

# Theory Uncertainties in Higgs Searches



All

(compiled by Giampiero)

Introduction to Section IX and X

BNL Workshop, 4–6 May 2011



## Ceterum censeo

*Corrections can (and will!) change in the transition from the total to integrated XS based on selection cuts*

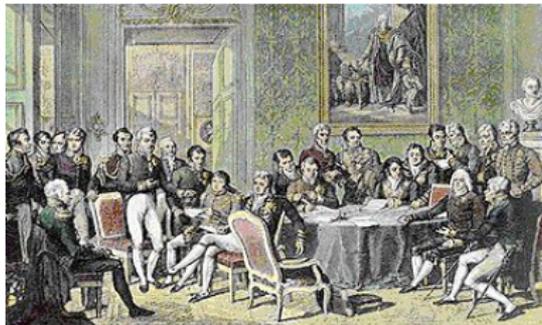
## Disclaimer:

All for the sake of the Summer Conferences, with the understanding that these are a short-term fixes rather than long-term agreements, written in stone ...



we want to work out a reasonable procedure  
come up with quick recommendation

} **compromise**



## Options

- 1 We do some *deep* investigation to discover that the Bayesian approach is frustratingly difficult to apply because of the assessment of the likelihood function (see work of Glen Cowan) but not for the Summer
- 2 is it worth wasting time? ggF @ 140 GeV

method	68%(90%)CL	
quadratically	22.3%(22.7%)	} 2.7%(4.4%) ???????
envelope	24.9%(26.9%)	
linearly	25.0%(27.1%)	



## Procedure

- 1 Calculate  $\Gamma$ s and corresponding BRs for each parameter variation  $\leadsto$  individual PUs
- 2 Combine individual PUs for BRs (and  $\Gamma$ s) in quadrature  $\leadsto$  overall PU
- 3 Calculate errors for  $\Gamma$ s and corresponding BRs for each total TU  $\leadsto$  individual TUs
- 4 Combine the individual TUs linearly  $\leadsto$  overall TU
- 5 Combine the overall TU and the overall PU linearly  $\leadsto$  final uncertainties



## Questions in Ask Box

### Prescription needed

- central value of  $\sigma A =$  any NLO–MC re-weighted with  $H_qT$ ?
- Uncertainty from scale, how to select and vary the scale?
- Vary the PDF (MSTW2008NNLO) and take the 90% CL?
- Add difference MC@NLO – POWHEG? Negligible after re-weighting?
- Something more?
- Something less?



$$\sigma_{\text{vis}} = \sigma_T Af$$

### how to handle THUs in the combination:

- 1 take the inclusive XSs and their THUs from the CERN Yellow Report
- 2 estimate acceptance (except that on jet bin) uncertainties from scale, PDF,  $\alpha_s$  etc. using appropriate MC programs and assume they are independent of those on the total inclusive XSs
- 3 estimate jet bin uncertainties separately and implement them as
  - $f_0$  fully anticorrelated with the total XS ( $c = -0.99$ )
  - $f_1$  fully correlated with the total XS ( $c = 0.96$ );
  - $f_2$  fully correlated with the total XS ( $c = 0.95$ )
- 4 Take differences between different NLO MC generators as an independent systematic source



## QCD scale unc. in $H + 0, 1, 2$ -jets:

- 1 The scale dependence is considerably larger for  $H + 1, H + 2$  jets compared to  $H + 0$  jets or the full inclusive, mostly because they are computed to one order lower in QCD.
- 2 For  $H + n$  jets, when a jet veto is imposed there is an extra scale in the game, the  $p_T$  of the jet.
- 3 In the case of  $H + 1$  jet don't use  $M_H(M_H/2)$  but some combination like  $(M_H + p_T)/2$ .



# High-Mass

## Breit-Wigner:

- 1 How one can approximate Breit-Wigner lineshape to the exact calculation.
- 2 Heavy Higgs is ill-defined theoretically, and we have to wait the recommendation from theorists for each NLO MC.
- 3 Spectrum of Higgs  $p_T$  for heavy Higgs (are MCs correct in this region?)
- 4 Crude estimate of Higgs line-shape uncertainty including the interference effect with SM backgrounds.
- 5 Scale choice: there is no physical reason to take a very high scale, while outgoing four lepton scale is much lower (low Higgs  $p_T$ ?)



## PDF:

- 1 New recipe for NNLO?
- 2 What to do for estimating PDFU in differential XS?
- 3 New/pragmatic PDF4LHC recipe, update of PDF, PDF +  $\alpha_S$  error correlations?



## Summary:

( 2, 3, 4 )

- ① *Uncertainty in differential XS including acceptance*
- ② *Common issues: QCD scale, PDF +  $\alpha_s$ , NLO MC modeling, acceptance correction with Higgs XS, extrapolation from control to signal region*
- ③ *Common cuts: effect of jet-veto, Higgs  $p_T$ , etc.*
- ④ *Prepare a common guideline for ATLAS and CMS on these issues*



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## Adopt-a-THU program

The Adopt-a-THU program, is managed by the HXSWG. The program's main objective is to beautify YR2 and at the same time give authors the chance to encourage patronage by successfully maintaining THUs that display a sign with their name on it.

