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LOW P_T BIAS INTRODUCED BY A LARGE ACCEPTANCE CALORIMETER TRIGGER

by

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ABSTRACT

It is argued that the large acceptance calorimeter triggers now being employed for the investigation of deep-inelastic hadron-hadron scattering introduce a strong low-p_T bias, thus masking any possible jet structure. Suggestions are made on how to trigger on jets using such calorimeters.

It has been suggested that information on the collisions between individual partons could be obtained from the study of large-transverse momenta jets in hadron-hadron interactions [1,2]. Data taken with small solid angle calorimeters have shown the existence of jets at high p_T [3] and as expected the jet cross sections are about two orders of magnitude larger than single-particle high-p_T cross sections [2,4]. However, the use of a small acceptance calorimeter trigger may introduce a jet bias such that events are selected which simulate jets due to statistical fluctuations [5]. To overcome these difficulties it has been suggested that deep inelastic hadron-hadron collisions be studied with large acceptance calorimeters [6,7]. Recently several experimental groups have started operating such devices [8,9] and the first results are now becoming available.

This kind of experiment triggers on events with high transverse momentum energy deposited into a segmented calorimeter covering a wide rapidity range, with a 2π azimuthal acceptance. Other types of triggers are also used with smaller azimuthal acceptance, they will be important in our subsequent discussion. The experimental results are rather surprising since the measured cross sections are much larger than those expected in a QCD 4-jet model and moreover the events are characteristically non-jet like.

It is our purpose in this letter to discuss some aspects of the data and the models proposed so far to explain them. We also suggest a conventional low-p_T explanation for the unexpected features of the data and conclude the letter by suggesting a procedure for triggering on jets with such large acceptance calorimeters.

In order to illustrate the difficulty in explaining the data with a 4-jet QCD model we show in *Fig. 1* the results of a Monte-Carlo calculation[≠1] we have performed, compared with a similar calculation by the NA5 collaboration [8] together with their experimental results. The discrepancy between our 4-jet results and theirs is mainly due to the different treatment of the intrinsic transverse momentum of the partons. The NA5 calculation introduces an intrinsic transverse momentum for the hard and soft jets, of equal magnitude and opposite direction. As a consequence they find that approximately 40% of the transverse energy in the calorimeter comes from the forward and backward spectator jets, while we find only between 10% and 20%. The same effect has been drastically emphasized by Singer et al. [13] in an attempt to explain the non-planarity of the NA5 events[≠2]. This procedure of introducing an intrinsic transverse momentum bias obviously enhances the cross section, since the transverse momentum observed in the calorimeter does not have to come now entirely from the hard process ($p_T^{obs} > p_T^{hard}$) and the hard cross-sections fall-off steeply with p_T^{hard} [14]. However we think that this is an artificial procedure to increase the final cross section, since it seems that there is no justification for it as the calorimeter covers 2π in azimuth and therefore the intrinsic transverse momentum of the partons will be in all possible directions and not necessarilly alligned [14][≠3].

We now would like to call attention to a remarkable feature of the data whose importance has not been sufficiently emphasized. Let us compare the data obtained with different triggers, characterized by an azimuthal acceptance $\Delta\phi$. Both the NA5 and the E557 results can be parametrized as,

$$\frac{d\sigma^{\Delta\phi}}{dE_T} = A\ e^{-\alpha_{\Delta\phi} E_T} \tag{1}$$

($\Delta\phi = 2\pi$ and π for NA5 and 2π, $\frac{4\pi}{5}$ for E557)

Evidence for the low-p_T, spherically symmetric nature of these events can be provided by the following argument: the total integrated transverse energy, $E_{tot.}$, deposited in the 2π calorimeter, is aproximatelly twice that deposited into the π calorimeter, due to the assumed isotropy of the events. $E^{\Delta\phi}_{tot.}$ is given by,

$$E^{\Delta\phi}_{tot.} = \frac{1}{\sigma_{in}} \int E_T \frac{d\sigma^{\Delta\phi}}{dE_T}\, dE_T \tag{2}$$

where σ_{in} is the total inelastic cross section. From the simple parametrization given in (1) we obtain,

$$E^{\Delta\phi}_{tot.} = \frac{c}{\alpha^2_{\Delta\phi}} \tag{3}$$

where c is just a constant, the same for all triggers. We can now postdict what should be the relationship between the slopes $\alpha_{\Delta\phi}$. From (3) and the assumed isotropy of the events, we ob tain,

$$\frac{\alpha_{\pi}}{\alpha_{2\pi}} = 2^{1/2} \quad \text{and} \quad \frac{\alpha_{4\pi/5}}{\alpha_{2\pi}} = 2.5^{1/2} \tag{4}$$

The above relations are remarkbly well verified: for the NA5 experiment $\alpha_{2\pi} = 1$ and $\alpha_{\pi} = 1.4 \simeq 2^{1/2}$, while for E557, which is at a different energy and rapidity interval[≠4], $\alpha_{2\pi} = 0.85$ and $\alpha_{4\pi/5} = 1.3 \simeq 2.5^{1/2} \times 0.85$.

