Other B physics at the Tevatron

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On behalf of the CDF and DØ Collaborations

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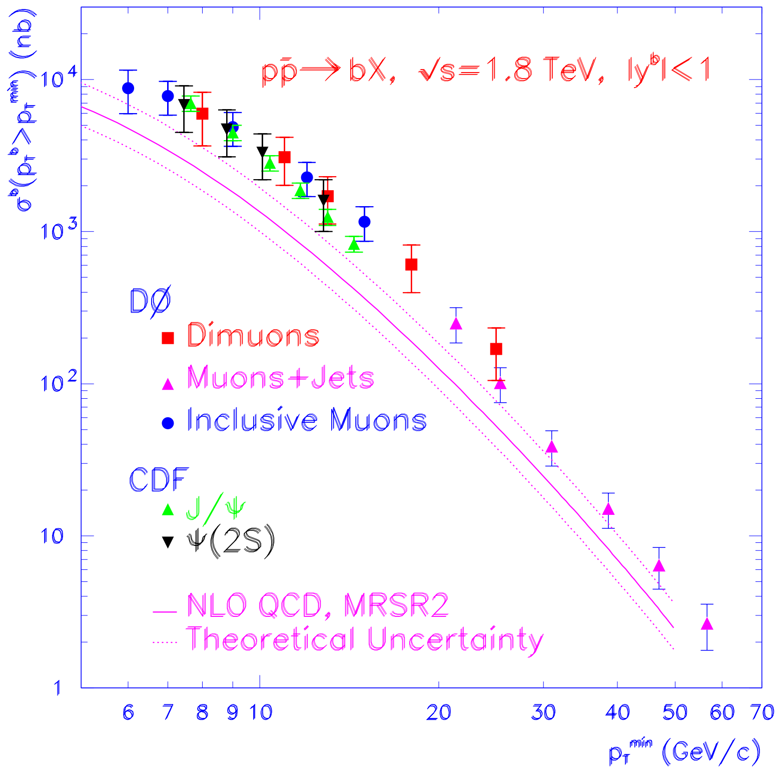
Run-II inclusive J/ψ cross section and determination of the total b quark production (CDF)

Run-I measurements of high p_T b cross sections are factor of 2 larger than QCD NLO prediction – a problem even though more recent theoretical work has reduced this to an *'acceptable level'* of

r (exp/thy) = 1.7 ±.5 (thy) ± .5 (exp).



Starting point is the measurement of inclusive J/ ψ production (reported by Kai Yi)

Based on L =39.7pb^{-1} , and uses a dimuon trigger and covers all the J/ψ p_T range

σ ($p\bar{p} \to J/\psi$, $|y|<0.6$) * Br($J/\psi \to \mu^+\mu^-$) = 240 ±1 (stat) ±30(syst) nb

⇓

B-fractions from L_{xy}/p_T distributions

J/ψ needs boost ; MC study of b→ ψX production

For $p_T(\psi)$= 1.0 to 1.25 GeV $p_T(b)$ > 0,2 GeV ⇒ γβcτ> 45 microns

⇓

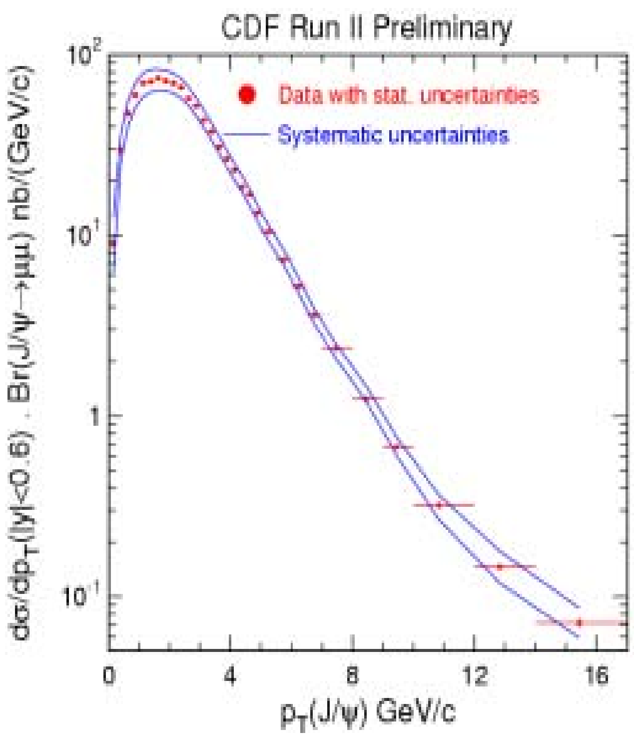
$d\sigma(H_b \to J/\psi)/dp_T(J/\psi)$

Results were unreliable unless $p_T(\psi)$ >1.25; now apply acceptance correction

⇓

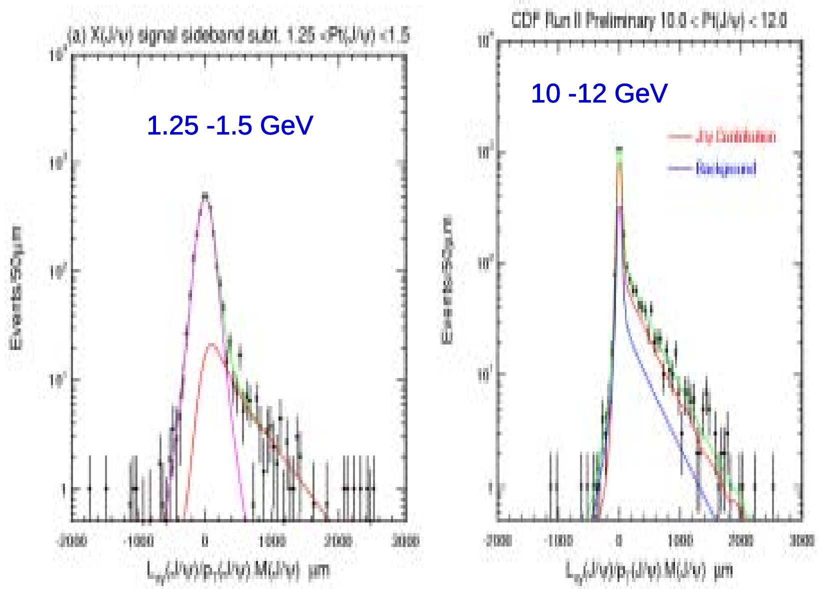
$d\sigma(H_b \to J/\psi)/dp_T(H_b)$ and $\sigma_{total}(H_b \to J/\psi)$

