Cosmic-ray double-core γ-family events at ultrahigh energies*

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This paper presents a detailed account of our analysis of ultrahigh-energy cosmic-ray double-core γ-family events observed in emulsion chambers at mountain levels. Extending the leading-order perturbative QCD jet calculations for hadron-hadron collisions to hadron-nucleus collisions by including nuclear effects, we performed a Monte-Carlo simulation of cosmic-ray particle interaction and propagation in the atmosphere [1]. We compared our simulation results with the data including the general properties of γ-family events and the special features of double-core events from from two experiments at Mt. Chacaltaya [2] and Mt. Kanbala [3].

We find a significant excess of event rates at large transverse momenta with respect to our prediction based on perturbative QCD in both sets of data. We also find that the excess cannot be accounted for by a compositeness model of quarks with a characteristic energy scale lower limit $\Lambda_c > 1.4$ TeV or a possible value of $\Lambda_c \simeq 1.6$ TeV from the CDF [4].

We discuss possible onset of new physics indicated by the large discrepancy at $E_{\rm lab} \sim 10^4 - 10^5$ TeV, an energy region beyond the reach of existing colliders but within the range of future hadron colliders such as the proposed Large Hadron Collider at CERN. It seems to be particularly feasible to study the new physics indicated by our analysis with a wide acceptance detector system designed for the dedicated study of forward physics at the LHC [5].

References

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