Tevatron における
ヒッグス粒子探索と新物理探索

基研研究会　素粒子物理学の進展２０１１

3/2/2011

筑波大学　佐藤構二

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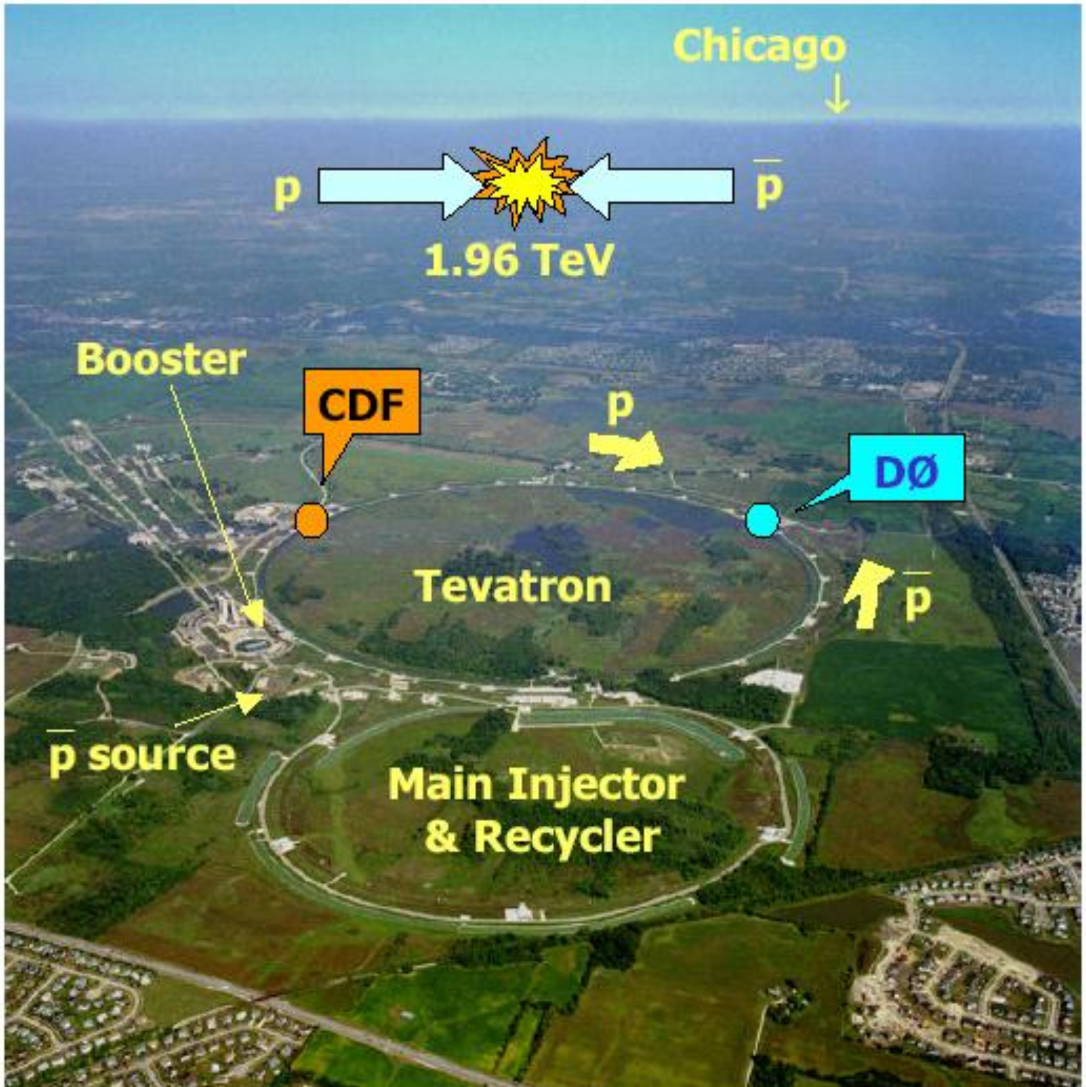
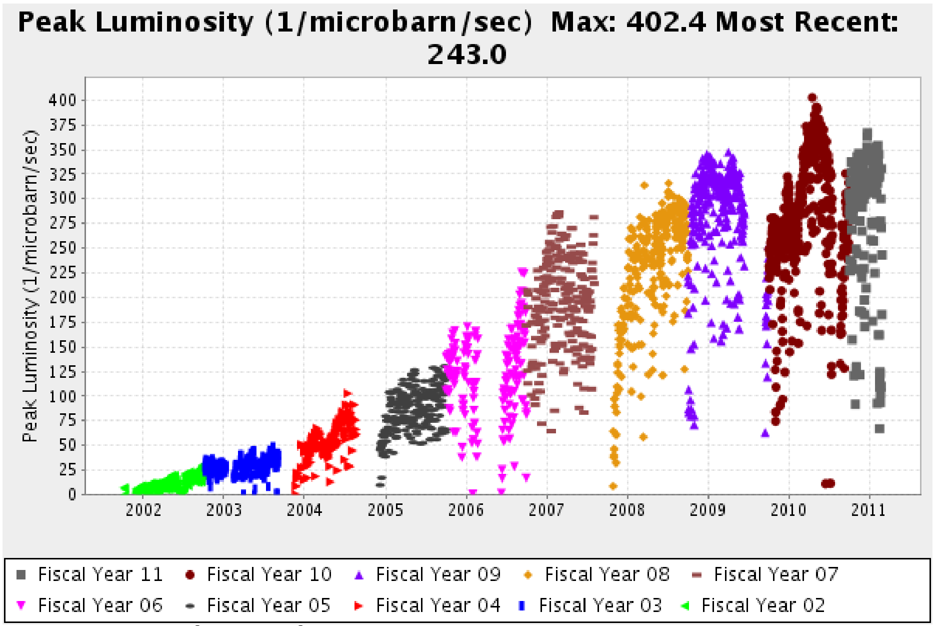
Introduction

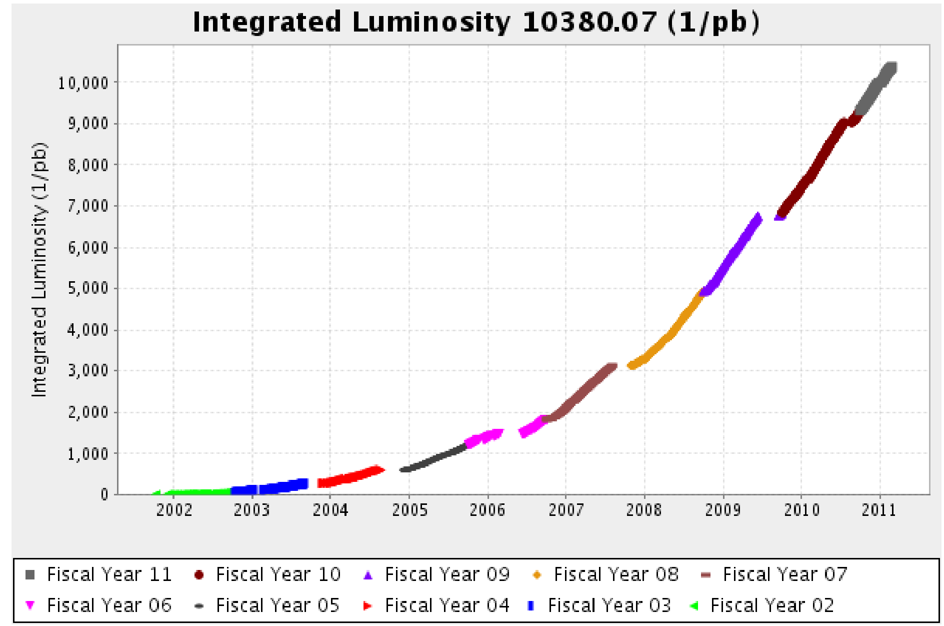
Tevatron Run II



- $p-\bar{p}$ collisions at $\sqrt{s}$ = 1.96 TeV (1.8 TeV in Run I).
- Run II started in Summer 2001.
- Two multi-purpose detectors for wide range of physics studies.

Tevatron Run II — Luminosity Status



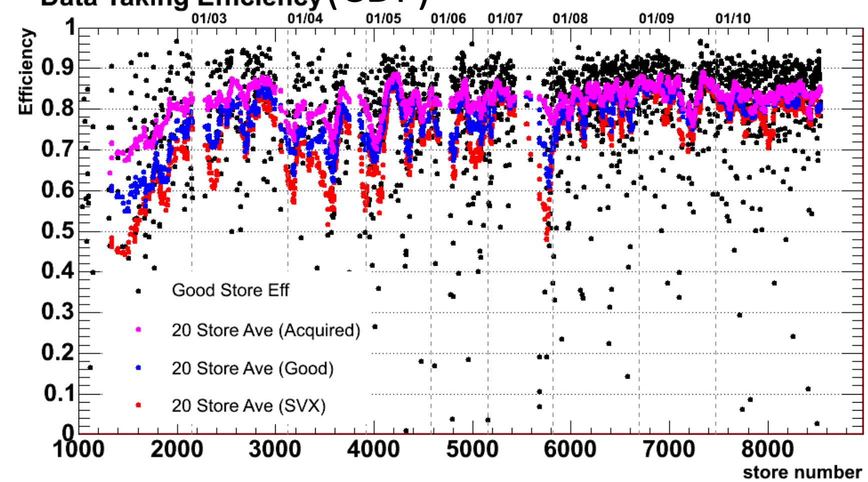


- Typical Peak Luminosity :

  $3\text{-}4 \times 10^{32}$ cm^2 s^{-1}.
- Delivers 60 - 70 pb^{-1}/week.
- Integrated Luminosity: 10.4 fb^{-1}
  - Recorded by CDF: 8.7 fb^{-1}.
- Recent CDF analyses typically use up to ~7 fb^{-1}.
- Typical data taking efficiency of CDF: ~ 85%

  No significant drop after 10 years of running.

Data Taking Efficiency (CDF)

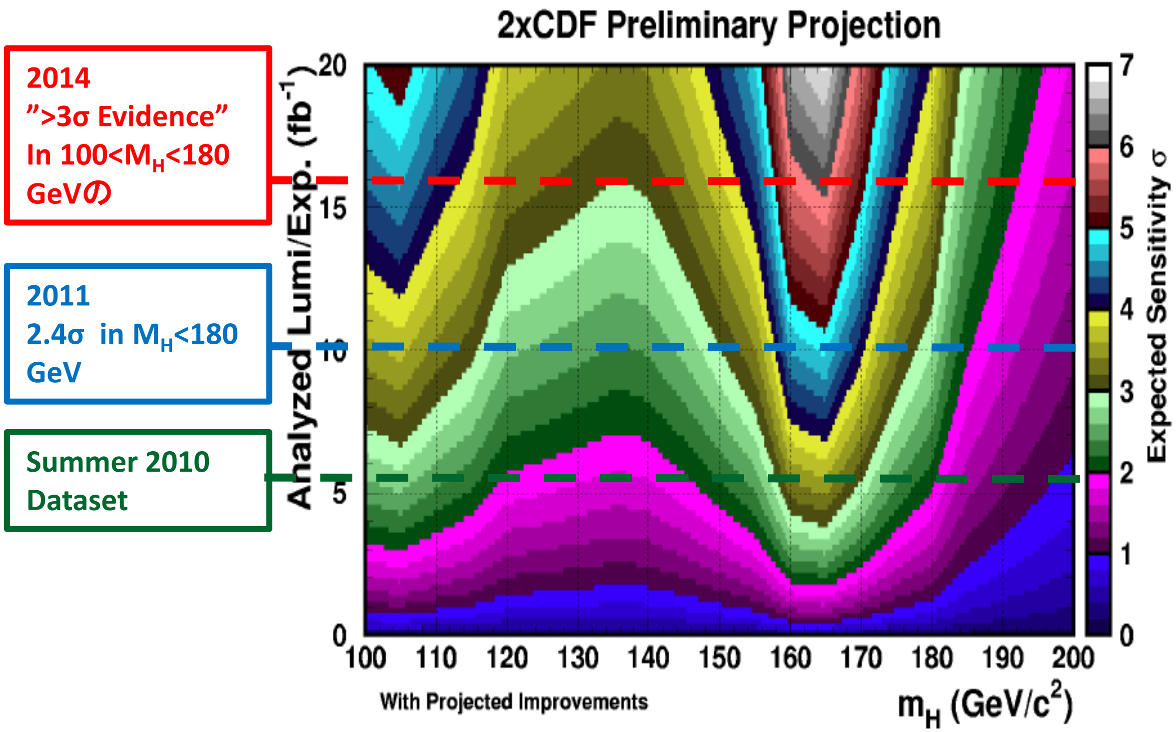


Tevatron Plans

- 2010: strong discussion on 3 year extention of Tevatron up to FY2014.
- Tevatron was expected to compete with LHC in SM Higgs searches.

Recommendation 1: The panel recommends that the agencies proceed with a three-year extension of the Tevatron program if the resources required to support such an extension become available in addition to the present funding for HEP. Given the strong physics case, we encourage the funding agencies to try to find the needed additional resources. (October 26, 2010, P5 report)

SM Higgs Discovery Potential of Tevatron (2010 Projection)



Tevatron Termination

Fermilab *Today* Tuesday, Jan. 11, 2011

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Calendar

Have a safe day!

Tuesday, Jan. 11
3:30 p.m.
DIRECTOR'S COFFEE BREAK - 2nd Flr X-Over
THERE WILL BE NO ACCELERATOR PHYSICS AND TECHNOLOGY SEMINAR TODAY

Wednesday, Jan. 12
12:30 p.m.
Physics for Everyone - Ramsey Auditorium
Speaker: Patrick Fox, Fermilab
Title: The hunt for the Higgs
3:30 p.m.
DIRECTOR'S COFFEE BREAK - 2nd Flr X-Over
4 p.m.
Fermilab Colloquium - One West
Speaker: Tom Malzbender, Hewlett Packard
Title: Imaging the Antikythera

Special Announcement

New year, new laboratory blogs on *Quantum Diaries*

QUANTUM DIARIES
Thoughts on work and life from particle physicists from around the world.

Living in an era when the latest discoveries in physics regularly make headlines, it can be easy to miss the individual contributions from the scientists and institutions around the globe making these advances possible. Highlighting these contributions, along with the quirky world from physicists working behind the scenes, has been the focus of Quantum Diaries since it launched in 2005. Quantum Diaries is sure to continue in that role, and has relaunched with four physics laboratories in its ranks: Brookhaven, CERN, Fermilab and TRIUMF. Each of the laboratories will be posting regular updates to Quantum Diaries and have already gotten started.

http://www.quantumdiaries.org/

Director's Corner

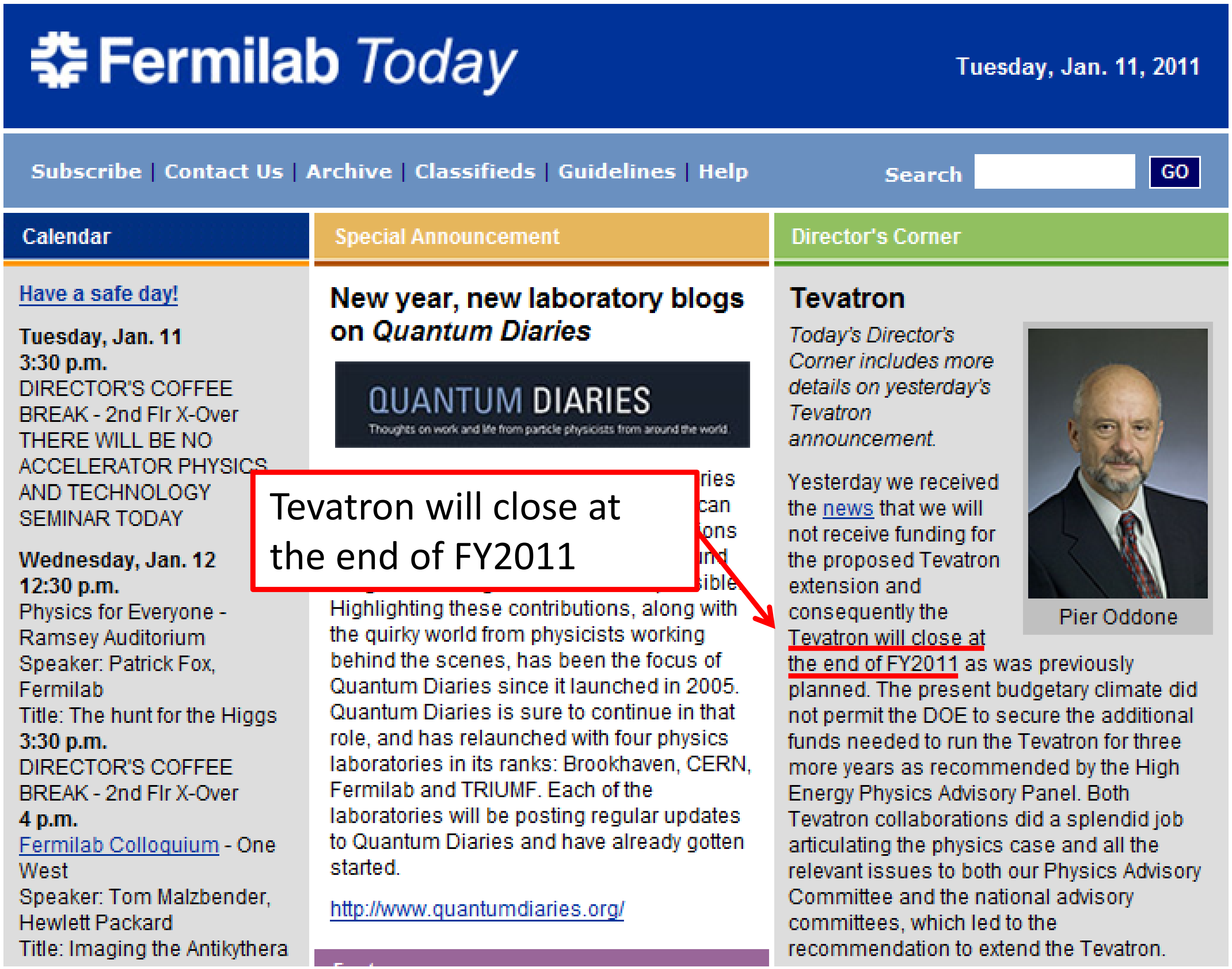
Tevatron

Today's Director's Corner includes more details on yesterday's Tevatron announcement.


Pier Oddone

Yesterday we received the news that we will not receive funding for the proposed Tevatron extension and consequently the Tevatron will close at the end of FY2011 as was previously planned. The present budgetary climate did not permit the DOE to secure the additional funds needed to run the Tevatron for three more years as recommended by the High Energy Physics Advisory Panel. Both Tevatron collaborations did a splendid job articulating the physics case and all the relevant issues to both our Physics Advisory Committee and the national advisory committees, which led to the recommendation to extend the Tevatron.

Tevatron Termination



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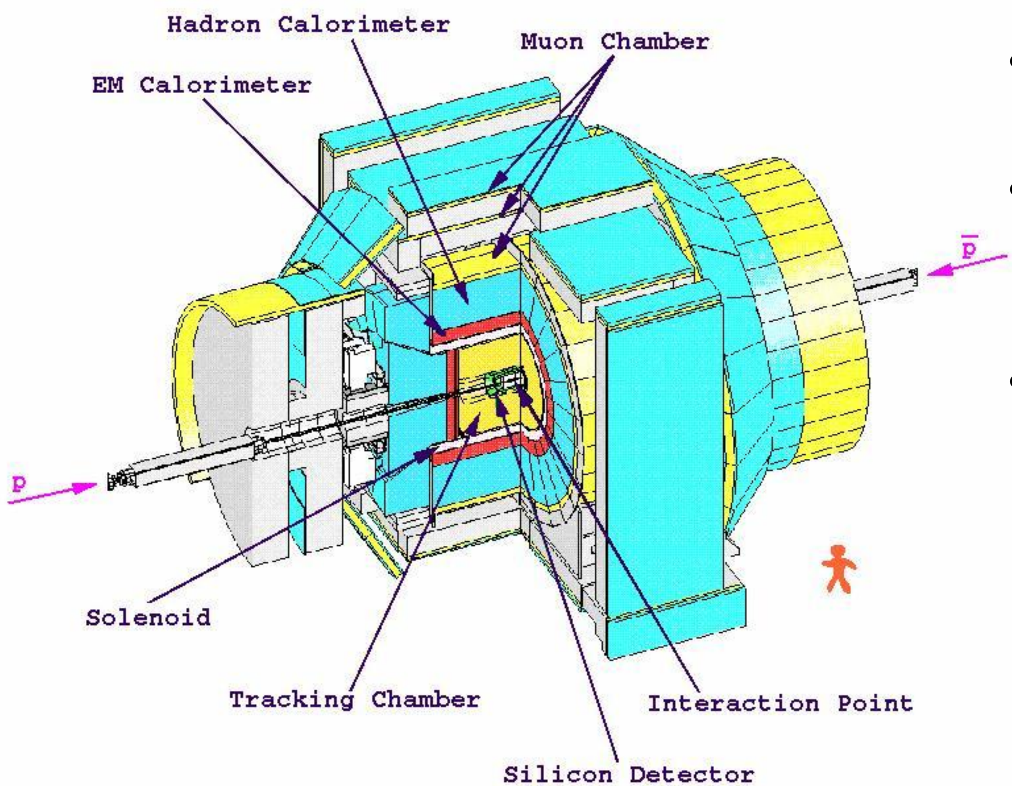
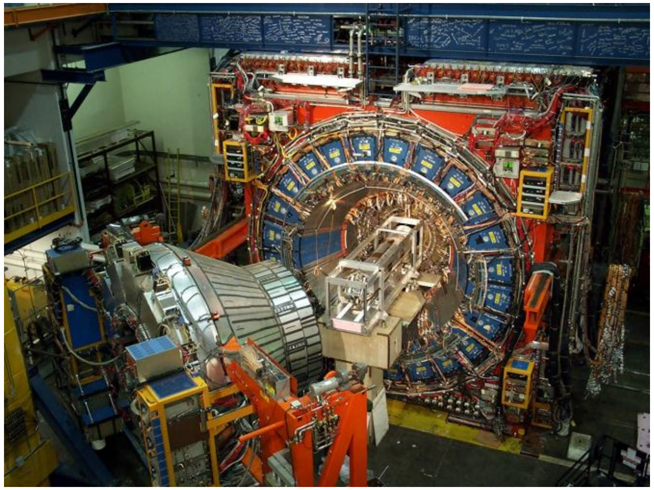
Collider Detector at Fermilab

Multi-purpose detector

- Tracking in 1.4 T magnetic field.
  - Coverage $|\eta|<\sim1$.
- Precision tracking with silicon.
  - 7 layers of silicon detectors.
- EM and Hadron Calorimeters.
  - $\sigma_E/E \sim 14\%/\sqrt{E}$ (EM).
  - $\sigma_E/E \sim 84\%/\sqrt{E}$ (HAD).
- Muon chambers.





Collider Detector at Fermilab

~600 physicists from
12 nations and 61 institutions

USA

Argonne National Lab.
Baylor Univ.
Brandeis Univ.
UC Davis
UC Los Angeles
UC San Diego
UC Santa Barbara
Carnegie Mellon Univ.
Univ. of Chicago
Duke Univ.
Fermilab
Univ. of Florida
Harvard Univ.
Univ. of Illinois
The Johns Hopkins Univ.
LBNL
MIT
Michigan State Univ.
Univ. of Michigan
Univ. of New Mexico
Northwestern Univ.
The Ohio State Univ.
Univ. of Pennsylvania
Univ. of Pittsburgh
Purdue Univ.
Univ. of Rochester
Rockefeller Univ.
Rutgers Univ.
Texas A&M Univ.
Tufts Univ.
Wayne State Univ.
Univ. of Wisconsin
Yale Univ.

Canada

McGill Univ.
Univ. of Toronto

Russia

JINR, Dubna
ITEP, Moscow

Germany

Univ. Karlsruhe

Switzerland

Univ. of Geneva

UK

Glasgow Univ.
Univ. of Liverpool
Univ. of Oxford
Univ. College London

Italy

Univ. of Bologna, INFN
Frascati, INFN
Univ. di Padova, INFN
Pisa, INFN
Univ. di Roma, INFN
INFN-Trieste
Univ. di Udine

Spain

IFAE, Barcelona
CIEMAT, Madrid
Univ. of Cantabria

France

LPNHE, Paris

Korea

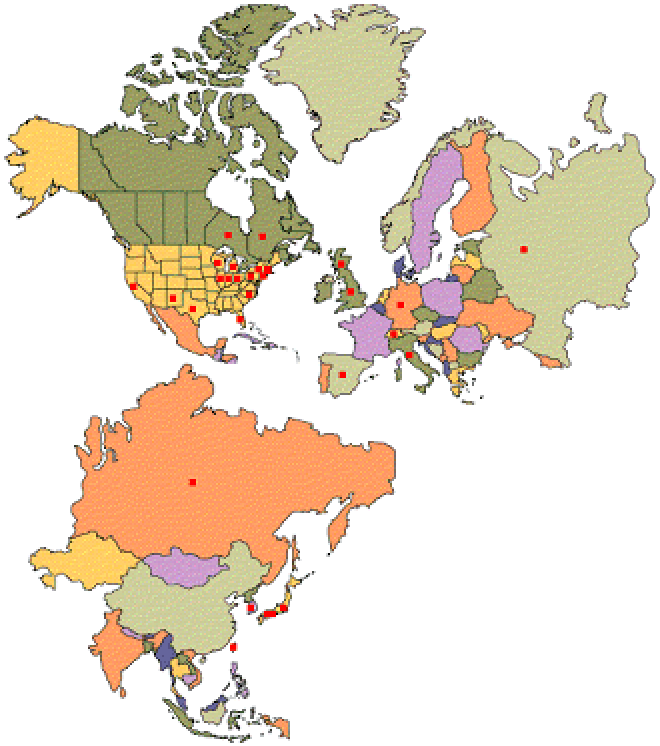
KHCL

Japan

KEK
Okayama Univ.
Osaka City Univ.
Univ. of Tsukuba
Waseda Univ.

