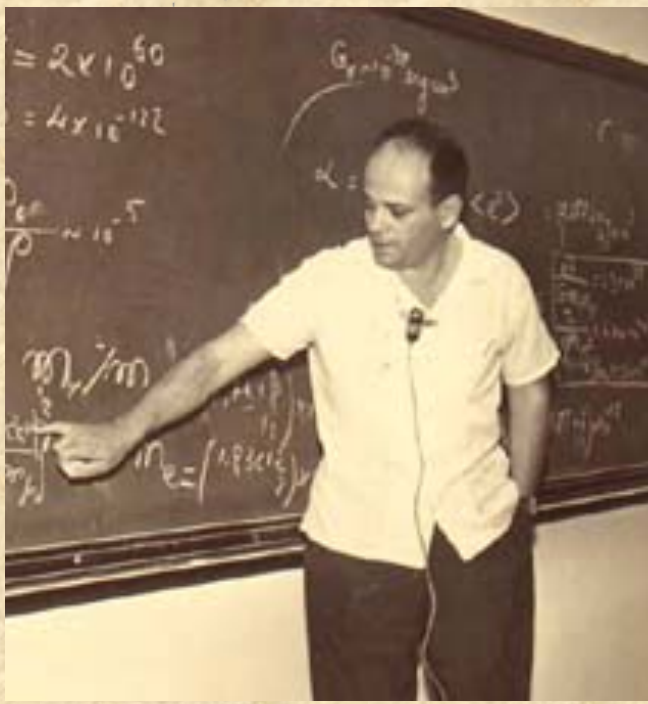
LATTES



Large Array Telescope to Tracking Energetic Sources

Ronald Cintra Shellard
CBPF


Lattes
Ochiallini

LATTES

Lattes started as a name and a project submitted to CNPq at least in 2009:

Edital CNPq/MCT no 14/2008 -- Universal

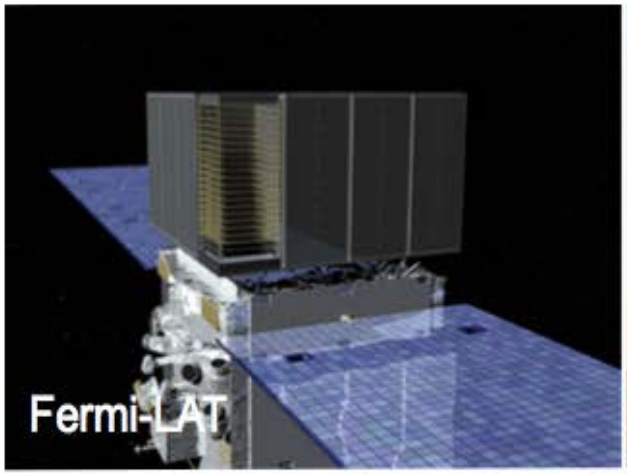
Título: *LATTES e AUGER*

Solicitante: Ronald Cintra Shellard

Instituição: Centro Brasileiro de Pesquisas Físicas

Além do programa do Observatório Pierre Auger, pretendo desenvolver e construir um projeto associado, o Large Array Telescopes for Tracking Extensive Sources (LATTES) [3], um instrumento desenhado para detectar a componente de alta energia dos raios gama emitidos nas explosões de raios gama (*Gamma Ray Bursts*, GRB). Faremos uma descrição mais detalhada deste projeto, adiante.

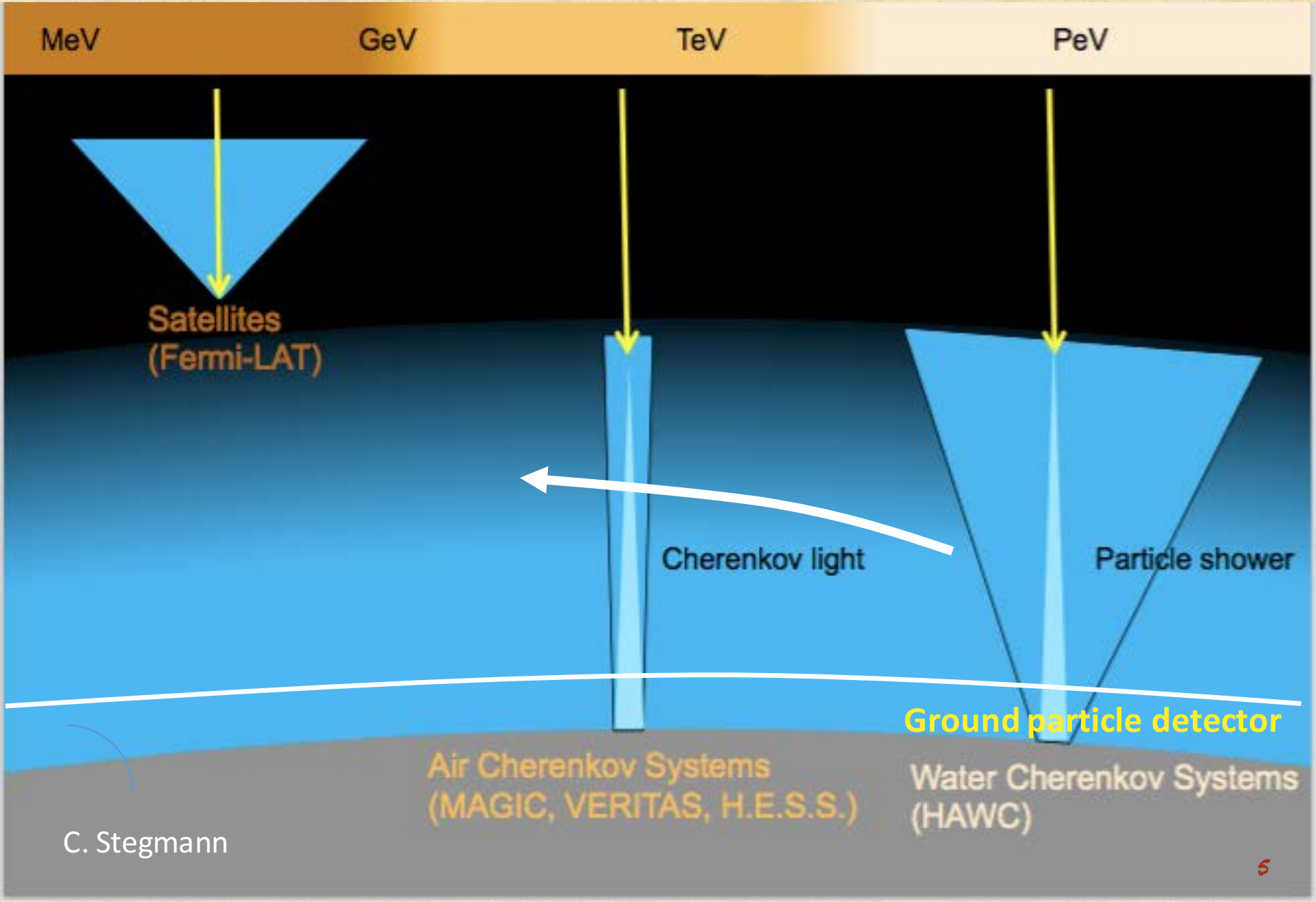
Very high Energy Gamma Rays



	Fermi LAT	IACTs	HAWC
Effective area	1 m^2	**10^5 m^2**	**10^5 m^2**
Field of view	**20% of the sky**	3° – 5°	**15% of the sky**
Energy res.	10%	**10%**	100% – 20%
Angular res.	6° – 0.3^o	**0.1^o**	1° – 0.2^o
Duty cycle	**Full year**	1400 h/year	**Full year**

