Measurement of the differential cross section for top-quark-pair production in the dilepton channel at $\sqrt{s}$ = 13 TeV with the CMS detector

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❶ Introduction

- **Motivation**: probe top-quark-pair production at $\sqrt{s}$ = 13 TeV and compare results with predictions from perturbative QCD calculations
- Measurements of top-quark and $t\bar{t}$-system kinematics in the full phase space, and of the jet multiplicity in a fiducial phase space
- Data recorded by the CMS experiment in 2015 corresponding to L_{int} = 2.2 fb^{-1}

❷ Event selection

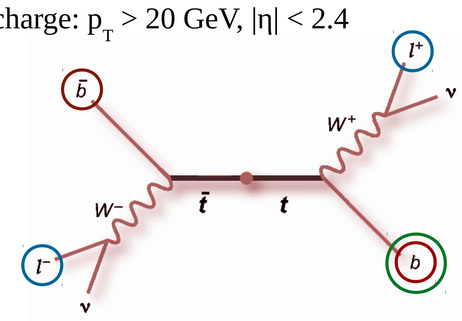
Signal: only $t\bar{t}$ events with two leptons that do not originate from decays of tau leptons; simulated with Powheg v2+Pythia8

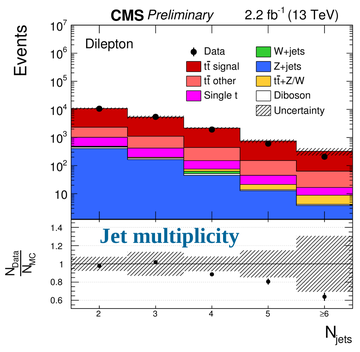
Event selection criteria:

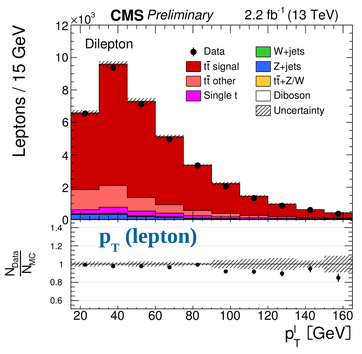
- exactly two isolated **leptons** with opposite charge: p_T > 20 GeV, |η| < 2.4
- at least two **jets**: p_T > 30 GeV, |η| < 2.4
- m(ll) > 20 GeV
- at least one identified **b jet** (b-tag)

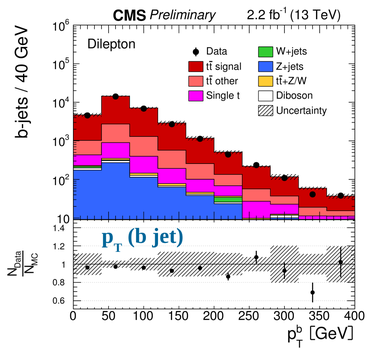
Additionally for ee and μμ channels:

- E_T^{miss} > 40 GeV
- Z mass veto: |m(Z) – m(ll)| > 15 GeV





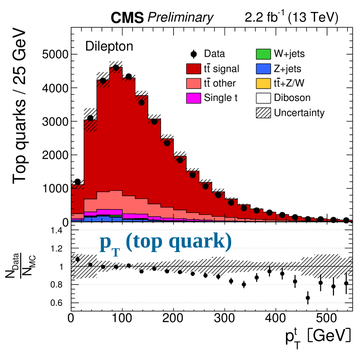


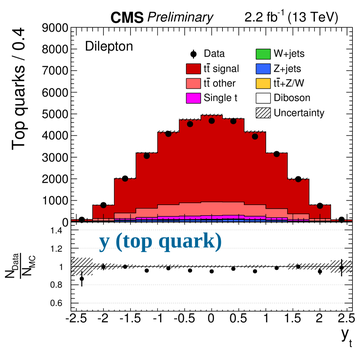


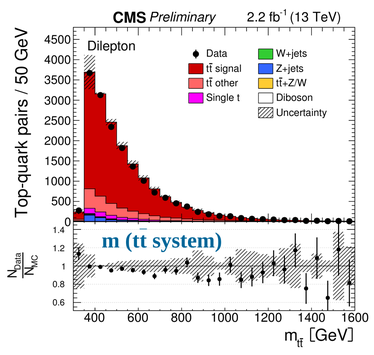
❸ Kinematic reconstruction

Two undetectable neutrinos after top decay: kinematic reconstruction needed

- Kinematics of top quarks are determined by solving system of equations with respect to neutrino momenta (six unknowns) using inputs: 2 jets, 2 leptons, E_T^{miss}
- Constraints: $E_T^{miss} = p_T(\nu) + p_T(\bar{\nu})$, m(W) = 80.4 GeV, m(t) = m($\bar{t}$) = 172.5 GeV
- Examination of all possible lepton-jet pairs with assigned weight accordingly to expected true m(l,b) spectrum
- Each event reconstructed 100 attempts with smearing energies and directions of lepton and b jet candidates by their resolutions
- Top quarks constructed as weighted average of solutions for all smeared attempts







❹ Differential cross section

For a given variable *X*, normalized differential cross section is determined as:

$$\frac{1}{\sigma}\frac{d\sigma_i}{dX_i} = \frac{1}{\sigma}\frac{x_i}{\Delta_i^X}$$

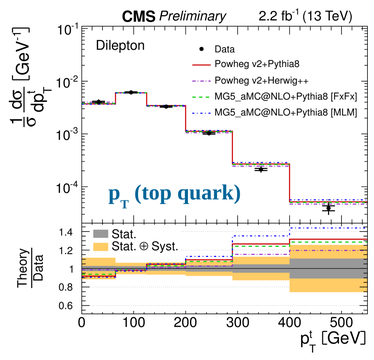
- x_i respresents number of signal events observed in data after background subtraction and corrected for detector efficiencies, acceptances, and migrations
- Δ_i^X – bin width in units of *X*; σ – measured total cross section in visible phase space
- Regularized SVD unfolding using response matrix as calculated from $t\bar{t}$ signal sample simulated with Powheg v2+Pythia8

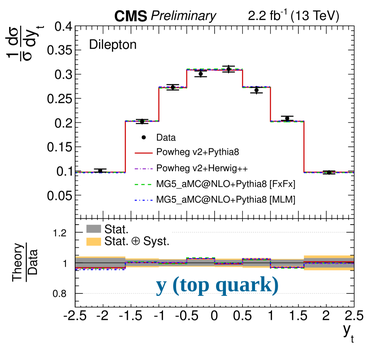
❺ Results

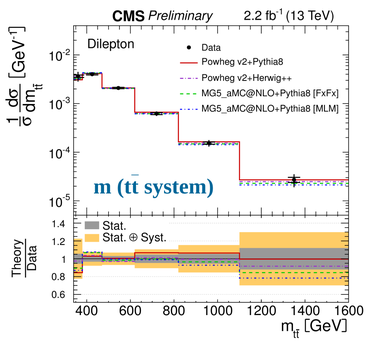
- Normalized differential $t\bar{t}$ production cross sections confronted with MC predictions and state-of-the-art standard model QCD predictions to beyond-NLO accuracy
- Overall uncertainty ranges from 3 − 30% with largest contributions from theory related sources or statistical component depending on the bin

