Astroparticle Physics

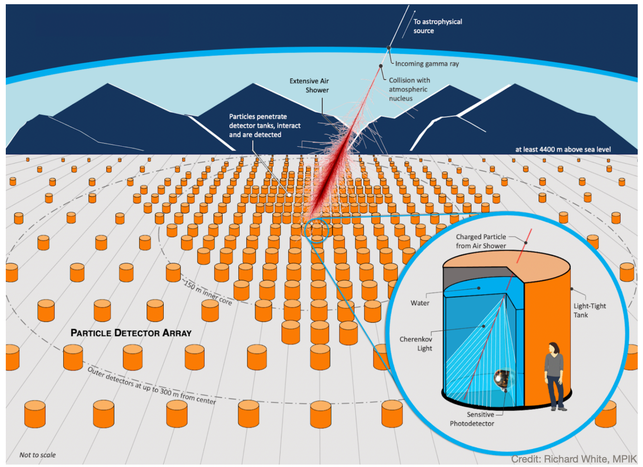
Ruben Conceição

RECFA visti to Portugal, Lisboa, September 15th 2023

Portuguese participation (LIP) in Astroparticle Experiments

Alpha Magnetic Spectrometer (AMS-II)

Pierre Auger Observatory



Southern Wide-field Gamma-ray Observatory (SWGO)

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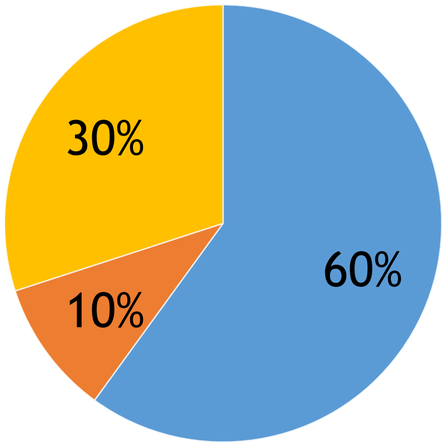
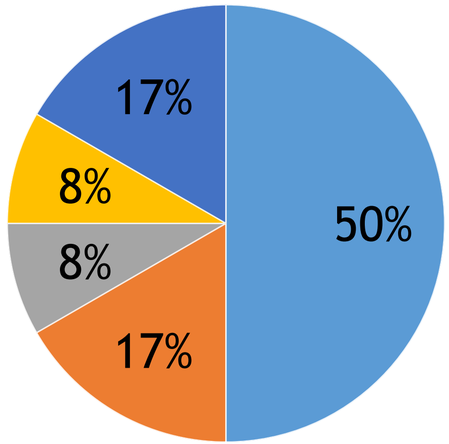
People

3.5 FTEs



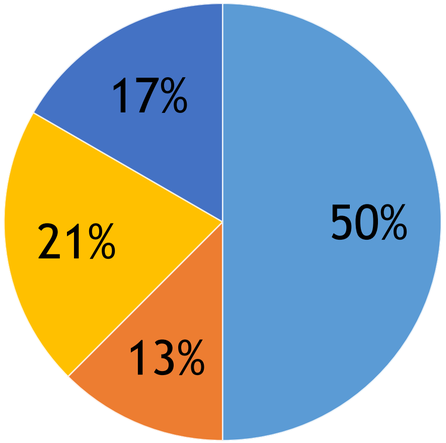
Alpha Magnetic Spectrometer (AMS-II)

11.4 FTEs

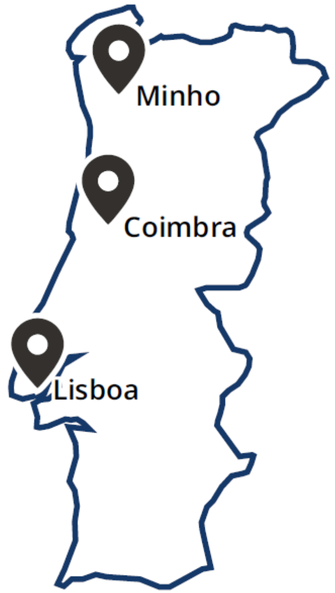


Pierre Auger Observatory

7.2 FTEs



Southern Wide-field Gamma-ray Observatory (SWGO)



Seniors | PhD students | MSc students | BSc students | Technicians

- Teams distributed over the 3 LIP poles (Coimbra, Lisbon, Minho)
- Connection with local universities

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Funding and production

Alpha Magnetic Spectrometer (AMS-II)

CERN Fund - 45k (2 yr)

Pierre Auger Observatory

CERN Fund - 125k (2 yr)
CERN Fund - 70k (2 yr)

Southern Wide-field Gamma-ray Observatory (SWGO)

PTDC - 250k (3 yr)

