CDF/D0 Combined Upper Limit on Higgs Production

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- The Higgs results included so far are:
  - CDF: $lvbb_S$, $lvbb_D$, $vvbb$, $llvv$
  - D0: $evbb_S$, $evbb_D$, $mvbb_S$, $mvbb_D$, $vvbb_S$, $vvbb_D$, ee,$e\mu$, $\mu\mu$
  - There are new CDF results on the way...

- A Bayesian framework is used to compute the upper limit with all 13 channels combined.

- This would allow us to handle the systematic properly on the large number of background and efficiency parameters involved.

- The same method was used in WH search and Run1 combined Higgs limit at CDF.

Likelihood Function

- $\mathcal{L}(R, \vec{s}, \vec{b}|\vec{n}) = \prod_{i=1}^{Nc} \prod_{j=1}^{Nbins} \frac{\mu_{ij}^{n_{ij}} \cdot e^{-\mu_{ij}}}{n_{ij}!}$
  - $R = \sigma \cdot B/SM$; s= $\sigma_i^{SM} \cdot B^{SM} \cdot \epsilon_{acc} \cdot L$.
  - $\vec{b}$: backgrounds
  - $\vec{n}$: data
  - N_C: channels
  - N_{bins}: histogram bins.
  - $\mu_{ij} = R \cdot s_{ij} + b_{ij}$.

- The expected signal event depends on:
  luminosity, btag sf, lepton id, jes, ISR/FSR+PDF, and the rest uncertainties

- The background consists of:
  HF, Mistag, top, non-W, diboson (WW), and other.

Priors, Posterior Densities and Upper Limit on R

- The priors for efficiencies and backgrounds are truncated Gaussian densities with its expected value within its uncertainty.

- Assign a flat prior to the number of Higgs events, instead of Higgs xsec.
  $\pi(R, \vec{s}, \vec{b}) = s_{tot} \cdot \theta(R \cdot s_{tot}) \cdot \pi(\vec{s}) \cdot \pi(\vec{b})$

- Posterior density:
  $p(R|\vec{n}) = \frac{\int d\vec{s} \int d\vec{b} \mathcal{L}(R,\vec{s},\vec{b}|\vec{n}) \cdot s_{tot}}{\int dR \int d\vec{s} \int d\vec{b} \mathcal{L}(R,\vec{s},\vec{b}|\vec{n}) \cdot s_{tot}}$

- 95% Upper Limit:
  $\int_0^{R_{0.95}} p(R|\vec{n}) dR = 0.95$

Source of Correlated Systematic (CDF)

Channels	$l\nu b\bar{b}_S$	$l\nu b\bar{b}_D$	$\nu\nu b\bar{b}$	W^+W^-
Luminosity (%)	6.0	6.0	6.0	6.0
btag SF(%)	5.3	16.0	6.3	0.
Lepton ID (%)	2.0	2.0	2.0	3.0
JES (%)	3.0	3.0	8.0	1.0
I(F)SR+PDF(%)	4.0	10.0	2.0	5.0
Trigger (%)	0.0	0.0	0.02	0.0
Backgrounds				
HF (%)	33.0	34.0	0.	0.
Mistag (%)	22.0	15.0	16.0	0.
Top (%)	13.5	20.0	18.0	0.0
QCD (%)	17.0	20.0	-34.0	0.
Diboson (%)	16	25	18	11
Others (%)	0.	0.	0.	-(12-18)

- The positive value means correlated, the negative value means uncorrelated
- The results seems insensitive to these correlations changing from 100% to 0%
- Common to D0: 4% on Luminosity; 8% on σ_t; 6% on σ_{EW}; 10% on $\sigma_{H\to WW}$

Source of Signal Systematic (D0)

