Differential $t\bar{t}$ cross-sections and EFT limit extraction in boosted events at ATLAS

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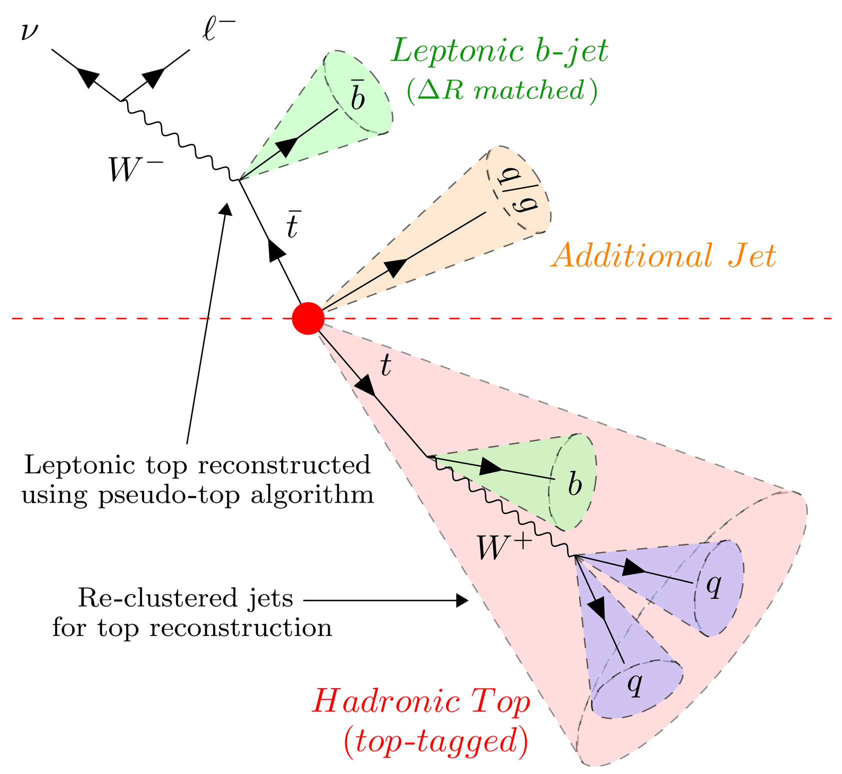
Analysis strategy

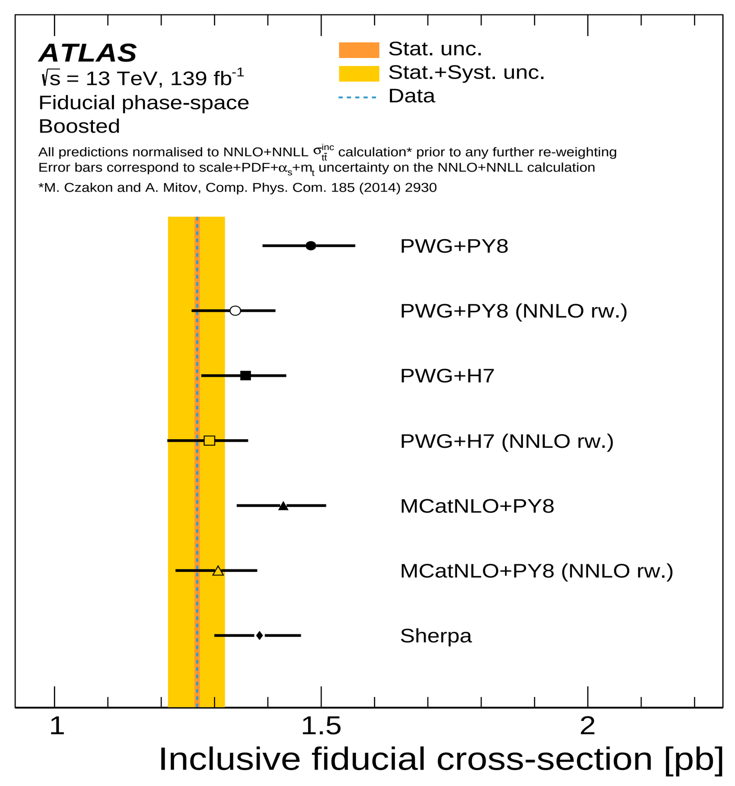
- Differential cross-section measurements of highly boosted $t\bar{t}$ events with additional jets at 139 fb^{-1}
- Select events in lepton+jets channel with:
  1 lepton, 2 b-tagged jets, ≥ 1 high p_T re-clustered R=1 jet with $120 < m$ [GeV] < 220
- Reduce jet energy scale (JES) uncertainty using Jet Scale Factor (JSF) method
- Unfold distributions to particle-level and compare to NLO+PS generators
- Extract limits on two $t\bar{t}$ sensitive EFT operators (O_{tG}, $O^{(8)}_{tq}$) using hadronic top p_T distribution

