Results on HQ Physics at TeV Energies

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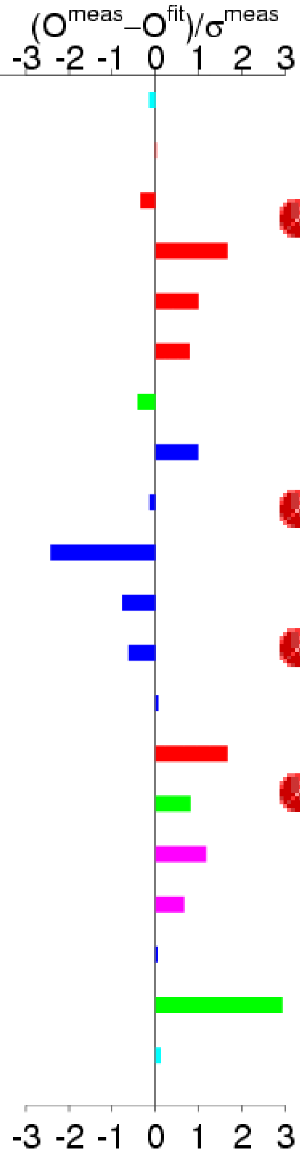
- **Introduction**
  - B Hadron Producers
- **Selected HQ Result from the Tevatron**
  - Masses and Lifetimes
  - Charmless B decays
  - Hadronic mass moments
  - Pentaquarks
- **Brief Look into the Future**
  - B_S mixing prospects
- **Conclusion ....**

Current Understanding of Matter

	Measurement	Pull
$\Delta\alpha^{(5)}_{had}(m_Z)$	0.02761 ± 0.00036	-0.16
m_Z [GeV]	91.1875 ± 0.0021	0.02
Γ_Z [GeV]	2.4952 ± 0.0023	-0.36
σ^0_{had} [nb]	41.540 ± 0.037	1.67
R_l	20.767 ± 0.025	1.01
$A^{0,l}_{fb}$	0.01714 ± 0.00095	0.79
$A_l(P_\tau)$	0.1465 ± 0.0032	-0.42
R_b	0.21644 ± 0.00065	0.99
R_c	0.1718 ± 0.0031	-0.15
$A^{0,b}_{fb}$	0.0995 ± 0.0017	-2.43
$A^{0,c}_{fb}$	0.0713 ± 0.0036	-0.78
A_b	0.922 ± 0.020	-0.64
A_c	0.670 ± 0.026	0.07
A_l(SLD)	0.1513 ± 0.0021	1.67
$\sin^2\theta^{lept}_{eff}(Q_{fb})$	0.2324 ± 0.0012	0.82
m_W [GeV]	80.426 ± 0.034	1.17
Γ_W [GeV]	2.139 ± 0.069	0.67
m_t [GeV]	174.3 ± 5.1	0.05
$\sin^2\theta_W(\nu N)$	0.2277 ± 0.0016	2.94
$Q_W(Cs)$	-72.83 ± 0.49	0.12



- **The Standard Model is extremely successful description of the world of particle physics.**
- **Nobody seems satisfied with it.**
- **Too many free parameters?**
- **Leaves many important questions unanswered ....**

Flavour Changing Interactions in SM

Important questions about SM:

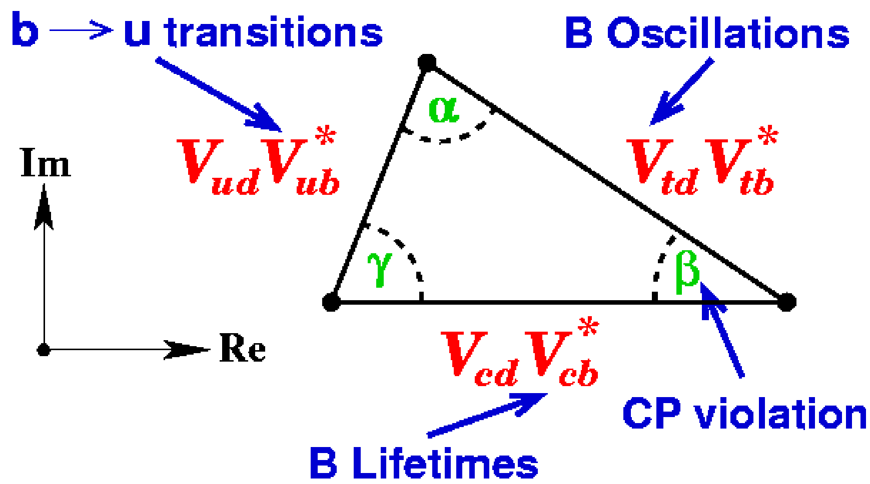
1. What is the origin of electroweak symmetry breaking?
   => Higgs mechanism
2. What is the origin of flavour symmetry breaking?
   => Flavour changing interactions

- In SM flavour changing processes depend on CKM matrix
- Individual matrix elements not predicted by SM- must be measured by flavour changing interactions

$$\begin{pmatrix} d' \\ s' \\ b' \end{pmatrix} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} \begin{pmatrix} d \\ s \\ b \end{pmatrix}$$

B hadron decays measure
5 CKM matrix elements

Unitarity of CKM matrix:

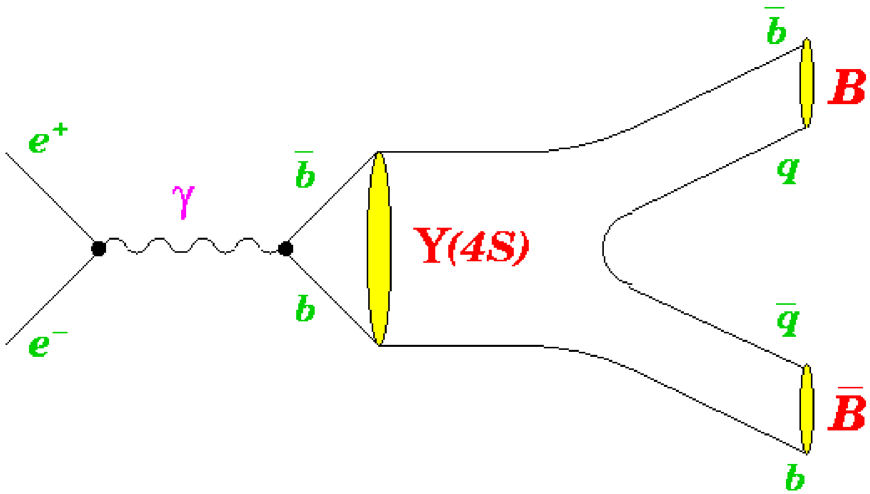


Goal of present & future B physics:

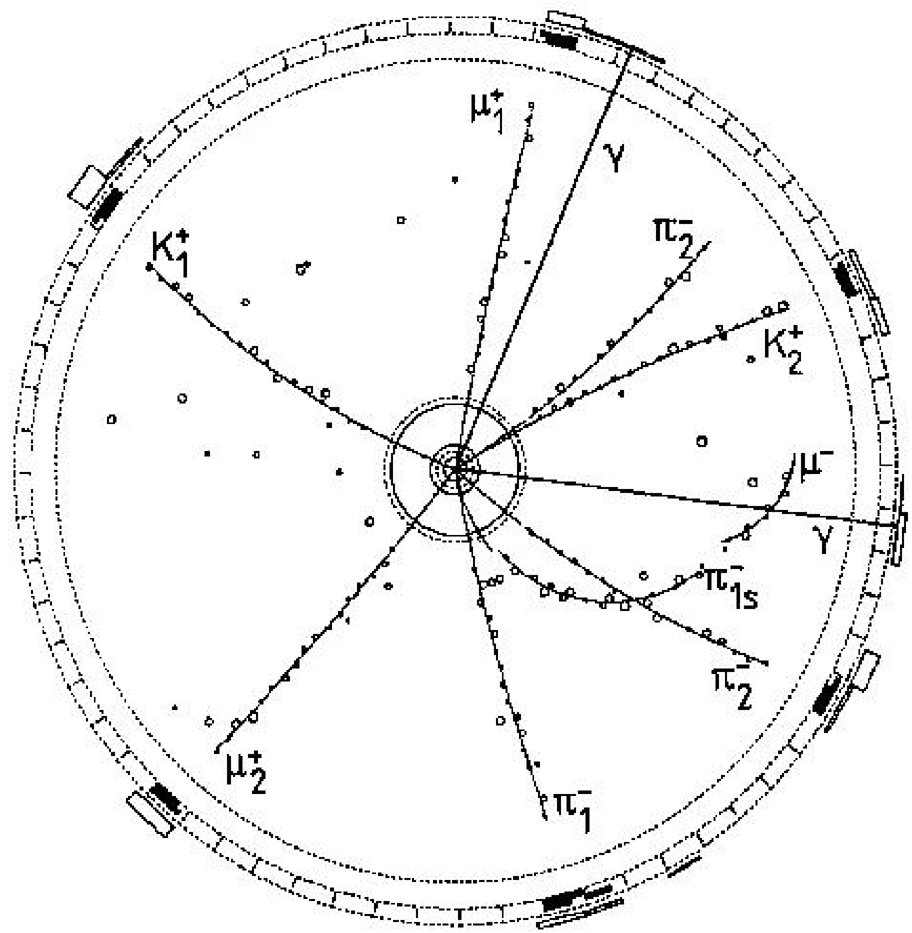
- Test flavour changing interactions in all possible ways
  => *Theoretically clean modes versus experimental accessibility*
- Measure sides and angles of CKM triangle in many ways
  => *Overconstrain triangle*

B Hadron Producers

$\Upsilon(4S)$: $e^+e^- \to \Upsilon(4S) \to B\bar{B}$



ARGUS:



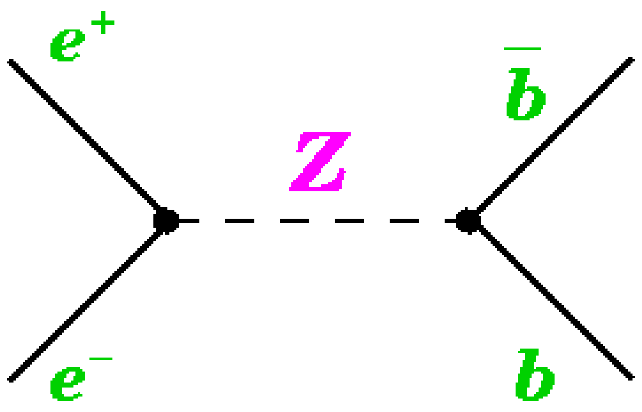
The Players:

ARGUS & CLEO (Pioneers)

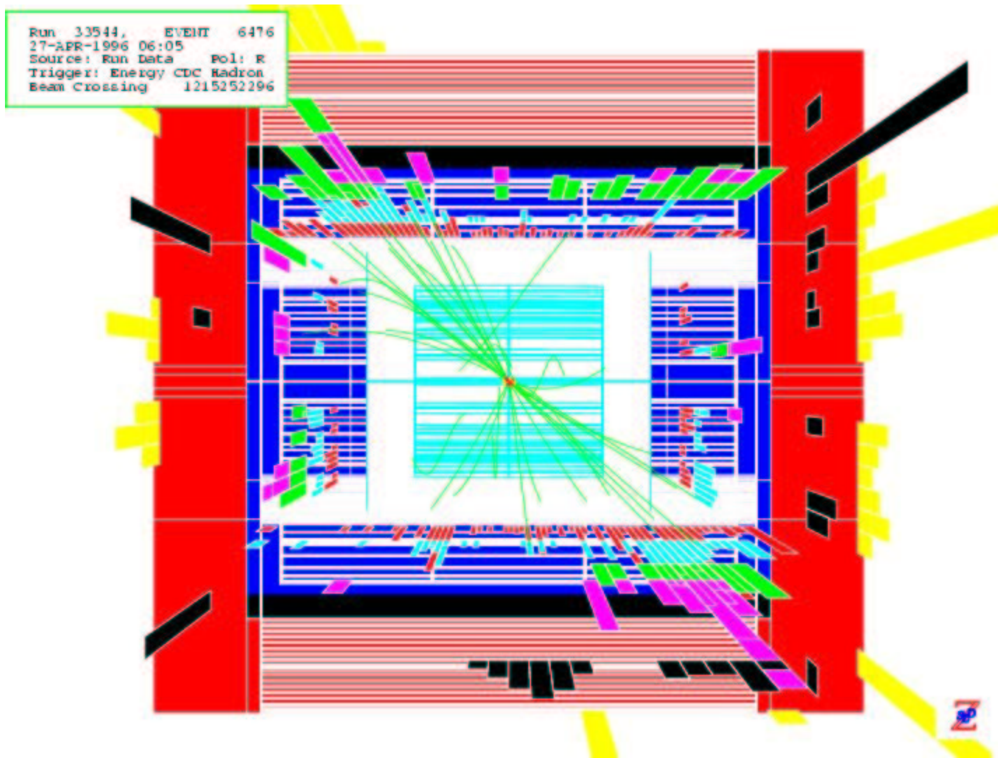
BaBar & Belle (B Factories)

B Hadron Producers

Z^0: $e^+ e^- \to Z^0 \to b\bar{b}$



SLD:



The Players:

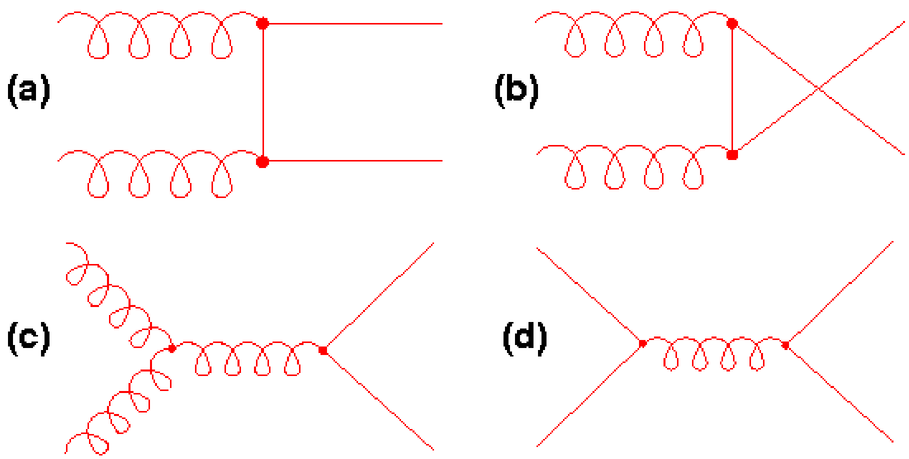
ALEPH, DELPHI, L3, OPAL

SLD

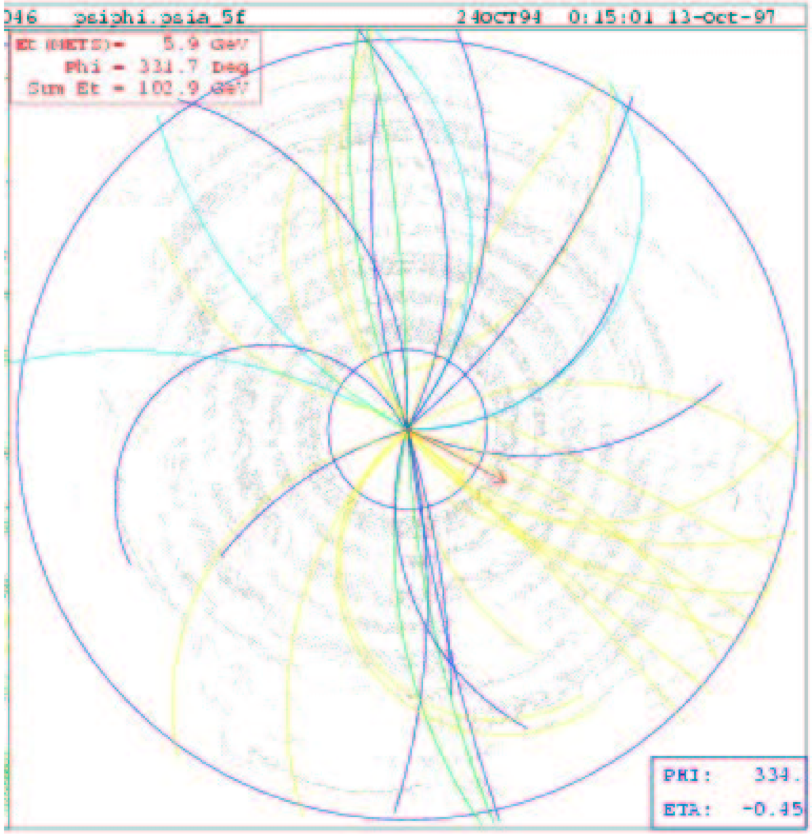
B Hadron Producers

Tevatron: $p\bar{p} \rightarrow b\bar{b}X$

- Lowest order $\mathcal{O}(\alpha_s^2)$ diagrams for $b\bar{b}$ production
  - (a)-(c) gluon-gluon fusion
  - (d) quark-antiquark annihilation



CDF:



The Players:

(UA1), CDF & D0

Other B producers: Hera-B, FNAL fixed target

The Future: LHCb, BTeV, Atlas, CMS

What's up with this (✈✱❀✖✌✇✿↕✪) dark energy in the universe?

Why the (✈✱▼✖✌✇↕✪) do we want to do B physics at a hadron machine ?

