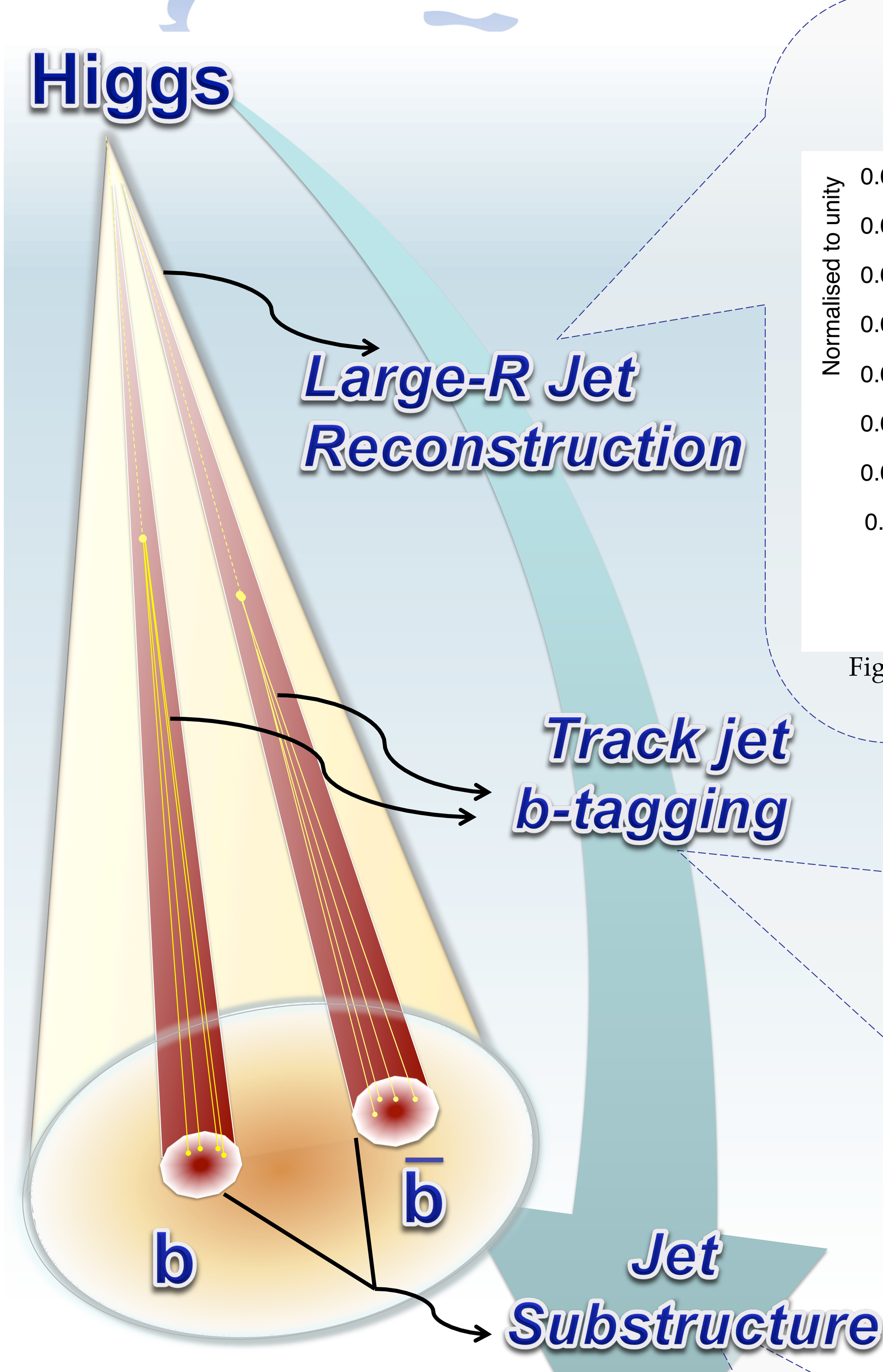
# Boosted H→$b\bar{b}$ Tagger In Run II

*Merve Sahinsoy*

On behalf of *the ATLAS Collaboration @ ICHEP 2016*

*Abstract*

Several searches for Higgs bosons decaying to b-quark pairs benefit from the increased Run II centre-of-mass energy by exploiting the large transverse momentum (boosted) Higgs boson regime, where the two b-jets are merged into one large-radius jet. ATLAS uses a boosted H→bb tagger