Measurement of Normalized Differential Top-Quark Pair Production Cross Sections

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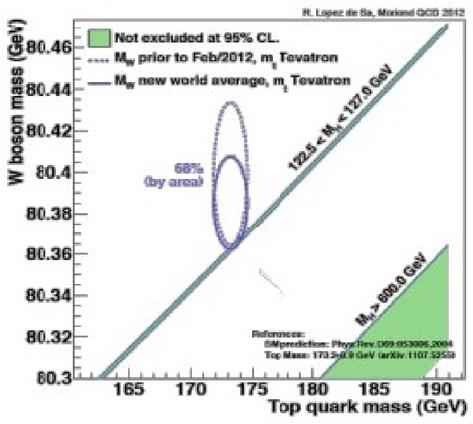
Introduction & Motivation

Within the Standard Model (SM) the top quark plays an important role:
- same $t\bar{t}$ and Higgs boson production process at the LHC energy regime (*gg* fusion)
- *t*-quark physics important test of SM

The LHC 2012 data taking period:
- produced a large number of $t\bar{t}$ events, ~5M
- allows **precision measurements of SM**
- in a new energy regime √s = 8 TeV

The measurement of normalized differential cross section is performed in the *l*+jets and dilepton decay channels of the $t\bar{t}$ pairs.



Event Selection & Reconstruction

Dilepton

At least 2 isolated leptons (*e* or *μ*)
- opposite sign
- p_T >20 GeV/c and $|\eta| < 2.4$
- $m_{ll} > 20$ GeV/c²

At least 2 jets
- p_T >30 GeV/c and $|\eta| < 2.4$

At least 1 b-tag jet

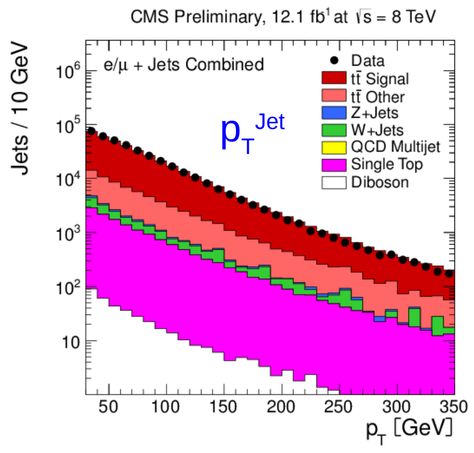
Only in *ee* or *μμ* channels
- $|m_{ll} - m_Z| > 15$ GeV/c²
- $E_T^{Miss} > 40$ GeV/c

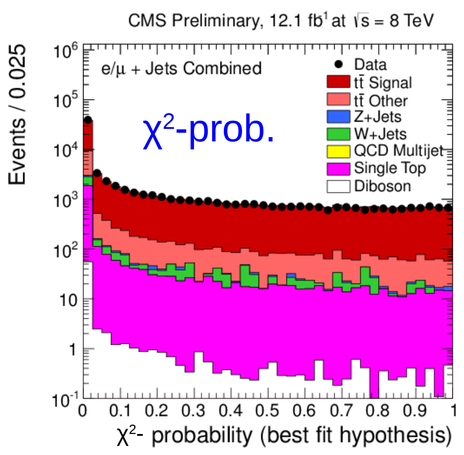
***l*+jets**

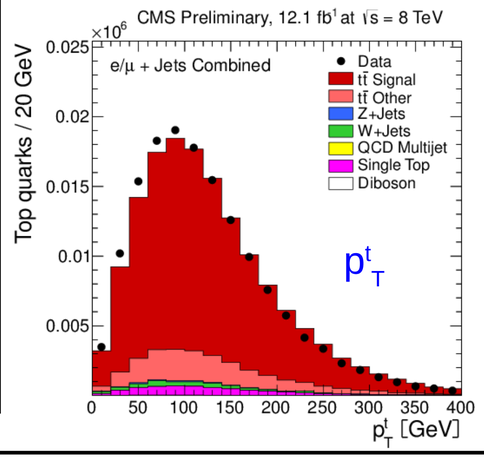
1 isolated leptons (*e* or *μ*)
- p_T >30 GeV/c
- $|\eta| < 2.1$
- veto additional leptons

