LHCC Poster Session - CERN, 21 March 2012

Search for heavy quarks in dilepton and lepton+jets channels with the ATLAS experiment at √s = 7 TeV

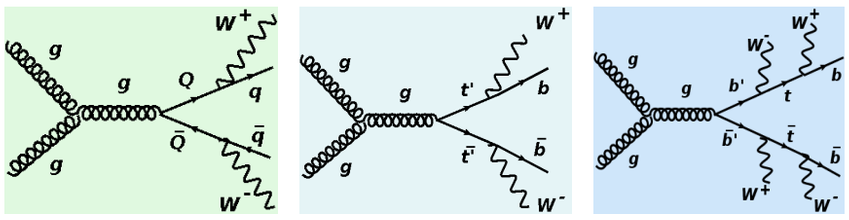
Physics motivations

The Standard Model of particle physics is incomplete : some problems are not solved such as *the matter-antimatter asymmetry in the Universe, the hierarchy of energy scales, the fine tuning of the Higgs mass.* Experimentally, we observe dark matter, dark energy and neutrino masses, not explained by the SM

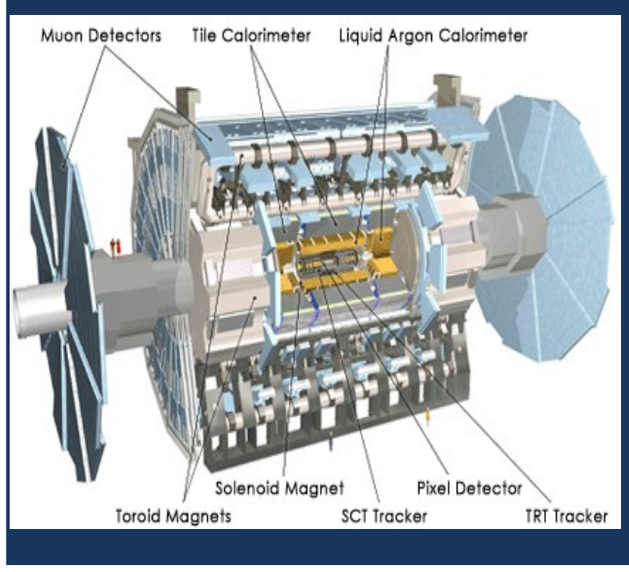
Some problems are solved in models with a fourth generation of heavy chiral fermions (t', b') that provide new sources of CP violation and allow for a heavier Higgs boson while remaining consistent with precision electroweak data (via some hypothesis on m(b'), m(t')).

l+jets : $W_1 \to l\nu$
$W_2 \to q\bar{q}'$

dilepton : $W_1 \to l\nu$
$W_2 \to l\nu$



The ATLAS Detector



Inner tracking detector (silicon pixel, silicon strips and transition radiation detectors in a solenoid magnet) → reconstruction of charged particle tracks and vertices

Calorimeters (electromagnetic and hadronic) → reconstruction of particle showers

Muon spectrometer (in a toroid magnet) → reconstruction of muon tracks

Background

dilepton final state :

diboson (WW, WZ, ZZ) (estimated with HERWIG)
fake rate (data-driven : matrix method)

- *opposite sign leptons:*
  $t\bar{t}$ and single top (estimated with MC@NLO+HERWIG)
  Z+jets (estimated with (ALPGEN+HERWIG)
- *same sign leptons :*
  $t\bar{t}W$, $t\bar{t}Z$, $t\bar{t}W^+W^-$ (estimated with MadGraph + Pythia)
  charge flip (data-driven)

l+jets final state :

diboson (estimated with HERWIG)
$t\bar{t}$ and single top (estimated with MC@NLO+HERWIG)
Wjets , Z+jets (estimated with ALPGEN+HERWIG)
multijets (data-driven)

Model

- Production and decay of the events generated with PYTHIA
- Production cross-section is calculated using HATHOR.

σ(m(Q)=300 GeV) = 8.00 pb
σ(m(Q)=450 GeV) = 0.68 pb

Systematic Uncertainties

The systematic uncertainties are due to :

- objects calibration, resolution and energy scale, missing energy
- trigger and reconstruction efficiencies
- Initial and final state radiations
- generator (uncertainties on cross section)
- pile-up and luminosity
- uncertainties on data-driven methods estimates
- modeling of the b tagging algorithm

b' model (b' → tW⁻)

same sign dilepton final state

Selection criteria :

>= 2 same sign leptons (e,μ)
$|m_{LL} - m_Z| > 10$ GeV with $m_{LL} > 10$ GeV
n(jets) >= 2 jets
$E_T^{miss} > 40$ GeV
$H_T = \Sigma p_T > 350$ GeV

Only the range m(b') > (m(t) + m_W) is considered : b' → tW^- 100%

Results

Study performed for √s = 7 TeV and an integrated luminosity of 1.04 fb^{-1}.

