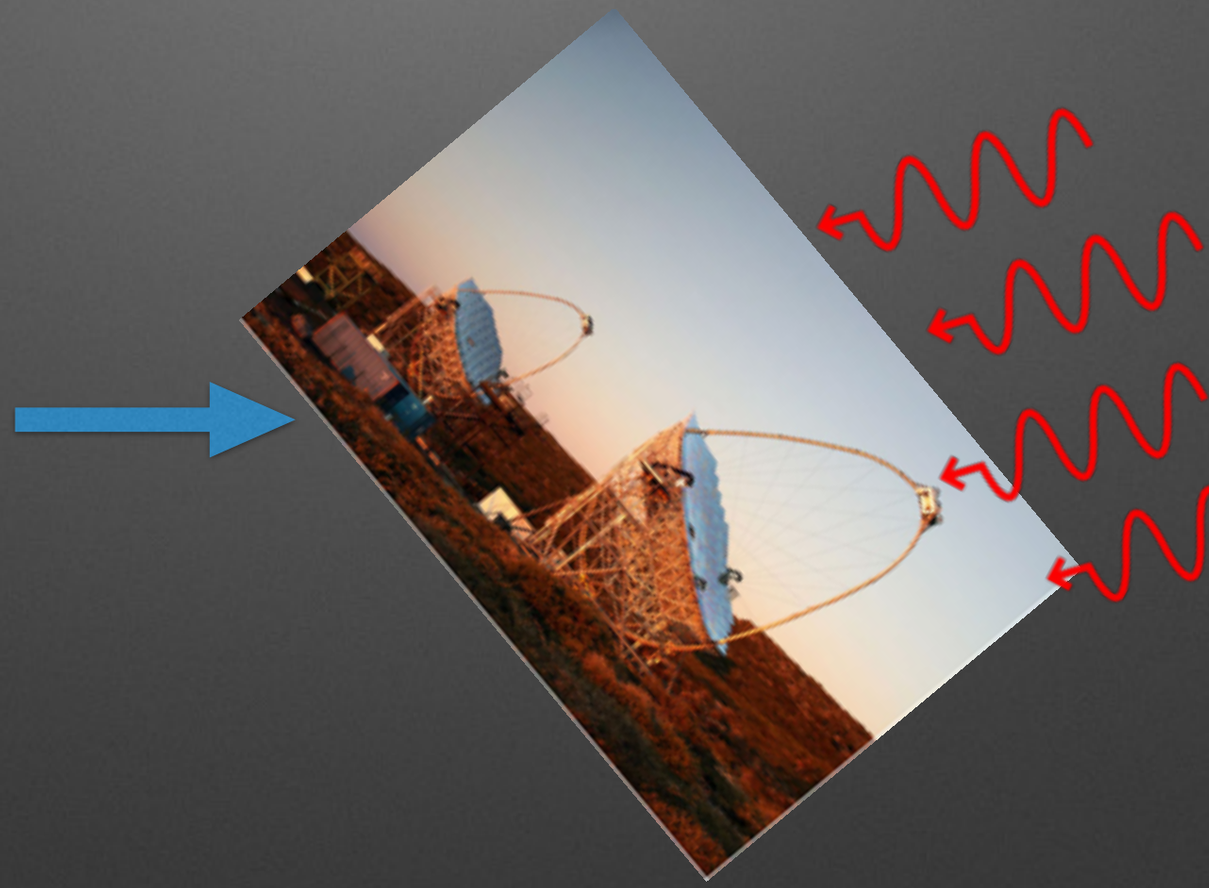
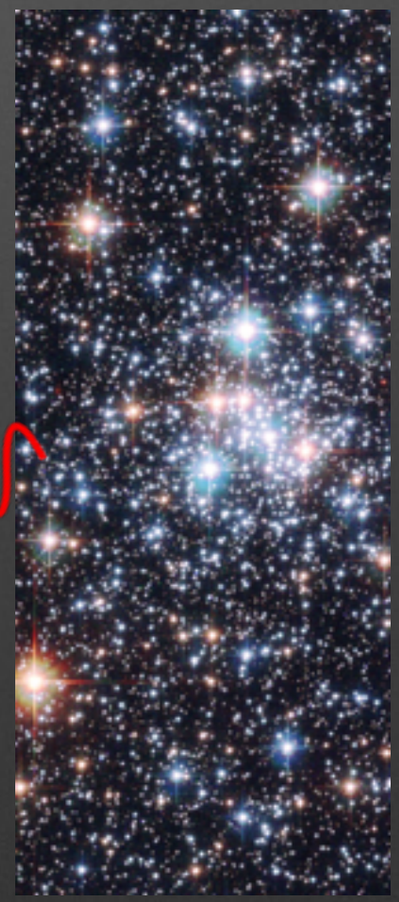
Very Large Zenith Angles Observations with the MAGIC telescopes





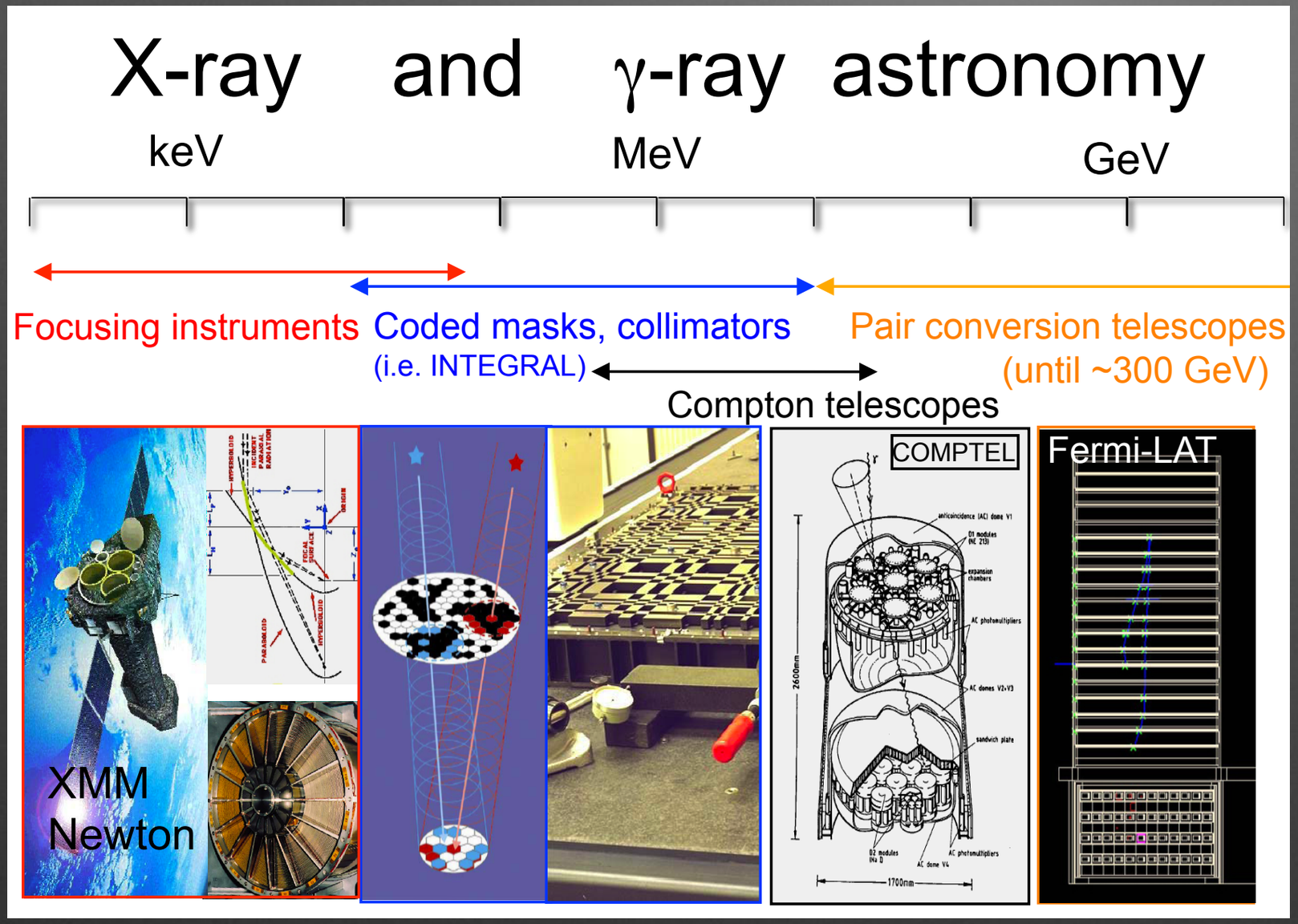
Michele Peresano, on behalf of the VLZA team and MAGIC collaboration

