El Observatorio Pierre Auger

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Outline of the talk

- El Observatorio Pierre Auger
- Extensiones
- AugerPrime
- Trabajo en la BUAP
- Resumen

El Observatorio Pierre Auger

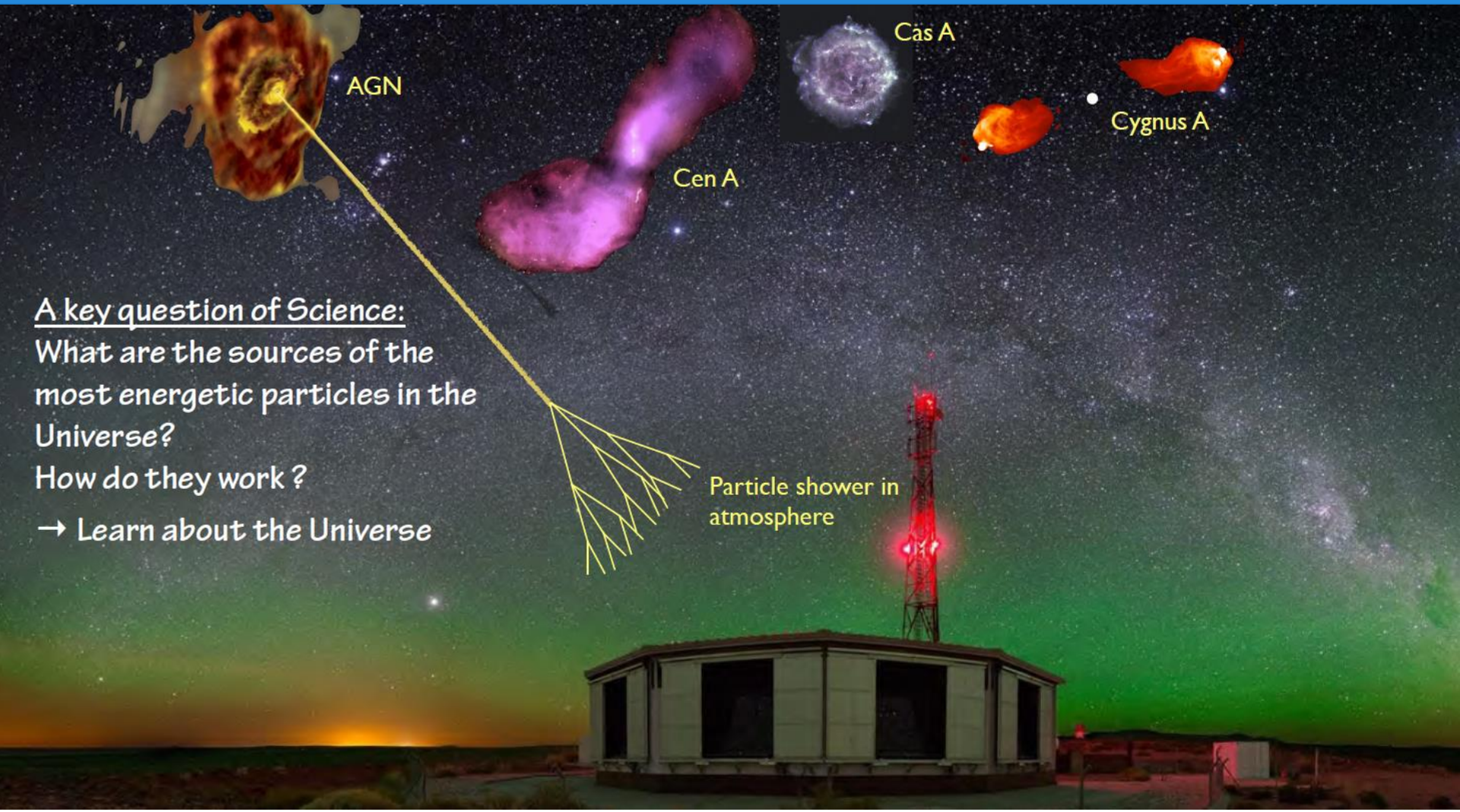
Pierre Auger Observatory

The Pierre Auger Observatory (PAO) is the largest experiment for studying ultra-high energy cosmic rays, it is located in Argentina near the Malargüe city, it was completed in May 2008 and inaugurated in November 2008. It is taking data in stable manner since January 2004. The main objective of the project is to detect the cosmic ray particles with energy higher than 10^{18} eV.

The properties that we want to measure are of CR are:

