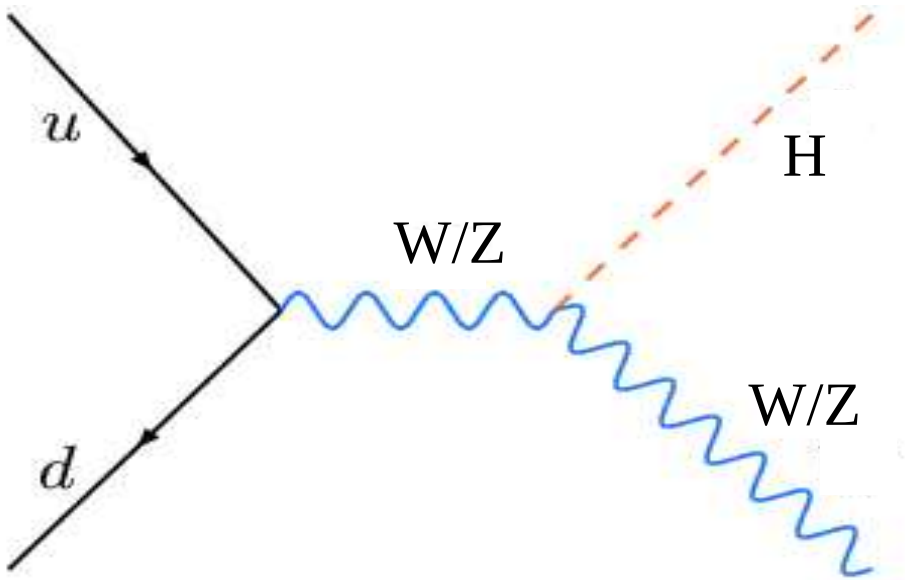
Search for Associated Higgs Boson Production at DØ

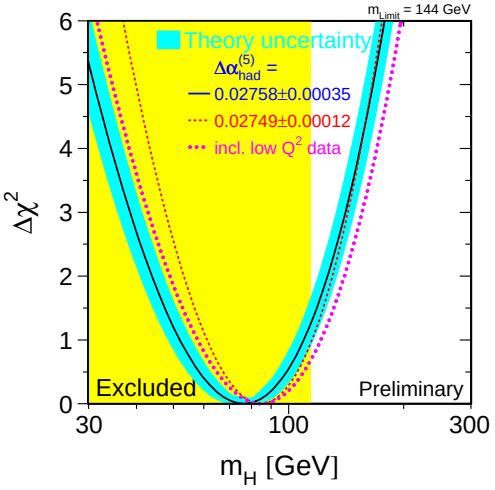


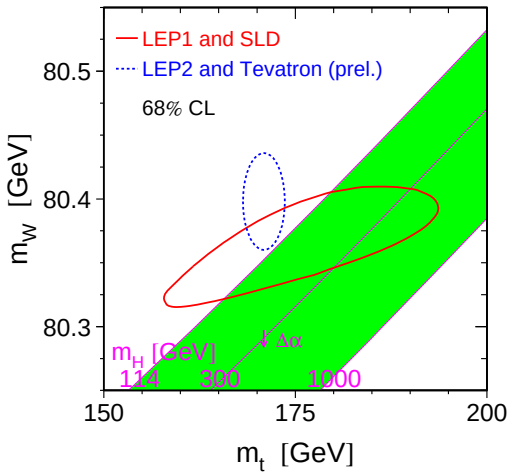
Jonas Strandberg

on behalf of the DØ collaboration

Introduction

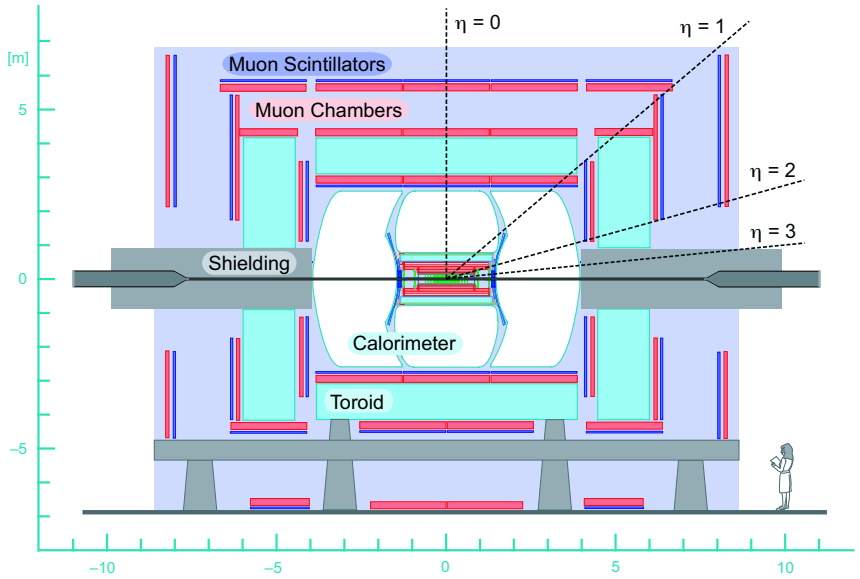
- The SM parameters fit to EW precision data prefers a light Higgs boson.
- The most sensitive search channels for $114 < m_H < \sim 135$ GeV at the Tevatron is associated Higgs production.
- Leptonically decaying W or Z boson allows for rejection of multijet background.

