Elastic LIDAR Monitoring of the Night-sky Brightness over Roque de los Muchachos Observatory

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ANACAPRI, 14/07/2022

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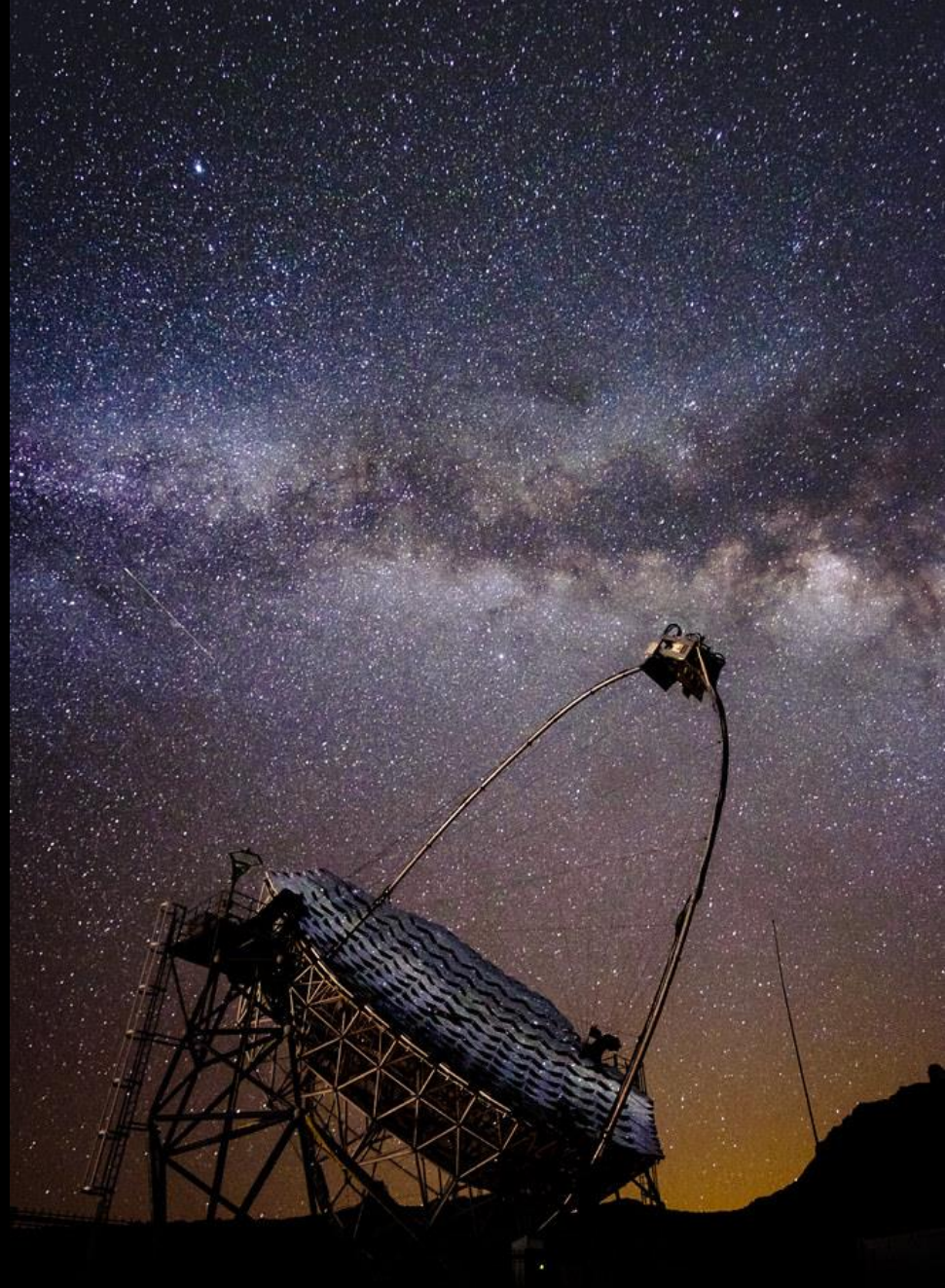
Motivation

- Dependence of NSB on transmission
- The effects of light pollution on NSB?
- Apply MAGIC LIDAR results (2013 – 2020) on future operations with PMTs (MAGIC and CTA) under certain conditions in order to maximally increase their sensitivity



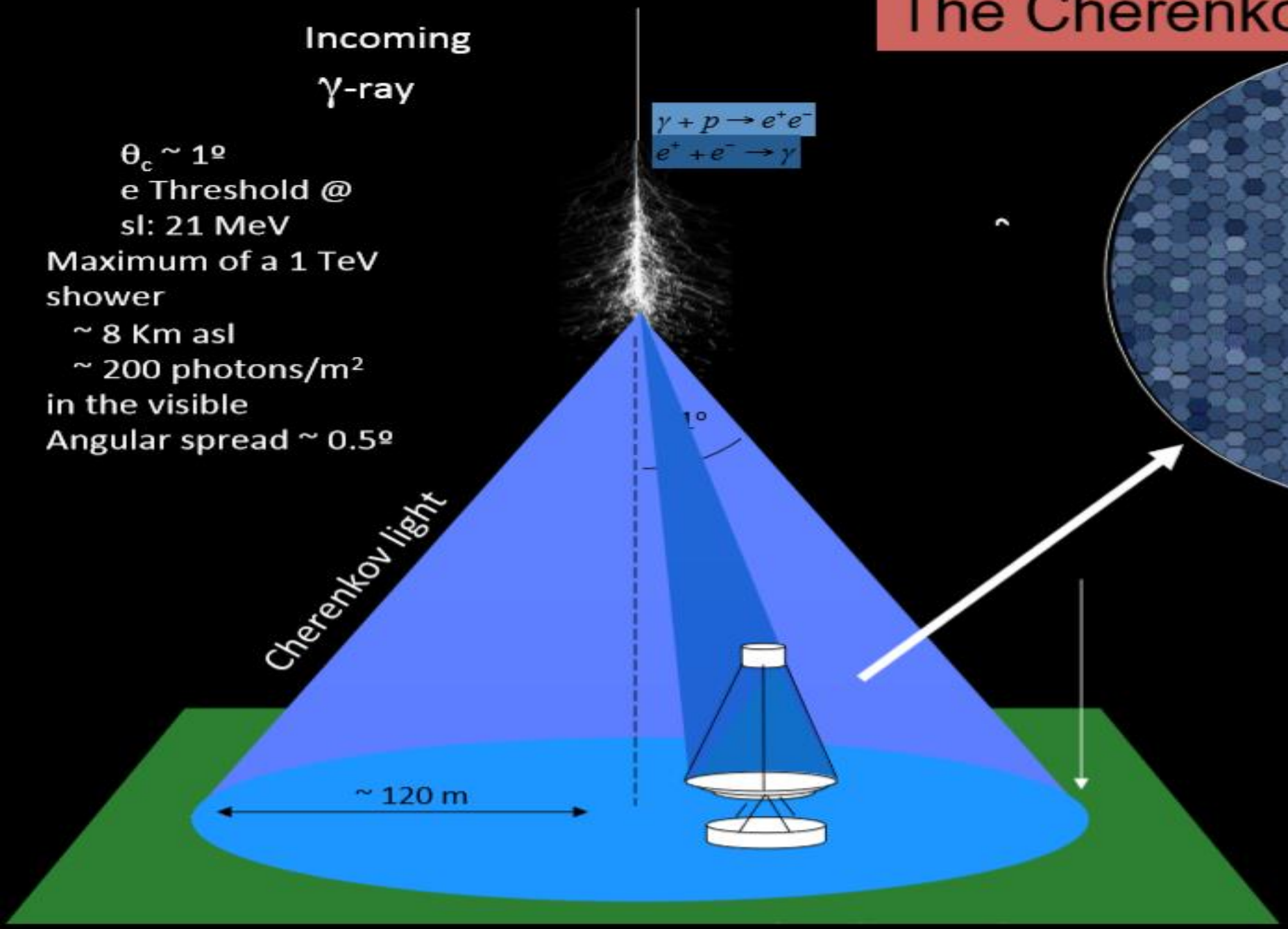
The Cherenkov technique

Incoming

γ-ray

$\theta_c \sim 1º$
e Threshold @
sl: 21 MeV
Maximum of a 1 TeV shower
~ 8 Km asl
~ 200 photons/m²
in the visible
Angular spread ~ 0.5º

