RAPIDITY GAPS BETWEEN JETS AT DØ

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ABSTRACT

Results are presented from a search for events with a rapidity gap between high transverse momentum jets produced in the Fermilab Tevatron $p\bar{p}$ collider at $\sqrt{s} = 1.8\,\mathrm{TeV}$. The DØ detector is used to tag particles between the two highest transverse energy jets with $E_T > 30\,\mathrm{GeV}$. A significant excess of events is observed at low tagged particle multiplicity which is qualitatively consistent with a color-singlet exchange process.

Rapidity gaps, namely regions of rapidity containing no final-state particles, are expected to occur between jets when a color-singlet is exchanged between the interacting hard partons.[1] The exchange of a photon,[2] $W^{\pm}$, Z^0 or hard QCD Pomeron[3,4] is expected to give such an event topology. Although the cross section for electroweak gauge boson exchange is small, the cross section for two-gluon Pomeron exchange is believed to be significant,[3,5] and roughly 10% of jet events may be due to Pomeron exchange.[3] Typical color-octet jet events (single gluon or quark exchange) have particles between jets, but rapidity gaps can arise from fluctuations in the particle multiplicity, which is expected to have a negative binomial or similar distribution.[6]

Rapidity gaps will not be observed in the final state, however, if spectator interactions produce particles between the jets. Approximately 10-30% of rapidity gap events are expected to survive spectator interactions.[3,7] Thus roughly 1-3% of jet events are expected to have an observable rapidity gap between the jets from Pomeron exchange.

Although it is not possible to distinguish color-singlet rapidity gaps from those that occur in color-octet exchange on an event-by-event basis, differences in the expected particle multiplicity distributions can be used to search for a color-singlet signal. This signal is expected to appear as an excess of events at low particle multiplicity compared to a negative binomial-like distribution.

The data sample used in this analysis is derived from a special high-$\Delta\eta_c$ trigger[8] implemented to obtain events with large pseudorapidity separation ($\Delta\eta_c = |\eta_1 - \eta_2| - 2R$) between the cone edges ($R = \sqrt{\Delta\eta^2 + \Delta\phi^2} = 0.7$) of the two highest E_T jets. In the offline analysis, events are required to have at least two jets, each with $E_T > 30\,\mathrm{GeV}$ and $|\eta| > 2$. Events with more than one interaction in a proton-antiproton crossing are removed since they include a source of particles not associated with the triggering interaction. The calorimeter[9] is used to measure the multiplicity distribution of tagged particles between the two highest E_T jets. Particles are tagged in the electromagnetic section of the calorimeter by requiring $E_T > 200\,\mathrm{MeV}$ in a calorimeter tower.[8]

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*Representing the DØ Collaboration

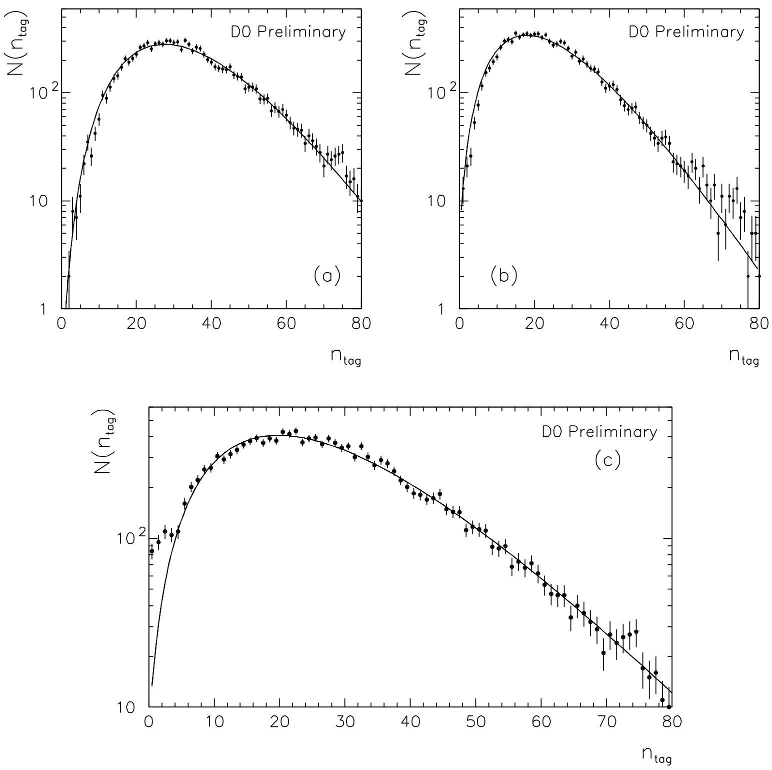

Fig. 1. The tagged particle multiplicity distributions obtained from color-octet events (a,b) and the inclusive event sample (c) for $\Delta\eta_c > 3$. Negative binomial fits to the data (solid lines) are also shown.

