MC Modelling

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for the CMS TOP PAG

LHC TOP WG meeting
17-18 May 2016

Outline

- Overview of ttbar NLO MC setups in CMS for Run2:
  - **Madgraph5 + Pythia 8 with MLM merging** (tt+0,1,2,3j)
  - **Madgraph5_aMC@NLO + Pythia 8 with FxFx merging** (tt+0,1,2j)
  - **Madgraph5_aMC@NLO + Pythia 8 / Herwig++**
  - **POWHEG + Pythia 8 (default setup for Run 2)**
  - **POWHEG + Herwig++**
- Matrix Element point of view
- Parton Shower point of view
  - α_s(ISR) tuning
- UE measurement with ttbar

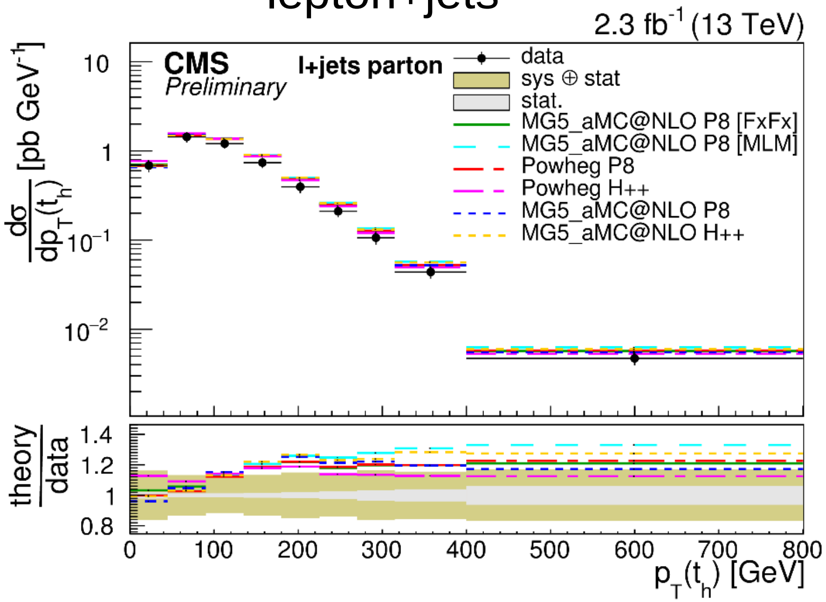
(*) Detailed fragmentation studies (mostly Pythia 6) are shown this afternoon by B. Stieger in his talk on top mass

