Performance of a local electron density trigger to select extensive air showers at sea level.

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Abstract

Time coincident voltage pulses in the two closely spaced (1.6m) plastic scintillators have been recorded. Most of the recorded events are expected to be due to electrons in EAS whose cores fall at some distance from the detectors. This result is confirmed from a measurement of the frequency distribution of the recorded density ratios of the two scintillators.

Introduction. A threshold local electron density selection requirement is the simplest method of detecting extensive air showers. With this system the minimum shower size (and hence primary energy) that produces a threshold trigger is reasonably well defined but for a given recorded density, showers with a wide spread of core distance and shower size can satisfy the trigger requirement. Near the shower core (<1m) the electron density is believed to increase more rapidly with decreasing core distance than at larger core distances and it is possible that small core distance showers could be selected by a density ratio requirement.

Experimental arrangement and results. EAS were selected by a twofold coincidence Δ_A ($\geqslant 27.5\mathrm{m}^{-2}$). Δ_B ($\geqslant 27.5\mathrm{m}^{-2}$) between two plastic scintillators A and B each of area 80 x 50 cm = $0.4\mathrm{m}^2$, their long sides being parallel and their centres being separated by a distance of 1.6m. For each trigger the number of particles N_A and N_B traversing each scintillator was recorded using a computerised data acquisition unit and figure 1 shows the frequency distribution of the density ratio N_A/N_B and also N_B/N_A. It is seen that the most probable value of the frequency ratio is close to unity in both cases and that the distributions show a long tail. The peaking of the density ratio at a value close to unity is consistent with the known slope of the electron density lateral structure function as a function of core distance and the estimates of the median core distance of showers that produce a local electron density greater than some threshold value are shown in table 1 (Ashton and Parvaresh, 1975).

The data can also be used to evaluate the integral density spectrum of electrons at sea level and the result is shown in figure 2 where the minimum of the two recorded densities was used in evaluating the integral spectrum. For density thresholds in the range $2\text{-}40\mathrm{m}^{-2}$ the integral spectrum was measured directly by counting the rate of twofold coincidences. It is seen from figure 2 that the present measurements are consistent with the best estimate given by Greisen (1960)for $\Delta > 27.5\mathrm{m}^{-2}$ but that for smaller densities a somewhat larger rate is observed. Also shown in figure 2 is the response of the two counters A and B measured individually to the global cosmic ray flux where the output pulse height from either detector is plotted in terms