$\gamma + p \rightarrow e^+e^-$
$e^+ + e^- \rightarrow \gamma$



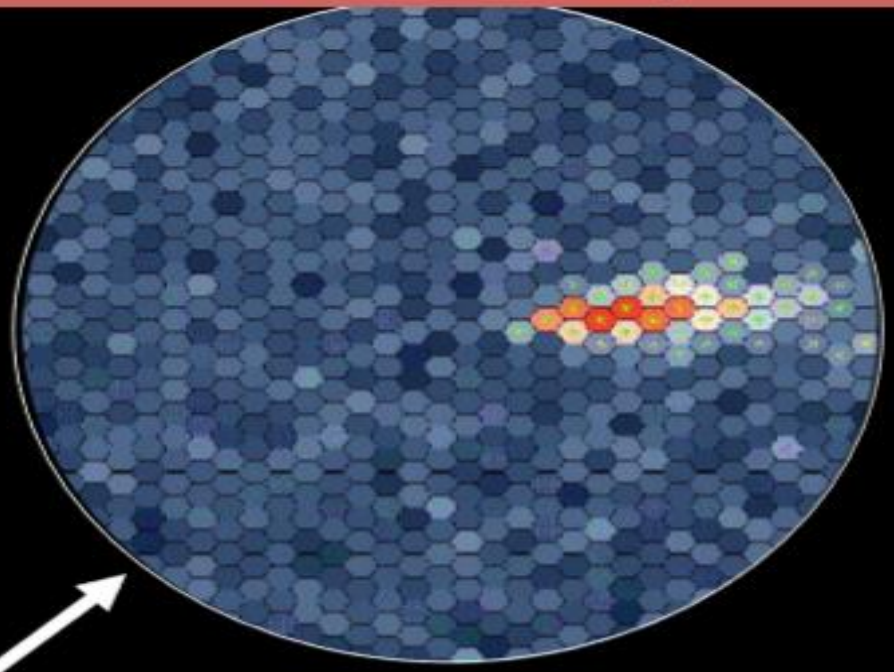
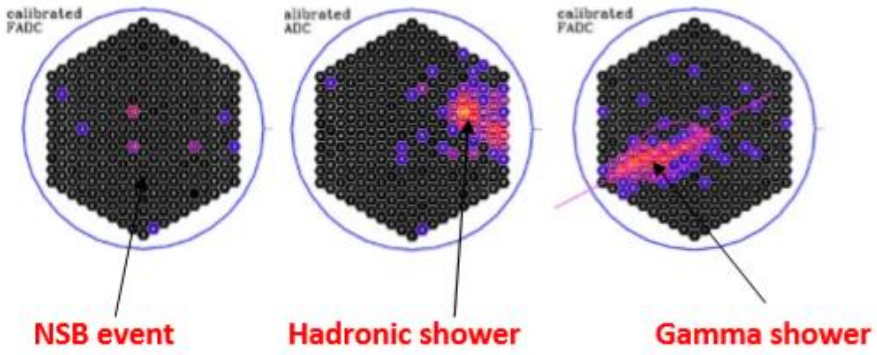


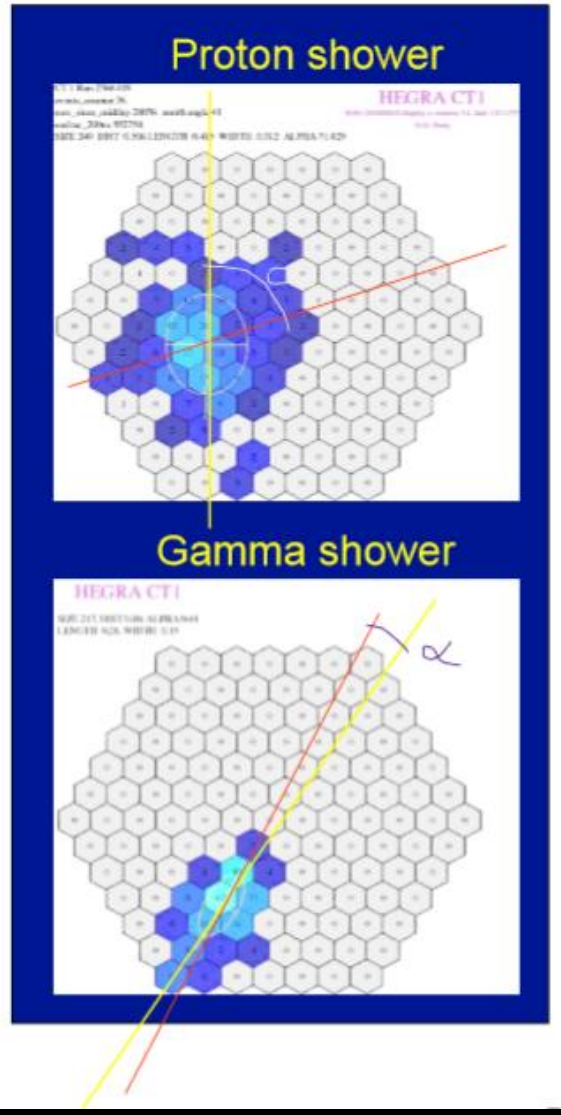
Image intensity
➔ Shower energy

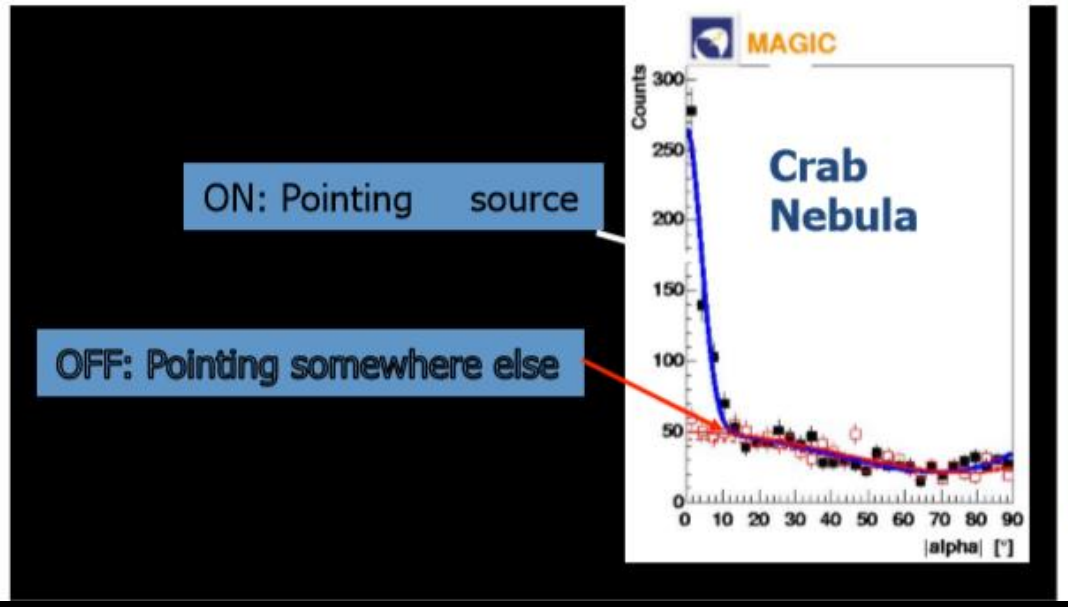
Image orientation
➔ Shower direction

Image shape
➔ Primary particle

γ/h Separation



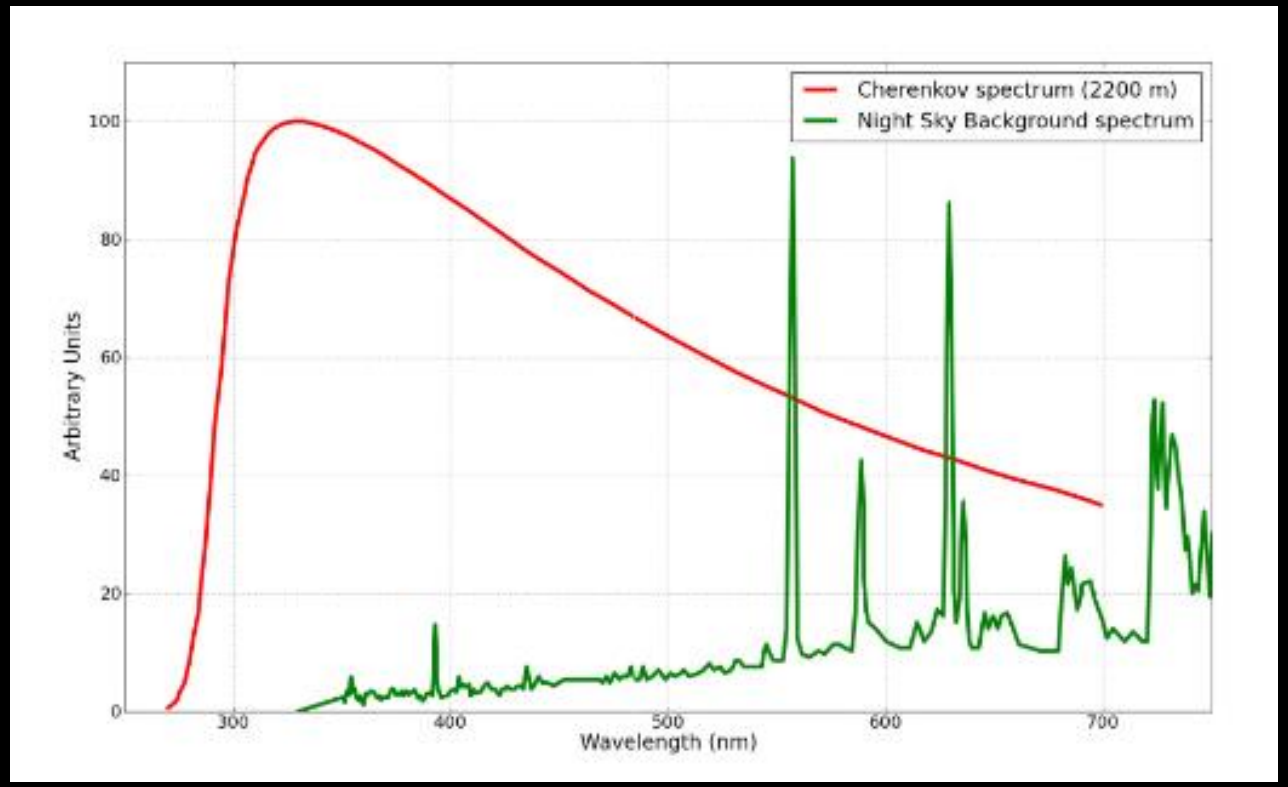




Night sky background

NSB -> The median of the maximum night sky brightness, measured in a moonless and clear night at high galactic latitude

Even if no visible astronomical objects are present in given part of the sky, there is always some low luminosity present, mostly due to light diffusion from the atmosphere



The original Cherenkov spectrum (red curve) and the night sky spectrum (green curve)
Source: Guberman, D., Cortina, J., Hahn, A. Light-Trap: A SiPM Upgrade for Very High Energy Astronomy and Beyond, 2017

Light pollution

Any type of artificial light in the environment that is introduced directly or indirectly by humans

