Measurement of the top-quark pair production cross section in the dilepton channel in pp collisions at 8 TeV

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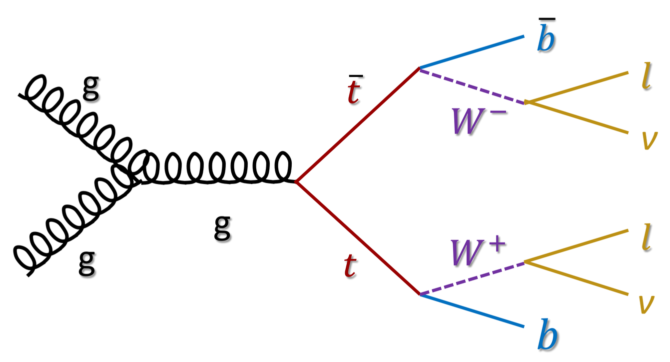
Abstract

The poster presents the measurement of the top-antitop quark ($t\bar{t}$) production cross section in proton-proton collisions at $\sqrt{s}$ = 8 TeV with the CMS experiment at the LHC, using a data sample corresponding to an integrated luminosity of 5.3 fb^{-1}. The measurement is performed by analyzing events with a pair of electrons or muons, or one electron and one muon, and at least two jets, one of which is identified as originating from hadronization of a bottom quark.

Top Pair Dilepton Channel

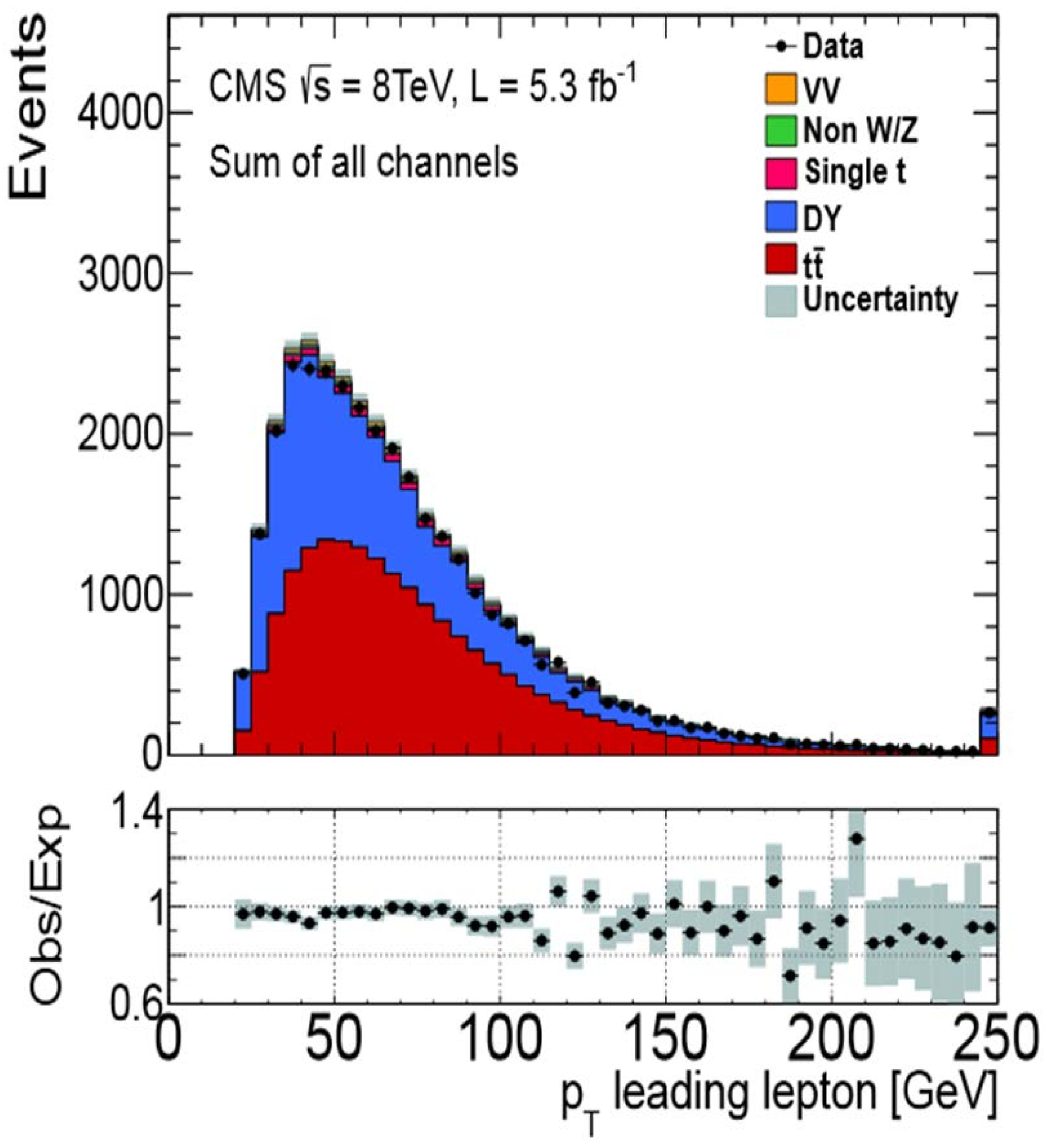
$$pp \to t\bar{t} + X, \qquad t\bar{t} \to (W^+b)(W^-\bar{b}) \to (l^+\nu b)(l^-\bar{\nu}\bar{b})$$

