Large International Astrophysics Observatories in Argentina

TOPICS:

1. **The Pierre Auger Observatory** — **auger.org.ar**
2. **The QUBIC Observatory** — **qubic.org.ar**
3. **The ANDES Laboratory** — **andeslab.org**
4. **Outreach** — **iteda.wp-ms.ahuekna.org.ar**
5. **RR.HH.** — **cuaa.wp-ms.ahuekna.org.ar/cursos/**

Alberto Etchegoyen – ITeDA(CNEA, CONICET, UNSAM) – 24/Jul/2023

The Pierre Auger Observatory

Science Aim:

1.- Create a new branch of science: charged-particle astronomy.

2.- Understand hadronic interactions at the highest energies.

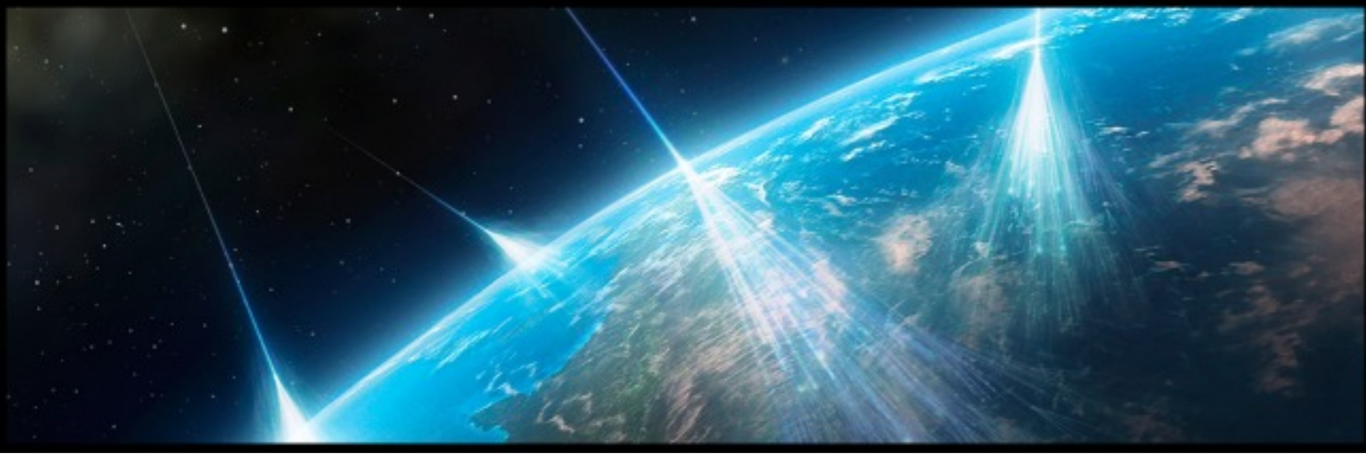
The Pierre Auger Collaboration

More than 400 scientists from 18 countries:

Argentina, Australia, Belgium, Brazil, Czech Republic, Colombia, France, Germany, Italy, Mexico, Netherlands, Polonia, Portugal, Romany, Peru, Slovenia, Spain, USA

Cosmic Rays

- High-energy cosmic rays are particles from the outer space impinging on Earth constantly and in all directions
- Approximately 10^4 cosmic rays arrive to Earth per square meter per second
- They were discovered in 1912 by Victor Hess, who received the Nobel Prize for this discovery.

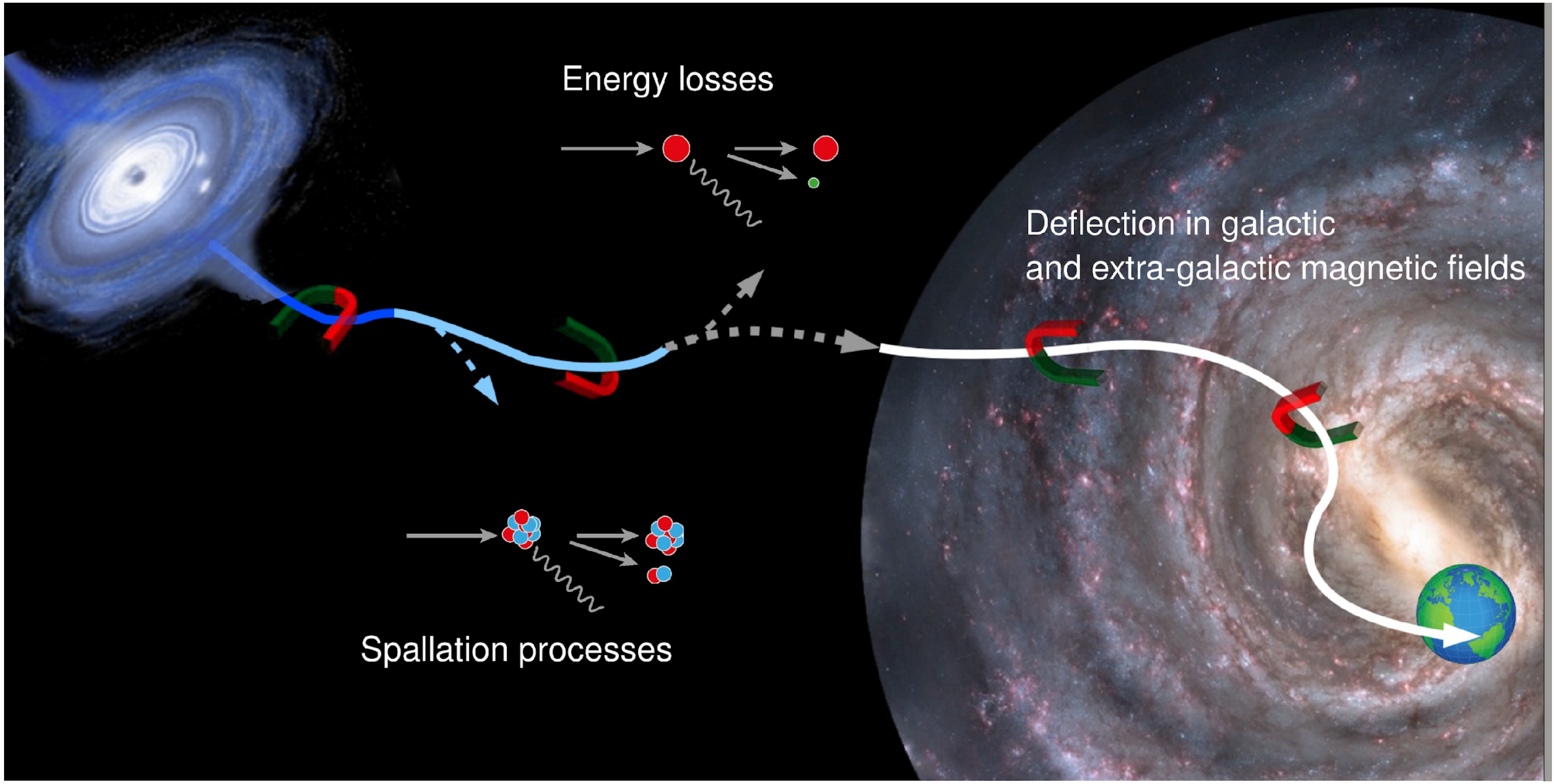


High-Energy Cosmic Rays

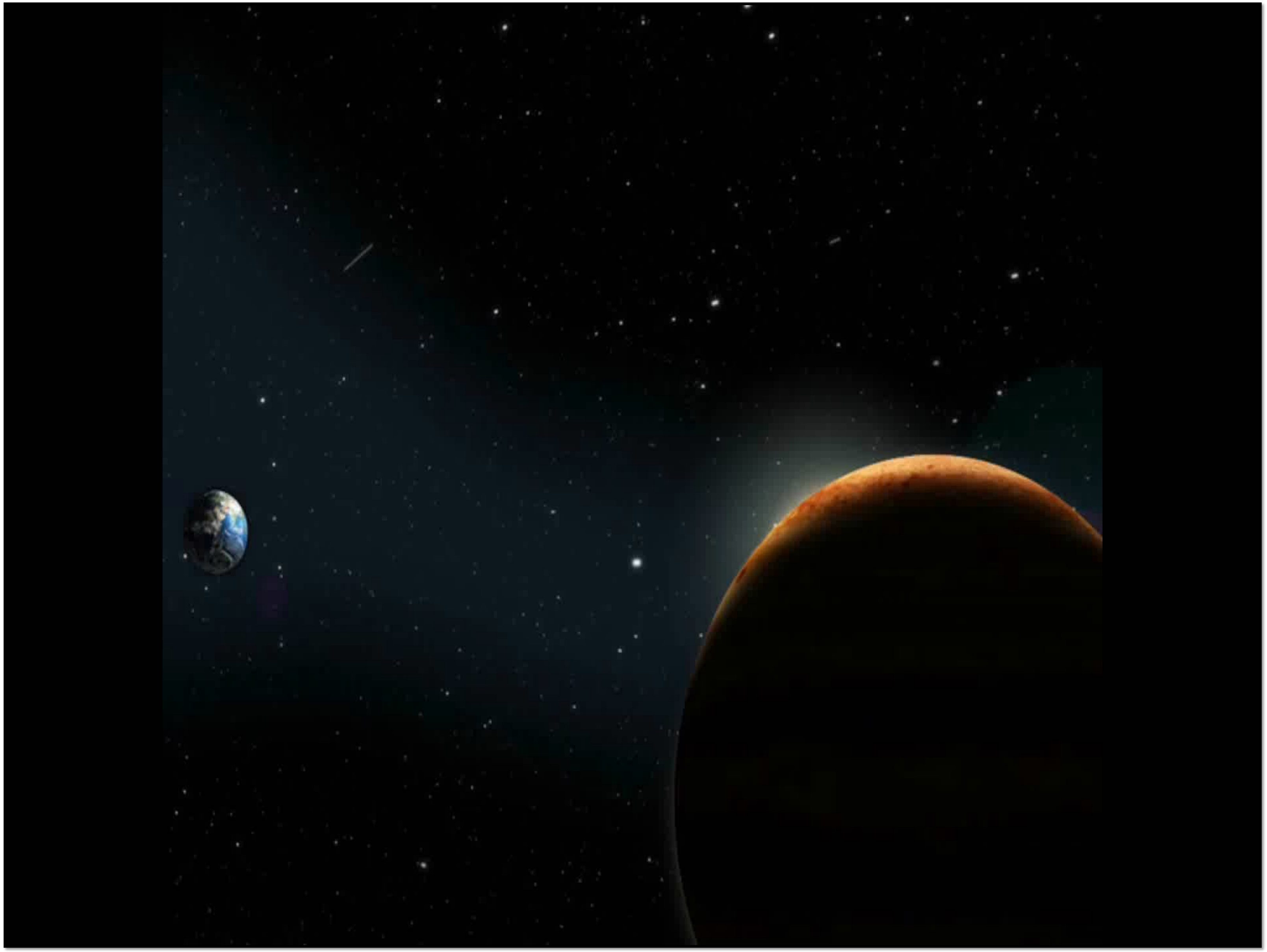
- High-energy cosmic rays generate showers of secondary particle when interacting with the atmosphere molecules.

- They are studied by detecting these showers.

High-Energy Cosmic Rays



Where do they come from? **How are they accelerated?** **What is their composition?**



The First Large Physics International Project in Argentina

Observatorio Pierre Auger, Mendoza

1992 J. Cronin (*Nobel Prize Winner*) & A. Watson suggest building a giant array

1995 Design report + **collaboration formation** + **site selection by International Collaboration in UNESCO Headquarters, Paris, Nov 1995**

1999 1st Signature of International Agreement

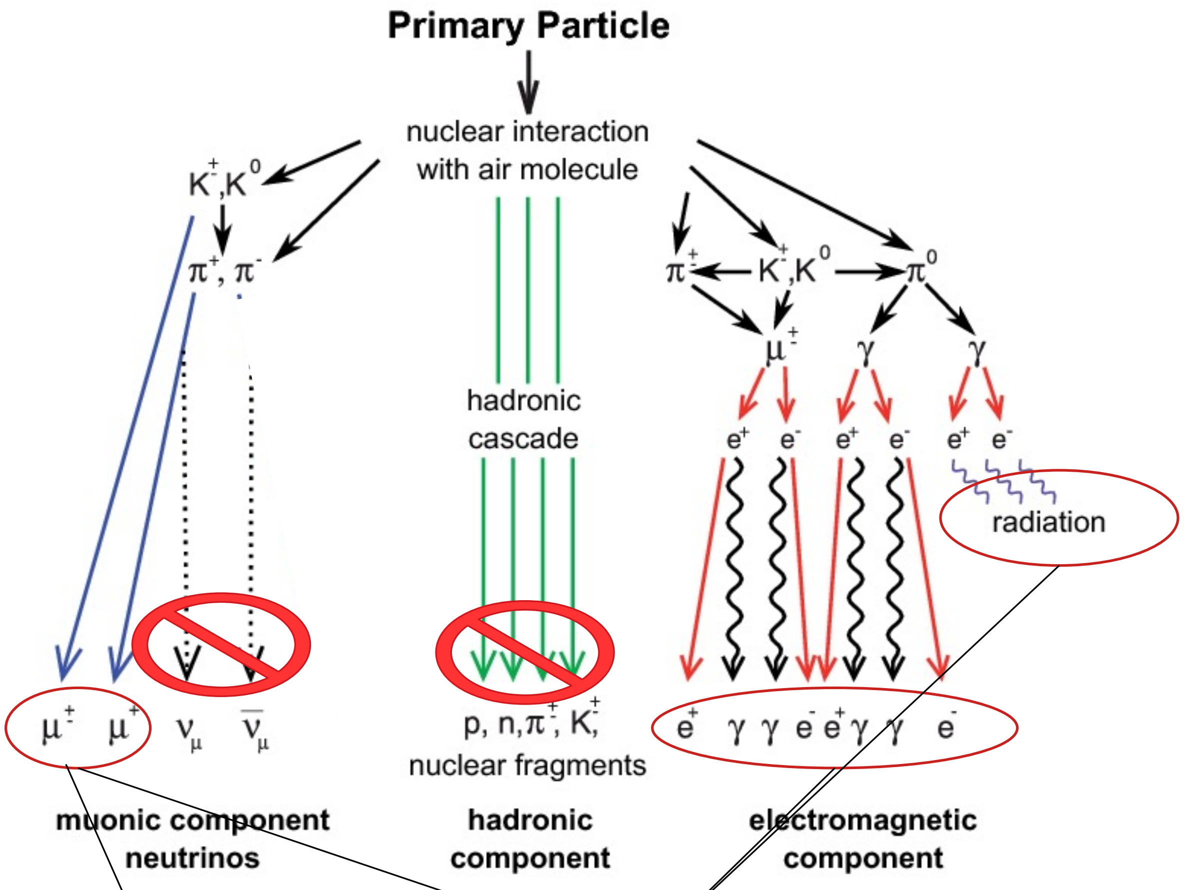
2001 PAO **Engineering Array (EA)** operated for 6 months

