

Higgs Searches at Tevatron

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Outline

- The CDF and DØ Detectors
- Tevatron
- Higgs searches at Tevatron
 - general remarks
 - production and decays
 - SM Higgs Searches
 - MSSM Higgs Searches
- Summary

The CDF and DØ Detectors

→ CDF

→ new

- silicon detector
- drift chamber
- TOF PID system

→ upgraded

- calorimeter
- muon system
- DAQ/Trigger
- displaced-vertex trigger

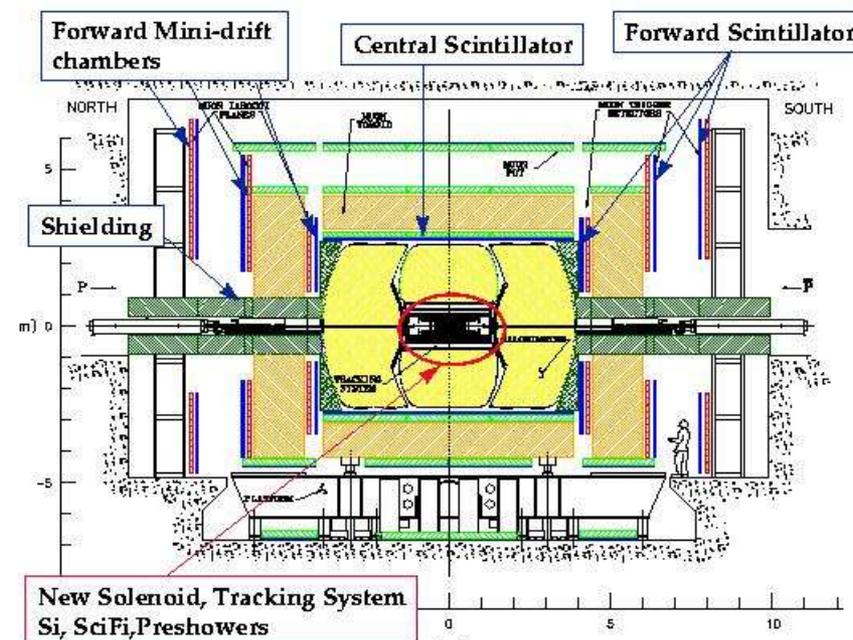
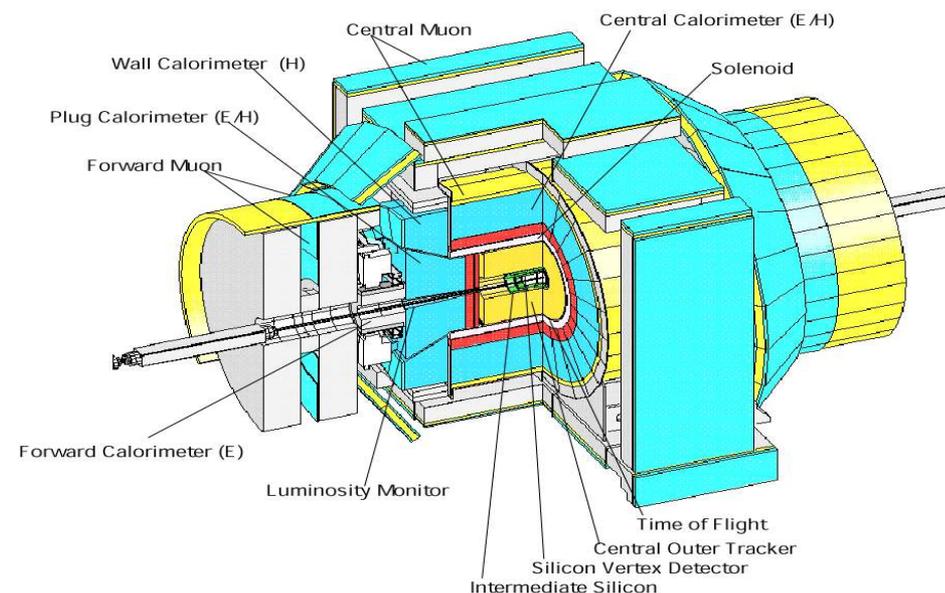
→ DØ

→ new (tracking in B-field)

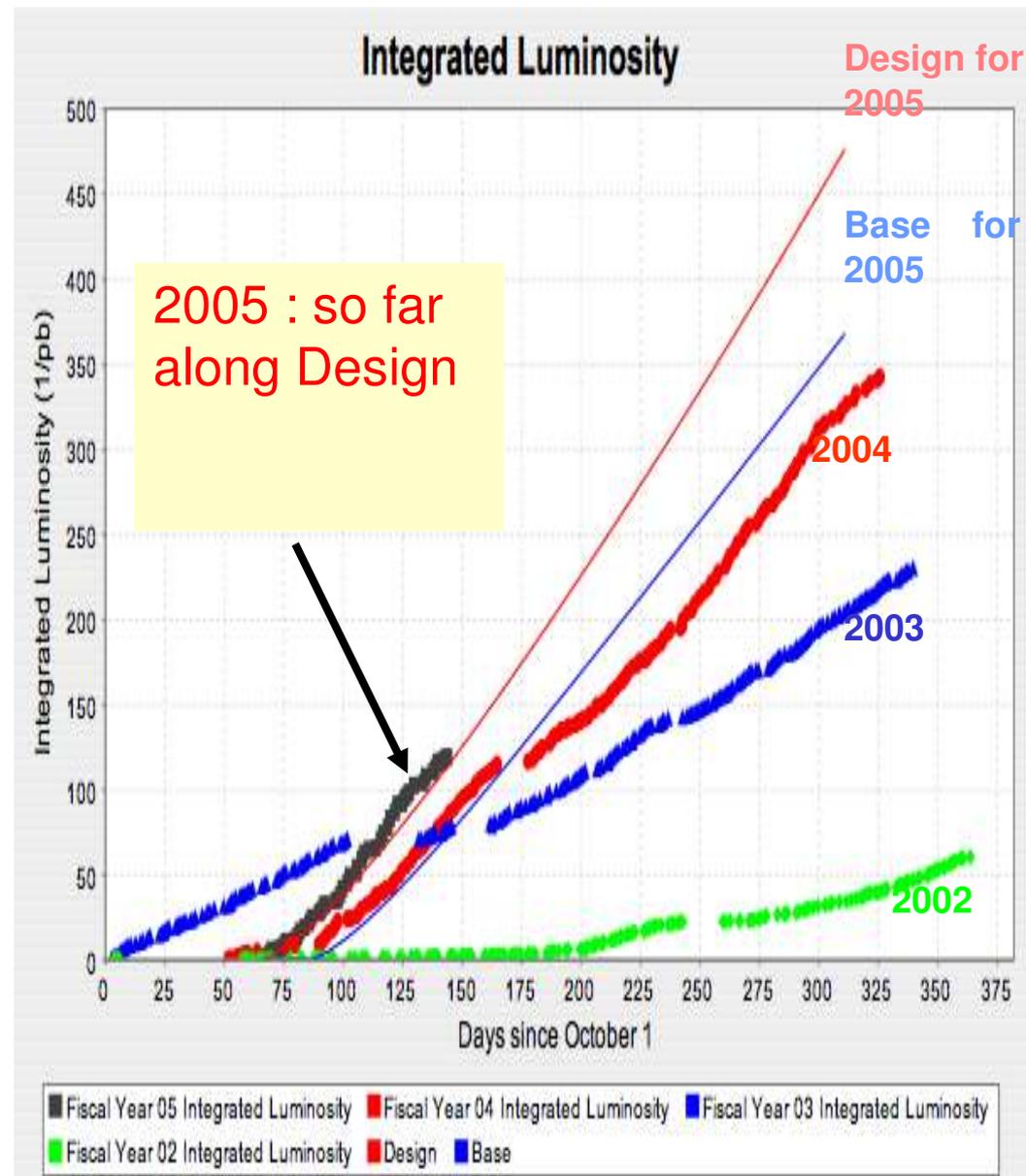
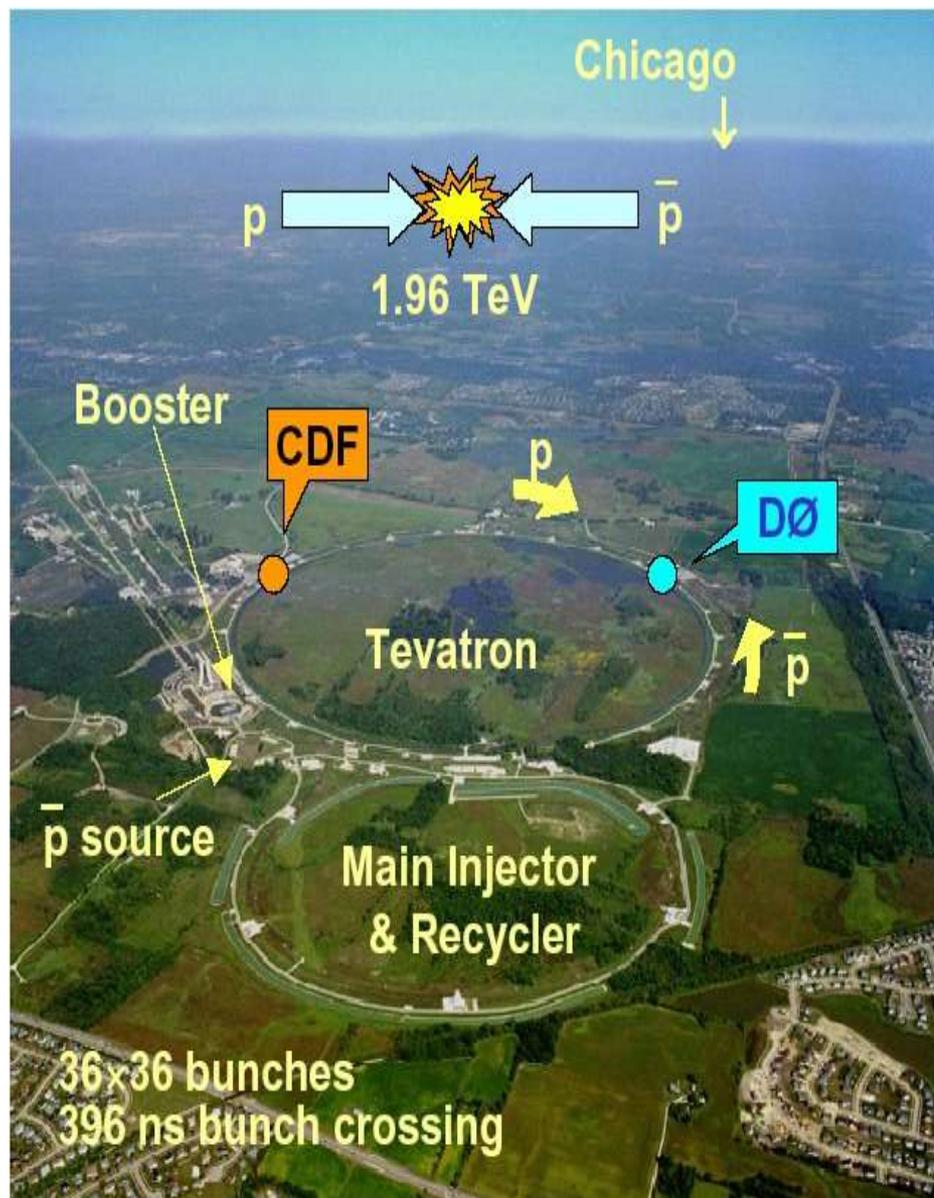
- silicon detector
- central fiber tracker

