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Top quark related questions raised during the ATLAS-CMS Monte Carlo Generators Workshop

<https://indico.cern.ch/event/588781/timetable/>

Efe Yazgan

TOPLHCWG Meeting
6-7 June 2017, CERN

Is there a need of comparisons among different tune models (pythia/herwig/sherpa?)

Deepak Kar

Summary

Tuning uncertainties?

Tunes relevant for very specific phase spaces?

No

Better constraining gluon splitting

Is pure PS tuning dead?

Maybe

Tuning Model Parameters in CMS Run II

E.Y.

- Charged particle multiplicity and pT-sum densities (in the transverse region) ==> Can not constrain MPI and shower ISR simultaneously.
- First, tune shower α_s^{ISR} (==> perturbative parameter that determines inclusive event properties) ==> but from a specific process:
 - ttbar jet kinematics ==> Sensitive to shower α_s^{ISR} but not so much to the UE.
 - Nominal ttbar simulation: Powheg+Pythia8 ==> include hdamp in the tuning.
- Then fit UE & MinBias data at 13 TeV to tune MPI parameters.
- Verify the tune with MinBias, DPS, UE, Drell-Yan, W/Z+jets, ... data.

==> The tune results in lower shower α_s^{ISR} and higher hdamp.

==> Describes UE & MB observables well.

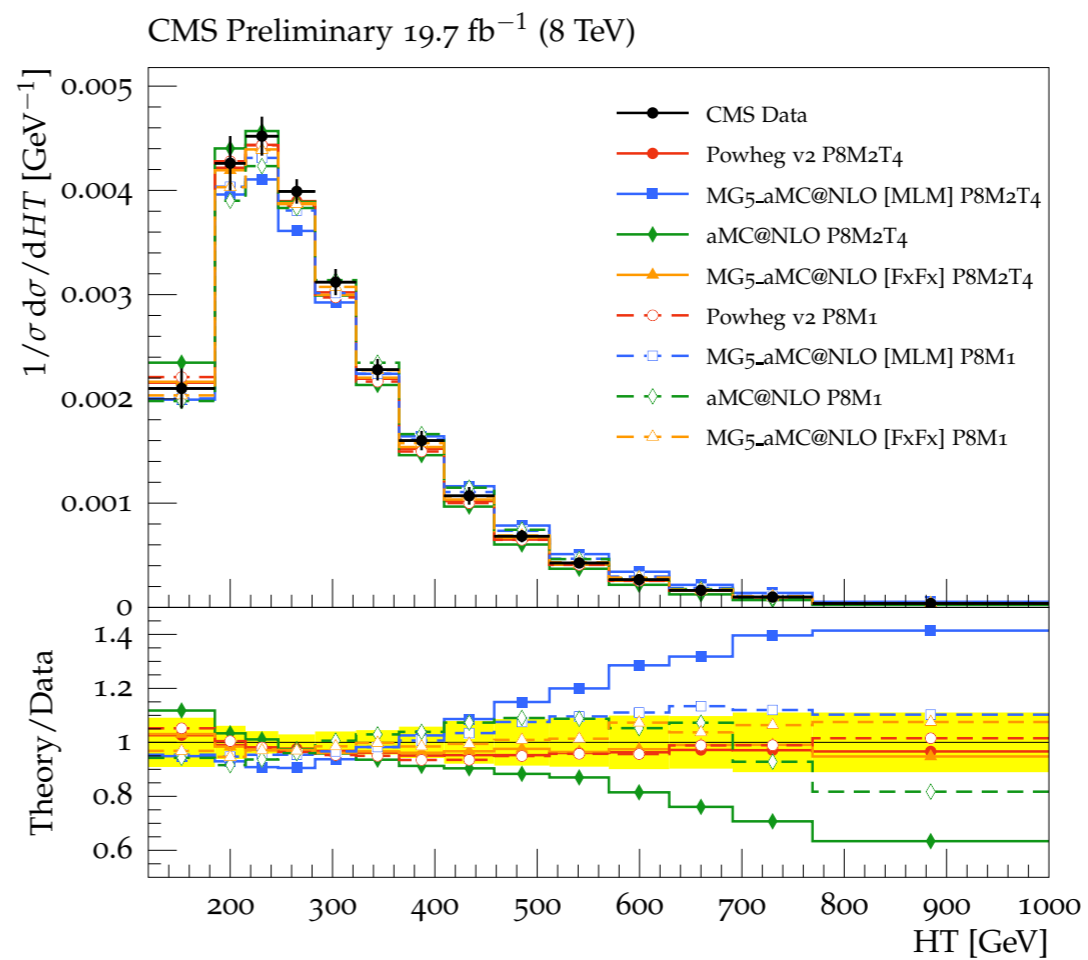
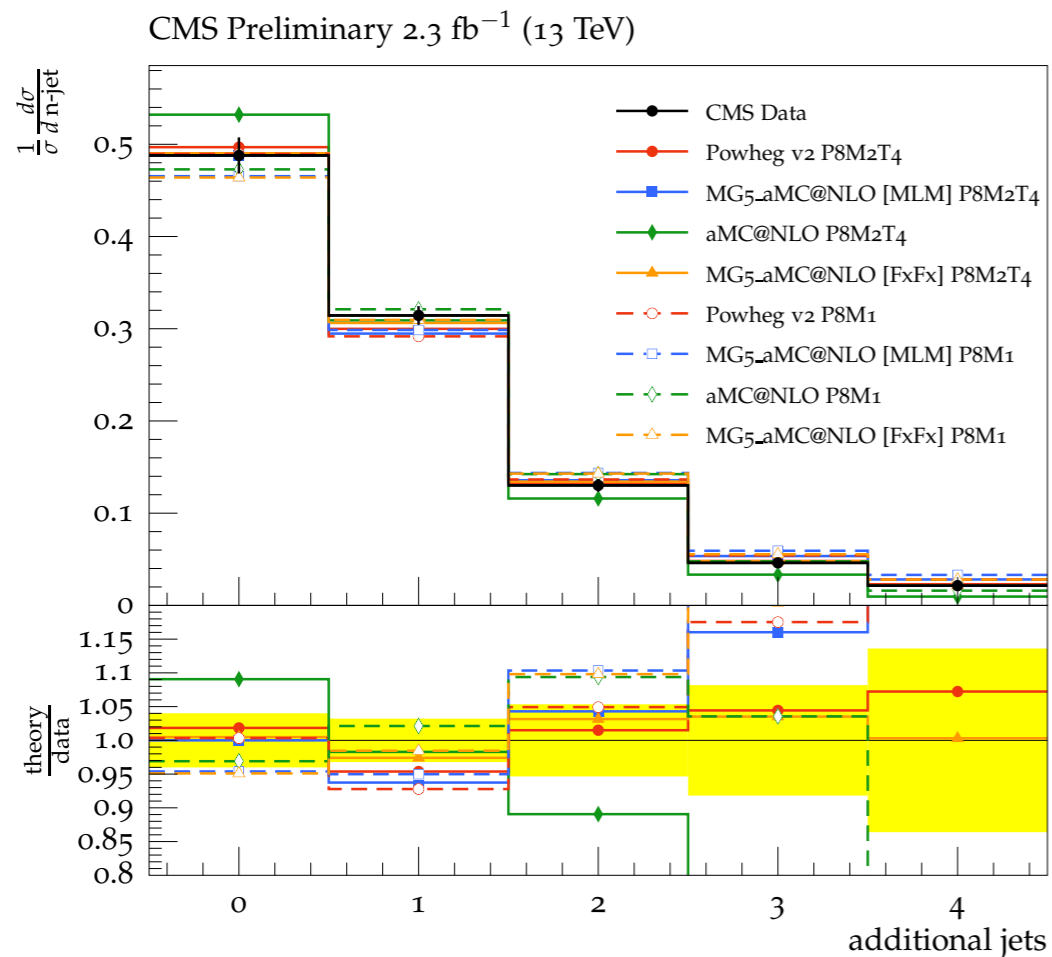
==> Powheg+Pythia8 and MG5_aMC@NLO [FxFx] with the new tune provide good description of all top quark distributions (except top pT)

