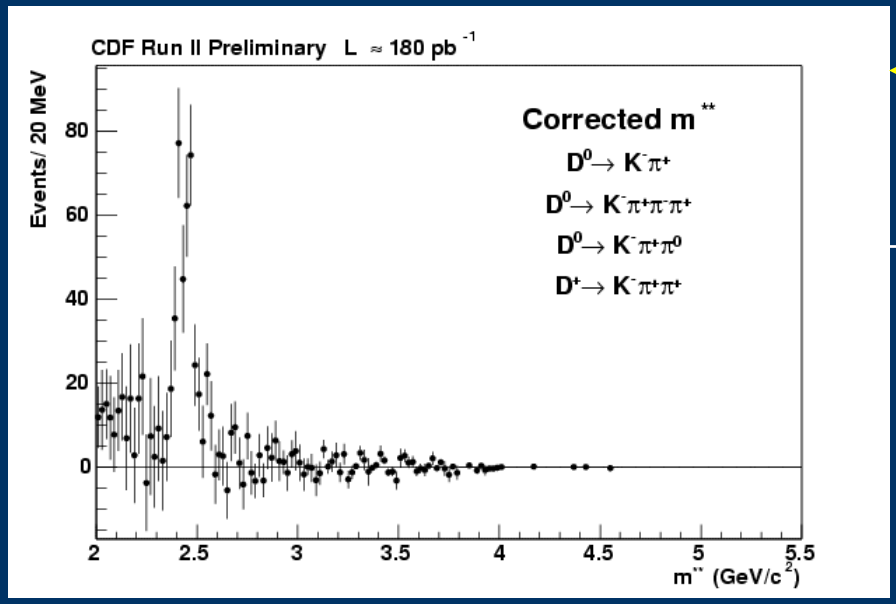
Mass and Width

$M(D_1)-M(D^*)=411.7\pm0.7\pm0.4$

$\Gamma(D_1)=20.5\pm1.7\pm1.3$ MeV

$M(D_2)-M(D^*)=594.0\pm0.6\pm0.5$

$\Gamma(D_2)=49.5\pm2.1\pm1.2$ MeV



Secondary D** ← B →D**^{0} l ν

$$m_1 = \left\langle m^2_{D^{**}} \right\rangle = \left(5.83 \pm 0.16_{stat}\right) GeV^2$$

$$m_2 = \left\langle \left(m^2_{D^{**}} - m_1\right)^2 \right\rangle = \left(1.30 \pm 0.69_{stat}\right) GeV^4$$

Hadronic moments of B (M_1,M_2)

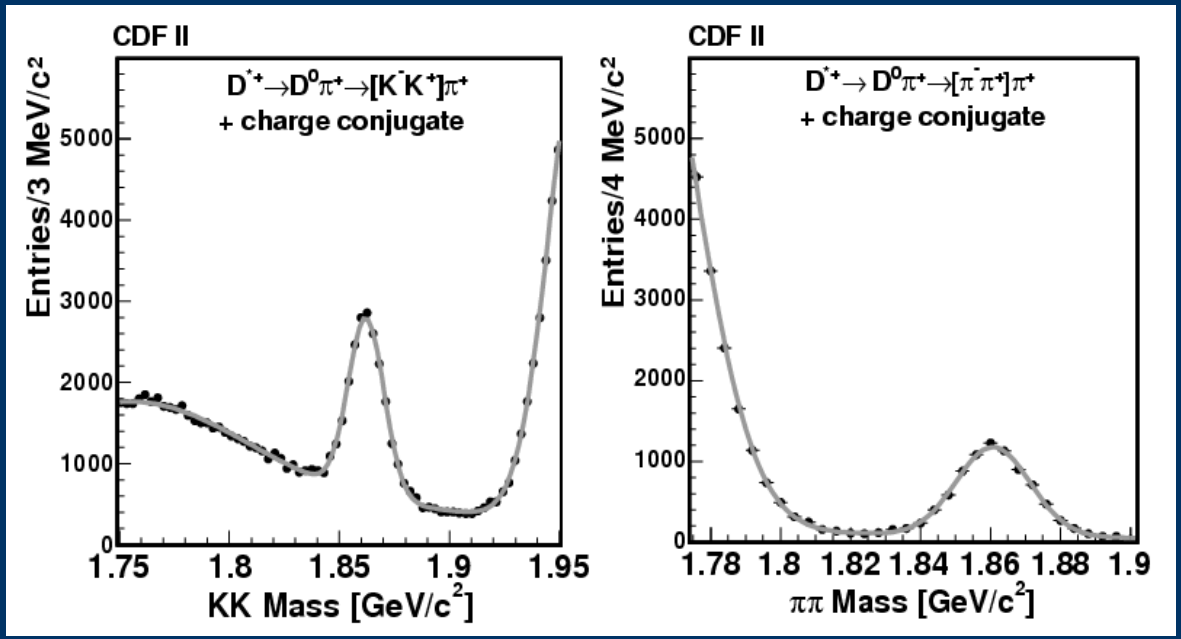
Non-pert. HQET parameters (Λ ,λ_1)

