RINGLIKE INELASTIC EVENTS IN COSMIC RAYS AND ACCELERATORS

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In cosmic rays [1-3] and in accelerators [4] there were observed single inelastic processes with densely produced (azimuthally isotropic) groups of particles exhibiting spikes in the pseudorapidity plot of an individual event (i.e. ringlike events).

Theoretically the existence of such processes was predicted [5] as a consequence of Cherenkov gluon radiation or, more generally, of deconfinement radiation [6].

Nowadays some tens of such events have been accumulated at 400 GeV [7] an at 150 TeV [8].

Analyzing ringlike events in proton-nucleon interactions at 400 GeV/c we show [7] that they exhibit striking irregularity in the positions of pseudorapidity spikes' centers which tend to lie mostly at 55,90 and 125° in cms. It implies rather small deconfinement lengths of the order of some fermi.

We have chosen high-multiplicity events with $n_{ch} \gtrsim 12$ among all proton-nucleon interactions at 400 GeV in the photoemulsion experiment [9]. There were 284 events available. To select ringlike events we use some criteria (for more details see [7]) which single out those events with dense groups in the pseudorapidity plot containing more than 6 charged particles within the unit pseudorapidity interval.

In total 59 among 284 event have been chosen as ringlike events what corresponds to 1 mb of their production cross section.

The very important feature of ringlike events is the position of rings. The center of a ring should be in some way close to the direction of the gluon emission in the above treatment. We have determined the positions of the centers of rings in all 59 events. They are shown in Fig.1.

In Fig.2 we show the example of one ringlike event (among 59 available).

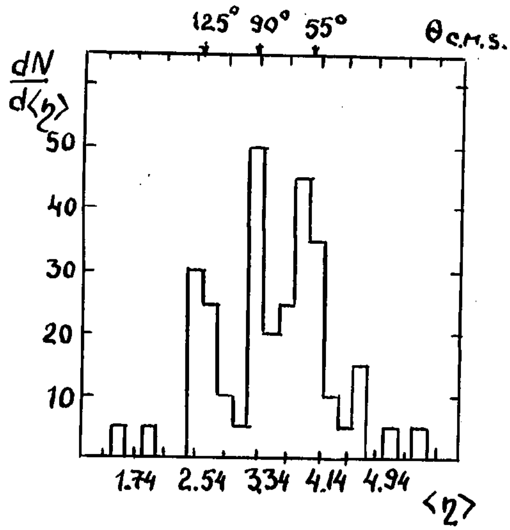

Fig.1 The pseudorapidity distribution of spikes' centers.

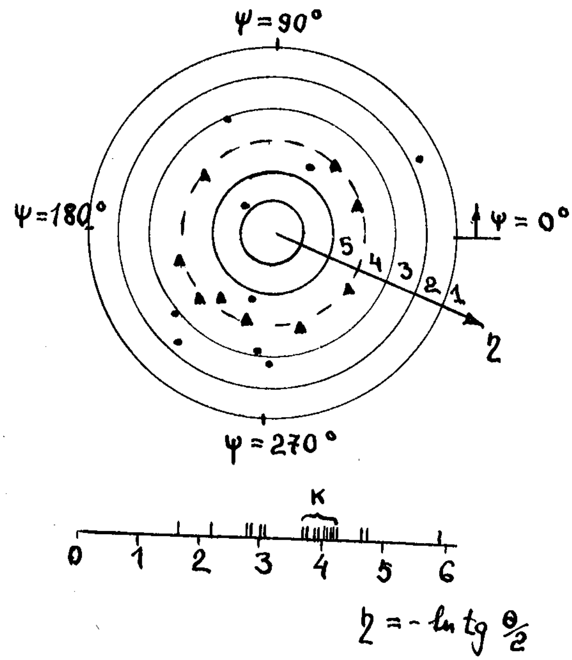

Fig.2 The pseudorapidity distribution (a) and the pseudorapidity azimuthal plot (b) of a pN-event (0+0+18p) with a ring of 9 charged particles ($\langle \eta \rangle = 4.02$, $\langle \Delta\eta \rangle = 0.066$). Triangles mark the particles, points correspond to other particles.

The most striking feature of Fig.1 is the irregularity in appearance of rings *) and their tendency to rather large cms angles (upper axis).

The only reliable explanation is that the particles within the rings are produced by some process the formation length of which is rather short. Actually, the large emission angles of Cherenkov gluon radiation were predicted [5] in 1979

*) The indirect confirmation to such irregularity can be drawn from ISR-data [10] about two-particle rapidity correlations (for more details see [7]).

as a consequence of a thinness of hadronic targets. Later it was shown [6] that the deconfinement of quarks within hadronic targets can provide stronger effect at the same angles. The maximum of forward (in cms) emission of gluon jets appears at the laboratory angle

$$\theta_{lab} \approx (2\pi/\omega\ell)^{1/2} , \qquad (1)$$

where ω is an energy of a gluon jet (i.e. of a group of particles) and ℓ is a formation length which should be close to the deconfinement length. Let us remind that an analogous value for protons usually increases with primary energy E of an emitting particle as $\omega^{-1}\gamma^2 \approx \omega^{-1}(E/m)^2$ i.e. it must be very large at 400 GeV and correspondingly the emission angle is small (of the order of m/E according to (1)).

The average number of emitted within the ring gluons in an individual event is estimated [6] as about 3 at 400 GeV and about 6 at 150 TeV. Therefore the rings could be totally isotropic at 150 TeV while some azimuthal substructure may be noticeable at 400 GeV. We have not investigated it in detail.

If the maxima at 55 and 125° shown in Fig.1 are interpreted as ones due to gluon emission by deconfined quarks then using (1) together with the obvious inequality $\omega < E$ one gets

$$\ell \gtrsim 2\,fm. \qquad (2)$$

The hadron momenta have not been measured [9] and therefore we can not estimate the value of ω in (1). However reasonable assumptions about transverse momenta show that the gluon radiation length ℓ can not be much larger than, say, 10 fm.

This conclusion is strikingly different from above estimates for photon radiation length. It shows the fundamental difference between the electromagnetic and colour currents, the last one being strongly confined within small space regions. The formula (1) provides unique means to determine the extension of that region.

In conclusion, the ringlike events (i.e. events with high density of secondary particles within a narrow pseudorapidity interval) provide an unique possibility to define the length of action of deconfined colour currents. The above investigation shows that this length appears to be quite short (of the order of the hadron size). They also could reveal such important facts as the vector nature of gluons and the macroscopic features of the quark-gluon medium (for example, its refractivity). Further experimental work with higher statistics is needed for detailed study of those problems.

References

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