The Southern Wide-field Gamma-ray Observatory

R. Conceição for the SWGO LIP group

SWGO
The Southern Wide-field
Gamma-ray Observatory

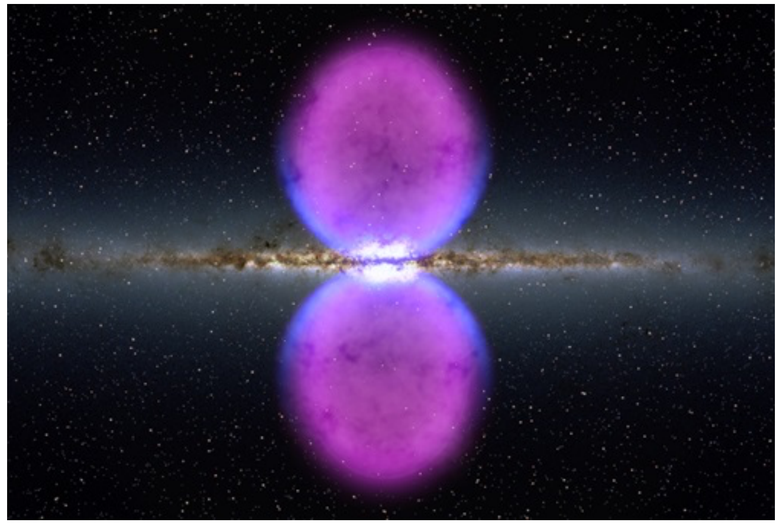
LIP

TÉCNICO LISBOA

3rd IGFAE/LIP meeting, 4th July 2022

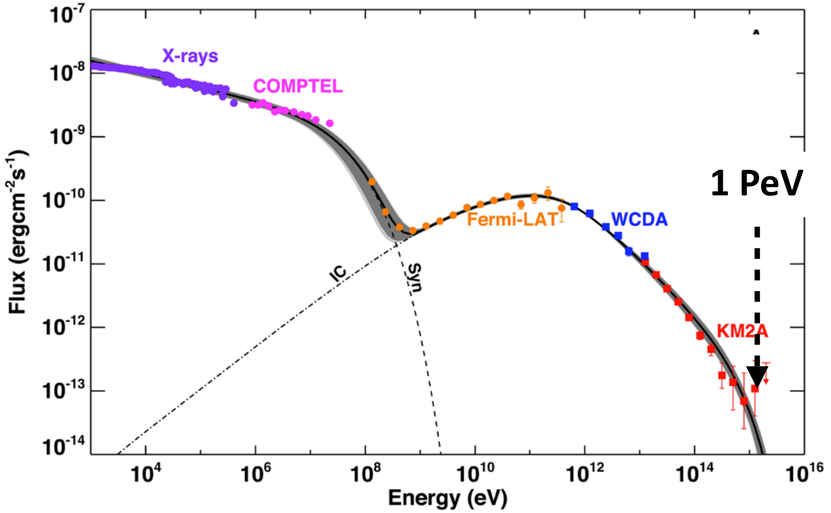
The VHE gamma-ray Sky

Fermi Satellite



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

LHAASO experiment

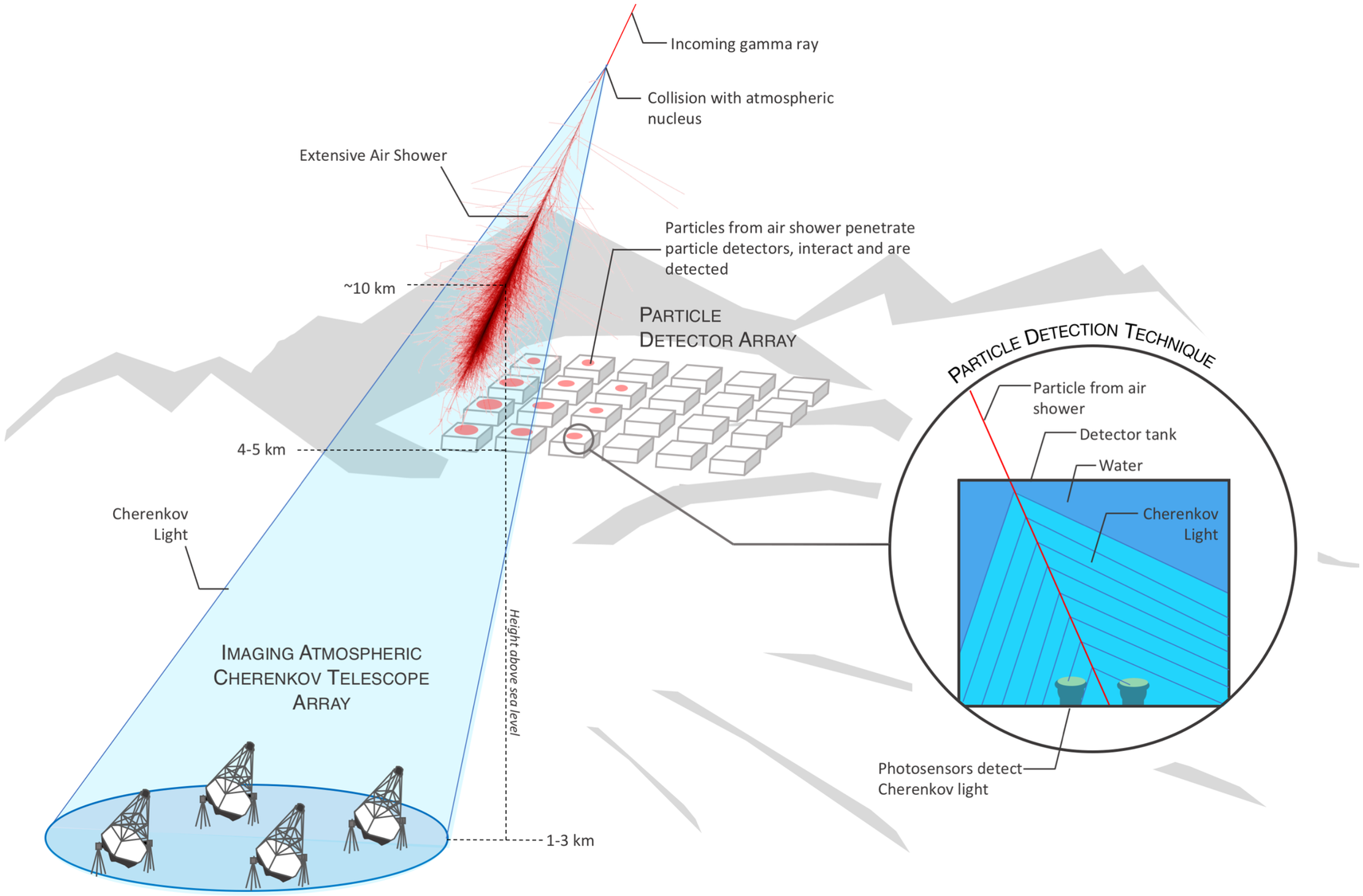


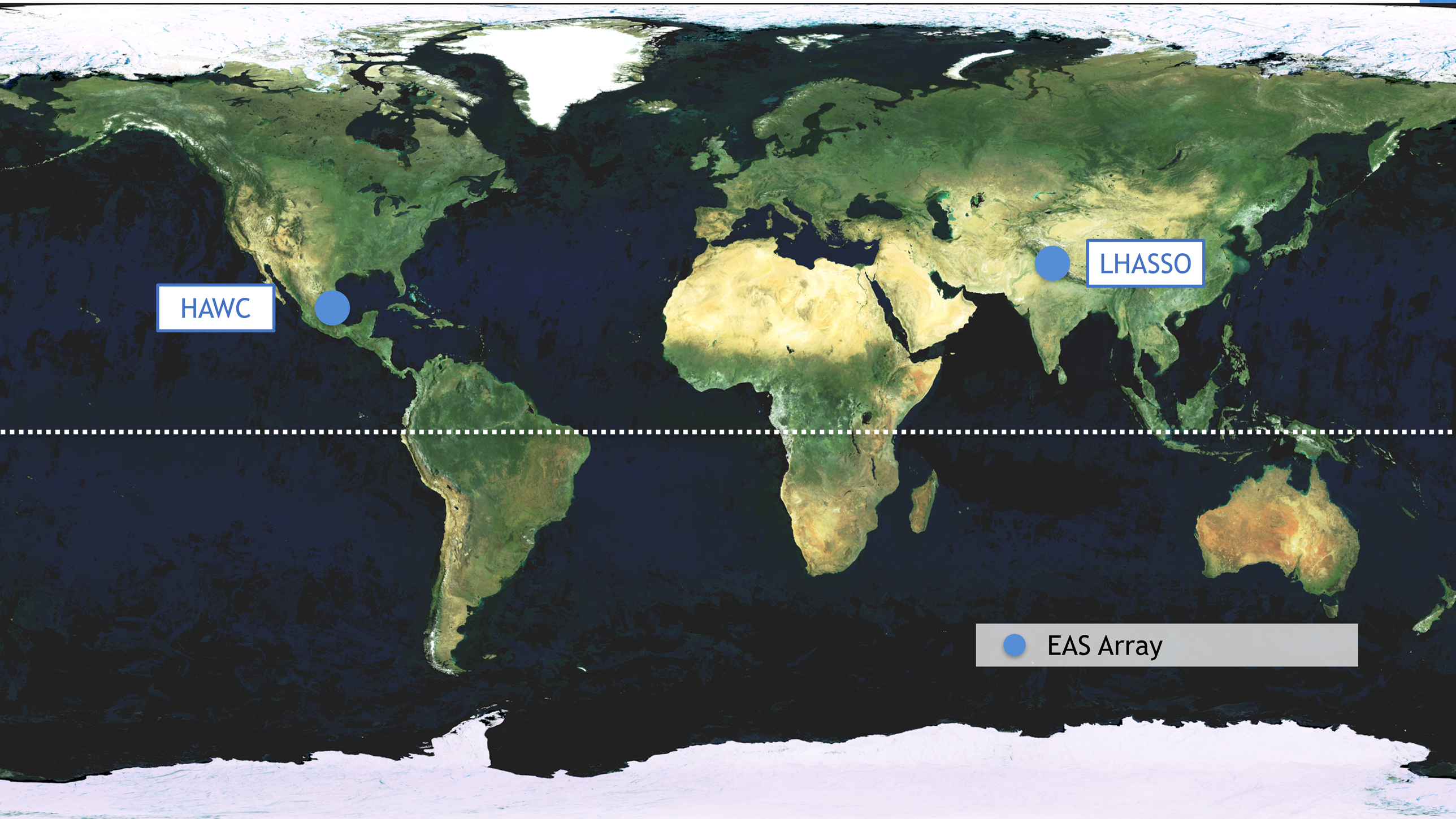
PeV gamma-ray emission from the Crab Nebula

