Secondary High Mass Higgs Searches at the Tevatron

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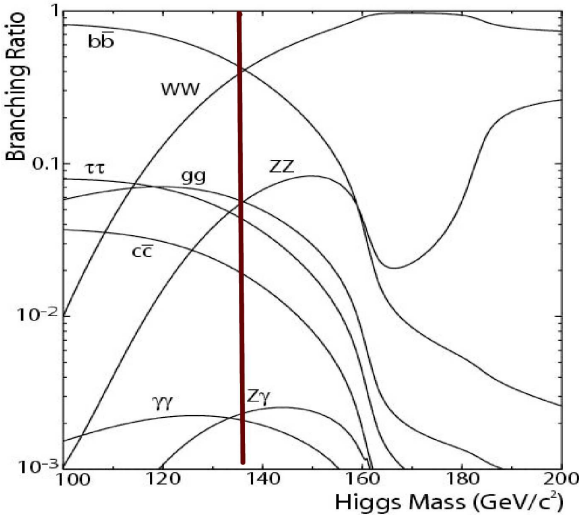
Intro: SM Higgs Searches at the Tevatron

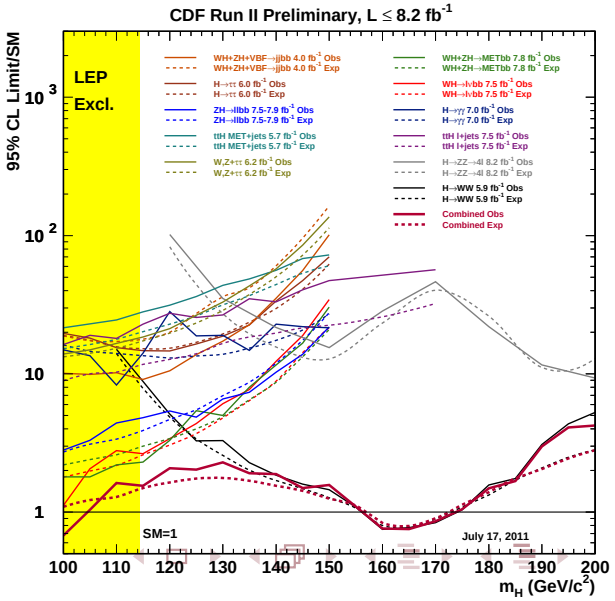
Higgs Search Comes in Many Pieces:

- *Low Mass:* Main focus on $H \to b\bar{b}$ *(Lepton + b-jets signature)*
- *High Mass:* Main focus on $H \to WW \to l\nu l\nu$ *(2-Leptons + $\not{E}_T$ signature)*

Current Tevatron Limits:

Exclusion extends from $[100 \to 108]$, $[156 \to 177]$ GeV





Other Important High Mass Searches

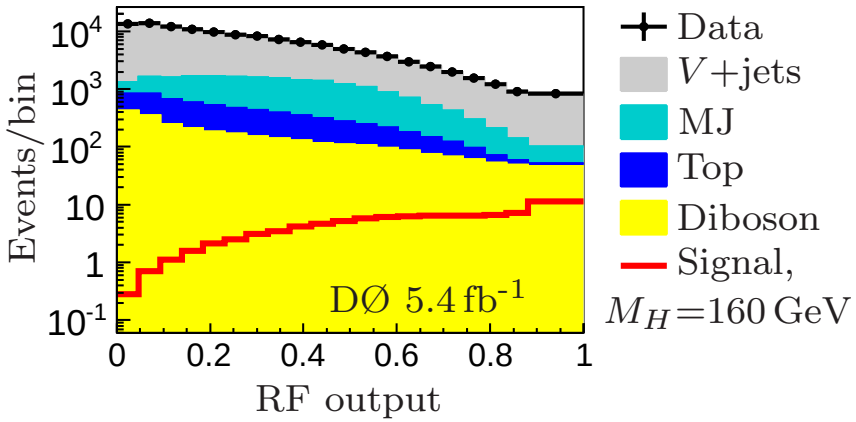
Non-Dilepton High Mass Searches: *There are several other high mass searches that strongly supplement the Higgs search. Three are...*

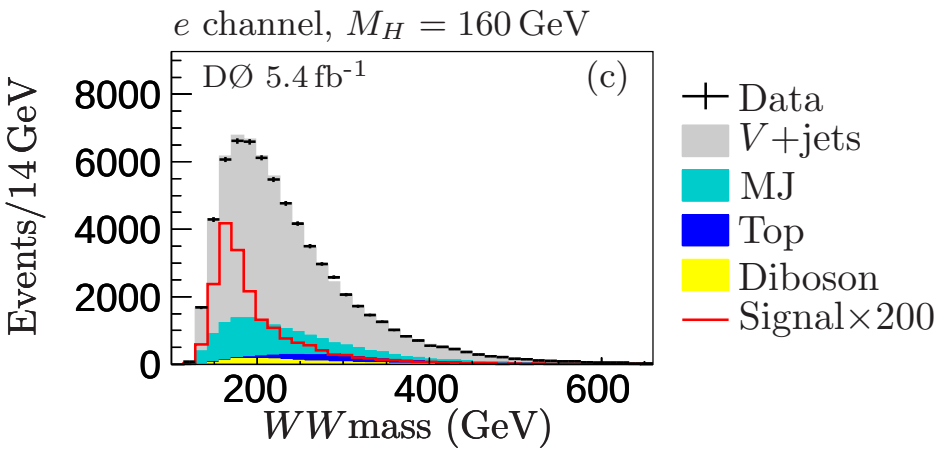
- Semileptonic: $q\bar{q} \to H \to WW \to l\nu + 2\text{jets}$
- Direct Z-Pair Decay: $q\bar{q} \to H \to ZZ \to llll$
- 3-Lepton Signature: "Associated Production w/ Vector Boson"
  - $q\bar{q} \to W^* \to HW \to WWW \to l\nu l\nu l\nu$
  - $q\bar{q} \to Z^* \to HZ \to WWZ \to l\nu + 2\text{ jets} + ll$

