Probing the comic-ray e+/- spectrum at TeV energies with MAGIC very large zenith data

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Motivation

The life time (Propagation distance) of very high energy electrons is limited by synchrotron radiation and inverse Compton scattering

If we can see TeV electrons:

⇒Reveal interesting acceleration and propagation mechanisms from local

⇒Hint to new physics (eg. Annihilation or decay of TeV dark matter particles)

If we cannot see TeV electrons:

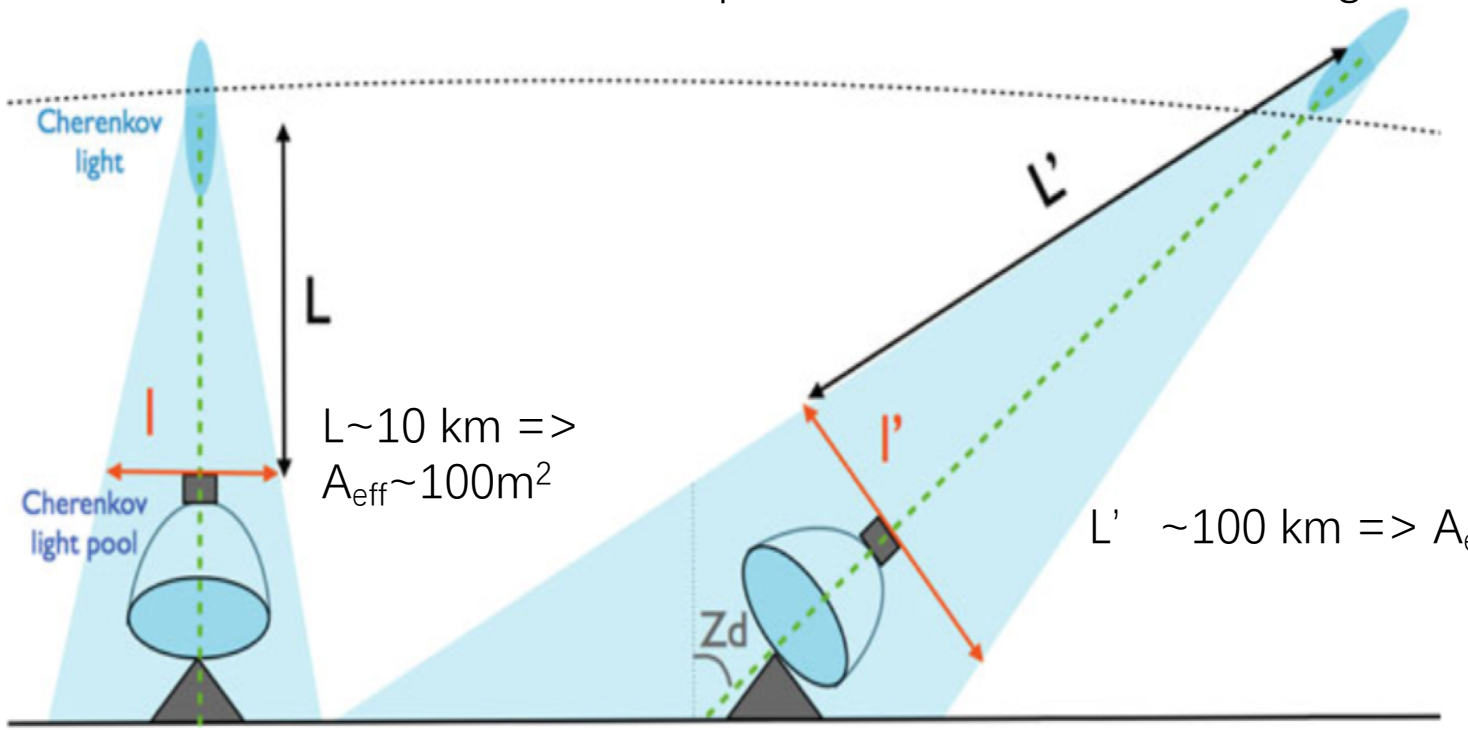
⇒Confirm a cut-off of the cosmic-ray electron spectrum at TeV provides constraints on cosmic-ray and dark matter physics

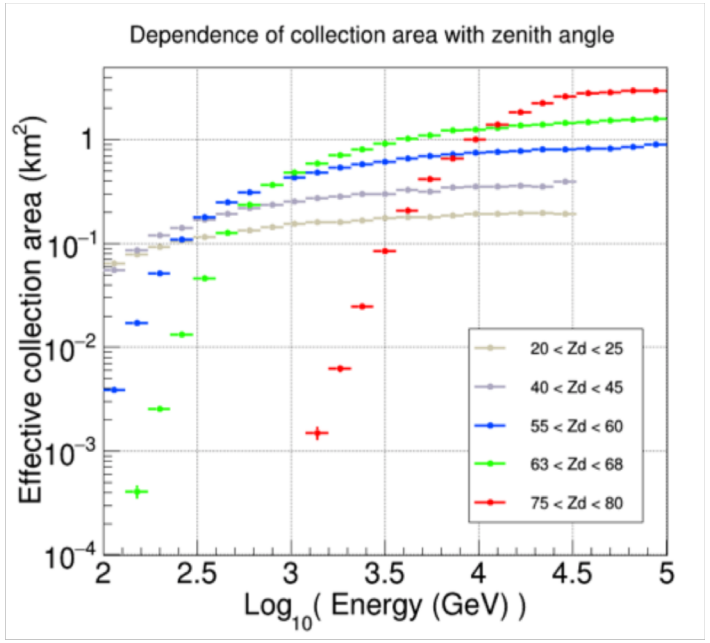
MAGIC Telescopes

- Located on La Palma, Canary Islands, Spain (28.8°, 17.9°, at 2225m)
- Distance between two telescopes is 85m
- The first telescope started to take data in 2004, and stereo observations with both telescopes commenced in 2009.
- Energy threshold of ~ 50GeV
- Diameter $D = 17m$ of the parabolic reflector dish
- Field of View of 3.5°

Very Large Zenith Observation of Magic

Difference in the shower development between low Zd and high Zd.





