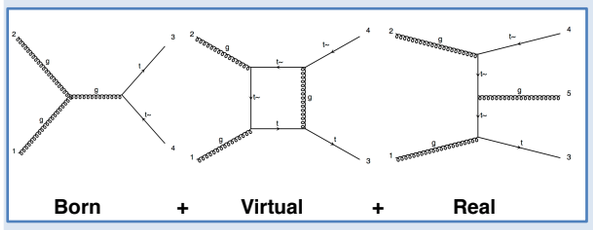
Simulation of Top Quark Production for the ATLAS Experiment

Event Generation

Event generators use hard-scattering matrix elements (ME) to calculate cross-sections up to a fixed-order. Parton showers (PS) model the fragmentation and hadronisation of partons. Generators differ on the procedure for calculating real and virtual amplitudes and in the matching of NLO radiation between ME and PS in order to preserve the total cross-section.

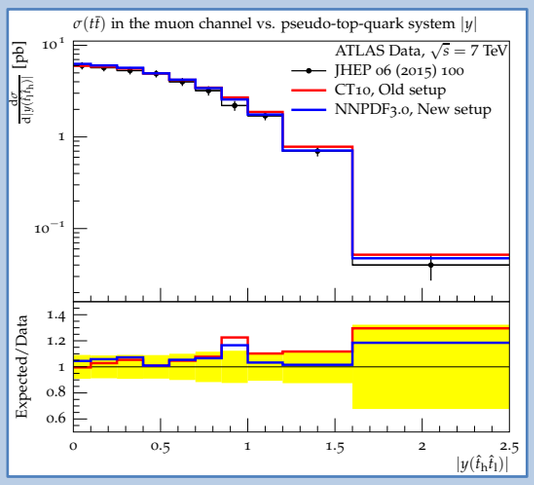


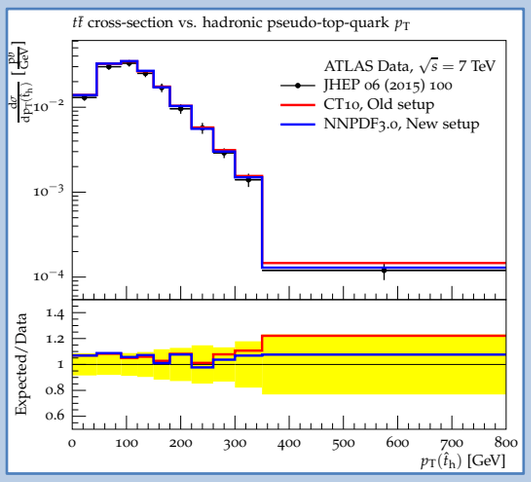
Top at NLO

A range of generators at leading and next-to-leading order interfaced to parton shower models are used by ATLAS and tested against unfolded top measurements. Comparisons among generators offer an handle to quantify modelling, shower and UE uncertainties

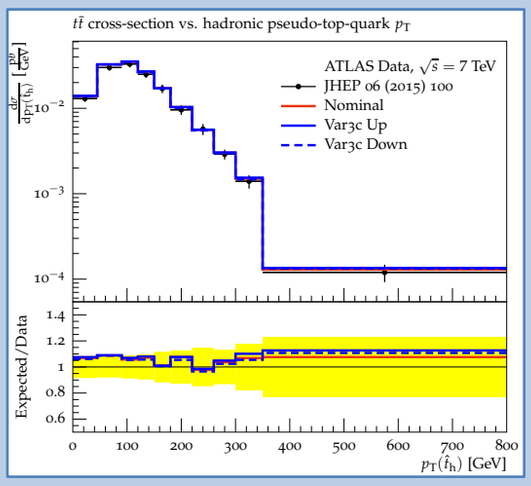
Powheg + Pythia 8 Studies

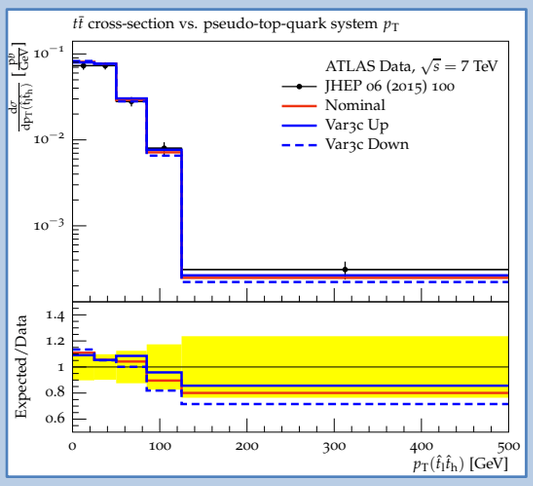
The current default sample used in ATLAS top physics analyses is Powheg+Pythia 6. Optimisation of Powheg+Pythia 8 is necessary before transitioning from Pythia 6 to Pythia 8.





