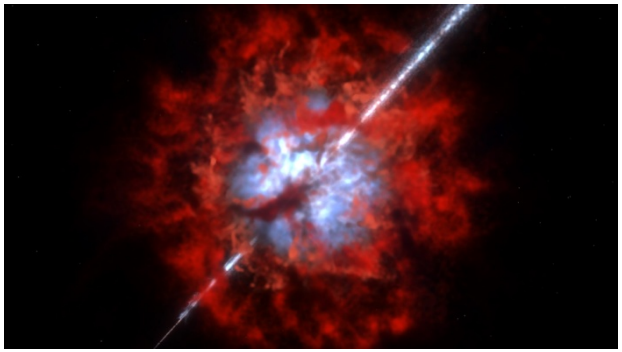
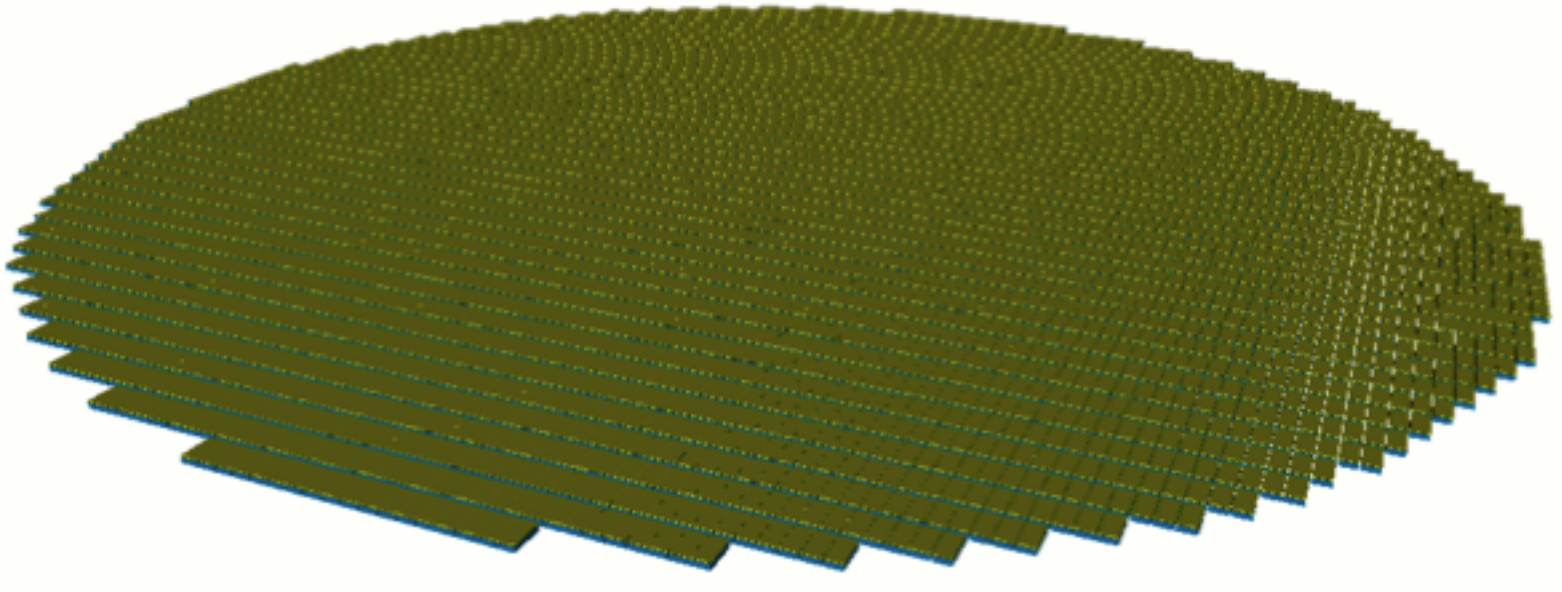
# LATTES

Large Array Telescope for
Tracking Energetic Sources





LIP

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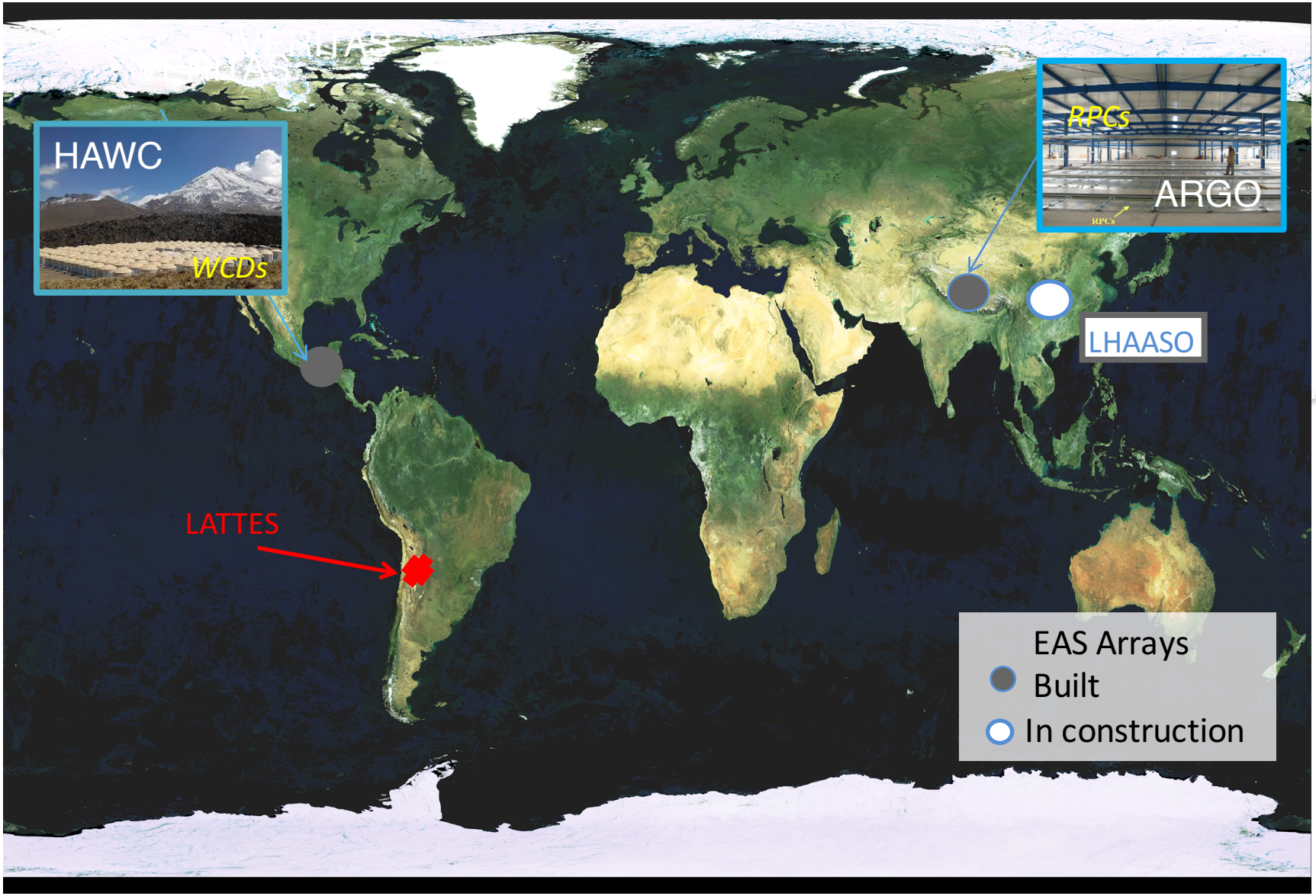
FCT Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA EDUCAÇÃO E CIÊNCIA

