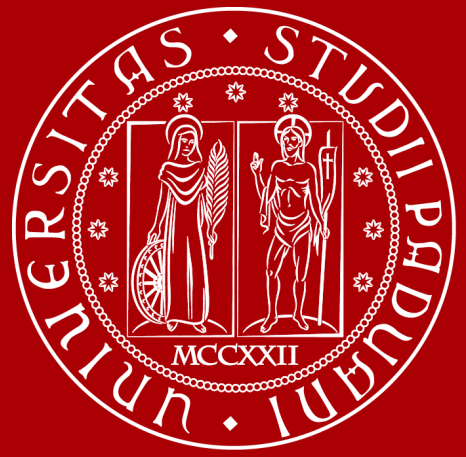

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Research program:

Optimal array layout for the SWGO performance in the PeV energy range

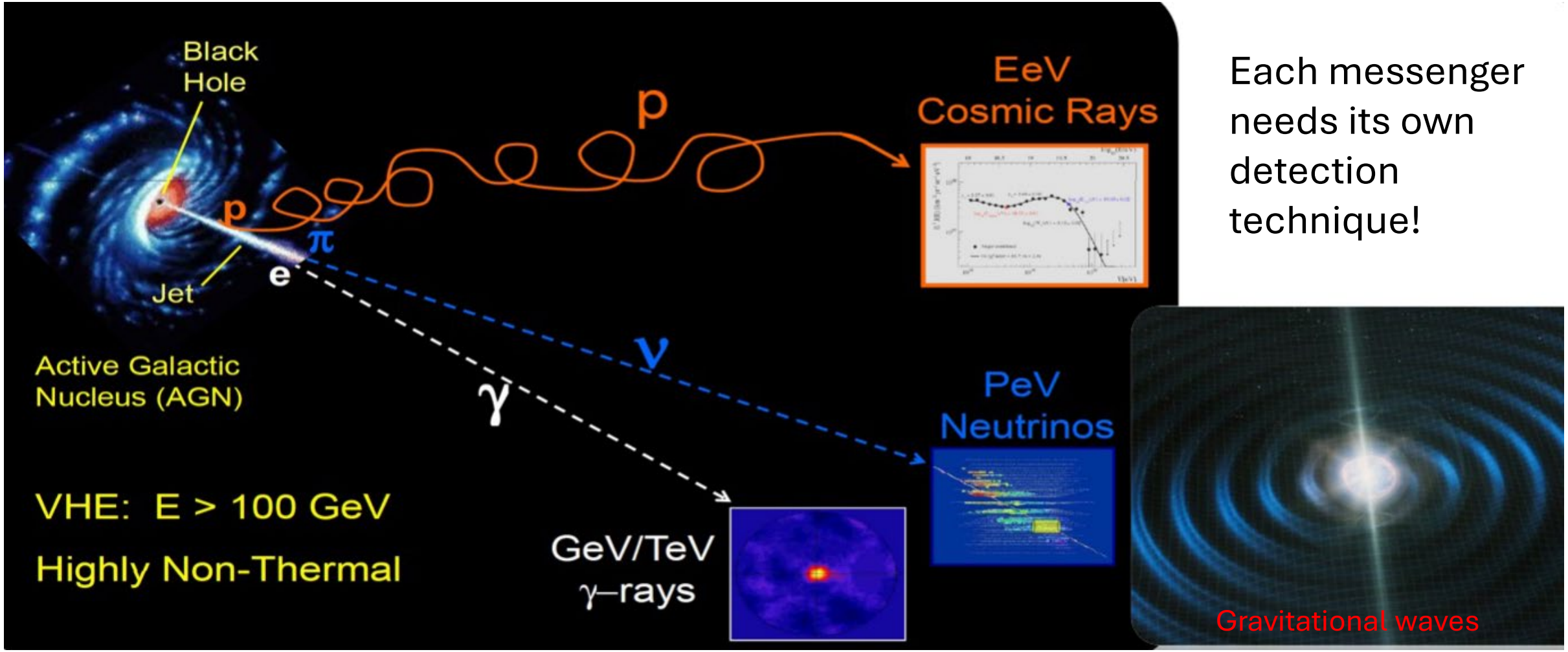