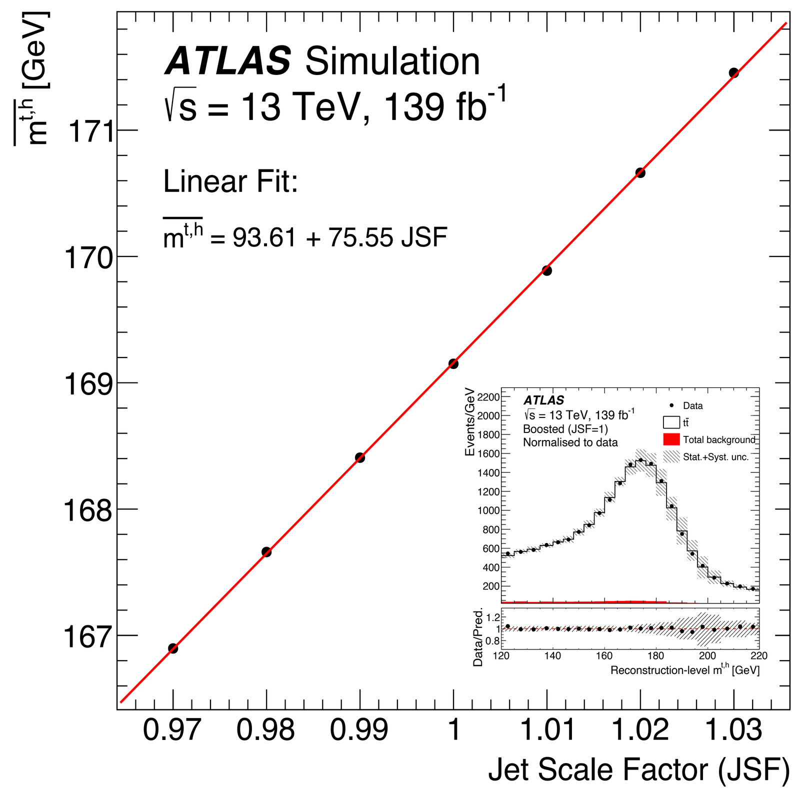


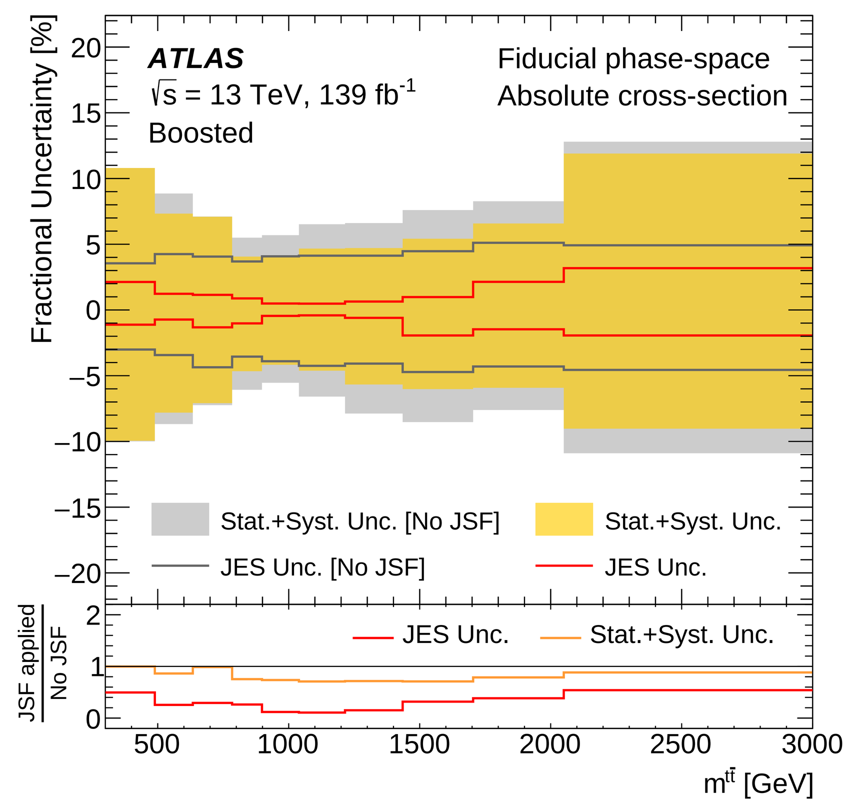
Process	Expected events
$t\bar{t}$	84 200 ± 2600
Single top quark	1710 ± 280
$t\bar{t}V$ ($t\bar{t}W + t\bar{t}Z + t\bar{t}H$)	850 ± 110
Multijet	560 ± 370
W+jets	420 ± 160
Z+jets	84 ± 43
Diboson	41 ± 21
Total prediction	87 900 ± 2700
Data	75 743