Funding is used essentially for travelling, grants and small R&D projects

Collaboration members fee paid via MoU

Production in 2022

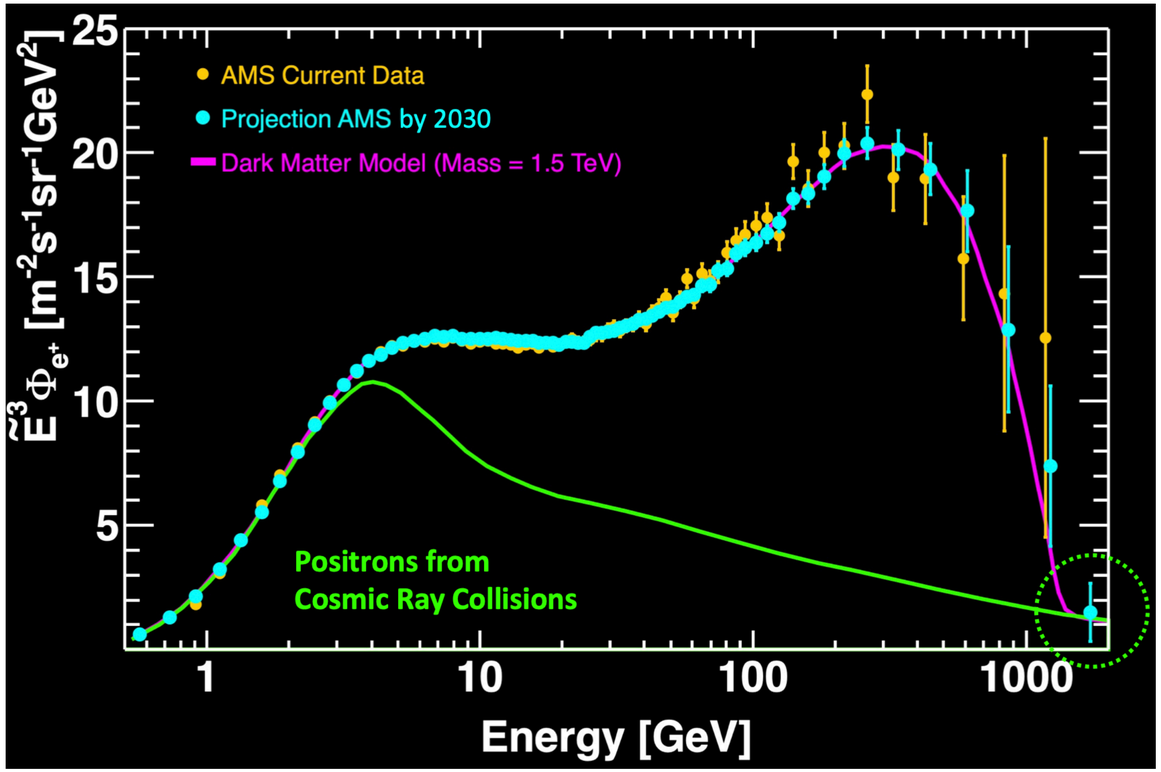
Articles in international journals:	**2** Direct contribution **1** Indirect contribution
Notes:	**2** LIP Students notes
Advanced Training Events:	**4** Oral presentations **2** Student presentations
Seminars:	**9** Outreach seminars

Articles in international journals:	**3** Direct contribution **4** Indirect contribution
Preprint:	**3** Preprints
Notes:	**1** Collaboration note **1** LIP Student note
Datasets, software packages:	**1** Dataset
International conferences:	**4** Oral presentations
Nat.& Internat. meetings:	**4** Oral presentations
Collaboration meetings:	**8** Oral presentations
Advanced Training Events:	**2** Oral presentations **4** Student presentation
Completed theses:	**1** MSc

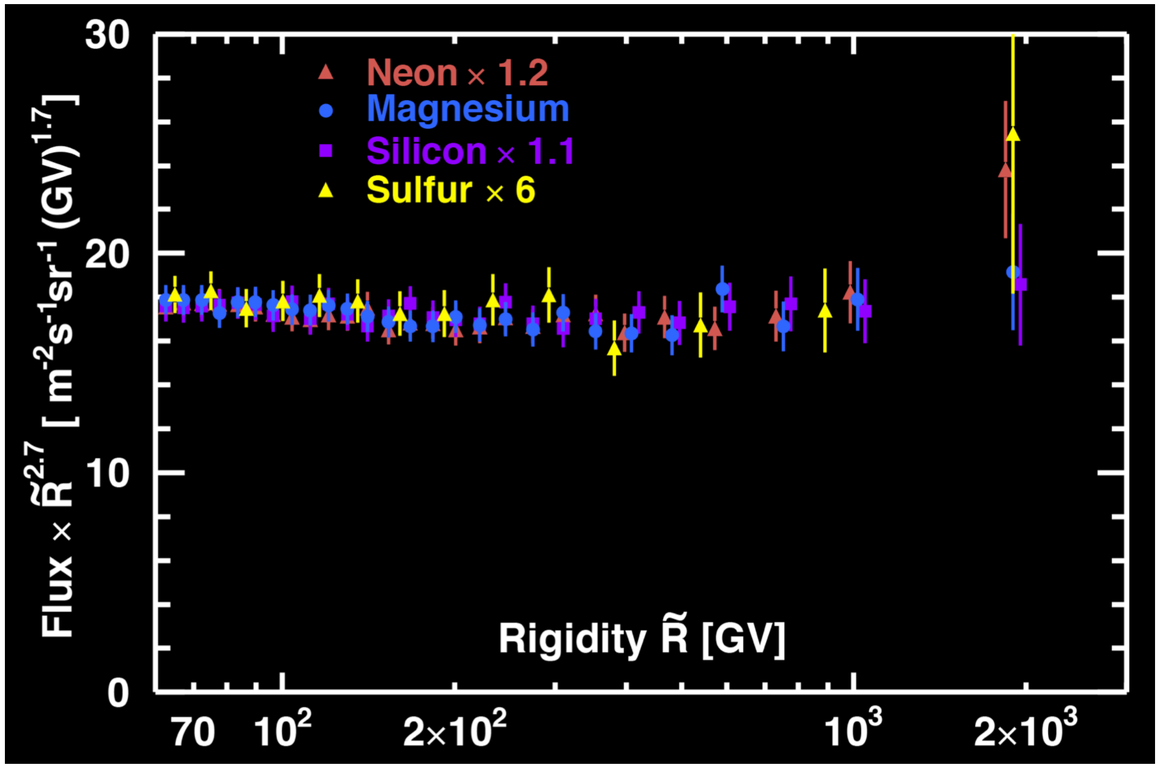
Articles in international journals:	**6** Direct contribution
Preprint:	**2** Preprints
Notes:	**3** Internal notes **2** LIP Students notes
International conferences:	**3** Oral presentations
Nat.& Internat. meetings:	**3** Oral presentations **4** Posters
Collaboration meetings:	**10** Oral presentations
Advanced Training Events:	**2** Oral presentations **4** Student presentations
Seminars:	**4** Seminars