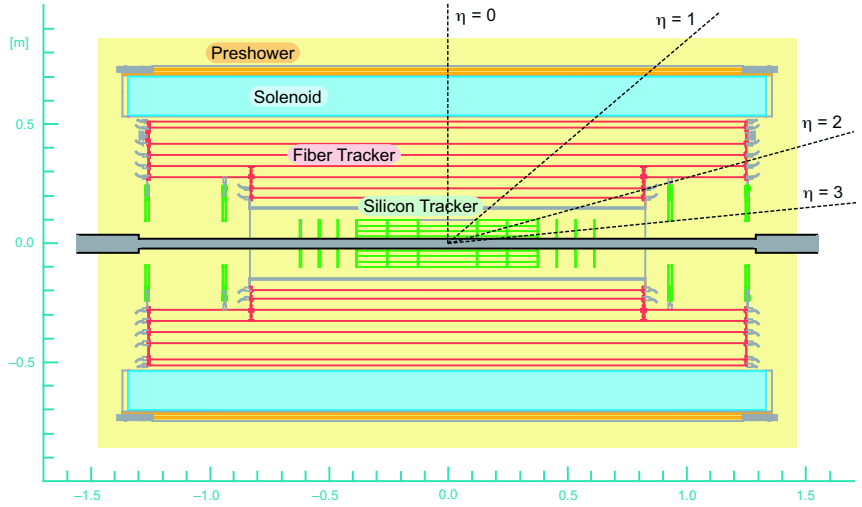




- DØ results for the summer are still in internal review, no updated results in this talk.
  - Typical $\mathcal{L} \approx 1\ \mathrm{fb}^{-1}$.
  - No RunIIb data (2006-2007 data).
- Try to give an idea of what to expect for the Lepton-Photon conference (LP07).

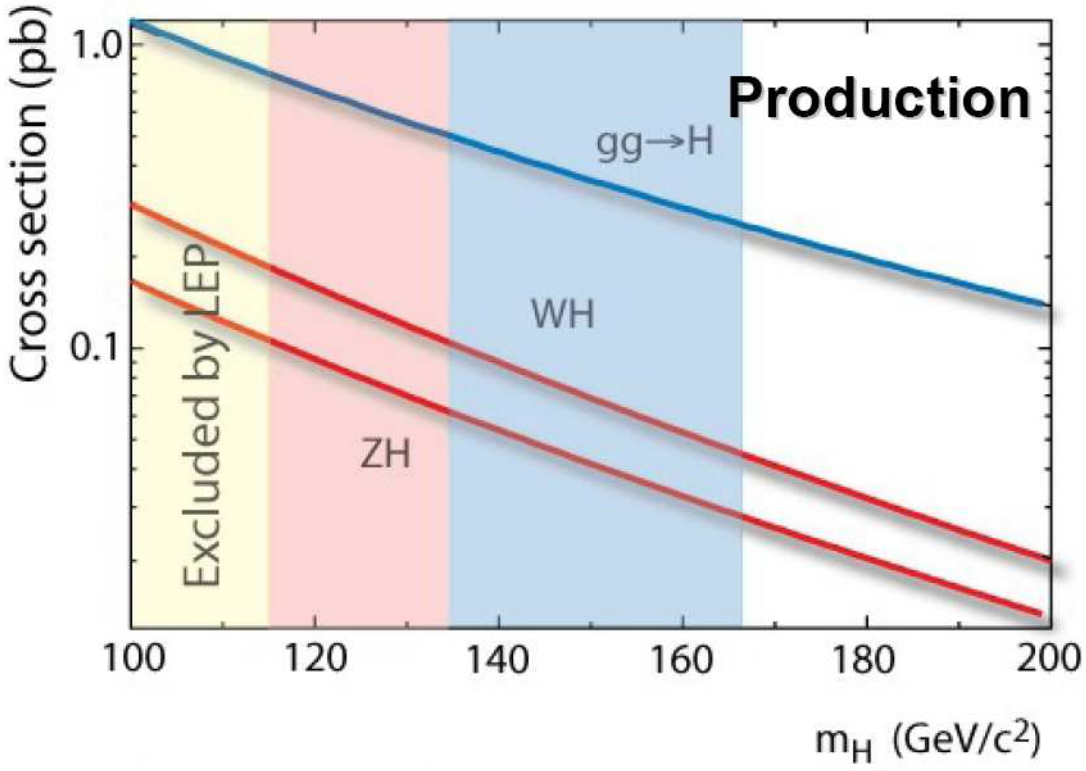
The DØ Detector





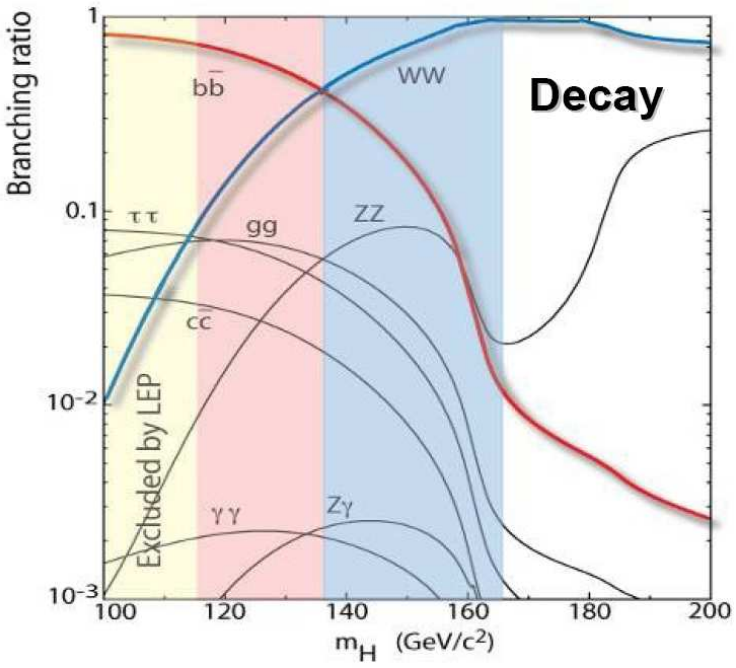
- Liquid Ar and U calorimeter.
- Three-layer Muon system with coverage out to $|\eta| < 2$.
- Magnetic fields provided by a 2 T solenoid and a 1.8-2 T toroid.
- Si and Fiber Tracking detectors.
- New innermost layer of the silicon detector installed in spring 2006.
  - Will be used in updated results shown at LP07.