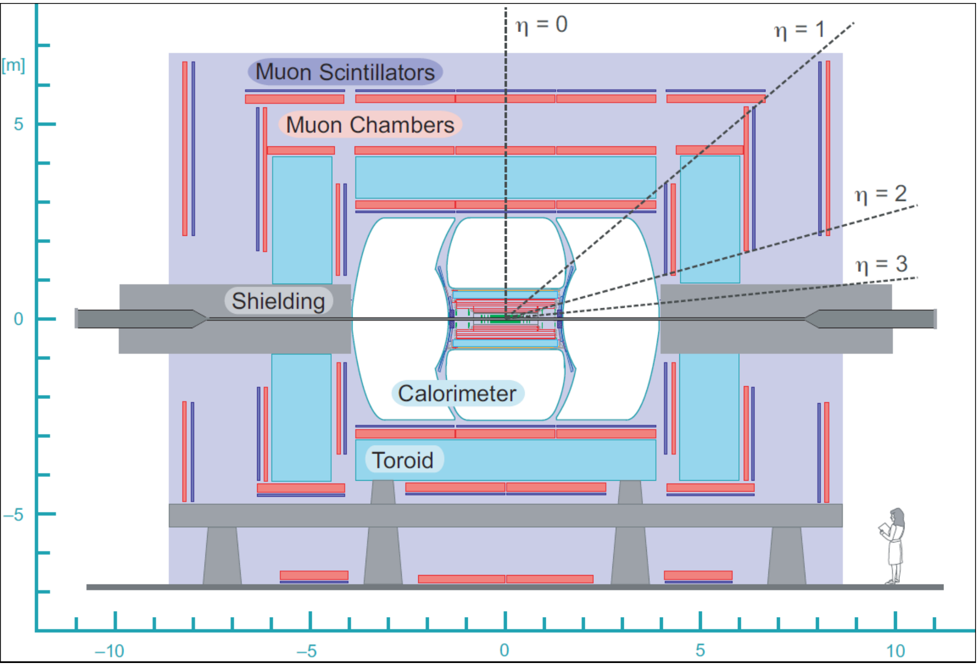
Taiwan

Academia Sinica



D0 Detector

Multi-purpose detector



- Silicon detector covering up to |h|<3 rapidity
- Compact scintillating fiber tracker
- 2.0 Tesla axial B field
- Hermetic U/liquid Ar calorimeter
- Extended muon coverage

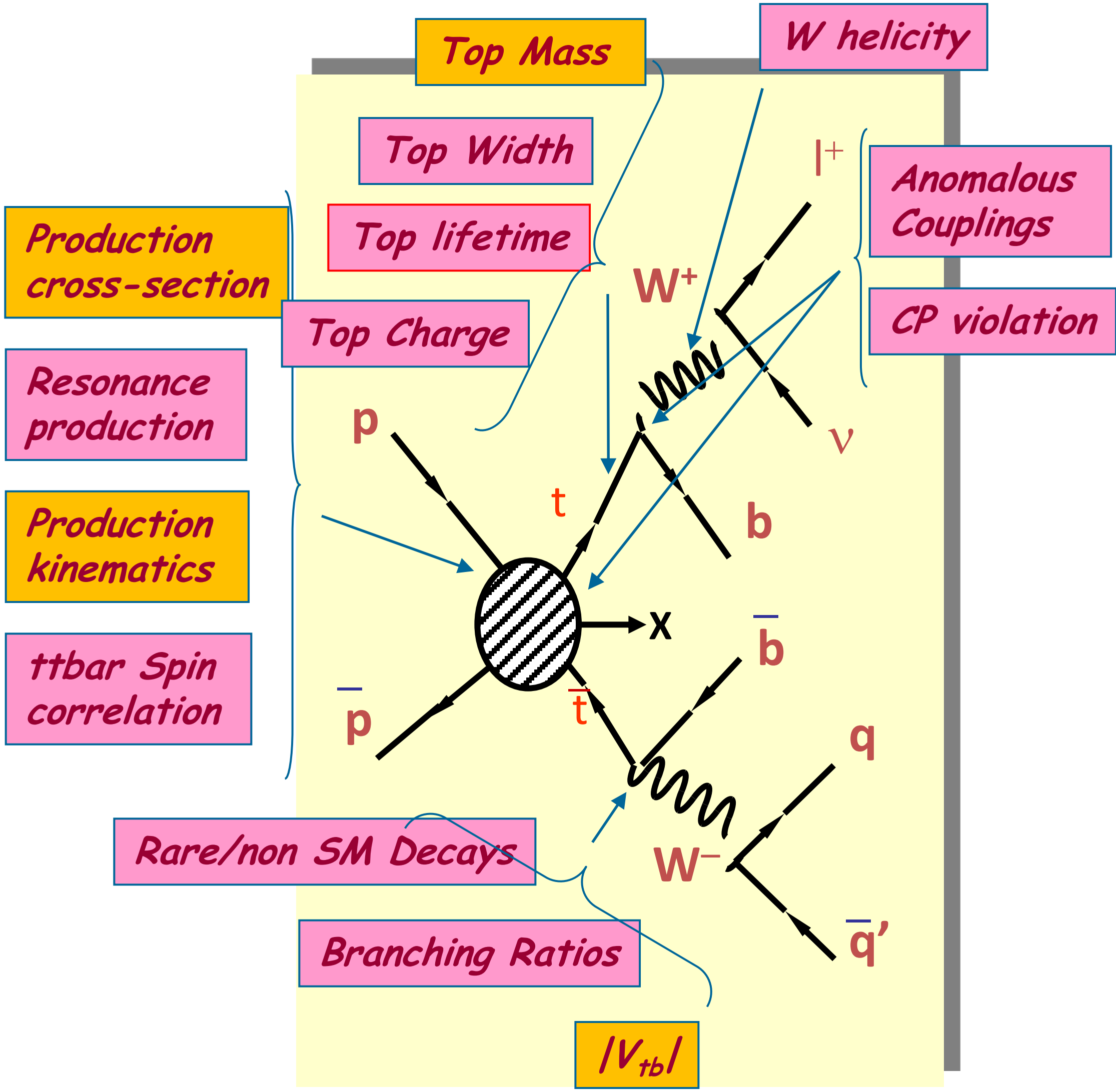
Top Physics

Top Physics at Tevatron

- Top quark was observed at TEVATRON in 1995.
- Top is still the least studied observed particle.
- Any deviation from SM might suggest new physics!!
- Top mass is unexpectedly heavy ~35×m_b.
  - Special role in EWSB?

ttbar decay modes:

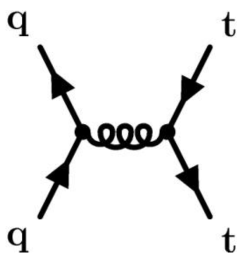
	BR (%)	Bkgd.
Di-lep.	5	Low
L+jets	30	Moderate
All had.	44	High
τ+X	21	τ-ID hard



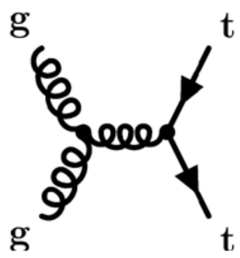
Top Pair Cross Section (L+jets)

- Top quark is mostly produced in pairs at Tevatron.

σ(NLO) = 7.4 +0.5-0.7 pb



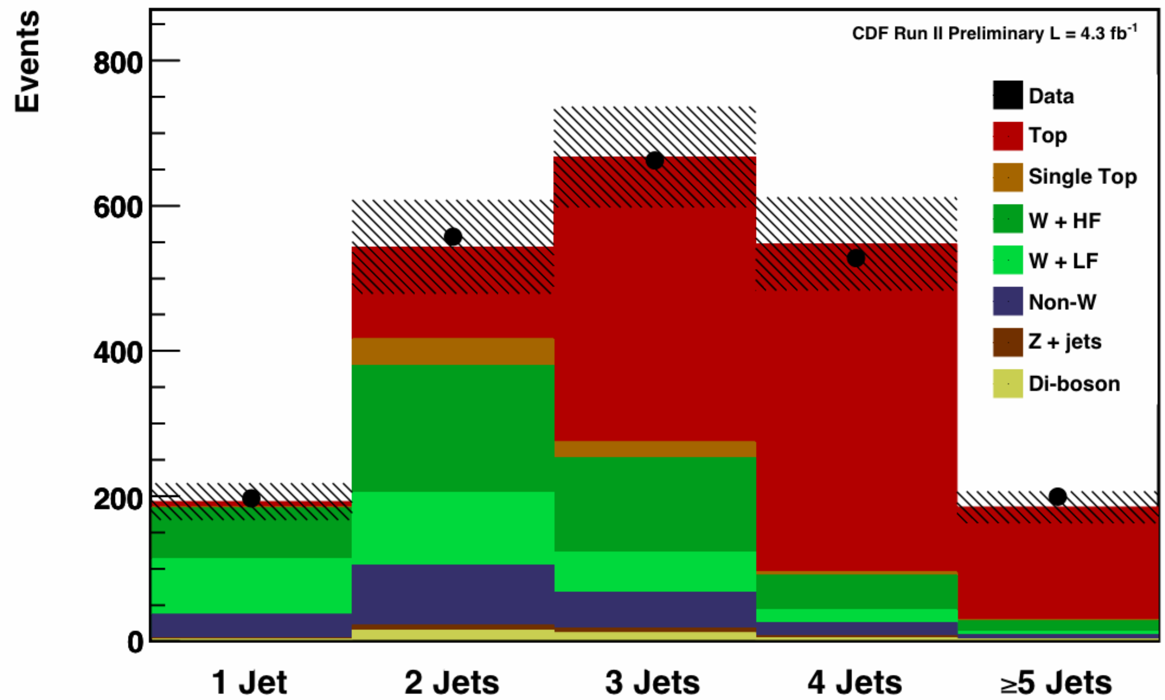
~85%



~15%

Event selection:

- 1 lepton Pt>20, |η|<2.0
- MET>25
- ≥3 jets with Pt>20 , |η|<2.0
- ≥ 1 jet b-tagged



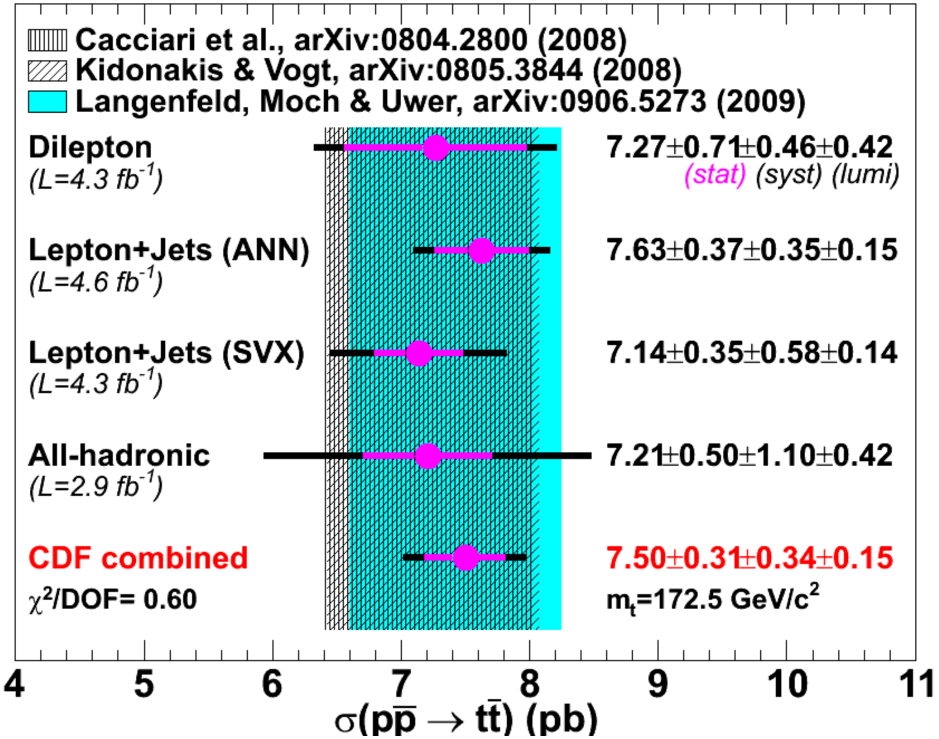
σ_{tt} = 7.04 ± 0.34 (stat.) ± 0.55 (syst.) ± 0.43 (lumi.) pb

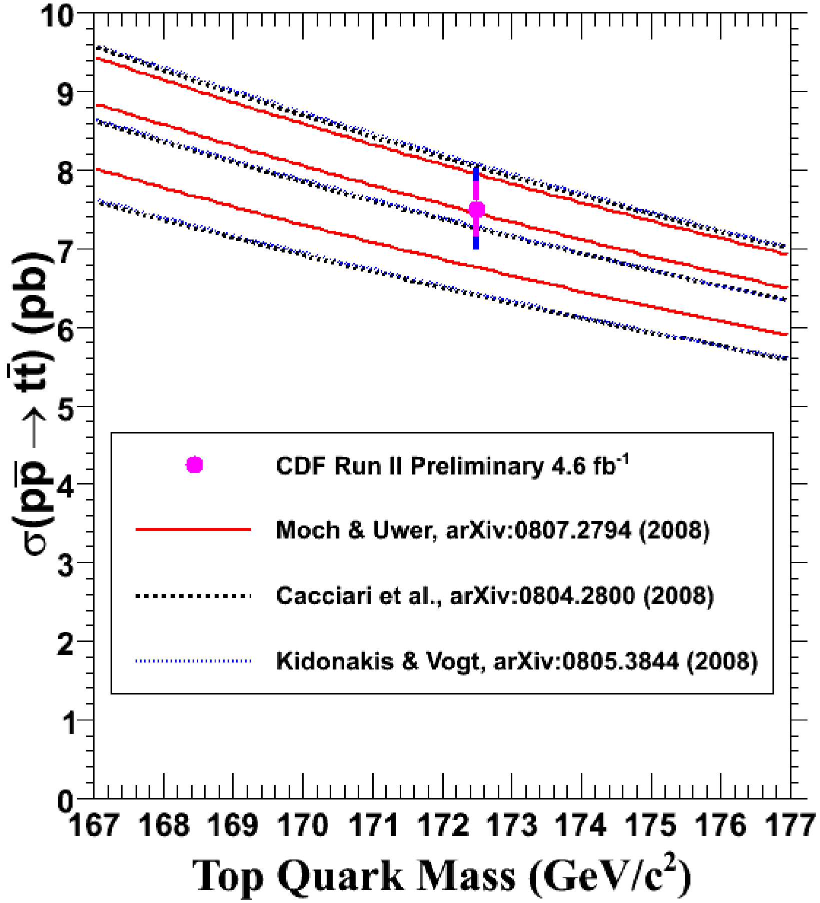
The dominant luminosity systematic can be canceled out by measuring ratio σ_{tt} / σ_Z.

σ_{tt} = 7.14 ± 0.34 (stat.) ± 0.58 (syst.) ± 0.14 (theory) pb (4.3 fb^{-1})

Top Pair Cross Section Summary

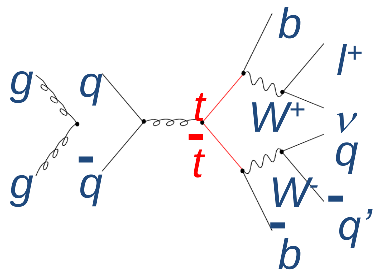
- Cross section is sensitive to both production and decay anomaly.
- The difference between different decay modes might indicate new physics.
- CDF measures xs with various decay modes/methods, and the results are consistent with SM.

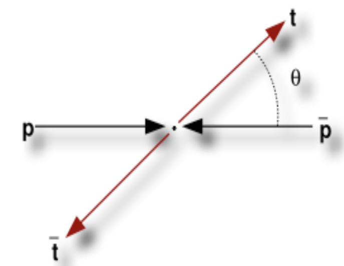




Forward Backward Assymmetry

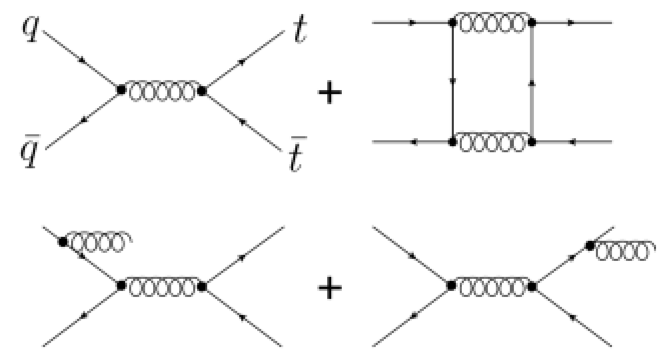
- **CDF Analysis in L+jets** channel.
- Related to qqbar initial state - specially interesting at Tevatron.
- Interference terms between LO and NLO diagrams → ~5% asymmetry.

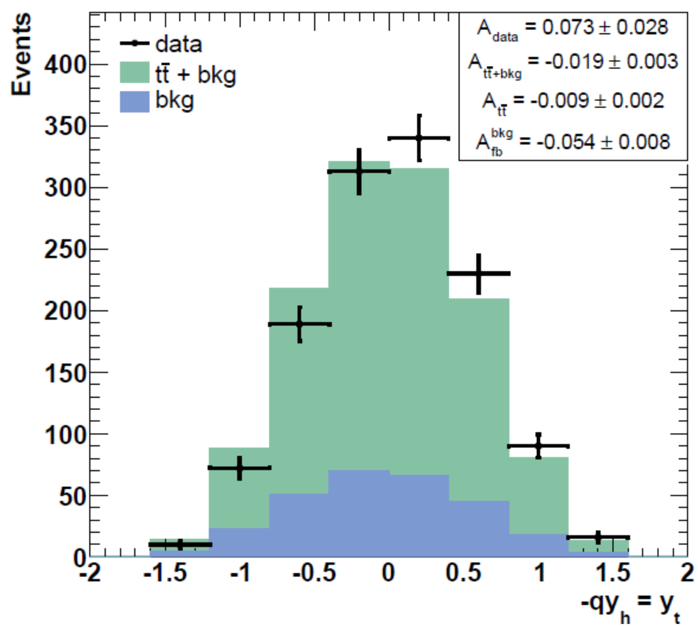




$$A^{p\bar{p}} = \frac{N(-qy_h > 0) - N(-qy_h < 0)}{N(-qy_h > 0) + N(-qy_h < 0)}$$

q: lepton charge
y_h: rapidity of hadronic top





5.3 fb^{-1}, Summer 2010

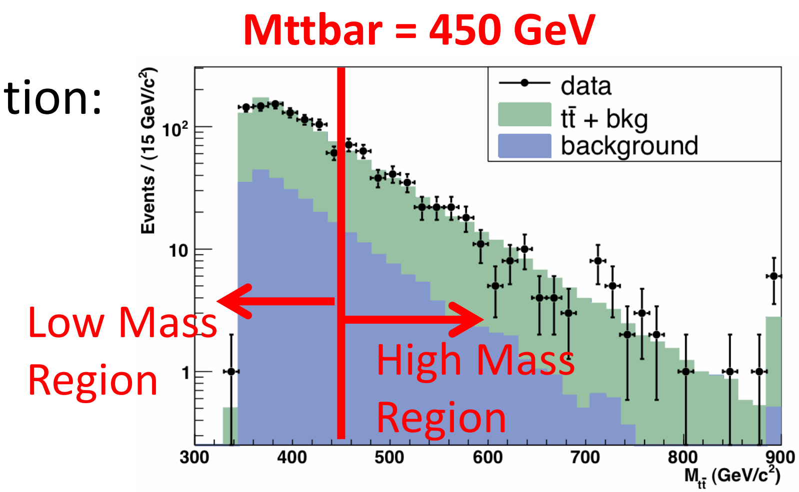
A_{FB} = 15.8± 5.0(stat) ±2.4(syst) %

A_{FB}^{SM} = 3.8 ± 0.6 %

~2.1 σ deviation

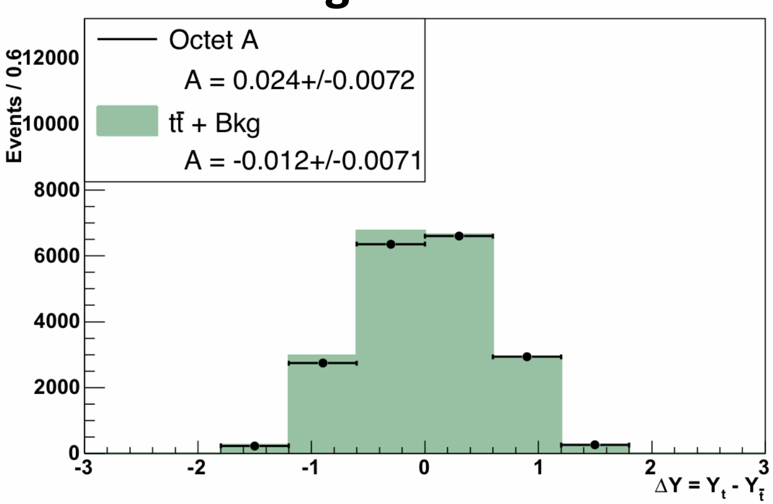
M_{ttbar} Dependence of A_{FB} in L+jets at CDF (2)

M_{ttbar} Distribution:



5.3 fb^{-1}, Winter 2011 update

Low Mass Region

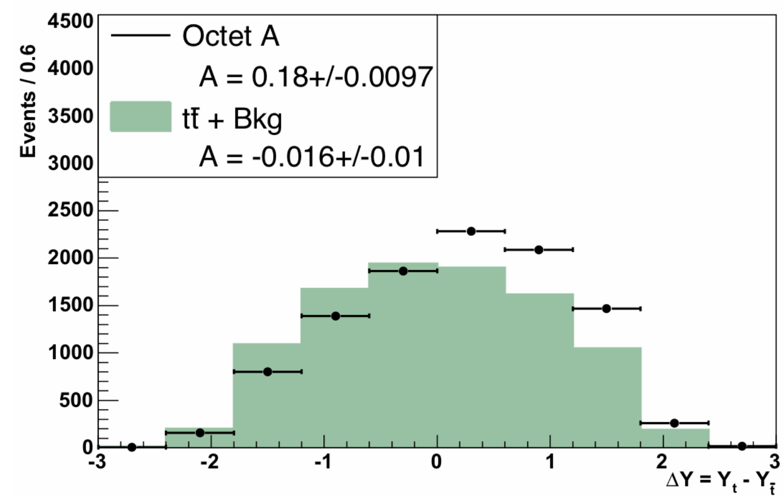


A_{FB} = -11.6 ± 15.3 %

A_{FB}^{SM} = 4.0 ± 0.6 %

consistent

High Mass Region



A_{FB} = 47.5 ± 11.4 %

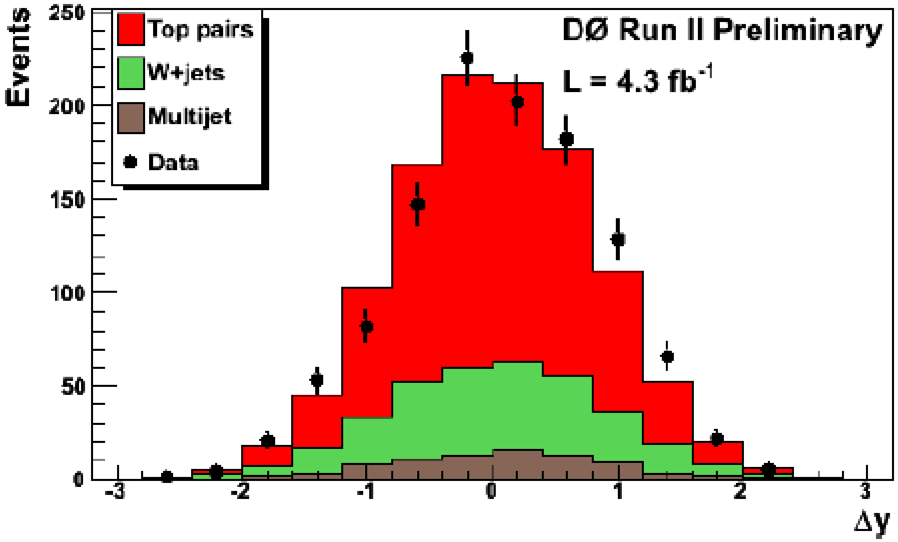
A_{FB}^{SM} = 8.8 ± 1.3 %

~3.3 σ deviation

A_{FB} Measurement in L+jets at D0

- **D0 analysis in L+jets**.
- Asymmetry defined as:

$$A_{fb} = \frac{N^{\Delta y>0} - N^{\Delta y<0}}{N^{\Delta y>0} + N^{\Delta y<0}}$$ $\Delta y = y_{top} - y_{anti\text{-}top}$



Thought not as significant, same trend as CDF!!