103° Congresso Nazionale SIF, Trento, September 15th 2017

Outline

- Introduction:
  - Particle energy influence on instruments in (high energy) astrophysics
  - Extensive air showers and Cherenkov radiation
- Very Large Zenith angles:
  - Dealing with the atmosphere: LIDAR, Pyrometer and SBIGs
  - Low level cuts
- Summary

Particle energies and instruments in high energy astrophysics



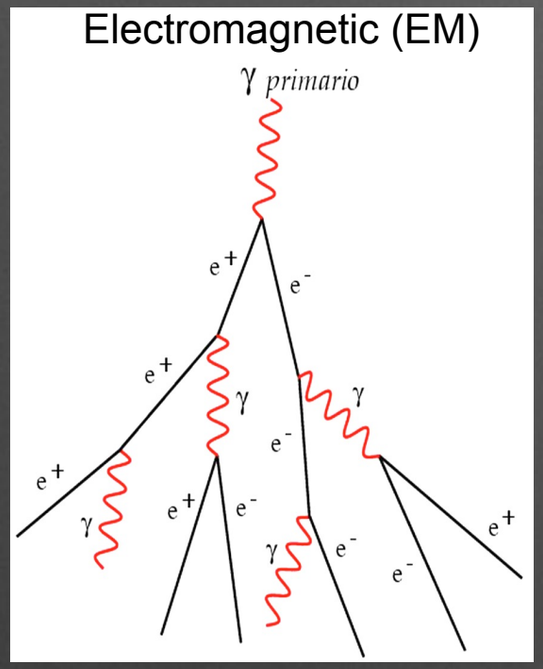
TeV —> PeV??

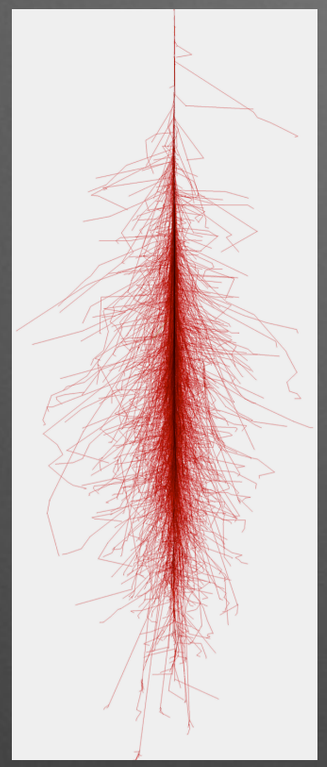
Cherenkov telescopes
(MAGIC: from about 50 GeV)

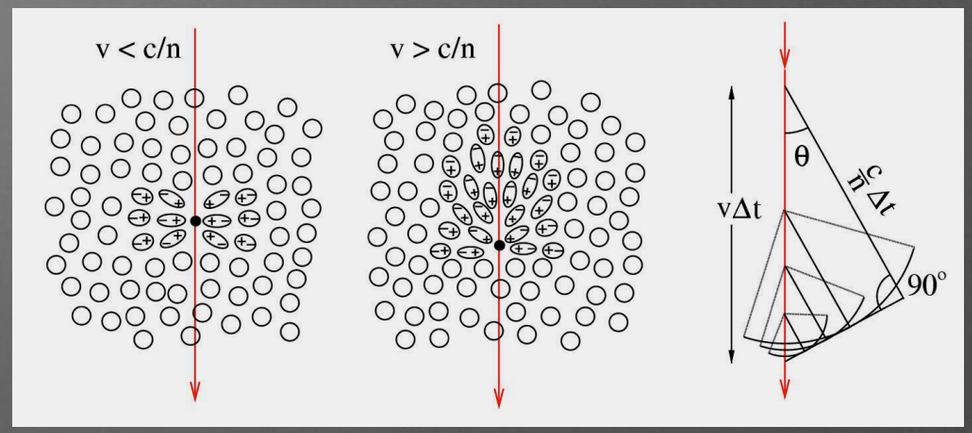
Small effective area → Low detection rates

Limited radiation length!

Extensive air showers and Cherenkov radiation

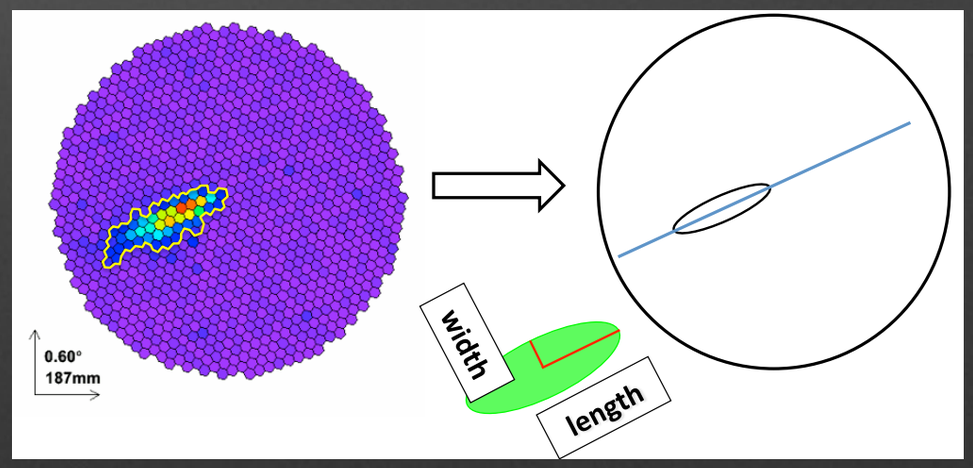






Charged secondary particles propagating in atmosphere generate Cherenkov radiation

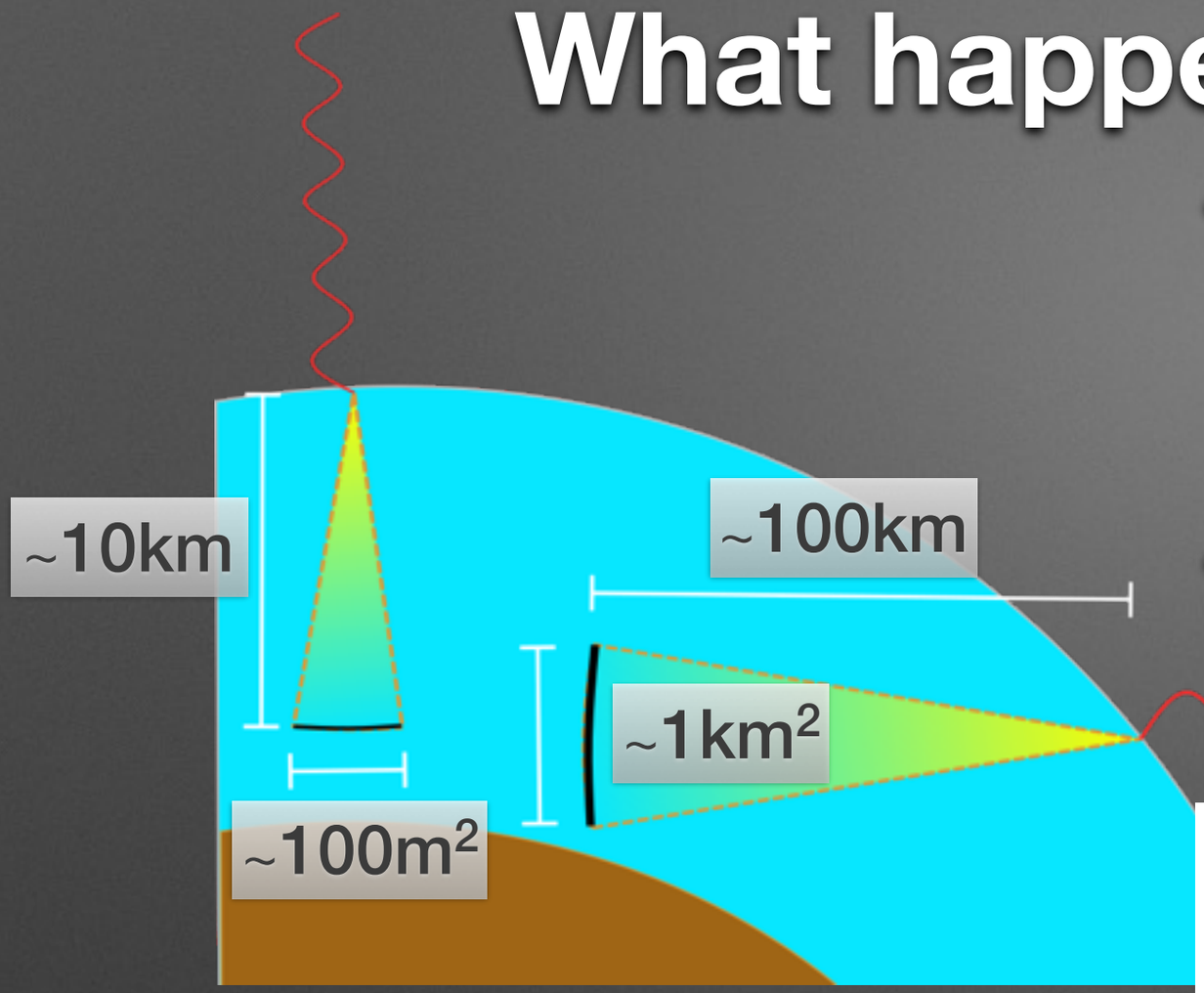
Focus on EM showers
Hadronic showers are background!