C. Stegmann

Experimental techniques



C. Stegmann

LATTES

LATTES objective is to build a detector operating 24/7, with an opening of $\pi\ \mathrm{rad}^2$

Gamma Energy > 100 GeV

Altitude above 5.000m

Capability of detecting transients

In South America (interesting objects)

- Non Thermal processes in the Universe
- Transients
- Physics of extreme objects
  - SNR, AGN, GRB

Sources of potential interest

- The *Galactic centre* (Sagittarius A*) , at declination -29 degrees.
- *HESS J1640-465* is one of the most luminous TeV gamma-ray sources in the Galaxy at declination – 46 degrees. Discovered by HESS is positionally coincident with a known supernova remnant. The observed spectrum extends up to about 10 TeV.
- *RX J1713.7 - 3946* coincident with a supernova remnant. The spectrum extends up to about 100 TeV
- *Centaurus A* (NGC5128), the AGN closest to us at a distance of about 4 Mpc is at declination - 43 degrees. This is a well known radio galaxy emitting electromagnetic radiation in a very wide range of frequencies. HESS has detected photons from Centaurus A of energy up to 6 TeV .
- The three strong gamma-ray emitters have been found by HESS in the *Large Magellanic Cloud (LMC)* a satellite galaxy of the Milky Way distant about 50 kpc at declination of – 70 degrees with photon energy extending up to about 20 TeV.

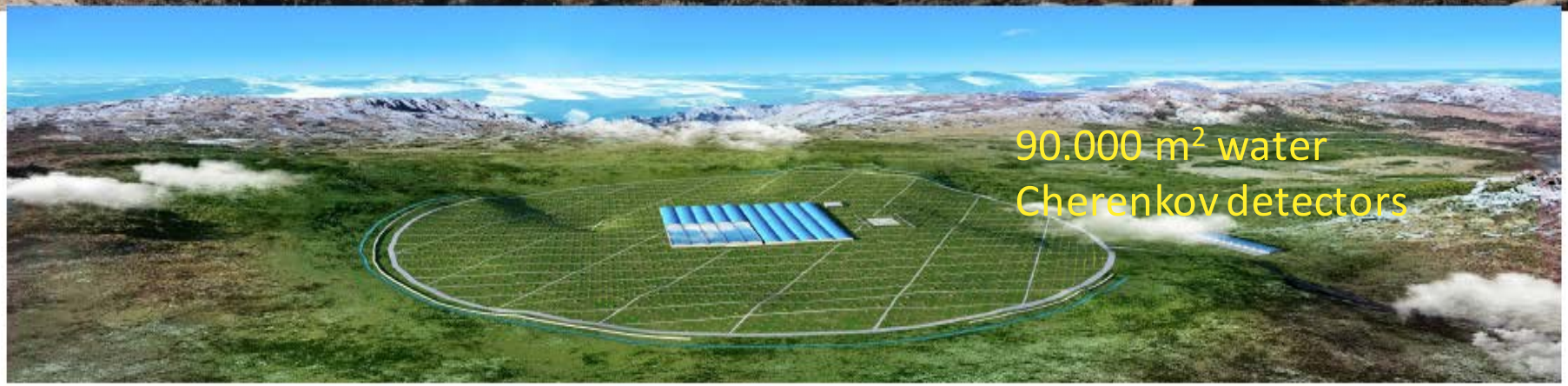
HAWC (Northern Hemisphere)

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

LHAASO Project

36^0 N

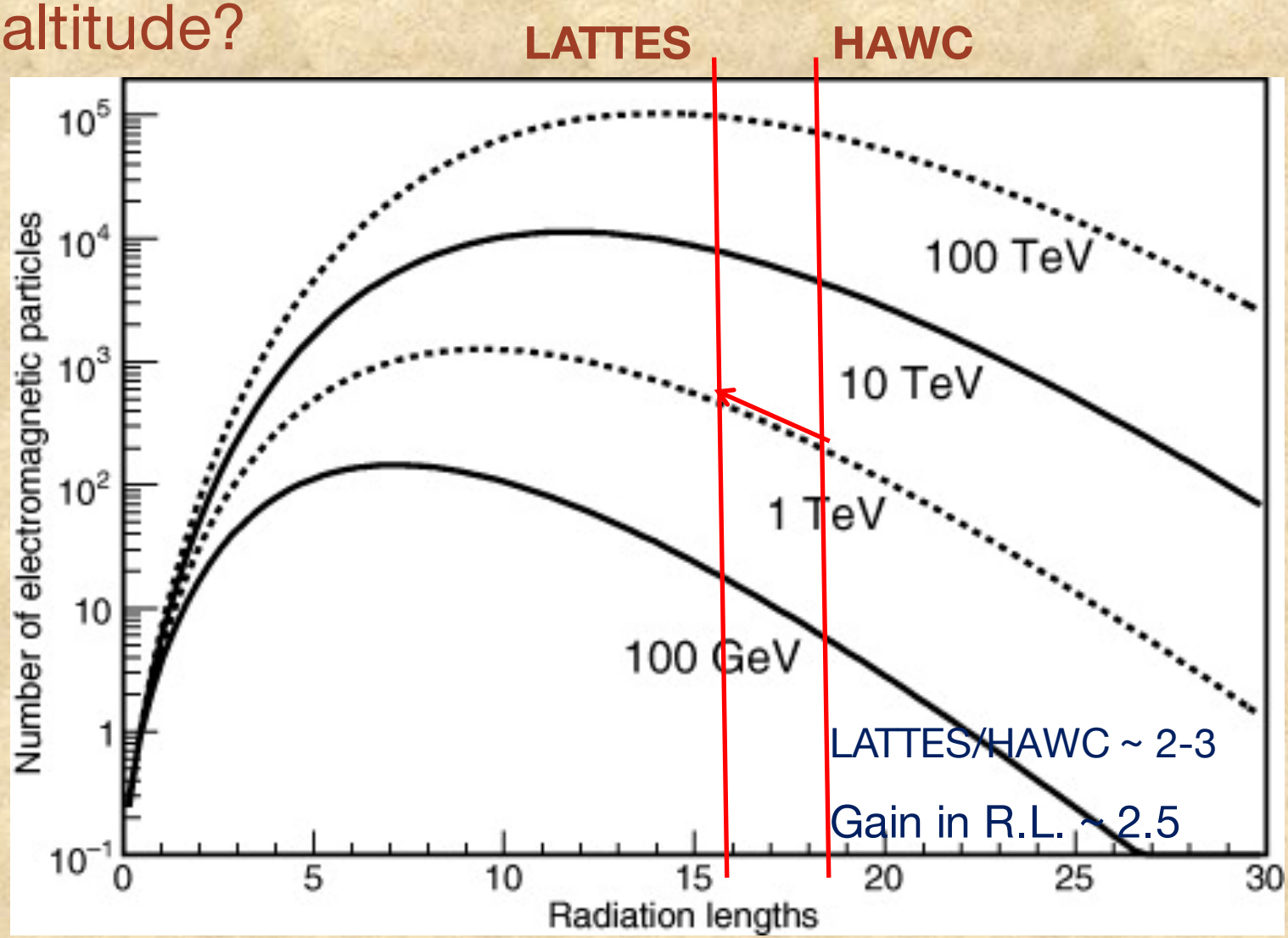
Zhen Cao IHEP, China, Beijing



III Astrophysics Workshop, Sao Paulo, Brazil, 2014

LATTES

Why altitude?