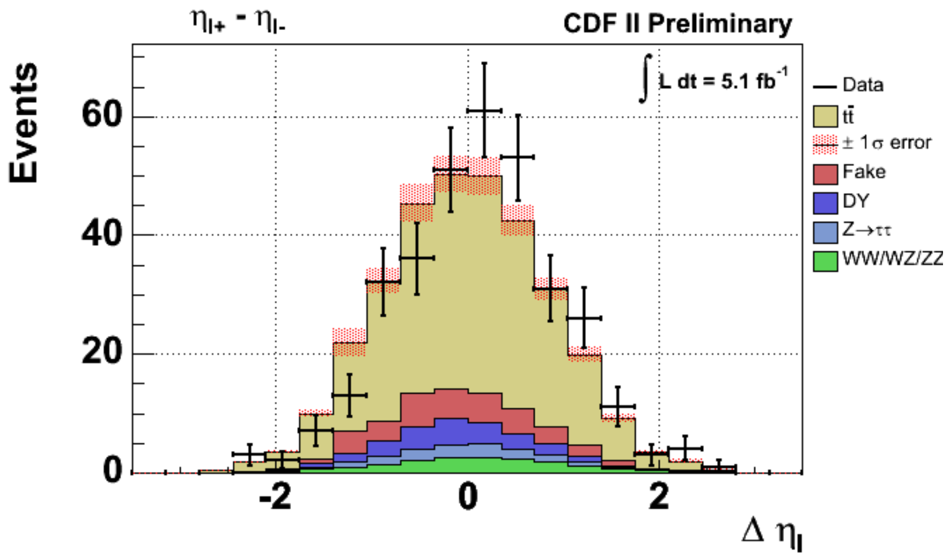
4.3 fb^{-1}, Summer 2010

A_{FB} = 8± 4(stat) ±2(syst) %

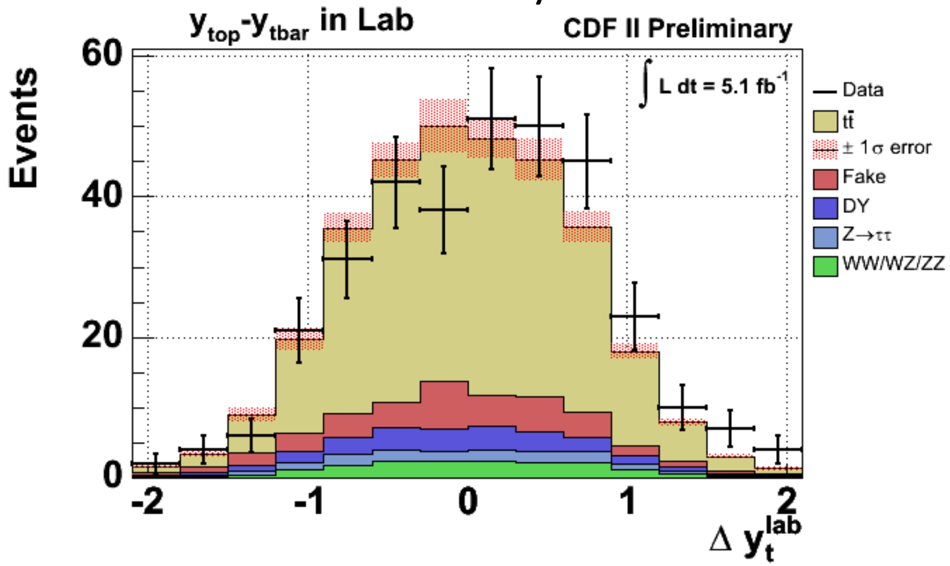
$A_{FB}^{SM} = 1^{+2}_{-1}$ %

A_{FB} Measurement in Dilepton at CDF

Lepton Δy distribution



Full Reconstruction Δy distribution



$5.1\ fb^{-1}$, Winter 2011

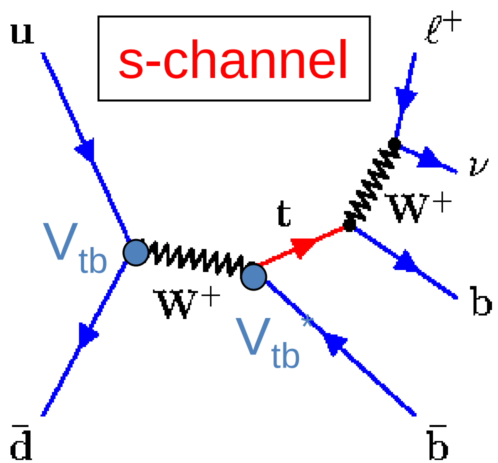
A^{obs}_{FB} = 13.8 ± 5.4 %

A^{SM}_{FB} = -1.5 ± 2.3 %

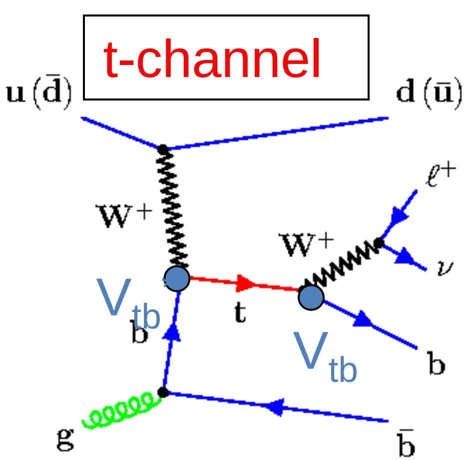
2.1σ deviation

Single Top Production

- Top quark is sometimes singly produced Tevatron.
  - 1 lepton, MET, 2 or 3 jets
  - S/B separation by Matrix Element (ME)



0.884±0.11 pb (NLO)

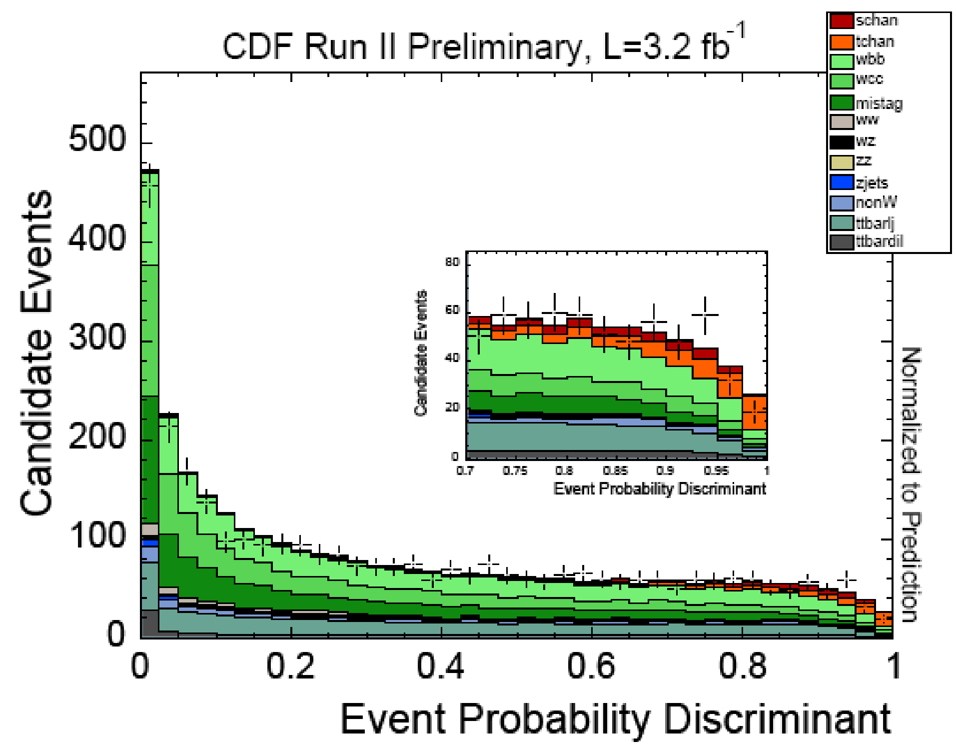


1.98±0.25 pb (NLO)

$$EPD = \frac{b \cdot P_{singletop}}{b \cdot P_{singletop} + b \cdot (P_{Wb\bar{b}} + P_{t\bar{t}}) + (1-b) \cdot (P_{Wc\bar{c}} + P_{Wcj} + P_{Wgg})}$$

Signal ME

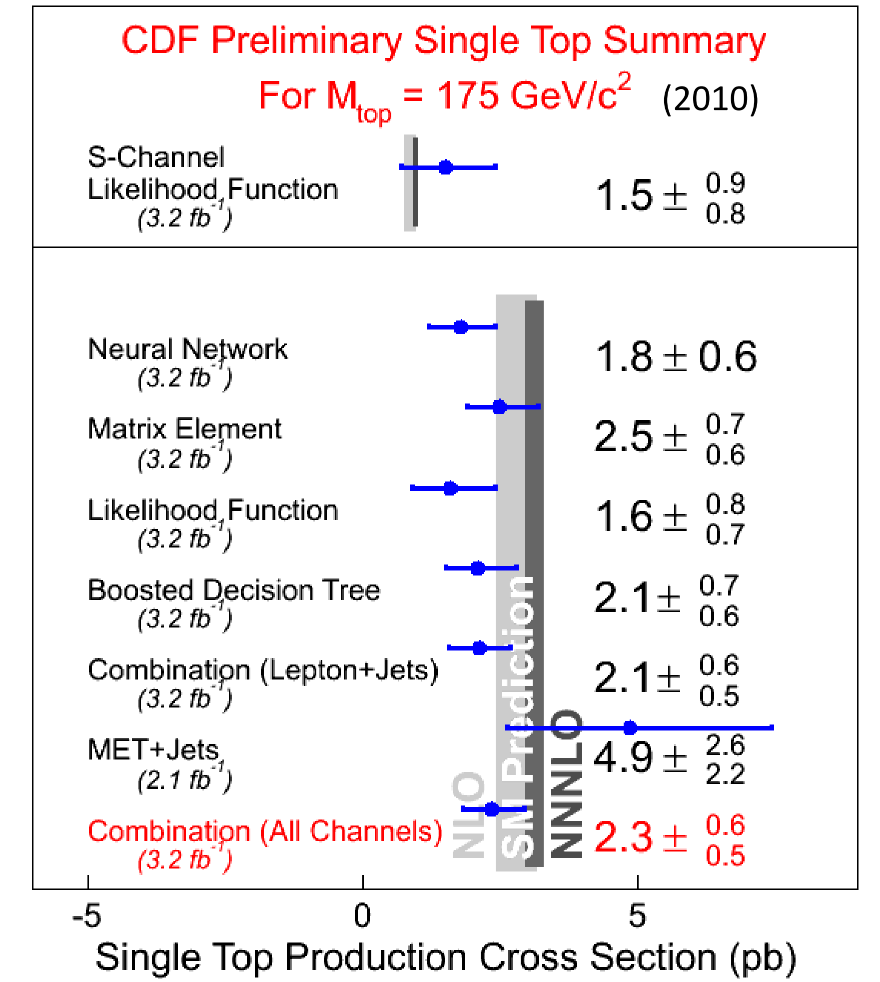
bkgd ME



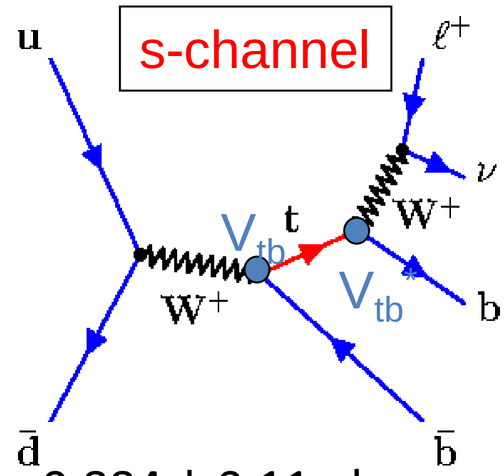
$\sigma_{t+s\text{-}chan} = 2.5^{+0.7}_{-0.6}$ pb (3.2 fb^{-1})

4.3 σ effect

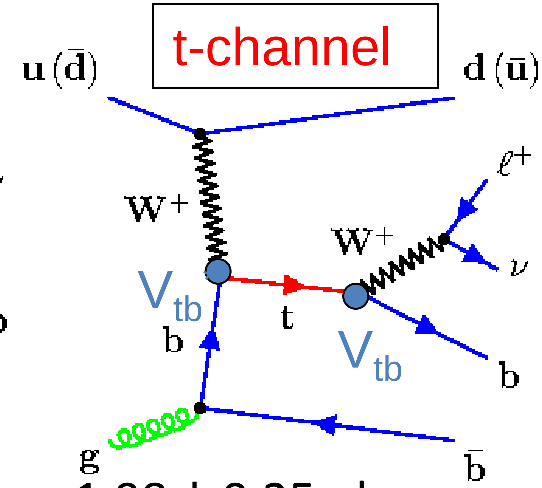
Single Top Combined Result



NLO: Z.Sullivan, Phys.Rev.D70,114012 (2004) NNNLO: N.Kidonakis, Phys.Rev.D74,114012 (2006)



0.884$\pm$0.11 pb (NLO)



1.98$\pm$0.25 pb (NLO)

5.0 σ observation!!

$\sigma_{t+s\text{-}chan} = 2.3^{+0.6}_{-0.5}$ pb

$\sigma_{t\text{-}chan} = 0.8 \pm 0.4$ pb

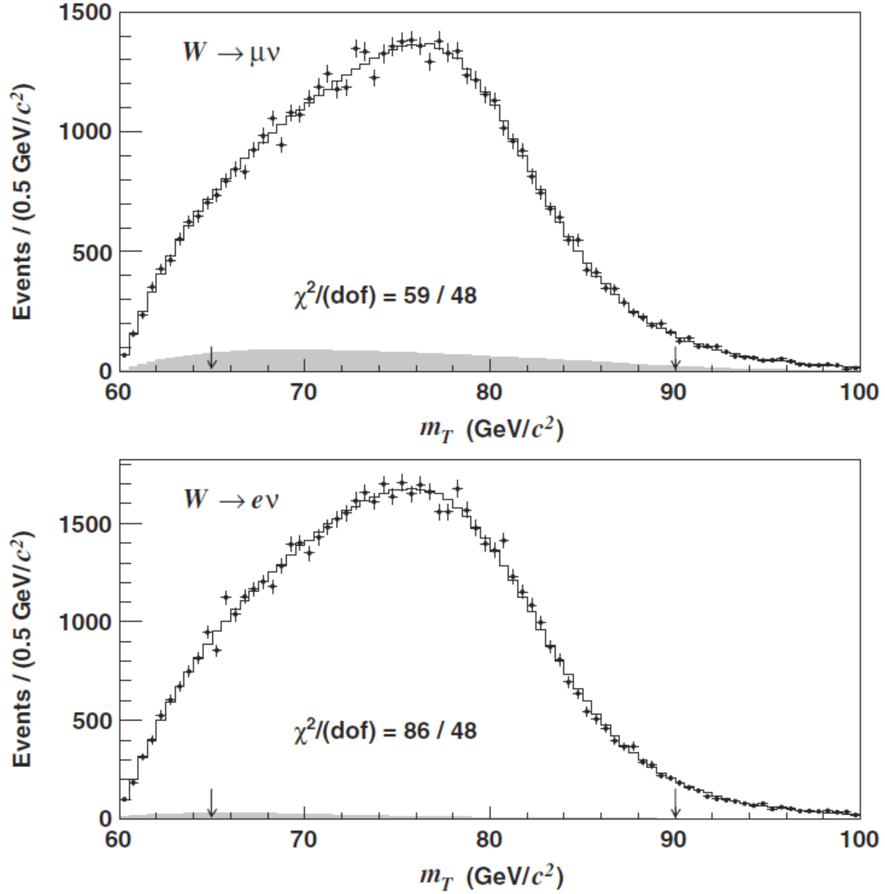
$\sigma_{s\text{-}chan} = 1.8^{+0.7}_{-0.5}$ pb

$|V_{tb}|$ = 0.91 ± 0.11 (exp.) ± 0.07 (theory)

$|V_{tb}|$ > 0.71 at 95% C.L.

W Mass Measurement

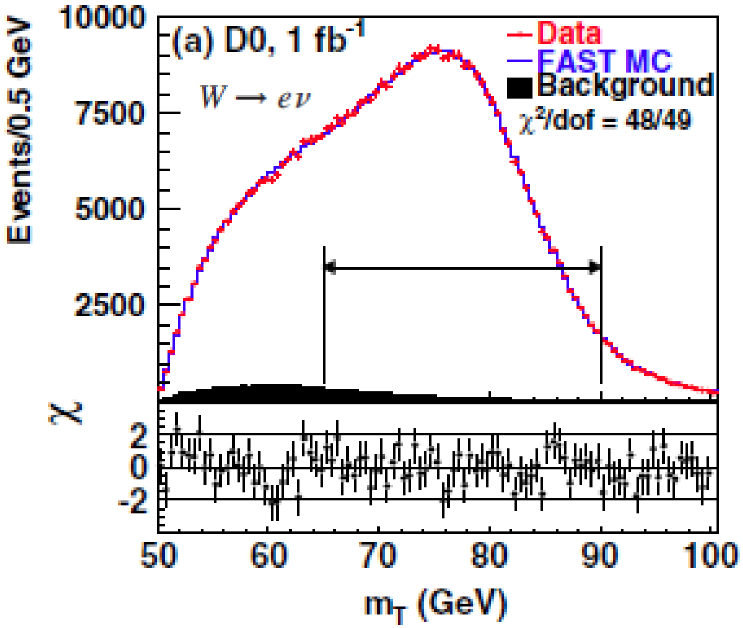
CDF, 200 pb^{-1} (2007)



$$M_W = 80\,413 \pm 34_{stat} \pm 34_{syst}$$

Best single measurement of the time.

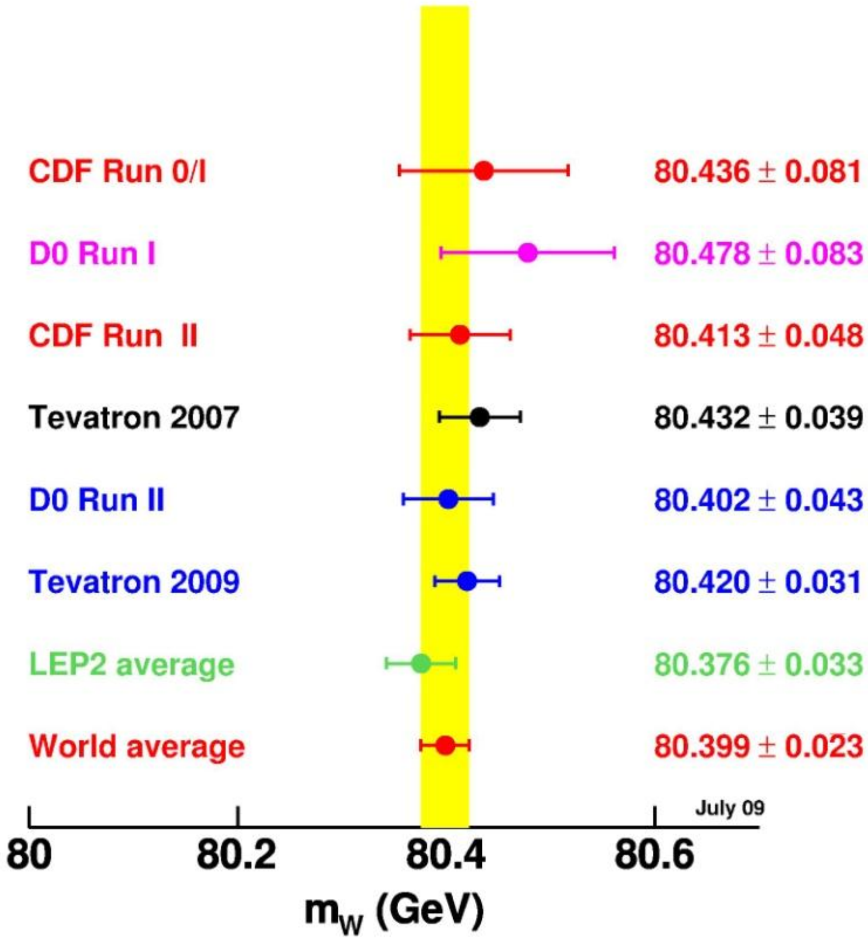
D0, 1 fb^{-1} (2009)



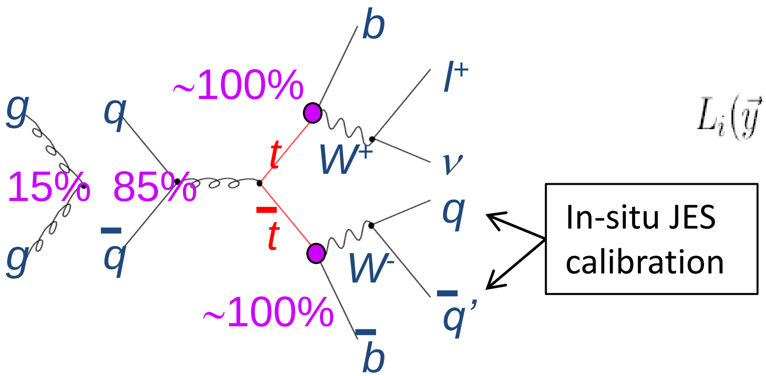
$$M_W = 80.401 \pm 0.021(\text{stat}) \pm 0.038(\text{syst})\ \text{GeV}$$

Best single measurement!

W Mass World Average



Top Mass Measurement in L+jets Events (CDF)



PDFs | Matrix Element

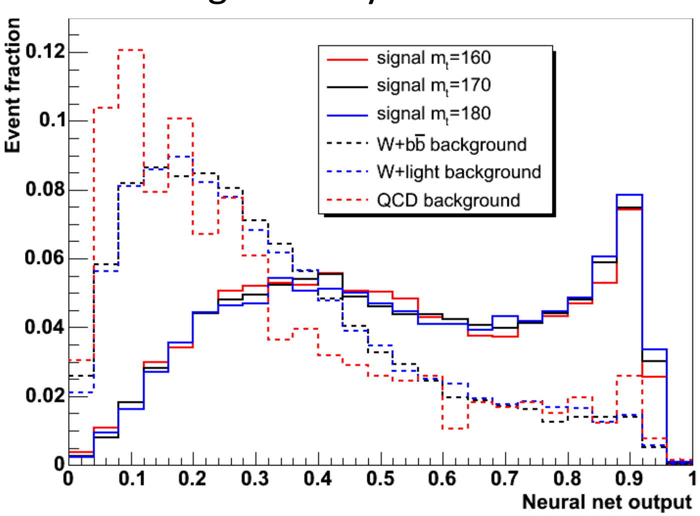
$$L_i(\vec{y} \mid m_t, \Delta_{\mathrm{JES}}) = \int \frac{f(z_1)f(z_2)}{FF} \, \mathrm{TF}(\vec{y} \mid \vec{x}, \Delta_{\mathrm{JES}}) \, |M(m_t, \vec{x})|^2 \, d\Phi(\vec{x})$$

Detector Response Func.

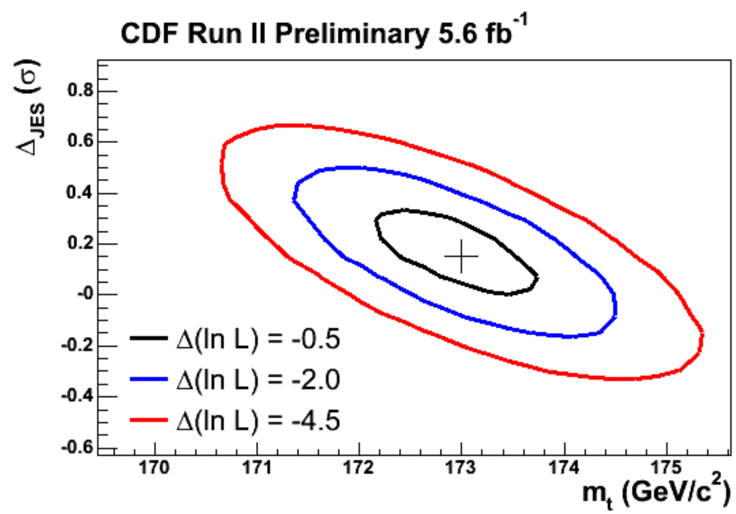
x: parton level momenta
y: measured momenta

	1-btag	2>b-tag
Background	261.8 ± 60.6	28.0 ± 9.6’
Top signal	767.3 ± 97.2	276.5 ± 43.0
Observed Data	1016	247

Controls background by a Neural Net Discriminant:



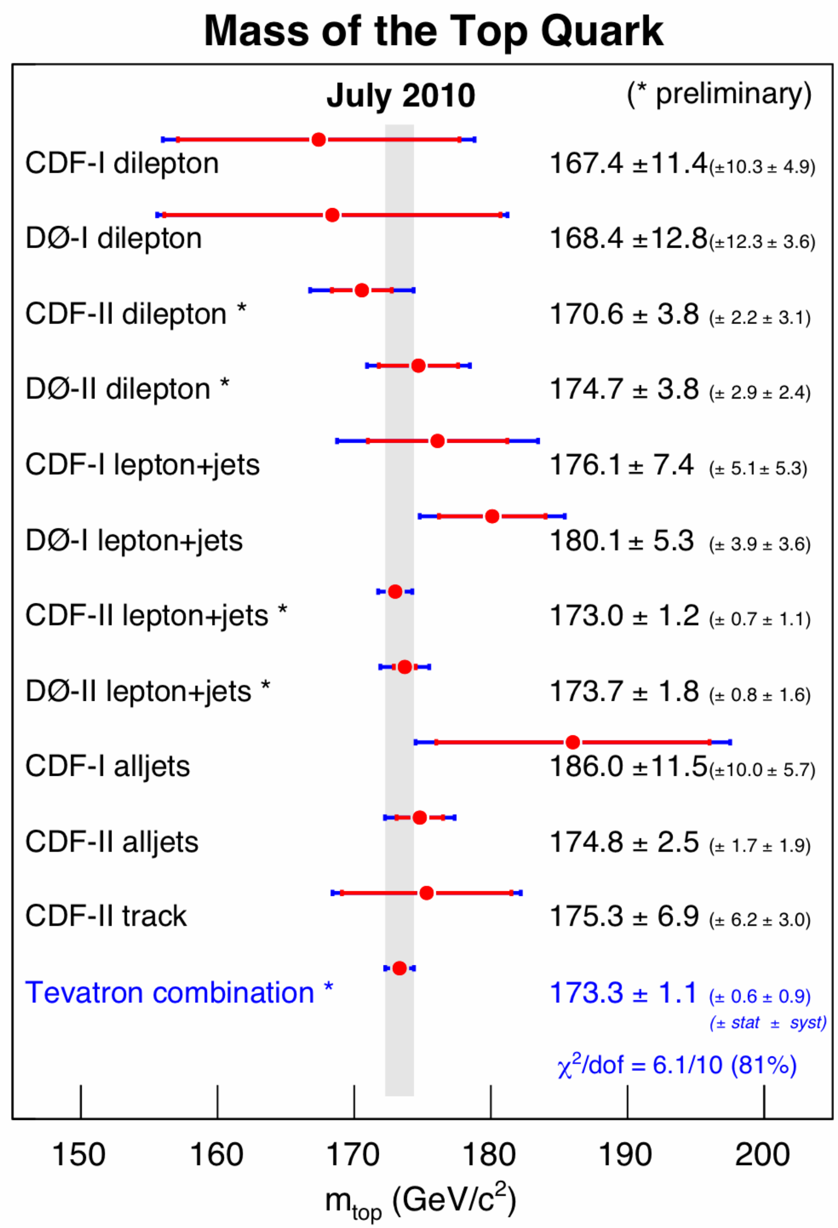
2-D likelihood Fit to data :



m_t = 173.0 ± 0.7 (stat.) ± 0.6 (JES)
± 0.9 (syst.) GeV/c^2
= 173.0 ± 1.2 (total) GeV/c^2

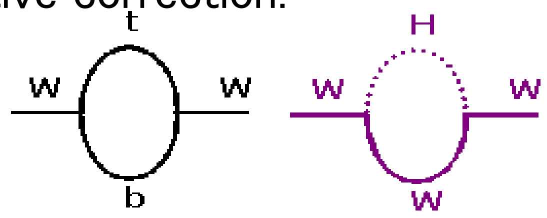
Best single measurement, 0.7% precision!

