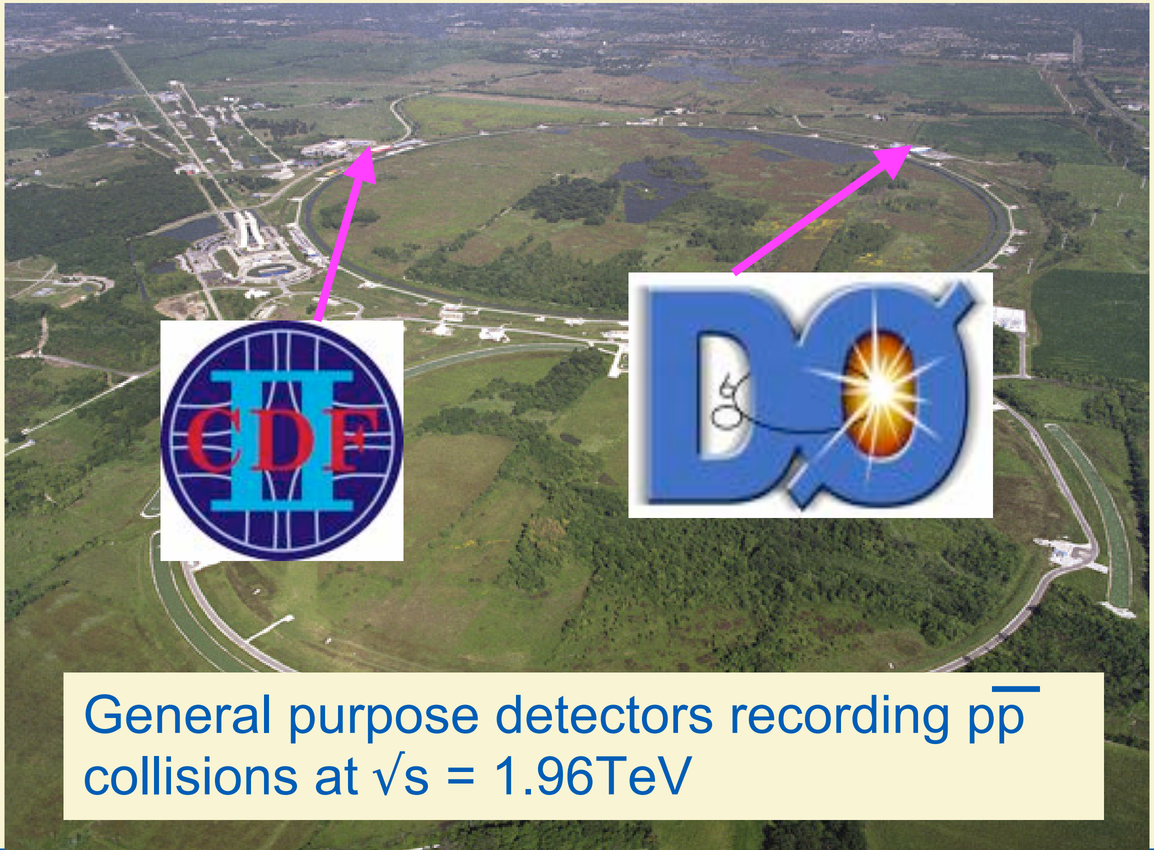
Recent Heavy Flavor Results

Lifetimes, FCNC, & Rare Decays at the Tevatron



Sneha Malde

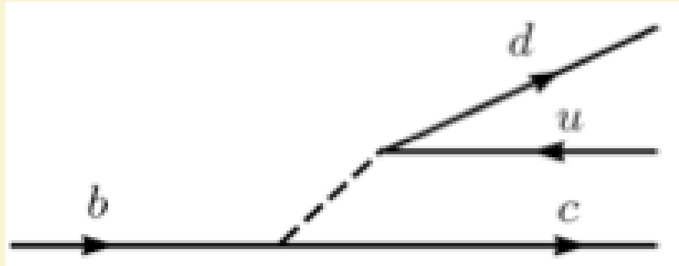
University of Oxford & University of Pittsburgh

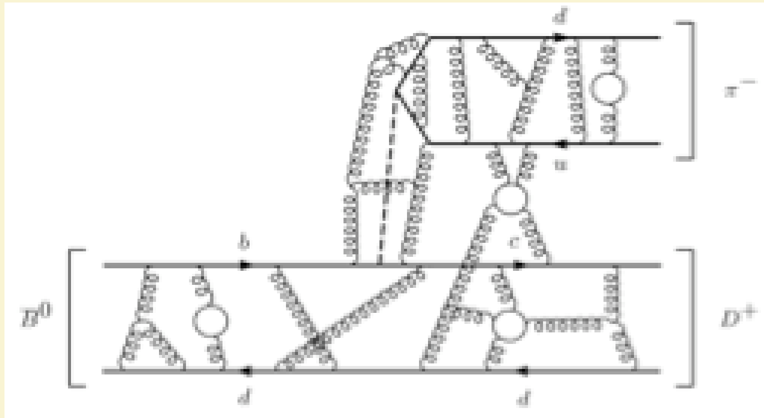
on behalf CDF and D0

Hadron Lifetimes

Spectator model: all B hadrons have the same lifetime

Difference from light quark interactions





Expected Hierarchy:

$\tau(B_u) > \tau(B_d) \sim \tau(B_s) > \tau(\Lambda_b) >> \tau(B_c)$

Ratio Predictions (HQE):

$\tau(B^+) = 1.063 \pm 0.027\ \tau(B_d)$

$\tau(\Lambda_b) = 0.88 \pm 0.05\ \tau(B_d)$

Lifetimes important for understanding the interactions of quarks inside hadrons

HQE is used to calculate Γ_{12} and semileptonic asymmetry

A.Lenz arXiv:0802.0977

Lifetimes in decays with J/Ψ

4 Channels : $B^+ \rightarrow J/\Psi K^+$

$B^0 \rightarrow J/\Psi K^*$

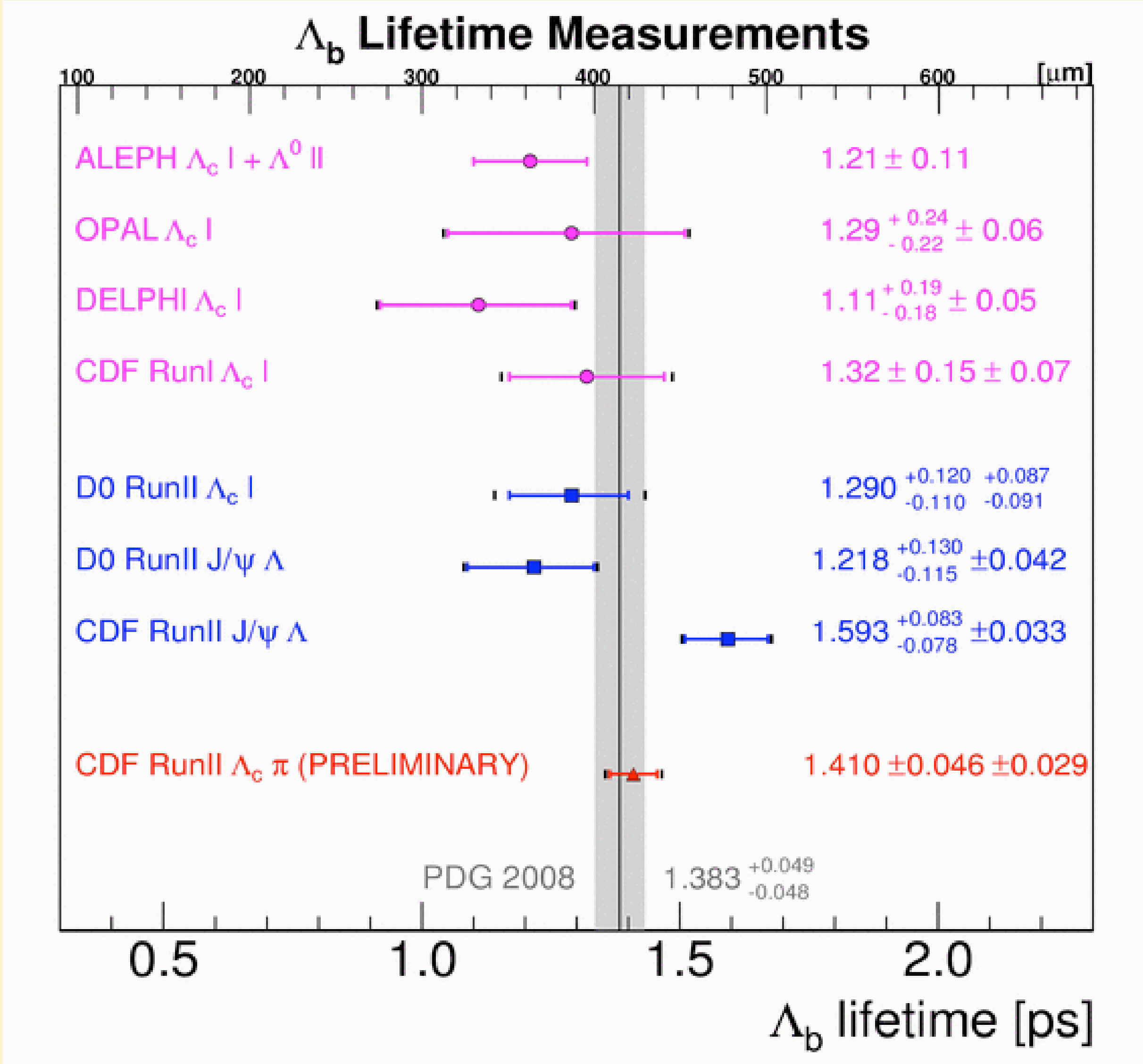
$B^0 \rightarrow J/\Psi K_s$

$\Lambda_b \rightarrow J/\Psi \Lambda$

Uses $4.3 fb^{-1}$ of data

Aims to solve the Λ_b 'puzzle'

Yield in the control modes gives opportunity for the most precise B^+ and B^0 lifetimes