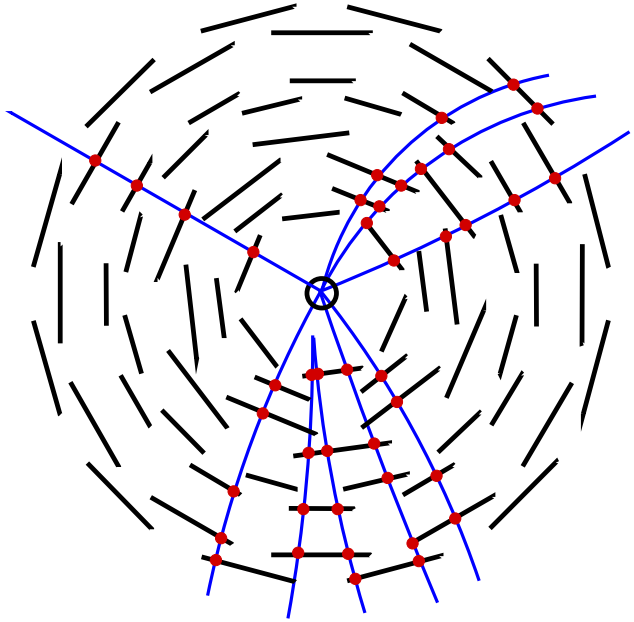
Higgs Production at the Tevatron



- Expected cross section $\sigma(VH)$ of the order of 0.1 pb.
- With $BR(W \to \ell\nu) \sim 0.1$ and typical event selection efficiency of $\sim 10\%$, expect about $2\ \mathrm{event/fb^{-1}}$ of data (per lepton type).

Higgs Decay and b-tagging



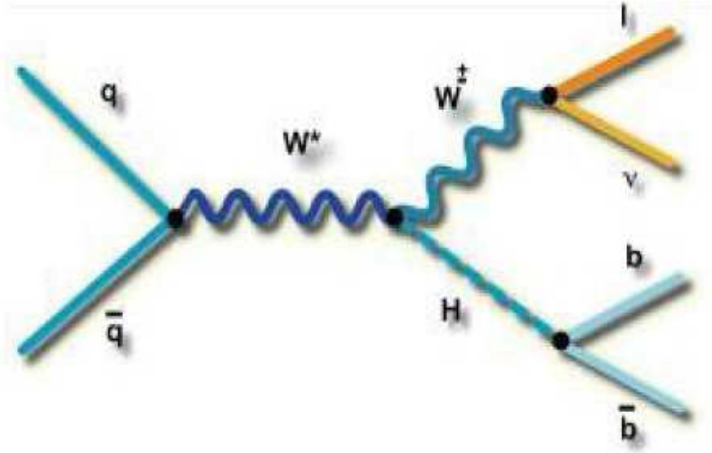


- For $114 < m_H < \sim 135$ GeV, the decay $H \to b\bar{b}$ dominates.
- For $m_H \gtrsim 135$ GeV the $H \to WW$ decay is more sensitive.

- Decays of b-hadrons produce displaced tracks and vertices.
- All analyses use a NN-based b-tagging algorithm.
  - High I.P. tracks, SVX ...