Top Mass World Average

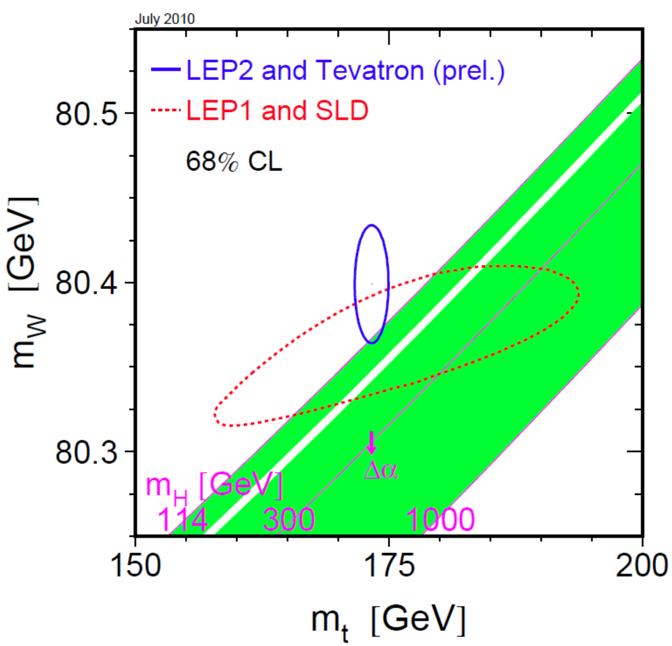


Constraint to SM Higgs Mass (Jul 2010)

Precise W and Top Mass measurements constrains the SM Higgs Mass due to the radiative correction:

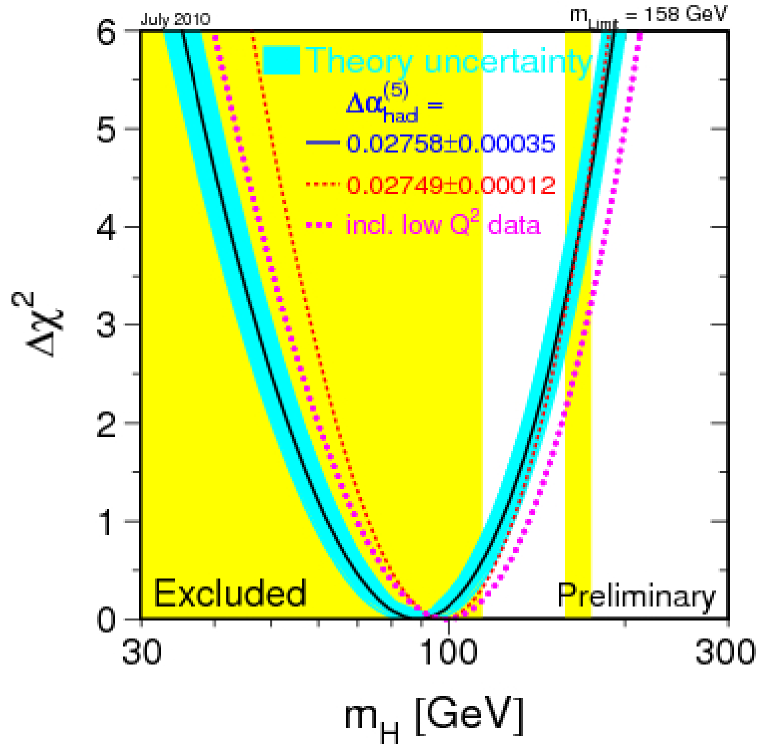


$\Delta M_W \propto M_T^2$ $\Delta M_W \propto \ln M_H$



$M_{top} = 173.3 \pm 1.1$ GeV/c²

$M_W = 80.399 \pm 0.023$ GeV/c



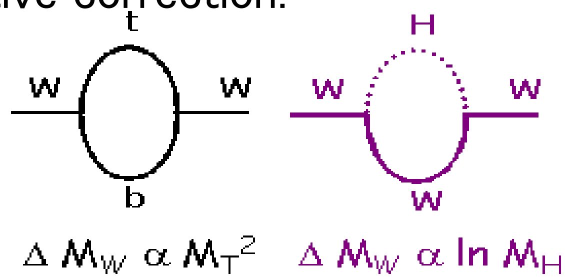
m_H < 158 GeV @ 95% CL

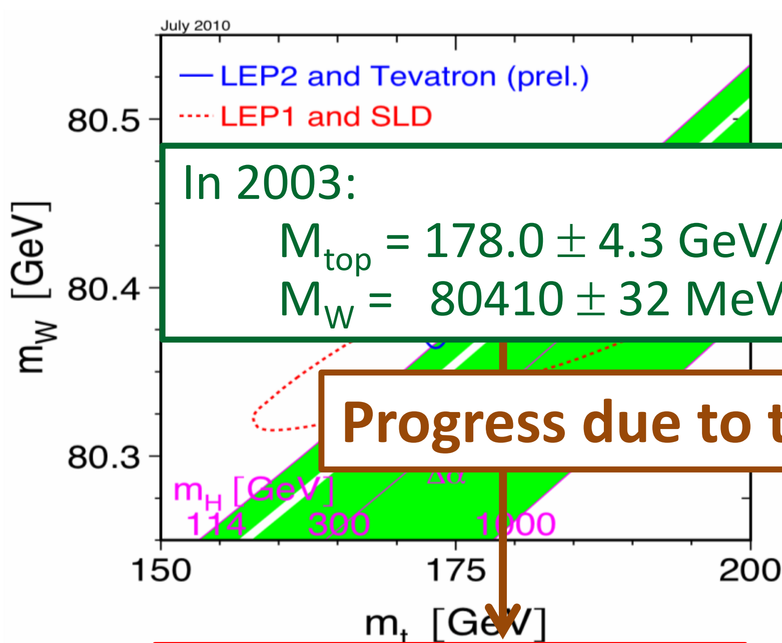
(mH = 89.0 +35/-26 GeV)

m_H < 185 GeV @ 95% CL including LEP2 direct search limit

Constraint to SM Higgs Mass (Jul 2010)

Precise W and Top Mass measurements constrains the SM Higgs Mass due to the radiative correction:

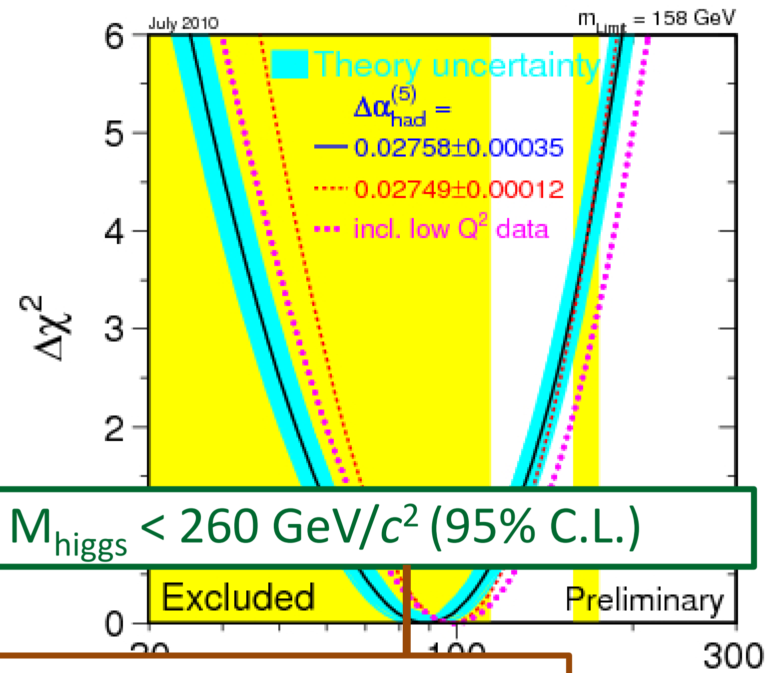




In 2003:

M_{top} = 178.0 ± 4.3 GeV/c^2

M_W = 80410 ± 32 MeV/c^2



M_{higgs} < 260 GeV/c^2 (95% C.L.)

Progress due to the TEVATRON Run II Results

M_{top} = 173.3 ± 1.1 GeV/c^2

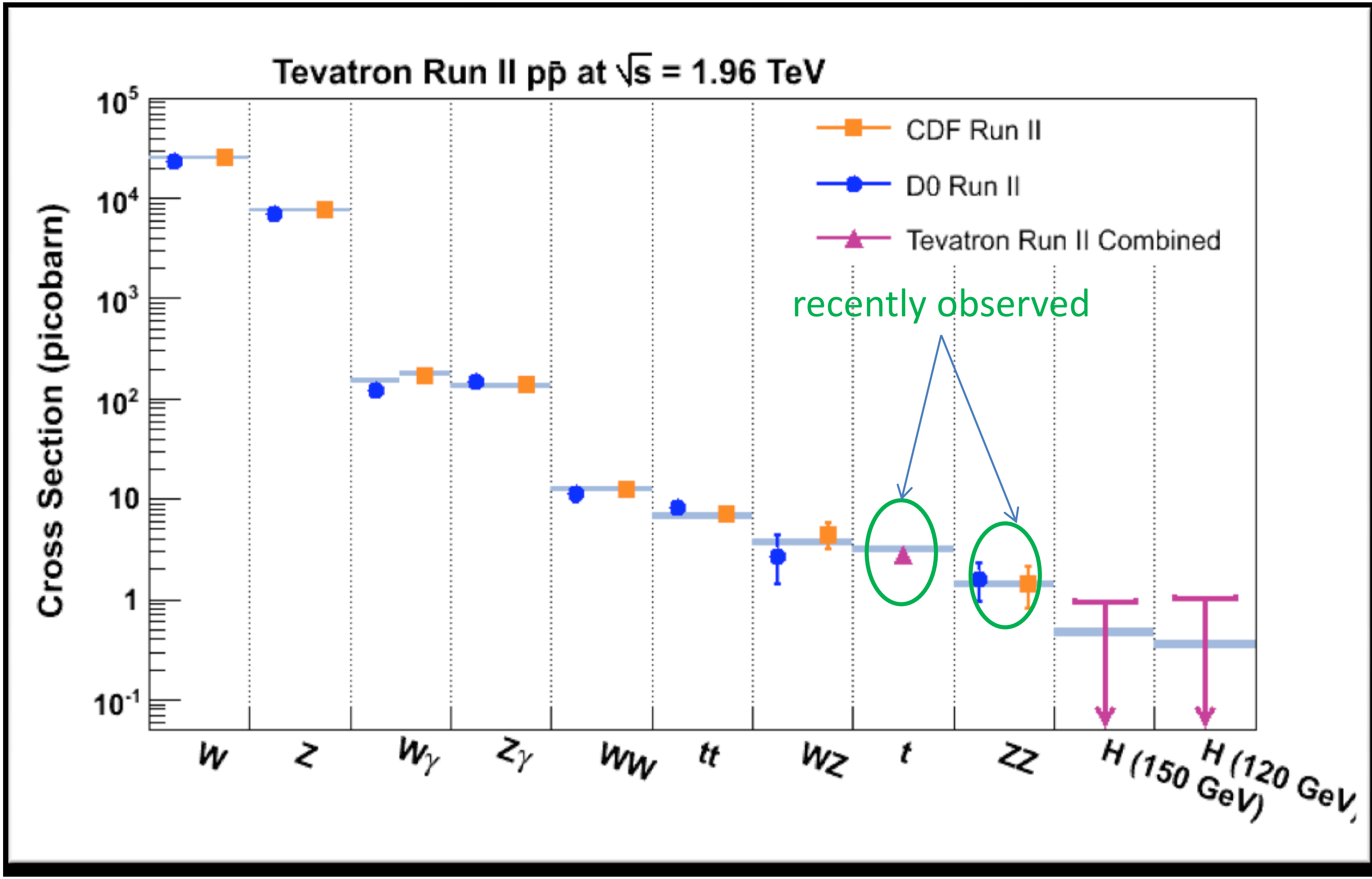
M_W = 80.399 ± 0.023 GeV/c^2

mH < 158 GeV @ 95% CL

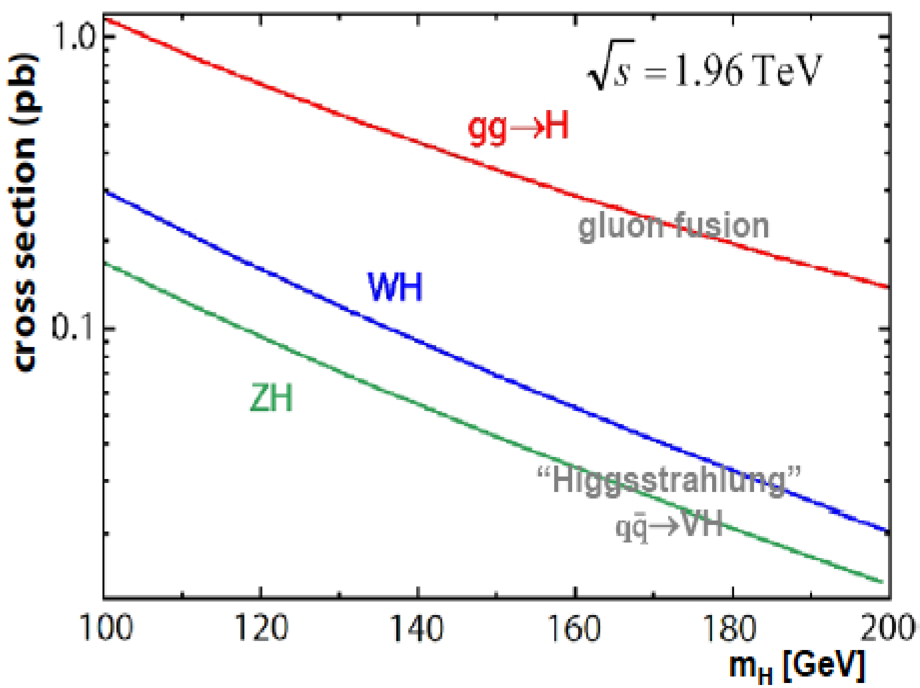
(mH = 89.0 +35/-26 GeV)

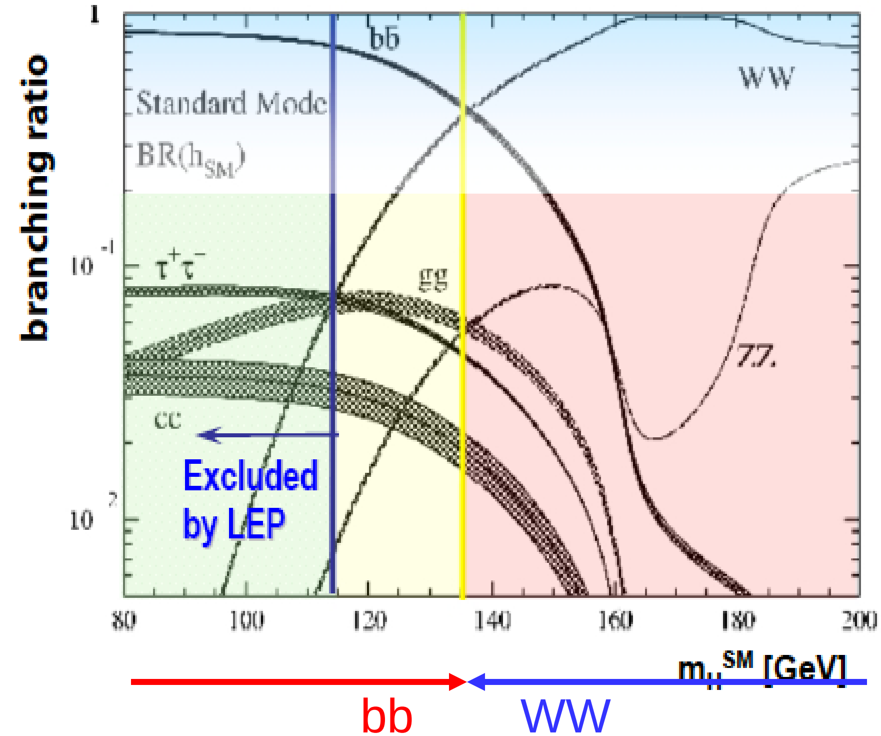
Direct Search for Higgs Bosons

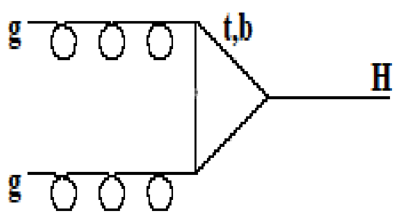
Production Cross Sections

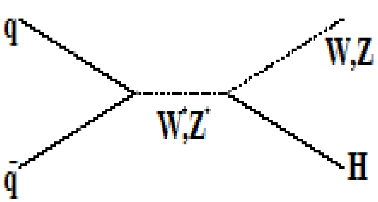


SM Higgs Properties at Tevatron





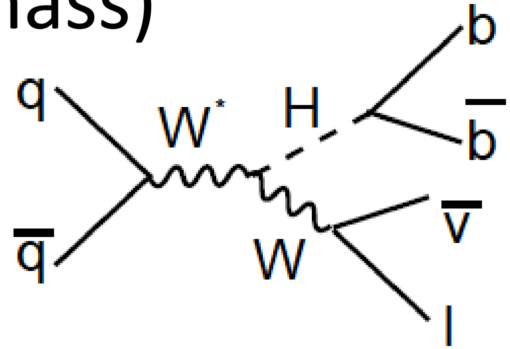




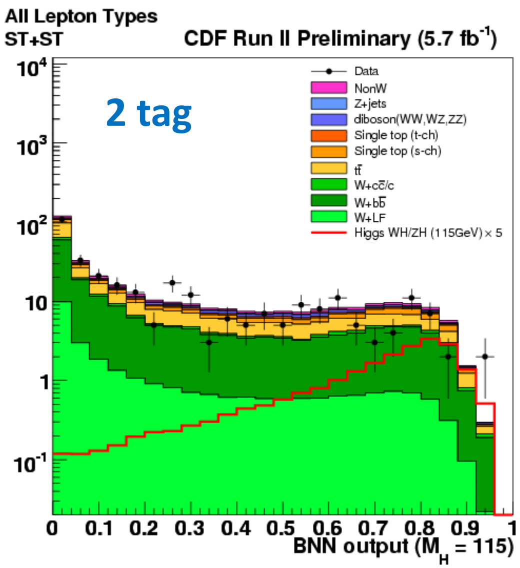
- mH<135 GeV (low mass):
  - gg→H→bb is difficult to see.
  - Look for WH/ZH with leptonic vector boson decays.
- mH>135 GeV (high mass):
  - Easiest to look for H→WW with one or two W decaying to lepton.

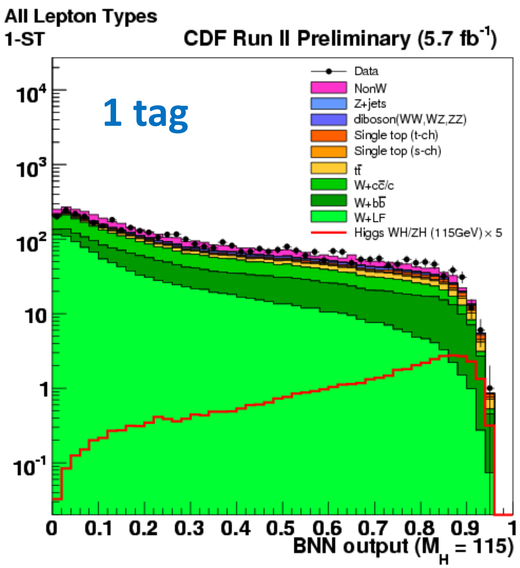
$WH \to l\nu bb$ (low mass)

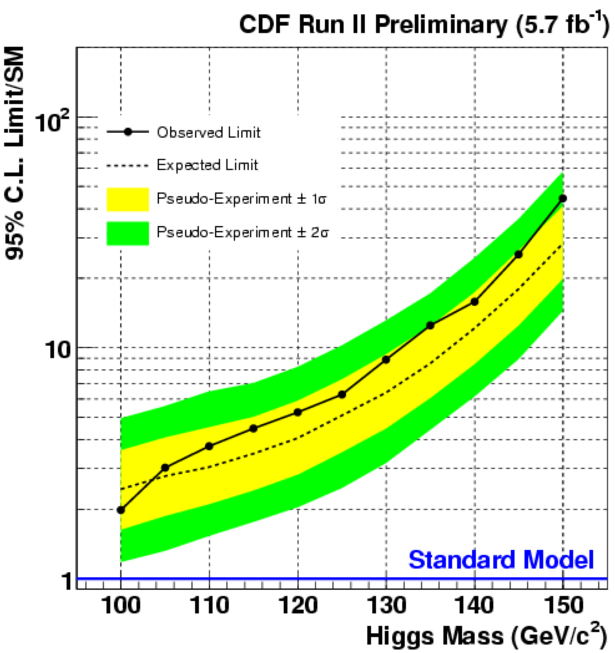
- S/B separation by NN.
- Four tagging categories, using 3 algorithms (including NN tagger).
- NN based *b*-jet energy correction



NN Outputs:



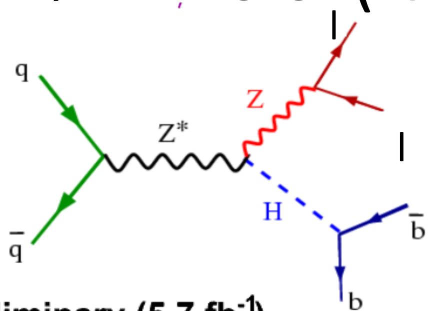




<u>Observed upper limit</u>

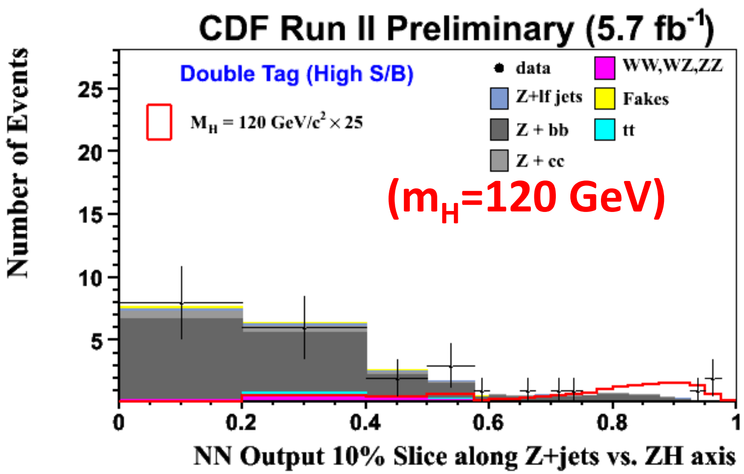
4.5 x σ(SM)(@115 GeV)

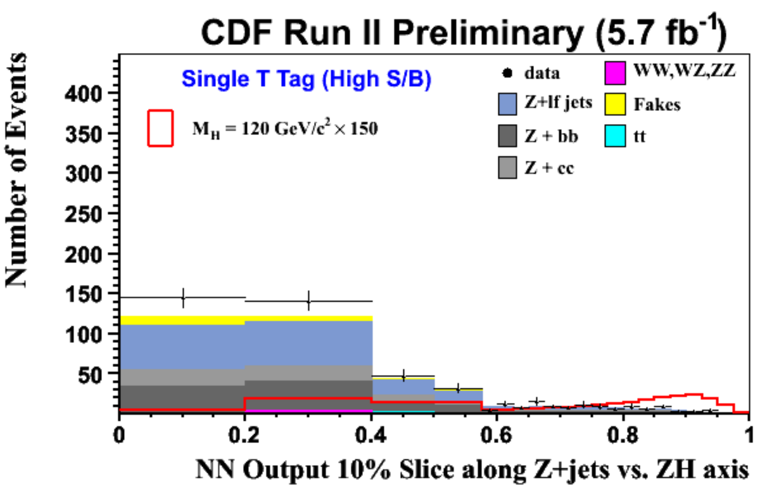
$ZH \rightarrow ll+bb$ (low mass)

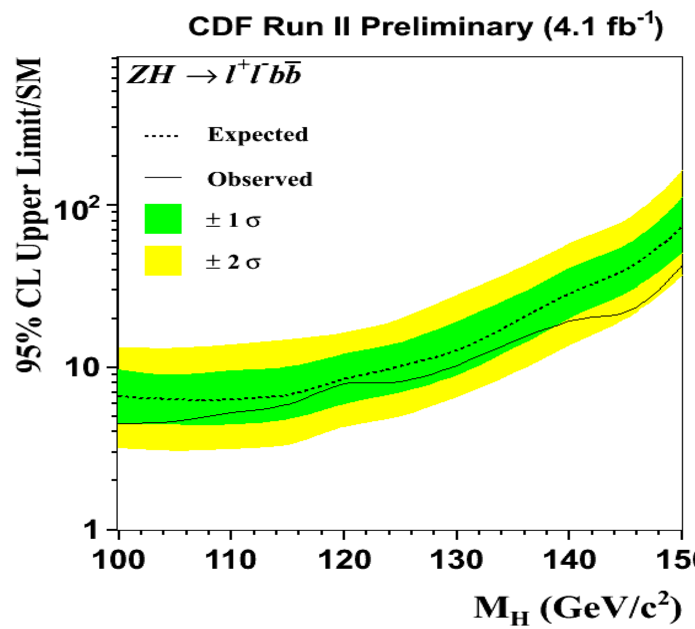


- 3 b-tag categories with 2 algorithms.
- S/B separation by NN.
- Improved lepton coverage with new loose muon category.
- Dominant backgrounds:
  - Z+jets, top, diboson

NN Outputs:





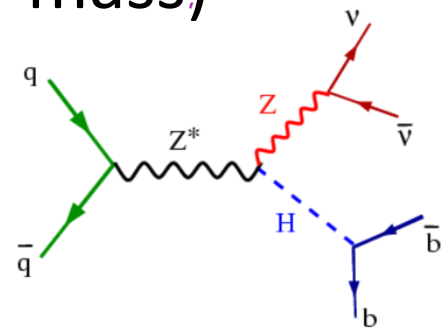


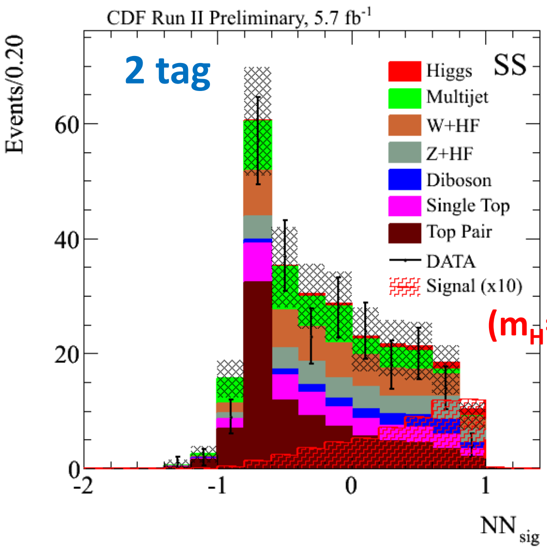
Observed upper limit

6.0 x σ(SM)(@115 GeV)

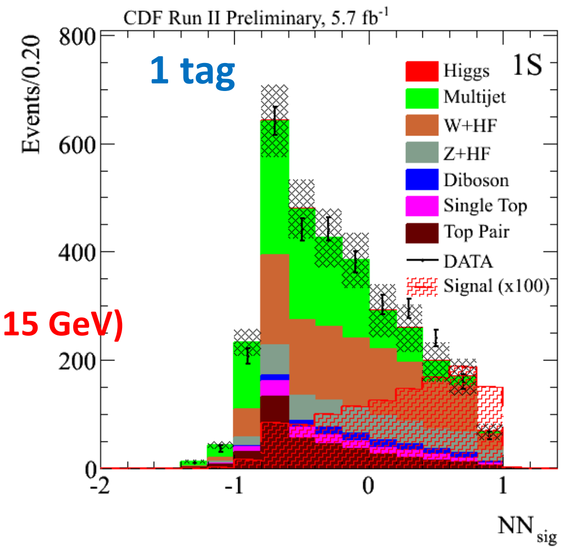
WH/ZH→MET+bb (low mass)

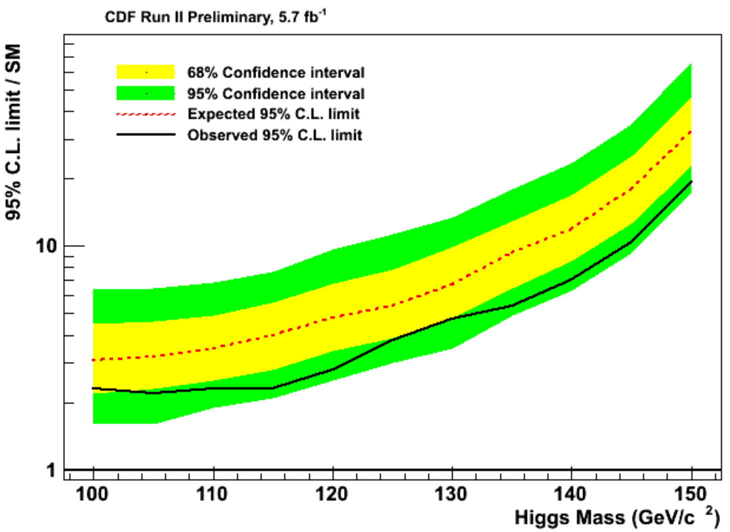
- Target process: *ZH→ννbb*
  - Also complementary to *WH→lνbb* search.
- 3 b-tag categories with 2 algorithms.
- S/B separation by NN.
- Dominant backgrounds:
  - QCD with MET miscalculation
  - *W/Z*+jets, top, diboson





(m$_H$=115 GeV)

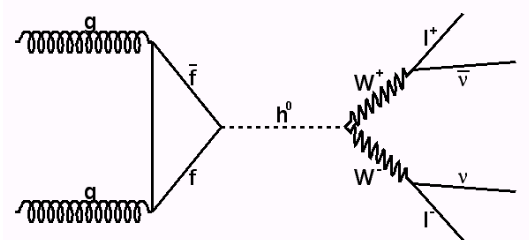




Observed upper limit

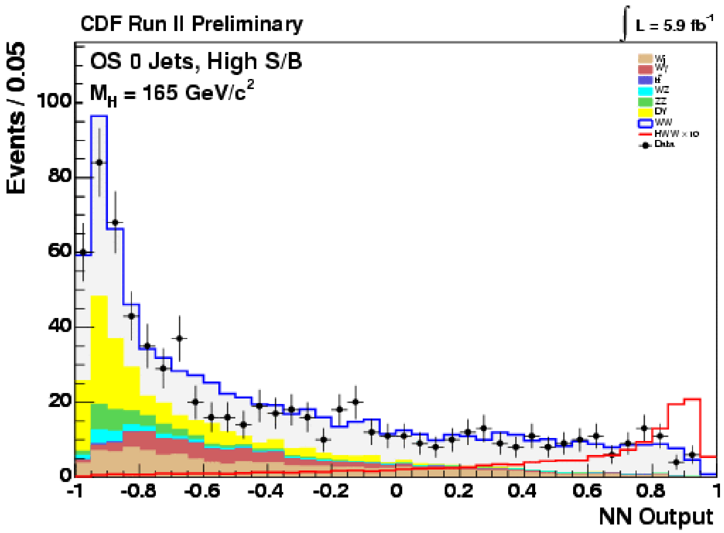
2.3 x σ(SM)(@115 GeV)

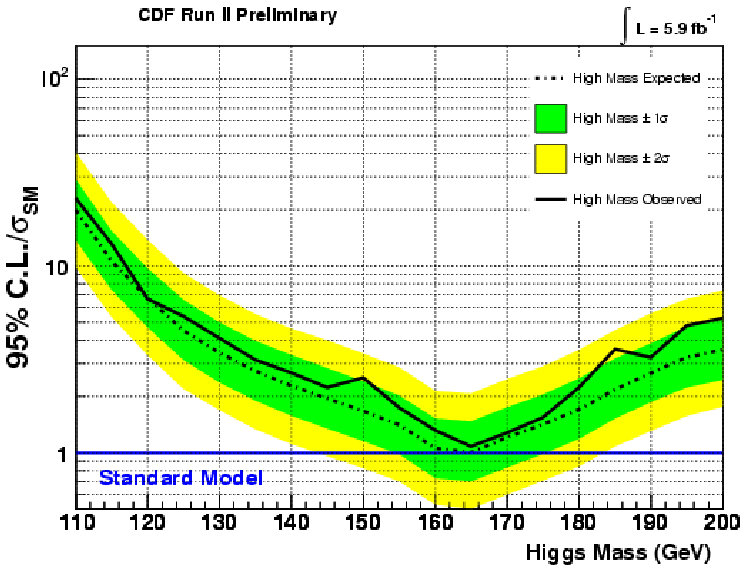
$H \rightarrow WW^* \rightarrow l^+ \nu l^- \nu$ (high mass)



- Opposite Sign 2 leptons.
  - Lepton acceptance improved by using isolated tracks.
- S/B separation by NN.
  - Matrix element calculation result input to NN.
- Dominant background
  - DY, Diboson, top
- Independently analyses OS/SS 2 leptons + 1/2 jets events to include WH→WWW and VBF H→WW signal inacceptance.

