Nijmegen HEN-338/1991

LOW p_T INTERMITTENCY in π^+p and K^+p COLLISIONS at 250 GeV/c

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ABSTRACT:

Density fluctuations are studied in rapidity, separately for low and intermediate transverse momentum particles. In our data, the effect of intermittency is increased when the analysis is restricted to low p_T particles.

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Density fluctuations in multiparticle production have recently gained considerable attention. To study these fluctuations in detail, Białas and Peschanski [1] have suggested to analyze scaled factorial moments of the multiplicity distribution in smaller and smaller phase-space bins, down to the experimental resolution. Including the case of a non-constant overall rapidity distribution, these moments can be defined as a double average starting "vertically" (over events):

$$\langle F_i \rangle_v = \frac{1}{M} \sum_m \frac{\frac{1}{N_{evt}} \sum_{evt} F_{i,m}}{\langle n_m \rangle^i} \quad . \tag{1}$$

Here, M is the number of phase-space bins $\delta y = \Delta y/M$ into which an original region Δy is subdivided, n_m is the multiplicity in bin m ($m = 1, ..., M$), $F_{i,m} = n_m(n_m - 1).....(n_m - i + 1)$ is the factorial of order i in bin m, and $\langle n_m \rangle = \frac{1}{N_{evt}} \sum_{evt} n_m$ is the mean multiplicity in bin m.

If self-similar fluctuations of many different sizes ("intermittency") exist, then the dependence of the moment on the size of the phase-space bin follows the power law

$$\langle F_i \rangle \propto \delta y^{-f_i}, \tag{2}$$

with the intermittency strength $f_i > 0$. Otherwise, saturation of the moments at small δy is expected.

Intermittency has been studied in e^+e^- [2-6], μp [7], ν-nucleus [8], hadron-hadron [9,10], hadron-nucleus [11, 12] and nucleus-nucleus [11,13-16] collisions. Brief reviews are given in [17,18,19,20]. In general, the effect is not fully reproduced by presently used models, so that further experimental input is needed for necessary improvements.

One of the most urgent questions in this respect is whether semi-hard effects [21,22], observed to play a rôle in the transverse momentum behaviour even at our energies [23], or low-p_T effects [24,25,26] are at the origin of intermittency. A first indication for at least some contribution from low-p_T effects comes from our most prominent "spike" event [9a], where 5 out of 10 tracks involved have $p_T <$ 0.15 GeV/c. Furthermore, while currently used hadron-hadron models predict intermittency to vanish for small transverse momenta [10a], the UA1 data show a slight increase of the intermittency strengths f_i when transverse momenta are restricted to $0.15 < p_T < 0.5$ GeV/c. Because of the UA1 bias against $p_T <0.15$ GeV/c, low-p_T effects cannot be studied in the UA1 data, however.

In this letter we report on the study of intermittency in different regions of low and intermediate transverse momentum in the NA22 experiment. In this CERN experiment, the European Hybrid Spectrometer (EHS) is equipped with the Rapid Cycling Bubble Chamber (RCBC) as a vertex detector and exposed to a 250 GeV/c tagged positive, meson enriched beam. In data taking, a minimum bias interaction trigger is used. The details of the spectrometer and the trigger can be found in previous publications [27,28].

Charged particle tracks are reconstructed from hits in the wire- and drift-chambers of the two lever-arm magnetic spectrometer and from measurements in the bubble chamber. The average momentum resolution $\langle \Delta p/p \rangle$ varies from a maximum of 2.5% at 30 GeV/c to around 1.5% above 100 GeV/c. In the rapidity region Δy under consideration ($-2.0 < \Delta y < 2.0$), the experimental resolution varies between 0.01 and 0.05 units.

