Measurement of the associated production of a single top quark and a W boson in pp collisions at $\sqrt{s} = 13$ TeV(CMS-PAS-TOP-17-018)

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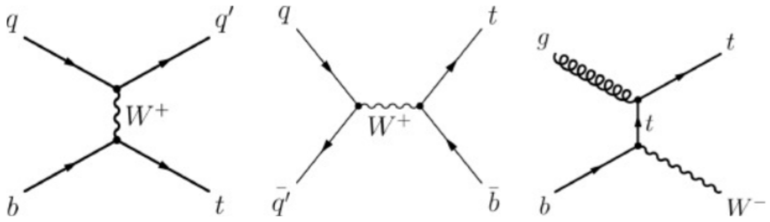
Second Iran & Turkey Joint Conference on LHC Physics
October 23-26, 2017 (1-4 Aban 1396)

Introduction

Single top quarks, observed for the first time by the CDF and D0 experiments at the Tevatron, are produced via the electroweak interaction.
There are Three different production modes:

- The exchange of a virtual W boson (t-channel)
- The production and decay of a virtual W boson (s-channel)
- **The associated production of a top quark in association with a W boson(tW channel).**



Motivation

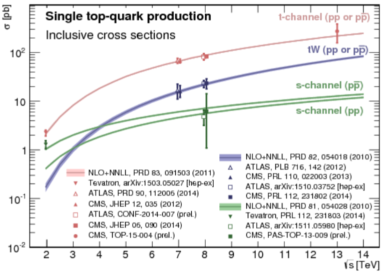
- Associated tw production is very interesting process
  - Sensitive to new physics
    - Sensitive to modification of the w-t-b interaction
    - Sensitive to physics which modifies the top decay properties, in particular to FCNC interaction
    - An excellent probe for the V_{tb} coupling
  - Role as a background to SUSY and Higgs searches
  - Interferes at next-to-leading order (NLO) with top quark pair production

History

- ATLAS: Evidence for tW at 7 TeV
- CMS: Evidence for tW at 7 TeV

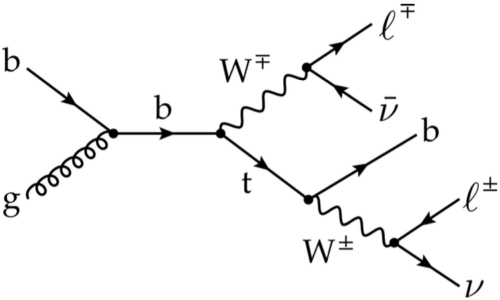
- ATLAS: Measurement of the production cross-section of tW at 8 TeV
- CMS: Observation of tW at 8 TeV

- ATLAS: Measurement of the cross-section for tW at 13 TeV
- CMS: Measurement of the cross-section for tW at 13 TeV



Model of interest in this Analysis

- Events with two leptons and a jet originated from a b quark are considred
- Using eμ channel only



Data samples and triggers

- Data collected during the full LHC 2016 run at 13 TeV corresponds to 35.9 fb^{-1}
- SingleElec, SingleMuon, and MuonEG primary datasets (by adding single lepton triggers, trigger efficiency is increased by around 5%)
- Triggers designed to select events in the dilepton channel have been considered as:
  - Di-lepton trigger: The muon p_T thresholds are 23 and 8 GeV, and the electron p_T thresholds are 12 and 23 GeV
  - Single-lepton triggers: The muon trigger p_T threshold is 24 GeV and the electron p_T threshold is 27 GeV

MC datasets

tw signal process is simulated at NLO using powheg
Standard Model processes that give the same signatures signal are background$\rightarrow$ rely on Monte Carlo predictions

- The main background is $t\bar{t}$:powheg-pythia8
- Other backgrounds
  - DY: M50 and M10to50 amcatnloFXFX-pythia8
  - W+jets: madgraphMLM
  - ttV: amcatnloFXFX-pythia8
  - VV: pythia8

