Measuring the differential cross section for top quark pair production at 8 TeV

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The large top quark samples produced at the Run-I of the LHC allow performing measurements of top quark production and properties at unprecedented precision. These measurements are fundamental for testing the quality of the standard model (SM) and for searching for new physical phenomena beyond its scope.

Precise understanding of top quark pair ($t\bar{t}$) production is crucial for:

- precise tests of QCD in different regions of the phase space
- testing and tuning theory predictions and models with measurements
- revealing presence of new physics
- important background for Higgs and many new physics searches

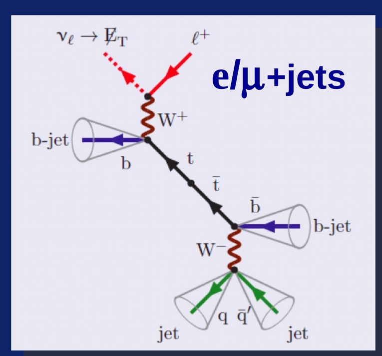
Measurements of $t\bar{t}$ production cross section as a function of $t\bar{t}$ kinematic observables are presented, using 20 fb^{-1} of data at 8 TeV :

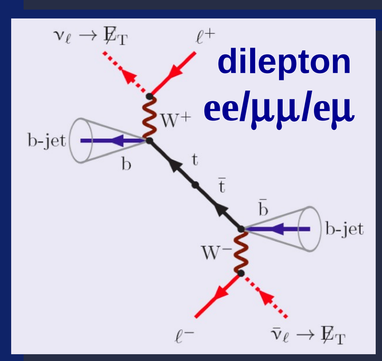
- Observables: **leptons, b-jets, top quarks, and $t\bar{t}$ system**
- Performed in the **dilepton** and **lepton+jets** decay channels
- Comparison to perturbative QCD theoretical predictions

(1) Select a pure $t\bar{t}$ sample

In dilepton (l+jets) channels, require:

- **At least 2 opposite-sign (exactly 1) e/μ**
  - Isolated
  - p_T > 20 (33) GeV, |η| < 2.4 (2.1)
  - dilepton QCD veto: m_{ll} > 20 GeV
  - l+jets: veto other leptons with looser criteria
- **At least 2 (4) anti-k_T jets with R = 0.5**
  - p_T > 30 GeV, |η| < 2.4
- **In ee and μμ channels:**
  - veto the Z peak: | m_Z – m_{ll}| > 15 GeV
  - E_T^{miss} > 40 GeV
- **At least 1 (2) b-tagged jet(s)**





$t\bar{t}$ signal purity: ~80%
Main backgrounds:
$t\bar{t}$ Other, single t, Z+jets (dilepton), W+jets (l+jets)