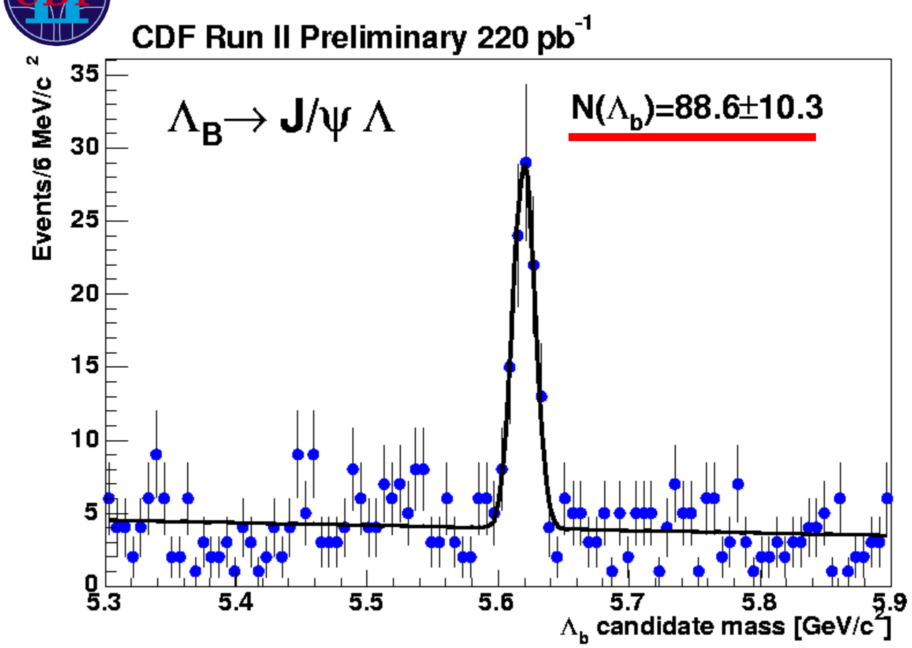
B Physics at Hadron Machines

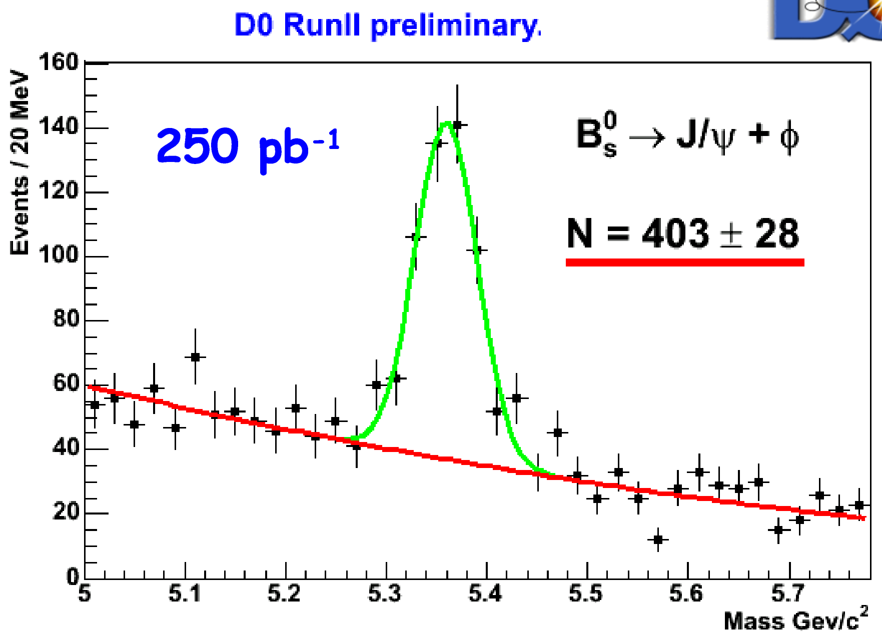
Advantages of B Physics at Hadron Machine:

All B hadrons are produced: $B^0, B^+, B_S^+, B_c^+, \Lambda_b^0$

Enormous cross section:

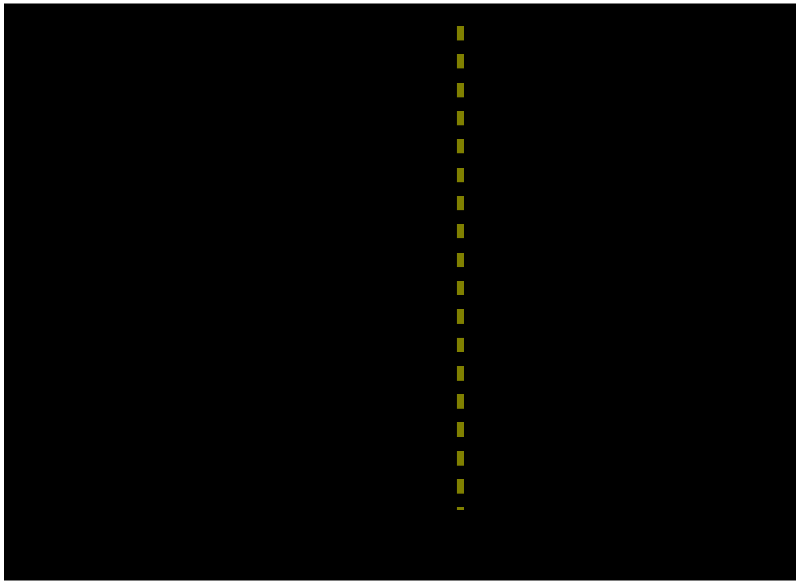
- **B-factory:** $\sigma(\Upsilon(4S) \rightarrow B\bar{B}) \sim 1 \text{ nb}$
- **Tevatron:** $\sigma(p\bar{p} \rightarrow b\bar{b}) \sim 100\ \mu\text{b}$





B Trigger at Hadron Machines

Comparison with charm production



- **Total inelastic cross section:**

  $\sigma(total)/\sigma(b)$~1000

➔ **It's all about the trigger!**

B Triggers:

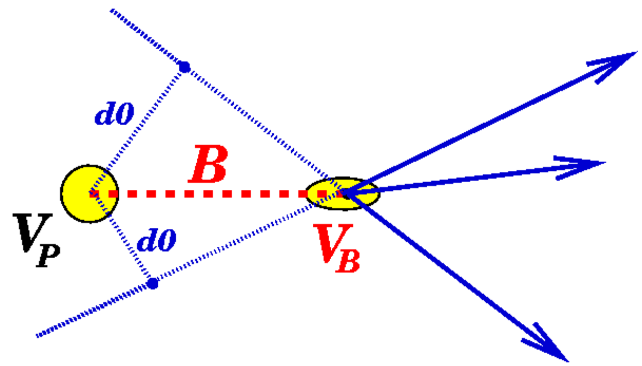
- **B trigger based on leptons (Run I)**

➔ **Dilepton trigger: J/ψ, B mixing**

➔ **Single lepton: semileptonic B decays**

- **Displaced track trigger (CDF)**

  (exploit 'long' B lifetime)



Level 1: Fast track trigger (XFT) finds charged track with p_T > 1.5 GeV/c

Level 2: Link tracks into silicon; require track impact parameter > 100 μm (SVT)

Access to hadronic B decays
=> B physics program fully competitive with B factories

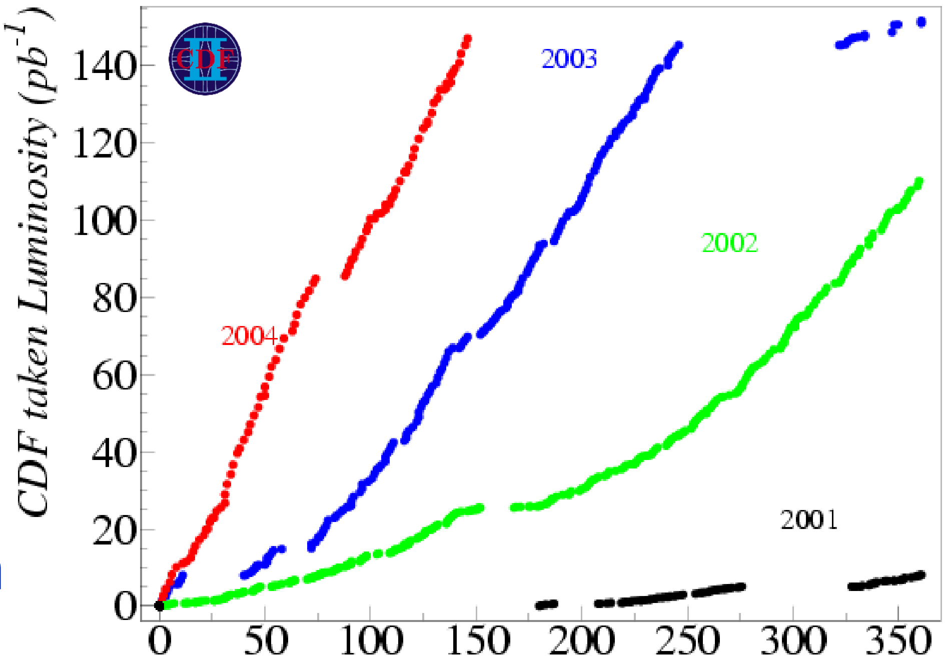
Heavy Quark Results from Tevatron

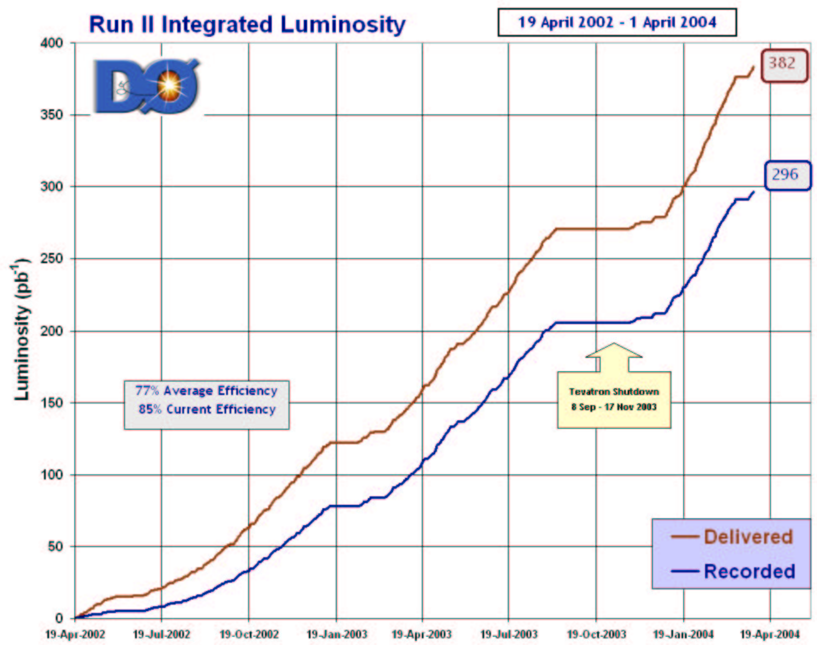
Tevatron Run II

Tevatron Performance:

- Tevatron has been working well in 2004
- Record initial luminosity = $= 7.3 \times 10^{31}\ sec^{-1}\,cm$
- $>300\ pb^{-1}$ on tape
- $\sim100\text{-}250\ pb^{-1}$ used for analysis
- (Run I: $\sim100\ pb^{-1}$)

- CDF & D0 data taking efficiency ~80-90%

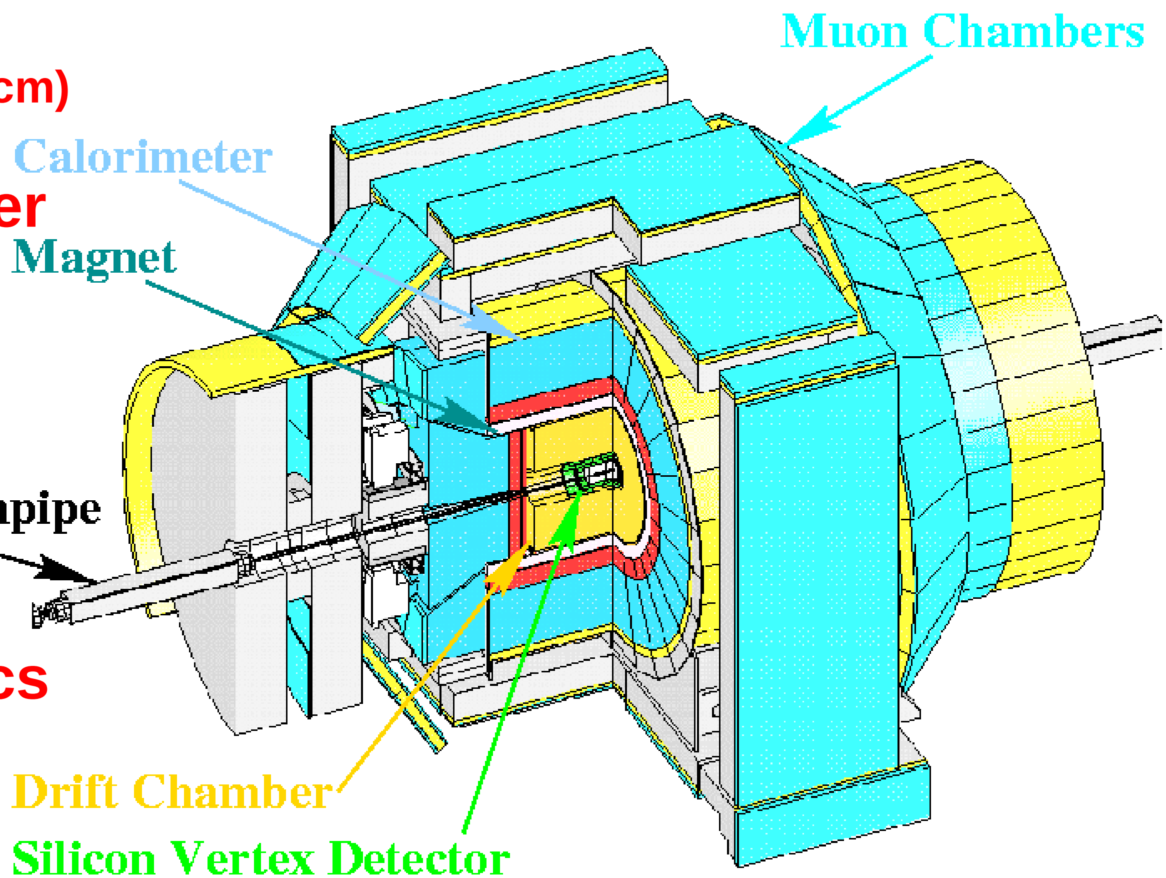




Run II: CDF Detector

The Upgraded CDF Detector:

- **Tracking upgrade:**
  - Silicon:
    Beampipe layer + 5 layers + 2/1 outer (forward) layers (radial 1.5 - 28 cm)
    Full coverage of luminous region; Si tracking up to $|\eta| < 2$
  - Central Outer Tracker:
    30,200 sense wires (44 - 132 cm)
    96 dE/dx samples
- **New endplug calorimeter**
- **Improved muon coverage**
- **Trigger/DAQ upgrade**
  - Fully pipelined
  - All digital (132 ns)
  - Silicon trigger at L2
- **New frontend electronics**
- **Time-of-flight system**

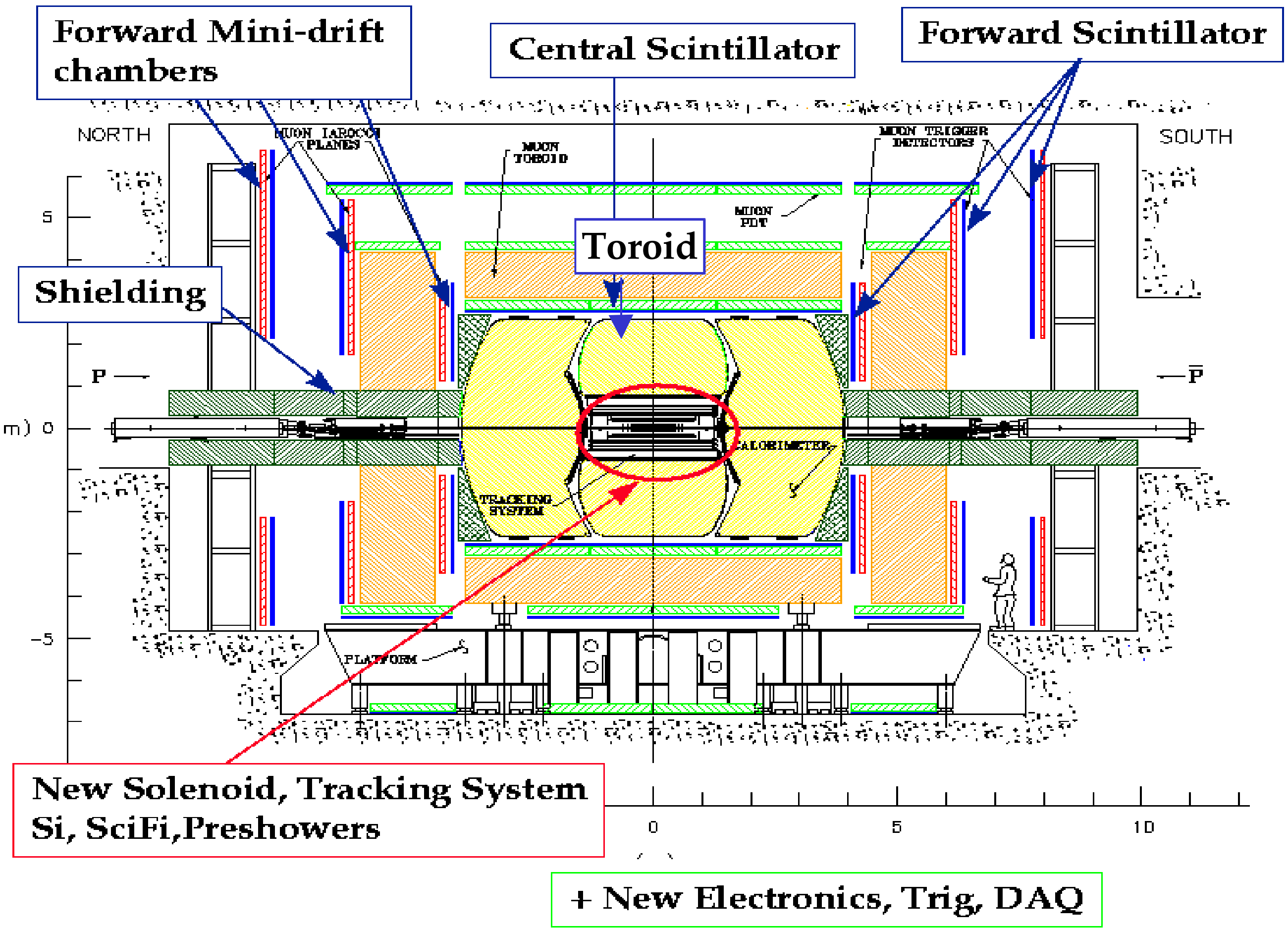


Run II: D0 Detector

The Upgraded D0 Detector:

What's new at D0:

- New detector elements:
  - solenoid, silicon tracker, fiber tracker
  - new preshower detector
- Improved muon system
- Enhanced trigger system
- Extra shielding around beamlines



Tevatron HQ Results at APS 2004

List of CDF & D0 Heavy Quark Results at APS 2004:

- Observation of Semileptonic B Decays to Narrow D** Mesons
- Flavor Oscillations in B^0 Mesons with OS Muon Tagging
- B^0 Mixing with Same Side Tagging
- Measurement of Lifetime Ratio for B^0 and B^+ Mesons
- Measurement of B Lifetimes in B->J/ψ K Decays
- Observation of X(3872)
- Limit and Sensitivity for Rare Decay $B_s \rightarrow \mu\mu$
- Polarization Amplitudes in B->VV
- BR and A_{CP} in $B^+ \rightarrow \phi K$
- B^0 Mixing with SST in Fully Reconstructed B Decays
- Study of Jet Charge Tagging
- Measurement of Hadronic Moments in Semileptonic B Decays
- Pentaquark Search in $\theta^+ \rightarrow pKs$
- Pentaquark Search in $\theta_c \rightarrow pD^*$
- Pentaquark Search for $\Xi(1860)$
- B_s -->VV Lifetimes
- Measurement of B Hadron Masses
- Measurement of BR($B^+ \rightarrow J/\psi\pi$)
- Observation and BR of $B_s \rightarrow \phi\phi$
- Search for B_c --> $J/\psi\mu X$
- Soft-Electron Reconstruction for $B_c \rightarrow J/\psi eX$
- BR and A_{CP} in $D^+ \rightarrow \pi^+\pi^-\pi^+$

Impressive Heavy Quark Program in Progess at Tevatron

(List might be incomplete)

Selected Run II Results

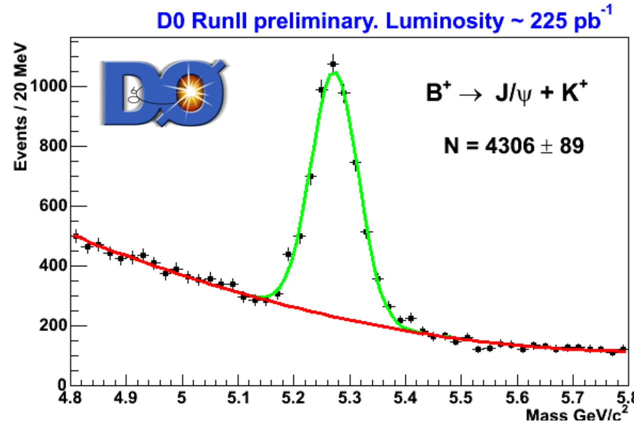
Exclusive B Decays:

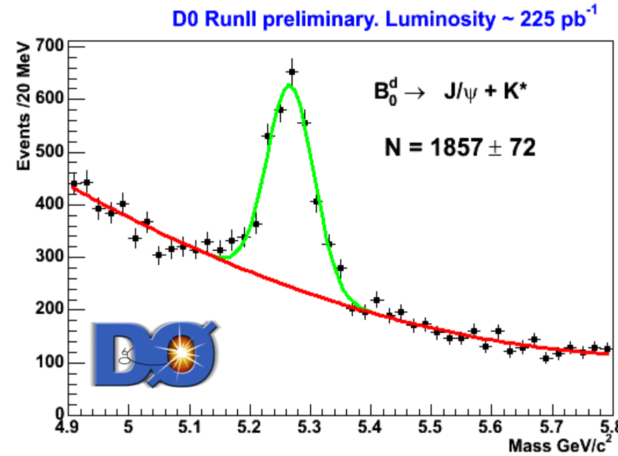
Accumulate large samples of fully reconstructed B hadrons:

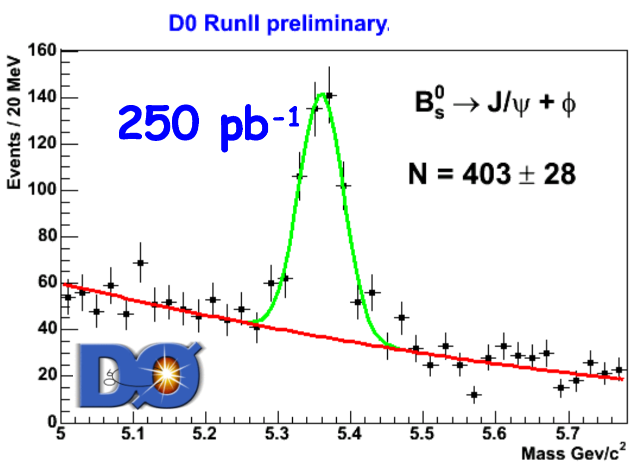
finds in 250 pb^{-1}:

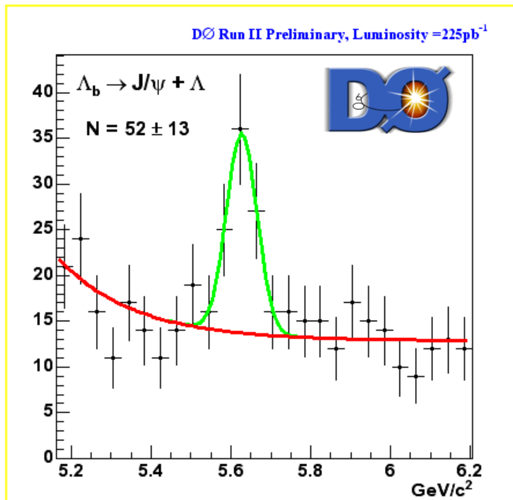
$B^+ \to J/\psi K^+$	(N ~ 4300)
$B^0 \to J/\psi K^0_S$	(N ~ 375)
$B^0 \to J/\psi K^{*0}$	(N ~ 1900)
$B^0_s \to J/\psi \phi$	(N ~ 400)
$\Lambda_b \to J/\psi \Lambda$	(N ~ 52)

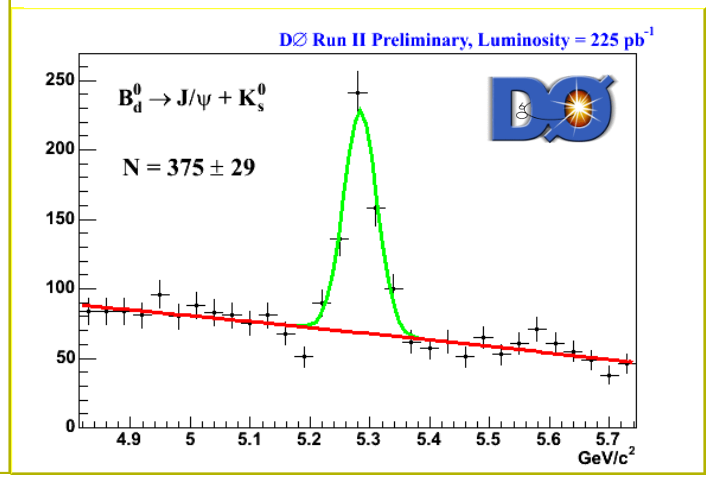
Clean signals - good S/B











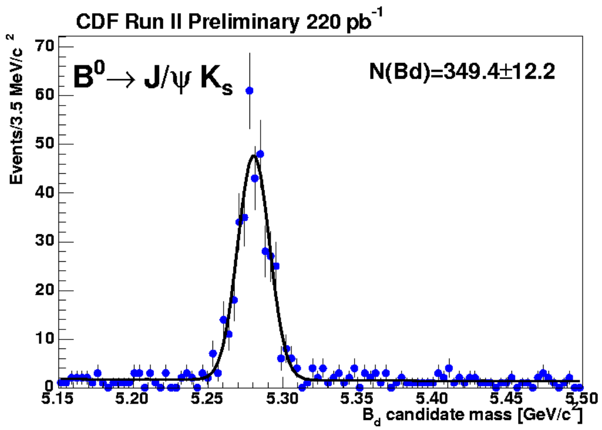
Selected Run II Results

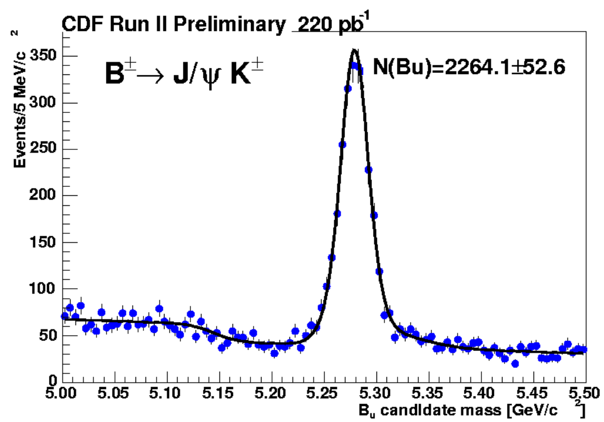
Exclusive B Decays:

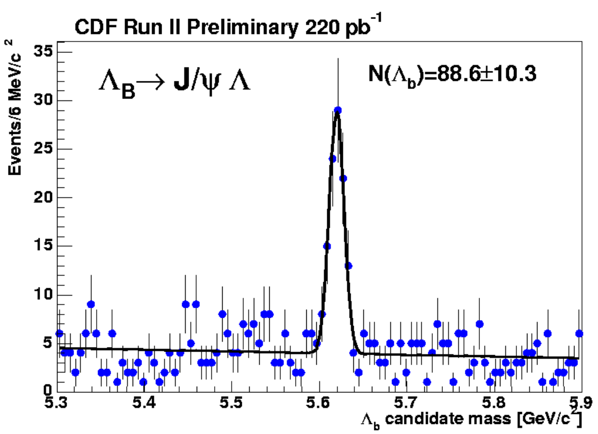
Precision mass measurements
from exclusive B -> J/ψ X

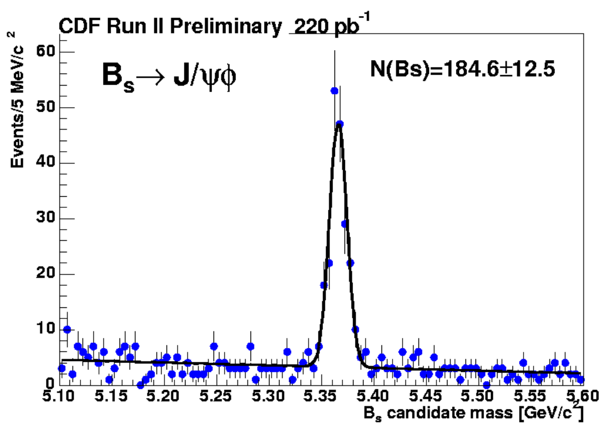
$$m(B^+) = (5279.10 \pm 0.41 \pm 0.34)\ \mathrm{MeV}/c^2$$
$$m(B^0) = (5279.57 \pm 0.53 \pm 0.30)\ \mathrm{MeV}/c^2$$
$$m(B_s^0) = (5366.01 \pm 0.73 \pm 0.30)\ \mathrm{MeV}/c^2$$
$$m(\Lambda_b) = (5619.7 \pm 1.2 \pm 1.2)\ \mathrm{MeV}/c^2$$

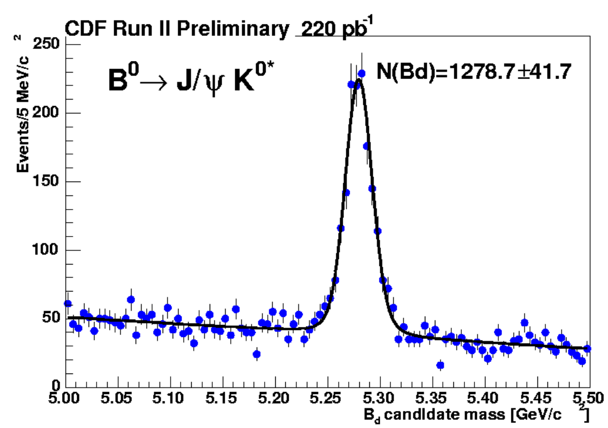
(current world best values)









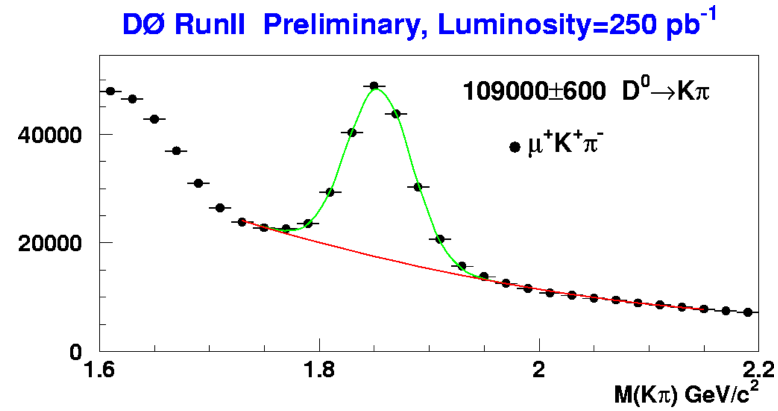


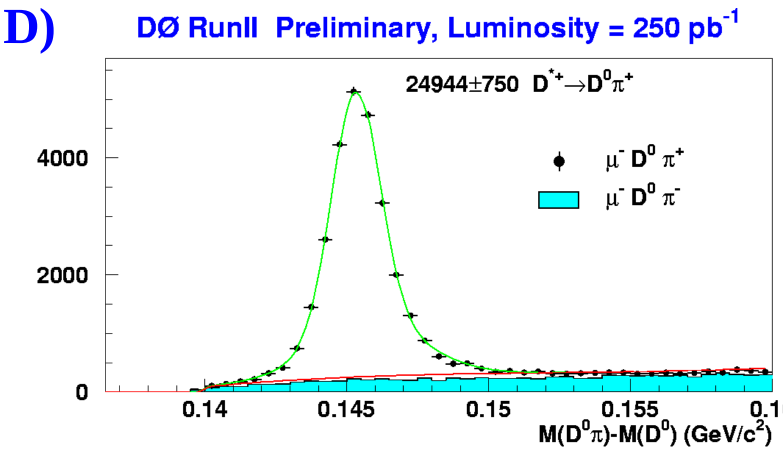
B Lifetimes

$\tau(B^+)/\tau(B^0)$ from Semileptonic Decays

Novel Analysis Technique

- Measure directly lifetime ratio instead of indivdual lifetimes
- Make use of:
  - $\bar{D}^*$ mainly from B^0 (B^+ 12%, B^0 86%, B_s 2%)
  - $\bar{D}^0$ mainly from B^+ (B^+ 82%, B^0 16%, B_s 2%)
  - Group events into 8 bins of Visible Proper Decay Length:
  - Measure $r = N(\mu D^*)/N(\mu D^0)$ in each bin
  - In both cases fit D^0 signal to extract $N(\mu D)$
  - Use slow pion only to distinguish B^0 from B^+ (no lifetime bias)
- Account for feed-down from D** using MC

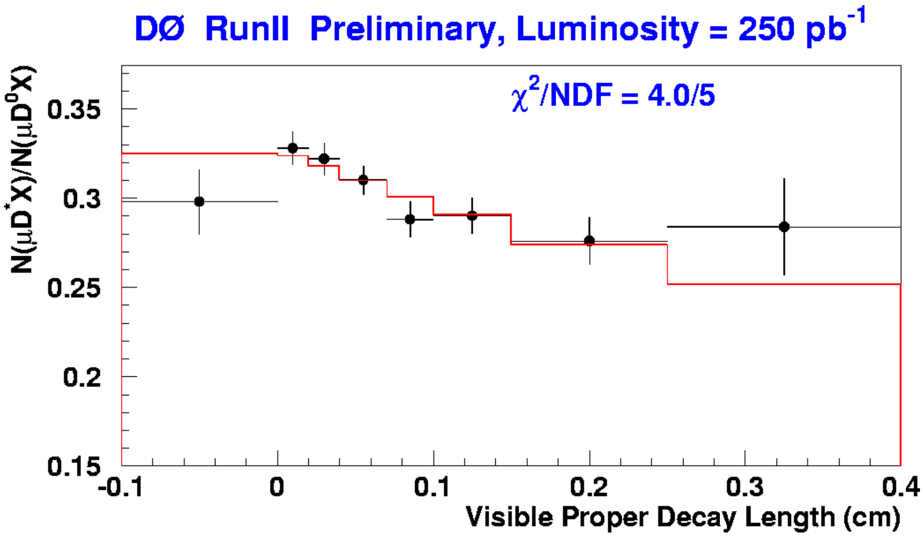




B Lifetimes

$\tau(B^+)/\tau(B^0)$ Lifetime Ratio

Use binned χ^2 fit of event ratios to determine $\tau(B^+)/\tau(B^0)$



DO Preliminary result:
$\tau(B^+)/\tau(B^0) = 1.093 \pm 0.021 \pm 0.022$

Competitive with B factories

Lifetimes from excl. B -> J/ψ K

Use fully rec. B decays

$c\tau_{Bu}$ = 498.1±9.9(stat)±2.4(syst)

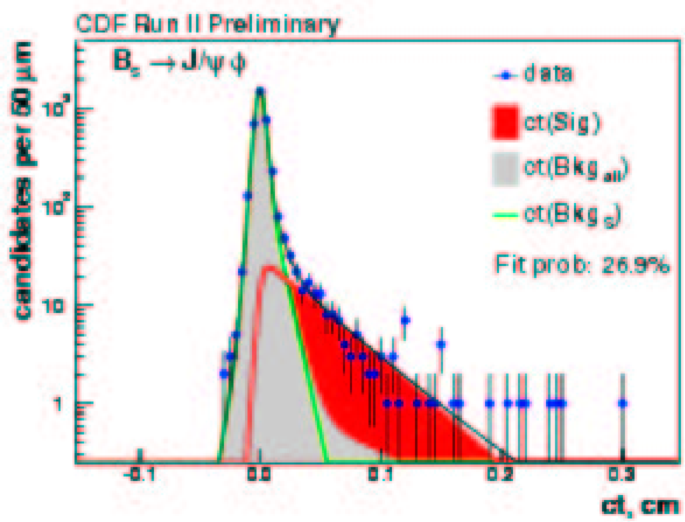
$c\tau_{Bd}$ = 461.3±15.4(stat)±2.4(syst)

$c\tau_{Bs}$ = 410.4±30.0(stat)+2.4-2.9(syst)

$\tau_{Bu}/\tau_{Bd} = 1.080 \pm 0.042$

$\tau_{Bs}/\tau_{Bd} = 0.890 \pm 0.072$

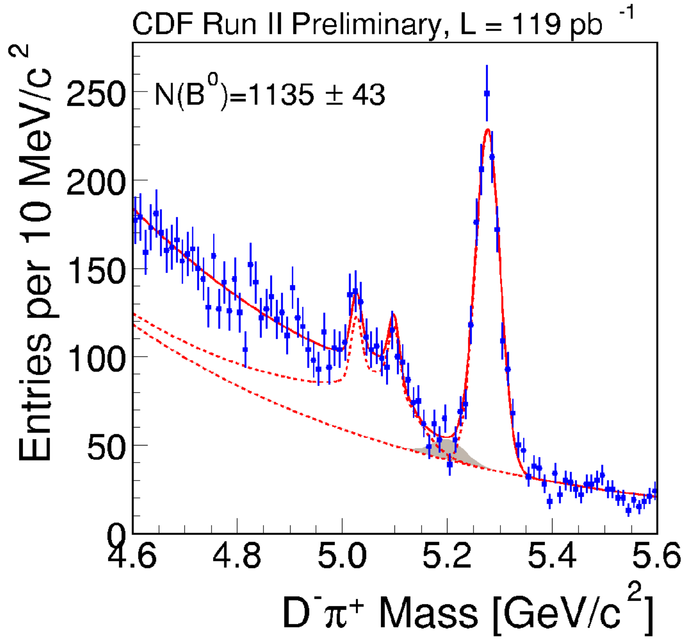
$B_s \to J/\psi\phi$ decay length



Charmless B Decays

Examples of B signals using displaced track trigger at CDF from 2003:

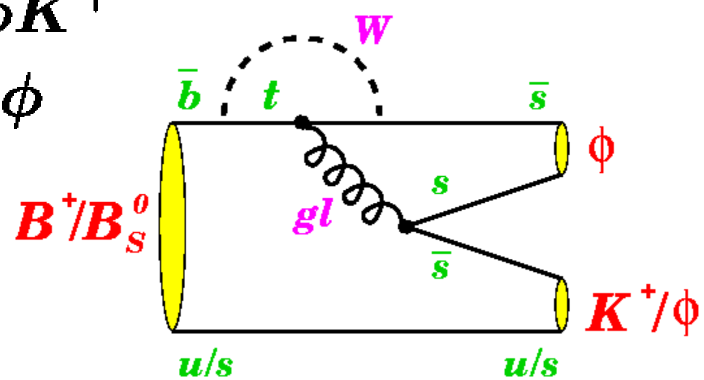
$B^0 \rightarrow D^+\pi^- \quad \Lambda_b \rightarrow \Lambda_c\pi$



