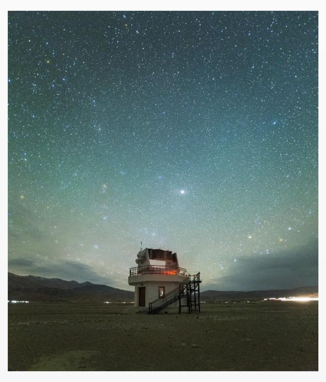
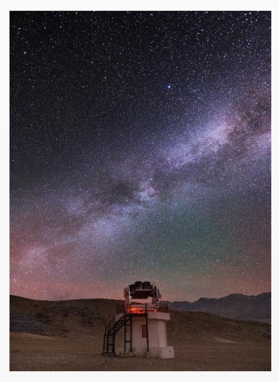
Preserving the Night: Combating Light Pollution for the Future of Astronomy





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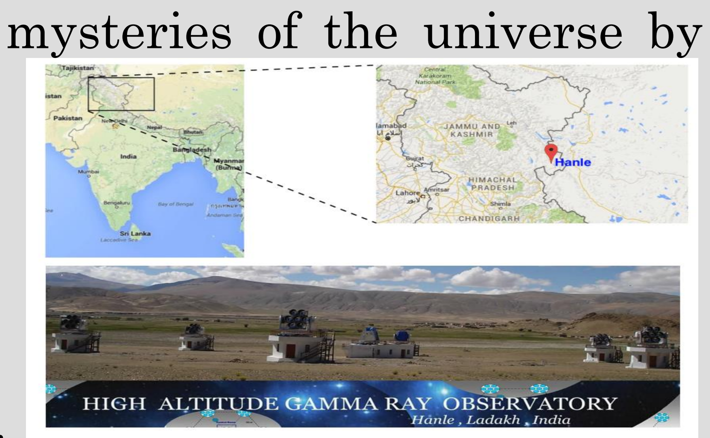
INTRODUCTION

The High Altitude Gamma Ray (HAGAR) Observatory, located in Hanle, Ladakh, is one of the premier facilities dedicated to observing very high energy gamma rays from celestial sources. Given its altitude of about 4,300 meters (14,100 ft.) above sea level, the observatory is strategically placed to minimise the impact of atmospheric interference, which is a significant concern for observations of gamma rays and other cosmic phenomena. We aim to study emission regions and processes responsible for gamma ray production in these sources.

1. SIGNIFICANCE IN STUDYING COSMIC PHENOMENON

HAGAR plays a pivotal role in unlocking the mysteries of the universe by investigating phenomena such as:

- Gamma-ray bursts
- Active galactic nuclei
- Supernova remnants
- Origin of cosmic rays
- Pulsars and pulsar wind nebulae



By studying gamma rays, we gain crucial insights into the most energetic processes occurring in the cosmos, shedding light on the dynamics of celestial bodies, their evolution, and the fundamental laws governing the universe.

3. IMPACT OF LIGHT POLLUTION ON SCIENTIFIC OBSERVATION

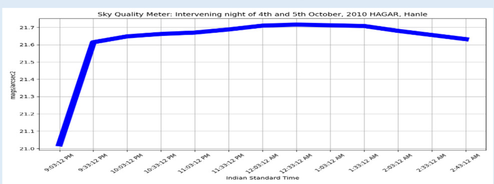
Light pollution presents a substantial obstacle to HAGAR, diminishing both its sensitivity and data quality. As artificial lighting expand, the adverse effects of light pollution on astronomical observations become more evident:

Reduced Sensitivity: Excessive artificial light obscures faint gamma-ray signals, diminishing HAGAR's sensitivity and limiting its ability to detect and analyse cosmic phenomena accurately.

Unihedron Sky Quality Meter –LE is affixed to the central mirror of Telescope 7 and records data at 5 minute intervals.

Increased background Noise: Light pollution introduces unwanted background noise in observation data, comprising the clarity and precision of measurements, thereby impeding the identification and characterisation of gamma-ray sources.

