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Measurement of Jet Multiplicity Distributions in Semi-Leptonic Top Quark Pair Events

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Motivation

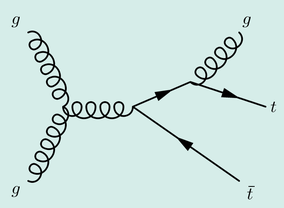
The large amount of data collected by the CMS experiment in 2011 enables detailed investigations of top quark pair production. An interesting aspect is additional QCD radiation, which can lead to an increased number of jets in a $t\bar{t}$ event. Physics motivation of a $t\bar{t}$+jets analysis:

- Important background for Higgs and new physics analyses
- Test of perturbative QCD at top mass energy scale
- Sensitive to possible anomalous top gluon couplings
- Top quark pair charge asymmetry at NLO accuracy in $t\bar{t}$ + 1 jet calculations

$t\bar{t}$ Production

Top quark pair production at LHC in 2011:

- Center of mass energy of $\sqrt{s} = 7\,\text{GeV}$
- Gluon fusion favored over $q\bar{q}$ annihilation
- Increased probability of additional radiation compared to lower energy collisions



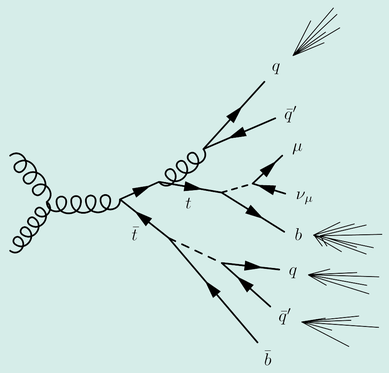
$t\bar{t}$ Decay

Semileptonic decay signature:

- Two bottom quarks
- Two light quarks (hadronic W boson decay)
- Charged lepton & neutrino (leptonic W boson decay)

Background processes considered:

- Single top (MC)
- Z+jets (MC)
- Diboson (MC)
- W+jets (MC + data-driven normalization)
- QCD multijet (data-driven estimation)



Two separate differential cross section measurements

A

Jet Multiplicity Measurement

Measurement of differential cross section with respect to jet multiplicity:

1. Subtraction of background process contributions from data
2. Correction for bin migration due to detector effects $\rightarrow$ unfolding
3. Binwise calculation of $t\bar{t}$ cross section

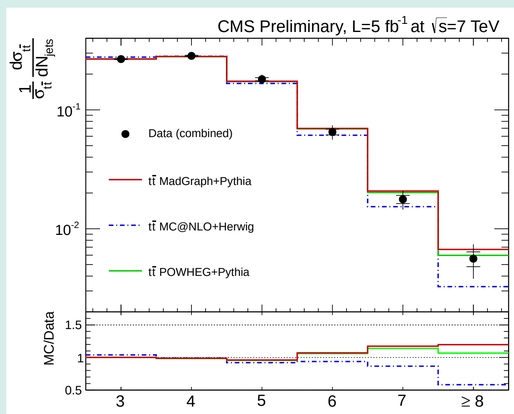
Cross Section Calculation

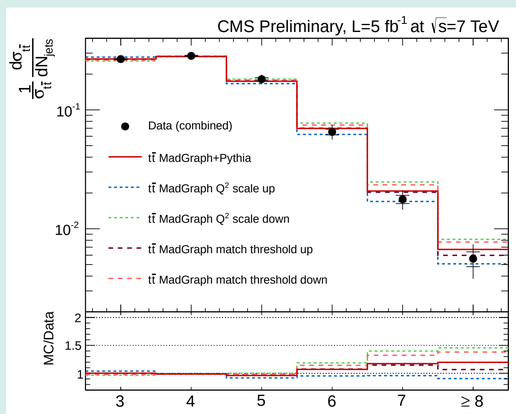
$$\frac{d\sigma_{t\bar{t}}^{measured}}{\sigma_{t\bar{t}} \cdot dN_{jets}} = \frac{1}{\sigma_{t\bar{t}}^{measured}} \cdot \frac{(N_{Data}^{i} - N_{Bkg}^{i})}{\epsilon^{i} \cdot A \cdot \mathcal{L}}$$