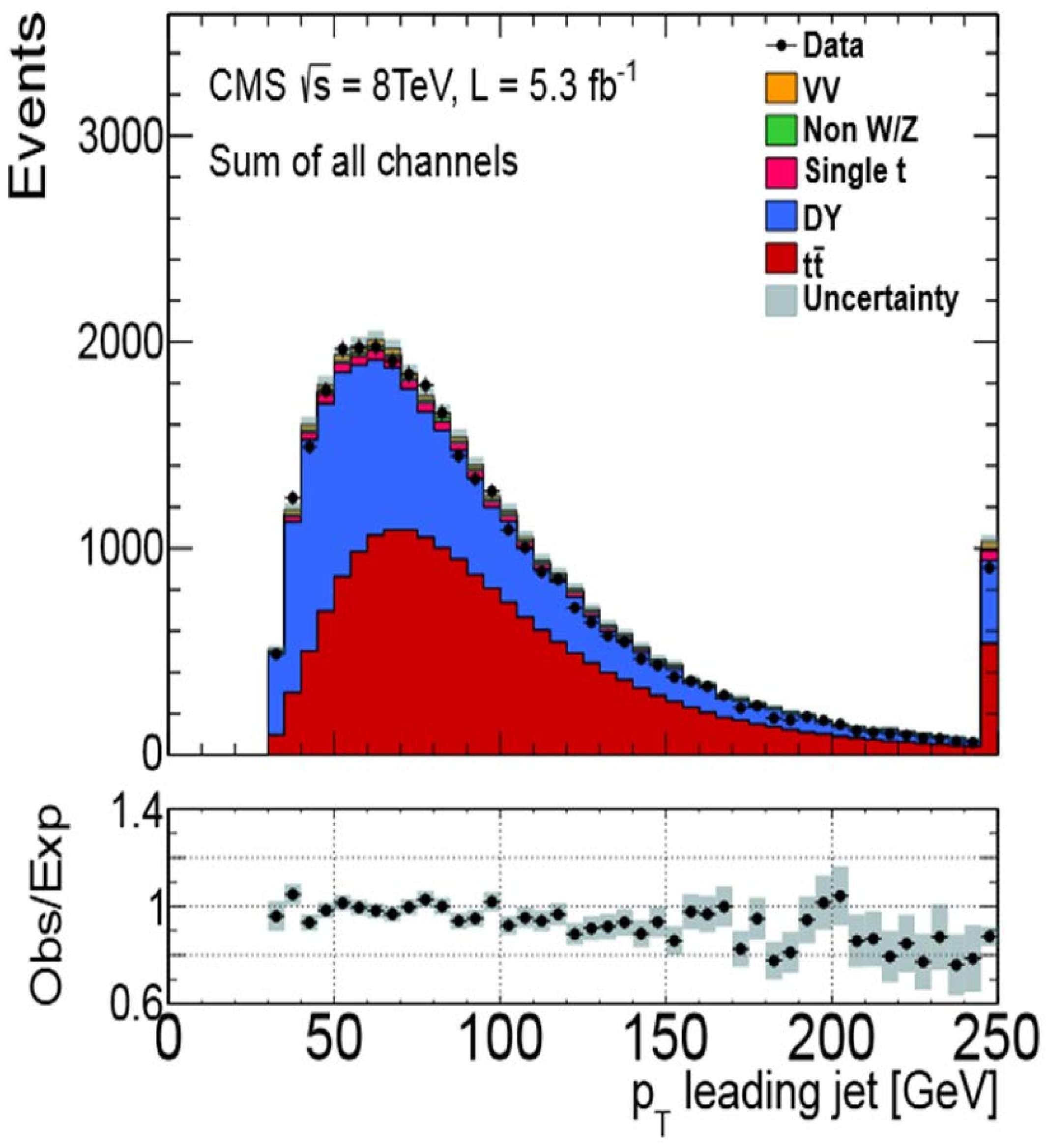
- ✓ Smallest branching fraction
- ✓ Expected to be the least contaminated by background processes, because it has the fewest hadrons, it is also the least sensitive to the calibration of the jet energy scale.
- ✓ two neutrinos in the final state: under-constrained system
- ✓ $\sum p_T$ of the neutrinos constrained by the $\not{E}_T$ system
- ✓ The dominant SM backgrounds for this channel are Z^0+Jets, single top in the tW channel and semi-leptonic $t\bar{t}$ decays where one of the top quarks decays into a lepton.