The Semileptonic Search ($l\nu jj$)

- Performed by: D0 only
- Signal from $H \to WW \to l\nu jj$
- Signature: High p_T lepton, $\not{E}_T$, at least 2 jets
- "RF" = Random Forest of Decision Trees to distinguish signal-like events from background-like events.

Process	e Channel	μ Channel
$gg \to H$	46.3	34.7
$qq \to qqH$	6.4	4.4
V+jets	52158	47970
Multijet	11453	2720
top	2433	1598
Dibosons	1584	1273
Data	67627	53562





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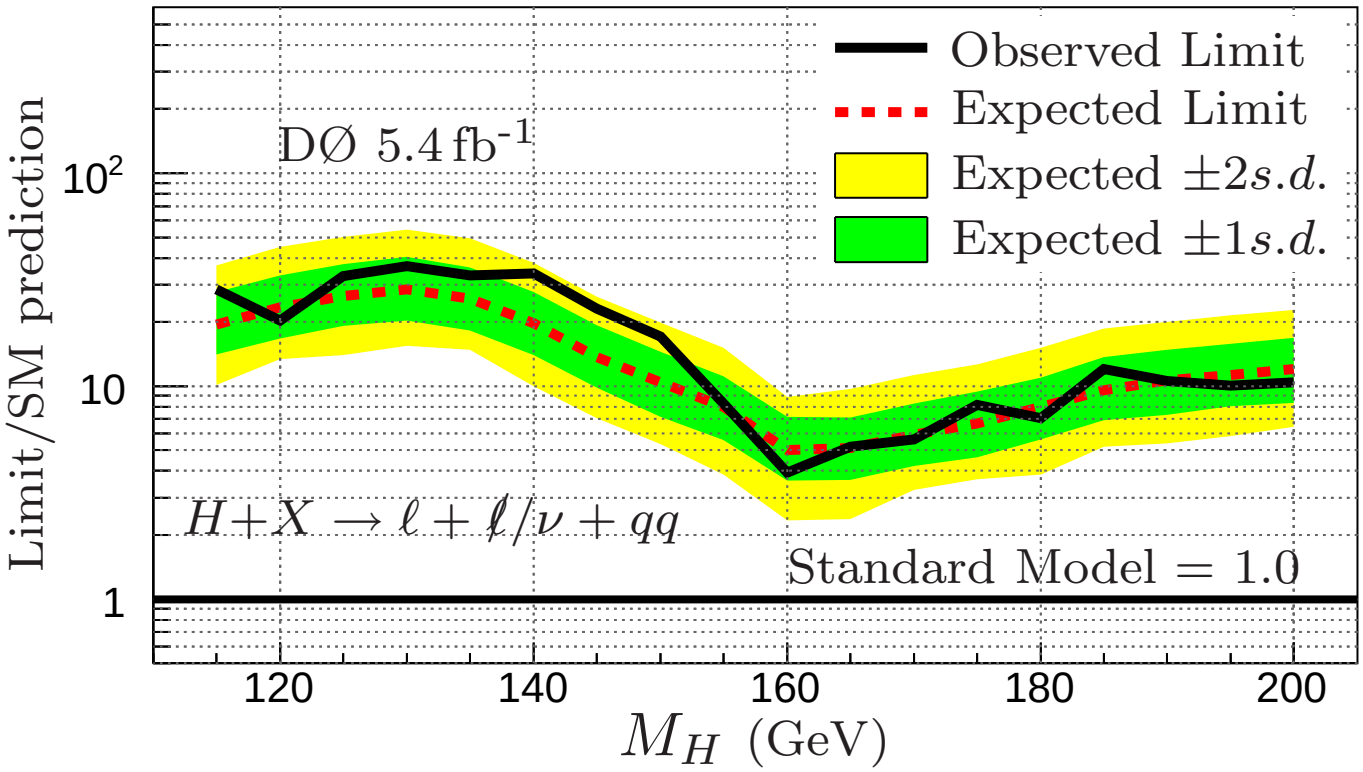