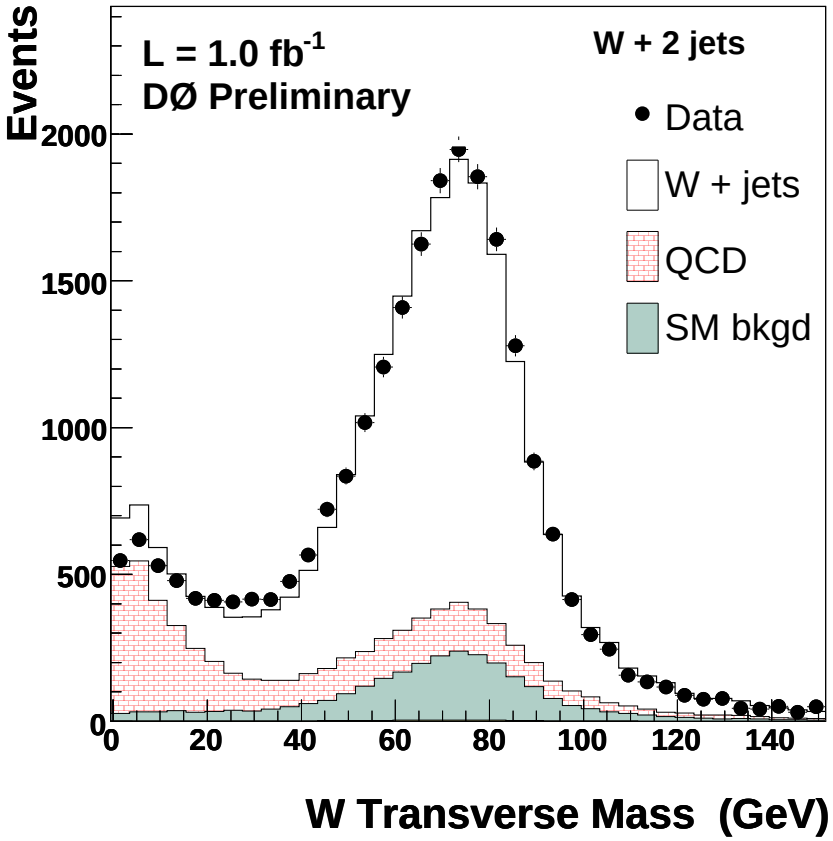
WH - Cut Based Analysis

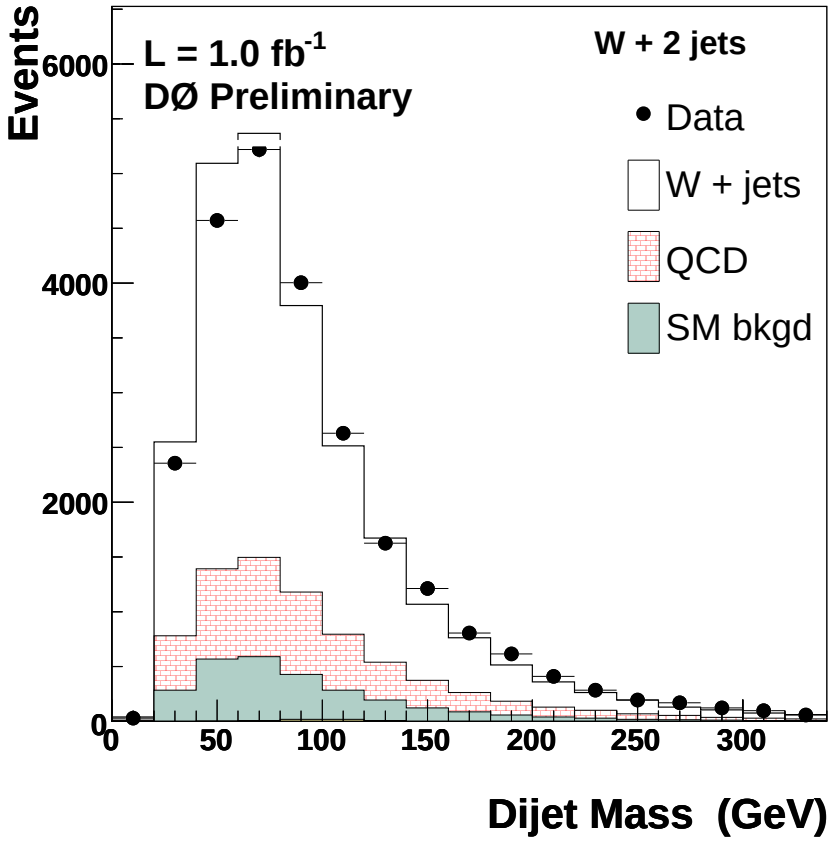
- WH is the most sensitive channel for a Higgs with $m_H < 135$ GeV.
- Expected $\sigma(WH) \times Br(H \to b\bar{b}) = 0.13$ pb for $m_H = 115$ GeV.
- $1\ \mathrm{fb}^{-1}$ of data analyzed in the e+jets and the μ+jets channels.
- Event Selections:
  - Equal to two jets with $p_T > 20$ GeV and $|\eta| < 2.5$.
  - An electron or a muon with $p_T > 20$ GeV.
  - A well reconstructed primary vertex with > 2 tracks.



  - $\not\!\!E_T > 20$ GeV.
  - Either two loose NN b-tagged jets (70% b, 4.5% l-tag eff.) ...
  - ... or one tight NN b-tagged jet (48% b, 0.5% l-tag eff.).

