The Southern Wide-field Gamma-ray Observatory

R. Conceição for the LIP-SWGO group

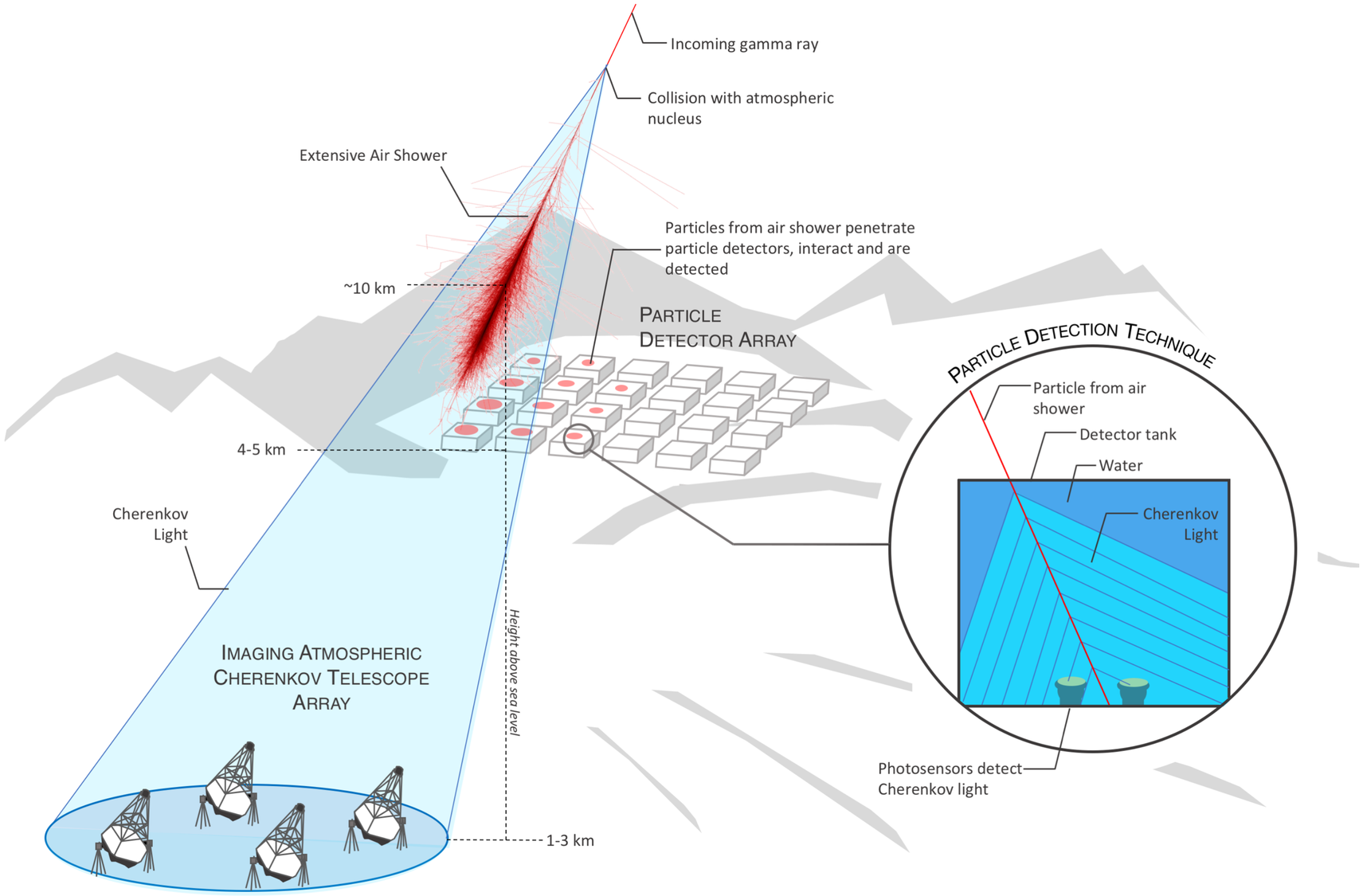
SWGO
The Southern Wide-field
Gamma-ray Observatory

LIP

TÉCNICO LISBOA

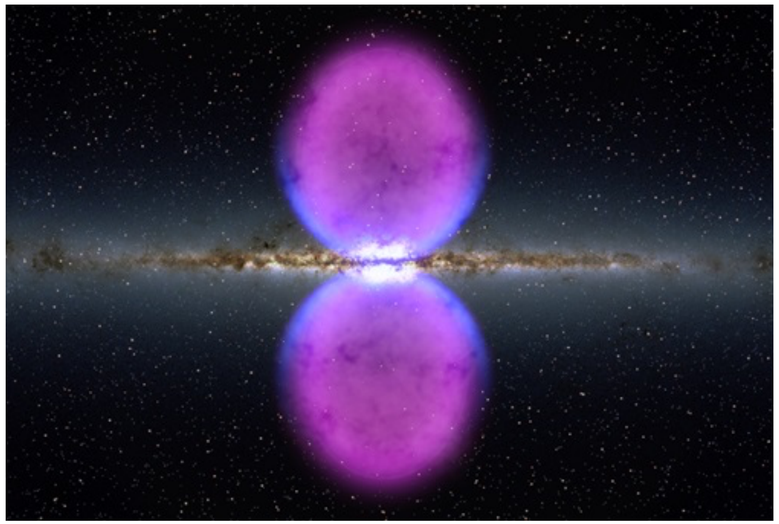
Jornadas do LIP, 9th July 2022

High-energy gamma-ray detection techniques



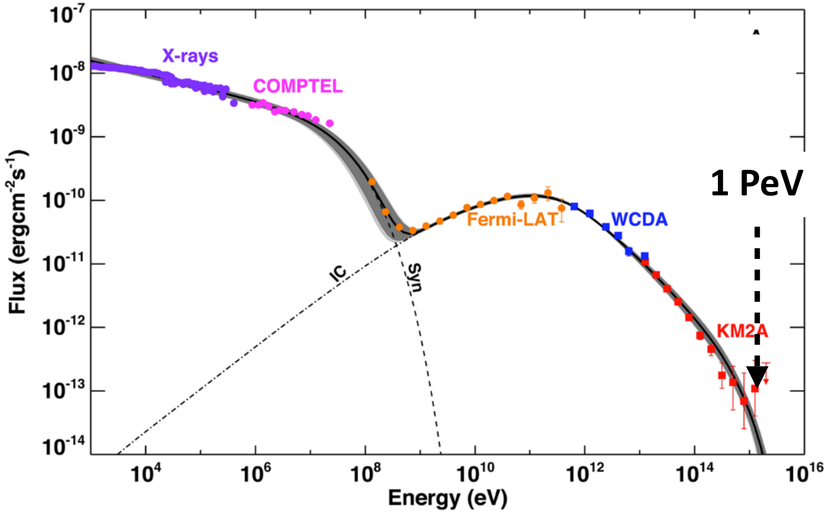
The VHE gamma-ray Sky

Fermi Satellite



Fermi bubbles - extended gamma-ray emission (up to ~100 GeV) in outbursts our Galaxy

