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Site-selection studies at Gurushikar, Mt. Abu for project 'GRACE'

M. L. Sapru, C. L. Bhat, M. K. Kaul, S. K. Kaul, S. R. Kaul,
V. K. Dhar, R. K. Kaul, R. C. Rannot and A. K. Tickoo
Bhabha Atomic Research Centre, Nuclear Research Laboratory, Trombay, Bombay 400 085

Abstract. Holding the promise of yielding up to 1150 hrs of good-quality atmospheric Cerenkov data per calender year, Gurushikar in Mt. Abu, Rajasthan, offers itself as a good observatory site for our proposed new gamma-ray astrophysics experiments.

Key words : VHE/UHE γ-rays—cloud-cover—extinction coefficient—dust load—wind speed—site survey

1. Introduction

Gamma-ray astronomy studies at TeV and PeV energies, employing the ground-based Atmospheric Cerenkov Technique at Gulmarg, have constituted the main research activity of our laboratory during the past two decades. Important experimental investigations have been carried out on the gamma-ray burst phenomenon (Bhat *et al.* 1980) and VHE/UHE emissions from compact sources (see Razdan 1989 for a review). Based on the resulting experience, we are planning now to set up two high-sensitivity experiments, TACTIC and MYSTIQUE at TeV and PeV energies respectively under the project GRACE (for 'Gamma-ray Astrophysics Cerenkov Experiments'). An important pre-requisite for the success of these experiments is the choice of a proper observatory site. Accordingly, a site survey programme covering 8 potentially interesting locations, was initiated in early 1991.

2. Site evaluation criteria

For our present purpose, a good observatory site should satisfy the following essential conditions : (i) Largest number of clear days per annum, (ii) around 15 hectares of encumberance-free land (primarily for MYSTIQUE), (iii) operational ease : mild weather, good infrastructural facilities and logistic support, (iv) minimal light interference of man-made origin. (v) high altitude, low dust content and low precipitation. (Atmospheric seeing is not a particularly critical parameter in Cerenkov studies).

2.1. *Effective observation time*

Cloud imagery data, provided by the INSAT satellites for the 5-year period 1987-91, has been studied for this purpose. Figure 1 summarizes the results : 67% days per annum are

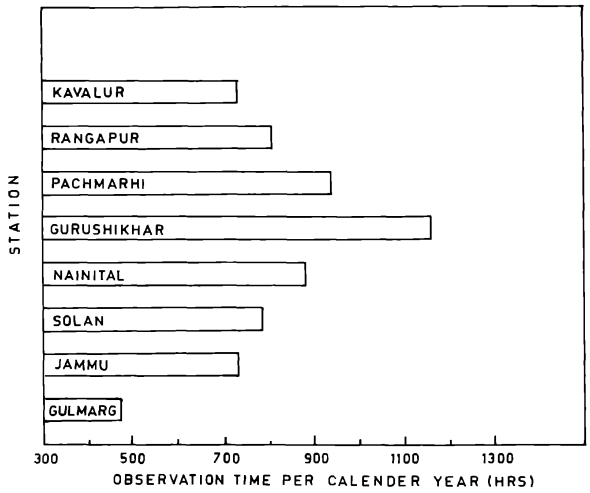

Figure 1. The bar-graph shows that Gurushikar, Mt. Abu, has the highest fraction of cloud-free nights per year among the 8 locations used in the analysis.

expected to be cloud-free at Gurushikar (the highest percentage for any known Indian observatory site), translating to ~ 1150 h of effective observation time per year. This marks an impressive ~ 2.5-fold jump over the corresponding time possible from Gulmarg. Equally important, the observation time at Gurushikar is distributed essentially evenly for 9 months of a year (September-May), at ~ 110 h per month. This should permit a more uniform coverage of various interesting (α, δ) regions, as is evident from figure 2. In view of this significant advantage, Gurushikar was short-listed for additional studies.

