B Physics at CDF

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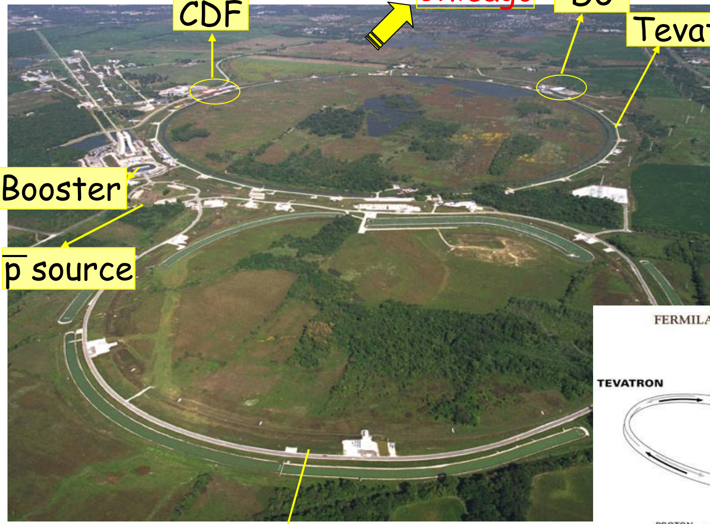
Outline:

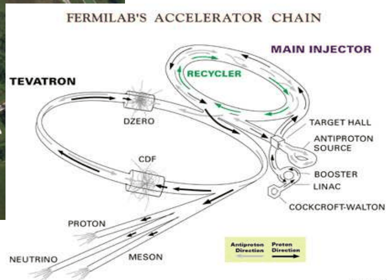
- The new detector and trigger
- Charm physics, what a surprise!
- b-meson and b-barion new measurements:
  - masses
  - lifetimes
- Towards the future:
  - B_s mixing
  - CP Violation
  - Rare B_s decay

(B_s mixing and CP Violation: } Branching Ratio measurements)

The New Machine

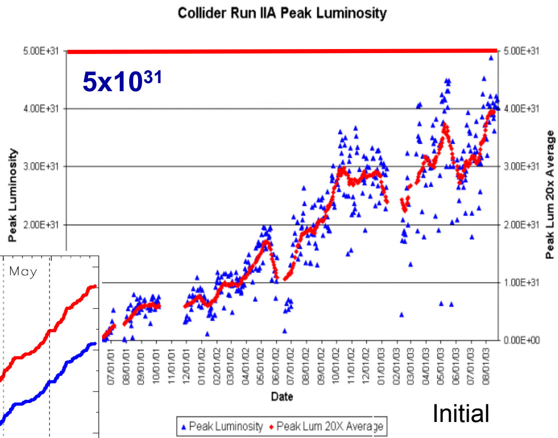


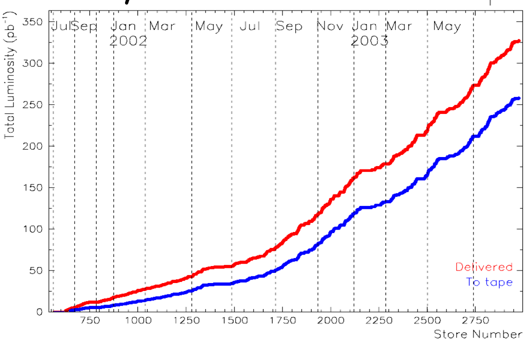
- L^{goal}_{peak}: ~$2\times10^{32} s^{-1} cm^{-2}$
- 36 bunches
- 396 ns crossing time
- $\sqrt{s}$ 1.8⇒1.96 TeV



TeV Luminosity (current situation)

- Peak luminosity
  - Best 5.2×10^{31}
- Delivered/on tape
  - 330/260 pb^{-1}
- ~ 200 pb^{-1} available for analysis now



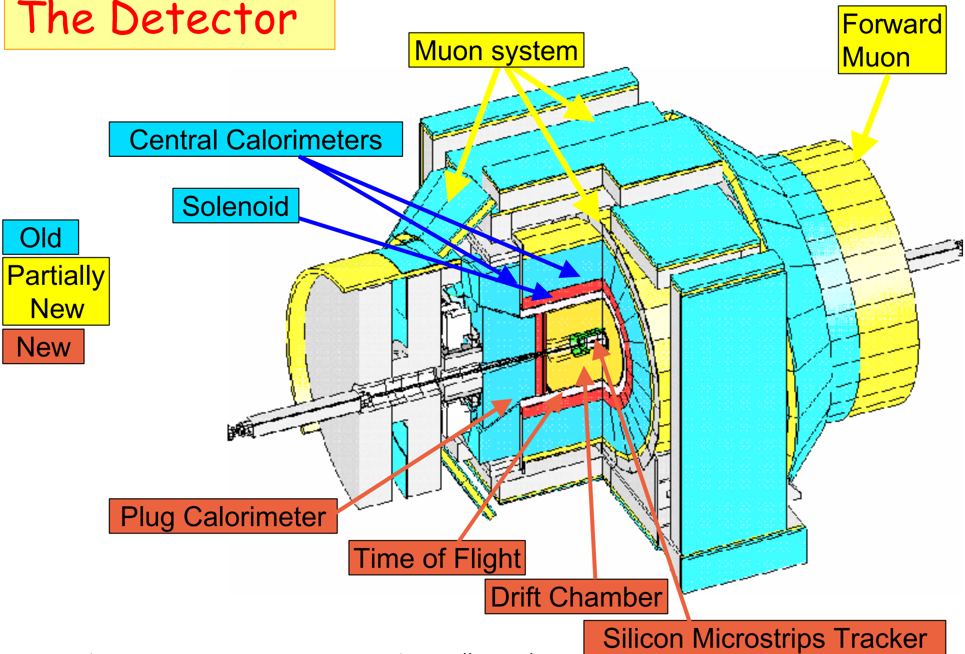


Initial instantaneous

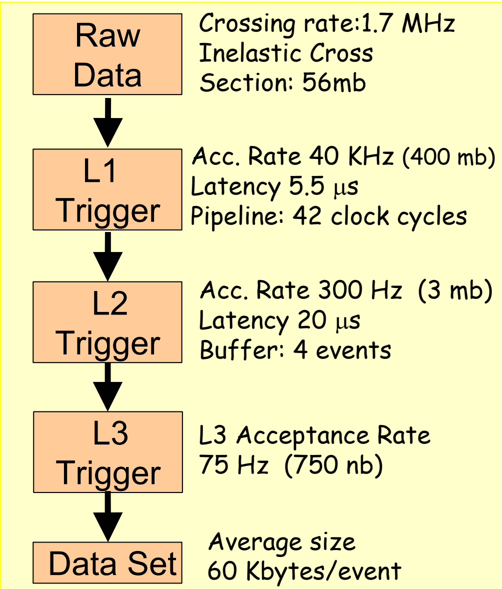
Integrated

Luminosity

The Detector



Trigger Overview



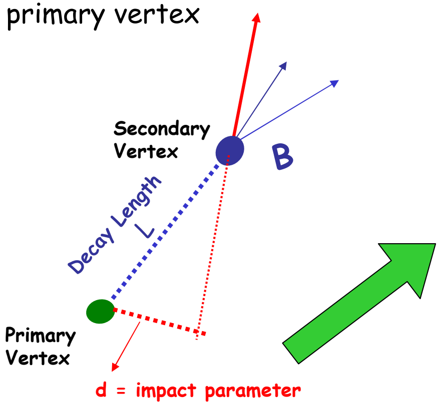
Level 1 synchronous streams:
- Calorimeter
- eXtremely Fast Tracker
- Muons

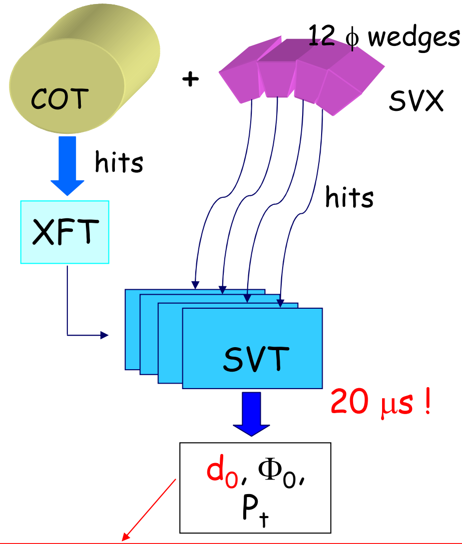
Level 2 asynchronous systems:
- Calorimeter Clustering
- Silicon Vertex Tracker
- Shower Maximum

