LATTES

Concept for a next generation detector

André Torcato

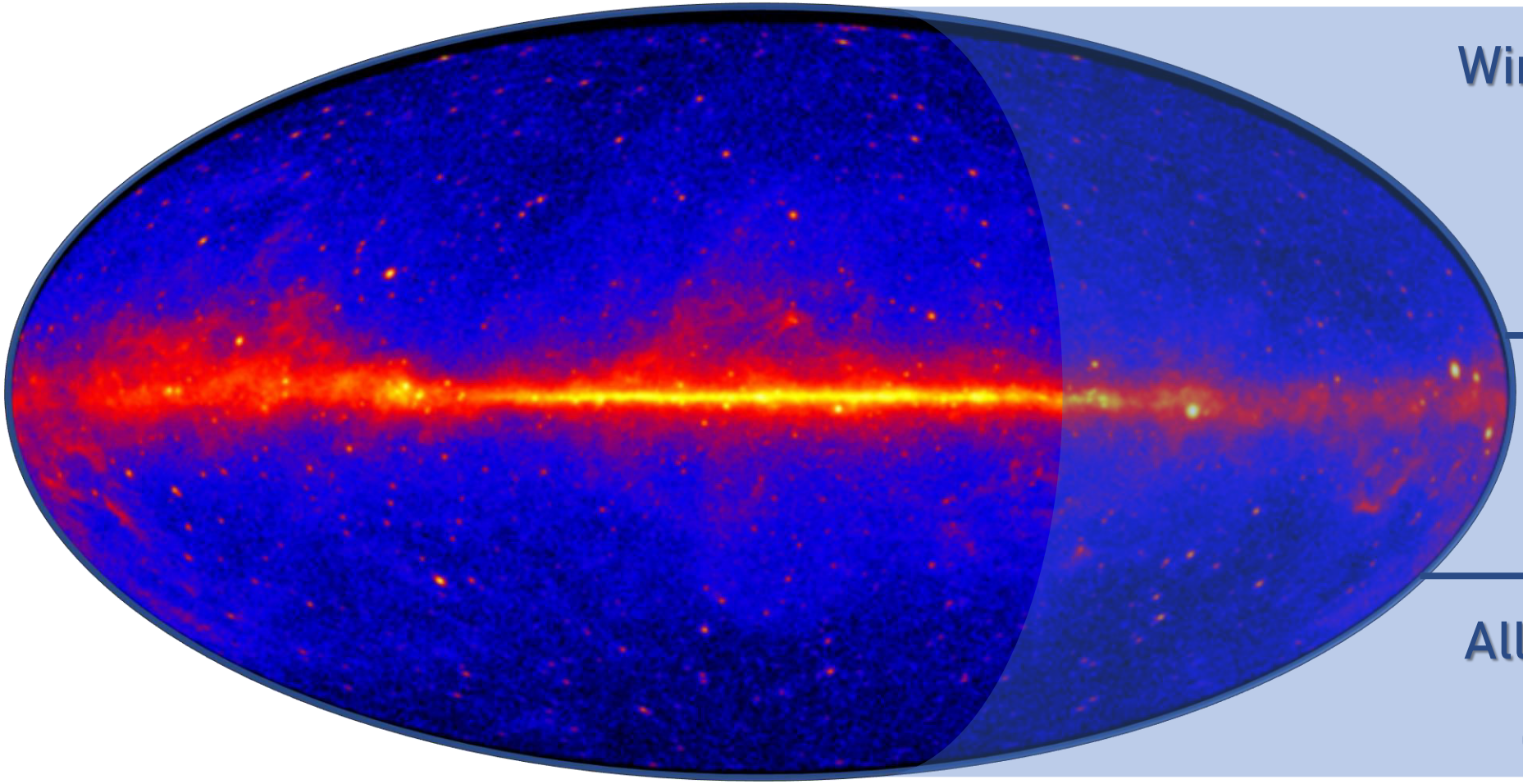
Melissa Serra, José Cordeiro, Sara Marques, José Jesus

Supervisors: Ruben Conceição, Bernardo Tomé, Mário Pimenta

Outline

- Introduce the LATTES project and its importance
- Elaborate on the work developed on this internship
- Give insight to future work