Can tunes starting from specific processes be used in other configurations and processes?

- ▶ Do not try to tune away things which can't be possibly tuned, or tuned only by overstretching predictions (N_{jet}), or significantly affected by underlying ME's (overtuning: see sect.3.3 of 1511.00847)

Stefano Frixione

CMS: powheg+pythia8 ttbar ==> large njets bins ==> jets only from shower



MLM with the new pythia tune ==> central values: large deviations (even changes top pT)

another e.g. ATLAS: Z observables —> matched vs pythia-only give similar results but means vs multiplicity poorly modelled (preliminary)

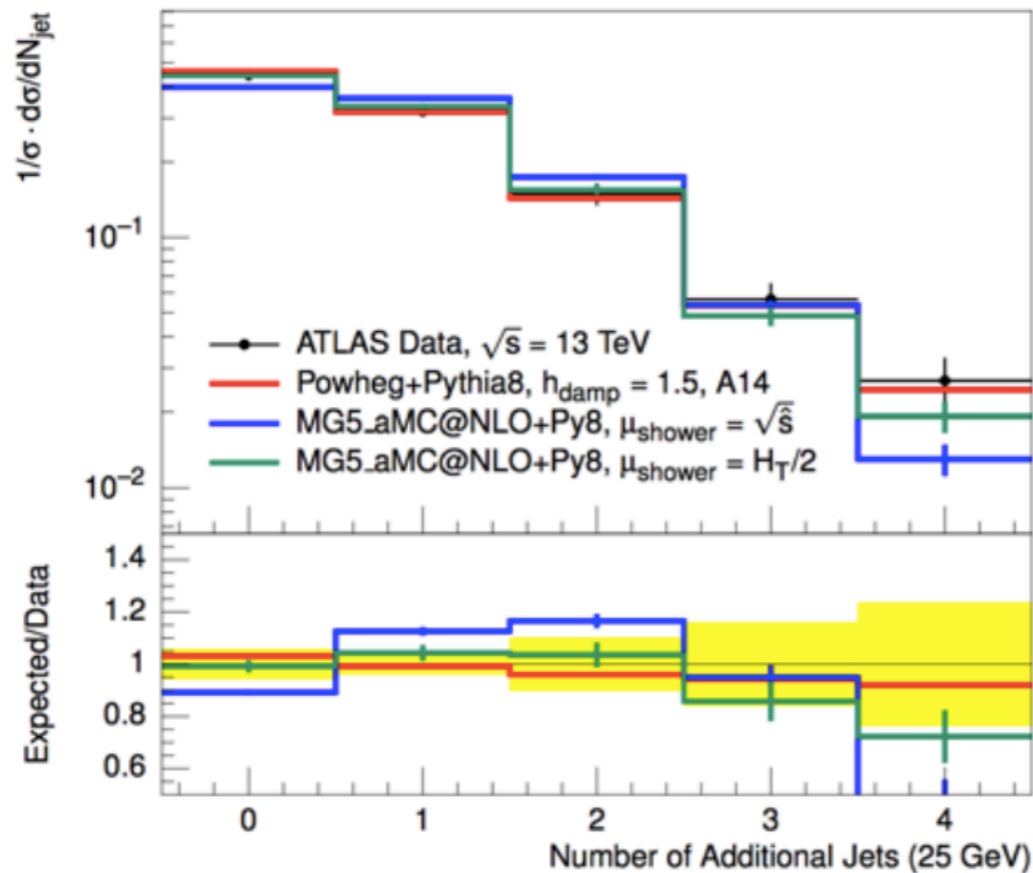
Can tunes starting from specific processes be used in other configurations and processes?

Stefano Frixione

- ▶ **But** (and this is not contradictory): beyond a certain level of precisions, tunes are necessary, and generator-specific
- ▶ E.g.: as you tune h_{damp} , you might tune the shower reference scale (I'm not saying you should; other MC parameters must be tried first)

Studies of μ_q :

Jay Howarth



- * At what point do we decide to do that?
- * Are we already there or only affected by different settings in different setups?

Show α_s Tuning in Different Configurations

E.Y.

- Powheg is less sensitive to tuning of the shower α_s than MG5_aMC@NLO+Pythia
- Not trivial to directly predict the outcomes of using the optimized shower α_s in other configurations (esp. matched/merged).
 - Consistency of the α_s value in the PS and ME may be important for matched/merged emissions (see Cooper et al. EPJ C72 (2012) 2078 that advocates this for MLM).
 - Powheg+Pythia ==> N/A: first emission is handled by Powheg (down to ~ 1 GeV), all subsequent emissions by Pythia
 - MG5_aMC@NLO + Pythia [FxFx & MLM] ==> applies to first ~ 3 emissions.
 - aMC@NLO + Pythia [w/o merging] ==> applies to first emission
 - Different α_s values may be needed for matched and unmatched emissions.

Further studies ongoing to ensure FxFx and MLM will behave better than Powheg and MC@NLO as expected from additional ME accuracy .

ME α_s^{14}
(high for LO configs)

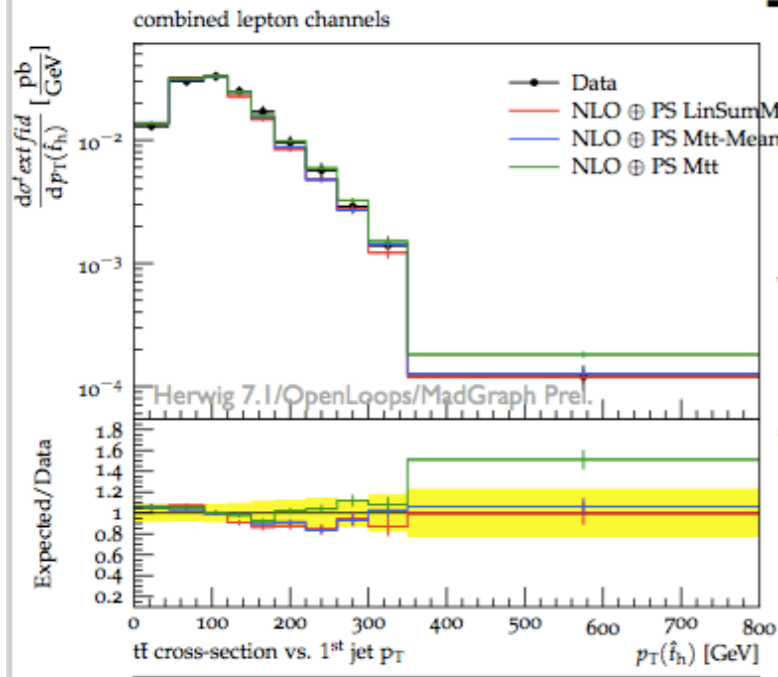
Low α_s

Or

* Can tuning q_{cut} fix the problem? \rightarrow No

* Can « tuning » starting shower scale fix the problem in MLM? \rightarrow Not so trivial.