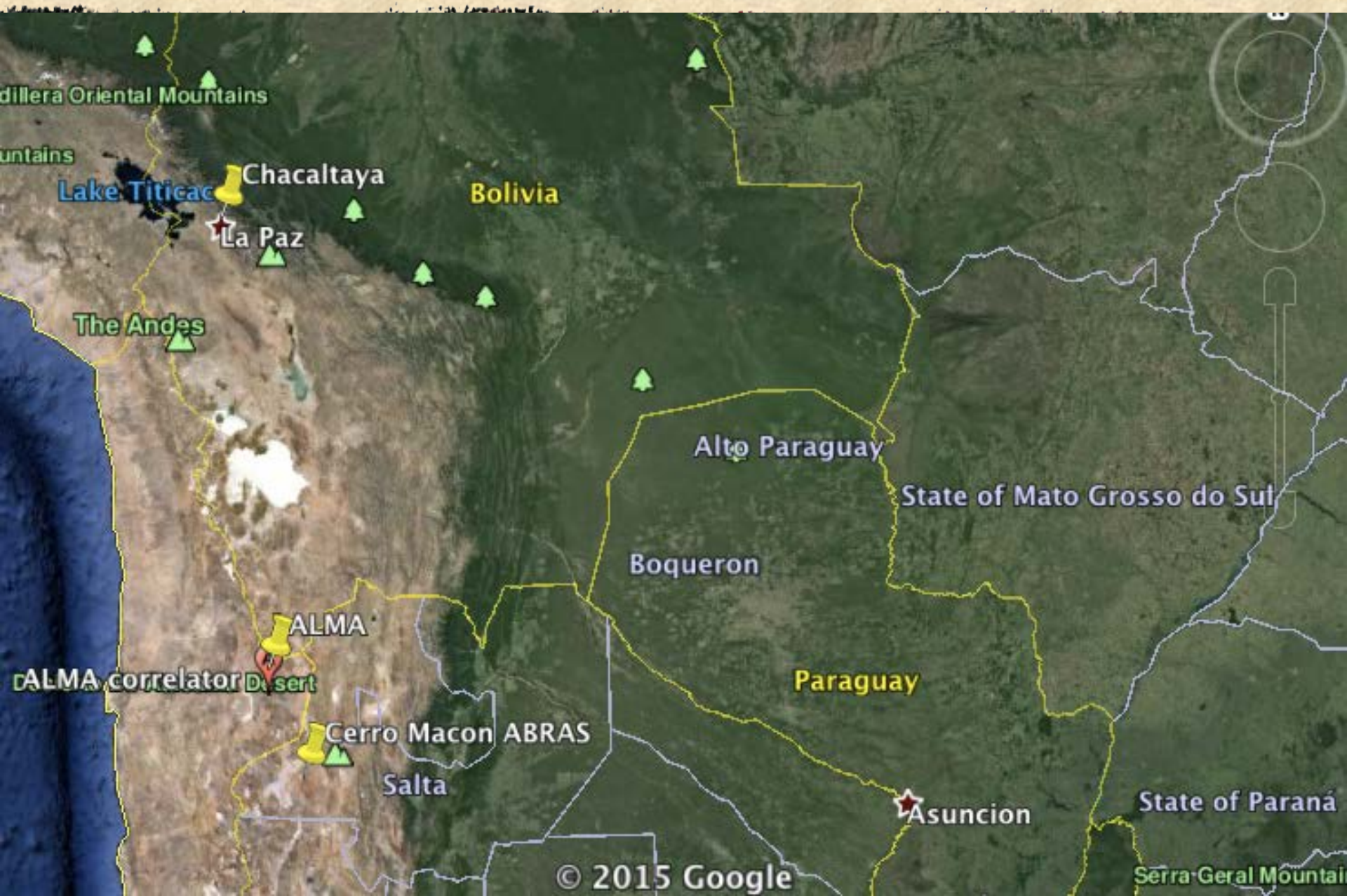
Sites for LATTES

Chacaltaya Observatory, Bolivia, near La Paz
Latitude **16.3 S**, altitude **5200 m** a.s.l.

ALMA Site - Atacama desert**,** large plateau, Chile at the border with Bolivia
Latitude **23.7 S** , altitude **5060 m** a.s.l. (could be higher)

Air pressure ~ 50 % of sea level !

