Fixed Order and Resummed Uncertainties with the Stewart-Tackmann Method

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based on discussions with Ye Li, Xiaohui Liu, Frank Petriello, Frank Tackmann

ST Method for Fixed Order Cross Sections

Basic ansatz of ST method:

Uncertainties in inclusive jet bins are uncorrelated

Using the ansatz, any element of covariance matrices for any set of inclusive, exclusive jet bins can be determined

$$\Delta^2_{\rm FO}(\geq n, = m) = \begin{cases} \Delta^2_{\geq n} & \text{if } m = n\,, \\ -\Delta^2_{\geq n} & \text{if } m = n-1\,, \\ 0 & \text{otherwise}\,. \end{cases}$$

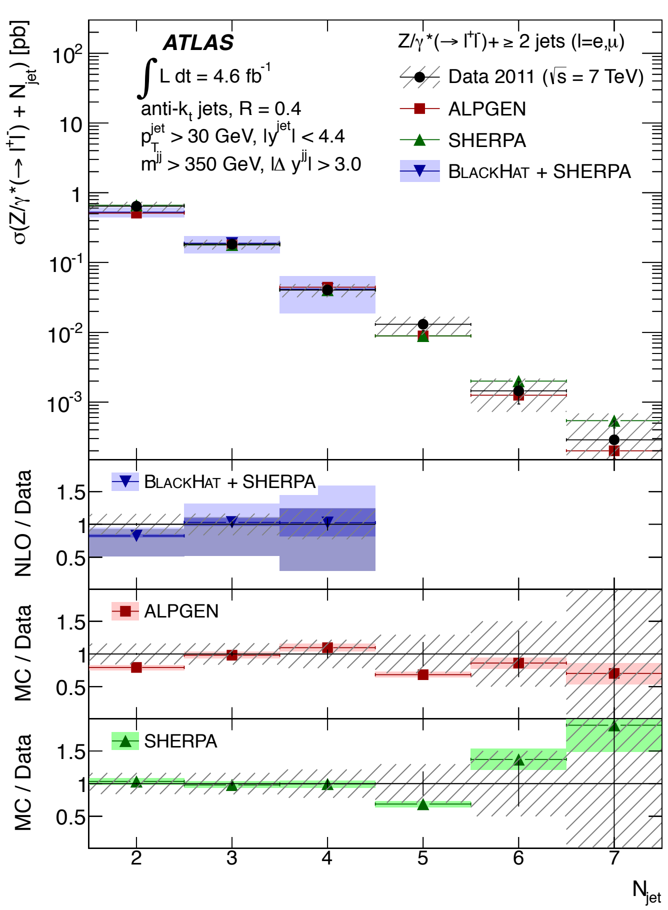
$$\Delta^2_{\rm FO}(= n, = m) = \begin{cases} \Delta^2_{\geq n} + \Delta^2_{\geq n+1} & \text{if } m = n\,, \\ -\Delta^2_{\geq n} & \text{if } m = n-1\,, \\ -\Delta^2_{\geq n+1} & \text{if } m = n+1\,, \\ 0 & \text{otherwise}\,. \end{cases}$$