2008 End of PAO construction, start of phase-1 data

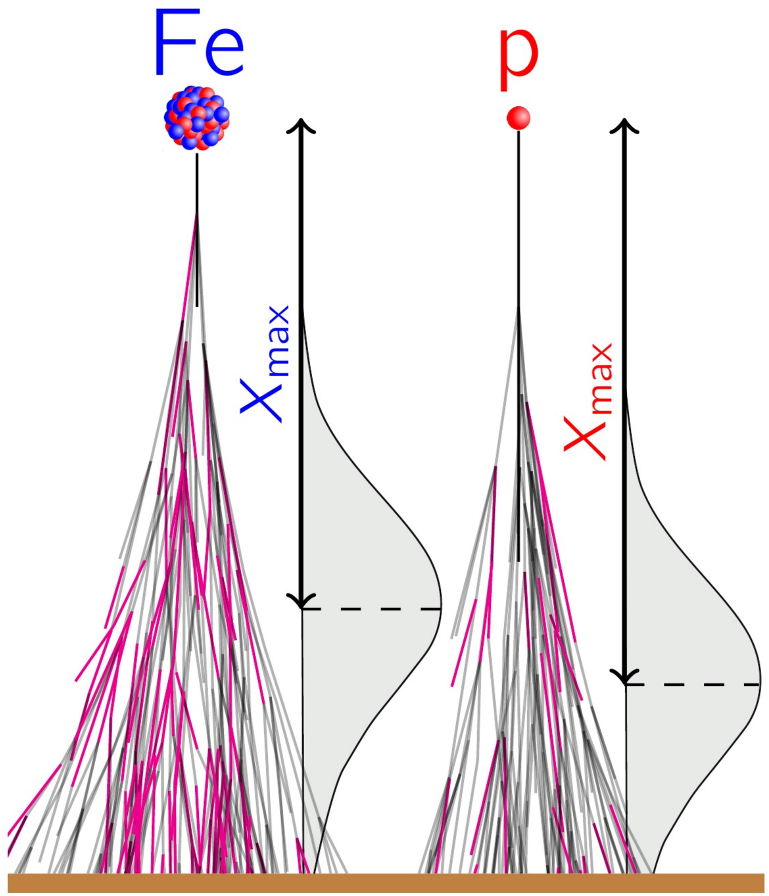
The Pierre Auger Observatory established a new paradigma in the field of UHECR

2015 2nd Signature of International Agreement & AugerPrime

Air Shower Generation



Accessible to ground based detectors
Accessible to underground detectors



Optical Telescopes: the heavier the particle the shallower the EAS and lesser the shower-to-shower fluctuations.

The Pierre Auger Observatory

Surface detector (SD)

100% duty cycle

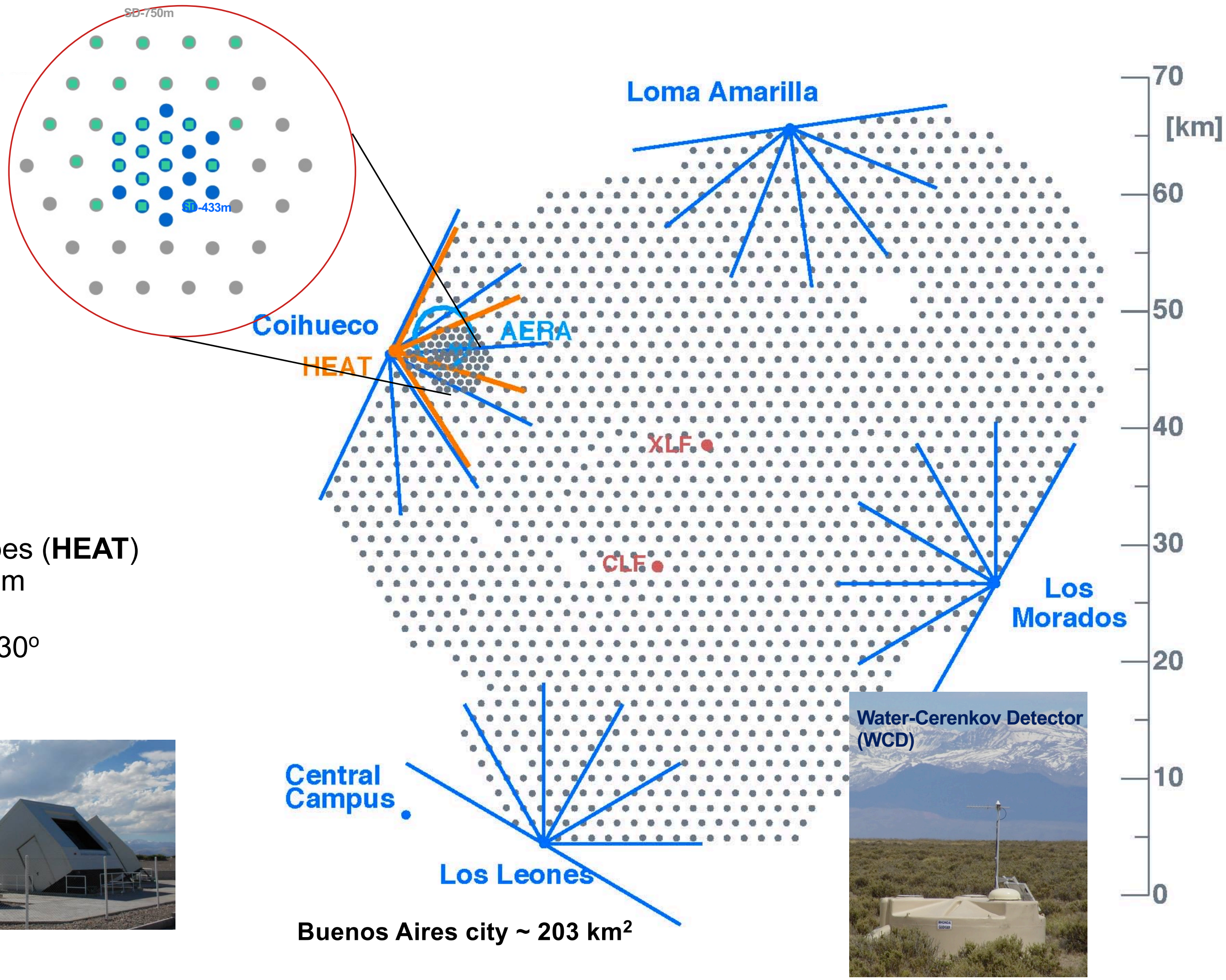
SD-1500m	SD-750m	SD-433m
3000 km^2	23.5 km^2	1.9 km^2
1600 WCDs	61 WCDs	19 WCDs
E^{v}_{thr} 2.5 EeV	E_{thr} 0.1 EeV	E_{thr} 0.03 EeV
E^{i}_{thr} 4.0 EeV		

Fluorescence detector (FD)

15% duty cycle

4 units x 6 telescopes
overlooking SD-1500m
FoV 30º x 30º
Minimum elevation 1.5º

1 units x 3 telescopes (**HEAT**)
overlooking SD-750m
FoV 30º x 30º
Minimum elevation 30º



The Pierre Auger Observatory

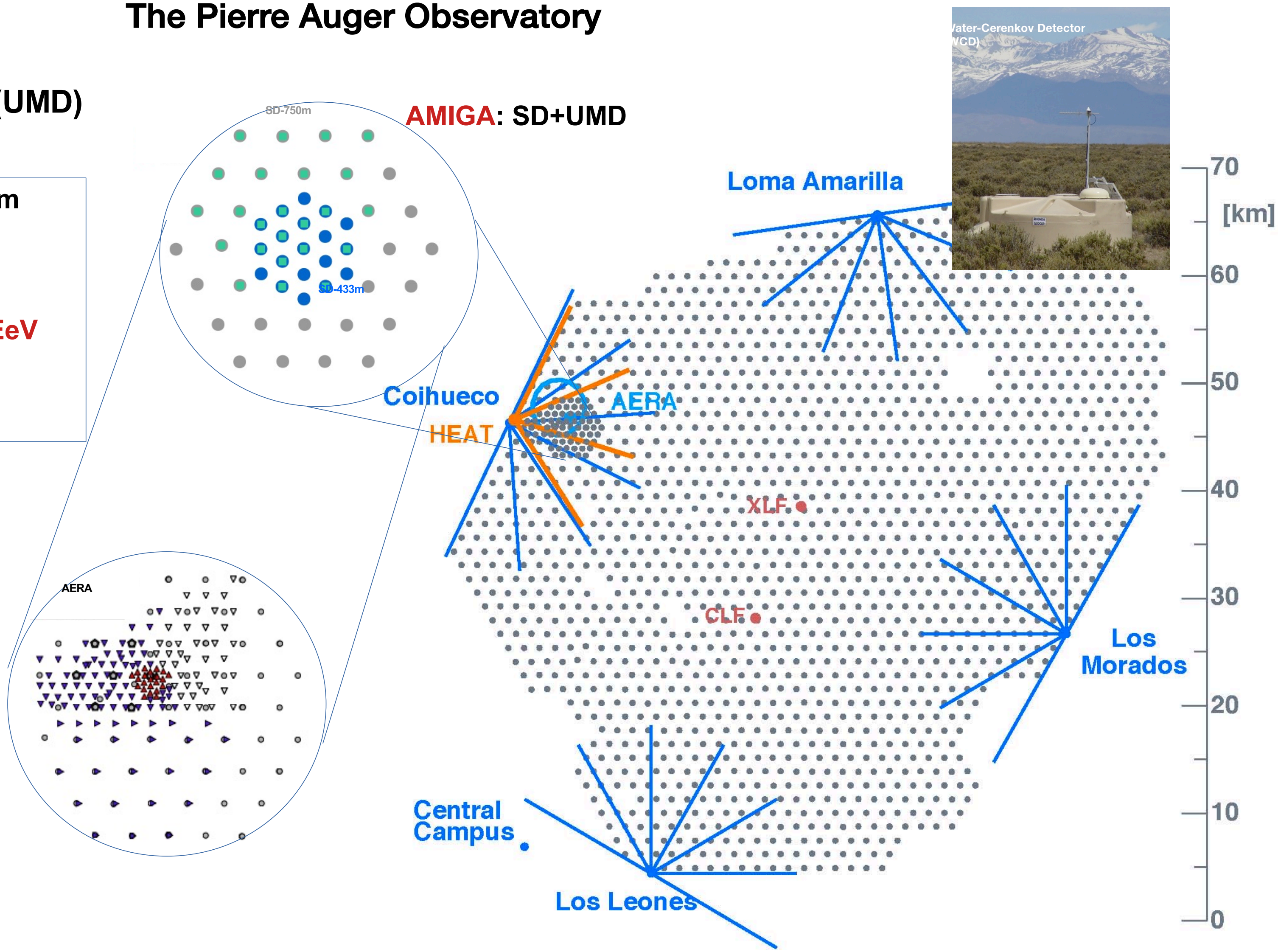
Underground Muon detector (UMD)
100% duty cycle

