Low Mass SM Higgs Search at the Tevatron

Duncan Brown

LPNHE (Universities VI and VII) Paris

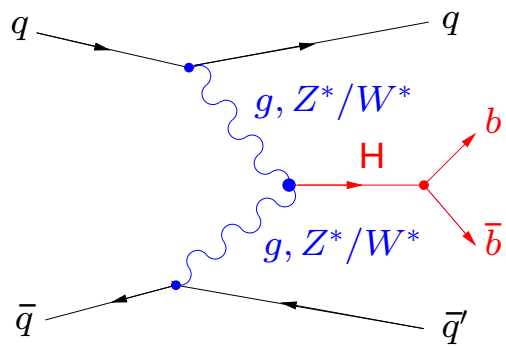
On Behalf of the CDF and DØ Collaborations

22nd Rencontres de Blois

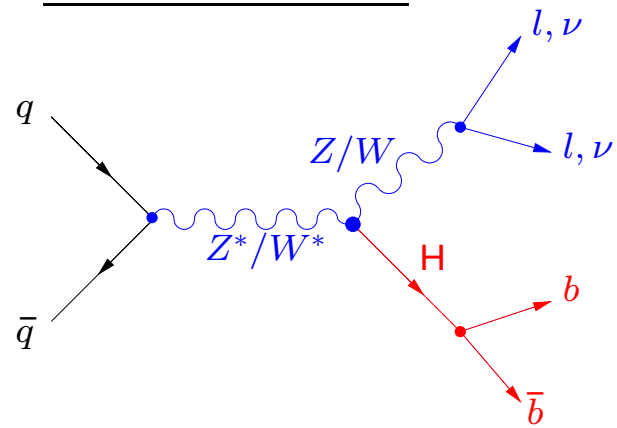
July 18th 2010

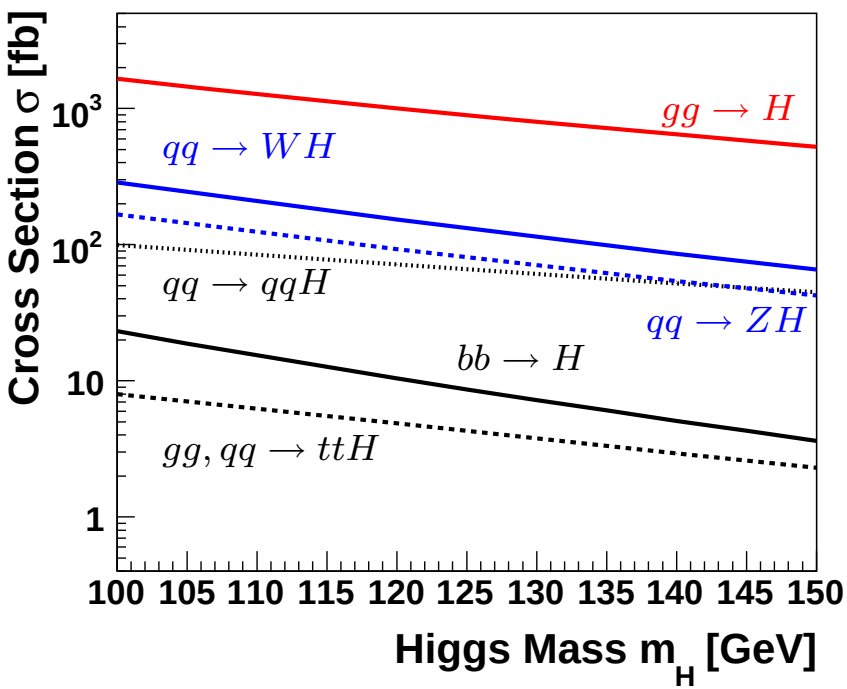
Low Mass SM Higgs Searches

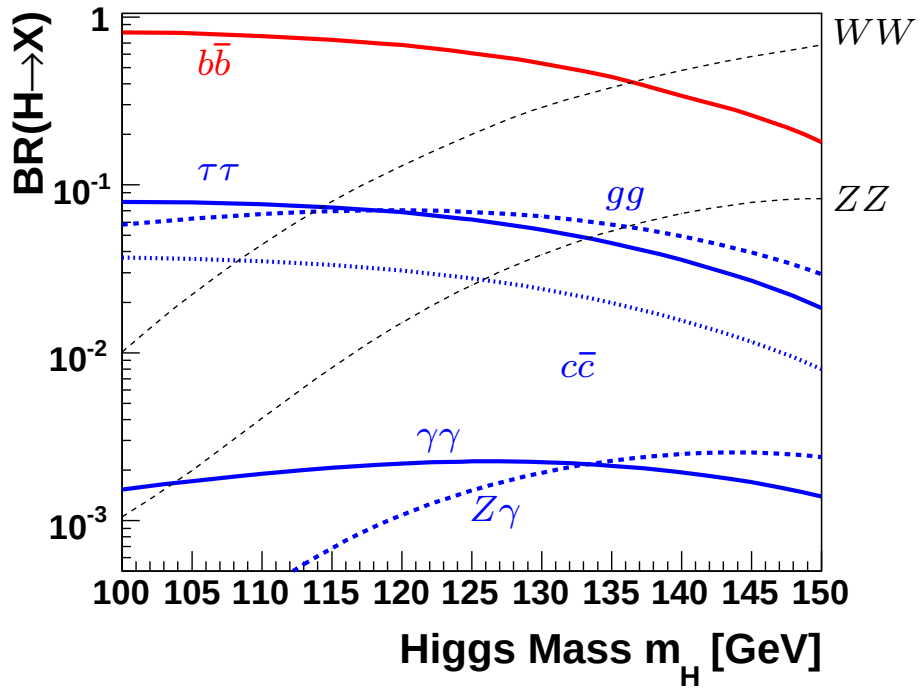
$gg \to H$ and Vector Boson Fusion (VBF)