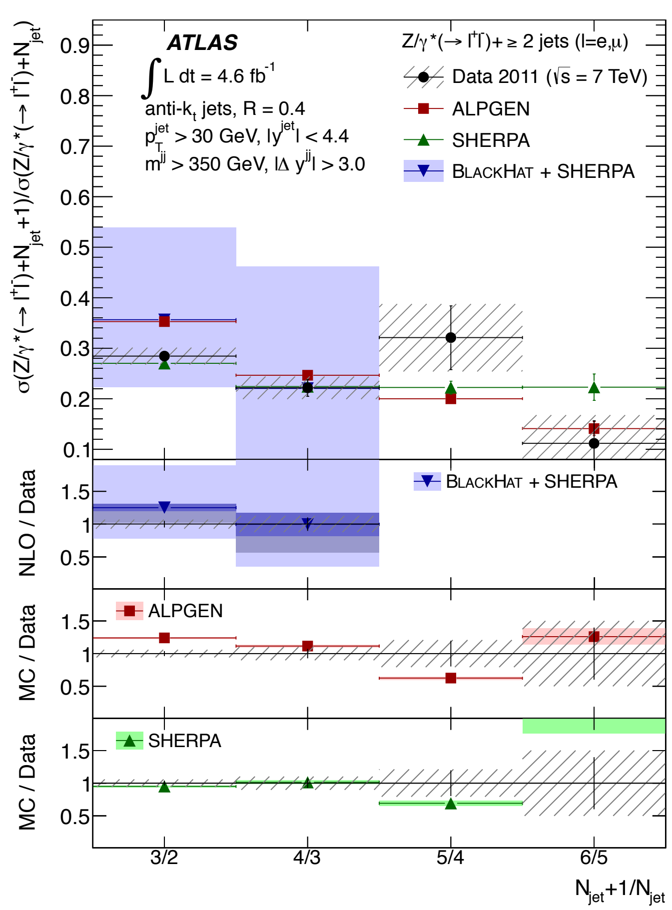
Ratios of Exclusive Cross Sections

Interesting case is ratios of exclusive cross sections $R_n = \frac{\sigma_{n+1}}{\sigma_n}$

$$\left(\frac{\Delta_{=n}{}^2}{\sigma_n{}^2} + \frac{\Delta_{=n+1}{}^2}{\sigma_{n+1}{}^2}\right)^{1/2} < \frac{\Delta_{R_n}}{R_n} < \frac{\Delta_{=n}}{\sigma_n} + \frac{\Delta_{=n+1}}{\sigma_{n+1}}$$

Pretty tight bound on fractional uncertainty of R_n in terms of fractional uncertainties in exclusive bins - *useful cross check*





The ST-derived uncertainties in these ratios are relatively large

Are these uncertainties reasonable, or is there a better ansatz?

Is there a general class of observables like this?

ATLAS, 1304.7098

Resummation Uncertainties

Goal: have a consistent framework to assess uncertainties
in exclusive 0-jet, 1-jet, and inclusive 2-jet bins

Banfi, Monni, Salam, Zanderighi Becher, Neubert, Rothen Stewart, Tackmann, Walsh, Zuberi	exclusive 0-jet cross section 0-jet efficiency inclusive 1-jet cross section
Liu, Petriello	exclusive 1-jet cross section 1-jet efficiency inclusive 2-jet cross section

ATLAS/CMS will use the results of these studies (in some form) for their analysis
unified uncertainty framework will make results more applicable

Resummation Uncertainties

With resummation, the ST ansatz(es) differ
and are (subjectively) more robust

property: uncertainty comes from two sources: fixed order and resummation, which can be separately estimated, $C = C_\mu + C_{\rm res}$ (FO + resum)

$$C_\mu = \begin{pmatrix} \Delta^2_{\mu{\rm tot}} & \Delta_{\mu{\rm tot}}\Delta_{\mu 0} & \Delta_{\mu{\rm tot}}\Delta_{\mu\geq 1} & \Delta_{\mu{\rm tot}}\Delta_{\mu 1} & \Delta_{\mu{\rm tot}}\Delta_{\mu\geq 2} \\ \Delta_{\mu{\rm tot}}\Delta_{\mu 0} & \Delta^2_{\mu 0} & \Delta_{\mu 0}\Delta_{\mu\geq 1} & \Delta_{\mu 0}\Delta_{\mu 1} & \Delta_{\mu 0}\Delta_{\mu\geq 2} \\ \Delta_{\mu{\rm tot}}\Delta_{\mu\geq 1} & \Delta_{\mu 0}\Delta_{\mu\geq 1} & \Delta^2_{\mu\geq 1} & \Delta_{\mu\geq 1}\Delta_{\mu 1} & \Delta_{\mu\geq 1}\Delta_{\mu\geq 2} \\ \Delta_{\mu{\rm tot}}\Delta_{\mu 1} & \Delta_{\mu 0}\Delta_{\mu 1} & \Delta_{\mu\geq 1}\Delta_{\mu 1} & \Delta^2_{\mu 1} & \Delta_{\mu 1}\Delta_{\mu\geq 2} \\ \Delta_{\mu{\rm tot}}\Delta_{\mu\geq 2} & \Delta_{\mu 0}\Delta_{\mu\geq 2} & \Delta_{\mu\geq 1}\Delta_{\mu\geq 2} & \Delta_{\mu 1}\Delta_{\mu\geq 2} & \Delta^2_{\mu\geq 2} \end{pmatrix}$$

$$\text{basis: } \{\sigma_{\geq 0}, \sigma_{=0}, \sigma_{\geq 1}, \sigma_{=1}, \sigma_{\geq 2}\}$$

$$\Delta_{\mu{\rm tot}} = \Delta_{\mu 0} + \Delta_{\mu\geq 1}\,,$$
$$\Delta_{\mu{\rm tot}} = \Delta_{\mu 0} + \Delta_{\mu 1} + \Delta_{\mu\geq 2}\,.$$