Level 3:
- Offline-like

New displaced tracks trigger

Tracks coming from
B decays are displaced
respect to
primary vertex

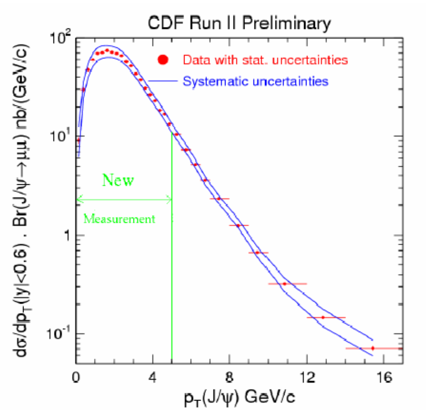




Good as offline (35 μm including beam spot)

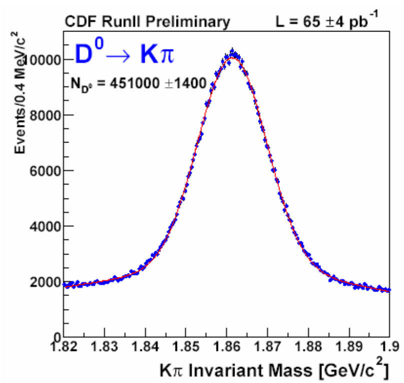
The charm physics at CDF

di-muons trigger



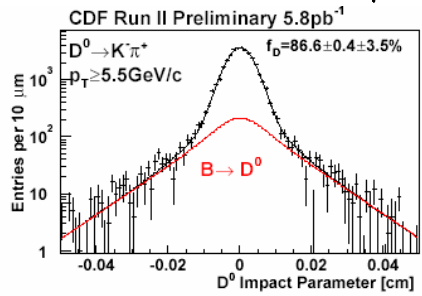
$\sigma(p\bar{p} \to J/\psi\ |y|<0.6) \cdot Br(J/\psi \to \mu\mu) =$ $240 \pm 1 \pm 30$ nb

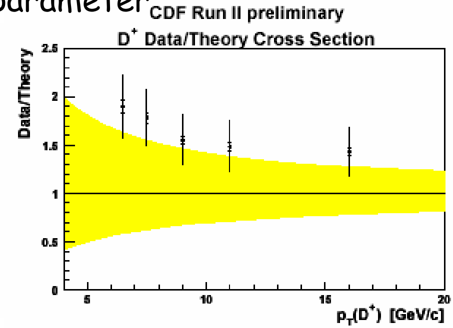
With SVT:
large samples of:
D^0, $D^\pm$, D_s, D^* …



The charm: D Cross Sections

Direct fraction from impact parameter

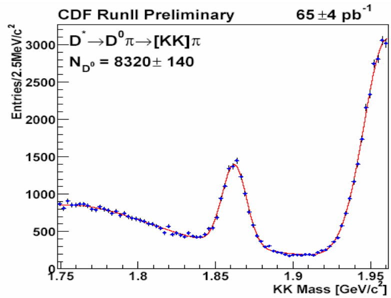


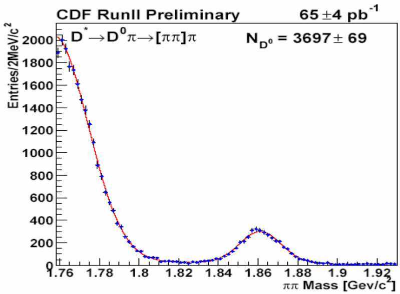


(D^0, $p_T > 5.5$GeV) = 13.3±0.2±1.5 μb
(D^{*+}, $p_T > 6$GeV) = 5.2±0.1±0.8 μb
(D^+, $p_T > 6$GeV) = 4.3±0.1±0.7 μb
(D^+_s, $p_T > 8$GeV) = 0.75±0.05±0.22 μb

CP Violation: Cabibbo suppressed D Decays

CP asymmetries for $D^0 \to KK$ and $D^0 \to \pi\pi$
Tag the flavor with D^*: $D^{*+} \to D^0\pi^+$ while $D^{*-} \to \bar{D}^0\pi^-$





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

FOCUS 2003: $(9.93 \pm 0.14 \pm 0.14)\%$

$\Gamma(D^0 \to \pi\pi)/\Gamma(D^0 \to K\pi) = (3.686 \pm 0.076 \pm 0.036)\%$

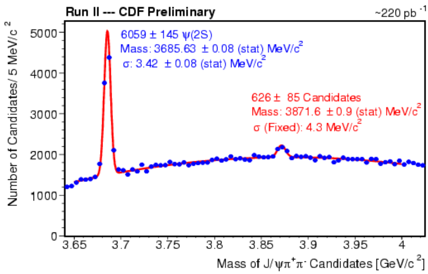
FOCUS 2003: $(3.53 \pm 0.12 \pm 0.06)\%$

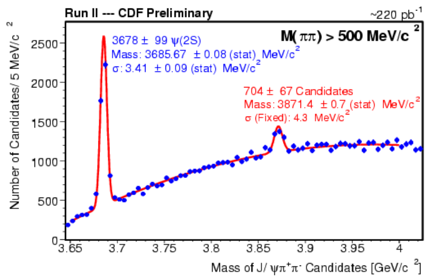
$A(D^0 \to KK) = (2.0 \pm 1.7 \pm 0.6)\%$ $A(D^0 \to \pi\pi) = (3.0 \pm 1.9 \pm 0.6)\%$

PDG: $(0.5 \pm 1.6)\%$ PDG: $(0.5 \pm 1.6)\%$

Hunting for new states: X(3872)

- Belle observes a new state $B \rightarrow XK \rightarrow J/\psi\ \pi^+\pi^- K$ final state of narrow width.
- Tevatron: this state produced directly, or via *B* decays.
- CDF observes this state at the same mass.
- Belle reports that $M(\pi\ \pi)$ distribution suggests a ρ resonance.
- CDF sees a preference for $M(\pi\ \pi) > 500MeV \Rightarrow$ needs to be finalized!

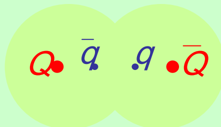




What is X(3872)?

Two leading candidates:

1. A c-cbar state $\Rightarrow$ like the 1 $^3D_2$ state
   $M(X)$= 3872 MeV/c^2 vs. $M(1^3D_2)$= 3810 MeV/c^2



2. D*D "molecule" (suggested by Belle)
   - $M(D^0) + M(D^{0*}) = 3871.2 \pm 1.0$ MeV
   - $X \rightarrow \chi_c \gamma$ not yet observed (large signal if $^3D_2$)
   - $X \rightarrow J/\psi\ \rho$ forbidden for $^3D_2$ state

Additional measurements to pin down the quantum numbers:

- Helicity angles
- $M_{\pi\pi}$ distribution (resonance structure)

Mass Measurements

Test of Heavy Quark Effective Theory (HQET)

- radiative corrections in expansions $\alpha_s(m_b)$ (perturbation theory)
- non-perturbative corrections with an expansion in powers of Λ_{QCD}/m_b

- Competitive measurements for B^0 and $B^\pm$

  $M(B^0) = 5280.30 \pm 0.92 \pm 0.96$ MeV

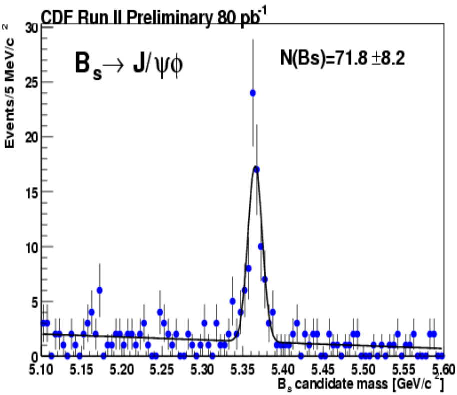
  $M(B^\pm) = 5279.32 \pm 0.68 \pm 0.94$ MeV