→ upgraded

- calorimeter
- muon system
- DAQ/trigger

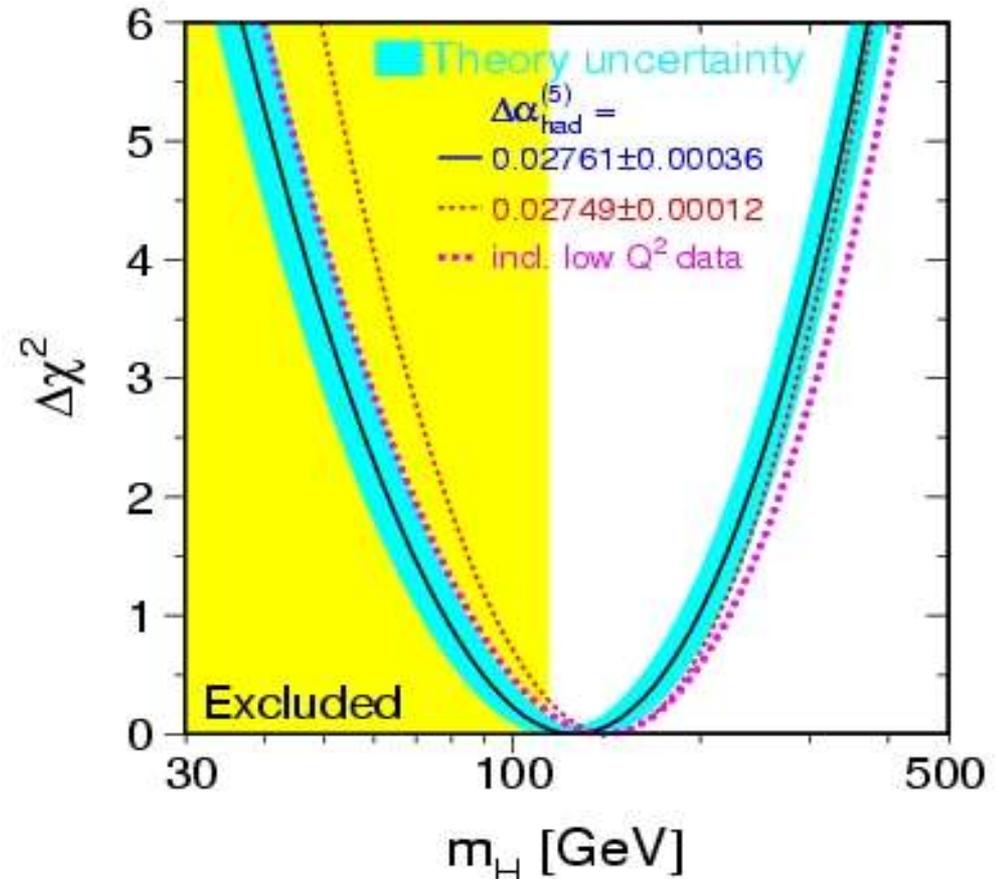
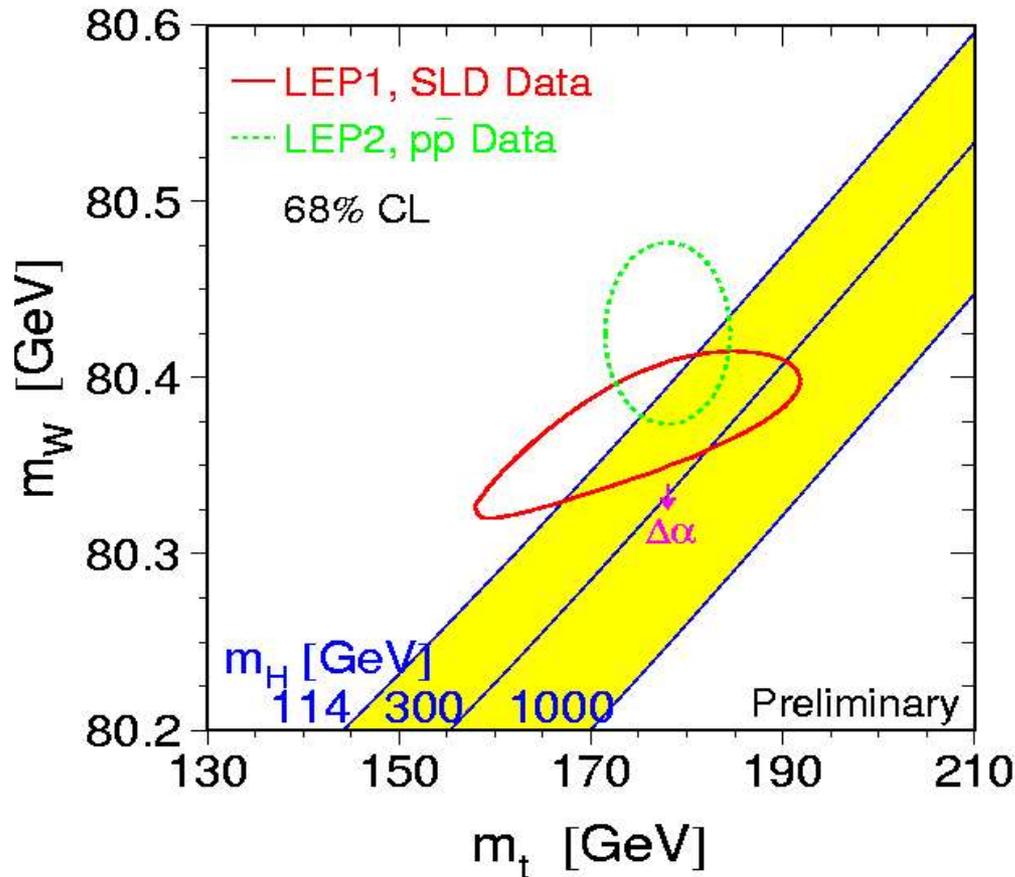


