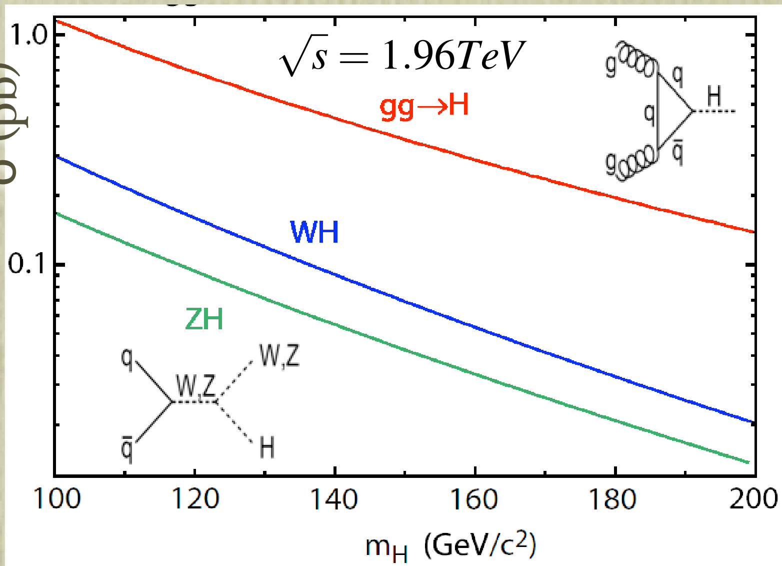
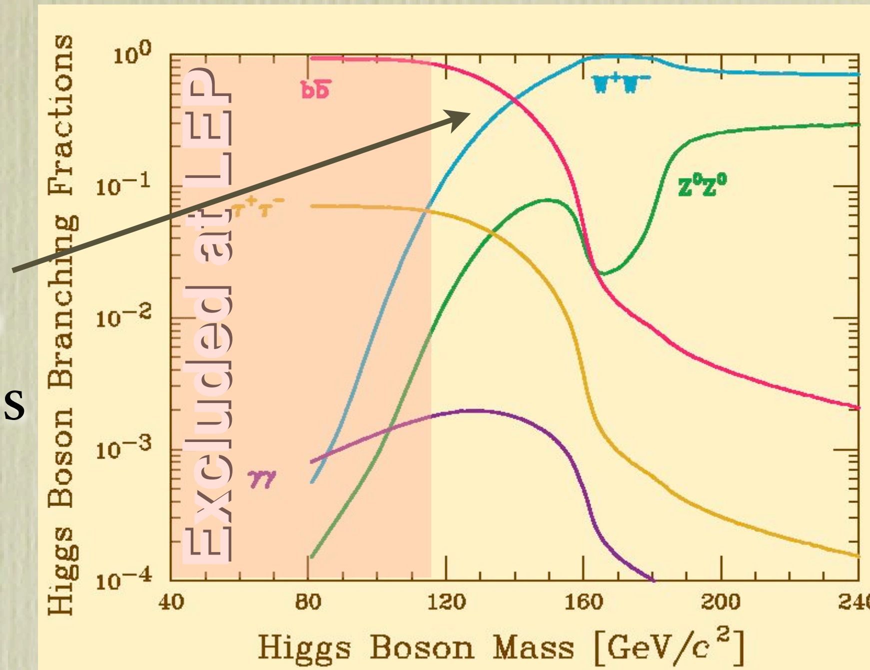
SM Higgs Searches at DØ

Sabine W Lammers
Columbia University
on behalf of the DZero Collaboration
20 February, 2006

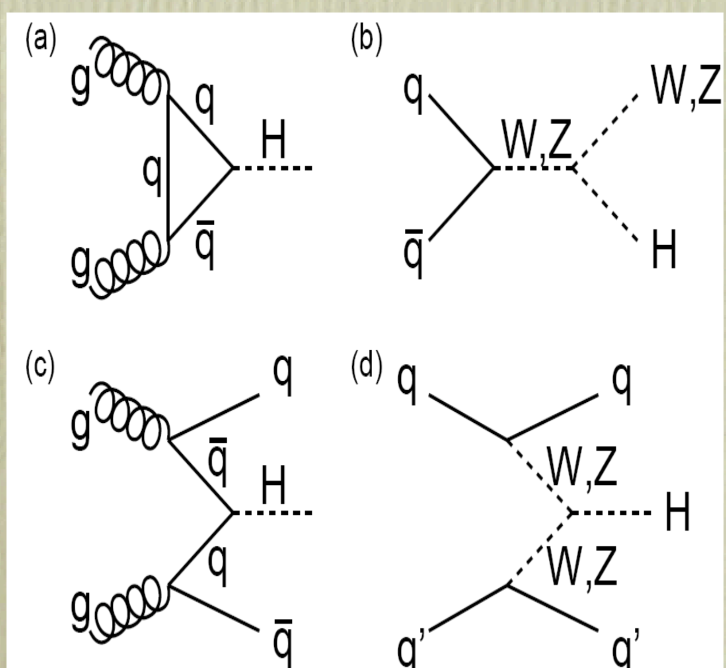
Production Mechanisms, Decays and Search Channels



$b\bar{b}$ (W+W-) final states dominate at low (high) Higgs masses

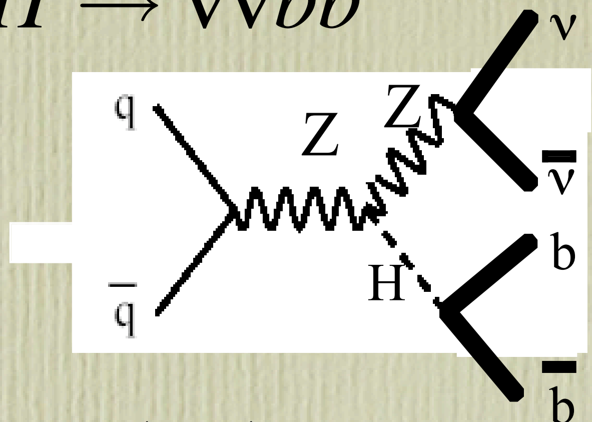


Dominant production by gluon fusion,
also Higgsstrahlung, Vector-Boson Fusion(VBF)

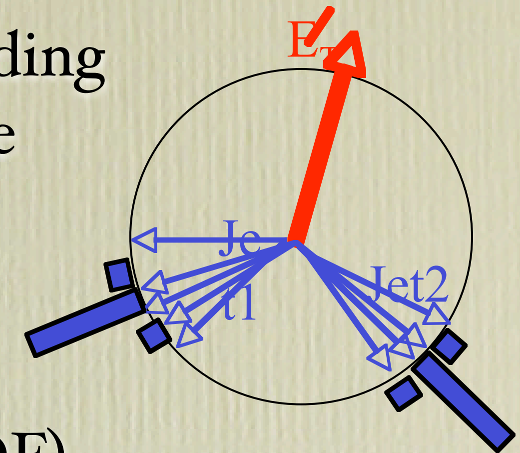


DZero Search Channels (recent results)	Data
$ZH \rightarrow \nu\bar{\nu}b\bar{b}$	261 pb-1
$WH \rightarrow e\nu b\bar{b}$	382 pb-1
$H \rightarrow WW^* \rightarrow \ell^+\nu\ell'^-\bar{\nu}$	299-325 pb-1
$WH \rightarrow WWW^* \rightarrow \ell^\pm\nu\ell^\pm\nu q\bar{q}$	363-384 pb-1

$ZH \to \nu\bar{\nu}b\bar{b}$

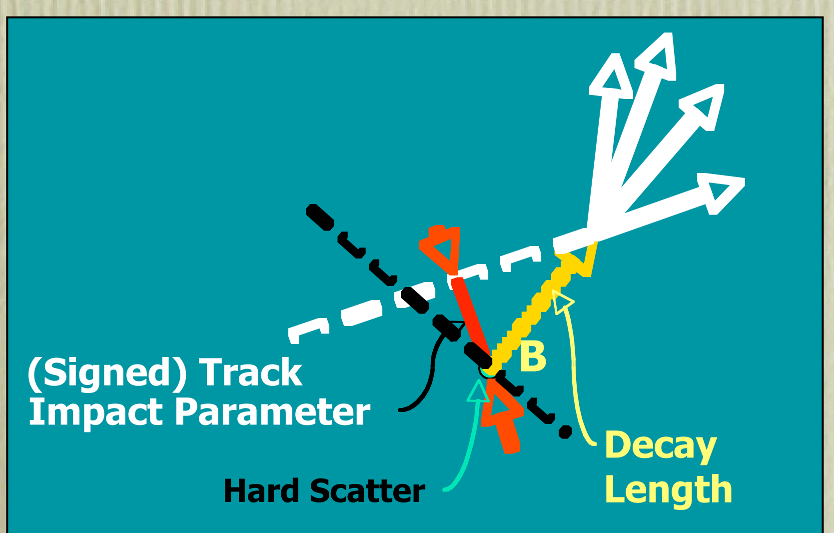


Needs good understanding of calorimeter response and b-tagging!



