Improvements on the Higgs searches in the high mass region at CDF

M. Bauce on behalf of the CDF collaboration

INFN Padova

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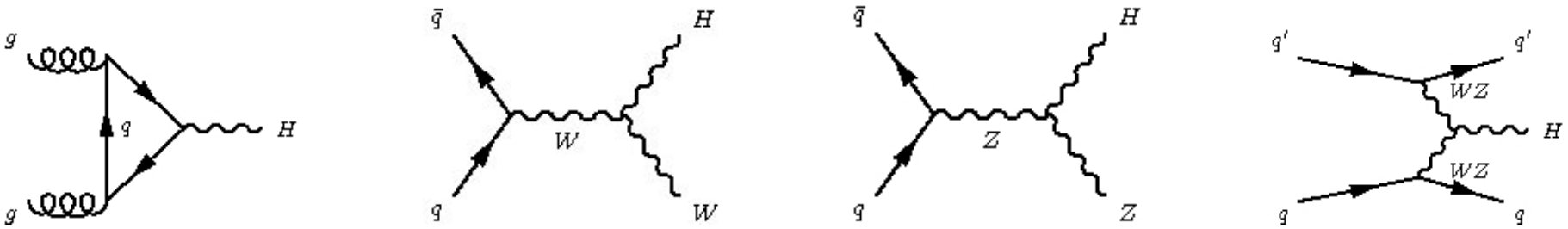
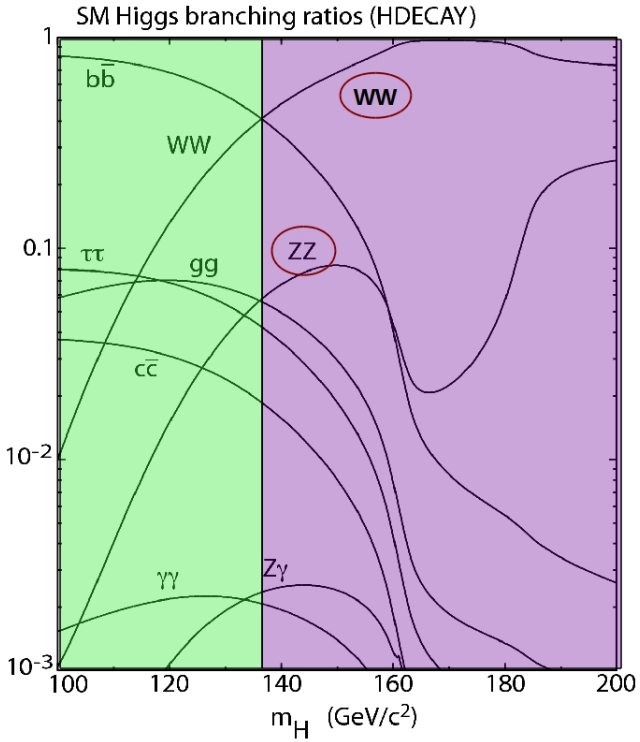
Higgs production and decay

- Four main production mechanism at Tevatron: $\sigma_{SM}^{m_H=165\ GeV} \sim 0.6\ pb$

$gg \to$ H (78 %) $q\bar{q} \to$ WH (9 %) $q\bar{q} \to$ ZH (6 %) $qq' \to qq'H$ (7 %)



- All of them become important with increasing sensitivity.