γ-Ray Astrophysics



Window to extreme phenomena in the Universe

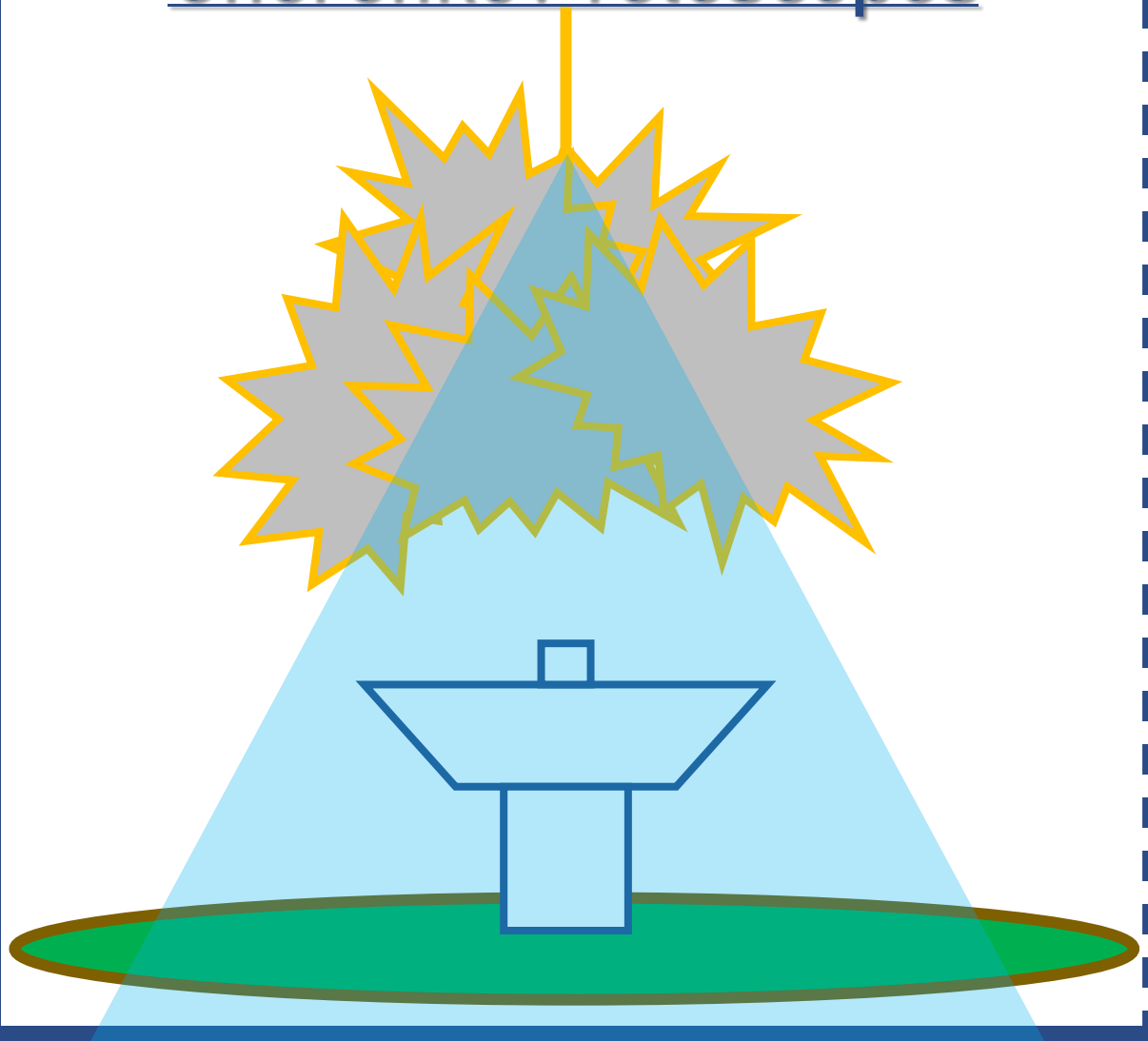
Energy between 50 GeV and 100 TeV

Allows for the Study of New Physics

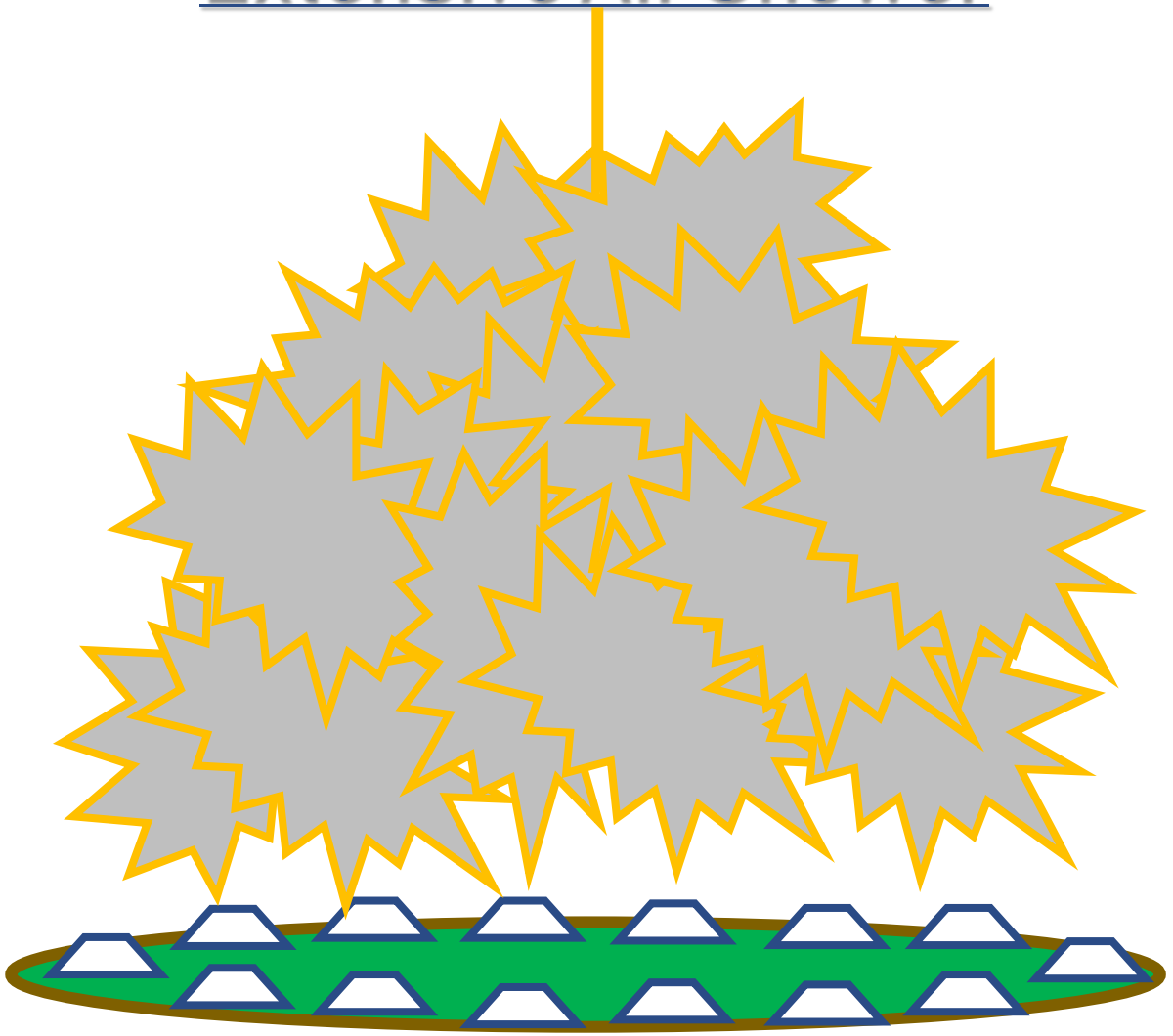
Fermi γ-Ray Space Telescope: https://svs.gsfc.nasa.gov/11342

