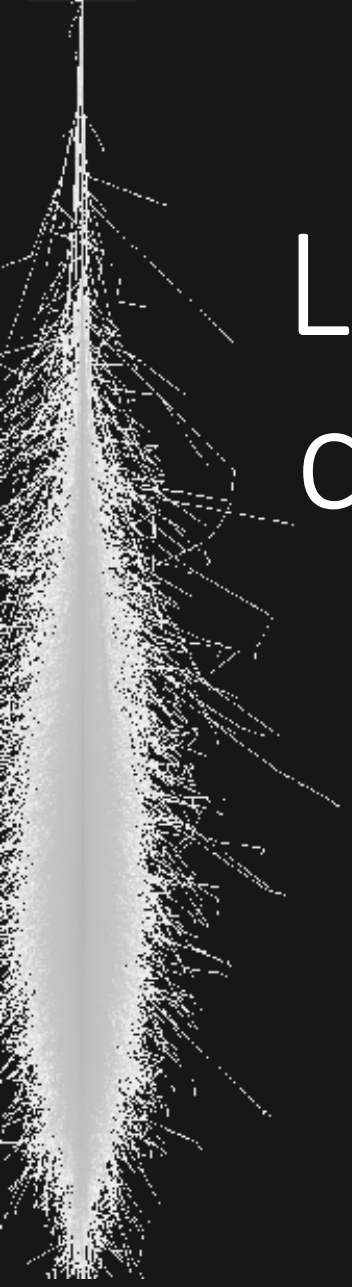


LATTES: A new detector concept for gamma-ray astrophysics

Optimization of the shower core reconstruction

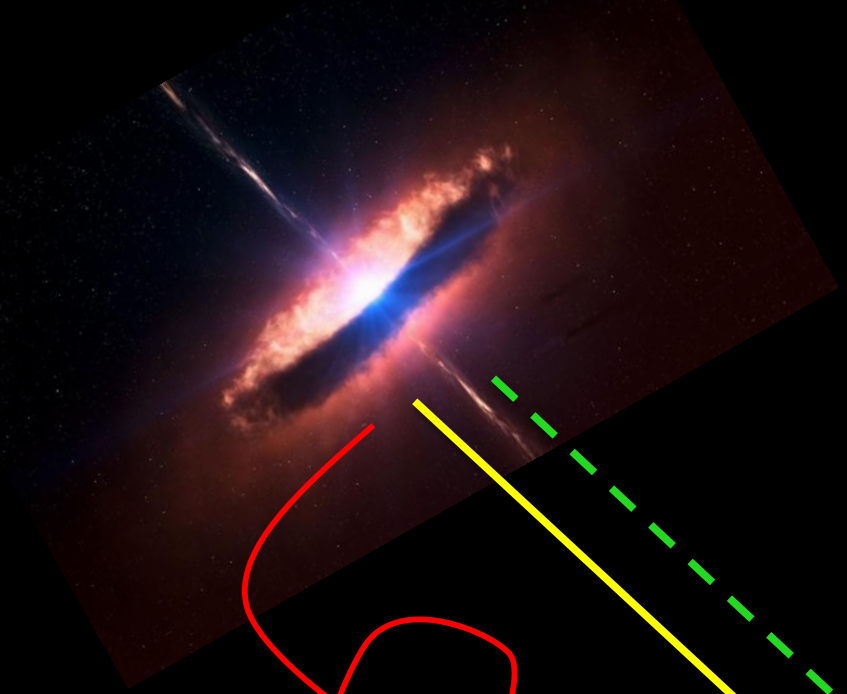
Afonso do Vale
Inês Vieira

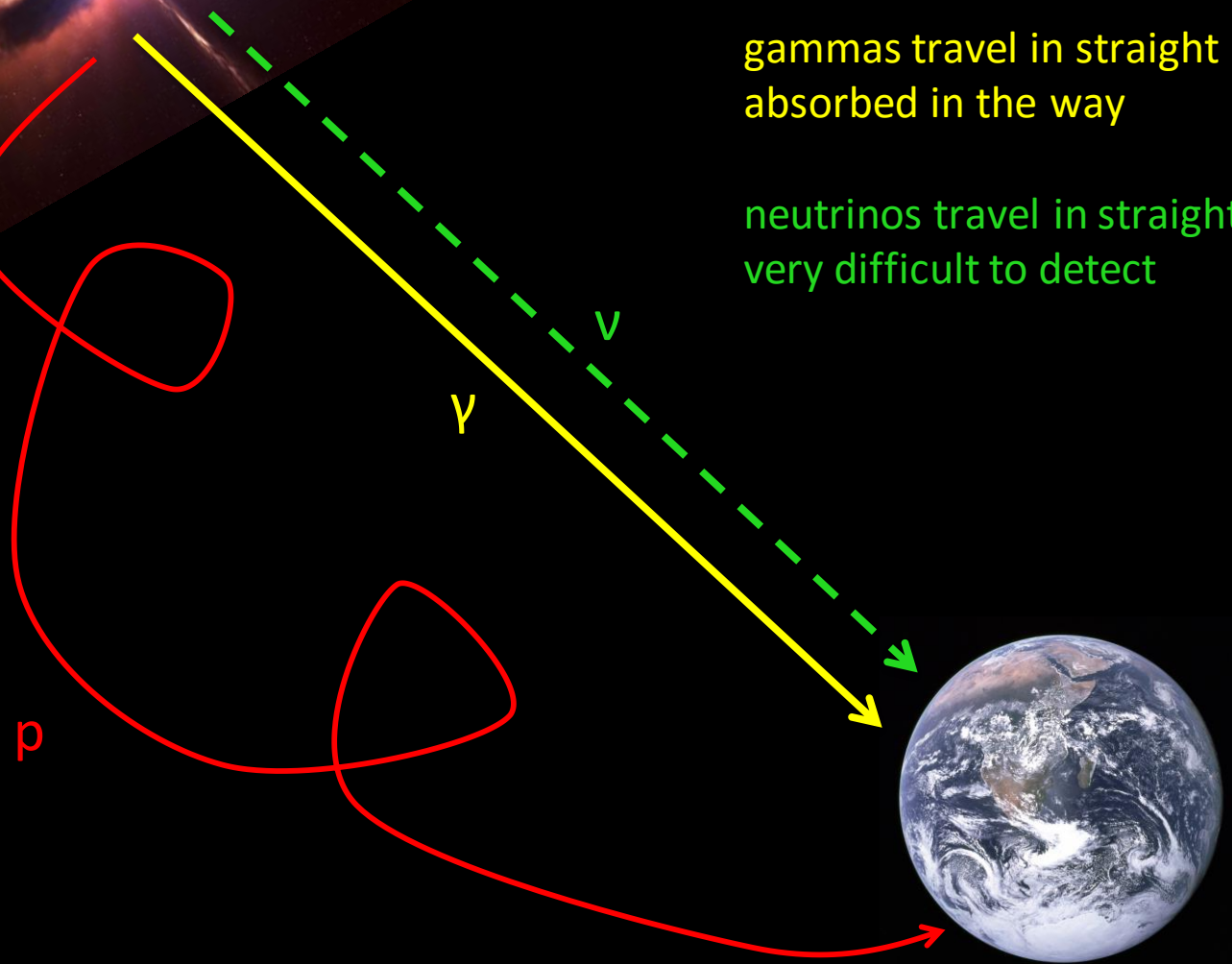
Why gamma rays?