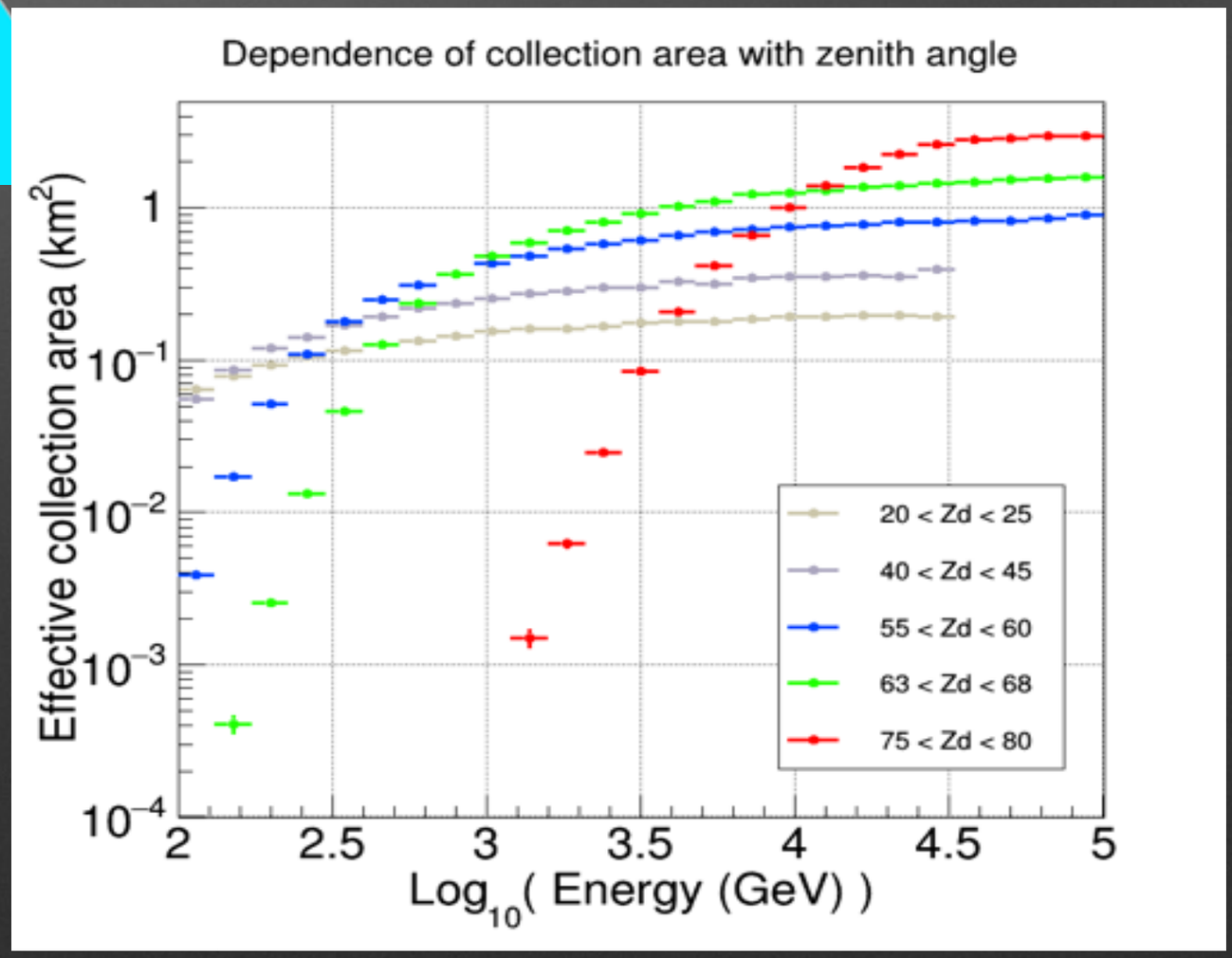
Information about primary particle recovered from image fitting of Cherenkov-induced photoelectrons

What happens at VLZA?

- Given atmosphere profile, high zenith showers have longer developments
  - we loose lower energy events
- For the same angular extension, light pool increases and so does the collection area!