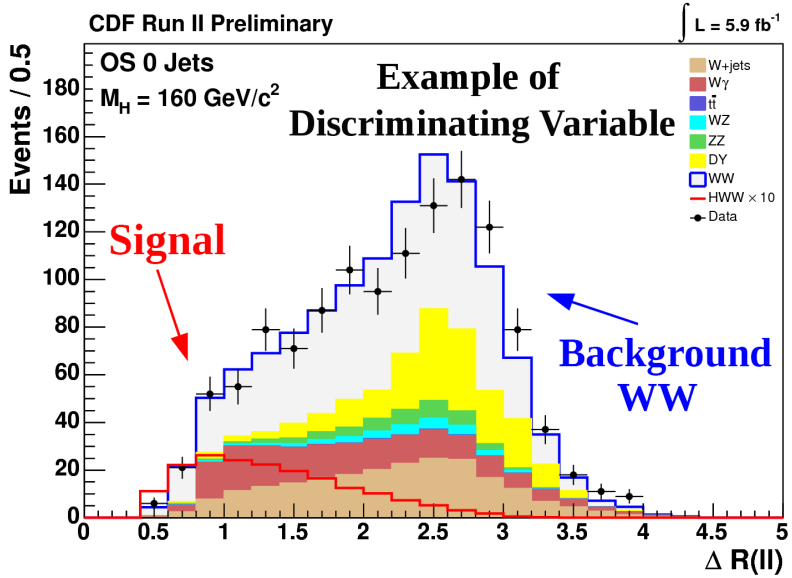


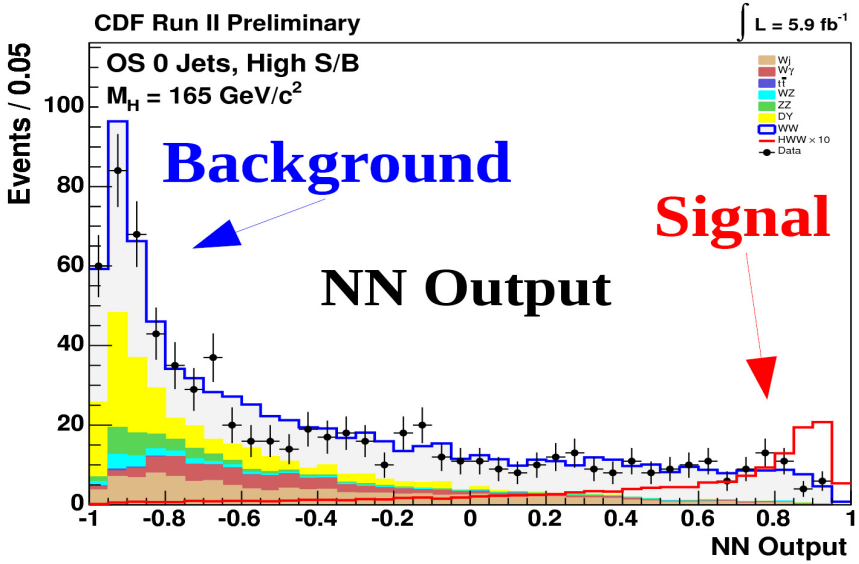
- **High mass region** defined for $M_H \geq 135$ GeV/c^2
  - H→WW is the dominant decay channel
  - H→ZZ is also relevant for M_H ranges where WW is not the most sensitive ([140-150] & [>180] GeV/c^2)
- **This analysis considers** H→WW decay channel
- W decays:
  - W→ $\ell\nu$, ℓ=e,μ,τ
  - W→hadrons have large background, not yet included in the analysis

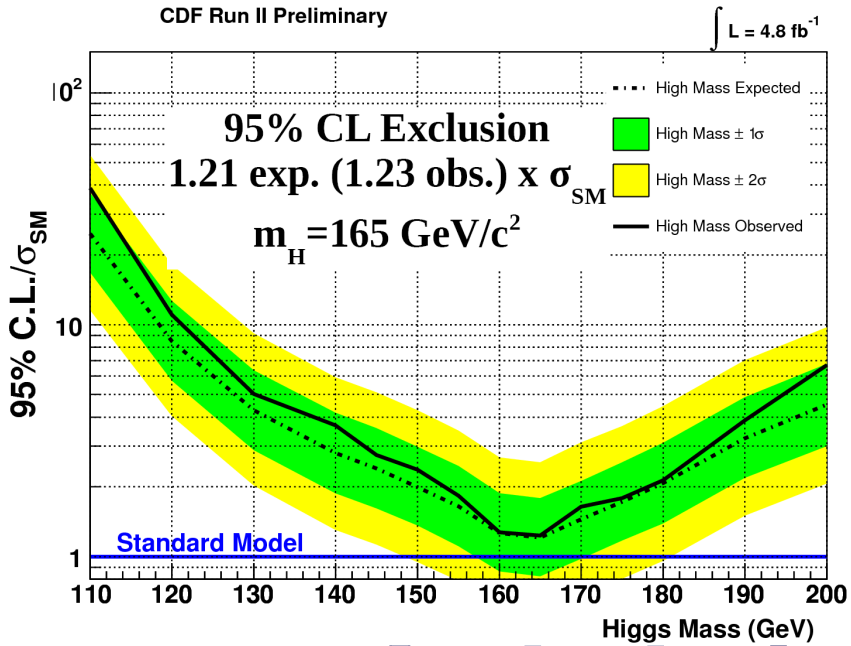
H→WW* Analysis

Multi-channel analysis

- 2 leptons (e,μ) in the final state
- Separated by event topology
- Different dominant background
  - O.S. 0 jets → WW
  - O.S. 1 jet → DY
  - O.S. 2 or more jets → $t\bar{t}$
  - S.S. 1 or more jets → W+jets
  - O.S. M_{ll}<16 GeV/c^2 → Wγ (fake)
- Neural Network trained for each M_H
- Different set of variables for different *channel*