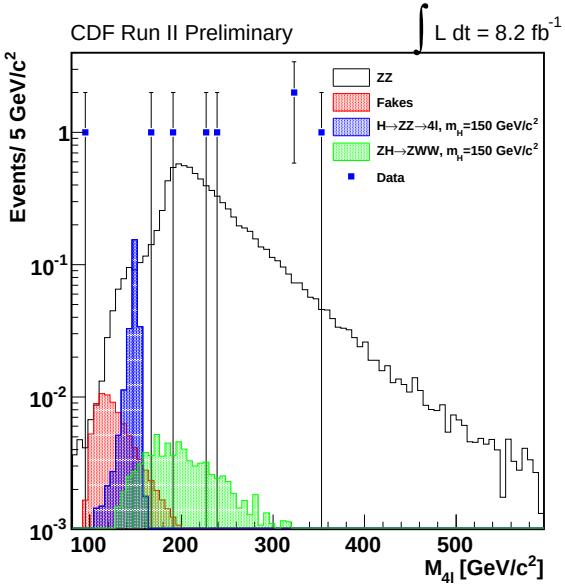
- Expected Limit of 1.0: Sensitive to SM Higgs
- Observed Limit of 1.0: SM Higgs ruled out w/ 95% confidence

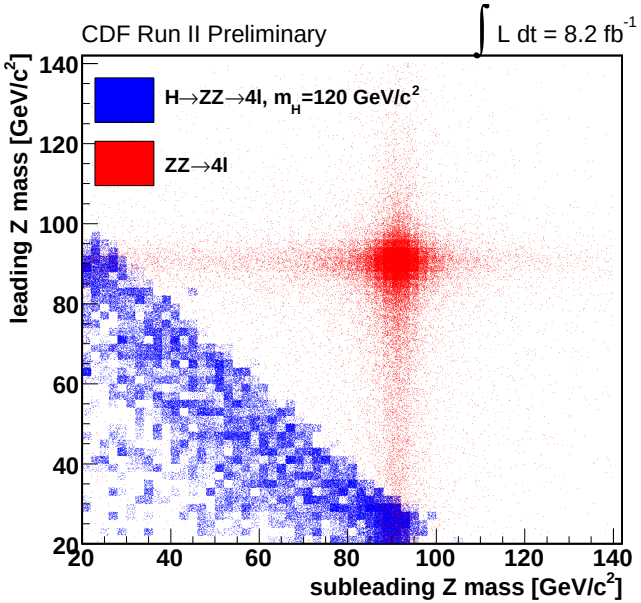
Direct Z-Pair Decay ($H \to ZZ \to llll$)

- Performed by: CDF only
- Signal from $H \to ZZ \to llll$
- Signature: Exactly 4 high p_T leptons
- Loose Z-lepton pair selection: Same flavor, opp. sign pairs, $20 < m_{ll} < 140$ GeV$/c^2$

CDF Run II Preliminary	$\int \mathcal{L} = 8.2$ fb^{-1}		
$M_H = 150$ GeV$/c^2$			
ZZ	8.83	$\pm$	1.12
$Z(\gamma)$+jets	0.30	$\pm$	0.10
Total Background	9.13	$\pm$	1.12
$gg \to H \to ZZ$	0.196	$\pm$	0.025
$VH \to V + ZZ$	0.036	$\pm$	0.005
$ZH \to Z + WW$	0.093	$\pm$	0.012
$VBF \to H \to ZZ$	0.019	$\pm$	0.002
Total Signal	0.325	$\pm$	0.028
Data		8	

$H \to 4\ell$





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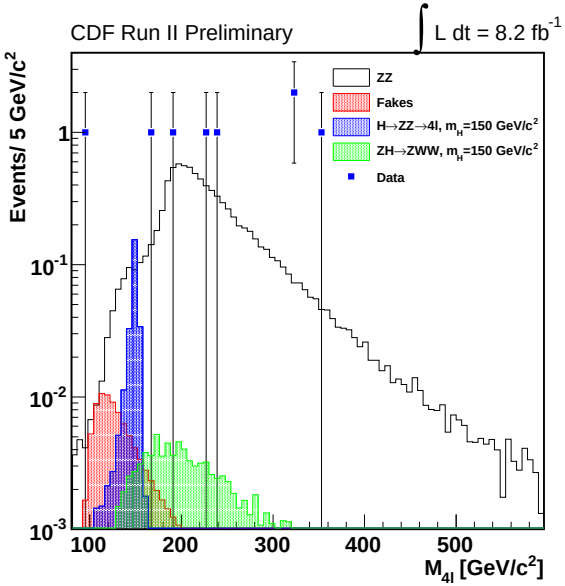