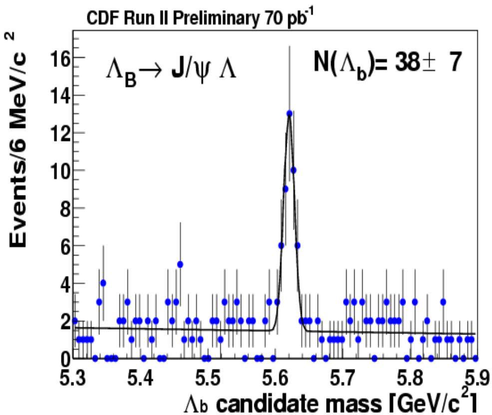
Mass Measurements

- World best measurements for B_s and Λ_b

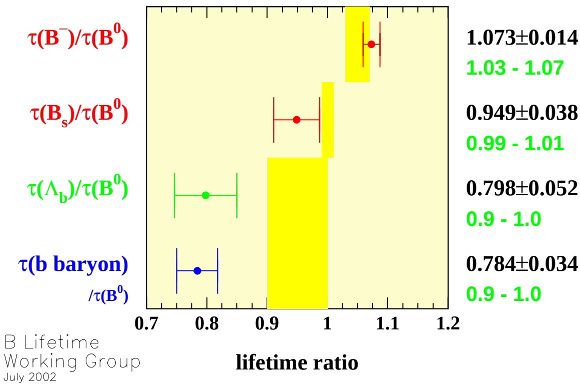
  $M(B_s) = 5365.50 \pm 1.29 \pm 0.94$ MeV

  $M(\Lambda_b) = 5620.4 \pm 1.6 \pm 1.2$ MeV





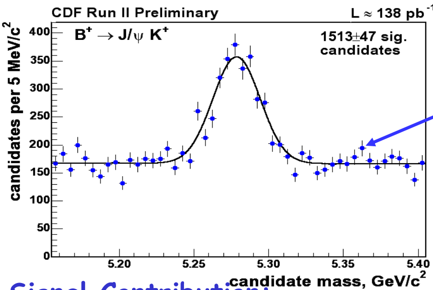
Lifetimes: Data -Theory



To explain the large experimental differences hard spectator effects necessary, soft interactions contributes $\leq 2\%$

Lifetimes: the method

Check the $B^{\pm}$ and B^0 lifetimes against Babar/Belle

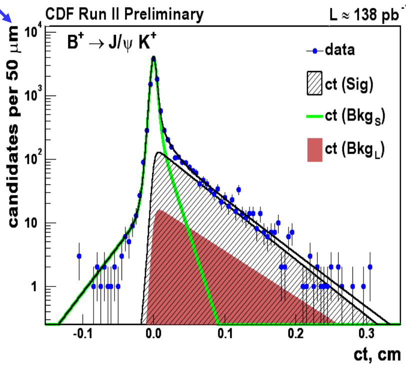


Fit Method:

Simultaneous fit of

M(B)→signal fraction, define sidebands

cτ(B)→lifetime



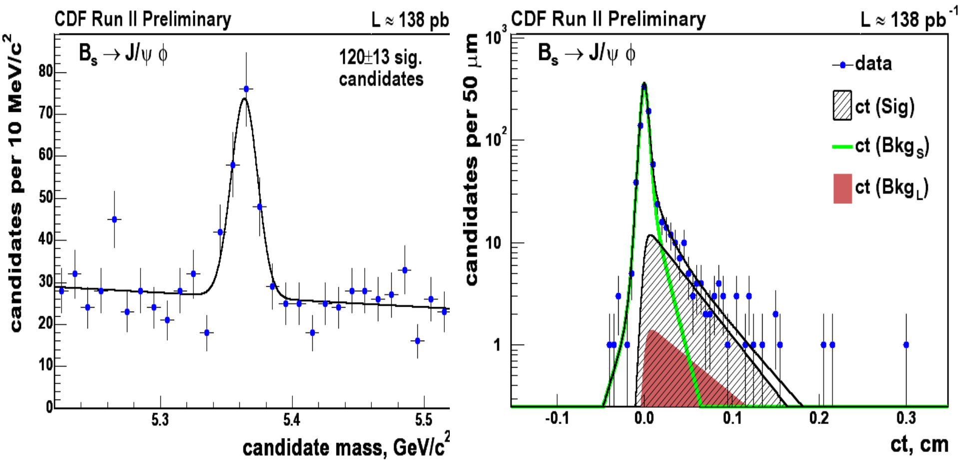
Signal Contribution:

$$F_{sig} = \frac{1}{c\tau}\exp\left(\frac{-t}{c\tau}\right) \otimes G(t, s\sigma_i)$$

Background Parameterisation:

$$F_{bkg} = \begin{pmatrix} (1 - f_- - f_+ - f_{++})\delta(t) \\ + \frac{f_-}{c\tau_-}\exp\left(\frac{t}{c\tau_-}\right) + f_+ \frac{f_+}{c\tau_+}\exp\left(\frac{-t}{c\tau_+}\right) \\ + \frac{f_{++}}{c\tau_{++}}\exp\left(\frac{-t}{c\tau_{++}}\right) \end{pmatrix} \otimes G(t, s\sigma_i)$$

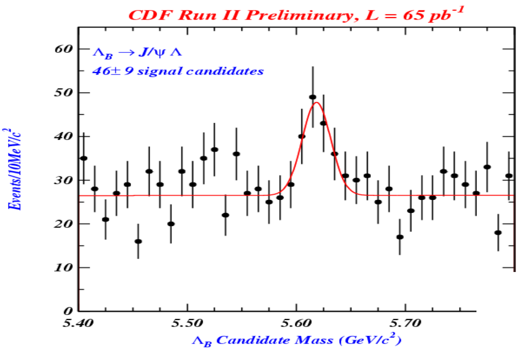
New results: B^0_s Lifetimes



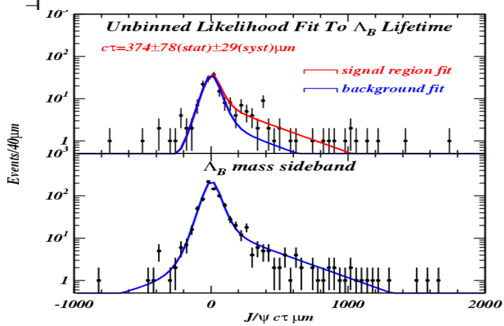
$\tau = 1.33 \pm 0.14(\mathit{stat}) \pm 0.02(\mathit{syst})$ ps

(uncorrected for CP composition)

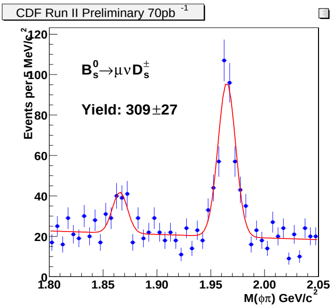
New results: Λ_b Lifetimes



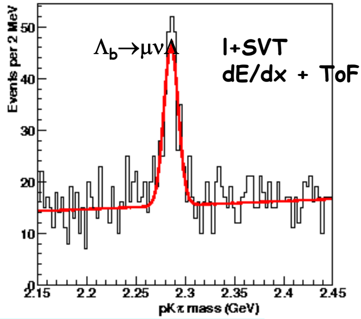
1.25 ± 0.26 ± 0.10 ps



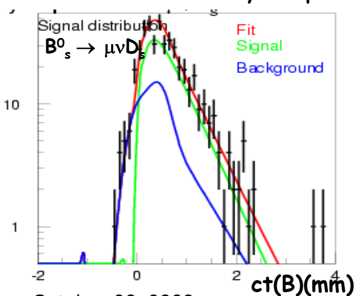
Semileptonic Lifetimes



Signal to noise ratio better than expected !



