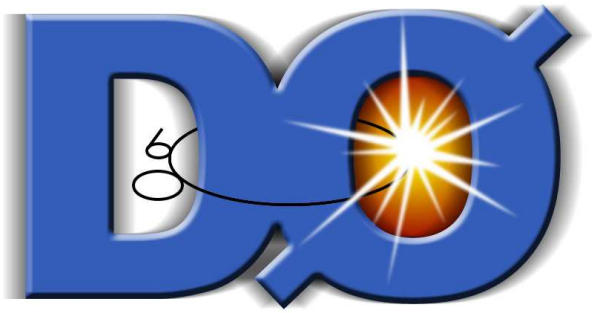
Search for $WH \to \ell\nu b\bar{b}$ Final States at the Tevatron

Duncan Brown

LPNHE (Universities VI and VII) Paris

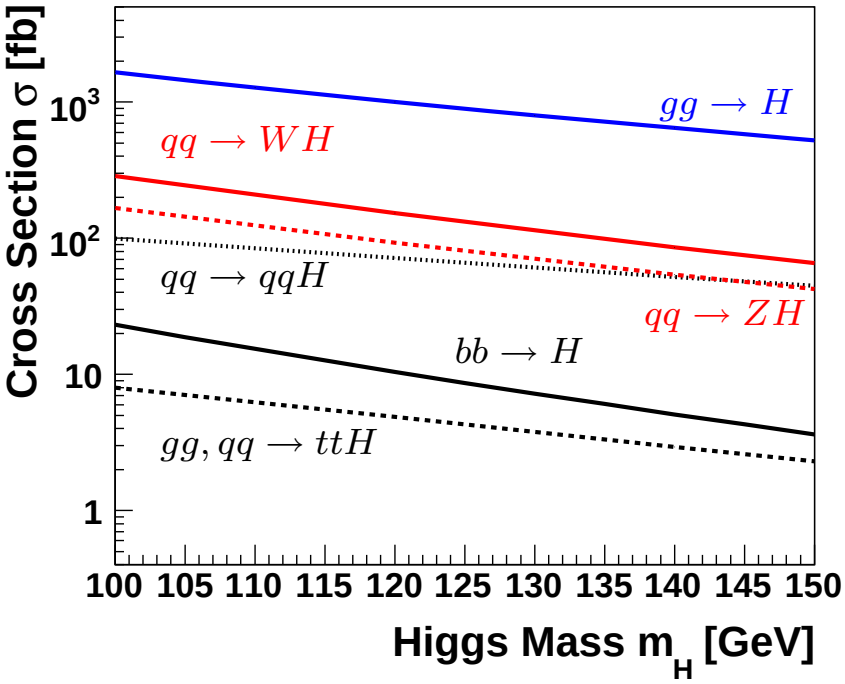
On Behalf of the CDF and DØ Collaborations

