LATTES

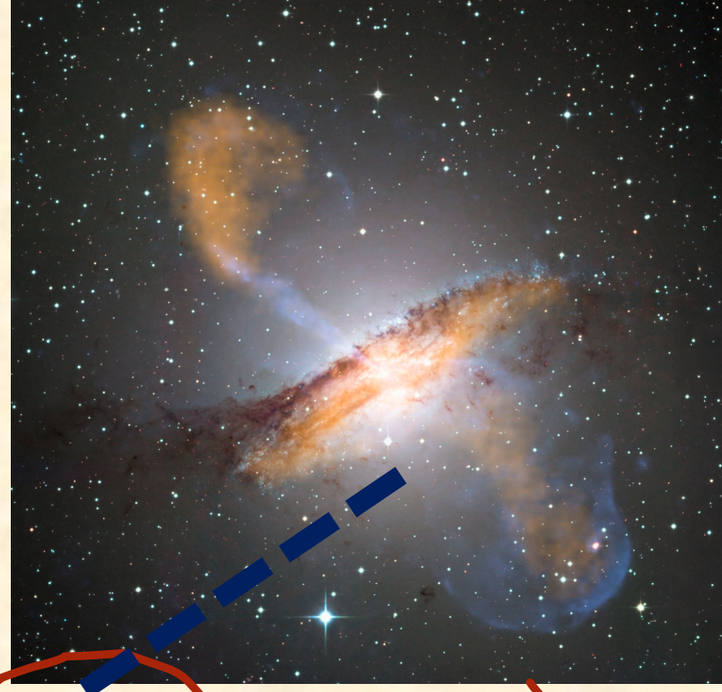
A Window to the Extreme Universe

Ronald Cintra Shellard
CBPF – Rio de Janeiro

LATTES - Vulcano Workshop 2018

Why gamas?

Cosmic rays

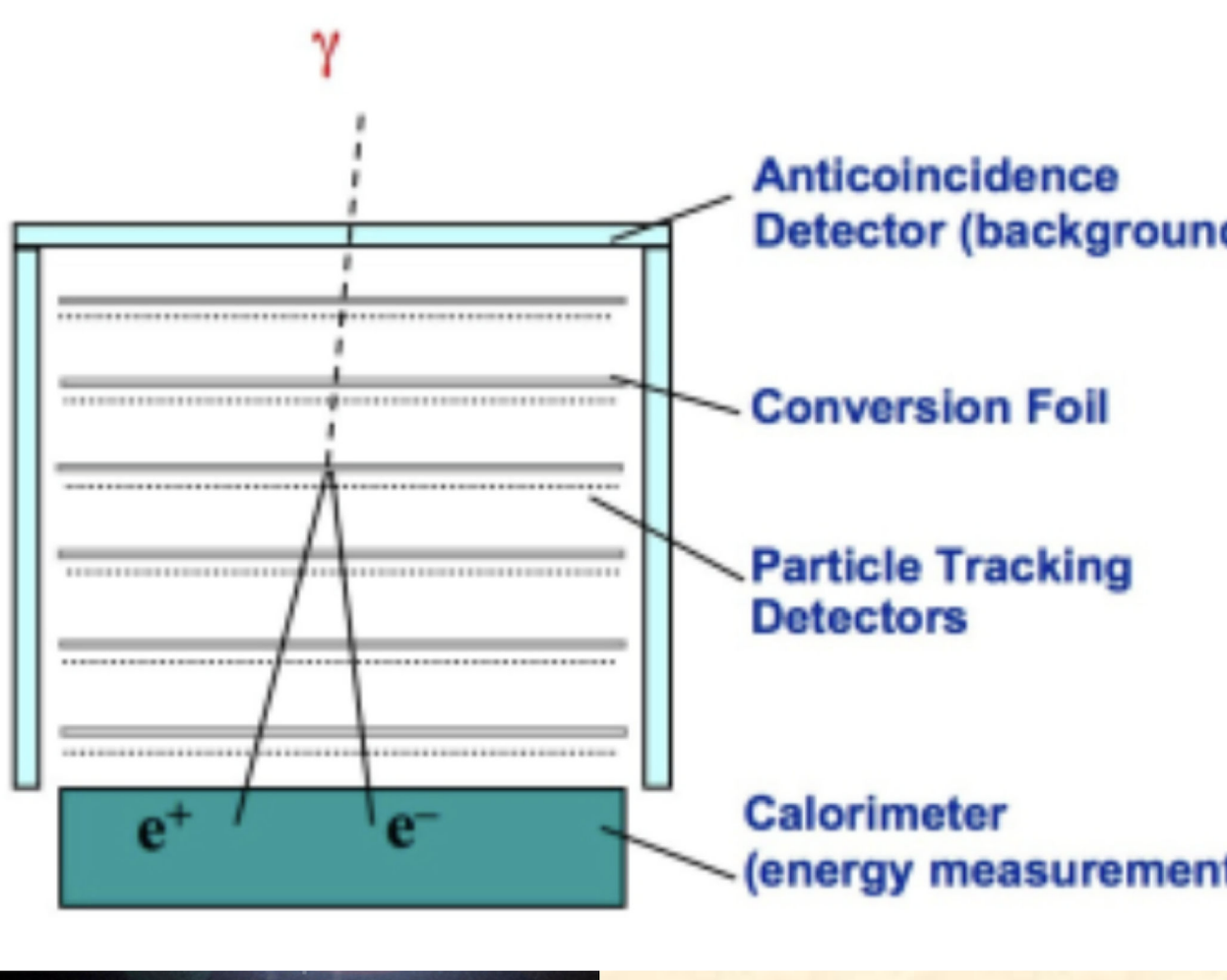


Gamma rays

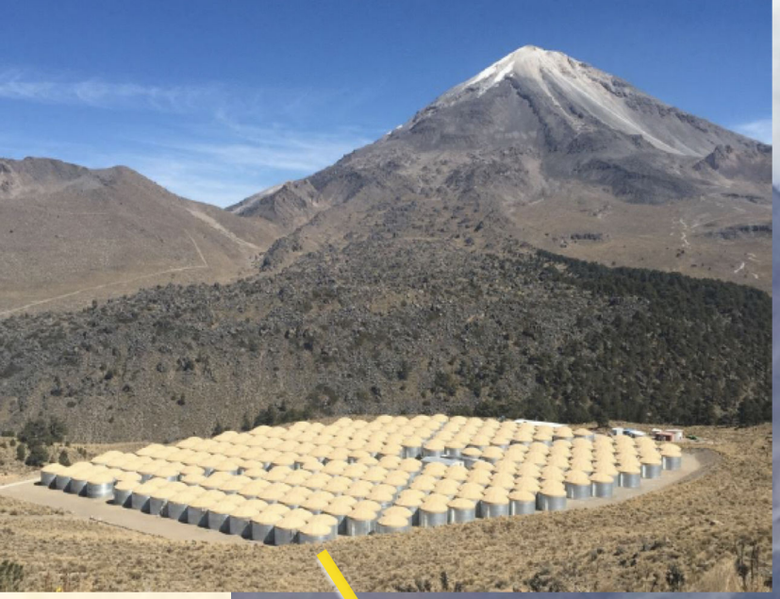
How can you detect gamma rays?

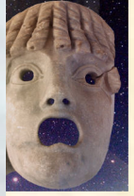
- *Go to space and setup a particle detector, so you can detect pair conversion – Fermi-LAT*
- *Look at the sky with a large mirror and detect the Cherenkov light generated by the air shower (IACT) – HESS, MAGIC, VERITAS*
- *Detect the air shower directly with a particle detector – , MILAGRO, ARGO-YBJ, HAWC*

FERMI-LAT


γ
Anticoincidence
Detector (backgroun
Conversion Foil
Particle Tracking
Detectors
e+
e−
Calorimeter
(energy measurement

Gamma rays – IACT Ground observatories (high energies)





HAWC

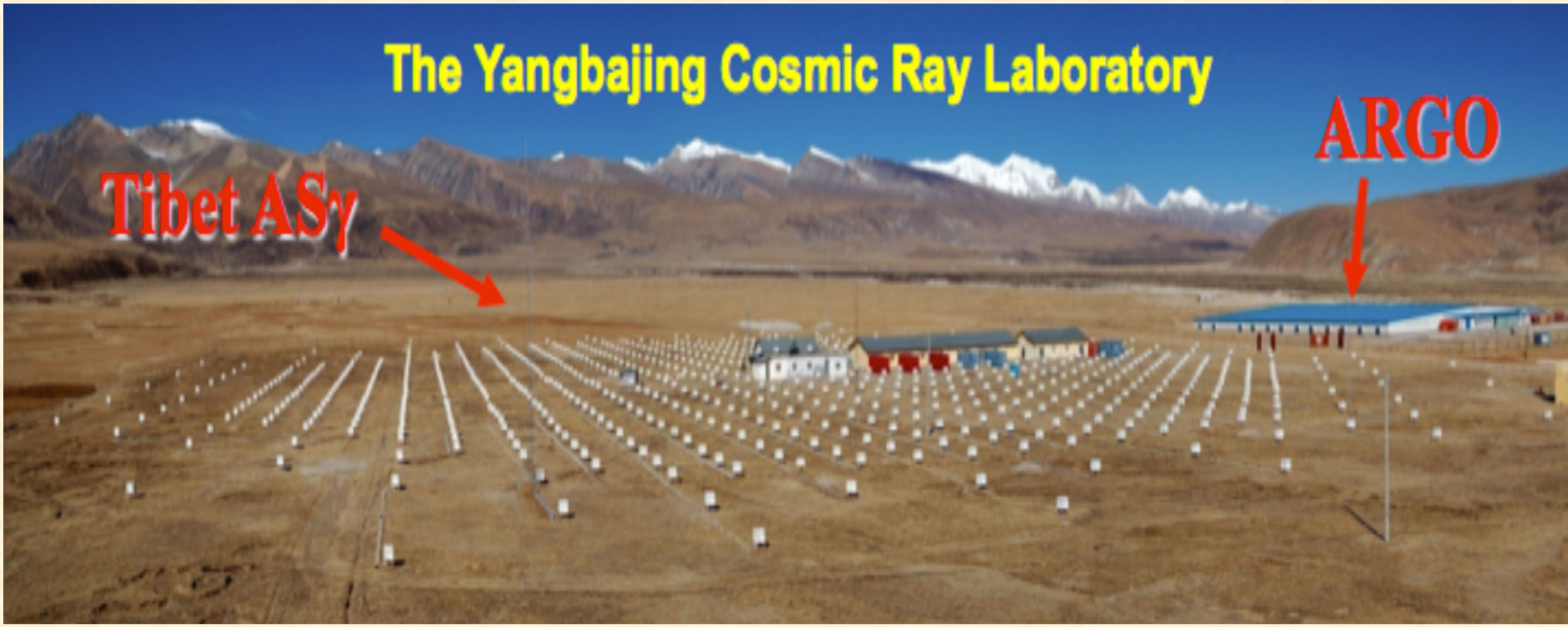
ARGO-YBJ experiment

Longitude: 90° 31' 50" East
Latitude: 30° 06' 38" North

4300 m above sea level ~ 600 g/cm^2

INFN IHEP/CAS

90 km North from Lhasa (Tibet)



