Search for Heavy Quarks at the ATLAS Experiment

New Heavy Quarks

4^{th} Generation

- simple extension of the Standard Model (SM) by one fermion family -

Motivation: number of fermion families not fixed in the Standard Model (SM), electroweak symmetry breaking [1], baryogenesis (?) [2]

Searches: $m_{t'} > 656$ GeV @ 95% CL (lepton + jets) [3], $m_{b'} > 670$ GeV @ 95% CL (same-sign dileptons) [4], assuming 100% branching fraction in corresponding decay channels

Status: recent results from Higgs searches exclude sequential 4^{th} generation in the SM [5], 4^{th} generation not excluded within extended Higgs sector [6]

Vector-like Quarks

- quarks, for which both chiralities transform in the same way under $SU(2) \times U(1)$ -

Motivation: predicted by many models beyond the SM: e.g. Universal Extra Dimensions [7], Little Higgs [8], E_6 Unification [9], show similar decay topologies as 4^{th} generation quarks, e.g. $t' \to q + W$, $b' \to t + W$, but also FCNCs like $b' \to b + Z/h$, $t' \to t + Z/h$

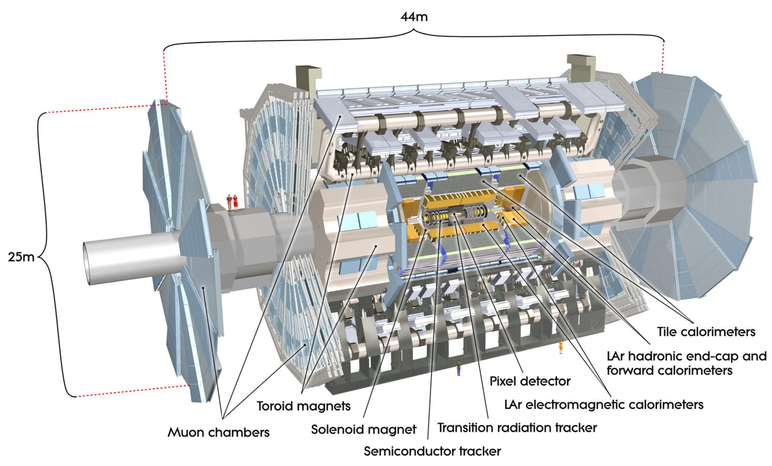
Searches: $m_Q > 1120$ GeV, > 1420 GeV @ 95% CL for q_Q = -1/3, 5/3 (lepton + jets) [10], $m_Q > 1080$ GeV @ 95% CL for $q_Q = 2/3$ (dileptons) [10], assuming single production of the VLQ and $\tilde{\kappa}_{qQ} = 1$

Status: existence untouched by the presence of a SM Higgs boson

The ATLAS Detector

ATLAS is a general purpose detector at the Large Hadron Collider (LHC) at CERN consisting of

- the **Inner Detector** inside the solenoid magnet (silicon pixels, silicon strips, transition radiation tracker): tracking, vertex reconstruction
- an **electromagnetic** (liquid Argon) and a **hadronic** (iron and plastic scintillators) **calorimeter**: energy measurements, particle identification
- a **muon spectrometer** inside the toroid magnet, consisting of drift tubes, gas chambers and resistive plate chambers: muon momentum reconstruction, muon trigger

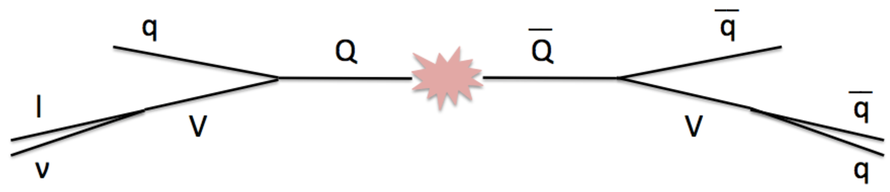


[11]

Plans

In the light of the search results (previous ones as well as the ones to be shown in spring 2013), I will investigate the following possible analysis projects of heavy up-type (T) or down-type (B) quarks:

1. $T\bar{T} \to q + W, \bar{q} + W$, with $q\bar{q}$, $q\bar{b}$, $b\bar{b}$ final states to study different mixing scenarios in the 4^{th} generation or VLQ model
2. $B\bar{B} \to q + W, \bar{q} + W$, with $q\bar{t}$, $q\bar{t}$, $b\bar{t}$ final states, for very massive B quarks using "boosted top" techniques (can be used in $T \to t + h/Z$ as well)



After detailed investigation, one of the above mentioned topics will be chosen and a respective analysis will be set up.

Main goals: reduce model-dependence, close regions of no exclusion

Strategy: investigate pair production of heavy quarks, making use of the decay kinematics

Boosted Object Reconstruction

With increasing mass of the heavy quark, its decay products (bosons and quarks) become more and more energetic, so that the decay products of the bosons and quarks start to merge in the detector. We will therefore investigate in more detail for both analysis projects, if searches for very massive B/T quarks can profit from algorithms based on fat jet techniques to reconstruct boosted top quarks or bosons.

Other Efforts

- extension of the monitoring software and radiation damage studies for the current silicon strip detector (SCT)
- detector development for the upgrade of the silicon strip detector for the high-luminosity phase of the LHC

Profit from the GK

- interesting lectures and paper discussions with other PhD students at block courses
- additional travel money

References

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