SQM reading vs IST over a period of 13 year



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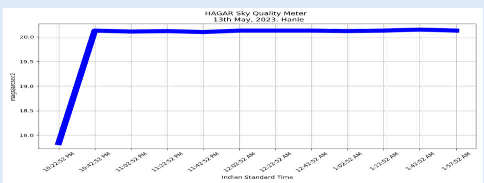

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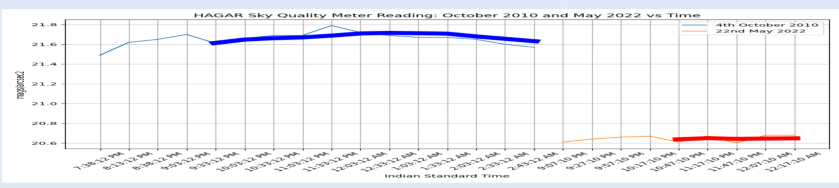


It is evident that HAGAR southern sky has declined over the course of a decade

Increased energy threshold: The primary benefit of being situated at a high altitude is the lowered energy threshold for detecting gamma rays. However, the elevated background levels lead to a rise in the energy threshold, thus undermining the advantage of such a location.

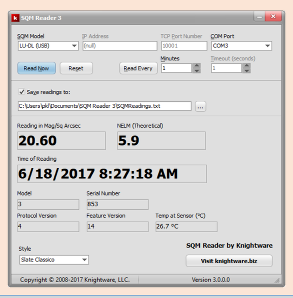
Data Quality Degradation: Interference from artificial light sources distorts observational data, leading to inaccuracies in data interpretation and hindering the advancement of our understanding of the universe.

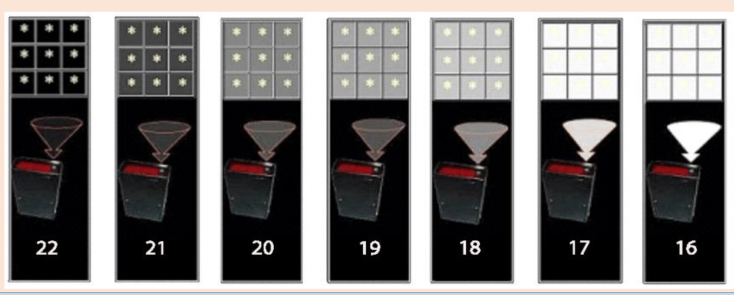
5. UNIHEDRON SKY QUALITY METER (SQM-LE)

i). HAGAR utilizes SQM-LE, an ethernet-enabled SQM model that measures brightness for night-time sky brightness monitoring.

ii). It is sensitive to visual light and measures the brightness of the night sky in magnitude per square arcsecond.

iii). Calibrate the effect of sky brightness on qualitative measures such as the Bortle scale.



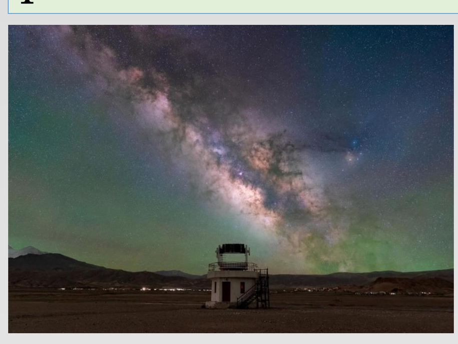


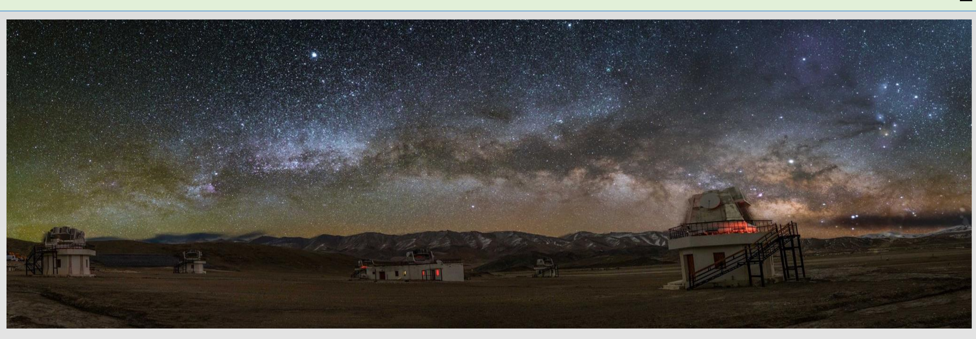
6. ACHIEVING PERFORMANCE REQUIREMENT OF TELESCOPE WITH SiPM BASED CAMERA via HDSR INITIATIVE