Future experiments Very High Energy Gamma Rays

Cherenkov Telescope Array

LHAASO Project

4400 masl

Begin to take data
By end of year

Very High Energy gamma rays

Quantity	***Fermi*-LAT**	**IACTs**	**EAS**
Energy range	20 MeV–200 GeV	100 GeV–50 TeV	400 GeV–100 TeV
Energy res.	5-10%	15-20%	~ 50%
Duty Cycle	80%	15%	> 90%
FoV	$4\pi/5$	5 deg × 5 deg	$4\pi/6$
PSF	0.1 deg	0.07 deg	0.5 deg
Sensitivity	1% Crab (1 GeV)	1% Crab (0.5 TeV)	0.5 Crab (5 TeV)

Sensitivity: one year for Fermi- LAT and EAS
50 hours for IACT

Very High Energy Gamma Instruments

Large Array Telescope for Tracking Energetic Sources

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Design and expected performance of a novel hybrid detector for very-high-energy gamma-ray astrophysics

P. Assis[a,b], U. Barres de Almeida[c], A. Blanco[d], R. Conceição[a,b,*], B. D'Ettorre Piazzoli[e], A. De Angelis[f,g,b,a], M. Doro[h,f], P. Fonte[d], L. Lopes[d], G. Matthiae[i], M. Pimenta[b,a], R. Shellard[c], B. Tomé[a,b]

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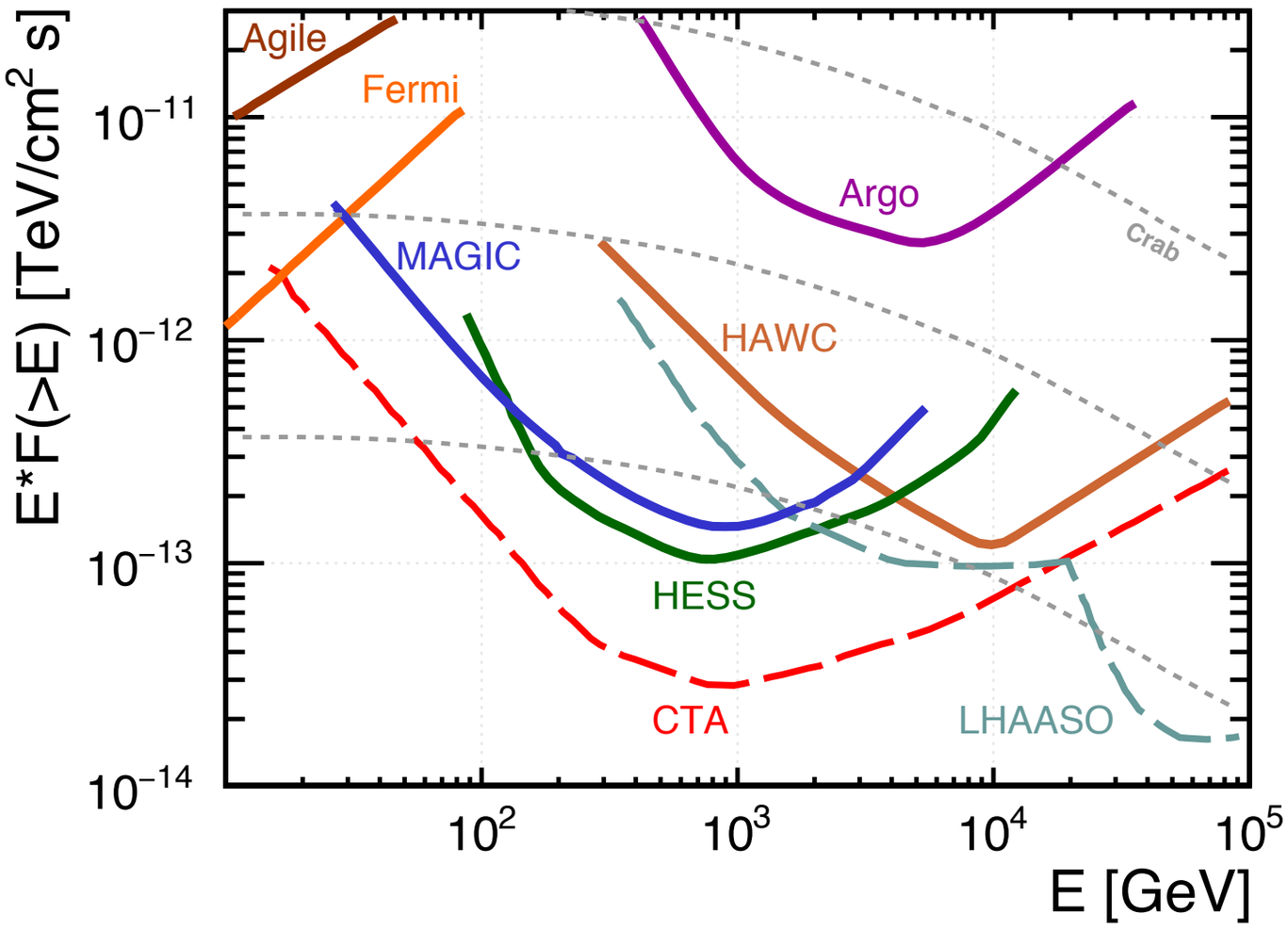
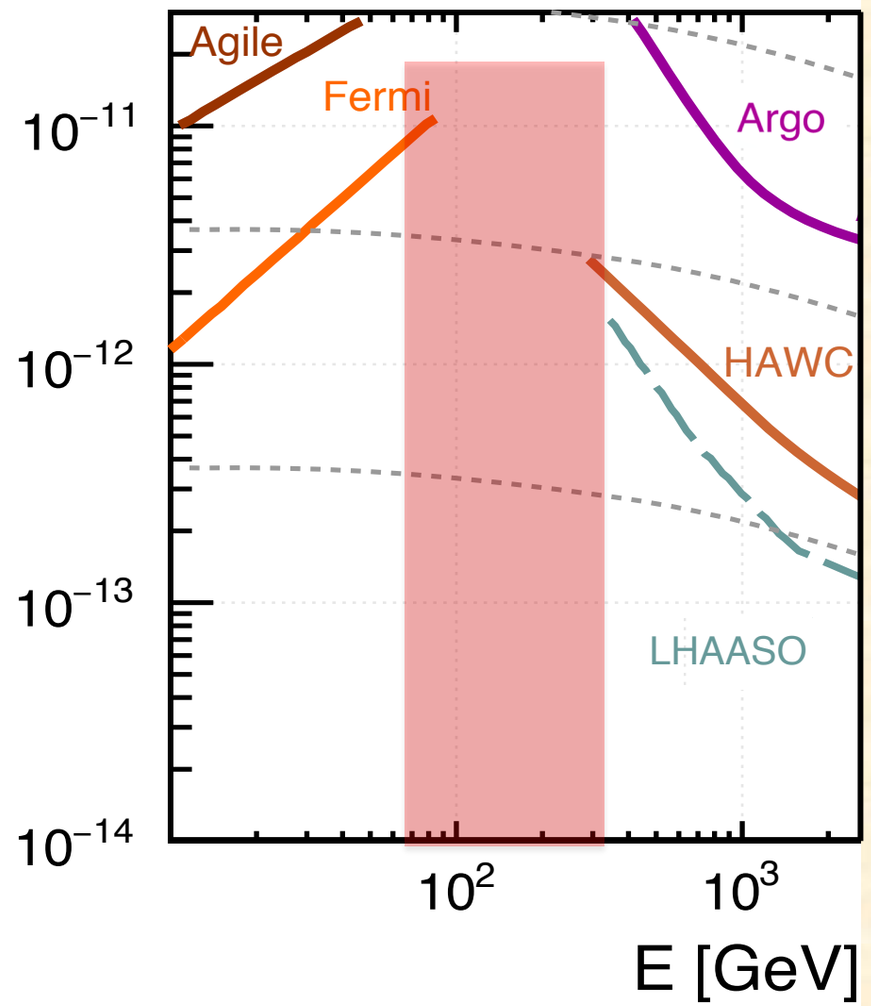
Why LATTES?

Why LATTES: Present situation





There are no large field of view experiment to:

- *Monitor the Center of the Galaxy*
- *Exploit the 100 GeV range*

LATTES Objectives

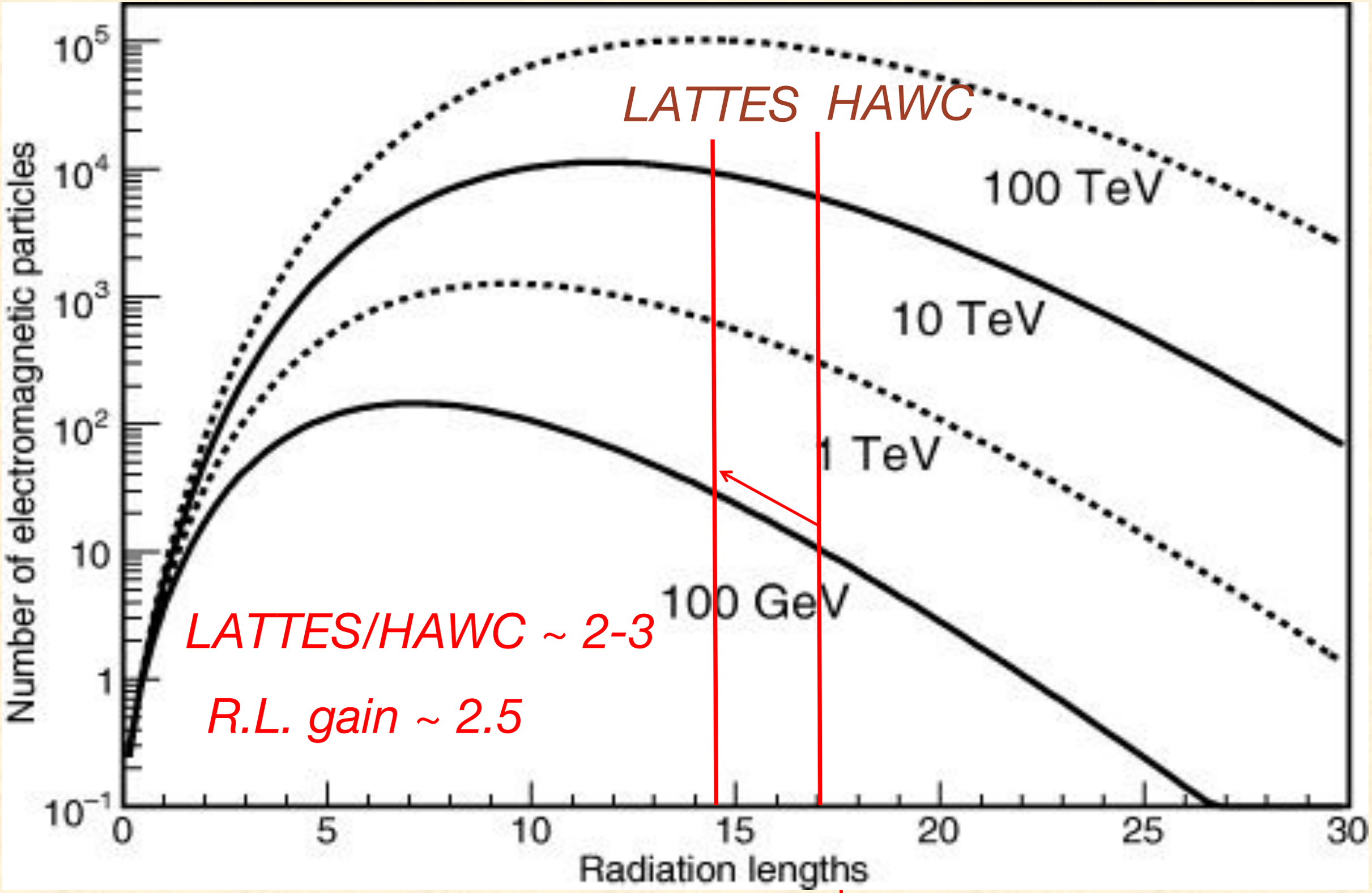
- *Build a gamma ray detector operating 24/7, field of view of* $2\pi/3\ \mathrm{rad}^2$
- *Low energy sensitivity ~ 100 GeV*
- *Altitude above 5.000m*
- *Capability to detect transients*
- *South America (interesting objets)*
  - *Non thermal process in the Universo*
  - *Transients*
  - *Extreme objets: SNR, AGN, GRB*