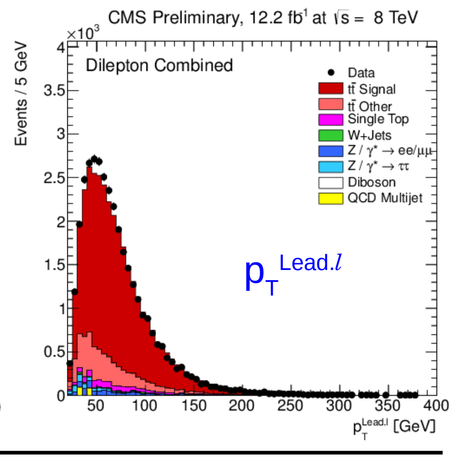
At least 4 jets
- p_T >30 GeV/c
- $|\eta| < 2.4$

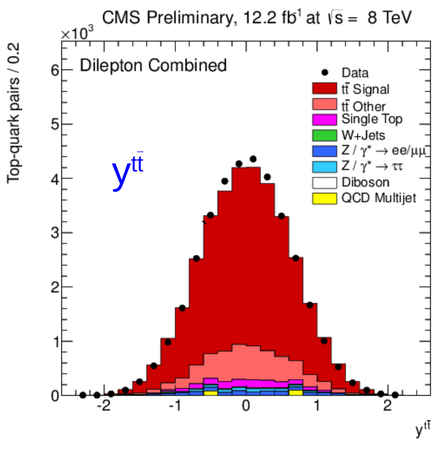
At least 2 b-tag jets

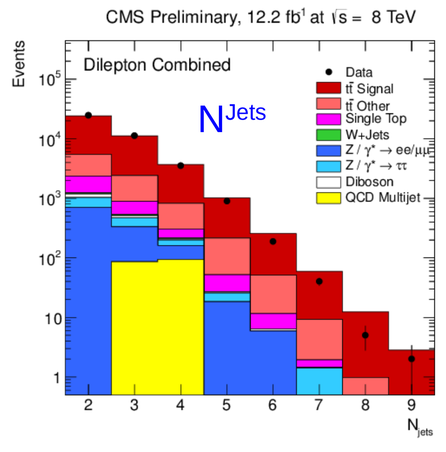












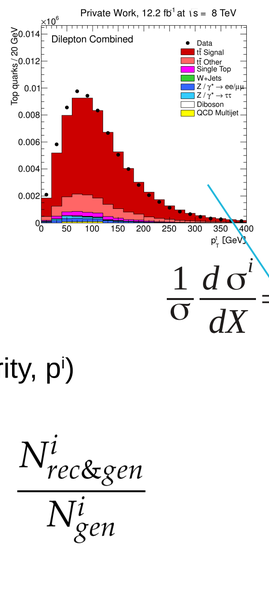
Unfolding & Normalized Differential Cross Sections

Why:
- correct the measurement for experimental migrations
- due to the finite resolution of the measurement

Method:
- regularized unfolding
- to **minimize** the global bin-by-bin **correlations**

Binning selection:
- keep migrations into the bins (purity, p^i) is above 40-50% in each bin

$$p^i = \frac{N^i_{rec\&gen}}{N^i_{rec}} \qquad s^i = \frac{N^i_{rec\&gen}}{N^i_{gen}}$$



$$\frac{1}{\sigma}\frac{d\sigma^i}{dX} = \frac{1}{\sigma}\frac{N^i_{data} - N^i_{bg}}{\Delta X^i \epsilon^i L}$$

Normalized differential cross sections measured in:
- full phase space: *t*-quark and $t\bar{t}$ pair properties
- visible phase space: lepton and/or jet properties

Visible Phase Space

Dilepton

Leptons
- p_T > 20 GeV
- $|\eta| < 2.4$

b-jets
- p_T > 30 GeV
- $|\eta| < 2.4$

***l*+jets**

Leptons
- p_T > 30 GeV
- $|\eta| < 2.1$

Jets
- p_T > 30 GeV
- $|\eta| < 2.4$

$t\bar{t}$ Event Reconstruction

$t\bar{t}$ system directly not measurable → event reconstruction
Input objects: reconstructed *l*, *jets* and E_T^{Miss}