Analysis Strategy

Data from the di-muon trigger -Selection based on rectangular cuts only

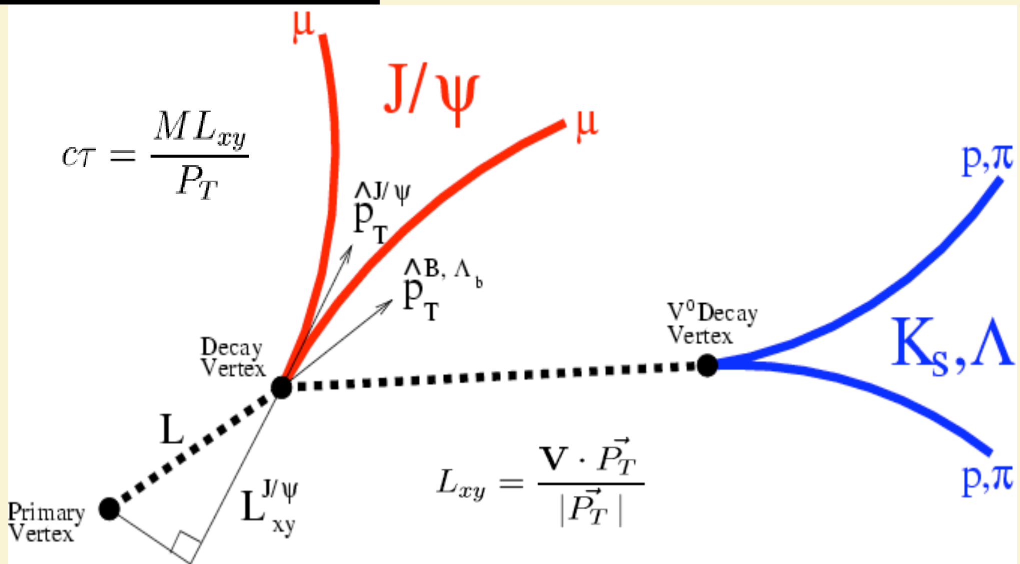
$B^+ \rightarrow J/\Psi\ K^+$	45000 ± 230
$B^0 \rightarrow J/\Psi\ K^*$	16860 ±140
$B^0 \rightarrow J/\Psi\ K_s$	12070 ±120
$\Lambda_b \rightarrow J/\Psi\ \Lambda$	1710+50

Yields in 4.3 fb^{-1}

Use the J/ψ vertex to determine the Decay Vertex for all modes

Makes detector resolution similar for all channels

Use the J/ψ sample for further study



Lifetime extracted from an un-binned likelihood fit, simultaneously in mass, decay time and decay time error

Controlling systematic uncertainties

Large yields in B^+ & B^0 ➔

Systematically limited using simple modeling of detector resolution.

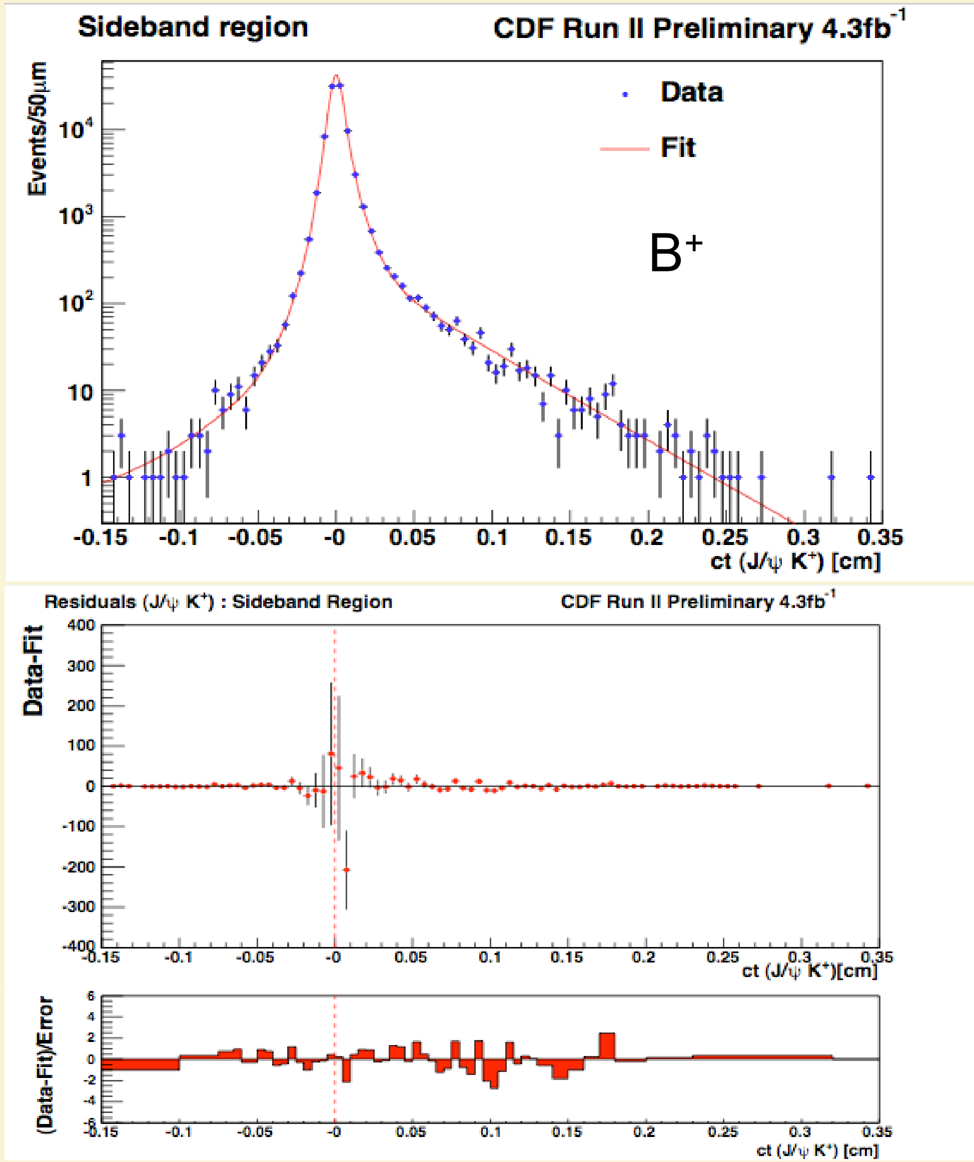
Background is mainly prompt.

Carefully model the mass sideband data ➔extract the scale factors that determine the detector resolution.

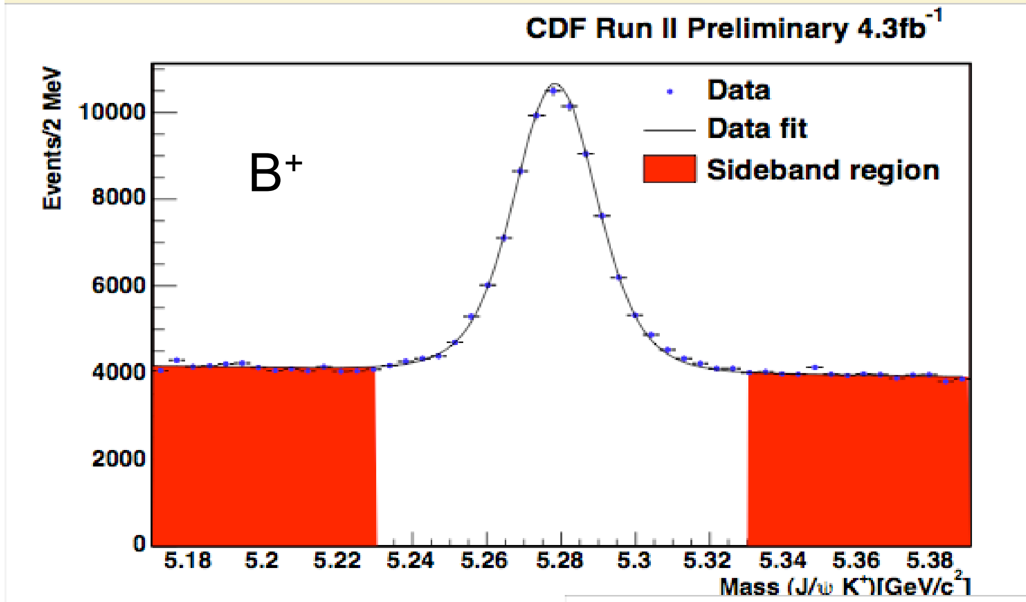
Overall systematic reduction for analysis

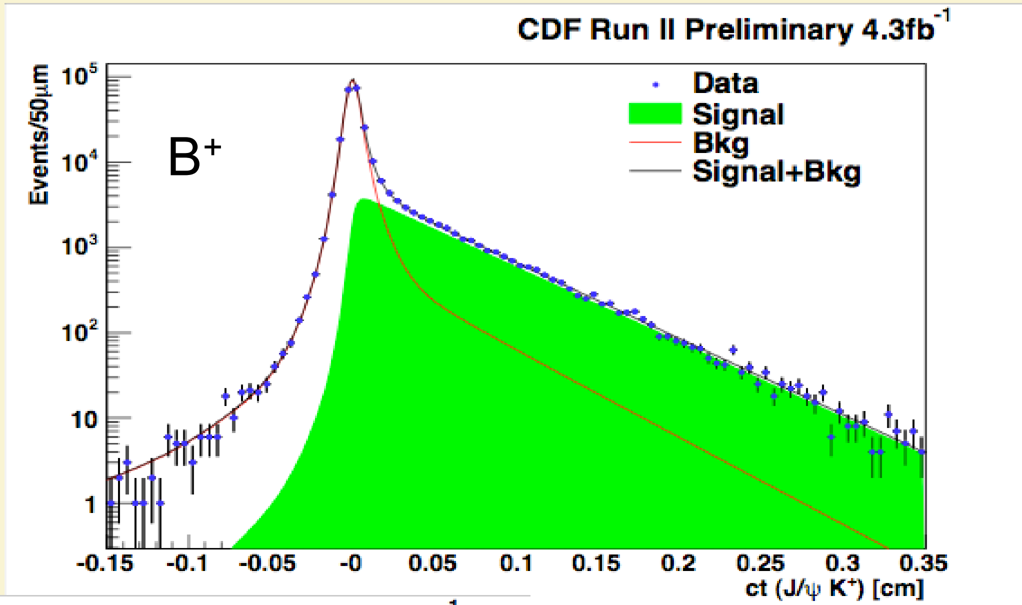
0.016 ps ➔ 0.008 ps (B^0)

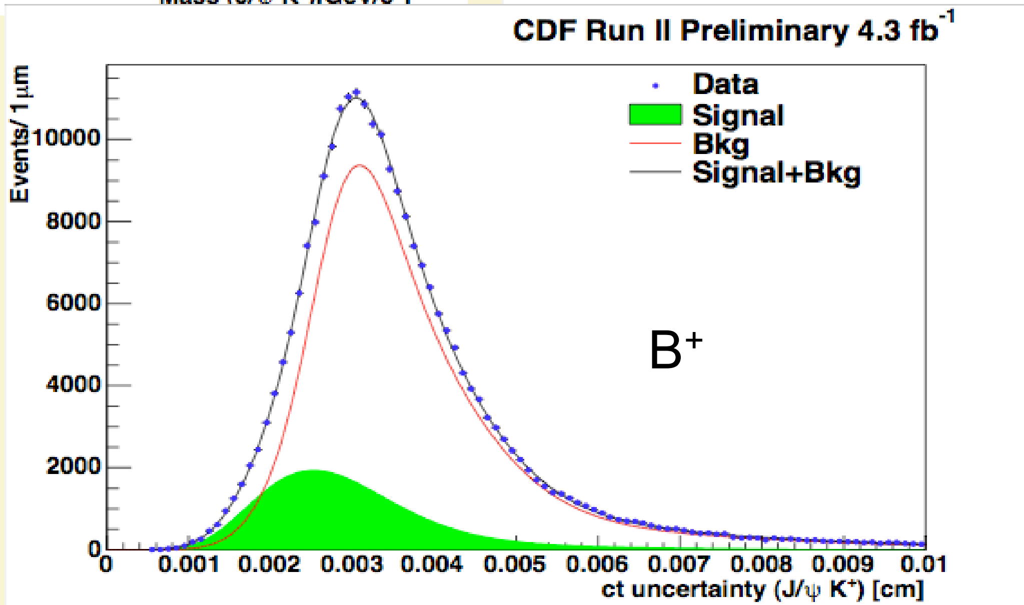
Systematic error now limited by detector alignment

