



Recent results from CDF

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for CDF collaborations

New Developments of Flavor Physics

2009

Mar. 9th, 2009

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- Tevatron Status
- B physics → by Junji Naganoma
- Top quark → by Koji Nakamura
- Search for SM Higgs → in this talk



Tevatron Run II

Still at the Energy Frontier



Tevatron:

- The world's highest-energy particle collider
- Proton-antiproton collisions at $\sqrt{s} = 1.96$ TeV
- Tevatron is performing really well:

Reach 6 fb^{-1} and $7\sim 8 \text{ fb}^{-1}$ expected by the end of 2009.



The CDF II Detector

■ Silicon Tracking Detectors

■ Central Drift Chambers (COT)

■ Solenoid Coil

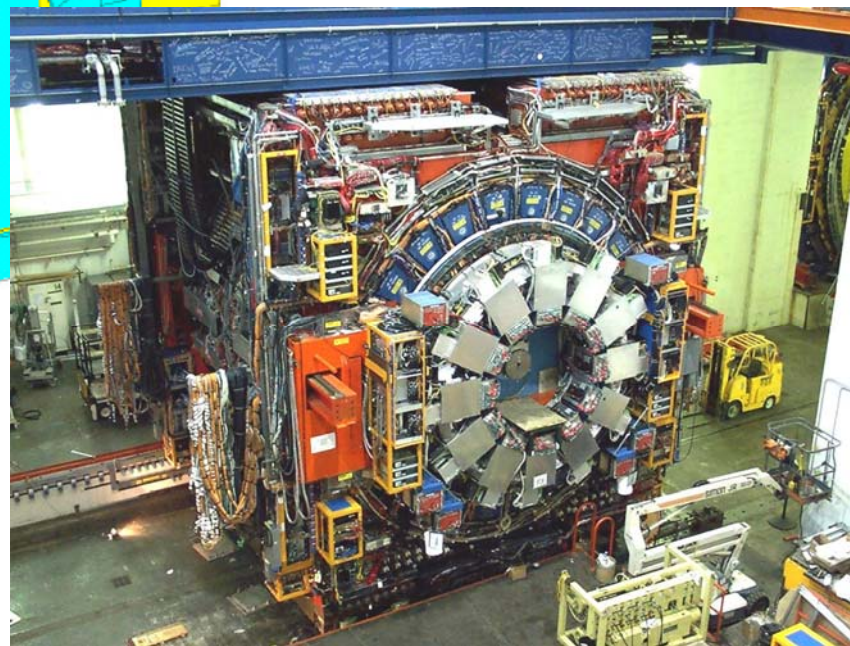
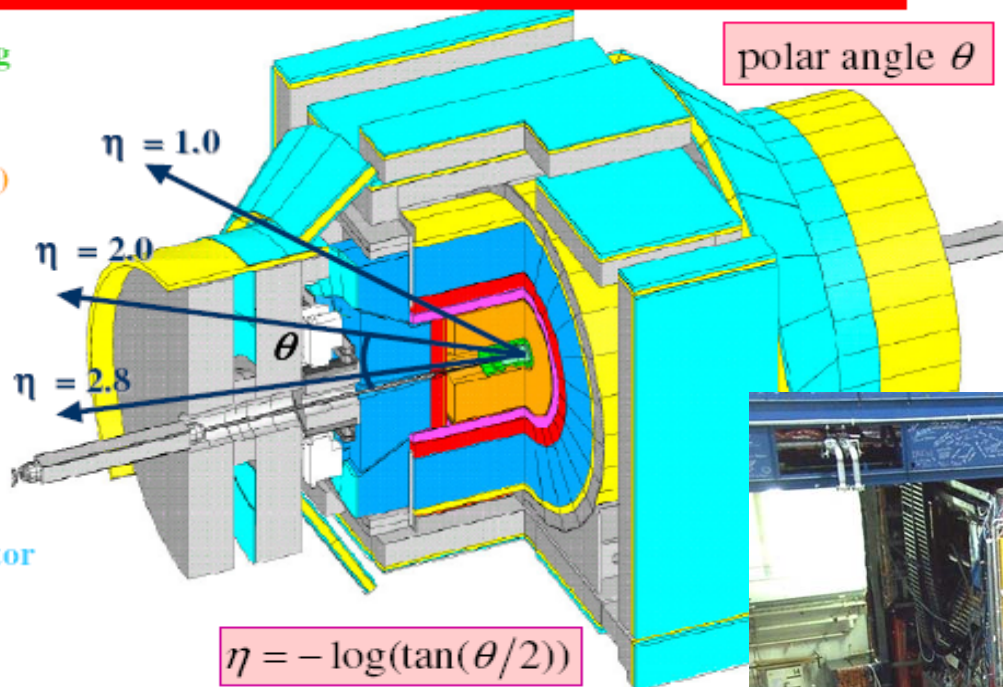
■ EM Calorimeter

■ Hadronic Calorimeter

■ Muon Drift Chambers

■ Muon Scintillator Counters

■ Steel Shielding

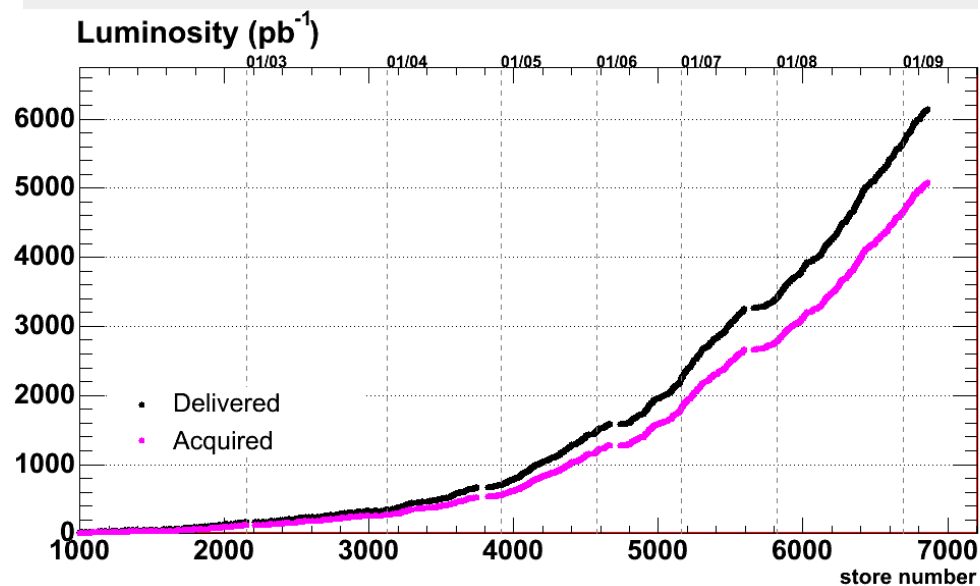
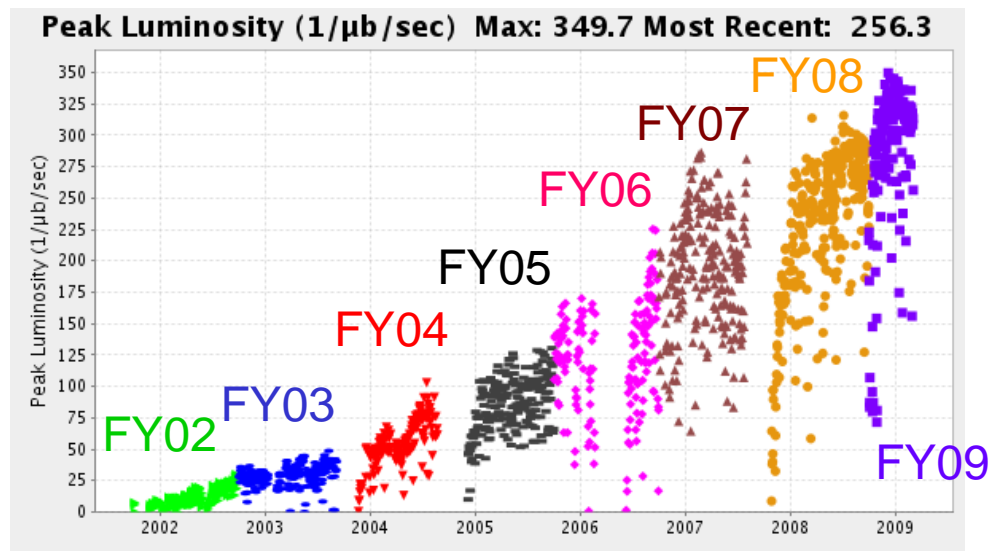