Associated Production

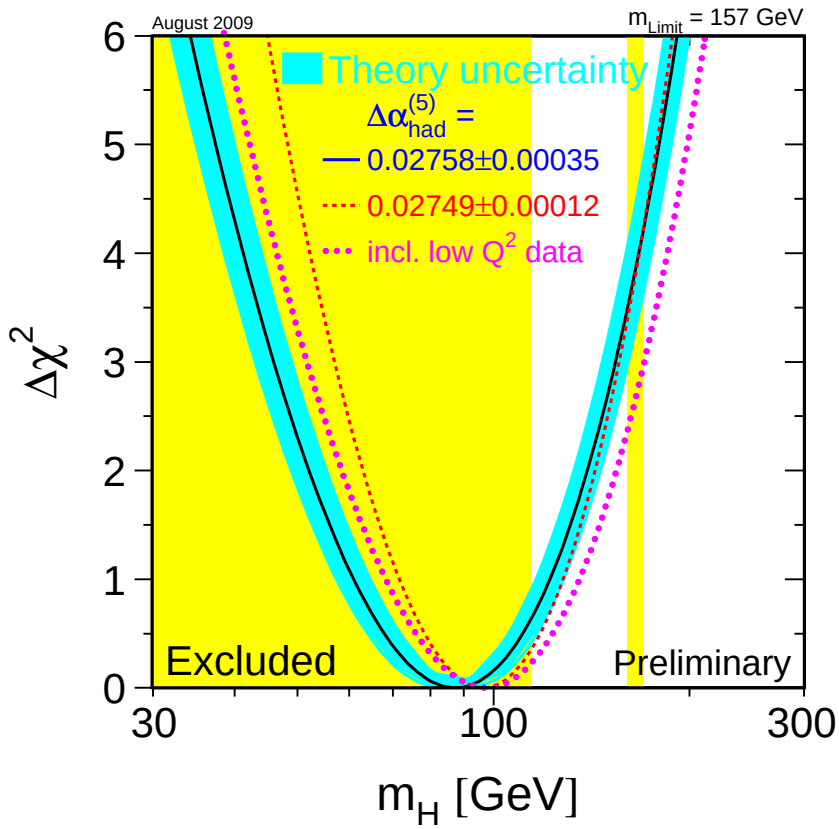


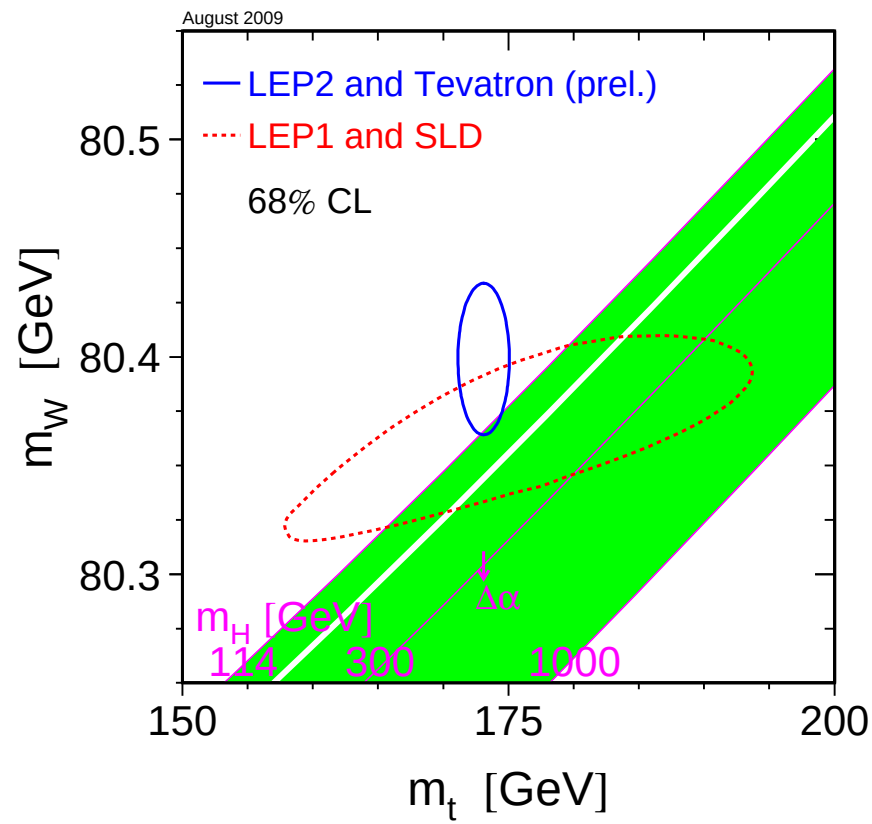




$\Rightarrow$ 90 Simultaneous Orthogonal Searches at the Tevatron

SM Higgs @ Low Mass





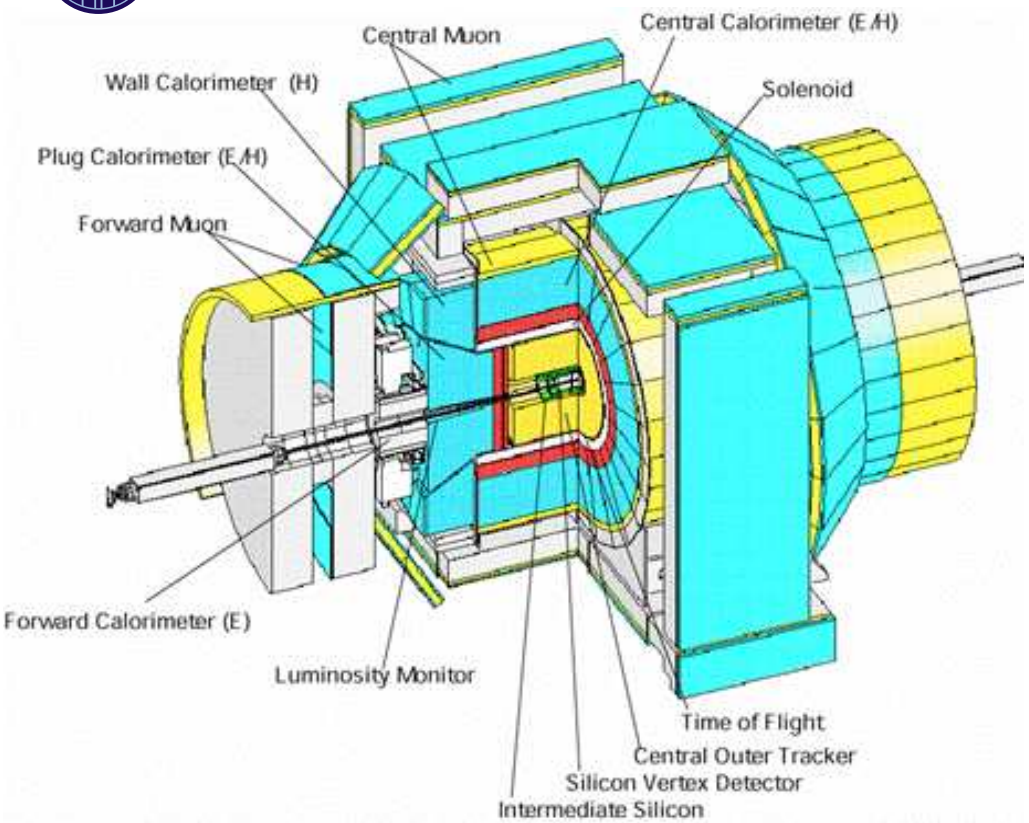
- Lower Limit: $m_H > 114.4$ GeV

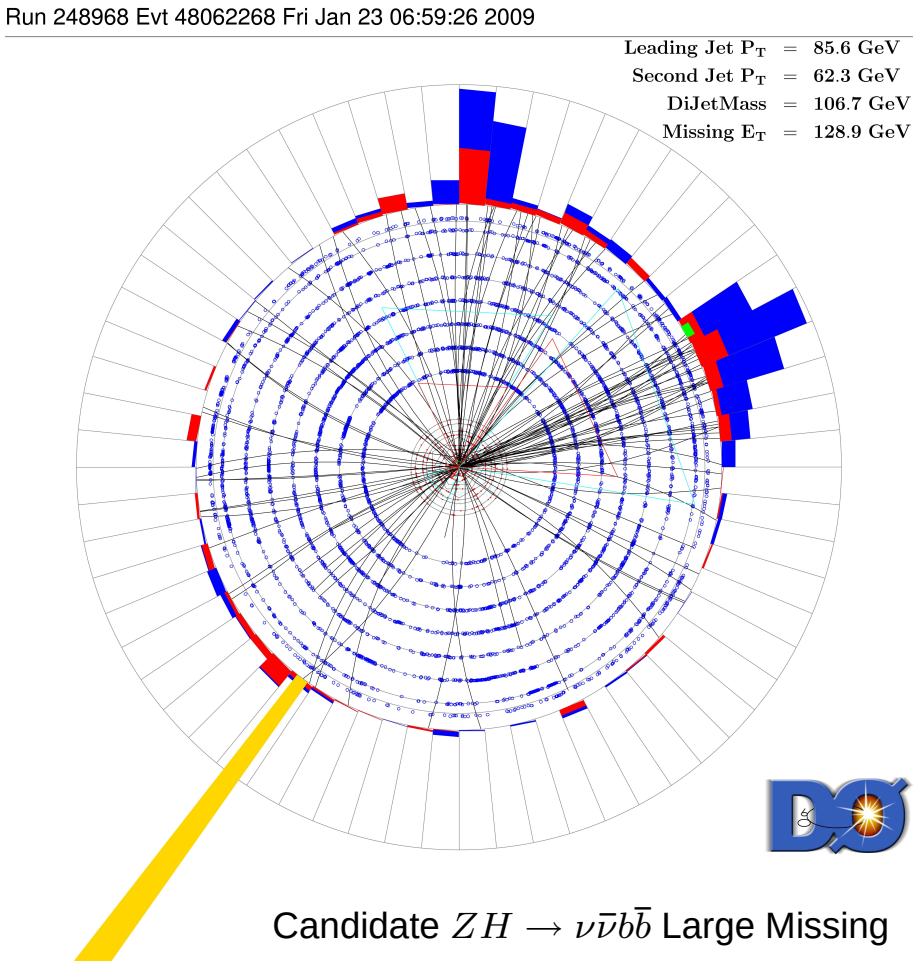
