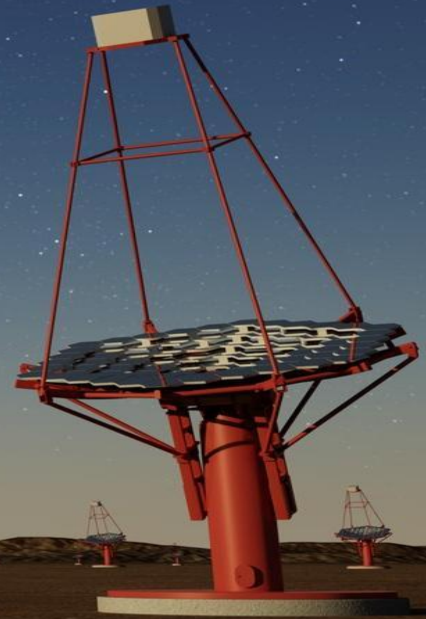
Advanced Analysis of Night Sky Background Light for SSTCAM



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Introduction

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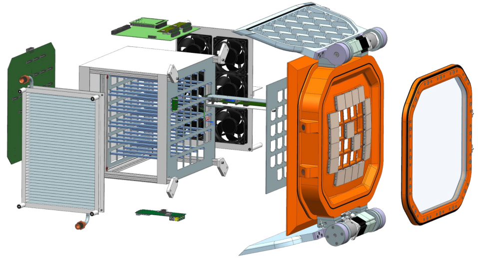
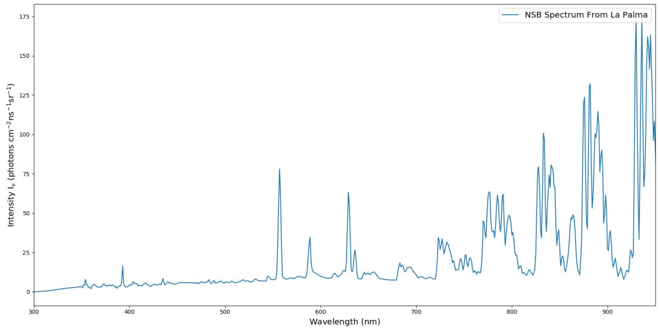
- Night Sky Background (NSB) is a complex phenomenon consisting of all light detected by Imaging Atmospheric Cherenkov Telescopes (IACTs) that is not attributed to Cherenkov emission.
- NSB is a mixture of light from airglow emission, Rayleigh and Mie scattering in the atmosphere, starlight, moonlight, population centres and other sources.
- Understanding NSB is important for understanding systematic uncertainties of IACT observations, as it affects the sensitivity and energy threshold. It is also important when optimising image cleaning and for camera thermal and electronic design.
- We focus on the Small Size Telescope Cameras (SSTCAMs) for upcoming Cherenkov Telescope Array (CTA). The CTA ‘alpha’ configuration includes 37 Small Size Telescopes (SSTs) equipped with SSTCAMs on a southern site in Chile.



Upper: SSTCAMs will have 2048 Silicon Photomultiplier (SiPM) pixels each with a ~0.2° field of view. Image Credit: SSTCAM Project. Lower: The NSB spectrum measured from La Palma; the borofloat SSTCAM front window will have a coating which will heavily suppress the shown airglow emission line NSB in the wavelength range above 500 nm [1]. Data Credit: [2].



NSB Model

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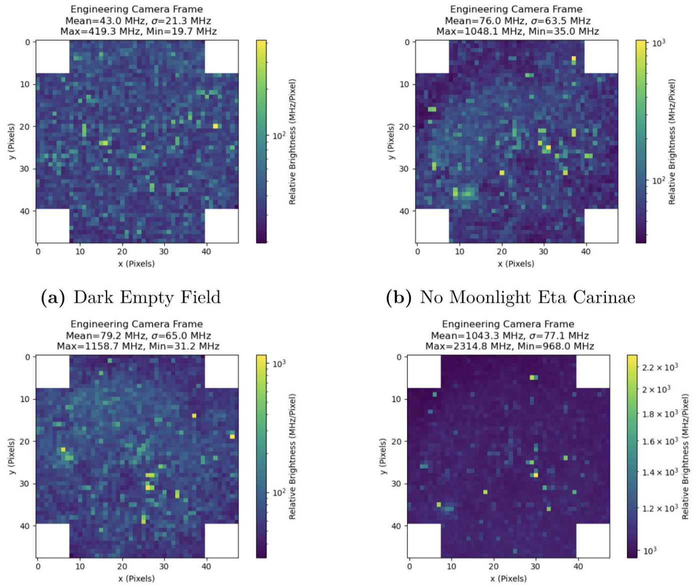
- Previous studies of NSB for SiPM cameras have focused on values for individual pixels, here we consider a complete camera statistically.

- We model NSB with the sky brightness model of Krisciunas + Schaeffer [3] combined with *Gaia* data using the *nsb* tool developed by H.E.S.S. [4]. We then approximate that the combination of this light is uniformly spread over the *Gaia* Blue Photometer (BP) band, and use known SST parameters (such as mirror area, pixel angular extent and telescope optical efficiency), to predict the SSTCAM NSB rate in MHz/pixel.

- As a worst-case scenario, the observations we generate are of the field of the colliding wind binary Eta Carinae, known to be a very bright field.