LIDAR system for the MAGIC telescopes

Light Detection and Ranging (LIDAR)

Observatorio de Roque de los Muchachos, La Palma, Spain

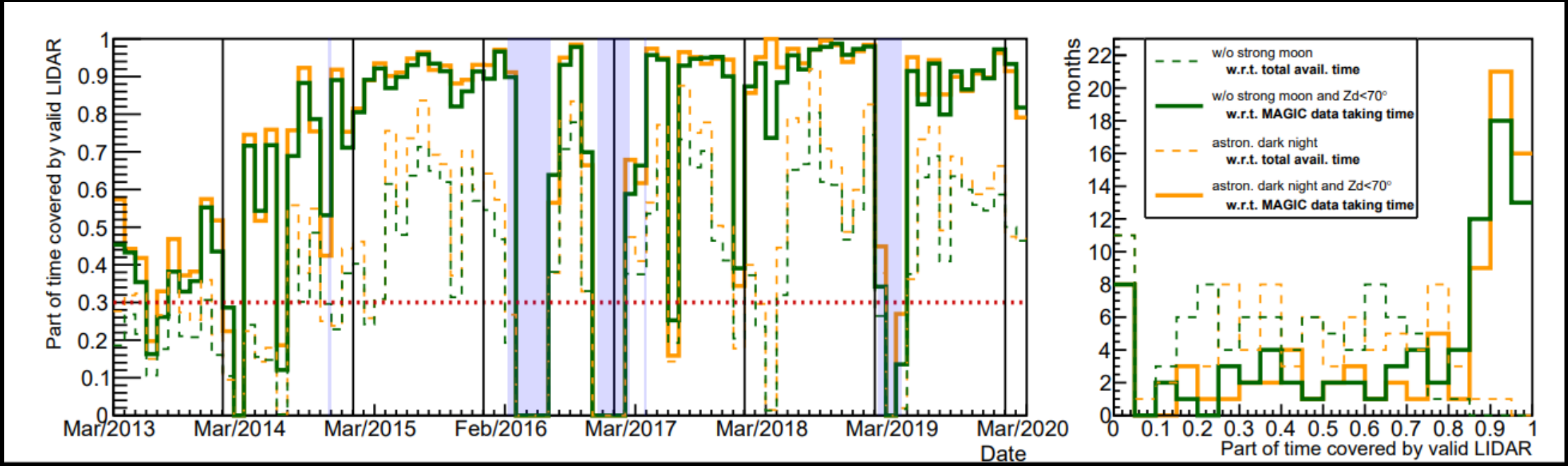
Installed inside a protective dome on the roof of the MAGIC control building

„Micro-power" LIDAR system operating at 532 nm with High QE Hybrid photon detector (HPD)

Simultaneously monitoring of the atmospheric conditions during the nightly MAGIC observations

A low pulse energy was chosen in order to minimize the possible interference with MAGIC and other nearby telescopes

