# LATTES : a next generation detector concept for gamma-ray astrophysics

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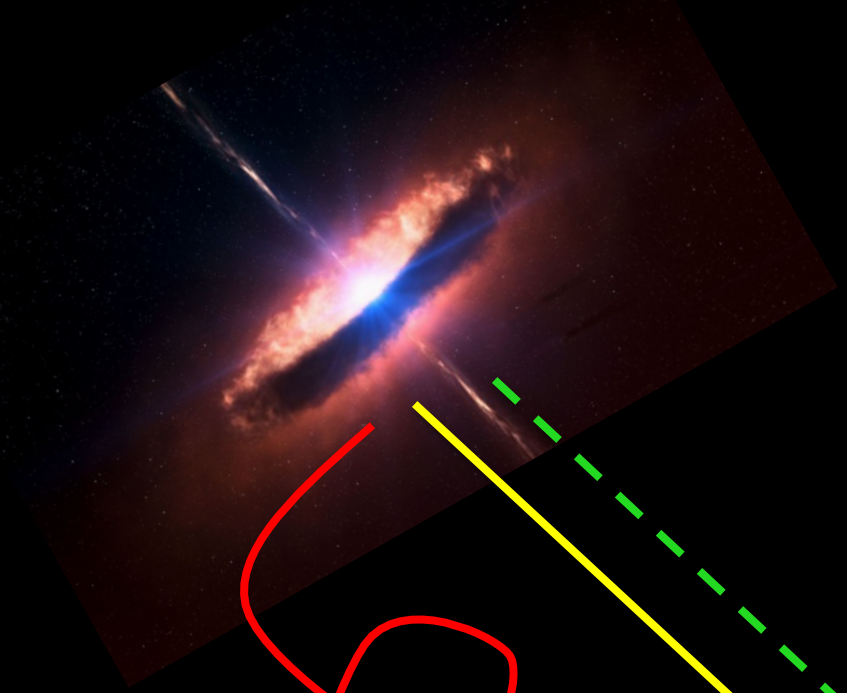
(on behalf of the LATTES LIP group)


**First Lisbon mini-school on Particle and Astroparticle Physics,**
**Costa da Caparica, 2-4 February 2016**

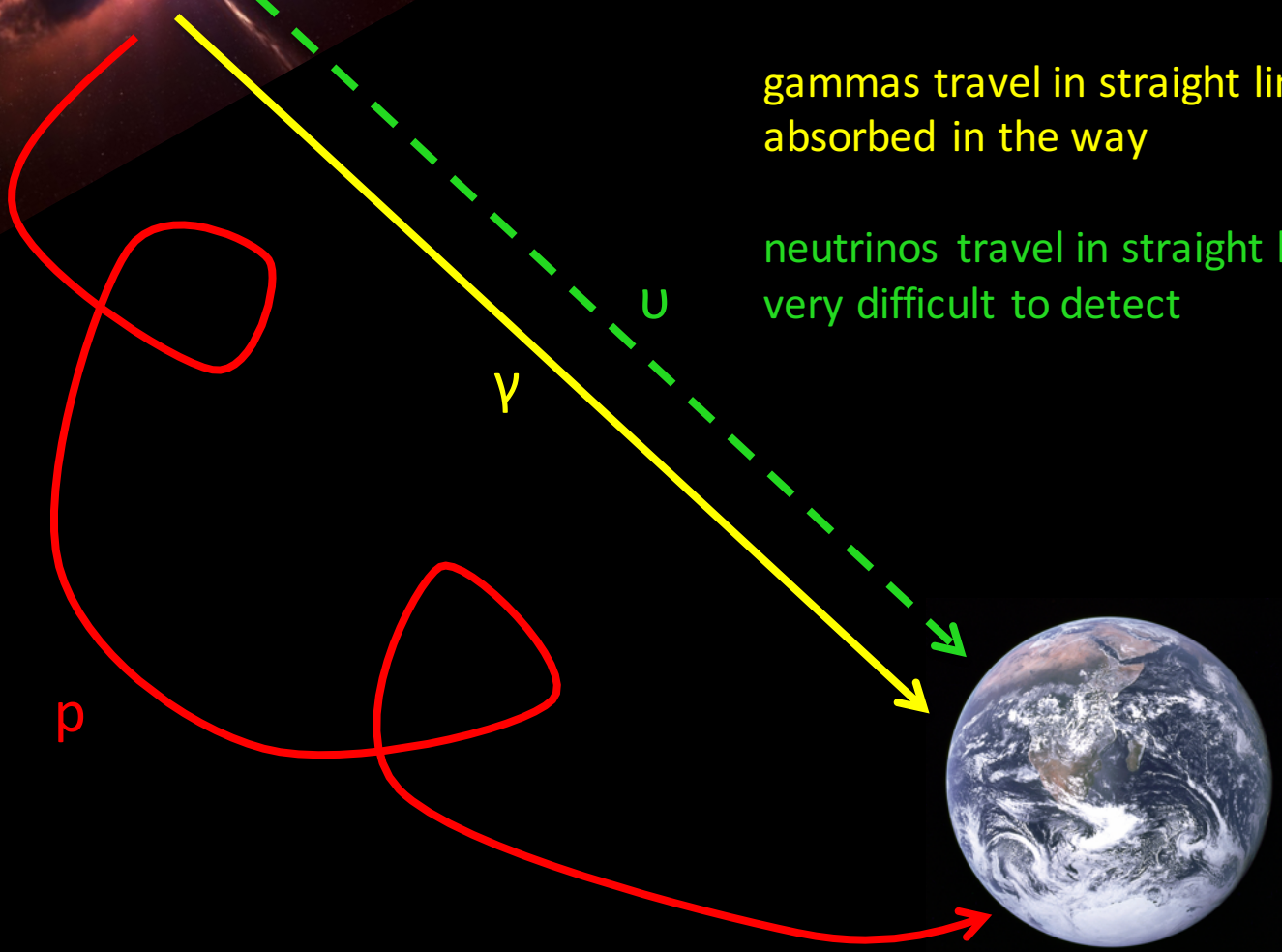
# Why gamma rays?