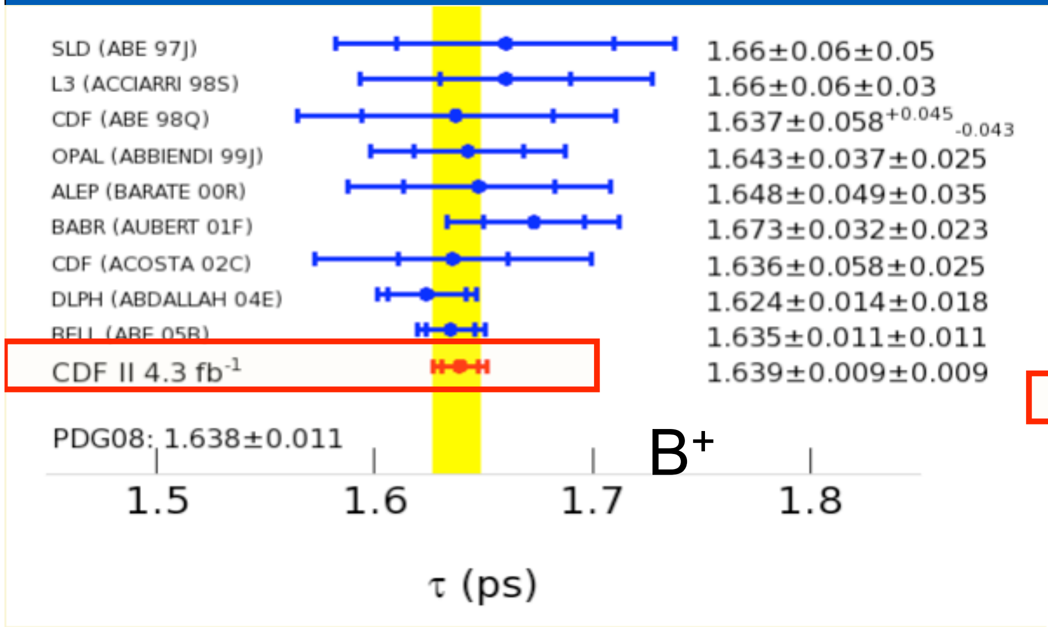


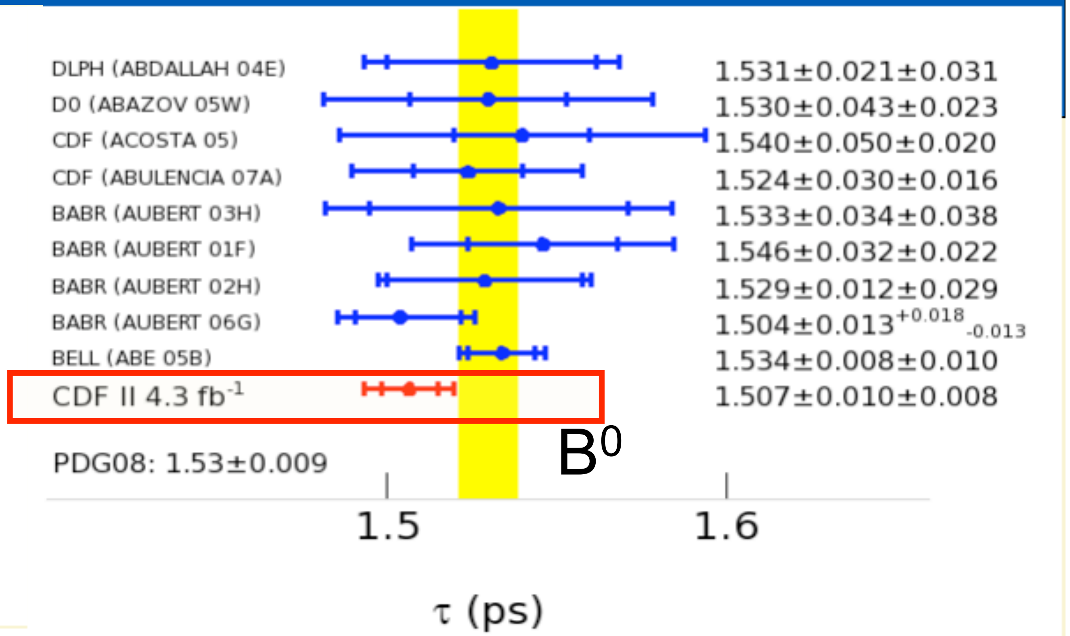
B+ Fit Projections

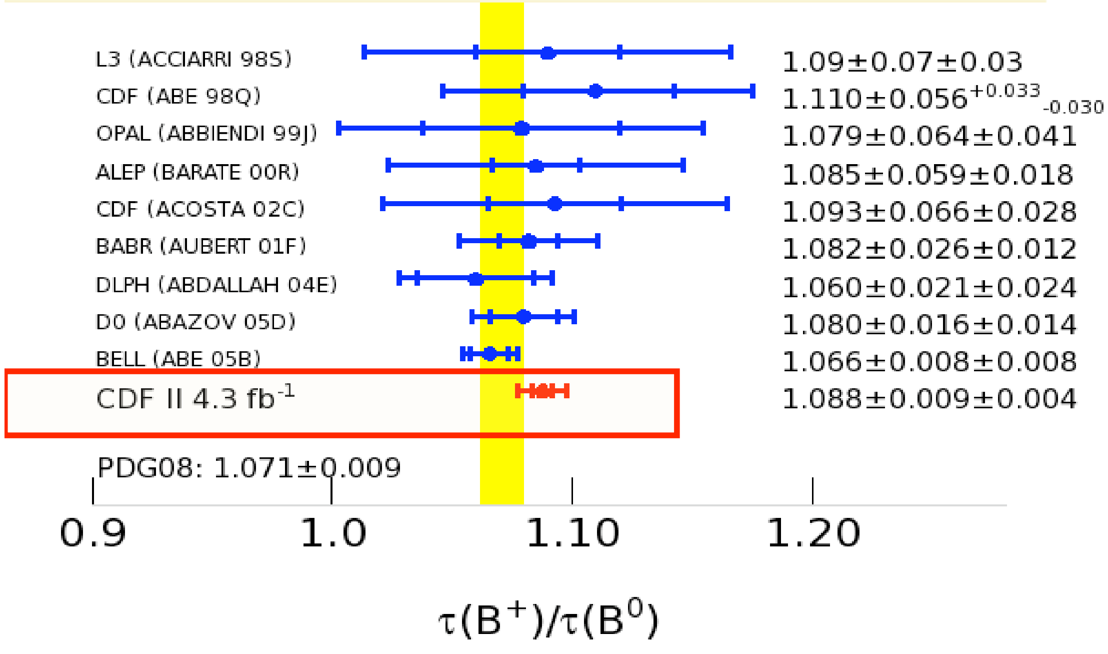












Results shown against PDG and other measurements

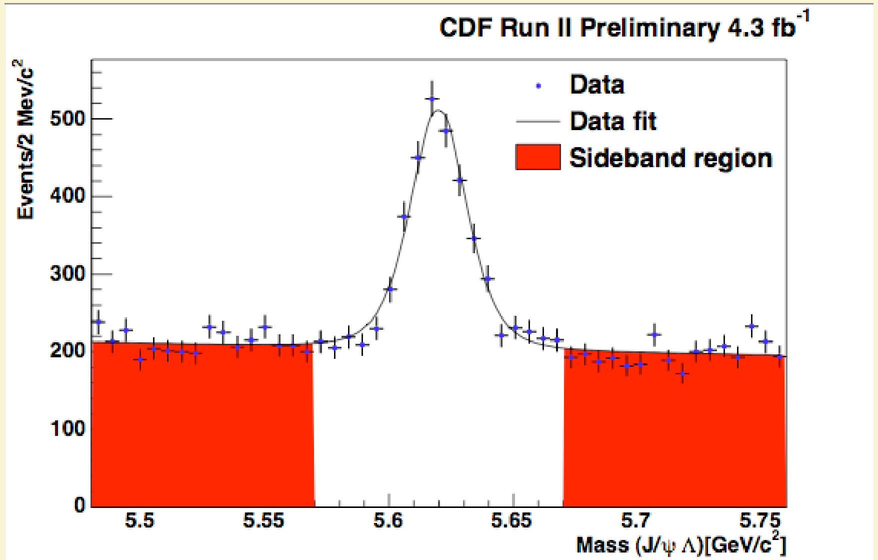
Most precise measurement of the B^+/B_0 ratio

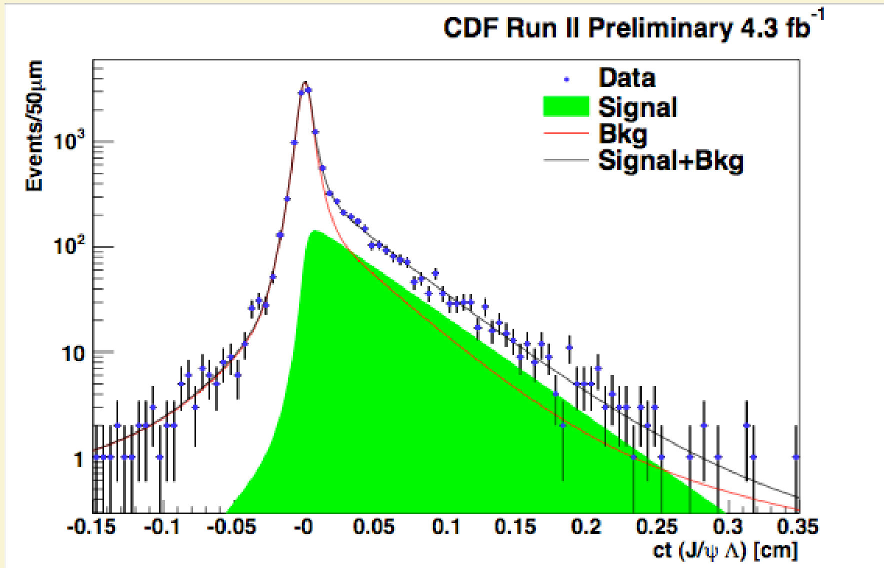
In agreement with theoretical prediction:

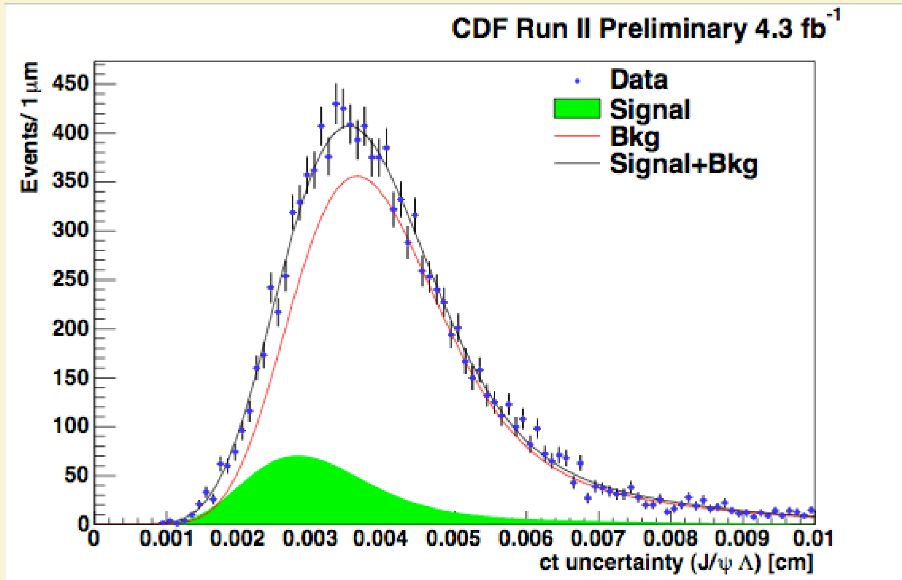
$\tau(B^+)=(1.063\pm0.027\ )\tau(B_d)$ (theory)

$\tau(B^+)=(1.088\pm0.009\ \pm0.004)\tau(B_d)$ (exp)

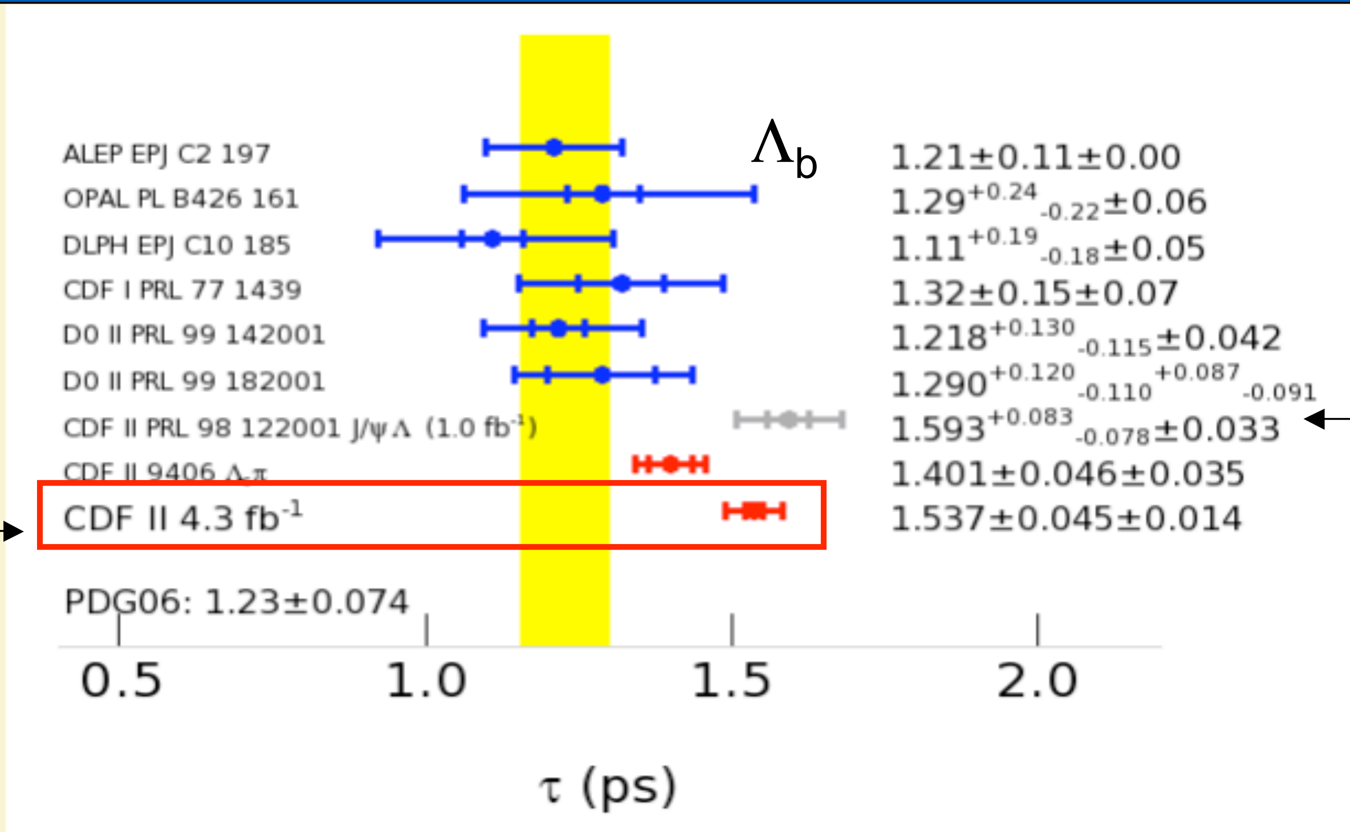
Λ_b Fit Projections







Λ_b Lifetime results



New Result

Previous result in same channel

Most precise Λ_b lifetime measurement

With 4.3 fb^{-1} the Λ_b lifetime remains higher in comparison to other measurements.

Measured Ratio: $\tau(\Lambda_b)/\tau(B_d) = 1.020\pm0.030(stat)\pm0.008(syst)$

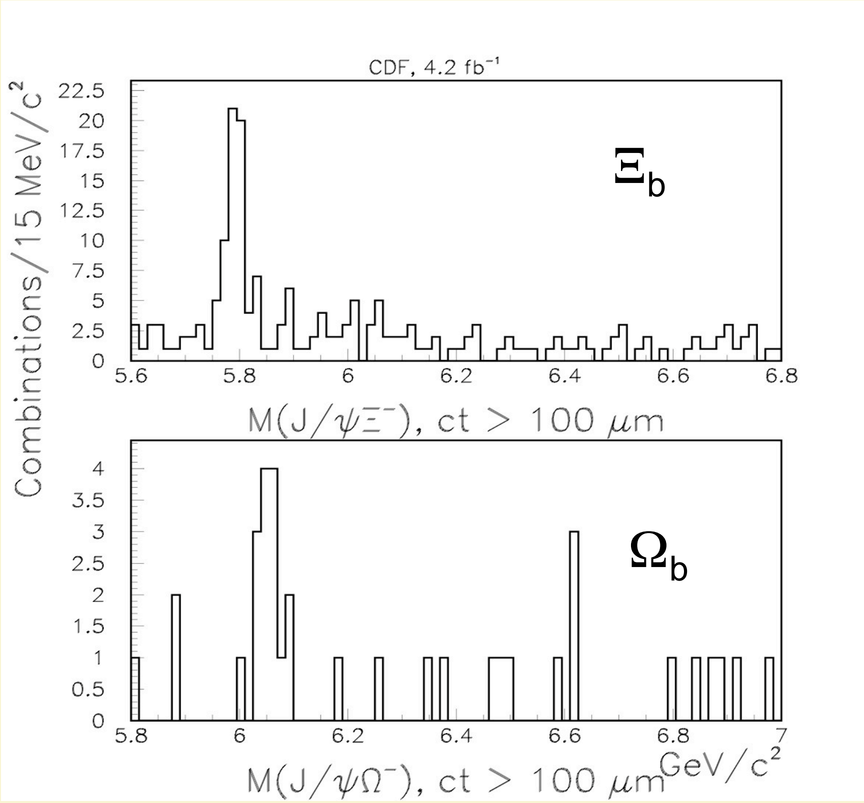
Theory: $\tau(\Lambda_b)/\tau(B_d) = 0.88\pm0.05$, although there are theories that favor a higher ratio 0.9-1.0

A.Lenz, arXiv:0802.0977

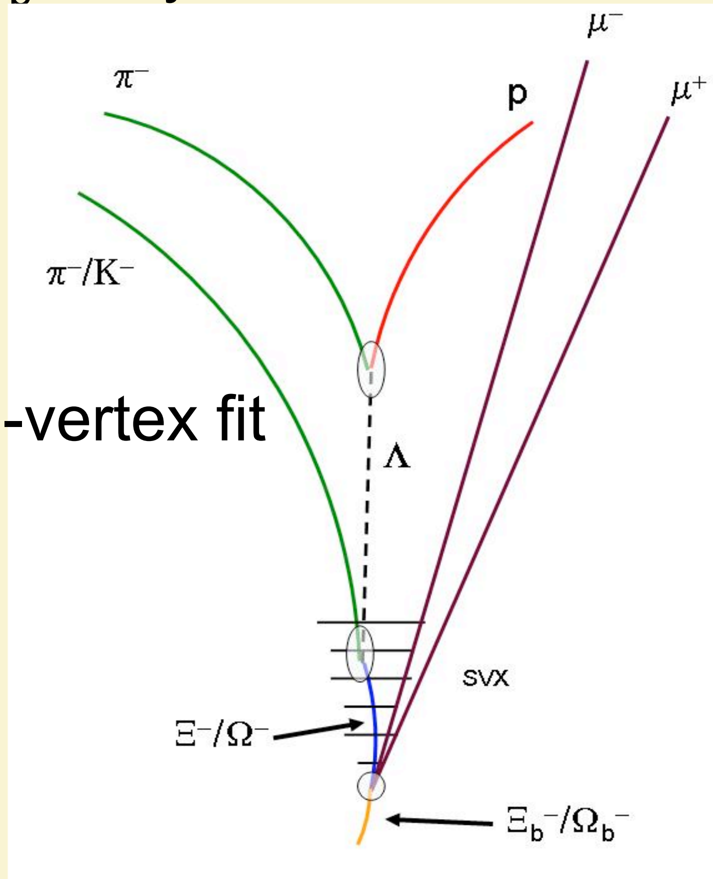
I.I Bigi, hep-ph/0001003

Heavier Baryons

CDF and D0 have observed the Ξ_b and Ω_b baryons



5-track 3-vertex fit



CDF uses these samples to measure lifetimes

Baryon lifetimes

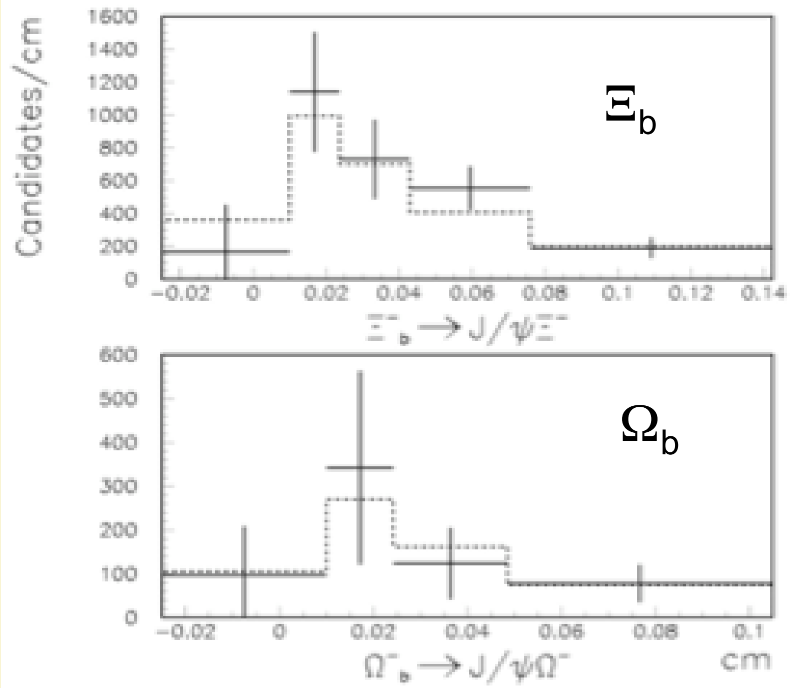
Low statistics (esp bkg) motivates a different approach to lifetime measurement

Data divided in bins of decay time

Mass fit in each bin determines N(sig. cand)

Number of signal candidates in each ct bin fitted to determine lifetime.

