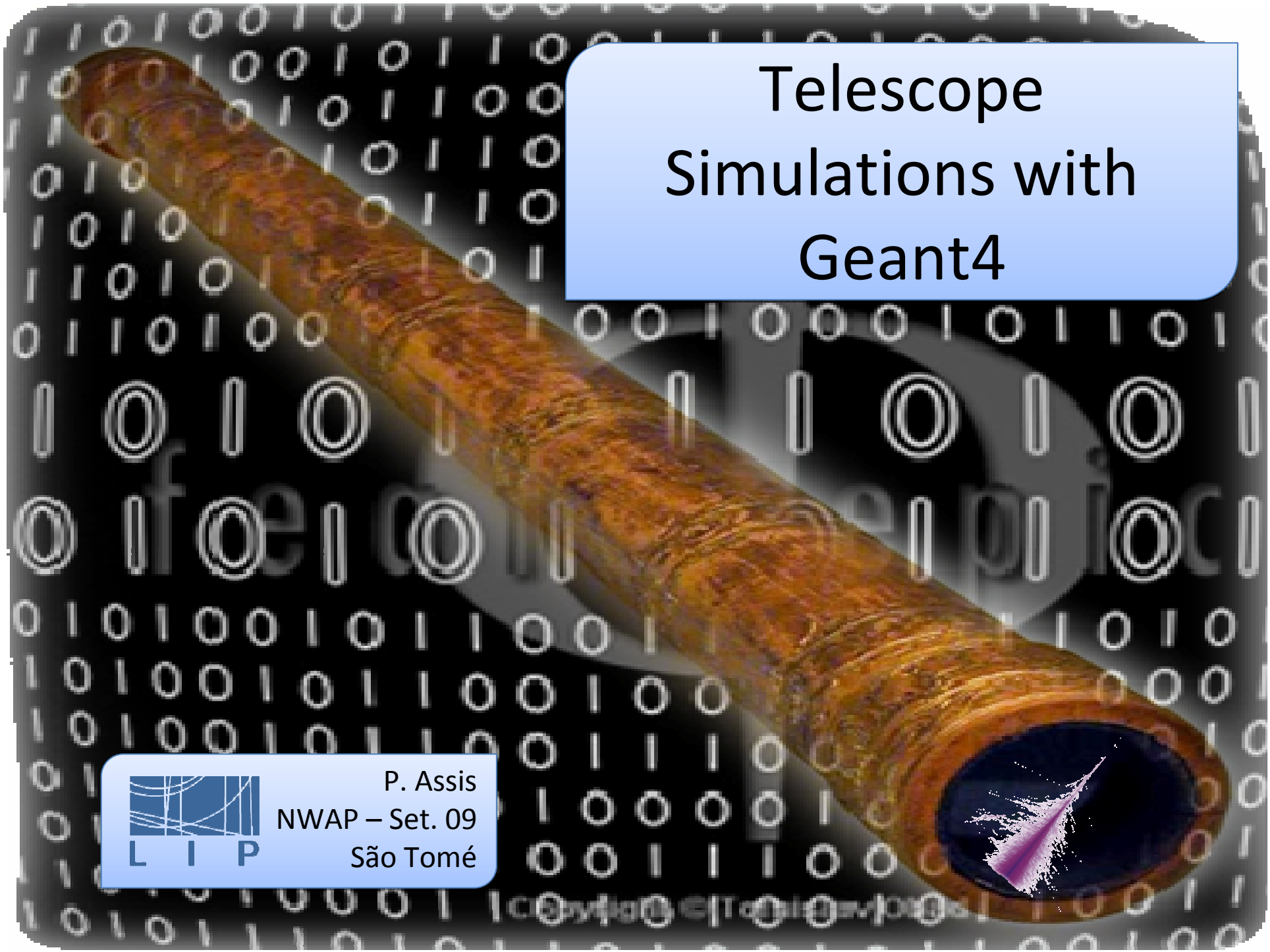
Telescope Simulations with Geant4



P. Assis

NWAP – Set. 09

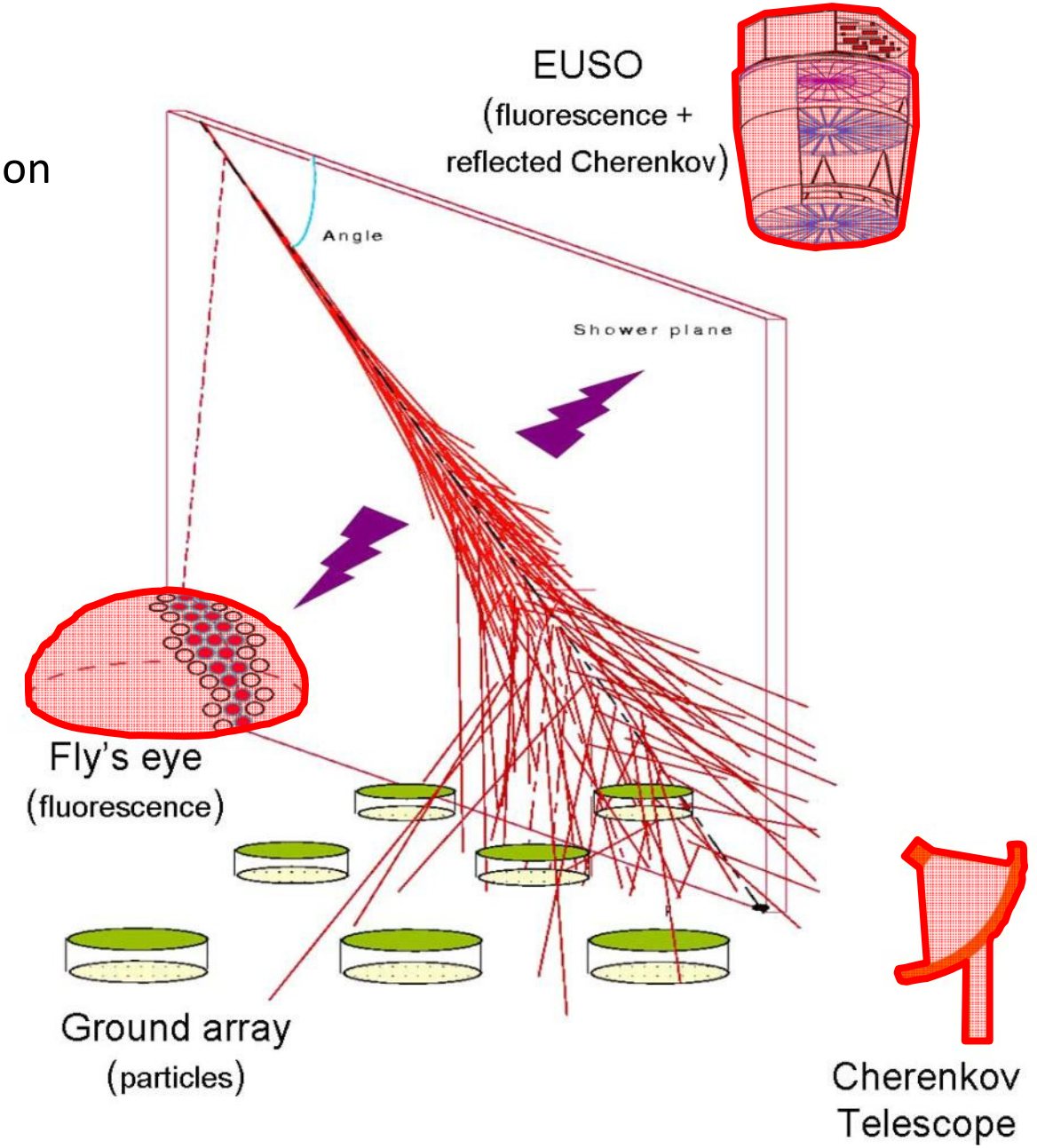
São Tomé

EAS Detection

Ground array – particle detection

Fluorescence Telescope

Cherenkov Telescope

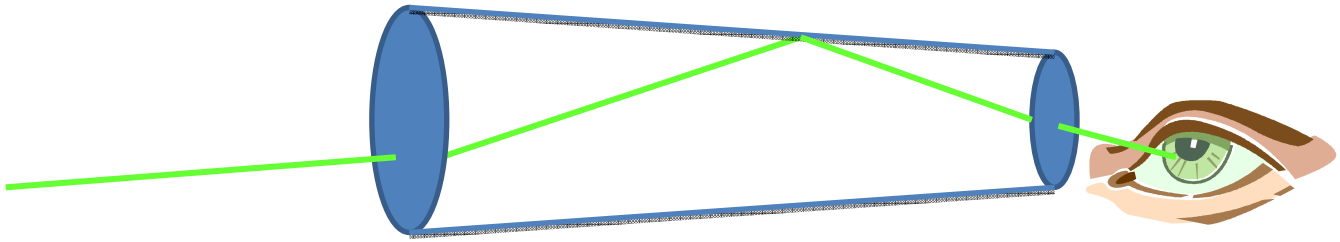


Geant4 simulation framework

- **Geant4** is a toolkit for the simulation of particle transport and interaction with matter, including:
  - Description of complex detector geometries;
  - Simulation of **Hadronic, Electromagnetic & Optical** physics processes;
  - Object Oriented design, allowing the implementation of flexible simulation applications, including new physics processes categories.
- **Geant4** applications are found in particle physics, astrophysics, medical physics, space exploration...

- **Geant4** has potential to be explored as an optics simulation tool.

Simulation Technique



Standard simulation

Sequence of operations coded:

- Input photon traced
- Refraction in lens #1
- Tracing inside telescope (reflected or killed in tube?)
- Refraction in lens #2
- Detected?