AMS-II

AMS-II - Main achievements

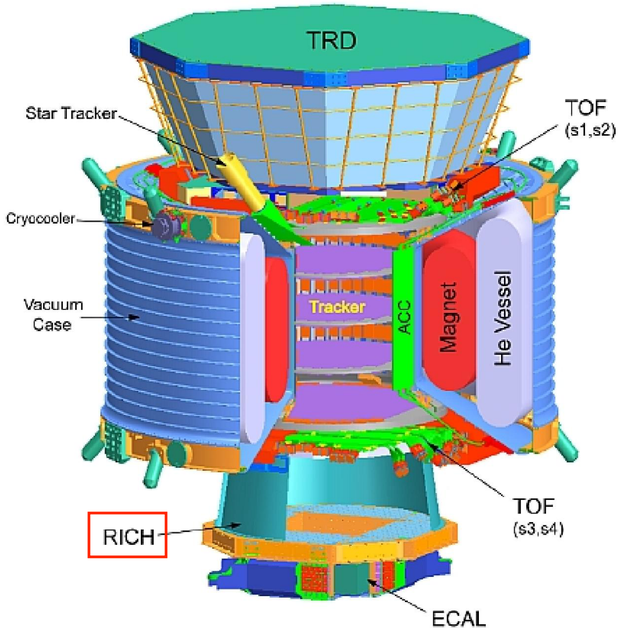


Positron Excess
Dark matter signal?
Unexpected Pulsar Wind?

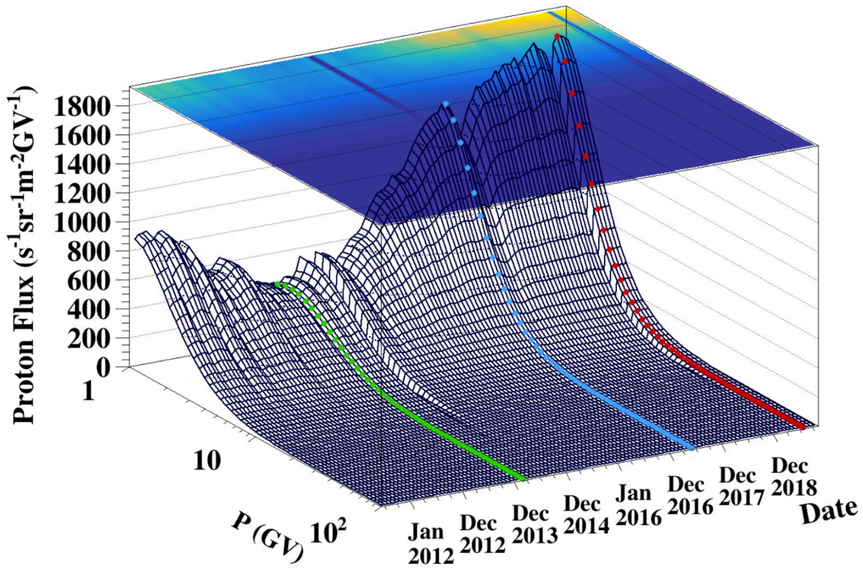


Nuclei Flux Measurement
Latest: Sulfur

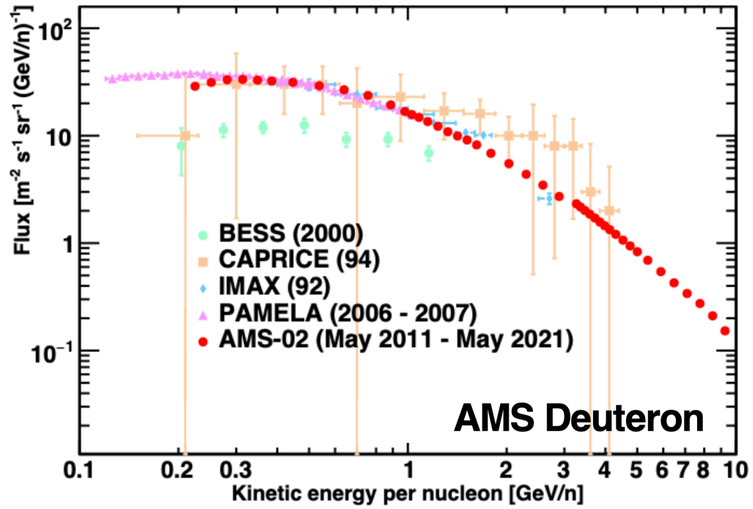
AMS-II - Main Portuguese contribution



Responsible for the RICH operation and analyses



Leading studies on Time Variability of Cosmic-ray flux



Measurements of Isotope fluxes (Deuteron and Boron)