- Energy
- Arrival direction
- Mass composition

El Observatorio Pierre Auger



La Colaboración Auger

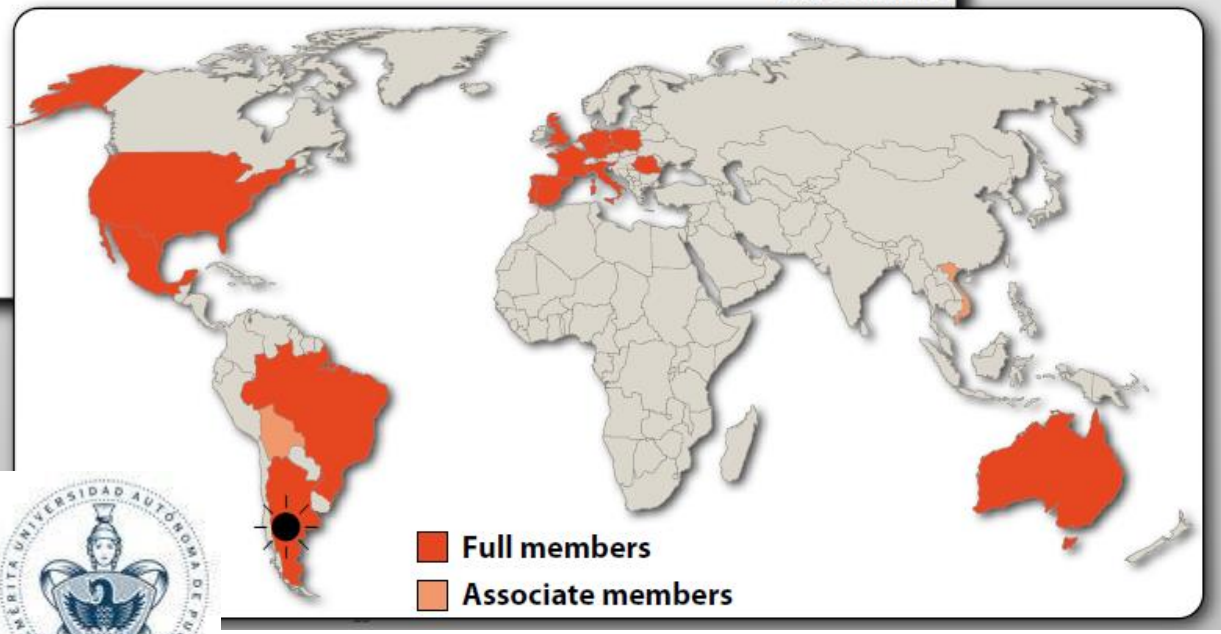
~500 Collaborators; 90 Institutions, 18 Countries:

Not just the site, became a second home and is a key partner in this project!

Argentina	Netherlands	Spain
Australia	Poland	USA
Brasil	Portugal	
Colombia	Romania	Bolivia*
Czech Republic	Slovenia	Vietnam*
France		
Germany		
Italy		
Mexico		

*Associated

PIERRE AUGER OBSERVATORY



LNS Laboratorio Nacional de Supercómputo del Sureste de México

BUAP

Detector Híbrido

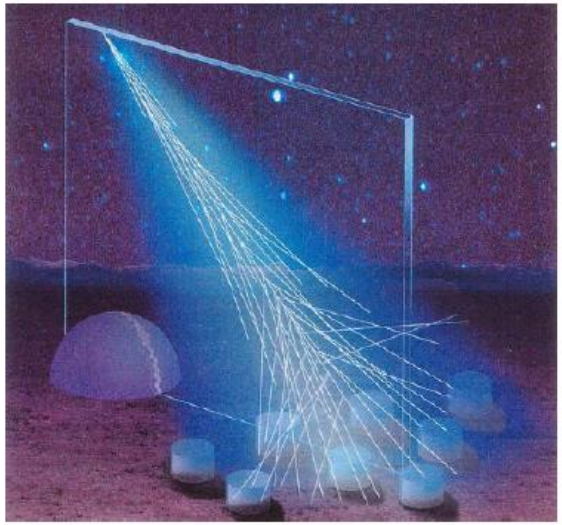
The most important characteristic of this experiment is the continual usage of so called hybrid detection when the same shower is detected by surface and fluorescence detector simultaneously

Fluorescence Detector

It detects the fluorescence light, generated by the EAS passing through the atmosphere as a result of excitation of air molecules, mainly Nitrogen (N_2).
Duty cycle 15%.

