Latest Results From Tevatron

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University of Birmingham

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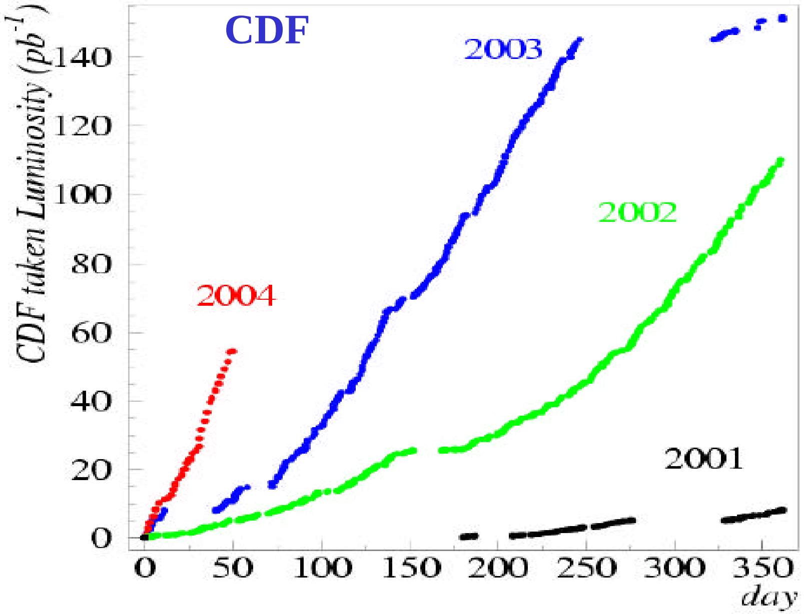
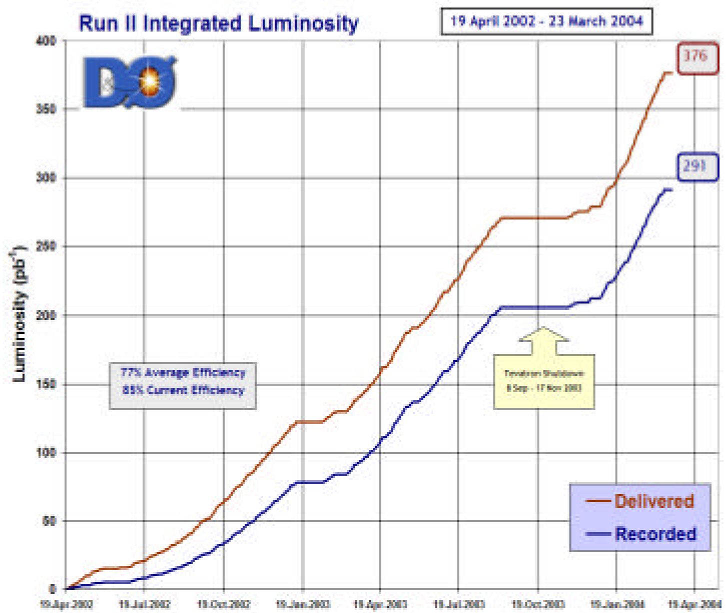
In this talk:

- Electro-weak physics;
- t-quark physics;
- B-physics;
- Searches for the new physics (Higgs boson etc.)

Tevatron Performance

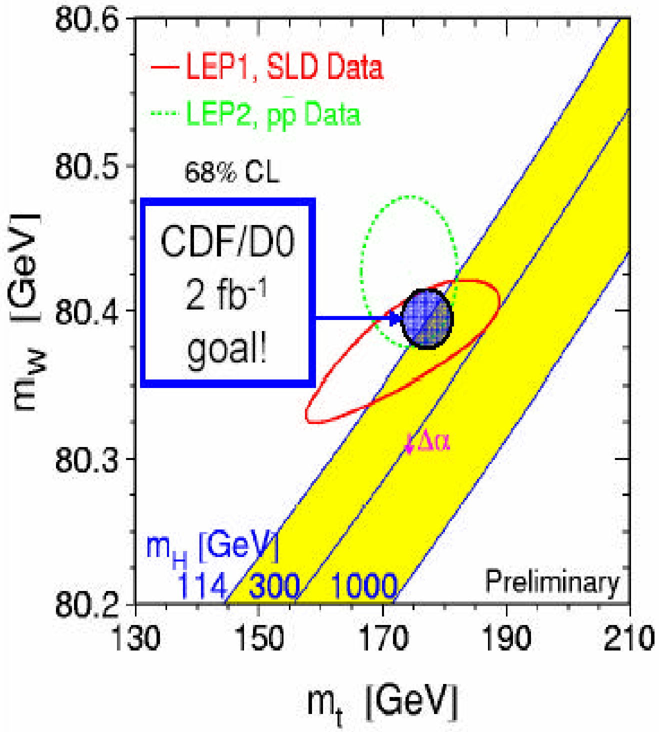




- **Permanently improving accelerator performance**
- **300 pb^{-1} of data on tape per experiment**
- **Record initial luminosity = 7.2 ´ 10^{31} $sec^{-1}cm^{-2}$**
- **70 pb^{-1} recorded in 2004 by DØ (March 2004)**
- **Used in analysis: 100-200 pb^{-1} (CDF), up to 250 pb^{-1} (DØ)**

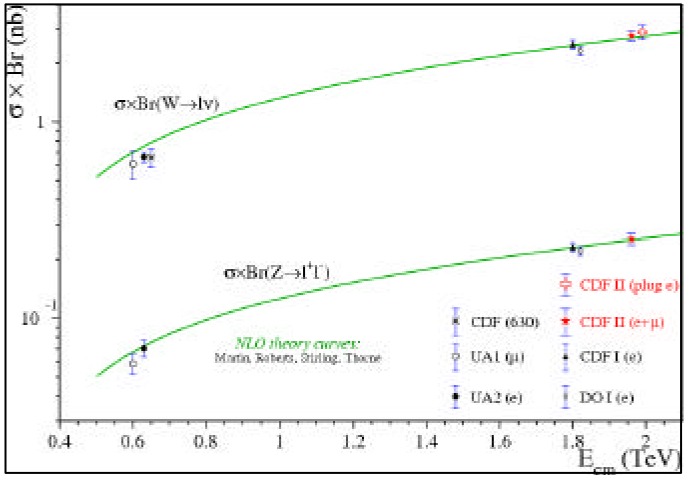
Electro-weak Results

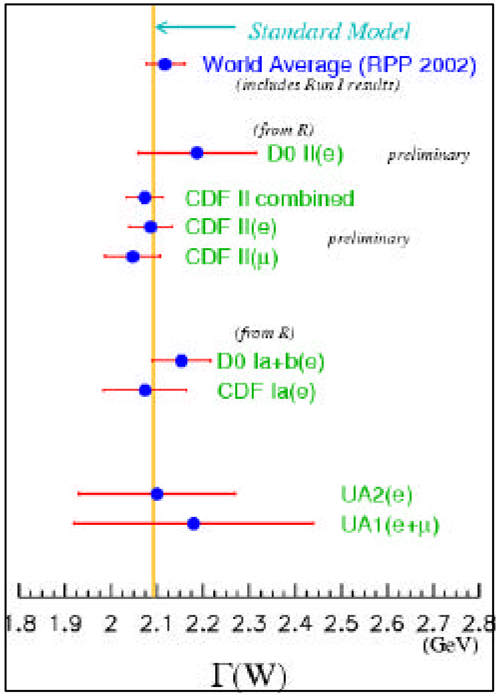
- **Tevatron gives important information on properties of W, Z^0 bosons and t-quark: their production cross-section, masses and widths;**
- **Combined with other precise measurements, they set constraint on the Higgs boson mass;**