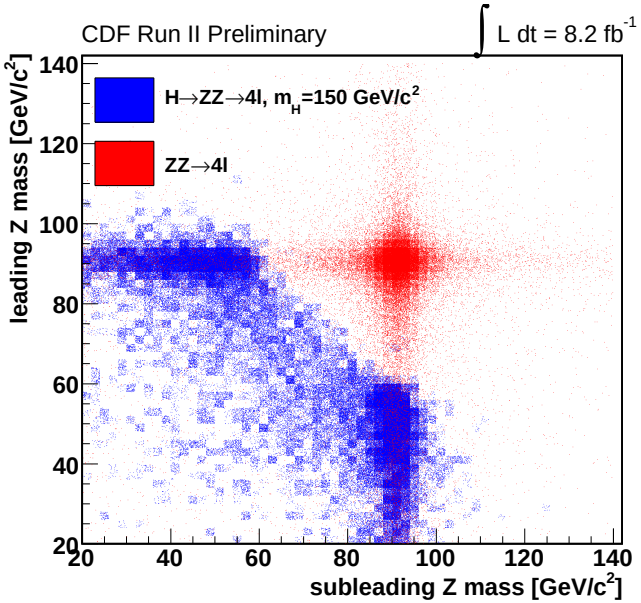

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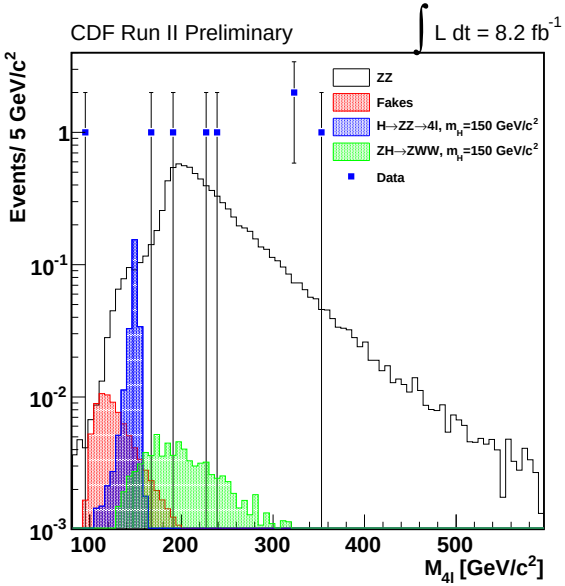

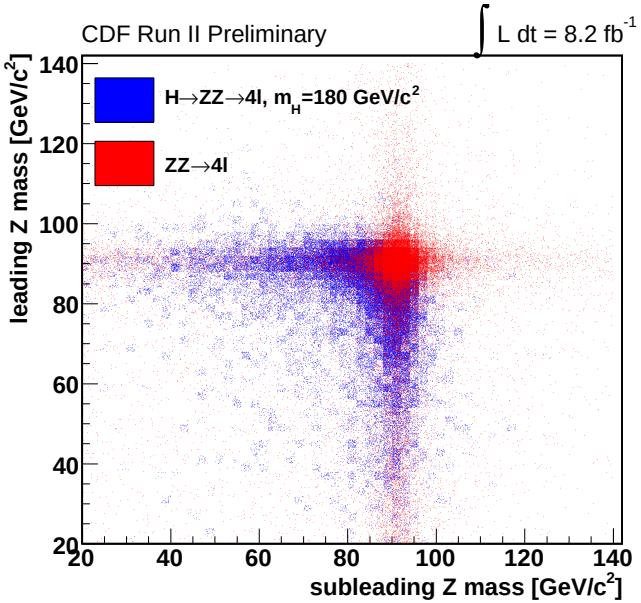

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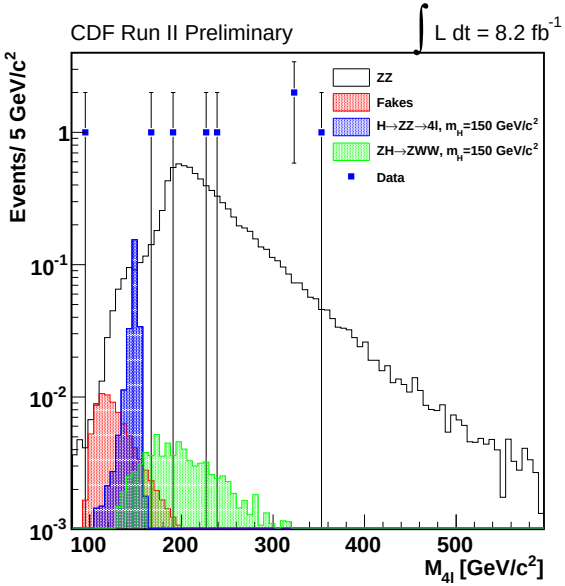