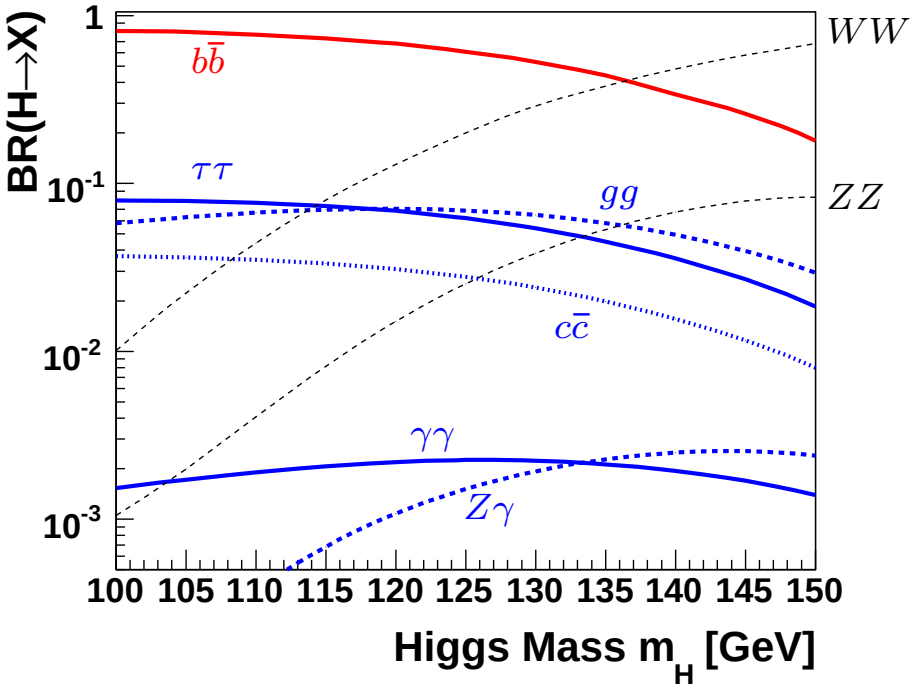


APS - Division of Particles and Fields

Providence RI, August 12th 2011

WH Production at the Tevatron

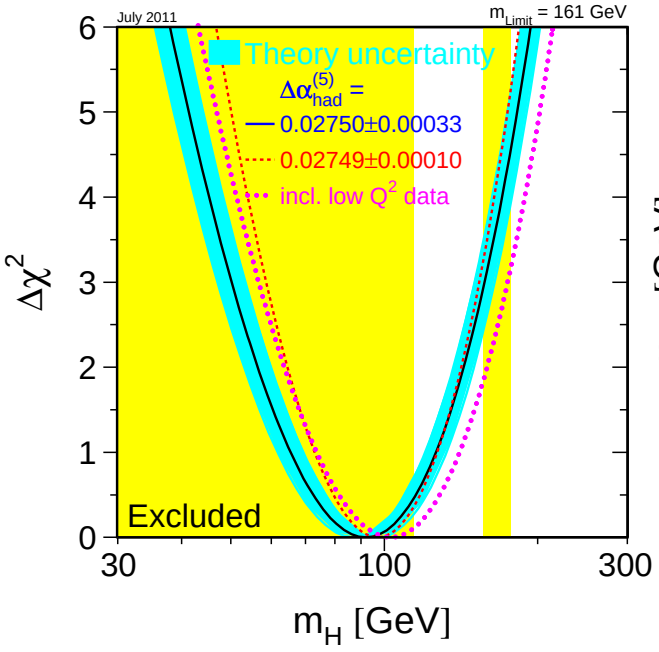


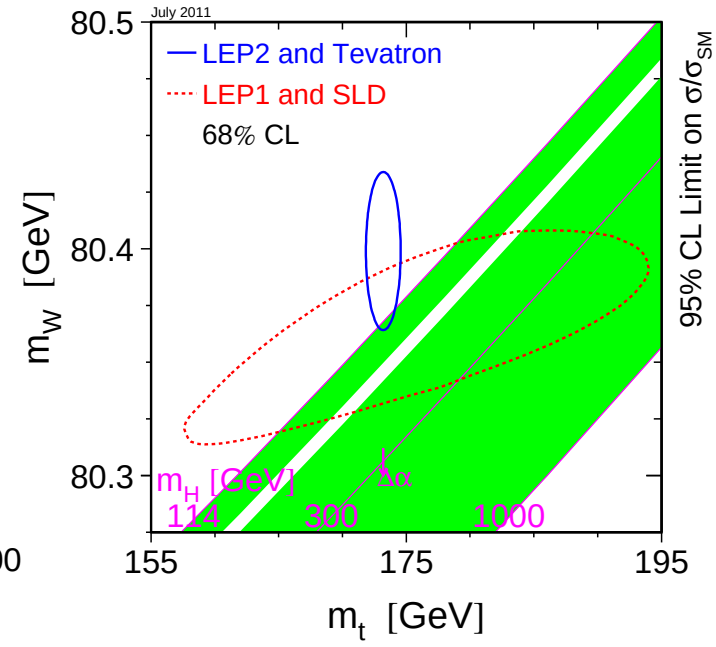


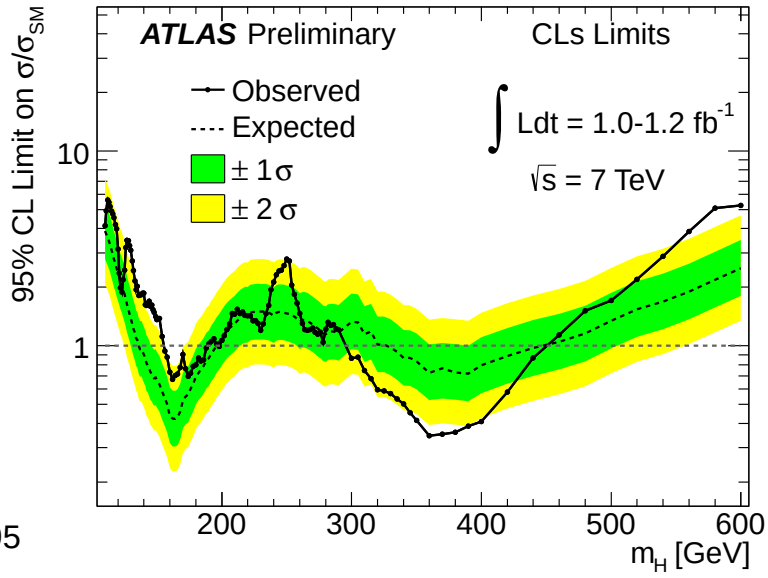
- Reconstructed $W \to \ell\nu$ to Suppress Jet Production Backgrounds
- Search for $H \to b\bar{b}$ Decays in Statistically Independent Samples

$\Rightarrow \ell\nu b\bar{b}$ Final State Searches Sensitive to a Low Mass Higgs

Standard Model Higgs and the Low Mass Regime







- Lower Limit: $m_H > 114.4$ GeV (at 95% CL)

  Excluded by LEP Direct $e^+e^- \to ZH$ Searches

- Upper Bound: $m_H < 161$ GeV (at 95% CL)

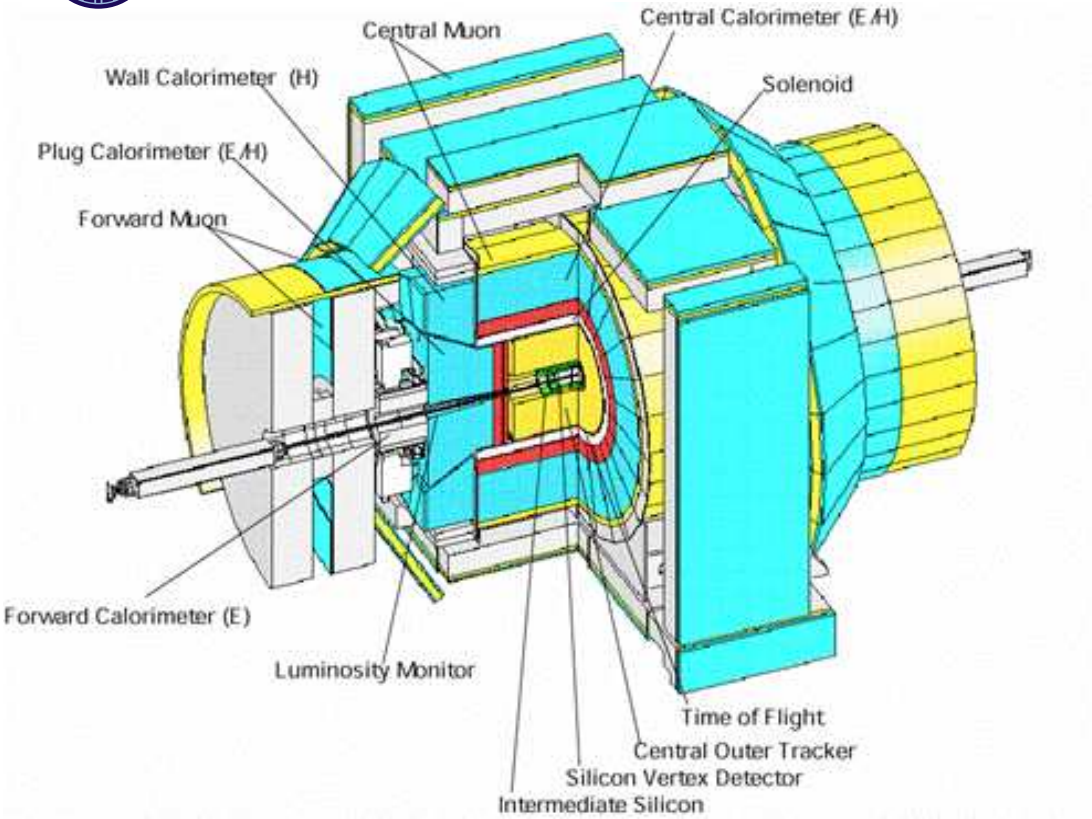
  Inferred from Fit to Precision Electroweak Measurements