LATTES Base Design

- *Exposition area of the order of 20.000 m^2*

  (mix of scientific arguments e realism about funding!)
- *Dense coverage of the area*
- *Detetors simple e robust. Low mantainance costs*
- *Good temporal resolution*
- Good hadronic background rejection
- *Good angular resolution*
- Scalable

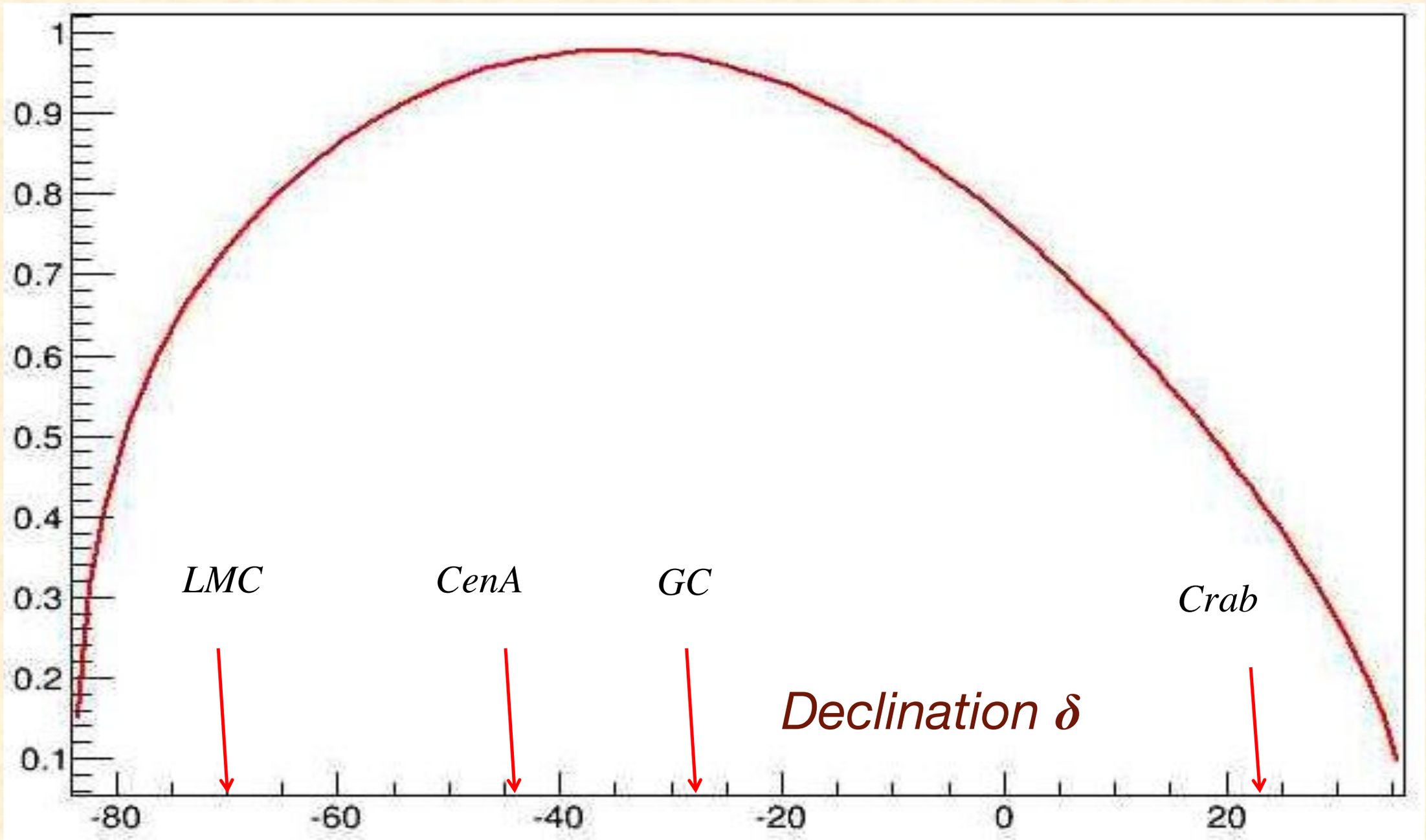
LATTES (Altitude?)



Exposition

- *Declinação (ângulo zenital) < 60^0*
- *Crab Nebula is a standard candle in the astrophysics of high energy gammas*

Alma (-23.7°)



CESAR

***C**alorimeter **El**ectromagnetic for **S**tudying **A**i**R** gammas*

Water Cherenkov detector

Measure the shower energy with good resolution

MARTA

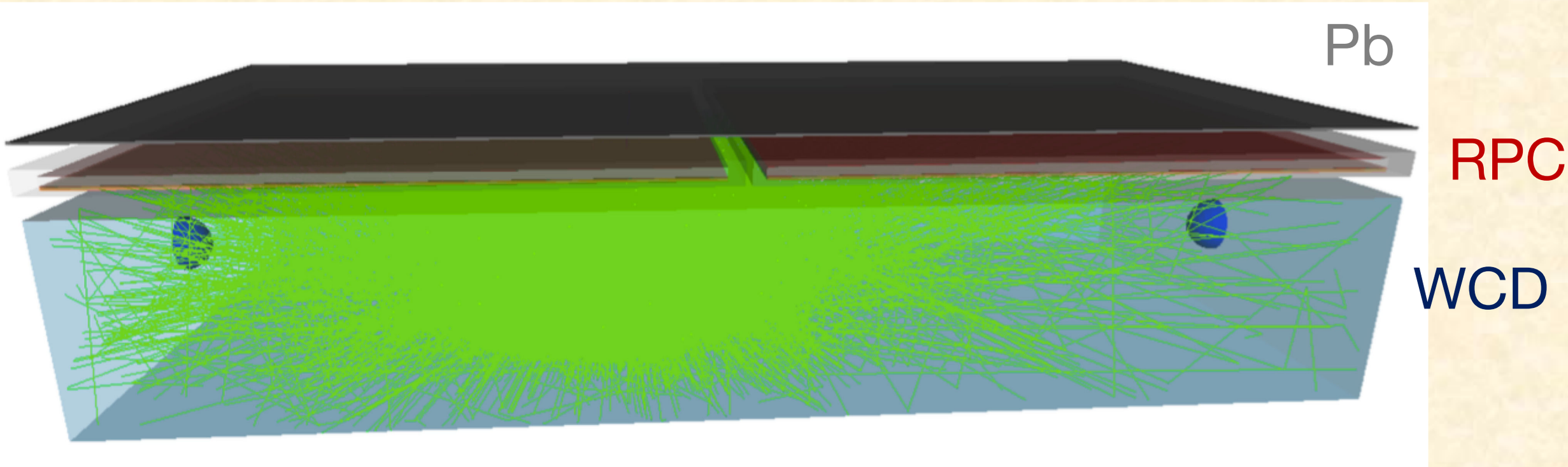
***M**uon **A**rray **R**pcs for **T**agging **A**irshowers*

Particle counter based on RPC technology

(RPC -- Resistive Plate Chamber)

Temporal resolution ~ 1 ns

LATTES Station



- *Thin slab of lead (Pb)*
  - *5.6 mm (one radiation lenght)*
- *Resistive Plate Chambers (RPC)*
  - *2 RPC per station*
  - *Each RPC with 4X4 reading pads*
- *Water Cherenkov Detector (WCD)*
  - *2 PMT (diameter 15 cm)*
  - *Dimension: 1.5 m X 3 m X 0.5 m*

