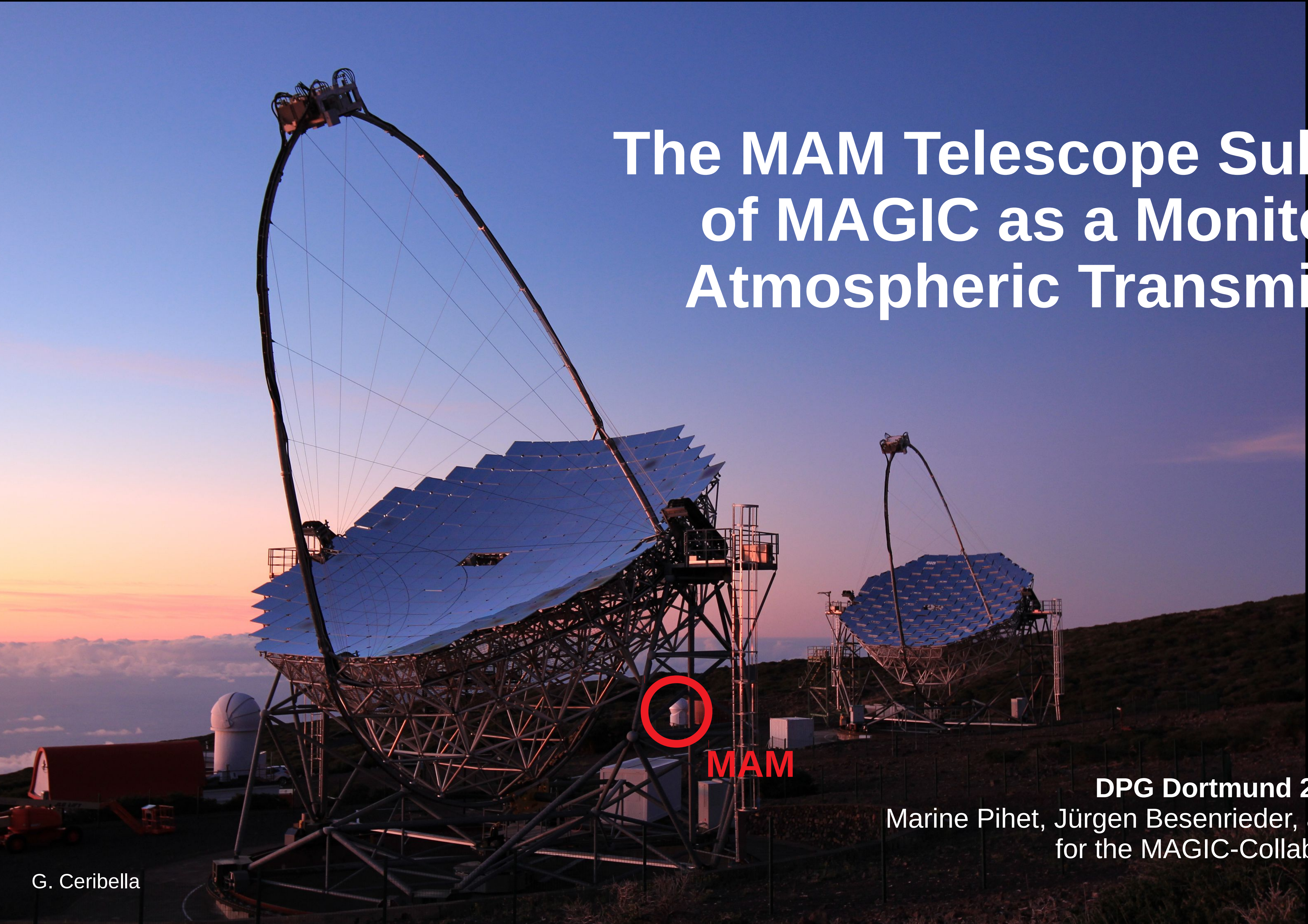
The MAM Telescope Subsystem of MAGIC as a Monitor for Atmospheric Transmission

G. Ceribella

DPG Dortmund 2021
Marine Pihet, Jürgen Besenrieder, and Razmik Mirzoyan
for the MAGIC-Collaboration

