

# The Heavy-Flavor Production Fraction Reweighting Procedure in ATLAS

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## Motivation

Flavor tagging is one of the key experimental techniques in ATLAS. The  $c$ - and  $b$ -tagging efficiencies vary among the different MC shower simulations, affecting the modeling uncertainties associated with flavor tagging. A dominant cause is the different heavy-flavor production fractions among the MC shower generators. A new analysis tool, the **HFProductionFractionTool**, is introduced, with a purpose to reweight the production fractions in MC to the common world-average values.

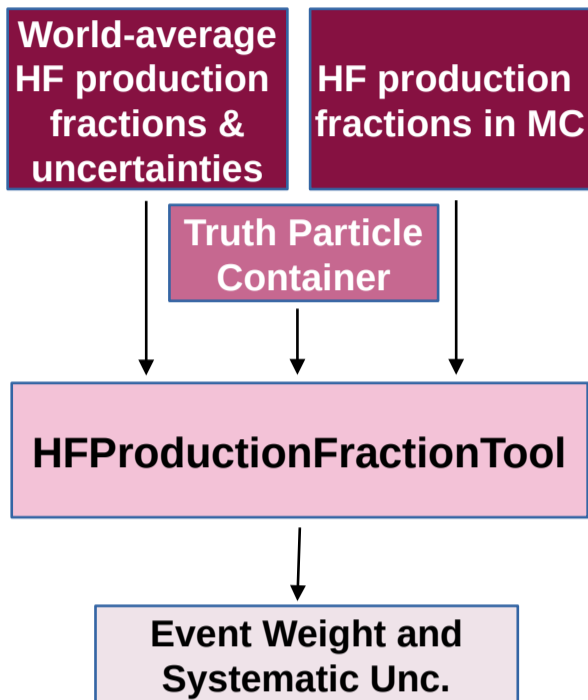
## Tool description

Selection of truth heavy-flavor hadron → Specification of event weight

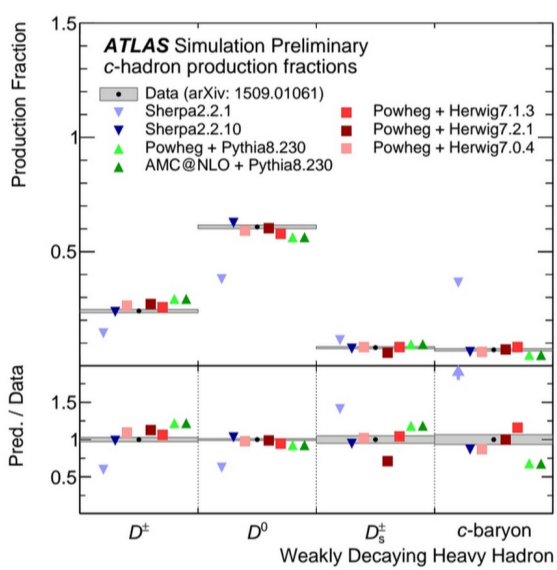
$$w = \prod_{HF \in V_{fid}} \frac{f^{Data}(HF)}{f^{MC}(HF)} \quad \leftarrow \text{World-average HF production fraction}$$

$$\quad \quad \quad \leftarrow \text{HF production fraction in MC}$$

In addition to the nominal event weight the tool provides five event weight variations which are summed in quadrature to derive the final uncertainty.



## Heavy-flavor production fractions

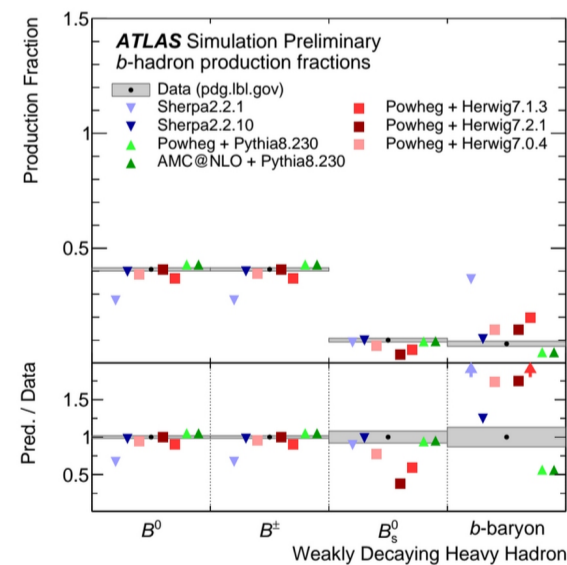


The HF production fractions in the simulated samples are calculated by counting the fraction of final state hadrons from  $c$ - and  $b$ -quarks

