OBSERVATORIO
PIERRE AUGER

WELCOME TO THE PIERRE AUGER OBSERVATORY!

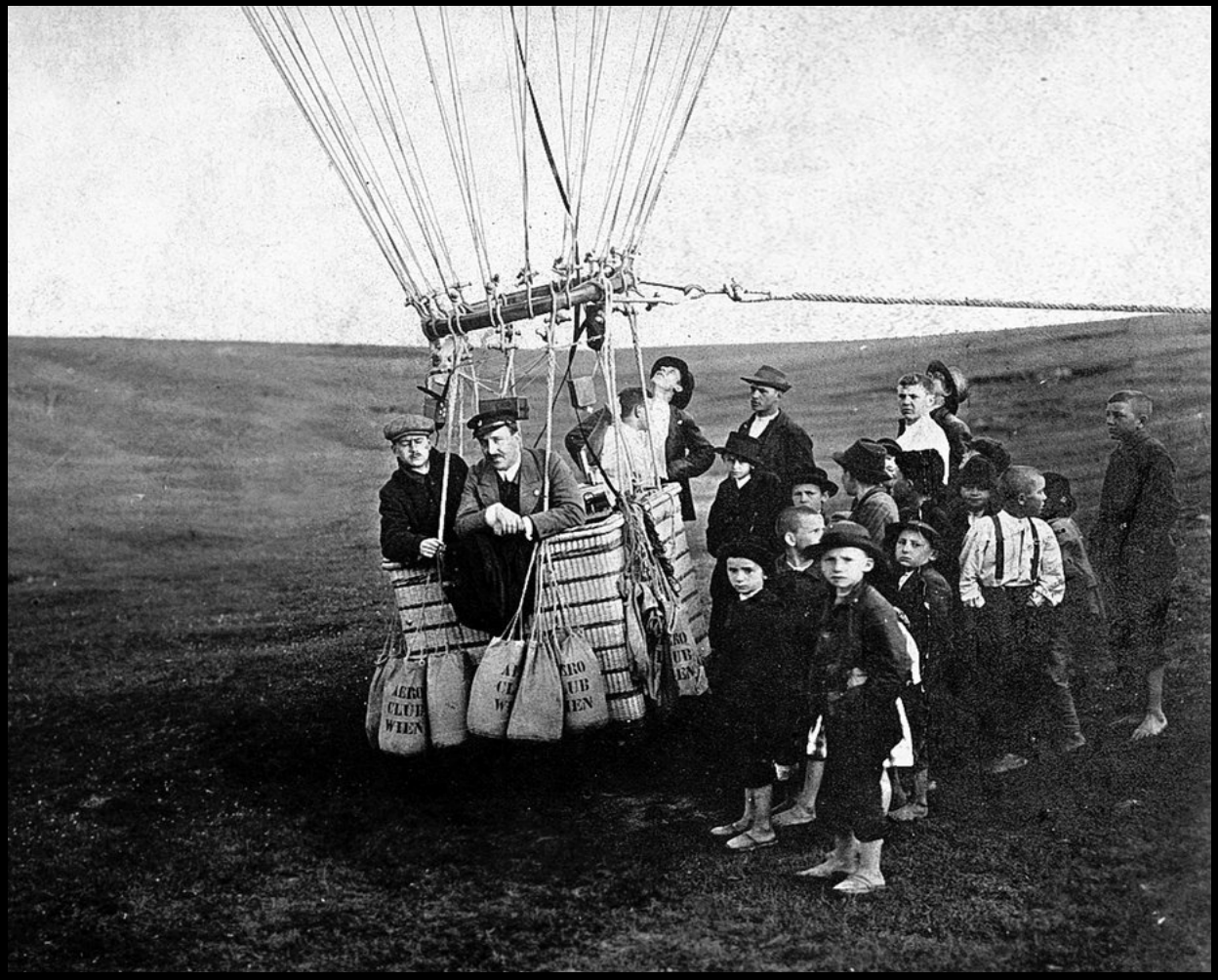
ISAPP, MALARGÜE, 2019

Ingo Allekotte
Project Manager
ingo@cab.cnea.gov.ar

A BIT OF HISTORY

- End of XIX Century: radioactivity known, highly penetrating radiation discovered.
- 1912: Viktor Hess flies up to 5000 m altitude with electroscopes:

DISCOVERY OF COSMIC ORIGIN OF RADIATION!



A BIT OF HISTORY

- 1930's Millikan-Compton debate composition: particles or photons?
  Denomination as “Cosmic Rays” misleading
  CR are mostly charged massive particles.

The New York Times

MILLIKAN RETORTS HOTLY TO COMPTON IN COSMIC RAY CLASH

Debate of Rival Theorists Brings Drama to Session of Nation's Scientists.

THEIR DATA AT VARIANCE

New Findings of His Ex-Pupil Lead to Thrust by Millikan at 'Less Cautious' Work.

"All the News That's Fit to Print."

The New York Times.

LATE CITY EDITION

MILLIKAN RETORTS HOTLY TO COMPTON IN COSMIC RAY CLASH

ROOSEVELT WORKS WITH HOUSE CHIEFS FOR FEDERAL CUTS

Mussolini Will Curb Industrial Output As a Means of Combating Depression

O'BRIEN TO EXTEND REFORM PROGRAM; TAKES OATH TODAY

LEHMAN TAKES OATH PRIVATELY TONIGHT IN CEREMONY HERE

REVELRY TO SPEED OLD YEAR, HAIL NEW

AMAZON WAR ZONE TOUCHES 4 NATIONS

WINTER QUITS POST IN ANTI-KOENIG ROW

HOOVER HITS LUCK, GETS 7-FOOT FISH

A BIT OF HISTORY

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  Denomination as “Cosmic Rays” misleading
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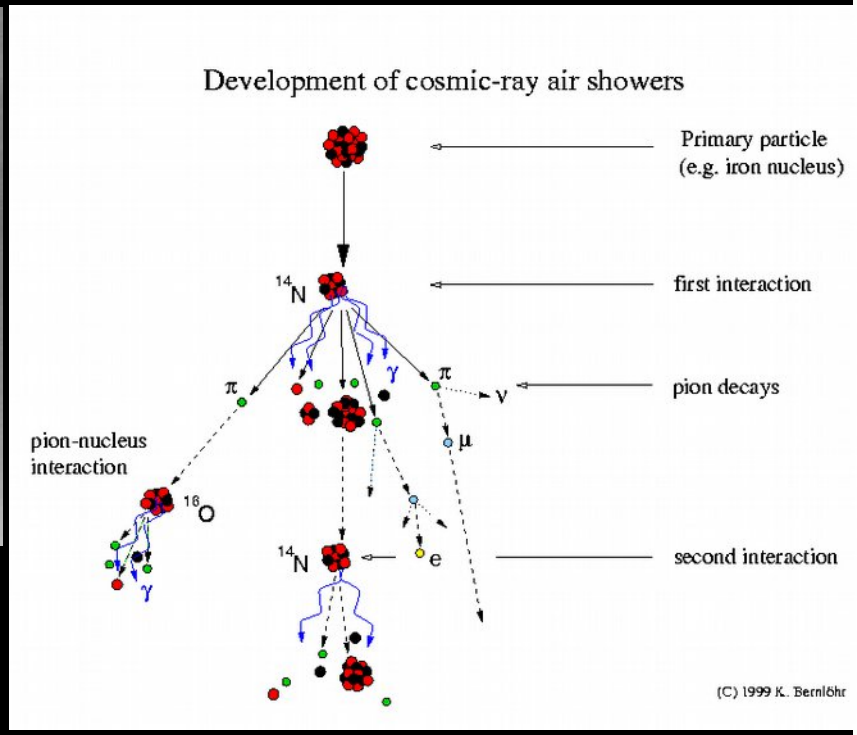
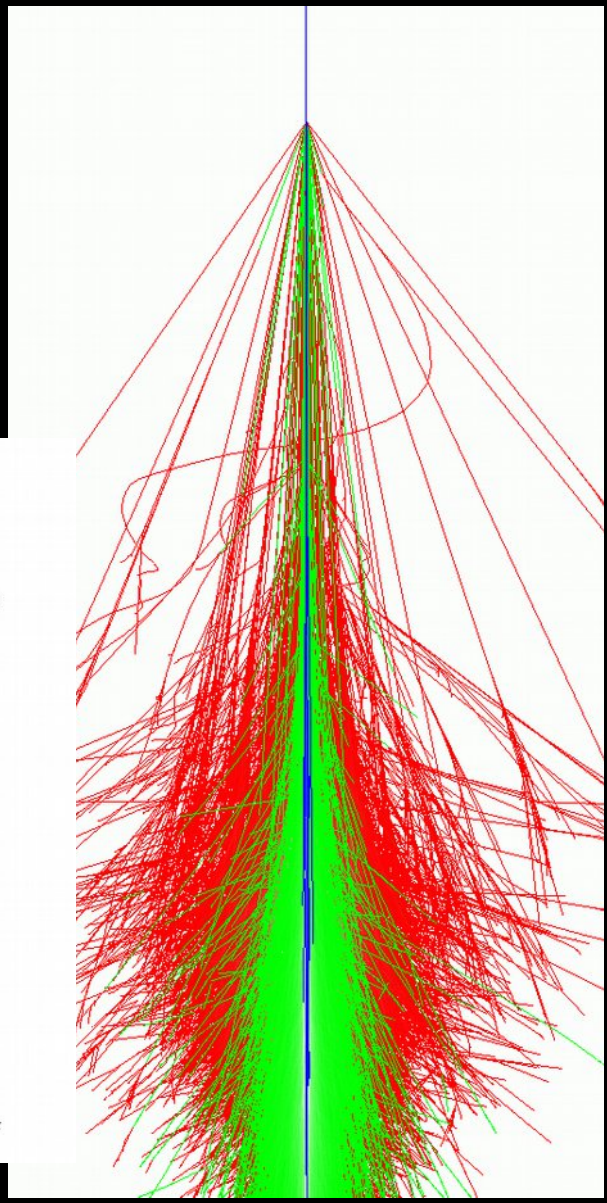
A BIT OF HISTORY

- 1938: Pierre Auger discovers “Extensive Air Showers”.
- Coincidences in Geiger counters
- Shower components:
  - Electrons, positrons, photons
  - Muons
  - Hadrons
- Energy of primary: estimated above 10^{15} eV





A BIT OF HISTORY

- 1950´s: CNEA performs cosmic ray studies in Mendoza, Argentina.
- Photographic emulsions to study particle interactions