The MAM Telescope Subsystem of MAGIC as a Monitor for Atmospheric Transmission



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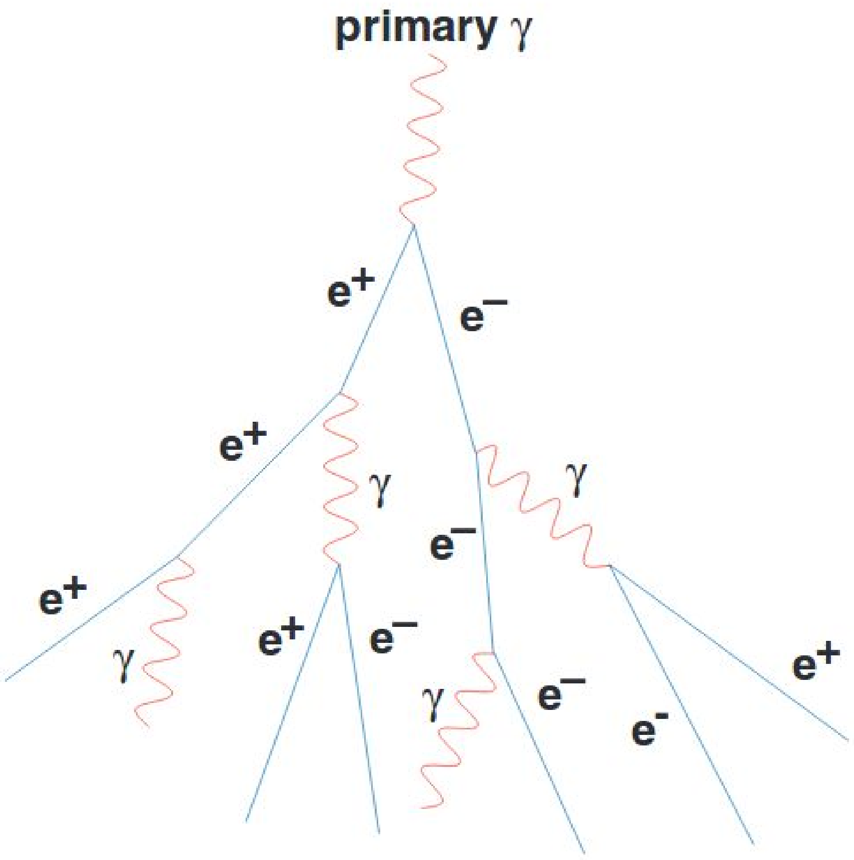
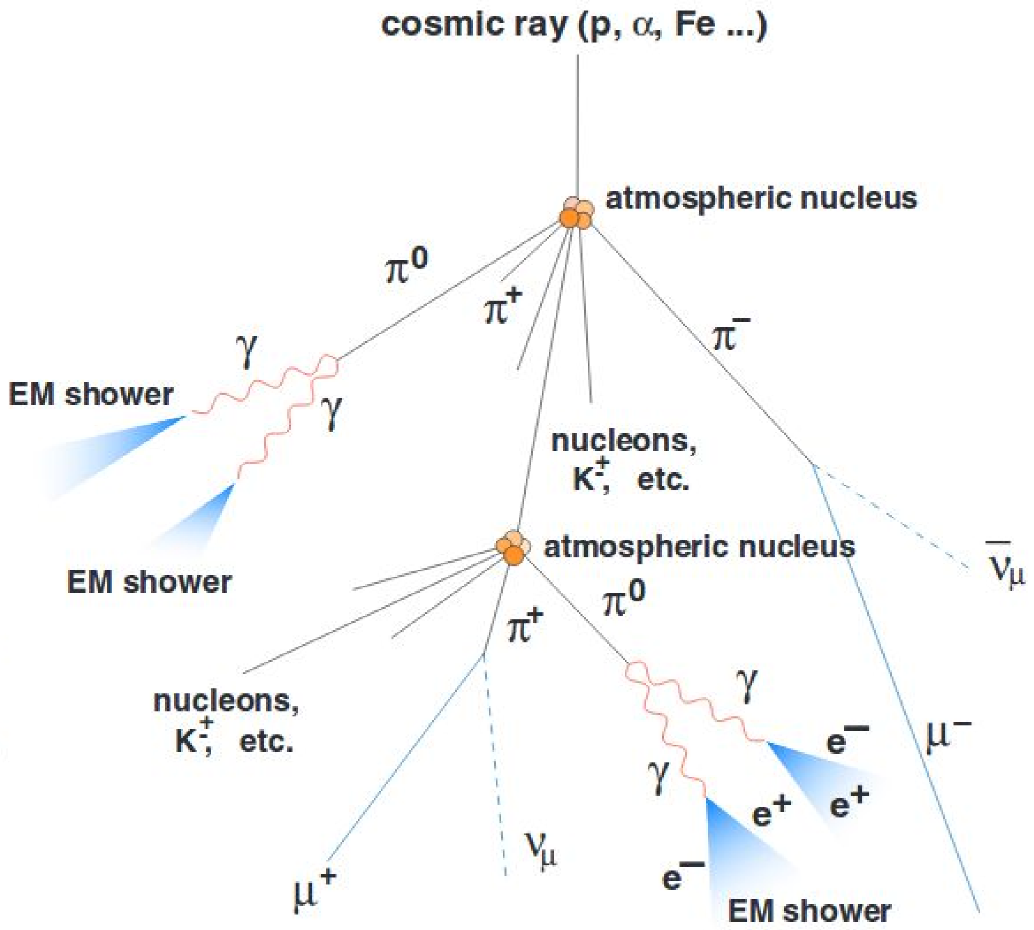
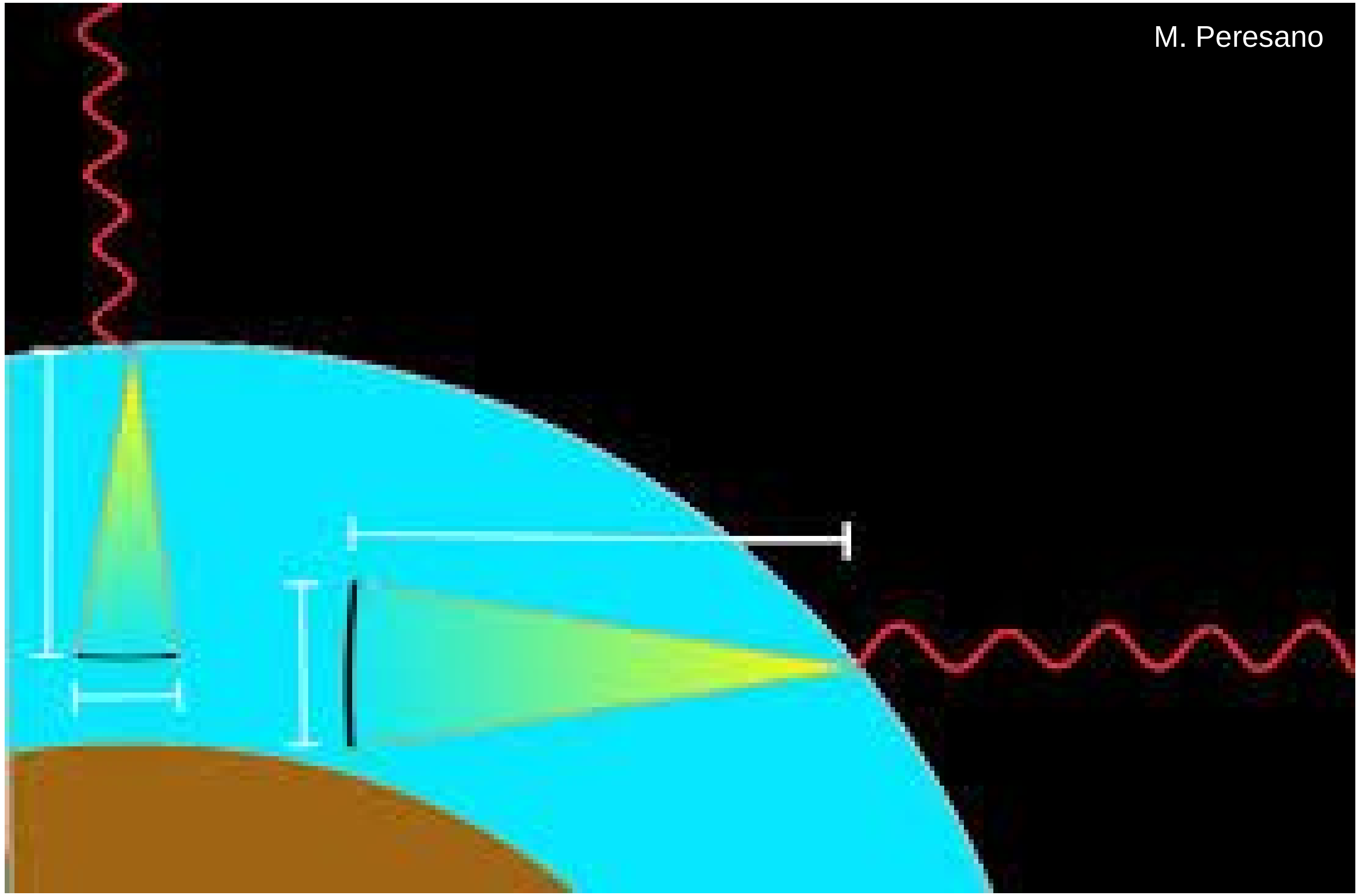
Airshowers