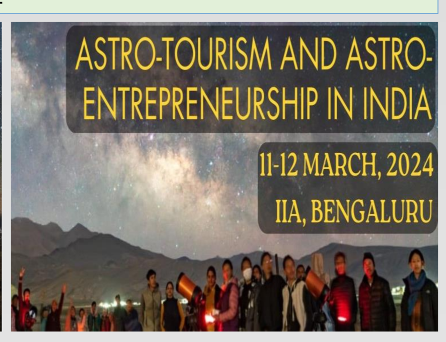
a).Given that Silicon Photomultiplier (SiPM) sensor's operational spectral range extends beyond the red region of the spectrum (600-900 nm), they are affected much more by ambient light compared to conventional PMTs.

b). As a result, this raises the telescope's energy threshold and impacts its sensitivity in detecting faint sources.

c). The HDSR initiative plays a significant role in optimizing the telescope's performance with a SiPM-based camera to achieve the best possible results.

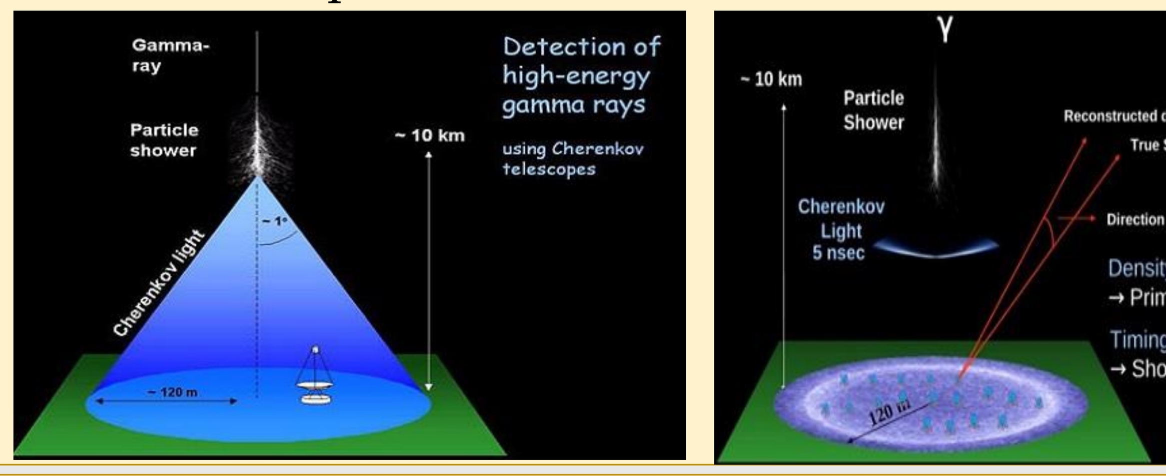






2. DETECTION PRINCIPLE

Very high energy gamma rays (> 100 GeV) are detected using atmospheric Cherenkov technique, where gamma ray produce electron-positron pair at the top of the atmosphere. Subsequent processes generate showers of charged particles in the terrestrial atmosphere, emitting bluish Cherenkov light. This flash lasts a few nanoseconds and spreads over a circular region with a radius of about 100 meters at observation level, detected by telescopes equipped with mirrors and Photomultiplier Tubes (PMT) at its focus.



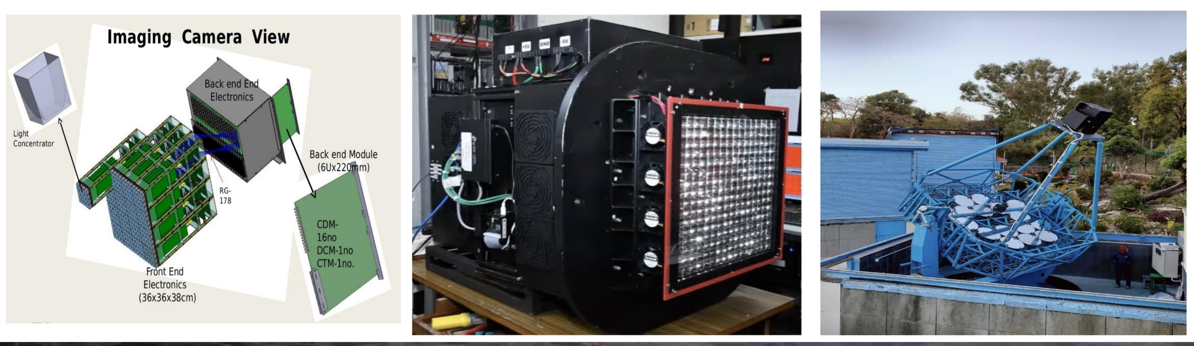
4. Hanle Dark Sky Reserve (HDSR) as a solution

HDSR aims to preserve pristine night skies by implementing controlled lighting measures and fostering public awareness of light pollution. Through responsible lighting practices and community education, it seeks to nurture both the aesthetic and scientific aspects of the night sky experience.