Direct CP Asymmetry

$D^{*\pm} \to D^0 \pi^\pm$ tag flavor of CP eigenstates (f)
$D^0 \to \pi\pi$, $D^0 \to KK$

to measure A_{cp}

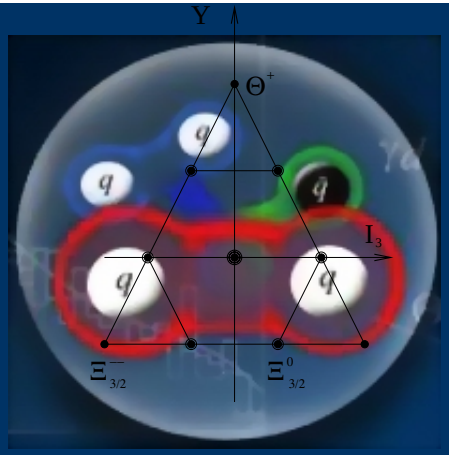
$$A_{CP} \equiv \frac{\Gamma(D^0 \to f) - \Gamma(\overline{D^0} \to f)}{\Gamma(D^0 \to f) + \Gamma(\overline{D^0} \to f)}$$



Mode	D^0	$\overline{D^0}$	Total
Kπ	88310±330	92600±340	180910 ±480
KK	8190 ±140	8030 ±140	16220 ±200
ππ	3660±69	3674±68	7334±97

$$A(D^\circ \to K^+K^-) = 2.0 \pm 1.2(stat) \pm 0.6(syst)\ \%$$
$$A(D^\circ \to \pi^+\pi^-) = 1.0 \pm 1.3(stat) \pm 0.6(syst)\ \%$$