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

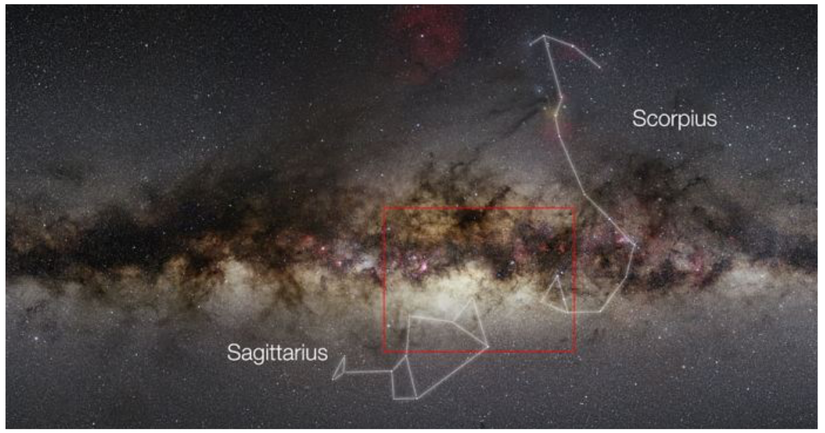
Energy [eV]

High-energy gamma-ray detection techniques




HAWC
LHASSO
EAS Array

Complementary to the powerful Cherenkov Telescope Array project



CTA

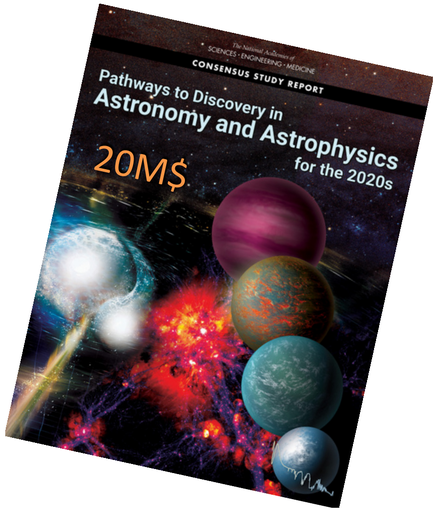
SWGO

SWGO collaboration

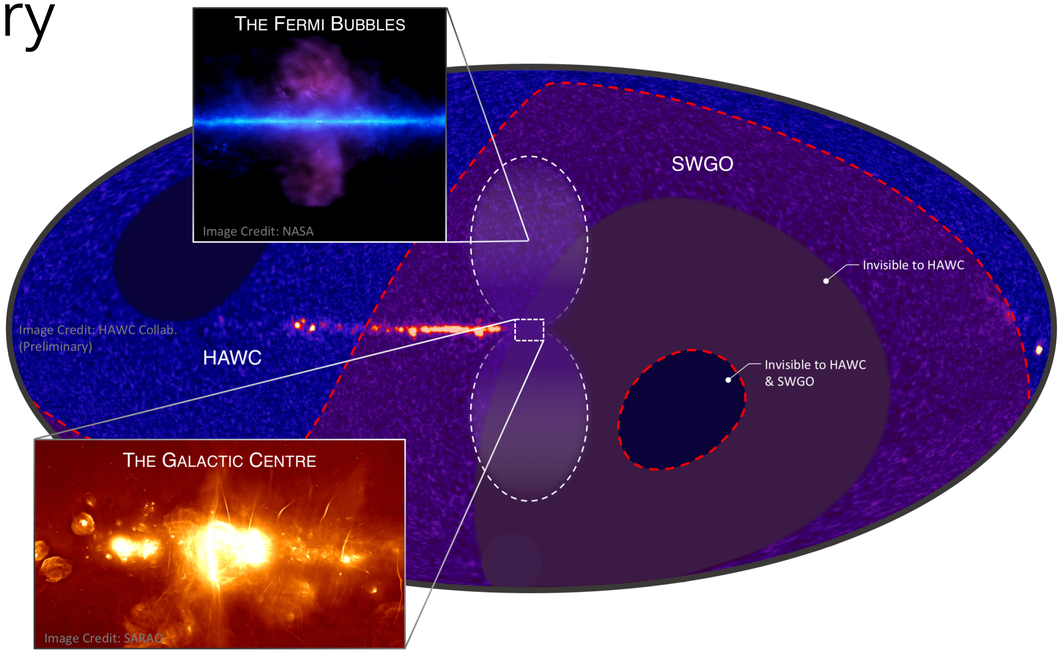
~3-year R&D project to design and plan the next generation wide field-of-view gamma-ray able to survey and monitor the Southern sky