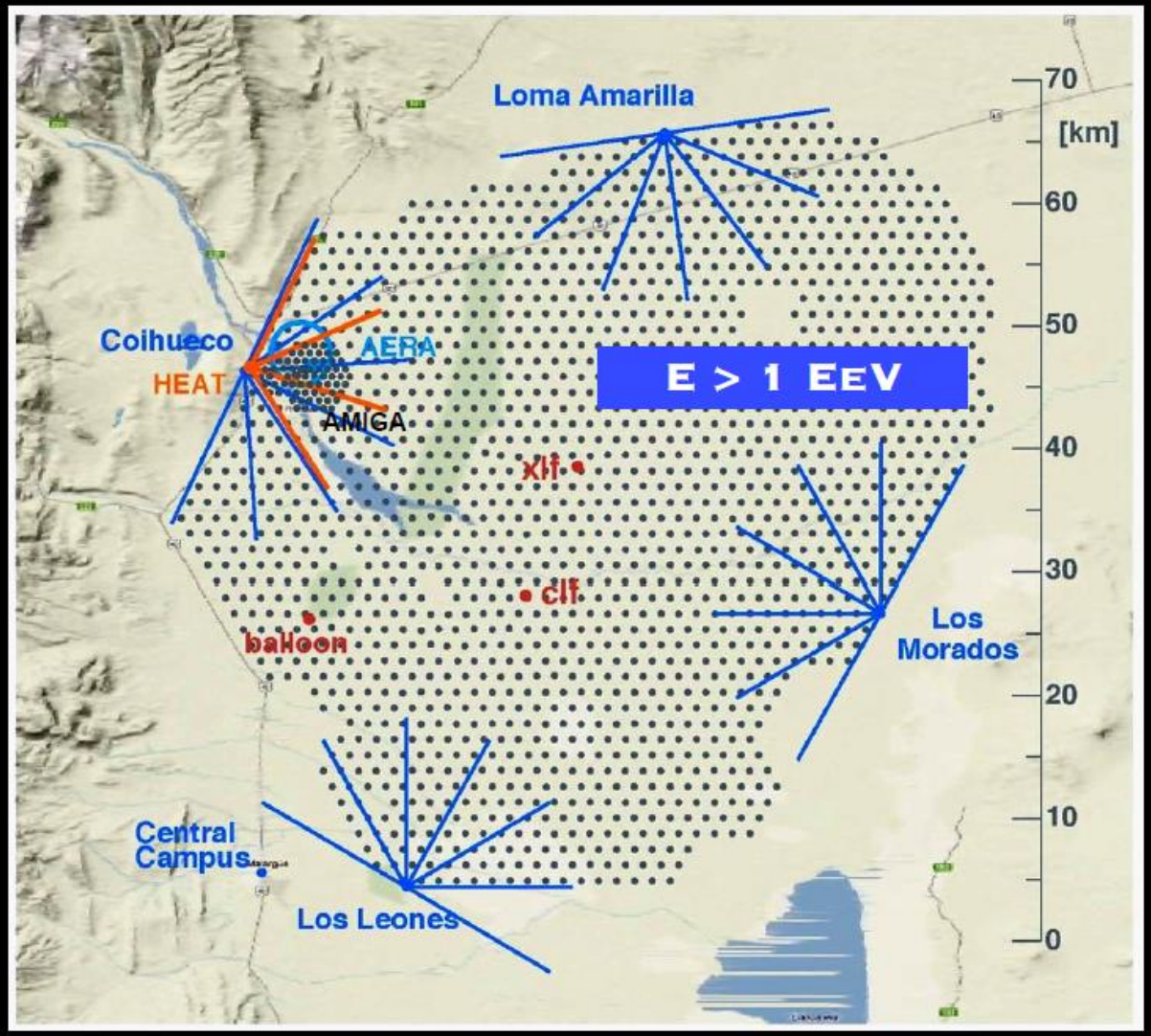
Surface Detector

It detects the secondary particles at ground level.
Duty cycle 100%.

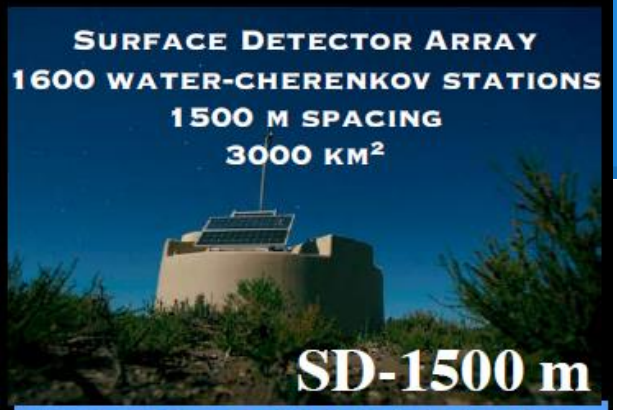


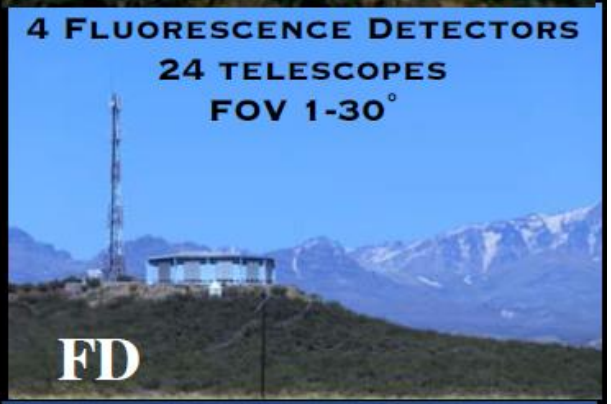
One important aspect of the hybrid detection is the energy calibration of SD measurements by FD data.

The Pierre Auger Observatory, Argentina



The initial detectors





Extensiones

FD extension

- High Elevation Auger Telescope (HEAT)

SD extension

- Auger Muons and Infill for the Ground Array (AMIGA)