Object selection - Leptons

tw dilepton final state is characterized by presence of a high-pt-isolated lepton pair associated with the missing transverse energy and b quark jet
The reconstruction of the different object is based on the particle flow algorithm
Lepton definition

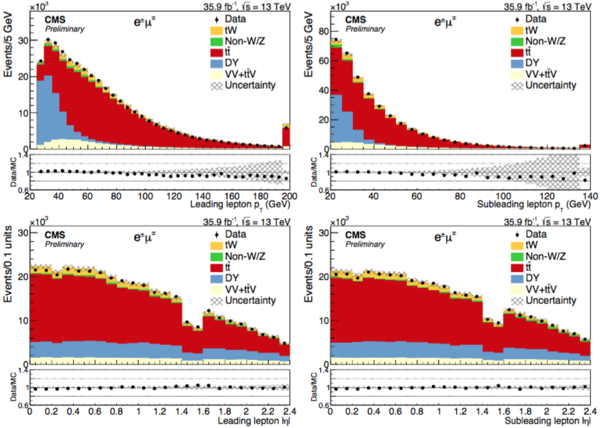
- Electons:The selection criteria for electron candiadte are:
  - Tight electron
  - Veto of transition region $1.4442 < |\eta_{SuCluster}| < 1.5660$
  - $p_T > 20$ GeV, $|\eta| < 2.4$
  - Relative electron isolation
- Muons:
  - Tight Global Muon
  - $p_T > 20$ GeV, $|\eta| < 2.4$
  - Particle Flow relative muon isolation $I_{rel} < 0.15$

Object selection - Jets and MET

- Jet
  - Jets are reconstructed by PF algorithm
  - $p_T > 30$ GeV, $|\eta| < 2.4$
  - $\Delta R_{lj} > 0.4$
  - Loose jet Id
  - Jet Energy Scale(JES) and Jet Energy Resolution(JER) corrections
- bjet
  - B-tag discriminator:Combined Secondary Vertex
  - Medium working point: $CSV > 0.8484$
- MET
  - Particle Flow MET is used in this analysis
  - In order to reduce the instrumental noise in the detector MET filters are applied

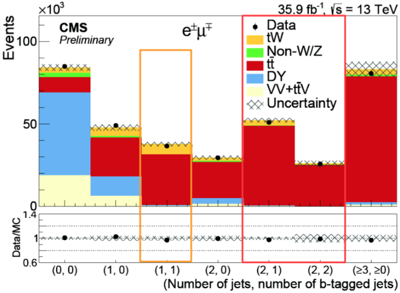
Event selection

- 1 isolated muon + 1 isolated electron (opposite charges) with $m_{ll} > 20$ GeV
- Leading lepton ($p_T > 25$ GeV)

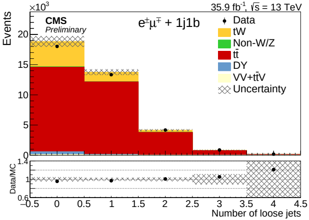


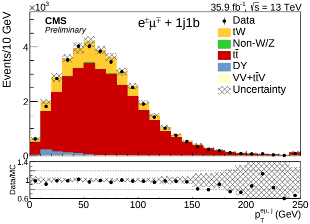
Analysis strategy

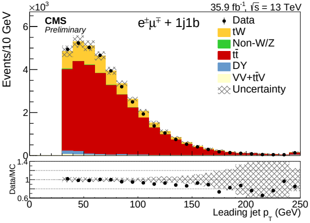
- Events categorized depending on number of jets and subset of b-tagged jets
- Further discrimination power in 1j1b and 2j1b regions provided by dedicated BDTs
- Sub-leading jet p_T in the 2j2b region to constrain $t\bar{t}$ background.
- Signal extraction performed using a likelihood fit to distributions in the different signal/control regions



- Input observables for 1j1b (ordered by importance):
- p_T of loose jet, p_T^{sys} , leading b jet p_T , loose jets, centrality, ...