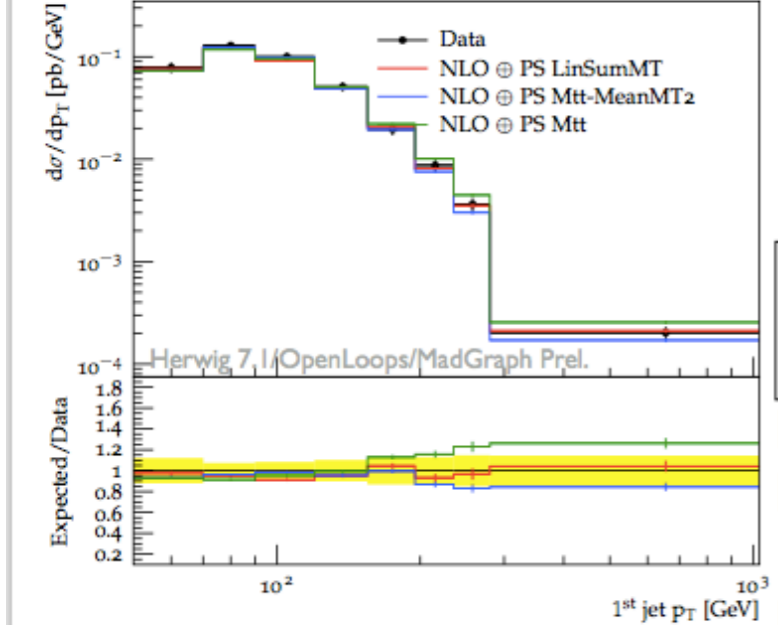
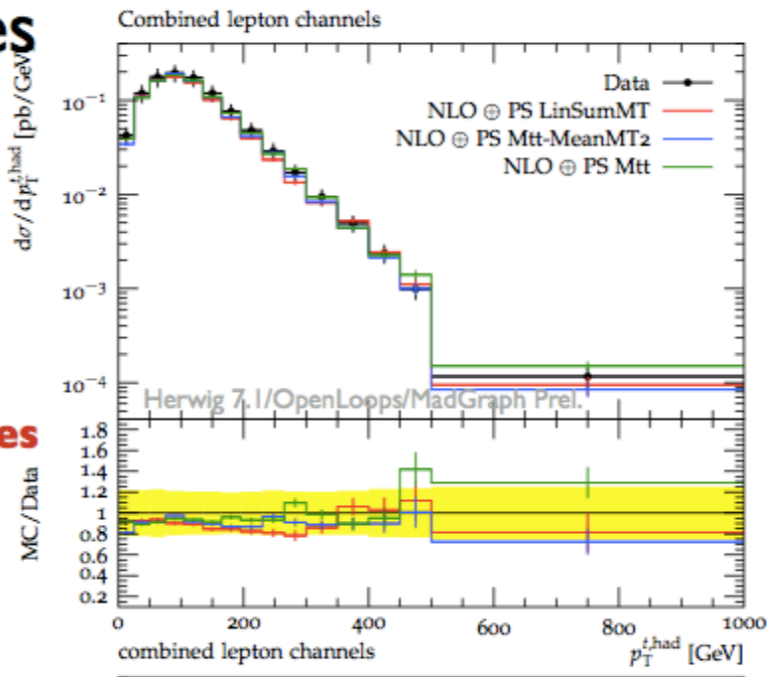
Top studies