- Time-variability of CR fluxes is an emerging topic in the scientific community
- AMS' high exposure time gives access to low abundance nuclei and antimatter fluxes due to the sheer amount of data
- Involvement in isotopic analysis benefits greatly from the group's RICH expertise

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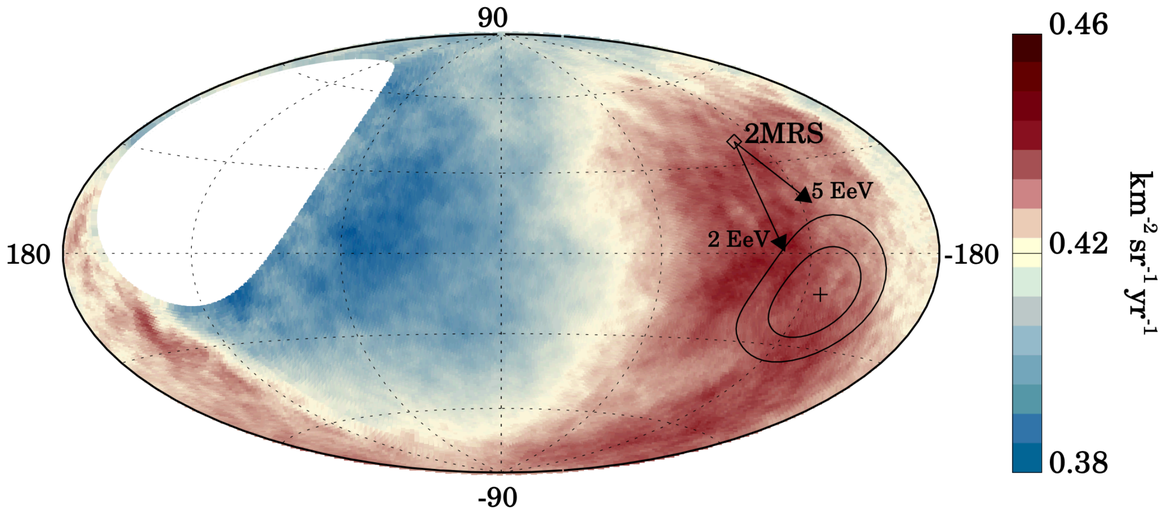
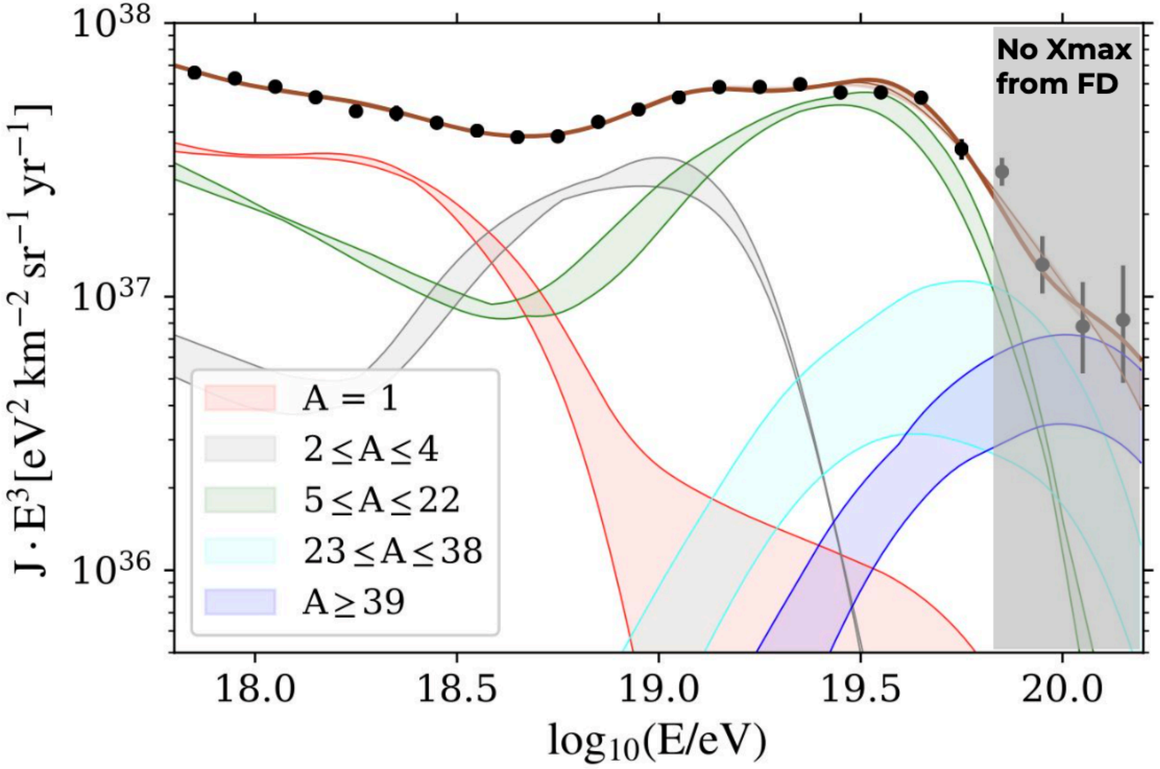
Pierre Auger Observatory