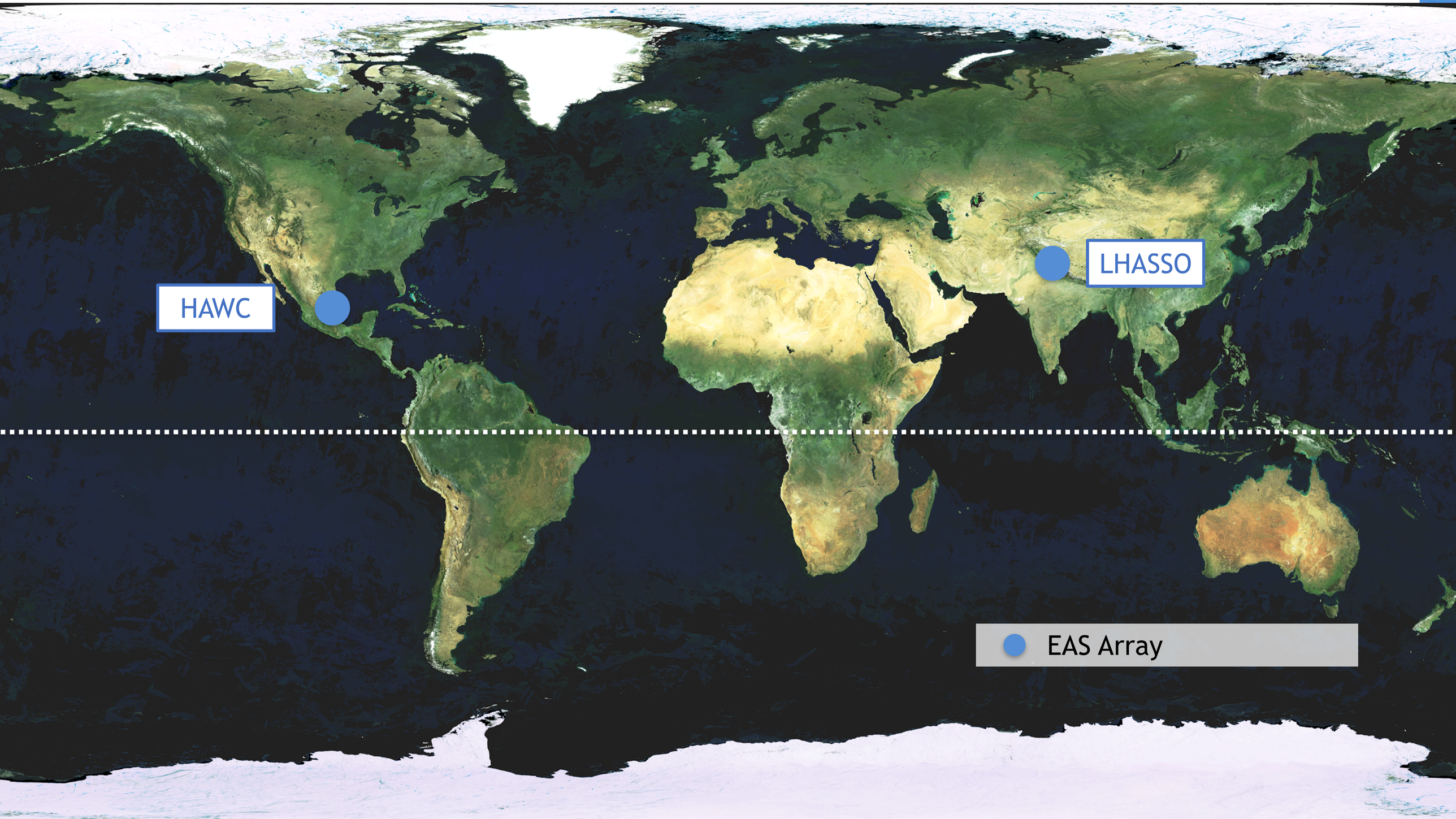
LHAASO experiment



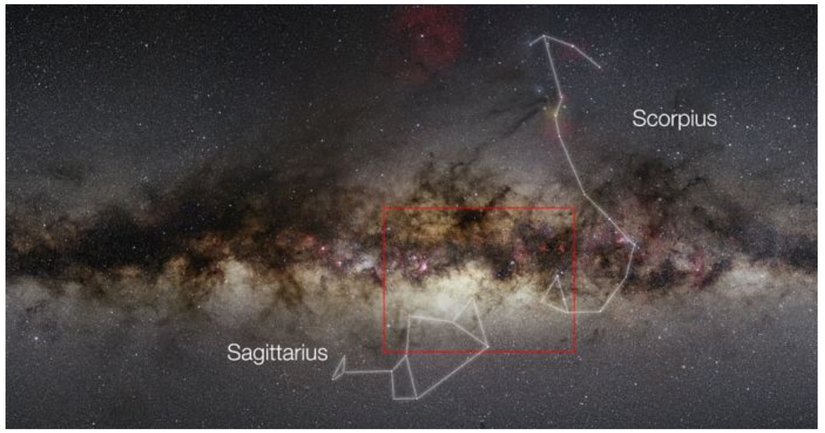
PeV gamma-ray emission from the Crab Nebula found thanks to LHAASO huge effective area

10^{11} 10^{12} 10^{13} 10^{14} 10^{15} 10^{16}

Energy [eV]


HAWC
LHASSO
EAS Array

Complementary to the powerful Cherenkov Telescope Array project



CTA

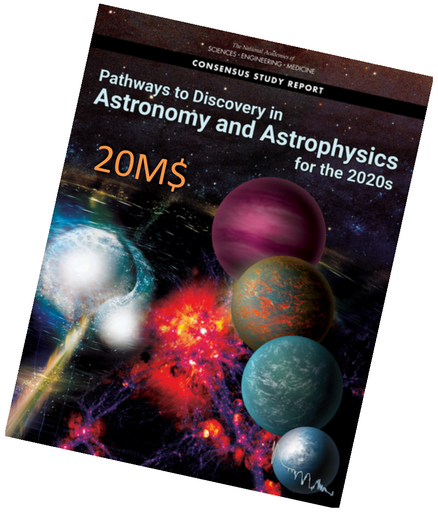
SWGO

SWGO collaboration

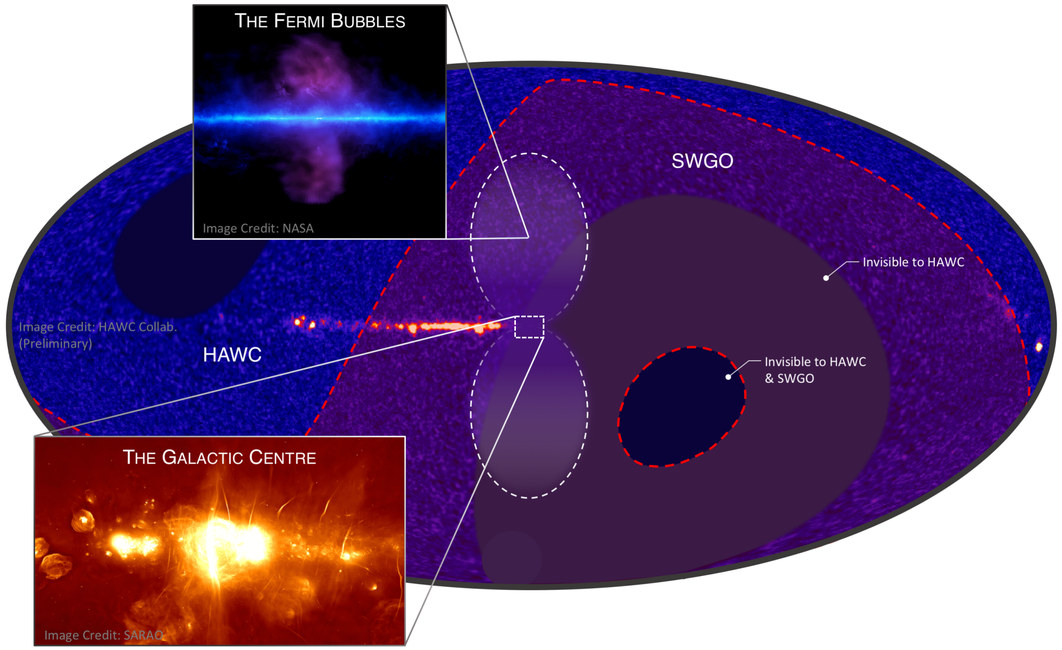
~3-year R&D project to design and plan the next generation wide field-of-view gamma-ray able to survey and monitor the Southern sky

- **S**outhern **W**ide-field **G**amma-ray **O**bservatory
  - → Formed at *July 1st 2019*
  - → 12 Countries / ~ 50 institutes / More than 100 scientists

		SWGO R&D Phase Milestones
✓	**M1**	R&D Phase Plan Established
✓	**M2**	Science Benchmarks Defined
✓	**M3**	Reference Configuration & Options Defined
	M4	Site Shortlist Complete
✓	**M5**	Candidate Configurations Defined
	M6	Performance of Candidate Configurations Evaluated
	M7	Preferred Site Identified
	M8	Design Finalised
	M9	Construction & Operation Proposal Complete



