Tevatron Results on
B spectroscopy, lifetimes and rare decays

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On behalf of the CDF and D0 Collaborations

13^{th} Lomonosov Conference

Moscow State University, August 23^{th}-29^{th} 2007

Outline

B spectroscopy:

- Ξ_b^- discovery
- Σ_b discovery
- B^{**} measurement

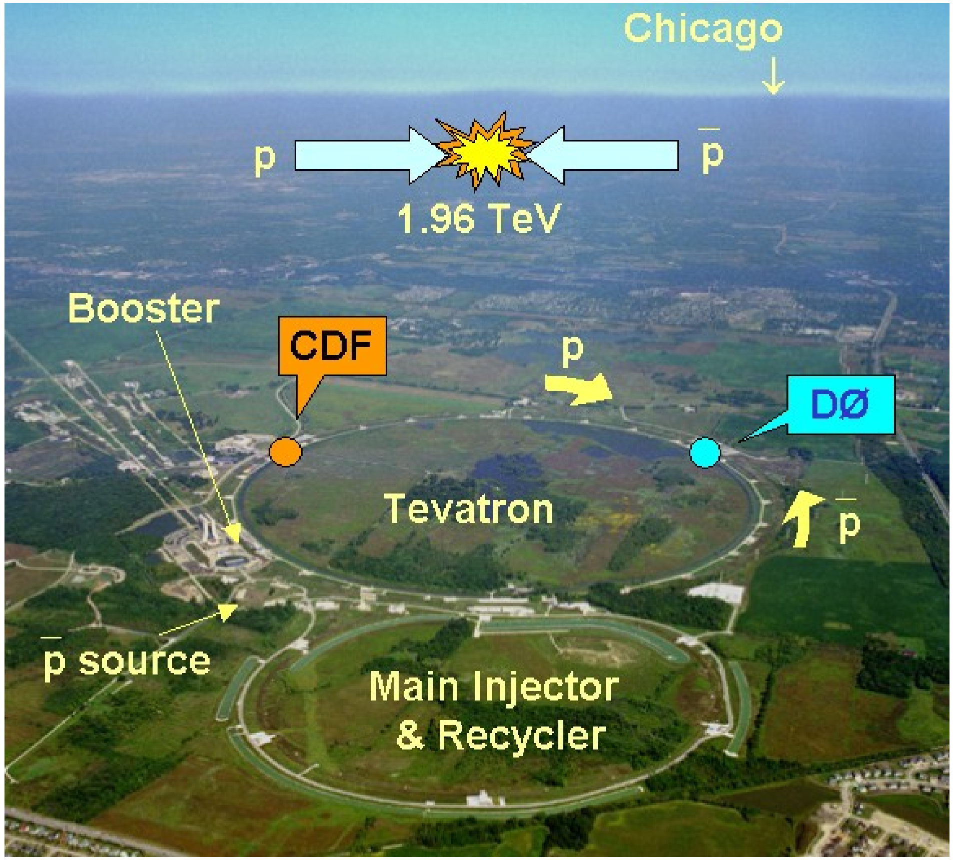
Lifetimes:

- D_0 evidence of oscillation
- Λ_b lifetime measurement
- Λ_b lifetime measurement using semileptonic decays

Rare decays:

- $B_{s\,(d)} \rightarrow \mu\mu$ limits

The Tevatron



The final collider in the Fermilab accelerators chain.

At present P-P$_{bar}$ collider operating at the highest energy in the world.

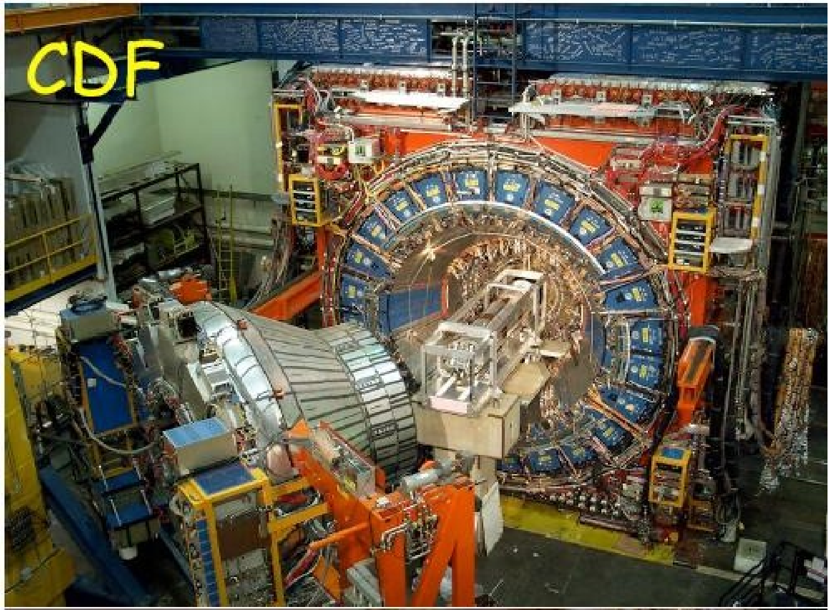
Able to probuce large samples of B_d,B_s,B_c,B baryons this is a unique place where to complement informations from the B factories.