Luis Recabarren - 39th Cycle

Supervisor: Prof./Dr. Michele Doro

1st year admission – 19/10/2023

State of the art

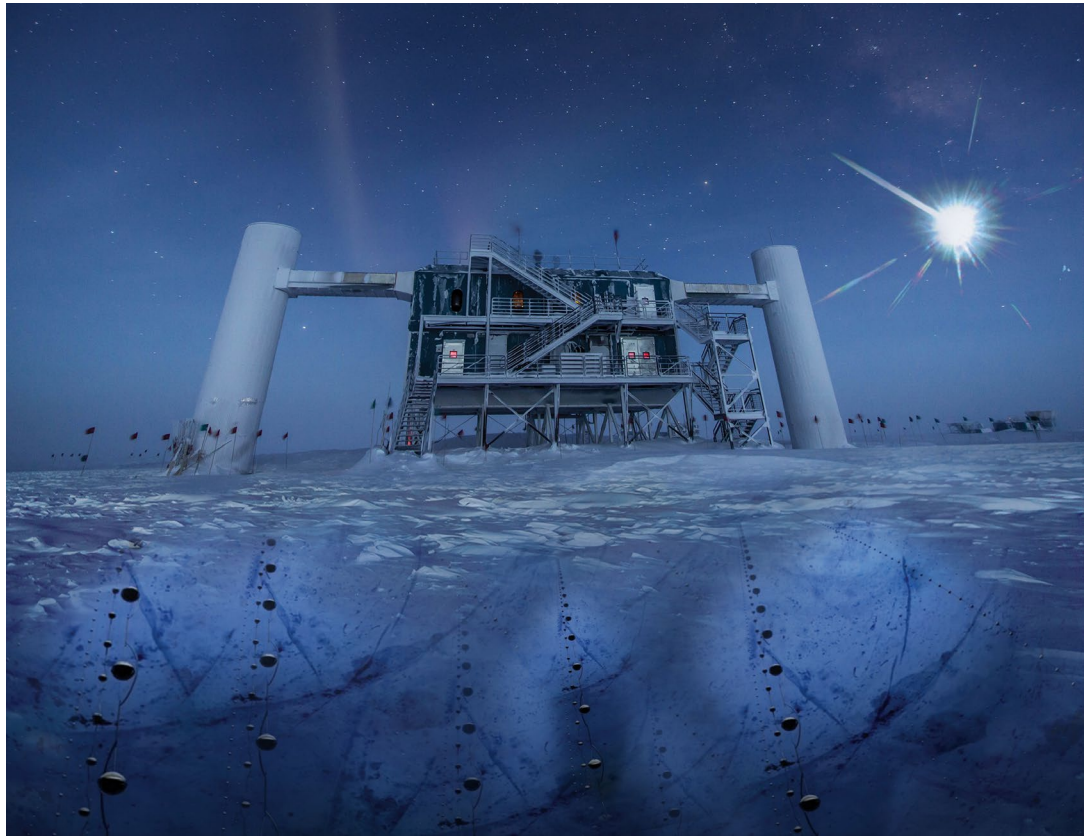
Multi-messenger astrophysics



Each messenger needs its own detection technique!