- proved to be very sensitive channel in Run 1 (at CDF)
- distinctive signature: two acoplanar jets and missing E_T
- physics backgrounds: Z+jets, W+jets, WZ, ZZ, top production
- instrumental backgrounds: multijet events with jet energy mismeasurement

B-tagging: lifetime probability algorithm searches for jets having tracks with large impact parameters (JLIP)



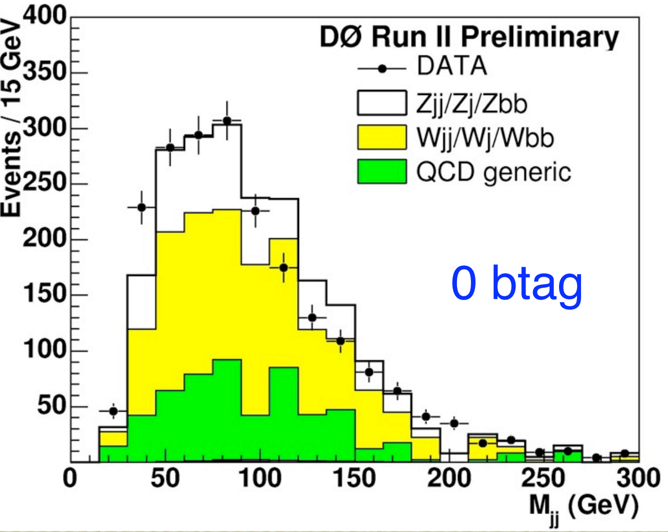
Event Selection:

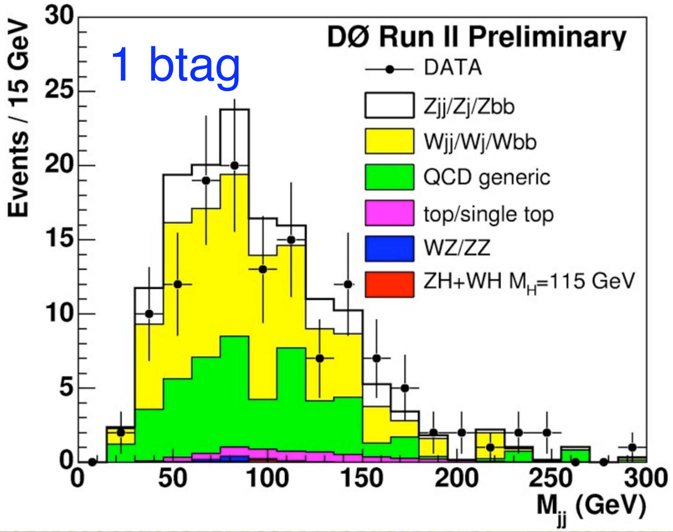
- 2 jets with p_T>20GeV and $|\eta|$<2.5
- missing E_T>25GeV
- no back-to-back event topology, no isolated tracks
- H_T(scalar sum of jet p_T)<200 GeV
- various track and asymmetry cuts for reducing instrumental background

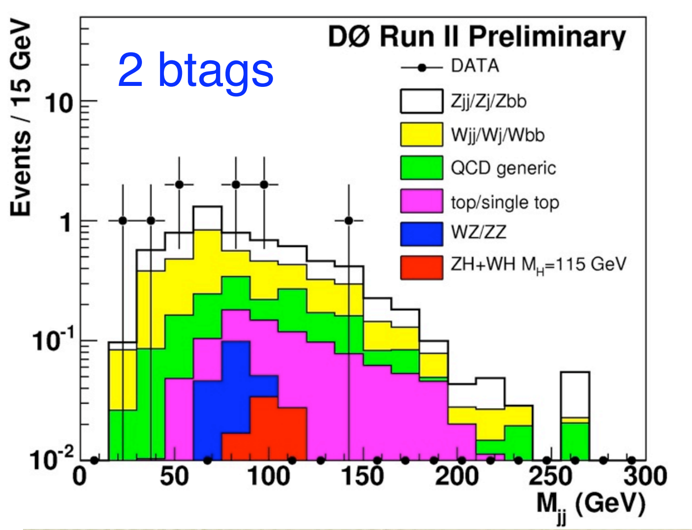
B-tagging efficiency ~43% with 0.5% mistag rate after "taggability" (jet-track quality cuts) and lifetime probability requirements are imposed.

$ZH \to \nu\bar{\nu}b\bar{b}$

Dijet masses with 0, 1, 2 btags







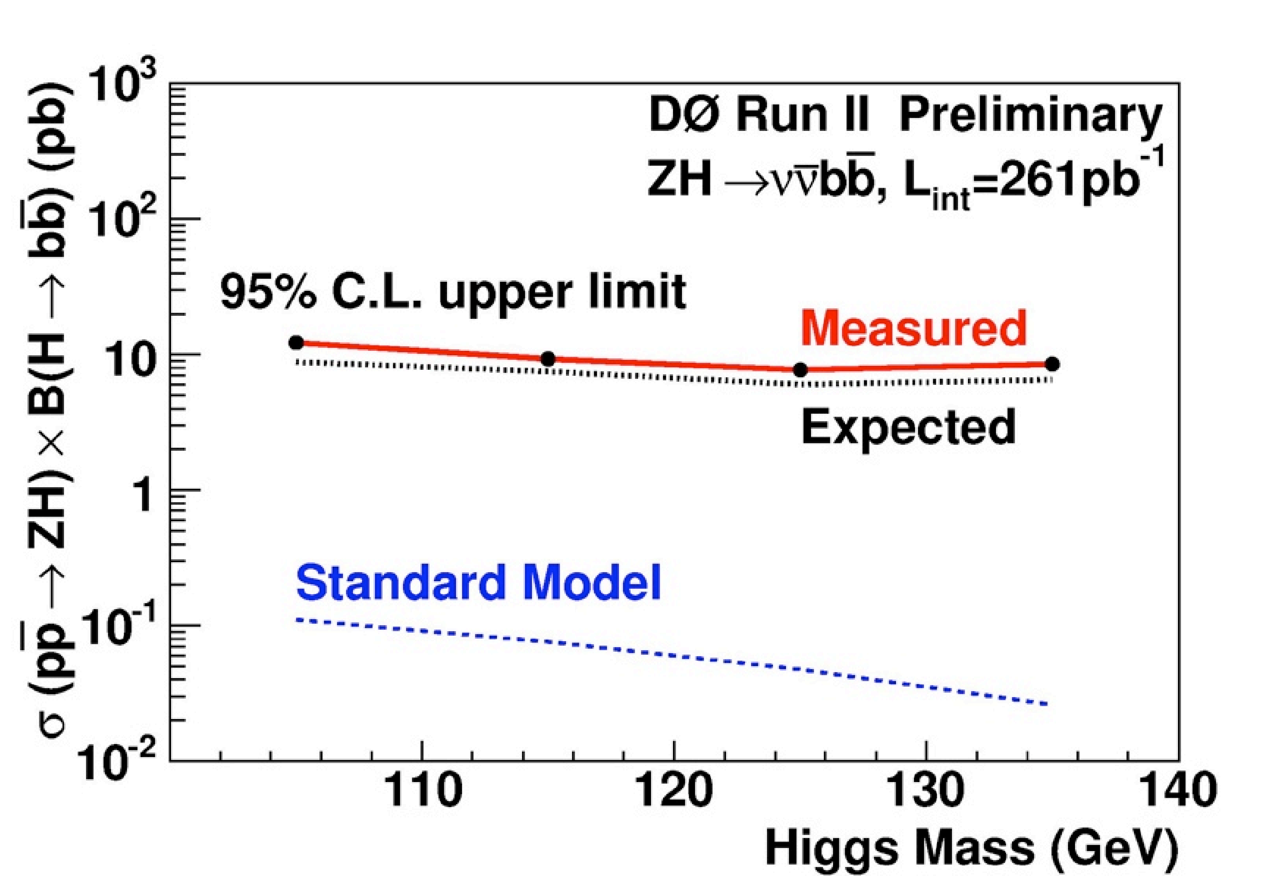
For m_H=115 GeV, expect 2.19 events in dijet mass window 80GeV < Mjj < 130GeV, observe 3

⇒ cross section limit of 9.3 pb at 95% confidence level

Systematic errors:

- 26% on signal acceptance
- 33% on background

New results in this channel with more data and increased sensitivity will be released soon!