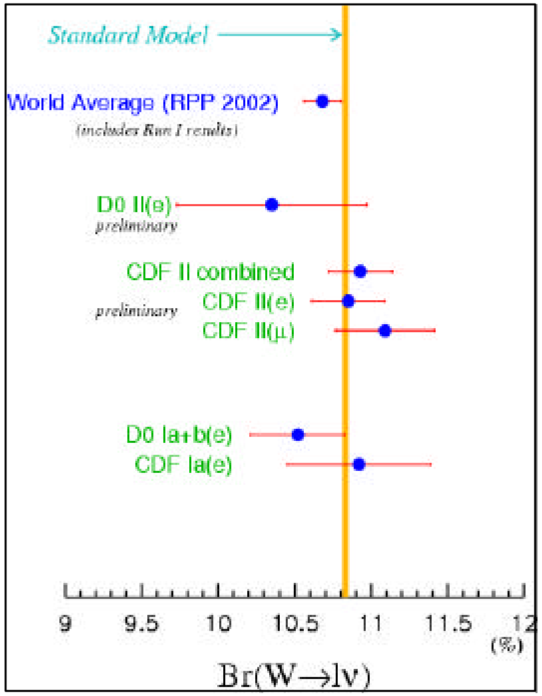


- **Many other interesting measurements with W, Z^0, e.g. W? and Z^0? production – information on triple boson coupling.**

W and Z^0 Production







CDF Results

s • Br(W) = 2777 ± 10(stat) ± 52(syst) ± 167(lum)

s • Br(Z^0) = 254.3 ± 3.3(stat) ± 4.3(syst) ± 15.3(lum)

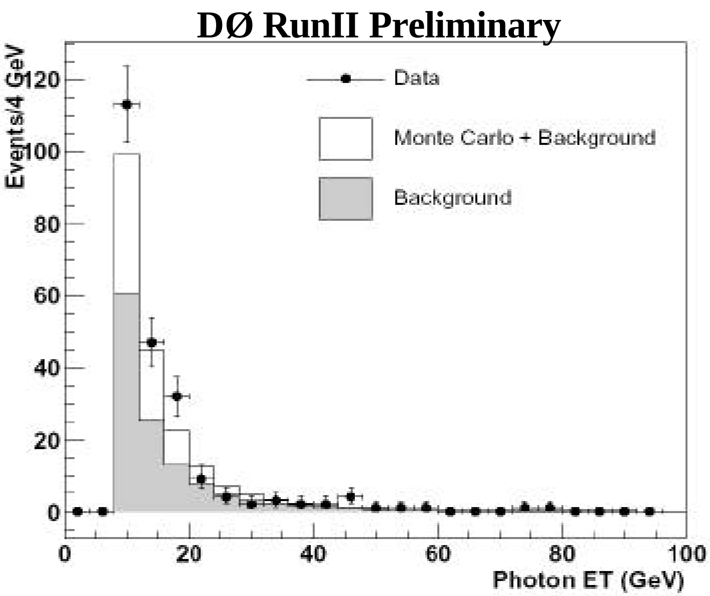
From ratio of cross-sections:

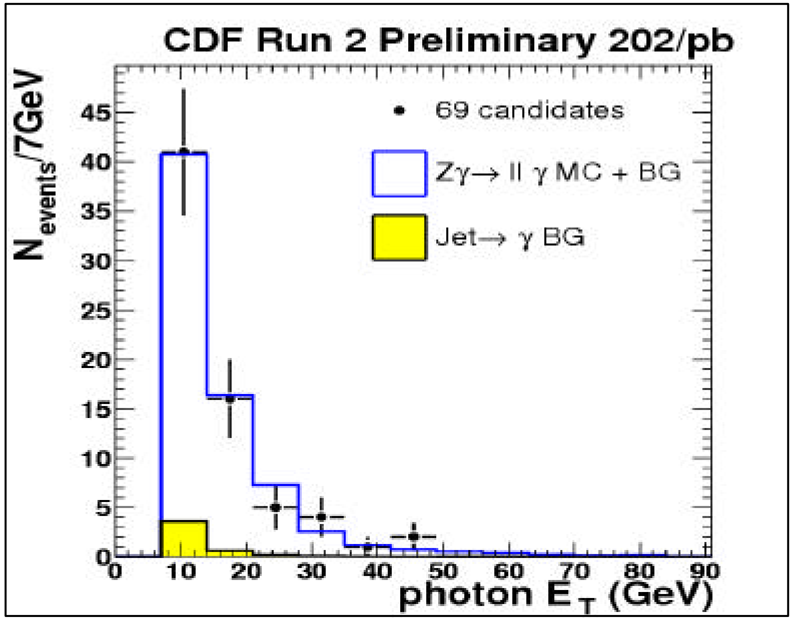
Br(W ® l ?) = 0.1093 ± 0.0021 (world average: 0.1068 ± 0.0012)

G_W = 2071.4 ± 39.8 MeV (world average: 2118 ± 42 MeV)

W? and Z^0? Cross-section

- **Two boson production is an important test of the Standard Model**
- **Possibility to search for anomalous tri-boson coupling**
- **s (W?) = 19.3 ± 6.7(stat) ± 1.2(syst) pb (DØ)   (Theory: 16.4 ± 0.4 pb)**
- **s (W?) = 19.7 ± 1.7(stat) ± 1.1(syst) pb (CDF) (Theory: 19.3 ± 1.4 pb)**
- **s (Z^0?) = 5.3 ± 6.7(stat) ± 1.2(syst) pb (CDF)   (Theory: 5.4 ± 0.3 pb)**

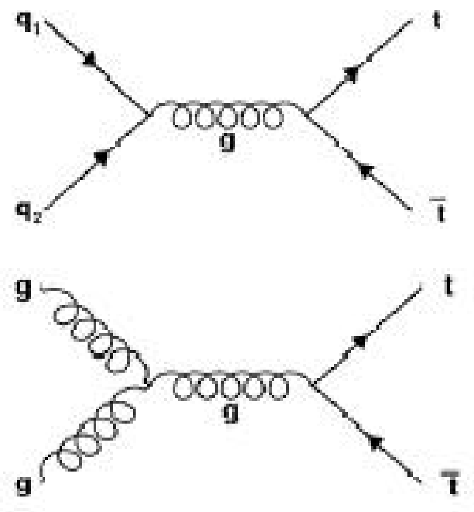




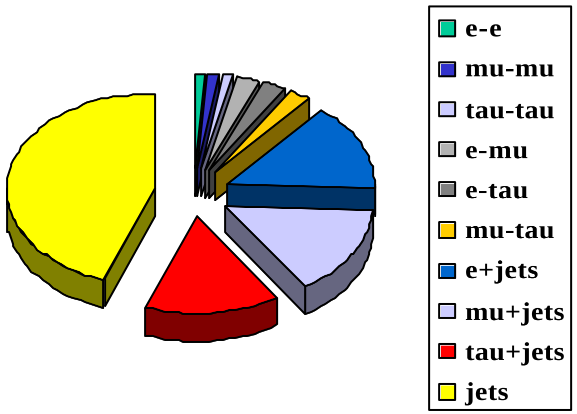
Top Quark

- **Heaviest known quark, can be produced and studied only at Tevatron at present;**
- $t\bar{t}$ **-pair is produced in strong interactions;**
- **Br(t ® W b) = 100%;**
- **Single top production: ~2 times smaller rate, not observed yet;**

