PROCEEDINGS OF SCIENCE

Top quark event modelling and generators

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State-of-the-art theoretical predictions accurate to next-to-leading order QCD interfaced with Pythia8 and Herwig++ event generators are tested by comparing the unfolded ttbar differential data collected with the CMS detector at 8 TeV. These predictions are also compared with the underlying event activity distributions in ttbar events using CMS proton-proton data collected in 2015 at a center of mass energy of 13 TeV.

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Studies are presented comparing ttbar differential distribution data collected with the CMS detector[1] at 8 TeV to state-of-the-art theoretical predictions. The predictions are accurate to next-to-leading order quantum chromodynamics and interfaced with the PYTHIA 8 and HERWIG++ event generators. The predictions of these simulation tools and a next-to-next-to-leading order calculation are compared to unfolded data distributions. All deviations of the theory predictions from the data remain inside the envelope considered for factorization and renormalization scale variations [2].

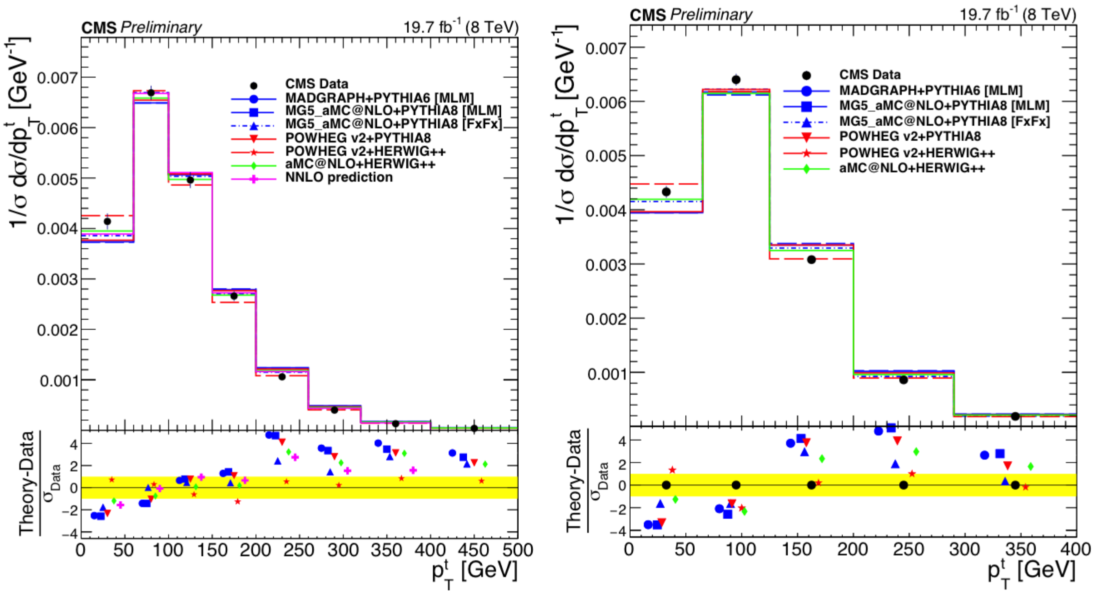

Figure 1: Normalized ttbar cross section in bins of p_T^t in data and MC at the parton-level. The yellow band indicates the 1σ difference of data from theory predictions. In the $l + jets$ channel, the NNLO predictions are also shown.

Measurements of the underlying event (UE) activity using charged particle properties in ttbar events in the $\mu + jets$ channel are presented. Proton-proton collision events at a center-of-mass energy of 13 TeV, corresponding to an integrated luminosity of 2.2 fb^{-1} recorded by the CMS detector at the LHC, are used for the measurements. The measurements are found to be consistent with the predictions from the QCD Monte Carlo model generators used by CMS for the LHC Run II data [3].

Exploratory studies of the underlying event (UE) activity and of the fragmentation and hadronization of b-quarks in final states containing a J/ψ are performed using ttbar candidate events. Proton-proton collision data acquired by the CMS experiment at a centre-of-mass energy of 8 TeV and corresponding to an integrated luminosity of 19.7 fb^{-1} are used. A good agreement is found using MADGRAPH plus the PYTHIA 6 Tune Z2 simulation. The effects predicted by alternative settings and generators for the characterization of the UE are also explored. These results are expected to contribute in the future to more precise measurements in the top quark sector in particular of the top quark mass by either constraining systematic uncertainties related to the modeling of the UE in ttbar events or by paving the way for alternative mass measurement methods.

