CMS data analysis tutorial: Exercise 3

Jun.-Prof. Dr. Christian Sander, Dr. Alexander Schmidt

September 2014

3 Cross-section of top quark production

In this exercise we will calculate the cross-section of top quark pair production at the LHC. The necessary ingredients are developed step by step.

- The first ingredient is the trigger efficiency ϵ^{trig}. We can trust the MC simulation to reproduce this efficiency correctly. Produce the trigger "turn-on" curve which shows the trigger efficiency depending on the muon transverse momentum p_{T}. Calculate the efficiency of triggering top quark events with a reconstructed and isolated muon of $p_{\text{T}} > 25$ GeV?
- The second ingredient is the acceptance ϵ^{acc} (not including the trigger). This includes the fact that we only select semi-leptonic top quark decays with muons. The branching fraction is well known, so we can take it from simulation. In addition, the acceptance includes all the selection cuts that have been found in Exercise 2. You can calculate the acceptance by comparing the number of generated top quark events with the number of selected events, after all your cuts.
- background subtraction: we also trust the simulation to correctly predict the number of background events after selection. Subtract the expected background from the observed (selected) data events.
- You can calculate the cross section now using the purity corrected observed events in data $N^{\text{obs}}_{\text{data}} * \text{purity}$. You have to apply corrections for trigger efficiency ϵ^{trig} and acceptance ϵ^{acc}.
- Compare your result with official publications of the ATLAS and CMS Collaborations.

3.1 Extension for very fast students

If you finish early with the above exercise, you should quote a statistical uncertainty for the cross-section as well.

You can also estimate the impact of systematic uncertainties. Several sources of systematic uncertainties must be taken into account for a proper measurement. The luminosity uncertainty is 10%. The uncertainty of the b-tagging efficiency is 10%. The uncertainty of the trigger efficiency is 5%. The cross-section uncertainty on background events can be assumed to be 10% (all values are approximate and conservative).