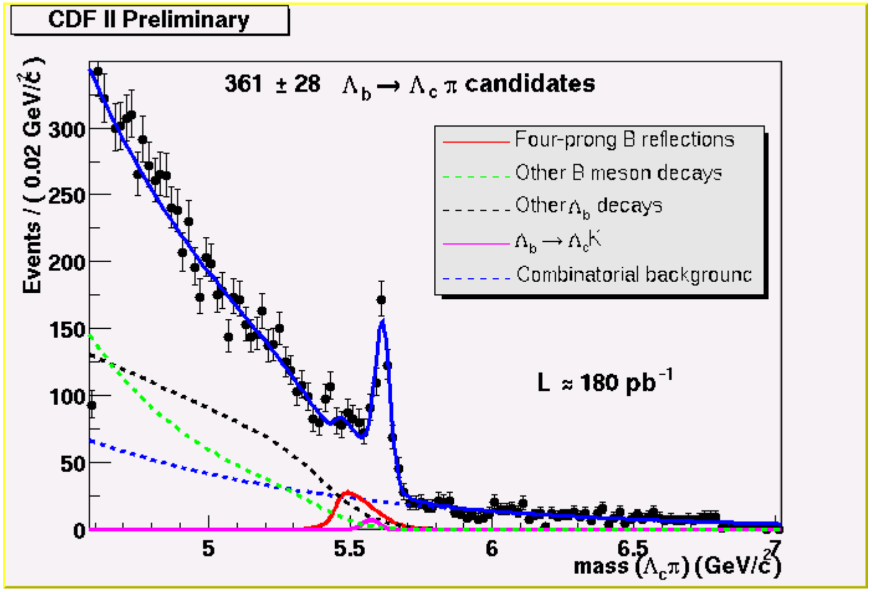
New: Search for charmless B decays from gluonic penguin decays

$B^+ \rightarrow \phi K^+$

$B_s^0 \rightarrow \phi\phi$

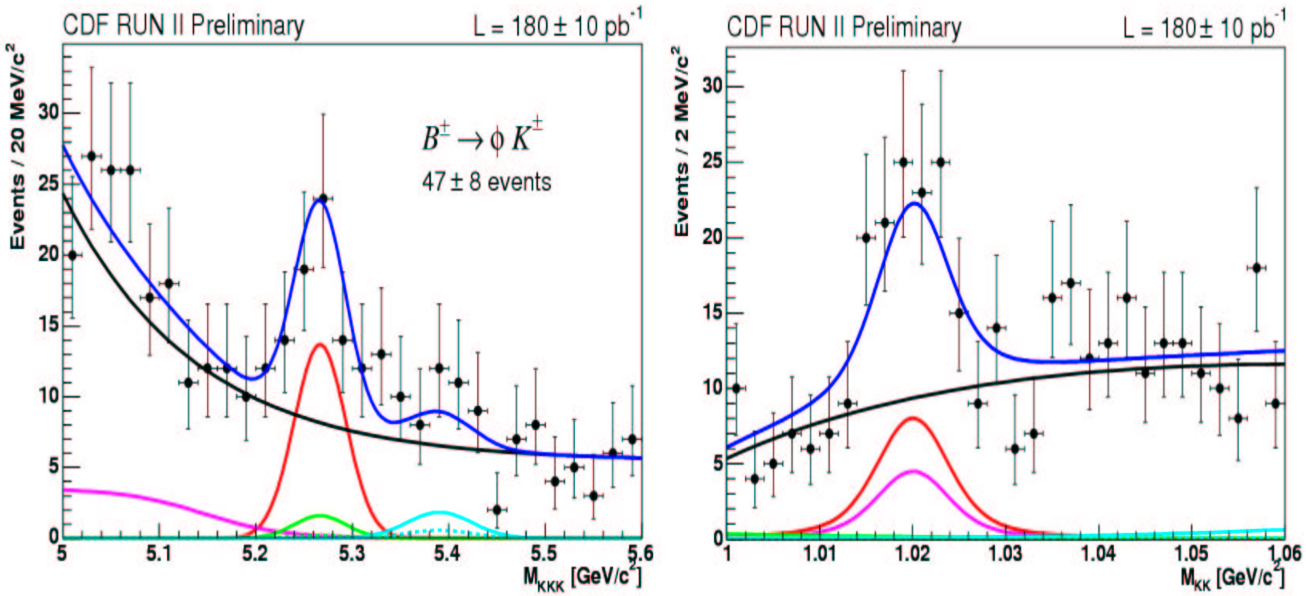


- **Decay of interest in light of possible anomalies by Belle/BaBar in $B^0 \rightarrow \phi K_s$**
- **$B_s \rightarrow \phi\phi$ has never been observed**
- **Use displaced track trigger (180 pb^{-1})**



Observation of B± -> ϕ K±

Updated BR measurement and first A_{CP} determination



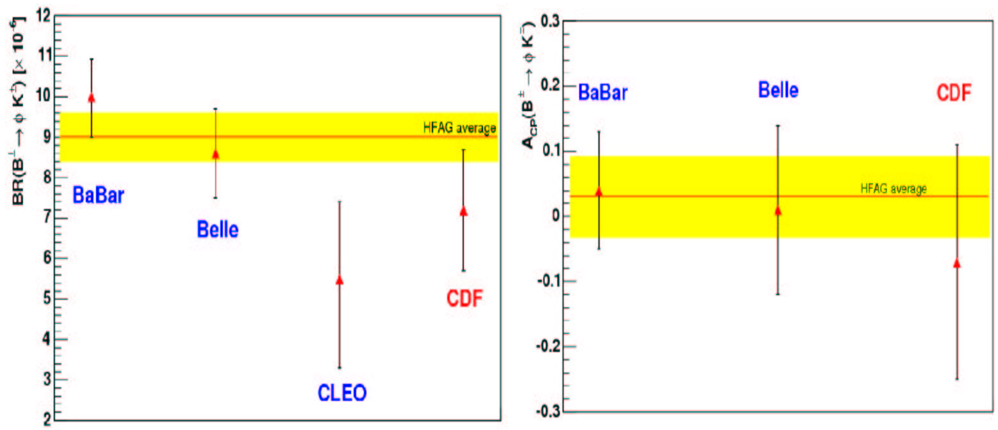
Legend:

- total PDF
- signal
- comb. BG
- phys. BG
- $B^{\pm} \to f_0 K^{\pm}$
- $B^{\pm} \to K^{*0}\pi^{\pm}$
- $B^{\pm} \to K^{\pm}K^{-}K^{+}$
- $B^{\pm} \to K^{\pm}\pi^{-}\pi^{+}$

- Fit result: N = 47±8 events
- Main background $B^{\pm} \to f_0 K^{\pm}$

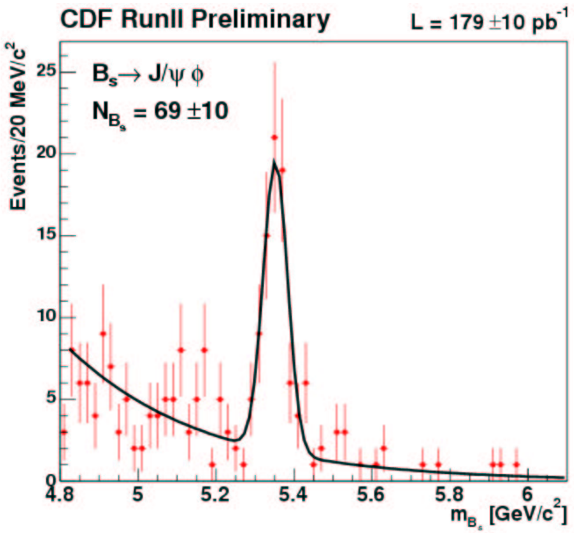
BR = (7.2 ± 1.3 ± 0.7) · 10^{-6}

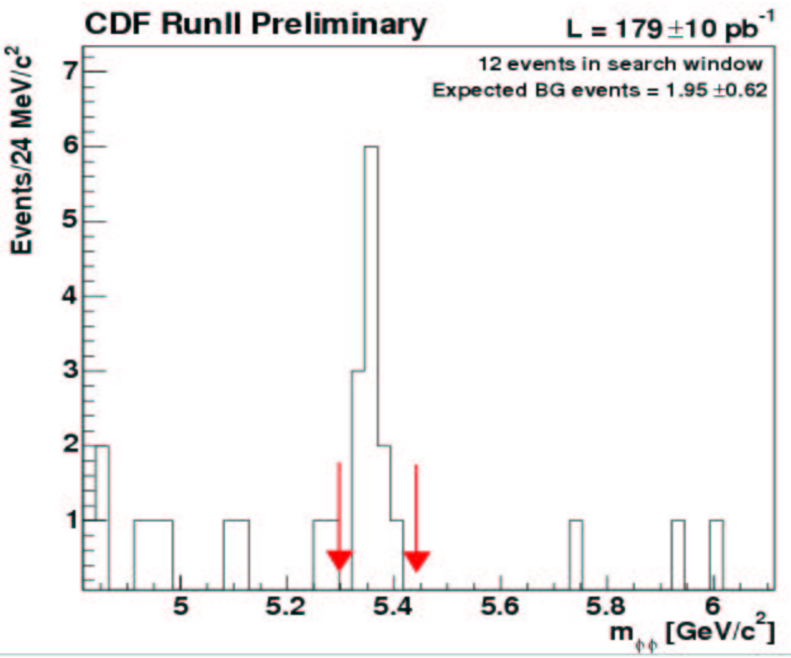
A_{CP} = 0.07 ± 0.17 ± 0.06



First Evidence for $B_s^0 \to \phi\phi$

- Search for $B_s^0 \to \phi\phi$: Perform blind analysis
- Use MC and high statistics 4-track modes for search optimization
- Normalize yield to $B_s \to J/\psi\phi$ decay (rel. eff.)
- Observe 12 events in search window



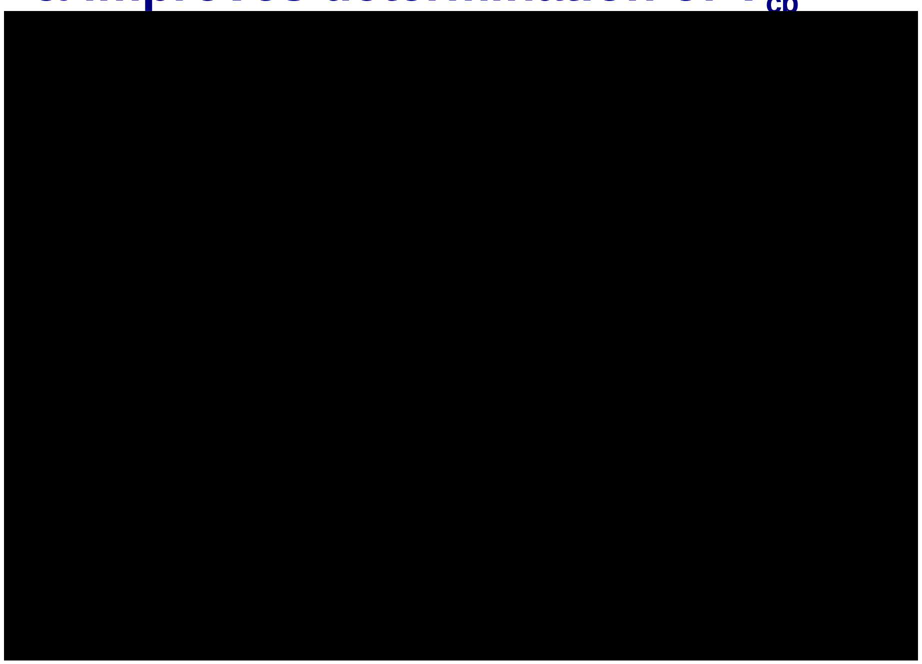


BR=(1.4 ± 0.6 ± 0.2 ± 0.5 (BR))·10^{-5}

(almost 5 sigma observation)

Hadronic Mass Moments

- Most precise determination of V_{cb} based on inclusive semileptonic decays
  $B \to X_c\, l\, \nu$ ($X_c = D^+/D^0/D^*/D^{**}$)
- Basic idea: OPE applied to HQET relates experimental width to V_{cb}:
  $\Gamma(B \to X_c l \nu) = |V_{cb}|^2 f(\Lambda, \lambda_1, \lambda_2, \ldots)$ ['form factors' in expansion in powers of m_B)
  $\Lambda, \lambda_1, \lambda_2, \ldots$ OPE parameters related to hadronic mass moments of $M^2(X_c)$ mass distribution in semi-leptonic decays
- Measurement of mass moments provides useful constraints on $\Lambda, \lambda_1, \lambda_2, \ldots$ & improves determination of V_{cb}



- Challenge: Reconstruct $B \to D^{**} l X$, with $D^{**} \to D^+/D^0/D^*\, X$
- Need to understand all possible reflections/cross-talks between various modes

Doable at hadron collider!
Preliminary analysis at CDF!

Hadronic Mass Moments

- **Preliminary Result of CDF Anlysis:**

  $M_1 = (0.459 \pm 0.037_{stat} \pm 0.0019_{exp} \pm 0.062_{BR})\ GeV^2$

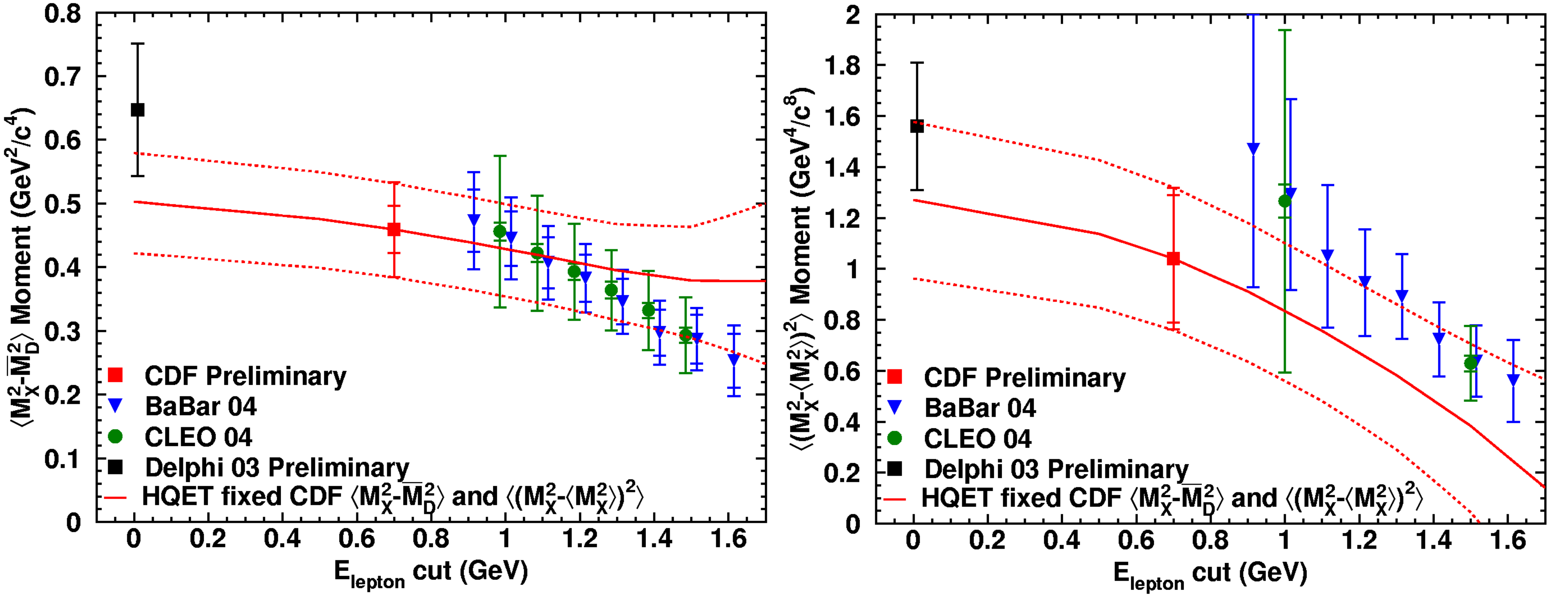
  $M_2 = (1.04 \pm 0.25_{stat} \pm 0.07_{exp} \pm 0.10_{BR})\ GeV^4$

  Dominant parameters in HQET expansion:

  $\Lambda = (0.390 \pm 0.075_{stat} \pm 0.026_{exp} \pm 0.064_{BR} \pm 0.058_{theo})\ GeV$

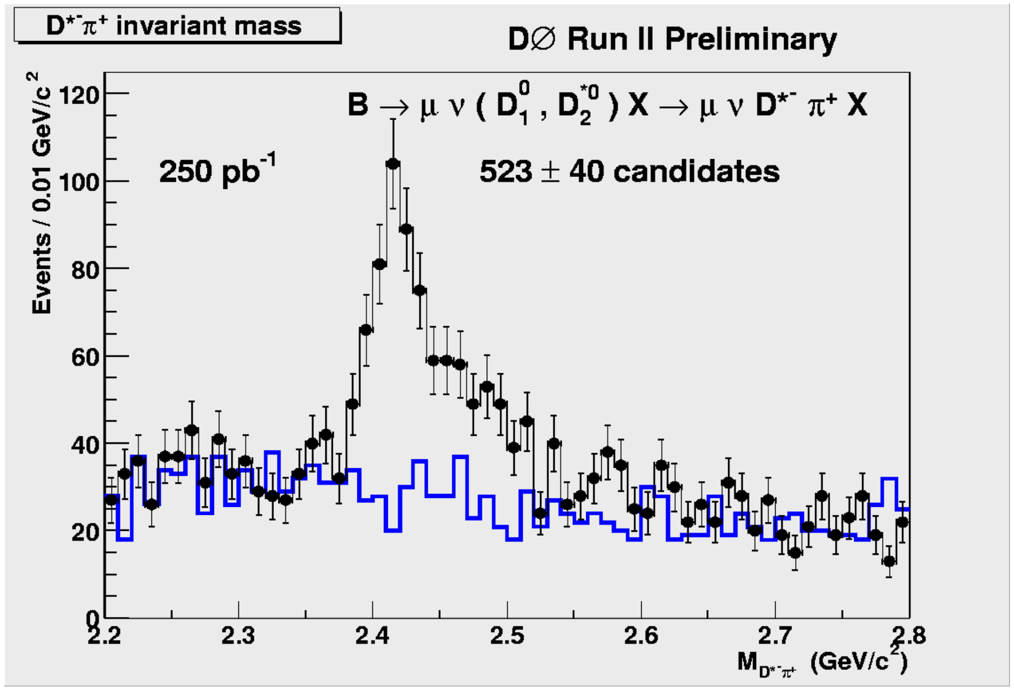
  $\lambda_1 = (-0.182 \pm 0.055_{stat} \pm 0.016_{exp} \pm 0.022_{BR} \pm 0.077_{theo})\ GeV^2$

Competitive with B-factories!



