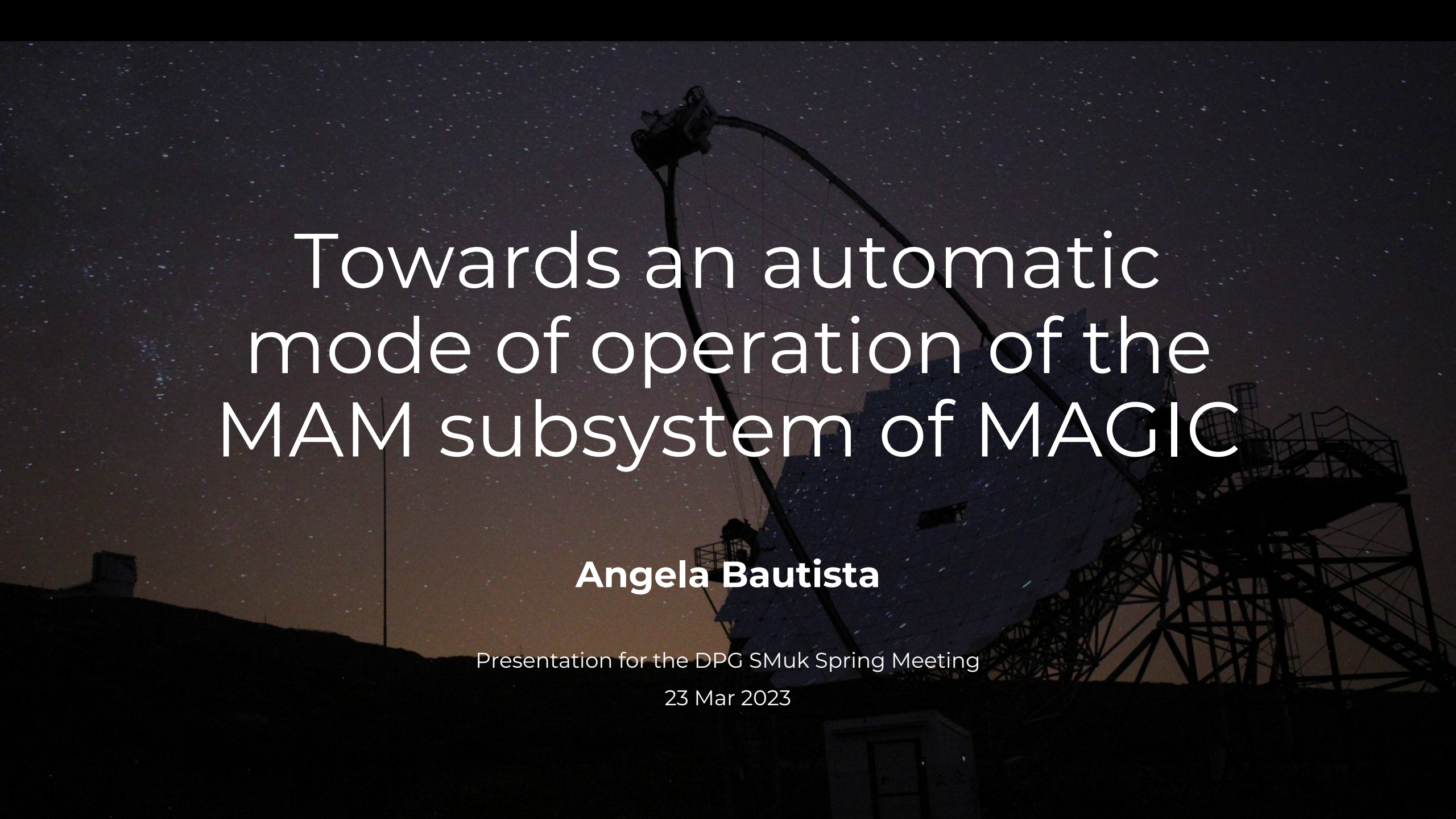


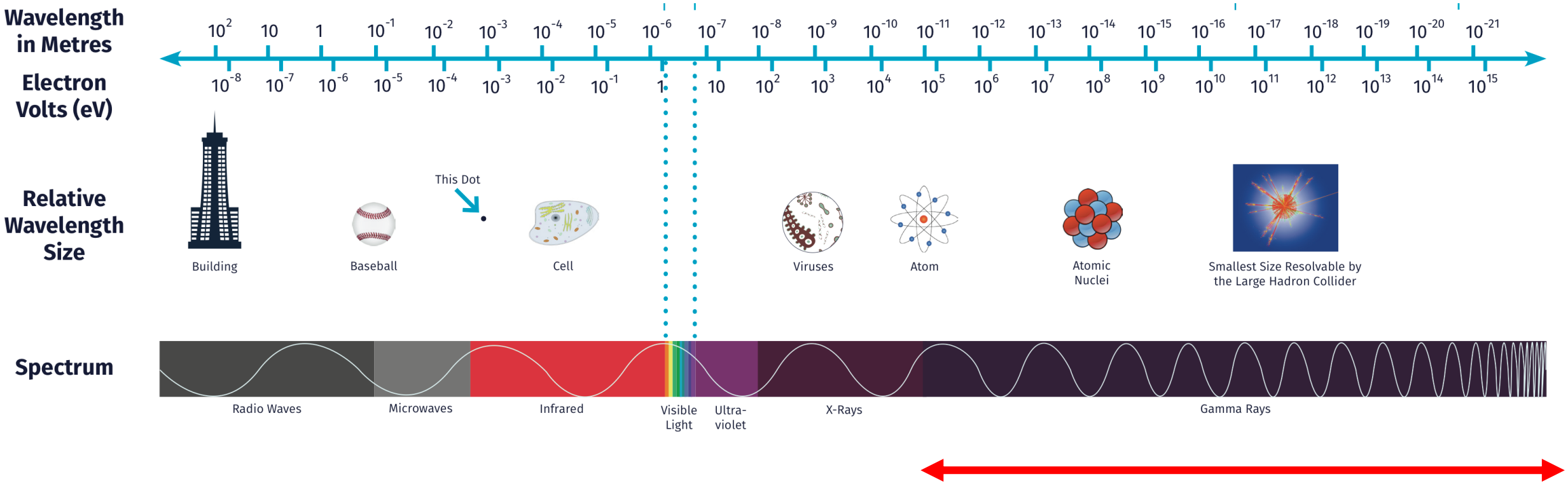
Towards an automatic mode of operation of the MAM subsystem of MAGIC