protons are deflected by the galactic magnetic fields

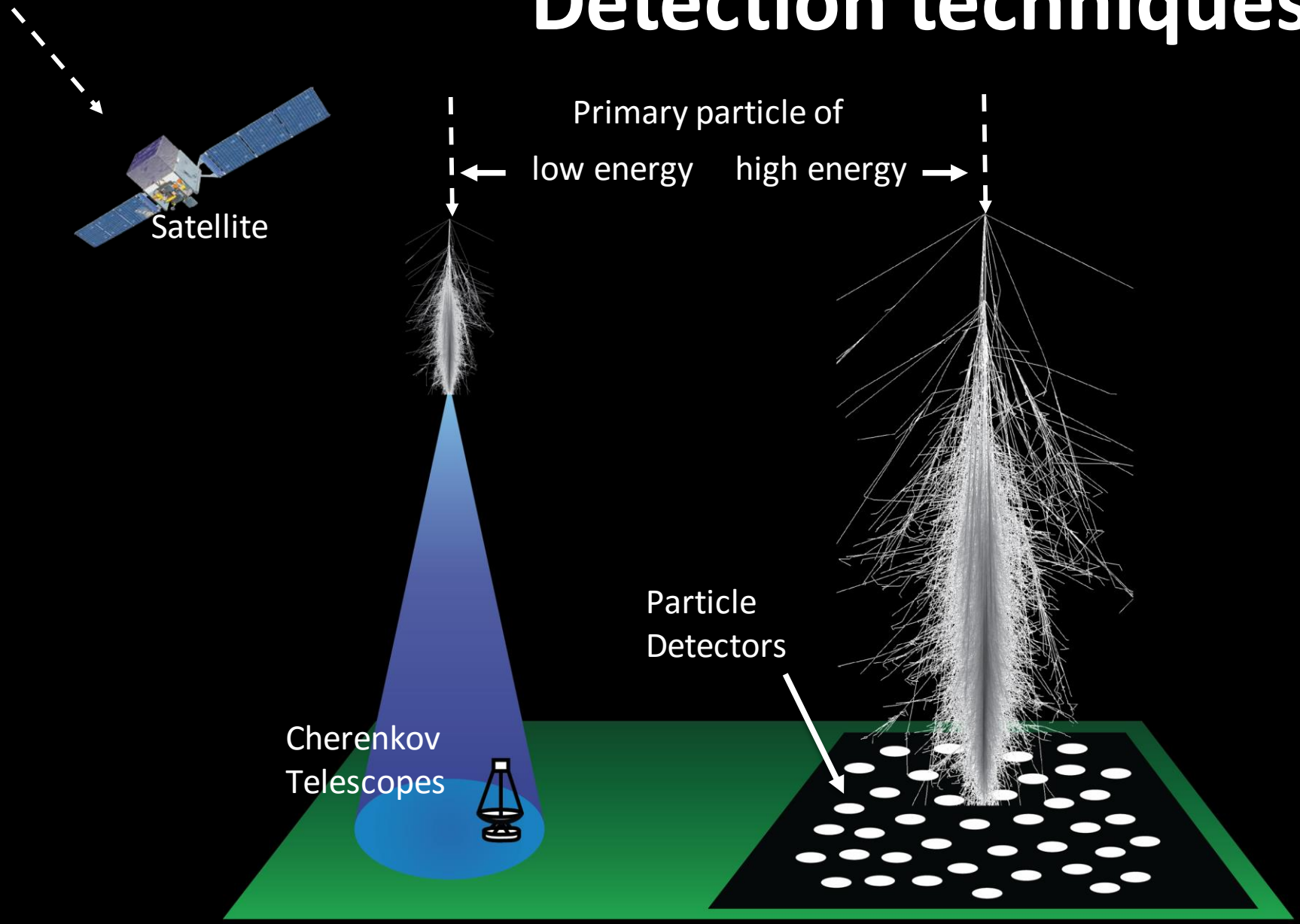
gammas travel in straight lines but can be absorbed in the way

