

# *MC & Tools at Les Houches 2017: summary of the summary*

Emanuele Re

CERN & LAPTh Annecy

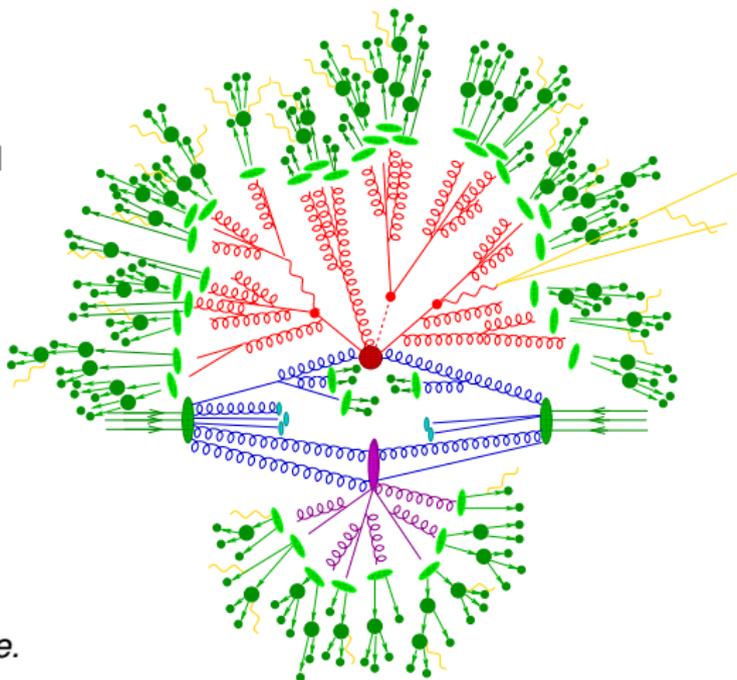


“LHC and the Standard Model: Physics and Tools”  
CERN, 19 June 2017

What we discussed?

1. heavy-flavours in initial and final state
2. resonance-aware NLO+PS
3. perturbative uncertainties & dedicated comparison among different event generators
4. tuning vs. scale variation
5. vector boson scattering

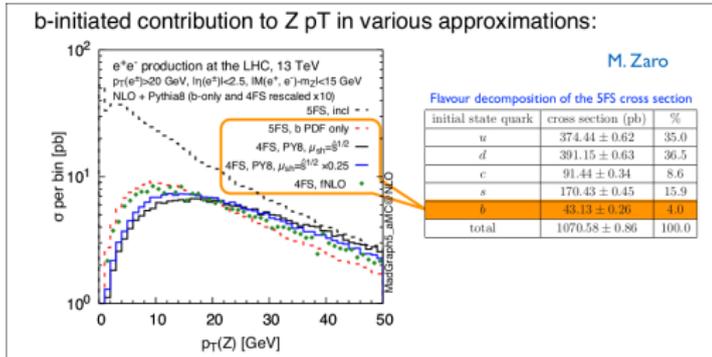
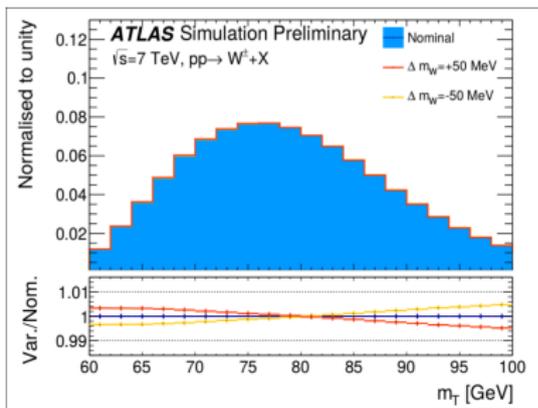
improvements of LHE format (*i.e.* ME $\leftrightarrow$  PS interface)



[sherpa's artistic view]