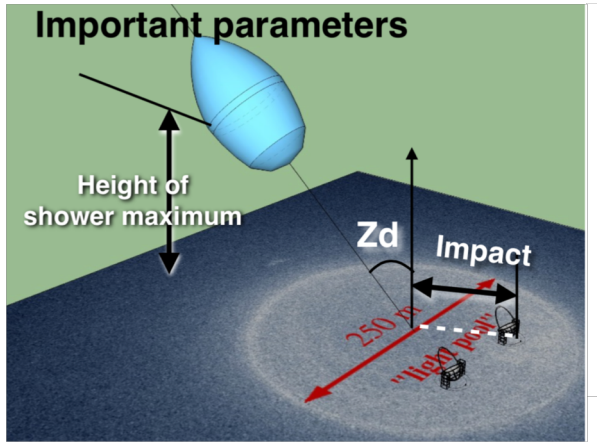
Limited radiation length
Small collection area

Longer radiation length
Larger collection area

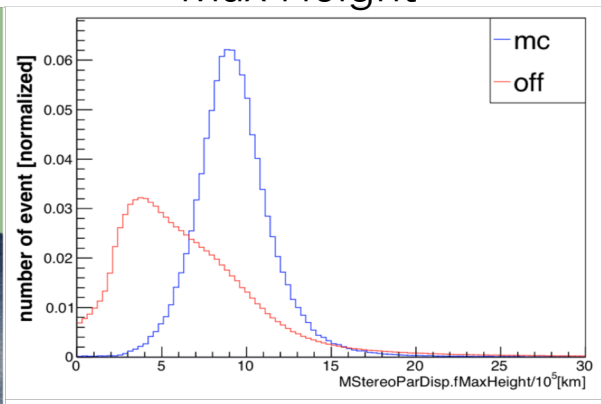
At high zenith, effective collection can be increased by 100 times compare to low zenith at energy > tens of TeV

Past Systematic Study of Azimuth Dependence

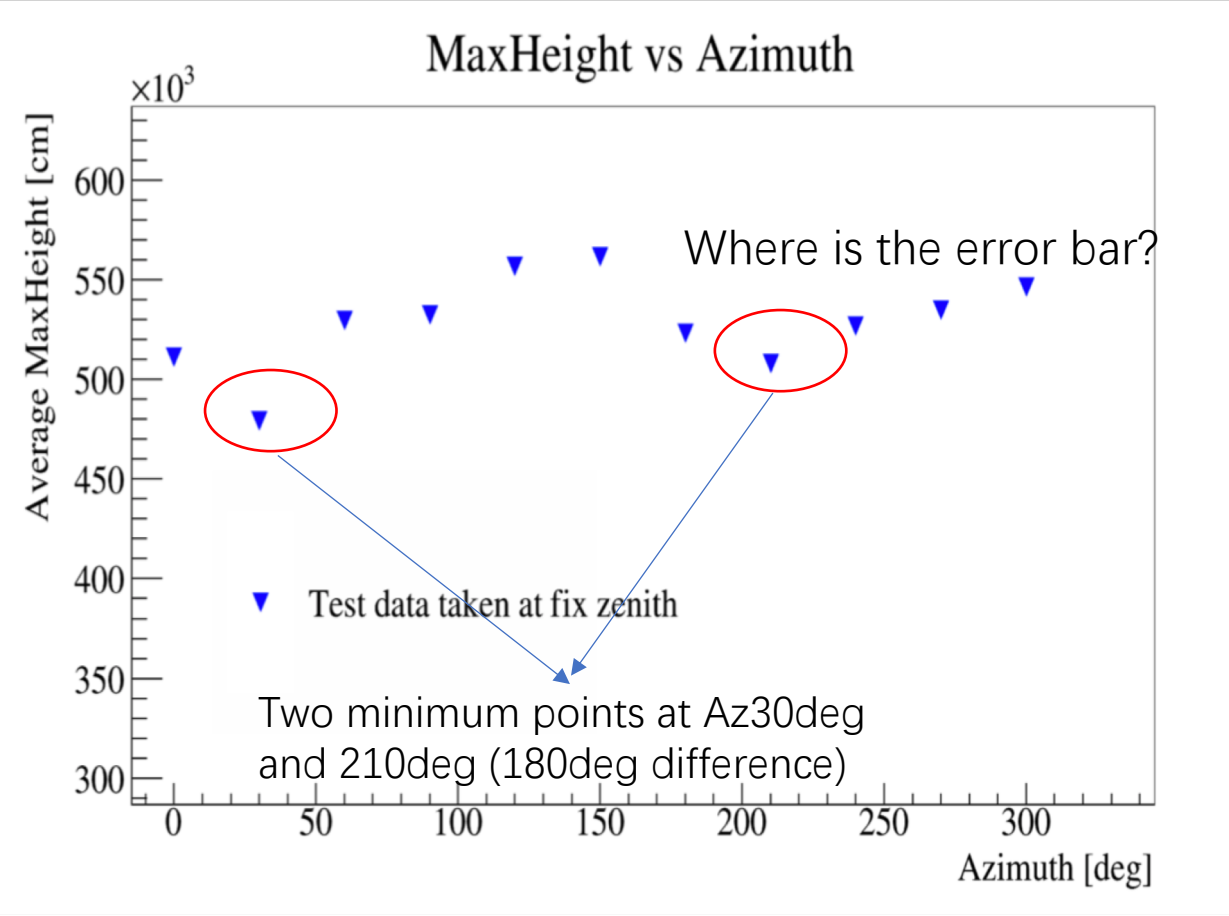
- In the previous study, they saw the energy spectrum variance dependent on direction (Azimuth dependence).
- It is because the contamination of back ground is different dependent on Azimuth.
- Shower MaxHeight (the height of the shower core) is a mighty tool for background rejection.
- The Azimuth dependence of MaxHeight of hadronic events was investigated.
  - Height difference of two telescopes cannot explain.
  - Magnetic filed effect cannot explain cannot explain.
  - Couldn’ t reproduce the same tendency in MC.