Angela Bautista

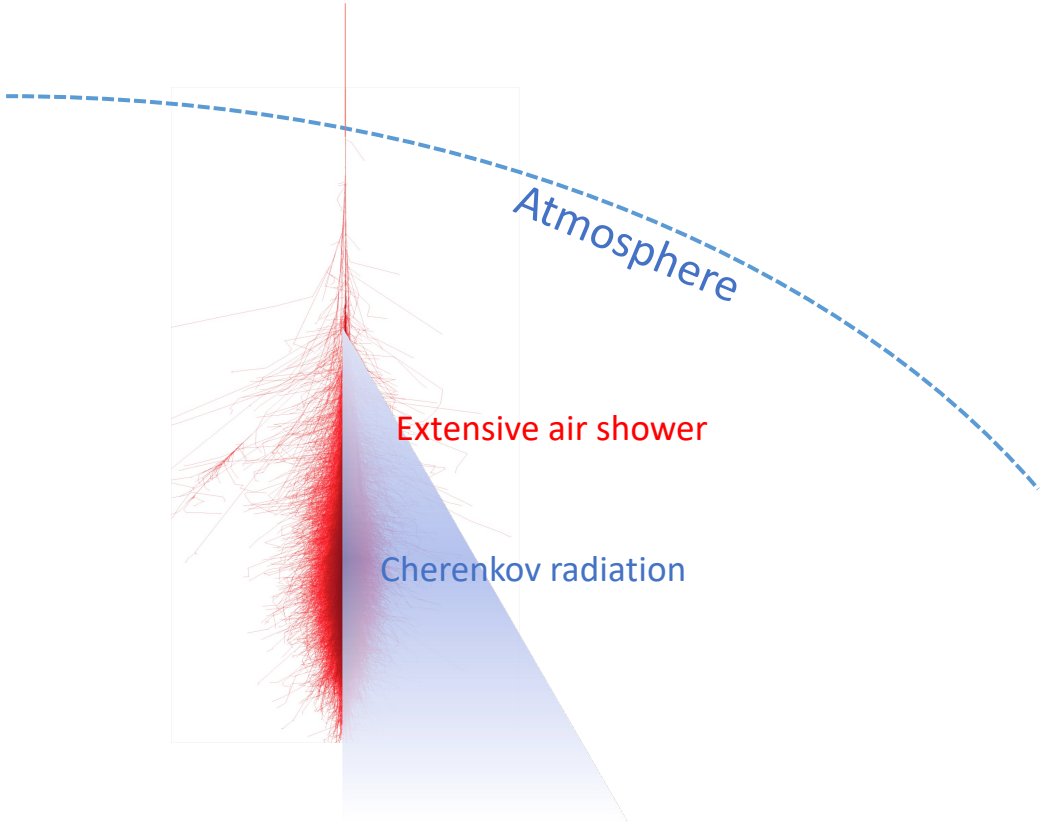
Presentation for the DPG SMuk Spring Meeting