neutrinos travel in straight lines but are very difficult to detect



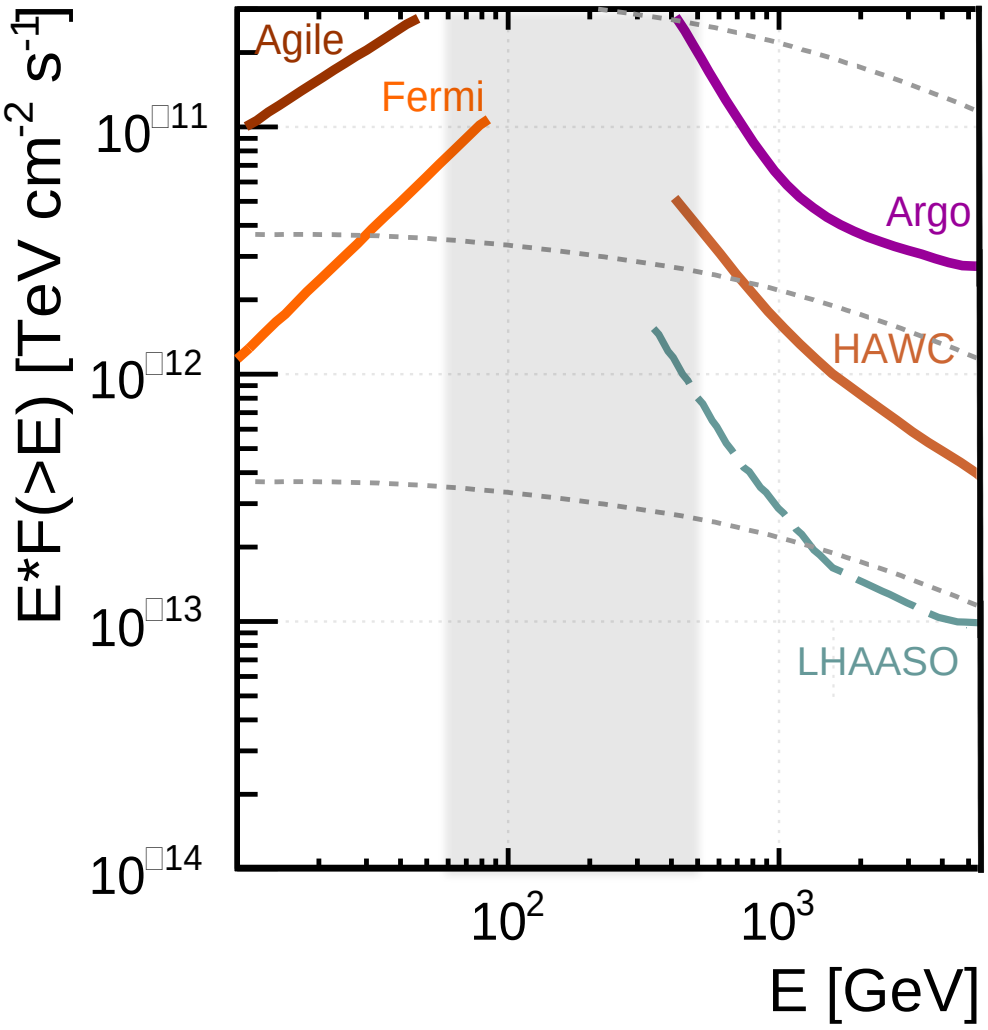


Detection techniques



Arrays at high altitude = large field of view + lower energies

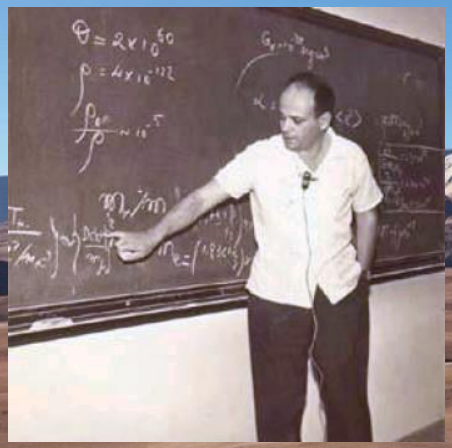
Requirements



- Build an EAS array experiment:
  - Located in the South Hemisphere
  - Low energy threshold:
    - High altitude
    - Next generation detector concept

LATTES @ ALMA site

Large Array Telescope for Tracking Energetic Sources



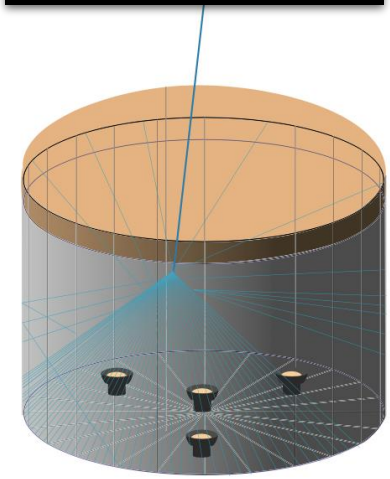
LATTES array

- **Planned site:**
  - **Atacama Large Millimeter Array site**
    - **Chajnantor plateau**
    - **Good position to survey the Galactic Center**
- **LATTES array baseline**
  - **Compact core array**
    - **Area: 20 000m^2**
    - **Target lowest energies (E_{min} ~ 100 GeV)**

LATTES: an hybrid detector

ARGO

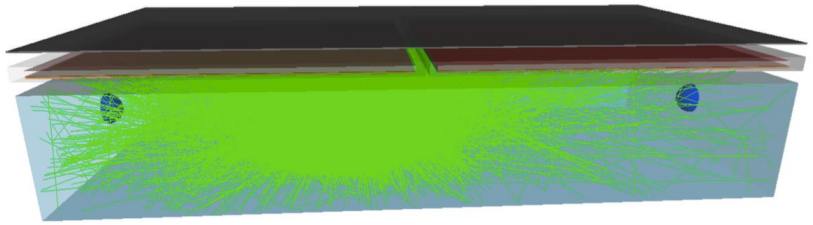
HAWC



LATTES

Hybrid detector

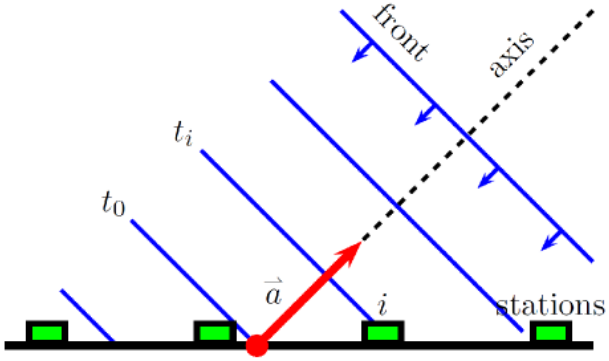
RPC (Resistive Plates Chamber) => Spatial and time resolution
(ability to reconstruct the shower geometry)