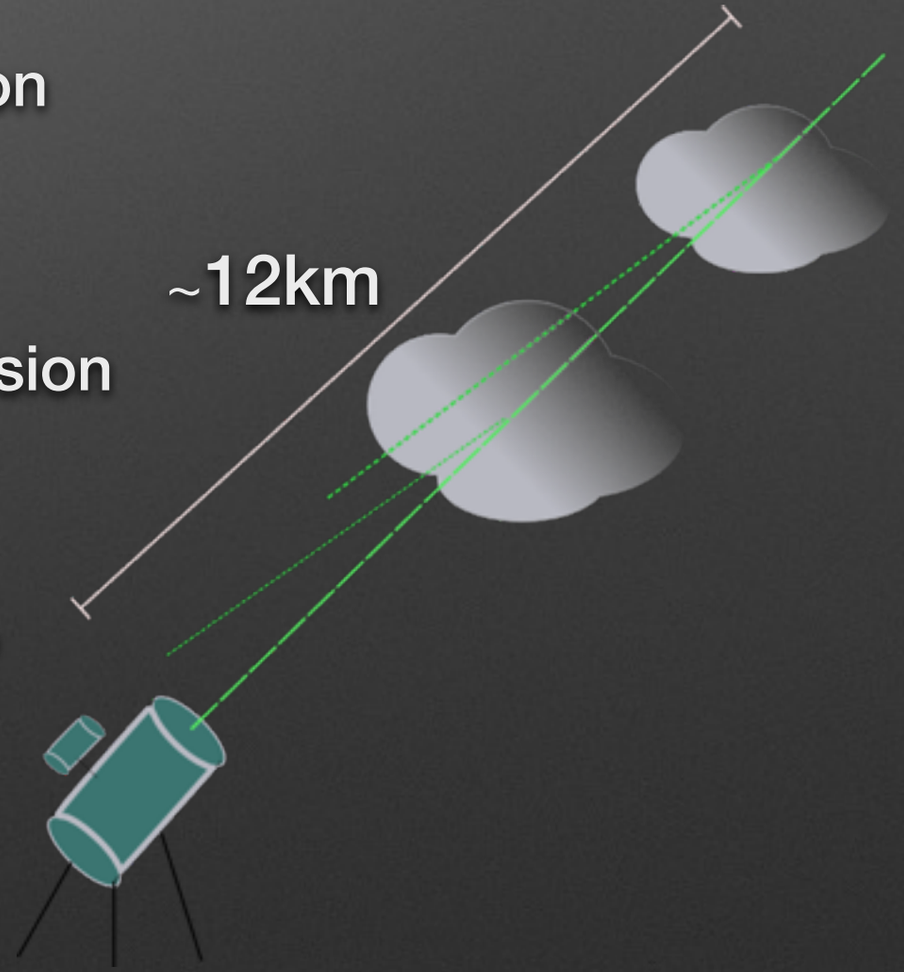


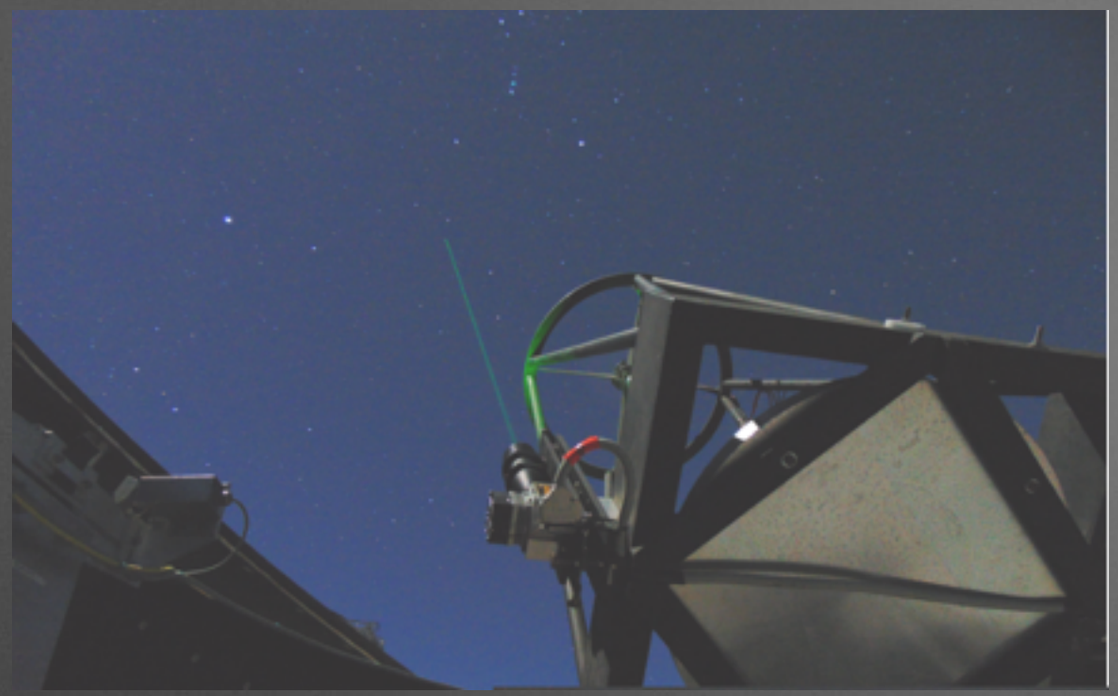
Towards larger angles the energy threshold increases,
but also does the collection area at higher energies!



Atmosphere at higher zenith angles

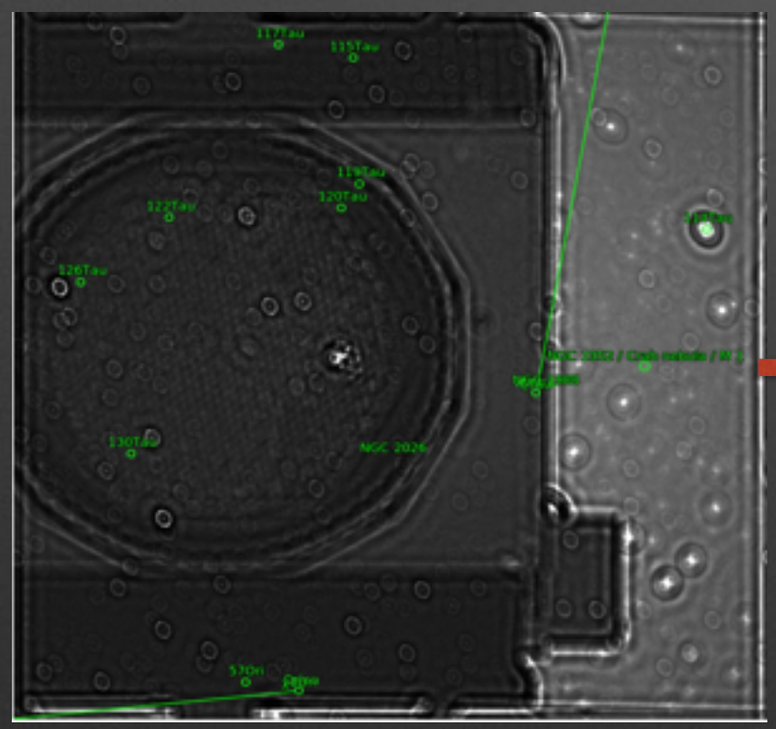
- We need information about transmission through atmosphere → biggest contribute to systematics at high zenith angles!
- Airmass is typically larger, so chances for clouds increase
- Unfortunately, micro-*LIDAR* system has limited power, i.e. laser shooting distance
- *Pyrometer* not reliable as zenith angle increases
- *SBIG pictures* provide measure for integral absorption
  - BUT: sparse sampling, blind to technical issues
- In principle no sudden gradients during zenith excursion
- What observables are important at VLZAs?
- How do they affect observations, in particular rates?