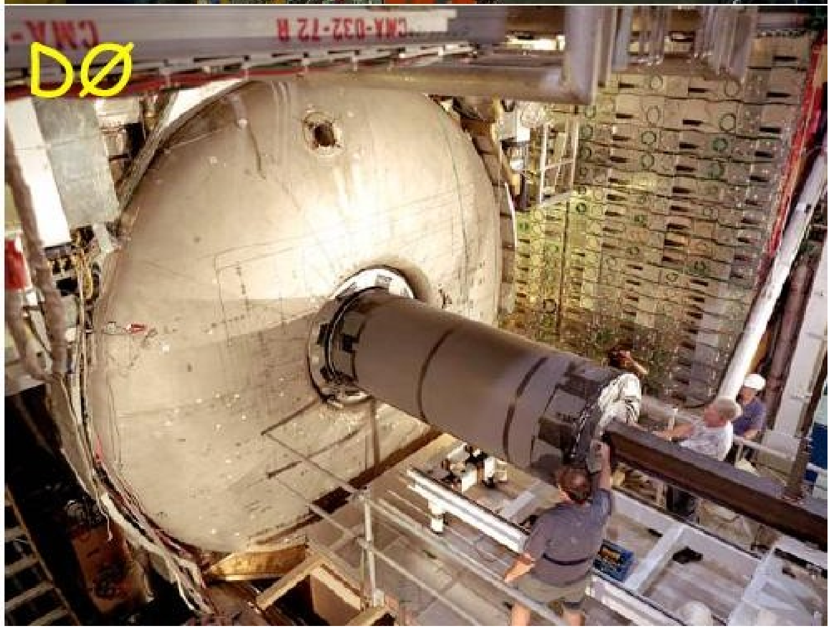
The collider is working very well:

~3 fb^{-1} integrated luminositiy delivered

~290 *10^{30} cm^{-2} s^{-1} peak istantaneous luminosity

Detectors overview





CDF

Excellent vertexing and mass resolution:
L00 (r_{inner} ~1.5 cm),7/8 silicon layers
Particle identification for charged particles:
De/Dx and Time of Flight measurements

D0

Excellent muon coverage and triggering:
acceptance $|\eta| < 2.2$
Good vertexing:
L0 upgrade (r_{inner} ~1.6 cm)

Peculiarity:

CDF:Trigger for Two Displaced Tracks
(to collect samples of hadronics B decay)

D0 :2 T solenoid and 1.8 T toroid reversed weekly.
(to reduce sensitivity to detector geometry.)

B spectroscopy I

An the Tevatron Collider is possible to produce heavy baryons with b and/or s quark(s) inside.
These particles cannot be produced in a B factory.

Tree of these states were recently observed at the Tevatron:

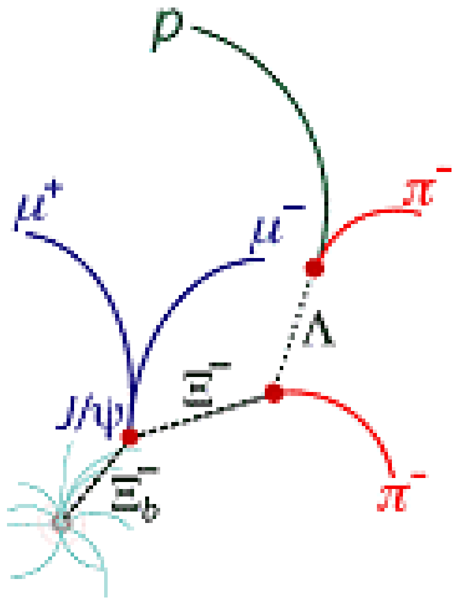
Ξ_b^- , Σ_b^+ , Σ_b^-

About the Ξ_b^- the two experiments made the observation and the measurement of the mass in the decay chain

$\Xi_b^- \to J/\psi\ \Xi^-$ Where $J/\psi \to \mu^+\mu^-$, $\Xi^- \to \Lambda^0\pi^-$, $\Lambda^0 \to p\pi^-$

The details on the D0 measurement were alredy expained in the present conference, and now i will describe the CDF measurement.

B spectroscopy I: Ξ_b^-



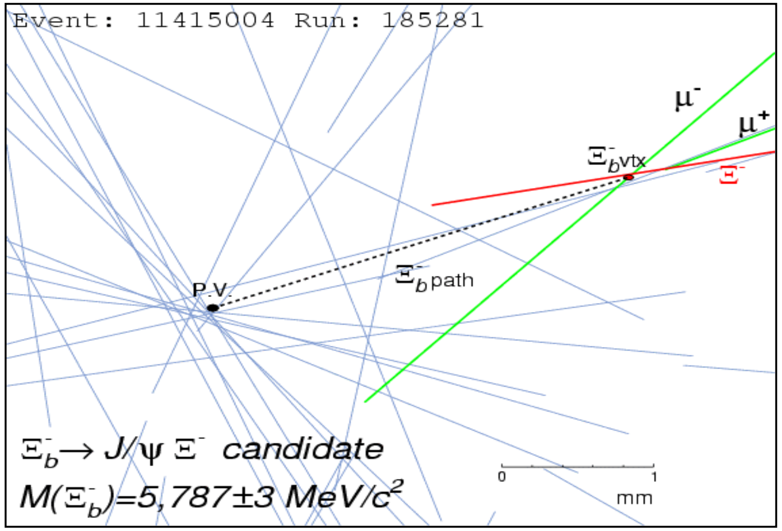
This analysis makes use of the tracking and muon identifications and is based upon data collected with a trigger that was dedicated to the collection of a J/ψ sample.

Then the Ξ^- reconstruction begins with a scan of all additional tracks found in each J/ψ event

Pair of oppositely charged track are considered as Λ candidates.
All pairs with an invariant mass within 10 MeV/c^2 of the Λ world average mass have their track parameters recalculated by subjecting them to a fit with the momenta of the two tracks constrained to form the Λ mass invariant.

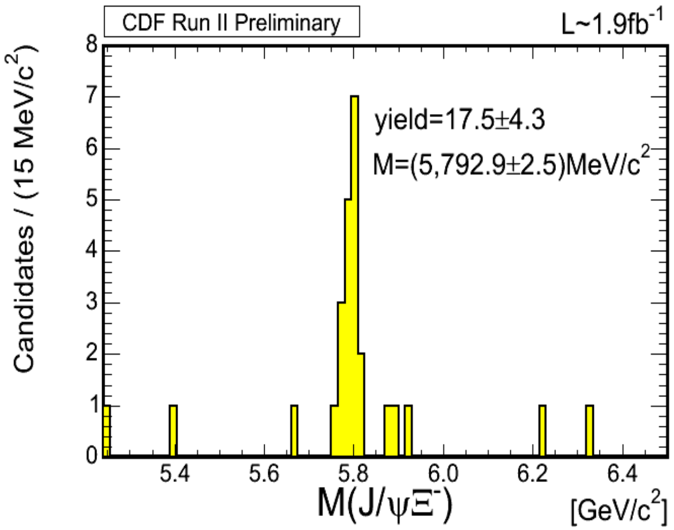
B spectroscopy I: Ξ_b^-

Utilization of Ξ^- tracks turns 5 tracks final state ($\mu\mu\pi p\pi$) into 3 tracks vertex ($\mu\mu\Xi$) similar to $B^+ \rightarrow J/\psi\ K^+$.