(a) Dark Empty Field (b) No Moonlight Eta Carinae

(c) Half Moonlight Eta Carinae (d) Full Moonlight Eta Carinae

NSB field of view maps showing the expected rate across the camera under four scenarios. These show an observation at the same altitude as Eta Carinae under dark observing conditions, and Eta Carinae under normal, CTA 0.5 fractional lunar illumination and fully moonlit observation conditions.

Time Gains and Flasher Calibration

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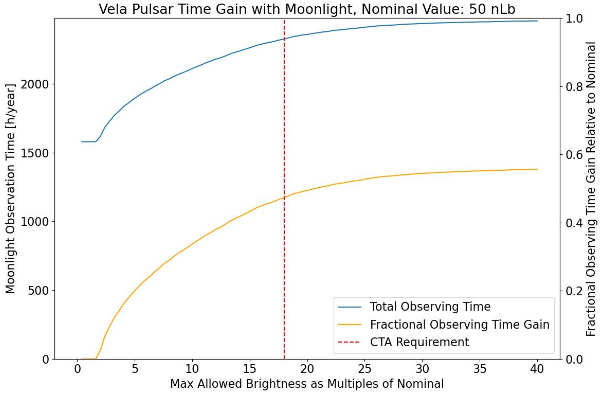
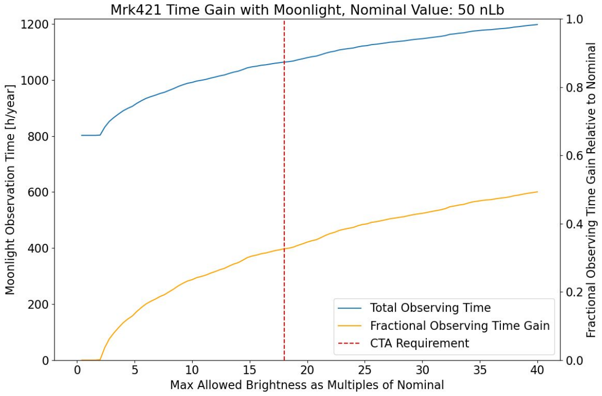
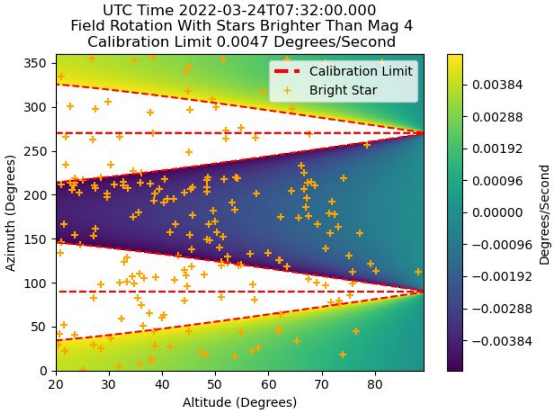
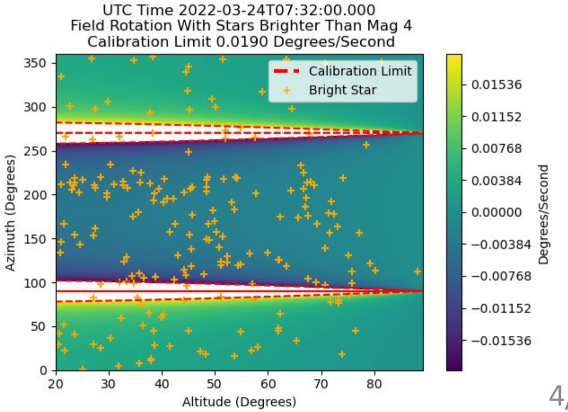




Left: Operating IACTs under higher NSB conditions allows for follow-up of more transients as the possible observing duration increases, the most noteworthy example of this is the MAGIC detection of the GRB 190114C (which was observed under 6x nominal NSB) [5]. These figures show the observation time gains possible for the Vela Pulsar and Markarian 421. It is difficult to disentangle source visibility but it appears the potential observing time gain is greater for galactic observations due to the increased stellar density in the galactic plane.

Right: Bright stars are a component of NSB that needs to be corrected for when calibrating the camera. These plots show the ability of the SSTCAM LED flat-fielding flashers to correct for the presence of such stars rotating in SSTCAM images, to the limit that the CTA intensity resolution requirement is met. The color gradient shows the field rotation as a function of altitude and azimuth; bright stars in the unshaded regions of the plots move too quickly to be completely corrected. The upper plot corresponds to 40s flasher re-calibration intervals and the lower to 10s flasher re-calibration intervals.





Discussion and Conclusions

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- Whole camera studies of NSB for SSTCAM have been performed that generate realistic field maps. These results are also consistent with existing predictions from Corsika/sim_telarray [6].
- Even under the highest realistic NSB rate scenarios, it will be possible to operate SSTCAM with only a small number of pixels having a reduced high voltage value. Disabling large blocks of pixels is unlikely to be necessary.
- Moderate observing time gains are possible by operating under high-NSB conditions for both galactic and extragalactic sources. This is particularly important given the new era of galactic IACT transients [7].
- The SSTCAM flasher calibration system enables the recovery of the camera calibration throughout the observation, ensuring good coverage over the entire sky.

References

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Acknowledgements

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