MAX-PLANCK-INSTITUT FÜR KERNPHYSIK

Astrophysical motivations for the construction of a wide FoV gamma-ray observatory in the southern hemisphere

R. López-Coto, H. Schoorlemmer, J. Hinton, V. Joshi, A. Jardin-Blicq, P. Surajbali, A. Viana -
Workshop on a wide field-of-view Southern Hemisphere TeV gamma-ray observatory - Puebla -11/11/16

Motivation

- We know we want to build a wide FoV VHE gamma-ray observatory in the Southern Hemisphere, but why?
  - -> Need to find physical motivations to convince funding agencies.

- The physics that will be on the reach of this detector will also influence its design and location.

- We need to be able to answer the questions:
  - Is this type of detector necessary?
  - Are there any sources that can only be observed by this instrument?
  - Can it perform better than any other instrument for given types of sources?

First idea:
Beat the IACT technique

- IACT Technique: Reasons for success
  - Powerful technique with:
    - large collection areas: ~10^5 m^2
    - good and improving angular resolution: < 0.1 deg
    - good energy resolution: down to 15 %
    - Many sources to detect and characterize.

- Present: MAGIC, HESS & VERITAS -> Already a point-like sensitivity better than HAWC's at E<10 TeV

- Future: CTA

The main ¿competitor?: CTA

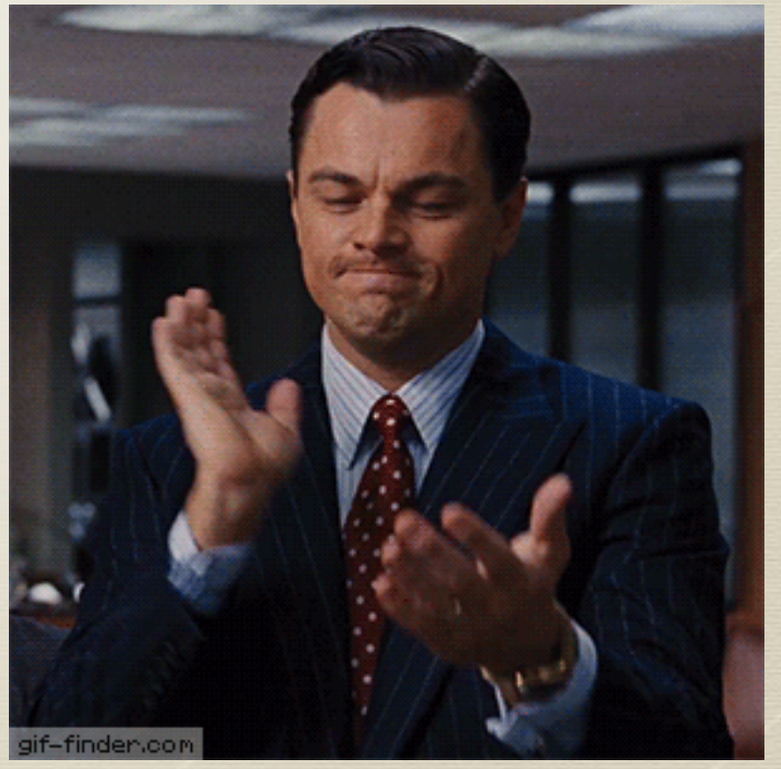
- See talk by D. Williams:
  - ~100 IACTs in the Southern Hemisphere.
  - ~10x better sensitivity that current IACTs.
  - < 10% energy resolution.
  - < 0.05 deg angular resolution.
  - ~ 8 deg FoV (telescope-dependent).

- Summary:
  - Outstanding point-like sensitivity.
  - Much better sensitivity to extended sources contained in the FoV than particle arrays.
  - Galactic plane survey will lead to a 2 mCrab sensitivity in the galactic plane.
  - Extragalactic plane survey will lead to a 6 mCrab sensitivity in 1/4 of the sky.