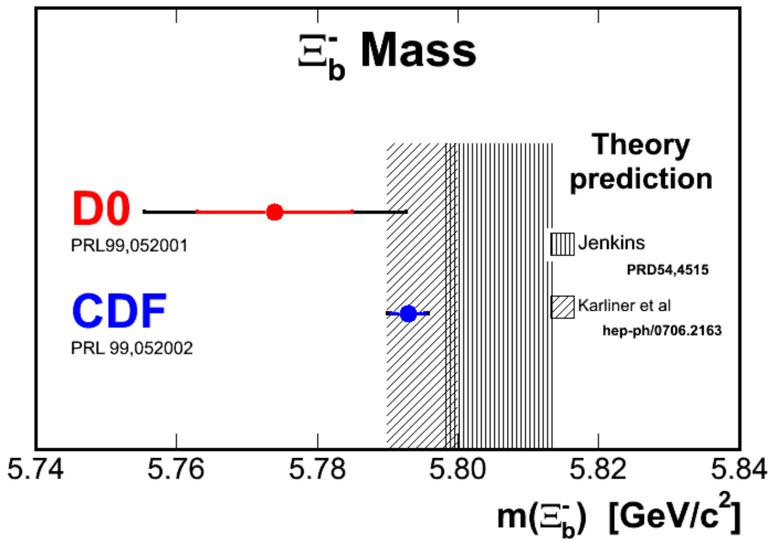
Selection criteria are data driven and independent of the signal under study:
optimize cuts to get best $B^+ \rightarrow J/\psi\ K^+$ and apply these cuts to $\Xi_b^- \rightarrow J/\psi\ \Xi^-$ signal.

The final result is a statistical significance of the Ξ_b^- signal over 7 σ



B spectroscopy I: Ξ_b^-

The masses and their uncertaints obtained from the five tracks were used in an unbinned likelihood fit to measure the Ξ_b^- mass.



The mass values are:

D0 (1.3fb^{-1}data)

5774±11(stat) ±15(syst) Mev

CDF (1.9 fb^{-1}data)

5792.9±2.5(stat)±1.7(syst) Mev

B spectroscopy II

CDF observed the new heavy baryons Σ_b and Σ_b^*
Using the fully reconstructed decay mode
$\Sigma_b^{(*)\pm} \rightarrow \Lambda_b^0 \pi^\pm$; $\Lambda_b^0 \rightarrow \Lambda_c^+ \pi^-$; $\Lambda_c^+ \rightarrow pK^- \pi^+$

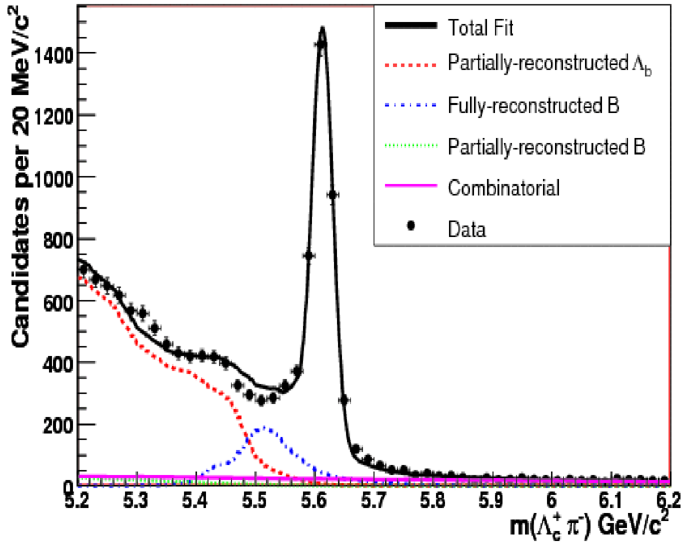
The model used is a HQET interaction between a heavy (bottom) quark and a cloud of two light quarks.
States containing ligth diquark in a simmetric color state are called Σ.
In the $\Sigma_b^{(*)}$ ground states the light diquarks system has Isospin=1 and $J^P=1^+$, which couples to the heavy quark spin and results in a doublet of barions with.

$$J^P=1/2^+ \ (\Sigma_b) \ \text{and} \ J^P=3/2^+ \ (\Sigma_b^*)$$

A displaced track trigger is employed to select the events sample .

B spectroscopy II

The invariant mass distribution of $\Lambda_c^+\pi^-$ candidates is shown overlaid with a binned Maximun likelihood fit, with a clear signal at the expected Λ_b^0 mass

