Search for parity violation in minimum bias Pb+Pb collisions at the SPS

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Recently Kharzeev, Pisarsky and Tytgat[1] argued that in hot QCD parity can be spontaneously broken. This effect leads to the possibility of creation of parity odd bubbles in high energy nuclear collisions and consequently to striking experimental signatures. Originally, it was proposed to observe the effect by looking for the non-statistical fluctuations in a P-odd quantity

$$P = \sum_{\pi^+,\pi^-} \frac{(\vec{p}_{\pi^+} \times \vec{p}_{\pi^-})_z}{p_{\pi^+} p_{\pi^-}}. \qquad (1)$$

For our analysis we use a slightly modified quantity. First, we change momentum in the denominator to the transverse momentum, we also divide the entire sum by the total number of $\pi^+\pi^-$ pairs. Then the quantity reduces to $\langle \sin(\Delta\phi) \rangle$, the mean sines value of the azimuthal angle difference between positive and negative pions. To address the question of non-statistical fluctuations in $\langle \sin(\Delta\phi) \rangle$ we use the subevent method[2, 3]. In this method one subdivides all particles into two subsystems, later called subevents "a" and "b", calculates the quantity under study on each of the subevents, and looks if the correlation. In our case we calculate

$$\langle \langle \sin(\Delta\phi) \rangle^{\{a\}} \langle \sin(\Delta\phi) \rangle^{\{b\}} \rangle = \sigma^2_{\sin(\Delta\phi),non-stat}. \qquad (2)$$

Note that statistical fluctuations in $\langle \sin(\Delta\phi) \rangle^{\{a\}}$ and $\langle \sin(\Delta\phi) \rangle^{\{a\}}$, are not correlated (by definitions) and what is left is exactly what one needs, the non-statistical, or dynamical, part of the fluctuations.

The results of the analysis are presented in Fig. 1 as a function of centrality, namely, as a function of the ratio of the energy observed in the zero degree calorimeter to the beam energy. Result indicate no parity violations in the collisions at the level of $\sigma_{\sin(\Delta\phi),non-stat} < 10^{-3}$.

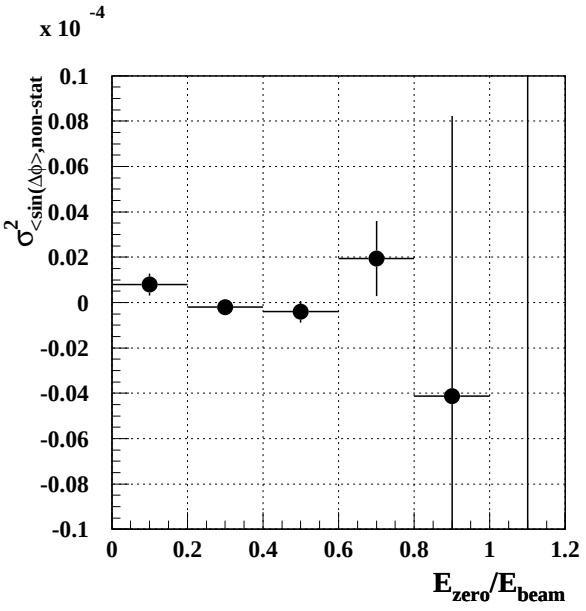

Figure 1: Dynamical fluctuations in $\langle \sin(\Delta\phi) \rangle$ as a function of centrality. The more central collisions are on the left.

References

[1] D. Kharzeev, R.D. Pisarski, and M.H.G. Tytgat, Phys. Rev. Lett., 81 (1998) 512; preprint hep-ph/9808366.

[2] A.M. Poskanzer and S.A. Voloshin, Phys. Rev., C53 (1998) 896.

[3] V. Koch, H.-G. Ritter, S. Voloshin, in preparation.