Conclusion

We should not (and effectively cannot) try to beat CTA

Thanks



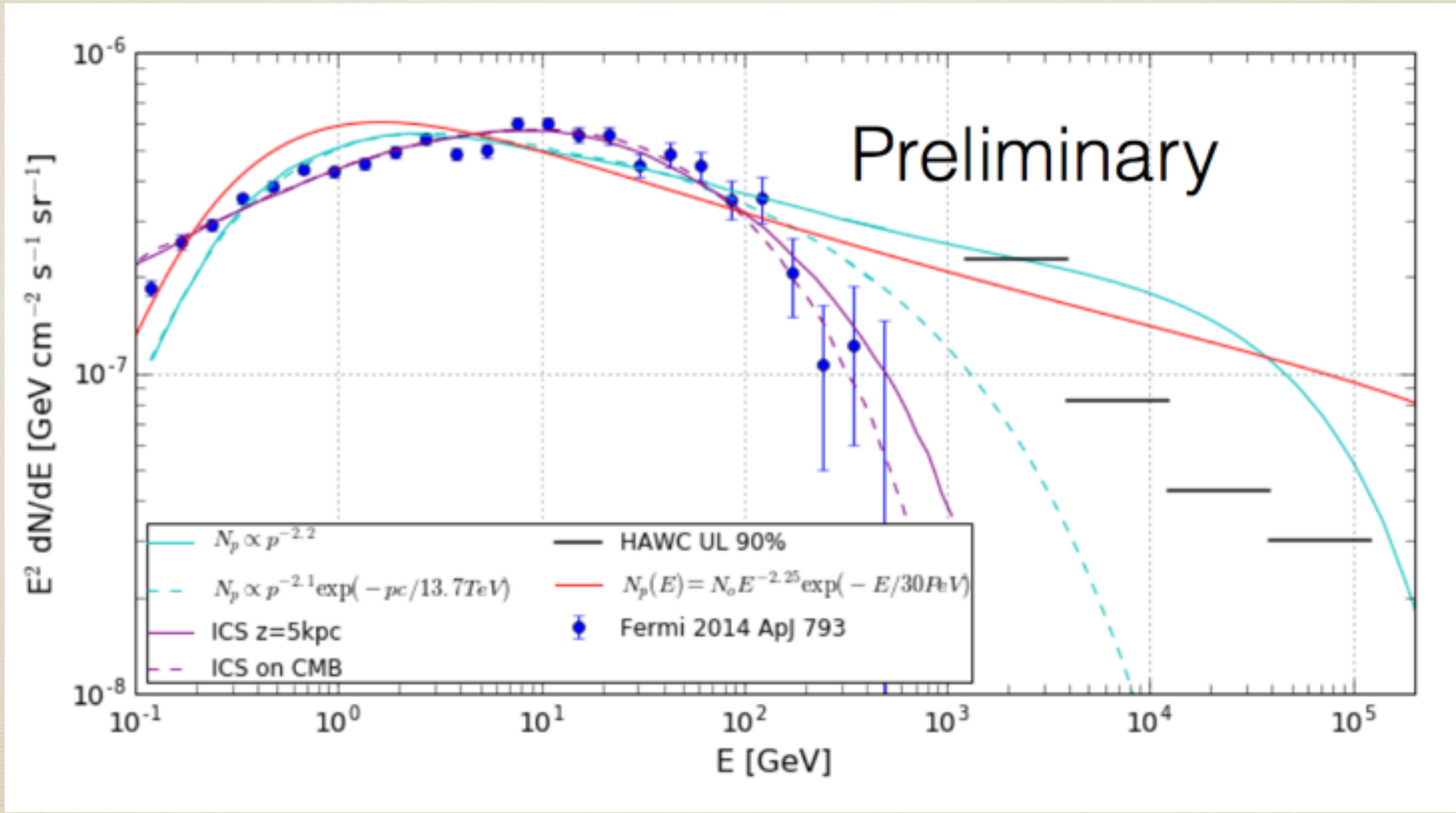
Physic cases evaluation

- Due to the forthcoming CTA, we will not be able to compete on point-like steady sources, not even at the highest energies
  - -> We should push to be **complementary**

- There are some things difficult for CTA as:
  - Very **extended** sources
  - **Strong flaring** sources lasting ~minutes
  - Flaring sources at sub-TeV energies to provide **triggers for CTA**
  - Continuous and unbiased monitoring of **transient events**

- We need to construct an instrument with:
  - ~ sr continuous sky coverage
  - Sensitive in the sub-TeV range for flaring events
  - Still with a good sensitivity at TeV energies for very extended sources.

