Leptoquarks; Why to upgrade the Forward Tracker.

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Abstract

The kinematics of leptoquark production have been studied. For a leptoquark mass of 200 GeV, $\sim$ 75% of the events have either the lepton or quark jet in the Forward Tracker (FT) (37.5% with the lepton and 37.5% with the quark jet, but never both). The momentum of the lepton and quark jets are always greater than 200 GeV/c. Hence delicate momentum measurement is required to determine the lepton charge in leptoquark decay.

Introduction

To give some feeling of how desirable it is to upgrade the FT, the kinematics of leptoquarks have been studied. The kinematics of the decay of a leptoquark formed from a bound state of a quark of momentum xP, where P is the 4-momentum of the target proton of energy 820 GeV and the incident electron of energy 27.6 GeV, were computed. Fig. 1 shows the results for the laboratory momentum of the decay electron, the lab angle cosine of the decay electron, the lab momentum of the quark and the lab angle cosine of the decay quark all as a function of the CM angle cosine of the decay electron. The decay angular distribution in the CM will be approximately flat in the latter variable.

Discussion of the Results

The FT covers the range of lab angle cosines of .906 to .996. From the second and fourth plots in Fig 1 it can be seen that this covers the range $0.2 > \mathrm{Cos}\theta > 0.95$ of both the electron and quark in the CM frame. Hence for an istropic distribution in this variable 37.5% of the electrons will be detectable in the FT and 37.5% of the quarks but never both together. From the first and third plots in Fig 1 it can be seen that the momenta of the electron and quark jets when detected in the FT will each be greater than 200 GeV/c. Figs 2 and 3 show the same plots for comparison for leptoquark masses of 150 GeV/c^2 and 250 GeV/c^2, respectively.

The design objective of the FT was for $\sigma(p)/p^2 \sim 0.003(GeV/c)^{-1}$. Hence in principle it should be possible to determine the sign of the lepton momentum at one standard deviation for momenta up to $\sim$ 300 GeV/c ie in most cases where the decay electron is detected without showering. The achieved momentum resolution for tracks of momenta more than 3 GeV/c from reconstructed vertices was 0.027. However, this resolution is dominated by multiple scattering. To achieve the design resolution the material which showers and multiply scatters should be reduced or removed. For example, in the high Q^2 and high y events which were published recently 3 events had the lepton in the FT. Of these 2 produced an electromagnetic shower rendering determination of their charge signs impossible.

In conclusion, a study of the kinemtics of leptoquark decay shows that a large fraction of such decays will be detectable in the FT. Hence an improvement in efficiency is highly desirable. The achievement of sufficient momentum resolution to determine the sign of the decay electron will require a reduction in the material budget in the forward region to reduce electron showering and multiple scattering.