NNLO K Factor

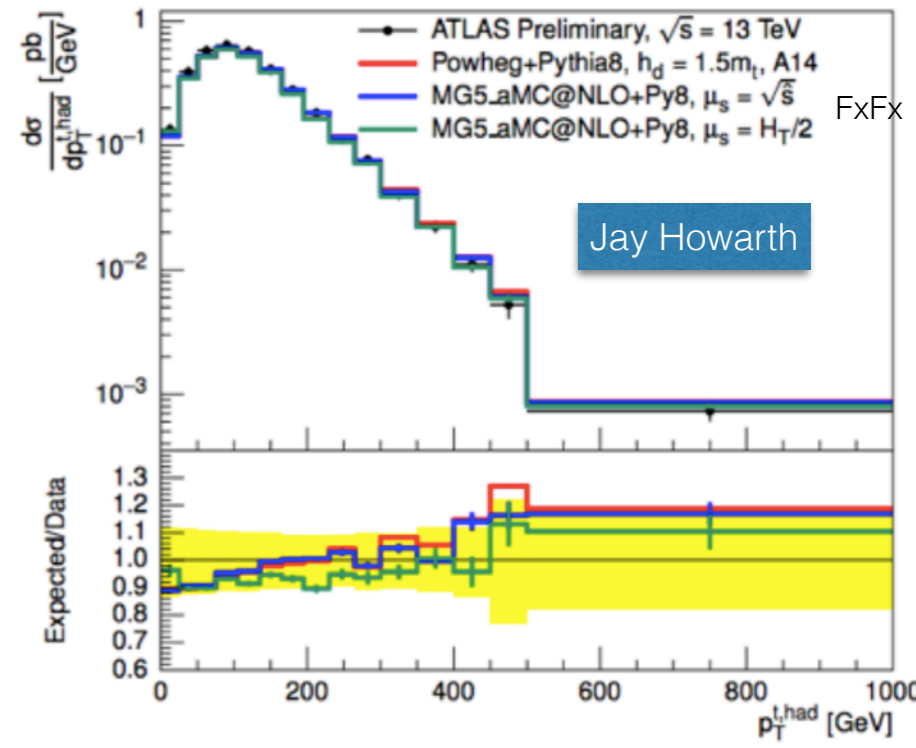
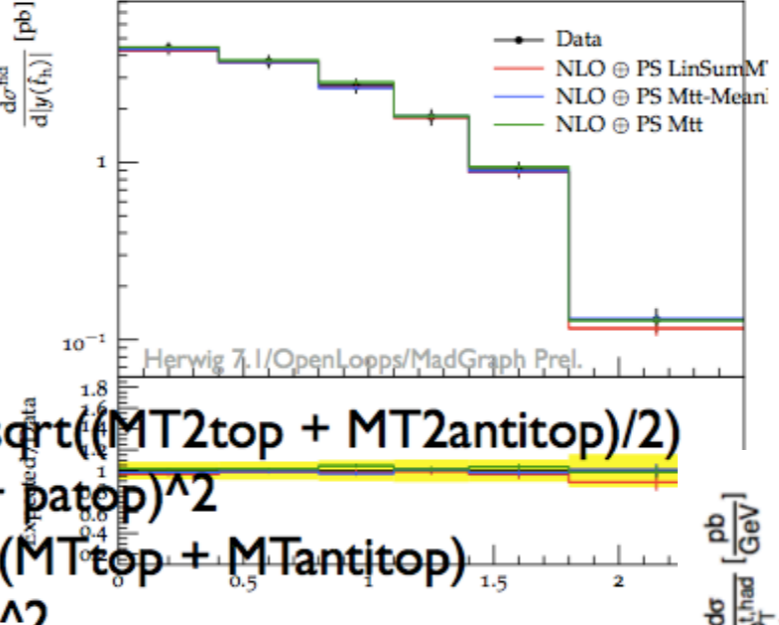
Various Scale Choices tested

Ongoing studies



S. Plätzer,
P. Richardson,
S. Webster

$MeanMT2 = \sqrt{((MT2_{top} + MT2_{antitop})/2)}$
 $Mtt = (p_{top} + p_{atop})^2$
 $LinSumMT = (MT_{top} + MT_{antitop})$
 $MT2 = E^2 - z^2$



- Improvement in central values from Herwig7.1.
 - Due to scale choices and what else?
- Can different scale choices in other setups (powheg/FxFx) fix the top pT problem (without jeopardizing some other properties, e.g. Njets)?

Uncertainty Recipes

Systematic uncertainties

ATLAS Prescriptions

- Uses either two-point systematic comparison or parameter variations.

	RUN 1	RUN 2
Scale	POWHEG μ_R, μ_F , hdamp variations	
Matrix Element	POWHEG -vs- MC@NLO	POWHEG -vs- MG5_aMC@NLO
Hadronisation	HERWIG++ -vs- PYTHIA6	HERWIG++(7) -vs- PYTHIA6(8)
Non-perturbative	Perugia Tunes	A14 Tunes
PDF	Envelope method	PDF4LHC eigenvectors
Other	Mass variations depending on analysis	

Jay Howarth

6

Systematic uncertainties

CMS Prescriptions

- Tricky to make definitive list, prescriptions vary with \sqrt{s} , time, and analyses.

	RUN 1	RUN 2
Scale	MG5 Q^2 variations	POWHEG μ_R, μ_F variations
Matrix Element	POWHEG -vs- MG5	POWHEG -vs- FxFx
ME - PS	Threshold variations.	hdamp variations
Hadronisation	b-frag., semi-leptonic B decays, HW6 vs PY6 JER	HERWIG++ -vs- PYTHIA8
Non-perturbative	Tune variations	CUET2P8M4
PDF	CT10 variations	CT14/NNPDF30 variations
Other	Mass variations and $p_T(t)$ reweighting	

Jay Howarth

7

- CMS moved into a factorized approach now for parton shower/hadronization uncertainties.
- Are there problems arising with the factorized approach?
- How can we improve and make it more flexible?

tt+heavy flavour

Andy Buckley

Main critical points for current measurements:

* 4F tt+bb NLO: need to investigate large differences among MC generators, but this is an extremely expensive process (CPU time) → sharing common LHFiles ?