UMD-750m
23.5 km^2
61 WCDs

E_{thr} 0.1 EeV

UMD-433m
1.9 km^2
19 WCDs

E_{thr} 0.03 EeV

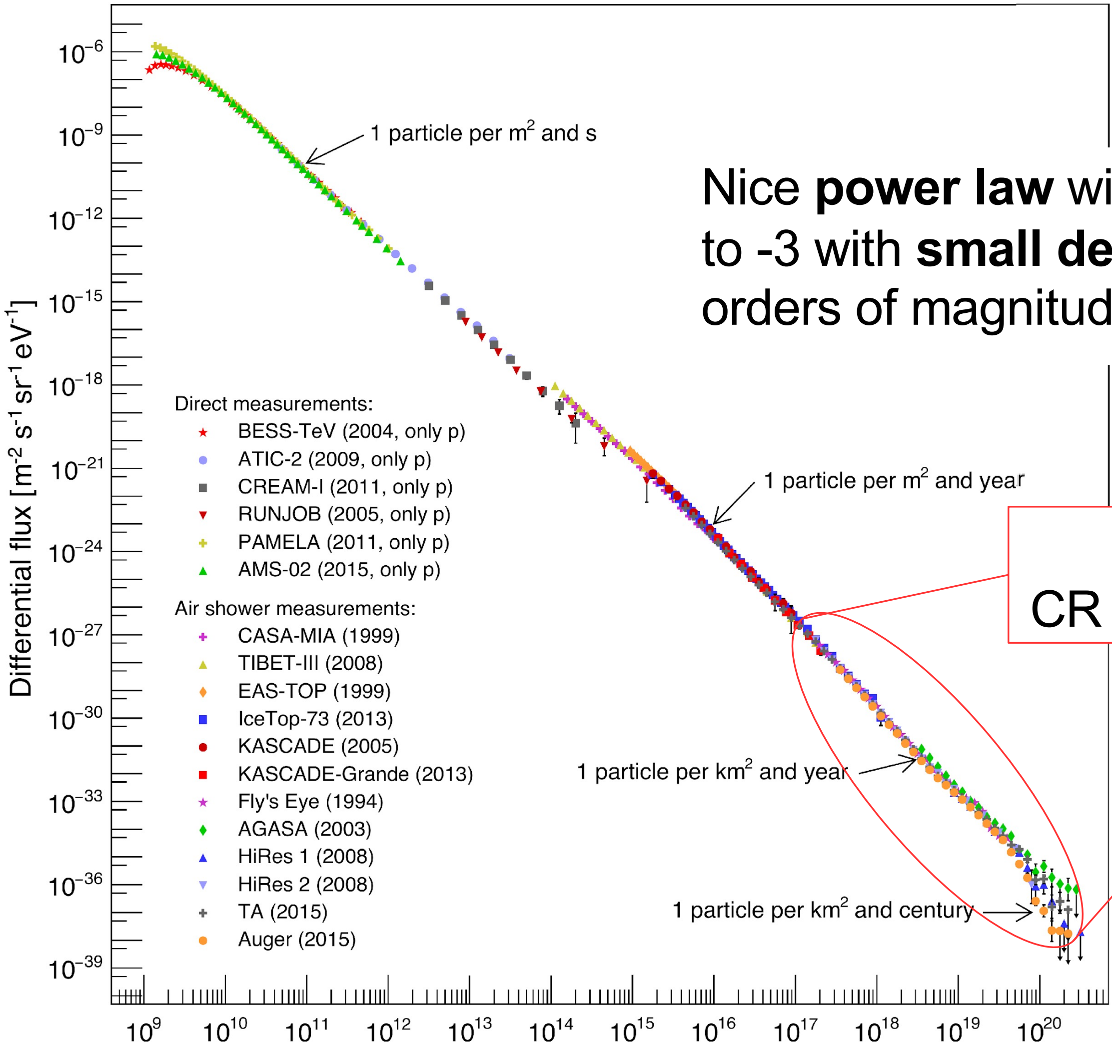


Radio detector (AERA)
100% duty cycle

30-80 MHz
153 radio stations over 17 km^2
Spacing from 150m to 750m

Upgraded over all the Observatory

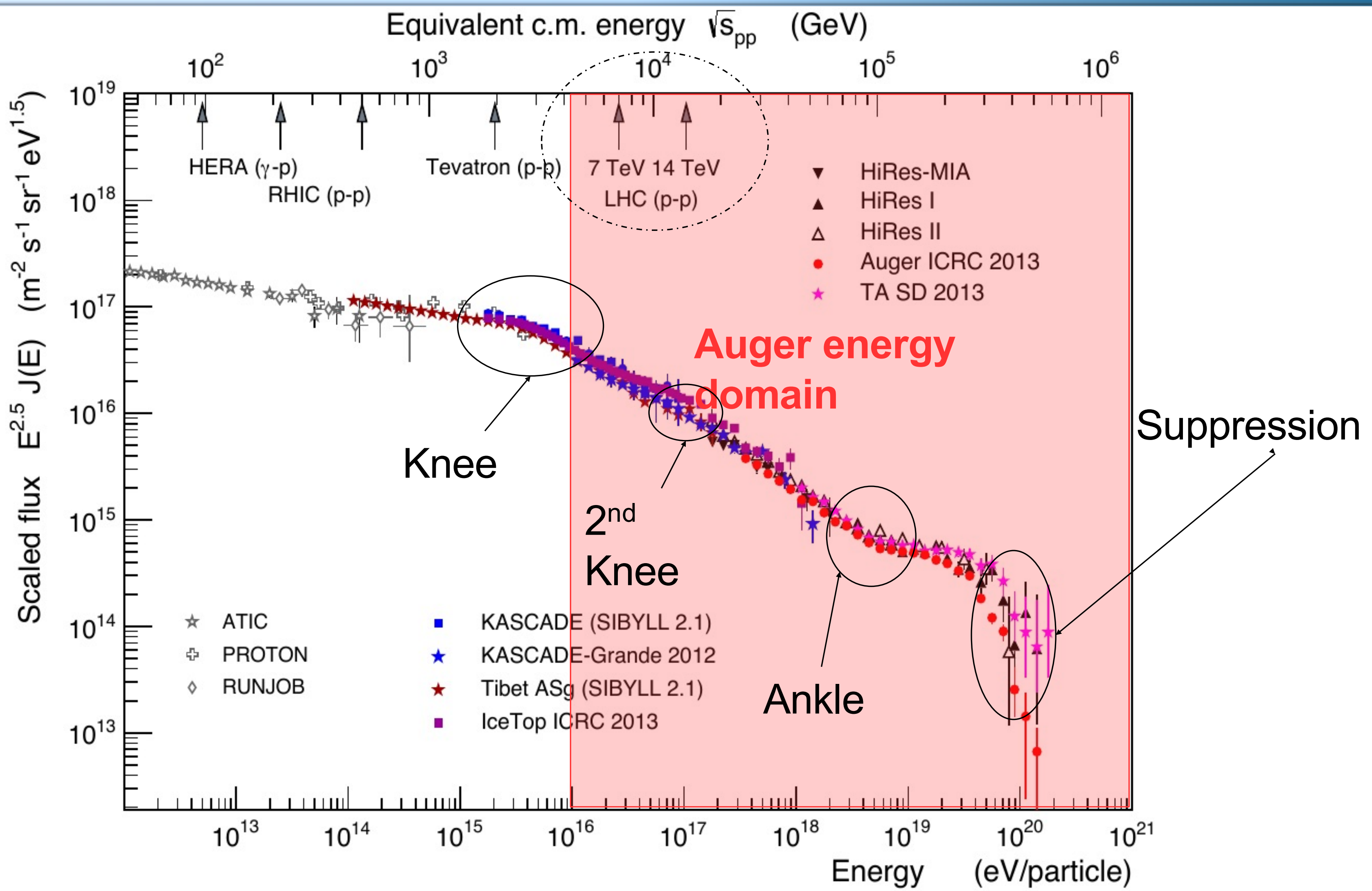
Ultra-High Energy Cosmic Rays



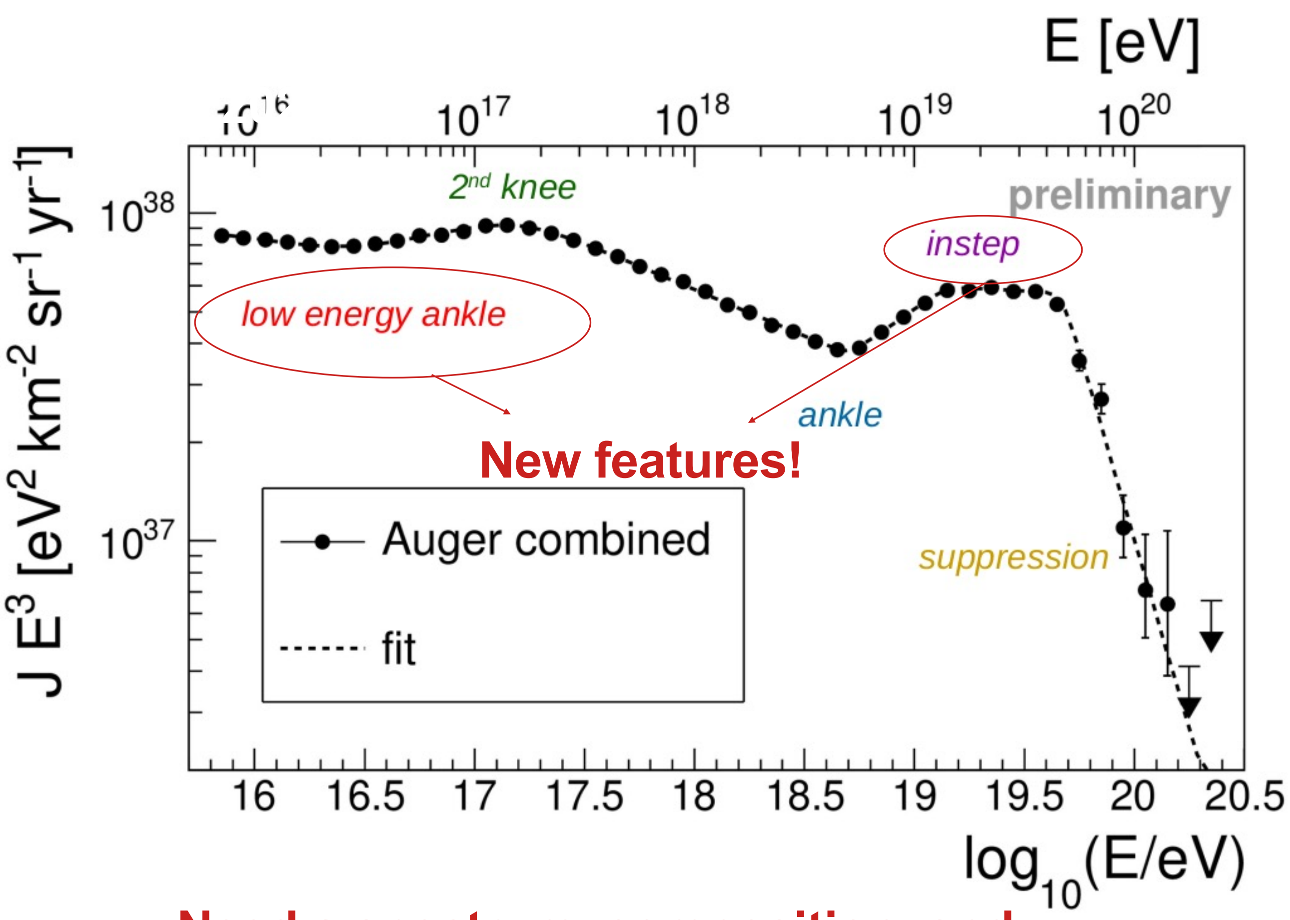
Nice **power law** with spectral index close to -3 with **small deviations** over 11 orders of magnitude!

Auger:
CR with energy > $10^{16.5}$ eV

Ultra-High Cosmic-Ray Spectrum Main Traits



Spectrum Features: New Questions



Need a spectrum, composition, and source distribution combined fit

Traditional questions:

What is the origin of the flux suppression?

- *Propagation effect?*
  "Greisen-Zatsepin-Kuzmin"

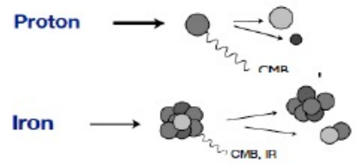


Photo-pion production

Photo-disintegration

- *Maximum injection energy?*

What is the origin of the ankle?

- *Propagation effect?*

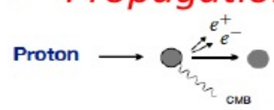
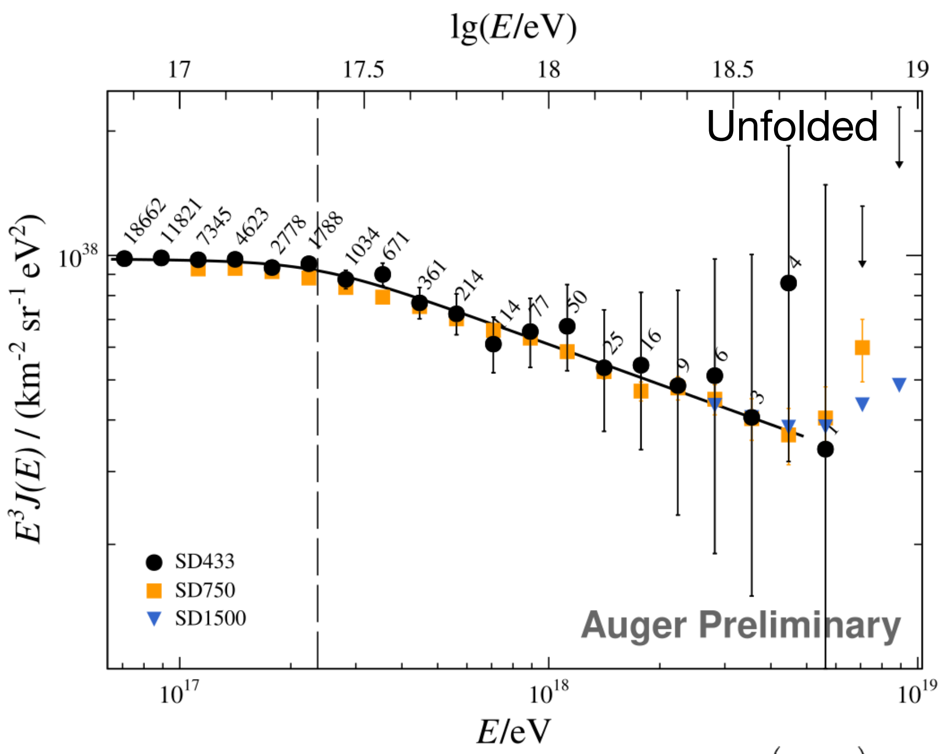


Photo-pair production

- *Transition effect?*
- *Interactions in the source environment?*

Second Knee: SD433 Spectrum



$$J(E) = J_0 \left(\frac{E}{10^{17}\,\mathrm{eV}} \right)^{-\gamma_0} \left[1 + \left(\frac{E}{E_{01}} \right)^{\frac{1}{\omega_{01}}} \right]^{(\gamma_0 - \gamma_1)\omega_{01}}$$

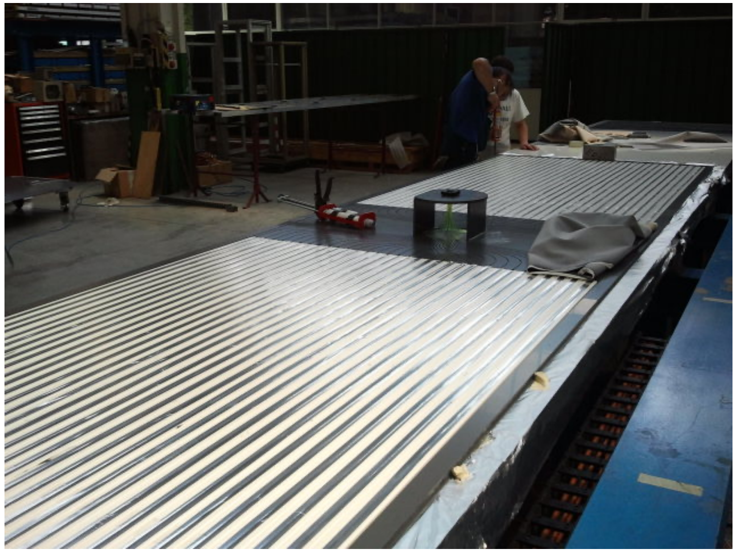
- Broken power law with soft transition spectrum

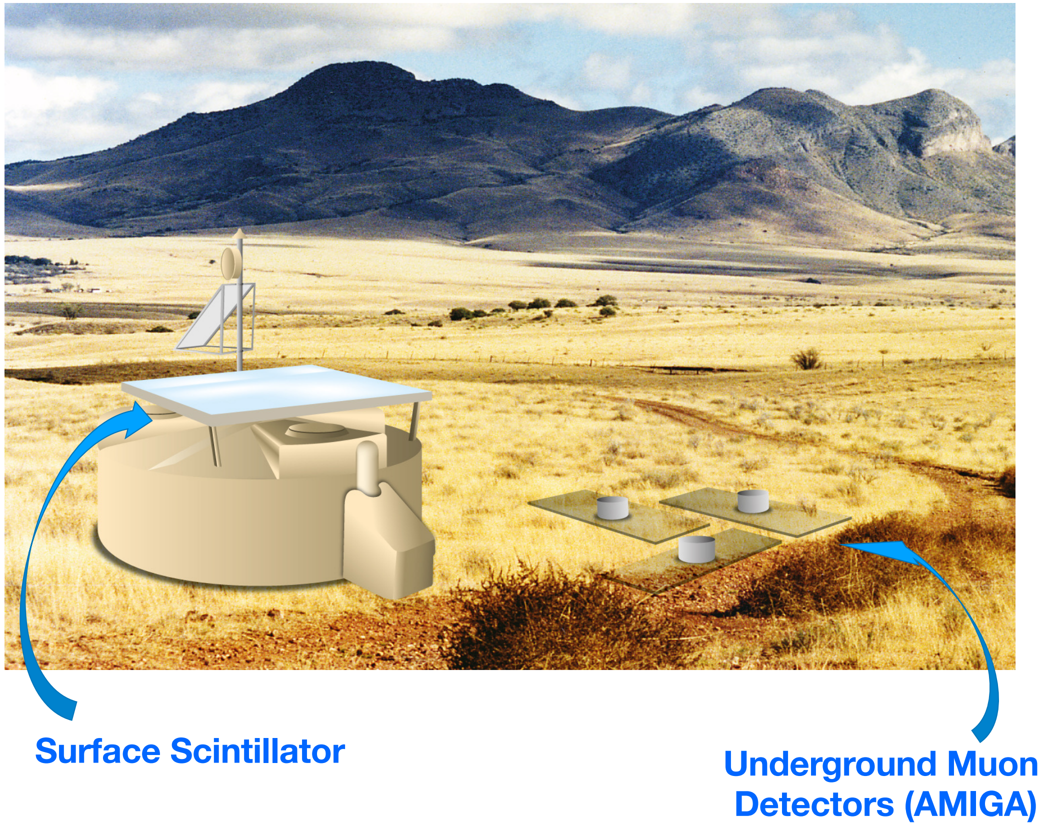
$\lg(E_{01}/\mathrm{eV})$	γ_0	γ_1
17.37 ± 0.10	3.02 ± 0.02	3.32 ± 0.08