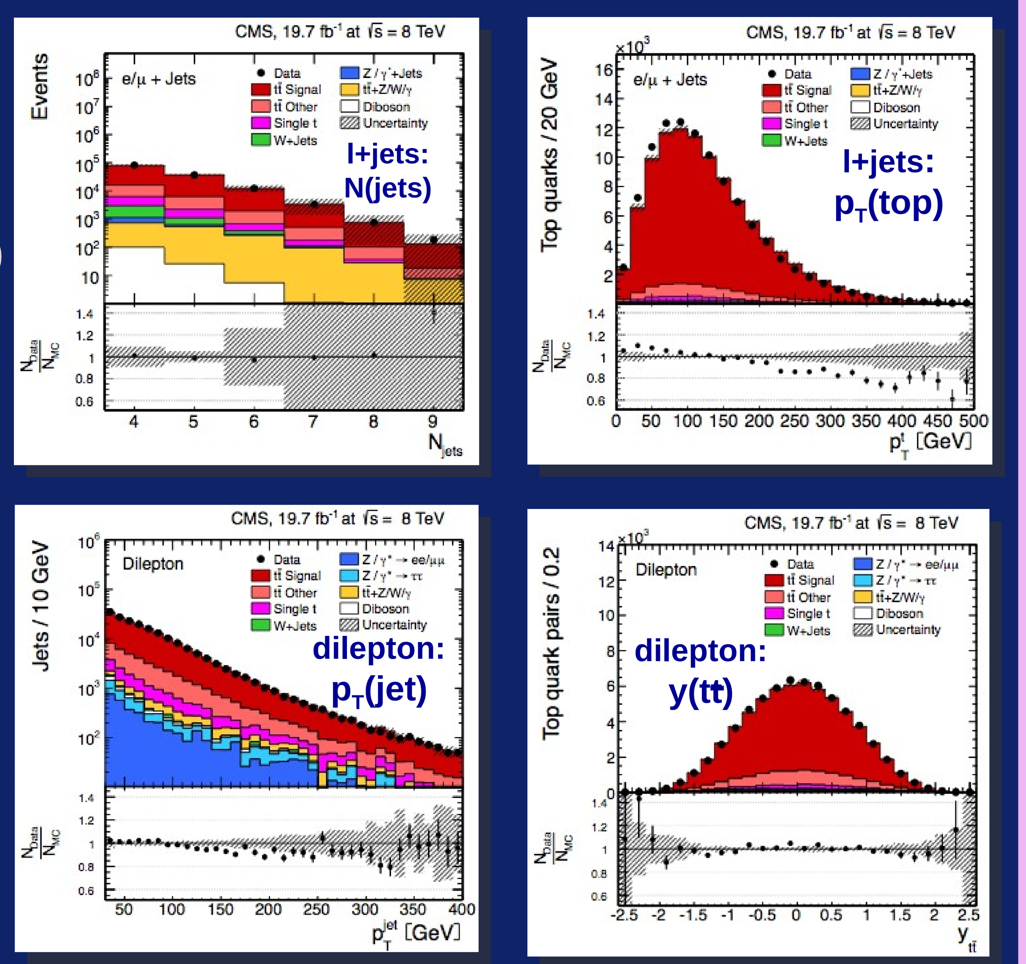
(2) Kinematic reconstruction of the $t\bar{t}$ system

Dilepton channel:

- Reconstruct neutrino momenta from p_T conservation and known m(W) and m(top)
- 4-fold ambiguity → take solution with lowest m($t\bar{t}$)
- Reconstruct event 100 times with varied b-jet and lepton 4-momenta
- Take lepton-jet combination with largest sum of weights according to true m(lb) distribution

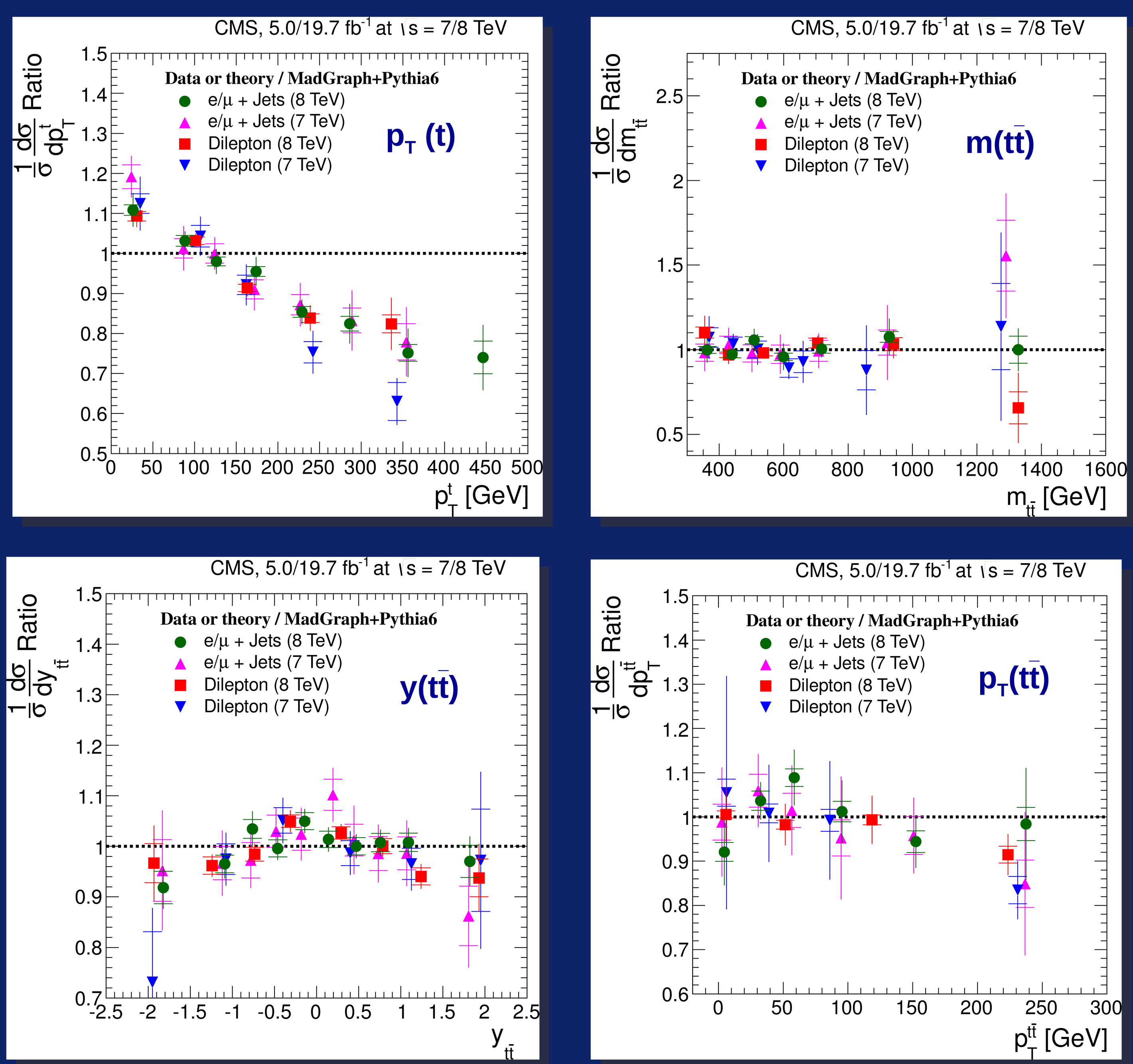
L+jets channel:

- Build permutations of jet-parton assignment (4/5 leading jets, use b-tag information)
- Vary 4-momenta of lepton, jets & neutrino within resolutions (constraints: m(W), m(t) = m($\bar{t}$)) → take 4-jet permutation with minimum χ^2
- Trick: first fit with fixed m(t), then use input for second fit with m(t) floating and cut on χ^2 → better assignment of b-jets to b-quarks



Reference $t\bar{t}$ prediction: MadGraph+Pythia6
Data are reasonably well described by simulation
The p_T spectra are steeper in data than in simulation

Consistent results between channels, both at 7 and 8 TeV



(3) Bin-wise cross section measurement

For each observable X, and in each bin i:

$$\frac{1}{\sigma}\frac{d\sigma}{dX_i} = \frac{1}{\sigma}\frac{\sum_j A^{-1}_{ij}\left[(N_{data,j} - N_{BG,j})\right]}{\Delta_{X_i}\cdot L}$$

- N_{data} : observed events in data
- N_{BG} : background events
- A^{-1} : inverse of response matrix used in unfolding
- Δ_X : width of bin
- L : integrated luminosity

- Correct for **detector effects and acceptance: regularized unfolding** (based on Singular Value Decomposition) using MadGraph+Pythia6 $t\bar{t}$ simulation

- **Top and $t\bar{t}$ observables:**
  Full phase space, parton level
  - top quarks after QCD radiation and before decay