REPÚBLICA PORTUGUESA

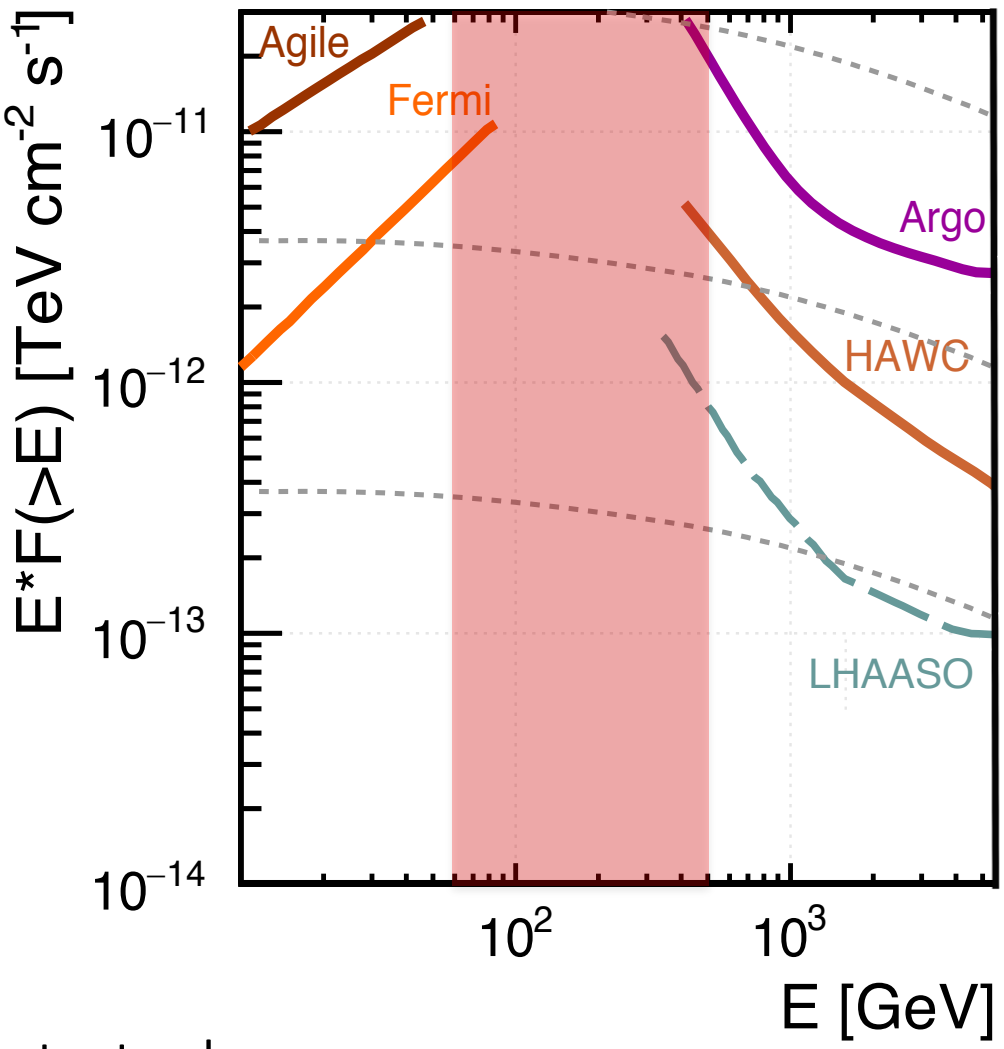
Mário Pimenta
September 2018

# Wide Field of View Gamma Ray Observatories

# Wide Field of View Gamma Ray Observatories

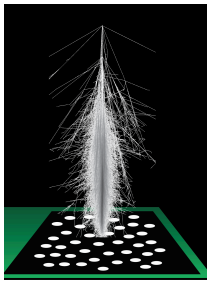


# The Energy challenge

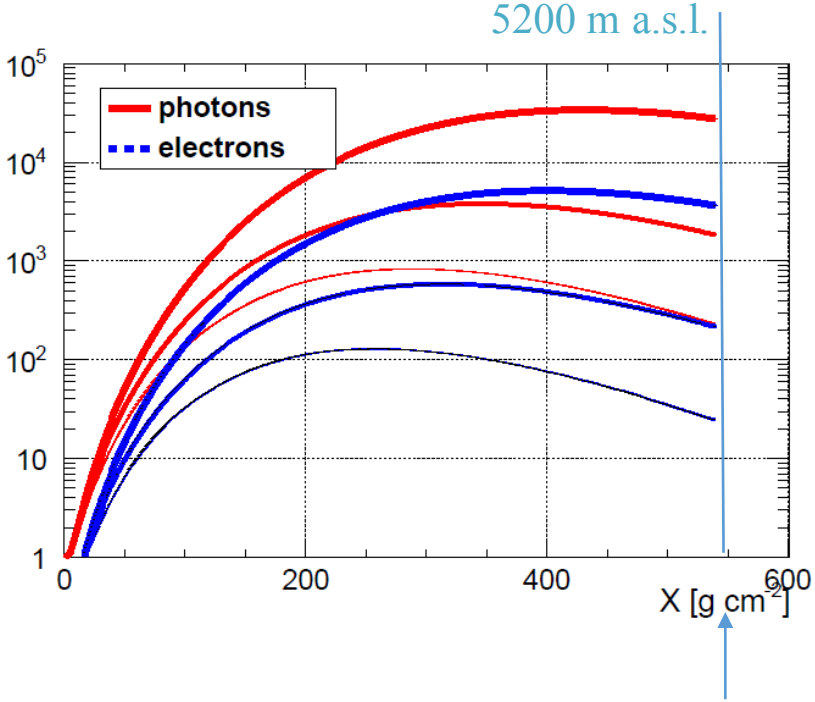



Differential sensitivity to steady sources in one year

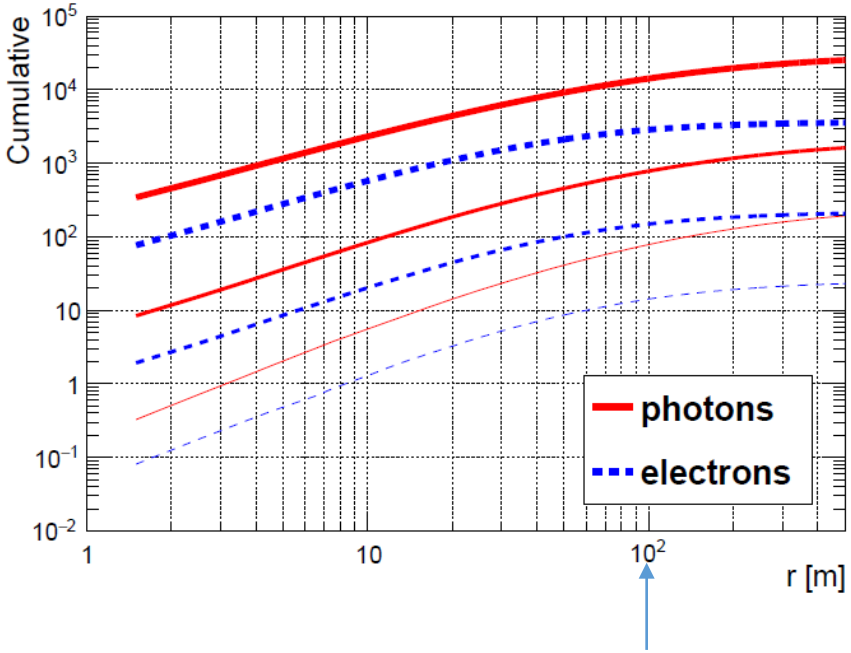
# Why low energies are so difficult?



Mean longitudinal profiles
100, 500 , 5000 GeV




Cumulative LDFs
100, 500 , 5000 GeV

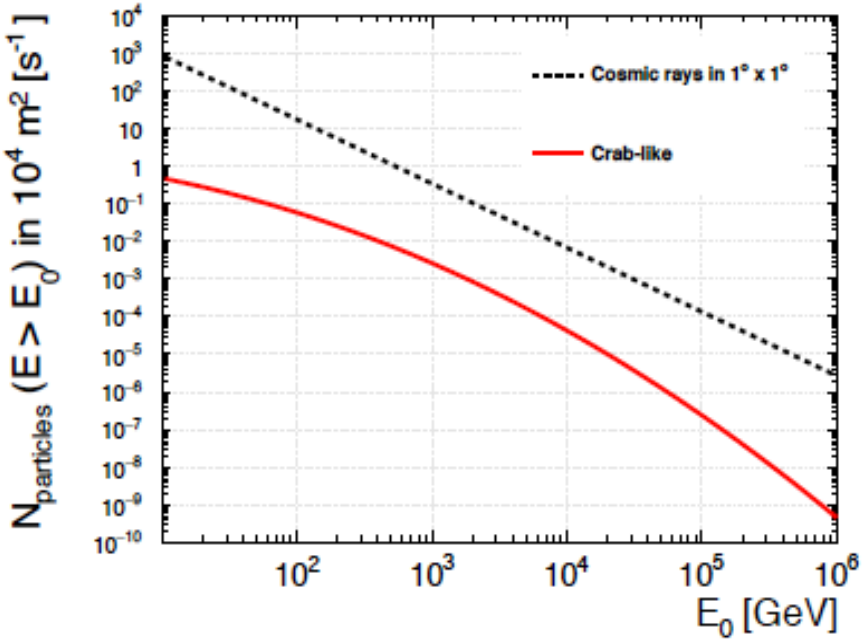



Number of particles at 100 GeV is quite low!
The large majority are photons

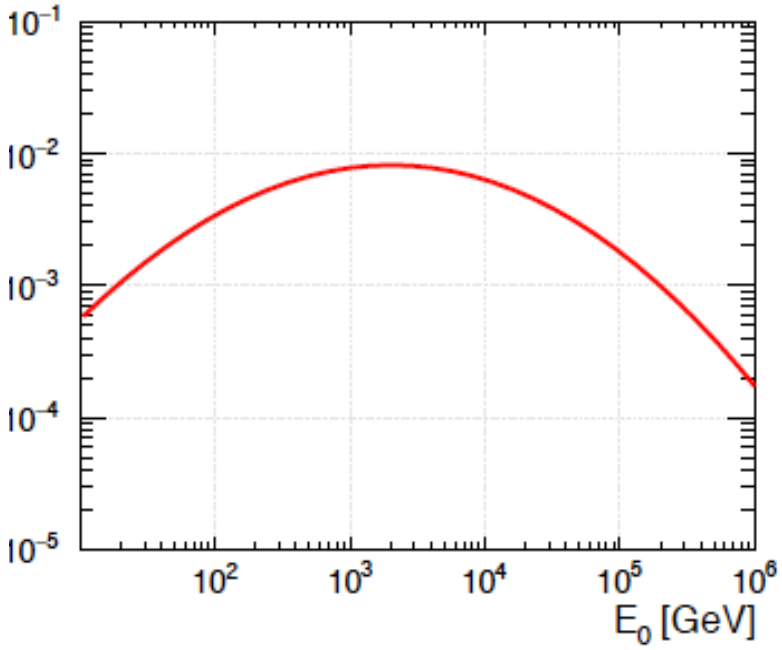
# High background !