Pierre Auger Observatory - Main achievements

Science 357 (2017) no.6537, 1266-1270



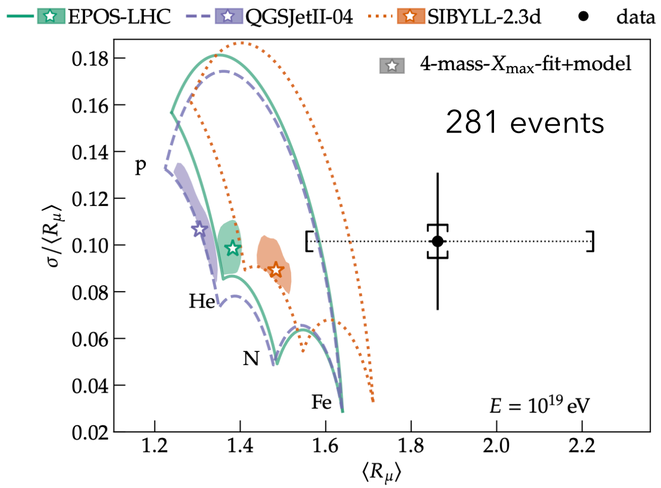
JCAP 05 (2023) 024

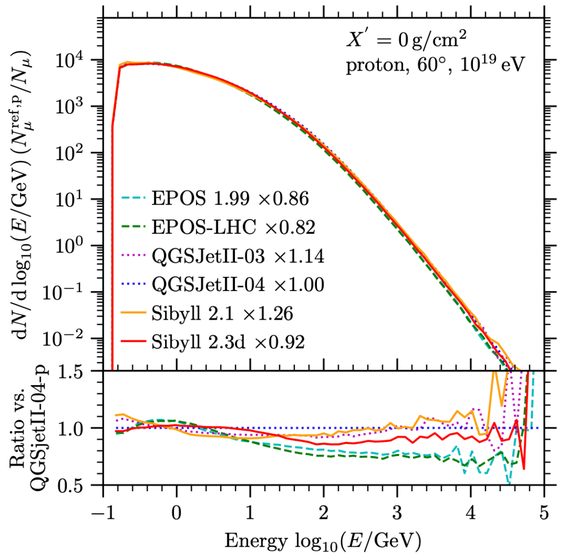


- Ultra-high-energy cosmic rays have an extra-galactic origin
- Flux suppression found at $E \sim 10^{19.6}\,\mathrm{eV}$ (Propagation effect? Source exhaustion?)
- Combined spectrum + composition fit suggest an acceleration mechanism $\propto A$, but…

Auger - Main Portuguese contribution

Shower Physics and Data analysis

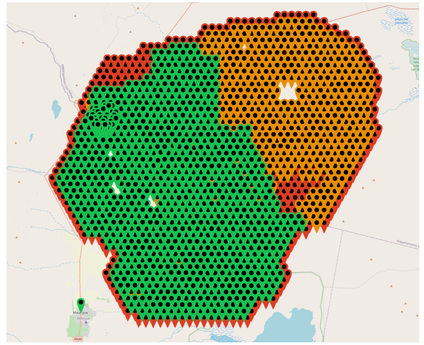


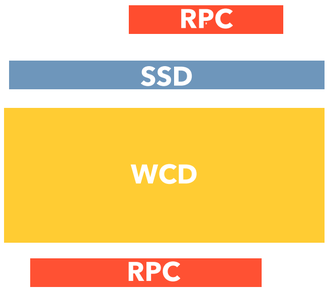


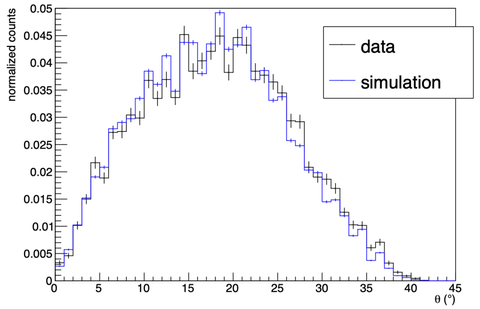
PhysRevLett.126.152002

JCAP03(2023)022

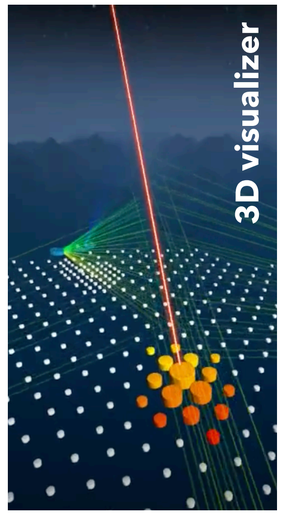
Calibration activities







Outreach



3 Auger Masterclass events!
12 institutions, 5 countries
~550 students

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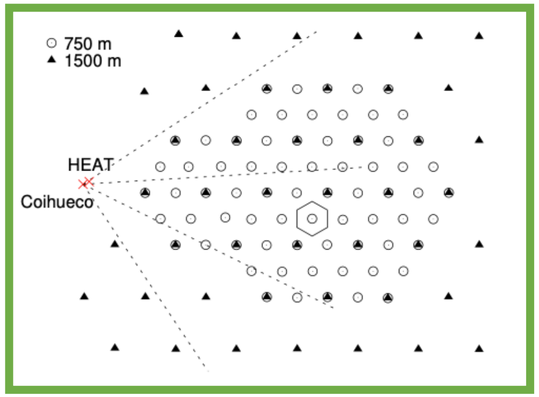
Multi-hybrid shower events