23 Mar 2023

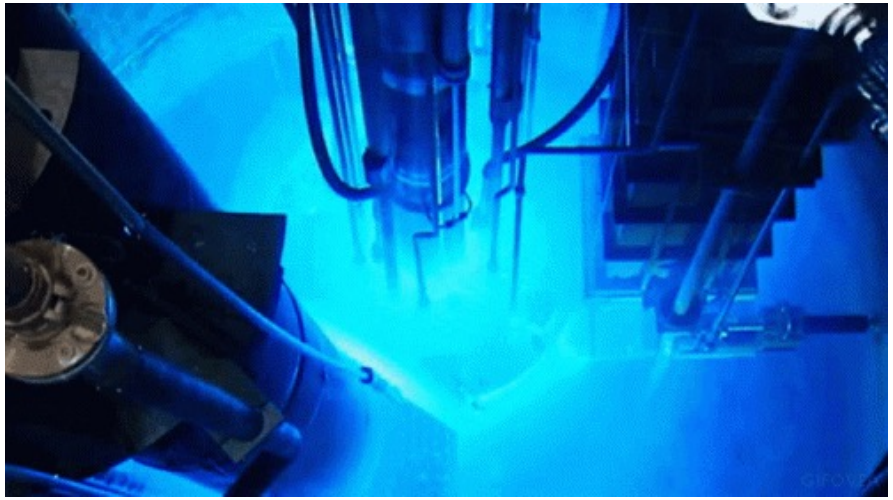
Ground-based Gamma-ray Astronomy



Ground-based Gamma-ray Astronomy



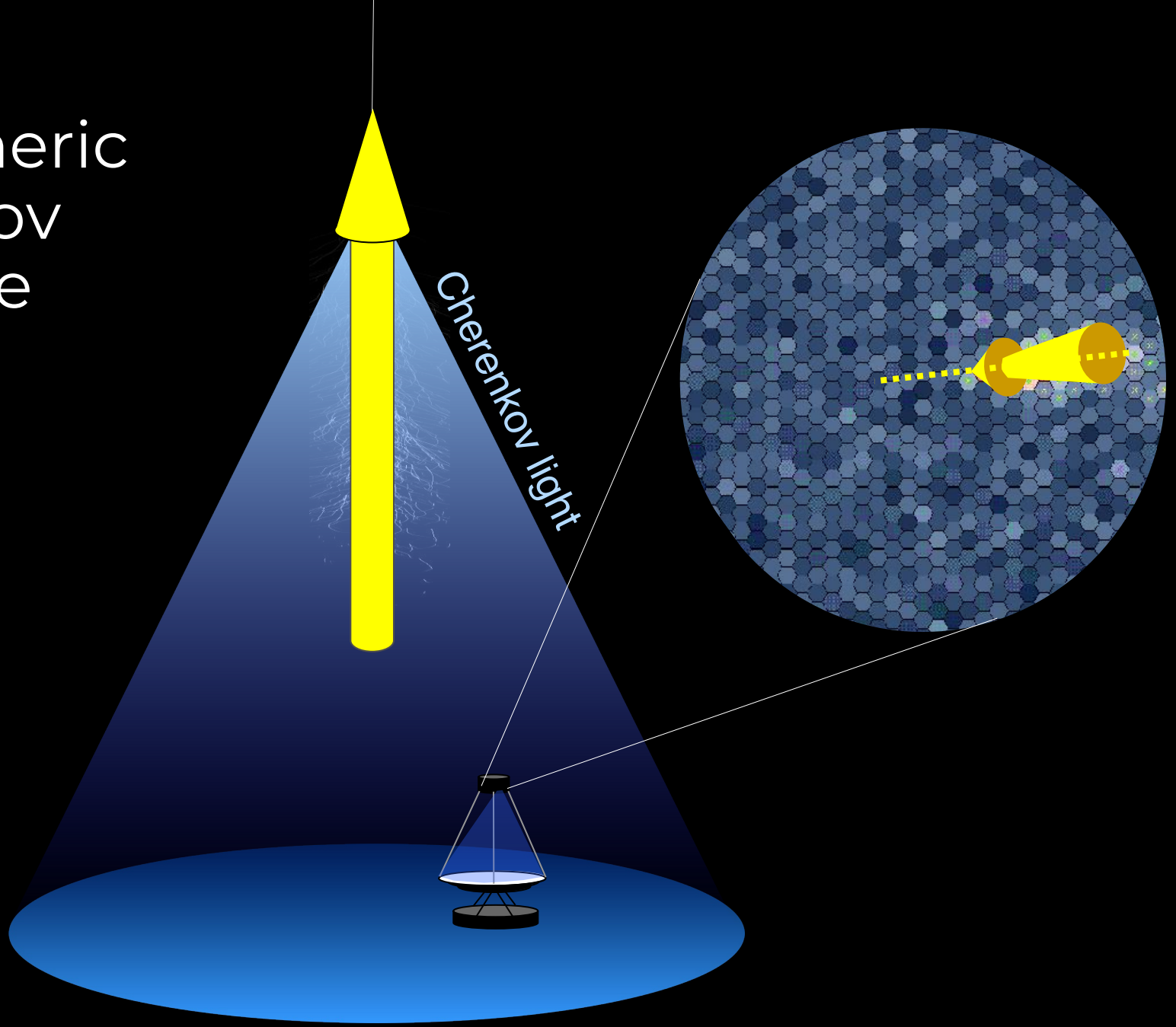
Very High Energy gamma-ray produces shower of secondary particles



