STRUCTURE OF LARGE AIR SHOWERS AT DEPTH 834 G CM^{-2} FLUCTUATIONS

John Linsley

Department of Physics and Astronomy, University of New Mexico
Albuquerque, New Mexico 87131, U.S.A.

It is shown that parameters α and η, which describe the lateral structure of air showers, are not unique functions of size and zenith angle. Values that were measured for 366 large showers form distributions whose natural breadth, corrected for 'reception fluctuations' is approximately 20% for α and 5 to 8% for η. The breadth of the η-distribution depends on zenith angle. It is greater for showers that penetrated a greater thickness of air.

1. Introduction. This is a continuation of the preceding paper, which I will refer to as (I). I will assume that (I) has been read and will be consulted for definitions and other background information. The results given there apply principally to the problem of energy calibration. Those given here apply to problems of determining the nature of high energy interactions, and of determining the mass spectrum of the primary particles.

2. Method and Results. The computation used for deriving values of α and η proceeds in steps, by iteration. The results to follow were derived from the output of Step 2, described in Table 1 of (I). The present results are preliminary. Final results will be given by Step 3, which has not yet been carried out.

The result for α was derived from a fraction ($\sim 1/3$) of the events, chosen by objective criteria favorable to accuracy in measuring that parameter. A search disclosed no systematic dependence of α on size or zenith angle, so this fraction was treated as a homogeneous group. Figure 1 shows a histogram of the measured values. The same values are plotted individually in Figure 2 of (I). The rms deviation from the mean, and the arithmetic average standard error of measurement, are given in Table 1. The quantity adopted here as 'natural breadth' of the α-distribution (or any of the η-distributions) is given by the following expression:

$$\left[(\text{mean square deviation}) - (\text{mean std. error})^2\right]^{\frac{1}{2}} \qquad (1)$$

In case of η, I used Equation 4 of (I) to calculate, for each event, the deviation between the measured value and the expected value. I then grouped the deviations according to zenith angle, using 80 g cm^{-2} increments of atmospheric thickness, as in (I), and calculated the remaining results given in Table 1. (The last row of values is exceptional in one respect; it belongs to an 'overflow' bin, depth range 1234-1560 g cm^{-2}.) Figure 1 shows histograms of the measured η-values for 2 of the θ-bins. In Figure 2, the natural breadth of the η-distributions is plotted as a function of atmospheric depth.

Table 1. Breadth of structure parameter distributions.

parameter	atmospheric depth	rms deviation	standard error	rms breadth		number of events
α	-----	0.276	0.094	0.260	± .018	120
η	874 g cm^{-2}	0.187	0.072	0.173	.013	104
"	954	0.187	0.073	0.173	.014	89
"	1034	0.215	0.080	0.200	.020	62
"	1114	0.261	0.080	0.249	.031	37
"	1194	0.289	0.081	0.278	.038	31
"	1378	0.274	0.079	0.262	.042	23

