Recent Tevatron Results

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On behalf of

CDF and DØ

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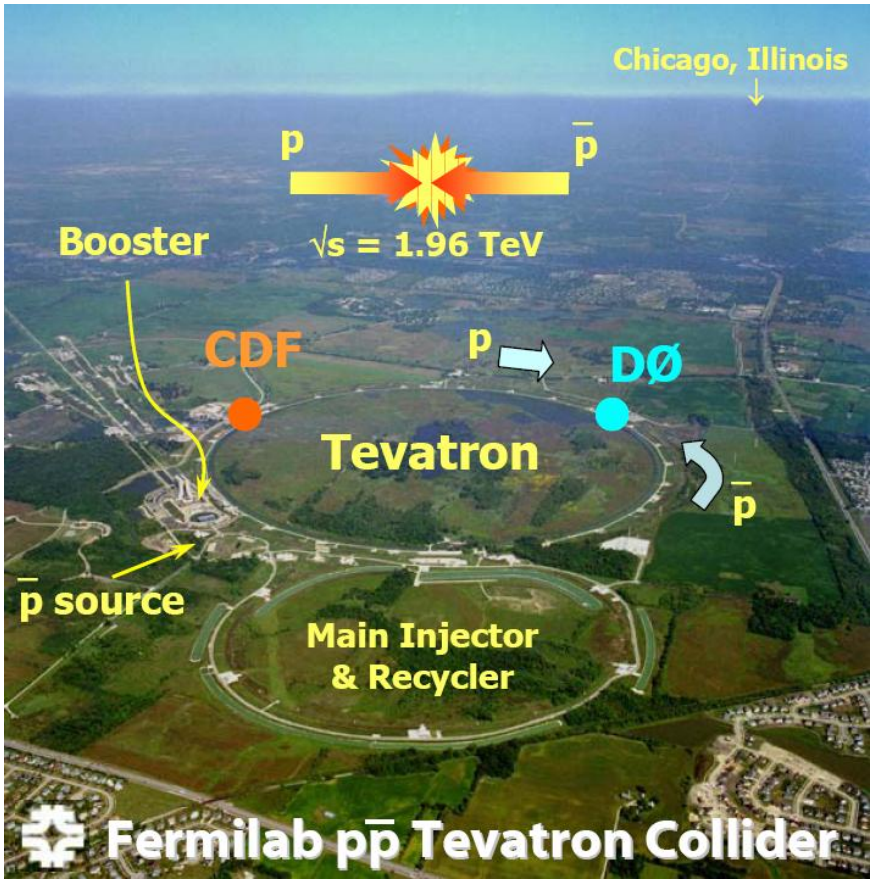
Outline

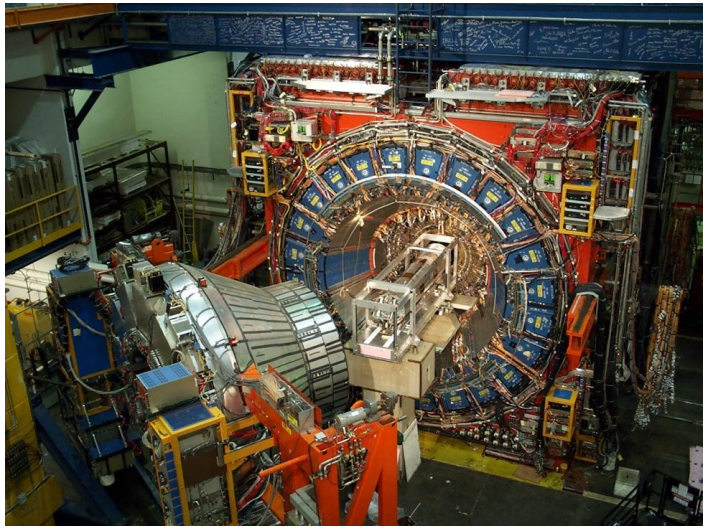
Introduction

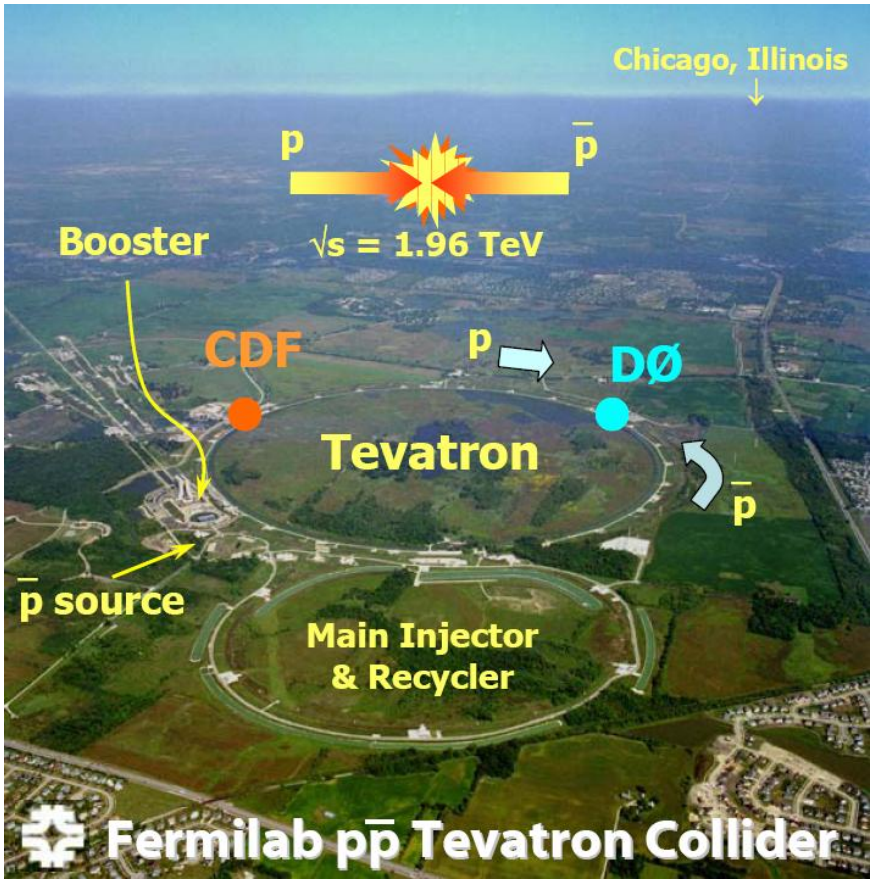
Results

Conclusions

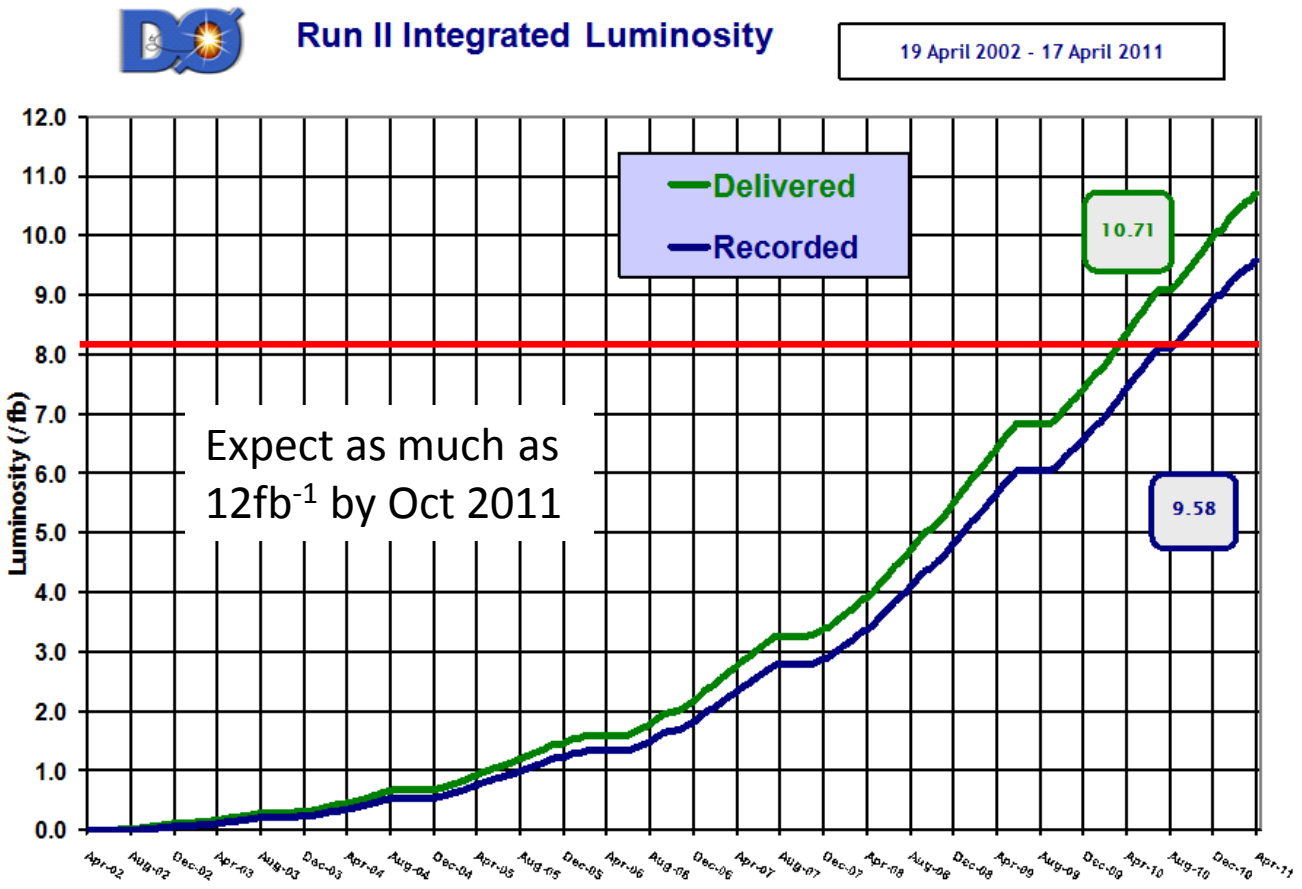


Tevatron, CDF, D0





Tevatron Performance



Average data-taking efficiency ~90%

Many thanks to Accelerator Division

A Wealth of Recent Results

By way of example: http://www-d0.fnal.gov/Run2Physics/ResultsWinter2011.html

Bottom Physics

Analysis	Luminosity	More Information
A measurement of B0s mixing using the flavor tagged deacay B0s->J/psi phi	6.1 fb^{-1}	Web Page
Combination of the D0 constraints on the CP violating phase phiS	up to 6.1 fb^{-1}	Web Page

Electroweak Physics

Analysis	Luminosity	More Information
Measurement of the Z/gamma* Z/gamma* production cross section using the fully charged leptonic decay channel from ppbar collisions at sqrt(s)=1.96 TeV	6.4 fb^{-1}	Publication
Measurement of sin2theta_eff and Z-light quark couplings using the forward-backward charge asymmetry in ppbar-->Z/gamma*-->e+e- events	5.0 fb^{-1}	Publication
Precise study of the Z/gamma* boson transverse momentum distribution in ppbar collisions using a novel technique	7.3 fb^{-1}	Publication

New Phenomena

Analysis	Luminosity	More Information
Search for W'-->tb resonances with left- and right-handed couplings to fermions	2.3 fb^{-1}	Publication
Search for resonant WW and WZ production in ppbar collisions at sqrt(s)=1.96 TeV	4.1-5.4 fb^{-1}	Publication
Search for single vector-like quarks in ppbar collisions at sqrt{s}=1.96 TeV	5.4 fb^{-1}	Publication
Search for pair production of the scalar top quark in the electron+muon final state	5.4 fb^{-1}	Publication
Search for new fermions ('quirks') at the Fermilab Tevatron Collider	2.4 fb^{-1}	Publication
Search for events with leptonic jets and missing transverse energy in ppbar collisions at sqrt(s)=1.96 TeV	5.8 fb^{-1}	Publication
Search for diphoton events with large missing transverse energy in 6.3 fb-1 of ppbar collisions at sqrt(s)=1.96 TeV	6.3 fb^{-1}	Publication
Search for a heavy neutral gauge boson in the dielectron channel with 5.4 fb-1 of ppbar collisions at sqrt(s)= 1.96 TeV	5.4 fb^{-1}	Publication

A Wealth of Recent Results

And….

QCD Results

Analysis	Luminosity	More Information
Azimuthal decorrelations and multiple parton interactions in gamma+2 and +3 jet events in ppbar collisions at sqrt{s}=1.96 TeV	1 fb^{-1}	Publication
A Measurement of the Ratio of Inclusive Cross Sections sigma(ppbar->Zbjet) / sigma (ppbar/Z+jet at sqrt(s) =1.96 TeV	4.2 fb^{-1}	Publication

Top Physics

Analysis	Luminosity	More Information
Measurement of spin correlation in ttbar production using dilepton final states	5.4 fb^{-1}	Publication
Search for flavor changing neutral current couplings in decays of top quarks	4.1 fb^{-1}	Publication
Search for W'-->tb resonances with left- and right-handed couplings to fermions	2.3 fb^{-1}	Publication
Measurement of color flow in ttbar events from ppbar collisions at sqrt(s)=1.96 TeV	5.3 fb^{-1}	Publication
Measurement of the top quark production cross section in the lepton+jets channel in proton-antiproton collisions at sqrt(s)=1.96 TeV	5.4 fb^{-1}	Publication
Measurement of the W boson helicity in top quark decays using 5.4 fb-1 of ppbar collision data	5.4 fb^{-1}	Publication
Determination of the width of the top quark	up to 2.3 fb^{-1}	Publication
Measurement of ttbar production in the tau+jets channel using ppbar collisions at sqrt(s)=1.96 TeV	1.0 fb^{-1}	Publication
Measurement of the top quark mass in final states with two leptons using the D0 detector	5.3 fb^{-1}	Web Page