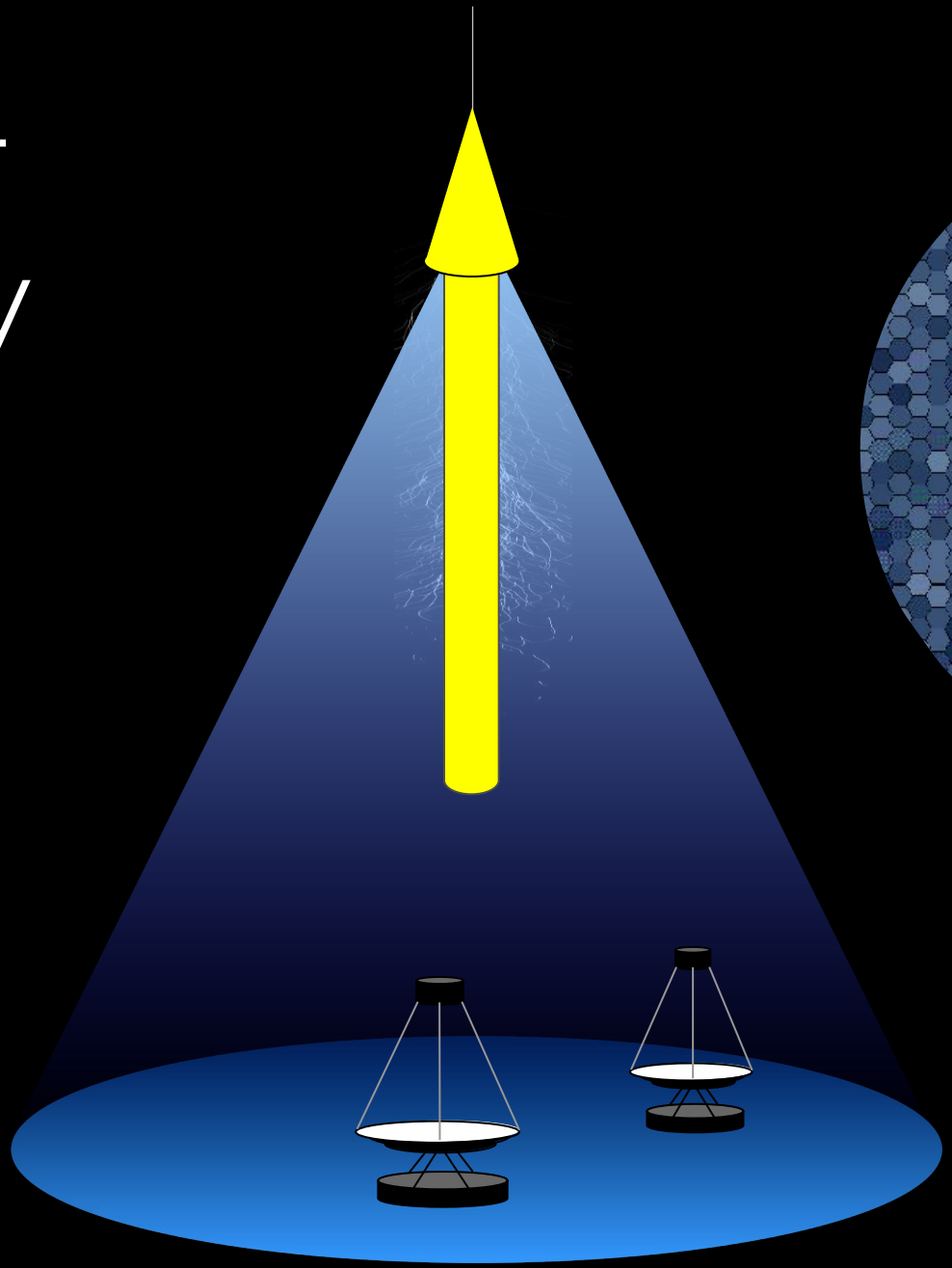
Credits:https://tenor.com/view/

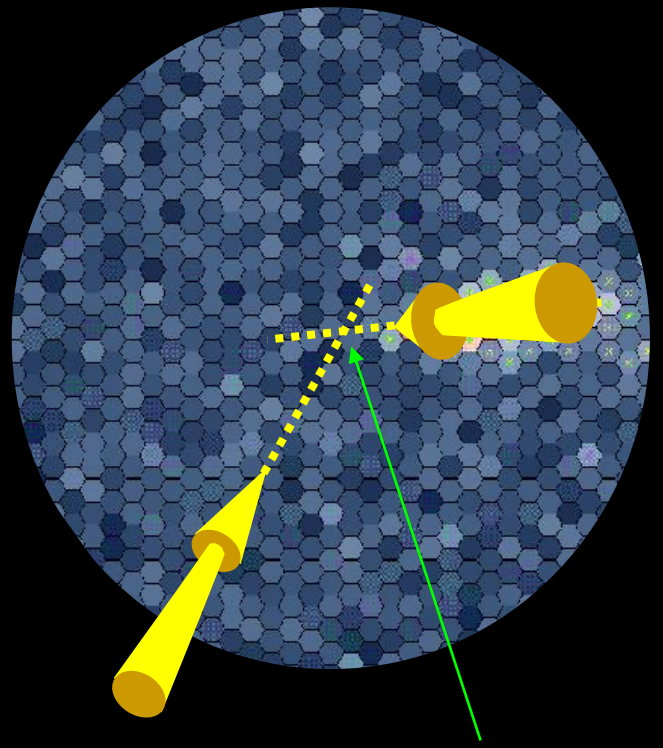
Cherenkov radiation: Light emitted when charged particles exceed the speed of light in a medium

Imaging Atmospheric Cherenkov Telescope (IACT)