0.025 0.025 0.025 0.025 0.025 0.025 0.025 0.025 0.025 ! DZero_sig_Lumi_pos 0

0.05 0.05 0.05 0.05 0.05 0.05 0 0 0 ! DZero_sig_JetID_pos 1

0.04 0.04 0.04 0.04 0.06 0.06 0.04 0.04 0.03 ! DZero_sig_JES_pos 2

0.03 0.03 0.03 0.03 0 0 0 0 0 ! DZero_sig_JetMult_pos 3

0.035 0.035 0.035 0.035 0 0 0 0 0 ! DZero_sig_JetMLM_pos 4

0.03 0.03 0.03 0.03 0.01 0.01 0 0 0 ! DZero_sig_Taggability_pos 5

0.055 0.055 0.04 0.055 0.03 0.07 0 0 0 ! DZero_sig_bTag_HF_pos 6

0.03 0.03 0 0 0 0 0 0 0 ! DZero_sig_EMTrigger_pos 7

0.03 0.03 0 0 0 0 0.03 0.02 0 ! DZero_sig_EMID_pos 8

0.04 0.04 0 0 0 0 0.02 0.02 0 ! DZero_sig_EMSmear_pos 9

0.03 0.03 0 0 0 0 0 0 0 ! DZero_sig_EMlike_pos 10

0 0 0.02 0.02 0 0 0 0 0 ! DZero_sig_MUTrigger_pos 11

0 0 0.02 0.02 0 0 0 0.022 0.03 ! DZero_sig_MUID_pos 12

0 0 0.041 0.041 0 0 0 0.024 0.01 ! DZero_sig_MUSmear_pos 13

0 0 0 0 0.05 0.05 0 0 0 ! DZero_sig_JetSmear_pos 14

0 0 0 0 0.05 0.05 0 0 0 ! DZero_sig_MJETTrigger_pos 15

0 0 0 0 0 0 0.01 0 0 ! DZero_sig_DiEMTrigger_pos 16

0 0 0 0 0 0 0 0.01 0 ! DZero_sig_EMUTrigger_pos 17

0 0 0 0 0 0 0 0 0.01 ! DZero_sig_DiMUTrigger_pos 18

Source of Background Systematic (D0)