- Exclude  $c$ -hadrons from  $b$ -hadron decays
- Kinematic cuts:  $|\eta(HF)| < 2.5$  &  $p_T(HF) > 5\text{GeV}$

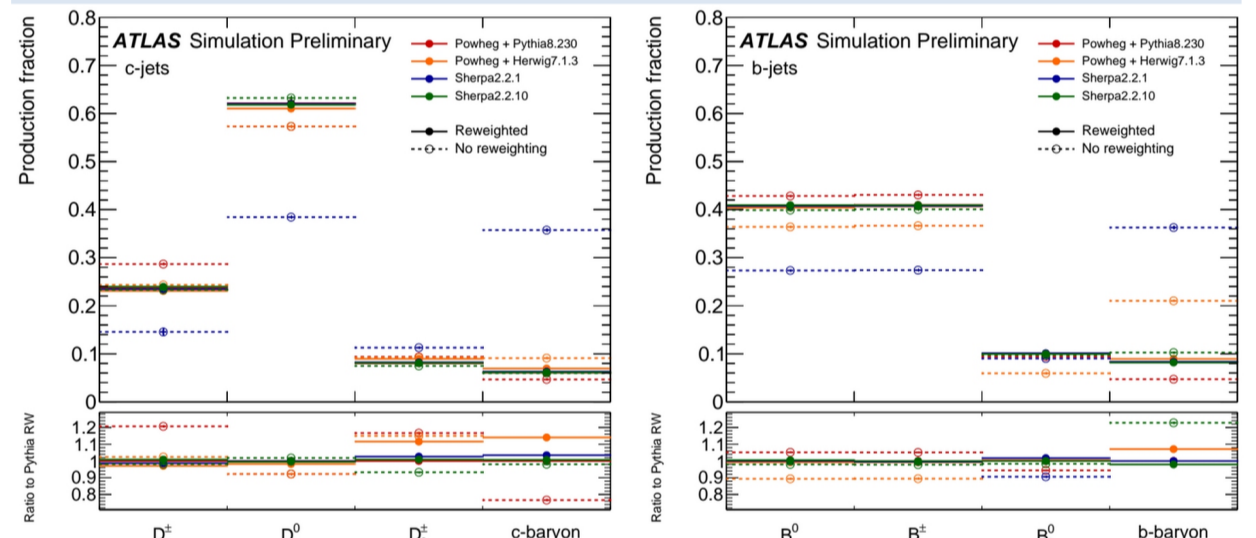
## Systematic uncertainties

- Eigenvector variations of the measurements, using their correlation matrices
- A set of alternative HF production fractions for each eigenvector variation (three for  $c$ -hadrons and two for  $b$ -hadrons- equal  $B^0$  and  $B^\pm$  production fractions)