Method tested and validated on Λ_b and B^0 decay channels



$\tau(\Xi_b^-) = 1.56^{+0.27}_{-0.25}$ (stat) $\pm$ 0.02 (syst) ps First fully reconstructed measurement

$\tau(\Omega_b^-) = 1.13^{+0.53}_{-0.40}$ (stat) $\pm$ 0.02 (syst) ps First measurement

Flavor changing Neutral Currents

Forbidden at tree level

B_d, $B_s \rightarrow \mu\mu$ highly studied. In the standard model expected branching ratios :

$BR(B_s \rightarrow \mu+\mu-)=(3.86\pm0.57)\times10^{-9}$ $(|V_{ts}|^2)$
$BR(B_d \rightarrow \mu+\mu-)=(1.00\pm0.14)\times10^{-10}$ $(|V_{td}|^2)$

Beyond the reach of the detector sensitivities.

New physics scenarios Brx100

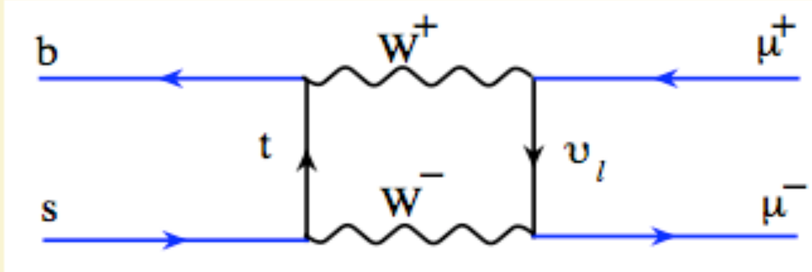
MSSM Br $\propto \tan^6(\beta)$

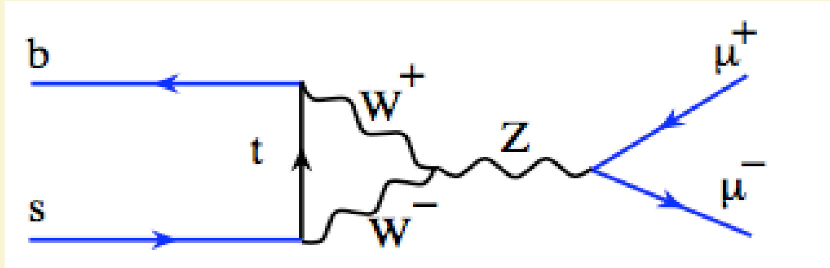
RPV also sensitive at low tan beta

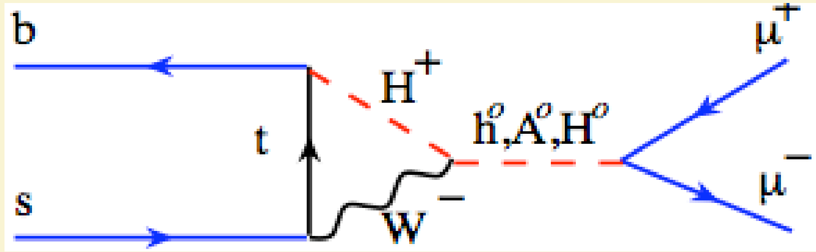
Limits on these ratios place constraints on new physics models.

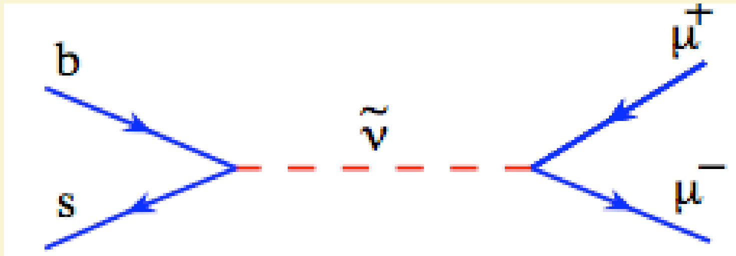
Limits can be set for B_s and B_d separately

Non-miminal flavor violating models can affect each mode differently.









$B_s \to \mu\mu$ - Analysis Strategy

$$B(B_s^0 \to \mu\mu) = N(B_s^0 \to \mu\mu) \times k$$

$$k = \frac{1}{N(B^+)} \times \boxed{\frac{\varepsilon(B^+)}{\varepsilon(B_s^0)}} \times \boxed{f\left(\frac{b \to B^+}{b \to B_s^0}\right)} \times \boxed{B(B^+ \to J/\Psi K^+, J/\Psi \to \mu^+\mu^-)}$$

Efficiency ratio from MC

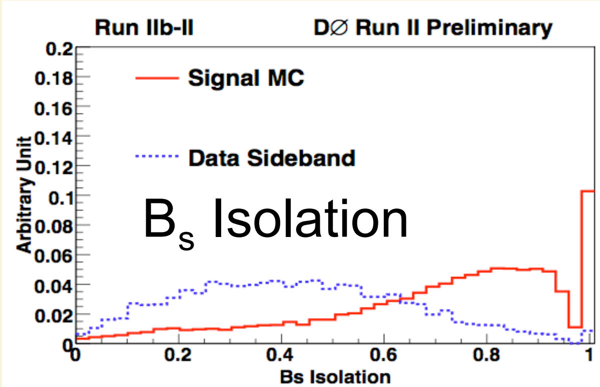
Fragmentation ratio between B^+ & B_s

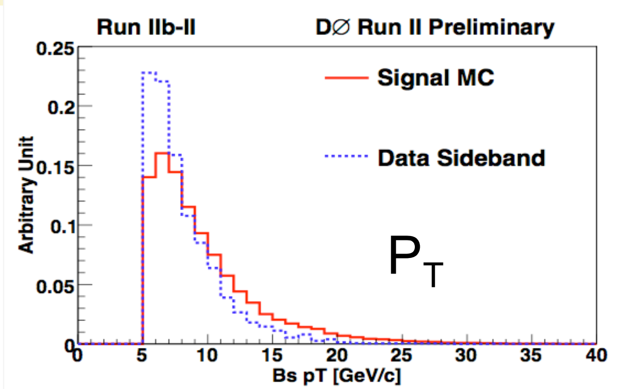
Branching fraction of normalization channel

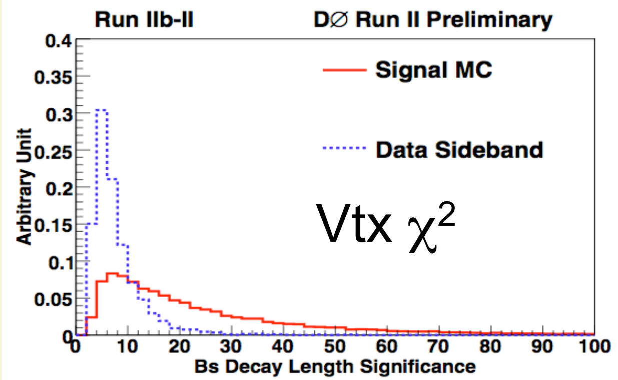
Background rejection

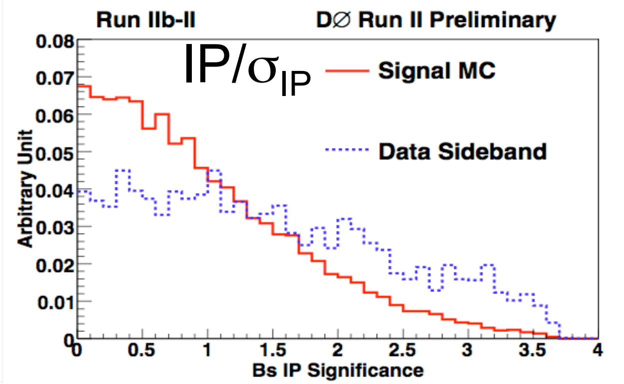
Boosted Decision Tree used to reduce background. Inputs:

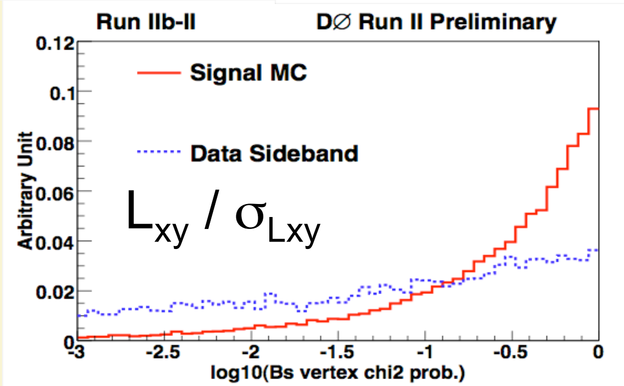
- B_s Isolation
- P_T
- Vtx χ^2
- IP/σ_{IP}
- L_{xy} / σ_{Lxy} (2D flight distance)