- Silicon vertex detector (1+5+2 layers)
- Central drift chamber (8 super layers)
- 1.4T solenoid
- Good particle identification (K, π)
- Central/Wall/Plug calorimeters
- Scintillator+drift chamber muon detectors



Tevatron Status

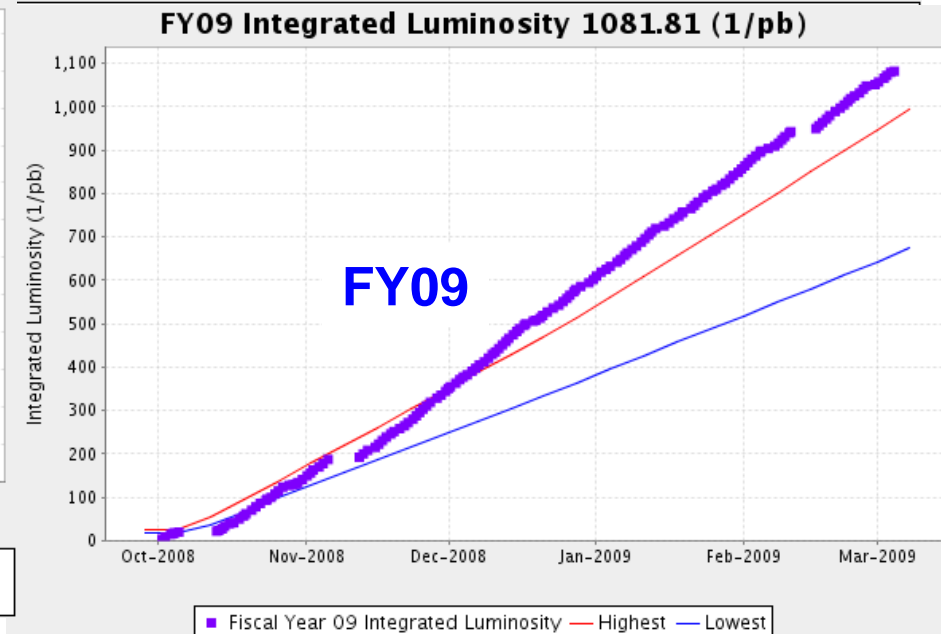
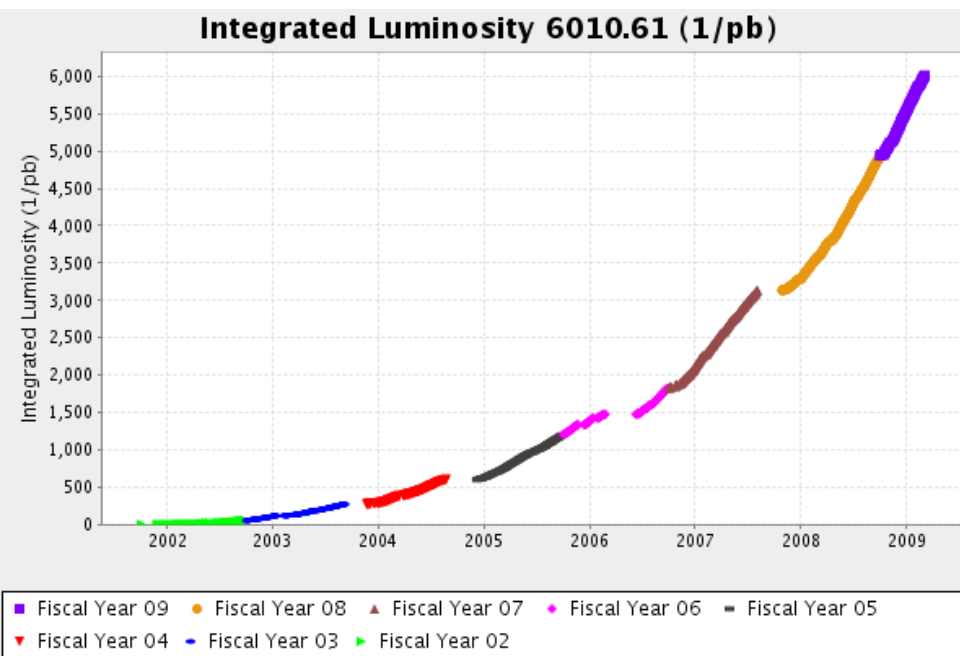
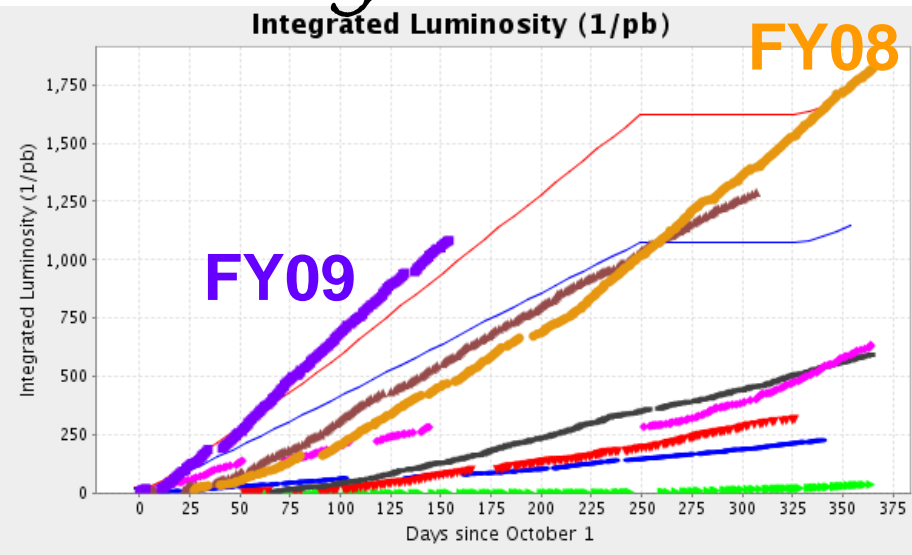
- Continually establishing new records!
 - Peak luminosity
 $\sim 3.5 \times 10^{32} \text{ cm}^{-2} \text{ s}^{-1}$
 - Weekly integrated luminosity
 $78 \text{ pb}^{-1}/\text{week}$
 - Annual integrated luminosity
 1.8 fb^{-1} (US FY 2008)
 - Average pbar accumulation rate
 - $21 \times 10^{10} \text{ pbar/ hour}$
- Very stable operation
 - Maximizing integrated luminosity
 - ~ 12 weeks shutdown in 2009 summer





Integrated Luminosity

- Integrated luminosities for each US FY
 - Extrapolation for FY2009: $\sim 2 \text{ fb}^{-1}$