Event Selection

- ✓ **Pileup**: Appropriate weights are applied to each simulated event , in order to reproduce the distribution of the number of interaction vertices in data
- ✓ Events pass standard dilepton triggers and are reconstructed using Particle Flow
- ✓ At least 2 Isolated leptons
  - ➢ lepton track vertex distance from beam spot in the transverse plain i.e **dB < 0.02**
  - ➢ P_T > 20 GeV,
  - ➢ |η| < 2.1(muon), |η|<2.5(electron)
  - ➢ Lepton isolation is corrected to take into account of pileup on an event by event basis
- ✓ Dilepton mass m_{ll} > 20 GeV
- ✓ | m_{ll} - 90 | ≥ 15 GeV/c^2 Out of Z Mass window (ee, μμ only)
- ✓ MET > 40 GeV (ee, μμ only)
- ✓ At least 2 jets
  - ➢ P_T > 30 GeV,
  - ➢ |η| < 2.5
  - ➢ at least one b-tag





Background estimation

Backgrounds in analysis arise from events

- ✓ with at least two prompt leptons(Z/W decays)
- ✓ with lepton and jets(Non-Z/W)
  - ➢ where at least one jet is incorrectly reconstructed as a lepton.
- ✓ Background yields from Single Top and Di-Boson events are estimated from simulation, while others are estimated from data
- ✓ **Drell-Yan:** Z-window region (76GeV<m_{ll}<106GeV) is vetoed in ee/μμ and used to rescale DY contribution

$$R_{out/in} = \frac{N_{DYMC}^{out}}{N_{DYMC}^{in}} \qquad k_{\mu\mu} = \sqrt{\frac{N^{\mu\mu,loose}}{N^{ee,loose}}}$$

$$N_{out}^{l^+l^-,obs} = R_{out/in}^{l^+l^-}(N_{in}^{l^+l^-} - 0.5N_{in}^{e\mu}k_{ll})$$

Prompt and fake rate measurement

Lepton fake rates are obtained from tag-and-probe technique applied on data and are extracted from a phase space dominated by QCD dijet events

- ✓ Leptons are selected by single lepton trigger
- ✓ Cuts defining this control region aim at reducing contribution from W and Z
- ✓ Events with W decays are rejected by requiring
  - ➢ E_T < 20 GeV
  - ➢ M_T < 15 GeV(muon only)
- ✓ Events with Z decays are discarded by vetoing Z mass window
- ✓ Low mass dilepton events are removed by m_{ll}>20GeV cut
- ✓ Remaining electroweak contamination for high P_T values is suppressed by assuming that the lepton fake rate flattens out above 35GeV.