algorithm [1] to separate the Higgs signal from the background processes.




- *Anti-kt R=1.0 (large-R) jets*
- *Pile-up and underlying event contamination removed with trimming, using $f_{cut}$ = 0.05 and $R_{subjet}$ = 0.2 [2]*

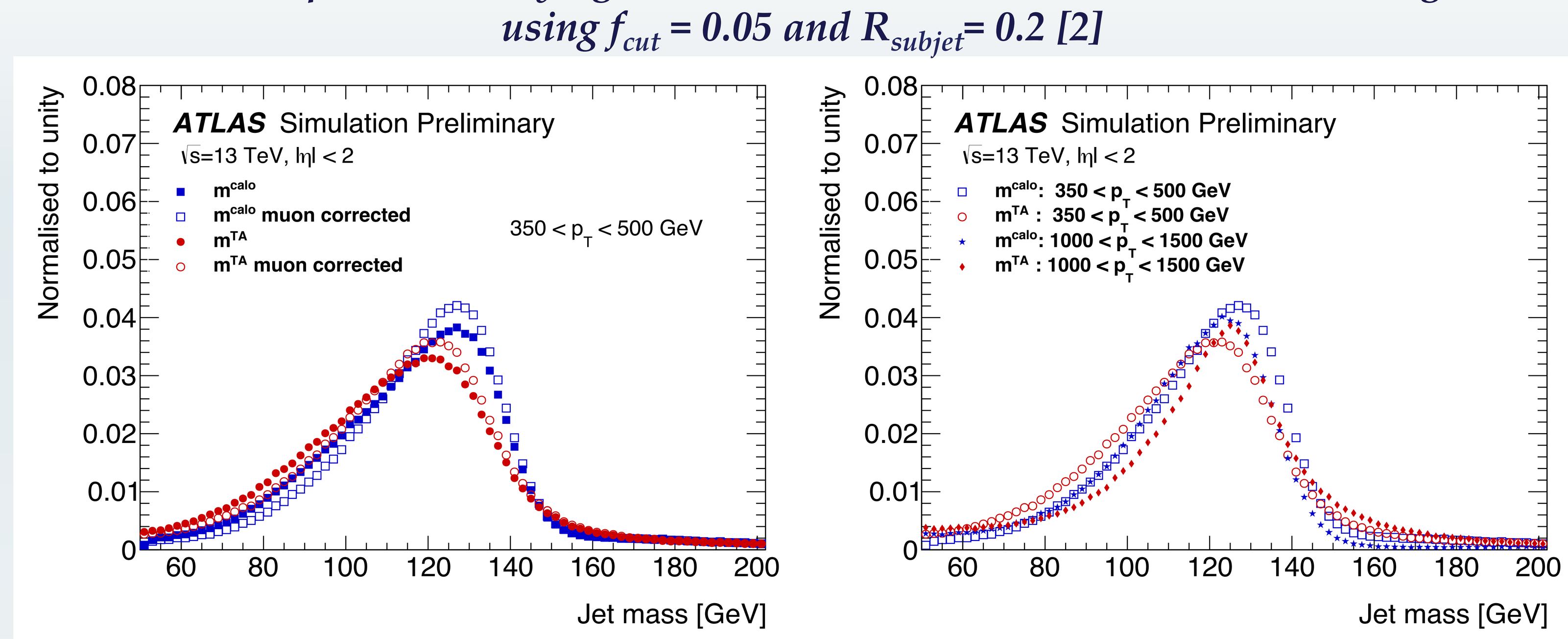



Figure 1: The calibrated and muon corrected $m^{calo}$ and $m^{TA}$ are shown for different $p_T$ ranges. The effect of the muon correction is shown for $m^{calo}$ and $m^{TA}$.

