Search for a High Mass SM Higgs Boson at the Tevatron

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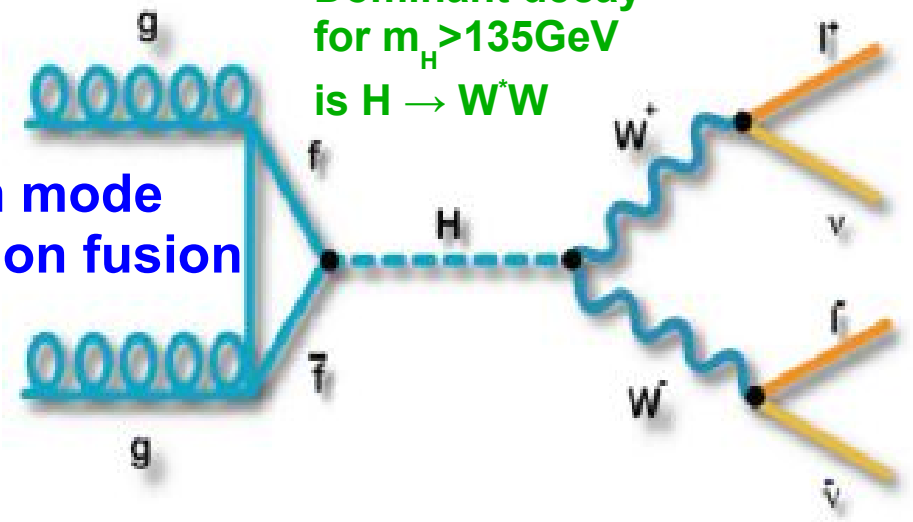
On behalf of the CDF and DØ collaborations

H → WW Overview

Dominant production mode at the Tevatron is gluon fusion

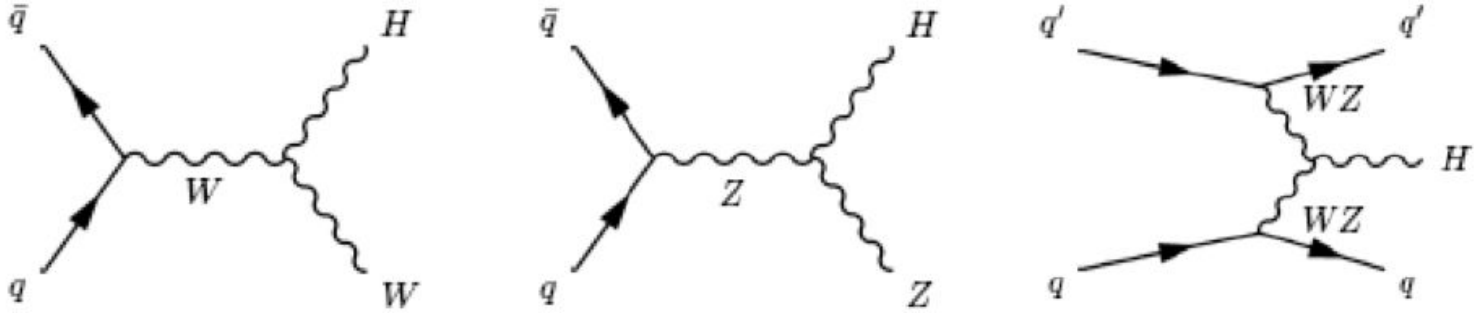


Dominant decay for m_H>135GeV is H → W*W

2 opposite charge high p_T leptons (electrons, muons) + Missing E_T

Consider all final states with 2 high p_T leptons and missing E_T:

Di-lepton + missing E_T search



Associated production and Vector Boson Fusion add ~35% more signal

Most sensitive Higgs search channel at the Tevatron
Both experiments are approaching SM sensitivity

$H \rightarrow WW$ Channels

- Opposite charge dileptons in the final state:
  - Gluon Fusion: $gg \rightarrow H \rightarrow WW^* \rightarrow l^+\nu l^-\nu$
  - Associated Production: $VH \rightarrow VWW^* \rightarrow l^+\nu l^-\nu+X$
  - Vector Boson Fusion: $qqH \rightarrow qqWW \rightarrow l^+\nu l^-\nu+X$
  - Low dilepton invariant mass search region
- Same charge dileptons in the final state:
  - $VH \rightarrow VW^+W^- \rightarrow l^\pm\nu l^\pm\nu+X$
- CDF: $4.8 fb^{-1}$
- DØ: $3.6 - 5.4 fb^{-1}$

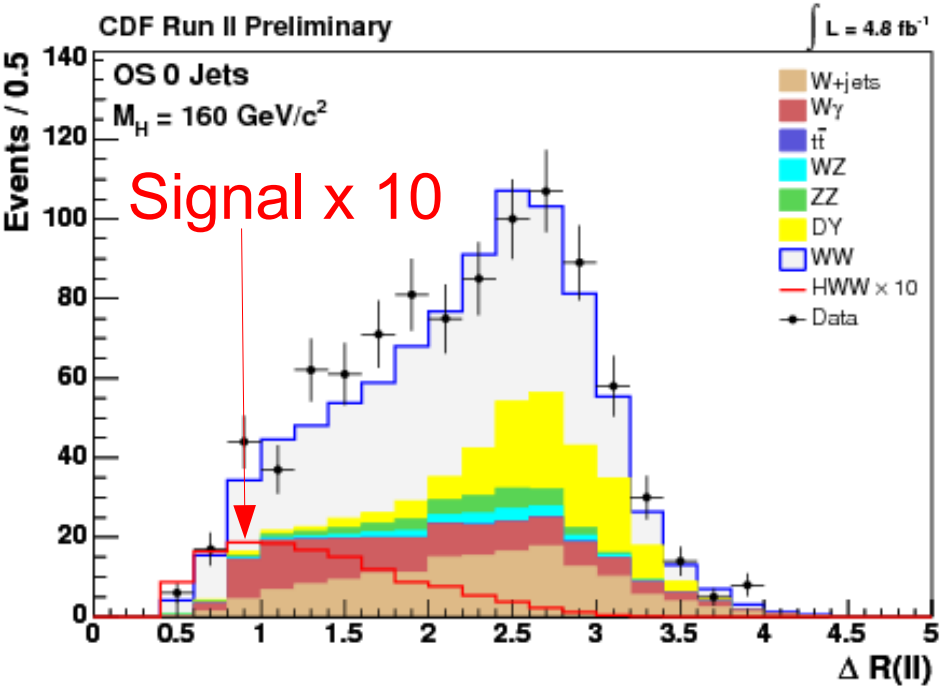
Analysis Overview

Event signature:

- Two isolated high pT leptons with opposite charge
- Large missing E_T

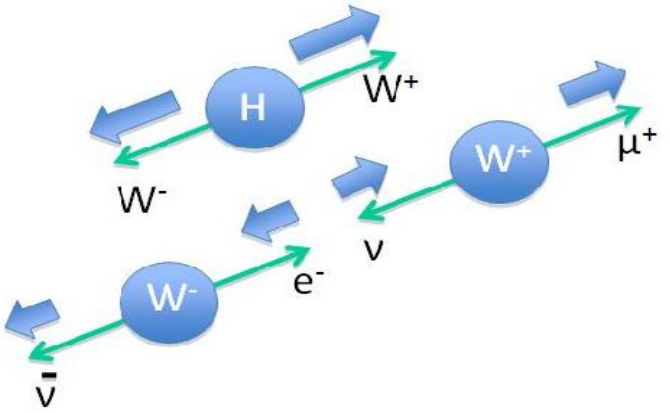
Backgrounds:

- Diboson (mainly WW)
- Drell-Yan
- Top, W+Jets, W+γ, Multijet



Take advantage of spin correlations:

- Di-lepton pairs from signal more aligned
- Di-lepton pairs from SM backgrounds more back-to-back
- Main discriminant against irreducible background from non-resonant W pair production



Signal and background cross sections are normalized with the highest order cross section available (NLO or better)

CDF: Event Selection

- Trigger High P_T lepton
- $P_T^{l1} > 20$ GeV
- $P_T^{l2} > 10$ GeV
- Opp Charge leptons
- $M_{ll} > 16$ GeV
- $P_T^{jet} > 15$ GeV
- $\not\!\!E_T^{spec} > 25$ (ee,μμ)
- $\not\!\!E_T^{spec} > 15$ (eμ)

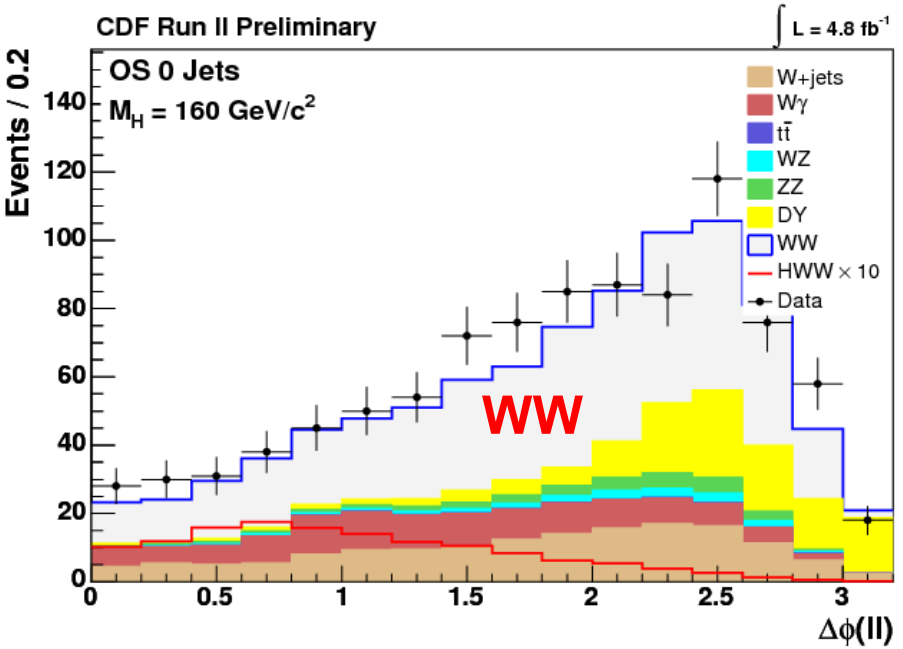
To maximize sensitivity, event samples are split by jet multiplicity:
→ 0-jet bin
→ 1-jet bin
→ ≥2-jet bin

