Single- and and double-differential cross-sections in $t\bar{t}$ final states in the ℓ+jets channel

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Introduction

We present measurements [1] of single and double differential cross-sections in $t\bar{t}$ final states in the ℓ+jets channel, corrected for detector resolution and acceptance effects, and presented as functions of the top-quark as well as and $t\bar{t}$ system kinematic variables and jet multiplicities in data from pp collisions at $\sqrt{s} = 13\,\text{TeV}$ collected in 2015 and 2016 by the ATLAS detector at the LHC, corresponding to luminosity of $36\,\text{fb}^{-1}$.

Data and Simulation

POWHEG+PYTHIA8 $t\bar{t}$ to model corrections. Data-driven estimate of the multijet background, MC-based W/Z+jets and single top events. Total of 1.3M (48k) events in the resolved (boosted) regime, expected purities 89% (86%), 1% (8%) data/prediction agreement.

Unfolding

Resolved and boosted topologies are followed, **particle and parton** results are obtained, **absolute as well as relative** cross-sections are measured. Unfolding summary:

$$\frac{\mathrm{d}^2\sigma}{\mathrm{d}X\,\mathrm{d}Y} = \frac{1}{\mathcal{L}\Delta X\Delta Y}\frac{1}{\epsilon_i}\mathcal{M}_{ij}^{-1}\,f_j^{\text{acc}}\,(D-B)_j\,,$$

where M^{-1} stands for a regularized matrix inversion using the iterative Bayesian method. In the resolved topology, an additional matching correction ensures that objects forming the pseudo top quarks are angularly well matched between the particle and detector levels. In unfolding to the parton level, the acceptance stands for dilepton events removal. In the resolved topology, parton level equals the full phase space, reconstructed using the KLFitter; in the boosted regime, the phase space is limited to partonic top quark $p_{\text{T}} > 350\,\text{GeV}$.

Conclusions

New observables presented, 2D spectra for the first time by ATLAS in the $t\bar{t} \to \ell$+jets. Improved systematics uncertainties in the boosted regime thanks to usage of reclustered jets ($R = 1$ jets built from $R = 0.4$ anti-k_t jets). Measurements provide detailed information on the top-quark production and decay, precision tests of modern MC generators, latest fixed-order calculations. Good agreement between predictions and the data within reduced systematic uncertainties w.r.t. previous ATLAS measurements. Systematics uncertainties dominant in most bins of most of observables. Comparisons to several MC setups are performed, also to different PDFs at the parton level [1].

References

[1] ATLAS Collaboration. Measurements of top-quark pair differential and double-differential cross-sections in the ℓ+jets channel with pp collisions at $\sqrt{s} = 13$ TeV using the ATLAS detector. 2019. `https://arxiv.org/abs/1908.07305`.

Acknowledgements

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Boosted Results

Example of the detector-level data/prediction agreement, and unfolding ingredients for a 1D spectrum in the boosted channel.

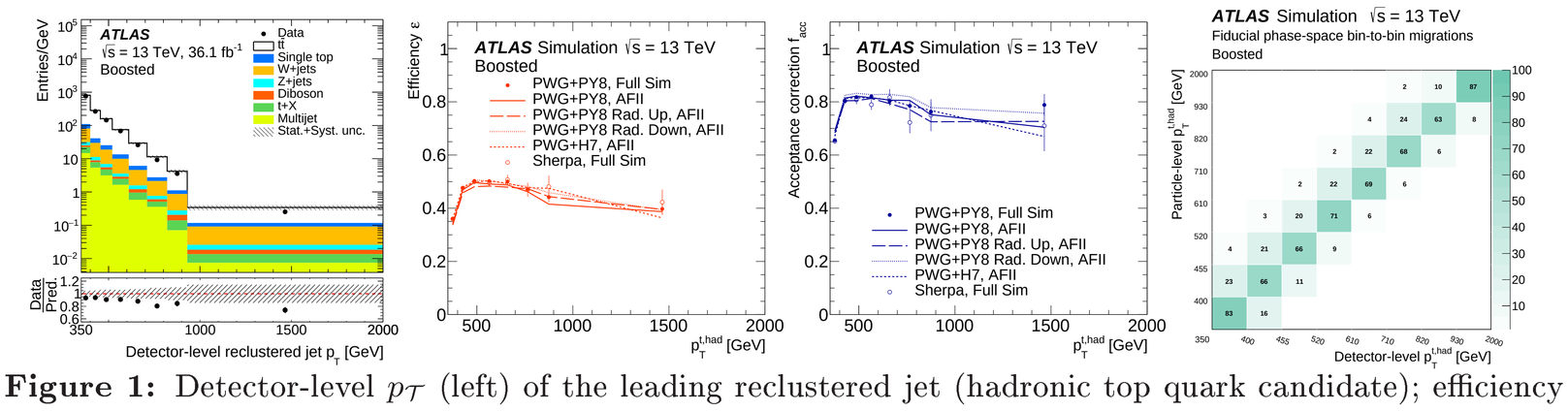

Figure 1: Detector-level $p_{\mathcal{T}}$ (left) of the leading reclustered jet (hadronic top quark candidate); efficiency and dilepton corrections (middle); and the migration matrix (right) between the particle and detector levels.

