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12. Revised by

Daniel J.R. Nordemann

9. Authorship

U.B. Jayanthi
I.M. Martin
K.R. Rao
J.O.D. Jardim

Responsible author

13. Authorized by

Nelson de Jesus Parada
Director

14. Abstract/Notes

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COSMIC DIFFUSE GAMMA RAYS-BALLOON OBSERVATIONS AT EQUATORIAL LATITUDE*

U.B. JAYANTHI; I.M. MARTIN; K.R. RAO; and J.O.D. JARDIM; Instituto de Pesquisas Espaciais, (INPE); Conselho Nacional de Desenvolvimento Científico e Tecnológico, (CNPq); São José dos Campos, SP, 12200, Brasil.

ABSTRACT. From the data obtained in a balloon flight made at São José dos Campos in 1979, we derive the spectral results for the diffuse background. The method of analysis employs atmospheric growth curves for deduction of the atmospheric background at a ceiling altitude of 4 mbar. The spectral results for the diffuse background in the 0.28-4.35 MeV indicate excess of flux above 1 MeV in agreement with the results reported by other experimenters. The presence of 0.51 MeV positron-electron annihilation line in diffuse component is evident from our observations.

RESUMO. *Radiação gama cósmica difusa - observações em balão em latitude equatorial.* A partir dos dados obtidos em um vôo de balão realizado em São José dos Campos em 1979, derivamos os resultados espectrais para o ruido de fundo difuso. O método de análise utiliza curvas de crescimento atmosférico com a finalidade de obter o ruido de fundo atmosférico para uma altitude de 4mb de atmosfera residual. Os espectros obtidos para o ruido de fundo difuso contínuo na faixa de 0.28-4.35 MeV indicam um excesso de fluxo acima de 1 MeV, concordando com os resultados

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publicados por outros experimentadores. A presença da componente difusa da linha de aniquilação elétron-pósitron (0.51 MeV) é evidente nas nossas observações.

INTRODUCTION

The existence of diffuse gamma radiation has now been well established and efforts are being continued to improve the precision in these measurements. This radiation perhaps may consist of contributions from individual galaxies and truly diffuse cosmic component. Among the individual galaxies 3C 273 has been confirmed to have gamma emission (Swanenberg et alii, 1978) and few reports have been published concerning Seyfert Galaxy NGC 4151 (Schönfelder, 1978). Isotropy measurements by Trombka et alii (1977) indicate 20 percent contribution from galactic plane. Estimates of superposition of γ radiation from various galaxies based on X-ray data exceed the observed flux and clearly stress the need for a change in spectral shape between x and γ ray energy regions (Bignami et alii, 1979). The diffuse isotropy models depend on the contribution from high energy interactions in intergalactic space. Among these, the models that explain gamma radiation as resulting from the decay of π^o mesons produced either in interactions of cosmic rays at high redshifts (Stecker, 1969) or in matter-antimatter annihilation (Stecker et alii, 1971; Stecker, 1978). These have better success in explaining the break in the observed spectrum at $\sim$ 1 MeV due to excess production of MeV photons that these models predict.

In view of the theoretical implications of the origin of this radiation, measurements have now concentrated in accurate determination of its energy spectrum. The detected flux in balloon experiments contains both diffuse cosmic radiation and atmospheric background. The greatest inaccuracy in these measurements is due to the large atmospheric background consisting of atmospheric γ rays and interactions in detector due to particle environment. We present here the results of observations of this diffuse component made at an equatorial latitude ($\lambda = 12^{o}S$), where the atmospheric contributions to the background are much lower, compared to high latitudes ($\lambda \sim 45^{o}N$).

EXPERIMENT DETAILS

The results presented here have been obtained from observations made with SOURCE II telescope flown for discrete sources observations. The telescope consisted of two identical 4" x 4" NaI(TI) detectors, with a vertical separation distance of 1.8 meters. An absorber consisting of aluminium and paraffin was placed midway between the detectors. The γ-ray events registered in the top detector assembly, an isotropic detector without any collimation and no material surrounding the detector within 50 cm, have been utilised for our calculations. The events, with energy losses between 0.28 and 4.35 MeV in the detector, have been pulse height analysed with a 128 channel analyser. Pressure data, to an accuracy better than $\sim$ 0.5 mbar, have been obtained by Rosemount .barometers. The encoded pulse height data and house keeping information,telemetered to ground via FM-FM system, were recorded on magnetic tapes.