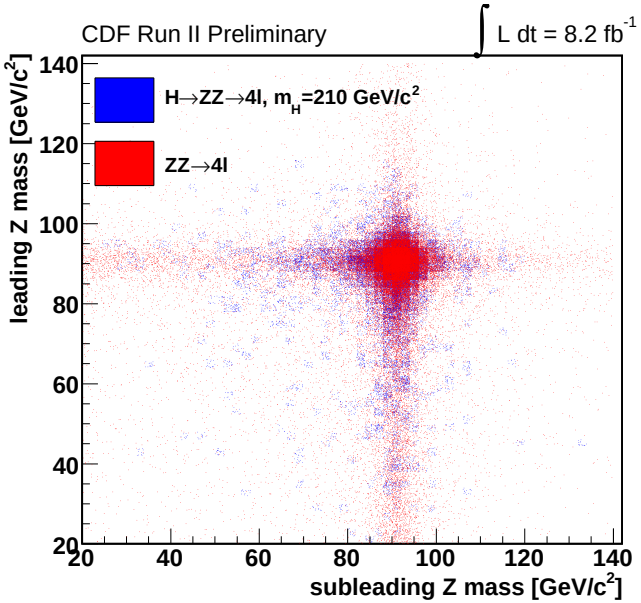

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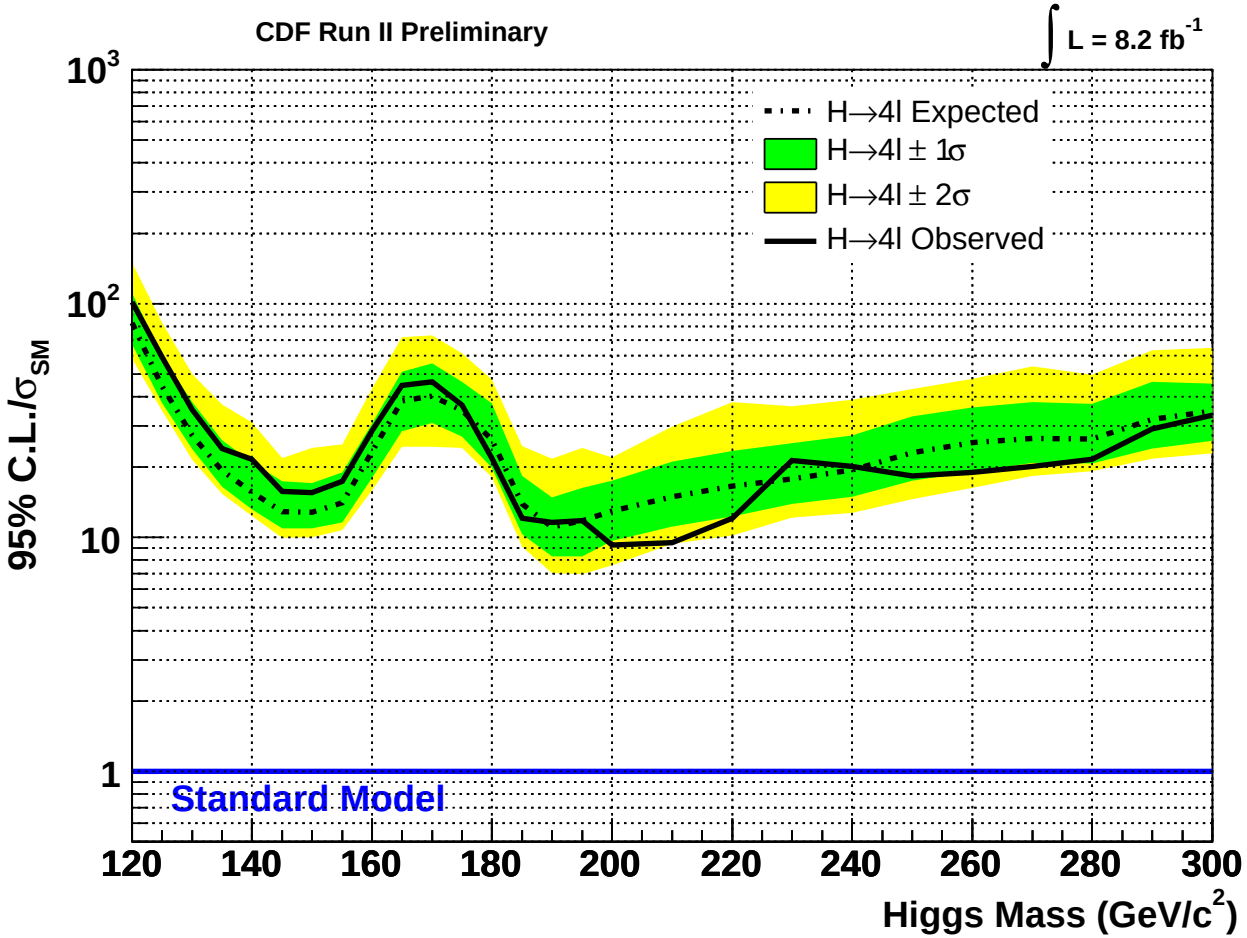


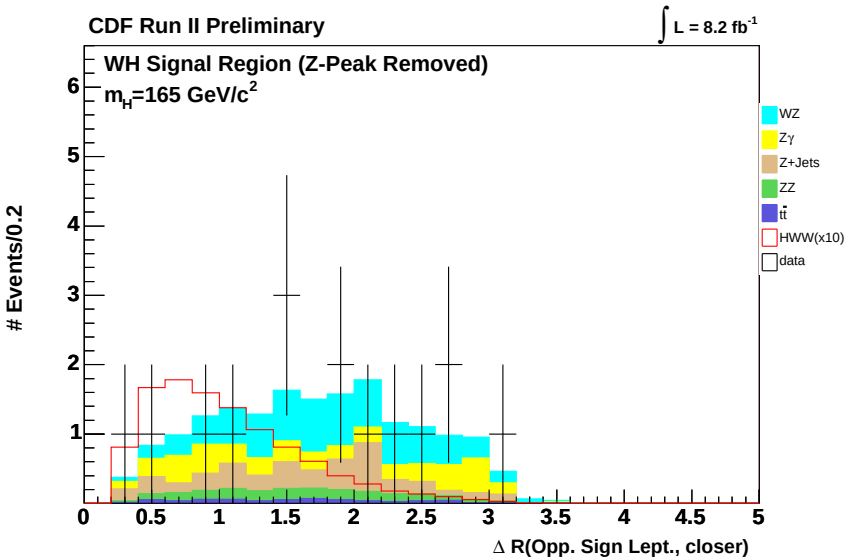
- $\sim$ 160 GeV: $H \to WW$ on-shell ($m_W \approx 80$ GeV)
- $\sim$ 180 GeV: $H \to ZZ$ on-shell ($m_Z \approx 90$ GeV)