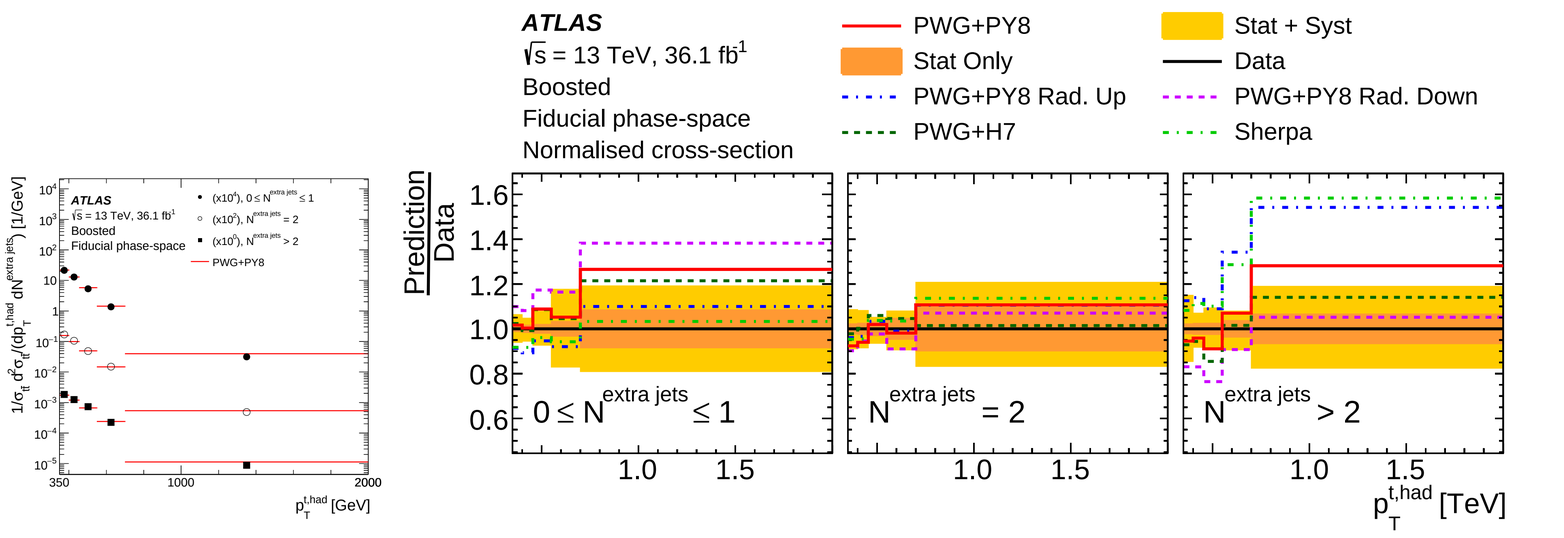

Figure 2: Particle-level normalised differential cross-section as a function of the p_{T} of the hadronically decaying top quark in bins of the number of additional jets in the boosted topology compared with the prediction obtained with the POWHEG+PYTHIA8. In the ratio of the measured cross-section to different Monte Carlo predictions the bands represent the statistical and total uncertainty in the data.