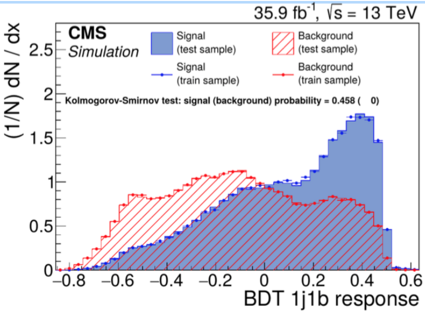


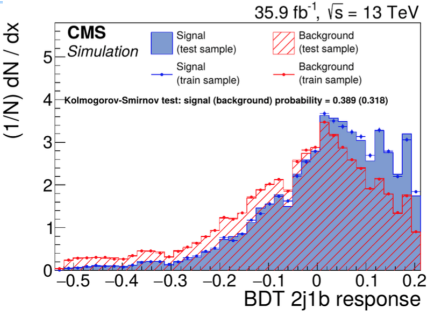




BDT Output

- separate BDTs trained in 1j1b/2j1b regions
- Signal/background separation clear

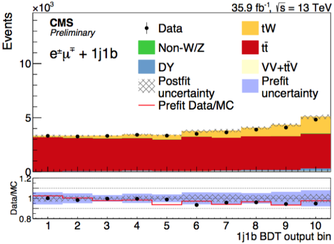


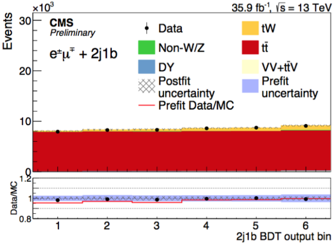


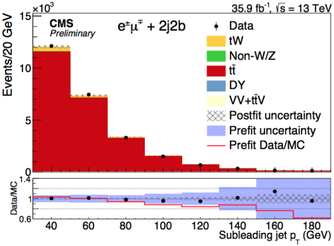
Signal extraction

- signal strength measured through ML fit to BDT in 1j1b, 2j1b and subleading jet in 2j2b
- Postfit distributions shown in the upper panel of the plots
- Ratio plot shows the postfit Data/Monte Carlo (points) and its uncertainty (strips)
- Ratio plot also shows prefit Data/Monte Carlo (red line) and its uncertainty (blue)

Signal extraction







Uncertainties and Results

- Uncertainties: The measurment of the tw production cross section is affected by different sources of systematic uncertainties that originate from detector effects and from theoretical modeling
  - **experimental:** statistics (2.8%), pileup (3.3%), jet energy scale (3.2%), electron/muon efficiencies (3.3%/3.1%) trigger efficiencies (2.7%), ...
  - **theoretical:** Q scale (2.7%), color reconnection (2.0%), ME/PS matching (1.8%), ...

- Results
  - $\sigma_{tW} = 63.1 \pm 1.8(Stat) \pm 6.0(sys) \pm 2.1(lumi)pb$
  - $\sigma_{tW}^{SM} = 72 \pm 2(Scale) \pm 3(PDF)pb$

Summary

- The full data set recorded by CMS at 13 TeV during 2016, corresponding to an integrated luminosity of $35.9 \pm 0.9\ fb^{-1}$ is used to measure the tW production cross section in the $e\mu$ channel
- The signal is measured using a BDT discriminants in the 1j1b and 2j1b categories and the subleading jet p_T distribution in the 2j2b category
- The measured cross section of the tW production is found to be $\sigma = 63.1 \pm 1.8(stat.) \pm 6.0(sys.) \pm 2.1(lumi.)pb$
- The measured cross section is consistent with the standard model prediction of $71.7 \pm 1.8(scale) \pm 3.4(PDF)$ pb.