TenTen 計画 R & D (2)

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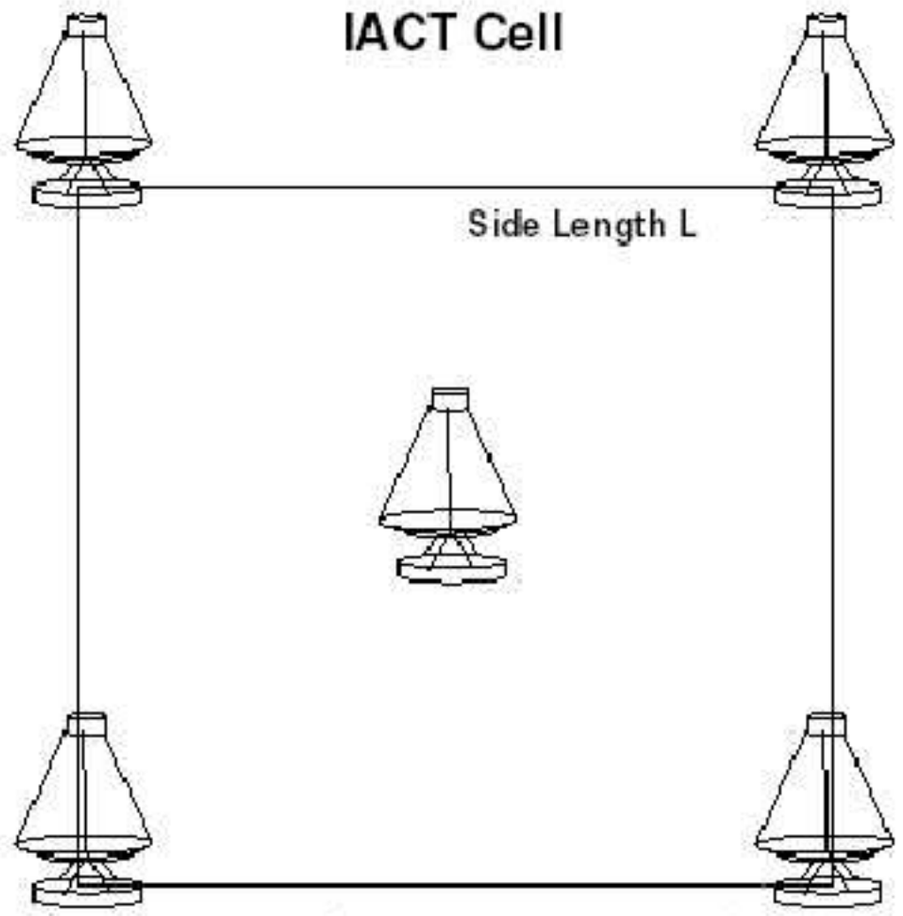
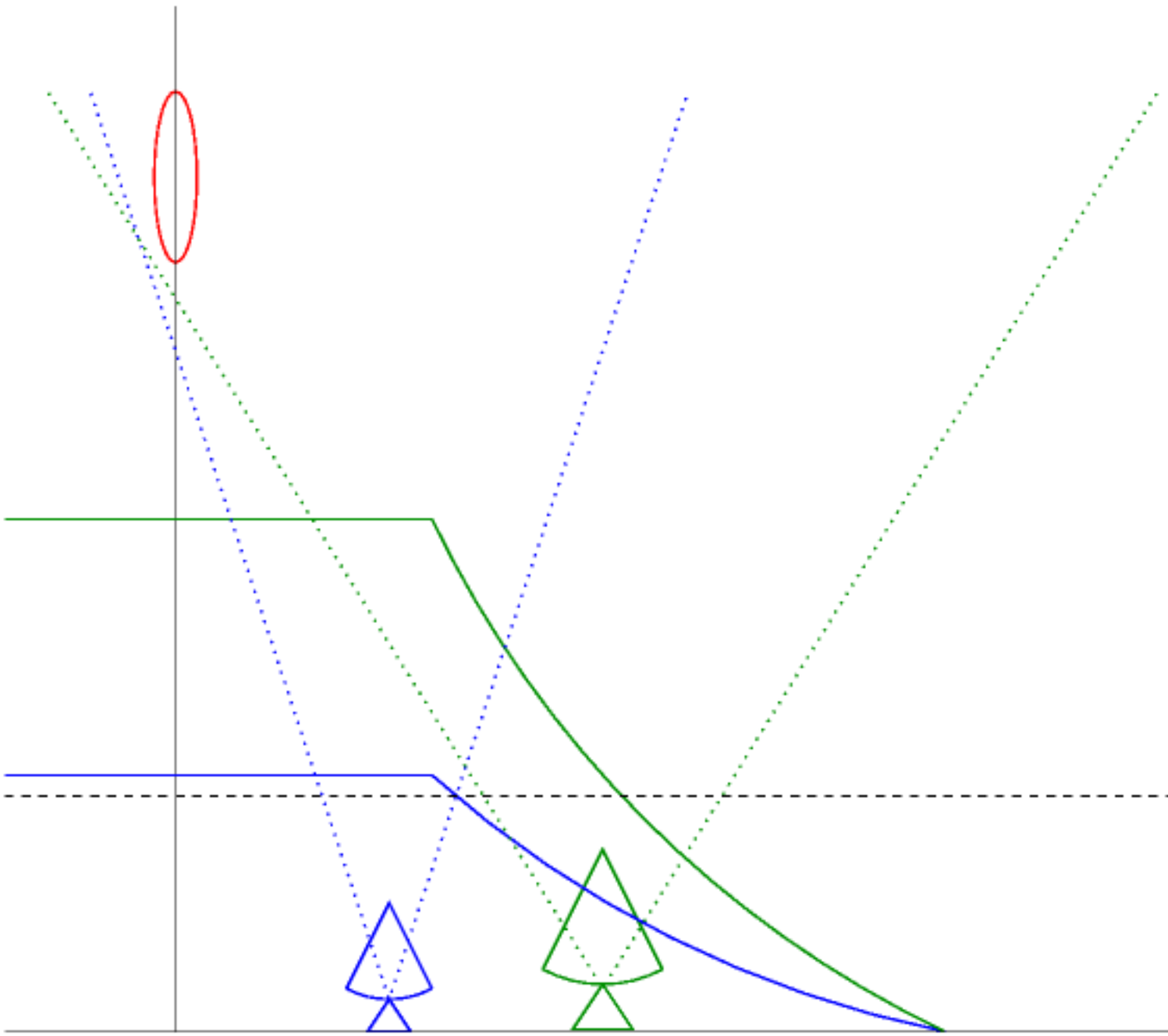
TenTen Project

- Original plan:
  - Effective area of 10 km^2 at energies 10 TeV and above
  - Stereoscopic array of 30-50 telescopes (full scale)

- TenTen → "PeV Explorer"
  - 1 cell (~5 telescopes) in Australia
    - Best site in Australia (dry, flat, and low altitude)
  - Cost-effective design:
    - Inter-telescope spacing exceeding 250 m
    - Mirror area 10-20 m^2
    - Field of view 5°-10°
  - Long exposure (several 100 hr) → key science