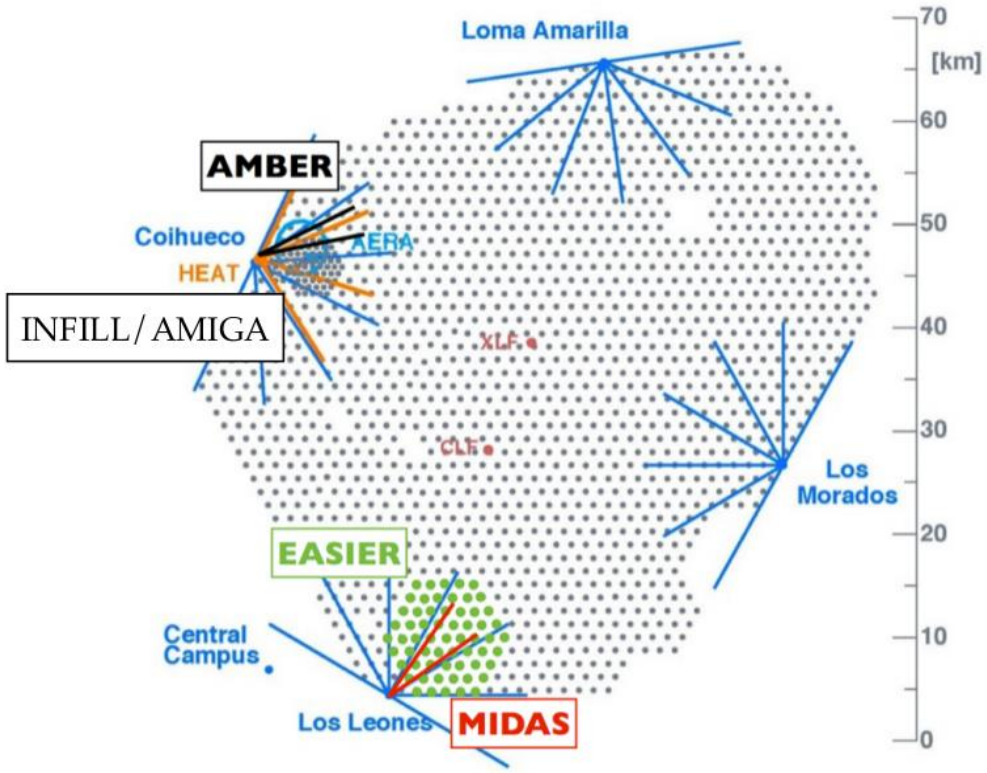
Objective:

- extend observations down to lower energy
- obtain better composition information

Infill + HEAT ⇒ low energy hybrid trigger

Radio detection

- AERA (MHz)
- AMBER (GHz)
- EASIER (GHz)
- MIDAS (MHz, GHz)

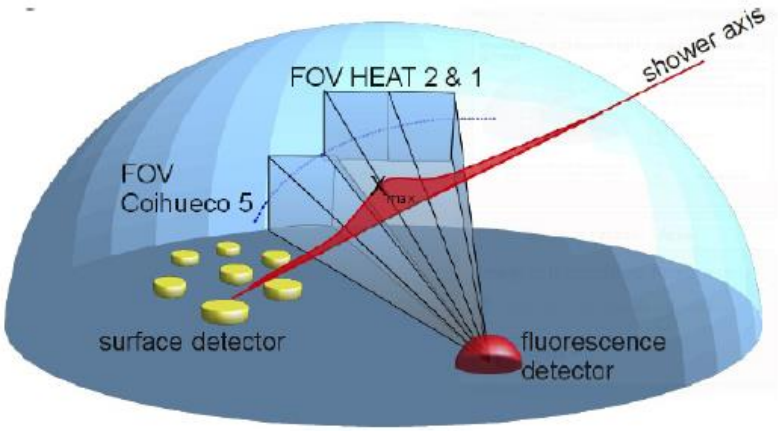


Extensiones

High Elevation Auger Telescopes

HEAT

- 3 tiltable telescopes.
- 180 m from Coiheuco site.
- Field of view from 30^0 to 60^0 in elevation.
- operated as independent site
- Infill area in FOV
- Energy $\geq 10^{17}$eV.

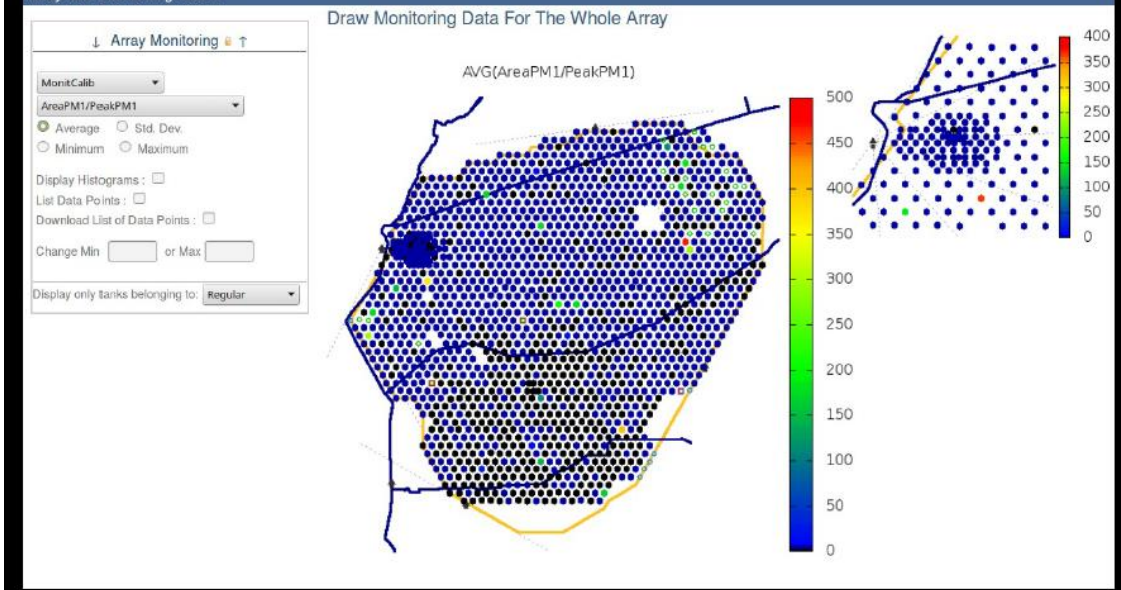


Virtual eye 6 (HeCo)