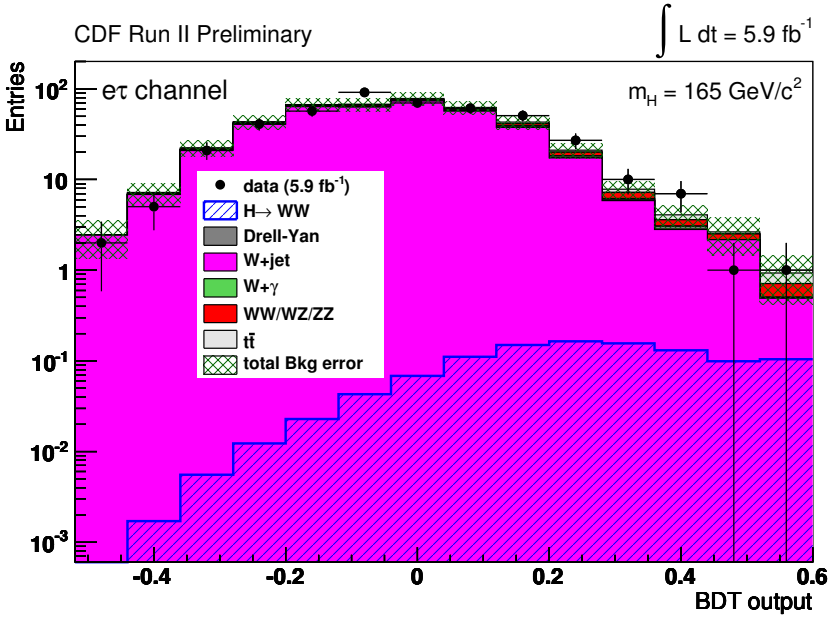


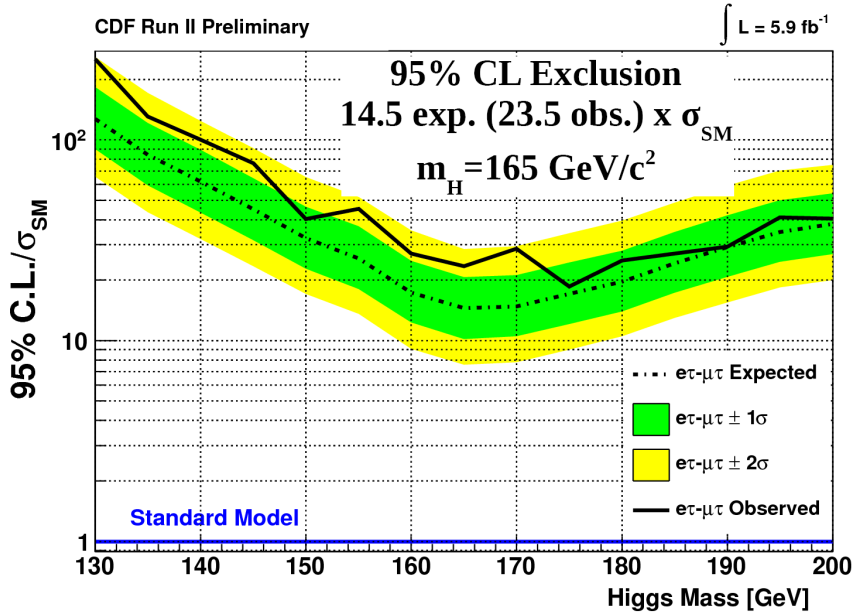
H→WW* with Hadronic Tau decay channel + 4% signal

Include W→ $\tau + \nu$ →hadrons+ν

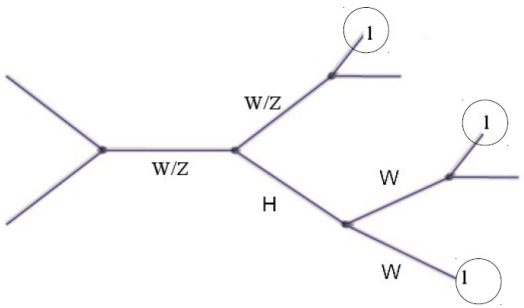
- One trigger e or μ, one hadronically decaying tau in the final state
- Main **background**: W+jets (**jet faking** τ)
  - Validated with background dominated control regions
- Signal efficiency dominated by τ reconstruction efficiency
- Boosted Decision Tree (BDT):
  - τ ID variables + kinematic variables

CDF Run II Preliminary	$\int \mathcal{L} = 5.9$ fb^{-1}		
$m_H = 160$ GeV/c^2			
dijet, γ+ jet	9	±	27
$Z \to \tau\tau$	0.8	±	0.4
$Z \to \ell\ell$	48.8	±	6.4
W+jets	624	±	77
Wγ	3.3	±	0.4
Diboson (WW, WZ, ZZ)	25.3	±	2.7
$t\bar{t}$	15.5	±	2.8
Total Background	726	±	82
$gg \to H$	1.08	±	0.10
WH	0.261	±	0.026
ZH	0.167	±	0.017
VBF	0.095	±	0.011
Total Signal	1.60	±	0.11
Data	741		