- **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



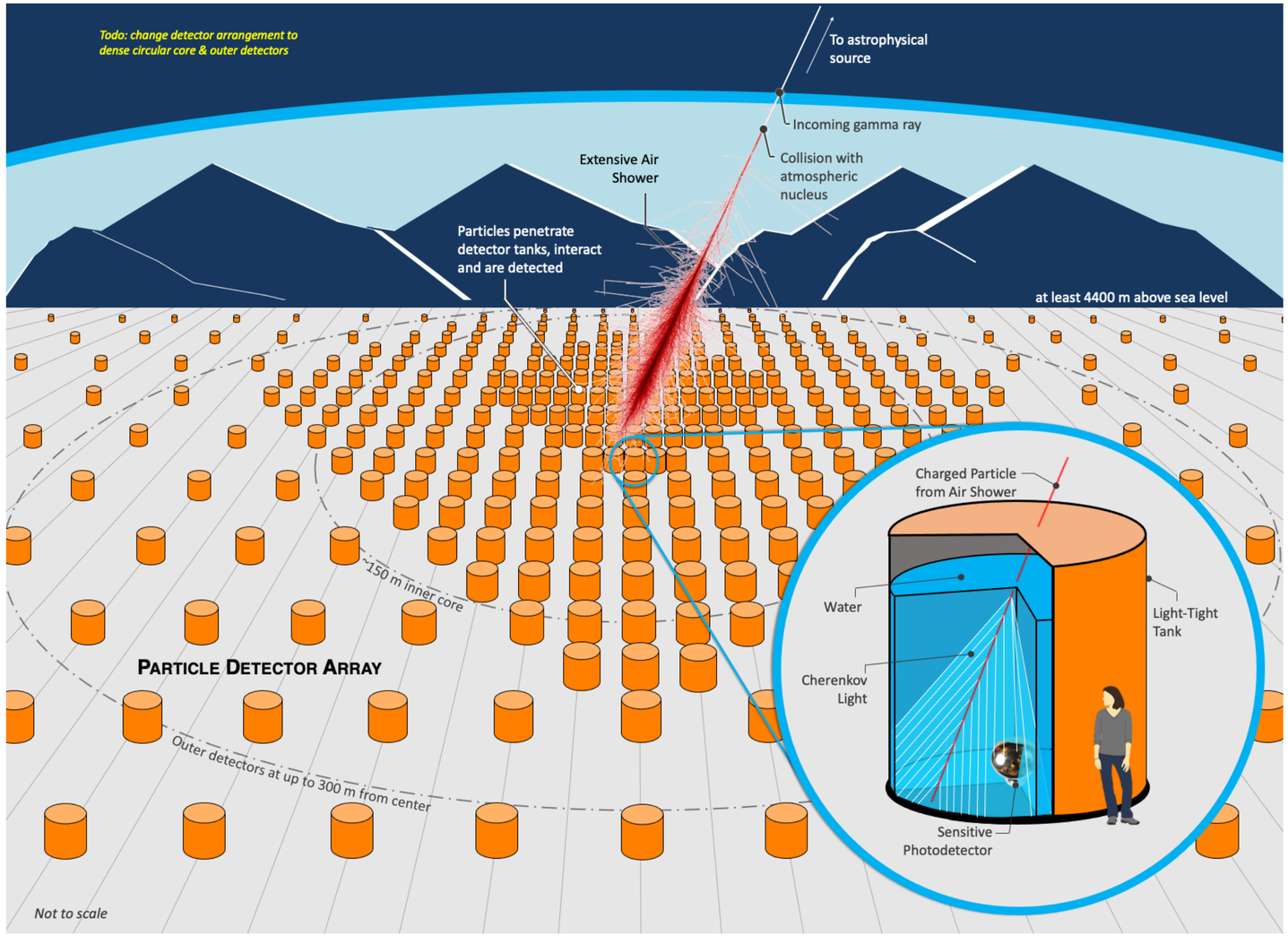
The scientific goal



www.swgo.org

The challenge…

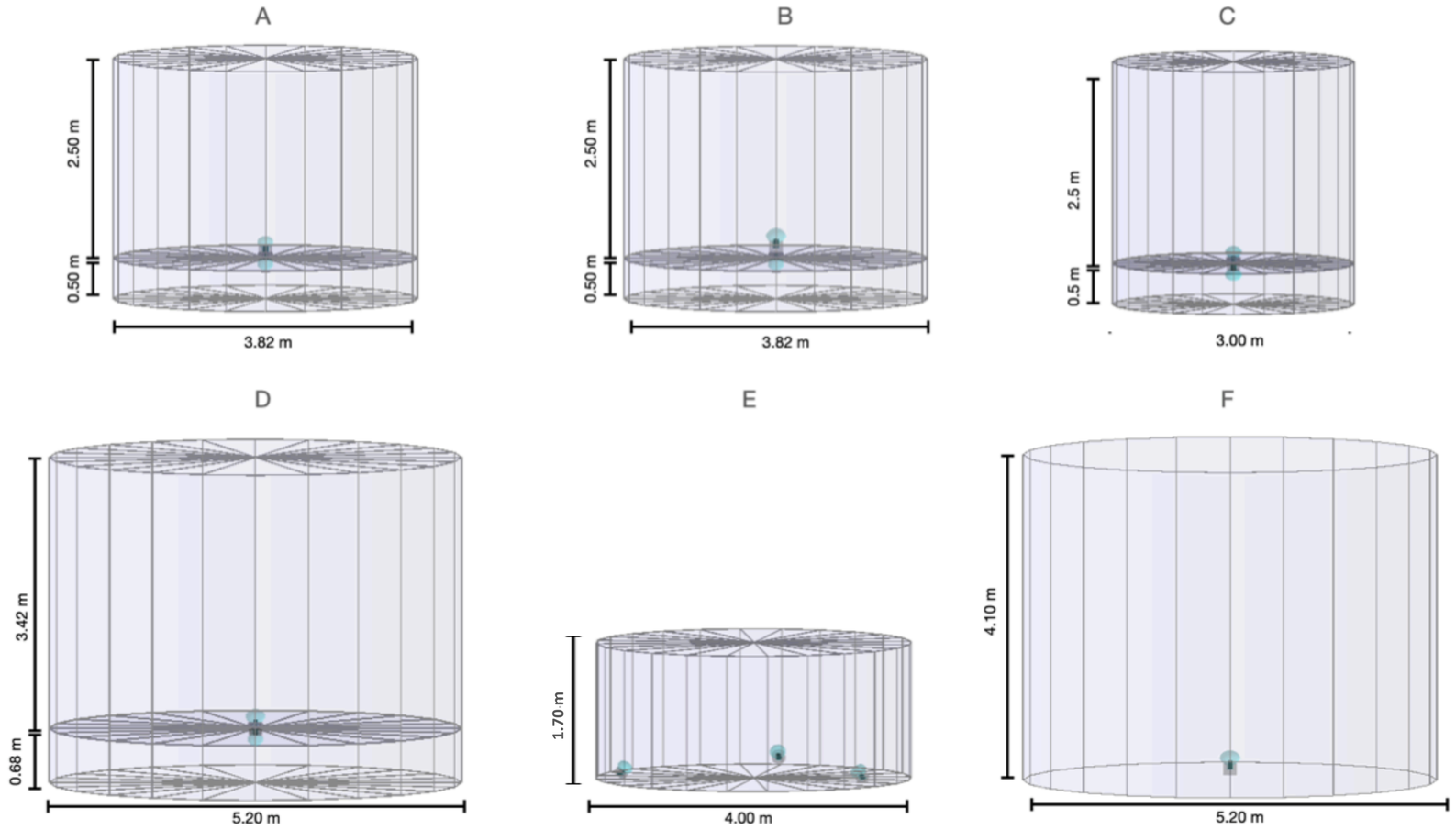
- To design an experiment able to fulfil the following requirements:
  - → **Muon tagging**/counting capability
  - → Lower energies
    - ✓ to be placed at **high altitude** (~5000 m a.s.l.)
    - ✓ **Compact array**
  - → Higher energies
    - ✓ **Large area** (~ few km^2)




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

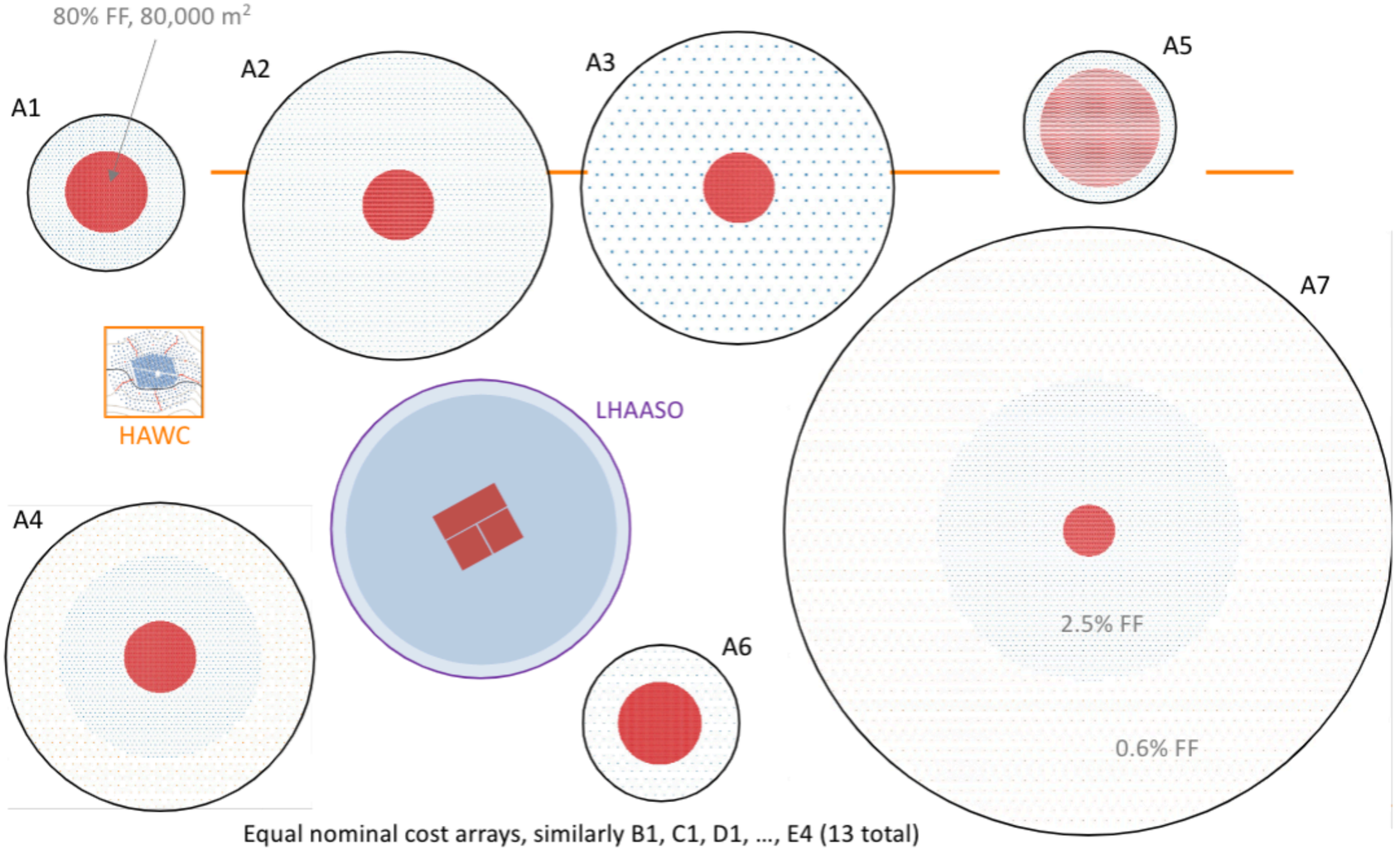
Label	Layers	PMT (upper + lower)	Diameter (m)	Depth (upper)	Depth (lower)	Nominal Cost (kUSD)
A	2	8"HQE +8"	3.82	2.50	0.50	9.68
B	2	10"HQE + 8"	3.82	2.50	0.50	10.66
C	2	8" +8"*	3.00	2.50	0.5	6.90
D	2	10"HQE + 8"	5.20	3.42	0.68	14.32
E	1	3×8"	4.00	1.70	-	11.82
F	1	10"HQE	5.20	4.20	-	11.54