Extensiones

- 60 WCD stations, 750 m
- Near and in FoV of HEAT

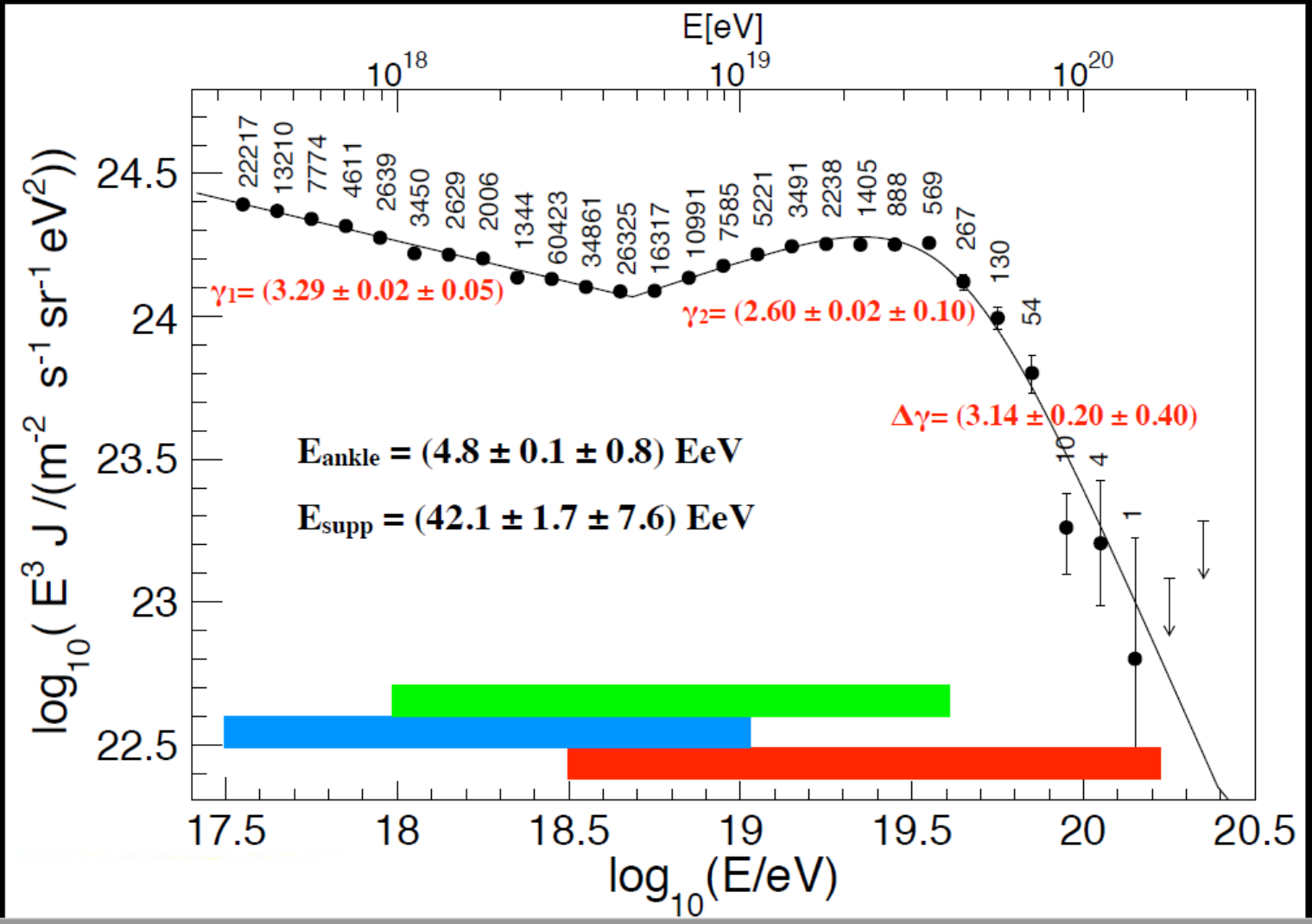
•Array overview used as plot



Results

4 data sets combined: SD 750 m, FD (hybrid), SD 1500 m (0-60˚), SD 1500 m (60-80˚)