- Preliminary LHC High Mass Exclusions

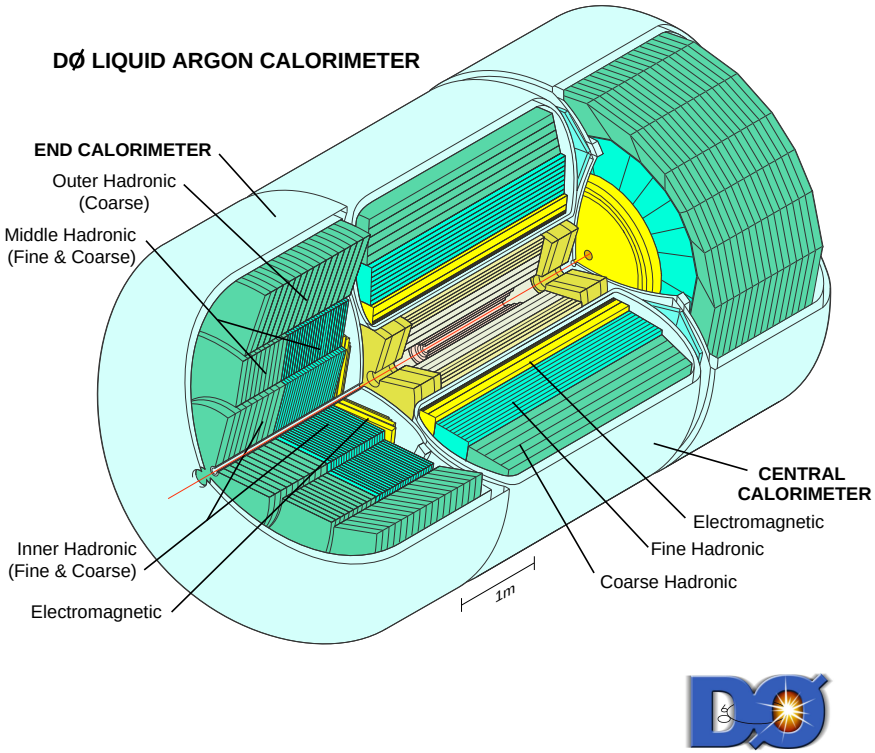
Multiple Measurements $\Rightarrow$ SM Higgs Low Mass Region

Experimental Signatures

CDF Detector



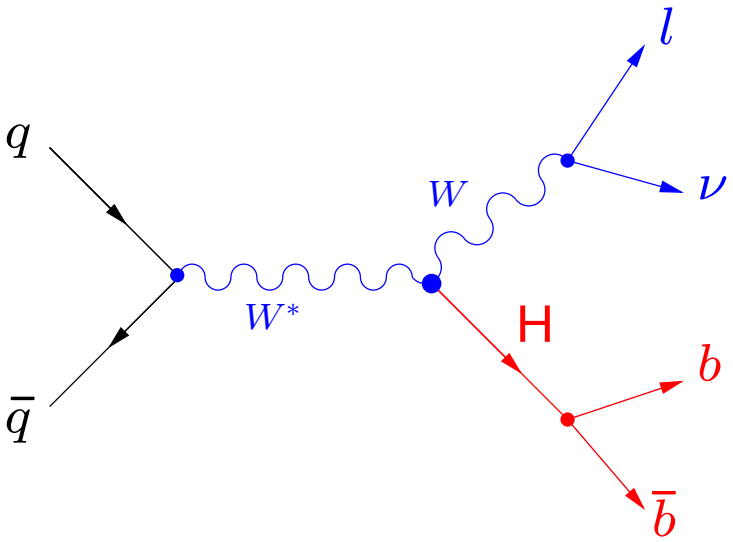
DØ Calorimeter

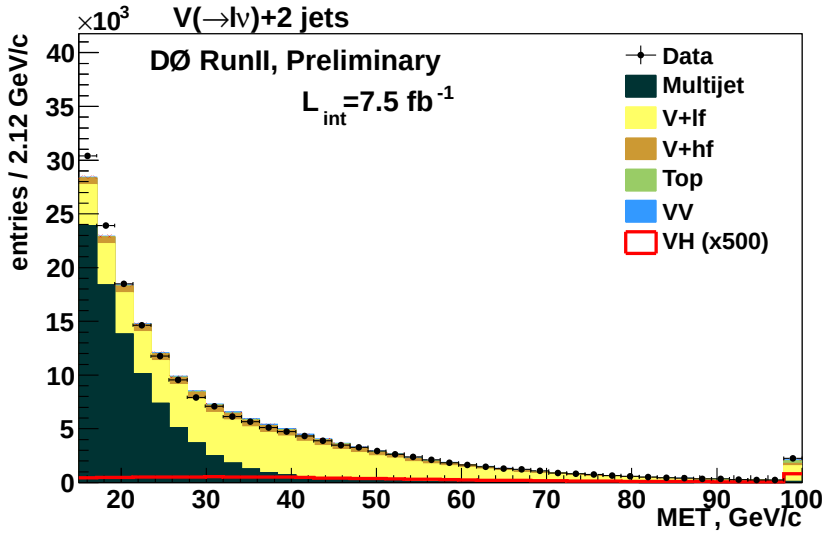


- Tracking, EM and Hadronic Calorimeters, Muon Detectors ...
  - $\ell\nu b\bar{b}$ Searches Utilize Complete Detector Information

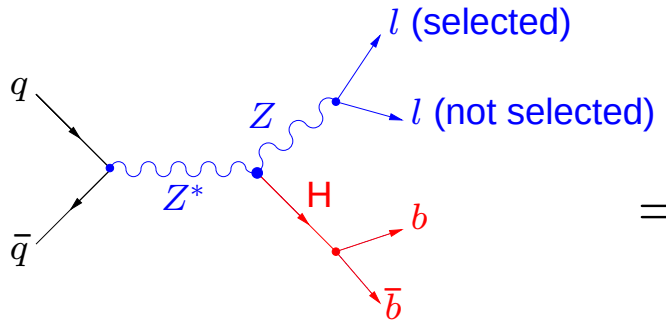
Search Sample Selection

- W Bosons: Isolated Leptons ($l = e, \mu$) and Missing Transverse Energy ($\not\!\!E_T$)