State of the art: Detection at ground

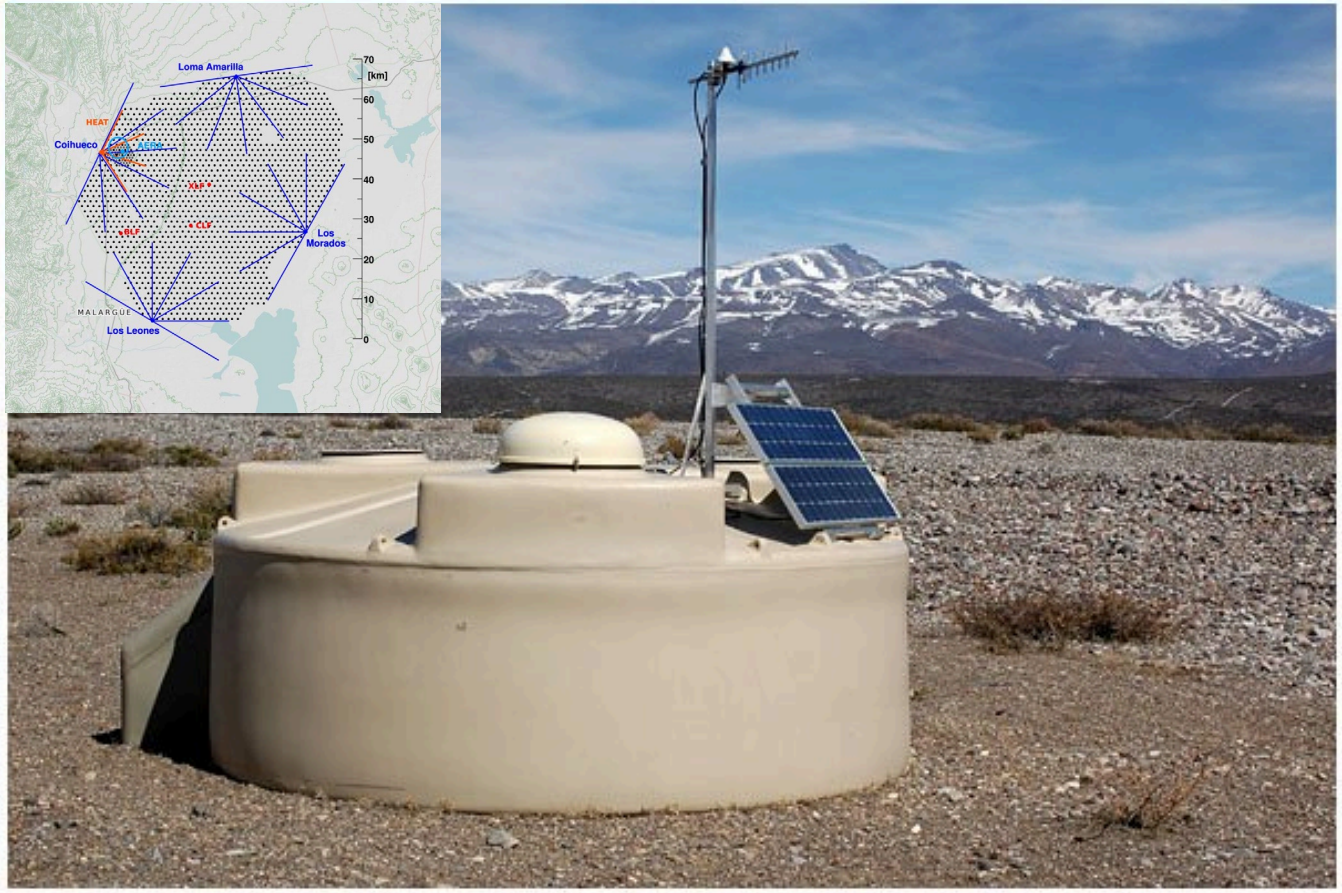
IceCube (Antarctica) → neutrinos



LIGO (USA) → Gravitational Waves

State of the art: Detection at ground

Pierre Auger (Argentina) → Cosmic Rays (CRs)



Top to bottom: HAWC (Mexico). LHASSO (China) → Gamma Rays (GRs)