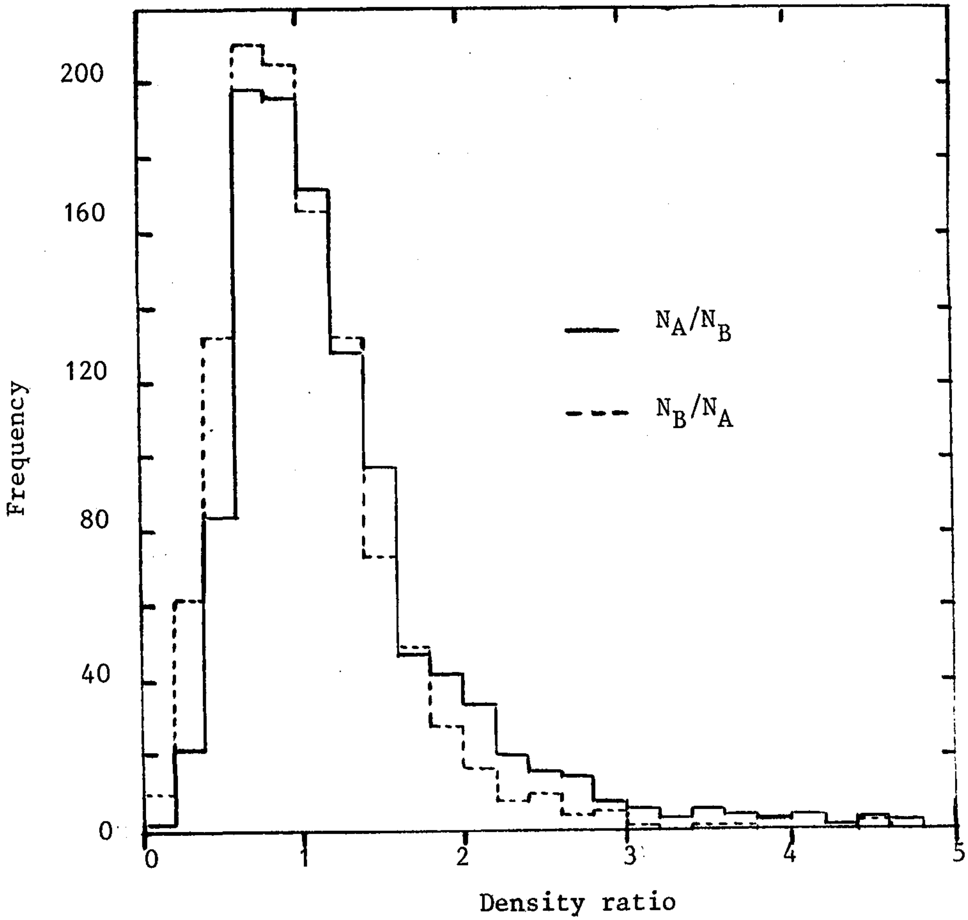

Figure 1. Frequency distribution of the ratio N_A/N_B where N_A, N_B are the number of particles traversing scintillators A and B which each have area $0.4m^2$. EAS were selected by requiring $\geqslant 11$ particles to traverse both scintillators simultaneously and the ratio N_A/N_B is evaluated if both N_A and N_B satisfy $11 \leqslant N \leqslant 134$ as the passage of >134 particles through either scintillator saturated the recording system. Total number of shower triggers =1184. Number of evaluated density ratios =1122. i.e. 62 shower triggers saturated at least one channel of the recording system. Number of observed triggers with $N_A/N_B>5$ and hence not plotted in the figure =10 (N_A/N_B = 8.1, 10.3, 7.6, 8.1, 5.5, 6.4, 7.7, 8.6, 6.2, 6.4). Also plotted is the ratio N_B/N_A (dashed histogram). Number of observed triggers with $N_B/N_A>5$ =2 (N_B/N_A=6.2,5.7).

of the equivalent density of particles traversing it. Extrapolating the measured distributions suggests that for $\Delta \geqslant 600m^{-2}$ EAS could be selected using only a single detector rather than the coincidence between two detectors as used in the present work.

