COSMIC RAY INTENSITY VARIATIONS AT
PRIMARY RIGIDITIES NEAR 1900 GV

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ABSTRACT

Preliminary analysis of an experiment monitoring cosmic
ray muons yields a first sidereal harmonic amplitude
for rigidities around 1900 GV of $(7.95\pm3.97)10^{-4}$ at
5.1 ± 1.9h right ascension. A significant anti-sidereal
first harmonic is, however, also seen.

1. Introduction   Over the past ten years or so steady progress has
been made in determining the anisotropy of arrival directions of cosmic
rays over a very wide energy region of the primary particles. We report
here on preliminary results from an experiment designed to monitor the
temporal variation of cosmic ray muons with energies greater than about
$1.6 \; 10^{11}$ eV carried out in a road side tunnel in Hong Kong at $\lambda = 22.23^{O}$N,
$\phi_E = 114.6^{O}$E. Details of the experiment are reported in [1] and in an
accompanying paper at this conference (Lee and Ng , HE 4.5-15).

2. Basic Data of the Experiment   The telescope, composed of
individually monitored cylindrical proportional counters, is situated
under a rock burden of varying thickness with an intensity weighted
average depth of 573 hg cm^{-2}. This corresponds to a mean muon
threshold energy of 157 GeV. Using a factor of 12.2 to relate the muon
threshold to primary rigidity [2], [3] we have a value for the median
rigidity, $R_{med} = 1915$ GV.

The present report is based on observations made in the period
November 1983 - March 1985, during which time the duty cycle was 80%.
No selection, or cuts, have been imposed at this stage on the data,
which totals $1.27 \; 10^7$ counts - an average count rate of 1280 $hour^{-1}$. A
small systematic decrease in the count rate is observed, with an average
fractional rate of change equal to $(-1.6\pm0.6)10^{-5}$. This would contri-
bute to a first harmonic, (at 6 h), a fractional amplitude of $0.32 \; 10^{-4}$,
much smaller than the formal standard deviation, $\sqrt{2/N} = 4 \; 10^{-4}$, dictated
by the statistics of observation.

3. Harmonic Analysis   An analysis of the data to extract first and
second harmonics at solar, sidereal and antisidereal frequencies has
been performed. Only data from uninterrupted solar days of operation
were included. This was analysed, month by month, by binning it into
12 cell phase histograms. For sidereal and antisidereal frequencies
the phase corresponding to the centre of the bi-hourly solar cell was
used in determining a, weighted, mean phase for each cell of the
composite histogram, with suitable correction to equalise exposure time
for each such cell also being applied. Using fractional deviations of
a cell from the overall cell mean for the month as variable the first
and second harmonics for the three cases were calculated, (in the case
of the sidereal and antisidereal histograms using a trapezoidal rule
integration because the mean phases of the cells in these cases, in

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general, are not equidistant). The mean square deviation (variance) of the cell rate, averaged over the 16 months was 14% larger than the Poissonian expectation.

The harmonic amplitudes r, and phase of maximum ϕ, are shown in the table. The formal standard deviation on the amplitudes is

	amp. x 10^4	phase/h	k_o	amp. x 10^4	phase/h	k_o
Solar	1.19	19.0	0.05	7.60	0.1±2.0	1.77
Sidereal	7.95	5.1±1.9	2.62	6.14	4.4±2.5	1.20
Anti-Sidereal	9.57	11.7±1.6	2.91	1.63	0.0	0.08

$\sigma_r = \sqrt{\frac{2}{N}} = 3.97 \ 10^{-4}$, while for the phases $\sigma_\phi = \sigma_r/r$ is shown for those amplitudes which are significant. Also shown in the table is the parameter $k_o \equiv r^2 N/4$, which determines the significance of these dispersions [4]. From the presentation of the data on harmonic dials, fig.1, it is clear that both the sidereal and antisidereal first harmonic amplitudes are formally significant. The unwelcome appearance
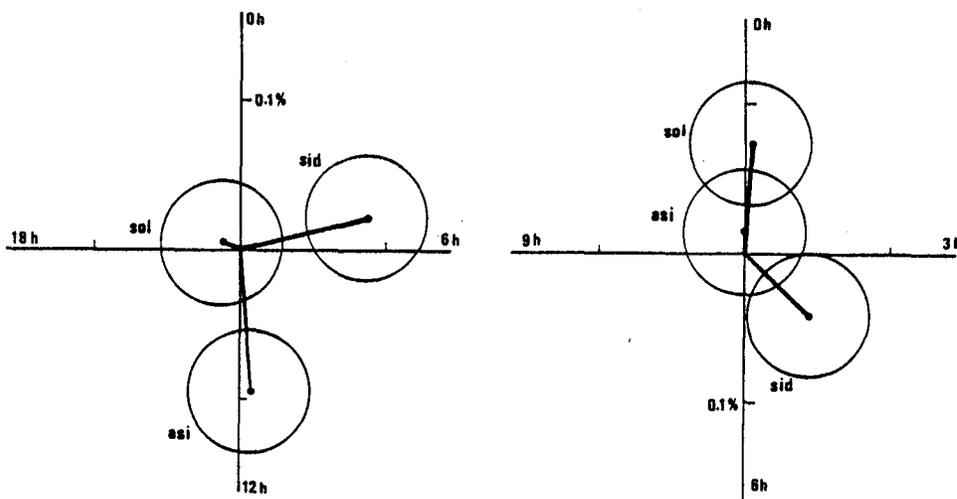