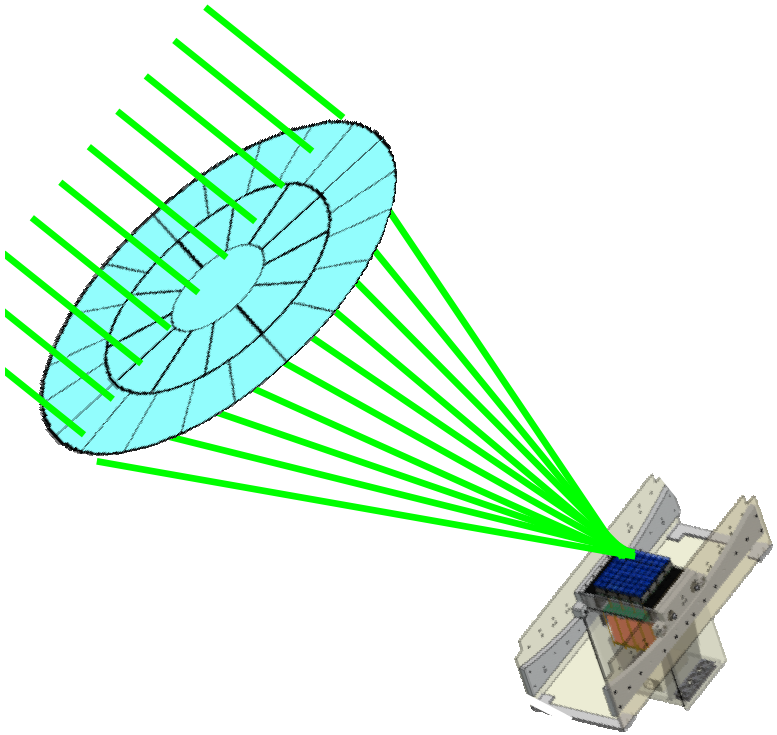
Geant4 Simulation

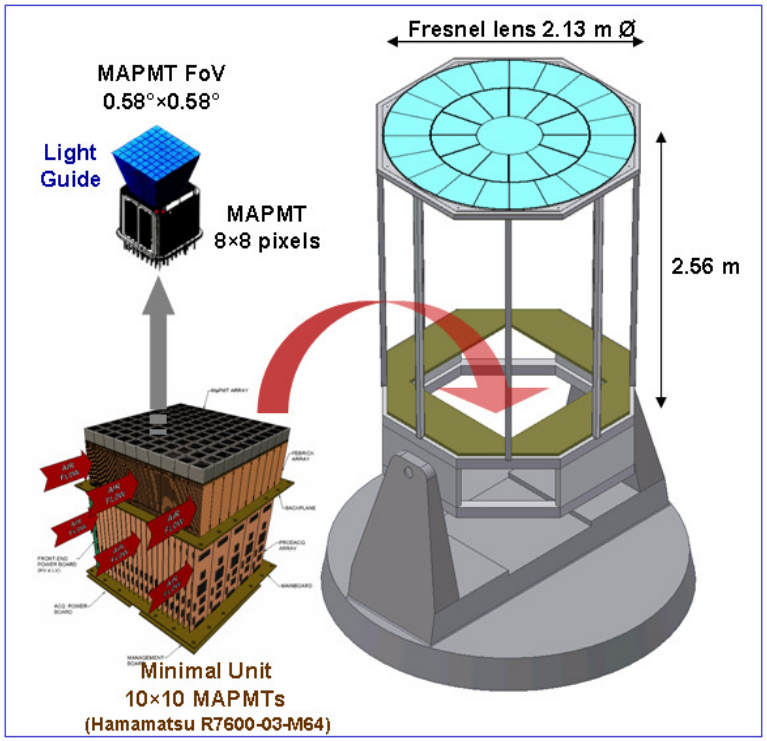
System geometry, materials and properties defined

- Input photon “shot”
- Photon traced
- Photon interaction w/ material (was detected?)

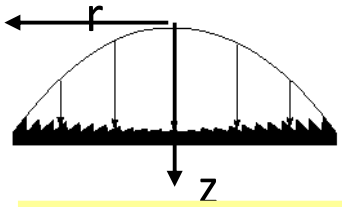
GAW – Gamma Air Watch

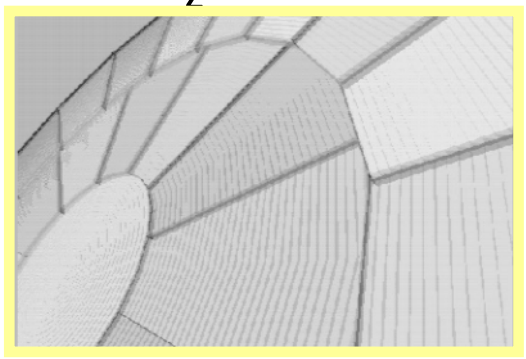
A Large Field of View Cherenkov Telescope
– Fresnel lens
– Highly pixelated Focal Surface
– Single Photon Counting

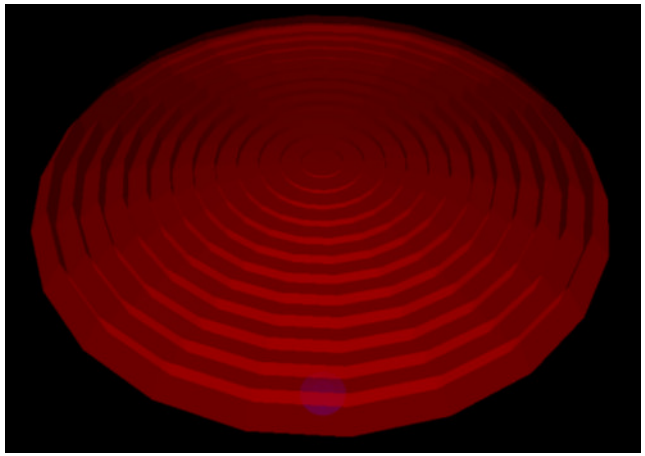


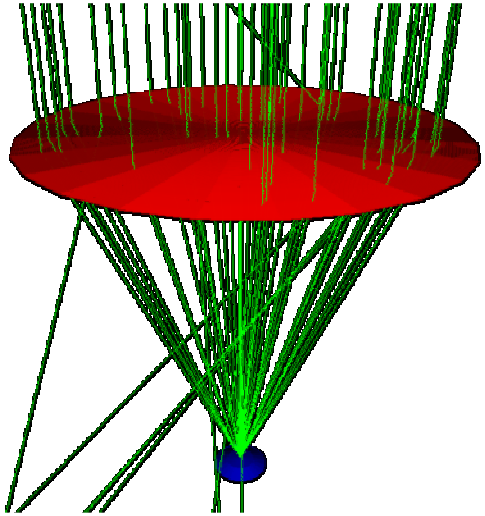


Fresnel lens simulation

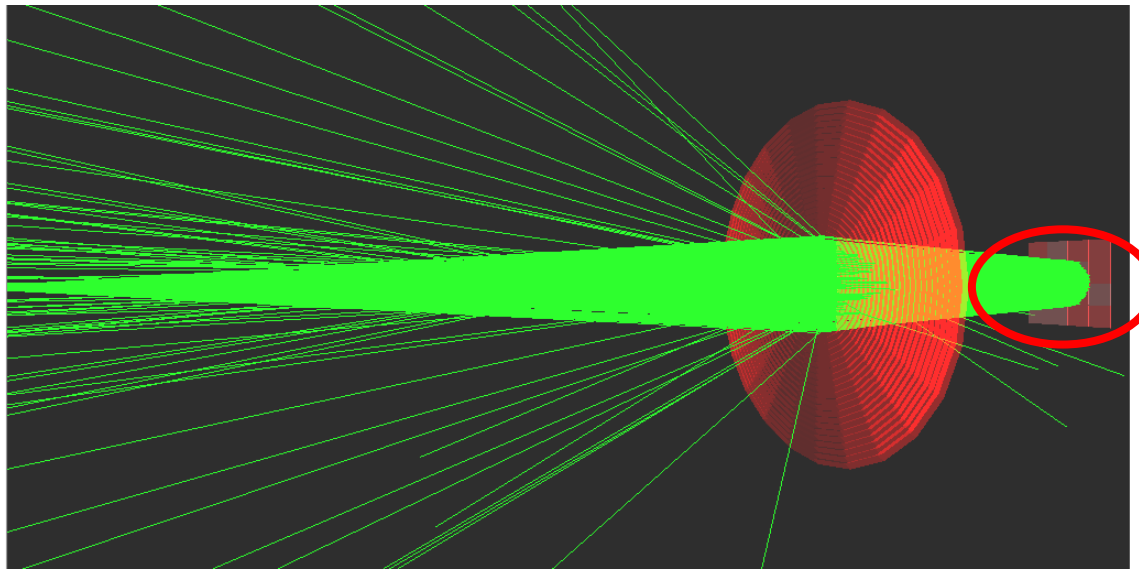


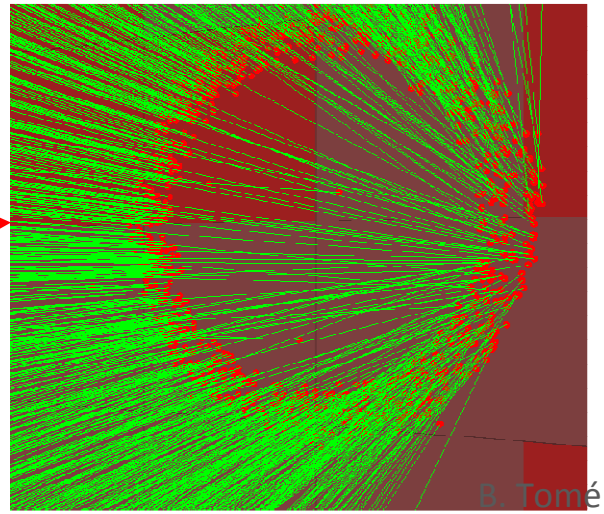






Cherenkov light from a muon

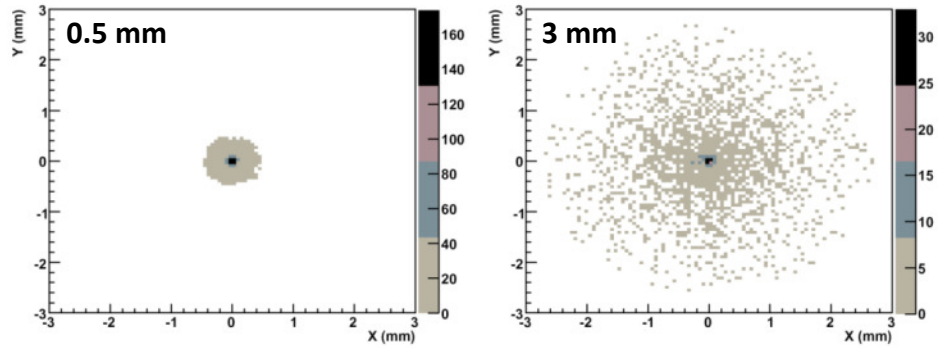




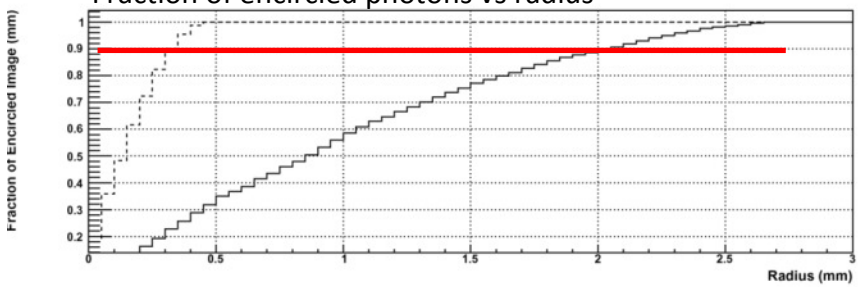
Studies of Fresnel optics performance

Point spread function vs groove size

On-axis, monochromatic light (λ=320 nm)