IACT array

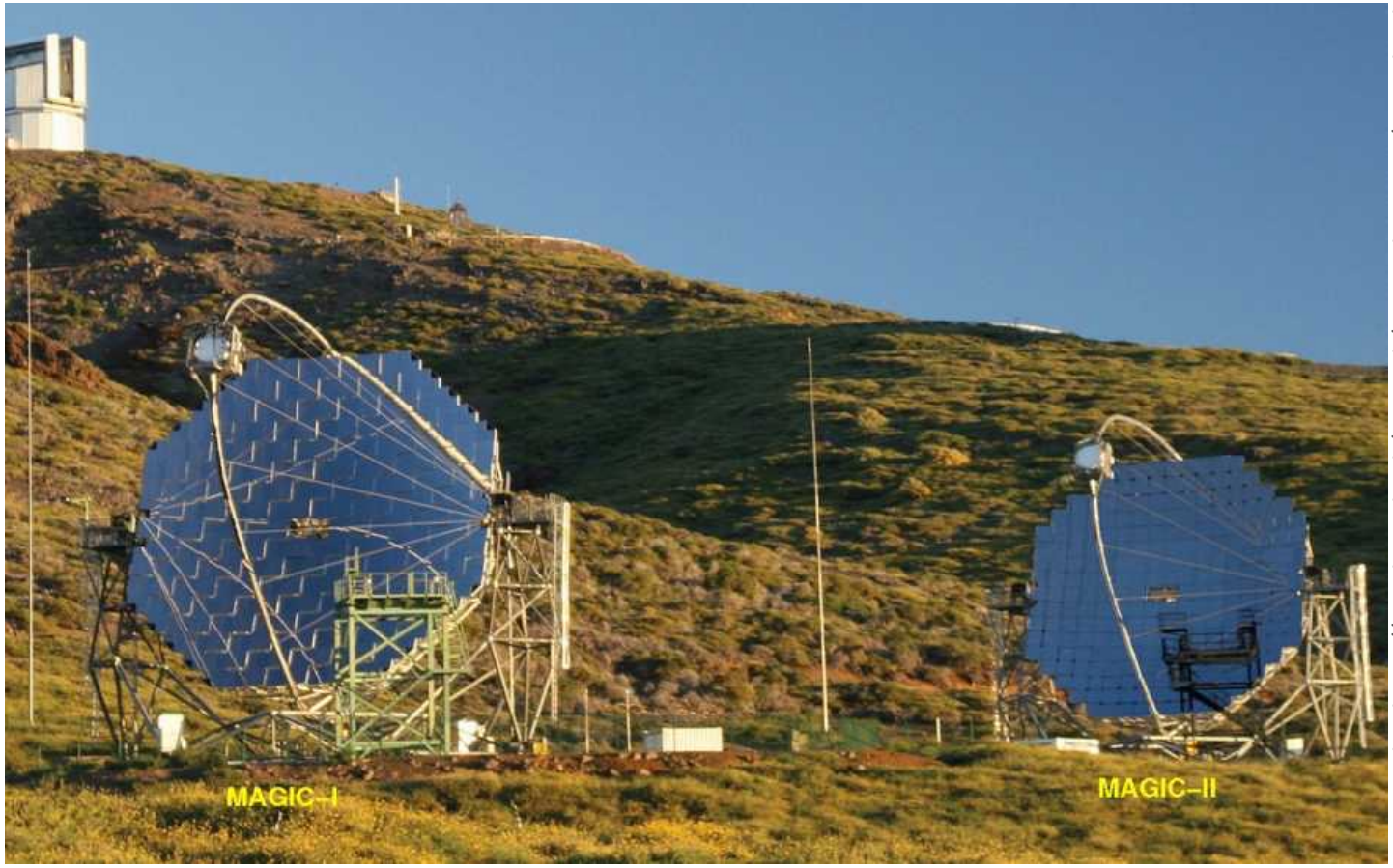




gamma-ray direction

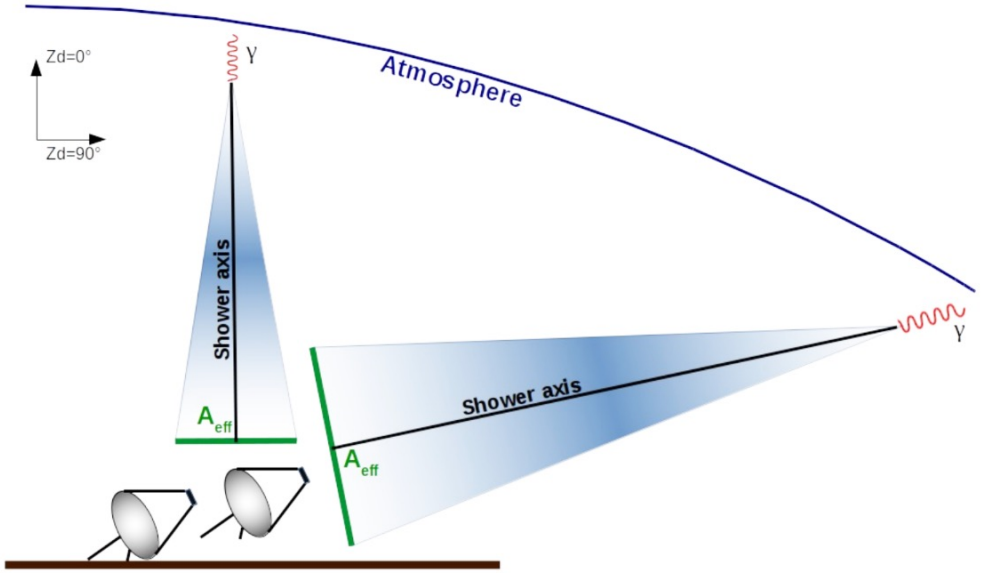
The MAGIC Telescopes

- Two 17-m diameter Imaging Atmospheric Cherenkov Telescopes (IACTs)
- Detect gamma rays in the Very High Energy range, 20 GeV to 100 TeV
- Cherenkov photons used to estimate the energy of the incident gamma-ray