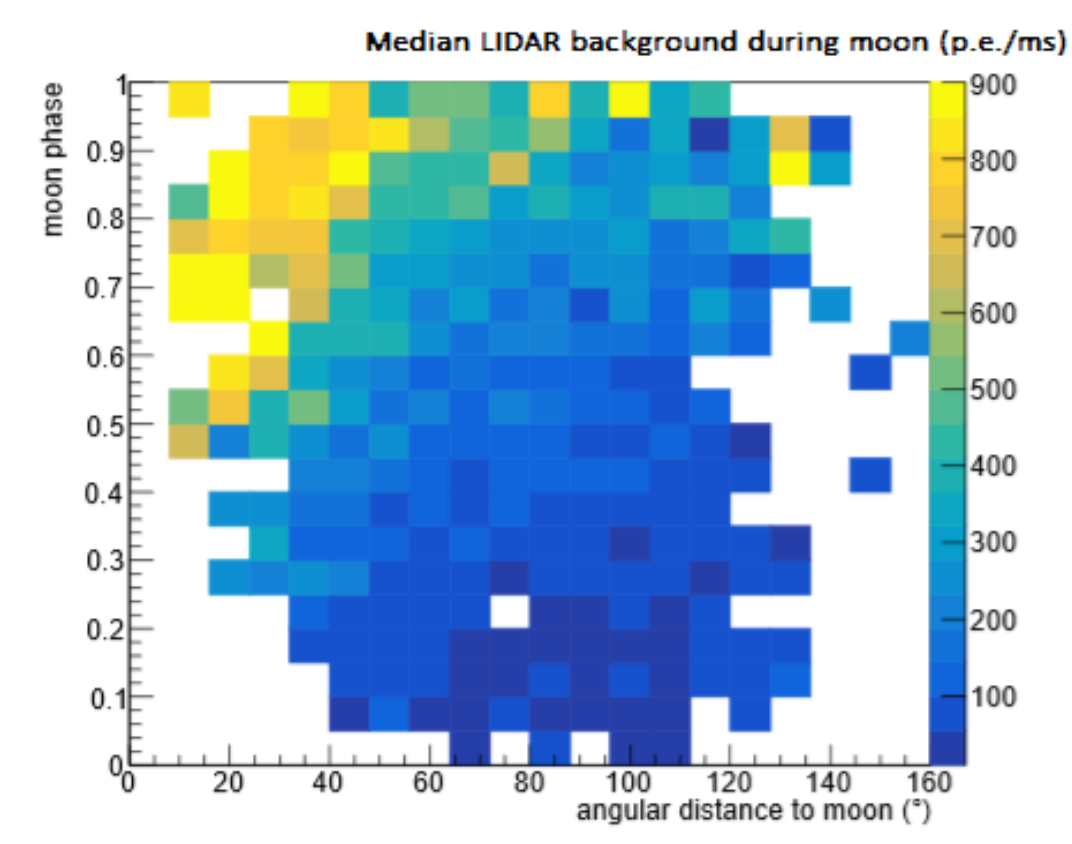
Coverage of the MAGIC LIDAR data

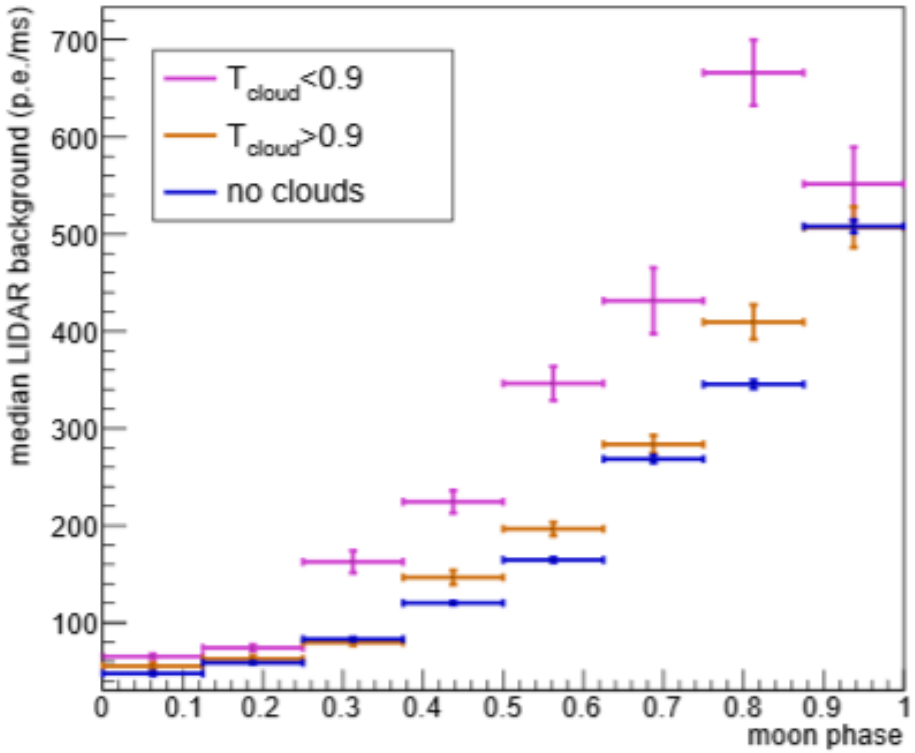


Time-evolution of valid
LIDAR coverage, every bin represents one month

Distribution of monthly
LIDAR data coverage

Median LIDAR background

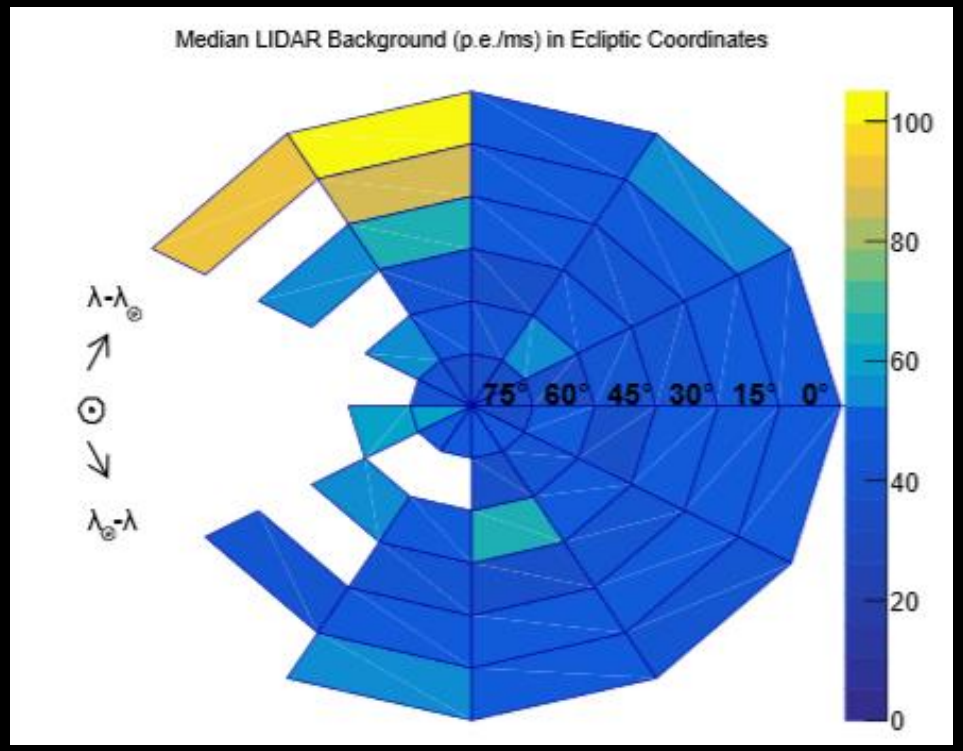




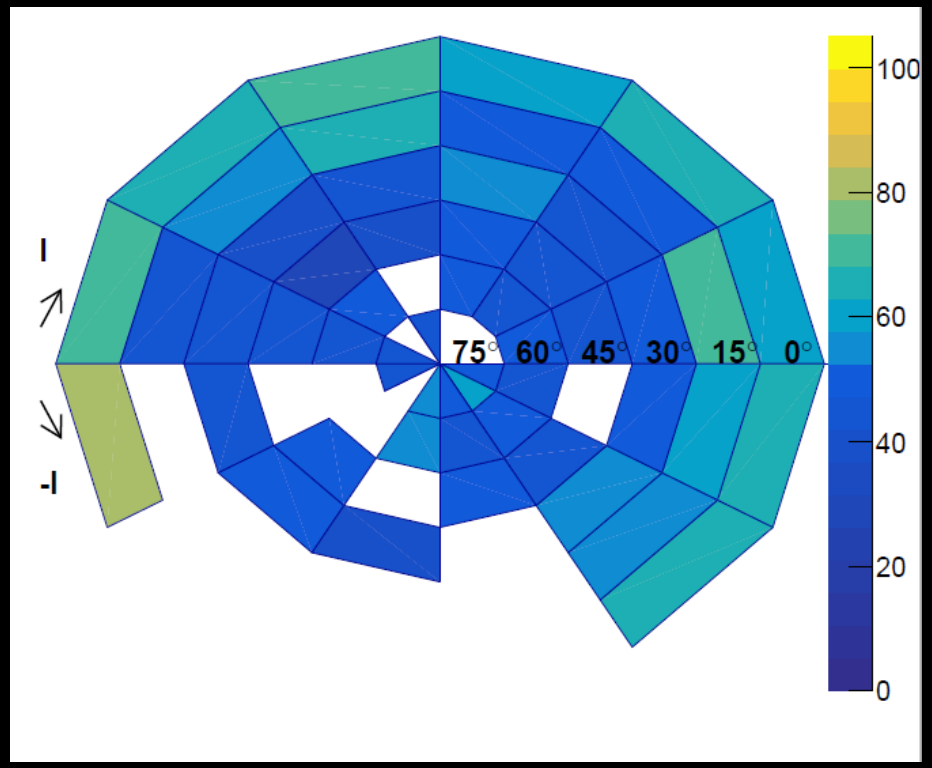
Median LIDAR background rates observed as a function of angular distance to the moon and the moon phase for cloudless nights

Median background rates as a function of moon phase, for data with cloud base higher than 2 km and cloud top lower than 12 km above ground. Galactic star fields and those affected by zodiacal light had been excluded

Zodiac light (left) and hourly variations (right)

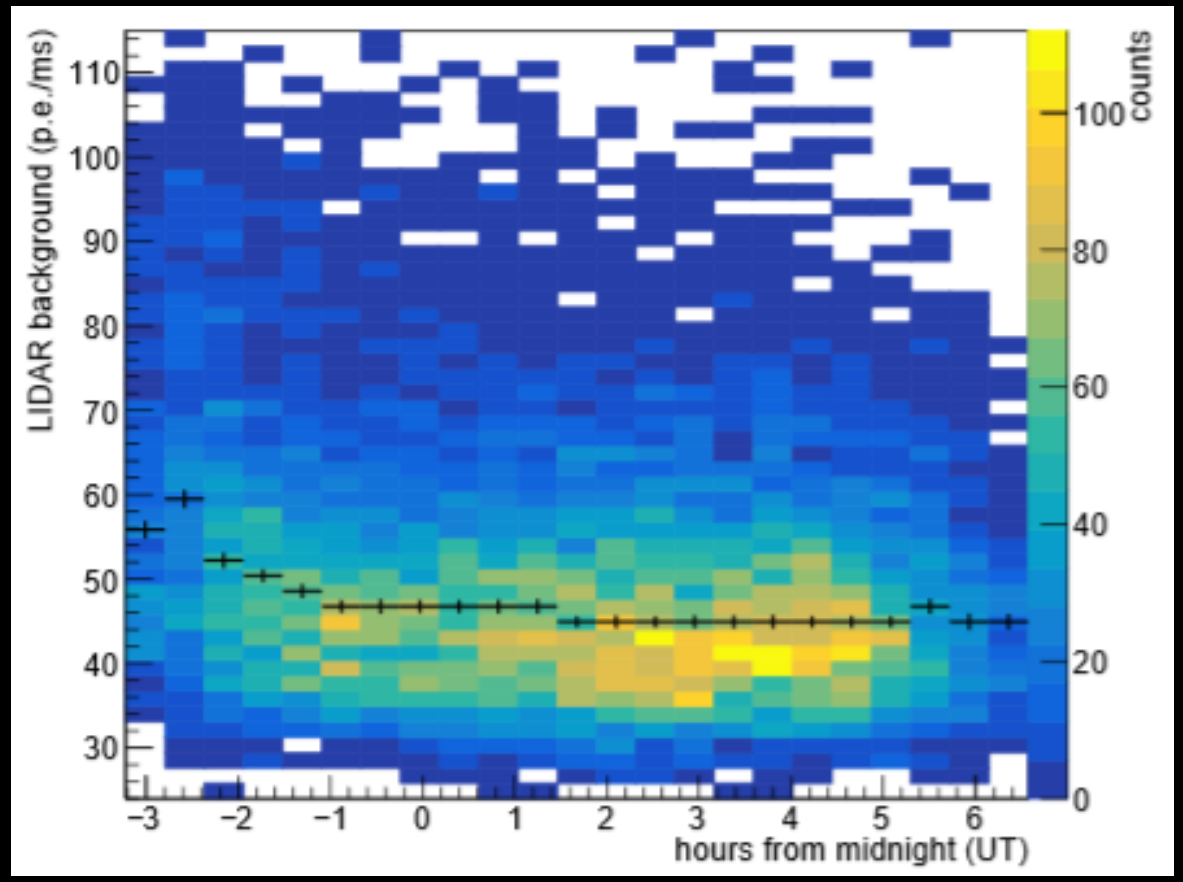


Observed median LIDAR background rates in ecliptic coordinates. Moon, twilight data, galactic fields and data taken before 23 h UTC time have been excluded



Observed median LIDAR background rates in galactic coordinates. Moon, twilight data, galactic fields and data taken before 23 h UTC time have been excluded

