SIDEREAL VARIATIONS DEEP UNDERGROUND IN TASMANIA

J.E.Humble, A.G.Fenton and K.B.Fenton
Physics Department, University of Tasmania
Box 252C, G.P.O., Hobart, Tasmania, Australia, 7001

1. Introduction. Data from the deep underground vertically directed muon telescopes at Poatina, Tasmania, have been used since 1972 for a number of investigations, including the daily intensity variations, atmospheric influences, and checking for possible effects due to the interplanetary magnetic field (1-3). These telescopes have a total sensitive area of only $3m^2$, with the result that the counting rate is low (about 1680 events per hour) and the statistical errors on the results are rather large. Consequently, it was decided several years ago to construct larger detectors for this station. The first of these telescopes has been in operation for two complete years, and the results from it are presented here.

2. Site and Equipment. The equipment is located at a vertical material depth of 139.4m underground in a hydro-electric power station. The mean density has been estimated as 2.56g cm^{-2}, giving a vertical absorber of 357hg cm^{-2}. This corresponds to a muon cut-off of about 100 GV and median primary rigidity $\sim$ 1200 GV. The geographic coordinates are 41.8^0S, 146.9^0E.

When fully operational, there will be three proportional counter telescopes each having a sensitive area of approximately $4m^2$ and semi-cubical geometry (2mx2mx1m). In each telescope there are four trays of 10cm diameter proportional counters made from thin-walled copper water pipe, with soldered brass ends and glass-metal seals. These were given a prolonged outgassing at temperatures close to 100^0C before being filled with standard P-10 gas (90% argon plus 10% methane) at atmospheric pressure. Each counter was tested by pulse-height analysis of the background radiation soon after filling and again several months later as a check for leaks. During the two year period there have been no counter replacements, and no evidence for loss of detecting efficiency, a problem frequently experienced with GM counter telescopes. The four trays of counters are arranged in two crossed pairs at the top and bottom of the telescope frame so that there is a possibility of looking for narrow angle effects or grouping the data into broader directions e.g. east and west of the vertical, and for studying multiple particle events.

3. Results. The first and second harmonics for each of the years 1983 and 1984 separately, and the totals for the two-year period are shown in Table 1, analysed according to solar, sidereal and anti-sidereal time. In this Table the Poisson errors are shown; these are somewhat smaller than the standard errors obtained from the scatter in the individual values arising during analysis of a year's data.

As may be seen from the Table, the first harmonic in solar time is not convincingly different from zero; nor is there a significant anti-sidereal variation. None of the second harmonics are significantly different from zero. On the other hand, the first harmonic in sidereal time is significant during both years as well as in the total. On estimating the errors from the scatter in the values of the components of the vectors we find the amplitude of the first harmonic for the total period 1983-1984 to be (0.081±0.045)% with its maximum at 2.43±2.25 hours.

TABLE 1

	First Harmonic		Second Harmonic	
	Amplitude(%)	Max (hr)	Amplitude(%)	Max (hr)
Solar				
1983	0.053±0.035	3.14± 2.77	0.024±0.035	10.80±6.00
1984	-0.006±0.035	10.59±12.00	0.036±0.035	1.30±2.70
Total	0.026±0.025	3.63± 4.94	0.024±0.025	0.63±6.00
Sidereal				
1983	0.111±0.035	4.41± 1.23	0.022±0.035	1.40±6.00
1984	0.058±0.035	1.92± 2.46	0.005±0.035	8.11±6.00
Total	0.081±0.025	2.43± 1.20	0.009±0.025	2.37±6.00
Anti-sidereal				
1983	0.032±0.035	7.37±12.00	0.038±0.035	10.20±2.34
1984	0.026±0.035	23.41±12.00	0.023±0.035	5.77±6.00
Total	0.019±0.025	4.41±12.00	0.014±0.025	5.86±6.00

4. Discussion. Results from the new, more stable equipment at Poatina appear to confirm the existence of a first harmonic in the daily variation in sidereal time reported earlier, and are consistent with small or non-existent first harmonics in solar and anti-sidereal time. All the second harmonics appear to be small, if not zero at these energies. It will be important to establish the magnitude and phase of any of the variations (other than the 24-hour sidereal wave) which turn out to be present, since these will be crucial in testing models of the anisotropy by comparison with northern hemisphere results. Since these are evidently of very small amplitude, a long period of observation will be required using the full $12m^2$ detector system. The higher total counting rate available with the complete system should assist also in our investigation of the reasons for the observed standard errors being appreciably larger than from counting statistics alone. Systematic influence such as uncorrected atmospheric effects or year to year variations in the anisotropy itself may be responsible, apart from instrumental variability which is thought to be very small in the new designs.

5. Acknowledgements. We wish to thank the Hydro-Electric Commission of Tasmania and its staff for the excellent facilities provided at Poatina. This work is supported in part by the Australian Research Grants Scheme.

6. References.

1. Fenton A G and Fenton K B (1975). 14th Int.Cos.Ray Conf., Munich, Conference Papers 4, 1482-1484.
2. Fenton A G, Fenton K B and Humble J E (1977). 15th Int.Cos.Ray Conf. Plovdiv, Conference Papers 11, 242-244.
3. Humble J E, Fenton A G, Fenton K B and Lyons P R A (1979). 16th Int. Cos.Ray Conf., Kyoto, Conference Papers 4, 258-262.