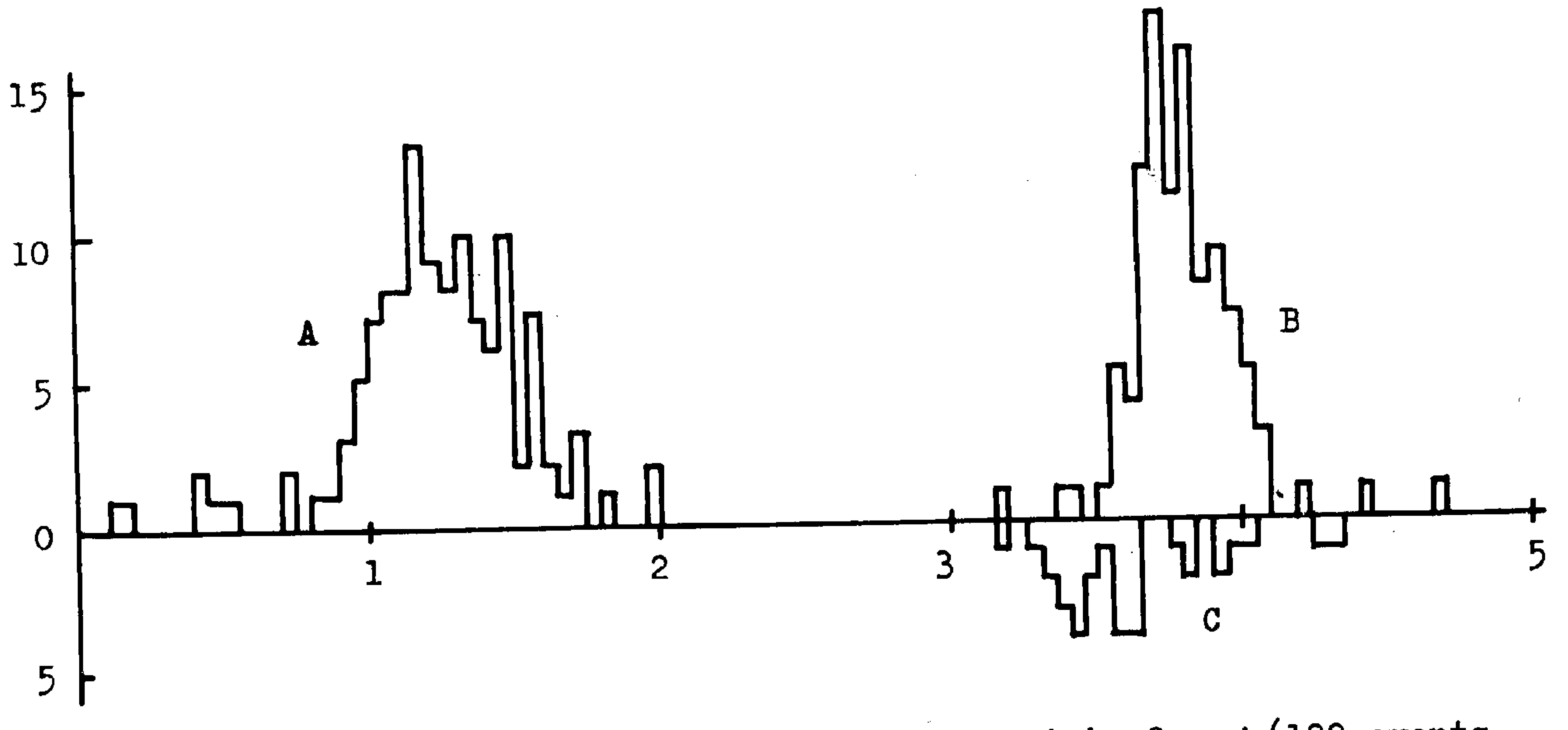

Fig. 1. Histograms of structure parameters. Curve A is for α (122 events with $(R_{min}/R_o) < 0.5$); curves B and C are for η (104 events at depth 834-914 and 31 events at depth 1154-1234 g cm^{-2}, respectively).

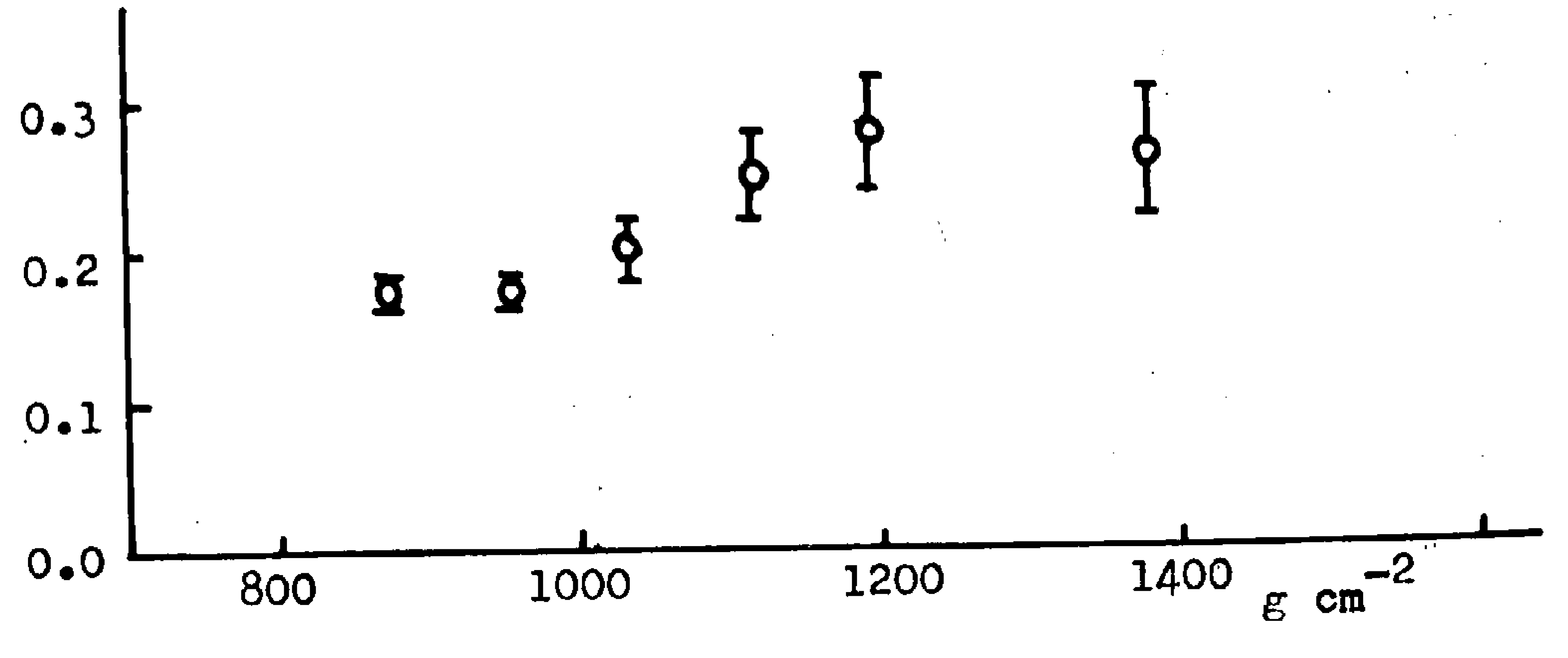

Fig. 2. Breadth of η-distribution as a function of atmospheric depth.

3. Discussion. The possibility that the breadth of the α-distribution is also depth-dependent has not yet been investigated. Also, the question of correlation between η and α is still open.

The present result for α is similar to results obtained for smaller showers by many authors (Fukui et al 1960, Vernov et al 1963, Khristiansen et al 1971, Aseikin et al 1975, Betev et al 1975). The result for η supports a finding by Kawaguchi et al (1973) that a small proportion of showers with $N \sim 10^7$ at sea level are significantly flatter than average, in lateral structure, at distances greater than 1 Moliere unit. For making comparisons it is convenient to use the idea of an 'effective s' given by Equation 8 of (I).

4. Acknowledgement. This work was supported by the U.S. National Science Foundation.

5. References. References for this set of papers are listed together at the end of the last paper.