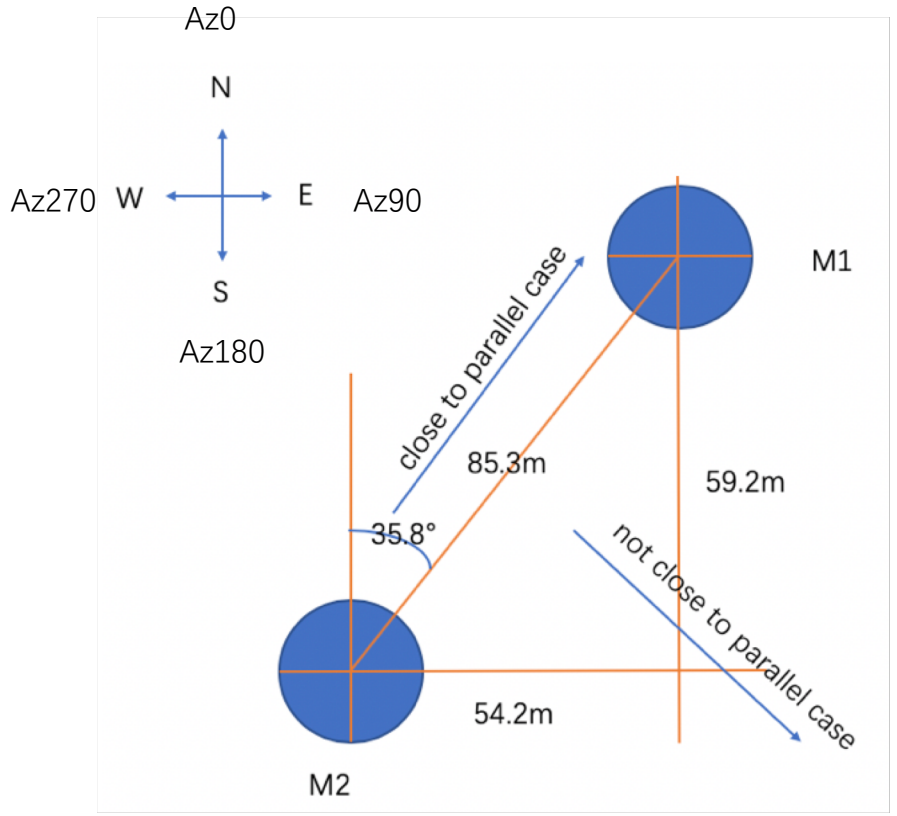
Max Height



Past Systematic Study of Azimuth Dependence

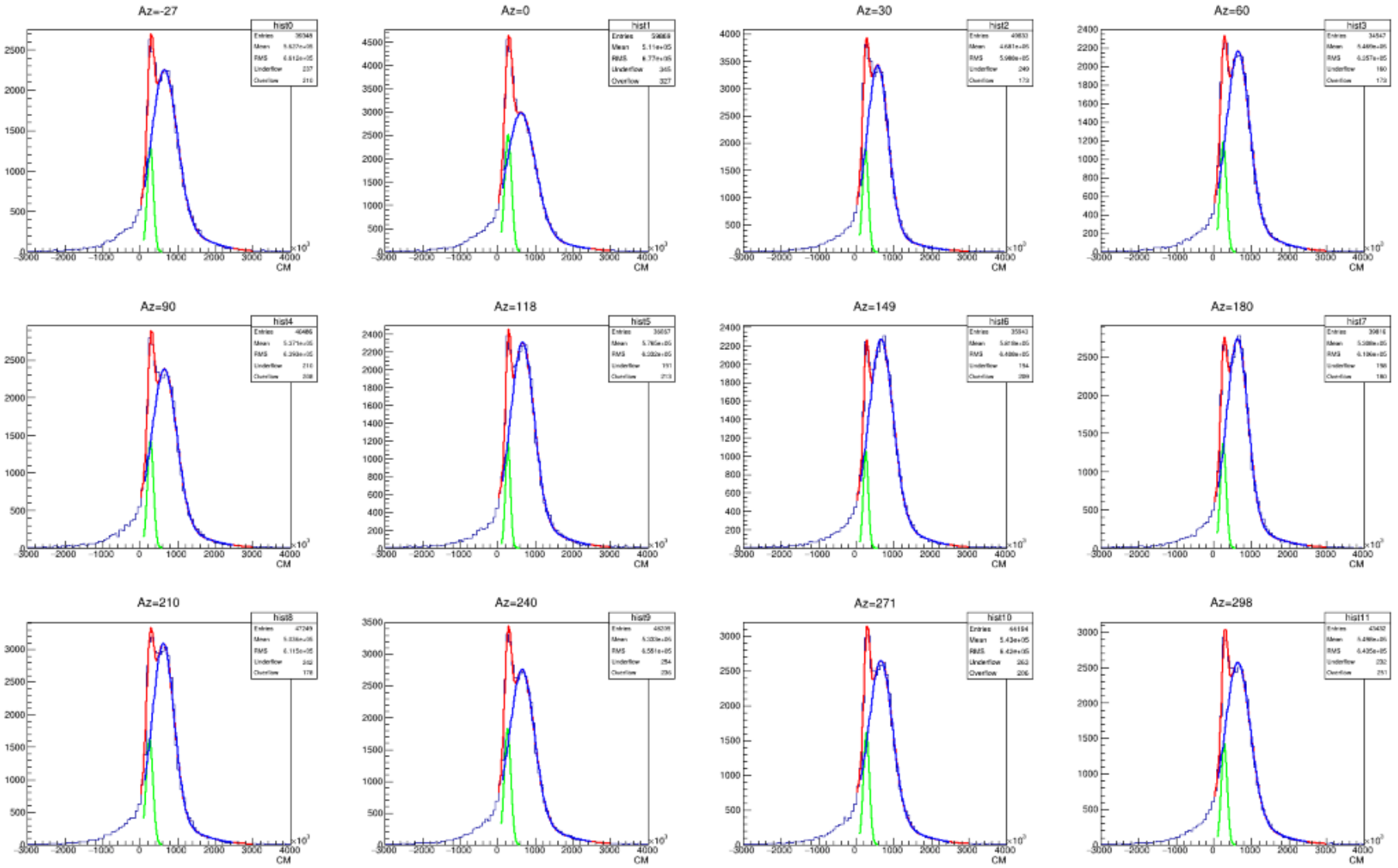


Azimuth dependence on fixed direction observation (Zd 30deg)
Mallot's PhD thesis