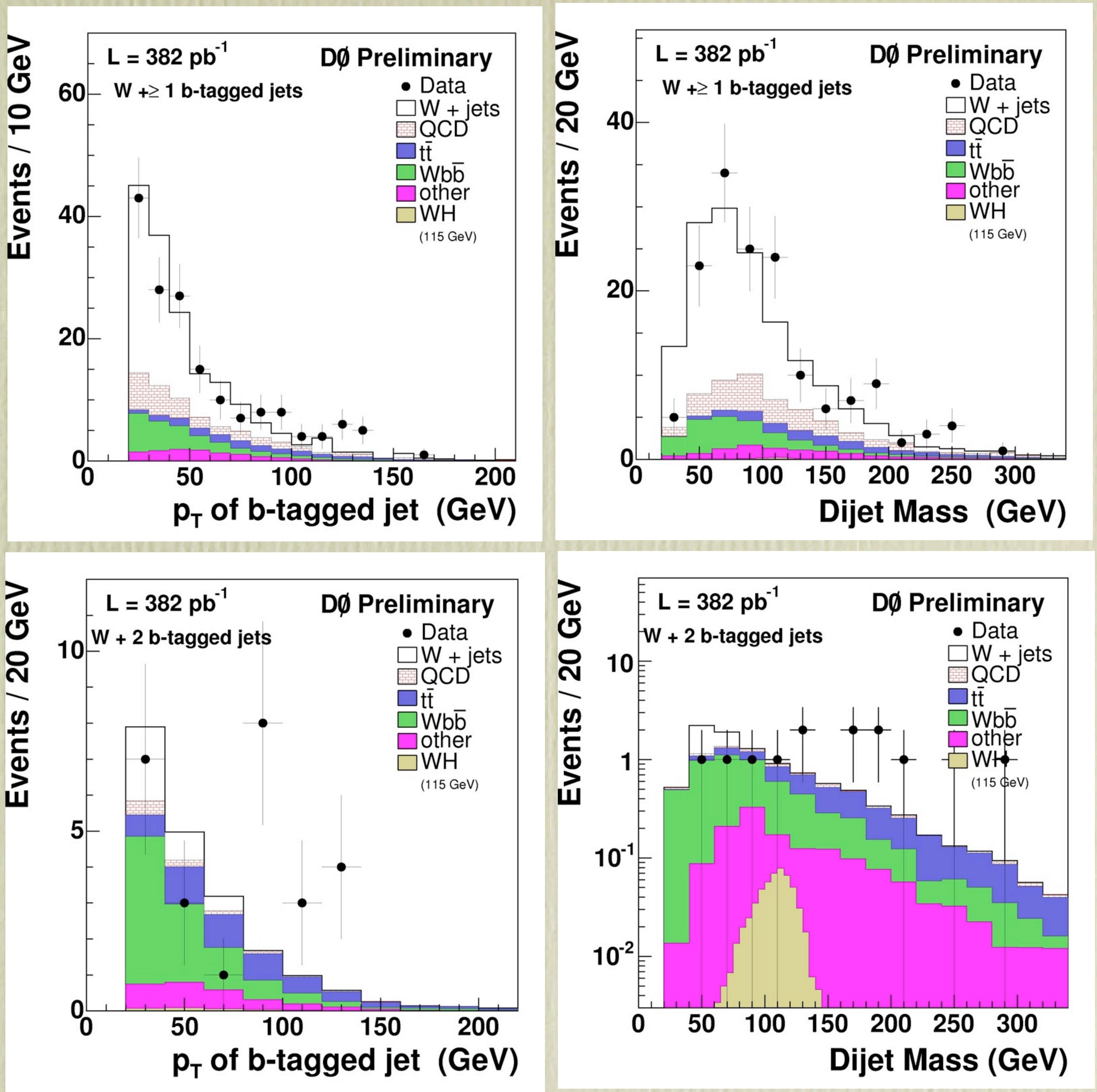
$WH \rightarrow e\nu b\bar{b}$

Event Selection:

- electron pT>20GeV and |η|<1.1
- electron quality and shaping cuts, veto second lepton
- missing ET>25GeV
- 2 jets with pT>20GeV and |η|<2.5 (at least 1 b-tagged)

JLIP b-tagging employed

Single and double b-tagged jet distributions



Single b-tagged sample used as control; double b-tagged sample used to extract limit (from dijet mass distribution)

Backgrounds: W+jets, multijet, tt, single top, WZ

$WH \rightarrow e\nu b\bar{b}$

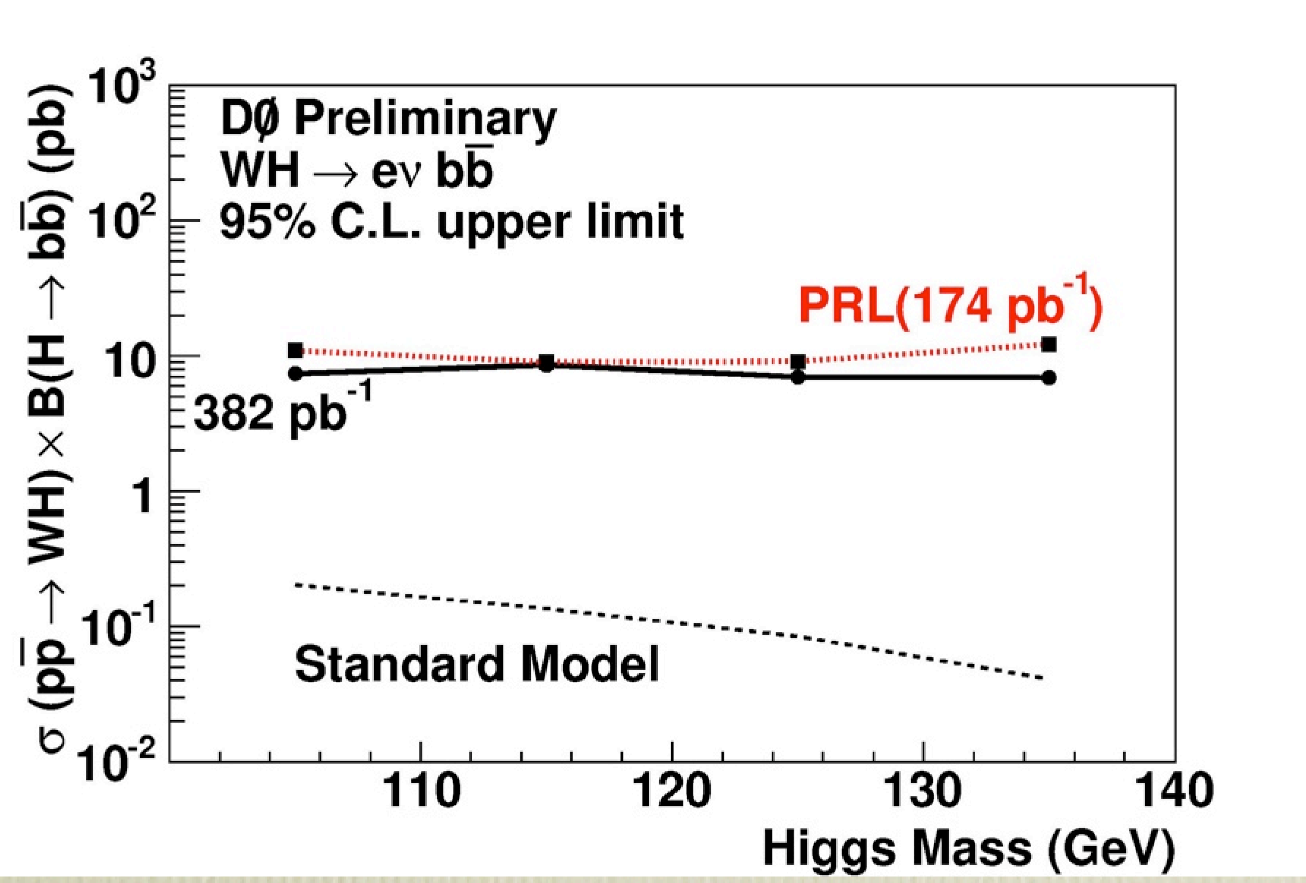
Expected signal and background events at various stages of the analysis:

	W+2jets	W+2b	W+2b $85<m_{b\bar{b}}<135$GeV
$Wb\bar{b}$	44.8±10.7	4.29±1.03	1.10±0.26
WH	0.94±0.2	0.14±.03	0.12±0.03
Total Background	3771±911	5.73±1.45	2.37±0.59
Total Expectation	3816±921	10.2±2.4	2.49±0.62
Data	3844	13	4

4 events observed in mass window 85GeV < $m_{b\bar{b}}$<135GeV, with 2.37 ± .59 expected from background => upper limit on WH cross section = 8.6pb.