Very extended sources



See talk by H. Ayala

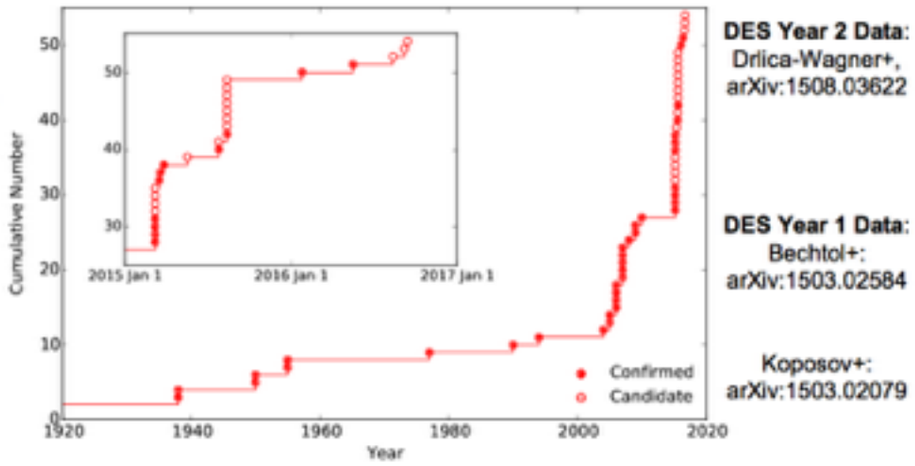
Triggers for IACTs

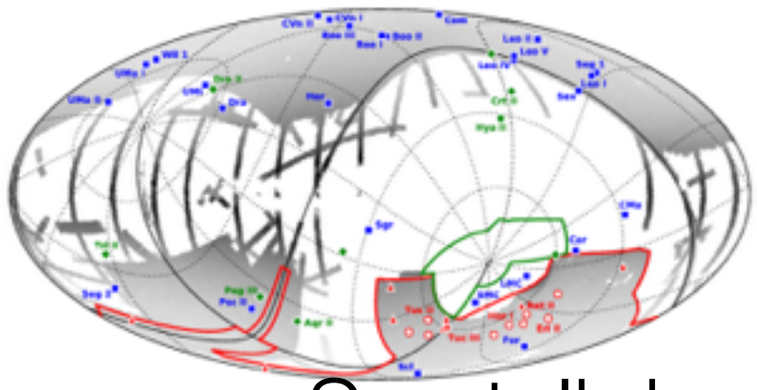
Southern Dwarf Galaxies

Los Alamos NATIONAL LABORATORY

13

- Dwarf galaxies are high-DM mass, low-luminosity objects
  - Stacked analysis limits DM well
- DES has discovered many new dwarf galaxies (and candidates)
  - All in Southern hemisphere
  - ~half of all known candidates
- LSST (at 30° South) will also find low-brightness objects like dwarfs
  - First science searches in 2021
- Will have lots of new dwarfs to stack
  - But mostly in Southern sky



