

Update combined SM Higgs Limit at CDF for Win08 (Blessing)

W.-M. Yao, T. Junk, N. Krumnack, and others

Higgs Discovery Group Meeting , 3/7/2008

- Use the exactly same Bayesian method as last time
- Updated the combination up to 2.4 fb^{-1} results since ASPEN 08:
 - $WH \rightarrow l\nu b\bar{b}$: 1.9 fb^{-1} (CDF 9136, T. Masubuchi et al): added phex
 - $ZH \rightarrow \nu\nu b\bar{b}$: 1.7 fb^{-1} (CDF 8678, B. Parks et al)
 - $ZH \rightarrow l^+l^-b\bar{b}$: 1 fb^{-1} (CDF 8422, J. Efron et al)
 - $gg \rightarrow H \rightarrow W^+W^- \rightarrow l^+l^-\nu\nu$ in 2.4 fb^{-1} (CDF 9195, Dean Hidas et al): NN+ME
 - $VH \rightarrow \tau^+\tau^- + 2jet$: 2.0 fb^{-1} (CDF 9179, K. Yorita and Y.-K. Kim): new
- Documentations:
 - CDFNote 8816, P. Fernandez et al. (Will update soon)
 - CDFNote 8784, Tom Junk

Standard Model Higgs Production and Decay

Mass (GeV/c ²)	σ_{WH} (fb)	σ_{ZH} (fb)	σ_{WW} (fb)	$B(H \rightarrow b\bar{b})$ (%)	$B(H \rightarrow W^+W^-)$ (%)
110	207.70	123.33	1281	77.02	4.41
115	178.08	106.70	1099	73.22	7.97
120	152.89	92.70	1006	67.89	13.20
130	114.51	70.38	801	52.71	28.69
140	86.00	54.20	646	34.36	48.33
150	66.14	41.98	525	17.57	68.17
160	51.03	32.89	431	4.00	90.11
170	38.89	26.12	357	0.846	96.53
180	31.12	20.64	297	0.541	93.45
190	24.27	16.64	249	0.342	77.61
200	19.34	13.46	211	0.260	73.47

- What we measure: the ratio of 95% upper limit on Xsec times branching ratio to SM.
- Assume the same for different channels. 10% is assigned to $g \rightarrow H \rightarrow W^+W^-$ and VBF cross sections.

Systematic Uncertainties

Channels	$l\nu b\bar{b}$			$\nu\bar{\nu} b\bar{b}$		$l^+l^- b\bar{b}$		W^+W^-		$\tau^+\tau^-$
	STST	STJP	STNN	STST	STJP	ST	DT	HS/B	LS/B	
Acceptance										
Lumi (%)	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
btag (%)	8.4	8.9	5.0	8.6	9.2	5.3	16	0.0	0.0	0.
Lepton (%)	2.0	2.0	2.0	2.0	2.0	1.	1.	1.5	1.5	5.0
JES (%)	3.0	3.0	3.0	S	S	3.0	3.0	0.0	0.0	5.0
MC (%)	5.6	4.9	5.0	4.0	4.0	3.0	3.0	2.2	2.2	4.0
Trigger (%)	0.0	0.0	0.	S	S	0.0	0.0	0.0	0.0	0.0
Backgrounds										
Mistag (%)	9	8	9	20	29	13	24	0.0	0.0	-6.7
QCD (%)	18	18	18	-50	-50	-50	-50	-29	-23	-15
V+HF (%)	45	45	42	40	40	40+S	40+S	0	0	-20
Top (%)	15	15	15	16	18	20	20	15	15	13
Diboson (%)	10	10	10	20	20	20	20	10	10	10

- The WW systematics are divided into various sources(met, conversion, NNLO, xsec, PDF, lepton ID, and triggers) , which are treated corrected with other channels.
- The positive value means correlated, the negative value means uncorrelated, but corrected in the same dataset.
- Shape systematic uncertainties (S) included

Technique for Limit Combination

- Bayesian framework
 - Use Bayesian posterior probability
 - Assume flat prior density for the number of Higgs events

- Combined Binned Poisson Likelihood:

$$\mathcal{L}(R, \vec{s}, \vec{b}|\vec{n}) = \prod_{i=1}^{N_C} \prod_{j=1}^{Nbins} \mu_{ij}^{n_{ij}} e^{-\mu_{ij}} / n_{ij}!$$