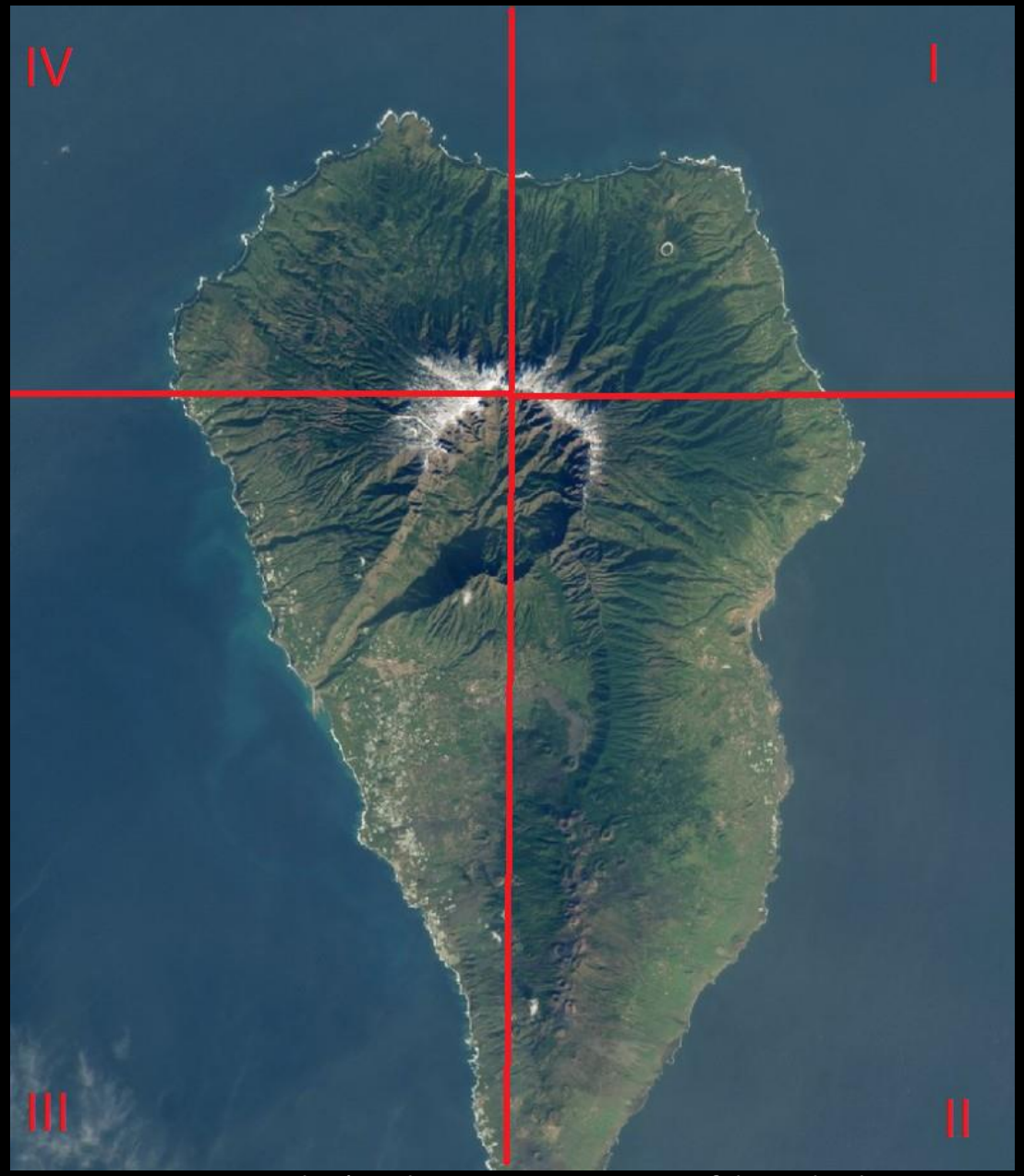
Hourly variatons



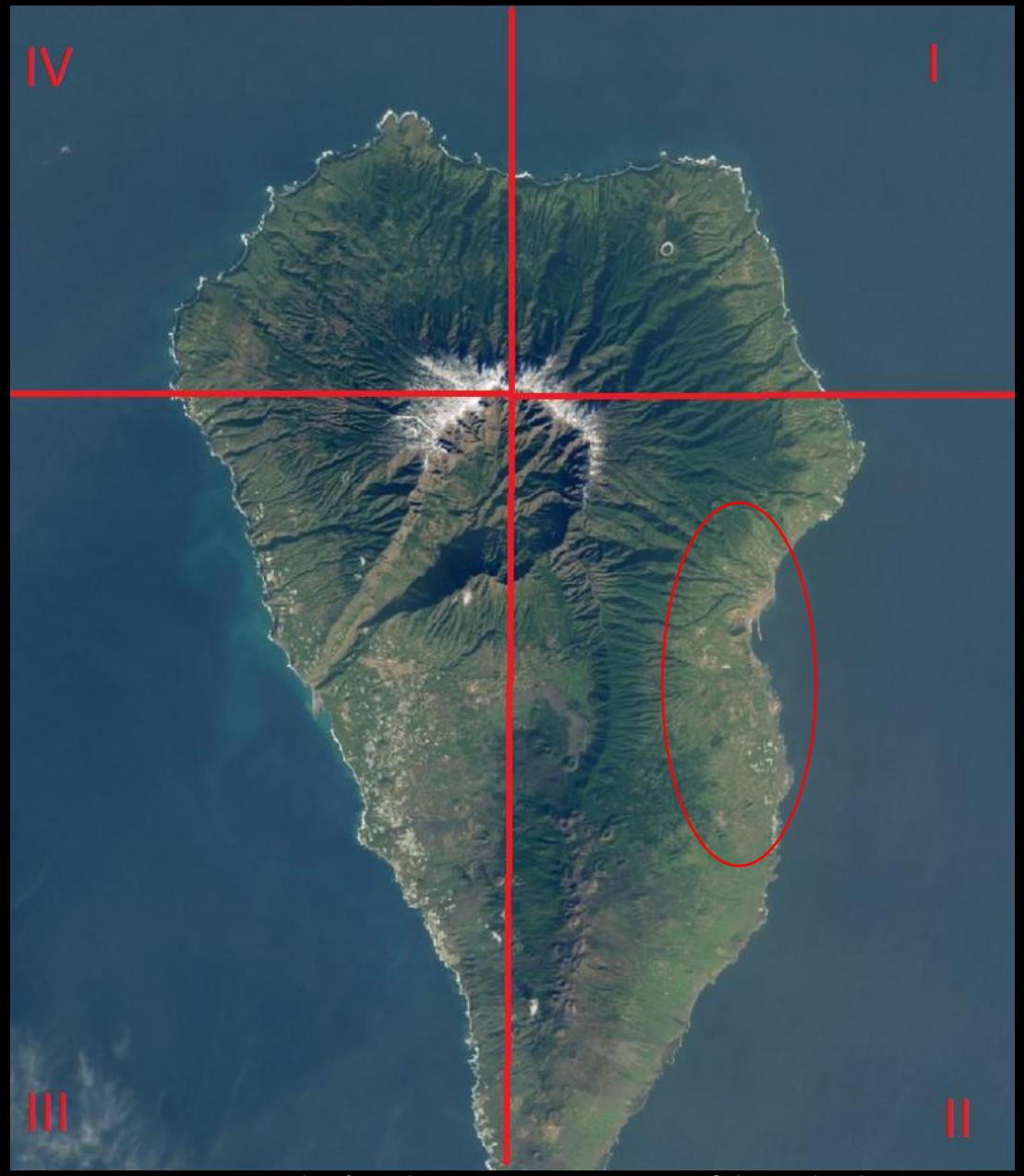
Observed LIDAR background rates, as a function of local time. Moon, twilight, zodiacal light and galactic fields have been excluded.

Slight increase in NSB visible before 23 h local time

IAC's Office for the Protection of the Sky (OTPR)