Tevatron/Luminosity

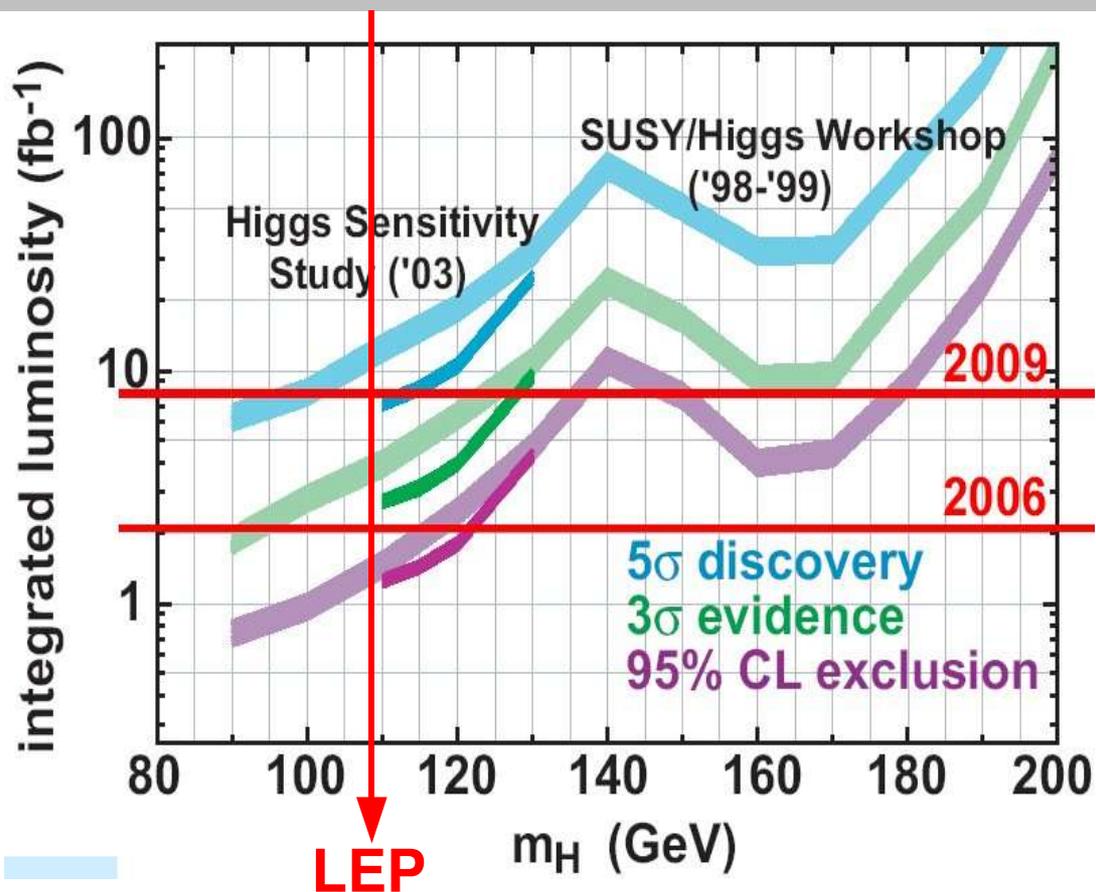


Higgs Mass Constraints

- SM Higgs mass constraints:
 - direct searches: $m_H > 114.4$ GeV
 - precision EW fits: $m_H = 126^{+73}_{-48}$ GeV



Higgs Search Prospects at Tevatron

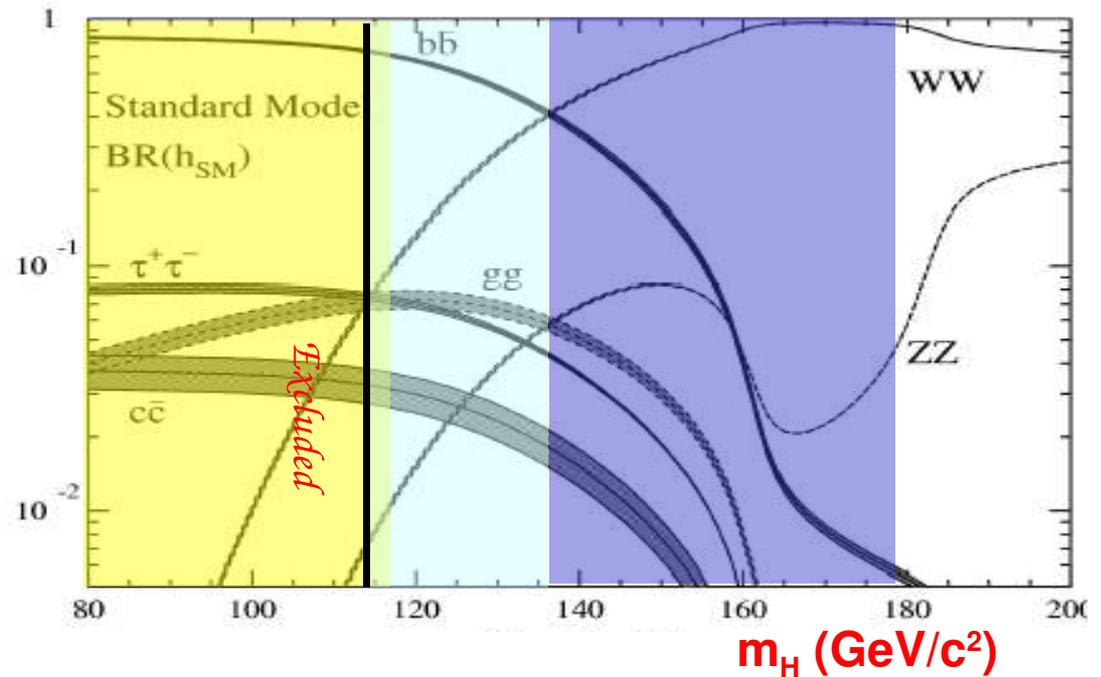
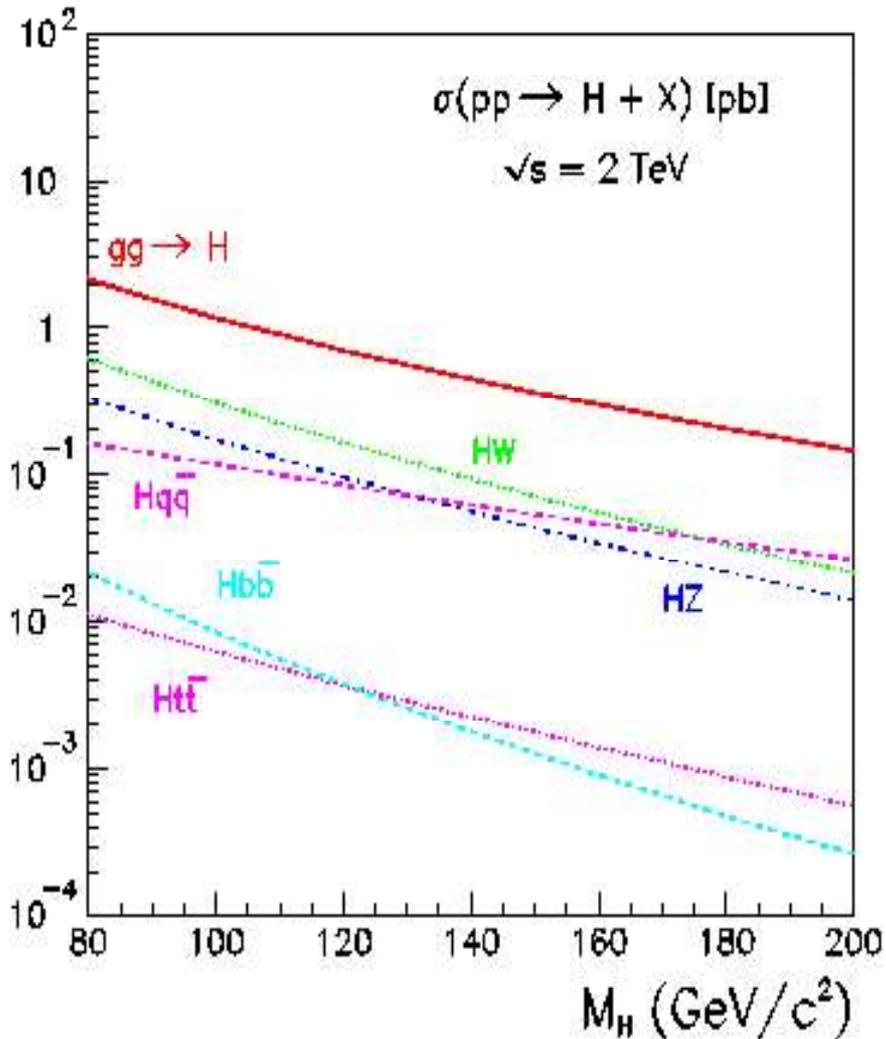