Systematics

The precision measurement of $\sigma_{t\bar{t}}$ in e$^+$e$^-$ and μ$^+$μ$^-$ channels got limited due to two additional sources of uncertainty

- ✓ DY background estimation
- ✓ Propagation of the JES to the E_T estimation

Source	e$^+$e$^-$	μ$^+$μ$^-$	$e^{\pm}\mu^{\mp}$
Trigger efficiencies	4.1	3.0	3.6
Lepton efficiencies	5.8	5.6	4.0
Lepton energy scale	0.6	0.3	0.2
Jet energy scale	10.3	10.8	5.2
Jet energy resolution	3.2	4.0	3.0
b-tagging	1.9	1.9	1.7
Pileup	1.7	1.5	2.0
Scale (μ_F and μ_R)	5.7	5.5	5.6
Matching partons to showers	3.9	3.8	3.8
Single top quark	2.6	2.4	2.3
Drell-Yan	10.8	10.3	1.5
Non W/Z leptons	0.9	3.2	1.9
Total systematic	18.6	18.6	11.4
Integrated luminosity	6.4	6.1	6.2
Statistical	5.2	4.5	2.6

Results

For the first time an experimental measurement at 8 TeV is more precise than the corresponding theoretical* prediction

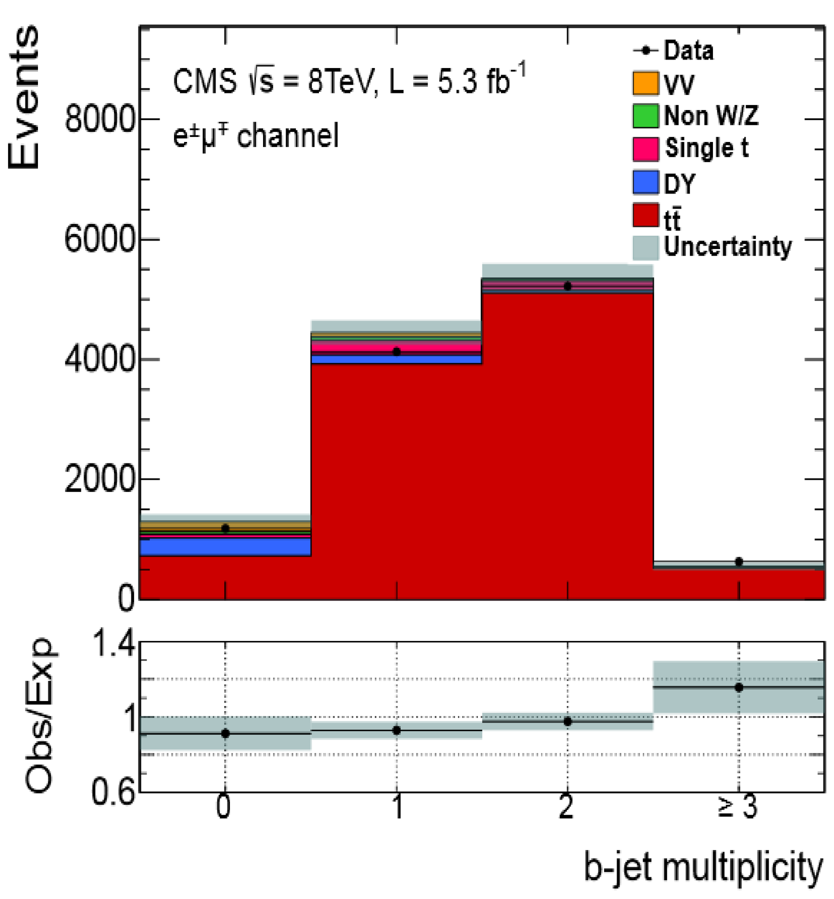
$$\sigma_{t\bar{t}} = 239.1 + (scale)^{+9.2(3.9\%)}_{-14.8(6.2\%)} + (pdf)^{+6.1(2.5\%)}_{-6.2(2.6\%)}\ pb$$