On our way towards time dependence…

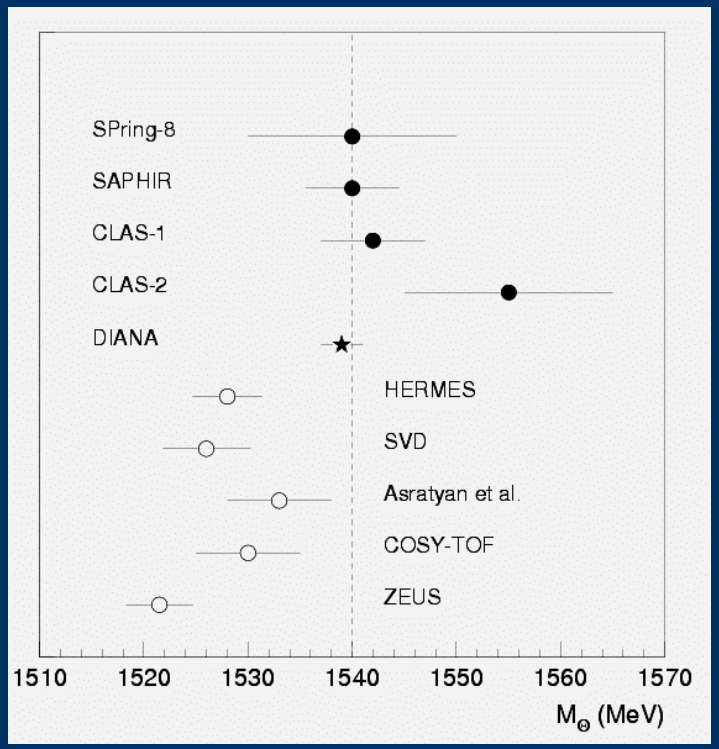


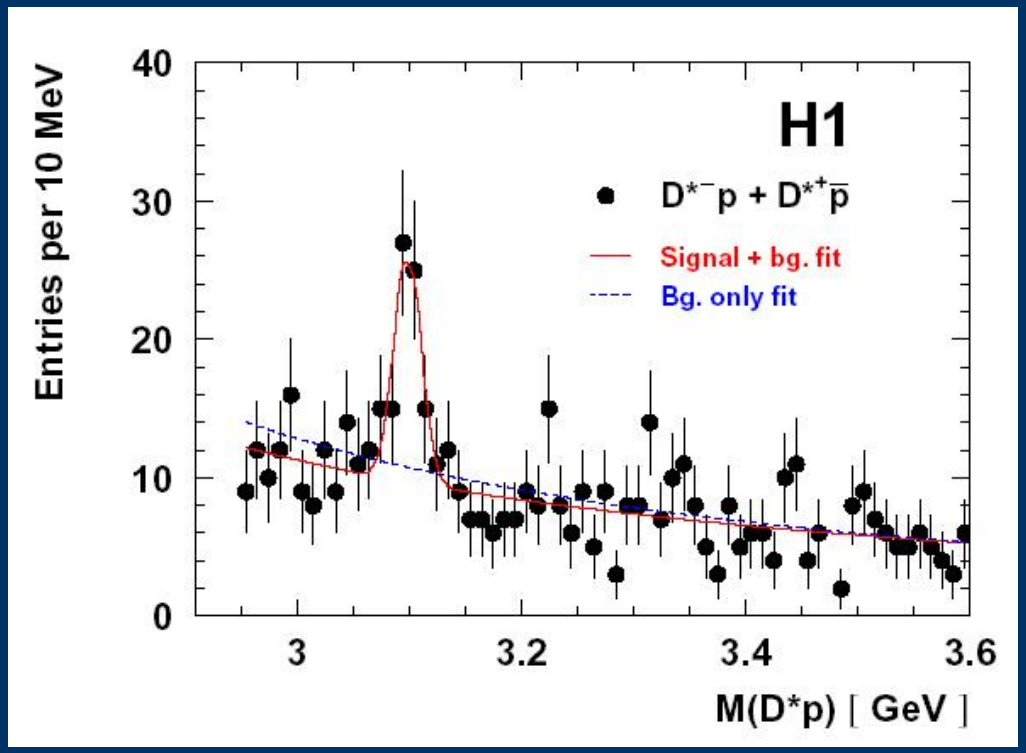
PentaQuarks

- *predicted by Diakonov, Petrov, Polyakov (1997)*
- **($qqqq\bar{q}$) state : $\Theta^+(uudd\bar{s})$ → p Ks (nK^+)**
- **Mass ~ 1530 MeV/c^2 and Width ~ 15 MeV/c^2**

