UNDERGROUND MEASUREMENTS ON SECONDARY COSMIC RAYS.

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INTRODUCTION. This report summarizes some recent measurements made at the Poatina cosmic ray station (41.8 S 149.9 E, 347 m.w.e.) from August 1983 July 1984. The cosmic ray primary particles responsible for events detected at the station have a median primary energy of 1.2 TeV. The motivation for part of this work has come from the reported detection of narrow angle anisotropies in the arrival direction of cosmic rays (e.g. 1,2,3).

EQUIPMENT. A new particle telescope composed of 2 metre long, 10 cm diameter proportional detectors was installed at the Poatina station early in 1983. The detectors are arranged in four layers, each layer contains 19 detectors situated side by side to form a flat plane of detectors. These layers of detectors are arranged as two upper and two lower sets with the detector axes at right angles for the layers within each set. The side elevation of the telescope is shown in figure 1.

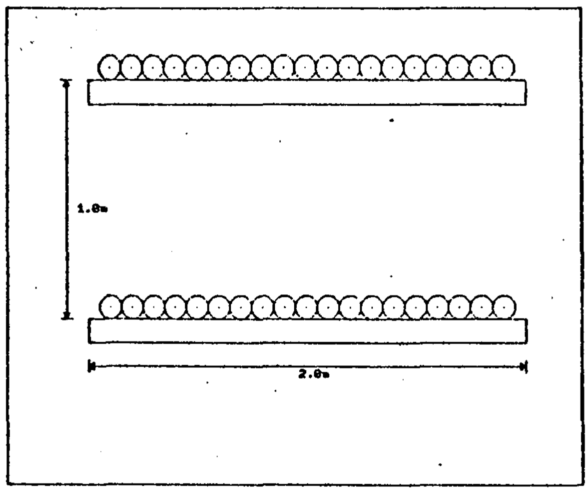

Figure 1. Side elevation of the telescope.

When a coincidence is detected between the four layers, the status of each detector is recorded by a small on-line computer. These events are accumulated for a period of 20 minutes, and are then stored as a record on magnetic recording tape. Additional information such as date, time and total count rate are also stored as part of each record. The telescope detects 2000 events per hour, and the quantity of data generated per week is 2 megabytes. The magnetic recording tapes used were good quality C90 audio tapes, and the recording principle was pulse width modulation at a data rate of 6600 bits per second on two tracks.

Due to the layout of the detectors, the arrival direction, the number of particles and the lateral spread of particles for each event can be estimated. The angular sensitivity pattern of the telescope is shown in figure 2 along one half of one axis of the telescope.

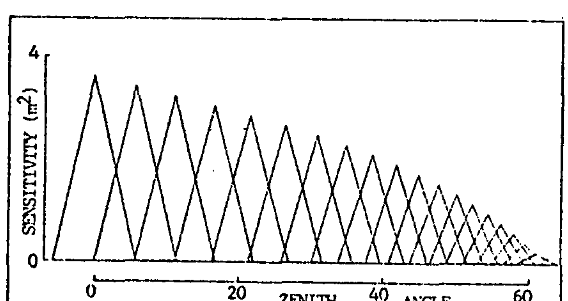

Figure 2. Angular response of the telescope.

ANALYSIS. The events containing more than one particle are analysed for arrival direction, particle muliplicity and particle spread by comparing the arrangement of triggered detectors in the upper and lower sets of detectors. The analysis scheme assumes events contain only high energy particles, and all particles in an event are travelling parallel to each other. Due to the relatively low spatial resolution for particle positions within the telescope, it is only possible to decode events which have particles travelling close to parallel with all particles passing through each layer of detectors. Multiple particle events that cannot be sensibly analysed are classified as complex, and by visual inspection appear to be mainly single particle events with one additional detector involved - possibly due to to a knock-on electron or random background coincidences. About 18% of the total number of events contain more than one particle, and 25% of these events could be sensibly analysed.

The remaining events were consistent with only one particle traversing the telescope. The single particle events that were detected in the central 9 x 9 direction bins of the telescope were accumulated into local intensity maps - i.e. a map per 20 minute observation period (the 20 minute observation time was chosen so the angular movement of the telescope due to the Earth's rotation was similar to the 5 degree angular resolution of the telescope). For each 20 minute observation period, the count recorded for each of these 81 direction bins was normalized against the total count for all the 81 bins and the long term response of the telescope. This process removes wide angle variations such as atmospheric effects, and any variation in detector efficiency.

Celestial intensity maps are generated by averaging the intensities detected in telescope bins which have their central direction contained within common regions of 6 degrees in right ascension and 6 degrees in declination. These celestial maps are produced for each sidereal rotation of the Earth, and can then be combined as required.