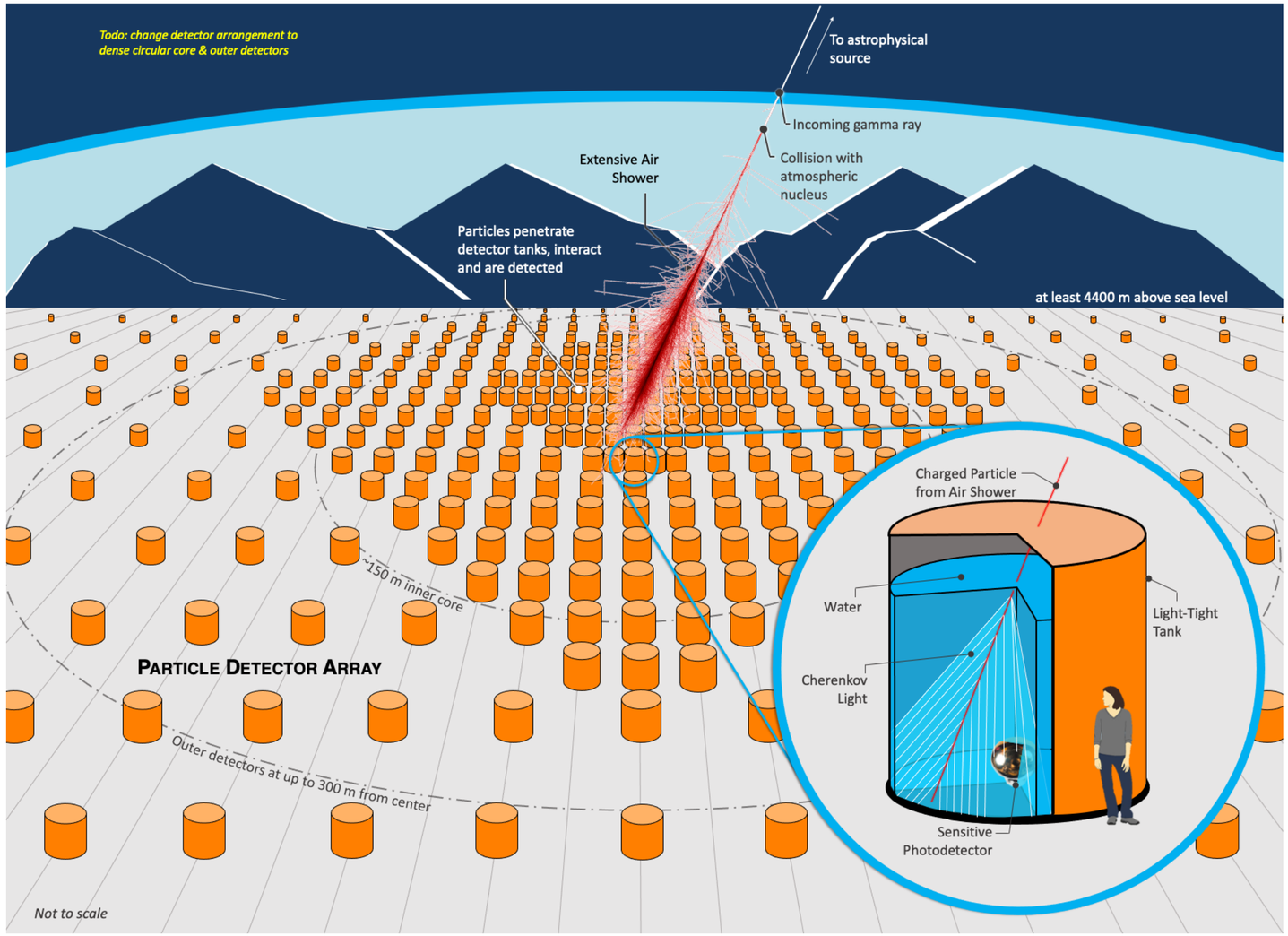
The scientific goal



www.swgo.org

The challenge…

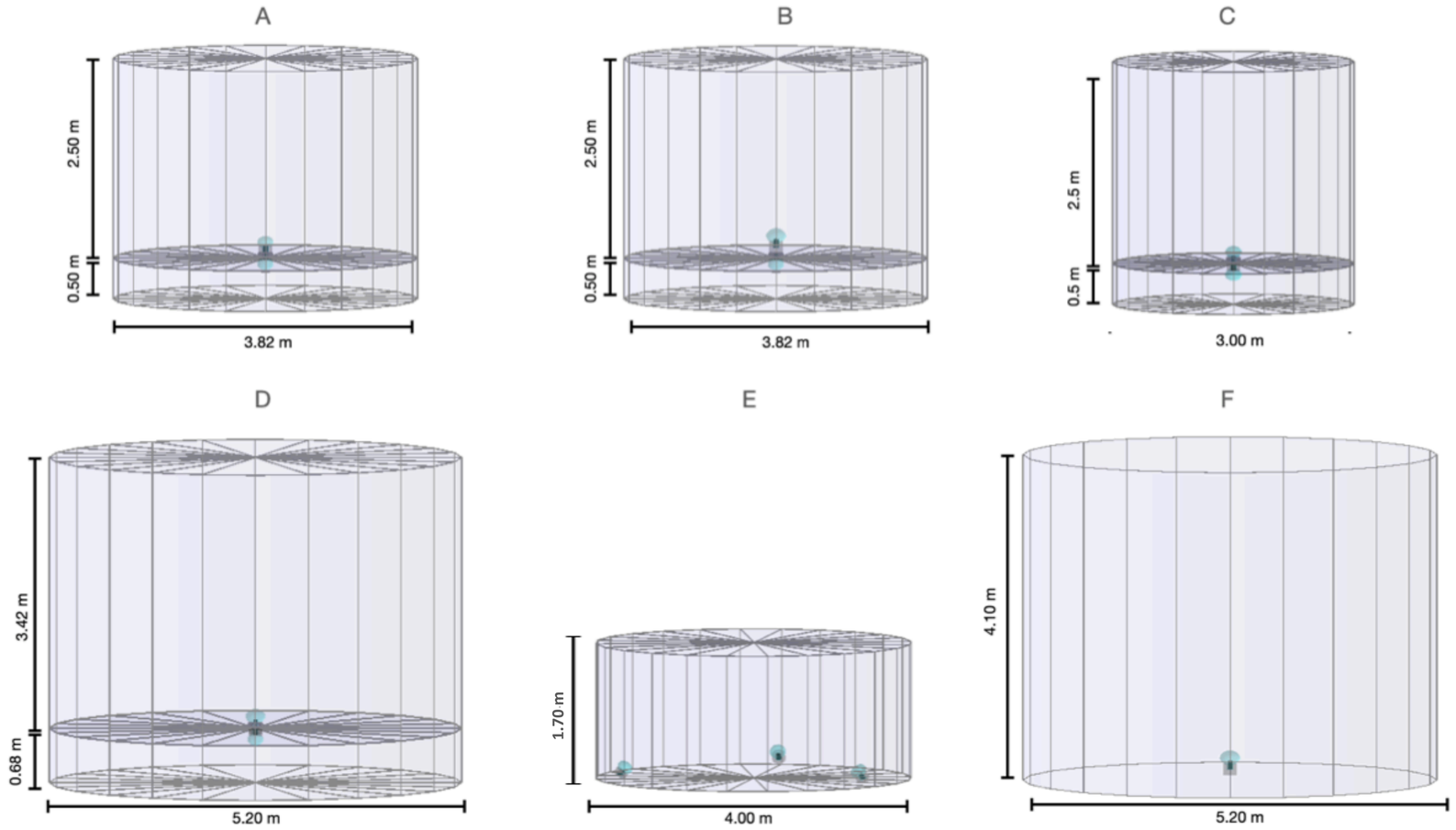
- To design an experiment able to fulfil the following requirements:
  - → **Muon tagging**/counting capability
  - → Lower energies
    - ✓ to be placed at **high altitude** (~5000 m a.s.l.)
    - ✓ **Compact array**
  - → Higher energies
    - ✓ **Large area** (~ few km^2)




Bolivia 4.7k
Chile 4.8 k
STATE OF ACRE
Peru
13° S
Lake Sibinacocha (Peru)
Yanque (Peru)
Imata (Peru)
Chacaltaya (Bolivia)
Bolivia
Cochabamba
AAP Pajonal (Chile)
24° S
Alto Tocomar (Argentina...
Chile
Argentina 4.8 k
Peru 4.9 k

Explore different detector concepts

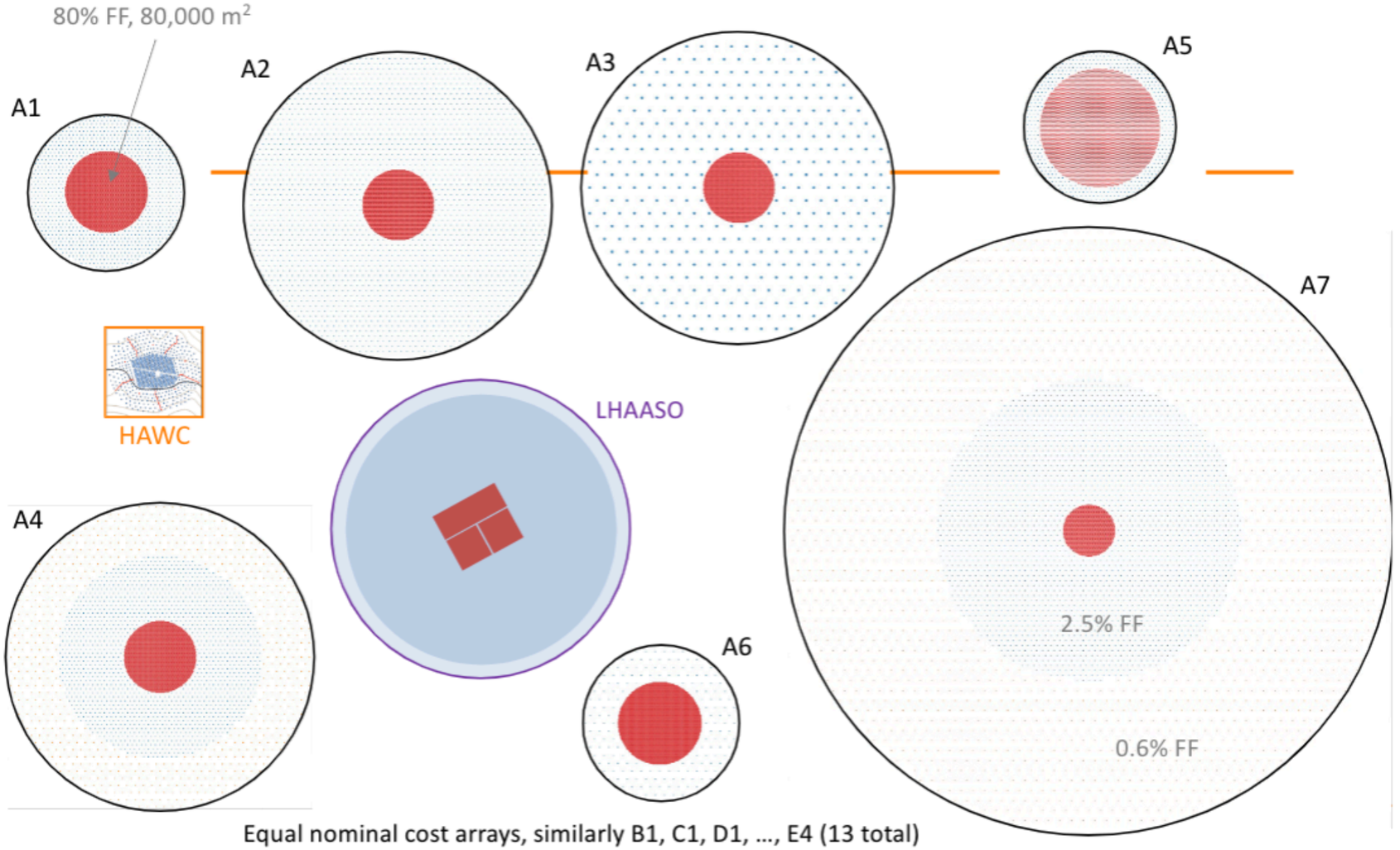
Label	Layers	PMT (upper + lower)	Diameter (m)	Depth (upper)	Depth (lower)	Nominal Cost (kUSD)
A	2	8"HQE +8"	3.82	2.50	0.50	9.68
B	2	10"HQE + 8"	3.82	2.50	0.50	10.66
C	2	8" +8"*	3.00	2.50	0.5	6.90
D	2	10"HQE + 8"	5.20	3.42	0.68	14.32
E	1	3×8"	4.00	1.70	-	11.82
F	1	10"HQE	5.20	4.20	-	11.54



- Use sensible arguments / first studies to make obtain reasonable station concepts
- Test different station concepts
- Test different DLWCD sizes
- Test different PMT sizes