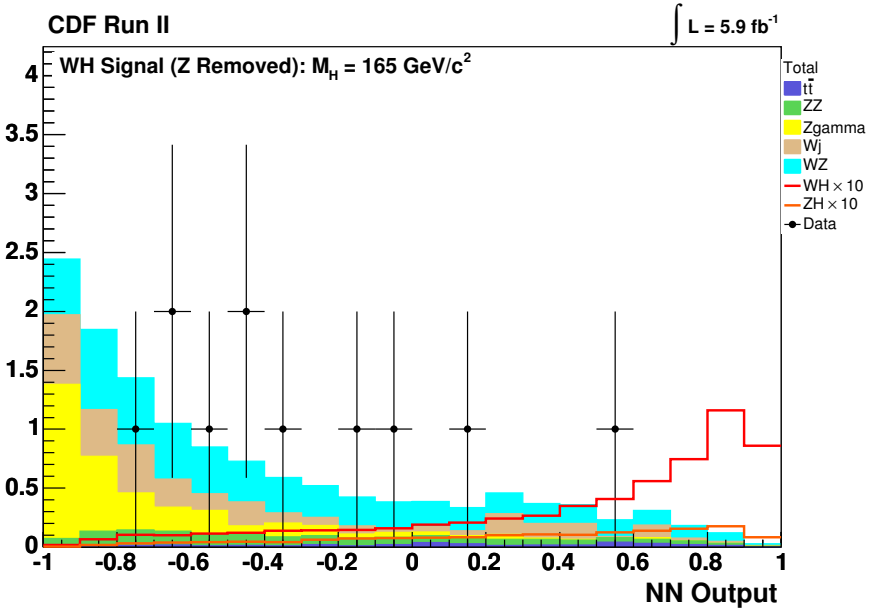


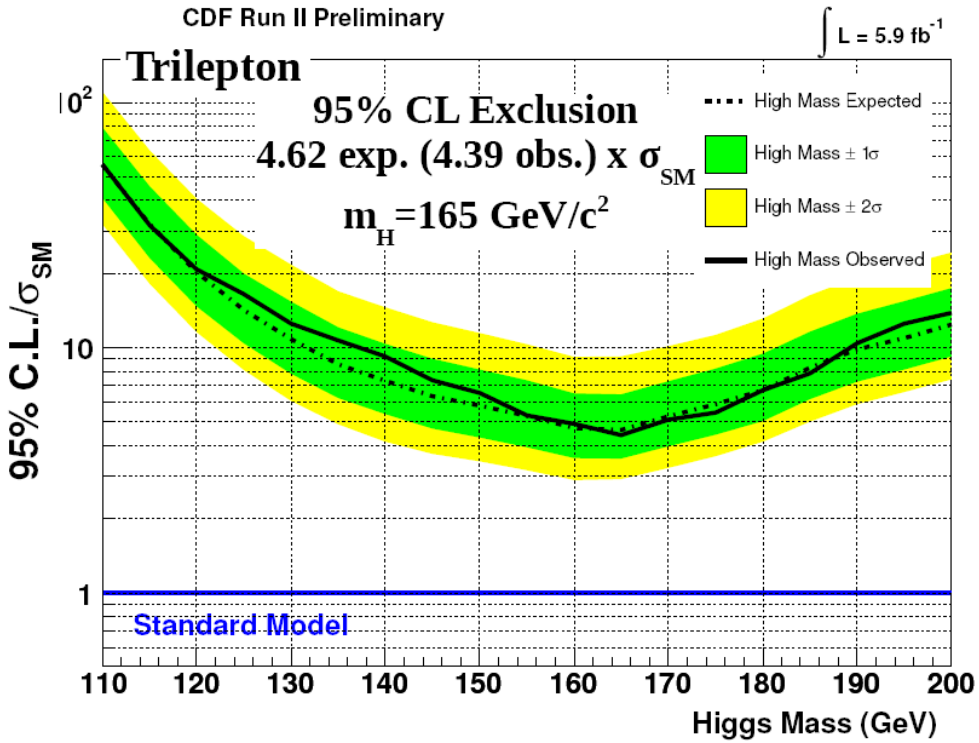
Tri-lepton - orthogonal to the main HWW analysis + 3.8% signal



- Split analysis in three channel:
  - ***inZ***: $\ell\ell$ S. Flav., $m_Z \pm 15$ GeV/c^2, **1 jet**
  - ***inZ***: $\ell\ell$ S. Flav., $m_Z \pm 15$ GeV/c^2, **2+ jets**
  - ***No-Z***: orthogonal to *inZ*, **any jets**
- NN with different set of variables