PeV Explorer Concept

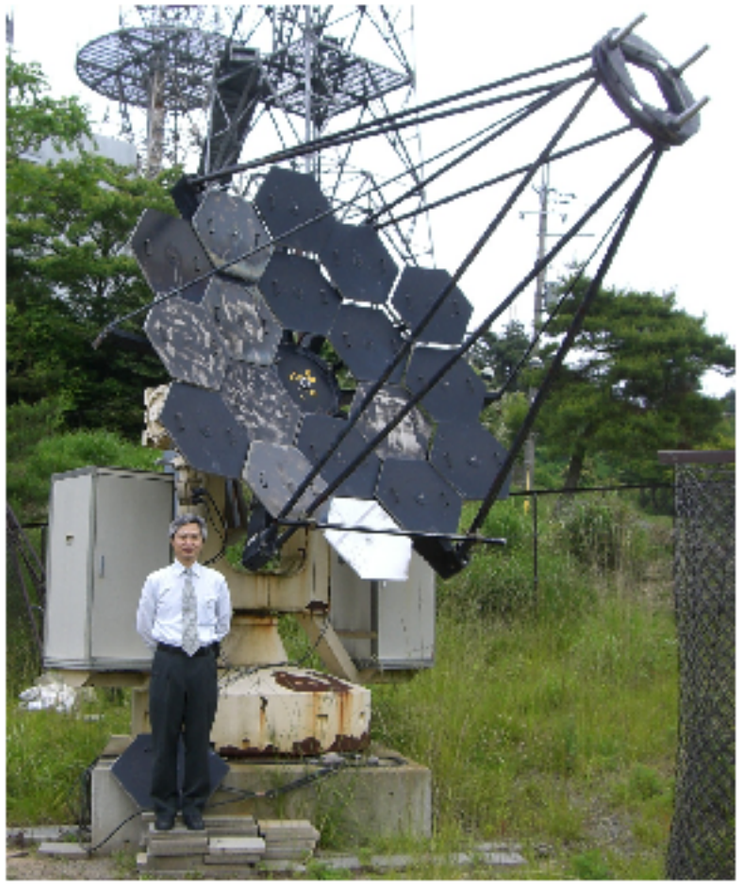


- Cherenkov plateau
  - Radius ~ 150 m
- Cherenkov tail observable with larger aperture
  - Expand effective area
- Wider FoV necessary
- Effective area is a function of:
  - Telescope aperture
  - Telescope span
  - Field of view

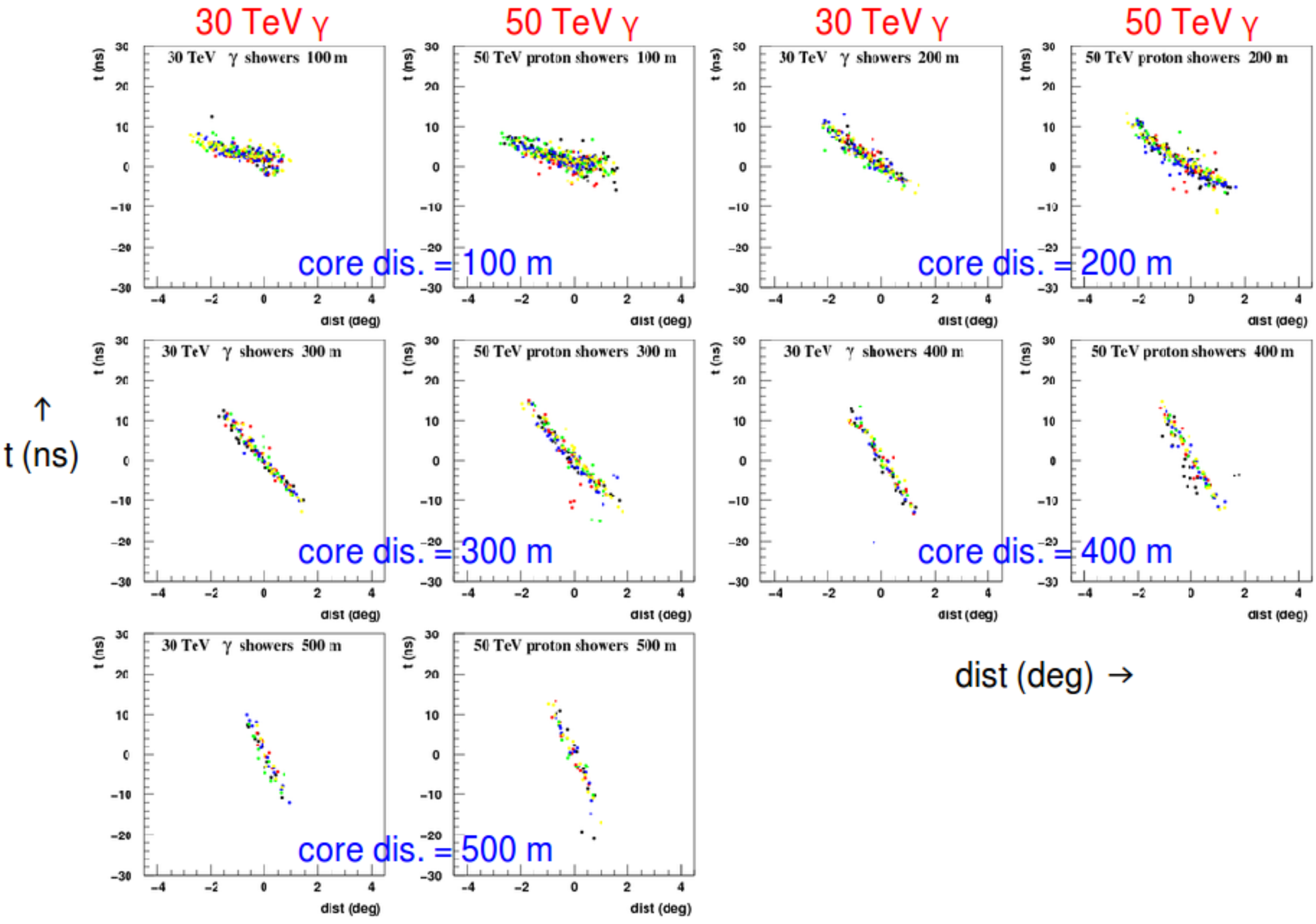
Plyasheshnikov et al. 2000

R & D

- Low power consumption system & high capacity battery
  - Make the telescopes independent of the power line
  - Analog Memory Cell (AMC) ASIC → 遠山講演
- Automatic calibration of the telescope attitude
  - Many telescopes → reduce the burden of manual measurements
  - GPS compass → 中山講演
- Test observations at Akeno
- Simulation study
  - Cherenkov image time gradient
    - Stamatescu et al. (Adelaide group)