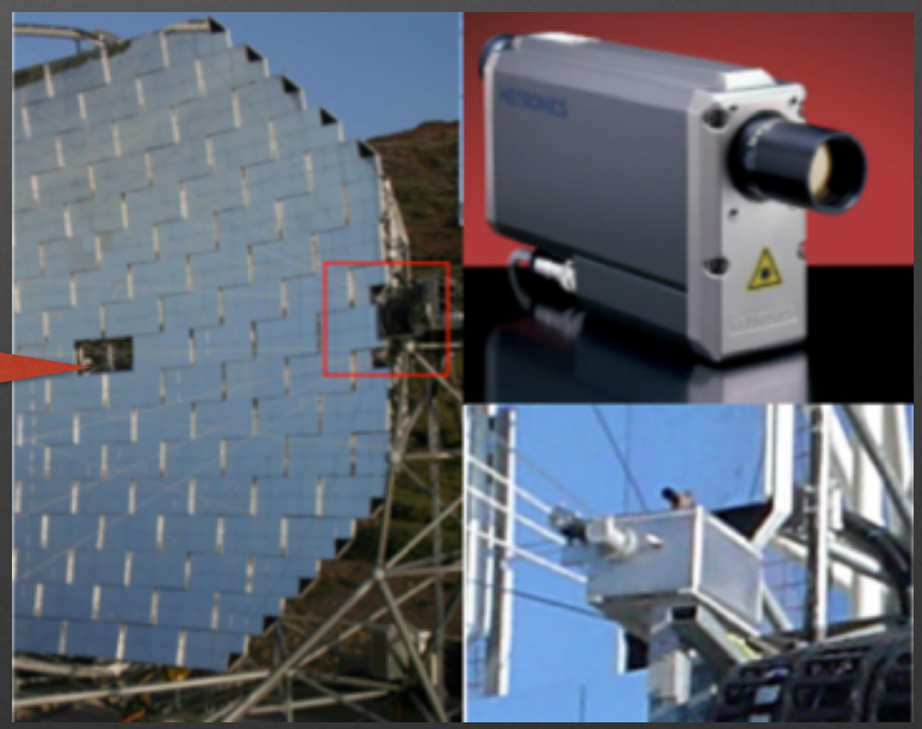


LIDAR in action

LIDAR from its dome



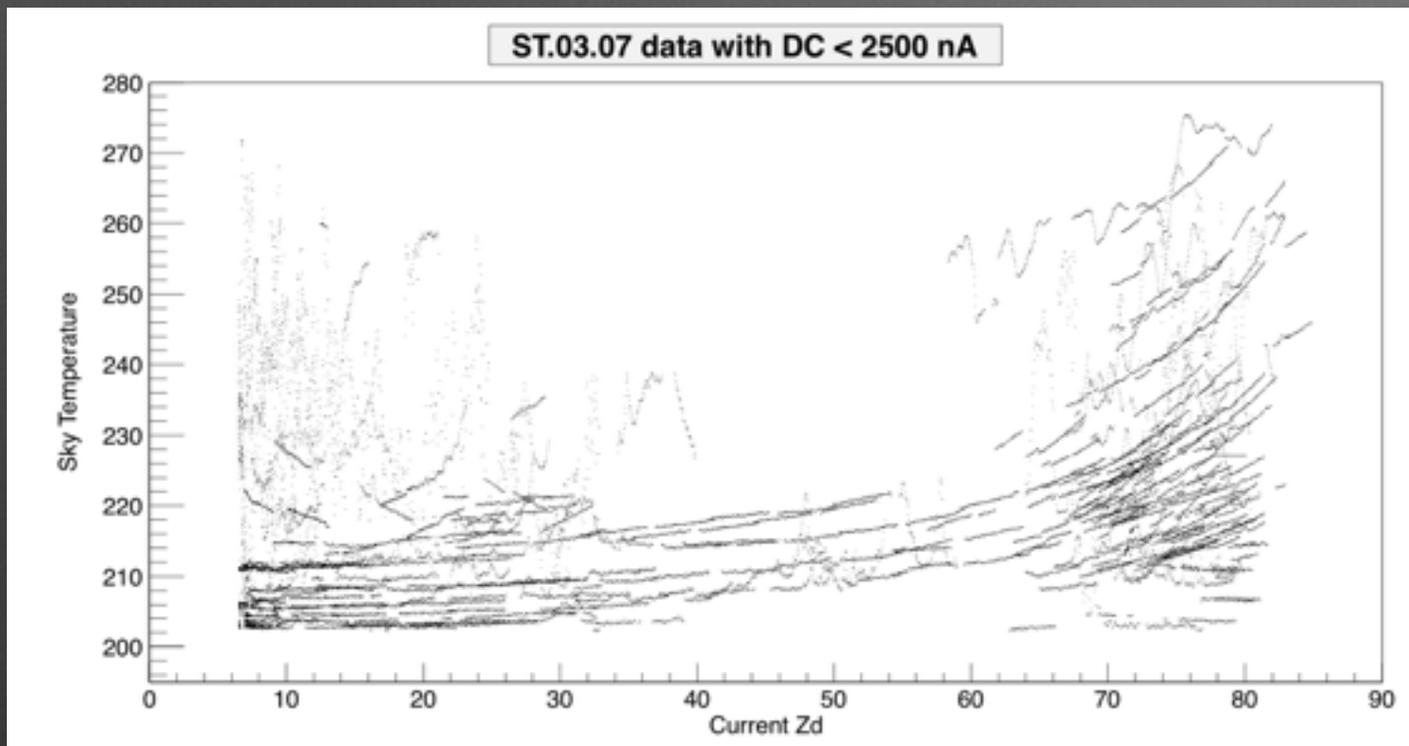
SBIG camera view

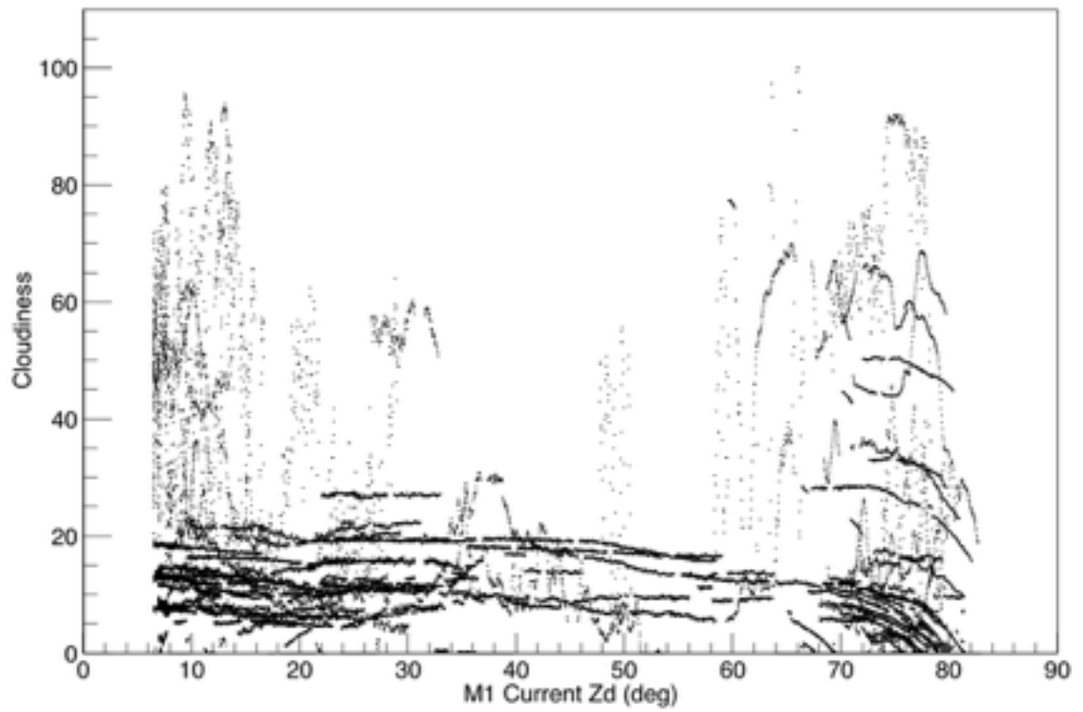


Pyrometer and its position within MAGIC-1

Pyrometer data

VLZA = atmosphere thickness increasing ⇒ average bias towards higher values





Sky Temperature only effectively measured observable…
…other Pyrometer variables are correlated (i.e. Cloudiness)

Current calibration not perfect: with no clouds still possible ~35%

SBIGs: how we use them

- Measure of the star brightness as function of Zd with SBIG CCD cameras in MAGIC FoV (one or more filters)

$$m = M - 2.5 \log \left(\frac{I}{I_0} \right)$$

- Intensity of radiation through atmosphere damped by optical depth “τ”, based on absorption coefficient “α” and density “ρ” of medium

$$I = I_0 e^{-\tau} \qquad \tau = \int_{ground}^{edge} \alpha \rho \mathrm{d}h$$

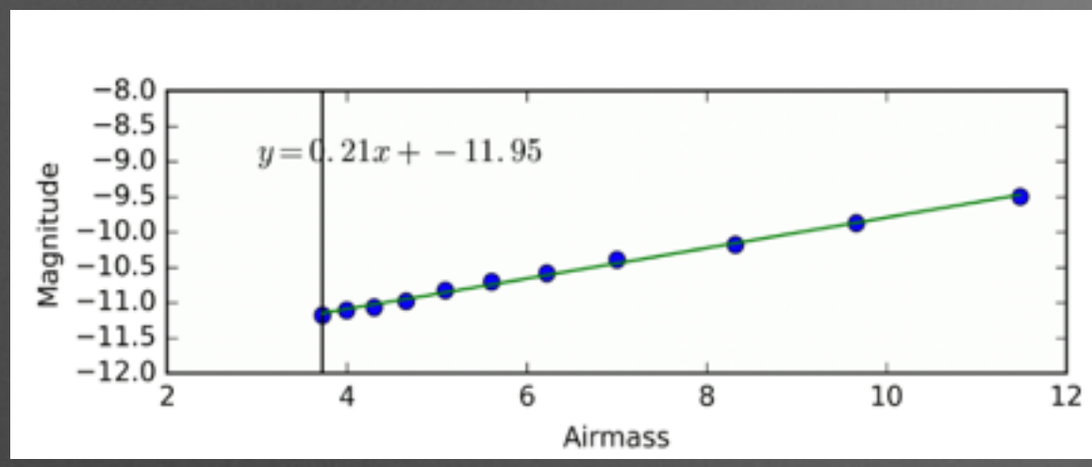
- Converting in terms of airmass dependency from zenith angle “Zd” we obtain a linear relation for “good” nights