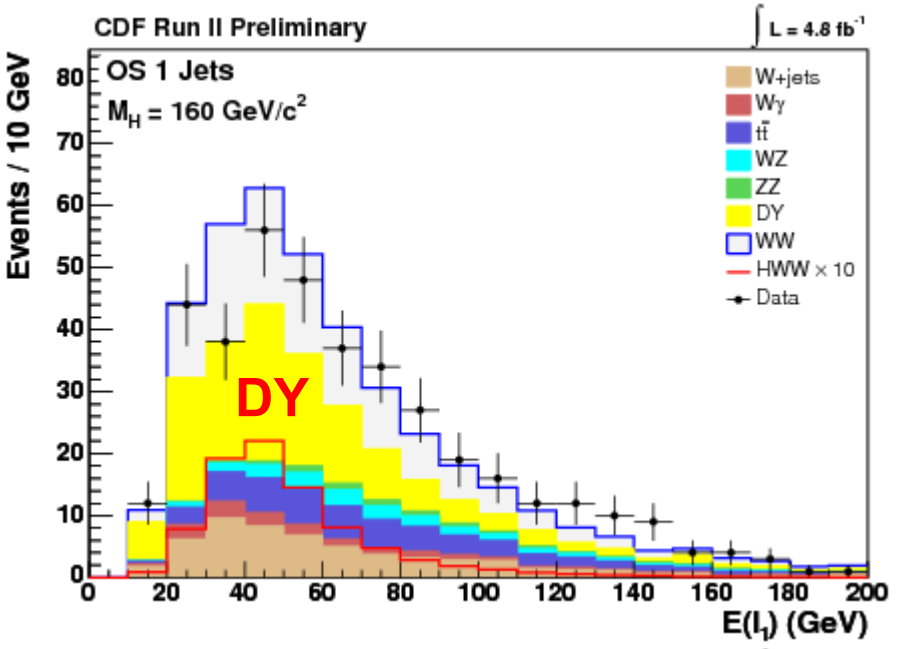
To increase signal acceptance, events with low dilepton invariant mass (M_{ll}<16GeV) are considered separately

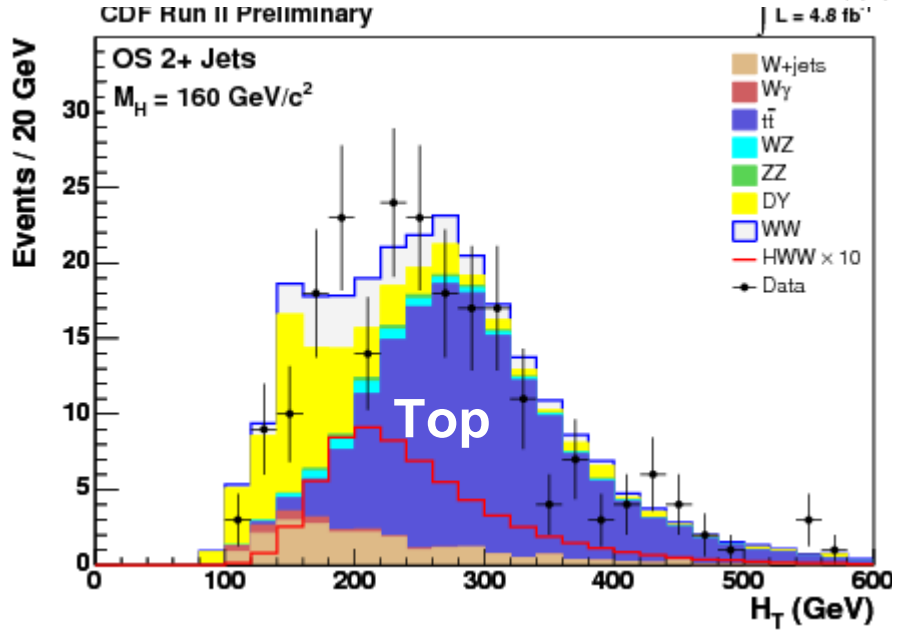
~30 Higgs events expected after final selection (m_H=165GeV)

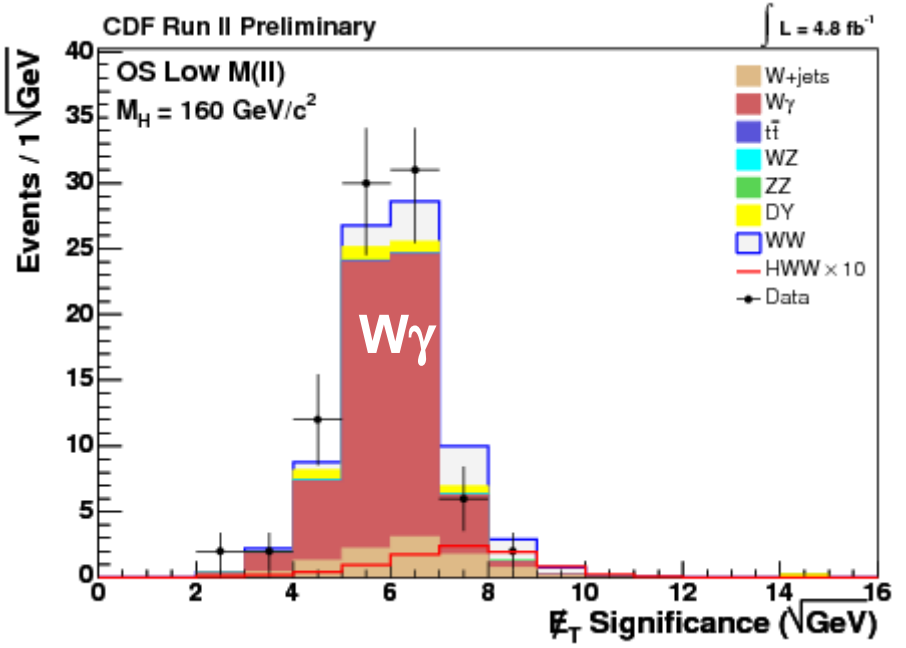
Sub-channel	N(Signal) m_H=165GeV	N(Bkgd)	N(Data)
0-jet	12.6 ± 1.7	893 ± 79	950
1-jet	8.2 ± 1.7	406 ± 52	393
≥2-jet	6.4 ± 1.8	254 ± 33	224
Low M_{ll}	0.75 ± 0.12	81 ± 7	85