Detecting γ-Rays I

Cherenkov Telescopes



Extensive Air Shower



Detecting γ-Rays II

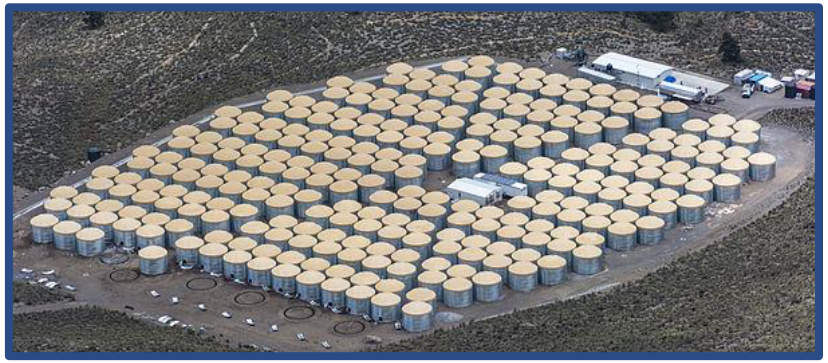
Cherenkov Telescopes

MAGIC: http://www.magic.iac.es/

VERITAS: https://veritas.sao.arizona.edu/

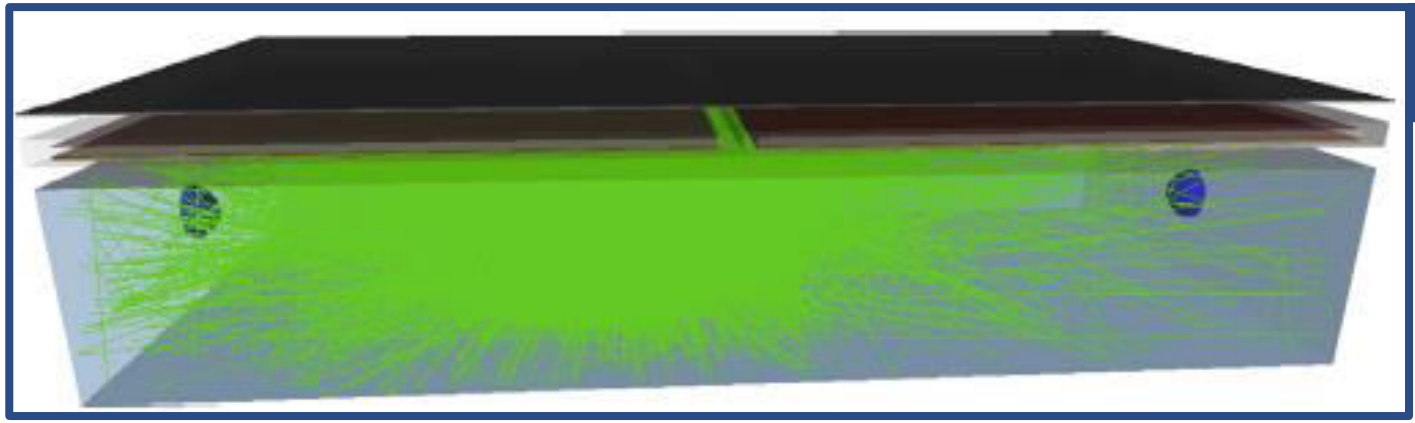
Extensive Air Shower

ARGO: http://argo.na.infn.it/



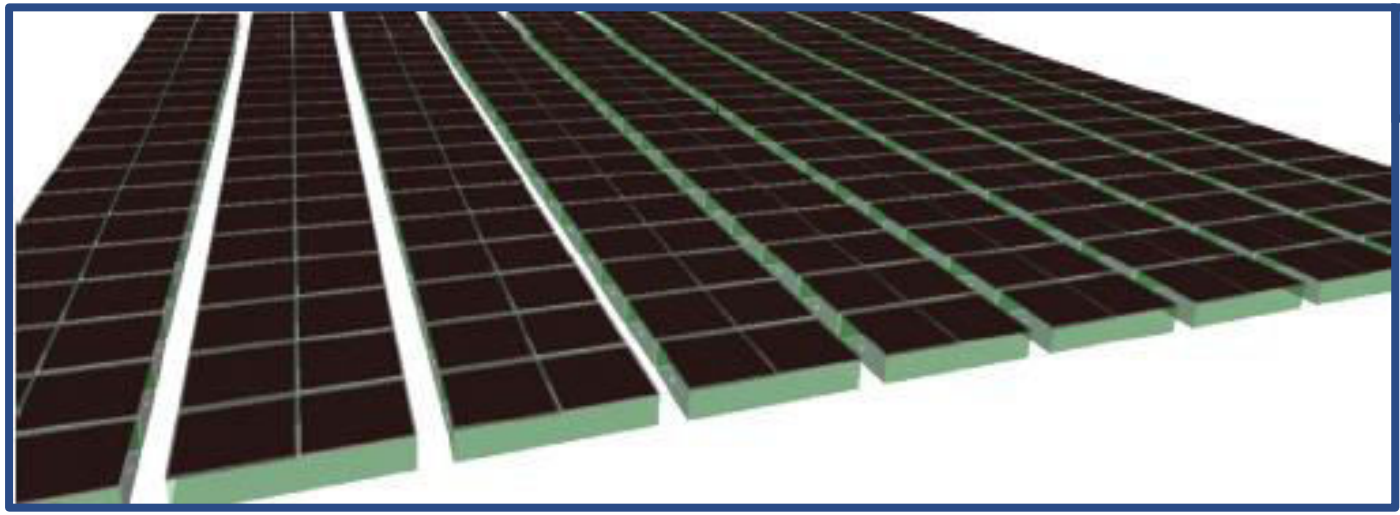
HAWC: https://www.hawc-observatory.org/

LATTES: Next Generation Detector



Station: $3 \times 1.5 \times 0.5\ m^3$

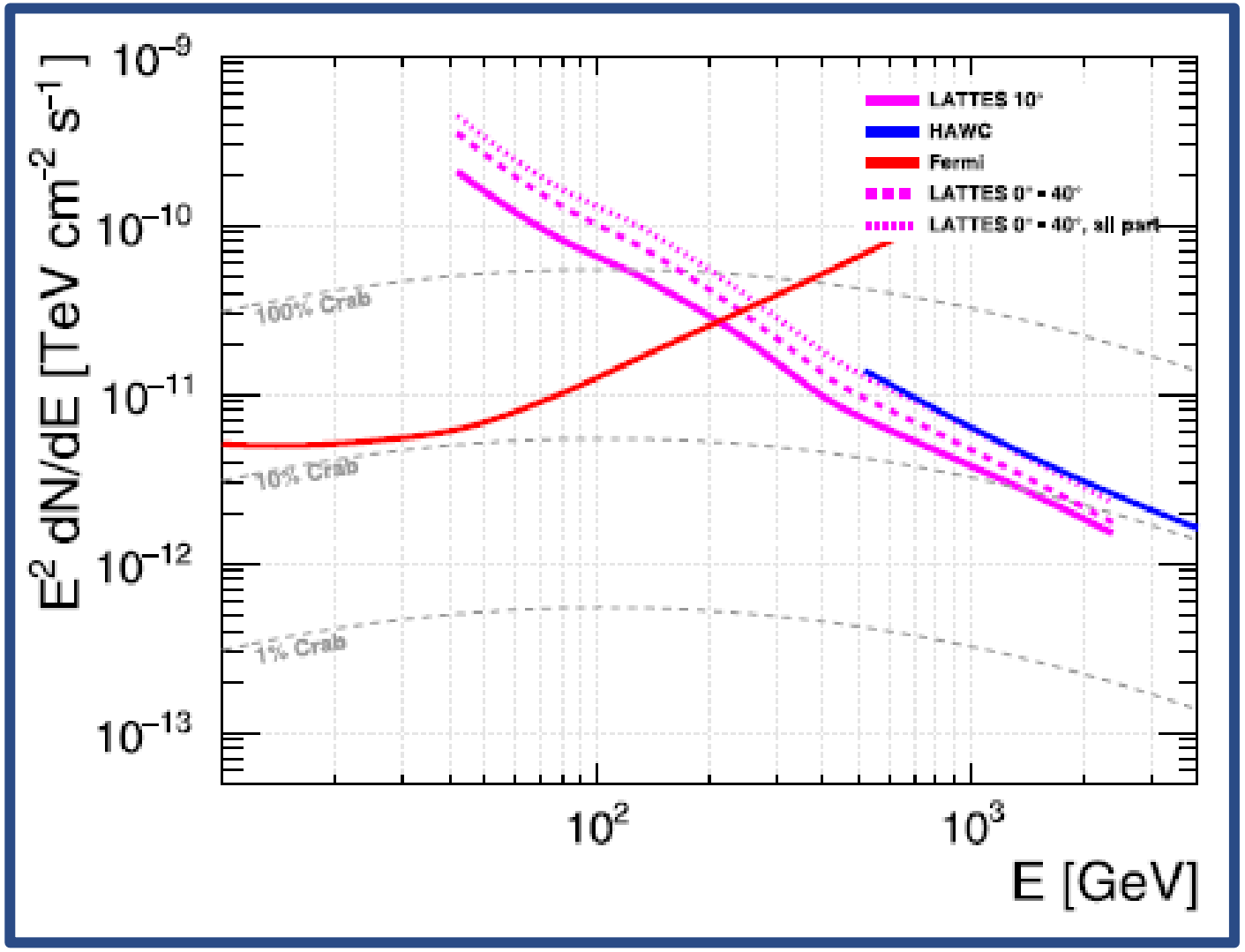
- RPCs on top of WCDs
- PMTs on the side
- Interior walls in white