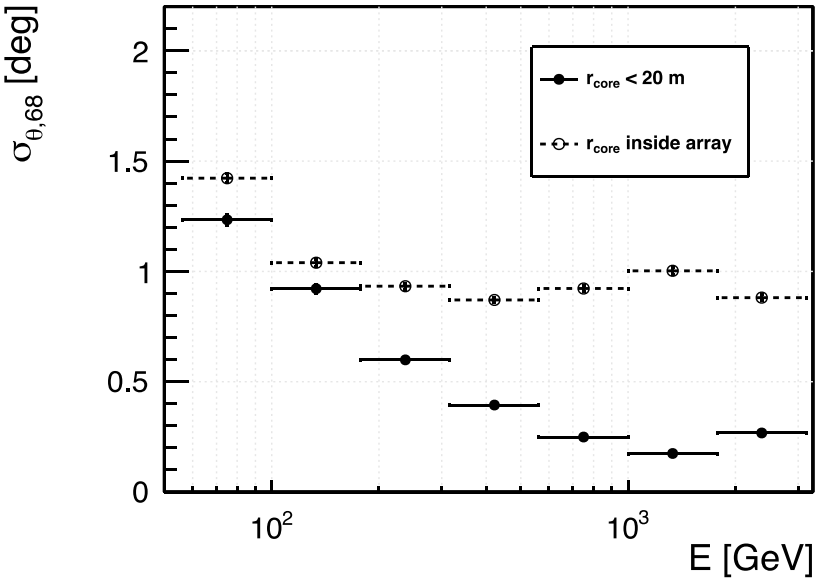
WCD (Water Cherenkov Detector) => Calorimetry
(ability to trigger at low energies)

Reconstruction of shower geometry

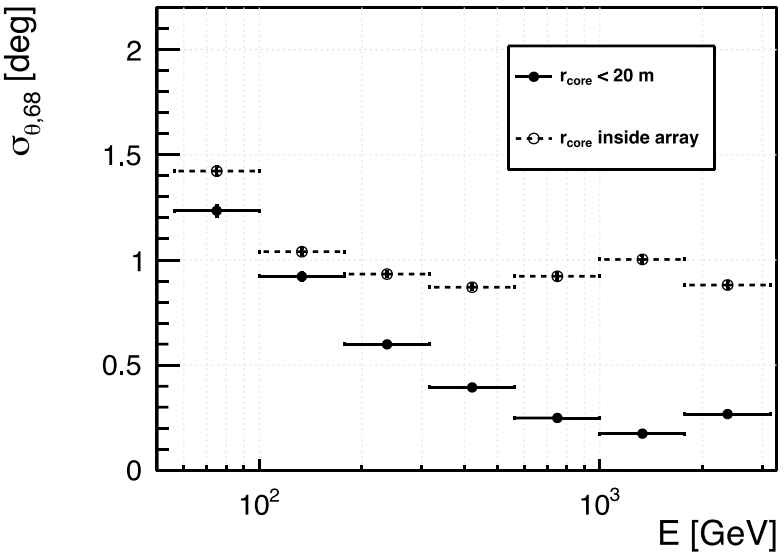
- Use RPC hit time information to reconstruct the shower
  - Take advantage of high spatial and time resolution
- Using a shower front plane model
  - Good geometry reconstruction in center of array but not at borders