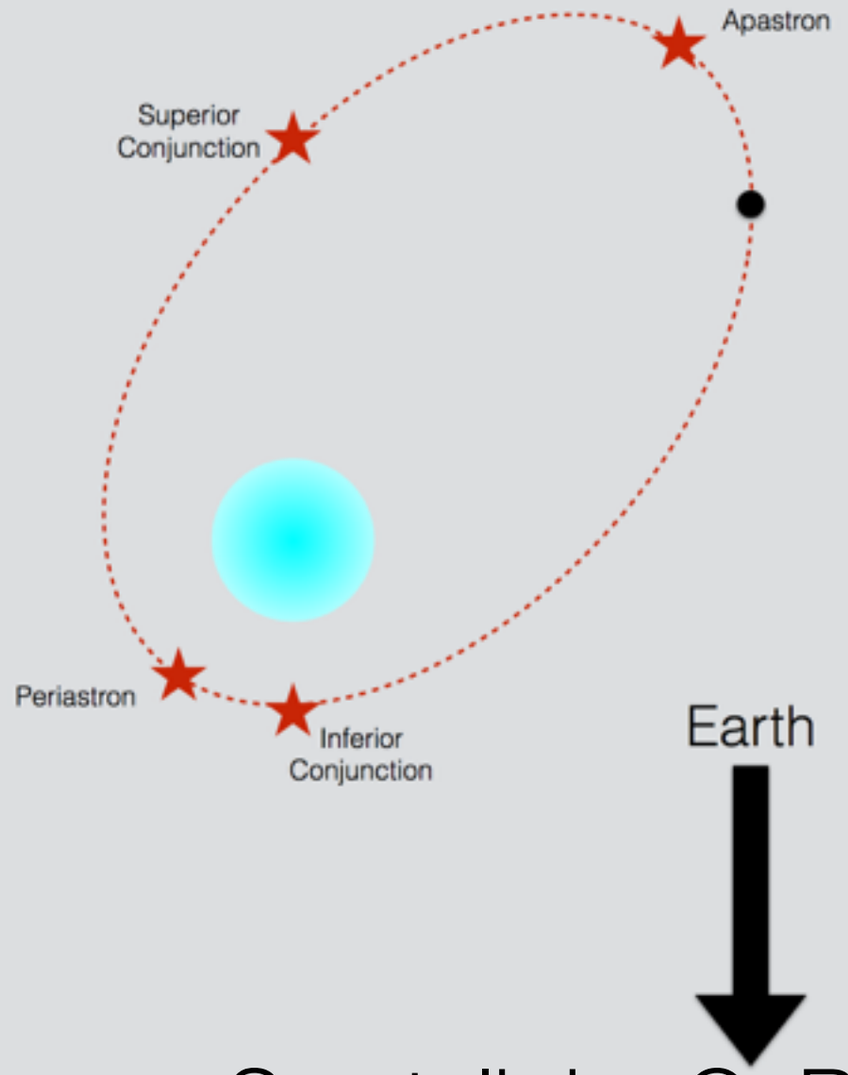


See talk by P. Harding

Continuous and unbiased monitoring

What does a γ binary look like?

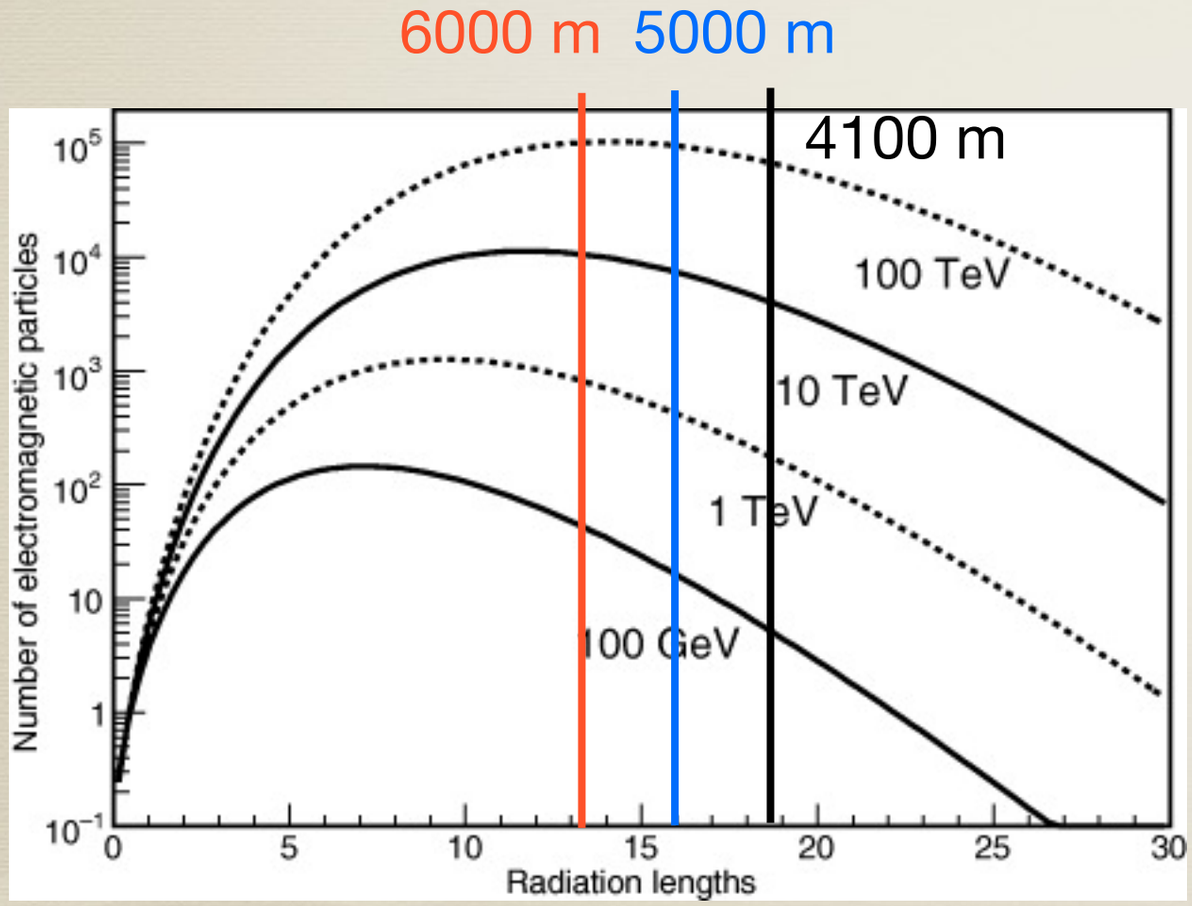
- O/B type star
- Compact Companion
- Emission highly dependent orbital position
- Emission at all energies
  - Radio → TeV
- Wide range of periods