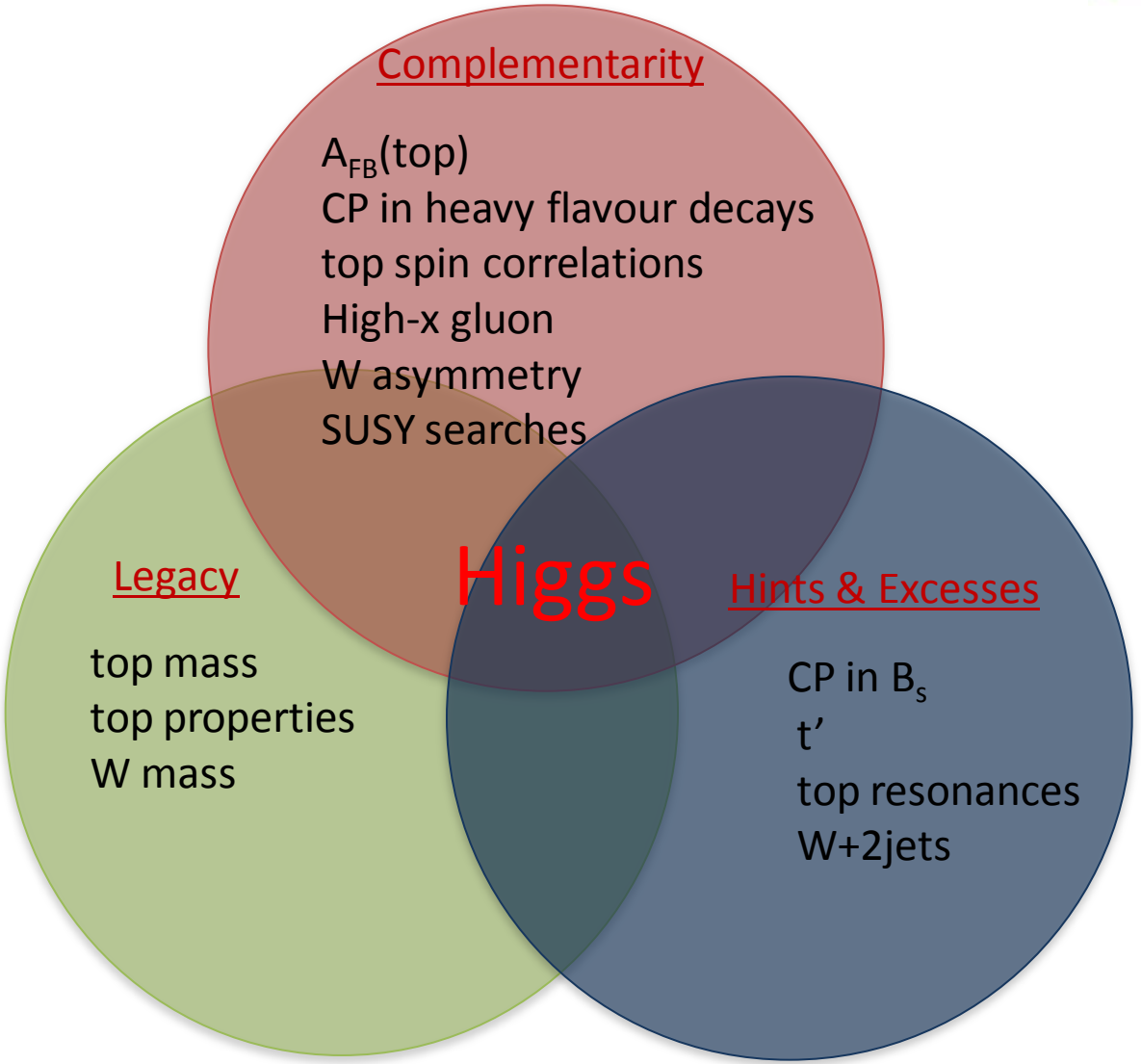
A Wealth of Recent Results

And 'finally'…

Higgs Physics

Analysis	Luminosity	More Information
Combined CDF and D0 upper limits on standard model Higgs boson production with up to 8.2 fb-1 od data	up to 8.2 fb^{-1}	Web Page
Combined upper limits on standard model Higgs boson production in the WW, tautau and gammagamma decay modes in up to 8.2 fb-1 of data from the D0 experiment	up to 8.2 fb^{-1}	Web Page
Search for neutral Higgs bosons phi b -->tau_e tau_had b with 3.7 fb-1 of D0 data	3.7 fb^{-1}	Web Page
Search for a fermiophobic Higgs boson in the di-photon final state using 8.2 fb-1 of D0 data	8.2 fb^{-1}	Web Page
Search for Higgs boson production in dilepton plus missing transverse energy final states with 8.1 fb-1 of ppbar collisions at sqrt(s)=1.96 TeV	8.1 fb^{-1}	Web Page
Search for the Standard Model Higgs boson the tau+tau- + 2 jets final state	4.3 fb^{-1}	Web Page
Search for the Standard Model Higgs boson in mu+tau_had+<= 1 jet final state with 7.3 fb-1 of data	7.3 fb^{-1}	Web Page
Search for the Standard Model Higgs Boson in gammagamma+X final states at D0 using 8.2 fb-1 data	8.2 fb^{-1}	Web Page
Search for the Standard Model Higgs boson in the ZH-->vvbb channel in 6.2 fb-1 of ppbar collisions at sqrt(s) =1.96 TeV	6.2 fb^{-1}	Web Page
Search for the standard model Higgs boson in the H-->WW-->lvqq decay channel	5.4 fb^{-1}	Publication
Search for WH associated production in 5.3fb-1 of ppbar collisions at the Fermilab Tevatron	5.3 fb^{-1}	Publication
Search for neutral Higgs bosons in the multi-b-jet topology in 5.2 fb-1 of ppbar collisions at sqrt(s)=1.96 TeV	5.2 fb^{-1}	Publication
Search for ZH-->llbb production in 4.2 fb-1 of ppbar collisions at sqrt(s)=1.96 TeV	4.2 fb^{-1}	Publication

And likewise: http://www-cdf.fnal.gov/physics/physics.html


Complementarity
A_{FB}(top)
CP in heavy flavour decays
top spin correlations
High-x gluon
W asymmetry
SUSY searches
Legacy
top mass
top properties
W mass
Higgs
Hints & Excesses
CP in B_s
t'
top resonances
W+2jets

Top and W Mass

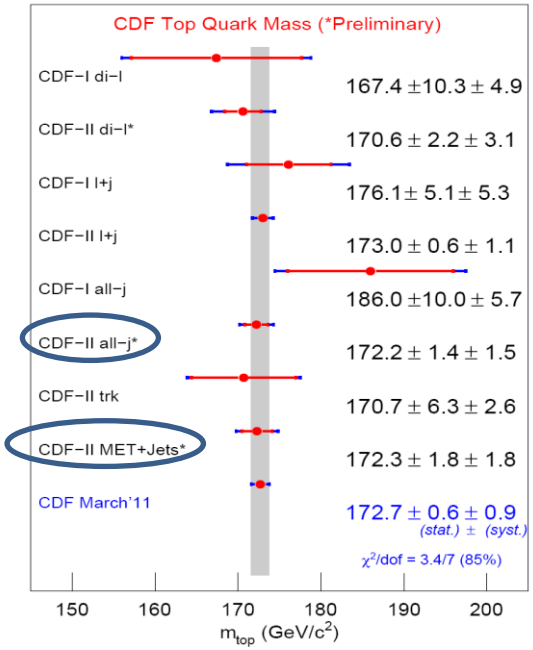
Top mass

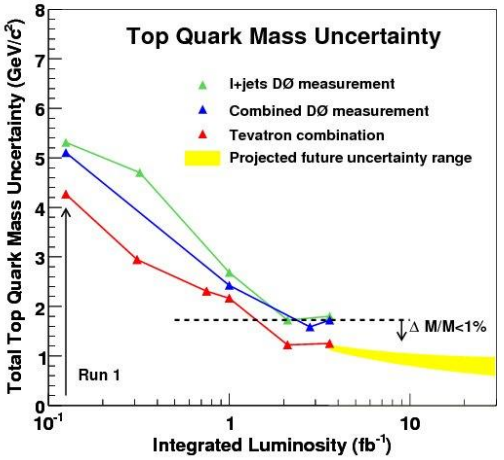
- Current Tevatron precision of 0.7%

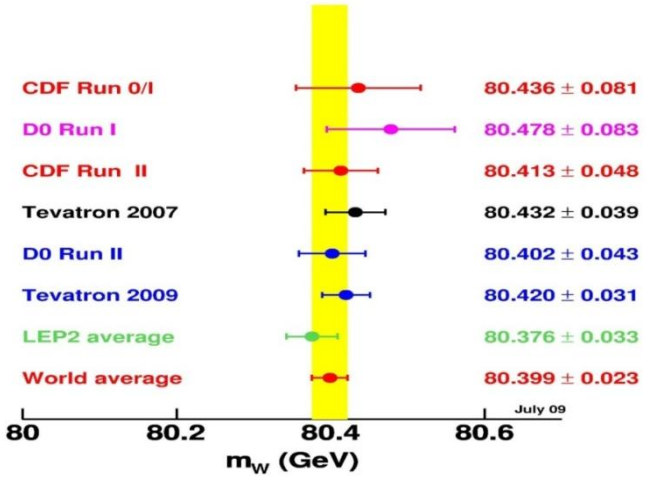
CDF alone now at 0.6%

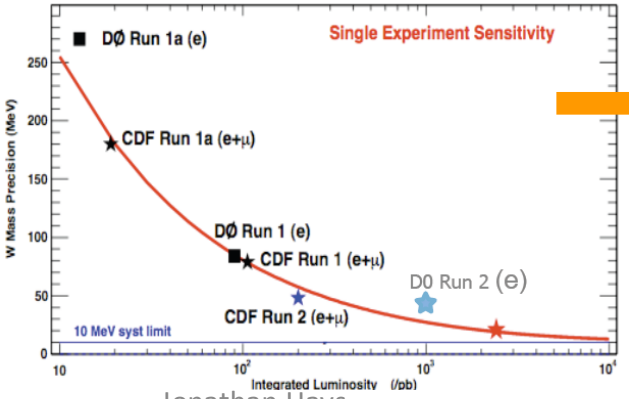
W mass

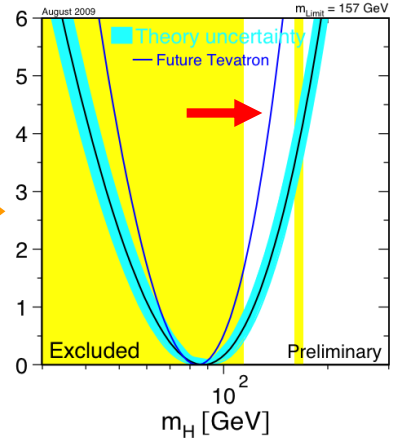
Current Tevatron precision of 31MeV







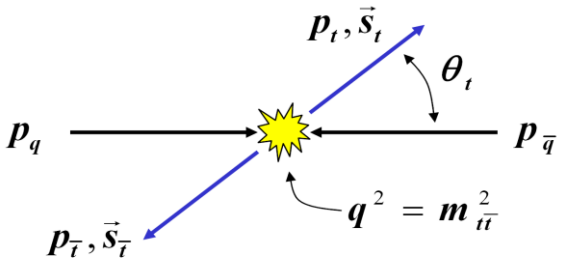




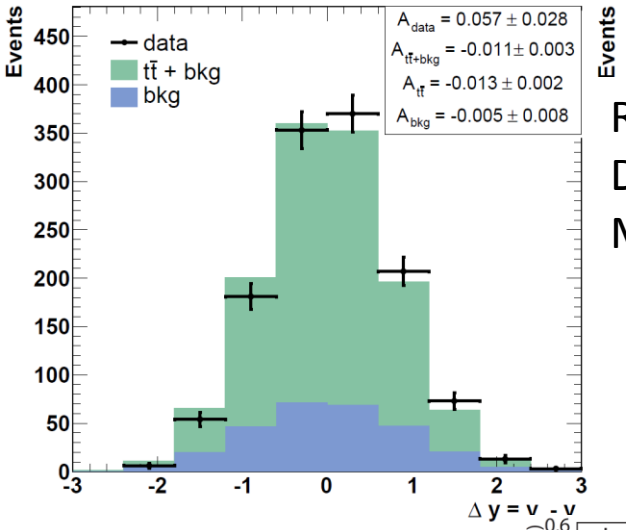
m_H<117GeV

Other 'Top' Results

Production Asymmetry A_{FB}



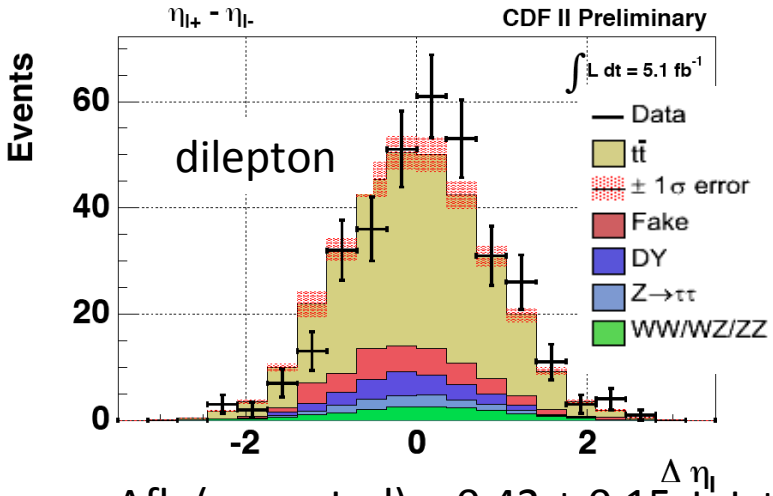
lepton+jet



Raw A_{FB}

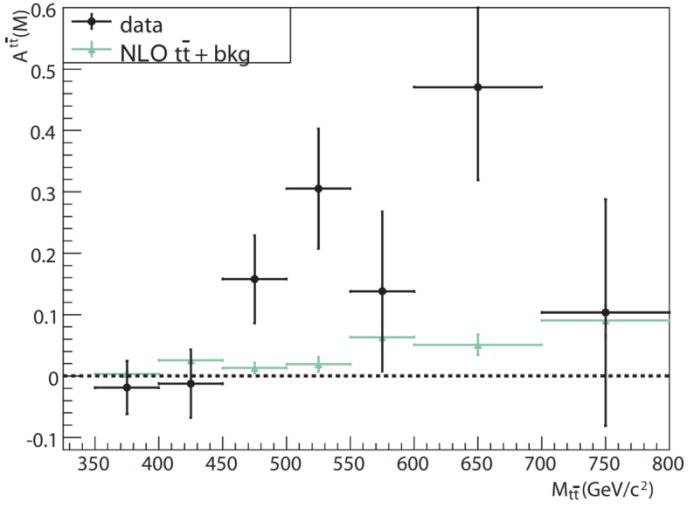
Data: 0.057±0.028

MC@NLO: 0.017±0.004



$$A_{obs}^{\Delta\eta_l} = 0.138 \pm 0.054$$

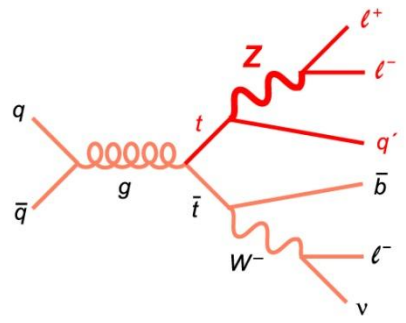
$$A_{pred}^{\Delta\eta_l} = -0.022 \pm 0.022$$

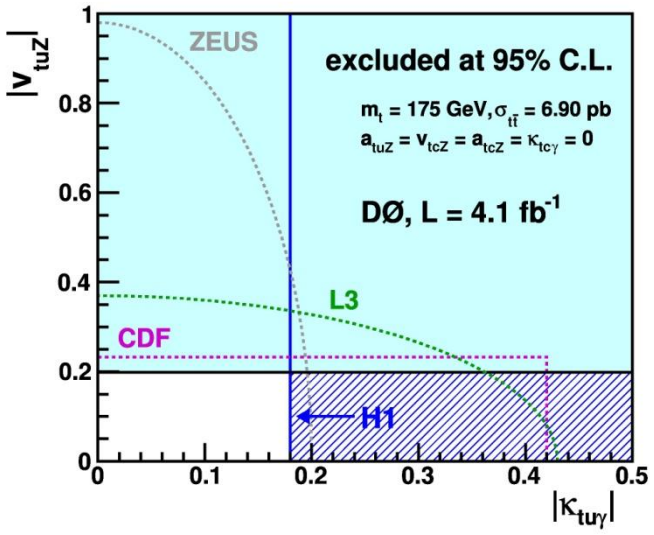


Afb (corrected) = 0.42 ± 0.15stat ± 0.05syst

Other 'Top' & Electroweak Results

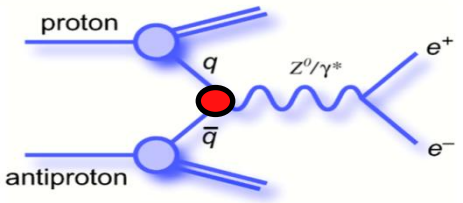
eg FCNC



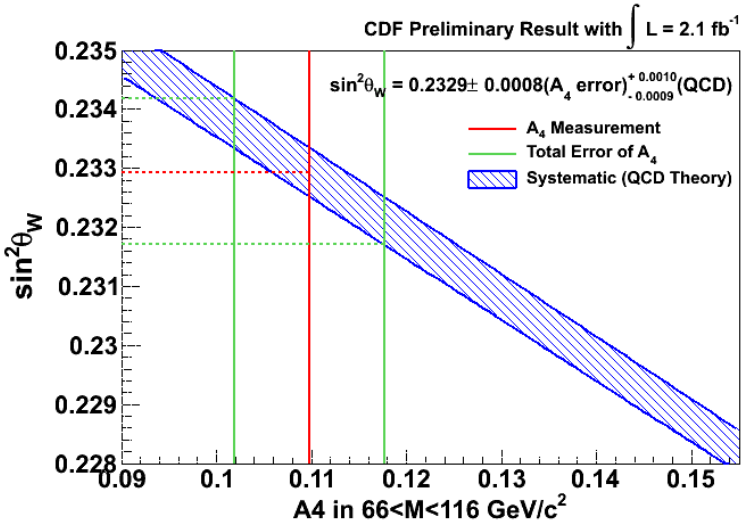


World's best limit

eg $\sin\theta_W$



World's best for light quarks!