## Crab vs cosmic rays

Rate




Signal /Background

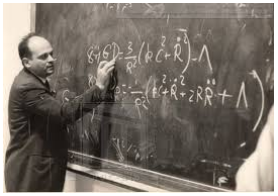



Event rate ($1^o$x$1^0$) above a given energy on a perpendicular surface of 10 000 $m^2$

# Key factors

- altitude
- Segmentation
- Detector unit trigger threshold
- Time resolution
- Area
- FoV
- Reliability and good control of systematics
- Standalone operation
- Cost

# LATTES

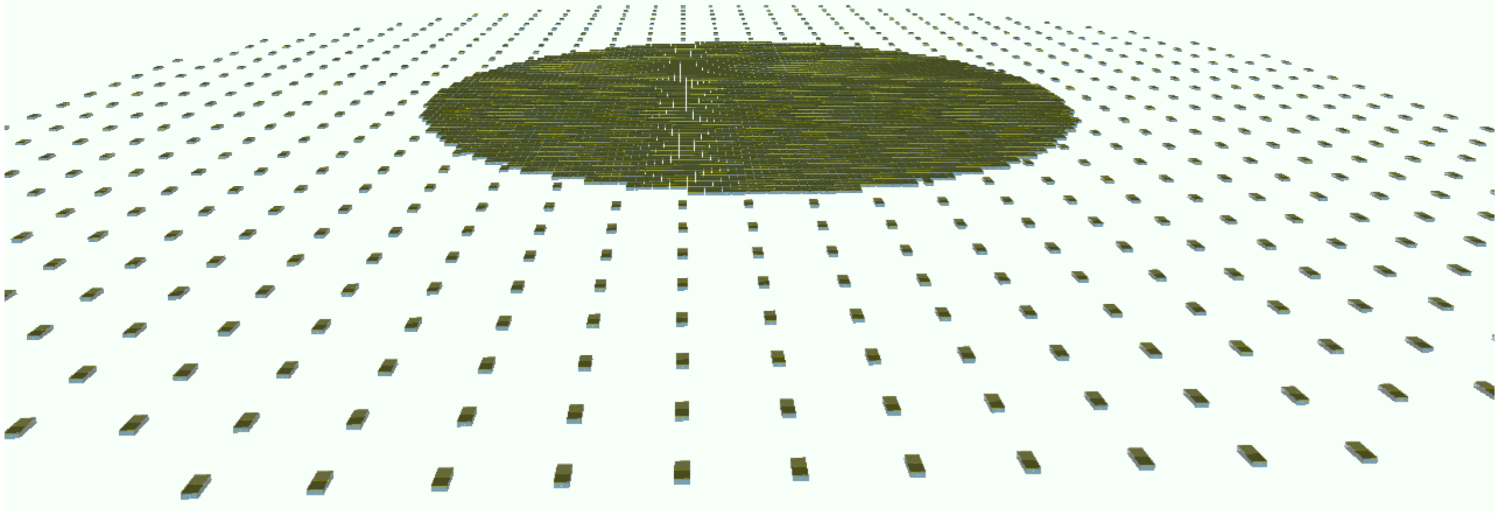


## Large Array Telescope for Tracking Energetic Sources

Energy range 50/100 GeV – 100 TeV

Baseline dimensions :

- Core array 20000 $m^2$
- Total area 100000 $m^2$



Brazil / ITALY/ Portugal/ Czech Republic

(China) /( Spain)

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

# Science Case

See talk
Giovanni la Mura

## Gamma-ray physics

- Flares and transient sources (GRBs, jets from AGNs …).
- Extended photon sources (Galactic Center, Fermi bubbles, …)
- Indirect dark matter (DM) searches.

## Multi-Messenger (astro)physics

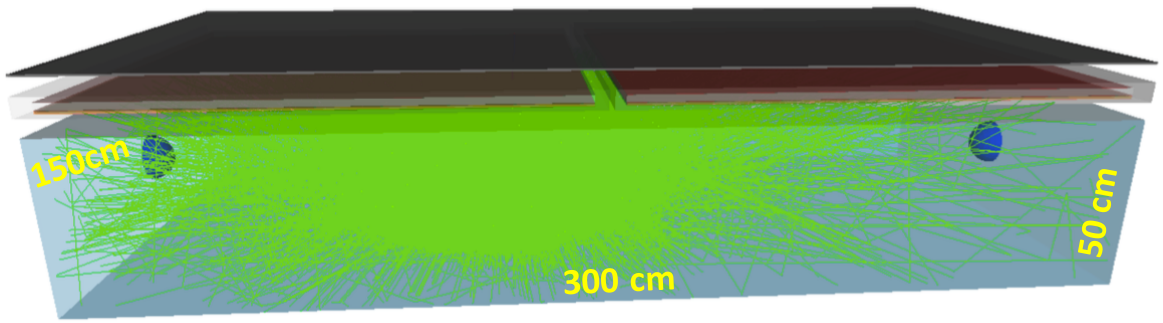
- Electromagnetic counterparts of extreme energy phenomena :
  - Gravitational Waves.(NS-NS, NS-BH, BH-BH mergers)
  - Neutrino bursts

## Cosmic-ray physics

- Electrons + positrons spectra
- Cosmic rays up to the first "knee"

