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A Southern Hemisphere Search for a Nonrandom Component in Cosmic Rays

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Abstract

A search has been made for a nonrandom component in Southern Hemisphere cosmic radiation with energies greater than $\sim 10^{14}$ eV. We find no evidence to correspond to the positive effect reported in the Northern Hemisphere by Bhat *et al.*

In a recent paper, Bhat *et al.* (1980) presented evidence suggesting that there may be a large nonrandom component in cosmic rays of energy $\geqslant 10^{14}$ eV, with a Northern Hemisphere point-source origin. Some corroborative evidence has also been presented by Badino *et al.* (1980). We have searched for similar effects in the Southern Hemisphere and have been able to place an upper limit on such a flux in the Southern Hemisphere which is well below any of the reported fluxes.

Bhat *et al.* (1979) studied the time spacing distribution of cosmic ray showers detected by atmospheric Cerenkov light coincidence systems. They showed that the showers which they detected (with energies $\gtrsim 10^{14}$ eV) have time spacings which are not exponentially distributed (as expected for random events) but, in fact, have an appreciable excess of time spacings below ~ 30 s. They examined the arrival times of showers corresponding to these spacings and showed that there is an appreciable excess from celestial right ascensions 05 ± 03 hr (Bhat *et al.* 1980). The overabundance constitutes $\sim 12\%$ of the total events. Badino *et al.* (1980) similarly examined the time distribution of muons from primary cosmic rays of energy $\gtrsim 5 \times 10^{13}$ eV and found $\sim 1\%$ excess of total muons with time spacings below $37 \cdot 5$ s. Bhat *et al.* used a total of 9879 events and Badino *et al.* recorded 5894 muons. Clay and Gerhardy (1980) described a study of time spacings for showers with primary energies $\gtrsim 10^{15}$ eV and found no significant excess ($< 3\%$) at small intervals for a total of $\sim 80\,000$ events. We have now studied showers with primary energy thresholds of $\sim 2 \cdot 5 \times 10^{14}$ and $\sim 1 \cdot 5 \times 10^{14}$ eV and again find no evidence for a nonrandom excess.

We used pairs of scintillator particle detectors in the Buckland Park Air Shower Array (Crouch *et al.* 1981) (latitude 35° S.), firstly with a spacing of 42 m and later with spacing 30 m. The detectors (each of area 1 m^2 and thickness 50 mm) were operated in coincidence with individual discriminators set at the two-particle level. Coincidences between the pair of detectors were used as inputs to a Commodore PET computer which measured the spacings between coincidences using its internal clock and recorded the spacing distribution. When detectors with a spacing of 42 m were used, a mean period between coincidences of 65 ± 1 s was obtained and this configuration was used to accumulate 8803 events. An exponential fit to these data gave a probability of 15% that these events were random in time, on the basis of a chi-squared test. The data were then analysed by fitting an exponential to spacings greater than 30 s and comparing this function with the data for spacings below 30 s. An excess of 124 events was found in the spacing interval below 30 s, corresponding to a 1·4% excess when compared with the total flux. A similar procedure was used for the 30 m spacing, for which 37 882 events were recorded with a mean spacing of 39 s. There was a probability of 50% on the basis of a chi-squared test that all these data fitted a simple exponential time distribution. An excess of 493 events was found for spacings below 30 s, 1·3% of the total flux.

However, we *expect* that the full spacing distribution will not be a true exponential since the mean rate of events will change with time producing a sum of exponentials. This resulting distribution will approximate to an exponential but will have an excess at low spacings (see e.g. Clay 1974). The main cause of rate changes for our experiment is expected to be atmospheric pressure variations and we therefore ran the experiment again (30 m spacing) but with a digital barometer also connected to the PET, and accumulated independent spacing distributions in six 5 mbar pressure intervals from 1000 to 1030 mbar. As expected, the mean rate varied as a function of atmospheric pressure and a fit to the mean rates of the pressure intervals produced an air shower barometric coefficient of 10·0% $(\mathrm{cmHg})^{-1}$ (1 cmHg $\equiv$ 1·33 kPa), close to values found in the literature (Bennett *et al.* 1962).

We have therefore taken the spacing distributions for the two most populous pressure intervals (a total of 31 539 events out of $\sim$55 000 total events), fitted exponentials to predict how many events should be in the 0–30 s interval period of each, and compared the predictions with the observed totals. We predict from our data, on the basis of random events, that $16\,665 \pm 87$ events would be found with spacings of 0–30 s in the combined pressure interval 1015–1025 mb, and we find experimentally $16\,653 \pm 129$ events. We thus find no evidence for any unexpected departure from a random spacing of our events in the spacing interval discussed by the other workers.

In conclusion, for cosmic ray showers with energies above $\sim 10^{14}$ eV we have been unable to find any evidence to confirm observations by Bhat *et al.* (1979) and Badino *et al.* (1980) that there is a departure from randomness in cosmic ray arrival times. It may be that their effect is due to a Northern Hemisphere source as they suggest. This would be outside the limits of our normal zenith angle (hence declination) distribution of showers, which extends up to $-5°$ in declination. We can say however, that any Southern Hemisphere equivalent is below 5% of the flux of the observation claimed by Bhat *et al.*

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