CDF: Data Modeling







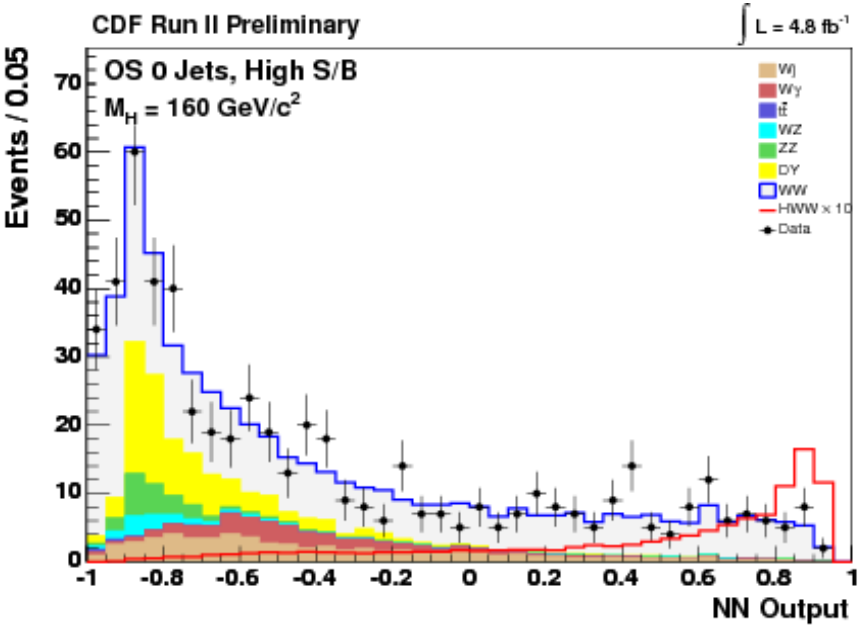


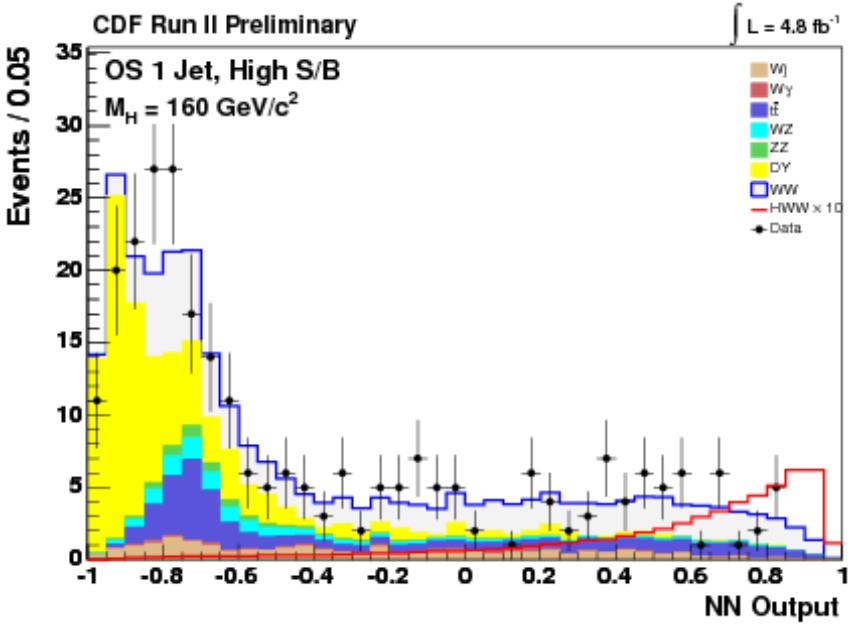
CDF: Multivariate Discriminant

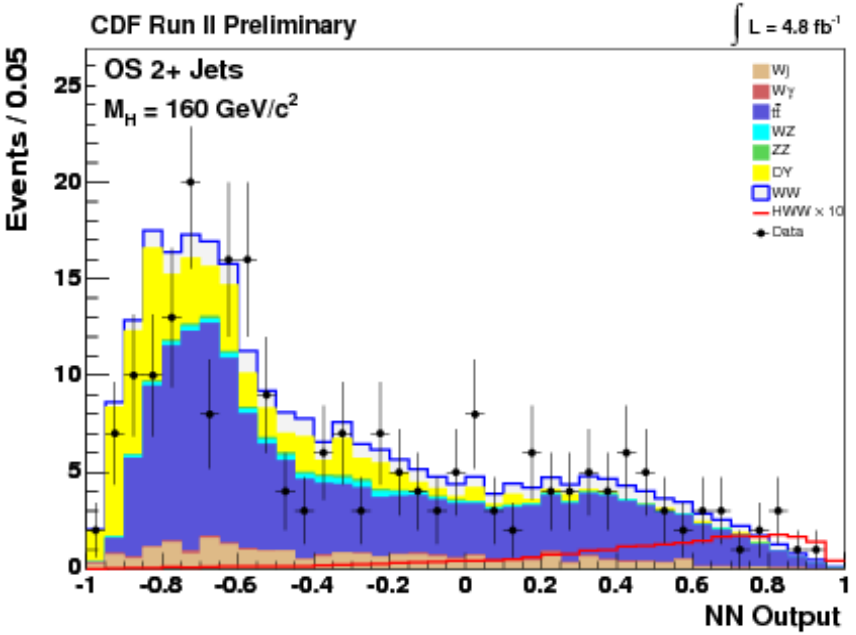
Using a Neural Network to separate a potential Higgs signal from background

Using additional Matrix Element input for the 0-jet Neural Network

Split 0-jet and 1-jet samples further into loose & tight lepton ID (Low & High S/B)







CDF: $VH \rightarrow VW^+W^- \rightarrow l^\pm \nu l^\pm \nu + X$

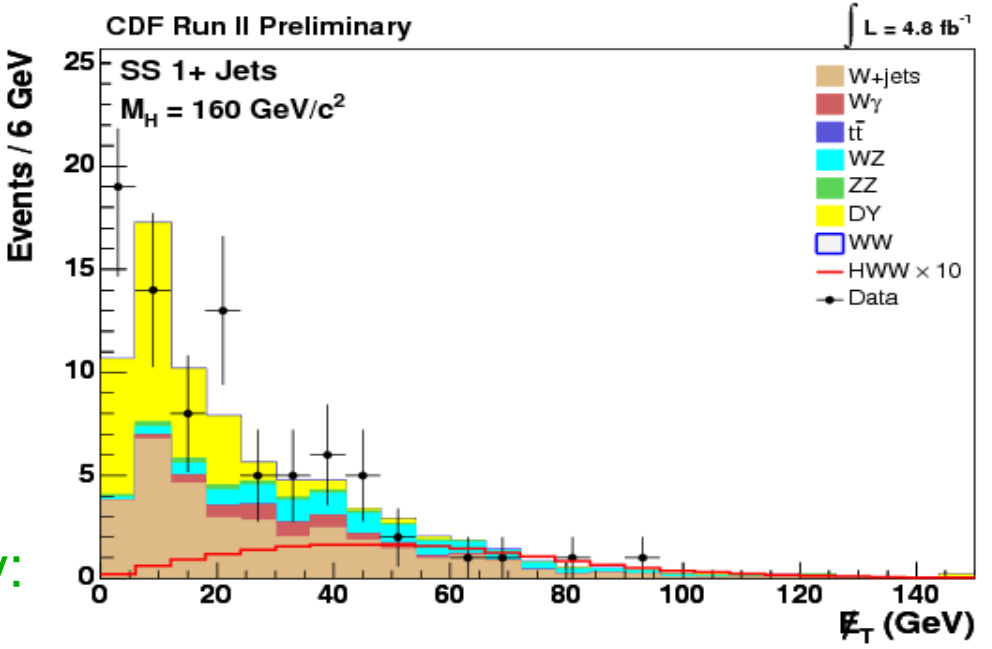
Search for Higgs signal in sample with same sign dileptons to further increase sensitivity both in the intermediate (~130GeV) and high (~160GeV) mass regions

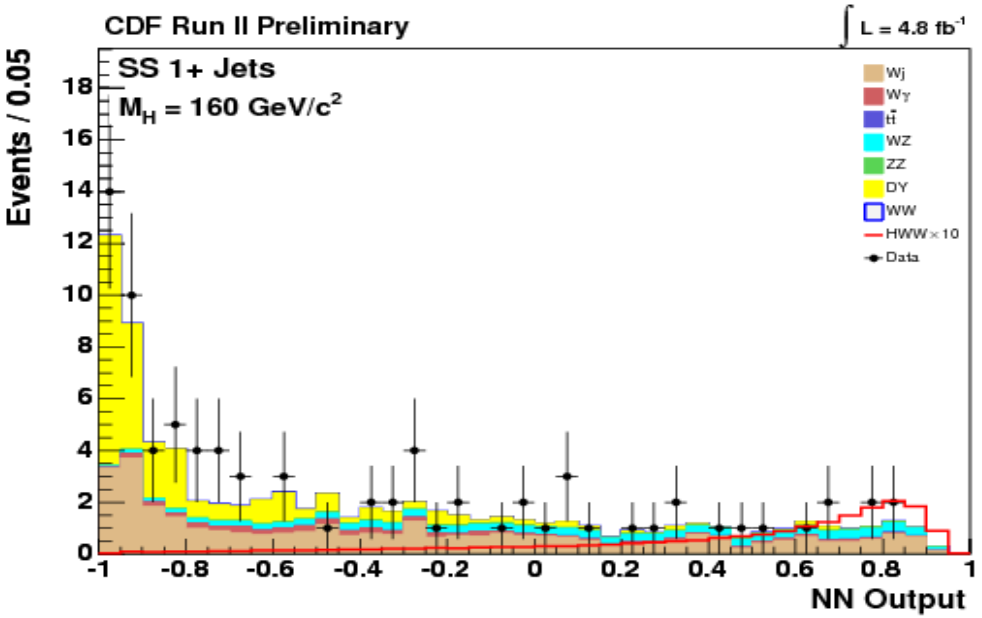
VH → VWW where V (W or Z) and one of the Ws from H decay leptonically:

$VH \rightarrow VW^+W^- \rightarrow l^\pm \nu l^\pm \nu + X$

Largely reduced SM background due to like sign

Instrumental backgrounds: Charge flips and fake leptons





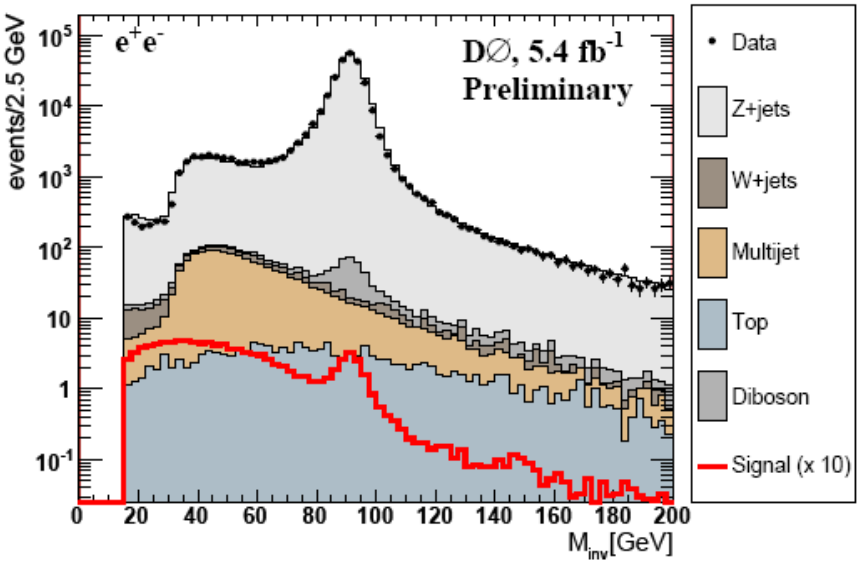
DØ: Event Selection

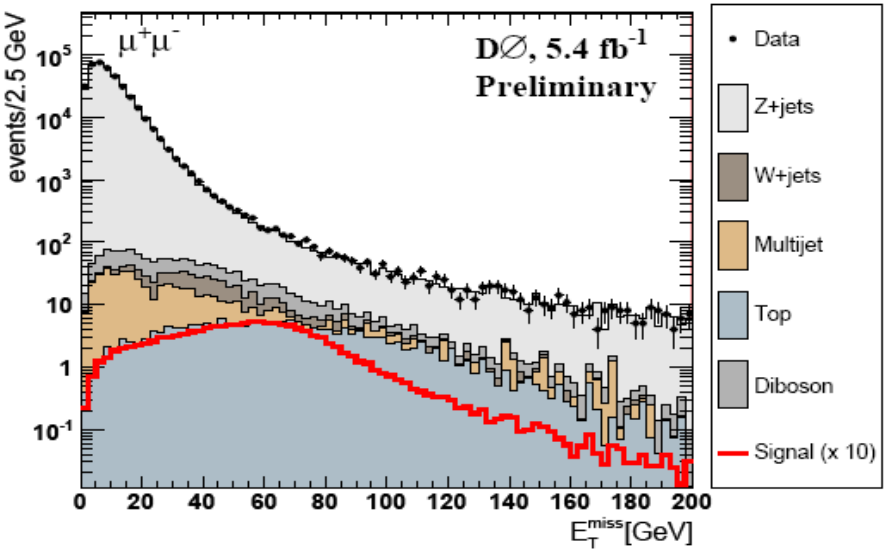
To maximize sensitivity, event samples are split by lepton flavor:
→ **eμ, ee, μμ** sub-channels

Preselection:
Two high p_T, isolated, oppositely charged leptons
Invariant mass > 15GeV

Final selection:
ΔΦ between leptons < 2
Missing ET > 20 GeV (25 for μμ)
Scaled missing ET > 6 GeV (ee and eμ only)
Minimum transverse mass > 20 GeV

Sub-channel	N(Signal) m_H=165GeV	N(Bkdg)	N(Data)
eμ	13.5 ± 0.1	396.5 ± 4.2	390
ee	7.21 ± 0.01	424 ± 3.6	421
μμ	9.03 ± 0.1	1626 ± 11	1613

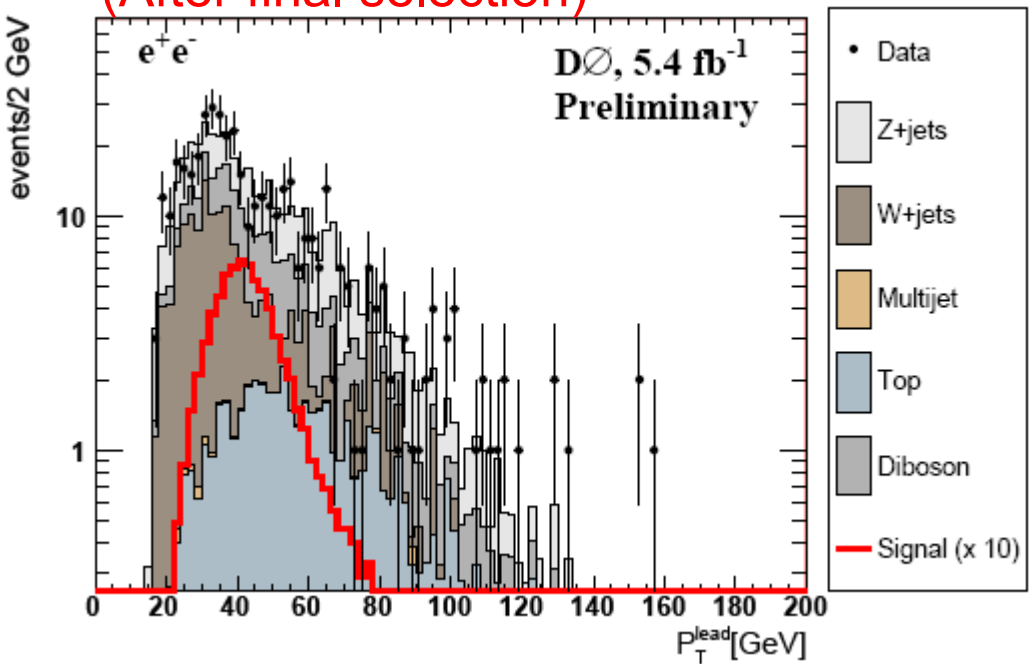


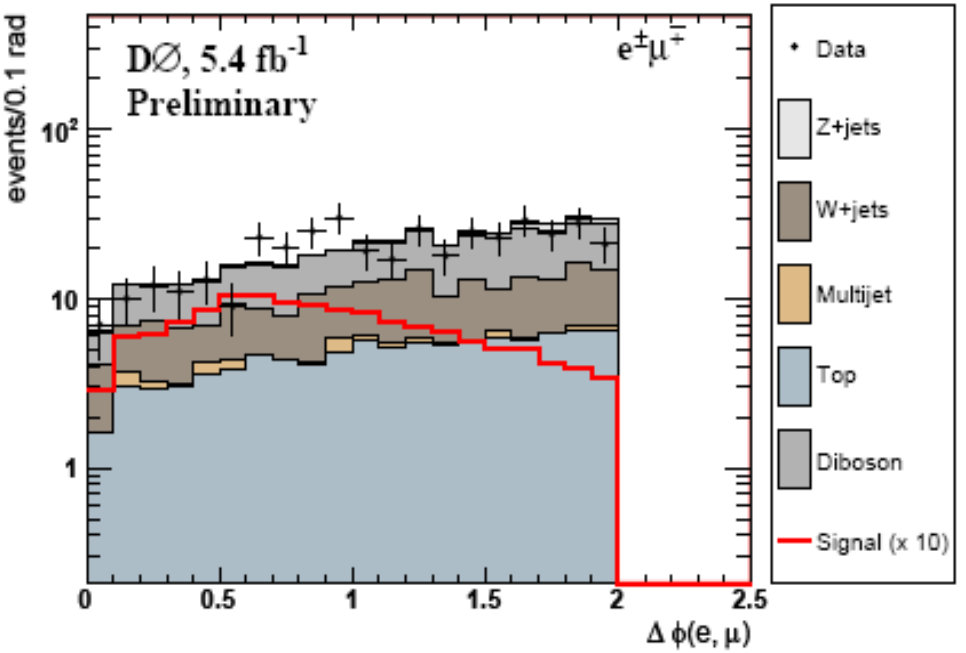


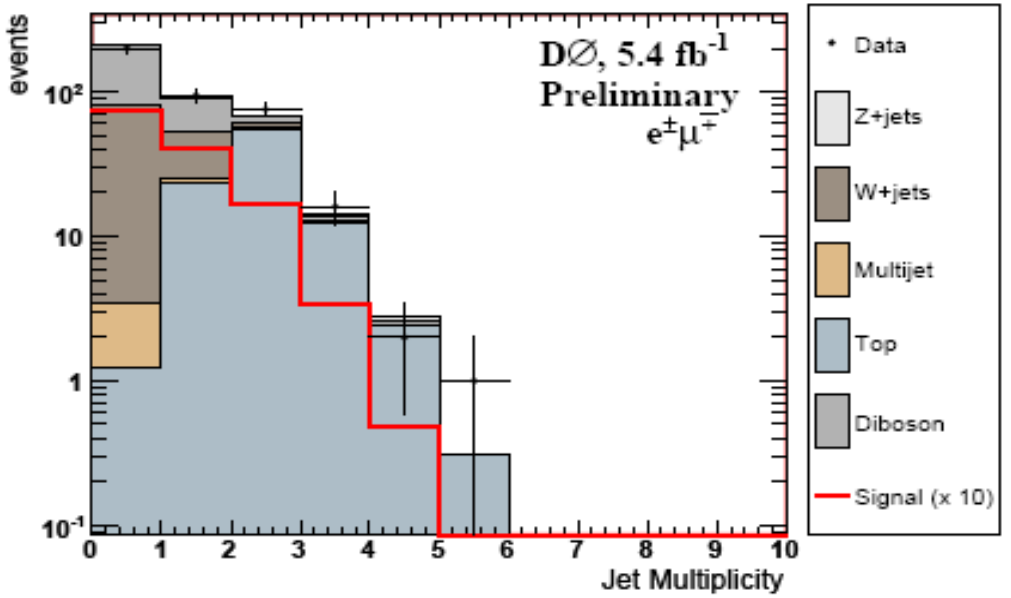
M_{ll} and missing E_T after pre-selection

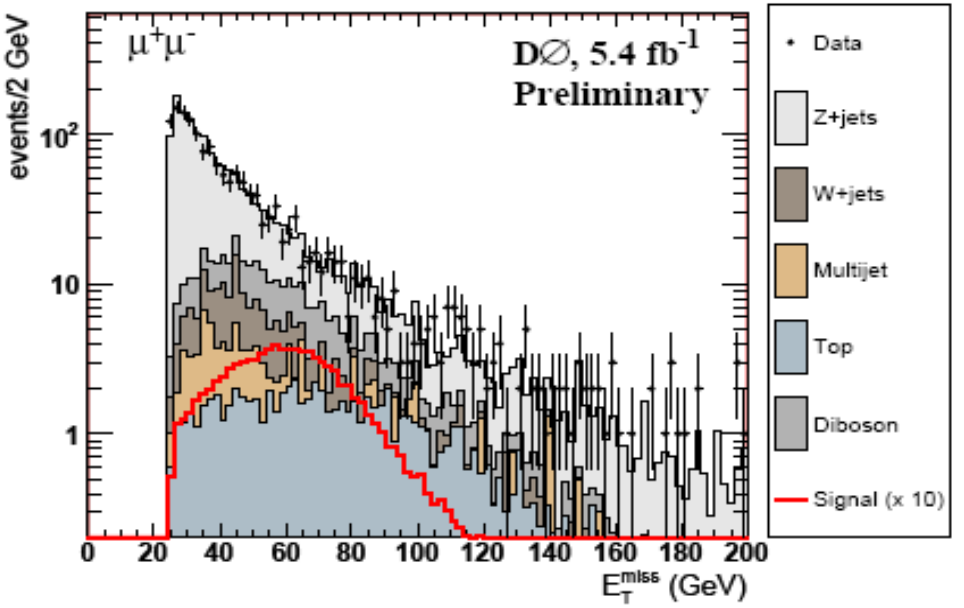
DØ: Data Modeling

(After final selection)