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

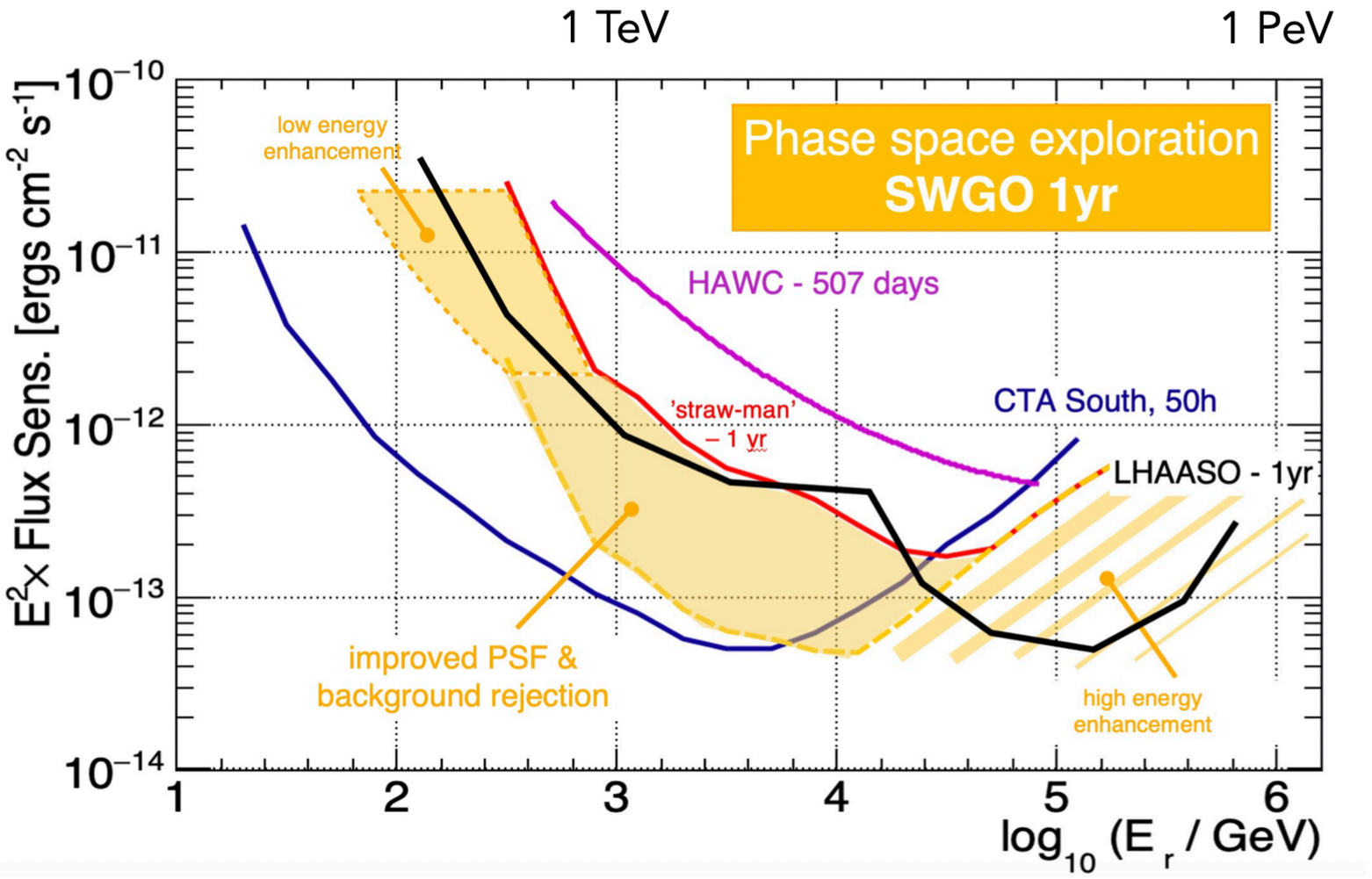
All detector stations present in the SWGO simulation framework

Explore different array layout configurations



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

Expected Sensitivity



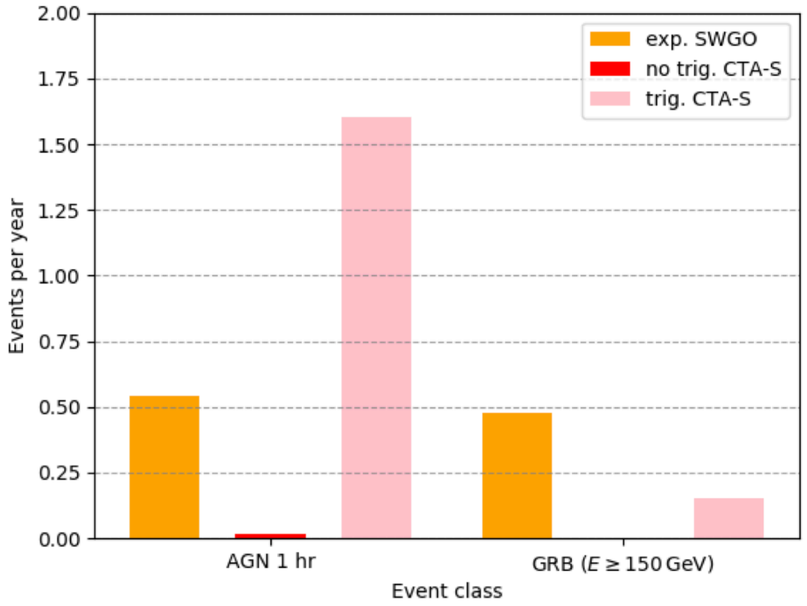
Explore new ideas, detector concepts, array layout configuration to increase the observatory sensitivity