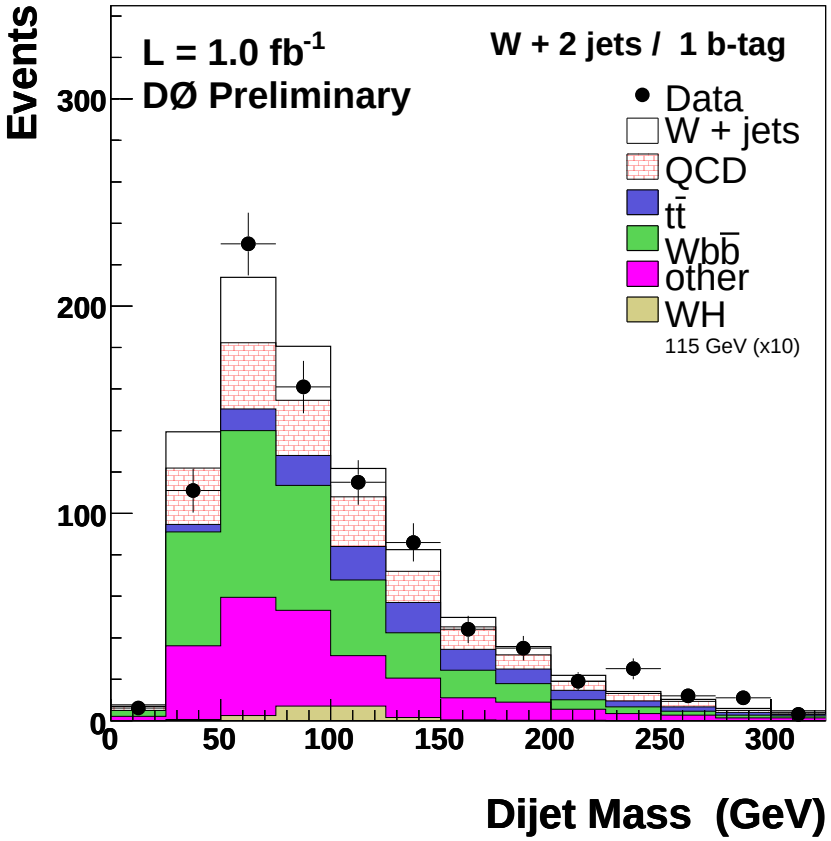
Sample before b-tagging

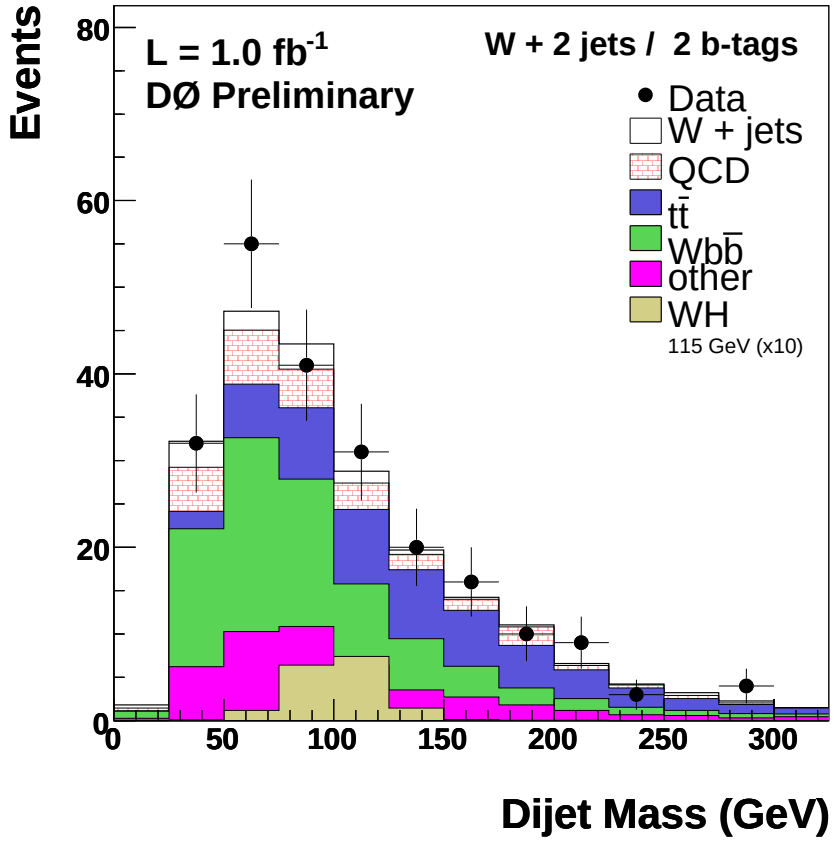




- Multijet (QCD) background estimated from data, other backgrounds estimated from simulated samples. Relatively pure W+jets sample.

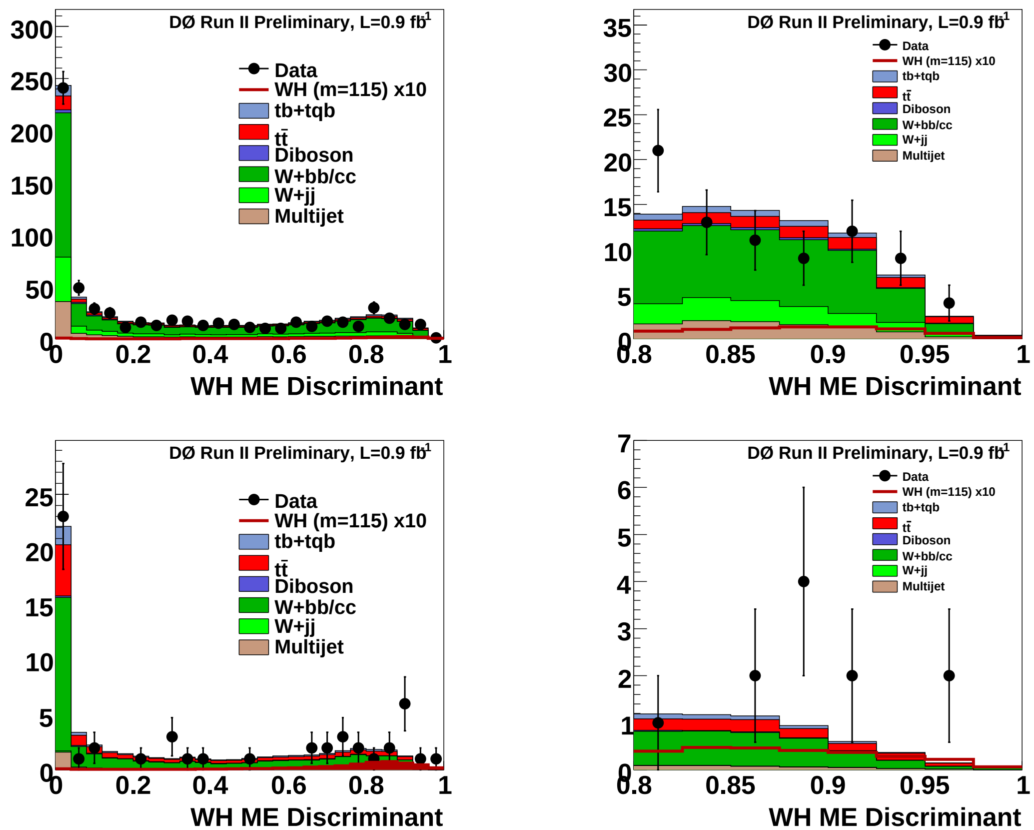
Sample after b-tagging





- Limit on $\sigma(WH) \times Br(H \to b\bar{b})$ derived from the invariant mass distribution of the jets. Expected 3.6 signal events ($m_H = 115$ GeV).