$p_T(H_b)$ ⇔ $p_T(J/\psi)$ correlation needs to be deconvoluted



Compared to Run I - coverage extends to low p_t due to better muon trigger

Example of fitting results

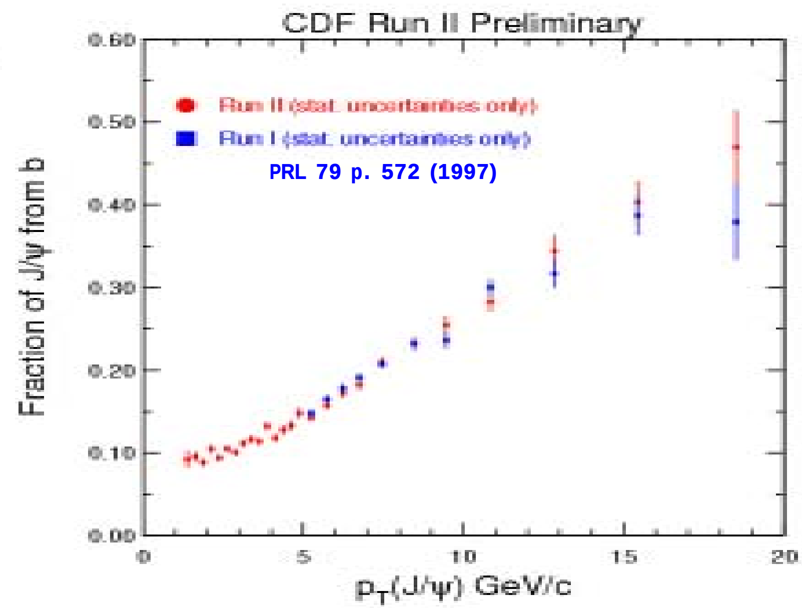


--B contribution,

--Prompt + fake J/ψ,

--Total Fit

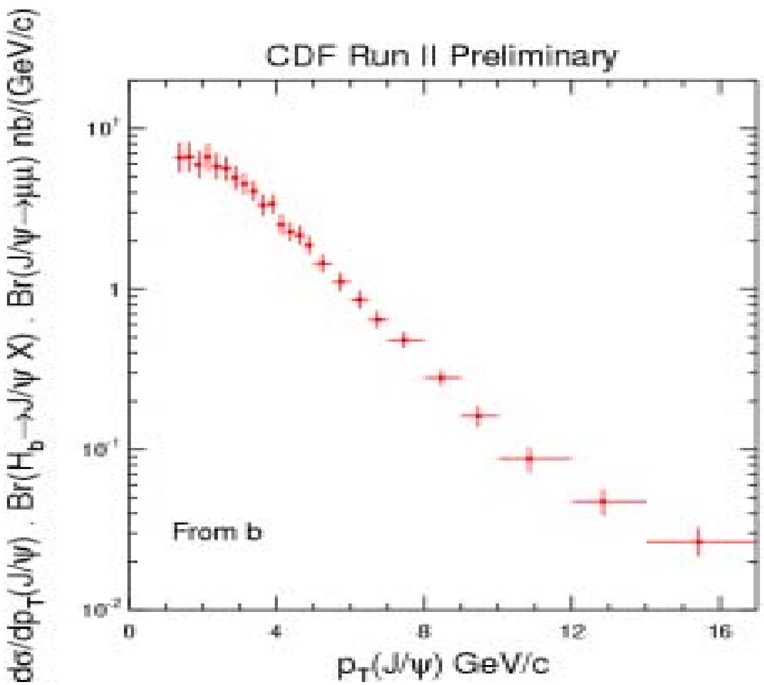
B-fraction results



Systematic error is dominated by resolution (1-8%) and MC input spectrum (2-7%)

Differential cross section for $B \to J/\Psi$

$d\sigma(H_b \to J/\psi)*BR = d\sigma(inclusive)*BR* f_b *A(B)/A(inclusive)$

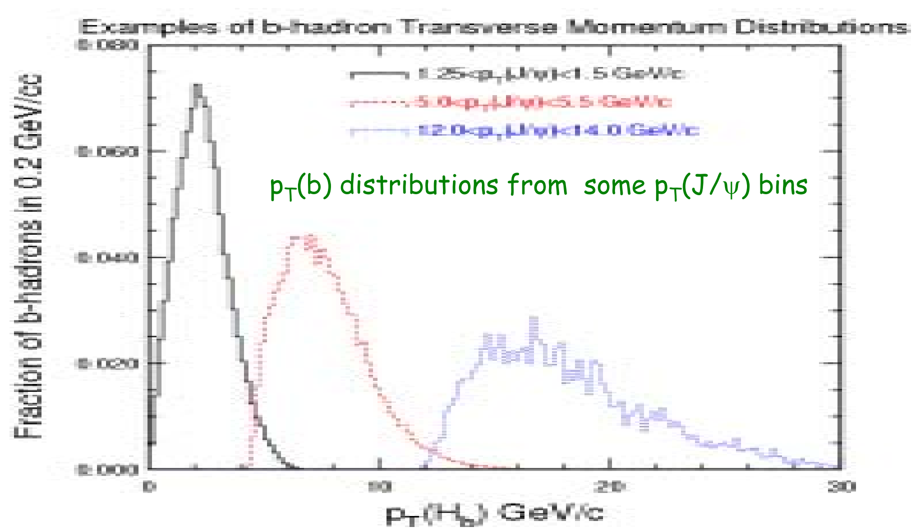


Systematic error (10-20%) is dominated by the J/Psi polarization uncertainties in the acceptance calculations:

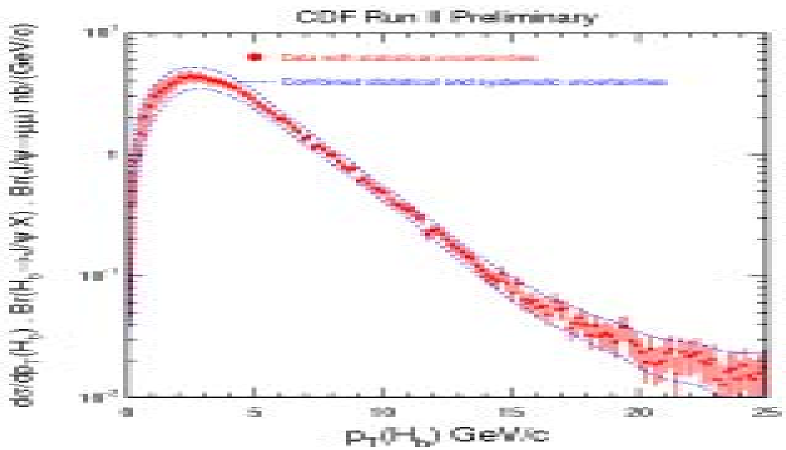
$\alpha = 0.15 \pm 0.3$ (inclusive)

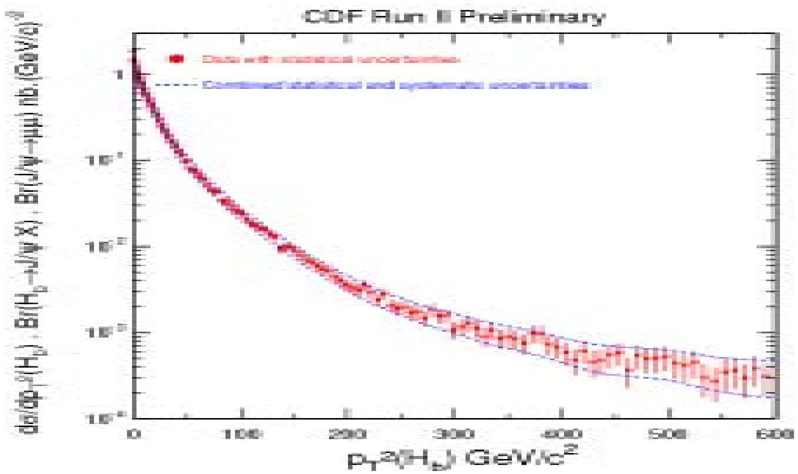
$\alpha = 0.0 \pm 0.5$ ($B \to J/\psi$)

To extract a cross section one has to unfold the $p_T(H_b) \Leftrightarrow p_T(J/\psi)$ correlation



Differential $d\sigma/dp_T(B)$ as function of $p_T(B)$





Total cross section for $B \to J/\psi$

$\sigma(p\bar{p} \to B, |y|<0.6) * BR(B \to J/\psi) * BR(J/\psi \to \mu^+\mu^-) = 24.5 \pm 0.5(stat) \pm 4.7(syst)$ nb

(B = b-hadron or anti b-hadron)

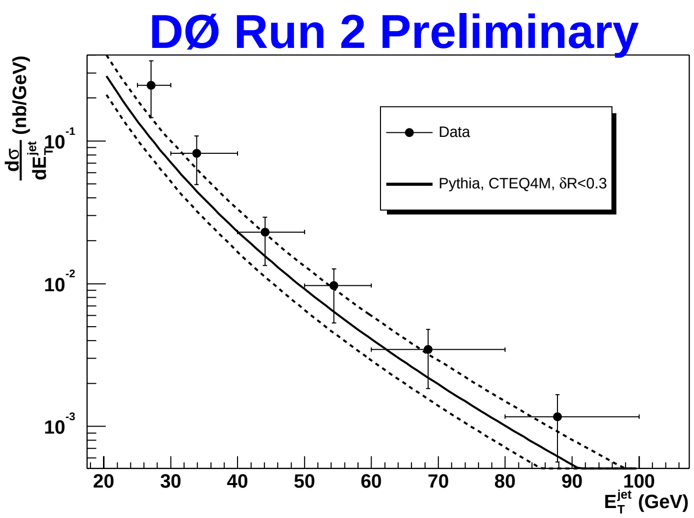
Total b quark cross section at Tevatron:

using BR($B \to J/\psi$) = 1.16 ± 0.10% and BR($J/\psi \to \mu^+\mu^-$) =5.88 ± 0.10% (from PDG 2003)

$\sigma(p\bar{p} \to b, |y|<0.6) = 18.0 \pm 0.4(stat) \pm 3.8(syst)$ μb (single b quark)