Geometric position of two telescopes

MaxHeight Distribution of Fixed Zenith Data at Each Az

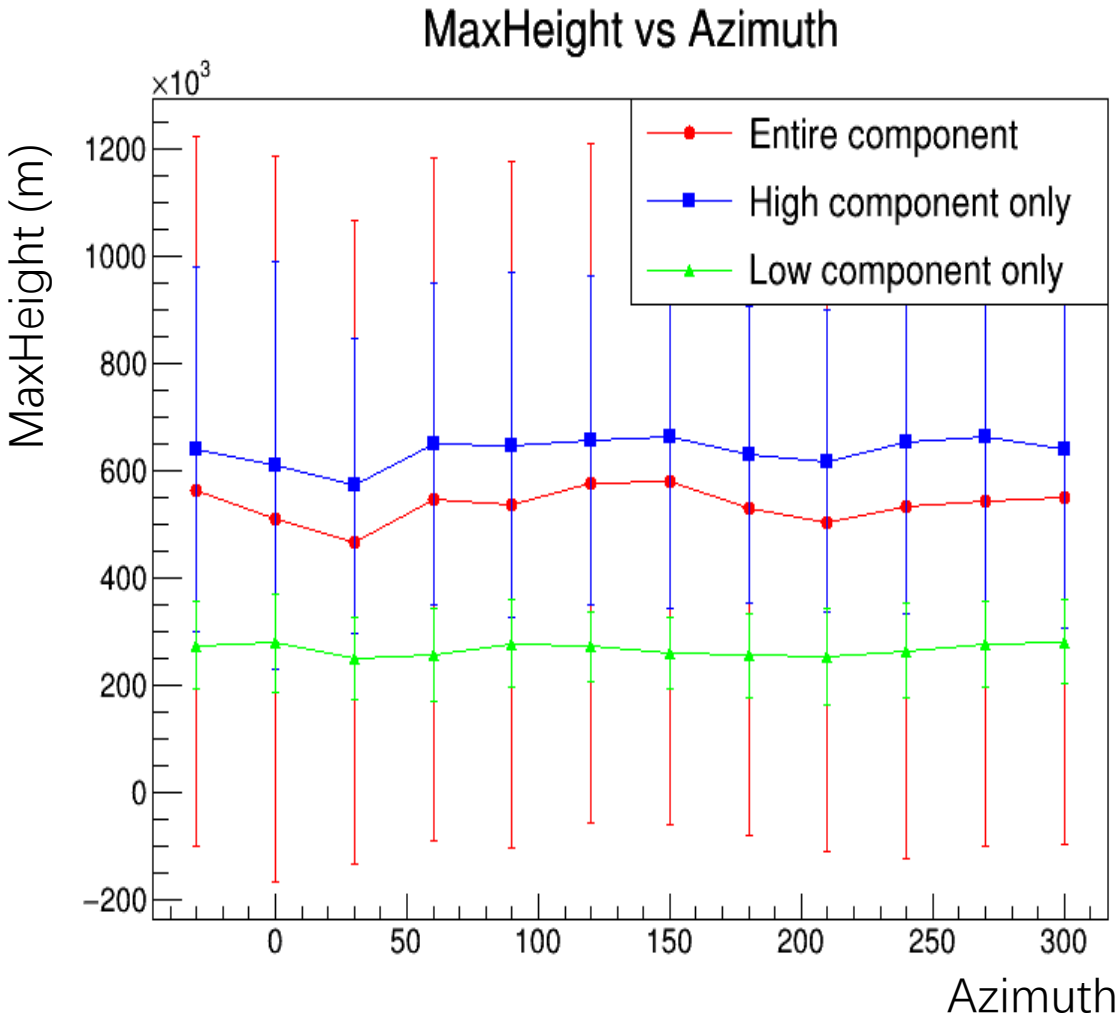


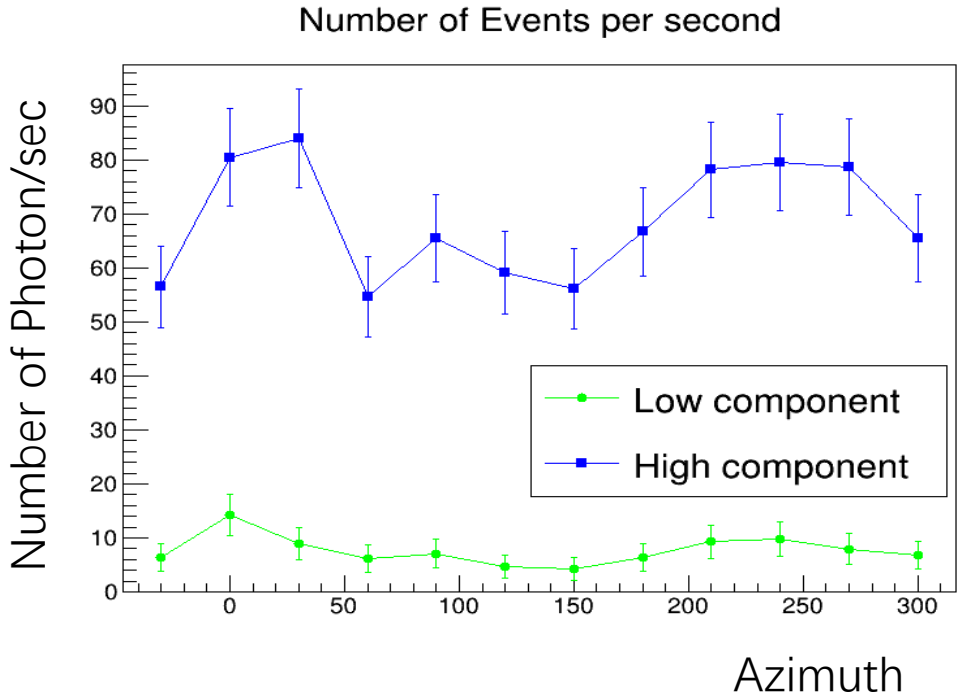
Double peak is clear to be seen.

