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Elliptic flow in a nuclear interaction of an astroparticle at energy ~10^{16} eV

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107 cascades, produced in a 10^{16} eV nuclear interaction, were detected in a stratospheric emulsion chamber. Their azimuth distribution reveals a distinct anisotropy. Estimation of the elliptic flow coefficient v_2 gives a value of 0.35 ± 0.02. The p_t distribution of the cascade is also azimuth-anisotropic and its maximum coincides with the direction of the impact parameter.

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Introduction

Here we present an analysis of a nuclear interaction of a ~10^{16} eV astroparticle. The event has been detected by the stratospheric emulsion chamber at 30 km altitude. The route of the balloon ran from the Kamchatka peninsula to the Volga river basin. The flight duration was 150 hours. The probability of an event with ~10^{16} eV detected by a 0.25 m^2 detector is estimated to be about ~10^{-3}. The remarkably low probability of the event caused us to distinguish it with a proper name STRANA.

Experiment

Fig. 1 illustrates the layout of the nuclear interaction inside the chamber [1, 2]. In (A) an astroparticle collided with an air atom at 300m above the chamber [3]. 107 product particles (B) produced cascades (C) in the calorimeter lead layers. Particle energies and coordinates were derived from the sizes and positions of darkness in the X-films.

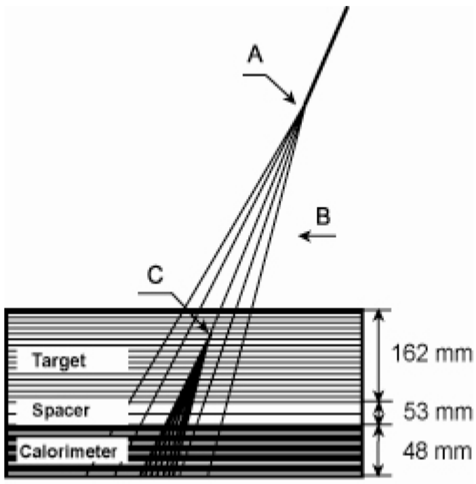

***Figure 1**: Nuclear interaction inside the chamber*

The detector was assembled with 100 Plexiglas layers (Target and Spacer) and 9 lead layers of total 9 cascade unit thickness (Calorimeter). All 109 layers were interspersed with 50 mcm nuclear emulsion spread over flexible triacetate base. The lead layers inside Calorimeter were additionally interspersed with X-ray films to detect electron-photon cascades. The Fig 2 illustrates an X-ray film image with spots of darkness in the central region of the STRANA event. The film was at the depth of 8 cascade units.

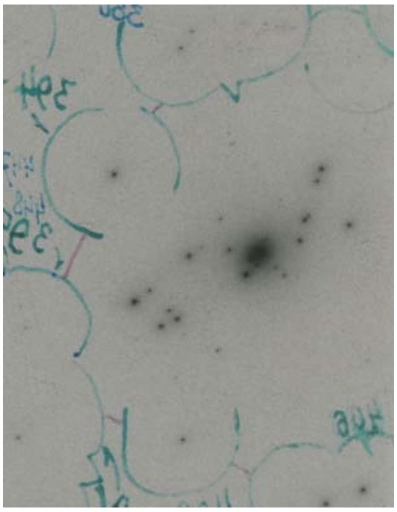

***Figure 2**: X-Ray event image at the depth of 8 cascade units*

Data and Analysis

The complexity of the detector allowed several measurements. In particular, we could measure the flow ellipticity at $\sim 10^{16}$ eV by analysis of the azimuth distribution of the secondary particles. As an ellipticity parameter the second harmonic coefficient v_2 of the Fourier transform has been selected [4]. Fig. 3 gives cascade distribution over the azimuth angles. The energy threshold for cascade detection was about 1 TeV. The angles were derived from the darkness coordinates, which were projected unto the plane normal to the astroparticle direction. Cascades were counted in 8 azimuth sectors of 45^o each. Noticeable loss in cascade number was only in two sectors: 0-45^o and 315-360^o, where essential part of the secondary particles escaped through the side planes of the chamber. Therefore distribution was approximated without taking into account the first and the last sectors, and the v_2 value was derived to be 0.35±0.02.