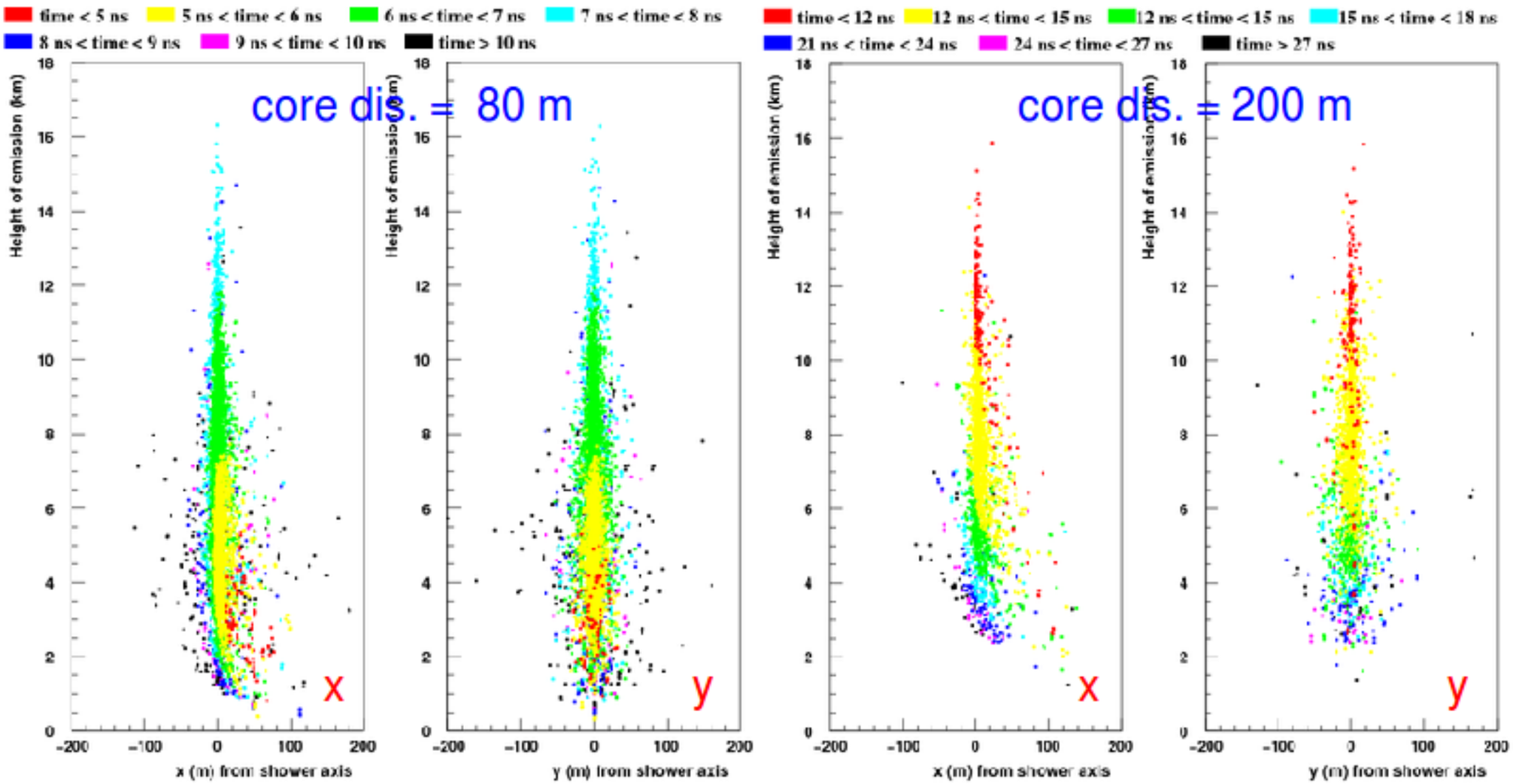


Cherenkov Image Time Gradient



What Causes the Time Gradient?

- Cherenkov photons emitted in deeper atmosphere more delayed at large core distances
  - Distance to the shower more increases in deeper atmosphere with increasing the core distance

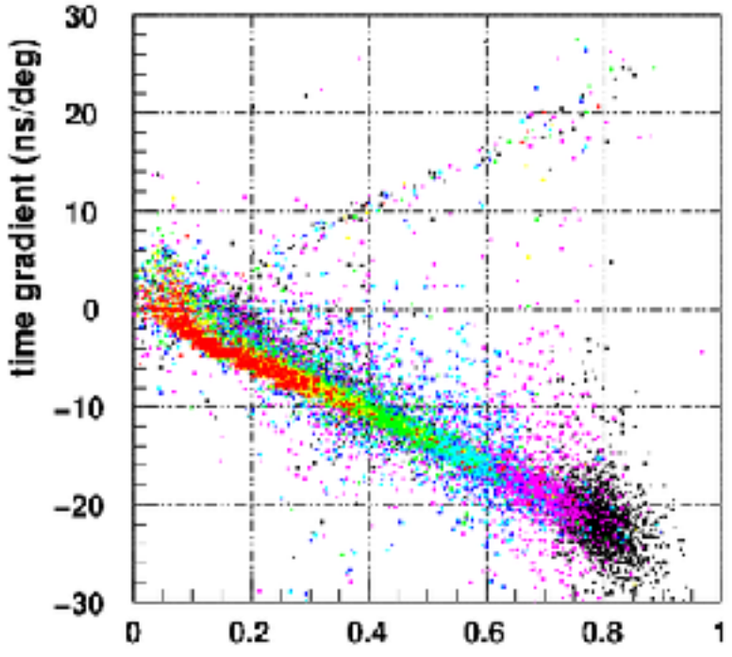


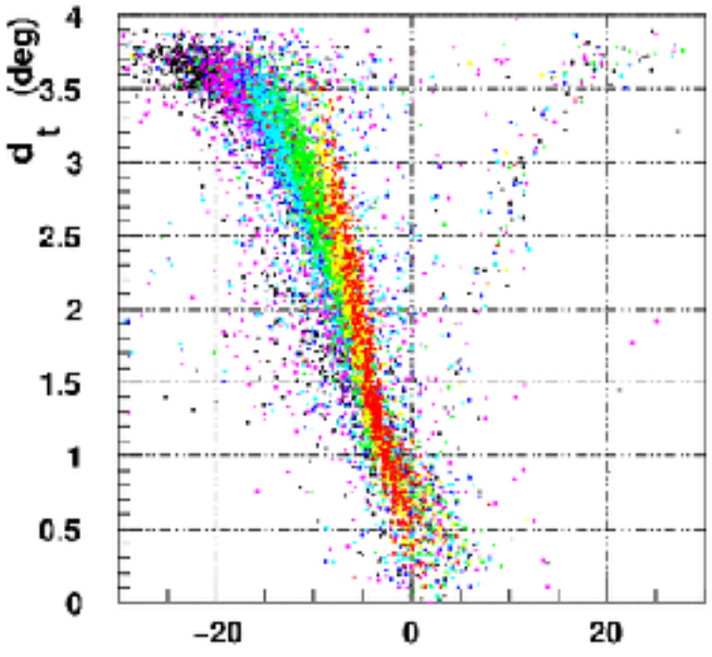
(a) telescope is at $x = 80$ m, y $= 0$ m

