Comments on LATTES low energy reconstruction

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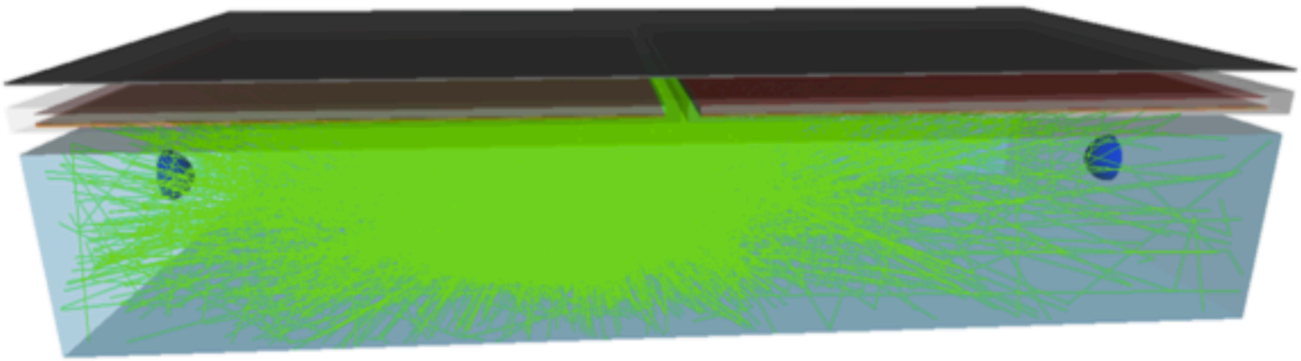
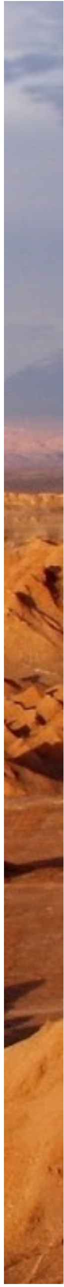
For the LATTES team

7th LATTES meeting, Coimbra, September 28th 2018



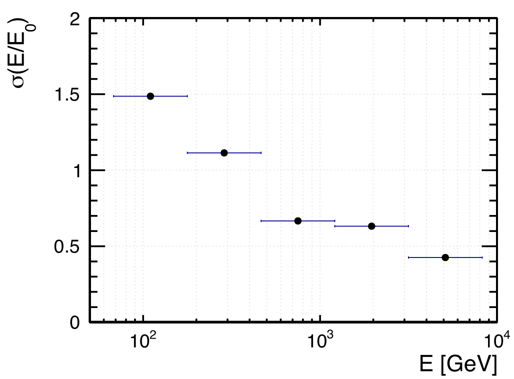
LATTES

Can this detector concept be used to accurately detect and reconstruct low energy gamma-ray showers (~100 GeV)?