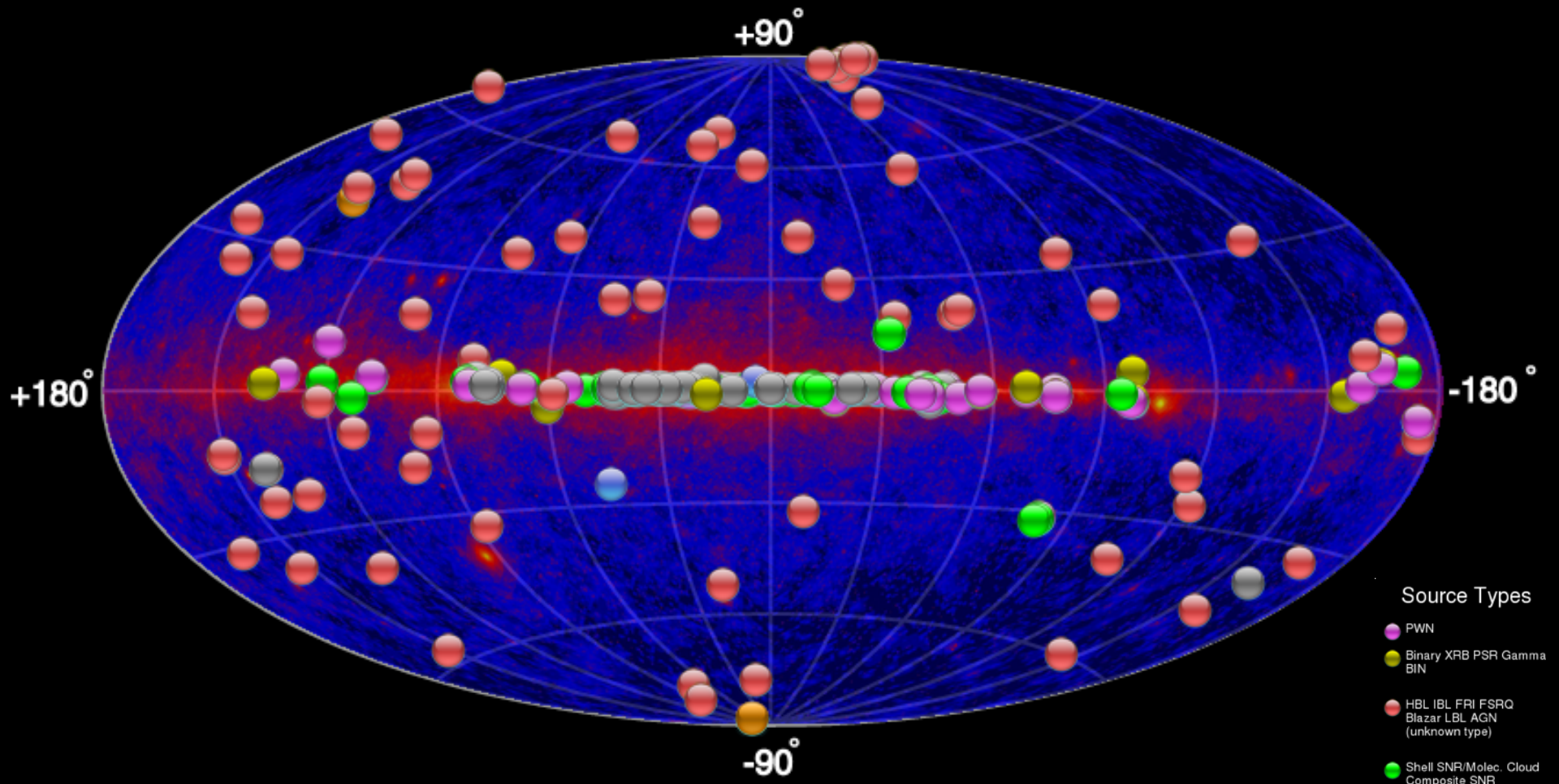
protons are deflected by the galactic magnetic fields