Events are accepted for the present analysis when measured and reconstructed charge multiplicity are consistent, charge balance is satisfied, no electron is detected among the secondary tracks and the number of badly reconstructed (and therefore rejected) tracks is 0. Elastic events are excluded. Furthermore, an event is called single-diffractive and excluded from the sample if the total charge multiplicity is smaller than 8 and at least one of the positive tracks has $|x| > 0.88$. After these cuts, our "cleaned" inelastic non-single-diffractive sample consists of 59 200 π^+p and K^+p events. The average in (1) is normalized to this sample, including events with no tracks in $-2.0 < y < 2.0$.

For momenta $p_{LAB} < 0.7$ GeV/c, the range in the bubble chamber and/or the change of track curvature is used for proton identification. In addition, a visual ionization scan has been used for $p_{LAB} < 1.2$ GeV/c on the full K^+p and 62% of the π^+p sample. Particles with momenta $p_{LAB} > 1.2$ GeV/c are not identified in the present analysis and are treated as pions.

Earlier results on the full p_T range using "horizontal" averaging are presented in refs. [9b].

Our present results for $\ln\langle F_i \rangle$ versus $-\ln \delta y$ are given in Figs.1a,b for particles with transverse momentum p_T below and above 0.15 GeV/c, in Figs.1c,d for p_T below and above 0.3 GeV/c. Particles with p_T below the cut (Figs.1a,c) show an effect much stronger than those above the cut (Figs.1b,c).

We do not claim straight lines in Fig.1, but use fits as an indication to measure the increase of $\ln\langle F_i \rangle_v$ over the region $1 > \delta y > 0.1$. In Fig.2a, the fitted values of f_i are compared to those obtained in the full p_T range, in the reduced form $d_i = f_i/(i-1)$. Restricting the analysis to particles with $p_T < 0.15$ or 0.30 GeV/c indeed leads to an *increase* of the d_i, while a *decrease* is observed for $p_T > 0.15$ or 0.30 GeV/c.

We have verified that a similar dependence on p_T is visible in the full event sample (including events with track losses). For further analysis of possible biases see [29].

In Fig.2b, we present expectations from the FRITIOF [30] model at similar statistics, again for all tracks and those with p_T smaller and bigger than 0.15 or 0.3 GeV/c, respectively. Besides the known fact [9] that FRITIOF gives too low slopes already for the full sample, this model does not reproduce the p_T dependence of the effect.

We conclude that the intermittency observed in our data is due to low transverse momentum particles and not due to semi-hard effects. Since, on the contrary, hard effects dominate in e^+e^- and lh collisions, a study of the p_T dependence in these could be of utmost importance in the search for the origin of intermittency.

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Figure Captions:

Fig.1 $\ln\langle F_i\rangle_v$ as a function of $-\ln\delta y$ for various p_T cuts as indicated. Data in numerical form can be obtained by bitnet from U632007 at HNYKUN11.

Fig.2 $d_i = f_i/(i-1)$ as a function of the order i for p_T cuts as indicated. Lines are to guide the eye.