Credits: https://ipa.phys.ethz.ch/research/ResearchProjects/magic.html

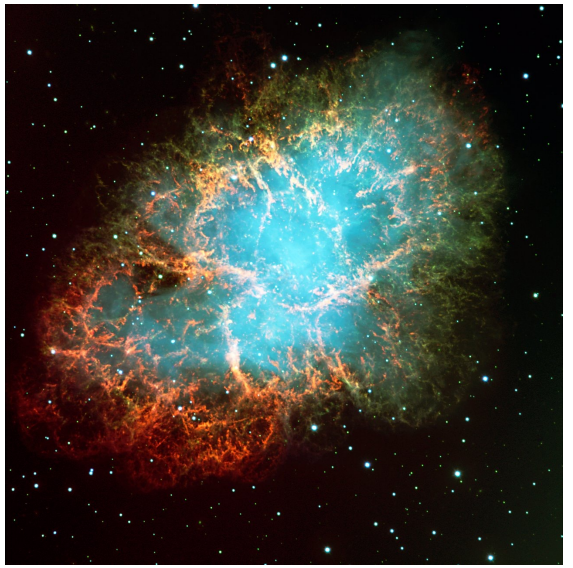
Very Large Zenith Angle (VLZA) Observations

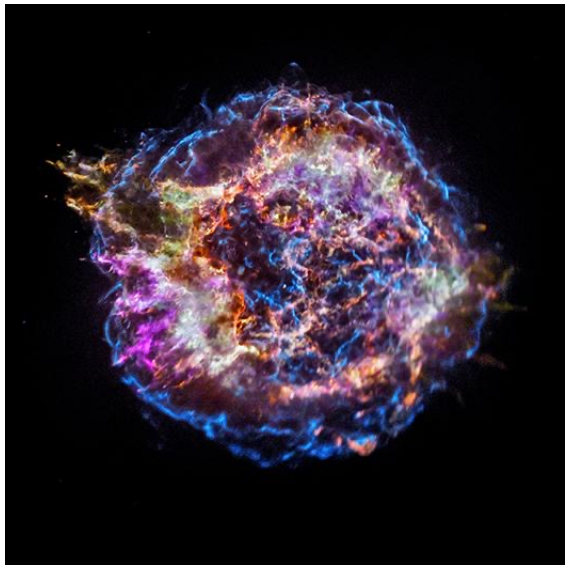


Credits: van Scherpenberg, J. (2023) Very Large Zenith Angle Observations with MAGIC

- Only the most energetic gamma-rays reach the detectors
- Detect gamma-rays with energies above 100 TeV with MAGIC

The hunt for PeVatrons!



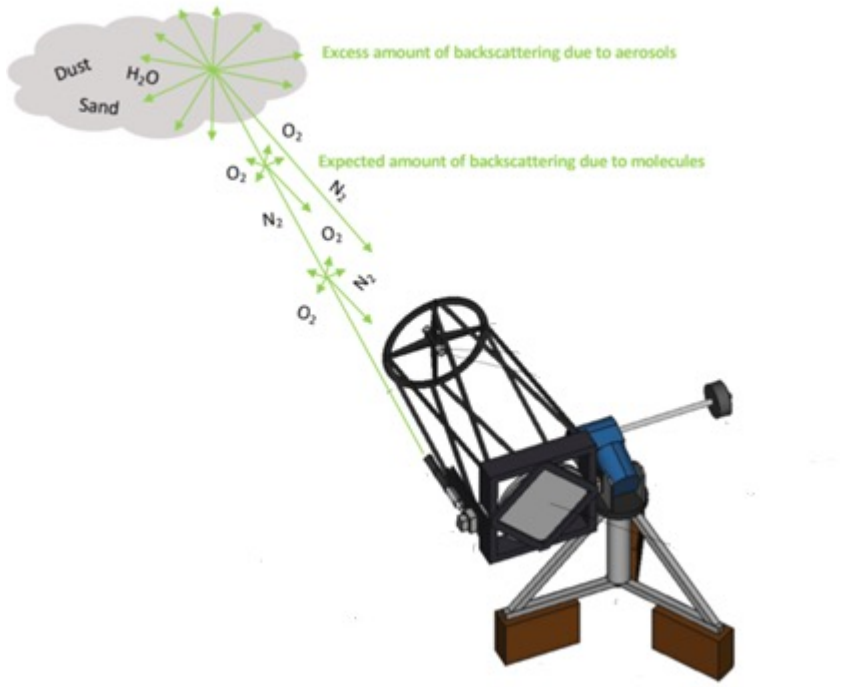


What are they?

- We can probe particle acceleration up to the PeV range with gamma-rays with energies in the UHE range (above 100 TeV)

We are looking for them with MAGIC!