- Good agreement between SD433 and SD750 spectra

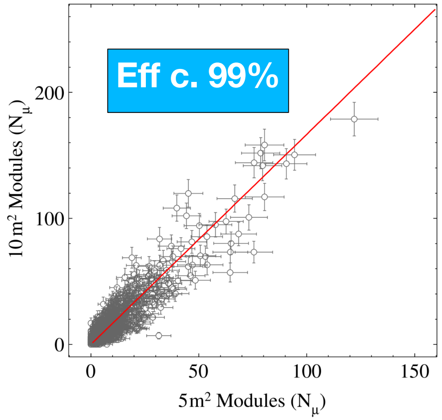
ITeDA latest result (ICRC July/2023): second knee found, both before and after slopes well defined with the 433m AMIGA array!! (see next slides)

AMIGA: Auger Muons and Infill for the Ground Array





Twin analysis & detector efficiency studies



AMIGA Scintillators

WLS fibers: Saint Gobain

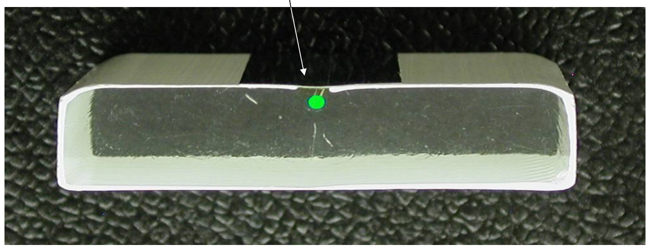
1.2 mm diameter

Scintillator strips are extruded polystyrene doped with fluor (2 types):

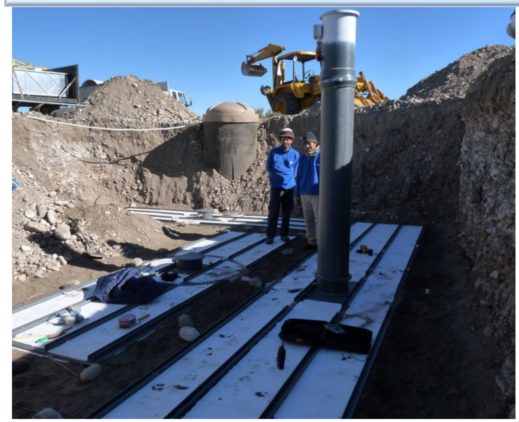
PPO (1%) and POPOP (0.03%)

Co-extruded TiO_2 reflective coating

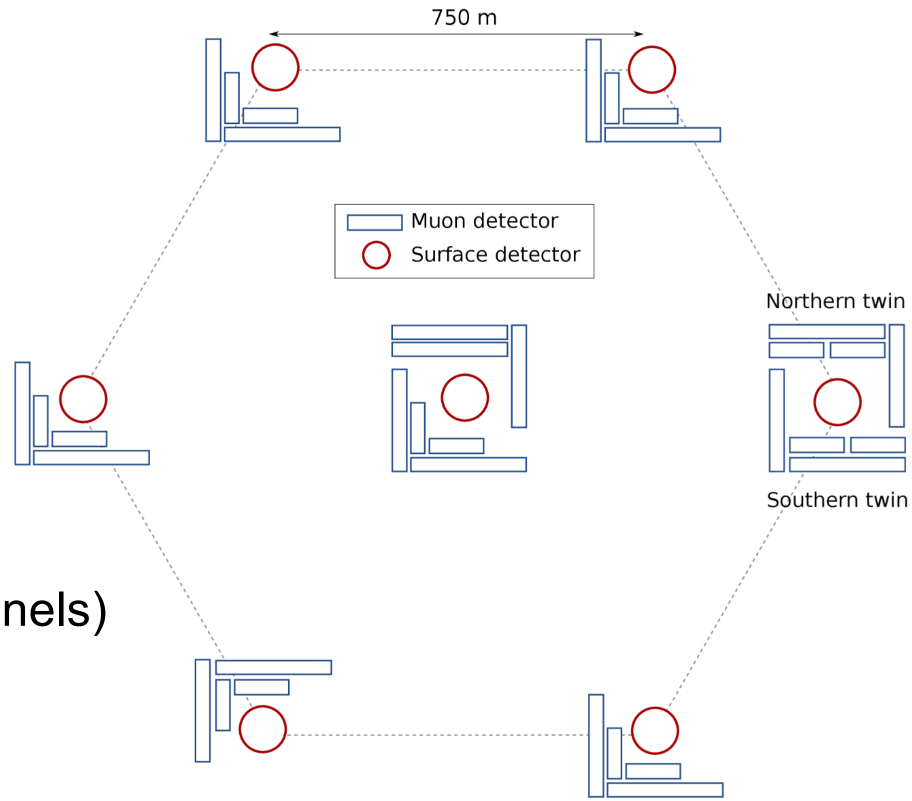
Fiber is glued into groove and covered with reflective foil



Engineering Array of AMIGA UMDs



UMD-750m
23.5 km^2
61x30m^2 Plastic Scintillators
buried 2.3m triggering from WCDs

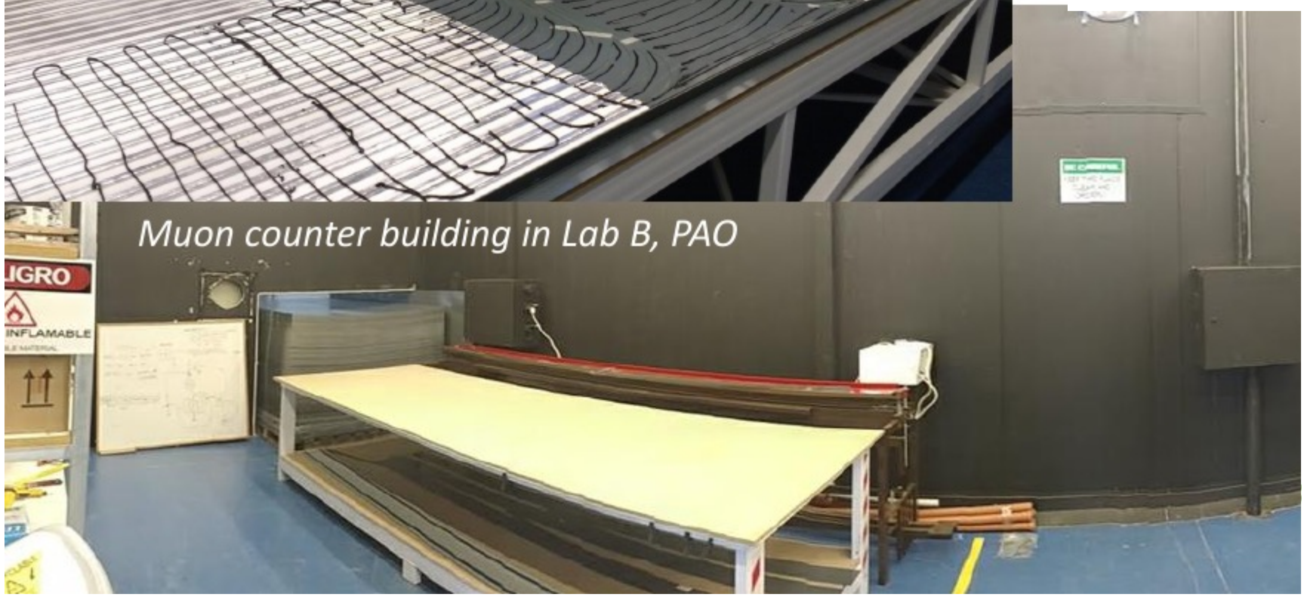


EA served for:
Validation of detection system (End-to-End)
Optimization of optical devices (PMT→SiPM)
Optimization of electronics (ASICs)
Optimization of dynamic range (2 extra analog channels)

Engineering Array built in ITeDA, Production Phase in Malargüe

Production Phase: Now Assembled in Malargüe/POA

New eKits with Binary + ADC channels



Muon counter building in Lab B, PAO

Assembled ACQ board

Assembled Citiroc board

Example of assembled SiPM board

UMD Deployment

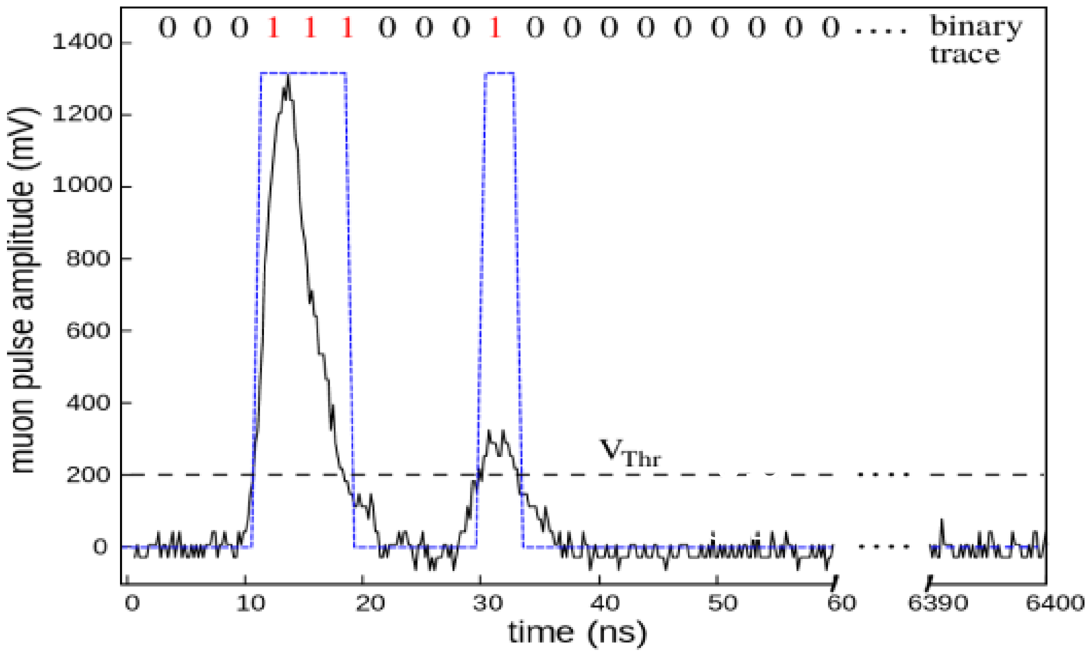
A complete deployment (30m^2)

Current production rate: 2,5 complete equipped (with electronics) stations per month

Binary Traces (away from the shower core)

Highly **segmented** scintillators: 64 per unit

Binary trace PMT

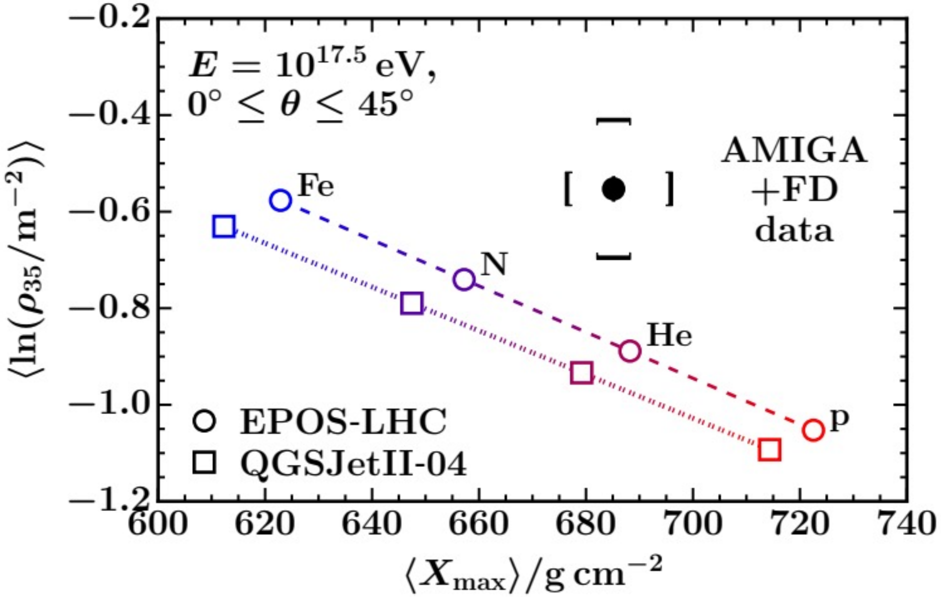


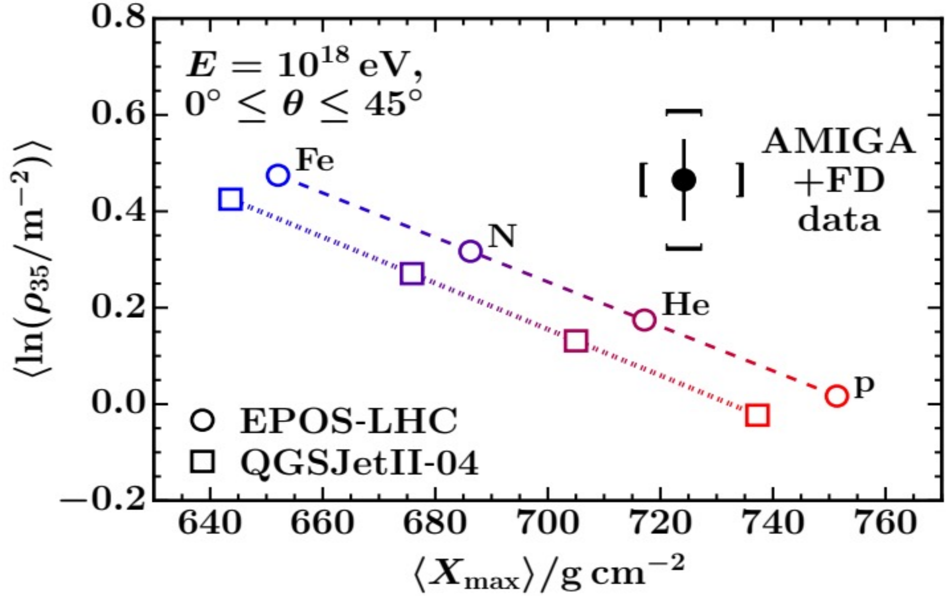
1 muon = "111" or "101" (minimal pattern required)

- **Sampling @ 3.125 ns**
- **Inhibition window: 25 ns**

Muon Deficit: Comparison Simulation with Real Data

Bi-parametric analysis: X_{max}, ρ





Muon deficits in LHC-tuned hadronic models

@$10^{17.5}$ eV

EPOS 38%

QGSJe 50%

$10^{18.0}$ eV

EPOS 38%

QGSJet 53%

HADRONIC MODEL WRONG!

