FIRST OBSERVATION OF CORRELATIONS BETWEEN HIGH TRANSVERSE MOMENTUM
CHARGED PARTICLES IN EVENTS FROM THE CERN PROTON ANTIPROTON COLLIDERUA1 Collaboration, CERN, Geneva, Switzerland

G. Arnison¹⁰, A. Astbury¹⁰, B. Aubert², C. Bacci⁹, R. Bernabei⁹, A. Bézaguet⁴,
 R. Böck⁴, T.J.V. Bowcock⁶, M. Calvetti⁴, T. Carroll⁴, P. Catz², S. Centro⁴,
 F. Ceradini⁹, S. Cittolin⁴, A.M. Cnops⁴, C. Cochet¹¹, J. Colas²,
 M. Corden³, D. Dallman¹², S. D'Angelo⁹, M. DeBeer¹¹, M. Della Negra², M. Demoulin⁴,
 D. Denegri¹¹, D. DiBitonto⁴, L. Dobrzynski⁷, J.D. Dowell³, M. Edwards³, K. Eggert¹,
 E. Eisenhandler⁶, N. Ellis³, P. Erhard¹, H. Faissner¹, G. Fontaine⁷,
 J.P. Fournier¹¹, R. Frey⁸, R. Frühwirth¹², J. Garvey³, S. Geer⁷, C. Chesquière⁷,
 P. Ghez⁴, K.L. Giboni¹, W.R. Gibson⁶, Y. Giraud-Heraud⁷, A. Givernaud¹¹,
 A. Gonidec², G. Grayer¹⁰, P. Gutierrez⁸, R. Haidan⁴, T. Hansl-Kozanecka¹,
 W.J. Haynes¹⁰, L.O. Hertzberger⁸, C. Hodges⁸, D. Hoffmann¹, H. Hoffmann⁴,
 D.J. Holthuizen⁸, R.J. Homer³, A. Honma⁶, W. Jank⁴, P.I.P. Kalmus⁶, V. Karimäki⁵,
 R. Keeler⁶, I. Kenyon³, A. Kernan⁸, R. Kinnunen⁵, H. Kowalski⁴, W. Kozanecki⁸,
 D. Kryn⁷, F. Lacava⁴, J.P. Laugier¹¹, J.P. Lees², H. Lehmann¹, R. Leuchs¹,
 A. Leveque¹¹, D. Linglin², E. Locci¹¹, T. Markiewicz⁴, G. Maurin⁴,
 T. McMahon³, J.P. Mendiburu⁷, M.N. Minard², M. Moricca⁹,
 F. Muller⁴, A.K. Nandi¹⁰, L. Naumann⁴, A. Norton⁴, A. Orkin-Lecourtois⁷,
 L. Paoluzi⁹, G. Piano Mortari⁴, M. Pimiä⁵, A. Placci⁴, E. Radermacher¹,
 J. Ransdell⁸, H. Reithler¹, J.P. Revol⁴, J. Rich¹¹, M. Rijssenbeek⁴, C. Roberts¹⁰,
 C. Rubbia⁴, B. Sadoulet⁴, G. Sajot⁷, G. Salvi⁶, G. Salvini⁹, J. Sass¹¹,
 J. Saudraix¹¹, A. Savoy-Navarro¹¹, D. Schinzel⁴, W. Scott¹⁰, T.P. Shah¹⁰,
 M. Spiro¹¹, J. Strauss¹², K. Sumorok³, F. Szoncso¹², C. Tao⁴, G. Thompson⁶,
 J. Timmer⁴, E. Tscheslog¹, J. Tuominiemi⁵, J.P. Vialle⁴, J. Vrana⁷,
 V. Vuillemin⁴, H. Wahl¹², P. Watkins³, J. Wilson³, M. Yvert², E. Zurfluh⁴

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Aachen¹-Annecy (LAPP)²-Birmingham³-CERN⁴-Helsinki⁵-Queen Mary College, London⁶-Paris
 (Coll. de France)⁷-Riverside⁸-Roma⁹-Rutherford Appleton Lab.¹⁰-Saclay (CEN)¹¹
 Vienna¹² Collaboration

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Abstract

In events at centre of mass energy 540 GeV from the CERN $\bar{p}p$ collider, we have found clear evidence for correlations in rapidity and azimuthal angle between high transverse momentum charged particles. These correlations increase with transverse momentum and are much stronger than the general two-particle correlations in minimum bias events. By analogy to ISR results, a qualitative interpretation in terms of hard scattering and fragmentation of partons is discussed.

I. Introduction

High transverse momentum phenomena in pp collisions have been extensively studied at the CERN ISR¹⁾. In particular correlations in the presence of a high transverse momentum particle exhibit features which are consistent with the widely adapted framework of parton scattering and subsequent fragmentation of the partons into hadrons²⁾. We report here evidence for similar strong correlations among high p_t particles in $\bar{p}p$ collisions at the CERN SPS collider at a centre of mass energy of 540 GeV.

II. Data Taking and Event Selection

The present results are based on the reconstruction of charged tracks in the UA1 central detector. The basic configuration and the analysis procedures and performance are discussed in a previous paper³⁾ on the subject of inclusive charged p_t spectra. Two data samples, each taken with a magnetic field of 0.56 Tesla, have been combined to provide sufficient statistics for a first look at high p_t correlations. The first sample was also used for the inclusive spectra and consists of about 48000 events recorded with a low bias trigger. The second sample of about 39000 events was obtained with an additional trigger requirement of at least 30 GeV transverse energy deposit in the central electromagnetic and hadronic calorimeters which fully cover the rapidity region $|y| < 3.0$.