- sensitivity in the mass region above LEP limit starts **above 2fb⁻¹**
- meanwhile:
 - optimize analysis techniques
 - improve understanding of detectors
 - search for non-SM Higgs with higher production cross-section

→ Integrated luminosity required per experiment, to either exclude a SM Higgs at 95% C.L. or discover it the 3σ or 5σ level (no systematics).

Higgs Production and Decays

- SM Higgs production cross-section is small: 0.1-1.0pb depending on m_H



- search strategies depend on m_H :
 - **$m_H < 135 \text{ GeV}$** : associated production WH/ZH with $H \rightarrow b\bar{b}$ decay
background: top, $Wb\bar{b}$, $Zb\bar{b}$, ...
 - **$m_H > 135 \text{ GeV}$** : $gg \rightarrow H$ production with decay to WW^*
background: electroweak WW production...

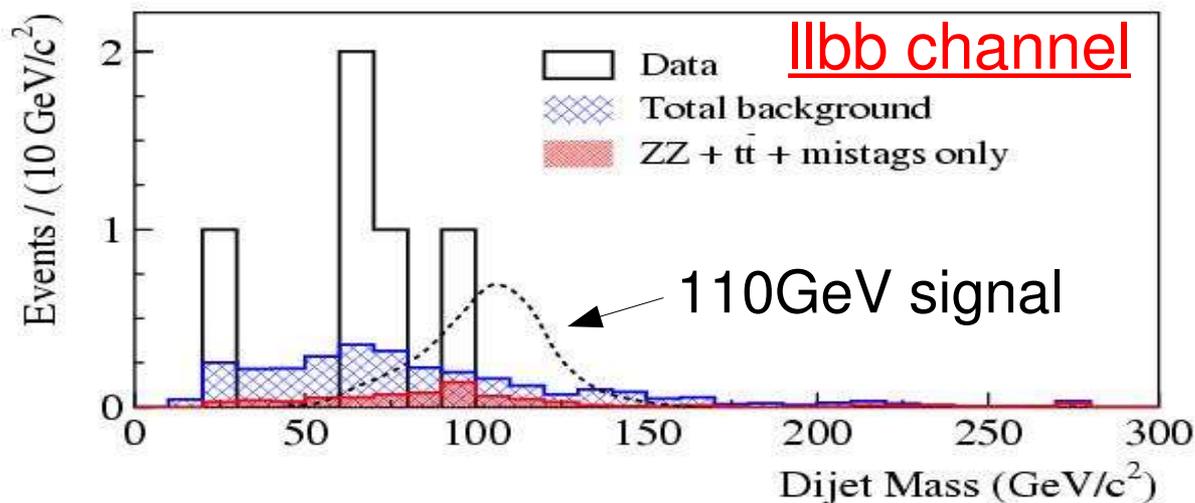
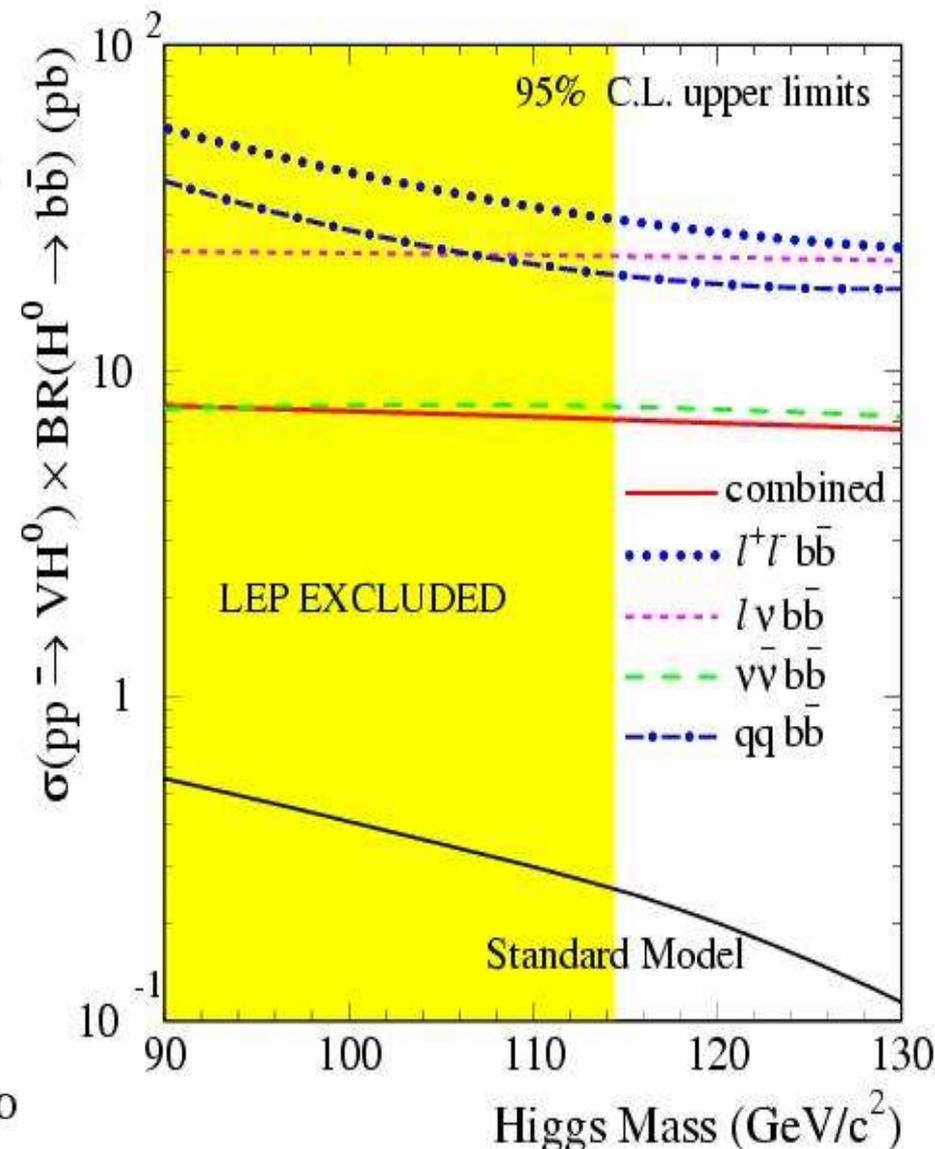
Higgs Searches at Tevatron

- the wide possible Higgs mass range and the number of theory models lead to huge variety of search options and strategies
- not all them can be covered
- in the following focus on a a small selection of results:
 - SM Higgs searches:
 - Run1 results
 - $HW \rightarrow WWW/HZ \rightarrow WWZ$
 - $H \rightarrow WW$
 - MSSM Higgs searches
 - hbb search
 - $h \rightarrow \tau\tau$
- many more analyzes in progress
for more information please visit:
 - <http://www-cdf.fnal.gov/physics/exotic/exotic.html>
 - <http://wwwd0.fnal.gov/Run2Physics/higgs/pubresults.html>

All limits are
given with 95% C.L.