Lower (green) component is fitted by gaussian

Higher (blue) component is fitted by double gaussian

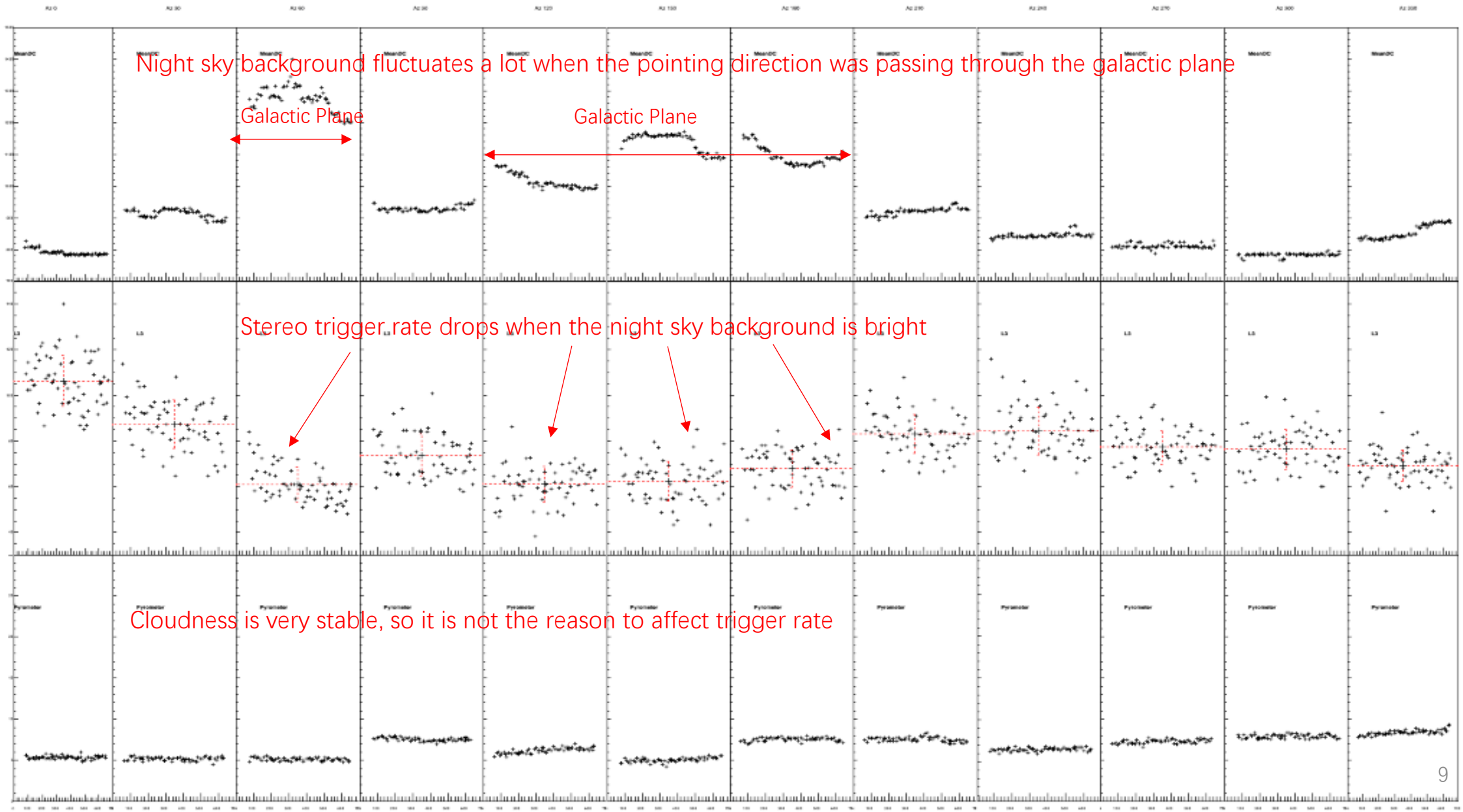
MaxHeight and Trigger Rate for two components