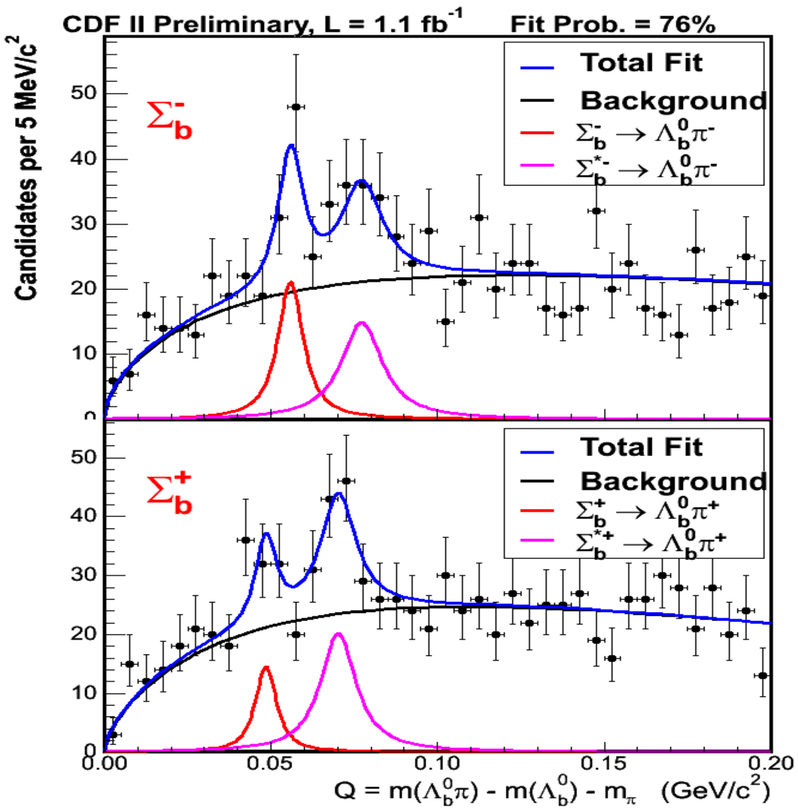


Fit on the selected $\Lambda_b^0 \rightarrow \Lambda_c^+\pi^-$

The reconstruction of $\Sigma_b^{(*)}$ proceeds by combining Λ_b^0 canditates with all remaining high quality tracks

The $\Sigma_b^{(*)}$ are selectedin two subsamples using the charge of the pion from the $\Sigma_b^{(*)}$:
In the $\Lambda_b^0\pi^-$ this pion has the same sign as the pion from Λ_b^0 and in the subsample $\Lambda_b^0\pi^+$ the charge is opposit.

B spectroscopy II



The dominant background is the combination of prompt Λ_b^0 baryons with extra tracks produced in the hadronization process.

The Λ_b^0 hadronization background is obtained from $\Lambda_b^0 \to \Lambda_c^+ \pi^-$ PYTHIA simulation.

The final results are:

$m(\Sigma_b^+) = 5807.8^{+2.0}_{-2.2}$(stat.) ± 1.7(syst.) MeV/c^2

$m(\Sigma_b^-) = 5815.2 \pm 1.0$(stat.) ± 1.7(syst.) MeV/c^2

$m(\Sigma_b^{*+}) = 5829.0^{+1.6}_{-1.8}$(stat.) $^{+1.7}_{-1.8}$(syst.) MeV/c^2

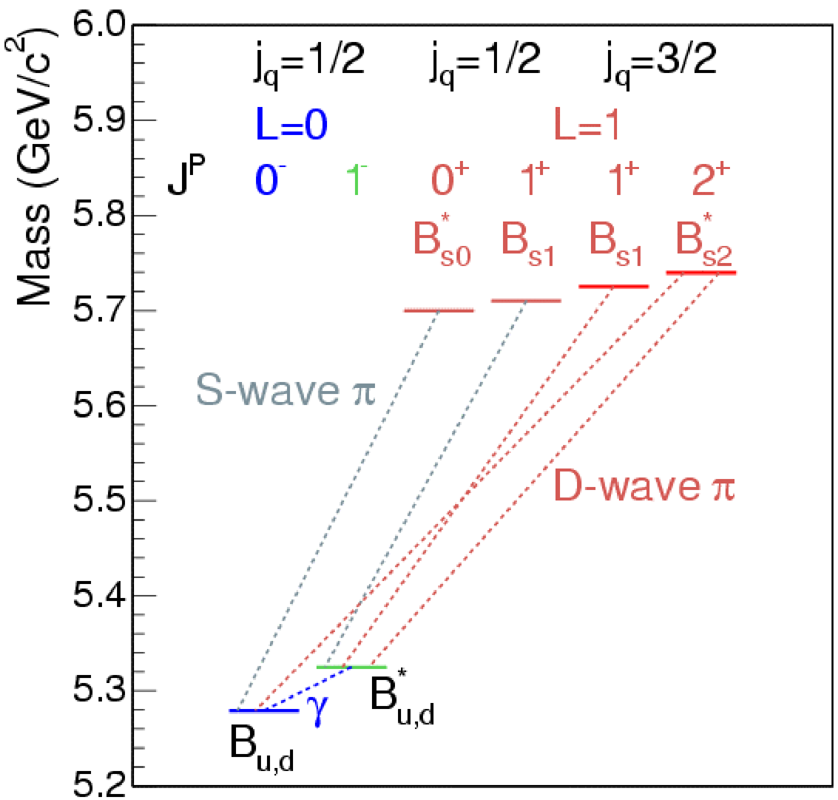
$m(\Sigma_b^{*-}) = 5836.4^{+2.0}_{-1.8}$(stat.) $^{+1.8}_{-1.7}$(syst.) MeV/c^2

The probability for the background only to produce a similar signal is less than 8.3 *10^{-8}

B spectroscopy III

Study of the excited staes in the $B_{u,d}$ mesons (orbitally excited (L=1) B^{**0} mesons)

A model heavy/ligth quark interaction can be applied easily at a B meson composed by a b and u,d quarks.
The first excited state occour when the light quark have an orbital angolar momentum L=1.



The b quark has a J spin=1/2 and the light quark has total angular momentum
$J_l = |L \pm 1/2|$
The total angolar momentun of the meson will be $J = 1/2 \pm J_l$

The staes can be labeled using L and J and in the limit of large b mass they total angular momentum and flavor became good quantum numbers.

B spectroscopy III

CDF measured the mass and the width in the fully reconstructed decays $B^{**0} \rightarrow B^{+} \pi^{-}$ or in the decay $B^{**0} \rightarrow B^{+*} \pi^{-}$ ($B^{+*} \rightarrow B^{+} \gamma$), where we do not detect the γ.