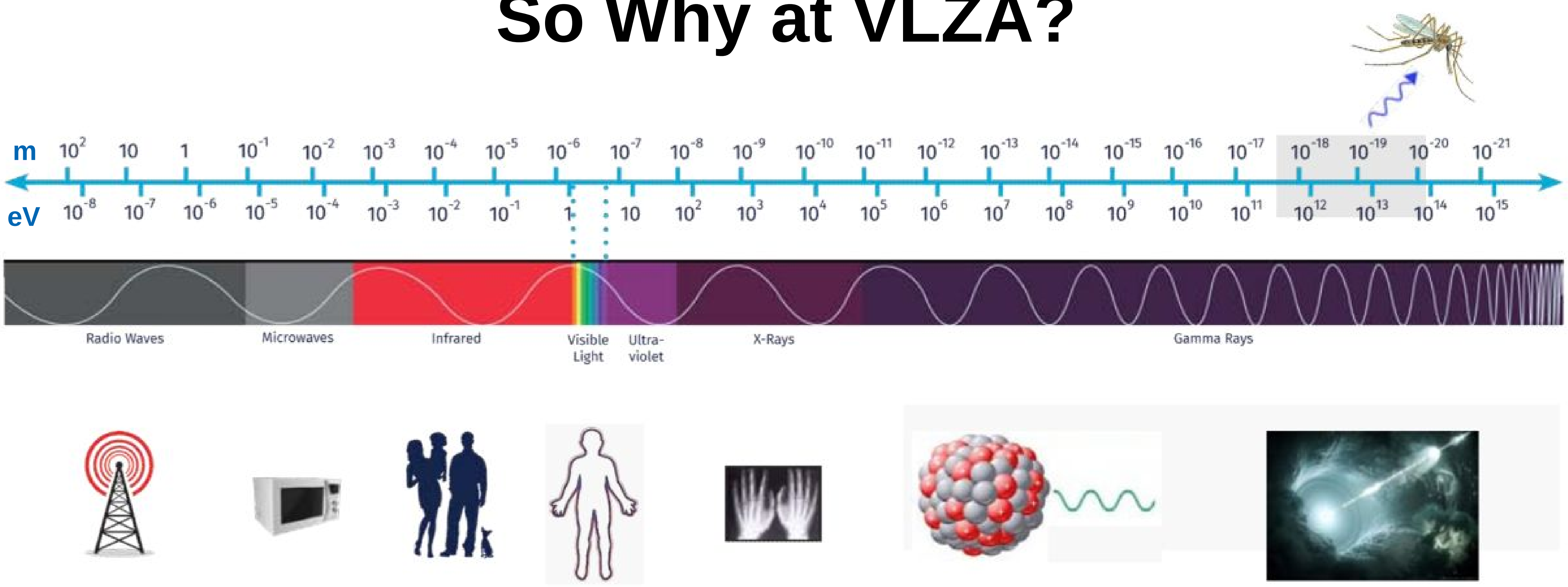
R.M. Wagner

Very Large Zenith Angle (VLZA) Observations



- Long way through atmosphere
- Strong extinction

So Why at VLZA?



M. Hütten

- Search for the most energetic photons at PeV
- VLZA technique increases probability for detection*

* Mirzoyan et al. 2020

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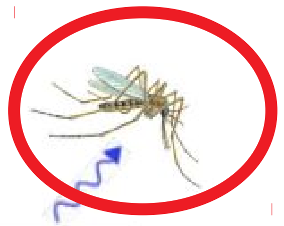

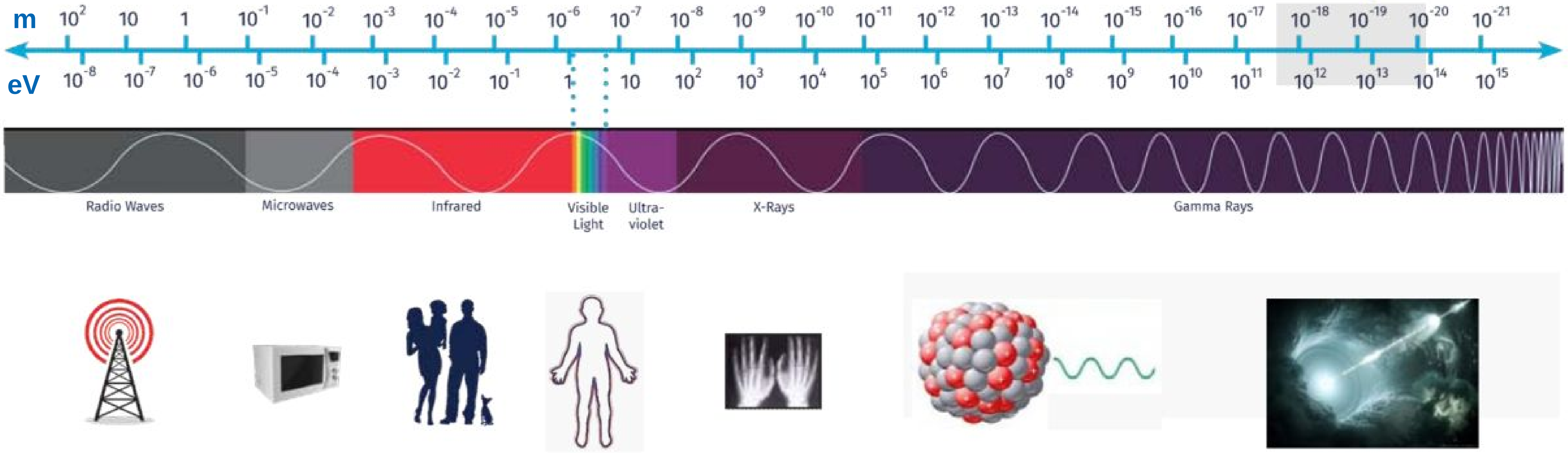

M. Hütten

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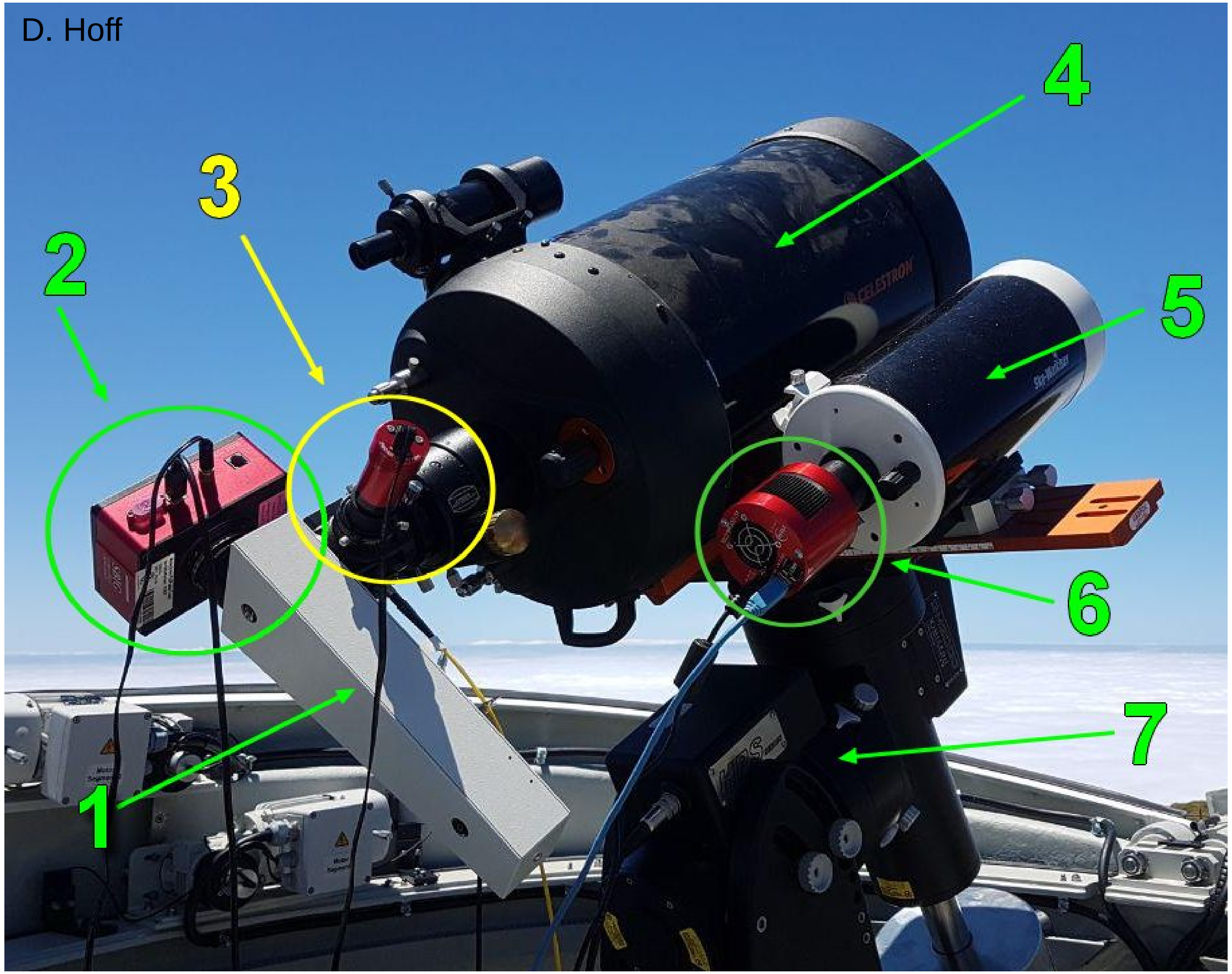
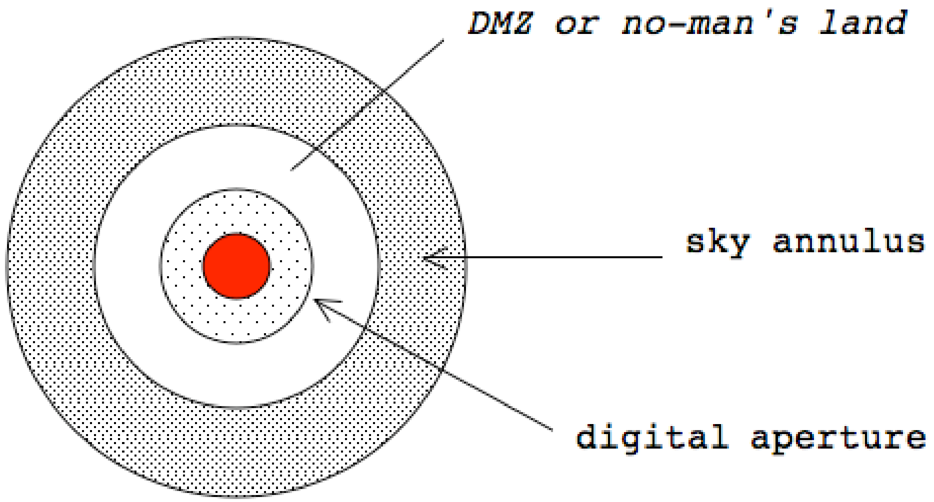
MAM‘s Task