The effect of A14 UE/PS tune variation uncertainties have been studied from the standpoint of top physics. Variation 3c which changes α_s in the eigentune by ±10% has been shown to have the largest impact and covers the size of the alternative variations.



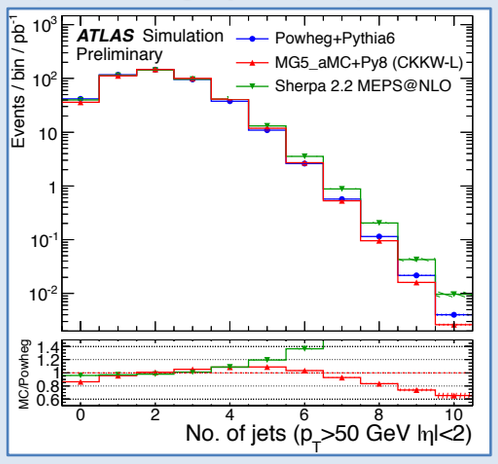


This leads to the following generator uncertainty prescription foreseen for future ATLAS top analyses using Powheg+Pythia 8 as the nominal.

Systematic	Details
Radiation (High)	0.5μ, A14 var3c up, $h_{damp} = 2m_{top}$
Radiation (Low)	2.0μ, A14 var3c down, $h_{damp} = m_{top}$
NLO Subtraction Scheme	Powheg versus MG5_aMC@NLO
Fragmentation Model	Herwig++/7 versus Pythia 8

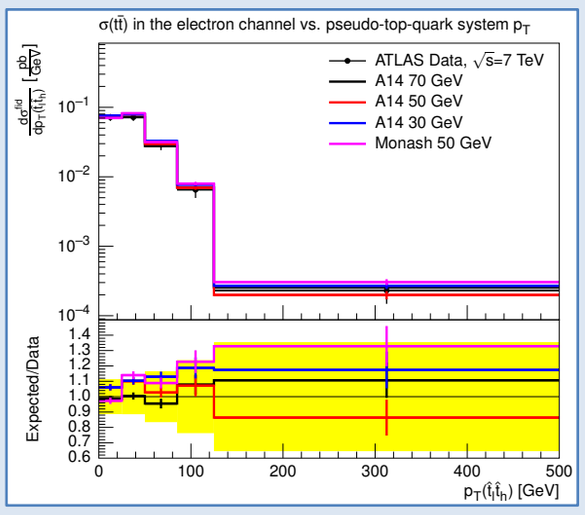
Multi-Leg MadGraph

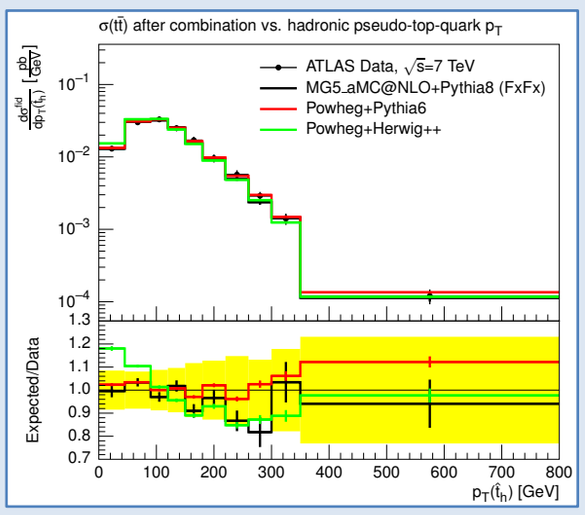
Multi-leg LO+PS samples can be used to provide a more precise prediction than inclusive NLO samples at high jet multiplicities.



FxFx Merging

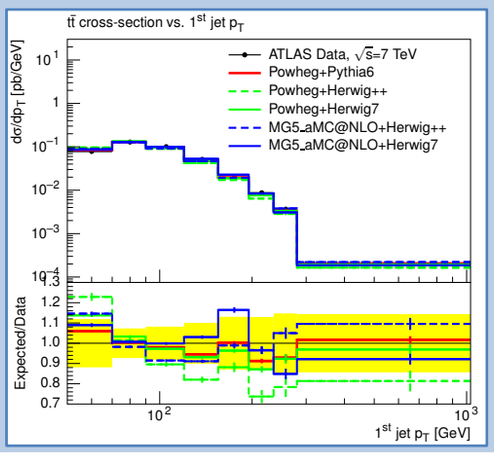
The FxFx merging technique allows the combination of multiple NLO+PS samples with different final state jet multiplicities.
This can reach NLO precision in jet multiplicities beyond what is possible in an inclusive NLO sample.
Studies varying the FxFx merging scale (μ_Q = 30, 50, 70 GeV) have been performed using MG5_aMC@NLO+Pythia 8, where good agreement is observed with 7 TeV data.