# LATTES concept: an hybrid detector






Pb

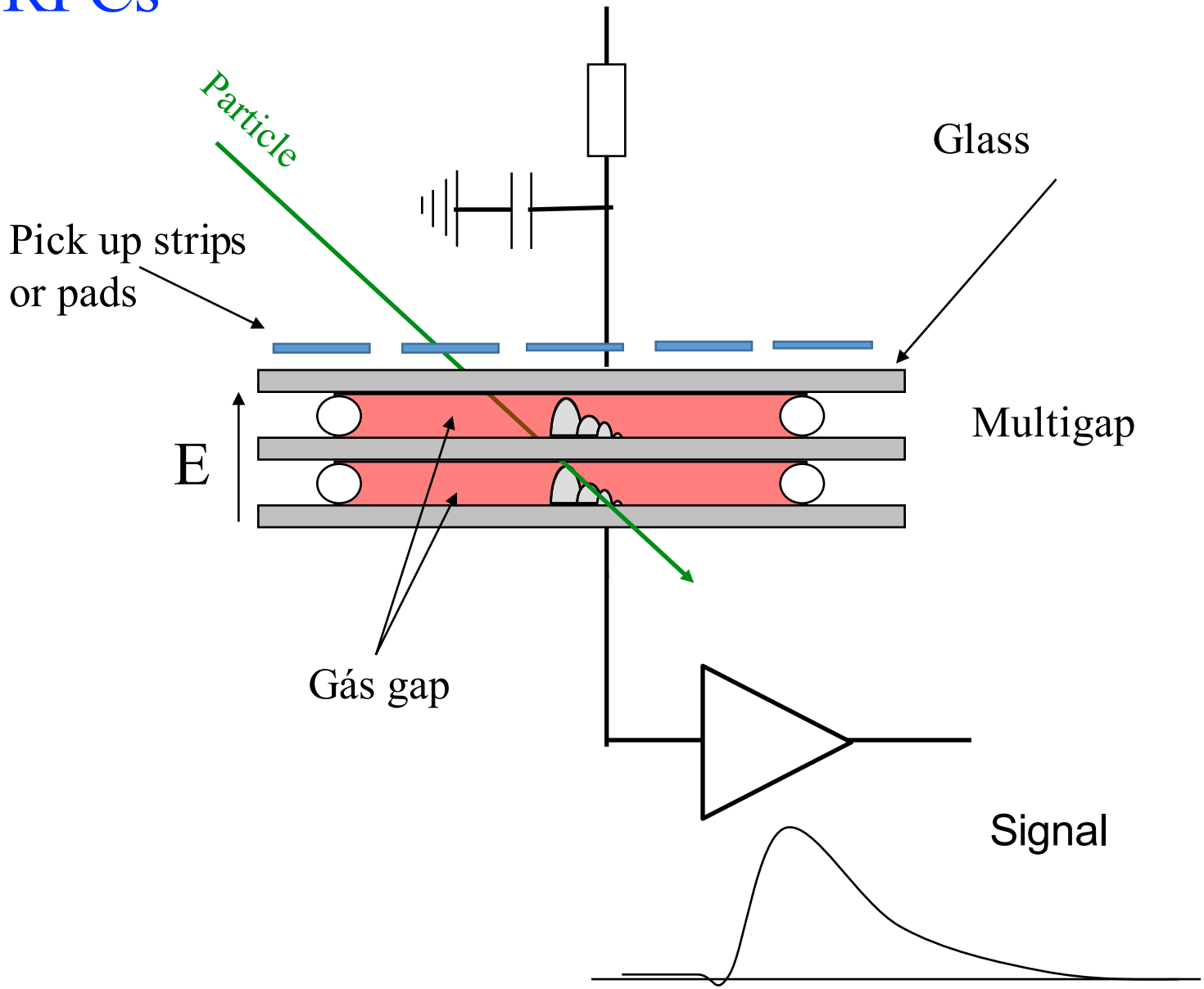
RPC

WCD


RPCs : time and spatial resolution

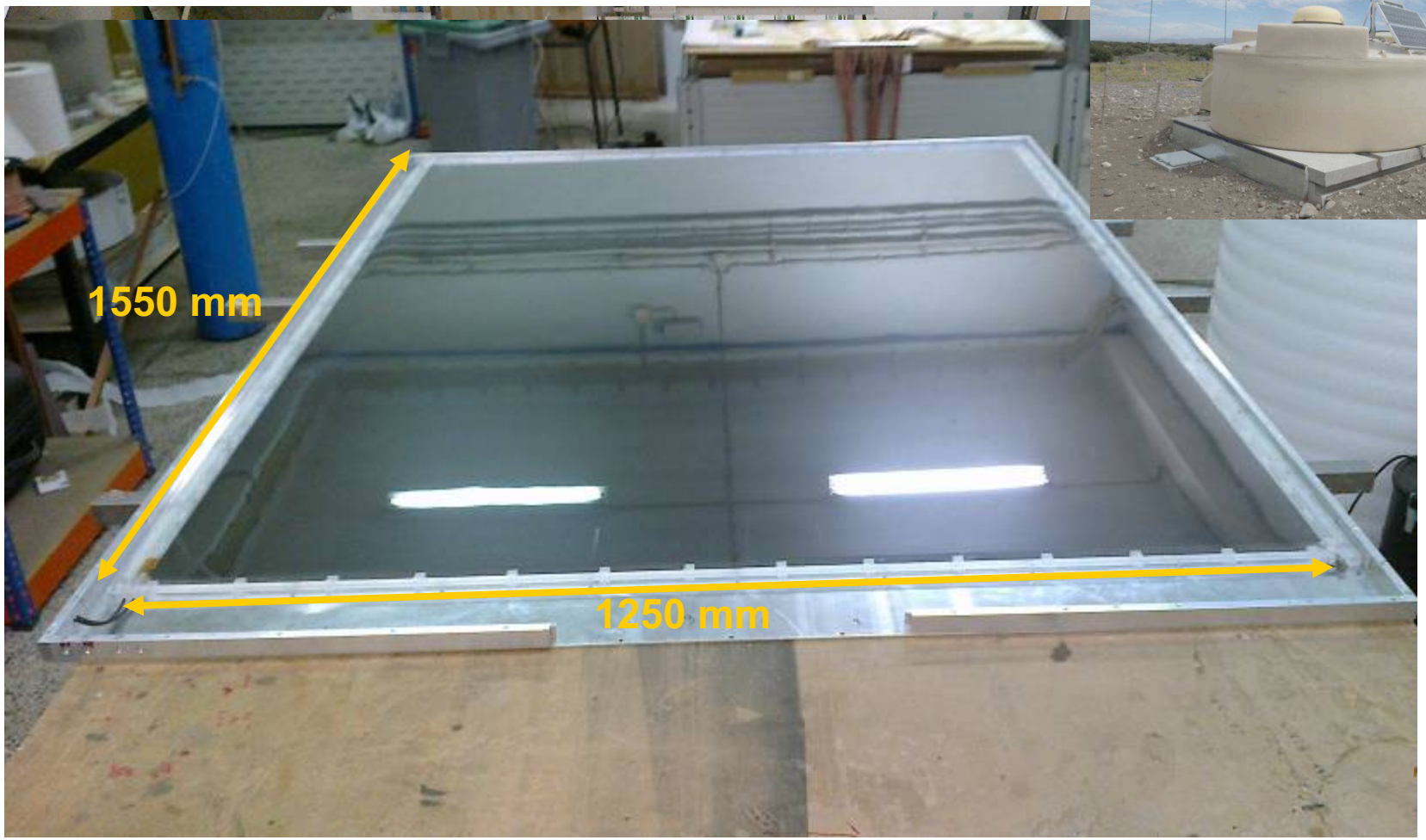
WCDs: e.m. energy, g/h discrimination and trigger

# RPCs


Particle
Glass
Pick up strips
or pads
E
Multigap
Gás gap
Signal

# MARTA RPCs

Very low gas flux, outdoor operation



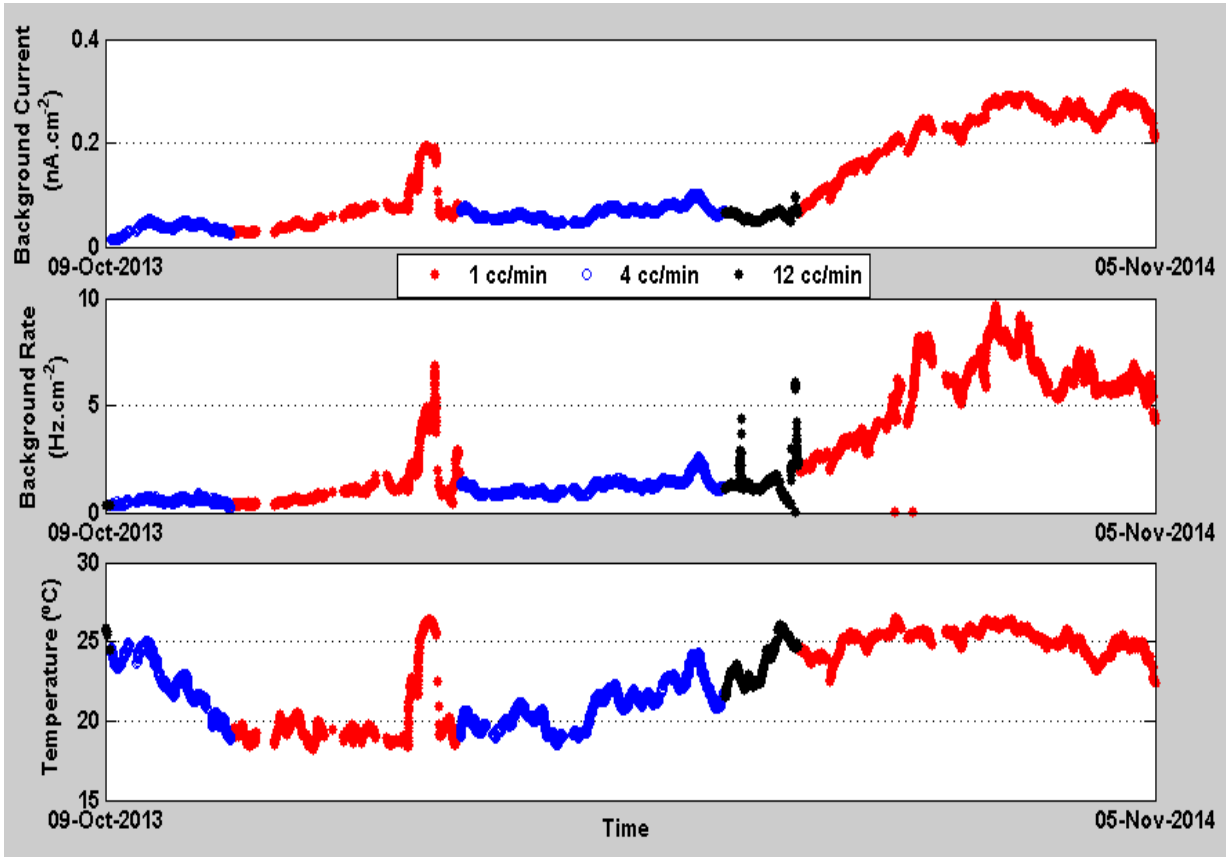
# MARTA RPCs: assembled unit

## Integrated electronics and HV

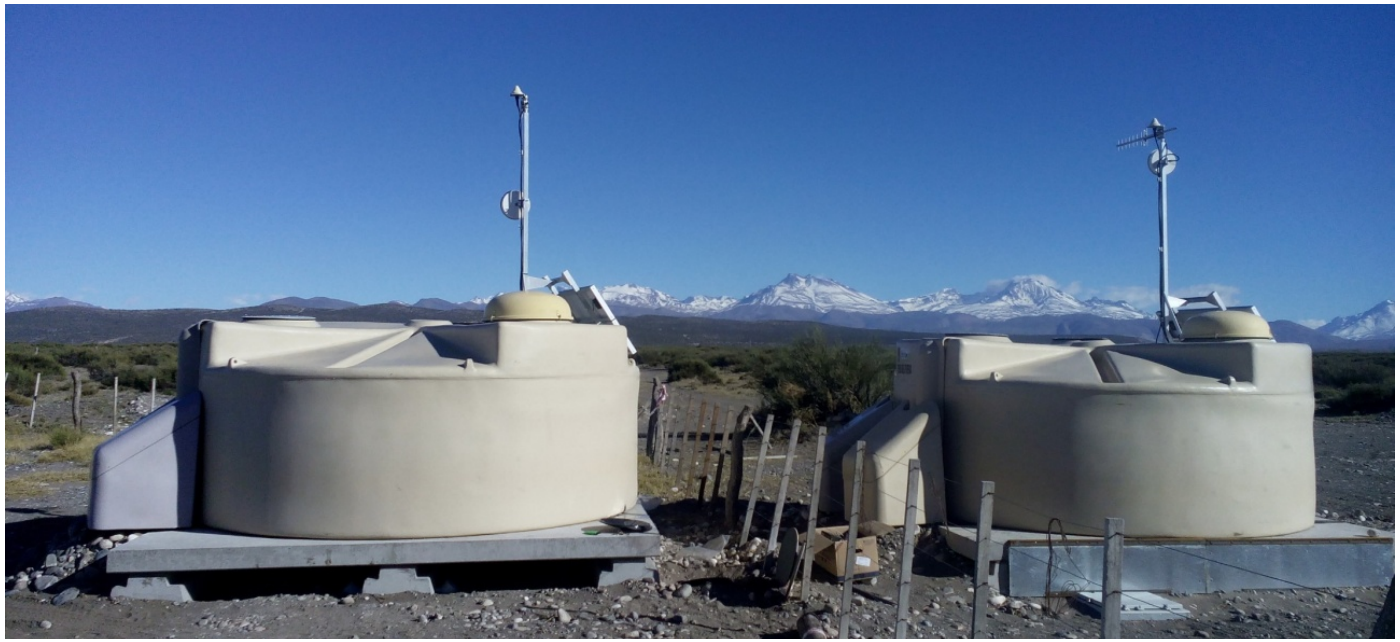
# MARTA RPCs - Lab tests

60 MARTA RPC units produced and tested at Coimbra

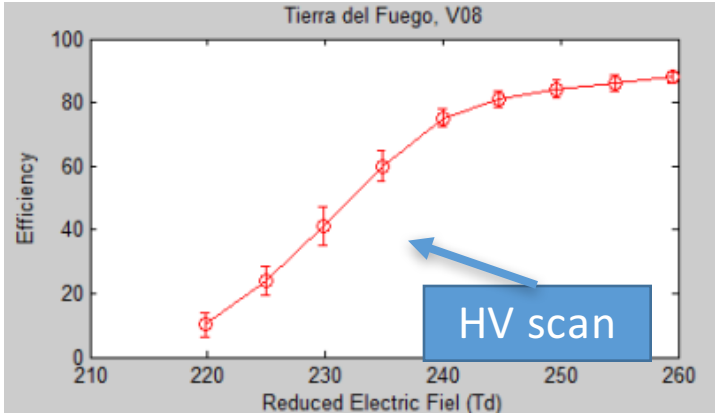
After 8 months operating at 1 cc/min no undesirable effects were observed in the chamber performance,