(b) telescope is at $x = 200$ m, y $= 0$ m

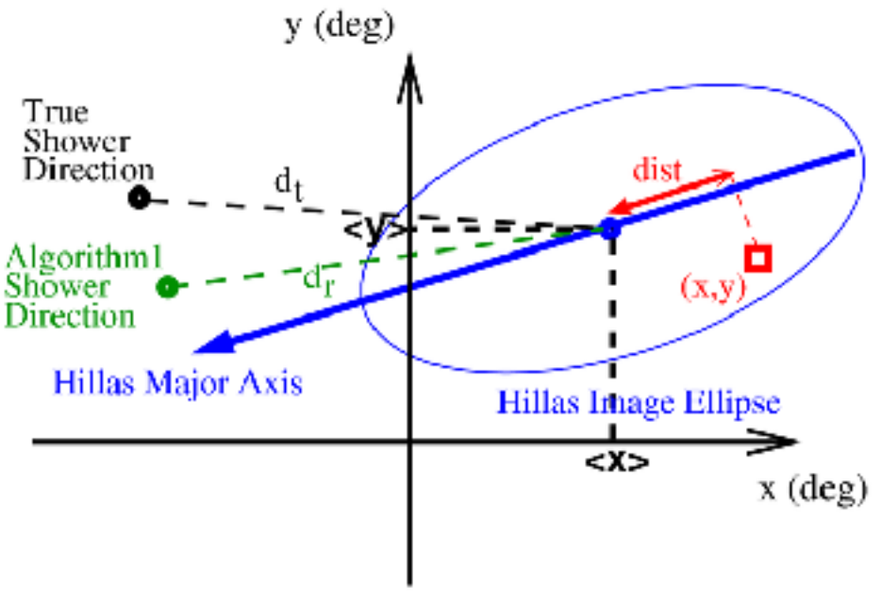
Time Gradient Utilized in the Shower Reconstruction

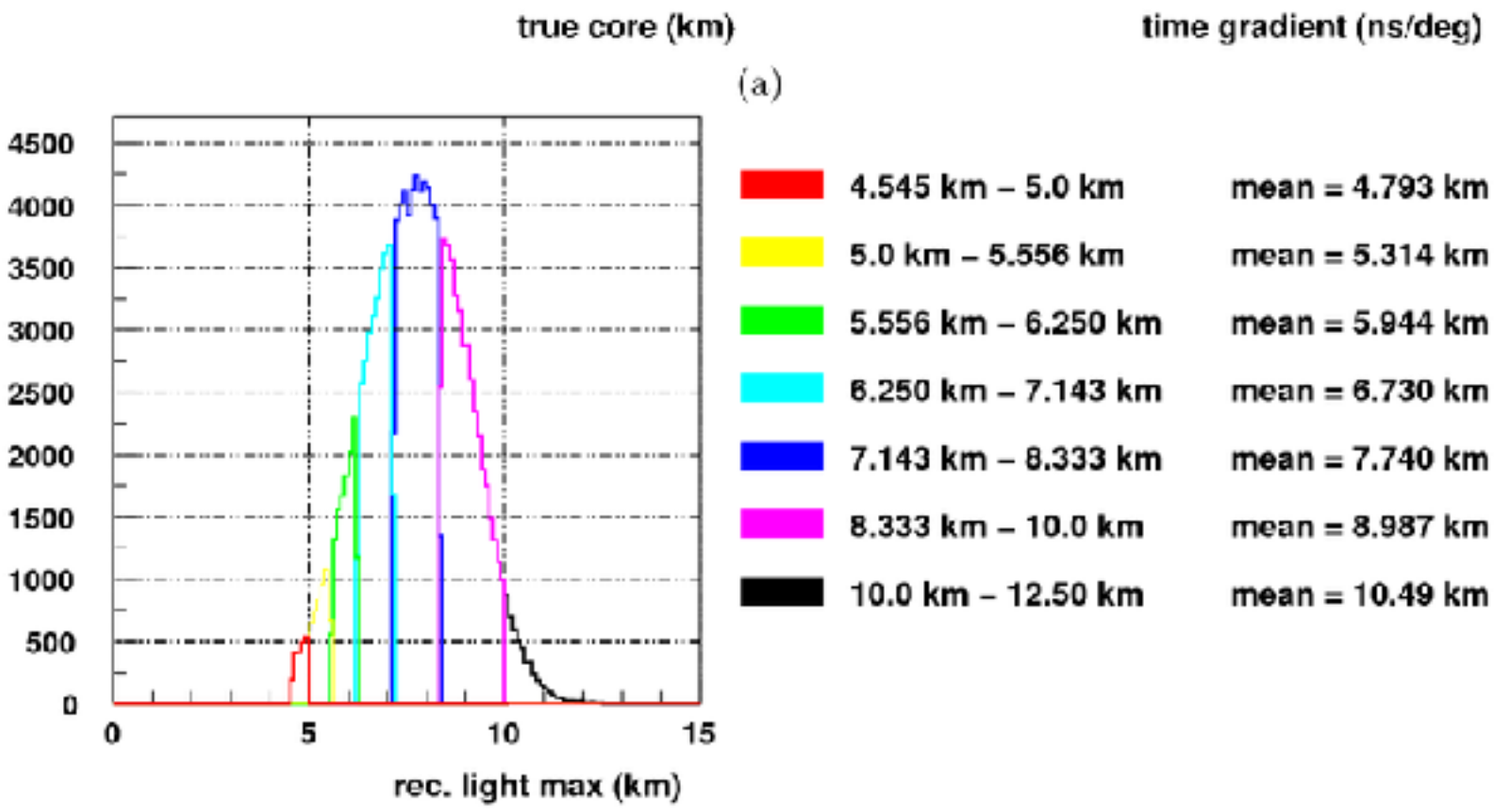
- Arrival-time gradient along the major axis
  - Dependent with the image distance and the core distance





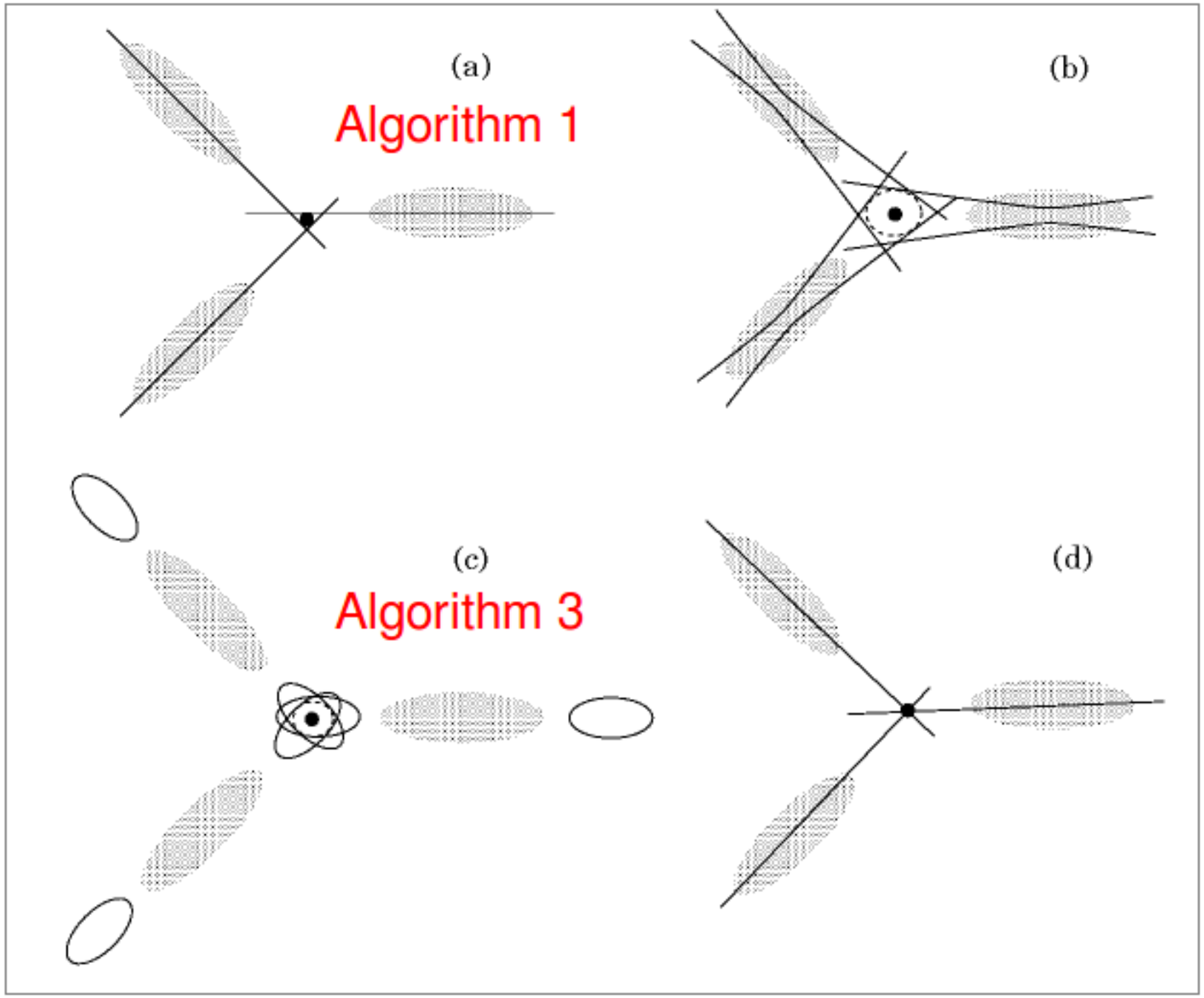
- Some dependency with the emission height