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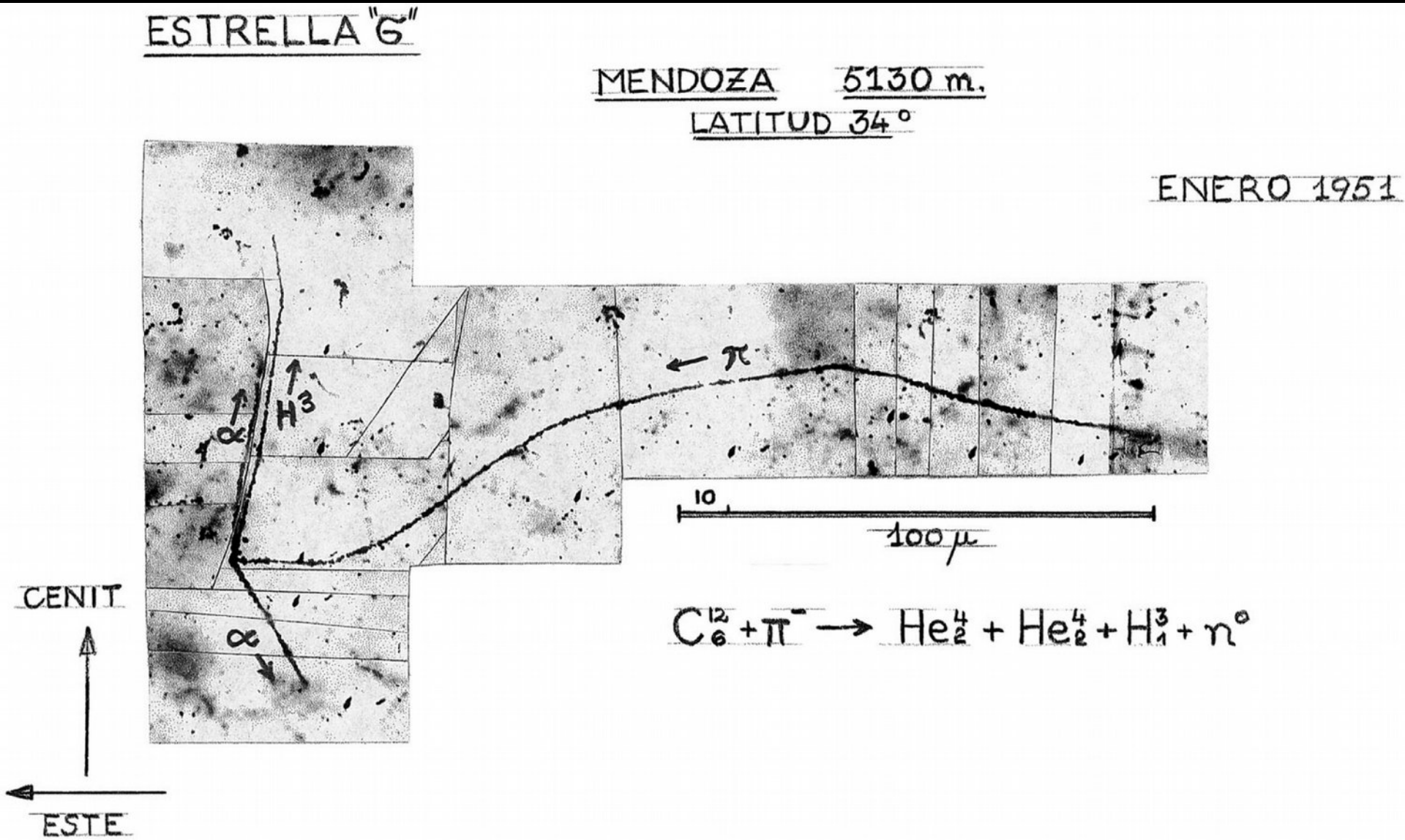
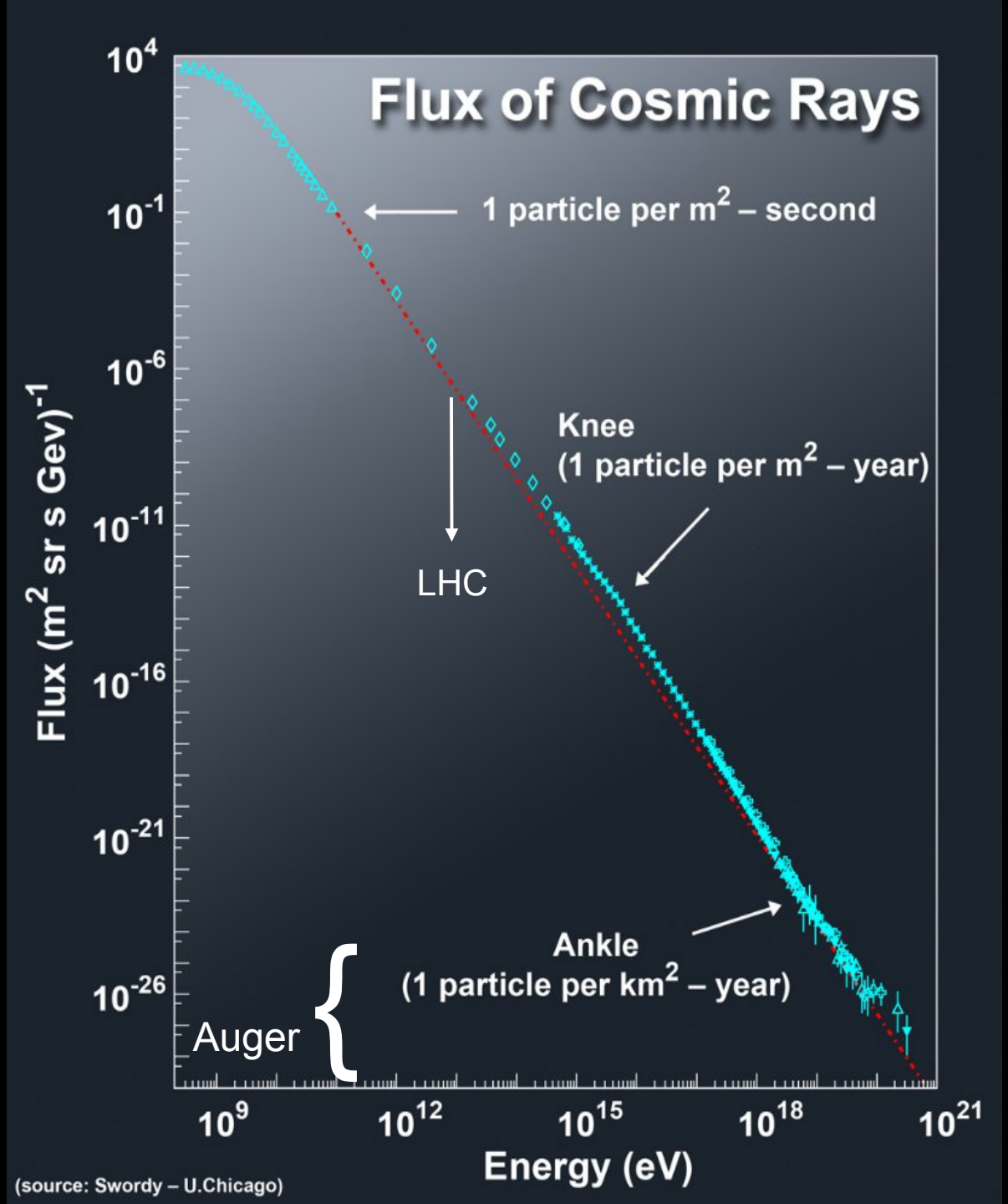



Flux of Cosmic Rays
1 particle per m2 – second
Knee
(1 particle per m2 – year)
LHC
Ankle
(1 particle per km2 – year)
Auger
Flux (m2 sr s Gev)-1
Energy (eV)
10^4
10^-1
10^-6
10^-11
10^-16
10^-21
10^-26
10^9
10^12
10^15
10^18
10^21
(source: Swordy – U.Chicago)

A BIT OF HISTORY

- At “low” energies: satellite experiments to study primary cosmic rays
- At high energies: ground-based experiments:
  - Volcano Ranch (USA)
  - Yakutsk (USSR)
  - Sugar (Australia)
  - Agasa (Japan)
  - Haverah Park (UK)
  - Kascade - KGrande (Germany)
  - Fly's Eye - HiRes - Telescope Array (USA)

Events with $E > 10^{20}$ eV!

GZK cutoff:
interaction with CMBR
propagation?

A BIT OF HISTORY

- Agasa (Japan): scintillator surface detectors
- HiRes: atmospheric fluorescence detectors

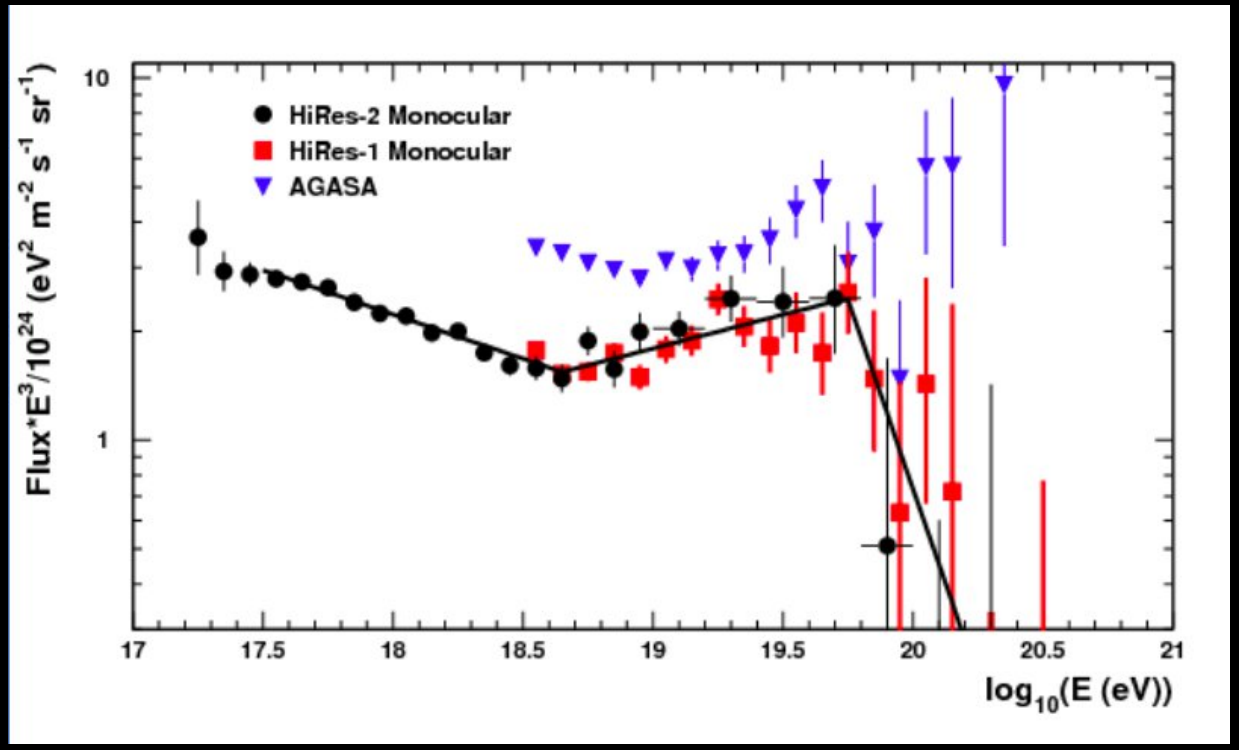
Interaction with CMBR? GZK cutoff?

Origin of UHECRs? UHECR astronomy?

Composition?

Magnetic fields?

New physics?



THE PIERRE AUGER OBSERVATORY
in Malargüe, Argentina

Problems with Ultra-High Energy Cosmic Rays ($E > 10^{18}$ eV):

- **very few! (one per km^2 per CENTURY at $E > 10^{19}$ eV)**
- **sources unknown**
- **source location unknown**
- **propagation not understood**
- **composition unknown**
- **ultra-high energy collissions never studied**
- **unknown unknowns?**

James Cronin, 1931-2016
Chicago University

“THE GIANT ARRAY PROJECT”
(still today, we have GAP-Notes)

1992 - 1995:

To build a 5000 km2 detector

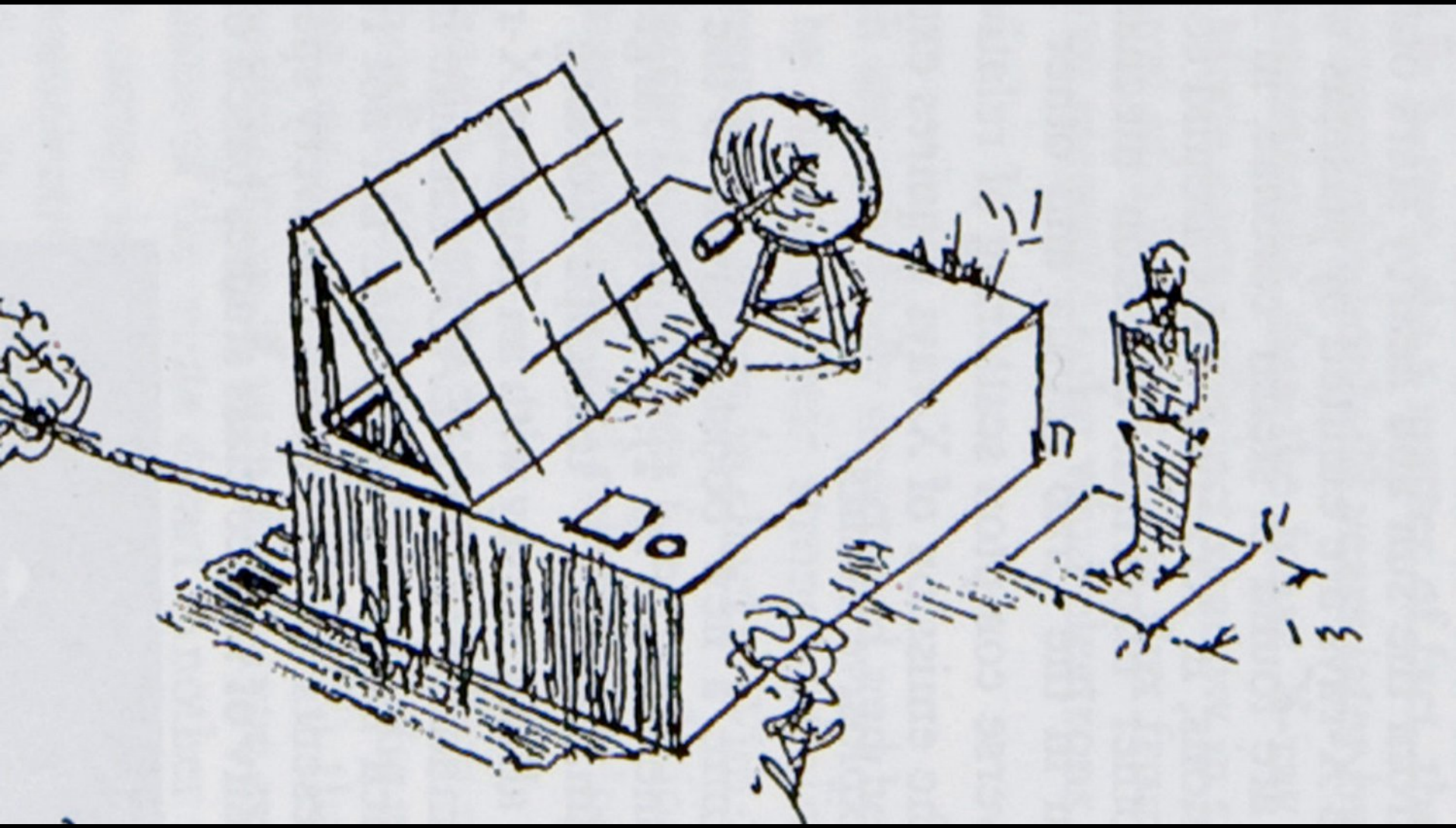
Hybrid: surface detectors
and fluorescence detectors

Both hemispheres

In the South:
Australia?
South Africa?
Argentina? (Mendoza? Patagonia?)