Updating for Winter 2011…

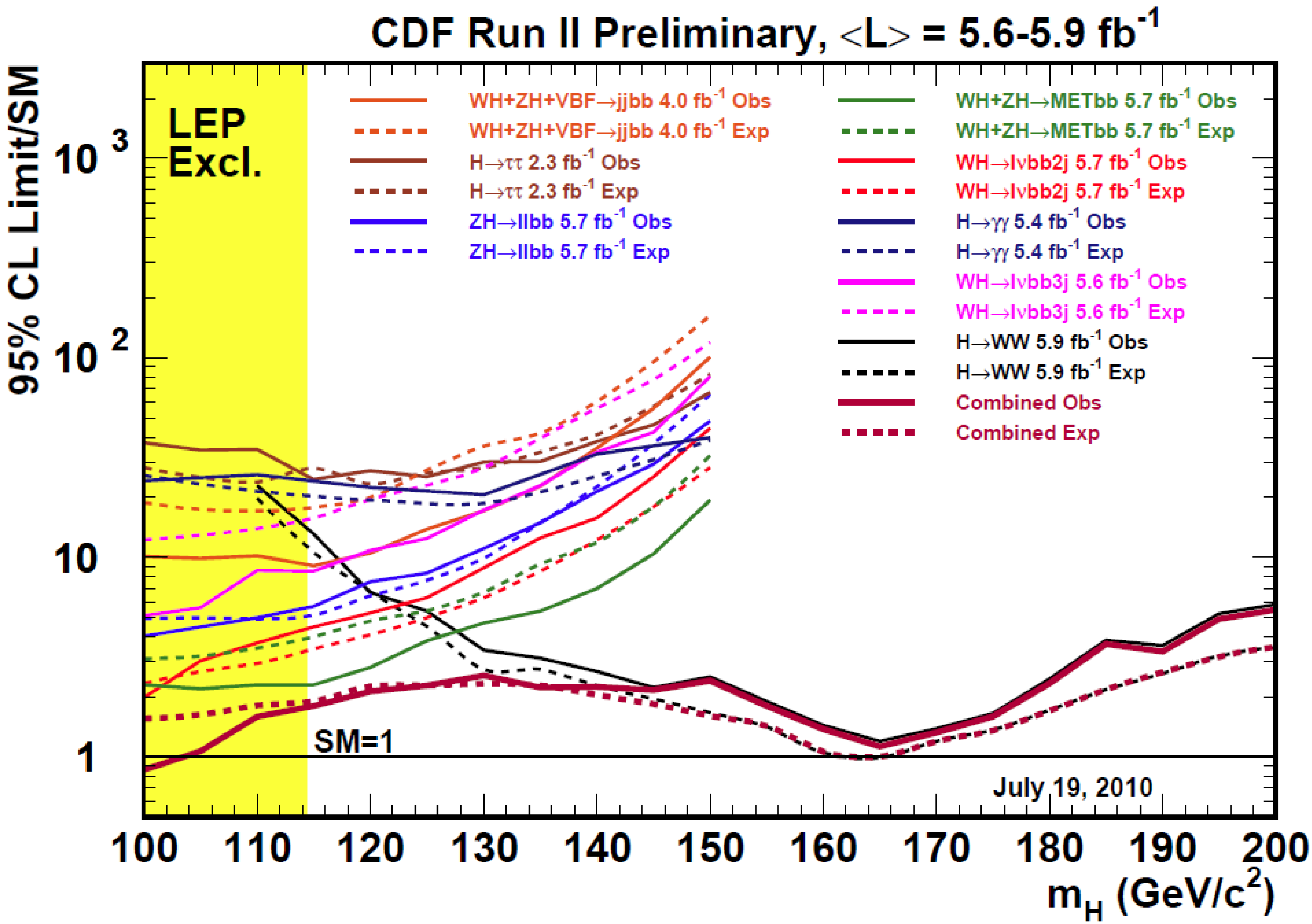




Observed upper limit :

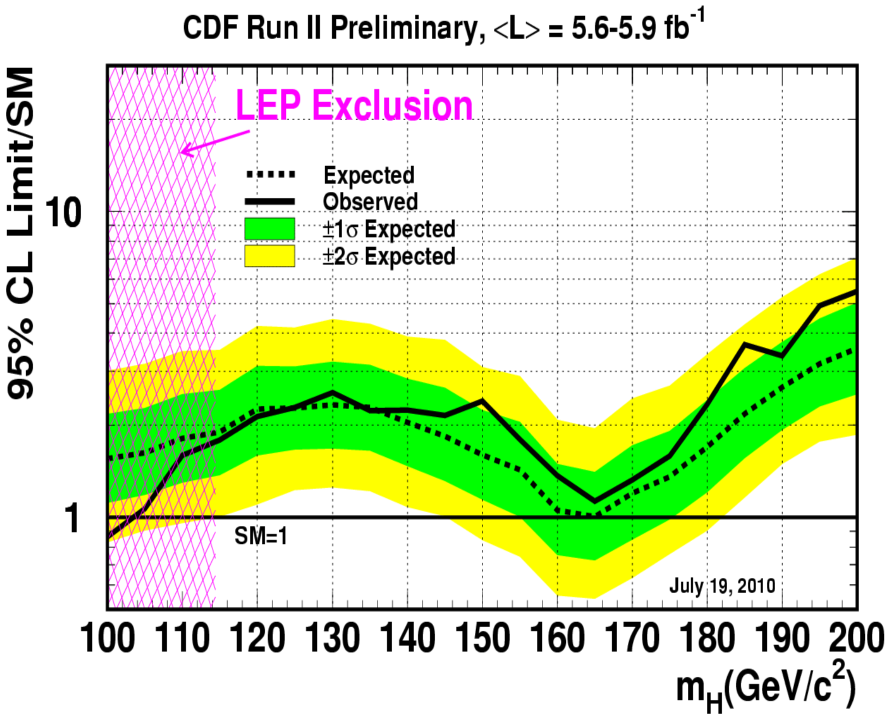
1.08 x σ(SM)(@165 GeV)

Summary of SM Higgs Searches at CDF

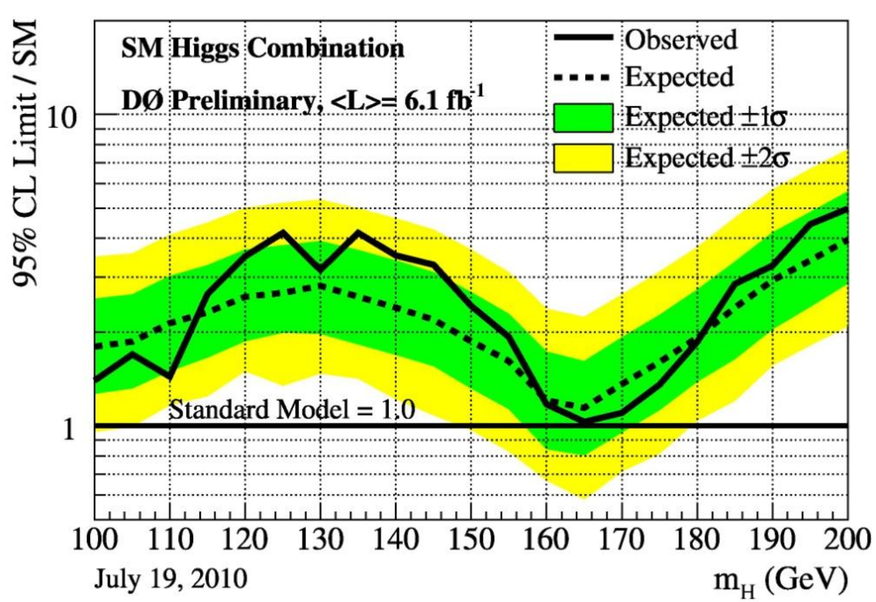


SM Higgs
CDF and D0 Combined Limits

CDF Combined:



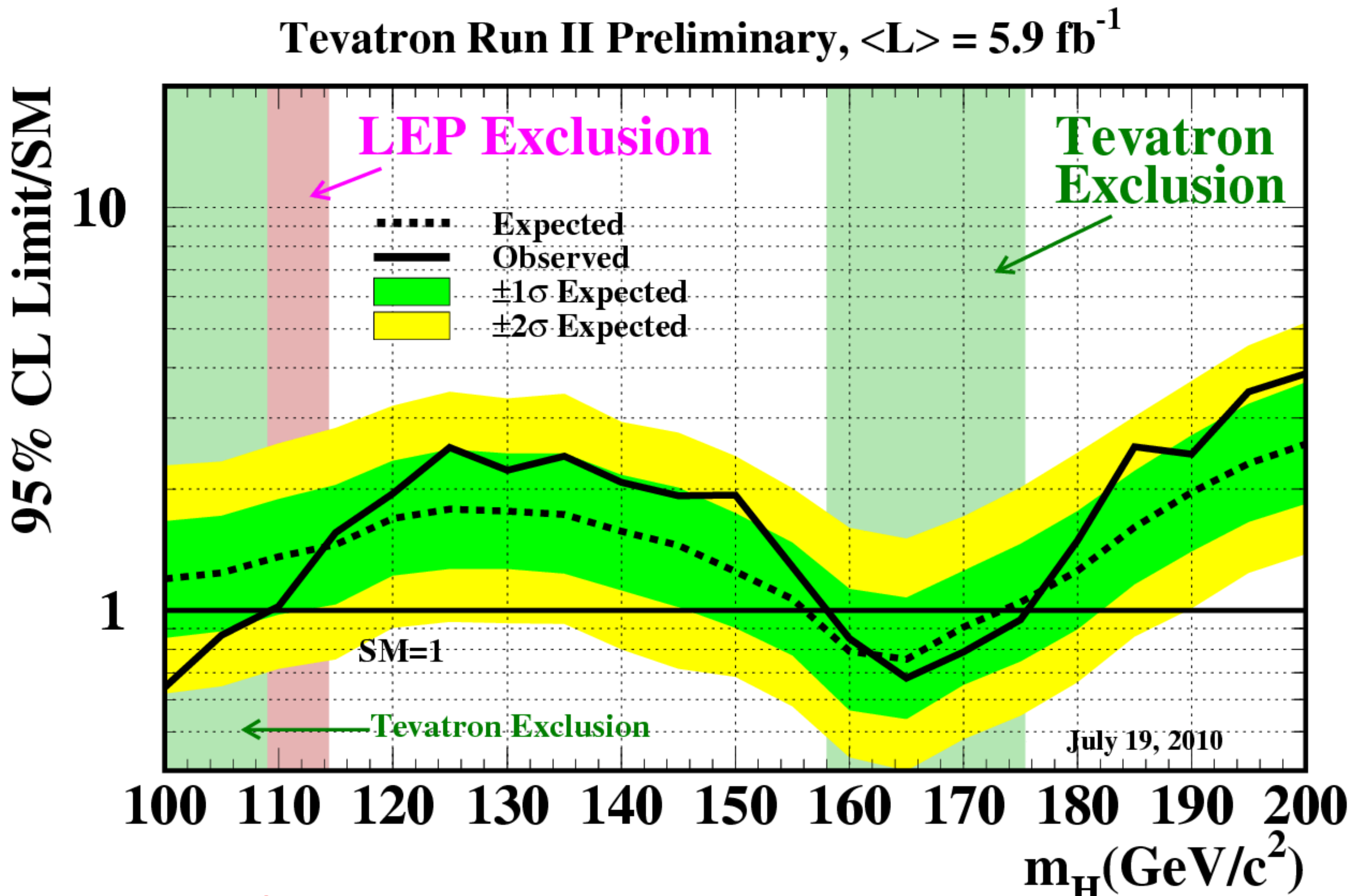
D0 Combined:



SM Higgs

Updating High mass combination for Winter 2011...

Tevatron Combined Limit

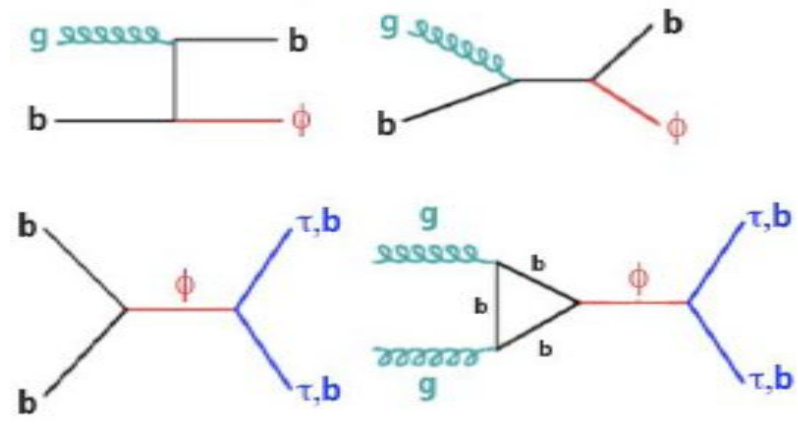


95% CL exclusion : $158 < m_H < 175$ GeV

$m_H < 110$ GeV (LEP2: $m_H < 114.4$ GeV)

Search for MSSM Higgs

- Extended Higgs sector in SUSY models
  - ϕ = (H^0, A^0, h^0) and $H^{\pm}$
- Higgs coupling enhancement at large $\tan\beta$:
  - Large increase ($\times \sim\tan^2\beta$) in production cross sections compared to SM: $gg \rightarrow \phi$, $gb \rightarrow b\phi$
- for M_A>100 GeV.
  - $Br(\phi \rightarrow \tau\tau) \sim 9\%$
  - $\phi \rightarrow bb \sim 90\%$

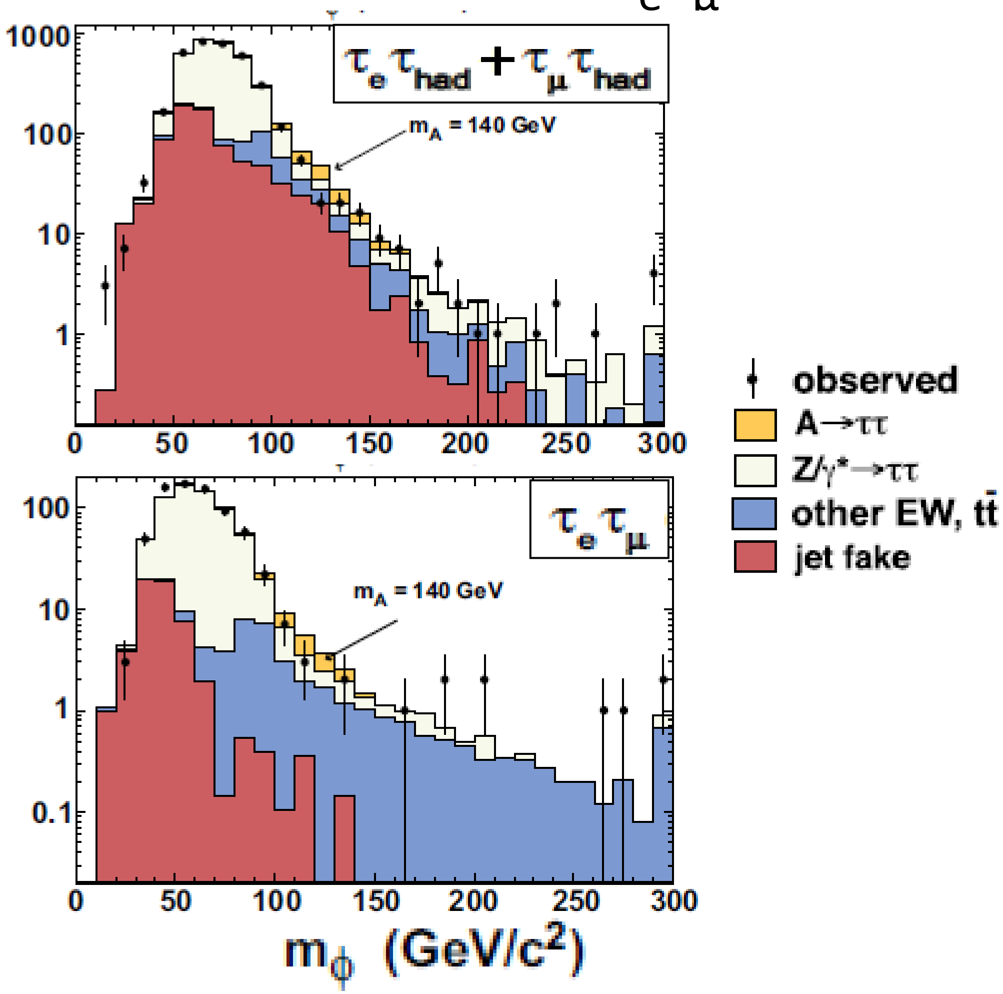


→ Useful search modes at Tevatron:
- $\phi \rightarrow \tau\tau$
- $\phi + b \rightarrow \tau\tau + b$
- $\phi + b \rightarrow bb + b$

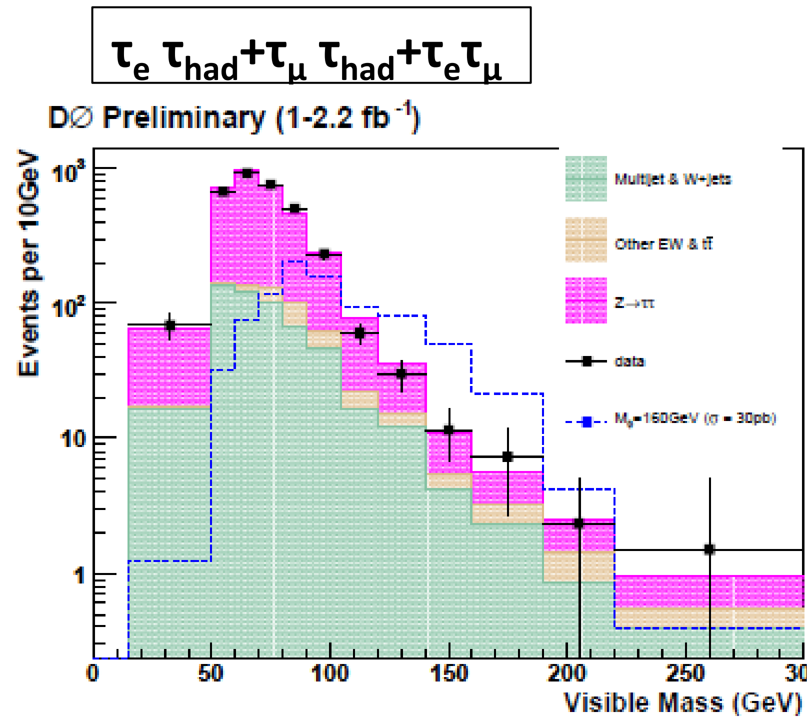
MSSM $\phi \rightarrow \tau\tau$

- Both experiments analyzed $\tau_e\, \tau_{had}$, $\tau_\mu\, \tau_{had}$, $\tau_e\tau_\mu$ channels (Opposite Sign)

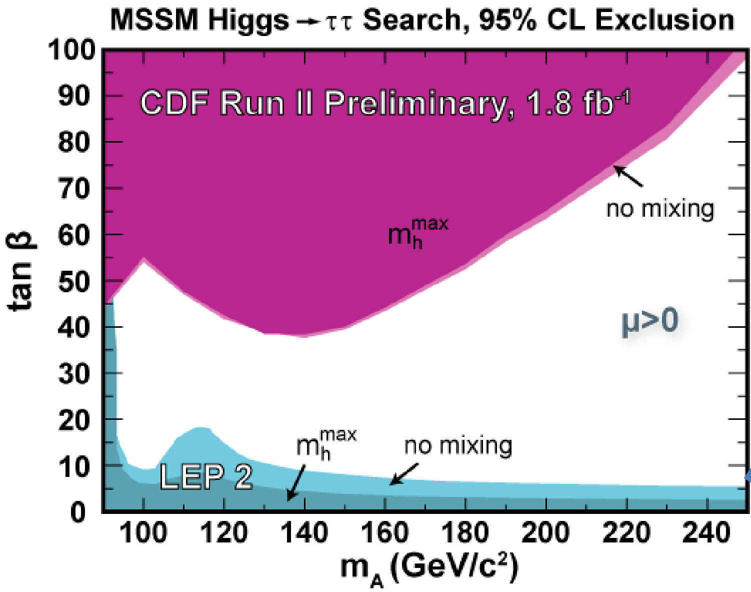
CDF 1.8 fb^{-1} (2007)

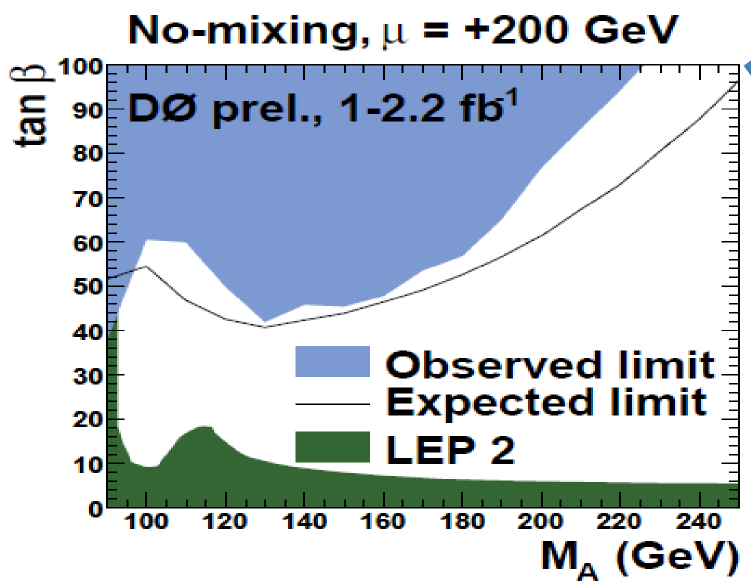


D0 2.2 fb^{-1} (2008)

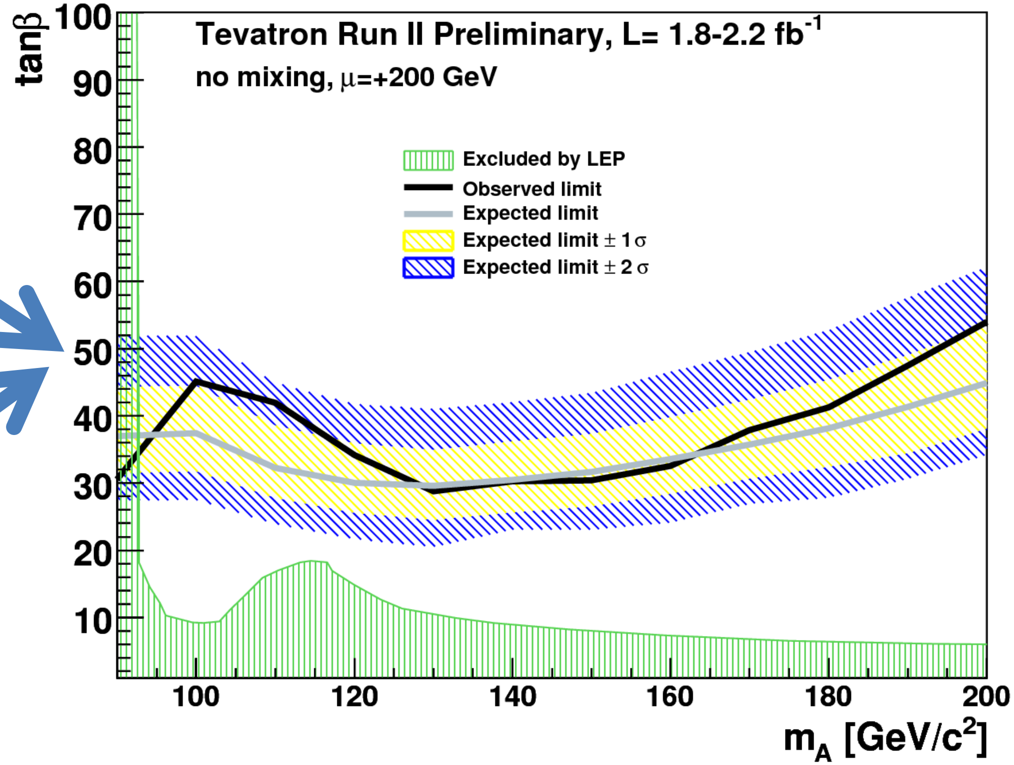


MSSM $\phi \rightarrow \tau\tau$ Tevatron Combination





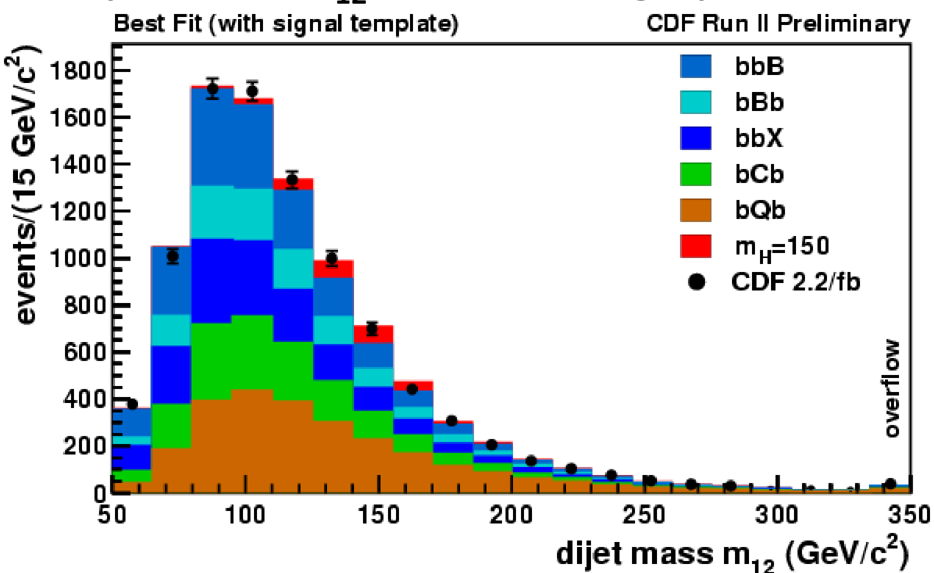
Combined, 2010



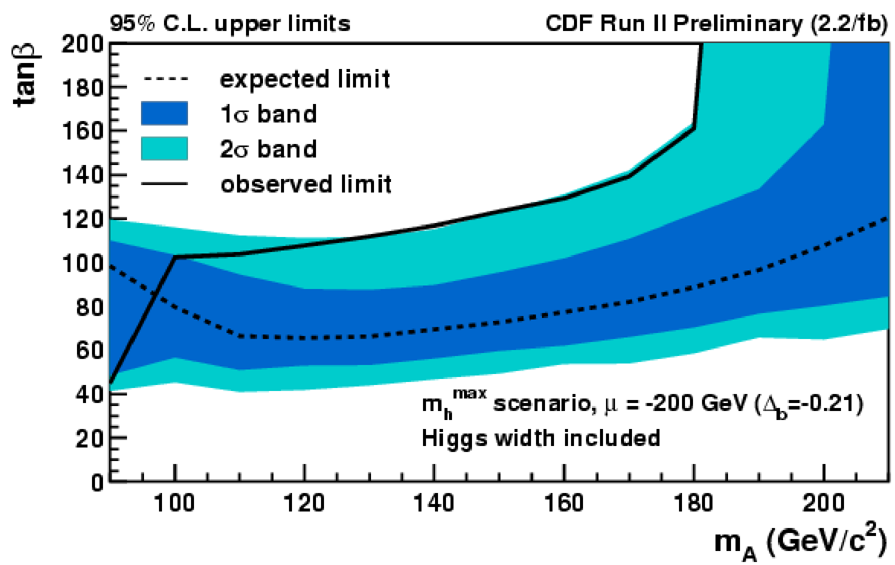
MSSM ϕb→bbb at CDF

- Analyze events with 3 b-tagged jets.
- Utilizes trigger-level b-tagging.
- Fully data-driven multi-jets backgrounds.
- Define a flavor separator based on M_{vtx} for improved background understanding.

