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HIGH LATITUDE GAMMA RAYS ASSOCIATED WITH VIRGO

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Abstract

A more detailed analysis is made of the energy spectrum of the diffuse component of extragalactic gamma rays over the range of 0.3-10 GeV, obtained from the EGRET instrument at the Compton Gamma Ray Observatory. The derived excess energy spectrum of high galactic latitude, $b>60°$, using intercept method shows that it is correlated with Virgo cluster (over lsr) and average Virgo intensity is about 20 percent of total diffuse extra galactic intensity. The Virgo predicted models seem to be overestimated.

Introduction

The search for the extragalactic origin of cosmic rays is of great importance because of its rich source of astronomical and cosmological information [1,2,5,6]. The anisotropy results of the highest energy cosmic rays $\geq 10^{19}$ - 10^{20} show that these, mainly proton particles, are of extragalactic origin [4]. The clusters of galaxies as the origin of ultra high energy cosmic rays have been postulated by some workers [1,3]. Moreover, it is proposed that these particles are produced in galaxies in the central regions of clusters. The particles diffuse out under the influence of randomly directed intergalactic magnetic fields. The estimated lifetime of cosmic rays in the local supercluster is on the order of 10^{10} years. Assuming a matter density of 0.2 g/cm^2 of material implies negligible probability of interaction. At the ultra high energies $\geq 5\times10^{19}$, however, there is an important interaction with the relic 2.7 k black body radiation. Cosmic ray protons (with constant rate) experience losses by way of interaction on their way out and energetic gamma rays are produced. The importance of the study of these extragalactic gamma rays is that they should give evidence on whether galaxy clusters, especially the strong Virgo cluster with its pronounced properties [2] (i.e. early stage of evolution, distance and its cell size of uniform magnetic field) is the origin of ultra high energy cosmic rays.

Keywords: Gamma Rays; Virgo cluster of galaxies

Data Analysis

The data used is from the latest gamma ray satellite (Compton Gamma Ray Observatory) the preliminary results of which are given in the paper of Osborne *et al.* [1]. Gamma ray energy range is from 35 MeV to 100 GeV. The data in that paper has been presented in galactic latitude $|b|$ = 10-20, 20-30, 30-40, 40-60 and $b>60°$. In the present work, gamma ray energy bands were chosen to be 30-50, 50-70, 70-100, 100-150, and 150-300 MeV, 0.3-0.5, 0.5-1, 1-2, 2-4, 4-100 GeV, where the last energy band was not considered. We looked at different galactic quadrants and energy bands for excess of extragalactic gamma ray for $b>60°$ associated with Virgo (4th quadrant of galaxy with coordinates of l = 284, b = 74 deg). The extragalactic gamma ray intensity, I_0, is defined as the intercept of gas at zero column density of gas, $N(H) = 0$. It is experimentally proved that galactic gamma ray intensity ($b<10$) is proportional to the column density of gas along line of sight. For comparison, the data was also analyzed for $b<-60$ degree.

Graphs of extragalactic excess of gamma rays, δ, δ/I_0 versus gamma ray energy for $b>60°$ and $b<-60°$ and each galactic quadrant are shown in Figure 1. From the figure, significant gamma ray excess is shown in 4th quadrant of $b>60°$, the Virgo direction. For $b>60°$ we calculated $\Delta = [(\delta_{III} + \delta_{IV}) - (\delta_I + \delta_{II})]/2$, and obtained the graphs Δ and Δ/I_0 versus gamma ray energy which present the energy spectrum for the excess associated with Virgo.