It has been previously suggested that low-p_T models are better suited for explaining the data [8,16]. The above result is in agreement with these suggestions, notice, however, that we have not employed any specific low-p_T model in deriving our result. It is clear that given the unexpected high multiplicity observed in such events [8,9], there is no hope of seeing rare hard jet events whose probability is much lower than the abundant low-p_T processes. Now, the question arises on how to trigger on jets with such large acceptance calorimeters. It seems to us that there is a way of overcoming this low-p_T bias, provided one finds a quantity that is more sensitive, in a given kinematical regime, to those events which are not spherically symmetric. For instance, energy correlation measurements, performed by dividing the full calorimeter into two complementary sections of azimuthal coverage π (to be called 1 and 2),in which one requires as triggering conditions,

$$E_1 > E_{cut} \tag{5}$$

could select hard jets. In the above condition, E_1 is the transverse energy in the two trigger quadrants of the calorimeter and E_{cut} is the imposed cut on the transverse energy in the complementary quadrants, that is $E_2 < E_{cut}$. The behaviour we expect is illustrated qualitatively in *Fig. 2*, where we show the double differential cross section $\frac{d\sigma}{dE_1 dE_2}$ as function of the trigger energy E_1. If there is only low-p_T physics then this cross section should vanish for $E_1 \geqslant E_{cut}$. Therefore events with $E_1 > E_{cut}$ should contain a contribution from hard processes with at least an energy $E_{hard} = E_1 - E_{cut}$, provided, of course, $E_1 - E_{cut} \geqslant 2GeV$ or so, a typical scale marking the onset of the high-p_T region. The expectation is that the jet cross section measured in this way, being free of a jet trigger bias, turns ou to be greater than jet cross sections measured by limited acceptance detectors [3].

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NOTES

≠1 - Our QCD 4-jet model generates 4 jets, two hard and two spectators, according to a Monte Carlo programme. We have used structure functions from νN data, including scale breaking effects [10], with $Q^2 = 4\ p_T^2$, $\Lambda = 0.3\ GeV$. The QCD two-body cross sections involving initial quarks and gluons were used [11], with the QCD running coupling constant. The hadronization of both jet systems was done according to the Feynman-Field fragmentation scheme [12]. No intrinsic transverse momentum was assumed for the initial partons, due to the spherical symmetry of the triggering conditions.

≠2 - It must be remarked that ref. [13] shows only the planarity distribution. No results for the cross sections are presented.

≠3 - Recently, Fox and Kelly [15] have suggested a similar effect but coming from an explicit gluon bremstrahlung in the initial state instead of a tilt on the spectator jets as done in [13].

≠4 - For the single arm calorimeter trigger ($\Delta\phi = \pi/2$ or $\pi/5$) the assumption of spherical symmetry is expected to break since a jet trigger bias comes now into play.

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FIGURE CAPTIONS

Fig. 1. Comparison of our QCD 4-jet model (solid line), with the NA5 similar calculation (dashed line) and experimental data for the 2π calorimeter [8].

Fig. 2. Qualitative behaviour expected for the double differential cross section defined in the text, with $E_2 < E_{cut}$. The dashed line indicates the extrapolation of the low-p_T behaviour.