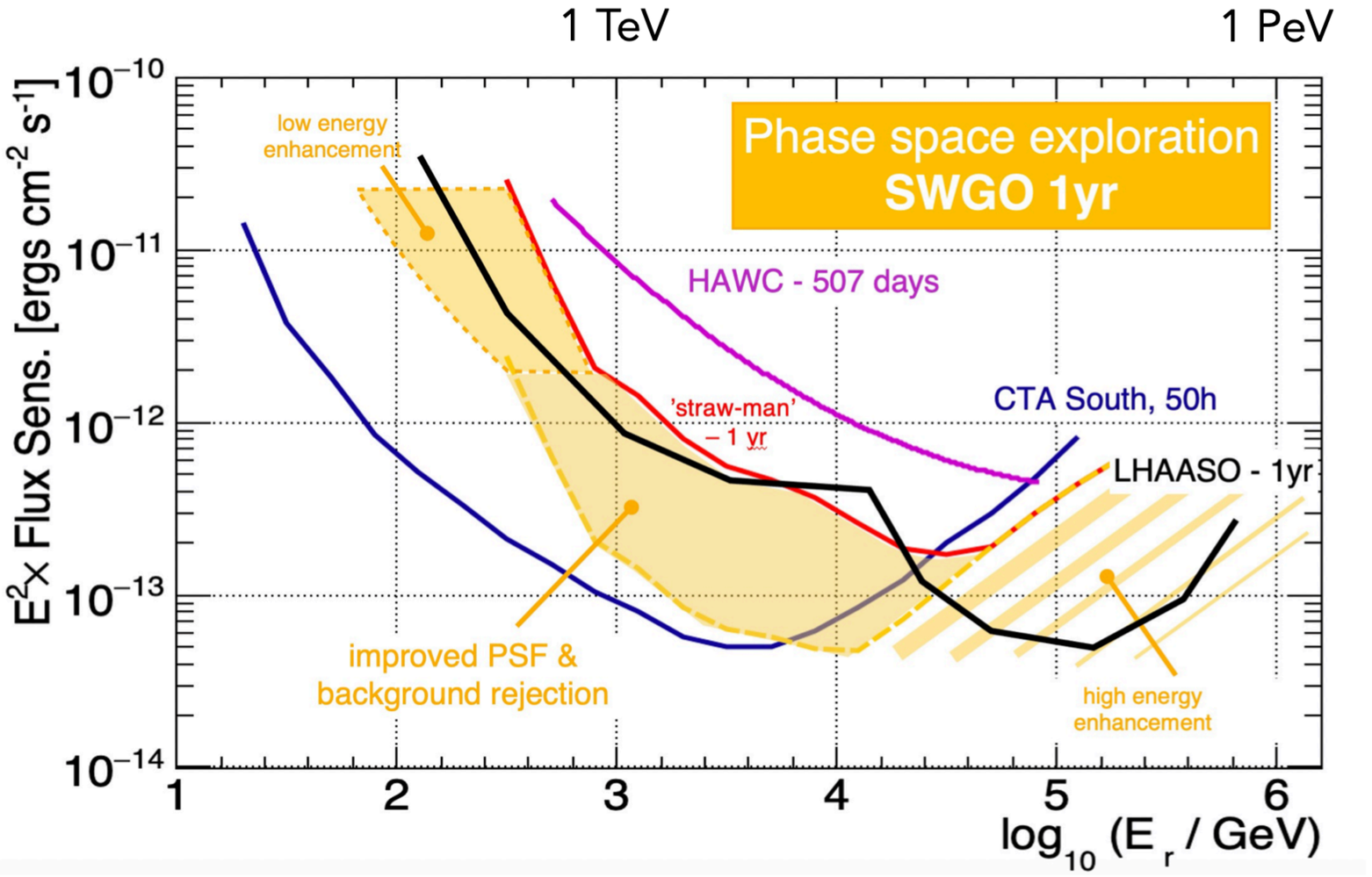
All detector stations present in the SWGO simulation framework

Explore different array layout configurations



Equal nominal cost arrays, similarly B1, C1, D1, …, E4 (13 total)

Expected Sensitivity



Explore new ideas, detector concepts, array layout configuration to increase the observatory sensitivity

LIP-SWGO group

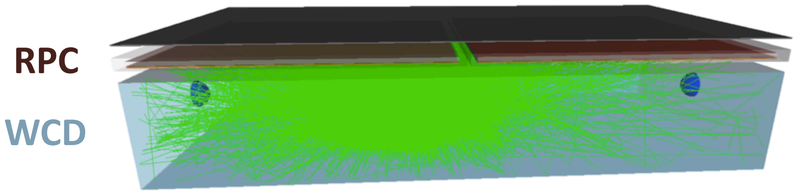
A brief history…

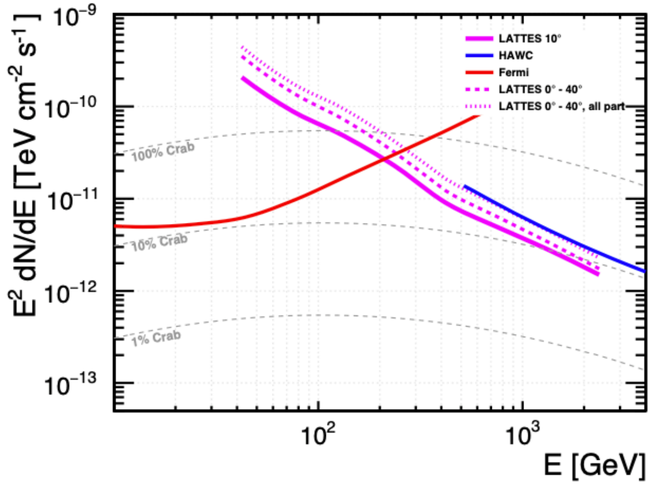
PTDC 2017

(LATTES)

Close the gap between satellite and ground-based measurements

Astropart.Phys. 99 (2018) 34-42





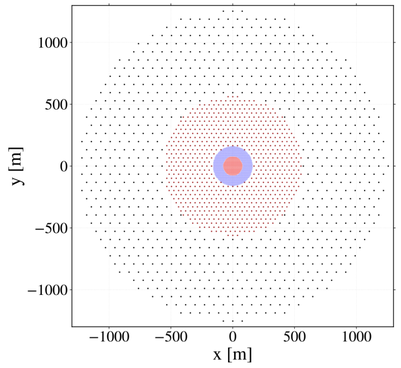
SWGO Convergence meeting at LIP in 2019

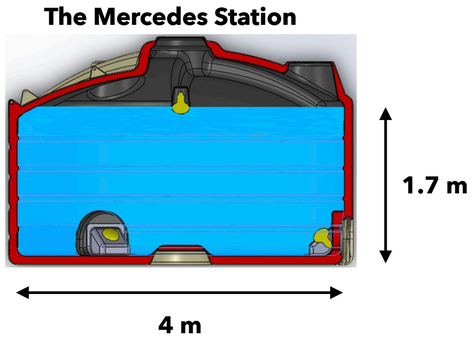
PTDC 2020

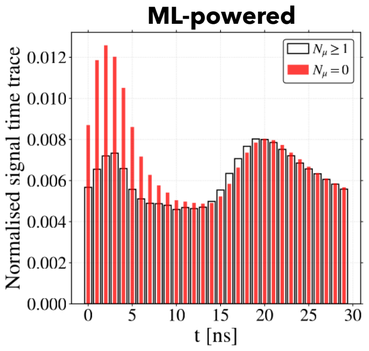
(SWGO)

Monitor the Southern sky from 100 GeV up to 10 PeV

Compact array + larger effective area = novel detector and analysis strategies needed







SWGO LIP Group

Alberto Blanco, Alberto Guillén, Alessandro De Angelis,
Bernardo Tomé, **Borja S. González***, Catarina Espírito Santo,
Fernando Barão, Giovanni La Mura, Jaime Alvarez-Muñiz,
José Carlos Nogueira, **Lucio Gibilisco***, Luís Lopes, Luís Mendes,
Mário Pimenta, Miguel Ferreira, Paulo Fonte, Pedro Abreu, Pedro Assis,
Pedro Brogueira, **Pedro Costa*,[1]**, Ruben Conceição

* New PhD students

[1] shared with Auger

Responsibilities at SWGO

Steering committe

Advisory group

Science | Simulation and Analysis | Detector R&D | Site selection | Outreach

- M. Pimenta - Member of the steering committee
- P. Brogueira - Member of the Advisory Group
- R. Conceição - Analysis and Simulation Working Group coordinator
- G. La Mura - Coordinator of the Extragalactic and Transients task
- L. Mendes - Coordinator of the Site Infrastructures task
- P. Assis - Software array trigger contact-person
- P. Abreu/C. Espírito Santo - Portuguese contact points for outreach activities