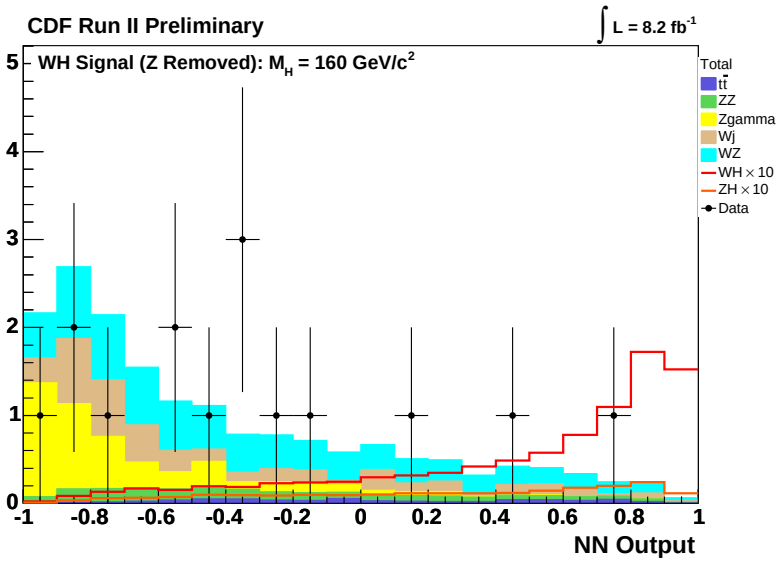
WH Trilepton ($WH \to l\nu l\nu l\nu$)

- Performed by: CDF only
- Signal from: $HW \to WWW \to l\nu l\nu l\nu$
- Signature: Exactly 3 high p_T lepton + $\not{E}_T$
- Neural network used to distinguish background from signal

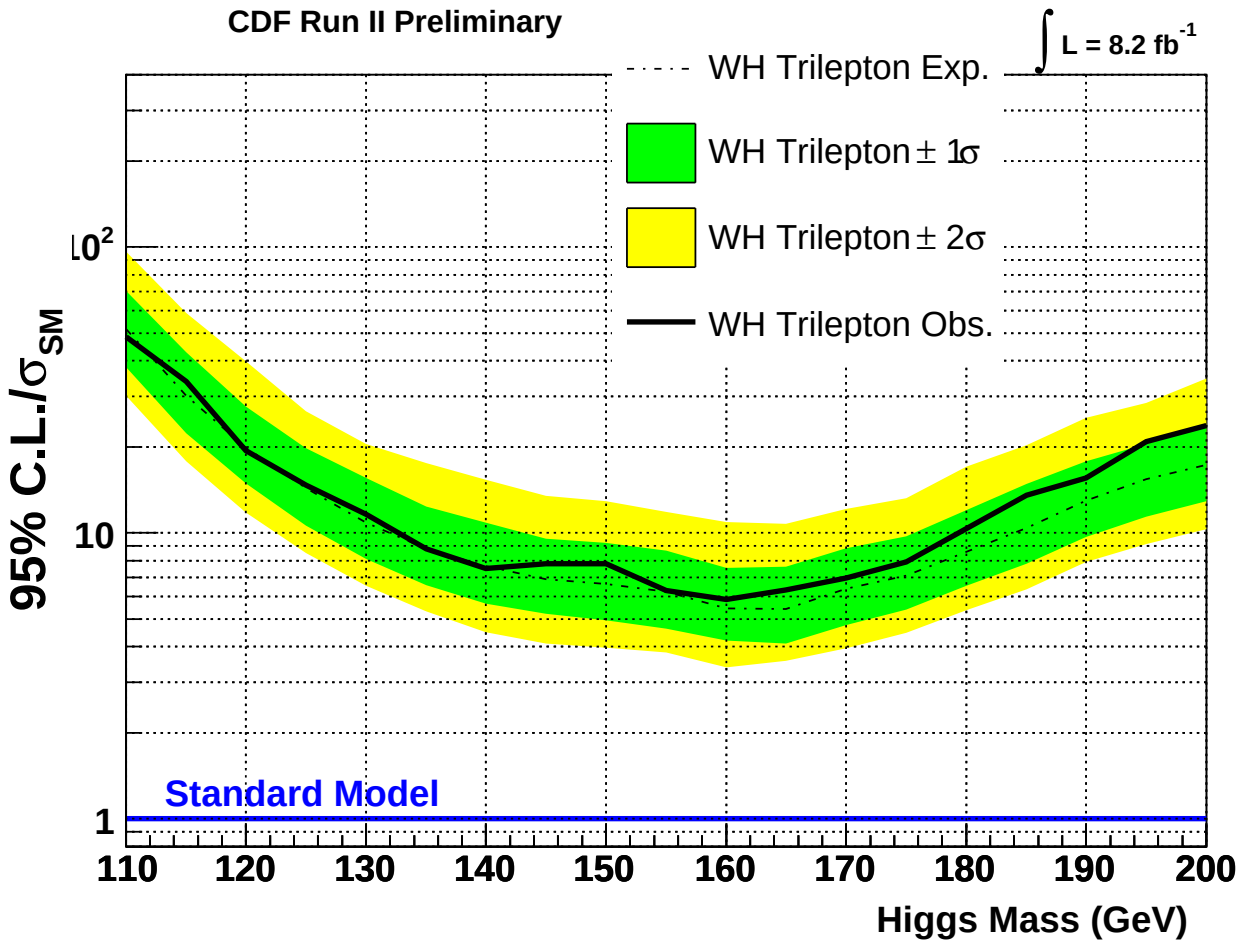
CDF Run II Preliminary	$\int \mathcal{L} = 8.2$ fb^{-1}		
$M_H = 165$ GeV/c^2			
$t\bar{t}$	0.64	$\pm$	0.20
WZ	7.1	$\pm$	1.0
ZZ	1.61	$\pm$	0.23
Z+jets	3.84	$\pm$	0.89
$Z\gamma$	4.21	$\pm$	0.84
Total Background	17.4	$\pm$	1.9
WH	0.89	$\pm$	0.12
ZH	0.203	$\pm$	0.028
Total Signal	1.09	$\pm$	0.15
Data		15	