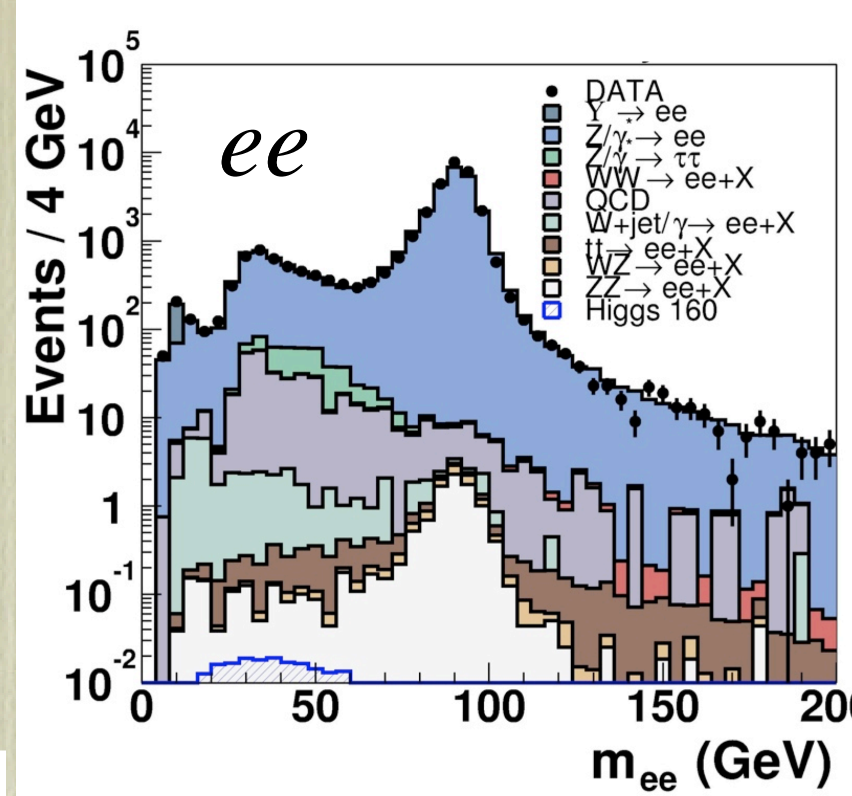
Look for improved limits using the same data in the next months. Analysis improvements include:

- increased electron acceptance
- optimized b-tagging likelihood
- separation of single and double b-tagged analyses



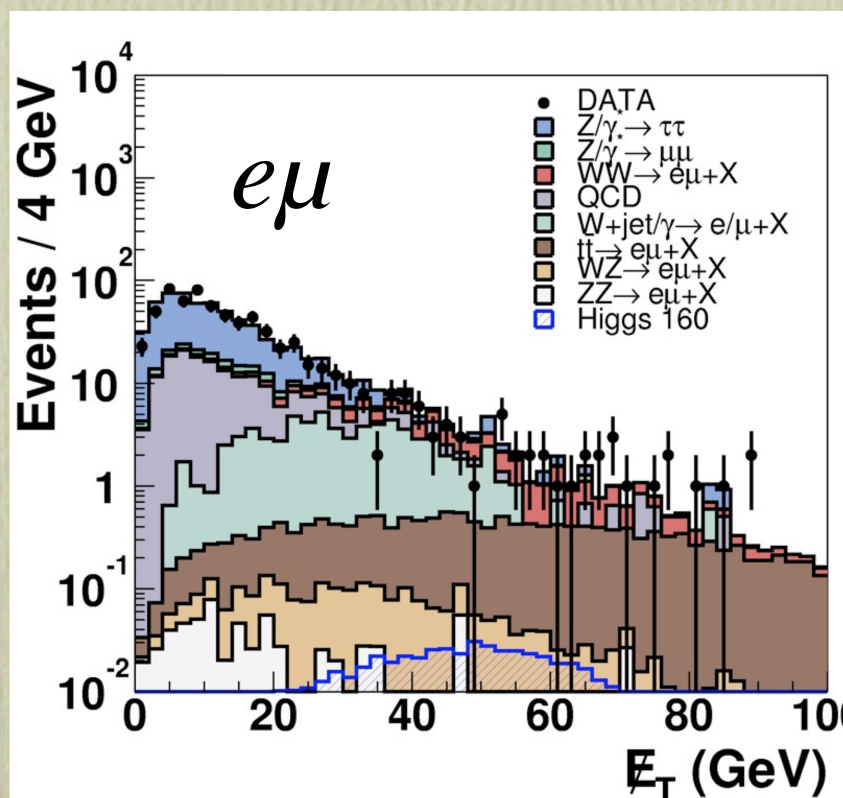
$H \to WW^* \to \ell^+ \nu \ell'^- \bar{\nu}$

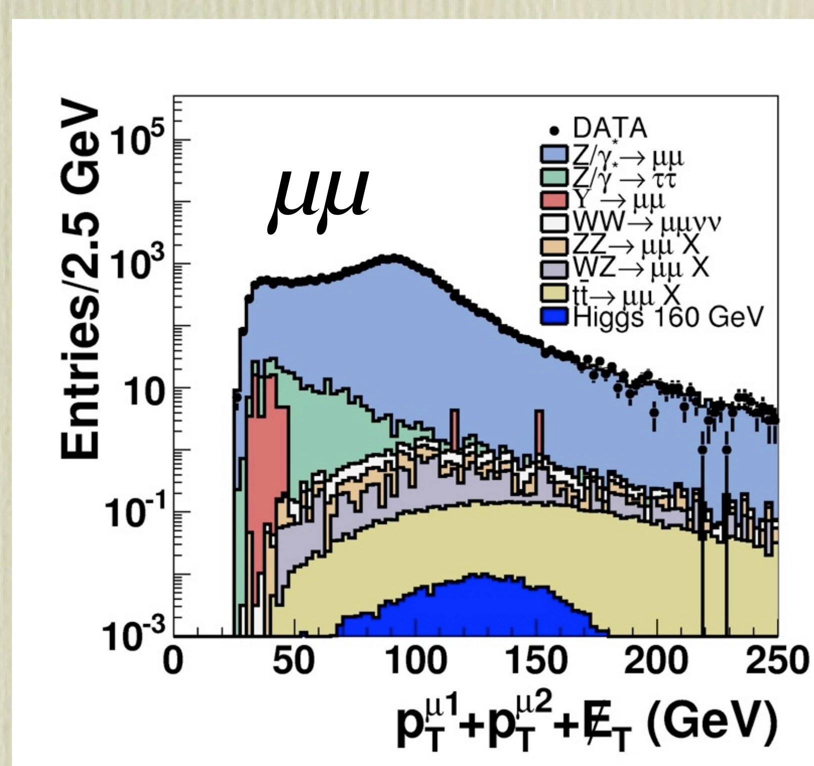
- Dominant production mechanism for higher mass Higgs
- 3 decay channels: $ee, e\mu, \mu\mu$
- Triggered by oppositely charged single/di-leptons
- Backgrounds: WW, WZ, ZZ,Drell-Yan, W+jets, W+γ, tt, multijets



Leptonic final state => excellent modeling of the data

Exhaustive list of backgrounds!

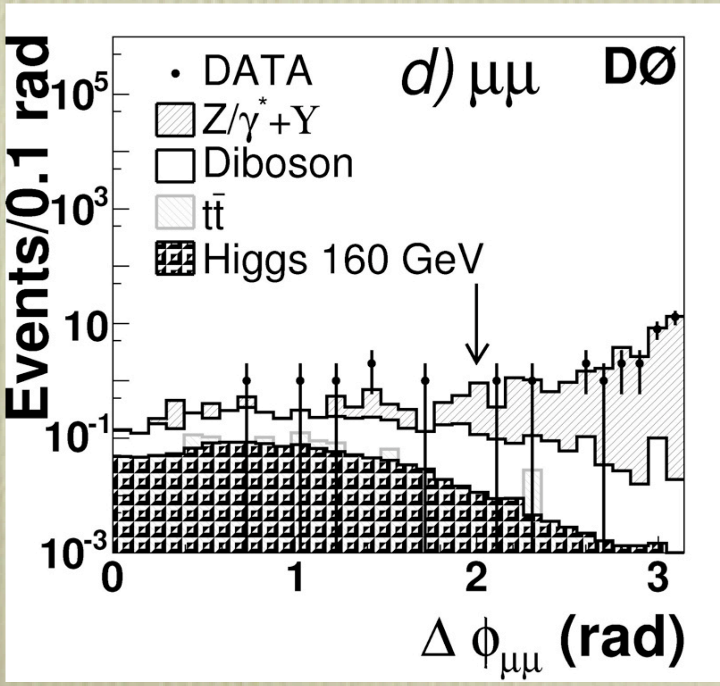




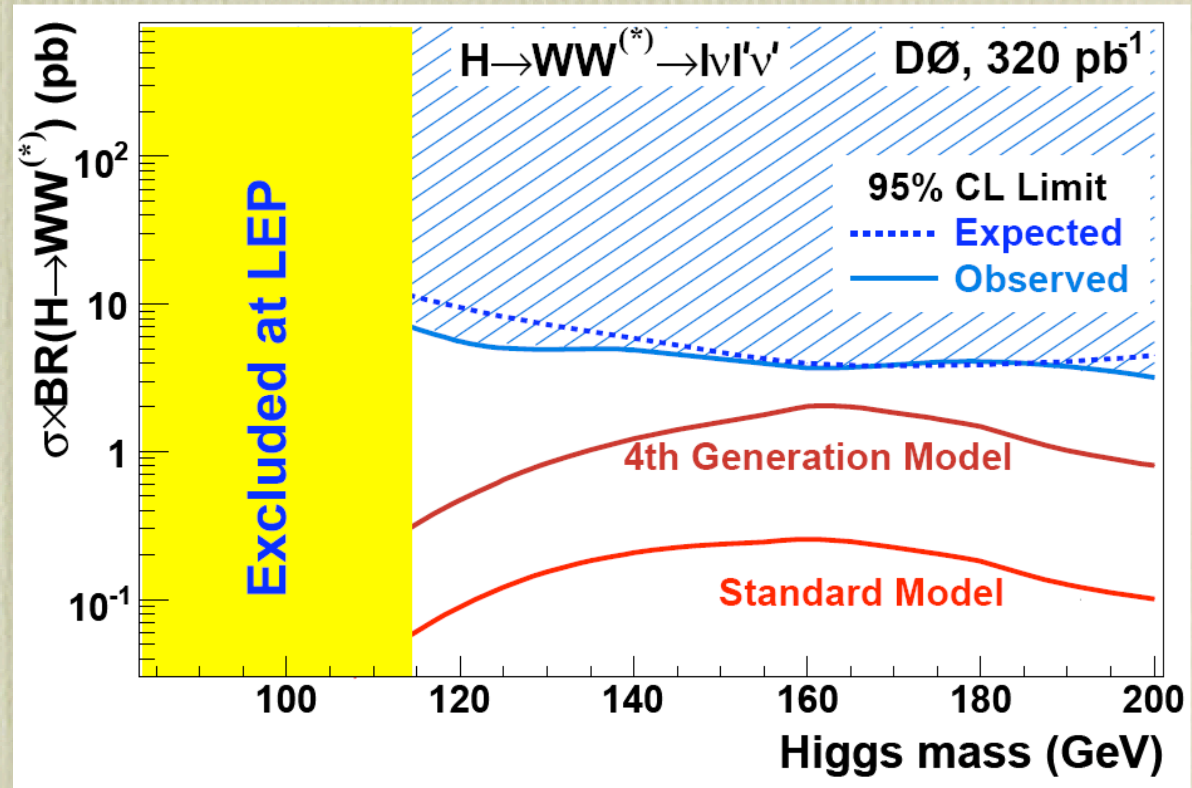
$H \to WW^* \to \ell^+ \nu \ell'^- \bar{\nu}$