CDF RunI Results

- final CDF cross section limits for associated Higgs production from RunI
- combination of 4 analysis channels:
 - llbb
 - vvbb
 - lvbb
 - qqbb
- results are based on 106pb^{-1}
- no evidence for signal

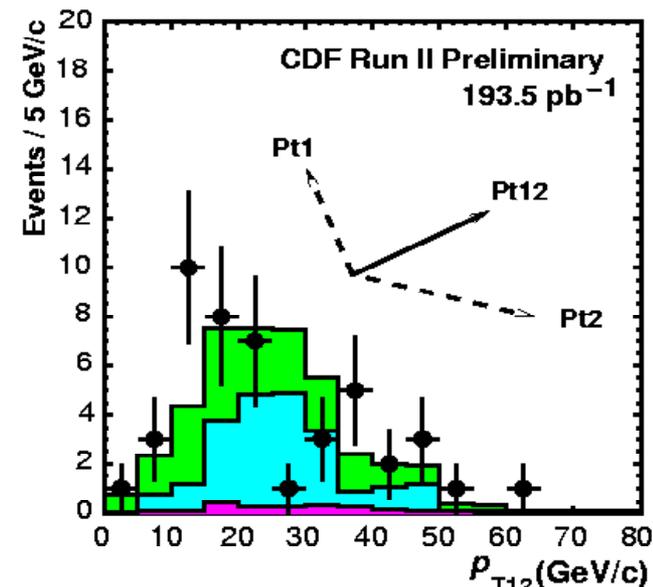
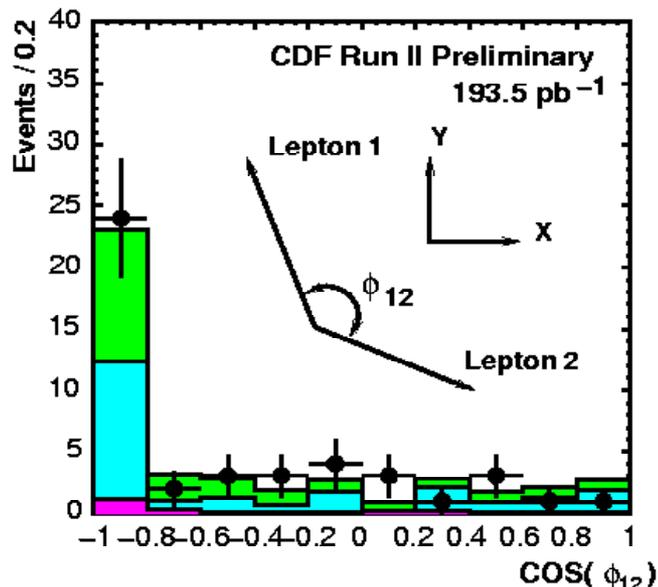
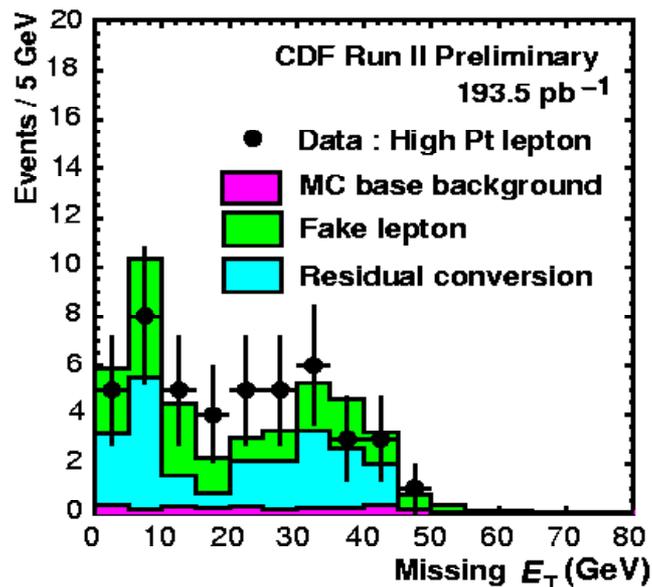
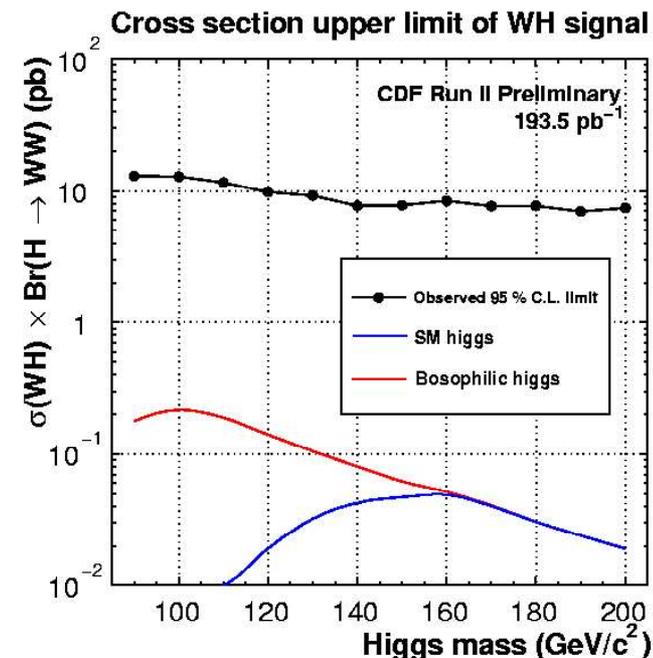


Search for $WH \rightarrow W\bar{W}$ (CDF)

- search for high p_T like-sign dilepton events
- $p_{T,1} > 20\text{GeV}$, $p_{T,2} > 16\text{GeV}$, $p_{T,12} > 35\text{GeV}$
- search in $(p_{T,1}, p_{T,2})$ plane
- results:

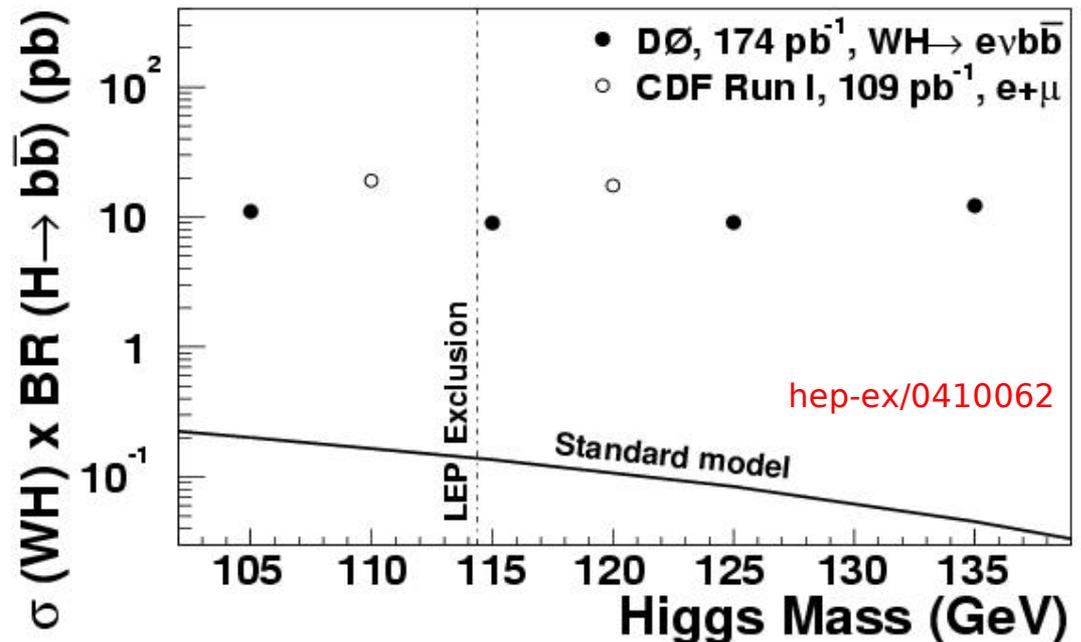
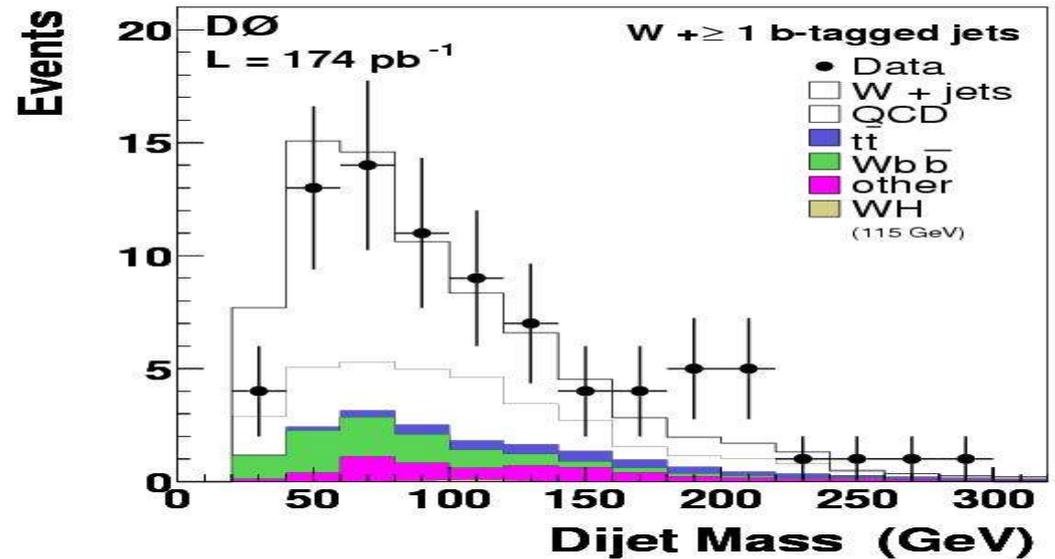
Bckgnd	Obs	Signal
0.95	0	0.06

(193.5 pb⁻¹, $m_H = 160\text{GeV}$)



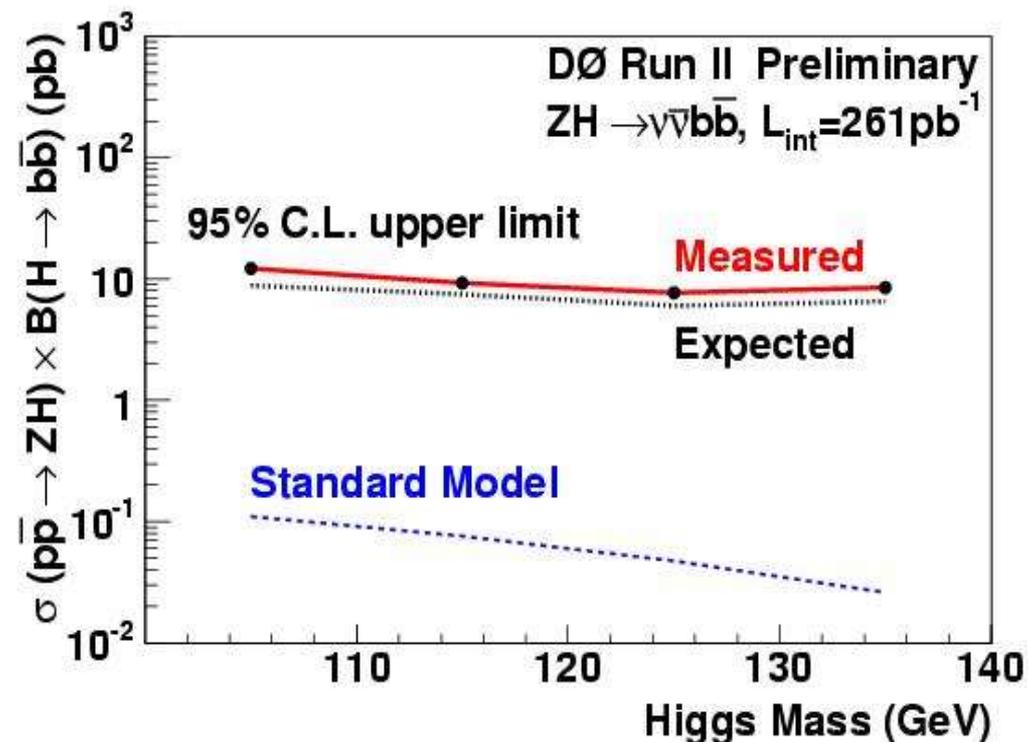
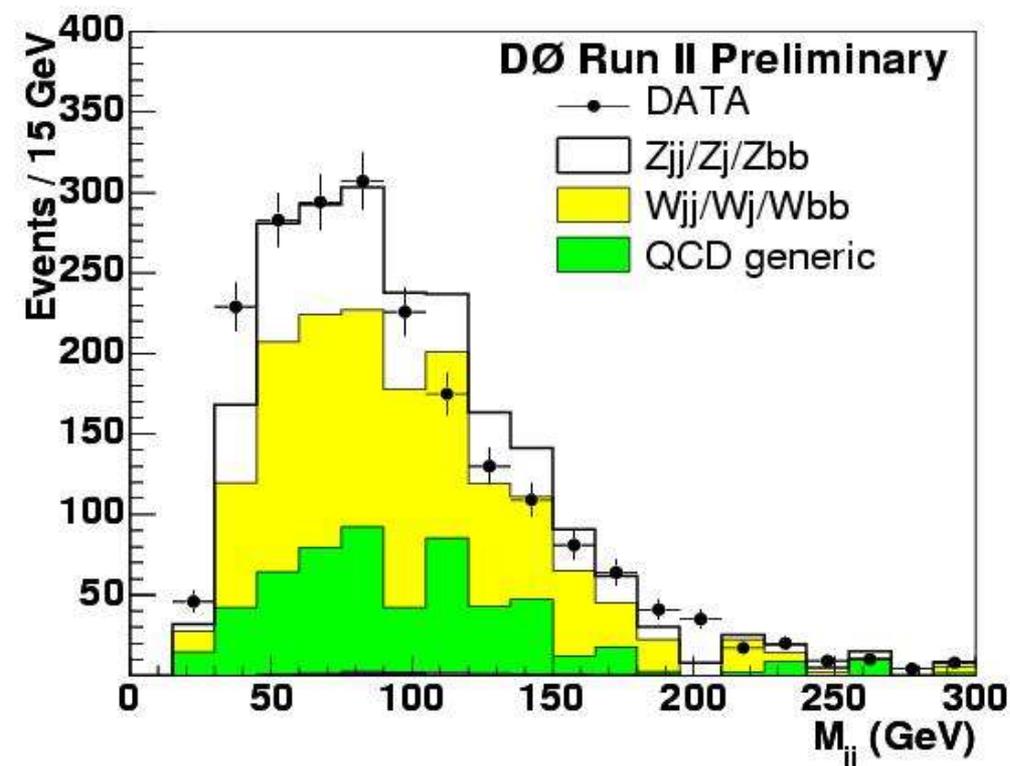
Search for $WH \rightarrow Wbb$ ($D\bar{O}$)