gammas travel in straight lines but can be absorbed in the way

neutrinos travel in straight lines but are very difficult to detect



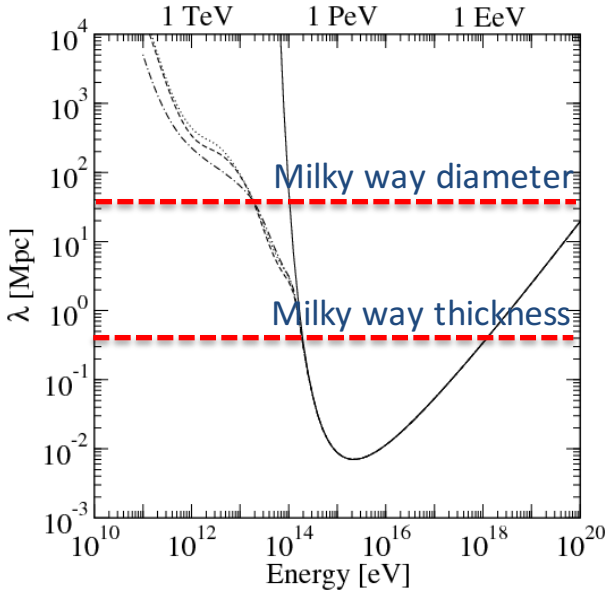
# The VHE gamma sky

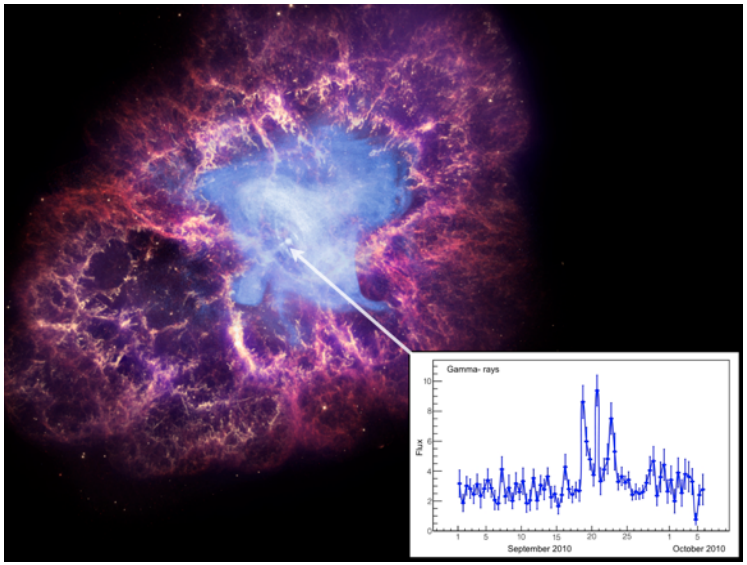



http://tevcat.uchicago.edu

# VHE gammas & key science questions

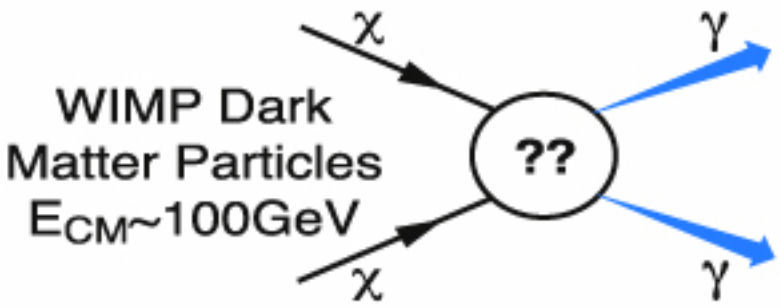
- **The origin of Cosmic rays**
  - PeV gamma rays are expected to be found in our galaxy due to cosmic ray interactions
    - But no detection yet!
      - E < 100 TeV
  - Where/what are the PeVatrons ?
    - Above some PeV, acceleration near supermassive black holes?



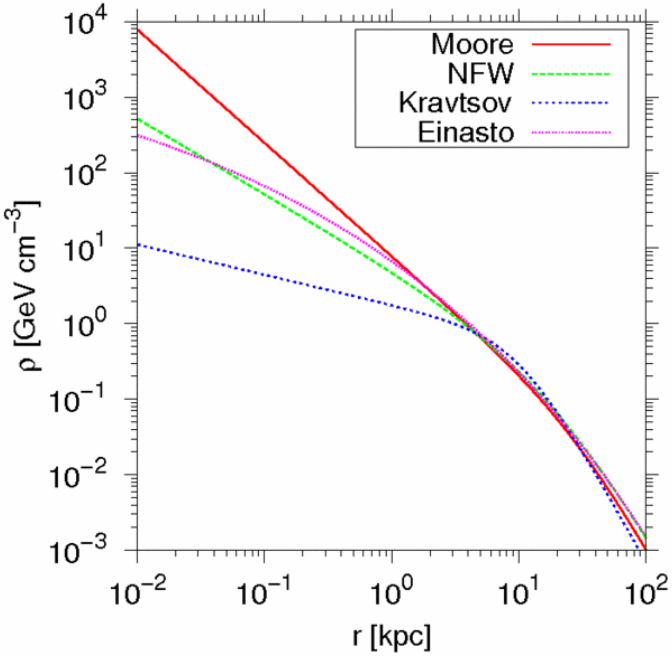



# VHE gammas & key science questions

- **Dark matter annihilations**
  - Many dark matter (DM) candidates are expected to produce gammas in a self-annihilation process
  - Look at the Galactic Center where the density of DM is expected to be higher