SWGO activities at LIP

Science

Transient Events

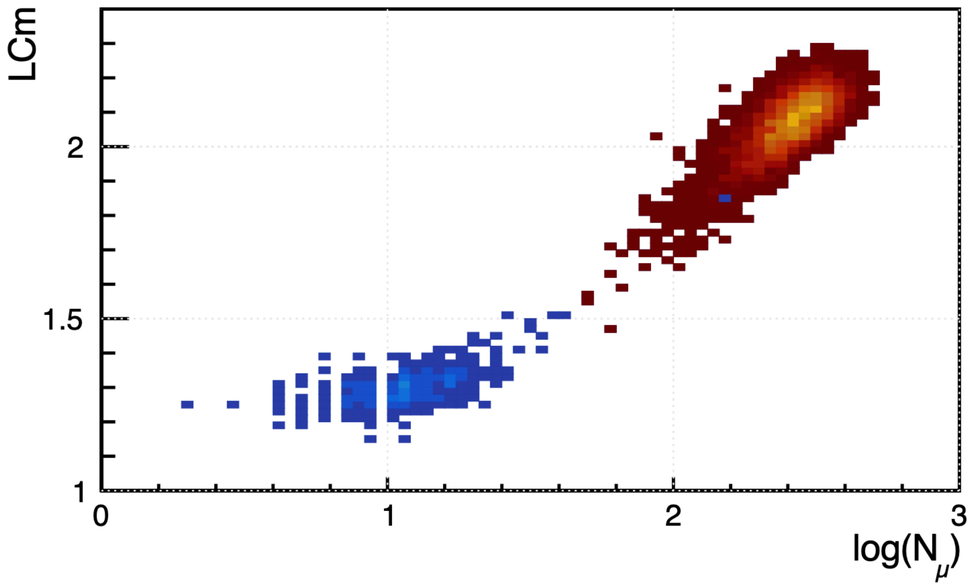
G. La Mura et al, *Mon.Not.Roy.Astron.Soc.* 497 (2020) 3, 3142-3148



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



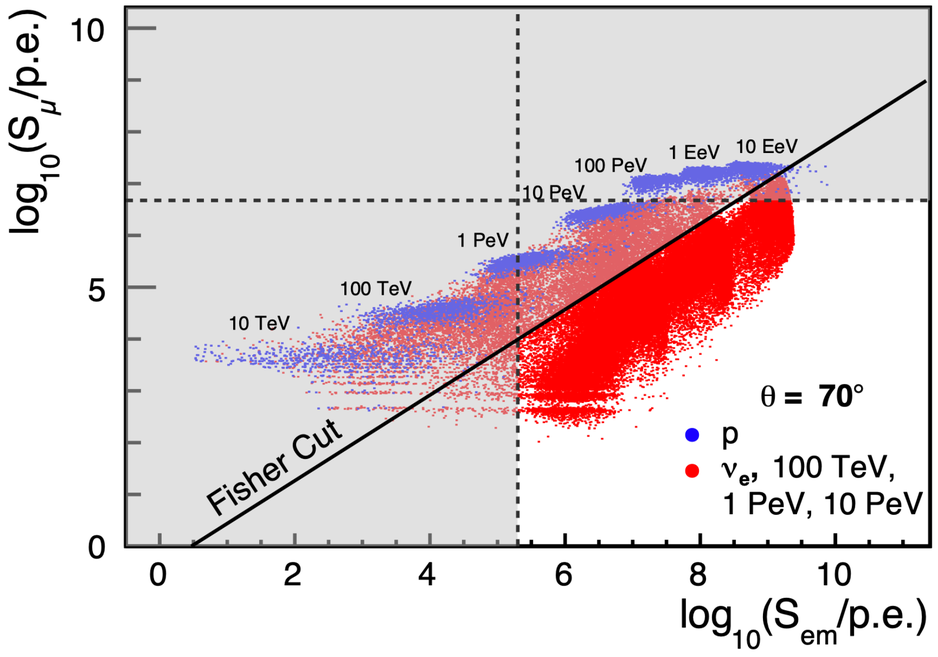
The azimuthal asymmetry of the shower ground pattern can be exploited as a g/h discriminator

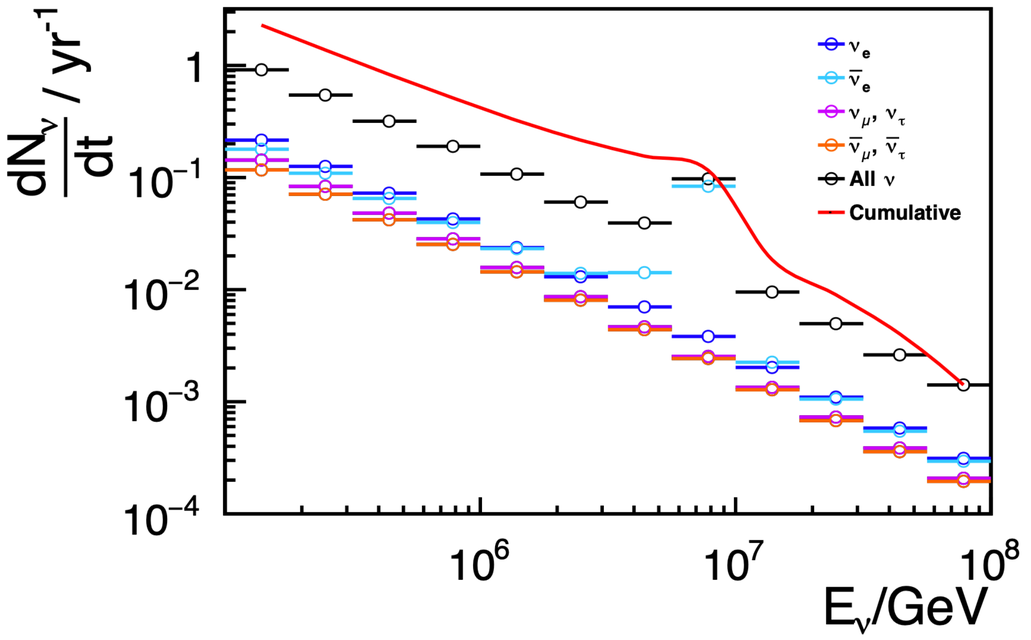
Science

IGFAE/LIP collab

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



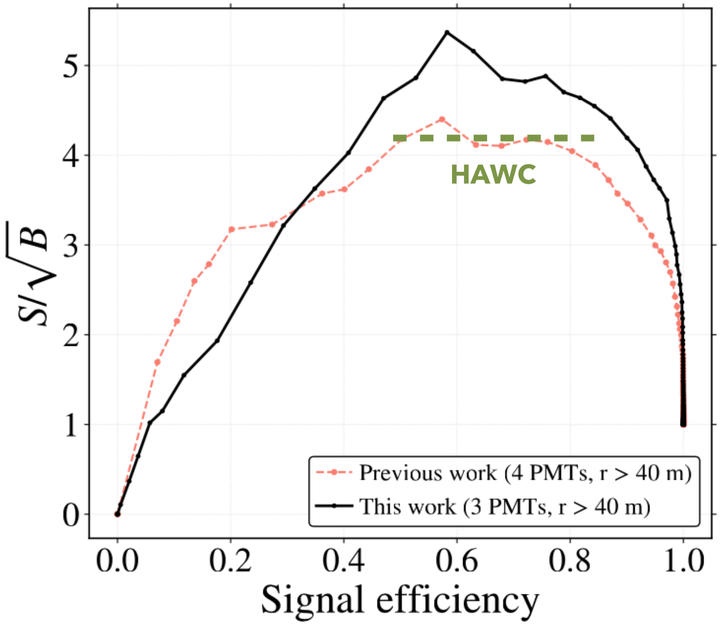


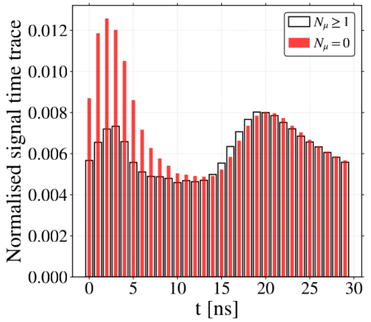
An experiment such as SWGO would be able to detect around 2 neutrinos with E>100 TeV per year

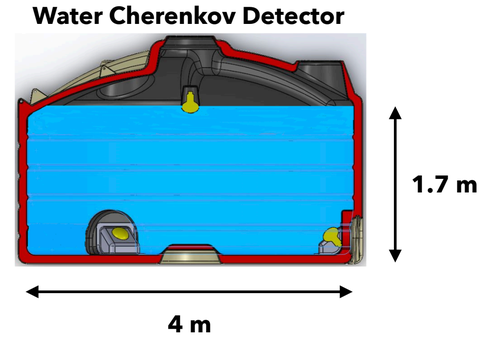
Detector concept + Reconstruction

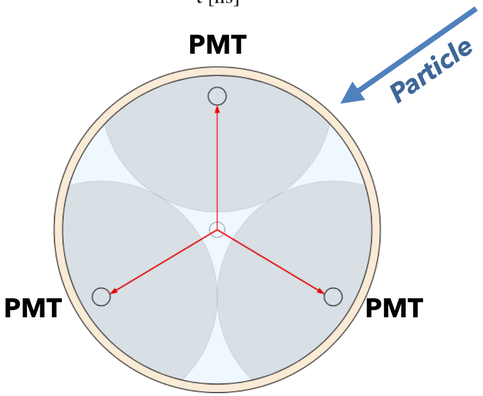
- **4 PMTs + ML analysis**
  - B. S. González et al, Eur.Phys.J.C 81 (2021) 6, 542
- **Mercedes station (3 PMTs) + ML analysis**
  - 4 m diameter - 1.7 m height
  - Submitted to EPJC