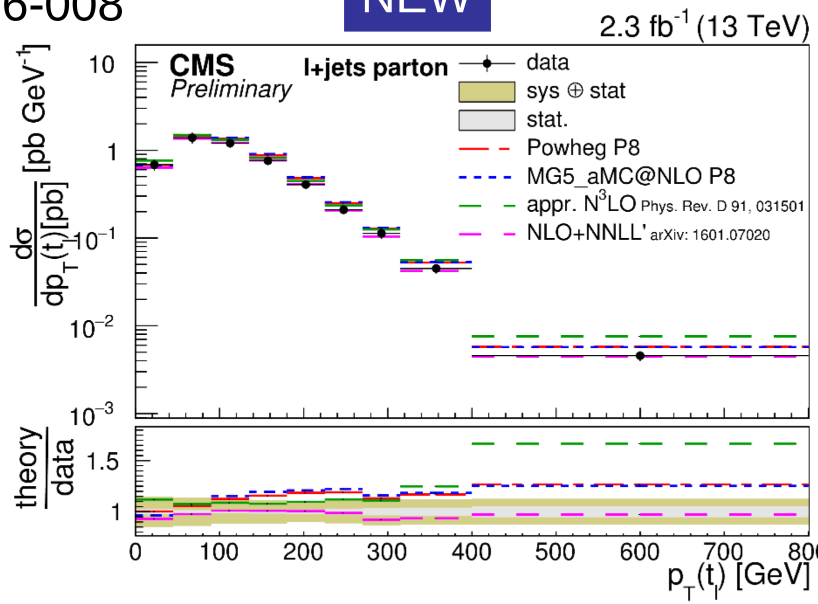
Current situation at 13TeV

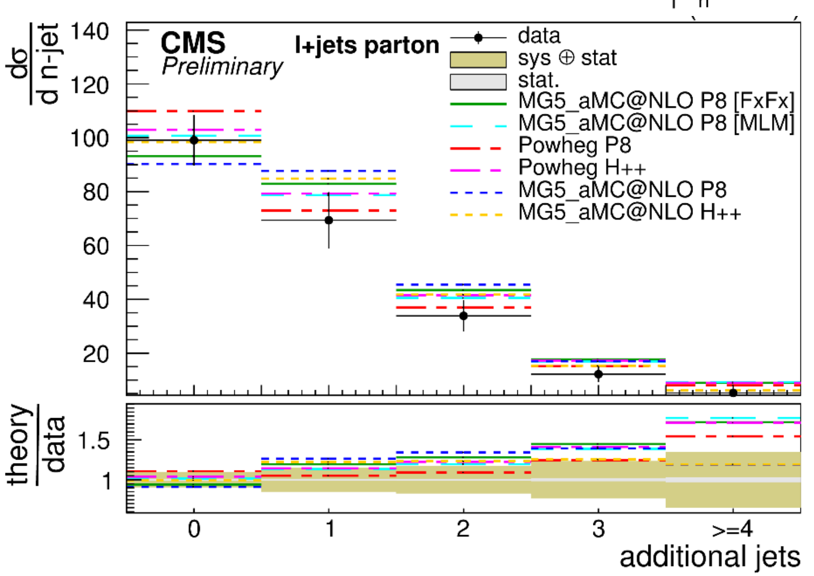
lepton+jets

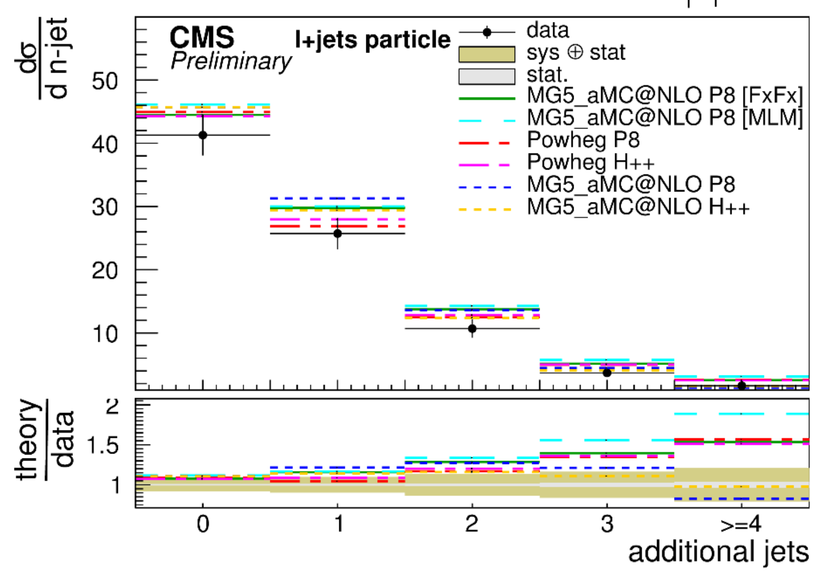
TOP-16-008

NEW



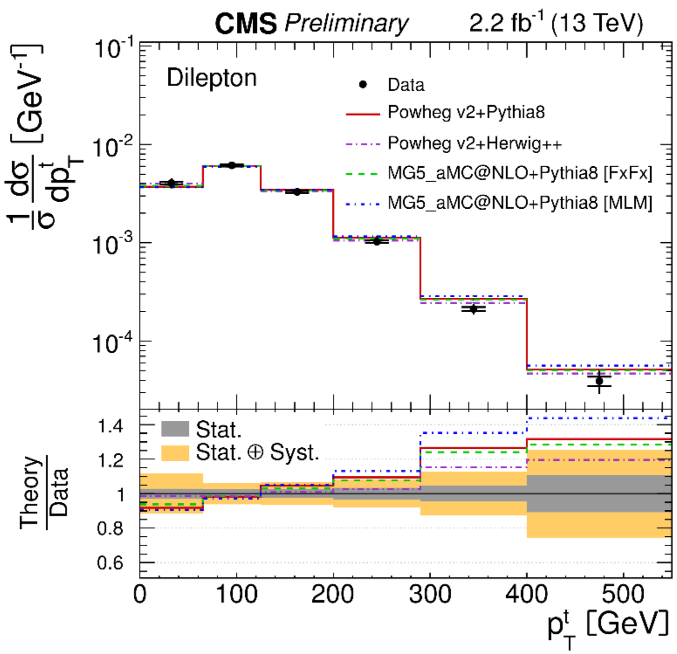


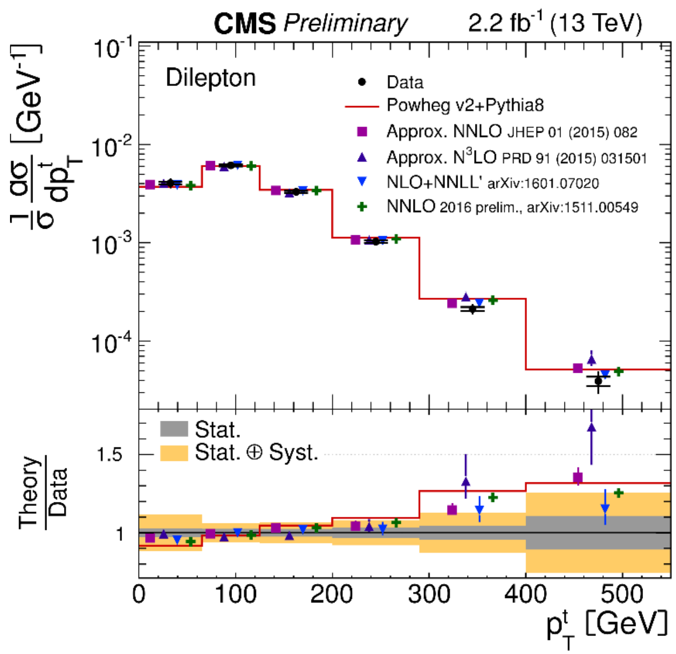




See details in O. H. Hindrich's talk

Current situation at 13TeV

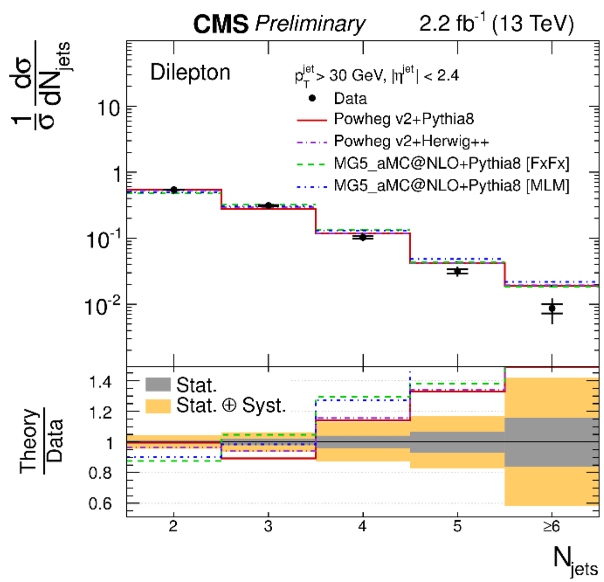




Dilepton

TOP-16-011

NEW

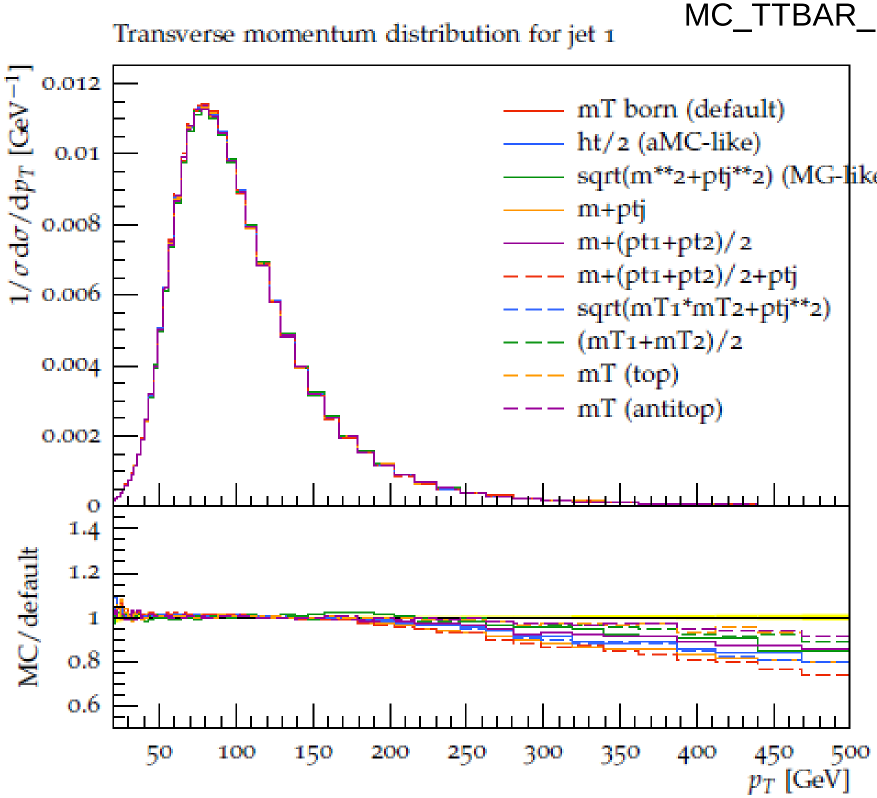


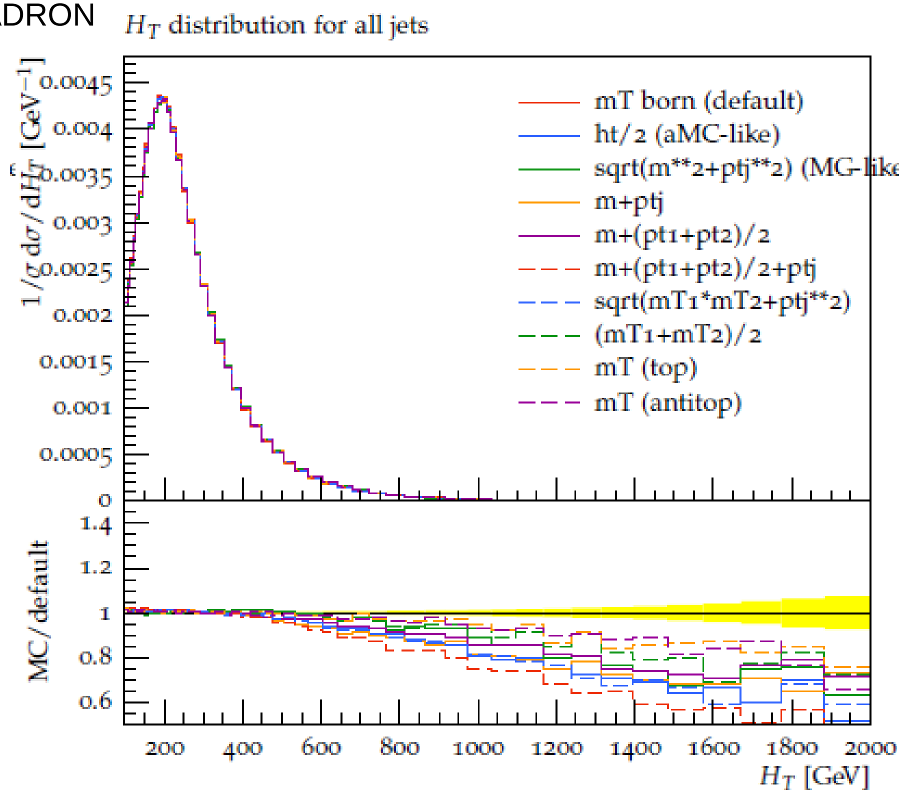
- Still poor description of top pT in dilepton and l+jets channels
- All configurations overshooting data at large jet multiplicity

Matrix Element Point of View

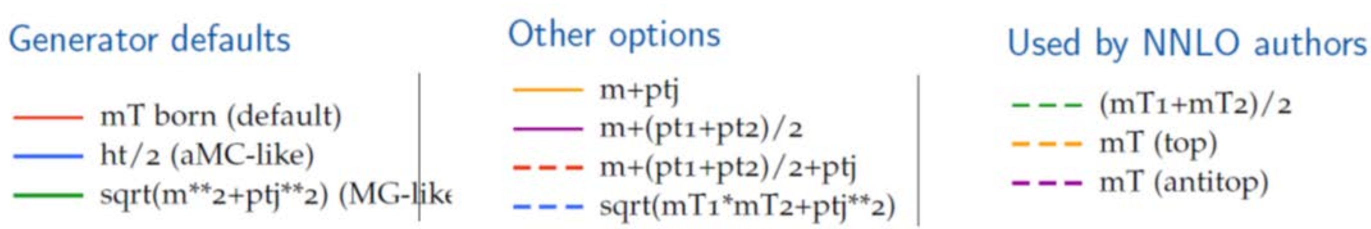
POWHEG alternative running scales (I)

MC_TTBAR_HADRON





- Implemented alternative dynamic scales for tt production in POWHEG (hvq) with help from Paolo Nason
- Based on real kinematics after emission (standard scale = born level).



POWHEG alternative running scales (II)