Resolved Results

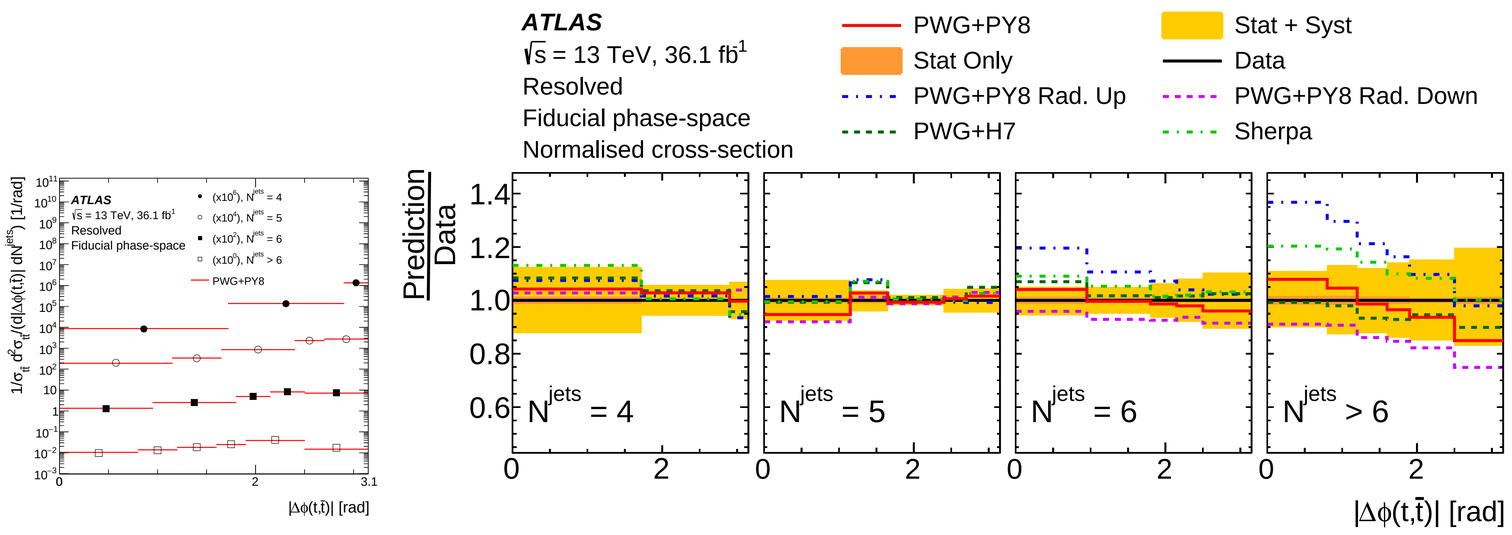

Figure 3: Particle-level normalised differential cross-section as a function of $|\Delta\phi\,(t,\bar{t})|$ in bins of the jet multiplicity in the resolved topology compared with the prediction obtained with the POWHEG+PYTHIA8 MC generator. Int the ratio of the measured cross-section to different Monte Carlo predictions the bands represent the statistical and total uncertainty in the data.

p-values and Resolved and Boosted Comparison

Observable	PP8		PP8 rad. up		PP8 rad. down	
	χ^2/ndf	p-val	χ^2/ndf	p-val	χ^2/ndf	p-val
H_{T}^{tt} vs $N_{\text{jets}}^{\text{extr}}$	9.7/19	0.96	57.9/19	<0.01	19.4/19	0.43
$\lvert p_{\text{out}}^{t,\text{had}}\rvert$ vs $N_{\text{jets}}^{\text{extr}}$	10.8/9	0.29	89.2/9	<0.01	31.9/9	<0.01
$\lvert\Delta\phi(t,\bar{t})\rvert$ vs $N_{\text{jets}}^{\text{extr}}$	21.8/18	0.24	125.0/18	<0.01	31.0/18	0.03
$p_{\text{T}}^{t,\text{had}}$ vs $\lvert p_{\text{out}}^{t,\text{had}}\rvert$	10.5/12	0.57	74.5/12	<0.01	25.3/12	0.01
$p_{\text{T}}^{t,\text{had}}$ vs $N_{\text{jets}}^{\text{extr}}$	14.2/16	0.58	45.7/16	<0.01	37.3/16	<0.01
$\lvert y^{t\bar{t}}\rvert$ vs $p_{\text{T}}^{t\bar{t}}$	28.5/12	<0.01	149.0/12	<0.01	23.2/12	0.03

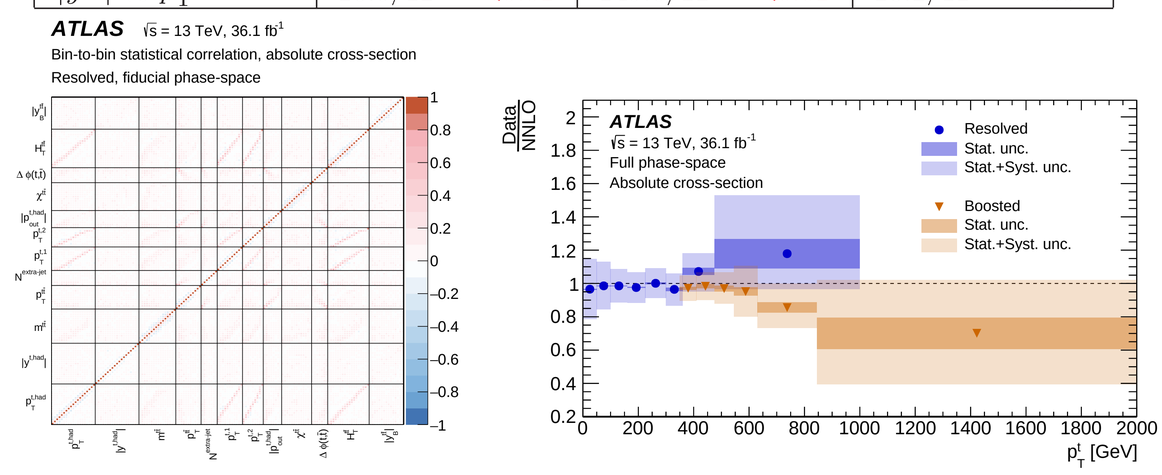

Figure 4: Correlation matrix between bins of distributions for simultaneous MC generators tuning (left). Comparison of data ratio to NNLO QCD in both resolved and boosted regime at the parton level (right).