Tevatron Prospects

FY2009

Run continues

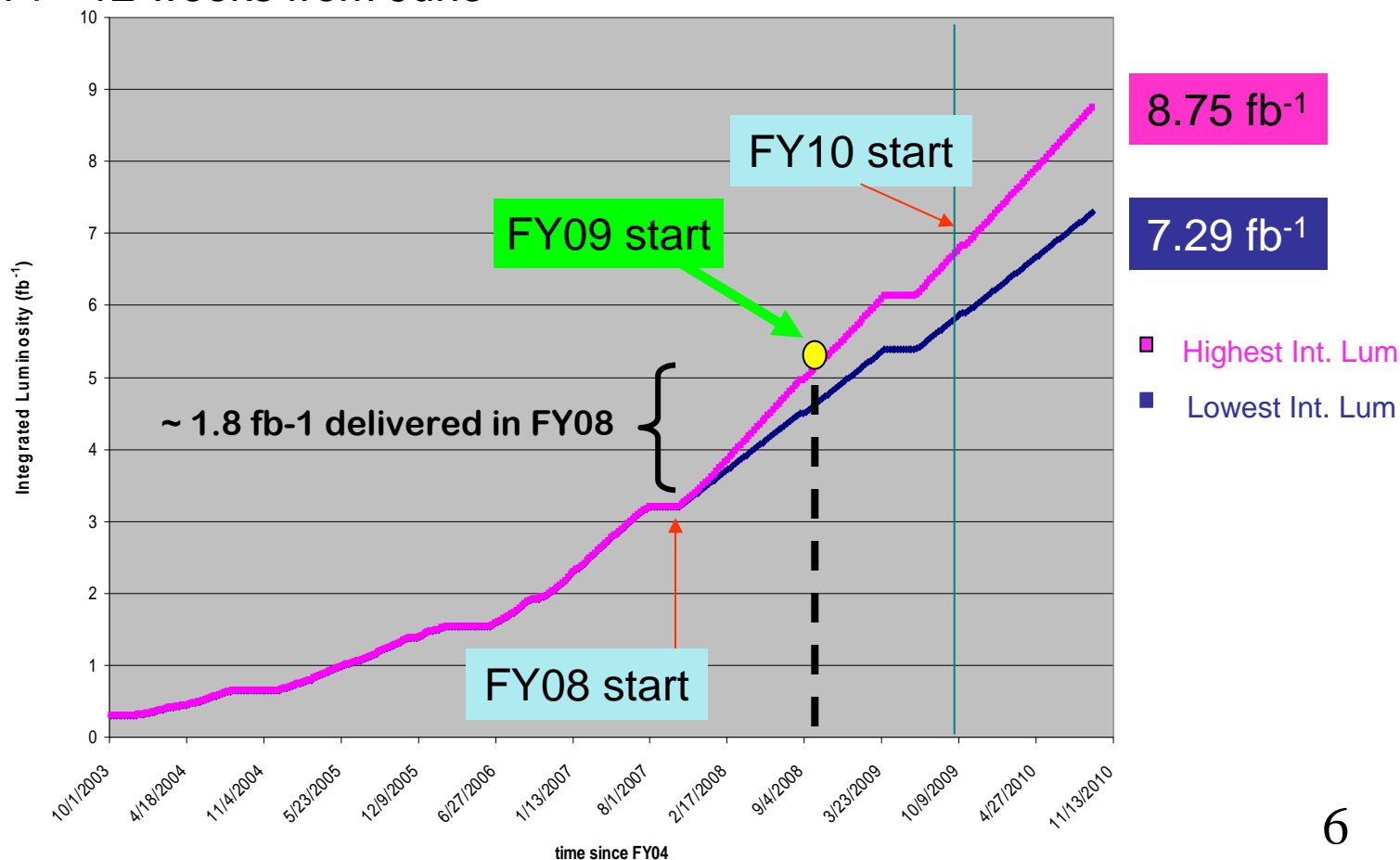
~2 fb⁻¹, total ~7 fb⁻¹

Shutdown : ~12 weeks from June

FY2010

Fermilab plans to run (if budget allows)
and CDF/DZero are ready

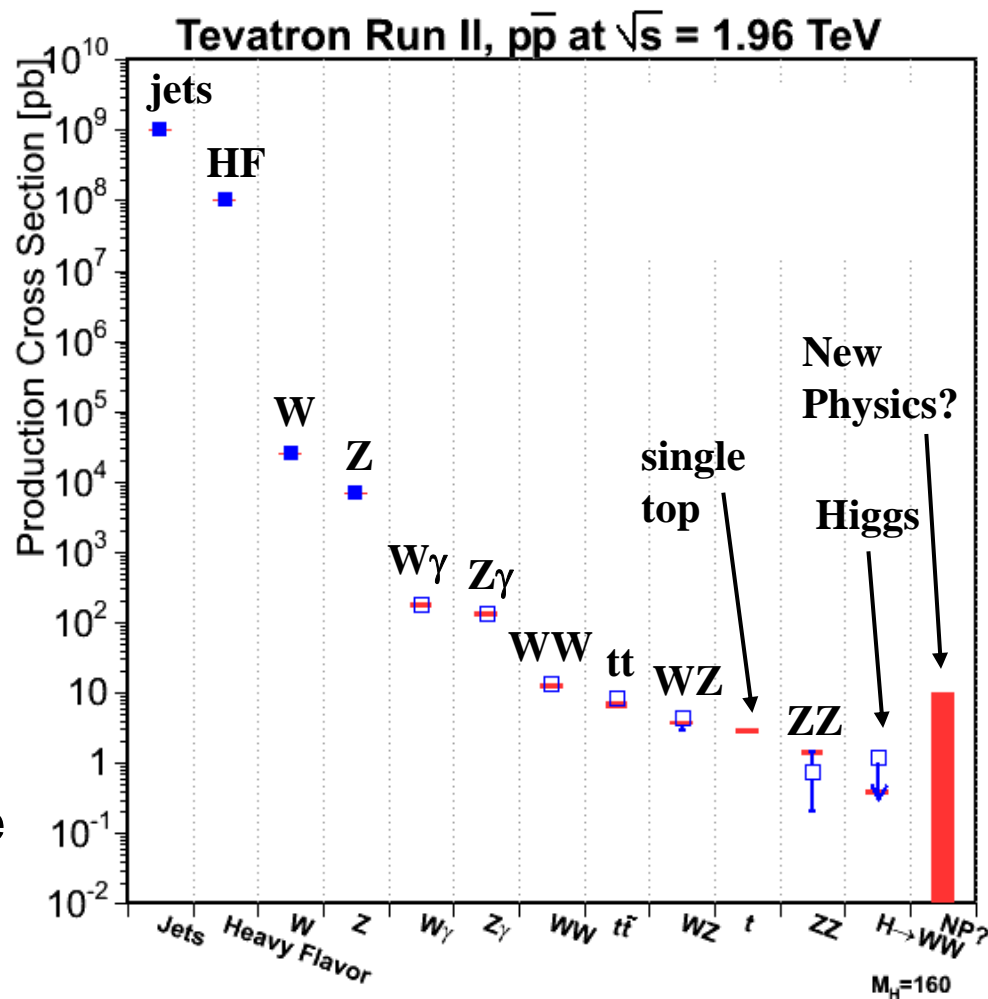
– Another ~2.5 fb⁻¹, total ~9 fb⁻¹





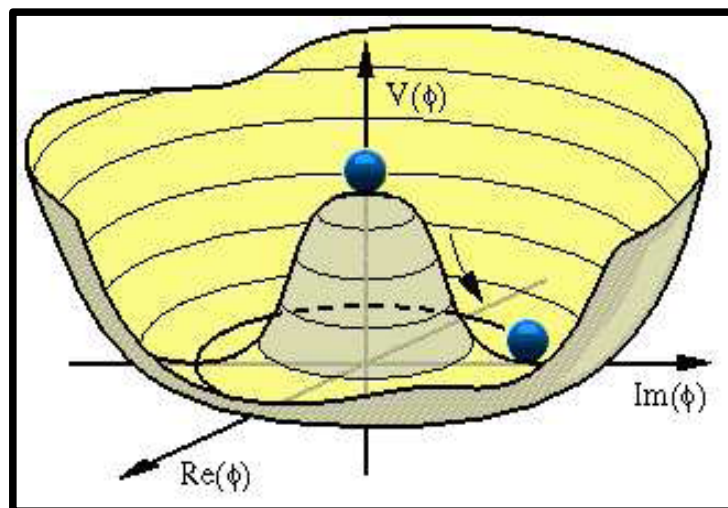
Physics Programs at Tevatron

- New SM process
 - WZ, ZZ, Single-Top, ...
- Top quark physics
- Precise measurement
 - W mass, ...
- Heavy flavor physics
 - $\sigma(bb) \sim 100\mu\text{s}$
- Higgs search
- Search for new physics
 - First exploration of TeV scale





SM Higgs Search





Higgs Cross-section and BR

Low mass Higgs region:

$$m_H < 135 \text{ GeV}/c^2$$

$H \rightarrow bb$ dominant decay.