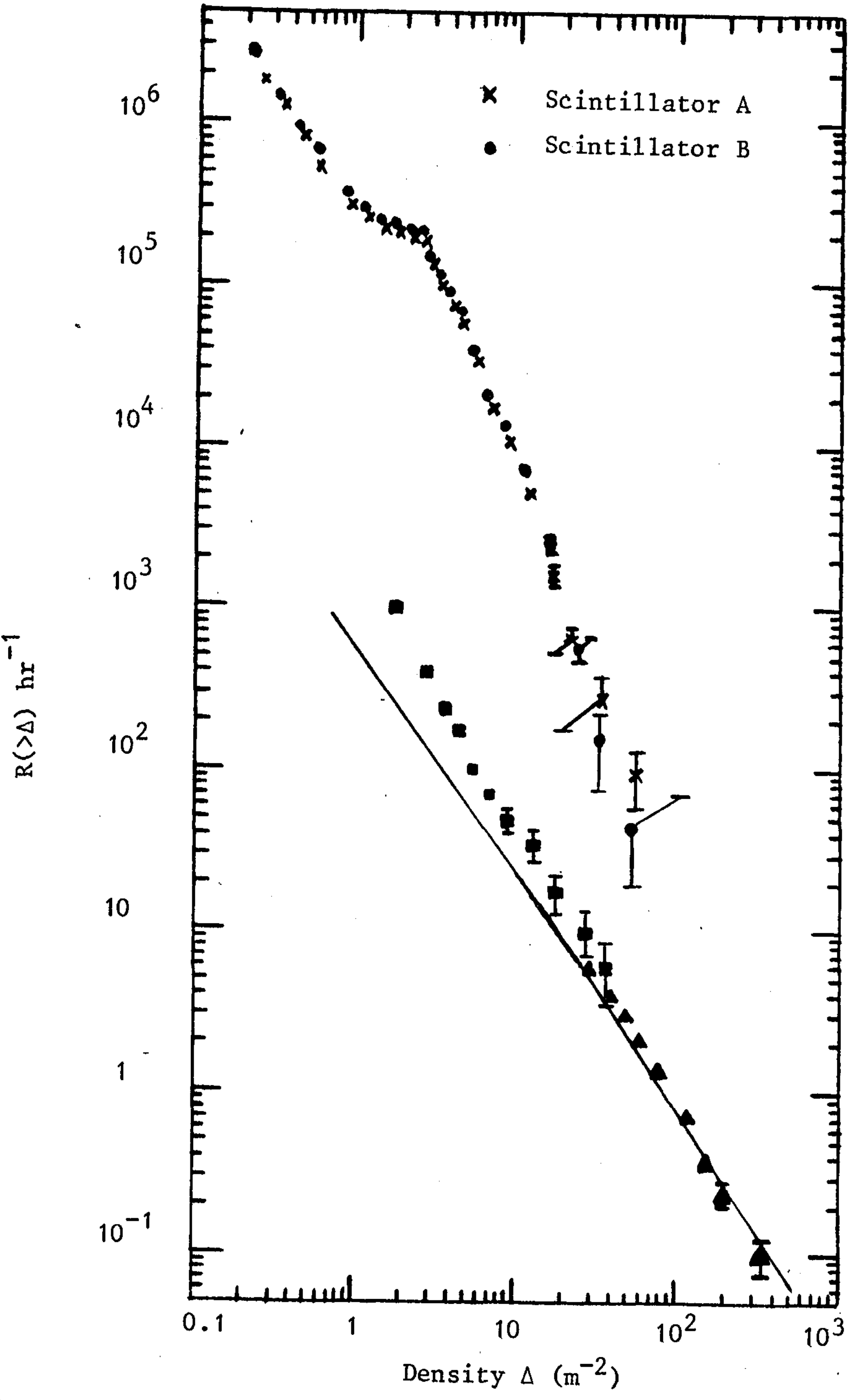

Figure 2. Integral rate response of scintillators A and B (each of area 0.4m^2) to the global cosmic ray flux. The pulse heights recorded by each scintillator have been converted to the number of equivalent particles traversing the scintillator at normal incidence and then expressed in terms of the density of equivalent particles incident on the scintillator. The traversal of the scintillator by single particles

Caption to Figure 2 continued.
corresponds to a density of 2.25m^{-2}. Also shown is the electron density spectrum measured using a twofold coincidence requirement. At small densities (■) the measurements were made by twofold coincidence counting while at high denities (▲) a computerised data acquisition unit was used. The solid curve is the expression.

$$R(>\Delta = 540\ \Delta^{-(1.3+.055\log_{10}\Delta)}hr^{-1}$$

for the sea level electron density spectrum given by Griesen (1960).

Threshold density (m^{-2})	Median core distance (m)	Median shower size	Minimum shower size
1	30	3.5.10^{4}	8.0.10^{2}
10	15	1.5.10^{5}	1.7.10^{3}
40	11	2.1.10^{5}	5.5.10^{3}
300	6	7.0.10^{5}	3.0.10^{4}
1,000	3.5	1.5.10^{6}	8.0.10^{4}

Conclusion. The value of almost unity for the most probable value of the density ratio is consistent with the core distance of most of the showers falling at distances large compared with the separation (1.6m) of the counters A and B. The events observed in the tail of the distribution are interpreted as having a decreasing core distance, the larger the value of the density ratio.

References.

Ashton, F., and Parvaresh, A., 1975, Proc. 14th Int. Cosmic Ray Conf. (Munich), 8, 2719 - 2724.

Griesen, K., 1960, Ann.Rev.Nuc.Sci., 10, 63 - 108.