**Jet Mass:**
Calorimeter mass ($m^{calo}$) and track-assisted mass[3] ($m^{TA}$) are studied, while $m^{calo}$ is used to define the benchmarks.

$$m^{TA} = m^{track} \times \frac{p_T^{calo}}{p_T^{track}}$$

**Muon in Jet Correction**
Correction for muonic decays of b hadrons.
Find closest muons to any R=0.2 track jet within the large-R jet.
Add their momentum to the large-R jet ( affects $m^{calo}$ and $p_T^{calo}$).

**Mass Window Cuts**
Tight : 76 GeV < $m^{calo}$ < 146 GeV (68% of the mass distr.)
Loose : 93 GeV < $m^{calo}$ < 134 GeV (90% of the mass distr.)

***Improved mass resolution: with muon correction and combination of $m^{TA}$ & $m^{calo}$.***

- *Anti-kt R=0.2 (small-R) track jets to identify b-jets*
- *Associate them to the large-R jet area*

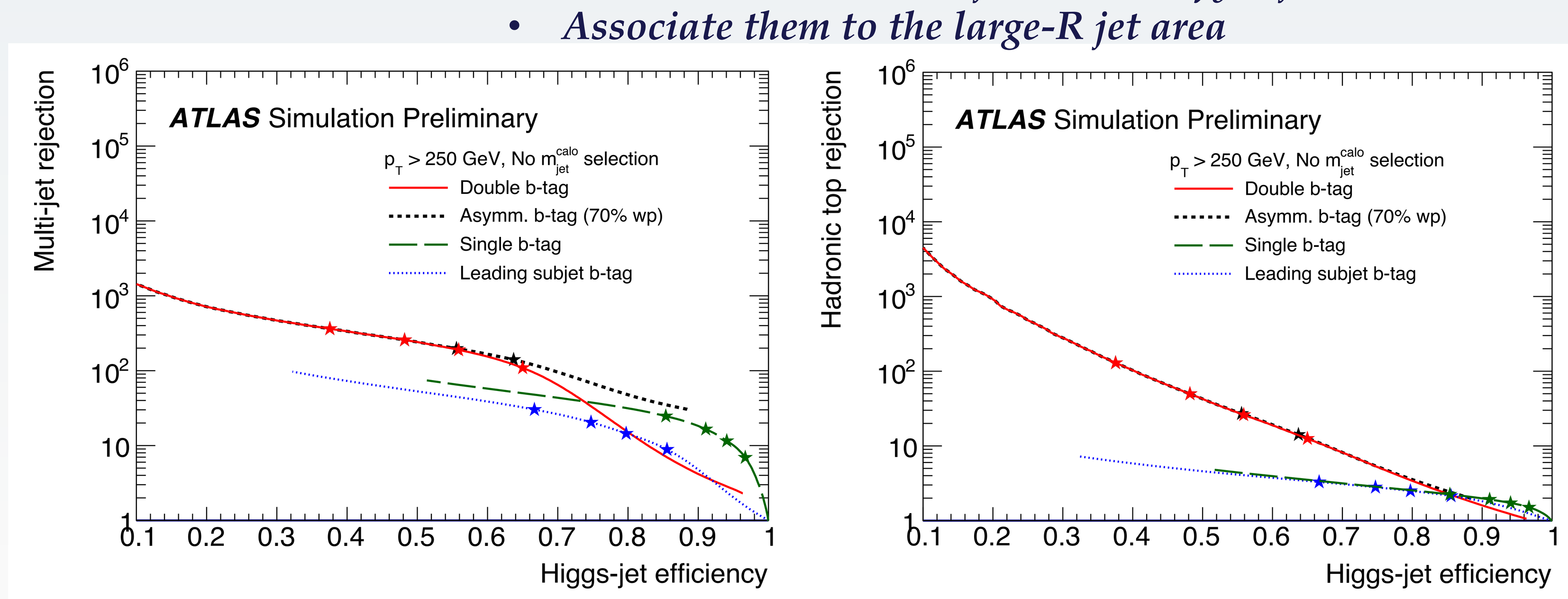



Figure 2: The rejection of inclusive multi-jets (hadronic top) versus Higgs-jet efficiency using large-R jets with $p_T$ > 250 GeV on the left (right), for various b-tagging requirements. The stars correspond to the 60%, 70%, 77% and 85% b-tagging WPs from left to right.

**Double b-tagging:** The two leading $p_T$ track jets must both pass the same *b*-tagging requirement.

**Asymmetric b-tagging:** Of the two leading $p_T$ track jets, the track jet with the largest *b*-tagging weight must pass the fixed 60%, 70%, 77% or 85% *b*-tagging working point threshold, while the *b*-tagging requirement of the other jet is varied.

**Leading subjet single b-tagging:** Only the leading $p_T$ track jet must pass the *b*-tagging requirement.

**Single b-tagging:** At least one of the two leading $p_T$ track jets must pass the *b*-tagging requirement.

## Boosted Higgs Tagging

Internal structure of a jet is useful discriminator. To discriminate Higgs jet from the multi-jet and hadronic top decays, $D_2^{(\beta=1)}$ substructure variable[4] is used. It is defined as a ratio of the two and three point **energy correlation functions**.