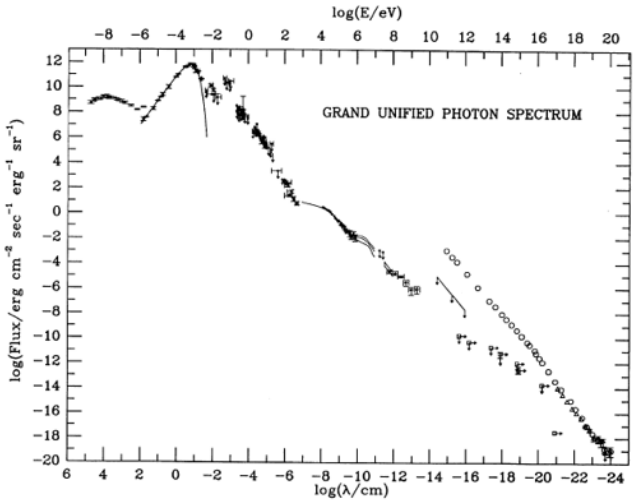



*DM density profile*

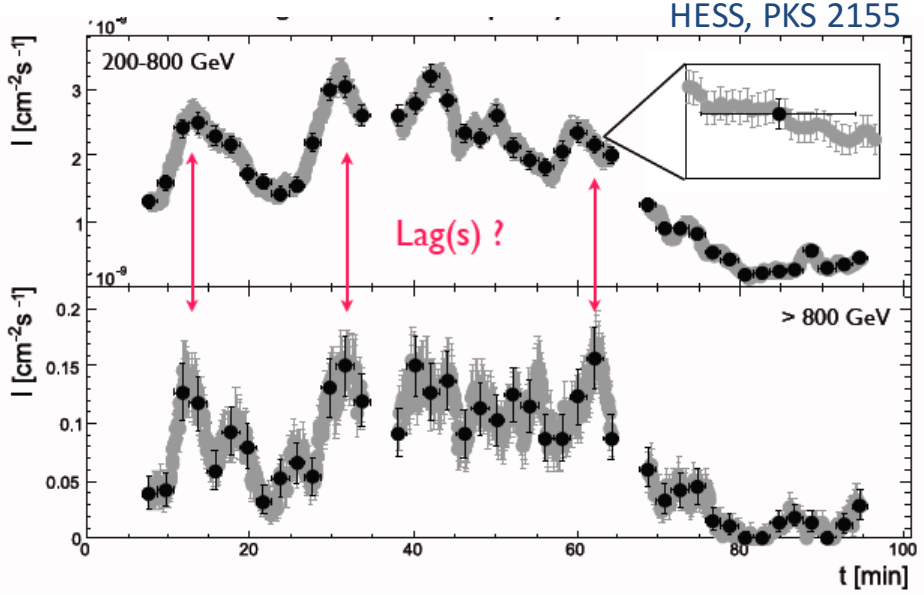


# VHE gammas & key science questions

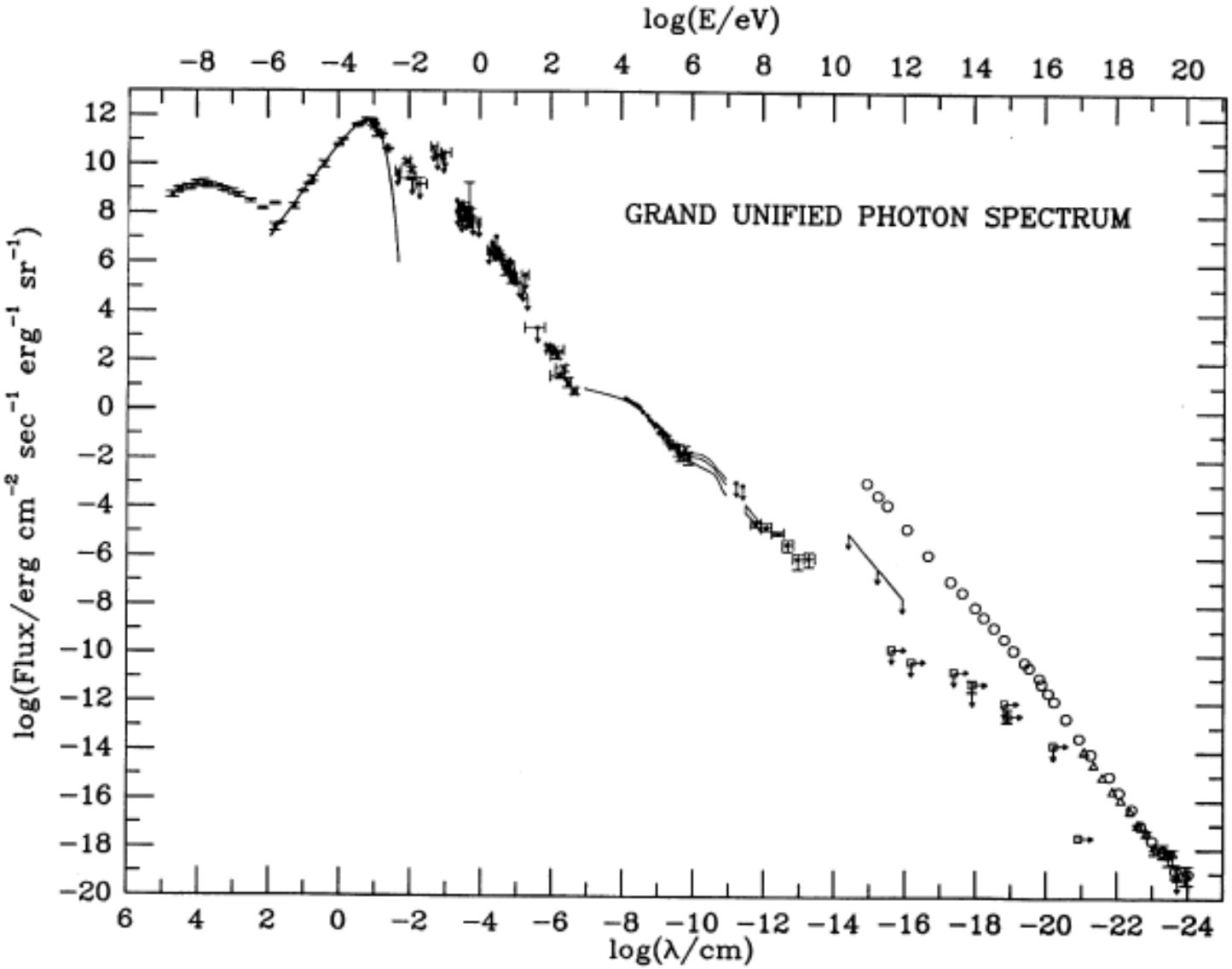
- **Cosmology**
  - Constraints on intergalactic magnetic and photon radiation fields in the Universe.
  - Tests of Lorentz violation : v(E) ?
    - Fundamental properties of quantum gravity.