  Excluded Region from LEP Direct $e^+e^- \to ZH$ Searches
- Upper Bound: $m_H < 157$ GeV (at 95% CL)

  Inferred from Fit to Precision Electroweak Measurements

Multiple Measurements $\Rightarrow$ Low Mass SM Higgs

Event Signatures



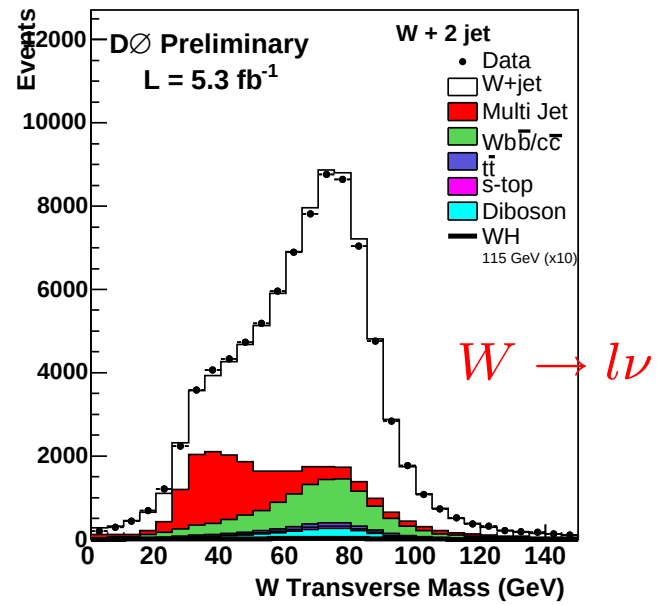


Candidate $ZH \rightarrow \nu\bar{\nu}b\bar{b}$ Large Missing Transverse Energy Event