AllSB-trilepNoZ





WH Trilepton ($WH \rightarrow l\nu l\nu l\nu$)



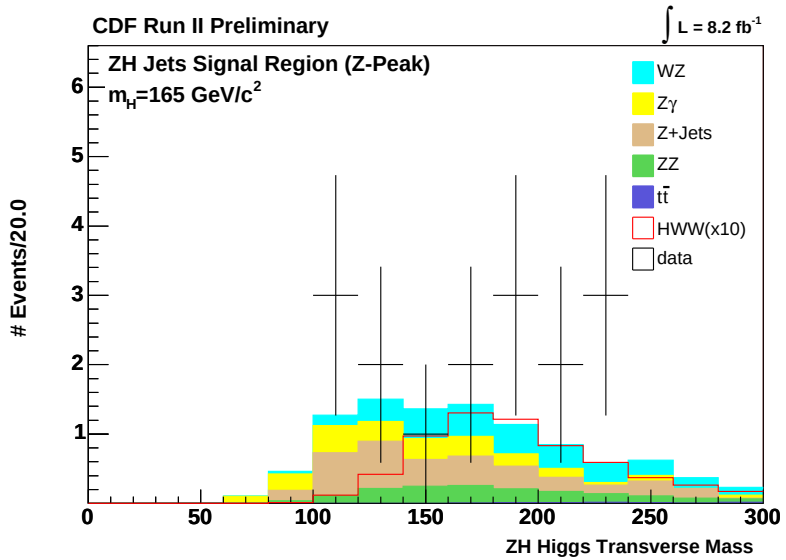
- Best Observed: $5.8(m_H = 160)$
- Best Expected: $5.5(m_H = 165)$

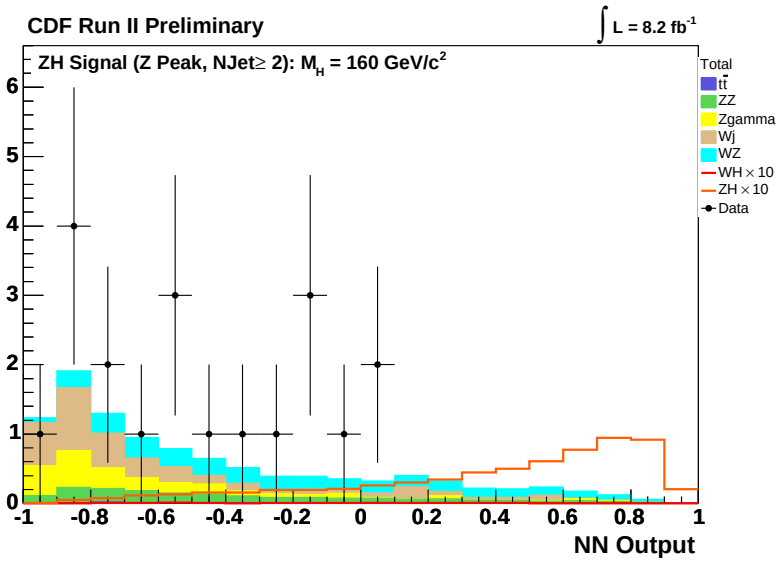
ZH Trileptons ($ZH \to lll\nu + \text{jets}$)

- Performed by: CDF only
- Signal from: $HZ \to WWZ \to l\nu + \text{jets} + ll$
- Signature: Exactly 3 high p_T lepton + $\not{E}_T$ + jets
- Neural network used to distinguish background from signal

