

# Modelling and tuning in precision physics

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# Monte-Carlo usage

Monte-Carlo Event Generators generally used in two different ways

## Theory prediction

- parameters in perturbative regime dictated by first principles or theory bias
- non-perturbative parameters determined universally in well-defined limited set of observables (same as PDFs)

## Data modelling

- all available parameters tuned to best reproduce measured data of specific process
- resulting distribution not predictive, but very useful to determine acceptances, efficiencies, etc.

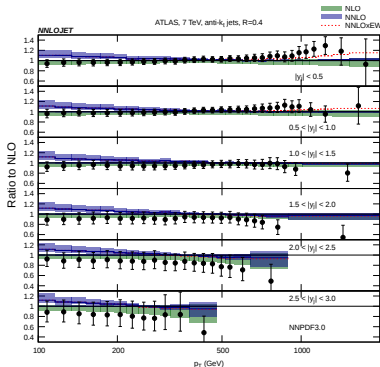
**Both valid use cases, but need to be aware which one one is using**

# Distributions used for tuning

Currie, Glover, Pires arXiv:1611.01460

## Example: PDF fits & incl. jet $p_T$

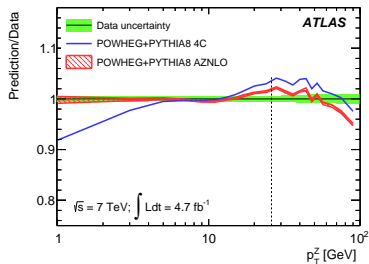
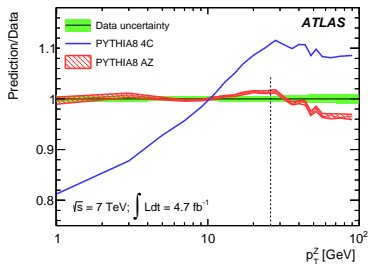
- input distribution in PDF fits
- up to recently fitted with NLO theory  
→ NLO curve is closure test
- NNLO was not used in the fit (and uses different scales than used in the fit)  
→ cannot close



**No predictions can be made for distributions that have been used to fit the non-perturbative models**



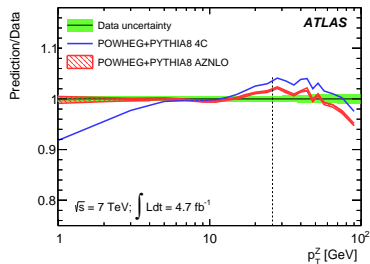
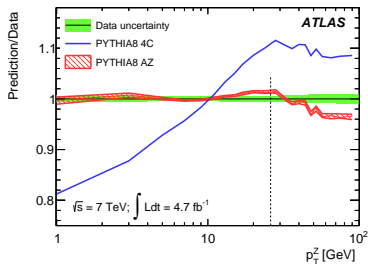
# Distributions used for tuning



- separate tune for LO and NLO to describe  $p_T(Z)$  best despite limited theoretical precision
- not a prediction anymore  
no problem for unfolding etc., problem for  $p_T(W)/p_T(Z)$

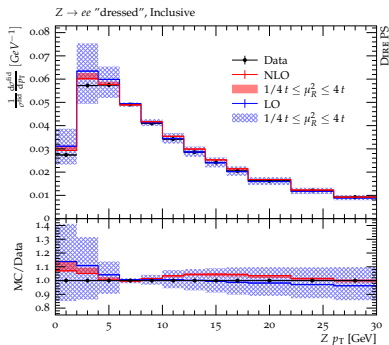
⇒ Way out: Find a proxy to constrain model, use here.  
Assess tuning and perturbative uncertainties.

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- ⇒ **Way out: Find a proxy to constrain model, use here.  
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# Parton shower uncertainties



- Parton Shower central value much better than it should be given its uncertainties
- ⇒ Just because it describes data reasonably well, does not mean its precision is equally good

# Conclusions

It is important to clearly distinguish the (at least) two types of MC Event Generator usage: theory prediction  $\leftrightarrow$  data reproduction.

**Do not mix and match!**

## Data reproduction:

- Good for what they have been fitted to, nothing else.

## Theory prediction:

- fit *non-perturbative* parameters to well-defined set of data.
- All *perturbative* parameters ( $\mu_R$ ,  $\mu_F$ ,  $t_{\text{shower}}^{\text{start}}$ ,  $h_{\text{damp}}$ , etc.) should be put to the **theoretically** preferred value and then varied by a conventional amount to arrive at an uncertainty.  
 $\Rightarrow$  Just because a central value is accurate, does not mean it is precise.
- Mismodelling not necessarily related to need for more tuning.  
Always investigate impact of better theory input.