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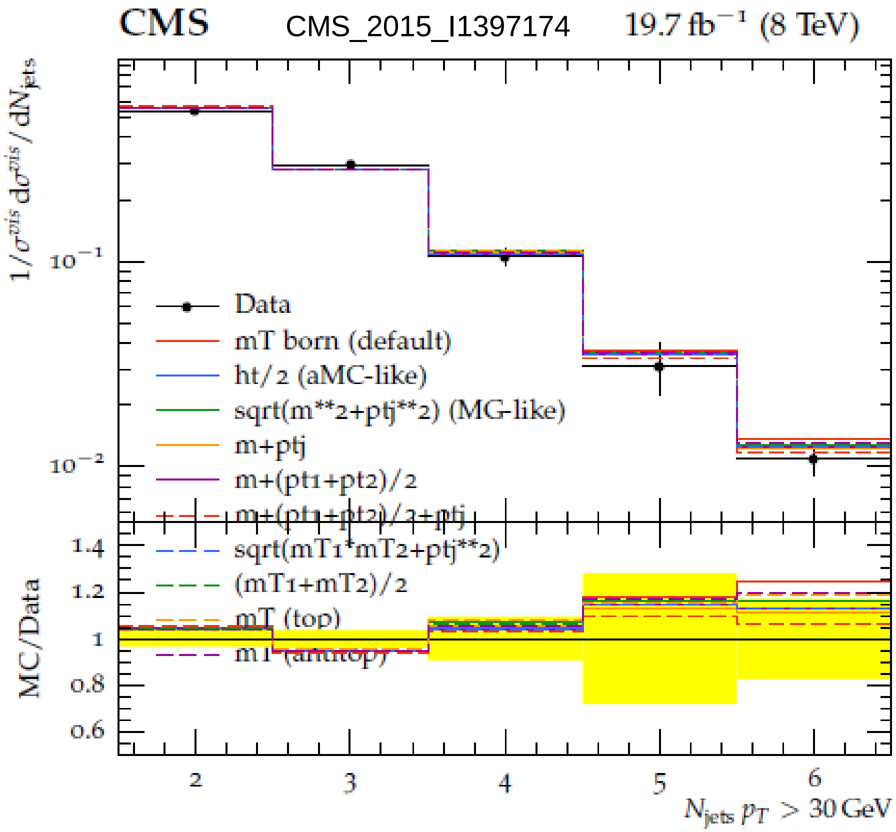
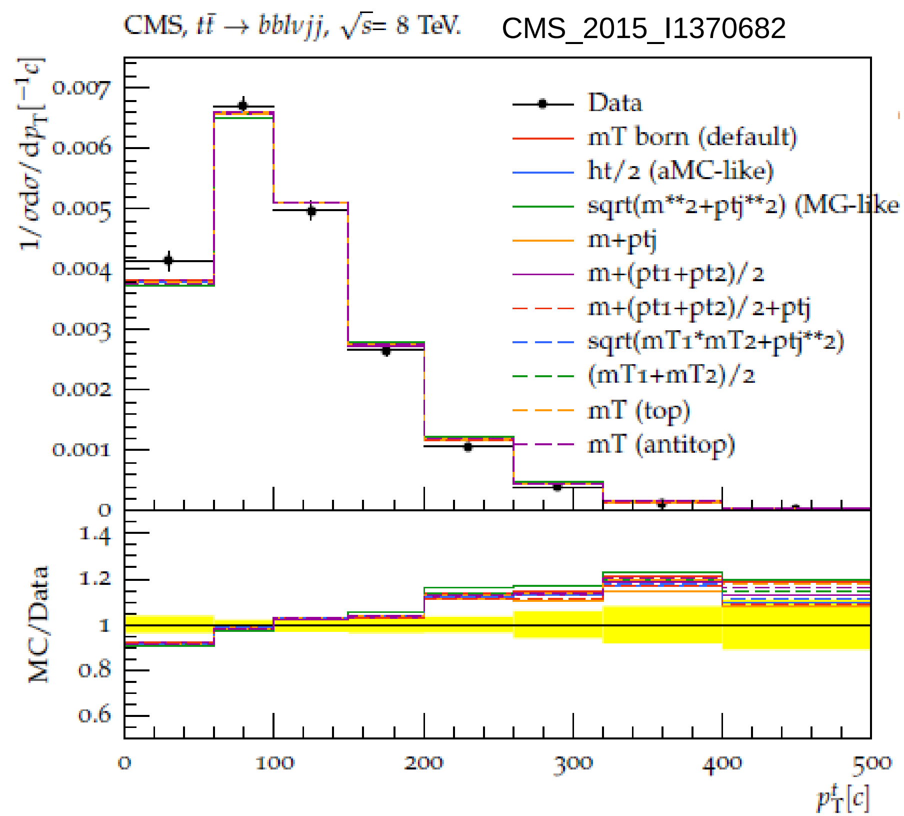
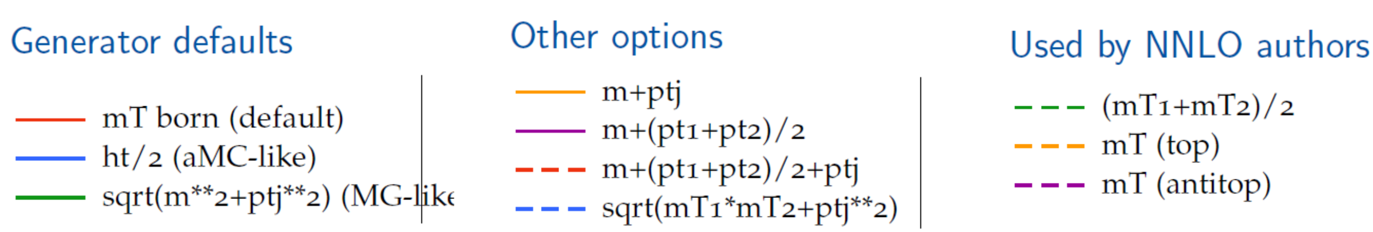
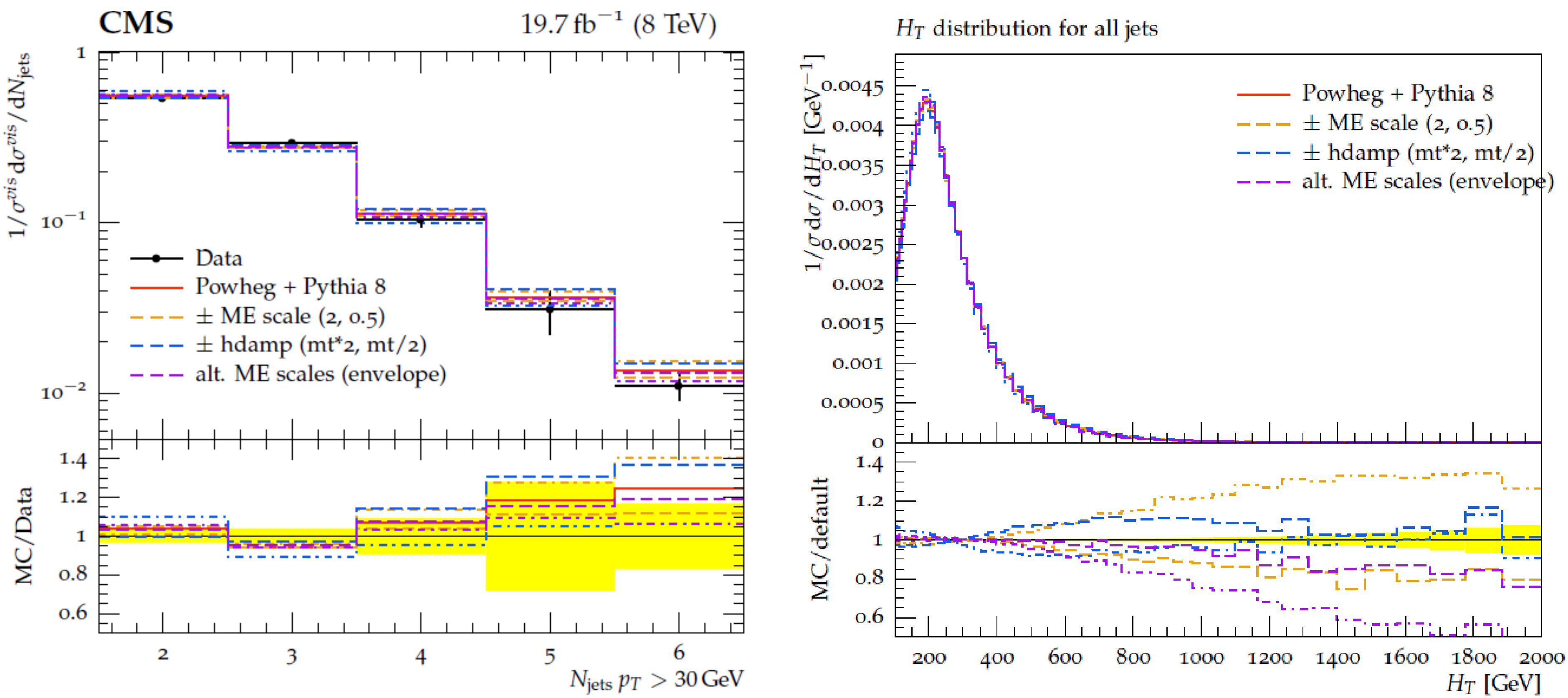




Alternative scales: Lower pT Jets→lower multiplicities, no (small) effect on top pT