t-quark production



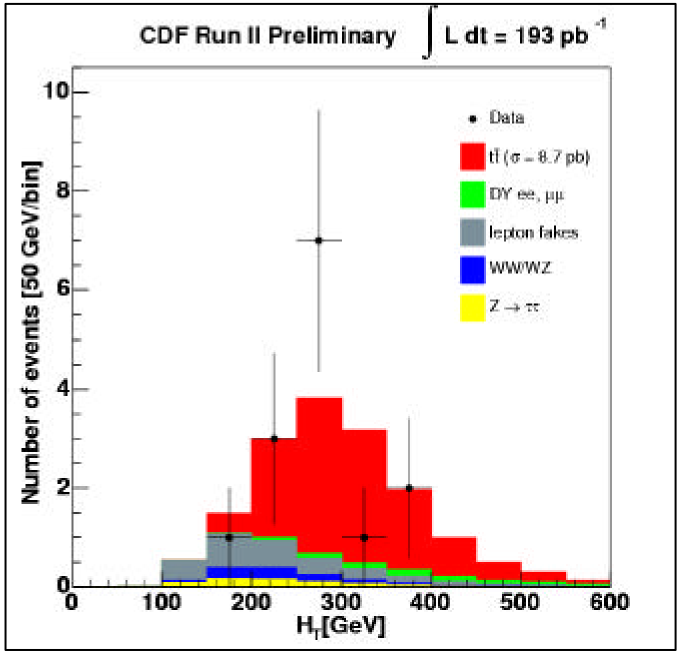
t-quark decay topologies

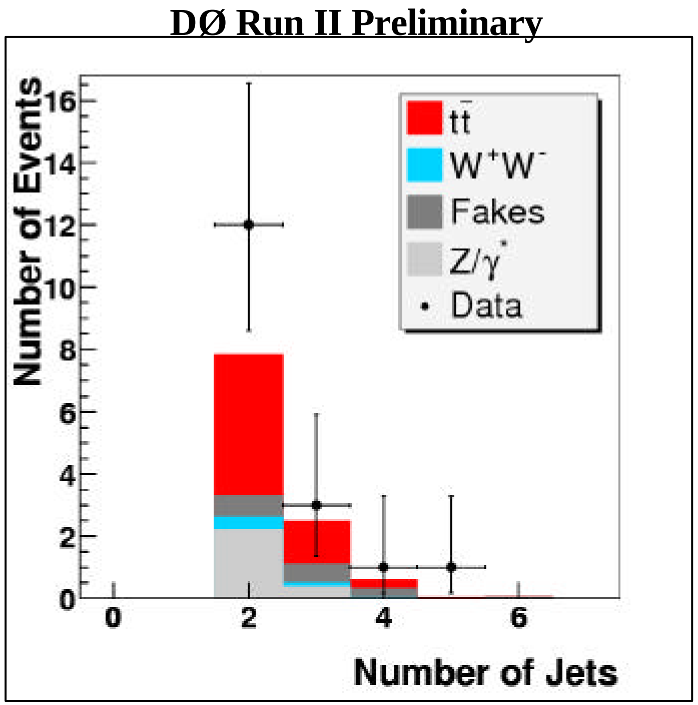


$t\bar{t}$: Dilepton Final State

Event Selection:

- **2 high P_T leptons;**
- **Large missing transverse energy;**
- **Large total transverse energy;**



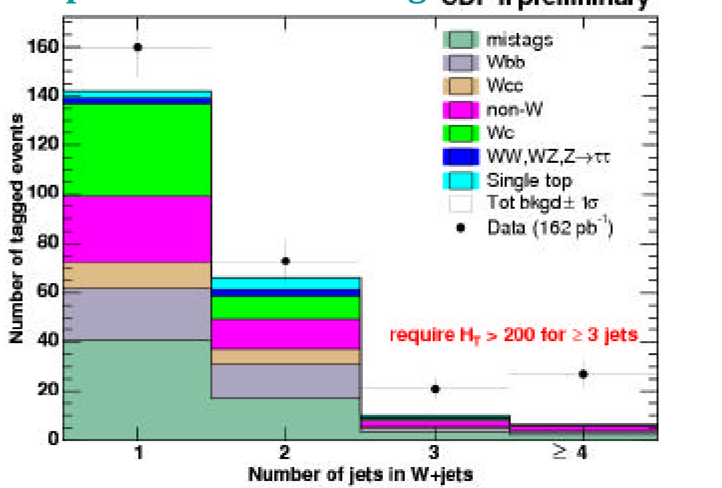


$t\bar{t}$: Lepton + Jet Final State

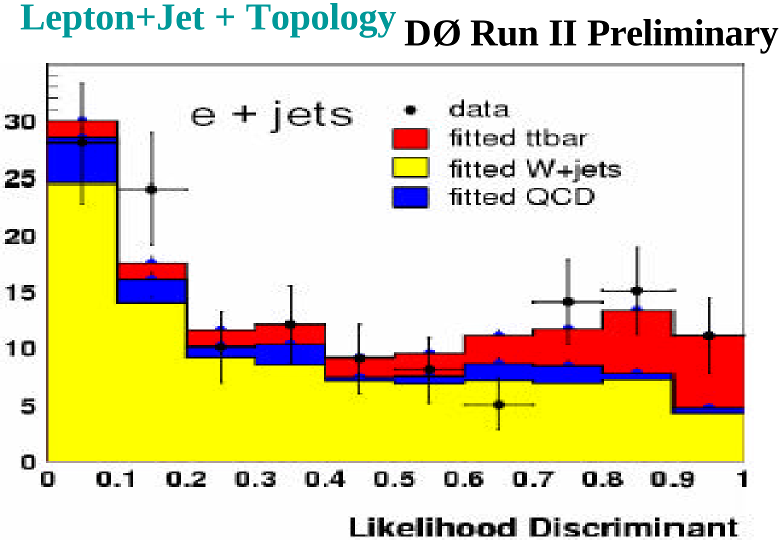
Much higher branching rate, but with larger background contribution. Each collaboration performs many different analyses varying the combination of the selection criteria. They include:

- **Lepton identification;**
- **Combination of topological variables;**
- **b-tagging (soft lepton or impact parameter - based);**