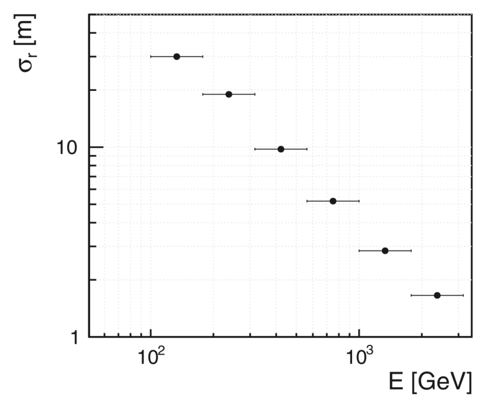


LATTES performance

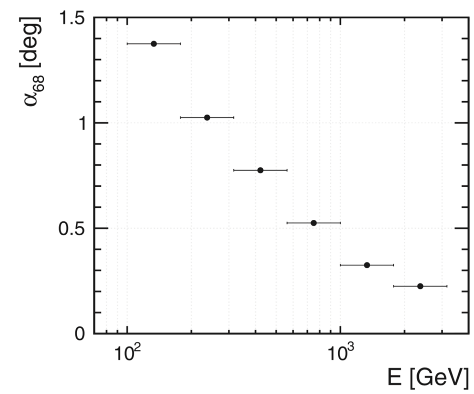
Energy Res



Core Res



Angular Res

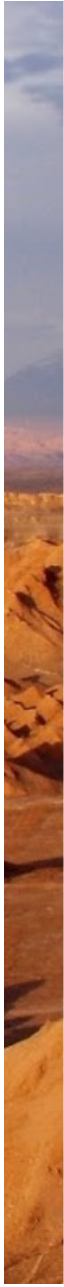


E = 200 GeV

sigma(E) = 100%

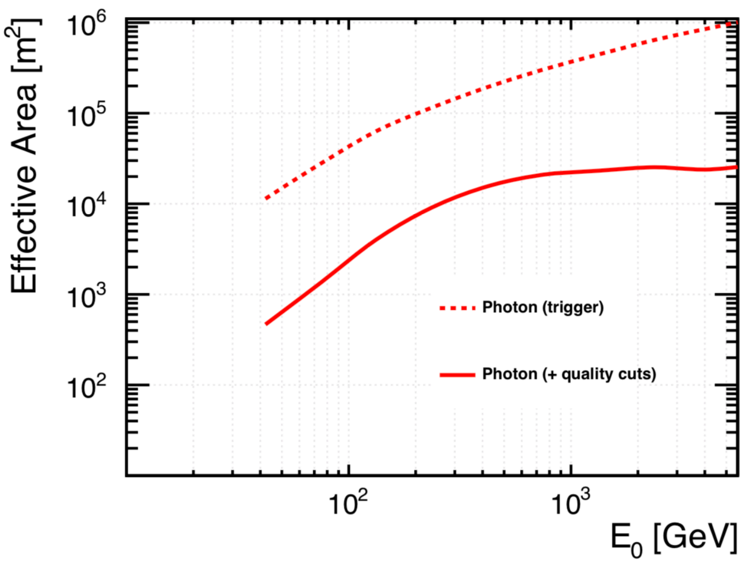
sigma(r) = 20 m

sigma(α) = 1°

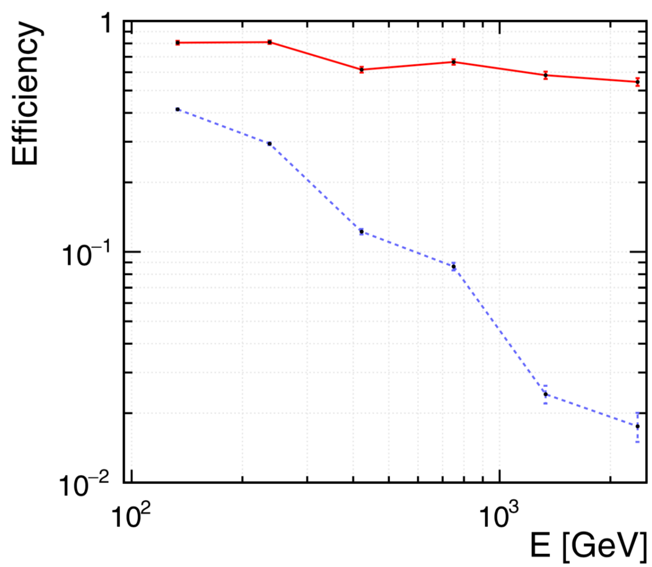


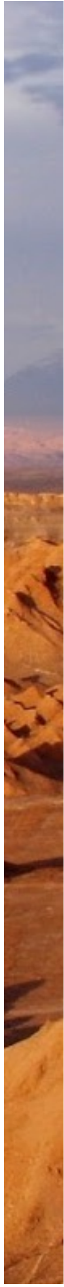
LATTES performance

Effective Area



G/H discrimination



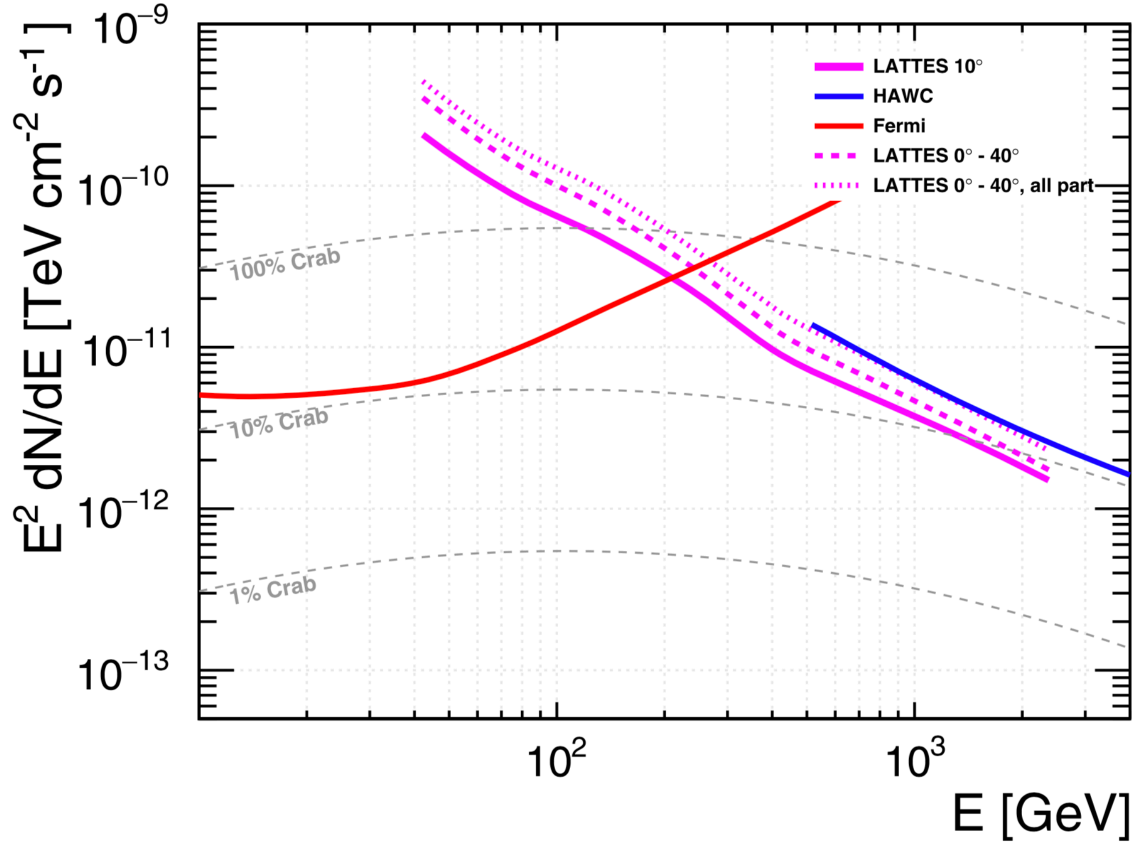


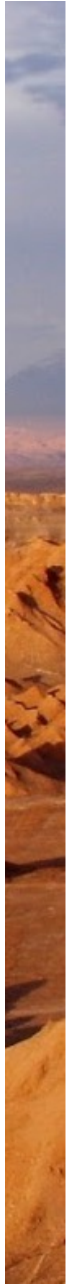
E = 200 GeV

Eff Area = 8 x 10^3 m^2

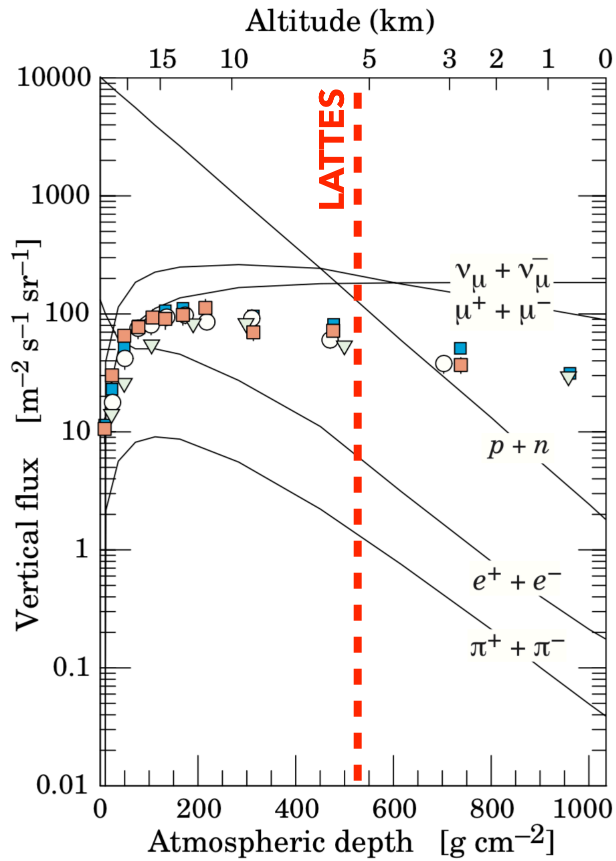
g_eff = 80% ; h_rej = 30%

LATTES performance



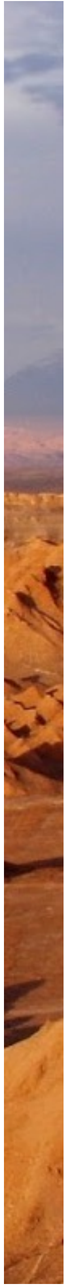


Same sensitivity as Fermi at E = 200 GeV but with an effective area about 10 000 times bigger

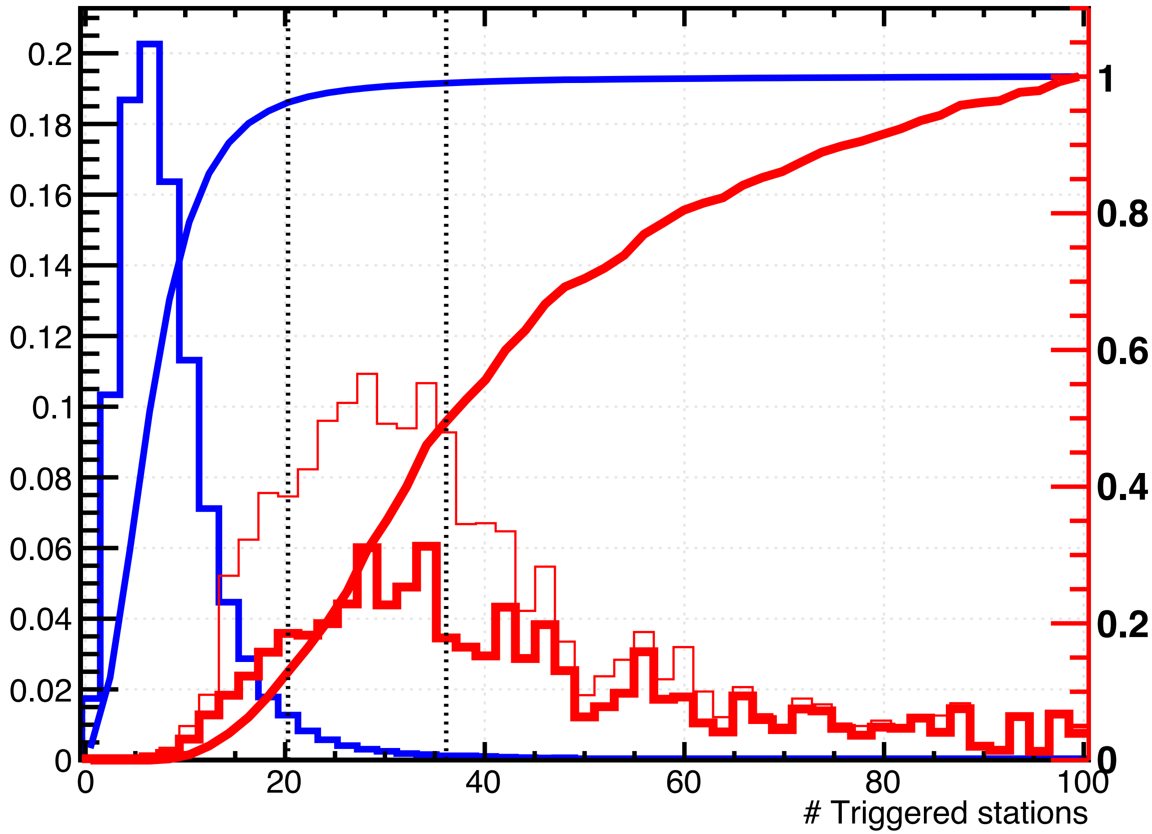


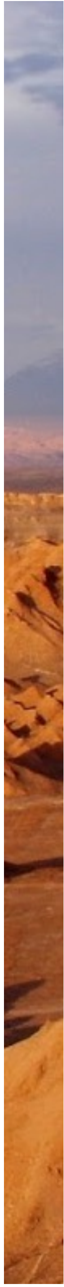
Atmospheric Particles

However, one has to deal with accidental cosmic rays that might contaminate gamma events



Typical numbers at E ~ 100 GeV

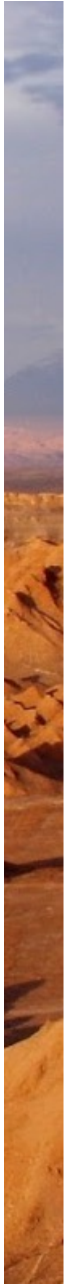




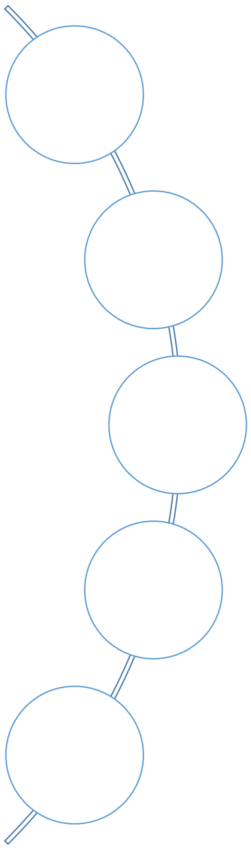
Nb Stations Background	Nb Stations Gamma Shower
8	**30**

What is a shower?