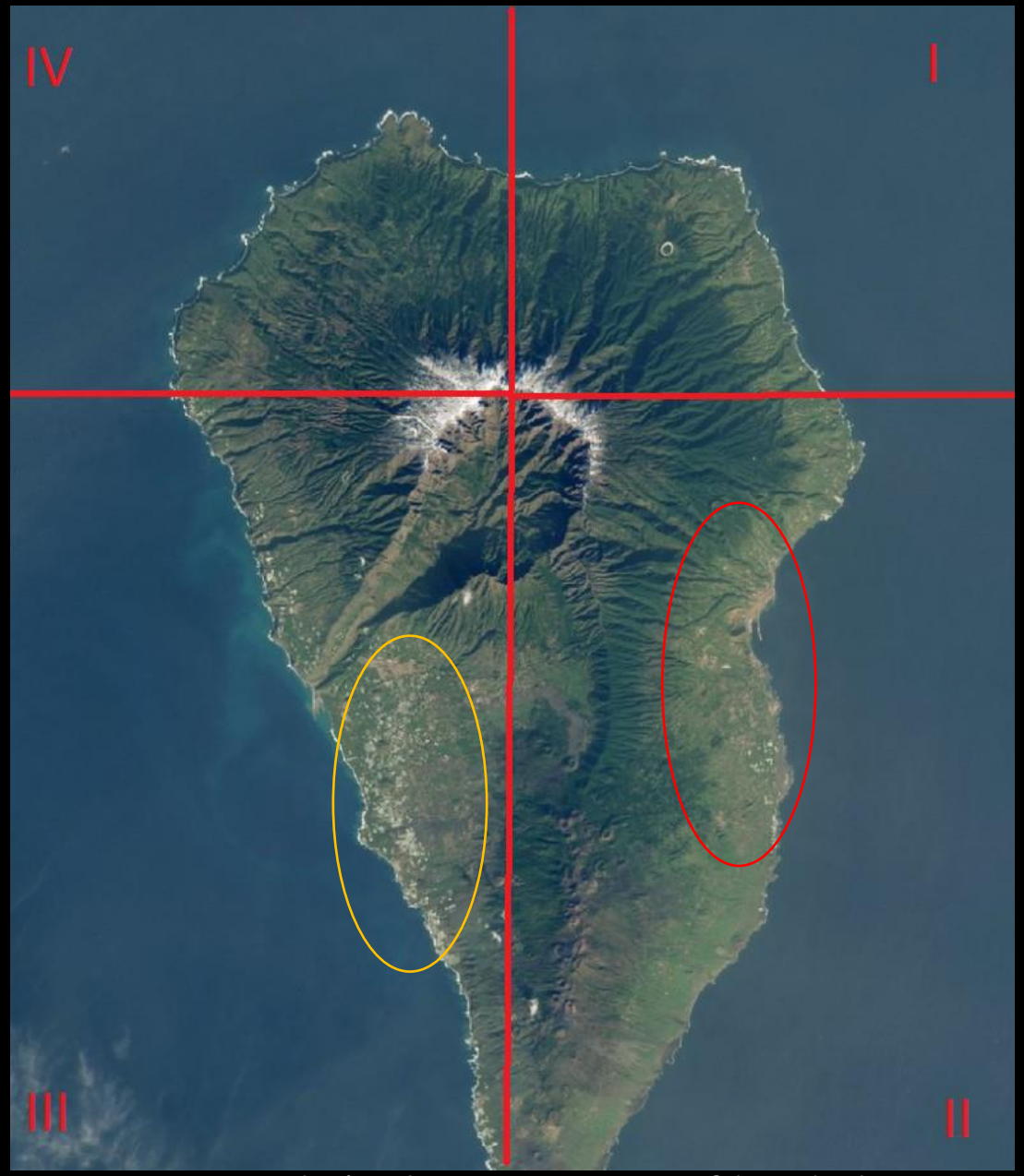

IV
I
III
II

Santa Cruz, population 16,330



Santa Cruz, population 16,330

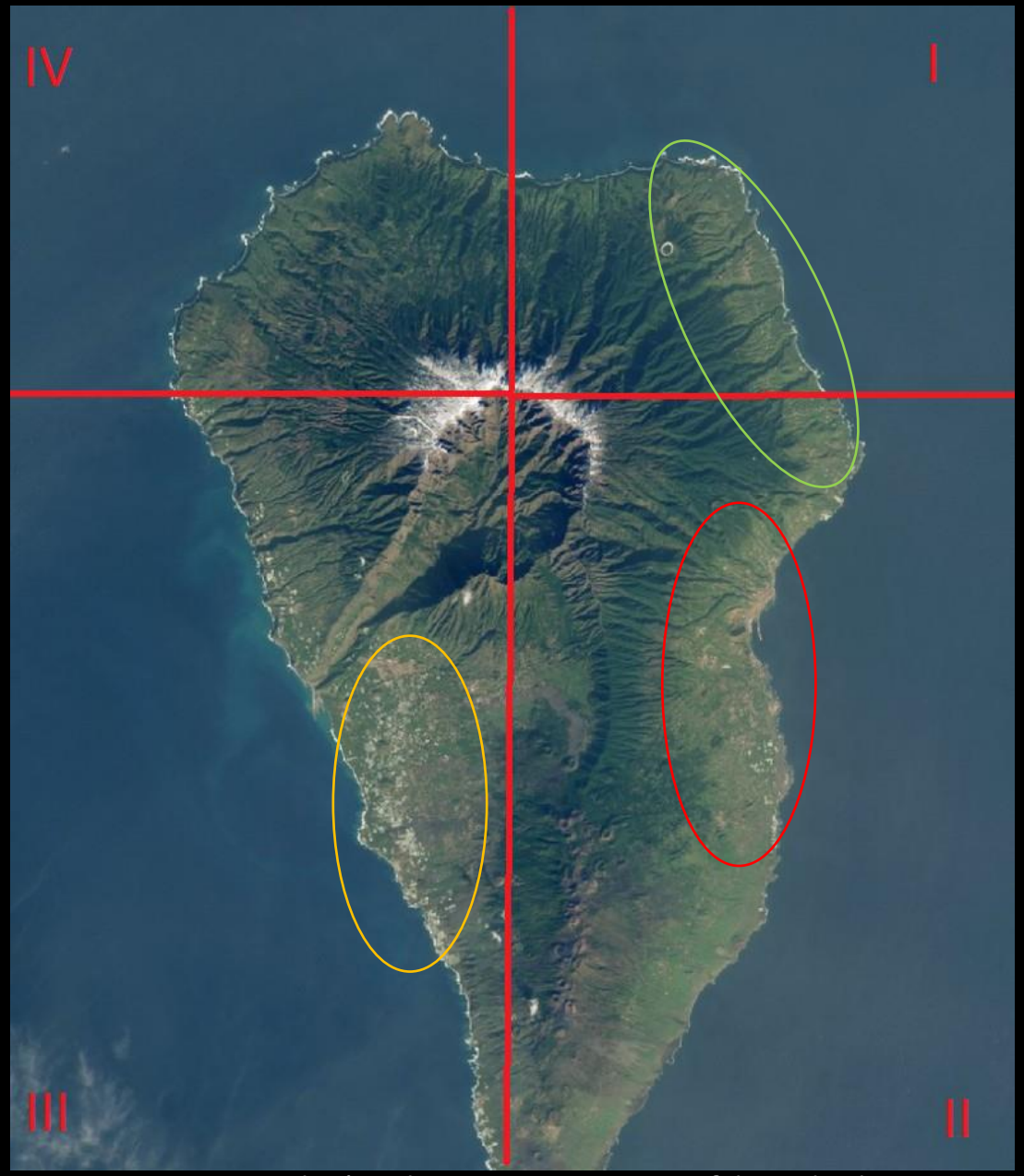
Los Llanos, population 20,171

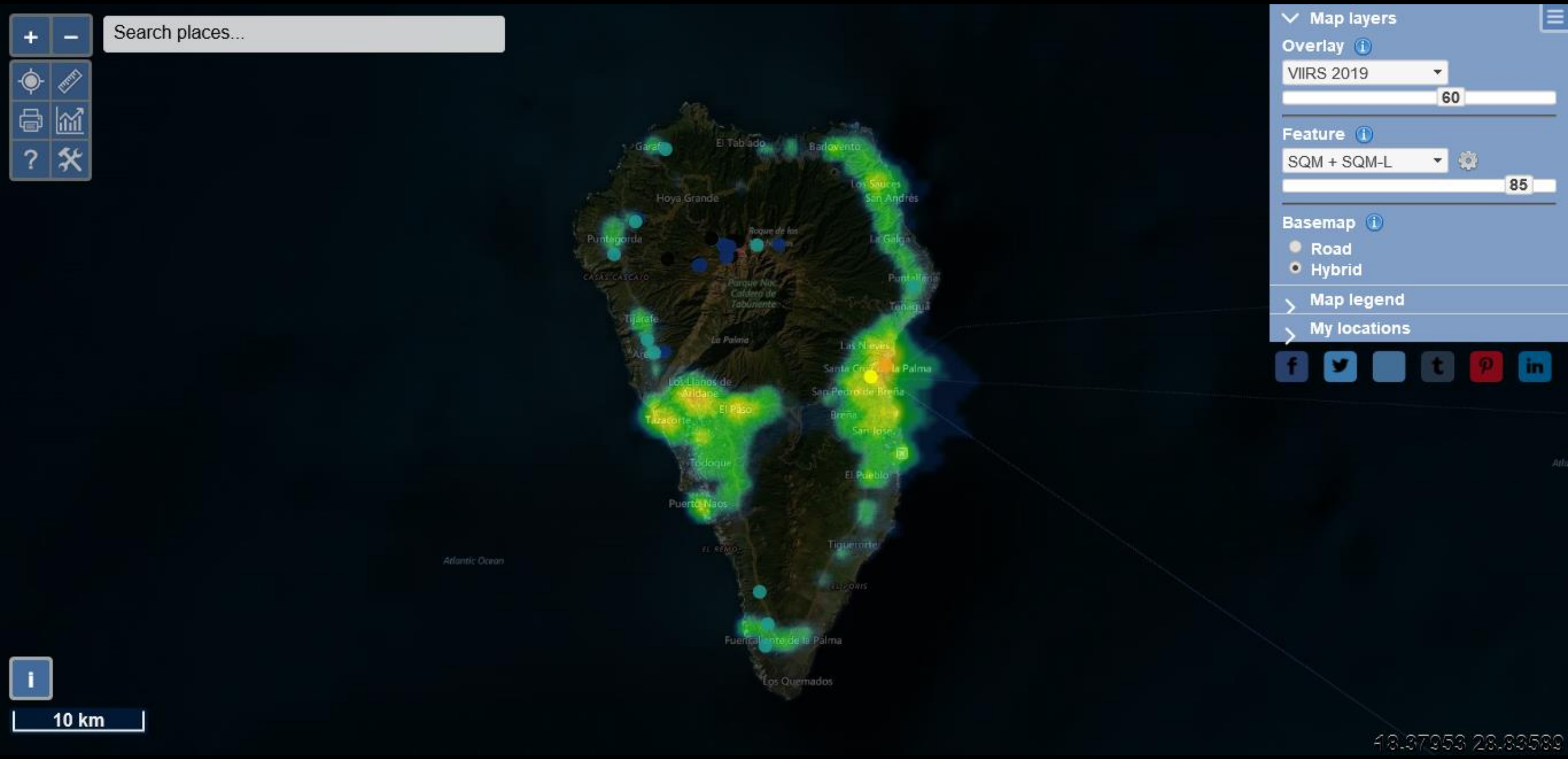


Santa Cruz, population 16,330

Los Llanos, population 20,171

San Andres y Sauces, population 4,473

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Puntallana
Tenagua