$\sigma(p\bar{p} \to b, |y|<1.0) = 29.4 \pm 0.6(stat) \pm 6.2(syst)$ μb (single b quark)

Work in progress (D0)



Early version of B jet cross section

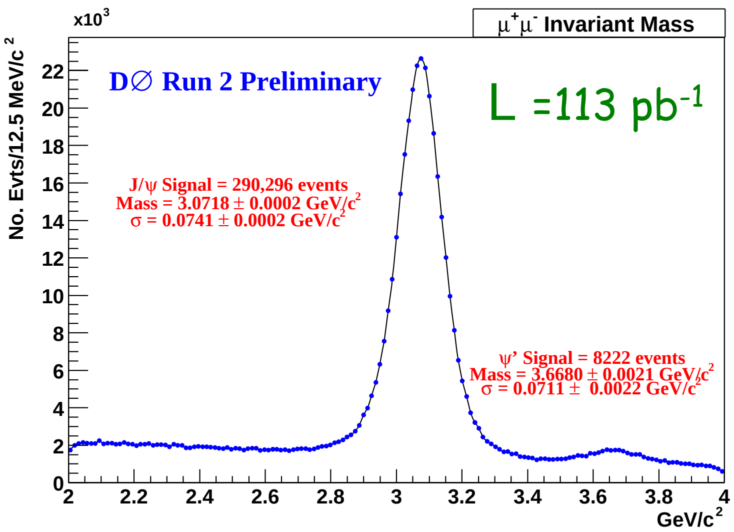
Uses an old version of the software, and a miniscule amount of the total luminosity (5 pb^{-1})

To be updated !!

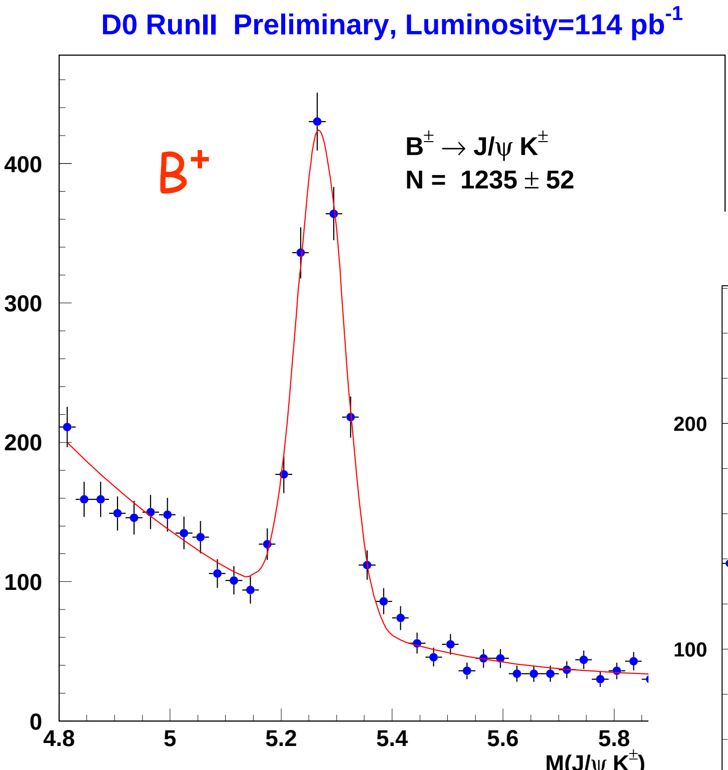
A significant sample of J/ψ's

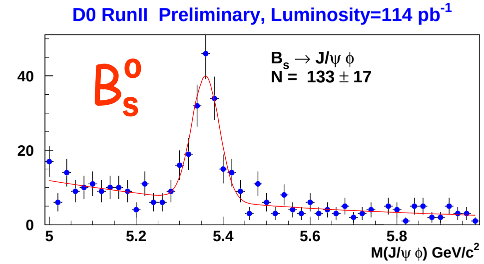
Soon to be increased by x2 (luminosity) and by 1.6 (better fitter)

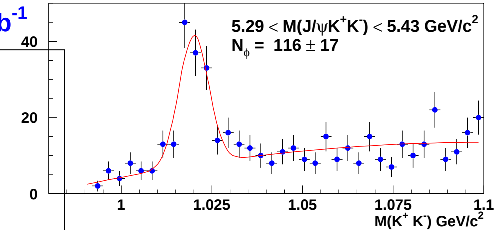
Expected total ~ 1 000 000 psi's

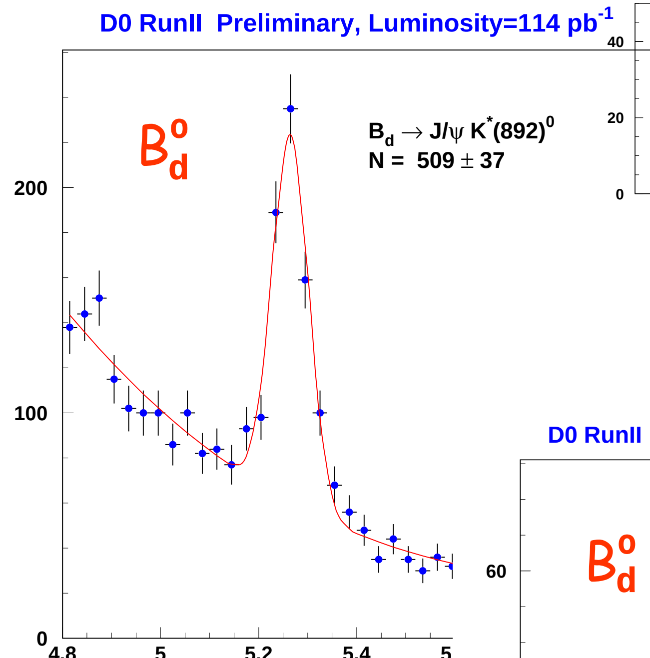


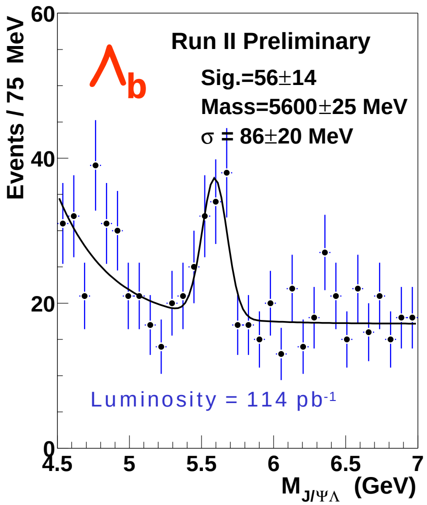
Observation of B hadrons with the DØ Detector

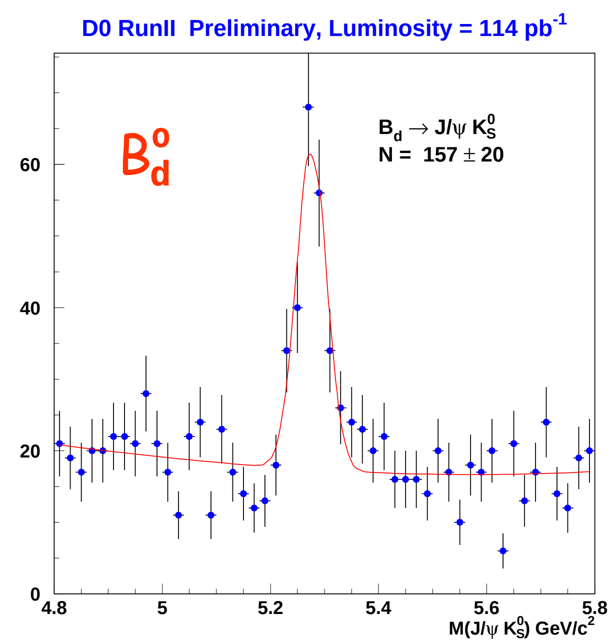












These signals have been used to determine lifetimes (presented in another talk S. Burdin)