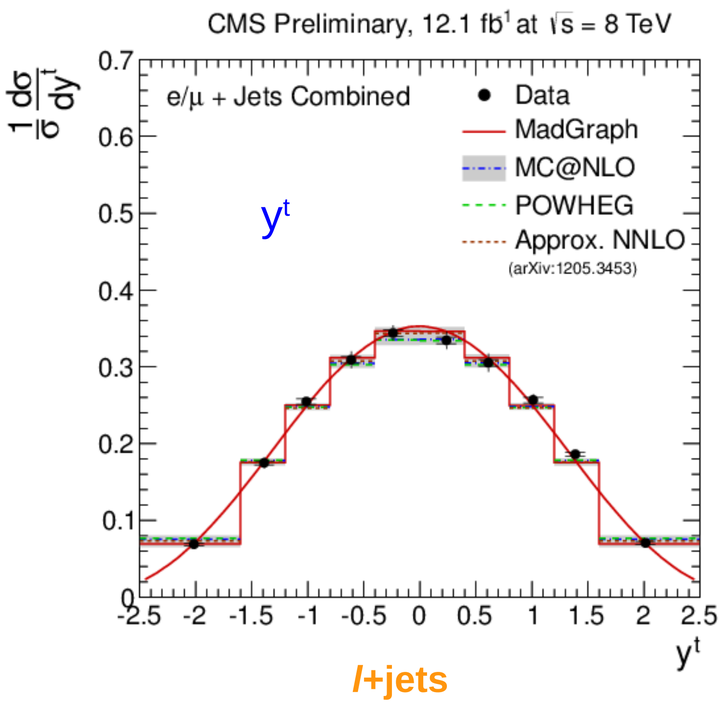
Dilepton
- system underconstrained due to 2 ν's
- $E_T^{Miss} = p_T(\nu) + p_T(\bar{\nu})$
- m_W = 80.4 GeV
- $m_t = m_{\bar{t}}$ = fixed
- m_t varied in 1 GeV steps in [100, 300] GeV range
- prefer solutions with b-tagged jets
- then with most probable ν spectrum

***l*+jets**
- vary *l, jet* and *ν* 4-momenta
- $E_T^{Miss} = p_T(\nu)$
- m_W = 80.4 GeV
- $m_t = m(qq'b) = m(l\nu b)$
- consider only the 5 leading jets
- b-tagging information used for b-jet association
- choose jet permutation that maximizes χ^2-probability

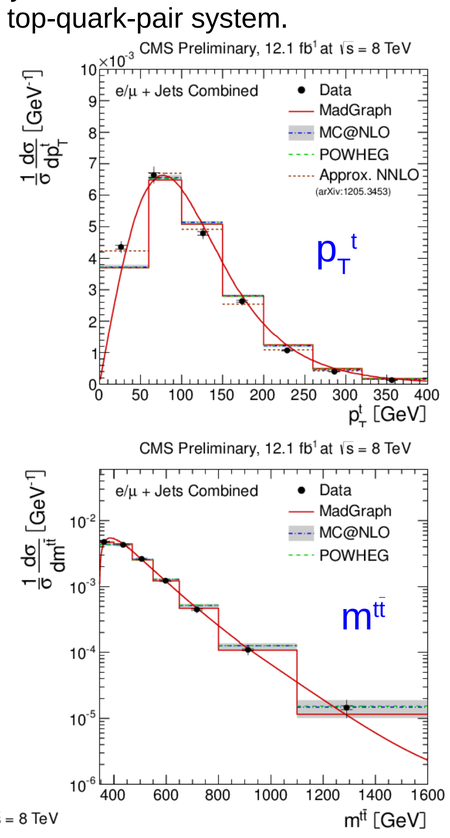
Results

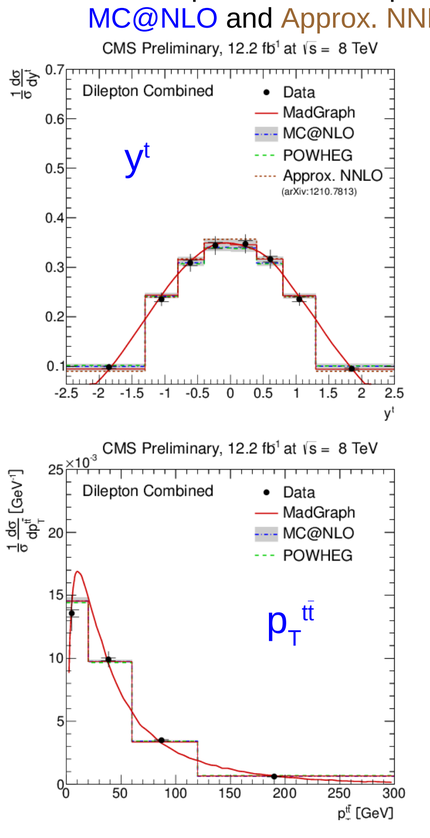
First CMS differential cross section measurements at √s = 8 TeV are shown as function of transverse momentum, (pseudo-)rapidity and invariant mass of the final state lepton, lepton-pair, b-jet, top quark and top-quark-pair system.