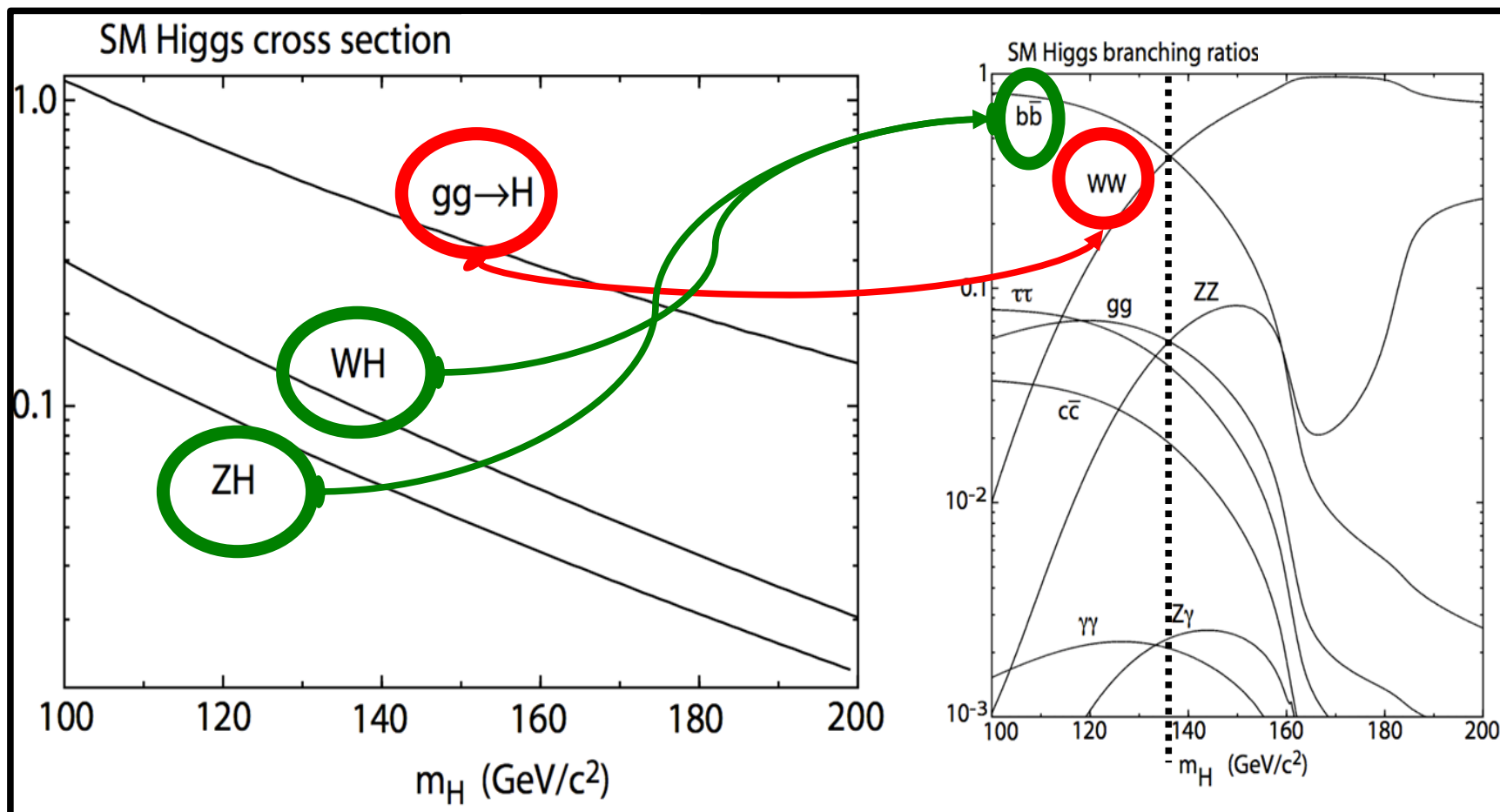
Search for associated W/Z production.

High mass Higgs region:

$$m_H > 135 \text{ GeV}/c^2$$

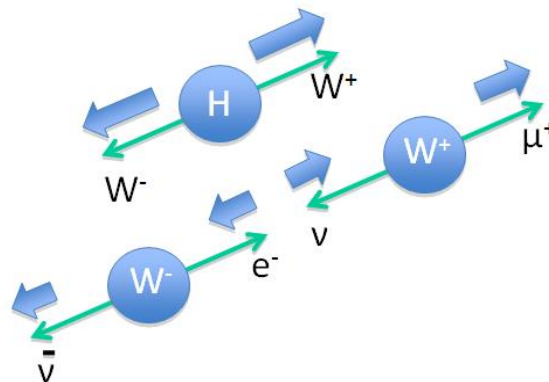
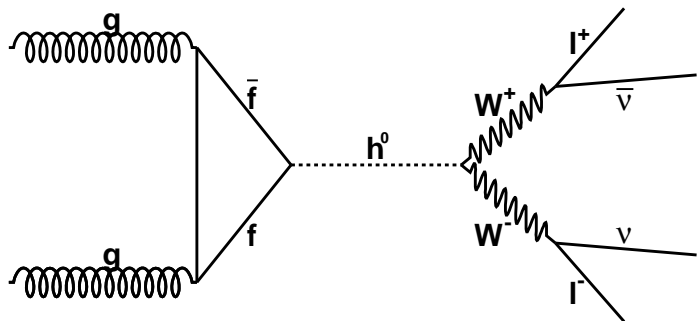
$H \rightarrow WW$ dominant decay.

Gluon fusion production search ($gg \rightarrow H$).

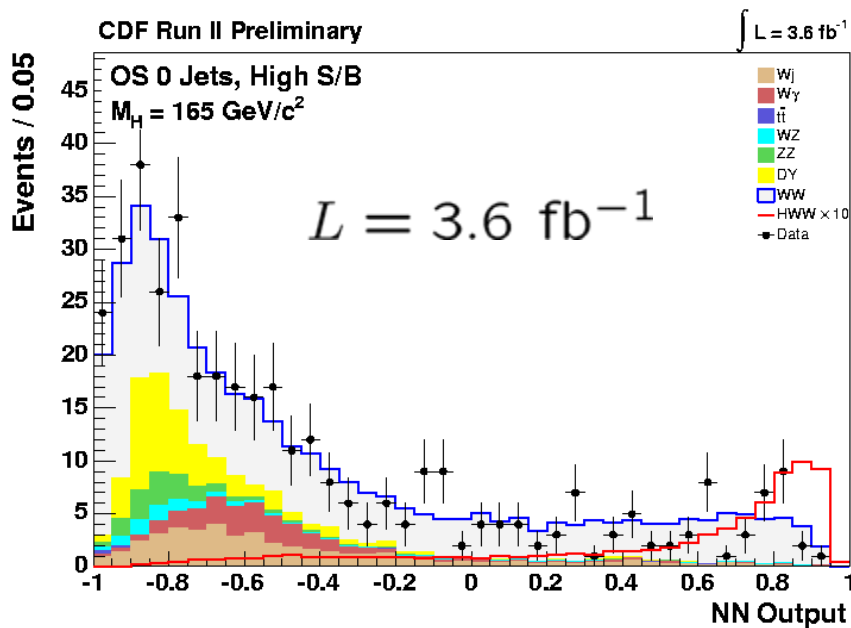
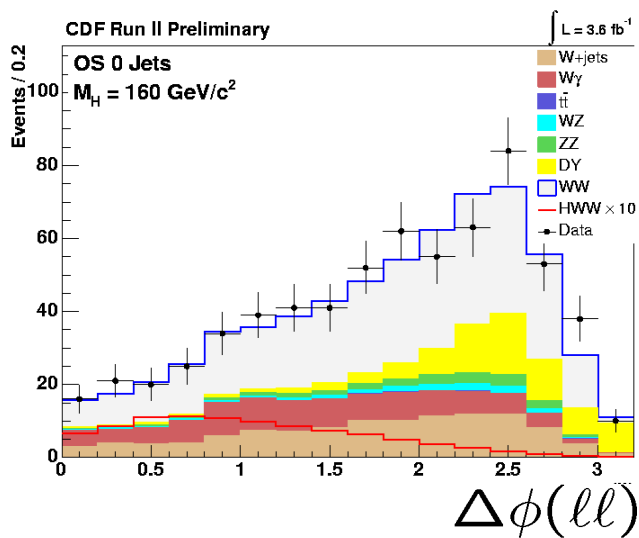