≈ 200 000 events, ≈ 50000 km^2 sr yr exposure, FOV: -90˚, +25 in δ

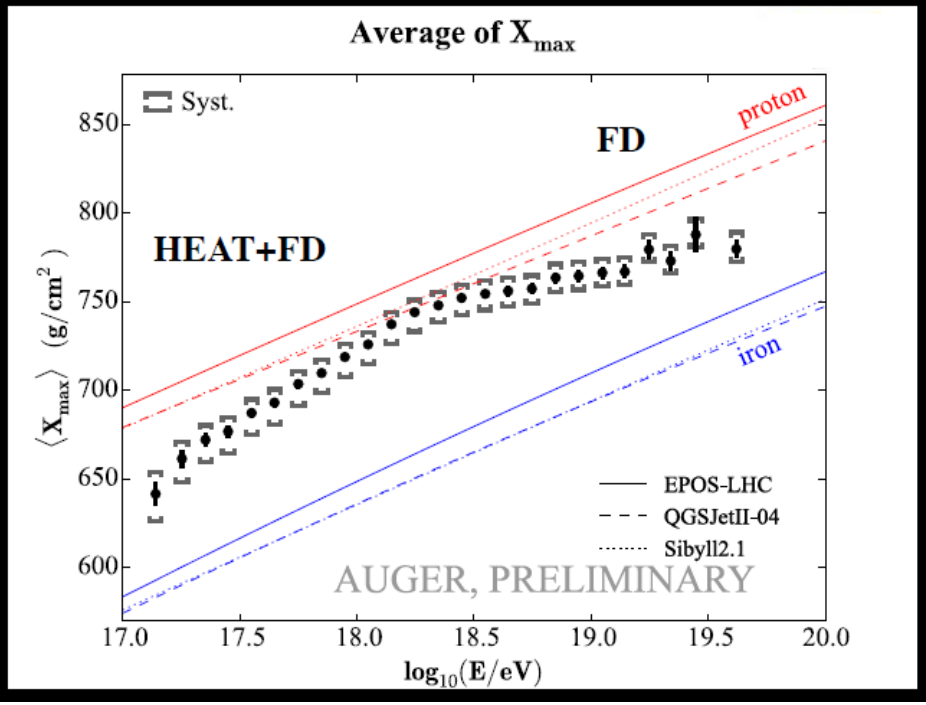


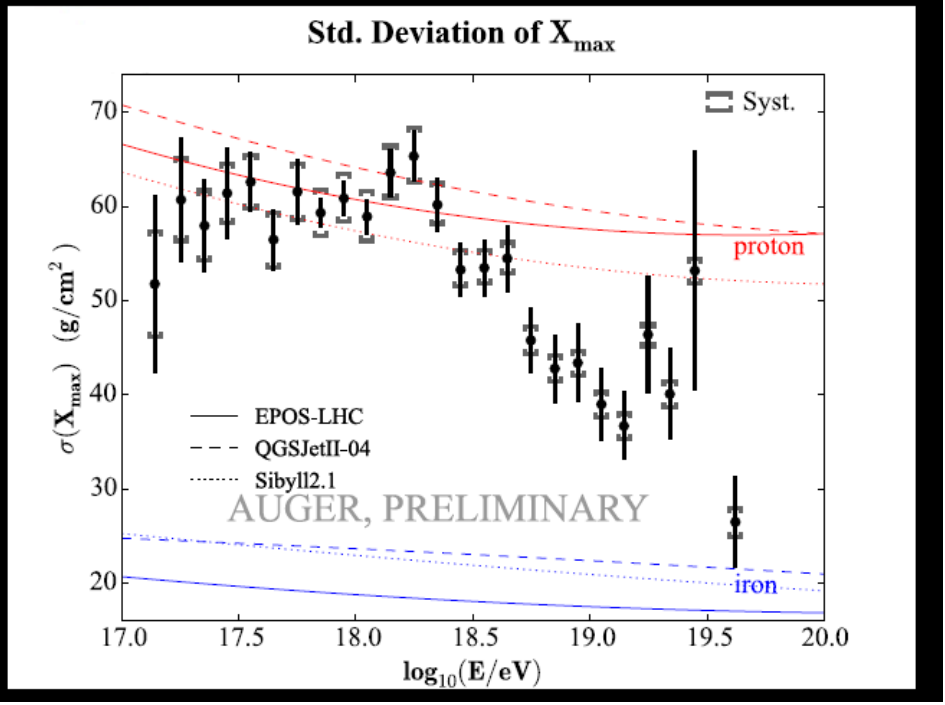
Results

Depth of shower maximum premiere observable for mass composition studies

HEAT data extends the FOV of the fluorescence detector up to 60°

Extension of the depth of shower maximum measurements down to 10^{17} eV





Results and Upgrade

After 10 years of operation

1. All-particle spectrum: unquestionable existence of a flux suppression above ≈ 40 EeV (GZK-reminiscent)

2. Trend towards a heavier composition at the highest energies (from Xmax data, very few data above 40 EeV). Spectrum and Xmax data together favors the scenario where the suppression is a source effect. **NEED FOR MASS COMPOSITION DATA IN THE SUPPRESSION REGION - ACCESSED BY THE SURFACE DETECTOR**