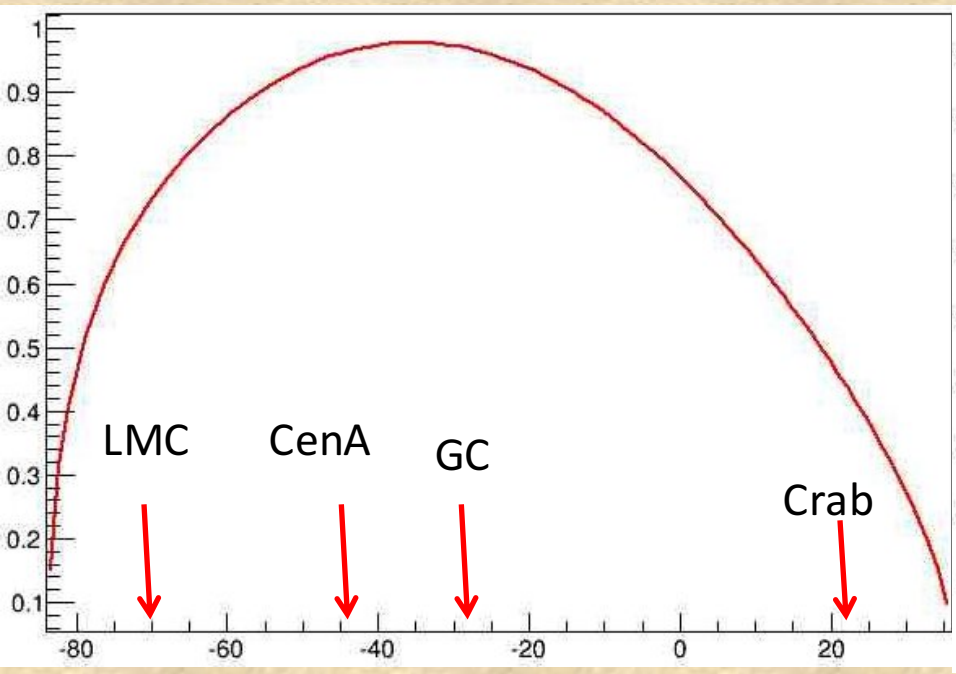
Sites for LATTES



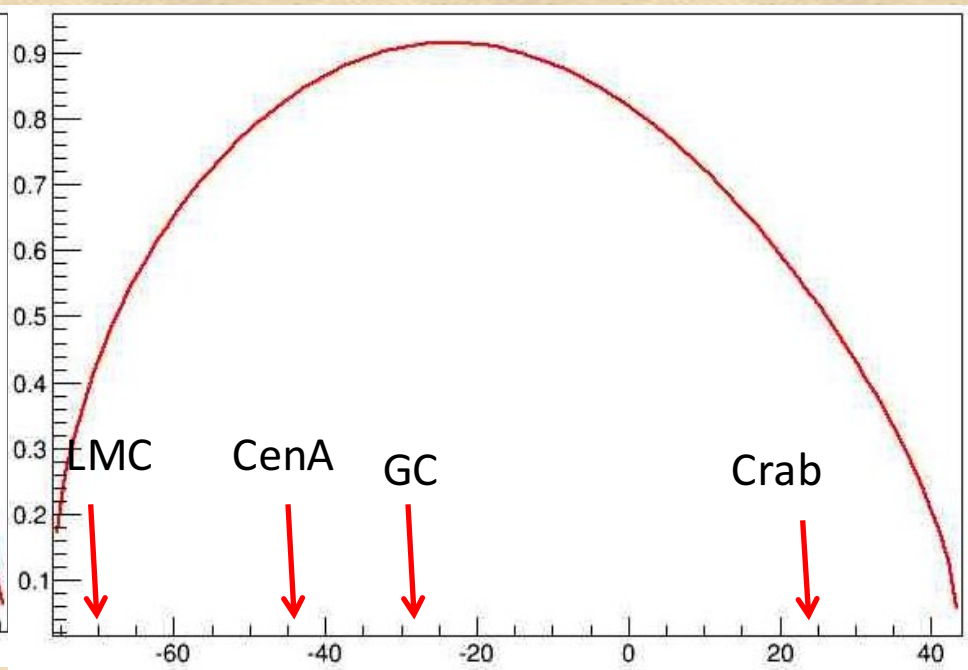
Exposure

Declination (zenith angle) < 60 degrees
Crab nebula is a kind of standard "candle" in high-energy photons astrophysics

Alma (-23.7°)



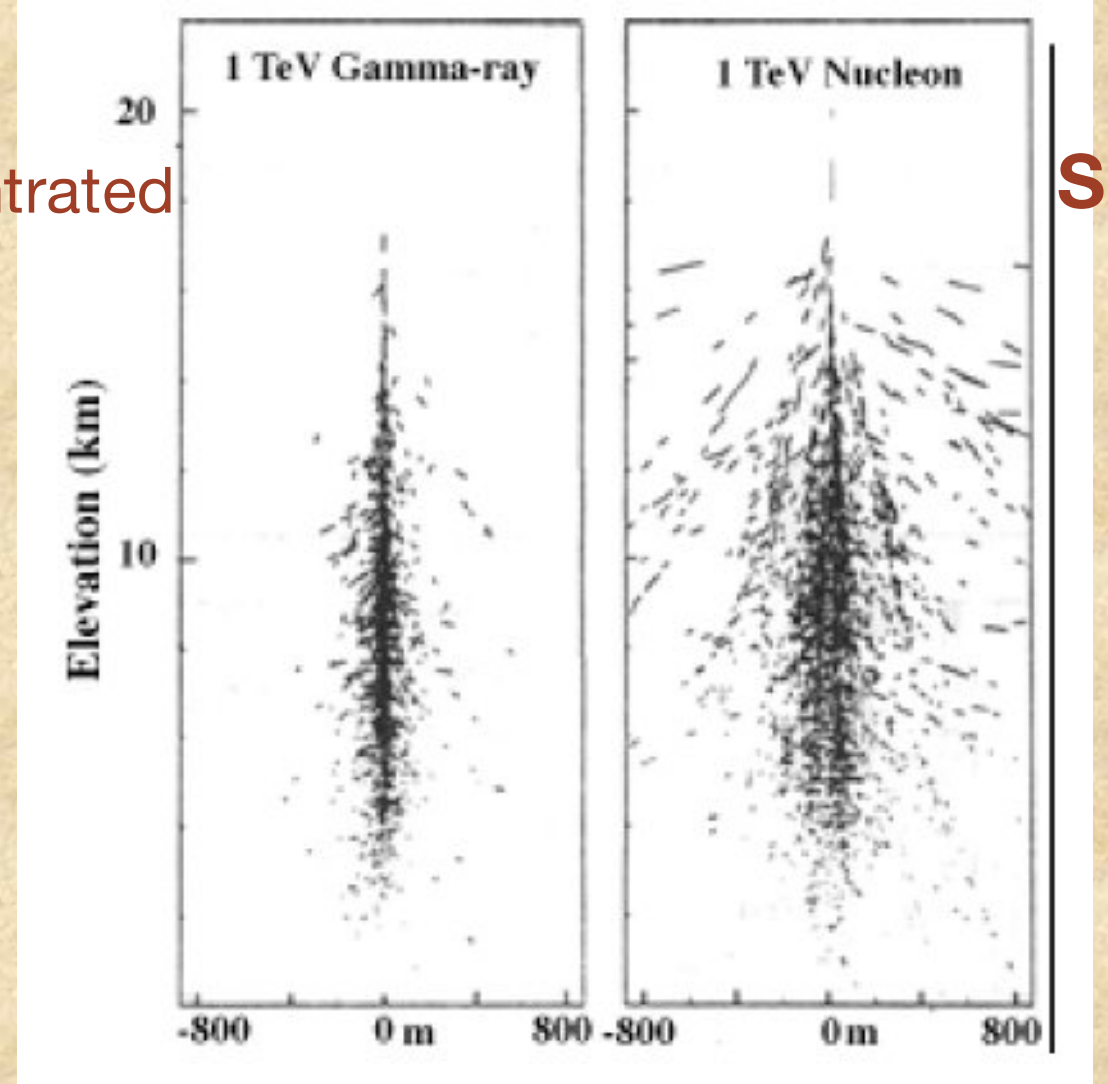
Chacaltaya (-16.3°)