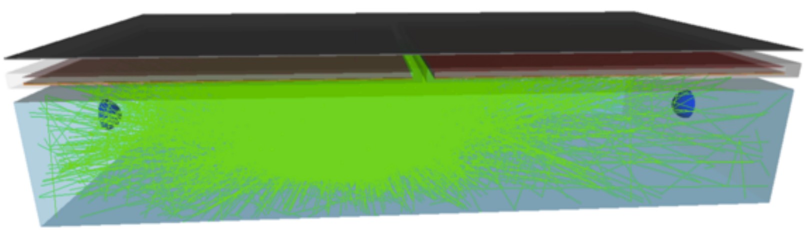
Let us have a look in to the LATTES shower geometry…



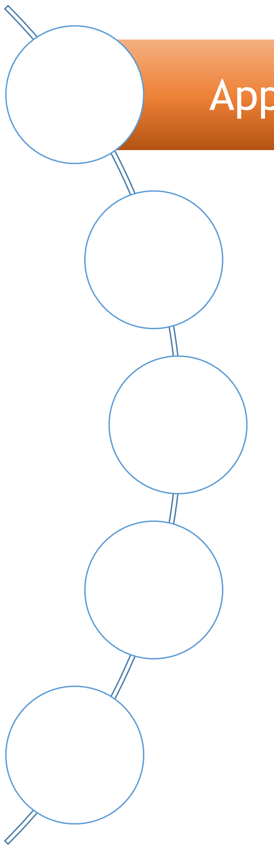
Reconstruction of shower geometry

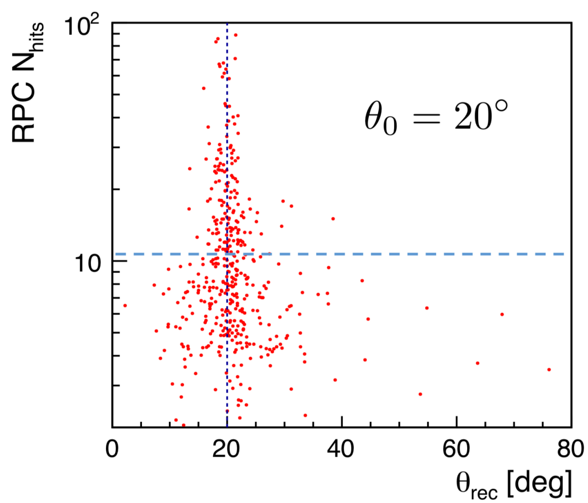


- Use RPC hit time information
  - Take advantage of high spatial and time resolution
  - Used time resolution of 1 ns

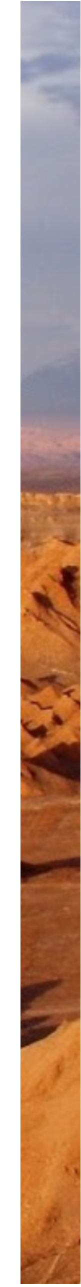


Reconstruction of shower geometry

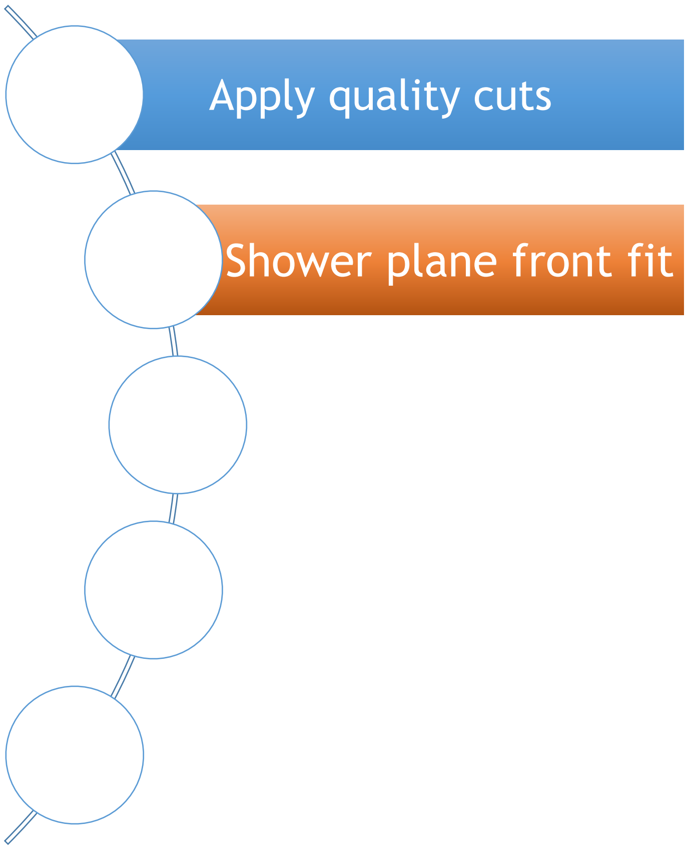




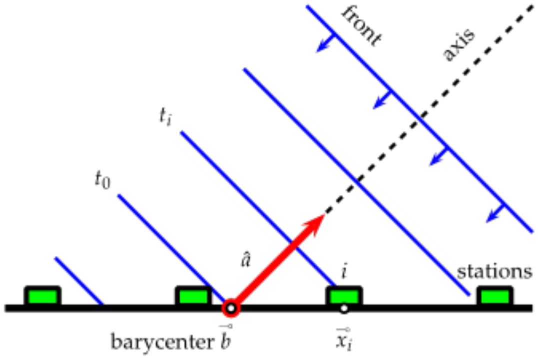
- ✧ Use RPC hit time information
  - ✧ Apply previous shower rec quality cuts
  - ✧ Apply cuts on the number of registered hits on the RPCs
  - ✧ Consider only RPCs in triggered WCD stations

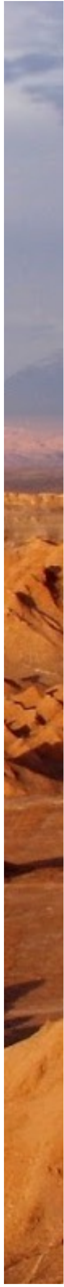


Reconstruction of shower geometry

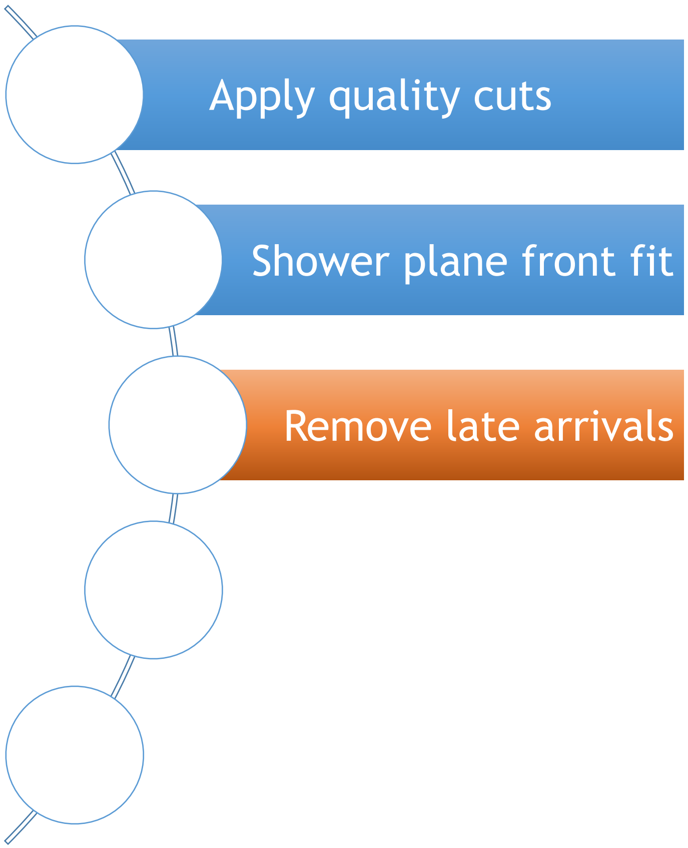


- Use RPC hit time information
- Perform shower reconstruction
- Use shower front plane approximation
- Analytical procedure

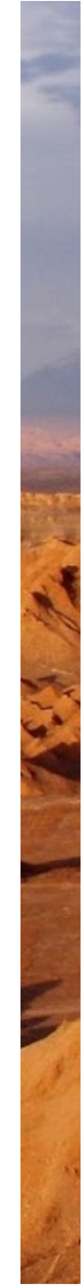




Reconstruction of shower geometry

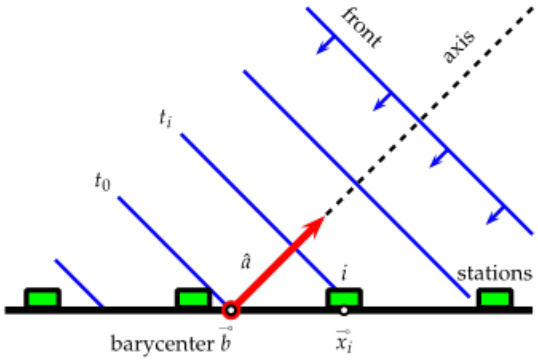


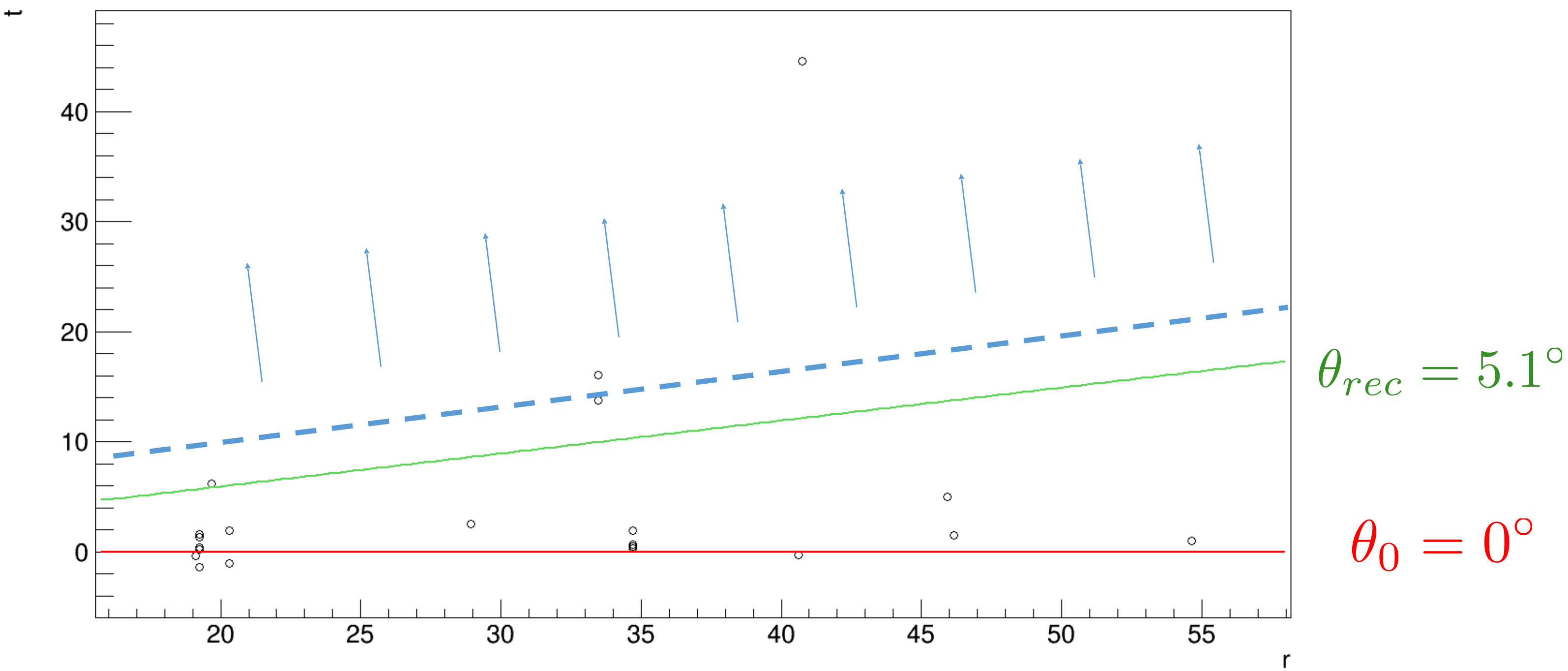
- Use RPC hit time information
  - Identify late arrivals with respect to Rec Shower Front
  - Mainly low energy electrons that lost correlation with shower front