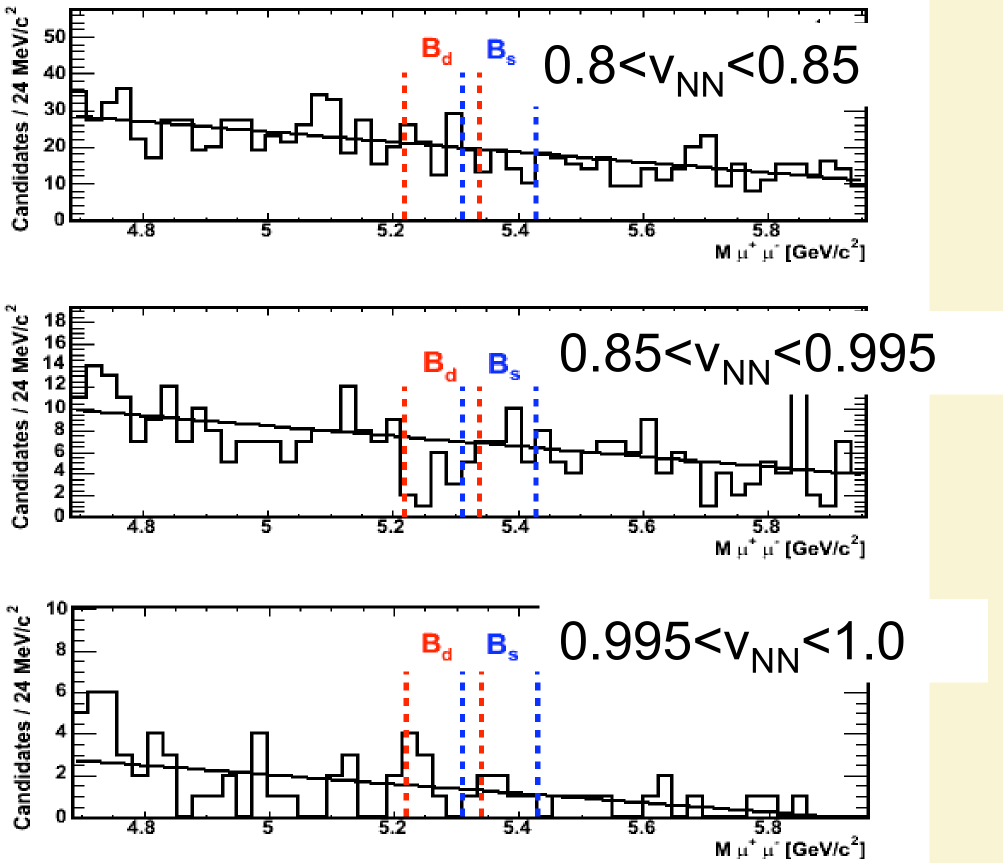


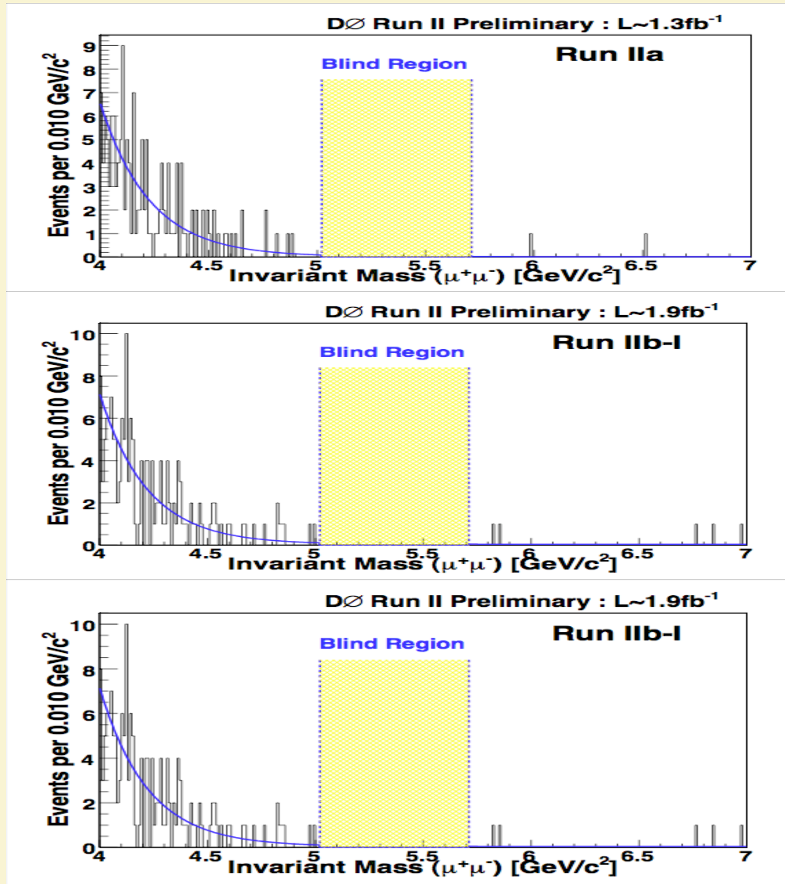




Very similar method used at CDF: slightly different variables and use of a neural net discriminant

Results





3 increasing bins of NN

3 data periods

$Br(B_d \rightarrow \mu\mu) < 7.6 \times 10^{-9}$ (95%CL)

$Br(B_s \rightarrow \mu\mu) < 4.3 \times 10^{-8}$ (95%CL)

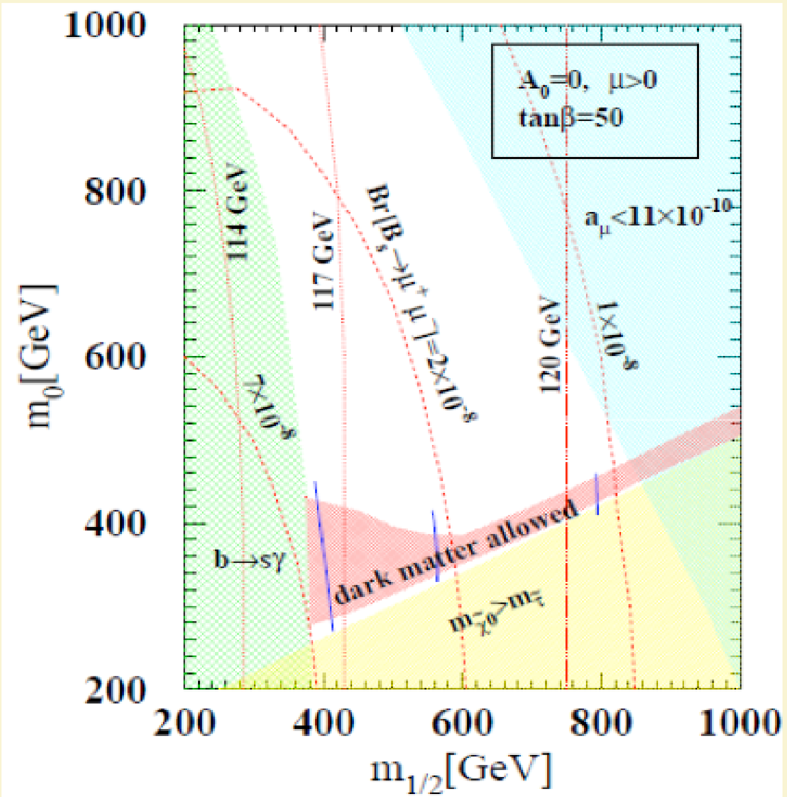
Expected upper limit (5 fb^{-1})

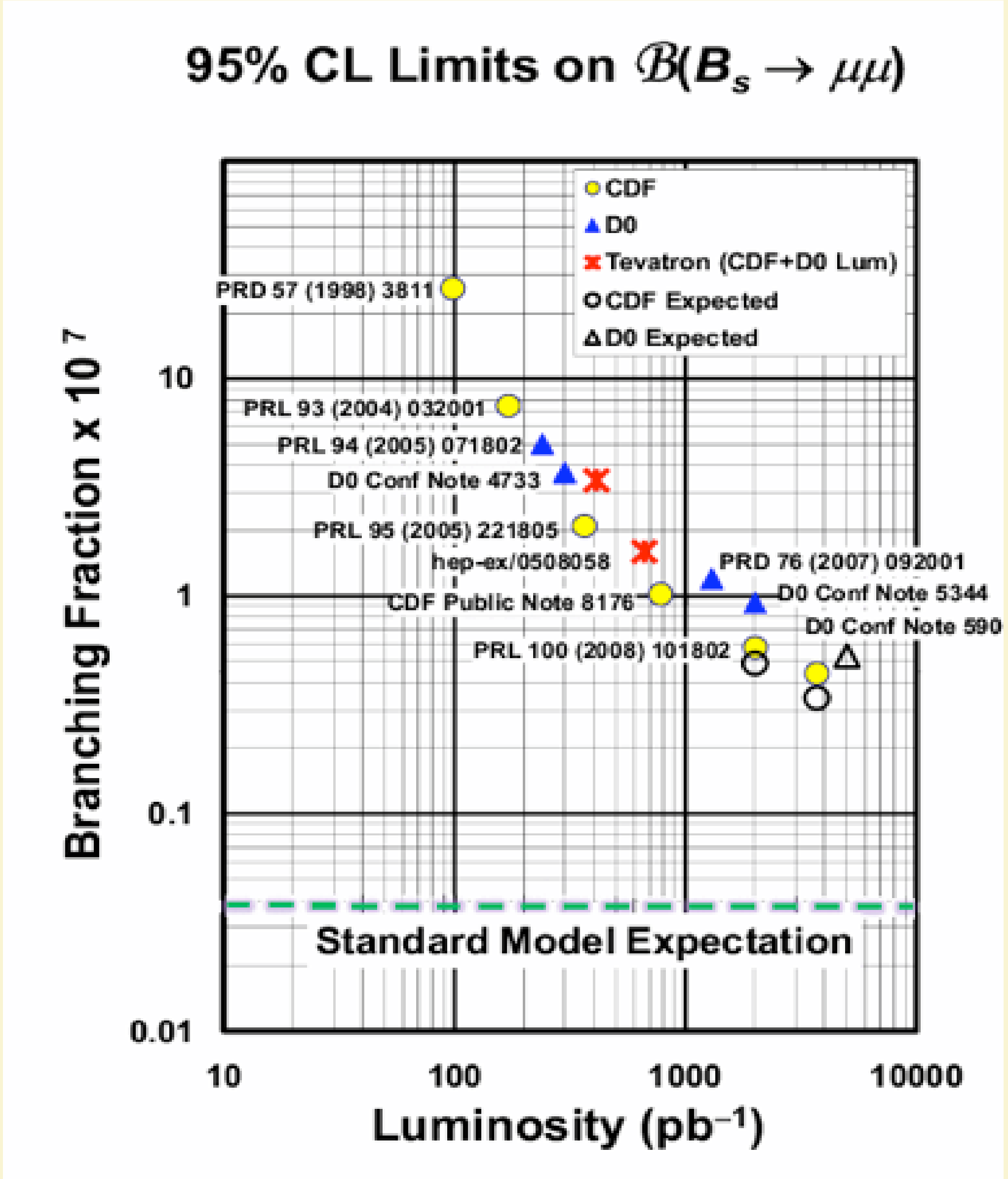
$Br(B_s \rightarrow \mu\mu) < 5.3 \times 10^{-8}$ (95%CL)