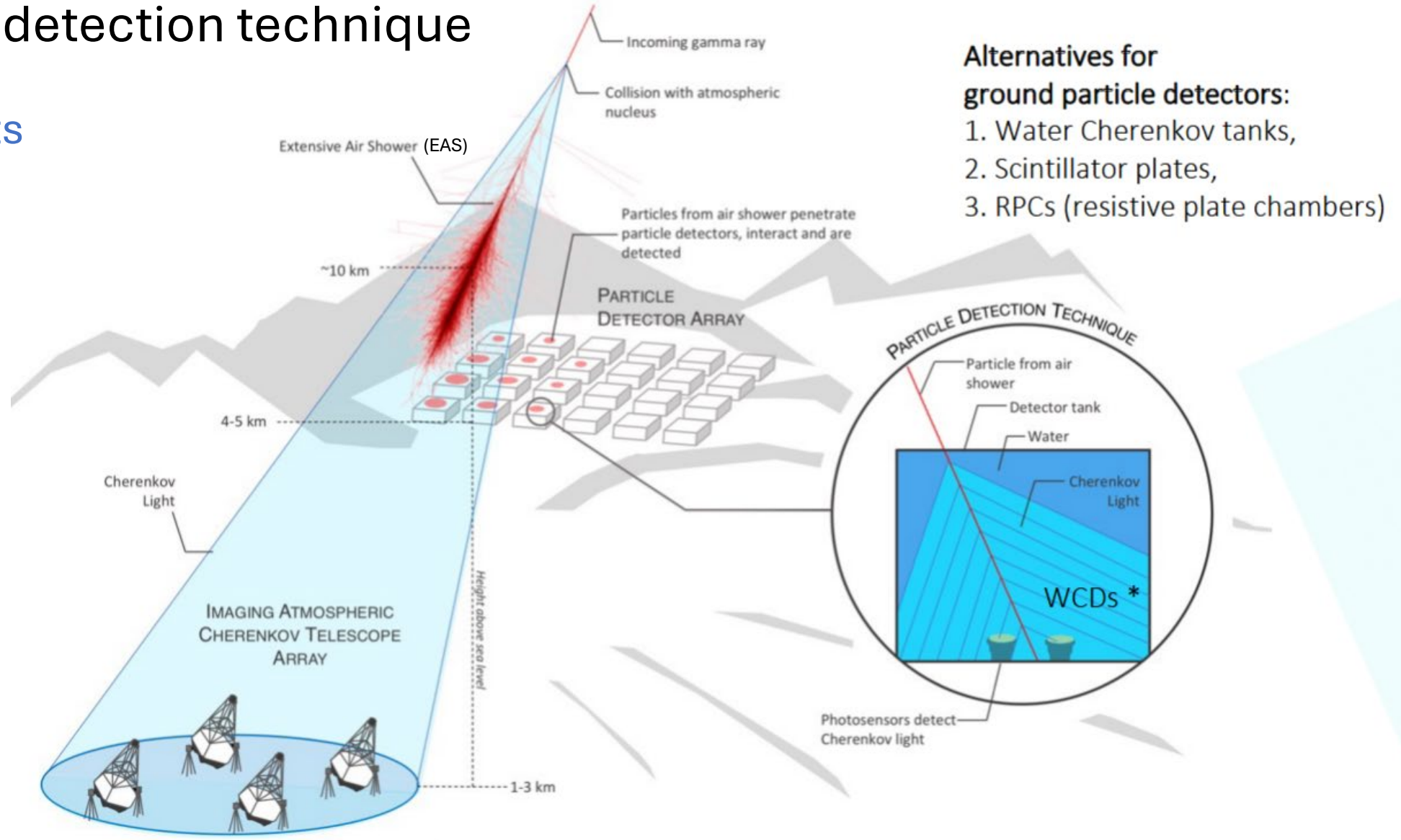
- Indirect observation → We observe the extensive air shower made of elementary particles.
- The goal is to reconstruct the shower to determine the energy and direction of CR/GR.

State of the art: GR astrophysics

The ground GR detection technique

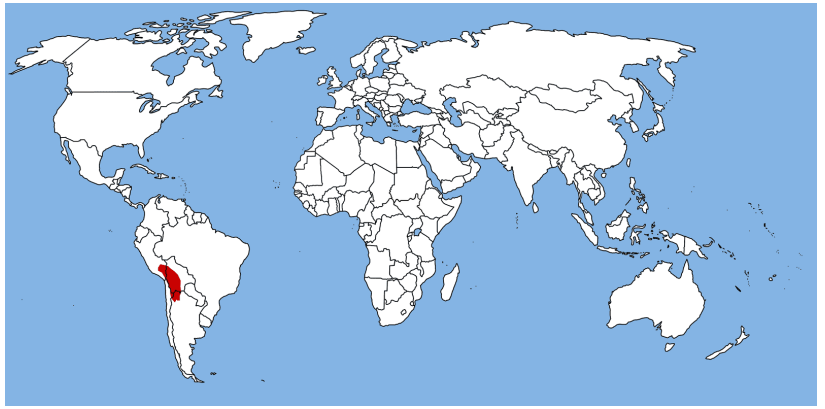
These experiments are located at the northern hemisphere only!