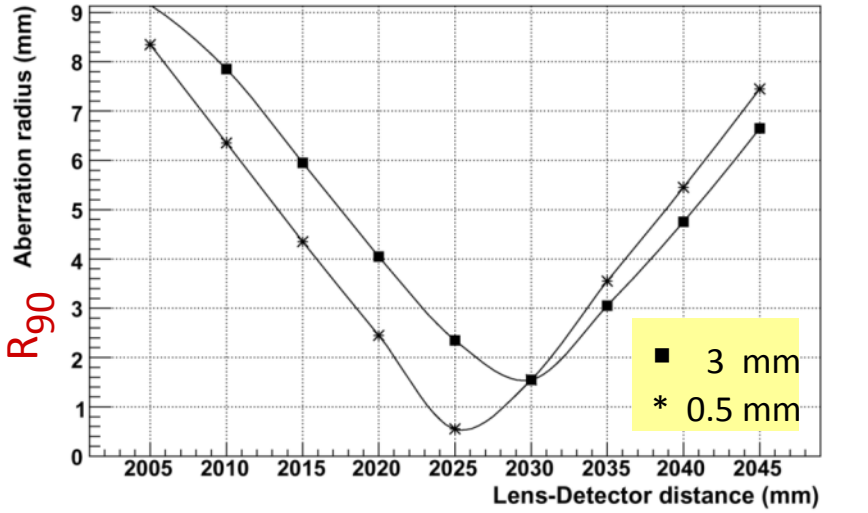
Fraction of encircled photons vs radius



Optimal focal distance vs groove size

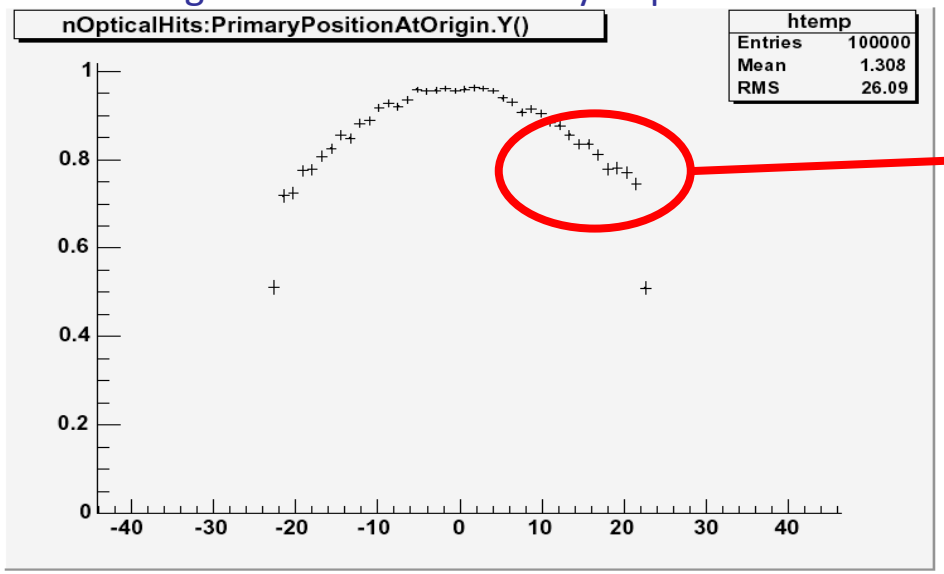
R_{90} vs Focal distance

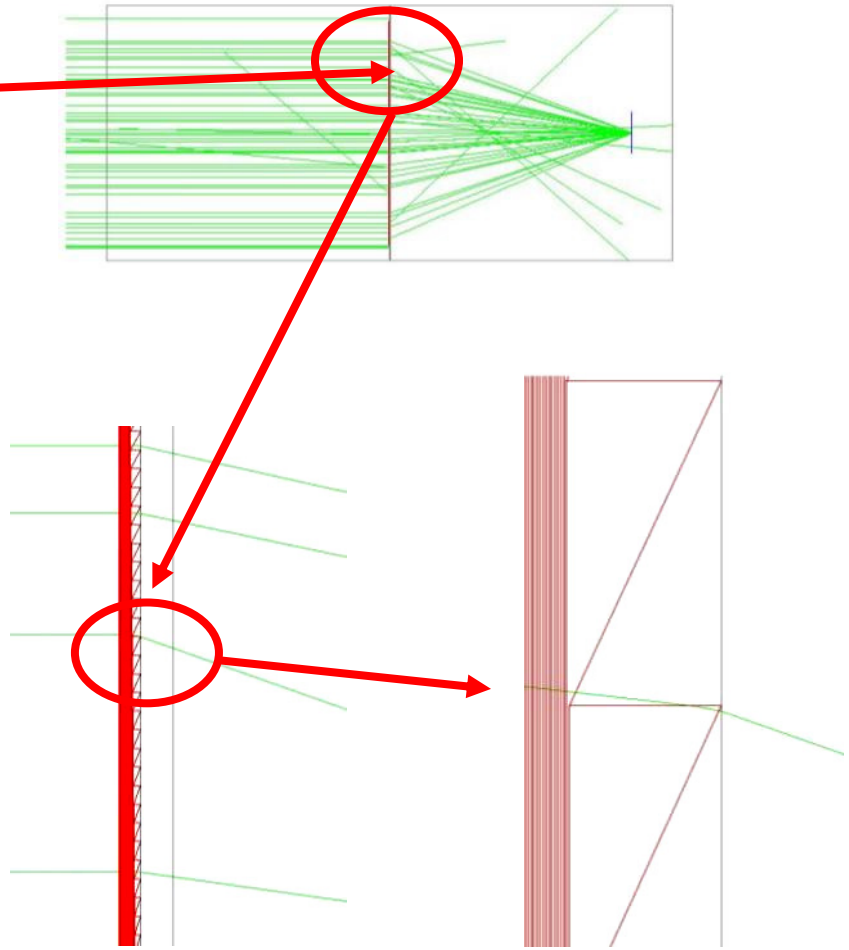
On-axis, monochromatic light (λ=320 nm)



Details…

Light collection efficiency vs position



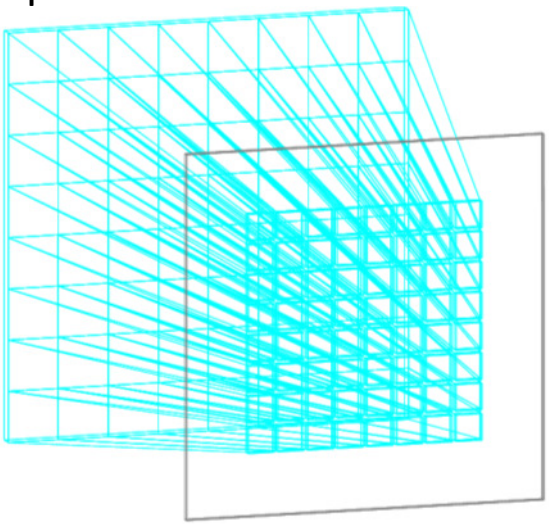


GEANT4 potential explored in detailed studies.