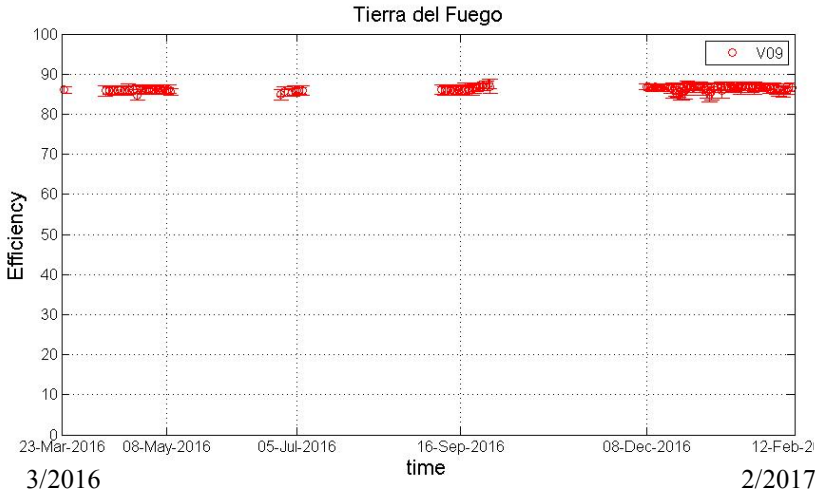


# Tests in the Pampa



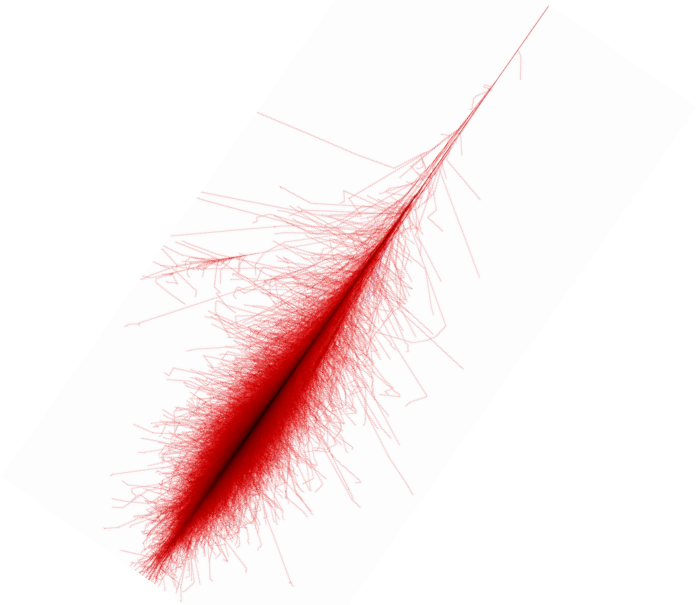
Efficient and stable detector

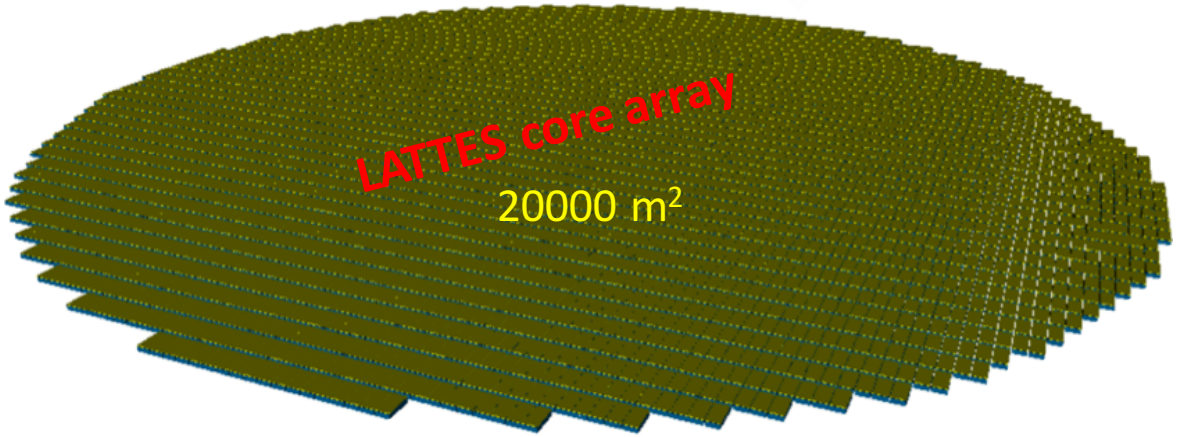


# End-to-end Simulation/Analysis chain


See talk
Bernardo Tomé

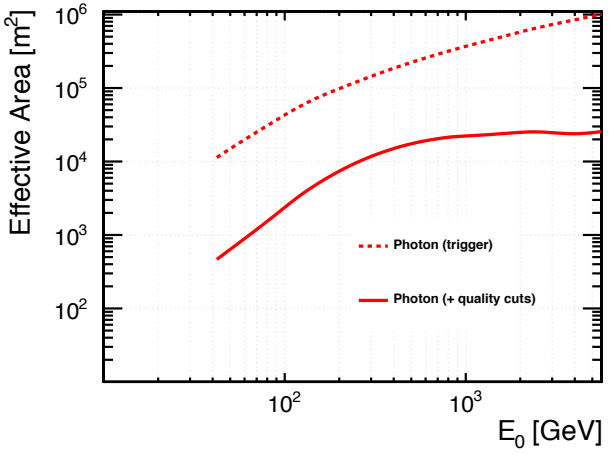




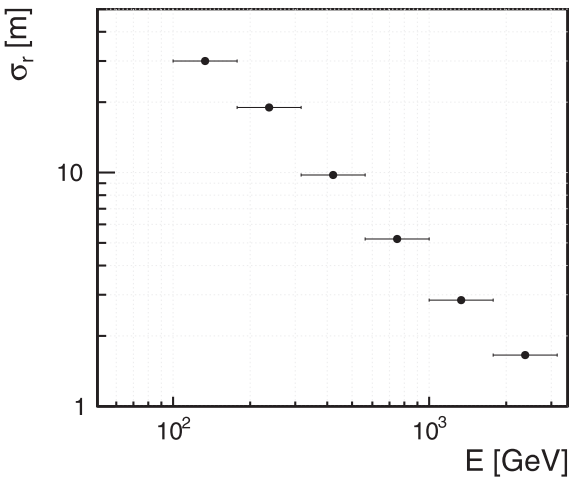
# Performance

See talk
Ruben Conceição

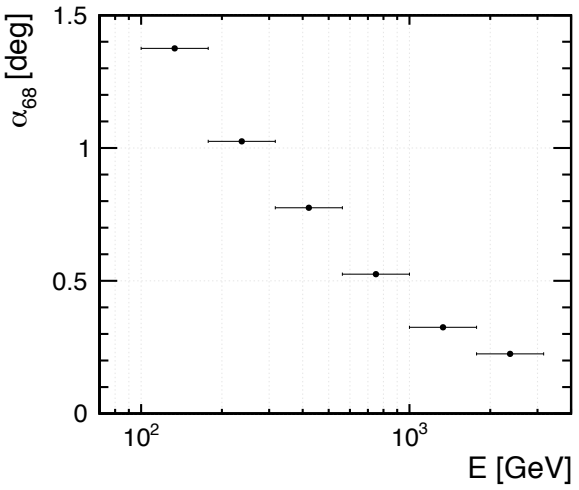
*Effective Area*



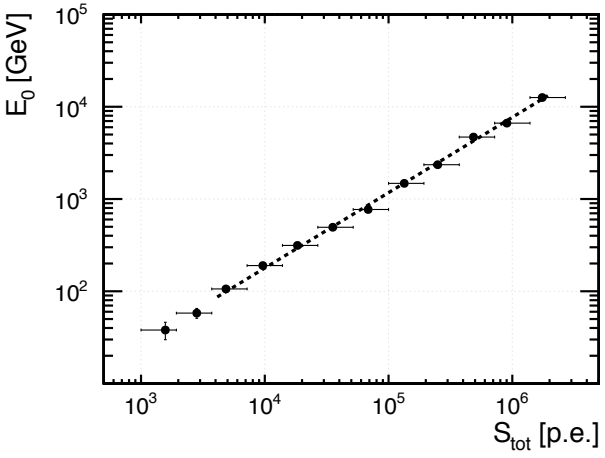

*Core Resolution*



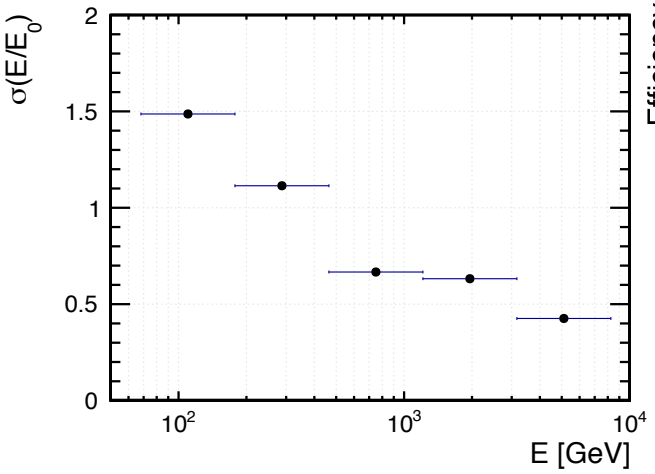

*Angular Resolution*



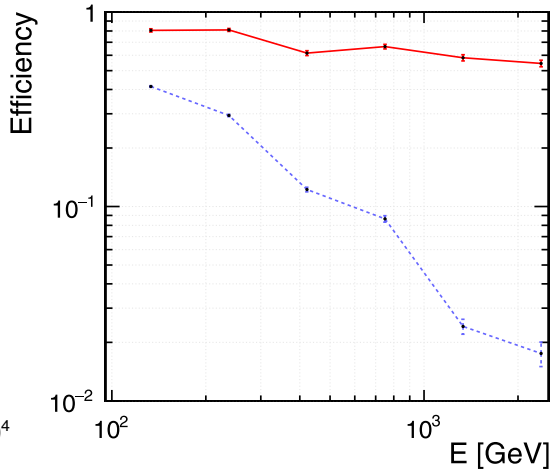

*Energy Calibration*




*Energy Resolution*

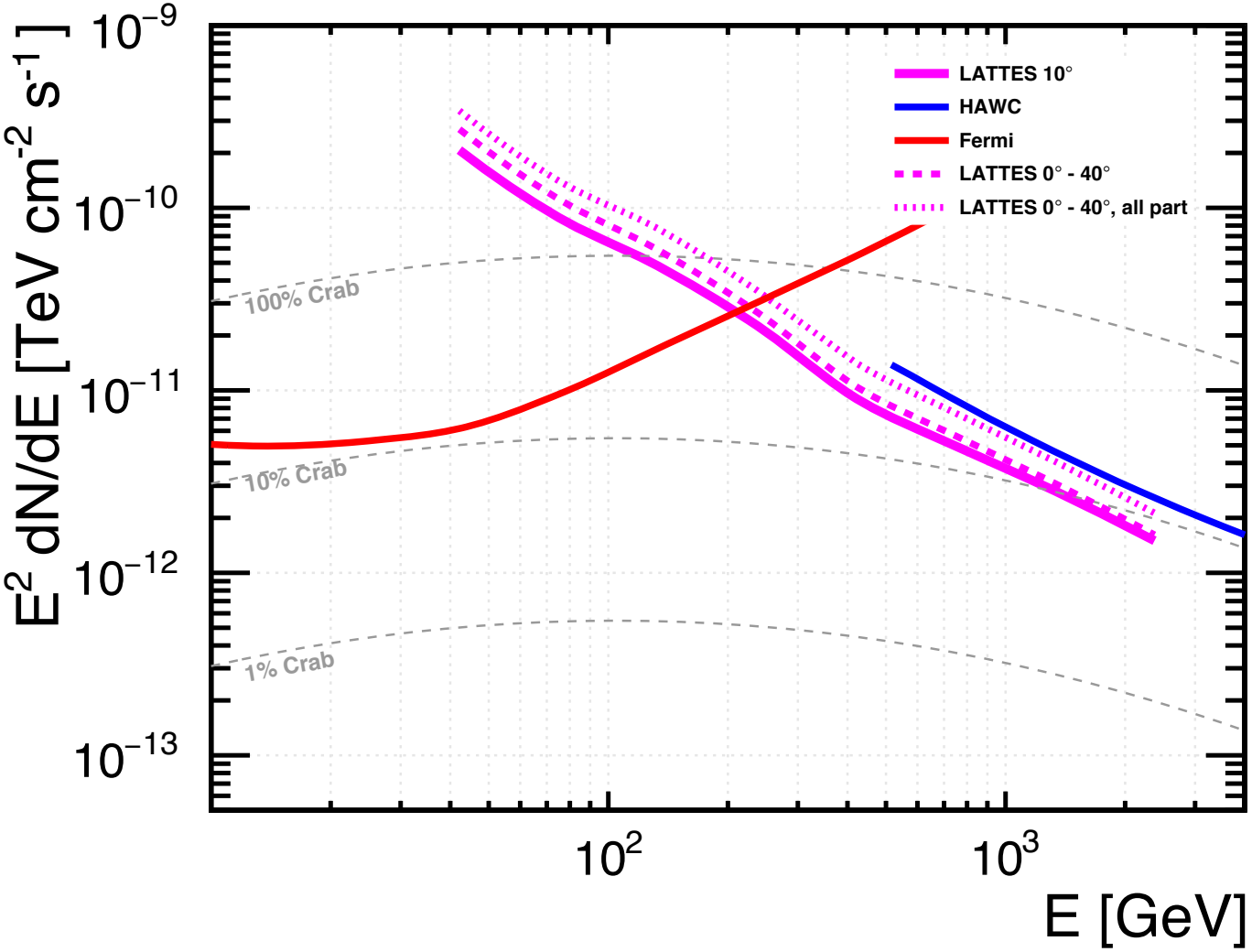



*g/h discrimination*



# Sensitivity

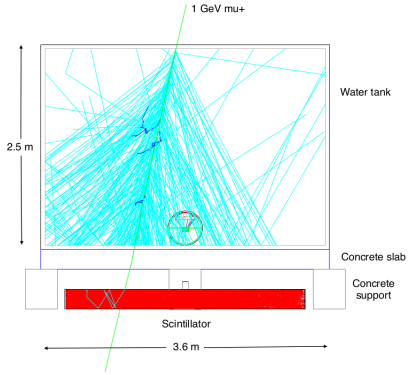