$$H \rightarrow WW \rightarrow l^+ \nu l^- \nu$$



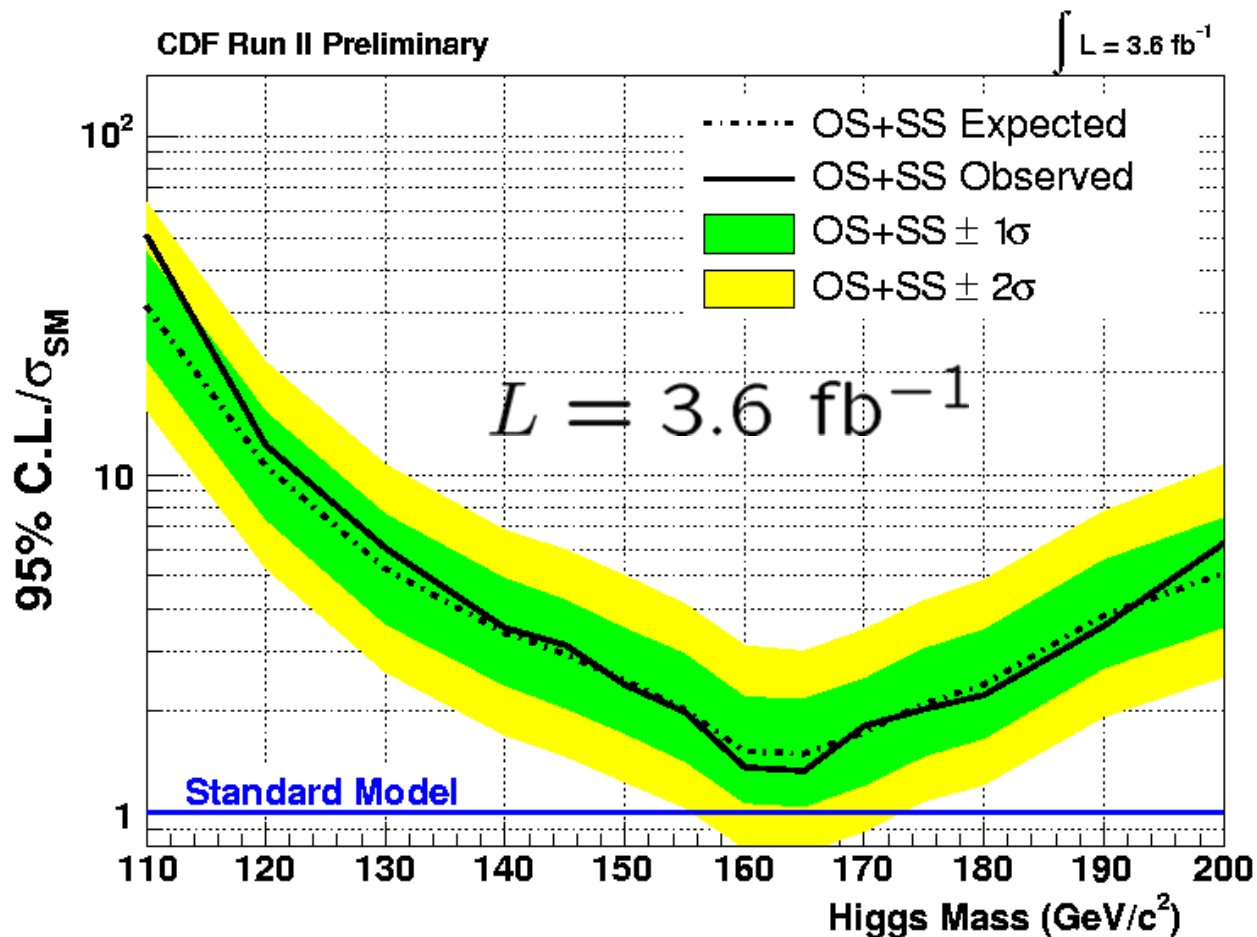
- 2 opposite sign leptons + MET
- WW from spin 0 higgs
 - leptons tend to same direction
 - $\Delta\phi$ is best discriminant
- Neural network technique





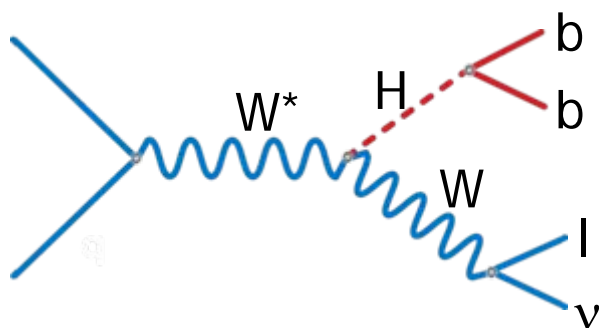
$$H \rightarrow WW, WH \rightarrow WWW^*$$

- Also search for same sign leptons for $WH \rightarrow WWW^* \rightarrow l^\pm l^\pm X$
- Limit: $< 1.45 \times \text{SM} @ M_H = 160 \text{ GeV}/c^2$





WH \rightarrow lvbb

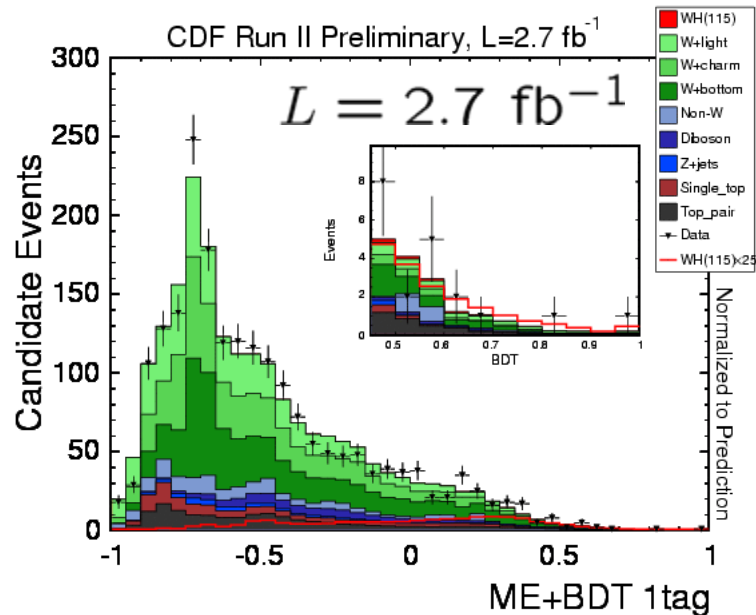
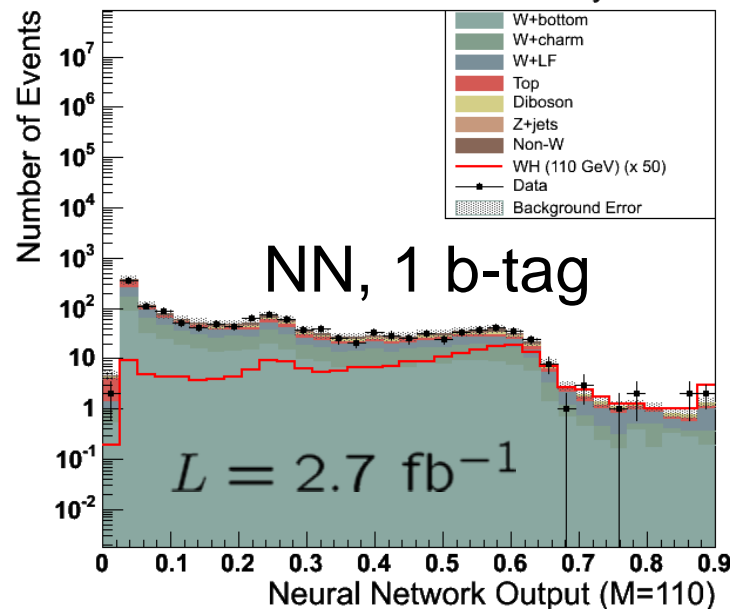