WH - Using Matrix Element (ME) Discriminant

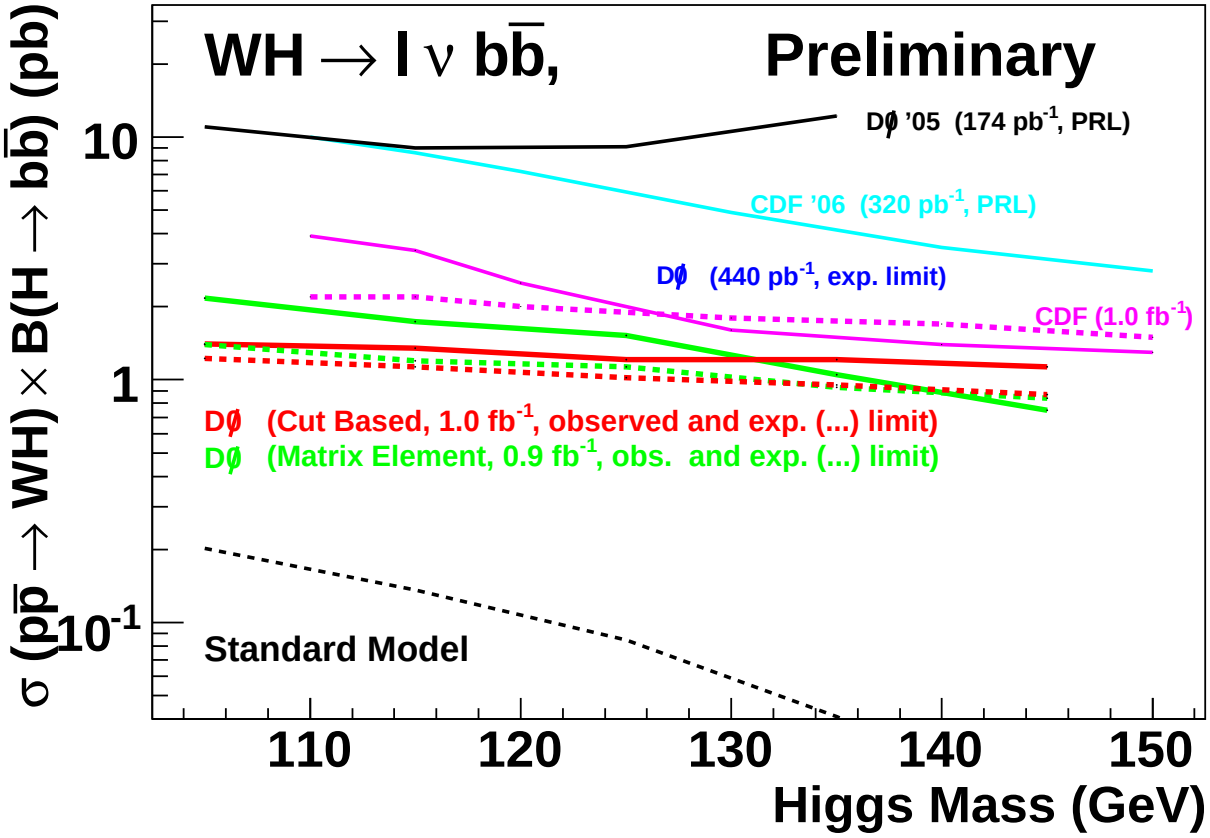


- Using LO ME to compute WH probability:

$$D(\vec{x}) = \frac{P_{WH}(\vec{x})}{P_{WH}(\vec{x}) + \sum_i c_i P_{B,i}(\vec{x})}$$

- Code imported from single top analysis.
  - Selections still to be optimized for WH.
- $900\ \mathrm{pb}^{-1}$ analyzed.
- Around 2σ excess of events in double tags.
  - Low statistics.
  - Not seen for ST.

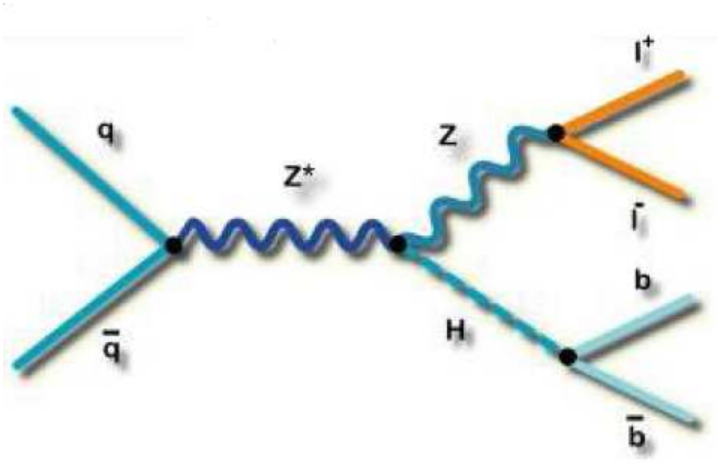
WH Cross Section Limit



- Dominant syst. uncertainties JES, b-tagging and W+h.f. content.
- Updated result using $1.5\ \mathrm{fb}^{-1}$ and NN discriminant for LP07.

