



# Measurement of the $t\bar{t}W$ and $t\bar{t}Z$ cross section at $\sqrt{s} = 8$ TeV with ATLAS

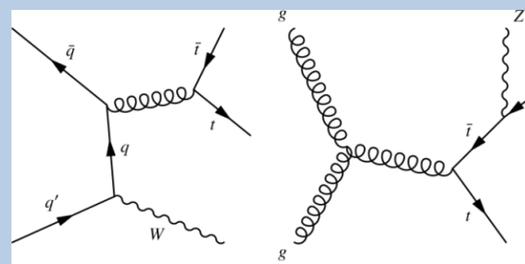
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## Introduction

The cross section of top-quark production with an associated  $W$  or  $Z$  boson is predicted by the Standard Model (SM). However, only a few experimental measurements are available and any deviation from the SM prediction would point at the existence of new physics. Furthermore, several models of physics beyond the SM predict a different  $t\bar{t}W$  or  $t\bar{t}Z$  cross section. Finally, these two processes are important backgrounds for Higgs physics and searches.

## Decay modes and channels

- $t\bar{t}W$ :**
- Opposite-sign (OS) dilepton
  - Same-sign (SS) dilepton
  - Trilepton
- $t\bar{t}Z$ :**
- OS dilepton
  - Trilepton
  - Tetralepton



Example of leading order diagrams for (left)  $t\bar{t}W$  and (right)  $t\bar{t}Z$

## Simulation of signal processes

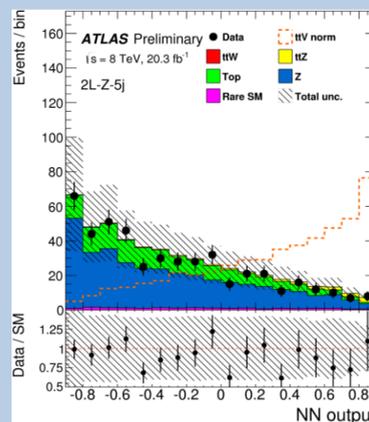
- Generated using the Madgraph5 leading-order generator with up to one additional parton
- CTEQ6L1 is used as parton distribution function
- The hadronization and fragmentation is simulated using Pythia 6 with the AUET2B tune
- The samples are normalized to next-to-leading order cross-section predictions computed with Madgraph5\_aMC@NLO, including the off-shell  $t\bar{t}Z/\gamma^*$  contribution and interference

## Methodology

- Each channel is divided into multiple analysis regions to enhance the sensitivity to signal
- A profile likelihood fit is performed over all regions to extract the cross section of  $t\bar{t}W$  and  $t\bar{t}Z$  production
- The systematic uncertainties are treated as nuisance parameters with prior uncertainties that are constrained from the fit
- The determination of confidence intervals and hypothesis testing are performed using a modified frequentist method
- The significance is computed using the asymptotic approximation described in EPJ C71 (2011) 1554

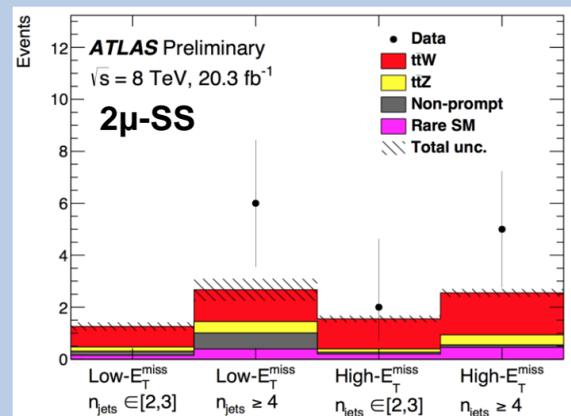
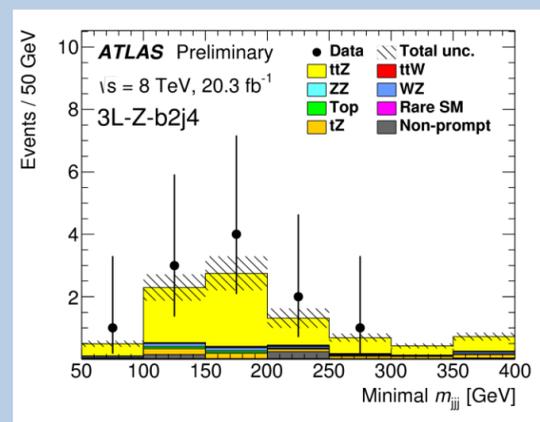
## 2LOS

Output of the neural network used to select events in the OS dilepton channel (before fit)

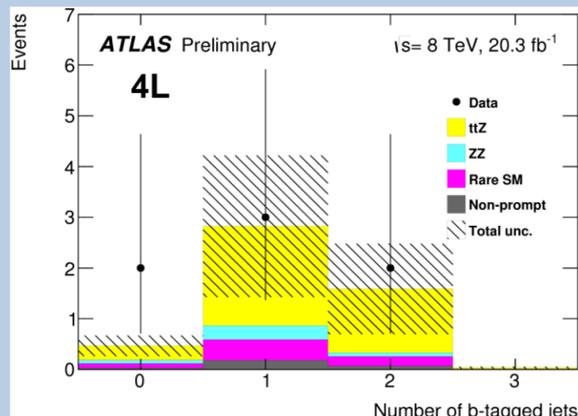


## 3L

Distribution of the minimal three-jet invariant mass in the trilepton channel (before fit)