Calibration Subsystems



Credits: Schmuckermaier, F. (2023) Correcting MAGIC Telescope data with the LIDAR

Light Detection and Ranging System (LIDAR)

Atmospheric corrections using backscattered light from a laser

LIDAR measures atmospheric transmission up to 70 deg zenith angle

NO LIDAR :(

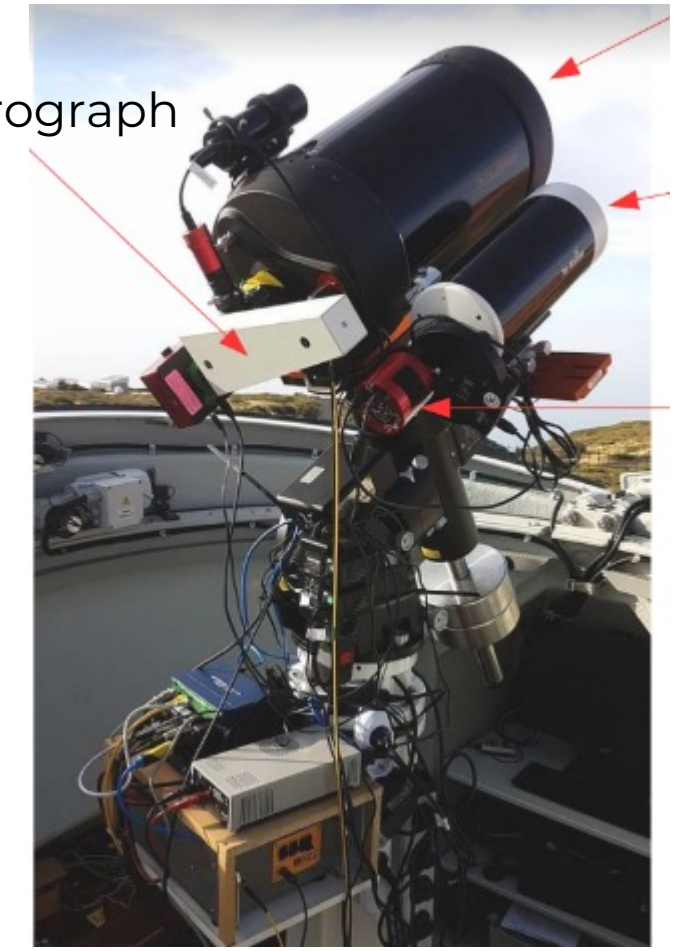
solution

MAGIC Atmospheric Minion (MAM)

Atmospheric corrections for VLZA observations

The MAGIC Atmospheric Minion (MAM)

- Subsystem to correct VLZA MAGIC data
- Task: monitor the atmospheric transmission (AT) in real time in the pointing direction of MAGIC using photometry and spectroscopy



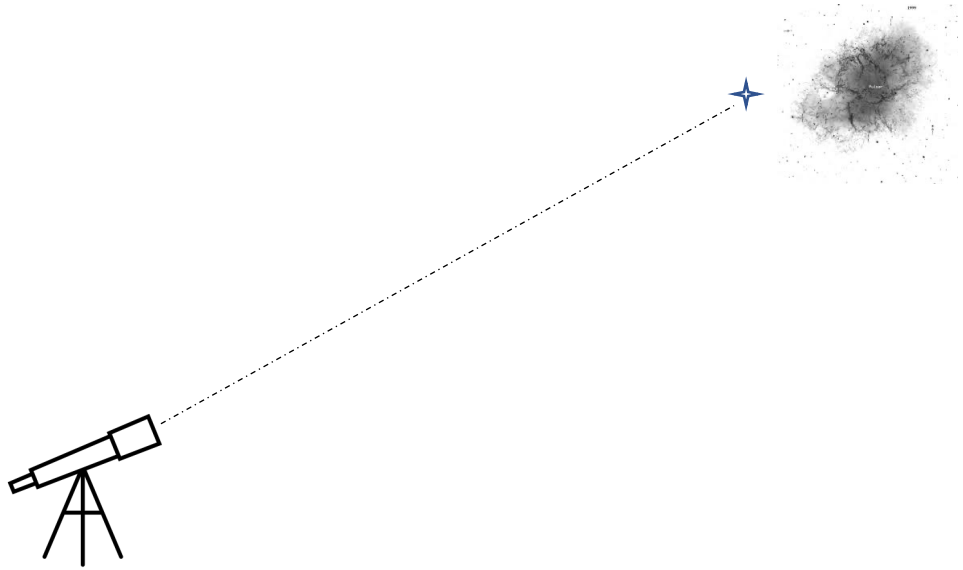
Credits: Pihet, M (2023) MAM Technical Operation Manual

Plan automatic mode of operation of MAM

- How? MAM will track a star in the close vicinity of a MAGIC target and measure the Atmospheric Transmission

- Photometric mode:

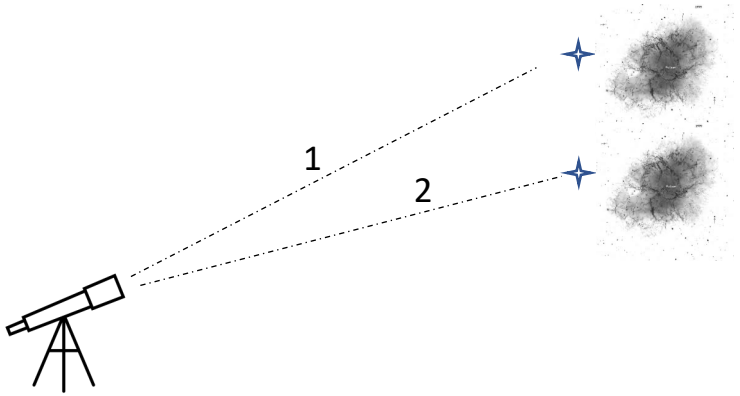
  - Focus on VLZA MAGIC targets
  - Identify bright stars for each target
  - Calibration of stars selected (we need this to measure transmission)



