Study of ttbar production in the dilepton channel with CMS Open Data

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Introduction and Motivation

We studied the **2011 datasets** available in CMS Open data in order **to reproduce the results** present in the article **“Measurement of the ttbar production cross section in the dilepton channel in pp collisions at $\sqrt{s}$=7 TeV”***. We are also using as support the internal analysis note CMS AN-11-477.

The main goal is to reproduce the cross section estimated in the paper. We are now in the **early stage**: <u>ttbar signal selection cuts</u> implementation.

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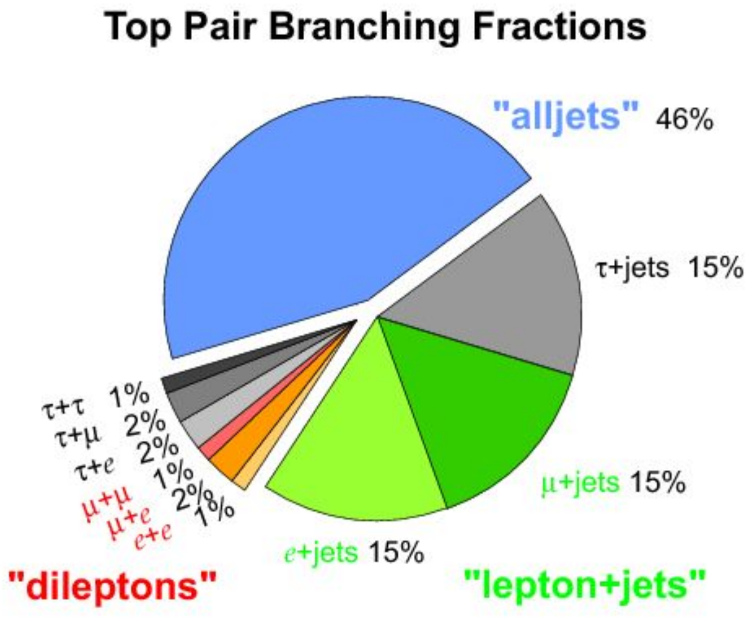
Overview of the Analysis



Source: DØ detector

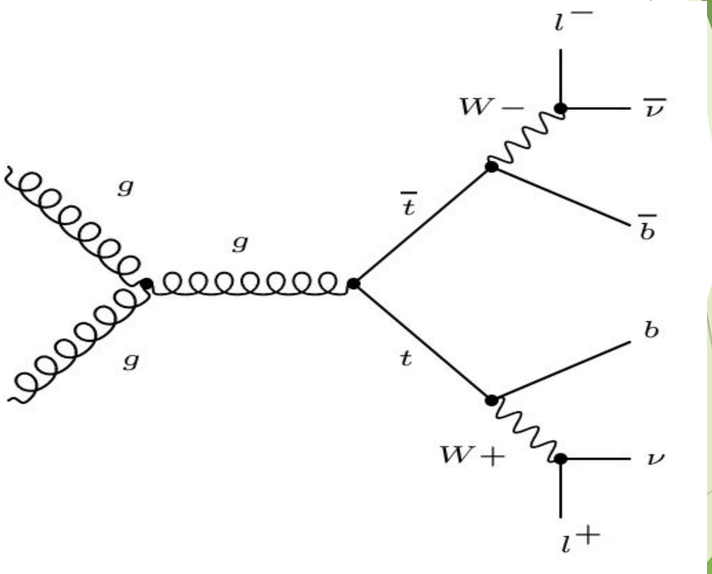


Image: ttbar production at the LHC

ttbar selection cuts

We are doing our study based on 2011 collision simulation data, specifically the simulation of events from the quark top pair decay.

- ttbar MC sample: http://opendata.cern.ch/record/1544 (54990752 events)

We started from an analysis code available on the CMS Open data site (http://opendata.cern.ch/record/5000) and adapted it for processing and selecting the signal.

It was not possible (too long!) to use the Virtual Machine to process the MC signal sample.

Triggers

In this study we choose triggers in order to select events that can be from the dilepton channel.

The triggers used are not the same as the ones used in the collaboration paper, as they do not exist in MC, but are quite similar.

- **dielectron:** HLT_Ele17_CaloIdT_CaloIsoVL_TrkIdVL_TrkIsoVL_Ele8_CaloIdT _CaloIsoVL_TrkIdVL_TrkIsoVL_v11
- **dimuon:** HLT_DoubleMu5_v6
- **electron+muon:** HLT_Mu8_Ele17_CaloIdT_CaloIsoVL_v9

Object Definitions: Muon*

- $p_T > 20$ GeV/c e |η|< 2,4;
- **GlobalMuon and TrackerMuon**;
- **GlobalMuonPromptTight**;
- **nHits**: Number of valid hits on inner tracker> 10;
- **X^2/ndof < 10**, for the global muon fit;
- **dxy < 0.02** : Transverse parameter impact <0.02 cm, applied to tracker;
- **rel_iso < 0.20** : Relative isolation of muon <0.20 for cones of 0.3 wrapped around muon direction;
- I m_z-PV_z I < 1 cm: Selected leptons must have a difference between their vertices and the PV (primary vertex) by the Z axis of less than 1 cm.