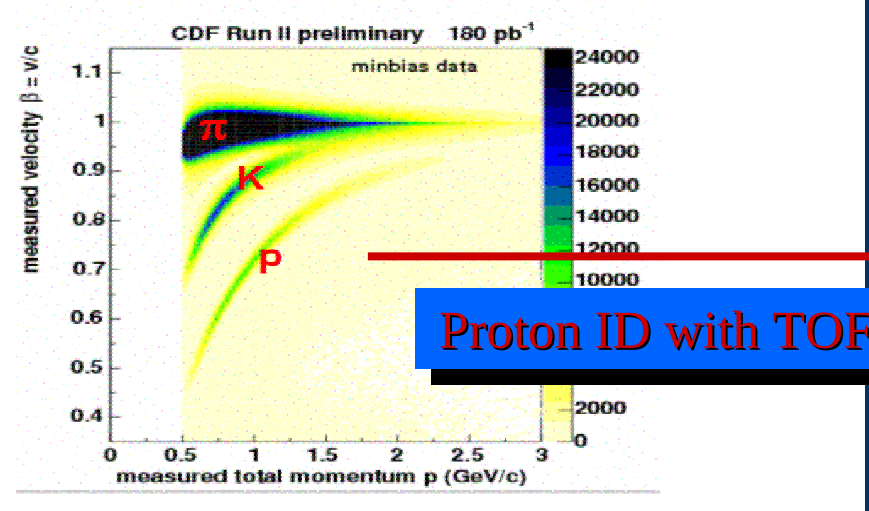
10 experiments report evidence
***HERA-B, PHENIX, BES* null obs.**

H1 claimed Θ_c →D^*p
@ 3099+/-3(stat.)+/-5(syst.) MeV/c^2





PentaQuarks @CDF?



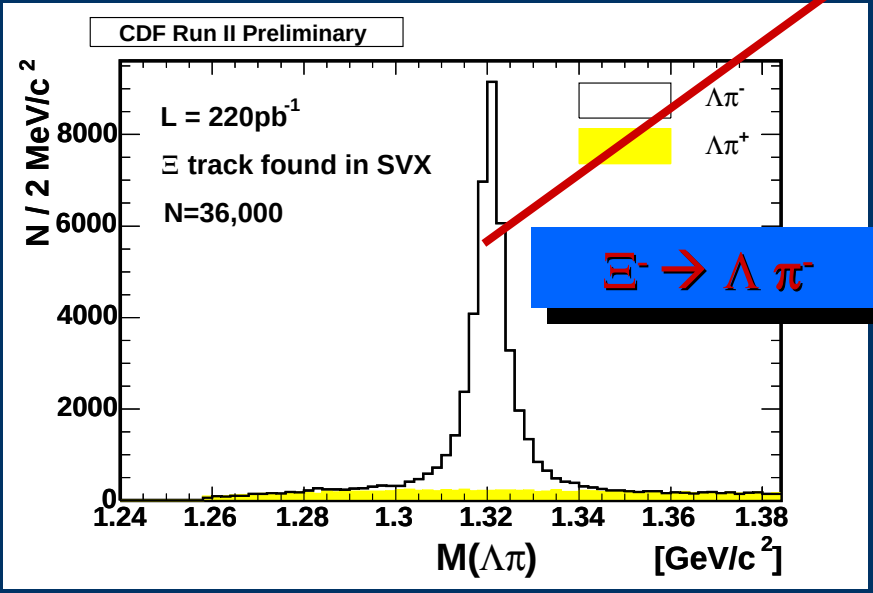
CDF Search Channels:

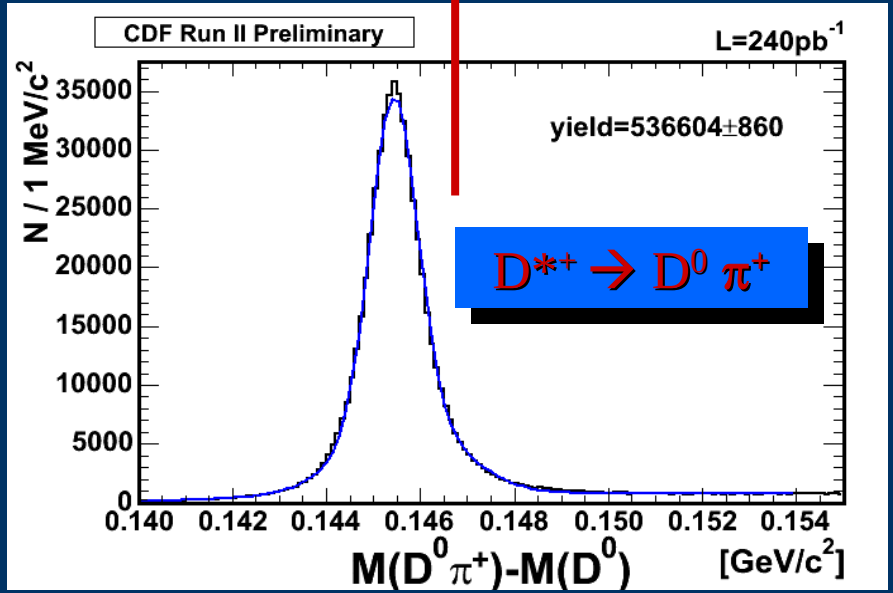
$\Theta c^0 \rightarrow D^{*+} p$ [$K^- \pi^+ \pi^+ p$]

$\Theta^+ \rightarrow Ks^0 p$ [$\pi^+ \pi^+ p$]

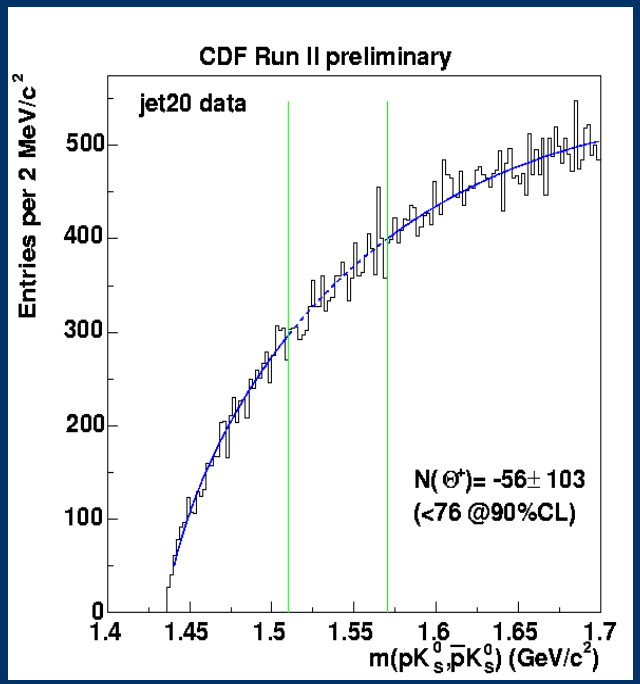
$\Xi^{--} \rightarrow \Xi^- \pi^-$ [$\pi^- \pi^- \pi^- p$]

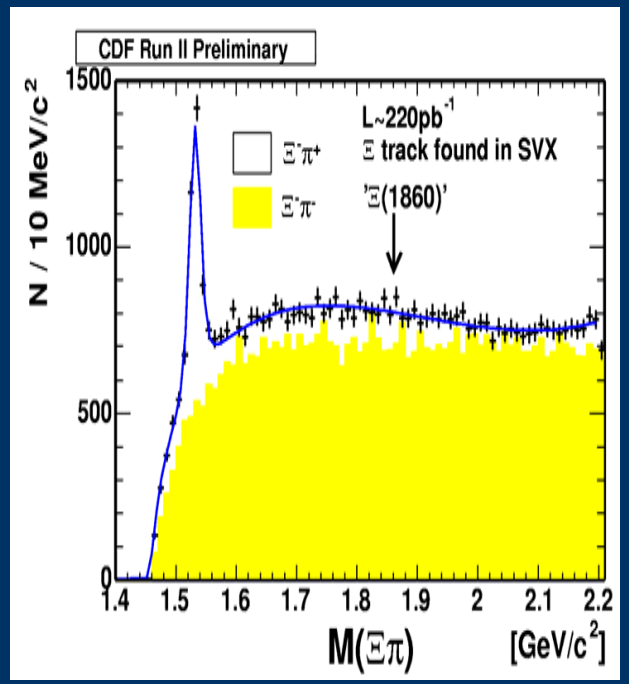
$\Xi^0 \rightarrow \Xi^- \pi^+$ [$\pi^- \pi^- \pi^+ p$]