Uncertainty reduction

- Use known top-quark mass and top-tagged jet mass ($m^{t,h}$) to reduce impact of JES uncertainties
- Scale jet energies, measure $m^{t,h}$ and derive linear parameterisation between $\overline{m^{t,h}}$ and scaling factor
- Read off value of JSF$_{\text{data}}$ and re-run analysis applying scale-factor to all jet energies
- Significantly reduces impact of JES at expense of increased statistical and $m^{t,h}$ modelling uncertainties
- Cut on $m_{\ell,b} < 180$GeV reduces single-top background uncertainties at high top p_T (by up to 70%)
- Total uncertainty of only **4.2%** on inclusive cross-section (improved from 7.9% at 36 fb^{-1} [1])



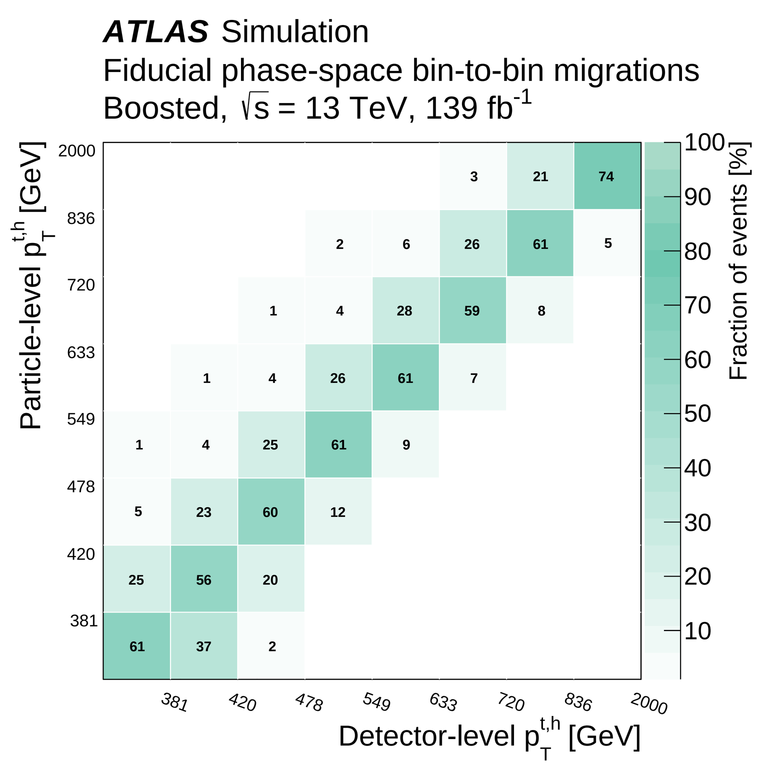


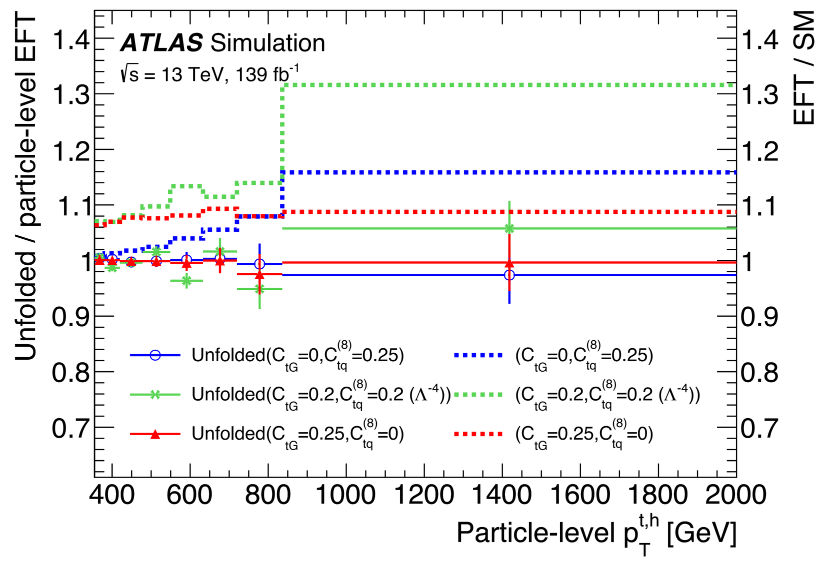


Lines: JES fractional uncertainty with/without JSF method applied

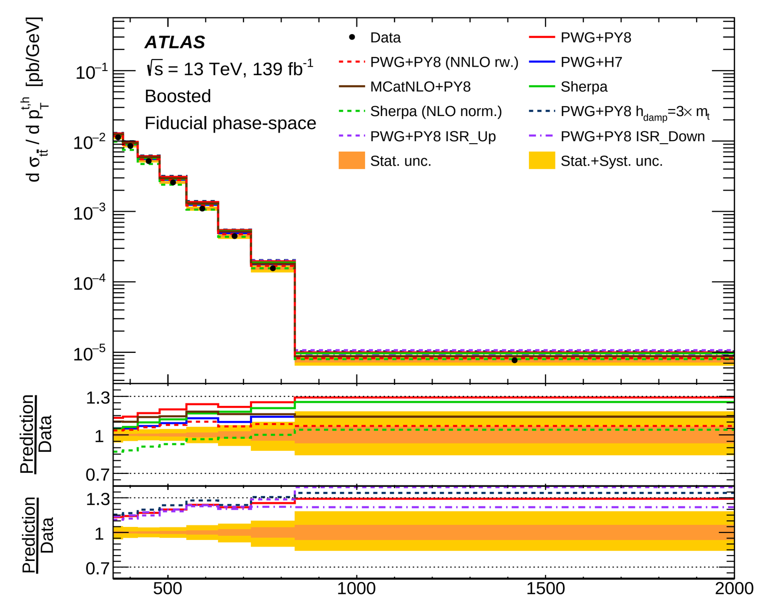
Bands: Total fractional uncertainty with/without JSF method applied

Ratio of JES (total) uncertainty with/without JSF method applied.