Upper limits at 95% CL on the cross sections are derived thanks to a single bin counting experiment, fitting the data to extract the most likely signal cross section.

Systematic undertainties are included as variations in the expected signal and background yields.

lepton + jets final state

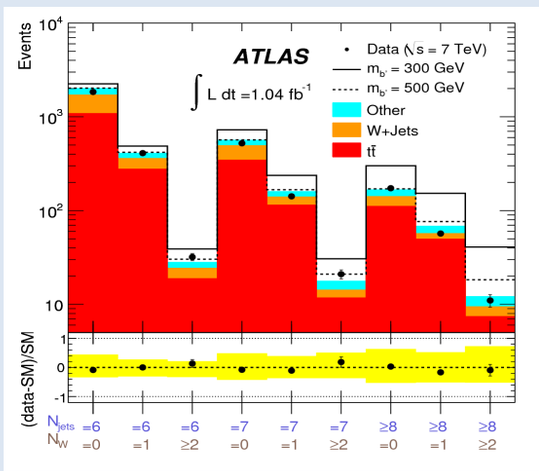
Selection criteria :

= 1 lepton (e,μ)
n(jets) >= 6 jets
$E_T^{miss} > 35$ (20) GeV for e (μ) channel
$m_T^W > 25$ GeV for e channel
$E_T^{miss} + m_T^W > 60$ GeV for μ channel

Results

A semi-boosted approach is used where $W \to q\bar{q}'$ are reconstructed if :
- ΔR(j,j) < 1.0
- m(j,j) consistent with W mass

→ 9 bins are studied, defined by N_W reconstructed (0,1,>=2) and N_{jet} (6,7,>=8).



Q model (Q → W⁺q)

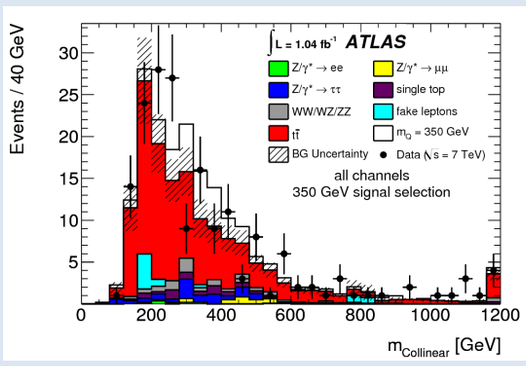
dilepton final state

Selection criteria :

= 2 opposite sign leptons (e,μ)
$|m_{LL} - m_Z| > 15$ GeV with $m_{LL} > 10$ GeV
n(jets) >= 2 jets
$E_T^{miss} > 60$ GeV for ee and μμ channel
$H_T = \Sigma p_T > 130$ GeV for eμ channel
$\Delta M(Q,\bar{Q}) < 25$ GeV
Mass-dependent requirements on H_T, E_T^{miss}, leading jet P_T and collinear mass are imposed as well to reduce the $t\bar{t}$ background.

Results

In order to reconstruct the mass, each neutrino is assumed to be collinear with the charged lepton from the same W decay



t' model (t' → W⁺b)

lepton + jets final state

Selection criteria :

= 1 lepton (e,μ)
$E_T^{miss} > 35$ (20) GeV for e (μ) channel
$E_T^{miss} + m_T^W > 60$ GeV
n(jets) >= 3 jets with at least 1 b-jet
P_T(leading jet) > 60 GeV
P_T(jet) > 25 GeV

Only the range m(t') < (m_W – m(b')) is considered : t' → W^+q 100%

Results

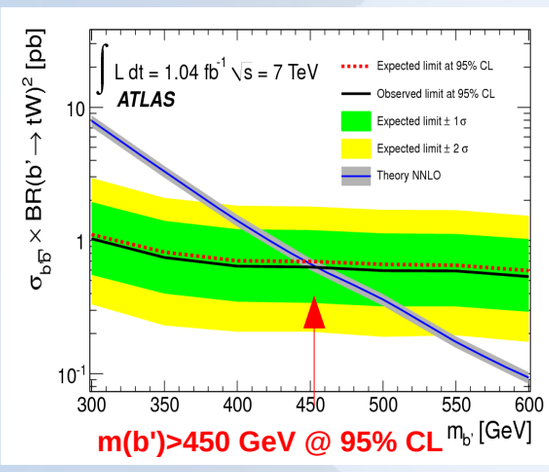
m_{reco} ~ m(t') is used as the discriminating variable :