Array: $20\,000 + 80\,000\ m^2$

- CoreArray + SparseArray
- Coverage area about 80%
- Altitude: $5200\ m$

Improving LATTES reconstruction



Time Resolution

José Jesus

γ/h Discrimination

Sara Marques, José Cordeiro

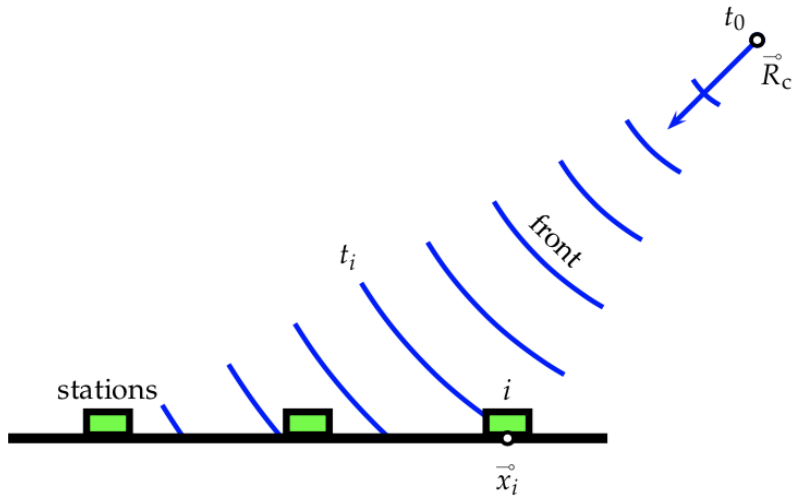
Event Analysis

André Torcato, Melissa Serra

Paper: Astroparticle Physics Volume 99, May 2018, Pages 34-42

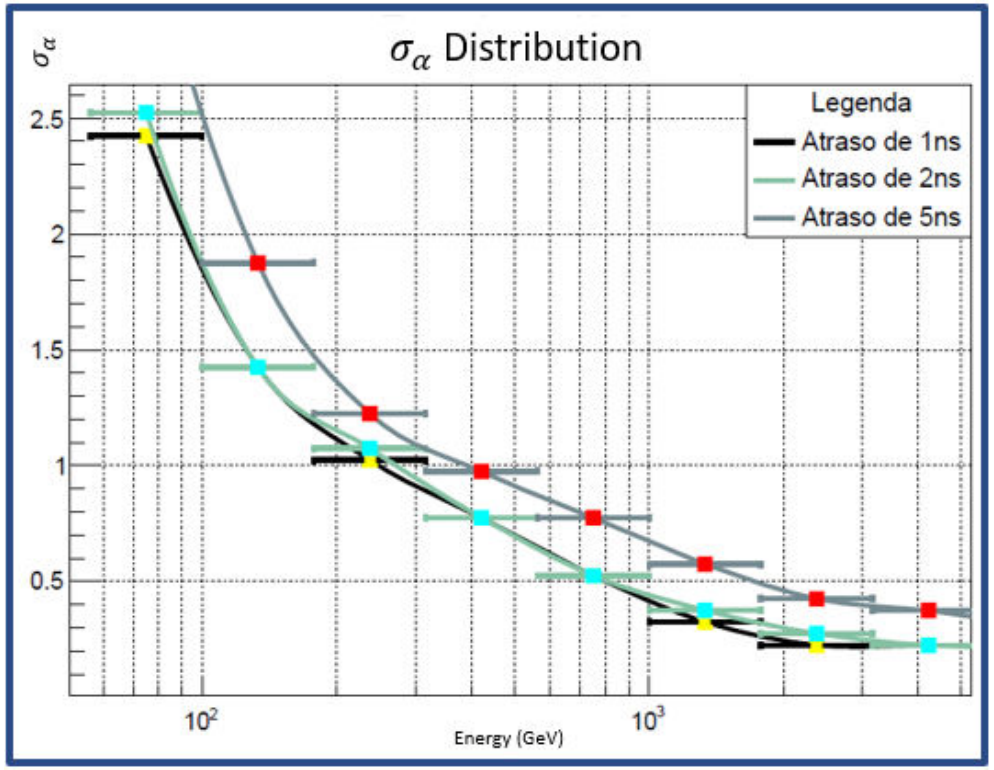
Time Resolution

Reconstruction of the Shower Geometry

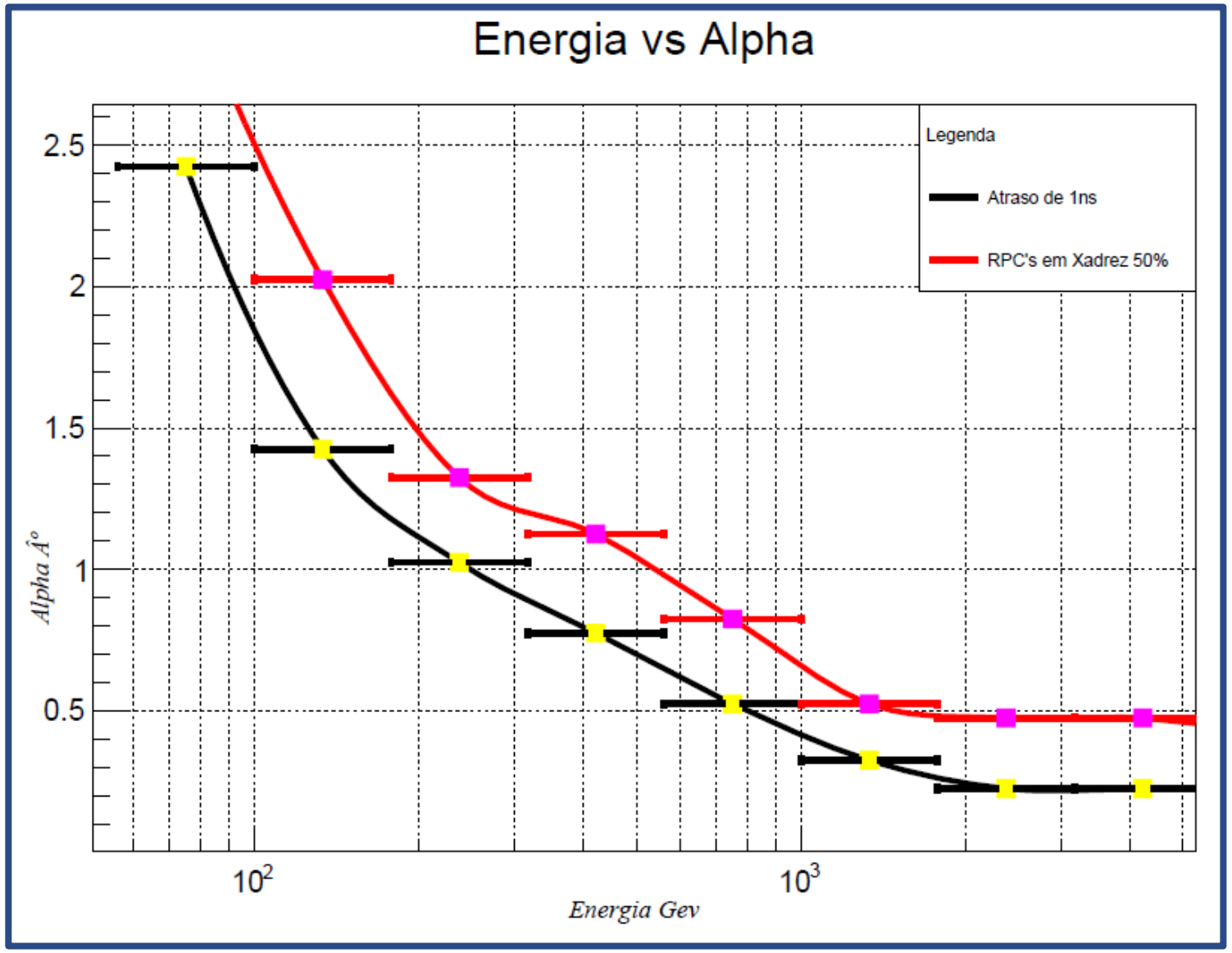


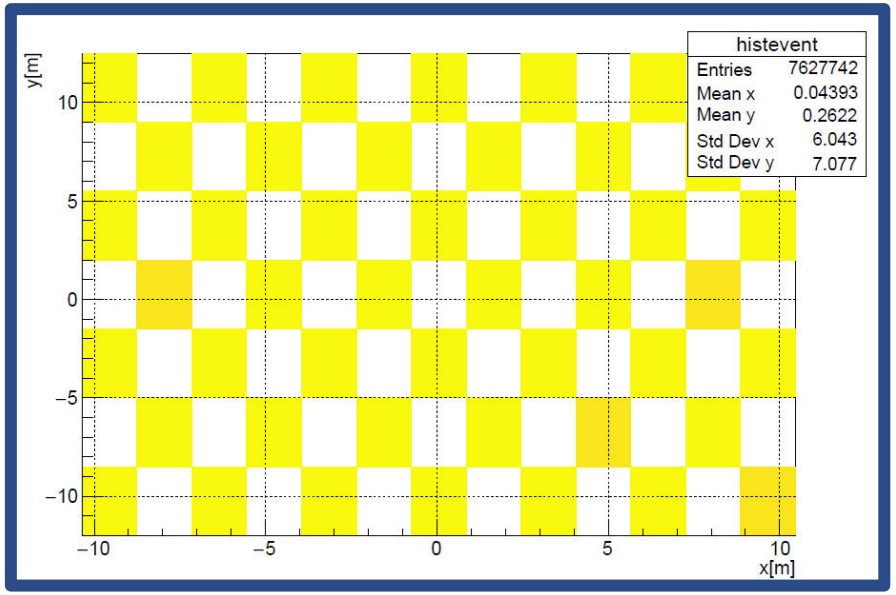
- The shower direction is obtained from the arrival time of particles at ground

