Measurement of the Jet Multiplicity in Dileptonic Top-Quark Pair Events at $\sqrt{s}$ = 8 TeV.

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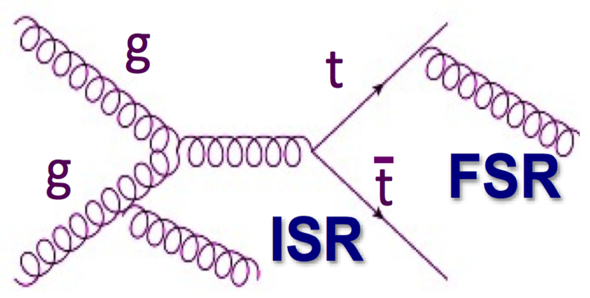
Motivation

At LHC energies, the fraction of $t\bar{t}$ events with additional hard jets in the final state is about half of the total number of events.

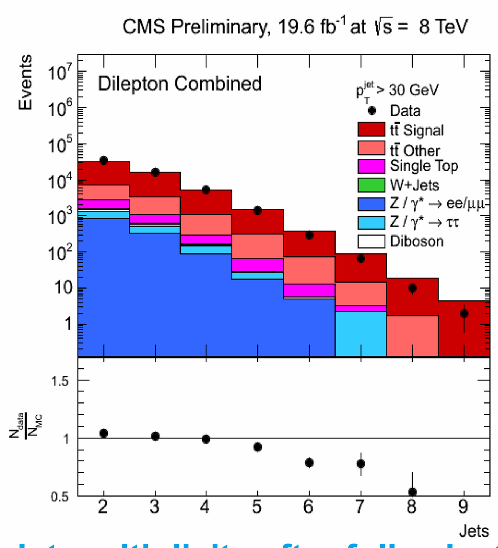


These processes include additional initial and final state radiation and provide a handle to:

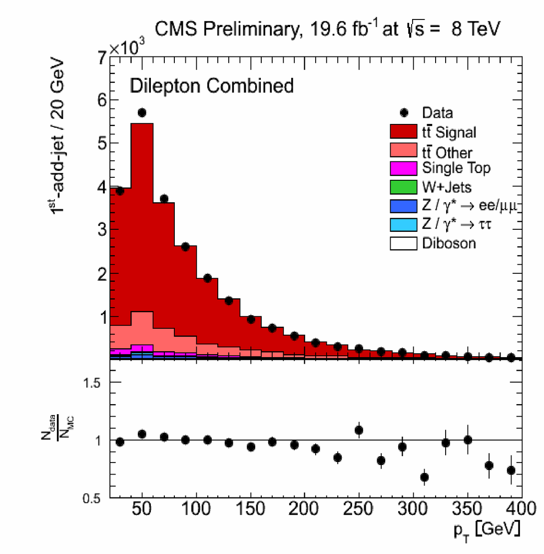
- **Constrain initial and final state radiation (ISR/FSR).**
- **Test perturbative QCD at the LHC energy regime.**
- **Test and tune predictions and models.**
- **Reveal presence of new physics manifesting in $t\bar{t}$+jets final states.**
- **Background for Higgs and new physics searches.**

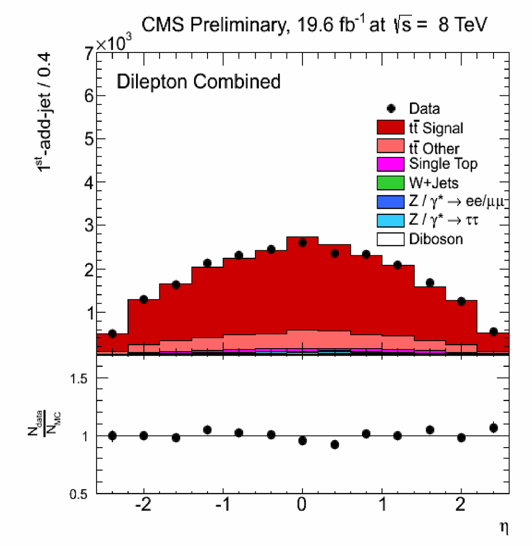
Event selection

- **At least 2 isolated leptons with opposite sign**
  p_T > 20 GeV | η | < 2.4
  Invariant mass m_{ll} > 20 GeV
- **At least 2 jets** (p_T > 30 GeV | η | < 2.4)
- **At least 1 b tagged**
- In e+e- / μ+ μ- channels:
  Veto the Z peak: | $m_Z - m_{ll}$ | > 15 GeV
  E_T^{miss} > 40 GeV



Jet multiplicity after full selection.





