Search for Second Generation Leptoquarks with ATLAS at the LHC

G. Krobath, M.-H. Genest, J. de Graat, C. Kummer, D. Schaile, C. Serfon, R. Ströhmer, and M. Wichmann

The astonishing similarities between the leptonic and the quark sector of the standard model lead to to the assumption that there could be particles which connect these two so far unconnected sectors. Leptoquarks, color triplets with fractional charge, carrying both lepton and quark quantum numbers, would be perfect candidates for such particles and are predicted by many extensions of the standard model, i.e. superstring-inspired E_6 models, Grand-Unifying-Theories etc. Limits coming from experiments on the proton decay, lepton flavor violating decays and on flavor changing neutral currents lead to the assumption that there must be three different generations of Leptoquarks, each coupling to just one generation of quarks and one generation of leptons. With this assumption Leptoquarks could be as light as O(200 GeV) [1].
At the LHC Leptoquarks would be produced in pairs via strong interactions (figure 1). Studying pair production has also the advantage that it, in contrast to single production, does not depend on the unknown Yukawa coupling constant (i.e. the coupling between the quark, lepton and the Leptoquark), but only on the Leptoquark mass and QCD.

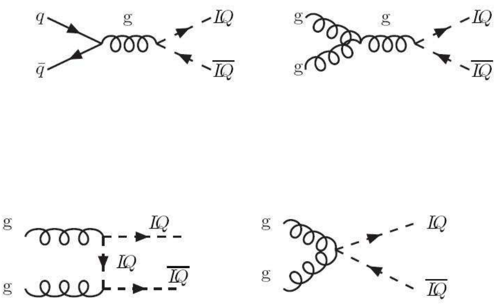

Fig. 1: pair production of Leptoquarks

This article deals with scalar Second Generation Leptoquarks pairs decaying into μ + jet + μ + jet to be measured with the ATLAS detector at the LHC. We assume the branching fraction of Leptoquarks decaying into a muon and a jet to be 1. The Monte Carlo data for this study has been created with a full simulation of the ATLAS detector. All events are required to have 2 reconstructed muons fulfilling the isolation cut (energy deposited in the calorimeter in a cone of $\Delta R = 0.2$ / $E_T^{muon} \leq 0.3$) with opposite sign, with a transverse momentum of at least 60 GeV and with $|\eta| \leq 2.5$ and 2 jets with a transverse momentum of at least 25 GeV with $|\eta| \leq 4.5$. S_T is the scalar sum of the transverse energies of the 2 muons and 2 jets. $M(\mu\mu)$ is the invariant mass of the dimuon system. The main backgrounds are $t\bar{t}$ events decaying leptonically and Z/γ^* ($\rightarrow \mu\mu$). The following S_T-, dimuonmass- and the reconstructed Leptoquark mass range-cuts have been optimized for each Leptoquark mass to achieve a 5σ discovery at the lowest luminosity possible. The mass distribution of the reconstructed Leptoquarks for m_{LQ} = 400 GeV (left) and $t\bar{t}$ (right) after the basic cuts can be seen in figure 2; the cuts for m_{LQ} = 400 GeV have been applied to the $t\bar{t}$ sample for this plot. In each event 2 Leptoquarks are reconstructed, so there are 2 possibilities to combine one muon with a jet. The combination which minimizes the difference $\Delta M = |M(\mu_1 j_{1'}) - M(\mu_2 j_{2'})|$ is used and the mean of the two reconstructed Leptoquark masses is taken. The 2 solid black lines indicate the Leptoquark mass range-cut. The reconstructed Leptoquark mass has to be in a range of 150 GeV for m_{LQ} = 400 GeV.

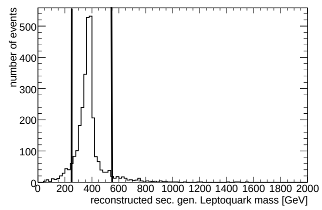

Fig. 2: reconstructed Leptoquark mass, sample m_{LQ} = 400 GeV

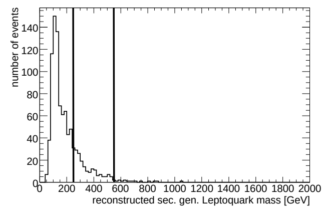

Fig. 2: reconstructed Leptoquark mass, sample $t\bar{t}$

S_T has to be at least 600 GeV for m_{LQ} = 400 GeV. The dimuonmass has to be at least 150 GeV for all Leptoquark masses. S_T plotted against the dimuonmass can be seen in figure 3 for m_{LQ} = 400 GeV (left) and for $t\bar{t}$ (right); the black lines in the figures indicate the S_T and dimuon cut.

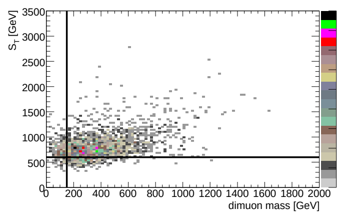

Fig. 3: m_{LQ} = 400 GeV

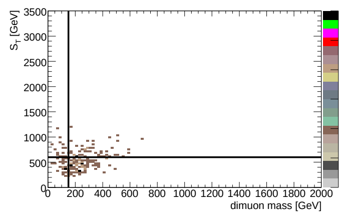

Fig. 3: $t\bar{t}$

The integrated luminosities needed for a 5σ discovery for the different Leptoquark masses after all described cuts can be seen in table 1. The systematic uncertainties which add up to about 30% have been included in this calculation; the main uncertainties are the error on the integrated luminosity, cross-sections, jet energy scale and the statistical uncertainty of the Monte Carlo samples.

Tested Leptoquark mass	Expected luminosity needed for 5σ discovery
300 GeV	1.4 pb^{-1}
400 GeV	6.1 pb^{-1}
600 GeV	71 pb^{-1}
800 GeV	602 pb^{-1}

Table 1: Integrated luminosities needed for 5σ discovery

References

[1] M. Leurer, Phys.Rev. **D49** (1994) 333