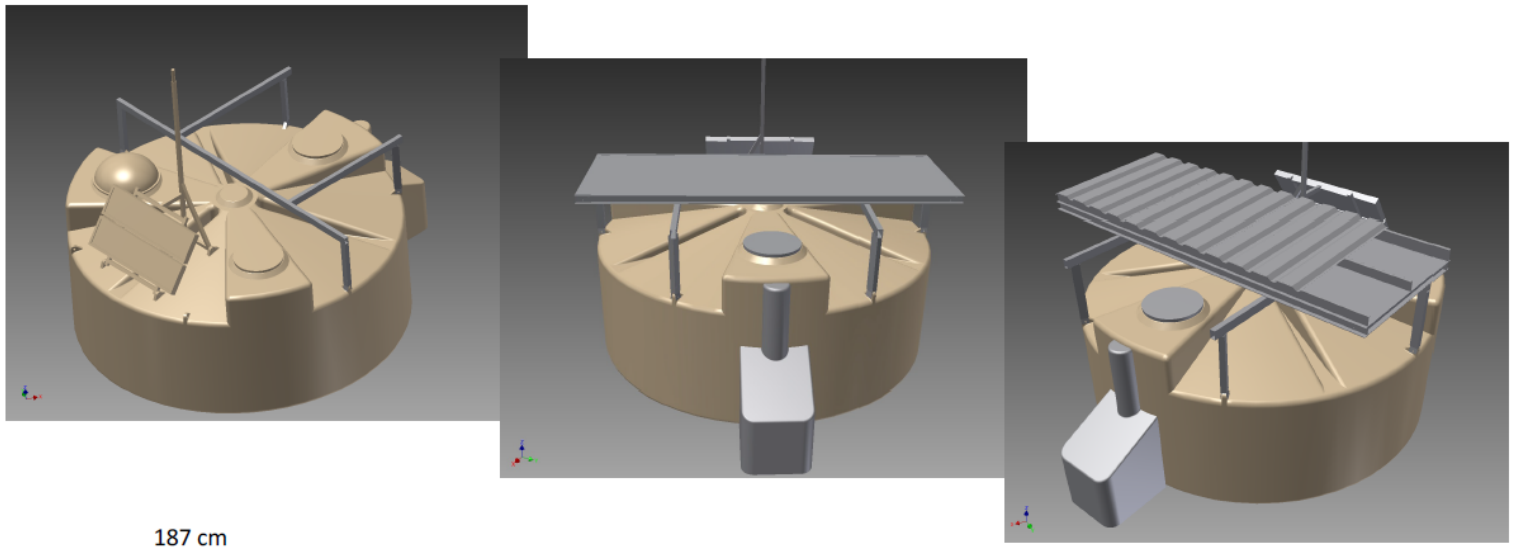
Auger data indicate that the most energetic particles are not only protons but mostly heavy, highly-charged, nuclei. These are deflected by cosmic magnetic fields, which makes it difficult to track back to their origin. Another ten years of operation is expected to double the data set and to identify the cosmic accelerators

AugerPrime

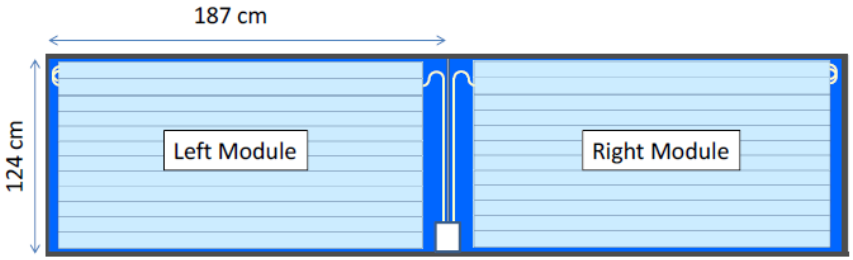
The key element of the upgrade will be the installation of a plastic scintillator on top of each existing surface detector stations. It will provide a complementary measurement of the showers allowing the reconstruction of muons and electromagnetic particles. The surface scintillator detector stations (SSD) will be deployed over the full 3,000-km2 area of the overall surface detector (SD).

Electronics prototypes (120 MHz)

Practical implementation

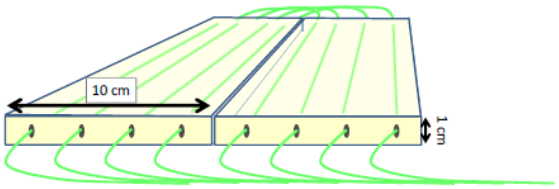


Simple and robust construction of detector module and mounting frame, double roof for thermal insulation



Two modules in one box per station, readout by one PMT, area ~4 m²

Read-out of scintillators with WLS fibers



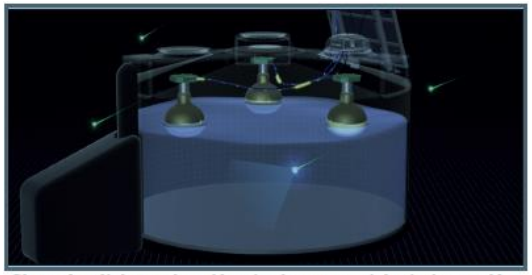
Both WCD and SSD to be connected to new 120 MHz electronics

Auger @ BUAP (2016)

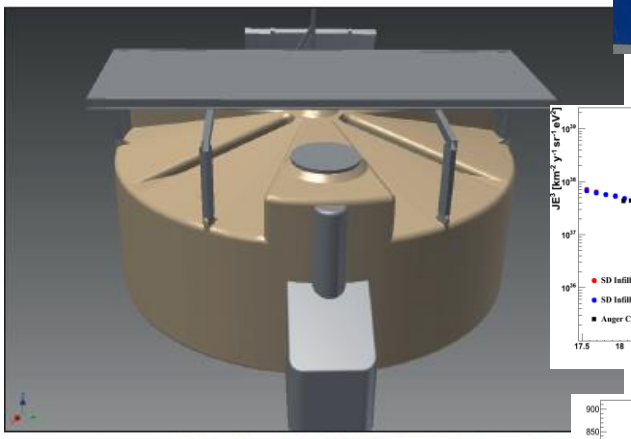
Dr. Humberto Salazar (DCyTIC)
Dr. Oscar Martinez Bravo (FCFM)
Dr. Epifanio Ponce L. (FCFM)
Dr. Enrique Varela Carlos (LNS)
PHD Students
M.C. Alejandra Parra
M.C Cederik de Leon