Preflight calibrations included the determination of response of each detector to gamma ray sources Cs^{137}, Na^{22}, Co^{60} and Am-Be. The detectors had a typical resolution ∿ 15 percent at 0.66 MeV. The SOURCE II telescope flown by a stratospheric balloon was launched from São José dos Campos ($23^{o}12$'S,45^{o}W) on March 31, 1979 at 04:30 UT. The balloon reached a ceiling of 4 mbar altitude at 06:08 UT and floated for six hours. The performance of the eletronics and the detector during the flight was satisfactory, as observed by the count rate information and 0.51 MeV atmospheric positron annihilation line.

RESULTS AND DISCUSSION

a) Continuum Spectrum:

The raw counting rates registered in the various energy channels, throughout the atmospheric ascent of the balloon, have been utilised to derive the atmospheric background of the continuum in the 0,28 to 4,35 MeV range. The comparison of our background counting at 4mbar atmosphere with the results of Trombka et alii (1977) obtained in Apollo 15 experiment has shown higher background rates in our omnidirectional detector by factors $\lesssim 2.0$ and much less than the values registered by detectors flown on balloons at high latitudes (Jayanthi et alii, 1982).

For the purpose of evaluation of diffuse background, we have grouped the counting rates into seven energy bands (0.28-0.40 MeV; 0.57-0.96MeV; 0.96-1.43 MeV; 1.43-1.90 MeV; 1.90-2.38 MeV; 2.38-2.85 MeV and 2.85-3.8 MeV) to provide statistically significant data. In Figure 1 we show the

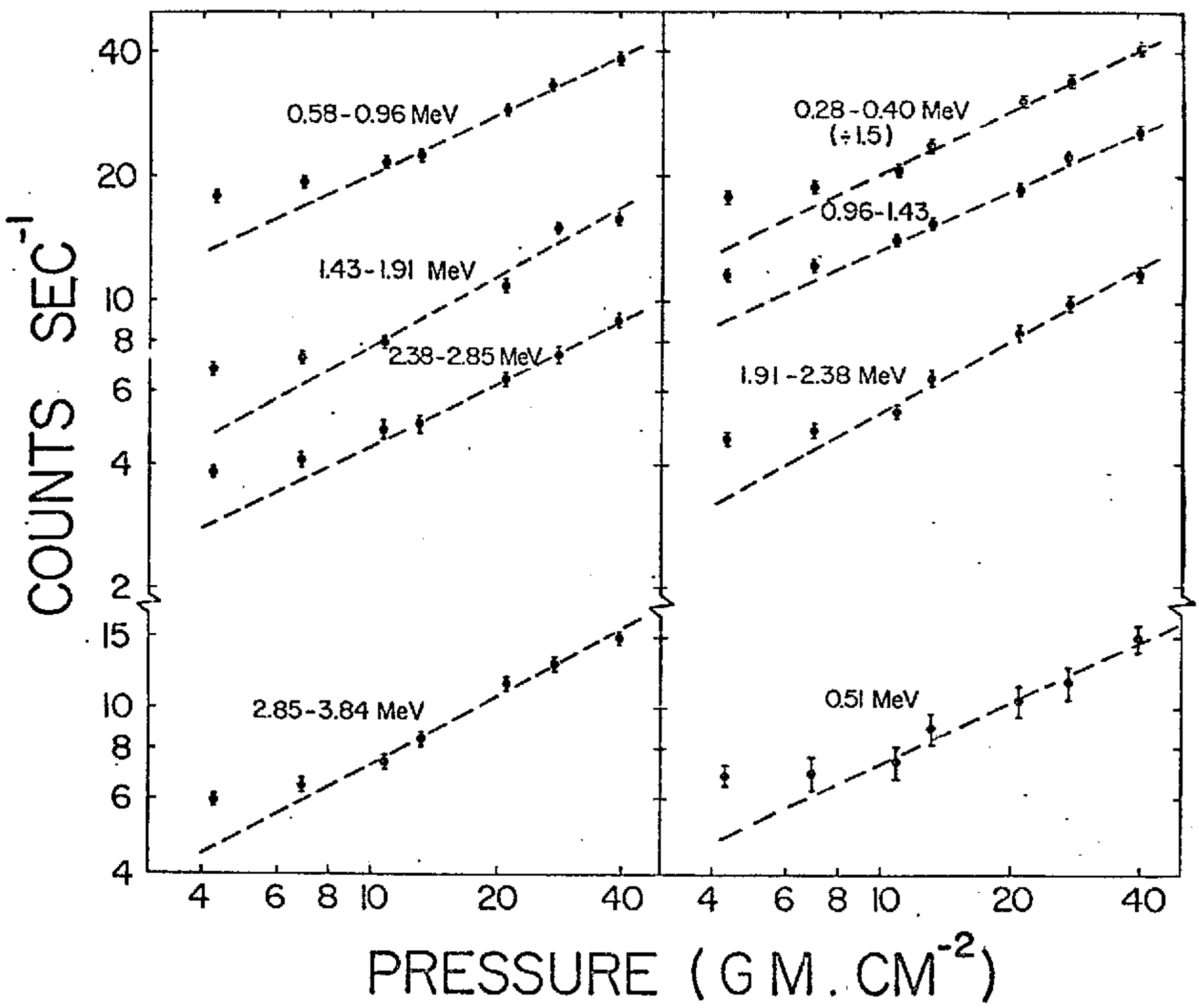

Fig. 1 - The atmospheric γ-ray count rates in various energy bands as a function of atmospheric altitude in SOURCE II flight. The dashed lines represent linear fits to the data.