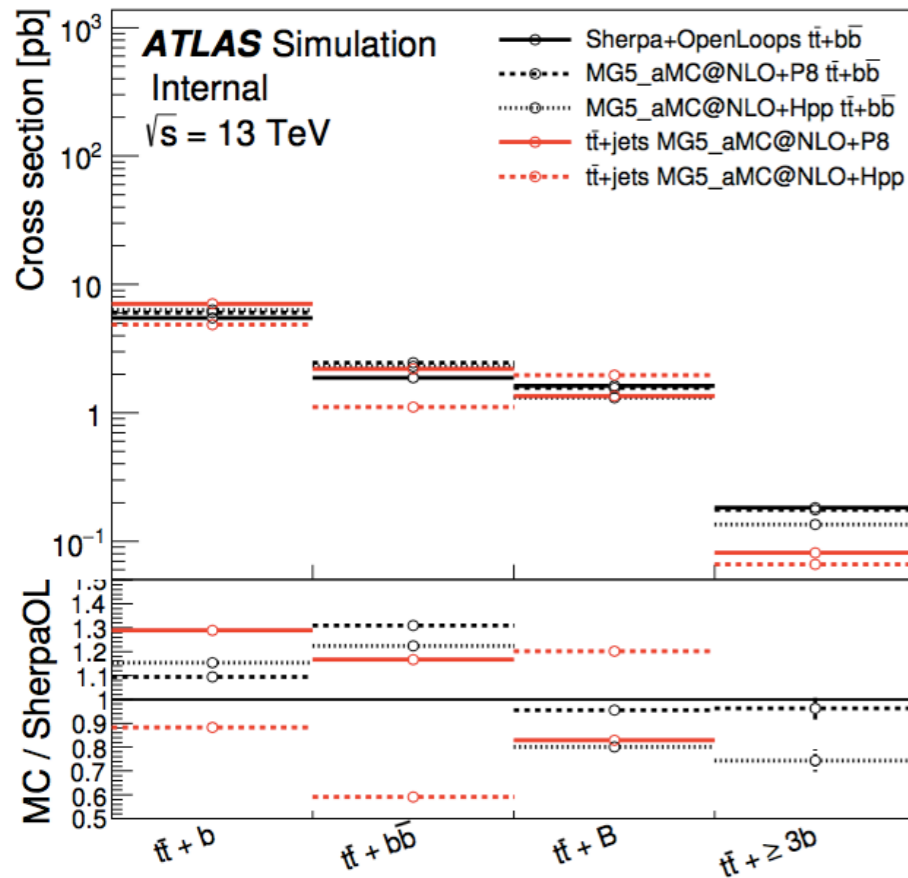
larger than single-generator systematics.
Under control?

Tune shower starting scale in mc@nlo to reduce differences?