Declination δ

Topology for protons and gammas

Concentrated



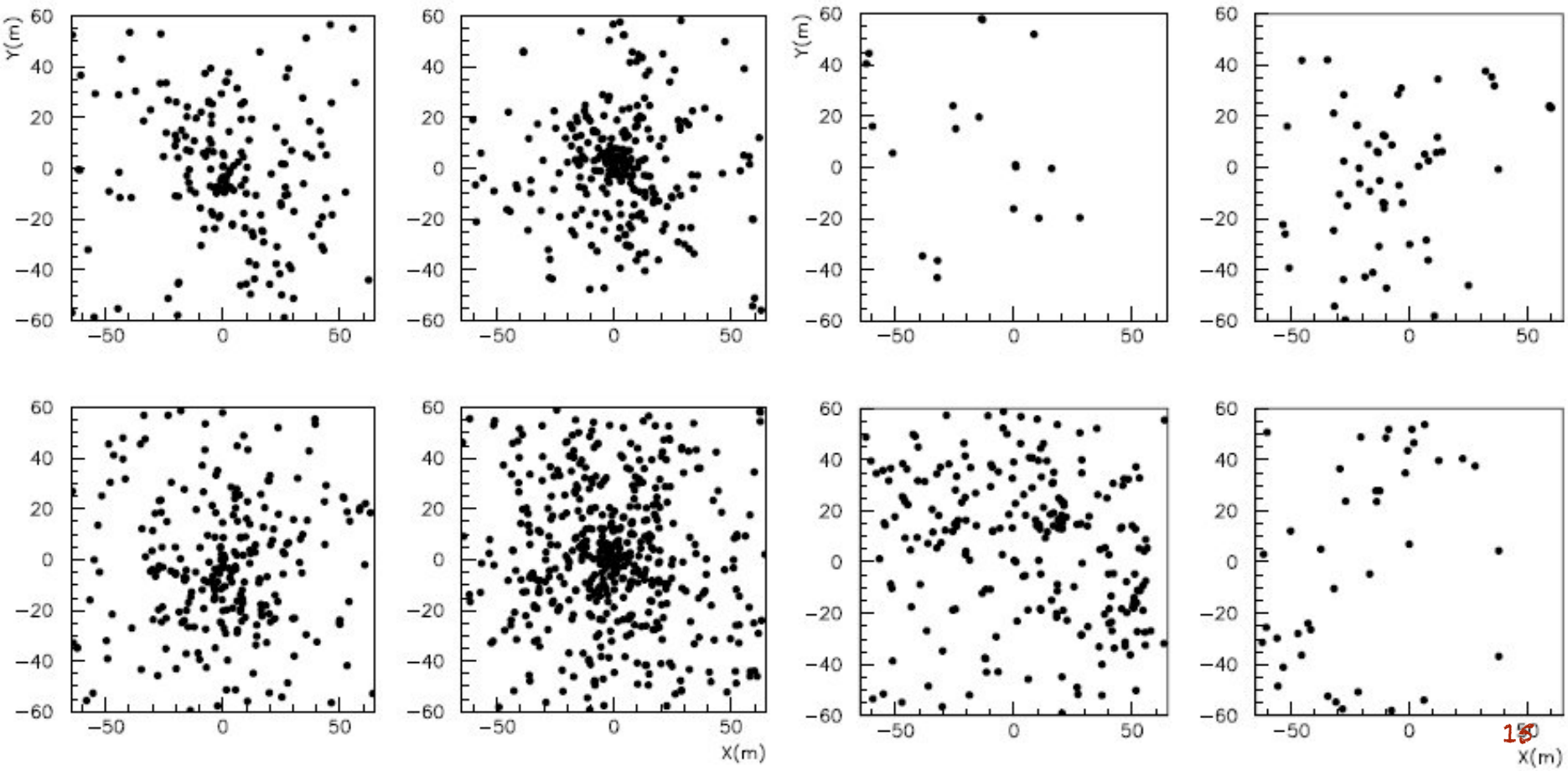
Sparse

Large spread of arrival times

1 TeV particles

Photons

Protons



Particle density (5000m)

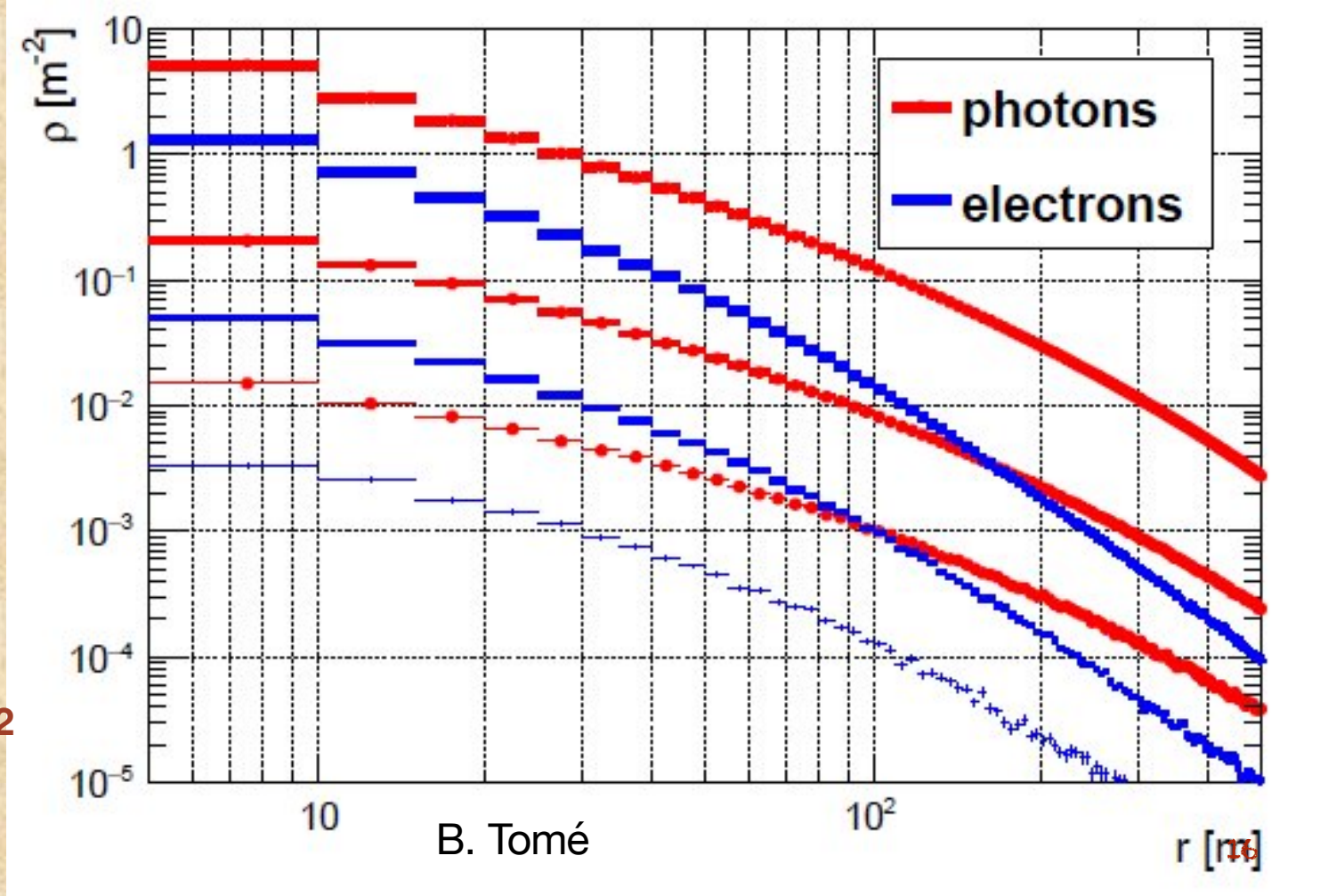
Photons are main component of the shower
Primary Photons 100 GeV, 500 GeV and 5 TeV

6 part/m²

0.3 part/m²

0.02 part/m²

Detector size at least 10 m²



B. Tomé

Baseline design

- Exposure area larger than 10.000 m^2

  (mix of science requirements and funds)
- Dense cover of the area
- Detectors simple and robust. Little maintenance
- Good time resolution
- Good hadronic backg rejection
- Good angular resolution
- Scalable

Baseline design – Conceptual design

CESAR

***C**alorimeter **El**ectromagnetic for **S**tudying **AiR** gammas*

Prototype being developed using glass radiator

Measure the energy of the shower with good resolution

MARTA

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

Particle counter based on RPC technology

Time resolution ~ 1 ns

Clear float glass

It is stable and, for thick plates, it is sturdy

water needs purification and control against pollution by bacteria and may evaporate and freeze.

Big manufacturers of plates of clear float glass (China).

Large production capabilities, prices are low.