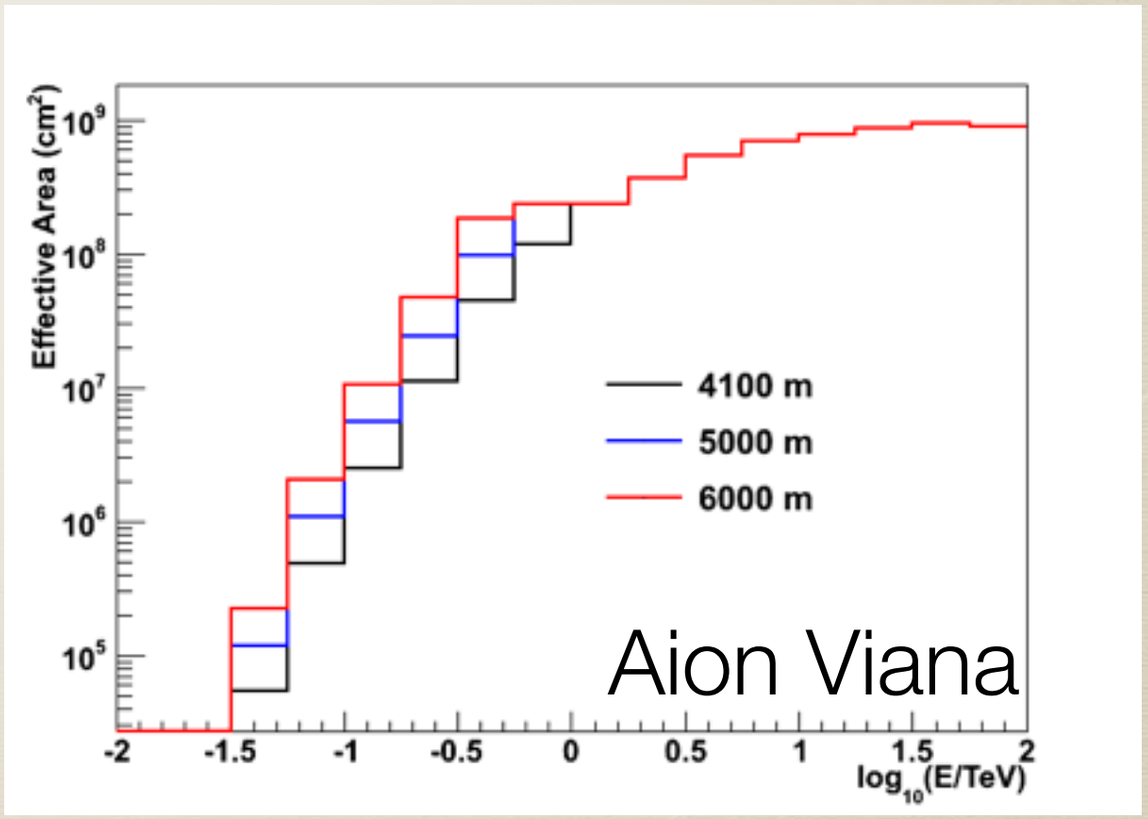


See talk by C. Brisbois

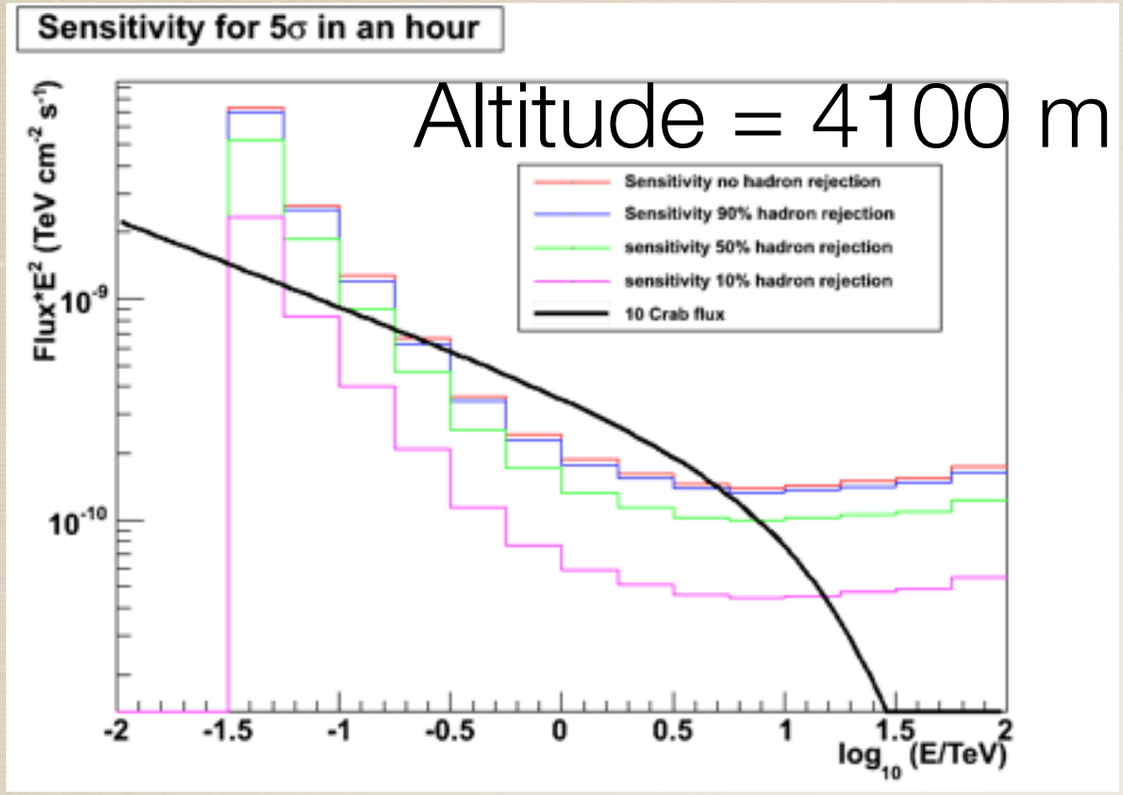
Capabilities to detect flaring sources

- We took HAWC's effective area rescaled by the number of particles for an array situated at different altitudes for E < 1 TeV