$1\ell + \cancel{E}_T + 2b$ jets

Bkg: W+bb, W+cc, W+qq, ttbar, ...

- Neutral network (NN) technique
 - Limit: $< 5.2 \times \text{SM}$ @ $M_H=115\text{GeV}/c^2$
- Matrix element (ME) + Boosted decision tree (BDT) technique
 - Limit: $< 5.24 \times \text{SM}$ @ $M_H=115\text{GeV}/c^2$

CDF Run II Preliminary 2.7 fb⁻¹

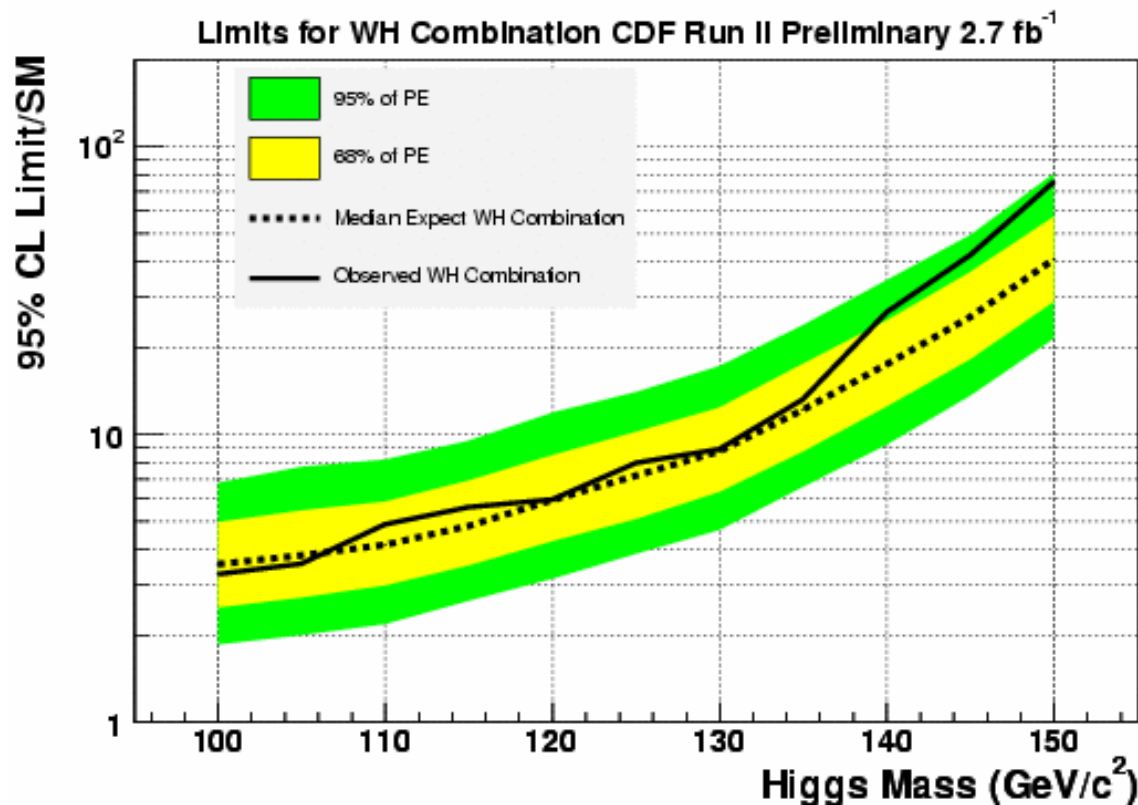




$WH \rightarrow l\nu b\bar{b}$ (Combined)

Updated on Nov 7, 2008

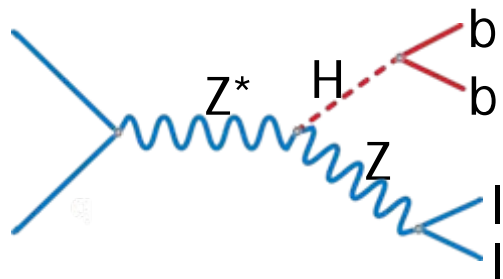
- Combined result of NN and ME+BDT
- Improved by 15%
- Limit: $< 4.8 \times \text{SM}$ @ $M_H = 115 \text{ GeV}/c^2$





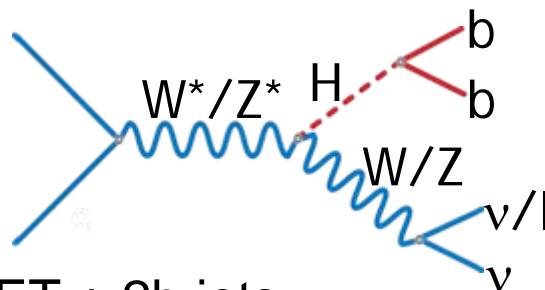
Other Low Mass Higgs Searches

$$ZH \rightarrow llb\bar{b}$$



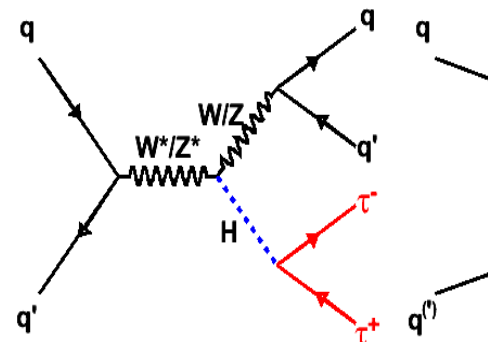
- 2lepton+2b-jets
- Limit: $< 7.1 \times \text{SM}$
@ $M_H = 115 \text{ GeV}/c^2$

$$ZH + WH \rightarrow b\bar{b} \cancel{E}_T$$



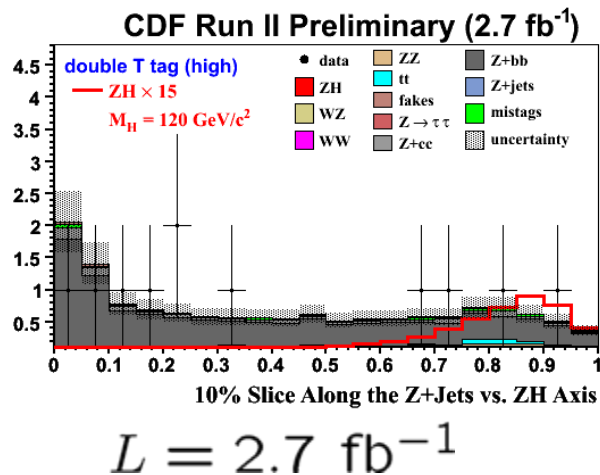
- MET + 2b jets
- Limit: $< 5.6 \times \text{SM}$
@ $M_H = 115 \text{ GeV}/c^2$