For plates of thickness up to 19 mm, cost 5 – 10 USD/m^2

Most modern big building around the world are essentially towers with walls made of float glass supported by steel frames. The overall wall area can be of the order of thousands of square meters

CESAR

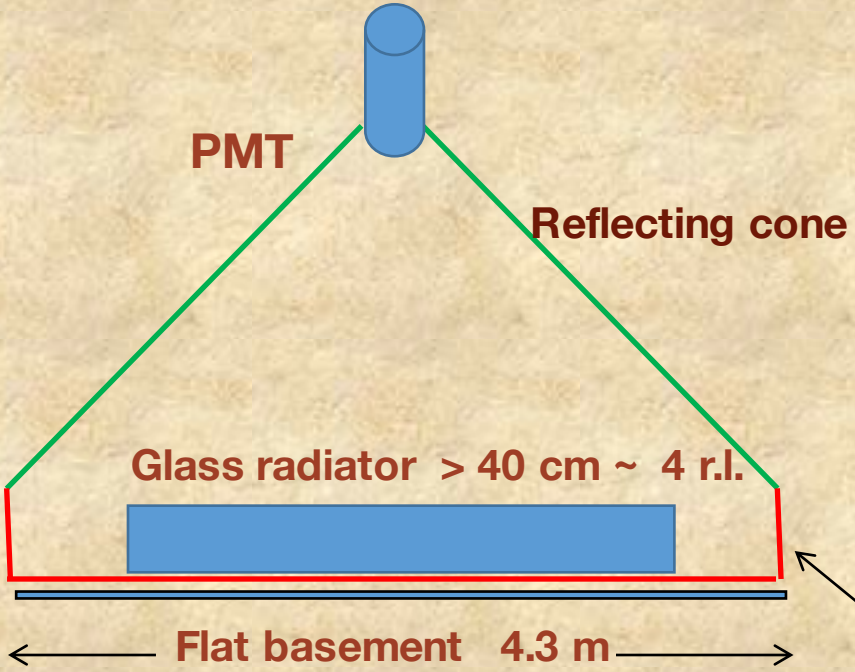
Clear float glass has very good physical properties.

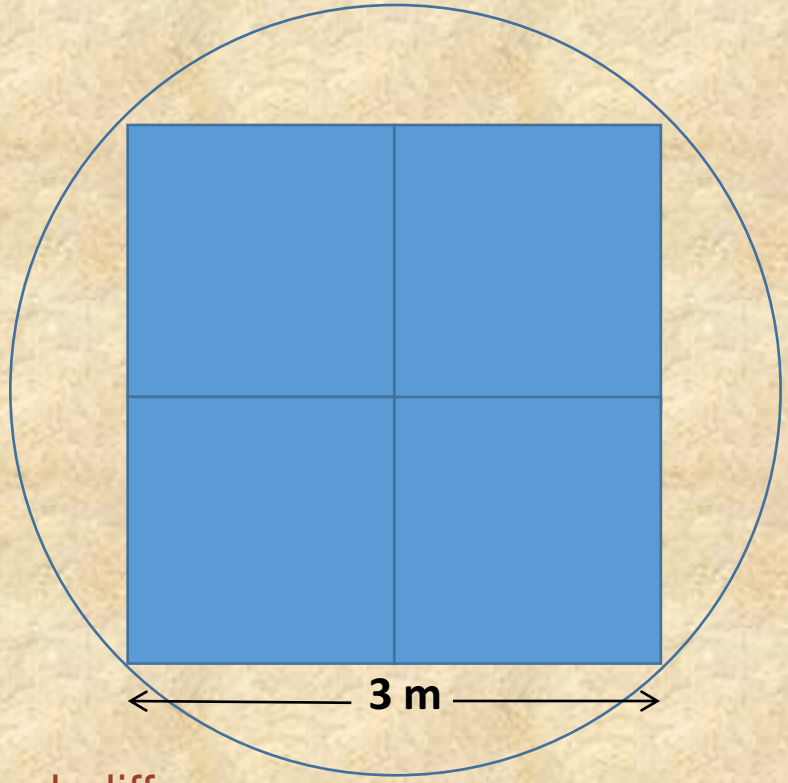
- Density 2.52 g/cm3
- Refractive index 1.5
- Transmission spectrum 0.3 – 3 μm (matches sensitivity of standard photocathodes)
- Radiation length 10.7 cm (allows compact design with respect to water , 36 cm)
- Critical energy 49 MeV (water 81 MeV)

Cesar - Sketch of a detector unit

Sandwich: 19 mm thick glass plate
Thin plastic sheet interlayed

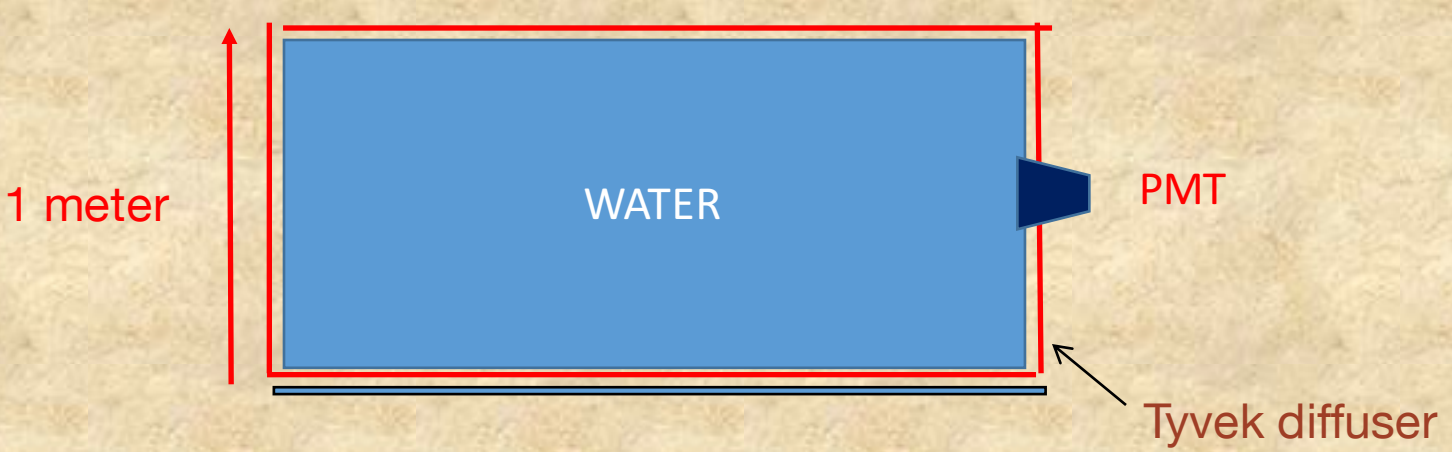
The basic glass element
1.5 m x 1.5 m x 19 mm
Weight: 106 kg





