Top-Antitop cross section measurement in the di-lepton decay channel with ATLAS

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Summary. — We present simulations of the production cross-section measurement of top-antitop pairs in the di-leptonic decay channel with the ATLAS detector. This study uses the Commissioning Service Challenge (CSC) data, which is the latest and centrally produced Monte-Carlo data set to validate the detector simulation before the actual data taking. The signal process was generated with MC@NLO [1] and important background processes were studied. A cut and count method and two likelihood methods were employed to measure the cross section and important systematic effects were investigated. The expected statistical and systematic errors for a luminosity of 100 pb⁻¹ are also given.

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1. – Di-lepton signature and background processes

The characteristic di-lepton signature is given by two opposite charged leptons(1) from the W decay and at least two jets from the decay of the two b-quarks as well as a large amount of missing transverse energy (ΔE_T) from the neutrinos.

The leptonically decaying Z in Drell-Yan events is an important background process for the di-leptonic subchannels with same flavor leptons. A very similar signature to the signal is produced by di-boson (W/Z) decays. Background processes that arise by misidentified leptons are mainly t\bar{t} lepton+jets, W+jets and QCD background events. Also single top events have been investigated.

2. – Cross section measurement methods

2.1. Cut and count method. – A simple cut based analysis on the lepton and jet p_T and on ΔE_T was optimized for the best S/√S+B. Events with same flavored leptons and

(1) The lepton identification is described in Ref. [2]. Additionally isolation from energy depositions in a hollow cone of ΔR < 0.2 of 6 GeV is required for electrons and isolation from reconstructed jets within ΔR < 0.2 is required for muons.
an invariant di-lepton mass compatible with the $Z$ mass were rejected. The optimized results require cuts of $p_T > 20$ GeV for all visible objects and $E_T > 35$ GeV for the $ee$ and $\mu\mu$ channel and 25 GeV for the $e\mu$ channel.

2.2. Likelihood method. – A second method employs the different shapes of signal and background in selected multidimensional distributions. A likelihood fit can determine the fraction of signal and background events in the total sample by fitting to the total event shape. The likelihood fit was performed with the distributions of the variables $|\Delta \phi|$ between the highest $p_T$ lepton and the $E_T$ vector, and $|\Delta \phi|$ between the highest $p_T$ jet and the $E_T$ vector.

2.3. Inclusive template method. – The inclusive template method uses templates based on the two-dimensional distributions of the $E_T$ and the jet multiplicity for the three dominant sources of $e\mu$ di-leptons, i.e. $t\bar{t}$ di-lepton, $Z \rightarrow \tau\tau$ and $WW$. This method requires leptons with tighter isolation criteria and rejects events with $E_T$ energy aligned with the muon in order to minimize events with misidentified leptons. The final fit has ten variables including the cross sections for the three processes.

3. – Systematic uncertainties

The effect of the jet energy scale uncertainty was estimated by rescaling all reconstructed jet vectors by $\pm 5\%$ and changing the missing transverse energy to preserve the total transverse momentum in the event. Initial and final state radiation was investigated with fast simulated samples in which PYTHIA [3] ISR and FSR parameters were increased by 100\% or halved. Finally the uncertainties from PDF variations were investigated by reweighting the events with the probability of both initial partons evaluated at the same $x_1$, $x_2$, and $Q^2$ value as in the generated event but with the error PDFs provided by the CTEQ and MRST collaboration. The error was evaluated by the Hessian approach [4].

4. – Summary

The following table summarizes the anticipated statistical and systematic errors evaluated at an integrated luminosity of 100 pb$^{-1}$. The full result will be published in the ATLAS CSC note.

\begin{align*}
(1) \text{Cut and Count method: } & \Delta \sigma/\sigma = (4(\text{stat})^{\pm 5}_{\pm 2}(\text{syst}) \pm 2(\text{pdf}) \pm 5(\text{lumi}))\% \\
(2) \text{Template method: } & \Delta \sigma/\sigma = (4(\text{stat}) \pm 4(\text{syst}) \pm 2(\text{pdf}) \pm 5(\text{lumi}))\% \\
(3) \text{Likelihood method method: } & \Delta \sigma/\sigma = (5(\text{stat})^{\pm 8}_{\pm 5}(\text{syst}) \pm 2.4(\text{pdf}) \pm 5(\text{lumi}))\%
\end{align*}

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