Transverse momentum (left) and pseudorapidity (bottom) of the first p_T leading additional reconstructed jet.

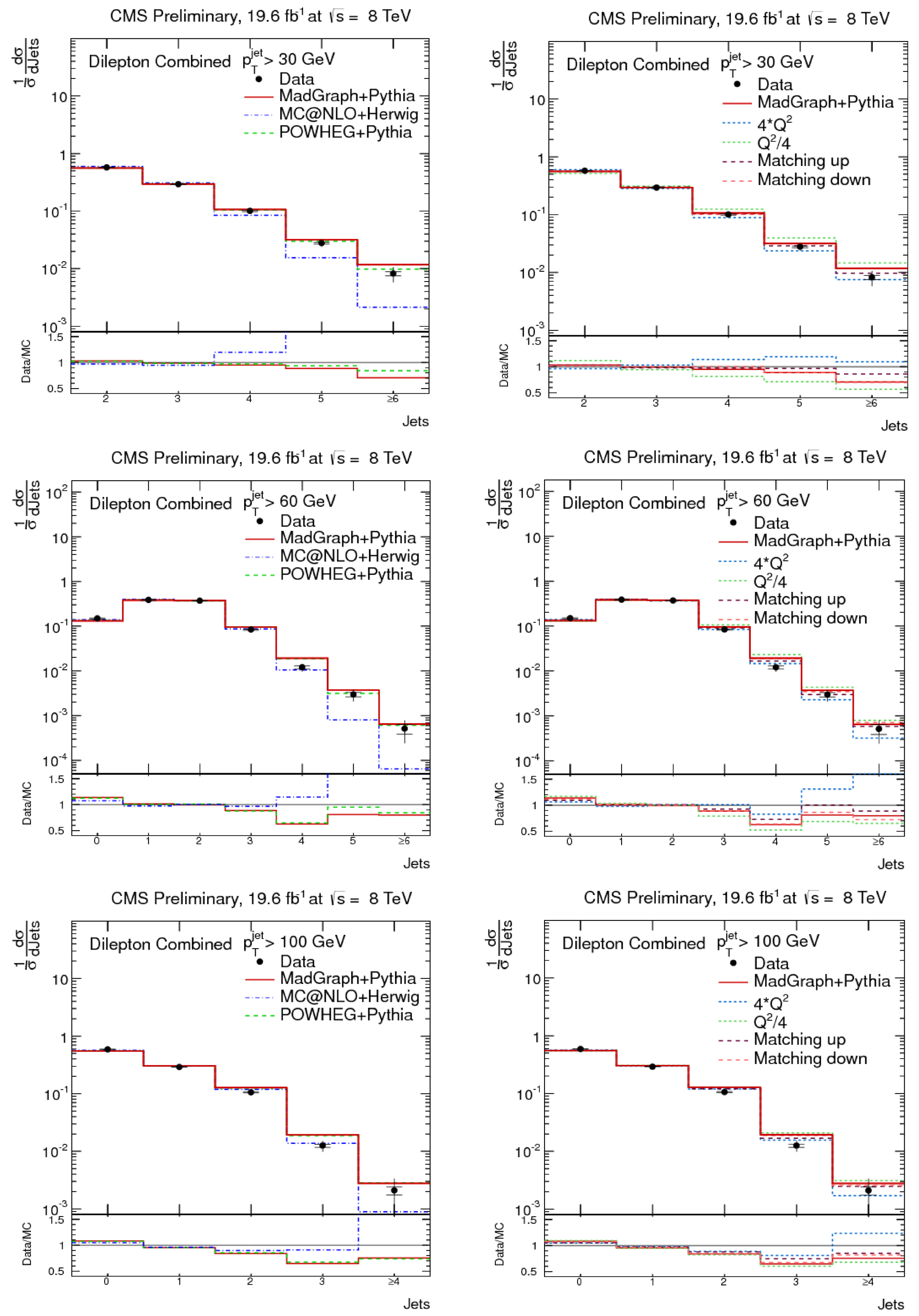
(Anti)Top-quark reconstruction:
System underconstrained

Kinematic reconstruction using boundary conditions
m_W = 80.4 GeV
$E_T^{miss} = p_T(\nu_1)+p_T(\nu_2)$
fix $m_t = m_{\bar{t}}$ and vary in 1 GeV steps from 100 to 300 GeV and chose solution with most b tagged jets, then with most probable neutrino spectrum

Data: 19.6 fb^{-1}, 8 TeV **Predictions:** MADGRAPH+Pythia, POWHEG+Pythia, MC@NLO+Herwig
MADGRAPH+Pythia with varied renormalization/factorization **(Q^2) scale**, **jet-parton matching scale**