- Impact of the time resolution in the reconstruction of the shower geometry



Shower geometry reconstruction



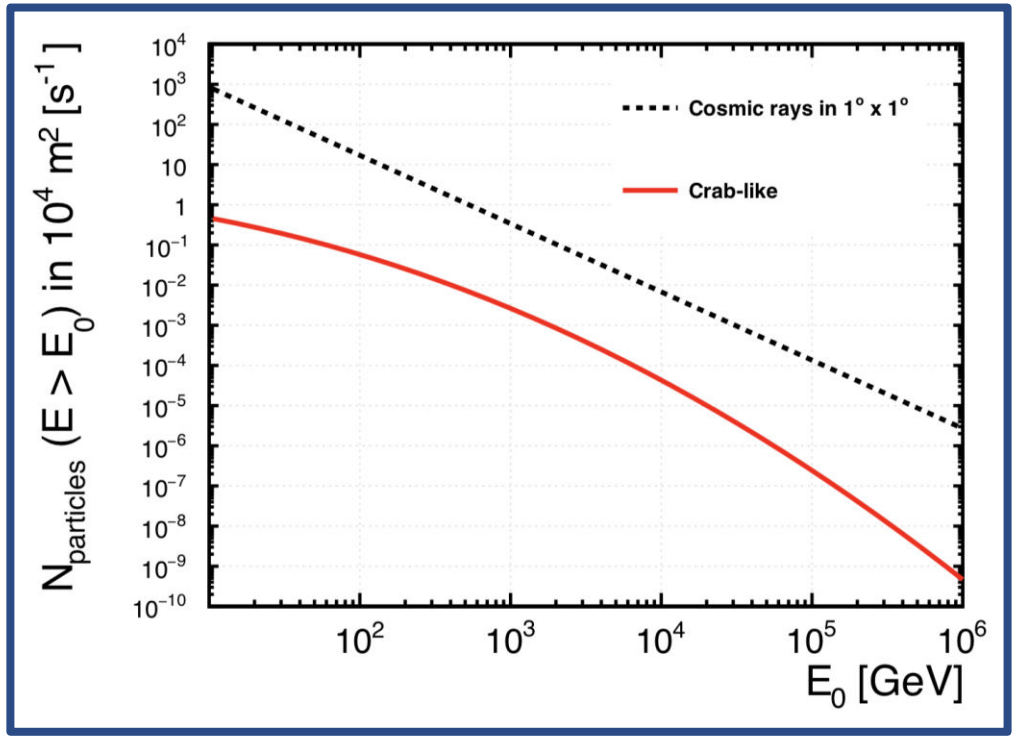


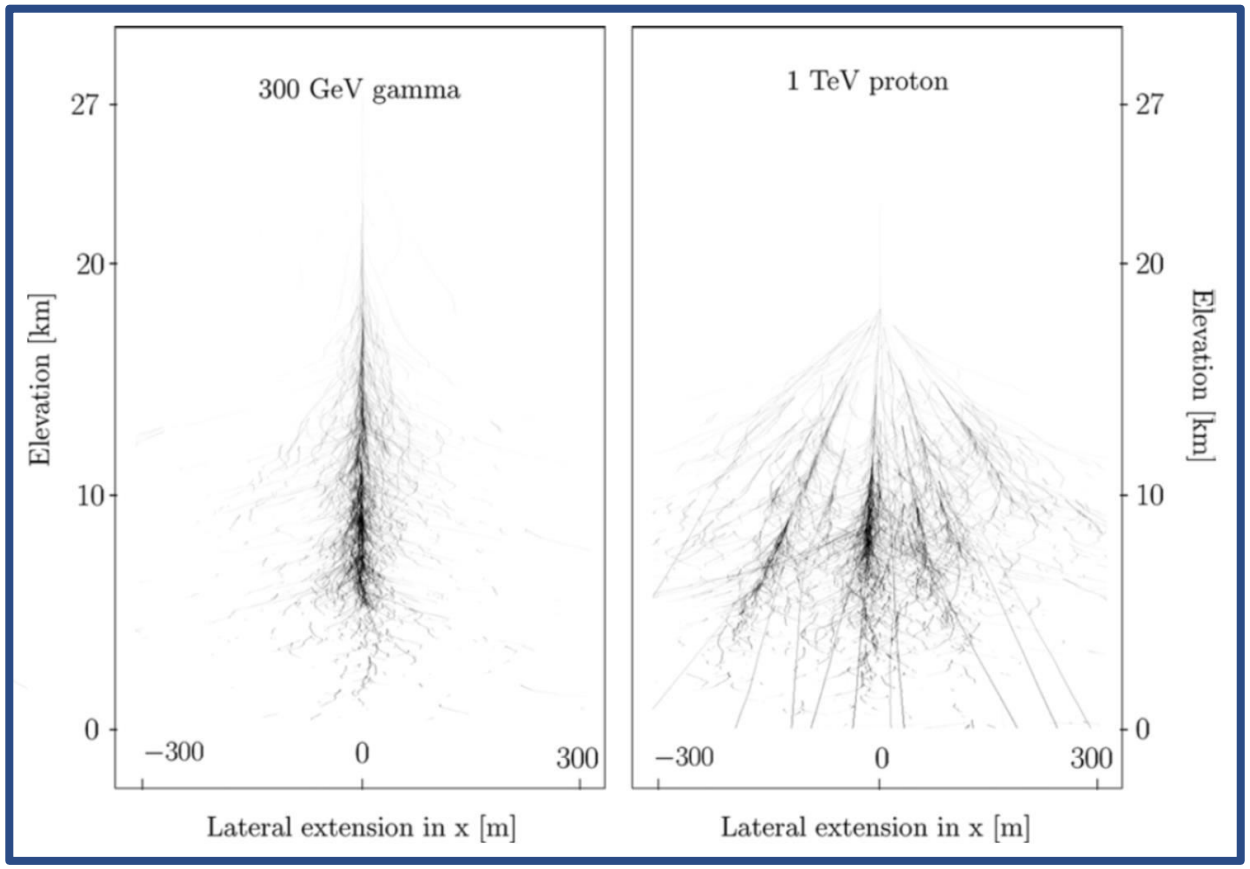
Different array configurations were studied

γ/h Discrimination

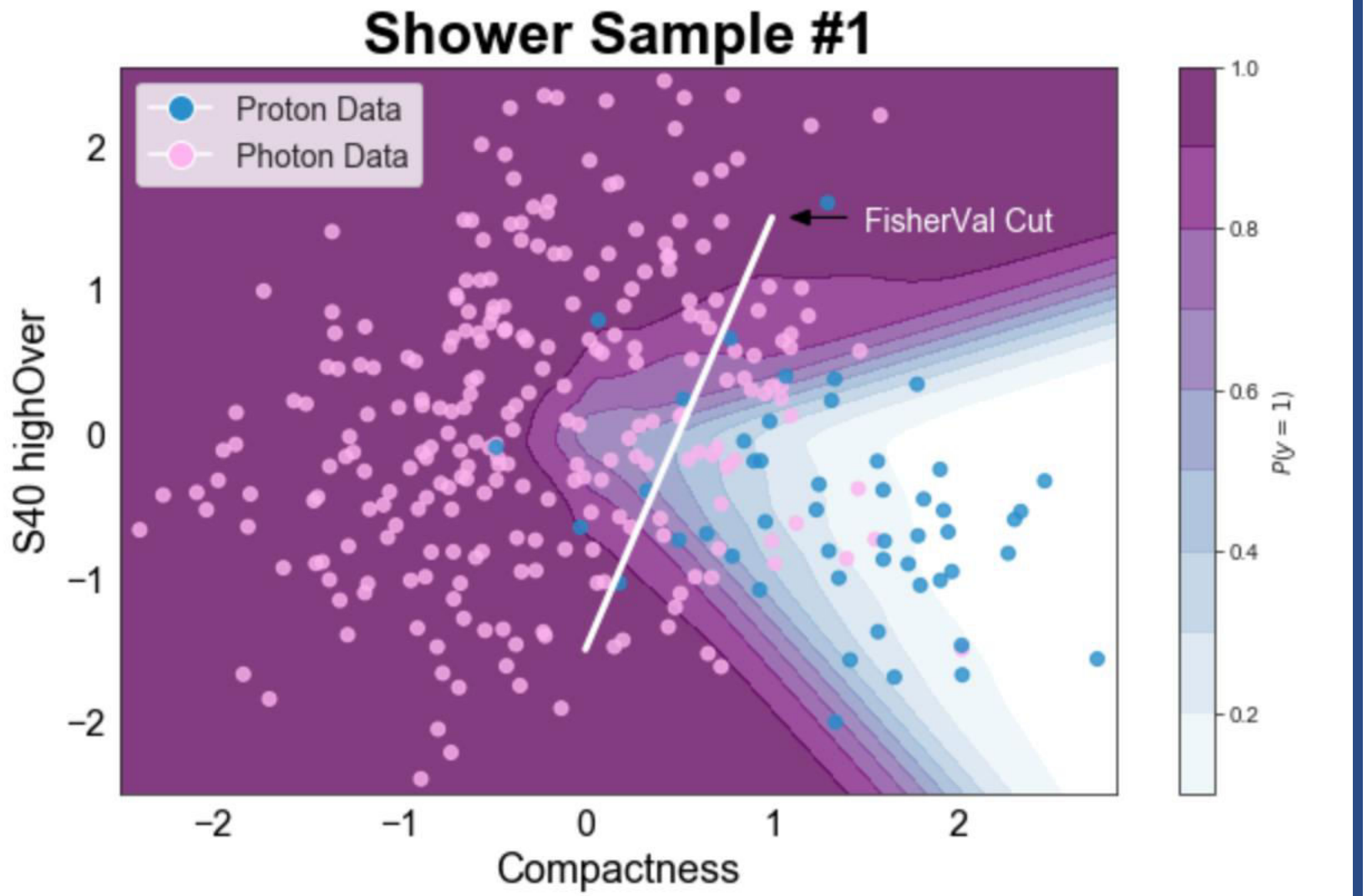
Separating background from signal

- Flux of hadron background overwhelms signal from γ's
- Shower morphology can be used to discriminate