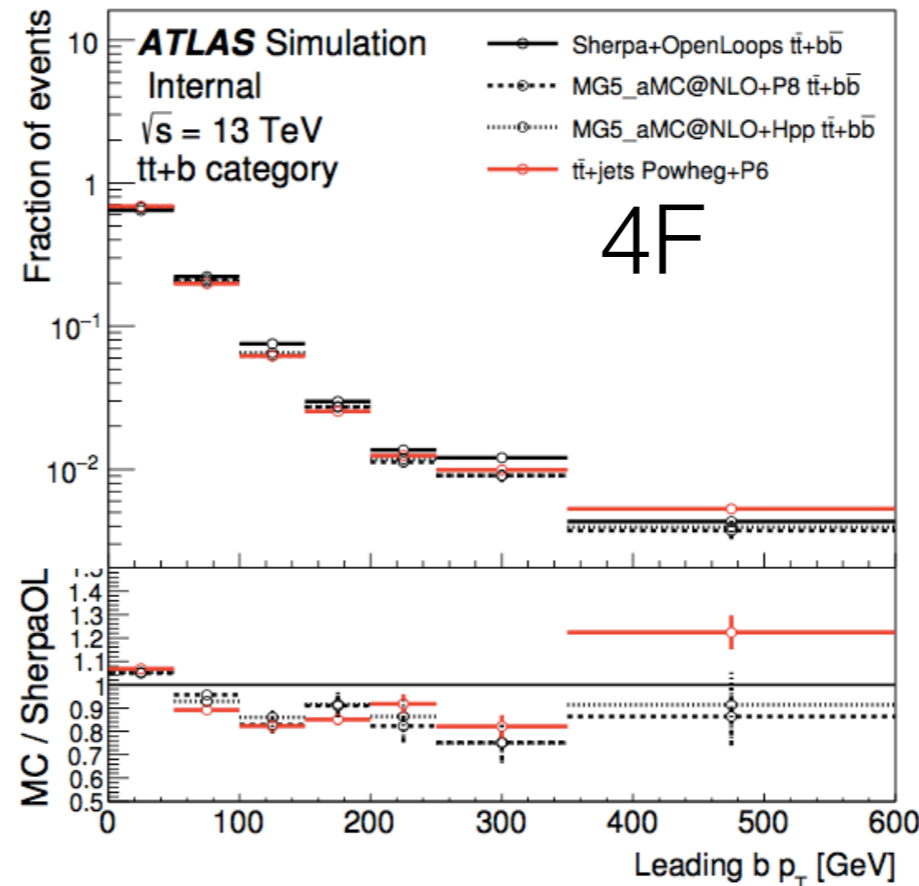
tt̄ + bb̄ cross-sections

$\sigma_{t\bar{t}b\bar{b}}/\sigma_{t\bar{t}jj} = 1.2-2.2\%$ measurement vs. theory have similar uncertainties from both ATLAS and CMS:

ATLAS top-quark production PUB note, ATL-PHYS-PUB-2016-016:



4F
5F



4F

MC norm uncertainty 30%, shape uncertainties 20%.
Significant 5F/4F & shower sensitivity

tt +heavy flavour

Main critical points for current measurements:

- * 4F $tt+bb$ NLO: need to investigate large differences among MC generators, but this is an extremely expensive process (CPU time) → sharing common LHEfiles ?
- * how to merge 4F $tt+bb$ and 5F tt +jets samples ? ==> how much can shower uncertainties be reduced?
- * $tt+H$ modelling (showering & hadronisation) starting to appear in the ranking list

<https://twiki.cern.ch/twiki/bin/view/LHCPhysics/ProposaltTH>
<https://twiki.cern.ch/twiki/bin/view/LHCPhysics/Proposaltbb>
<https://twiki.cern.ch/twiki/bin/view/LHCPhysics/ProposaltTV>

3/5/17

María Moreno Llácer – Modelling of $t\bar{t}+X$

31

Approach proposed in the LHC Higgs Yellow Report 4

- * NLOPS 4F $tt+bb$ sample
 - . can be applied in full phase space (no generation cuts)
 - . inclusive description of $tt+\geq 1 b$ -quarks
 - . includes $gb \rightarrow ttb$ contributions also in the 5F scheme
 - * Inclusive 5F tt +jets sample
 - . needs to be restricted to $tt+0 b$ -quarks to avoid double counting (veto events containing b -quarks not arising from showered top decays or MPI or UE)
- Ongoing discussions on possible implementations

María Moreno Llácer – Modelling of $t\bar{t}+X$

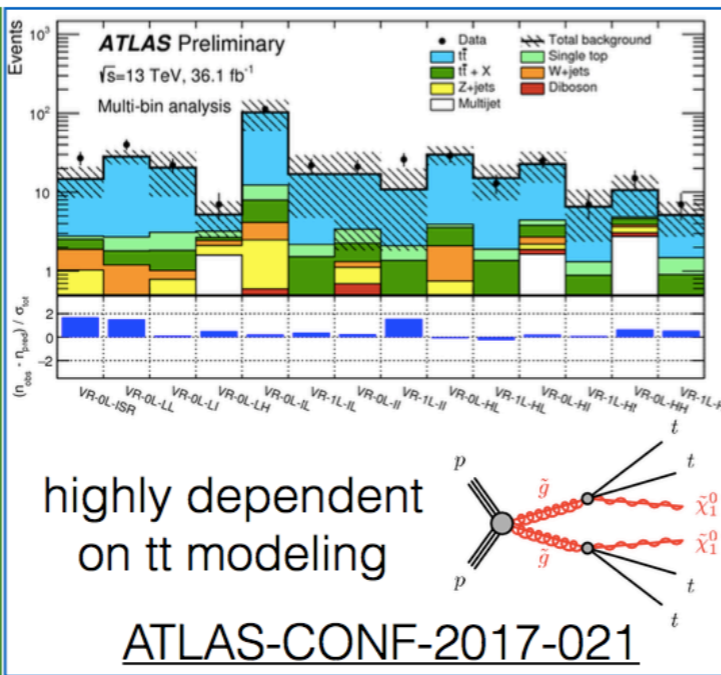
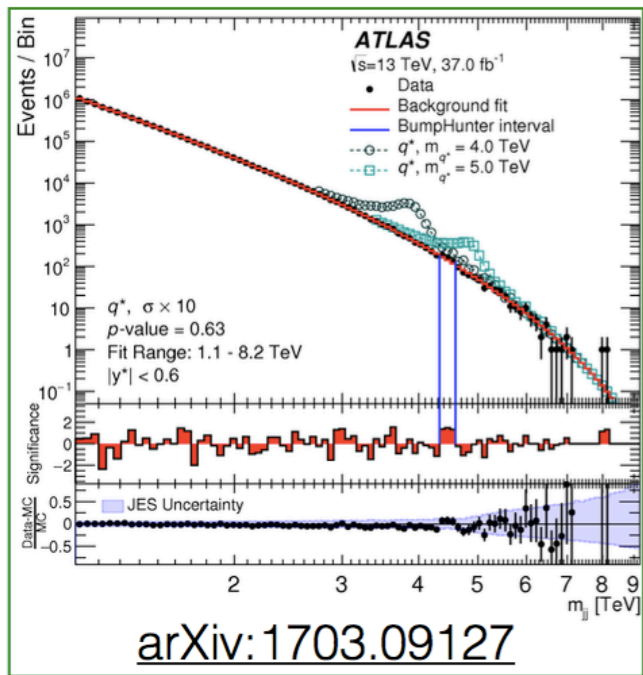
Questions Related to New Physics Searches