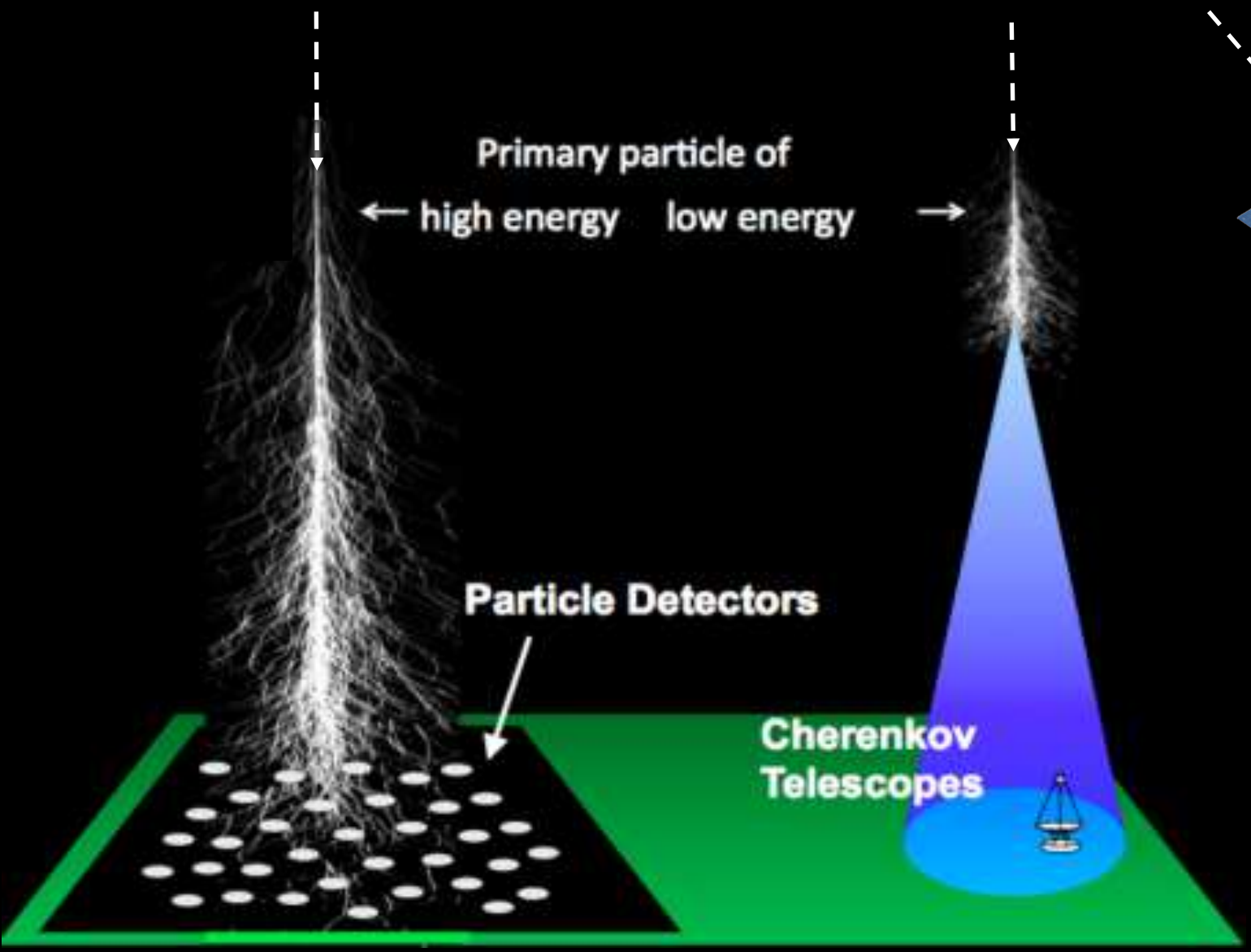

HESS, PKS 2155




No claim survived up to now ☹


log(E/eV)
−8 −6 −4 −2 0 2 4 6 8 10 12 14 16 18 20
GRAND UNIFIED PHOTON SPECTRUM
log(Flux/erg cm$^{-2}$ sec$^{-1}$ erg$^{-1}$ sr$^{-1}$)
12 10 8 6 4 2 0 −2 −4 −6 −8 −10 −12 −14 −16 −18 −20
6 4 2 0 −2 −4 −6 −8 −10 −12 −14 −16 −18 −20 −22 −24
log(λ/cm)

# Detection techniques

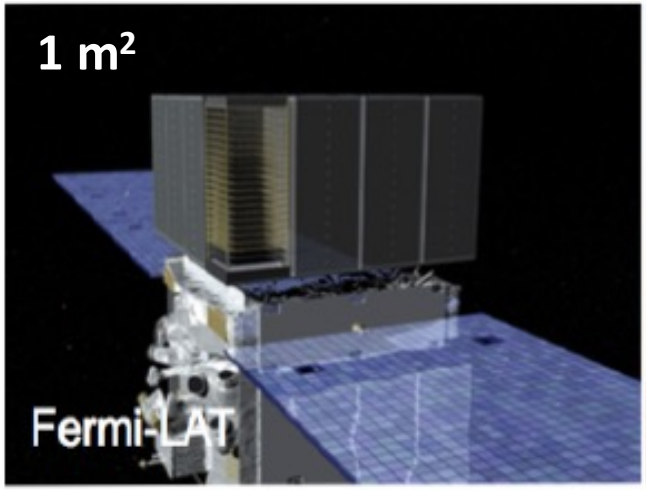



Satellite

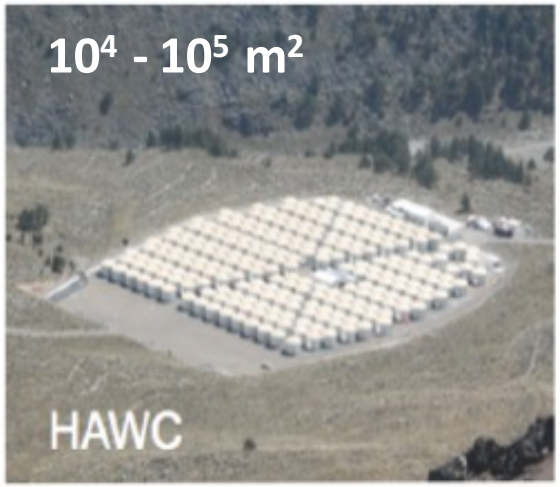
Or particle detectors at high altitude for low energies !


VERITAS
MAGIC
HAWC
Water Cherenkov tanks
HESS
ARGO
RPCs
RPCs
Present
Future
A. De Angelis