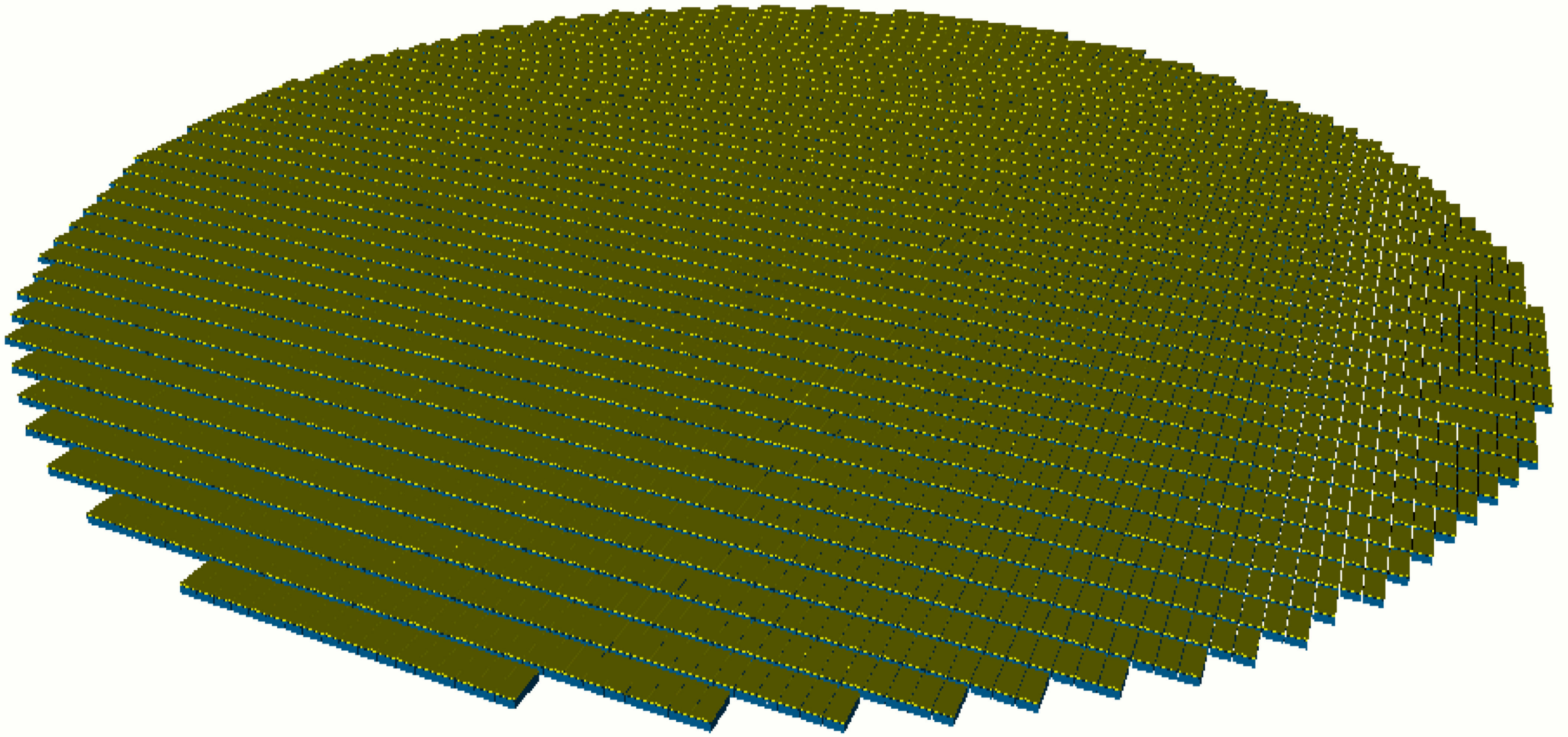
LATTES Layout

Conversor: 5.6 mm Pb

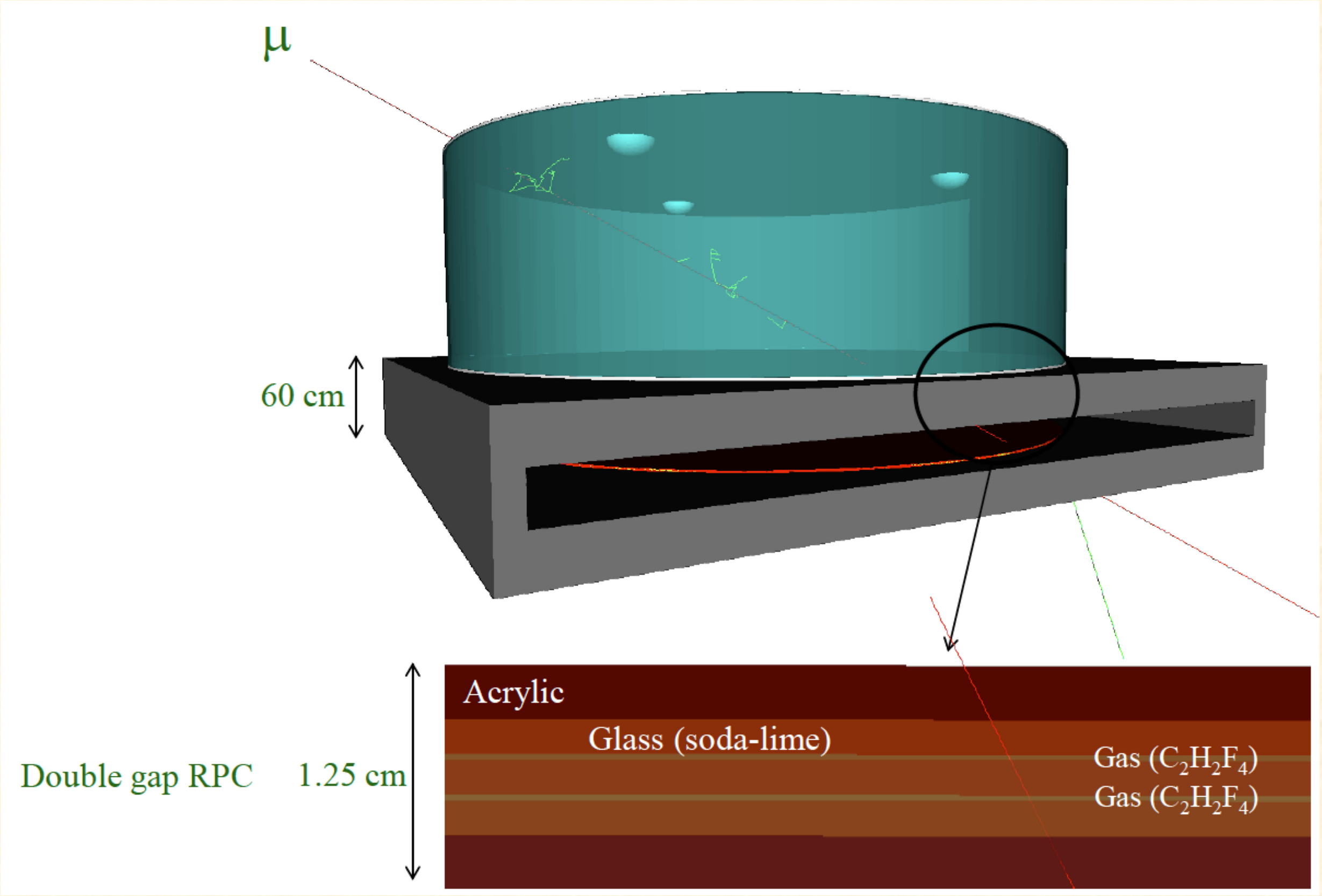
Pattern and timing: RPCs

Calorimeter and μ identification: WCD

~2000 stations

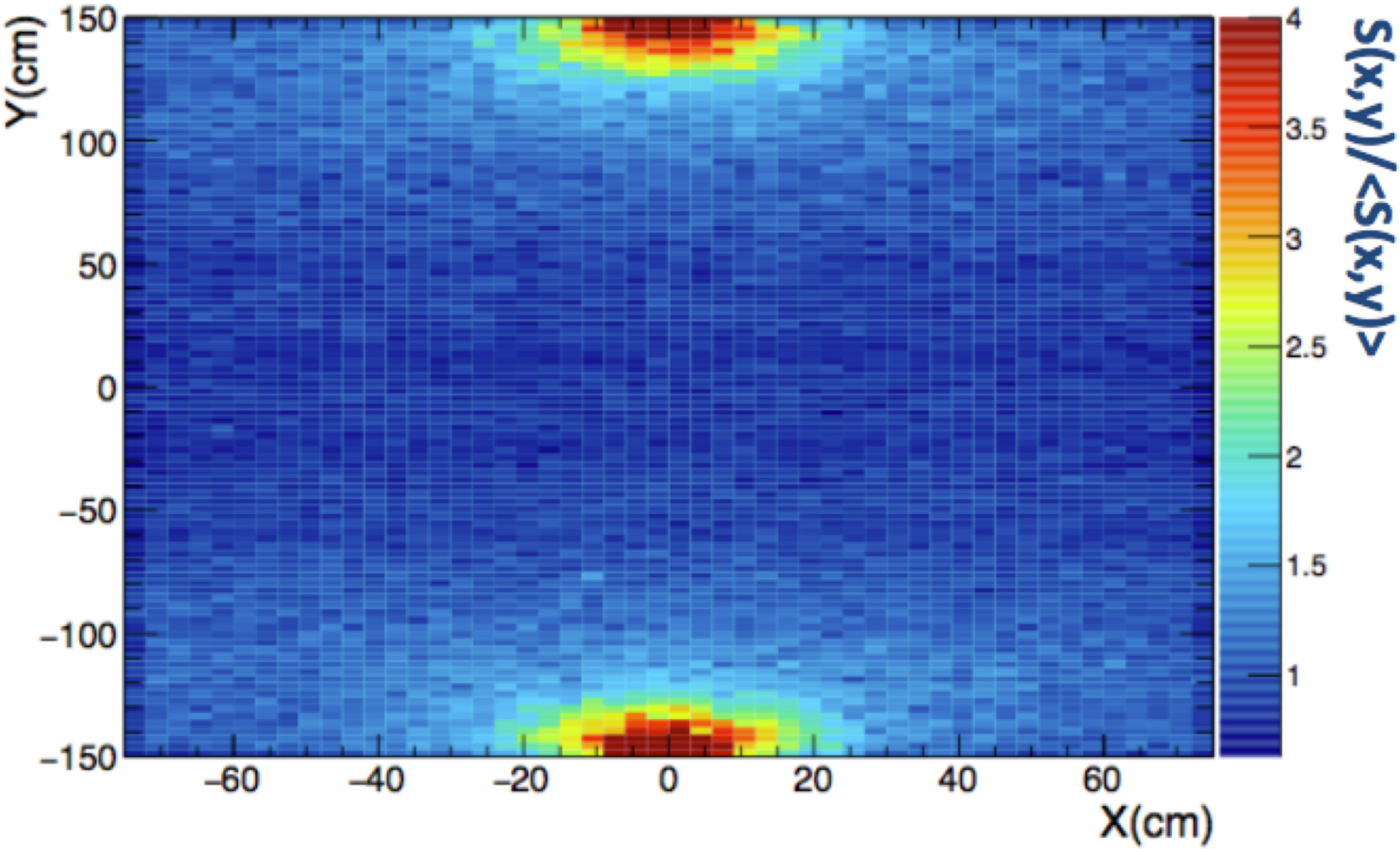


Muon Auger RPC for Tagging Airshowers - MARTA



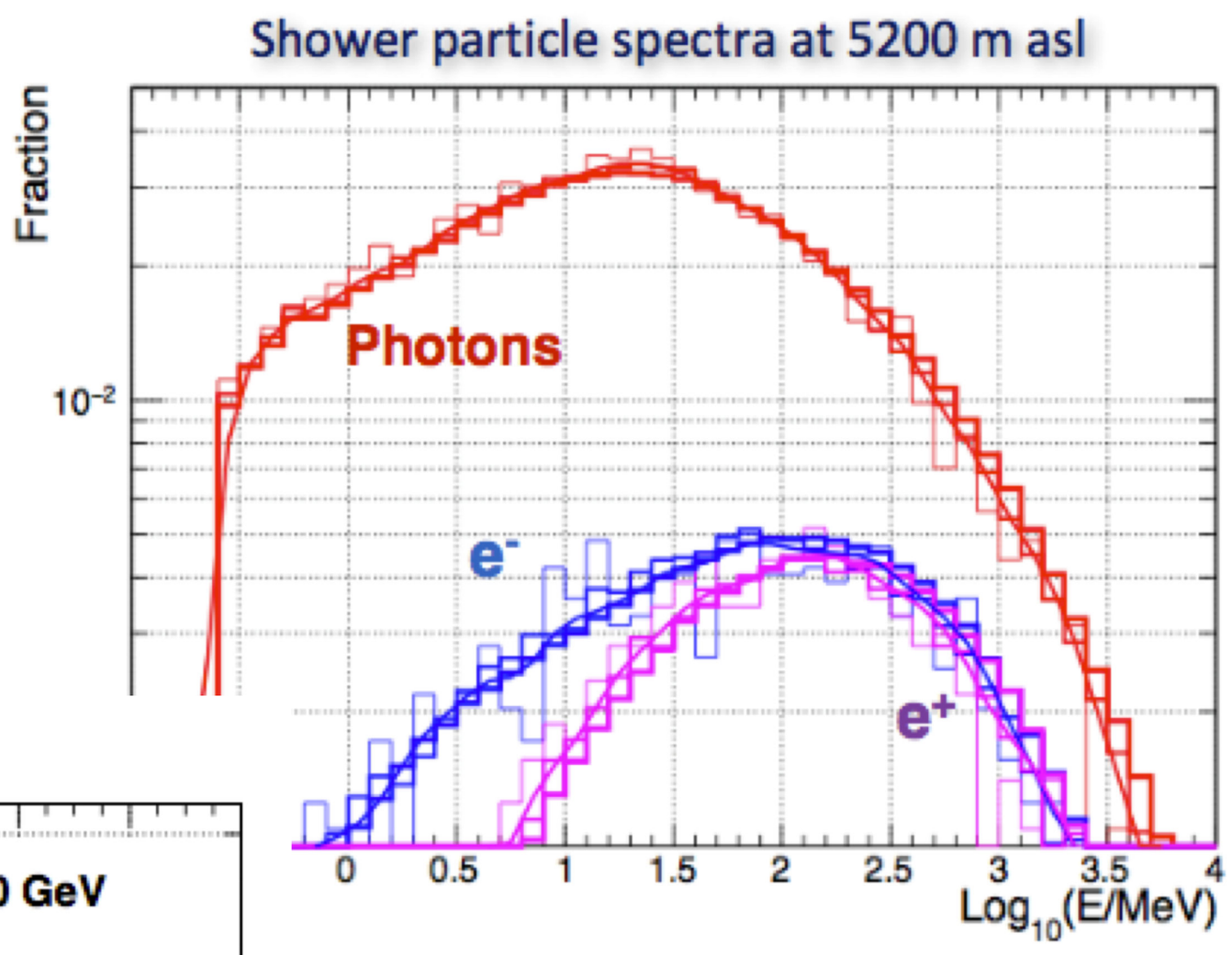
Simulation: Corsika for showers
GEANT for detectors