- Normalization using the measured incl. cross section $\sigma_{t\bar{t}}^{measured} = \frac{N_{N_{jets}\geq 3}^{measured-t\bar{t}}}{A \cdot \mathcal{L}}$
- Bin-by-bin unfolding via factor $\epsilon^{i} = \frac{N_{rec}^{i}}{N_{gen}^{i}}$

Jet Multiplicity Results

- Combination of lepton channel results (e+jets & μ+jets) with BLUE method
- Comparison of results with predictions from different MC generator combinations and shifts of generator parameters (Q^2 scale & ME/PS matching)





Conclusion

- Similar results for both measurements, largely good agreement with MC predictions
- Large systematic uncertainties $\rightarrow$ prevent the exclusion of specific modeling configurations
- Main contributions: jet energy scale (JES), MC generator parameters (Q^2 scale & ME/PS matching), and PDF

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Additional Jet Multiplicity Measurement

Measurement of the cross section differential in the number additional jets:

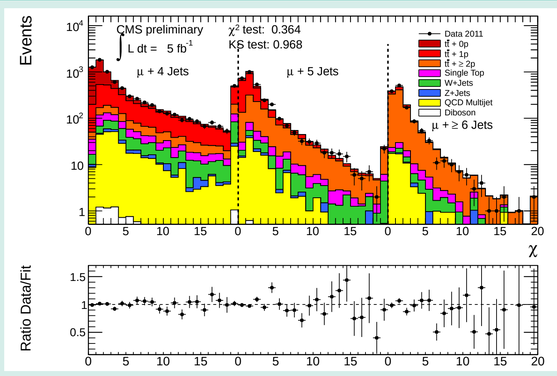
1. Identification of additional jets
2. Categorization of $t\bar{t}$ events with respect to number of additional jets
3. Template fit for cross section determination

Event Classification

Division of simulated $t\bar{t}$ signal sample into subsamples ($t\bar{t}$ + 0, + 1, & + $\geq$2 add. jets):

- Matching of jets according to MC truth information based on distance in between jet and top decay product
- $\Delta R < 0.5 \rightarrow$ jet from top decay product
- $\Delta R > 0.5 \rightarrow$ additional jet

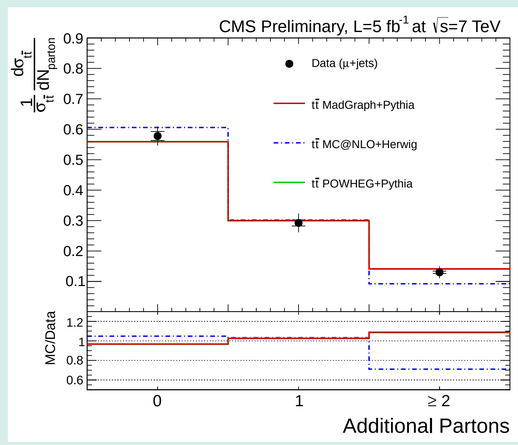
Template Fit

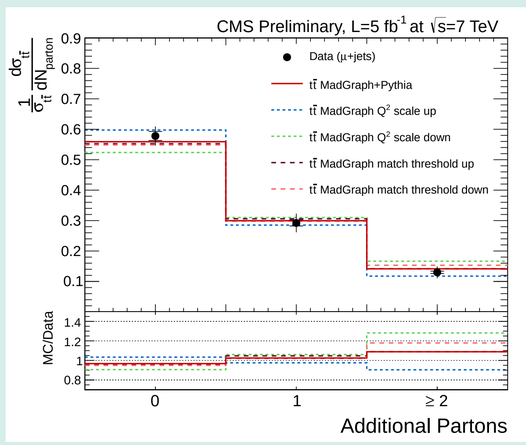


- Cross section determination by maximum likelihood fit
- Chosen fit variable: $t\bar{t}$ reconstruction quality value $\chi = \sqrt{\chi^2}$
- Simultaneous fit in three jet multiplicity bins ($N_{\text{jets}} = 4, 5, \text{and} \geq 6$)

Additional Jet Multiplicity Results

- Measurement performed in μ+jets channel
- Comparison of results with different MC generator combinations and shifts of generator parameters (Q^2 scale & ME/PS matching)





CMS-PAS-TOP-12-018: http://cdsweb.cern.ch/record/1494576

public twiki page: https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsTOP12018