CDF Run II Preliminary 70pb^{-1}



$$c\tau = \frac{L_{xy}}{\beta\gamma} = \frac{L_{xy}\ m(B)}{P_T(lD)} K,\ K = \frac{P_T(lD)}{P_T(B)}$$

k- factor from Monte Carlo
One more complication: lifetime bias from SVT

Fit results show discrepancy with PDG world average keep investigating

Lifetimes Summary

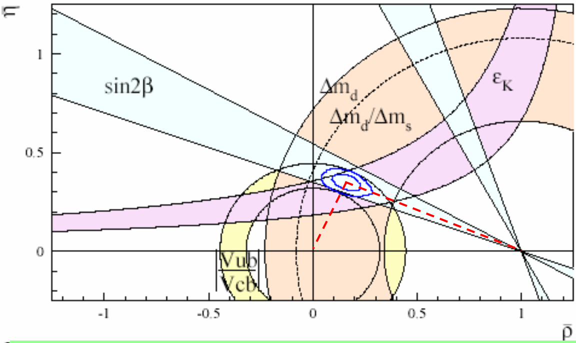
	CDF	World average
B^+	$1.63 \pm 0.05 \pm 0.04$ ps	1.671 ± 0.018 ps
B^0_d	$1.51 \pm 0.06 \pm 0.02$ ps	1.542 ± 0.016 ps
B^0_s	$1.33 \pm 0.14 \pm 0.02$ ps	1.461 ± 0.057 ps
Λ_b	$1.25 \pm 0.26 \pm 0.10$ ps	1.233 ± 0.077 ps

Lepton + displaced SVT measurement in progress high statistics sample

Measurements of polarization states in B^0_s decay and of $\Delta\Gamma_s/\Gamma_s$ → in progress

Future 2 fb^{-1}: $\sigma(\Delta\Gamma_s/\Gamma_s)$~few % ($B_s \to J/\psi$, $B_s \to D_s\pi$, $B_s \to D_s l\nu$)

Standard Model: global fit



Results:

$\bar{\rho}$= 0.162 ± 0.046
$\bar{\eta}$= 0.347 $^{+0.029}_{-0.026}$

sin2β = 0.705 ± 0.035
sin2α = -0.13 $^{+0.28}_{-0.23}$
γ = 64.5 $^{+7.5}_{-6.5}$

Test of the CP violation within the Standard Model:
sin2β = 0.658±0.054 (CKM fit excluding sin2β and ε_K)
sin2β = 0.734±0.055 (direct measurement)

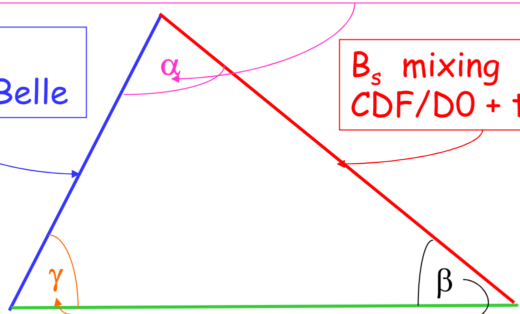
Δm_s predictions:
$\Delta m_s = 20.9^{+3.9}_{-4.3}$ ps^{-1}

The Unitarity Triangle

$B \to \pi\pi$ (Babar/Belle/CDF?) Serious theoretical problem
$B \to \pi\rho$, $B \to \rho\rho$ (Babar/Belle/CDF??)

$b \to u l \nu$
CLEO/Babar/Belle

B_s mixing
CDF/D0 + theory



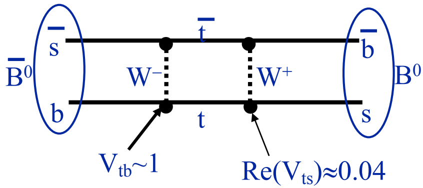
$B^+ \to D^0 K^+$ (Babar/Belle/CDF)
$B_s \to D_s^- K^+$ (CDF eventually??)
$B_s \to KK$ (CDF??)

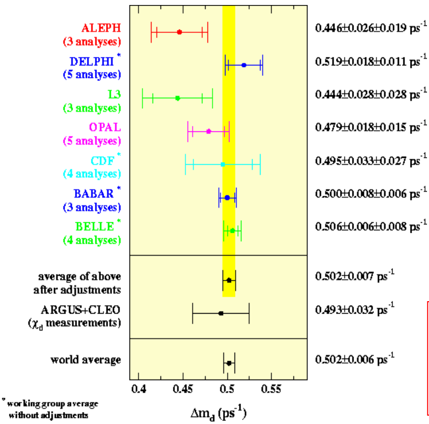
$B \to J/\psi\ Ks$
Babar/Belle
Still interesting??

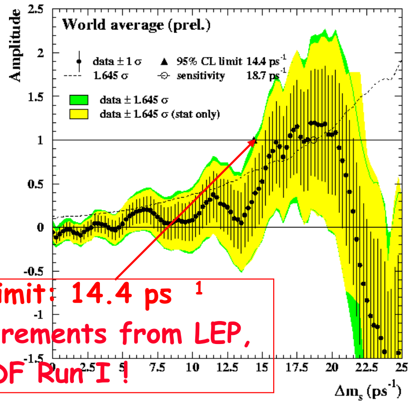
B_d and B_s Mixing Frequencies

B_s oscillation much faster than B_d because of coupling to top quark:

$Re(V_{ts}) \approx 0.040 > Re(V_{td}) \approx 0.007$







Current limit: 14.4 ps-1

13 measurements from LEP, SLD & CDF Run I !

Towards B_s Mixing

- B_s or $\overline{B}_s$ at the time of production?
  - Initial state flavor tagging
  - Tagging "dilution": D=1-2w D=1  D=0 
  - Tagging power proportional to: εD^2

Typical power (one tag):
εD^2 ~(1%) at Tevatron
εD^2 ~(10%) at PEPII/KEKB

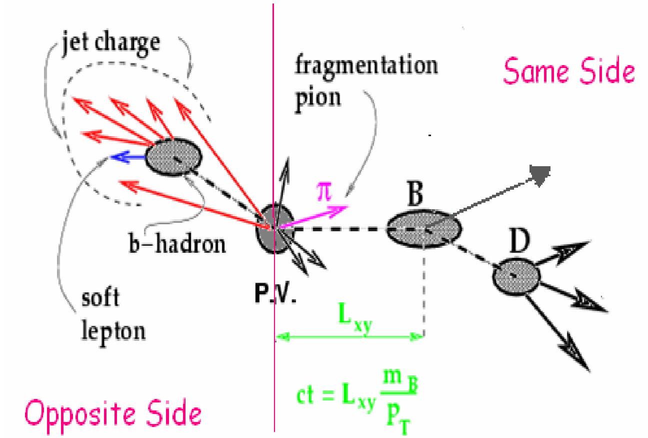
- B_s or $\overline{B}_s$ at the time of decay?
  - Final state flavor tagging
  - Can tell from decay products (e.g. $B_s \rightarrow D_s^- \pi^+$)
- Yields
  - Need lots of decays (because flavor tagging imperfect)
- Proper decay time

$$ct = \frac{L_{xy}}{(\beta\gamma)} = \frac{L_{xy} m_B}{p_T}$$

uncertainty →

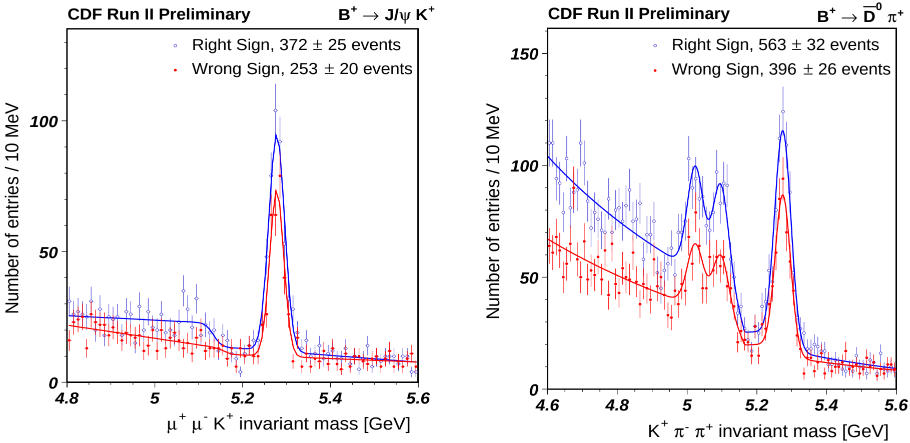
$$\sigma_{ct} = \frac{m_B}{p_T}\sigma_{L_{xy}} \oplus ct\left(\frac{\sigma_{p_T}}{p_T}\right)$$