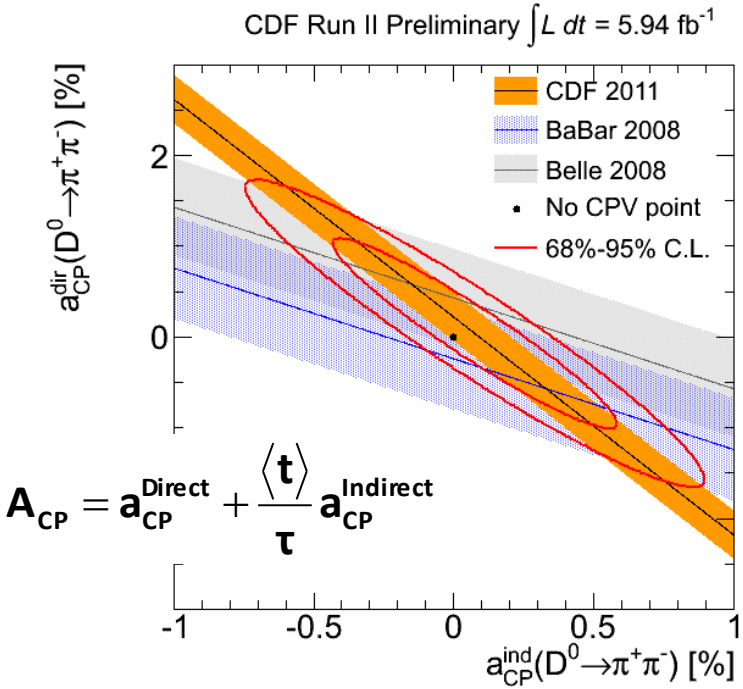
Complementarity

Proton-Antiproton: enables high precision CP measurements due to symmetric initial state

eg $D^0 \longrightarrow K^+K^-$ & $\pi^+\pi^-$

$$A_{CP} = \frac{\Gamma(D^0 \to h^+h^-) - \Gamma(\bar{D}^0 \to h^+h^-)}{\Gamma(D^0 \to h^+h^-) + \Gamma(\bar{D}^0 \to h^+h^-)}$$

$A_{CP}(D^0 \to \pi^+\pi^-) = +0.22 \pm 0.24 \pm 0.11$ %



$$A_{CP} = a_{CP}^{Direct} + \frac{\langle t \rangle}{\tau} a_{CP}^{Indirect}$$

World's best results

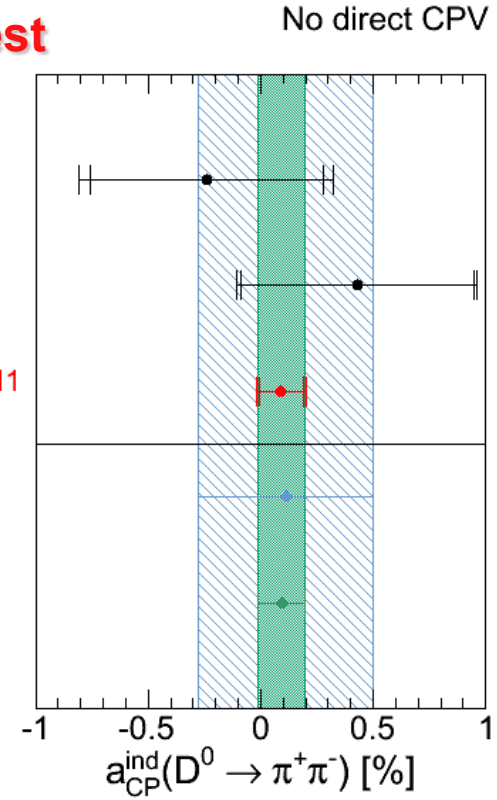
BaBar 2008
(-0.24±0.52±0.22)%

Belle 2008
(0.43±0.52±0.12)%

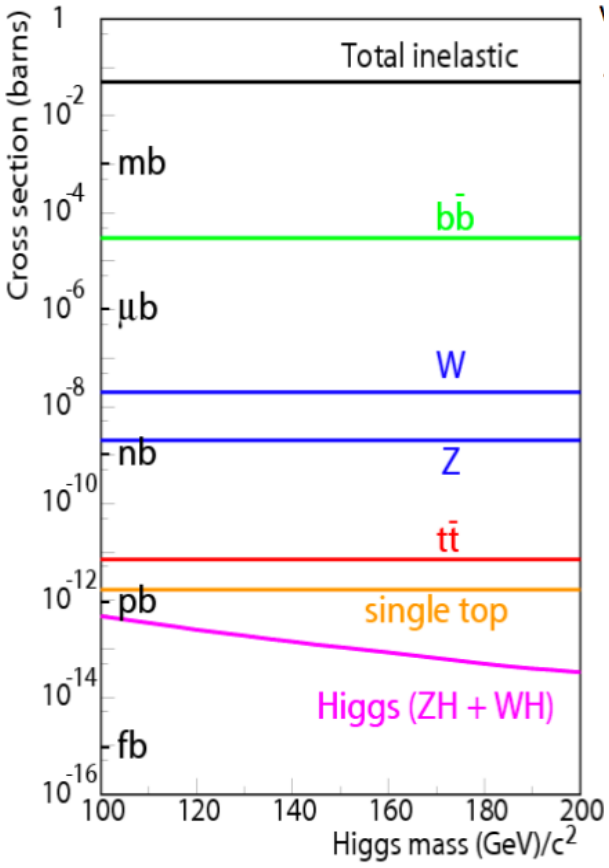
CDF Preliminary 2011
(0.09±0.10±0.05)%

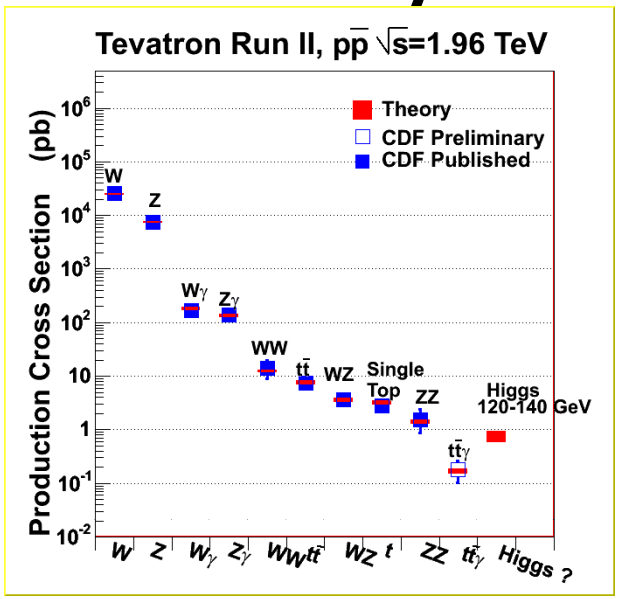
B-Factories Average
(0.11±0.39)%

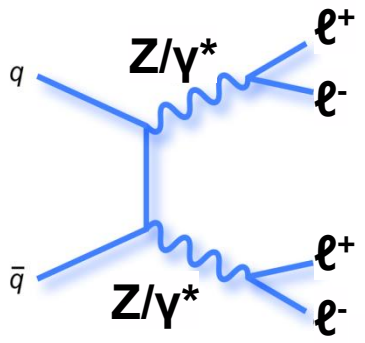
New Average
(0.09±0.11)%

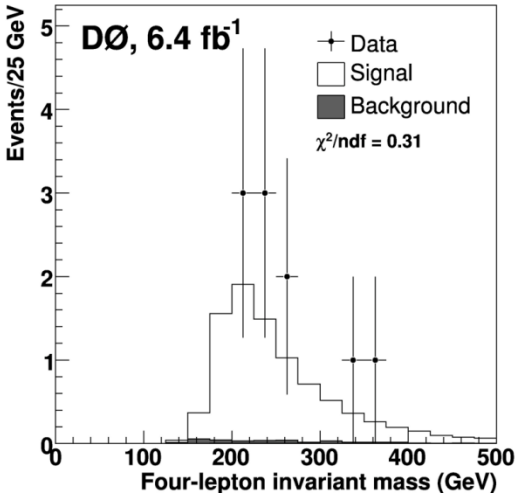


Alternatively…









σ(ZZ) =1.35±0.45(stat)±0.15(syst) pb

Standard Model Higgs

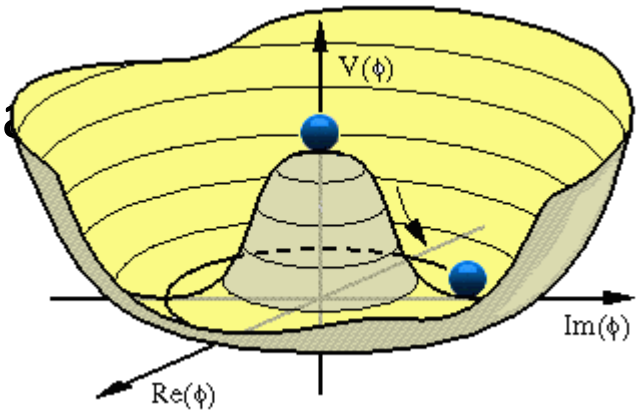
Higgs mechanism

Additional scalar field in SM Lagrangi

→ mass to W,Z & fermions

Predicts neutral, spin 0 boson

But not its mass



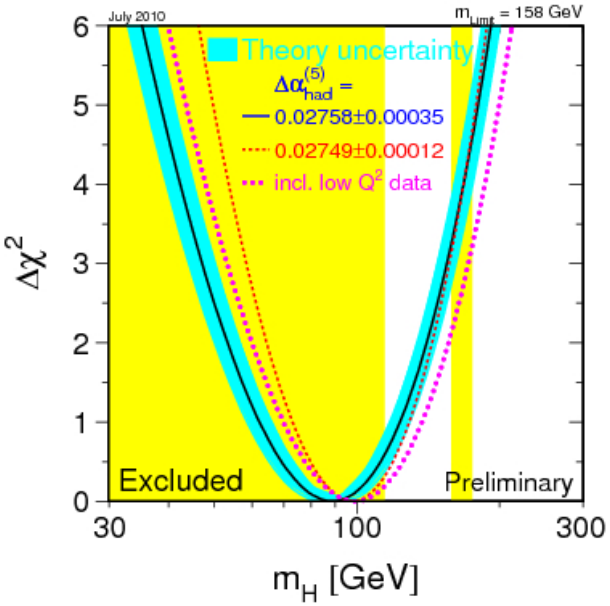
Direct searches at LEP2

$m_H > 114.4$ GeV

Precision data favour a light Higgs

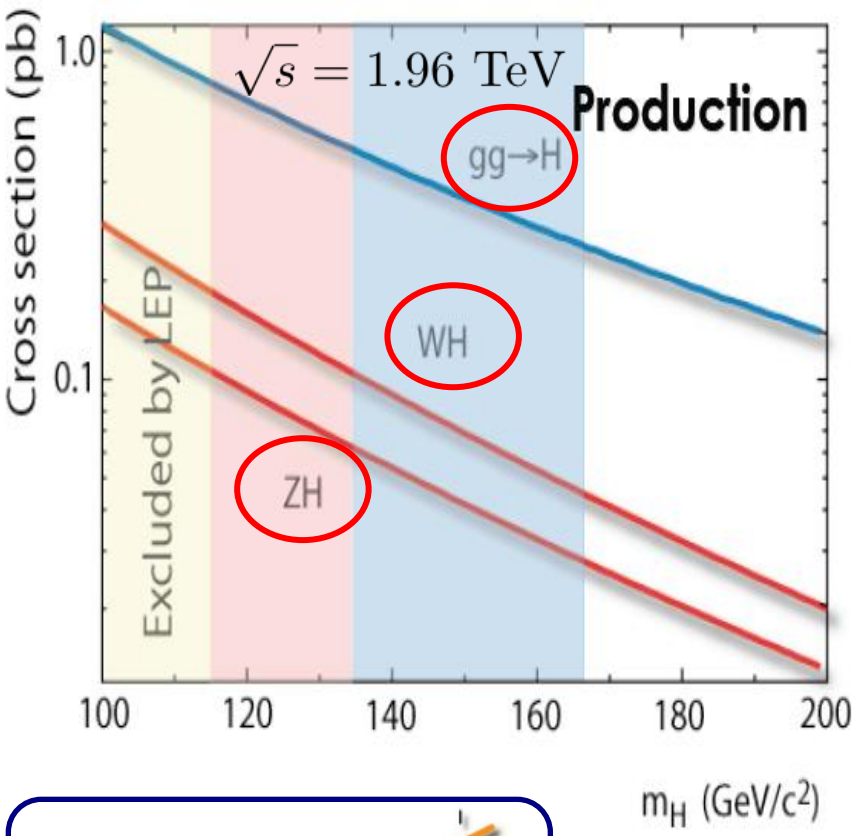
$m_H < 185$ GeV if LEP2 limit included

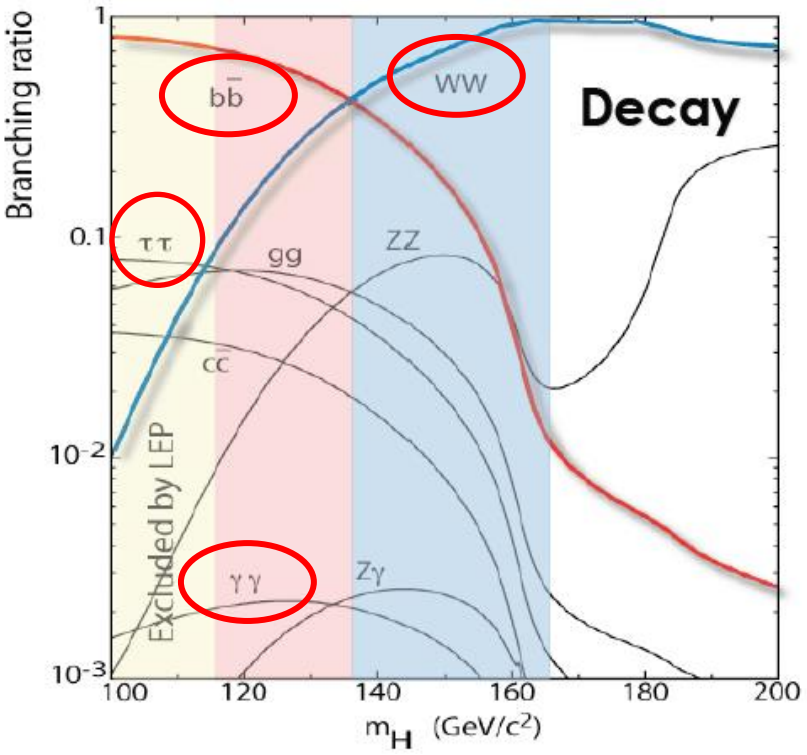
→ Accessible at Tevatron

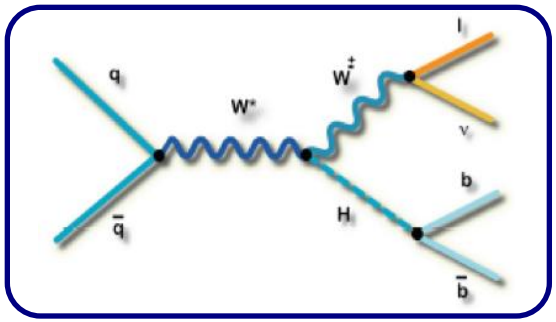


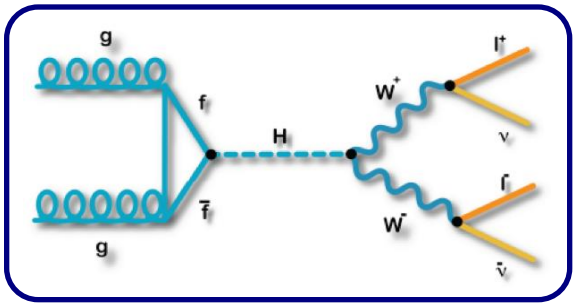
(Not finding the Higgs boson will contradict SM & revolutionize particle physics…)