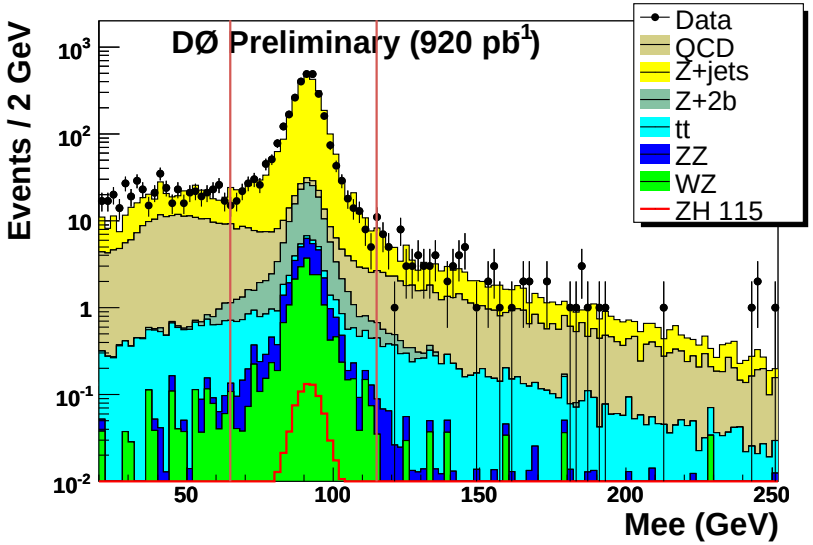
$ZH \to \ell\ell bb$ Analysis

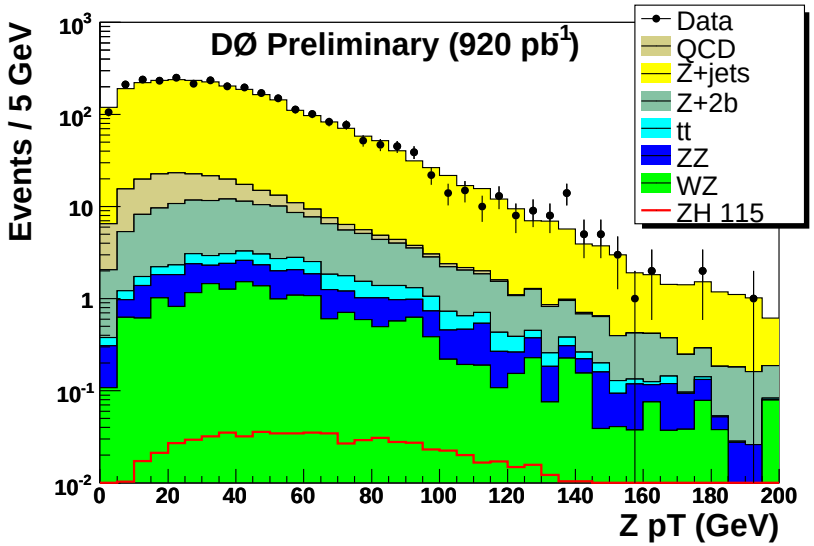
- ZH with $Z \to \ell^+\ell^-$ is one of the more sensitive channels.
- Small production rate, $\sigma(ZH) \times Br(H \to b\bar{b}) = 0.085$-$0.02$ pb.
- $920\ (840)\ \mathrm{pb}^{-1}$ of data analyzed in the ee ($\mu\mu$) channel.
- Event Selections:
  - At least two jets with $p_T > 15$ GeV and $|\eta| < 2.5$.
  - Two electrons or two muons with $p_T > 15$ GeV.
  - The $\ell\ell$ invariant mass within $65 < M_{\ell\ell} < 115$ GeV (ee) or $70 < M_{\ell\ell} < 110$ GeV ($\mu\mu$).



  - The reconstructed Z $p_T > 20$ GeV in the $\mu\mu$ channel.
  - A well reconstructed primary vertex with > 2 tracks.
  - 2 jets b-tagged with a NN-based tagger (72% b, 6% l-tag eff.).

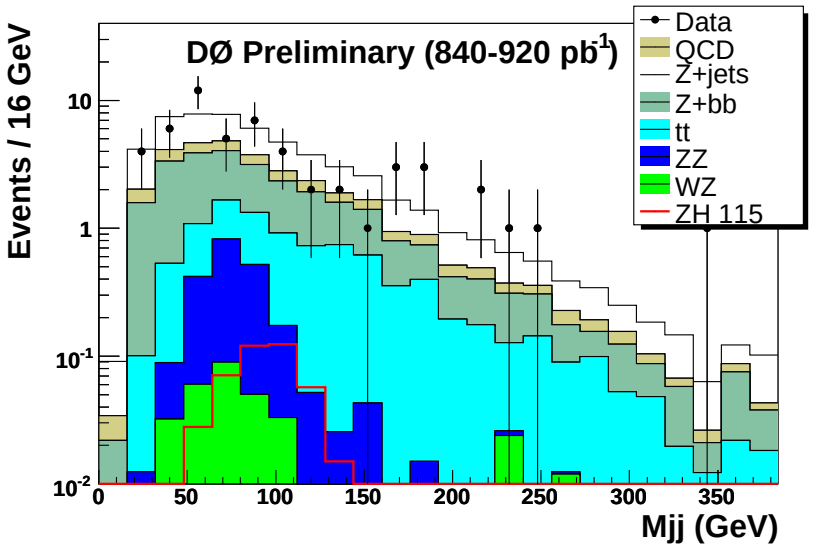
$ZH \to \ell\ell bb$ Data Sample Before b-tagging

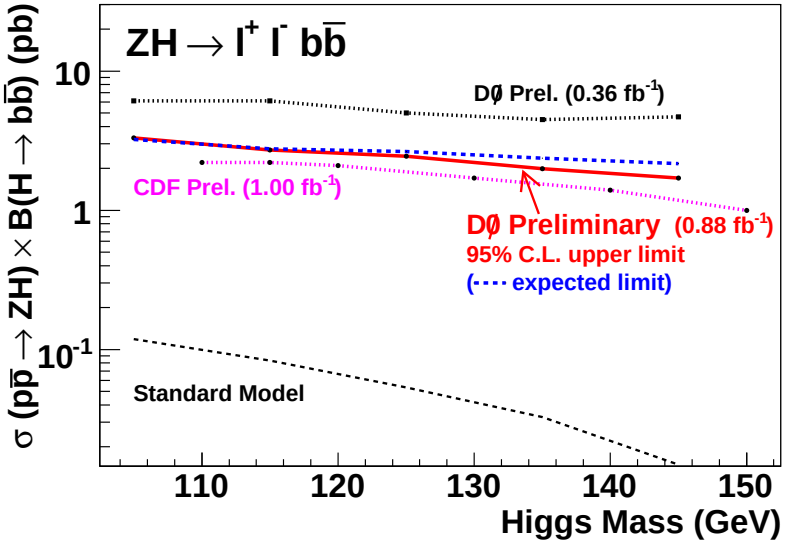




- Dominant background is Z+jets.
- Simulated Z+jets samples are scaled to the yield in the Z peak.
- Reconstructed Z gives good rejection against multijet events.
- The Z p_T distribution poorly simulated in the Z+light jets sample.
  - Events are reweighted before b-tagging to correct this.
- Reweighted distribution shown.

$ZH \to \ell\ell bb$ Cross Section Limit



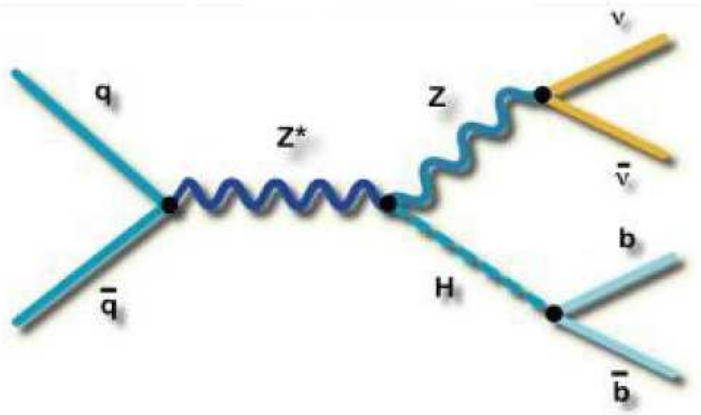


- Look for mass peak in M_{jj} after b-tagging has been applied.
- For $m_H = 105$-155 GeV, look for excess in mass window
  $m_H - 1.5w < M_{jj} < m_H + 1.5w$ (ee)
  $m_H - 1w < M_{jj} < m_H + 2w$ $(\mu\mu)$
  where w is exp. width of M_{jj}.