$$H \rightarrow \tau\tau$$

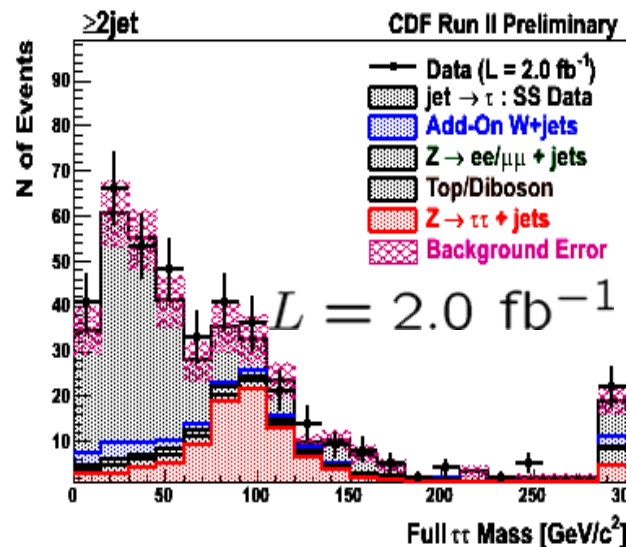
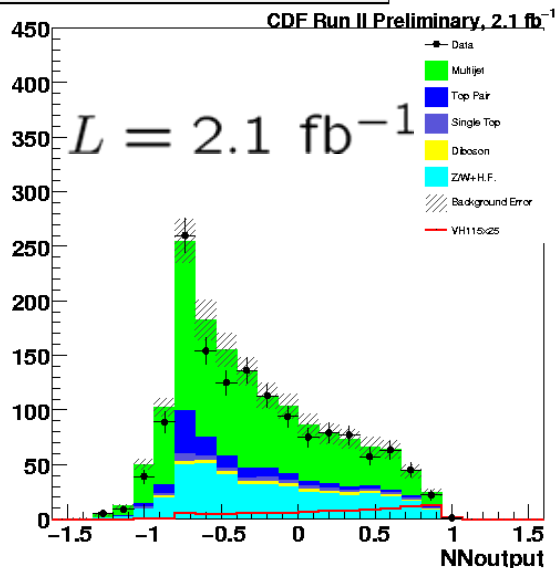


- τ had + τ lep + 2 jets
- Limit: $< 25 \times \text{SM}$
@ $M_H = 115 \text{ GeV}/c^2$

Number of Events

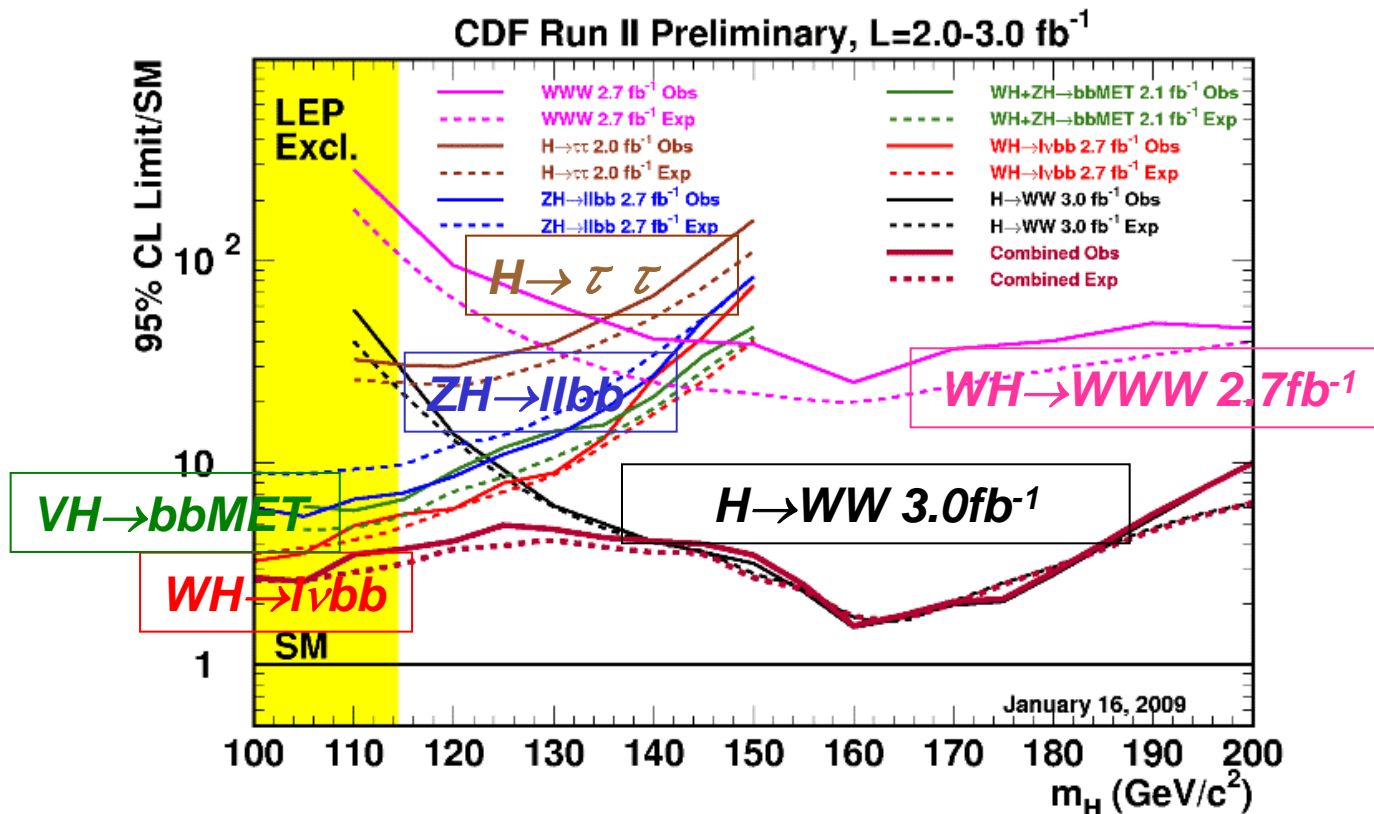


NNoutput, Signal Region, Exclusive ST





CDF Combined Results



Updated on Jan 16, 2009

- $H \rightarrow WW$, $WH \rightarrow WWW \ 3.6 \text{ fb}^{-1}$ results NOT included
- Limits: $< 3.2 \times \text{SM} \ @ \ M_H=115 \text{ GeV}/c^2$
 $< 1.7 \times \text{SM} \ @ \ M_H=160 \text{ GeV}/c^2$

