QCD Background for Semileptonic $t\bar{t}$ Decays in ATLAS at the LHC

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At the Large Hadron Collider at CERN top-antitop ($t\bar{t}$) events will be produced with a cross section of around 800 pb. With about 30% probability top pairs decay into final states with four jets, including two b jets, a charged lepton[1] and its neutrino. This study estimates QCD background for a cross section measurement in this semileptonic $t\bar{t}$ decay channel during the first year of ATLAS at the LHC, corresponding to an integrated luminosity of 10 fb^{-1}.

In this early phase b-jet and τ lepton identification algorithms might not yet be available and are hence not used in this study. The largest expected backgrounds are events with leptonic W decays and additional jets as well as pure QCD multijet events where one jet is misidentified as an electron.

The $t\bar{t}$ events have been simulated with the next-to-leading-order generator MC@NLO, interfaced to the full GEANT4 detector simulation. For the QCD background ALPGEN samples together with a parametrised detector simulation have been used [1]. No W + jets background events have been available so far.

To estimate the QCD background each jet in the QCD sample has been considered once as reconstructed as a 'fake' electron. The QCD background has been modeled with an assumed probability $P(j \to e)$ for such a misreconstruction of 10^{-3}. Table 1 gives the cross sections of the different parton multiplicities in the hard interaction as obtained from ALPGEN, the average number of reconstructed jets[2] per event and the resulting effective cross section for fake electron events according to the relation

$$\sigma_{\text{eff}} = \sigma \cdot P(j \to e) \cdot \langle n_{\text{jets}} \rangle$$

partons	σ [pb]	$\langle n_{\text{jets}} \rangle$	σ_{eff} [pb]
3	$4.88 \cdot 10^6$	1.937	9452
4	$4.84 \cdot 10^5$	2.739	1325
5	$5.02 \cdot 10^4$	3.650	183
6+	$4.90 \cdot 10^4$	3.835	188

Table 1: Expected effective cross section of the QCD samples with jets reconstructed as electrons.

The following event selection criteria have been applied: exactly one isolated lepton with a transverse energy of at least 20 GeV, missing transverse energy ($\not{E}_T$) larger than 30 GeV and 4 – 6 jets with transverse energies over 20 GeV. Additional requirements are a transverse W mass reconstructed from the lepton and $\not{E}_T$ between 30 and 120 GeV and the presence of a combination of 2 jets with an invariant mass at most 10 GeV apart from the W mass with an invariant mass not more than 25 GeV away from the top mass when a third jet is added.

In the early phase of ATLAS the calorimeter energy resolution might be reduced. To study such scenarios the measured energies have been smeared additionally with Gaussian distributions of the width $\sigma = c \cdot \sqrt{E}$, and $\not{E}_T$ has been corrected accordingly. It is visible from Fig. 1 that a smearing parameter of $c = 35 \cdot \sqrt{\text{MeV}}$ adds a smearing of about the original resolution.

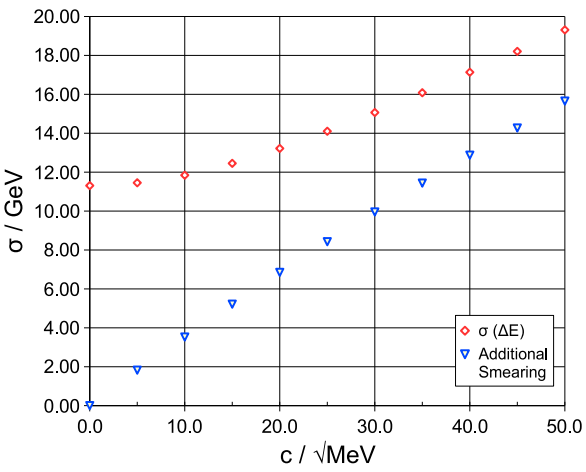

Fig. 1: In red squares the total jet energy resolution and in blue triangles the contribution by the additional smearing.

A direct comparison between the resulting $\not{E}_T$ distributions after all cuts illustrates the loss of signal purity and reduction of selection efficiency in such a scenario, see Fig. 2.

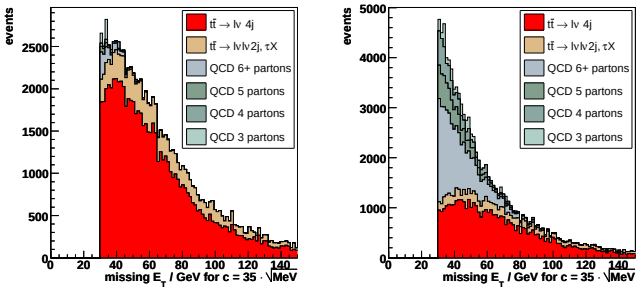

Fig. 2: $\not{E}_T$ distributions after the cuts without an additional smearing (left) and with an extra smearing of $c = 35 \cdot \sqrt{\text{MeV}}$ (right).

So only minor QCD background contributions are expected unless the energy resolution of the detector stays far behind expectation. In a next step the W + jets background will be added, the cuts will be optimised and trigger efficiencies have to be taken into account.

References

[1] M. Lambacher *et al.*, this report, p. 43

[1] As the identification of τ-lepton decays is challenging only electrons and muons are considered.
[2] Cone jets with a radius of 0.4.