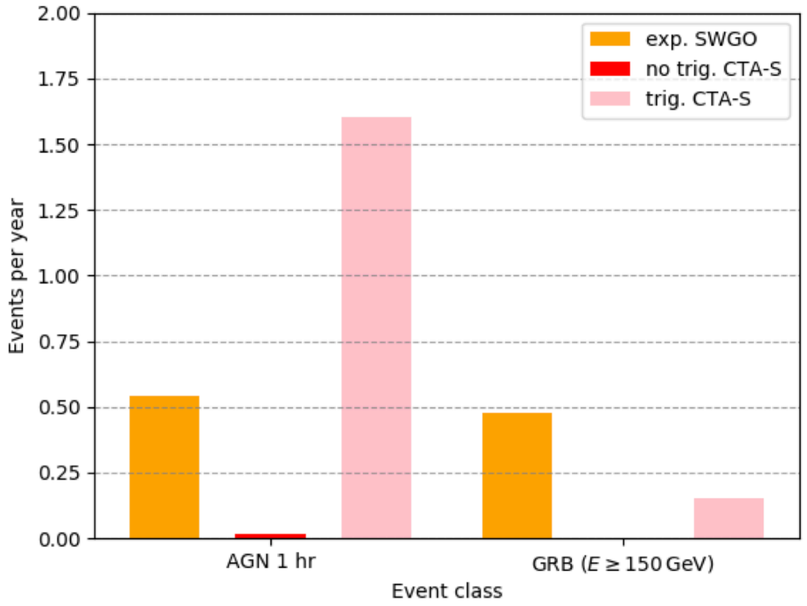
SWGO activities at LIP

Some highlights

Science

Transient Events

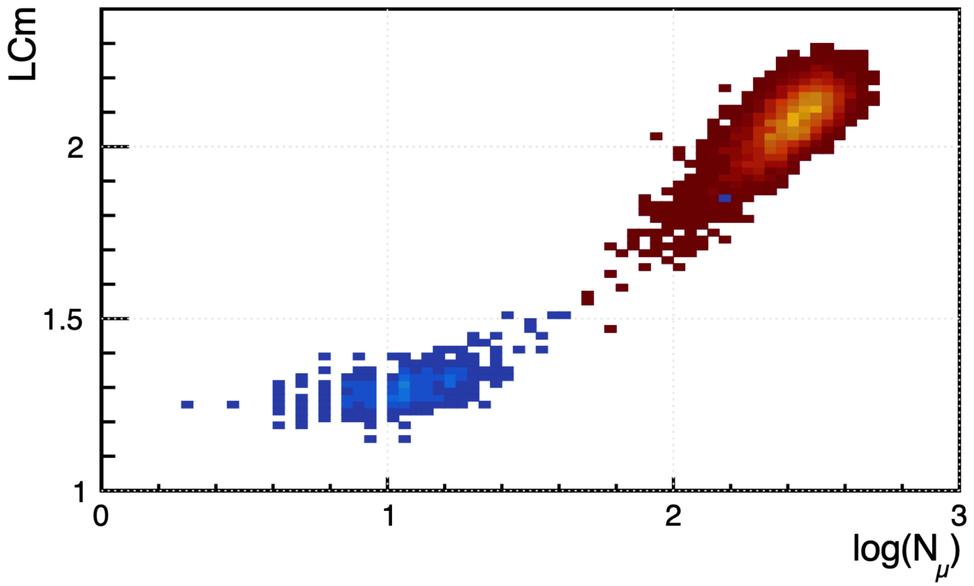
G. La Mura et al, *Mon.Not.Roy.Astron.Soc.* 497 (2020) 3, 3142-3148



SWGO is a powerful transient detector highly complementary to CTA observations

New gamma/hadron discriminator

R. Conceição, L. Gibilisco, M. Pimenta, B. Tomé, submitted to JCAP

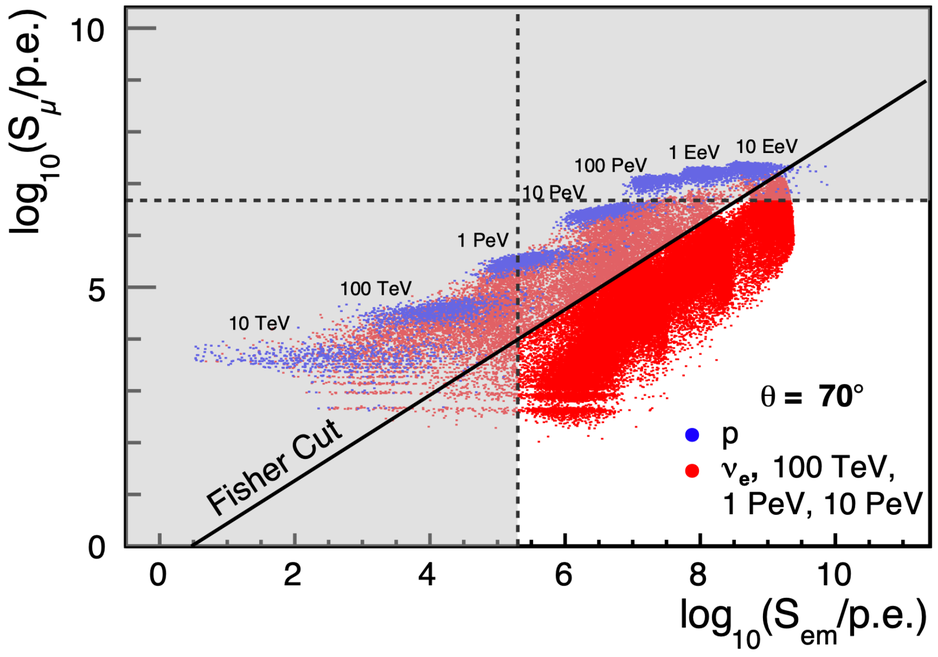


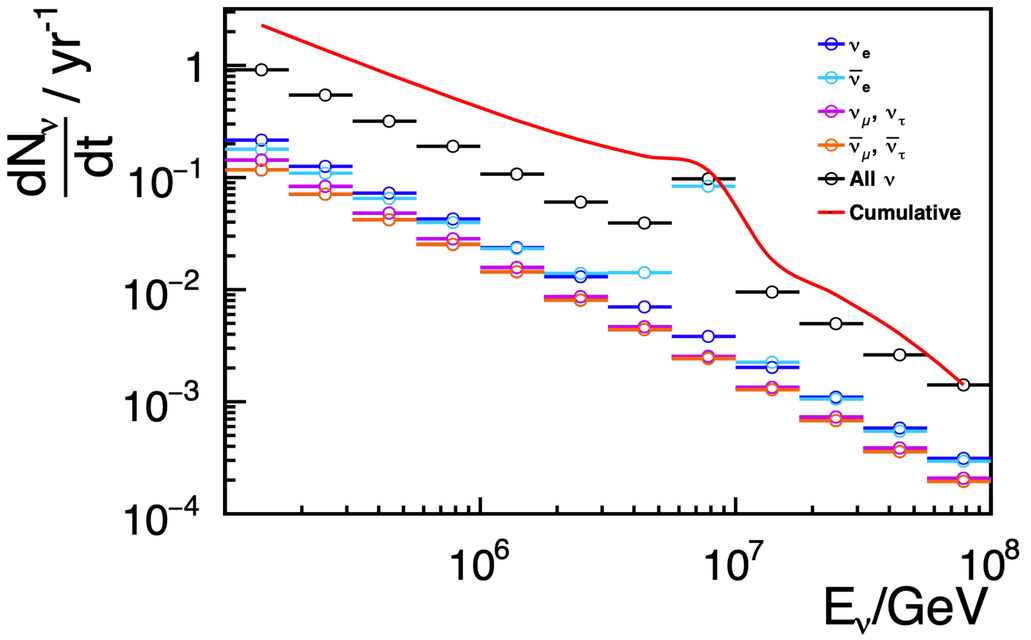
The azimuthal asymmetry of the shower ground pattern can be exploited as a g/h discriminator

Science

Sensitivity to Astrophysical Neutrinos exploring inclined showers

J. Alvarez-Muñiz, R. Conceição, P. Costa, M. Pimenta, B. Tomé, to be submitted to PRD in the coming days



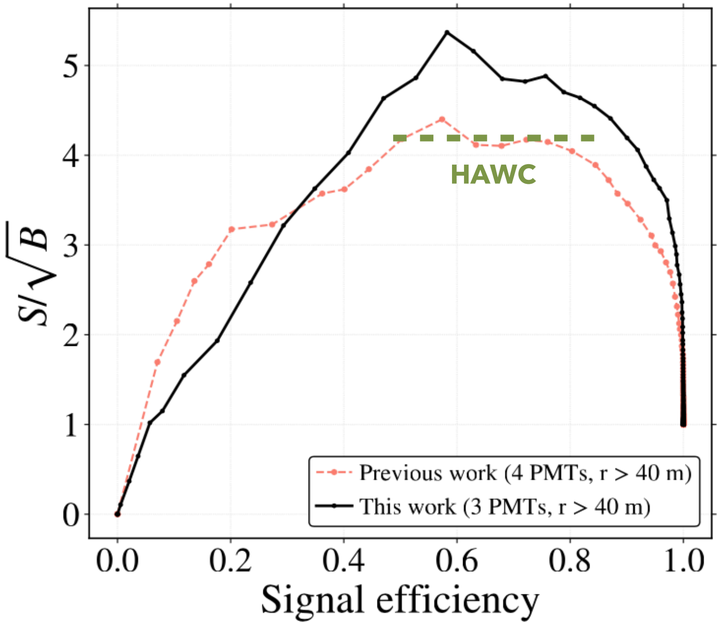


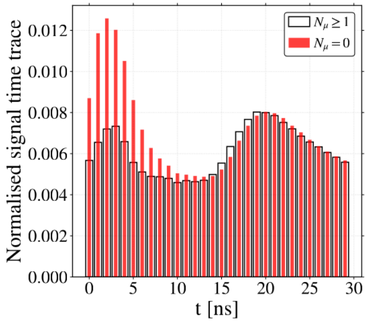
An experiment such as SWGO would be able to detect around 2 neutrinos with E>100 TeV per year