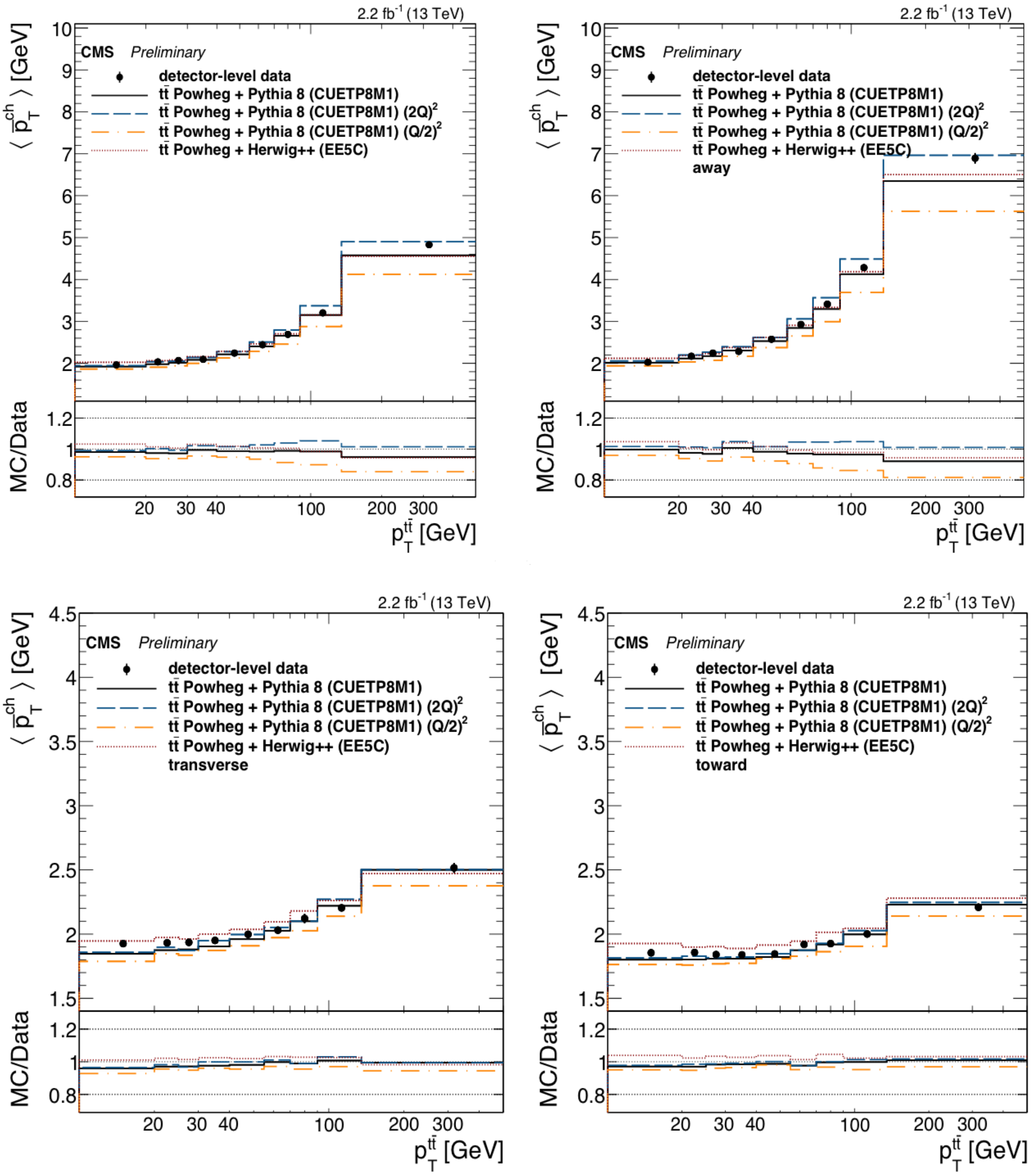

Figure 2: The average p_T per charged particle vs p_T^{tt} for the overall sample and the away (top), transverse and toward regions (bottom) defined with respect to $\Delta\phi$. Data at the detector level are compared with the POWHEG + PYTHIA 8 predictions with the CUETP8M1 tune generated with the nominal Q2 scale as well as (2Q)2, and (Q/2)2, and with the POWHEG + HERWIG++ sample with the EE5C tune.