$$m = M + \beta * airmass(Zd)$$

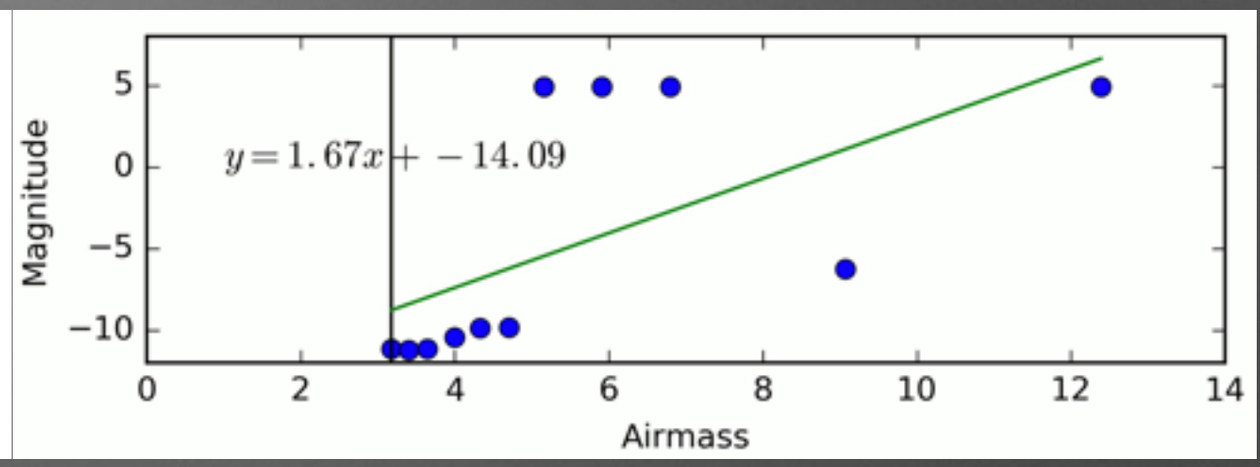
Energy correction based on atmosphere properties in MCs and scaled by **measured** transmission

