

Progress Report

A search for rare top quark decays in proton-proton collisions, with center of mass energy $\sqrt{s} = 13$ TeV, collected at the ATLAS experiment at the Large Hadron Collider(LHC) is ongoing by Professor James Brau and graduate student Jason Barkeloo. This search follows a similar search done at $\sqrt{s}= 8$ TeV which was able to set new limits on the branching ratio of the rare top quark flavor-changing neutral current (FCNC) decay mode involving a photon.

In the Standard Model (SM) of particle physics the top quark decays to a W boson and a bottom quark ($t \rightarrow bW$) almost 100% of the time. A neutral current decay, where the top quark decays to a neutral boson (photon, Z quark or Higgs boson) and an up or charm quark (e.g. $t \rightarrow q\gamma$) is heavily suppressed through the GIM-Mechanism [2] as well requiring an off-diagonal mixing in the CKM-Matrix [4]. FCNC decays can occur through loop processes. These processes are significantly more rare: SM branching ratios for these FCNC decays of the top quark are of order 10^{-17} to 10^{-12} [3], significantly beyond current experimental reach. Many beyond the standard model theories exist which predict large enhancements in the top sector of these decays (e.g. various supersymmetry models, Randall-Sundrum models). Observation of these FCNC decays would require a very large enhancement, eight to twelve orders of magnitude, to the SM Branching ratio and would be an absolute indication of new physics. Current upper limits on the branching ratio $\text{BR}(t \rightarrow q\gamma)$ from the CMS experiment at the LHC are $\text{BR}(t \rightarrow c\gamma) < 1.7 \times 10^{-3}$ and $\text{BR}(t \rightarrow u\gamma) < 1.3 \times 10^{-4}$, with the full 8 TeV dataset[1]. The 8 TeV ATLAS limits using the full 2012 data set of 20.3 fb^{-1} an upper limit for $\text{BR}(t \rightarrow q\gamma) < 6.3 \times 10^{-4}$ was observed.

We are performing a search for the FCNC in the $t\bar{t} \rightarrow bWq\gamma$ channel at ATLAS, using $\sqrt{s} = 13$ TeV pp collisions. Specialized Monte Carlo simulation events for this process have been created after validation with the ATLAS collaboration's top quark group. Simulated events inside of the ATLAS detector have been created for all of the decay channels of the FCNC process for top-quark pair events including the top or antitop undergoing FCNC decay while the other goes through the SM typical decay. The W boson decays are included as well and samples have been produced for both the leptonic mode ($W \rightarrow l\nu$) and hadronic mode ($W \rightarrow qq$).

There are many SM processes that can mirror the final state of our signal processes including $t\bar{t}$, W+jets, Z+jets, including processes that have an associated photon as well. Investigations have begun on how to minimize the background contributions without loss of signal sample events. A cut based analysis is planned to eliminate as much background as possible and look for an excess of events. Any excess would imply some new physics otherwise a new branching ratio can be set which can help set restrictions on current and future theoretical models.

References

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