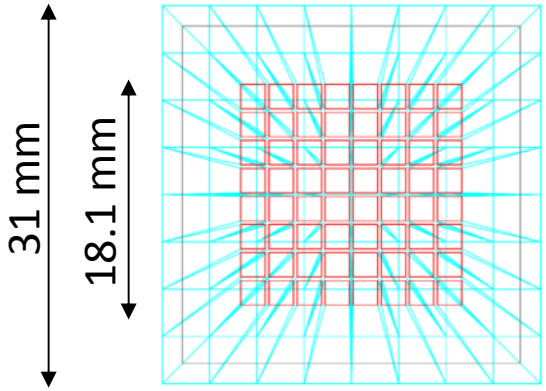
GAW light guides

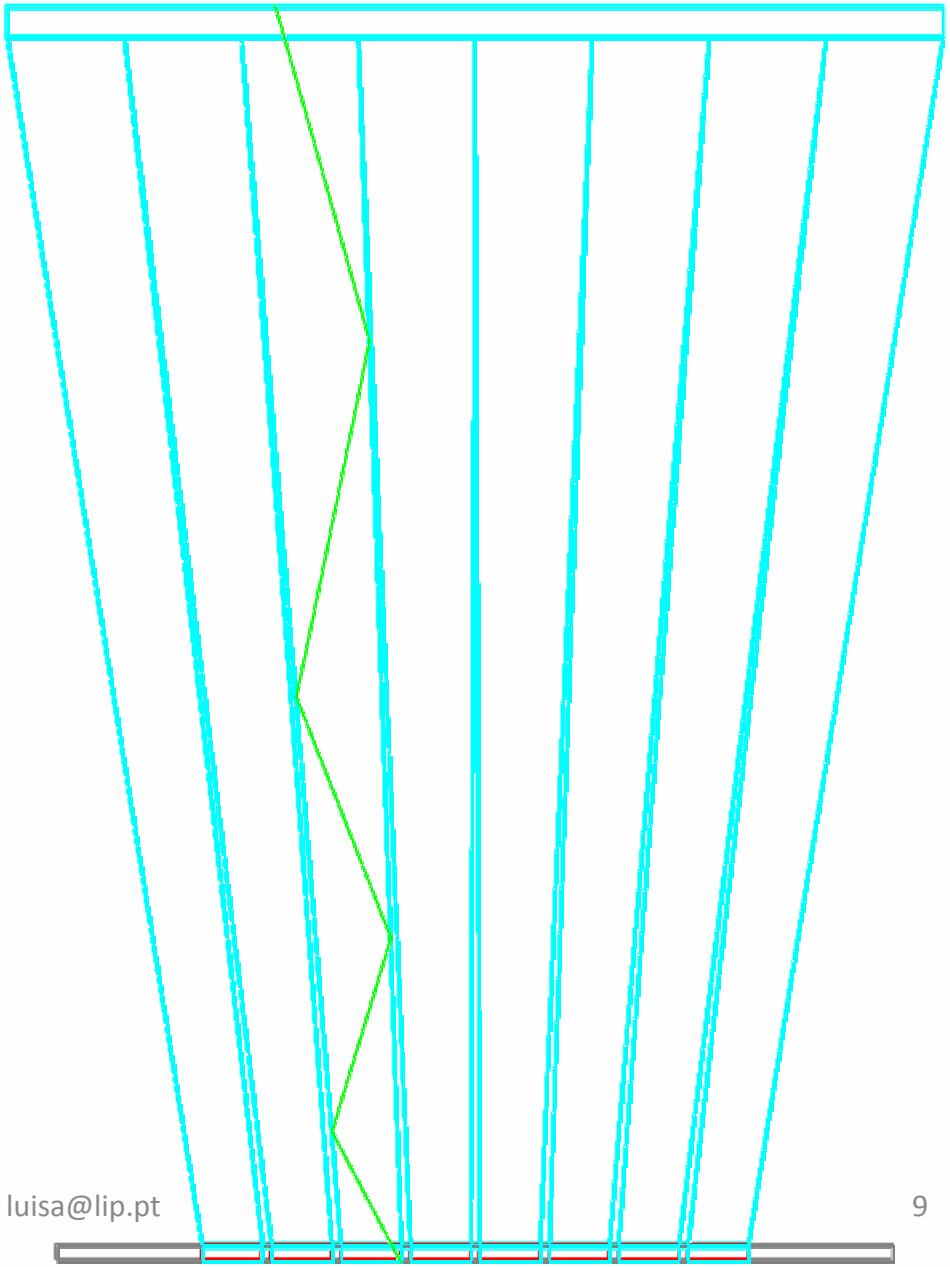
L. Arruda

Prespective view



Top view

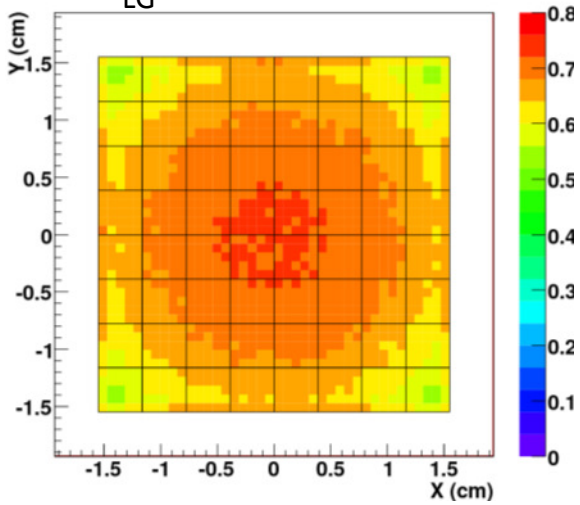




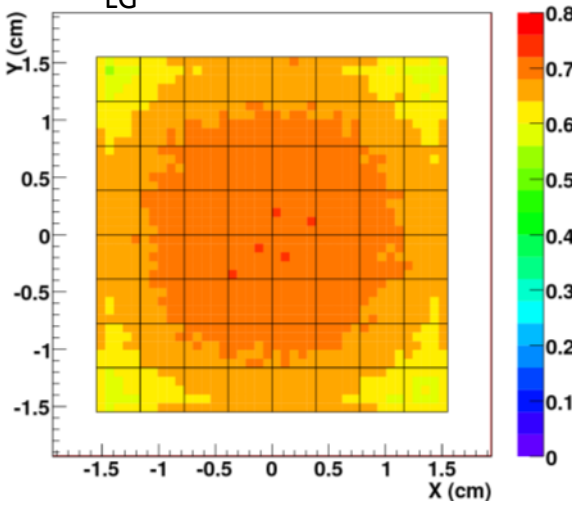
luisa@lip.pt

Results: ε_{LG} vs (X,Y)

