Cherenkov gluons or Mach waves?

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1. Introduction (hep-ph/0507167)

If z-axis is chosen along the body propagation, then in both cases emission

in an infinite medium at rest

is directed along the cone with the polar angle θ defined by the condition

$$\cos\theta = \frac{c_w}{v}. \tag{1}$$

For Cherenkov photons $c_w = c/n$ where n is the index of refraction, for Mach waves $c_w = c_s$ where c_s is the sound velocity in the medium.

$$n(\omega) = 1 + \Delta n = 1 + \frac{2\pi N}{\omega^2} F(\omega). \tag{2}$$

Here ω is the photon frequency, N is the density of the scatterers (inhomogeneities) of the medium. The forward scattering amplitude $F(\omega)$ is normalized by the optical theorem

$$\mathrm{Im}F(\omega) = \frac{\omega}{4\pi}\sigma(\omega), \tag{3}$$

where $\sigma(\omega)$ is the total cross section of photon interaction in the medium.

For hadrons

$$Re n(\omega) = 1 + \Delta n_R(\omega) = 1 + \frac{3m_\pi^3}{8\pi\omega}\sigma(\omega)\rho(\omega), \quad (4)$$

where $\rho(\omega) = ReF/ImF$ and now $F(\omega)$ $(\sigma(\omega))$ is the pion-nucleon amplitude (cross section).

The resonance region:

$$\Delta n_R^r = \frac{3m_\pi^3}{2\omega_r^2\Gamma}. \quad (5)$$

Here ω_r is the pion energy required to produce a resonance. It can be of the order of m_π. Since the widths Γ are of the order of hundred MeV for known resonances, Δn_R^r can be of the order of 1, i.e., large angle θ .

Very high energies:

$$\Delta n_R^h(\omega) \approx \frac{a}{\omega} \ll 1, \quad (6)$$

where $a \approx 2 \cdot 10^{-3}$ GeV at $\rho \approx 0.1$. Small θ but much larger than the bremsstrahlung angles.

Two types of Cherenkov gluons:

1. low energy (resonance region), large angle in the target rest system (backward moving in c.m.s.);

2. high energy, small angle in the target rest system (large angles in c.m.s.).

Mach waves: large angle in the target rest system (if c_w is of the order of v).

2. The background for Cherenkov gluons at RHIC and LHC energies.

We look for high energy Cherenkov gluons (type 2) emitted by the forward (backward) moving partons of colliding nuclei. Each one should produce a jet centered at the angle θ. Thus, find two peaks at large c.m.s. angles (i.e., in the central pseudorapidity region)! Mach waves could be responsible for such effect only at $c_s \ll c$.

To estimate the background we have used the HIJING model for central collisions ($b=0$) for AuAu collisions at RHIC energy $\sqrt{s}=200A$ GeV and for PbPb collisions at LHC energy $\sqrt{s}=5500A$ GeV. 3500 events were generated in each case.

Then the spikes in individual HIJING events exceeding the inclusive pseudorapidity distribution of the number of produced particles by more than one and two standard deviations have been separated. They can appear either as purely statistical fluctuations or as hard QCD-jets. Figs 1a and 2a show the examples of such events (each one for RHIC

and LHC energies, correspondingly) plotted over the smooth inclusive pseudorapidity distributions. Peaks exceeding the distributions are clearly seen. All simulated events have been plotted in such a way and centers of peaks defined.

Finally, the distribution of the centers of these peaks is plotted. Figs 1b and 2b show these distributions for peaks exceeding the inclusive plot at RHIC and LHC energies by two or one standard deviations. It is seen that these distributions are flat with extremely small irregularities. This appeals to our expectations that statistical fluctuations and QCD jets do not have any preferred emission angle. They can be considered as background plots for experimental search for Cherenkov gluons which do have such preferred angle. If experimental data on group centers distribution show some peaks at definite pseudorapidity values over this background, this can be an indication on new collective effect, not considered in HIJING.