## Performance of the Tagger

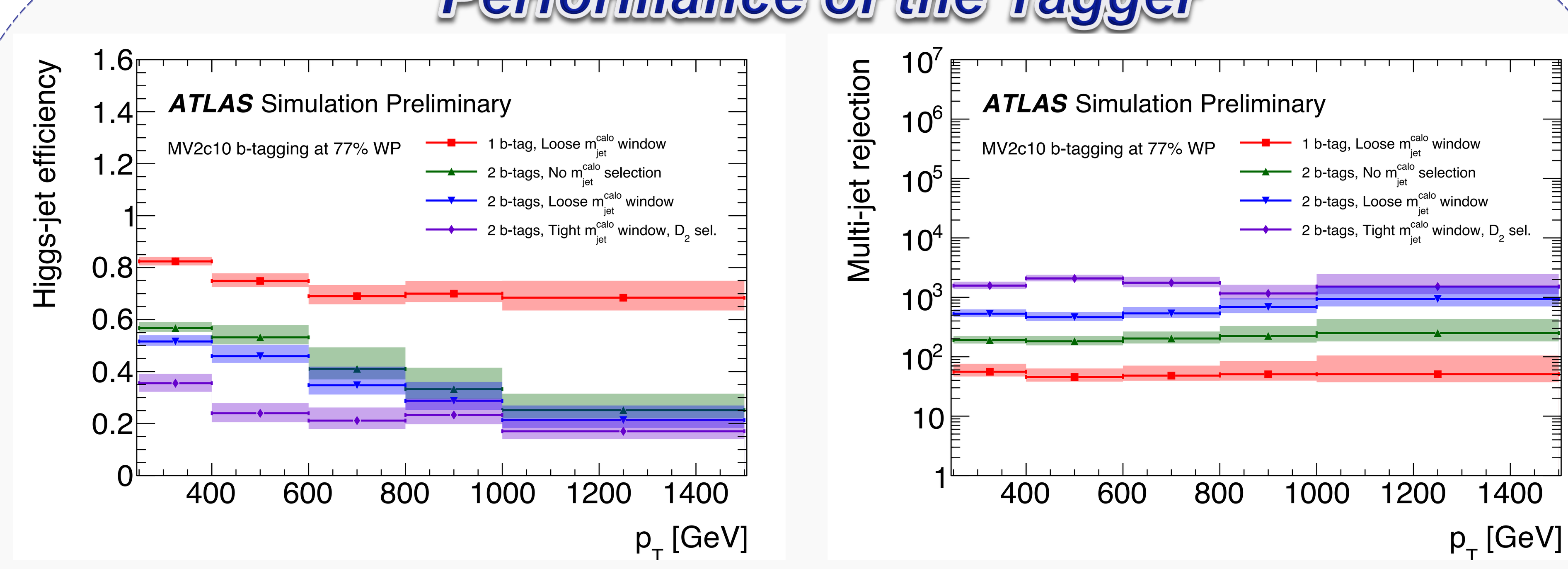
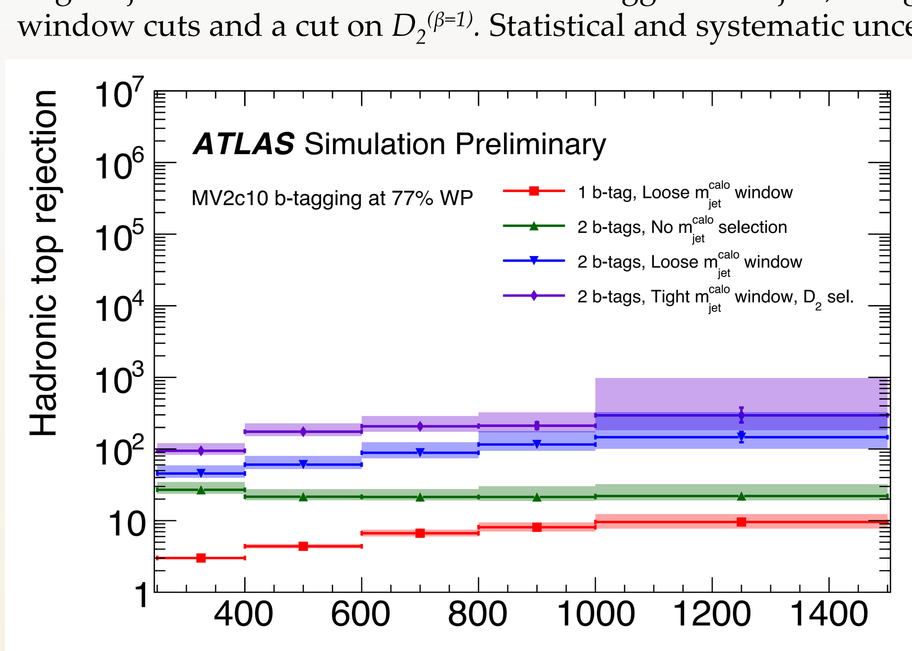



Figure 3: Higgs-jet signal efficiency, Multi-jet background rejection and Hadronic top background rejection as a function of the $p_T$ of large-*R* jets with one or two associated *b*-tagged track jets, using the 77% *b*-tagging WP, and requiring various Higgs-jet mass window cuts and a cut on $D_2^{(\beta=1)}$. Statistical and systematic uncertainties are given in shaded bands.

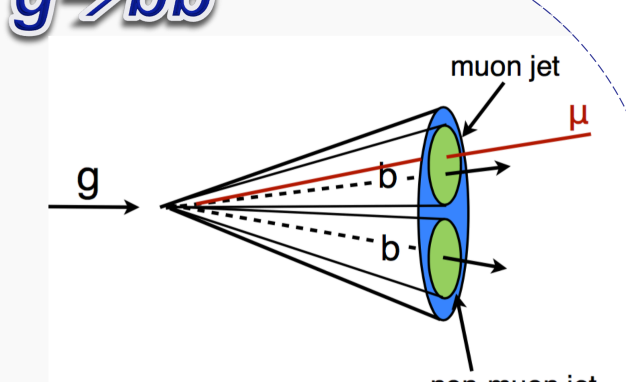



Several benchmarks are defined and provided for the analysers together with the uncertainties.