Differential sensitivity to steady sources in one year



# South Observatory proposals

ALTO project : Linnaeus University (Sweden)

WCDs + scintilators

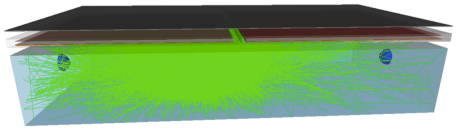



SGSO Alliance: initiated by HAWC scientists

white book on the science case

LATTES : Brasil, Italy, Portugal, Czech Republic

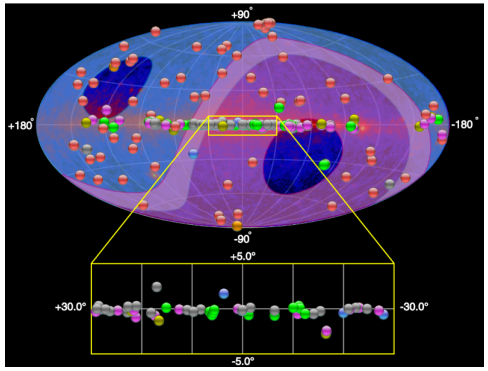
WCDs + RPCs



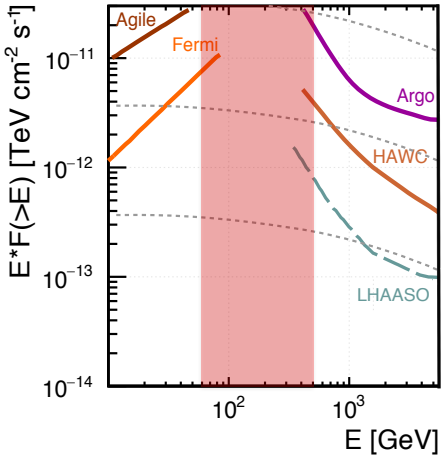
We should converge to a single proposal !

# A wide field of view gamma-ray observatory in South America will be built!

## When? How?

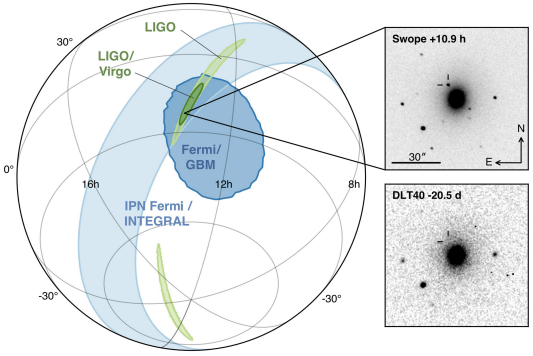



- **A broad energy range :**
  From satellites to the highest energies




- **Complementarity to:**
  CTA, IceCube, KM3NET, GW observatories
  (transients, sources variability, extended sources … )