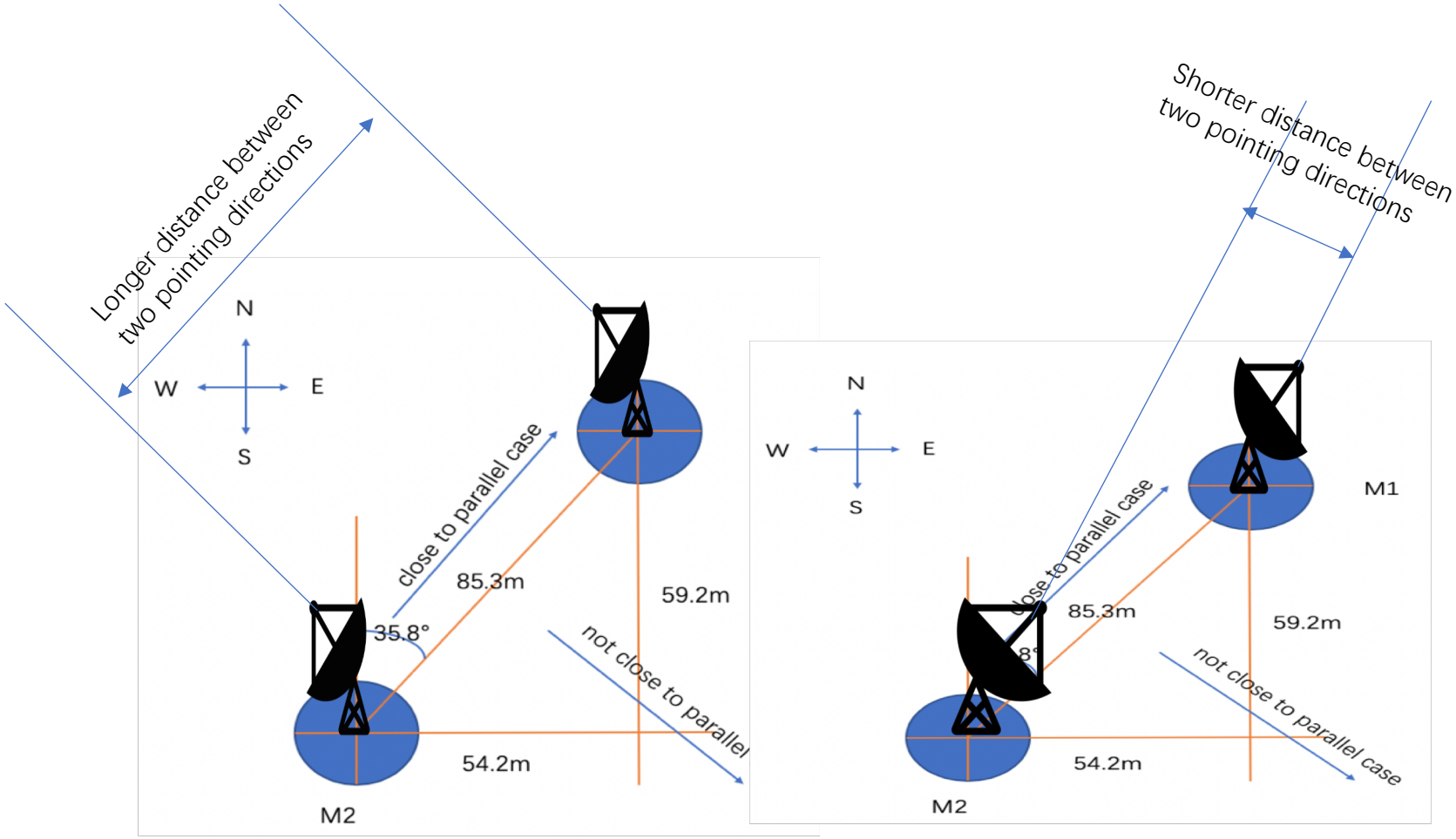


MaxHeight distribution for higher component has a minimum at 30deg.
At 210deg, the anomaly is not so obvious.
MaxHeight distribution for lower component seems stable.
For both components we can see the peak of trigger rate around Az30 and 210deg.
Is it because the observation condition is unstable?
Is low component local muons?

Variability of the Observation for fixed Zenith 30deg



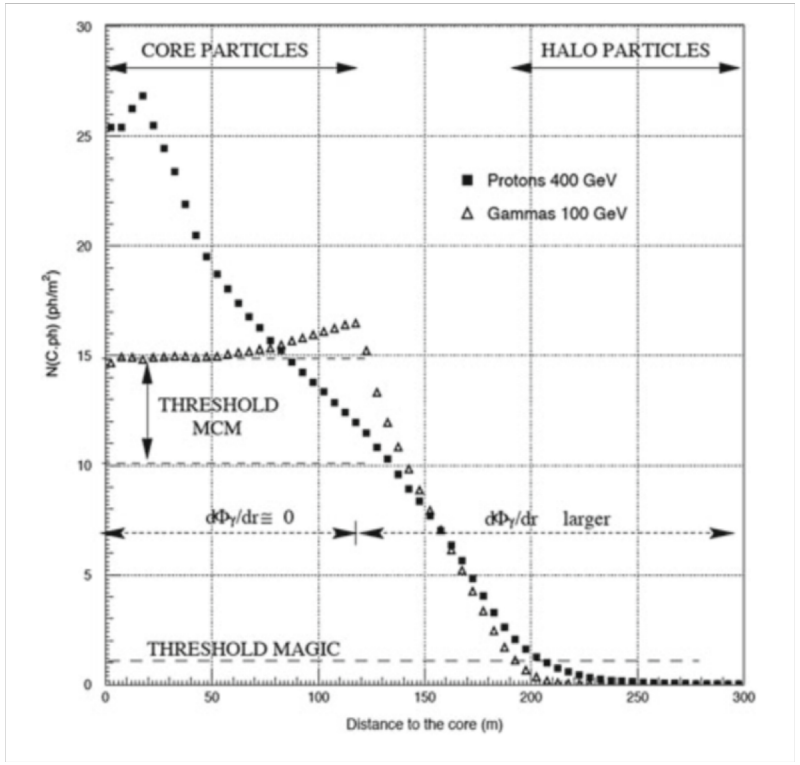
Different Distance of Pointing Directions for Different Geometric Position



When two telescopes are pointing at the close to parallel case, shorter orthogonal component Of two telescopes are expected.