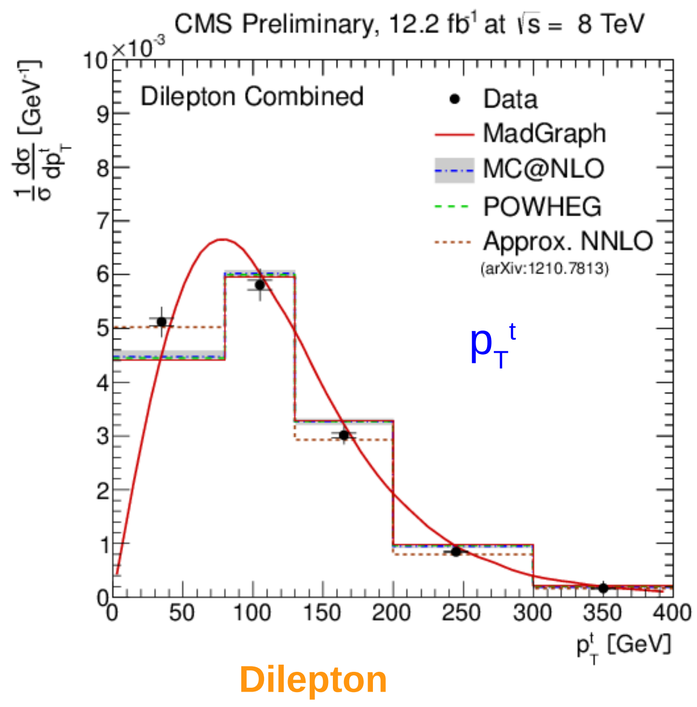
Bin-center-correction applied to the measured data points.
For comparison with respect the measurement MadGraph, POWHEG, MC@NLO and Approx. NNLO (when available) predictions shown.



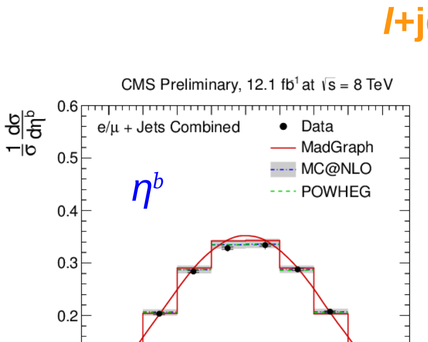
l+jets

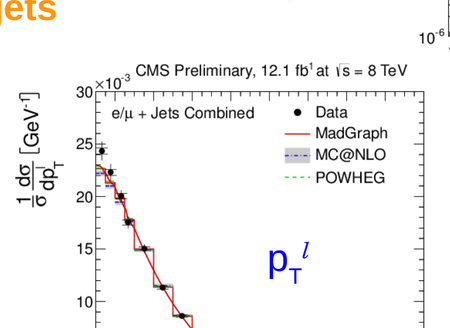






Dilepton





Summary

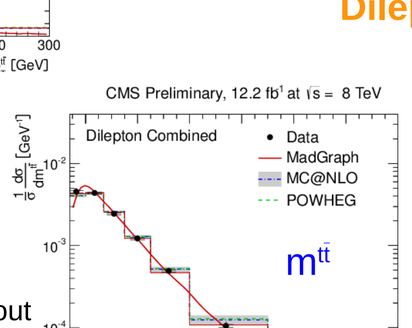
$t\bar{t}$ differential cross sections in *l*+jets and dilepton channel are measured. Results show a **good agreement with SM** predictions within the uncertainties, although top quark transverse momentum prefers Approx. NNLO predictions.

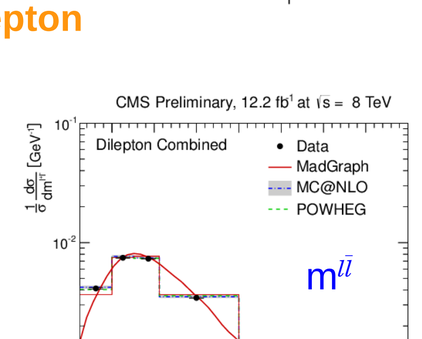
Uncertainties

Estimated independently in each
- bin
- distribution
- channel

Global uncertainties cancel out
- due to normalization

Main uncertainties arise from
- Q^2 scale: 1-4%
- Matching: 1-3%





Documentation

Dilepton: CMS TOP-PAS-12-028
https://cds.cern.ch/record/1523664

l+jets: CMS TOP-PAS-12-027
https://cds.cern.ch/record/1523611