Tyvek diffuser

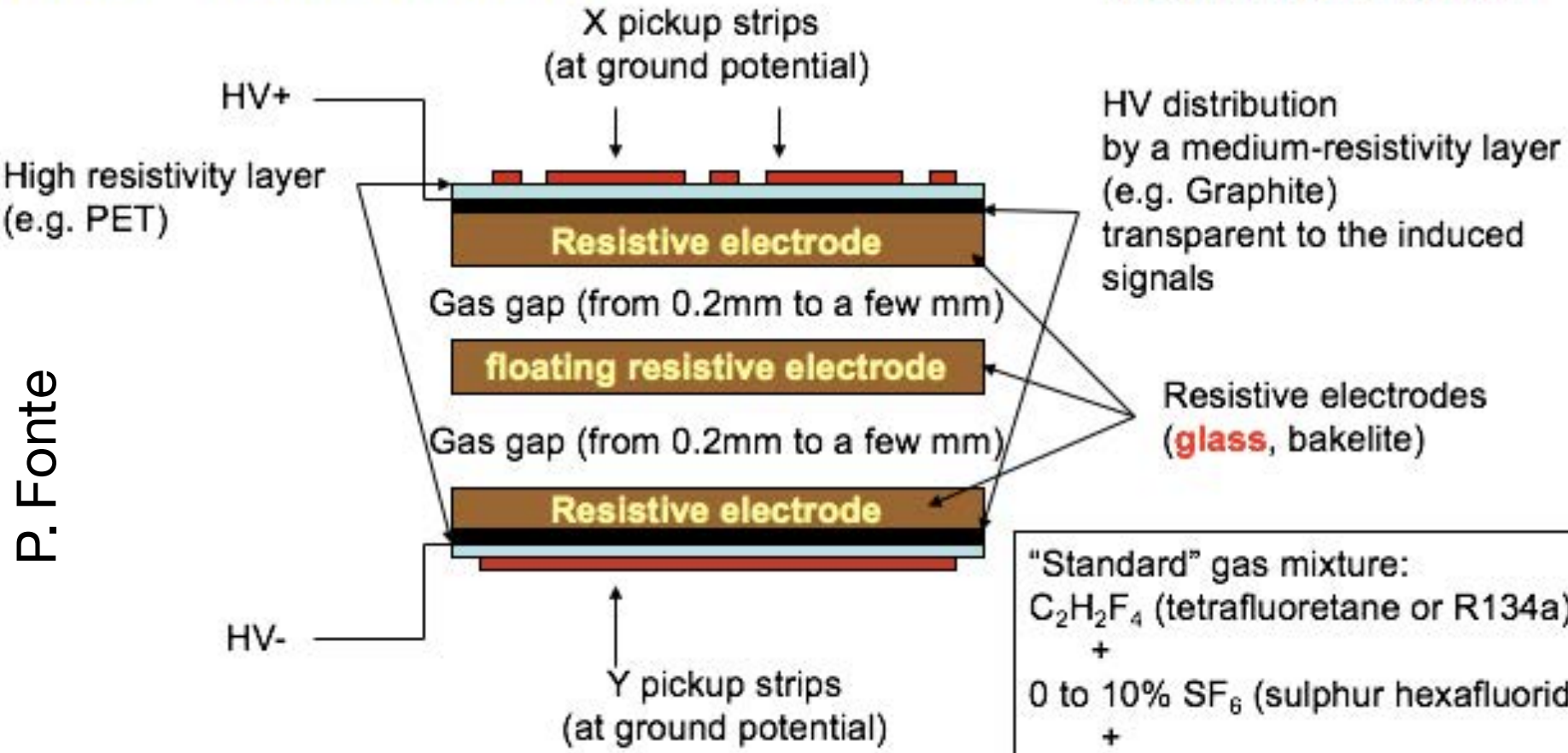
Cesar – Alternative Water tank



MARTA

RPCs* - basic structure

Many variations allowed



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

P. Fonte

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

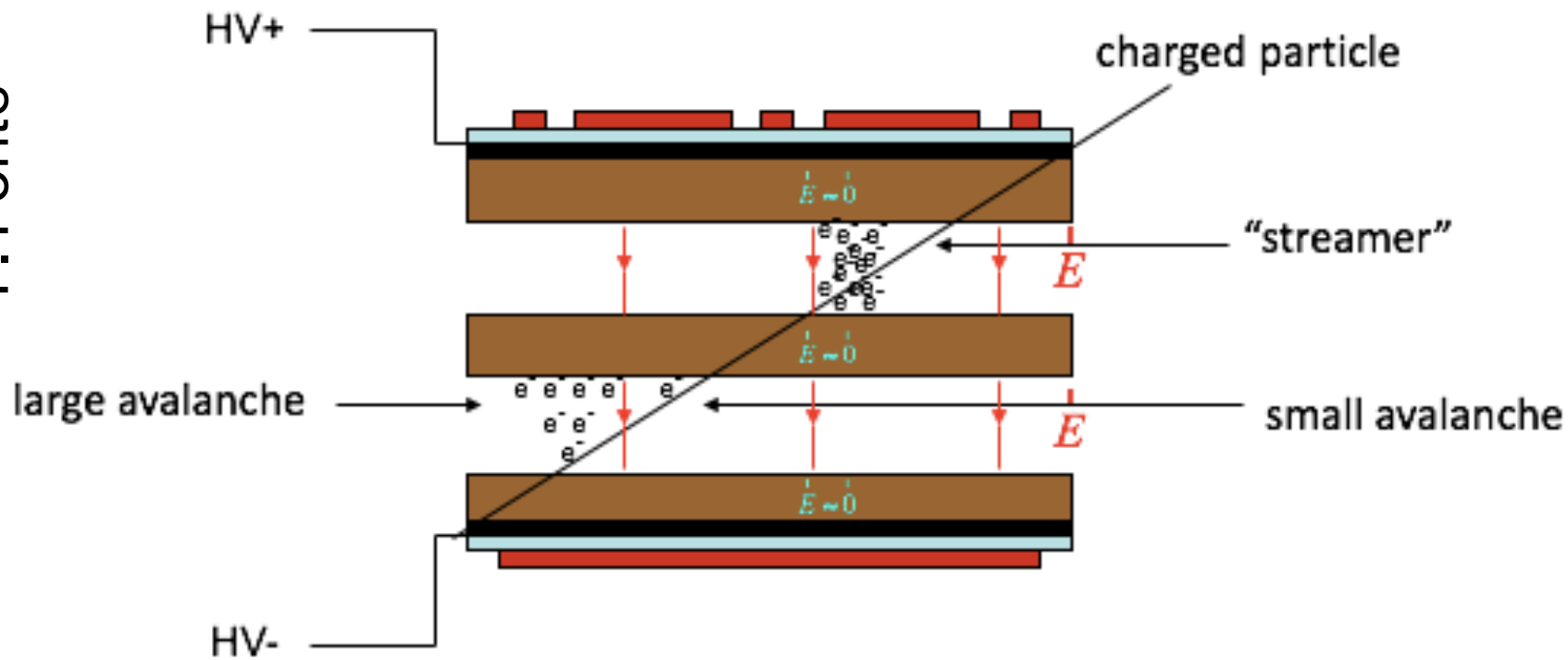
⇒ very safe detector, although limited to low particle rates (~2kHz/cm²)

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

RPCs – gas multiplication

MARTA

P. Fonte



Streamer mode: only streamers are detected - every particle must start a streamer.
Avalanche mode: all avalanches are detected. Efficiency depends on electronics' sensitivity.

Charged particles ionize the gas. The released electrons are accelerated by the applied field and multiply in avalanche.
The final avalanche size depends exponentially on the position of the initial electron. Only ionizations that take place far from the anode contribute to efficiency ⇒ <u>single gap efficiency 75% to 90% ⇒ several gaps needed</u>

MARTA

Requirements

Originally a detector to use in Auger

1-Very large area @ low cost -> gaseous detector

2-Segmented readout for particle counting,
fiducial area selection, etc. -> gaseous detector

3-Reasonable timing (~5ns) -> gaseous detector

4-Standalone operation

5-Outdoors operation -> resilience to environmental effects

6-Low maintenance -> very low gas flow

7-Little aging at zero particle flow (mostly dark current)

Avalanche-mode glass RPCs fit well requirements 1-4 and we believe have fair chances for the rest.