FUTURE EXPERIMENT

SiPM IMAGING CAMERA: HAGAR group is currently engaged in design and development of G-APD (SiPM) based camera for 4m class IACT telescope. This camera is installed and undergoing tests on vertex element of TACTIC telescope run by BARC at Mt. Abu. After successful completion of tests at Mt. Abu we plan to shift the telescope to Hanle and dedicate it for monitoring of bright blazars.

The SiPM camera, comprising 256 pixels with light concentrators and SiPM technology, offers advantages over traditional PMTs. SiPM pulses are directed to front-end electronics for conditioning and providing suitable biases for standard operations. Subsequently, the 256 conditioned pulses are processed, digitized, and recorded by back-end electronics upon a valid trigger, with data packets then transmitted to remote servers for archival and control facilitated via fast Ethernet connectivity to remote PCs.



CONCLUSION

Join us in embracing the magic of the night sky and advocating for dark sky initiatives to preserve its splendor. By supporting efforts to reduce light pollution, we can protect our celestial wonders and pave way for a vibrant science village where discovery and innovation thrive under the stars.

Let's unite to create a luminous future where both our skies and scientific endeavors illuminate our path forward.

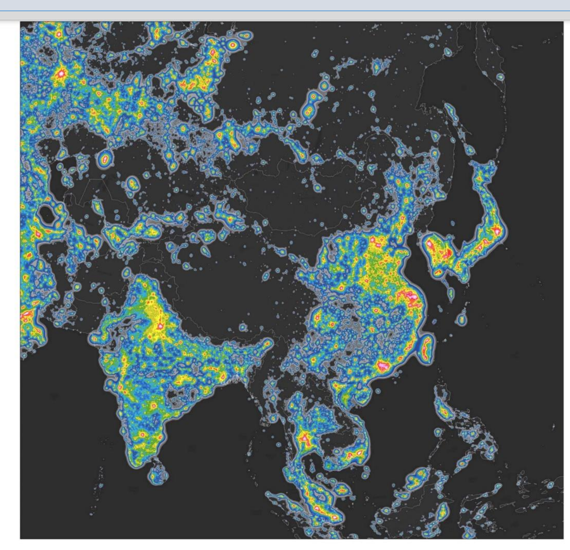


Fig. 7. Map of Asia's artificial sky brightness, in twofold increasing steps, as a ratio to the natural sky brightness. Table 1 indicates the meaning of each color level.

Table 1. Color levels used in the maps. The first column gives the ratio between the artificial brightness and the natural background sky brightness (assumed to be 174 μcd/m^2); the second column gives the artificial brightness (μcd/m^2); the third column gives the approximate (that is, assuming a natural background of 22 mag/arcsec^2) total brightness (mcd/m^2); and the fourth and fifth columns give the colors.

Ratio to natural brightness	Artificial brightness (μcd/m^2)	Approximate total brightness (mcd/m^2)	Color
<0.01	<1.74	<0.176	Black
0.01–0.02	1.74–3.48	0.176–0.177	Dark gray
0.02–0.04	3.48–6.96	0.177–0.181	Gray
0.04–0.08	6.96–13.9	0.181–0.188	Dark blue
0.08–0.16	13.9–27.8	0.188–0.202	Blue
0.16–0.32	27.8–55.7	0.202–0.230	Light blue
0.32–0.64	55.7–111	0.230–0.285	Dark green
0.64–1.28	111–223	0.285–0.397	Green
1.28–2.56	223–445	0.397–0.619	Yellow
2.56–5.12	445–890	0.619–1.065	Orange
5.12–10.2	890–1780	1.07–1.96	Red
10.2–20.5	1780–3560	1.96–3.74	Magenta
20.5–41	3560–7130	3.74–7.30	Pink
>41	>7130	>7.30	White

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