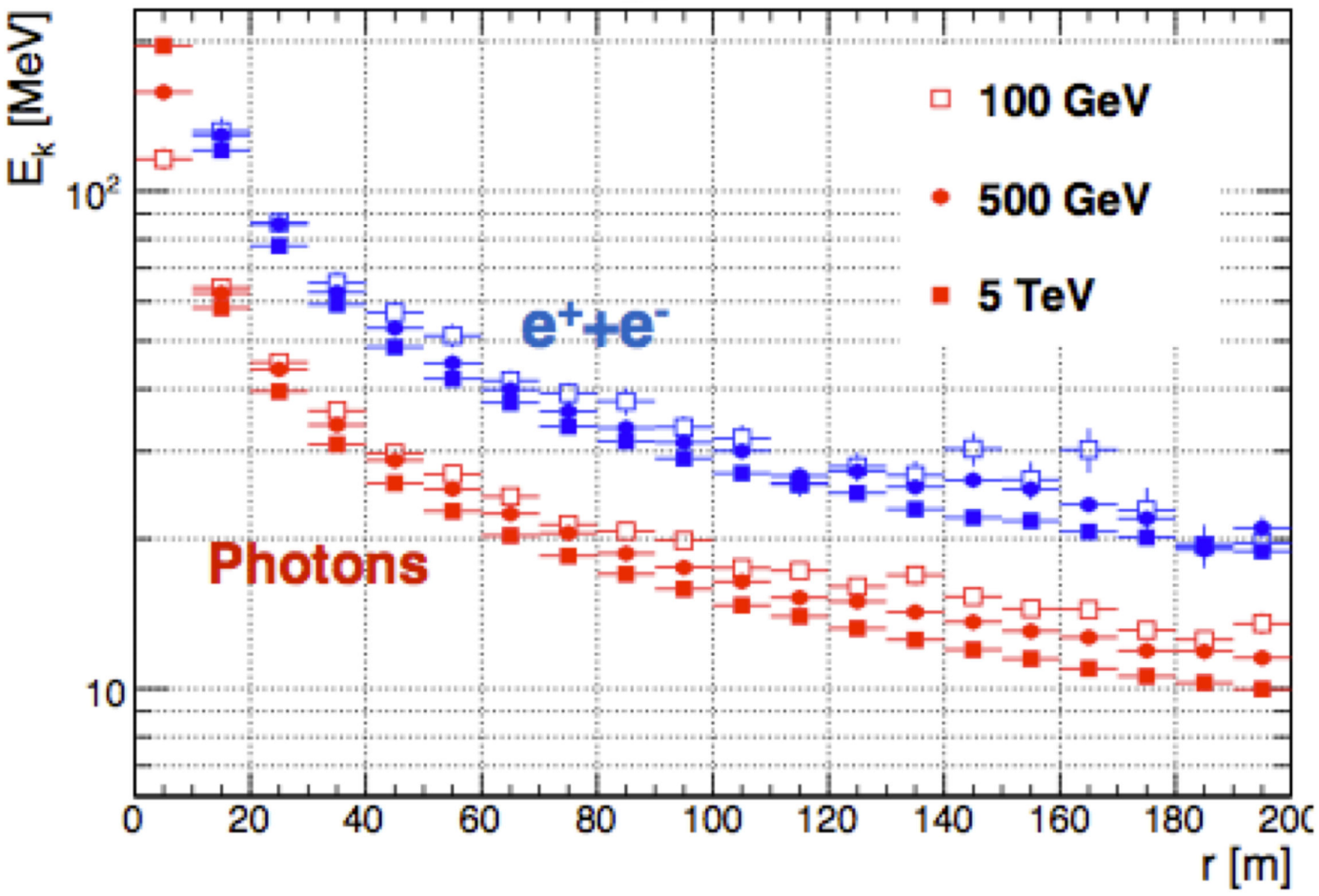
WCD signal uniformity



Why lead converter?