ansatz: fixed order uncertainties
in different jet bins are totally correlated

Resummation Uncertainties

$$\text{basis: } \{\sigma_{\geq 0}, \sigma_{=0}, \sigma_{\geq 1}, \sigma_{=1}, \sigma_{\geq 2}\}$$

$$C_{\text{res}} = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & \Delta^2_{\text{res}=0} & -\Delta^2_{\text{res}=0} & 0 & -\Delta^2_{\text{res}=0} \\ 0 & -\Delta^2_{\text{res}=0} & \Delta^2_{\text{res}=0} & 0 & \Delta^2_{\text{res}=0} \\ 0 & 0 & 0 & \Delta^2_{\text{res}=1} & -\Delta^2_{\text{res}=1} \\ 0 & -\Delta^2_{\text{res}=0} & \Delta^2_{\text{res}=0} & -\Delta^2_{\text{res}=1} & \Delta^2_{\text{res}=0} + \Delta^2_{\text{res}=1} \end{pmatrix}$$

ansatz: $\Delta(=0, =1) = 0$

reasonable since the 0-jet, 1-jet exclusive uncertainties are separately estimated

$$\begin{aligned}
\text{total incl.:} \quad & \Delta^2_{\text{tot}} = \Delta^2_{\mu\text{tot}} \,, \\
\text{excl. 0-jet:} \quad & \Delta^2_0 = \Delta^2_{\mu 0} + \Delta^2_{\text{res}=0} \,, \\
\text{excl. 1-jet:} \quad & \Delta^2_1 = \Delta^2_{\mu 1} + \Delta^2_{\text{res}=1} \,, \\
\text{incl. 1-jet:} \quad & \Delta^2_{\geq 1} = (\Delta_{\mu\text{tot}} - \Delta_{\mu 0})^2 + \Delta^2_{\text{res}=0} \,, \\
\text{incl. 2-jet:} \quad & \Delta^2_{\geq 2} = (\Delta_{\mu\text{tot}} - \Delta_{\mu 0} - \Delta_{\mu 1})^2 + \Delta^2_{\text{res}=0} + \Delta^2_{\text{res}=1} \,.
\end{aligned}$$

Estimating Uncertainties

need to estimate resummed and fixed order uncertainties for the resummed cross section

$$\sigma_0(\mu_H, \mu_{\rm ns}, \mu_B, \mu_S, \nu_B, \nu_S)$$

$\Delta_{\mu 0}$: vary *all* scales up and down collectively (by 2, 1/2)
also can vary resummation profile shape

$\Delta_{\rm res=0}$: vary (groups of) individual scales up and down

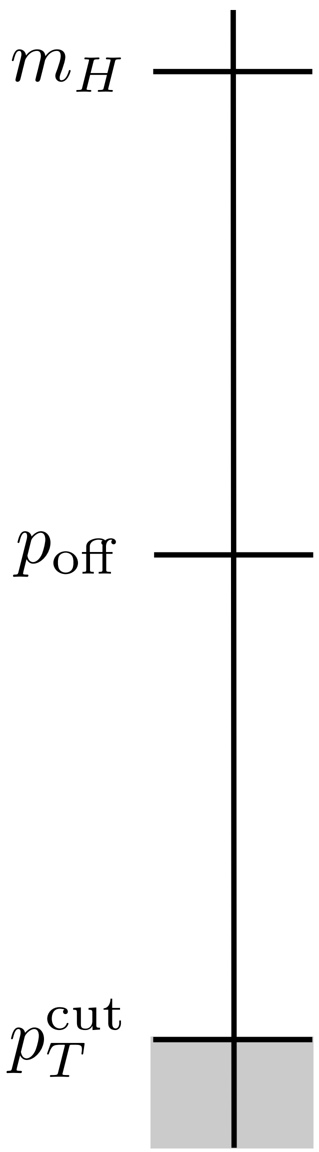
} take envelope in each case

scale variation more subjective than fixed order

same basic ideas can be reapplied to other resummed cross sections (e.g. 1-jet)

Open Questions: 1-Jet Bin

two regions of p_{TJ} for 1-jet bin



$p_T^{\mathrm{cut}} \ll p_{TJ} \sim m_H$

resummation performed by Petriello, Liu

looking at common uncertainty scheme

currently described with FO

$p_T^{\mathrm{cut}} \sim p_{TJ} \ll m_H$

what uncertainty is correct?
direct scale variation may have pinches
looking at options