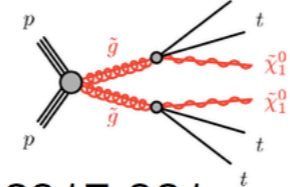
Introduction



- Some searches are *nearly* independent of the quality of Monte Carlo, while many are **not**

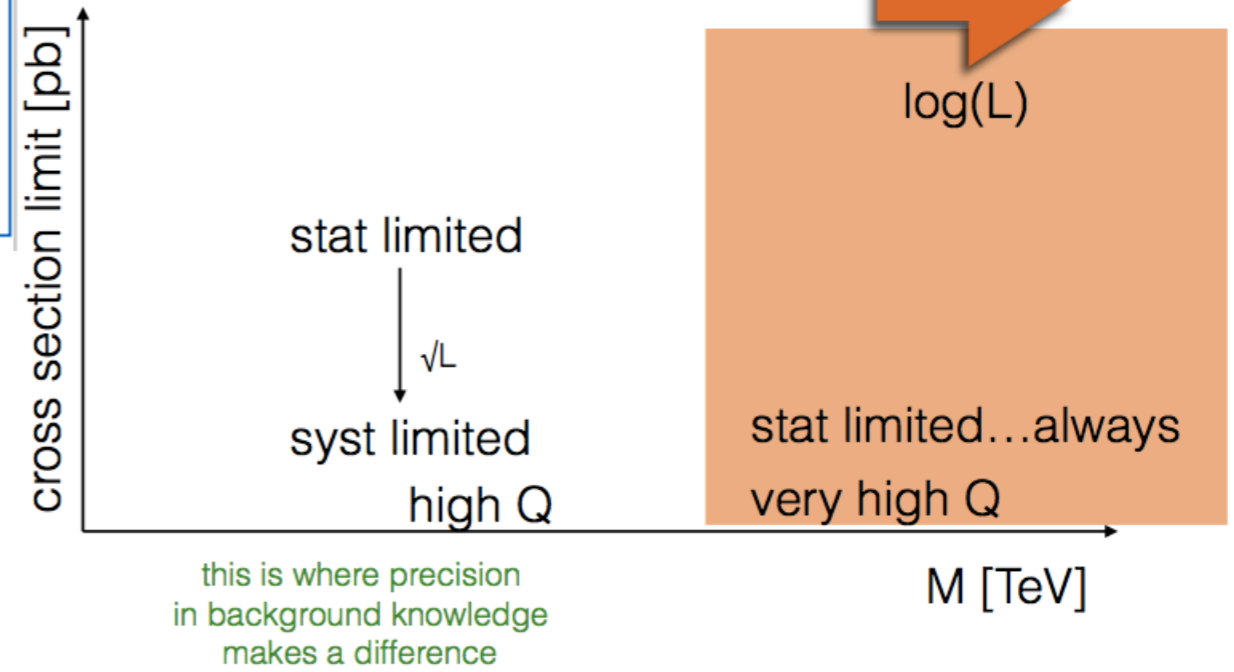


highly dependent on tt modeling



Gabriel Facini

Search Lifetime



psychology - how low can you go??

Questions Related to New Physics Searches

- In searches in the extremes of the phase space, dependence on top p_T , high N_{jets} , ...
 - Use predictions with the most accurate ME accuracy.
 - How to calculate modelling systematics?
 - Single generator in different settings or compare different generators?
 - Consider parton shower uncertainties?
 - How to treat $t\bar{t}$ / tW interference?
- Can BSM searches provide useful info **from control regions** for MC tuning? **(not re-interpretation)**
 - What would be the minimal info delivered?
 - Will there be users of this info?

More Than Limits

- How to compare currently **non-unfolded distributions** to new MC version outside of ATLAS?
 - We often reweigh or only show “post-fit” MC.
If given MC before this, would it be useful?
 - Is **folding i.e. via Rivet routines** a viable option?
- What *regions of phase space near where searches are being done* are interesting to measure in order to understand MC better?
 - If you had **one wish**, it would be to see a plot of...
- To what *extent is it important to unfold distributions* in order for generator authors to improve MC?

Other questions

- Which order of PDF should be used in parton showers?
- Will be addressed during the forthcoming theory institute, on June, 16th (morning)
<https://indico.cern.ch/event/572734/timetable/#b-259238-pdfs-pdfs-in-shower-m>
- ...?