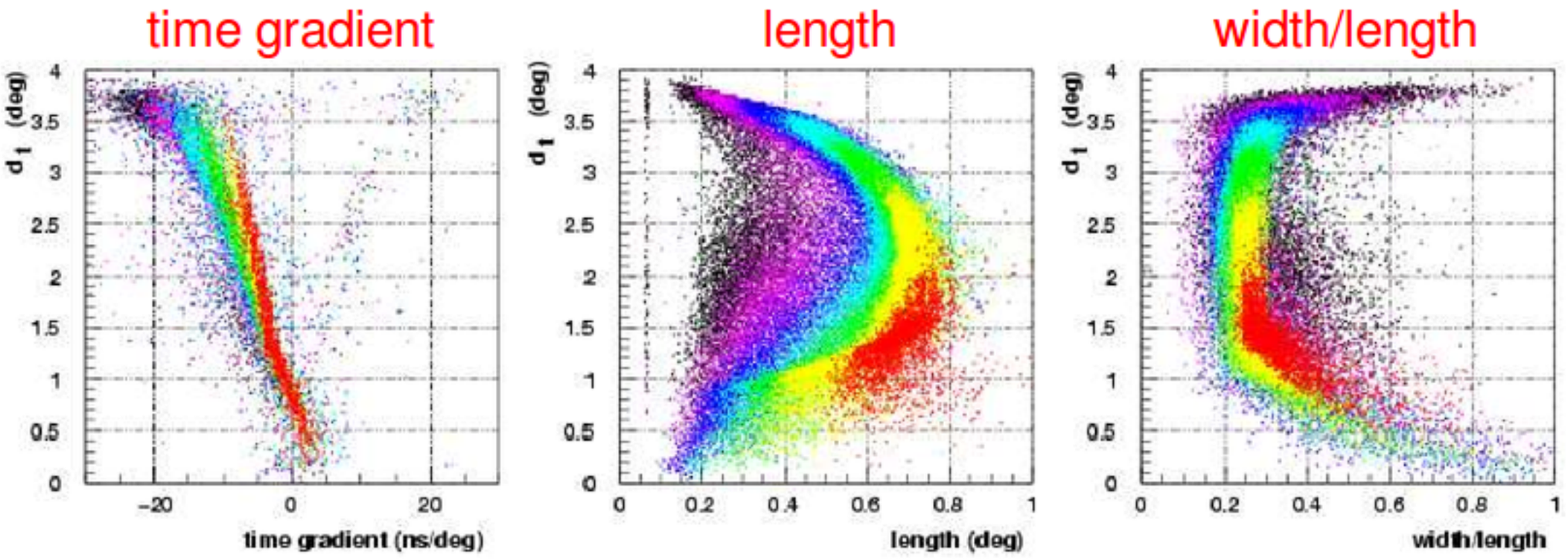
Arrival Direction Reconstruction Basics

- Some algorithms considered
  - Hofmann et al. 1999
- Algorithm 1
  - Weighted mean of intersection points
  - Basic & simple
- Algorithm 3
  - Weighted mean of arrival direction PDFs
  - Distance estimator:
    - width/length
  - Better than Algorithm 1



Comparison of Distance Estimators

d_t

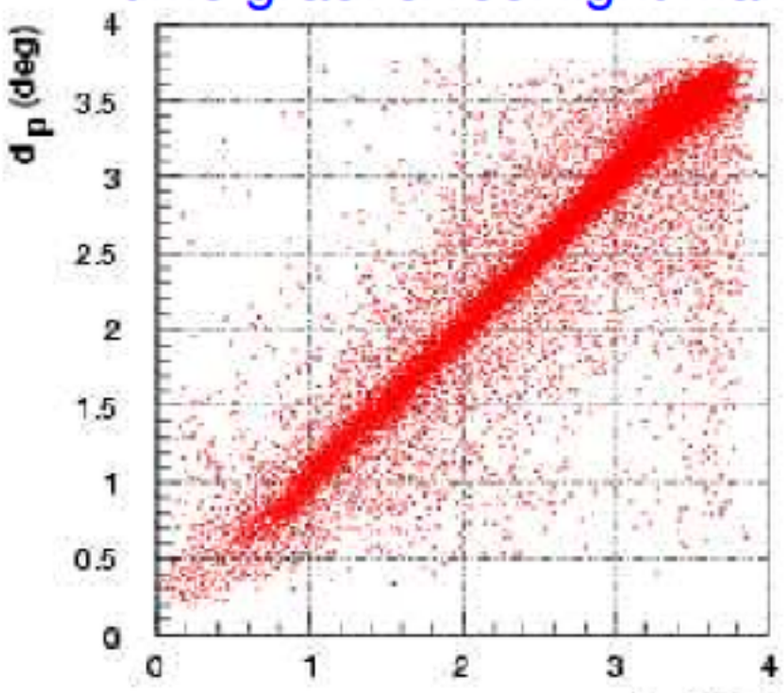


Resolution of Distance Estimation

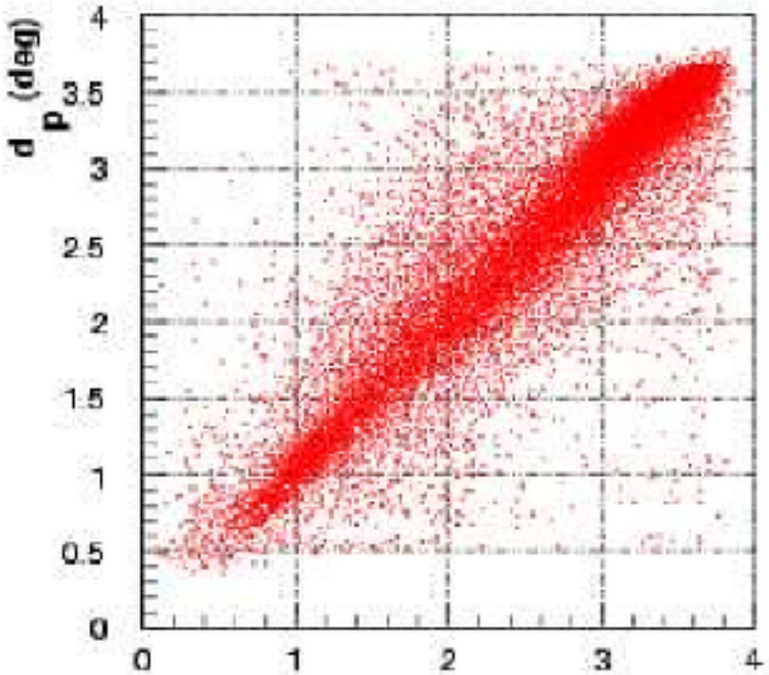
- Algorithm 3 with length or width/length as distance estimator fails
  - In the intermediate distance range

- Best correlation with time gradient and rec. light max.