Conclusions Auger

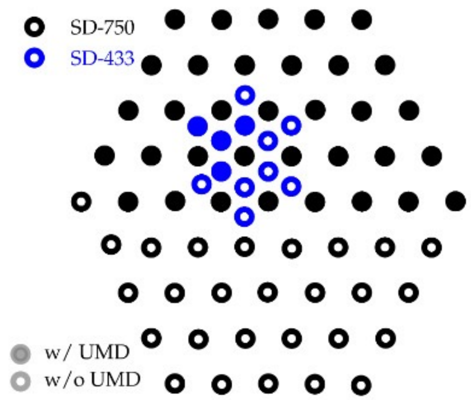
Main issue: Need to disentangle the primary cosmic-ray composition (FD Shower Maximum and Muon Number):

- Charge-particle astronomy with lighter particles (multi-messenger studies)
- Understand Hadronic Interactions

AMIGA chosen by International Review Panel and the International Collaboration In competition with other two International Projects (TOSCA and MARTA) to be part of AugerPrime alongside SSD.

AMIGA conceptual design, prototyping, and production by ITeDA:

- *Simulations, Data Acquisition, and Reconstruction.*
- *Scintillator Modules.*
- *Photosensors (SiPMTs), pulses characterizations.*
- *Telecommunications from detectors to Central Station.*
- *Electronics Design, Commissioning and WCD Interconnection.*
- *Photovoltaic System.*
- *Deployment.*
- *Outreach*
- *Administration and Costs.*

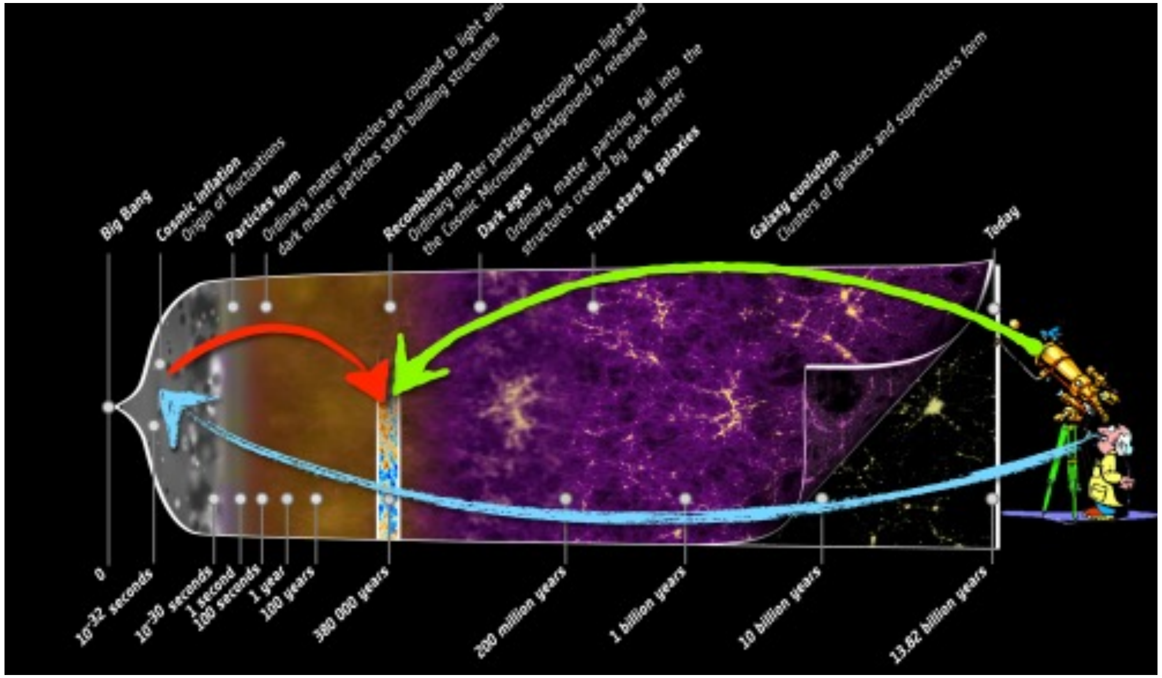


The Pierre Auger Observatory Legacy

The QUBIC Observatory

Science AIM

BIG BANG: Observational Data of Inflationary Universe



QUBIC (“Q & U Bolometric Interferometer for Cosmology”)

QUBIC is an international observational cosmology collaboration. It aims to detect cosmic microwave background radiation (CMB) that may keep traces of primordial gravitational waves from the early universe (10^{-35} seconds after the Big Bang, time of Universal Inflation).
Bolometers are microsensors working at very low temperatures that heat up when detecting the CMB, thus allowing its detection.

Etymologically, bolometer comes from the Greek and means light-beam measurement. When working at temperatures close to absolute zero, they have very little electronic noise, that is, the signal/noise ratio is very good. Another type of light sensors are interferometers that allow the wavelength of the incident light to be determined. What makes QUBIC unique is the union of both technologies: bolometric interferometry, thus allowing low noise and distinguishing from other polluting signals coming from our galaxy.

The Observatory was inaugurated in November 2022 in Altos Chorillo, Salta.

Q and U are Stokes parameters that describe the polarization state of electromagnetic radiation.

Universal Inflation?

The universe's spatial curvature — a measure of how initially parallel beams of light diverge as they propagate. Our universe is approximately "flat," meaning that parallel lines never meet, apply everywhere. There are infinite possible curvature values that the universe might have had. Alan Guth was inspired to devise a mechanism that forced flatness on the universe. He began developing the inflationary universe paradigm in 1979. When the universe grows by orders of magnitude, any residual spatial curvature left after inflation is negligible.

Guth's paper also explained the uniformity of the universe. Observations show that distant regions of the cosmos have nearly identical amounts of CMB radiation. In the standard Big Bang scenario, these regions had never been close enough to one another for their temperatures to equilibrate. Inflation solved it by allowing for widely separated regions of the universe to have previously been in contact, reaching a single temperature in a much smaller universe prior to inflationary expansion.

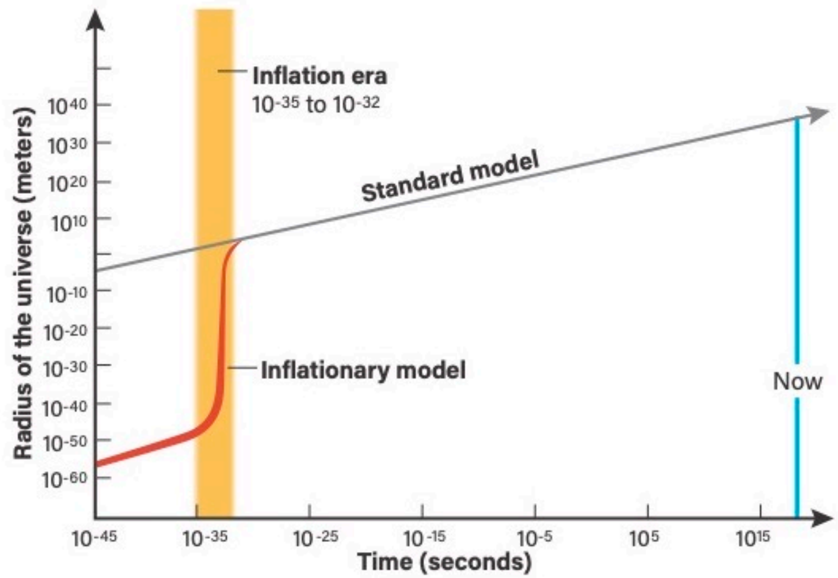
See talks in this School for further details (Mirbabayi).

B-Modes

By the early 1990s, cosmologist showed that, if inflation took place, it would inevitably result in primordial gravitational waves. In the early 1980s, Russian physicist Alex Polnarev predicted these gravitational waves would distort space-time in a way that induces specific patterns/polarization in the light of the CMB. This polarization was later called B-modes (obtained from Q and U Stokes Parameters)

If detected, B-modes would confirm inflation.
Definitive evidence remains elusive.

The search continues



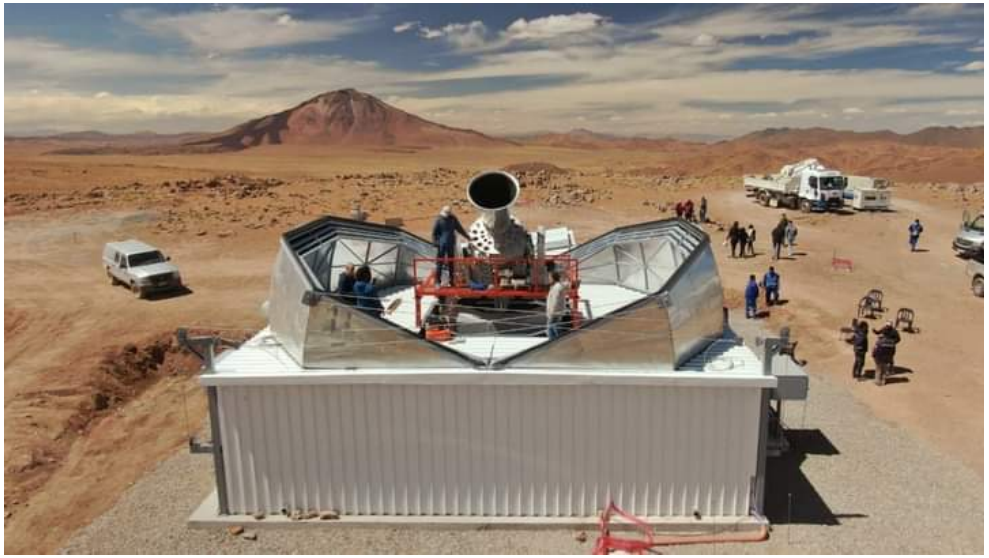
At the end of the Inflation Era, the Universe expanded several orders of magnitude.

QUBIC Site


QUBIC
QU Bolometric Interferometer for Cosmology
QUBIC Site: Alto Chorrillos
near San Antonio de los Cobres
(Salta, Argentina)
Vulcano Tuzgle
QUBIC
LLAMA
Road 51
Gazoduct + Optical fiber

QUBIC Observatory

The QUBIC International Observatory aims to detect cosmic microwave background radiation (CMBR) which contains information on the primordial gravitational waves of the early universe. The first detection module was installed in Altos Chorillo, Salta in November 2022.



Telescope mount, designed and built in Argentina
Accuracy 0.01°

QUBIC Bolometer in the Observatory

INTERNATIONAL COLLABORATION
Argentina, Francia, Italia, Ireland,
United Kingdom, United States

2021:Telescope Shelter & Integration Lab

Telescope shelter. Structure designed by ITeDA Mendoza in Regional CNEA-Mendoza.
Based on the LIDAR shelter of the Auger Observatory
Revised by Dept. Technology of Composite Materials- GDTPE
Inaugurated in Nov 2022

Integration Laboratory in the Regional NorOeste– CNEA, Salta (330 m^2) All detection systems are and will be integrated here before transferring them to the Observatory

Design and construction of the Integration Laboratory and construction of the telescope shelter by the Technical Assistance Department Technical – CNEA- Córdoba – GEMP

QUBIC Four-Party Agreement: Signed 22/Dec/2017

October 2021: Integration Laboratory Inauguration @ RNO-CNEA

Integration Laboratoy Inaugurationn QUBIC – Ciudad Salta

Sr. Ministro de Ciencia, Tecnología e Innovación de la Nación, Lic. Daniel Filmus,

Sr. Ministro de Educación, Cultura, Ciencia y Tecnología de la Provincia de Salta, Mag. Matias Canepa,

Sra. Presidenta de CNEA, Dra Adriana Serquis

Sra. Presidenta del CONICET, Dra. Ana Franchi,

Unveiling Commissioning plate

Buildings

Integration Laboratory, Salta

Central Station, San Antonio de los Cobres, to be shared with LLAMA

ITeDA New Cryogenic Laboratory

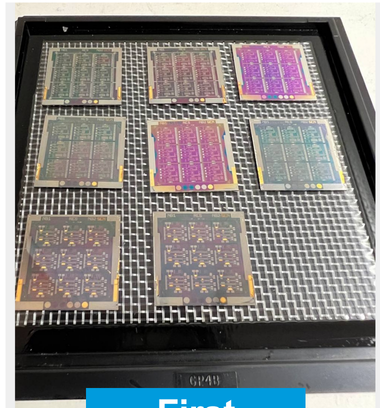
New cryostat laboratory to test sensors with temperatures between 50-300 mK with all relevant electronics. Working together in CNEA with KIT (Germany). This equipment is essential to manufacture QUBIC and ANDES cryogenic quantum sensors.