Observation of D** at D0

- Start from $B \to \mu\nu D^*X$ sample, add another π^+
- Look at invariant mass of $D^{*-}\ \pi^+$ system
- Observe excess in right-sign combinations
- Interpret as merged $D_1^0(2420)$ and $D_2^{*0}(2460)$



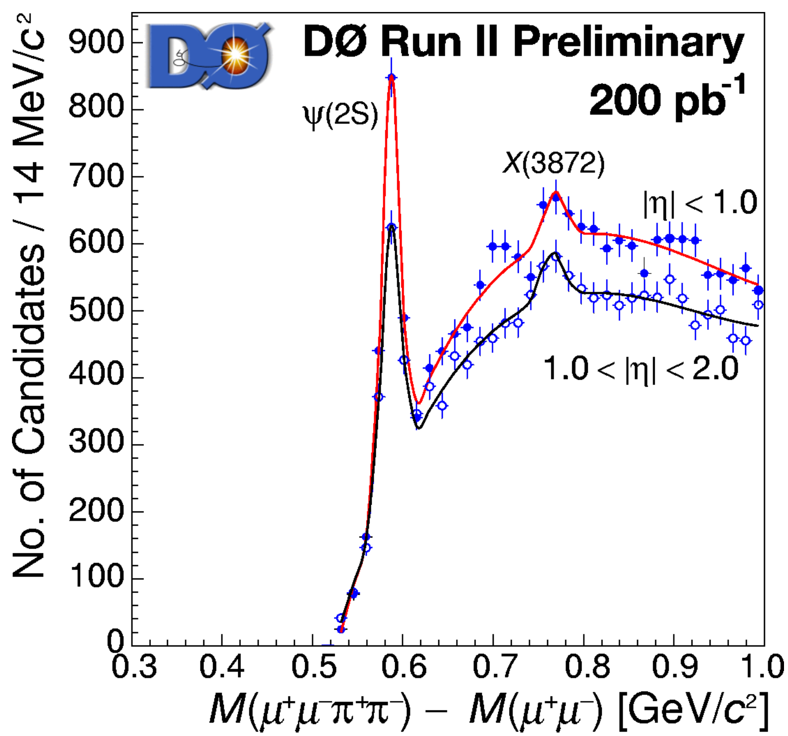
$$Br(B \to \{D_1^0, D_2^{*0}\}\ \mu\ \nu\ X) \times Br(\{D_1^0, D_2^{*0}\} \to D^{*+}\ \pi^-) =$$

$$\underline{(\ 0.280\ \pm 0.021 \pm 0.088\ )\ \%}$$

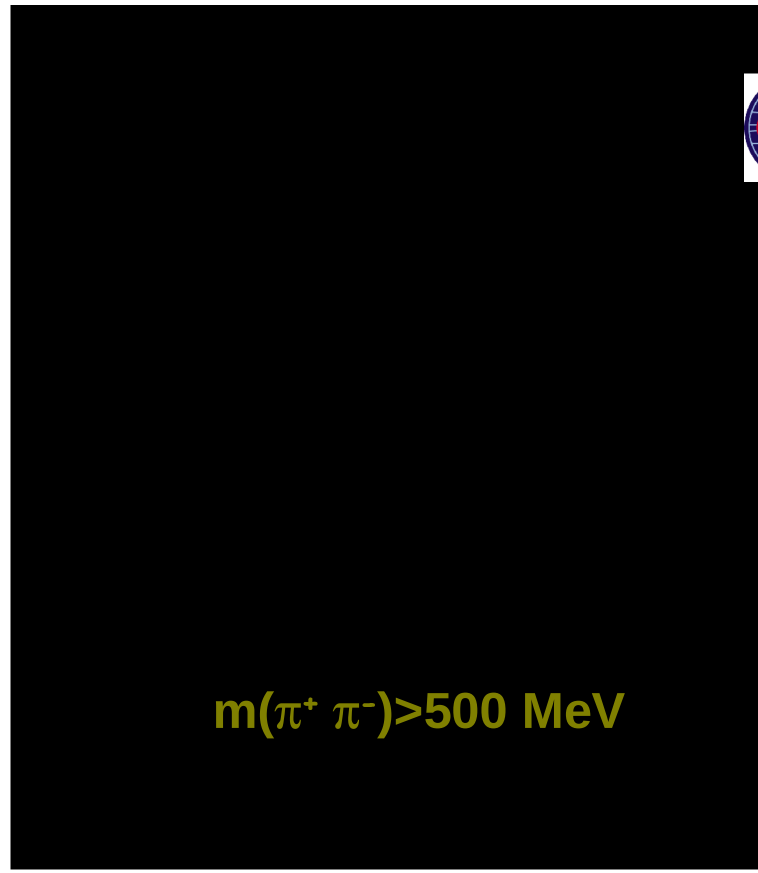
X(3872) $\rightarrow$ J/Ψ $\pi^+ \pi^-$

Aug. 2003, Belle announced new particle at m~3872 MeV/c^2
Observed in B$^+$ decays: B$^+$ -> K$^+$ X(3872), X(3872) $\rightarrow$ J/Ψ $\pi^+ \pi^-$
N = 35.7±6.8, m = (3872.0±0.6±0.5) MeV/c^2

X(3872) confirmed by CDF & D0:

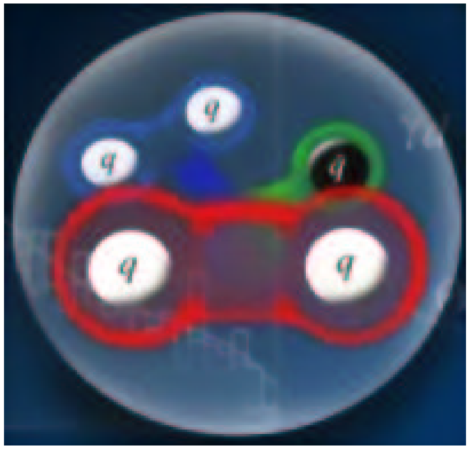


N = 300 ± 61
Δm = (768±4±4) MeV/c^2



N = 730 ± 90
m = (3871.3±0.7±0.4) MeV/c^2

Pentaquarks



Five quark state: 4 quarks + 1 anti-quark

flavour (anti-quark) $\neq$ flavour(quarks)

Predicted by Diakonov, Petrov, Polyakov (1997)

States observed so far:

$\Theta^+ : |u\,u\,d\,d\,\bar{s}\rangle$

$\Xi^{--} : |s\,s\,d\,d\,\bar{u}\rangle$ $\quad \Xi^0 : |\bar{s}\,\bar{s}\,\bar{d}\,d\,\bar{u}\rangle$

$\Theta_c^0 : |u\,u\,d\,d\,\bar{c}\rangle$

Discuss first: Θ^+

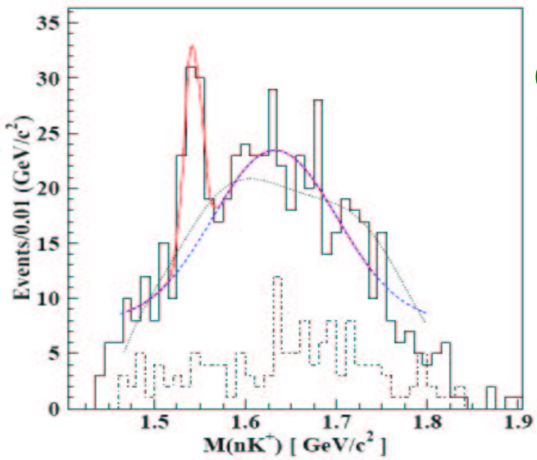
mass ~ 1530 MeV, width < 15 MeV

Decays equally to nK^+ and pK^0

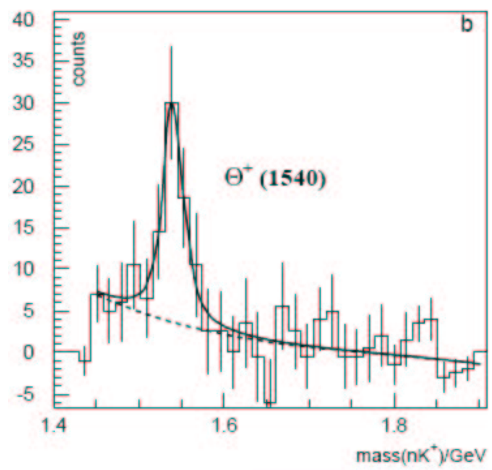
(Jaffe, Wilczek PRL 91, 232003)

Pentaquarks

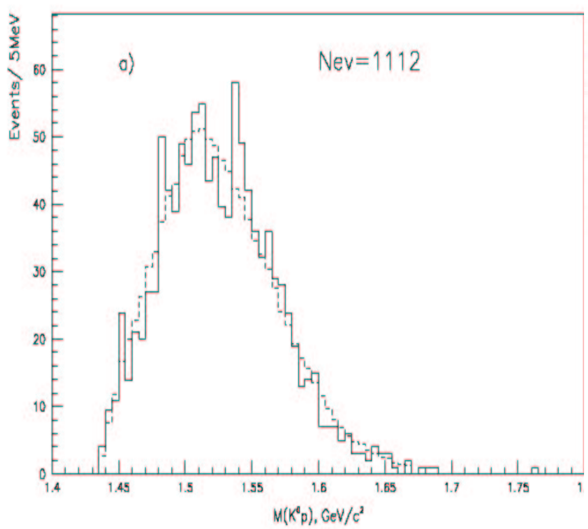
Θ^+: Reported evidence in nK^+



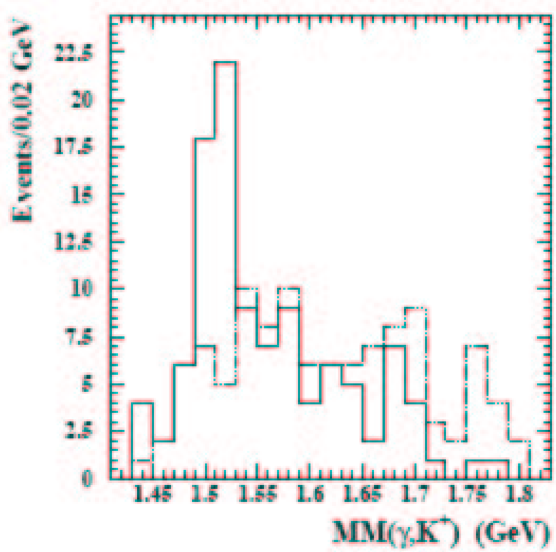
CLAS
hep-ex0307018



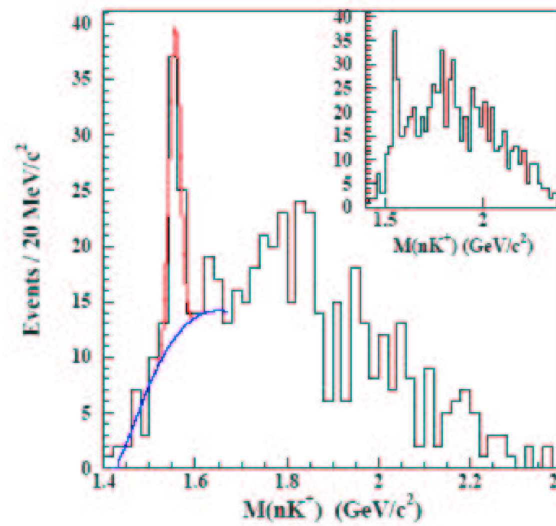
SAPHIR
hep-ex0307083



DIANA hep-ex0304040



LEPS hep-ex0402005

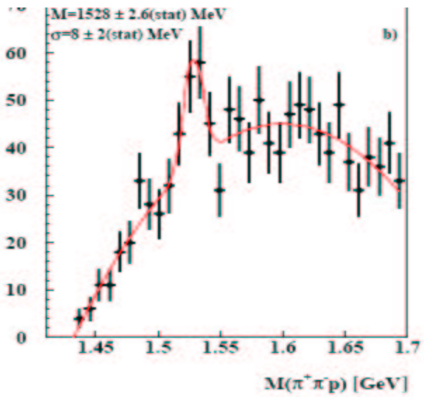


CLAS-2 hep-ex0402005

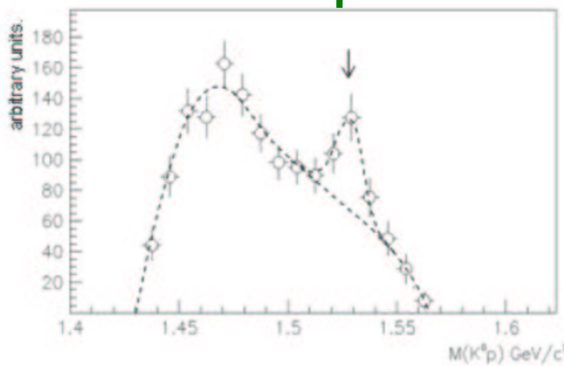
Pentaquarks

Θ^+: Reported evidence in pK^0

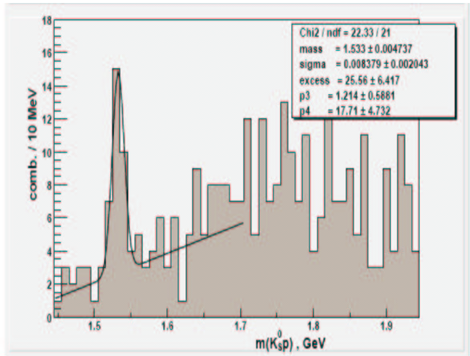
HERMES hep-ex0312044

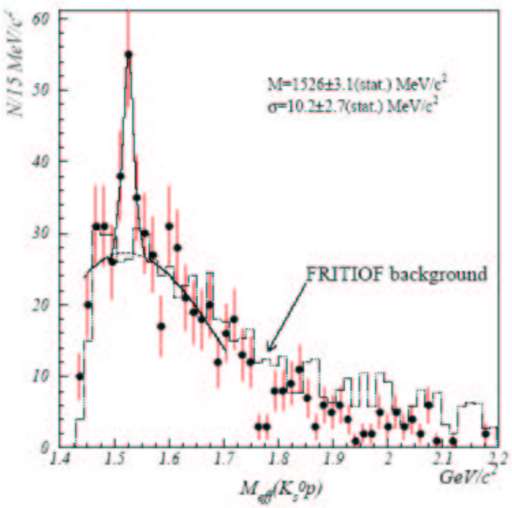


COSY-TOF hep-ex0403011

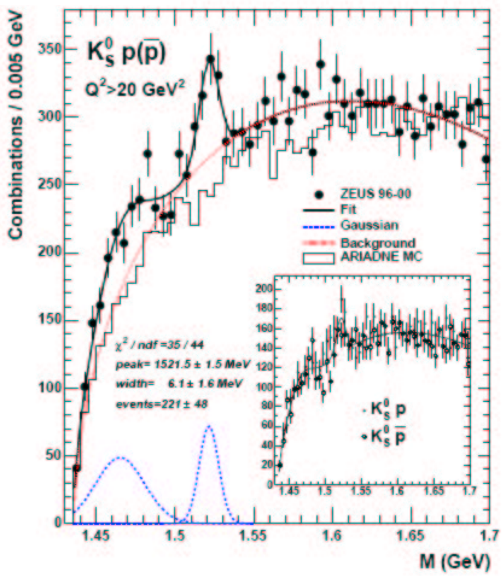


Asratyan et al.hep-ex0309042





SVD
hep-ex0401024

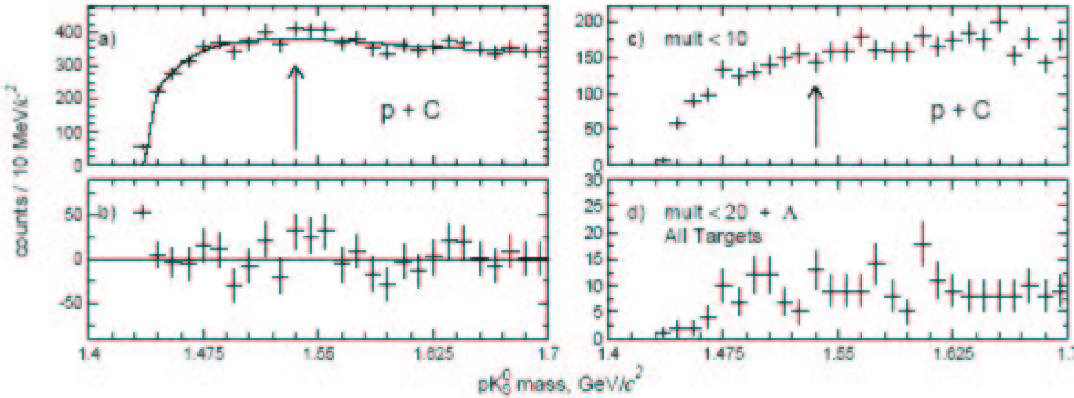


ZEUS
hep-ex0403051

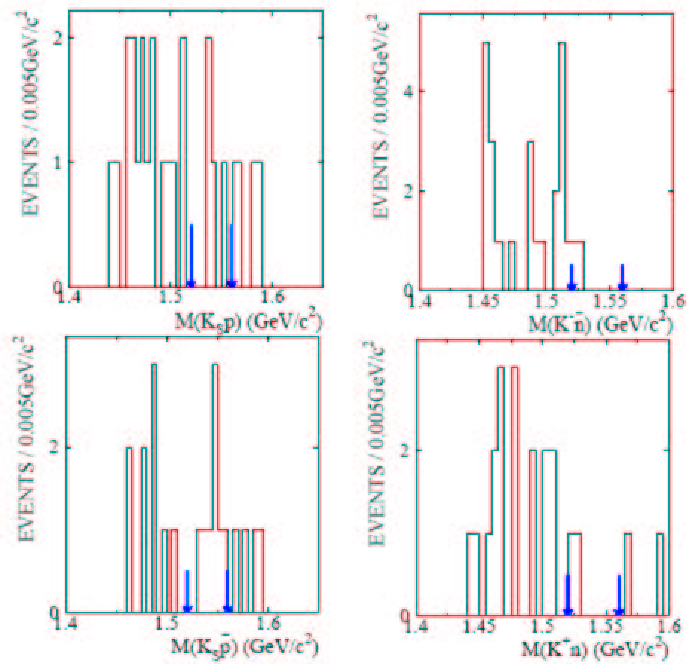
Pentaquarks

Θ^+: Reported negative evidence

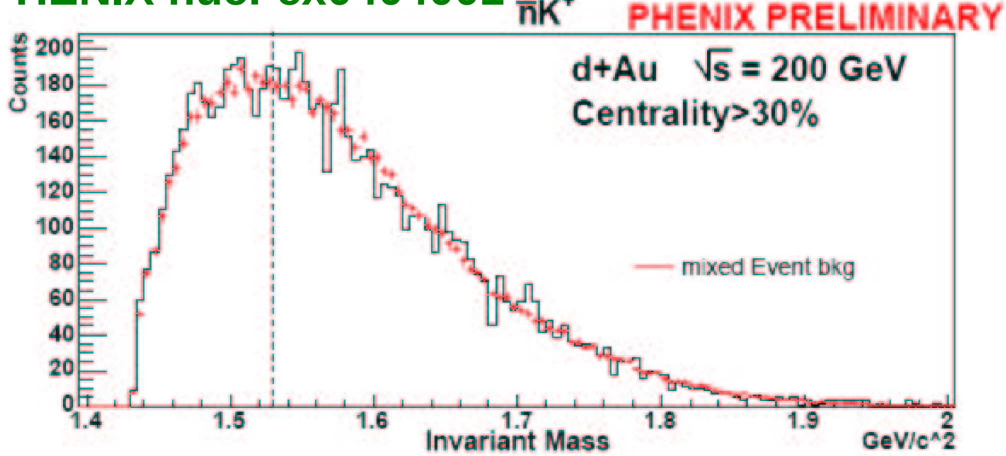
HERA-B hep-ex0403020



BES hep-ex0402012



PHENIX nucl-ex0404001



BaBar at APS (prelim.)