γ/h Discrimination



Linear Discriminante (Fisher) allows a good separation

Simple artificial neural networs can improve g/h discrimination

Keras + Scikit-learn + ANN with 3 layers

More simulation statistics necessary to apply parametric cuts

Event Analyses

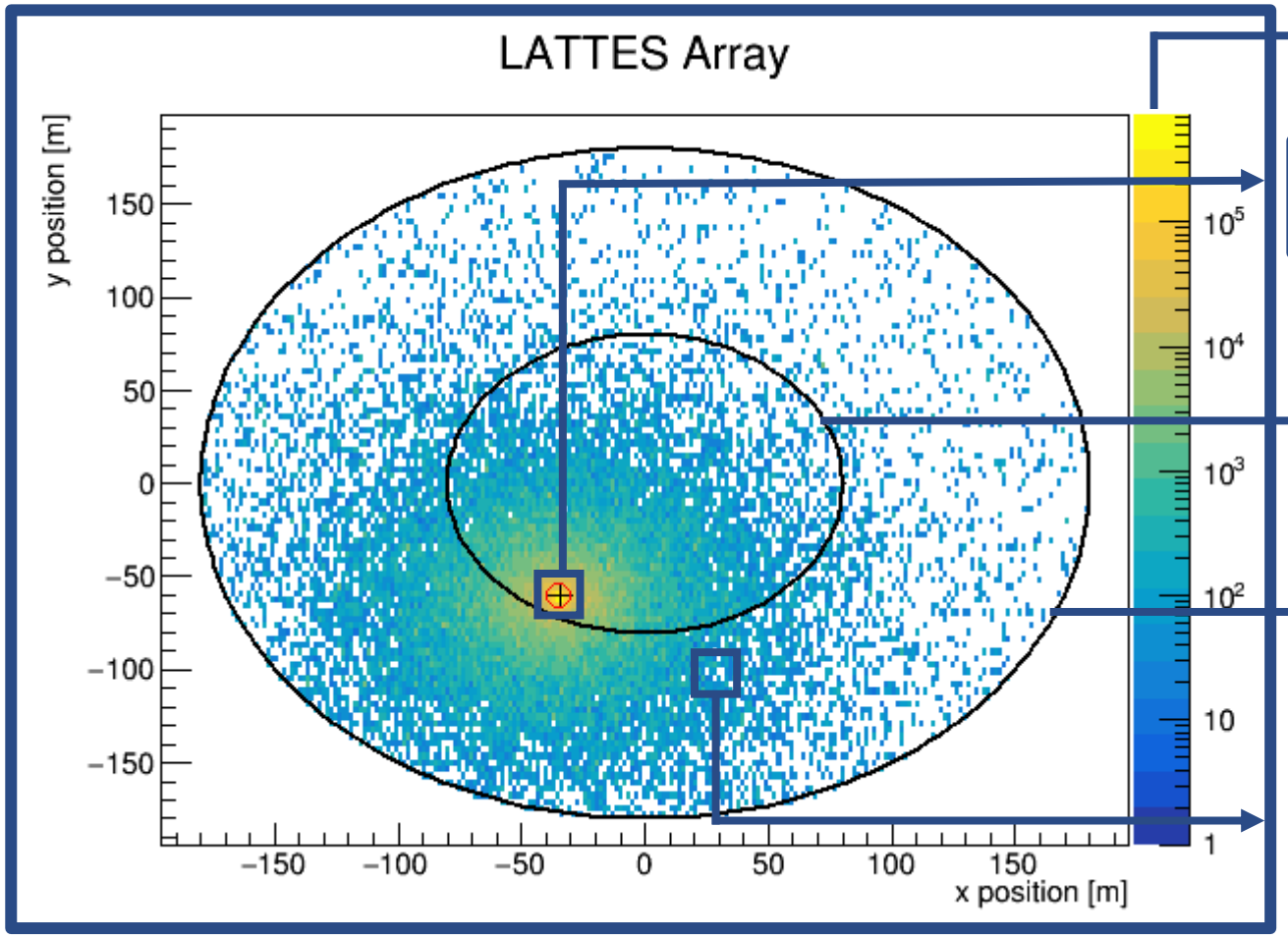
Characterizing the responses of the stations

- Describing the events, visualizing them graphicly and tracing their fit curve

- Discovery of failed events correspondent to failed fits that opens up more improvement for LATTES

- E0;
- Erec;
- WCD x position;
- WCD y position;
- WCD Signal;
- CoreSim;
- CoreRec;
- CoreRecBar

LATTES: Event Visualizer I



Intensity scale of Cherenkov signal

+ : Simulated Core(CoreSim) of γ-Ray

○ : Reconstructed Core(CoreRec) of γ-Ray

Dense Region, i.e, CoreArray

Radius = $80\ m$; Area ≈ $20\ 000\ m^2$

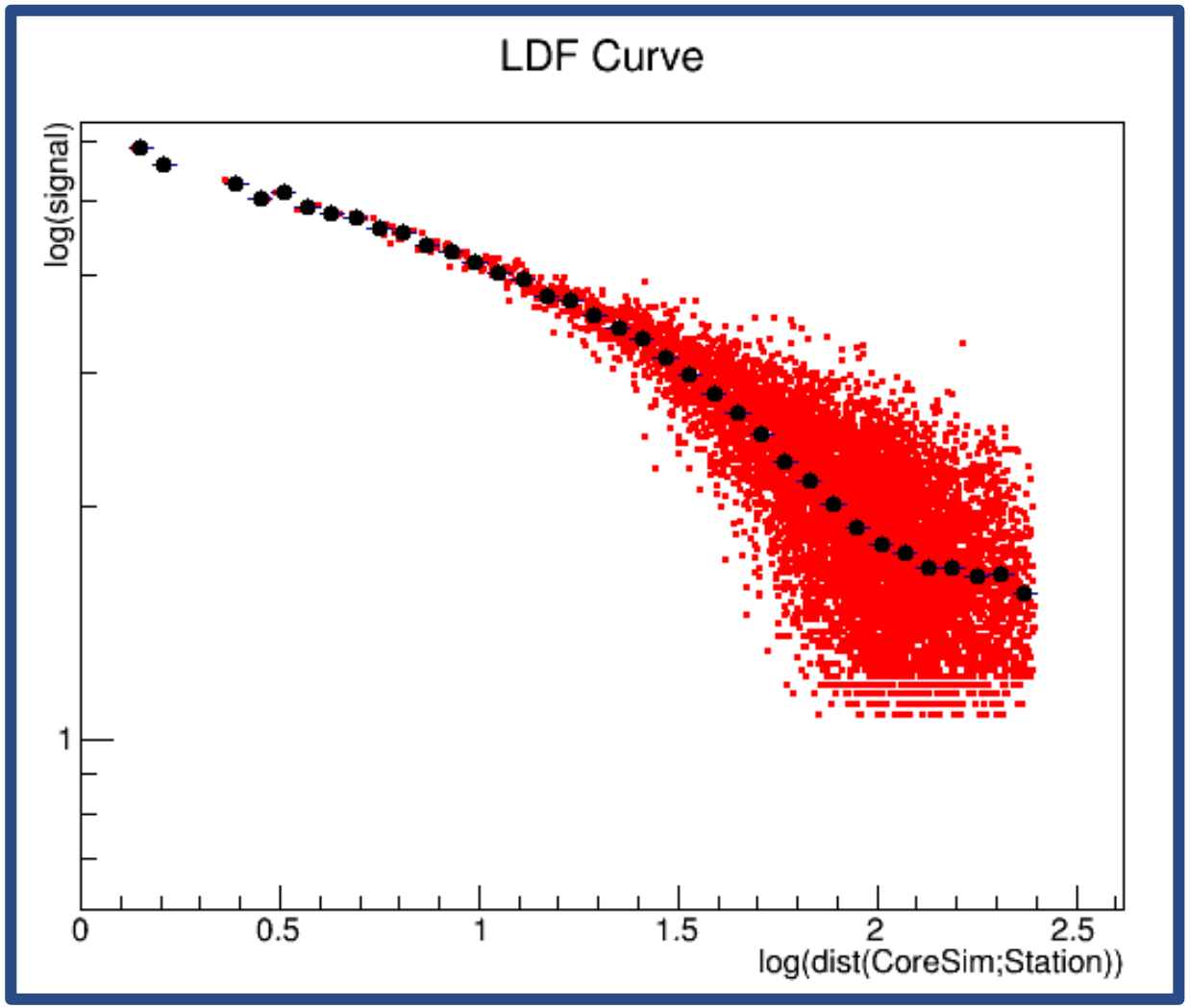
Sparse Region, i.e, SparseArray

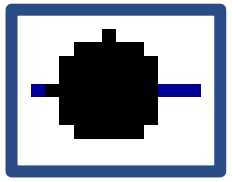
Radius = $180\ m$; Area ≈ $100\ 000\ m^2$