SBIGs: what we get

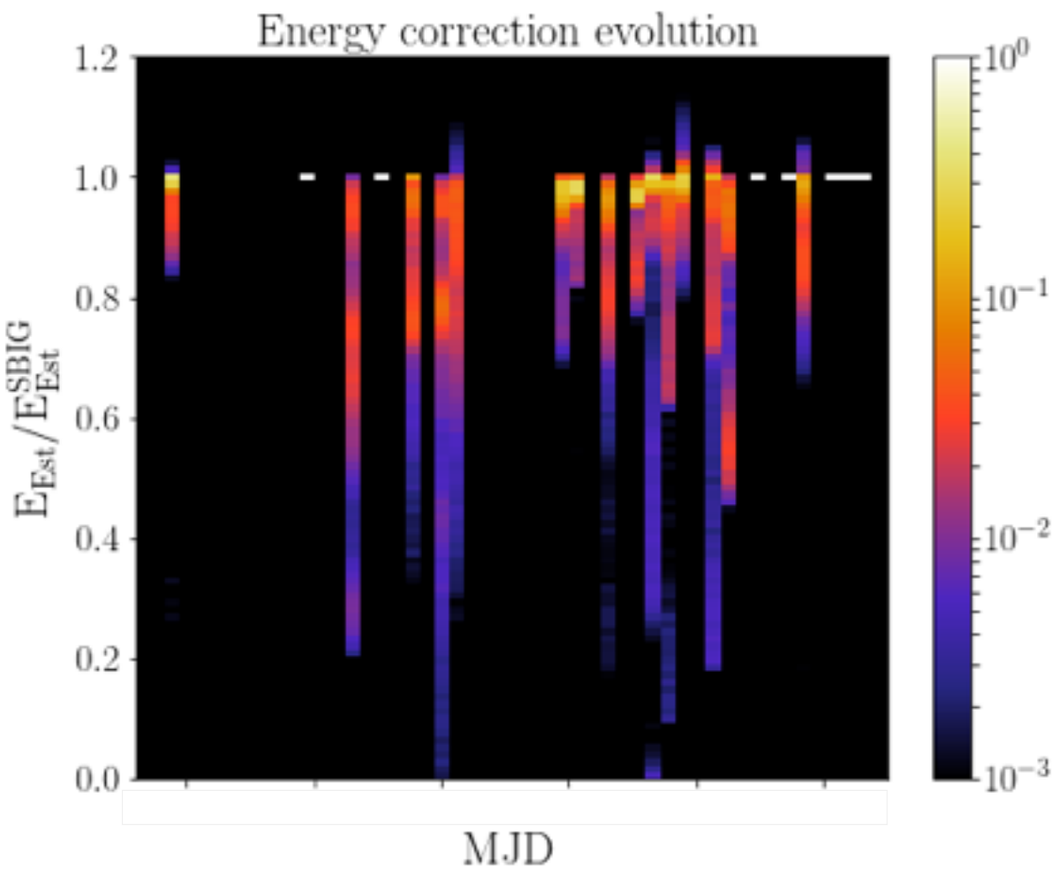
Good night

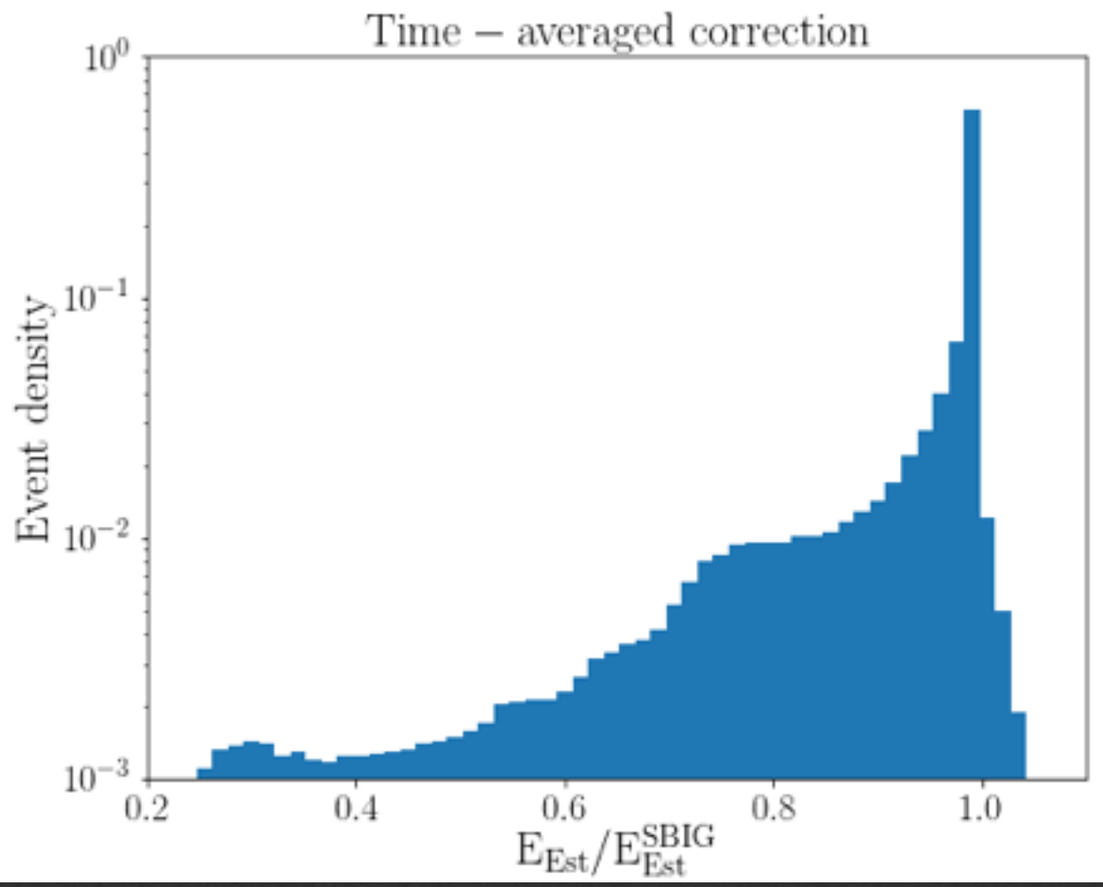


Bad night

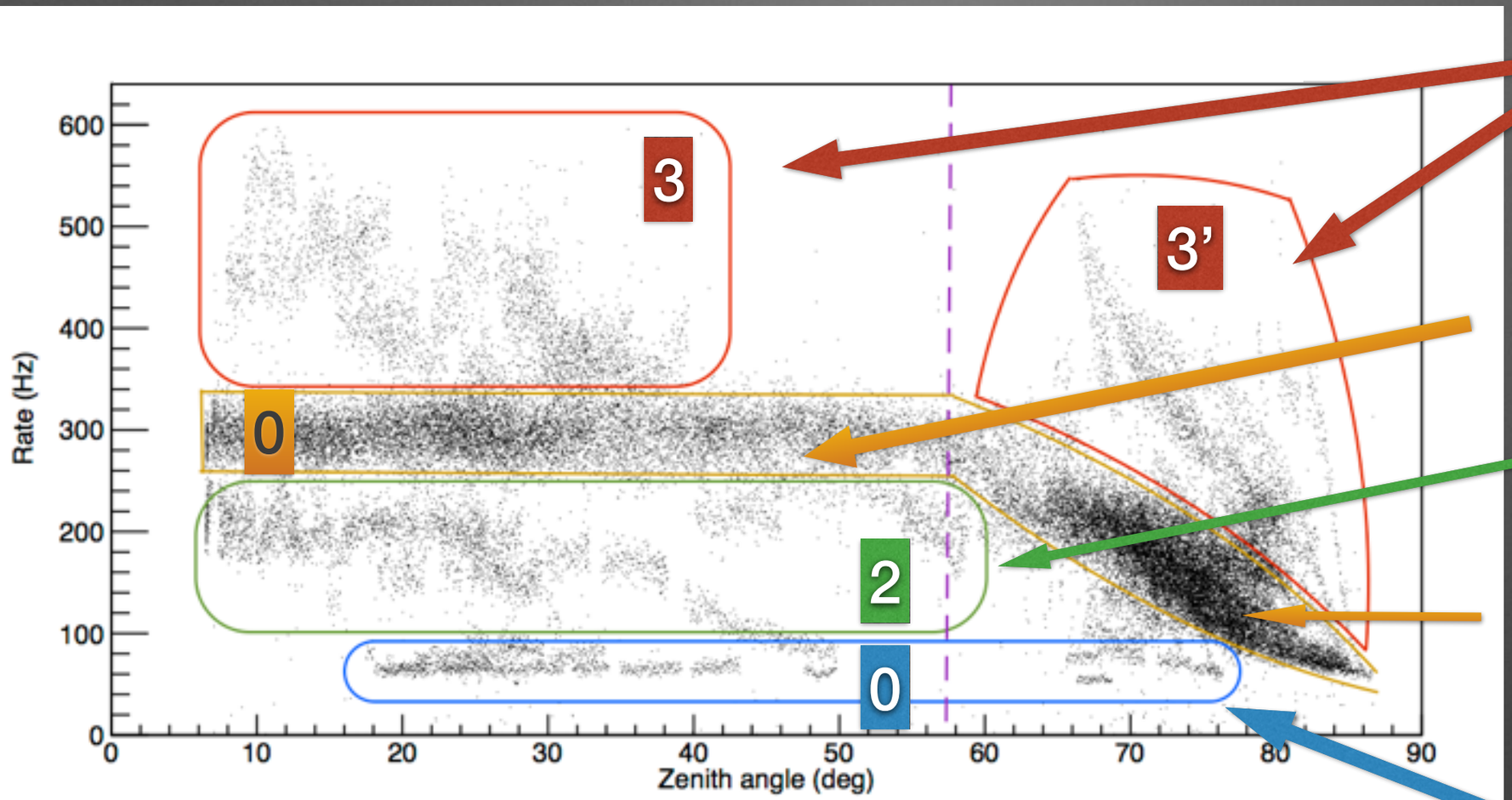


Correction applied over estimated energy E_{Est}





Example of rate evolution with zenith angle



mostly variable diffusion

"good" stable rates

mostly variable absorption

interesting VLZA data
BUT mixed!

Different night sky background

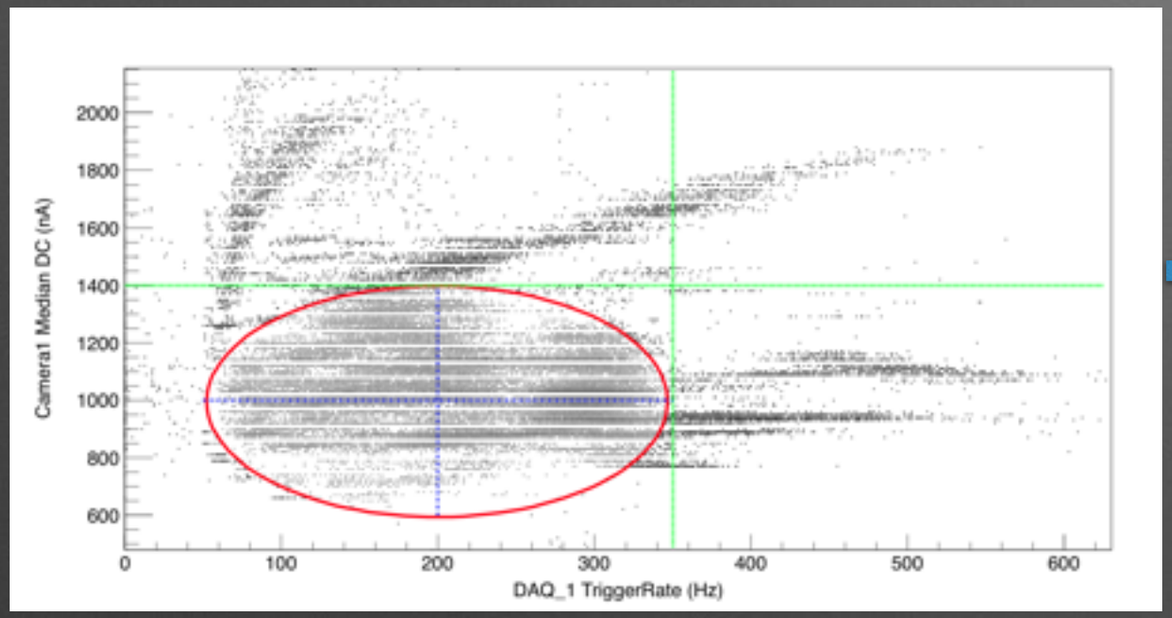
Ratio gammas/CRs decreases with Zd ⇒ shrinking of data ⇒

data quality + background rejection more important at high Zd

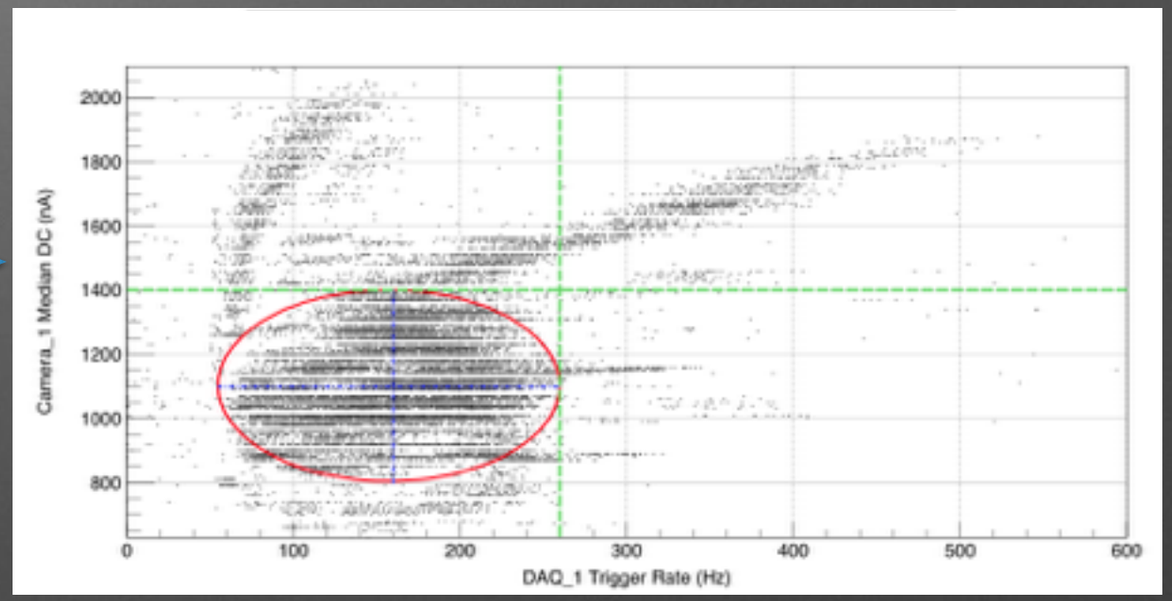
How strong is the change? Before turning point easier to study…