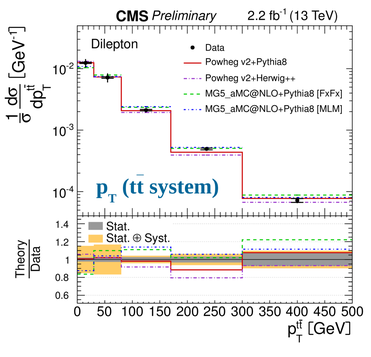
Parton level, full phase space

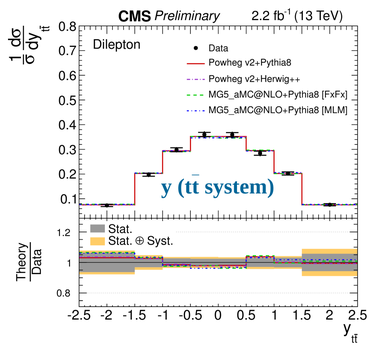
Compared to MC



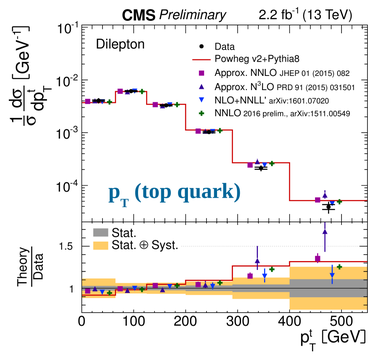


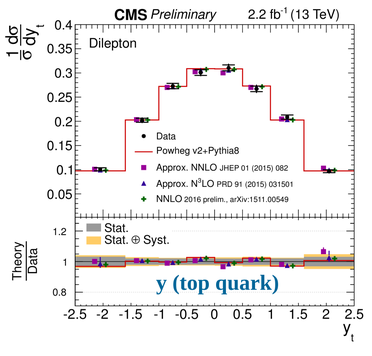


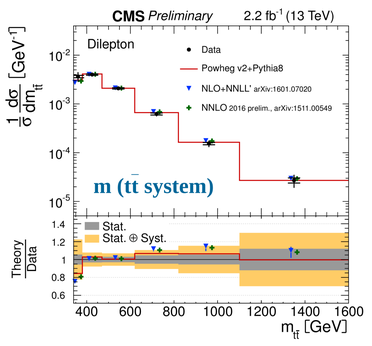


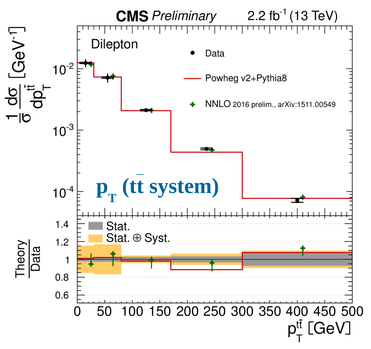


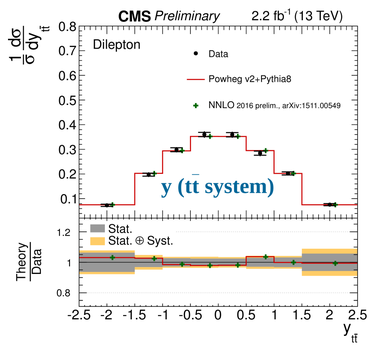
Compared to fixed order calculations



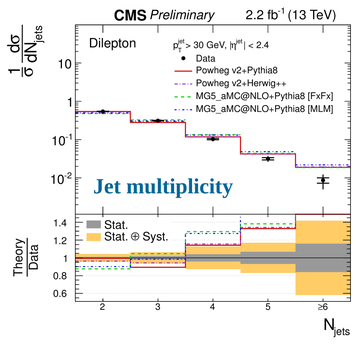








Particle level, fiducial phase space



❻ Summary

- Normalized differential $t\bar{t}$ production cross sections were measured at 13 TeV in pp collisions using data corresponding to 2.2 fb^{-1} collected by CMS detector in 2015
- Measurements done in bins of p_T(t), y(t), p_T($t\bar{t}$), m($t\bar{t}$), y($t\bar{t}$) and jet multiplicity:
  - → generally, data are in agreement with modern standard model QCD predictions for all measured distributions
  - → higher jet multiplicities in data are not uniformly described by any of considered Monte Carlo predictions
  - → top quark p_T spectrum in data is found to be softer than Monte Carlo predictions and is better described by beyond the NLO-accuracy QCD calculations

Reference: CMS PAS TOP-16-011

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