# (V)HE gamma detectors performance

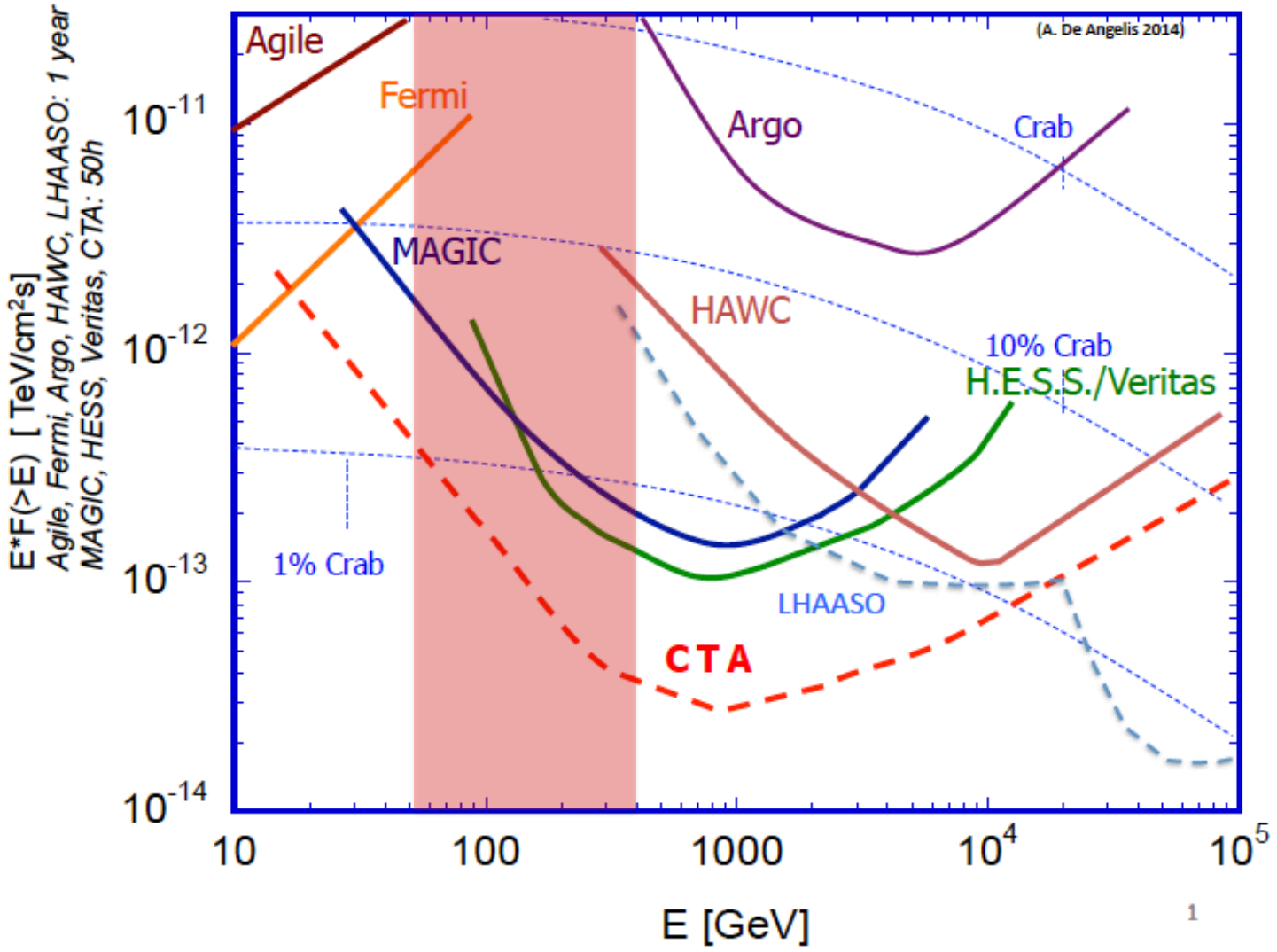







| Quantity | Fermi | IACTs | EAS |
|---|---|---|---|
| Energy range | 20 MeV–200 GeV | 100 GeV–50 TeV | 400 GeV–100 TeV |
| Energy res. | 5-10% | 15-20% | ~ 50% |
| Duty Cycle | 80% | 15% | > 90% |
| FoV | $4\pi/5$ | $5° \times 5°$ | $4\pi/6$ |
| PSF | 0.1° | 0.07° | 0.5° |
| Sensitivity | 1% Crab (1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

A. De Angelis




- Good sensitivity in the 100 GeV region is the challenge !
- Cover a gap between satellite and ground based instruments.
- A large collection area starts to be needed and large FoV also important

# LATTES @ ALMA site

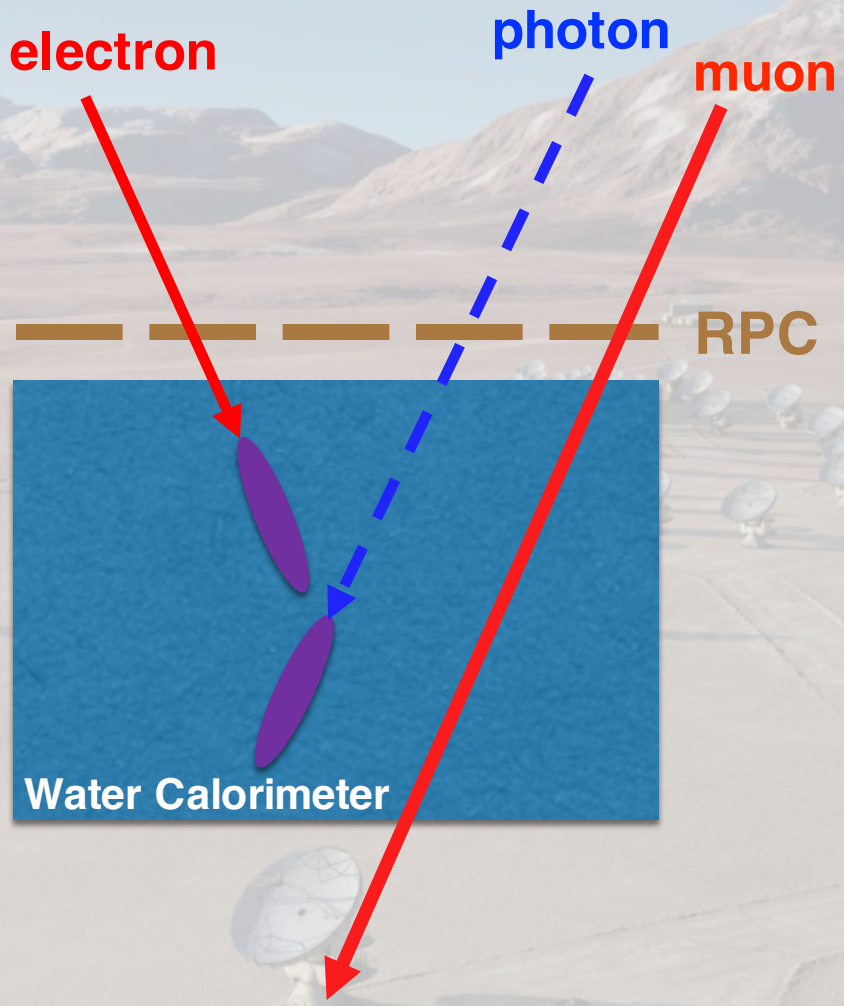
**Large Array Telescope for Tracking Energetic Sources**