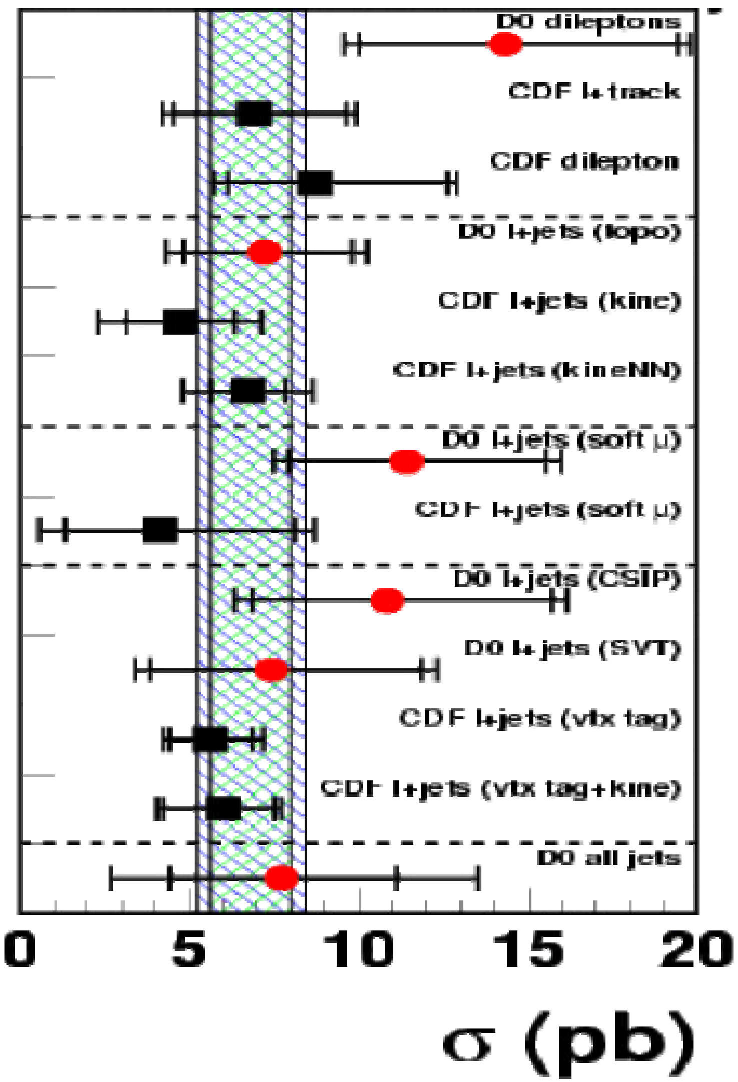
Lepton+Jet + Vertex Tag



Lepton+Jet + Topology



$t\bar{t}$: Cross-section Summary



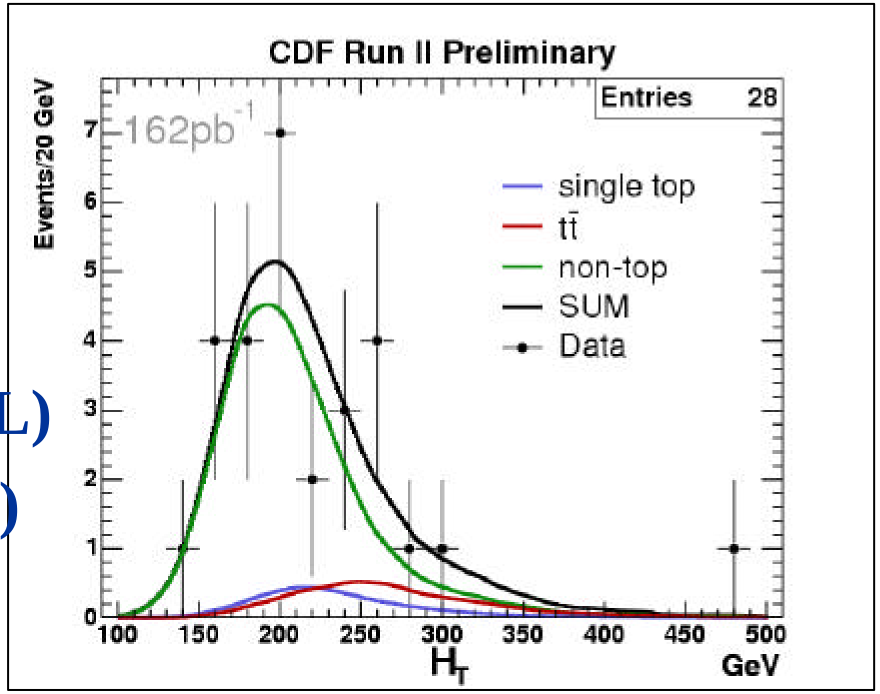
140 pb^{-1}	14.3	$^{+5.1}_{-4.3}$	$^{+1.9}_{-2.0}$	pb
200 pb^{-1}	6.9	$^{+2.7}_{-2.4}$	$^{+1.3}_{-1.3}$	pb
193 pb^{-1}	8.7	$^{+3.9}_{-2.6}$	$^{+1.5}_{-1.5}$	pb
141 pb^{-1}	7.2	$^{+2.6}_{-2.4}$	$^{+1.6}_{-1.7}$	pb
195 pb^{-1}	4.7	$^{+1.6}_{-1.6}$	$^{+1.8}_{-1.8}$	pb
195 pb^{-1}	6.7	$^{+1.1}_{-1.1}$	$^{+1.6}_{-1.6}$	pb
92 pb^{-1}	11.4	$^{+4.1}_{-3.5}$	$^{+2.0}_{-1.8}$	pb
126 pb^{-1}	4.1	$^{+4.0}_{-2.8}$	$^{+2.2}_{-2.2}$	pb
40 pb^{-1}	10.8	$^{+4.8}_{-4.0}$	$^{+2.1}_{-2.0}$	pb
40 pb^{-1}	7.4	$^{+4.4}_{-3.6}$	$^{+2.1}_{-1.8}$	pb
162 pb^{-1}	5.6	$^{+1.2}_{-1.2}$	$^{+0.7}_{-0.7}$	pb
162 pb^{-1}	6.0	$^{+1.5}_{-1.6}$	$^{+0.8}_{-0.8}$	pb
162 pb^{-1}	7.7	$^{+3.4}_{-3.3}$	$^{+4.6}_{-3.8}$	pb

Other Results With Top Quark (CDF)

- **R_s = s $_{LL}$/ s $_{LJ}$: 0.46 < R_s < 4.45 (95% CL)**

  Sets the limit Br(t ® Xb) < 0.46 for additional all hadronic t ® Xb decay;

- **Br(t ® Wb) > 0.12 (95% CL);**



- **Single top production:**

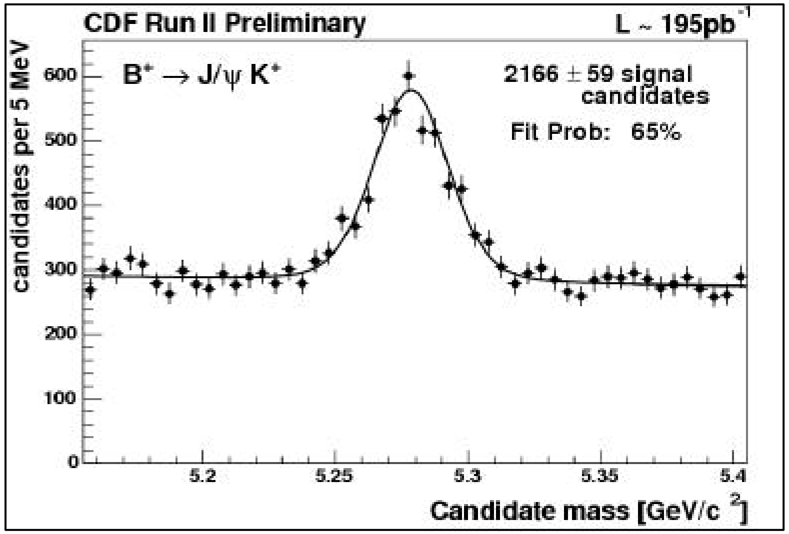
Combined: s < 13.7 pb (95% CL)

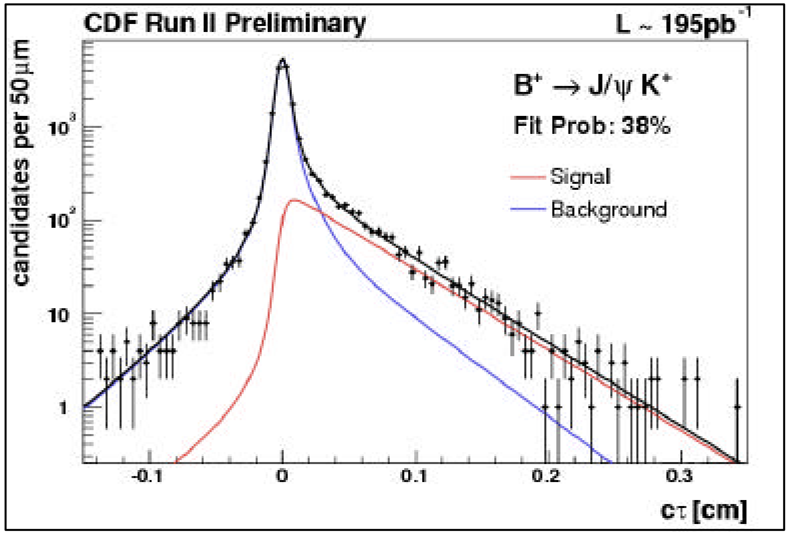
t-channel: s < 8.5 pb (95% CL)

B-physics

- **Tevatron – good place for B-physics:**
  - **Large production rates of *b*-quarks;**
  - **Production of B_s, ? $_b$, not accessible at *b*-factories;**
  - **Rich *b*-quark spectroscopy (B^{**}, B_c, ? $_b$, O_b etc.);**
- **More difficult task than at *b*-factories:**
  - **Detectors were not constructed specifically for *b*-physics;**
  - **Large background level: sophisticated triggers required;**
  - **More complicated events, many interactions overlaid;**

Lifetime of Different B-hadrons (CDF)