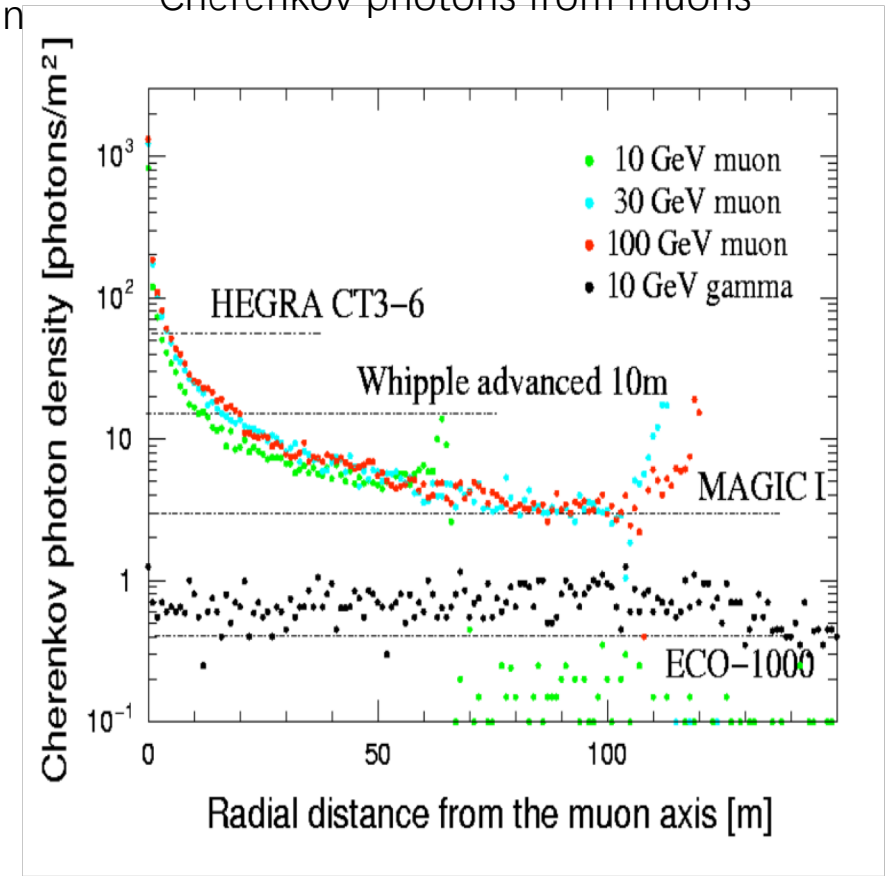
Distance and Stereo Trigger Rate

Cherenkov photons from gamma and proton

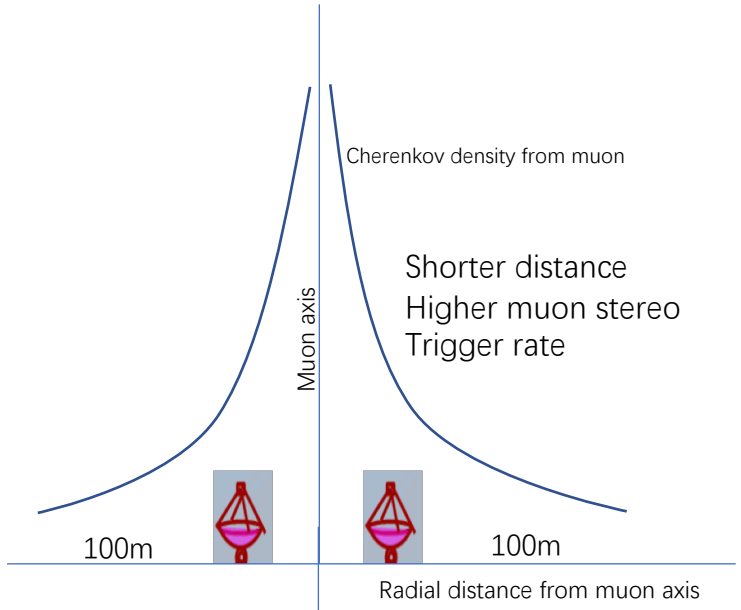


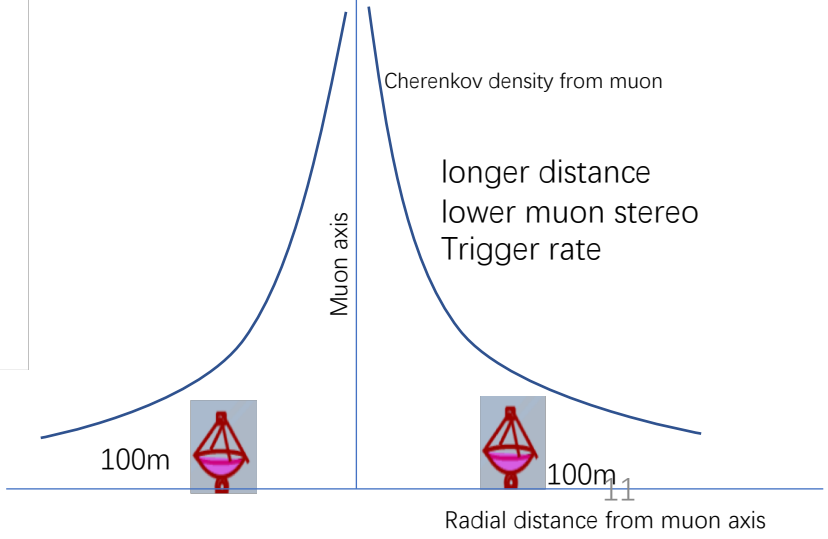
Barrio et al. 1998

Cherenkov photons from muons



Albrecht Karle lecture 2006

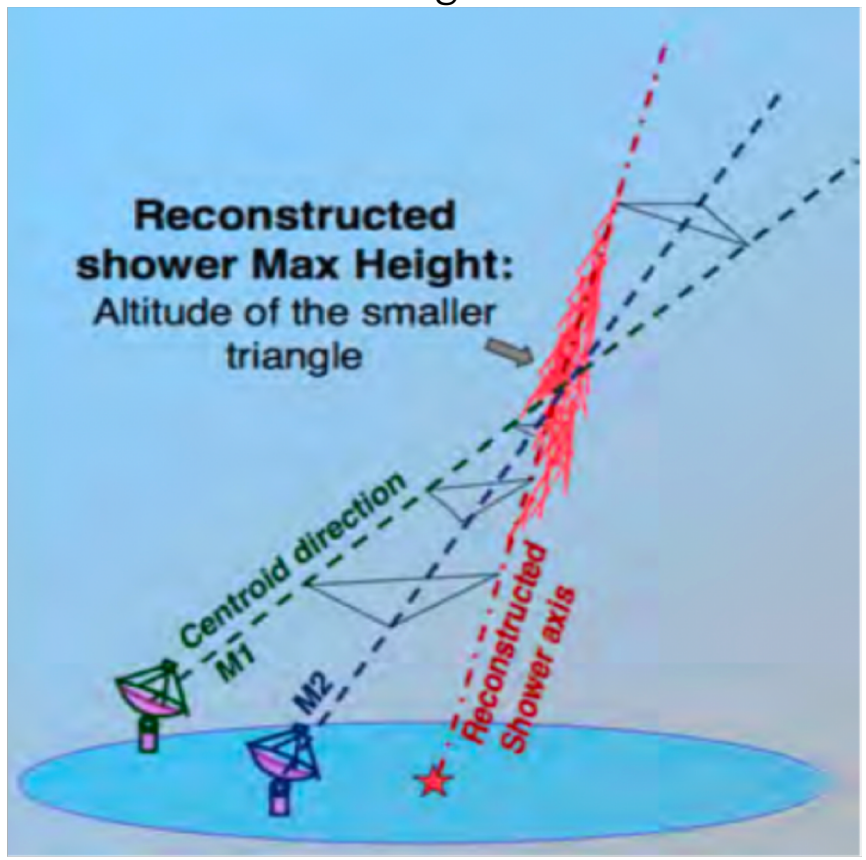




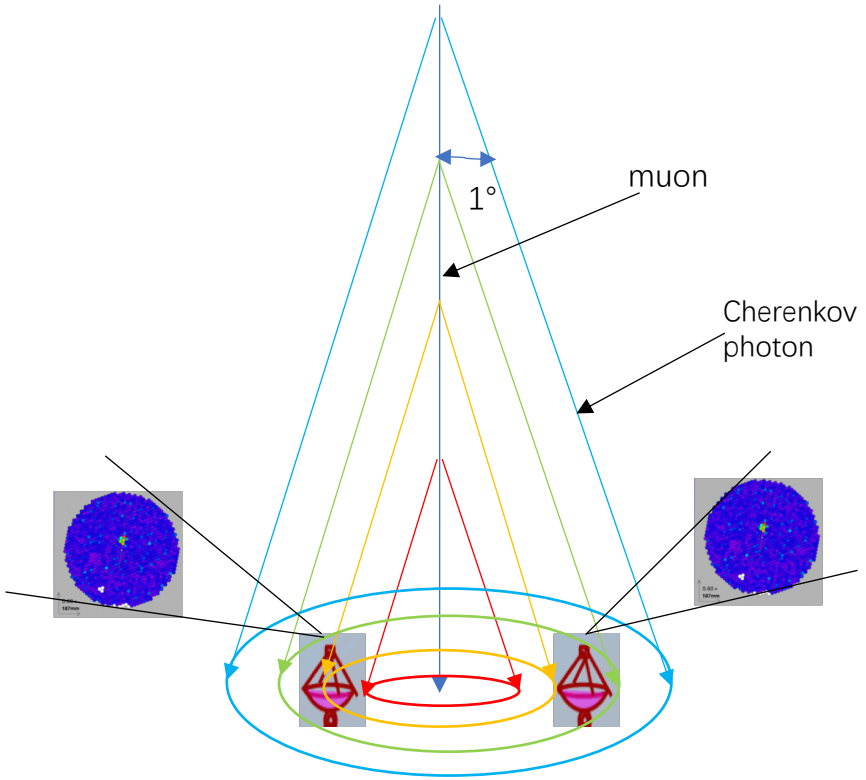
Shorter distance, Higher muon stereo Trigger rate; longer distance lower muon stereo Trigger rate

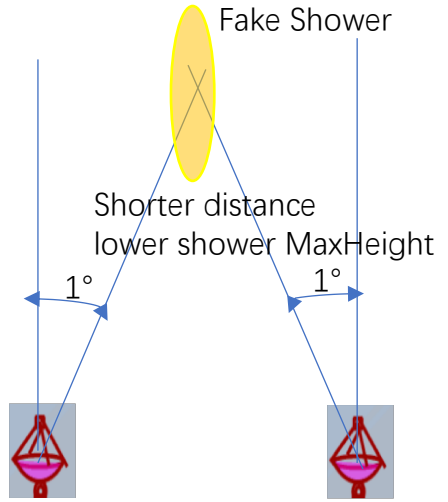
Distance and shower MaxHeight

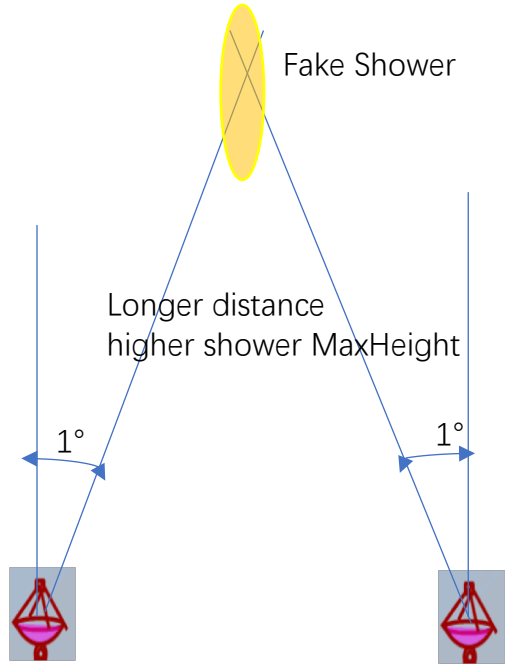
In case of gamma



In case of single muon, Cherenkov light is
Only emitted at constant Cherenkov angle of 1°







Shorter distance lower shower MaxHeight; Longer distance higher shower MaxHeight

Plan

- Check the trigger rate of MC proton to see if it is different from reality. If not, try to reproduce the same tendency by simulating MC with large view cone to make sure local muons trigger rate similar to reality.

- The background of fixed zenith 30deg data seems not so stable, maybe new observation proposal should be launched.

- Check very high zenith data to see if the same azimuth dependence exists.

Summary

- It is very attractive to use very large zenith data to enlarge the e+/- spectrum.
- In the past study, flux dependence on azimuth at low zenith was seen, and different background contamination at different is the reason, as a mighty tool for background rejection, maxheight dependence was studied.
- Past study ONLY show average distribution of shower maxheight and they can neither explain the reason nor reproduce the same tendency (low maxheight at Az30 and 210) for MC data.
- To clarify systematics at low zenith can provide us hints for high zenith systematic study.

- We revisited the data, and see:

  Shower MaxHeight shows double peak distribution.

  Maybe high component is the proton, low component is muon.

  Shower MaxHeight and trigger rate show Azimuth dependence.

  Maybe relate to night sky background.

  Maybe relate to geometric position of two telescopes.