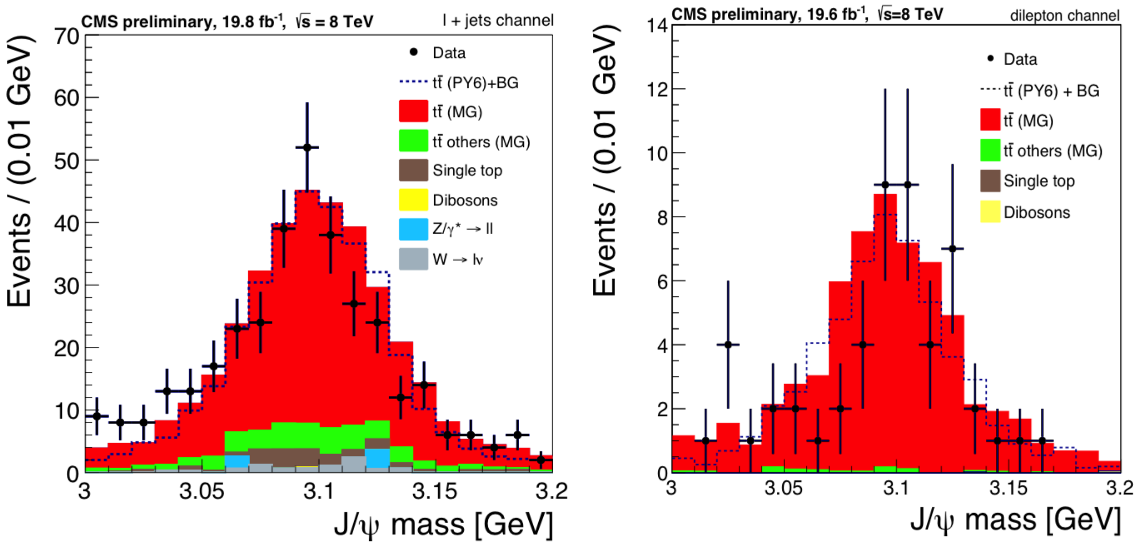

Figure 3: The distribution of the mass in the J/ψ mass region is shown separately for the $l + jets$ (left) and in the dilepton (right) channels and compared to the total simulation-based pre- diction. The simulated prediction, normalized by the theoretical cross section and integrated luminosity, is shown stacked for each sub-process and it is compared to the data represented as markers. An alternative prediction based on a stand-alone PYTHIA 6 sample is shown super-imposed as a dashed line.

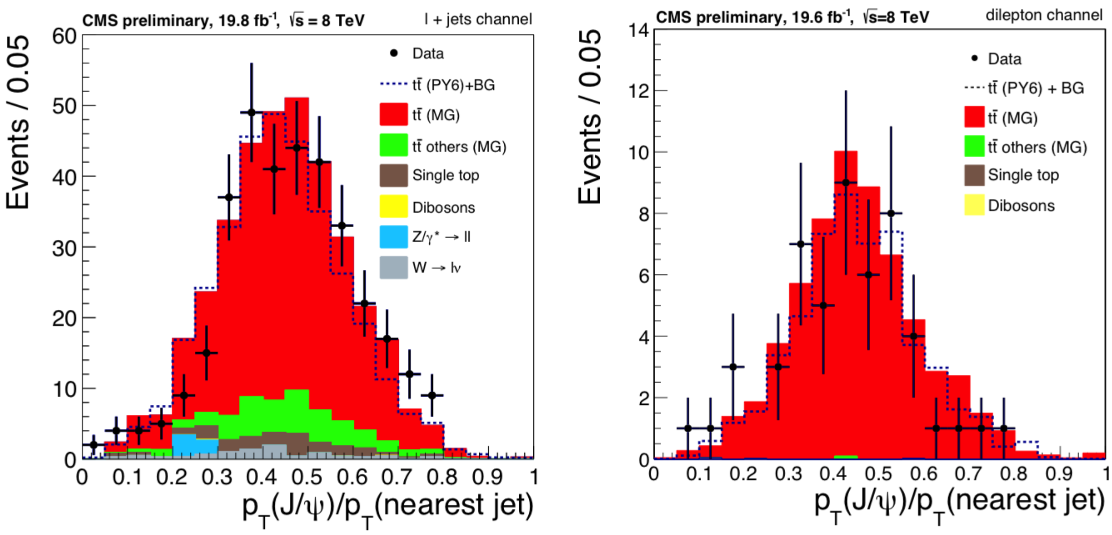

Figure 4: The fraction of the jet momentum carried by the J/ψ in the $l + jets$ (left) and dilepton (right) channels. In all distributions the total simulation-based prediction is shown stacked for each sub-process and it is compared to the data represented as markers. An alternative prediction based on a stand-alone PYTHIA 6 sample is shown superimposed as a dashed line.

Both the UE and J/ψ properties studies open the door towards an improved description of ttbar events and are expected to contribute to more precise measurements in the top quark sector in particular by improving the precision of the measurement of the top quark mass with a more realistic assessment of the systematic uncertainties or the exploration of alternative techniques [4].

References

[1] CMS Collaboration, "The Compact Muon Solenoid (CMS) experiment at the CERN LHC" http://inspirehep.net/record/796887?ln=en

[2] Comparisons of Theory Predictions for the ttbar Process with Data from pp Collisions at $\sqrt{s}$= 8 TeV - CMS Collaboration CMS-PAS-TOP-15-011

[3] Underlying event measurement with ttbar+X events with p-p collision data at $\sqrt{s}$=13 TeV - CMS Collaboration CMS-PAS-TOP-15-017

[4] Study of the underlying event, b-quark fragmentation and hadronization properties in ttbar events - CMS Collaboration CMS-PAS-TOP-13-007