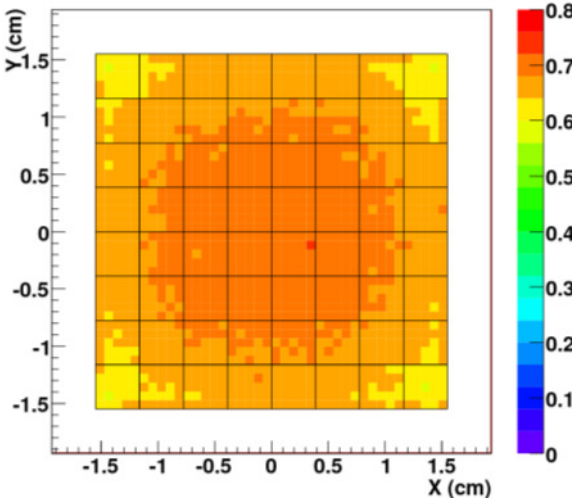
h_{LG}= 30 mm



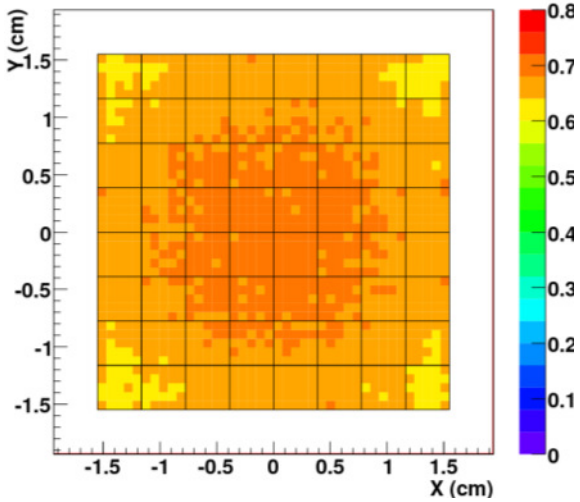
h_{LG}= 35 mm



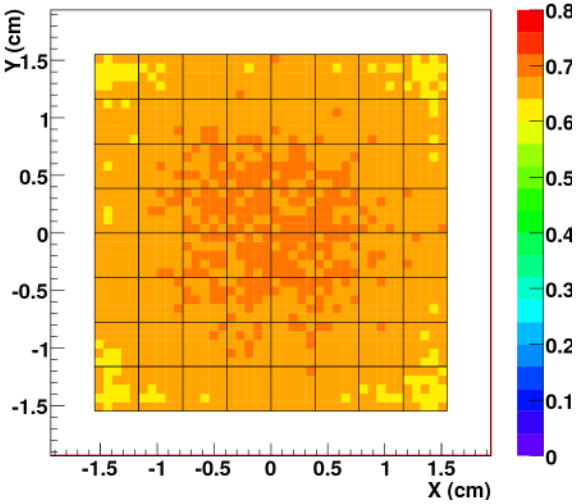
h_{LG}= 40 mm



h_{LG}= 45 mm

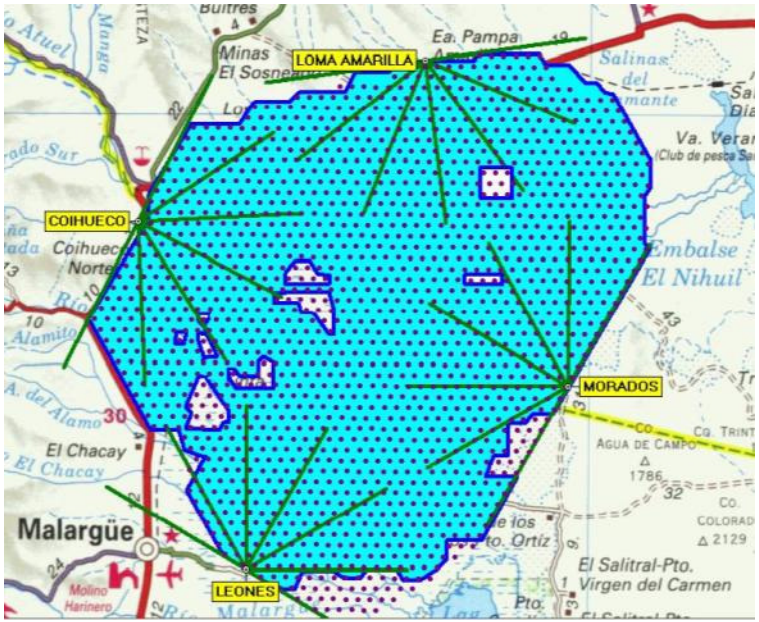


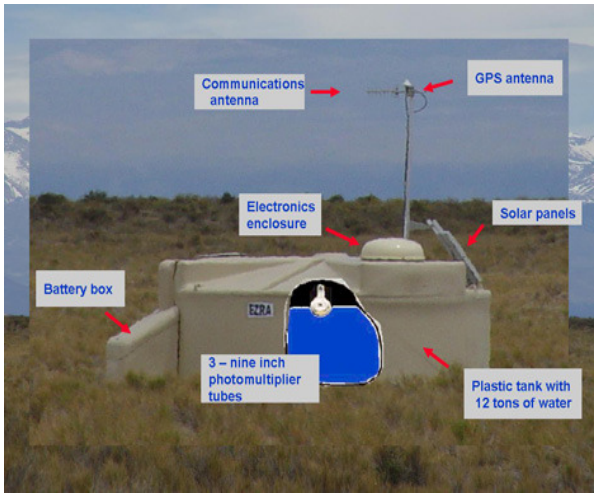
h_{LG}= 50 mm

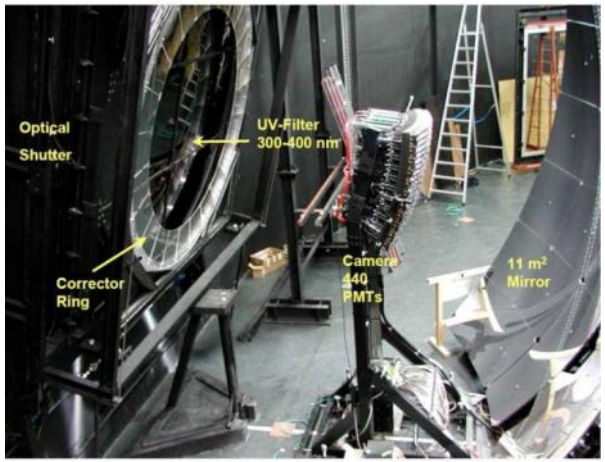


ε_{LG} more uniform with the impact point for higher h_{LG}

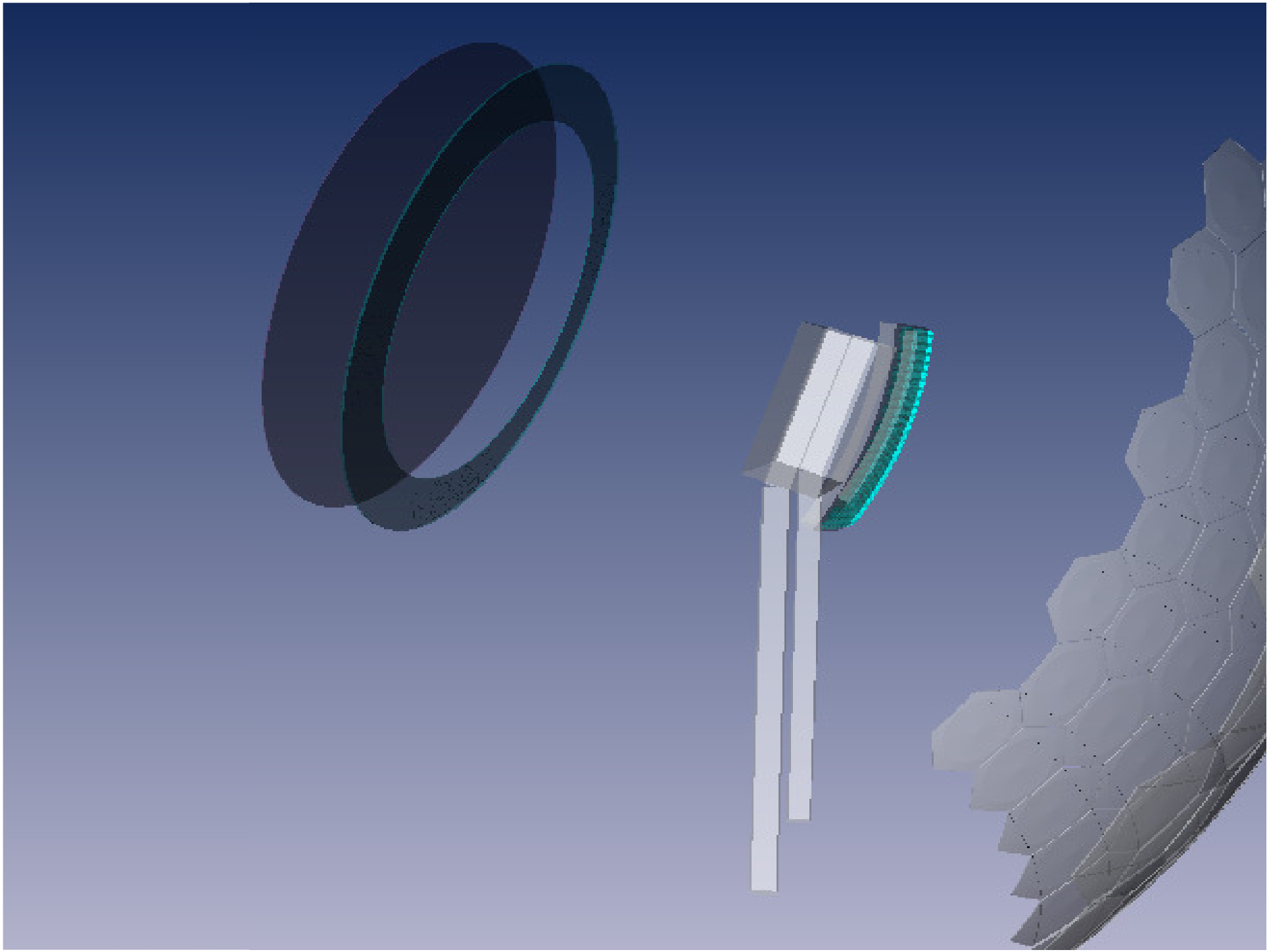
Pierre Auger Observatory

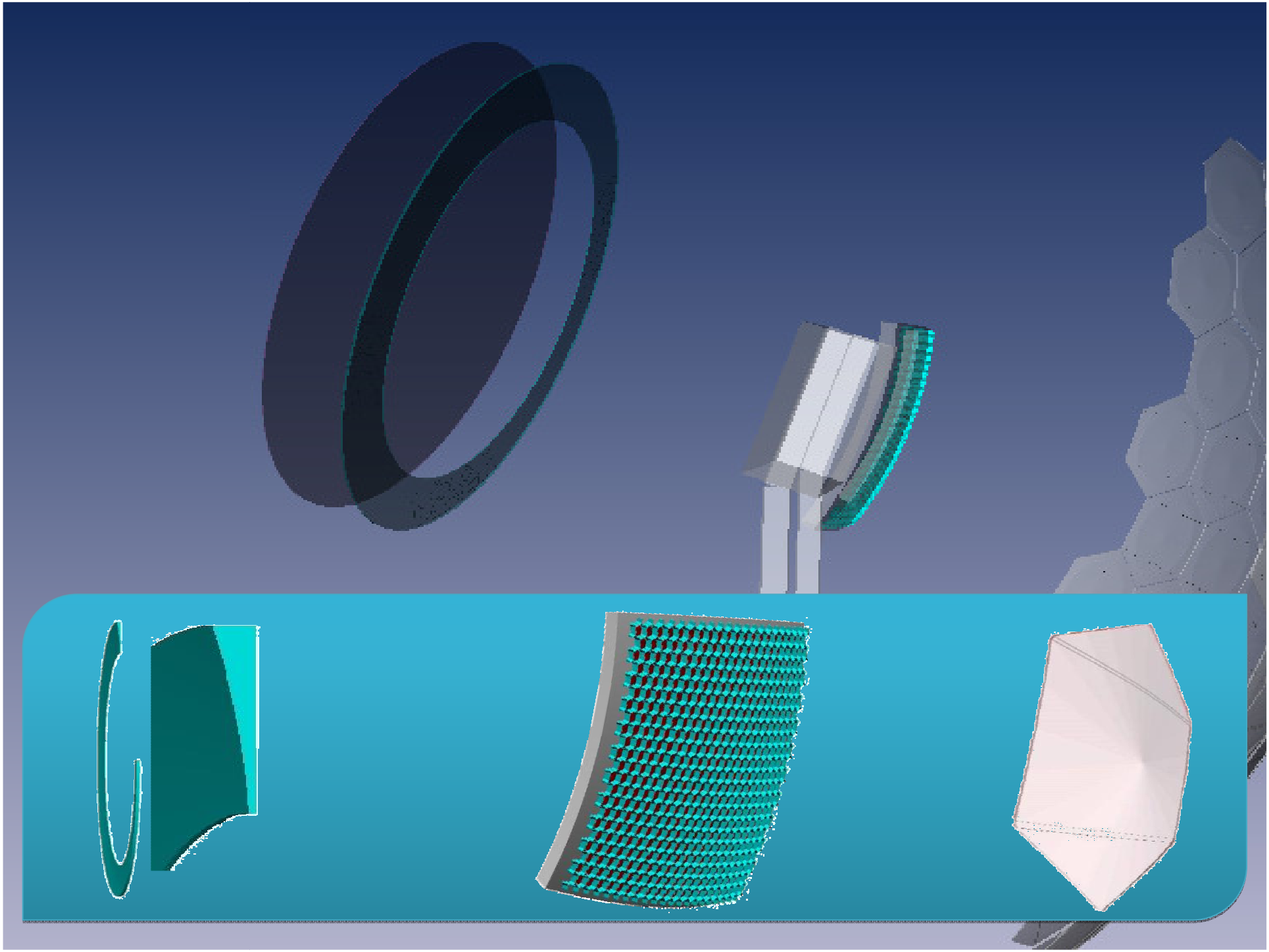




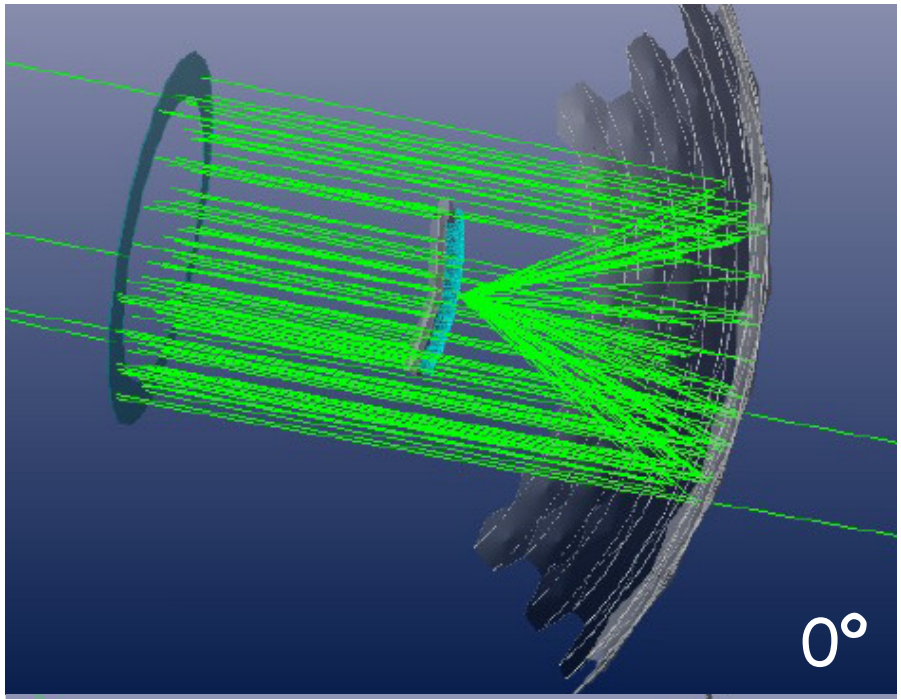


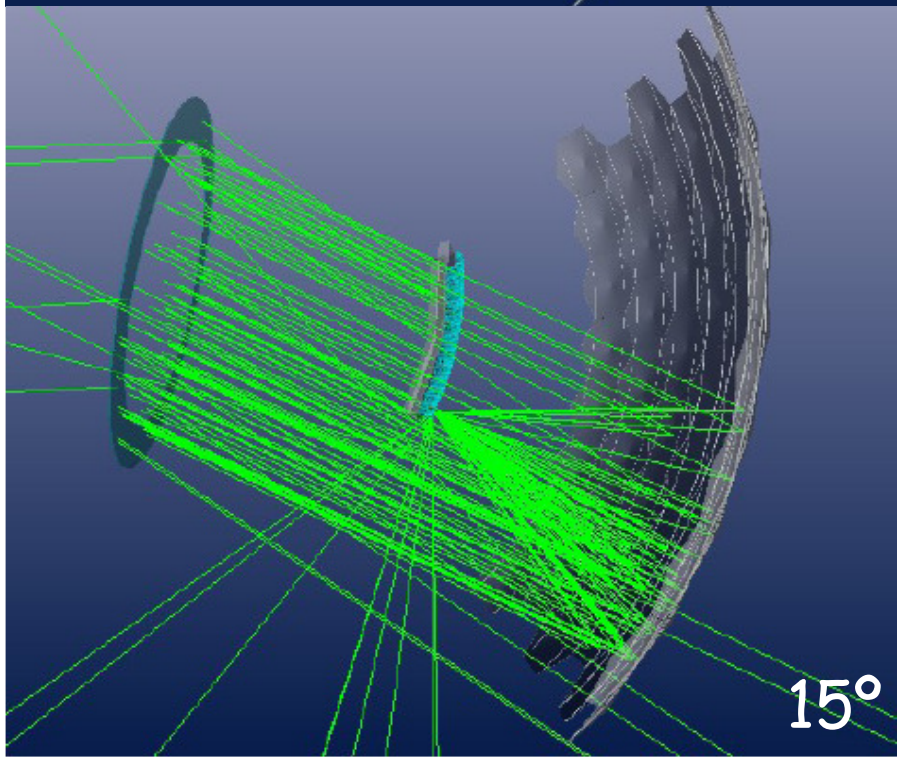