- Monitoring of atmospheric transmission
  - in pointing direction of MAGIC
  - in real time
  - at VLZA
- Photometry and Spectroscopy



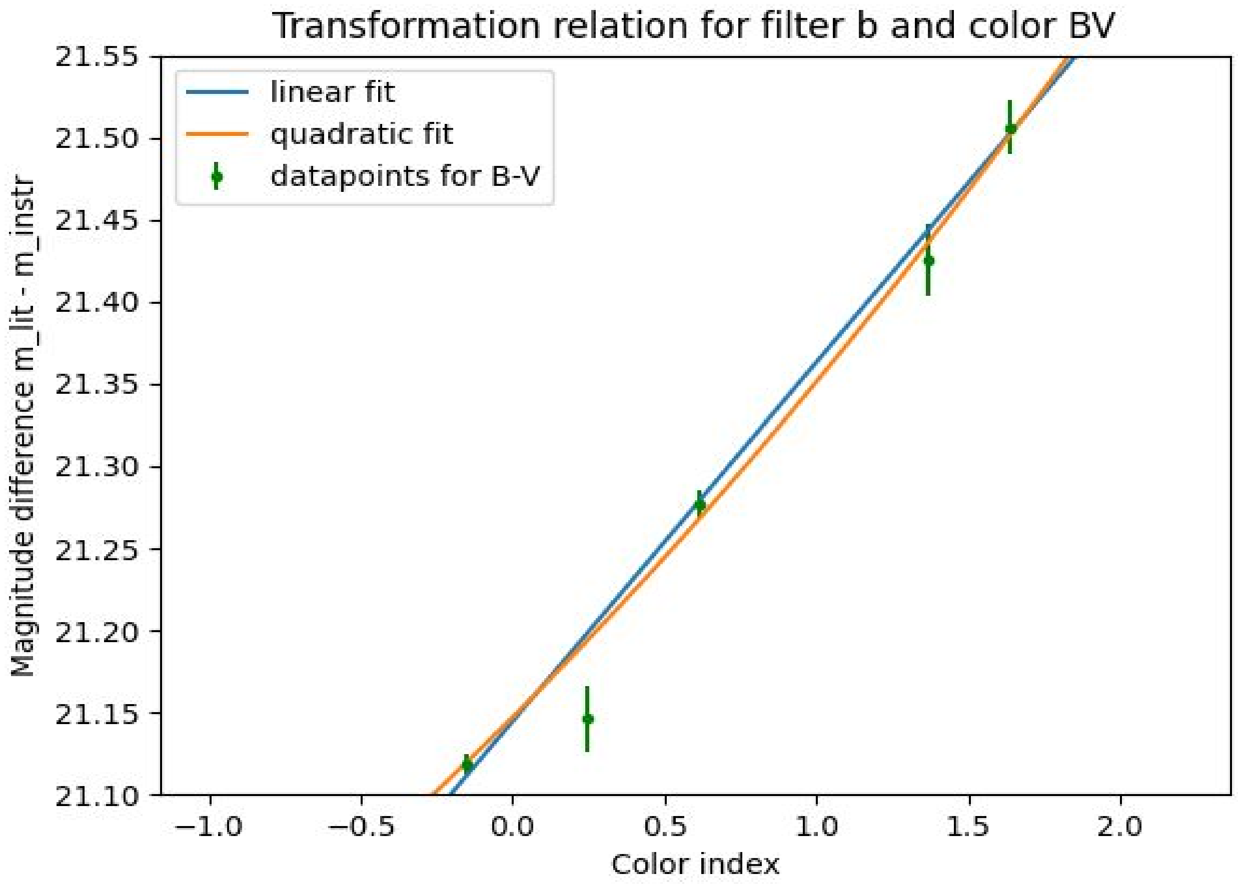
Concept for Photometric Measurements



- Aperture photometry
- Requirement: Knowledge of brightness of a star outside the atmosphere
- Use existing catalog or create one with MAM
- Test first concept with Landolt catalog