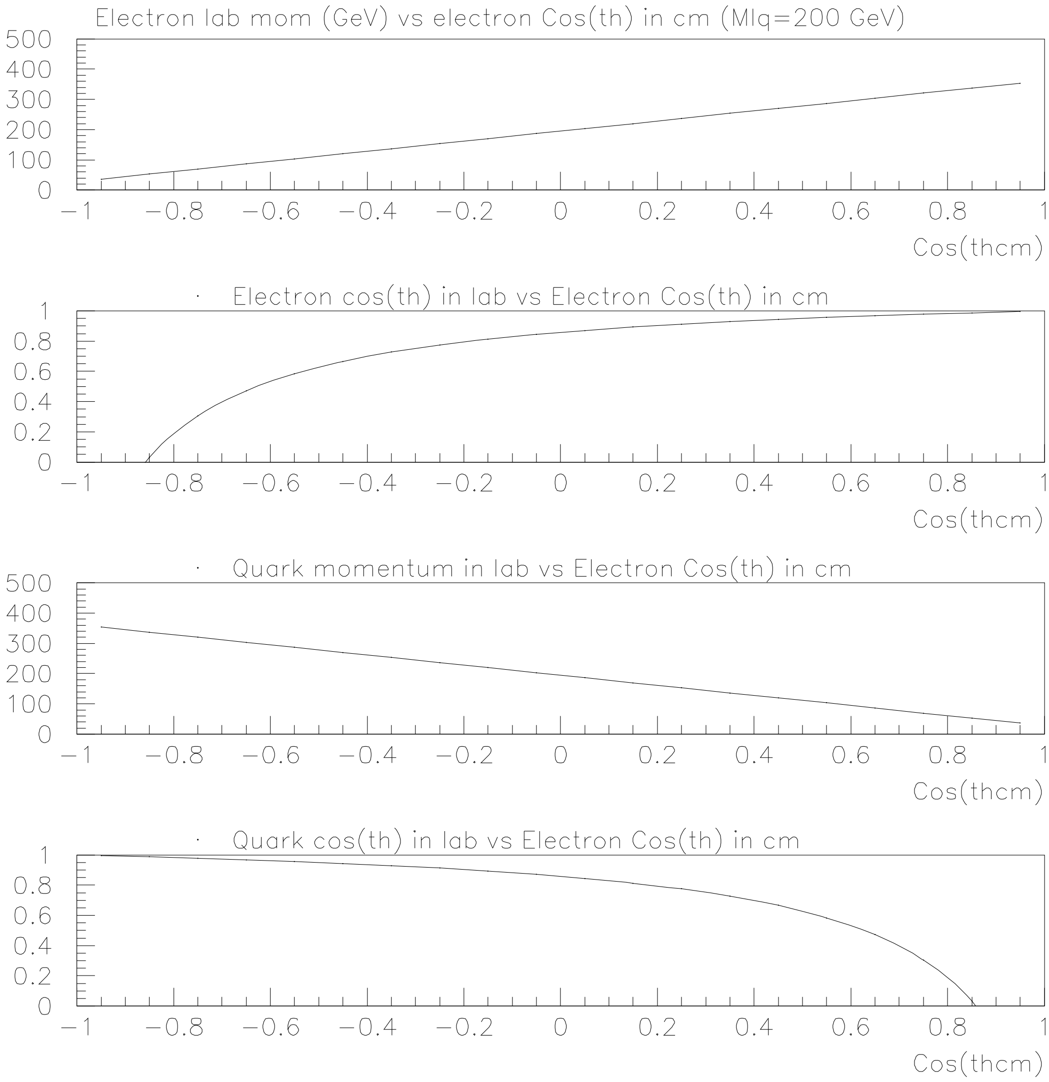

Fig 1. Distributions of the lab variables as a function of cosine of the electron angle in the centre of mass for production of a leptoquark of mass 200 GeV/c^2 by 27.6 GeV electrons on 820 GeV protons.