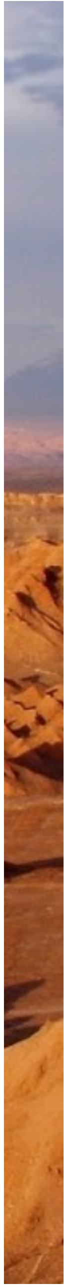


Removal of late arrivals

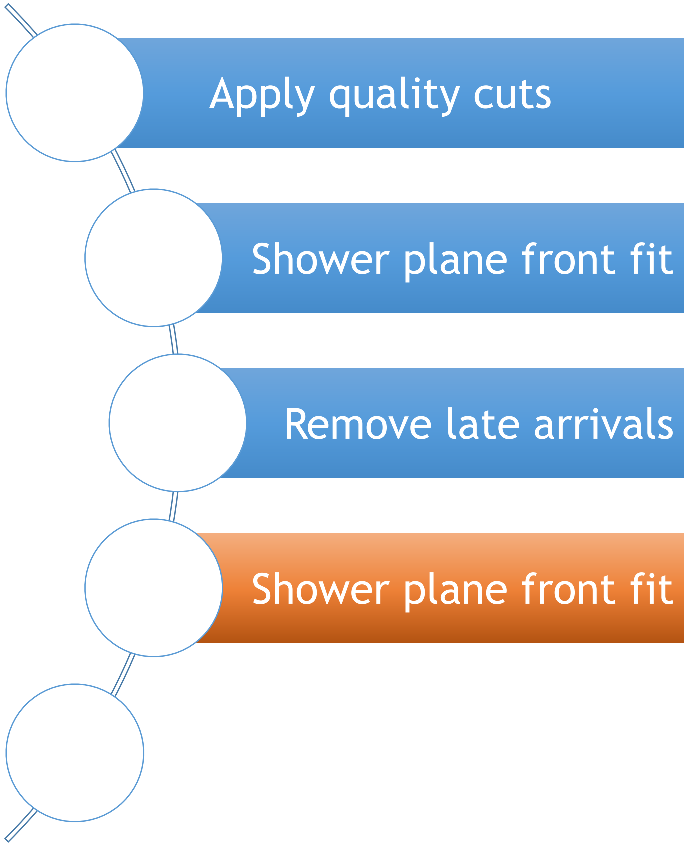
- Example of a vertical gamma shower
- Plot depicts arrival time (ns) distance to simulated shower core (m)



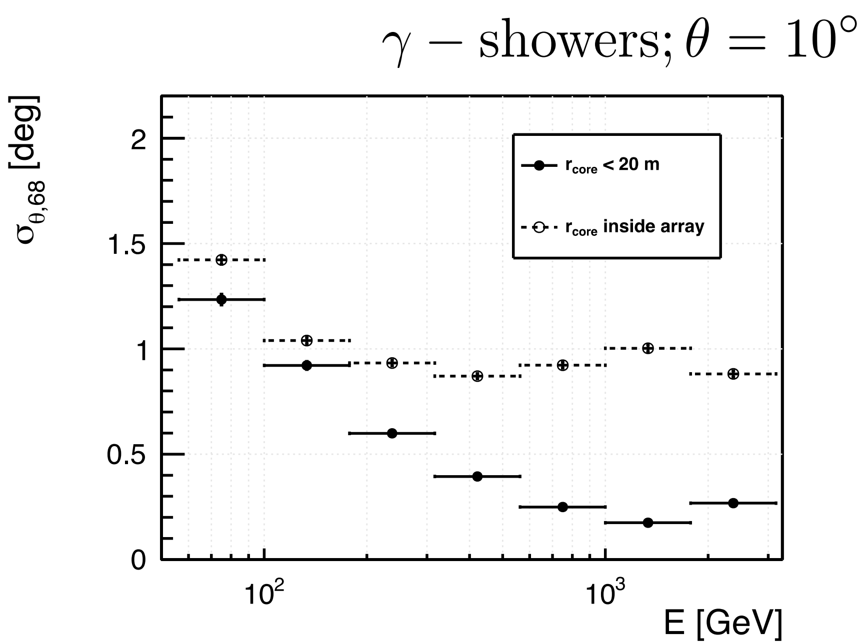


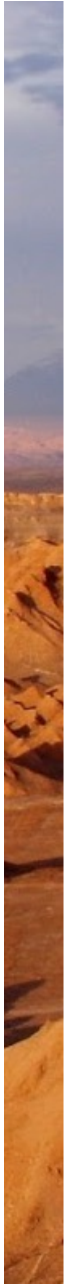


Reconstruction of shower geometry

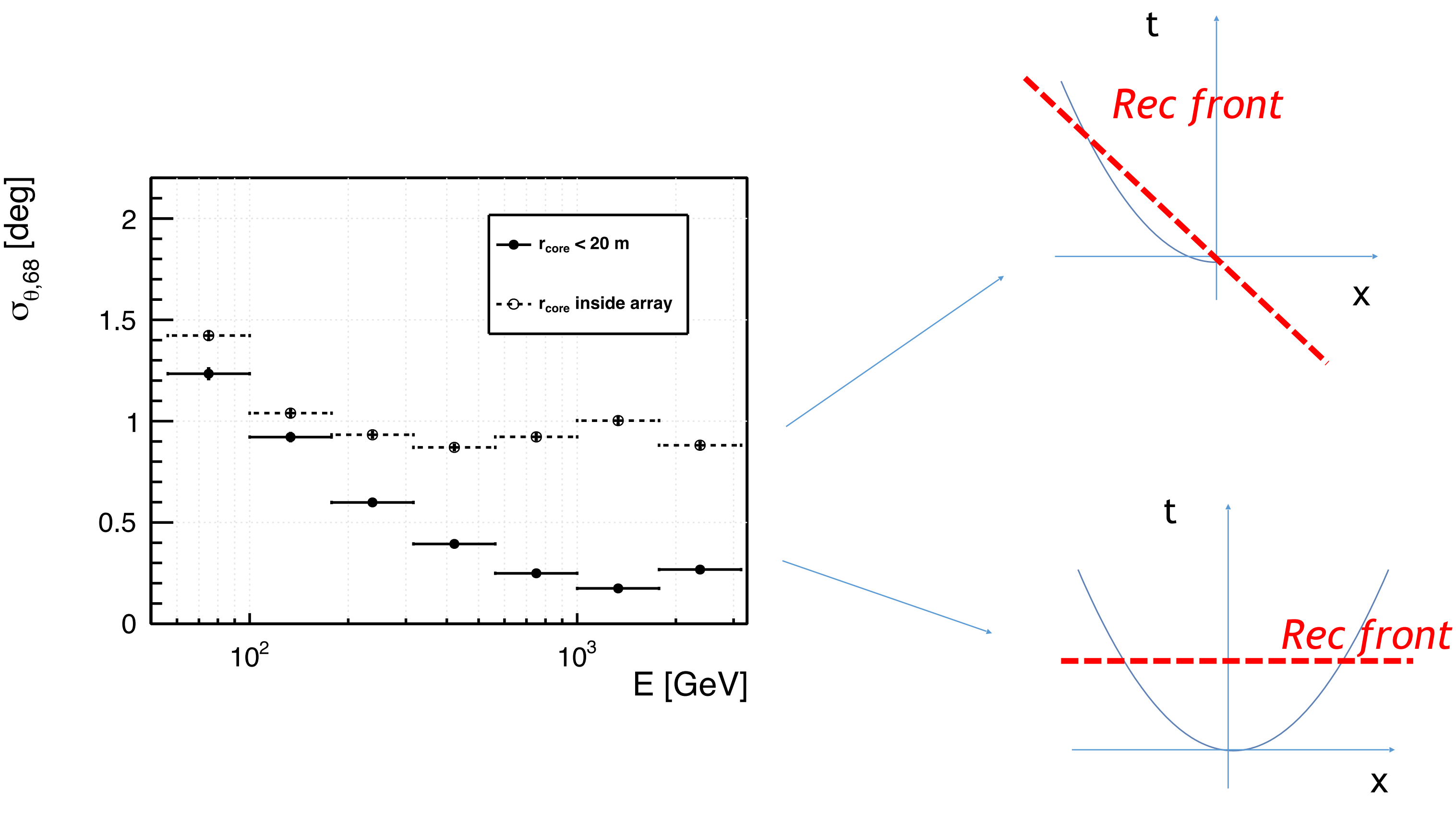


- Use RPC hit time information
  - Repeat fit without arrivals
  - Initial guess for next step