Then the B^{+} mesons are fully reconstructed in three decay channels:

$B^{+} \rightarrow J/\psi K^{+}$ ($J/\psi \rightarrow \mu^{+} \mu^{-}$), $B^{+} \rightarrow D^{0} \pi^{+}$ ($D^{0} \rightarrow K^{+} \pi^{-}$), and

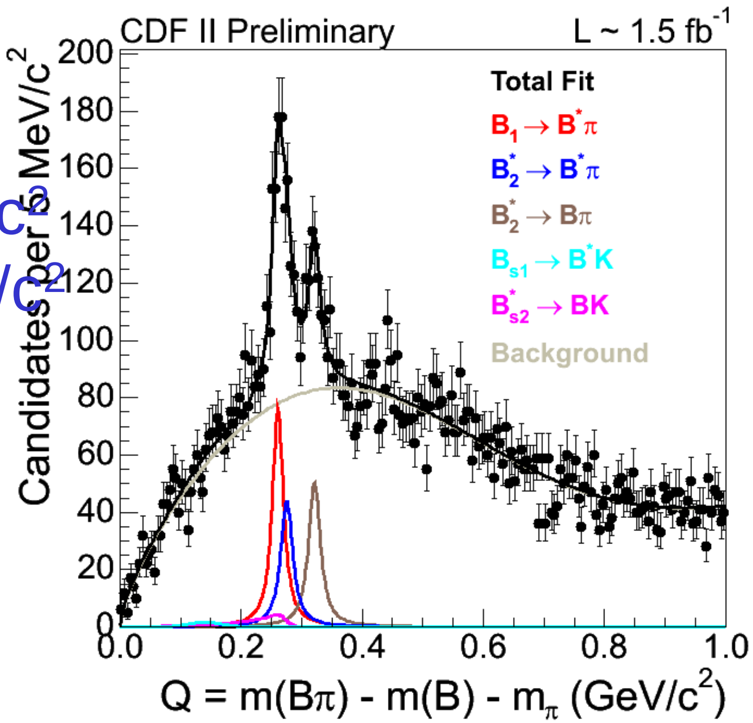
$B^{+} \rightarrow D^{0} 3\pi^{+}$ ($D^{0} \rightarrow K^{+} \pi^{-}$).

The resulting mass and width measurements of this analysis are obtained using an unbinned maximum likelihood fit to the combined mass difference $Q = m(B\pi) - m(B) - m(\pi)$

$m(B_1^{0}) = 5725.3^{+1.6}_{-2.1}$ (stat.) $^{+0.8}_{-1.1}$ (syst.) MeV/c^2

$m(B_2^{*0}) = 5739.9^{+1.7}_{-1.8}$ (stat.) $^{+0.5}_{-0.6}$ (syst.) MeV/c^2

$\Gamma(B_2^{*0}) = 22.1^{+3.6}_{-3.1}$ (stat.) $^{+3.5}_{-2.6}$ (syst.) MeV/c^2



B spectroscopy III

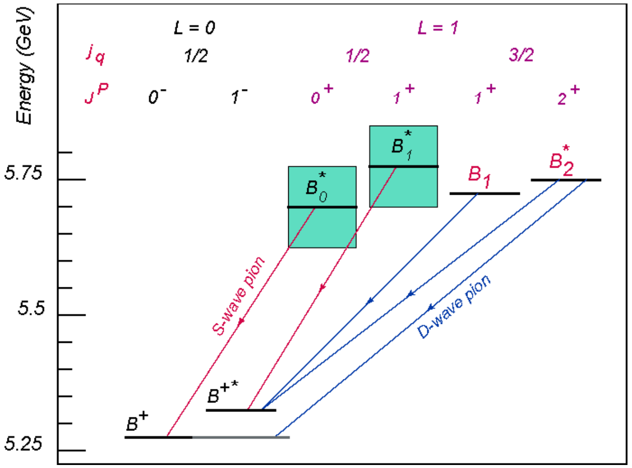
In the D0 analisys are observed the decays

$B_1 \rightarrow B^{+*}\pi^-$; $B^{+*} \rightarrow B^+\gamma$

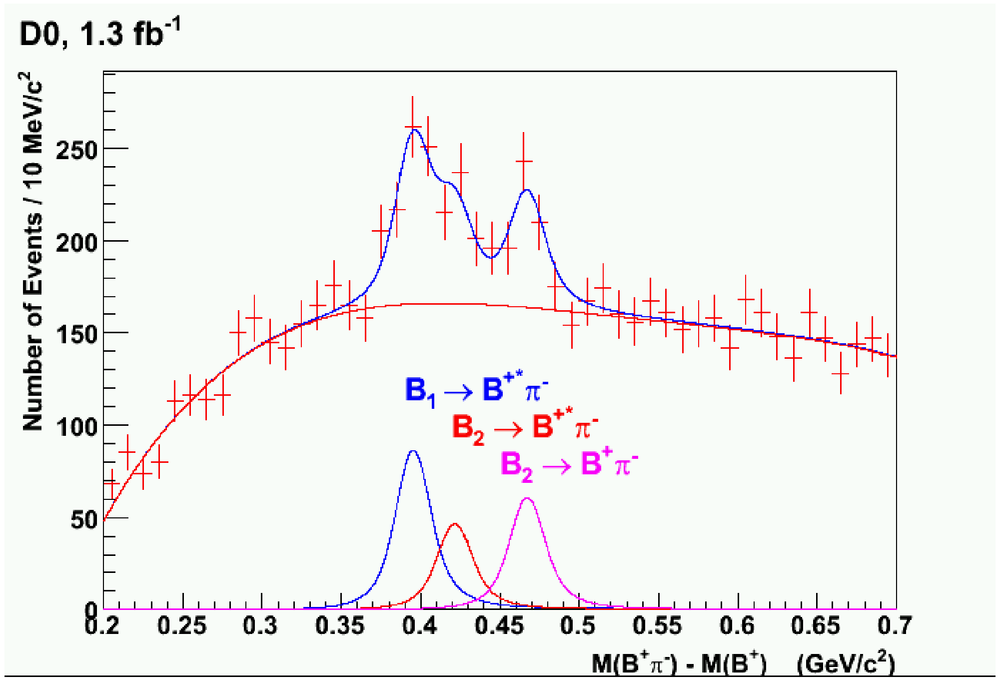
$B_2^* \rightarrow B^{+*}\pi^-$; $B^{+*} \rightarrow B^+\gamma$