Di-jet mass, m_{12} of the leading 2 jets:



2.2 fb^{-1}

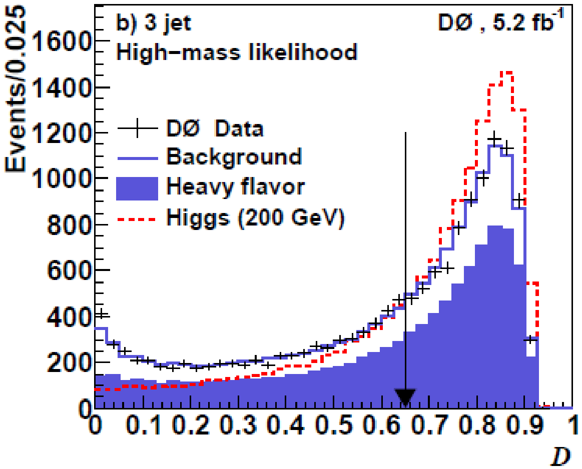


~ 2σ deviation from background at ~140 GeV

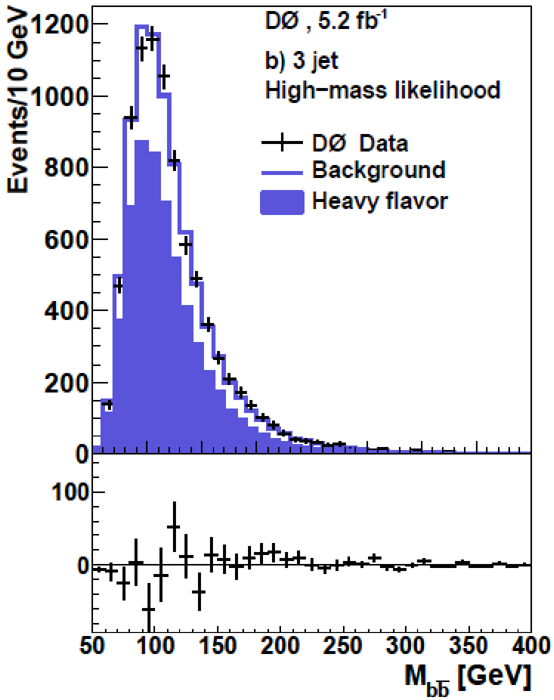
MSSM ϕb→bbb at D0

- Analyze events with 3 b-tagged jets.
- Subdivide candidates into 3- and 4-jets samples.
- S/B separation by Likelihood Discriminant.

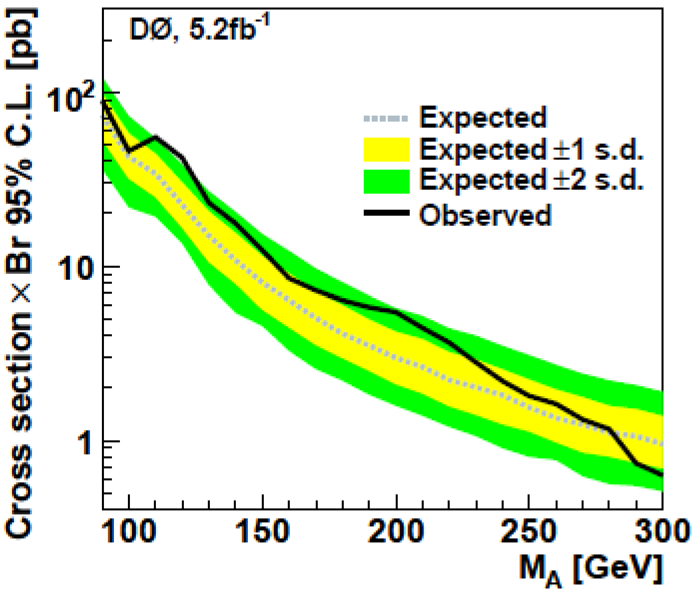
Likelihood Discriminant:



Di-jet mass:

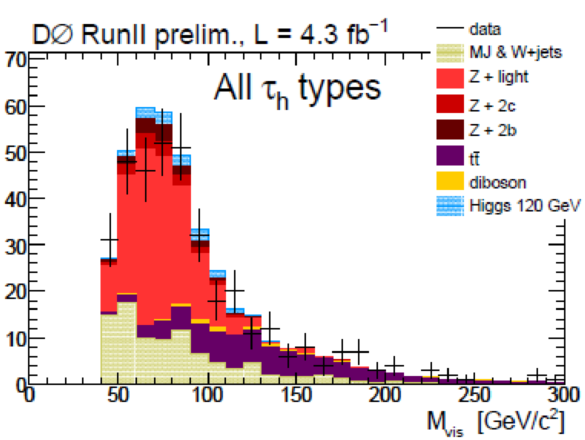


Upper Limit on Cross Section:

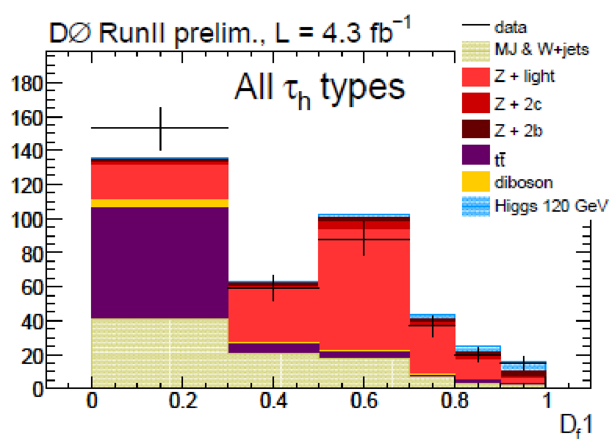


MSSM $\phi b \rightarrow \tau\tau b$ at D0

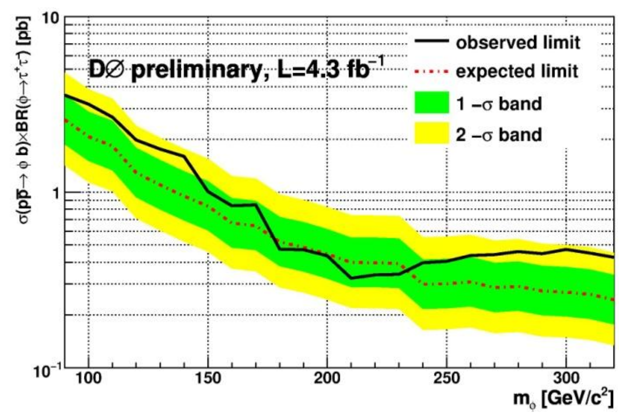
- A new search channel!!
- Search in $b\tau_{\mu}\tau_{had}$ channel.
  - Event selection: Isolated μ, τ_{had}, MET and a b-tagged jet.
- Improve S/B separation using NN-based discriminant.
- Dominant Bkg: Z+jets, ttbar, multi-jets.



Reconstructed Higgs Mass (GeV)



NN-based Discriminant

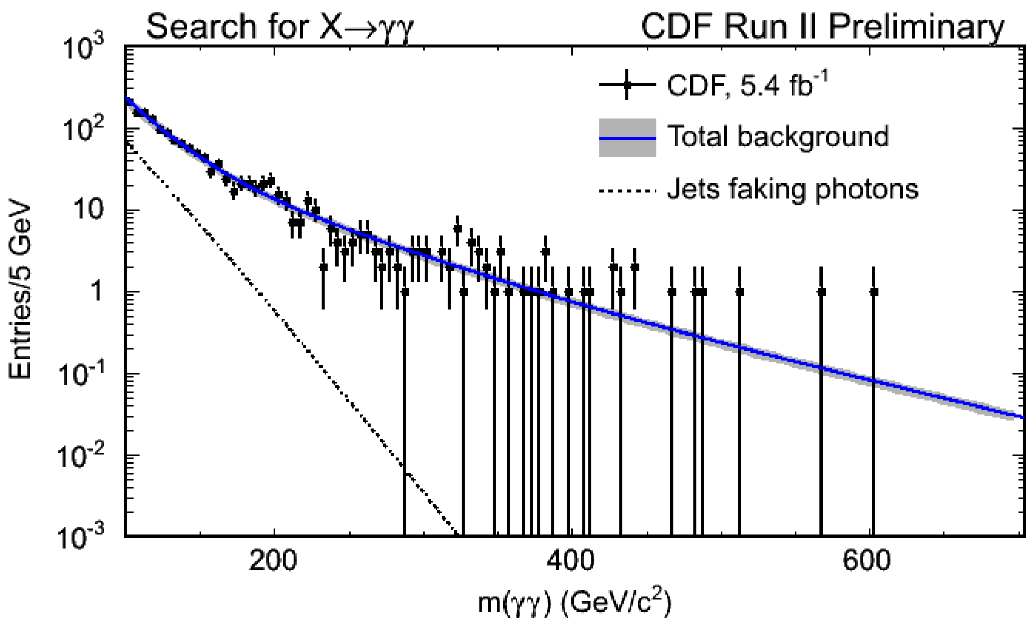


Upper Limit on Cross Section

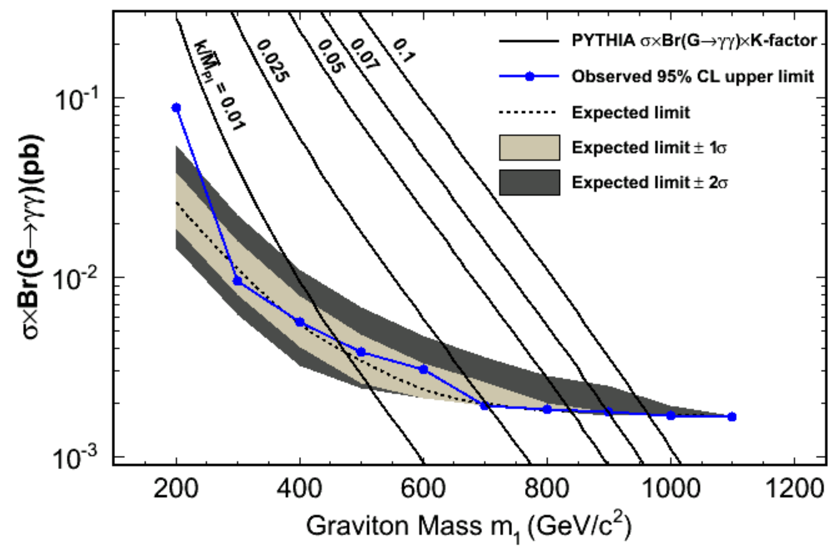
Exotic Physics Searches at CDF

Search for Diphoton Resonance (5.4 fb^{-1})

- Select events with 2γ's with Et>15 GeV.
- Main background: SM 2γ and jets faking photons.



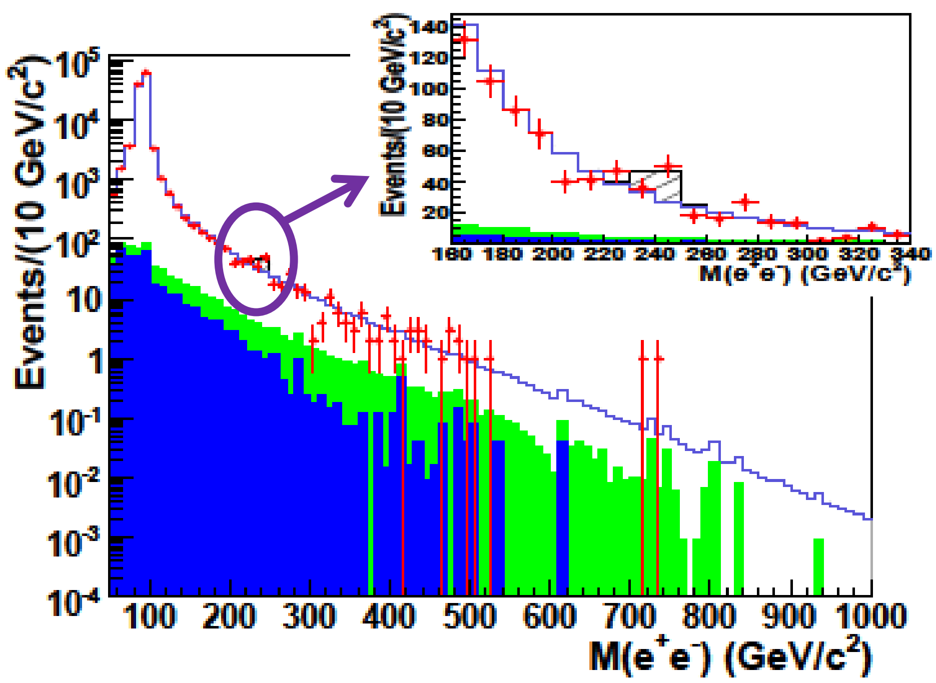
Limit on Randall-Sundrum Graviton Production Cross Section:



Result consistent with SM.

Excess around 200 GeV: 13% probability.

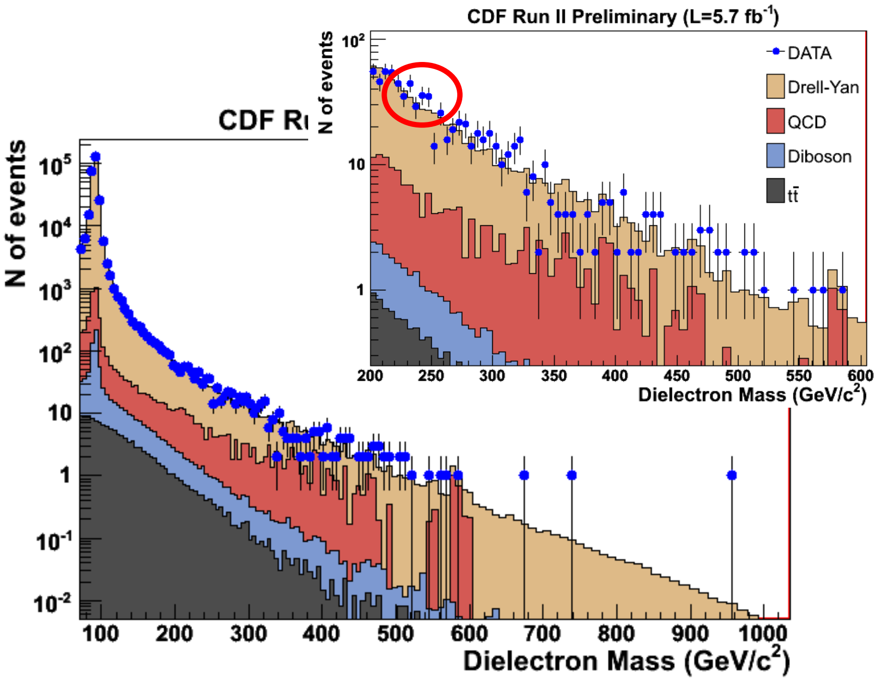
Dielectron Resonance Search in 2009 (2.3 fb^{-1})



- A 2.5σ excess around M_{ee}=240 GeV mass region!!

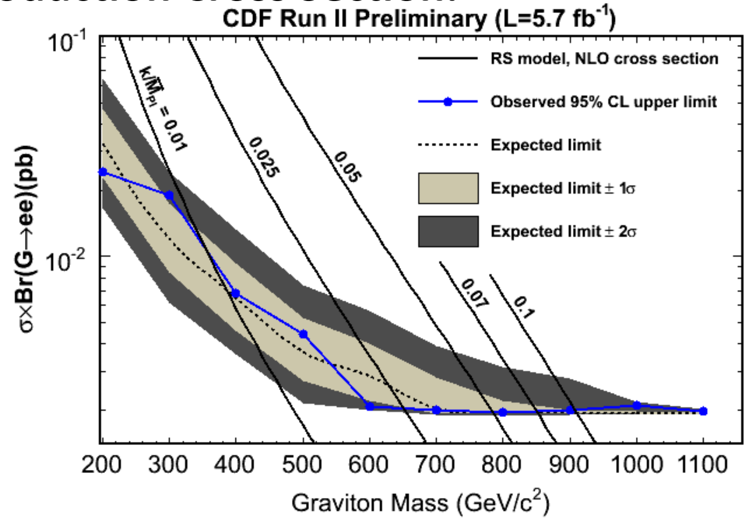
Dielectron Resonance Search in 2011 (5.7 fb^{-1})

- 1 electron with Et>20 GeV, $|\eta|<1.1$.
- Opposite sign second electron with Et>20 GeV, $|\eta|<2.8$.

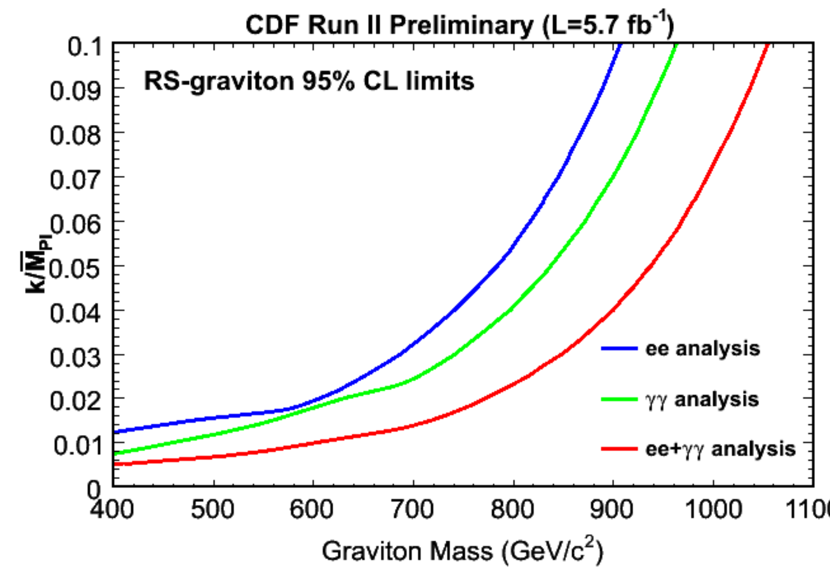


Previous excess ~240 GeV is reduced to a 1.7σ effect.

Limit on Randall-Sundrum Graviton Production Cross Section:



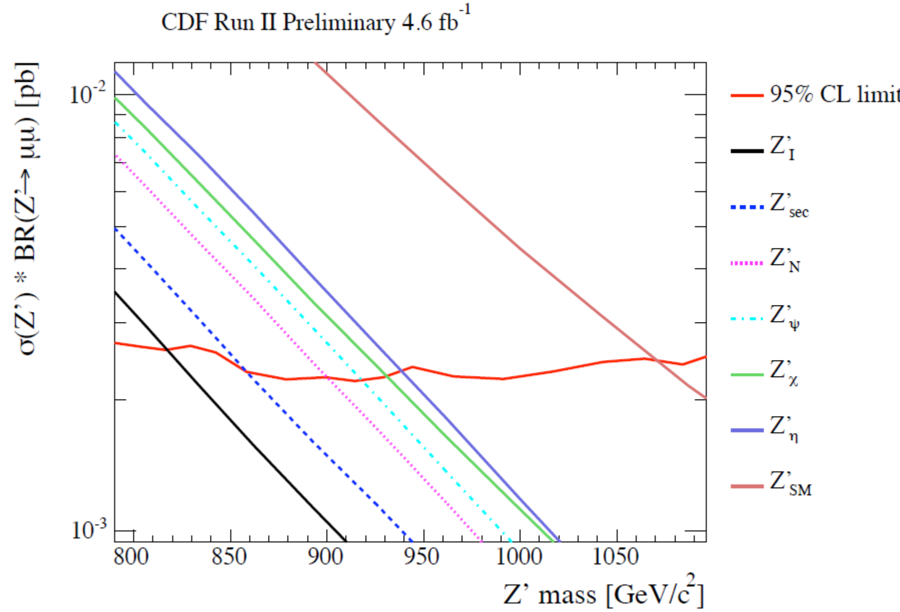
R-S Graviton Mass Limit (ee+$\gamma\gamma$ combined):



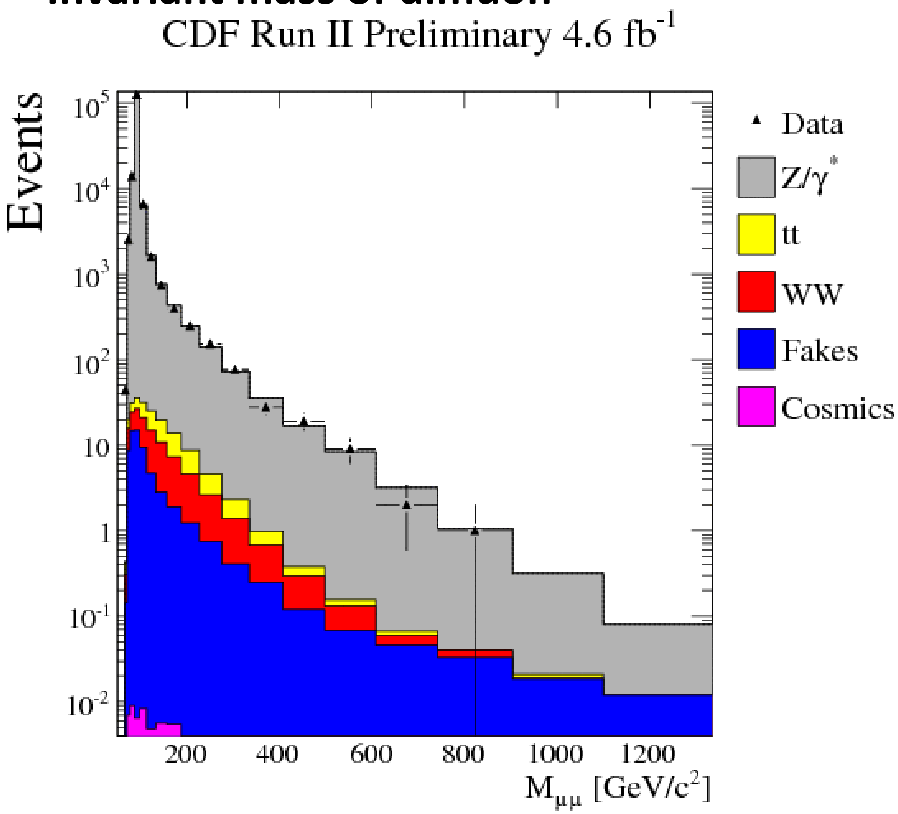
Dimuon Resonance Search (4.6 fb^{-1})

- Two opposite sign muons with Pt>30 GeV, |h|<1.1.