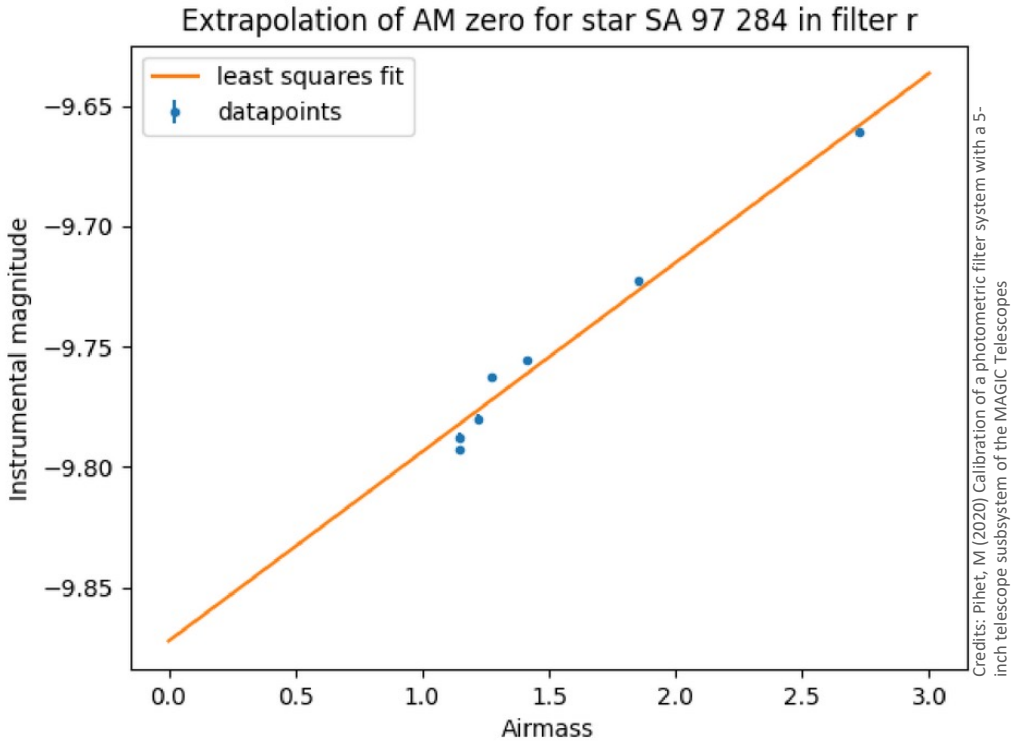
Requirement: magnitude at airmass zero

Plan automatic mode of operation of MAM

How can we measure the magnitude at airmass zero?



Measure the magnitude at different zenith angles



- Repeat this process, we should obtain the same magnitude at airmass zero.
- Next step, calculate atmospheric transmission.

- More VLZA targets.
- Spectroscopic mode, take a spectra and measure the atmospheric transmission

Take Home Message

- MAM installed at the MAGIC site to correct for the atmospheric effects during VLZA observations
- It will measure the atmospheric transmission in real time in the pointing direction of MAGIC
- MAM subsystem will be crucial for the hunt of PeVatrons with MAGIC!

Credits: Pihet, M (2023) MAM Technical Operation Manual

Backup

Atmospheric Transmission

- Flux observed F:

$$F = F_0 e^{-\tau X}$$

- F_0: total flux of a star in units of s^{-1}, number of det. photons per second
- τ: optical depth of the atmosphere, X: airmass
- Atmospheric transmission T: Fraction of starlight reaching the observer

$$T = \frac{F}{F_0} = e^{-\tau X}$$

- Atmospheric transmission:

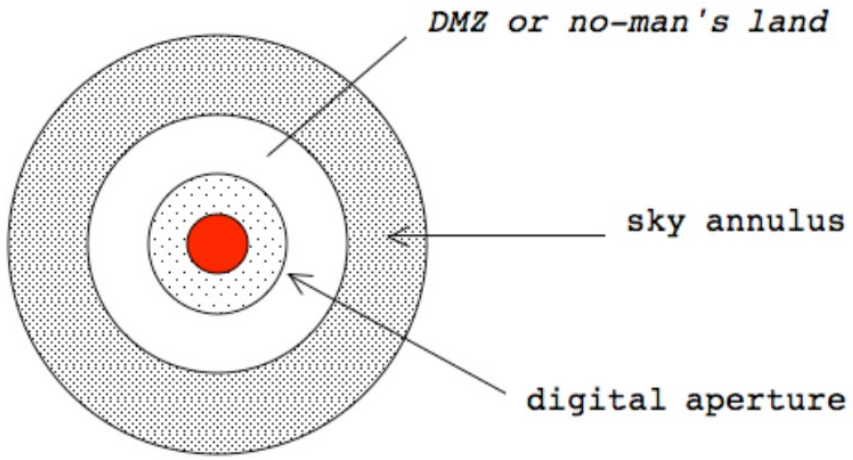
$$T = 10^{-0.4(m_{instr} - m_{instr,AM0})}$$

Flux Measurement

- Aperture photometry
- Total flux of a star:

$$S = F - n_{pix}N_s$$

-S: total electron count of the star
-n_pix: total number of pixels in the aperture
-Ns: total number of sky electrons per pixel
-F: total count inside of the inner aperture



Flux Measurement

- Aperture photometry with growing curve correction