**Chajnantor plateau**

**5000 meters altitude in north Chile**

- **Low energy threshold and good background rejection**
- **Large FoV coverage**
- **Large area + low cost**
- **Reliability and good control of systematics**

# LATTES station baseline concept




- Explore shower particle patterns with good spatial resolution using Resistive Plate Chambers (RPCs)
- Measure energy flow in calorimeter
- Combined detection:
  - sensitivity to low energy showers;
  - photon/proton discrimination

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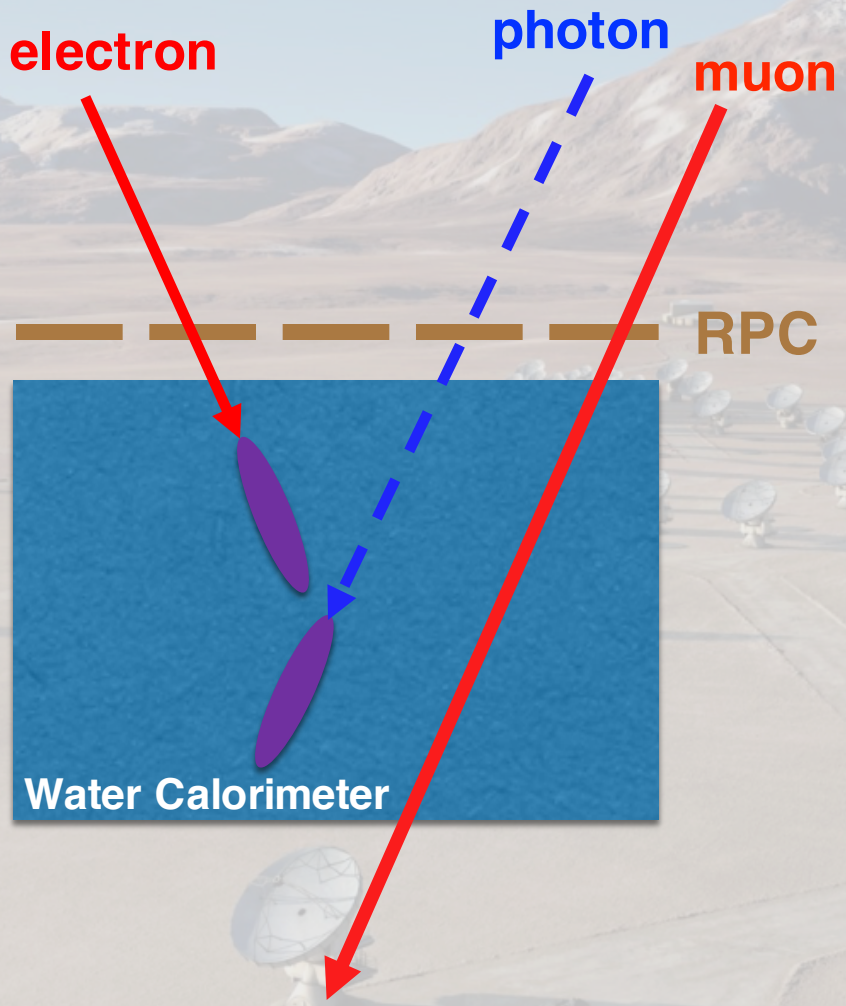


- Explore shower particle patterns with good spatial resolution using Resistive Plate Chambers (RPCs)
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- Combined detection:
  - sensitivity to low energy showers;
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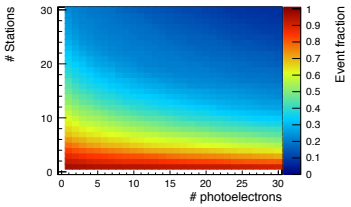
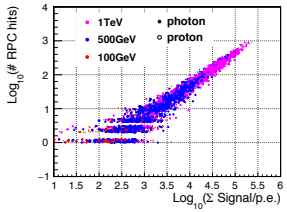
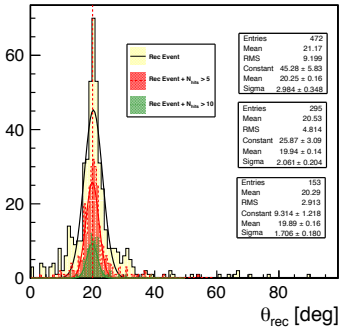
- Still several open questions to be addressed :
  - To convert or not to convert the photons ?
  - How to operate a gaseous detector at 5000 m (air pressure ~ 0.5 atm) ?
  - Water freezing is an issue ?
  - Alternative designs ?