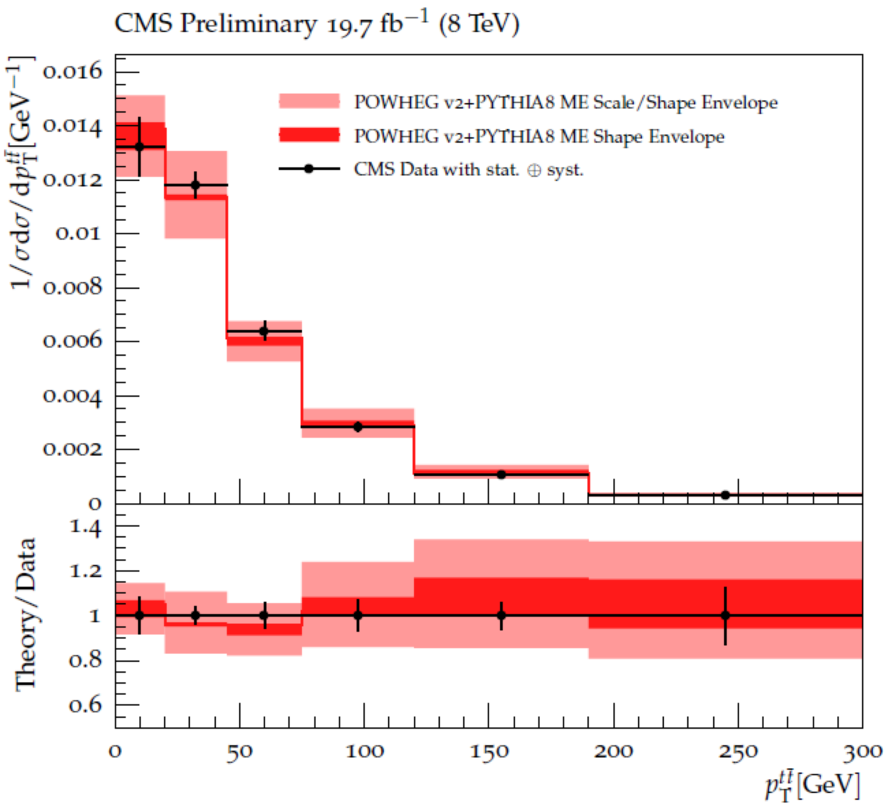


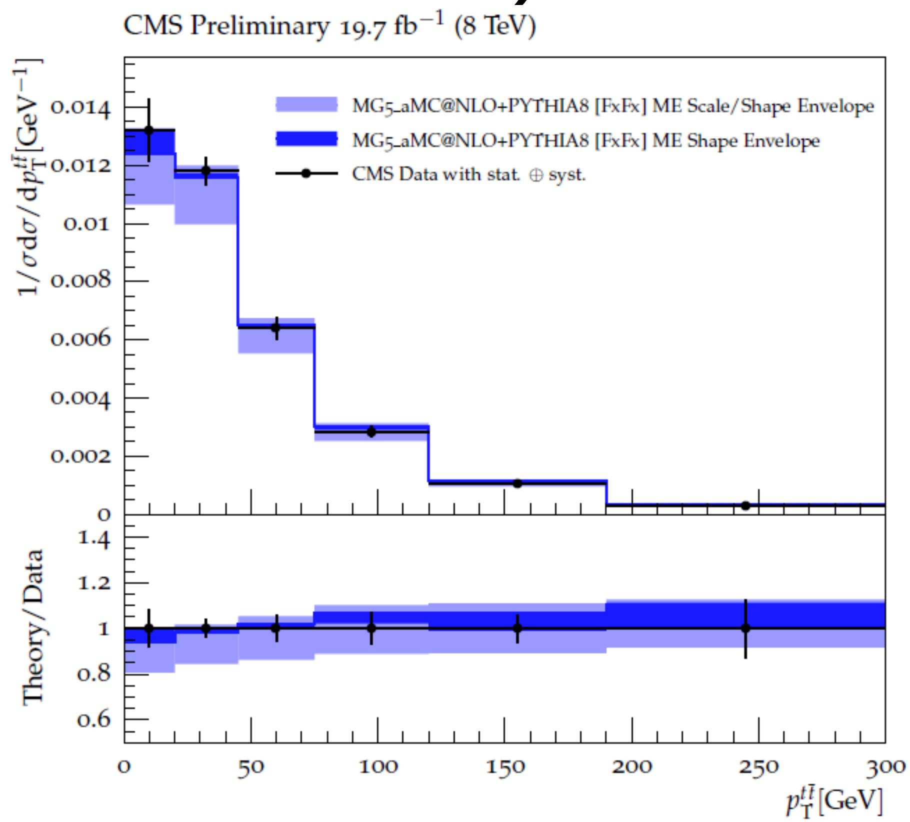
ME scale uncertainties in POWHEG



- ME scale uncertainties: standard variations by factor 2, bracket hdamp variation
- Alternative scales give larger scales (lower α_S)

ME scale uncertainties Powheg vs. aMCatNLO (TOP-15-011)





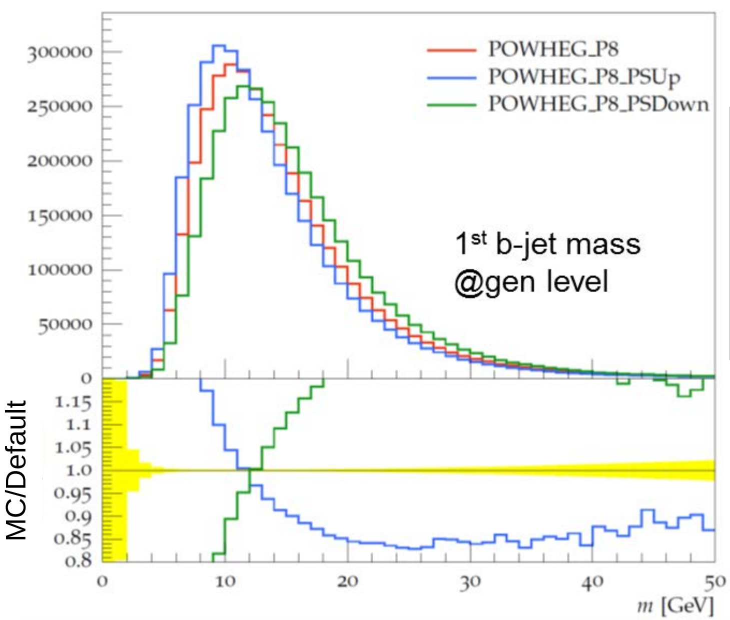
- Smaller uncertainties for MG5_aMCatNLO FxFx sample, but asymmetric
- Renormalization envelope misses the relevant shape variation which is nevertheless covered by the full (scale) uncertainty band
- But aMCatNLO does not fit 13TeV data well: matching/merging scale uncertainty ignored, often small w.r.t. $\mu R/\mu F$

Parton Shower View

ISR+FSR variations

- Current PS scale up/down samples do simultaneous ISR/FSR variation
- Effect on number of radiated leptons, b/light quark masses

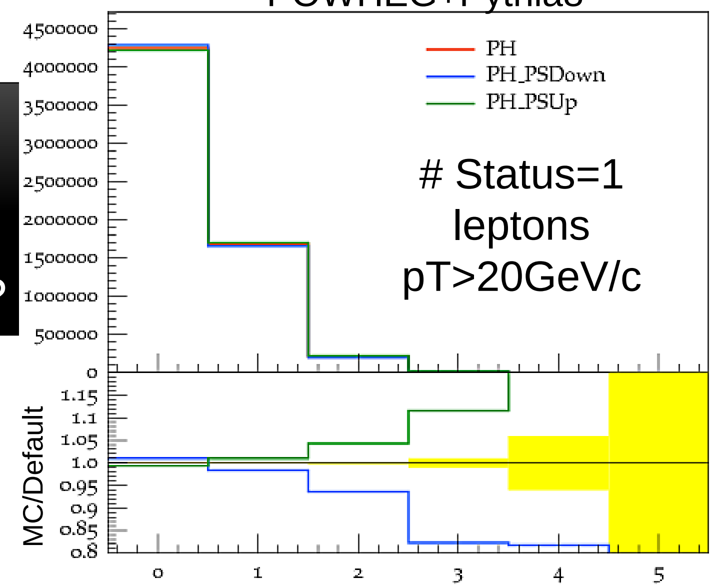
- Next generation MC: automated PS uncertainties, included in Pythia 8.219:
- “Variations of the QCD renormalisation scale for both initial-and final-state showers can now be computed on the fly, provided as a list of alternative weights for each event, representing the probability that the given event would have occurred under different shower assumption”



POWHEG+Pythia8

Can PS scale weights handle these changes in multiplicities?