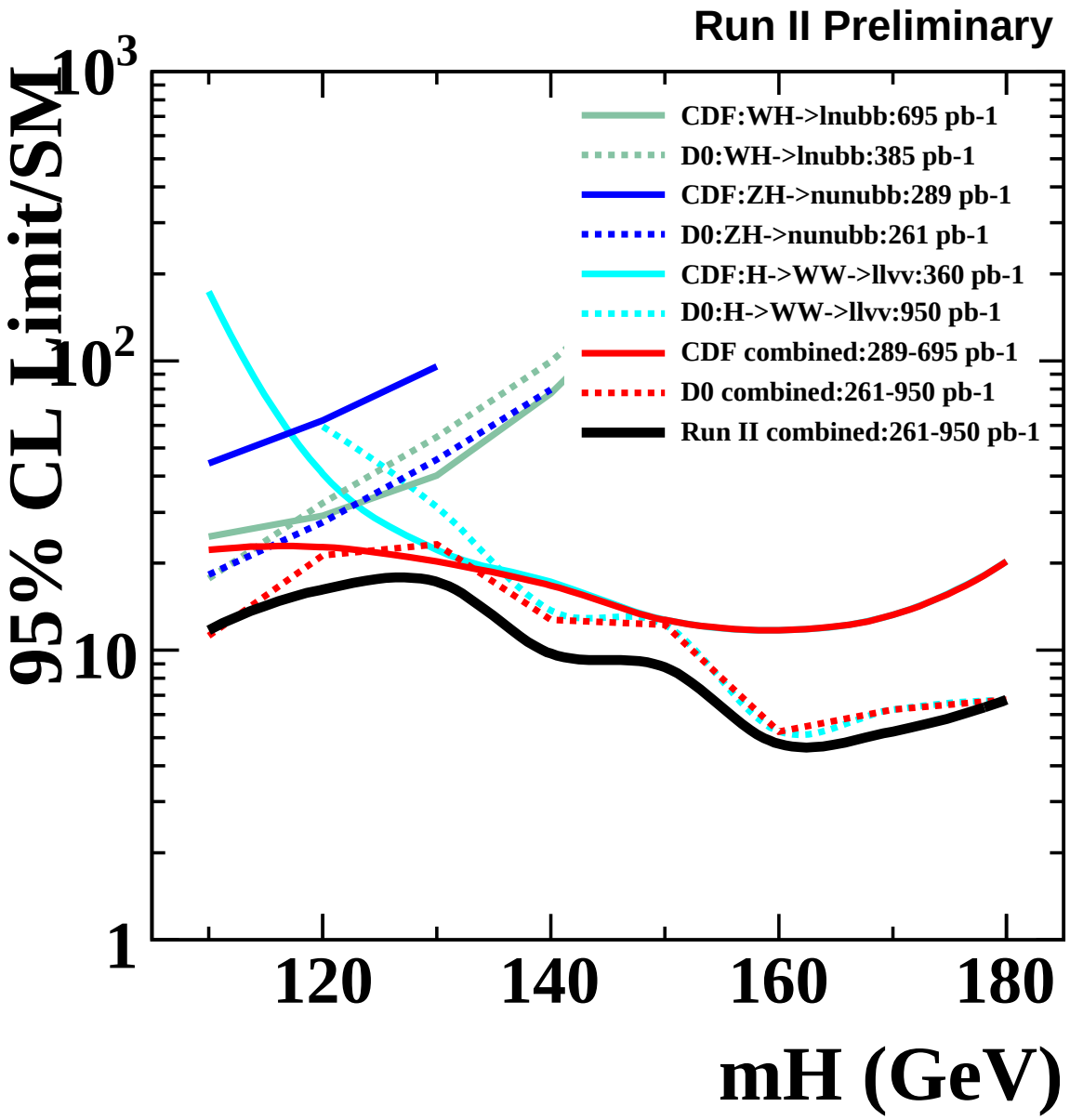
0.025 0.025 0.025 0.025 0.025 0.025 0.025 0.025 0.025 ! DZero_bkgd_Lumi_pos 0
0.05 0.05 0.05 0.05 0.06 0.06 0 0 0 ! DZero_bkgd_JetID_pos 1
0.04 0.04 0.04 0.04 0.06 0.06 0.05 0.05 0.03 ! DZero_bkgd_JES_pos 2
0.03 0.03 0.03 0.03 0 0 0 0 0 ! DZero_bkgd_JetMult_pos 3
0.035 0.035 0.035 0.035 0 0 0 0 0 ! DZero_bkgd_JetMLM_pos 4
0.03 0.03 0.03 0.03 0.01 0.01 0 0 0 ! DZero_bkgd_Taggability_pos 5
0.055 0.055 0.04 0.055 0.04 0.07 0 0 0 ! DZero_bkgd_bTag_HF_pos 6
0.03 0.03 0 0 0 0 0 0 0 ! DZero_bkgd_EMTrigger_pos 7
0.03 0.03 0 0 0 0 0.04 0.03 0 ! DZero_bkgd_EMID_pos 8
0.01 0.01 0 0 0 0 0.03 0.02 0 ! DZero_bkgd_EMSmear_pos 9
0.03 0.03 0 0 0 0 0 0 0 ! DZero_bkgd_EMlike_pos 10
0 0 0.02 0.02 0 0 0 0 0 ! DZero_bkgd_MUTrigger_pos 11
0 0 0.02 0.02 0 0 0 0.029 0.031 ! DZero_bkgd_MUID_pos 12
0 0 0.041 0.041 0 0 0 0.024 0.01 ! DZero_bkgd_MUSmear_pos 13
0 0 0 0 0.02 0.02 0 0 0 ! DZero_bkgd_JetSmear_pos 14
0 0 0 0 0.04 0.04 0 0 0 ! DZero_bkgd_MJETTrigger_pos 15
0 0 0 0 0 0 0.02 0 0 ! DZero_bkgd_DiEMTrigger_pos 16
0 0 0 0 0 0 0 0.02 0 ! DZero_bkgd_EMUTrigger_pos 17
0 0 0 0 0 0 0 0 0.02 ! DZero_bkgd_DiMUTrigger_pos 18
0.08 0.08 0.06 0.08 0.07 0.1 0 0 0 ! DZero_bkgd_bTag_LF_pos 19
0.15 0.15 0.15 0.15 0.15 0.15 0 0 0 ! DZero_bkgd_Xsec_HF_pos 20
0.11 0.11 0.11 0.11 0.11 0.11 0.11 0.11 0.11 ! DZero_bkgd_Xsec_LF_pos 21
0.33 0.33 0.33 0.33 0.33 0.33 0.33 0.33 0.33 ! DZero_bkgd_Xsec_QCD_pos 22

- Generate a common Gaussian for each systematic source
- Multiply them to count for total systematic for each individual backgrounds