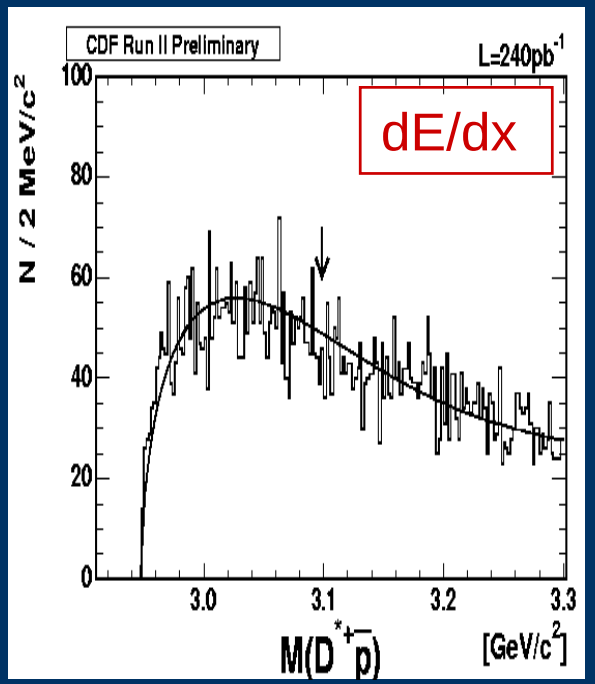




PQ Search Results @CDF