POWHEG+Pythia8

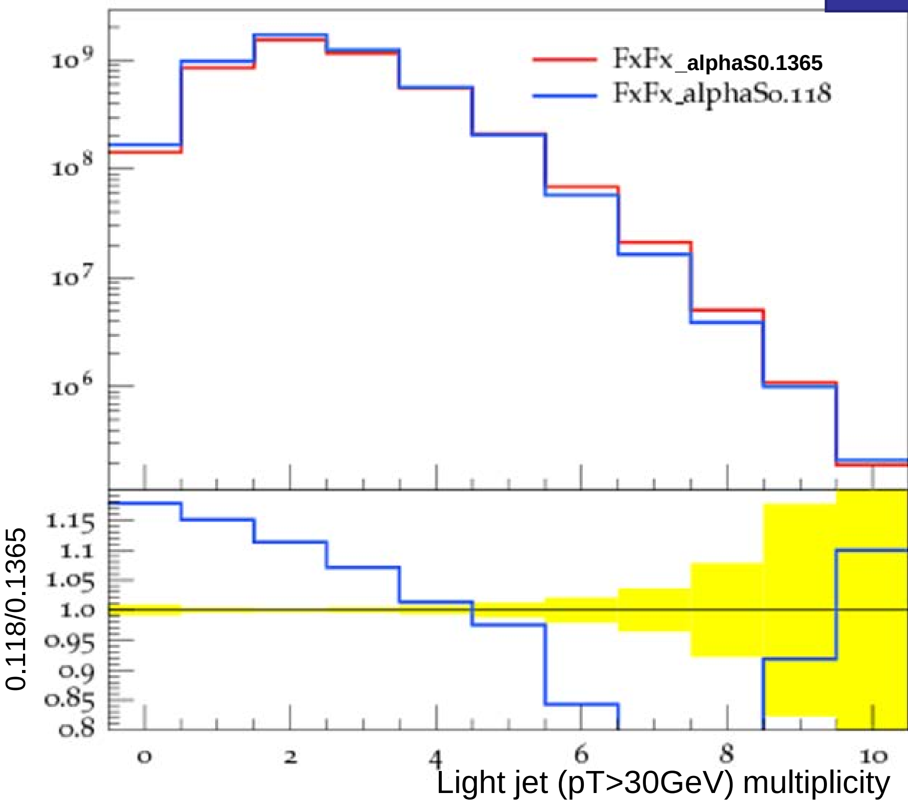


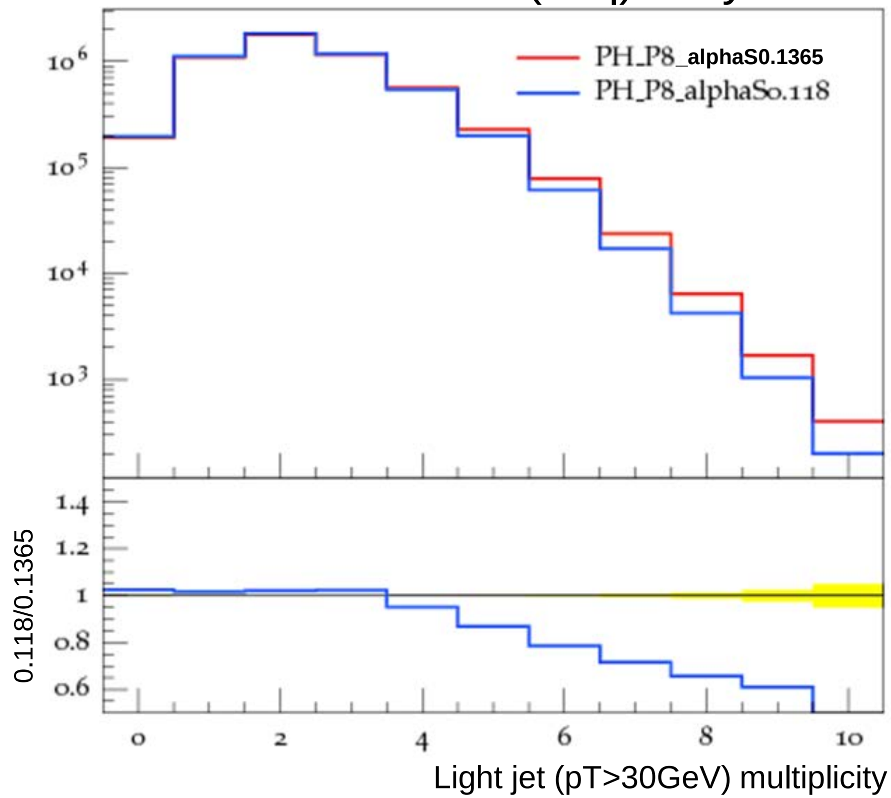
Test of the matching scheme (I)

MG5_aMCatNLO FxFx

Dilepton

POWHEG (hvq) + Pythia 8





- Pythia 8 Monash tune (CUETP8M1, α_S =0.1365 for ISR&FSR) harder than Pythia 6:
  - ✓ Direct effect in POWHEG for any additional jet
  - ✓ MLM and FxFx matching should compensate the effect
- Basically for POWHEG αS only affects the distribution in the shower-dominated region, whereas for aMC@NLO it also does the multiplicity bins covered by the ME.

Test of the matching scheme (II)

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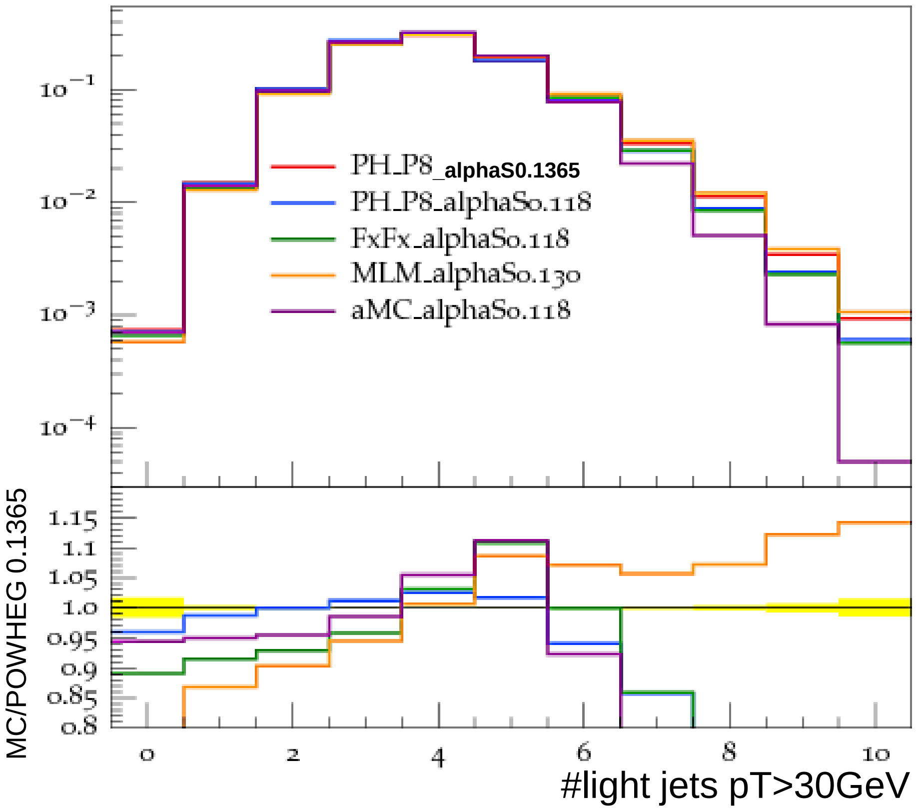
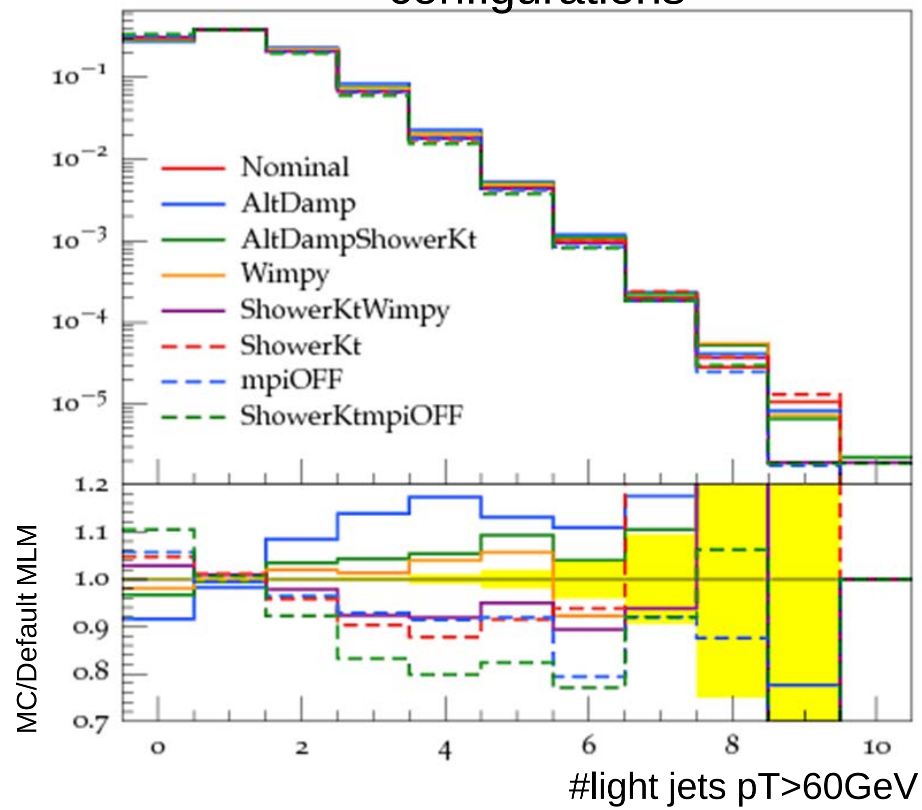
Dilepton

POWHEG+Pythia 8 as reference



MLM additional shower configurations

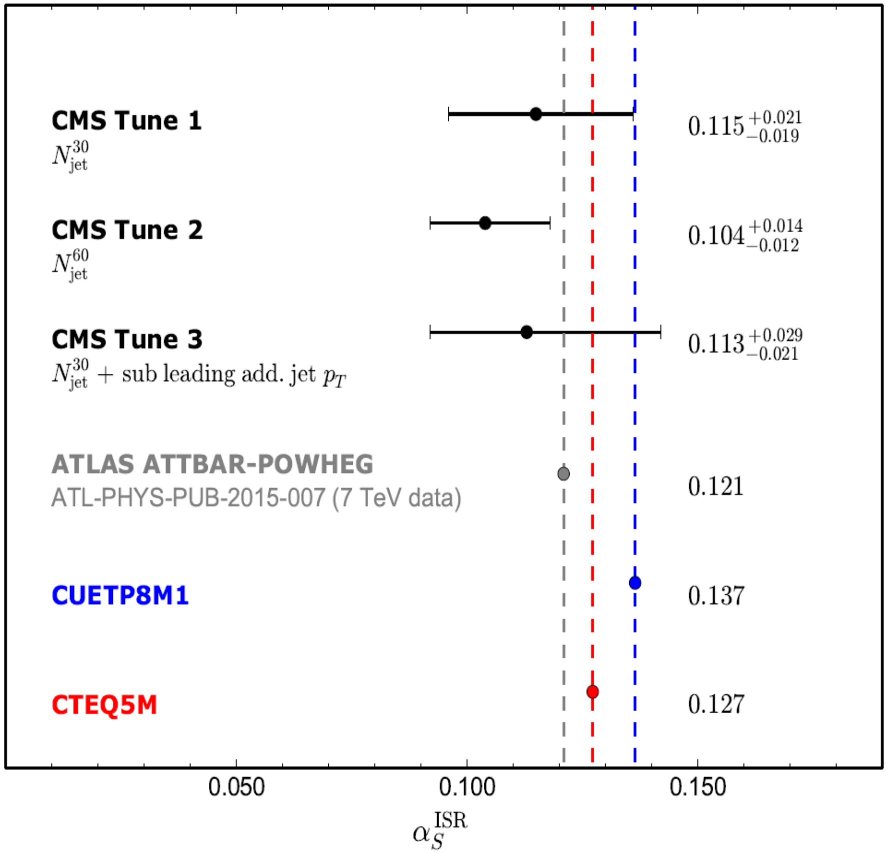


α_S(ISR) parameter to tune, to not mess LEP tuning (FSR) in hadronic res. decays:

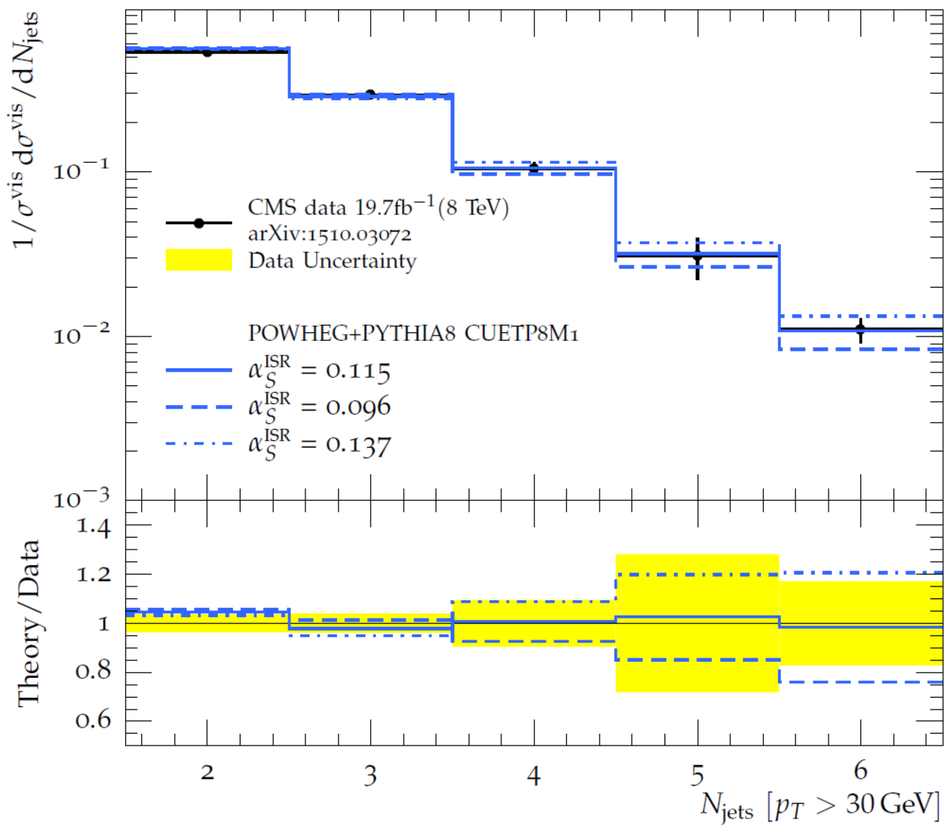
- aMC@NLO handles the first emission for both ISR and FSR but does NOT handle the matching of the first emission for hadronic resonance decays.
- Same for POWHEG. No conclusion in additional showers for MG5 (MLM)

α_s(ISR) tuning

Tuning using Professor



Supplementary material to TOP-12-041



Tuning α_S (ISR) with the Njets > 3 bins (where jets predominantly originate from the parton shower) used as input to Professor

α_S (ISR) = 0.115
– describes the overall jet multiplicity distributions better (indep. of the threshold)
– brackets previous results

α_s variation $\rightarrow \mu_R$ variation

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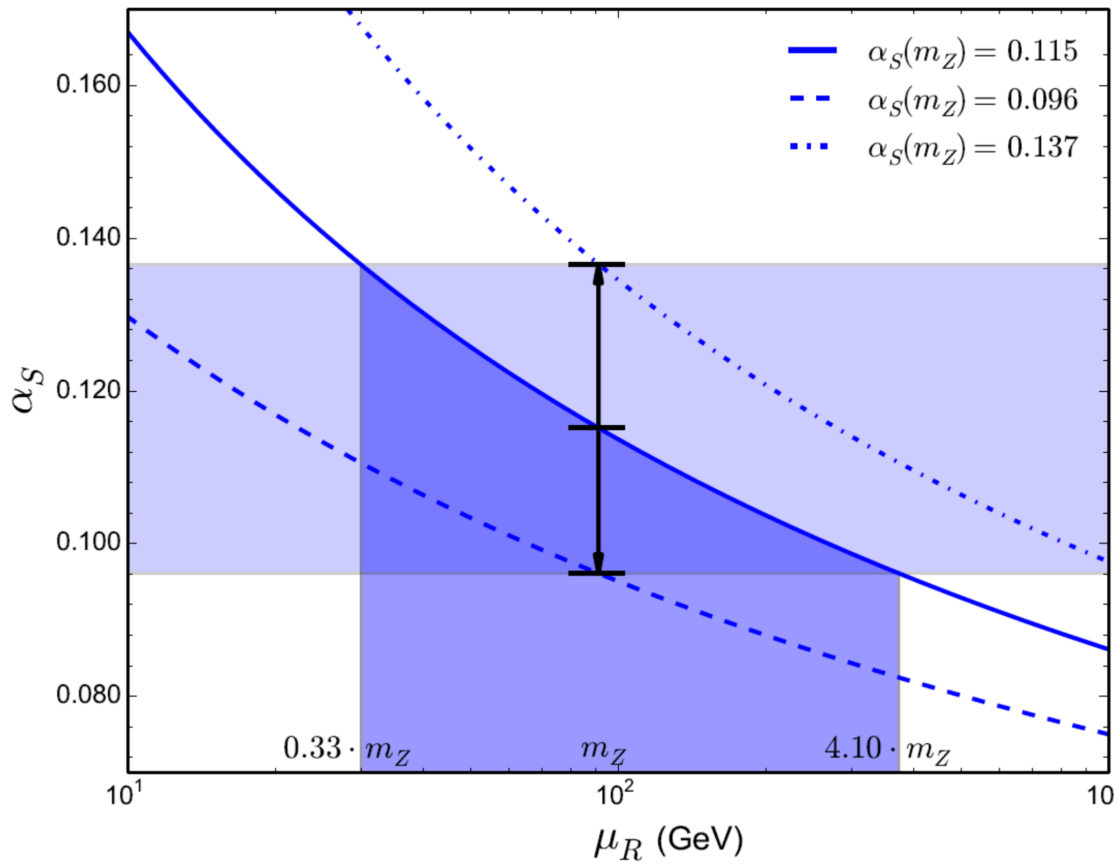
α_s^{ISR} (central)	Errors	Percentages	μ_R (GeV)
0.115	+0.021	18.6%	30.1
	-0.019	16.5%	373.9