Towards B_s Mixing: Flavor tagging



Strategy: use data for calibration
(*e.g.* $B^{\pm}\to J/\psi K^{\pm}$, $B^{\pm}\to D^0\pi^{\pm}$, $B\to l^+X$) "know" the answer, can measure right sign and wrong sign tags

Flavor tagging: Same side

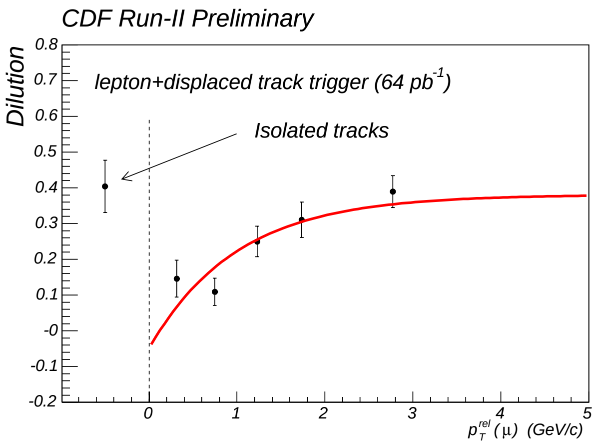


εD^2=(2.4±1.2)% ($B^\pm \to J/\psi K^\pm$) εD^2=(1.9±0.9)% ($B^\pm \to D^0\pi^\pm$)

$B^+/B^0/B_s$ correlations are different ⇒ need optimization for B_s i.e. kaon tagging

Flavor tagging: Opposite Side

Lepton tagging: εD^2=(0.7±0.1)% (l + SVT)

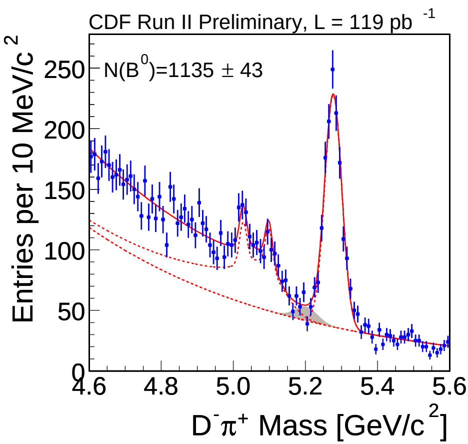


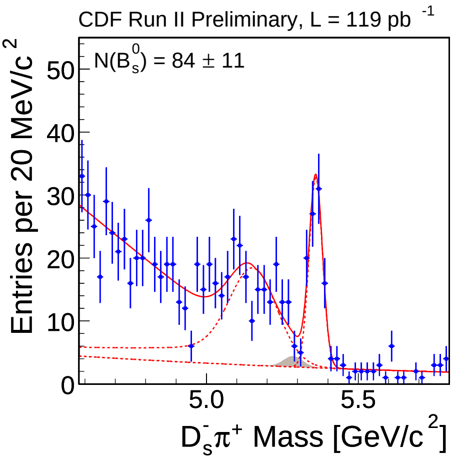
$B_s \to D_s\pi$ $D_s \to \varphi\pi$ Yield

$$\frac{N(B_s)}{N(B_d)} = \frac{f_s}{f_d}\,\frac{\varepsilon_s}{\varepsilon_d}\,\frac{Br(B_s \to D_s^-\pi^+)\;Br(D_s^- \to \varphi\pi^-)\;Br(\varphi \to k^+k^-)}{Br(B_d \to D^-\pi^+)\;Br(D^- \to k^+\pi^-\pi^-)}$$

Monte Carlo

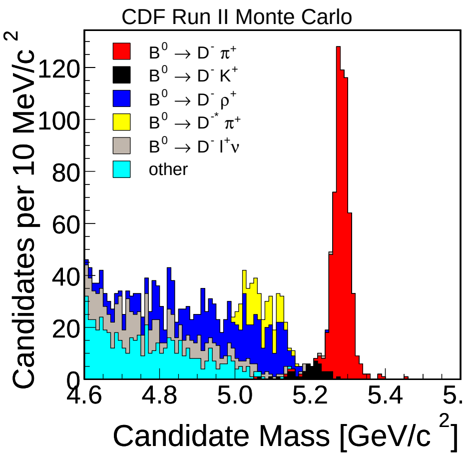
PDG

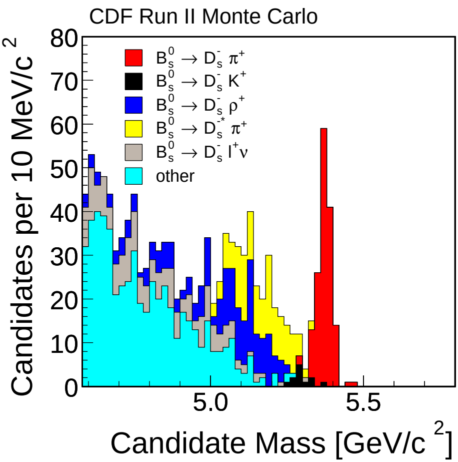




$B_s \to D_s \pi$ $D_s \to \varphi \pi$ Yield

Big effort in a full detector and trigger simulation optimization “à la LEP” to measure the efficiencies





$B_s \to D_s\pi$ $D_s \to \varphi\pi$ Yield result

New Result !

$$\frac{f_s}{f_d}\,\frac{Br(B_s \to D_s^- \pi^+)}{Br(B_d \to D^- \pi^+)} = 0.35 \pm 0.05(\text{stat.}) \pm 0.09(\text{Br.}) \pm 0.04(\text{syst.})$$

$$\frac{Br(B_s \to D_s^- \pi^+)}{Br(B_d \to D^- \pi^+)} = 1.4 \pm 0.2(\text{stat.}) \pm 0.2(\text{syst.}) \pm 0.4(\text{Br.}) \pm 0.2(\text{Pr.})$$

B_s Mixing sensitivity

- From data, now have some knowledge of the pieces that go into measuring Δm_s
  - *Yields* — *S = # signal events*
  - *Flavor tagging* — *tagging power = εD^2*
  - *Signal-to-noise* — *S/B = signal/background*
  - *Proper time resolution* — *σ_t = proper time resolution*
- The sensitivity formula:

$$Significance = \sqrt{\frac{S\varepsilon D^2}{2}} e^{-\frac{(\Delta m_s \sigma_t)^2}{2}} \sqrt{\frac{S}{S+B}}$$

- Significance (in number of standard deviations) is "average significance"

B_s Mixing sensitivity: hadronic decays

Ingredients:

- σ_t= 67 (45) fs
- εD^2 = 4% (11%)
- S/B = 2:1 (2:1)
- S= 1600/fb^{-1} (8000) (only $B_s \rightarrow D_s\pi$ $D_s \rightarrow \varphi\pi$)

  used $(f_s/f_d)^{CDF}$=0.427 $(f_s/f_d)^{PDG}$=0.232

  missing reconstruction efficiencies

2σ sensitivity for Δm_s =15ps^{-1} with ~0.5fb^{-1} of data

This is not the end of the story, we can improve…

B_s Mixing sensitivity: hadronic decays cont'd

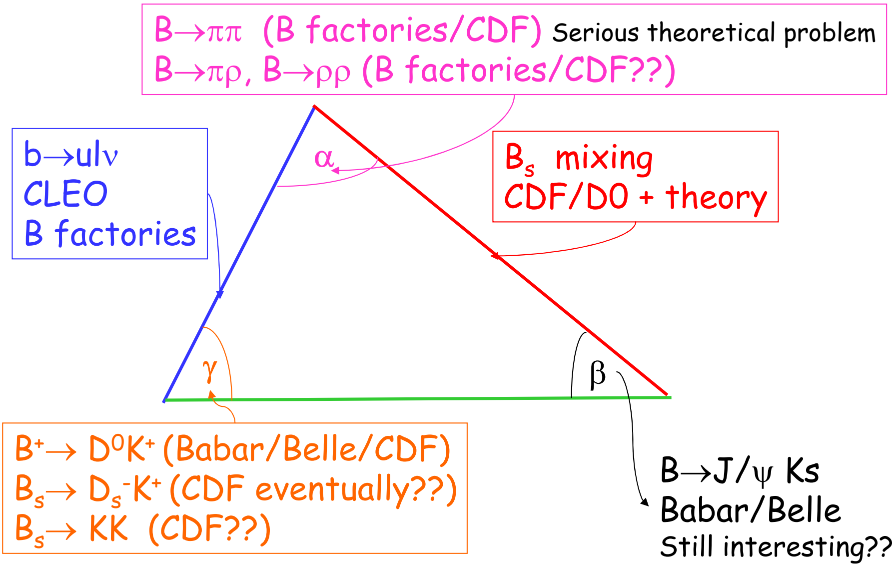
...but let's be conservative

- σ_t= 50 fs $\rightarrow$ (event-by-event vertex + L00)
- εD^2 = 5% $\rightarrow$ (kaon tagging)
- S/B = 2:1 $\rightarrow$ (unchanged)
- S= 2000/fb^{-1} $\rightarrow$ (add 3π, improve trigger efficiency)