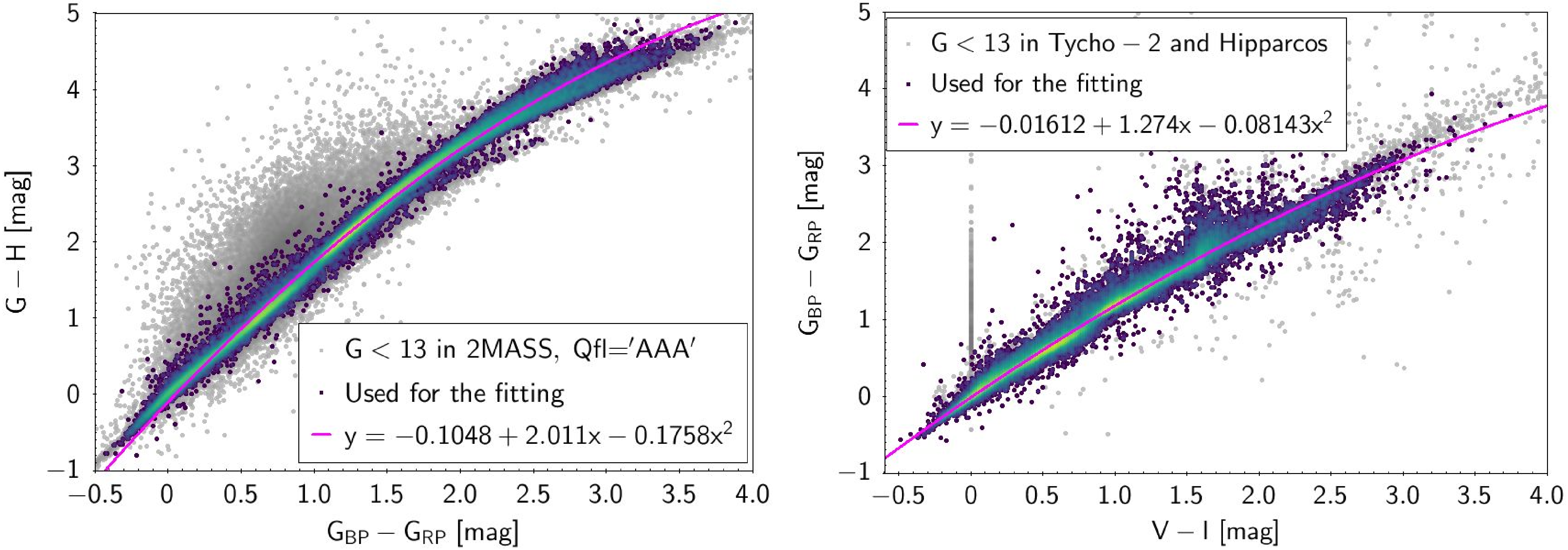
Status Report and Recent Work

- Photometric calibration in November 2020
- Transformation relations consistent for green and blue filter
- Sparse sampling (only five stars)



Many stars are needed for a very reliable calibration.

This would be nice...



Riello et al. 2020

Status Report and Recent Work

- First measurements of transmission two weeks ago
- Work on
  - Software Improvements and bug fixing
  - Improvement of data reduction
  - Automating the analysis
  - Communication to central control of MAGIC

Conclusion and Outlook

- Small steps in search for most energetic photons
- Promising results from calibration
- Concept with existing catalog is complex and susceptible to systematics
- Analysis of first measurements of transmission ongoing
- Work on automatic mode

Looking foward to the first detection of a PeV gamma ray!

Bibliography

Figures and Information:

(1) Self-made pictures

(2) MAGIC outreach material

(3) Pihet, M. Calibration of a Photometric Filter System with a 5-inch Telescope Subsystem of the MAGIC Telescopes. Bachelor's thesis, Ludwigs-Maximilians-University (LMU) Munich, 2020.

(4) Riello, M., et al. Gaia Early Data Release 3: Photometric content and validation. Astronomy & Astrophysics, 2020. doi:10.1051/0004-6361/202039587.

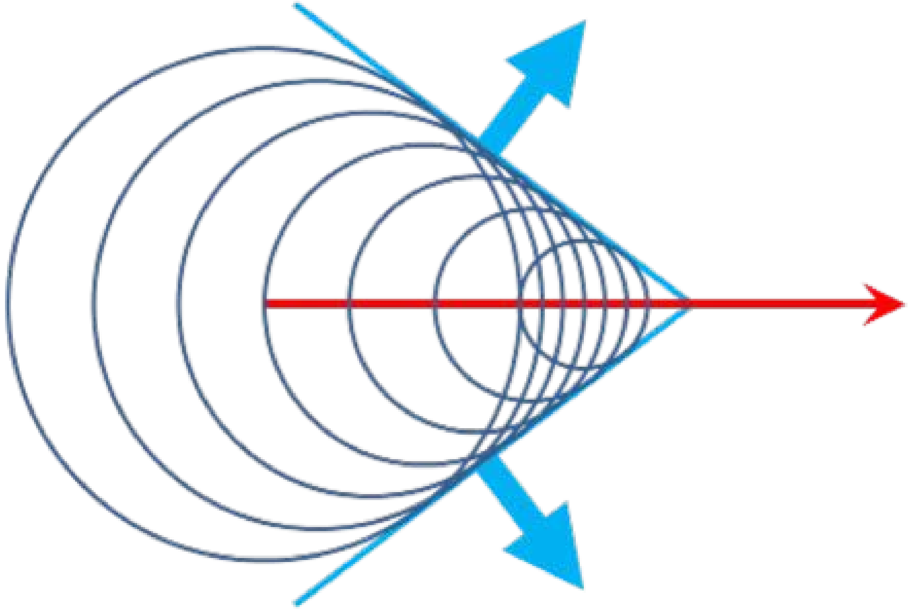
(5) Mirzoyan, R., et al. Extending the observation limits of Imaging Air Cherenkov Telescopes toward horizon. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, vol. 952:161587, 2020. doi:10.1016/j.nima.2018.11.046.

(6) Hütten, M. Das Forschungsgebiet Astroteilchenphysik. MAGIC Masterclass Vortrag, Max Planck Institute for Physics, 2021.

(7) Van Scherpenberg, J. A Novel Glass-Mirror Design for Imaging Atmospheric Cherenkov Telescopes and Observations of the Crab Nebula with the MAGIC Telescopes at Very Large Zenith Angles. Master's thesis, Technical University Munich (TUM), 2018.

Backup

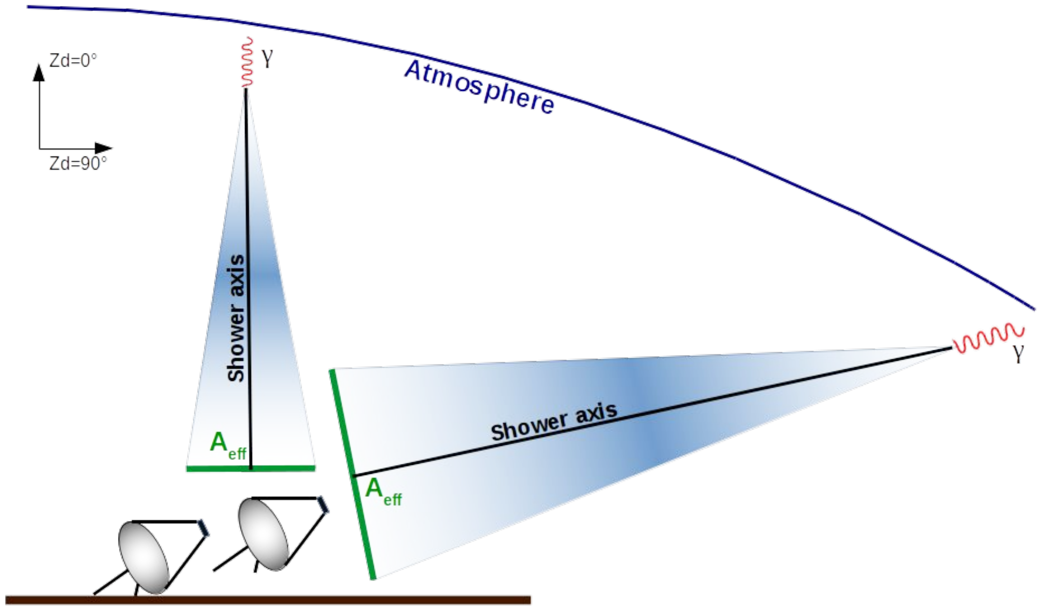
Cherenkov effect



S. Dutch

- Electromagnetic analogue of the sonic boom
- Charged particle in a medium
- $v > c/n$
- Polarisation of medium
- Emission of Cherenkov radiation on a cone
- Refractive index n determines cone opening angle