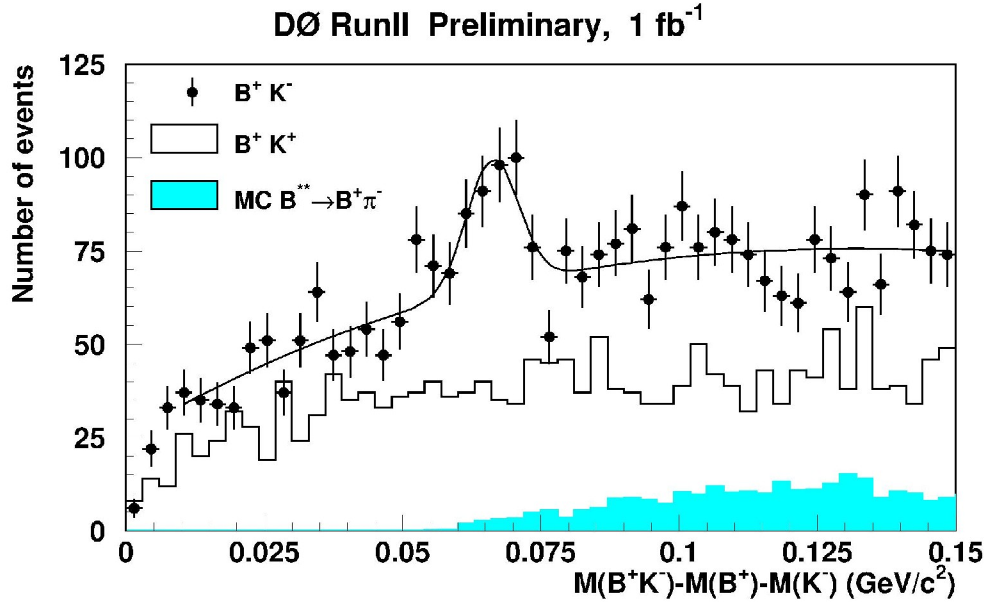
$B_2^* \rightarrow B^+\pi^-$;

And D0 plot the mass difference $\Delta M = M(B^+\pi^-) - M(B^+)$



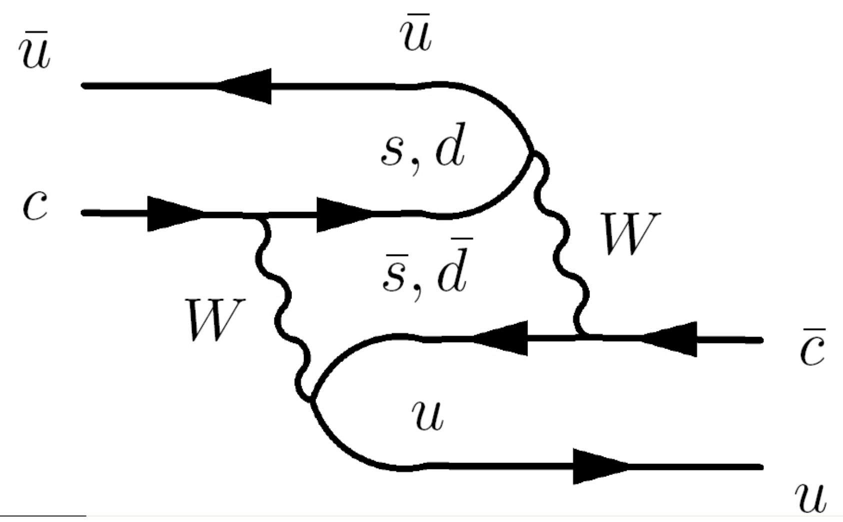
$$M(B^{*0}_{S2}) = 5839.1 \pm 1.4\ \text{Mev}/c^2(\text{stat})$$





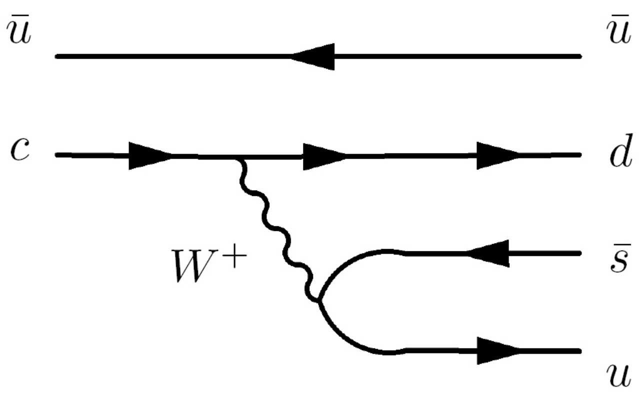
Evidence of D_0 meson oscillation

CDF time dependent measurement of D^0-D^0bar mixing, using approximately 1.0 fb^{-1} of CDF II data.
The measurement is done evaluating the ratio between "Wrong Sign“ and "Right Sign“, where "Right Sign“, refers to the decay chain $D^* \rightarrow \pi^+ D^0$, $D^0 \rightarrow K^- \pi^+$, which results from the Cabibbo Favored decay of D^0."Wrong Sign" refers to the decay chain $D^* \rightarrow \pi^+ D^0$, $D^0 \rightarrow K^+ \pi^-$, which results from Doubly Cabibbo Suppressed decays and charm mixing