DC - Rates

Overall conservative cut, no moon conditions…



higher Zd

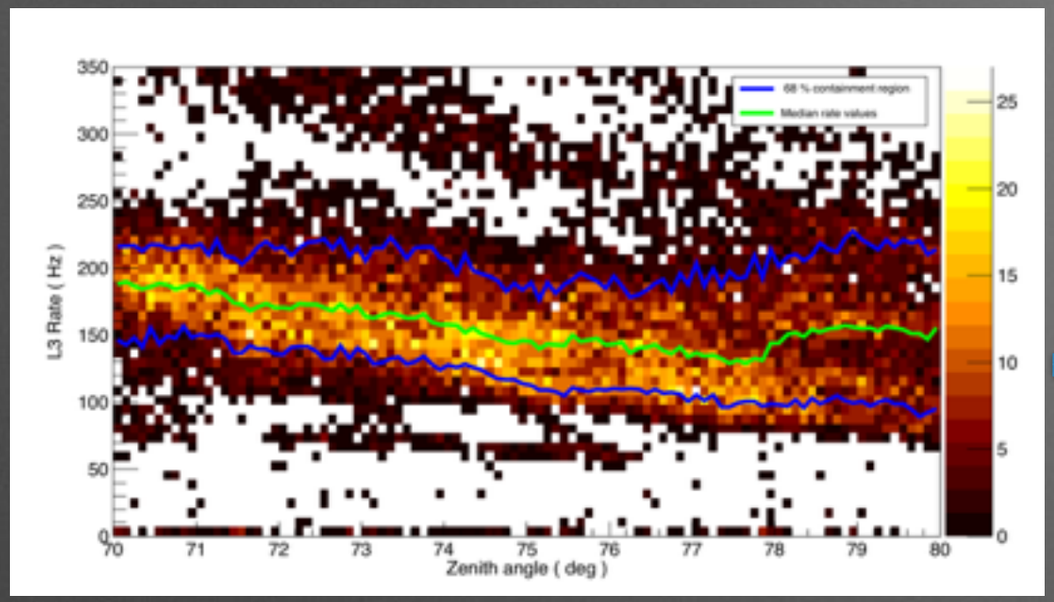


Rate shrinks as previous slide shows

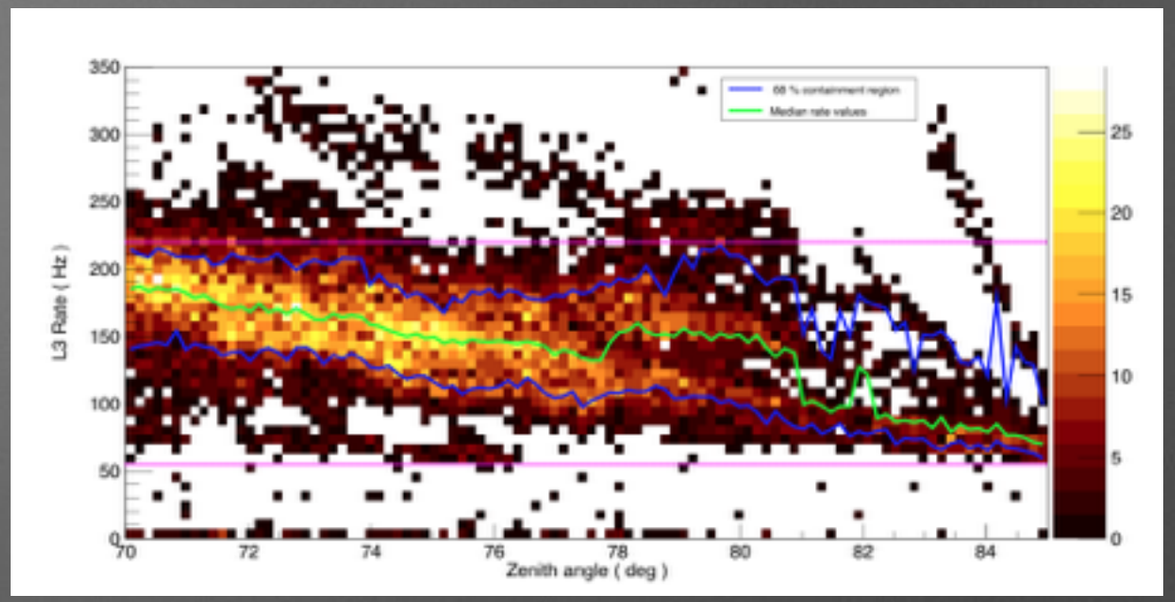
DC is rather “democratic” : all showers are less frequent, either due to gammas or not

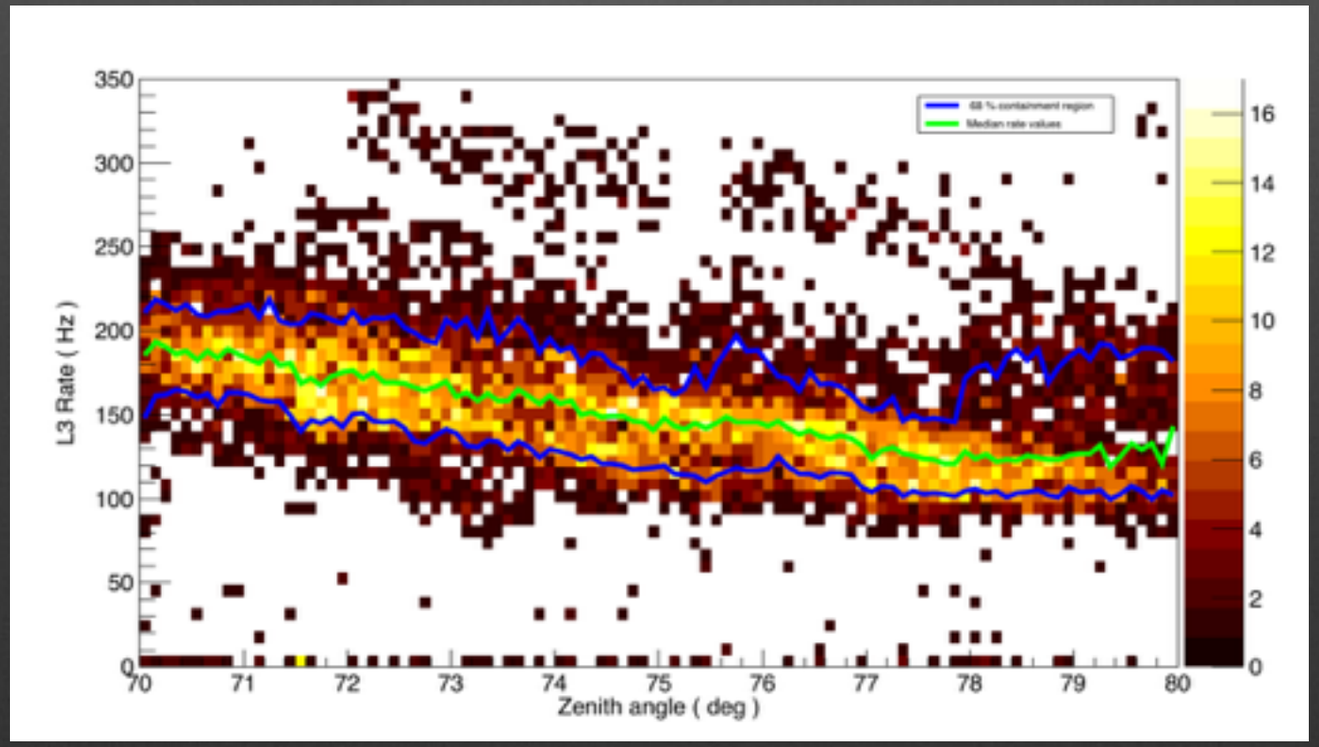
DC and rate are almost the only useful low level cuts at the moment…

Example of non-adaptive rate cut for VLZA



Previous cuts





Final rate cut

Summary

- Atmospheric quantities are more sensitive at VLZA and deserve more study
  - Atmosphere still biggest player for systematics…
  - …but with the help of SBIGs and possibly new instruments could be put under control
- Interplay between DC, zenith angle and rates can help at least dealing with basic hardware issues
- Exploiting VLZA data means improving our sensitivity at the highest energies…
- …and understanding systematics is fundamental in order to boost our sensitivity.

image credits: MAGIC collaboration