# heavy flavour in the initial state

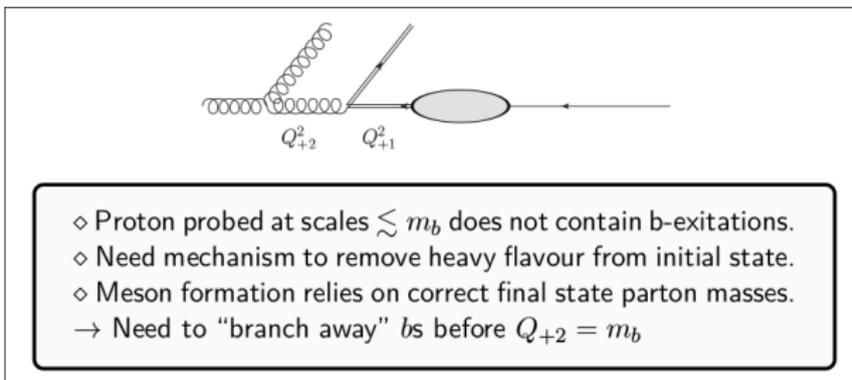
- ▶ **W-mass extraction**: fit to  $Z$  data  $\Rightarrow$  predict  $p_{T,W} \Rightarrow$  template fits.
- ▶ heavy-quark initiated processes have a non-negligible contribution.



[slide from M. Zaro [talk](#) in Louvain, March '17]

# heavy flavour in the initial state

- ▶ in a PS generator, approximations (and modelling) are needed; each generator adopt, in general, different choices.



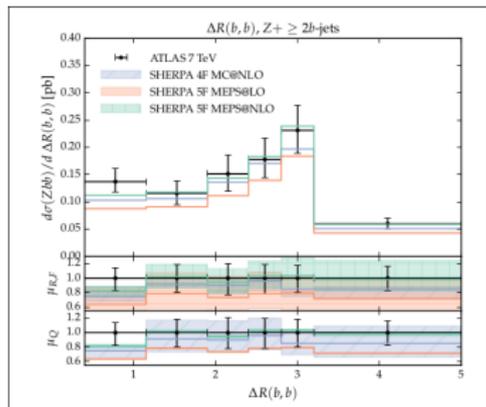
[from S. Prestel talk at LH]

## ★ study how different implementations of flavour excitation (spacelike $g \rightarrow Q\bar{Q}$ ) affect the $p_{T,Z}$ and $p_{T,W}$ shape, and the leptonic distributions:

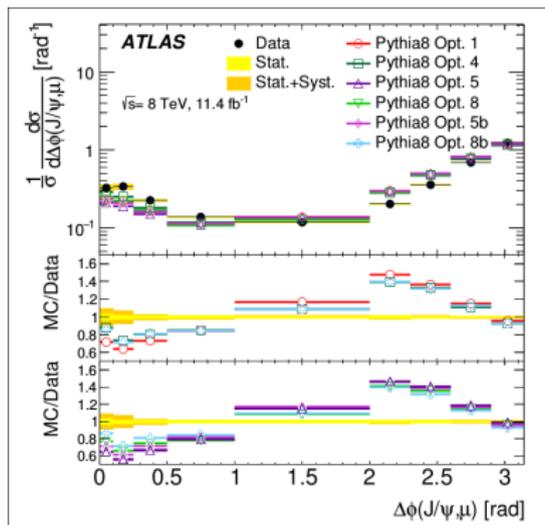
- . (at least part of) these effects were studied in the ATLAS W-mass paper (with Pythia8)
- . further ongoing studies [Bagnaschi, Maltoni, Vicini, Zaro; in progress]
- . we'll try to be complementary to the discussions on Thursday (“ $M_W$  topical meeting”).

# heavy flavour in the final state

- ▶ for  $Vb\bar{b}$ , the agreement MC/theory has improved, thanks to the availability of better tools.



[Krauss, Napoletano, Schumann '16]