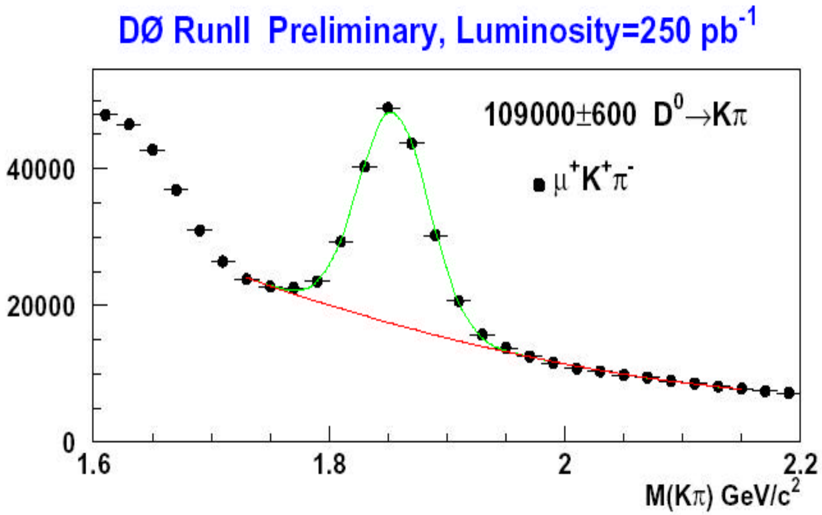


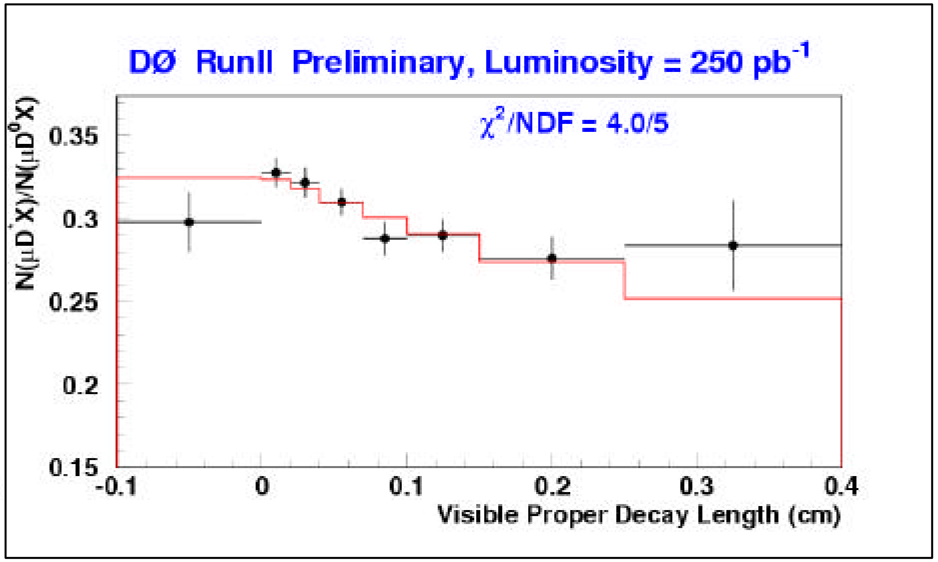


CDF determines lifetimes of different B hadrons in exclusive decays B® J/? X

B-hadron	CDF measurement	PDG value
B^+	1.66 ± 0.04 ± 0.02	1.674 ± 0.018
B^0	1.49 ± 0.05 ± 0.03	1.542 ± 0.016
B_s	1.33 ± 0.14 ± 0.02	1.461 ± 0.057
? $_b$	1.25 ± 0.26 ± 0.10	1.229 ± 0.080

B^+/B^0 Lifetime Ratio



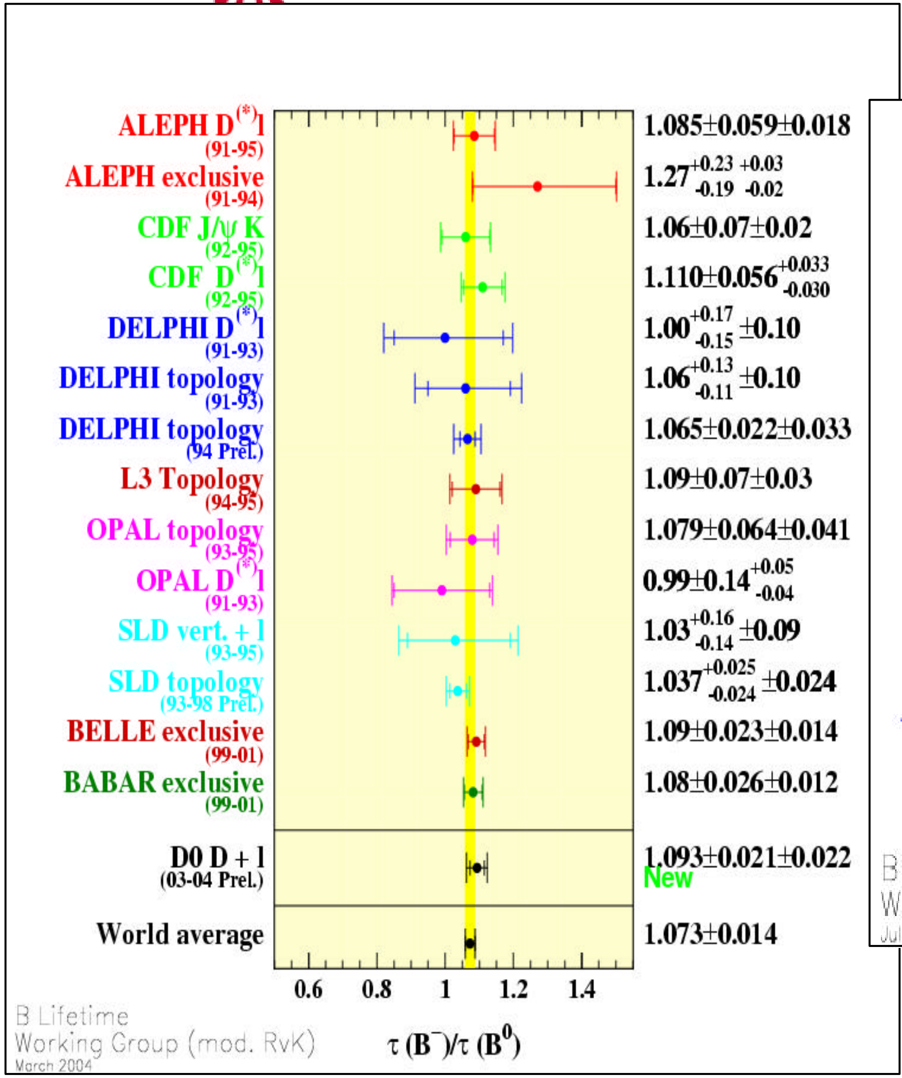


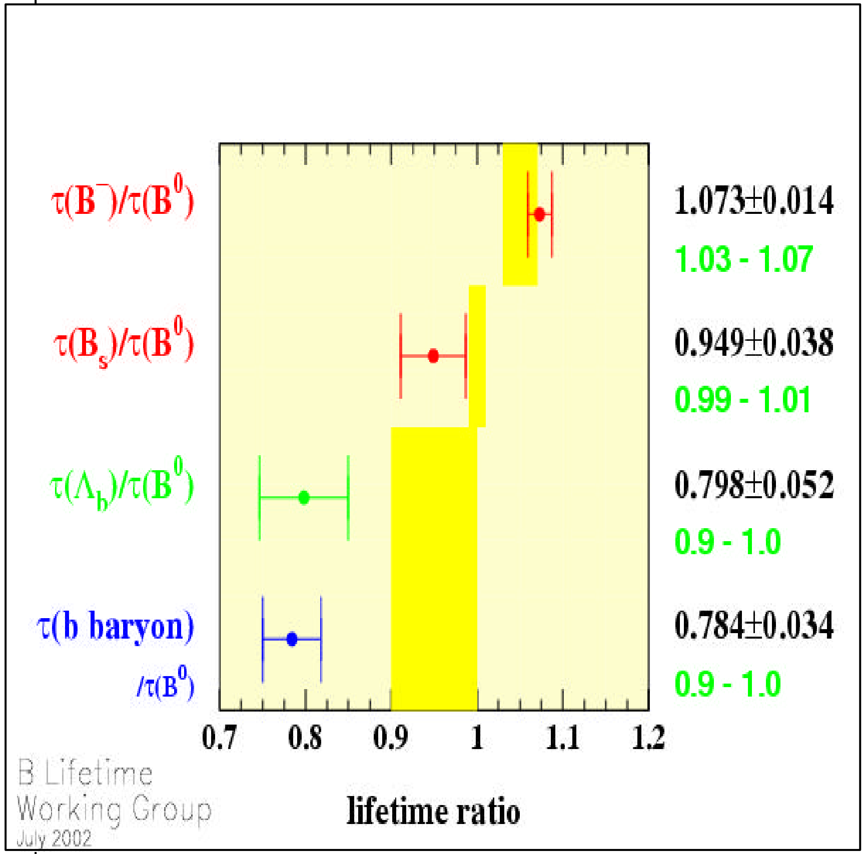
DØ measures lifetime ratio of B^+ and B^0 using large sample of semileptonic decays B^+ ® μ^+?D^0X, B^0 ® μ^+?D^{*-}X decays. t^+/t^0 is determined from N(μ^+?D^{*-}X)/ N(μ^+?D^0X) at different decay distances.

t^+/t^- = 1.093 ± 0.021 ± 0.022 DØ, semileptonic

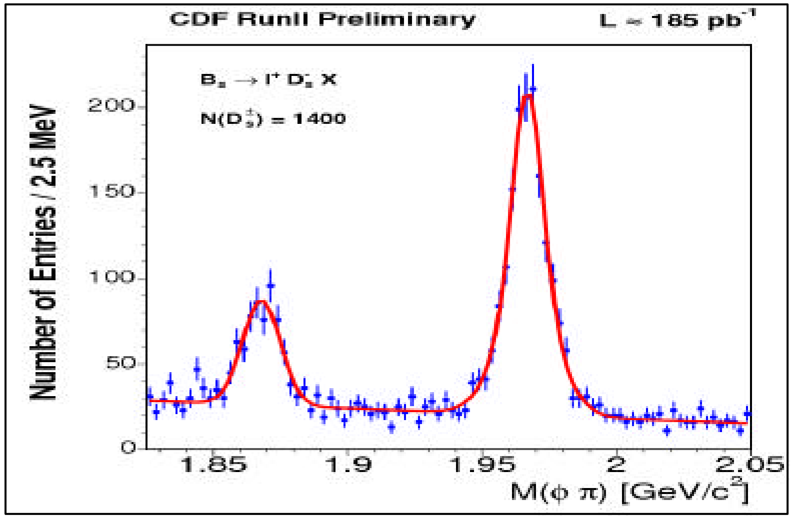
t^+/t^- = 1.119 ± 0.046 ± 0.014 CDF, exclusive J/?

