Search for single top quark production through FCNC at ATLAS experiment

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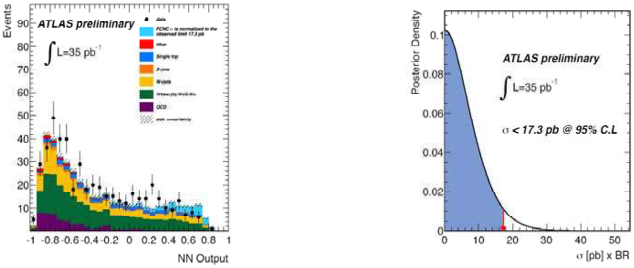
1 Introduction

Flavour changing neutral currents (FCNC) are strongly suppressed in the Standard Model (SM). Although absent at tree level, small FCNC contributions are expected at one-loop level. For the top quark, the expected FCNC branching fractions to gauge bosons, e.g. $t \rightarrow q$+gluon, are predicted to be at the level of 10^{-13} [1]. There are, however, extensions of the SM which predict the presence of FCNC contributions and significantly enhance the FCNC rates compared to the SM predictions. ATLAS has studied direct single top-quark production through FCNC $qg \rightarrow t \rightarrow bW$ [2], where the u(c) quark interacts with a gluon to produce a single top quark, and then top quark decays via SM process, $t \rightarrow W + b$.

2 Analysis method

ATLAS data collected in 2010 with an integrated luminosity 35 pb^{-1} are used. Protos [3] is used to simulate the direct production of top quarks via FCNC. The top quark decays as expected in the Standard Model. Only the leptonic decay of the W boson is considered.

Events have to accepted by a single-lepton triggers containing an electron or a muon. The events are required to have only one reconstructed isolated lepton with $p_{\mathrm{T}} > 20$ GeV. The missing transverse energy, $\not{E}_{\mathrm{T}}$, in the muon channel should be $\not{E}_{\mathrm{T}} > 20$ GeV and in the electron channel $\not{E}_{\mathrm{T}} > 35$ GeV. In order to reject QCD multijet events the sum of $\not{E}_{\mathrm{T}}$ and $m_{\mathrm{T},W} = \sqrt{2p_{\mathrm{T},\ell}\not{E}_{\mathrm{T}}(1 - \cos(\ell, \phi_{\not{E}_{\mathrm{T}}}))}$ should be $\not{E}_{\mathrm{T}} + m_{\mathrm{T},W} > 60$ GeV in the muon channel, and $m_{\mathrm{T},W} > 25$ GeV in the electron channel. Since the signal process gives rise to only one high-p_{T} b-quark jet, exactly one reconstructed jet with $p_{\mathrm{T}} > 25$ GeV is required, which has to be identified by the secondary vertex algorithm. The neural network (NN) package NeuroBayes [4] was used to separate signal and background events. The following variables used to train the NN (sorted by their significance) are: the P_T of the reconstructed W boson, $\Delta R(b, lep)$, lepton charge, m_{top}, $\Delta\phi(W, b)$, η_b, W-boson helicity, $p_{T,b}$, $p_{T,t}$, η_ℓ, $\not{E}_T$, m_T^W and $\Delta\phi(\ell, b)$. The NN output including data and MC are shown in Figure 1a.



a) b)

Figure 1: a) Posterior probability function of the observed events including all systematic uncertainties. b) Neural network output distribution including a signal sample scaled to the cross section of the observed upper limit.

3 Results

No evidence for anomalous FCNC single top-quark events was found so far, an upper limit at 95% C.L. was set on the corresponding cross section using a Bayesian method, with a binned maximum likelihood fit of the NN output distribution. The signal prior chosen to be flat, the effect of systematic uncertainties is parametrised in the likelihood function by using nuisance parameters assuming Gaussian priors.

Rate normalization effects and shape distortions of the template distributions are considered; uncertainties in the jet energy scale, b-tagging efficiencies, lepton identification and trigger efficiencies, the amount of initial and final state radiation, and parton distribution functions have the highest effects. Monte Carlo integration over all parameters in the likelihood function was done to calculate the limit. The signal posterior density function (PDF) is shown in Figure 1b. The expected limit is chosen to be the median value of 10000 pseudo experiments, the plus and minus sigma errors are chosen to be the 16% and 84% quantiles respectively. A 95% C.L. cross-section times branching fraction limit was set as $\sigma_{qg\to t}\times\mathrm{BR}(t\to bl\nu) < 17.3$ pb.

References

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