James Cronin, Chicago University
Alan Watson, Univ. of Leeds

"THE GIANT ARRAY PROJECT"
(still today, we have GAP-Notes)



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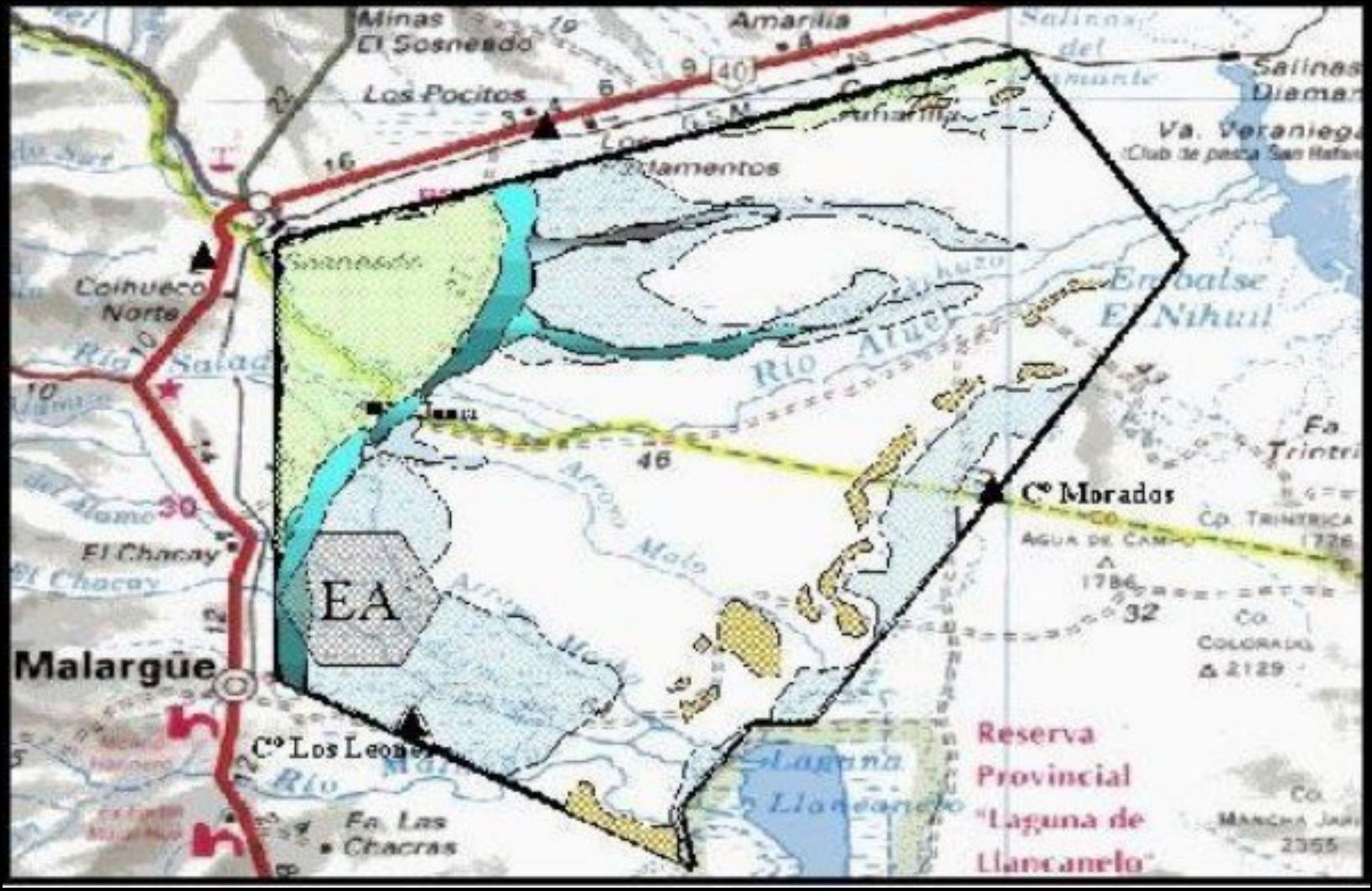

What was needed to tackle the challenge:

- 18 countries (nowadays 17)
- 86 institutions
- > 500 scientists, engineers, technicians
- $(USD) 53 millions (construction costs)
- a 3000 km^2 flat surface…

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- > 500 scientists, engineers, technicians
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- a 3000 km^2 flat surface…

The Pierre Auger Observatory

Ultra-high energy cosmic rays:

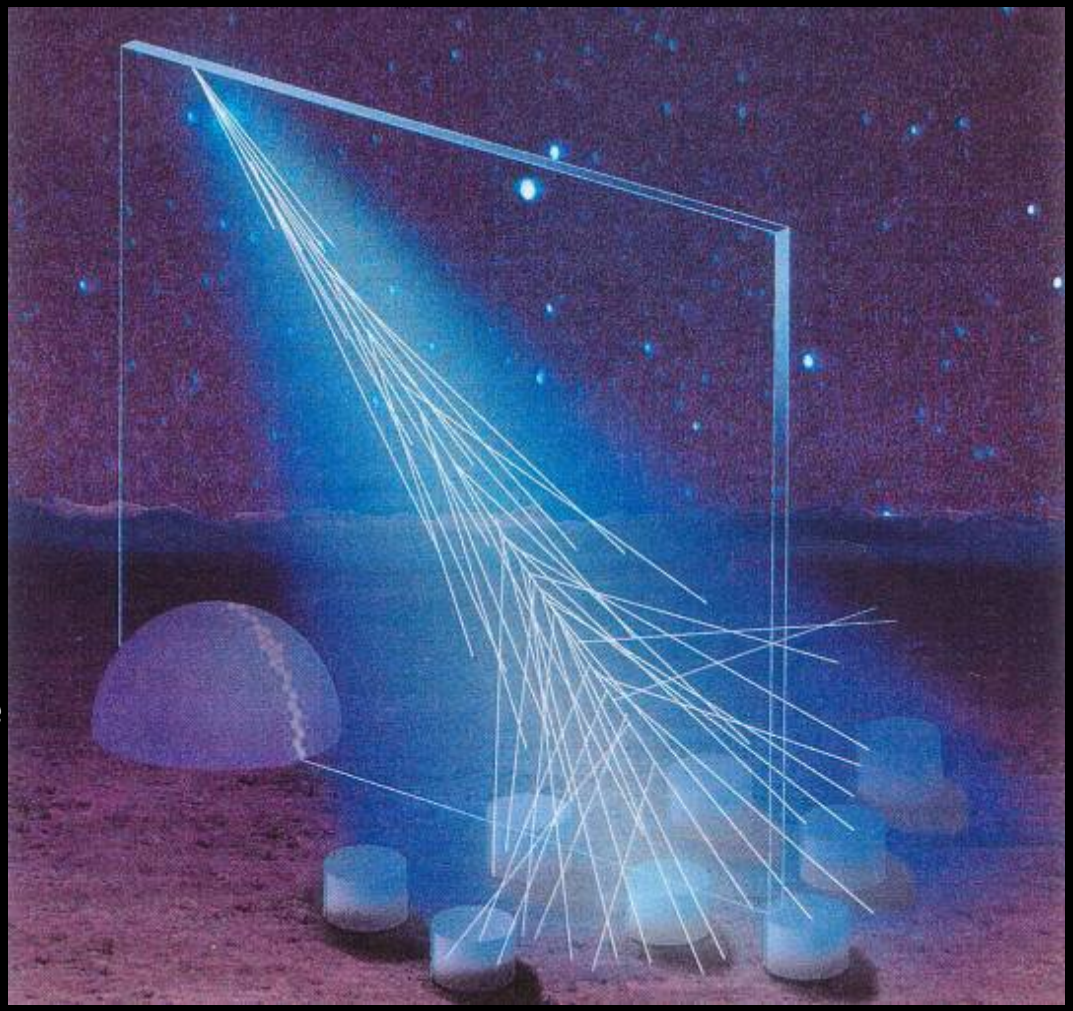
Very few - large surface:
3000 km^2!

Hybrid system:

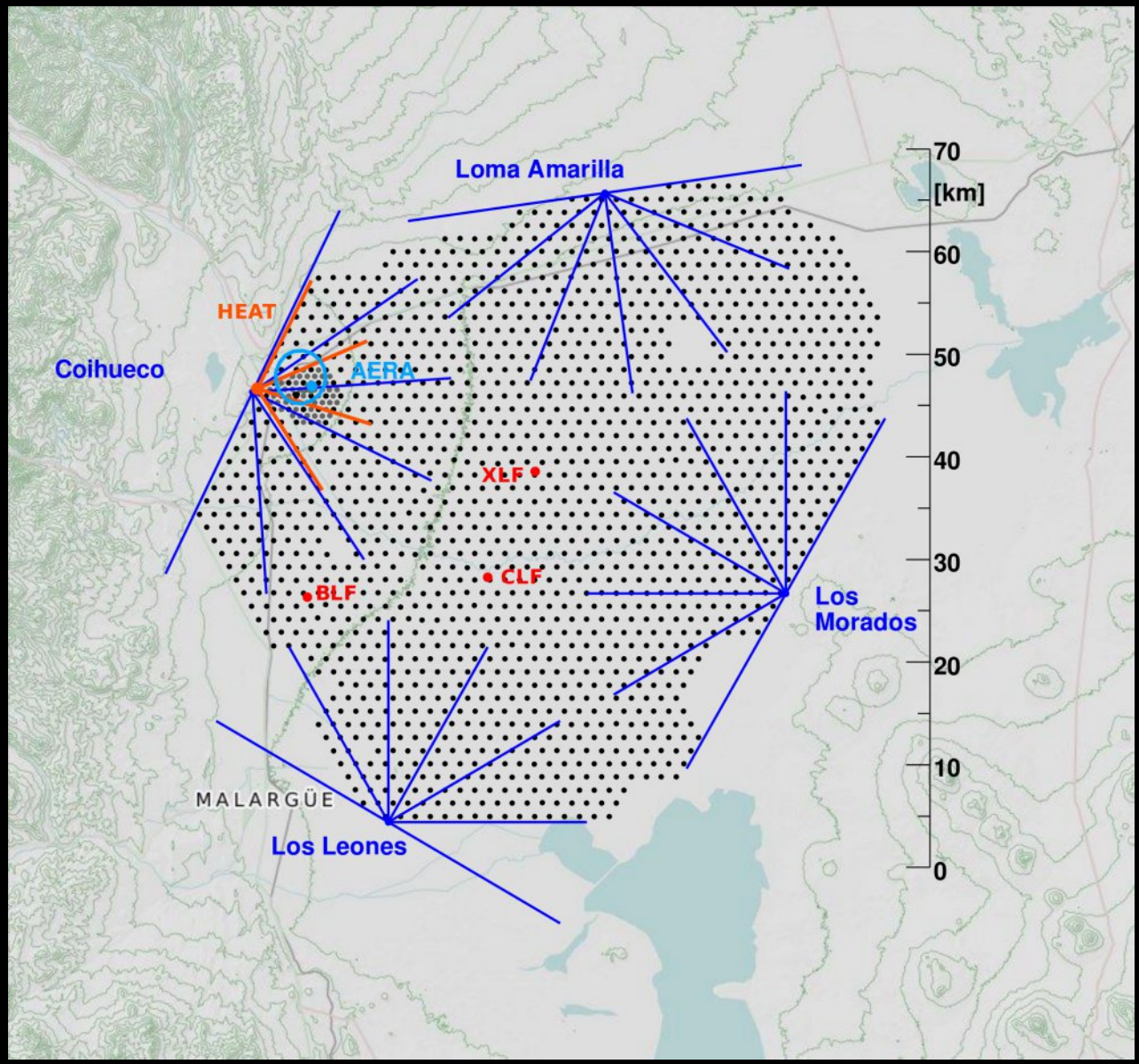
- 1600 surface detectors sample particles at ground level