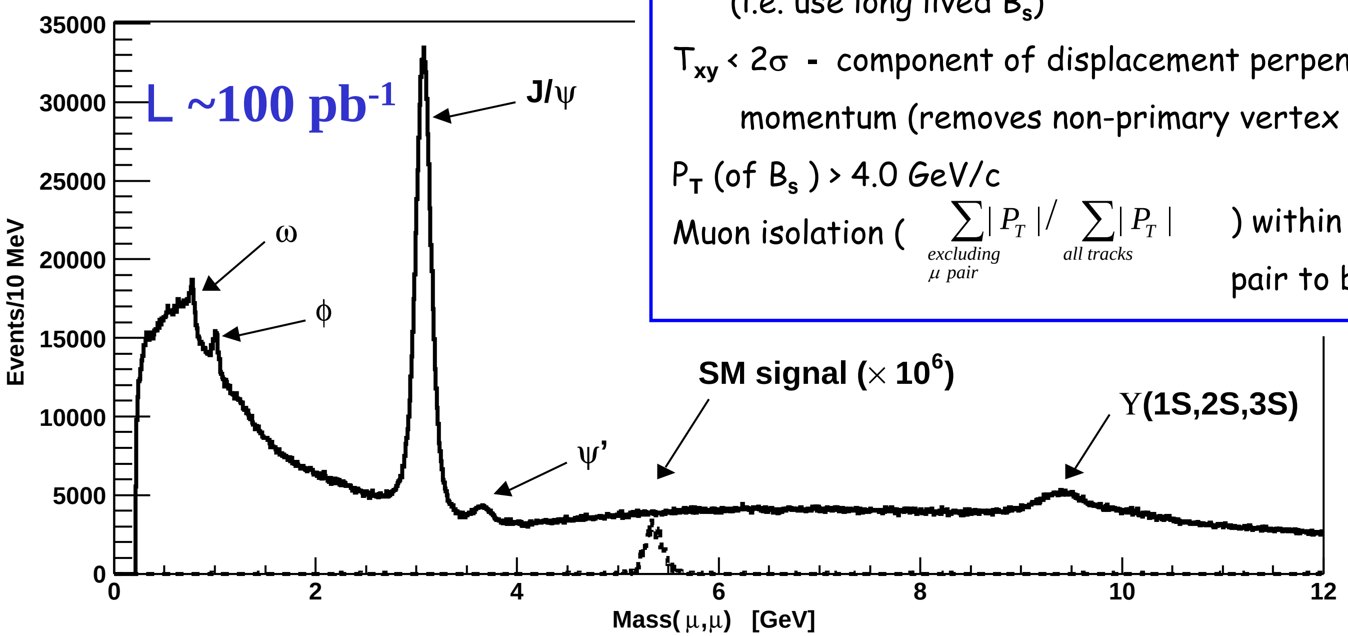
Search for the decay $B_s \rightarrow \mu^+\mu^-$ (DØ and CDF)

An interesting channel because for a large part of the parameter space of the MSMM this rate is larger than the one expected by the SM by a factor of 1000. SM expectation is $3.8 \pm 1.0 \times 10^{-9}$

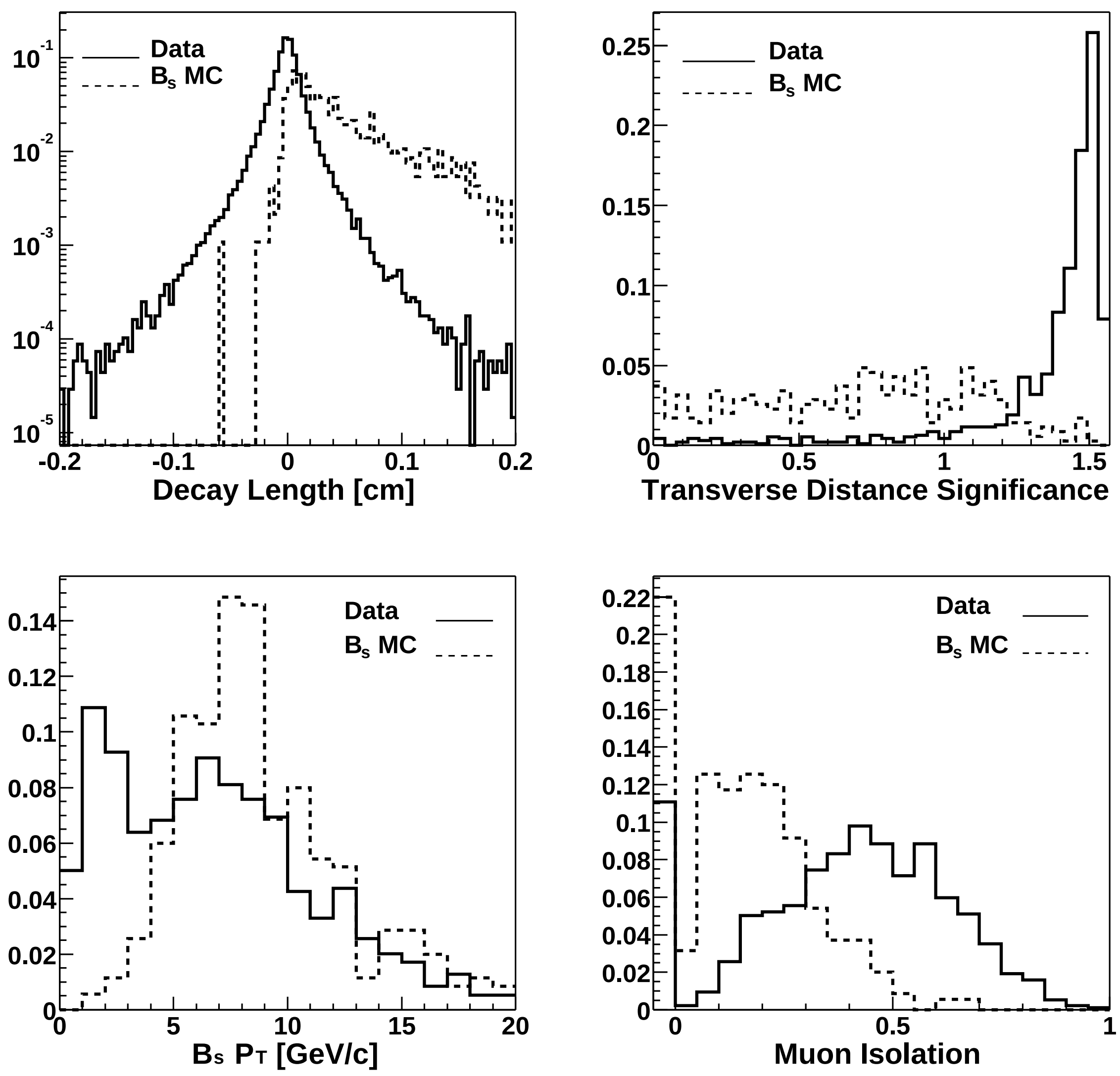
Limit until now was from Run I CDF : $BR(B_s \rightarrow \mu^+\mu^-) = 2.0 \times 10^{-6}$ at the 90% C.L.

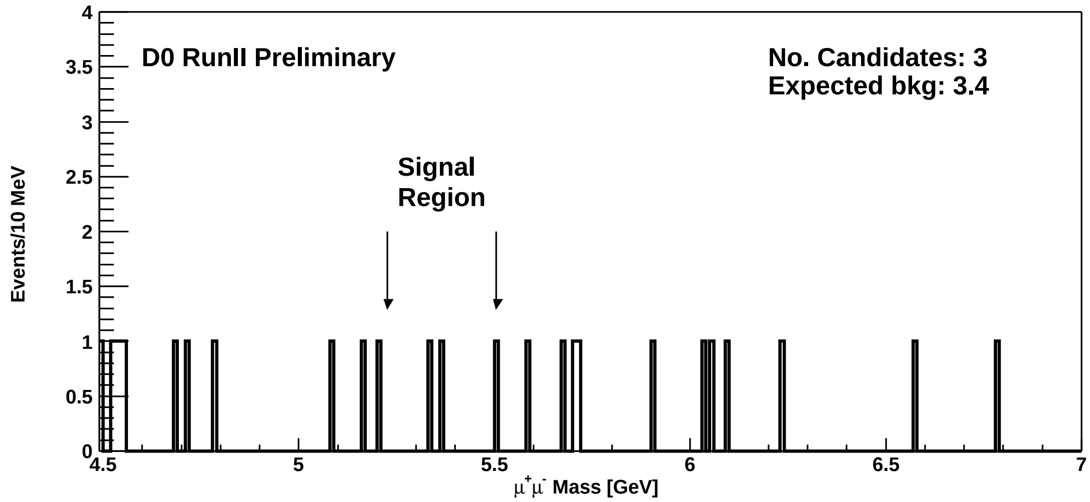
DØ analysis :