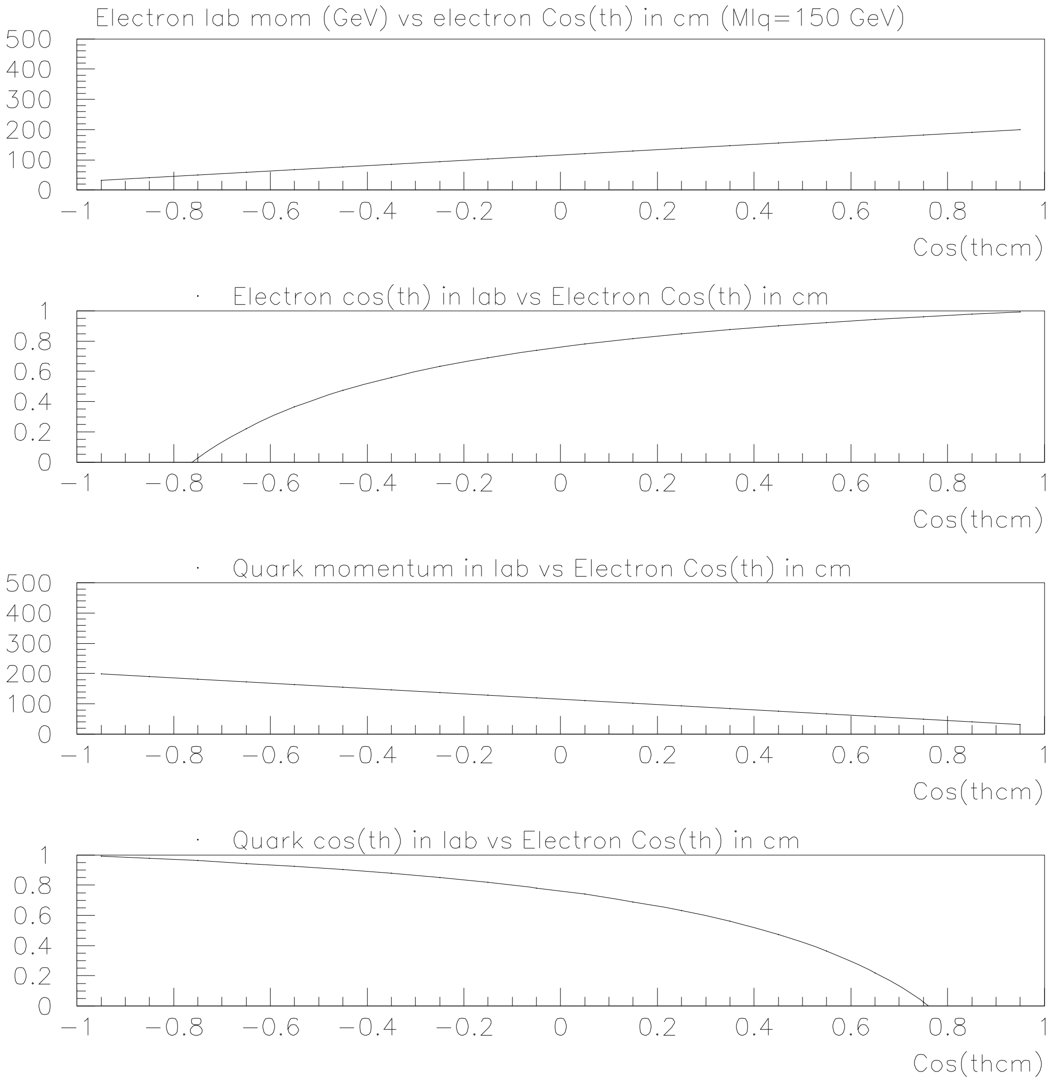

Fig 2. Distributions of the lab variables as a function of cosine of the electron angle in the centre of mass for production of a leptoquark of mass 150 GeV/c^2 by 27.6 GeV electrons on 820 GeV protons.

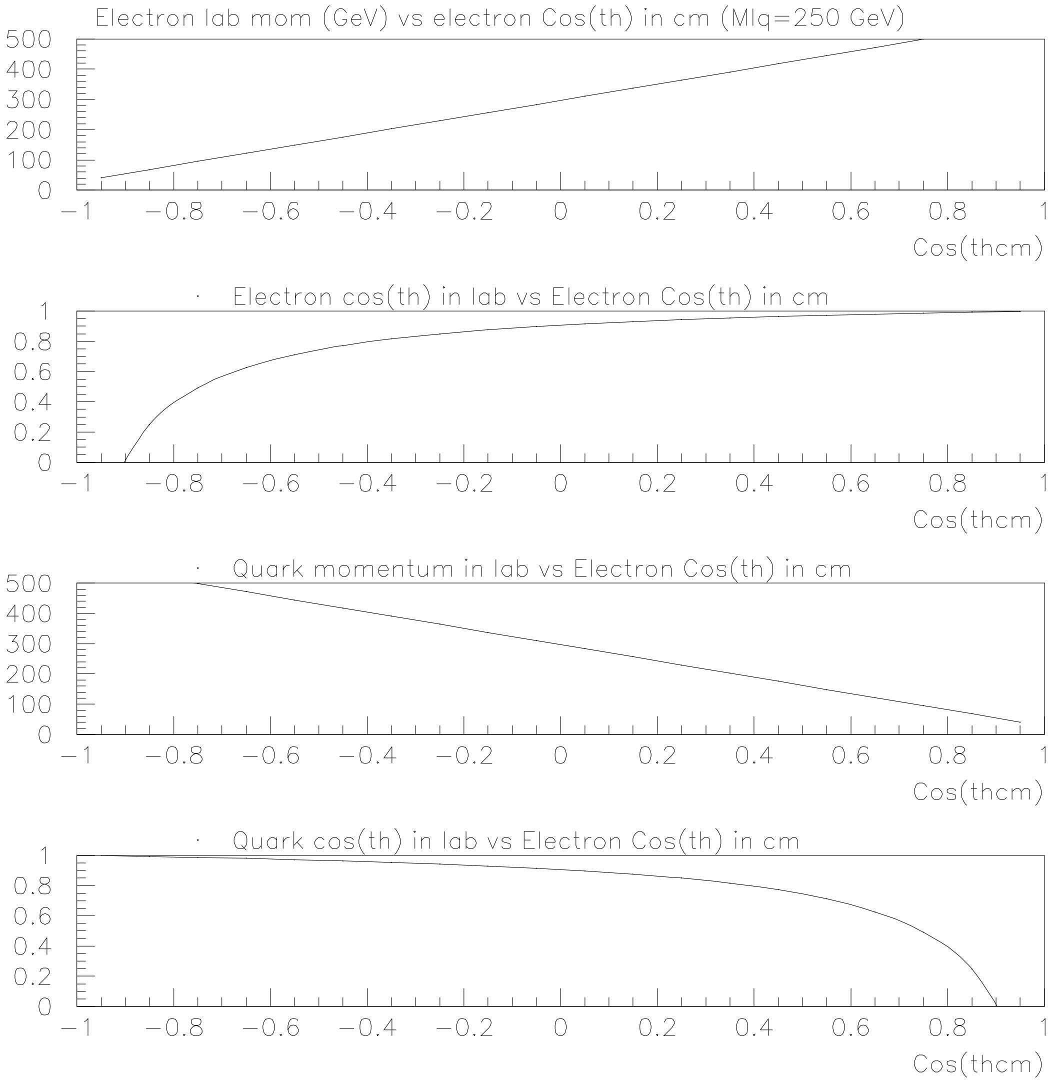

Fig 3. Distributions of the lab variables as a function of cosine of the electron angle in the centre of mass for production of a leptoquark of mass 250 GeV/c^2 by 27.6 GeV electrons on 820 GeV protons.