- 27 telescopes collect fluorescence light in atmosphere (in 4 buildings + 3 “containers”)

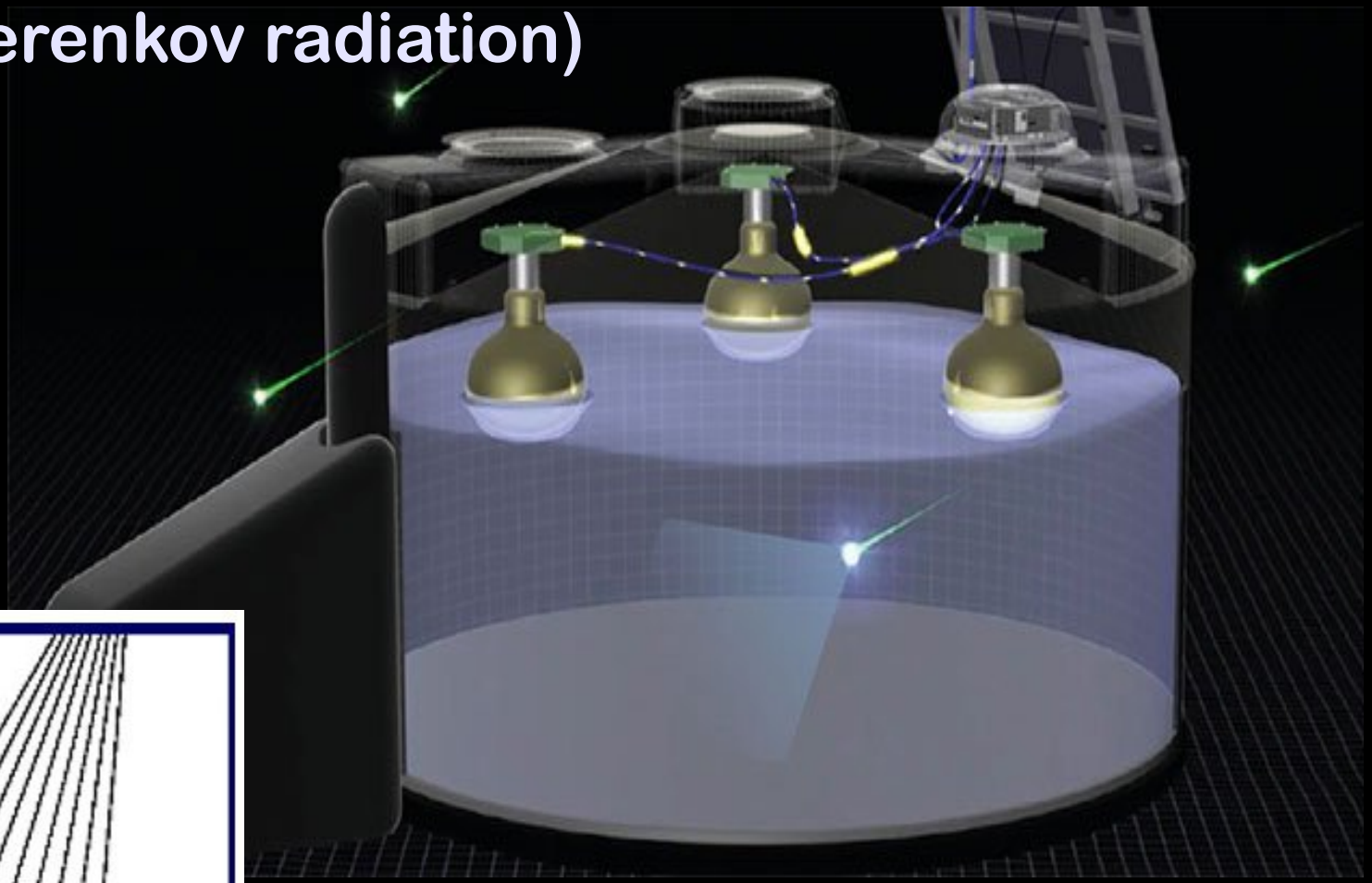
Reconstruction of Energy, direction, composition, time

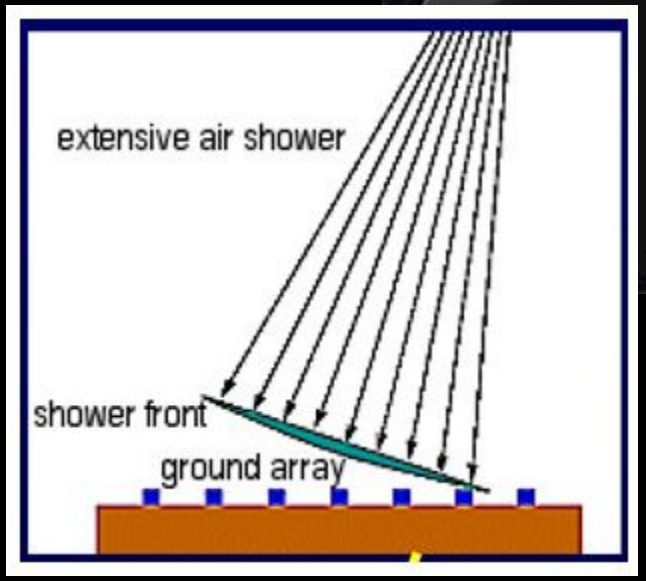


PIERRE AUGER OBSERVATORY



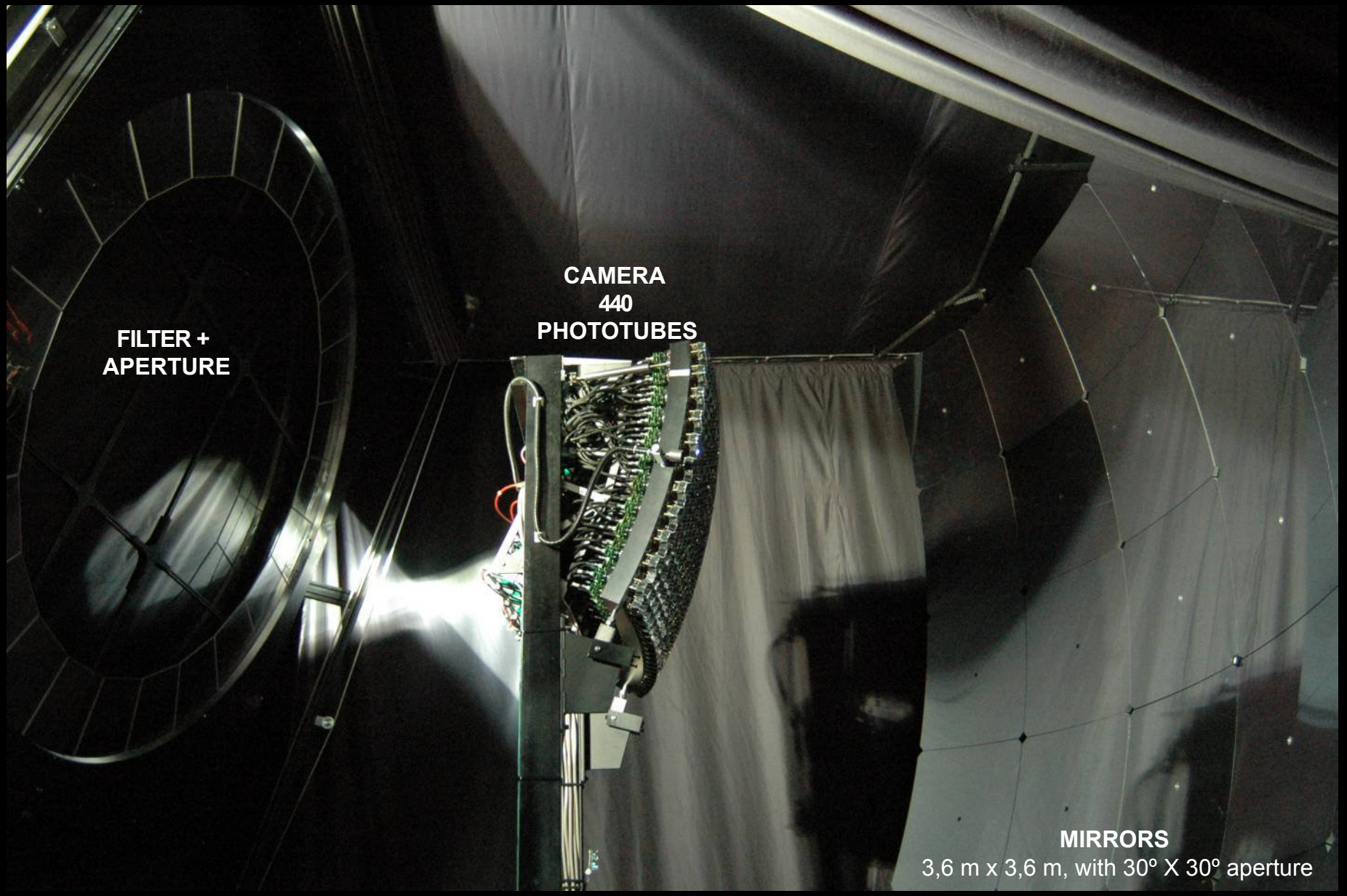
1600 surface detectors. Spacing: 1500 m. (Cherenkov radiation)