- require
 - electron: $p_T > 20\text{GeV}$, $|\eta| < 1.1$
 - $ME_T > 25\text{GeV}$
 - 2 jets: $p_T > 20\text{GeV}$, $|\eta| < 2.5$
- results are based on 174pb^{-1}
 - 2540 evts
(2580 ± 630 expected)
 - ≥ 1 b-tag: 76 evts
($72.6 \pm 20\text{exp}$)



Search for $ZH \rightarrow ZWW$ (DØ)

- first search for ZH production at Tevatron RunII
- signature: ME_T ($\nu\nu$), 2 b-jets
- strategy:
 - tag events with ME_T
 - search for excess in dijet mass distribution



Search for $H \rightarrow WW$

→ three channels:

$$H \rightarrow WW^* \rightarrow l\nu l\nu$$

(with $l = e, \mu, e\mu$)

→ selection:

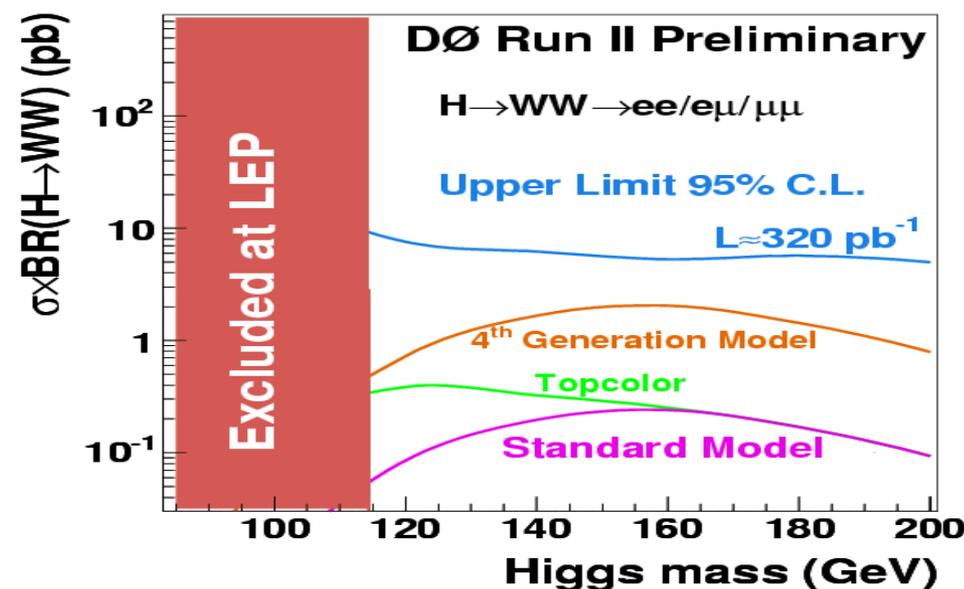
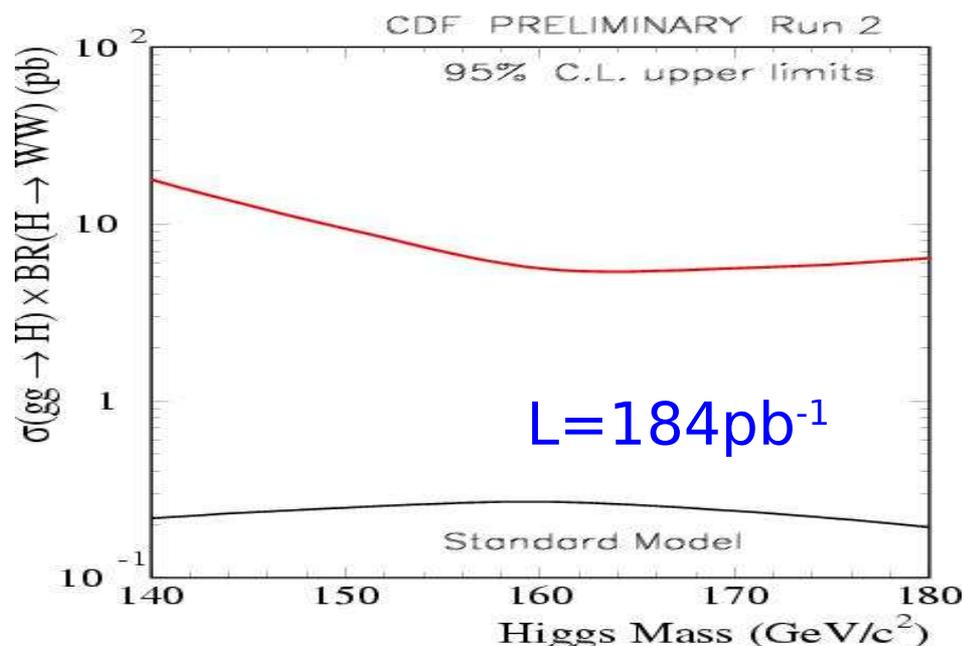
- two leptons with opposite charge
- isolation
- p_T and E_T requirements
- cut on invariant dilepton mass

→ results:

- efficiencies: 4-17% (DØ)

	Bkgnd	Obs	σBR	L_{int}
CDF	5.8	3	5.6	184 pb ⁻¹
DØ	17.7	20	5.3	320 pb ⁻¹

($m_H = 160 \text{ GeV}$)

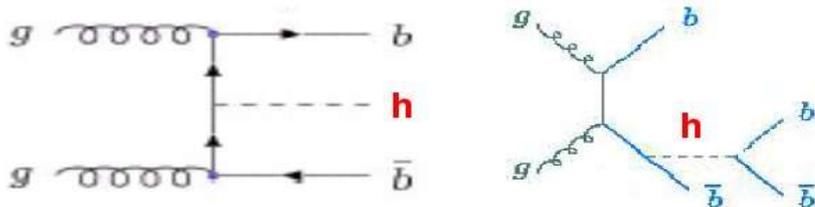


Search for MSSM Higgs: $hb\bar{b}$ ($D\emptyset$)

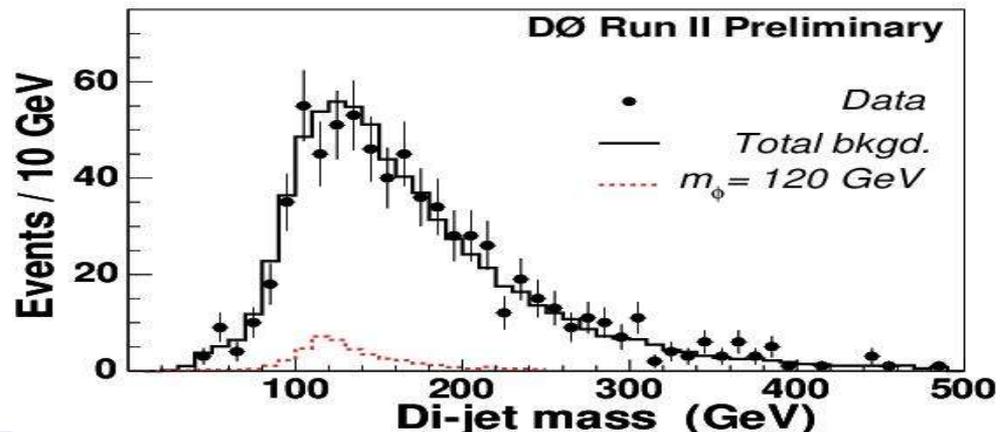
Two Higgs Doublets $\mathcal{H}_1, \mathcal{H}_2$ and 5 physical states

2 CP-even neutral Higgses	h^0, H^0	$m_h < m_H$
1 CP-odd neutral Higgs	A^0	
2 charged Higgses	H^\pm	
Free parameters:	$\tan\beta = v_2/v_1$	(VEV ratio)
	α	(mixing angle of h, H)
	μ	Higgs mass parameter
	A_0	common trilinear
		Higgs-sfermion coupling