2.2. *Location*

Gurushikar (~ 1700 m asl., 24.65°N, 72.78°E) is the highest peak feature of the Aravali mountain range passing through Rajasthan. It is connected by a ~ 20 km long motorable road

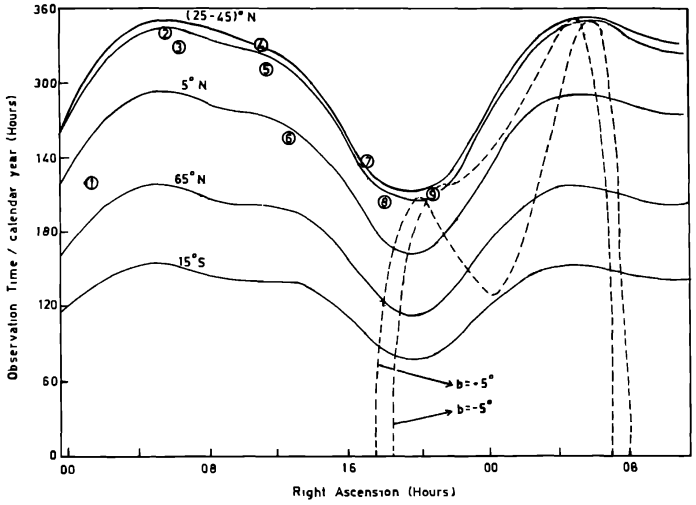

Figure 2. Expected observation time per calender year at Gurushikar for a given (α, δ) value, and the galactic plane region ($|b| < 5°$). Labelled circles represent the well known source candidates: (1) Cas γ-1, (2) Crab Nebula/Pulsar, (3) Geminga, (4) MK 421, (5) E 1114 + 182, (6) 3C273, (7) Her X-1, (8) AM Her and (9) Cyg X-3.

to the main town of Mt. Abu. Around 20 hectares of usable land are available for locating TACTIC and MYSTIQUE experiments by the side of the existing Infrared Observatory of the Physical Research Laboratory, Ahmedabad (figure 3). The topography of the site also allows low elevation viewing. Space- and time-coordinated observations are possible with the Infrared Observatory at Gurushikar and the TeV γ-ray experiments at Pachmarhi (Acharya 1993) and possibly Tien-Shan (Nikolsky *et al.* 1993).

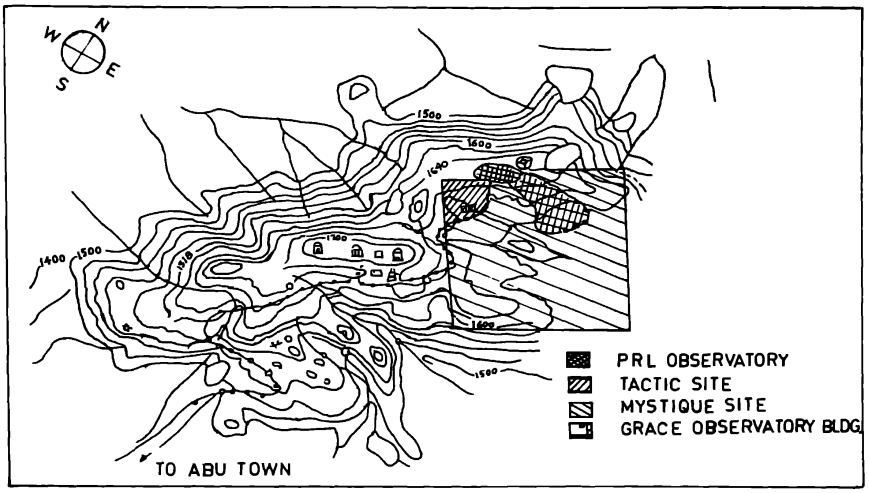

Figure 3. Topographical map of the TACTIC and MYSTIQUE sites.

2.3. *Atmospheric extinction and dust load*

Given the arid environment of Gurushikar, it was felt desirable to carry out dust load measurements alongwith those for atmospheric extinction at this place. The extinction measurements were carried out over the entire spectral band of interest ($\lambda \sim 300$-500 nm) for the atmospheric Cerenkov work (Kaul *et al.* 1993). Observations carried out during two spells, 1992 April 29-June 5 (pre-monsoon) and 1992 October 22-30 (post-monsoon), lead to a mean extinction coefficient $k = (0.47 \pm 0.10)$ and (0.31 ± 0.07) for the two cases respectively, to be compared with $k \sim 0.35$ at Gurushikar altitude for a standard atmosphere (Elterman 1968).