Although the color-octet particle multiplicity between jets is expected to have a negative binomial-like distribution, it is important to show that detector effects do not cause a significant deviation from the expected distribution, especially at low multiplicity. The Monte Carlo PYTHIA has been shown to be consistent with negative binomial particle multiplicity distribution between jets for events generated with conditions similar to the high-$\Delta\eta_c$ trigger.[10] Simulation of the DØ geometric acceptance and particle tagging efficiency gives a multiplicity distribution which is also consistent with a negative binomial distribution. No deviation is observed at low multiplicity, indicating that detector effects do not generate an artificial excess.

An enriched color-octet subsample of the data was also studied. This sample was obtained by requiring a jet ($E_T > 8\,\mathrm{GeV}$) to be in the $\Delta\eta_c$ region between the two leading jets. Figure 1(a) shows the tagged particle multiplicity distribution between the two highest E_T jets for $\Delta\eta_c > 3$. Figure 1(b) shows the multiplicity distribution between the jets after excluding the multiplicity of tagged particles within a cone of $R = 0.7$ of the jet in the $\Delta\eta_c$ region. Both distributions are consistent with a negative binomial distribution.

The inclusive tagged particle multiplicity distribution for events with $\Delta\eta_c > 3$ is shown in Fig. 1(c). A very significant (41σ) excess is observed at small particle multiplicity compared to a negative binomial fit. The starting bin of the fit has been

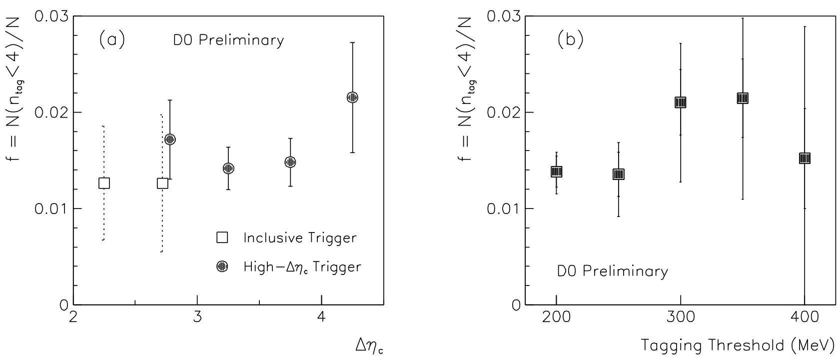

Fig. 2. The fractional excess $f = N(n_{tag} < 4)/N$ above a negative binomial fit to the tagged particle multiplicity distribution as a function of $\Delta\eta_c$ (a) and tagging threshold (b).

chosen to minimize the resulting χ^2. Fitting the entire distribution gives a χ^2/df of 2.1 while starting the fit at $n_{tag} = 4$ gives a much improved χ^2/df of 0.9. Fitting at higher n_{tag} does not improve the quality of the fit.

The excess above the fit has been determined by subtracting the negative binomial fit from the data for $n_{tag} < 4$. A preliminary fractional excess of $f = N(n_{tag} < 4)/N = (1.4 \pm 0.2^{(stat)} \pm 0.2^{(fit)}) \times 10^{-2}$ is obtained, where the systematic error has been obtained by varying the starting point of the fit in the range $0 \leq n_{tag} \leq 10$. The observed excess is relatively constant with $\Delta\eta_c$ as shown in Fig. 2(a) and not strongly dependent on the calorimeter tagging threshold (Fig. 2(b)) although the systematic error of fitting becomes larger with higher thresholds.

DØ has measured the tagged particle multiplicity distribution between jets. A significant excess of events is observed at low tagged particle multiplicity compared to a negative binomial distribution. This excess is consistent with expectations for a color-singlet exchange process, possibly indicating observation of a strongly interacting color-singlet.

References

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