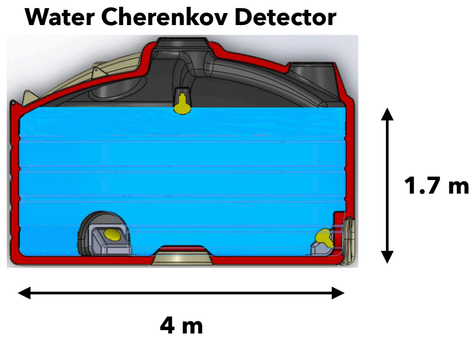
Detector concept + Reconstruction

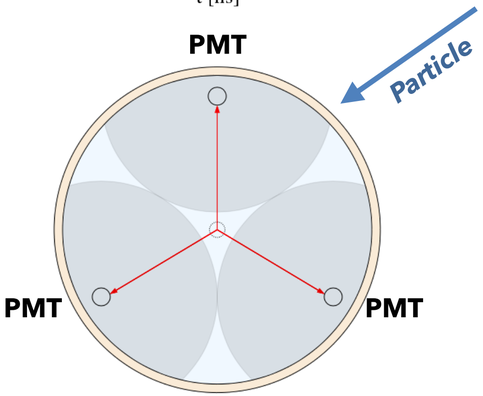
- **4 PMTs + ML analysis**
  - B. S. González et al, Eur.Phys.J.C 81 (2021) 6, 542
- **Mercedes station (3 PMTs) + ML analysis**
  - 4 m diameter - 1.7 m height
  - Submitted to EPJC

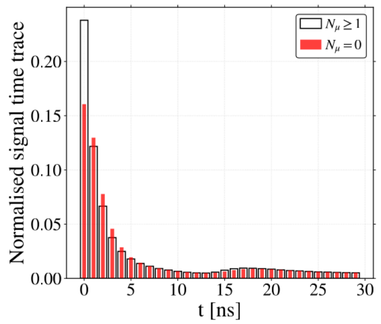
Excellent gamma/hadron discrimination capability

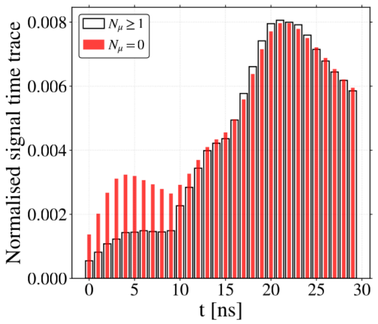






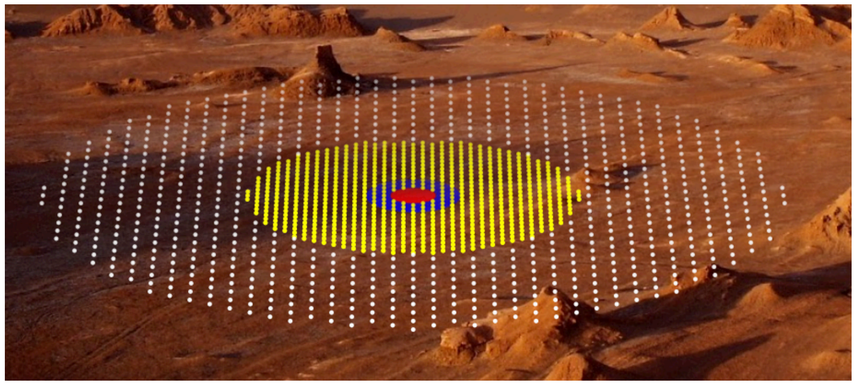




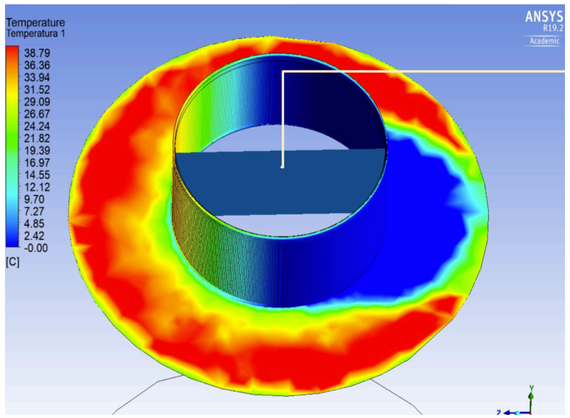


Other activities…

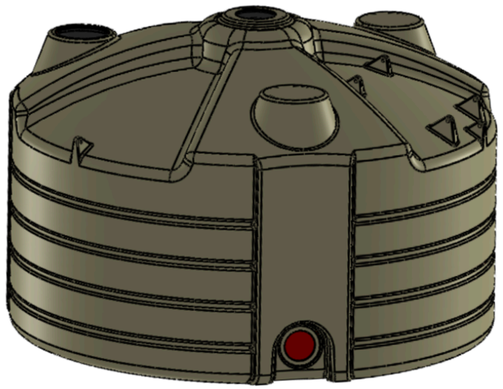
Layout configuration in phases



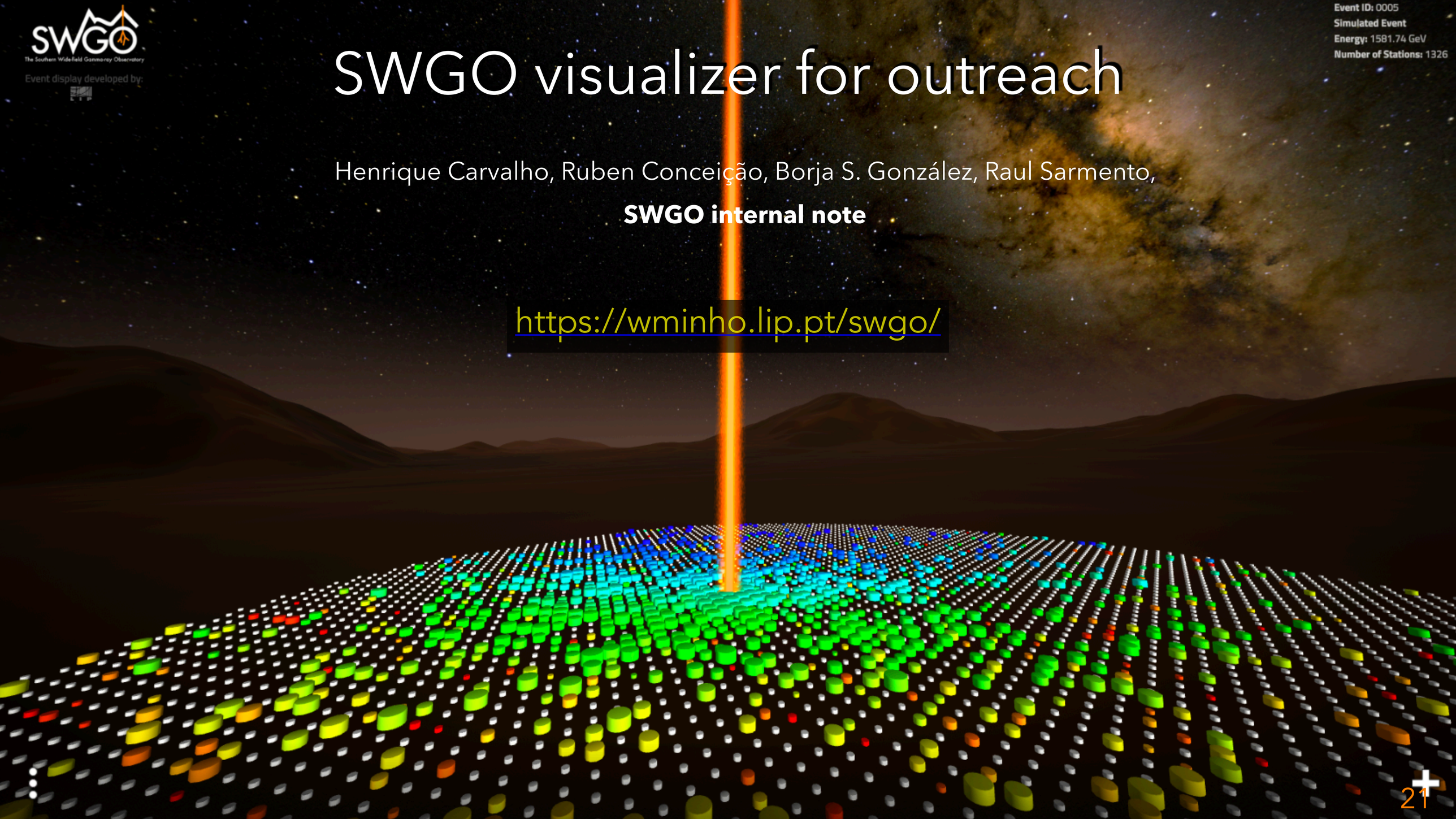
Thermal Simulations



Detector prototyping and Site procurement



R&D of RPC detectors for calibrations in-situ



SWGO visualizer for outreach

Henrique Carvalho, Ruben Conceição, Borja S. González, Raul Sarmento,

SWGO internal note

https://wminho.lip.pt/swgo/

Summary

- The Southern Sky needs a wide field VHE-UHE gamma-ray observatory

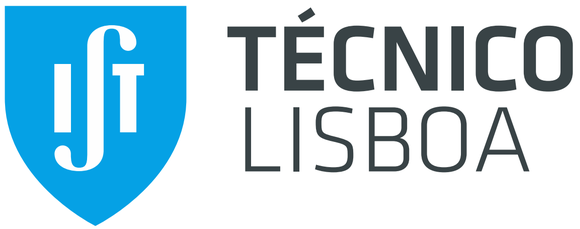
  → Complete view of the TeV-PeV sky : **complementary to LHAASO** in the Northern hemisphere

  → Monitor the transient sky : **strong synergies with CTA** and the new generation neutrino telescopes