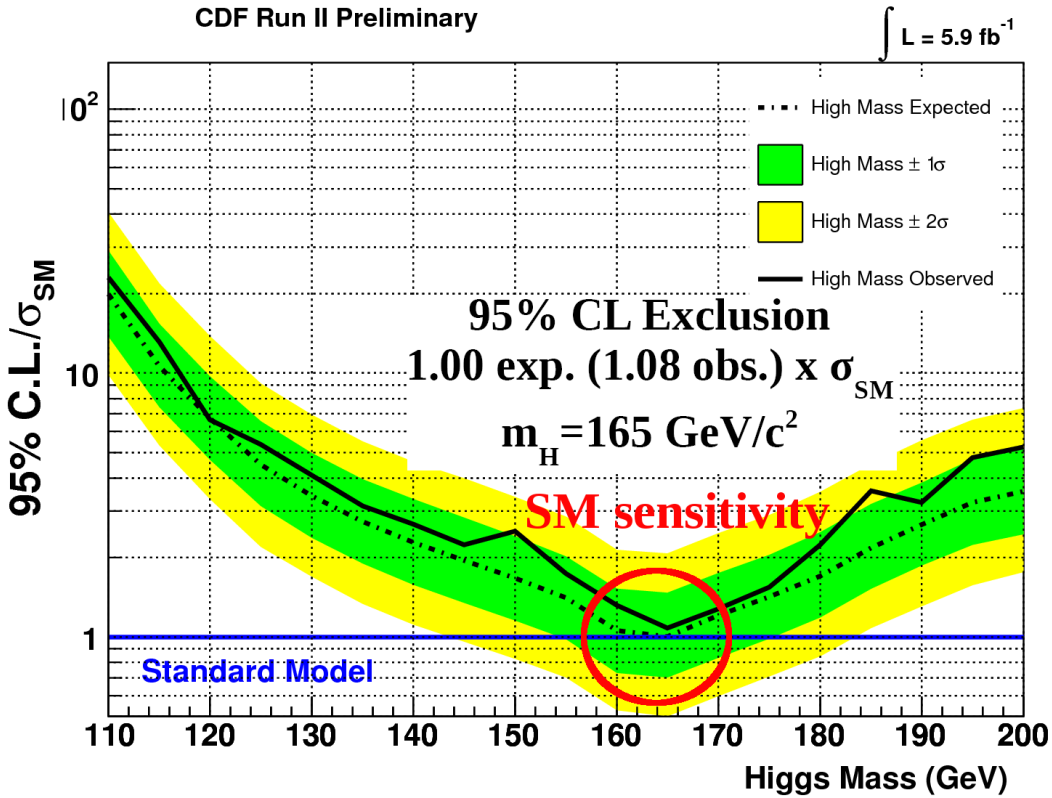
CDF Run II Preliminary			$\int \mathcal{L} = 5.9$ fb^{-1}
$M_H = 165$ GeV/c^2	noZ	inZ 1 jet	inZ 2+ jets
$t\bar{t}$	0.37±0.11	0.067±0.030	0.084±0.022
WZ	5.35±0.76	8.5±1.4	2.30±0.52
ZZ	1.30±0.18	3.97±0.57	1.34±0.26
W+jets	2.92±0.72	5.1±1.3	1.41±0.36
$Z\gamma$	3.13±0.62	4.14±0.85	1.42±0.38
Total Background	13.1±1.5	21.8±2.7	6.5±1.1
WH	0.611±0.084	0.0280±0.0046	0.0085±0.0017
ZH	0.159±0.022	0.203±0.032	0.491±0.072
Total Signal	0.77±0.11	0.231±0.035	0.500±0.73
Data	11	26	16





Latest results on 5.9 fb^{-1}

- Binned likelihood for each H mass and for each channel combined
- Standard Model exclusion sensitivity reached around M_H=165 GeV/c^2



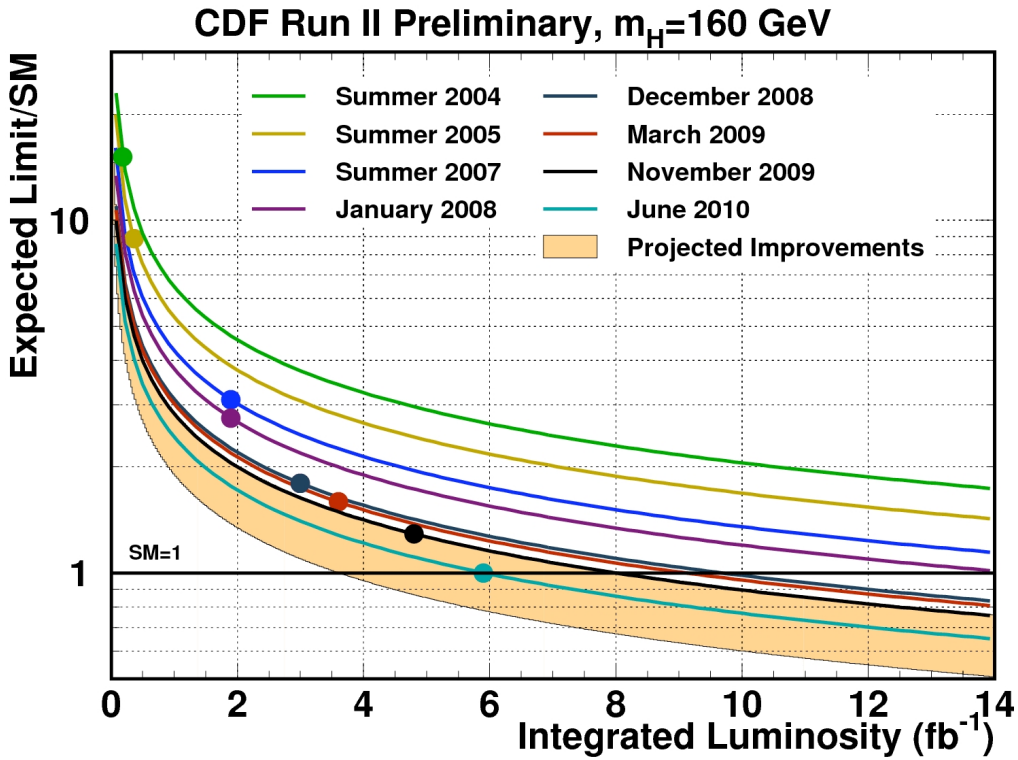
- Exclusion limits for the different channels, M_H=165 GeV/c^2

M_H= 165 GeV/c^2	OS 0 jets	OS 1 jet	OS 2+ jets	SS 1+ jets	Low MII	Tri-lep No Z	Tri-lep Z 1J	Tri-lep Z 2+ J	Hadronic Taus	Combined
Exp. Limit	1.67	2.35	3.16	4.86	11.20	7.37	31.80	9.16	14.50	1.00
Obs. Limit	2.39	2.46	6.14	5.92	7.21	7.85	36.40	10.40	23.50	1.08