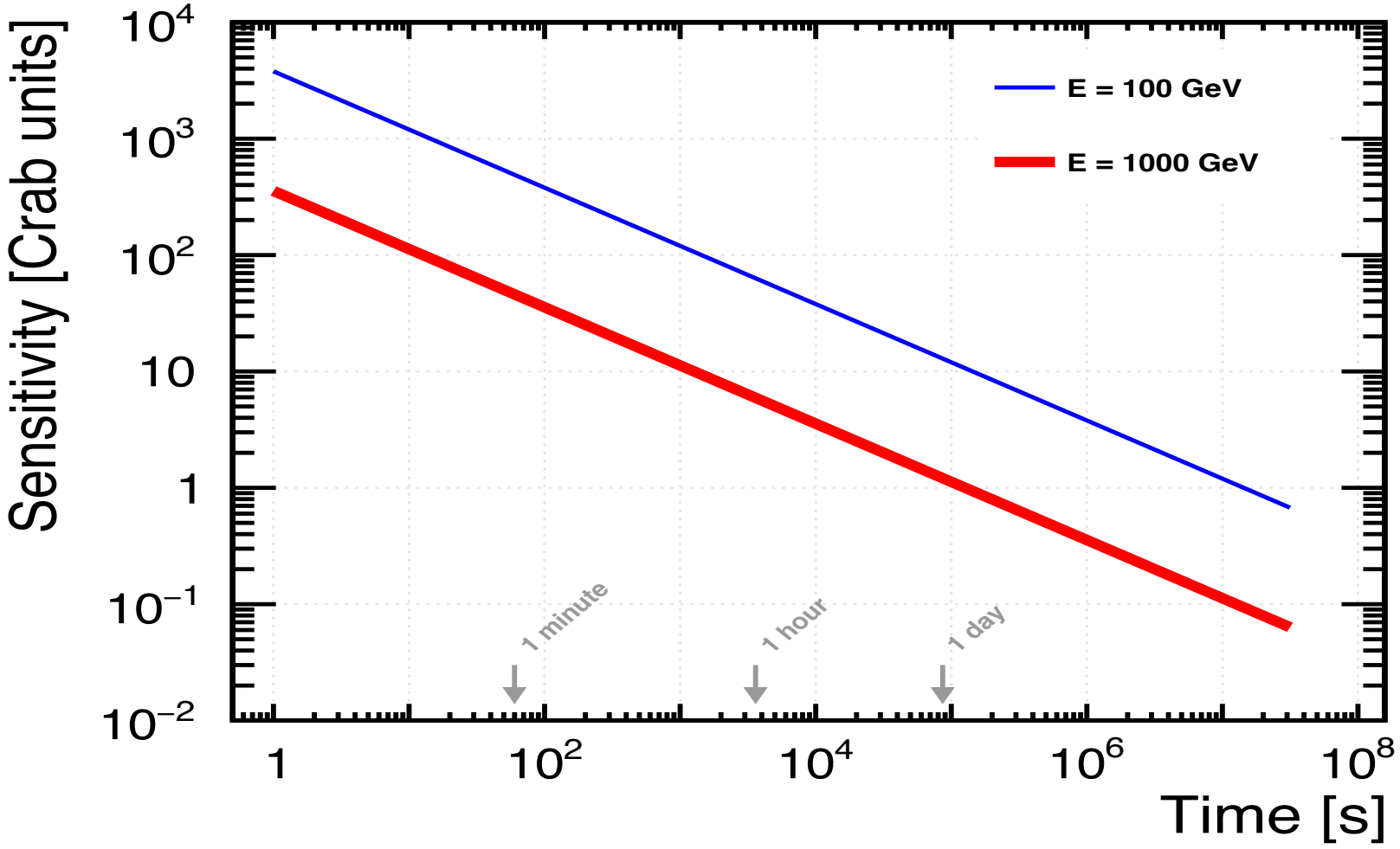
- **Build on the experience of successful observatories:**
  Argo, HAWC, Auger, …




- **Low maintenance / reasonable cost**

# Sensitivity

Differential sensitivity to steady sources as a function of time

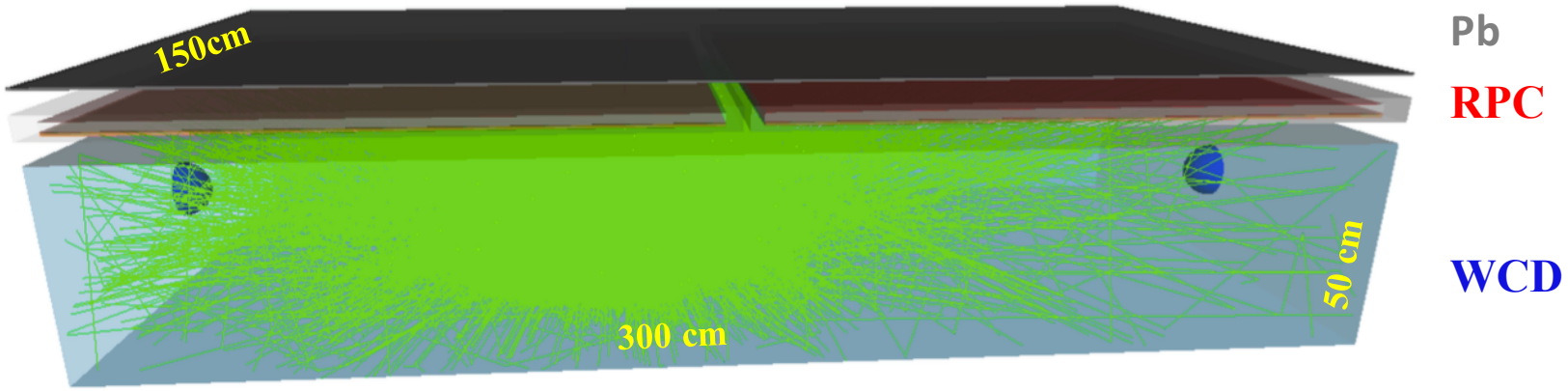


# LATTES Group

- Brazil – CBPF
- ITALY - Padova and Rome
- Portugal : LIP
- Czech Republic : Institute Physics, Academy of sciences

- (China: Tsinghua University)
- ( Spain: Granada)

# Baseline design : the unit station




– Thin lead plate

- To convert the secondary photons
- Improve angular reconstruction

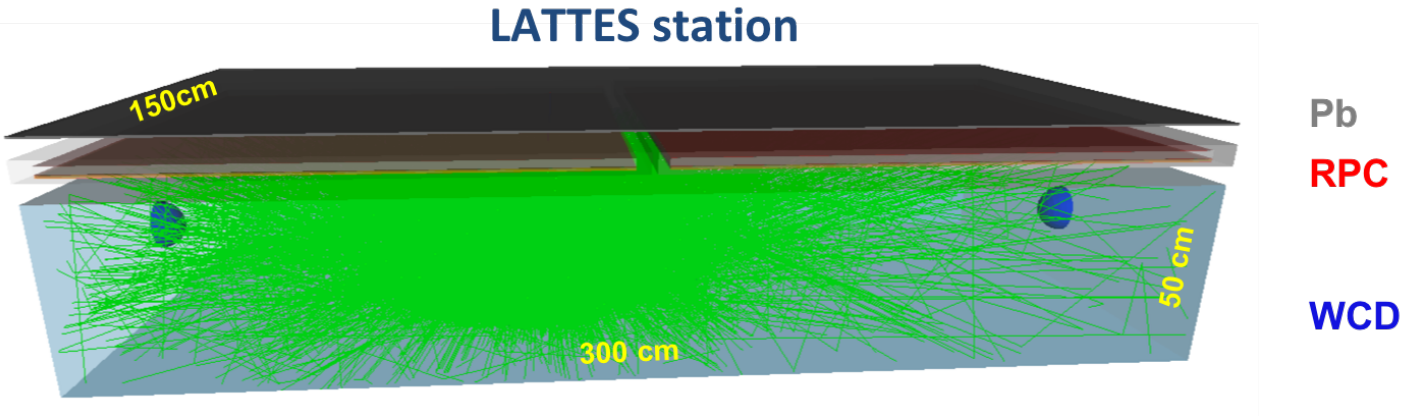
– Resistive Plates Chamber

- 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

# Baseline design : the unit station




## Thin lead plate (**Pb**)

- 5.6 mm (one radiation length)

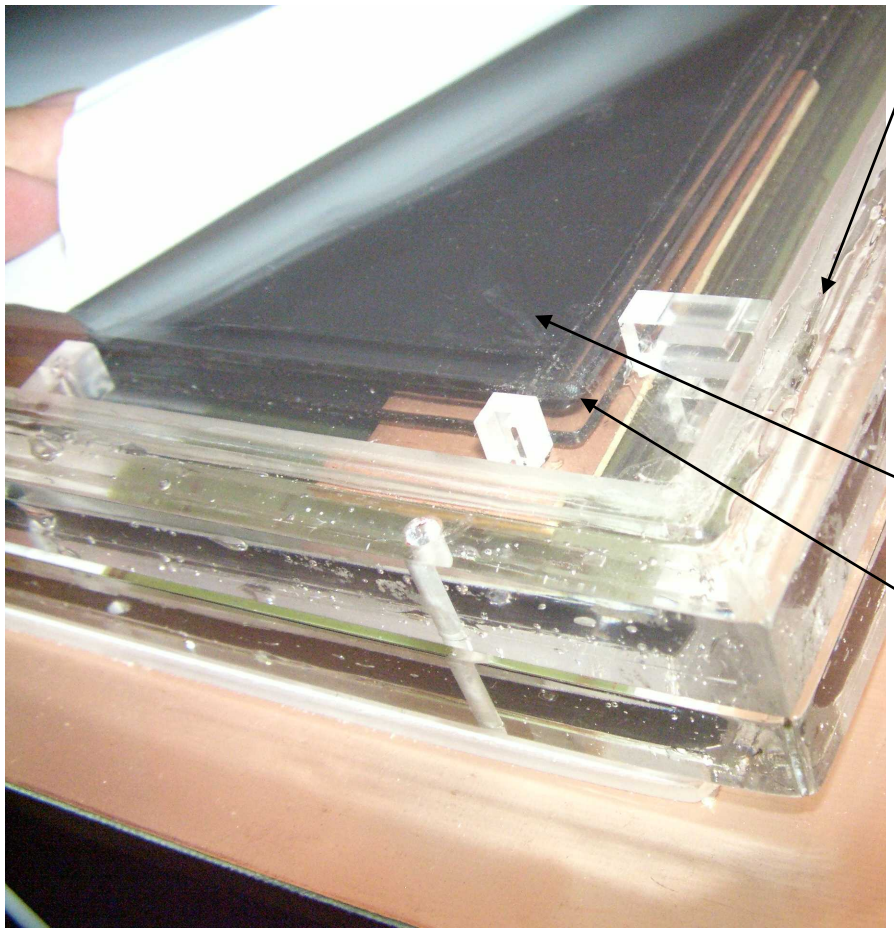
## Resistive Plate Chambers (**RPC**)