Higgs at the Tevatron









Strategy: Leave no stone unturned

All signal production and decay processes

eg W/Z+H and qqH at high mass

eg photons & taus, hadronic decays of W's

Optimise leading channels

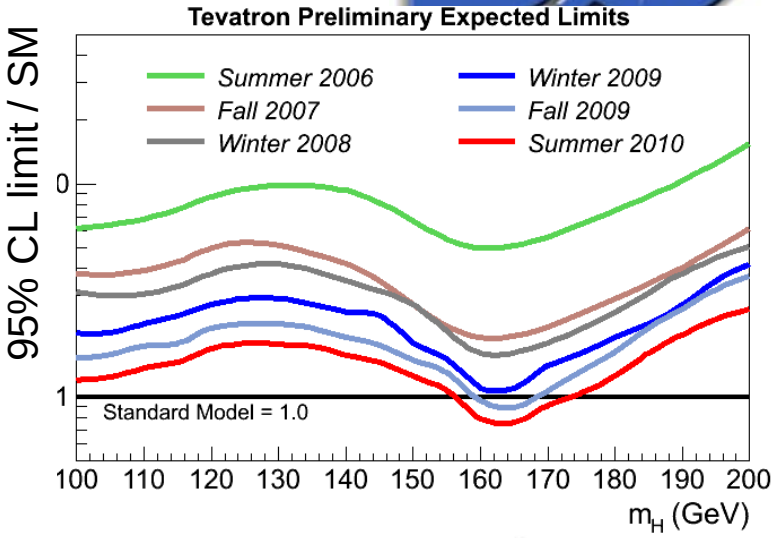
eg b-tagging & mass resolution at low mass

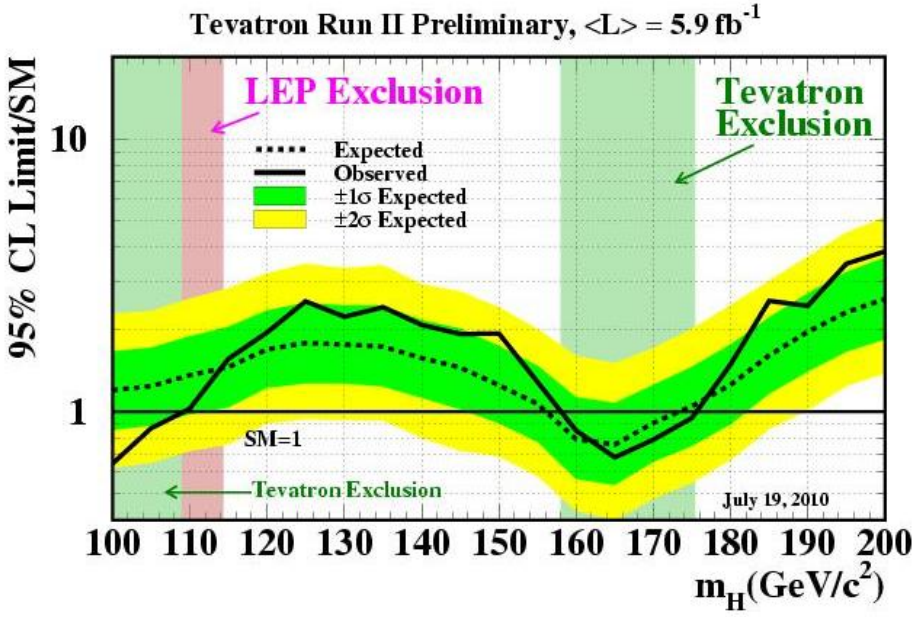
Constrain systematics with data

Improved final discriminants

eg neural networks, boosted decision trees…

Combine across all channels & experiments



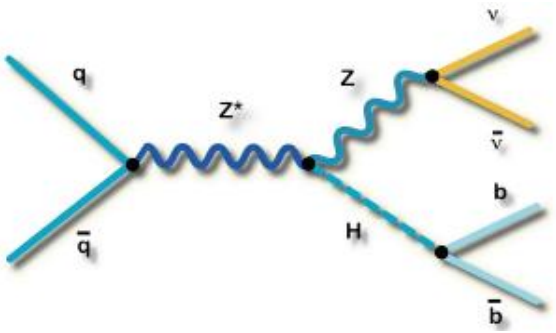


Low Mass: ZH→νν̄bb̄

One of most powerful,
but challenging channels

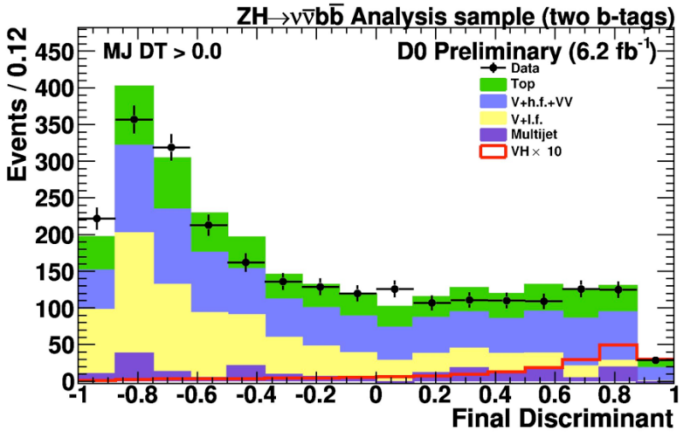
Improved use of b-tagging information
15% gain in sensitivity

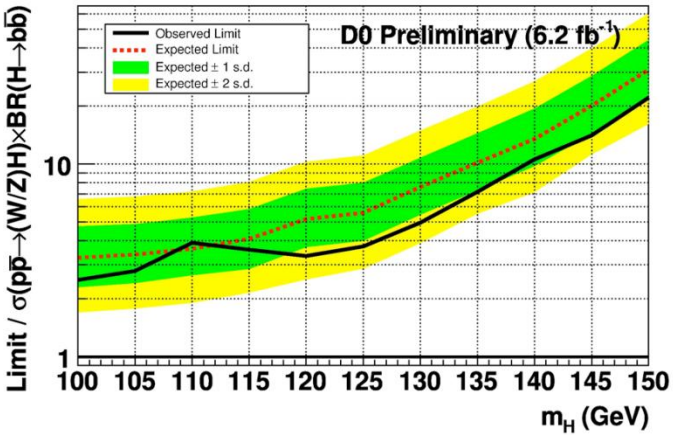
Boosted decision trees
To reject multijet background
As final discriminant
Split into 1 and 2 b-tag samples



Missing transverse energy

Two high p_T jets, acoplanar, b-tagged





m_H=115 GeV, 95% CL

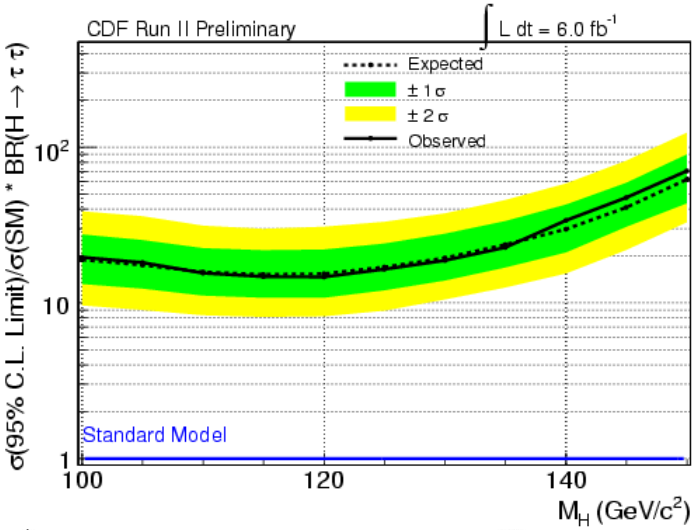
Expected: 4.0×SM

Observed: 3.4×SM

‘Low’ Mass: Additional channels

$H \rightarrow \tau\tau$

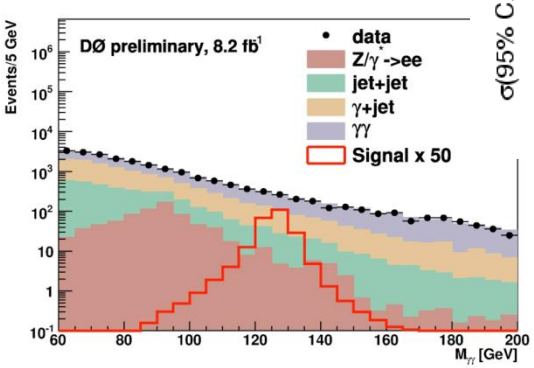
- 2nd largest BR at low mass
- Tau pair + 1or 2 jets



m_H=115 GeV

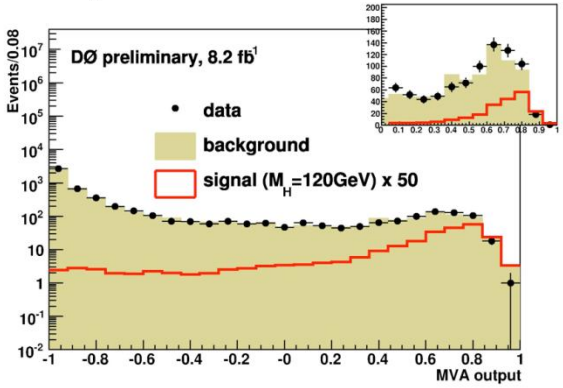
Expected: 15×SM

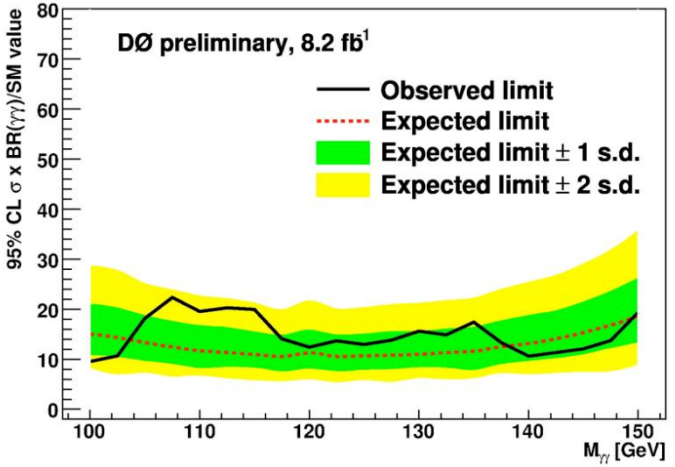
Observed: 15×SM



$H \rightarrow \gamma\gamma$

- More data
- Boosted decision tree
  - ~30% gain in sensitivity





m_H=115 GeV:

Expected: 11×SM

Observed: 20×SM

High Mass

New high mass combination for winter 2011

All channels updated / improved

New channels

CDF

Channel	Luminosity (fb^{-1})	m_H range (GeV/c^2)
$H \to W^+W^-$ $2\times$(0,1 jets)+(2+ jets)+(low-$m_{\ell\ell}$)+(e-τ_{had})+(μ-τ_{had})	7.1	130-200
$WH \to WW^+W^-$ (same-sign leptons 1+ jets)+(tri-leptons)	7.1	130-200
$ZH \to ZW^+W^-$ (tri-leptons 1 jet)+(tri-leptons 2+ jets)	7.1	130-200

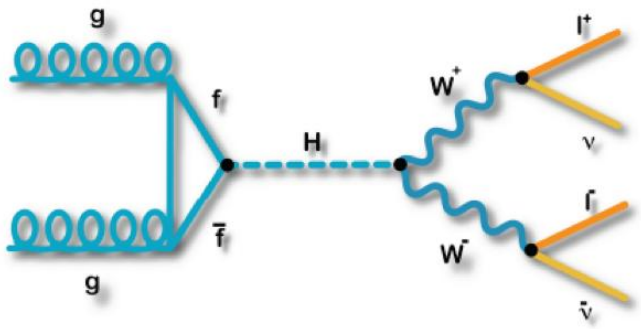
D0

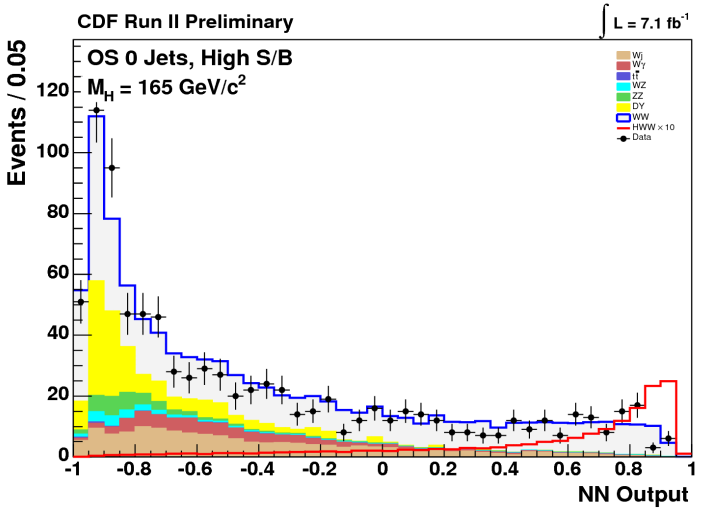
Channel	Luminosity (fb^{-1})	m_H range (GeV/c^2)
$H \to W^+W^- \to \ell^\pm\nu\ell^\mp\nu$ (0,1,2+ jet)	8.1	130-200
$H \to W^+W^- \to \mu\nu\tau_{had}\nu$	7.3	130-200
$H \to W^+W^- \to \ell\bar{\nu}jj$	5.4	130-200
$VH \to \ell^\pm\ell^\pm + X$	5.3	130-200
$H+X \to \ell^\pm\tau^\mp_{had}jj$	4.3	130-200
$H \to \gamma\gamma$	8.2	130-150

