Search for Higgs Boson in $H \rightarrow WW \rightarrow l\nu jj$

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「フレーバー物理の新展開」研究会

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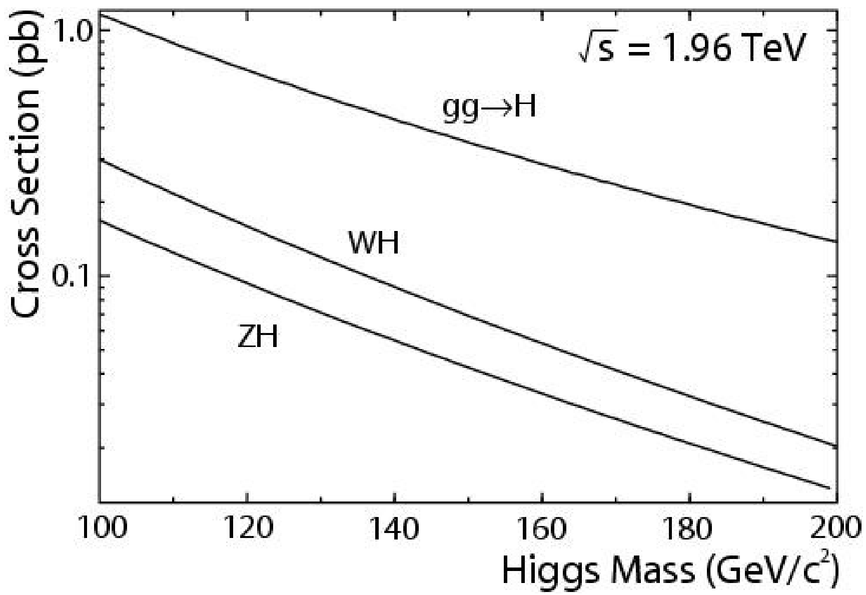
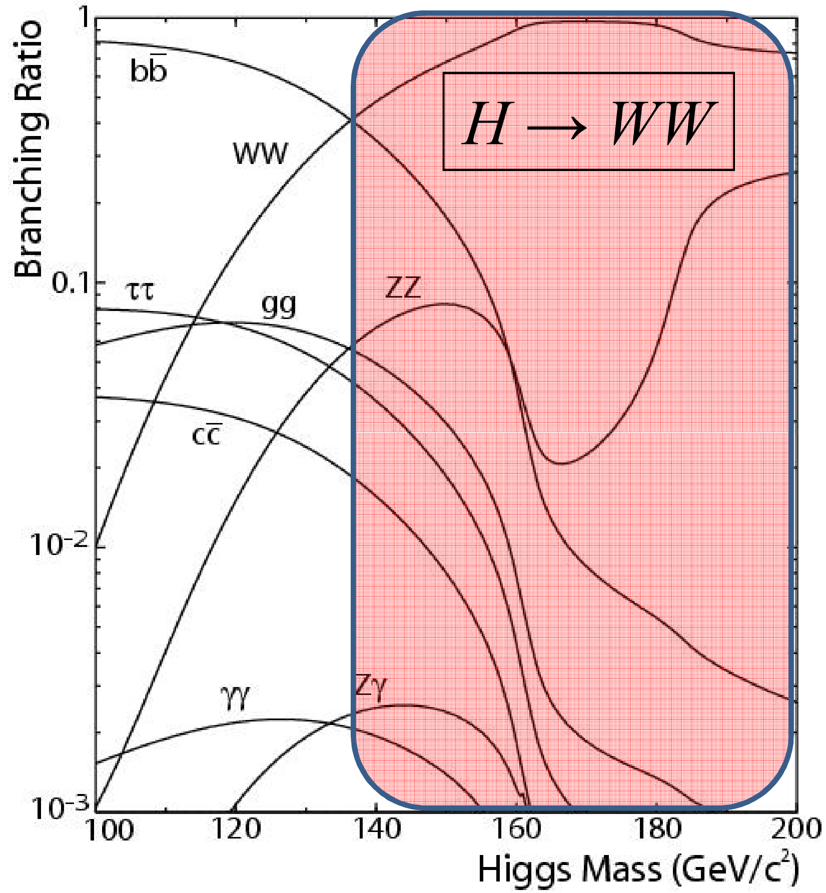
Higgs Boson Production Cross section and Branching Ratio



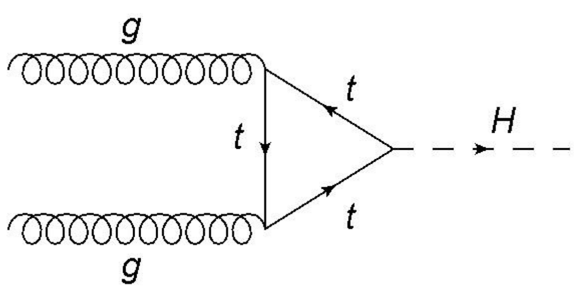


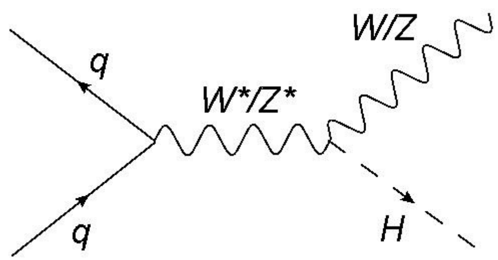
Main production modes of standard model Higgs are gg → *H*, *WH* and *ZH*.

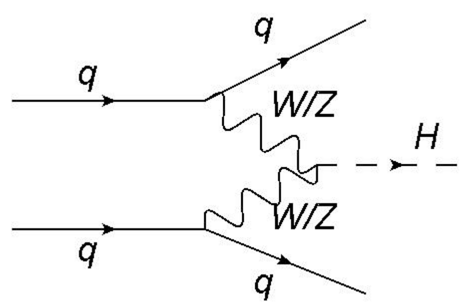
SM Higgs decays mainly into *WW* for M_H > 135 GeV.

High Mass Search

- $gg \rightarrow H \rightarrow WW \rightarrow l\nu l\nu$
  - ✓ Dominant search mode
  - ✓ Analysis considers WH, ZH, VBF modes.
  - ✓ Backgrounds
    dibosons (WW, WZ, ZZ) , Z/γ^*, $t\bar{t}$, $W\gamma$, W+jets
- $gg \rightarrow H \rightarrow WW \rightarrow l\nu jj$
  - ✓ Addition of this mode will enhance CDF sensitivity
  - ✓ Backgrounds
    W+jets , dibosons, single top, $t\bar{t}$, non-W





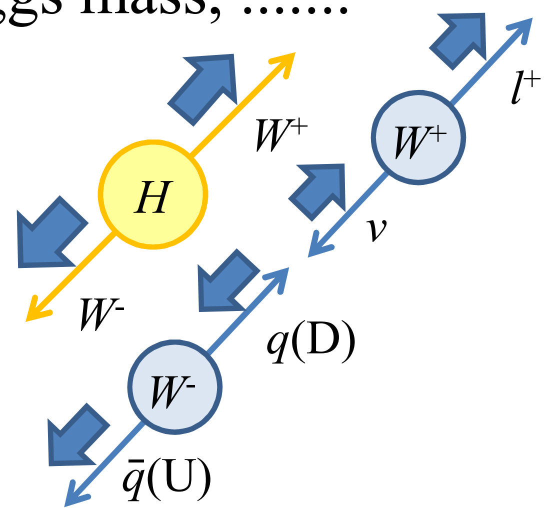


Motivation and Analysis Idia

$H \rightarrow WW \rightarrow l\nu jj$

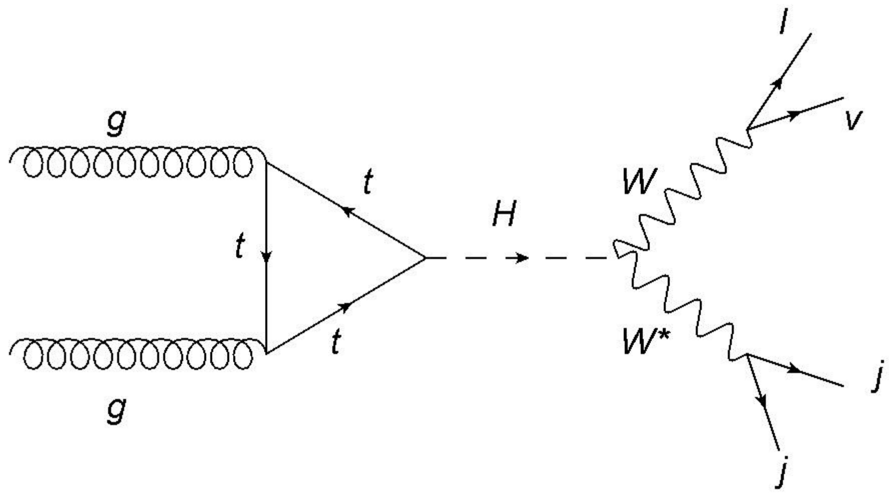
- $WW \rightarrow l\nu jj$ has a branching ratio 6 times larger than $WW \rightarrow l\nu l\nu$, though it will have a huge QCD $W + 2j$ background.
- We can take advantage of the decay kinematics of the Higgs (spin=0), by tagging charm jets.
- Finally compose Likelihood discriminant for S/B separation.
  - Angular distribution between lepton and down type jet.
  - Dijet mass, reconstructed higgs mass, ...