- Tevatron Higgs Searches Utilize Complete Detector Information

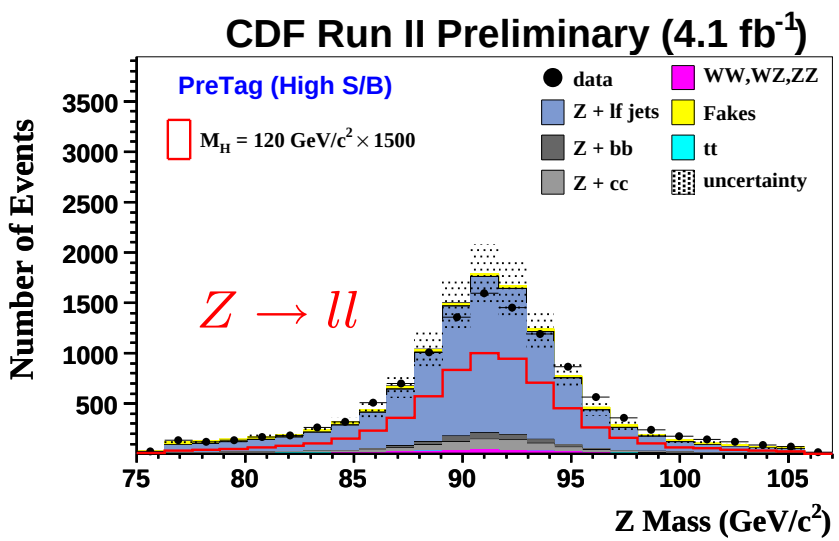
Preselection: Associated Production Samples

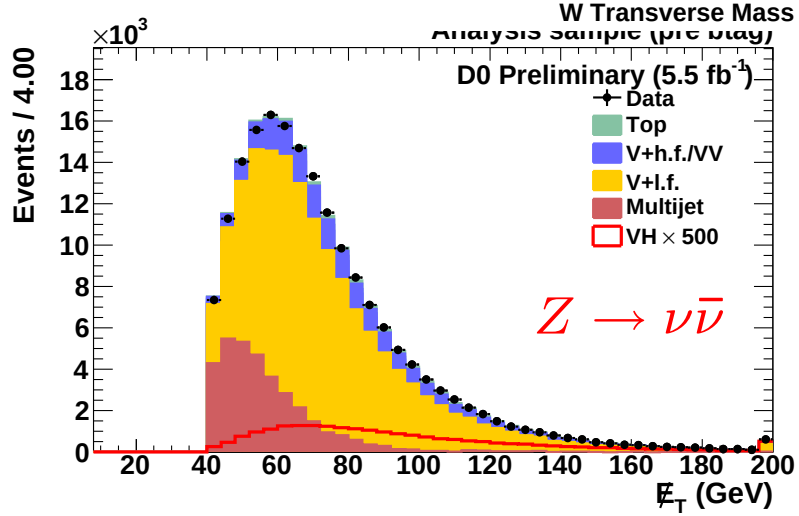
- $H \rightarrow b\bar{b}$ Decays: 2 Prong Jet Pre-Selections
  $\Rightarrow$ 3-Prong Jet Pre-Selections allow for Additional QCD Radiation



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

  (Further Searches use Tau Lepton Final States)



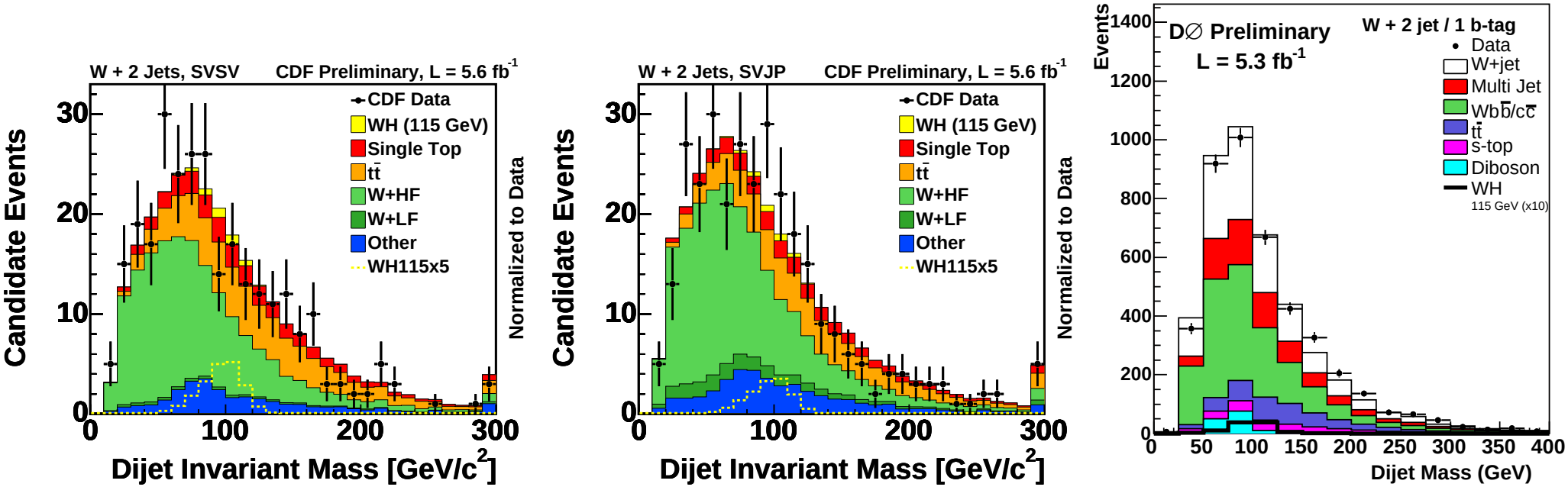


- Many BKGDs: Normalized to Theory Predictions and/or Modelled and Validated in Separately Selected Control Samples

Associated WH $\rightarrow l\nu b\bar{b}$ Production

- Preselect: $W \rightarrow e\nu$ and $W \rightarrow \mu\nu$ in 2(3) Jet Events
- 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