Event Selection:

- p_T>15(10) GeV for leading(trailing) lepton
- missing E_T>20GeV
- scaled missing E_T>15GeV
- invariant mass cut on dileptons
- sum of p_T of leptons and missing E_T
- H_T(scalar sum of jet p_T)<100GeV
- azimuthal angle between two leptons $\Delta\phi_{ll}$<2.0 - distinctive angular correlation of leptons due to scalar nature of Higgs boson.



Higgs production limits extracted from combination of three decay modes for 6 different Higgs boson masses. Modified frequentist method used.



M_H (GeV)	100	120	140	160	180	200
Expected limits (pb)	20.3	9.5	5.9	4.0	3.9	4.5
Observed limits (pb)	18.5	5.6	4.9	3.7	4.1	3.2

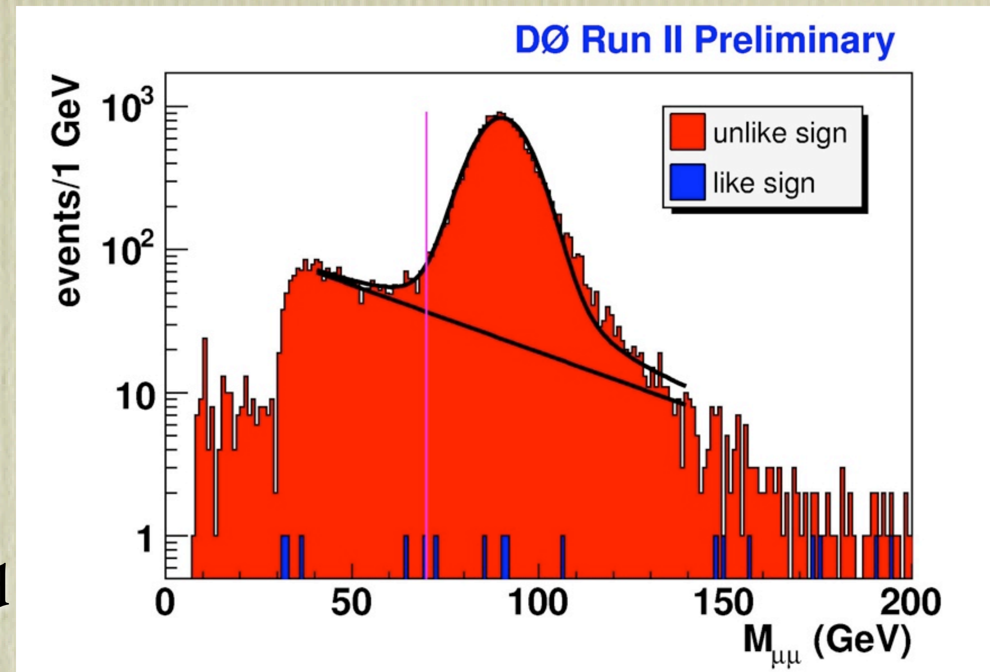
$WH \rightarrow WWW^* \rightarrow \ell^{\pm}\nu\ell^{\pm}\nu q\bar{q}$

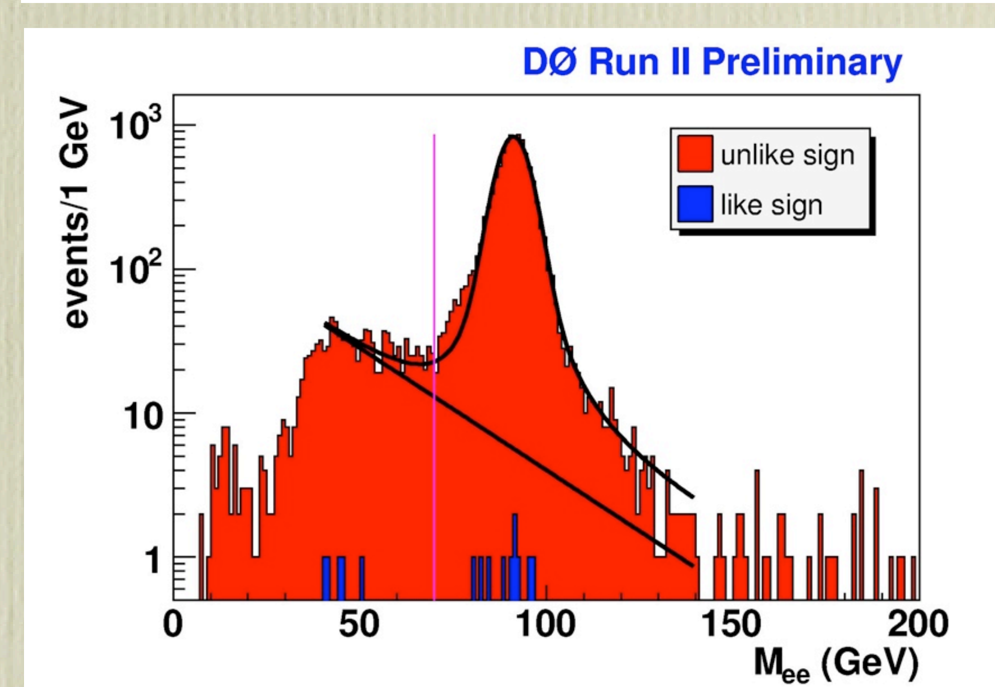
This associated Higgs production mode makes use of like-sign isolated lepton (electrons or muons) signature

- one of W's from Higgs decay has same-sign lepton as associated W
- avoids large SM backgrounds (Z/γ^*, WW, tt production) present in direct $H \rightarrow WW^*$ searches
- background from "charge flips" accounted for by estimating flip probability from data (ratio of like to unlike sign events at high invariant mass ($M_{ll}>70$ GeV)

Event Selection:

- dilepton (ee,eμ,μμ) trigger
  - EM cluster with $p_T>15$ GeV, $|\eta|<1.1$, matched to central track
  - isolated muon with $p_T>15$ GeV
- third lepton veto
- missing $E_T>20$ GeV