- Dominant syst. uncertainties:
  - Jet energy scale.
  - b-tagging efficiency.
  - Z+heavy flavor cross sections.
- Work ongoing to update the result using a NN discriminant.

$ZH \rightarrow \nu\nu bb$ Analysis

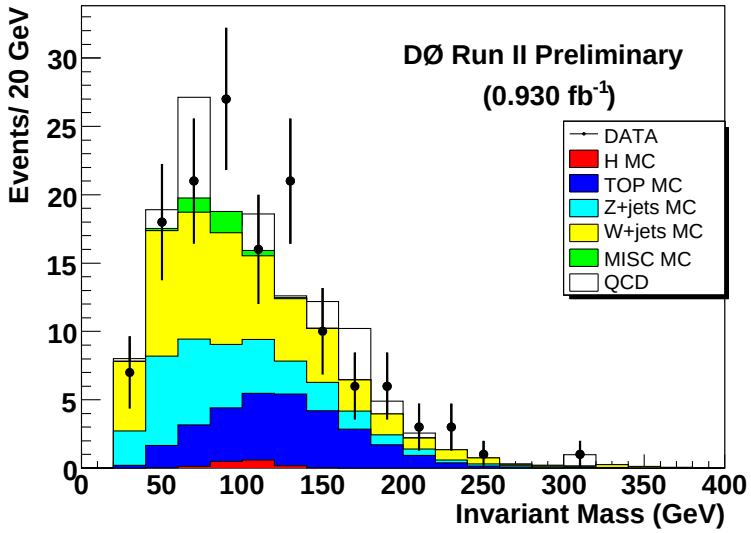
- $BR(Z \rightarrow \nu\nu) \approx 20\%$ in contrast with $BR(Z \rightarrow ee/\mu\mu) \approx 3.34\%$.
- No visible leptons to trigger on, also harder to reject multijet events.
- $930\ \mathrm{pb}^{-1}$ of data analyzed.
- Event Selections:
  - At least two jets with $p_T > 20$ GeV and $|\eta| < 2.5$.
  - No isolated leptons.
  - $\Delta\phi(jet_1, jet_2) < 165°$.
  - $\not\!\!E_T > 50$ GeV.
  - $H_T < 240$ GeV.
  - A well reconstructed primary vertex with > 2 tracks.

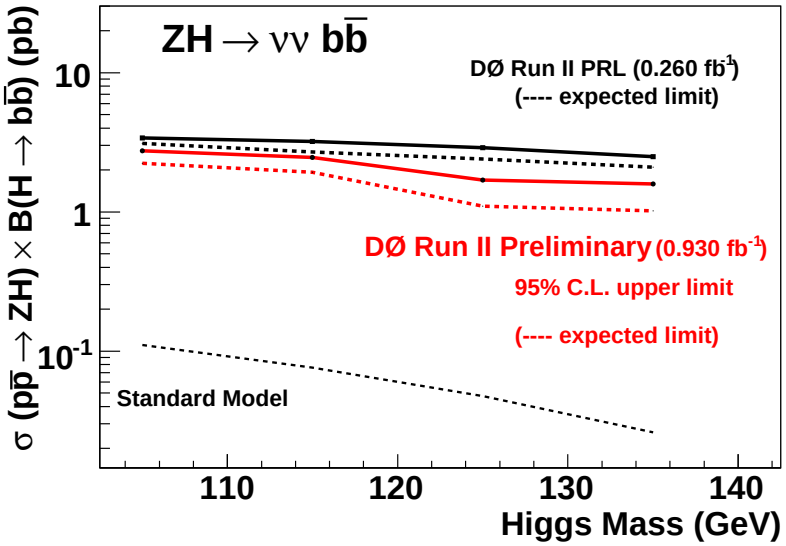


  - One tight NN b-tagged jet (43% b, 0.3% l-tag eff.).
  - One loose NN b-tagged jet (72% b, 6% l-tag eff.).
  - Selections to remove multijet:

$$min\Delta\phi(\not\!\!E_T, jets)$$
$$\Delta\phi(\not\!\!E_T, p_T^{neg.\ trk.})$$
$$Asym(\not\!\!E_T, \not\!\!H_T)$$

$ZH \to \nu\nu bb$ Cross Section Limit





- Expect 1.4 ZH events after b-tagging with an expected background of 63.3 events.
- Limit on $\sigma(ZH) \times BR(H \to b\bar{b})$ extracted from the the M_{jj} distribution.

- Limit ranges from 2.7 to 1.6 pb for $m_H = 105$-135 GeV.
- Overall syst. uncertainty 15% (14%) for signal (background).
- Expect updated result using 1.5 fb^{-1} for the LP07 conference.

Conclusions and Outlook

- Limits on the $\sigma(VH) \times Br(H \to b\bar{b})$ production rate for $m_H = 115$ GeV:

Channel ($\mathcal{L} \approx 1\ \mathrm{fb}^{-1}$)	Exp. Limit	Obs. Limit	SM Exp.
WH cut based	1.1	1.3	0.13
WH ME discriminant	1.2	1.7	0.13
$Z(\to \ell\ell)H$	2.8	2.7	0.08
$Z(\to \nu\nu)H$	1.9	2.5	0.08

- Expect updated results with 1-1.5 pb^{-1} for LP07. Besides increased data set, several improvements are envisioned for these analyses:
  - Trigger selections, NN, event selections, $WH \to WWW$ ...
- Combined with CDF, we will soon start probing the expected standard model production rates. Stay tuned!