$H+X \rightarrow l^+l^- +$ missing E_T

m_H>135 GeV, H→W*W dominates

Clean - use gg → H production





W/Z+H, qqH also contribute

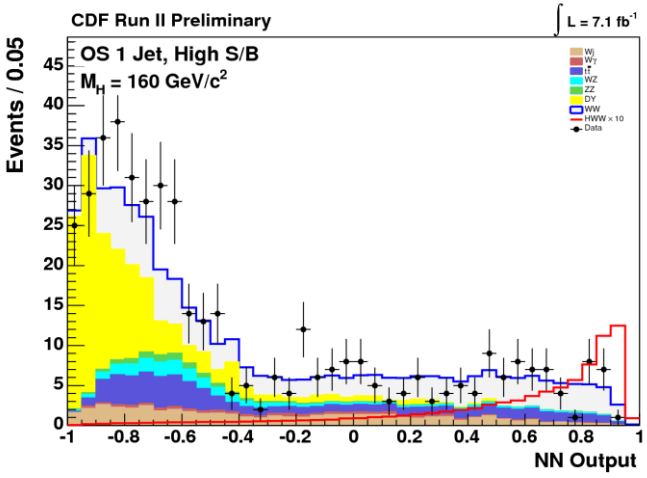
Subdivide

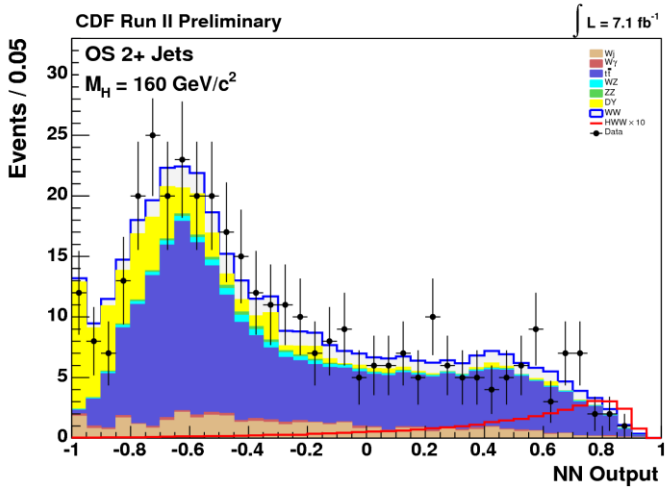
By jet multiplicity

lepton quality

Use MVA

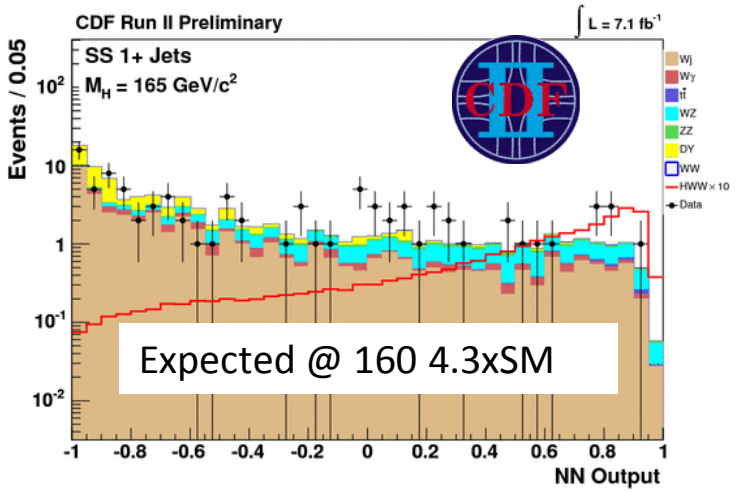
With differing inpu



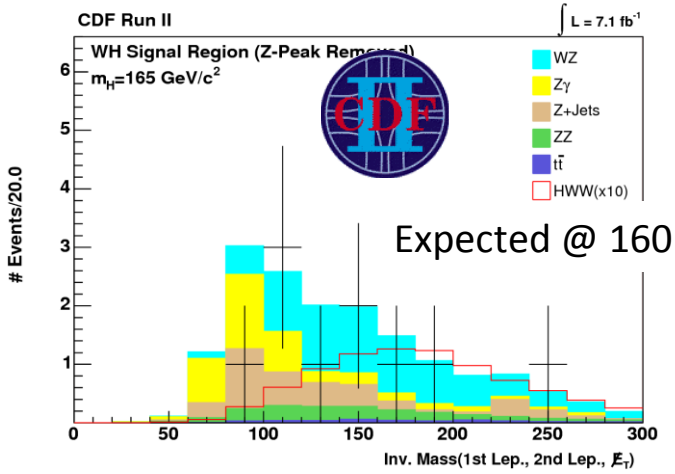


Additional Channels

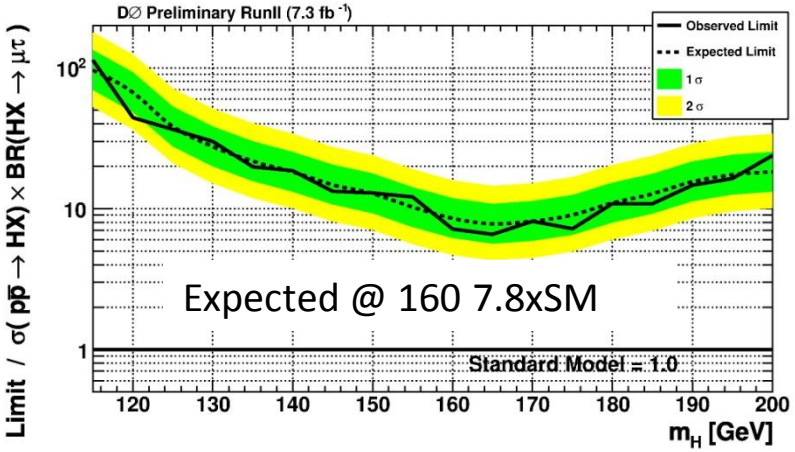
W/Z H same sign dilepton



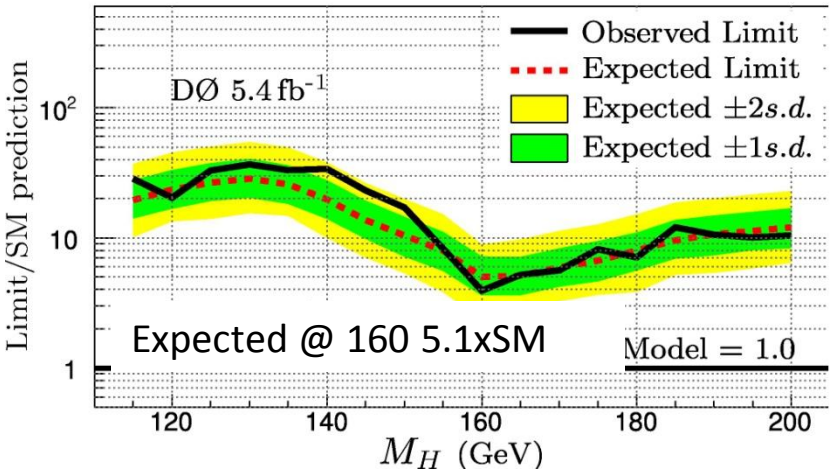
Trileptons: WH



gg→H→WW→τμνν



gg→H→WW→lμqq



Combination

Two statistical approaches
- Agree better than 5% over all masses

Operate on binned final discriminants

Systematics (& correlations) included
- Rate and shape effects considered
- Impact mitigated with constraints from data

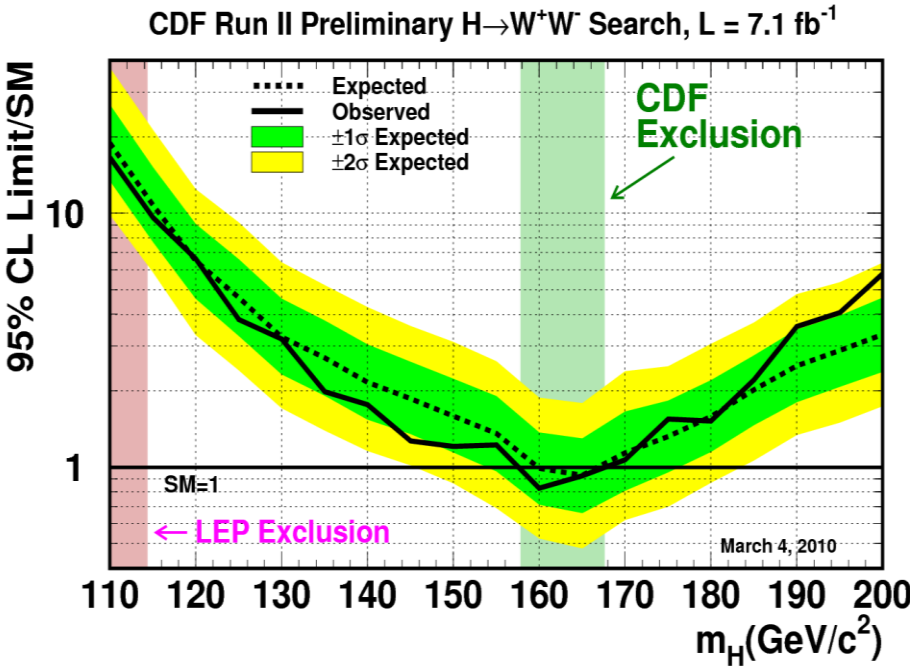
gg→H: NNLO +NNLL
- arXiv:0811.3458, arXiv:0901.2427

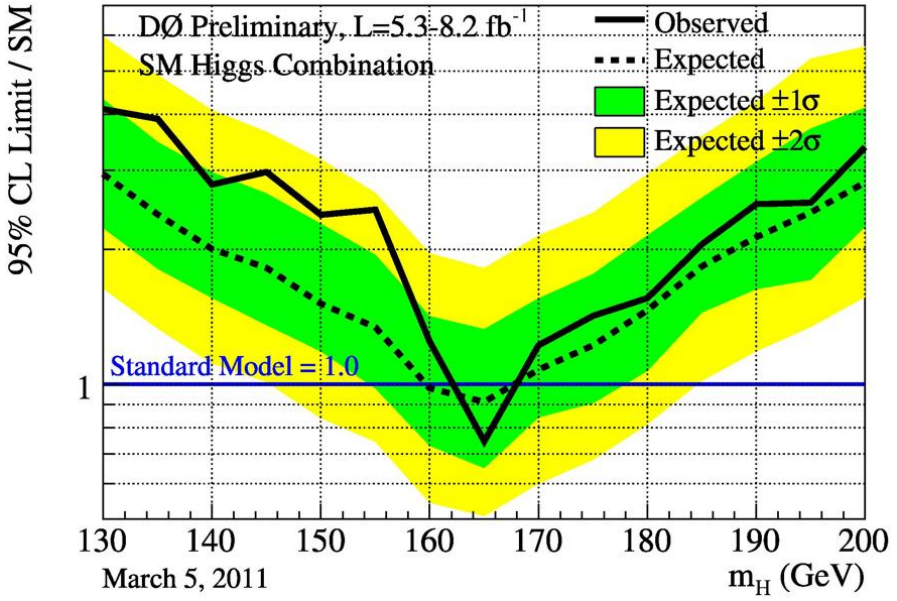
Use MSTW2008 NNLO PDFs
- Error prescription from PDF4LHC

Errors evaluated by jet bin

Further details on combinations: **http://tevnphwg.fnal.gov**

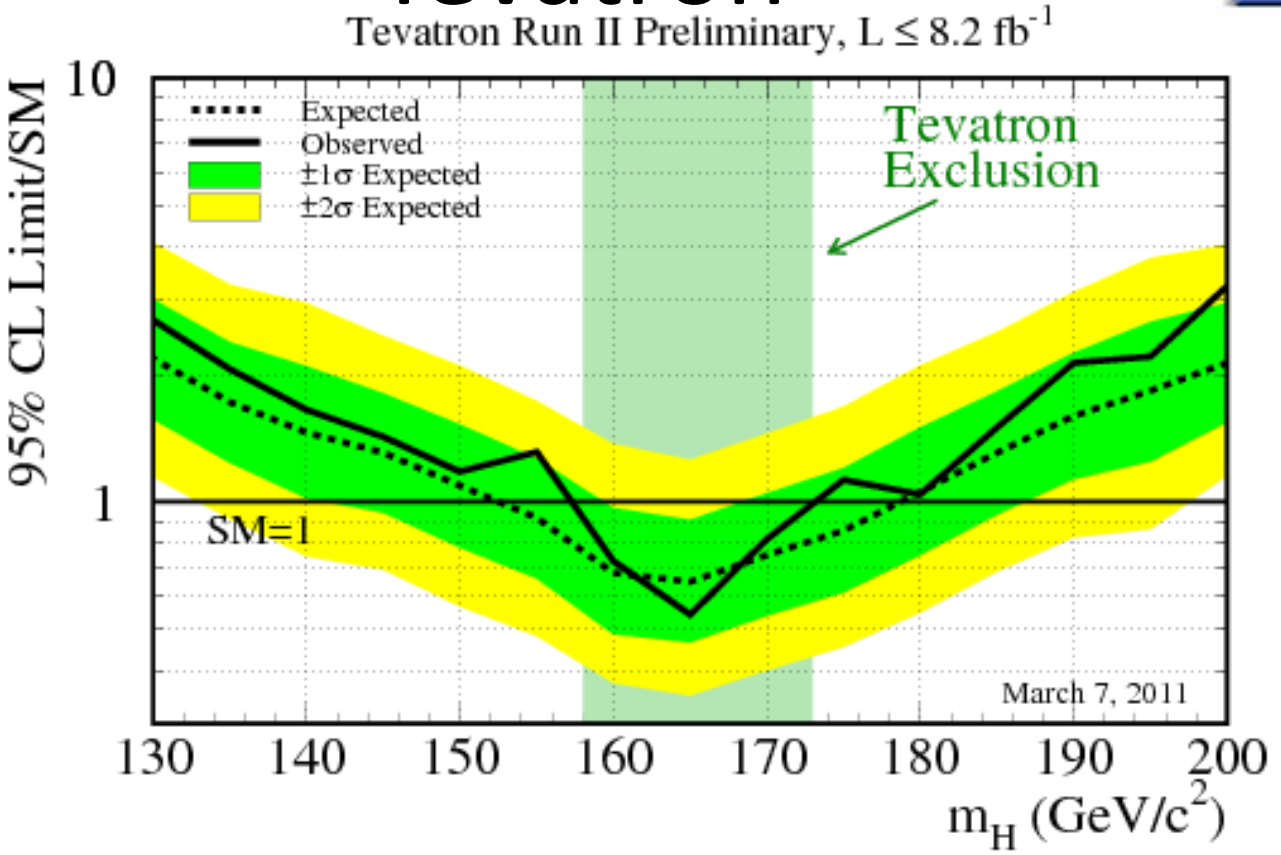
By Experiment





- Exclusion by each experiment:
  - CDF: excludes SM Higgs for $158 < m_H < 168$ GeV
  - DØ: excludes SM Higgs for $163 < m_H < 168$ GeV