Unexplored Southern Hemisphere sky!



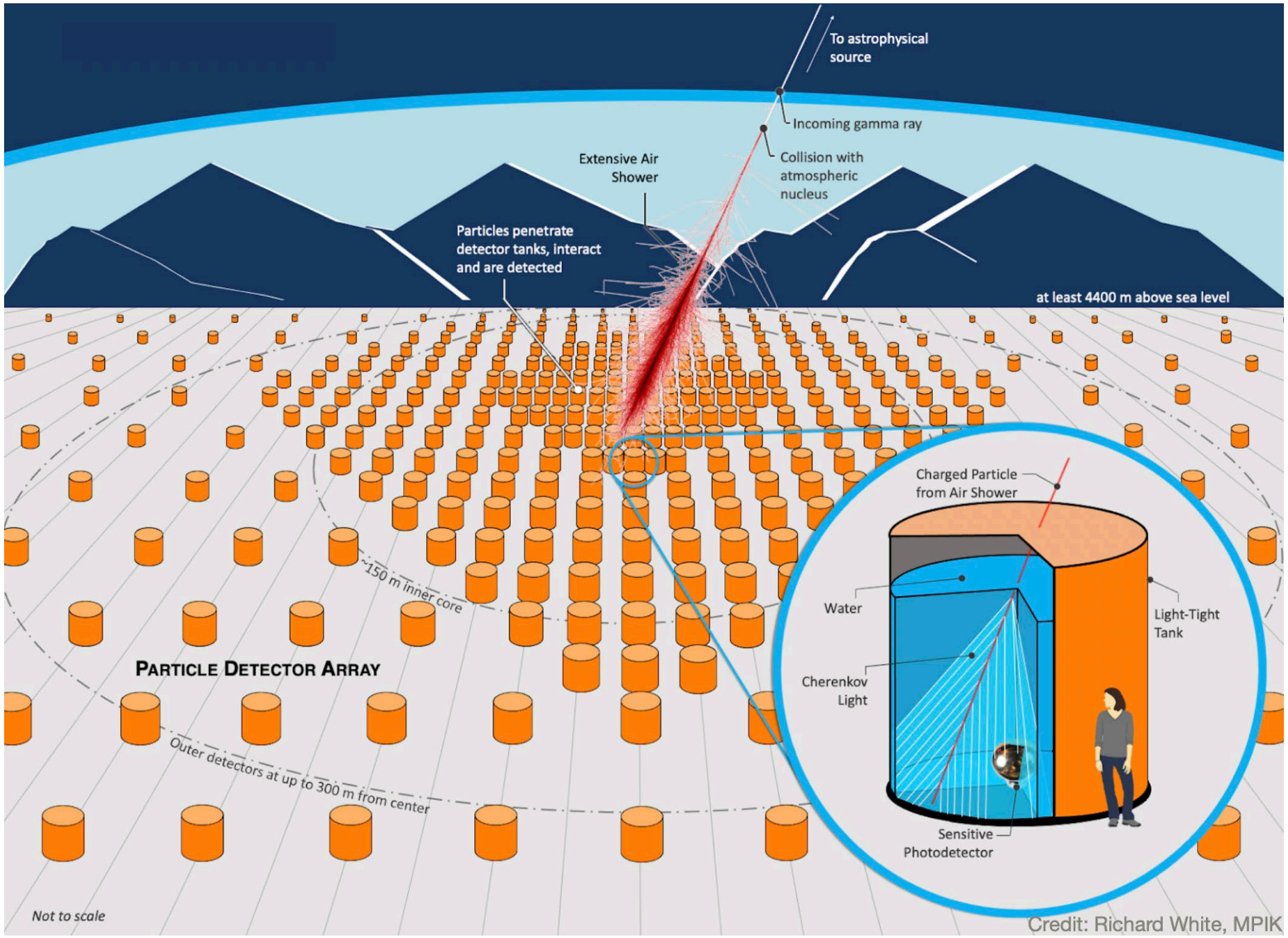
The Southern Wide-field Gamma-ray Observatory (SWGO)

- World-class international collaboration (14 countries, 80 institutes). UniPd is one of the founders.
- Currently in the R&D phase.
- Location: Andes between 10° - 30° South latitude, at 4700 m.a.s.l. (Also known as altiplano).
- Candidate sites: Chile, Argentina, Bolivia, and Perú.
- Cover an area ~1-2 $\mathbf{km^2}$. Water Cherenkov detector units (WCDs).
- Span energies from 100 GeV – PeV
- SWGO will be the most advanced GR observatory of its kind.