RESULTS. The relative rate of detection of multiple particle events is shown in figure 3, and the spread of the particles in multiple events is shown in figure 4. Both rates have been adjusted for the loss of sensitivity caused by the finite size of the telescope. There are three contributions to figure 4: Below 0.2 metres there is a contribution from muons with an associated knock-on particle, below 0.8 metre separation there is a contribution apparently arising from rock showers, and outside this separation the events are assumed to result from multiple muons from atmospheric interactions.

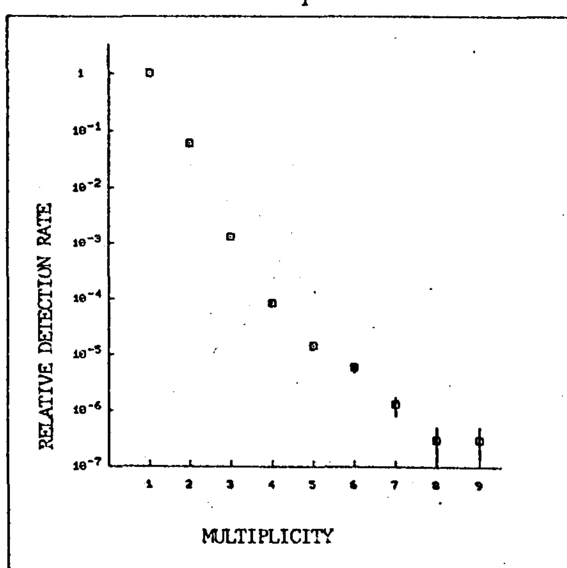

Figure 3. Relative detection rate versus particle multiplicity.

The roughness of intensity with respect to celestial coordinates has been considered by comparing the measured r.m.s. deviation of intensity to that expected from counting statistics. This comparison as a function of declination is shown in figure 5 (the errors are 1 s.d.), and it can be seen that apart from the -31 and -37 degree declination bands, the variation is explained completely by Poisson error. The declination band centred on -31 degrees contains a large positive excess at R.A. = 36 degrees, and this feature may be responsible for the excessive deviation in the -31 and -37 declination bands. It appears that this excess is due to a narrow angle flux of 1.3 +/- 0.3 x 10-8 particles/cm2/sec.

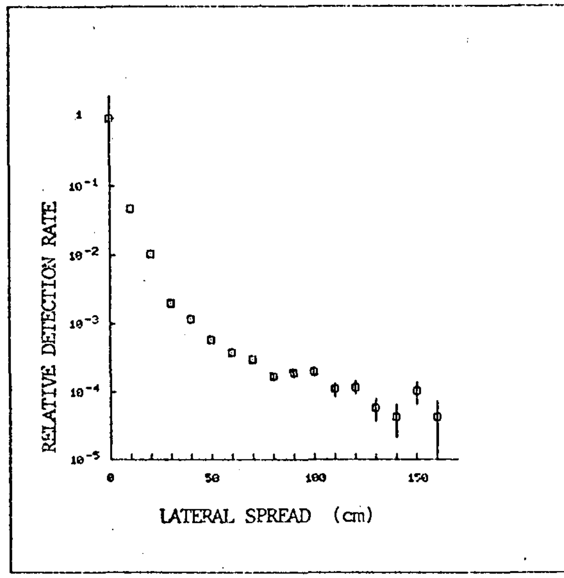

Figure 4. Relative detection rate versus lateral particle spread.

DISCUSSION. The right ascension of this excess (2.4 h) coincides with the phase of a previously detected sidereal anisotropy (4). The previous anisotropy was measured at Poatina with wide angle telescopes (semi-cubic geometry), and the amplitude is consistent with the anisotropy being produced by the narrow angle feature reported here. Measurements made in the northern hemisphere (e.g 5) have established the existence of a sidereal anisotropy with similar amplitude and phase to the wide angle measurements at Poatina, but it is unlikely that the narrow angle anisotropy at declination -37 degrees would have much effect on these measurements. This suggests that the sidereal anisotropy detected at Poatina is a narrow angle anisotropy, and may not have the same origin as northern hemisphere measurements. The consistency with the previous measurements which were reported for the period 1972 to 1974 suggests that the feature is stable with time.