- Two good muons (see spectrum below)
- L_{xy} > 550 microns and $\sigma(L_{xy})$<150 microns along the Bs direction (i.e. use long lived B_s)
- $T_{xy} < 2\sigma$ - component of displacement perpendicular to the B_s momentum (removes non-primary vertex backgrounds)
- P_T (of B_s) > 4.0 GeV/c
- Muon isolation ($\sum_{\substack{excluding \\ \mu\ pair}} |P_T| / \sum_{all\ tracks} |P_T|$) within ΔR<1 of muon pair to be less than 0.39



DØ - Run II Preliminary - L ~100 pb^{-1}



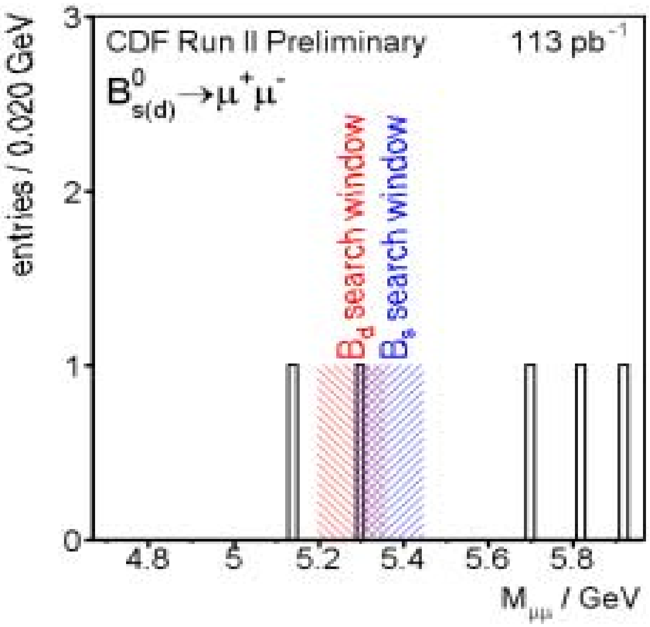


3 events seen with a background of 3.42 ± 0.79

Use the chain $B^+ \to J/\psi K^+$, $J/\psi \to \mu^+\mu^-$ for normalization (198 ±17 evts)
[also the decay $B_s \to J/\psi\ \phi$, $\phi \to K^+K^-$, $J/\psi \to \mu^+\mu^-$ with 89 ± 20 events was used with very similar result]

90% C.L. for $BR(B_s \to \mu^+\mu^-) < 1.6 \times 10^{-6}$

using Feldman- Cousins method



CDF analysis :

Based on 113 pb^{-1}

Discriminating variables are :

$m(\mu^+\mu^-)$, $c\tau$, $\Delta\Phi$, isolation

$\Delta\Phi$ pointing consistency (angle between sec. vertex vector and B momentum vertex)

isolation is $\sum_{\text{excluding } \mu \text{ pair}} |P_T| / \sum_{\text{all tracks}} |P_T|$, within $\Delta R<1$ of muon pair

One event survives and falls into both the B_s and B_d mass windows.

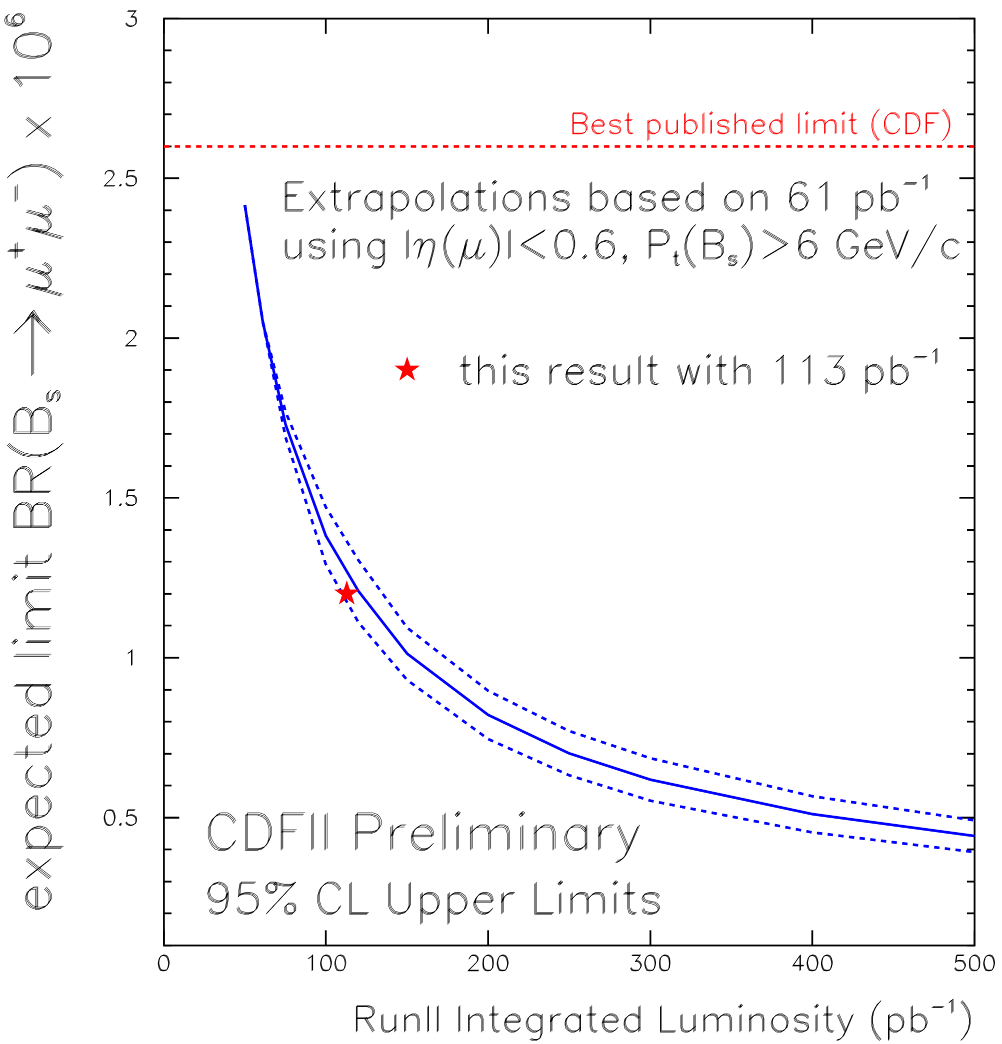
A very detailed study of backgrounds as a function of the isolation parameter and the muon pair mass gives an expectation of 0.54 ± 0.20 and 0.59 ± 0.23 background events events respectively.

$BR(B_s \to \mu^+\mu^-) < 9.5\times10^{-7}$ at the 90% C.L. new Run II CDF result

$BR(B_s \to \mu^+\mu^-) < 1.6 \times 10^{-6}$ Run II D0 result

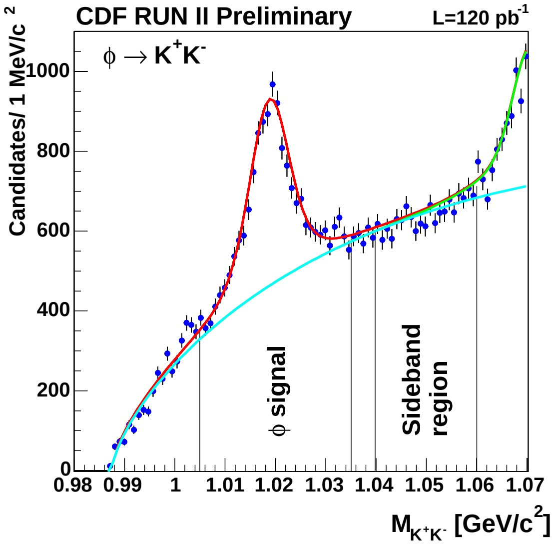
$BR(B_s \to \mu^+\mu^-) = 2.0\times10^{-6}$ Older Run I CDF result

$BR(B_d \to \mu^+\mu^-) < 2.5\times10^{-7}$ at the 90% C.L. (this is approx. x2 weaker than BaBar/Belle limits)