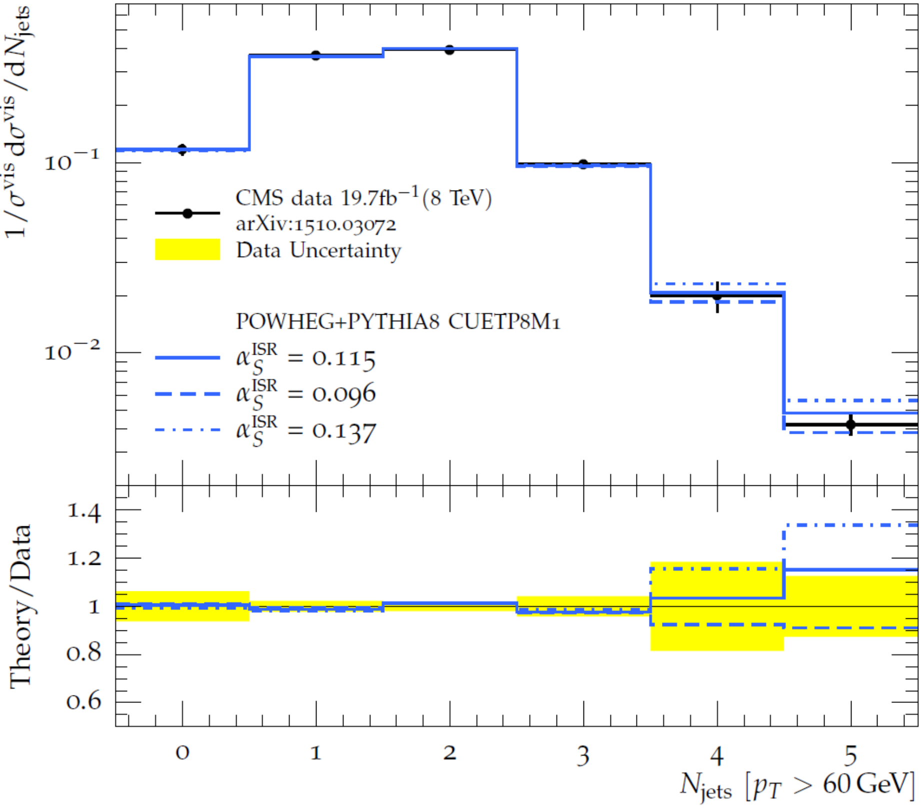


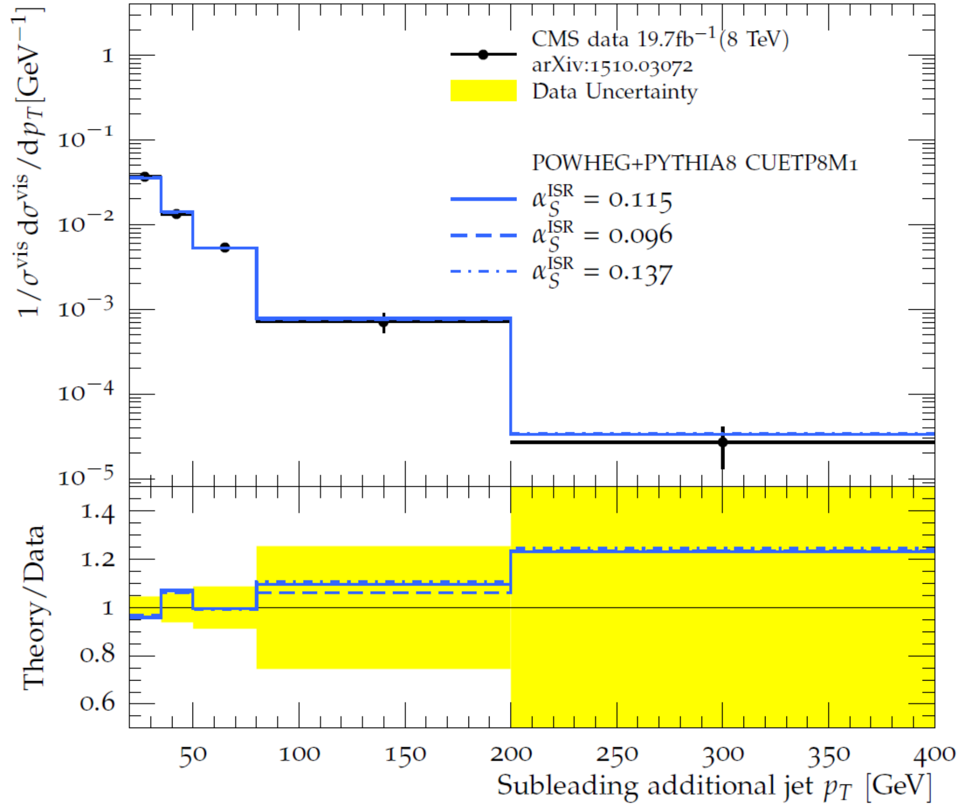
$$\alpha_s \approx \frac{1}{\beta(n)\ln\left(\frac{\mu_R^2}{\Lambda_{QCD}^2}\right)}$$

- Start off with μ_R=91.2 GeV
- Compute Λ_{QCD} that corresponds to central α_s.
- Determine how much much μ_R should be varied to get the upper and lower bounds of α_s.

The uncertainties on α_s^{ISR} correspond to a x0.33, x4 variation on μ_R

PS scale uncertainties





Tuning α_S (ISR) with the Njets > 3 bins (where jets predominantly originate from the parton shower) used as input to Professor

- α_s^{ISR} too high from Monash tune
- New preliminary tune brings njets distribution into agreement for POWHEG+PYTHIA8 at 8 & 13TeV

UE measurement with ttbar

UE measurement in ttbar (I)

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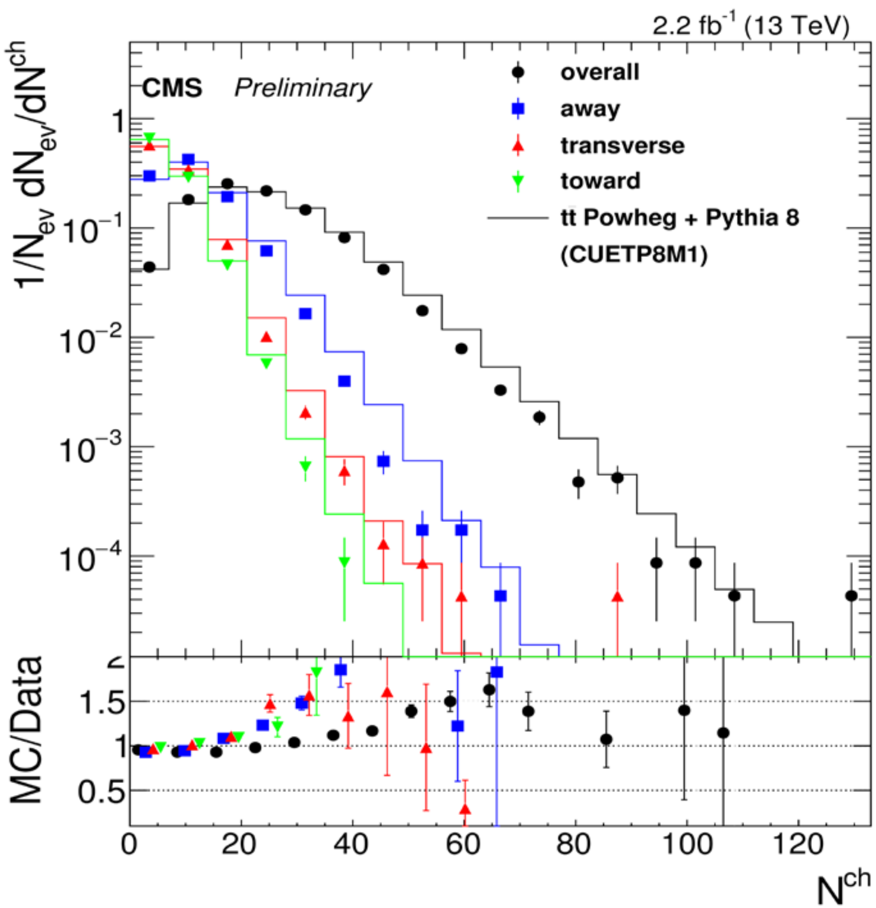
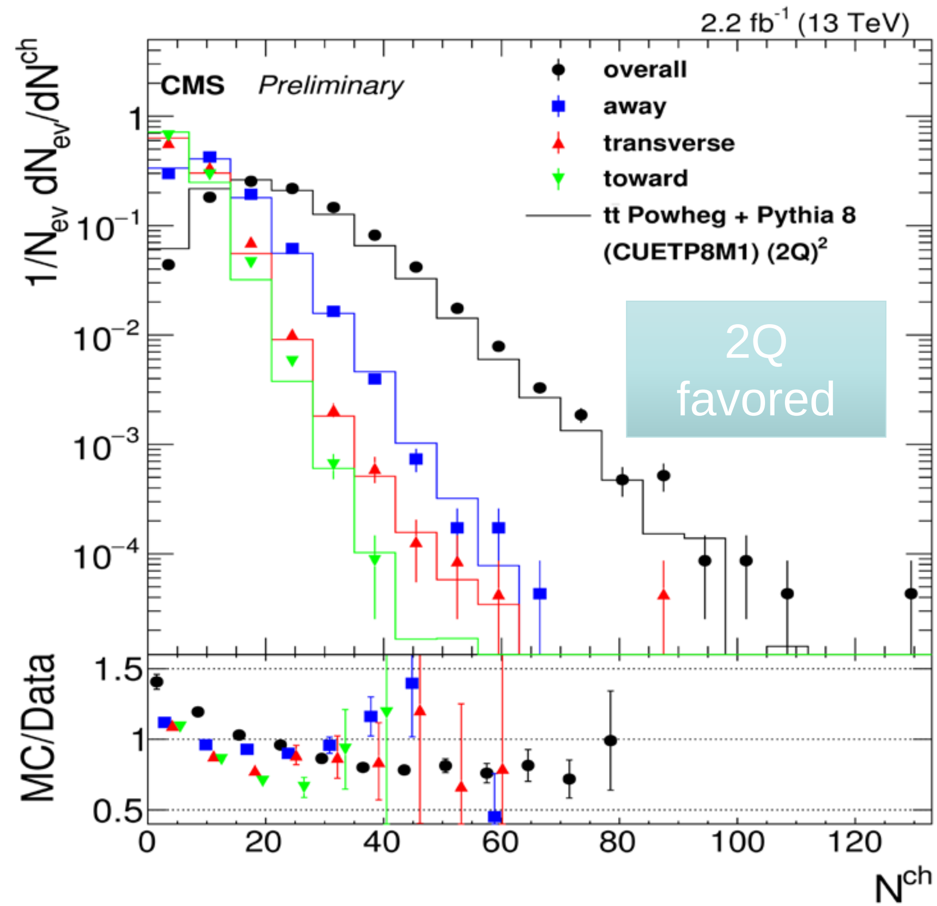
TOP-15-017 μ+jets NEW





- Measurement of charged particle multiplicity and mean/summed pT
- Sensitive to UE, ISR, PS cutoffs; currently being prepared for paper with unfolded results http://cms-results.web.cern.ch/cms-results/public-results/preliminary-results/TOP-15-017/index.html

UE measurement in ttbar (II)