# Activities @ LIP

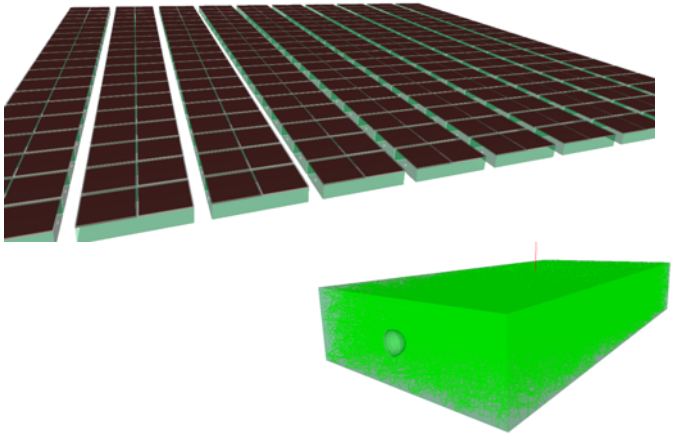
## Analysis tools & detector performance studies



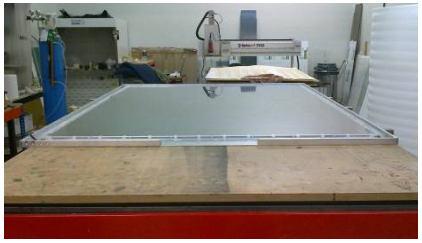



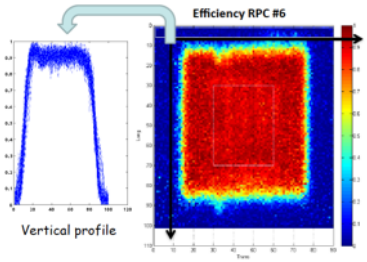




## Geant4 detector simulations

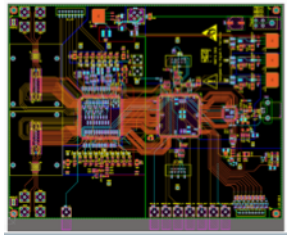


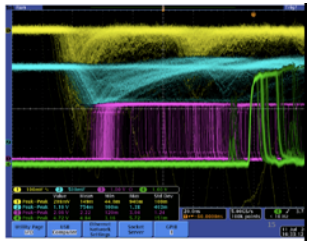
## RPC detector studies

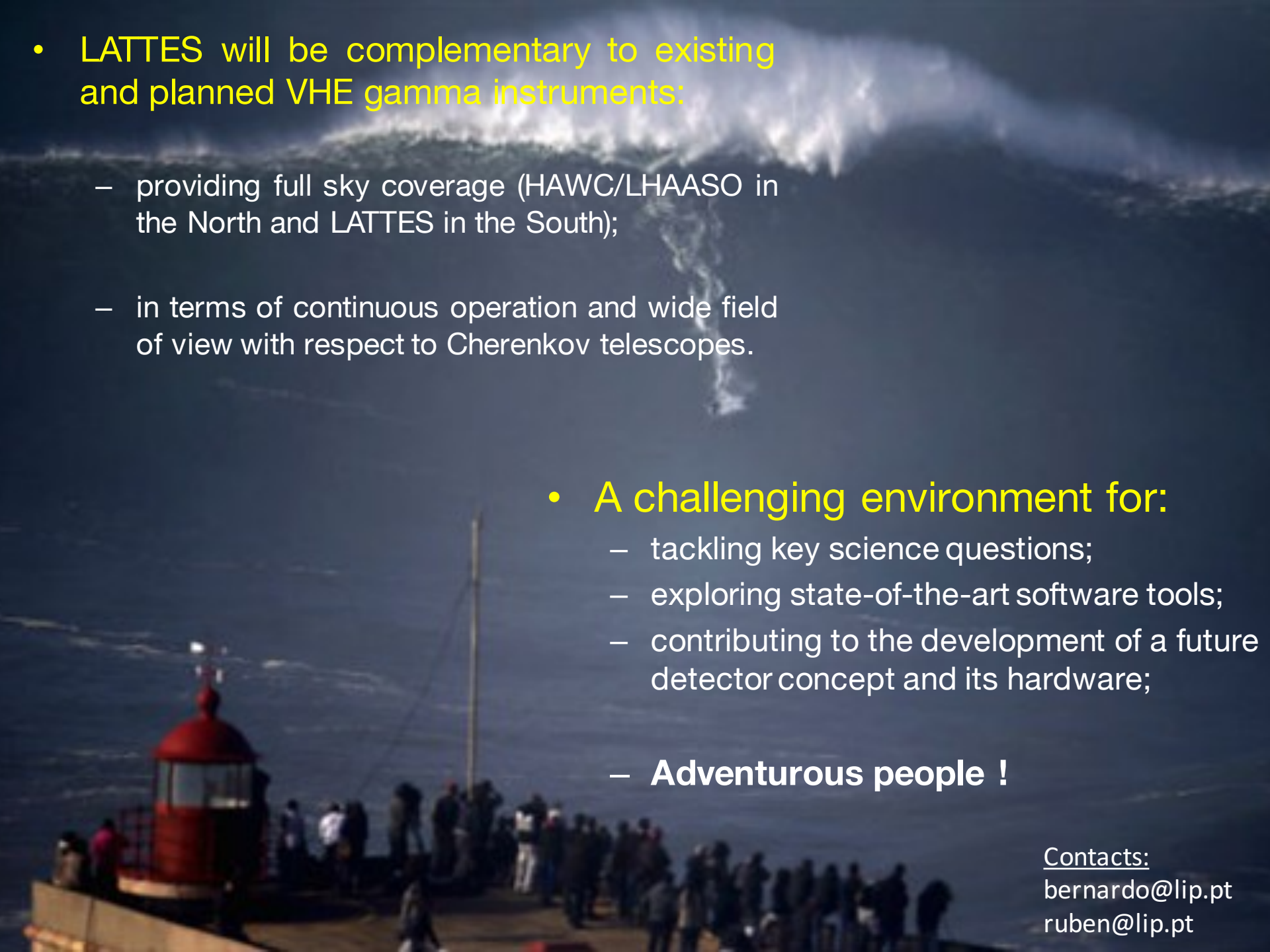





## Electronics and data-acquisition







- LATTES will be complementary to existing and planned VHE gamma instruments:
  - providing full sky coverage (HAWC/LHAASO in the North and LATTES in the South);
  - in terms of continuous operation and wide field of view with respect to Cherenkov telescopes.

- A challenging environment for:
  - tackling key science questions;
  - exploring state-of-the-art software tools;
  - contributing to the development of a future detector concept and its hardware;
  - **Adventurous people !**

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END