B-hadron Lifetimes: Summary

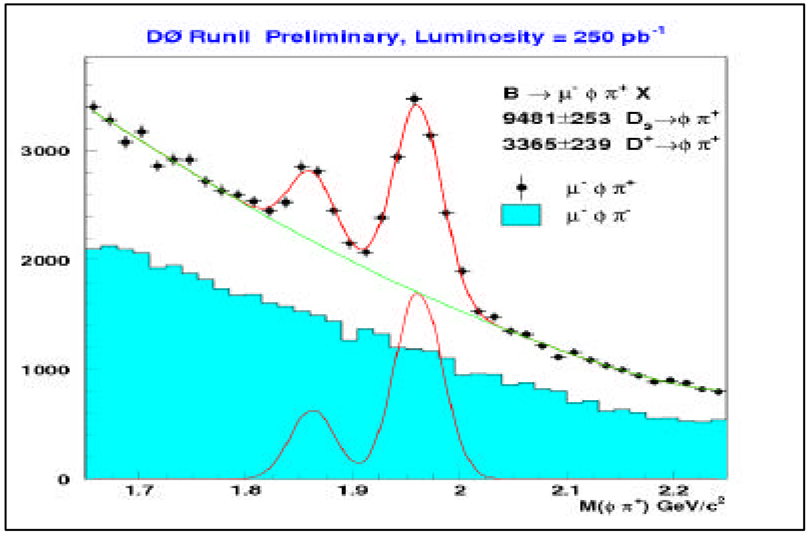




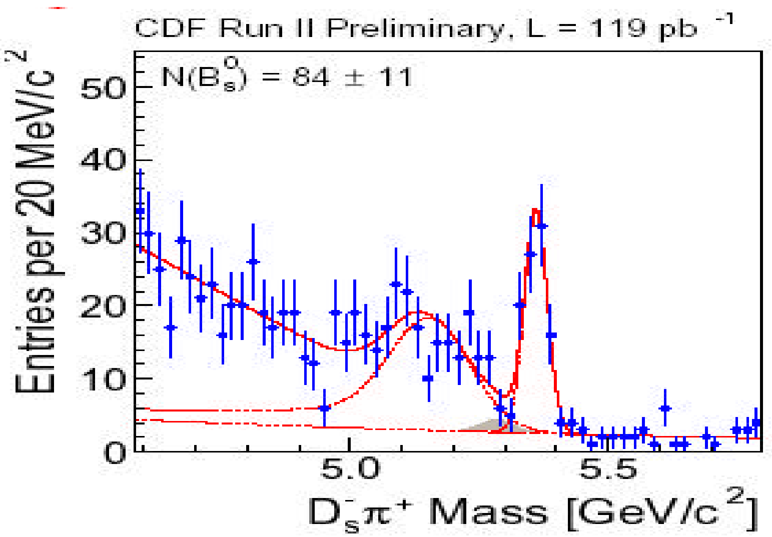
B_s Signals



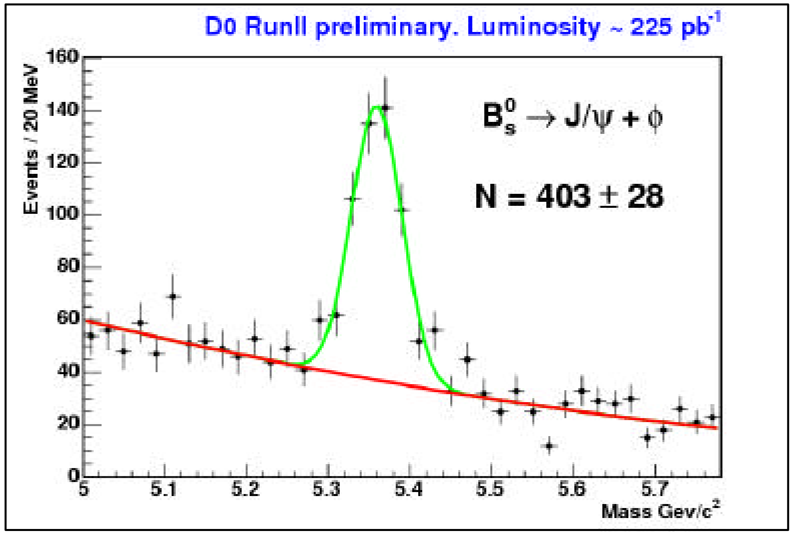
CDF RunII Preliminary
L ≈ 185 pb⁻¹
B_s → l⁺ D_s⁻ X
N(D_s⁺) = 1400
Number of Entries / 2.5 MeV
M(φ π) [GeV/c²]



DØ RunII Preliminary, Luminosity = 250 pb⁻¹
B → μ⁻ φ π⁺ X
9481±253 D_s→φ π⁺
3365±239 D⁺→φ π⁺
μ⁻ φ π⁺
μ⁻ φ π⁻
M(φ π⁺) GeV/c²



CDF Run II Preliminary, L = 119 pb⁻¹
N(B_s⁰) = 84 ± 11
Entries per 20 MeV/c²
D_s⁻π⁺ Mass [GeV/c²]

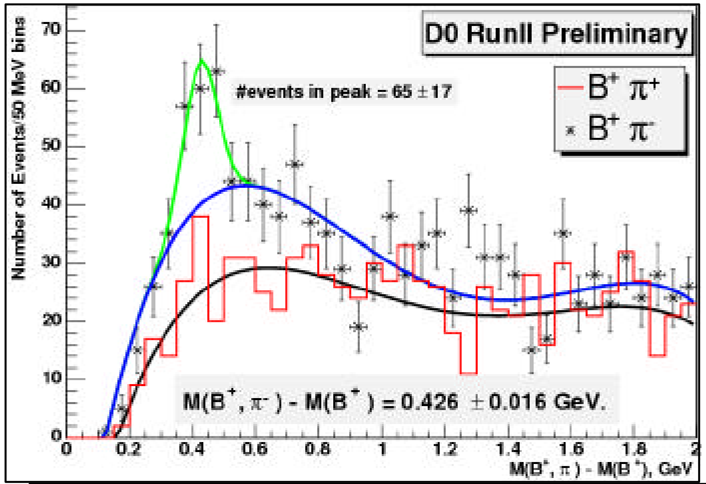


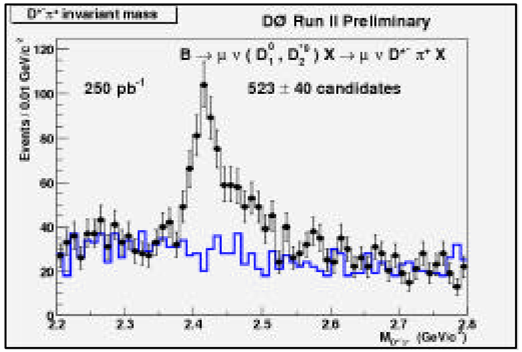
D0 RunII preliminary. Luminosity ~ 225 pb⁻¹
B_s⁰ → J/ψ + φ
N = 403 ± 28
Events / 20 MeV
Mass Gev/c²