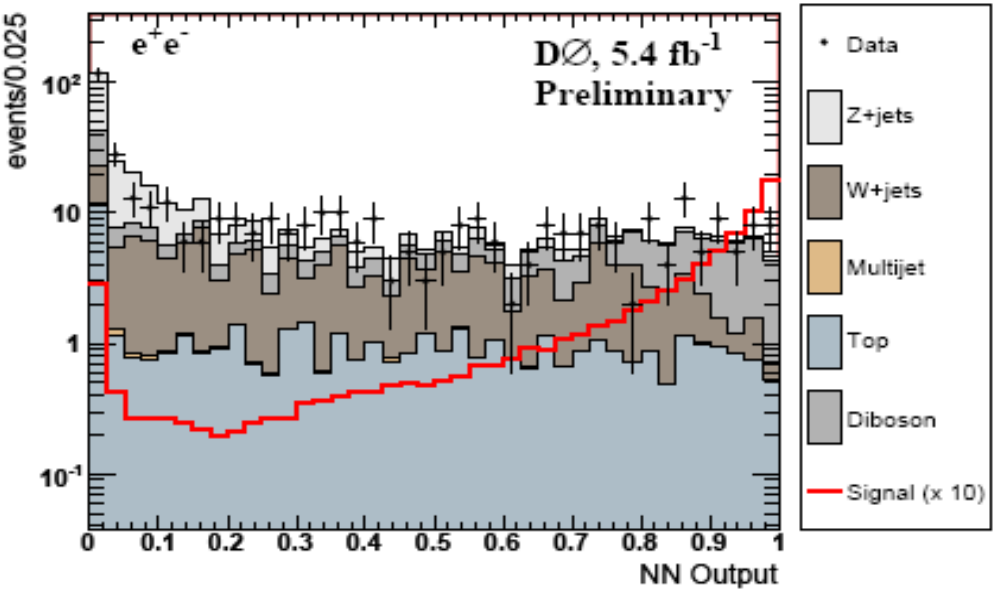


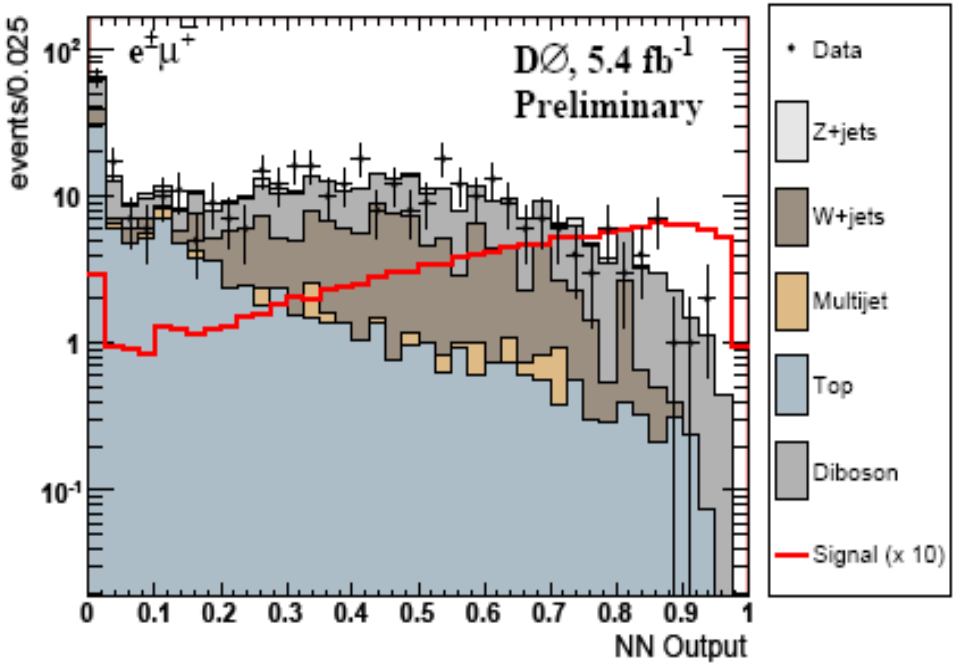
DØ: Multivariate Discriminant

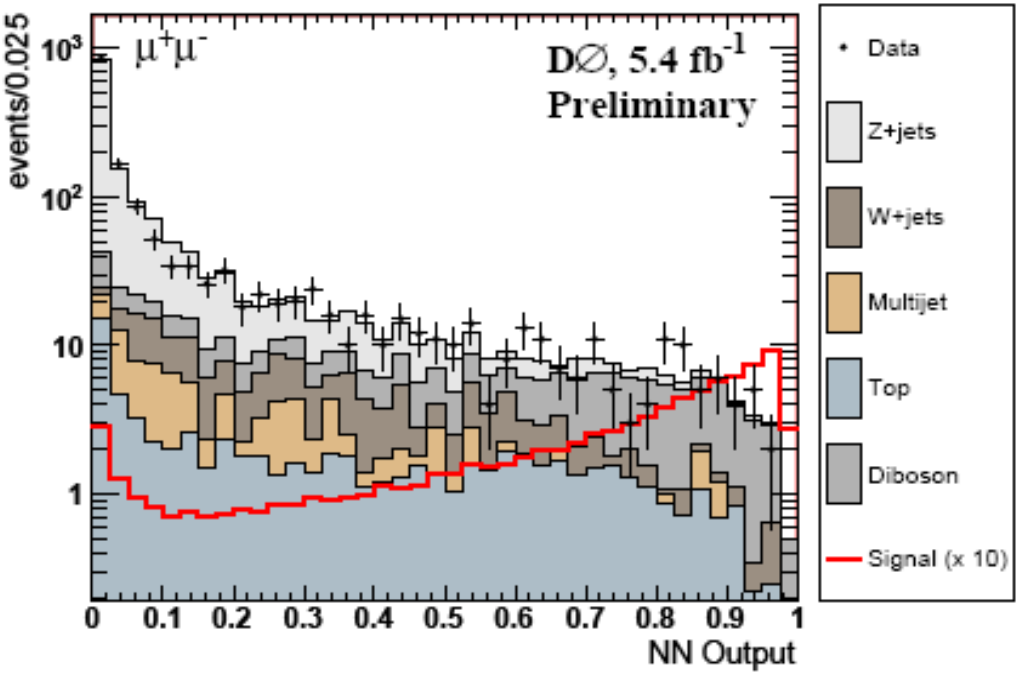
Using a Neural Network to separate a potential Higgs signal from background

Uses 12 kinematic and topological input variables (including jet multiplicity)

Split samples according to lepton flavor







DØ: $VH \rightarrow VW^+W^- \rightarrow l^\pm \nu l^\pm \nu + X$

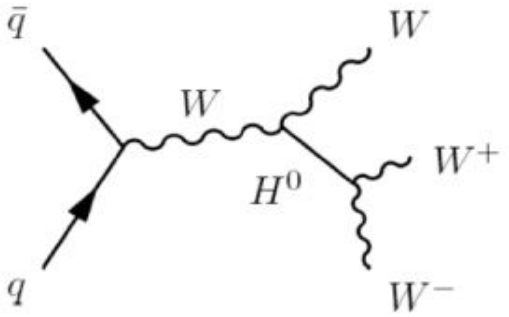
Requires 2 like sign isolated leptons (electrons or muons) with p_T>15GeV

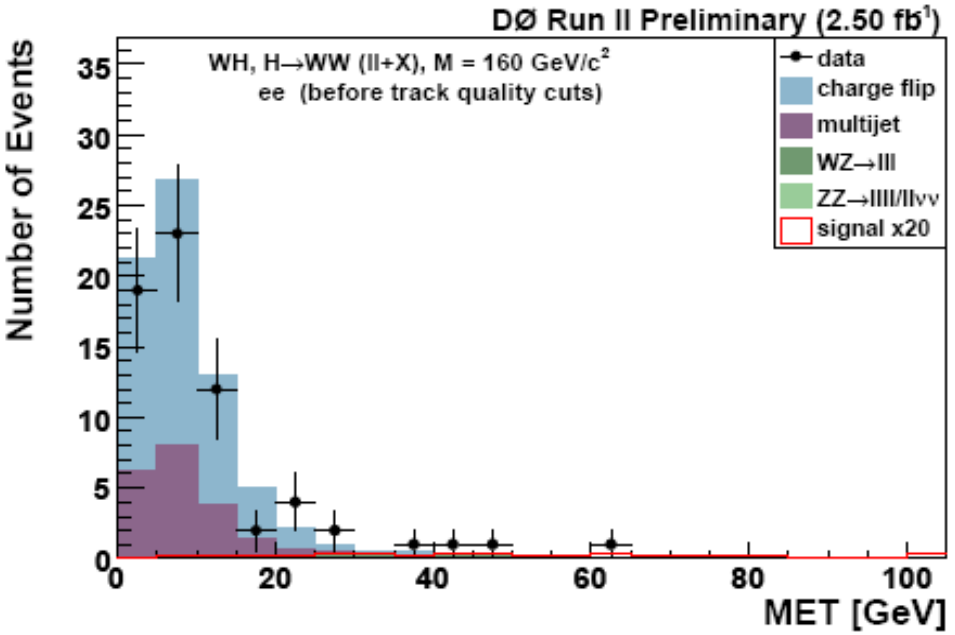
Use likelihood based discriminant to separate signal from backgrounds