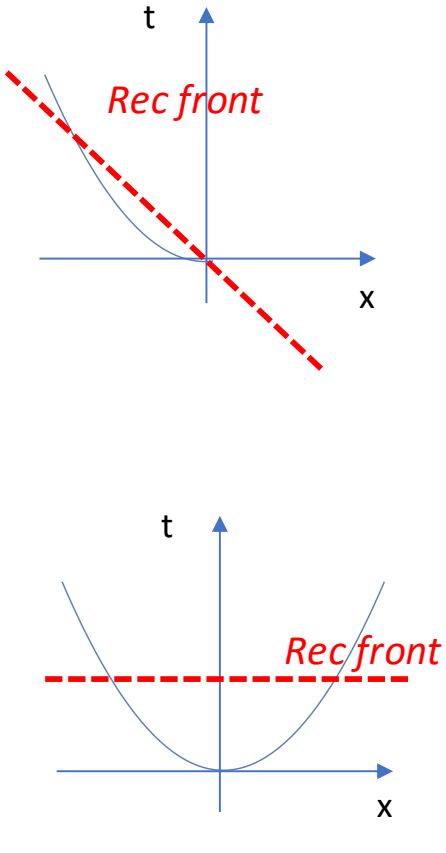


$\gamma - \text{showers}; \theta = 10^\circ$



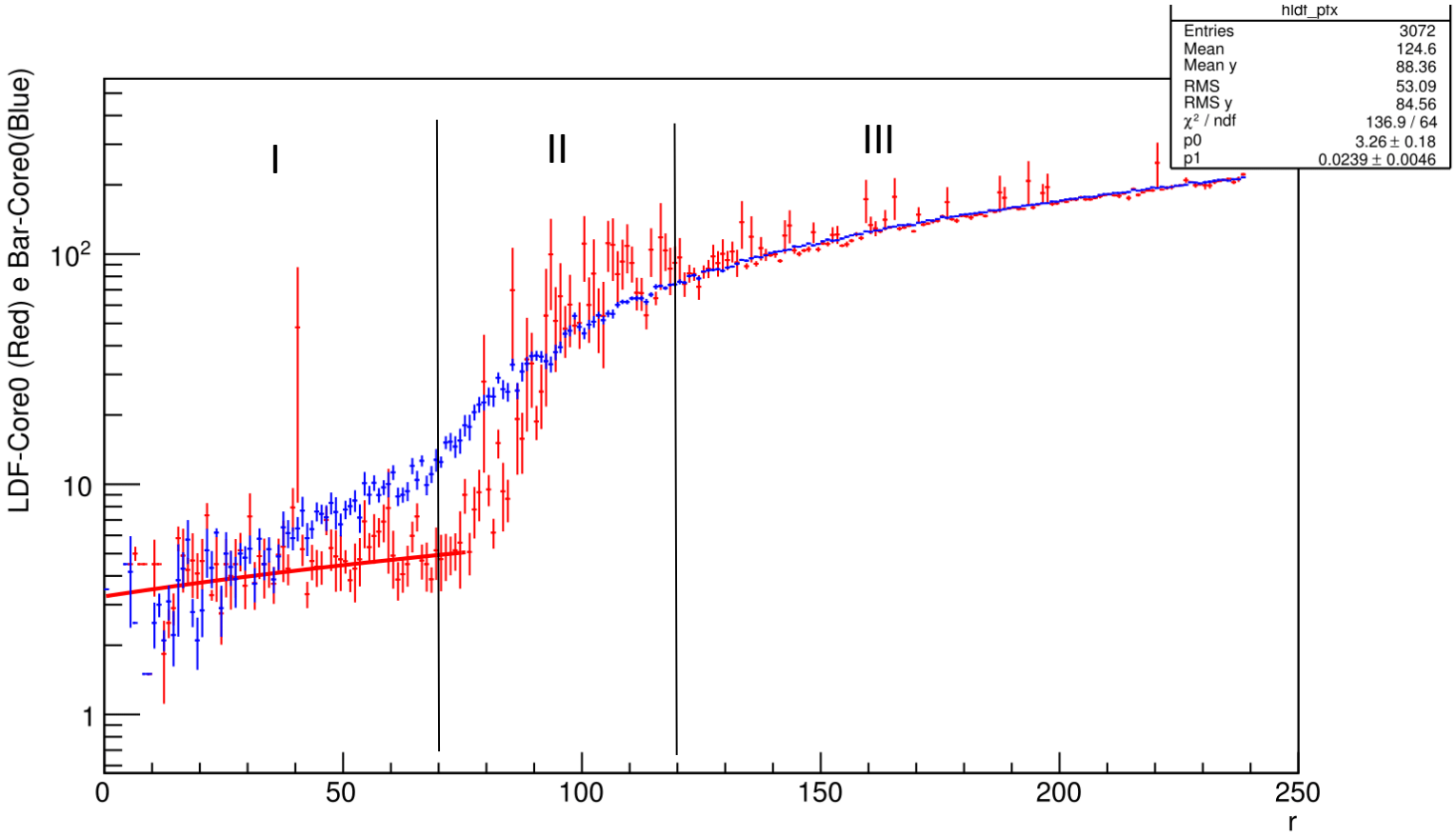
Improving the geometry reconstruction





Solution: implement a conic fit instead of fitting a plane

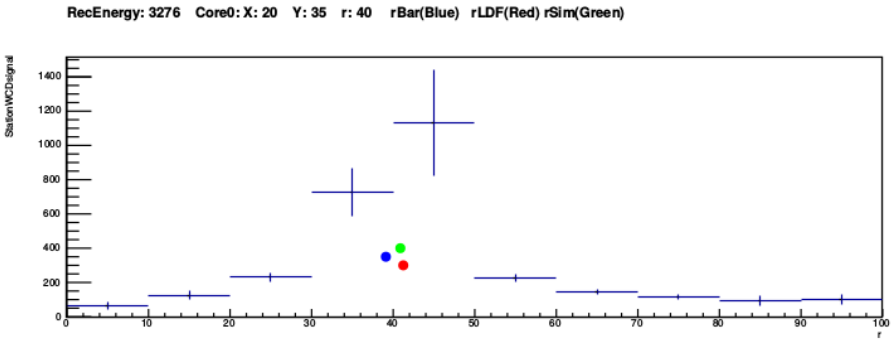
(implies an excellent core reconstruction!!)

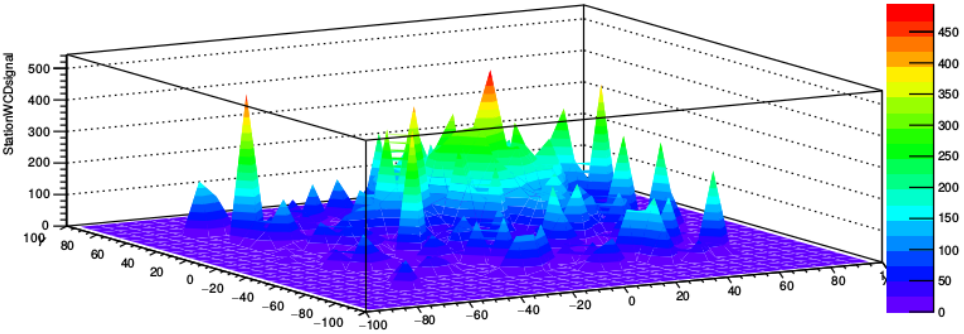


- Error of the core position reconstruction:
  - Blue: Reconstruction using the barycenter of the signals
  - Red: Reconstruction using a fit to the shower footprint