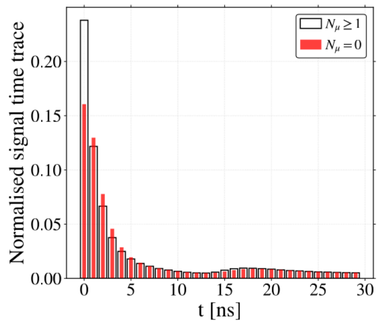
Excellent gamma/hadron discrimination capability

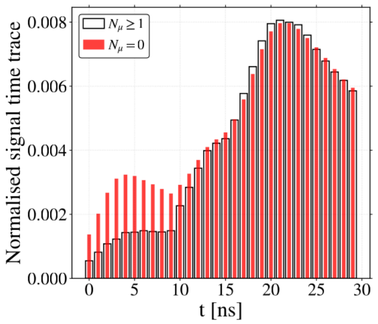






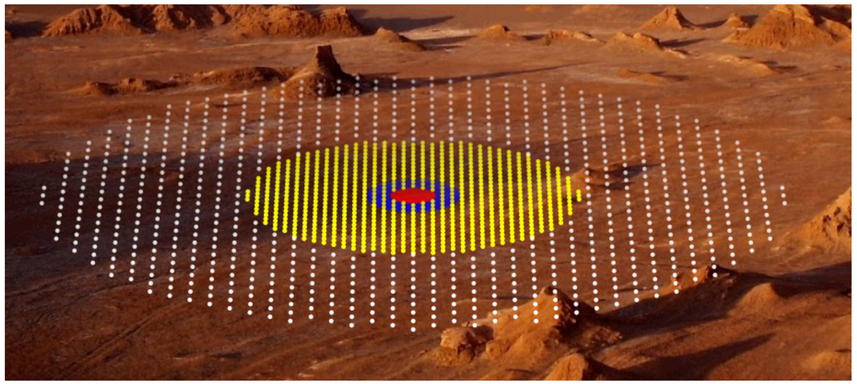




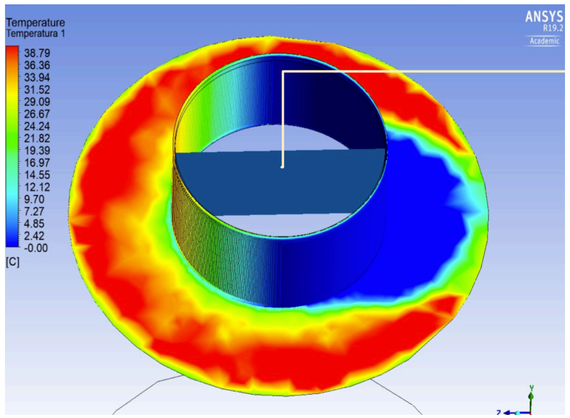


Other activities…

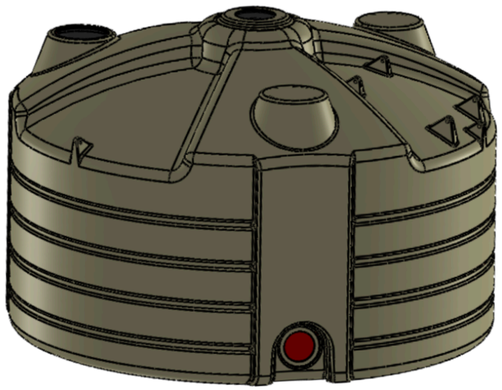
Layout configuration in phases



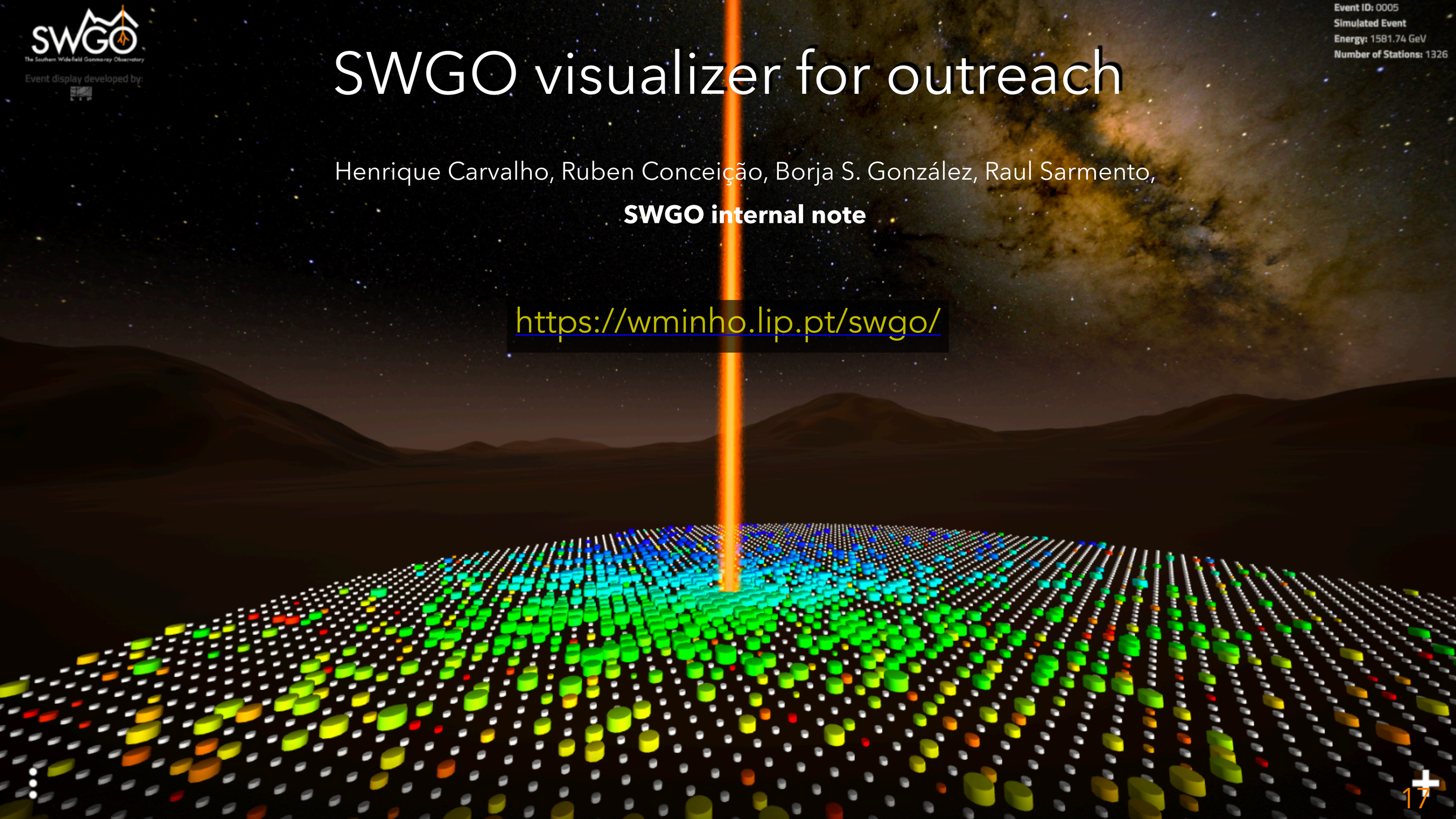
Thermal Simulations



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

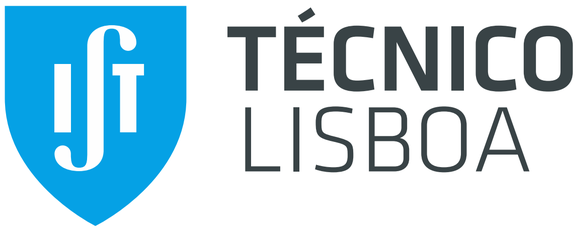
  → Monitor the transient sky : **strong synergies with CTA** and the new generation neutrino telescopes