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Las Nieves
Santa Cruz de la Palma
San Pedro de Breña
Los Llanos de Aridane
El Paso
Tazacorte
Breña
San José
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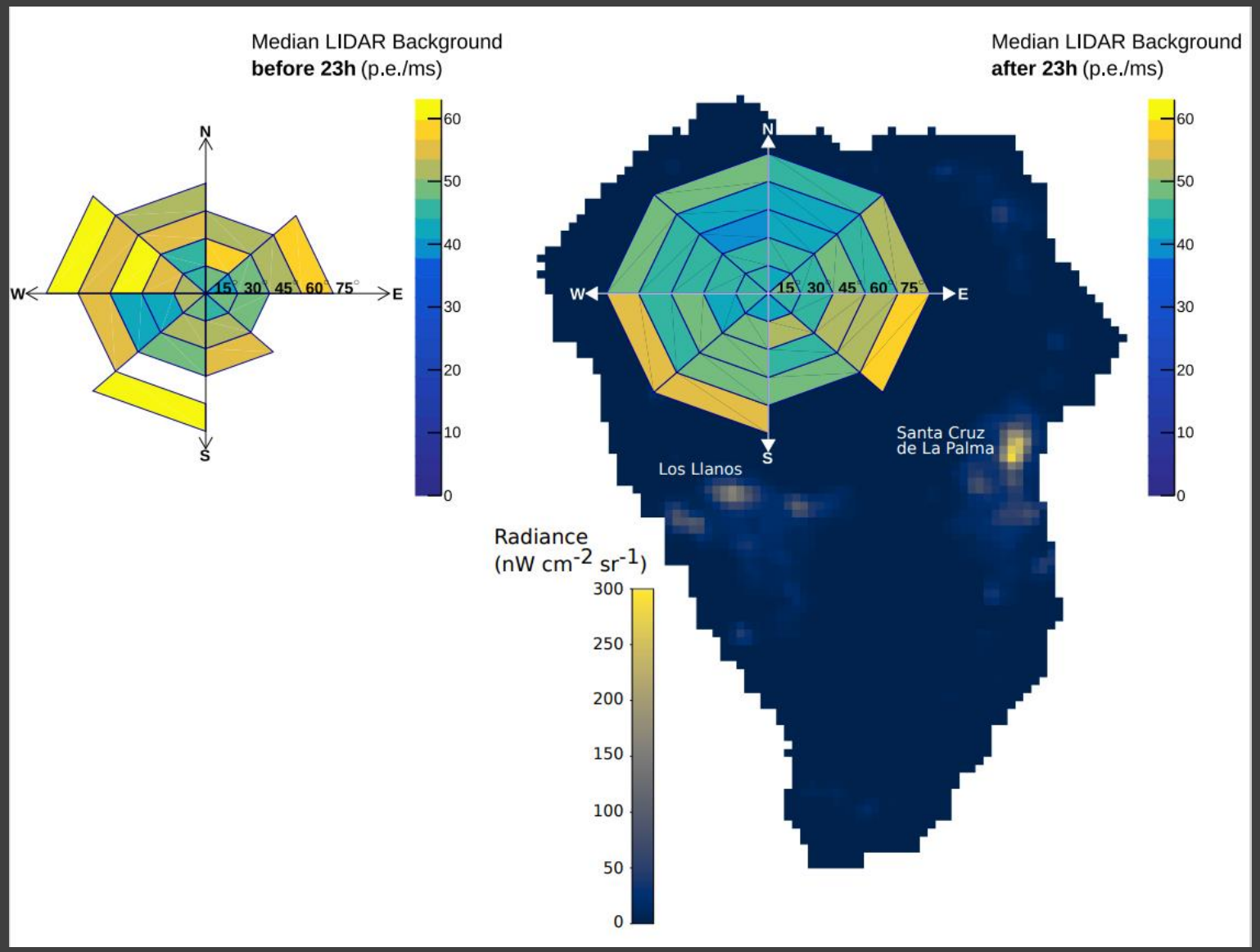
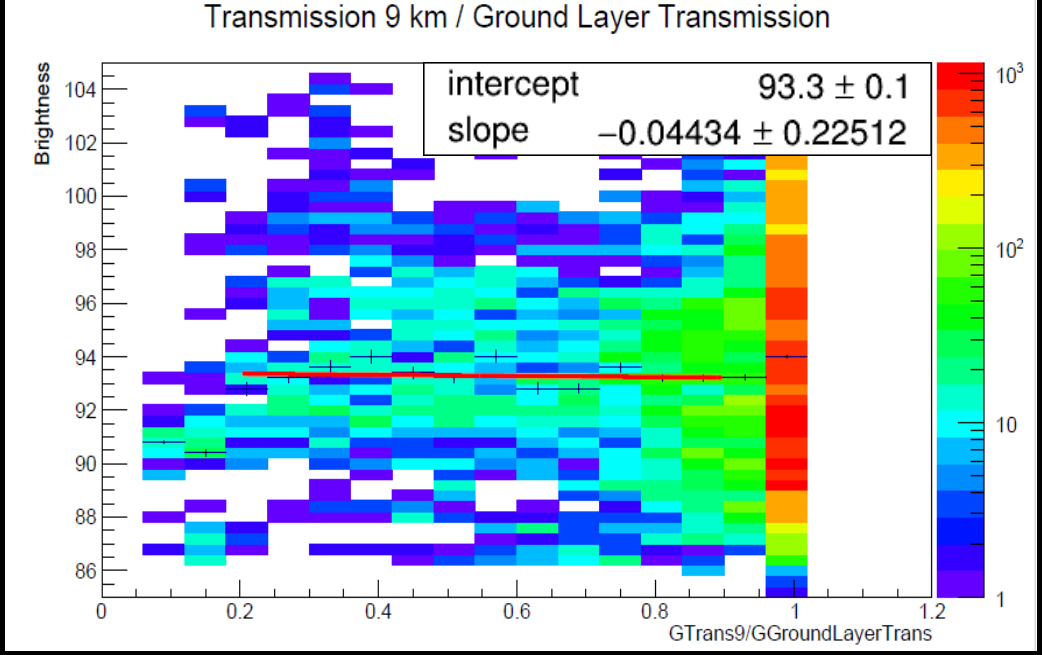


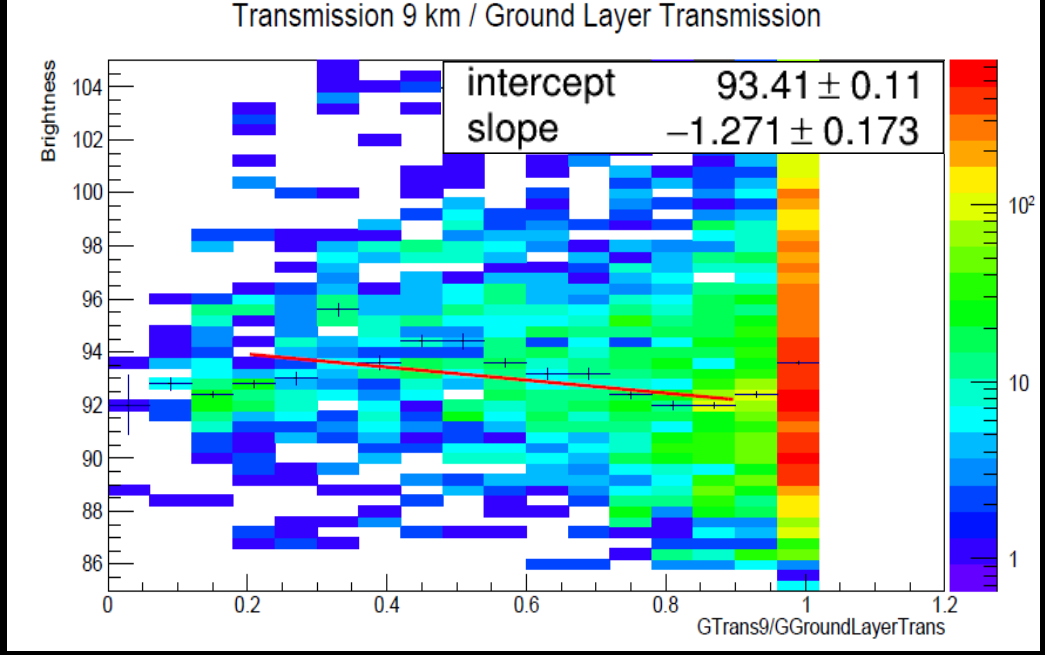
Observed median LIDAR background rates in local coordinates