One Single Station

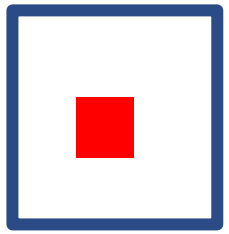
$3\ m$ x $1.5\ m$

LATTES: Event Visualizer II

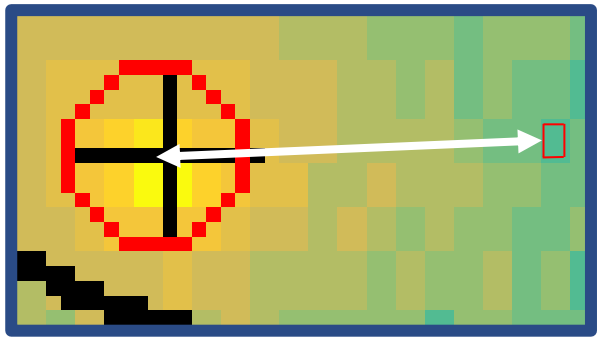




Medium of y value for each x bin
- ROOT object: TProfile

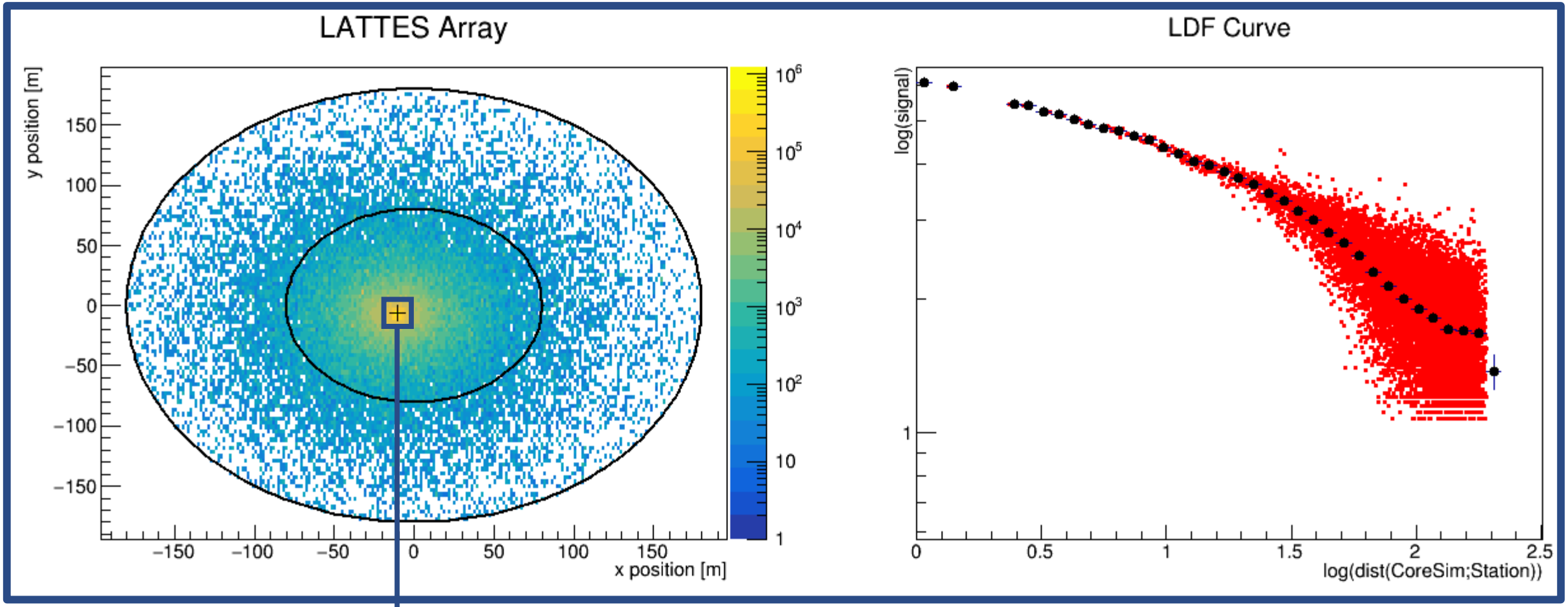


Value of y to given x
- ROOT object: TGraph



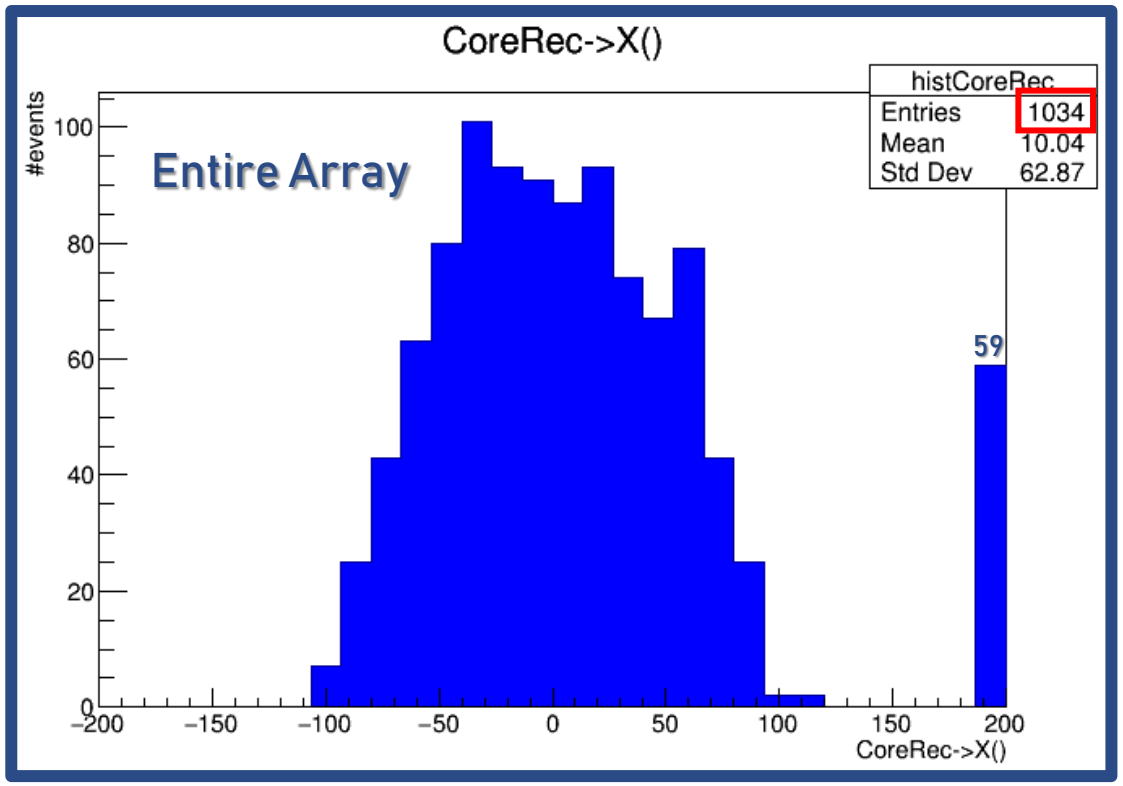
Distance between CoreSim and one single station: x value used