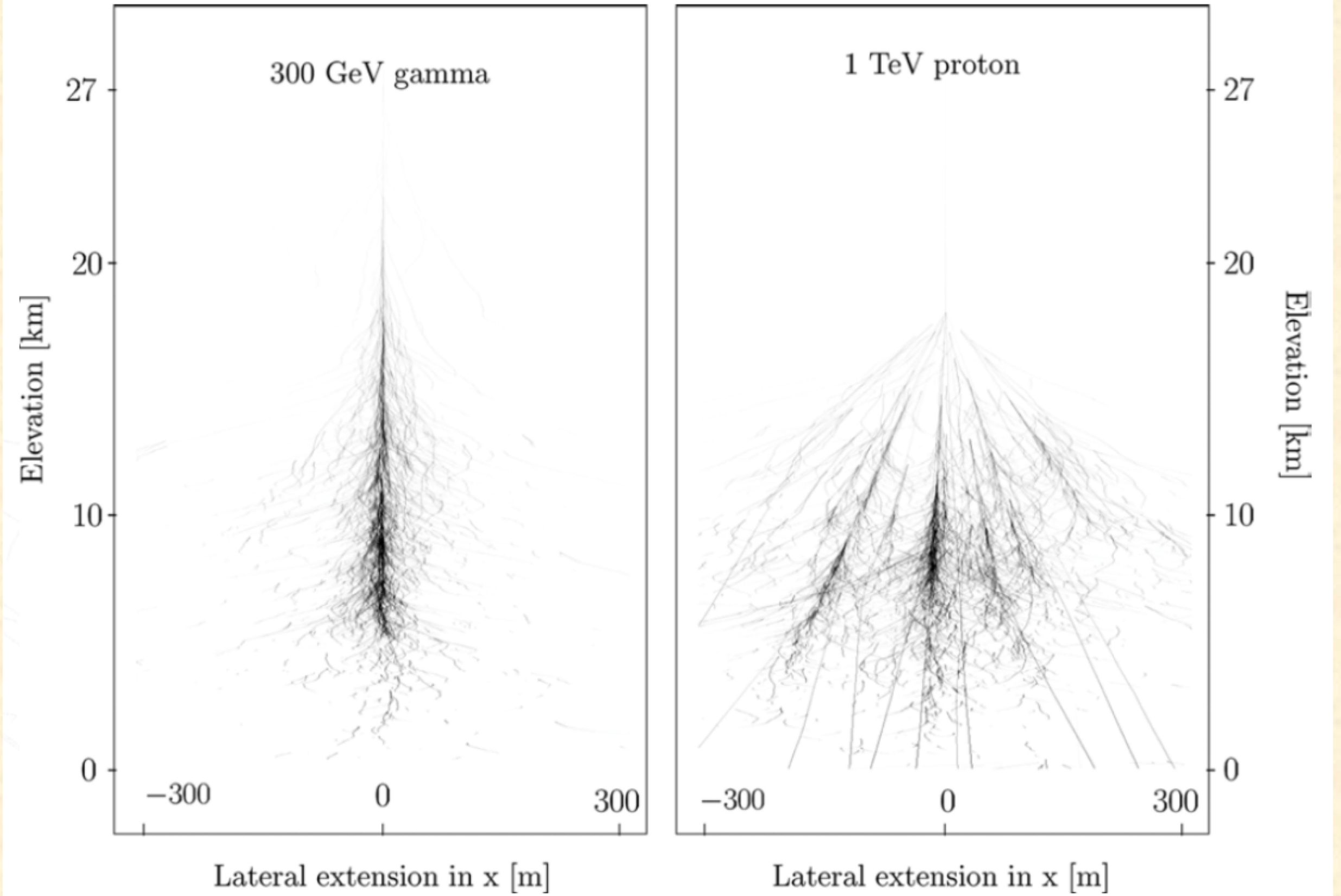
Convert gammas

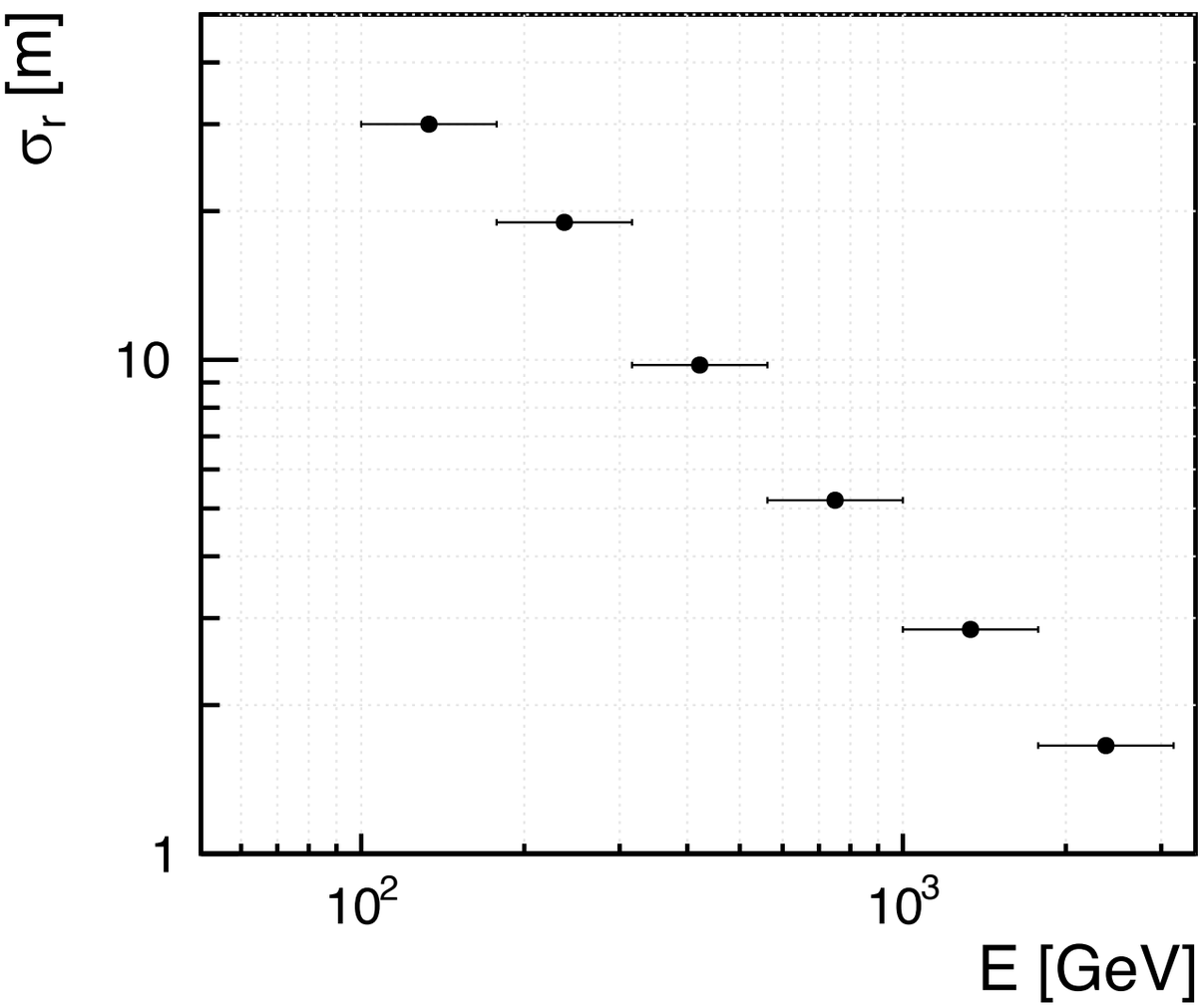


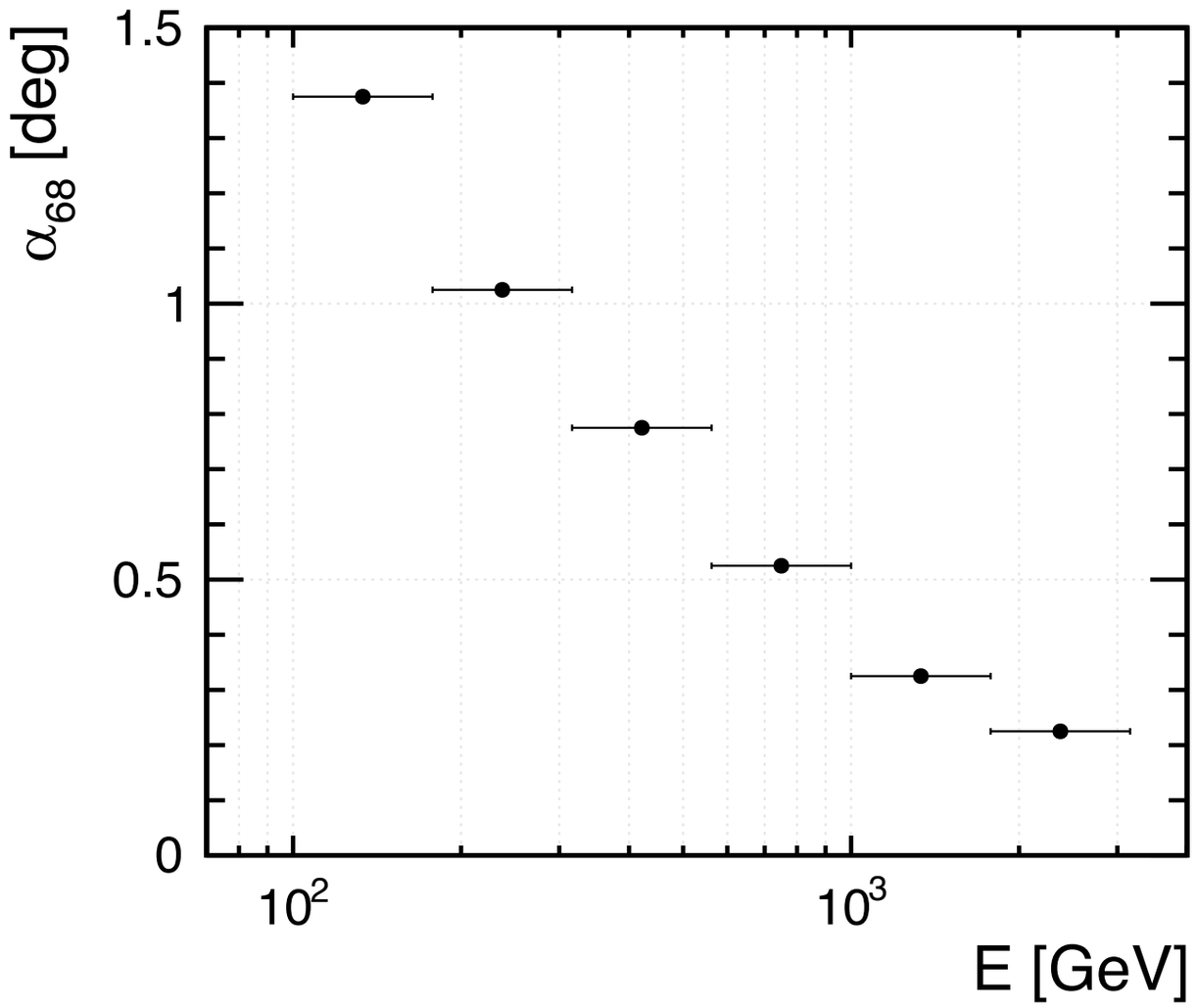


Measure energy of shower particles

Topology of gammas and protons

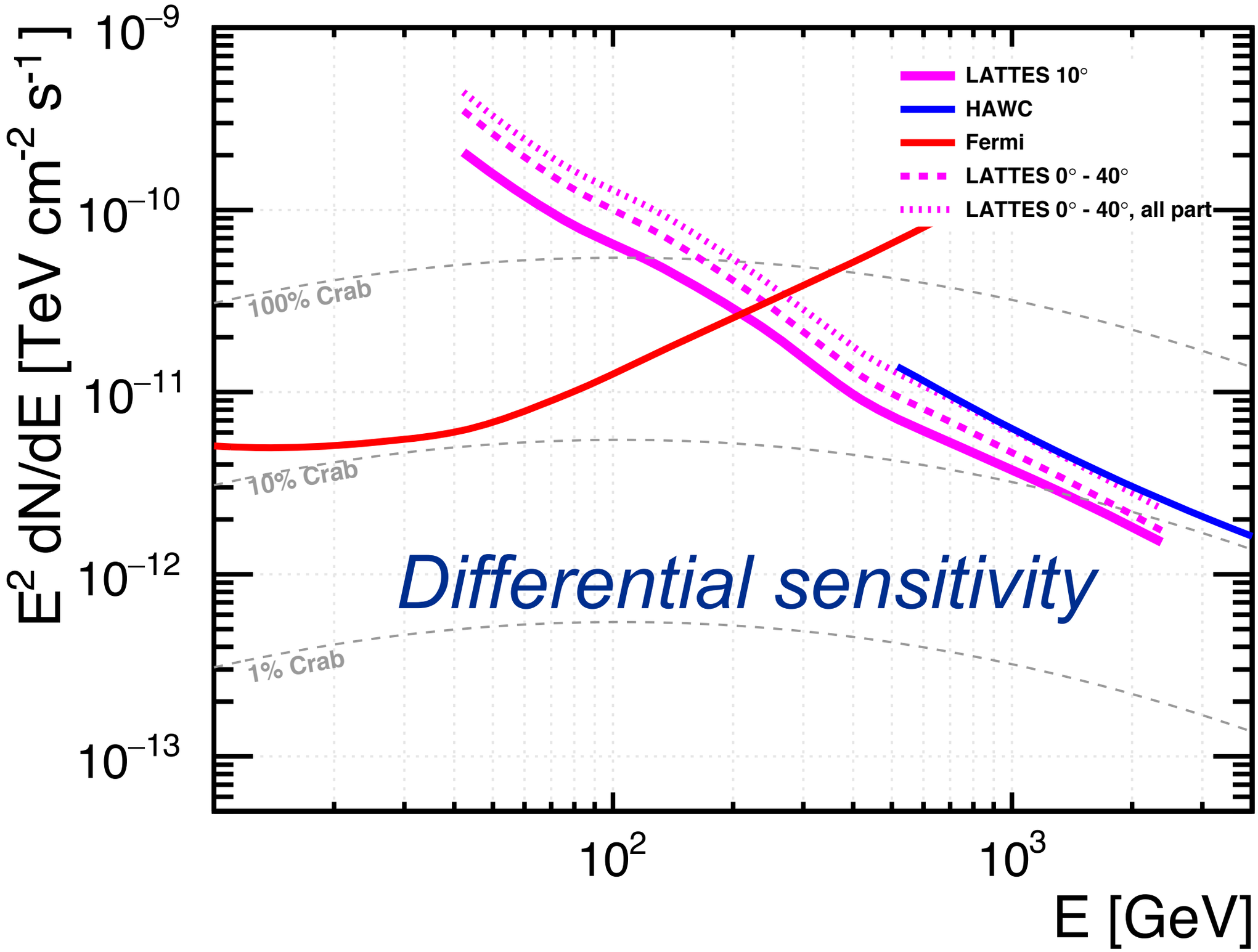


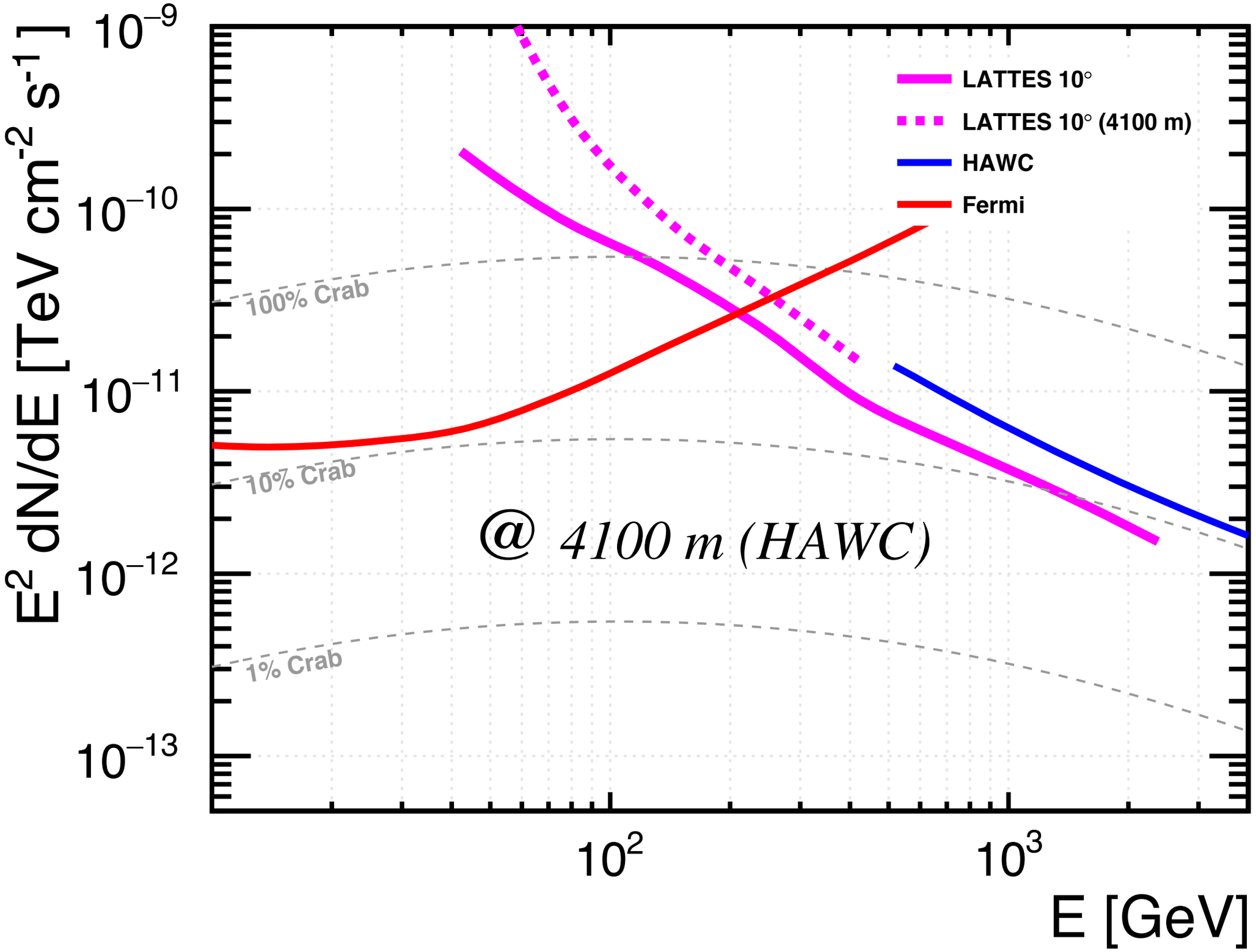




Shower core position

Angular resolution θ – 10°


LATTES 10°
HAWC
Fermi
LATTES 0° - 40°
LATTES 0° - 40°, all part
100% Crab
10% Crab
1% Crab
Differential sensitivity
E² dN/dE [TeV cm⁻² s⁻¹]
10⁻⁹
10⁻¹⁰
10⁻¹¹
10⁻¹²
10⁻¹³
10²
10³
E [GeV]