W Decay Mode
$l\nu \sim 10$ %
$cs, ud \sim 30$ %



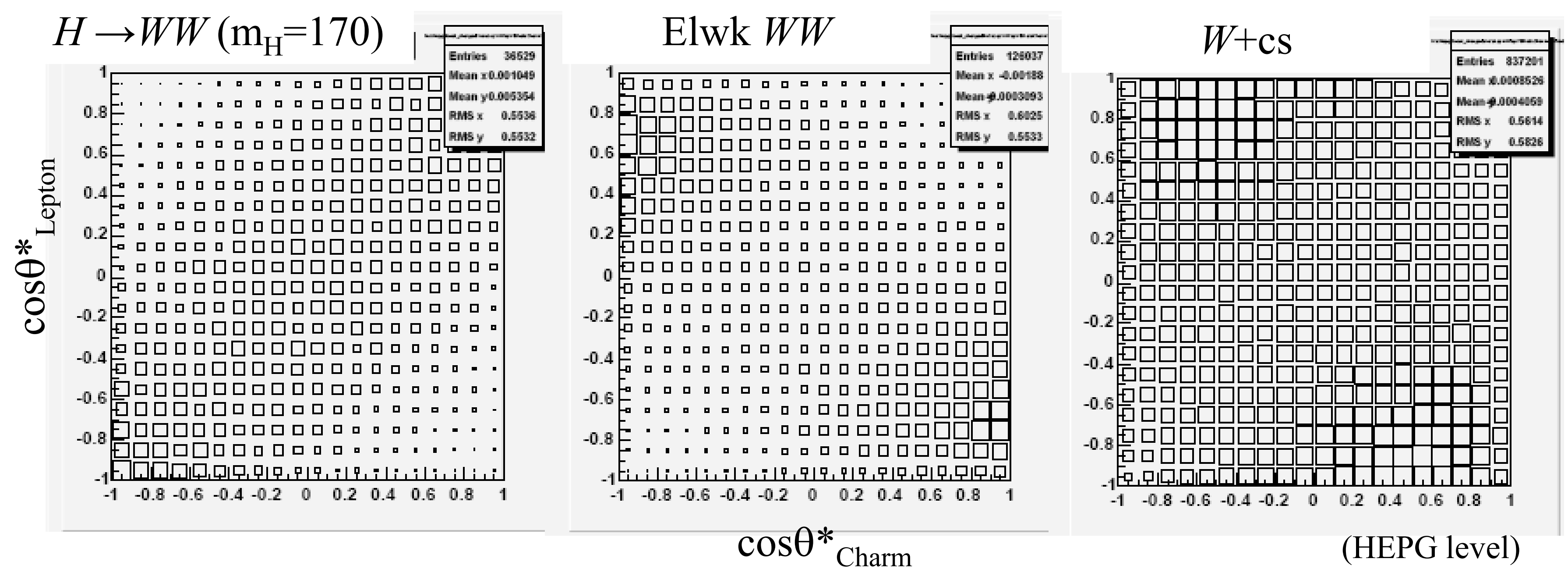
Base Cuts

- Signal topology: $H \rightarrow WW \rightarrow l\nu jj$
- Standard set of cuts for l + MET + exact 2 jets
  - One Lepton (CEM/CMUP/CMX)
    - $E_T > 20$ GeV, $|\eta| < 1.1$
  - MET > 20 GeV
  - Exact 2 jets
    - $E_T > 20$ GeV, $|\eta| < 2.0$



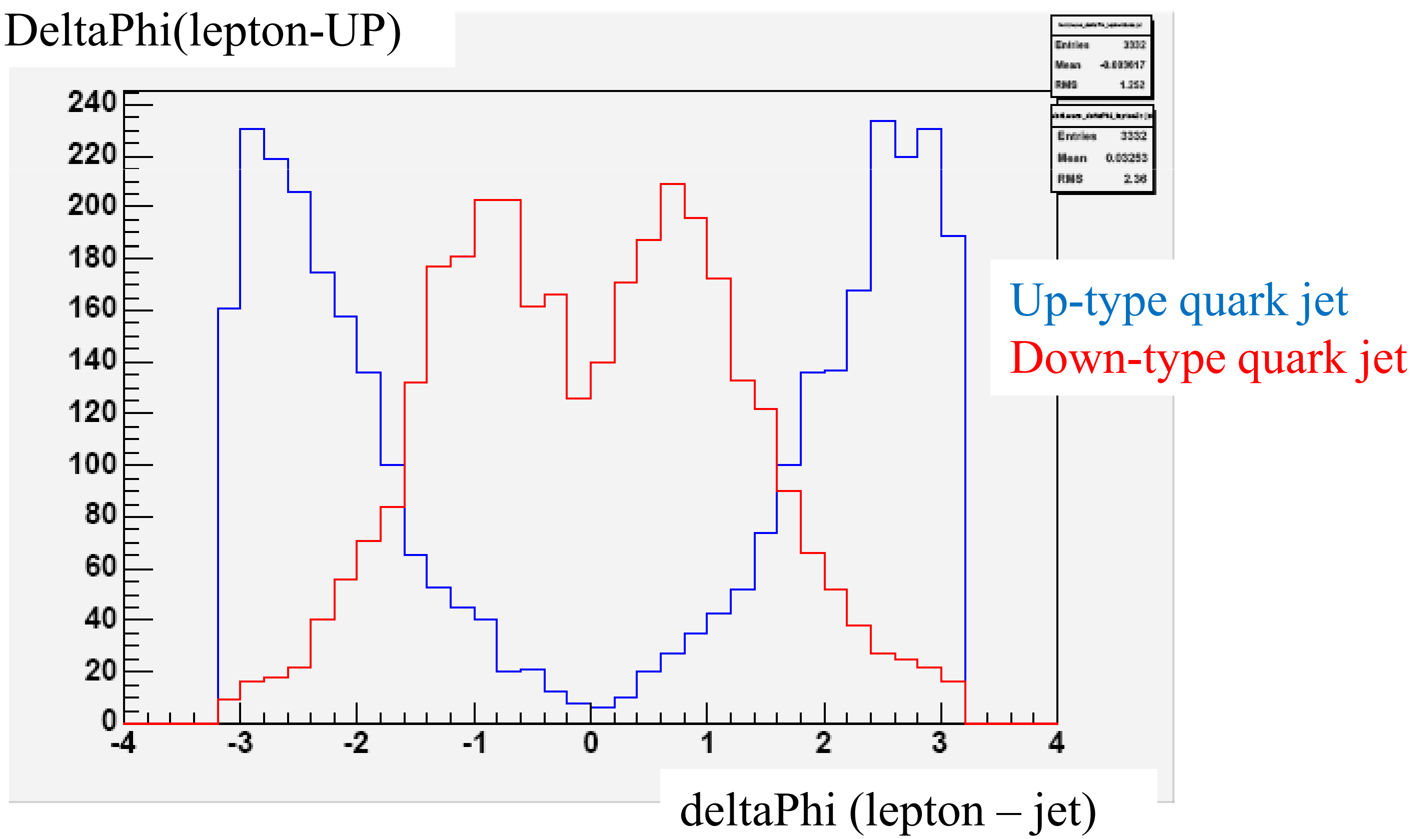
Why tag charm?

- We of course use NoTag sample for search as well.
- Half of signal is $H \rightarrow WW \rightarrow l\nu cs$:
  - Tag charm jets with JetProb<0.05 to obtain pure search sample, finally combine tagged and no-tag samples.
  - C-tagging will enable use of unique kinematics of Higgs decay, because Higgs has a spin=0.



