









The resulting distributions are shown in Table 1 where a comparison is made between simulated (predicted) and observed declination dependences. These data are presented in terms of the experiment with poorer counting statistics in each case. The northern sky data contain 2661 events and the equatorial data  $\sim 10^5$  events. The simulated data contain 12 802 events.

It is clear from Table 1 that the equatorial ( $0^\circ$ ) simulation proves to be symmetrical in declination, as expected. Also, there is no statistically significant evidence for an anisotropy in the Buckland Park southern data. It also appears that the data from the northern site are close to the isotropic distribution. However, there are serious discrepancies between the observed data from the equatorial site at  $10\cdot 22^\circ$  N. and its simulation, there being an appreciable excess of observed events from the north.

#### 4. Discussion of Results

There appears from the equatorial ( $10\cdot 22^\circ$  N.) experimental work to be a case for suggesting that an appreciable anisotropy exists for cosmic rays of energy  $\sim 10^{16}$  eV. However, these data are not consistent with other data presented here. The data from the northern site show no evidence for an appreciable excess from the higher northern declinations and the combination of Akeno and Adelaide data puts an upper limit to the intensity anisotropy well below that implied by the equatorial experiment (of well over 10%). It would appear likely therefore that this particular experiment contains an appreciable systematic bias in its arrival direction derivation, possibly amounting to several degrees. Such a bias could be produced by one detector channel being systematically different to others in its time response, or there could possibly have been a non-horizontal array ground plane.

**Table 2. Upper limits to the difference in intensity at different declinations**

The primary energy of the cosmic ray showers is  $\sim 10^{16}$  eV

Difference	Upper limit	Experiment
$I(10^\circ-30^\circ \text{ N.})/I(50^\circ-70^\circ \text{ N.}) - 1$	$\lesssim 10-20\%$	Northern <sup>A</sup>
$I(20^\circ-40^\circ \text{ N.})/I(20^\circ \text{ S.}-0^\circ) - 1$	$\lesssim 30\%$	Equatorial <sup>B</sup>
$I(60^\circ \text{ S.})/I(5^\circ \text{ S.}) - 1$	$\lesssim 7\%$	Present work
$I(35^\circ \text{ S.})/I(35^\circ \text{ N.}) - 1$	$\lesssim 10\%$	Buckland Park-Akeno <sup>C</sup>

<sup>A</sup> Clark (1957). <sup>B</sup> Chitnis *et al.* (1960). <sup>C</sup> Clay and Gerhardy (1982).

The data from the northern experiment are suggestive of a small excess from the south. There is an excess of observed events over that simulated of  $\sim 5-10\%$  and a corresponding deficit for northerly events. Since the counts from the south are consistently high and those from the north low, it is possible that this effect is also a systematic effect. The data are, of course, normalized but this would still only reduce the number of degrees of freedom of the analysis marginally. One can therefore probably use the observed anisotropies in declination only as upper limits on the true astrophysical anisotropy. Table 2 contains these upper limits to the difference in intensity measured at different declinations. These data are presented in terms of measured intensity ratios and, on the assumption that a conventional anisotropy may be derived from them, can be converted simply to a value of  $(I_{\max} - I_{\min})/(I_{\max} + I_{\min})$ . For instance, the 7% upper limit for the Buckland Park data would correspond to a conventional anisotropy upper limit of  $\approx 3\cdot 5\%$ .

## 5. Conclusions

We have examined experimental data concerning the dependence on declination of the intensity of cosmic radiation with energies of  $\sim 10^{16}$  eV. Upper limits of any dependence are not stringent when compared with the data on the dependence on right ascension. However, the best now available suggests a useful upper limit on the declination anisotropy  $(I_{\max} - I_{\min}) / (I_{\max} + I_{\min})$  of  $\approx 3.5\%$ , which is comparable with some current limits on the anisotropy in right ascension at these energies.

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