- If n(jets) = 3 → m_{reco} = M(j1,j2,j3)
- If n(jets) > 3 → m_{reco} is estimated by performing a kinematic likelihood fit (KLfitter) to the $t'\bar{t}' \to l\nu b\bar{b}q\bar{q}'$ hypothesis with :
  - m(t')=m($\bar{t}'$)
  - m(lν) = m(j1,j2) = m_W

A binned maximum likelihood ratio technique is used to fit the mass ditribution to the observed data in order to measure $\sigma(pp \to X\bar{X})$.
Statistical interpretation to the fitted cross section is done using the CLs technique.

Exclusion Plots for the b'

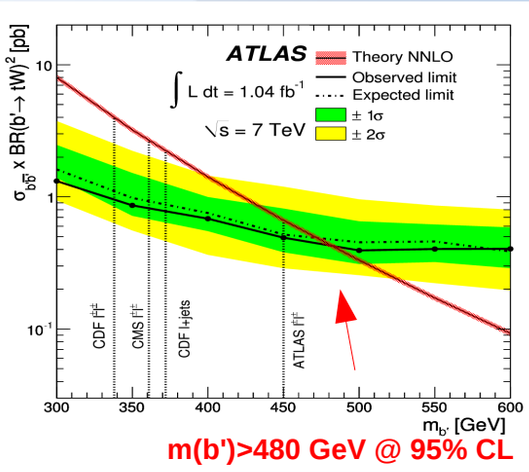
dilepton final state



m(b')>450 GeV @ 95% CL

arXiv : 1202.5520 [hep-ex]

lepton + jets final state

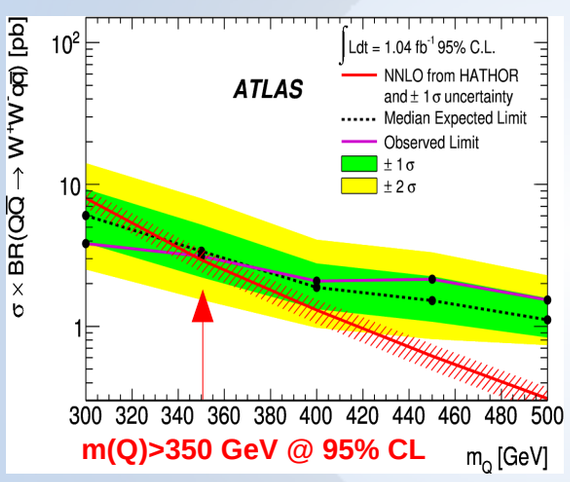


m(b')>480 GeV @ 95% CL

arXiv : 1202.6540 [hep-ex]

Exclusion Plots for the Q and t'

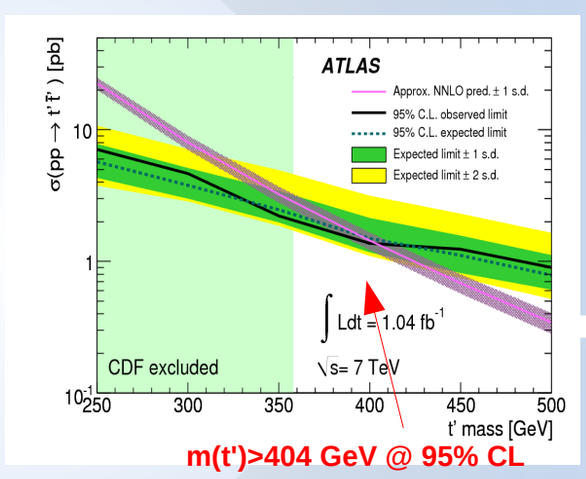
dilepton final state



m(Q)>350 GeV @ 95% CL

arXiv : 1202.3389 [hep-ex]

lepton + jets final state



m(t')>404 GeV @ 95% CL

arXiv : 1202.3076 [hep-ex]

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ATLAS EXPERIMENT