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

Very open for new partners and new ideas

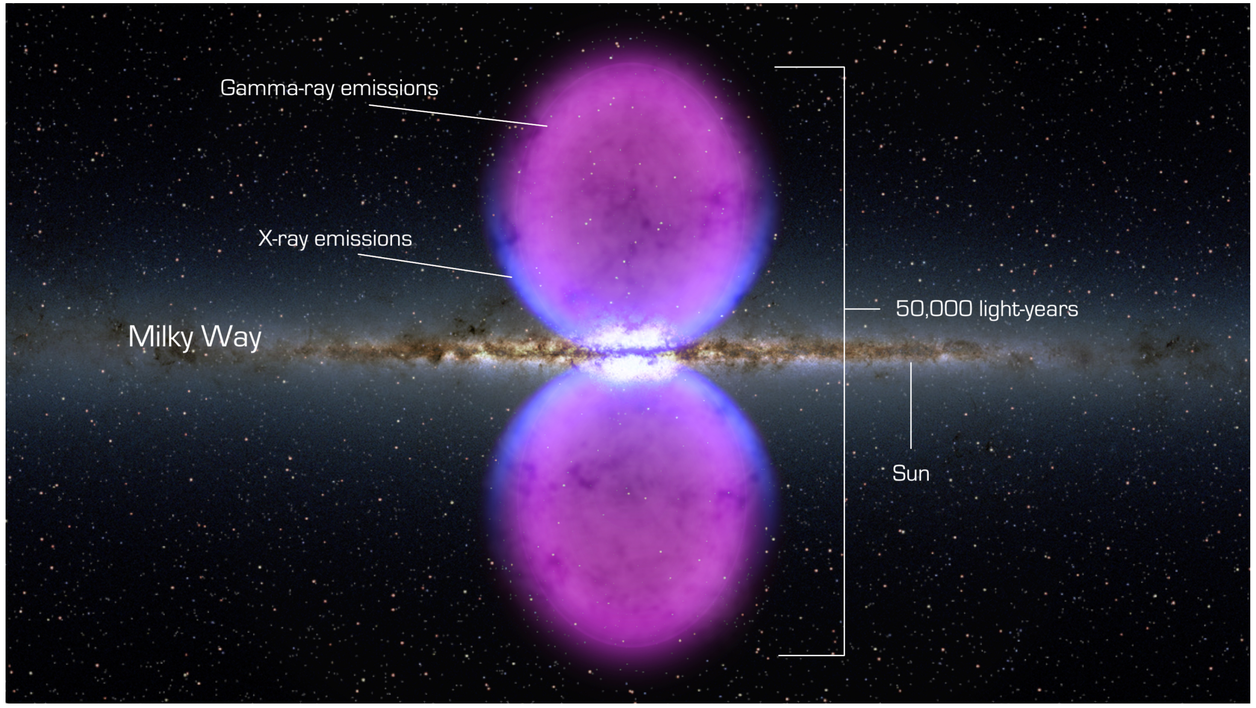
SWGO collaboration

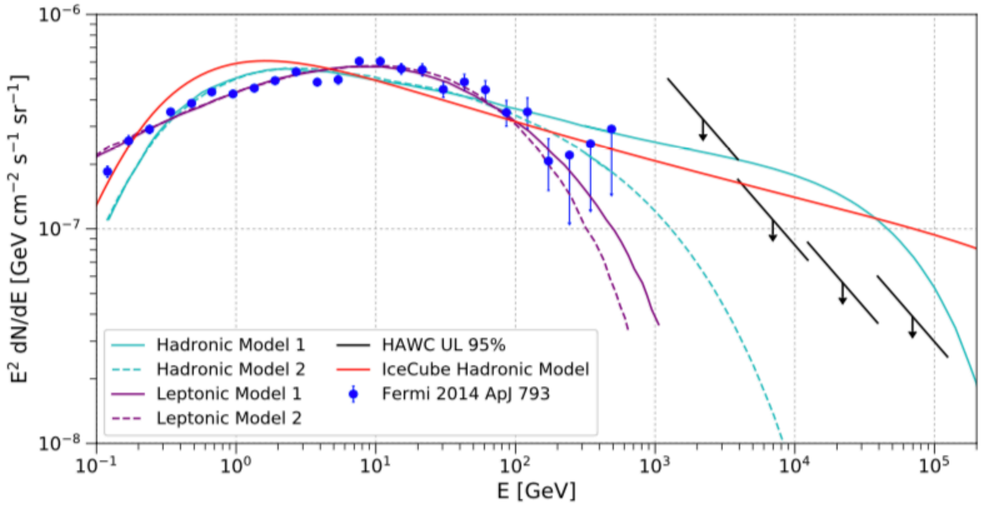
Acknowledgements



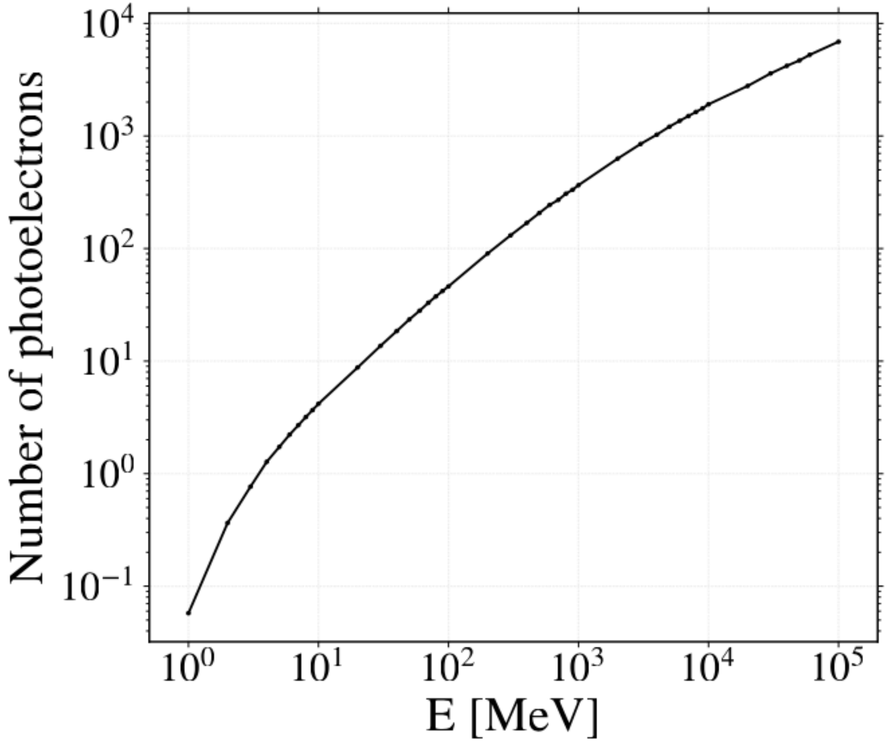
BACKUP SLIDES

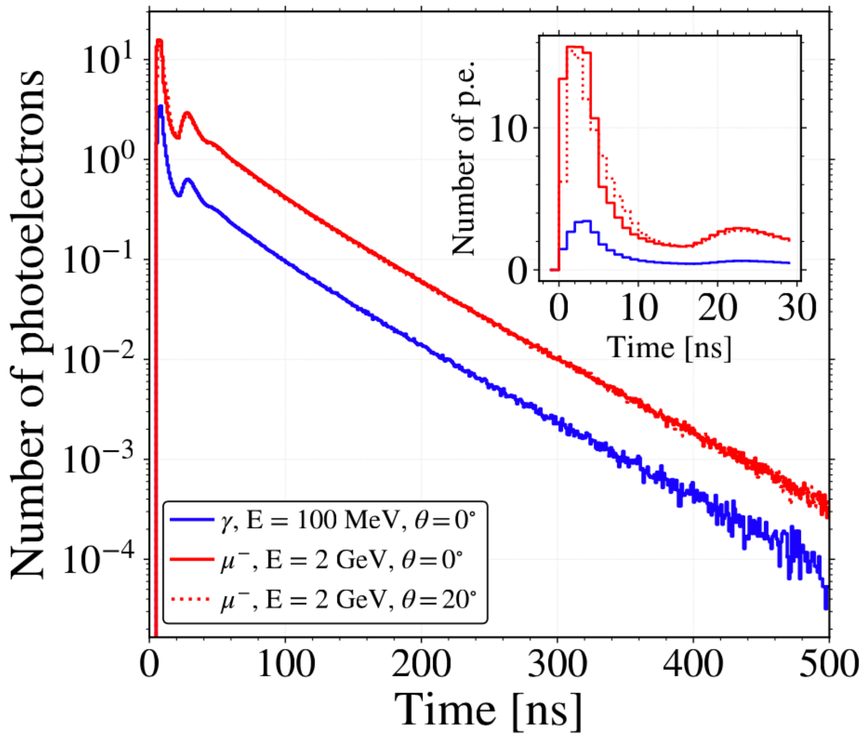
Fermi Bubbles





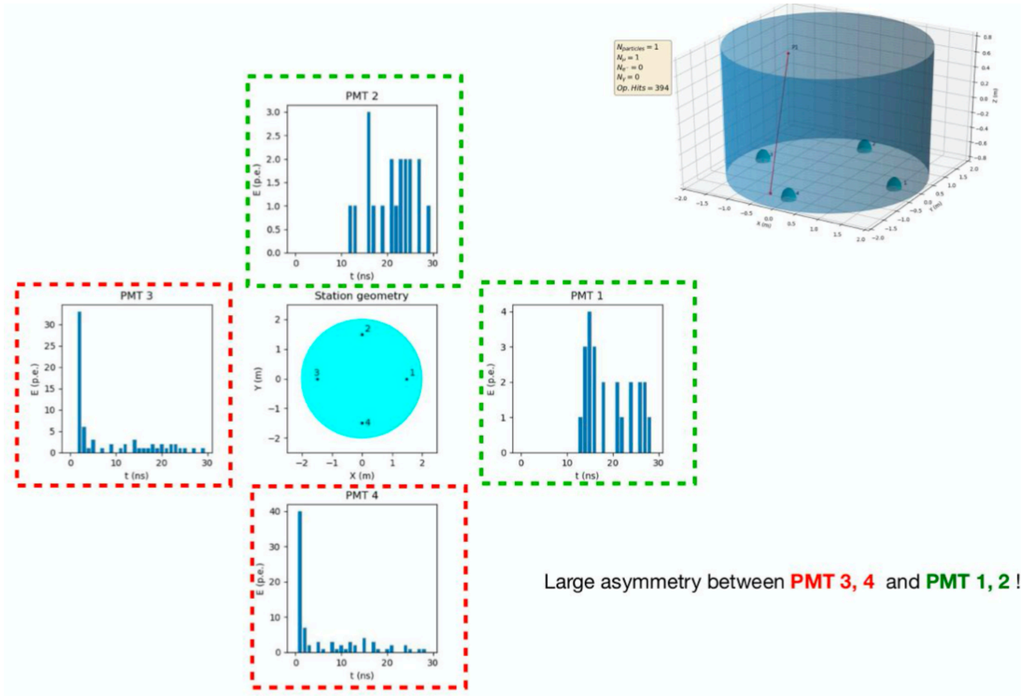
Mercedes Station

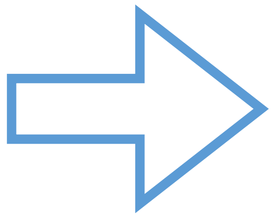