Moon, twilight, zodiacal light and galactic fields have been excluded previously

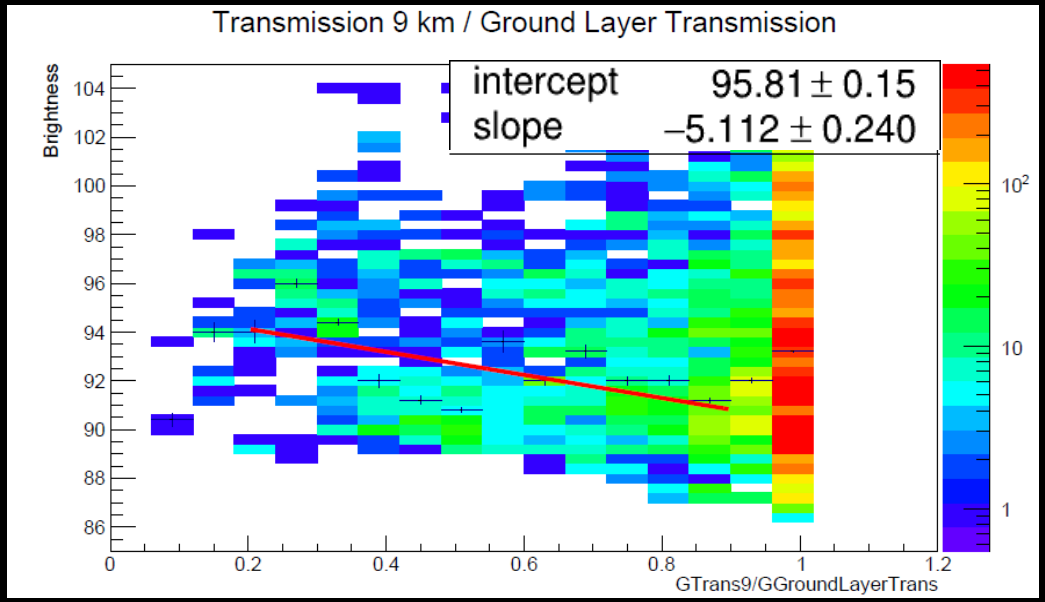
Extragalactic background



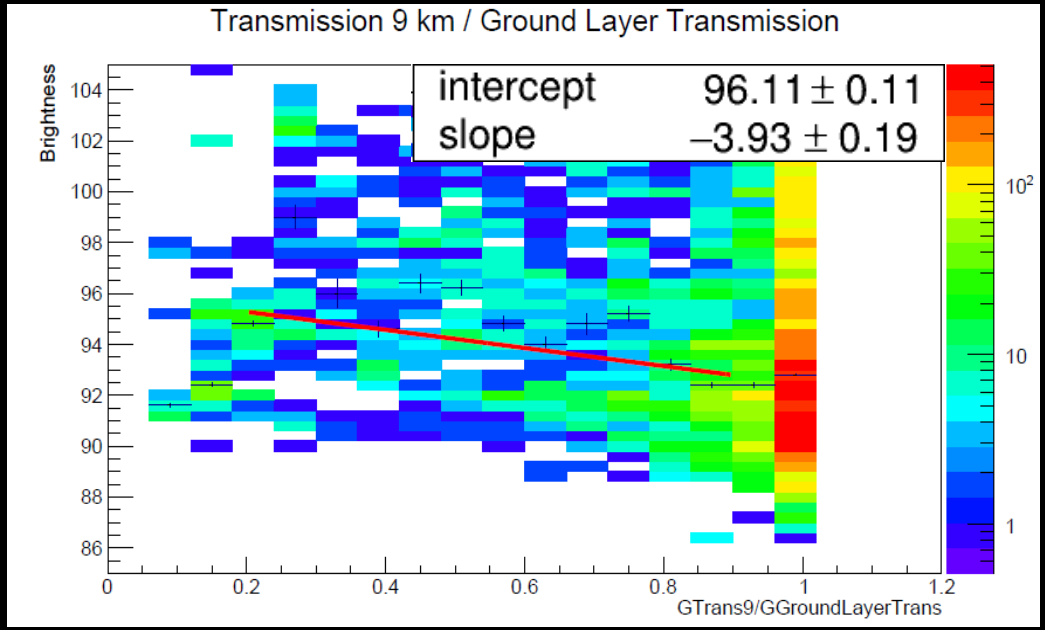
IV. 270° < Az < 360°



I. 0° < Az < 90°

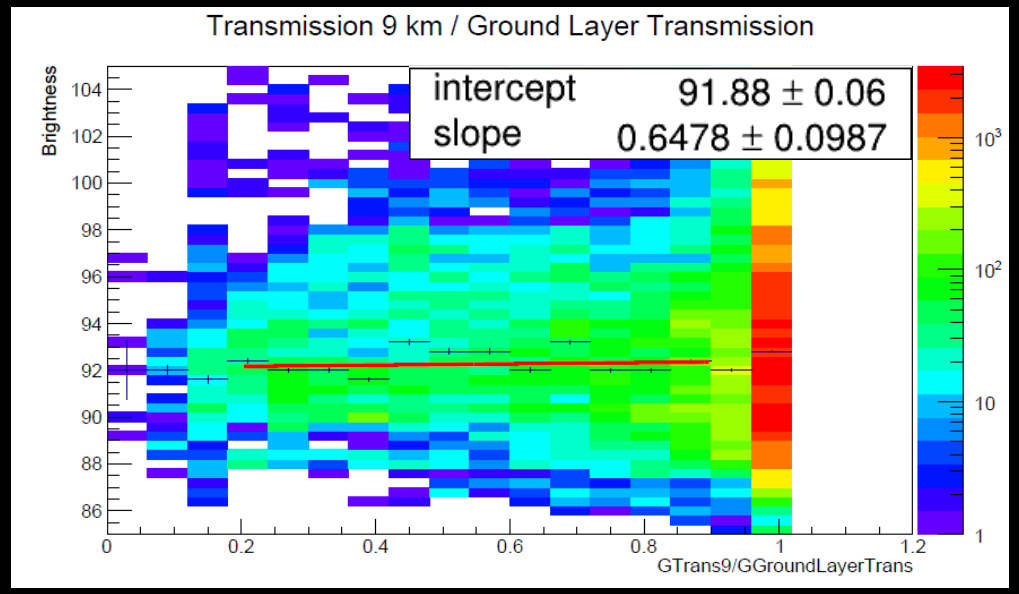


III. 180° < Az < 270°

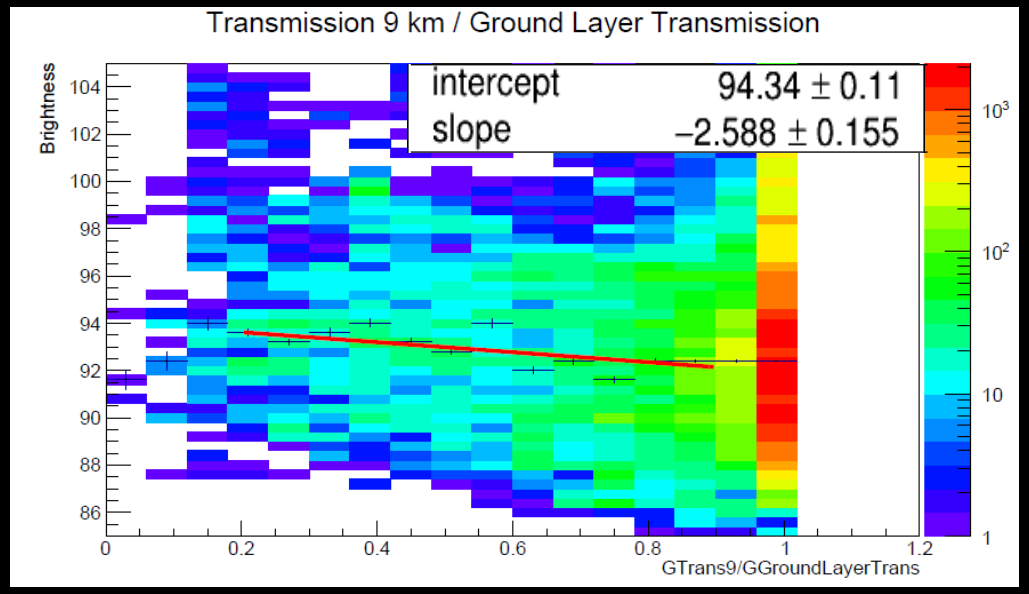


II. 90° < Az < 180°

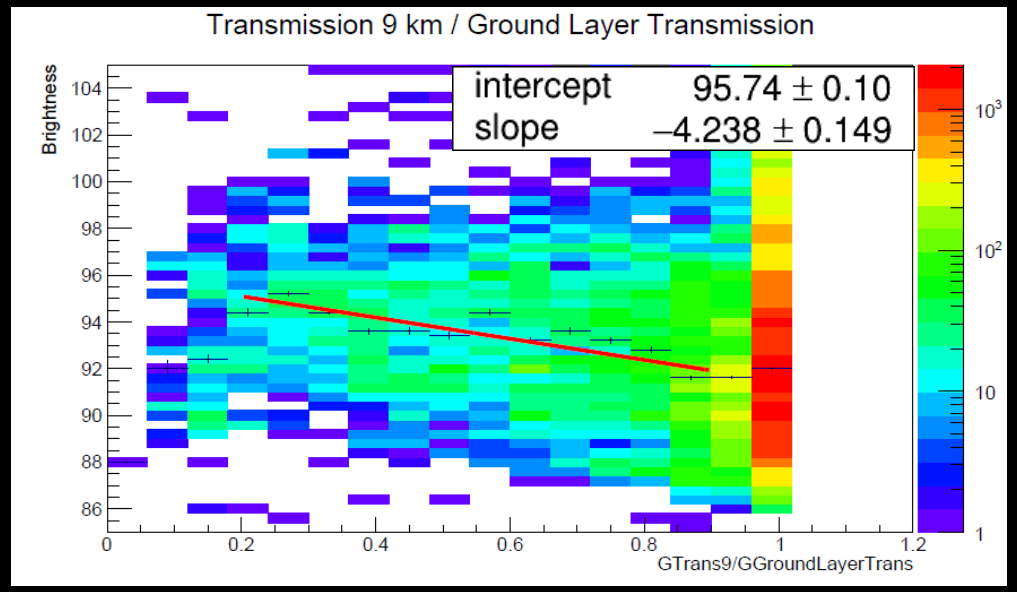
Galactic background



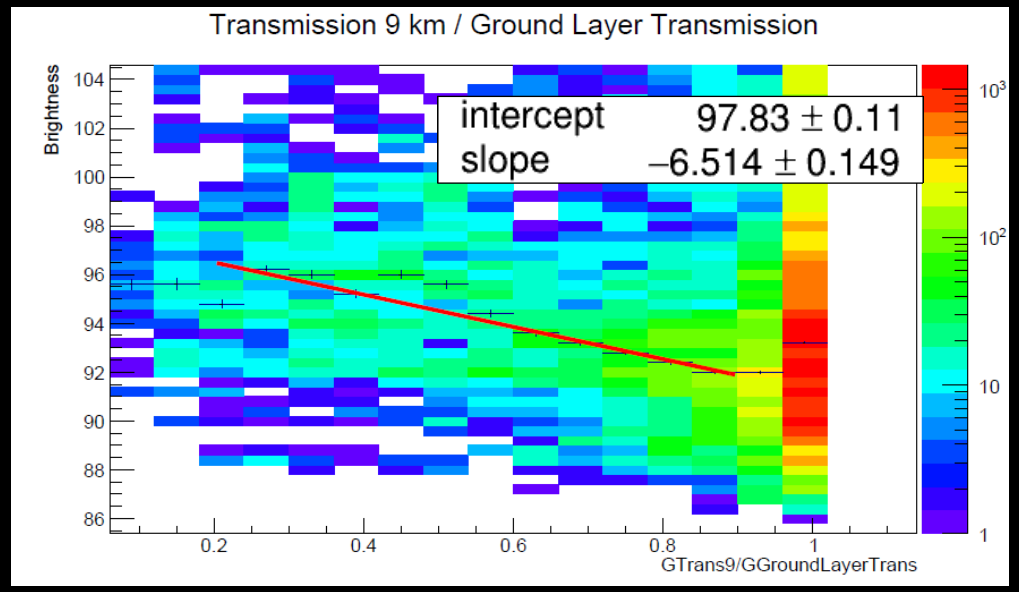
IV. 270° < Az < 360°



I. 0° < Az < 90°



III. 180° < Az < 270°



II. 90° < Az < 180°

Conclusions

- The absolute calibration of the MAGIC LIDAR system was used to produce corrected photo-electron background rates representative of the LoNS
- A significant increase in photon background rates was found to be due to the back-scattering of background light
- Increase with the optical depth of clouds during moonlight conditions
- This analysis clearly identifies the evening zodiacal light and the Galactic plane
- Residual anthropogenic contributions to the 532 nm background light were found
- Applications to CTA and other new generations of Cherenkov telescopes

Acknowledgements

- MAGIC collaboration and shifters
- Insituto de Astrofisica de Canarias
- Spanish grant PID2019-107847RB-C42, funded by MCIN/AEI/10.13039/501100011033
- German BMBF and MPG
- Croatian Science Foundation (HrZZ) Project IP-2016-06-9782
- University of Rijeka Project uniri-prirod-18-48
- Goddard Space Flight Center in Greenbelt, Maryland, USA

THANK YOU FOR YOUR ATTENTION!

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