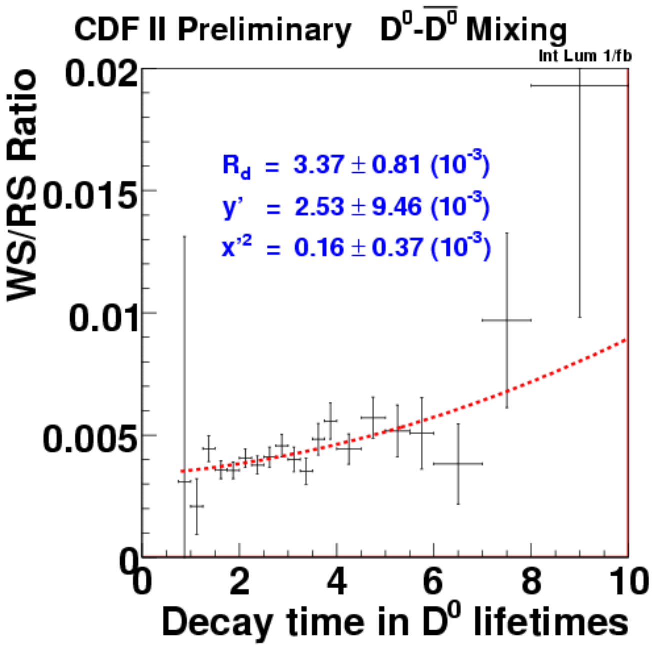


The oscillation can be represented as a mixing long distance interaction box.

Evidence of D_0 meson oscillation



Doubly Cabibbo Suppressed decays



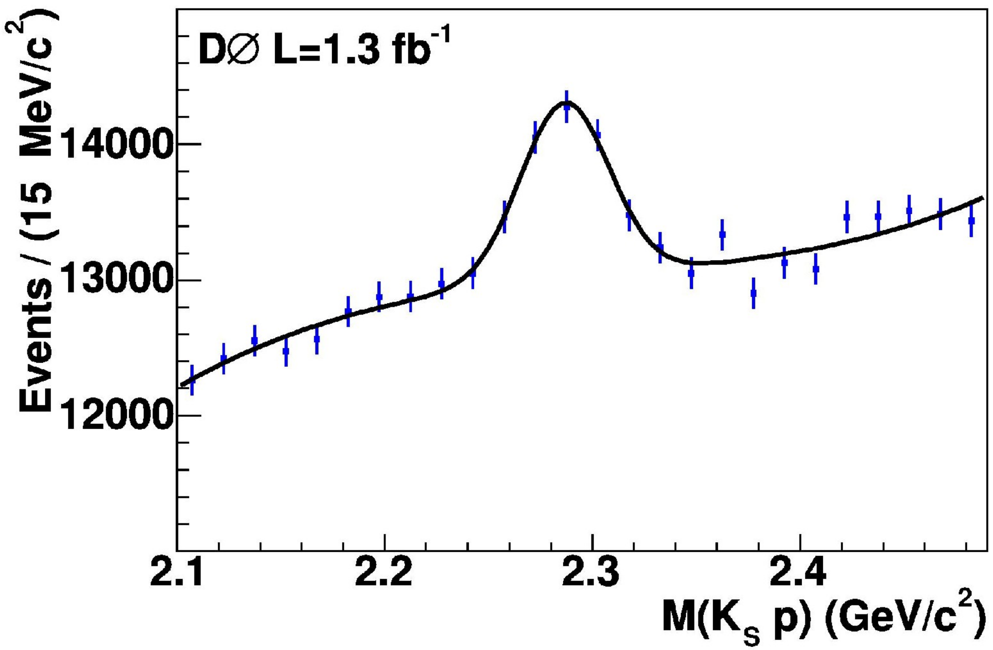
Best fit for mixing parameters are:
(uncertainties are combined stat. and syst.)

- Rd = 3.37 +/- 0.81 (times 10^-3)
- y' = 2.53 +/- 9.46 (times 10^-3)
- x'^2 = 0.16 +/- 0.37 (times 10^-3)

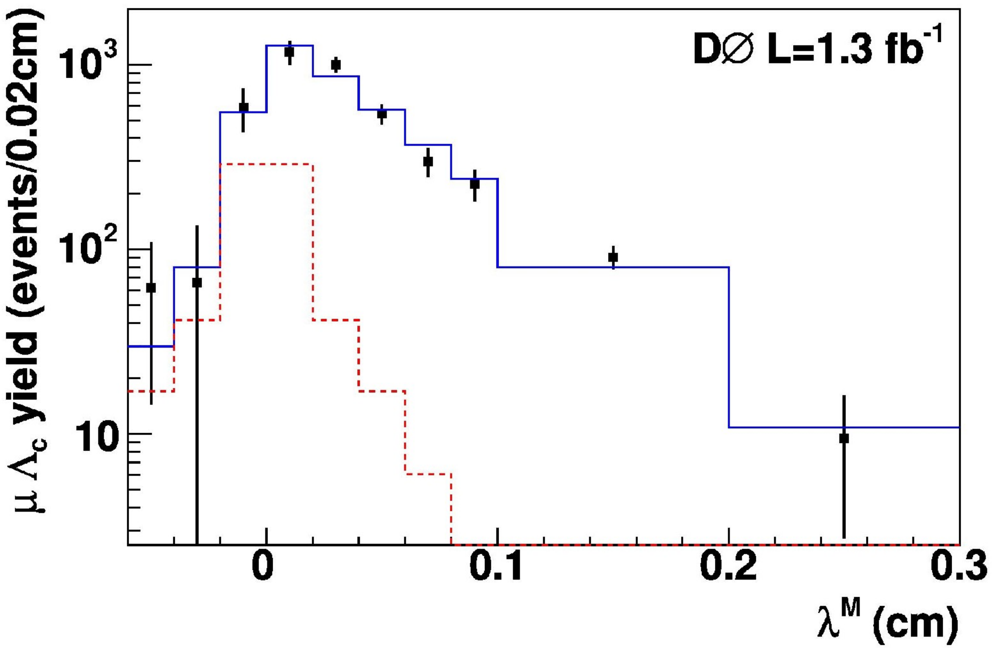
No-mixing probability (Bayesian statistics)
0.13% (equivalent to 3.2 standard deviations)

Lifetime II

D0 performed a measurement of the Λ^0_b reconstructed in the semileptonic decays:
in the decay $\Lambda^0_b \rightarrow \Lambda_c^+ \mu \nu_{bar}$+X
Using 4437±329 signal candidates the measure of the lifetime is $\tau(\Lambda_b)$= 1.290±110(syst) ±0.091(stat)ps