Best published limit (CDF)
Extrapolations based on 61 pb^{-1}
using $|\eta(\mu)|<0.6$, $P_t(B_s)>6$ GeV/c
this result with 113 pb^{-1}
CDFII Preliminary
95% CL Upper Limits
expected limit $BR(B_s \rightarrow \mu^+\mu^-) \times 10^6$
RunII Integrated Luminosity (pb^{-1})
0
100
200
300
400
500
0.5
1
1.5
2
2.5
3

$B^{\pm} \to \phi K^{\pm}$ (CDF)



in comparison to $B^{\pm} \to J/\psi K^{\pm}$

Two Track Trigger sample

$|\eta| < 1.4$, 3 Silicon hits,

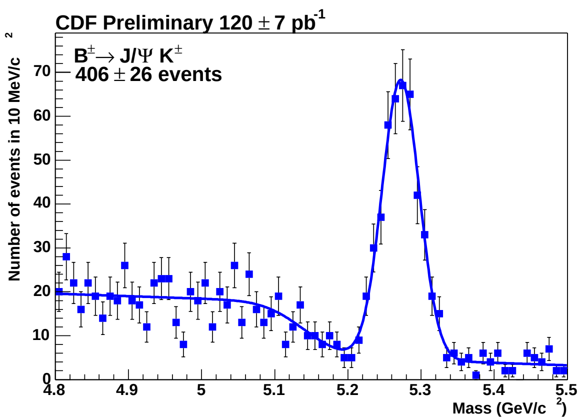
25 axial & 25 stereo COT hits

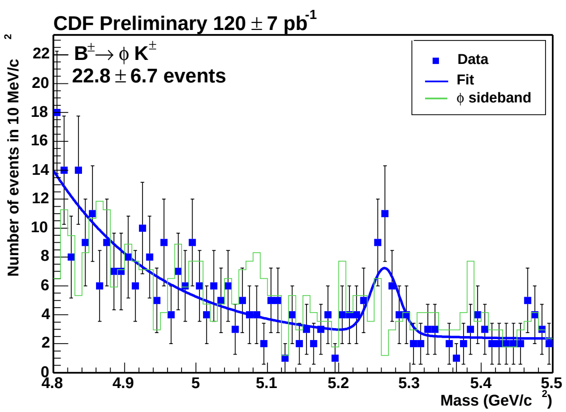
$L_{xy} > 200$ microns, IP(B) < 100 microns

Impact parameter for tracks > 100 microns

PT(non trigger K) > 1.5 GeV/c, isolated (>0.5)

Select ϕ and J/ψ mass regions





A small signal is observed and one can set the following limits

$$\frac{BR(B^{\pm} \to \phi K^{\pm})}{BR(B^{\pm} \to J/\psi K^{\pm})} = 0.0068 \pm 0.0021(stat) \pm 0.0007(syst)$$

$$BR(B^{\pm} \to \phi K^{\pm}) = (6.9 \pm 2.1(stat) \pm 0.8(syst)) \times 10^{-6}$$

PDG value is $(7.9^{+2.0}_{-1.8}) \times 10^{-6}$

$B_s \to K^\pm K^\mp$ (mostly) but also $B^0 \to h^\pm h^{\mp\prime}$ (CDF)

Analysis technique similar to the ones previously presented.

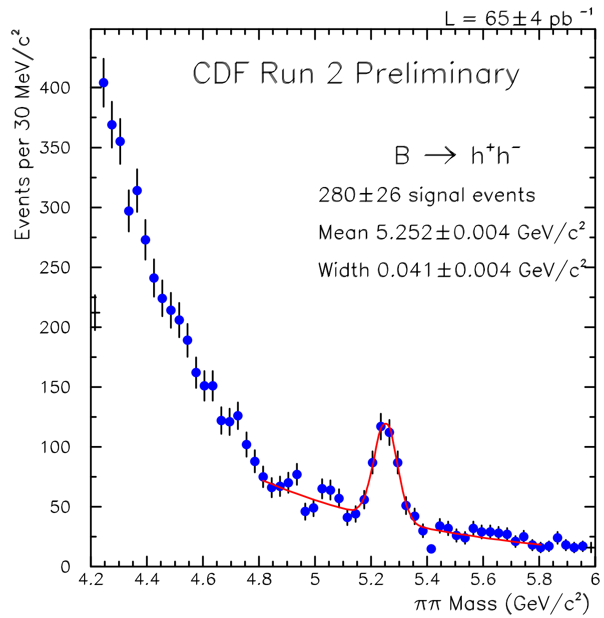
Based on 65 pb-1

Lxy > 300 microns,

impact parameter of both tracks > 150 microns,

impact parameter for the B < 80 microns,

and isolation cut > 0.5



Problem – how to disentangle the four contributions

$B_d \to \pi^\pm\pi^\mp$, $B_d \to K^+\pi^-$, $B_s \to K^-\pi^+$, $B_s \to K^\pm K^\mp$

(and CC states)

with limited particle identification capabilities.

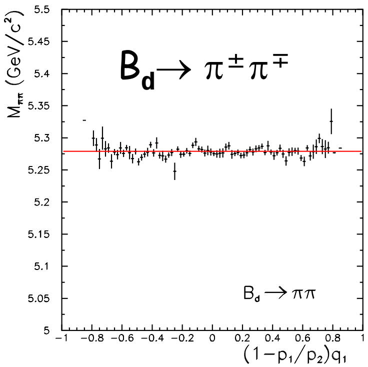
(dE/dx is the only handle, and this provides 1.16 sigma π/K separation !)

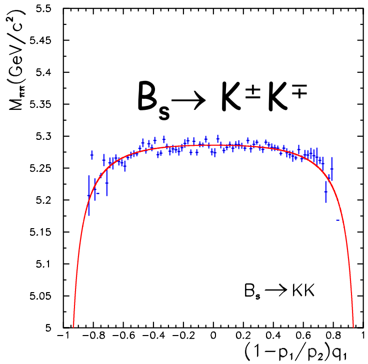
Use a statistical (weighting) process, where a parametrization and fit is done in two parameters:

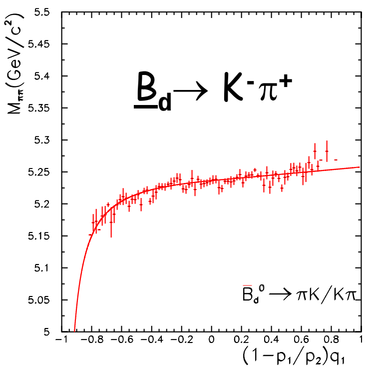
$M_{\pi\pi}$ - the invariant mass of the track pair assuming pion masses for both tracks and

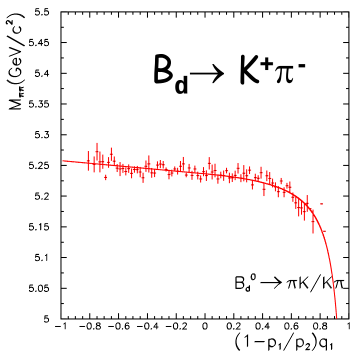
$$\alpha = (1 - \frac{p_1}{p_2}) \cdot q_1$$

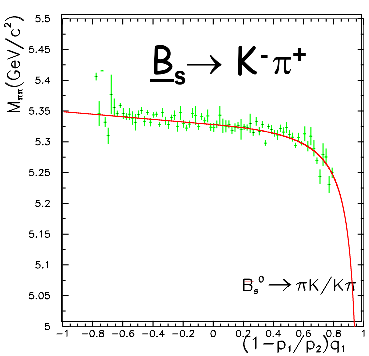
where p1 is the smaller and p2 the larger 3-d momentum, and q1 the charge for the particle with the smaller momentum

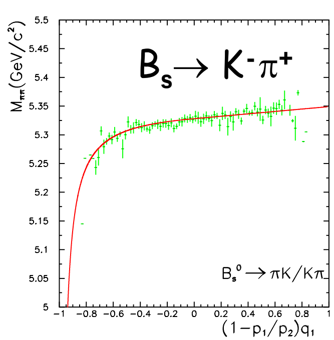

$B_d \to \pi^\pm\pi^\mp$
$B_d \to \pi\pi$
$M_{\pi\pi}$ (GeV/c^2)
$(1-p_1/p_2)q_1$