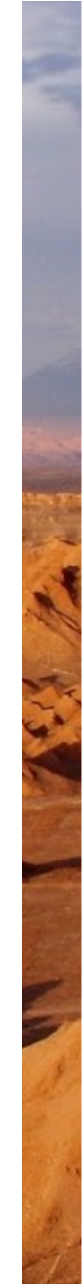


Impact of shower curvature



Solution: implement a conic fit instead of fitting a plane

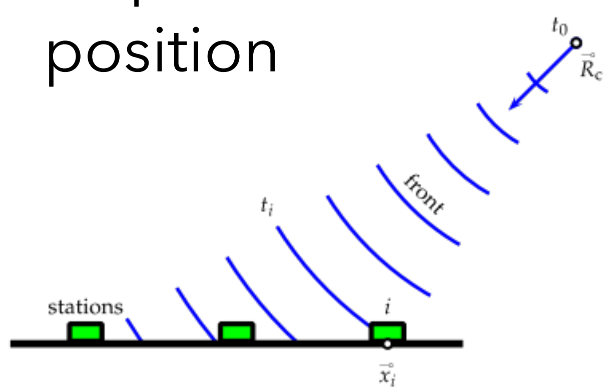
$$\chi^2 = \sum (c \cdot (T_n - T_0) - X_n \cdot -Y_n \cdot m - R_n \cdot \alpha)^2$$



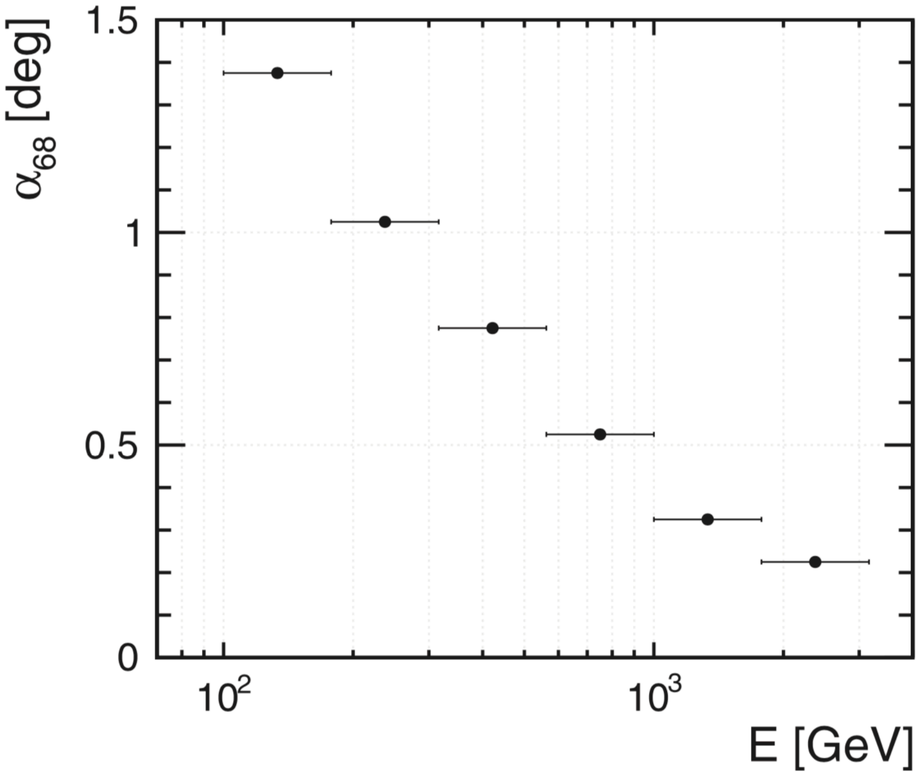
Reconstruction of shower geometry

1. Apply quality cuts
2. Shower plane front fit
3. Remove late arrivals
4. Shower plane front fit
5. Shower conic front fit

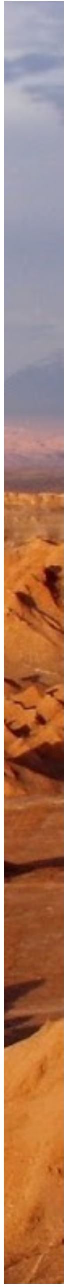
- Use RPC hit time information
  - Fit the shower geometry using a shower conic front model
  - Depends on core position



Shower geometry reconstruction

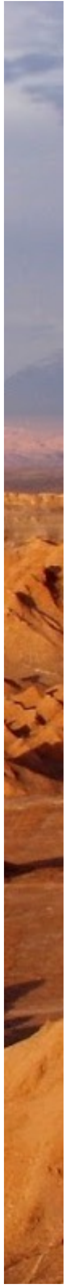


A good angular resolution can be achieved for all events reconstructed inside the array



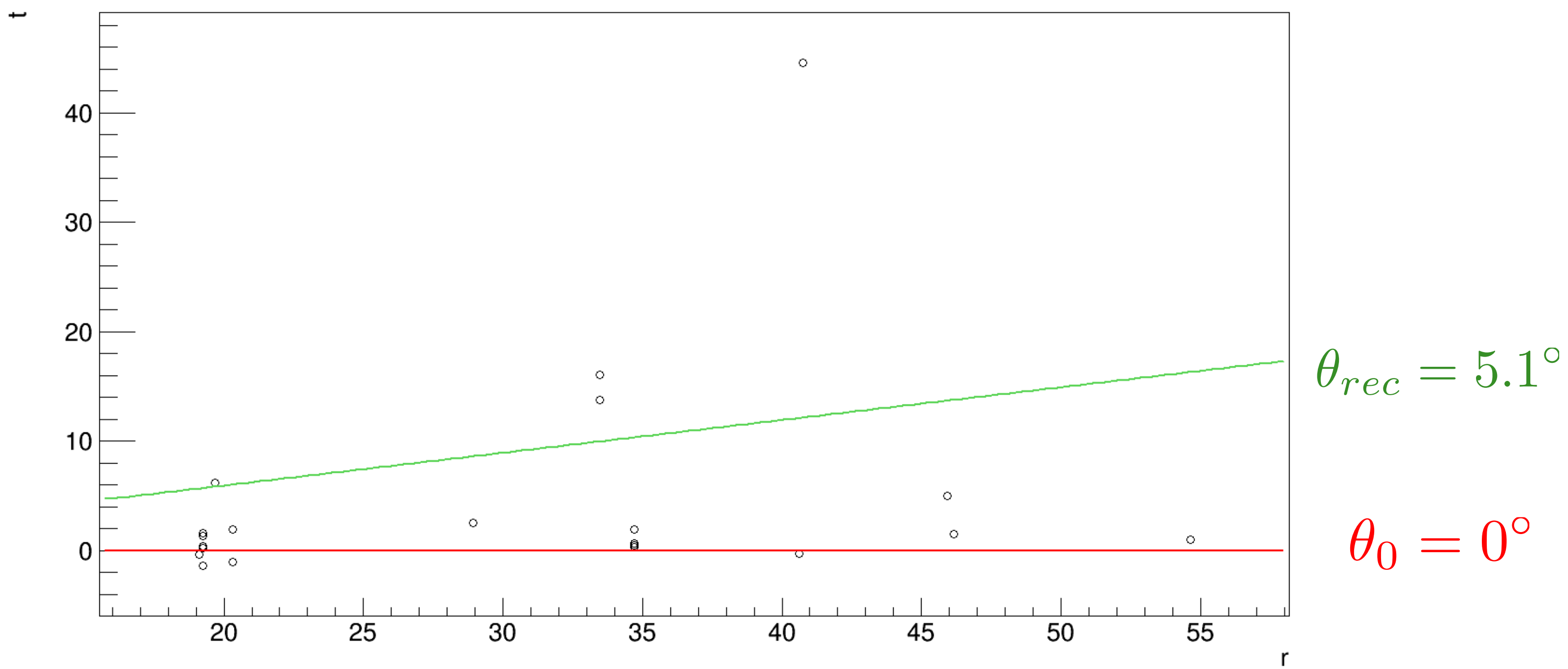
How to remove accidental stations?

A brainstorming….