**Single:**
**at least 1 b-tag + 90% Higgs efficiency mass cut**
**Very Loose:**
**double b-tag**
**Loose:**
**double b-tag + 90% Higgs efficiency mass cut**
**Medium:**
**double b-tag + 68% Higgs efficiency mass cut**
**Tight:**
**Medium + Cut on $D_2^{(\beta=1)}$**

## Data/MC Studies with $g \to b\bar{b}$

- Cross check the performance of **b-tagging and modelling of jet substructure** variables
- Use di-jet events, select muons for b enriched samples
- Correct flavor fractions in MC with impact parameter significance fit for muon and non-muon track-jets



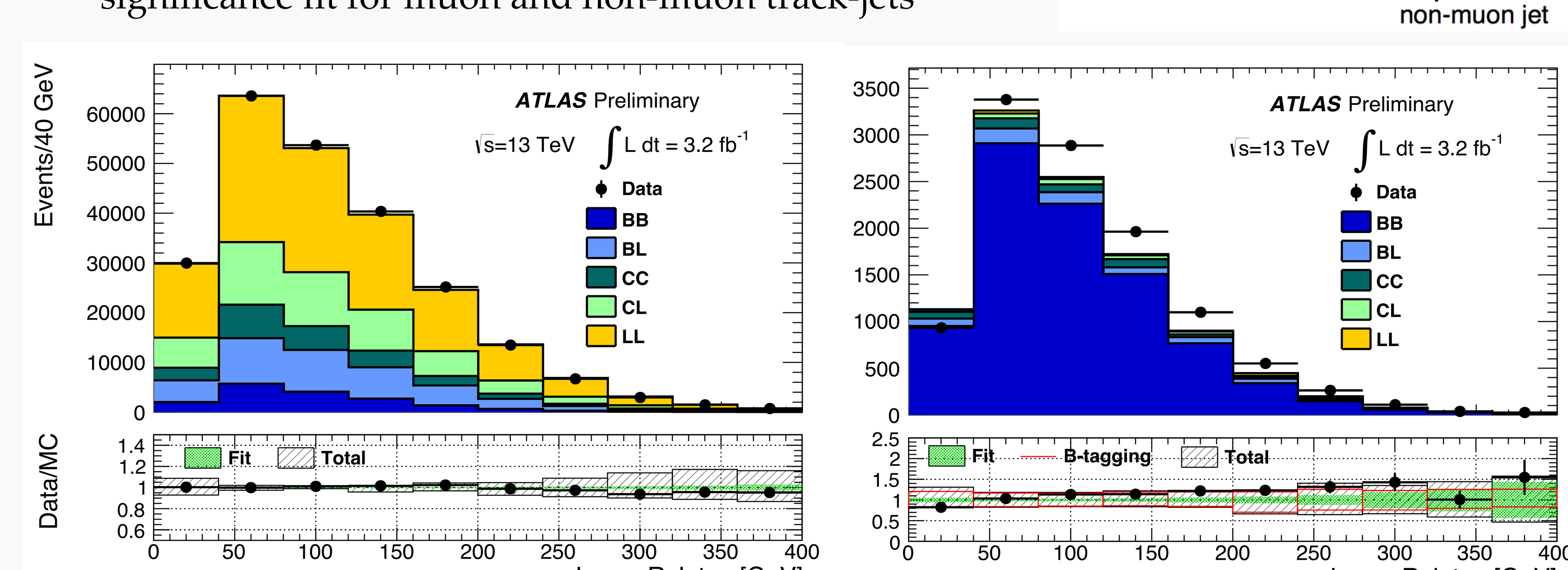




Figure 4: Large-R jet mass distribution before and after b-tagging. The lower panel shows the ratios of the distributions measured in data to their predictions, indicating the uncertainty on the predictions resulting from the template fitting procedure, from the limited simulated sample sizes, jet energy, mass and $D_2^{(\beta=1)}$ scale and resolution uncertainties, b-tagging systematics and their combination.