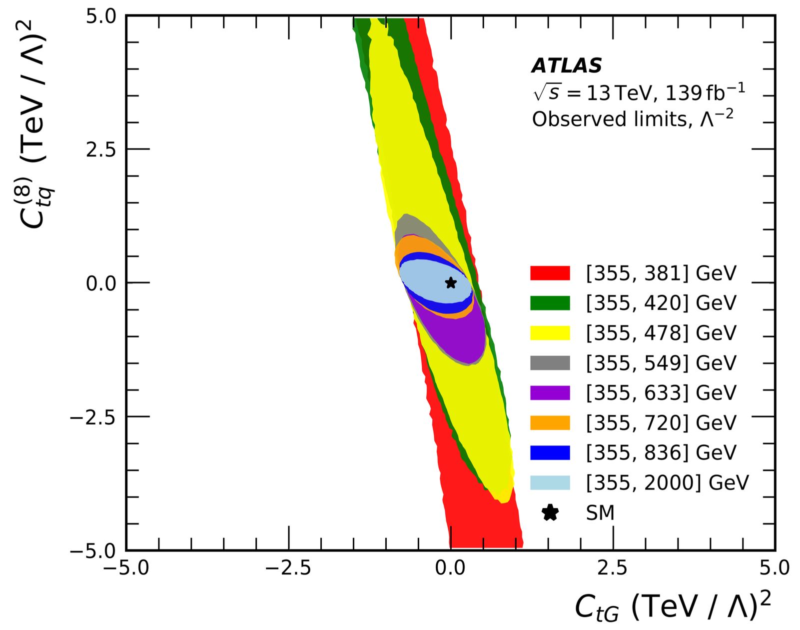




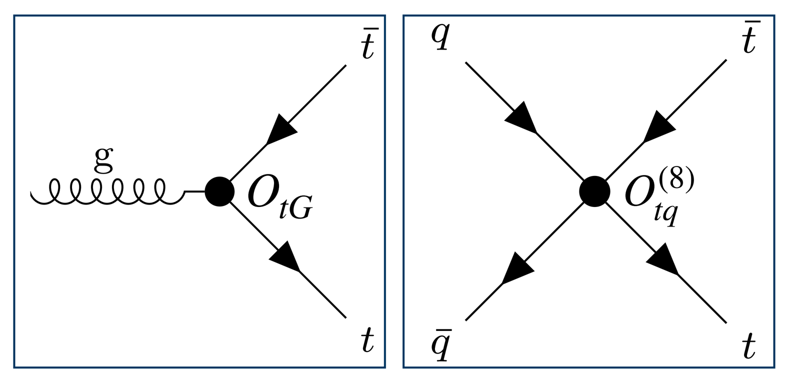
Test of unfolding stability (unfolded/particle-level) in presence of injected EFT contributions

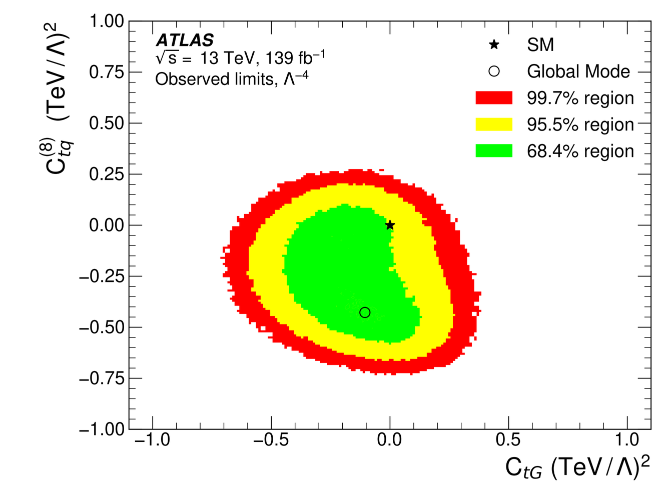


$t\bar{t}$ cross-section in bins of hadronic top p_T



Evolution of 95% credibility area as bins are progressively added to interpretation (Λ^{-2})





Model	C_i $(\Lambda/\text{TeV})^2$	Marginalised 95% intervals Expected	Marginalised 95% intervals Observed	Individual 95% intervals Expected	Individual 95% intervals Observed	Global fit 95% limits [2]
Λ^{-4}	C_{tG}	[−0.44, 0.35]	[−0.53, 0.21]	[−0.44, 0.28]	[−0.52, 0.15]	[0.006, 0.107]
	$C^{(8)}_{tq}$	[−0.57, 0.17]	[−0.60, 0.13]	[−0.57, 0.18]	[−0.64, 0.12]	[−0.48, 0.39]
Λ^{-2}	C_{tG}	[−0.44, 0.44]	[−0.68, 0.21]	[−0.41, 0.42]	[−0.63, 0.20]	[0.007, 0.111]
	$C^{(8)}_{tq}$	[−0.35, 0.35]	[−0.30, 0.36]	[−0.35, 0.36]	[−0.34, 0.27]	[−0.40, 0.61]

Unfolded differential cross-section measurements

- Correct for detector effects using iterative Bayesian unfolding (IBU) and propagate uncertainties
- Validate unfolding by injecting moderate EFT contributions and recovering modified particle-level
- Differential cross-section measurements compared to NLO simulation and NLO re-weighted to NNLO
- Re-weighting observed to improve the agreement between data and theory
- Systematics dominated, leading uncertainties: $t\bar{t}$ modelling, flavour tagging, small-R jets

Differential EFT limit extraction

- Probe sensitivity to new physics at high energy scale using EFTs ($\Lambda = 1$TeV)
- Use differential distribution to disentangle and constrain two sensitive Wilson coefficients; C_{tG} and $C^{(8)}_{tq}$
- Build function of cross-section in terms of Wilson coefficients and fit to data using EFTfitter
- Observe no evidence for new physics and excellent sensitivity to $C^{(8)}_{tq}$, stronger limits than global fit [2]
- Successfully disentangle effects of O_{tG} and $O^{(8)}_{tq}$ operators showing power of differential measurement

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[1] Eur.Phys.J. C 80 (2020) 1092 (pp.71) [2] JHEP 11 (2021) 089 (pp.56)