Boson + Jet Event Structure at D0

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Photon + Jet Rapidity Correlations:

Since the dominant direct photon production process at the Tevatron is that of $q+g \rightarrow q+\gamma$ (QCD Compton Scattering), study of direct photon event structure can provide information about gluon distributions. Specifically, when one fixes the angle of the photon, one can probe a range of parton momentum fractions by looking at the angular distribution of the leading jet. This distribution may also be affected by color-coherent emissions and other higher order effects. The following are preliminary results of a study in which the leading jet η distributions are examined for several ranges of photon η.

A Run 1B sample of photon candidates was selected using the EM1_GIS_HIGH trigger (L1[1,12], L2[1,40,gis]), corresponding to approximately $35pb^{-1}$. Standard photon cuts were applied:

- EM Fraction $\geq$ 96%
- (E_T in Isolation Cone - E_T in Core Cone) $\leq$ 2GeV
- H-matrix $\chi^2 \leq 100$
- No track in road
- Noise cuts
- Missing $E_T \leq E_t^{\gamma}/2$
- $z_{vertex} \leq 50$cm

as well as a cut to remove candidates with (integer) detector eta between 10 and 15 (-10 and -15). The photons were required to have P_T above 45 GeV in order to select a region where the photon purity is expected to be enhanced. For the central region ($-0.9 \leq \eta \leq 0.9$), where the photon purity has been determined, the photon purity at 60 GeV (the mean P_T of the sample used here) is approximately 60%. The sample was further subjected to the "golden" photon cut, which requires less than 1% of energy to be deposited in the EM1 layer, and which increases the purity of the photon sample since the main source of background, jets which fluctuate to an isolated π^o, shower (on average) earlier than direct photons. For the central region, at 60 GeV, this cut is estimated to increase the purity from 60% to 75%. As the photon purity has not yet been established in the forward region, the level of signal there is not well known; however, the use of the standard photon cuts, along with the golden cut and high P_T threshold, should provide a reasonable starting point in looking for a signal. In addition to the above cuts on the photon, standard jet quality cuts were applied to the leading jet.

To verify the quality of the Run 1B data sample, the photon candidate sample (with and without the golden photon cut) was compared to the Run 1A data sample in both the central and forward calorimeters. The distributions of fractional energy deposited in EM1 and of energy in the annulus between the isolation and core cones were compared and appear consistent. The photon purity for the Run 1B sample was estimated using the EM1 fraction method, and the resulting purity agrees well with the Run 1A photon purity, especially at the higher P_T region of this analysis.

This sample (without background subtraction) was binned in 5 regions of $|\eta^{\gamma}|$ (0.0-0.3, 0.3-0.6, 0.6-0.9, 1.5-2.0, 2.0-2.5)and the "signed η" ($\mathrm{Sign}(\eta^{\gamma}) \times \eta^{j}$) of the leading jet was plotted (Figure 1). The data show a tendency for the leading jet to follow the photon candidate forward, though not fully. As an estimate of the behavior of the background, candidates in the photon sample were anti-selected - selected especially to fail the photon cuts. This should preferentially select highly electromagnetic jets. The criteria used were:

- Isolation $E_T \geq$ 2GeV
- $\frac{EM1}{E_{tot}} \geq 1\%$ ('anti-golden")
- One or more of
    1. 2 or more tracks
    2. EM fraction $\leq .96$
    3. Hmatrix $\chi^2 \geq 150$

with the Missing E_T, acceptance, and noise cuts retained as in the golden photon case. The leading jet signed η distributions for this sample are shown in Figure 2, and indicate a much smaller tendency for the leading (non-photon candidate) jet to follow the electromagnetic jet forward. To cross-check the behavior of this background sample, events in the sample with $45\mathrm{GeV} \leq P_T \leq 55\mathrm{GeV}$ were compared against a sample in the same range measured as part of the inclusive dijet triple differential cross section. The two samples give consistent results, which indicates that the electromagnetic jet event sample behaves similarly to that of normal jets. A NLL QCD prediction, using a J. Owens, et. al. Monte Carlo generation program (with energy resolution smearing and a photon isolation cut matching that used on the data), was also generated and the resulting distribution is shown in Figure 3. The mean of the leading jet signed η distributions for each case are plotted as a function of $|\eta^{\gamma}|$ in Figure 4; errors are statistical only, calculated as the R.M.S. of the distribution divided by $\sqrt{N}$. While this analysis is not sufficiently mature to make any quantitative statements about comparison with theory, the golden photon candidate sample does appear to push further out in signed η_j than the background sample, a trend in qualitative agreement with the QCD prediction.

This analysis is essentially an uncorrected triple differential photon cross-section, $dN/dP_T^{\gamma}d\eta_{\gamma}d\eta_j$, integrated over the P_T^{γ} region above 45GeV. The full cross section, $d\sigma/dP_T^{\gamma}d\eta_{\gamma}d\eta_j$, will require a more thorough knowledge of the photon purity, and will likely be restricted to the central region until the forward region purity is determined. Also, it will be informative to form the cross section in bins of P_T, especially at lower P_T where smaller parton momentum fractions are accessible. However, decreasing purity at lower P_T will require an accurate knowledge of the photon fraction as part of a careful subtraction of the jet background distribution.