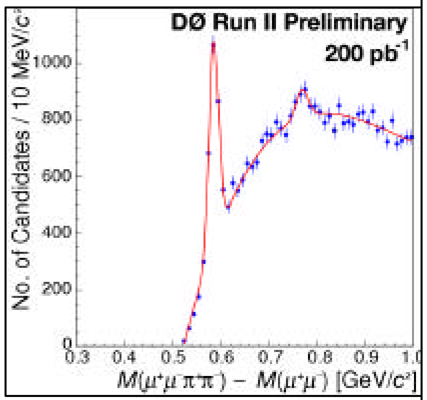
(Heavy) Quark Spectroscopy

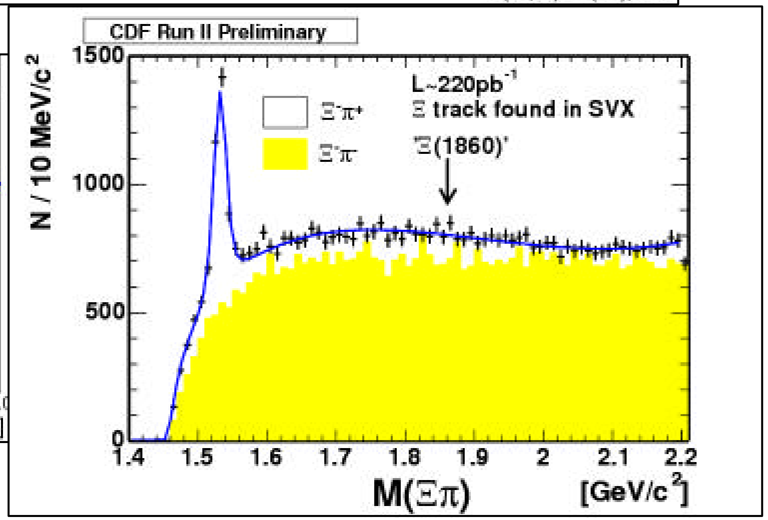
Renaissance of spectroscopy:

- **B^{**} study, production rate and mass (DØ) (see talk of M.Doidge at parallel session);**
- **B ® μ^+?D^{**} branching rate (DØ);**
- **X(3872) ® J/? p^+ p^- , confirmation of BELLE signal (DØ, CDF);**
- **Search for pentaquark ? (1862) ® ? p : no signal (CDF);**









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Other Results in B-physics

- **Search for $B_{s(d)}$ ® $\mu^{+}\mu^{-}$:**

  Br(B_s ® $\mu^{+}\mu^{-}$)< 7.5´ 10^{-7}; Br(B_d ® $\mu^{+}\mu^{-}$)< 1.9´ 10^{-7} (CDF) (95% CL);

  Sensitivity of DØ (not actual limit yet):

  Br(B_s ® $\mu^{+}\mu^{-}$)< 1.0´ 10^{-6} (95% CL);

- **Milestone in preparation for the search for B_s oscillation:**

  B_d oscillation in Run II: 0.506 ± 0.055 ± 0.049 (DØ);

- **D^0 decay rates (CDF):**

  G(D^0 ® K^+K^-) / G(D^0 ® Kp) = 9.96 ± 0.11 ± 0.12%

  G(D^0 ® p^+p^-) / G(D^0 ® K^+p^-) = 3.608 ± 0.054 ± 0.040%

  G(D^0 ® K^+K^-) / G(D^0 ® p^+p^-) = 2.762 ± 0.040 ± 0.034

- **CP asymmetry in D^0 decays (CDF):**

  A(D^0 ® K^+K^-) = 2.0 ± 1.2 ± 0.6%

  A(D^0 ® p^+p^-) = 1.0 ± 1.3 ± 0.6%

Search for New Physics

- Tevatron provides the largest CMS energy;
- Currently, it is the only possible place to search for the new physics;
- It was one of the main goals of Run II, detectors were adjusted especially for this task;

But:

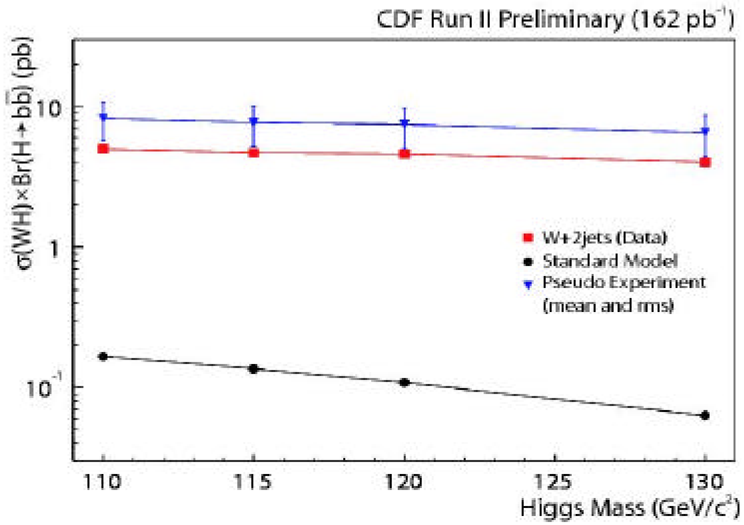
- Signal is hidden under huge background;
- Current luminosity is not sufficient to observe the SM Higgs boson;

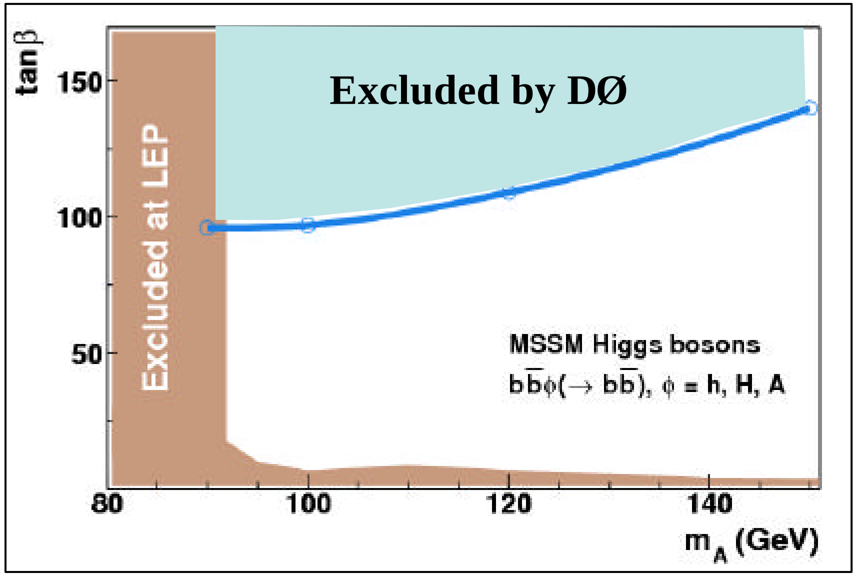
Still:

- Non-minimal models can be tested already now;
- Many exotic particles (leptoquarks, exited leptons, extra dimensions) can be searched for;

- **Experiments report many new results in the searches, but only limits, no indication of the signal yet.**