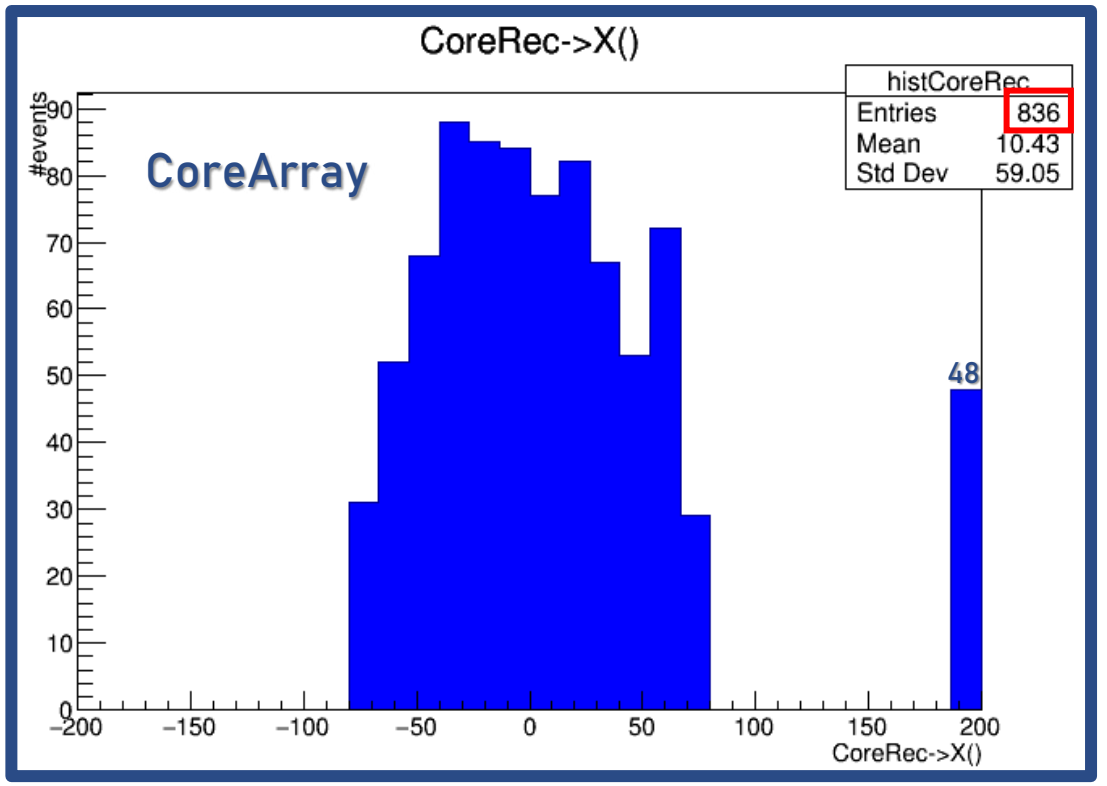
Events with failed CoreRec



No CoreRec (○)

How many events?





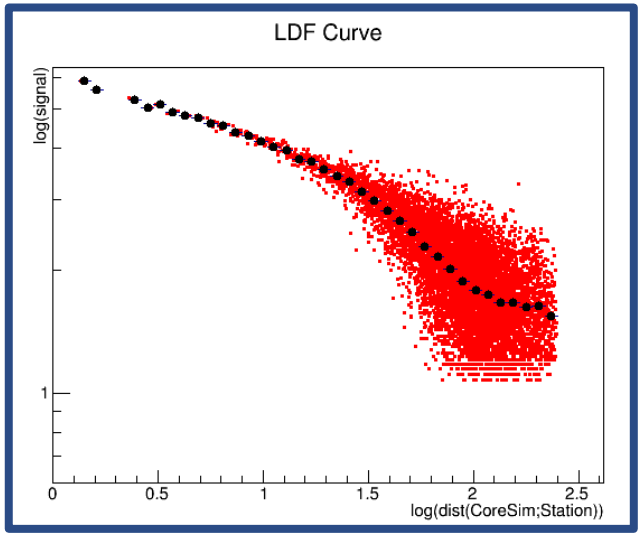
- % of failed events in Entire Array: $\frac{48}{836} \approx 5.74\ \%$
- % of failed events in CoreArray: $\frac{59}{1034} \approx 5.706\ \%$

$\frac{48}{59} = \boxed{81\%}$

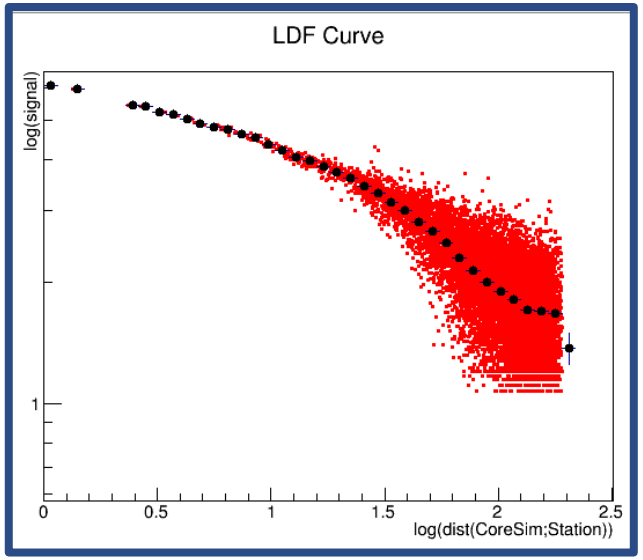
A shift in the focus of the project…

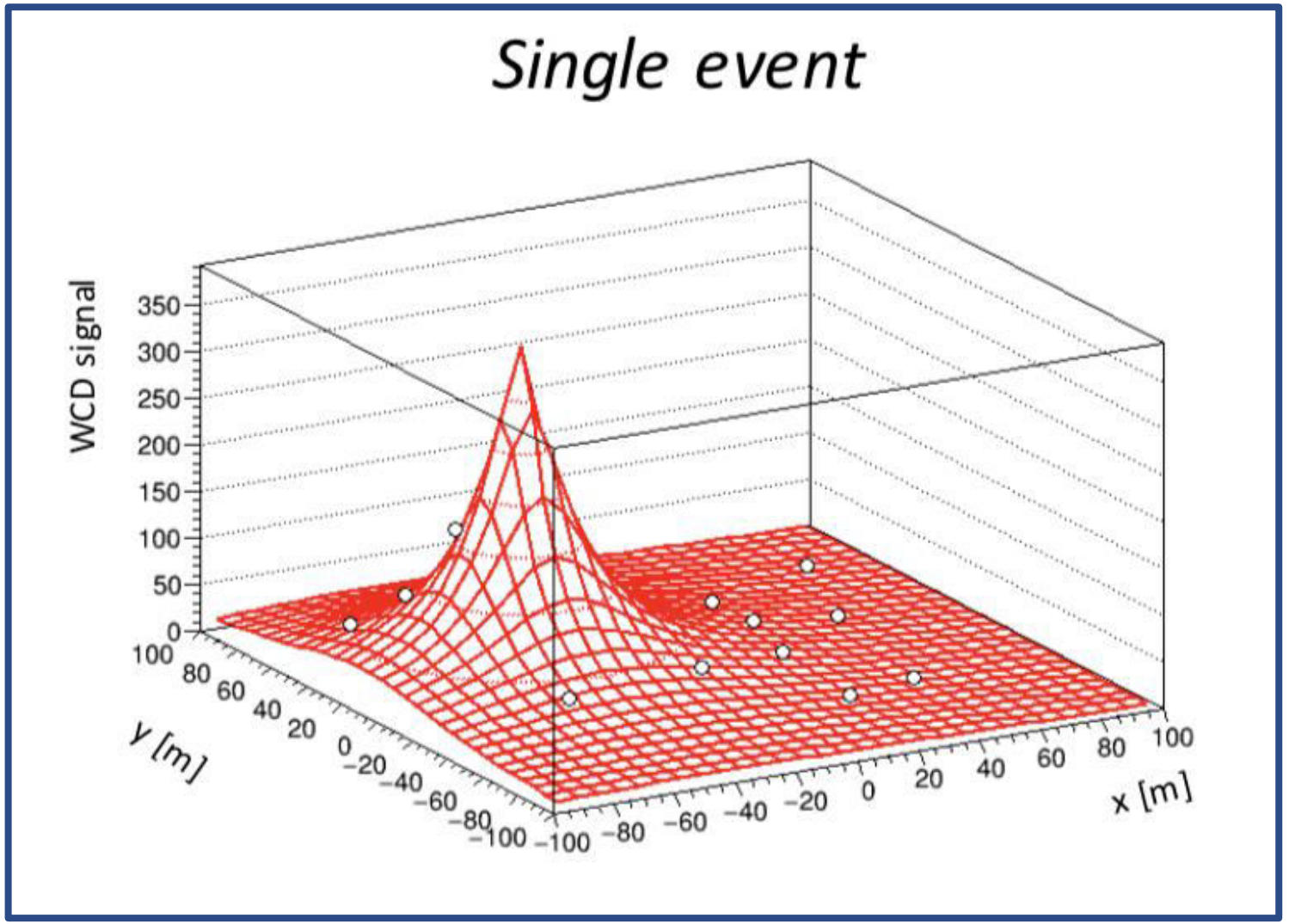
Analysing Failed Events

Fit OK



Fit Fail





Summary

- LATTES has a strong potential to study astrophysical γ-rays

- Improvements were identified in current LATTES reconstruction and will be further developed