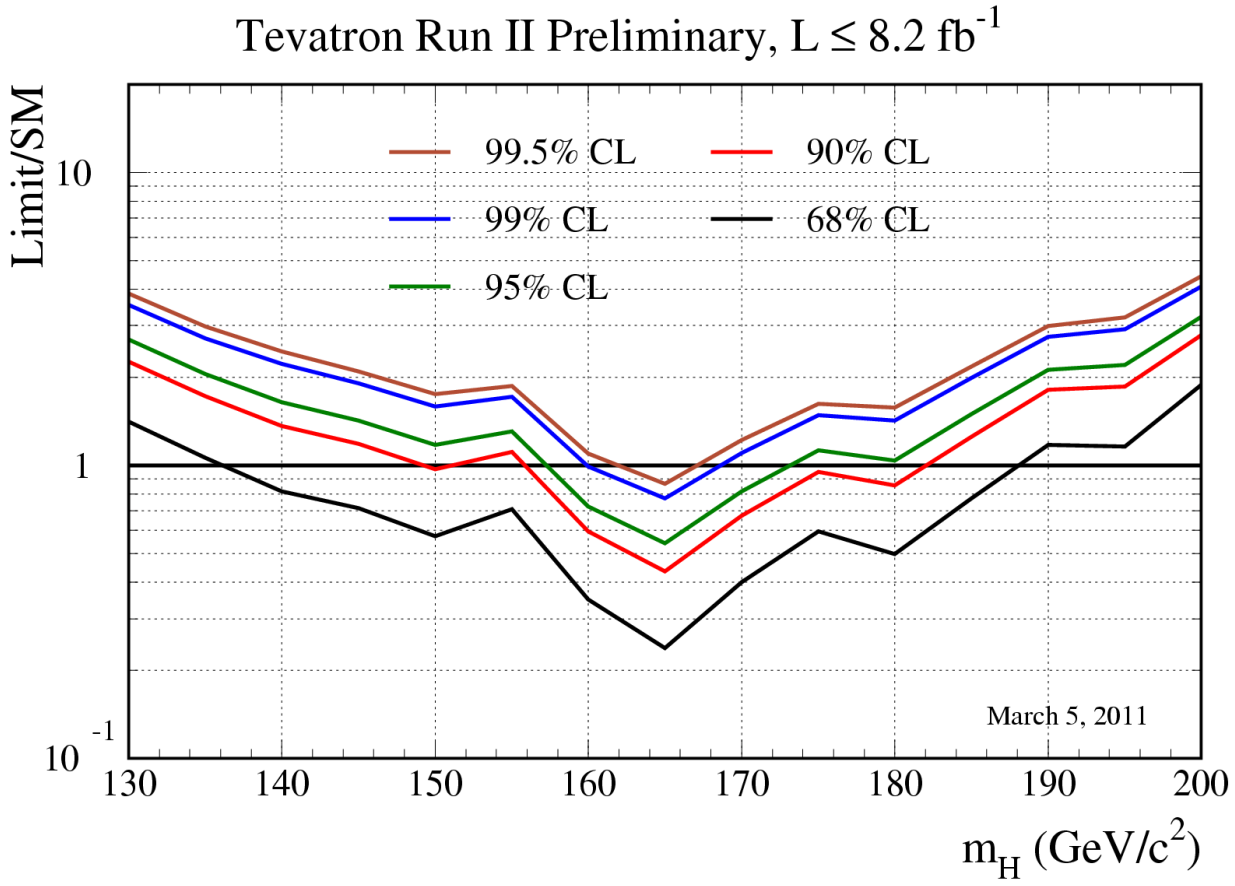
Tevatron



SM Higgs excluded at 95% CL for **158 < m_H < 173 GeV**

Expected exclusion at 95% CL **153 < m_H < 179 GeV**

Tevatron

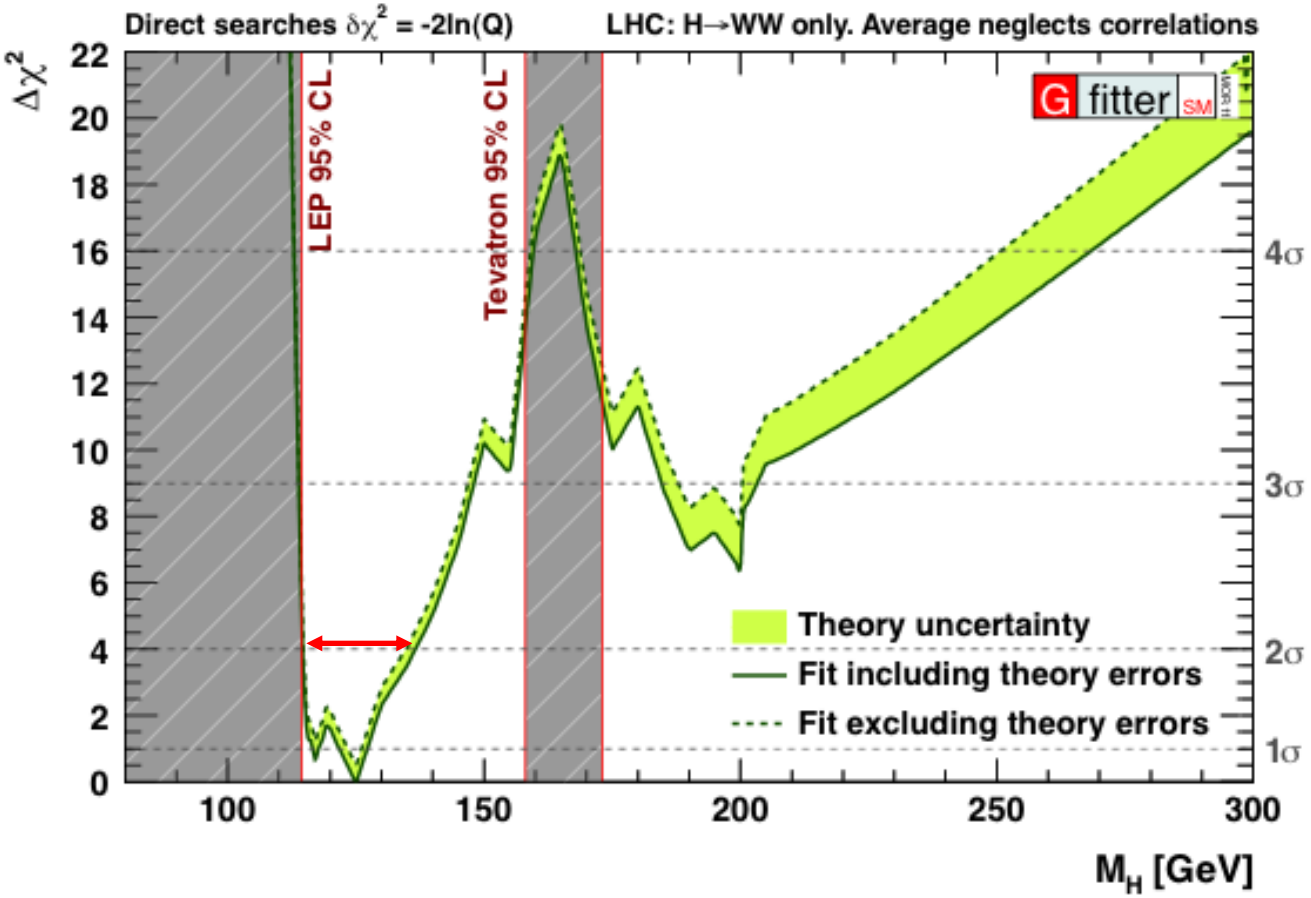


SM Higgs excluded at 99.5% CL for **$162 < m_H < 166$ GeV**

Combining Direct & Indirect Limits

At 95% CL:

Allowed region <140GeV



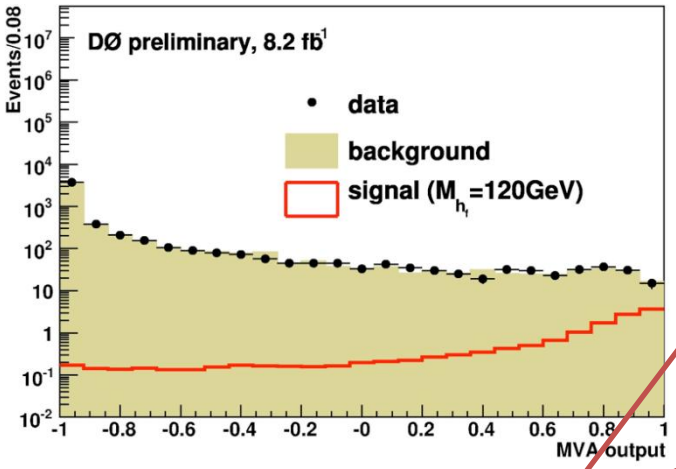
Gfitter: combines direct and indirect constraints