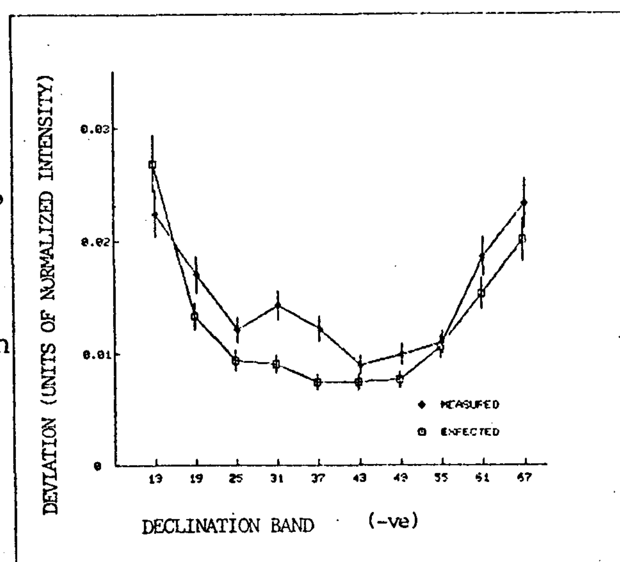

Figure 5. Standard deviation of normalized intensity for different declination bands.

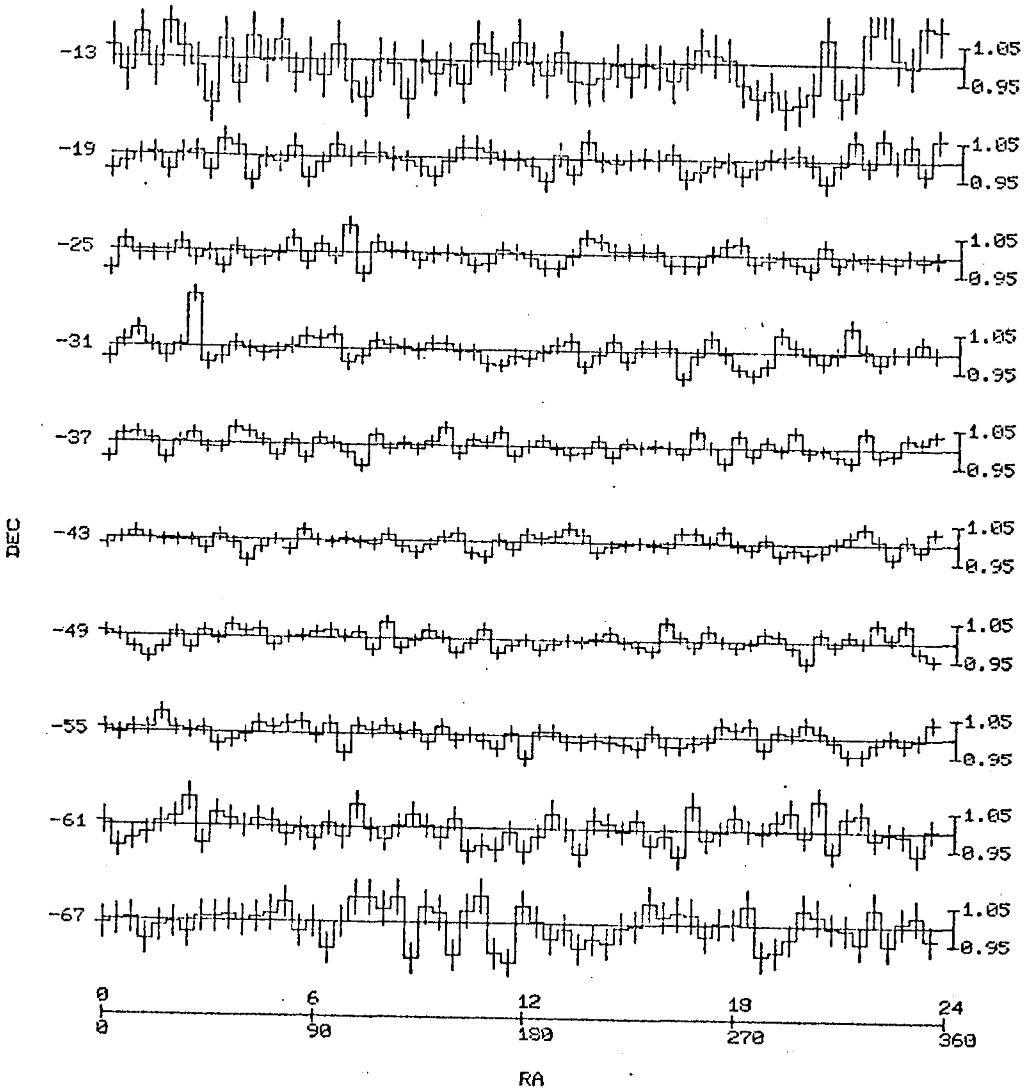

Figure 6. Celestial map of normalized intensity. This map has been produced by using data from every fifth day. The smearing due to sampling in solar time is minimised, and the amplitude of the anisotropy is slightly greater than for the total data set.

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