Au+Au, 3500 events, b = 0 fm, $\sqrt{s}$=200A GeV
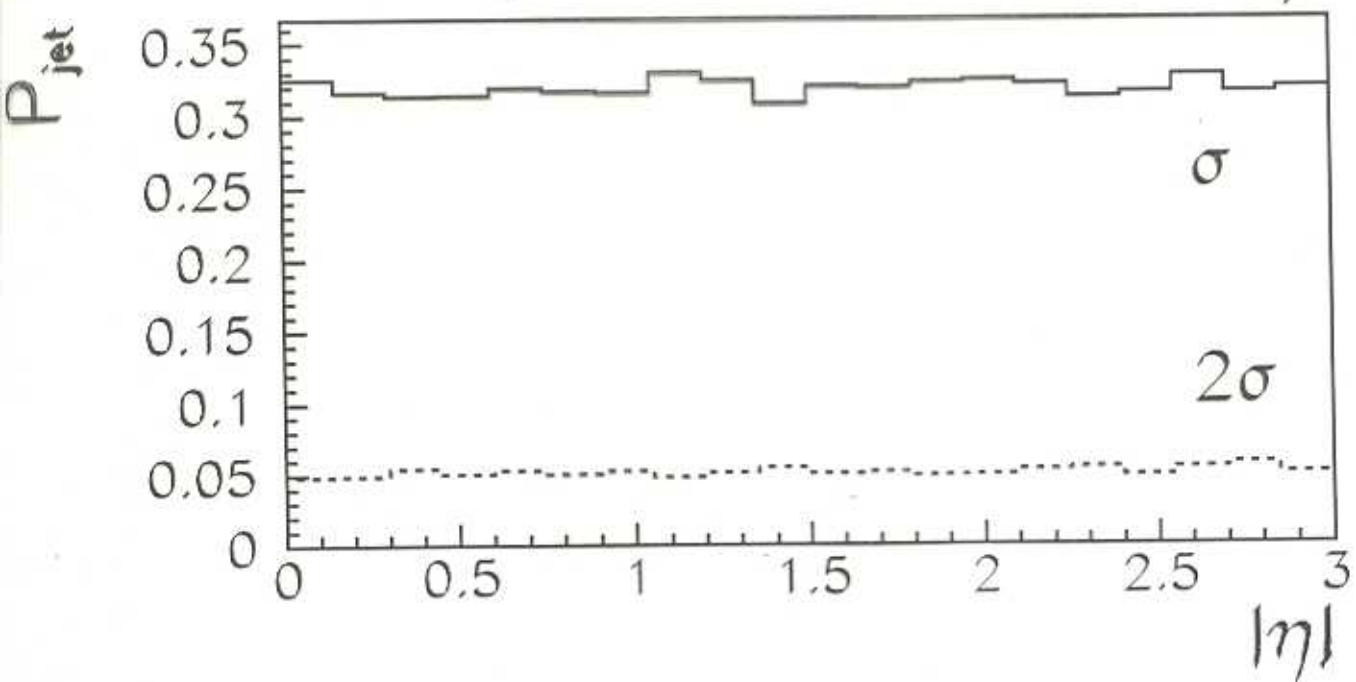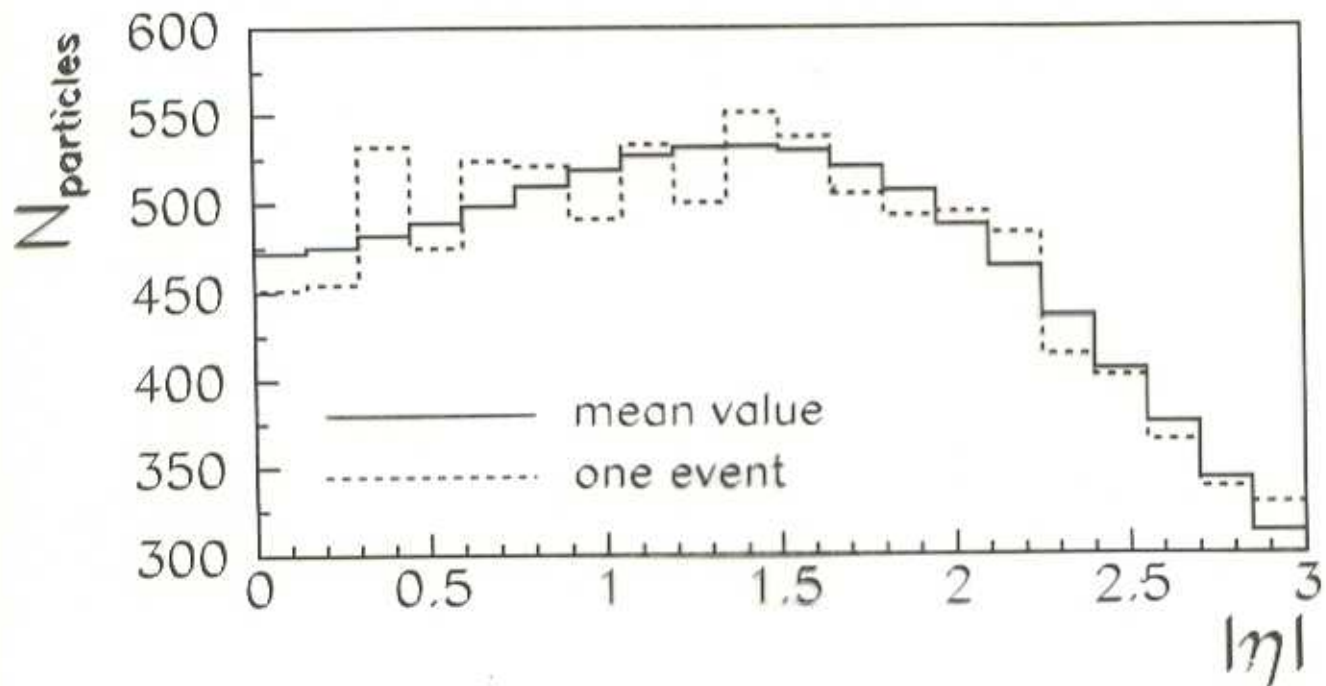
Pb+Pb, 3500 events, b = 0 fm, √s=5500A GeV