The rapidity and azimuthal correlations have been studied in selected events where the transverse momentum of the highest p_t particle in the rapidity interval $|y| < 2.5$ (software "trigger" particle) exceeds 4 GeV/c. The total number of events which satisfy this criterion is 1074, consisting of 251 (0.5%) from the low bias data and 823 (2.1%) from the high E_t data. The four times larger yield from the high E_t sample is roughly consistent with the increased average track multiplicity (factor ~ 2) plus the flatter p_t spectrum at higher multiplicity³⁾ (factor ~ 2.5). In addition about 85% of the low bias events selected by the software trigger satisfy the high E_t trigger requirement ($E_t > 30$ GeV). This suggests that the high E_t data is a relatively unbiased sample for the present study.

III. Rapidity and Azimuthal Correlations

Figure 1 shows the distributions of rapidity and azimuth for all other particles in each event ("secondaries") plotted relative to the trigger particle. The rapidity distributions are given separately for the azimuthal hemispheres "towards" (centred on) and "away" (opposite to) the trigger.

For towards secondaries a clear correlation is seen in both rapidity and azimuth, increasing strongly with secondary p_t . The two dimensional plots of figure 2 illustrate that high p_t secondaries tend to cluster around the trigger in both rapidity and azimuth. Additional evidence is given in figure 3 where the p_t distribution for towards secondaries which are close to the trigger ($\Delta y = \pm 1/2$, $\Delta \phi = \pm 30^\circ$) is compared to the inclusive minimum bias p_t spectrum.

For away secondaries, the relative rapidity distribution remains broad for all cuts on secondary p_t . However an azimuthal correlation emerges around 180° with respect to the trigger as the secondary p_t increases. This indicates that high p_t away secondaries are preferentially coplanar with the trigger and the incoming beams. In addition, a narrow rapidity correlation is seen locally if the rapidity of other away secondaries is plotted relative to the highest p_t particle (if > 1 GeV/c) in the away hemisphere. Figure 4 shows that this correlation again increases with secondary p_t .

The narrowness of the observed correlations, especially in rapidity, and the fact that they increase strongly with p_t , makes it unlikely that they are due to acceptance irregularities of the only partially equipped central detector. As a further check, however, figure 5 shows the rapidity and azimuthal density of all secondary particles with respect to a randomly chosen trigger particle in unselected low bias events. There is little evidence for any azimuthal correlation and only a weak structure in rapidity, independent of secondary p_t and suggestive of general short-range correlations as measured at the ISR⁴⁾.

IV. Possible Interpretation

The above results can be qualitatively understood in the framework of parton scattering and fragmentation of the partons into hadrons. The particle with

the highest transverse momentum defines reasonably well the direction of the scattered parton, since it takes a large fraction of the parton momentum due to the steep fall of the inclusive p_t -spectrum. In those cases where additional high p_t particles exist on the towards side they tend to cluster around the trigger particle because of their limited transverse momentum with respect to the parton axis in the fragmentation process (Figs.1-3).

On the away side the direction of the scattered parton is unknown. This is the reason why the high p_t particles are smeared over a wide range in rapidity. Once the parton direction on the away side is defined by a high p_t particle, the away secondaries show a similar correlation with respect to this particle as towards particles with respect to the trigger. Whereas the narrow correlations in rapidity between two high p_t particles on the same side could also be explained by the decay of low mass resonances, the strong coplanarity of two high p_t particles in opposite hemispheres favours the picture of two scattered partons.

V. Conclusions

Strong correlations have been observed in both rapidity and azimuthal angle between high p_t particles, in particular suggesting coplanar production of two clusters in opposite azimuthal hemispheres. As at the ISR, hard scattering and fragmentation of partons offers a possible interpretation. Further analysis will continue on the internal properties of the clusters, especially when larger data samples become available in the near future.

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Figure Captions

- Fig. 1a) Rapidity difference between secondaries in the towards hemisphere and the trigger particle of $p_t > 4$ GeV/c ;
- b) Azimuthal angle difference between all secondaries and the trigger particle of $p_t > 4$ GeV/c ;
- c) Rapidity difference between secondaries in the away hemisphere and the trigger particle of $p_t > 4$ GeV/c ;
- d)-f) As for a)-c) but with p_t of secondary > 1 GeV/c ;
- g)-i) As for a)-c) but with p_t of secondary > 2 GeV/c.

- Fig. 2 Correlation between rapidity difference and azimuthal angle difference of secondaries with respect to the trigger particle of $p_t > 4$ GeV/c ;
- a) for all secondaries ;
- b) for secondaries with $p_t > 1$ GeV/c ;
- c) for secondaries with $p_t > 2$ GeV/c.

- Fig. 3 p_t spectrum of towards secondaries within $\Delta y = \pm 0.5$ and $\Delta \phi = \pm 30^\circ$ of the trigger particle in rapidity and azimuthal angle, compared to the minimum bias inclusive p_t spectrum.

- Fig. 4 Rapidity difference between the highest p_t particle in the away hemisphere and other secondaries in the away hemisphere ;
- a) for all such secondaries ;
- b) for secondaries with $p_t > 0.8$ GeV/c ;
- c) for secondaries with $p_t > 1.5$ GeV/c.

- Fig. 5a) Rapidity difference between secondaries in the towards hemisphere and a randomly chosen trigger particle ;
- b) Azimuthal angle difference between all secondaries and a randomly chosen trigger particle ;
- c) Rapidity difference between secondaries in the away hemisphere and a randomly chosen trigger particle ;
- d)-f) As for a)-c) but with p_t of secondary > 1 GeV/c ;
- g)-i) As for a)-c) but with p_t of secondary > 2 GeV/c.

Figure 1

Figure 2

Fig. 3

Figure 4

Figure 5