growth curves of the count rates obtained for 5 min duration bins in these energy bands, as a function of the atmospheric depth for altitudes above 40 g cm $^{-2}$. In the absence of any theoretical models for the growth curves, we have chosen linear fits to the atmospheric background between 40 g cm^{-2} and 10 g cm $^{-2}$. The deviations from the extrapolated values at altitudes above 10 g cm^{-2} indicate the presence of diffuse radiation, as at the reach of the float no known sources have transited. The only known γ ray source, galactic centre, transited three hours afterwards. These extrapolation fits have been extensively employed in X and γ ray diffuse background measurements (Bleeker and Deerenberg,1970; Daniel et alii, 1972. White et alii 1977). The slopes for the individual fits have dispersion less than 10 percent around a mean value of 0.52. The excess counts registered at the float altitude above the growth curve extrapolated values, were converted into photon flux, taking into consideration the directional response of the telescope and the atmospheric attenuation for the omnidirectional detector.

In Figure 2 we have plotted the derived cosmic diffuse γ - radiation spectral measurements. Also plotted are the results obtained by Trombka et alii (1977), Mandrou et alii (1979) and Schönfelder et alii (1980) in the 0.3 to 10 MeV range for comparison among the published observations. The results of Trombka et alii (1977) were obtained from observations made by omnidirectional detector with charge particle rejection system on Apollo mission and employed extensive analysis to remove the various background contributions due to spacecraft and detector, neutron activation, natural radioactivity etc. The results of Mandrou et alii (1979) were obtained from detectors with active collimation for γ rays flown on balloons at 3g cm^{-2} and 2.4 g cm^{-2} altitudes in France and Brasil respectively. They have subtracted from the float count rates the total background estimates due to atmospheric photons using semi empirical fit method of Lin (1975), neutron induced background in the CsI(Tl) shield and spallation. The large area Compton telescope results of Schönfelder et alii (1980) in a balloon flight at 3.5 g cm^{-2} altitude employed atmospheric growth curves in the 1-20 MeV energy range. Our spectral results are in satisfactory agreement with the balloon observations of Mandrou et alii (1979) and Schönfelder et alii (1980). In comparison with the Apollo results, we obtain higher values for our measurements by $\lesssim$ 2 factors. The lack of charged particle rejection system perhaps accounts for this discrepancy.We have employed omnidirecional detectors and the effects due to neutron induced activity at equatorial latitude in Na(Tl) crystal are negligible compared to the atmospheric photon background(Mandrou et alii, 1979).

As mentioned in the introduction, the gamma energy spectral results in the 0.3 to 5.0 MeV for the diffuse background is of interest because of the suggested break. The near smooth connection in the spectra of hard x rays (0.02-0.2MeV) and the high energy γ region (30-100 MeV) suggest an excess of photons around 1 to 5 MeV energy band. Although this bump is evident in all the measurements, the statistical uncertainties prevent from drawing a certain conclusion (Trombka et alii 1977).Our results agree in the 0.28-1.5 MeV range with a spectral index ~ -2.0 noticed at hard x-ray region.The spectral shape flatten to ~ -1.5 in the 0.96 to 4.31 MeV range, in essential agreement with other observations.

b) 0.51 MeV GAMMA LINE

The peak at 0.51 MeV line due to positron-electron annhilation is seen in all spectra at altitudes above 600 g cm^{-2}. The flux at this peak was estimated by subtracting the background (obtained by least-square fit to the adjacent channel count rates) from the count rates in the channels that contain this line flux. The atmospheric growth curve for this line flux is shown in Figure 1. The flux measured in our flight at 4 mbar altitude is 0.084 ± 0.005 photons cm^{-2} sec^{-1} at our geomagnetic latitude $\lambda \sim 12^o$. This value is in essential agreement with the observations of other groups at equatorial latitudes (Jayanthi et alii, 1982). As in the case of continuum the extraterrestrial flux can be evaluated from the extrapolation of the growth curve which represents the atmospheric contribution. We obtain for the cosmic component a value of 0.074 ± 0.018 photons cm^{-2} s^{-1} after taking into consideration the angular response of the detector, the atmospheric absorption and the photo-peak efficiency.

