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PROBLEMS IN ACCOUNTING FOR THE SOFT AND HARD COMPONENTS IN TRANSVERSE ENERGY TRIGGERS

by

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Abstract

It is argued that for a transverse energy trigger, the cancellation theorem of DeTar, Ellis and Landshoff is not valid. As a consequence, the problem of accounting for soft and hard components in this kind of trigger becomes complicated and no simple separation between them is expected.

1. Introduction

With the coming into operation of large acceptance calorimeters triggering on the transverse energy, unexpected features have appeared defying a simple perturbative QCD interpretation [1]. The cross section $d\sigma/dE_T$ (E_T is the total transverse energy deposited in the calorimeter) is about two orders of magnitude larger than the simplest QCD 4-jet model [1]. Furthermore, the observed event structure resembles more that of a low-p_T cluster model than that expected in the QCD jet model. A first attempt to overcome this disagreement is to attribute a rather large fraction ($\sim$40% at SPS) of the transverse energy deposited in the calorimeter to the beam and target jets [1], in addition to their significant role in explaining the lack of planarity in the event structure [2]. To obtain these results, it is essential to assume an intrinsic transverse momentum for the partons, which are aligned, tilting by the same amount the spectator jets. This procedure, although fully justified for single particle or narrow jet triggers [3], is in the context of a 2π (in azimuth) calorimeter, just an artificial procedure to enhance the hard scattering cross section and widening the planarity distribution.

Another approach, makes use of noncollinear gluon emission from initial and final partons [4,5]. The results of references [4] and [5] differ on the significance of gluon bremsstrahlung at the energy of the NA5 experiment. Whereas it is claimed in [4] that all existent data, from SPS to $p\bar{p}$ collider energies can be understood in this approach, in [5], on the contrary, the effect of gluon breamsstrahlung is much less significant at both NA5 and collider energies. It is clear that the purpose of introducing these complications is to dilute the "jetness" of the event structure, while enhancing the hard scattering cross section. From a detached point of view, it is however hard to distinguish between this far fetched modification of the simple parton model and ordinary low-p_T physics.

It is our purpose in this article to call attention to the prominent role played by low-p_T physics for the transverse energy triggers. Our approach to this problem consists in calling attention to a cancellation theorem by DeTar, Ellis and Landshoff [6]. This is examined in the next section, while Section 3 is devoted to our conclusions and remarks on nuclear target effects.

2. Initial and Final State Soft Interactions

An important issue in the parton model approach to hard processes is whether or not the initial and final state interactions modify the parton model results*. Cardy and Winbow [9] and DeTar, Ellis and Landshoff [6] showed that the diffractive corrections to Drell-Yan like processes (large-p_T single particle, muon pair production) give asymptotically a vanishing contribution to the single particle inclusive cross section, even though they do modify the event structure: a hard event will have superimposed on it an ordinary low-p_T pionization structure. The physical pic-

* In the following we do not consider interactions between spectator and active partons which are considered in Ref. [7]. Spectator-spectator interactions in the Drell-Yan process, mediated by gluons, have been treated in [8].

ture behind this result is **:

(i) a distinction can be made between those states accessible through the hard process, let us call them $|H\rangle$ and those which can only be reached through pionization, call them $|P\rangle$ with $\langle P|H\rangle=0$,

(ii) the amplitude A_H for obtaining the hard states receives two contributions, the simple parton model amplitude, $A_H^{P.M.}$ and that corrected for initial and final state interactions A_H', therefore $A_H=A_H^{P.M.}+A_H'$.

Calling A_p the amplitude for the pionization states $|P\rangle$ the single particle inclusive cross section is calculated from,

$$\sum_H |A_H^{P.M.} + A_H'|^2 + \sum_p |A_p|^2 = \sum_H \left[|A_H^{P.M.}|^2 + |A_H'|^2 + 2\mathrm{Re}\, A_H^{P.M.} A_H'\right] + + |A_p|^2 \quad (1)$$

Expression (1) corresponds to the Mueller diagrams obtained by the slicings L_1, L_2 and L_3 indicated in Fig. 3.1 of reference [6]. The result of DeTar et al. is that even though the slicings L_1, L_2 and L_3 are individually non-vanishing their sum is zero for the single particle cross section $Ed\sigma/d^3p$. Notice that each of these slicings, represented by the diagrams of Fig. 1, do alter the event structure associated with the hard scattering.