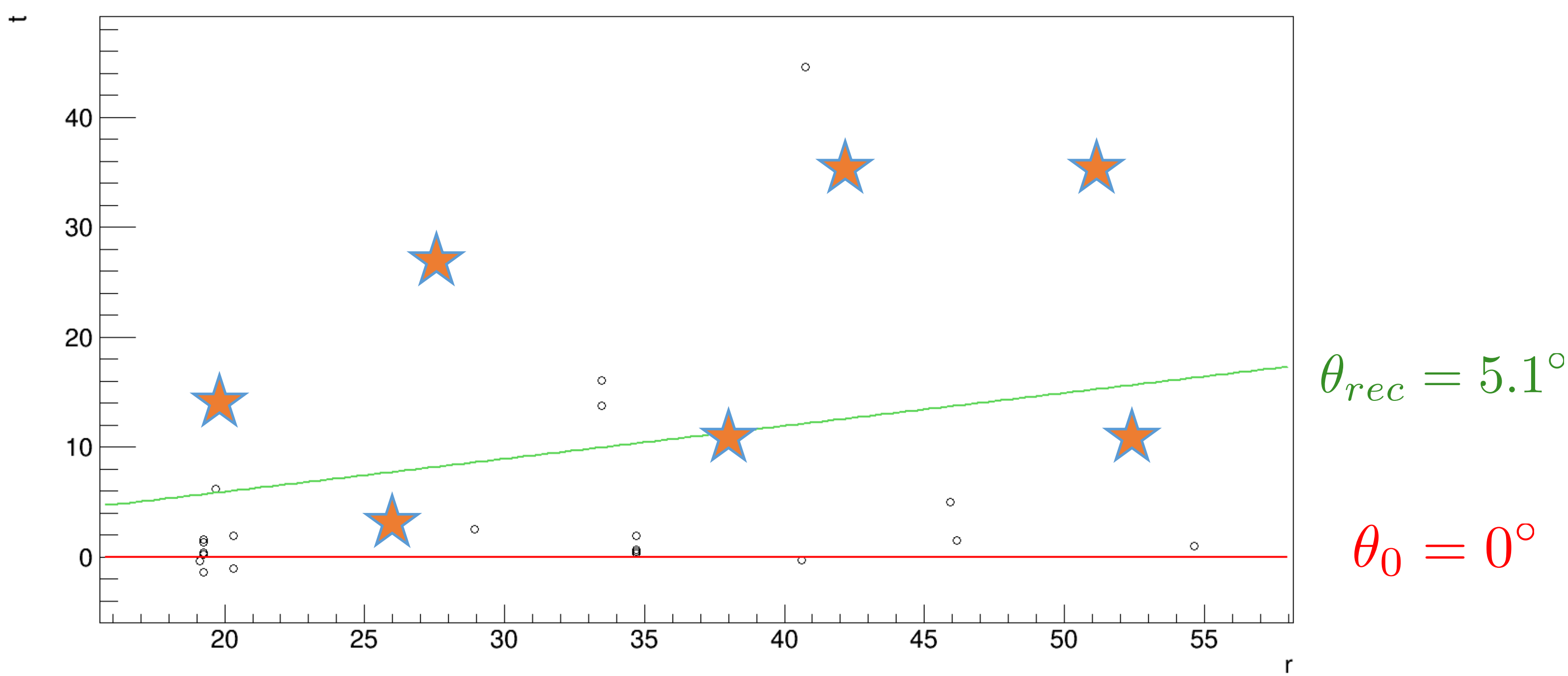
Possible strategy to eliminate accidentals

- Reverse engineer strategy to eliminate late arrivals



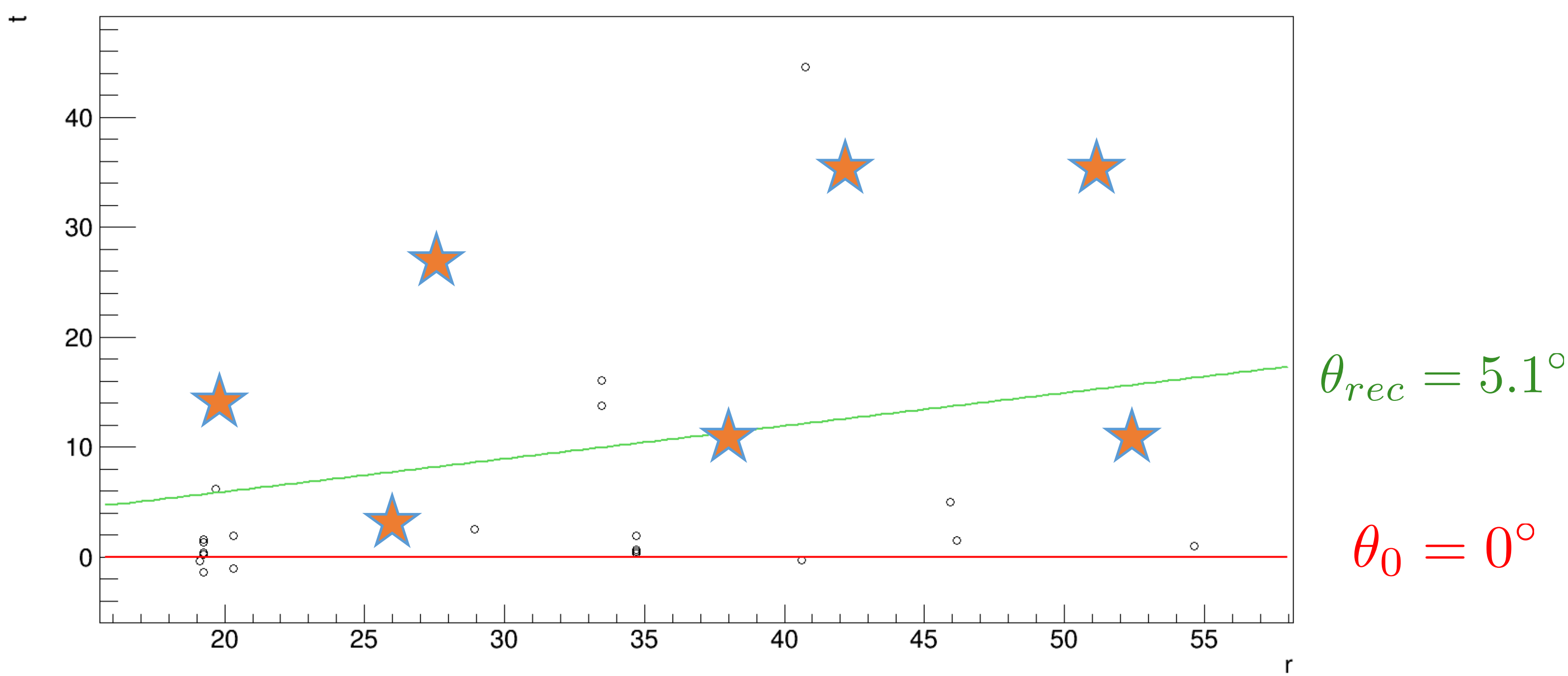
Possible strategy to eliminate accidentals

- Reverse engineer strategy to eliminate late arrivals
- This plot would be uniformly contaminated with accidentals



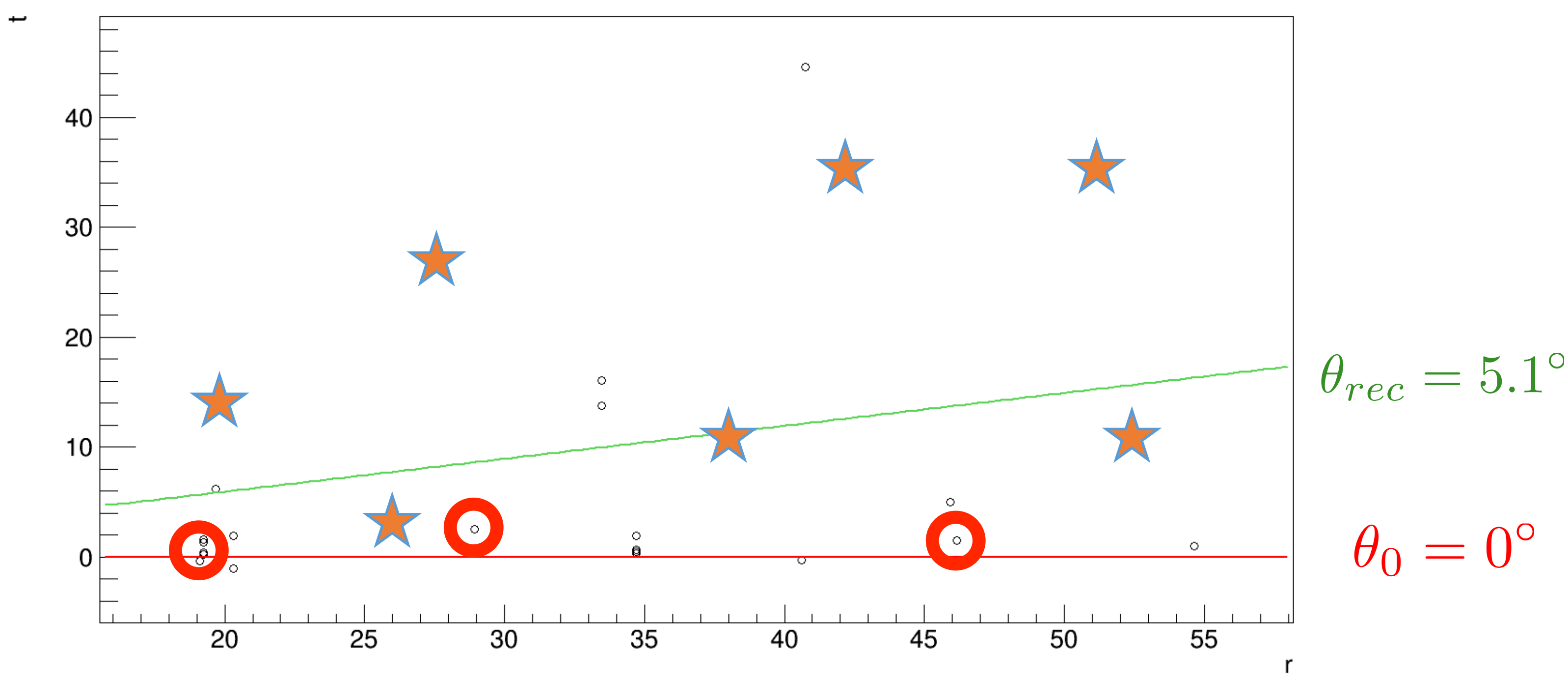
Possible strategy to eliminate accidentals

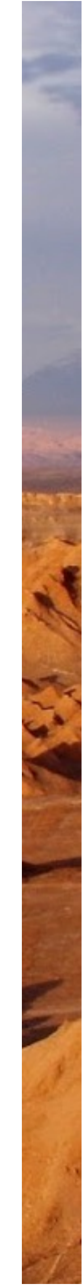
- Only a problem if they fall far from the shower plane
  - Given the standard LATTES reconstruction, accidentals in the shower plane should have a reduced impact on:
    - Core and energy determination
    - g/h discrimination