- Data/MC comparison is shown in figure 5 for double b-tagging rate where rate is defined as;

$$\text{rate} = \frac{\text{all selected large-R jets with 2 b-tags}}{\text{all selected large-R jets}}$$

***Applying the flavor correction, good Data/MC agreement within the uncertainties!***

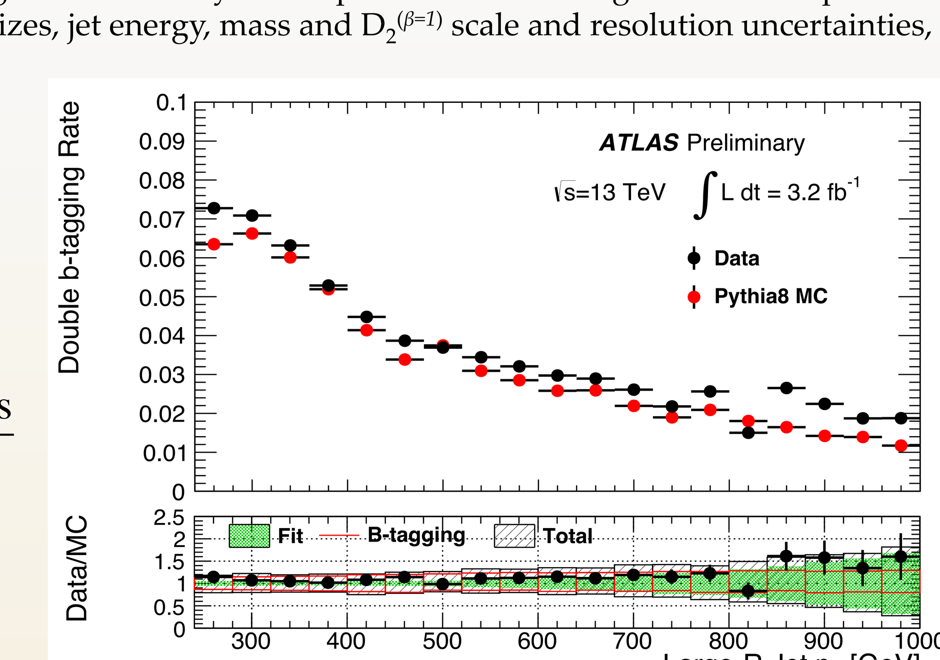



Figure 5: Double b-tagging rate is plotted for both data and MC depending on the large-R jet $p_T$ distributions

***Different Higgs-tagger configurations* have been studied and 5 benchmark taggers are provided for physics analyses.**
***Performance studies with alternative jet mass definitions** are presented.*
***Data/MC comparisons shown for the tagger's performance and good agreement found for the √s=13 TeV ATLAS Run 2 Data.***

References:
1 - ATLAS Collaboration, *Boosted Higgs→bb Boson Identification with the ATLAS Detector at √s=13 TeV*, ATLAS-CONF-2016-039.
2 - D. Krohn, J. Thaler and L.-T. Wang, *Jet Trimming*, JHEP 02 (2010) 084.
3 - ATLAS Collaboration, *Jet mass reconstruction with the ATLAS Detector in early Run 2 data*, ATLAS-CONF-2016-035.
4 - A. J. Larkoski, G. P. Salam and J. Thaler, *Energy Correlation Functions for Jet Substructure*, JHEP 06 (2013) 108.

UNIVERSITÄT HEIDELBERG ZUKUNFT SEIT 1386
KIRCHHOFF-INSTITUTE FOR PHYSICS
HGSFP
ATLAS EXPERIMENT