5σ sensitivity for Δm_s =18ps^{-1} with ~1.7fb^{-1} of data
5σ sensitivity for Δm_s =24ps^{-1} with ~3.2fb^{-1} of data

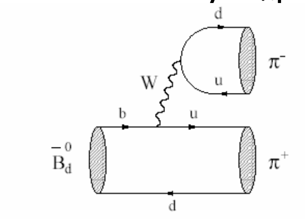
Δm_s=24ps ^{1} "covers" the expected region based upon indirect fits.

The Unitarity Triangle



B → hh: α(?) and γ

$B^0 \to h^+h^-$ decay amplitudes:



+

Following the Fleischer idea: PLB 459 (1999), 306
Separate A_{CP} components into $B^0 \to \pi\pi$ ($sin2\alpha_{eff}$) and $B_s \to kk$ ($sin2\gamma$) (U-spin symmetry assumed)

Small

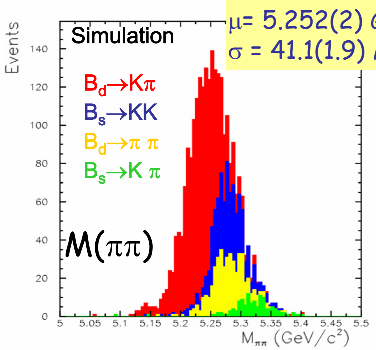
$$A_{CP}(B^0) = A_{CP}^{\rm dir} \cos \Delta m_d t + A_{CP}^{\rm mix} \sin \Delta m_d t$$

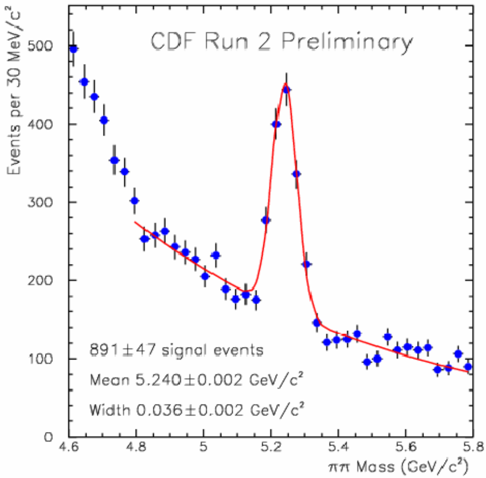
$$A_{CP}(B_s) = A_{CP}^{\rm dir} \cos \Delta m_s t + A_{CP}^{\rm mix} \sin \Delta m_s t$$

Large but unknown

B → hh: Sample composition

μ= 5.252(2) GeV/c^2
σ = 41.1(1.9) MeV/c^2





Mixture of:

$B_d \rightarrow \pi\pi$
$B_d \rightarrow \pi k$
$B_s \rightarrow k\pi$
$B_s \rightarrow kk$

Difficult separation: can't use ToF dE/dx ~1.16σ

Separate on statistical base

$B \rightarrow hh$: Sample separation

Use a multidimensional unbinned likelihood fit

For each particle use:

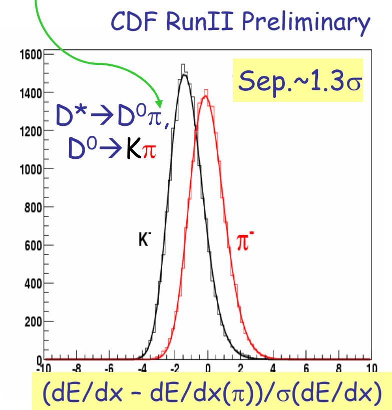
dE/dx (Calibrated on D^*)

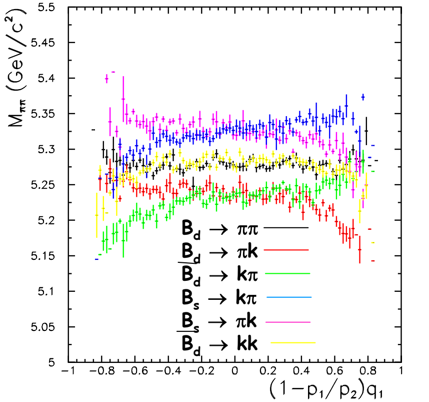
Kinematics: $m(\pi\pi)$ and α

Pion momenta: p1<p2

$\alpha = (1-p1/p2)\cdot q1$

Charge of N° 1





$B \to hh$: Results

First observation of $B_s \to KK$

Mode	Yield ($65pb^{-1}$)
$B_d \to K\pi$	148±17(stat)±17(syst)
$B_d \to \pi\pi$	39±14(stat)±17(syst)
$B_s \to kk$	90±17(stat)±17(syst)
$B_s \to k\,\pi$	3±11(stat)±17(syst)

$$\frac{Br(B_s \to kk)}{Br(B_d \to K\pi)} = 2.71 \pm 1.15$$ includes error on f_s/f_d

Self-tagged $B_d^0 \to K^+\pi^-$:
time integrated A_{CP} :

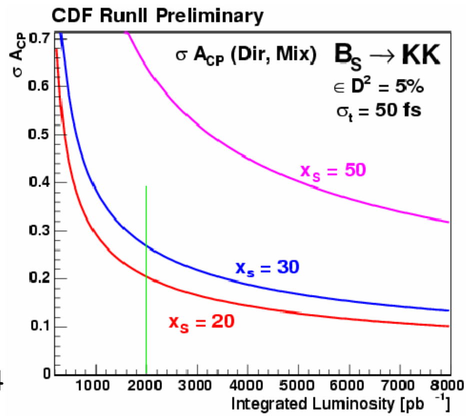
$$A_{CP}(B_d \to K\pi) = 0.02 \pm 0.15(stat) \pm 0.02(sys)$$

Systematic error comparable to B factories

$B \to hh$: The future

Mode	Yield ($2\ fb^{-1}$)	Yield ($3.5\ fb^{-1}$)
$B_d \to K\pi$	6700	11,725
$B_d \to \pi\pi$	1770	3097
$B_s \to kk$	4040	7070
$B_s \to k\,\pi$	1070	1870

$x_s = \Delta m_s \cdot \tau_{Bs}$
$x_s = 20 \to \Delta m_s \sim 14$
$x_s = 30 \to \Delta m_s \sim 21$
$x_s = 50 \to \Delta m_s \sim 34$



$B_s \to \mu^+\mu^-$ Search

FCNC are forbidden at tree level in the Standard Model
The expected BR ~10^{-9}

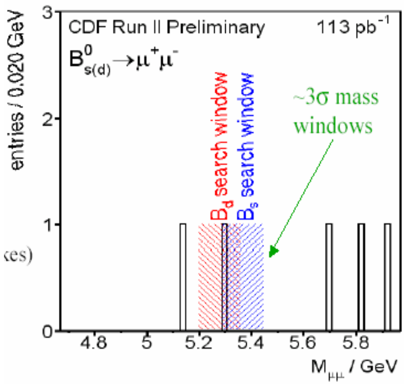
Many SUSY Models predicts a large enhancement in the branching ratio (~10^{-6}). The rate is proportional to $\tan(\beta)^6$.