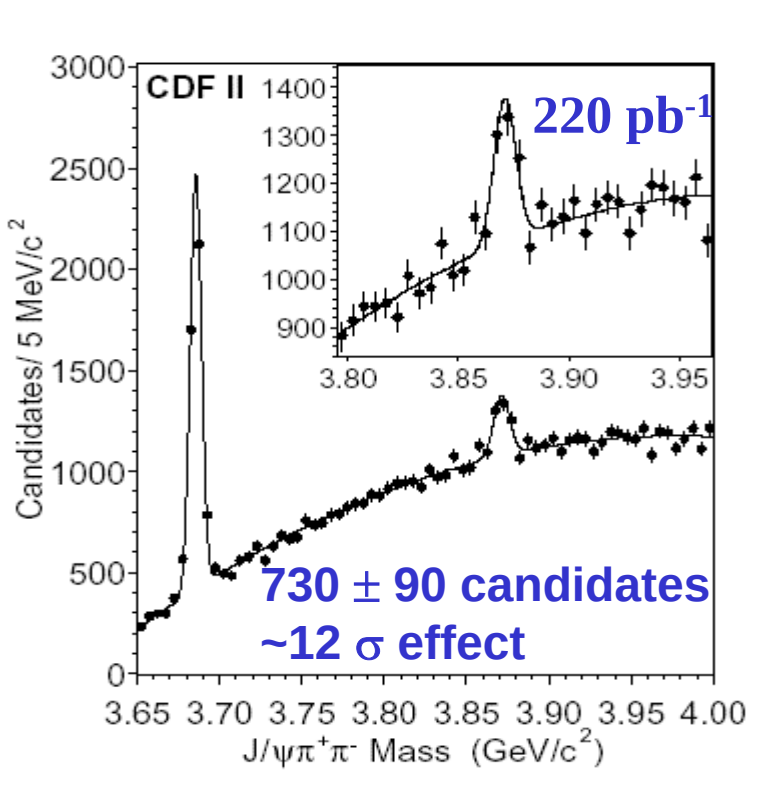


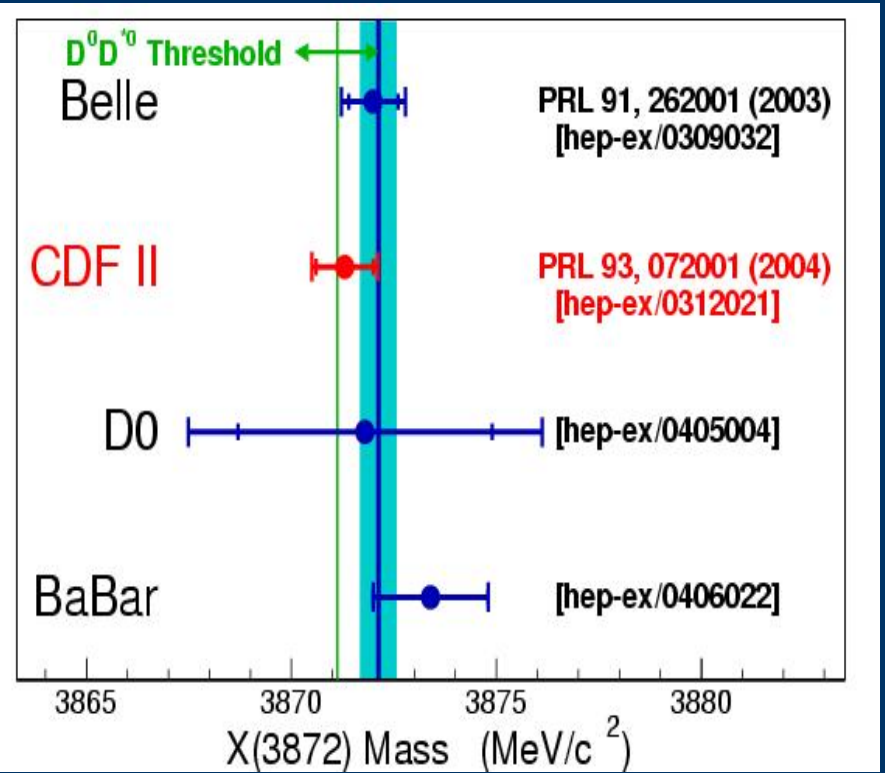
Null Signal So Far!