- 2 RPCs per station
- Each RPC with 4x4 readout pads

## Water Cherenkov Detector (**WCD**)

- 2 PMTs; 15 cm diameter
- inner walls covered with white diffusing Tyvek

# MARTA RPCs (construction details)



Signal-transparent and nice-looking acrylic box, 1mm thick covers

Permanently glued

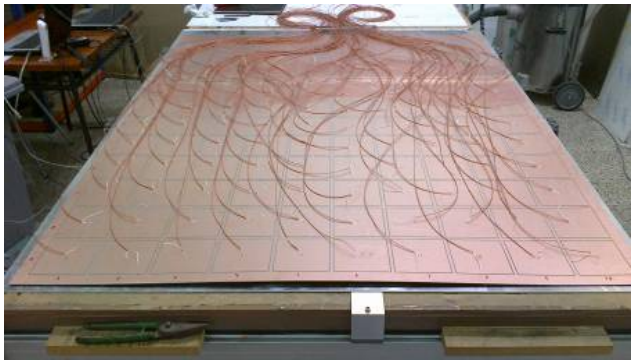
RPC fits tightly inside

- ✓ good electrode support mechanics
- ✓ excellent HV insulation
- ✓ excellent gas tightness

HV layer, also signal-transparent

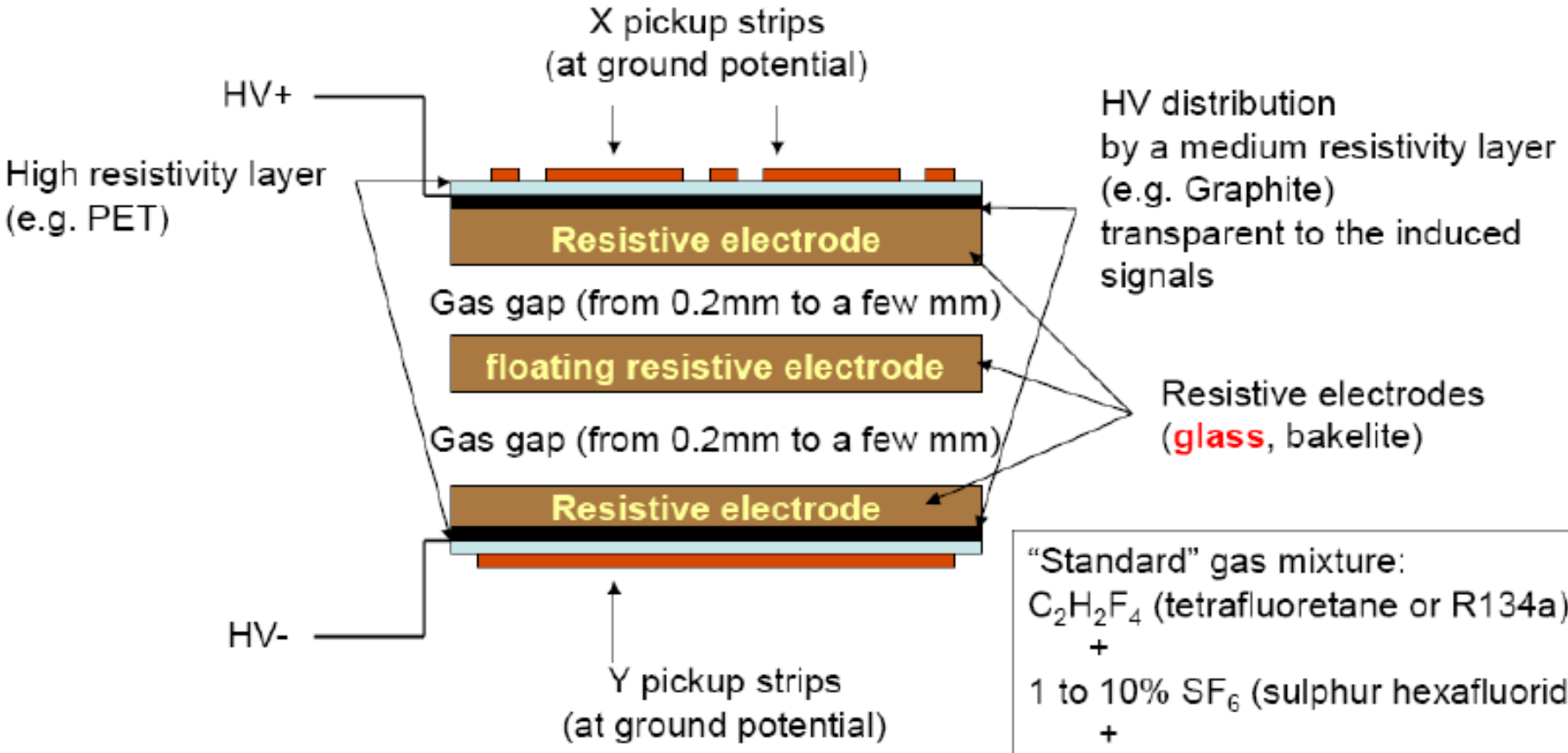
3 RPC glasses (2mm soda-lime)

External pickup electrodes



# 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)

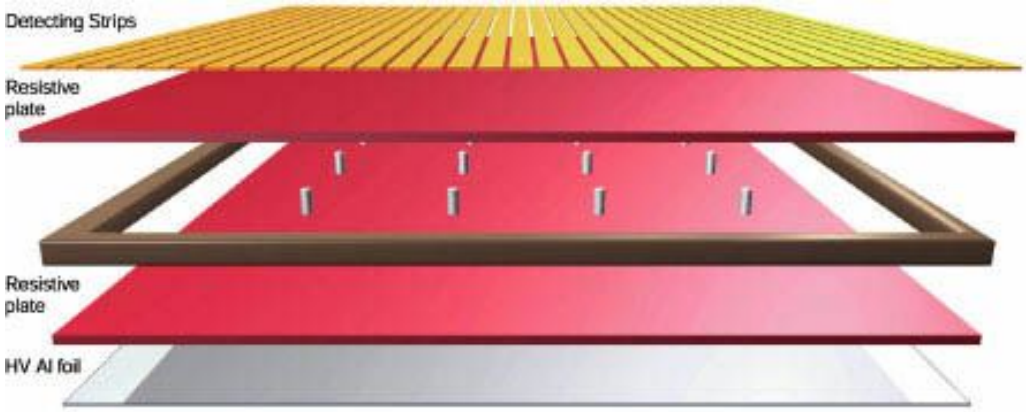
**The current is limited by the resistive electrodes: no sparks by construction**

**Þ very safe detector, although limited to low particle rates (~2kHz/cm$^2$)**

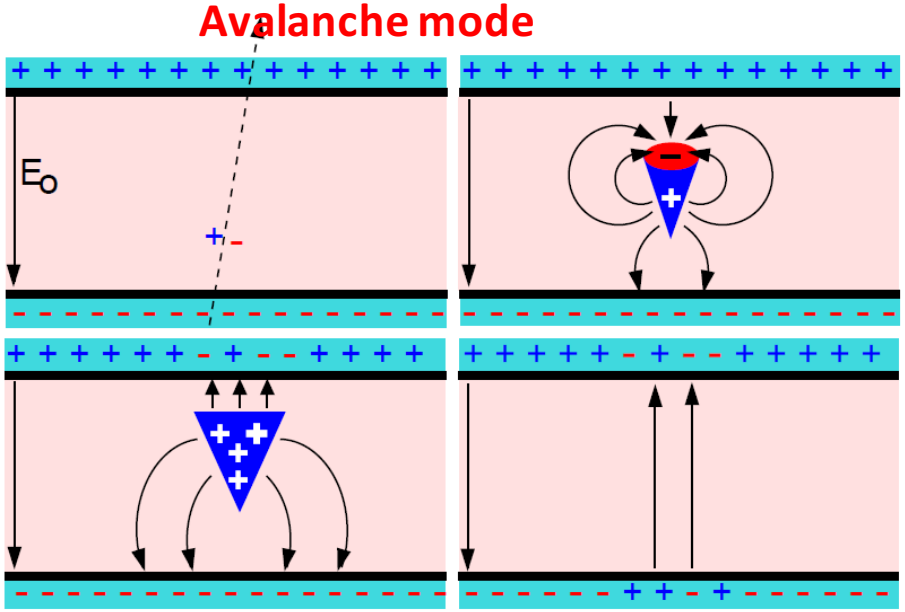
**Þ excellent efficiency (99%), time (~50 ps) and position resolution (~100μm)**

# RPCs Resistive Plate Chamber

- Gaseous detector
- Planar geometry
- uniform electrical field imposed.
- High resistive plates in between the electrodes limit the avalanche current.
- Signal is picked up by the induction of the avalanche in the readout pads.




**Avalanche mode**




**Streamer mode**