- Additional Sensitivity to $Z/\gamma^* \to \ell\ell$ Decays and Tau Leptonic Channels



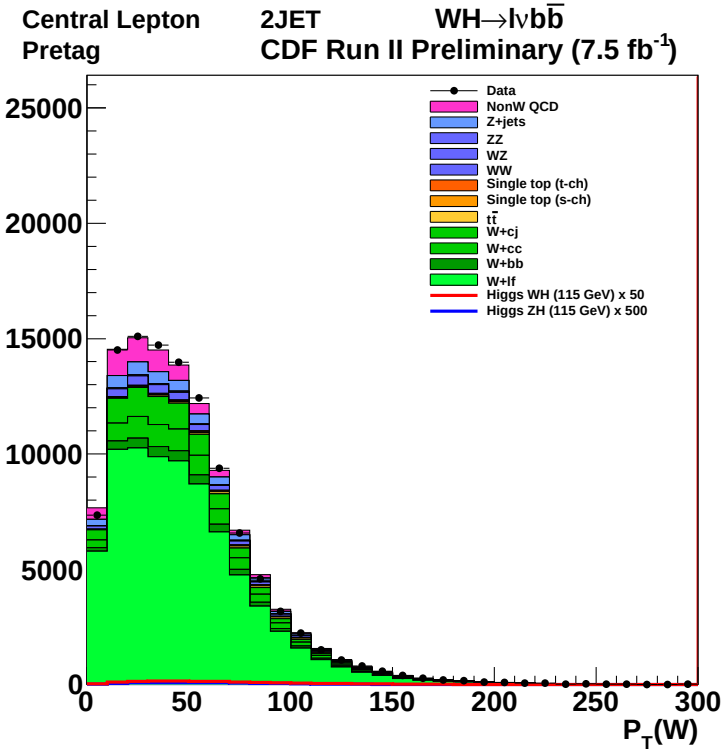
- $H \to b\bar{b}$ Decays: 2-Jet Selections

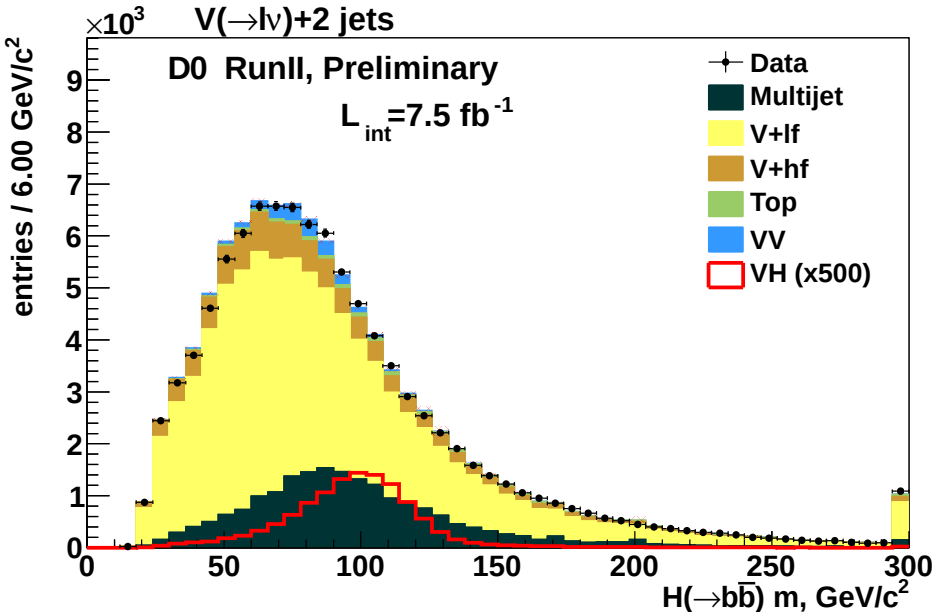
$\Rightarrow$ 3-Jet Selections allow for Additional QCD Radiation

$\Rightarrow$ Additional Sensitivity in Multiple Statistically Independent Search Samples

Associated WH Production

- $\mathcal{L}= 7.5\ \mathrm{fb}^{-1}$ Analyzed ! : Four Initial Selected Data Samples ...





CDF: 2 Jets in four Leptonic Trigger, Angular and Reconstuction Categories

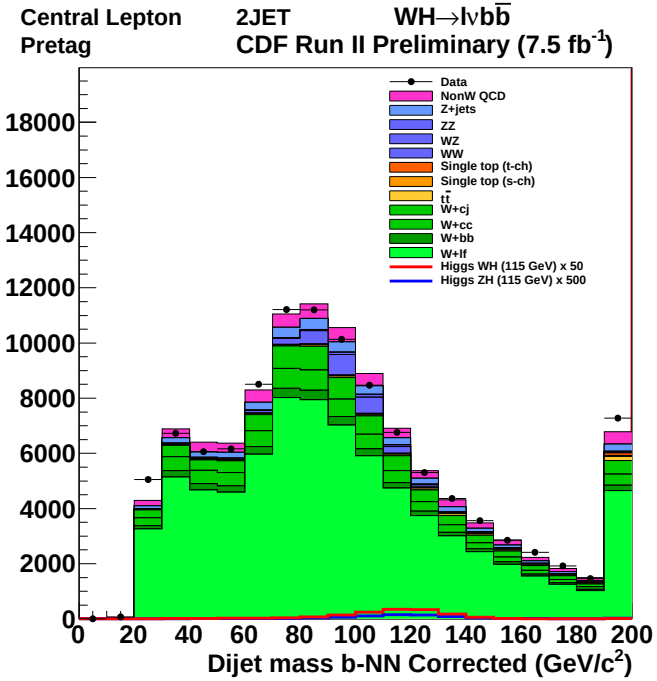
D0: Two Lepton Flavors in 2 & 3 Jet Events

$\Rightarrow$ Many BKGDs: Normalized to Theory Predictions and/or Modelled and Validated in Separately Selected Control Samples