Future Perspective

Improvements

- More data: $\sim$10 fb^{-1} by the end of 2011
- H$\rightarrow$ZZ
  - H$\rightarrow$ZZ$\rightarrow \ell\ell\nu\nu$: $\sim$ 1.45 signal events in $\sim$6 fb^{-1} for M_H=190 GeV/c^2
  - $\sim 15 \cdot \sigma_{SM}$ (*naively*) expected limit for M_H=190 GeV/c^2
- H$\rightarrow$WW$\rightarrow \ell\nu$jj: *in progress*
  - Significant BR but large background
- Improvements on lepton ID
  - Lower leptons p_T requirements
  - Loosening lepton isolation cut



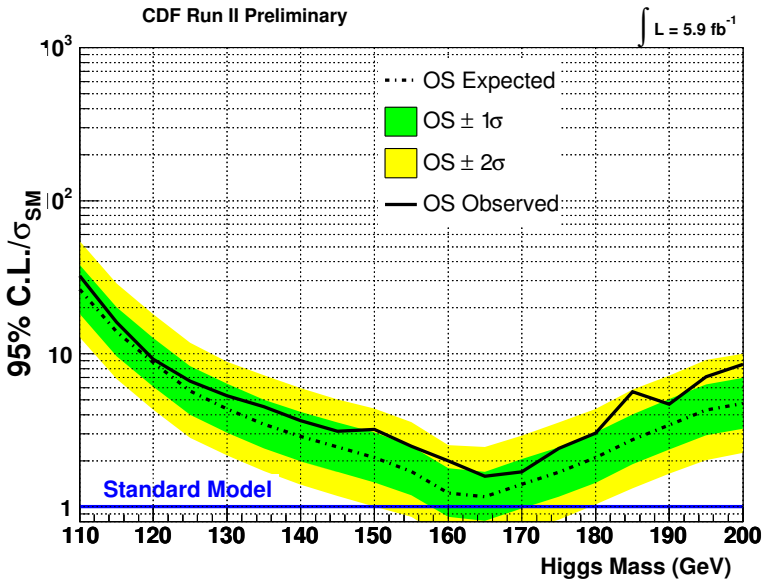
CDF is on the race to the Higgs!

Additional material

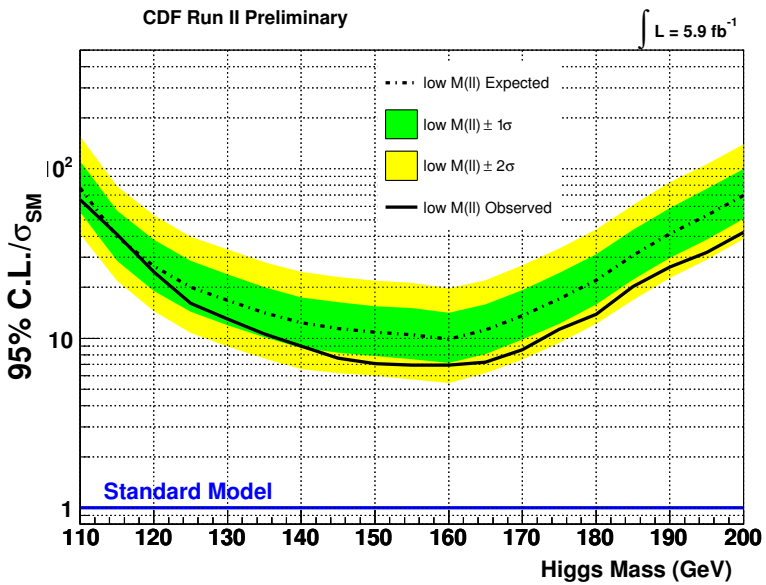
▶For further informations on the analysis see the public web page:

http://www-cdf.fnal.gov/physics/new/hdg//Results_files/results/hwwmenn_100618

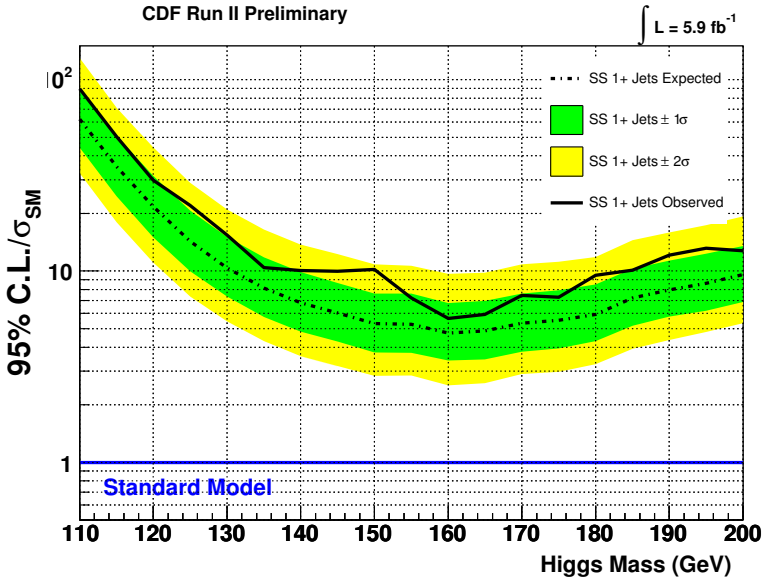
▶ OS combined



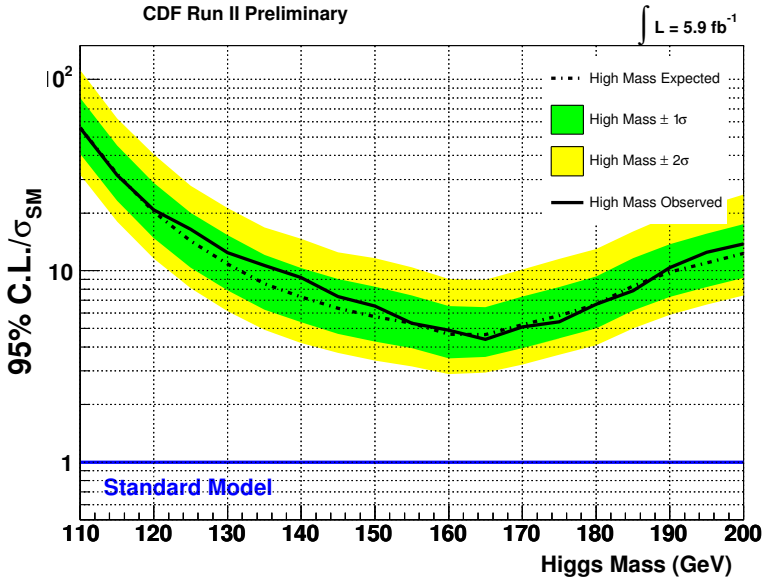
▶ Low $M_{\ell\ell}$



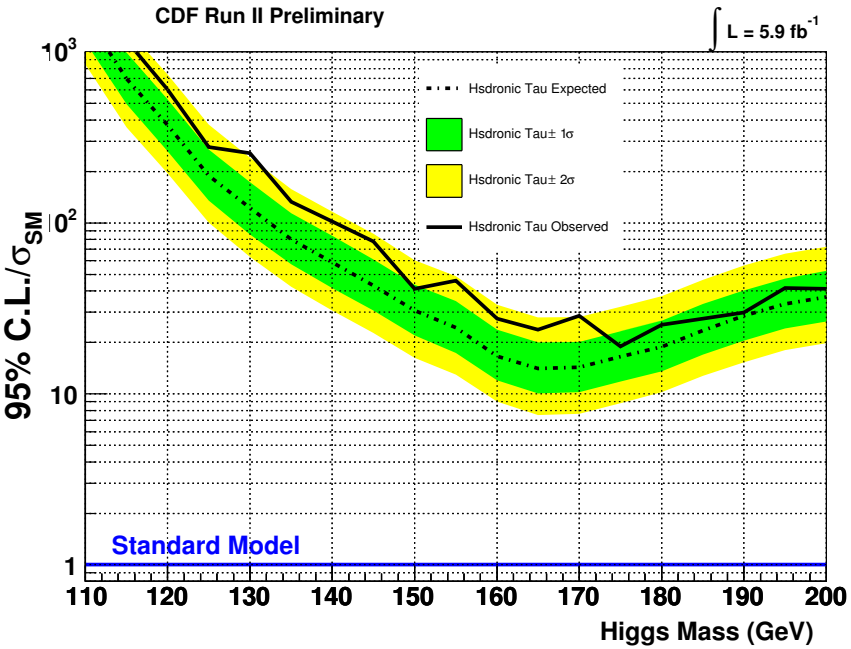
▶ SS



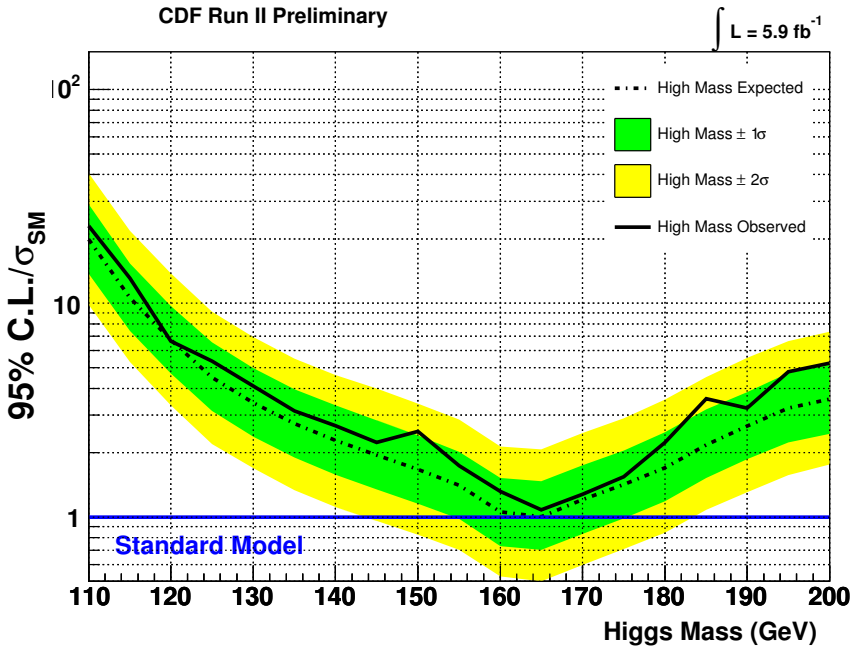
▶ Trilepton



▶ Tau



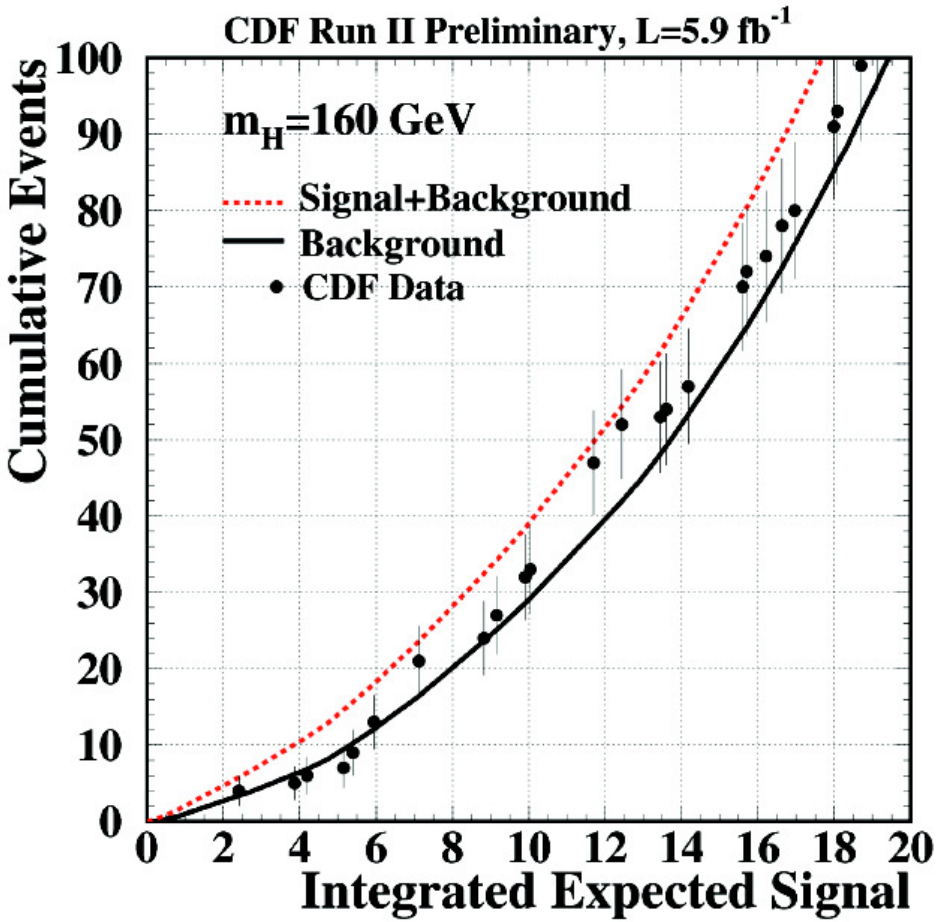
▶ All channels



▶ Combined Limits

High Mass	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	200
$-2\sigma/\sigma_{SM}$	9.85	5.31	3.34	2.19	1.69	1.34	1.12	0.96	0.83	0.70	0.53	0.50	0.60	0.71	0.85	1.08	1.30	1.57	1.76
$-1\sigma/\sigma_{SM}$	13.78	7.41	4.69	3.13	2.38	1.90	1.58	1.35	1.15	0.98	0.73	0.70	0.83	0.99	1.18	1.53	1.86	2.23	2.45