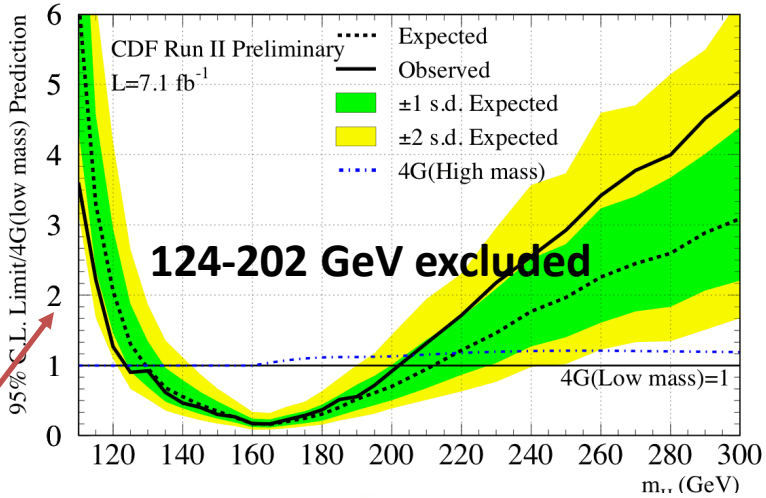
Higgs Beyond the SM…

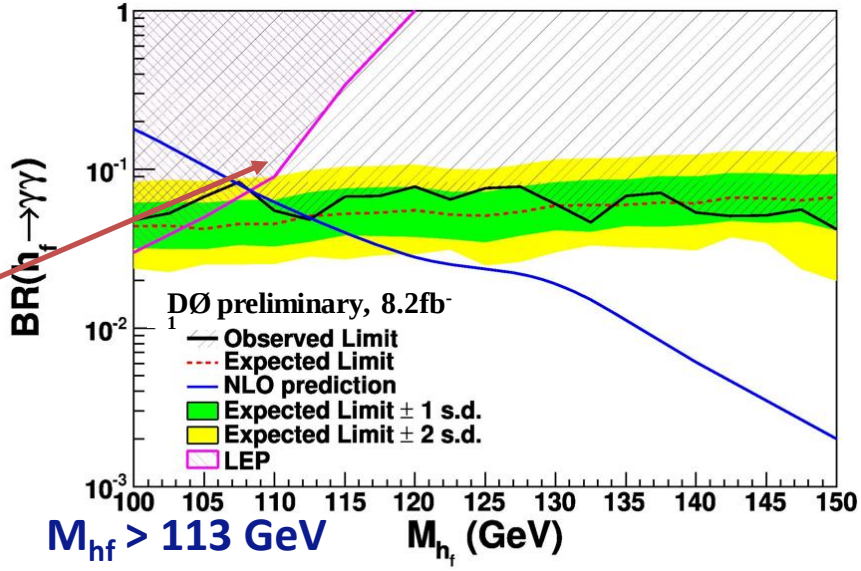
Wide range of searches

MSSM, NMSSM,

Fermiophobic, 4 Generations







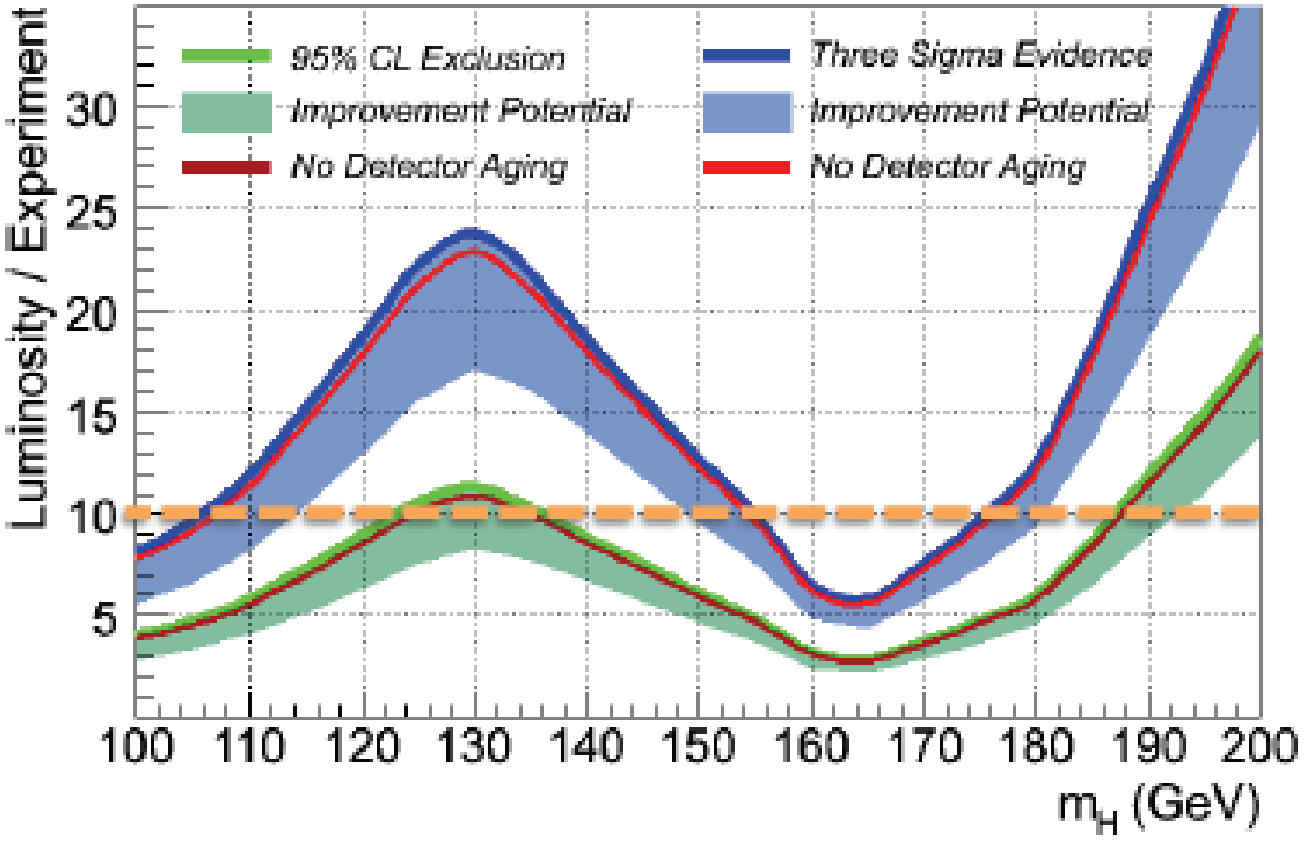
World's best limits

M_{hf} > 113 GeV

SM Higgs Prospects

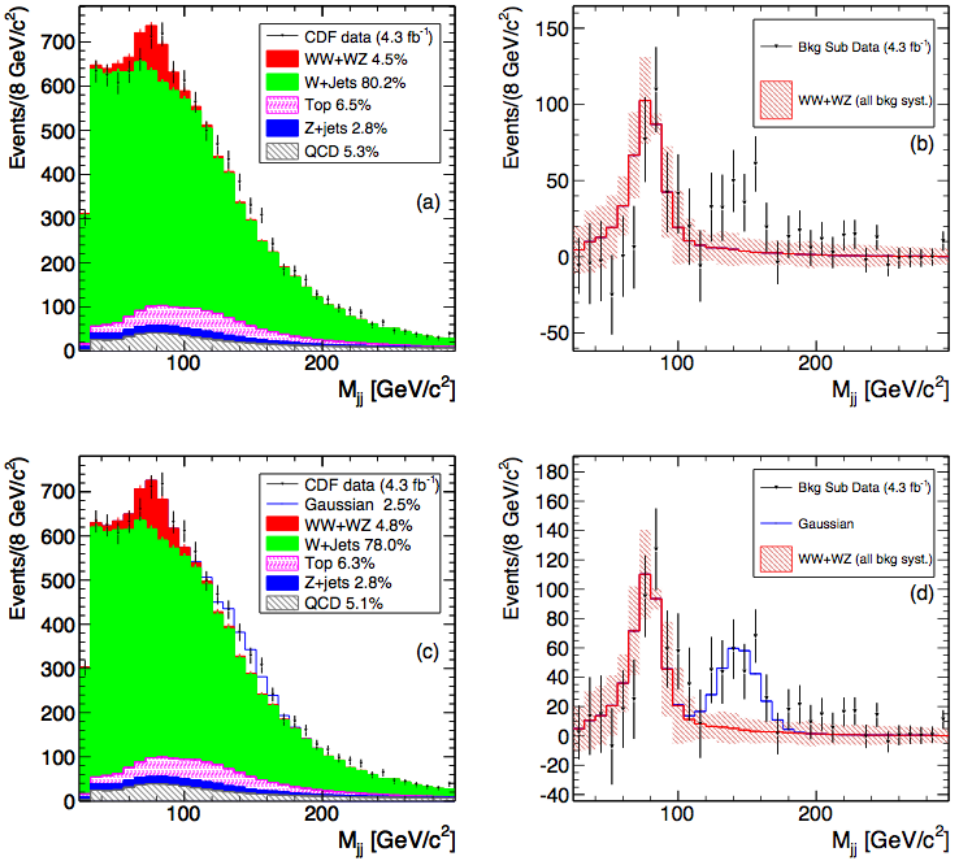
- Ongoing programme of improvements

Tevatron: Preliminary Higgs Projection



- Expect exclusion over whole mass range

W+2jets @ CDF



Interesting excess seen in di-jet invariant mass distribution

If real – exciting sign of new physics

D0 has similar analysis – repeating with CDF-like cuts
Expect results in a couple weeks

Conclusions

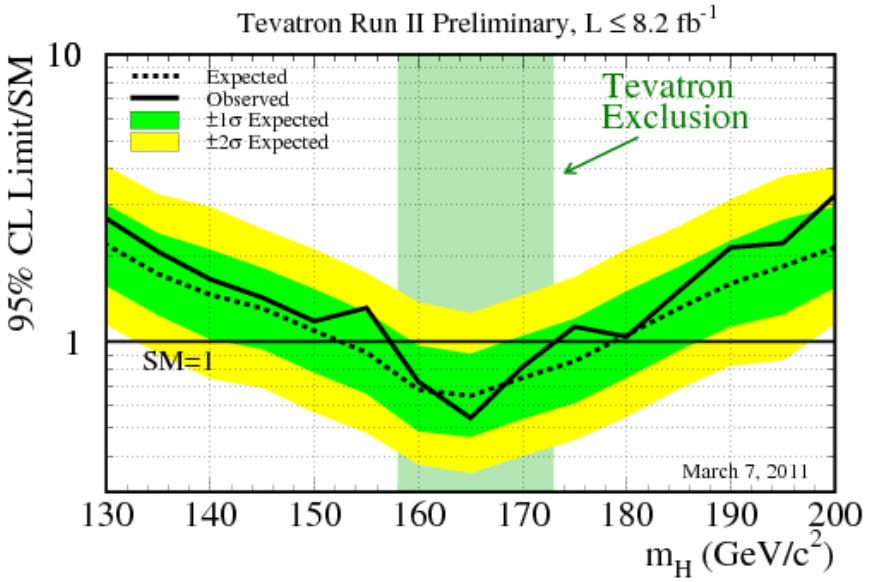
Tevatron and CDF/ DØ experiments continue to perform very well

Wealth of new results

- Across many areas

High mass Higgs combination

- **Observed: 158 < m_H < 173 GeV**
- **Expected: 153 < m_H < 179 GeV**
- **Single experiment exclusion**



Many new results soon

- eg BSM Higgs combination, full mass SM Higgs combination
- eg Updated W mass, Muon CP asymmetry

Stay tuned: Tevatron at its best!

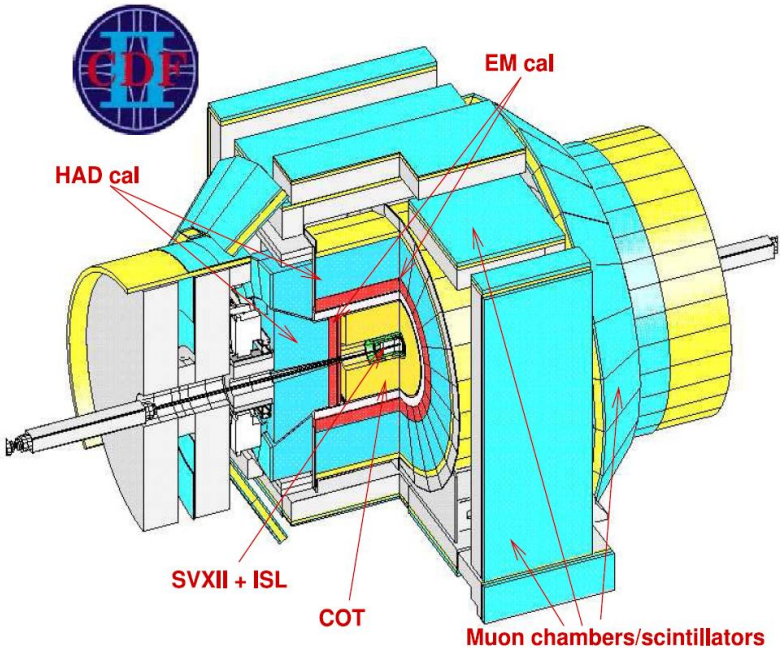
Thank you

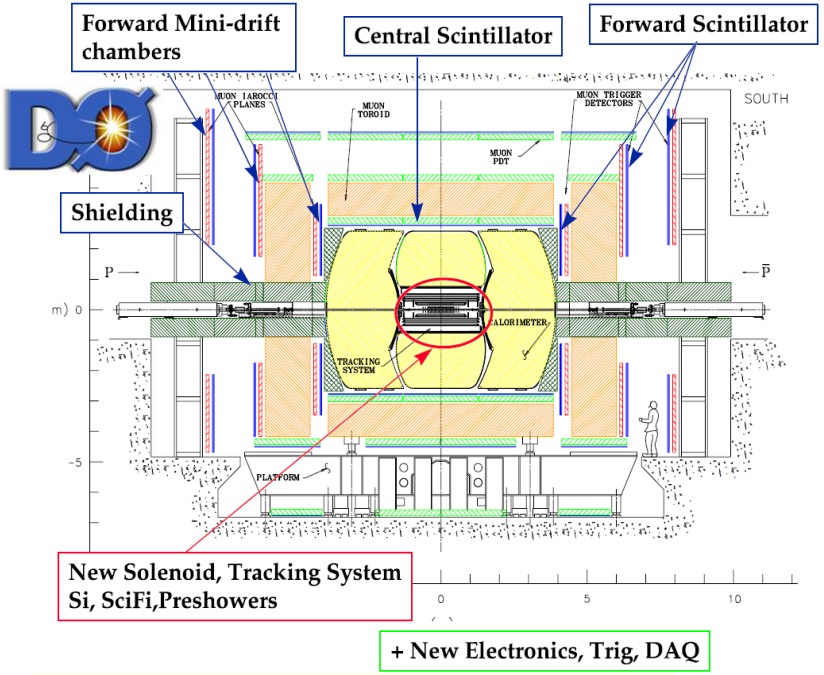
Backup slides

CDF and DØ Experiments

Both detectors extensively upgraded for Run IIa

- New silicon vertex detector
- New tracking system
- Upgraded muon chambers





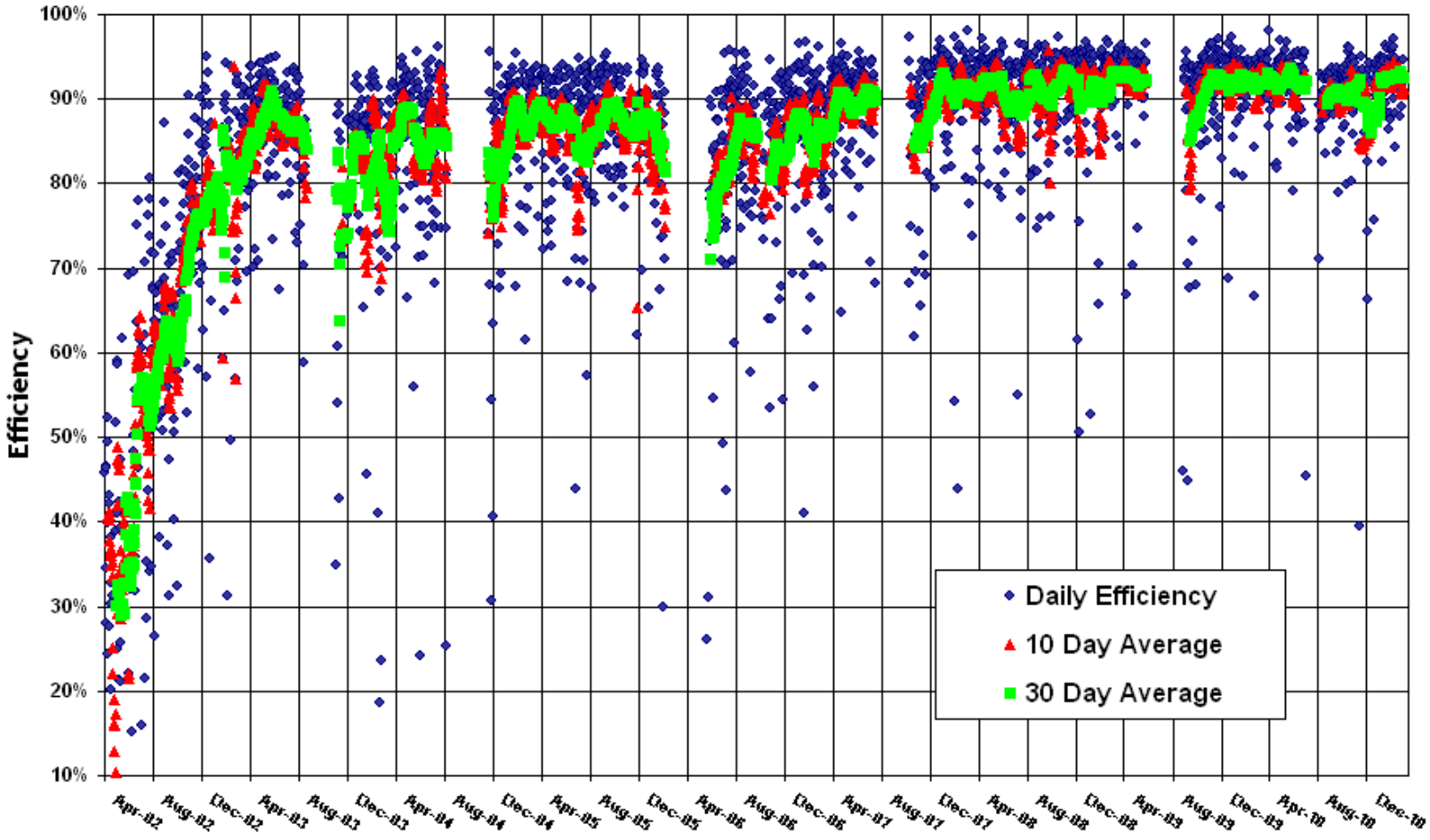
- DØ
  - New solenoid & preshowers
  - Run IIb: New inner tracking layer & L1 trigger

CDF: New plug calorimeter & ToF

DØ Data Taking

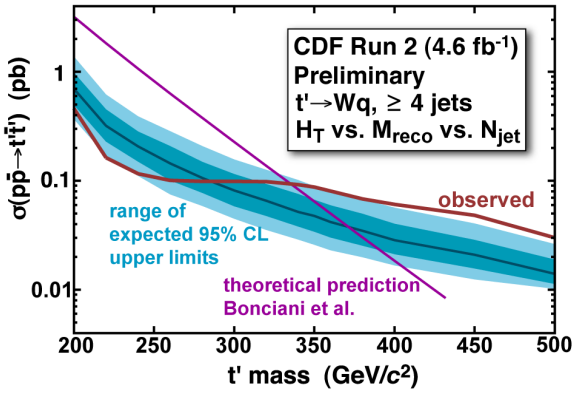
Daily Data Taking Efficiency

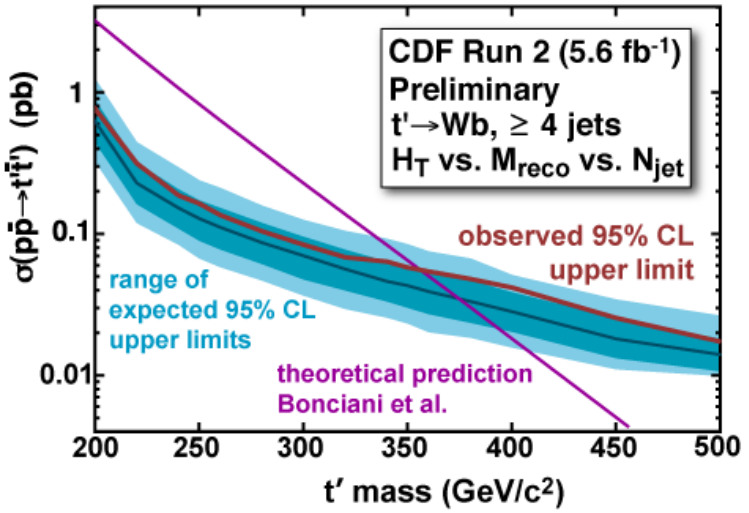
19 April 2002 - 20 March 2011



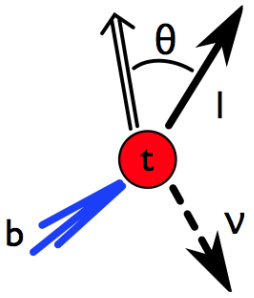
Other ‘Top’ Results

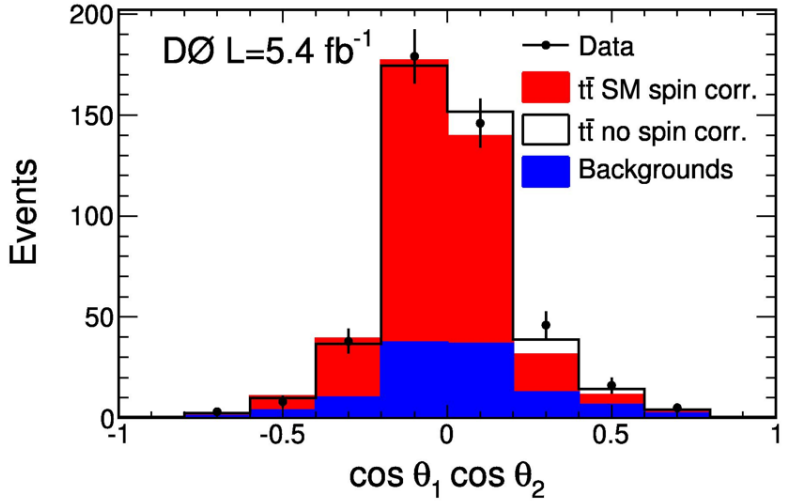
eg t’





