Jet bin prescription à la BNL proposal

Three methods were proposed, Frank T.'s, Jianming's I&II

A) Frank Tackmann's proposal

Generate MC possibly with re-weighting to HqT.

Calculate jet-bin uncertainties with fixed-order calculation for gg→H.

1) Assume no correlation in inclusive, ≥1-jet and ≥2-jet cross section errors.
   - Take inclusive cross section error from CERN YR.
   - Calculate ≥1-jet and ≥2-jet errors via MCFM/HNNLO/FEHiPro.
2) Transfer this diagonal 3x3 matrix into σ_0, σ_1 and $\sigma_{\geq 2}$ error matrix.
3) Also convert into 3x3 correlation matrix.

Division Into Jet Bins

To first approximation, one should treat perturbative series in σ_{total} and $\sigma_{\geq 1}$ as independent with uncorrelated perturbative uncertainties, similarly for $\sigma_{\geq 1}$ and $\sigma_{\geq 2}$

- First consider *inclusive* jet cross sections

$$\sigma_{\text{total}},\ \sigma_{\geq 1},\ \sigma_{\geq 2} \quad \Rightarrow \quad C = \begin{pmatrix} \Delta^2_{\text{total}} & 0 & 0 \\ 0 & \Delta^2_{\geq 1} & 0 \\ 0 & 0 & \Delta^2_{\geq 2} \end{pmatrix}$$

For short-term solution, we do not use absolute XS, but use following error correlation matrix based upon numbers with full simulation MC.

- Then transform to *exclusive* jet cross sections

$$\sigma_0 = \sigma_{\text{total}} - \sigma_{\geq 1}\,, \qquad \sigma_1 = \sigma_{\geq 1} - \sigma_{\geq 2}\,, \qquad \sigma_{\geq 2}$$

$$\Rightarrow \quad C = \begin{pmatrix} \Delta^2_{\text{total}} + \Delta^2_{\geq 1} & -\Delta^2_{\geq 1} & 0 \\ -\Delta^2_{\geq 1} & \Delta^2_{\geq 1} + \Delta^2_{\geq 2} & -\Delta^2_{\geq 2} \\ 0 & -\Delta^2_{\geq 1} & \Delta^2_{\geq 2} \end{pmatrix}$$

How to get $\Delta\sigma_{\geq i}$ in Practice

- Simplest: Use relative uncertainties from fixed-order codes

$$\Delta\sigma_{\geq i} = \left[\frac{\Delta\sigma_{\geq i}}{\sigma_{\geq i}}\right]_{\mathrm{FO}} \times \left[f_{\geq i}\right]_{\mathrm{MC}} \sigma_{\mathrm{total}}$$

  - for $\Delta\sigma_{\geq 1}$: HNNLO, FEHiP, MCFM should be identical
  - for $\Delta\sigma_{\geq 2}$: HNNLO, FEHiP give LO, can use MCFM for NLO

- Reweight to new HqT including all its uncertainties
  - propagates its uncertainties into $\sigma_{\geq 1}$
  - for $\Delta\sigma_{\geq 2}$: use HNNLO/FEHiP or MCFM

Example Numbers

Using HNNLO (Jianming's numbers) to get $\{\Delta\sigma_{\text{total}}, \Delta\sigma_{\geq 1}, \Delta\sigma_{\geq 2}\}$

cut	$\frac{\Delta\sigma_{\text{total}}}{\sigma_{\text{total}}}$	$\frac{\Delta\sigma_{\geq 1}}{\sigma_{\geq 1}}$	$\frac{\Delta\sigma_{\geq 2}}{\sigma_{\geq 2}}$	$\frac{\Delta\sigma_{0}}{\sigma_{0}}$	$\frac{\Delta\sigma_{1}}{\sigma_{1}}$
$p_T^{\text{cut}} = 30\,\text{GeV}, \eta^{\text{cut}} = 3$	10%	21%	45%	17%	29%