SURFACE DETECTORS

FLUORESCENCE TELESCOPES

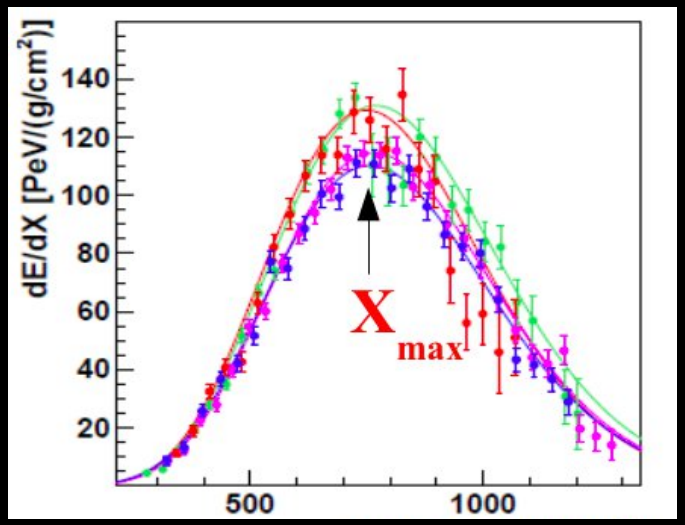


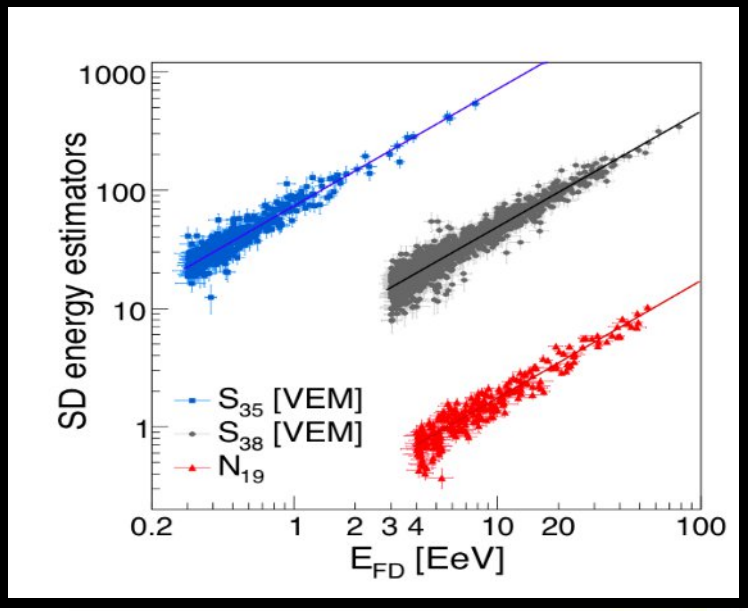
TELESCOPE BUILDINGS

24 telescopes in 4 buildings

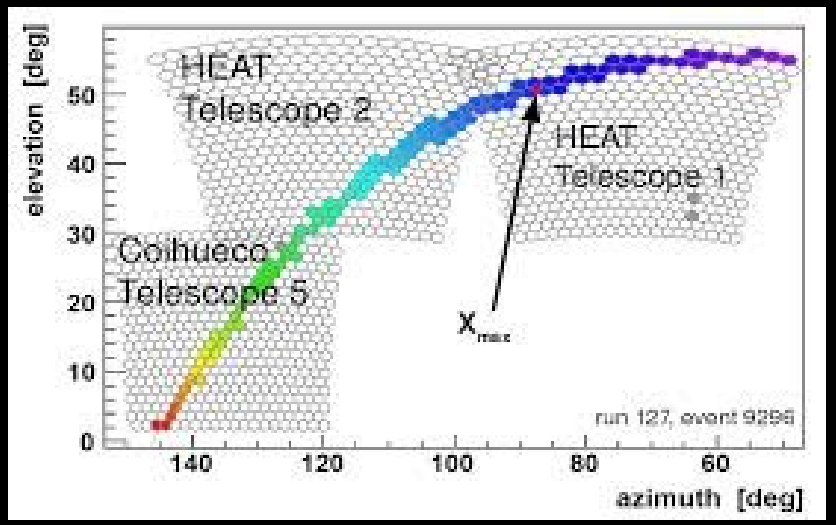
FLUORESCENCE DETECTORS

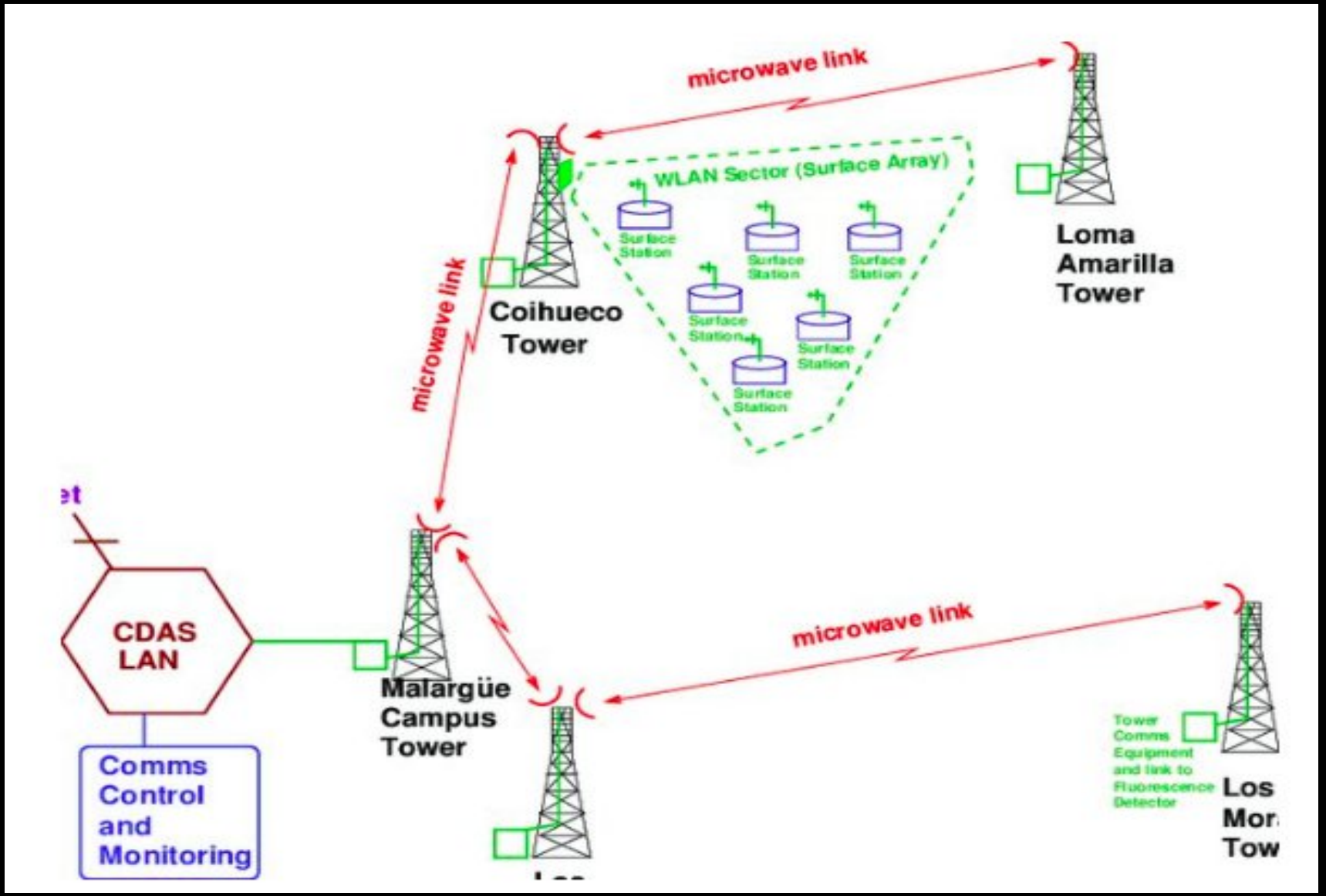
FD for ENERGY Callibration
E proportional to fluorescence light
Composition: Xmax showe maximum

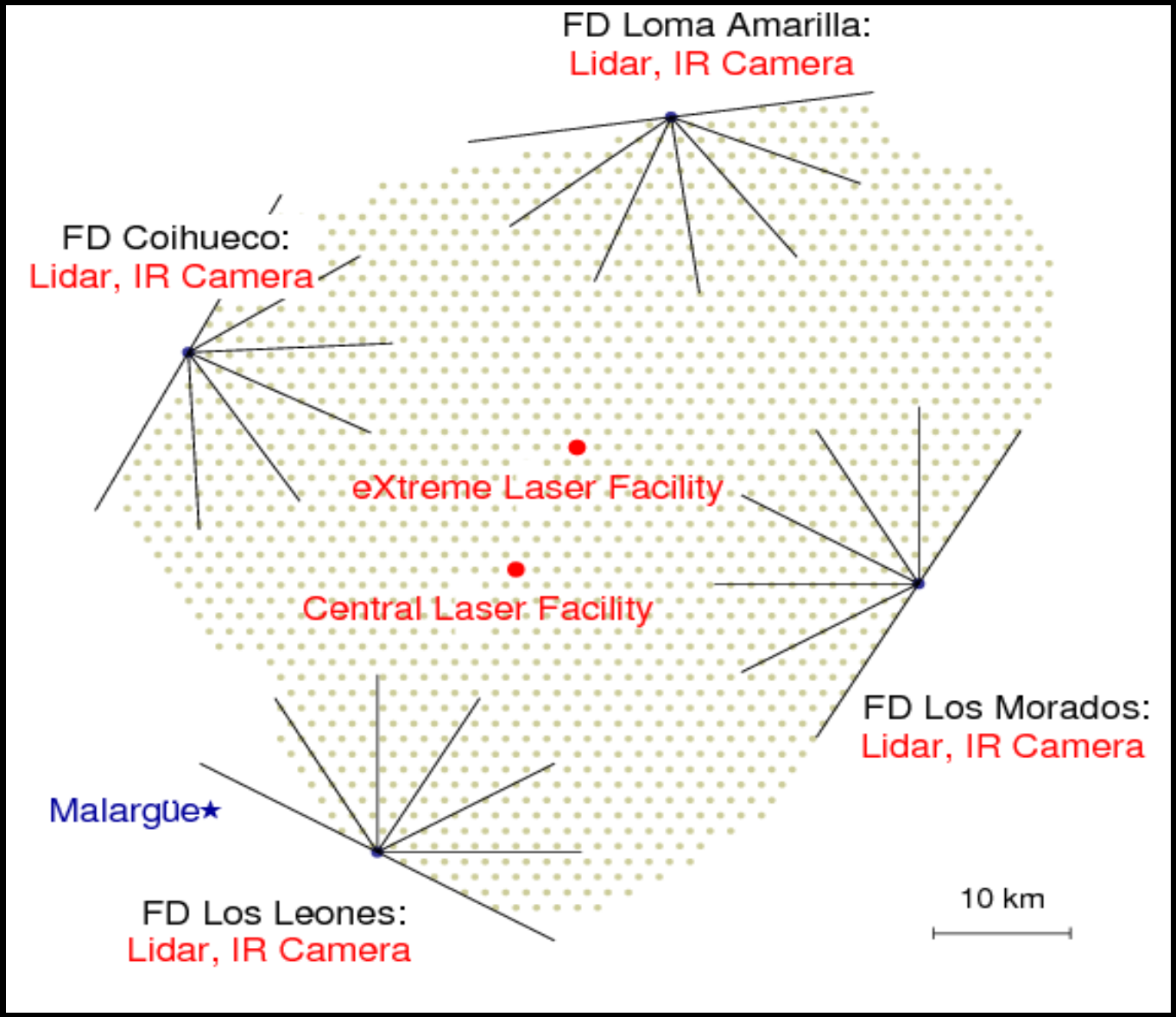




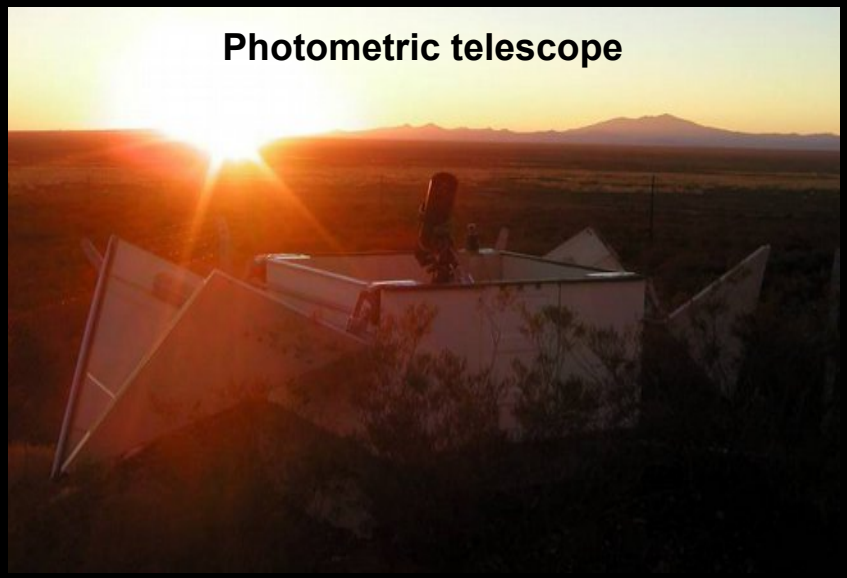
HEAT: larger elevation, lower energy




microwave link
WLAN Sector (Surface Array)
Surface Station
Surface Station
Surface Station
Surface Station
Surface Station
Surface Station
Loma Amarilla Tower
microwave link
Coihueco Tower
CDAS LAN
Comms Control and Monitoring
Malargüe Campus Tower
microwave link
Tower Comms Equipment and link to Fluorescence Detector
Los Mor Tow


FD Loma Amarilla:
Lidar, IR Camera
FD Coihueco:
Lidar, IR Camera
eXtreme Laser Facility
Central Laser Facility
FD Los Morados:
Lidar, IR Camera
Malargüe
FD Los Leones:
Lidar, IR Camera
10 km

ATMOSPHERIC MONITORING SYSTEMS



ATMOSPHERIC MONITORING SYSTEMS: atmospheric LIDARs

OPERATION OF THE OBSERVATORY

Central Station + Assembly Building

OPERATION OF THE OBSERVATORY

Local staff: 33 persons

Visiting scientists and technicians

Task groups

Local FD shifts

Remote FD shifts

WHAT KEEPS US BUSY NOW:
AUGER “UPGRADE”: AugerPrime - until 2025!