- Combined Posterior Density Function:

$$p(R|\vec{n}) = \int d\vec{s} \int d\vec{b} \mathcal{L}(R, \vec{s}, \vec{b}|\vec{n}) \times s_{tot} / \int dR \int d\vec{s} \int d\vec{b} \mathcal{L}(R, \vec{s}, \vec{b}|\vec{n}) \times s_{tot}$$

- 95% Credibility Upper Limit R_{95} :

$$\int_0^{R_{95}} p(R|\vec{n}) dR = 0.95.$$

Obs. Limits(Expected) for Individual Channels

- Producing Limits for $WH \rightarrow l\nu b\bar{b}$ (1.9 fb^{-1})

mh	110	115	120	130	140	150	160	180
Observed (WM)	6.8	8.0	9.8	15.6	37.9	85.1		
Expected (WM)	6.5	7.6	8.8	12.8	24.0	57.5		
Observed (Blessed)	6.8	8.2	9.8	15.8	37.8	85.2		
Expected (Blessed)	6.5	7.3	8.9	12.6	23.4	57.6		

- Producing Limits for $VH \rightarrow \nu\nu b\bar{b}$ (1.7 fb^{-1})

mh	110	115	120	130	140	150	160	180
Observed (WM)	9.4	7.7	9.8	13.2	20.7	46.6		
Expected (WM)	7.7	9.1	10.3	15.6	25.8	65.2		
Observed (Blessed)	9.6	8.0	9.5	12.8	20.0	44.3		
Expected (Blessed)	7.4	8.3	9.9	15.3	25.1	63.3		

- Some small differences are due to statistics and scan steps, but overall in good agreement.

Obs. Limits(Expected) for Individual Channels

- Producing Limits for $WW \rightarrow \nu\nu b\bar{b}$ (2.4 fb^{-1})

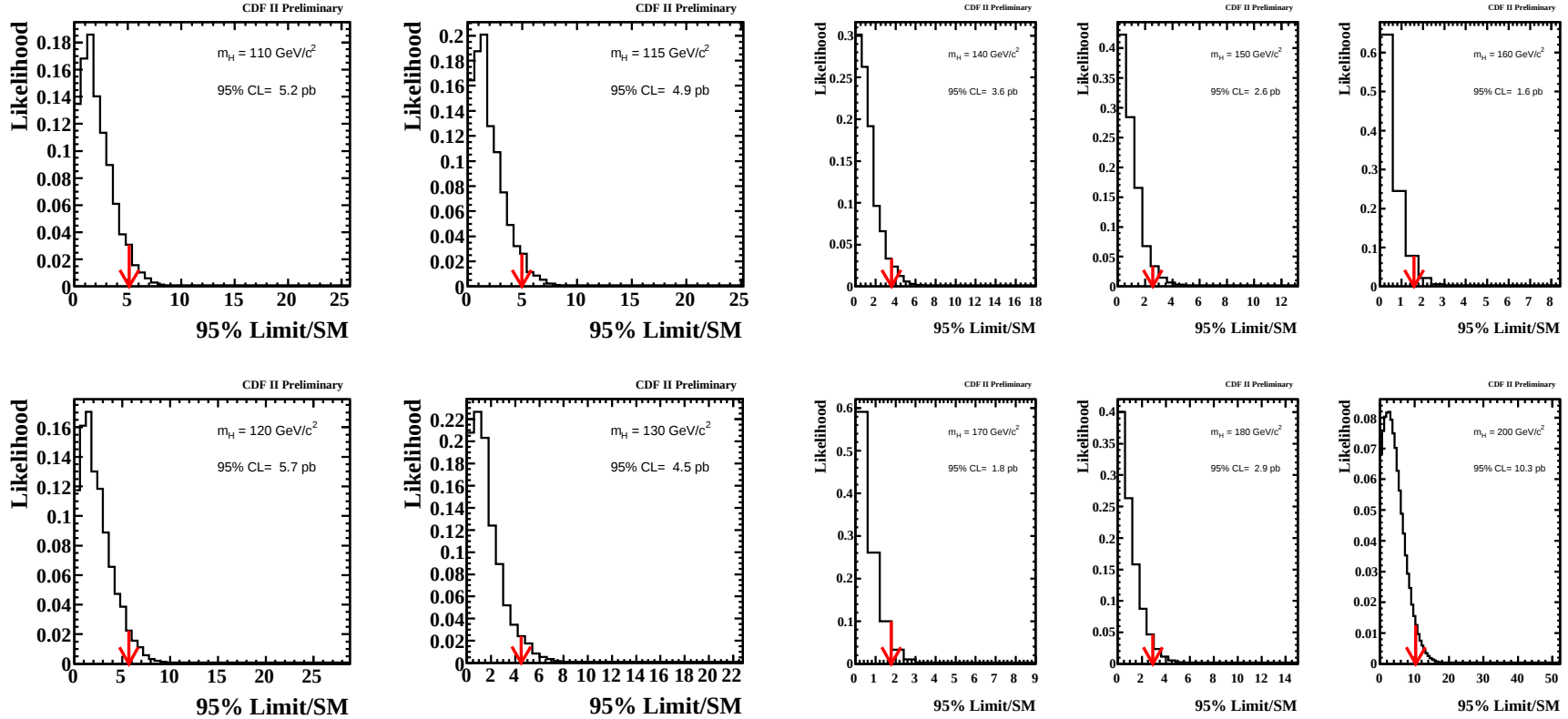
mh	110	120	130	140	150	160	180	200
Observed (WM)	56.9	17.1	5.57	3.34	2.56	1.57	2.90	10.4
Expected (WM)	59.8	19.5	9.5	5.82	4.32	2.46	4.03	8.2
Observed (Tom)	53.2	15.8	5.1	3.14	2.38	1.51	2.85	10.1
Expected (Tom)	60.4	19.7	9.2	6.01	4.27	2.53	3.85	8.10
Observed (Blessed)	54.3	15.8	5.40	3.23	2.44	1.56	2.81	10.0
Expected (Blessed)	58.9	18.8	9.1	5.75	4.14	2.44	3.79	8.1

