Search for Singly Produced Second-Generation Leptoquarks in $p\bar{p}$ Collisions

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Complementary to the search for leptoquark pair production, which is discussed in [1] one can also search for single leptoquarks, produced in association with a lepton. Figure 1 shows the leading-order Feynman diagram for this process in hadron collisions.

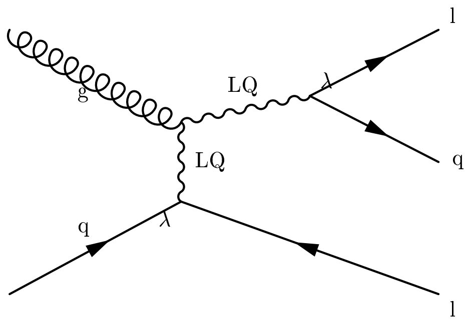

Fig. 1: Production of a single leptoquark in association with a lepton in $p\bar{p}$ collisions

This production process contains a Yukawa like coupling of the leptoquark to a quark and a lepton. The production cross-section is proportional to the square of the unknown coupling constant λ. Limits on the leptoquark mass from the search of single leptoquark production can therefore only be given as a function of λ. Since the final state only contains one leptoquark the production cross-section decreases less steeply with increasing leptoquark mass than the cross-section for leptoquark pair production. Up to now, the production of single second-generation leptoquarks has never been studied.

In the case where the leptoquark decays into a muon and a quark, the signature for single leptoquark production would consist of two high energetic muons and one jet. The event preselection is identical to that for leptoquark pairs described in [1] with the exception that only one jet is required. In order to separate a possible signal from the background, stringent cuts on the kinematic properties of the muons and the jet are required. The main background source are muon pairs from Z^0/γ^* decays which can be produced in association with jets.

Monte Carlo studies show that a significant fraction of the expected background events with reconstructed muon-pair masses ($M_{\mu\mu}^{rec}$) well above the Z^0 resonance are still due to events with a generated muon-pair mass ($M_{\mu\mu}^{gen}$) close to the mass of the Z^0. This is caused by the combination of the large cross-section at the Z^0-resonance and the possibility of mis-measuring the muon momentum which can lead to large reconstructed muon-pair masses ($M_{\mu\mu}^{rec}$). This effect is illustrated in Figure 2 which shows the generated muon pair-mass for events which are reconstructed with masses above 120 GeV (150 GeV). One can clearly see both the contribution from mis-measured Z^0 events and from events with a genuinly large muon-pair mass.

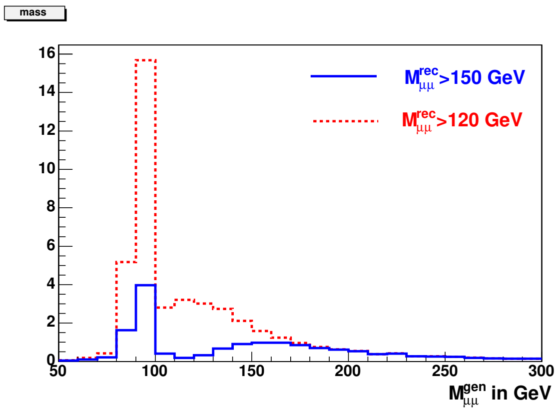

Fig. 2: Generated muon-pair mass for events for which the reconstructed muon-pair mass is above 120 GeV or 150 GeV, respectively

The mis-measured Z^0 events increase the background for an analysis which uses the reconstructed muon pair-mass to separate the signal from the background. For events with a mis-measured muon, the total reconstructed momentum in the plane transverse to the beam does not vanish. This can be exploited in a kinematic fit in which the muon momenta are allowed to be scaled within their uncertainties. Figure 3 shows that the muon-pair mass is moved back to the Z^0 mass for events with small generated muon-pair masses while events with genuine high muon-pair mass are not affected.

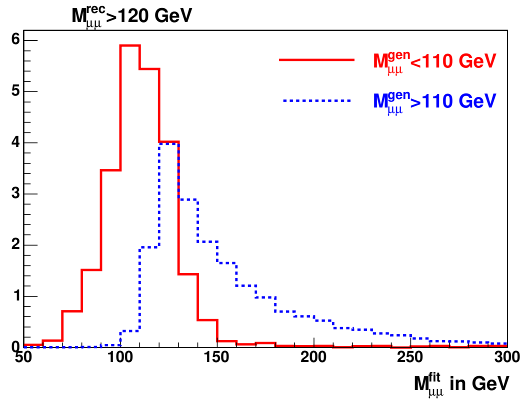

Fig. 3: Fitted muon-pair mass for events for which the reconstructed mass is above 120 GeV and for which the generated mass is above 110 GeV (red) or below 110 GeV (blue)

In an approach based on a neural network, which uses the muon-pair mass, the energy of the jet and the azimuthal angle between the two muons, it is possible to reduce the expected background for 100 pb^{-1} to 1 event while the efficiency for single production of a scalar leptoquark with a mass of 200 GeV remains above 5%.

References

[1] T. Christiansen *et al.*, this annual report, p. 40.