- **SWGO is advancing towards the design and site choices**

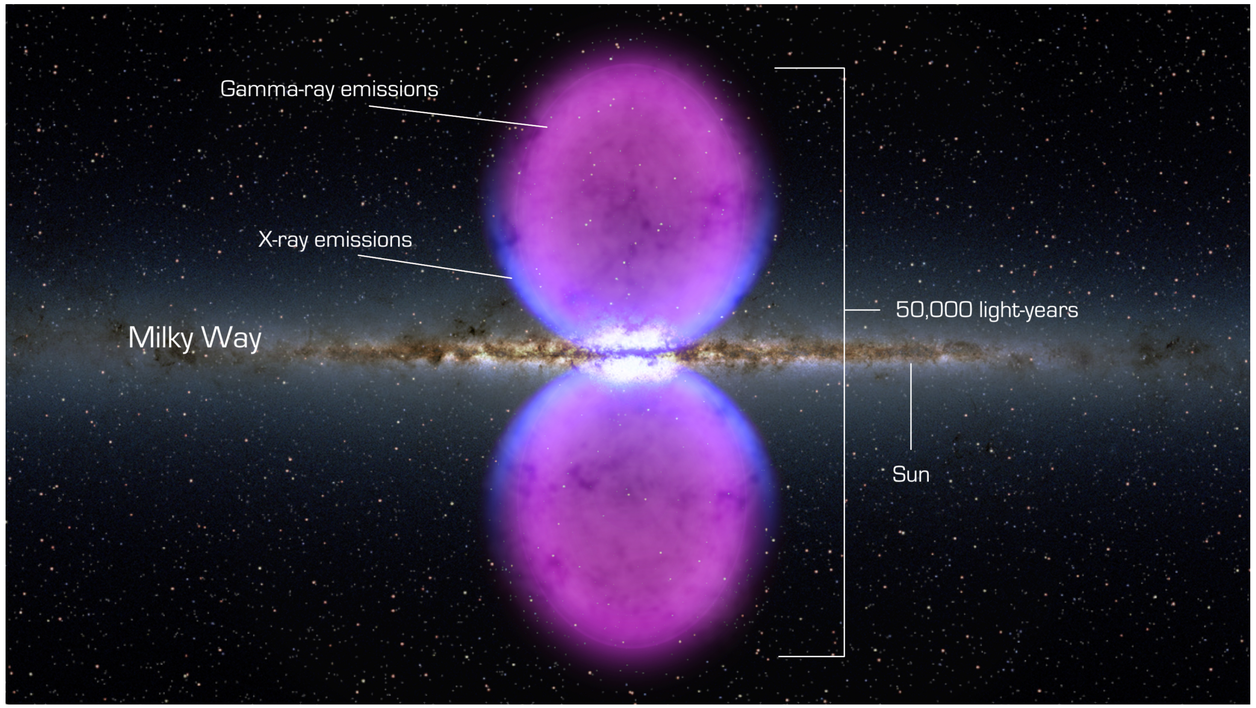
SWGO collaboration

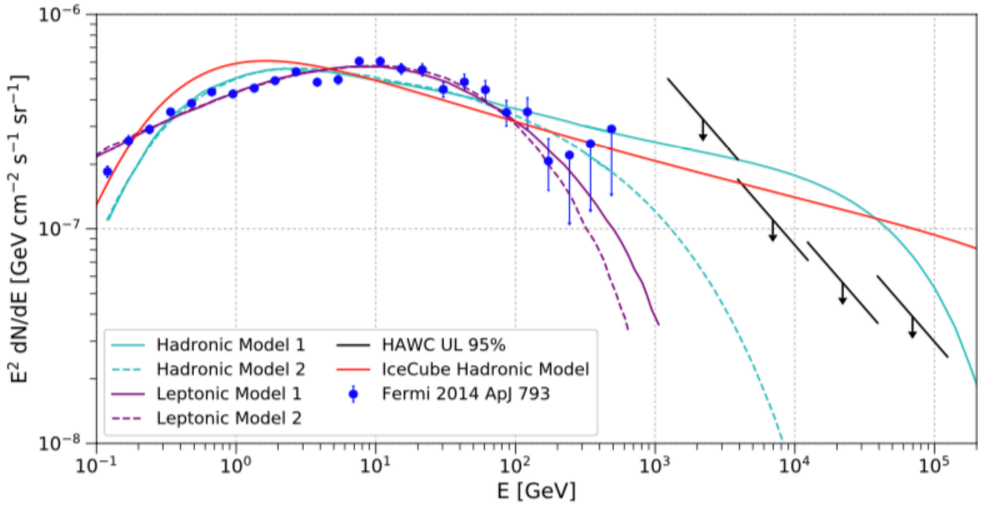
Acknowledgements



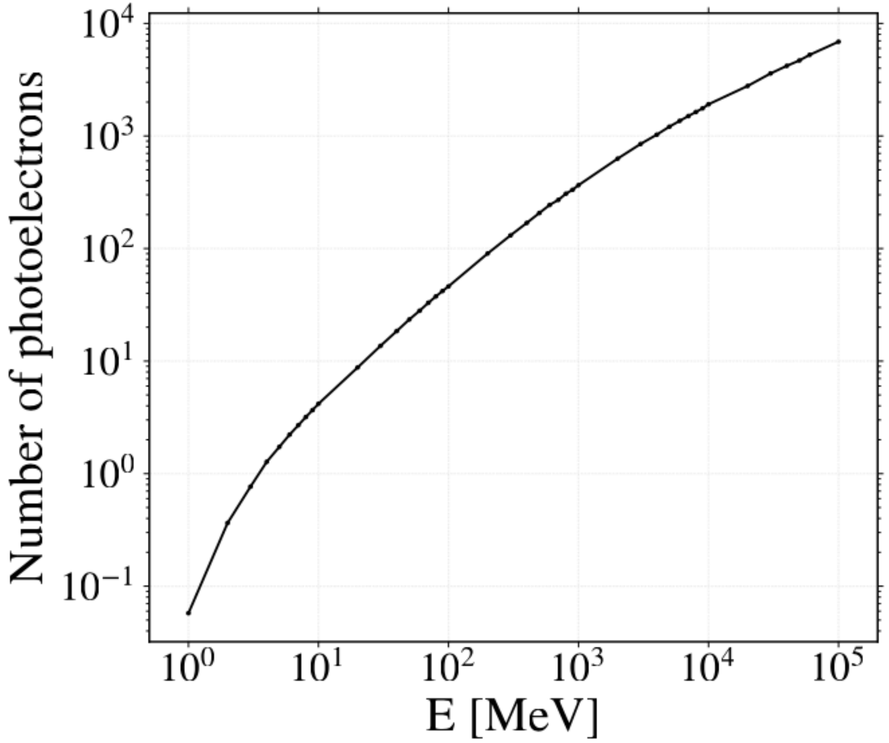
BACKUP SLIDES

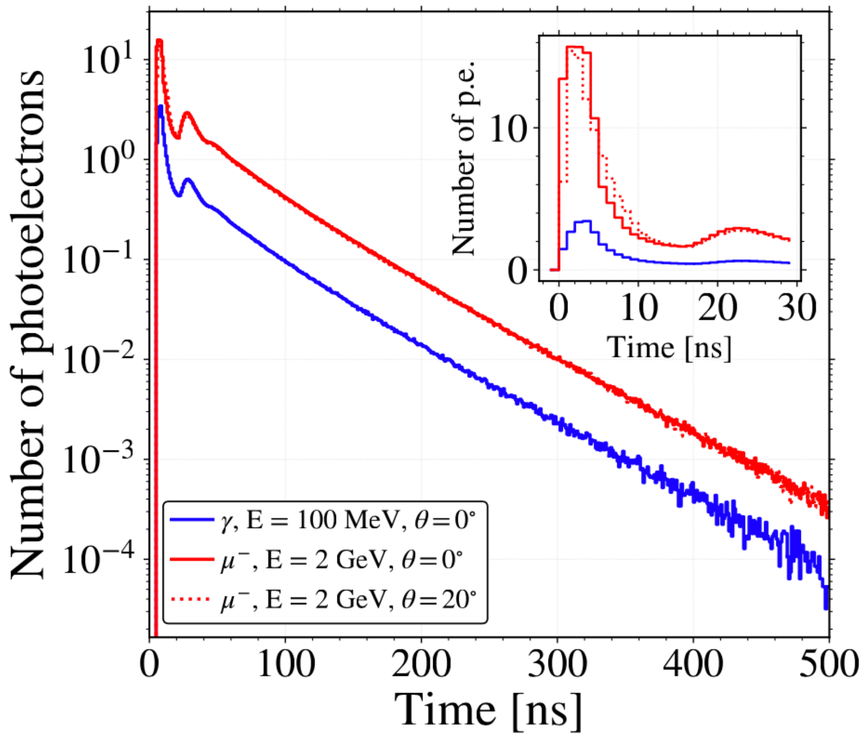
Fermi Bubbles





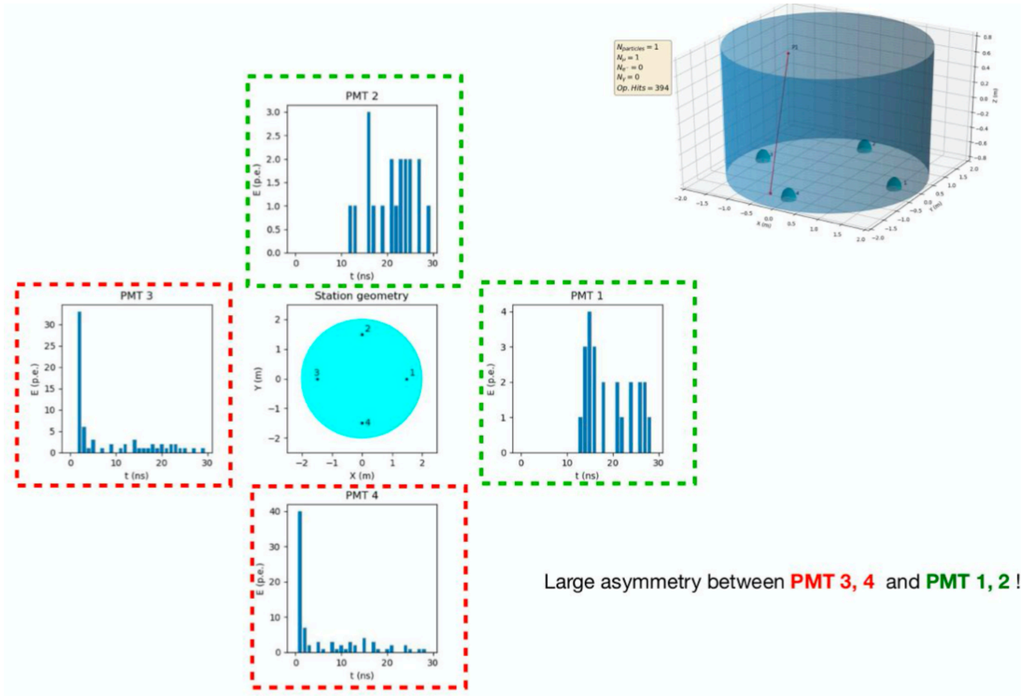
Mercedes Station

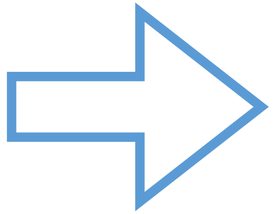


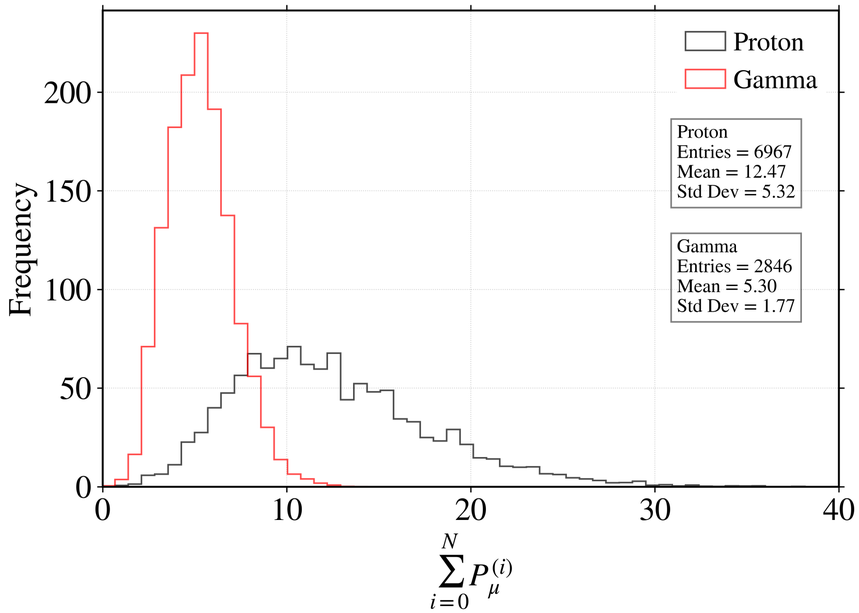


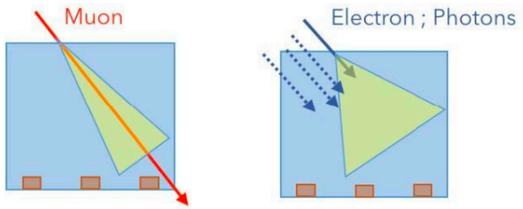
Muon tagging

- Explore signal asymmetry between PMTs using a Neural Network







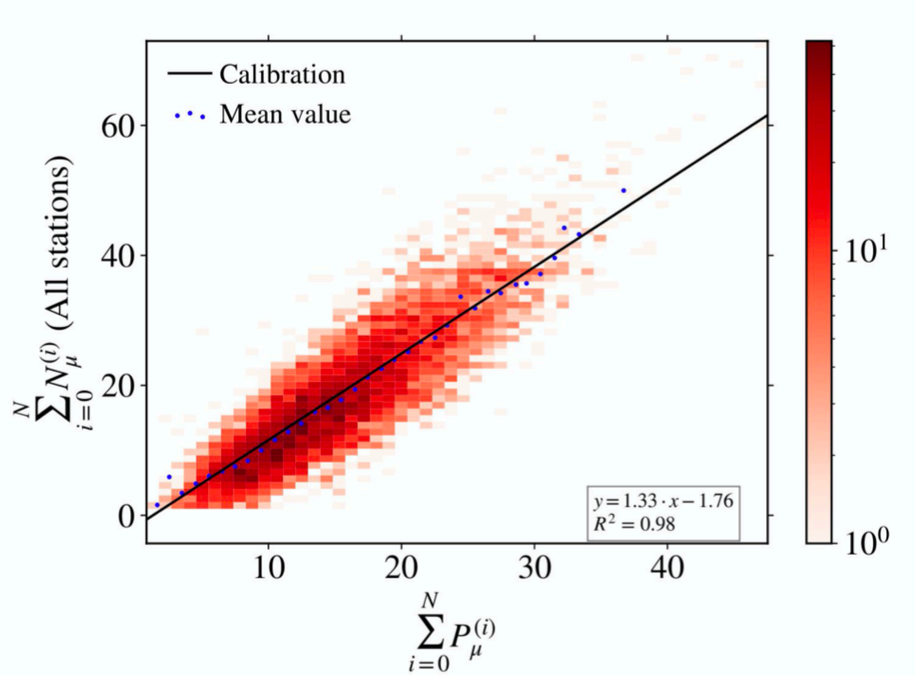


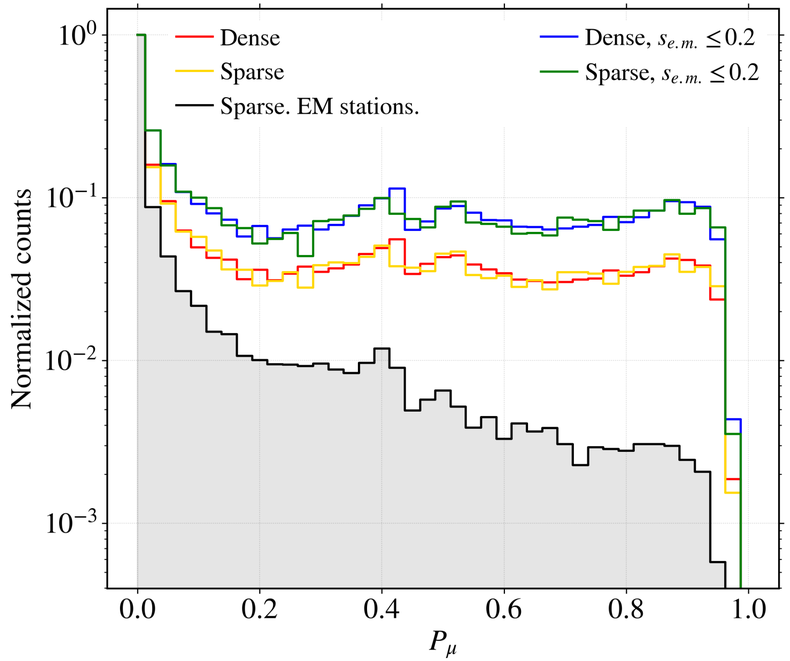