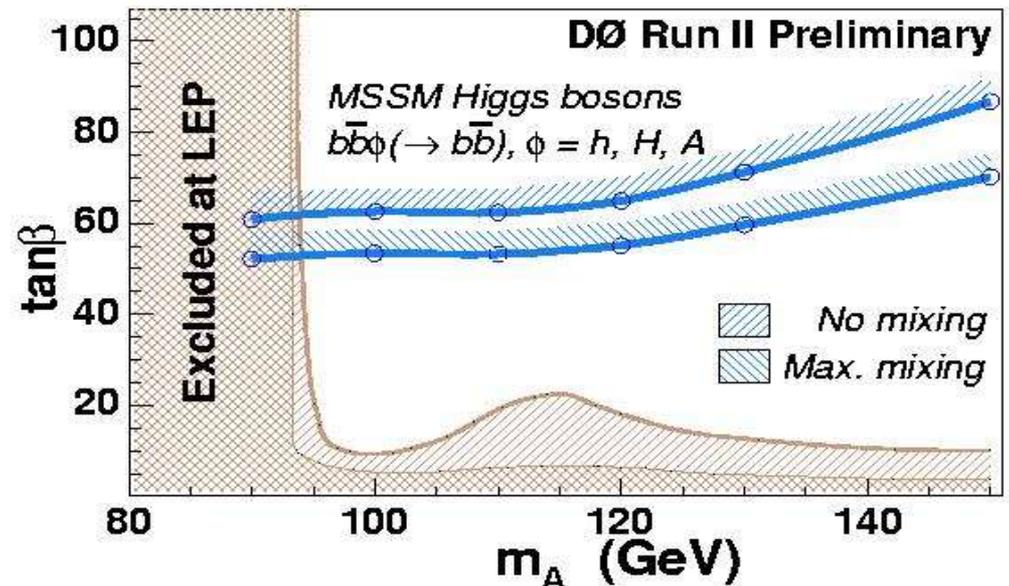
tree level: $m_h < m_z < m_H$
 rad.corrected: $m_h < 130 \text{ GeV}$ $Br(\phi \rightarrow b\bar{b}) \sim 90\%$



- search for neutral Higgs in a Two-Higgs-doublet MSSM SUSY model
- do not distinguish between h, H and A
- $D\emptyset$ analysis based on 260 pb^{-1}



- selection:
 - trigger on 3-jet events
 - off-line cut on leading jet E_T (optimized wrt m_H hypothesis)
 - ≥ 3 b-tagged jets
- main background:
 - QCD heavy flavor ($bbjj, ccjj, cccc, bccc, bbbb$)
 - QCD fakes ($jjjj$)
 - Other ($Z \rightarrow b\bar{b}, \rightarrow cc; tt$)
- no excess observed



Search for MSSM Higgs: $h \rightarrow \tau\tau$ (CDF)

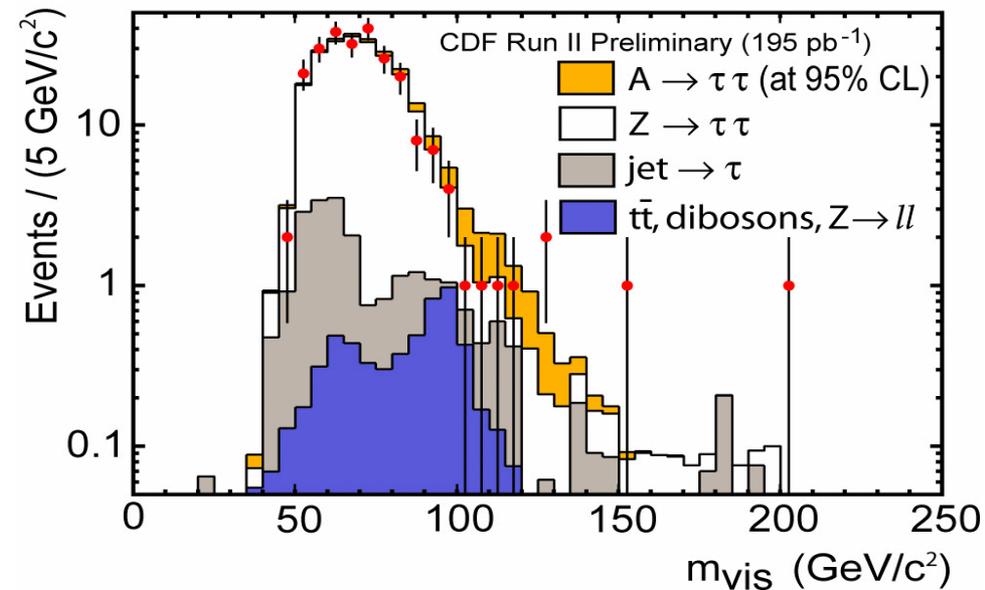
- require two τ 's:
 - $\tau \rightarrow \nu + \text{hadrons}$, $\tau \rightarrow \nu e/\mu$
- τ triggers (lepton + isolated track)
- Background:
 - multi-jet events
 - $W \rightarrow l\nu$
 - $Z \rightarrow ll$
- remove light quark bkgnd:
 - $H_T = |\mathbf{p}_T(\tau_1)| + |\mathbf{p}_T(\tau_2)| + ME_T > 50 \text{ GeV}$
- limit extracted from binned likelihood fit on mass-like discriminating variable $m_{\text{vis}}(l, \tau, ME_T)$

MSSM Higgs $\rightarrow \tau\tau$ Search, final events

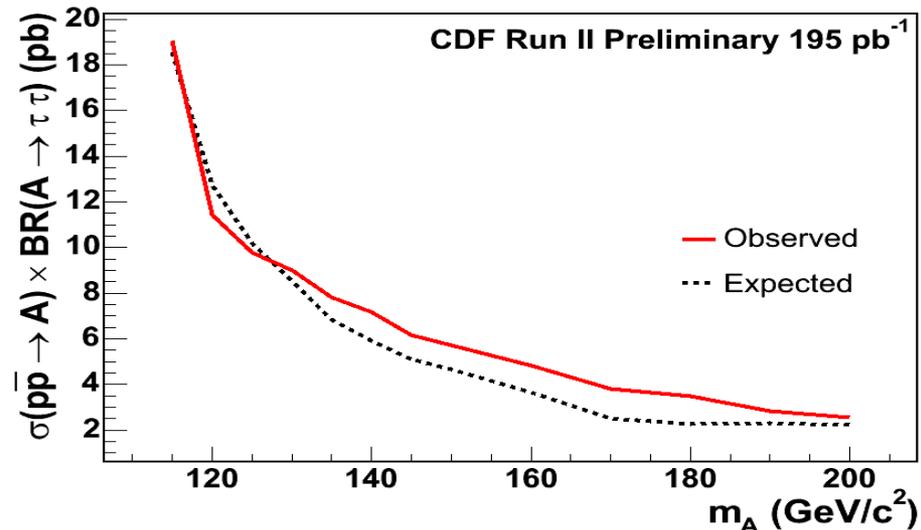
	$\tau_h \tau_e$	$\tau_h \tau_\mu$	Combined
$Z \rightarrow \tau\tau$	132.3 ± 17.1	104.1 ± 13.3	236.4 ± 29.5
$Z \rightarrow ll$	1.8 ± 0.2	4.9 ± 0.4	6.7 ± 0.6
$t\bar{t}, VV$	0.7 ± 0.1	0.8 ± 0.1	1.5 ± 0.1
$jet \rightarrow \tau$	12.0 ± 3.6	7.0 ± 2.1	19.0 ± 5.7
Total predicted	146.8 ± 17.5	116.8 ± 13.5	263.6 ± 30.1
Data	133	103	236

CDF Run II Preliminary

Higgs $\rightarrow \tau\tau$ Search, Example Fit for $m_A = 130 \text{ GeV}/c^2$



Higgs $\rightarrow \tau\tau$ Search, 95% CL Upper Limit



Summary

- so far no deviations from SM background observed
- hunt for Higgs boson in progress:
 - SM Higgs
 - sensitivity starts at 2fb^{-1}
 - non-SM Higgs
 - many different model tests underway
 - already see reduction in allowed phase space
 - build confidence
 - optimize analysis techniques
 - improve understanding of detector
- we are prepared for the years to come
 - expect substantial improvements in Higgs searches
 - 0.8fb^{-1} already on tape
 - 8.0fb^{-1} expected in RunII

Acknowledgment

I would like to thank all the people who were contributing to this talk!