If decay is observed soon $\Rightarrow$ new physics
If decay is not seen $\Rightarrow$ put a tight constraint on $\tan(\beta)$ and rule out some SUSY models

THIS IS A WIN-WIN SITUATION

$B_s \to \mu^+\mu^-$: Results

- It was a blind analysis
- Figure of merit for optimization: expected 95% CL upper limit on the branching ratio
- 1 event observed in the search window with an expected background of 0.54 ± 0.2 events
  (background is dominated by non-resonance fakes)

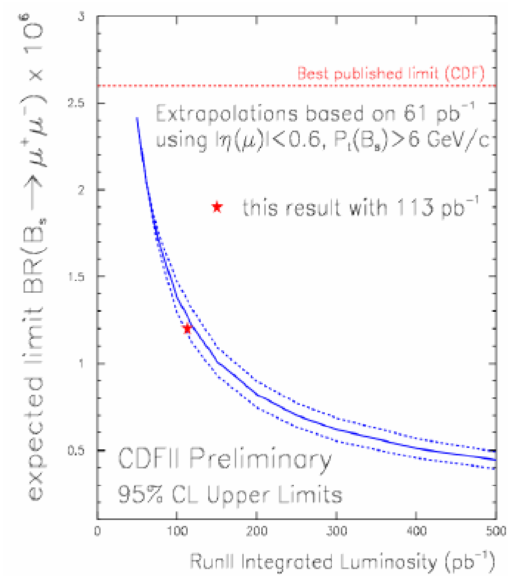


- The limit on the branching ratio:
  (based on 113pb-1 of data)
  $Br(B_s \to \mu\mu) < 9.5\times10^{-7}$ @ 90% CL
  $Br(B_s \to \mu\mu) < 1.2\times10^{-6}$ @ 95% CL

Factor 2 better than published limit !!

$B_s \to \mu^+\mu^-$: Projections

Theorists are very interested in the experimental progress of this analysis.



Conclusion

- New measurements of lifetimes, masses, Branching Ratio and rare decays for b-hadron
  New results for the winter conferences

- First measurements on charm physics
  (new and unexpected, we have to understand our capabilities)

- B_s mixing and CP violation are high precision measurements ⇒ we need time, statistics and students!

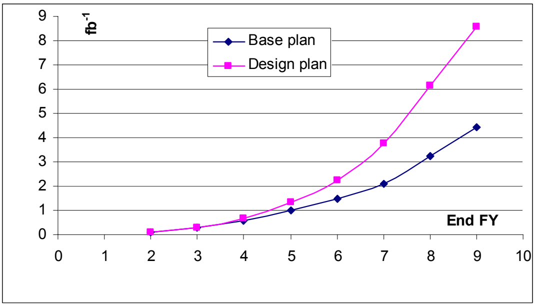
"Anyone who keeps the ability to see beauty never grows old"

(F. Kafka)

Backup slides

Extended Tevatron goals

- Fermilab has scaled down its plans for luminosity in June 2003
  - Silicon upgrade canceled!
    - No long shutdown in 2005
  - Design plan max luminosity: 2.94×10^{32}
- No recycler ~ base plan



Year	Base plan luminosity/ yr (fb^{-1})	Design plan Luminosity/ yr (fb^{-1})
FY02	0.08	0.08
FY03	0.20	0.22
FY04	0.31	0.38
FY05	0.39	0.67
FY06	0.50	0.89
FY07	0.63	1.53
FY08	1.14	2.37
FY09	1.16	2.42
Total	4.41	8.56

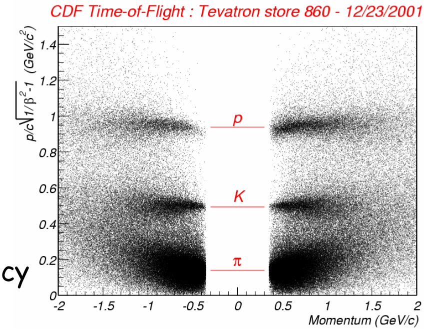
TOF performance

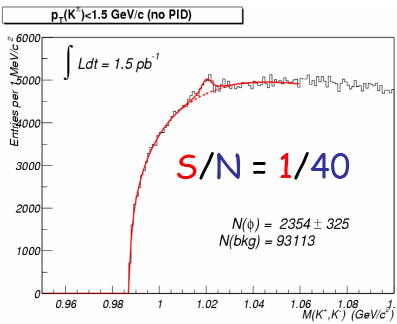
- TOF resolution (110ps) within 10% of design value

Background reduction in φ →**KK:**

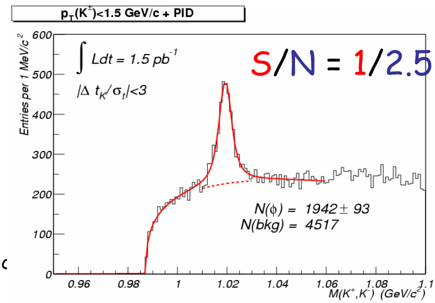
Low P_T (< 1.5 GeV/c) track pairs before and after a cut on TOF kaon probability

x20 bkg reduction, 80% signal efficiency



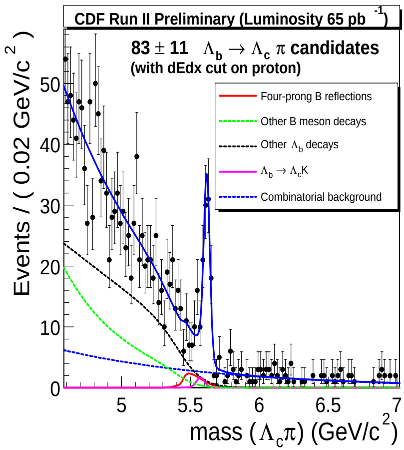


with TOF PID →



atella Luc

$\Lambda_b \to \Lambda_c \pi$ with $\Lambda_c \to pK\pi$



Backgrounds: real *B* decays

Reconstruct p as π: $B_d \to D^- \pi^+ \to K^+ \pi^- \pi^- \pi^+$

- Use MC to parametrize the shape.
- Data to normalize the amplitude
- Dominant backgrounds are real heavy flavor
- proton particle ID (*dE/dx*) improves S/B

Fitted signal:

$$N_{\Lambda_b} = 96 \pm 13(stat.)^{+6}_{-7}(syst.)$$

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

New Result !

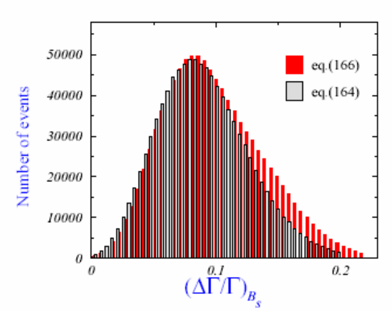
$BR(\Lambda_b \to \Lambda_c p^{\pm}) = (6.0 \pm 1.0(stat) \pm 0.8(sys) \pm 2.1(BR))\ 10^{-3}$

B_s, $\Delta\Gamma/\Gamma$

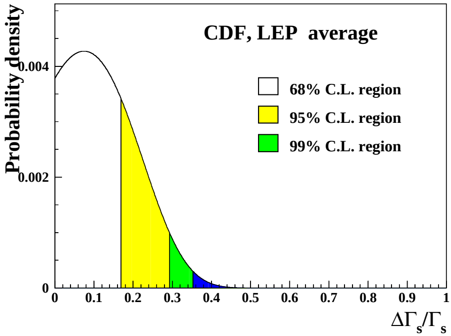
Definition: $1/\tau_{B_s} = \Gamma = (\Gamma_{long} + \Gamma_{short})/2 \quad \Delta\Gamma = \Gamma_{long} - \Gamma_{short}$

B_s Theoretical prediction:

$\Delta\Gamma/\Gamma < 0.29$ at 95% CL

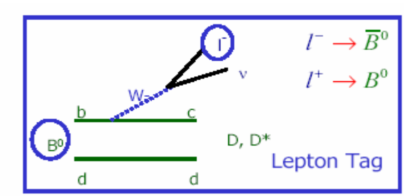


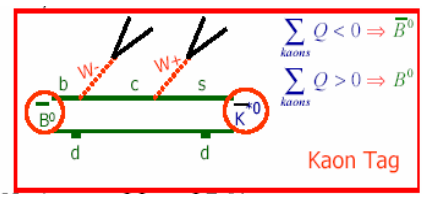
$\Delta\Gamma/\Gamma = 0.07^{+0.09}_{-0.07}$