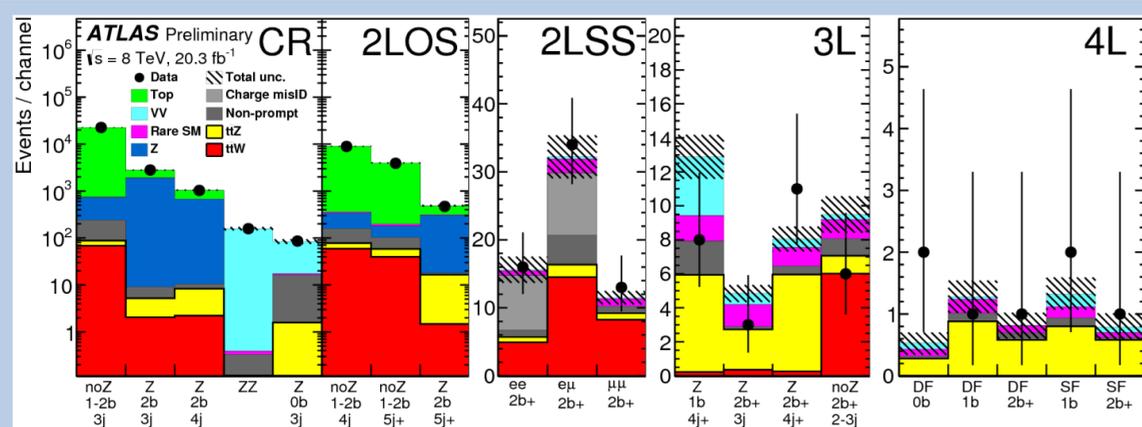
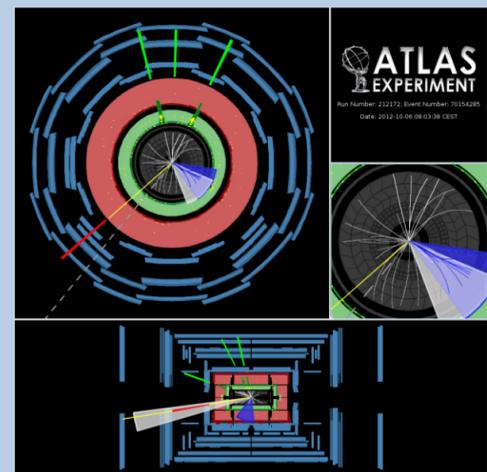


Distribution of events in the different regions of SS dimuon events (before fit)



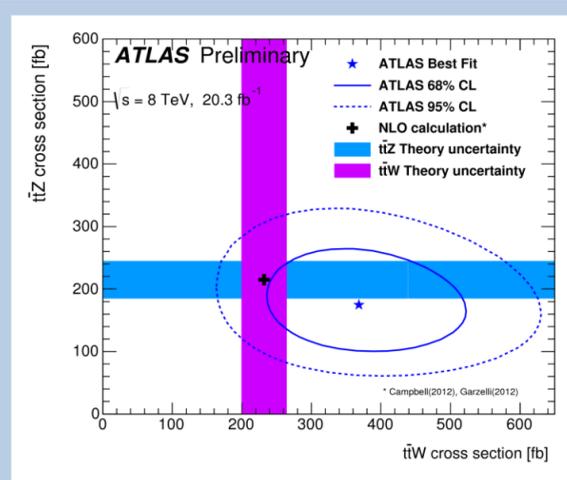
Number of  $b$ -tagged jets in the tetralepton channel (before fit)

Event display of a  $t\bar{t}Z$  candidate in the tetralepton channel with three electrons (green), one muon (red), two  $b$ -tagged jets (white and blue cones) and missing transverse momentum (dashed line)



Expected yields after fit compared to data in the 15 signal regions and 5 control regions used to measure the  $t\bar{t}W$  and  $t\bar{t}Z$  cross sections

Result of the two-dimensional fit to the  $t\bar{t}W$  and  $t\bar{t}Z$  cross sections along with the 68% and 95% confidence level uncertainty contours compared to NLO calculations






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## Results

A simultaneous fit to 20 regions measures:

- $\sigma_{t\bar{t}W} = 369^{+100}_{-91}$  fb (Expected significance: 3.2. Observed:  $5.0\sigma$ )
- Sensitivity dominated by same-sign dilepton channel
- $\sigma_{t\bar{t}Z} = 176^{+58}_{-52}$  fb (Expected significance: 4.5. Observed:  $4.2\sigma$ )
- Mainly measured from trilepton and tetralepton channel

These results are dominated by the statistical uncertainty and are consistent with the predictions of the Standard Model. The background only hypothesis (neither  $t\bar{t}W$  nor  $t\bar{t}Z$ ) is excluded at  $7.1\sigma$ .

Full note available as: ATLAS-CONF-2015-032 (<http://cds.cern.ch/record/2038143>)