LATTES 10°
LATTES 10° (4100 m)
HAWC
Fermi
100% Crab
10% Crab
1% Crab
@ 4100 m (HAWC)
E² dN/dE [TeV cm⁻² s⁻¹]
E [GeV]
10⁻⁹
10⁻¹⁰
10⁻¹¹
10⁻¹²
10⁻¹³
10²
10³

Site for LATTES

Site for LATTES

Guatin
San Pedro de Atacama
Mina Pirquitas
Abra Pampa
Iruya
Casabindo
Pairique Chico
Coranzuli
Toconao
Reserva Nacional Los Flamencos
Talabre
Olaroz Chico
Susques
Humahuaca
Uquía
Socaire
Tilcara
Huáncar
Cobres
Tilomonte
Huaitiquina
Purmamarca
Catua
Salar de Pocitos
Santa Rosa de los Pastos Grandes
San Antonio de los Cobres
Santa Rosa de Tastil
Jujuy
Palpala
Ciudad Perico
Tolar Grande
Lago Salar de Arizaro
La Poma
General Güemes
Salta
Cerrillos
Mina La Casualidad
Rosario de Lerma
40
27
52
51
9
2
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61
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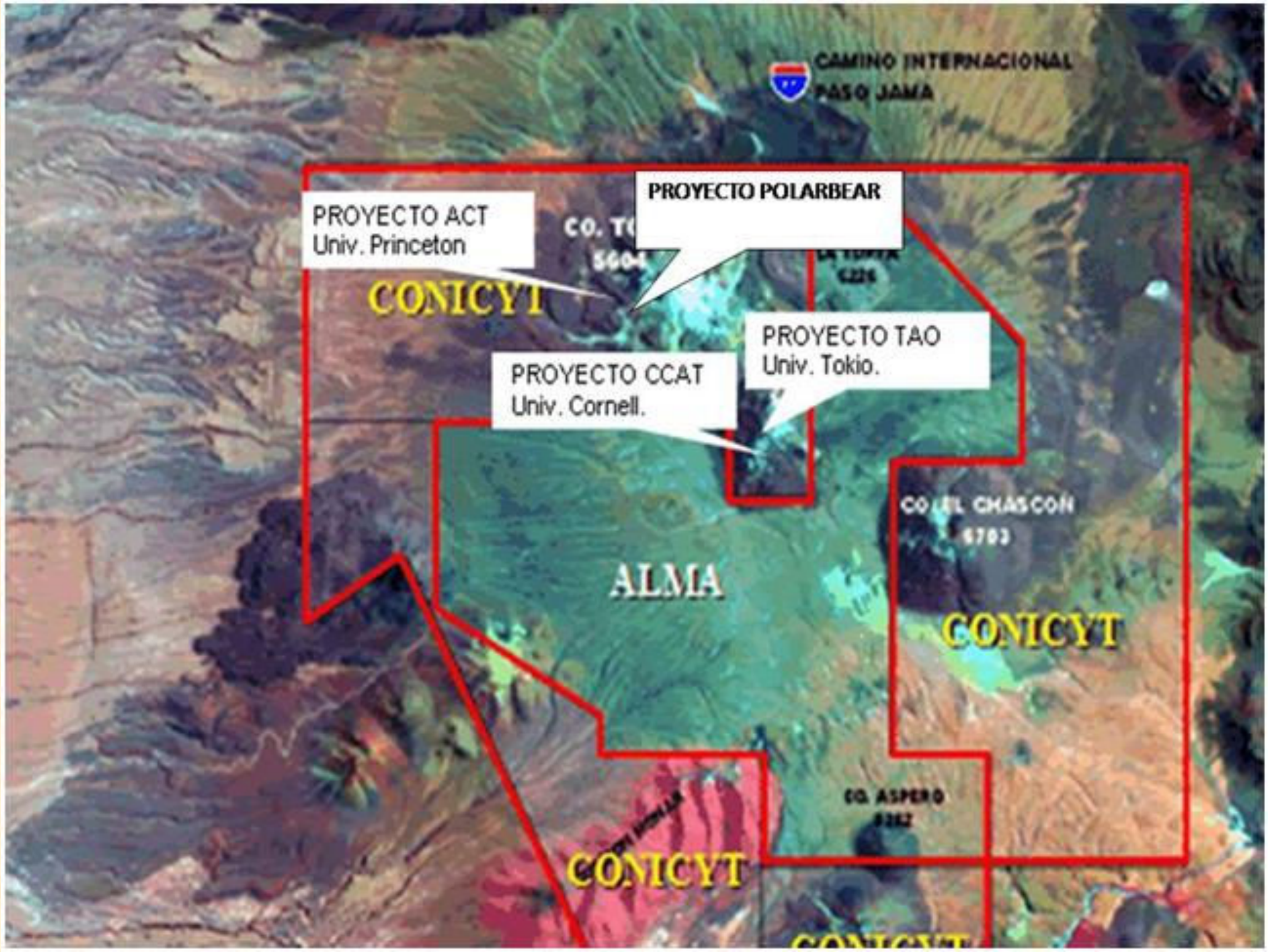
39
17
23



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Site for LATTES

Site for LATTES (Atacama Cosmology Telescope)

Site for LATTES

Conclusion

LATTES *is a gamma ray experiment with a large field of view (FOV) in South America*

- *Complementary to CTA to monitor Galactic Center*
- *Next generation of hybrid gamma ray experiments*
- *Good sensitivity to low energy (100 GeV)*

  Fill the gap between sattelite dada and ground measurements
- *Tool to alert on variable sources and transients*

Conclusion

LATTES *is complementary to:*

- *HAWC / LHAASO complete coverage of the sky*

  (HAWC/LHAASO -- North and LATTES -- South)
- *HESS/CTA continous operation and large field of view*
- *LATTES has the correct geographic properties in terms of latitude e altitude*

On the map of the Astroparticle Physics with gamma rays

LATTES is the missing piece !

LATTES MEETING

Prague, May 29-30, 2018

All invited!

Thank You!