Correlations for $\{\sigma_0, \sigma_1, \sigma_{\geq 2}\}$

$$\begin{pmatrix} 1 & -0.49 & 0 \\ -0.49 & 1 & -0.42 \\ 0 & -0.42 & 1 \end{pmatrix}$$

Correlations for $\{\sigma_{\text{total}}, f_0, f_1, f_2\}$

$$\begin{pmatrix} 1 & 0.44 & -0.33 & -0.22 \\ 0.44 & 1 & -0.92 & -0.10 \\ -0.33 & -0.92 & 1 & -0.31 \\ -0.22 & -0.10 & -0.31 & 1 \end{pmatrix}$$

B) Jianming Qian's proposal-I

Correlations: proposal 1

$$\sigma_{\text{vis}} = \sigma_{\text{tot}} \times A \times f$$

Fractions in each jet bin

- Take the total cross sections and their uncertainties from the CERN Yellow Report;
- Estimate jet veto/bin (scale) uncertainties separately and take into account potential correlations with those on the total cross sections

f_j correlation matrix

$$\begin{pmatrix} 1.00 & -0.95 & -0.98 \\ -0.95 & 1.00 & 0.88 \\ -0.98 & 0.88 & 1.00 \end{pmatrix}$$

σ_{tot} and f_j correlation:

0-jet=-0.99, 1-jet=0.96, 2-jet=0.95

from J. Qian

Reproduces the following uncertainties for the 0, 1 jet-bin cross sections, m_H = 165 GeV, p_T < 30 GeV veto:

- 5-6% in 0-jet bin
- 14-16% in 1-jet bin

C) Jianming Qian's proposal-II

Another proposal for errors

- Determine central values of jet bin fractions f_i from MC by each experiment for its selection;
- Calculate binned cross sections as

$$\sigma_i = f_i \times \sigma_{tot}$$

- Calculate uncertainties as

$$\Delta\sigma_i = \sqrt{(\Delta f_i)^2 \sigma_{tot}^2 + f_i^2 (\Delta\sigma_{tot})^2}$$

Gives 11-12% uncertainty in the 0-jet bin for the test study

i.e. ignore the correlations between jet fraction and total cross section, it's simpler !

- take the uncertainty on the total cross section from CERN Yellow Report;
- estimate the uncertainty on the faction using fixed order program such as HNNLO

from J. Qian

Proposal from Jianming

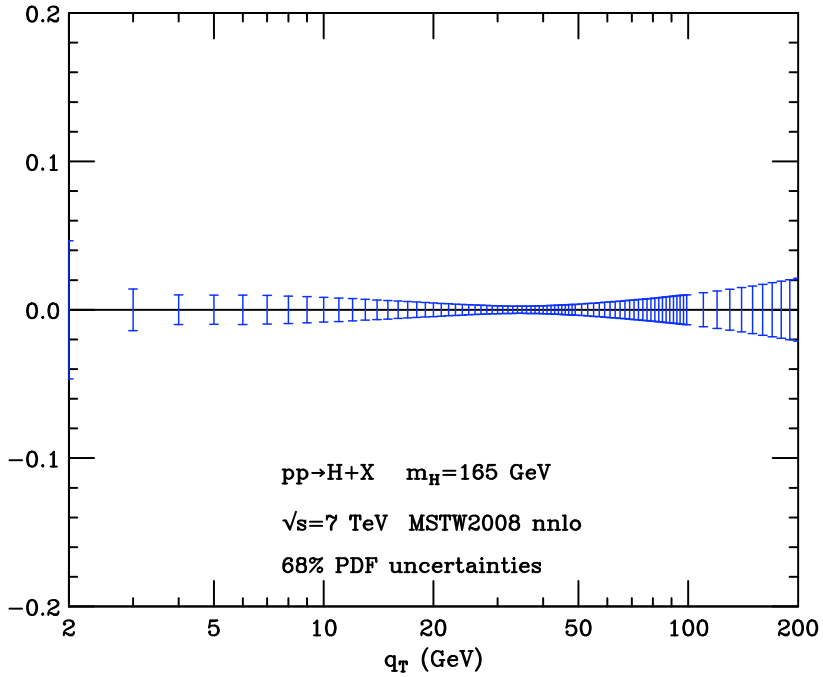
1) calculate cross sections in exclusive bins as
sigma_0 = f0 * sigma_tot
sigma_1 = f1 * sigma_tot
sigma_2 = f2 * sigma_tot