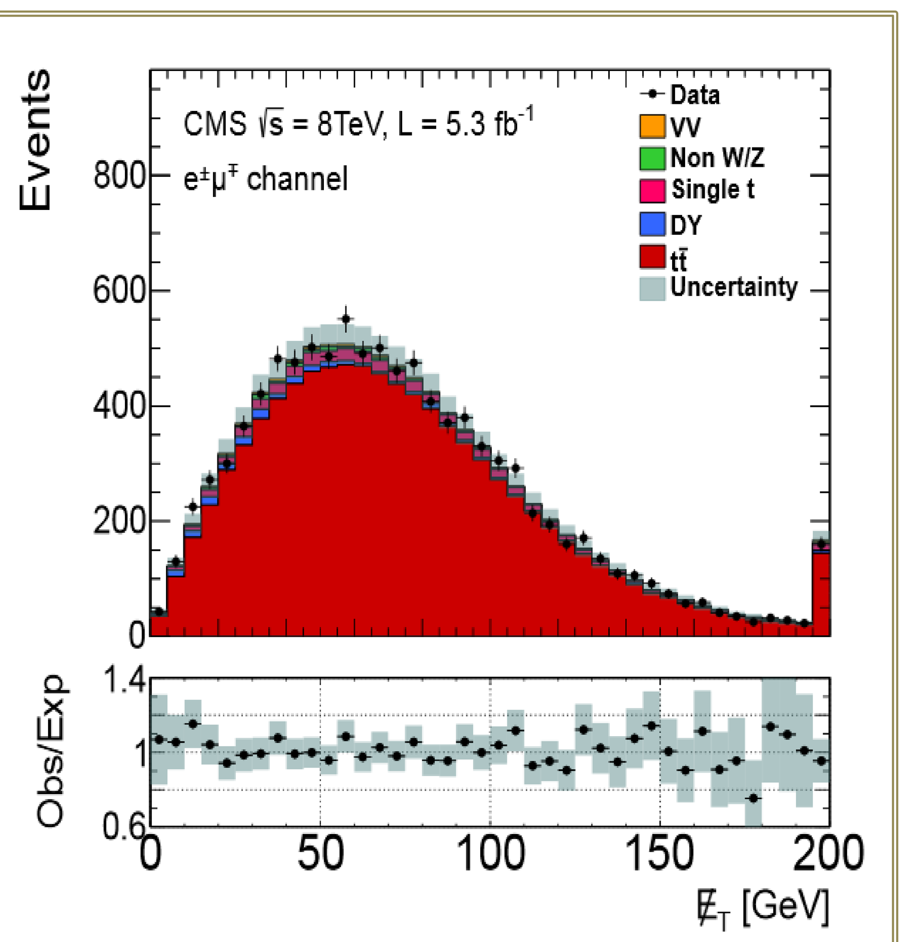
- ✓ Uncertainties are from statistical, systematic and integrated luminosity components, respectively

	e$^+$e$^-$	μ$^+$μ$^-$	$e^{\pm}\mu^{\mp}$
Data	3204	4180	9982
Dilepton signal	2728±182	3630±250	9624±504
ε_{total} (%)	0.203±0.012	0.270±0.017	0.711±0.033
$\sigma_{t\bar{t}}$(pb)	244.3±5.2±18.6±6.4	235.3±4.5±18.6±6.1	239.0±2.6±11.4±6.2

- ✓ Dependence of the acceptance on the top-quark mass is found to be quadratic within the present uncertainty of the top-quark mass. The cross-section dependence in the range 160–185 GeV can be parametrized as

$$\sigma_{t\bar{t}} / \sigma_{t\bar{t}}(m_t = 172.5) = 1.00 - 0.009 \times (m_t - 172.5) - 0.000168 \times (m_t = 172.5)^2$$





- ✓ For a top quark mass of 172.5 GeV, the $t\bar{t}$ cross section is measured to be

$$\sigma_{t\bar{t}} = 239 \pm 2.1\ (stat.) \pm 11.3\ (syst.) \pm 6.2\ (lumi)\ pb$$

which is in agreement with standard model predictions.

* arXiv:1303.6254

Reference: JHEP 02 (2014) 024