Cross section as a function of jet multiplicity

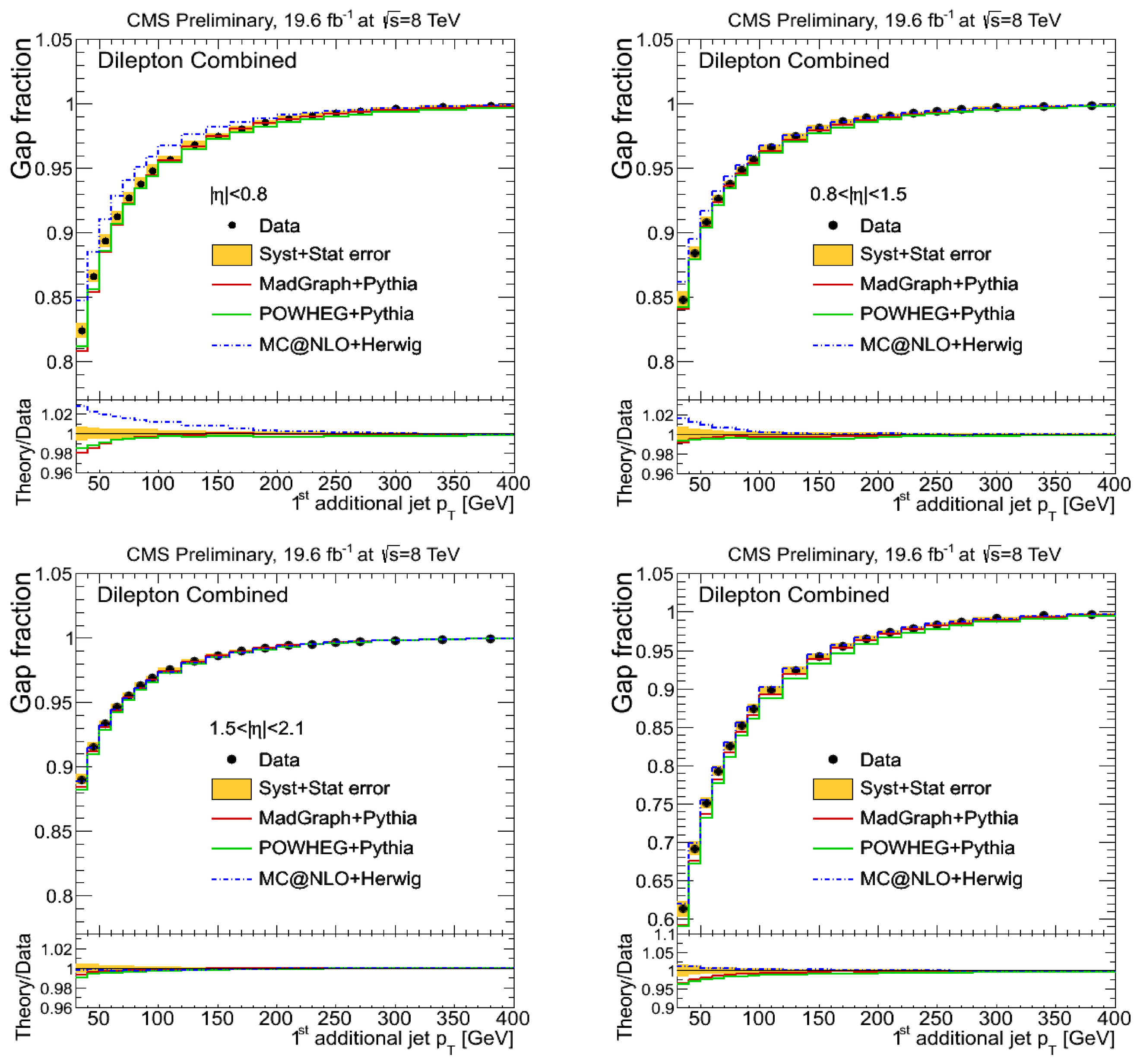
Regularized unfolding using Singular Value Decomposition (based on MadGraph+Pythia), normalized to in-situ cross section in visible phase space:
Leptons: p_T > 20 GeV, | η | < 2.4 Jets: p_T> 30 GeV, | η | < 2.4