(A plethora of measurements to fully understand the shower)

HEAT



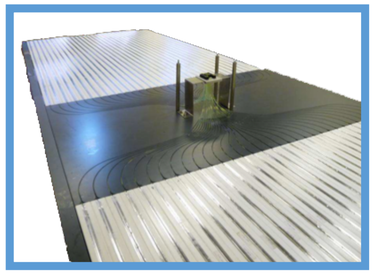
AMIGA

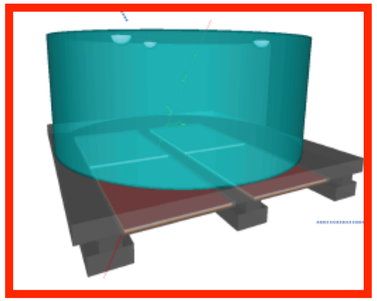
MARTA

Infill

LHC c.m. energy equiv to first interaction

Radio



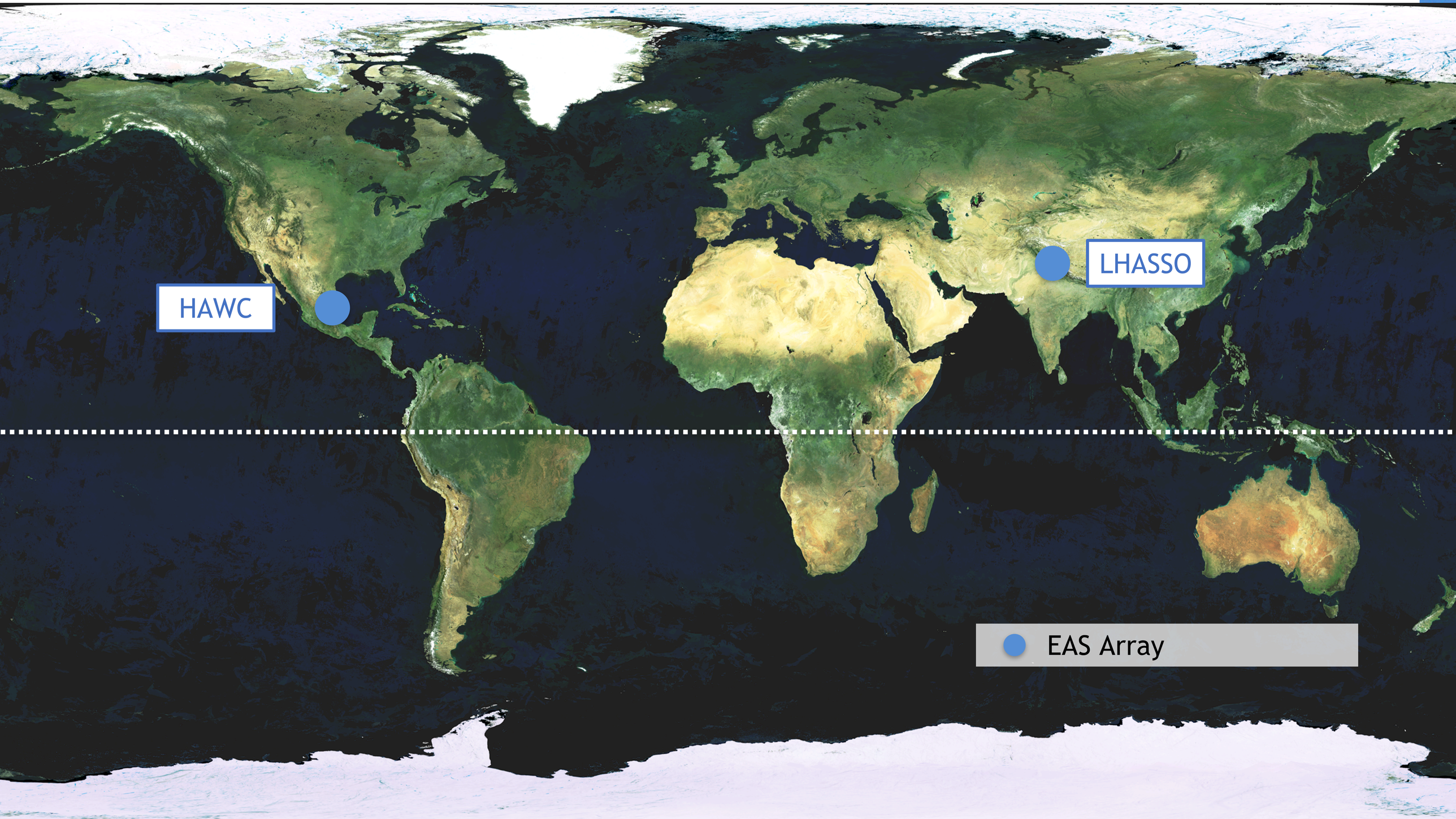


Auger Prime (SSD)