Figure 4 presents the results of the corresponding dust-load measurements (Meenakshy & Sadashivan 1993) : It is obvious that the mean dust-load immediately before the monsoons is significantly higher than that after the rainy season. However, it is reassuring that the above-referred dispersion in daily k values for the pre-monsoon period, representing the worst-case possibility, is too small to be troublesome for Cerenkov observations. The night sky brightness levels during the two observation-spells are comparable : $(1.34 \pm 0.50) \times 10^{12}$ photons m^{-2} s^{-1} sr^{-1} (pre-monsoon) and $(1.54 \pm 0.55) \times 10^{12}$ photons m^{-2} s^{-1} sr^{-1} (post-monsoon).

2.4. *Meteorological parameters*

The rainfall at Gurushikar is confined mainly to the monsoon period (June-August), with a total column of ~ 400 cm per season. During the period 1992 May-1993 April the wind speed has touched values in excess of 70 km h^{-1} for ~ 10 min. only; however, the average wind speed is ~ 15 km h^{-1}. Due to low profile of its detectors MYSTIQUE can operate in

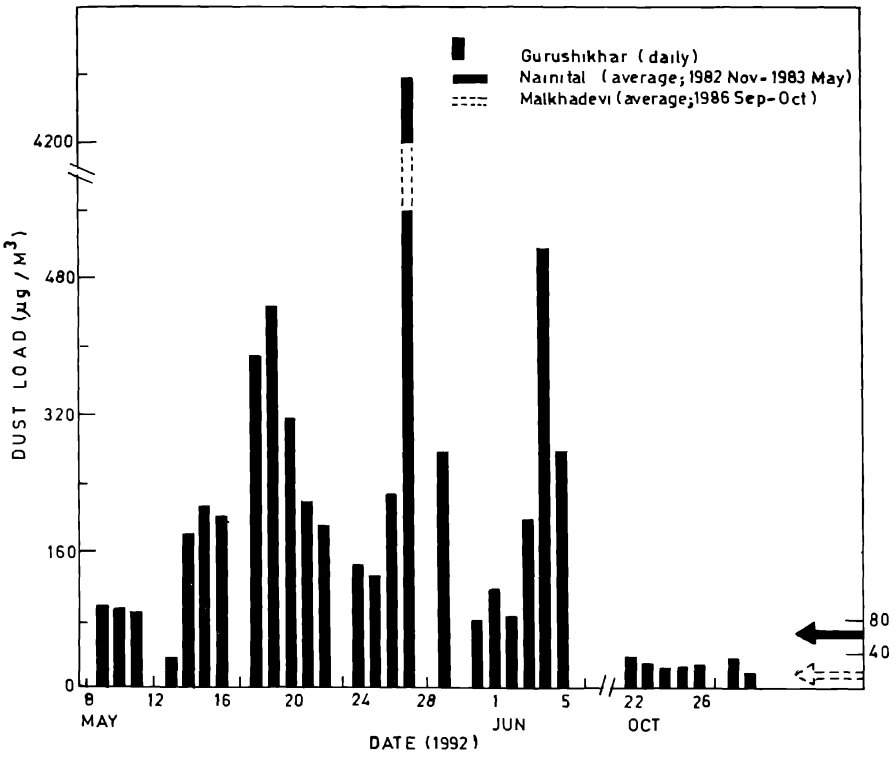

Figure 4. Dust load measurements carried out at Gurushikar for a few days before and after the summer rains are compared with those recorded at Naini Tal and nearby Malkhadevi.

the strong winds. On the other hand, TACTIC is being built to function in winds of up to 30 km h^{-1}, resulting in a further reduction in useful observation time by 3.5% only. Water vapour precipitation during the night-time is negligible in the non-monsoon period. Temperatures range between ~ 0°C (winter) to ~ 35°C (summer).

3. Conclusions

As Gurushikar adequately meets all the important stipulated conditions, it has been decided to set up the proposed GRACE Observatory there.

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