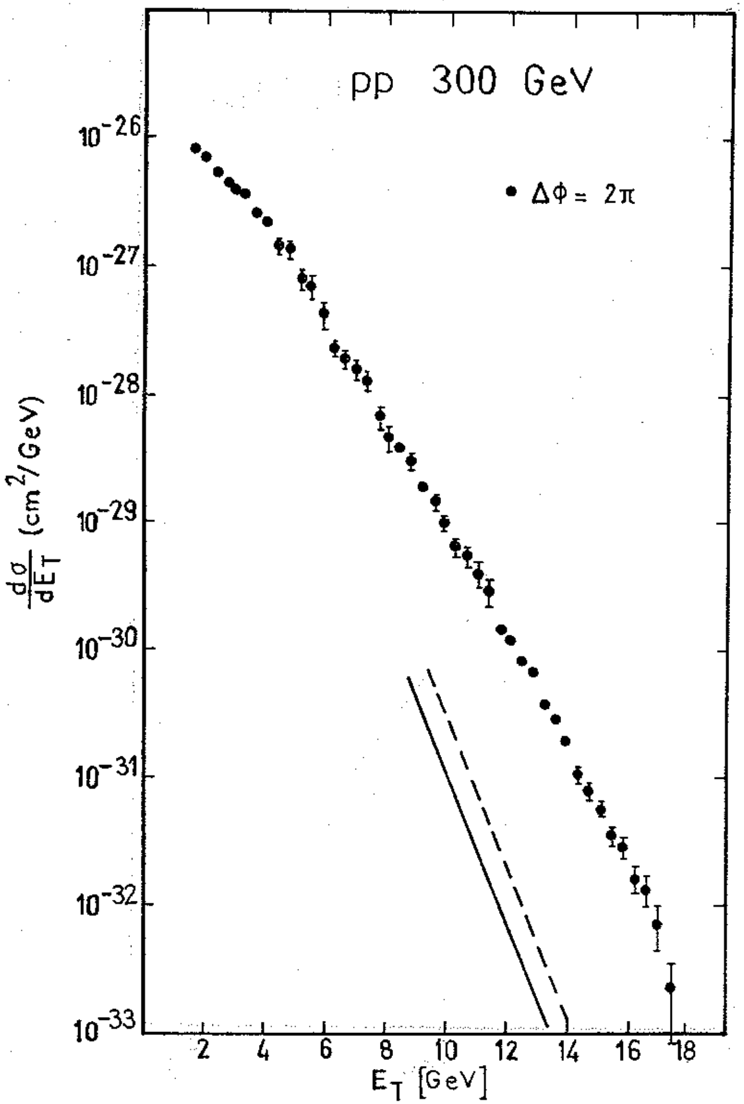

FIG. 1

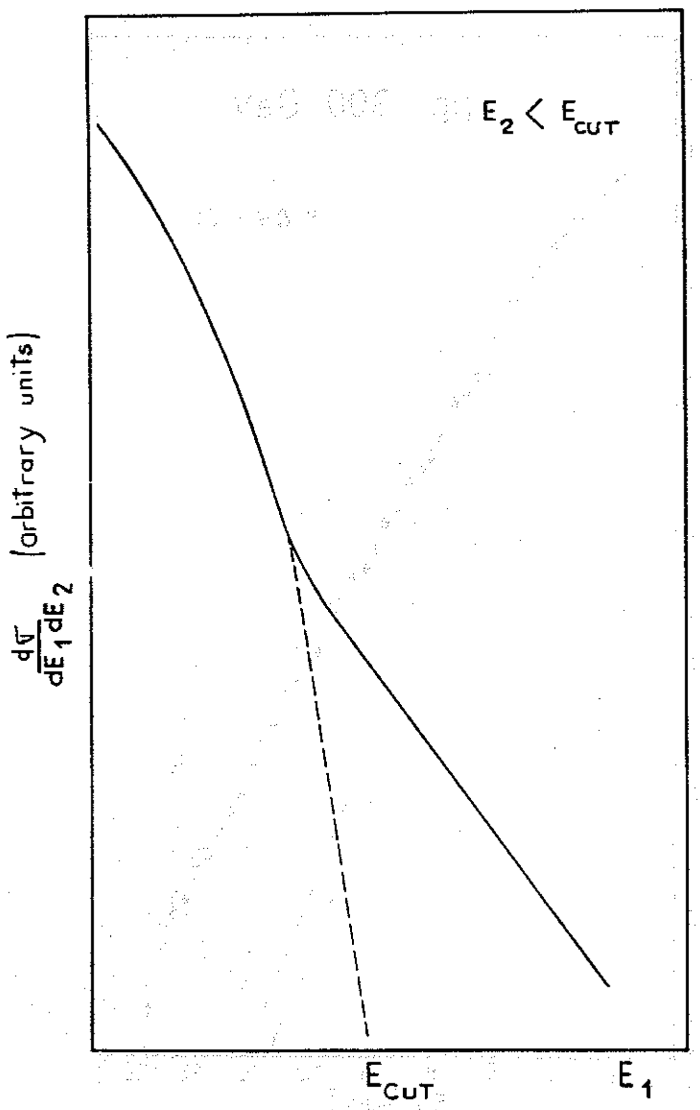

FIG. 2