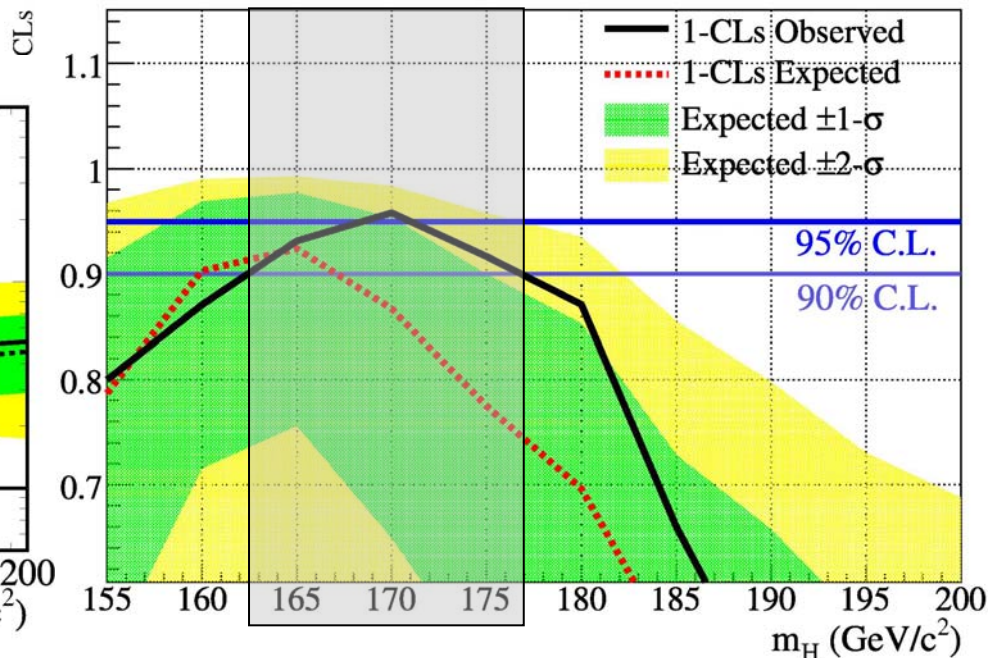
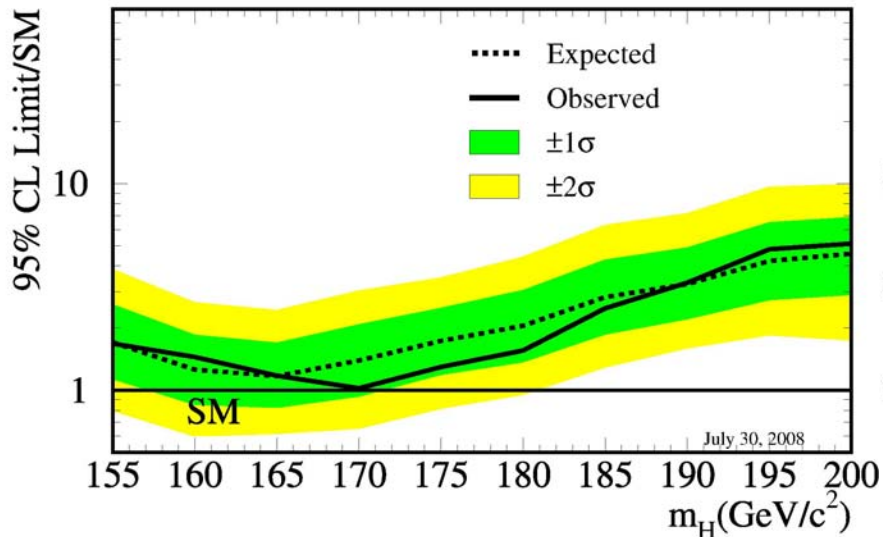


Higgs Exclusion @ Tevatron

CDF+DZero combination

Updated on Jul 30, 2008

Tevatron Run II Preliminary, $L=3 \text{ fb}^{-1}$



CDF + D0 combined :

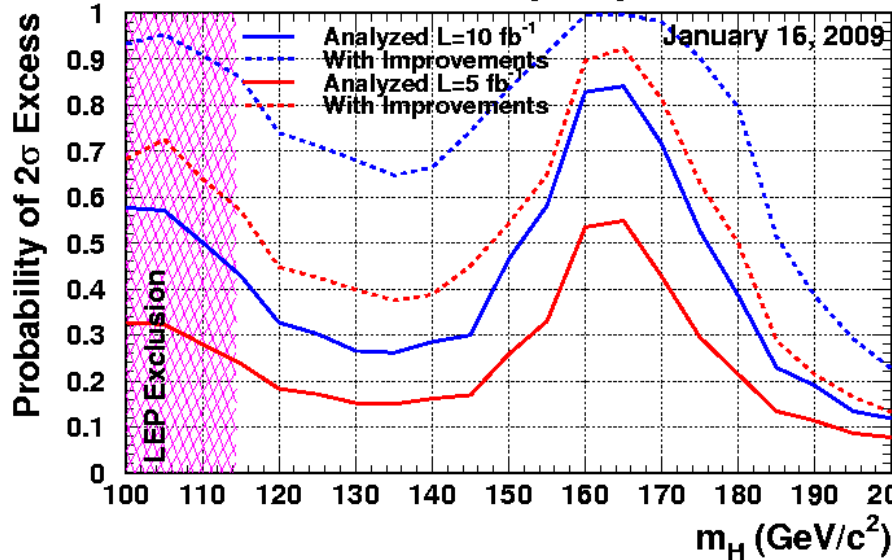
$m_H = 170 \text{ GeV}/c^2$ excluded (95%)

- One mass, 170 GeV, excluded @ 95% CL
- A 15 GeV window [162:177] excluded @ 90% CL

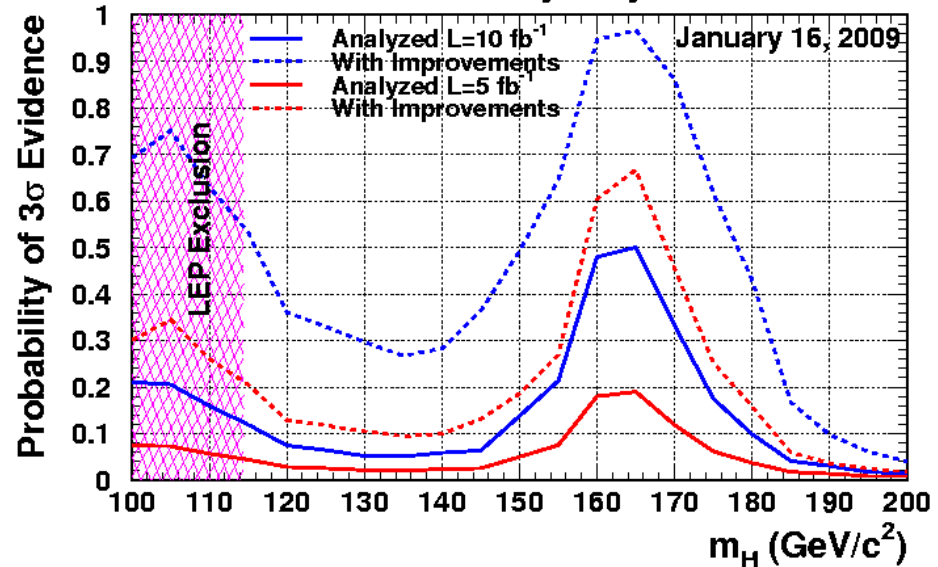


Projections

2xCDF Preliminary Projection



2xCDF Preliminary Projection



- CDF+DZero projections assuming they perform the same (2xCDF)
- Possible improvements:
 - Acceptance, Analysis method, jet/MET resolutions, ...
- Good possibility to see 3σ evidence to a Higgs of $160 \text{ GeV}/c^2$
 - Doesn't take data already analyzed into account.
- Good possibility to see 2σ excess to low mass higgs or to exclude at 95% CL if there is no higgs.



Summary

- Tevatron is operating well. Better than ever!
- CDF and DZero experiments are ready to run FY2010. $\int L dt \gtrsim 9 \text{ fb}^{-1}$ is expected.
- We are now sensitive to a Higgs of $160 \text{ GeV}/c^2$.
- Updated results on higgs search will be shown at Moriond **very soon!**
- **Exciting results on B and top physics will be shown by the following speakers.**



What is a Boosted Decision Tree?

- Weight W_i for each event(= 1 to start)
- Purity: $P = \frac{\sum W_s}{(\sum W_s + \sum W_b)}$
- Split until minimal #event reached or limit of purity reached
 - if $P > P_{min}$ “signal leaf”
 - if $P < P_{min}$ “background leaf”
- Boosting
 - if a signal event is on a bkg leaf or if a bkg event is on a signal leaf
 - weight modified
- Then training re-performed with the new weights