Identify the shower plane

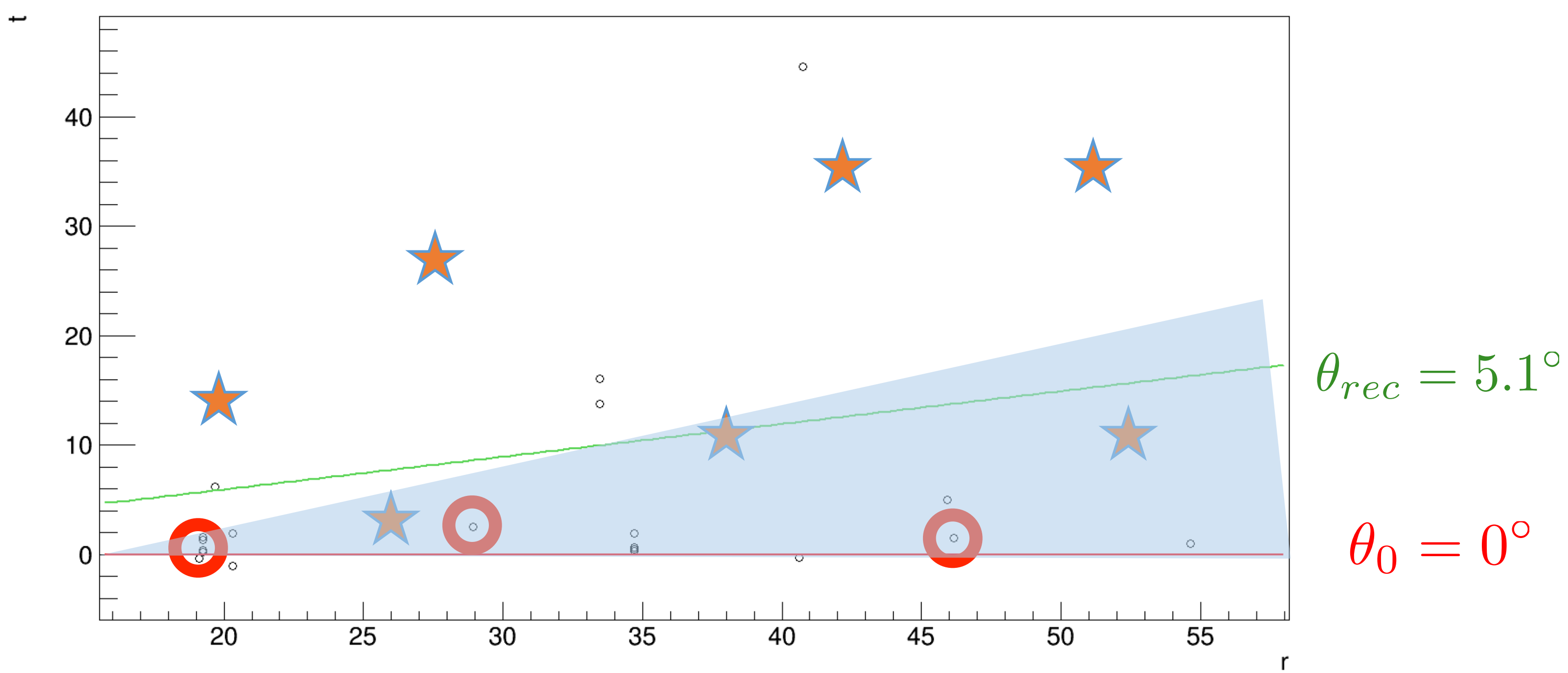
- Look for important stations:
  - High WCD signal
  - Multiple hits in the RPCs
  - Clustering in space-time (complex problem: ANN)
- Important step to define probable shower core





Identify the shower plane

- Use RPCs high segmentation and time resolution to exclude events that fall 3 sigma of initial guess
  - Sigma to be defined by simulations
  - Iterative process until best fit of shower front



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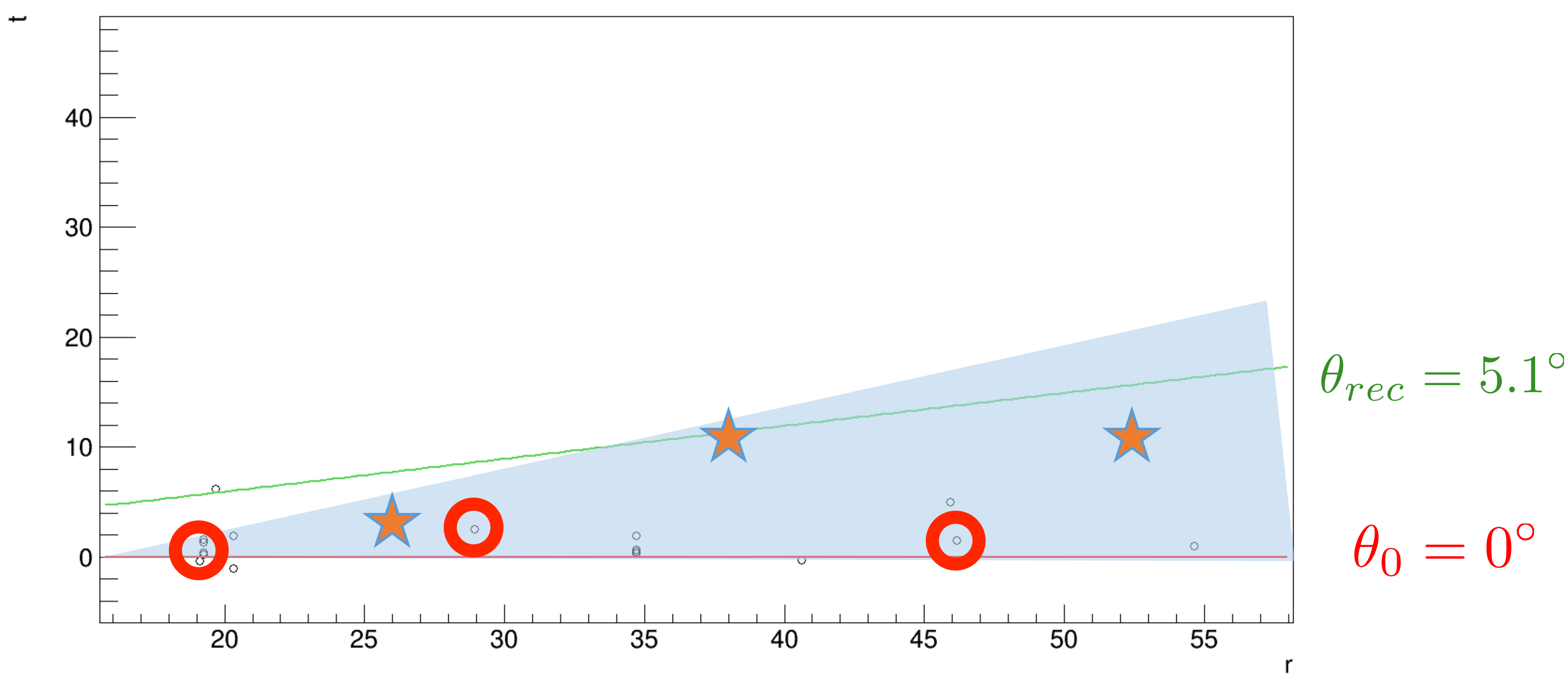
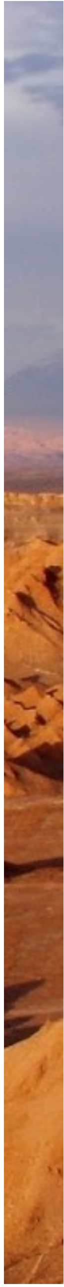
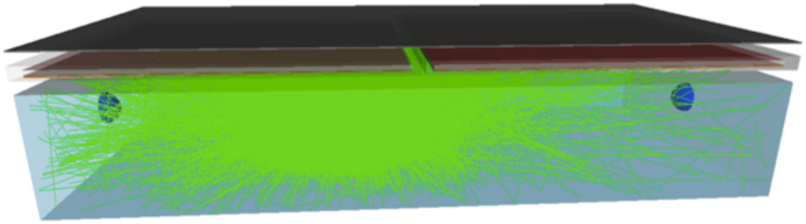
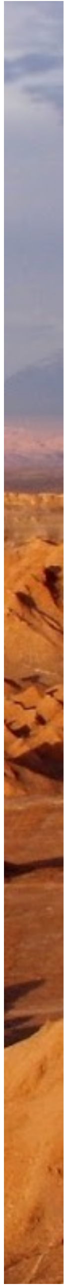




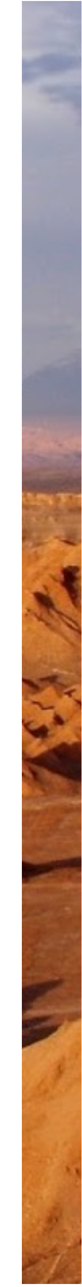
Next steps…

- Test this strategy using LATTES simulation + Accidentals simulation
- Re-assess performance of:
  - Energy, core and angular reconstruction
- Check efficiency of method and impact on:
  - Effective area
  - Sensitivity curve