Coming now to the transverse energy trigger, it is clear that the diagrams with initial and final state interactions and with pionization will contribute to the cross section as E_T is sensi

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** For details, the original paper [6] should be consulted (see also [10] for a discussion of this theorem).

tive to the whole event structure***. It is clear, from the very beginning that Mueller's theorem does not directly apply to $d\sigma/dE_T$, but we use the DeTar et al. theorem just as a guideline for analyzing the effect of soft interactions on the hard scattering process. Of course, no cancellation should occur since the variable E_T is not solely determined by the hard scattering part of the diagrams in Fig. 1. The fully calorimetric measurement is unable to distinguish where a given E_T comes from. From what has been said there is no reason why a genuinely soft contribution should not be included in $d\sigma/dE_T$. By this we mean a soft interaction without any hard component superimposed on it. This contribution was considered in [1] and [11]. In ref.[11] the cross sections for hard and soft interactions were simply added together. Our discussion shows that the problem of accounting for all contributions is far from trivial. As a matter of fact one has all the terms in expression (1) plus the usual soft interaction coming from the total inelastic cross section. We stress the fact that the non-cancellation of the several terms in (1) casts doubt on the use of QCD modified parton models for the transverse energy calorimeter trigger.

*** As remarked in [6], L_1 and L_3 include partial Pomeron cuttings. These may simulate beam and target jets wider than those expected from simple fragmentation. Recall that this effects was introduced in refs. [5] and [6] and is an essential ingredient in their attempt at explaining the data.

3. Conclusions

We argued that due to the non cancellation of initial and final state interactions (soft spectator-spectator interactions), the problem of accounting for soft and hard contributions to the E_T trigger is non trivial, spoiling the simple parton model approach with QCD corrections.

We finish by pointing out that a possible place where to look for the interplay of soft and hard components in calorimetric measurements is in nuclear target effects.

Recently the E557 collaboration [12] investigated the production of high transverse energy events in proton-nucleus collisions, using a large solid angle calorimeter. The cross sections are parametrized in the usual form $A^{\alpha(E_T)}$, with A the atomic number of the target. The data, shown in Fig. 2 exhibits a transition from the low-p_T value $\alpha \sim 2/3$ to $\alpha(E_T)>1$, at $E_T \sim 10$GeV for the 2π trigger. This may be indicative of a transition from the soft to the hard regime. It would be interesting to investigate quantitatively the interplay of the several contributions from Fig. 1 to the behaviour $A^{\alpha(E_T)}$.

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Figure Captions

1. The slicings L_1, L_2 and L_3 (see Fig. 3.1, ref. [6], corresponding to the different terms in (1). The wavy line represents any number of exchanged Pomerons. When cutting through a Pomeron one obtains the multiparticle pionization state indicated in L_2.

