HERA - LHC Workshop Proceedings

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Abstract
Here should be a short summary of your brilliant ideas which you will explain in more detail on the following pages

1 Working group summary

An understanding of the underlying event is an interesting physics topic in its own right but is also crucial in developing robust analyses for LHC physics.The underlying event can enhance central jet production reducing the effectiveness of the central jet veto in analyses such as the vector boson fusion Higgs channel or can reduce the isolation of leptons resulting in reduced efficiency for identifying isolated leptons.

The CDF collaboration has carried out studies of the underlying event in jet processes [1] and this was used to provide a tuning for PYTHIA. A new analysis [2] has extended these studies by extending the energy range of the leading jet from around 50GeV to 450GeV using Et from the calorimeter as well as particle pt measured in the tracker, and defining two-jet topologies as a subset of the leading jet to investigate the beam-beam and radiation components of the underlying event. Both PYTHIA tune-A and HERWIG+JIMMY were found to be in good agreement with the data, although both underestimate the transverse energy. The extension to higher energy scales shows that the underlying event activity increases with leading jet pt ie the hardness of the primary scatter, but by studying the maximum and minimum activity it is seen that this rise is largely due to radiation rather than beam-beam remnants.

However,the CDF analysis has been carried out primarily at 1.8TeV and some of the early 546GeV data has been analysed. This has meant that there is only limited information on the energy dependence of the underyling event. To cover a wider range of energy ATLAS [3] have used minimum bias data from the SppS and Tevatron covering 200 GeV to 1.8 TeV in addition to the CDF underlying event data to tune PYTHIA and HERWIG+JIMMY.Comparing the predictions of minimum bias and underlying event distributions at the LHC using the tuned PYTHIA,tuned HERWIG+JIMMY and PHOJET shows large variations, emphasising the need to understand the energy dependence of these processes better. The energy dependence has been investigated further by LHCb [4], again using minimum bias data to fit the parameters required for the model of energy dependence in PYTHIA.

Both the ATLAS and LHCb analyses have the implicit assumption that minimum bias and the underlying event have the same physics origin. While CDF data supports this, it would be helpful to probe the underlying event directly over a larger range of energy scales. HERA is in a prime position to make such a contribution by studying jets from photoproduction in an energy range corresponding to centre-of-mass energies in the region of 200GeV, fitting well with the low energy minimum bias data. In photoproduction, resolved photons behave like hadrons so that HERA is effectively a hadron-hadron collider [5]. Photoproduction data shows that particle flow and multi-jet measurements require models with multiple interactions to best describe the data but detailed studies of multiple interactions have not been made [6]. However, studies of particle and energy flow in the transverse region similar to that carried out by CDF could be made at HERA [6].

The problem of the pt-cutoff in the extrapolating the UE to LHC energies can be avoided by using the k factorization scheme as implemented in the LDC model [7] where soft emissions do not contribute to the total cross-section or pdfs, but do contribute to the properties of the event. The cross-section for a chain can be extracted from HERA data [**?**] and can be used to predict the minijet rate or multiple interaction rate in pp or ppbar collisions. The runnning of α_s introduces a cut-off scale between soft

and hard chains, however it has been shown that the total cross-section is insensitive to this cut-off and predictions for the mini-jet rate at the LHC are stable.

There are four simulation programmes that have been studied: PYTHIA [**?**], HERWIG+JIMMY [8], SHERPA [9] and PHOJET [**?**].

PYTHIA has a well developed model of minimum bias and the underlying event [?] [10]. It describes pp and ppbar but currently does not have a model for $\gamma^* p$ events at HERA. This is being developed as part of the workshop [**?**] so that underlying event data can be studies over a larger range of centre of mass energies [6].

HERWIG can be used to describe the describe the hard jets and has a model for soft underlying event based on the UA5 minimum bias model [**?**].

1.1 Your contribution

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References

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