(K_sP mass fit for the selected Λ candidates)



This is the most precise measurements in semileptonic Λ^0_b decays

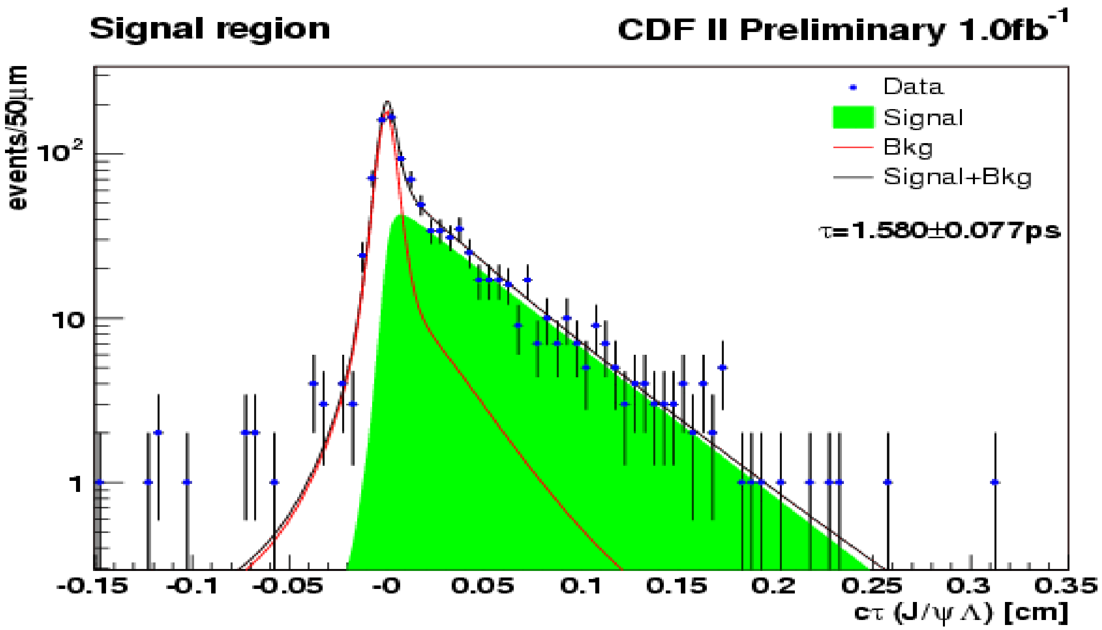
Lifetime III

CDF too perfomed Λ_b lifetimes mesurements using exclusive J/ψ decay channels, based upon 1 fb^{-1} of data.

The resulting mean lifetime measurement for the Λ_b is:

$\tau(\Lambda_b) = 1.580 \pm 0.077$ (stat.) ± 0.012 (syst.) ps

$\tau(\Lambda_b)/\tau(B^0) = 1.018 \pm 0.062 \pm 0.007$ (syst.)



The measurement performedby D0 is

$\tau(\Lambda b)/\tau(B0) = 0.811{+0.096}{-0.087}$(stat) ± 0.034(syst).

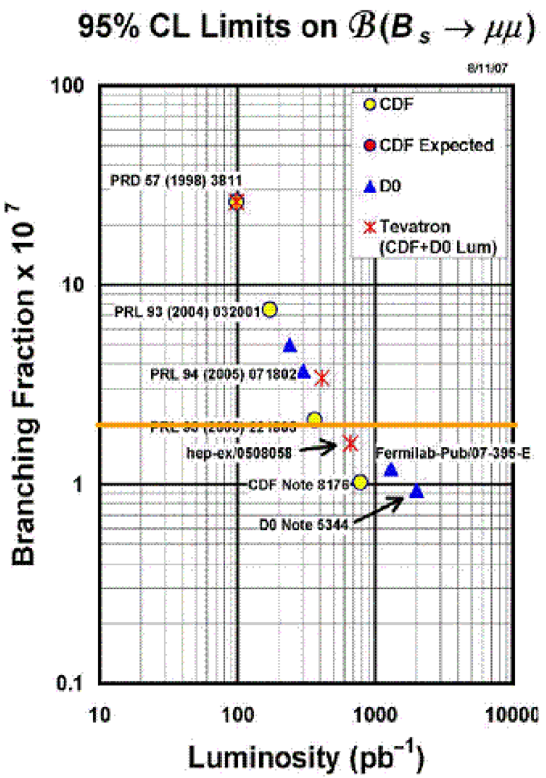
Rare decays I

Searches for the decays $B_s \rightarrow \mu\mu$ and $B_d \rightarrow \mu\mu$ can be a powerful tool to probe for physics beyond the SM. The SM predicts a BR($B_s \rightarrow \mu\mu$) of about 3.8×10^{-9}.
There are various extensions to the SM that predict an enhancement of this branching ratio by 1 to 3 orders of magnitude.
Many of these models are, presently, theoretically very interesting since some have some relevance to the deviation of the muon (g-2), neutrino oscillations, and dark matter/dark energy results .

Rare decays I

CDF mesurement using a dataset of 2 $fb^{-1}$is

$BR(B_s \rightarrow \mu\mu) < 5.8\times10^{-8}$ @95% CL
$BR(B_d \rightarrow \mu\mu) < 1.8\times10^{-8}$ @95% CL
$BR(B_s \rightarrow \mu\mu) < 4.7\times10^{-8}$ @90% CL
$BR(B_d \rightarrow \mu\mu) < 1.5\times10^{-8}$ @90% CL



D0 set the upper limit on this value
$BR(B_s \rightarrow \mu\mu) < 7.5 * 10^{-8}$ at 90% @CL
$BR(B_s \rightarrow \mu\mu) < 9.3 * 10^{-8}$ at 95% @CL
using 2 fb -1

Conclusion

In a P Pbar experiment is crucial to know very well the backgrounds and the behavior of the detectors.

All the references for these analysis can be fond in the public pages of the CDF and D0 B groups.

Back-up slides