South Site

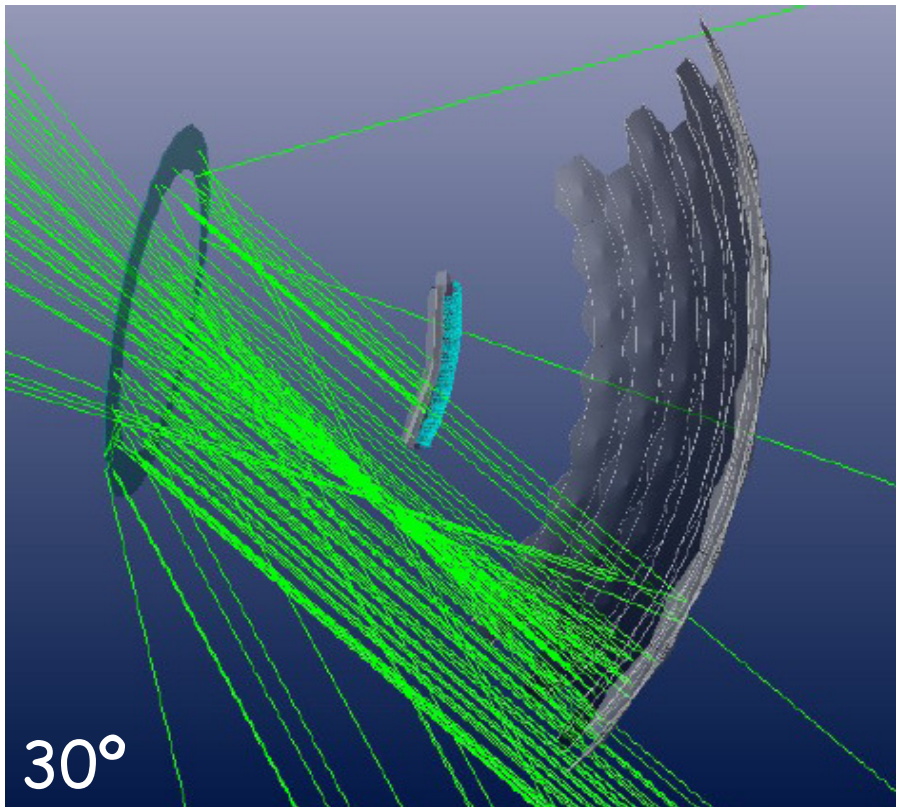




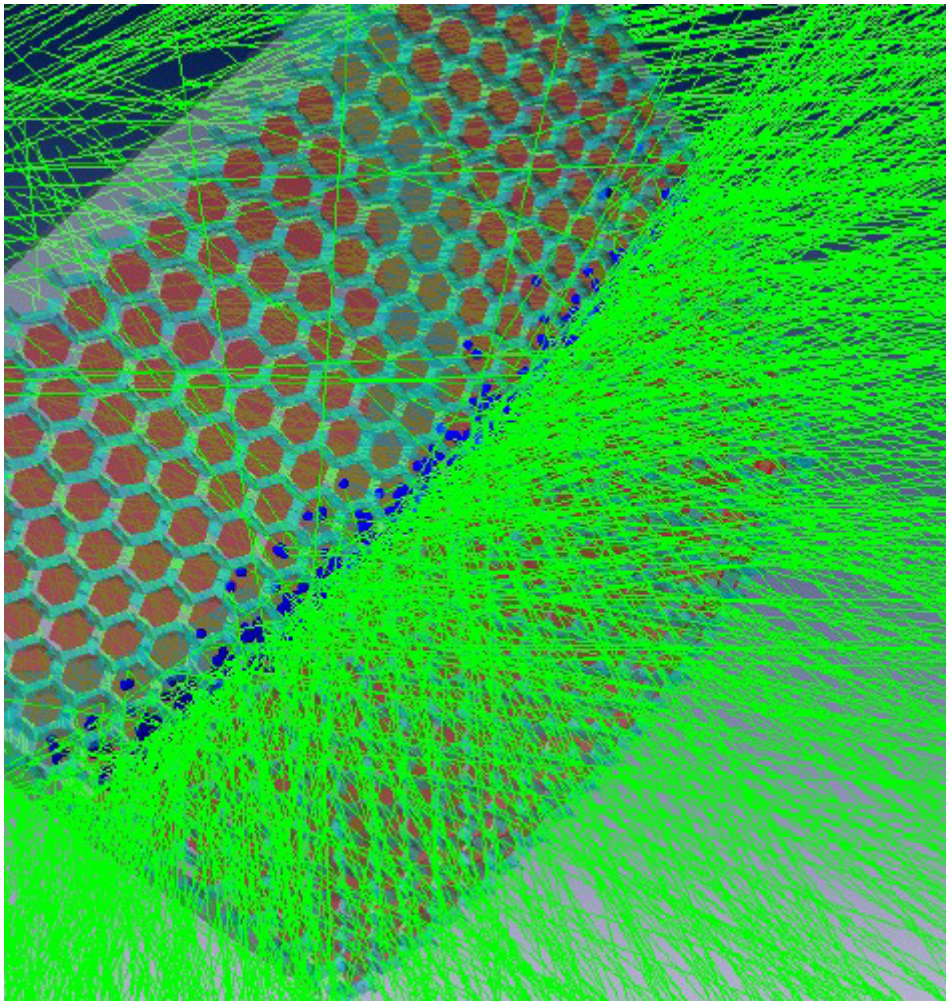
Parallel Rays



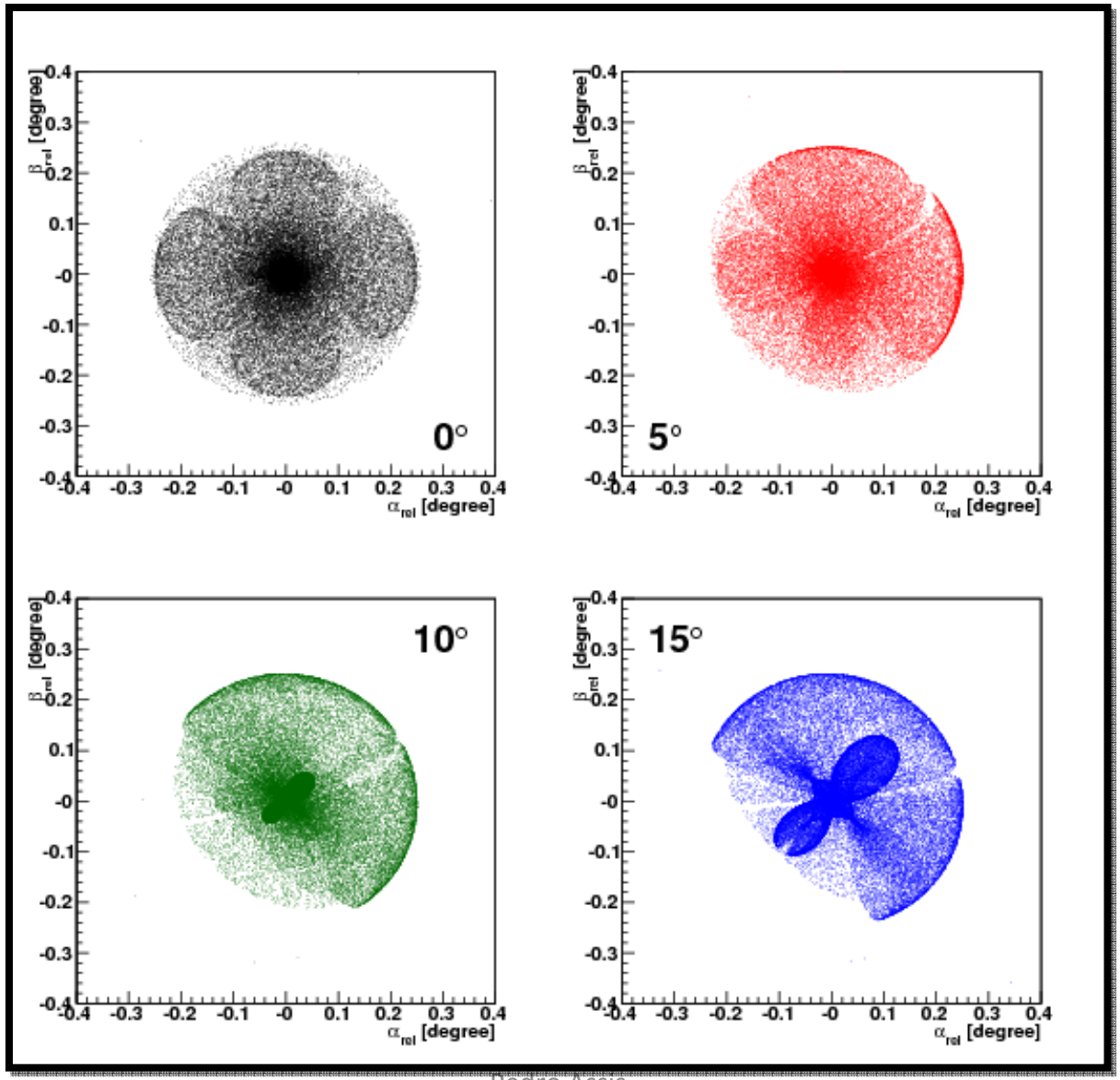




a shower in the camera

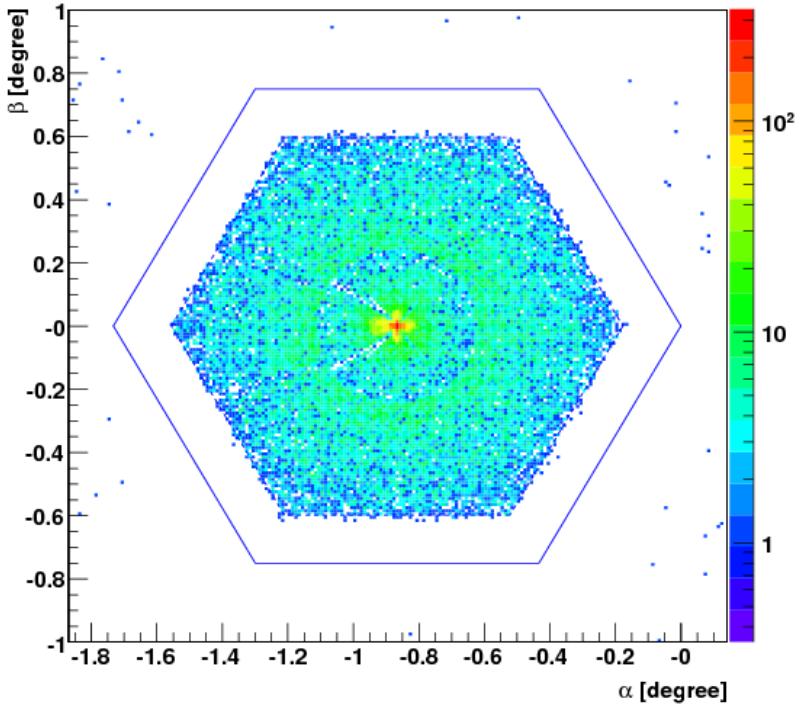


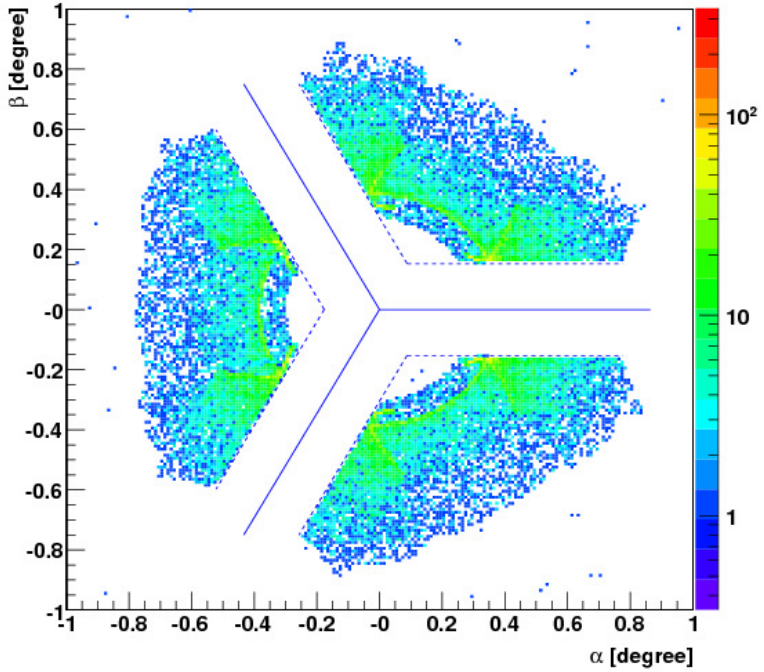
Optical Spot @ Focal Surface



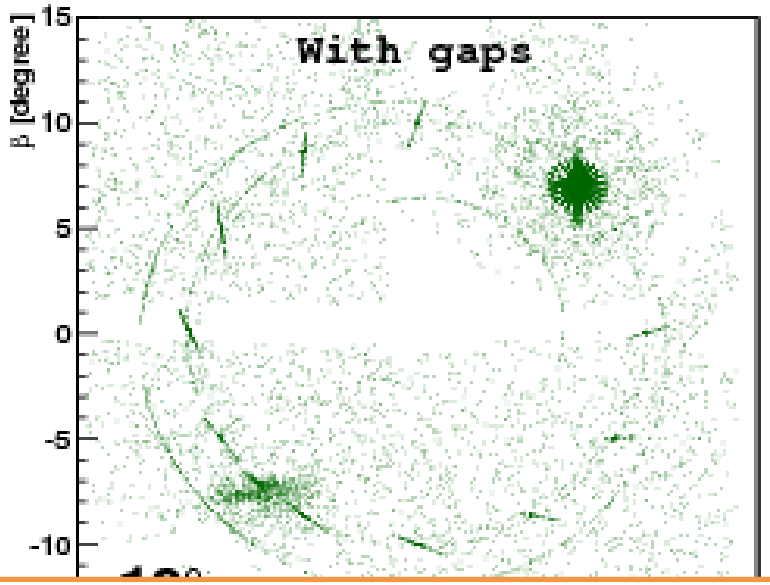
Spot @ PMTs

Density Maps





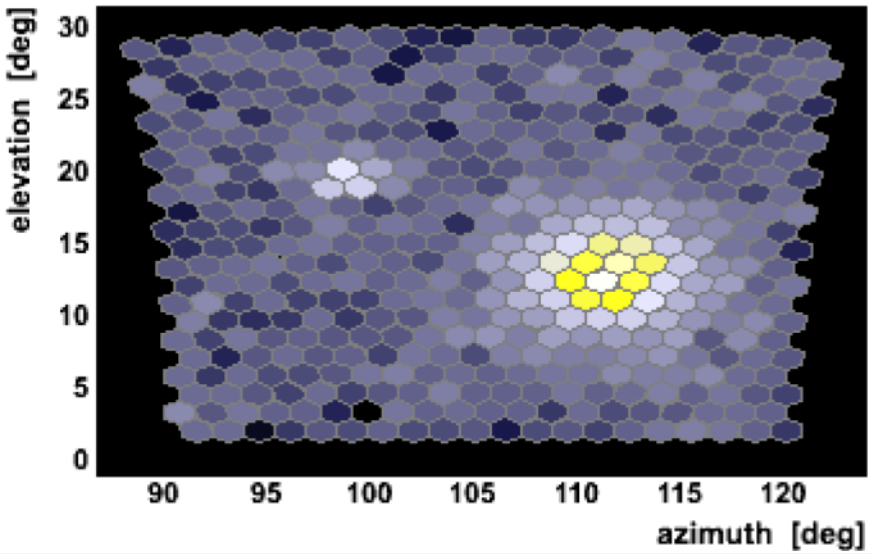
Features identified with G4 simulation



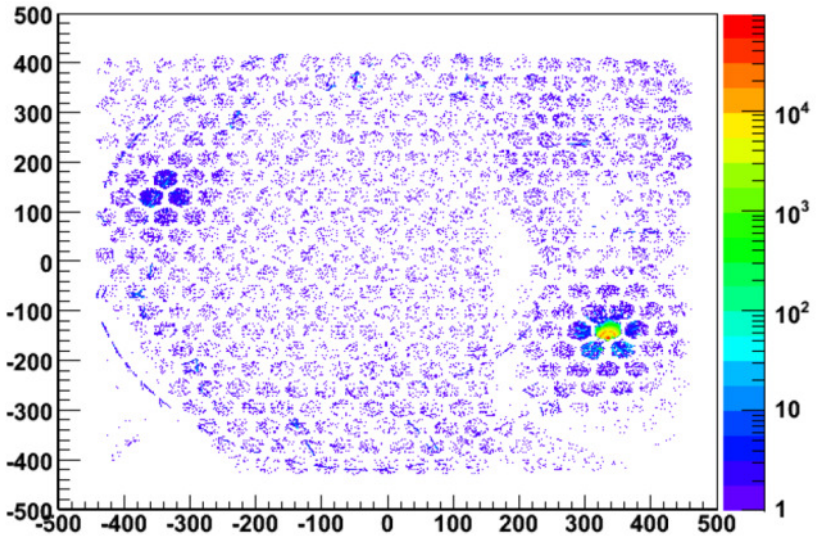
Calibration Studies with point source

Julia Parrisius