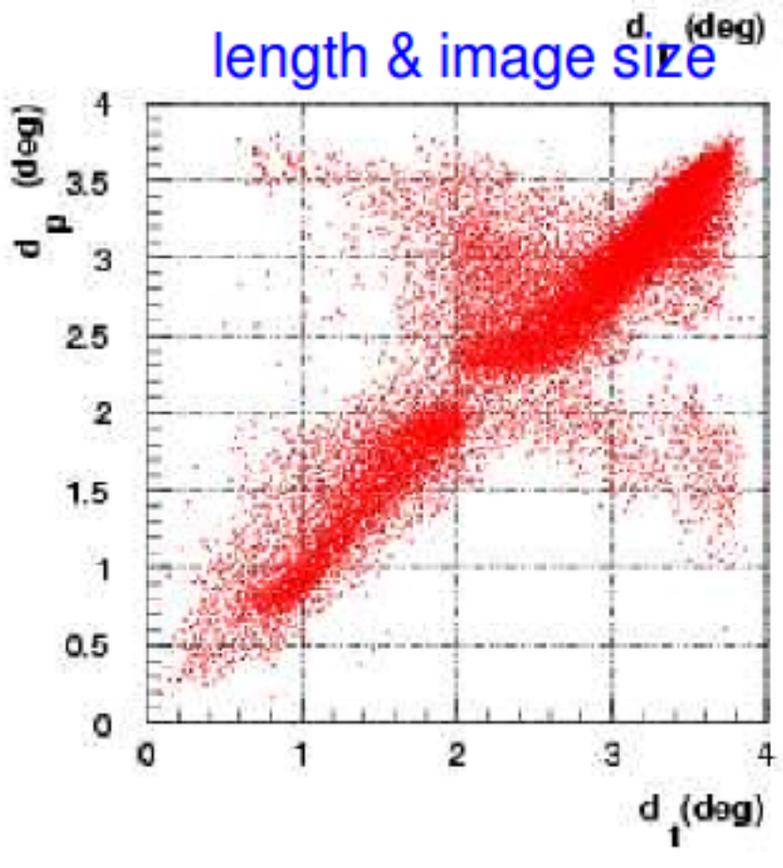
time grad. & rec. light max.