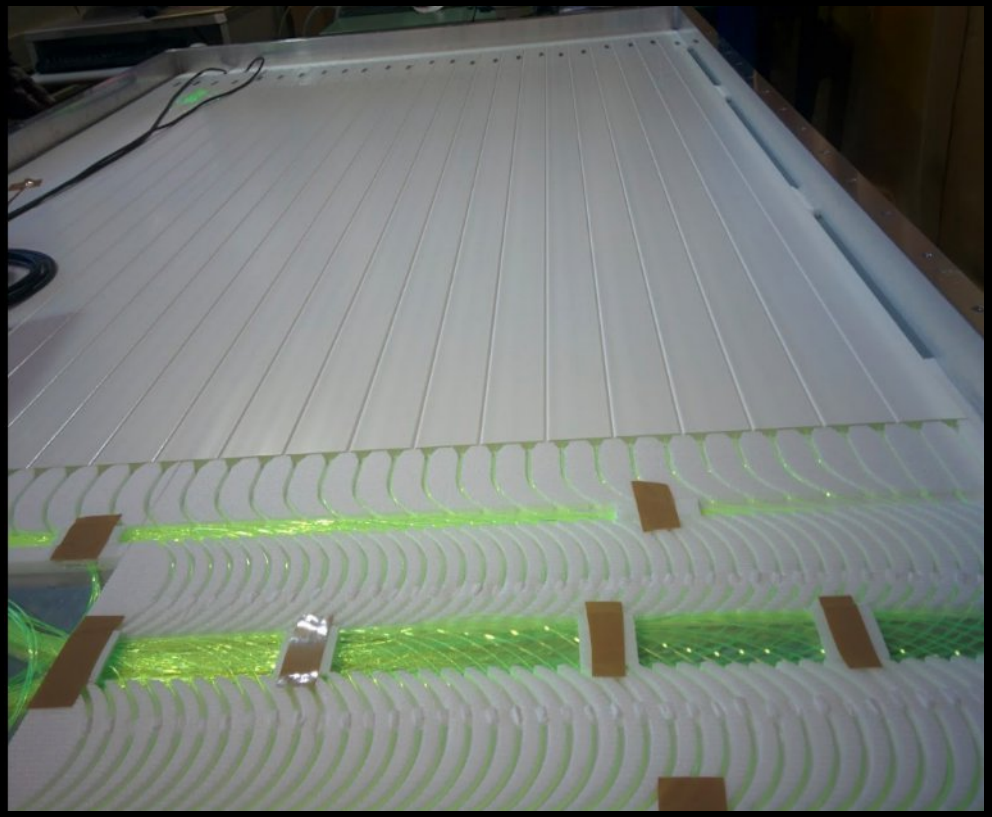
- To determine event-by-event composition at highest energies
- To search for protons at high energies (particle astronomy)
- Study Extended Air Showers and hadron interactions

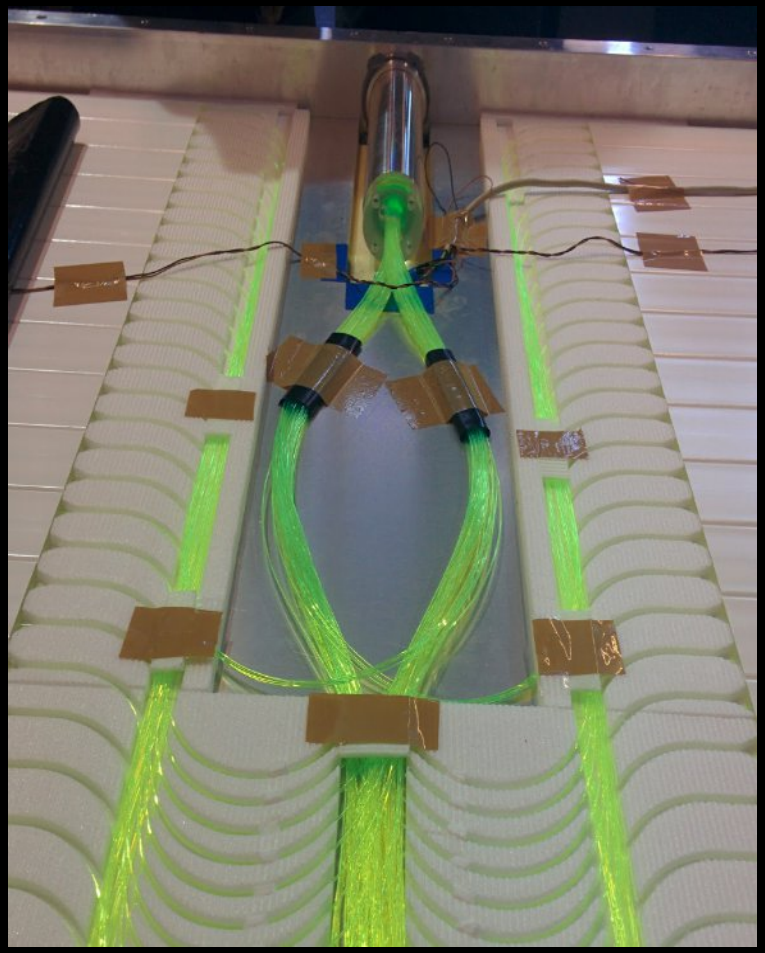
- SCINTILLATORS: SSD
- UNDERGROUND MUON DETECTORS: AMIGA
- RADIO DETECTION OF AIR SHOWERS
- new electronics
- Extension of FD uptime

To be installed until 2020, 12 MEUR.

AUGER “UPGRADE”: SSD

SSD: 1600 plastic scintillators (4 m^2 each) combined with SD





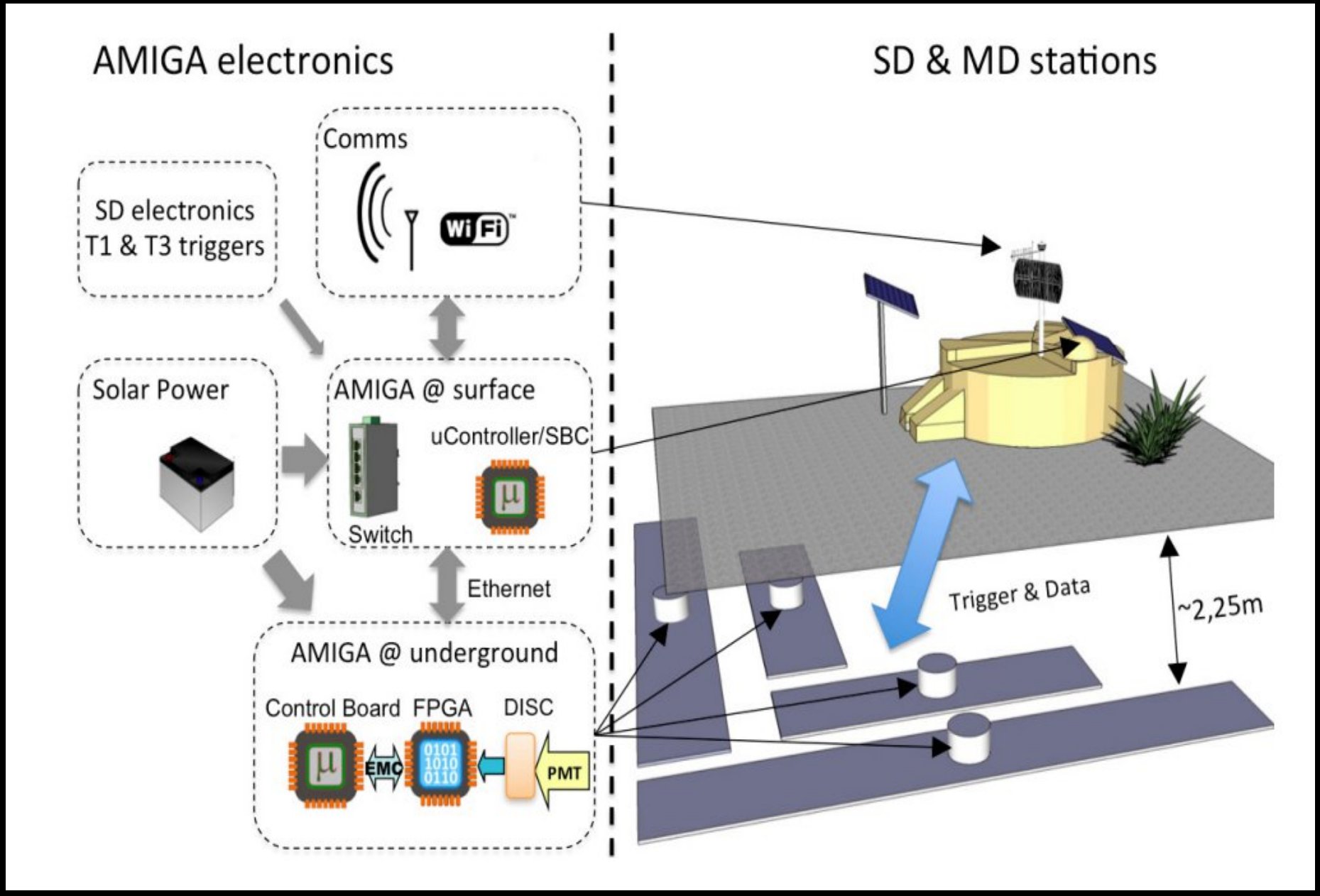
AUGER “UPGRADE”: SSD

First prototypes in the field!