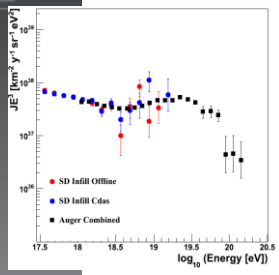
HPC for High Energy Physics: Auger

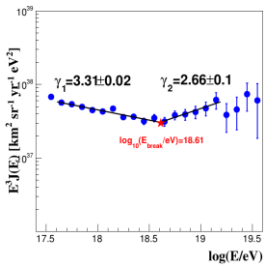
- Offline framework (**Offline v2r9p1)**
- CDAS
- Corsika v75000 (For shower simulations for energies from 10^{17}-10^{20}eV)
- CONEX v2r4.37(For FD shower simulations for energies from 10^{17}-$10^{18.5}$eV)
- GEANT4 (Simulation on Detector Response)
- ROOT
- ADST (For analysis)

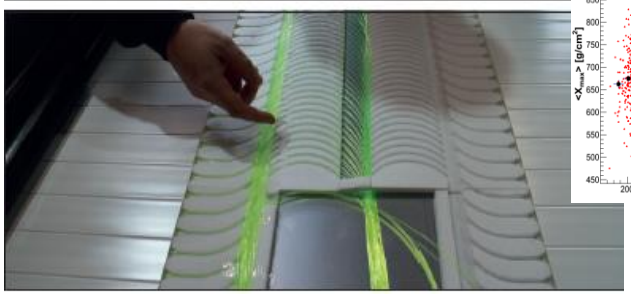


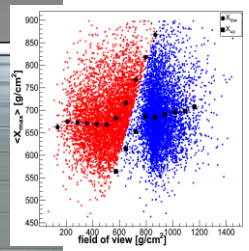
Cherenkov light produced by air-shower particles is detected by three photomultiplier tubes, which view the water volume

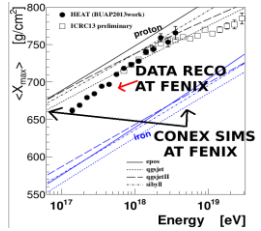






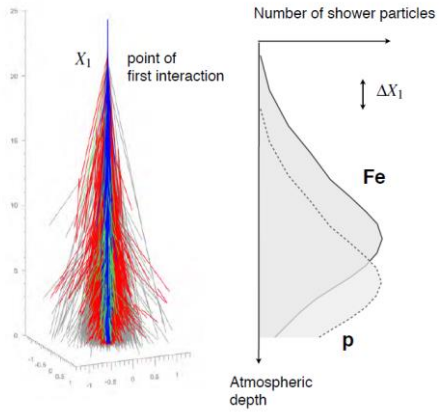


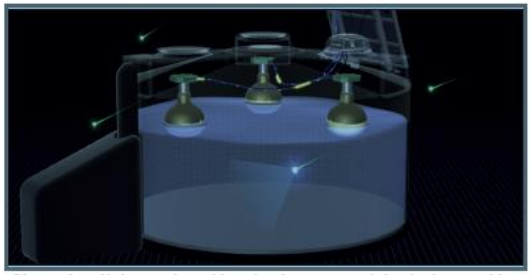




HPC for High Energy Physics: Auger

- MC Simulations for HEAT, ASCII using CONEX, CORSIKA, GEANT4
- Reconstruction and Data Analysis
- Electronic





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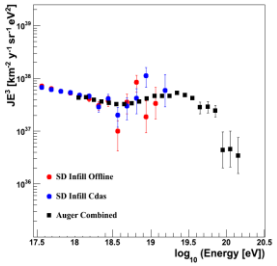

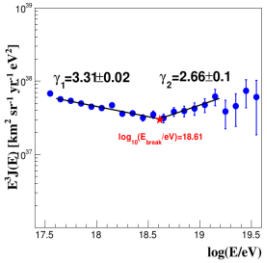

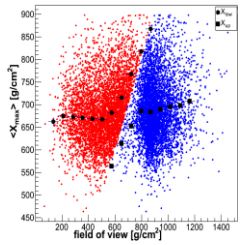

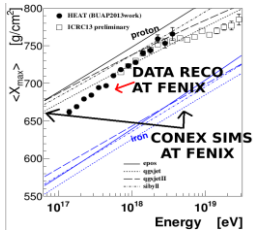

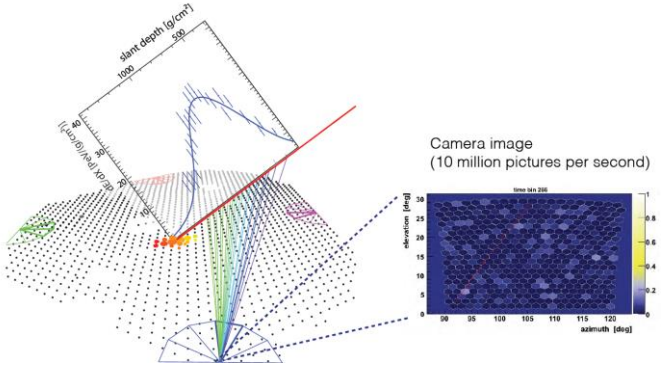

Auger Remote Control @ BUAP

Remote Control

New-comer: Benemérita Universidad Autónoma de Puebla (BUAP), Mexico

Enrique Varela, Alejandra Parra

https://www.auger.unam.mx/AugerWiki/RemoteShift

Auger Remote Control @ BUAP
Dr. Epifanio. M.C. Cederik

SUMMARY

- Data indicate that, in addition to the propagation effect known as GZK cutoff, this flux suppression may reveal the limiting energy of the most powerful cosmic particle accelerators.

- The Observatory Pierre Auger has begun the upgrade operations

Thank you for your attention