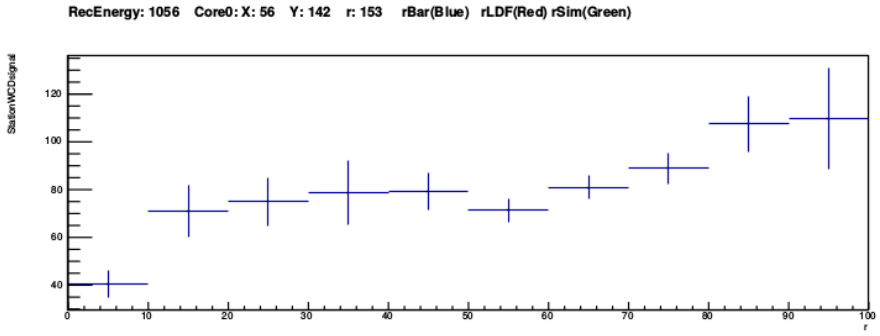
Event Display

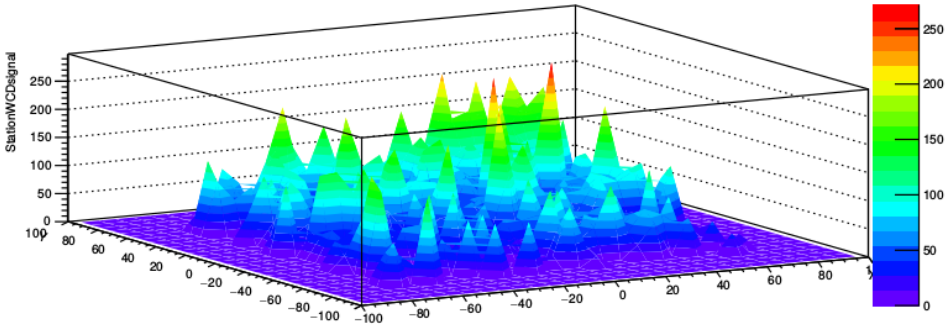
Region I



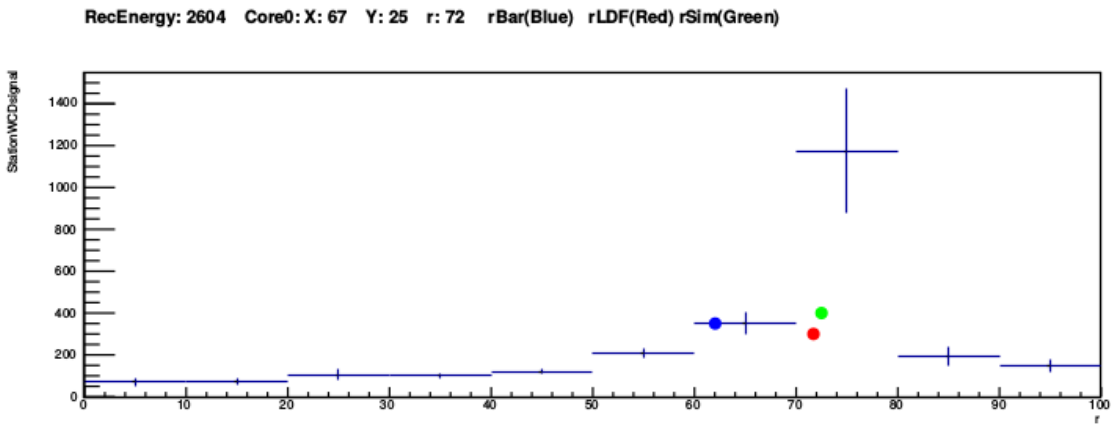


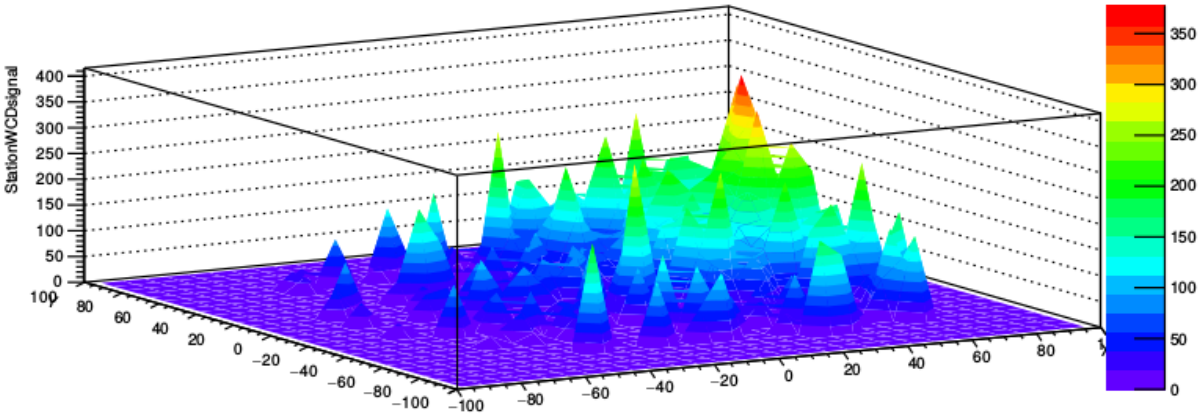
Region III

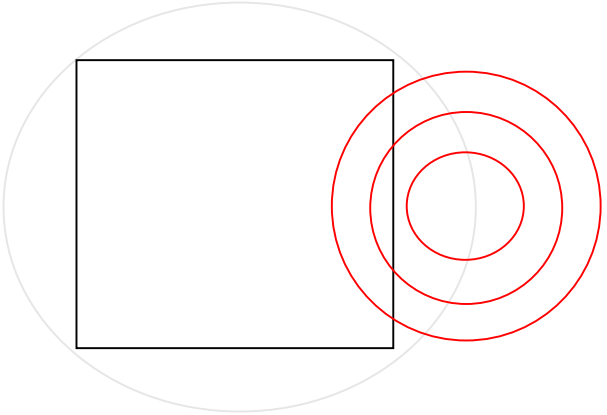




Understanding the bad reconstruction around Region II





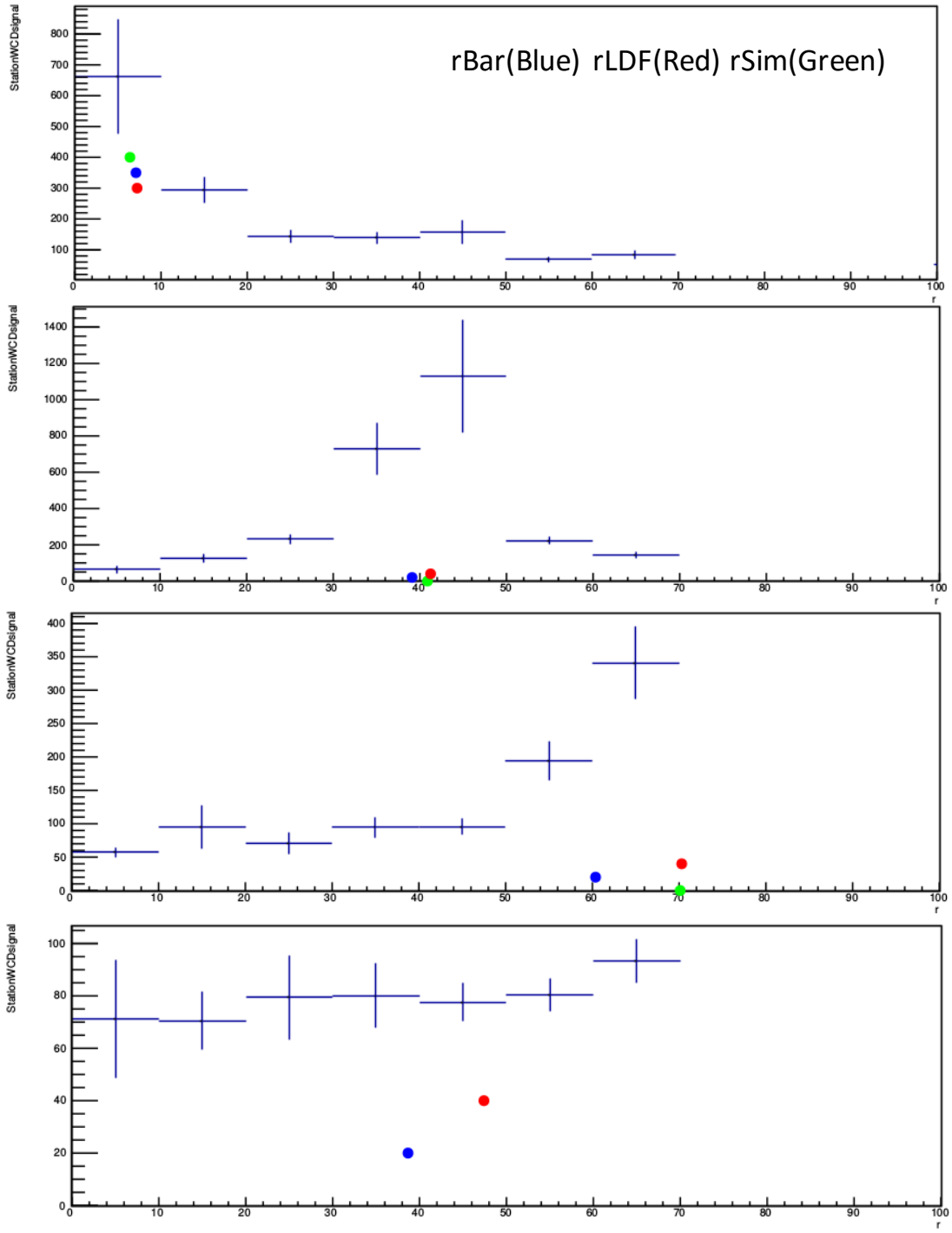


The array is studied through the radial distance =>

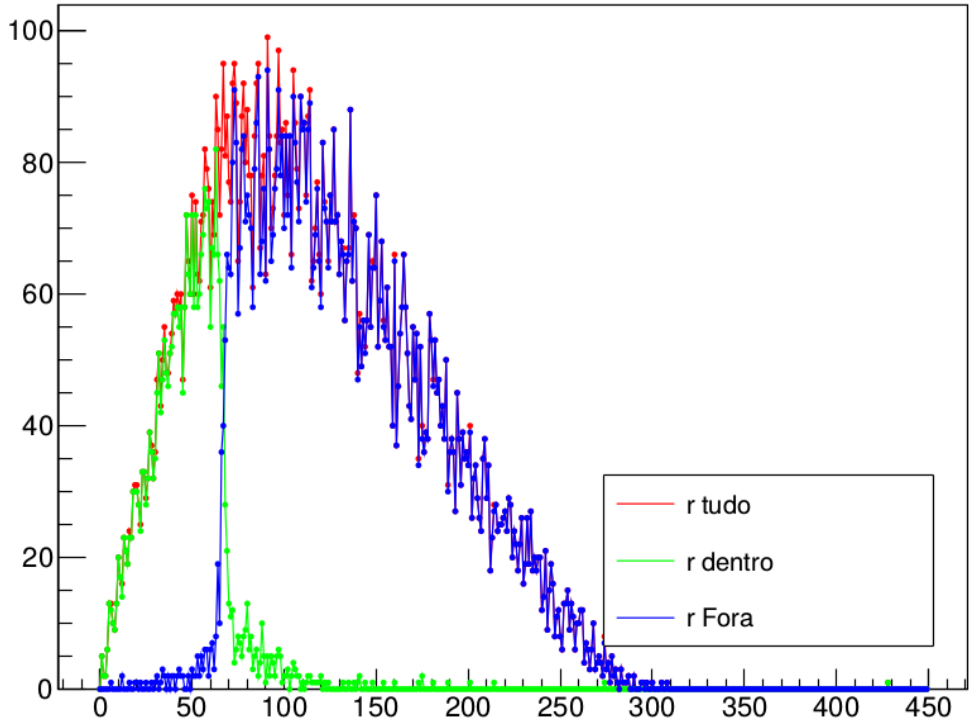