Median/σ_{SM}	**19.90**	**10.59**	**6.74**	**4.50**	**3.42**	**2.74**	**2.28**	**1.95**	**1.67**	**1.40**	**1.05**	**1.00**	**1.20**	**1.42**	**1.70**	**2.17**	**2.67**	**3.23**	**3.57**
$+1\sigma/\sigma_{SM}$	29.02	15.36	9.73	6.57	4.98	3.95	3.33	2.83	2.41	2.02	1.53	1.47	1.75	2.05	2.49	3.20	3.83	4.72	5.16
$+2\sigma/\sigma_{SM}$	40.58	21.79	13.83	9.11	6.95	5.50	4.62	3.99	3.40	2.86	2.14	2.07	2.48	2.90	3.55	4.51	5.55	6.67	7.35
Observed/σ_{SM}	**22.98**	**13.12**	**6.65**	**5.37**	**4.10**	**3.13**	**2.68**	**2.23**	**2.51**	**1.74**	**1.32**	**1.08**	**1.28**	**1.54**	**2.24**	**3.57**	**3.23**	**4.79**	**5.24**

Data statistical fluctuation



- Upward fluctuation of the data is homogeneus in NN Output range

Exclusion sensitivity expectation

- This plot considers 2 × CDF sensitivity (∼CDF+D0)