Measurement of the inclusive top-quark pair cross-section in the dilepton channel at 13 TeV with the CMS experiment

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Introduction

- Measuring the top pair cross section is the first step for understanding top physics
  - In the frame of the Standard Model (SM), test QCD predictions
  - Sensitivity to new physics beyond the SM (BSM)
  - Test the presence of new production mechanisms
  - Important background for many Higgs and BSM searches

- Predicted Inclusive cross section (NNLO + NNLL) $832 \pm 45$ pb at 13 TeV

- Today: measurement of the top pair cross section at 13 TeV using full 2015 data in the dilepton channel
  - Simple and robust Cut&Count method
  - Special focus on lepton identification
Cross section obtained with the following expression:

- $N$: number of observed events
- $N_{\text{bkg}}$: number of background events
- $A$: Detector acceptance (from MC)
- $\epsilon$: detector efficiency
- Includes reconstruction, trigger, Isolation and Identification efficiencies...
- $\text{Br}$: Branching ratio
- $\int Ldt$: integrated luminosity

$$
\sigma(pp \rightarrow t\bar{t}) = \frac{N - N_{\text{bkg}}}{(A \times \epsilon \times \text{Br}) \int Ldt}
$$
Lepton efficiencies and scale factors

- Lepton efficiency measurements are a central component of the top pair production measurement and are main source of uncertainty.

- Need a method based on real data to extract the identification/isolation efficiency:
  - Using data directly avoids depending on simulation and introducing bias due to detector behavior miss-modeling.
  - Efficiency measurements are closely related to physics analysis and the results depend on the selection.
  - Aimed for ttbar to dilepton analysis (signature: isolated, well reconstructed medium/high pT leptons).

- Tag&Probe: method based on Drell-Yan resonances where leptons have similar characteristics:
  - One lepton with stringent criteria tags the event.
  - Second lepton used as a probe.
  - "passing probes" are defined according to the efficiency to measure.
  - Efficiency = number of passing probes/all probes once the back ground is taken into account.
Lepton efficiencies and scale factors

> Selection of the $Z \rightarrow e^+e^-$ Sample for electron identification measurement:
  - Preselection of electrons with Kinematic cut $p_T > 20$ GeV/c and $|\eta| < 2.4$
  - Events with exactly two electrons fulfilling the opposite charge requirement
  - And in the range of $60. < M_{ee} < 120$ GeV/c$^2$

> Tag electrons:
  - Tighter kinematic cut $p_T > 25/30$ GeV/c and $|\eta| < 2.1$
  - Tight ID and Isolation
  - Matched to Single electron HLT

> Probe electrons:
  - All other electrons considered as a probe to study the efficiency (fulfilling or not the same criteria as the tag electron)

> Passing probes:
  - All probes passing the medium ID/Iso criteria
Lepton efficiencies and scale factors

- Invariant mass of the (passing probes, tag electron) and the (failing probes, tag electron).

- Once background is subtracted, Efficiency = No. passing probes / No. all probes.
Lepton efficiencies and scale factors

Applied to the analysis:

- Lepton SFs: ratio of data and MC efficiencies
- These SFs were used for the early measurement of the top pair cross section with 42 pb⁻¹ arXiv:1510.05302 and TOP-15-010
Top Pair Production in Dilepton Channel

> Event Selection:
  - >= 2 opposite sign high-pT leptons (ee, eμ, μμ) pT > 20 GeV, |eta| < 2.4
  - QCD veto: mll > 20 GeV
  - Z veto: |m_Z - m_ll| > 15 GeV (ee, μμ)
  - >= 2 jets pT > 30 GeV, |eta| < 2.4
  - MET > 40 GeV (ee, μμ)
  - >= 1 b-tagged jet

> Data Sets from 2015 25ns run with ~2.3 fb^{-1}

> MC Signal:
  - Nominal: Powheg v2 + Pythia8
  - Modeling systematic: aMC@NLO + Pythia8

> Measurement done in 3 channels (ee, eμ, μμ)
Kinematic distributions

Leading jets

Leading leptons
Results $\mu\mu$ channel

- Preliminary SFs and corrections applied

- $\sigma_{\mu\mu} = 891 \pm 15 \text{ (stat.)} \pm 90 \text{ (syst.) pb}$

- The systematic uncertainty is dominated by the Luminosity (4.6%) and the lepton efficiencies (3.1%)

- Results are in agreement with theory predictions
Results ee channel

- Preliminary SFs and corrections applied

- \( \sigma_{ee} = 819 \pm 18\ \text{(stat.)} \pm 96\ \text{(syst.)} \ \text{pb} \)

- The systematic uncertainty is dominated by the Luminosity (4.6%) and the lepton efficiencies (5%)

- Results are in agreement with theory predictions
Results $e\mu$ channel

- Preliminary SFs and corrections applied

- $\sigma_{e\mu} = 829 \pm 9$ (stat.) $\pm 82$ (syst.) pb

- The systematic uncertainty is dominated by the Luminosity (4.6 %) and the lepton efficiencies (3.8%)

- Results are in agreement with theory predictions
Summary

- Measurement of the top quark pair production cross section at 13 TeV with CMS was performed using ~2.3 fb⁻¹ collected data.

- Preliminary results presented in the three dileptonic channels:
  - \( \sigma_{ee} = 819 \pm 18 \) (stat.) \( \pm 96 \) (syst.) pb
  - \( \sigma_{e\mu} = 829 \pm 9 \) (stat.) \( \pm 82 \) (syst.) pb
  - \( \sigma_{\mu\mu} = 891 \pm 15 \) (stat.) \( \pm 90 \) (syst.) pb

- And shown to be consistent with the theory predictions.