In diffuse extraterrestrial gamma radiation, this line has been predicted and to date except for the results of Albernhe et alii (1979) others provided essentially upper limits (Metzger et alii, 1964; Ling et alii, 1977 and Trombka et alii, 1973). The results of Albernhe et alii (1979) have been obtained from balloon flights conducted in

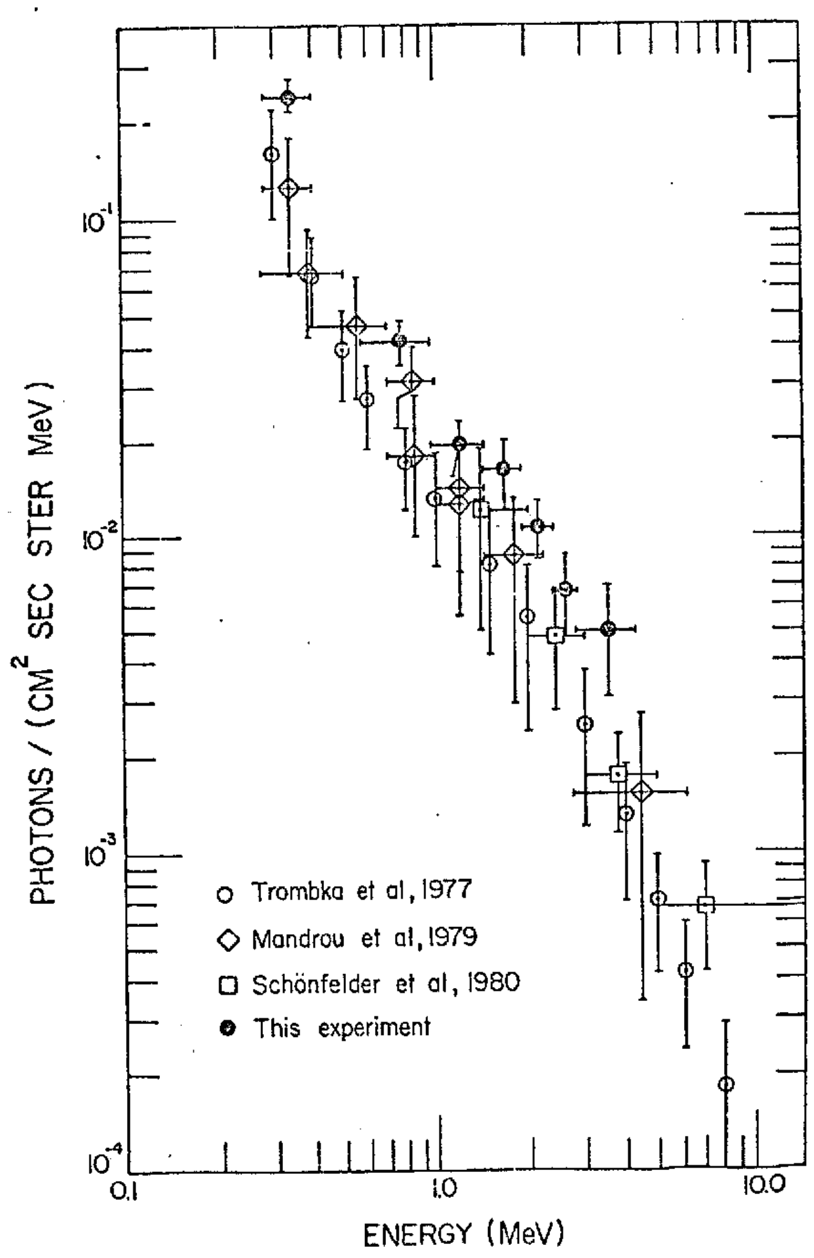

Fig. 2 - The spectral observations of diffuse gamma ray background by different experimenters.

France and Brasil in 1972 and 1973, respectively. They derived the diffuse componente flux from their Brazilian flight data, employing the slope of the growth curve observed in their French experiment for the extrapolation. This assumes that the diffuse component flux at the latitude of $\lambda = 45^{o}N$ is negligible. Their observations report a value of $(4.3 \pm 1.5) \times 10^{-2}$ photons $cm^{-2}\ s^{-1}$ compared to ours. However if we employ the technique we have utilised for their atmospheric growth curve slope, the results for this diffuse component flux identically agree with our value and give confidence in our observations. The results of Trombka et alii (1973) on Apollo experiment gave 0.030 ± 0.015 photons $cm^{-2}\ s^{-1}$. In view of the complex system of analysis employed for the observations by various groups, the agreement among the various observations seems to be satisfactory and clearly establishes the presence of this line in the diffuse component.

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