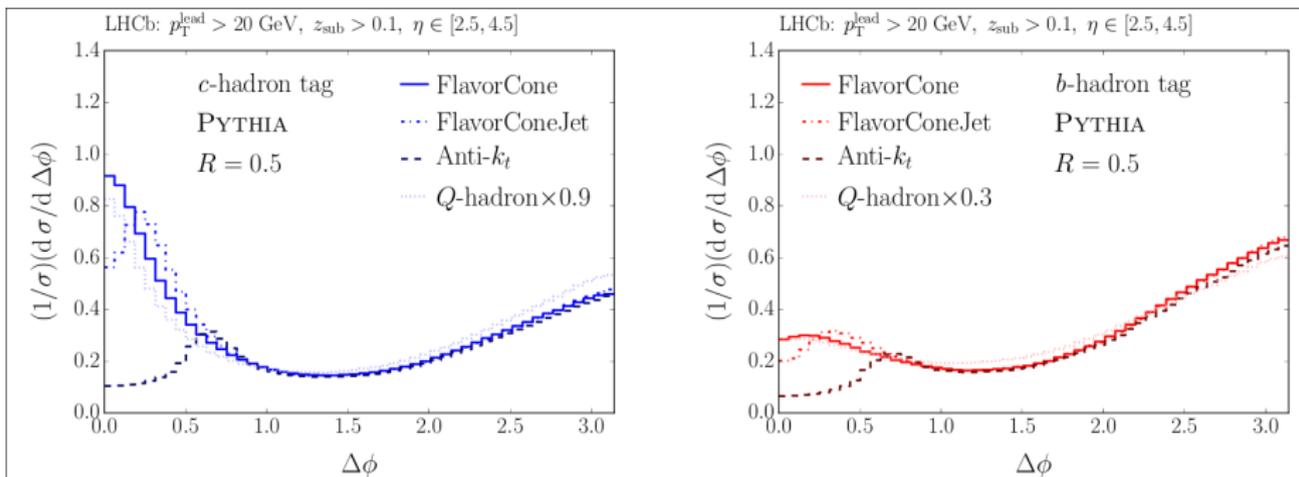


$pp \rightarrow B(J/\Psi(\mu\mu) + X)B(\mu + Y)$  [X-talk last week]

- ▶ improving the **parton-shower modeling** of  $g \rightarrow Q\bar{Q}$  remains an open problem (at least theoretically); new measurements are important to make progress.

# heavy flavour in the final state

- ▶ Can we find observables that inform parton shower developments and improvements?

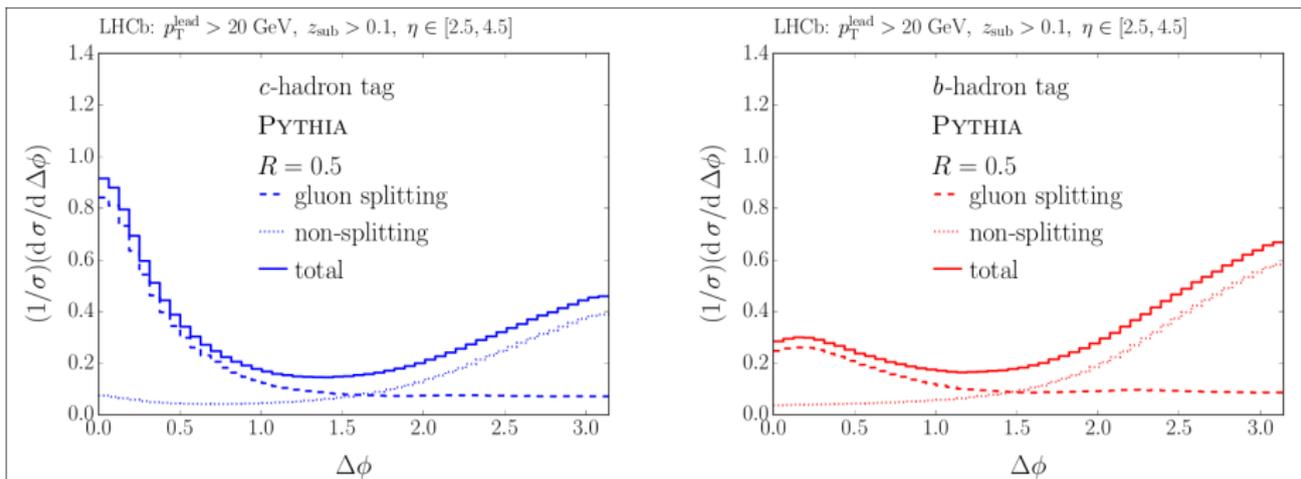


[Ilten et al. '17]

- ★ possible project: assess if using “flavour-aware” jet-algorithms can help in exposing differences among different MC choices.
- . if that is the case: motivation for an experimental measurement / feasibility.

# heavy flavour in the final state

- ▶ Can we find observables that inform parton shower developments and improvements?