AUGER “UPGRADE”: SSD

AUGER “UPGRADE”: SSD

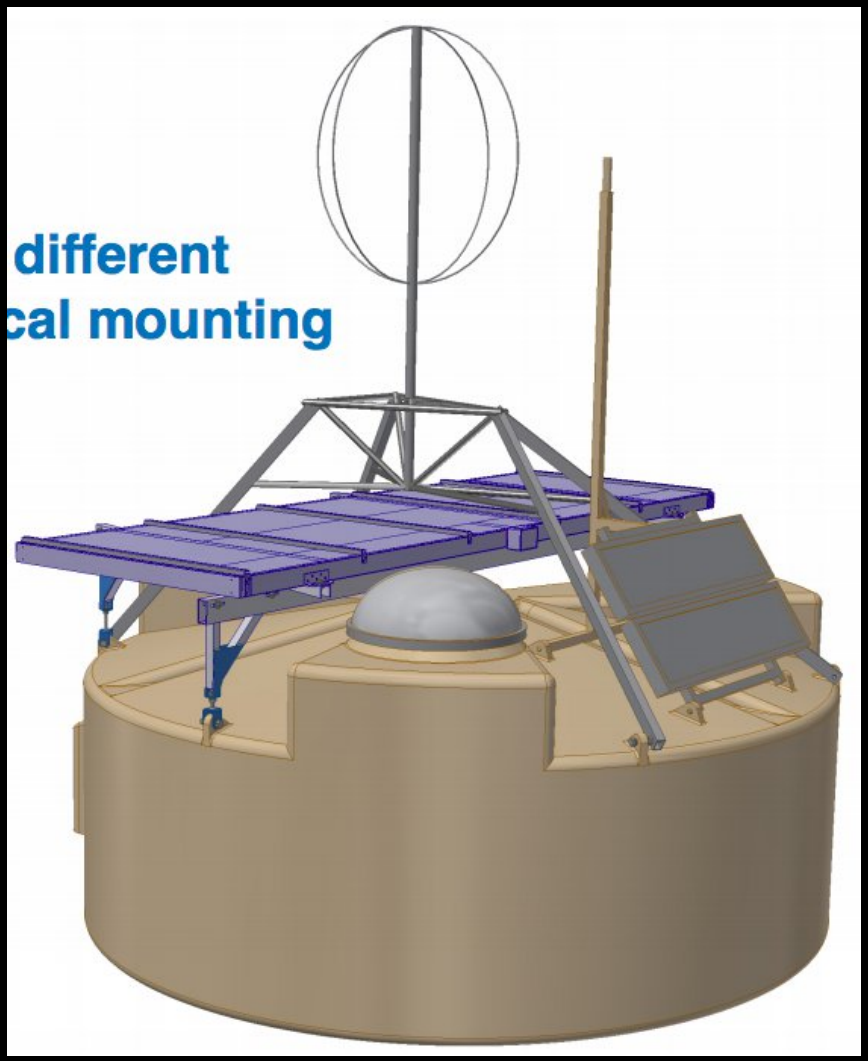
AUGER “UPGRADE”: AMIGA



AUGER “UPGRADE”: AMIGA

AUGER “UPGRADE”: AMIGA

AUGER “UPGRADE”: RADIO DETECTION



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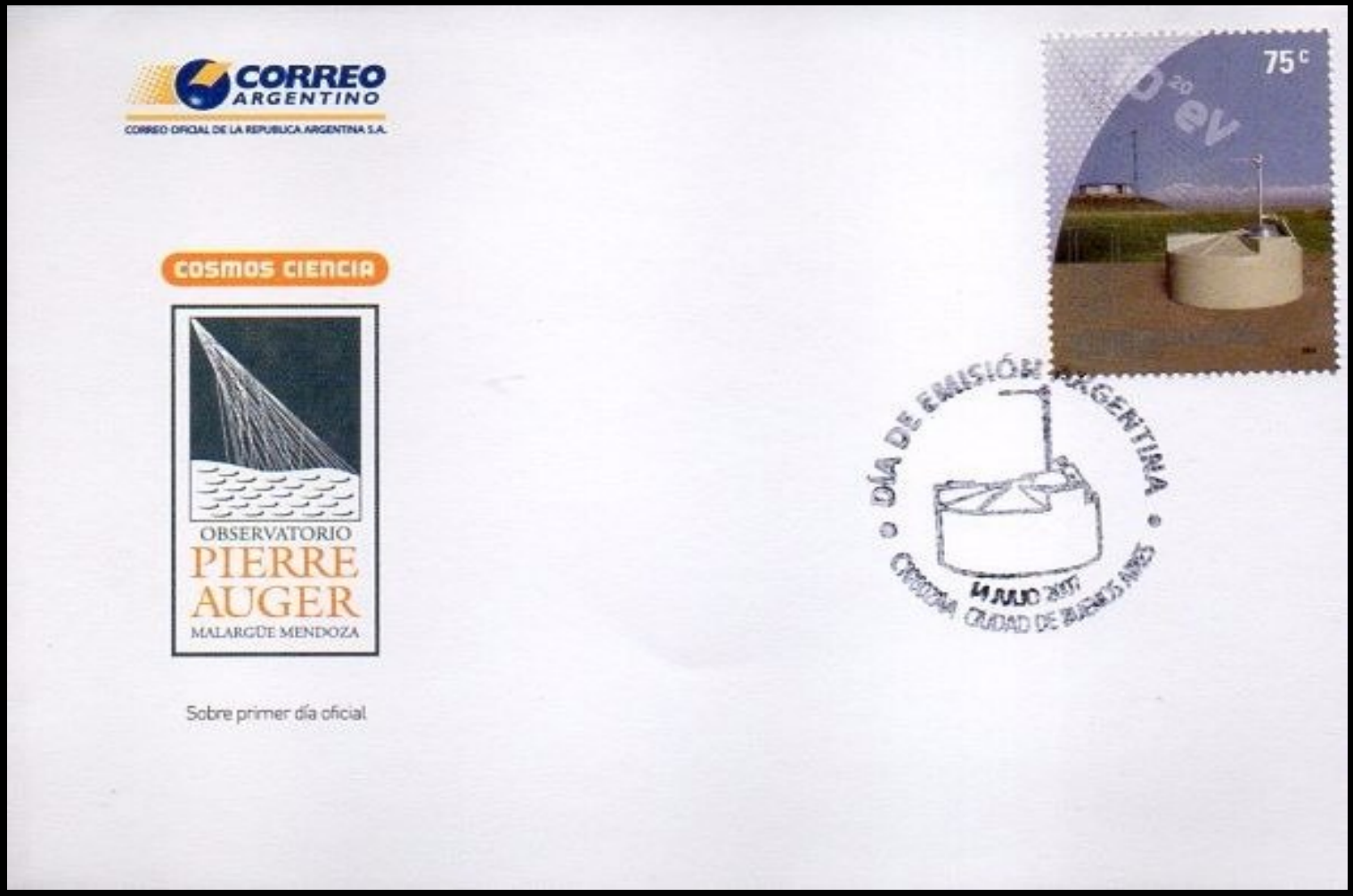
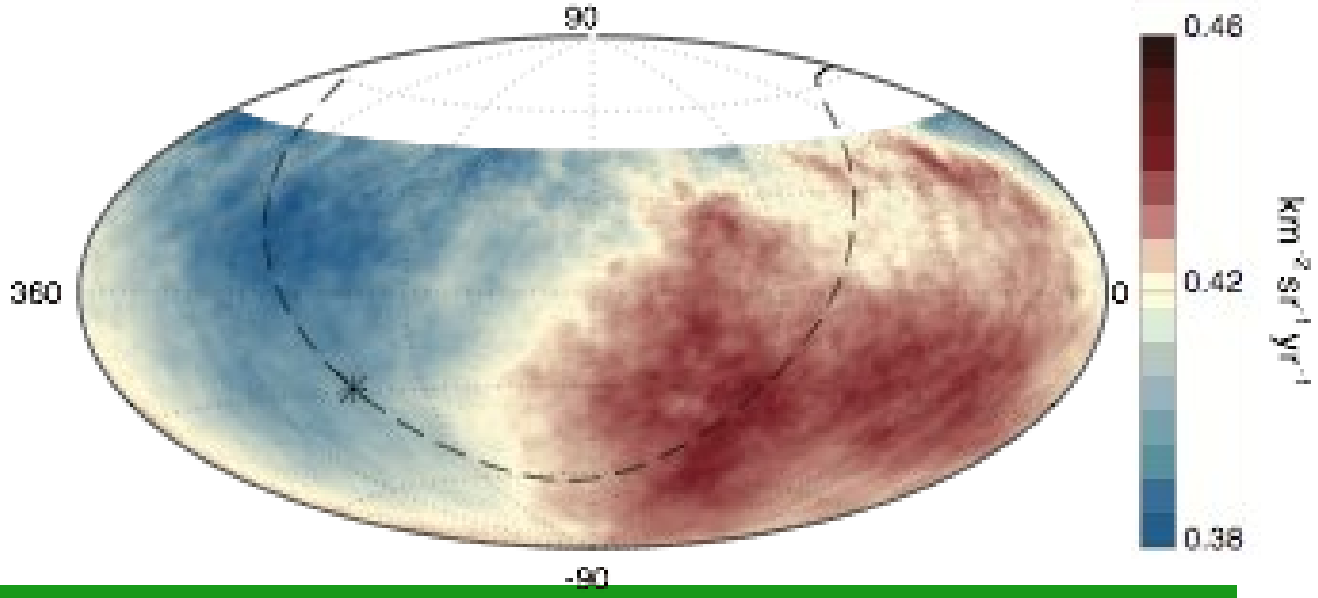


2017 Science Paper

We observe a 5.2 σ Dipole Excess at E > 8 EeV
The first significant observation of anisotropies in UHECR-history, a signature of extragalactic UHECR origin

Science
AAAS



Enormous echo in the international press with more than 200 different reports in the media

nature International weekly journal of science

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Archive > Volume 549 > Issue 7673 > News > Article

NATURE | NEWS

High-energy cosmic rays come from outside our Galaxy

Giant observatory announces long-awaited result.

Davide Castelvecchi

21 September 2017

The MiceTimes of Asia

Fresh and Independent News and Opinions from Singapore and Bangkok. Widest news coverage and fastest delivery.

PIERRE AUGER OBSERVATORY

INCREDIBLE

Land attack a distant galaxy, high-energy rays

By **paradox** - 23.09.2017 11

Share on Facebook | Tweet on Twitter | G+ | P

The earth has been exposed to 30 thousand rays.

Recently, scientists have found a source of high-energy rays, which have tremendous speed and it reaches to the Ground and attacking her.

New Scientist

DAILY NEWS 21 September 2017

Far-off galaxies are firing rare high-energy cosmic rays at us

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www.news.cn 新华网 NEWS www.xinhuanet.com

XINHUANET

Sunday, Nov

Ultra-high-energy cosmic rays come from galaxies far away: study

Source: Xinhua | 2017-09-22 03:21:45 | Editor: Mu Xuequan

Xinhuanet App 炫闻

Karl-Heinz Kampert

PIERRE AUGER OBSERVATORY

No fake news in RT...

Scientists Reveal Source of the Ultra-high Energy Cosmic Rays Striking Earth

TECH 20:50 24.09.2017 (updated 11:12 25.09.2017) Get short URL 3 3523 28 0

A team of astronomers from the Pierre Auger Observatory in Malargue, Argentina, has made an astonishing discovery - that the rare ultra-high energy cosmic rays which come to Earth from space arrive from specific areas far outside the Milky Way galaxy.

RIBE

SCIENTIFIC AMERICAN

English Cart 0 Sign

THE SCIENCES MIND HEALTH TECH SUSTAINABILITY EDUCATION VIDEO PODCASTS BLOGS STORE

nature

SPACE

High-Energy Cosmic Rays Come from Outside Our Galaxy

Giant observatory announces long-awaited result

Spektrum.de

Hintergrund | 21.09.2017 | Drucken | Teilen

KOSMISCHE STRAHLUNG

Weit gereist und voller Energie

So selten sind die Teilchen, dass es einen Detektor größer als das Saarland brauchte. Nun ist das Rätsel um den Ursprung extrem energiereicher Teilchen geklärt. Oder doch nicht?

SCIENTIFIC AMERICAN Brasil

Raios cósmicos de alta energia vêm de fora da Via Láctea

Com participação de brasileiros, achado contribui para ajudar a esclarecer um dos maiores mistérios da astronomia contemporânea

Karl-Heinz Kampert

NOV 12, 6:30 AM EST **International Business Times**

WORLD

Milky Way Ruled Out As Source Of Highest-Energy Cosmic Rays Hitting Earth

BY **HIMANSHU GOENKA** ON 09/22/17 AT 3:46 AM

Sunday, November 12, 2017

The Tribune

VOICE OF THE PEOPLE

Science Technology

Posted at: Sep 23, 2017, 10:06 PM; last updated: Sep 23, 2017, 10:06 PM (IST)

Cosmic rays striking Earth come from outside Milky Way

ntv

Starke "Oh-mein-Gott-Teilchen"

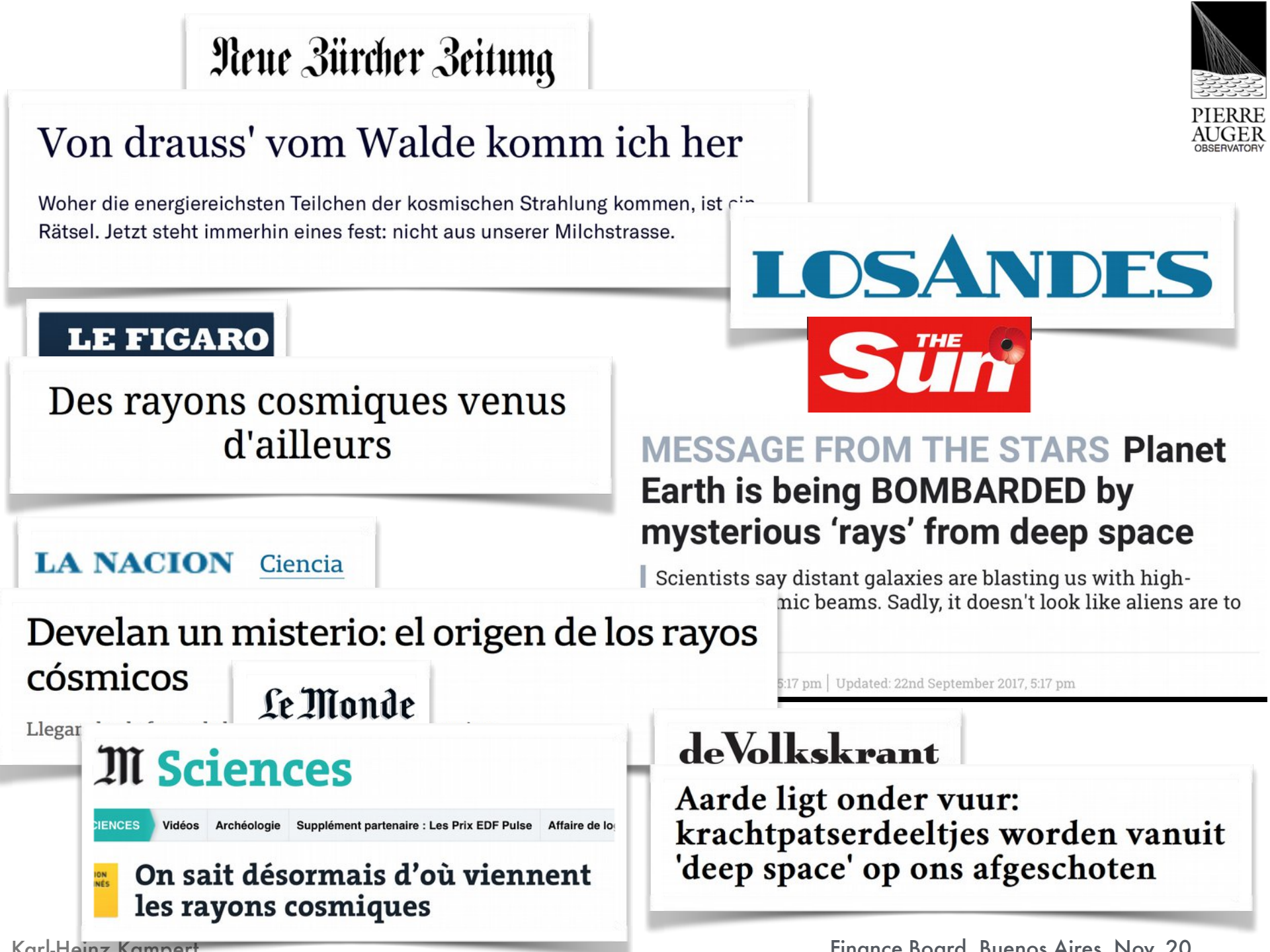
Ferne Galaxien senden Kosmische Strahlung