eg spin-correlations



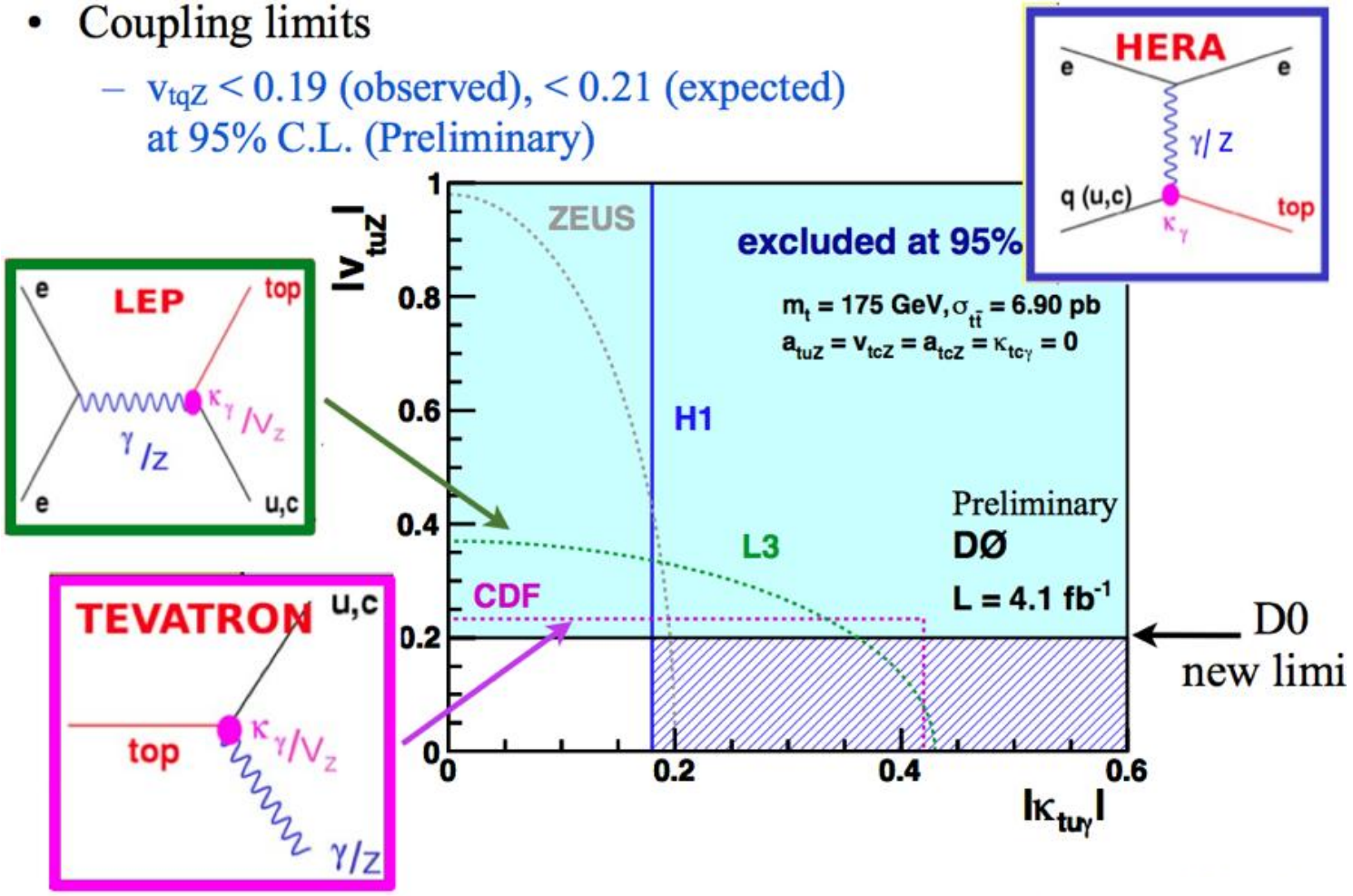


$$C = 0.10^{+0.45}_{-0.45}\,(\text{stat+syst})$$

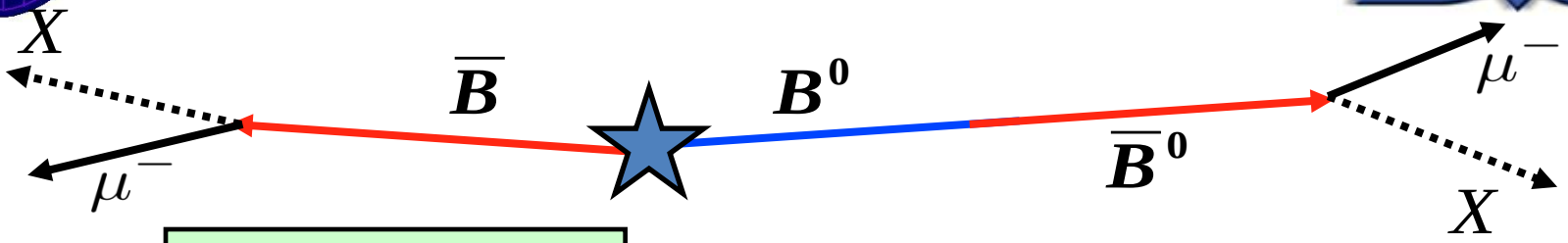
NLO QCD: $C = 0.777^{+0.027}_{-0.042}$

FCNC

- Coupling limits
  - $v_{tqZ} < 0.19$ (observed), < 0.21 (expected) at 95% C.L. (Preliminary)



CP Muon Asymmetry

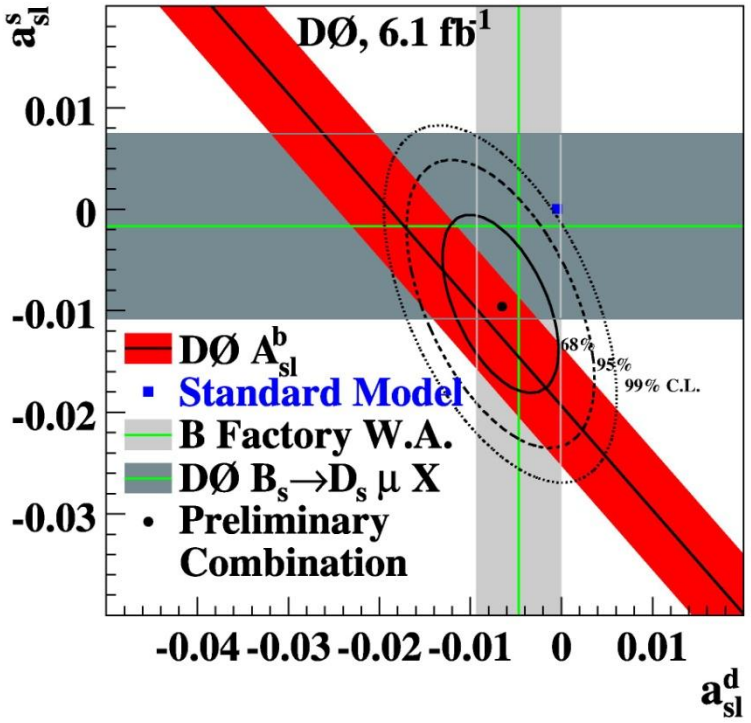


$$A_{sl}^b \equiv \frac{N_b^{++} - N_b^{--}}{N_b^{++} + N_b^{--}}$$

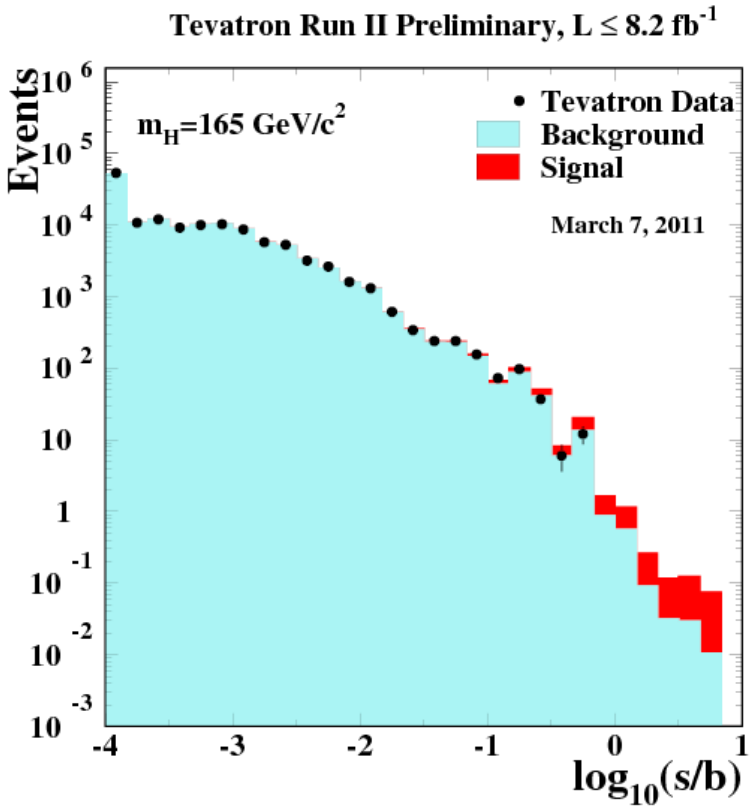
$$A \equiv \frac{N^{++} - N^{--}}{N^{++} + N^{--}}$$

$$a \equiv \frac{n^+ - n^-}{n^+ + n^-}$$

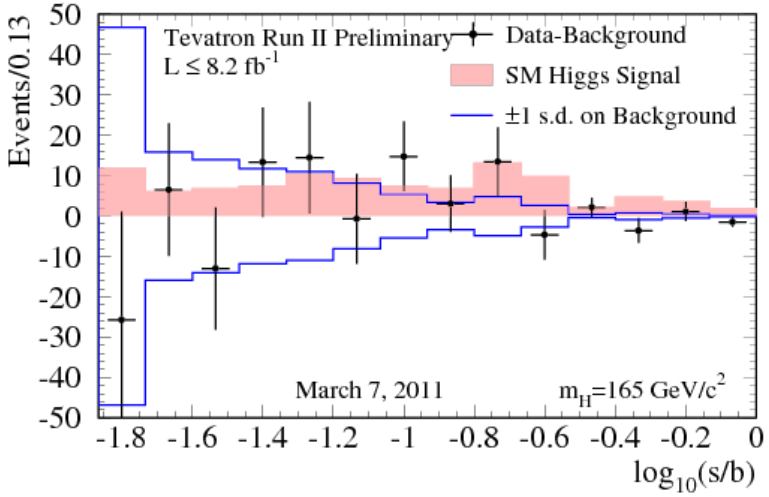
N^{++}, N^{--} : number of events with two like-sign dimuons
n^+, n^- : number of muons with given charge



Tevatron High Mass Combination



With background subtraction

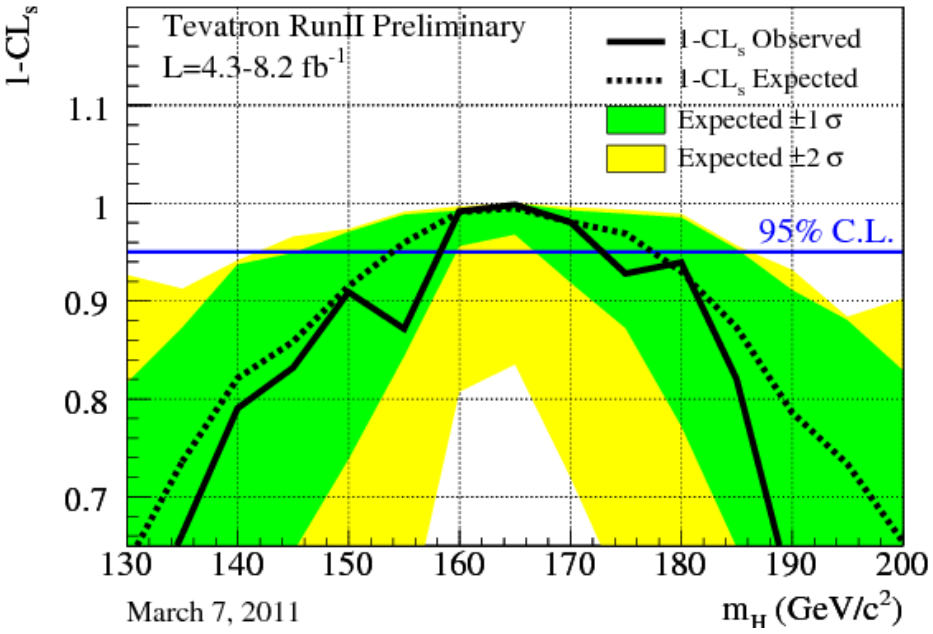


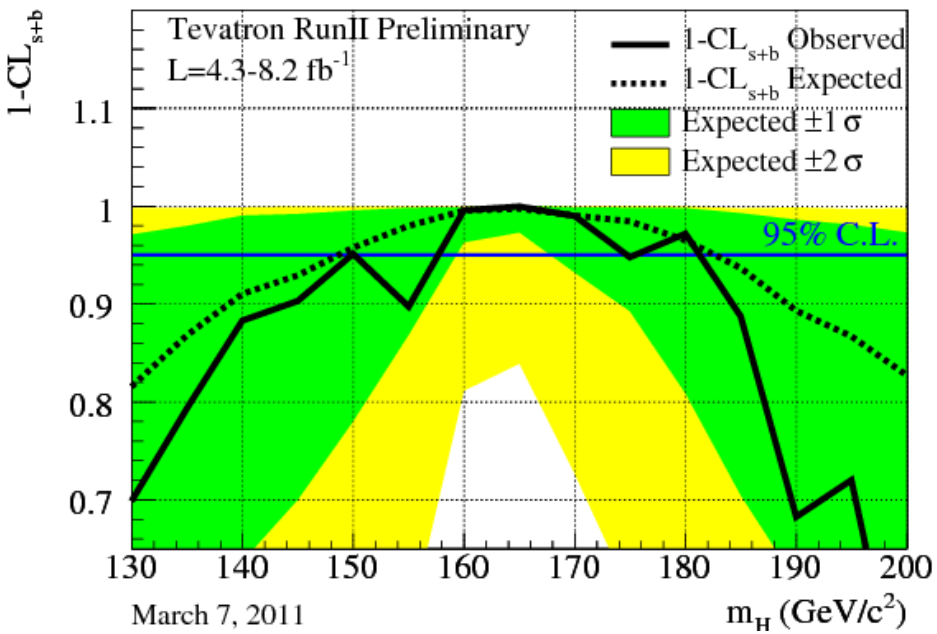
Agreement between background model and data very good

CL_s and CL_{s+b}

$CL_s = CL_{s+b}/CL_b$

CL_{s+b}





Same exclusion ranges as Bayesian approach