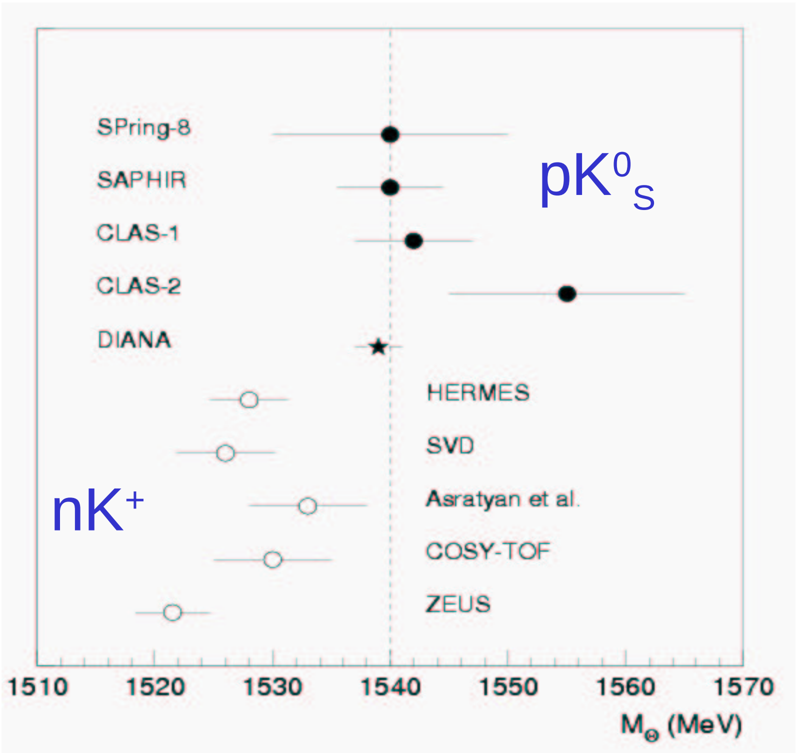
Pentaquarks

Θ^+: Summary of evidence
~10 positive reports, some negative reports

=> Search at Tevatron

Experiments	Mass (MeV)	Width (MeV)	Observation
SPring-8 [6]	1540 ± 10	< 25	nK^+
SAPHIR [7]	$1540 \pm 4 \pm 2$	< 25	nK^+
CLAS-1 [8]	1542 ± 5	< 21	nK^+
CLAS-2 [9]	1555 ± 10	< 26	nK^+
DIANA [10]	1539 ± 2	< 9	$K^+n \to K^0_S p$
HERMES [11]	$1528 \pm 2.6 \pm 2.1$	$17 \pm 9 \pm 3$	pK^0_S
SVD [13]	$1526 \pm 3 \pm 3$	< 24	pK^0_S
Asratyan *et al.* [12]	1533 ± 5	< 20	pK^0_S
ZEUS [14]	$1521.5 \pm 1.5 {}^{+2.8}_{-1.7}$	$6.1 \pm 1.6 {}^{+2.0}_{-1.4}$	pK^0_S, $\bar{p}K^0_S$
COSY-TOF [15]	1530 ± 5	$< 18 \pm 4$	$pp \to \Sigma^+ pK^0_S$

All signals in 3-6 σ range



Masses in agreement?

Pentaquarks at CDF

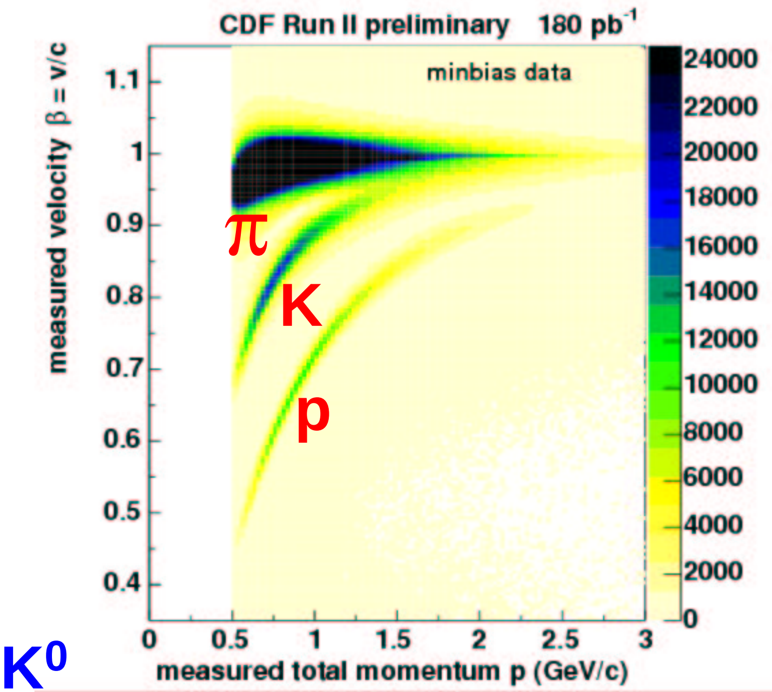
Search for $\Theta^+ \rightarrow pK_S^0 \rightarrow p\pi^+\pi^-$

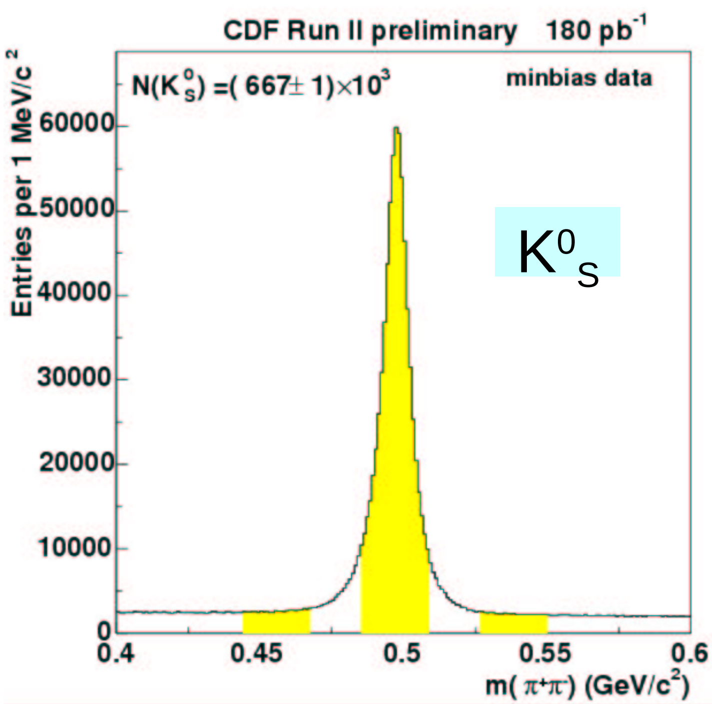
Use 2 energy ranges:

min.bias (23mio), jet20 (16mio)

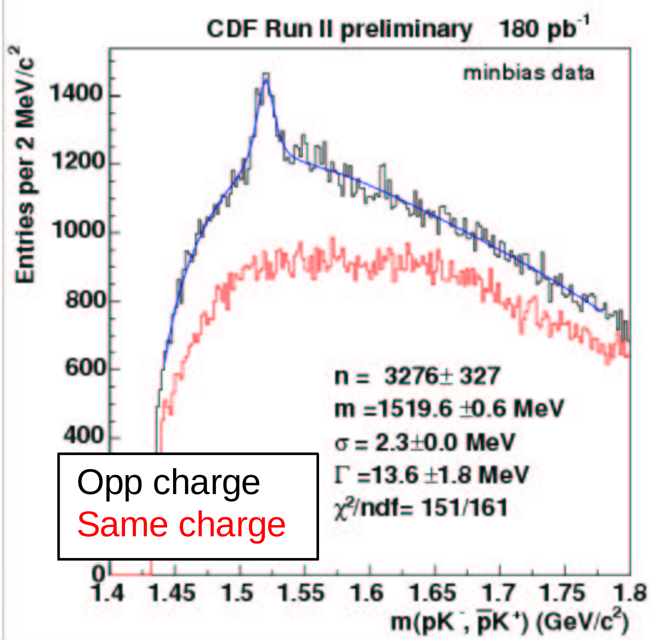
Identify protons with ToF

Reconstruct reference states

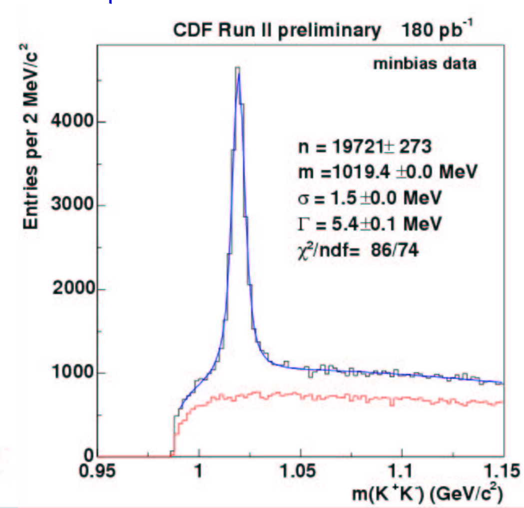




$\Lambda(1520) \rightarrow pK^0$

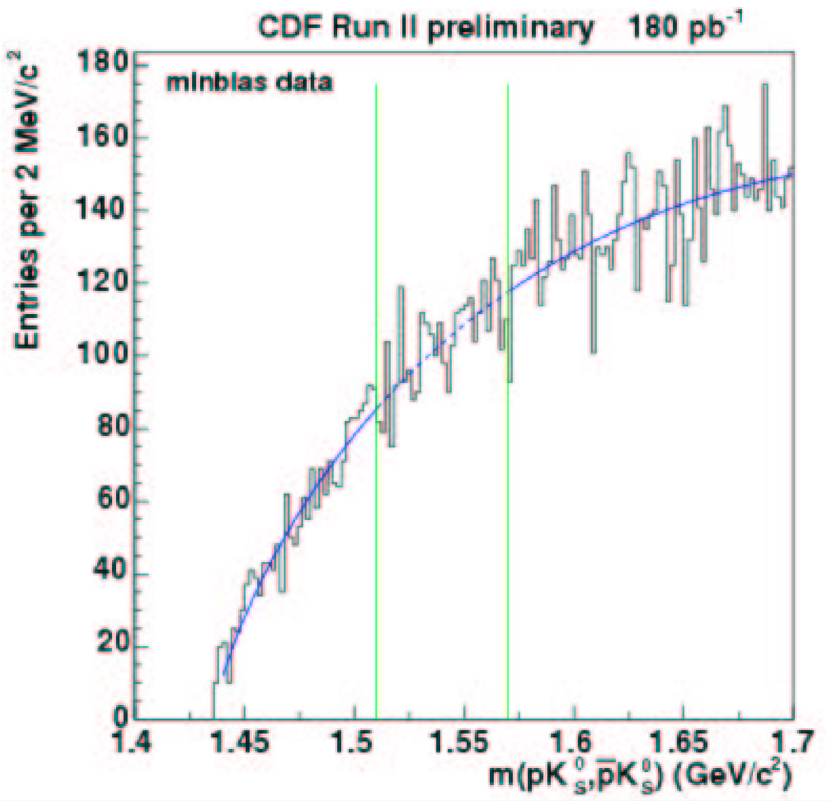


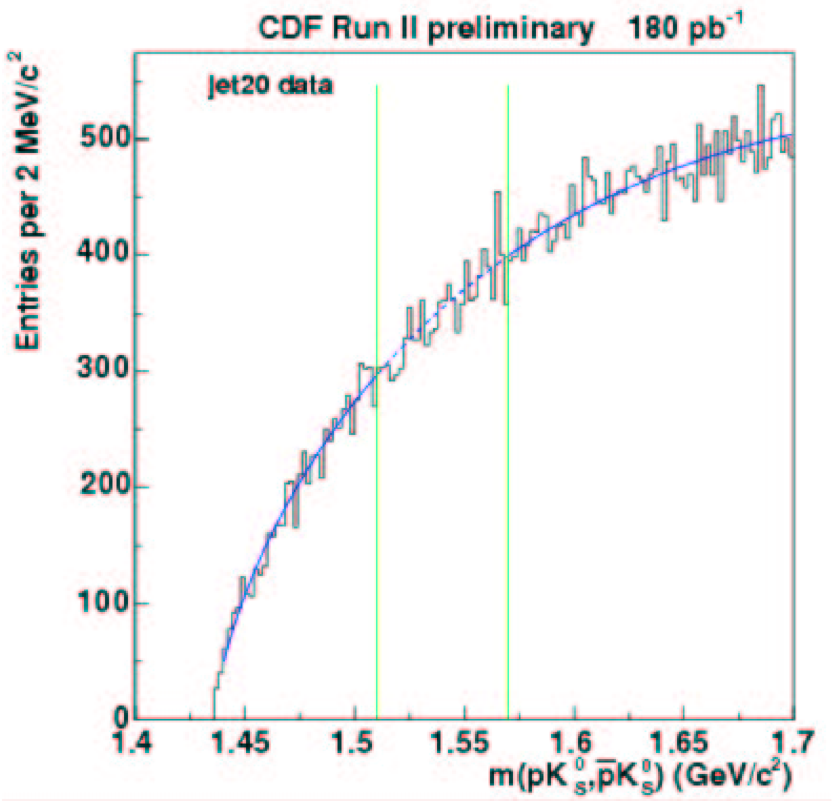
$\phi \rightarrow KK$



Pentaquarks at CDF

Search for $\Theta^+ \rightarrow pK^0_S \rightarrow p\pi^+\pi^-$





No evidence at CDF for narrow resonance

CDF is working on limit for $\sigma(\Theta^+/\Lambda(1520))$

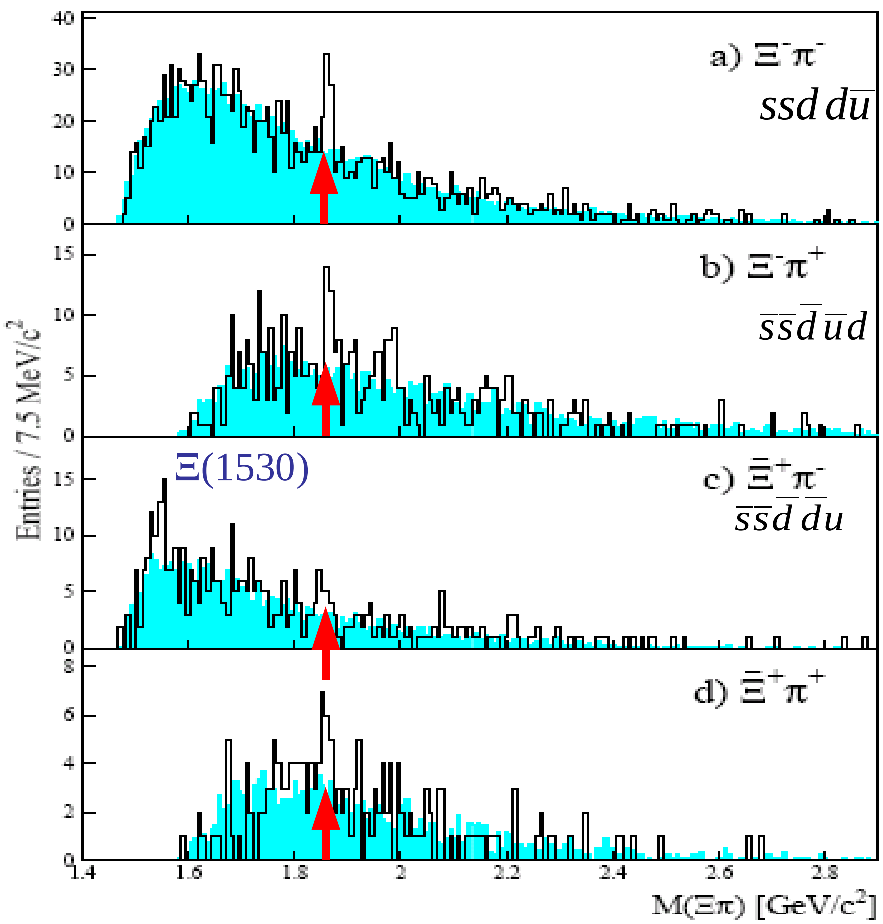
Pentaquarks at CDF

The cousin of Θ^+: Ξ^{--}

NA49 at CERN SPS (hep-ex/0310014)

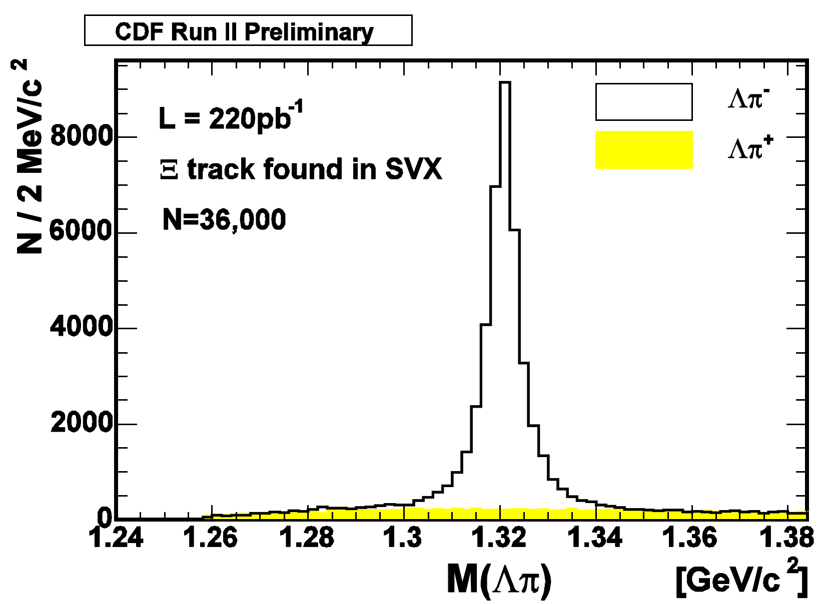
Observed in $\Xi\pi$ mass, N=67.5 events

m = 1.862 ± 0.002 GeV



Search for Ξ(1860) at CDF:

- Search for
$$\Xi^{--}_{3/2} \rightarrow \Xi^-\pi^-, \ \Xi^0_{3/2} \rightarrow \Xi^-\pi^+$$
- CDF developed dedicated tracking of long-lived hyperons in Si. detector
- Clean sample of 40k Ξ (x20 stat. NA49)
- Use established $\Xi(1530)^0 \rightarrow \Xi^-\pi^+$ as calibration signal

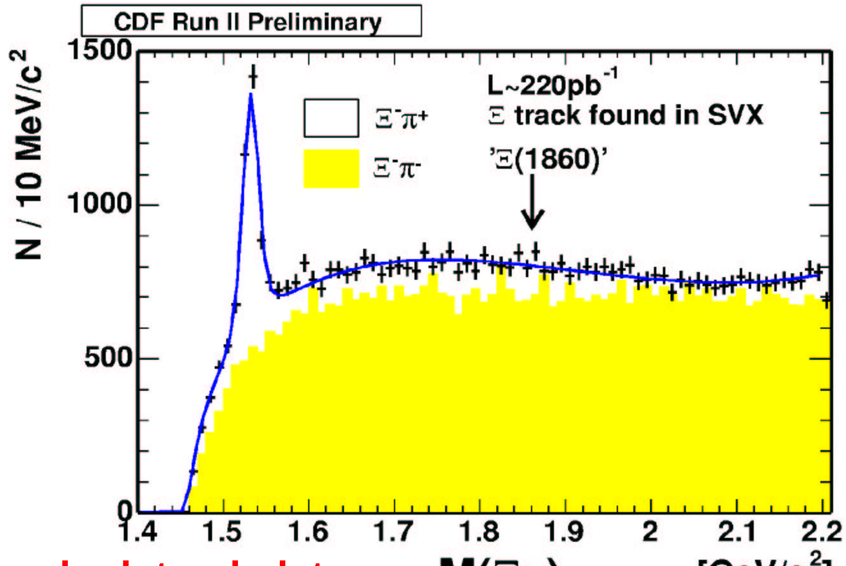


Pentaquarks at CDF

Search for Ξ(1860) at CDF:

- No evidence for narrow signal found in 2 data samples (had. track & jets)