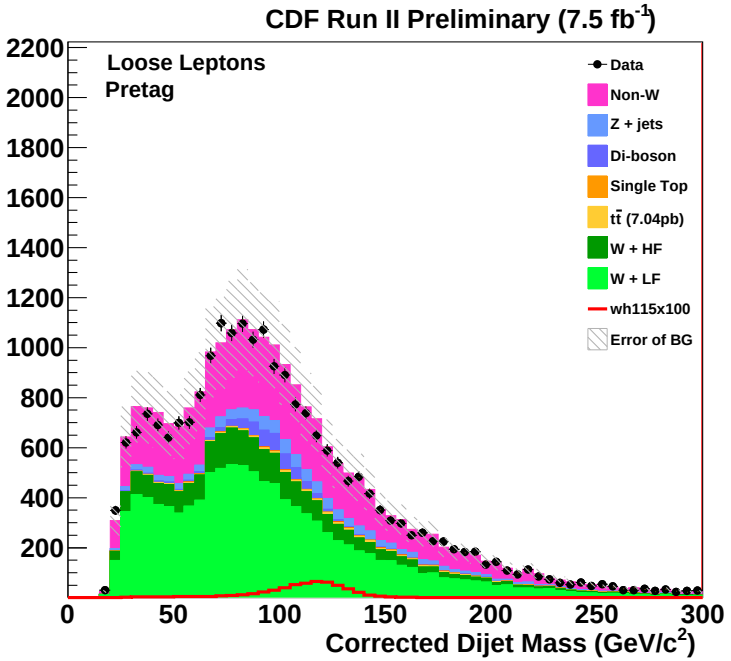
Increasing Sensitivity ...

....Beyond Increase in Luminosities ...

- Dijet Mass Resolution has Direct Impact on Upper Limits:



⇐ CDF : Improved via b-jet corrections (from 15% to 11%)



- CDF / DØ :

  Looser Lepton Reconstruction Criteria ⇒

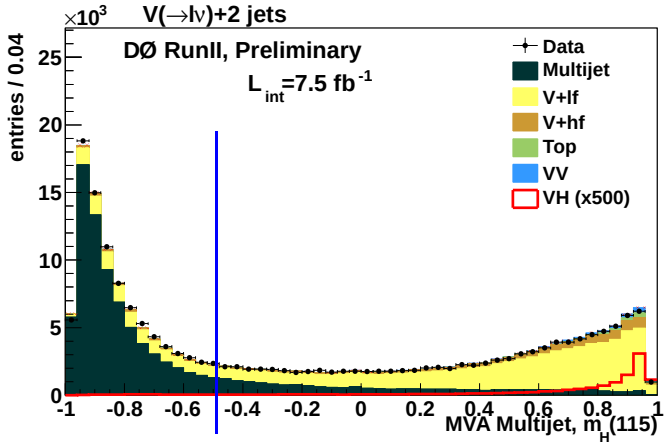
  (CDF Now Include Additional Sample)

⇒ Improvements Applied to Increase Sensitivity.