- Producing Limits for $VH \rightarrow \tau^+\tau^- + 2jet$ (2.0 fb^{-1})

mh	110	115	120	130	140	150	160	180
Observed (WM)	31.8	30.5	34.6	38.0	63.5	152.8		
Expected (WM)	25.3	23.7	23.7	31.4	49.3	104.2		
Observed (Tom)	30.1	30.9	29.6	37.2	62.4	146.9		
Expected (Tom)	25.8	24.8	24.2	32.3	52.8	111.7		
Observed (Blessed)	32.5	30.5	30.0	39.5	67.5	159.0		
Expected (Blessed)	25.8	24.8	24.2	32.3	52.8	111.7		

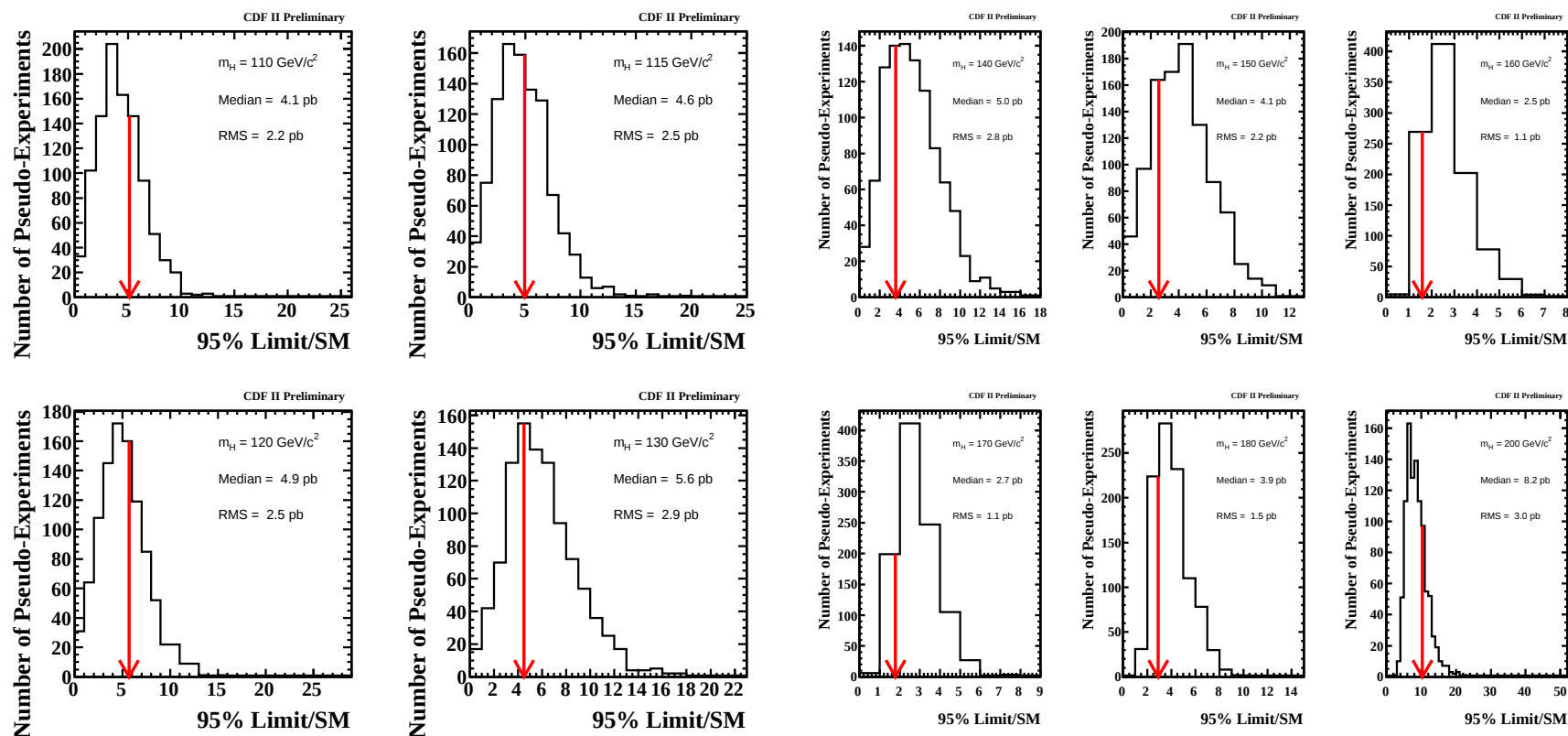
- Some small differences are due to statistics and scan steps, but overall in good agreement.

Likelihood of Combined Fit with $1\text{-}2.4\text{ fb}^{-1}$



- Likelihood vs R as M_H (red line: 95% upper limit).