Site for Lunar Array Telescope for Tracking Energetic Sources

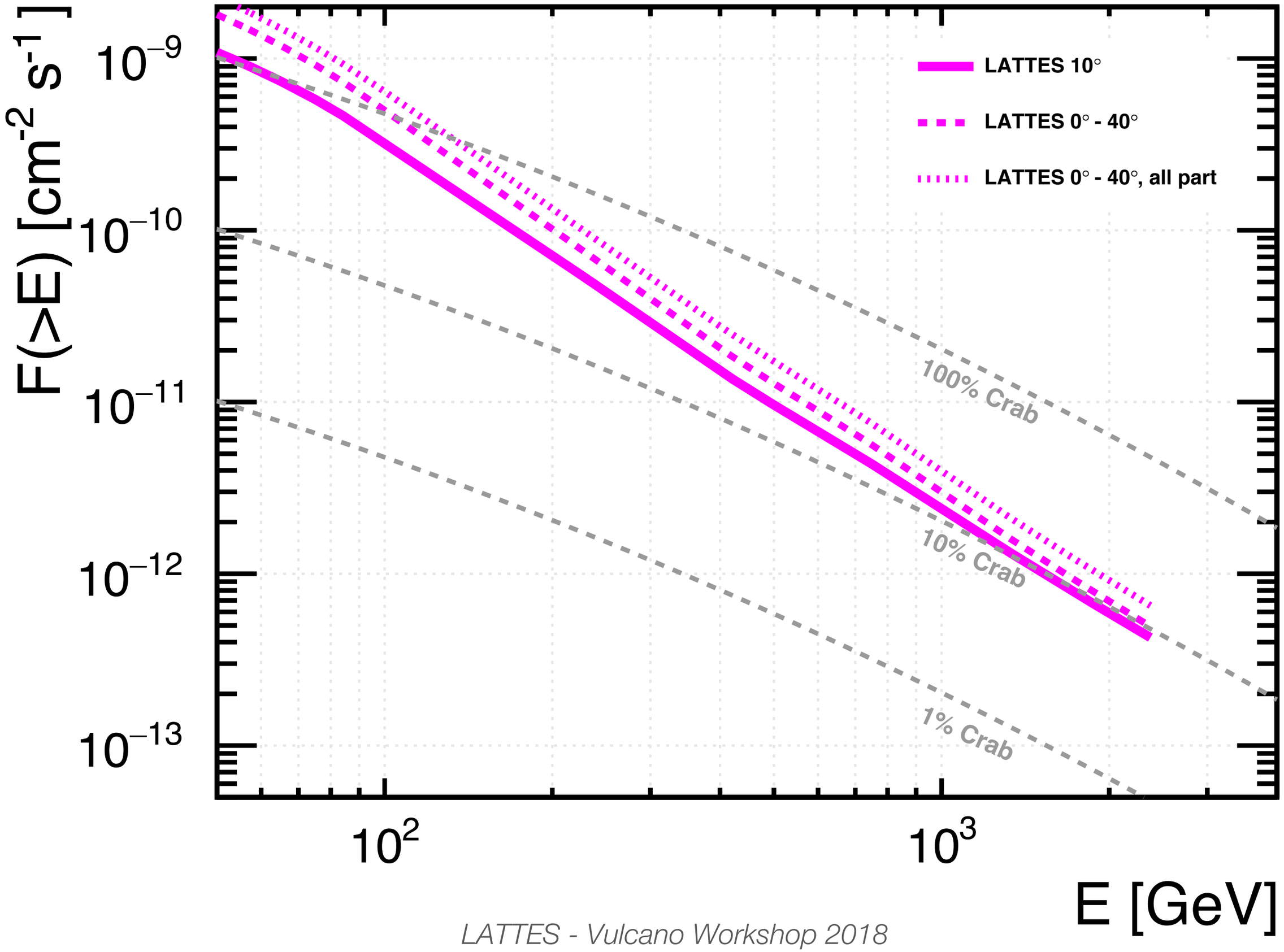
Grafite da Ciência

Um conceito inovador de arte e ciência

CBPF

Back up slides

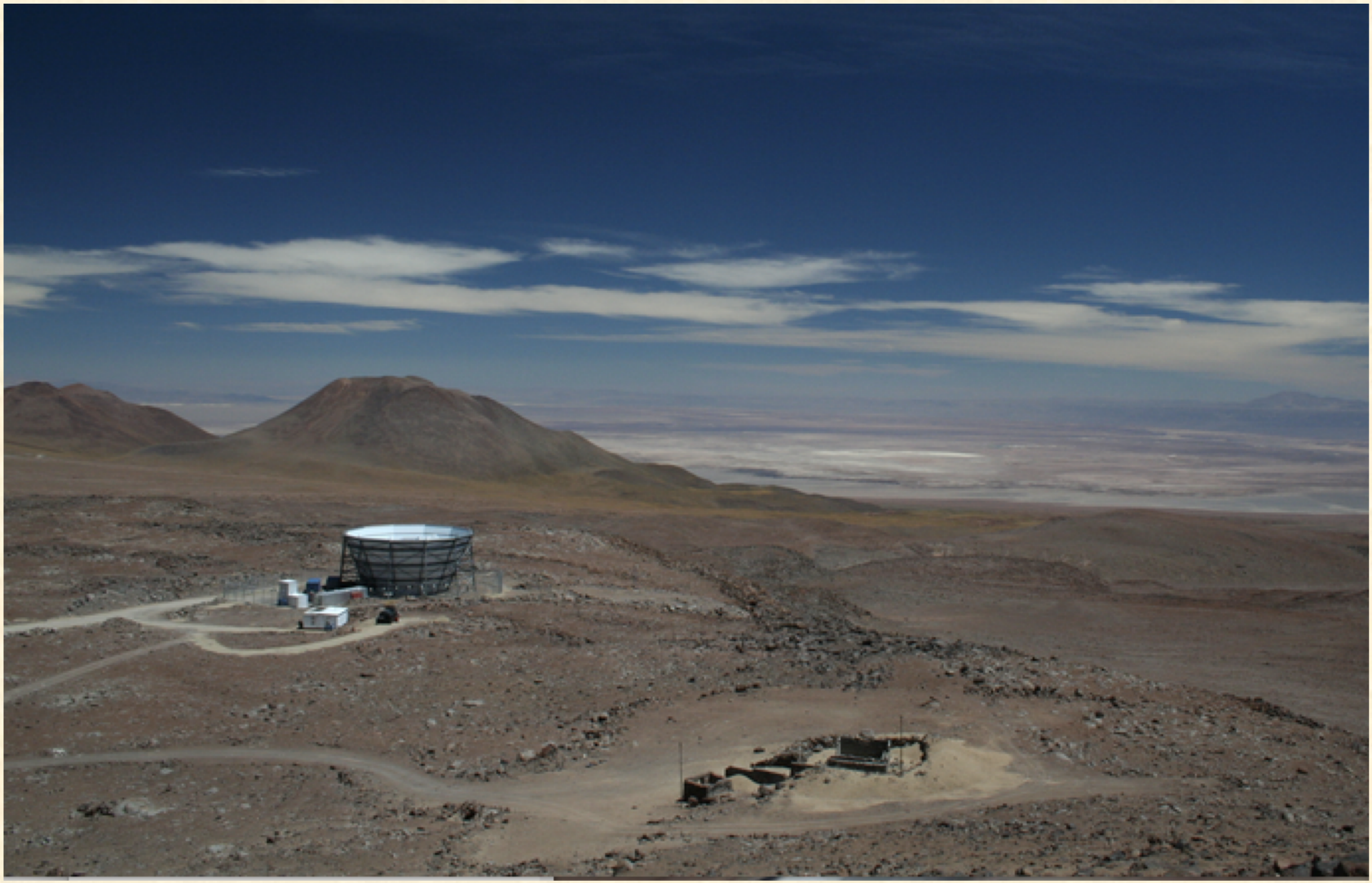
Integral sensitivity



HAWC (Northern Hemisphere)

- *Altitude 4.100 m.a.s.l.*
- *20.000 m^2 covered with 300 W.C. Tanks*
- *200 ton water + 4 Photomultipliers*

Site for LATTES



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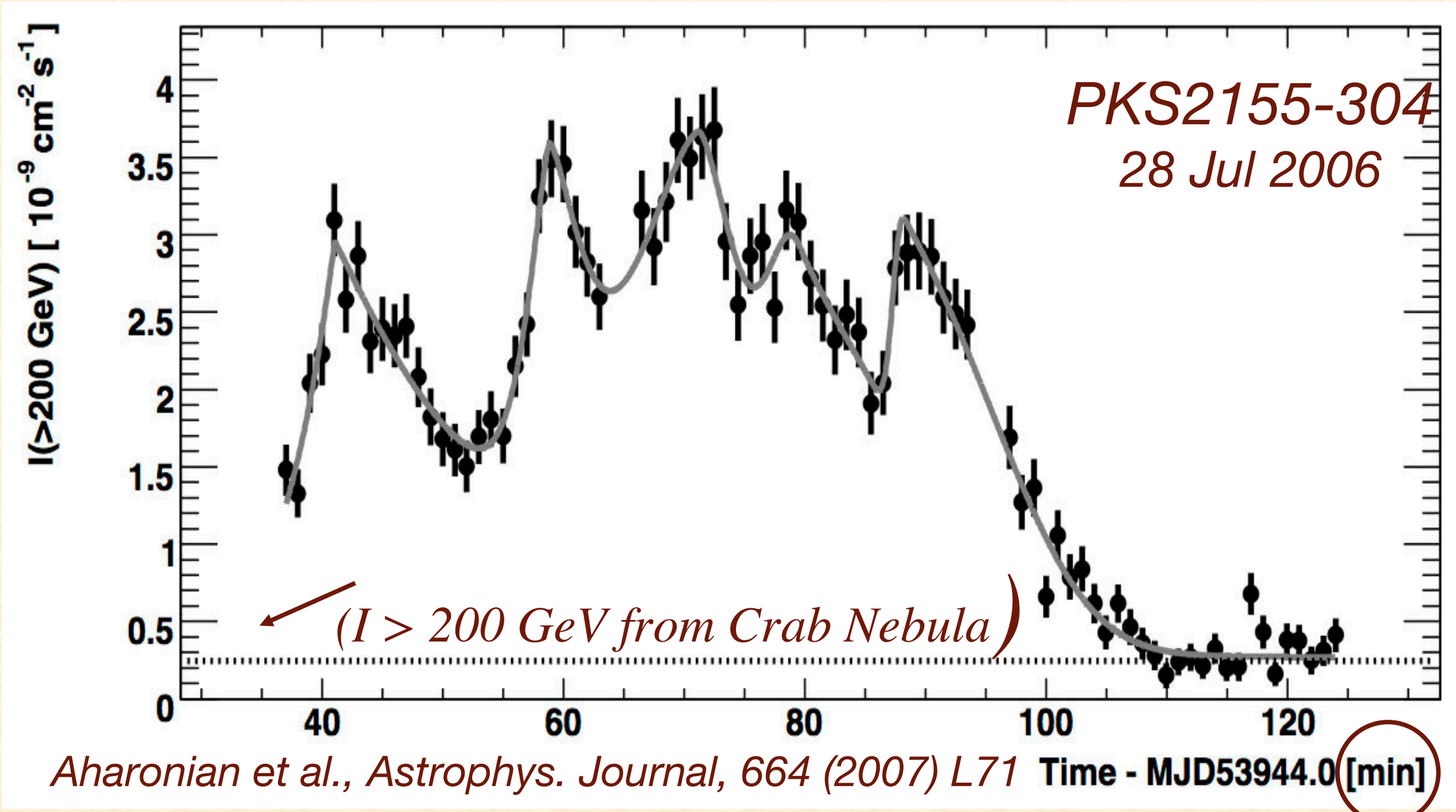
Flares

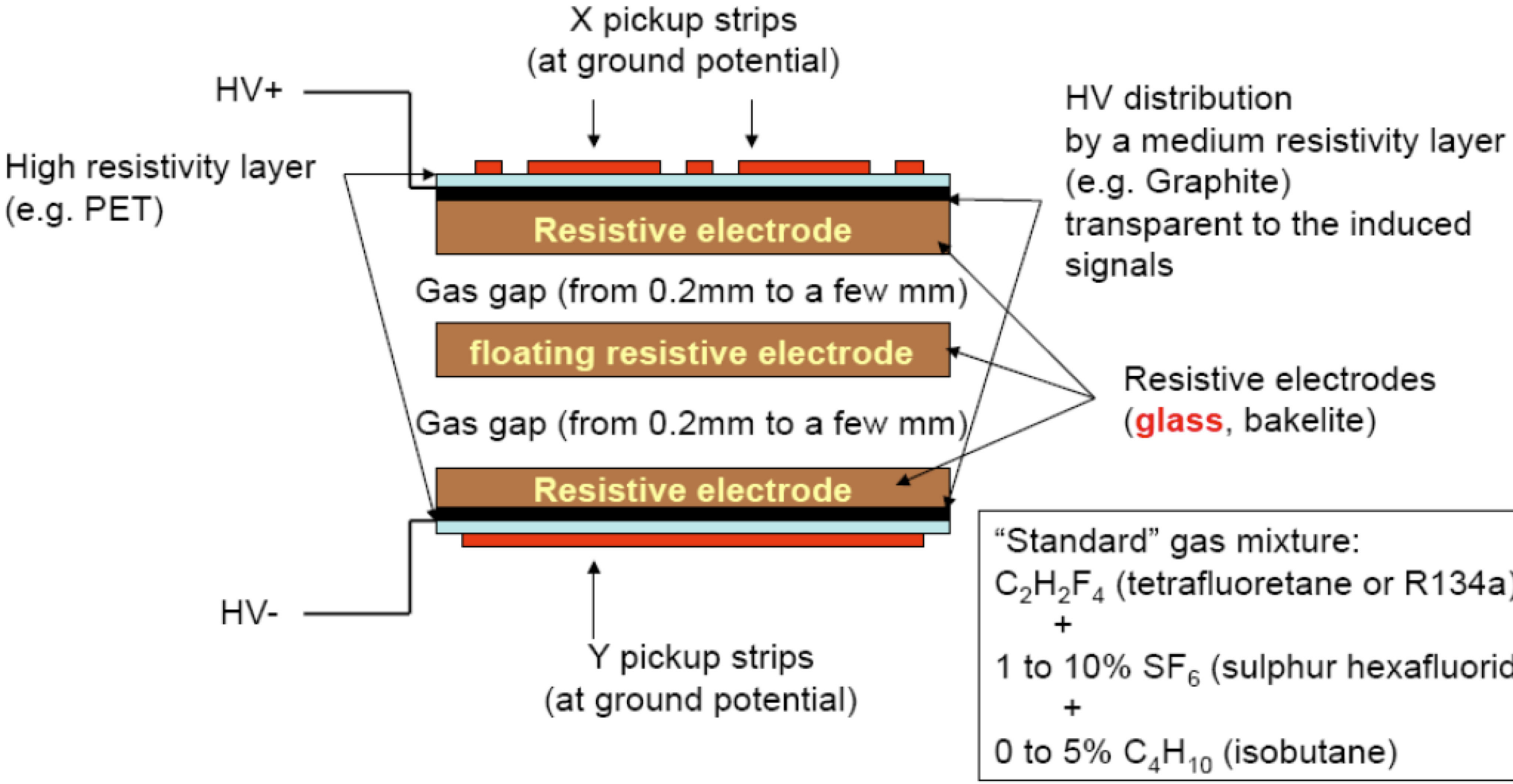


Aharonian et al., Astrophys. Journal, 664 (2007) L71

BL Lacs @ RA: 21h 58’ 52.18” DEC: -30h 13’ 18” ~450 Mpc

RPCs – basic structure

Many variations allowed



"Standard" gas mixture:
$C_2H_2F_4$ (tetrafluoretane or R134a)
+
1 to 10% SF_6 (sulphur hexafluoride)
+
0 to 5% C_4H_{10} (isobutane)

The current is limited by the resistive electrodes: no sparks by construction

Þ very safe detector, although limited to low particle rates (~2kHz/cm²)

Þ excellent efficiency (99%), time (~50 ps) and position resolution (~100µm)