Tasks performed by ITeDA:

i)Site Development; ii) Microfabrication; iii) Electronics, iv) Mount and calibration tower: v) Assembly, testing and calibration; vi) Simulations and data analysis; vii) Customs and transportation

Bluefors LD250
Installed: December 2022

AJA ATC2400 Sputter
Arrival: May 2023

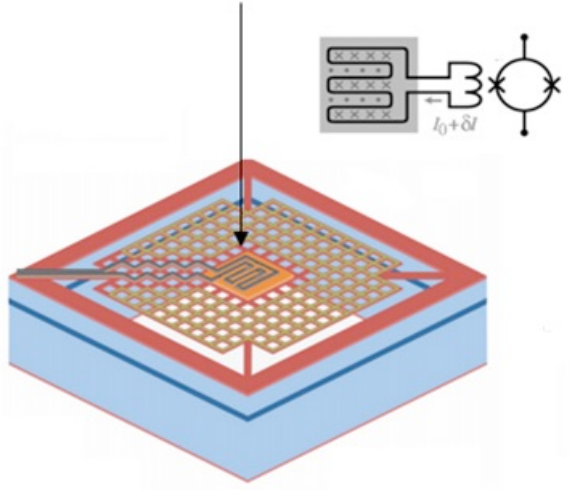


First sensor Prototypes Germany[2]

ITeDA refurbished laboratory for cryostat (cryostat, VNA, sputtering source, etc., 1.5MUSD)

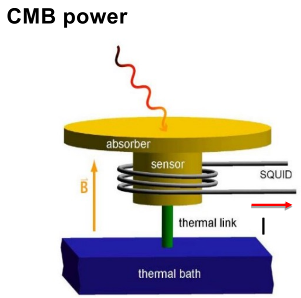
TES: Current Technical Demostrator Sensor

TES: Transition Edge Sensor

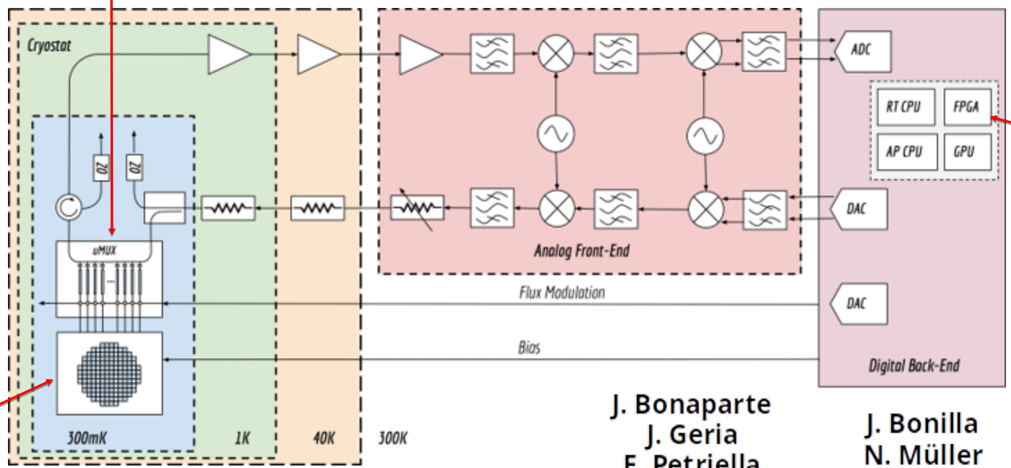


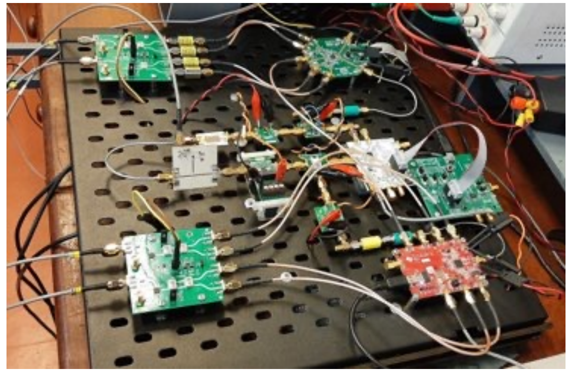
TES: absorbed CMB changes microsensor temperature thus leaving the superconducting phase with a strongly temperature-dependent resistance causing a change in current which is measured.

QUBIC (& ANDES) SENSOR PROTOTYPING

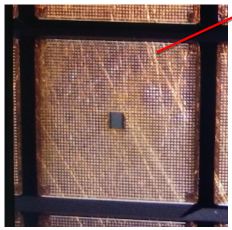


RF-SQUID
μMUX (20 %)





MMBs Readout Electronics (100%)



MMB and absorbers (80 %)

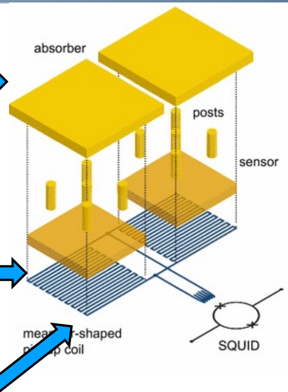
WP workflow and resources

Bolometers	SQUID Multiplexer	Flux signal	RF FrontEnd	Digital BackEnd
J. Bonaparte J. Geria E. Petriella M. Hampel S. Kempf (KIT - IMS)	J. Bonilla N. Müller A. Almela M. Berisso	J. Salum A. Fuster	M. Platino O. Sander (KIT - IPE) M. Garcia	L. Ferreyro

Magnetic MicroBolometers (MMB)Microsensors Fabrication

MMB consists of a broadband planar antenna that passes the signal through a filter in order to split it into two frequency bands (150 and 220 GHz).

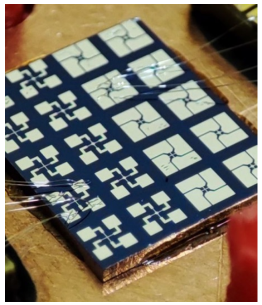
Then, the signal of each band is guided and measured by a MMB. The change produced in the MMB temperature leads to a change of the sensor magnetization, which generates a change of magnetic flux in a pickup coil

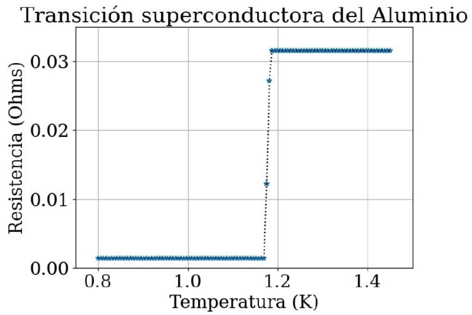


Microfabricación in Clean Room CNEA

Performed in collaboration with the Departamento de Micro y Nano Technology – CAC/CNEA and with CAB/CNEA.

First successful tries of manufacturing superconductors materials (Al sputtered on wafer), made in CNEA





Advantages of MMB over TES

- **Unlike other detectors, the MMB is not significantly affected by the nonuniformity of the thin-film thickness during fabrication processes.**

- **The current TES cryogenic system, due to the heat produced by the TES, can only work for 8hs/day and need to be cooled down the remaining 16hs/day. MMB works only in superconductor mode.**

- **TES have important signal saturation (flux jumps) that disenable measurements. Might worsen when measuring in the whole 130-250GHz band.**

Conclusions QUBIC

Main issue: Search for B-modes produced by primordial gravitational waves during the Inflation Era of the Universe

Integration Laboratory, Site Observatory made, Technical Demonstrator in place. Communication and Calibration Tower to be built

Cryogenic Quantum Sensors been designed and prototypes manufactured with KIT/Germany

Collaboration and Finance Board need an MoU signed for organization purposes

Tasks internally organized by ITeDA:

- *Site Development.*
- *Microfabrication MMB.*
- *Electronics MMB.*
- *Bolometer mount and calibration tower.*
- *Assembly, testing and calibration of measurement systems.*
- *Simulations and data analysis*
- *Customs and transportation.*
- *Outreach.*

ANDES Laboratory
Agua Negra Deep Experiment Site

At 1,700 m below the earth's surface, only a few particles are capable of penetrating the rocky layers, allowing them to be studied, without interference and with great precision (neutrinos, dark matter -80% matter in the universe).

Laboratorio ANDES – Túnel de Agua Negra
Agua Negra Deep Experiment Site

Where are underground laboratories built?

In mines:

- *advantage*

  may be built at any moment

- *disadvantages*

  interference with the mine.

  difficult and expensive access

In tunnels:

- *advantage*

  much easier access and operation

- *disadvantage*:

  can only be built simultaneously with the tunnel

ANDES Laboratory: El Túnel de Agua Negra

Bioceanic Corridor for Regional Integration

Commercial port in the Pacific ocean for Asia (China, India, Japan, …)

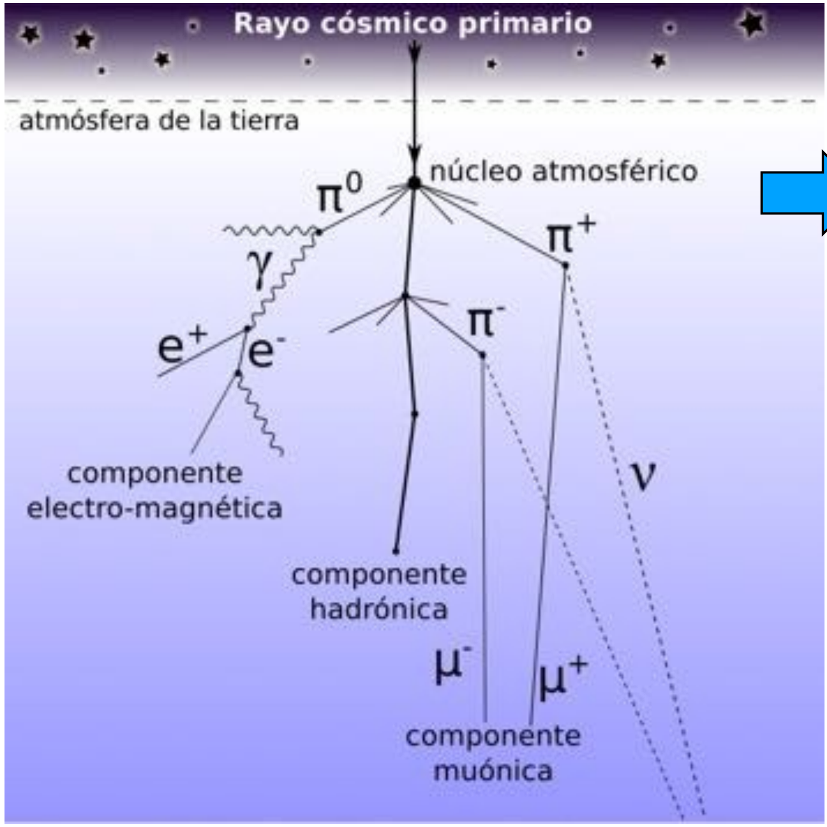
1.700 m rock (shielding)

2 tunnels, 12m each, 60m one from another, 14 km

ANDES Laboratory (40 MUSD)

Agua Negra Tunnel,
San Juan/Argentina – Coquimbo/Chile,
1.500 MUSD, IDB funds approved

Noice: Cosmic Rays



Impinging over a 1 m^2 at ground level every day:

- 10^8 muons
- 10^8 gammas/electrons/positrons
- 10^6 neutrons
- 10^{-3} neutrinos
- 10^{-7} supernova neutrinos
- Maybe 100 dark matter particles

} Weakly Interacting

Eliminate these particles

Underground Laboratory Needed!

ANDES Laboratory

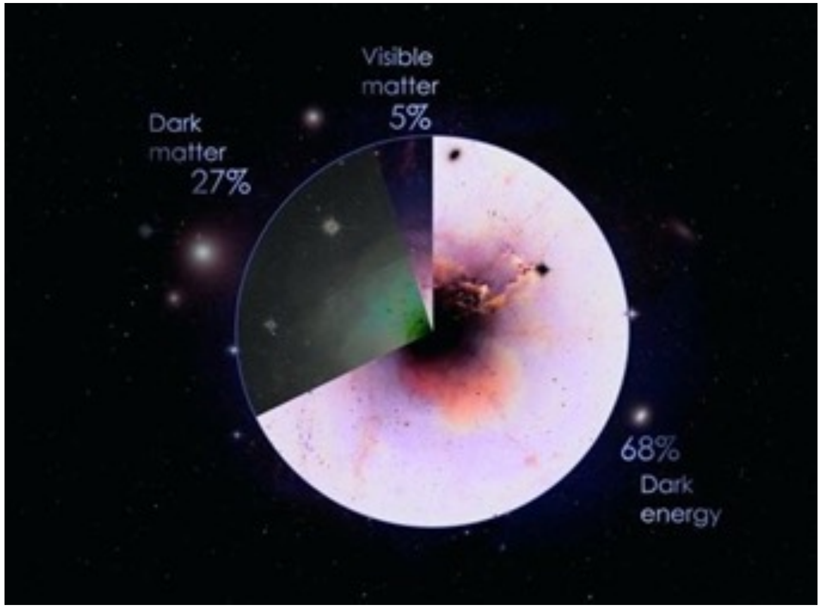
1) Astrophysics

1.1) Neutrino physics:

- **Double Beta Decay (Dirac vs. Majorana)**
- **Neutrino mass (beyond standard model)**
- **Solar Neutrinos**
- **GeoNeutrinos**
- **New Neutrinos?**
- **Do Neutrinos violate CP symmetry?**

1.2) Dark Matter

- **Time Modulation**
- **New Technologies**



2) Biology

Cellular Mutation

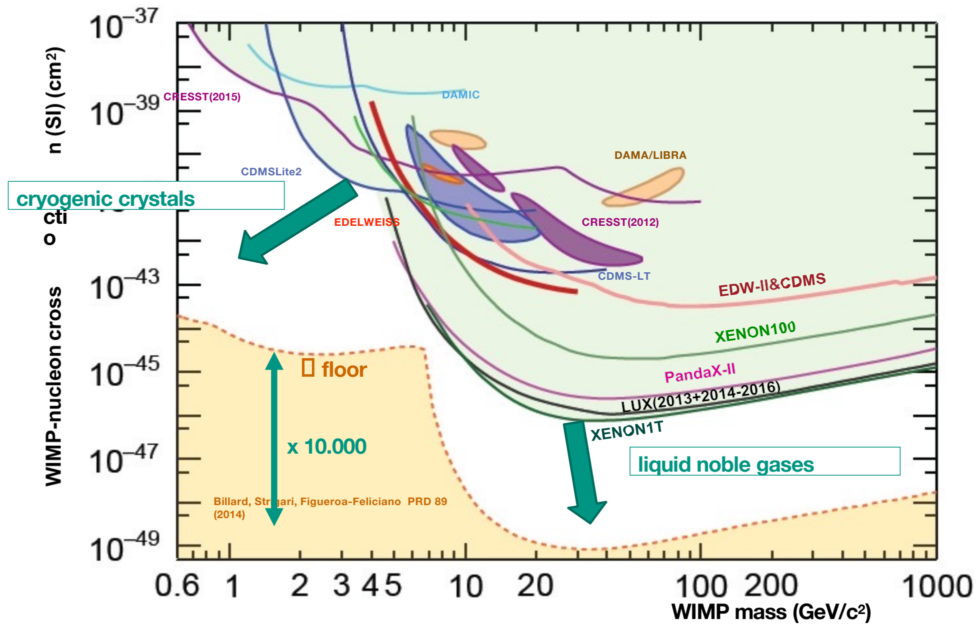
3) Geoscience

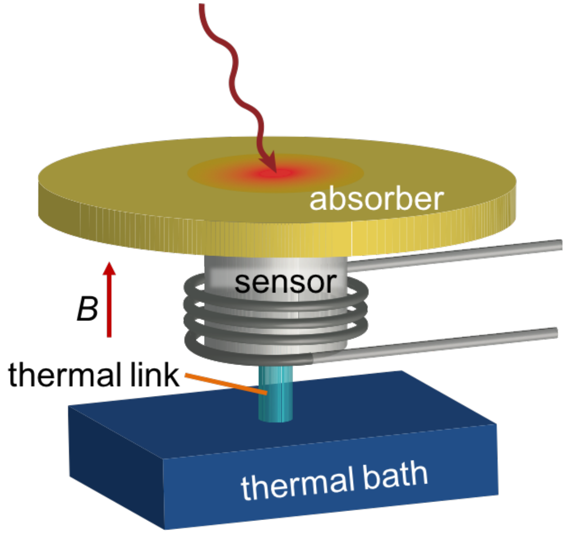
seismography; thermochronology; new materials; geodynamic model, lithographic mapping;... Geoactive region

4) Nuclear Astrophysics

- **Nucleosynthesis of early universe elements and other objects (very low cross-sections charged-particle nuclear reactions of astrophysical interest)**

Low Mass Dark Matter Prototypes





Cryogenic Quantum Detectors

See next slide

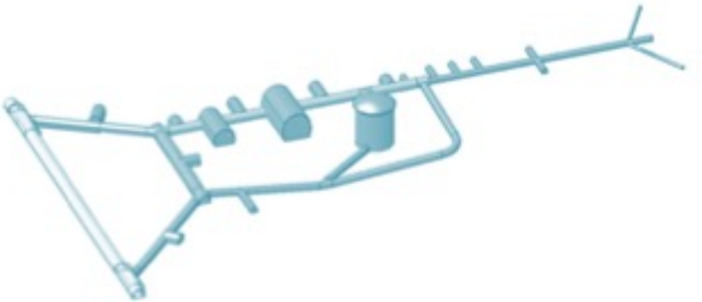
The neutrino floor is a theoretical lower limit on WIMP-like dark matter models that are discoverable in direct detection experiments: dark matter signals become hidden underneath a remarkably similar-looking background from neutrinos.