*Same cuts of the paper

Object Definitions: Electron*

- p_T > 20 GeV/c e |η|< 2,5;
- **Transverse parameter impact <0.04 cm**, applied to gsf-tracker;
- **Relative isolation of electron <0.20** for 0.3 cones wrapped around the electron direction;
- **ΔR(electron,muon)> 0.1** where muon is GlobalMuon or TrackerMuon and have more than 10 hits on the inner tracker;
- | e_z-PV_z | < 1 cm: Selected leptons must have a difference between their vertices and the PV (first vertex) along the Z axis of less than 1 cm;
- **Photon conversion rejection:** Number of hits lost on tracker <2, minimum distance between electron and its closest opposite signal tracker> 0.02 in r-ϕ plane and Δcos (Θ)>0.02.

*Same cuts of the paper

Object Definitions: Jets*

- p_T > 30 GeV/c e |η|< 2,5;
- **Jet energy correction applied**: L1Fastjet corrections compatible with PFnoPU, Level 2 and Level 3 jet energy corrections and L2L3Residual corrections for data;
- **Loose Jet Identification**: Having a fraction of charged hadronic energy > 0, a fraction of charged electromagnetic energy <0.99, a fraction of neutral hadronic energy <0.99 and a fraction of neutral electromagnetic energy <0.99;
- ***Jet-Lepton cleaning***: *We exclude all jets that have ΔR <0.4 with electrons and muons that have passed their respective selection cuts.*

*Same cuts of the paper

Determining the channel

- Opposite sign lepton pair;
  - For **μμ** and **μe**: at least one muon with $|\eta|<2.1$.
- M_{ll} > 20 GeV/c (**ee** and **μμ**) or M_{ll} > 12 GeV/c (eμ).

Events containing more than 2 selected leptons are classified as **ee**, **μμ** or **eμ** based on the following rule: Oppositely charged pairs of leptons that have the largest sum of p_T will be maintained.

Event Selection

- Opposite sign lepton pair and M_{ll} > 20 GeV/c or M_{ll} > 12 GeV/c (depending of the channel);
  - For μμ and μe: at least one muon with $|\eta|<2.1$
- Z veto ($76<M_{ll}<106$ GeV) only ee and μμ;
- E_T(Jet 1,Jet 2) > 30 GeV/c;
- MET>40 GeV for ee and μμ channels
  - no MET cut for eμ channel
- At least **two jet b-tagged** (jet with a Discriminant value higher than 0.244)

Monte Carlo normalization

The normalization of an event type is given by the product of luminosity with the cross section divided by the number of MC events.

$$W = \frac{L.\sigma}{N_{mc}}$$

Where the L = 2.3 fb^{-1}, σ = 164 pb at MC (ttbar)

Cut-flow: Channel μμ*

	This study	CMS Collaboration
Opposite sign lepton pair and M_{ll} > 20 GeV/c	2719,6 ± 52,1	2428,3 ± 67,3
Z veto (76<mll<106 GeV)	2076,0 ± 45,5	1845,8 ± 51,9
E_T(Jet 1,Jet 2) > 30 GeV/c	1452,0 ± 38,1	1373,7 ± 39,4
MET > 40 GeV	1096,4 ± 33,1	1040,5 ± 30,6
Number of B-Jets ≥ 1	1042,2 ± 32,3	990,6 ± 29,1
Number of B-Jets ≥ 2	676,1 ± 26,0	636,2 ± 19,0

*efficiencies and corrections not yet implemented

Cut-flow: Channel eμ*

	This study	CMS Collaboration
Opposite sign lepton pair and $M_{ll} > 12$ GeV/c	4242,7 ± 56,1	4334,0 ± 104,7
E_T(Jet 1,Jet 2) > 30 GeV/c	2993,9 ± 54,7	3252,6 ± 79,5
Number of B-Jets ≥ 1	2849,2 ± 53,4	3082,2 ± 75,3
Number of B-Jets ≥ 2	1861,6 ± 43,1	1969,4 ± 48,5

*efficiencies and corrections not yet implemented

Cut-flow: Channel ee*

	This study	CMS Collaboration
Opposite sign lepton pair and M_{ll} > 20 GeV/c	1653,0 ± 40,6	1913,5 ± 56,0
Z veto (76 < mll < 106 GeV)	1265,4 ± 35,6	1461,3 ± 43,4
E_T(Jet 1,Jet 2) > 30 GeV/c	890,8 ± 29,8	1072,8 ± 32,6
MET > 40 GeV	669,6 ± 25,9	801,1 ± 25,1
Number of B-Jets ≥ 1	635,9 ± 25,2	759,3 ± 23,7
Number of B-Jets ≥ 2	411,1 ± 20,3	482,2 ± 15,4

*efficiencies and corrections not yet implemented

Conclusion and future prospects

The cut-flow values found are close to the reference ones. Next, we are planning to review the steps taken so far, in order to ensure that all the cuts are implemented correctly.

After this cross-check we will include all the MC background samples and data. We will estimate the trigger and lepton efficiencies so that we can estimate the cross section.


That's all folks!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To Be Continued