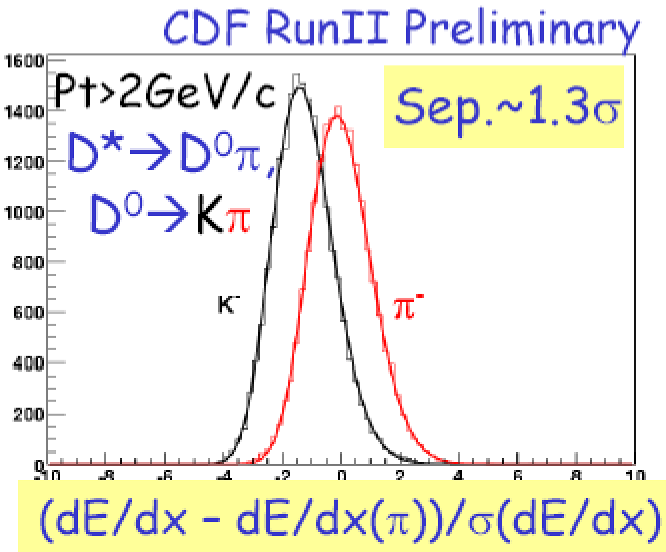

$B_s \to K^\pm K^\mp$
$B_s \to KK$
$M_{\pi\pi}$ (GeV/c^2)
$(1-p_1/p_2)q_1$

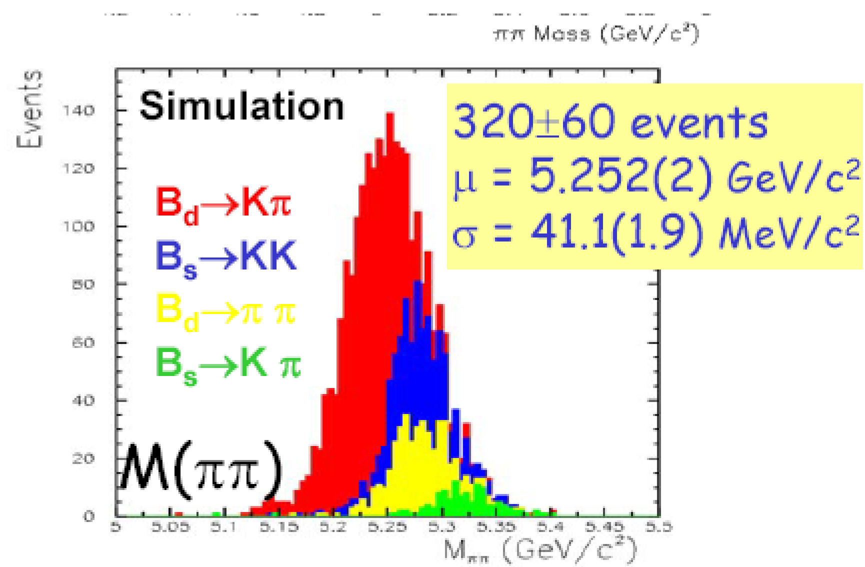

$\underline{B}_d \to K^-\pi^+$
$\bar{B}_d^0 \to \pi K/K\pi$
$M_{\pi\pi}$(GeV/c^2)
$(1-p_1/p_2)q_1$


$B_d \to K^+\pi^-$
$B_d^0 \to \pi K/K\pi$
$M_{\pi\pi}$(GeV/c^2)
$(1-p_1/p_2)q_1$


$\underline{B}_s \to K^-\pi^+$
$B_s^0 \to \pi K/K\pi$
$M_{\pi\pi}$(GeV/c^2)
$(1-p_1/p_2)q_1$


$B_s \to K^-\pi^+$
$B_s^0 \to \pi K/K\pi$
$M_{\pi\pi}$(GeV/c^2)
$(1-p_1/p_2)q_1$


CDF RunII Preliminary
Pt>2GeV/c
$D^* \to D^0\pi$,
$D^0 \to K\pi$
Sep.~1.3σ
K^-
π^-
$(dE/dx - dE/dx(\pi))/\sigma(dE/dx)$


ππ Mass (GeV/c^2)
Simulation
$B_d \to K\pi$
$B_s \to KK$
$B_d \to \pi\pi$
$B_s \to K\pi$
M(ππ)
320±60 events
μ = 5.252(2) GeV/c^2
σ = 41.1(1.9) MeV/c^2
Events
$M_{\pi\pi}$ (GeV/c^2)

A likelihood function combining a background parameterization (extracted from mass sidebands) and a weight for each event depending on its M and α values is used to estimate the number of events.

Raw particle fractions are : (total no. of events is 280 ± 26)

$B_d \to \pi^{\pm}\pi^{\mp}$	$B_d \to K^+\pi^-$	$B_s \to K^-\pi^+$	$B_s \to K^{\pm}K^{\mp}$
0.14 ± 0.05	0.53 ± 0.06	0.01 ± 0.04	0.32 ± 0.06

and the yield of $B_s \to K^{\pm}K^{\mp}$ = 90 ± 17(stat) ± 17(syst)

$$\frac{f_s}{f_d}\frac{BR(B_s \to K^{\pm}K^{\mp})}{BR(B_d^0 \to K^{\pm}\pi^{\mp})} = 0.74 \pm 0.20(stat) \pm 0.22(syst)$$

$$\frac{BR(B_d \to \pi\pi)}{BR(B_d \to K\pi)} = 0.26 \pm 0.11(stat) \pm 0.055(syst)$$

PDG shows 0.25 ± 0.06

$A_{CP}(B_d \to K^+\pi^-)$ = 0.02 ± 0.15 (stat) ± 0.017 (syst) BaBar has -0.102 ± 0.050 ± 0.016

$$A_{CP} = \frac{BR(\overline{B}_d^0 \to K^-\pi^+) - BR(B_d^0 \to K^+\pi^-)}{BR(\overline{B}_d^0 \to K^-\pi^+) + BR(B_d^0 \to K^+\pi^-)}$$

B** 'mass' measurement (DØ)

A conglomeration of 4 excited B mesons states (that are not resolved)

Studied via the fully reconstructed decays :

$$(a) \quad B_d^{**} \to B^+\pi^- \quad , \quad (b) \quad B^{**+} \to B_d\pi^+$$

Based on 115pb^{-1} where there were 1193 $\pm$ 52 B^+ and 463 $\pm$ 38 B_d (fully reconstructed)

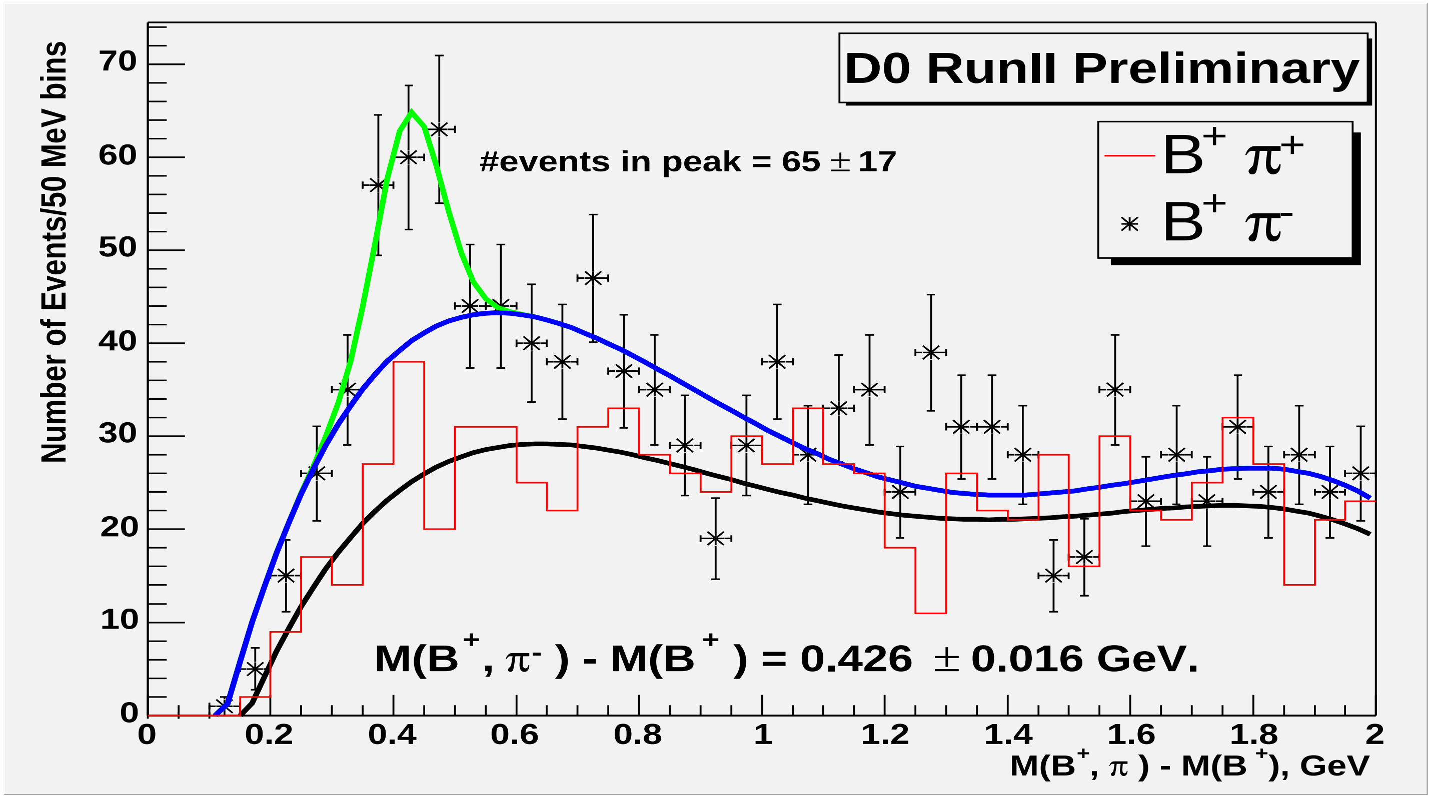
Good vertex (χ^2<16) , $P_T(\pi)$ > 0.9 GeV , at least two Si hits