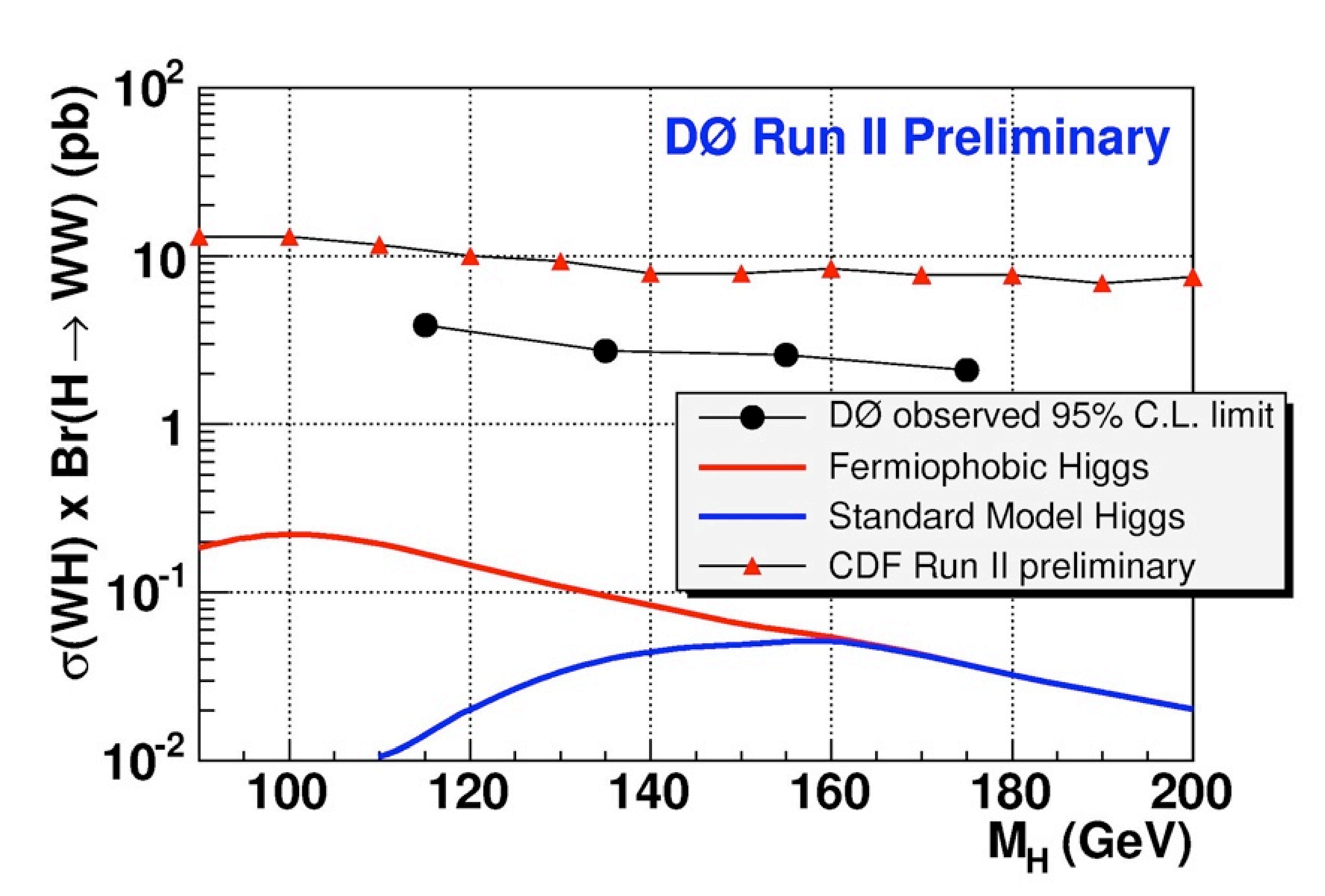


$WH \rightarrow WWW^* \rightarrow \ell^{\pm}\nu\ell^{\pm}\nu q\bar{q}$

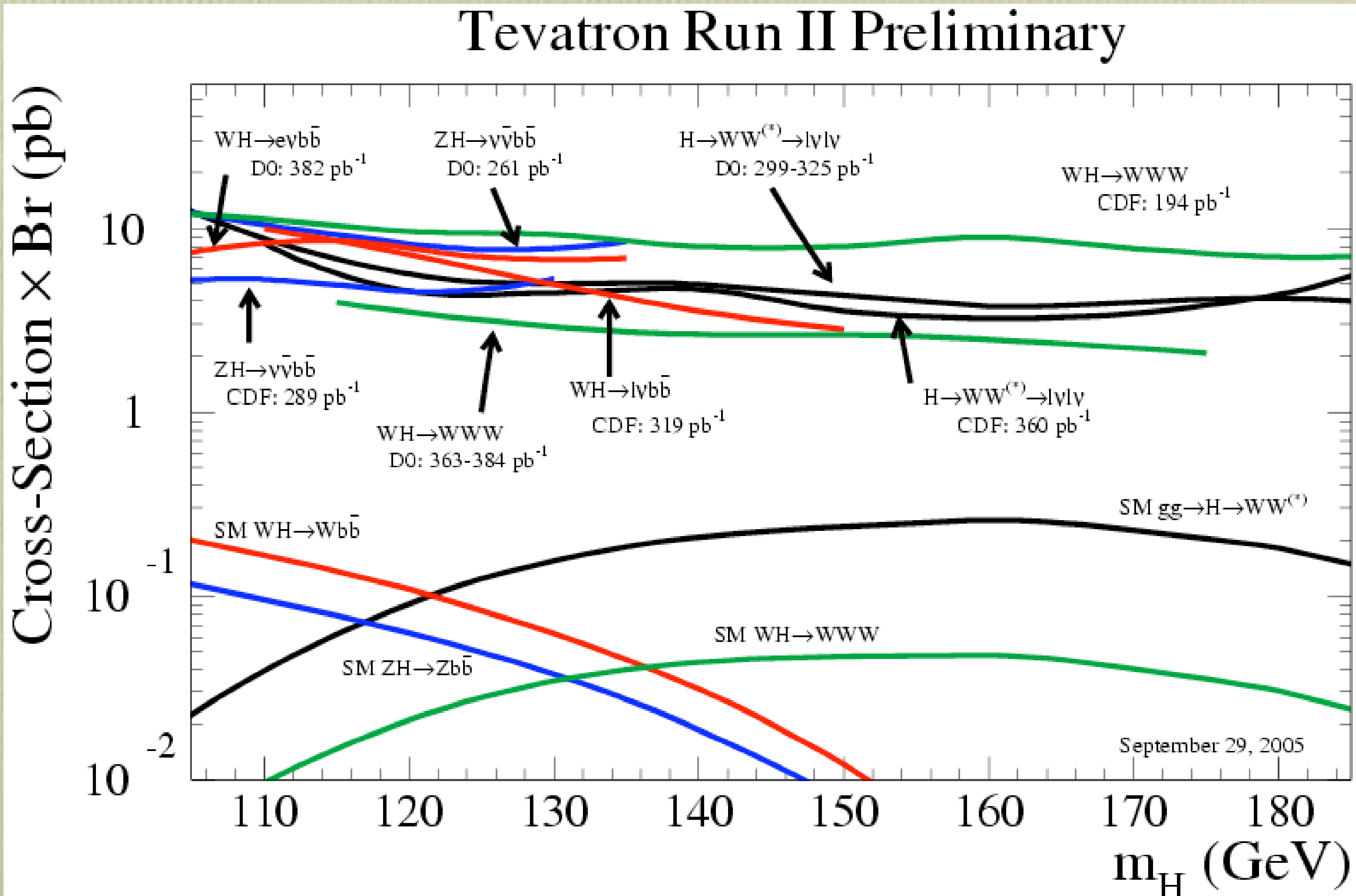
TABLE II: The number of observed and predicted events after all selection cuts.

	ee	$e\mu$	$\mu\mu$
observed data	1	3	2
WZ	0.43±0.03	0.33±0.03	0.16±0.03
charge flips	0.20±0.06	0.05±0.01	3.40±0.73
W/QCD	0.07±0.04	3.94±0.23	0.16±0.18
total background	0.70±0.08	4.32±0.23	3.72±0.75

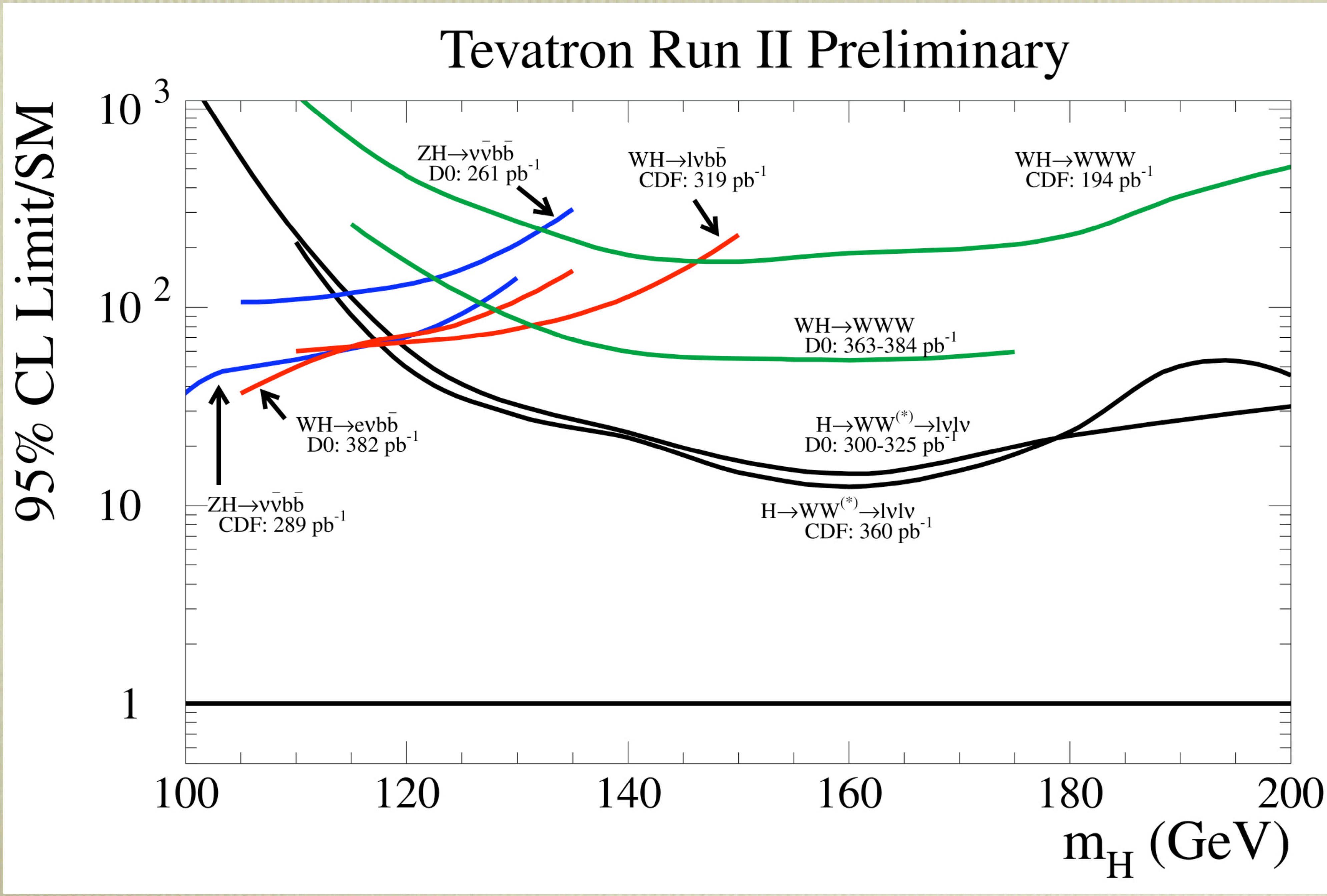
- Number of events found in data is compatible with SM background.
- Cross section upper limits calculated using the modified frequentist approach.