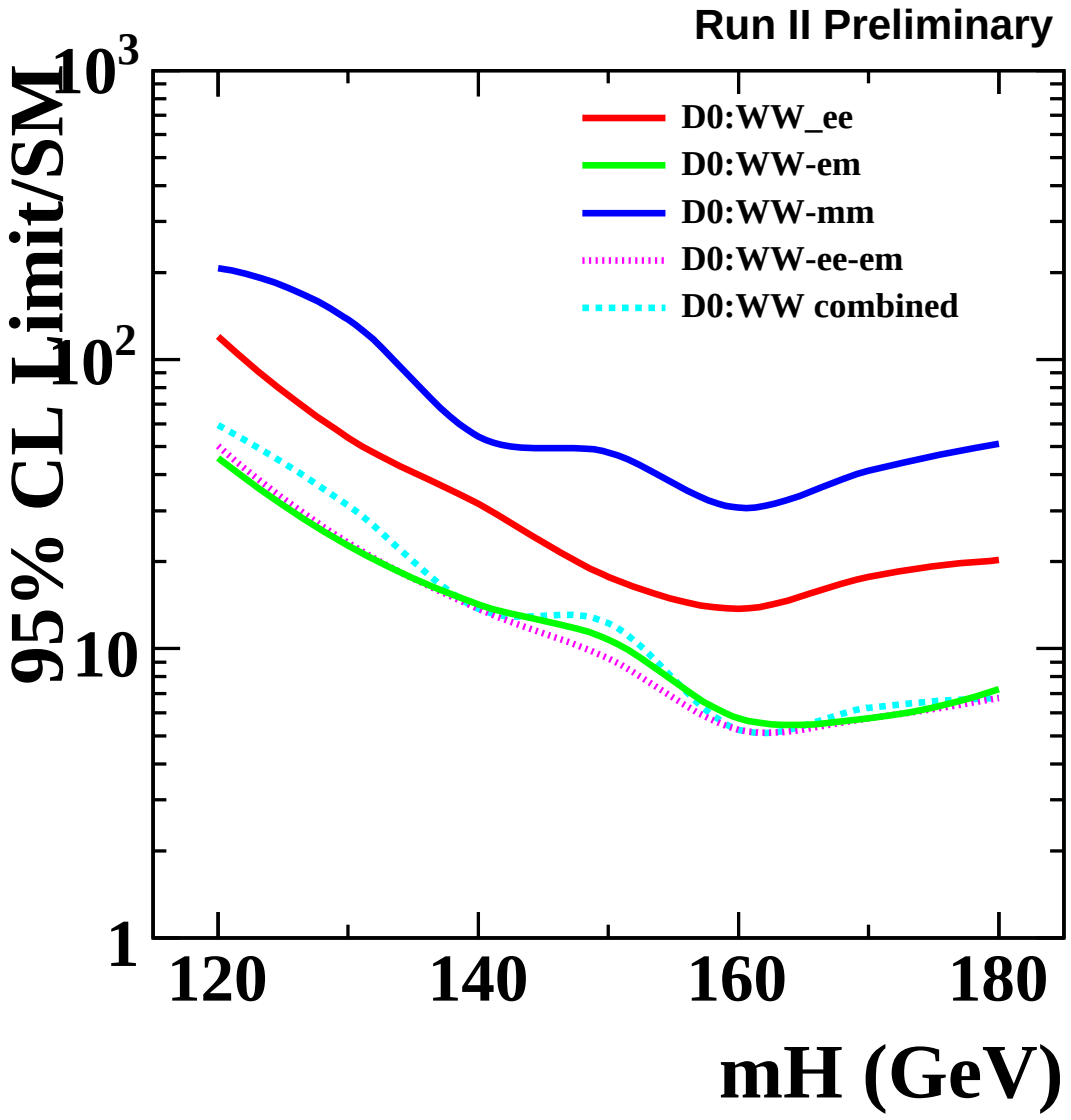
Some Assumptions Used So Far:

- Assign 10% uncertainty on signal xsec in WW channel only.
- Double the lepton id systematic for two electrons or two muons in the final state
- Double the btag systematic for double btags
- Rebin some of histograms, but no impact on the limits
- Higgs mass grid used with 110,120,130,140,150,160,170,180.
- Once the procedure is verified, we will compute the expected limit using pseudo-experiments.

Combined Limits



Comparision of D0 WW Limits



- The limit seems getting worse by including $WW \to \mu\mu\nu\nu$ data

Conclusion

- We obtain a combined Higgs limit from CDF/D0 using a Bayesian method.
- The returned limit for each individual channel seems reasonable, except, D0 $WW \to \mu\mu$ channel.
- Comments and suggestions are welcome.
- The expectation of Pseudo-experiments are under study.