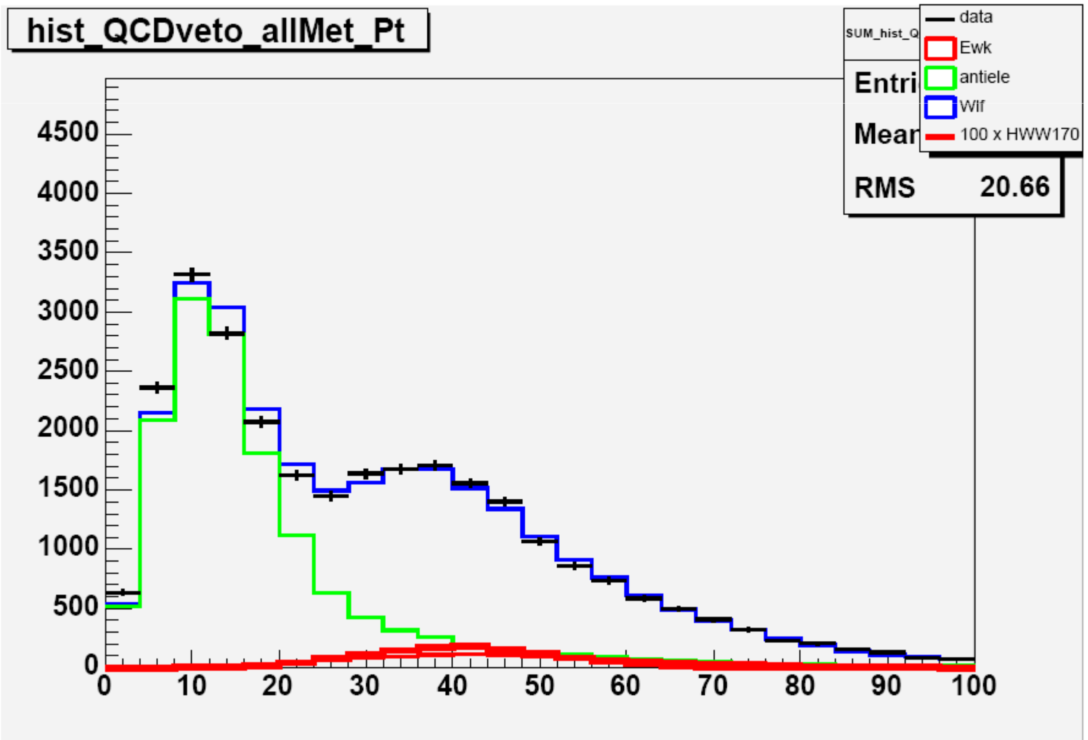
Up/Down-type distinction

- For events that are not tagged, we assume the jet that has smaller |DeltaPhi(lepton,jet)| as down-type for no-tag events.



Background Estimation

- We follow Method II prescription.
- Instead of recent QCD veto, we adopt an angular cuts:
  - Deltaϕ(MET,Jet1) > 1.9-MET/20
  - Deltaϕ(MET,Jet2) > 1.8-MET/25
- Fit MET distribution to obtain non-W normalization.



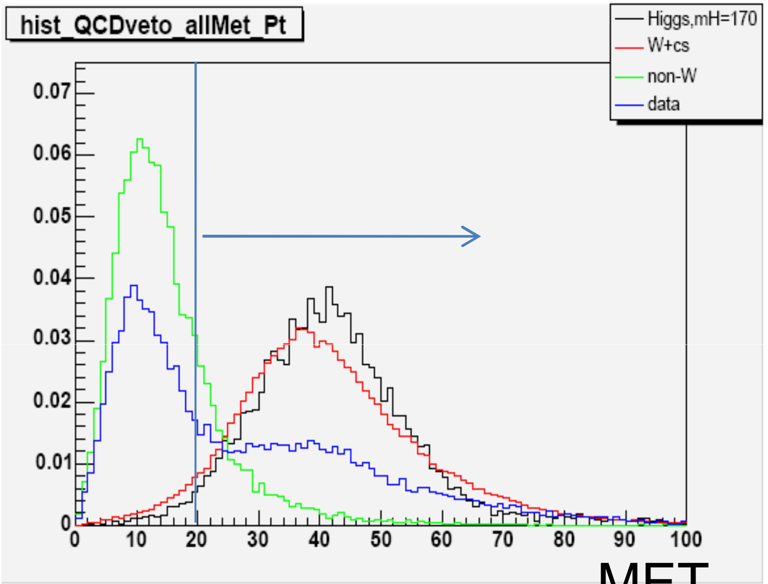
before MET and Mt cuts: 1.1 fb^{-1}

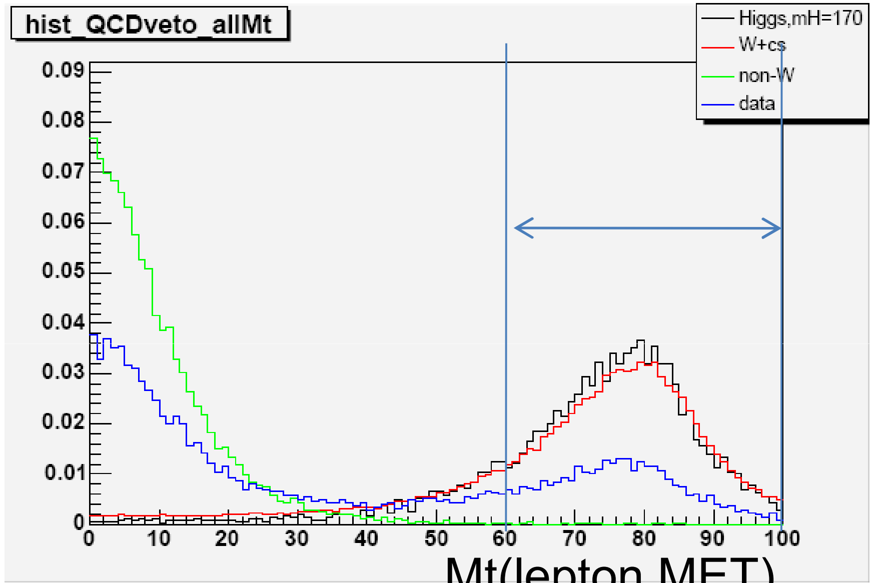
non-W	12938.38	±	170.37
W+jets	13419.55	±	162.50
ttbar	165.78	±	1.41
sing-t(s)	132.71	±	5.38
sing-t(t)	239.40	±	6.90
WW	614.68	±	8.85
WZ	104.16	±	1.12
ZZ	4.69	±	0.17
data	27620.00		

Search Sample

- After angular cuts, we require:
  - MET>20
  - 60<Mt(lepton,MET)<100

Efficiency:
$H \rightarrow WW(170)$: 79.3 %
Bkgd: 36.2 %





NoTag channel background:

non-W	57.51	±	0.76
W+jets	8385.32	±	101.54
ttbar	38.41	±	0.32
sing-t(s)	42.20	±	1.71
sing-t(t)	80.19	±	2.31
WW	360.02	±	5.18
WZ	51.80	±	0.56
ZZ	1.02	±	0.03

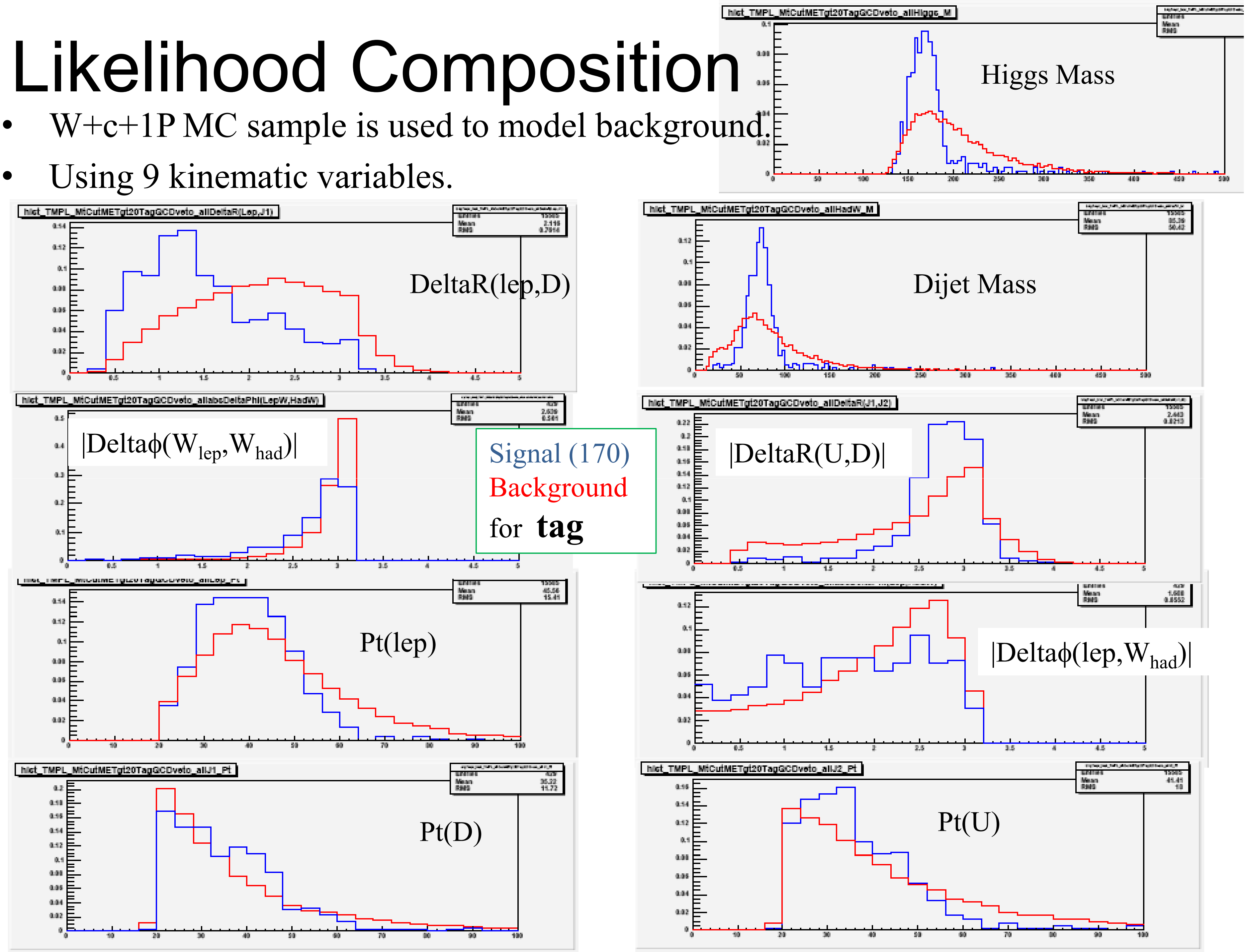
Tag channel background:

non-W	2.40	±	0.00
mistag	100.18	±	1.43
Wbb	79.15	±	0.96
Wcc	58.85	±	0.84
Wc	232.13	±	3.32
ttbar	34.66	±	0.29
sing-t(s)	37.87	±	1.53
sing-t(t)	77.80	±	2.24
WW	48.04	±	0.69
WZ	9.96	±	0.10
ZZ	0.18	±	0.01

1.1 fb^{-1}

Likelihood Composition

- W+c+1P MC sample is used to model background.
- Using 9 kinematic variables.



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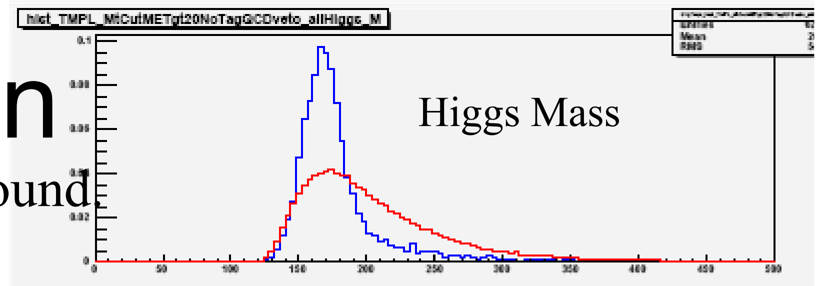
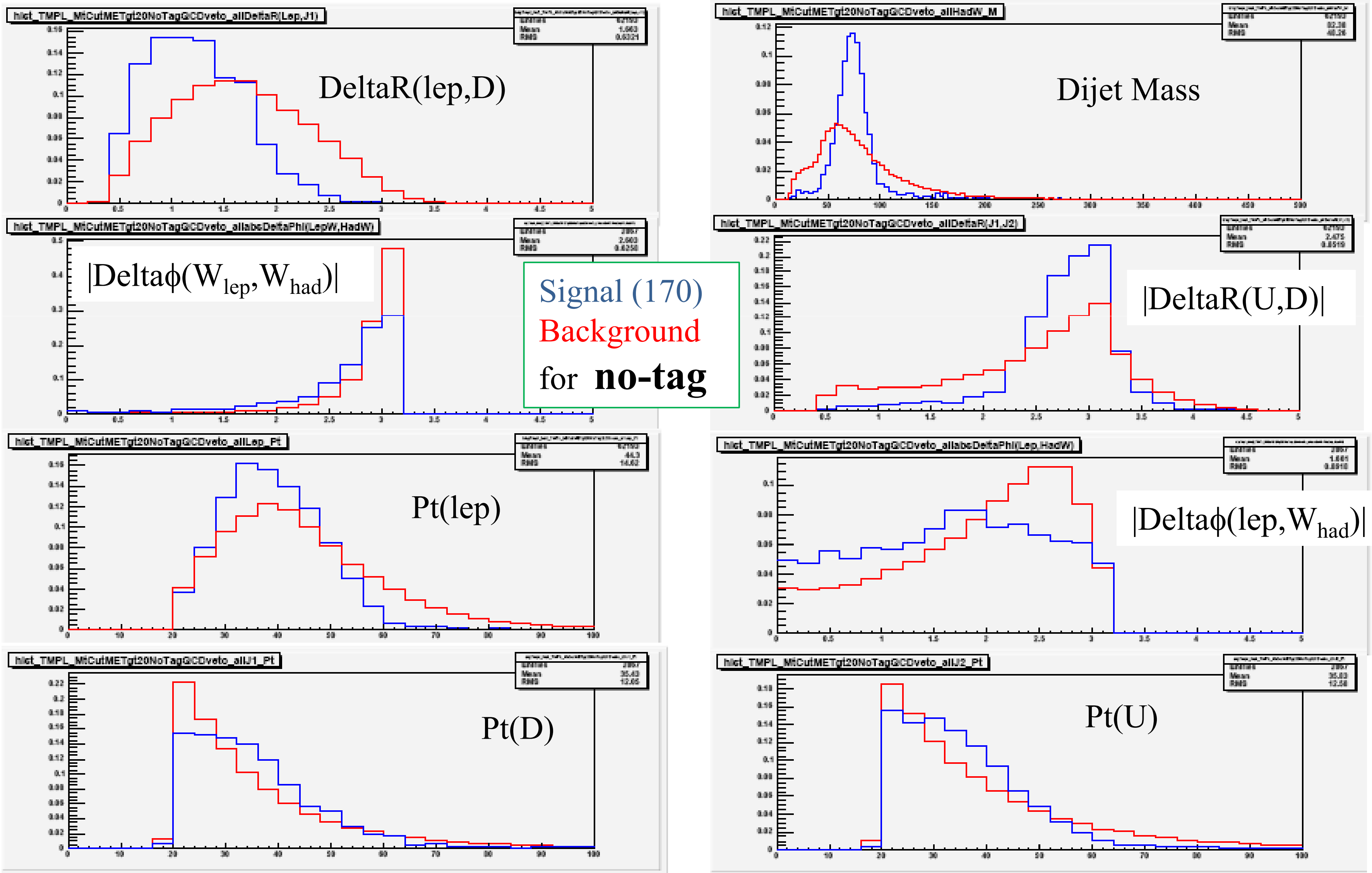
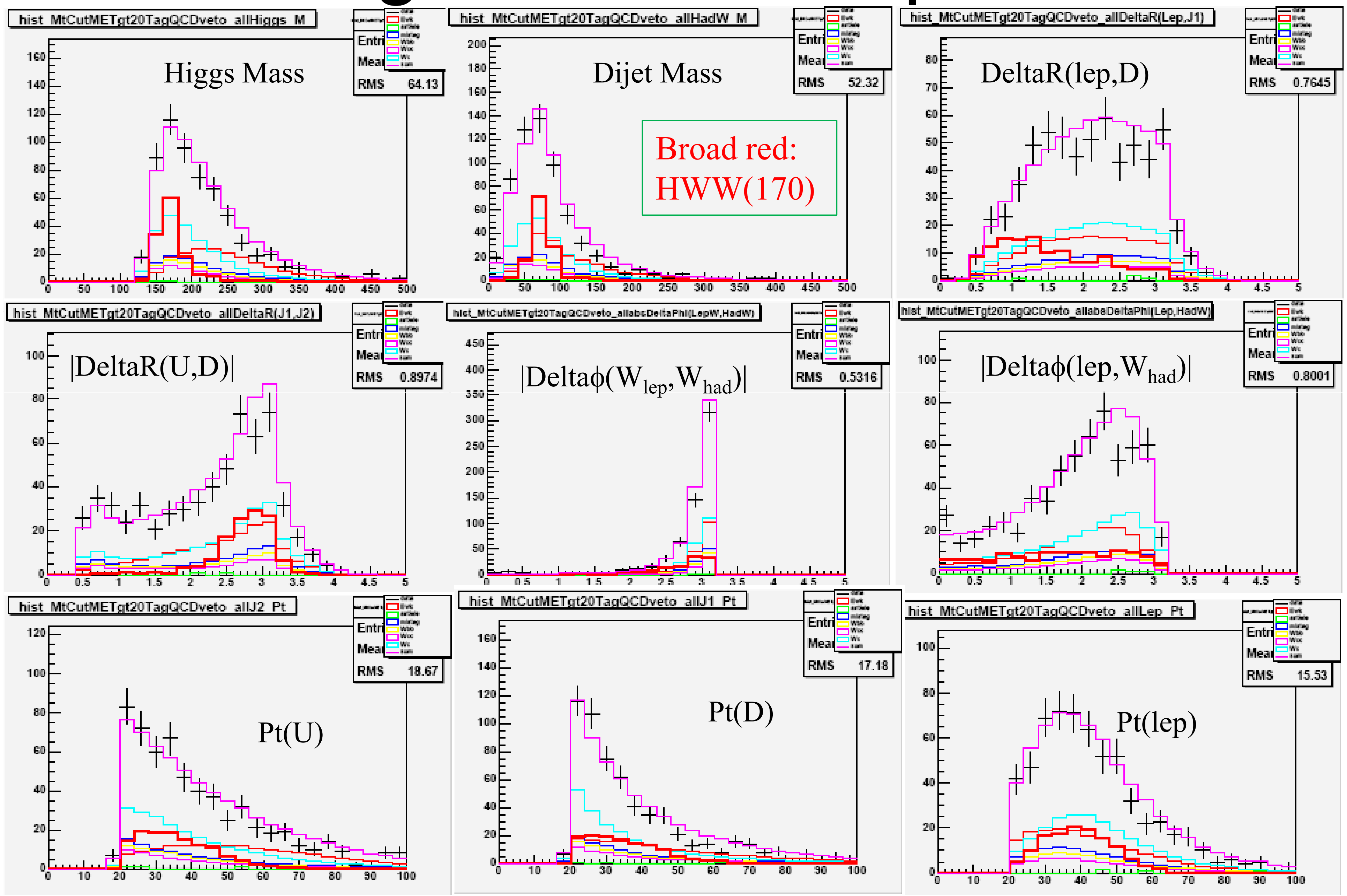
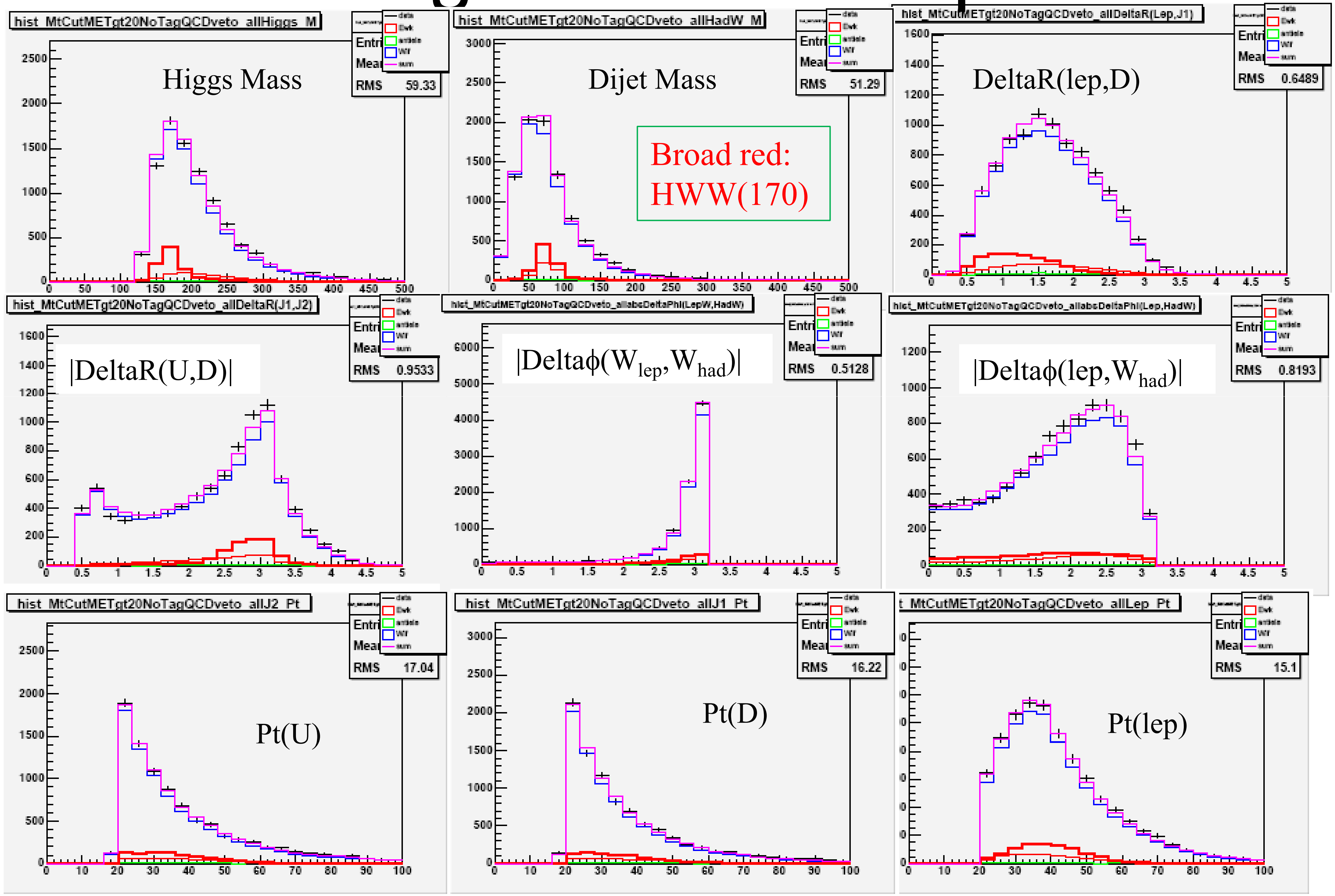