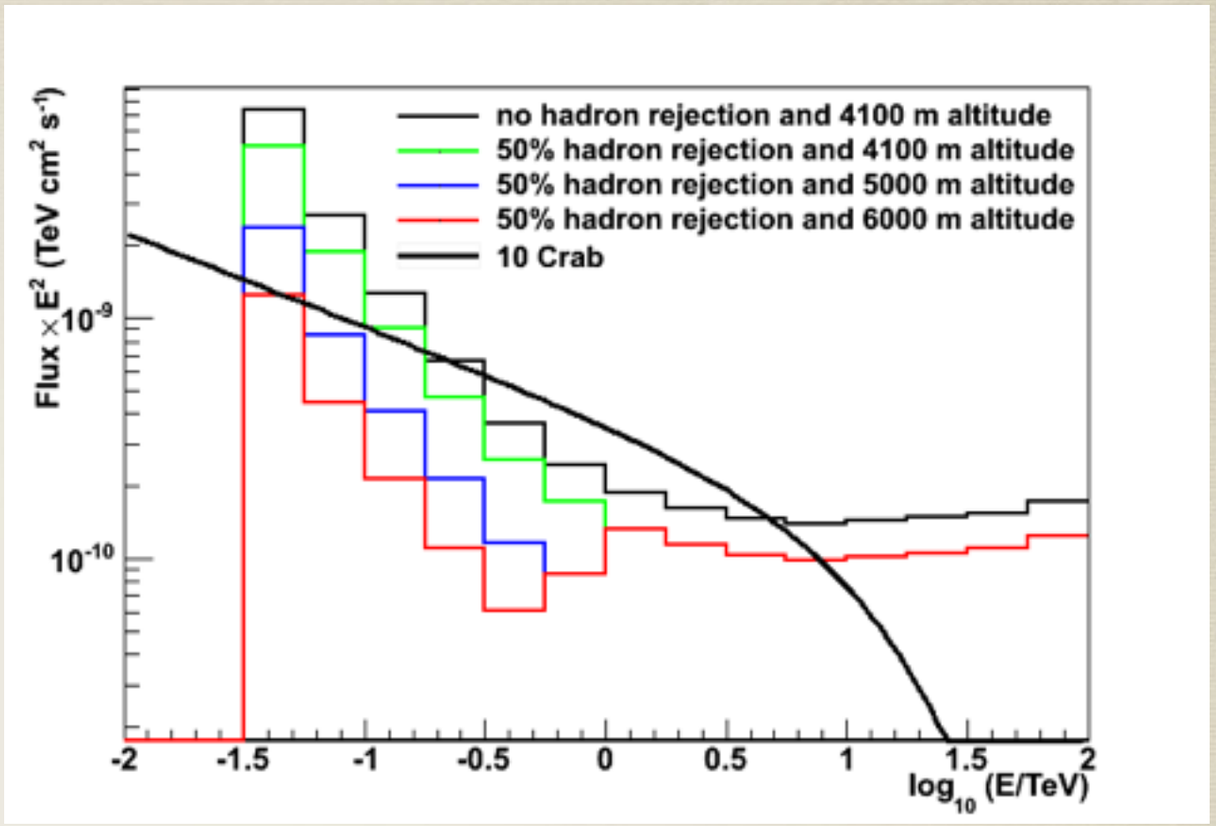




Flaring AGN Sensitivity



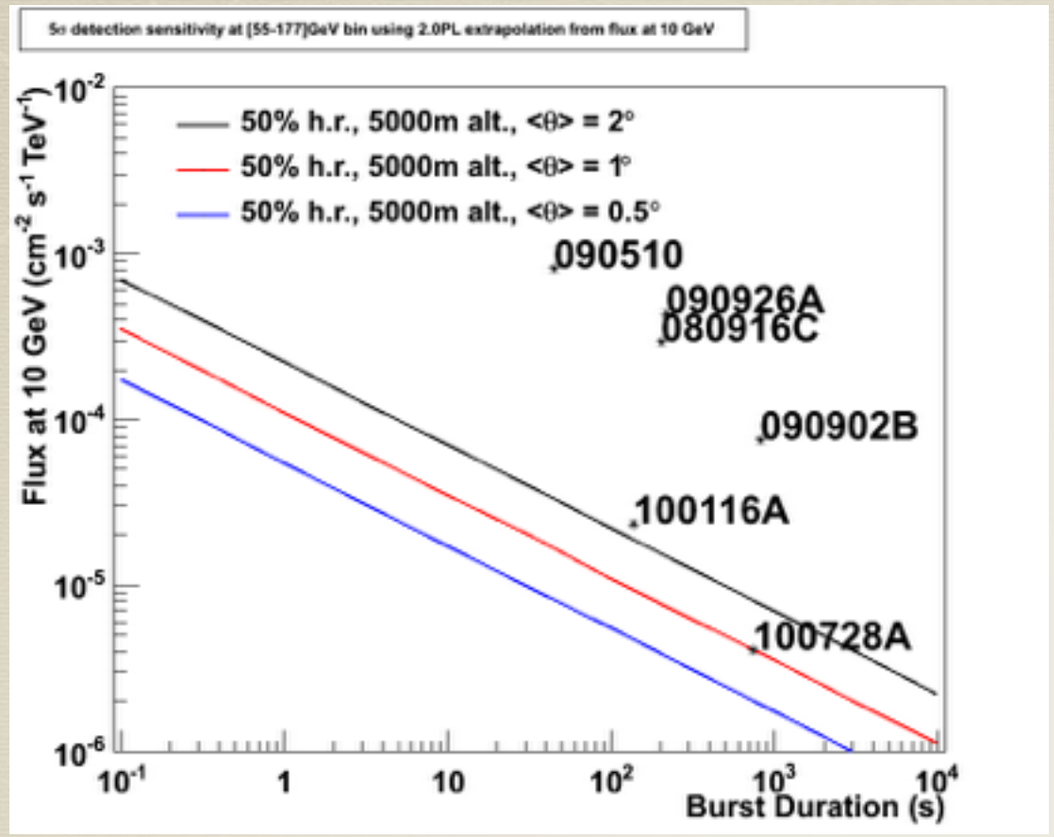
Sens vs hadron rejection



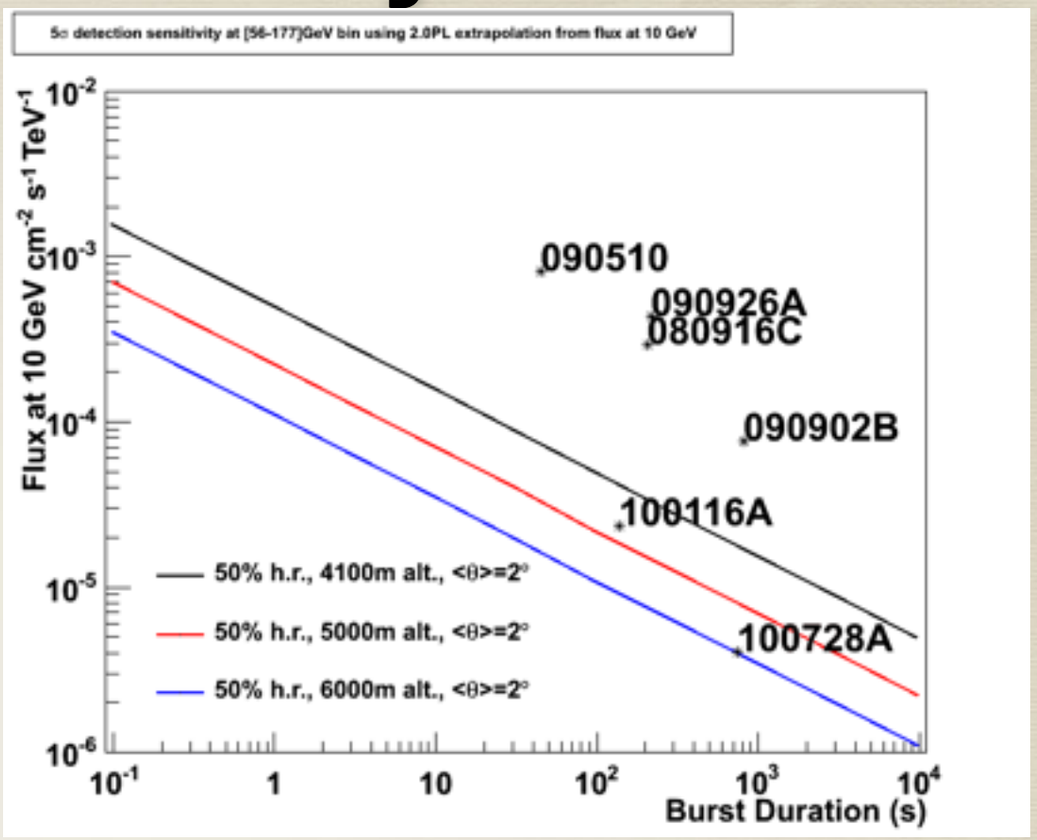
Sens vs Altitude

- Differential sensitivities for 5σ per bin and 1 h of observations.
- Unknown hadron rejection or altitude -> we simulated several.
- We compare our results with the flare of an AGN for 1 h with a flux of 10 Crab.
- Detectable at any energy bin at an altitude of 6000 m

GRB Sensitivity



Sens vs angular resolution



Sens vs Altitude

- We consider a GRB described by a power-law with index 2.0
- Differential sensitivities for 5σ detection of a GRB in the 56-177 GeV range.
- Points: Estimations for the extrapolated spectrum of Fermi GRB with photons with E > 10 GeV.

Summary

- Clear idea of how and for what is the detector sought
  - -> Express them in form of a paper: “Astrophysical motivations for a wide FoV gamma-ray observatory in the Southern Hemisphere”

- Design of an idealized detector -> evaluate detection capabilities and sensitivities depending on shape, size and altitude.
  - Use results from the shower physics study presented by H. Schoorlemmer to drive this design

- Final step: design of different realistic detector layouts to select the one that meets our needs.