Main challenges:

- Very low gas flow operation
- Resilience to humidity

P.Fonte

MARTA

AUGER

Electrodes	2 mm soda-lime glass
Gap thickness	2 x 1 mm gaps, "multigap" construction
HV, signal-transparent layer	Controlled resistivity acrylic paint
Gas tightness, HV insulation	Acrylic box
Mono-component gas mixture	R-134a (tetrafluorethane)
Gas flow rate	0.5 cc/min, equivalent to 1 kg/year
Signal pick-up electrodes	8x8 pad matrix, with 180x140 mm^2
Electromagnetic shielding and structural case	Aluminium box

P.Fonte

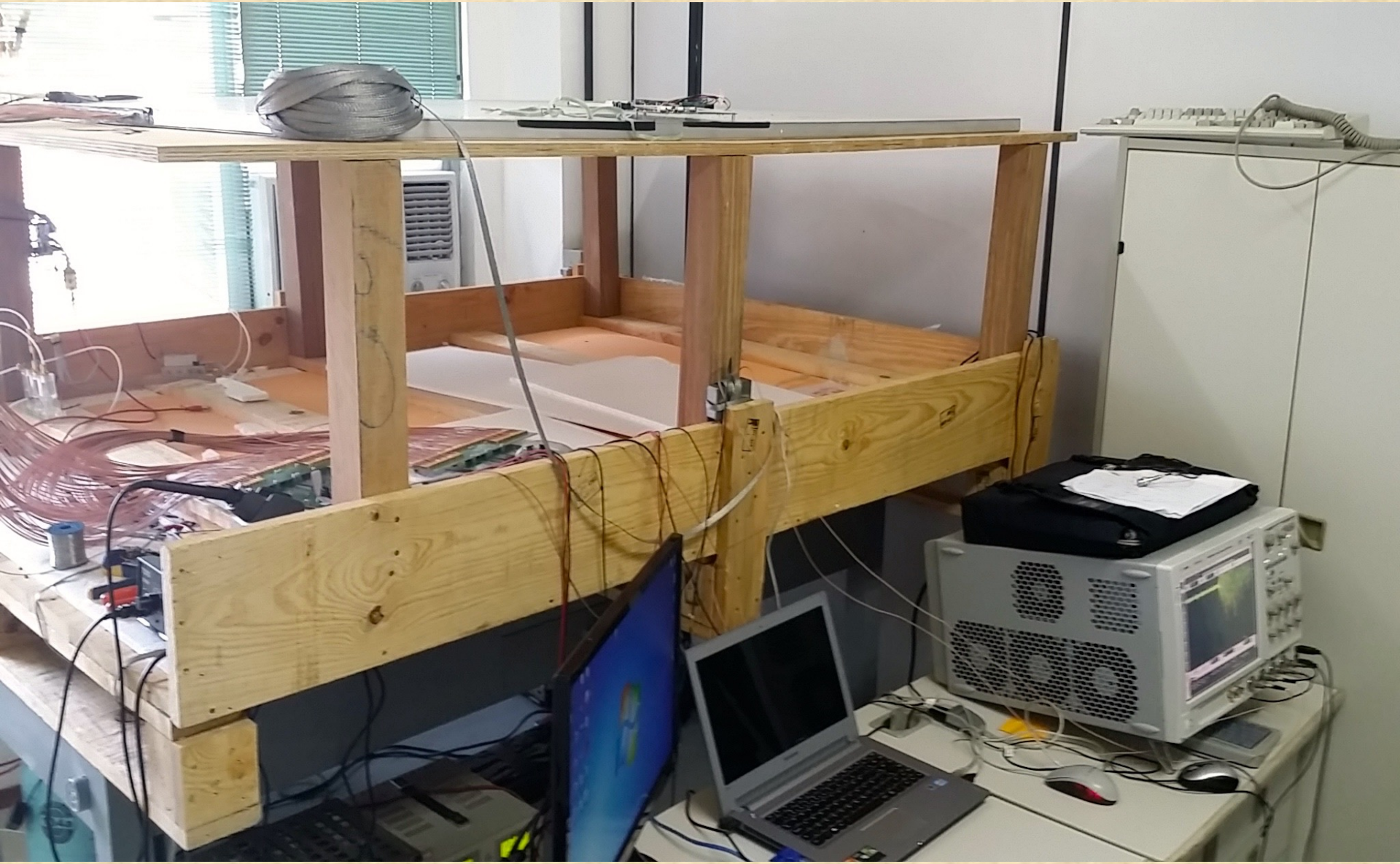
MARTA

Chambers in operation
with HV since Jan 2014

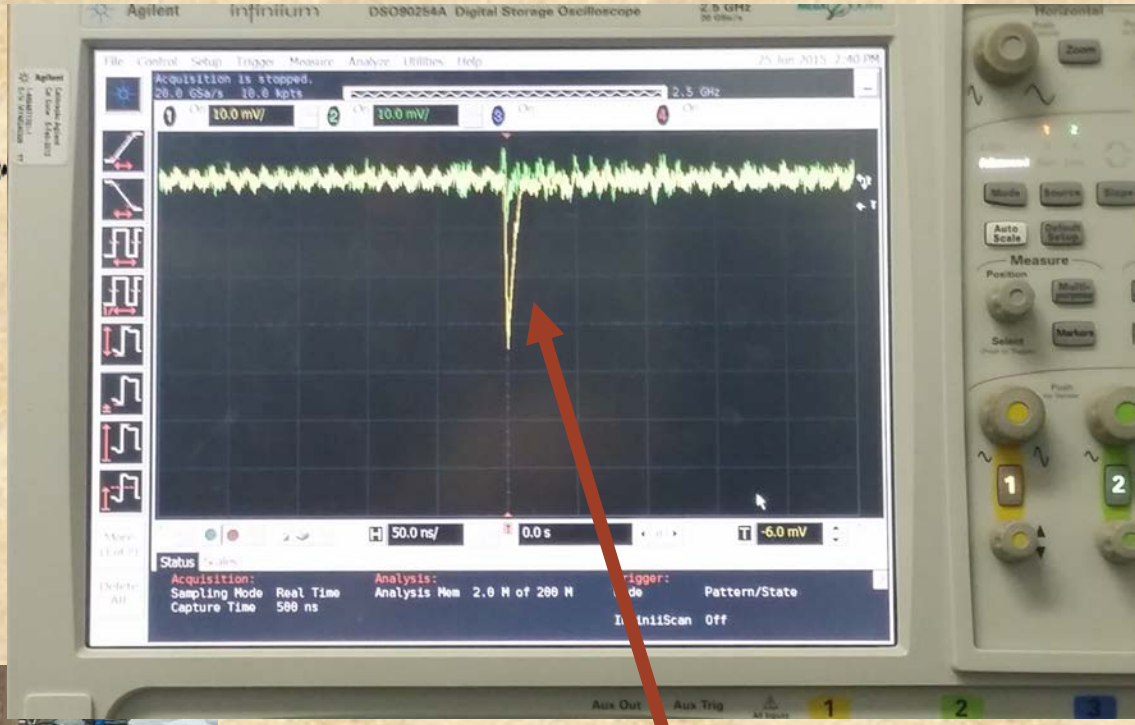
4 RPC's

2RPC's

MARTA in Rio



MARTA in Rio



A cosmic ray!

Angular Resolution

Expect an angular resolution of a fraction of degree (about 0.5^0 @ 1 TeV, and about 0.1^0 @ 10 TeV

The orientation of the front of the showers is obtained from measurements of the time of arrival of the shower front on the detector units. RPC are very fast !

Discrimination of gamma-ray vs. protons

-The basic experimental method relies on the different topology of the hits distribution which is sparse for hadronic showers and quite concentrated for photon showers.

- The proposed detectors are rather small and therefore the response is fast. This will allow implementing an additional method of discrimination based on the rise time and thickness of the front of the shower. This method has been successfully used by the Auger collaboration in the higher energy region.

Conclusions

LATTES is complementary to:

- HAWC / LHAASO providing full sky coverage (HAWC/LHAASO in the North and LATTES in the South)
- HESS/CTA in terms of continuous operation and wide field of view

Conclusions

LATTES has the right geographical properties in terms of latitude and altitude

On the chessboard of astroparticle physics with gamma rays

LATTES is the missing piece !

Conclusions

Thanks