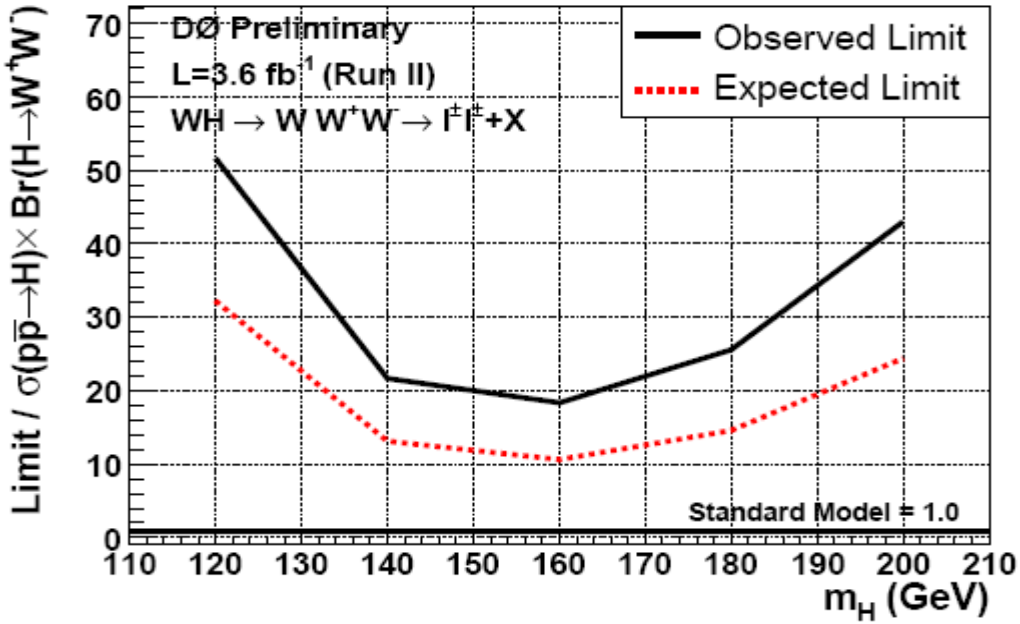
Largely reduced SM background due to like sign requirement

Main backgrounds:
Charge flips and fake leptons

Adds 10% of sensitivity to high mass Higgs search





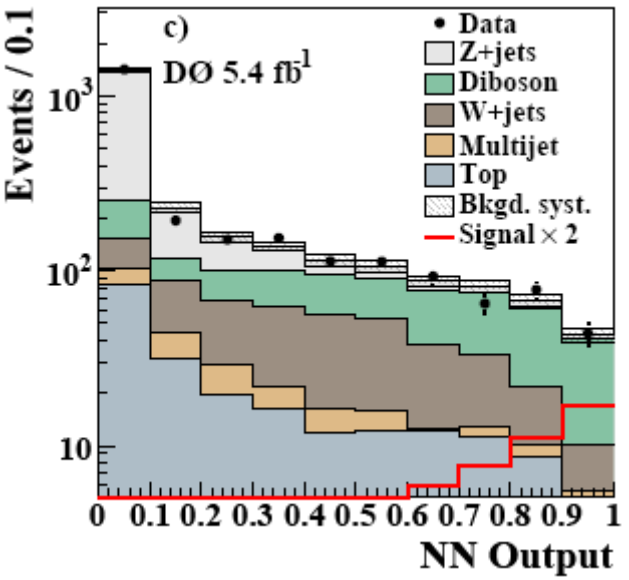


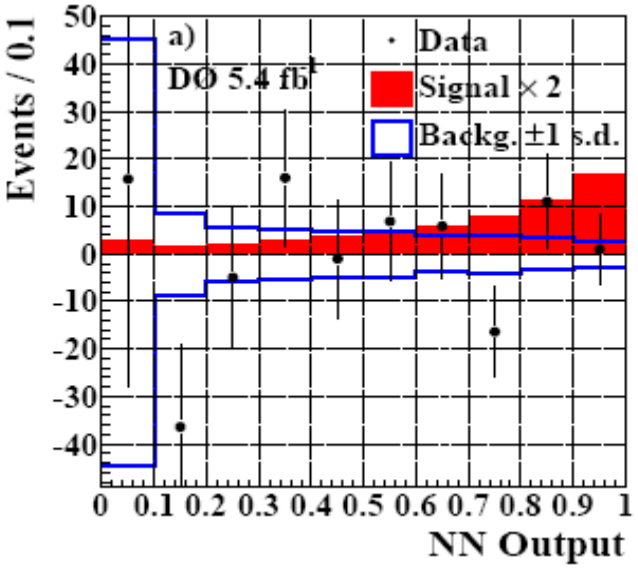
Systematics

Sample of systematics considered:

Relative uncertainties [%]

Systematic Uncertainty	Type	Value
Jet Energy Scale	Shape & Norm	3-17
Jet ID Efficiency	Shape & Norm	6-18
Jet Resolution	Shape & Norm	2
Cross Sections	Flat Norm	6-10
Multijet Background	Flat Norm	2-20
Parton Distribution Function	Flat Norm	8
Lepton ID	Flat Norm	2.5-4
Lepton Momentum Scale	Shape & Norm	2-8
p_T of WW/H/Z	Shape & Norm	1-5
Luminosity	Flat Norm	6.1