Charmed PentaQuark $(uudqc)_{q=c,s,u,d}$ searches are underway

Exotic State: X(3872) → J/ $\psi\pi^+\pi^-$

CDF confirmed Belle discovery and Pursing production mechanisms



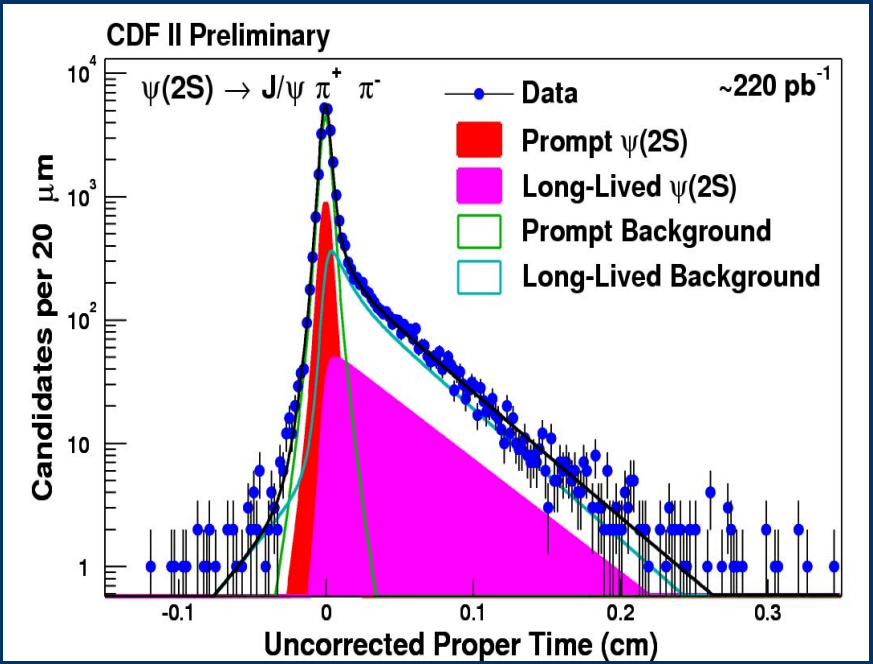


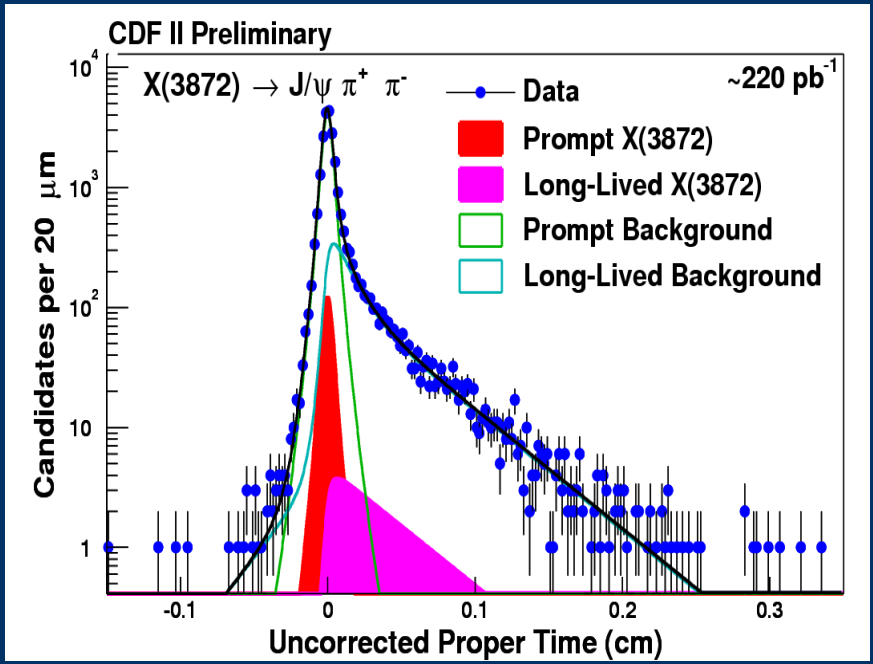
$M_X = 3871.3 \pm 0.7\ (stat) \pm 0.4\ (sys)\ MeV/c^2$

Belle: $M_X = 3872.0 \pm 0.6\ (stat) \pm 0.5\ (sys)\ MeV/c^2$

From Belle, B→X(3872) X
Is all CDF signal from B's?
Any direct X-production? How much?

X(3872) Prompt Fraction





displaced fraction

28.3±1.0 (stat)±0.7 (syst) %

displaced fraction

16.1±4.9 (stat.)±2.0 (syst) %

X(3872) mostly prompt → ψ(2S)-like

M ($\pi\pi$) distribution and Angular measurements are underway

Summary and Outlook

- Tevatron keeps breaking its record
- CDF II detector fully functional serving as hep frontier
- CDF II is a top-tier machine for Top
- CDF II is a competitive b-factory
- CDF II is a successful charm factory too
- Many other exciting measurements are coming

Are you ready for the era of fp^{-1} ?