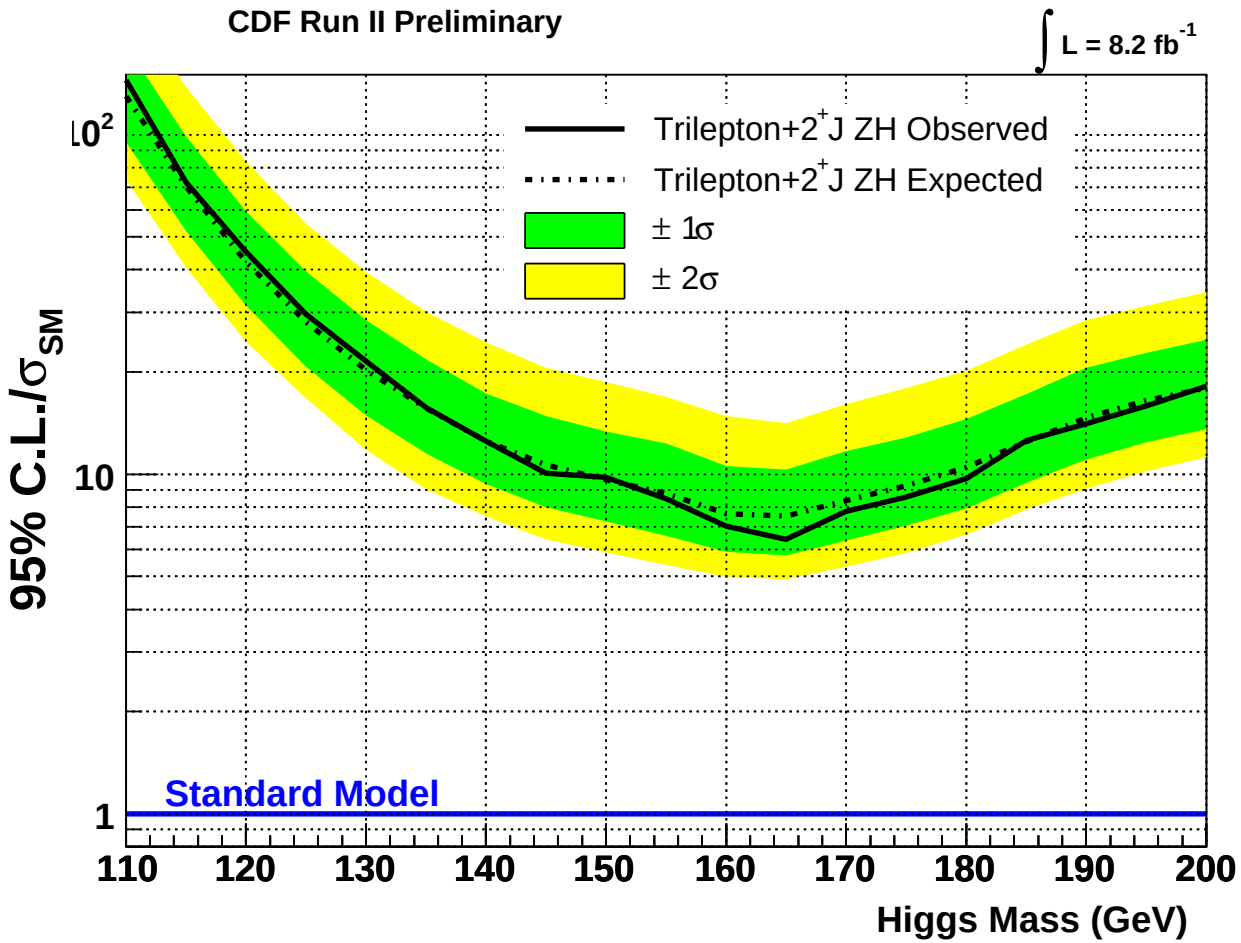
CDF Run II Preliminary	$\int \mathcal{L} = 8.2\ \text{fb}^{-1}$		
$M_H = 165\ \text{GeV}/c^2$			
$t\bar{t}$	0.141	$\pm$	0.038
WZ	3.65	$\pm$	0.84
ZZ	1.91	$\pm$	0.38
Z+jets	6.4	$\pm$	1.6
$Z\gamma$	2.55	$\pm$	0.66
Total Background	14.6	$\pm$	2.4
WH	0.0133	$\pm$	0.0034
ZH	0.72	$\pm$	0.11
Total Signal	0.74	$\pm$	0.11
Data	21		

AllSB-trilepZ2j





ZH Trileptons ($ZH \to lll\nu + \text{jets}$)



- Best Observed: $6.4(m_H = 165)$
- Best Expected: $7.5(m_H = 165)$

Best Limits by Channel:

Channels	Lumi.(fb^{-1})	Best Exp.	Best Obs.
$l\nu jj$	5.4	5.0($m_H = 160$)	3.9($m_H = 160$)
$H \to ZZ$	8.2	11.1($m_H = 190$)	9.3($m_H = 200$)
$WH \to l\nu l\nu l\nu$	8.2	5.5($m_H = 165$)	5.8($m_H = 160$)
$ZH \to lll\nu$+ 1 jets	8.2	25.7($m_H = 155$)	28.0($m_H = 160$)
$ZH \to lll\nu$+ $\geq$ 2 jets	8.2	7.5($m_H = 165$)	6.4($m_H = 165$)