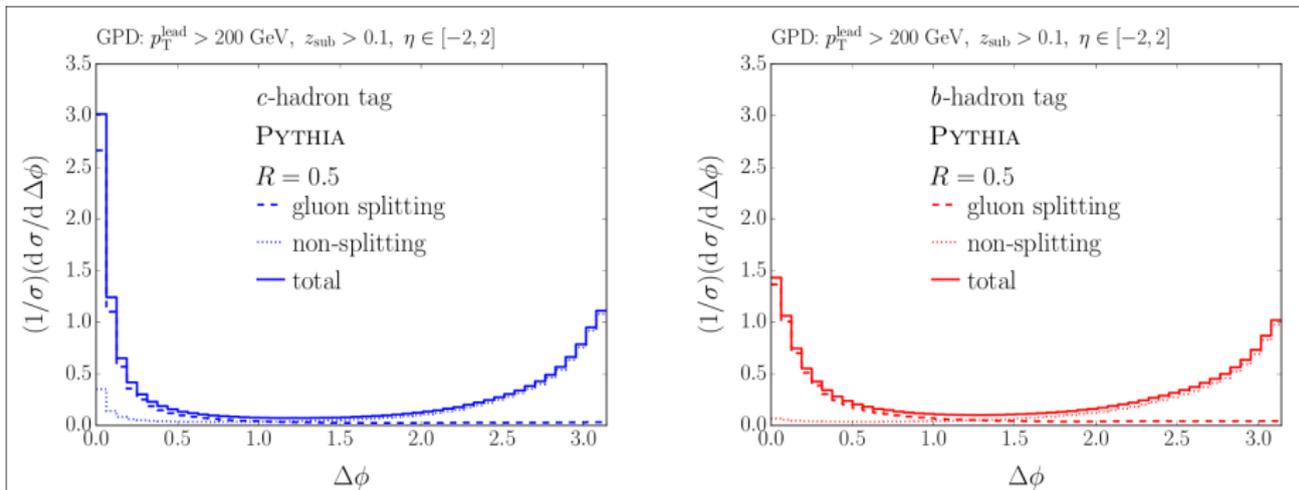


[Itten et al. '17]

- ★ possible project: assess if using “flavour-aware” jet-algorithms can help in exposing differences among different MC choices.
- . if that is the case: motivation for an experimental measurement / feasibility.

# heavy flavour in the final state

- ▶ Can we find observables that inform parton shower developments and improvements?



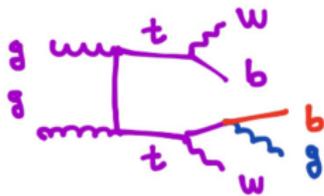
[Ilten et al. '17]

- ★ possible project: assess if using “flavour-aware” jet-algorithms can help in exposing differences among different MC choices.
  - if that is the case: motivation for an experimental measurement / feasibility.

# NLO+PS & intermediate resonances

- ▶ **measurement of the top mass**: likely to be achieved from **combination of different strategies**: total x-section,  $t\bar{t}$  + jet, leptonic spectra,  $b\bar{b}$  endpoint and distribution,...

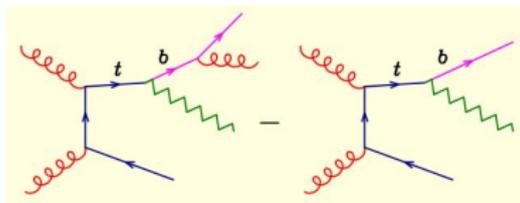
[see e.g. [TOP LHC Working Group](#)]



[figure credit: R. Franceschini]

- ▶ some techniques rely on looking into the kinematics of visible particles from top-decay;
- ▶ important that simulations are as accurate as possible, and associated uncertainties are quantified.

- ▶ The problem, in a nutshell: (in the POWHEG context)



$$d\sigma = d\Phi_{\text{rad}} \bar{B}(\Phi_B) \frac{R(\Phi_B, \Phi_{\text{rad}})}{B(\Phi_B)} \times \exp \left[ - \int \frac{R(\Phi_B, \Phi_{\text{rad}})}{B(\Phi_B)} d\Phi_{\text{rad}} \right]$$

- $\Phi_B \rightarrow (\Phi_B, \Phi_{\text{rad}})$  mapping doesn't preserve virtuality:
  - $R/B$  can become large also far from collinear singularity, but it shouldn't.
- POWHEG radiation should have a well-defined resonance assignment, otherwise the shower will not preserve invariant masses, **distorting the BW shape**:
  - need to define a resonance history.