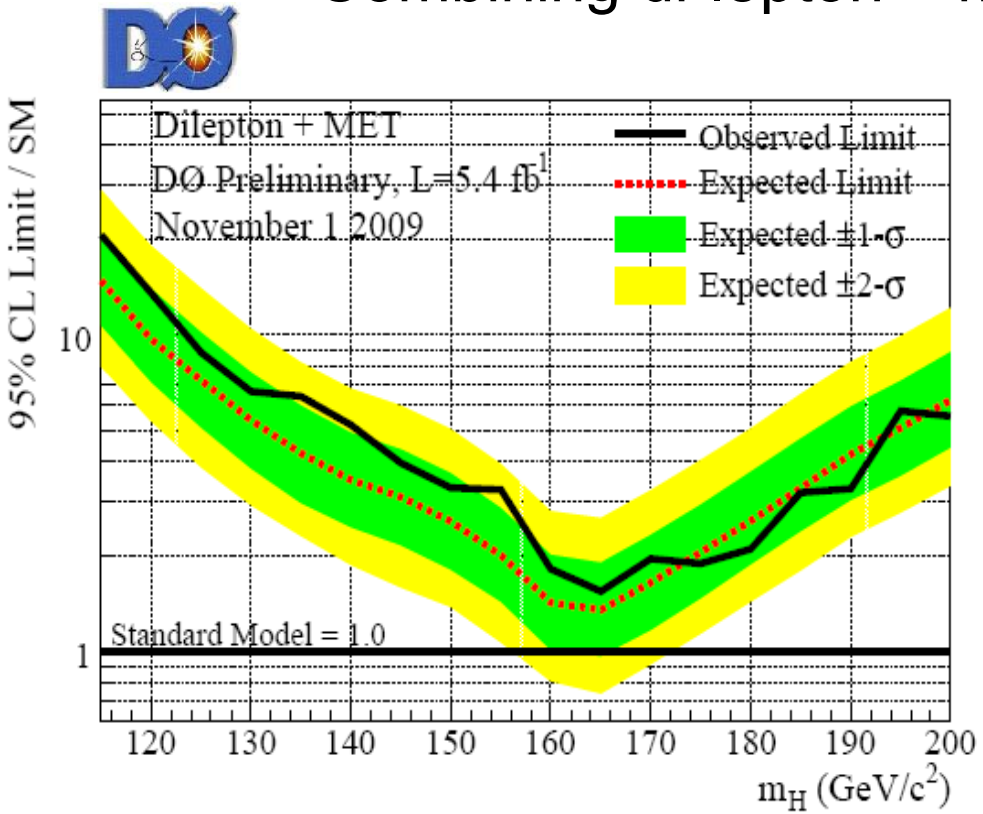


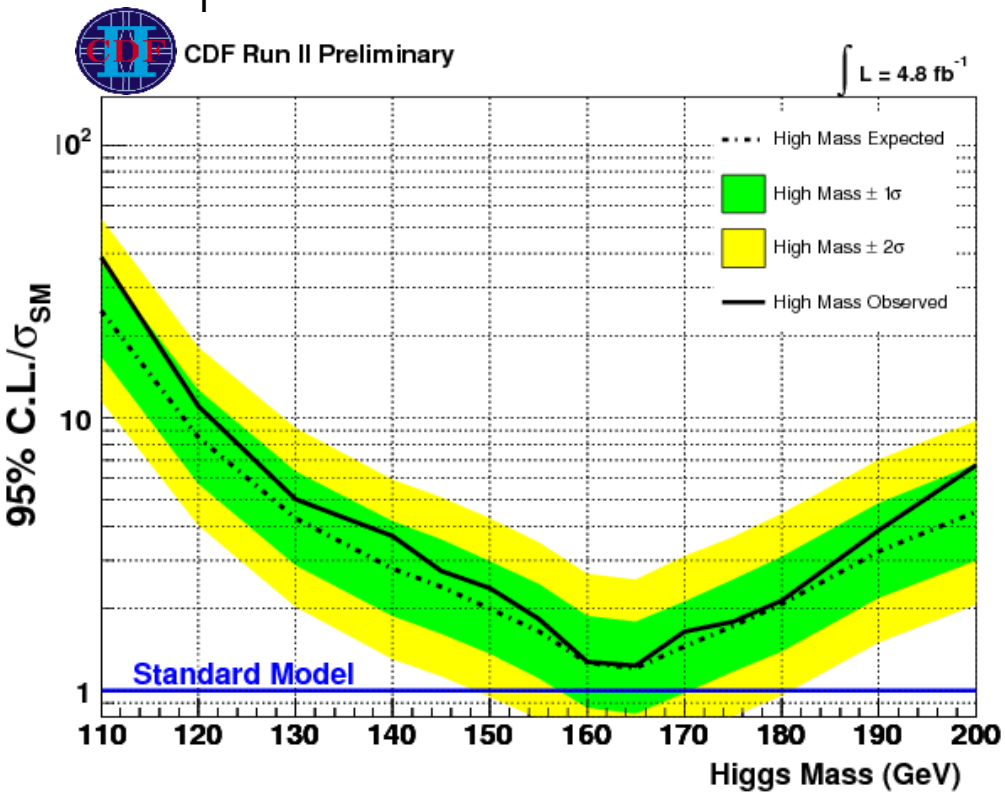
Exclusion Limits

No significant excess of signal-like events is observed

NN outputs used to set exclusion limits at 95% CL

Combining di-lepton + missing E_T sub-channels





m_H=165GeV: Exp 1.36xSM, Obs 1.55xSM

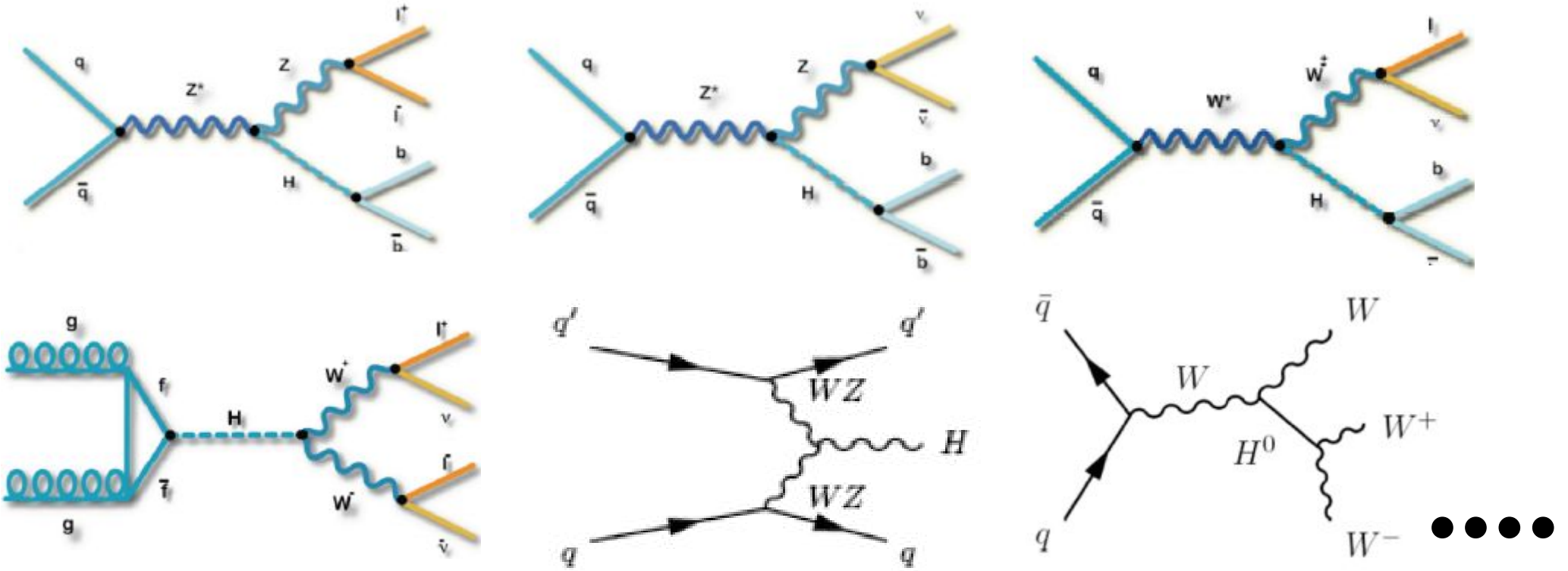
(w/o same-sign analysis)

m_H=165GeV: Exp 1.21xSM, Obs 1.23xSM

With additional luminosity and improvements expect single experiment exclusion around m_H = 165 GeV in the near future

Tevatron Combination

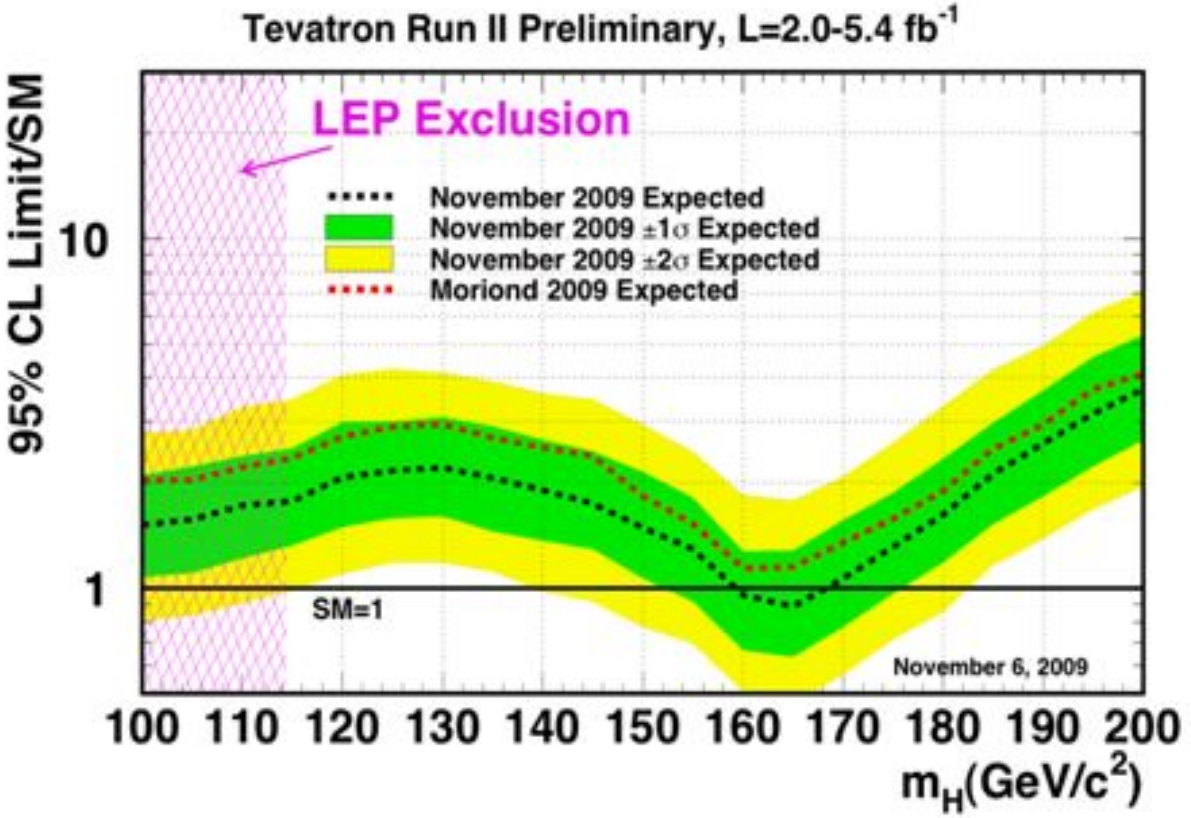
Combination of 36 (54) orthogonal final states for CDF (DØ) to maximize sensitivity



Use different statistical methodologies (Bayesian, modified frequentist)
→ Results agree within 5%