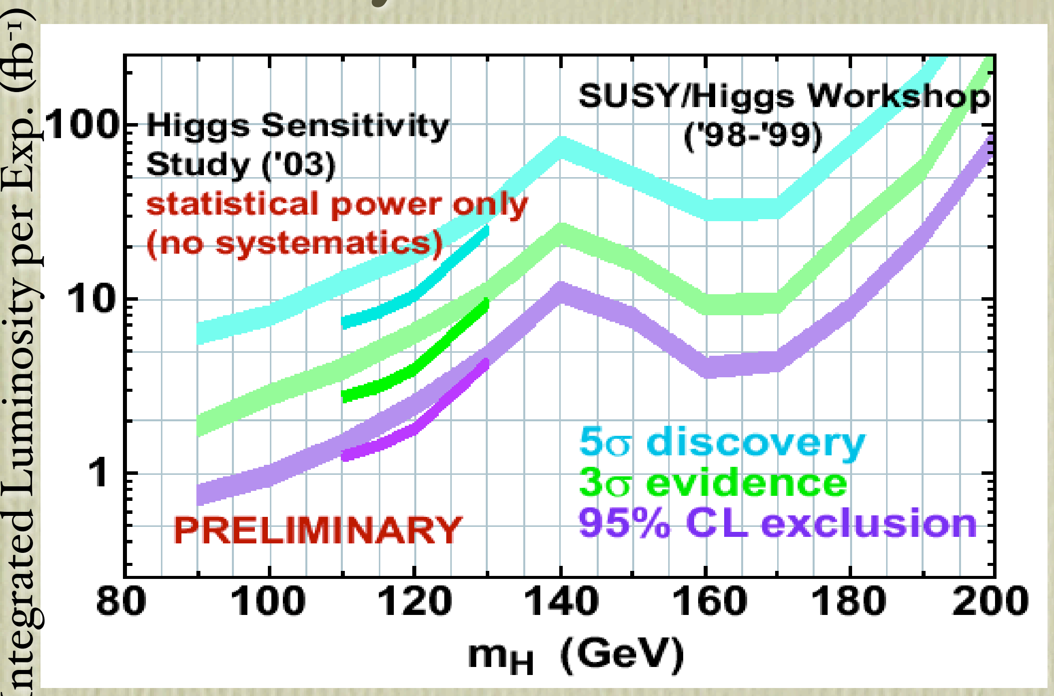
Where We Stand Now

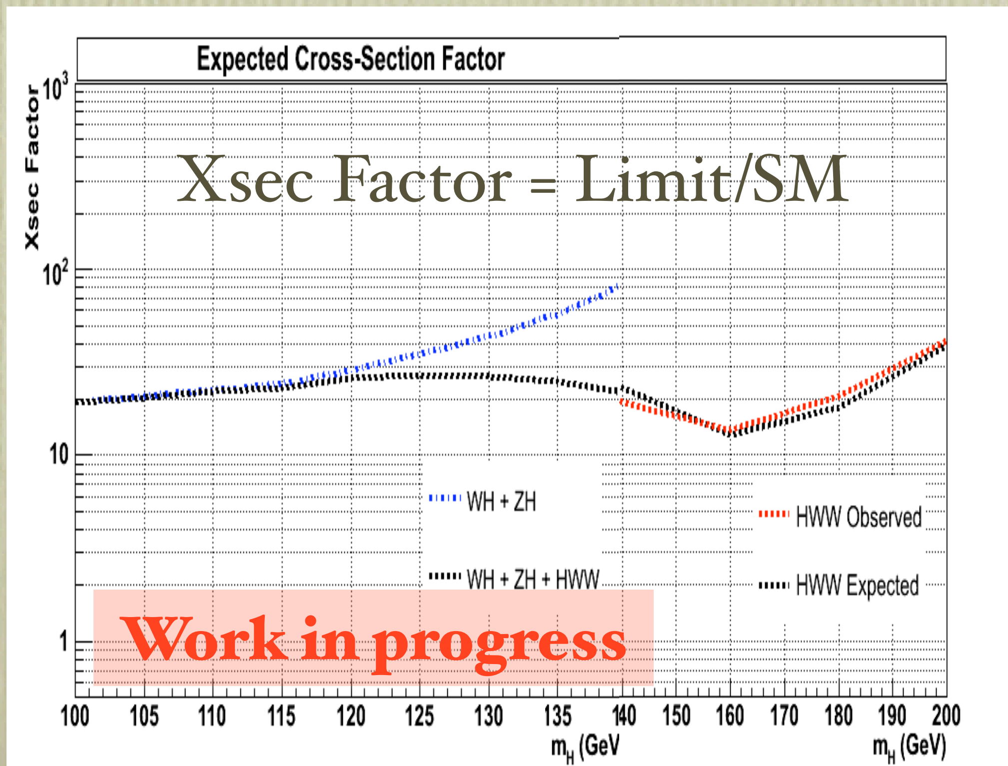


Or put a different way... Limit/SM



Sensitivity Studies





Current results from CDF and DZero show that optimal sensitivity (as predicted by past Higgs working group meetings) has not yet been reached (typically by factor 2-3).

Due to a variety of factors:

- selection efficiency
- b-tagging efficiency
- trigger efficiency
- larger backgrounds
- mass resolution

To bridge gap between current limits and SM prediction, we can advance in a number of ways:

- add/combine channels
- combine experiments
- optimize analysis techniques
- use more data

Look for analyses with 1 fb^{-1} of data in the summer!

Neural Network (NN) Algorithms

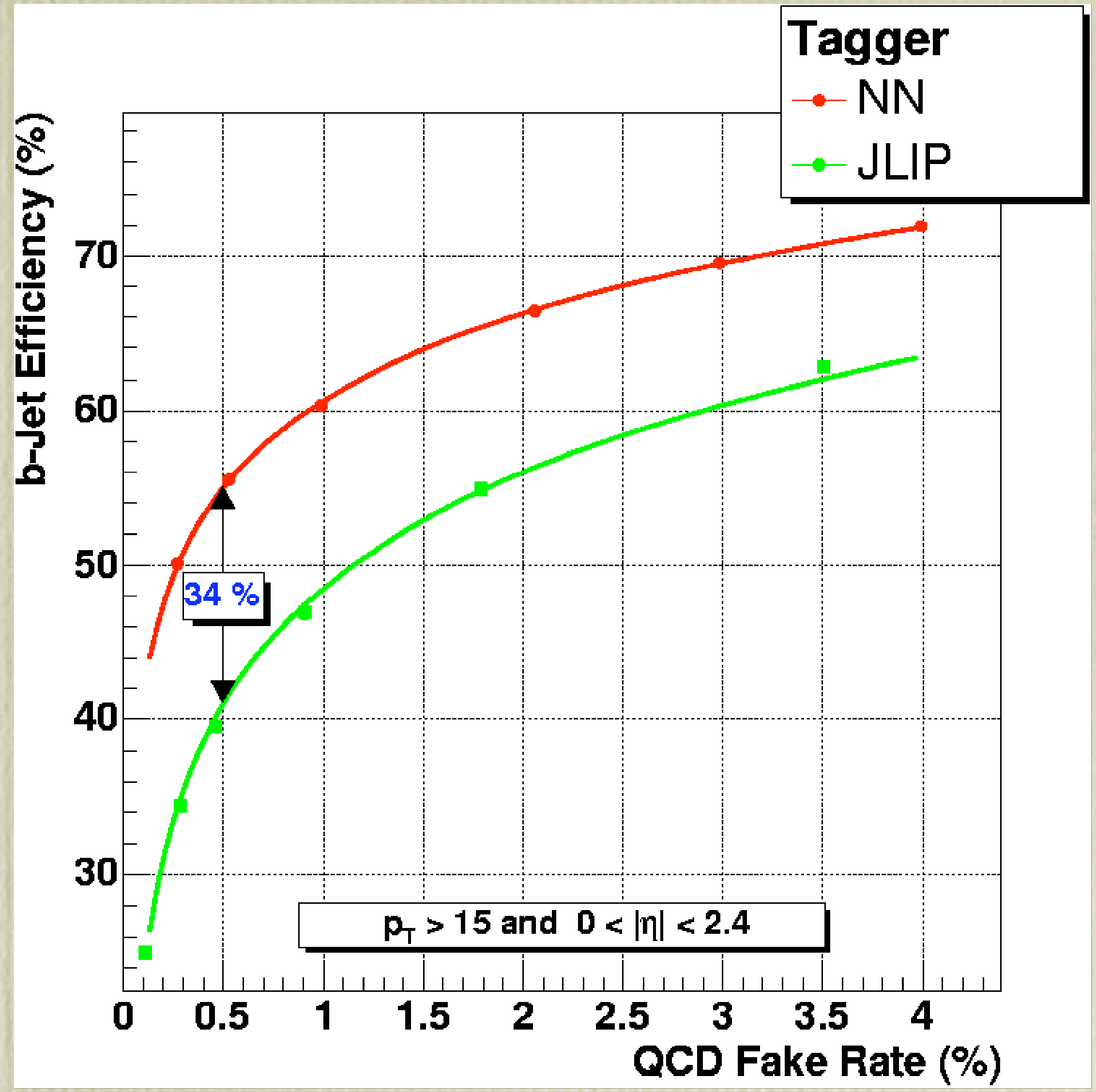
Neural-network b-tagging algorithm yields 34% increase in b-jet ID efficiency for the same fake rate.