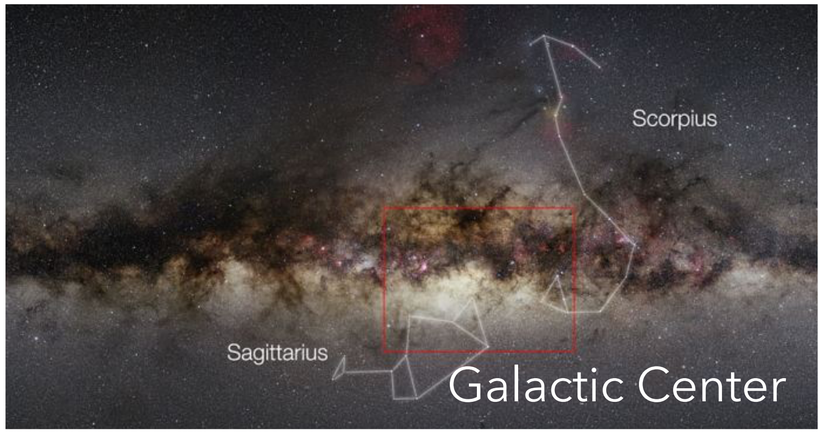
10^{16} 10^{17} 10^{18} 10^{19} 10^{20} Energy [eV]

The observatory is expected to operate until 2035

SWGO

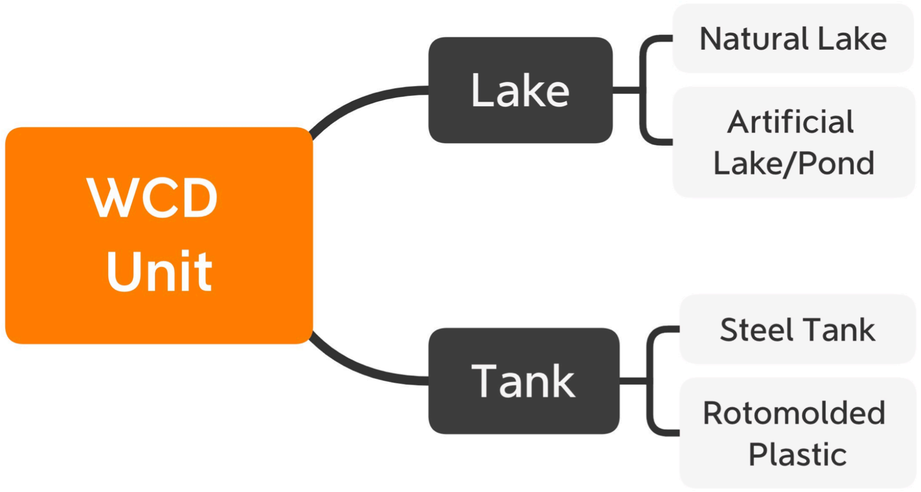

HAWC
LHASSO
EAS Array

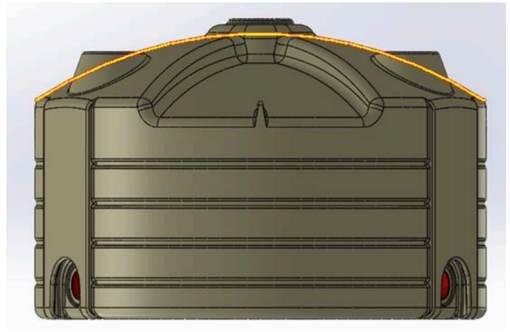
Complementary to the powerful Cherenkov Telescope Array project



- > 100 scientists
- 14 countries
  - → 64 institutes
- 10 countries with supporting scientists

Detector - exploring different WCD concepts





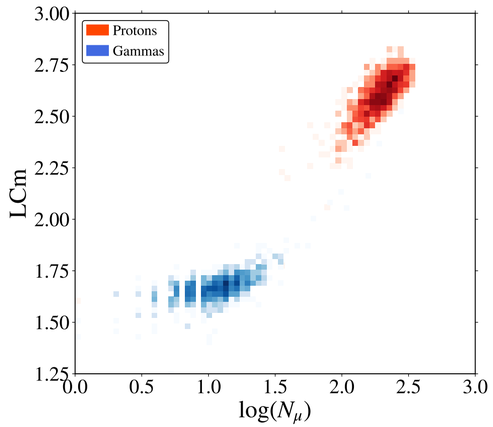
Several Prototypes

In construction - analysed in LAB

- taking data in the field

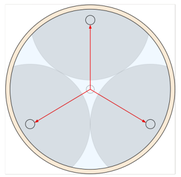
[LIP] Pursuit for a next-generation observatory

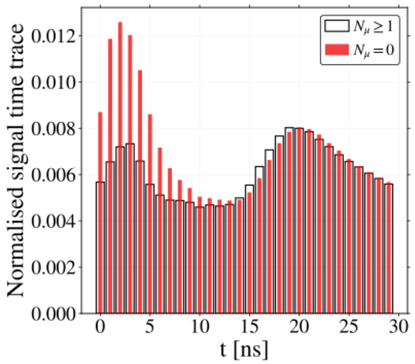
Novel shower observables for gamma/hadron discrimination



