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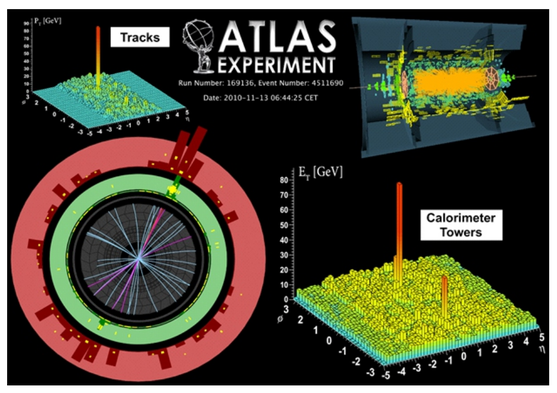
INVESTIGATION OF ANGULAR DISTRIBUTIONS IN THE INTERACTION OF COSMIC-RAY PARTICLES WITH A DENSE TARGET AND COMPARISION WITH DATA OF THE LARGE HADRON COLLIDER

T.Kh. Sadykov, O.A. Novolodskaya, S.Zh. Tokmoldin, N.S. Pokrovsky, Y.M. Tautayev, N.N. Zastrozhnova
LTD Institute of Physics and Technology Almaty Kazakhstan

Institute for Physics and Technology

The High Mountain Cosmic Ray Station



**The Large Hadron Collider (LHC)
Detection of two-jet events**

Studies of interactions of cosmic ray particles with a dense target using X-ray emulsion chambers (REC) have been carried out on the high altitude research station of cosmic rays, located at an altitude of 3340 m in the Tien-Shan mountains. [1,2]. REC method is based on X-ray emulsion detectors that enable to collect statistics for determined time period. The main object of study is a group of genetically related particles (gamma rays and hadrons) with sufficiently high energy, which result from interaction with solid target or with air nuclei of primary high-energy particles. These groups of particles called families.

To determine azimuthal anisotropy in interaction of cosmic-ray particles two-particle correlations were used, which is a powerful tool for studying the formation mechanism of particles in high-energy collisions of hadrons and nuclei. These studies provide important information characterizing quantum chromodynamics (QCD) in the power mode, especially hadronization mechanism and possible collective effects due to the particles high density, which can be achieved in such collisions.

From a consideration of the distribution presented it is evident that it is divided into three families, separated from each other. The left side corresponds to small EPC heights, the central part grouped around target events and the right side with the families of atmospheric interactions. Thus, using information from ionization calorimeter and application of above criteria enable to select 2657 gamma rays families from 10,199 recorded events. Further, 462 events were selected at gamma rays families with $n \geq 4$. Two-dimensional correlation functions as $\Delta\eta$-$\Delta\varphi$ were studied for these events. Where $\Delta\eta$ – difference by pseudorapidity ($\eta = -\ln(\tan(\theta / 2))$ with the polar angle, measured as the deviation from beam axis, $\Delta\varphi$ is the difference between azimuth angles of two particles.

To find two-dimensional correlation function in plane of $\Delta\eta$-$\Delta\varphi$ Gaussian kernel PDE can be application in Monte-Carlo generation with N events generated in a k-dimensional parameter space. These events are distributed by some unknown PDF, f(x). Gaussian kernel method carry out an assessment the value of the PDF at x point by the summary of Gaussains that centered at the Monte Carlo generated points, $\{y_i, i=1, N\}$ [4]:

$$f(x) = \frac{1}{N|V|^{\frac{1}{2}}(2\pi h)^{k/2}} \sum_i^N exp\left[-\frac{d_i^T V^{-1} d_i}{2h^2}\right]$$

Where $d_i = (x-y_i)$, V is a covariance matrix, and h is an additional scaling factor

The distribution similar to distribution obtained in the ATLAS experiment have been obtained after data (Figure 1) processing. [5]

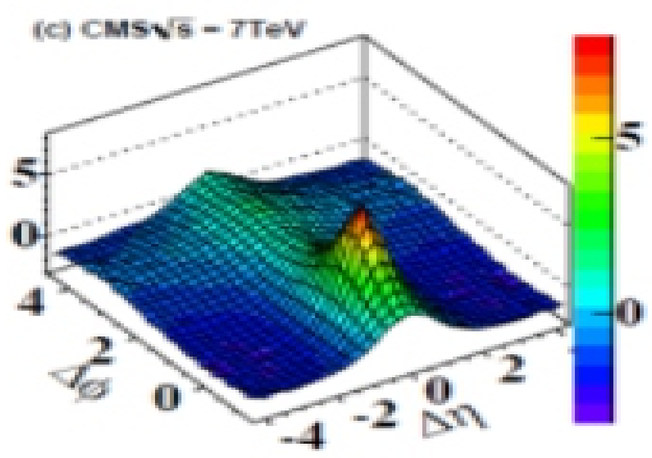


Figure 1 - the two-particle correlation function of pseudorapidity and azimuthal angles in PP-collisions in the experiment Atlas

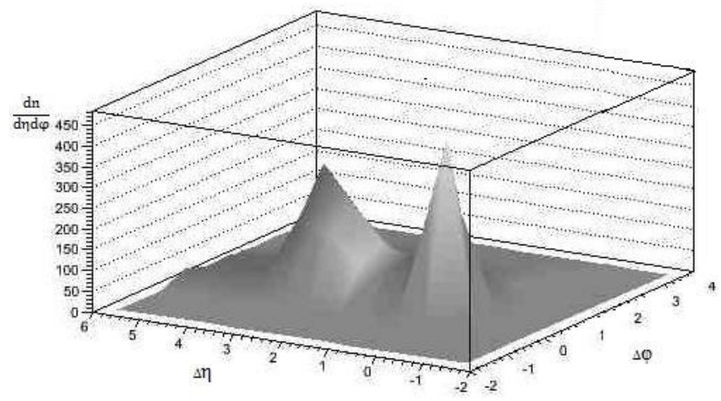


Figure 2 - the two-particle correlation function of pseudorapidity and azimuthal angles in PP-collisions obtained in cosmic ray experiments

As can it can be clearly seen from the figures 1 and 2 distinct structure in two-dimensional correlation function is observed in events with the high multiplicity. In comparison with result of two-dimensional correlation function in PP interaction at energy of 7 TeV in the LHC (Figure 1) should be noted that the resulting data have a good similarity with the two-dimensional data correlation function in cosmic rays (Figure 1). It can be concluded that in cosmic rays at approximately the same energies mainly protons are detected interacting with such light material as graphite. In future, these structures will be described with a simple model of "independent clusters" in order to quantify their strength (cluster size) and distribution of η (width of cluster decay). This is the first observation of such a structure in two-particle correlation function of cosmic ray particles interaction with matter.

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[5] Observation of Long-Range, Near-Side Angular Correlations in Proton-Proton Collisions at the LHC. The CMS Collaboration_ arXiv:1009.4122v1 [hep-ex] 21 Sep 2010.