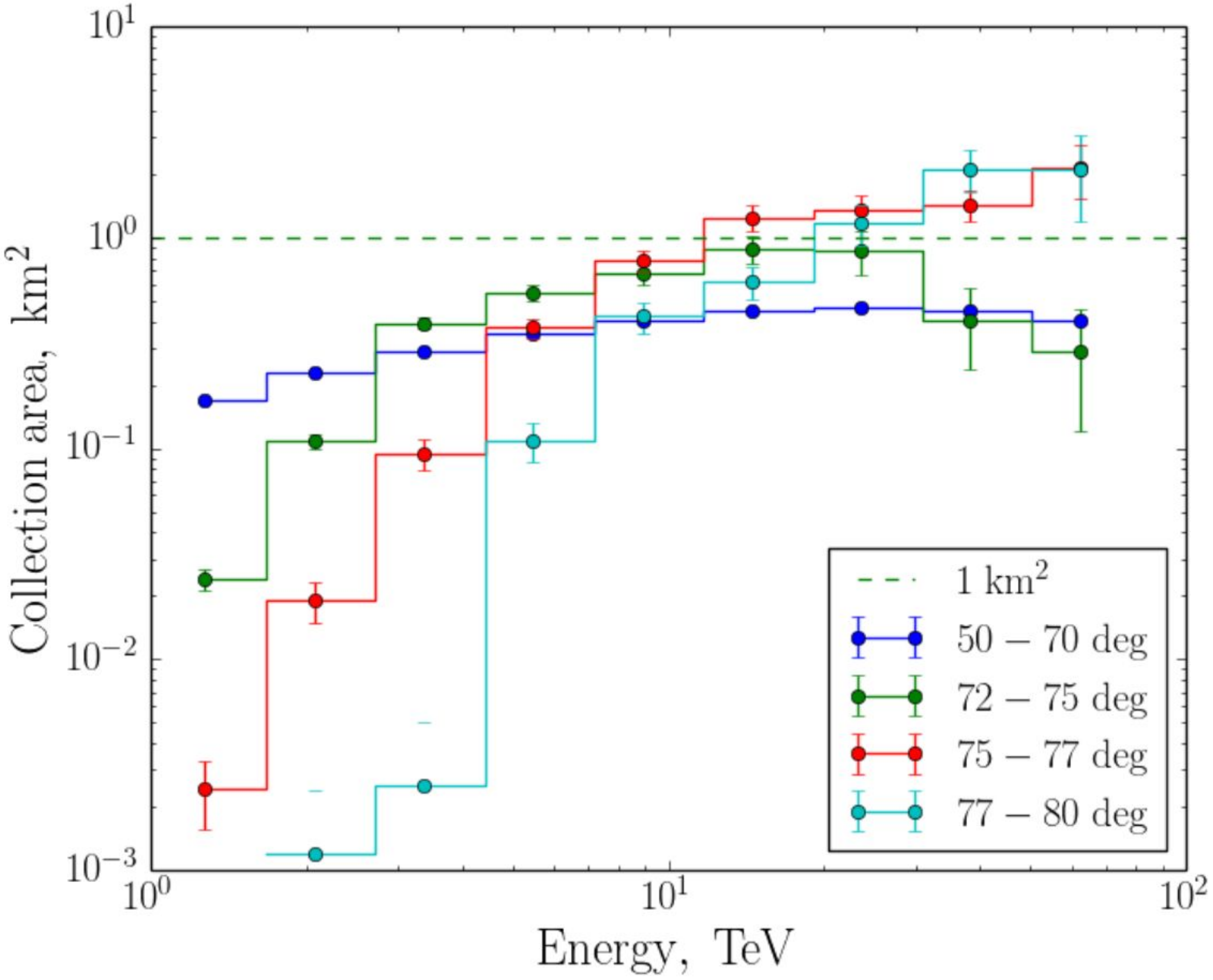
Why at VLZA?



J. van Scherpenberg

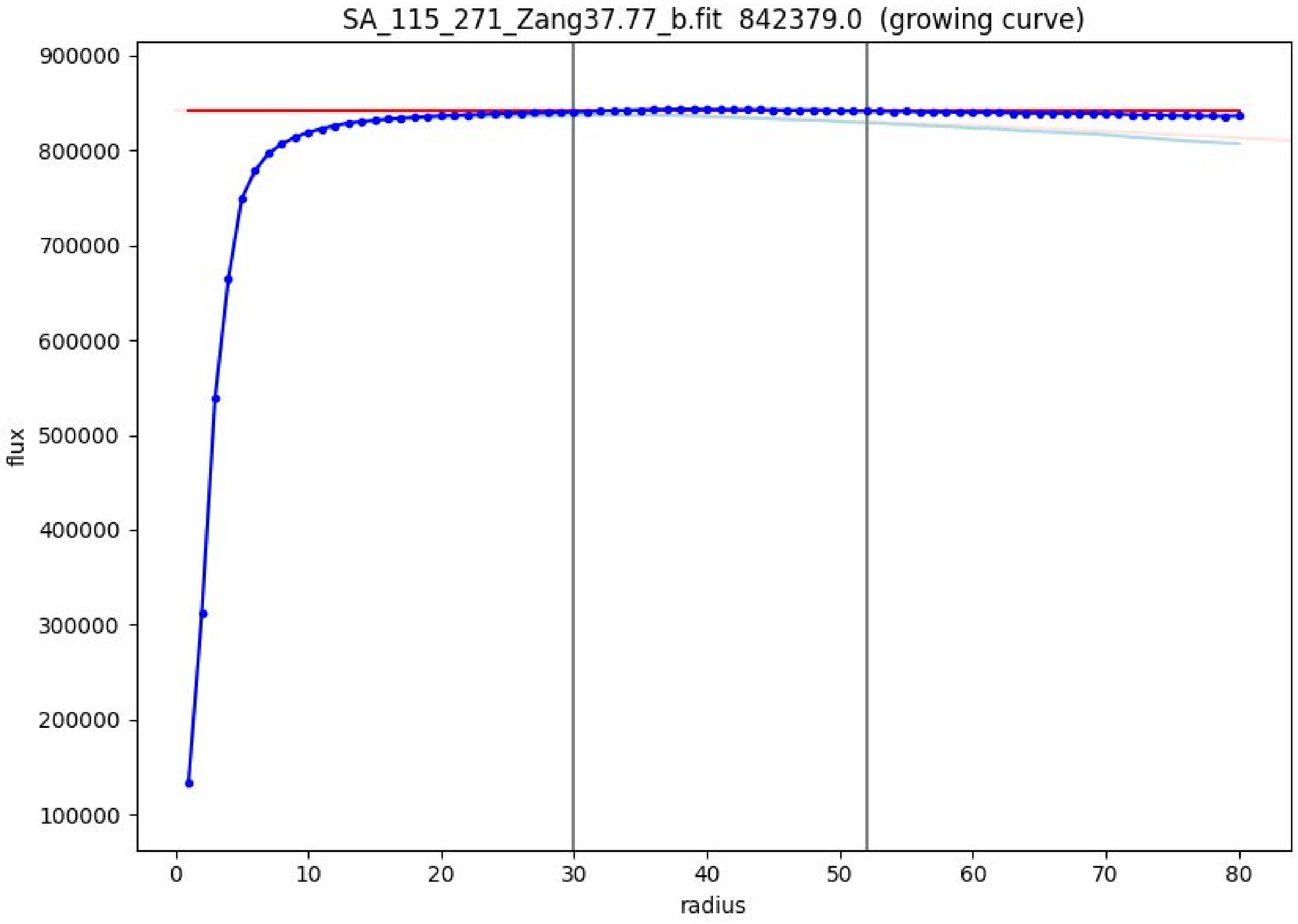
- Longer way through atmosphere (VLZA)
- Light cone has more time to expand
- Collection area increases
- Probability for the light to hit the detectors increases
- Energy threshhold for detection is higher
- Only Cherenkov light from most energetic photons survives
- Only observations of sources with VHE gamma-ray emission (PeVatron candidates)