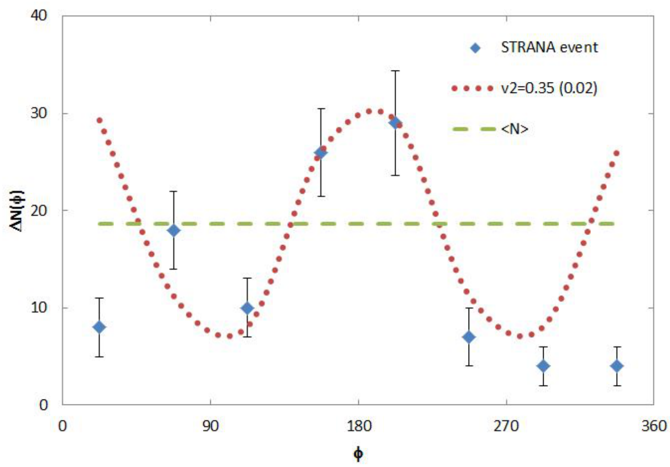

***Figure 3**: Number of cascades vs azimuth*

The symmetry of the azimuth distribution indicates to a small angle of the interaction parameter vector relatively to the particle incident plane. The value of v_2 taken from the above approximation turned out to be several times higher than those obtained for Pb-Pb collisions at LHC [5]. If the difference happens to depend on the primary particle nature, there might be an interesting possibility to measure the chemical composition of astroparticles at ultra-high energies.

Fig. 4 shows the distribution of transverse momentum over azimuth angle for the STRANA event. Despite high variations, the average values for pt in the direction of the interaction parameter (φ ~ 180^o) turned out to be higher 3 GeV. This might be the result of high pressures of ultra-relative matter in that direction [5].

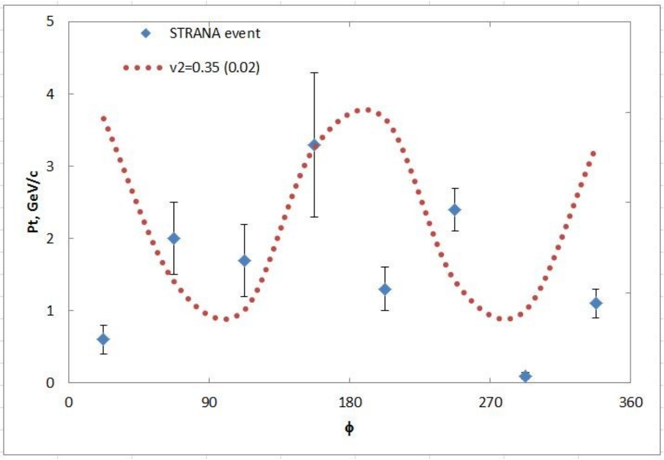

***Figure 4**: Transverse momentum vs azimuth*

Conclusion

Even at the success of the current experiments and further promising projects on particle accelerators [5], the results obtained in the analysis of the STRANA event indicate to a certain power of cosmic-ray techniques in the high-energy physics at 10^{15}-10^{16} eV. One of the major problems here arise due to an extremely low astroparticle flow. In order to overcome it, it is suggested to use long-term balloon flights along circumpolar routes [6]. A promising technique here would be application of scintillator detectors with fiber-optic readout.

References

[1] V. Osedlo, A. Managadze et al. *Anisotropic and Alignment Effects in STRANA superfamily with E_0 › 10^{16} eV*, 2007, *30 ICRC*, 4, 667-670

[2] O.D. Dalkarov, K.A. Kotelnikov, S.K. Kotelnikov. *Changes of interaction mechanisms in the knee region of the primary cosmic rays spectrum*, 2013, *33 ICRC*, 205

[3] V. Osedlo. PhD Thesis, Moscow University, 2007

[4] A.M. Poskanzer, S.A. Voloshin *Physical Review C*, 58,1671, 1998

[5] The ALICE Collaboration. [nucl-ex/1011.3914v2]15 Jun 2011

[6] A.S. Borisov, V.G. Denisova, K.A. Kotelnikov, et al. *Bulletin of the Lebedev Physics Institute*, 2011,38,6