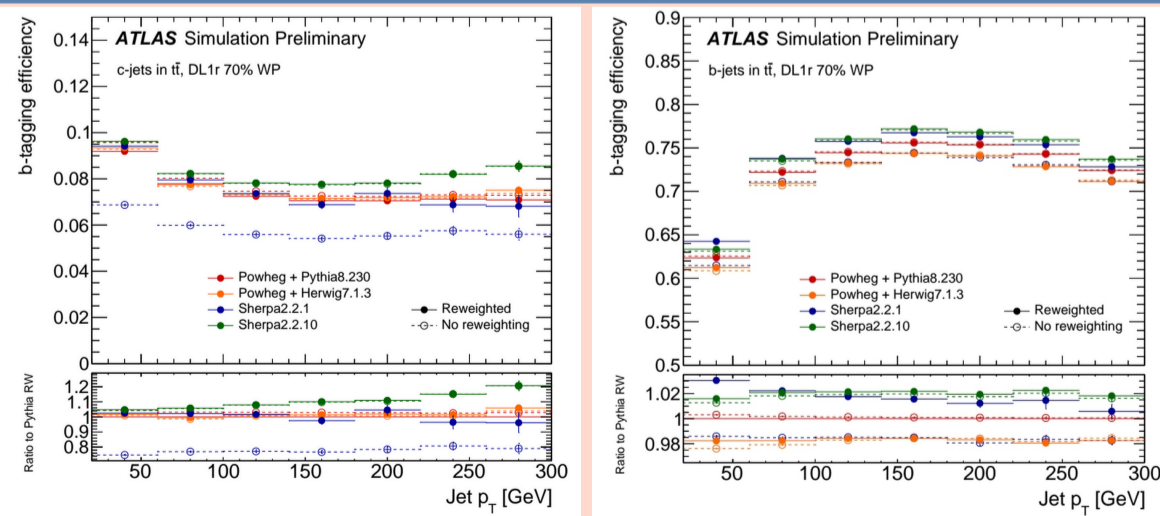
## Validation

$t\bar{t}$  samples generated with different MC shower software



- The production fractions before the reweighting (dashed lines) show large difference between the MC shower generators
- Sherpa2.2.1 has the worst agreement, with a very large baryon fraction
- The reweighting is done independently of the jet selection, only using the content of the truth hadron collection in MC
- After the weight from the tool is applied any large disagreement between the samples is eliminated

## Results

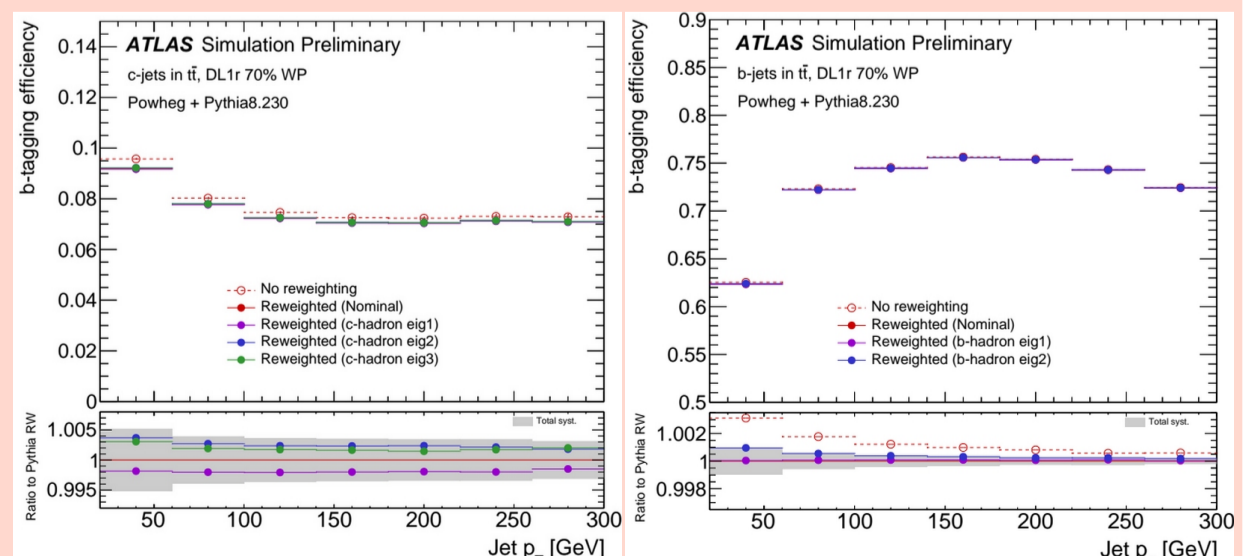


Usage of the tool:

- Directly by specialized analyses sensitive to heavy-flavor production fractions
- Part of the central heavy-flavor tagging calibration

After reweighting:

- Sherpa2.2.1 matches other samples within about 2%
- Still some differences between MC shower generators (due to difference in BRs and fragmentation functions)
- Less than 1% uncertainty (smaller for  $b$ - than  $c$ -jets)



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