Outlook

Search for (B_s➔μμ) already reduced allowed parameter space of SUSY models

These analysis analyse 3.7 and 5 fb^{-1}. More on tape





mSUGRA Arnowitt et al PLB 538 (2002) 121

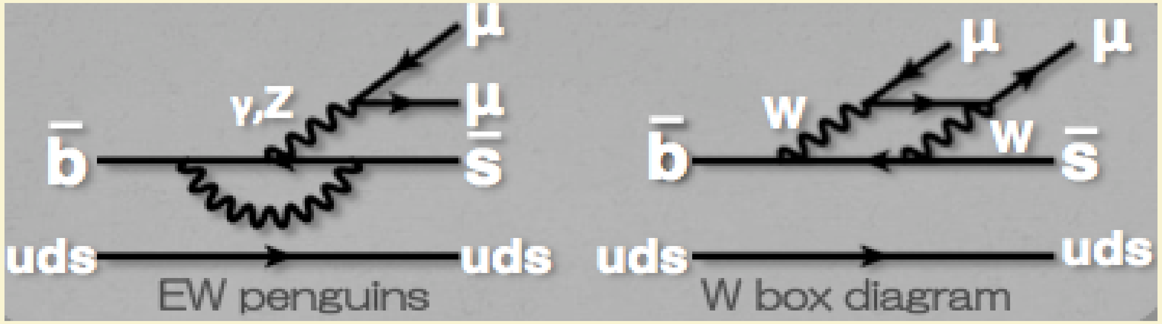
B→μμ h

SM Br ~10^{-6} -Are observable

Interesting observables:

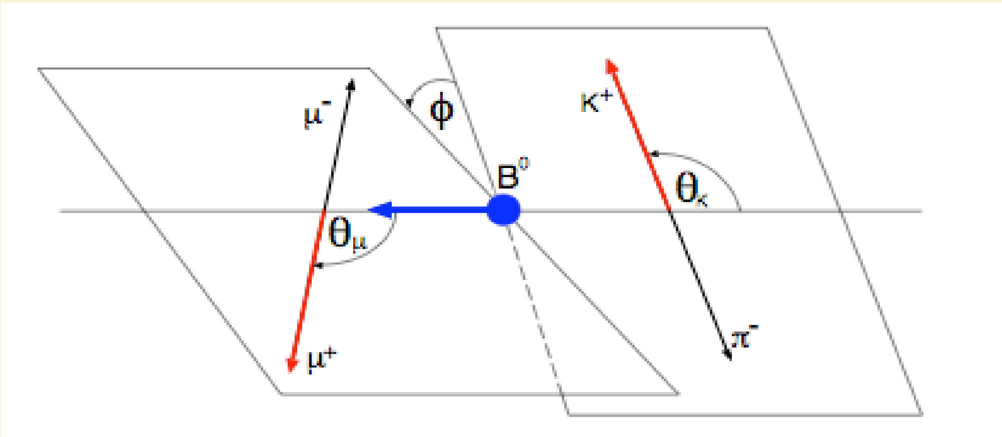
•Differential BR

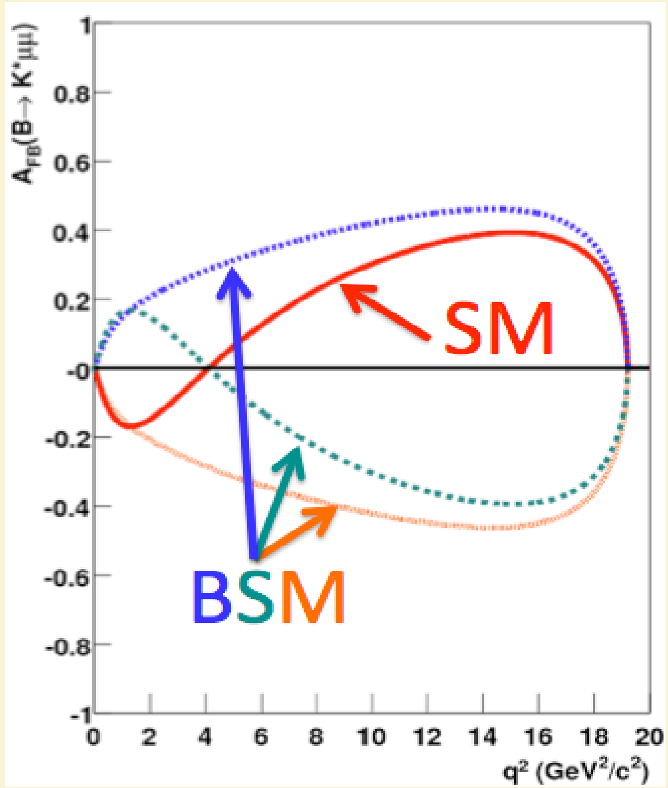
•Muon F-B asymmetry



Sensitive to Wilson Coefficients - Indicate whether underlying dynamics are governed by SM or NP

$$A_{FB}(q^2) = \frac{\Gamma(q^2, \cos\vartheta_\mu > 0) - \Gamma(q^2, \cos\vartheta_\mu < 0)}{\Gamma(q^2, \cos\vartheta_\mu > 0) + \Gamma(q^2, \cos\vartheta_\mu < 0)}$$

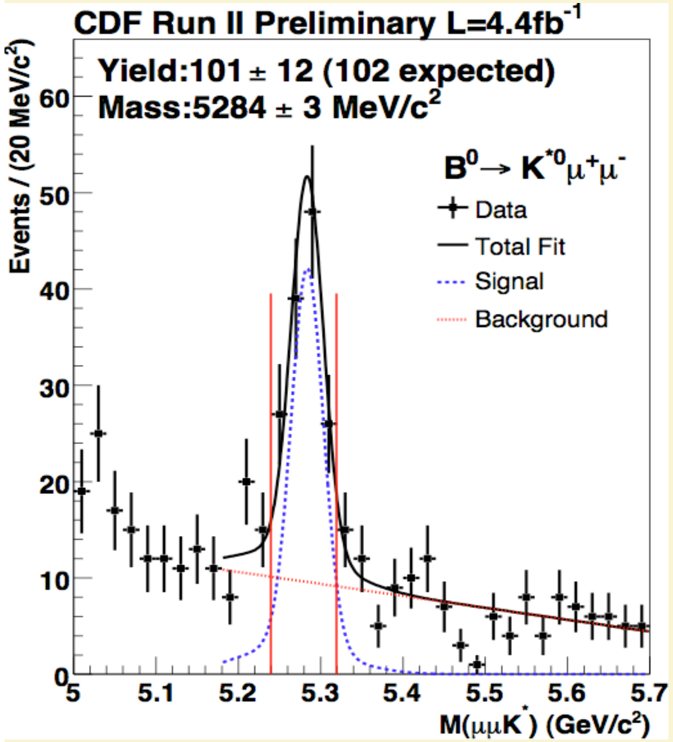


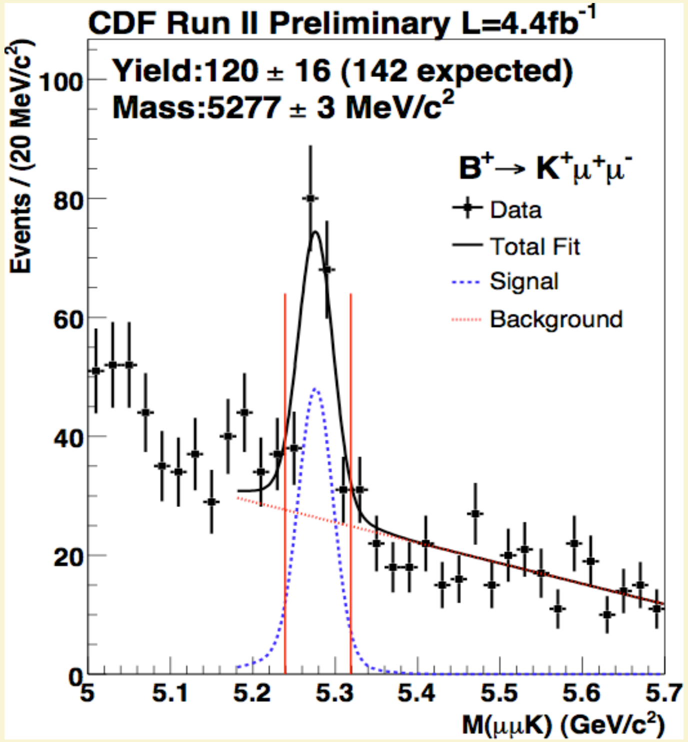


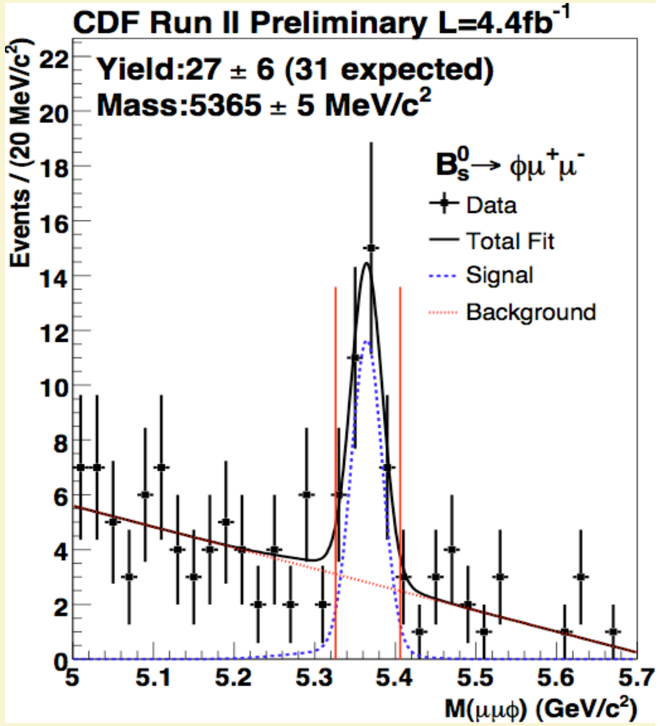
Observation of B→μμ h decays

Selection optimized by neural net

B→J/Ψh used as a control channel in measuring relative BR







$Br(B^0 \rightarrow \mu\mu K^*)$

$(1.06 \pm 0.14 \pm 0.09) \times 10^{-6}$

$Br(B^+ \rightarrow \mu\mu K^+)$

$(0.38 \pm 0.05 \pm 0.03) \times 10^{-6}$

$Br(B_s \rightarrow \mu\mu\phi)$

$(1.44 \pm 0.33 \pm 0.46) \times 10^{-6}$

First Observation

Competitive with world averages

Differential Br(B→K$^{(*)}$ μμ)

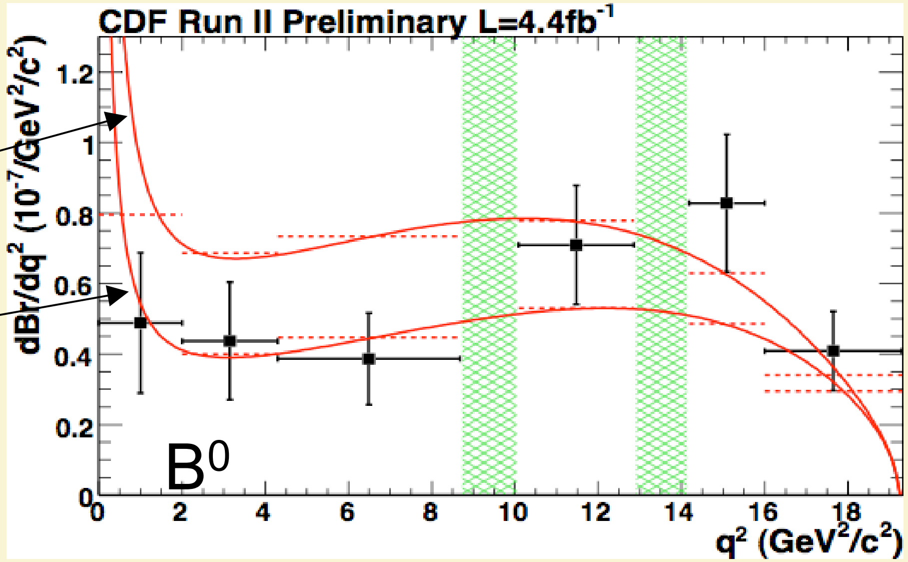
New physics could also appear in the differential Br vs $q^2 = M_{\mu\mu}^2$