Good gamma/hadron discrimination at E ~1TeV

S/sqrt(B) ~ 4 (similar to LATTES and HAWC)

Dense vs. Sparse array

- Explore signal asymmetry between PMTs using a Neural Network



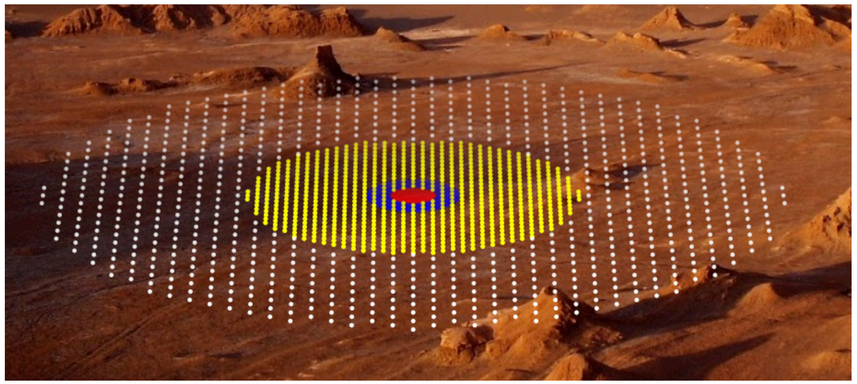


Sensitive to the overall number of muons in the shower event

Sparse vs. Dense array with similar performances

Other activities…

Layout configuration in phases



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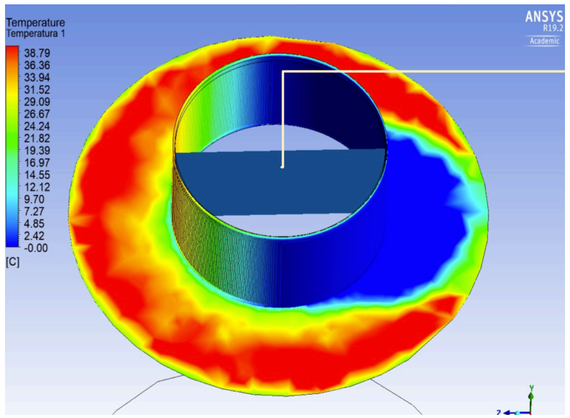

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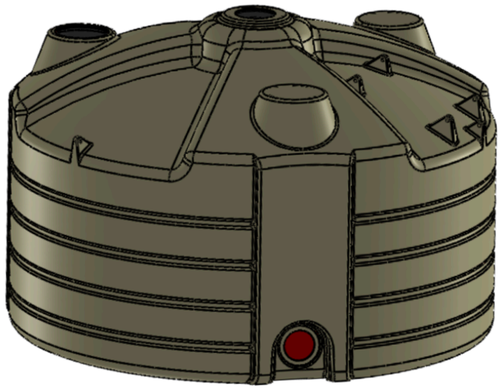

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