Fig.1 The first and second harmonics at solar, sidereal and anti-sidereal frequencies and their standard deviations

of the latter we have not so far succeeded in explaining. It does not seem that meteorological factors, not yet incorporated in the analysis, can account for such a large effect. Straightforward regression of the observed counting rates on the sea-level pressure, and the atmospheric temperature at the 200 mbar level yield coefficients $-0.04\pm0.02\%$ mbar^{-1} and $+0.12\pm0.07\%$ K^{-1} respectively. Further investigation is in progress to understand this aspect.

4. Results on Sidereal Harmonics

Allowing for the non-Gaussian distribution and bias in the mean [4], the expectation values for two sidereal amplitudes, their 95% and 5% confidence levels, their phase of maximum and its 68.3% confidence level are:

$$\xi_1 = 7.95(1.50, 14.71)10^{-4} \qquad \phi_1 = 5.1\pm2.1 \text{ h},$$

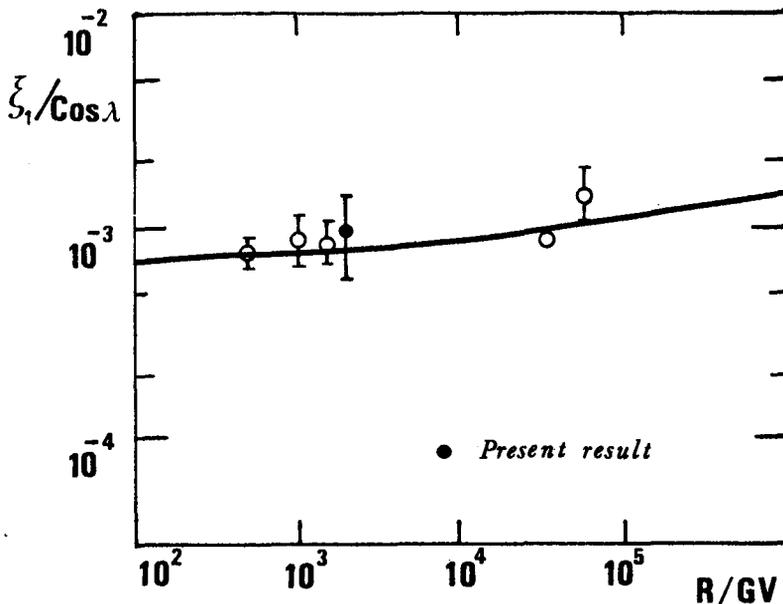$$\xi_2 = 5.28(0.0, 11.7)10^{-4} \qquad \phi_2 = 4.4\pm3.6 \text{ h}.$$

Fig.2 The projected first sidereal harmonic, corrected for solar motion, as a function of rigidity; the curve is due to Tan, paper OG 5.4-13 at this conference.

Although barely significant, especially in view of the unexplained anti-sidereal amplitude noted earlier, both these values are of similar magnitude to those found by other workers in similar regions of rigidity. A correction for solar motion relative to the local interstellar medium, following the parameters used in [2], when applied to the first harmonic amplitude leads to a value $\xi_1/\text{Cos}\lambda = 9.86 \ 10^{-4}$ at $\phi = 4.80\pm2.1$ h. This projected amplitude along with its formal standard deviation is shown in fig.2. Also shown there are the values of other workers as corrected in [2], along with a prediction by Tan, based on his non-uniform galactic disc model for cosmic ray propagation (paper OG 5.4-13 at this conference), corresponding to his

parameter ℓ_s = 5 kpc.

References

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