MC Collection Area at VLZA



Plot from Van Scherpenberg, Masters Thesis, 2018

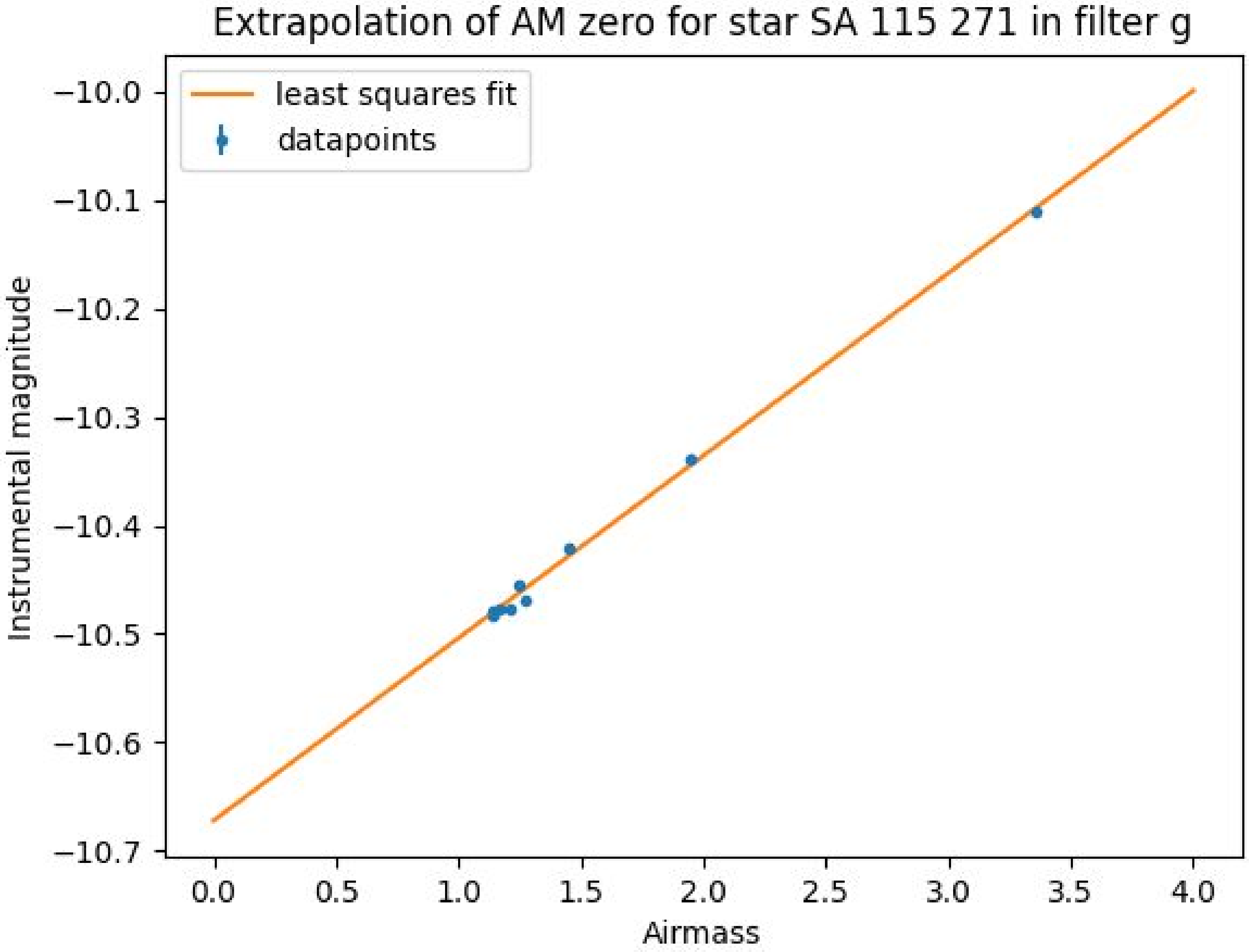
Flux Measurement



m = – 2.5 *log(F)