Pseudo-experiments with $1\text{-}2.4\text{ fb}^{-1}$



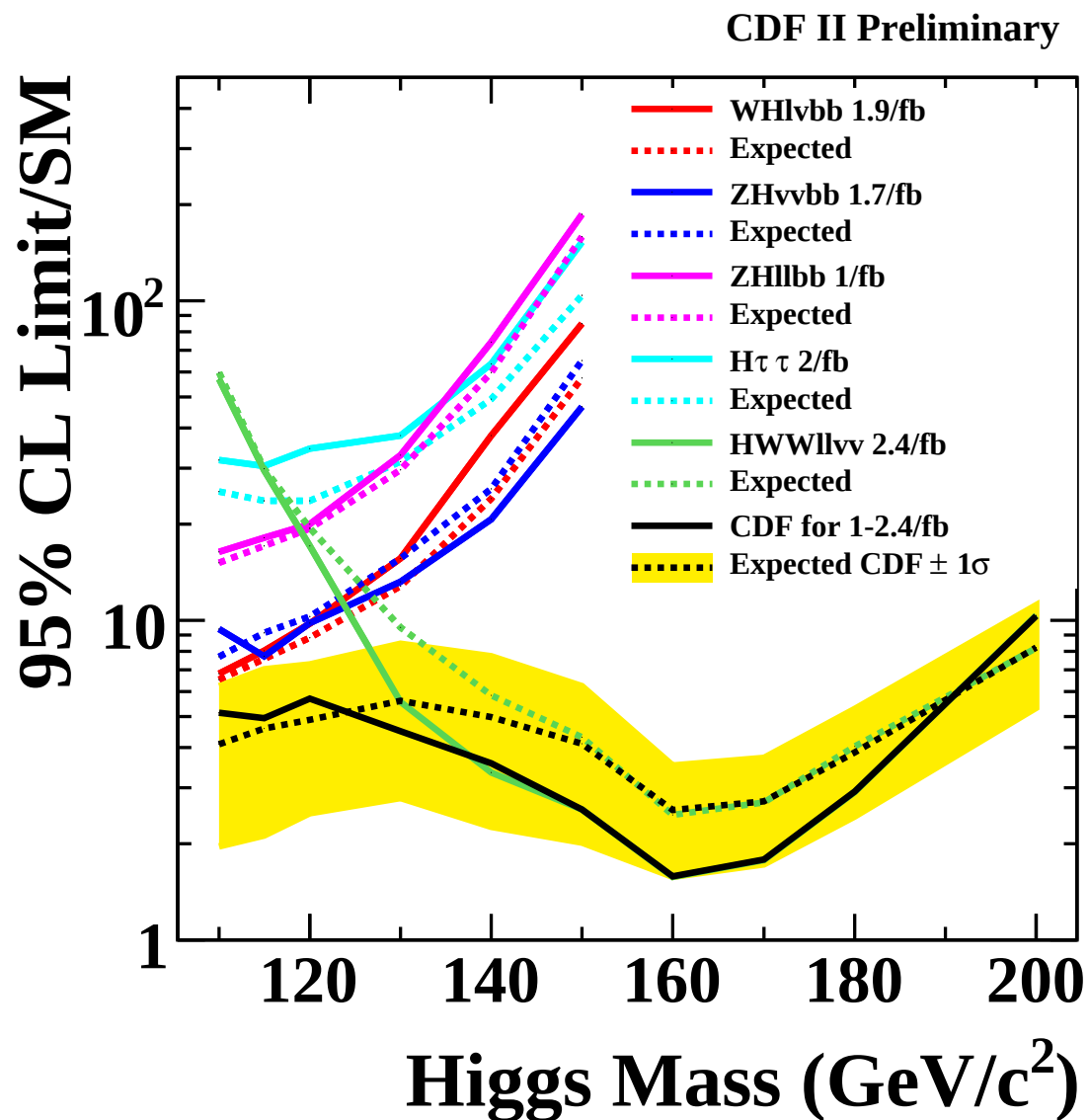
- The observed upper limit shown as in arrow in red, consistent with expectation.

CDF Combined Limit with 1-2.4 fb⁻¹

Mass (GeV/c ²)	New Combined		New Expected		ASPEN 08	
	WY	Tom	WY	Tom	Combined	Expected
110	5.15	5.62	4.09	4.24	5.8	4.3
115	4.95	5.00	4.50	4.39	5.8	4.8
120	5.70	6.08	4.88	5.13	5.8	5.4
130	4.50	4.72	5.61	5.80	5.2	6.5
140	3.58	2.97	4.99	5.23	4.8	6.3
150	2.56	2.33	4.13	4.18	3.2	5.1
160	1.58	1.48	2.55	2.50	1.8	3.2
170	1.79	1.66	2.72	2.61	2.2	3.3
180	2.91	2.63	3.86	3.76	3.2	4.7
200	10.34	9.15	8.24	7.97	12.8	10.4

- The limit is now approaching 5 at mh=115 GeV and 1.59 at mh=160 GeV

CDF Combined Limit with 1-2.4/fb



Conclusion

- We obtain a combined Higgs limit from CDF with a data sample of 1-2.4 fb⁻¹ using Bayesian method.
 - $WH \rightarrow l\nu b\bar{b}$ (1.9 fb⁻¹)
 - $ZH \rightarrow \nu\bar{\nu} b\bar{b}$ (1.7 fb⁻¹)
 - $ZH \rightarrow l^+l^- b\bar{b}$ (1.0 fb⁻¹)
 - $gg \rightarrow H \rightarrow WW \rightarrow l^+l^- \nu\bar{\nu}$ analysis (2.4 fb⁻¹)
 - $VH \rightarrow \tau^+\tau^- + 2jet$ analysis (2.0 fb⁻¹)
- Observed limits are mostly consistent with the expectation of Pseudo-experiments.
- The 95% CL upper observed (expected) limits are a factor of 5.0(4.5) and 1.58(2.55) away from the Standard Model cross section for Higgs mass at 115 and 160 GeV/c²
- We have improved the limit by 40% (20%) at low (high) masses over the luminosity gain since last summer (LP07).