Some problems in the region associated with the corners of the array => Change the array geometry to remove the corners and making it circular.

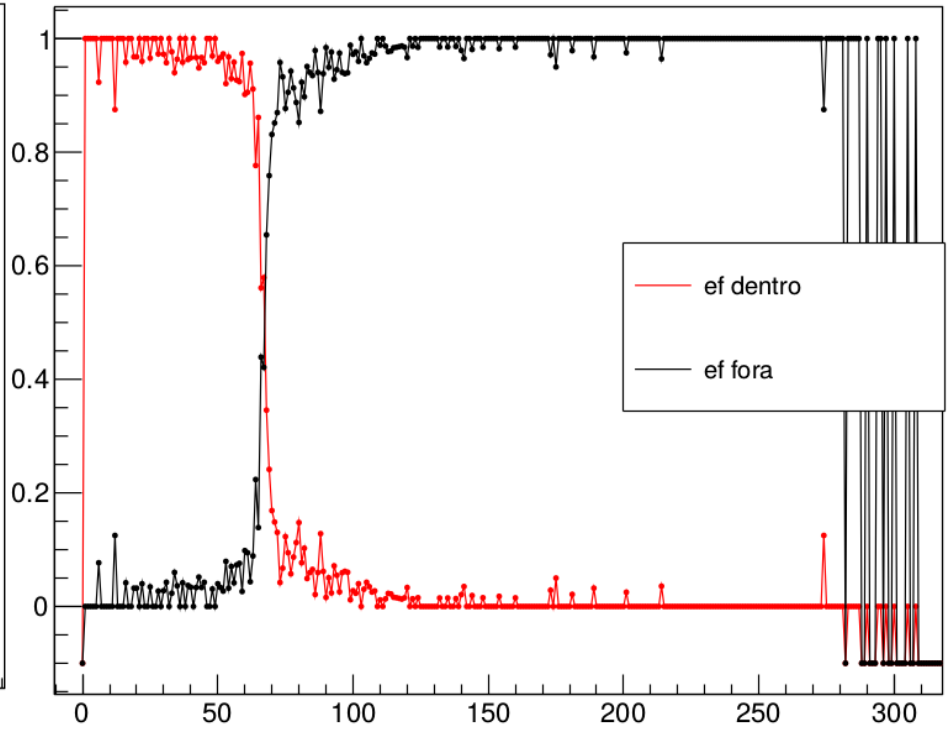
Event Classification

- We identified 4 general types of events:
  - The top 2 types identify events with cores inside de array
  - The bottom 2 types identify events with cores outside the array
- We can use this to classify the events and select the ones with cores inside the array