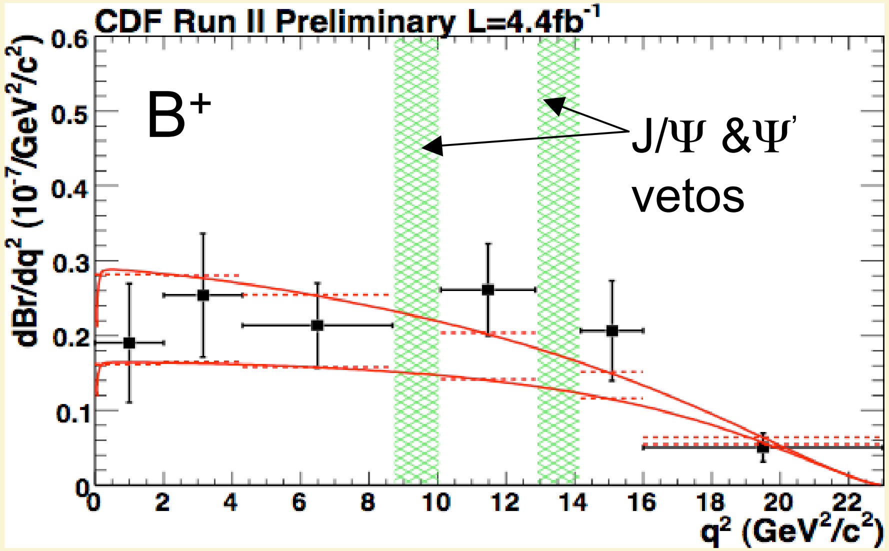
SM maximum

SM minimum

Uncertainy arises from SM form factors

Consistent with the SM

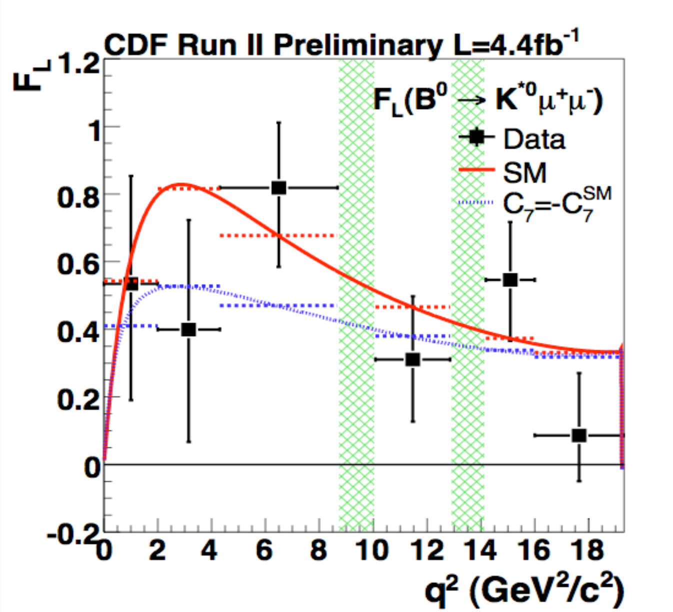


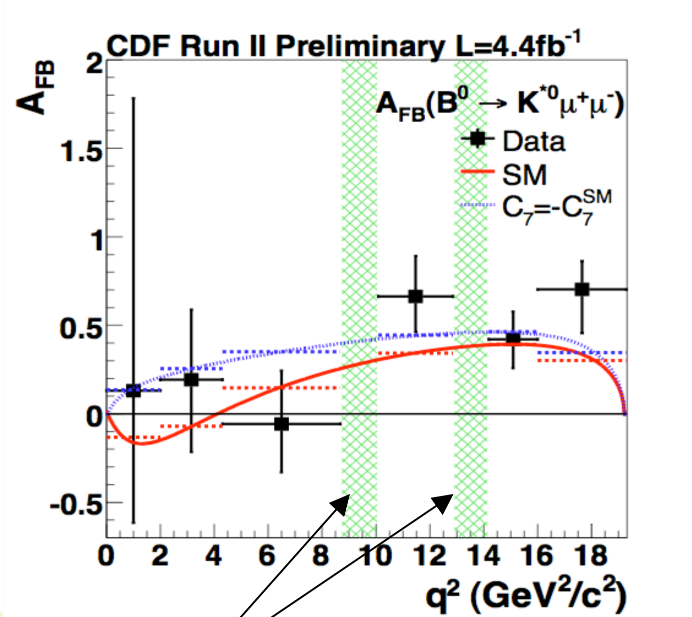


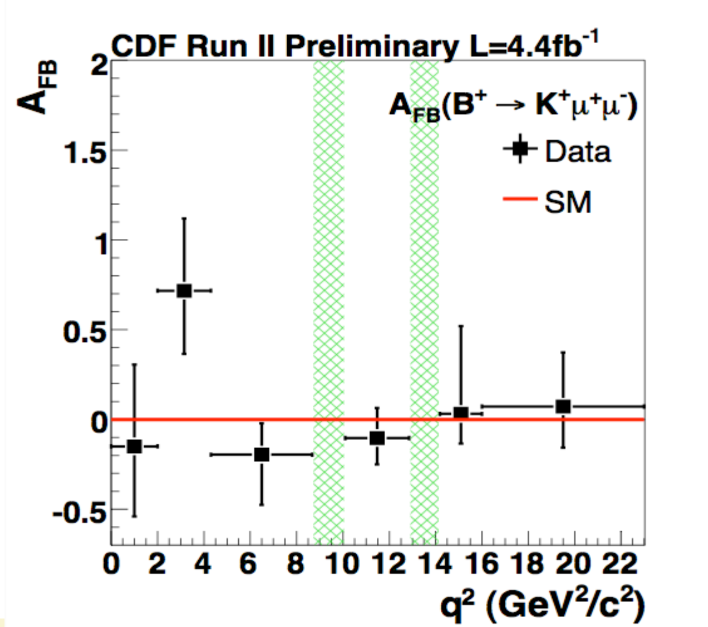
Asymmetry

F_L: K* Long Polarisation

Muon forward-backward asymmetry







J/Ψ & Ψ' veto

SM prediction

BSM scenario

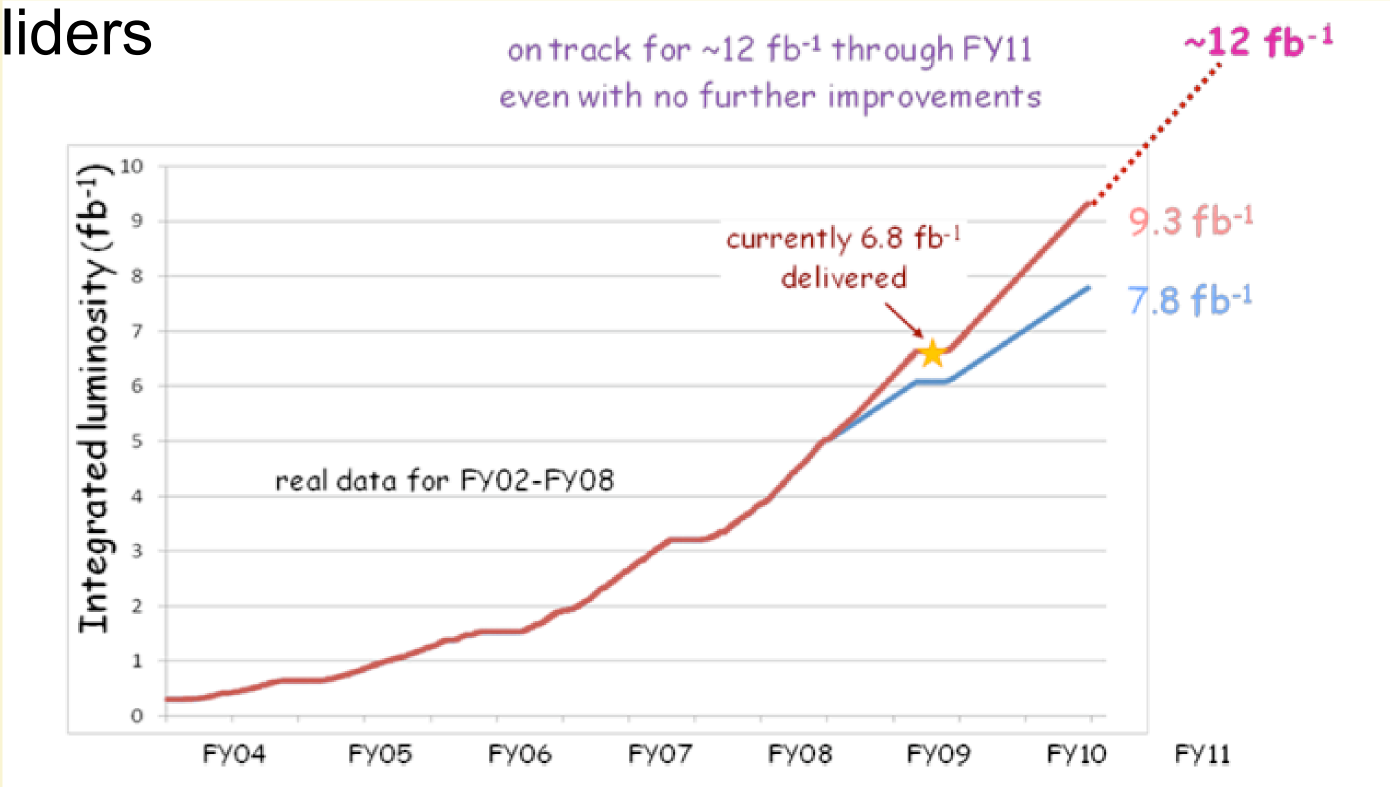
No inconsistencies with SM

Similar precision to B factory results

Conclusions

Best Lifetimes, Best Limits, First Observations, …..

Tevatron continues to showcase the possibilities of flavor physics at hadron colliders



Today's presentations shows results with less than half the expected Run 2 dataset.

Tevatron will continue to set tough standards to beat

CDF - selection

Similar strategy to D0. Uses ANN to reduce background

Variables

- λ^{3D} (proper decay time)
- Bs isolation
- $\Delta\alpha^{3D}$ (opening angle)
- $\lambda^{3D}/\sigma_{\lambda}^{3D}$
- $P_T(B_s)$
- $P_T(\mu)$

Looks for B_s and B_d separately

Non-miminal flavor violating models can affect each mode differently.