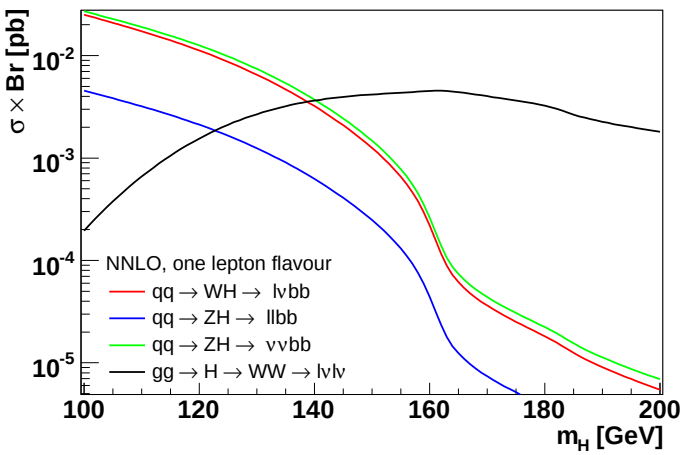
$\Rightarrow$ Orthogonal Double and Single b-Tagged Samples of Varying Sensitivity



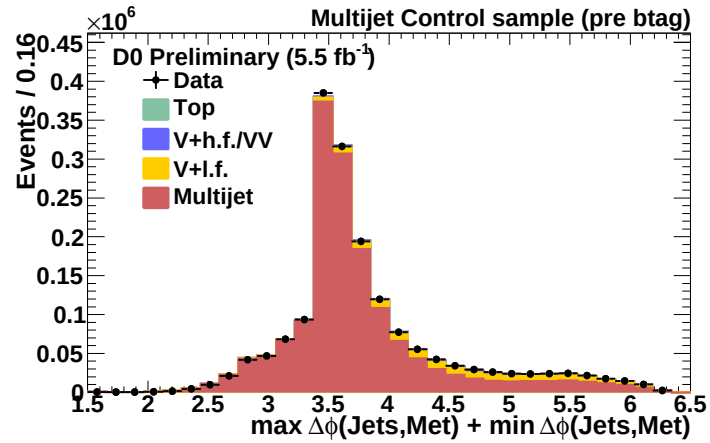
- Further Discriminant Techniques Reduce Remaining Backgrounds Further

Associated VH $\rightarrow \not{E}_T\, b\bar{b}$ Production

- Preselect: Significant $\not{E}_T$ in 2(3) Jet Events

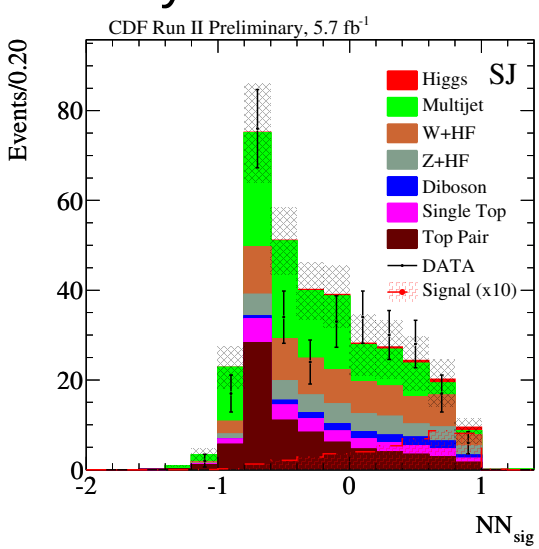


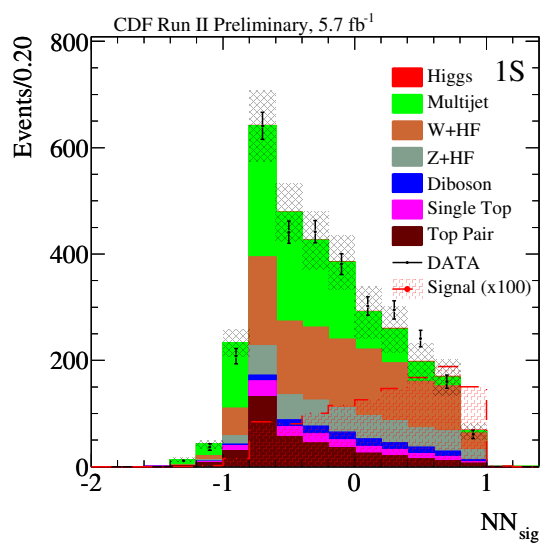
DØ Prel. Update: 6.4 fb^{-1} (ICHEP)



- Sensitive to $Z \rightarrow \nu\bar{\nu}$ (and $W \rightarrow l\nu$) Decays

- Preselection Exploits Correlated charged $\not{p}_T$ and $\not{E}_T$





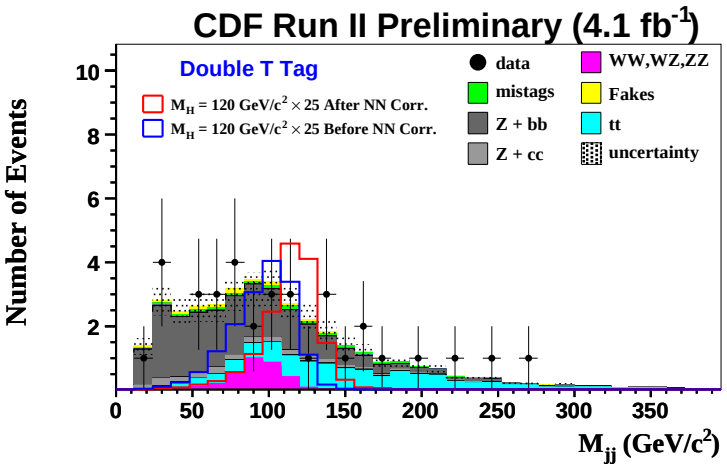
- Orthogonal Double and Single Tagged b-Jet Samples

- 2nd Stage Discriminant Suppresses Surviving BKGDs

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

- Preselect: $Z \rightarrow e^+e^-$ and $Z \rightarrow \mu^+\mu^-$ in 2 (3) Jet Events