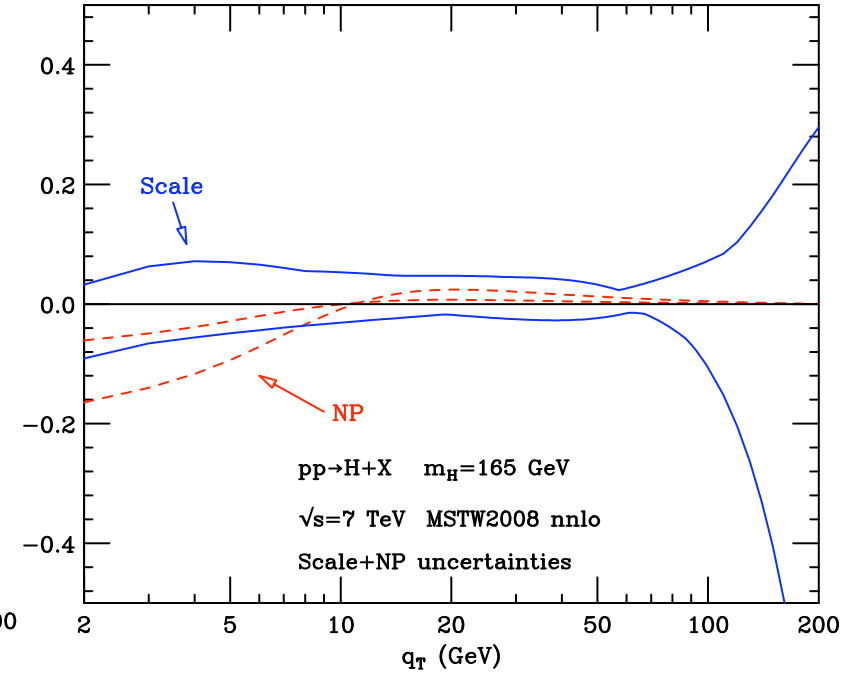
2) calculate error using standard error propagation procedure assuming fi and sigma_tot are independent:
d(sigma_0) = sqrt[d(f0)^2*sigma_tot^2 + f0^2*d(sigma_tot)^2]
d(sigma_1) = sqrt[d(f1)^2*sigma_tot^2 + f1^2*d(sigma_tot)^2]
d(sigma_2) = sqrt[d(f2)^2*sigma_tot^2 + f2^2*d(sigma_tot)^2]

This will guarantee that
d(sigma_i)/sigma_i > d(sigma_tot)/sigma_tot
a point emphasized by many theorists.

3) In combining Higgs search results from these three bins, the full correlation matrix among fi is taken into account. For mH=
1.00 -0.95 -0.98
-0.95 1.00 0.88
-0.98 0.88 1.00

Shape uncertainty





PDF uncertainties apparently have a small impact on the shape of the spectrum

As q_T increases different x ranges are probed

➡ Other PDFs could lead to more sizable effects

Scale uncertainties at the level of about ±5%
NP effects estimated as in Bozzi et al. (2005)

They become important at small q_T

Longer-term plan

- ✓ H→γγ, other H→WW/ZZ→4f channels for jet-binning ?
- ✓ Study beam thrust variable.
- ✓ Study transition of parton to particle level effect (ex. UE) with full simulation.