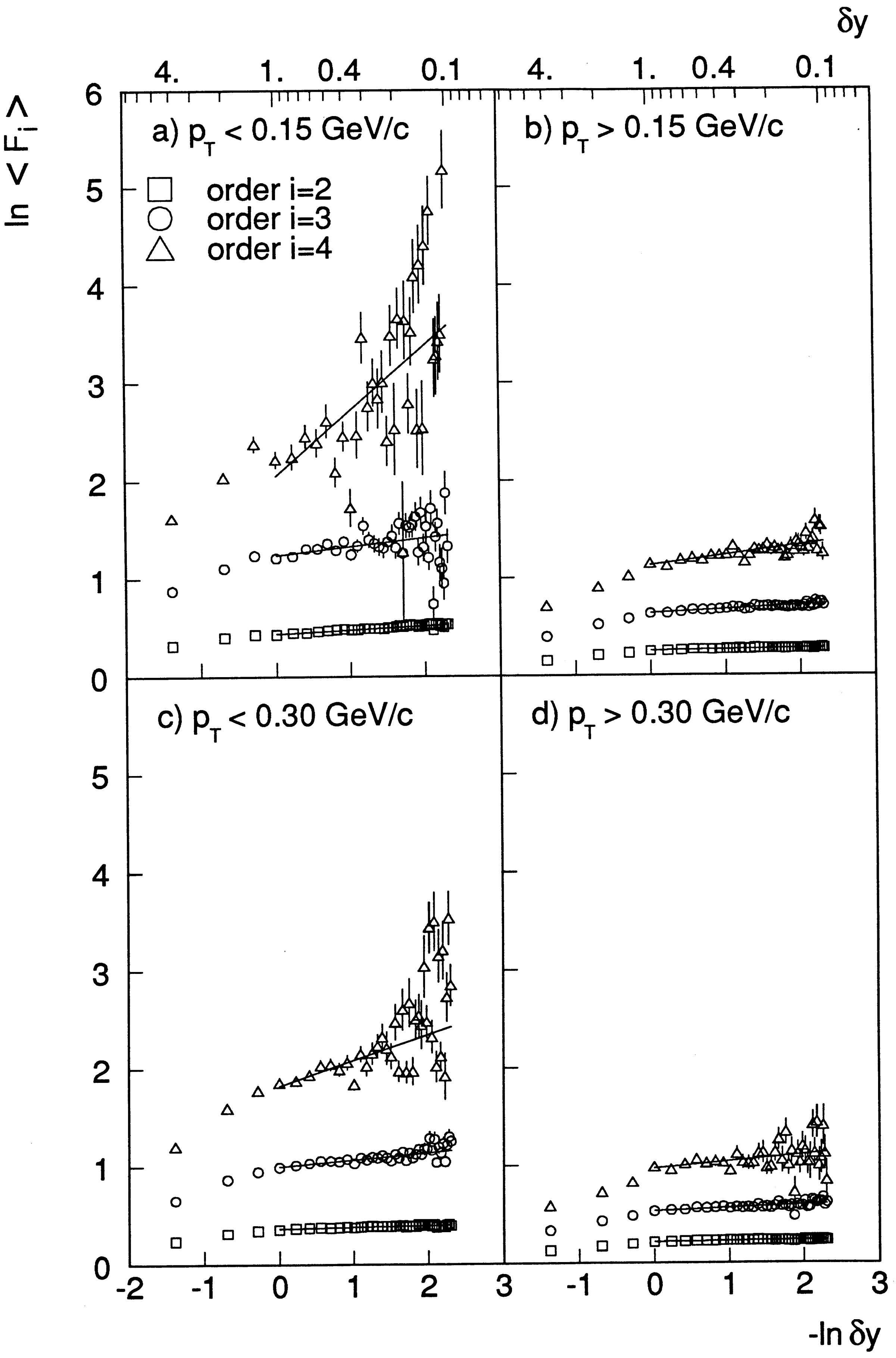
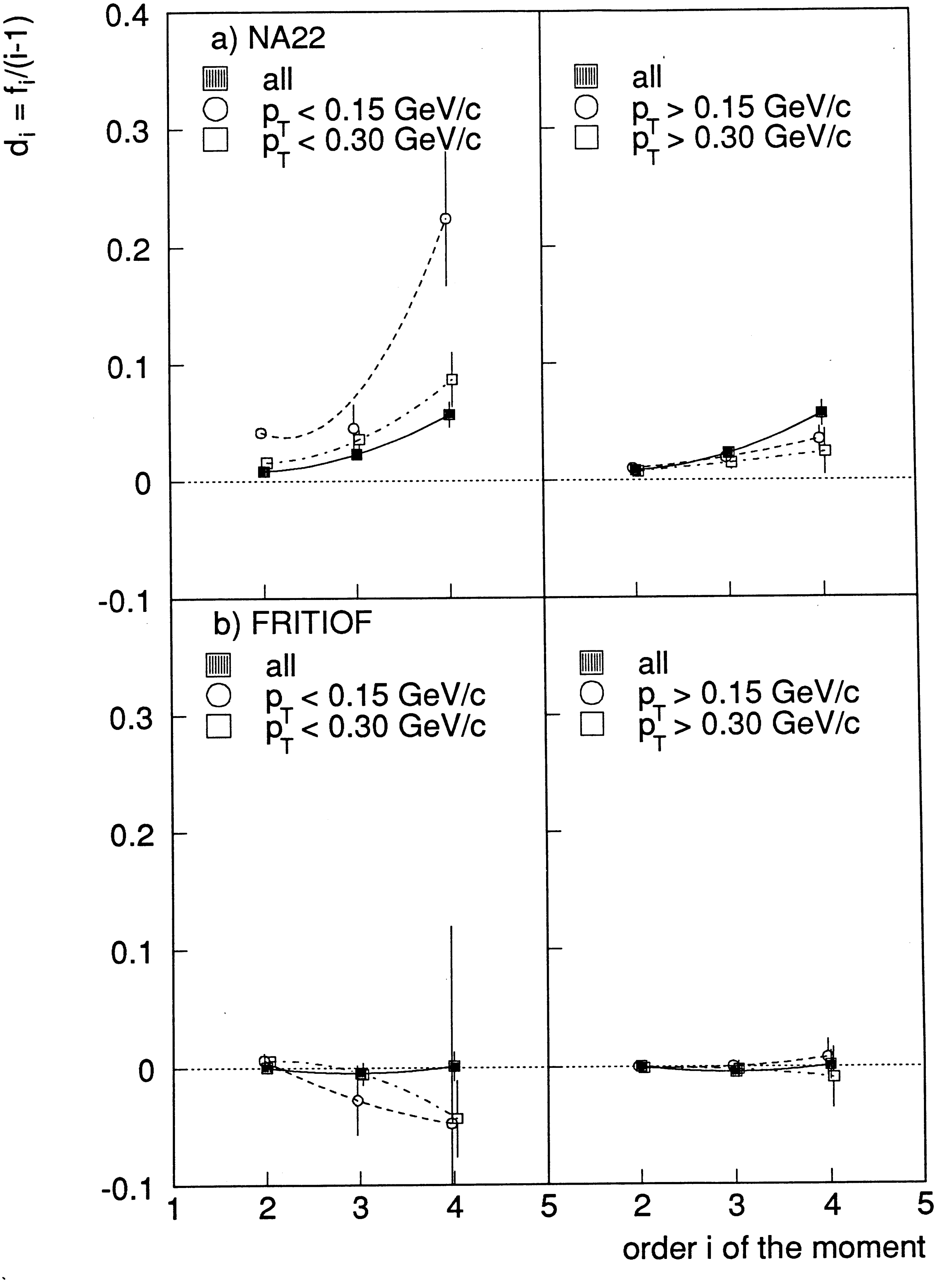

δy
4.
1.
0.4
0.1
ln < F_i >
a) p_T < 0.15 GeV/c
b) p_T > 0.15 GeV/c
c) p_T < 0.30 GeV/c
d) p_T > 0.30 GeV/c
□ order i=2
○ order i=3
△ order i=4
0
1
2
3
4
5
6
-2
-1
3
-ln δy

Fig. 1



$d_i = f_i/(i-1)$
0.4
0.3
0.2
0.1
0
-0.1
a) NA22
all
$p_T < 0.15$ GeV/c
$p_T < 0.30$ GeV/c
all
$p_T > 0.15$ GeV/c
$p_T > 0.30$ GeV/c
b) FRITIOF
all
$p_T < 0.15$ GeV/c
$p_T < 0.30$ GeV/c
all
$p_T > 0.15$ GeV/c
$p_T > 0.30$ GeV/c
1
2
3
4
5
2
3
4
5
order i of the moment

Fig. 2