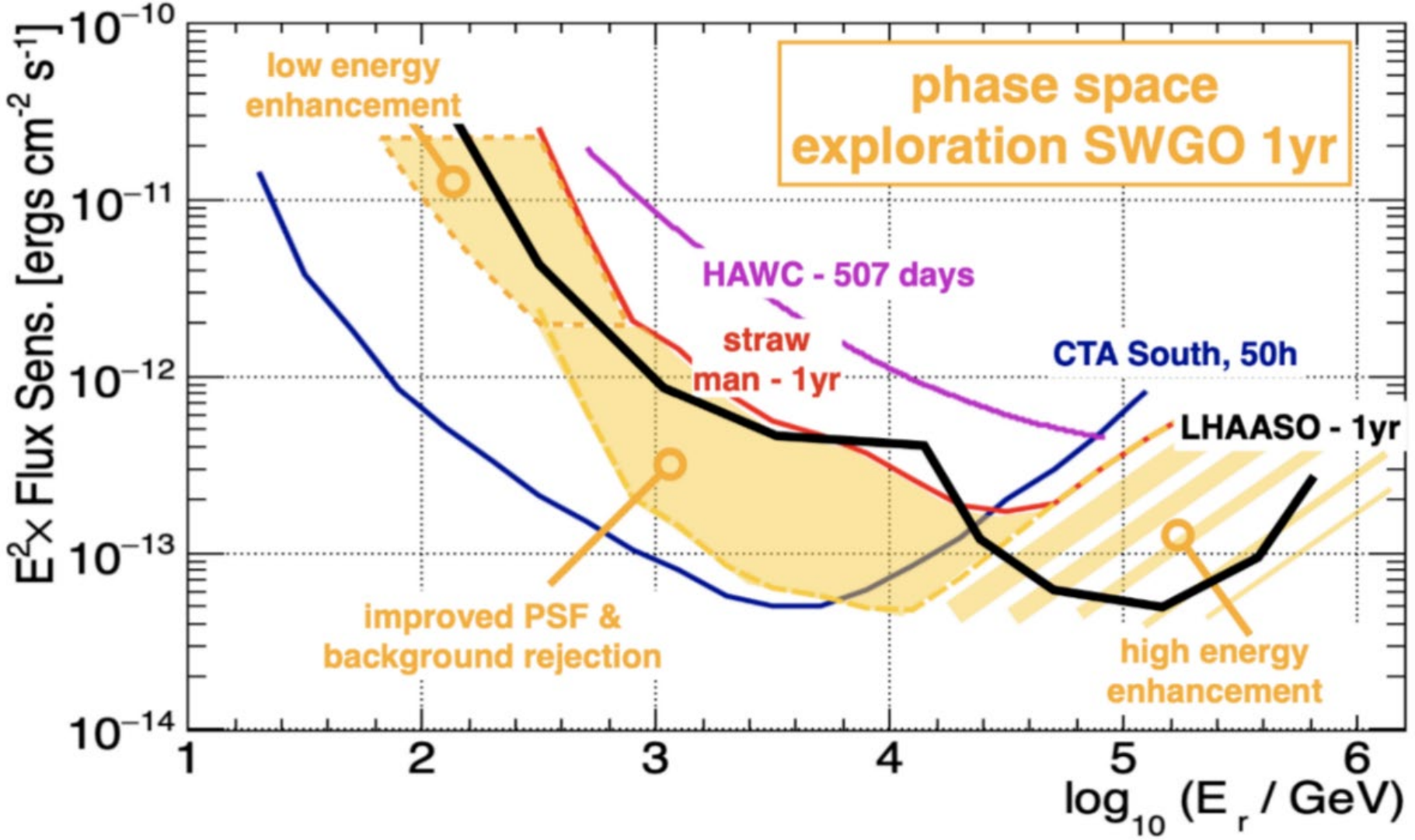


SWGO Array design

- The current design consider different areas with fixed WCDs density (fill factor). However:
- Are we sure if is it the optimal array design to have good sensitivity at the PeV energy scale?