  → Facilitates comparison with higher order QCD calculations

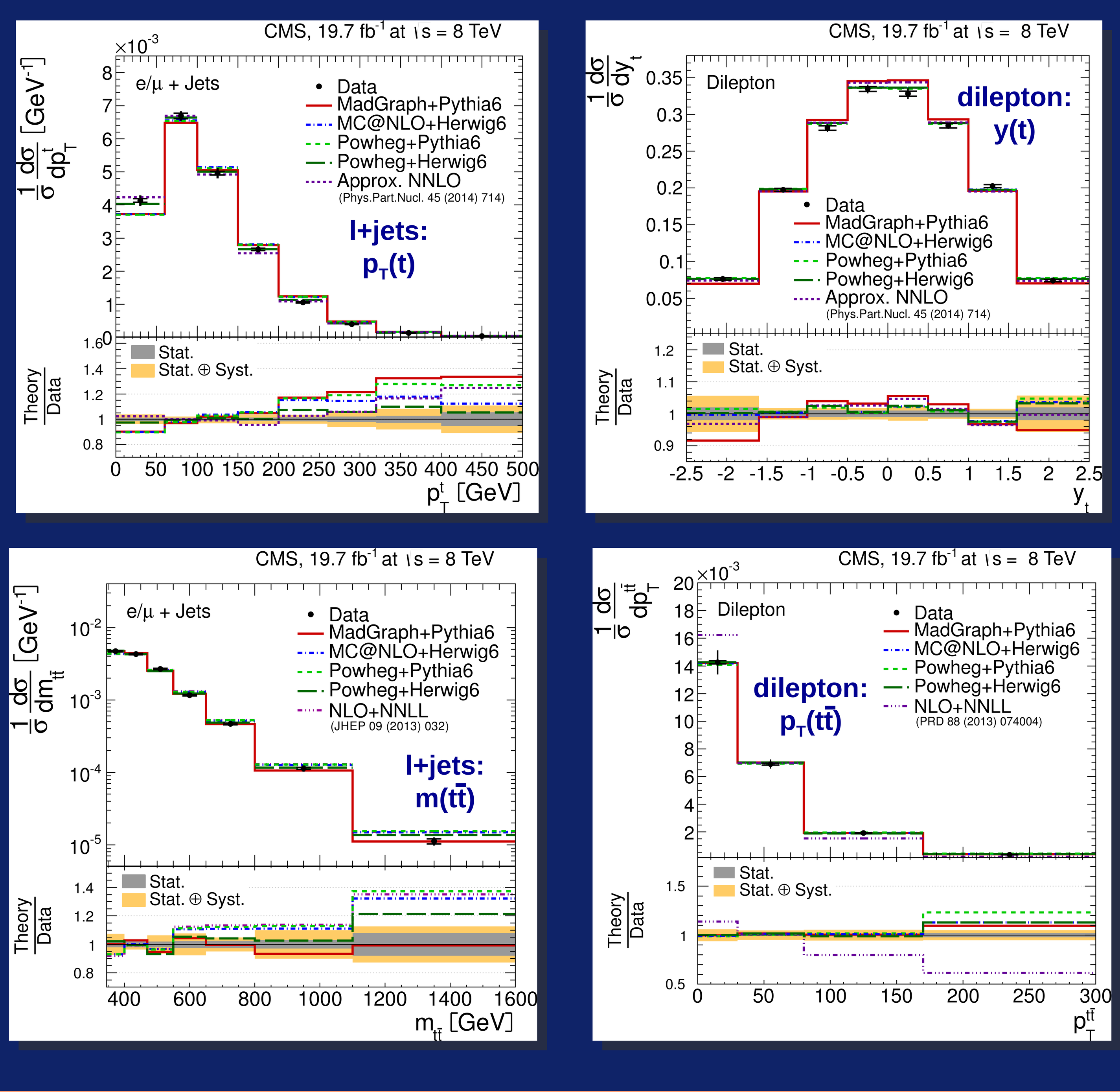
- **Leptons and b-jets:**
  Fiducial phase space, particle level
  - leptons in dilepton (l+jets): p_T > 20 (33) GeV, |η| < 2.4 (2.1) ; jets: p_T > 30 GeV, |η| < 2.4

  → Avoids extrapolation into regions not experimentally accesible

- **Normalize** to the in-situ measured total inclusive cross section σ

(4) Results

General good agreement between data and SM



- Predictions: MadGraph+Pythia6, MC@NLO+Herwig6, Powheg+Pythia6, Powheg+Herwig6, NLO+NNLL, approx NNLO (if available)
- Uncertainties: determined per bin, dominated by systematic (JES, $t\bar{t}$ model); **total precision: 3 – 10 %**

Pohweg+Herwig6 provides good description of data for all measured distributions

The p_T spectra of leptons, b jets, and top quarks in data is softer than expected

The p_T (t) spectrum in data is well described by the approx NNLO calculation

The m($t\bar{t}$) distribution in data tends to be lower than the predictions for large m($t\bar{t}$)

The p_T($t\bar{t}$) spectrum in data is well described by all predictions, except for the NLO+NNLL calculation

The η(b) distributions in data are slightly less central than in the predictions, worse described by MagGraph+Pythia6