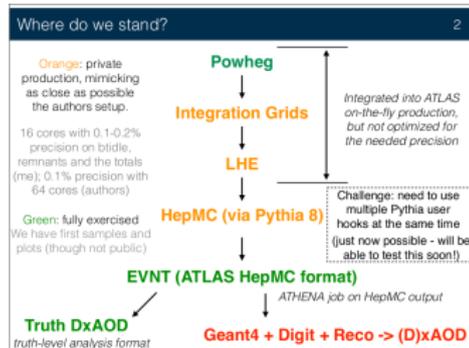
# NLO+PS & intermediate resonances

- ▶ ongoing phenomenological study on the impact on top mass extraction

[Ferrario-Ravasio, Jezo, Nason, Oleari; in progress]

- ▶ in the context of the [TOP LHC Working Group](#), this is a quite active field; we had a session with many of the people involved (TH, ATLAS and CMS)

- discussed how to validate (and optimize) the use of these new tools (in ATLAS and CMS), in the context of the  $m_t$  extraction



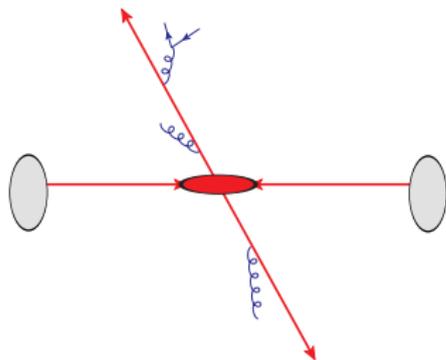
[slide: B. Nachman]

## ★ possible activities:

- ▶ EXP study comparing matching to [Pythia8](#) vs. [Herwig7](#)
- ▶ [single-top t-channel](#): resonance-aware POWHEG vs. MC@NLO

# perturbative uncertainties in MC generators

## Sources of uncertainty & correlations



### Uncertainties:

Short-distance cross section:

$$\mu_r^H, \mu_f^H, \text{PDF}^H, \alpha_s^H$$

Parton shower:

$$\mu_q^{PS}, \mu_r^{PS}, \mu_f^{PS}, \mu_{cut}^{PS}, \text{PDF}^{PS}, \alpha_s^{PS}$$

### ...correlated with:

$\mu_f^H$  with shower starting scale

$\mu_f^H, \text{PDF}^H$  with MPI

$\mu_q^{PS} / \mu_f^H$  and  $\text{PDF}^{PS} / \text{PDF}^H$

$\mu_r^{PS} / \mu_r^H$  and  $\alpha_s^{PS} / \alpha_s^H$  for NLO+PS

$\mu_{cut}^{PS}$  with "string  $p_\perp$ " & "primordial  $k_\perp$ "

1. Parton showers "undo" PDF evolution.
2. Short-distance x-sections for matching assume certain PS settings.
3. Hadron  $p_T$ s can be non-perturbative, or inherited from partons

Towards uncertainty recommendations?

---

Goal: Find consensus how to vary  $\mu_f^H$ ,  $\mu_r^H$  and  $\mu_q^{PS}$ .

If we find consensus, can we add  $\mu_r^{PS}$  and  $\mu_f^{PS}$  to the mix?

One possible way to find consensus could be to adopt conservative consistency conditions, e.g.:

◇ Backwards evolution of initial state showers allows only small differences of  $\mu_f^H$  and  $\mu_q^{PS}$

# perturbative uncertainties in MC generators

- ▶ probably we are not yet in the position of addressing this issue properly, **for the scales entering the PS evolution**
- ▶ but we agree on the allowed variations for the other scales
  
- ★ **(tentative) plan: detailed comparison of several MC generators.**
  - Drell-Yan;
  - several observables, without including non-perturbative effects;
  - first, look at scale variations in hard scattering and matching;
  - as a second step, possible to also look into scales in parton-shower.
  
- ▶ by having a **comparison with analytic resummation** (where available), hopefully we'll gain some insight on how to address the original question