ANDES Laboratory

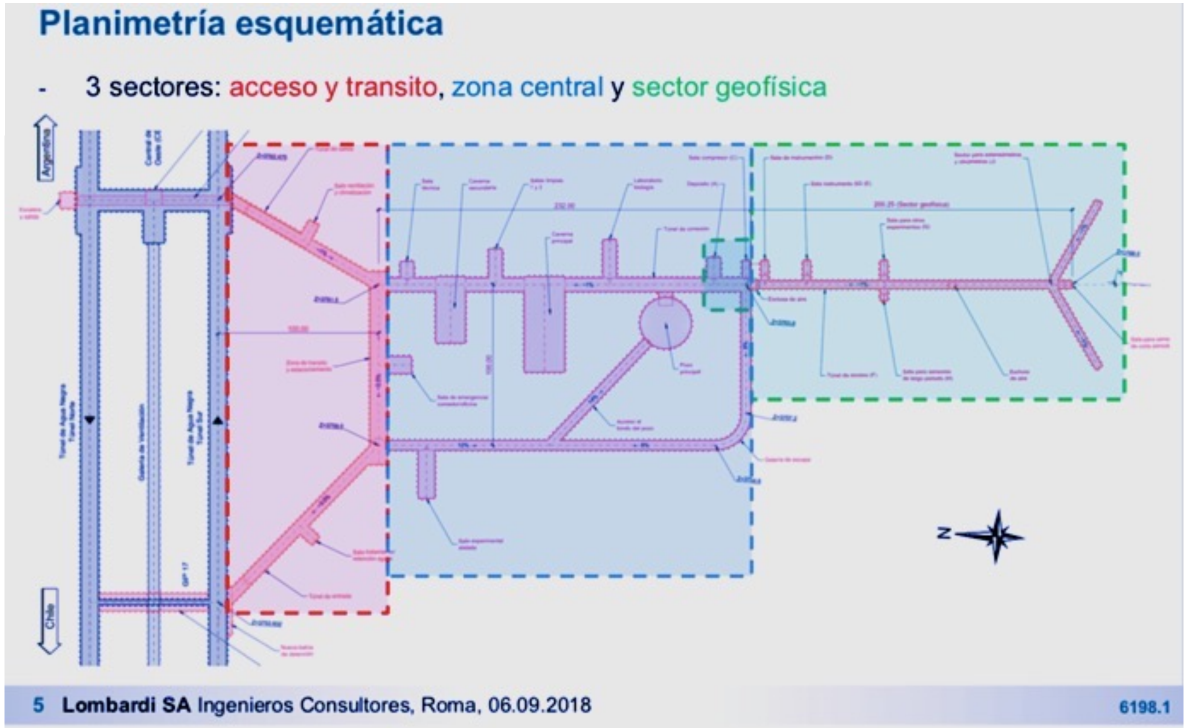
Bienvenida Congreso Internacional ANDES
(Junio 2017, Buenos Aires)
Presidente CNEA O.Calzetta, Ministro Infraestructura San Juan Ing. J.C. Ortiz Andino, Organizador A. Etchegoyen , Ministro MinCyT L. Barañao, Presidente INFN F. Ferroni, Rector UNSAM C. Ruta.

Bienvenida Congreso Internacional GeoCiencias ANDES
(November 2018, San Juan)
Subsecretaria de CyT Nación P. Nahirñac, Ministro Infraestructura San Juan J.C. Ortiz Andino, Gobernador S. Uñac, Coordinador Técnico EBITAN A. Zini, Representantes INFN G. Paparo y G. Saccorotti

ANDES Layout



Project Basic Engineering , Lombardi 2018



Paid by San Juan Government , 520.000 USD. Ready to enter in the call for tenders – see next slide.

Institutional Backing

CONVENIO CUATRIPARTITO PARA LA EJECUCIÓN DEL PROGRAMA INTERINSTITUCIONAL DE DESARROLLO DEL PROYECTO LABORATORIO INTERNACIONAL ANDES

República Argentina, a los 12 días del mes de ABRIL de 2018.

Dr. S. M. UÑAC Gobierno de la Provincia de San Juan	Dr. J. L. S. BARAÑAO Ministerio de Ciencia, Tecnología e Innovación Productiva
Lic. O. CALZETTA LARRIEU Comisión Nacional de Energía Atómica	Dr. H. A. CECCATTO Consejo Nacional de Investigaciones Científicas y Técnicas

EL GOBERNADOR DE LA PROVINCIA

DECRETA:

ARTICULO 1 ⁰ : Ratifíquese en todas sus partes el Convenio de Transferencia de Fondos, celebrado entre el Gobierno de la Provincia de San Juan, por una parte, representado por el Sr. Gobernador Dr. Sergio UÑAC y el Centro Latinoamericano de Física, por otra parte, representado por el Sr. Coordinador de su Unidad ANDES, Dr. Xavier BERTOU, suscripto a los 10 días del mes de Julio de 2018, y su Anexo, Contrato suscripto entre el Centro Latinoamericano de Física y la Consultora Lombardi S.A., que forman palte del presente Decreto.

ARTICULO 2 ⁰ : Apruébese un gasto por la suma de PESOS QUINIENTOS VEINTE MIL DOLARES ESTADOUNIDENSE CON 00/100 (USD 520.000,00), a fin de realizar la conversión a Pesos Argentinos, se utiliza el tipo de cambio vendedor del Banco Nación

CONVENIO ESPECÍFICO EN ASTROPARTÍCULAS

Entre la COMISIÓN NACIONAL DE ENERGÍA ATÓMICA, en adelante denominada "CNEA", representada en este acto por su Presidente Lic. Osvaldo CALZETTA LARRIEU, por una parte, y el INSTITUTO NACIONAL DE FÍSICA NUCLEAR, en adelante "INFN", representada por su Presidente Prof. Fernando FERRONI, por la otra, acuerdan celebrar el presente CONVENIO ESPECÍFICO encuadrado dentro del MEMORANDO DE ENTENDIMIENTO CIENTÍFICO, en adelante MoU, firmado entre las partes el 15 de noviembre de 2015 que se regirá por las siguientes cláusulas.

Bariloche, República Argentina, a los 10 días del mes de mayo del año 2017.

60,000 €/año total

Lic. Osvaldo CALZETTA LARRIEU Presidente CNEA	Prof. Fernando FERRONI Presidente INFN

Latin America Interest

LASF4RI

Latin American Strategy Forum for Research Infrastructure

Developing a strategy to strengthen Latin American Scientific Collaborations and their impact.

2020: LASF4RI: 10 Recommendations for the Scientific Development of Latin America

→ ANDES in the List 4 Priority Projects

ANDES Laboratory

Basic idea: dark matter interacts with a nucleus, transferring energy to it, and it is then measured. The idea is to build large detectors with low noise (ban other particles), for example Xenon1t, 1 ton of liquid xenon.

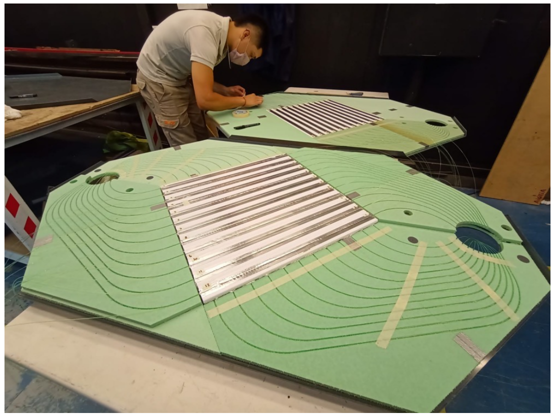
The secret to innovative and frontier science is the measurement system; the technology applied.

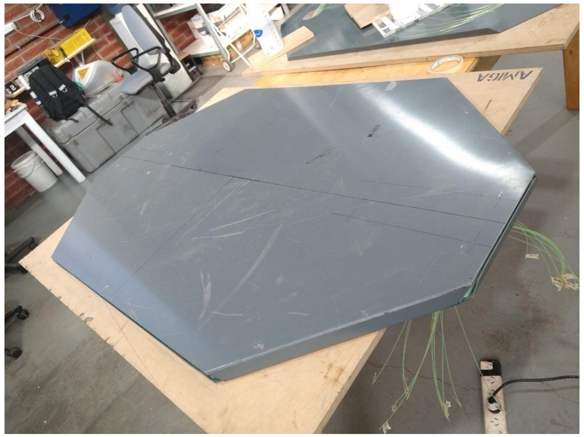
In order to improve signal/noise, muons need to be vetoed.

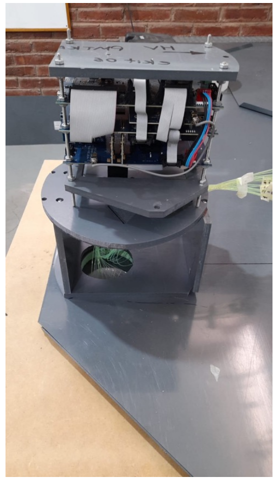
XENON1T

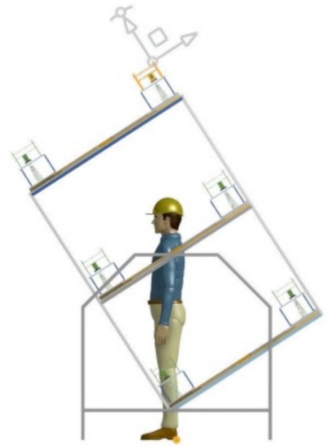
Prototypes: Muon Veto Detectors

The muons must be detected and eliminated so as not to confuse them with the signal one wants to detect (neutrinos, dark matter). We have built two muon telescopes, based on the AMIGA design. Each telescope has three detectors with two orthogonal planes each (4 x 4 cm2 pixels).









Muon Veto Telescopes

The three x-y detector planes covered with PVC are seen. In the image, tubes are where the electronics go.

The detectors are installed in the aluminium structure seen behind: top, middle and bottom. The structure can be translated and tilted in order to measurement in different directions of arrival of the muon.

They will be installed in August at the Casposo/San Juan mine and at University La Serena/Coquimbo/Chile.

The authorities at Mina Casposo have already given clearance to install the telescope. The mine has been visited and the place chosen at 300m deep.

Conclusions ANDES

Main issue: search for Dark Matter and Neutrino Properties

Muon Veto Telescopes built for Mina Casposo/San Juan and Universidad La Serena/Coquimbo

Cryogenic Quantum Sensors been designed and prototypes manufactured with KIT/Germany

Embryo tasks being organized between ITeDA and CAB/Arg and Univ. Valparaíso and La Serena/Chile

Tasks between Argentina and Chile:

- *Detector installations in Mina Casposo y Univ. La Serena*
- *Microfabrication MMC*
- *Simulations and data analysis*
- *Customs and transportation.*
- *Outreach*

OUTREACH

TECNÓPOLIS 2023

Tecnópolis is a mega-exhibition of science, technology, industry and art, based in Argentina, and the largest in Latin America, which takes place as of July each year (kick-off in 2011).