Tag Likelihood Inputs

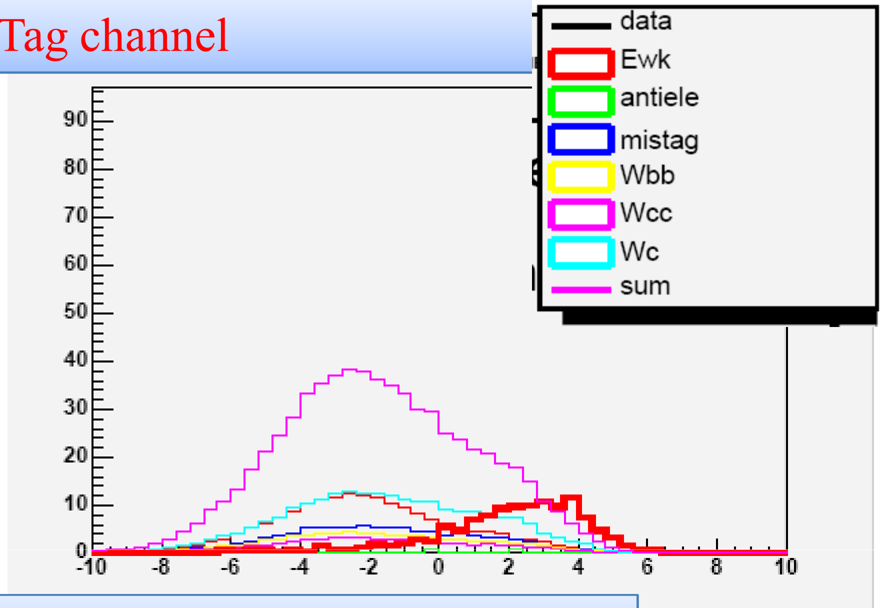


No-tag Likelihood Inputs



Likelihood Discriminant

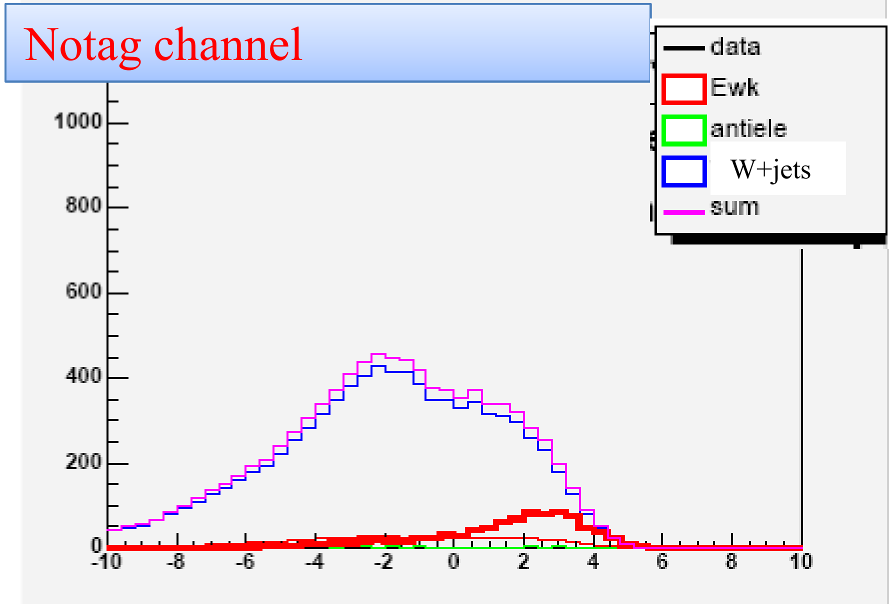
Tag channel



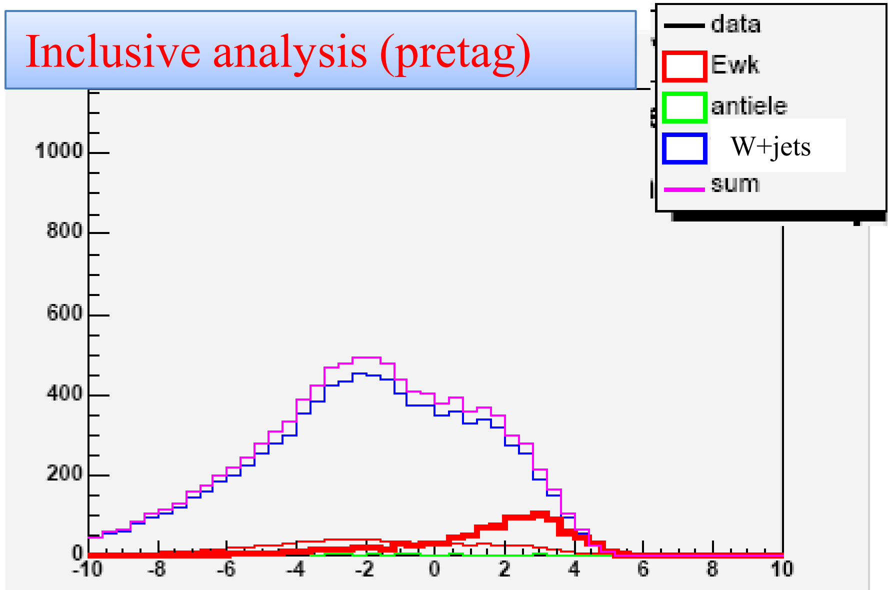
Higgs mass 170 GeV.
Analyzed data correspond to 1.1 fb^{-1}.

We performed the sensitivity study with histograms scaled to 3.4 fb^{-1}.

Notag channel



Inclusive analysis (pretag)



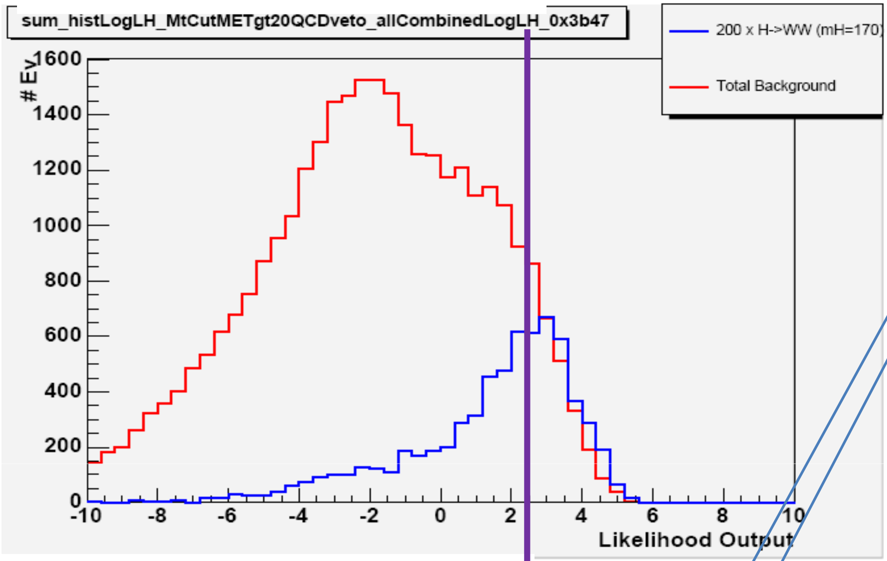
Sensitivity Estimation

- For now, no Pseudo-Exp, simply Poisson stat.
- Given S and B estimated number of signal and bkgd events, the likelihood for higgs production cross section s is:
  - $L(s,S,B) = P(S+B, AL\sigma+B) / N$
    - $P(n,m)$: Poisson dist. with center value m.
    - $N = \int_0^{\sigma_{max}} P(S + B, AL\sigma) d\sigma$
    - A = acceptance to signal.
    - L = luminosity.
- Combining 2 channels is performed by defining the likelihood as product of two Poisson functions.

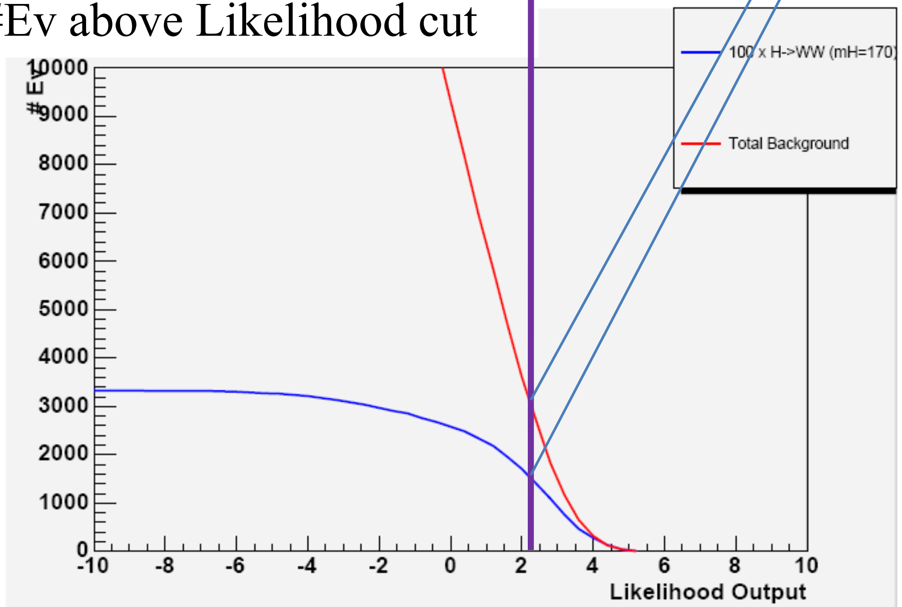
Estimation of Expected Limit

m_H = 170 GeV, inclusive analysis:

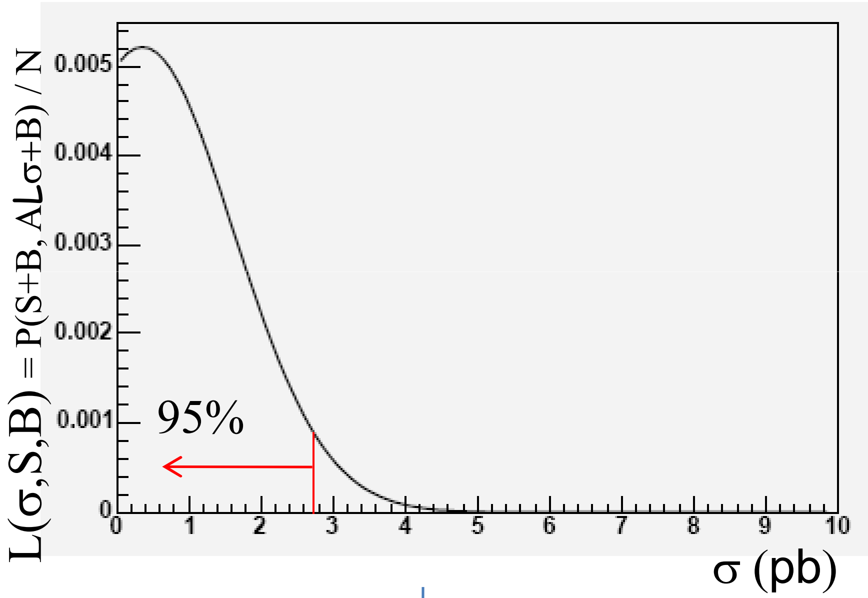
Likelihood discriminant



#Ev above Likelihood cut

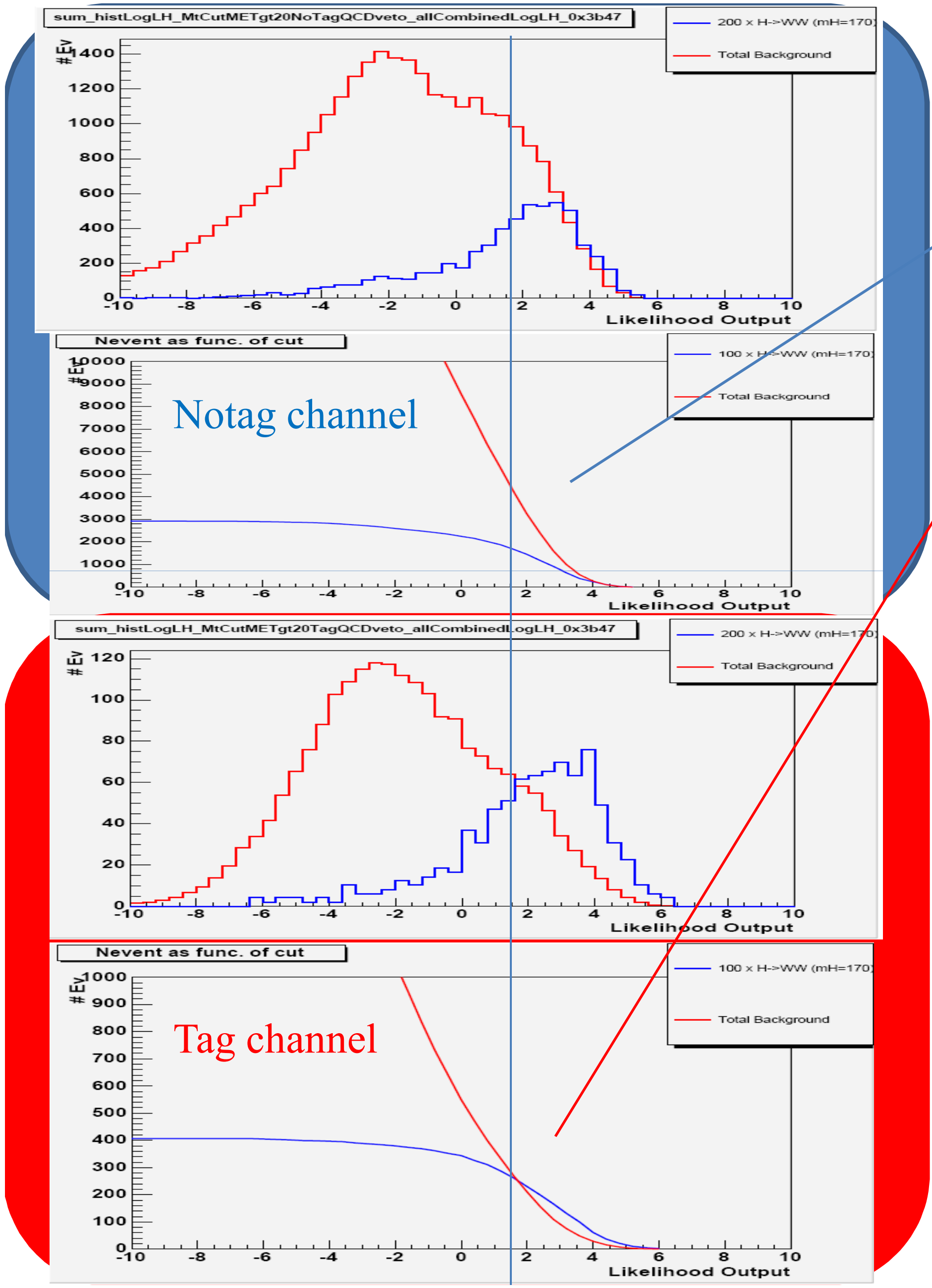


B=5832, S=21.8, A=1.79%



Upper limit on σ at 95% C.L.:
2.73 pb

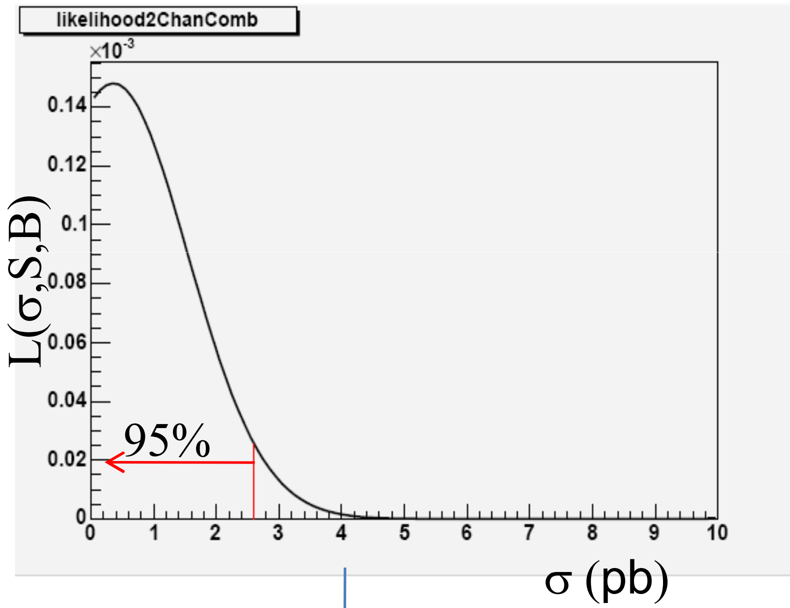
Estimation of Expected Limit



m_H = 170 GeV, tag+notag analysis:

B=4238, S=16.7, A=1.37%

B=269, S=2.61, A=0.21%



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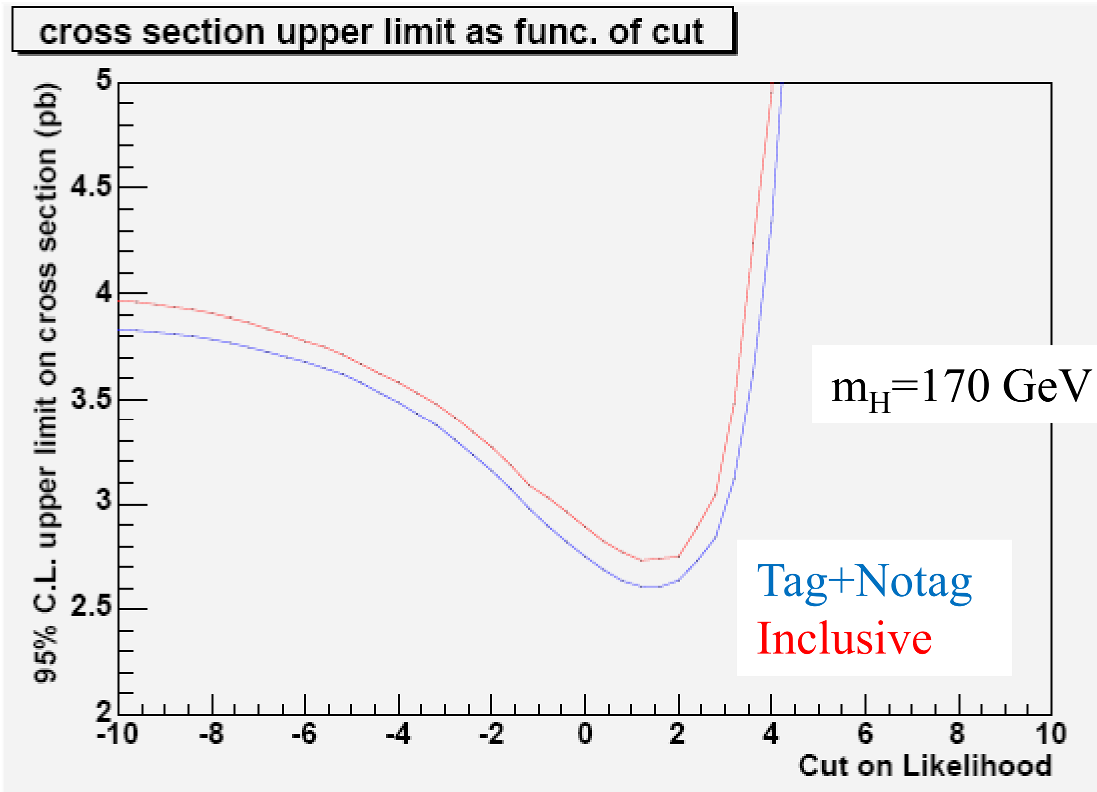
2.61 pb

Estimated Sensitivity

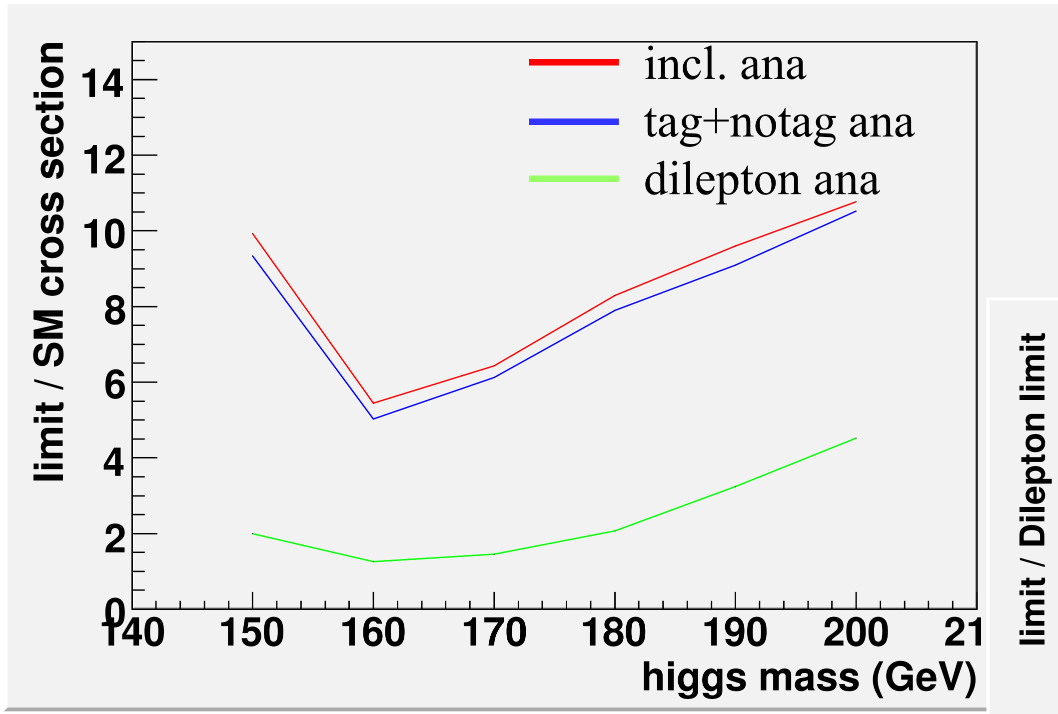
Statistical only, doesn't include systematic uncertainties.
Estimated 95% C.L. limit for 3.4 fb-1.