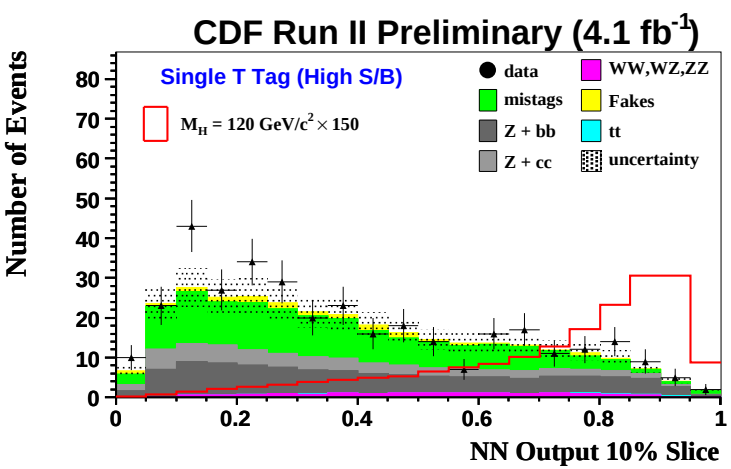
$\Rightarrow$ CDF / DØ : Two Further Z Boson Orthogonal Preselections

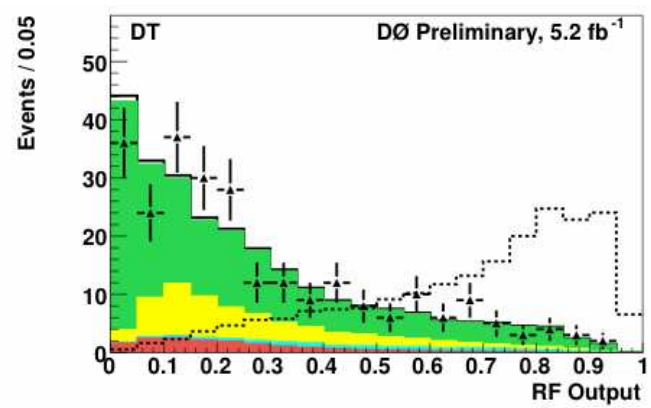


- Improved Dijet Mass Resolution (CDF)

- D0: Additional 3.1 fb^{-1} Added

- Orthogonal Samples: Double and Single b-Jets
- Background Discriminant Techniques Suppress Remaining Backgrounds:

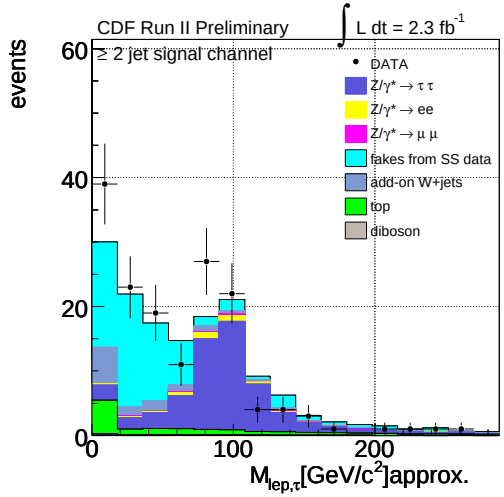




$\Rightarrow$ Data Limit Cross Section to within $\sim 10 \times$ SM Prediction ($M_H \leq 130$ GeV)

Searches in the $\tau\tau q\bar{q}$ Final State

- Selection Sensistive to H $\rightarrow \tau\tau$ and Z $\rightarrow \tau\tau$ Decays



- Total Five Contributing Processes:

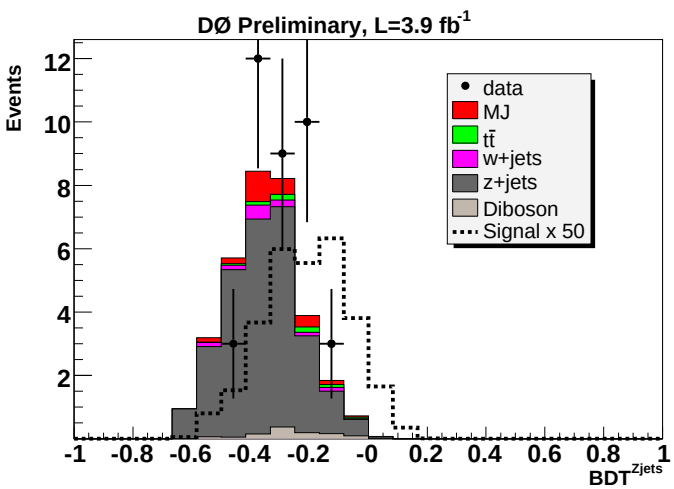
$\Rightarrow$ gg and VBF with H $\rightarrow \tau\tau$

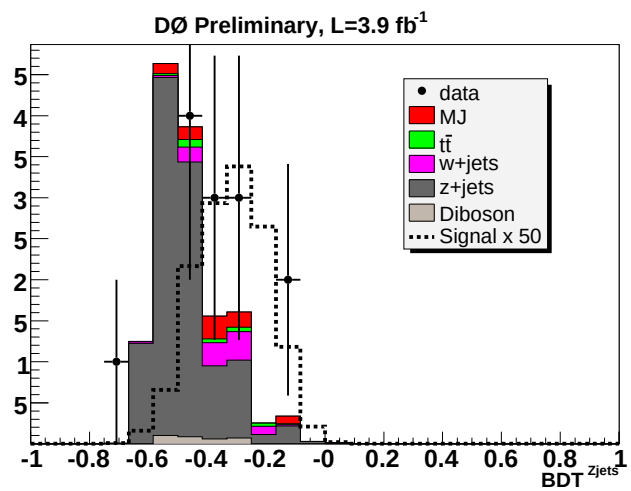
$\Rightarrow$ Associated Productions:

ZH $\rightarrow q\bar{q}\tau\tau$, ZH $\rightarrow \tau\tau b\bar{b}$ and WH $\rightarrow q\bar{q}\tau\tau$

