DØ Note # 2240
AZPH-EXP/94-01

Probing Color Coherency Using High pT W Events at the TEVATRON

G.E. Forden*
Department of Physics, University Arizona,
Tucson AZ

ABSTRACT

DØ has used $W \rightarrow e\nu$ events associated with a high pT jet to probe for the effects of extended source color dipole radiation in W-jet rapidity correlations. We have also studied the low energy flow in these events and shown an enhancement between the jet and the beam directions, indicating the effects of color coherency.

Charged W bosons are produced in $p\bar{p}$ events predominantly by two processes, the annihilation process and a diagram similar to Compton scattering. In both processes a color charge is removed from each incident hadron leaving an extended colored object, the proton remnants. This situation, far from being too "dirty" to provide useful information, is in fact a brilliant place to study radiative corrections. DØ has used events where a W, observed in the $e\nu$ channel, is produced in conjunction with a jet to study both the low energy flow referred[1] to as the "string drag effect" and a new measurement designed to probe the possibility that the primary jet is radiated by a spatially extended colored object. This later effect is expected to manifest itself as a reduction of the phase space available to the jet in the large pseudo-rapidity (η) regions for forward W's. We searched for this effect by studying the W-jet rapidity correlations.

Both analyses use similar W candidate selection criteria which are essentially those out lined in Reference 2. In addition both studies require the presence of a good,[3] primary jet with some minimum pT. It is necessary to reconstruct the W's rapidity for both these studies. This is done by constraining the W candidate to have the world average mass, 80.22 GeV. This results, in general, in two possible solutions for the W's longitudinal momentum. We can not use the electron charge to help resolve this ambiguity since DØ does not have a central magnetic field. Instead, we always choose the solution with the lower $|P_z(W)|$. Monte Carlo studies have indicated that this gives the correct solution the most often, given our knowledge of the event. It should be pointed out that W's reconstructed with large rapidities by this method have a large ($> 80\%$) chance of being correctly reconstructed. This algorithm systematically moves W's which were produced with large rapidities (but with a correspondingly smaller cross section) to the central region, which minimizes the effect of this systematic shift. This same algorithm is also used on Monte Carlo events in any comparisons performed.

The lowest order diagrams for the production of a high pT W all have an internal quark line whose virtuality is directly related to the W-Jet system invariant mass.

*Representing the DØ Collaboration

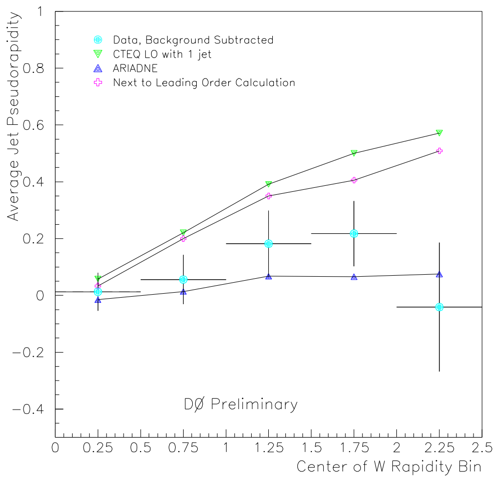

Fig. 1. The average jet rapidity of the primary jet as a function of reconstructed W rapidity. The LO, NLO and ARIADNE Monte Carlo predictions are also shown.

This mass tends to be minimized by the internal quark propagator. This can be accomplished when the W and jet have the same rapidity, but of course are opposite in ϕ. This behavior can be modified by various processes. The parton density functions might systematically inhibit various kinematicly allowed topologies. Color coherence effects producing radiated gluons preferentially between the primary jet and the beam remnants could systematically recoil the primary jet towards lower rapidities. Another possibility, as mentioned above, is that interference effects involving all the incident hadrons[4] constituents could restrict the primary jet to central rapidities.

We have studied the W-jet rapidity correlation for events where there is a jet produced with $pT > 16GeV$ and compared it to various Monte Carlos reflecting lowest order,[5] next to leading order[6] and extended color dipole[7] predictions. The average jet rapidity as a function of the W rapidity is shown in Figure 1 together with the predictions for the various Monte Carlos. It is clear that none of the Monte Carlos do a particularly good job of describing the data. However, by performing a χ^2 analysis on the actual jet rapidity distributions for those events with W rapidities greater than 1.0 we can exclude the leading order and the next to leading order at the 95% confidence level while there is an 18% chance that the discrepancies between ARIADNE, the color dipole model, and the data are due to statistical fluctuations alone.

We select those $W \rightarrow e\nu$ events which have a central jet with pT > 10 GeV and a reconstructed central W to compare the energy flow in an annulus around the jet and the corresponding annulus around the W. Both production mechanisms, the annihilation and the Compton scattering, produce at least one color string between the jet and a beam remnant (the annihilation process produces two, one to each remnant) and none to the color neutral W. The string drag effect should produce an increased energy flow on the line between the jet and either beam while this increase should not be present on the W side of the event. The inner radius of each annulus is $\Delta R = 0.7$ which corresponds to the standard DØ jet cone while the outer radius is $\Delta R = 1.5$.

Fig. 2. The energy flow around the jet, $dE/d\beta$, as a function of the angle β which is zero in the direction of the beam.

Polar coordinates centered on these cones are used to determine the energy flow with respect to the closest beam direction. We define a polar angle β which is zero in the direction of the beam. The energy flow $dE/d\beta$ is then the radial integral of this energy as a function of β. The resulting measurement of the energy around the jet is shown in Figure 2. The corresponding energy around the W does not show this enhancement at $\beta = 0$, the direction toward the beam. This is in qualitative agreement with analytic calculations by Dokshitzer et al.[8]

DØ has measured the rapidity correlation between high pT W's and the primary jets. We find that the jet stays central almost independent of the W's rapidity. This is in conflict with the leading order (LO) and next to leading order (NLO) QCD expectations which predict that the jet should follow the W's rapidity. The Monte Carlo ARIADNE, which is based on radiation patterns being determined by extended color dipoles, qualitatively predicts this and can not be ruled out. We have also shown that the low energy flow in high pT W events is in qualitative agreement with coherent radiation pattern predictions.

References

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