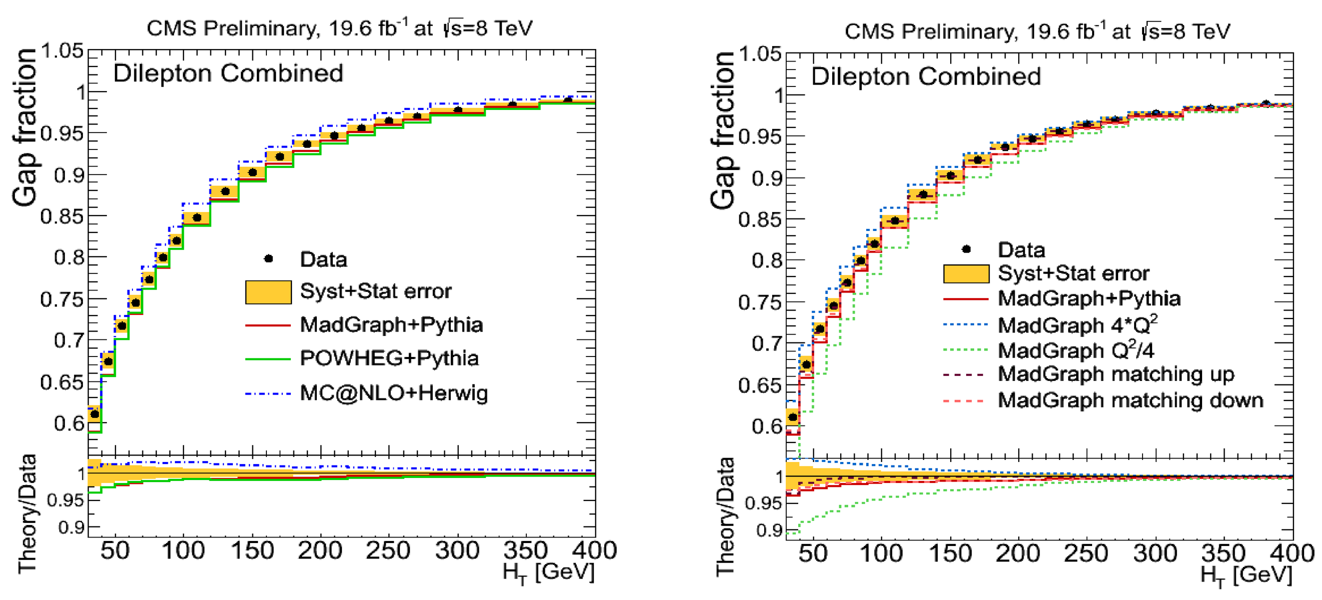
Multiplicity of jets with p_T>30 GeV, p_T>60 GeV and p_T>100 GeV.
→ **sensitive to amount of ISR/FSR.**
Dominant systematics: Jet energy scale & signal modeling.
All predictions give a reasonable description of the data.
MC@NLO+Herwig underestimates data for high multiplicities and low jet p_T thresholds. MadGraph with higher scales provides slightly better description of the data.

Gap fraction

Jet activity arising from quark and gluon radiation produced with the $t\bar{t}$ system can be quantified with the fraction of events **without** additional jets **above a p_T threshold** ("gap fraction") and by defining the gap fraction as the fraction of events in which the **scalar sum of the p_T (H_T)** of the additional jets is **less than a certain threshold.** The gap fraction is corrected to particle level (MadGraph+Pythia)



Gap fraction as a function of leading additional jet p_T for different jet |η| and in the visible phase space. → **sensitive to the leading-p_T emission.**
Dominant systematics: Jet energy scale & background contamination.
MC@NLO+Herwig describes data best for high jet |η| and in the visible phase space.



Gap fraction as a function of H_T of additional jets in the visible phase space.
→ **sensitive to all hard emissions accompanying the tt system.**
Dominant systematics: Jet energy scale & background contamination
Reasonable agreement between data and different predictions, MC@NLO+Herwig is slightly above, MadGraph+Pythia and POWHEG+Herwig are slightly below data.
MadGraph with higher scales provides a slightly better description of the data.

The measurement of the normalized top quark pair production cross section using 19.6 fb^{-1} at 8 TeV in the dilepton decay channel is presented as function of number of jets in the event. The comparison of the data with several QCD predictions shows reasonable agreement. MADGRAPH and POWHEG interfaced with PYTHIA describe the data well up to high jet multiplicities; while MC@NLO interfaced with HERWIG generates lower multiplicities than observed.
The gap fraction is measured as a function of the p_T of the leading additional jet and the scalar sum of the transverse momentum of all additional jets. MC@NLO interfaced with HERWIG seems to describe more accurately the gap fraction as a function of the p_T of the leading additional jet. For both, the gap fraction and jet multiplicities, the data seems to favor slightly higher scales in MadGraph interfaced with Pythia.

REFERENCE: CMS PAS TOP-12-041