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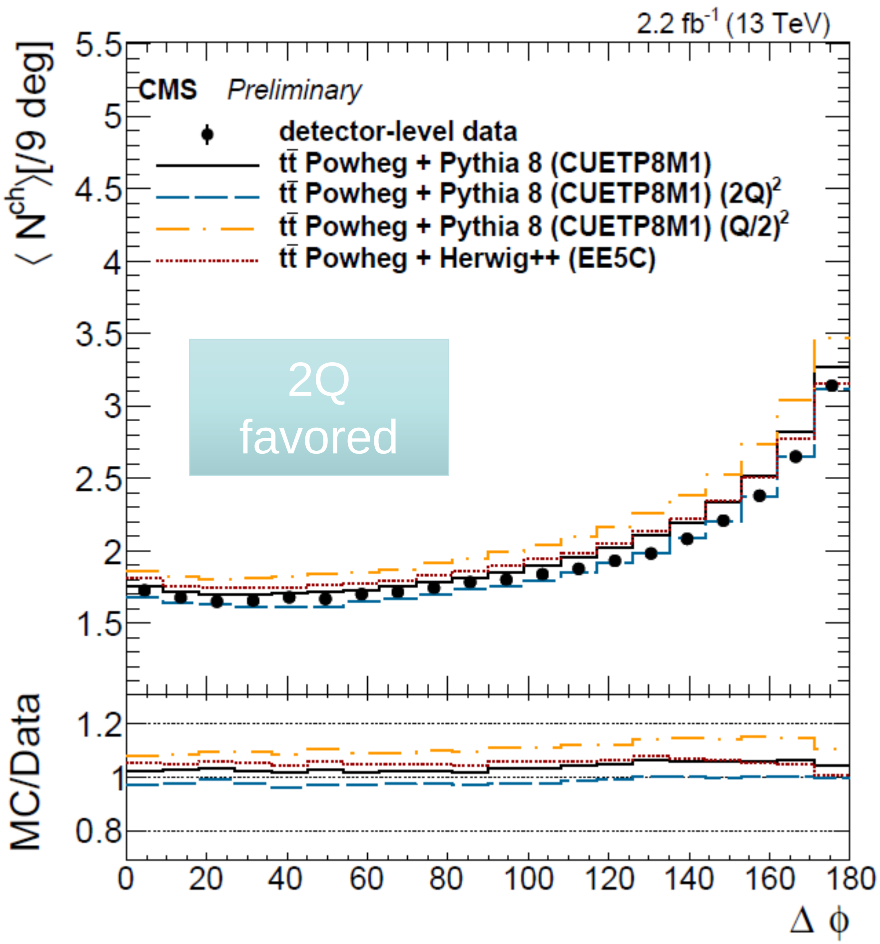
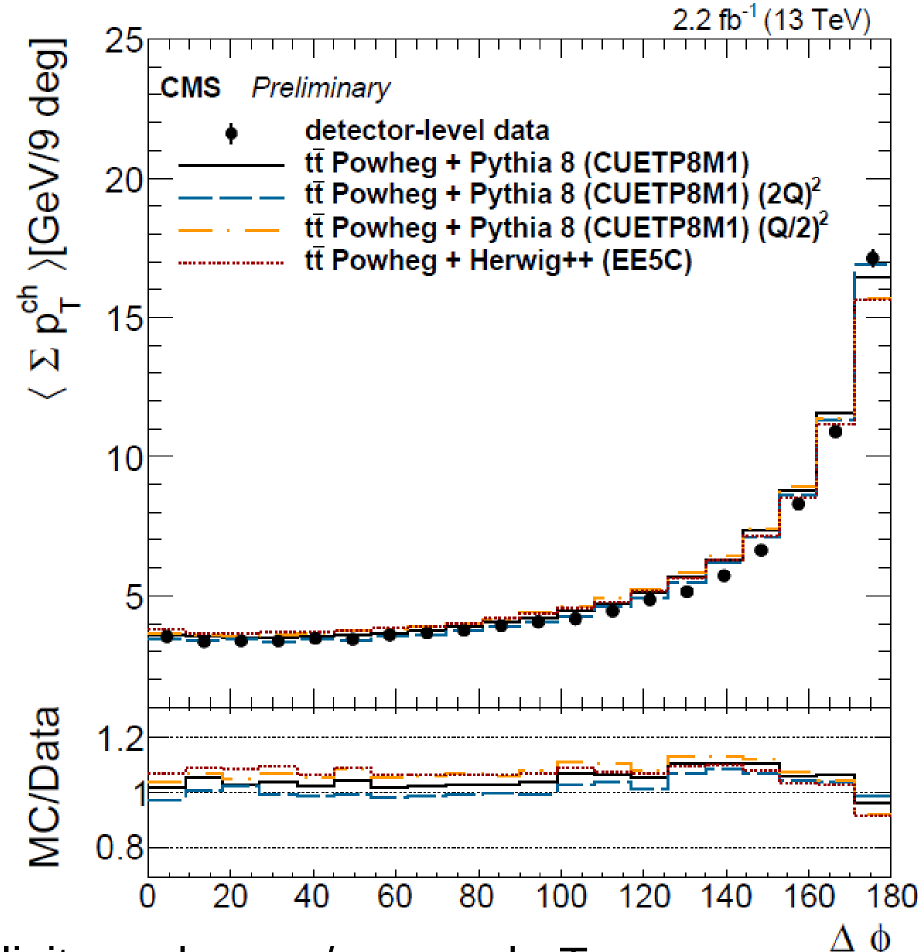
TOP-15-017 μ+jets NEW

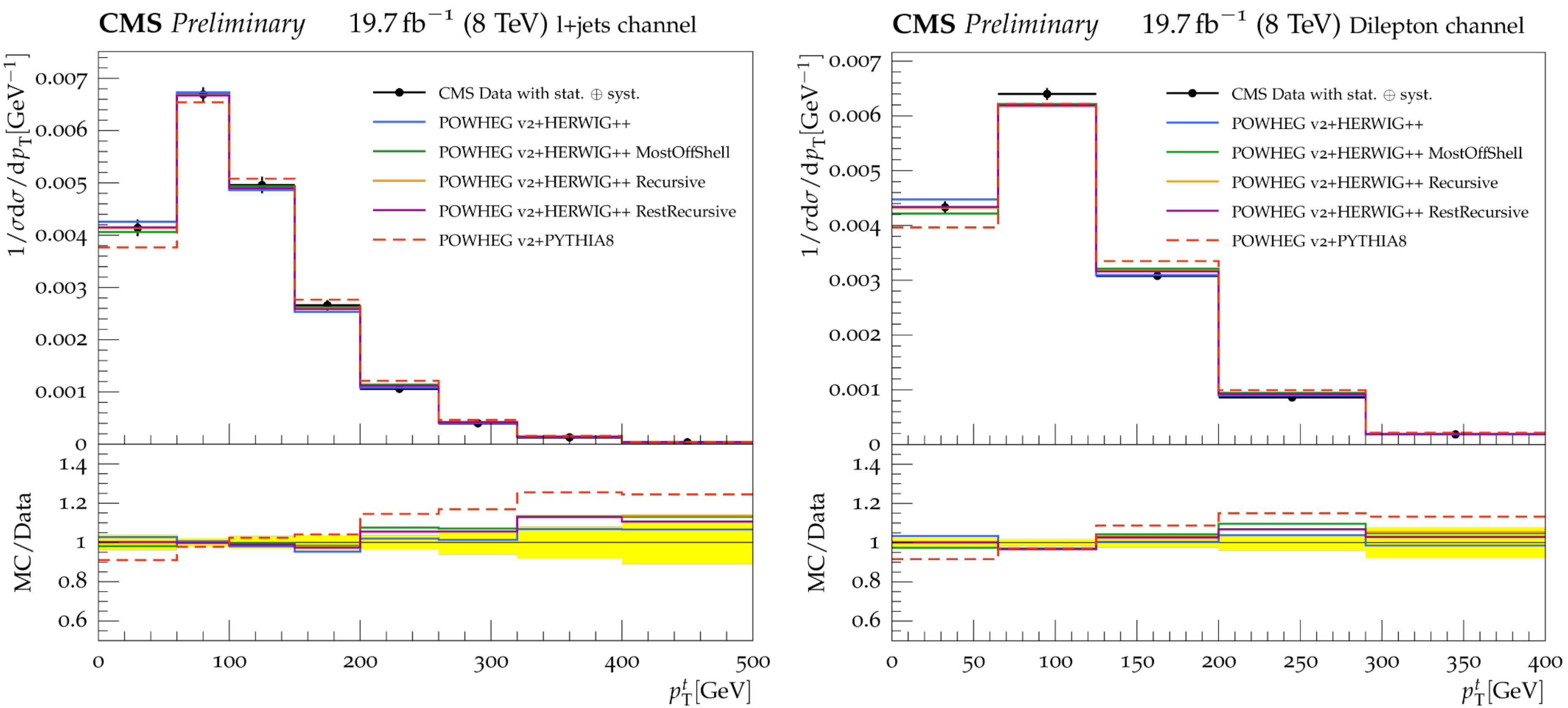




- Measurement of charged particle multiplicity and mean/summed pT
- The number of charged particles/Sum of the charged pT vs the angle with respect to the event-by-event axis defined using $p_T(tt)$

Other checks

HERWIG++ Reshuffling



- Consistent reshuffling options improving the Pythia 8 description.
- No major changes with different reshuffling options
- To be re-checked with Herwig 7

Auxiliary figures of TOP-15-011:
http://cms-results.web.cern.ch/cms-results/public-results/preliminary-results/TOP-15-011/index.html

Summary and conclusions

- Extensive suite of generator setups tried and more in the pipeline for 2016:
  - POWHEG+ PYTHIA 8 as default for Run2
  - Moving to Herwig7 ASAP and trying Sherpa
- 8/13 TeV data tend to agree with scale up variation
- Preliminary tuning of α_S(ISR) value to match 8TeV data at high jet multiplicities
  - makes the agreement at 13TeV for POWHEG+Pythia8 as good as 8TeV data with MG+Pythia6
- UE measurement with tt favouring scale up too
- Still no clear solution for top pT spectrum

EXTRA/BACKUP

Work in progress

- Sherpa and **Herwig 7** in development
  - Interface to CMSSW being created

- Trying EvtGen in **POWHEG** + **Pythia 8**
  - Using latest DECAY_NOLONGLIFE.DEC with long-lived states removed, to properly inject GEANT

- Testing improved handling of resonances (with radiation in decay) in **POWHEG** (ttb_NLO_dec), as well as Spin Correlations disabled

- **Pythia 8.219** being currently integrated in CMSSW to make use of new framework for automated parton-shower uncertainty bands.