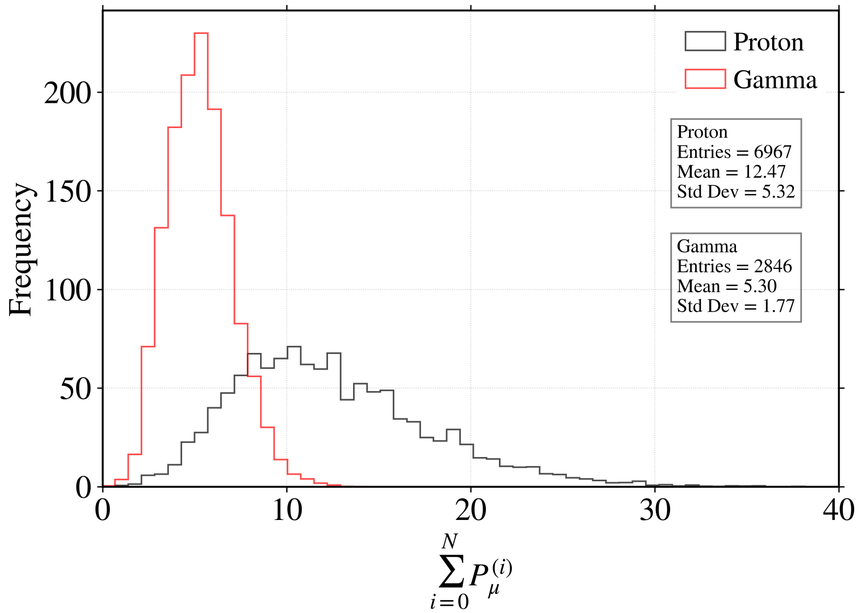


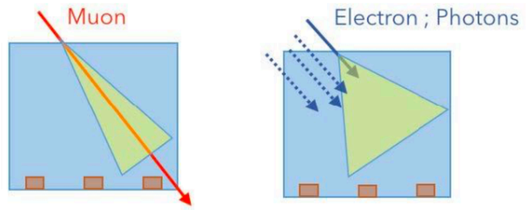
Muon tagging

- Explore signal asymmetry between PMTs using a Neural Network









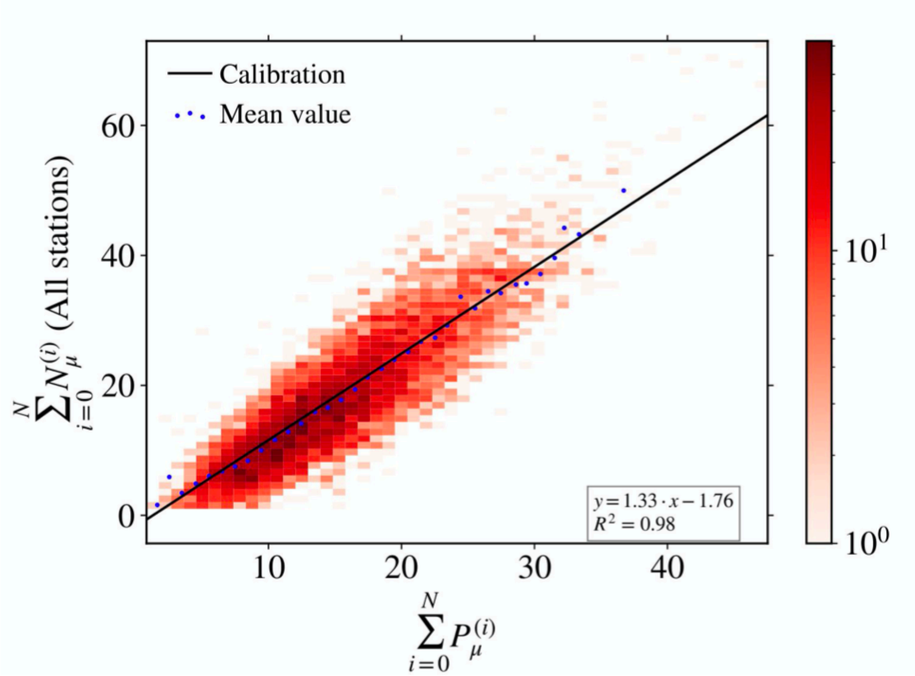
Good gamma/hadron discrimination at E ~1TeV

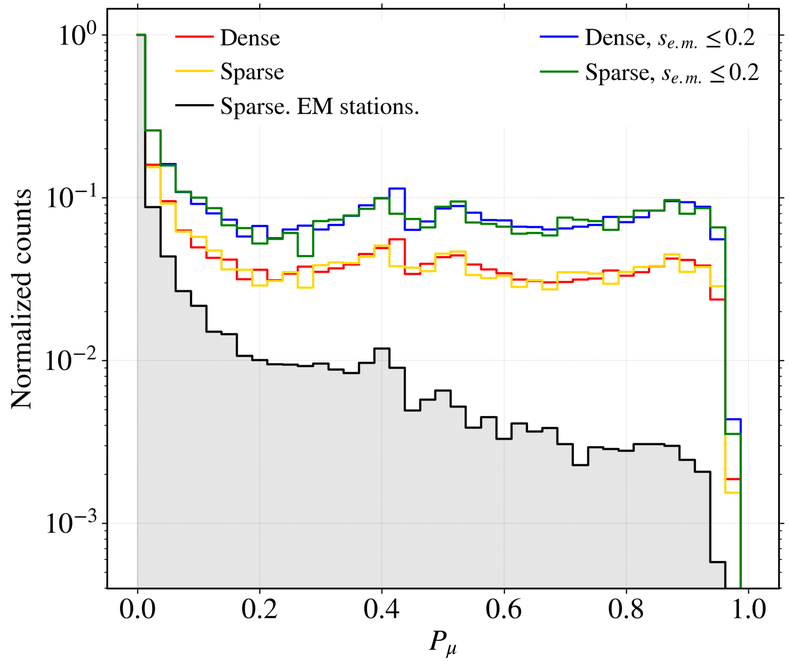
S/sqrt(B) ~ 4 (similar to LATTES and HAWC)

Dense vs. Sparse array

B. Serrano Gonzalez talk, A&S session

- 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