Towards B_s Mixing: Flavor tagging cont'd

- Opposite side tagging: identify the flavor of the other B

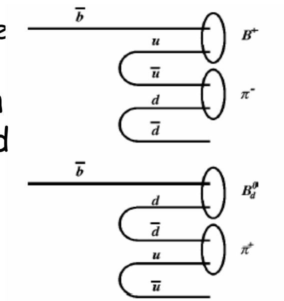




search for a lepton or kaon coming from B decay

reconstruct the "other b" charge

- Same side tagging: infer the production B flavor from particle charge produced "close" to the B:
  - fragmentation tracks
  - B^{**} production and $B^{**} \rightarrow B^0\pi$



B_s $\Delta\Gamma/\Gamma$ the future

CDF 2fb^{-1}:

4,000 $B_s \to J/\psi\phi$ $\sigma(\Delta\Gamma/\Gamma)$=0.05 if CP_{even}= 0.77
$\sigma(\Delta\Gamma/\Gamma)$=0.08 if CP_{even}= 0.5

75,000 $B_s \to D_s\pi$ measure $1/\Gamma$

2,500 $B_s \to D^+_s D^-_s$ CP even combined with $1/\Gamma$
$\sigma(\Delta\Gamma/\Gamma)$=0.06

More precise measurements at future experiments

CP violation: introduction

$$A(\overline{B} \to \overline{f}) = e^{+i\varphi_1}|A_1|e^{i\delta_1} + e^{+i\varphi_2}|A_2|e^{i\delta_2}$$

$$A(B \to f) = e^{-i\varphi_1}|A_1|e^{i\delta_1} + e^{-i\varphi_2}|A_2|e^{i\delta_2},$$

Where

- $|A_{1,2}|e^{i\delta_{1,2}}$ CP conserving strong amplitudes
- $\varphi_{1,2}$ CP violating CKM phases

"Direct CP" violation:

$$\mathcal{A}_{CP} \equiv \frac{\Gamma(B \to f) - \Gamma(\overline{B} \to \overline{f})}{\Gamma(B \to f) + \Gamma(\overline{B} \to \overline{f})} = \frac{|A(B \to f)|^2 - |A(\overline{B} \to \overline{f})|^2}{|A(B \to f)|^2 + |A(\overline{B} \to \overline{f})|^2}$$

$$= \frac{2|A_1||A_2|\sin(\delta_1 - \delta_2)\sin(\varphi_1 - \varphi_2)}{|A_1|^2 + 2|A_1||A_2|\cos(\delta_1 - \delta_2)\cos(\varphi_1 - \varphi_2) + |A_2|^2}$$

CP violation due to interference

Need to measure $\varphi_1 - \varphi_2$ but hadronic uncertanties

CP violation: mixing induced

$$\Gamma(\overset{(-)}{B^0_q}(t) \to f) = \left[\left| g_{\mp}^{(q)}(t) \right|^2 + \left| \xi_f^{(q)} \right|^2 \left| g_{\pm}^{(q)}(t) \right|^2 - 2\,\mathrm{Re}\left\{ \xi_f^{(q)} g_{\pm}^{(q)}(t) g_{\mp}^{(q)}(t)^* \right\} \right] \Gamma_f$$

where:

$$g_{+}^{(q)}(t)\, g_{-}^{(q)}(t)^* = \frac{1}{4}\left[e^{-\Gamma_{\mathrm{L}}^{(q)} t} - e^{-\Gamma_{\mathrm{H}}^{(q)} t} - 2\,i\,e^{-\Gamma_q t} \sin(\Delta M_q t) \right]$$

$$\left| g_{\mp}^{(q)}(t) \right|^2 = \frac{1}{4}\left[e^{-\Gamma_{\mathrm{L}}^{(q)} t} + e^{-\Gamma_{\mathrm{H}}^{(q)} t} \mp 2\,e^{-\Gamma_q t} \cos(\Delta M_q t) \right]$$

and Γ_f is the unevolved $B^0_q \to f$ rate

Rate for $\overset{(-)}{B^0_q}(t) \to \overline{f}$ follows $\Gamma_f \to \Gamma_{\overline{f}}$, $\xi_f^{(q)} \to \xi_{\overline{f}}^{(q)}$

$$\xi_f^{(q)} = e^{-i\Theta_{M_{12}}^{(q)}} \frac{A(\overline{B^0_q} \to f)}{A(B^0_q \to f)} \qquad \xi_{\overline{f}}^{(q)} = e^{-i\Theta_{M_{12}}^{(q)}} \frac{A(\overline{B^0_q} \to \overline{f})}{A(B^0_q \to \overline{f})}$$

$\Theta_{M_{12}}^{(q)}$ Is the CP violating weak phase

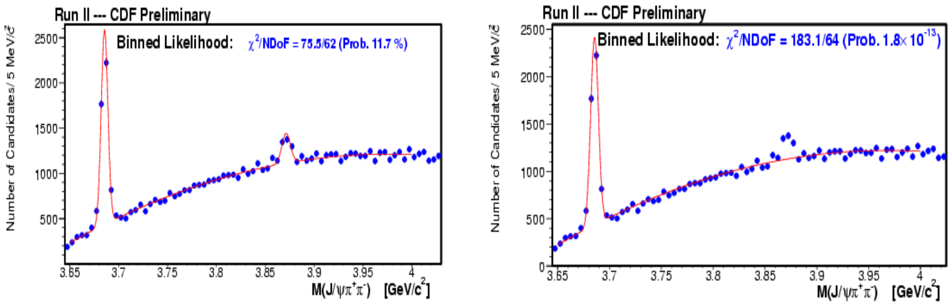
CP violation: mixing induced

If :

- f is CP eigenstate
- the amplitude for direct CP, $A_{CP}^{dir}=0$
- the amplitude due to $\Delta\Gamma$, $A_{CP}^{\Delta\Gamma}=0$

$$a_{\mathrm{CP}}(t) \equiv \frac{\Gamma(B_q^0(t) \to f) - \Gamma(\overline{B_q^0}(t) \to \overline{f})}{\Gamma(B_q^0(t) \to f) + \Gamma(\overline{B_q^0}(t) \to \overline{f})} = \pm \sin\phi \, \sin(\Delta M_q t)$$

Hunting for new states: X(3872) cont'd

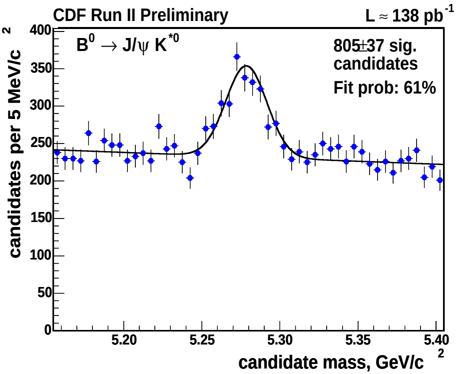


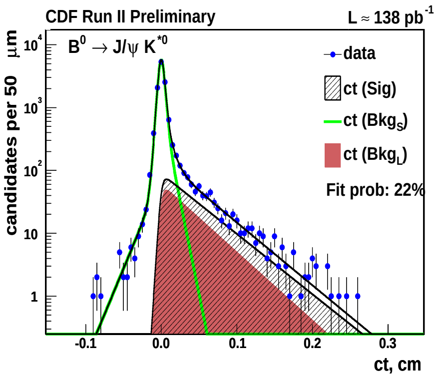
- Fit with and without a Gaussian for the X(3872) yields a significance of more than 10σ.
- Note relatively large cross section (times branching fraction) compared to the $\psi(2s)$.

New results: B^0 Lifetimes

$B^0 \to J/\psi K^*$ Control channel for $B_s \to J/\psi\varphi$

$B^0 \to J/\psi Ks$ Control channel for $\Lambda \to J/\psi\Lambda$





$\tau = 1.51 \pm 0.06(\mathit{stat}) \pm 0.02(\mathit{syst})$ ps