Fourth generation searches at ATLAS

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In the following, four analyses with searches for heavy quarks of a 4th generation are presented. The analysed data (1 fb^{-1}) were taken with the ATLAS detector [1] at the LHC at $\sqrt{s} = 7$ TeV. All analyses assume QCD pair-production of these Dirac fermions as a simple extension of the three generations Standard Model (SM), where the up-type quark is noted as t' and the down-type quark as b'.

4th generation quarks could play an interesting role in electroweak symmetry breaking [2]. A SM with four generations has also the property to generate gauge coupling unification at a scale of order $10^{15} - 10^{16}$ GeV [3]. There are also discussions in the literature if a fourth generation of quarks could play a central role in baryogenesis [4].

In the presented analyses, events are selected passing single electron or muon triggers. Electrons are selected with a transverse energy of $E_T > 25$ GeV, tight quality selection criteria, calorimeter isolation, and must be within $|\eta| < 2.47$ ($\eta = -\ln\tan\theta/2$), excluding $1.37 < |\eta| < 1.52$. Muons are selected with a transverse momentum $P_T > 20$ GeV, $|\eta| < 2.5$, isolation and a veto on cosmic muons. Muons overlapping with jets are removed. Jets are reconstructed with an anti-k_T algorithm and are required to have $P_T > 25$ GeV (unless otherwise stated) and $|\eta| < 2.5$. Jets overlapping with electrons are removed. H_T is defined as the scalar sum of jets and leptons P_T. The dilepton analyses apply cuts on the invariant mass m_{inv} of the leptons ($ee/\mu\mu$) of $m_{inv} > 15$ GeV and $m_{inv} \notin [81, 101]$ GeV. $m_T = \sqrt{2E_T^{Miss}P_T^{\ell}\left(1 - \cos\left(\Delta\Phi\left(E_T^{Miss}, P_T^{\ell}\right)\right)\right)}$ describes the transverse mass of lepton ℓ and neutrino in the single lepton analyses.

In [5] b' quarks are searched for in single lepton final states ($b' \to tW$, branching ratio BR=100%), where the events are required to have at least six jets, missing transverse energy $E_T^{Miss} > 35$ GeV and $m_T > 25$ GeV (e events), $E_T^{Miss} > 20$ GeV and $E_T^{Miss} + m_T > 60$ GeV (μ events) and high-P_T W decays into two jets are identified. The signal is extracted by a binned maximum-likelihood fit of nine bins in (N_W,N_{Jets}), where $N_W = 0, 1, \geq 2$ describes the number of reconstructed W bosons and $N_{Jets} = 6, 7, \geq 8$ the number of jets. No excess is found and a limit of $m_{b'} > 480$ GeV (Fig. 1) is set.

In [6] b' quarks are searched for in same-sign dilepton final states ($b' \to tW$, BR=100%). The events are required to have at least two jets ($P_T > 20$ GeV), $H_T > 350$ GeV and $E_T^{Miss} > 40$ GeV. The signal is extracted by a single-bin counting experiment. No excess is observed and a limit of $m_{b'} > 450$ GeV is set.

In [7] t' quarks are searched for in single lepton final states, ($t' \to bW$, BR=100%) where the events are required to have at least three jets (one with $P_T > 60$ GeV), at least one b-jet, $E_T^{Miss}+m_T > 60$ GeV, $E_T^{Miss} > 35$ GeV (e events) and $E_T^{Miss} > 20$ GeV (μ events). The reconstructed t' mass m_{reco} is used as discriminant in the signal extraction. No excess is found and a limit of $m_{t'} > 404$ GeV is set.

In [8] heavy 4th generation quarks Q (benchmark model: t') are searched for in opposite-sign dilepton final states ($Q \to qW$), where the events are required to have at least two jets, $H_T > 130$ GeV ($e\mu$ events) and $E_T^{Miss} > 60$ GeV ($ee/\mu\mu$ events). The signal is extracted by a fit of m_{coll}, which is the reconstructed heavy quark mass assuming the neutrinos from $Q \to qW \to q\ell\nu$ are approximately collinear to the charged leptons. No significant excess over expected background is observed and a limit of $m_Q > 350$ GeV is set.

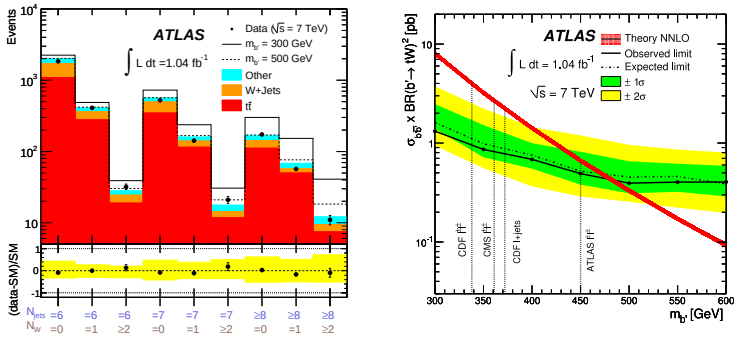

Figure 1: *Left:* Discriminant. *Right:* Limit on b' mass in single lepton final states [5].

References

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