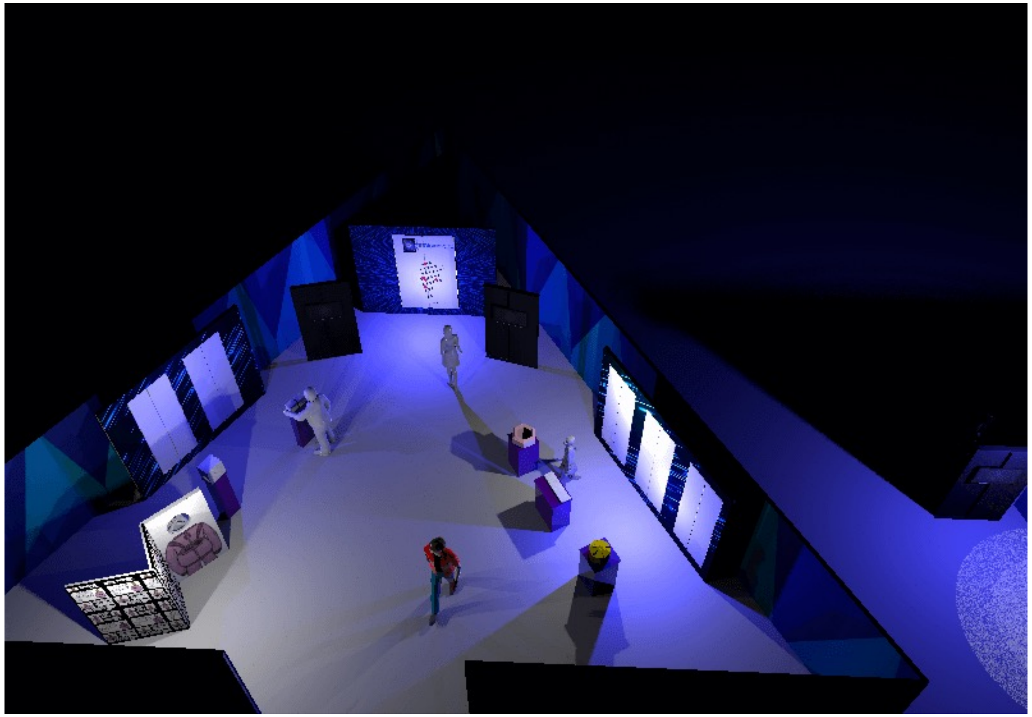
Central Stations

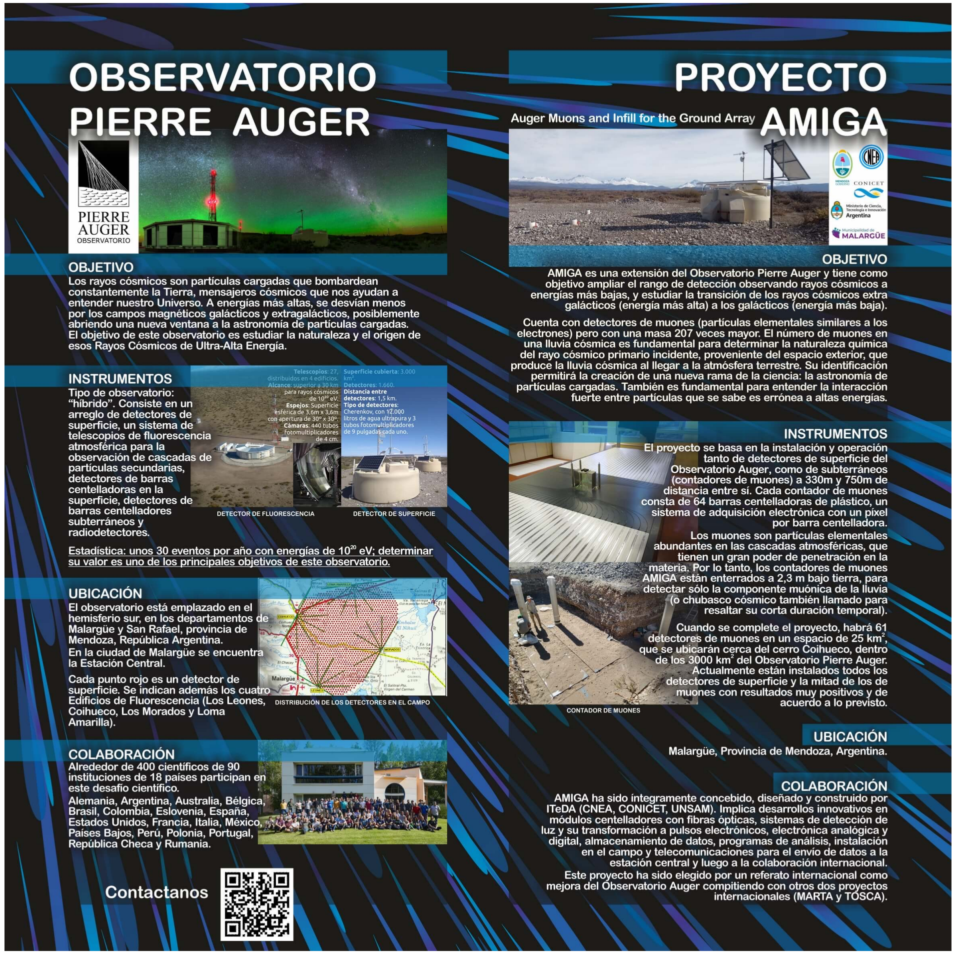
- **Two ANDES support Institutes, one in San Juan (see below) or another in La Serena**
- **Strong interaction with local universities**
- **Outreach: Visitors Centre, Education**

The Ministry of Science, Technology and Productive Innovation, the National Atomic Energy Commission and the National Council for Scientific and Technical Research undertake to promote the creation of an Institute of excellence in the Province of San Juan, oriented towards science and technology relevant to the ANDES Laboratory and its enabling technologies, with international HR training.

Signed by Gov. San Juan, MinCyT, CNEA, and CONICET

Tecnópolis





OBSERVATORIO PIERRE AUGER
PIERRE AUGER OBSERVATORIO
OBJETIVO
Los rayos cósmicos son partículas cargadas que bombardean constantemente la Tierra, mensajeros cósmicos que nos ayudan a entender nuestro Universo. A energías más altas, se desvían menos por los campos magnéticos galácticos y extragalácticos, posiblemente abriendo una nueva ventana a la astronomía de partículas cargadas. El objetivo de este observatorio es estudiar la naturaleza y el origen de esos Rayos Cósmicos de Ultra-Alta Energía.
INSTRUMENTOS
Tipo de observatorio: "híbrido". Consiste en un arreglo de detectores de superficie, un sistema de telescopios de fluorescencia atmosférica para la observación de cascadas de partículas secundarias, detectores de barras centelladoras en la superficie, detectores de barras centelladores subterráneos y radiodetectores.
Telescopios: 27, distribuidos en 4 edificios. Alcance: superior a 30 km para rayos cósmicos de 10²⁰ eV. Espejos: Superficie esférica de 3,6m x 3,6m con apertura de 30° x 30°. Cámaras: 440 tubos fotomultiplicadores de 4 cm.
Superficie cubierta: 3.000 km². Detectores: 1.660. Distancia entre detectores: 1,5 km. Tipo de detectores: Cherenkov, con 12.000 litros de agua ultrapura y 3 tubos fotomultiplicadores de 9 pulgadas cada uno.
DETECTOR DE FLUORESCENCIA
DETECTOR DE SUPERFICIE
Estadística: unos 30 eventos por año con energías de 10^{20} eV; determinar su valor es uno de los principales objetivos de este observatorio.
UBICACIÓN
El observatorio está emplazado en el hemisferio sur, en los departamentos de Malargüe y San Rafael, provincia de Mendoza, República Argentina.
En la ciudad de Malargüe se encuentra la Estación Central.
Cada punto rojo es un detector de superficie. Se indican además los cuatro Edificios de Fluorescencia (Los Leones, Coihueco, Los Morados y Loma Amarilla).
DISTRIBUCIÓN DE LOS DETECTORES EN EL CAMPO
COLABORACIÓN
Alrededor de 400 científicos de 90 instituciones de 18 países participan en este desafío científico.
Alemania, Argentina, Australia, Bélgica, Brasil, Colombia, Eslovenia, España, Estados Unidos, Francia, Italia, México, Países Bajos, Perú, Polonia, Portugal, República Checa y Rumania.
Contactanos
PROYECTO AMIGA
Auger Muons and Infill for the Ground Array
CONICET
Ministerio de Ciencia, Tecnología e Innovación Argentina
Municipalidad de MALARGÜE
OBJETIVO
AMIGA es una extensión del Observatorio Pierre Auger y tiene como objetivo ampliar el rango de detección observando rayos cósmicos a energías más bajas, y estudiar la transición de los rayos cósmicos extra galácticos (energía más alta) a los galácticos (energía más baja).
Cuenta con detectores de muones (partículas elementales similares a los electrones) pero con una masa 207 veces mayor. El número de muones en una lluvia cósmica es fundamental para determinar la naturaleza química del rayo cósmico primario incidente, proveniente del espacio exterior, que produce la lluvia cósmica al llegar a la atmósfera terrestre. Su identificación permitirá la creación de una nueva rama de la ciencia: la astronomía de partículas cargadas. También es fundamental para entender la interacción fuerte entre partículas que se sabe es errónea a altas energías.
INSTRUMENTOS
El proyecto se basa en la instalación y operación tanto de detectores de superficie del Observatorio Auger, como de subterráneos (contadores de muones) a 330m y 750m de distancia entre sí. Cada contador de muones consta de 64 barras centelladoras de plástico, un sistema de adquisición electrónica con un píxel por barra centelladora.
Los muones son partículas elementales abundantes en las cascadas atmosféricas, que tienen un gran poder de penetración en la materia. Por lo tanto, los contadores de muones AMIGA están enterrados a 2,3 m bajo tierra, para detectar sólo la componente muónica de la lluvia (o chubasco cósmico también llamado para resaltar su corta duración temporal).
Cuando se complete el proyecto, habrá 61 detectores de muones en un espacio de 25 km², que se ubicarán cerca del cerro Coihueco, dentro de los 3000 km² del Observatorio Pierre Auger. Actualmente están instalados todos los detectores de superficie y la mitad de los de muones con resultados muy positivos y de acuerdo a lo previsto.
CONTADOR DE MUONES
UBICACIÓN
Malargüe, Provincia de Mendoza, Argentina.
COLABORACIÓN
AMIGA ha sido íntegramente concebido, diseñado y construido por ITeDA (CNEA, CONICET, UNSAM). Implica desarrollos innovativos en módulos centelladores con fibras ópticas, sistemas de detección de luz y su transformación a pulsos electrónicos, electrónica analógica y digital, almacenamiento de datos, programas de análisis, instalación en el campo y telecomunicaciones para el envío de datos a la estación central y luego a la colaboración internacional.
Este proyecto ha sido elegido por un referato internacional como mejora del Observatorio Auger compitiendo con otros dos proyectos internacionales (MARTA y TOSCA).

Fundación Ahuekna

ITeDA carries out the management activities of the projects under its responsibility through a private law organization, the "AHUEKNA Foundation, Research and Technological Development". The foundation was established by three founding partners, namely, the government of the Province of Mendoza, the Municipality of the city of Malargüe and CNEA. AHUEKNA is also responsible for the administration of the funds granted to the Pierre Auger Observatory by the International Collaboration. AHUEKNA is an "importer/exporter" authorized by Customs/AFIP. Has the authorization of the MINCyT to import goods and/or inputs for scientific and/or technological research projects with the benefits granted by the ROECyT (Registry of Scientific and Technological Organizations and Entities), with exemption from taxes, levies and import fees, through the issuance of an "Exemption Certificate"

President: Manuel Platino. Imports/Exports Manager: Aníbal Gattone. Science: Alberto Etchegoyen.
Regulations and laws: Dr. (Lawyer) Ruben Denza. Accounting Head: Accountant Javier Yturre.

Ahuekna´s Budget

1. **As Auger Observatory Administrator: 1.6 million euros/year.**
2. **Budget from CNEA to ITeDA: 400 KUSD/year (salaries not included).**
3. **Budget from MinCyT to ITeDA, varies, in 2023: 400 KUSD (two last AMIGA scintillator batches).**
4. **Budget from SPU for Double Doctoral Degree: 45 KUSD**
5. **Budget from CONICET: Subsidies varying with time, subsidy to ITeDA´s functioning***
6. **Budget from UNSAM: 35 KUSD (mainly salaries of Double Doctoral Degree Lecturers and PhD Students)**

*** Main contribution from CONICET is to ITeDA´s Technicians salaries and Ph.D. Scholarships**

KIT-UNSAM Double Doctoral Degrees

(Astrophysics and Engineering)

C entro
U niversitario
A rgentino
A lemán

D eutsch-
A rgentinisches
H ochschul-
Z entrum

Karlsruhe Institute of Technology

UNSAM


Binationales Programm zur Förderung deutsch-argentinischer Hochschulnetzwerke

Antrag:
„Kooperation KIT-UNSAM“

Deutsch-Argentinisches Hochschulzentrum (DAHZ)
Centro Universitario Argentino-Alemán (CUAA)
Bonn/Buenos Aires, März 2011

Programa Binacional para el Fortalecimiento de Redes Interuniversitarias Argentino-Alemanas

Moción:
“Cooperación KIT-UNSAM”

Centro Universitario Argentino-Alemán (CUAA)
Deutsch-Argentinisches Hochschulzentrum (DAHZ)
Buenos Aires/Bonn, Marzo de 2011

Specific Cooperation Agreement (October 2014)

Beginning DDAp: 2015

First two German Students in ITeDA

First Argentinean Student in KIT

Foreing PhD students at ITeDA

Johannes HULSMAN (NL)

Gaia SILLI (ITA)

Varada VARMA (IN)

- Double Doctoral Degree in Astrophysics (DDAp) firmado 2013
- Movilidad financiada por DAHZ/CUAA, 67,5k€/año
- Propuesta IRS basada en experiencia con el DDAp

Elementos Centrales

- **Enfoque interdisciplinario:** desde el desarrollo de hardware hasta el análisis de datos
- Ciencia de frontera con **supervisión en cotutela**
- **Cursos estructurados** en temas generales y específicos
- **Al menos dos estadías de 6 meses** en la contraparte
- **Examen de doctorado en conjunto** en una de las Universidades

Doktor in Physik — KIT Karlsruhe Institute of Technology

Doctorado en Astrofísica — UNSAM Universidad Nacional de San Martín

UNSAM
UNIVERSIDAD NACIONAL DE SAN MARTÍN

HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

KIT Karlsruhe Institute of Technology

Research Structures in Argentina

Inauguration of the “Helmholtz International Research School for Astroparticle Physics and Enabling Technologies”

UNSAM, Nov. 20, 2018

Alberto Etchegoyen
Inv. Sup de CNEA y de CONICET
Helmholtz Internatinal Fellow

ITeDA Instituto de Tecnologías en Detección y Astropartícula

CNEA – Ministerio de Energía y Minería

CONICET – Ministerio de Ciencia, Tecnología e Innovación Productiva

UNSAM – Ministerio de Educación

2018 – 9 estudiantes KIT + 9 estudiantes UNSAM. Primeros 2 ingenieros

2023

PhD granted: 15 → Physics: 15

Current Students: 20 → Physics: 12 Engineering: 8

DDAp Review panel. April 2021 → Passed and funded until 2028

HIRSAp midterm review. Nov 2021 → Approved until end 2024

Double Degree PhD Students KIT or URTV

Call for candidates graduated or close to graduation in Physics, Engineering, or Astronomy with strong interest in Astrophysics and Enabling Technologies.

Mobility expenses to KIT (www.auger.org.ar) or University of Roma Tor Vergata (www.qubic.org.ar) are covered (two stays of 6 months).

To apply send CV, analytical certificate of approved subject and a recommendation letter to:

alberto.etchegoyen@iteda.cnea.gov.ar
diego.melo@iteda.cnea.gov.ar (QUBIC candidates)
diego.ravignani@iteda.cnea.gov.ar (Auger candidates)

Other cotutelle agreements (e.g. with Argentinean Universities) are welcome.

Conclusions

Argentina is hosting large physics international projects (Auger, QUBIC y ANDES) from the southern sky

ITeDA has developed a strong collaboration within Auger and it is being extended to QUBIC and ANDES for which Italy has vast experience (criogenics & astrophysics, geo and bioscience.)

The Future: Multi-Messenger studies

1.High Energy Neutrinos (ANDES)
2.High Energy Cosmic Rays (Auger)
3.High Energy Gamma Rays (CTA, SWGO)
4.Gravitational Waves (VIRGO, LIGO)
AND
1. Global CMB experiments (CMB-Stage 4 experiment)

only feasible by large global international collaborations

EVERYBODY WELCOME TO JOIN A PROJECT !!