Acknowledgements



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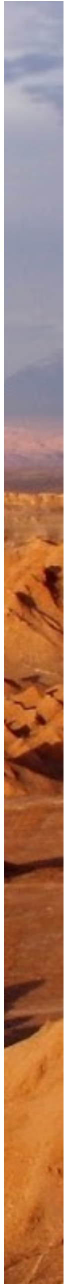
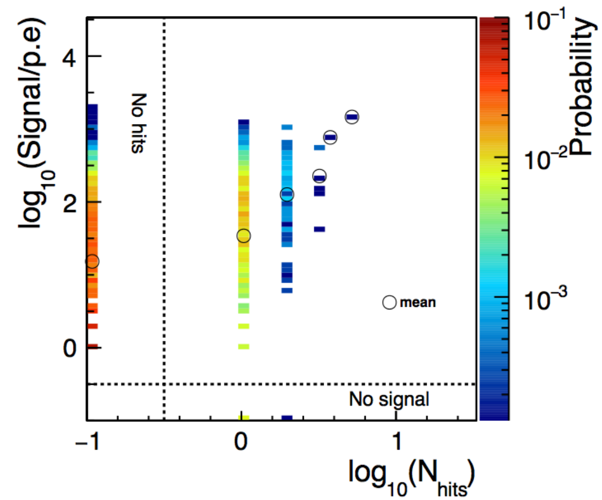
Backup slides

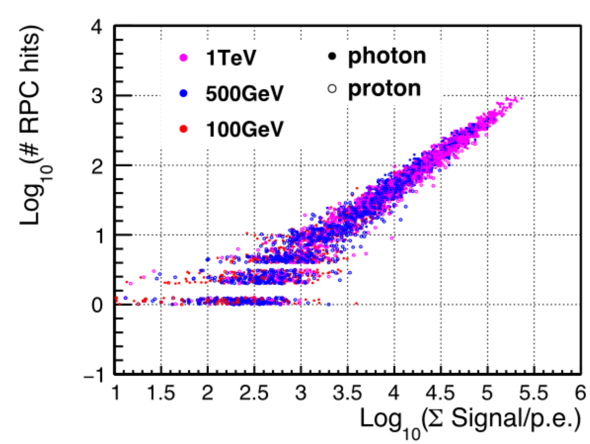


LATTES: a hybrid detector

- 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

WCD vs RPC (station level)

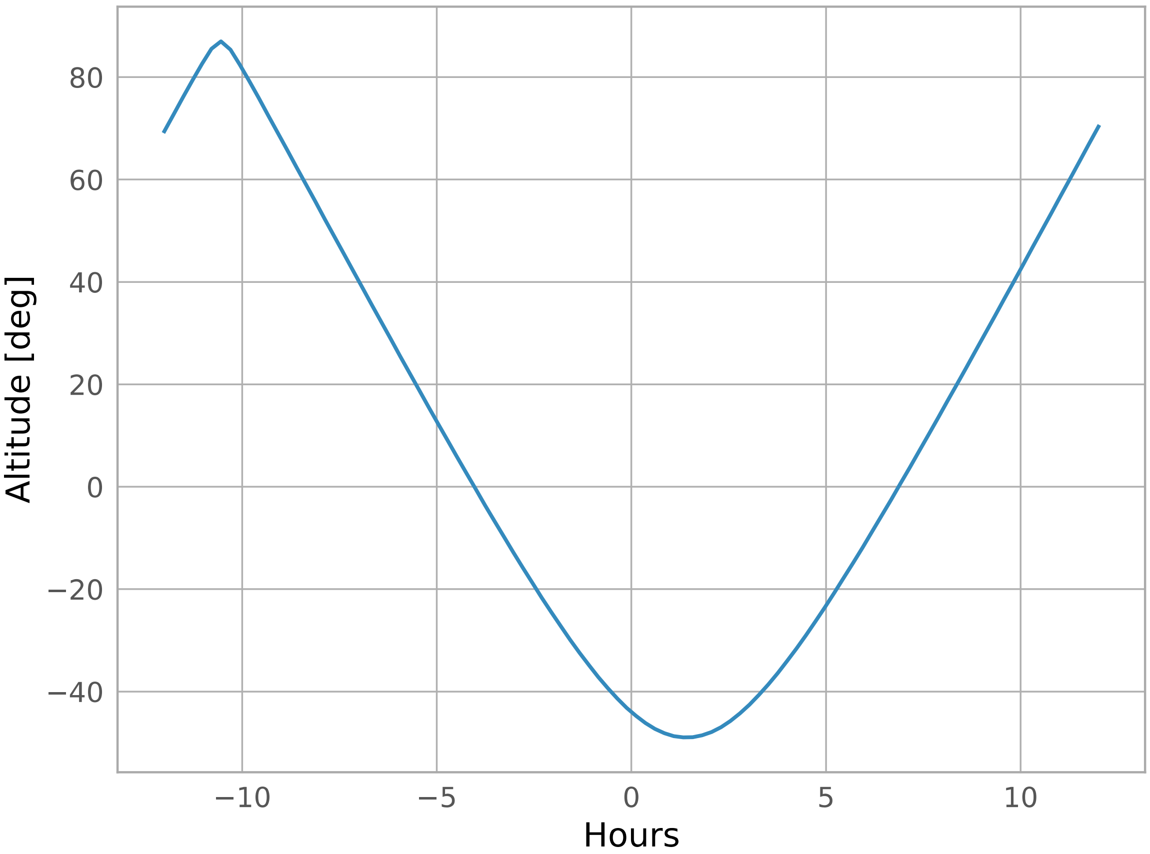


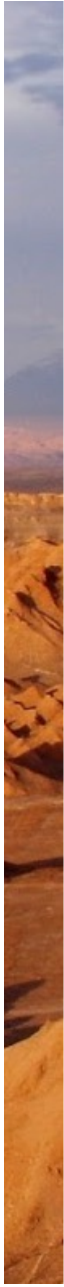


Complementarity

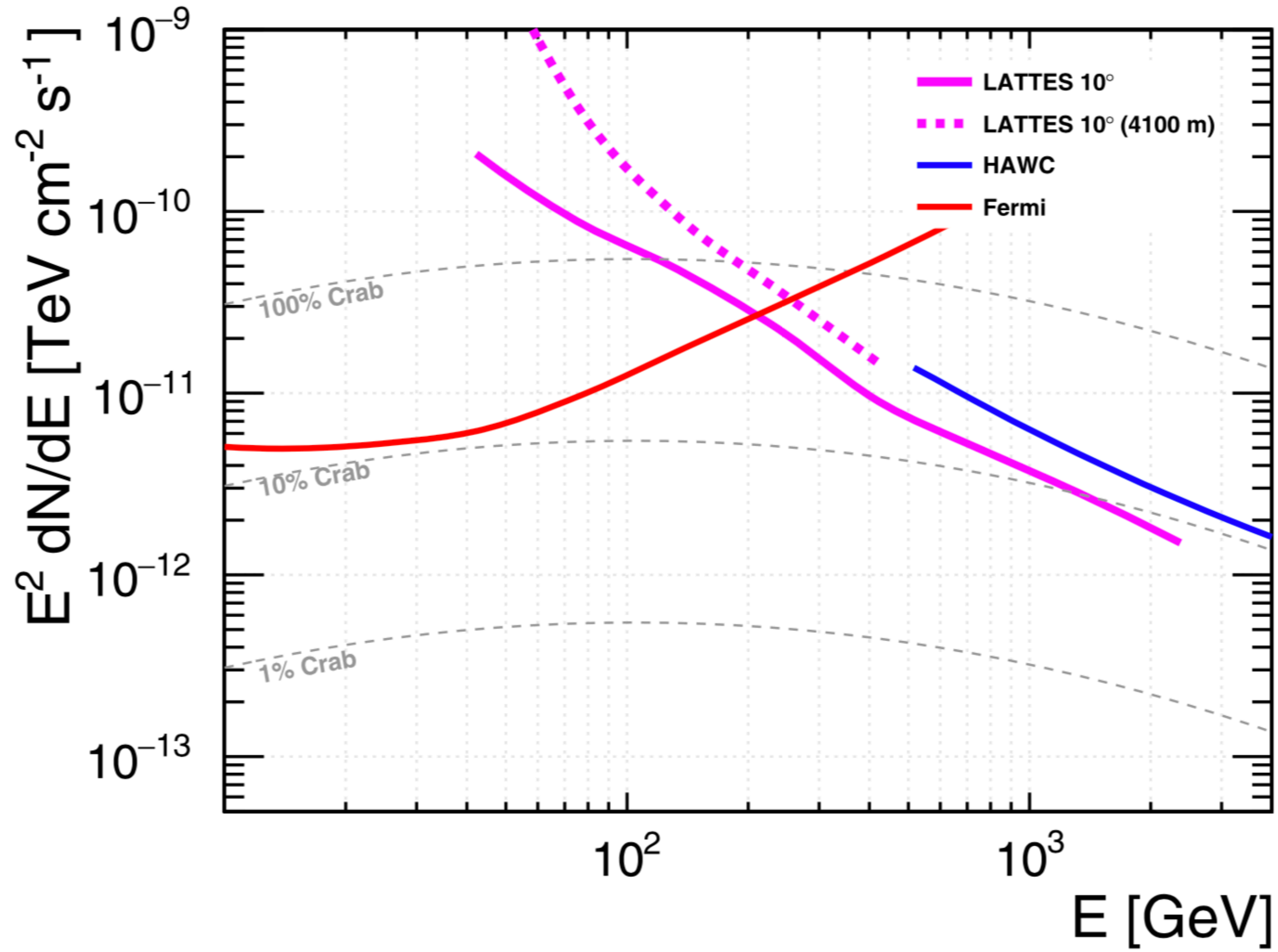
Inter-calibration

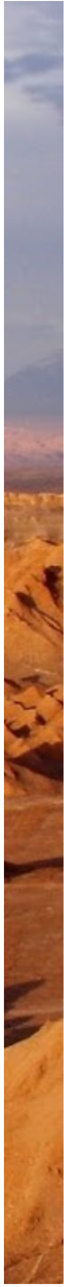
Crab





Impact of altitude





Reconstruction efficiency