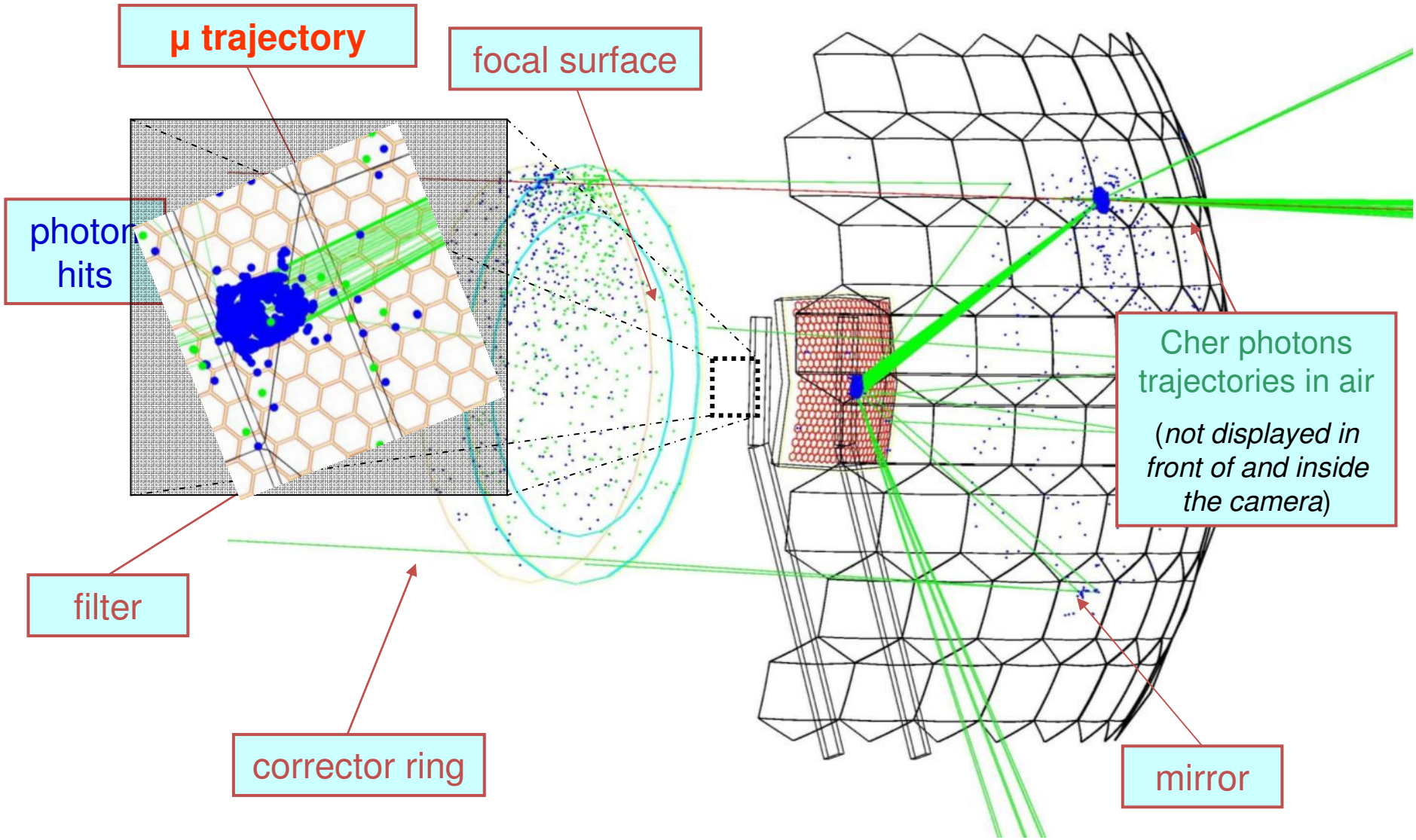
Data



Simulation w/ G4



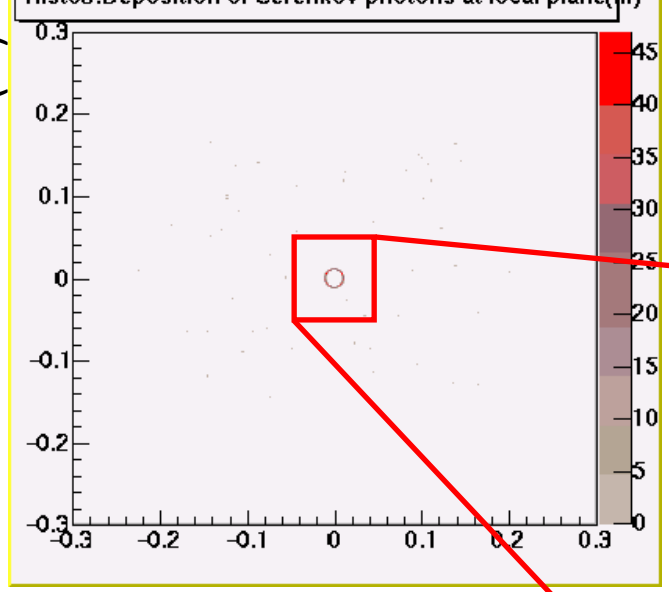
Seeing muons inside the telescope

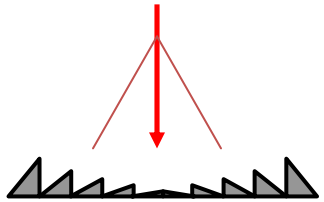


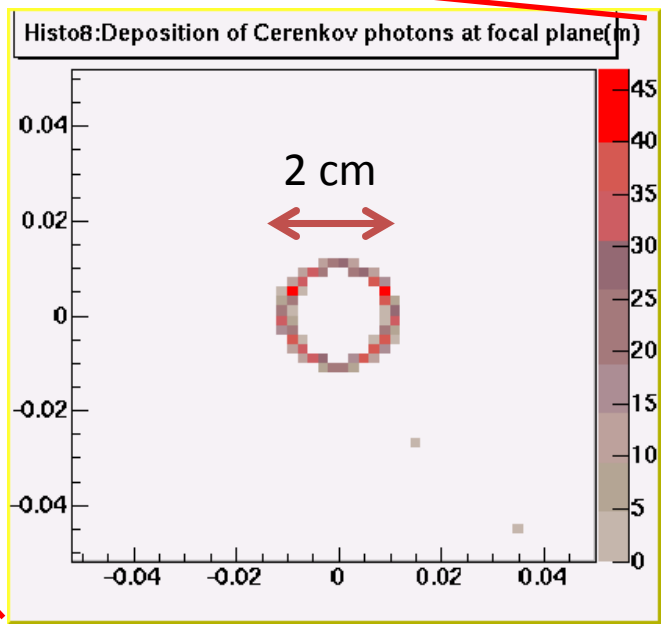
Cherenkov emmission by muons

(emmission restricted to $\lambda \sim 400$ nm)

Vertical downgoing μ along the lens axis







(2x2 mm^2 bins)

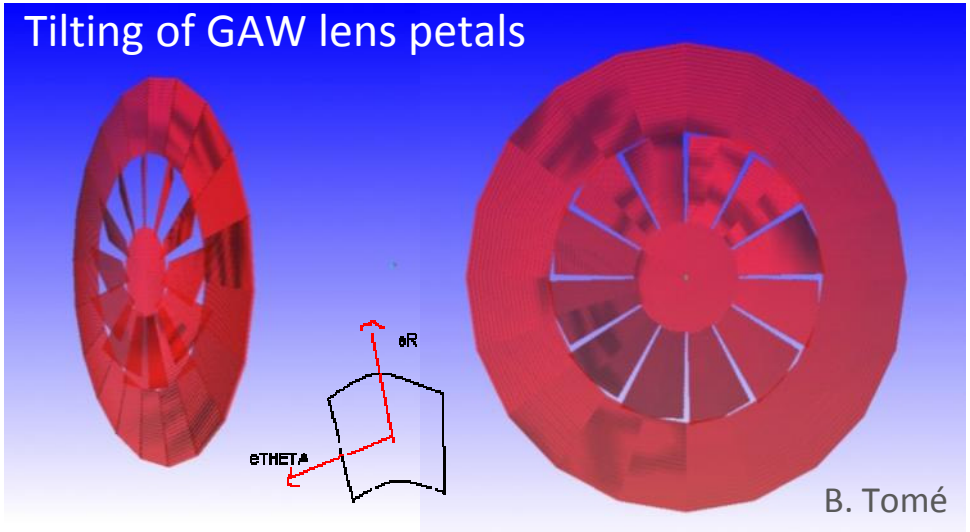
Changing the telescopes…

Changes in the telescope involve:

- Redefinition of the telescope geometry
- Redefinition of the optical properties of materials
- Redefinition of the processes

Example:

- Study and optimization of the Auger North Fluorescence Telescopes
- Simulation of component misalignments



Summary

Geant4 is a powerful and flexible toolkit for simulation of UV telescopes

GAW and Auger are using G4-based telescope simulations developed at LIP

Several detector features are better understood due to the realistic and detailed description of the detectors

Changes to the detectors can be easily implemented


O QUE SABEMOS DO UNIVERSO ?
4-5 SETEMBRO 2009 CIDADE DE SÃO TOMÉ, S.TOMÉ E PRÍNCIPE
O QUE SABEMOS DO UNIVERSO ?
Thank you

END