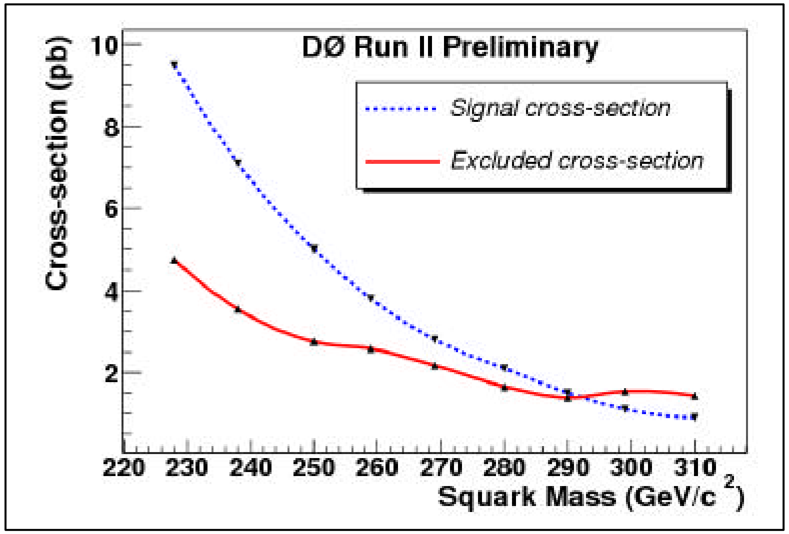
Search for the Higgs Boson



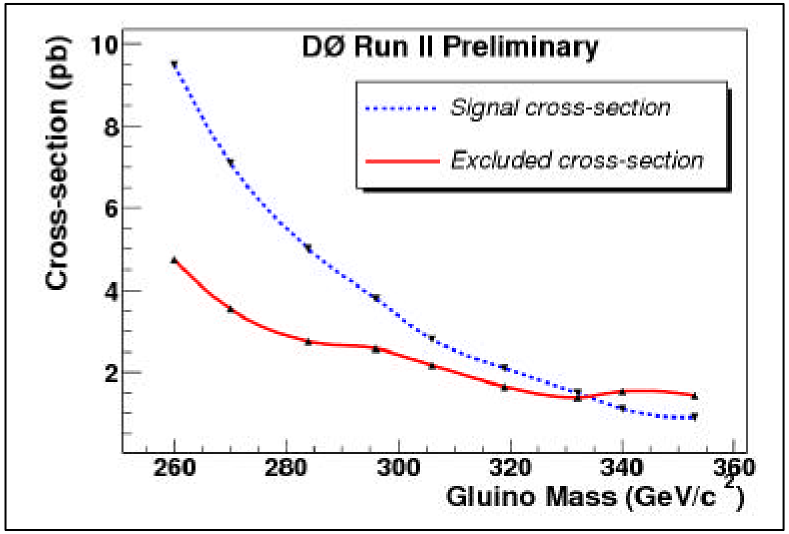


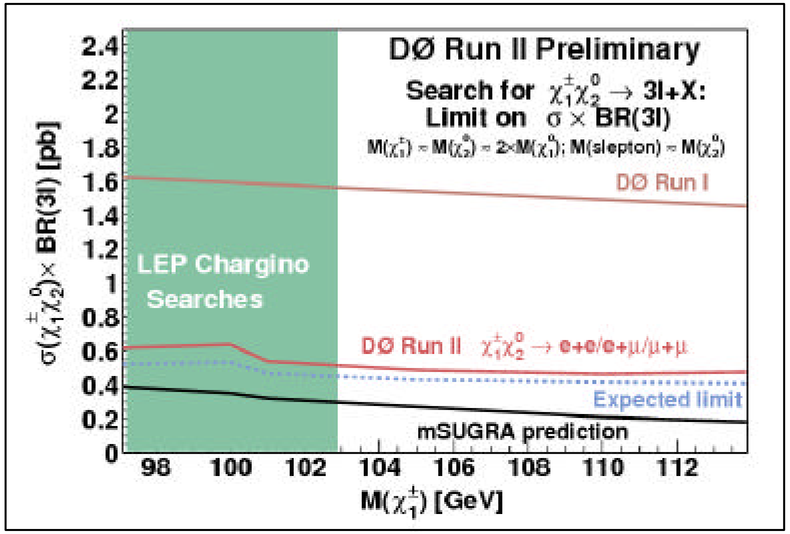
- **CDF search for the SM Higgs in $p\bar{p}$ ® HW ® $b\bar{b}l$? channel. They improved the Run I limit, but still well above the SM Higgs cross-section.**
- **D0 search for the MSSM Higgs boson in the multi-jet final state: $p\bar{p}$ ® $b\bar{b}h$ ® $b\bar{b}b\bar{b}$. They significantly extended the exclusion area for large tanß.**

SUSY Searches

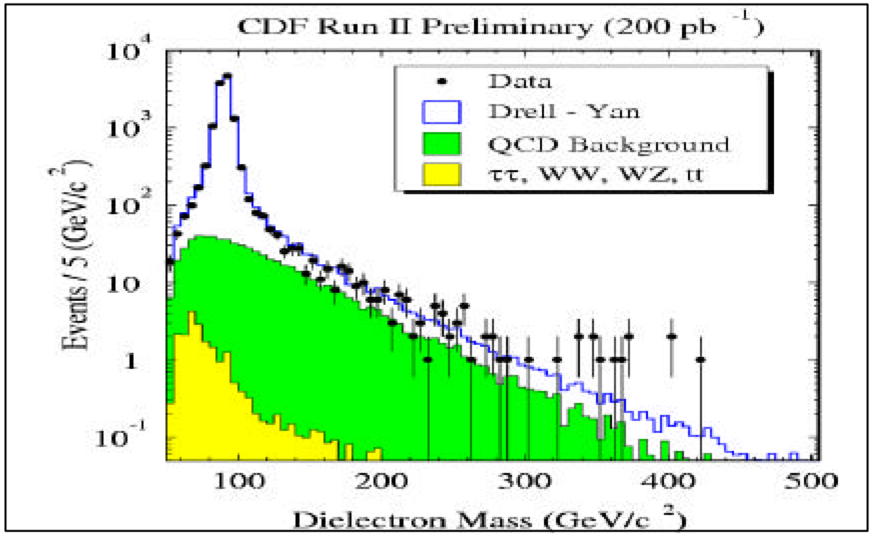


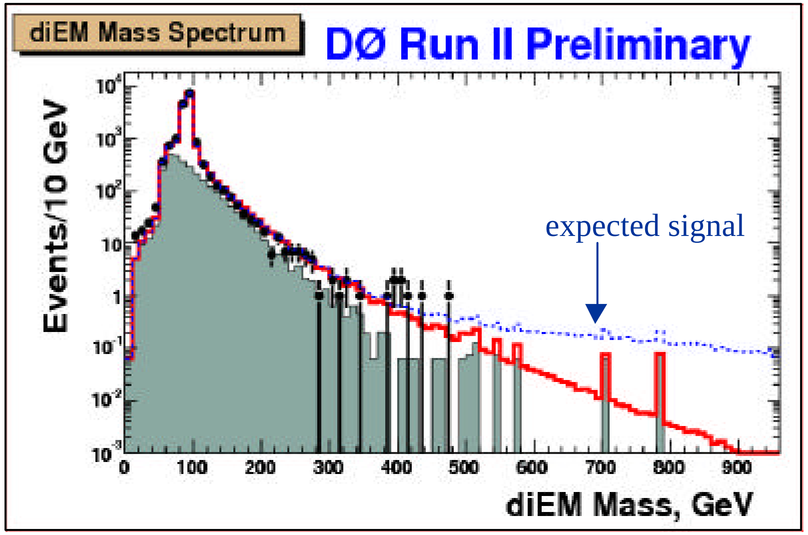
Many new limits on SUSY particles (DØ);
Better limits than in Run I;
For squark/gluino search in jets+MET topology: 4 events observed 2.7±1 event expected;
M(squark)>292 GeV; M(gluino)>333 GeV
(for m_0=25 GeV, A_0=0, tanß=3, μ=0);
Chargino-neutralino search in 3 leptons+MET final state significantly improves limit from Run I. Very close now to the model prediction.





Search for Large Extra Dimensions





- Large Extra Dimensions (LED) model provides interesting explanation for the large Plank scale and weakness of graviation.
- They can be reveal itself in deviation of e^+e^-- or ??- cross-section from SM prediction.
- No deviation is observed so far, but both CDF and DØ set new limits, which are the most restrictive to date.

CDF Run I	M_S > 1.11 TeV
DØ Run II	M_S > 1.36 TeV
DØ Run I+II	M_S > 1.43 TeV

(M_S is (3+n)-dimensional Plank scale)

- Same data can be analyzed in many different ways (Z¢, technicolor, RPV sneutrino etc.)

Conclusions

- **Performance of the Tevatron gradually improves, very close now to the design parameters, collected luminosity already ~2´ Run I;**
- **Both CDF and DØ report many new results, significantly improving achievements of Run I;**
- **New measurements of W, Z^0 and $t\bar{t}$ production;**
- **Promising results in B-physics: lifetimes of B-hadrons, *b*-spectroscopy. Large collected samples of B_s allow to expect measurements of B_s oscillation and CP-violation in B_s decays;**
- **Many new results in the searches for new physics, significantly improved limits of Run I;**

Tevatron provides exciting possibility to do the excellent physics in the pre-LHC era and to gain the precious experience of work at hadron collider, which can be very useful for LHC.