Limits on Z'



Invariant mass of dimuon

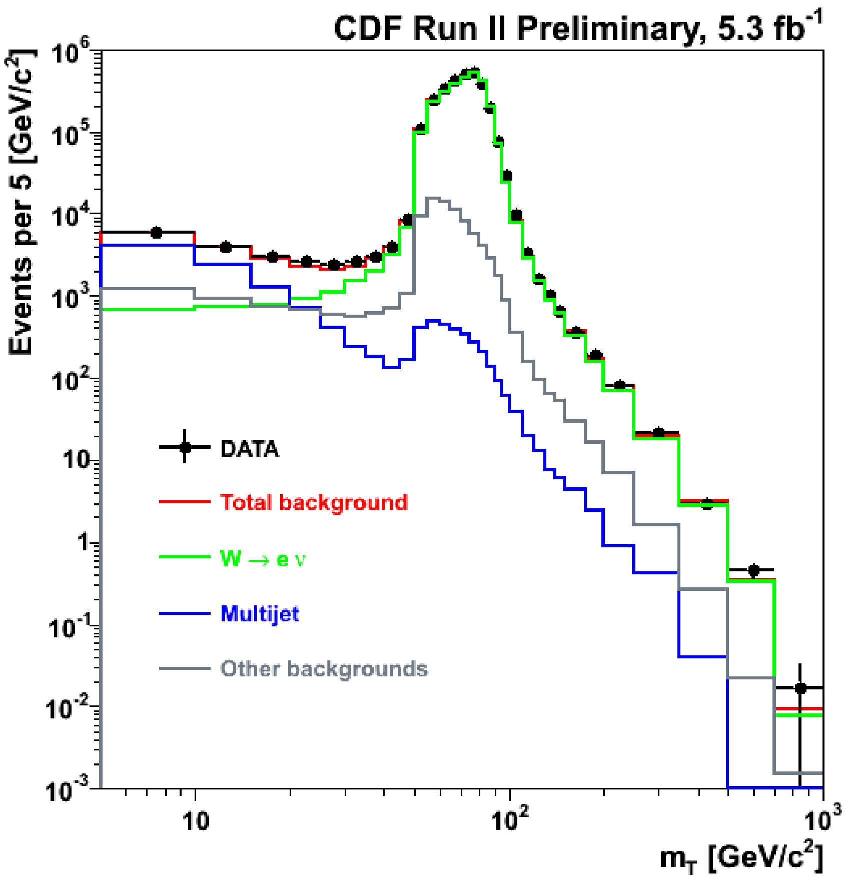


Model	Mass Limit (GeV/c^2)
Z'_I	817
Z'_{sec}	858
Z'_N	900
Z'_ψ	917
Z'_χ	930
Z'_η	938
Z'_{SM}	1071

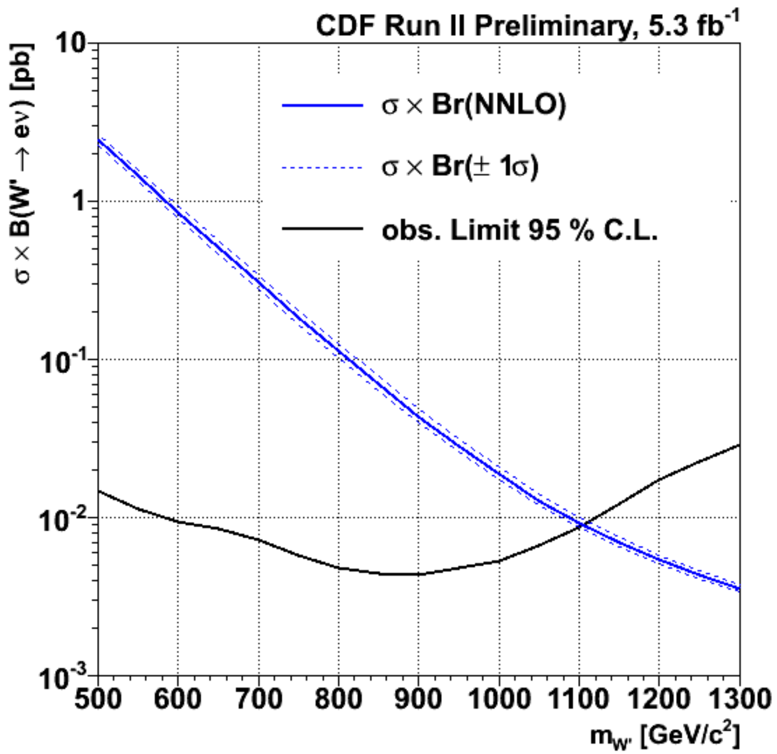
W' Search (5.3 fb^{-1})

- 1 electron with Et>25 GeV, $|\eta|<1.1$.
- MET>25 GeV.

Mt Distribution:



Observed Cross Section Limit:

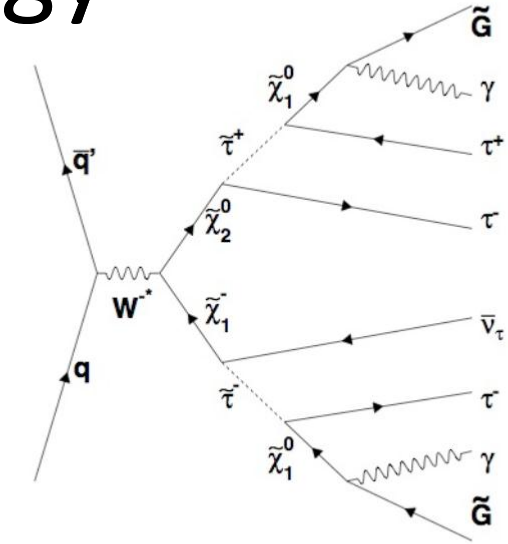


$M_{W'} > 1.1$ TeV (95% C.L.)

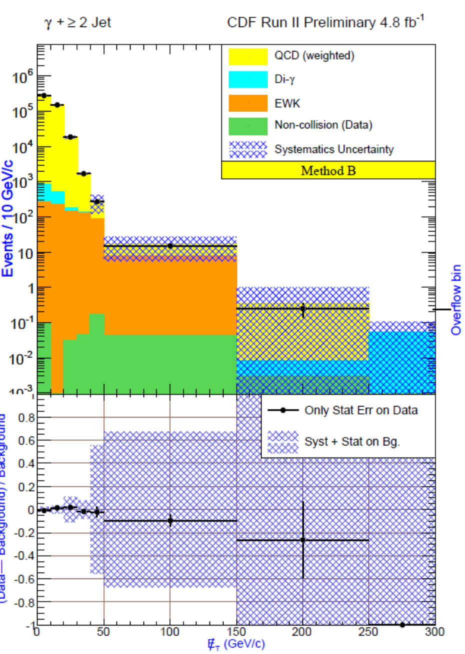
γ+jets+MET Topology

- Model independent search.
- 1 electron w/ Et>30 GeV, |η|<1.1.
- Jets w/ Et>15 GeV, |η|<3.0.
- MET>20 GeV.
- Scanned kinematic plots in 1 and 2 jet bins for abnormaly.

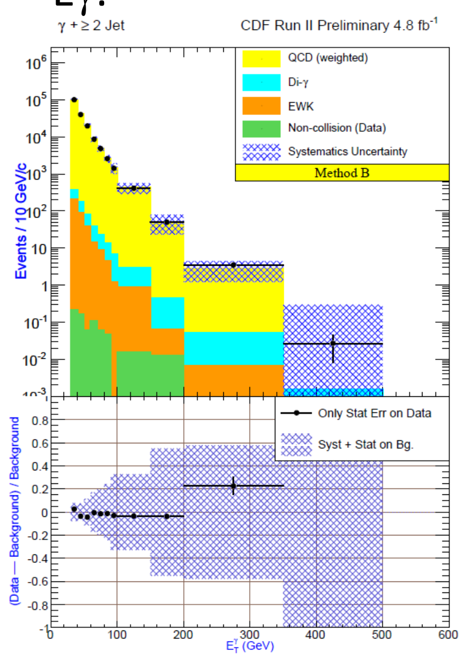
→ **Consistent with SM.**



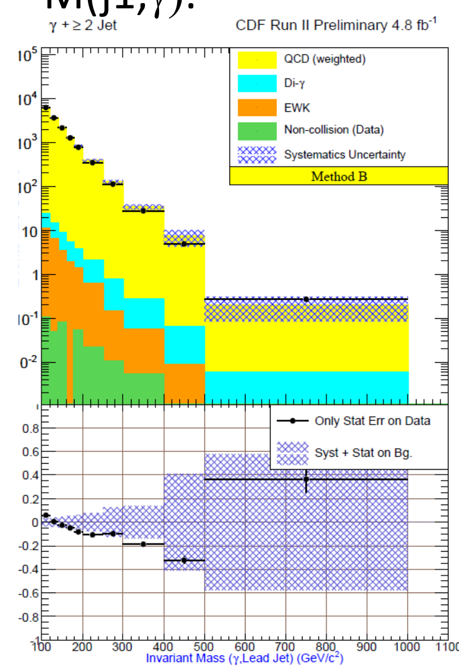
MET:



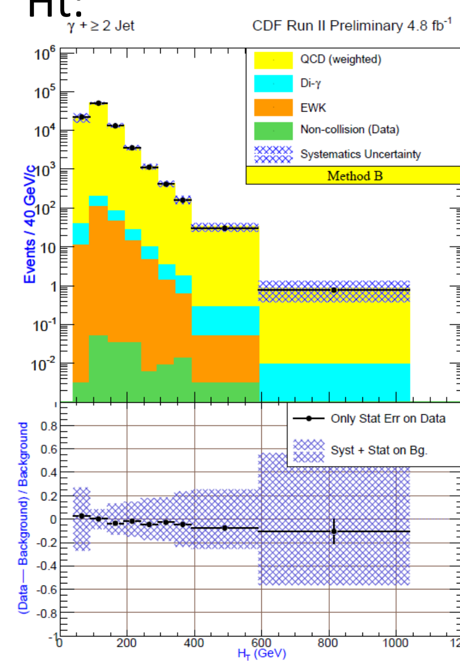
Eγ:



M(j1,γ):

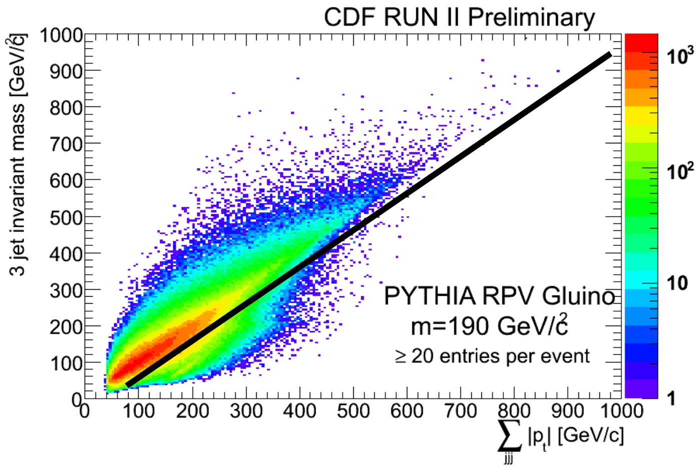


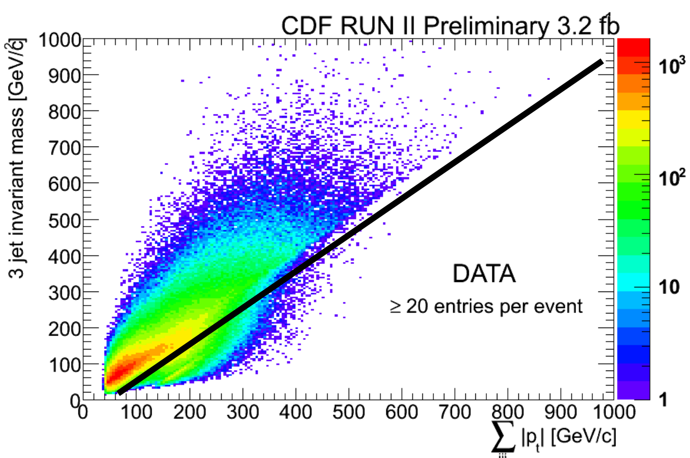
Ht:



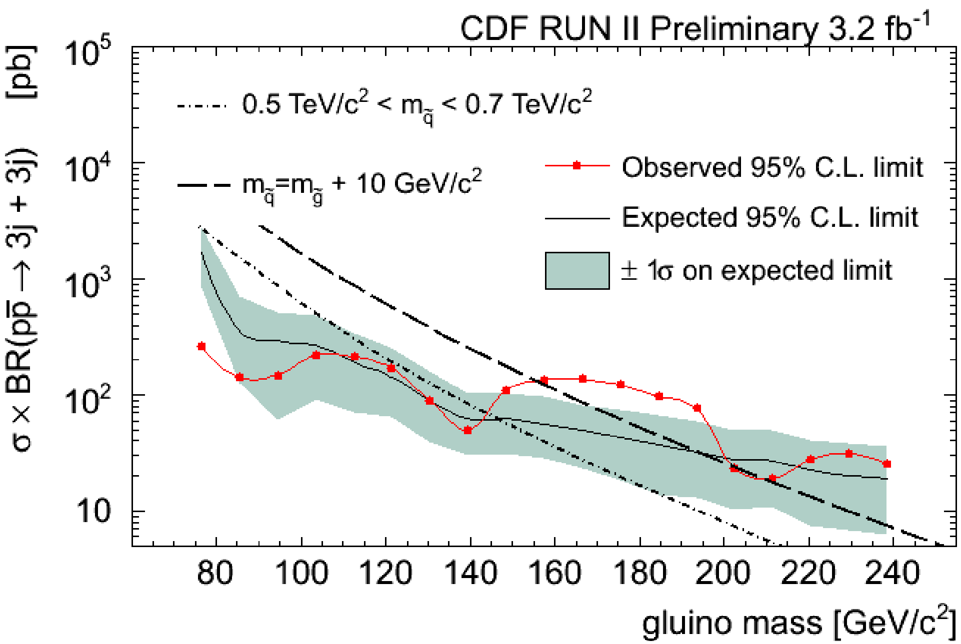
Multijets Resonance

- Model independent search for ppbar→QQ→3j+3j.
- 6 jets with Et>15 GeV, |η|<2.5.
- QCD background parameterized with 5 jet events.





- Separate 3-jet combinations that are potentially correlated using diagonal cut.
- Optimize cut for each point.
- Set limit for RPV gluino scenario:

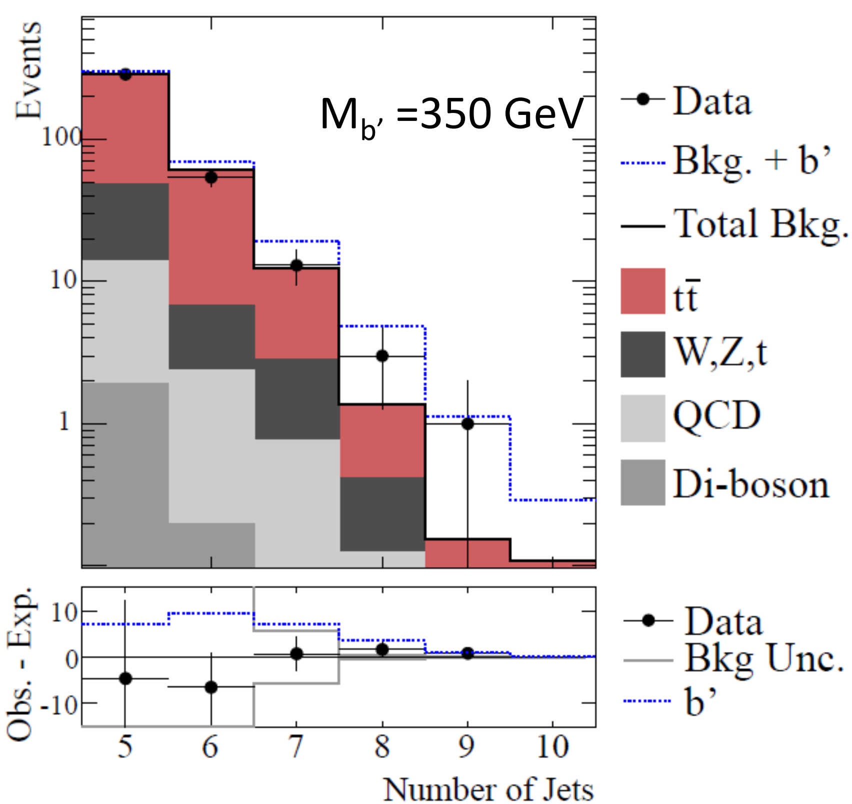


Mass below 144 GeV/c^2 excluded.

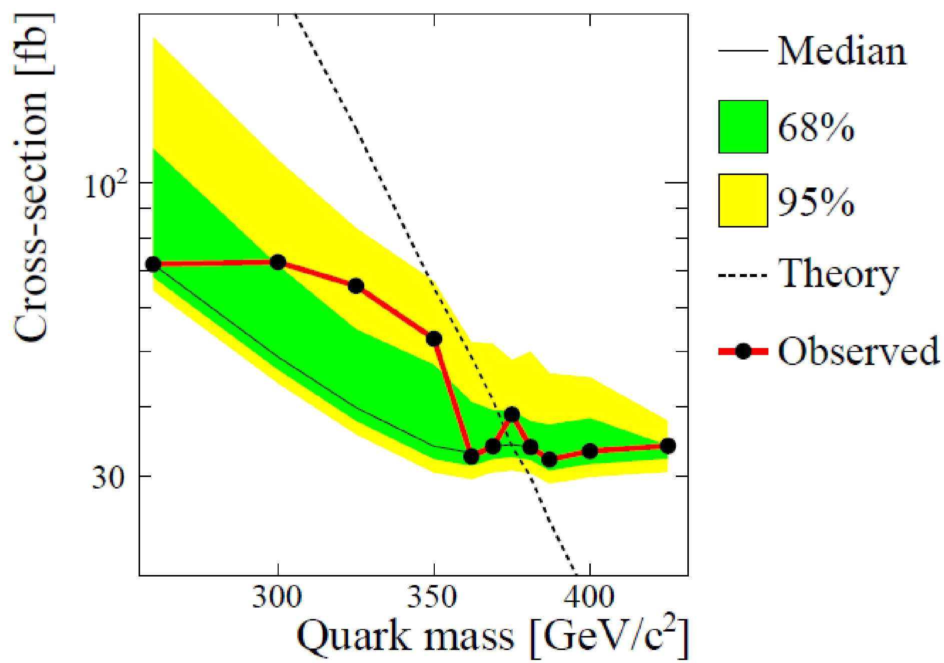
Search for b'

- Assume br(b'→tW)=100%.
- Search for : $b'\bar{b}' \rightarrow WtW\bar{t} \rightarrow WWbW\bar{W}\bar{b} \rightarrow \ell\nu qq'bqq'qq'b$
- 1 e/μ with Pt>20 GeV, |η|<1.1.
- MET>20 GeV.

Jet Multiplicity:



Cross section Limit:

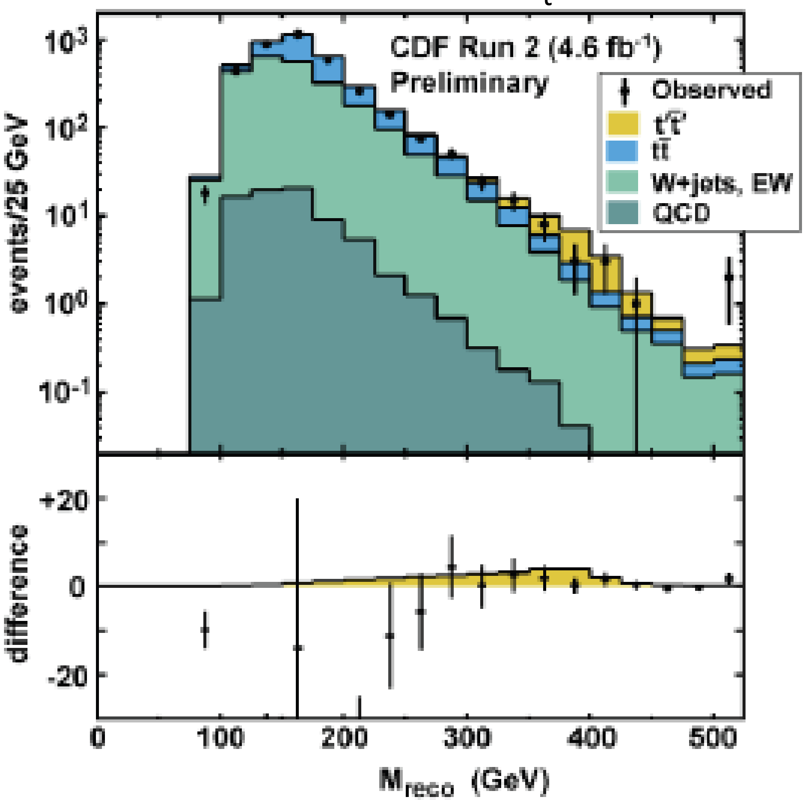


$M_{b'}$ > 372 GeV/c^2 (95% C.L.)

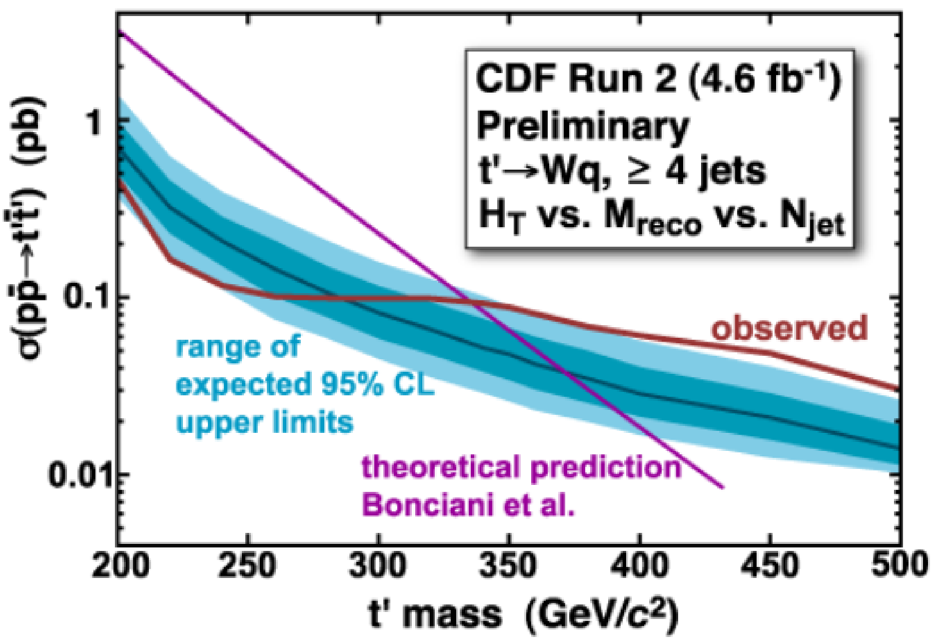
Search for t'

- t't'→WqWq→(lν)q(qq)q→l+4jets.
- 1 e/μ with Pt>25 GeV, |h|<1.1.
- MET>20 GeV.
- 4 jets with Et>20 GeV, |η|<2.0.

Reconstructed t' mass: $M_{t'}$ = 400 GeV



Limit on Cross Section:



$M_{t'}$ > 335 GeV (95% C.L.)

Summary

- Tevatron is running smoothly.
  - Integrated delivered luminosity: 10.4 fb^{-1}
  - Will be terminated at the end of FY2011.
- Top Physics
  - Mass measurement at 0.6% precision.
    - m_H < 158 GeV @ 95% CL.
  - Interesting deviation from SM in ttbar forward-backward asymmetry:
    - >2σ deviation from SM in L+jets and dilepton analyses at CDF.
    - >3σ deviation in high M_{ttbar} region.
- Higgs Search
  - SM Higgs Mass Region 158<M_h<175 GeV excluded (95% C.L.)
  - Main channels already have very elaborate analyses.
- Exotic Physics Searches
  - A wide variety of interesting search analyses.
  - So far, consistent with SM.
- B Physics
  - We have very interesting B physics results as well → Tomorrow morning.
- **CDF and D0 keep working hard to produce interesting physics results!!**

Backup

Fermilab *Today*

Tuesday, Jan. 11, 2011

Calendar

Have a safe day!

Tuesday, Jan. 11
3:30 p.m.
DIRECTOR'S COFFEE BREAK - 2nd Flr X-Over
THERE WILL BE NO ACCELERATOR PHYSICS AND TECHNOLOGY SEMINAR TODAY

Wednesday, Jan. 12
12:30 p.m.
Physics for Everyone - Ramsey Auditorium
Speaker: Patrick Fox, Fermilab
Title: The hunt for the Higgs
3:30 p.m.
DIRECTOR'S COFFEE BREAK - 2nd Flr X-Over
4 p.m.
Fermilab Colloquium - One West
Speaker: Tom Malzbender, Hewlett Packard
Title: Imaging the Antikythera Mechanism

Click here for NALCAL, a weekly calendar with links to additional information.

Upcoming conferences

Campaigns

Special Announcement

New year, new laboratory blogs on *Quantum Diaries*

Living in an era when the latest discoveries in physics regularly make headlines, it can be easy to miss the individual contributions from the scientists and institutions around the globe making these advances possible. Highlighting these contributions, along with the quirky world from physicists working behind the scenes, has been the focus of Quantum Diaries since it launched in 2005. Quantum Diaries is sure to continue in that role, and has relaunched with four physics laboratories in its ranks: Brookhaven, CERN, Fermilab and TRIUMF. Each of the laboratories will be posting regular updates to Quantum Diaries and have already gotten started.

http://www.quantumdiaries.org/

Feature

Physics for Everyone on Higgs hunt - 12:30 p.m. on Jan. 12

Director's Corner

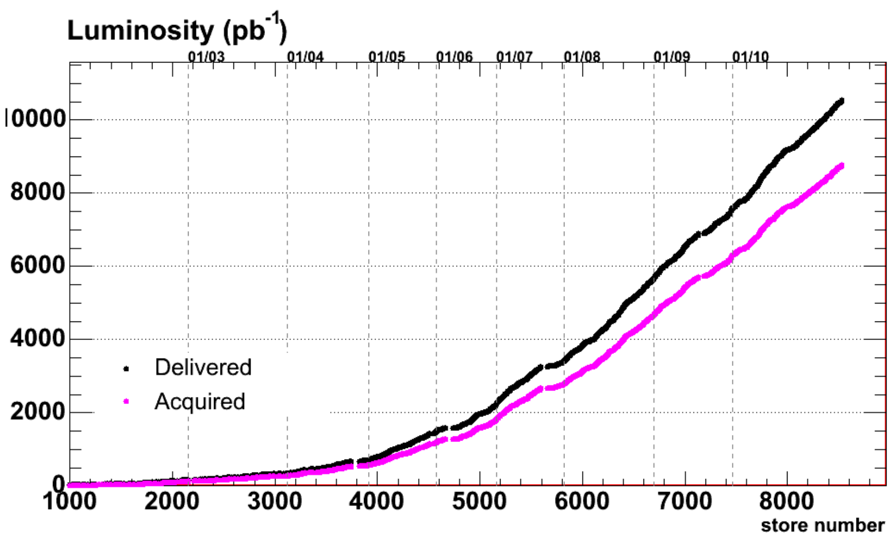
Tevatron

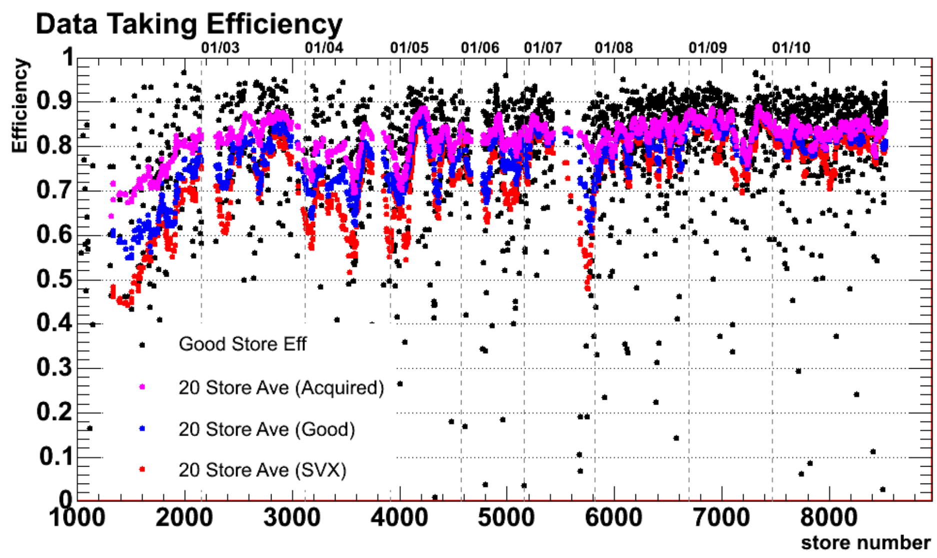

Pier Oddone

Today's Director's Corner includes more details on yesterday's Tevatron announcement.

Yesterday we received the news that we will not receive funding for the proposed Tevatron extension and consequently the Tevatron will close at the end of FY2011 as was previously planned. The present budgetary climate did not permit the DOE to secure the additional funds needed to run the Tevatron for three more years as recommended by the High Energy Physics Advisory Panel. Both Tevatron collaborations did a splendid job articulating the physics case and all the relevant issues to both our Physics Advisory Committee and the national advisory committees, which led to the recommendation to extend the Tevatron.