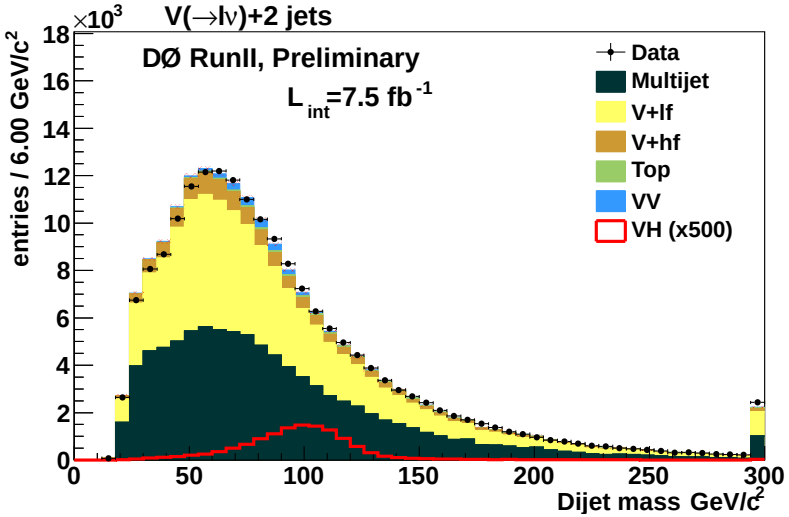
Multijet BKGD Suppression

- Multijet Background Further Suppressed using Discriminants

DØ: Multivariate Discrimination ⇒

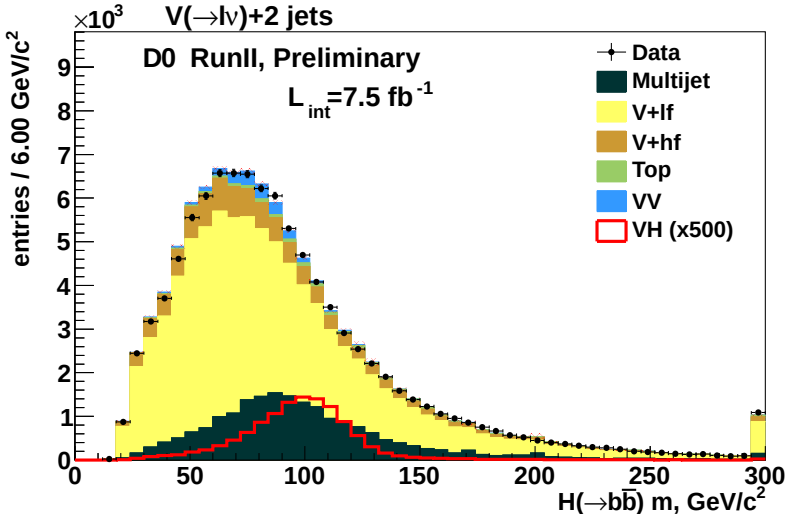


Before MVA



⇒

After MVA



- CDF: Apply Super Vector Machine (SVM) Approach

⇒ Increased Discrimination of Search Backgrounds

Orthogonal Search Samples

- Statistically Independent (Orthogonal) Samples also via b-tagging

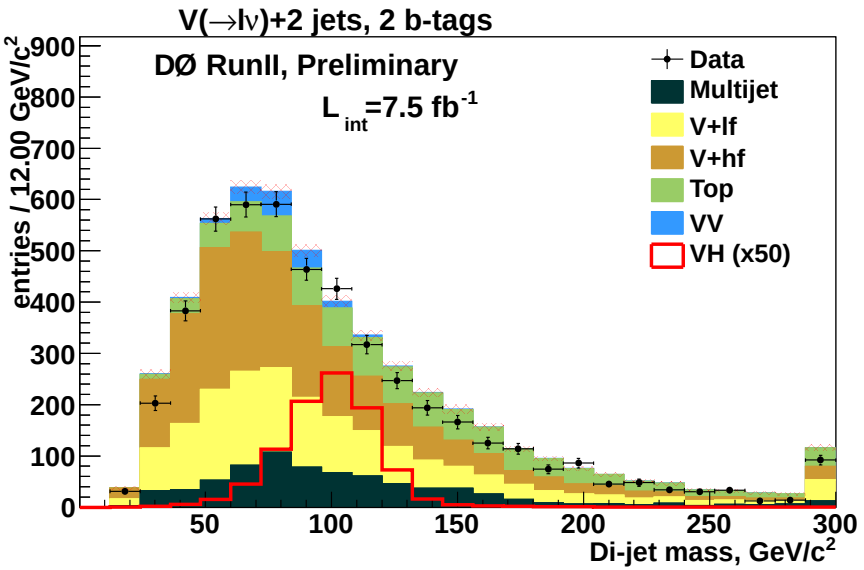
- Require at Least One b-tagged Jet:

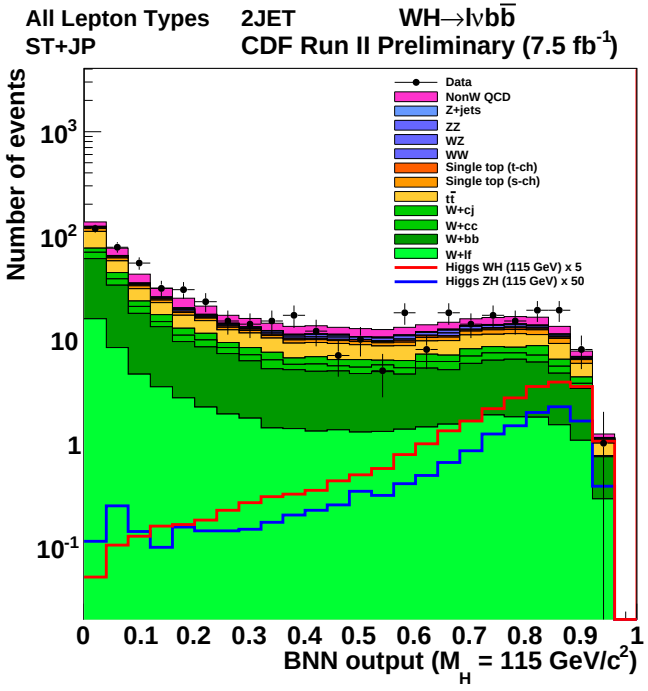
  $\Rightarrow$ Neural Nets

  $\Rightarrow$ Secondary Vertex (SV) Information

  $\Rightarrow$ Low Jet Probability (JP) to Originate from Primary Vertex

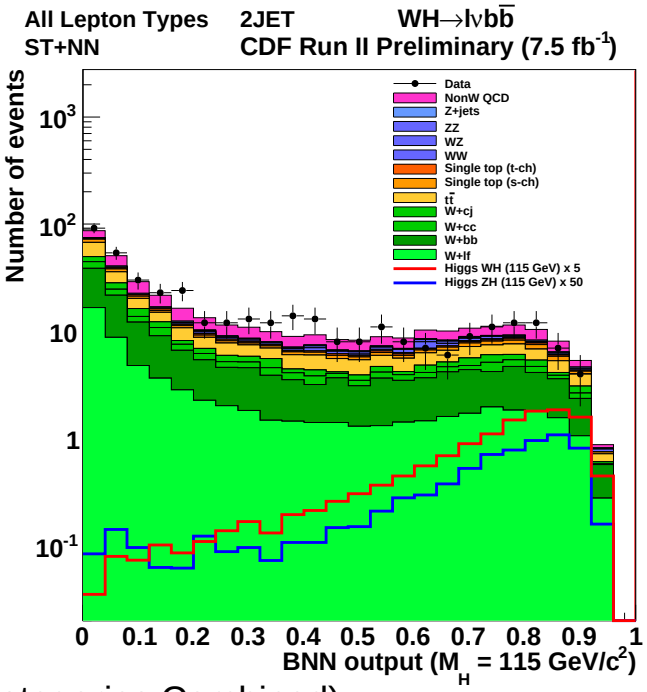
$\Rightarrow$ Orthogonal Double and Single b-Tagged Samples Improve Sensitivity

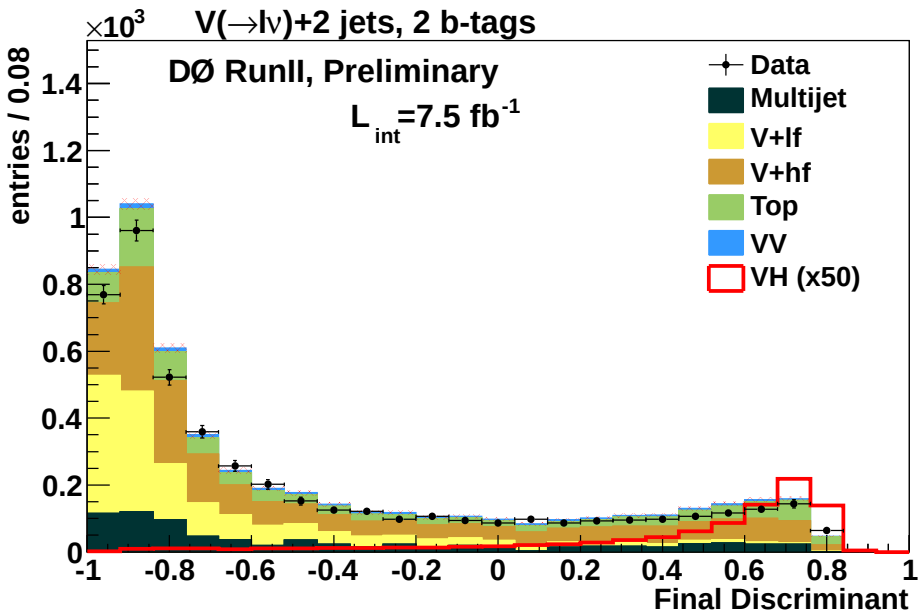




Multivariate Discriminants

- Multivariate Techniques to Discriminate Remaining (Sample Dependent) BKGDs





(Lepton Categories Combined)

- CDF: 2nd Stage Bayesian Neural Network (BNN) applied to each Sample

⇒ Eight Discriminating Input Variables Optimized in Dedicated Studies for Each Sample.