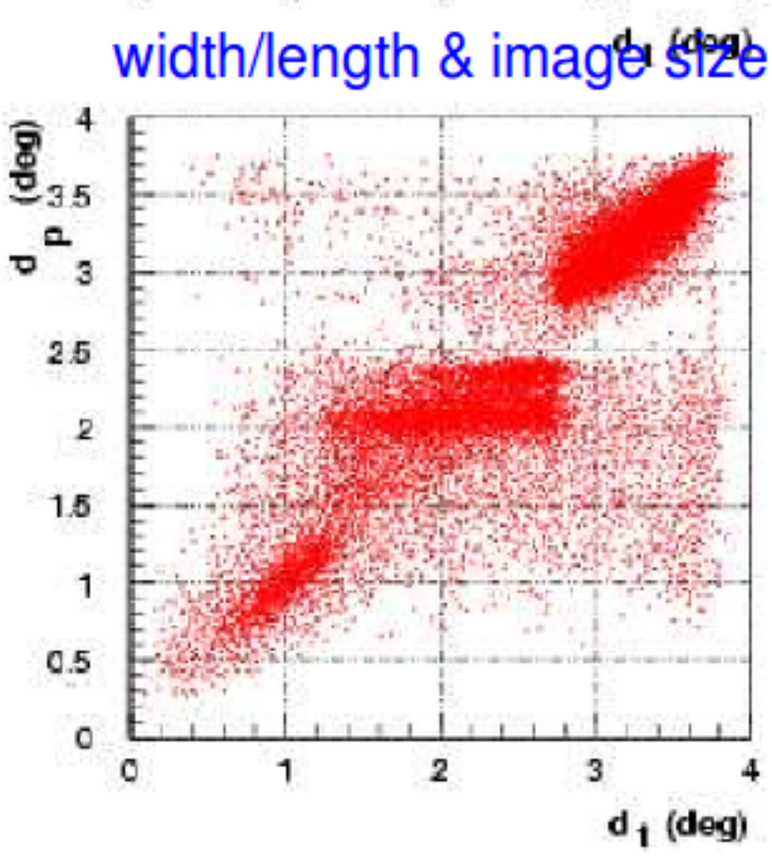
time grad. only



length & image size

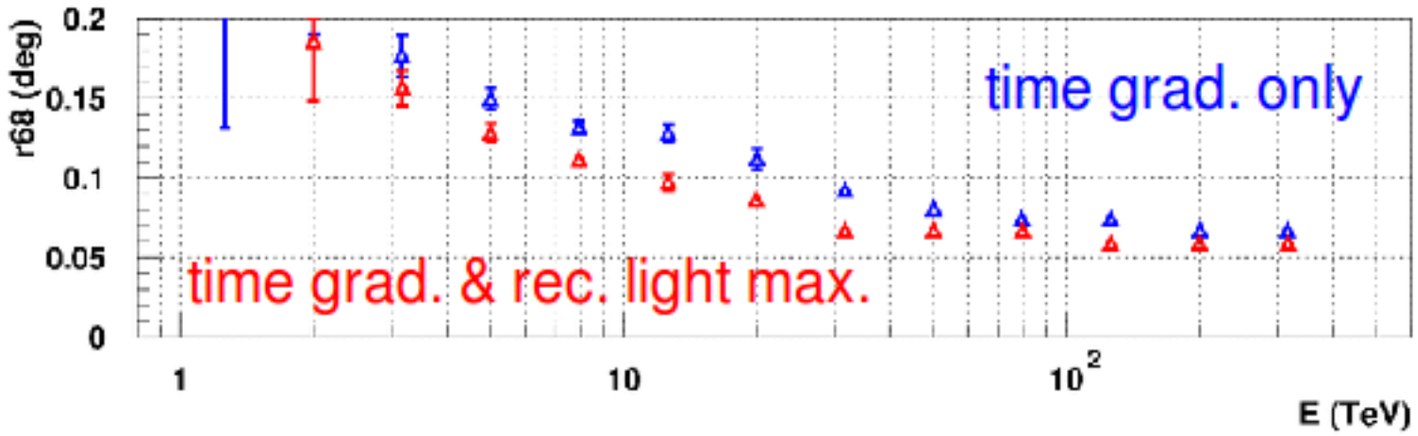


width/length & image size

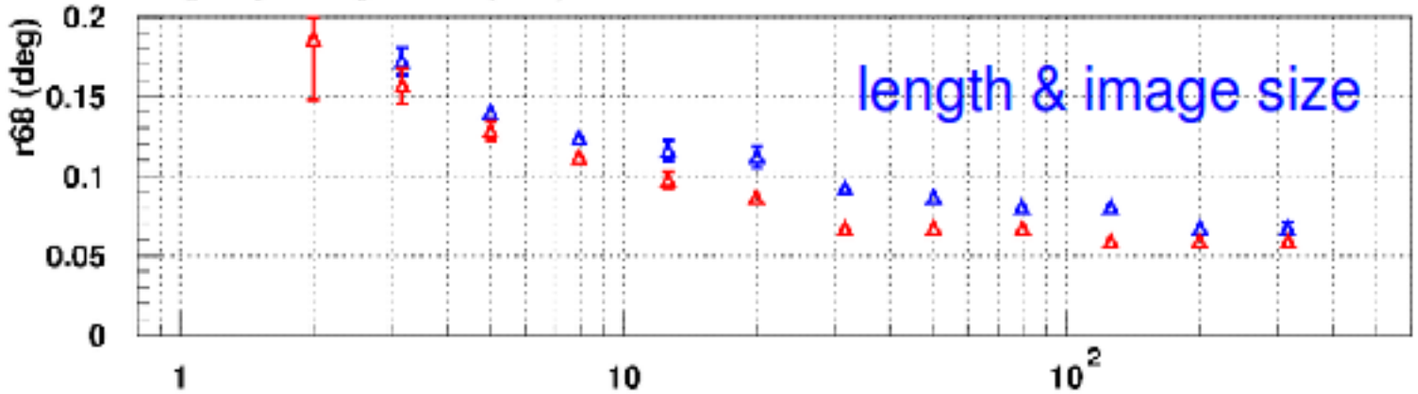


Angular Resolution

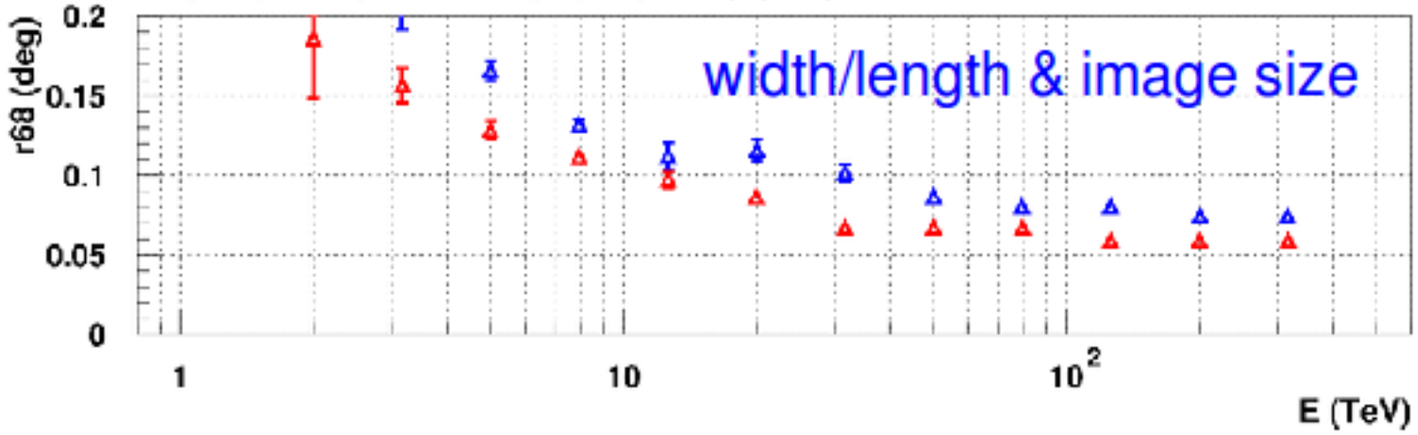
- Angular radius obtaining 68% of events
- Best results with time gradient and rec. light max.
  - ~20% improvements from the others



(a) Default Algorithm3 angular resolution (red) compared with Algorithm3 results for which d_p is obtained using only *time gradient* (blue)



(b) Default Algorithm3 angular resolution (red) compared with Algorithm3 results for which d_p is obtained using *length* coupled with $\log_{10}$(*image size*) (blue)



(c) Default Algorithm3 angular resolution (red) compared with Algorithm3 results for which d_p is obtained using *width/length* coupled with $\log_{10}$(*image size*) (blue)

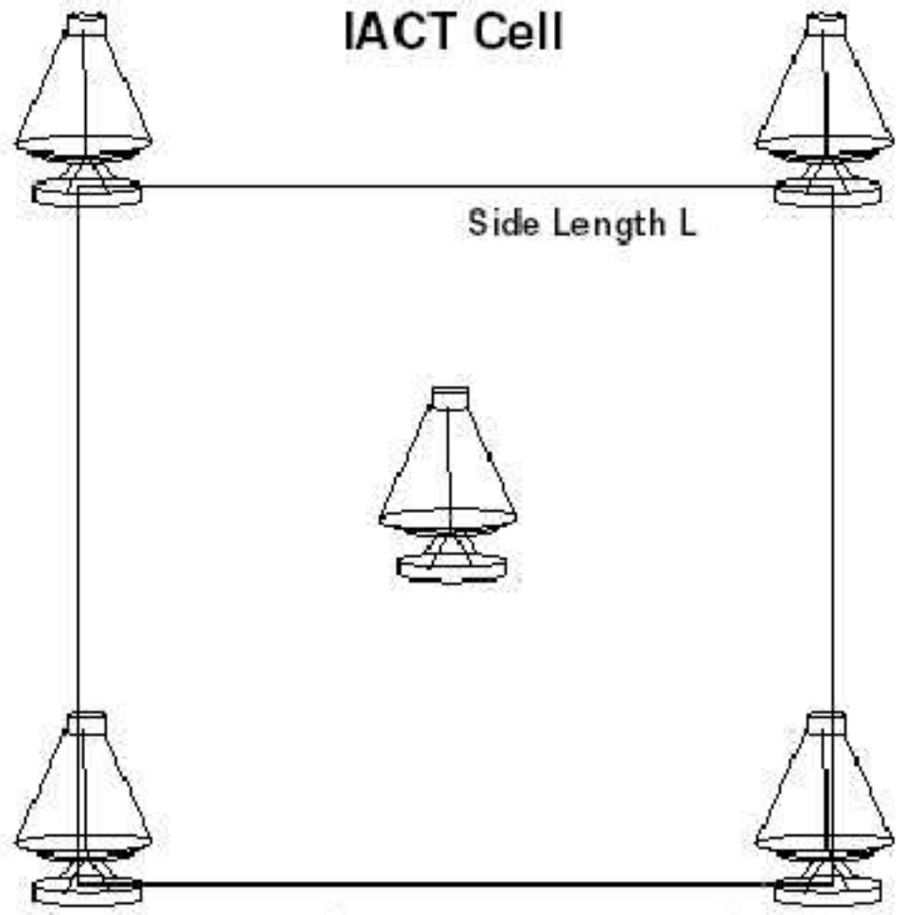
Summary

- TenTen → PeV Explorer
  - 1 cell with ∼5 telescopes in Australia
- R & D ongoing
  - Enjoy the next two talks
- Cherenkov image time gradient
  - Simulation study conducted by the Adelaide group
  - Good distance estimator especially at large core distances
    - Better than length or width/length
  - Angular resolution improved
    - ∼20% better than using traditional distance estimators