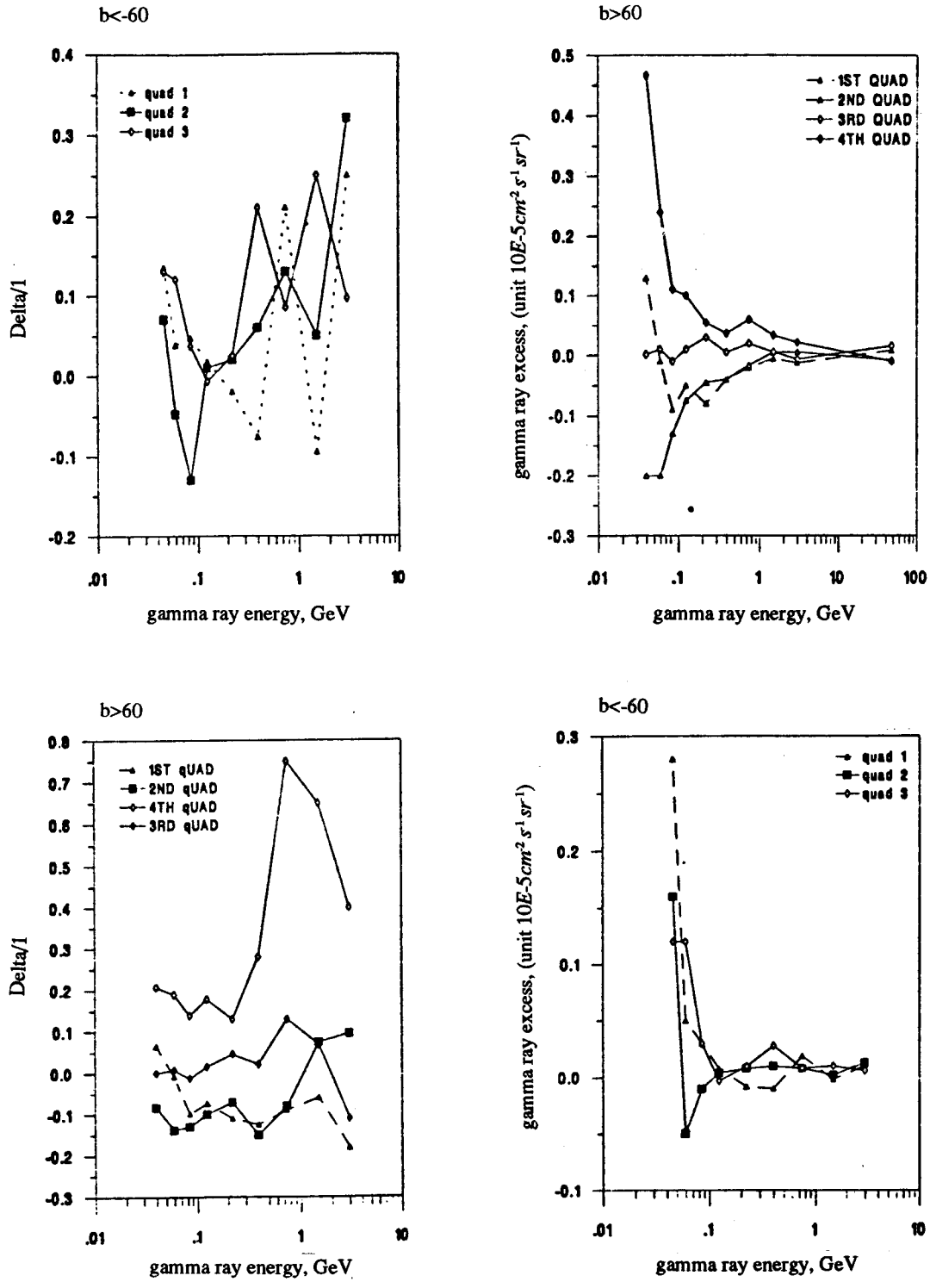

Figure 1. Differential and relative high latitude gamma ray excess versus gamma ray energy for b>60° and b<-60° and for different galactic quadrants

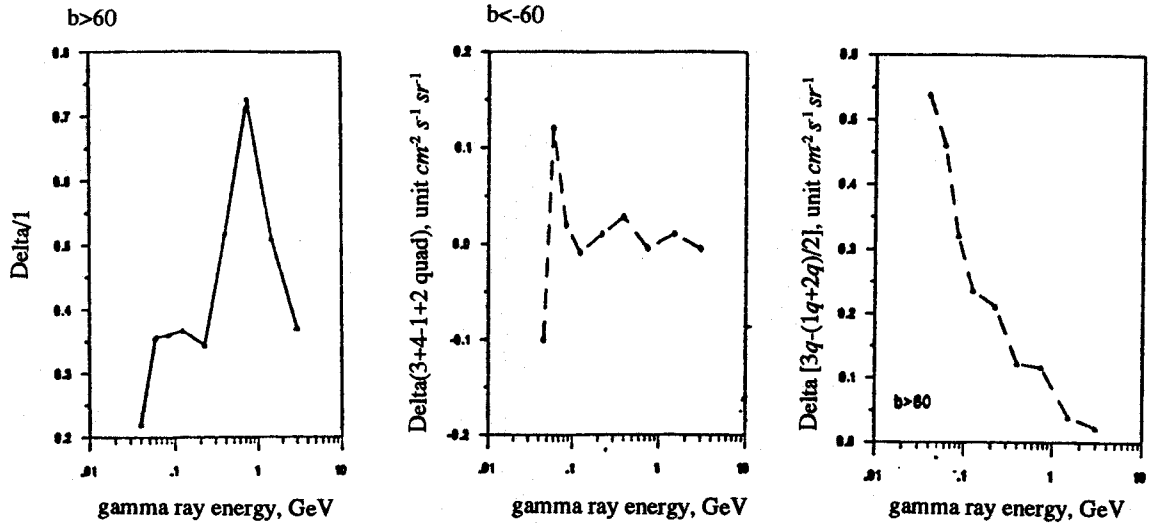

Figure 2. Differential and relative energy spectrum for the excess Δ, Δ/I associated with Virgo b>60°. For comparison the excess Δ for b<-60° galactic latitude is also shown