m: instrumental magnitude

F: total flux

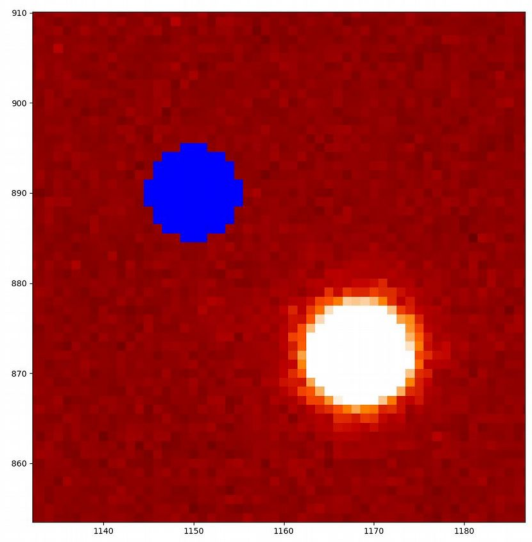


Extrapolation of Magnitude at AM0

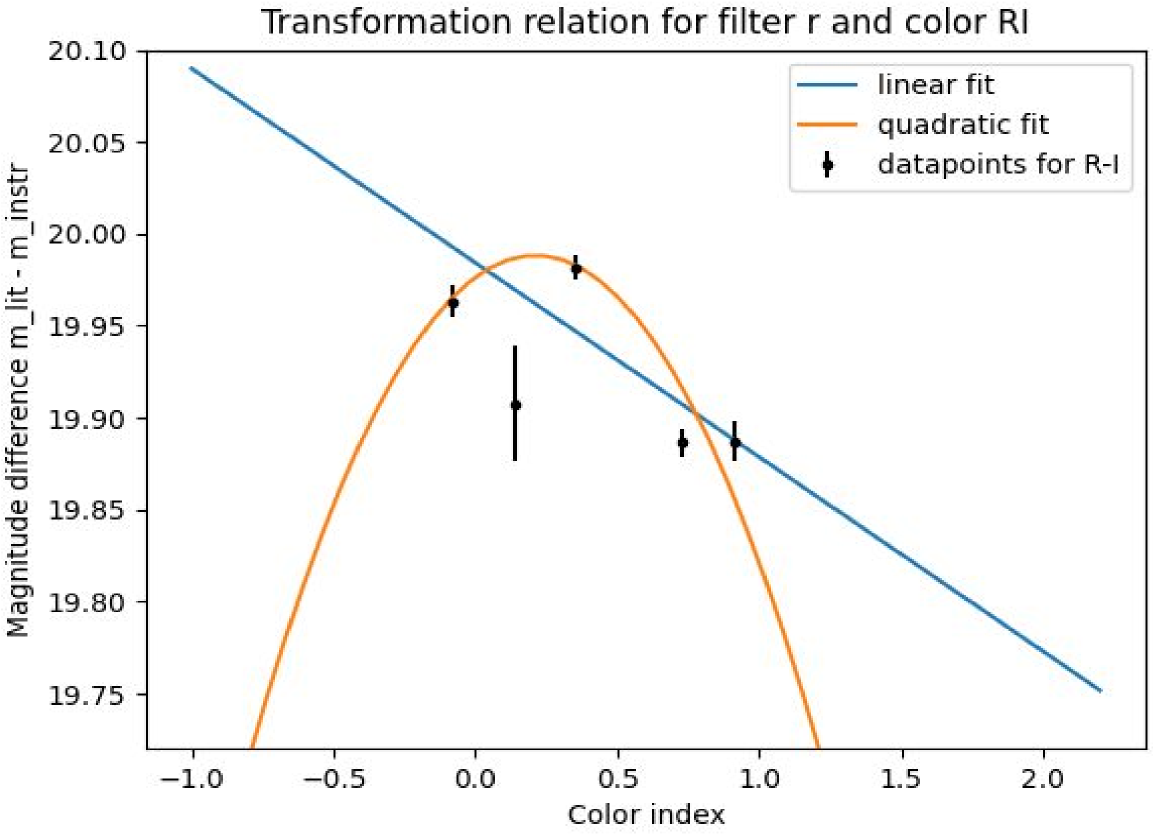
Intermediate Results

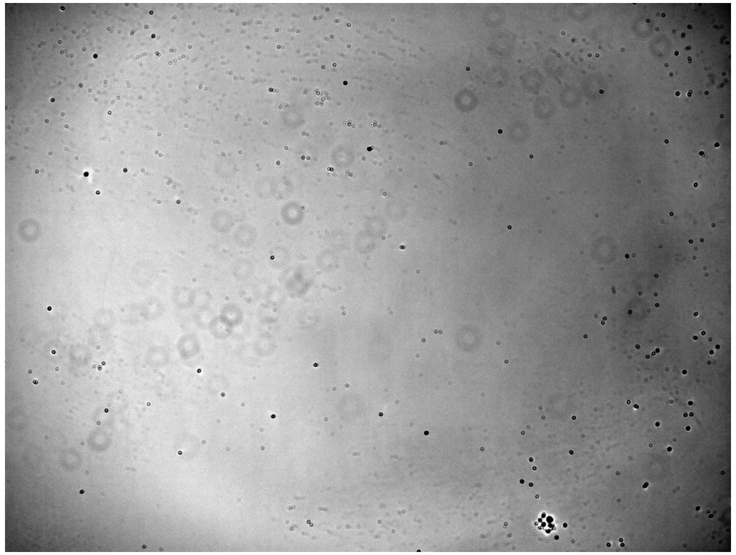
- Atmospheric extinction in different bands of the visible spectrum
- Agreement with the dependency on wavelength and color of the observed star
- Aperture photometry not suited for crowded star fields
- Lack of space for background estimation

SA 97 284					
filter	κ	σ_κ	$m_{\mathrm{instr},0}$	σ_{m}	excluded datapoint #
l	0.123	0.007	-10.712	0.010	
r	0.079	0.005	-9.872	0.009	
g	0.166	0.012	-9.428	0.016	
b	0.226	0.017	-9.274	0.023	



Transformation Relations Red Filter





- Transmission curves of red filters very different
- Lopsided transmission of red filter
- Systematic error in flux measurement for one star
- Very few stars

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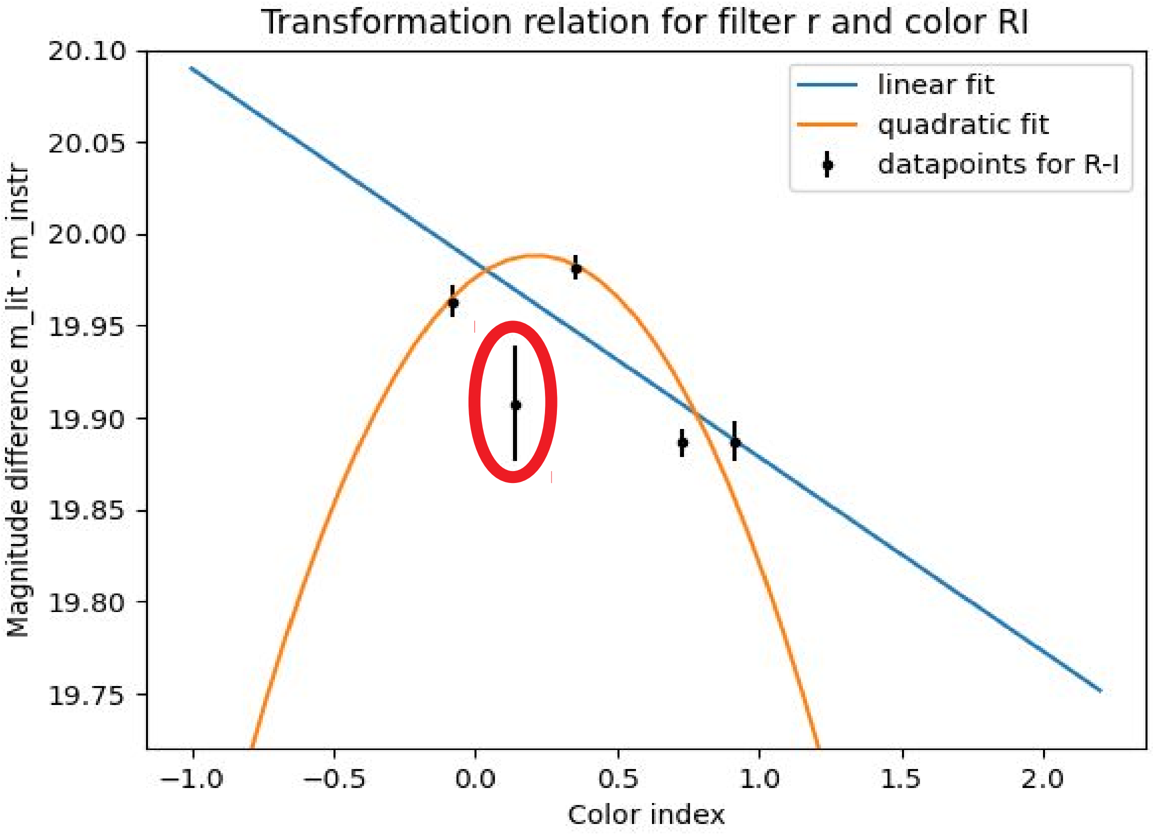

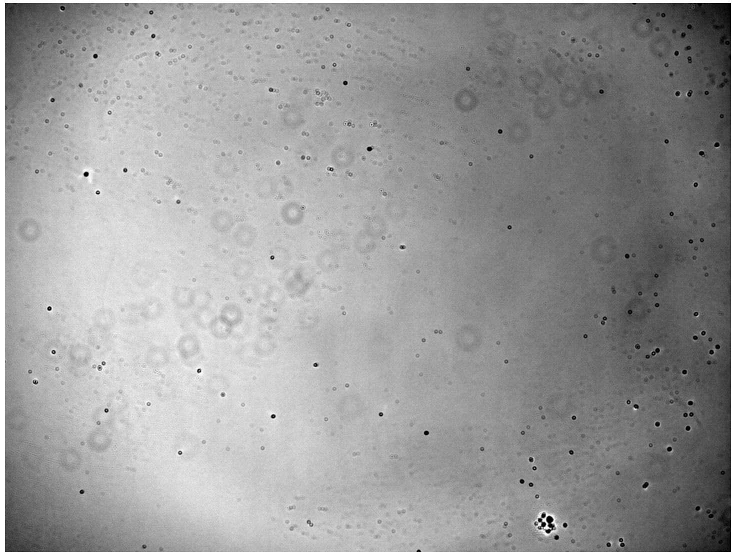

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Transmission curves