Compare the "right charge" combination i.e.

$$B_d^{**} \to B^+\pi^- \quad , \quad B^{**+} \to B_d\pi^+ \to K^+ \pi^+ \ldots$$

To the "wrong charge" combination

$$B_d^{**} \to B^\pm\pi^\pm \quad , \quad B^{**+} \to B_d\pi^+ \to K^+\pi^- \ldots$$



Plot the mass difference of B** and the B

Signal seen in the B_d^{**} channel of 65 ± 17 B's

No signal in the B^{**+} channel, but expectation was 16±7 B's

$\Delta m = 0.426 \pm 0.016\ GeV/c^2$

Measurement of $\frac{f_{\Lambda_b}}{f_d}\frac{BR(\Lambda_b \to \Lambda_c^+\pi^-)}{BR(\overline{B}^0 \to D^+\pi^-)}$ (CDF)

The observation of a significant signal (~7σ) of the decay $\Lambda_b \to \Lambda_c^+\pi^-$

Allows for the measurement of this branching ratio.

To minimize systematic errors the measurement of a ratio is being reported

$$\frac{f_{\Lambda_b}}{f_d}\frac{BR(\Lambda_b \to \Lambda_c^+\pi^-)}{BR(\overline{B}^0 \to D^+\pi^-)} = \frac{BR(D^+ \to K\pi\pi)}{BR(\Lambda_c^+ \to pK\pi)}\frac{N_{\Lambda_b}}{N_{\overline{B}^0}}\frac{\varepsilon_{\overline{B}^0}}{\varepsilon_{\Lambda_b}}$$

P_t(proton)>2 GeV/c ; P_t(π from Λ_b) > 2 GeV/c

$P_t(\Lambda_c)$> 4.5 GeV/c ; $P_t(\Lambda_b)$ > 7.5 GeV/c

$c\tau$ (Λ_b) > 225 microns, $c\tau$ (Λ_c from Λ_b) > -65 microns

d_0 (Λ_b) < 85 microns

P_t(proton) > P_t(π from Λ_c)

Λ_c mass window of 2.269-2.302 GeV/c^2

Vertex quality : $\chi^2_{xy}(\Lambda_b) < 30$, $\chi^2_{xy}(\Lambda_c) < 20$

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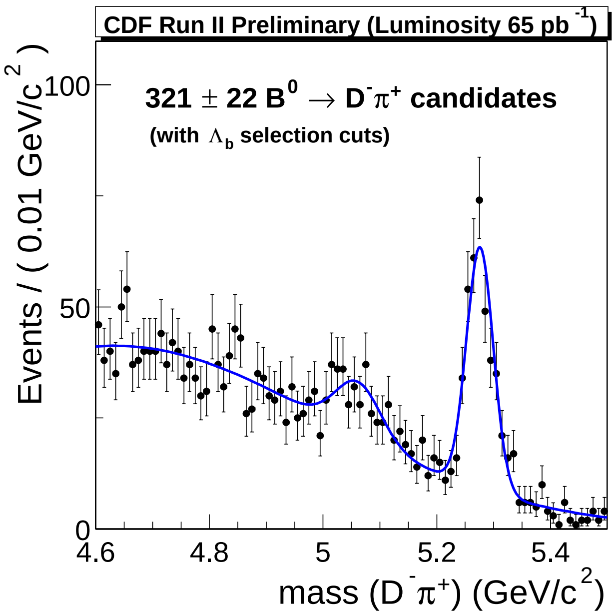

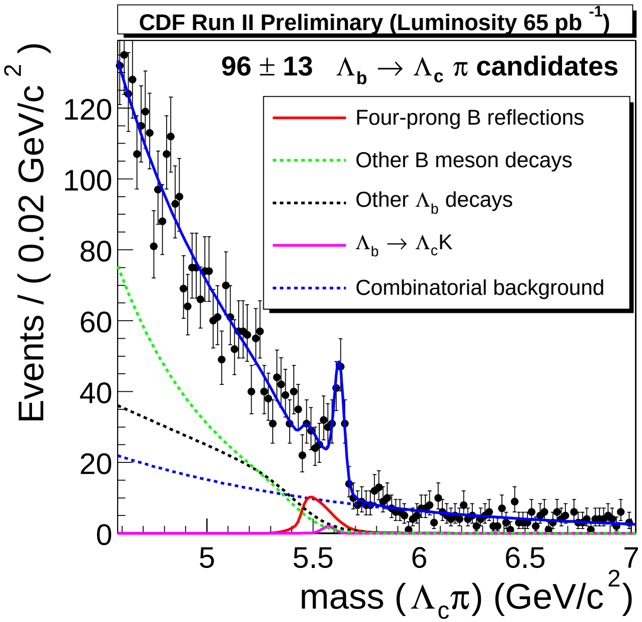

B^0's = 321 ± 22 ± 20 (stat,syst)

Λ_b's = 96 ± 13 ± 8 (stat,syst)

$$\frac{N_{\Lambda_b}}{N_{\overline{B}^0}} = 0.30 \pm 0.05(stat) \pm 0.03(syst)$$

$$\frac{\varepsilon_{\overline{B}^0}}{\varepsilon_{\Lambda_b}} = 1.20 \pm 0.02(stat) \pm 0.11(syst)$$

Backgrounds subtracted :

$\Lambda_b \to \Lambda_c^+ \pi^-$ Signal fit parameters

Four-prong B meson reflections

All other B meson decays

All other Λ_b decays

$\Lambda_b \to \Lambda_c^+K$ decays

True combinatorial background

$$\frac{N_{\Lambda_b}}{N_{\overline{B}^0}} = 0.30 \pm 0.05(stat) \pm 0.03(syst)$$

$$\frac{\varepsilon_{\overline{B}^0}}{\varepsilon_{\Lambda_b}} = 1.20 \pm 0.02(stat) \pm 0.11(syst)$$

$$\frac{f_{\Lambda_b}}{f_d} \frac{BR(\Lambda_b \to \Lambda_c^+ \pi^-)}{BR(\overline{B}^0 \to D^+ \pi^-)} = 0.66 \pm 0.11(stat) \pm 0.09(syst) \pm 0.18(BR)$$

Due to $BR(\Lambda_c \to pK\pi) / BR(D^+ \to K\pi\pi)$ which has a ±27% uncertainty

Using the PDG value for the fragmentation ratio of

f_{baryon}/f_d = 0.304 ± 0.053 one obtains :

$$\frac{BR(\Lambda_b \to \Lambda_c^+ \pi^-)}{BR(\overline{B}^0 \to D^+ \pi^-)} = 2.2 \pm 0.4(stat) \pm 0.3(syst) \pm 0.7(BR \text{ and } FR)$$