Most Higgs searches with b-jets in the final state will move to NN b-tagging.

Neural network event selections are being investigated.

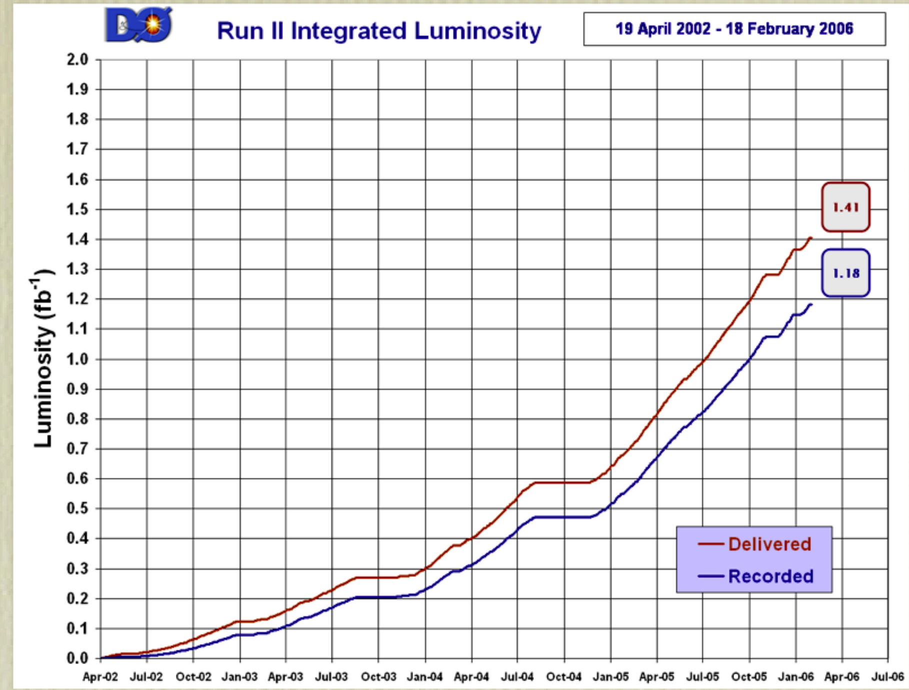
➤ CDF has tried this in ZH→llbb and found factor 1.5 improvement in sensitivity.

➤ DZero has improved single top sensitivity by factor ~2



Can gain by loosening b-tag requirements, also by combining separate single-tagged and double-tagged analyses.

Summary and Outlook



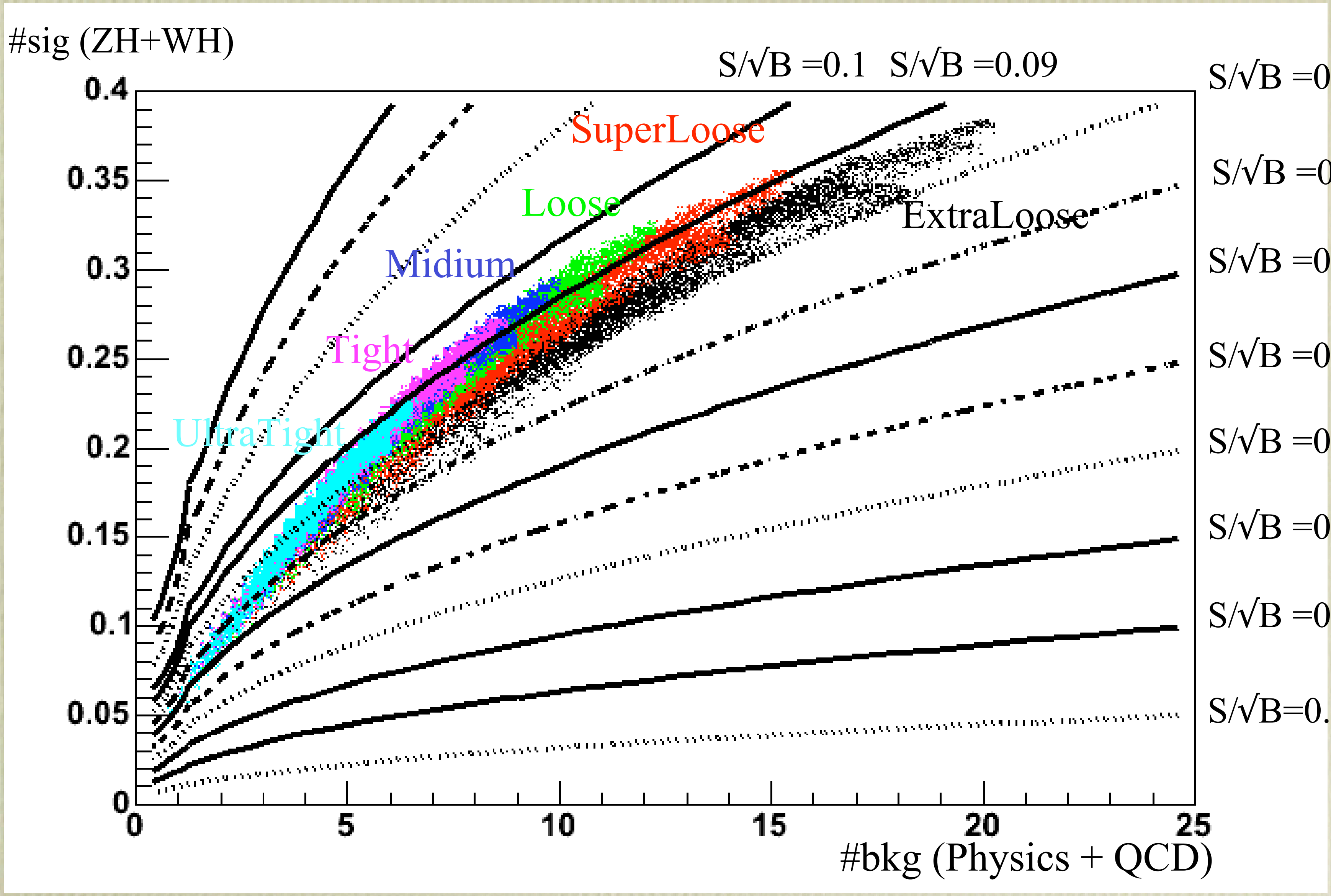
- Presented 4 recent searches for SM Higgs boson production
- No indication of a Higgs signal was observed, 95% confidence level limits on production cross section has been calculated
    - with current data/analyses, we are factor of 2-3 away from potential sensitivity, but are closing the gap

Excellent Tevatron performance!
Recent pbar stacking record of ~20mA/hr
Have 1fb^{-1} in the bag, hope for 7-8 in run2b
Trigger, silicon (Layer 0) detector upgrades
(→ installation next week!)

- A number of analysis techniques have been investigated which indicate very promising improvement in sensitivity to SM Higgs, including b-tagging optimization, neural network techniques, trigger and event selection optimization, combining search channels
- We are working toward results with 1 fb^{-1} of data and improved analysis techniques for this summer.

B-tagging

Signal vs. Background (M_H=115 GeV)



Can gain by loosening b-tag requirements, also by combining separate single-tagged and double-tagged analyses.

Improvements by Search Channel

For summer 2006, with 1 fb^{-1} data, we expect:

- WH/ZH include WHWWW and Z l^+l^- channel ! (*1.3)
- WH/ZH: use Neural Net Tagger (*1.34*1.34)
- WH/ZH: use Neural Net Selection (*1.8)
- WH/ZH: use TrackCalJets mass resolution (*1.3)
- WH(e): include End-Cap calorimeter
- WH(): improve QCD rejection loosen b-tag
- WH: include W (*1.4)

Total for WH/ZH: 1.34^2 * 1.3 * 1.2 =2.8 another gain of sqrt(2.8)=1.7 in sensitivi

(compare to the missing 1.5)