2. The exponent $\alpha(E_T)$ as a function of E_T for the 2π trigger (from Ref. [12].

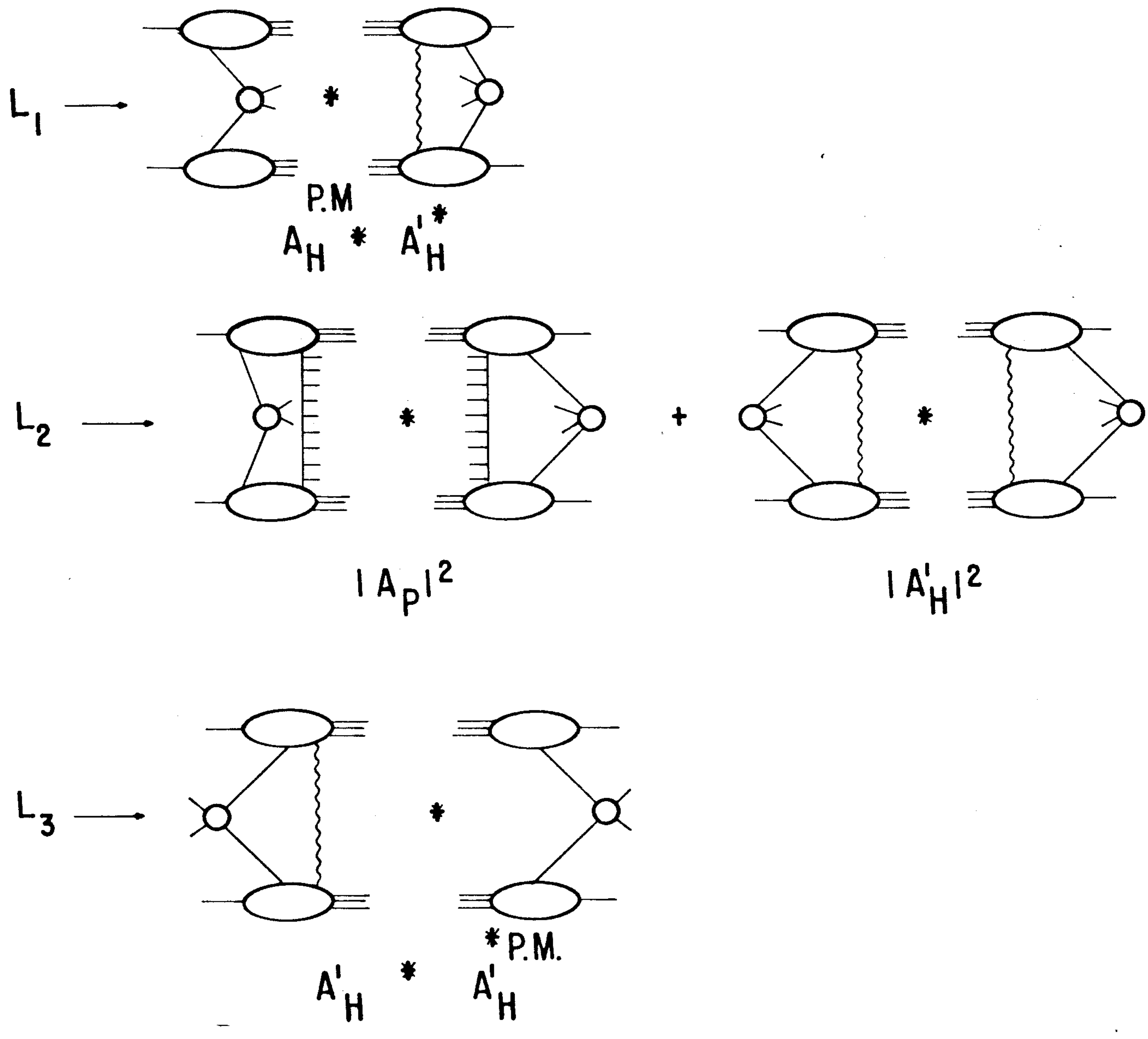

Fig. 1

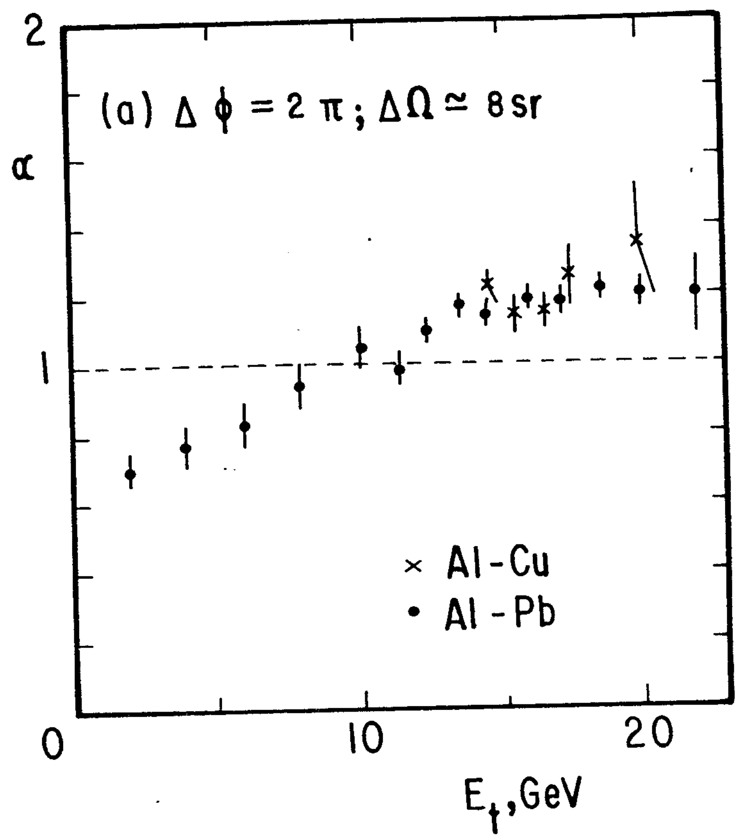

Fig. 2