$m_H = 105, 110, 115$ GeV

$m_H = 130, 145$ GeV





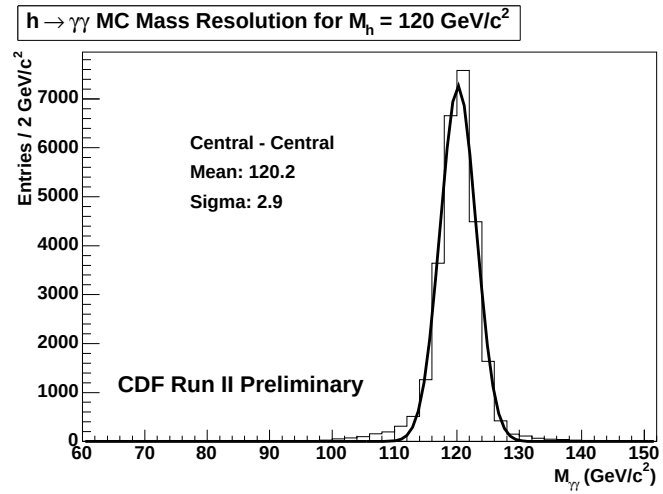
No Explicit b-Tagging Requirement

Preselect $\not{E}_T$, hadronic τ and $\tau \rightarrow \mu\nu_\tau\bar{\nu}_\mu$

- Combine BDT Discriminant Distributions from 32 Orthogonal Samples

Searches in the Di-Photon Final State: H $\rightarrow \gamma\gamma$

- Small Branching Ratio (Enhanced in Beyond Standard Model Scenarios)
- Sensitive to gg, VBF and Associated VH Processes

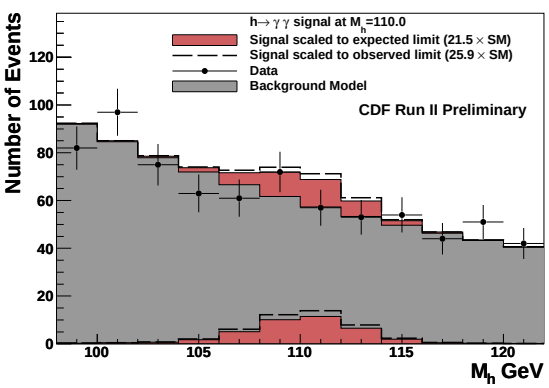


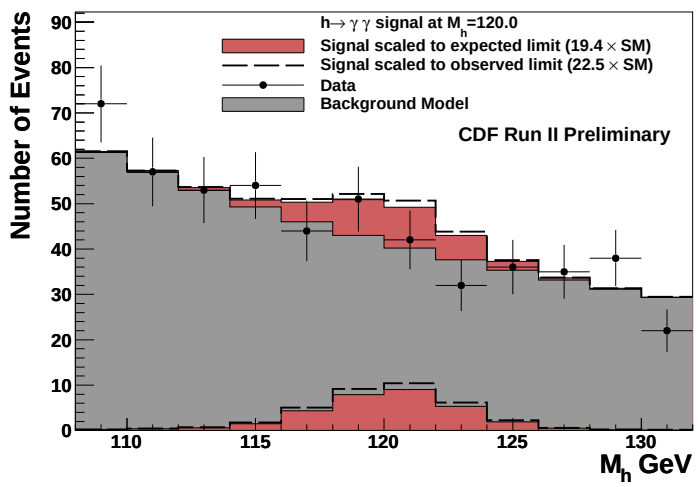
CDF Selection: Two Central Photons ($\eta_\gamma < 1.05$)

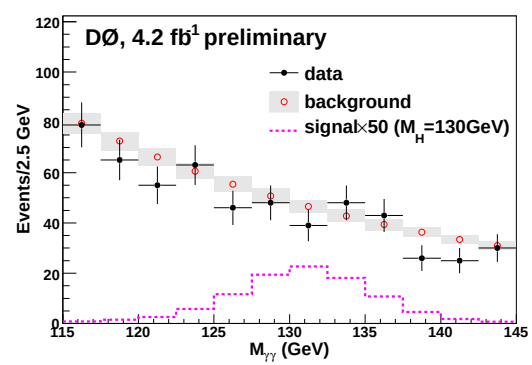
- Scan $M_{\gamma\gamma}$ Distributions for Narrow Resonances

Advantage Improved $\longrightarrow$
Photon Energy Resolution

- Exclude Signal Region and Fit Background (Repeat for Each Mass Point)