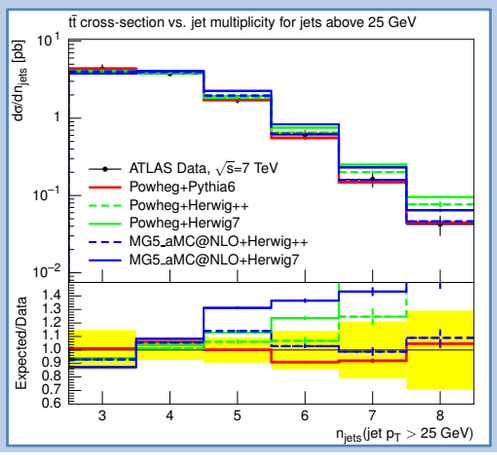


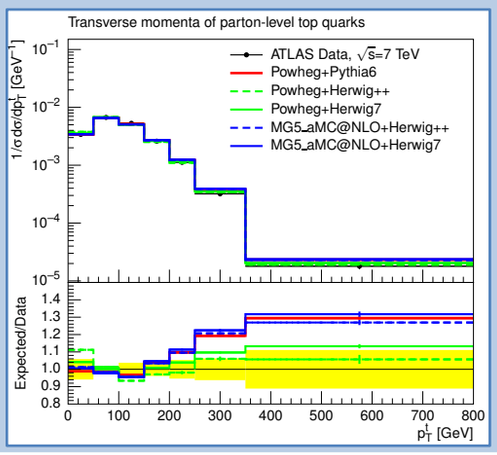


Herwig 7

Herwig++ has been used to provide an alternative model of parton showering to Pythia. Initial comparisons of Herwig 7 have been shown to improve the modelling of the top quark and top quark pair kinematics.

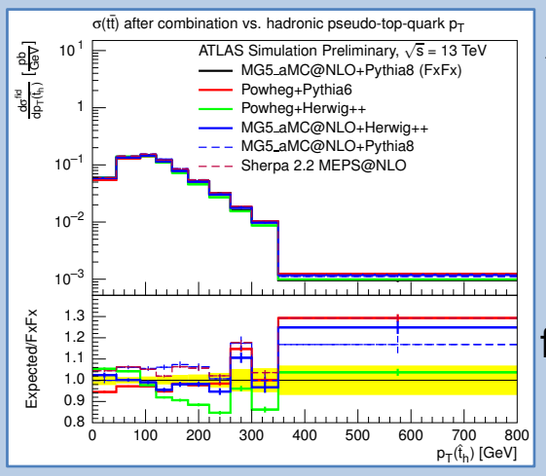






Generator	Shower	Precision	Scale (μ)	ME PDF
Powheg	Pythia 6	NLO	$\sqrt{(m_t^2 + p_{T,t}^2)}$	CT10
Powheg	Herwig++/7	NLO	$\sqrt{(m_t^2 + p_{T,t}^2)}$	CT10
Powheg	Pythia 8	NLO	$\sqrt{(m_t^2 + p_{T,t}^2)}$	NNPDF 3.0
MG5_aMC@NLO	Pythia 8	NLO	$H_T/2$	NNPDF 3.0
MG5_aMC@NLO	Herwig++/7	NLO	$\sqrt{(m_t^2 + (p_{T,t}^2 + p_{T,\bar{t}}^2)/2)}$	CT10
Sherpa 2.2	Sherpa	NLO (0,1), LO (2,3,4)	$\sqrt{(m_t^2 + (p_{T,t}^2 + p_{T,\bar{t}}^2)/2)}$	NNPDF 3.0
MadGraph	Pythia 8	Multi-Leg LO (0,1,2)	$\sqrt{(\Sigma m_T^2)}$ ∀ ME partons	NNPDF 3.0

Summary at 13 TeV



A range of top physics samples are available for Run-2 ATLAS analyses and further studies are ongoing.

Ian Connelly, on behalf of the ATLAS Collaboration

References: ATL-PHYS-PUB-2016-004, ATL-PHYS-PUB-2016-016

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ROYAL HOLLOWAY UNIVERSITY OF LONDON

ATLAS EXPERIMENT