Ratio of Semileptonic and Dileptonic $t\bar{t}$ Decays in ATLAS at the LHC

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The Large Hadron Collider at CERN will be a top factory as top-antitop ($t\bar{t}$) events will be produced with a cross section σ of around 830 pb at 14 TeV center-of-mass energy. With about 30% probability top pairs decay semileptonically into final states with four jets, lepton (electron or muon) and respective neutrino. For another 5% of the $t\bar{t}$ events a dileptonic decay is expected. Here the final state signature is composed of two jets, two leptons and two neutrinos. Deviations from the ratio of these two decays would be a sign of new phenomena, e.g. a light charged Higgs boson.

Given here is an estimate for the precision of such a cross section ratio measurement during the first year of ATLAS at 14 TeV at the LHC at the design luminosity of $10^{33}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$, corresponding to an integrated luminosity of $10\,\mathrm{fb}^{-1}$.

In the semileptonic decay channel the largest expected backgrounds are events with leptonic W decays and additional jets, and pure QCD multijet events where one jet is misidentified as an electron. Another background is single top events.

As described in [1] a good strategy for the suppression of background events in the first data by means of simple cuts is to require the firing of the "electron 25 GeV" or "muon 20 GeV" trigger, having exactly one electron or muon with a transverse momentum of at least 30 GeV, 4 or more jets with transverse momenta above 20 GeV of which at least 2 jets exceed 40 GeV, and missing transverse energy ($\not{E}_T$) larger than 20 GeV. With such a selection a precision for a cross section measurement of

$$\Delta\sigma/\sigma = \pm 0.2\%(\mathrm{stat}) \pm 12.5\%(\mathrm{syst}) \pm 10.0\%(\mathrm{lumi})$$

could be estimated, assuming 5% uncertainty on the jet energy scale, 10% on the background cross sections and 5% on the luminosity. Figure 1 gives the expected statistical error and the combined systematic and luminosity error as a function of the integrated luminosity. Apparently the analysis will be dominated by systematic uncertainties almost from the first day on.

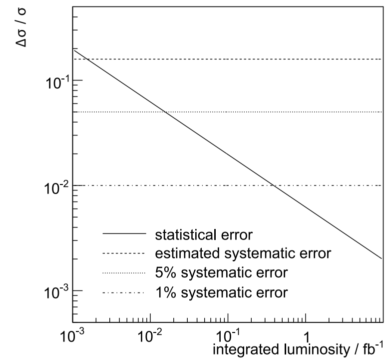

Fig. 1: Statistic and combined systematic error as a function of the integrated luminosity for the semileptonic channel.

In the dileptonic channel, background from Z + jets, dibosons (WW, WZ & ZZ) + jets, and W + jets has been considered. Here the selection requires again the firing of the "electron 25 GeV" or "muon 20 GeV" trigger, exactly 2 reconstructed leptons which must be oppositely charged, a first jet with transverse momentum above 55 GeV and a second above 40 GeV. When combined both leptons must not have a mass in the window between 80 and 100 GeV to reduce the Z background and as the final step $\not{E}_T$ must be at least 25 GeV. Here a precision of

$$\Delta\sigma/\sigma = \pm 0.5\%(\mathrm{stat}) \pm 6.0\%(\mathrm{syst}) \pm 6.5\%(\mathrm{lumi})$$

should be achievable. Even though the statistical precision is smaller in this channel the analysis will also be dominated by systematic uncertainties, see Figure 2.

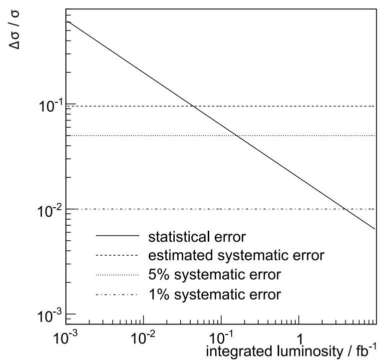

Fig. 2: Statistic and combined systematic error as a function of the integrated luminosity for the dileptonic channel.

Combining the analyses above for both channels yields a precision for the cross-section ratio $R_{\mathrm{ll/l}}$ of

$$\Delta R_{\mathrm{ll/l}}/R_{\mathrm{ll/l}} = \pm 0.7\%(\mathrm{stat}) \pm 7.7\%(\mathrm{syst}) \pm 3.1\%(\mathrm{lumi})$$

Even though a lot of systematic uncertainties cancel in the cross section ratio, in particular a large fraction of the error on the luminosity, Figure 3 shows that even here the focus has to be set on the systematic uncertainties for future improvements of this analysis which starts dominating the total error for an integrated luminosity of $60\,\mathrm{pb}^{-1}$ already.

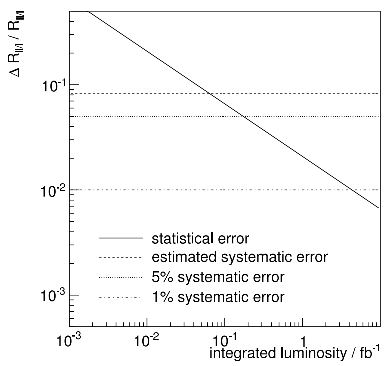

Fig. 3: Statistic and combined systematic error as a function of the integrated luminosity for the cross section ratio.

References

[1] Raphael Mameghani et al., annual report 2007, p. 39