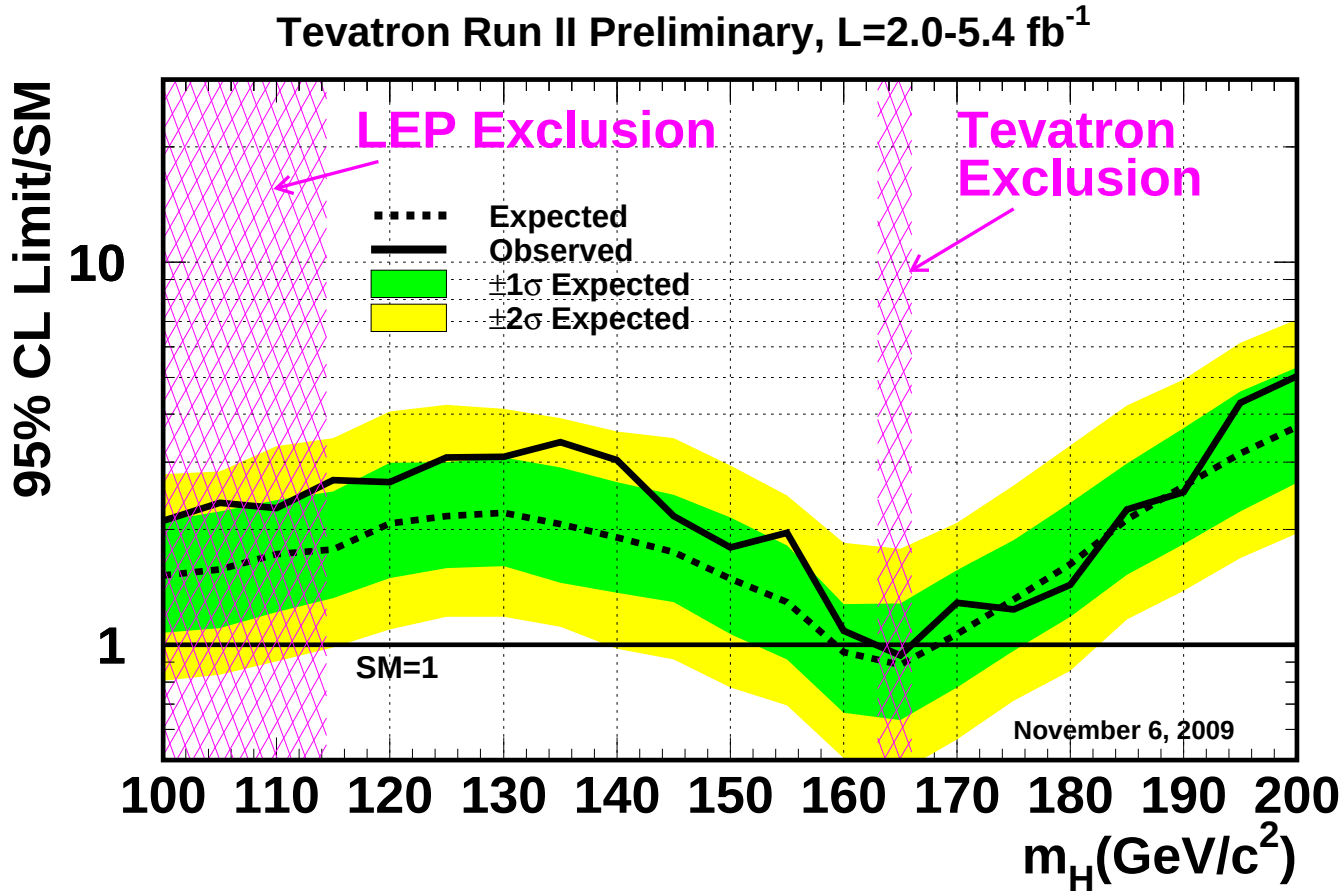




$\Rightarrow$ Complimentary Search Increases Overall Sensitivity

Tevatron Combined Limits

- Orthogonality Preserved Between Combination Analyses



- 36 CDF and 54 DØ Analyses Combined
- Update Expected @ ICHEP2010

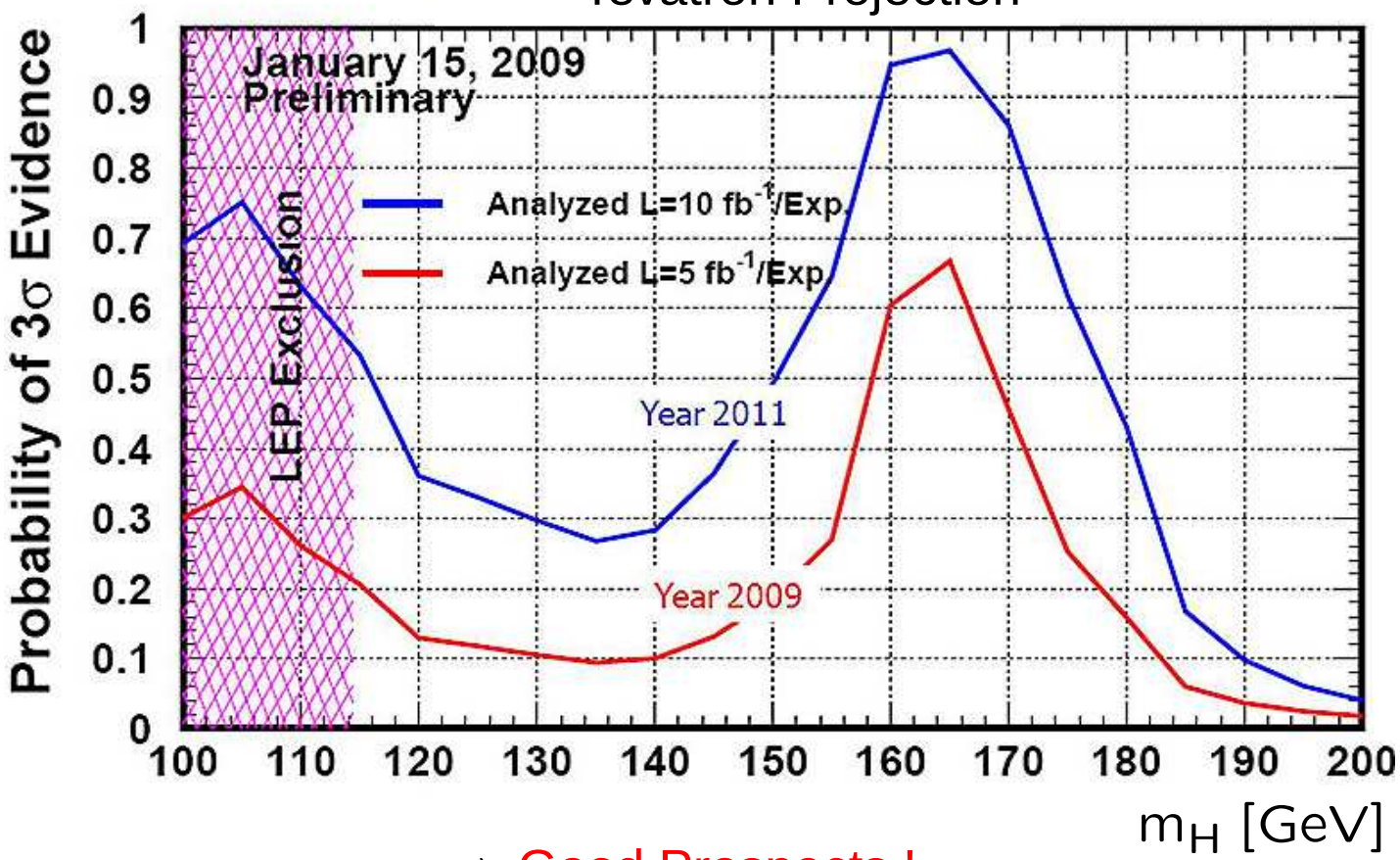
(Bayesian and Modified Frequentist Approaches Agree within 10%)

- Bands Incorporate Systematic and Poisson Statistical Uncertainties
- Observed Limit $<$ 2-3$\times$SM Prediction (within 1-2 Std. Deviations of Expectation)

Summary and Outlook

- Higgs Results at the Tevatron Continuing to Gain in Sensitivity
- High Tevatron Performance $\Rightarrow$ Continued Increases in Luminosity
- Rapid Turnaround from Data Collection to Results

Tevatron Projection



$\Rightarrow$ Good Prospects !