LCm - the shower footprint azimuthal fluctuations

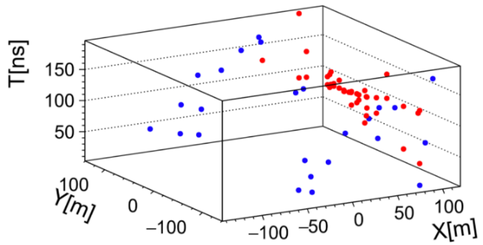
Improved data analysis with integrate machine learning algorithms

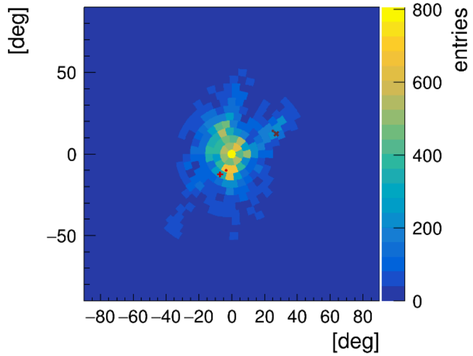




Analyse the PMT signal time trace with NN to tag muons

New trigger algorithms



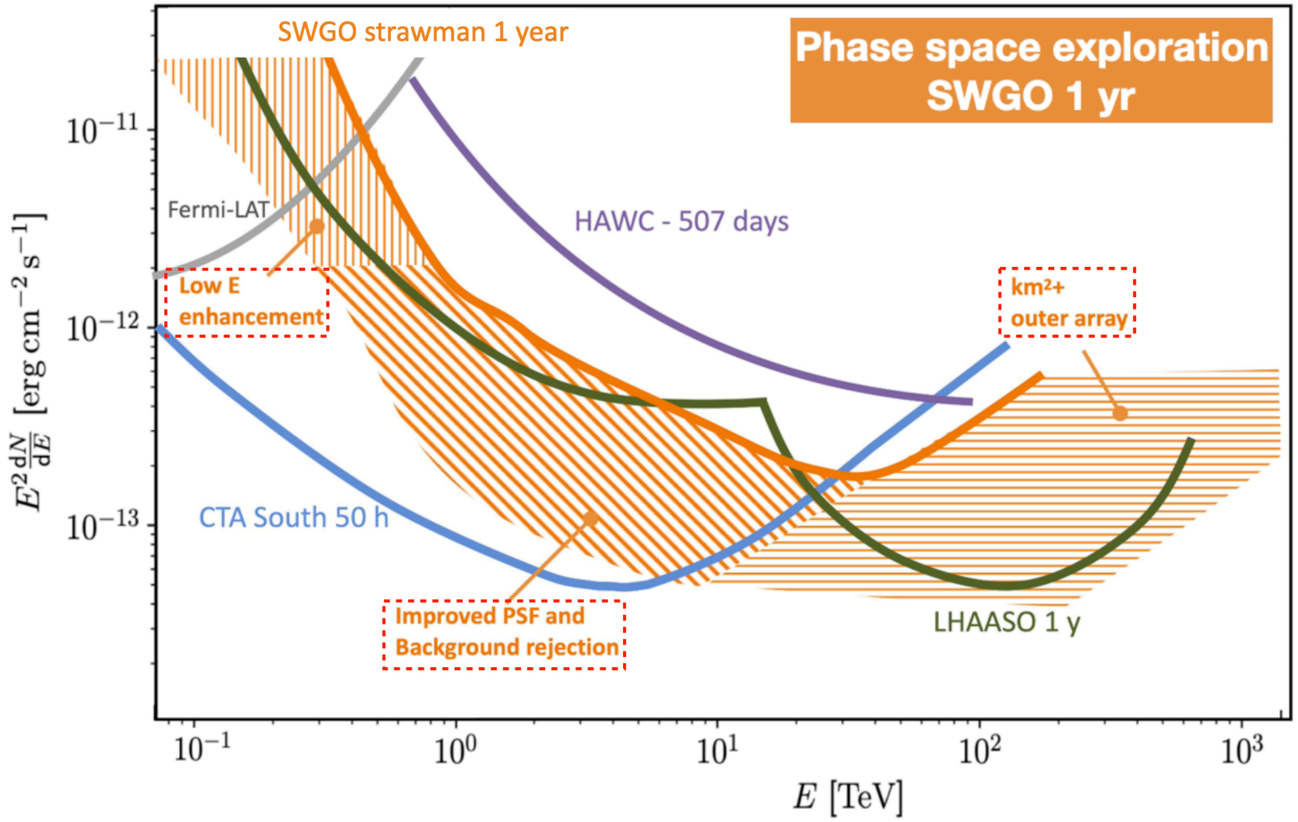


Lower the energy threshold to close the gap between satellite and ground-based experiments

Novel engineering solutions to build WCDs

Polyurethane tanks with thermal insulation and PMTs mounted from exterior

SWGO foreseen sensitivity



- Concept Design Report document (site + detector and array baseline decisions) ready by the end of 2024
- Immediately after, the collaboration will focus on obtaining funding, and an engineering array $\mathcal{O}(10\%)$ being built in 2026

Summary

Astroparticle experiments are entering a golden age substantially increasing their discovery potential

Despite their modest size and limited funding, Portuguese groups actively contribute to major astroparticle collaborations, driving the progress in the field

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