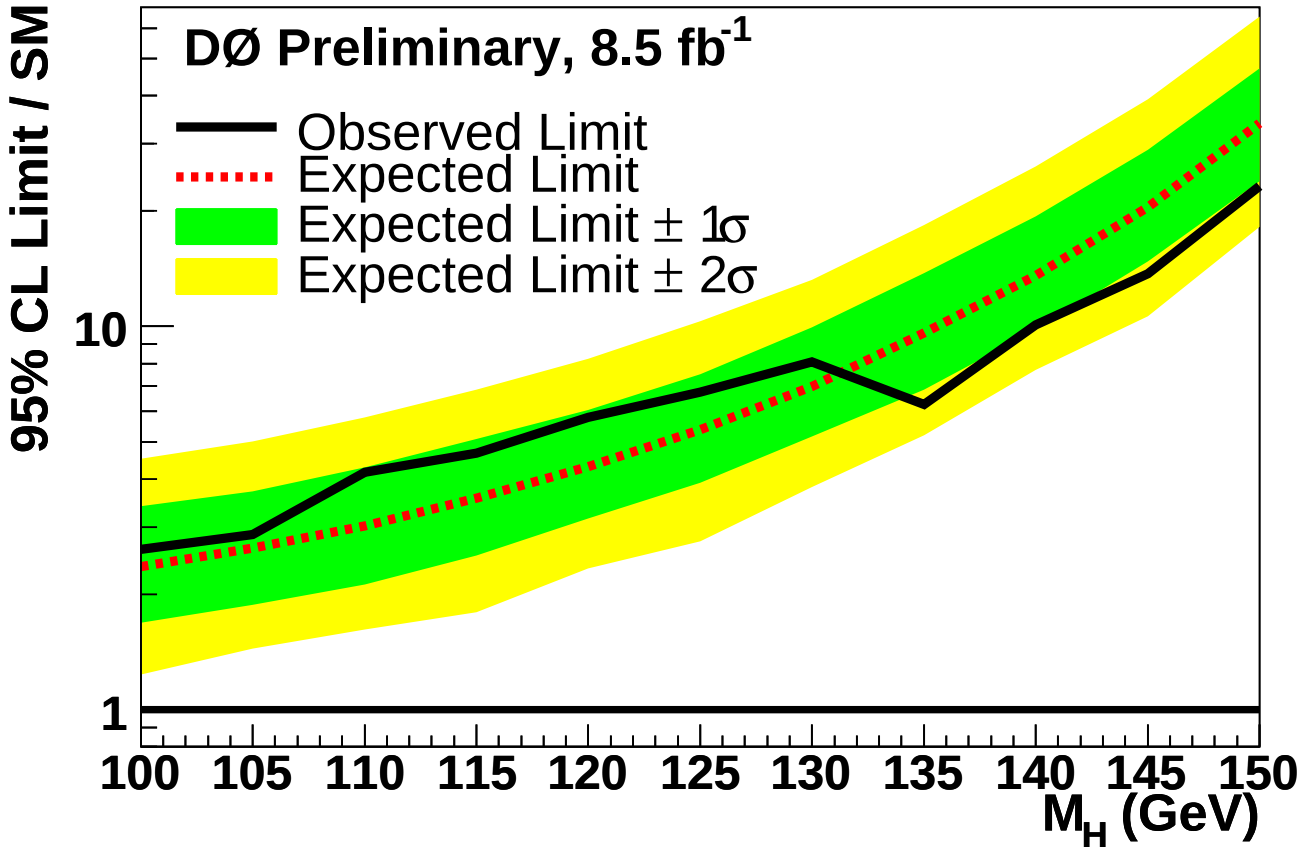
- DØ: Boosted Decision Tree Based Discriminant

⇒ 13 Discriminating Variables as Inputs.

⇒ Discrimination of Multiple Backgrounds

WH Cross Section Upper Limits

- Individual Orthogonal Samples Combined



Combined $7.5 + 1\text{fb}^{-1}$ Results

See: PRL 102, 051803 (2009)

- Bands Incorporate Systematic and Poisson Statistical Uncertainties

$\Rightarrow$ Observed (Expected) Limits 4.6 (3.5) $\times$ SM Prediction for $M_H = 115$ GeV

(11% Improvement beyond Luminosity)