	NA49	CDF (90%CL)
$\frac{N(\Xi^-\pi^+)}{N(\Xi(1530))}$	0.21	< 0.06
$\frac{N(\Xi^-\pi^-)}{N(\Xi(1530))}$	0.24	< 0.03



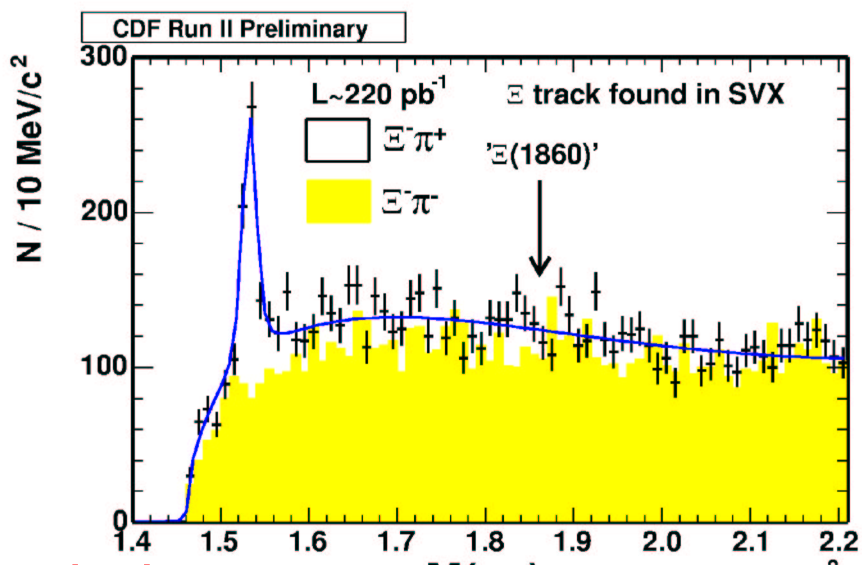
had. track data

Similar acceptance:

$$A = \frac{\sigma(pp \to \Xi(1530)) \cdot a(\Xi(1530))}{\sigma(pp \to \Xi) \cdot a(\Xi)}$$

NA49: A ~ 0.068

CDF: A ~ 0.061



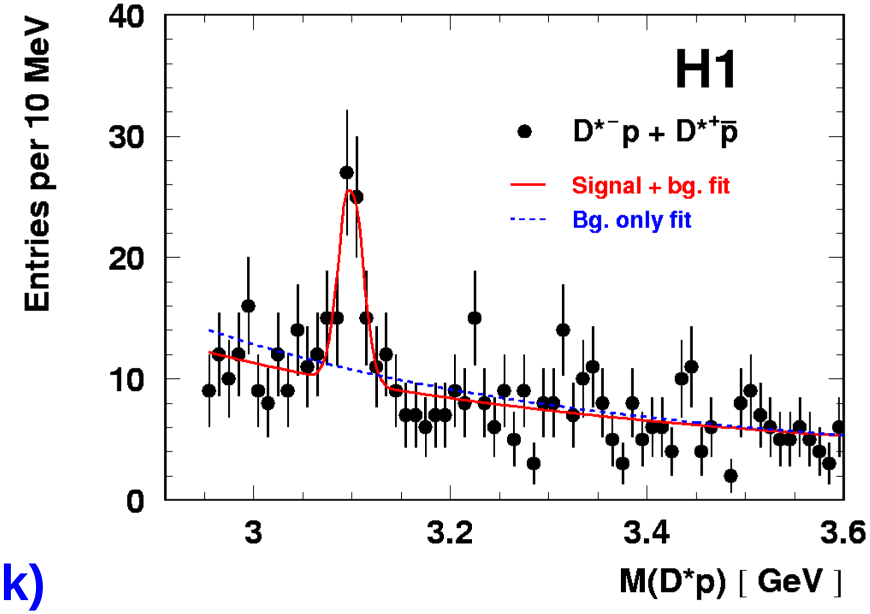
jet data

Pentaquarks at CDF

Search for Charmed Pentaquark

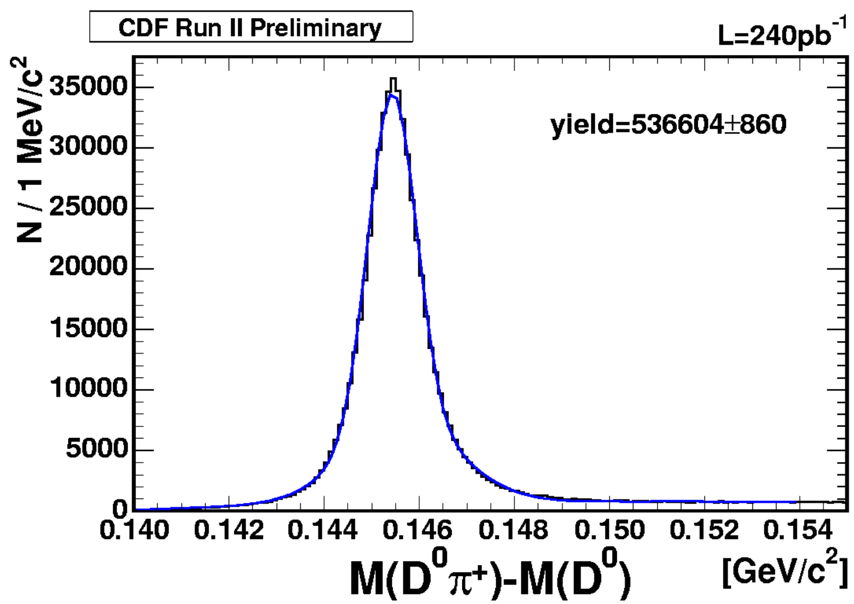
- March 2004: H1 at HERA:
- Evidence for $\Theta_c^0 : |u\,u\,d\,d\,\bar{c}\rangle$
- Reconstructed in $\Theta_c^0 \rightarrow D^{*+}\bar{p}$

  m=3099±3±5 MeV, N=51±11



CDF:

- Large sample of D^{*+} (0.5 mio)
- Use $D^{**} \rightarrow D^{*+}\pi$ as calibration mode (15k)



Pentaquarks at CDF

Search for Charmed Pentaquark

- Identify proton using ToF (p<2.75 GeV) and dE/dx (p>2.75 GeV) (~ 2σ separation each)
- No evidence of charmed pentaquark seen
- Combined upper limit: $\leq$ 29 events (90% C.L.)

Pentaquark production mechanism different in $p\bar{p}$ collisions?

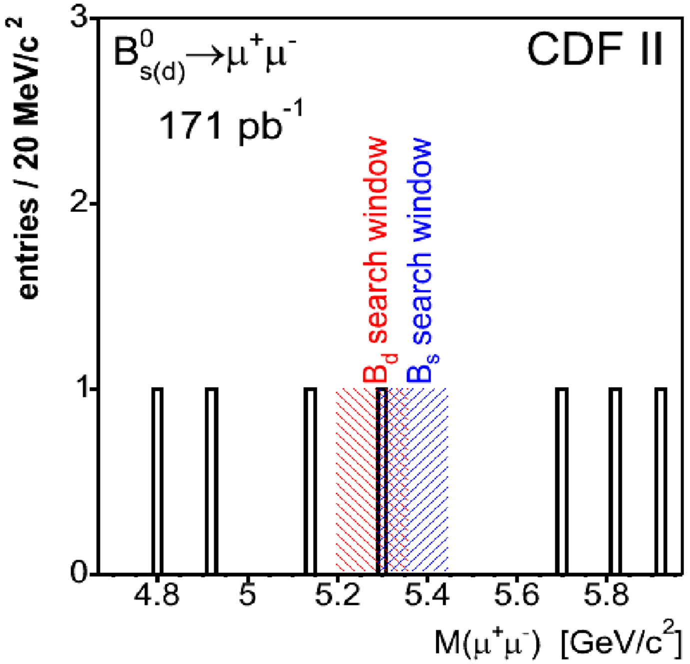
Rare Decays

Many other results not included

- Rare decays (separate talk)
- CDF:

  $Br(B_s \rightarrow \mu^+ \mu^-) < 5.8 \cdot 10^{-7}$ @ 90 % CL

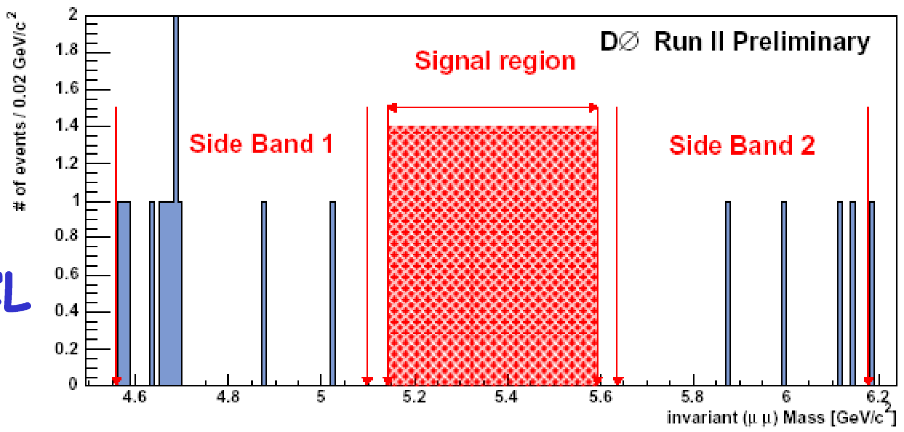
  $Br(B^0 \rightarrow \mu^+ \mu^-) < 1.5 \cdot 10^{-7}$ @ 90 % CL



- D0: Box of blind search not yet opened

- Expected sensitivity:

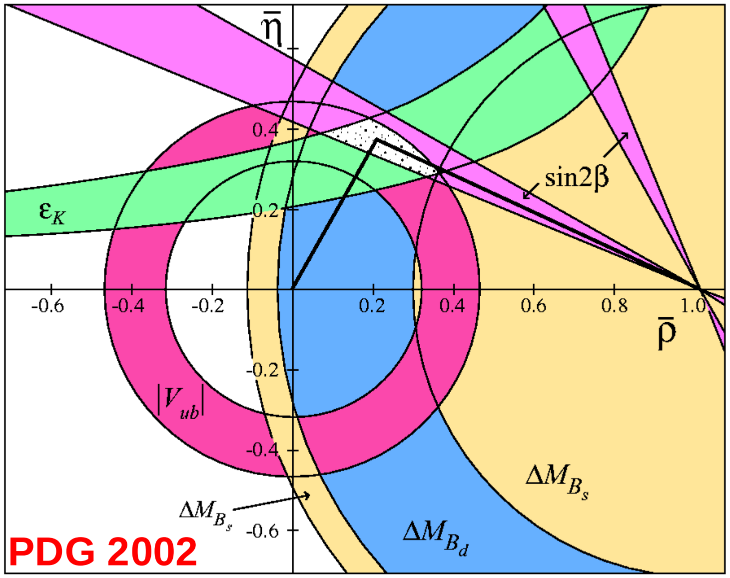
  $Br(B_s \rightarrow \mu^+ \mu^-) < 1.0 \cdot 10^{-6}$ @ 95 % CL



Brief Look into the Future

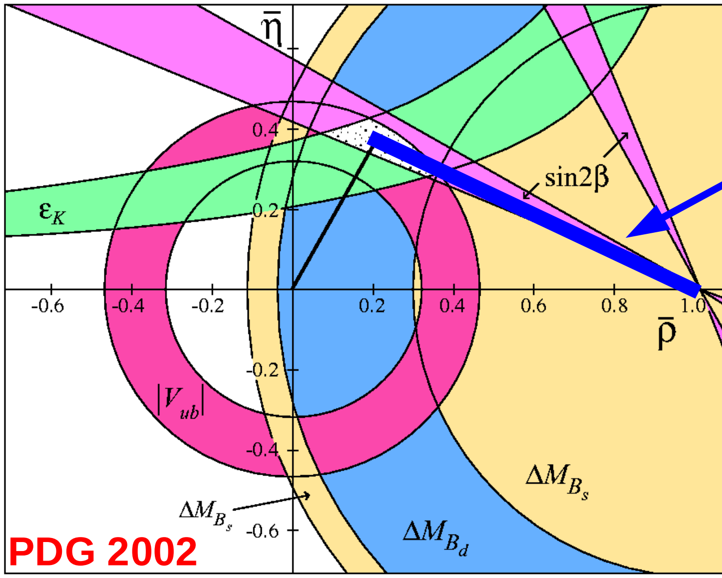
B_S Oscillations

Why are we interested in B_s Oscillations?

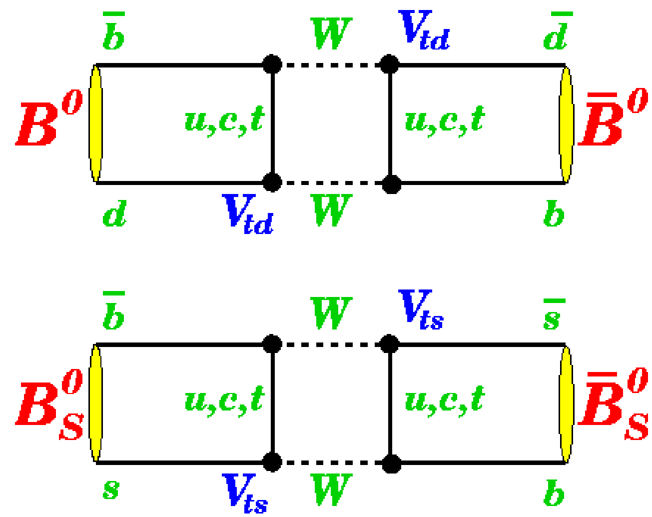


B_S Oscillations

Why are we interested in B_s Oscillations?



$$\frac{|V_{td}|}{|V_{ts}|}$$



$$\Delta m_d = \frac{G_F^2}{6\pi^2} m_B (f_B^2 B_B) \eta_B m_t^2 F\left(\frac{m_t^2}{m_W^2}\right) |V_{tb}^* V_{td}|^2$$

Experiment — Lattice QCD — CKM elements

[redacted] from Lattice

Want to measure:

$$\frac{\Delta m_S}{\Delta m_d} = \frac{m_{B_S^0}}{m_{B^0}} \frac{f_{B_S^0}^2 B_{B_S^0}}{f_{B^0}^2 B_{B^0}} \frac{|V_{ts}|^2}{|V_{td}|^2}$$

B_s Oscillations

Tevatron only place to observe B_s oscillations until LHC

Difficult measurement (give CDF prospects first):

Current conditions: Use fully rec. $Bs \rightarrow Ds\pi$

- **$S = 1600$ events/fb^{-1}**
- **$S/B = 2/1$**
- **$\varepsilon D^2 = 4$ % (SLT+SST+JQT)**
- **σ_t=67 fs**

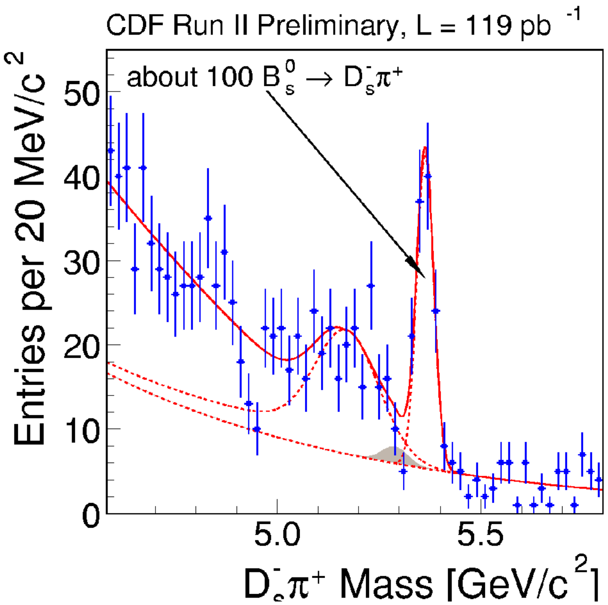
Short term: 500 pb^{-1} (no improvement up to 2005)

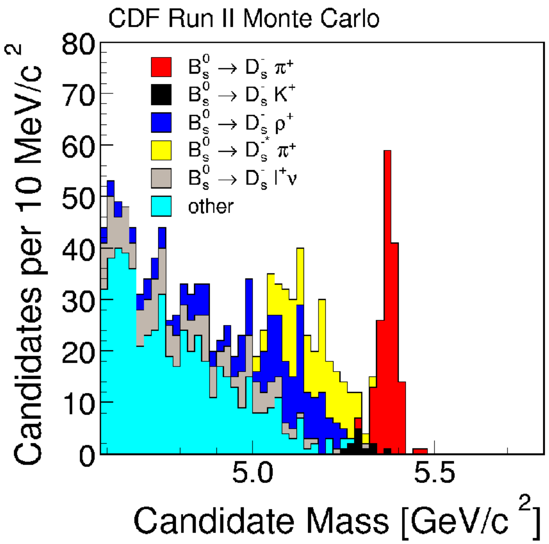
- **2σ (for $\Delta m_s = 15$ ps^{-1})**
- **Reach the current indirect limit.**
- **Cover the Standard Model favored range**

Beyond SM favoured range (conserv. improvements)

- **$5\ \sigma$ if $\Delta m_s = 18$ ps^{-1} with 1.8 fb^{-1}**
- **$5\ \sigma$ if $\Delta m_s = 24$ ps^{-1} with 3.2 fb^{-1}**

CDF & D0 work towards B_s mixing with high priority





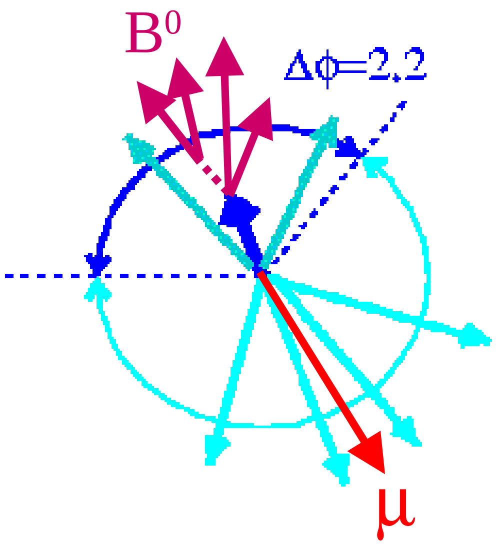
Towards B_S Oscillations

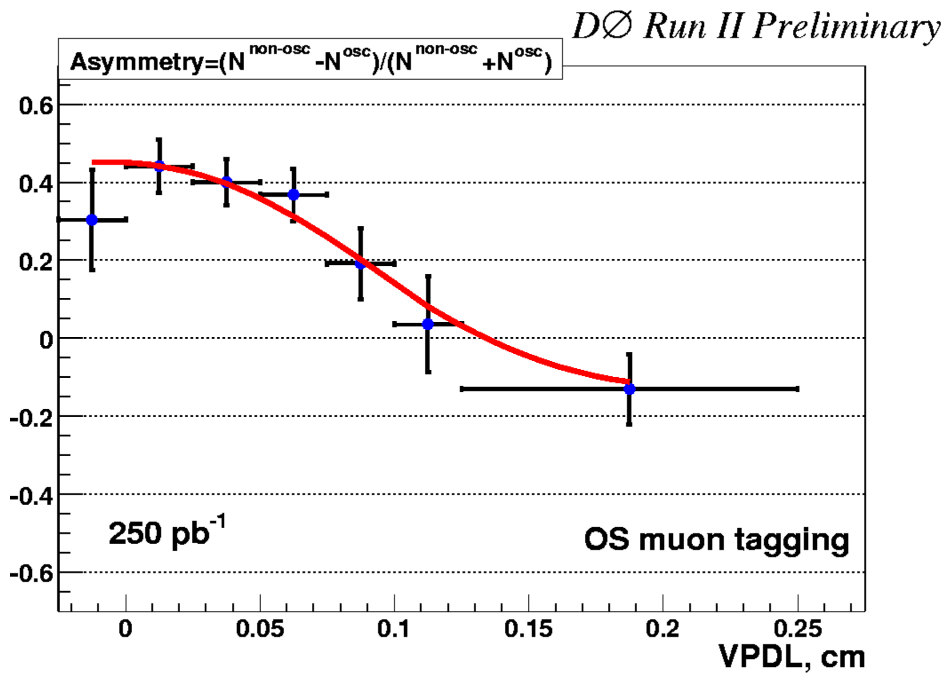
First Measurement of B^0 oscillations at D0