Backups

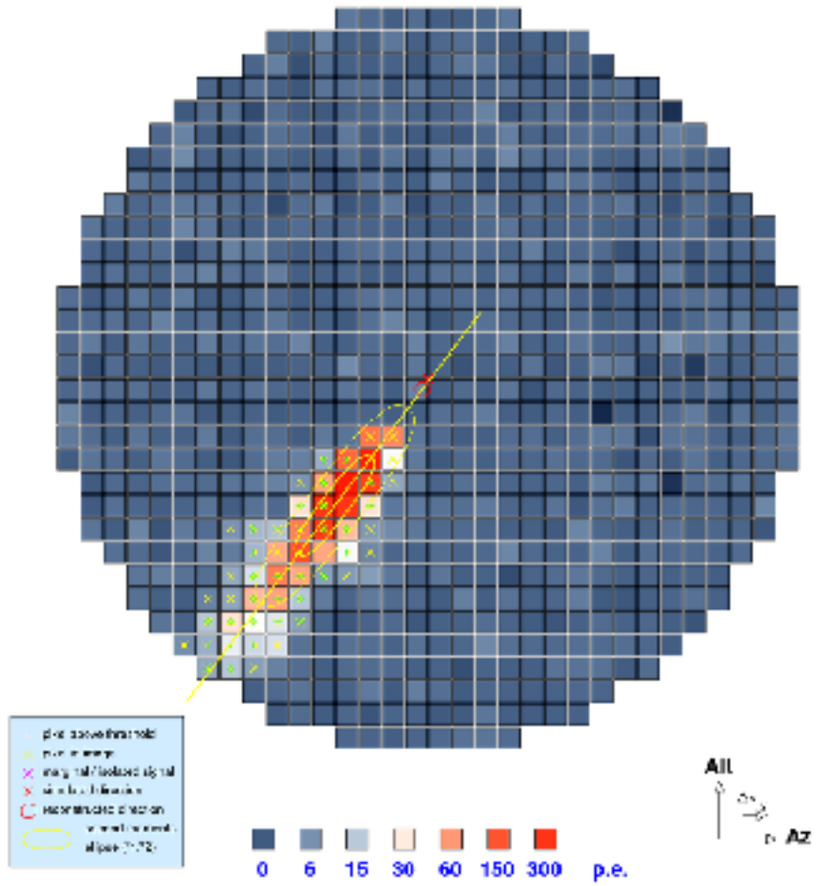
Simulation Details

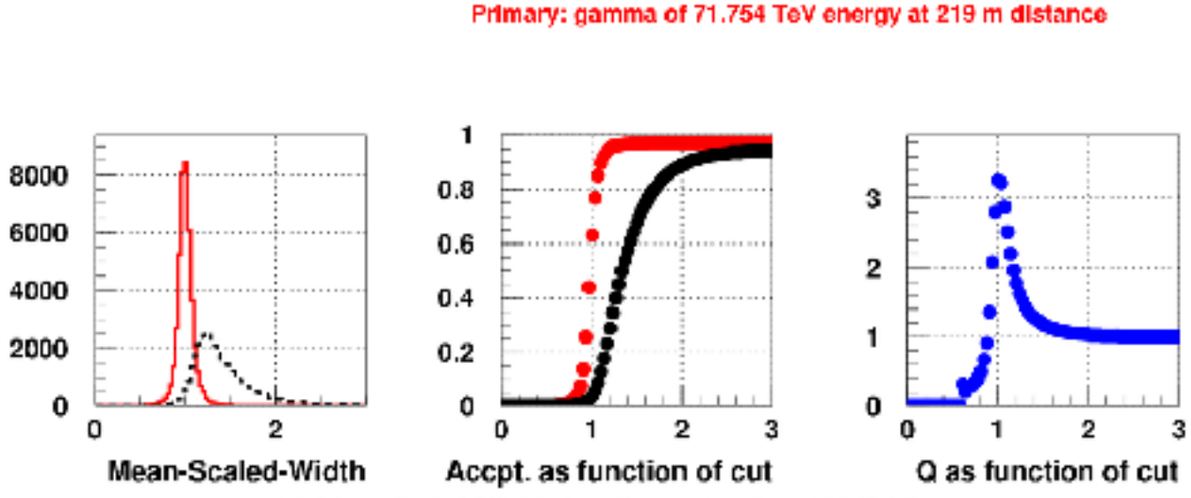
- CORSIKA v6.204 with SYBYLL and sim_telarray
- Cell of 5 telescopes
  - L = 500 m
  - Observation altitude 220 m a.s.l.
- Telescope
  - 6 m diameter, elliptic shape, f/1.5
  - 8.2° FoV made from 0.24° square pixels
- MODTRAN atmosphere
  - Tropical profile and maritime haze model
- Primaries
  - Gamma and proton
  - 1-500 TeV



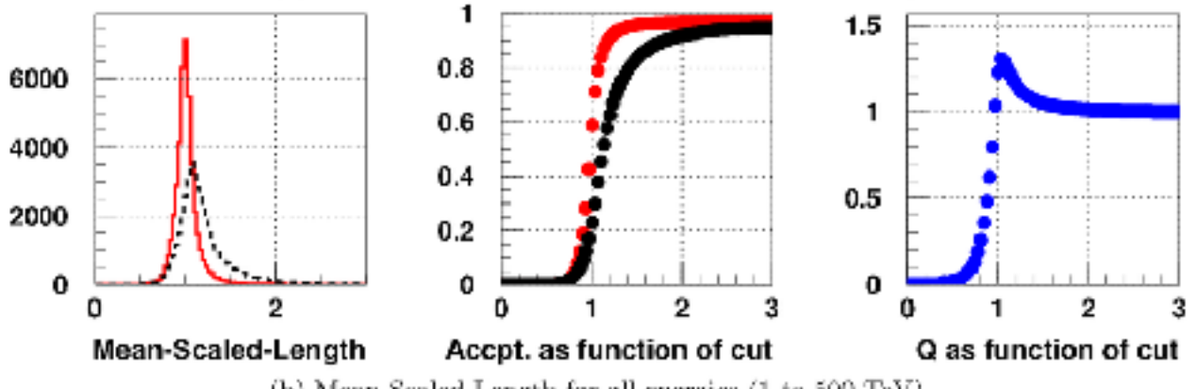
Gamma-Ray Selection Criteria, Etc.

- Stereoscopic trigger
  - At least 2 telescopes
- Two-level image cleaning:
  - Picture threshold 8 p.e.
  - Boundary threshold 4 p.e.
- Quality cuts:
  - image size > 60 p.e.
  - dis2 = max(cog + length) < 4°
- Mean scaled parameters:
  - MSW < 1.05
  - MSL < 1.2
  - MSNPix < 1.1





(a) Mean-Scaled-Width for all energies (1 to 500 TeV)



(b) Mean-Scaled-Length for all energies (1 to 500 TeV)

Optical Point Spread Function

- From the top:
  - Parabola
  - Davies-Cotton
  - Ellipse
- d80
  - Diameter of a circle of 80% photon containment
- Best off-axis performance in ellipse