SWGO Array layout design: Sensitivity



Research program: Objectives

- General: **Join the SWGO collaboration to contribute to the definitive observatory design.**
- Specifics:
  - The array design (first 4 months): Find the optimal layout to achieve the necessary sensitivity in the TeV-PeV energy scale.

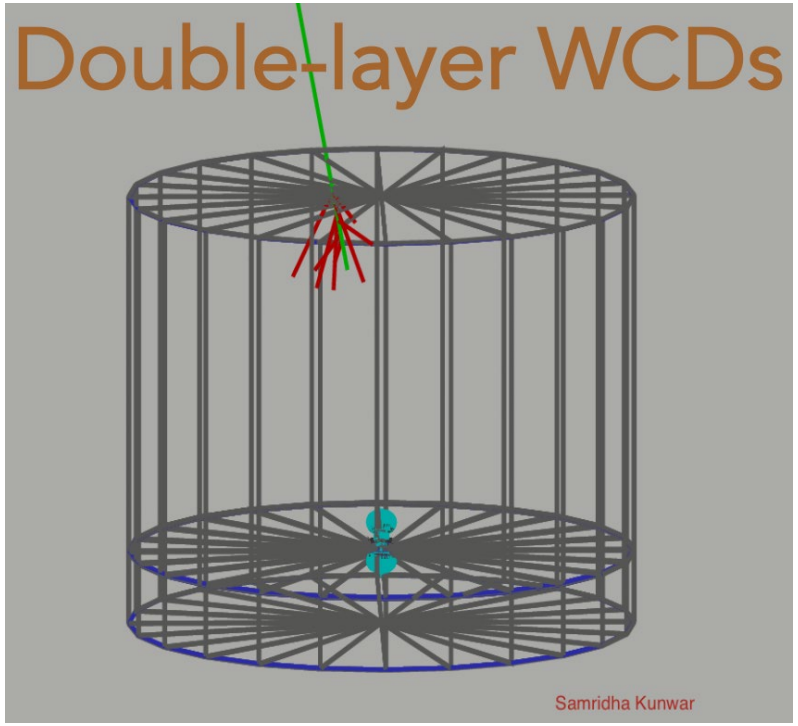
1. With Corsika (a powerful software that simulates EAS) we build look-up tables to study the spectral distribution of the secondary particles in each WCDs. (Python code)
2. Analytical method: A continue function that depends on the array parameters is built. This function is used to find the optimal configuration of WCDs. (C++ code)

1. Test in the Low Energy scale: 100 GeV – 100 TeV. Run the PeV simulations in the current arrays. Study the muon component in this regime.
2. Improve the model. Include the tank performance (new parameters).

Research program: Objectives

- After 4 months:

- Detector design & photosensors response: Contribute to the analysis for the detector design (e.g. 2 chambers to separate muons from EM particles). Study the response of scintillators developed by the SWGO Padova group.
- Scince Case (to be defined): Fundamental Physics a at PeV scale such as Dark Matter signatures, Axion-like particles, Lorentz invariance violation, Primordial black hole evaporation.



Research program: Collaborations & Congresses

- Congresses:
  - SWGO collaboration meeting, México, April 2024. Show some results/proposals for the array design.
- Collaborations:
  - National: SWGO Torino group → Simulations for array response at PeV energy scale. (During the first year)
  - International: - LIP (Lisbon, Portugal): SWGO group. Simulations, science and detector.

    - IAA (Granada, Spain): Ruben Lopez-Coto (SWGO affiliated). Science case.

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Research program: Conclusions

- SWGO is a frontier science experiment that certainly will make major advances in GR astrophysics.
- SWGO array problem is not trivial. A lot of techniques/methods and knowledge can be obtained working on this problem.
- To achieve the proposed objectives, it is required:
  - Documentation: SWGO articles, reviews, congresses.
  - Develop good programming skills.
  - Collaboration between different SWGO affiliated groups.
  - Multi-topics: High energy physics, physics of detectors, astrophysics, data analysis in physics.

Thanks for your attention!

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