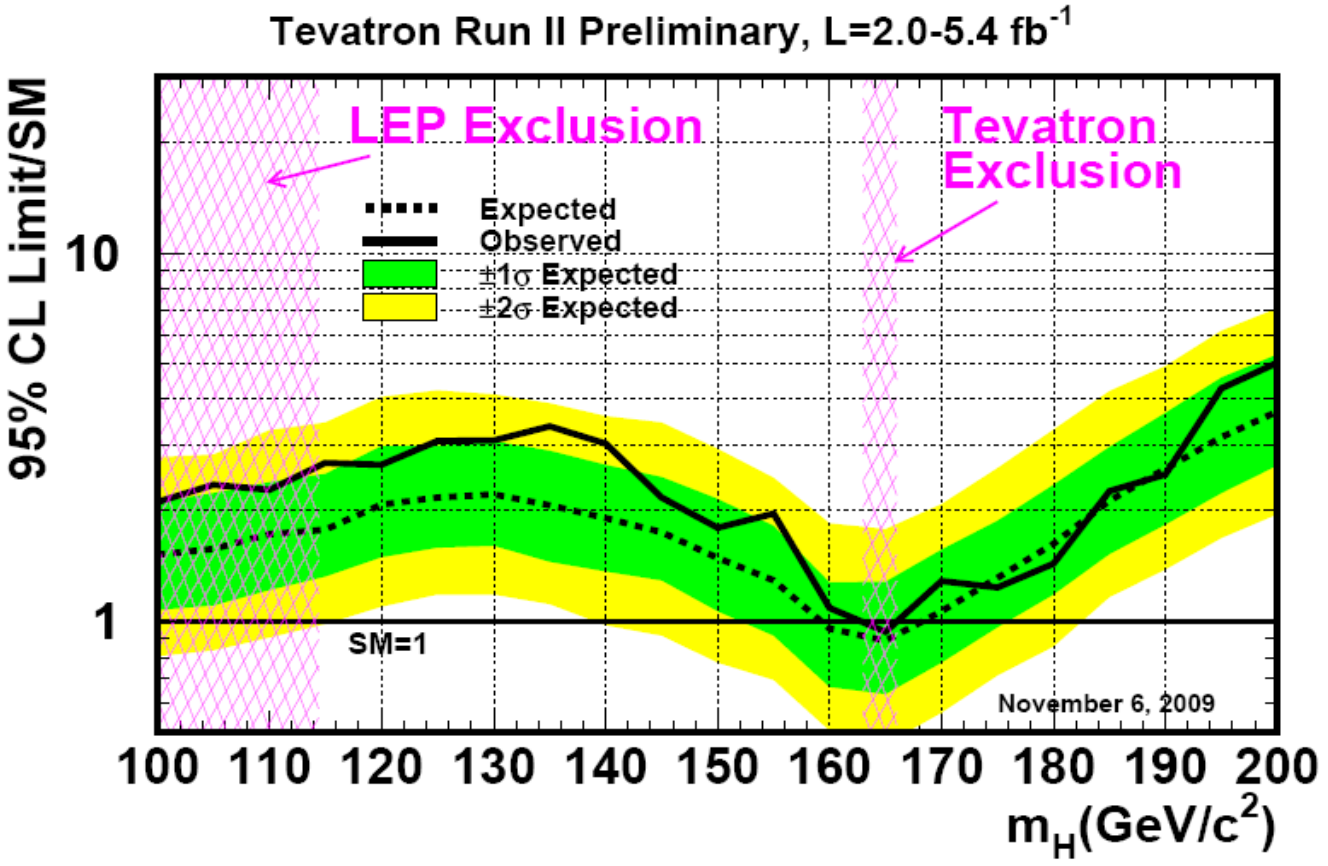
Improvements Since Last Combination

- More luminosity
- Increased signal acceptance
- Added more channels
- Improved b-tagging
- Improved dijet mass resolution
- More efficient use of multivariate techniques
- Improved background modeling
- Better control of systematics



- High Mass: expected exclusion for 159 to 168 GeV
- Low Mass (m_H=115GeV): 1.8xSM
- Better than 2.2xSM sensitivity for all mass points below 185 GeV

Combined Tevatron Limits



At m_H=165GeV:
Exp 0.89xSM, Obs 0.94xSM

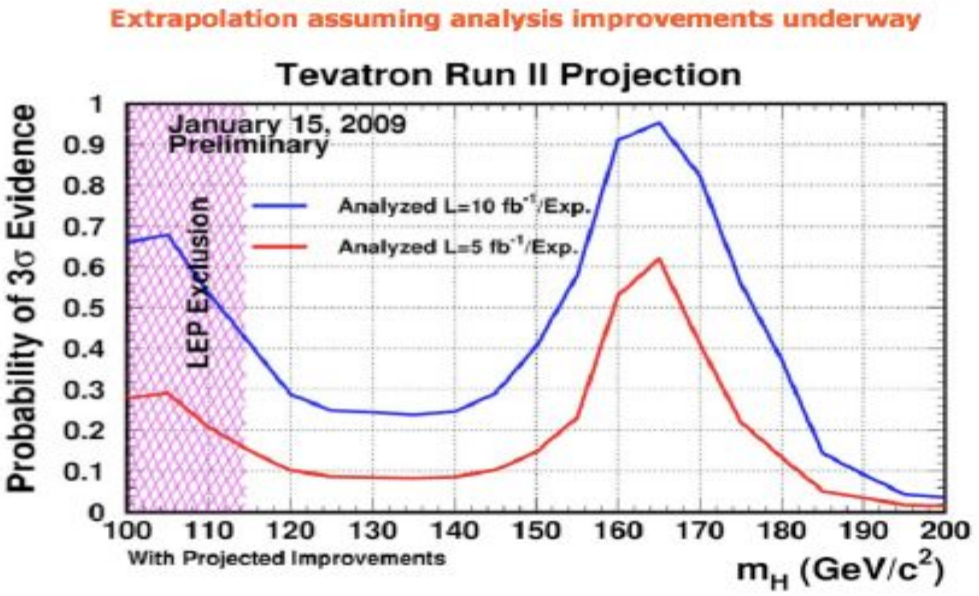
At m_H=115GeV:
Exp 1.8xSM, Obs 2.7xSM

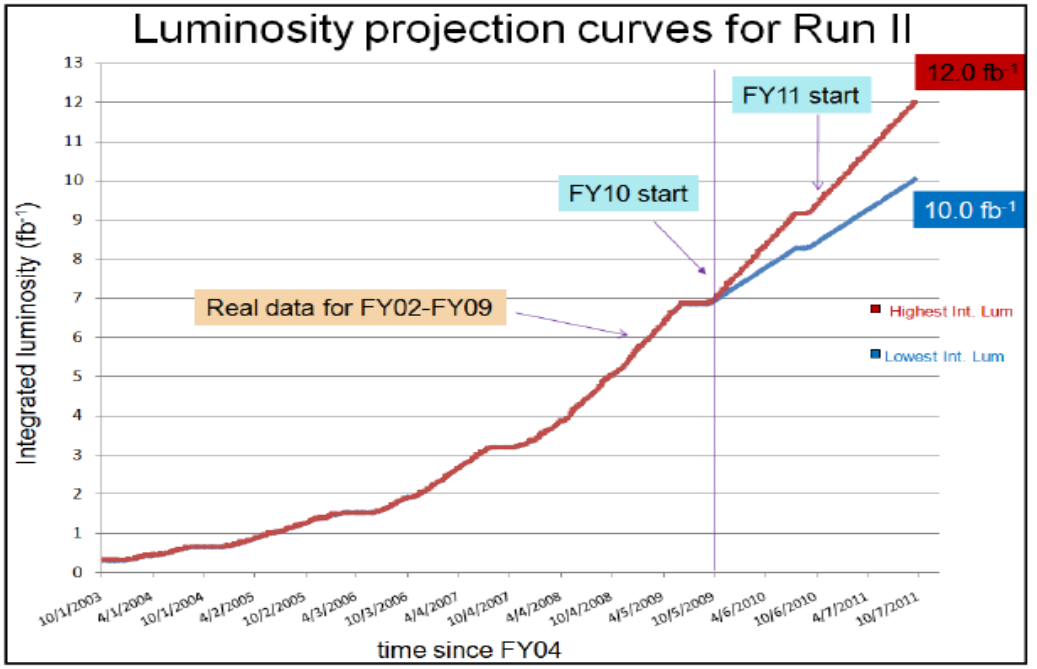
We exclude at the 95% CL the production of a SM Higgs boson in the mass range of 163 to 166 GeV

Expected limit excludes $159 < m_H < 168$ GeV

Tevatron Higgs Sensitivity Projection

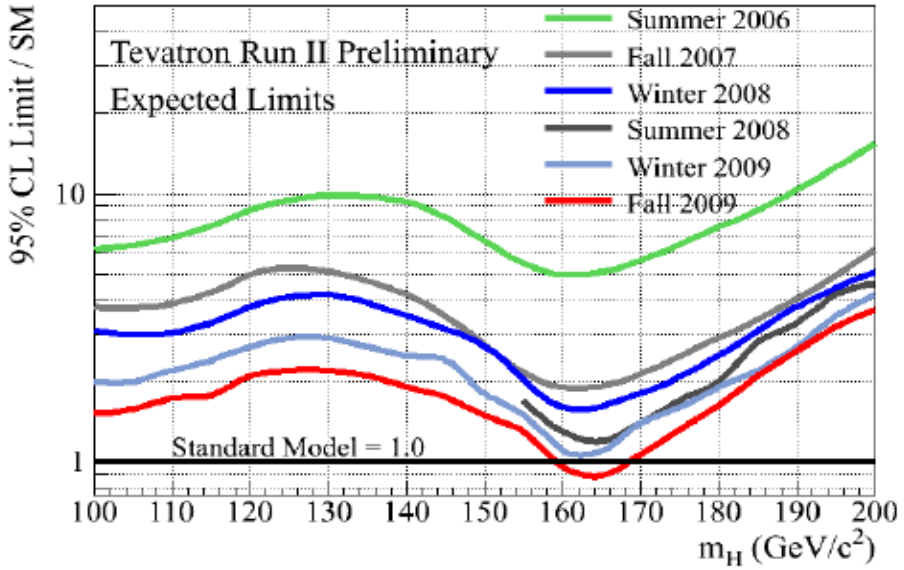
- Universal support by Fermilab and DOE for 2011 running
- Expect to have ~10fb^{-1} for analysis by the end of RunII
  - 2x more than used in current Tevatron combination
- With additional improvements will have sensitivity over the entire range preferred by EW fits





Summary

- Tevatron continues to rapidly improve Higgs search sensitivity
- Presented updated Tevatron results for high mass SM Higgs boson searches
  - In the high mass region both collaborations are expected to reach single experiment exclusion soon
- Both expected and observed limits now exclude SM Higgs production around m_H = 165 GeV:
  - Expected limits exclude $159 < m_H < 168$ GeV
  - Observed limits exclude $163 < m_H < 166$ GeV



By the end of Run II we expect to be sensitive over this entire mass range