Figure 2 shows the calculated mean intensity from Virgo (over about lsr) to be 20 per cent of total diffuse extragalactic intensity [1, Fig. 3]. For comparison of the result we repeated for b<-60° and calculated $\Delta = [\delta_{III} - (\delta_I + \delta_{II})/2]$ where the values, which are shown in Figure 2, turned out to be negligible.

Predicted Models

Besides the galaxy cluster models of origin of cosmic rays, which were mentioned earlier, Wdowczyk *et al.* [2] have also developed the model of Giler *et al.* [3], where a significant fraction of extragalactic cosmic rays comes from Virgo. They calculated predicted gamma ray intensity at 10^{14} eV, with respect to the angular deviation from the direction of Virgo, with the diffusion coefficient $D = 10^{35} E_{20} cm^2 s^{-1}$ named as model A and $D = 10^{34} E_{20}^{0.5} cm^2 s^{-1}$ as model B (E_{20} unit 10^{20} eV). They assumed that other clusters emit radiation at the same level as Virgo. For comparison with theoretical models, the expected spectrum from Virgo at energy 10^{14} eV was also converted to integral, (approximate integral of gamma ray intensity 0-30 degrees from direction of Virgo [2]) and then extrapolated to lower energy, assuming noncosmological model of gamma ray energy spectrum. The observed extrapolations and predicted models are shown in Figure 3.

Conclusion

The observed energy spectrum of Virgo cluster is shown in Figure 3. It reflects relatively that gamma ray

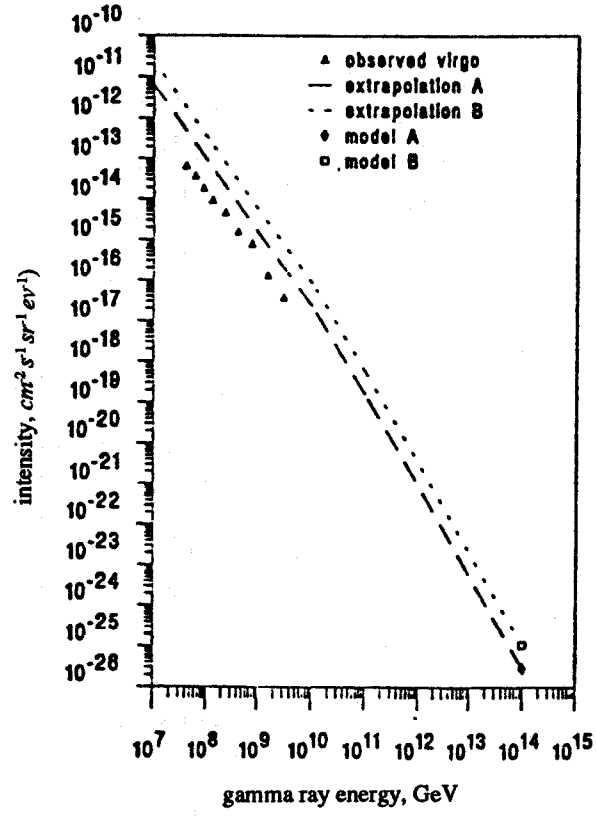

Figure 3. Virgo intensity (mean by b>60°) with predicted models. Extrapolations by assuming energy spectrum of noncosmological model

intensity is increasing (see Figure 1, 4th quadr) with energy and on average is calculated to be 20 per cent of the actual diffuse extragalactic background ($\sim 10^{-6}$ $E_\gamma^{-2.11}$cm^{-2}s^{-1}sr^{-1}GeV^{-1}). Discrepancy with the predicted models could be due to energy dependence on different origins of high energy gamma rays, or due to uncertainty of the parameters chosen in the predicted models (i.e. magnetic field of extragalactic space and its scale of irregularities, diffusion coefficient and the other cluster parameters as the local cluster density). In conclusion, there is strong experimental evidence in favor of cluster model or Virgo cluster for the origin of ultra energy cosmic rays.

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