We plan to extract every bit of physics we can from this final Tevatron running period. The Tevatron has already exceeded all expectations, and given the large datasets we will continue to find new results and discoveries in the Tevatron data for years to come. The life of this legendary machine has been marked by historic discoveries made


Luminosity (pb-1)
01/03
01/04
01/05
01/06
01/07
01/08
01/09
01/10
10000
8000
6000
4000
2000
0
Delivered
Acquired
1000
2000
3000
4000
5000
6000
7000
8000
store number


Data Taking Efficiency
01/03
01/04
01/05
01/06
01/07
01/08
01/09
01/10
Efficiency
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Good Store Eff
20 Store Ave (Acquired)
20 Store Ave (Good)
20 Store Ave (SVX)
1000
2000
3000
4000
5000
6000
7000
8000
store number

W Mass Syst. Uncertainty

TABLE II. Systematic and total uncertainties in MeV/c^2 for the m_T fits, which are the most precise. The last column shows the correlated uncertainties.

Systematic	$W \to e\nu$	$W \to \mu\nu$	Common
$p_T(W)$ model	3	3	3
QED radiation	11	12	11
Parton distributions	11	11	11
Lepton energy scale	30	17	17
Lepton energy resolution	9	3	0
Recoil energy scale	9	9	9
Recoil energy resolution	7	7	7
$u_\parallel$ efficiency	3	1	0
Lepton removal	8	5	5
Backgrounds	8	9	0
Total systematic	39	27	26
Total uncertainty	62	60	26

TABLE II. Systematic uncertainties of the M_W measurement.

Source	ΔM_W (MeV) m_T	p_T^e	$\not{E}_T$
Electron energy calibration	34	34	34
Electron resolution model	2	2	3
Electron shower modeling	4	6	7
Electron energy loss model	4	4	4
Hadronic recoil model	6	12	20
Electron efficiencies	5	6	5
Backgrounds	2	5	4
Experimental subtotal	35	37	41
PDF	10	11	11
QED	7	7	9
Boson p_T	2	5	2
Production subtotal	12	14	14
Total	37	40	43

MTM3 Top Mass Measurement

$$L(\vec{y} \mid m_t, \Delta_{\rm JES}) = \frac{1}{N(m_t)} \frac{1}{A(m_t, \Delta_{\rm JES})} \sum_{i=1}^{24} w_i L_i(\vec{y} \mid m_t, \Delta_{\rm JES})$$

with

$$L_i(\vec{y} \mid m_t, \Delta_{\rm JES}) = \int \frac{f(z_1) f(z_2)}{FF} \, {\rm TF}(\vec{y} \mid \vec{x}, \Delta_{\rm JES}) \, |M(m_t, \vec{x})|^2 \, d\Phi(\vec{x})$$

$\log L_{sig}(m_t, JES) = \Sigma_i[\log L_i(m_t, JES) - f_{bg}(q_i) \log L_{avg}(m_t, JES \mid background)]$

CDF Run II Preliminary, 5.6 fb^{-1}

Systematic source	Systematic uncertainty (GeV/c^2)
Calibration	0.10
MC generator	0.37
ISR and FSR	0.15
Residual JES	0.49
b-JES	0.26
Lepton P_T	0.14
Multiple hadron interactions	0.10
PDFs	0.14
Background modeling	0.34
Gluon fraction	0.03
Color reconnection	0.37
Total	0.88

SM combined channels

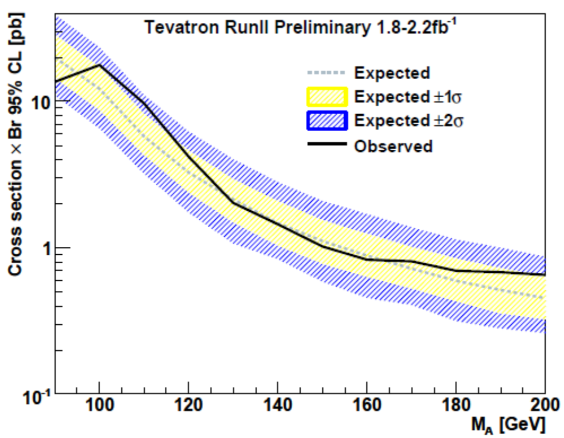
TABLE II: Luminosity, explored mass range and references for the different processes and final states ($\ell = e, \mu$) for the CDF analyses. The labels "2×" and "4×" refer to separation into different lepton categories.

Channel	Luminosity (fb^{-1})	m_H range (GeV/c^2)	Reference
$WH \to \ell\nu b\bar{b}$ 2-jet channels 4×(TDT,LDT,ST,LDTX)	5.7	100-150	[5]
$WH \to \ell\nu b\bar{b}$ 3-jet channels 2×(TDT,LDT,ST)	5.6	100-150	[6]
$ZH \to \nu\bar{\nu}b\bar{b}$ (TDT,LDT,ST)	5.7	100-150	[7]
$ZH \to \ell^+\ell^- b\bar{b}$ 4×(TDT,LDT,ST)	5.7	100-150	[8, 9]
$H \to W^+W^-$ 2×(0,1 jets)+(2+ jets)+(low-$m_{\ell\ell}$)+(e-τ_{had})+(μ-τ_{had})	5.9	110-200	[10]
$WH \to WW^+W^-$ (same-sign leptons 1+ jets)+(tri-leptons)	5.9	110-200	[10]
$ZH \to ZW^+W^-$ (tri-leptons 1 jet)+(tri-leptons 2+ jets)	5.9	110-200	[10]
$H + X \to \tau^+\tau^-$ (1 jet)+(2 jets)	2.3	100-150	[11]
$WH + ZH \to jjb\bar{b}$ 2×(TDT,LDT)	4.0	100-150	[12]
$H \to \gamma\gamma$	5.4	100-150	[13]

TABLE III: Luminosity, explored mass range and references for the different processes and final states ($\ell = e, \mu$) for the D0 analyses. Most analyses are in addition analyzed separately for RunIIa and IIb. In some cases, not every sub-channel uses the same dataset, and a range of integrated luminosities is given.

Channel	Luminosity (fb^{-1})	m_H range (GeV/c^2)	Reference
$WH \to \ell\nu b\bar{b}$ (ST,DT,2,3 jet)	5.3	100-150	[14]
$VH \to \tau^+\tau^- b\bar{b}/q\bar{q}\tau^+\tau^-$	4.9	105-145	[15, 16]
$ZH \to \nu\bar{\nu}b\bar{b}$ (ST,TLDT)	5.2-6.4	100-150	[17, 18]
$ZH \to \ell^+\ell^- b\bar{b}$ (ST,DT,ee,$\mu\mu$,ee_{ICR},$\mu\mu_{trk}$)	4.2-6.2	100-150	[19]
$VH \to \ell^\pm\ell^\pm + X$	5.3	115-200	[20]
$H \to W^+W^- \to e^\pm\nu e^\mp\nu, \mu^\pm\nu\mu^\mp\nu$	5.4	115-200	[21]
$H \to W^+W^- \to e^\pm\nu\mu^\mp\nu$ (0,1,2+ jet)	6.7	115-200	[22]
$H \to W^+W^- \to \ell\bar{\nu}jj$	5.4	130-200	[23]
$H \to \gamma\gamma$	4.2	100-150	[24]
$t\bar{t}H \to t\bar{t}b\bar{b}$ (ST,DT,TT,4,5+ jets)	2.1	105-155	[25]

MSSM $\phi \rightarrow \tau\tau$ Tevatron Combination



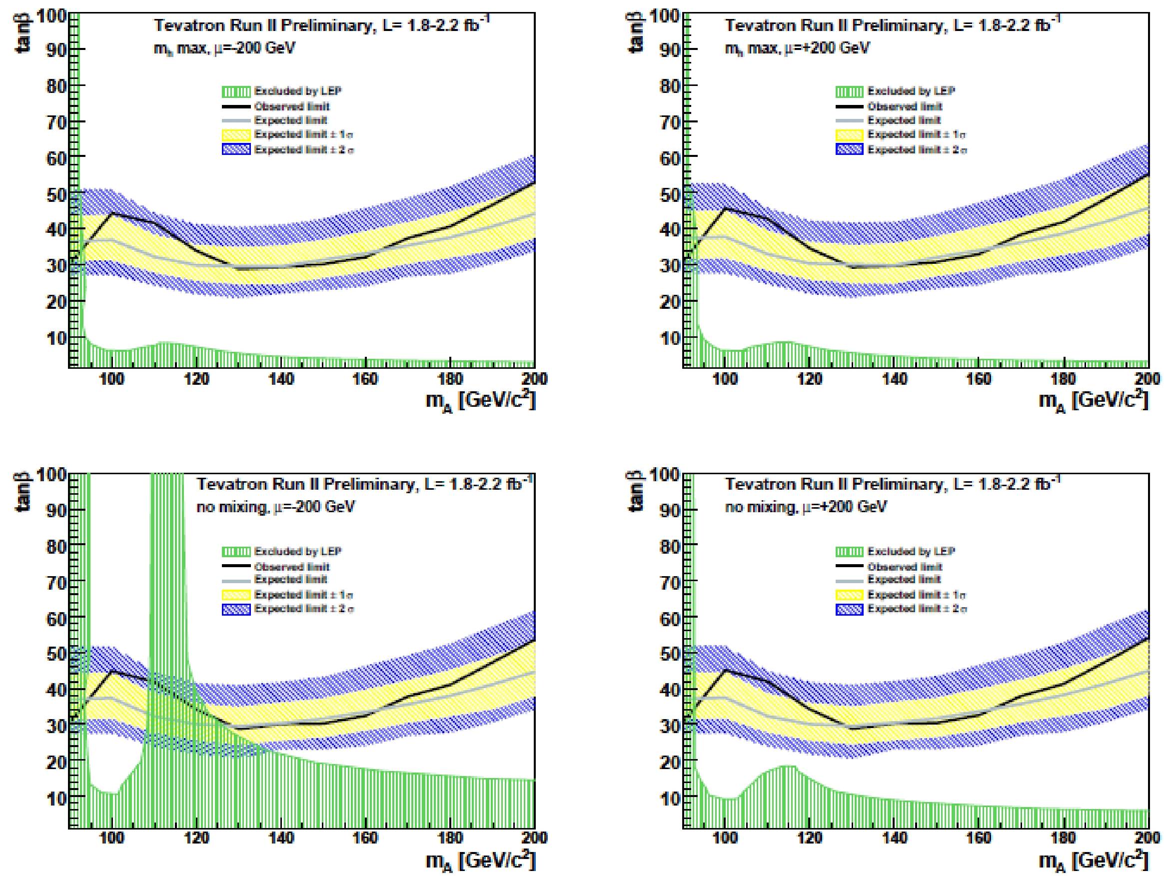
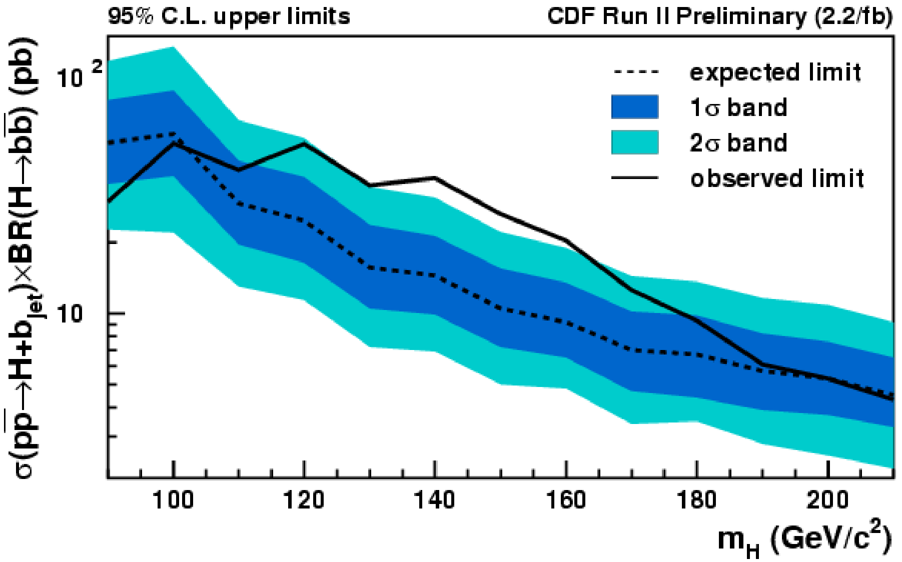
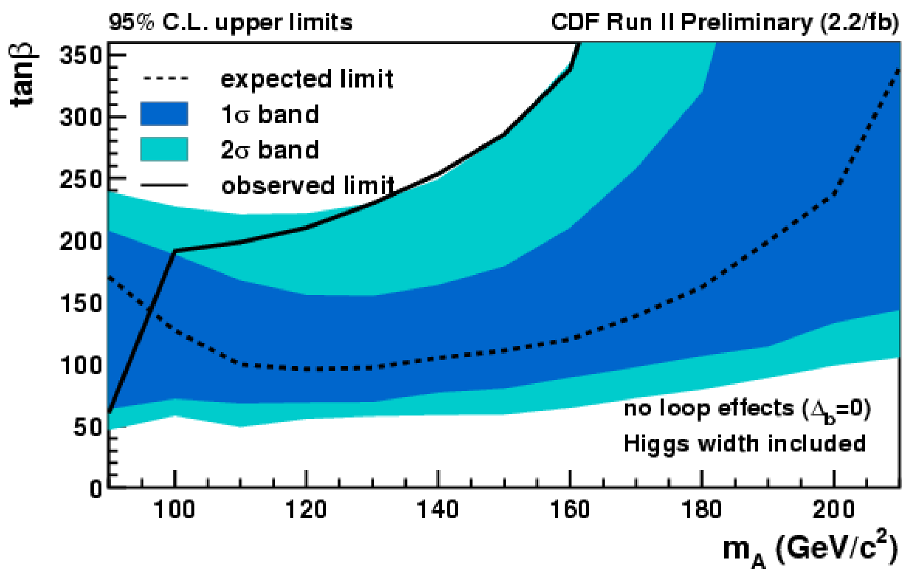
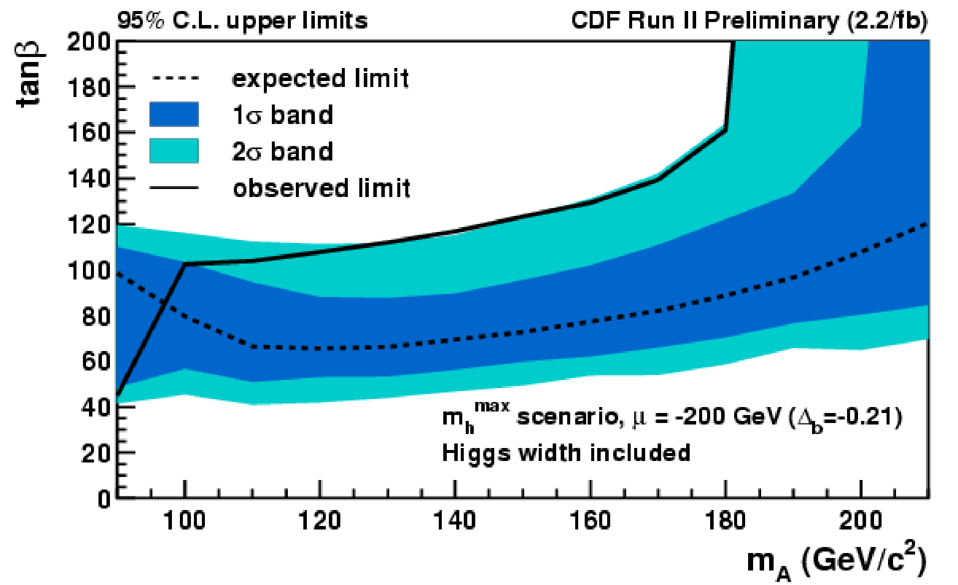


FIG. 4: 95% Confidence limits in the tanβ-M$_A$ plane for the 4 benchmark scenarios: maximal mixing (top) and no mixing (bottom) for $\mu < 0$ (left) and $\mu > 0$ (right). The black line denotes the observed limit, the grey line the expected limit and the hatched yellow and blue regions denote the ± 1 and 2 σ bands around the expectation. The shaded light-green area shows the limits from LEP.

MSSM $\phi b \rightarrow bbb$ at CDF





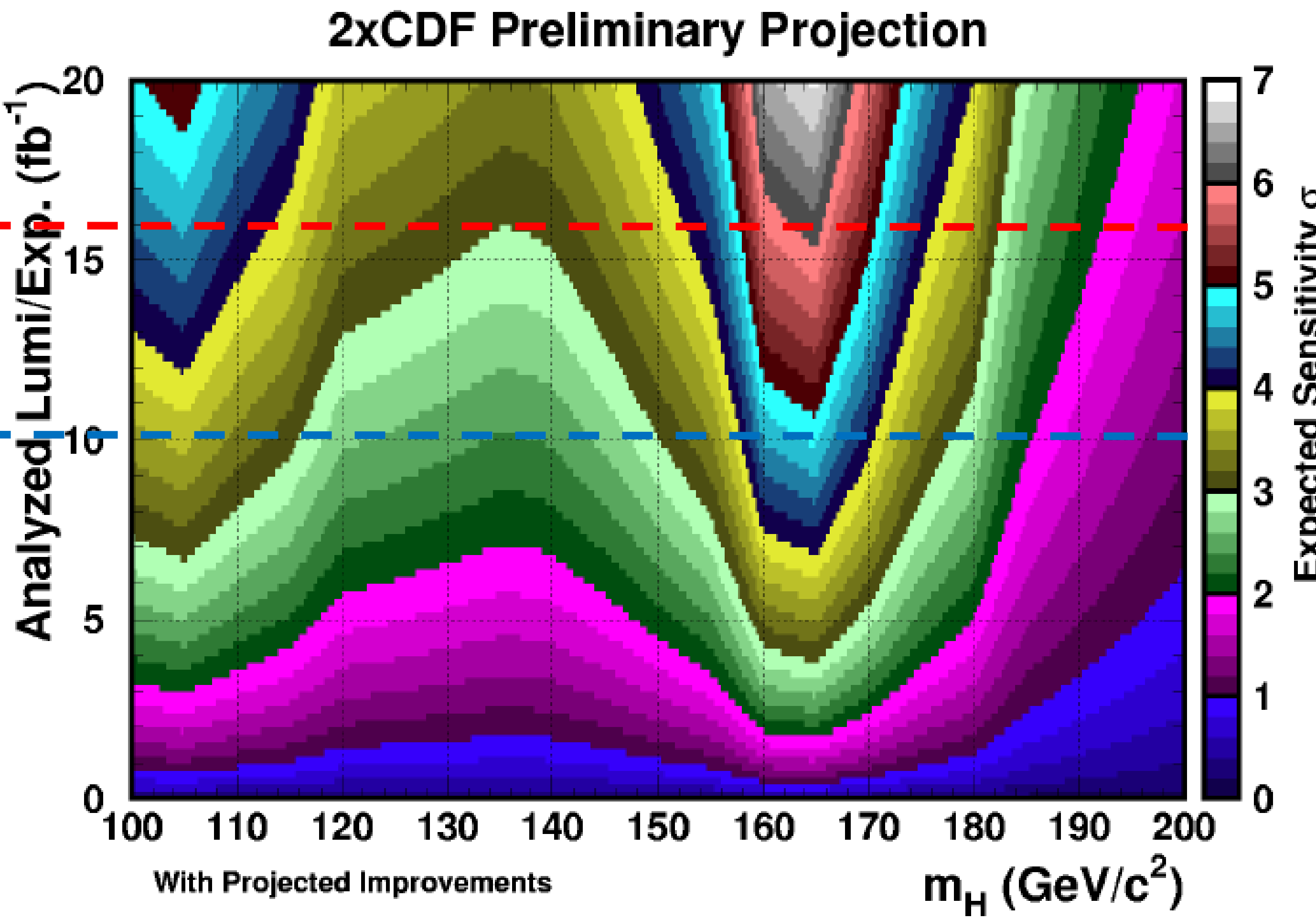


Tevatronの今後

発見に必要なルミノシティの予想値:

2014年末
$100<M_H<180$ GeV
の質量領域で
">3σ Evidence"

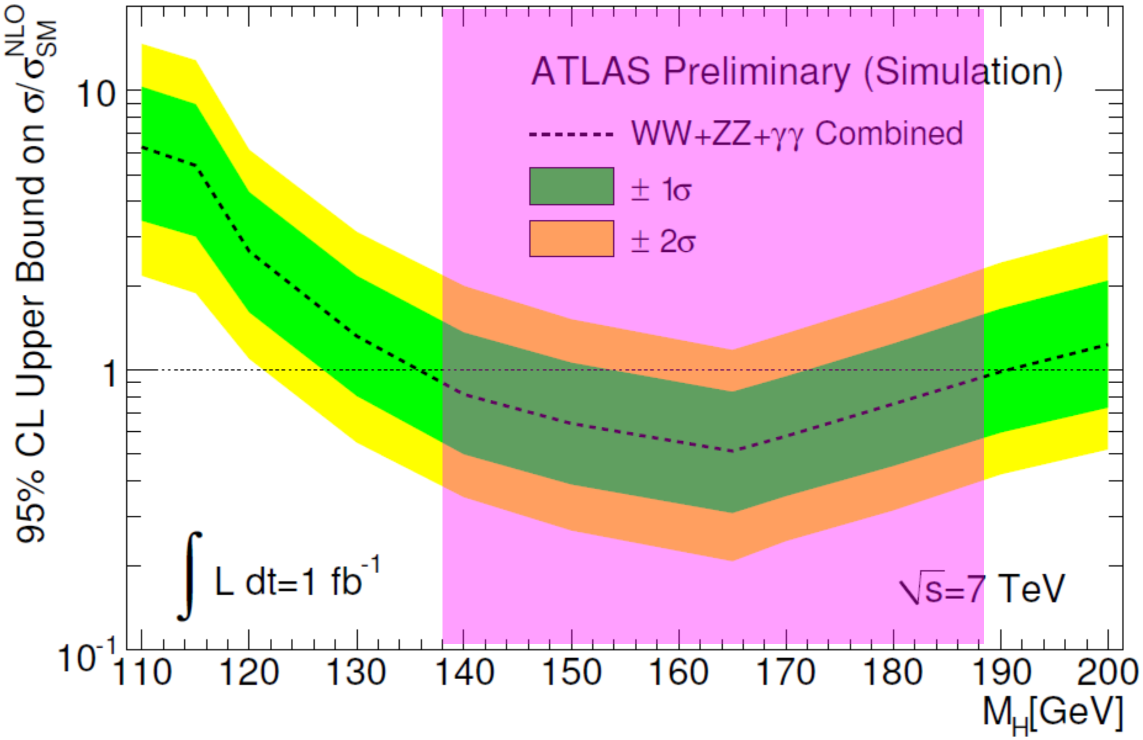
2011年末
$M_H<200$ GeVの全
質量領域で2.4σ



Tevatronは2014年までの実験延長を模索している(LHCとの兼ね合い)。

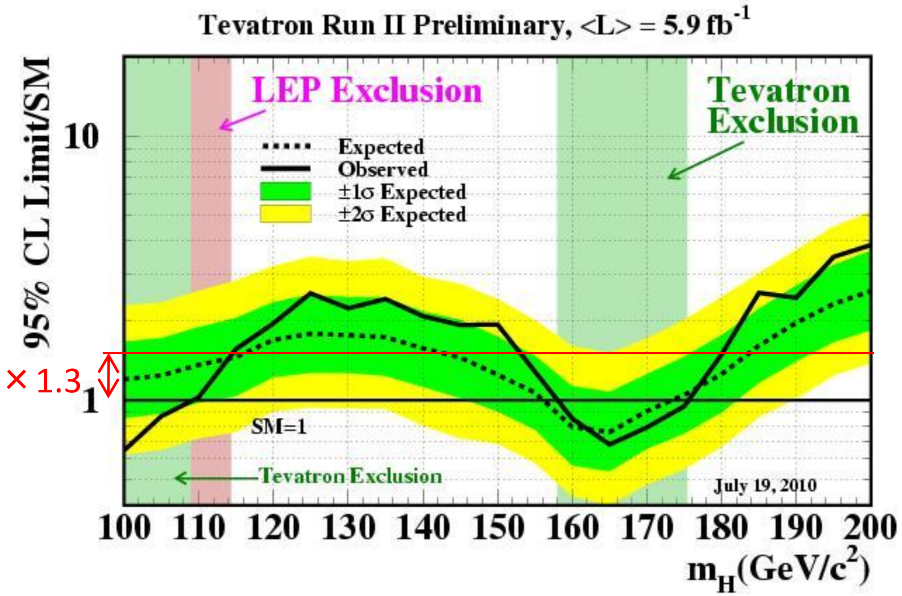
7 TeVでのATLASの棄却能力

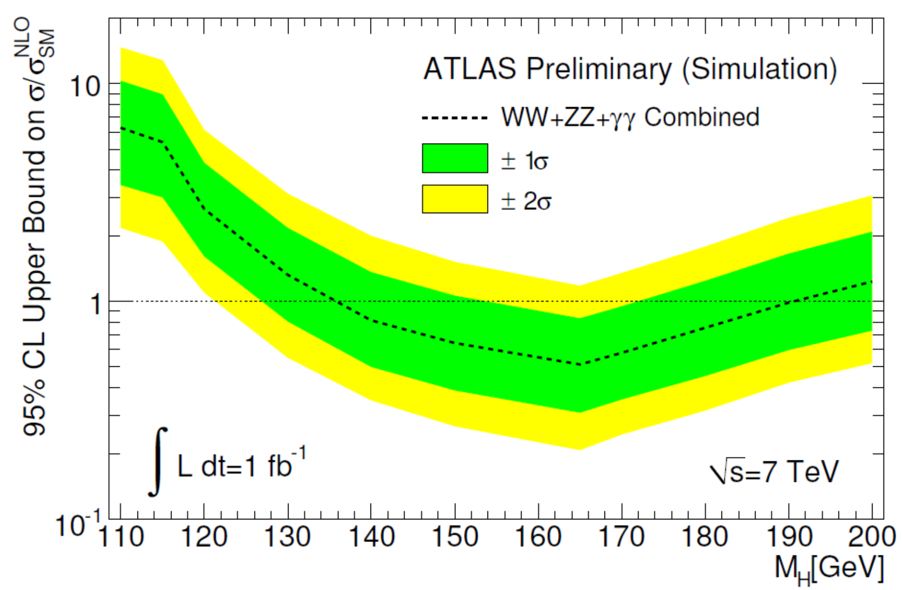
- **3探索モード**のみの合成:
  - H→WW→lνlν
  - H→ZZ→4l
  - H→γγ



- $1fb^{-1}$（**2011年末**に相当）のデータ量で、**135-188 GeV**のヒッグス質量を棄却することができる。

2011年の状況





リミットが√Lumでスケールするならば、2011年のTevatronは、√(10fb^{-1}/5.9fb^{-1})～1.3だけリミットを下げる。

⇒　上の赤線を跨ぐところが2011年の質量棄却領域になる。

⇒　142－184 GeVの領域を棄却できる。

ATLASは、2011年に135-188 GeVのヒッグス質量を棄却できる。

それまでに検出器の校正・理解は十分できるか？

解析手法はスムーズに確立できるか？

CMSとの足し合わせはすぐにできるか？