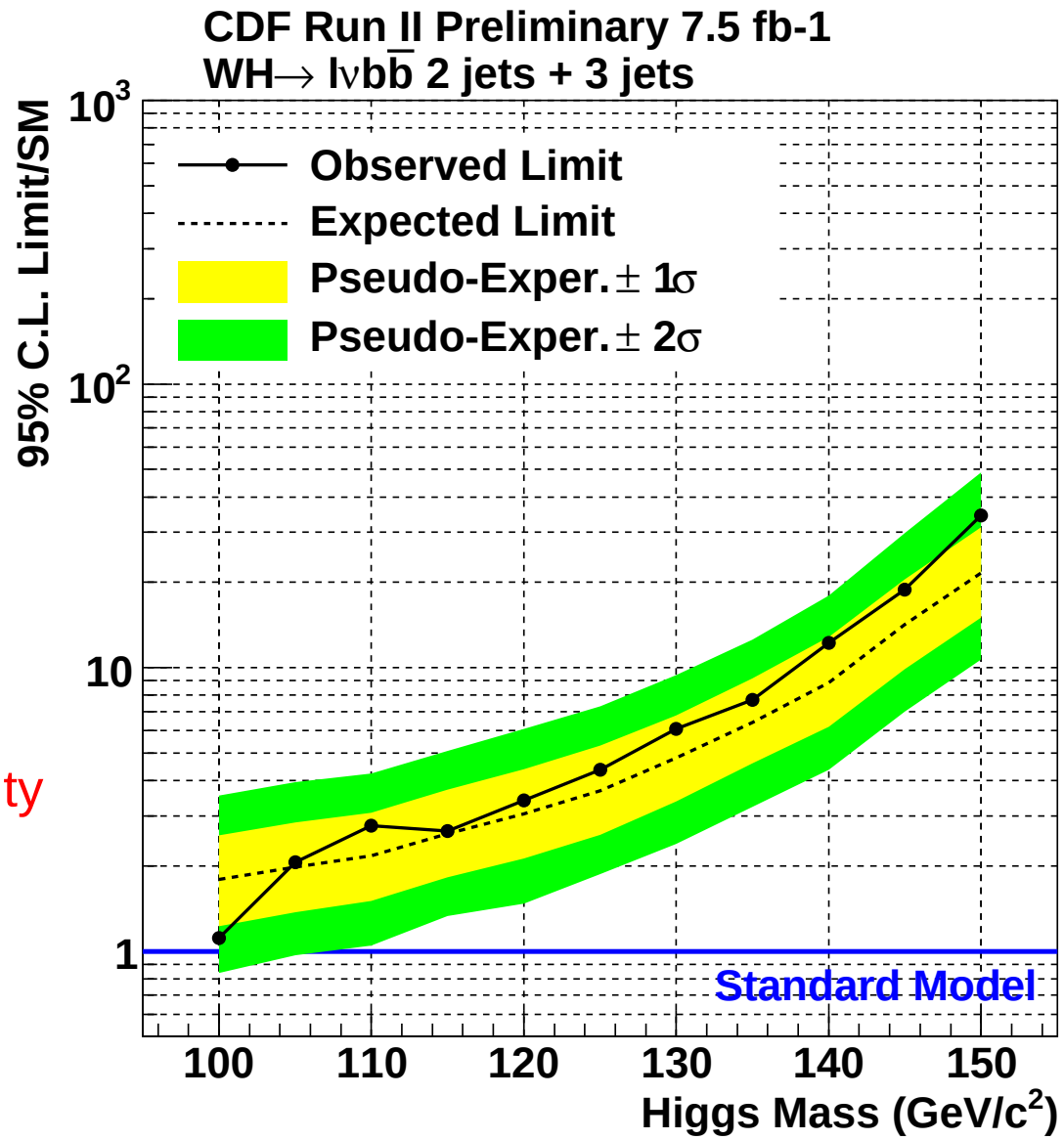
WH Cross Section Upper Limits

- 2-Jet (7.5fb^{-1}) Result Combined with Independent 3-Jet (5.6fb^{-1}) Result

  See: CDF Public Note 10217 (2011)

$\Rightarrow$ Observed (Expected) Limits
2.65 (2.6) $\times$ SM Prediction
for $M_H = 115$ GeV

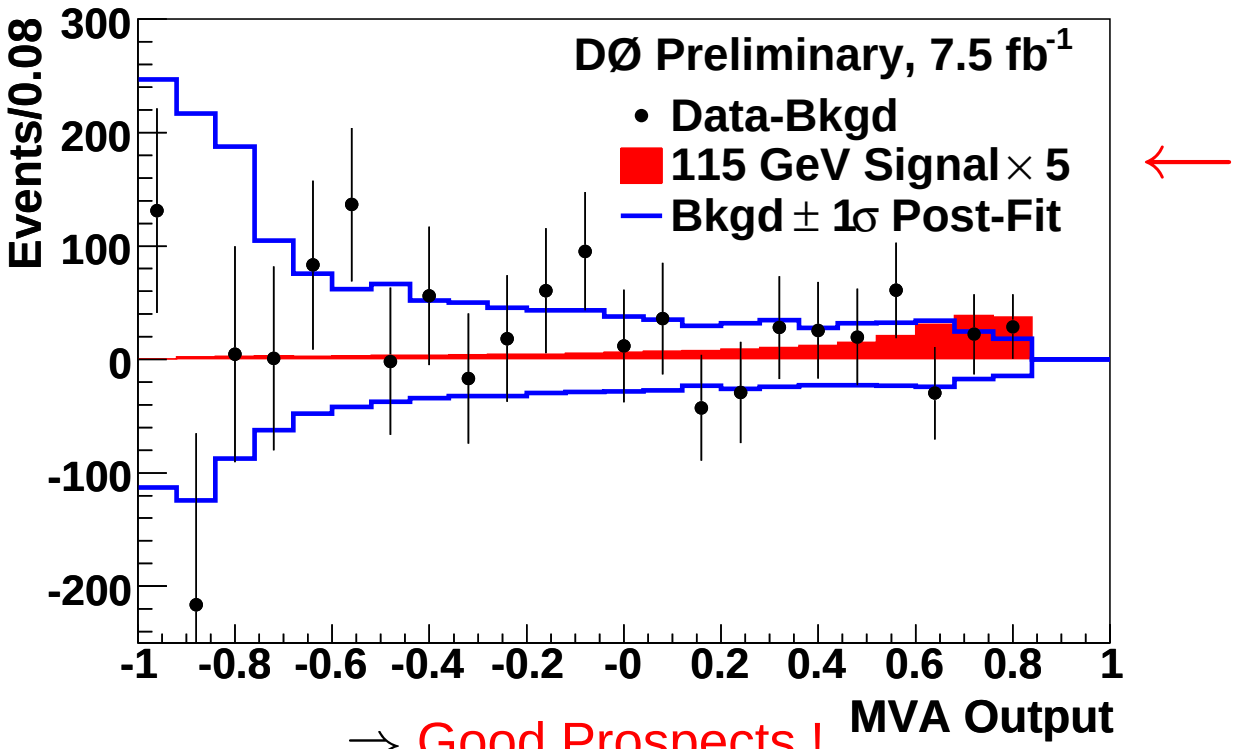
$\Rightarrow$ 17% Improvement in Total Sensitivity



Summary and Outlook

- Tevatron Associated $WH \rightarrow \ell\nu b\bar{b}$ Searches Very Sensitive to a Low Mass SM Higgs

- Results Now Incorporate $\sim$ 80% of Recorded Luminosities
  .. and Continue to Gain in Sensitivity



$\Rightarrow$ Good Prospects !