Use sample of semileptonic B -> $D^* \mu$ decays

Tagging procedure
- opposite side tight muon
- muon p_T > 2.5 GeV/c
- $\cos \Delta\phi(\mu, B) < 0.5$

Fit procedure
- Binned χ^2 fit





Preliminary results:

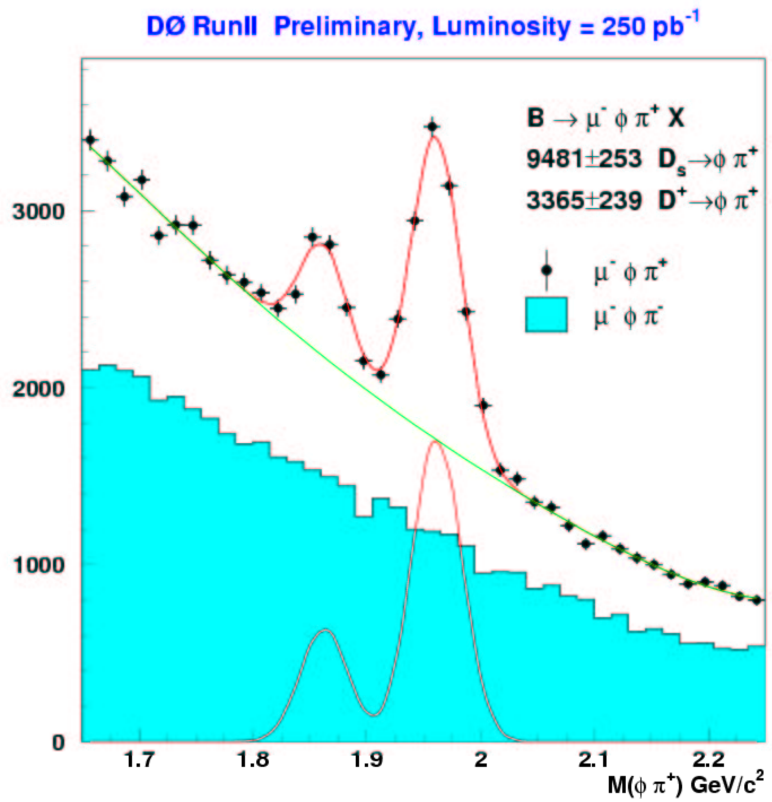
$\Delta m_d = 0.506 \pm 0.055 \pm 0.049\ ps^{-1}$

Tagging efficiency: 4.8 +/- 0.2 %
Tagging dilution: 46 +/- 4.2 %

One of the best measurements at a hadron collider

Towards B_S Oscillations at D0

Prospects for B_s^0 oscillations at D0:



Semileptonic decays $B_s \to \mu \nu D_s$ **:**

- very good statistics
- excellent yield: 9500 candidates in ~250 pb^{-1}
- if $\Delta m_s \cong 15$ ps^{-1}, first indication of B_s mixing might be possible with 500 pb^{-1}

Fully rec. hadronic decays:

- poor statistics
- excellent proper time resolution
- need a few fb^{-1} of data to reach $\Delta m_s \cong 18$ ps^{-1}

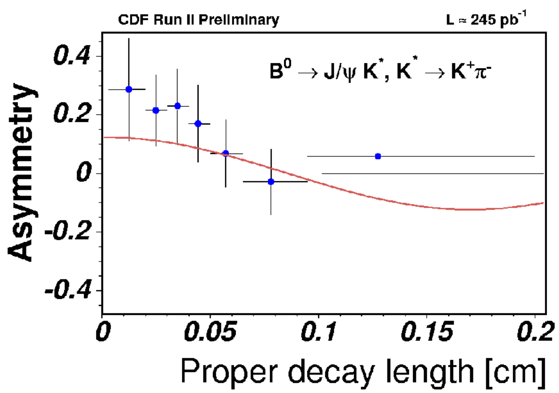
Towards B_S Oscillations at CDF

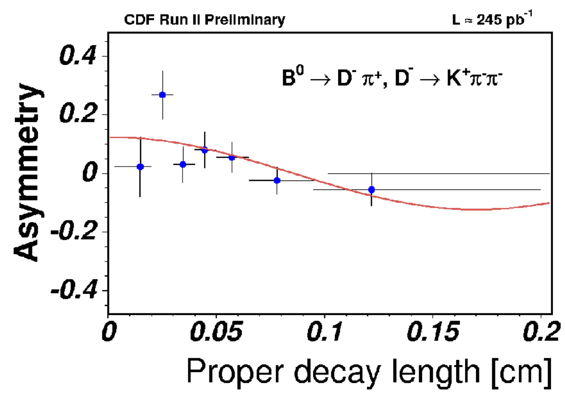
First Run II measurement of B^0 oscillations at CDF:

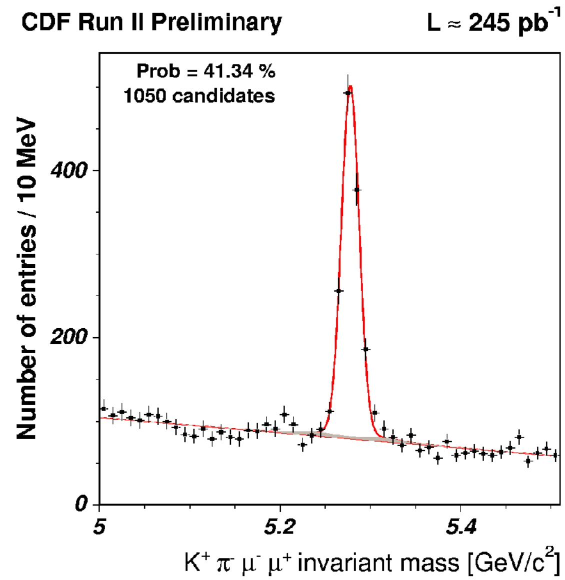
Use fully reconstructed $B^0 \to J/\psi K^*$ & $B^0 \to D^- \pi^+$

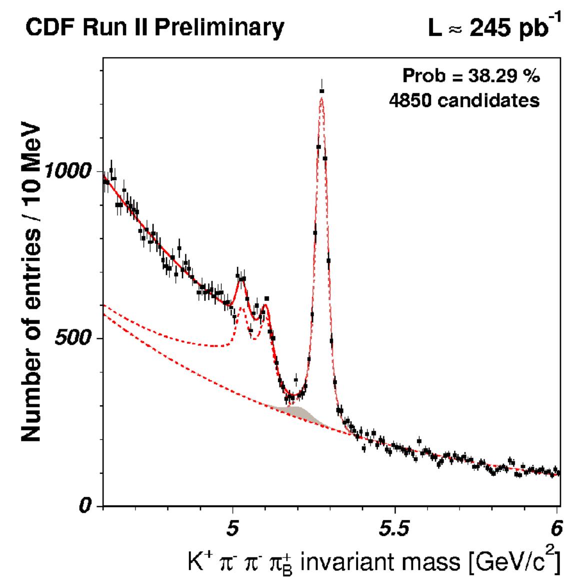
Use same side tagging

$$\Delta m_d = 0.55 \pm 0.10 \pm 0.01 \ ps^{-1}$$









CDF flavour tagging studies:

Same-side (B^0)	$\varepsilon D^2 \approx (1.0 \pm 0.5)\%$
Muon tagging	$\varepsilon D^2 \approx (0.7 \pm 0.1)\%$
JQT	$\varepsilon D^2 \approx (0.42 \pm 0.02)\%$
OS-Kaon	in progress

The Future

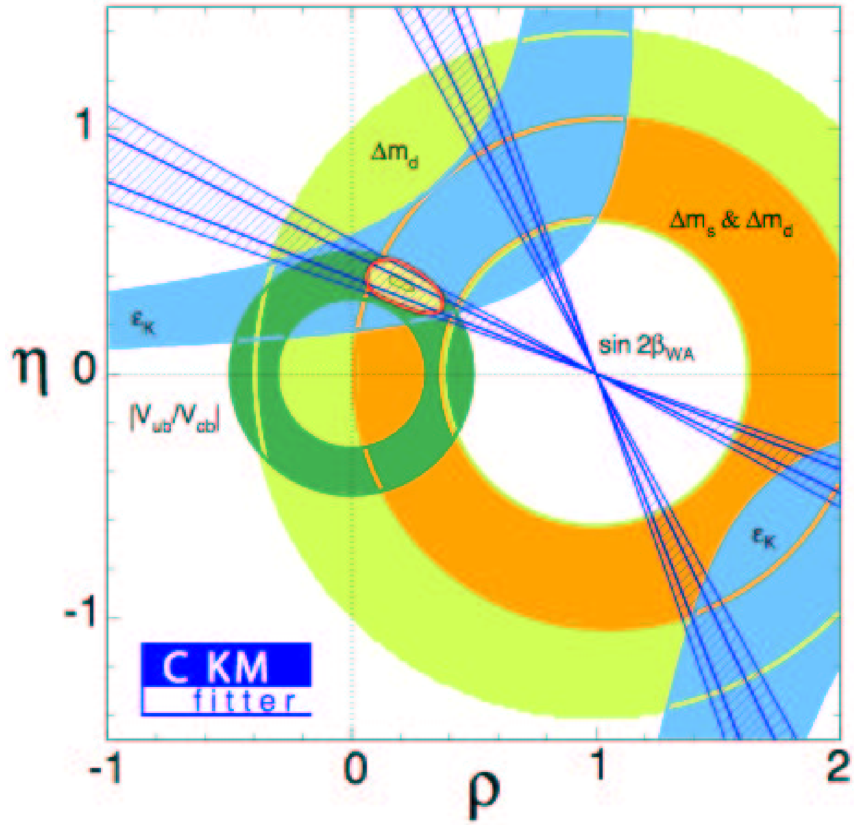
Goal of present & future B physics:

- **Test flavour changing interactions in all possible ways**

  => ***Theoretically clean modes versus experimental accessibility***

- **Measure sides and angles of CKM triangle in many ways**

  => ***Overconstrain triangle***

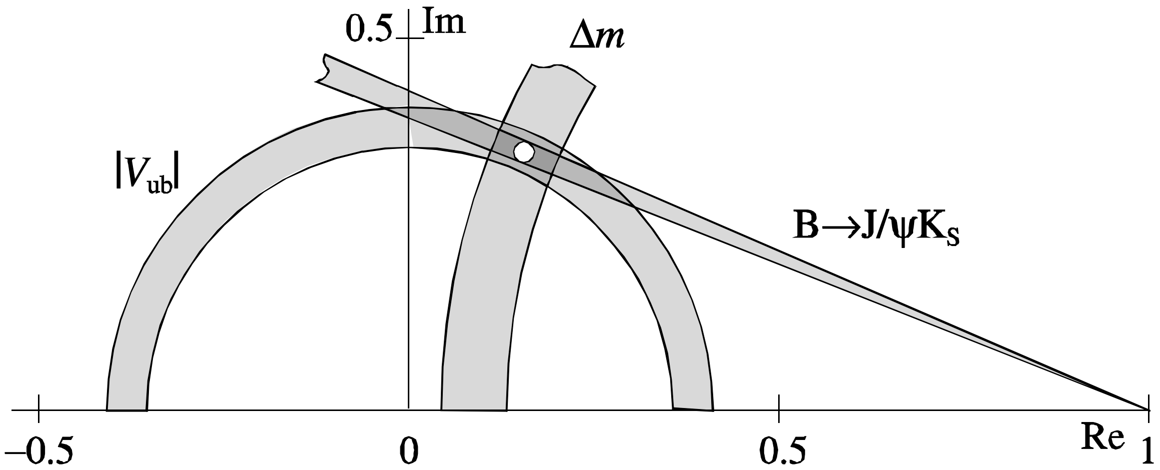


Shed more light on CKM Triangle

Possible CKM Scenarios

Want to overconstrain CKM triangle

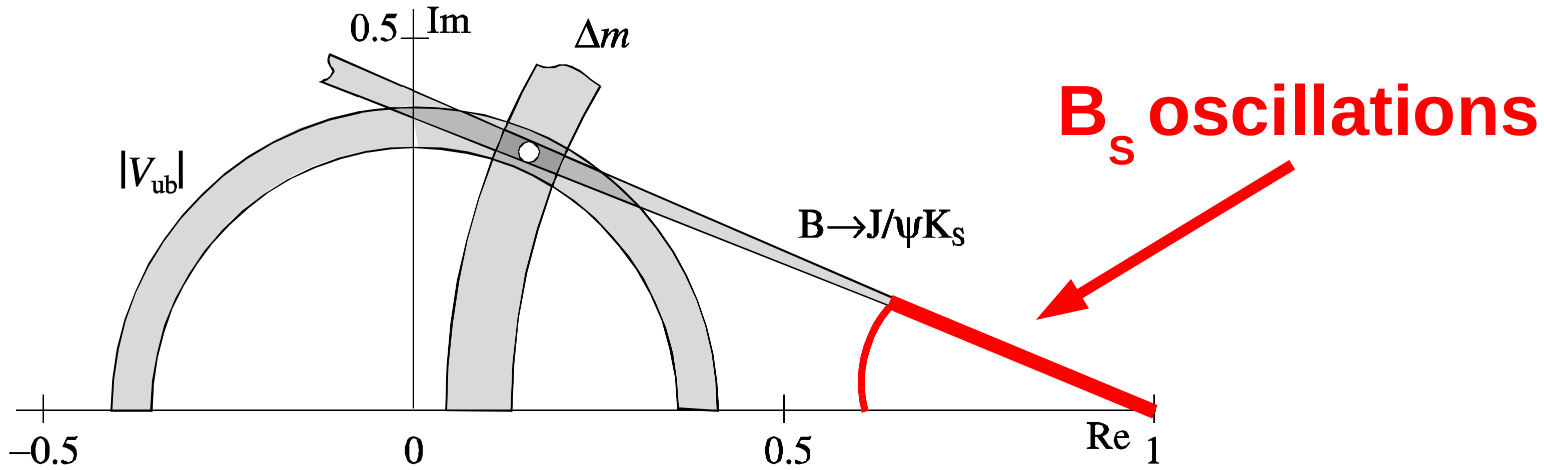
<u>Possible scenario:</u>



Possible CKM Scenarios

Want to overconstrain CKM triangle

Possible scenario:



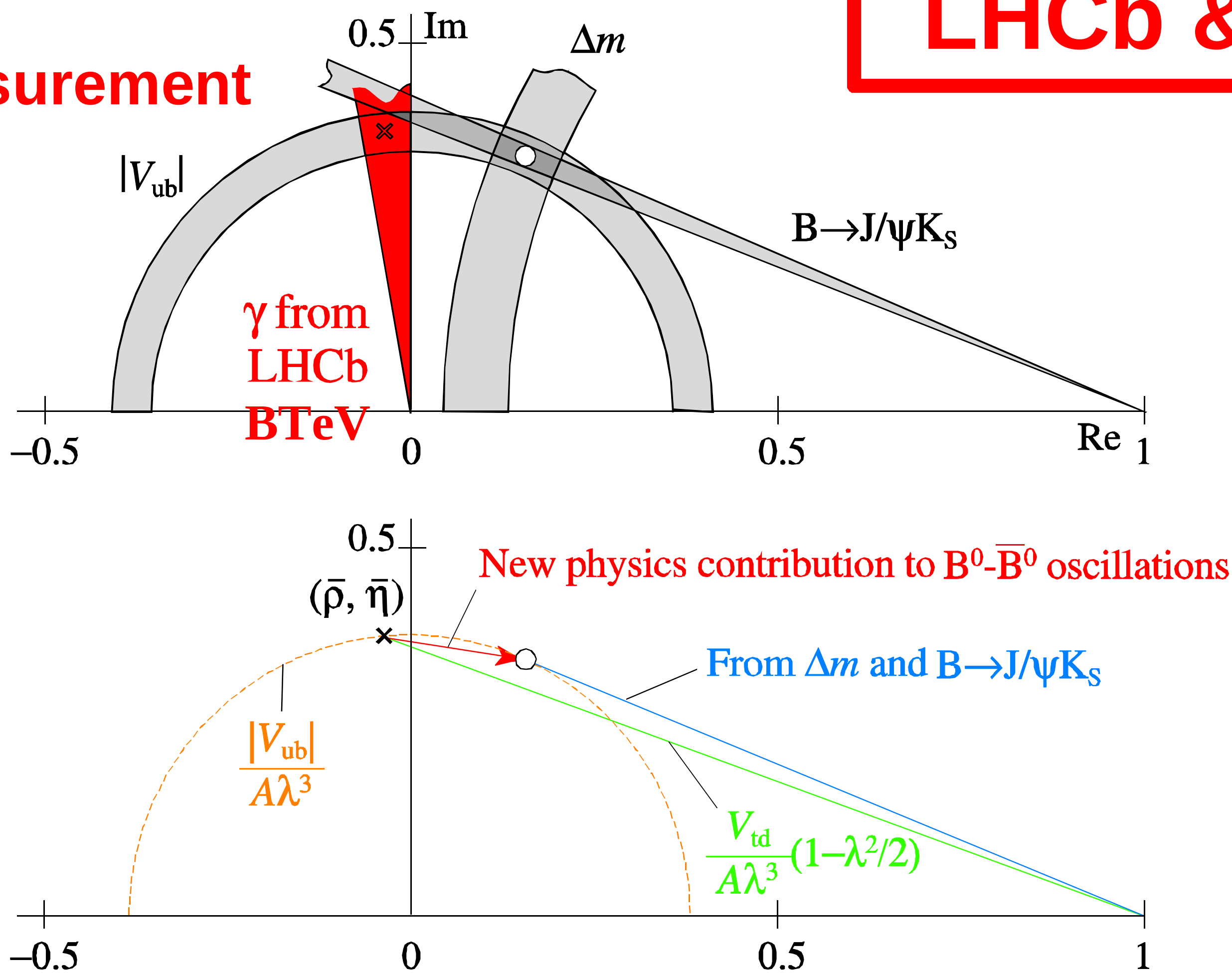
Possible CKM Scenarios

Want to overconstrain CKM triangle

Possible scenario:

Towards LHCb & BTeV

γ measurement



Conclusions

- **Wealth of new B physics results from CDF & D0**
  - D0 demonstrates very competitive B physics program in Run II
  - Many new results competitive with B factories
  - Negative pentaquark searches from CDF
- **CDF & D0 work towards measurement of B_S oscillations**
- **Looking forward to dedicated B physics experiments at a hadron collider (LHCb & BTeV)**