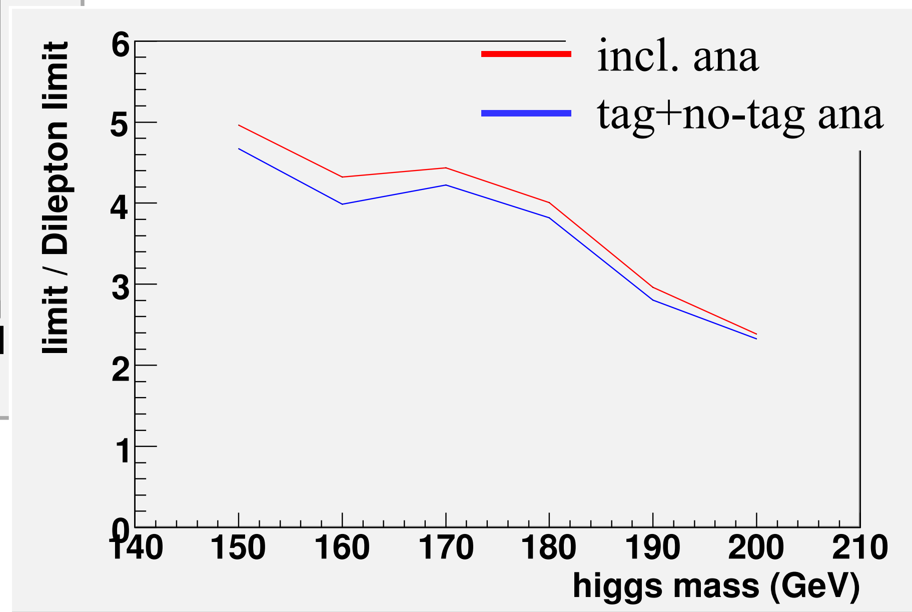


For each higgs mass assumption, we scan the cut on likelihood discriminant, and look for optimum cut that gives the lowest limit on cross section.

Expected sensitivity

Statistical only, doesn't include systematic uncertainties.
Estimated 95% C.L. upper limit for 4.8 fb^{-1}.
Dilepton number is from 4.8 fb^{-1} analysis.





Summary

- We are starting a search for SM Higgs boson decaying to $H \rightarrow WW \rightarrow l\nu jj$.
- We compose a likelihood discriminant with 9 kinematic variables as input.
- We estimate our upper limit on cross section will be x4.2 of the dilepton analysis at m_H=170 GeV, with the number going down with higher mass.

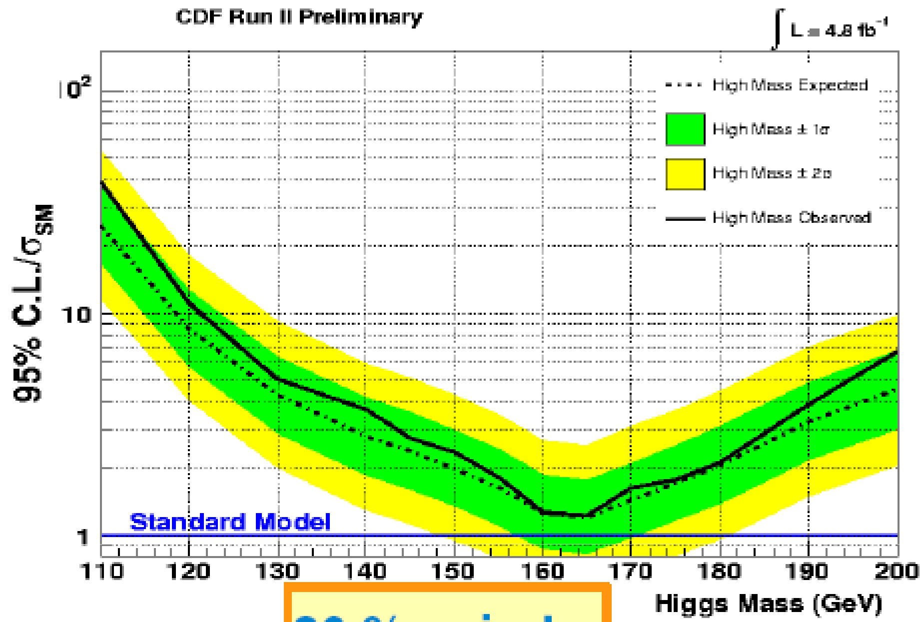
Backup

$H \rightarrow WW \rightarrow l\nu l\nu$

Recent Result 4.8 fb^{-1}

CDF Run II Preliminary	$\int \mathcal{L} = 4.8$ fb^{-1}		
	$M_H = 165$ GeV$/c^2$		
$t\bar{t}$	196	±	32
DY	342	±	61
WW	605	±	65
WZ	54.8	±	7.5
ZZ	42.3	±	5.8
W+jets	278	±	70
$W\gamma$	191	±	27
Total Background	1710	±	140
$gg \rightarrow H$	22.3	±	4.8
WH	4.38	±	0.57
ZH	1.59	±	0.21
VBF	1.61	±	0.26
Total Signal	29.8	±	5.1
Data	1733		

High Mass



20 % gain !

Win'09 (3.6fb^{-1})

		120	130	140	145	150	155	160	165	170	175	180	190	200
$-2\sigma/\sigma_{SM}$	15.48	5.31	2.60	1.69	1.47	1.23	1.04	0.79	0.77	0.88	1.08	1.21	1.92	2.52
$-1\sigma/\sigma_{SM}$	21.85	7.39	3.61	2.38	2.04	1.72	1.42	1.07	1.05	1.21	1.47	1.66	2.68	3.54
Median/σ_{SM}	**31.48**	**10.62**	**5.26**	**3.40**	**2.94**	**2.46**	**2.02**	**1.52**	**1.50**	**1.73**	**2.10**	**2.40**	**3.84**	**5.11**
$+1\sigma/\sigma_{SM}$	45.61	15.32	7.61	4.92	4.26	3.51	2.95	2.19	2.18	2.49	3.05	3.47	5.59	7.43
$+2\sigma/\sigma_{SM}$	63.79	21.54	10.71	6.82	6.01	5.02	4.14	3.12	3.00	3.49	4.24	4.88	7.78	10.66
Observed/σ_{SM}	**51.05**	**12.22**	**6.06**	**3.52**	**3.14**	**2.39**	**1.99**	**1.37**	**1.33**	**1.81**	**2.02**	**2.23**	**3.56**	**6.24**

Sum'09

	110	120	130	140	145	150	155	160	165	170	175	180	190	200
$-2\sigma/\sigma_{SM}$	11.56	4.05	2.03	1.30	1.13	0.95	0.79	0.61	0.58	0.69	0.80	0.96	1.50	2.06
$-1\sigma/\sigma_{SM}$	16.82	5.74	2.88	1.87	1.62	1.36	1.11	0.86	0.82	0.98	1.17	1.39	2.19	3.00
Median/σ_{SM}	**24.72**	**8.49**	**4.28**	**2.80**	**2.40**	**2.00**	**1.65**	**1.26**	**1.21**	**1.45**	**1.72**	**2.07**	**3.24**	**4.52**
$+1\sigma/\sigma_{SM}$	36.99	12.69	6.34	4.17	3.59	2.97	2.46	1.87	1.79	2.12	2.55	3.09	4.87	6.77
$+2\sigma/\sigma_{SM}$	53.71	18.15	9.16	5.94	5.12	4.28	3.49	2.68	2.55	3.11	3.66	4.46	7.03	9.76
Observed/σ_{SM}	**38.76**	**11.04**	**5.04**	**3.68**	**2.75**	**2.37**	**1.83**	**1.27**	**1.23**	**1.64**	**1.78**	**2.13**	**3.86**	**6.69**

$H \rightarrow WW$ group, Roman Lysák, CDF collaboration meeting Oct. 23 2009