Event Classification Results

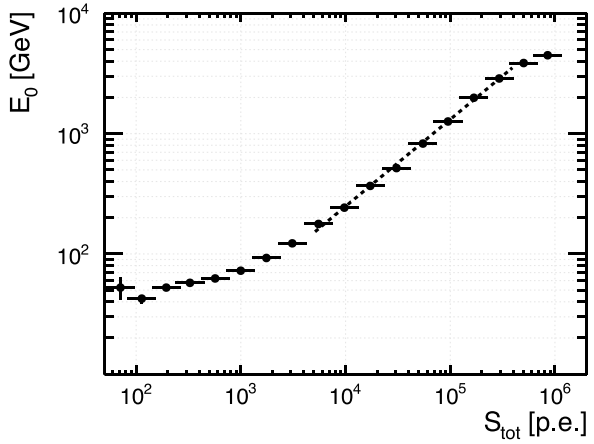




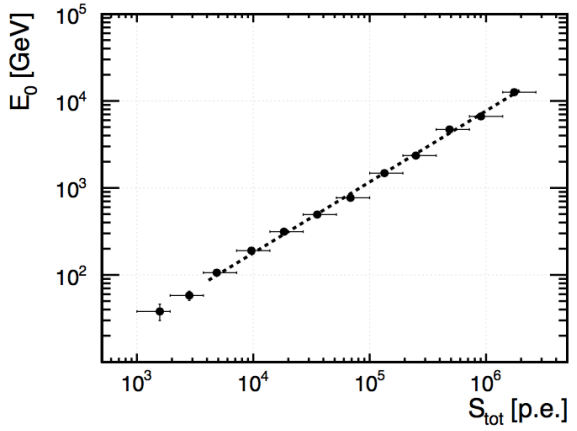
Summary

- The classification of events allowed to improve the shower core reconstruction
- Angular resolution with the conic fit for all the array is nearly as good as the plane fit only for the central array region

Energy Calibration



Before



After


VERITAS
MAGIC
ARGO
RPCs
HAWC
LATTES
HESS
Built IACT
Built Array
Planned IACT
Planned Array

Event Classification (2 methods)

Average signal

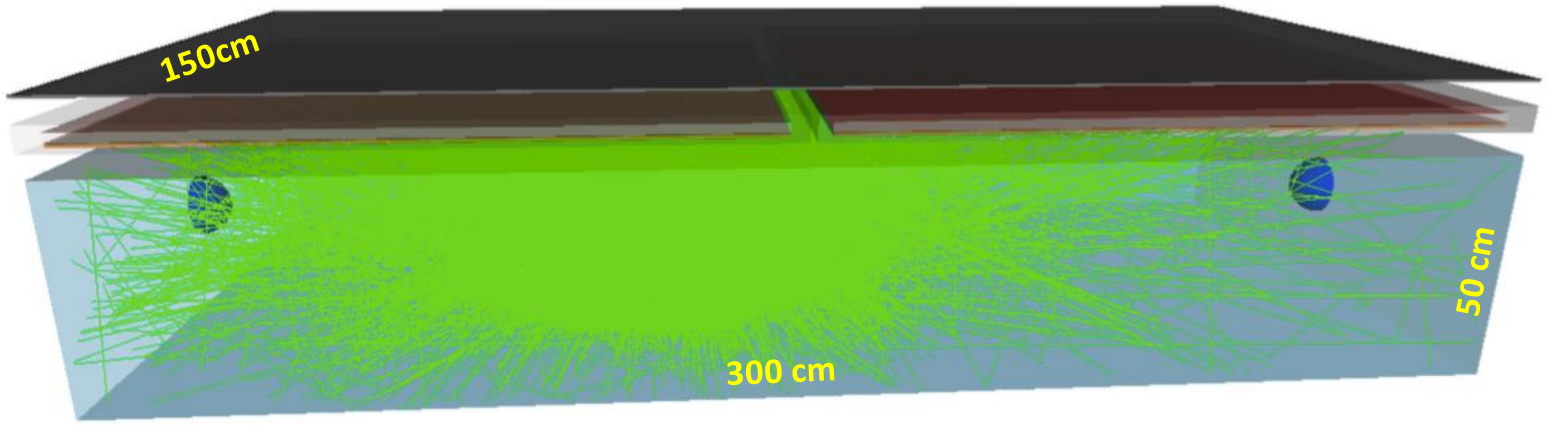
- Analyzing the compatibility between the average signal, the energy and the core position
- Example: An event with high energy and a central core is rejected if the average signal is below a predetermined value

Signal dispersion

- Trying to separate the last type from the others by studying the dispersion of the signal:

$$dispersion = \sum \frac{(signal[i] - average)^2}{signalerror[i]}$$

LATTES concept

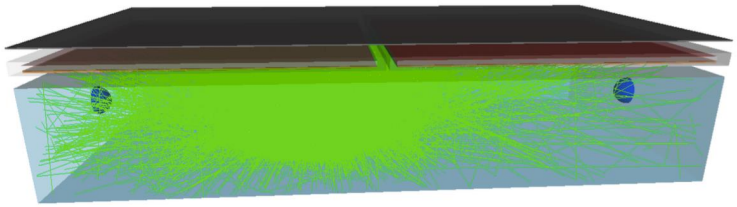


LATTES station

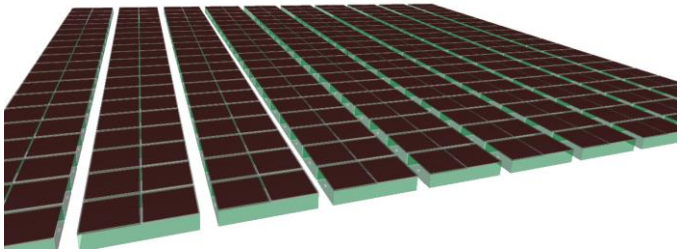
- Thin lead plate (**Pb**)
  - 5.6 mm (one radiation lenght)
- Resistive Plate Chambers (**RPC**)
  - 2 RPCs per station
  - Each RPC with 4x4 readout pads
- Water Cherenkov Detector (**WCD**)
  - 2 PMTs (diameter: 15 cm)
  - Inner walls covered with white diffusing paint

LATTES concept

- Hybrid detector:
  - Thin lead plate
    - To convert the secondary photons
    - Improve geometric reconstruction
  - Resistive Plates Chamber
    - Sensitive to charged particles
    - Good time and spatial resolution
    - Improve geometric reconstruction
    - Explore shower particle patterns at ground
  - Water Cherenkov Detector
    - Sensitive to secondary photons and charged particles
    - Measure energy flow at ground
    - Improve trigger capability
    - Improve gamma/hadron discrimination



LATTES station
1.5 m x 3 m x 0.5 m



LATTES core array
30 x 60 stations
100 x 100 m^2