La Voz de Galicia

Un equipo gallego identifica rayos cósmicos más allá de la galaxia

Los expertos aseguran que con este hallazgo nos estamos acercando para poder utilizar las direcciones de las partículas para poder averiguar dónde y cómo se producen

PIERRE AUGER OBSERVATORY

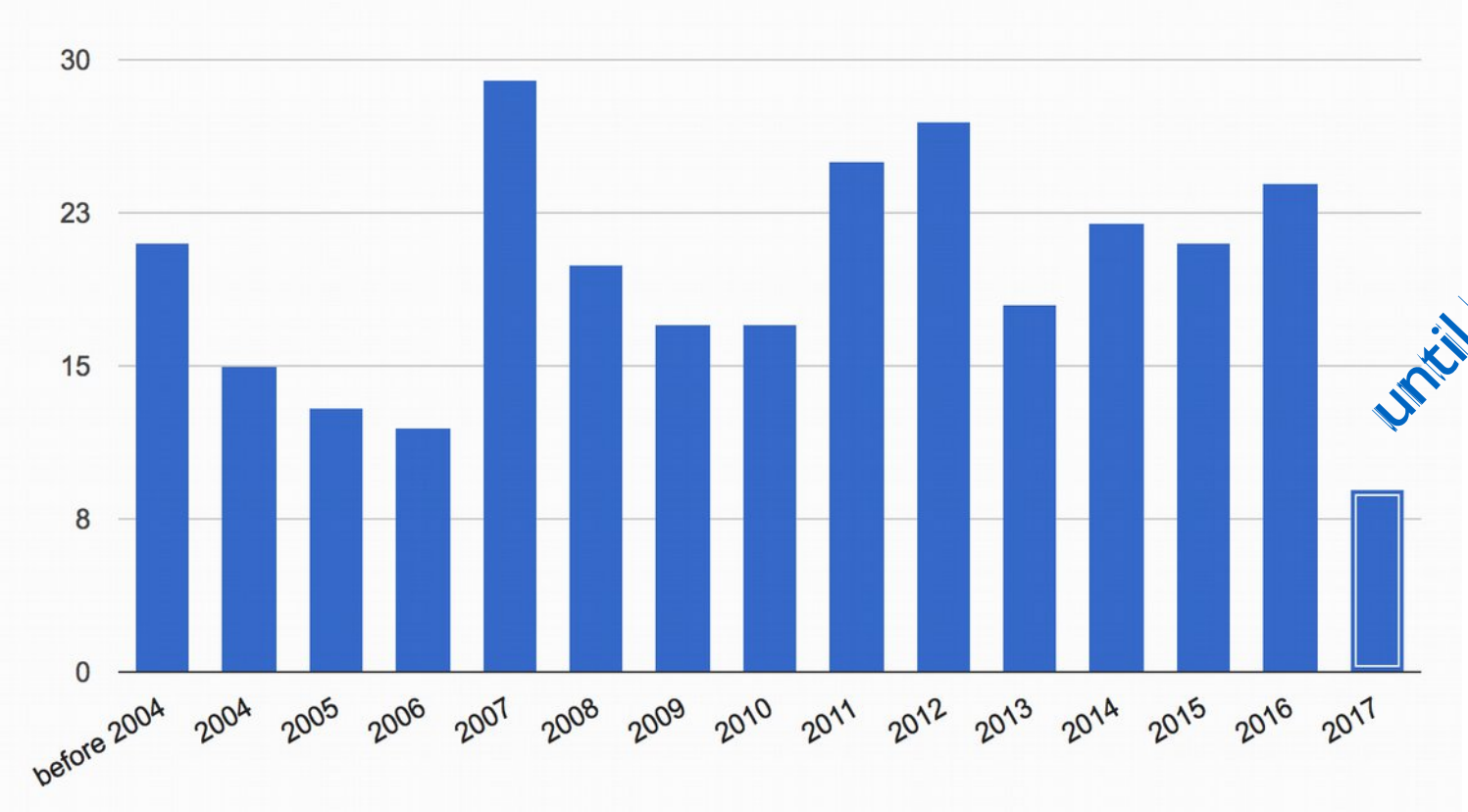


Karl-Heinz Kampert

Finance Board, Buenos Aires, Nov. 20

PhD Recipients by year

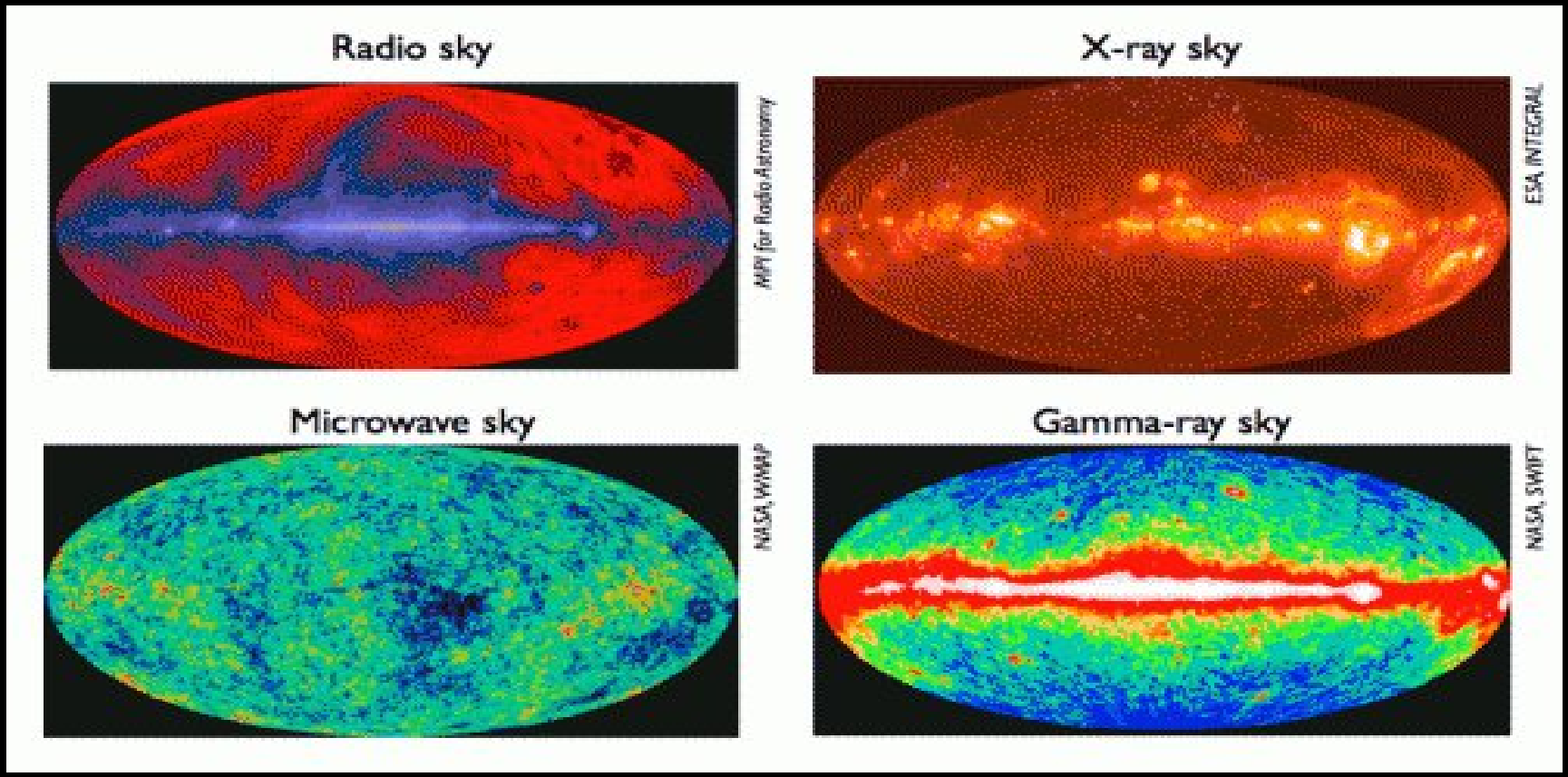
Total: 392 ; Ongoing: 102 ; Defended: 290



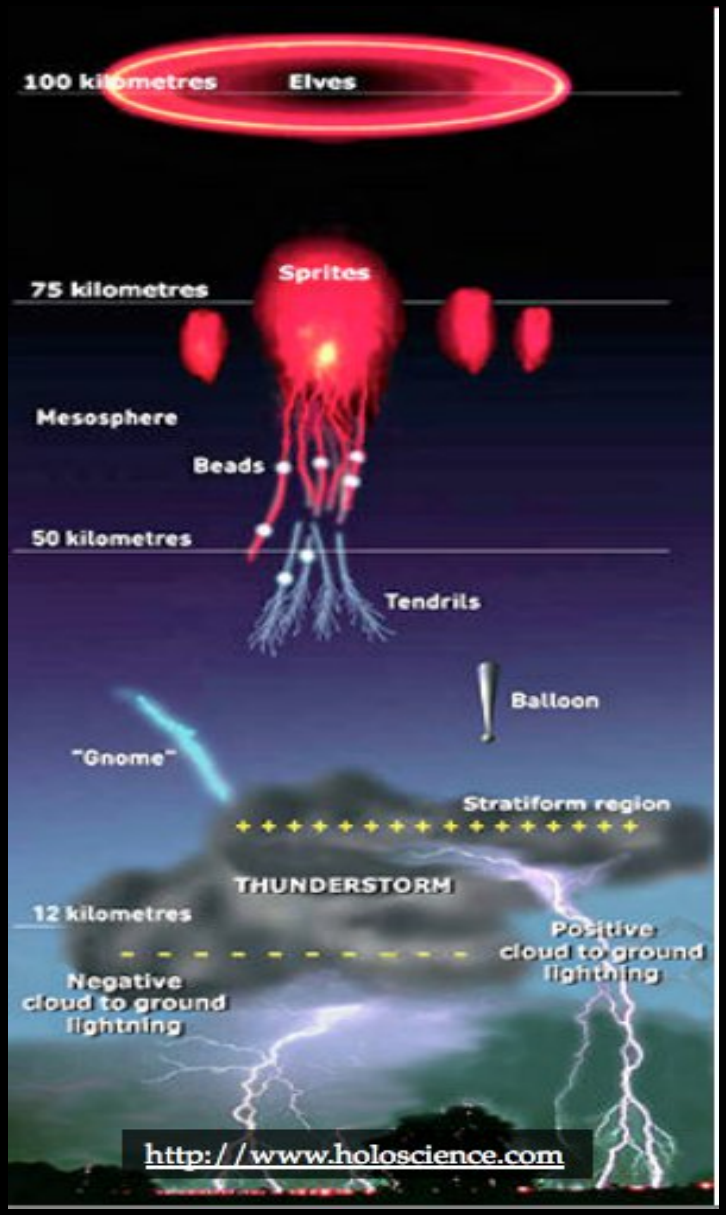
Auger produces a PhD student every 2.5 weeks!

ASTROPARTICLE PHYSICS

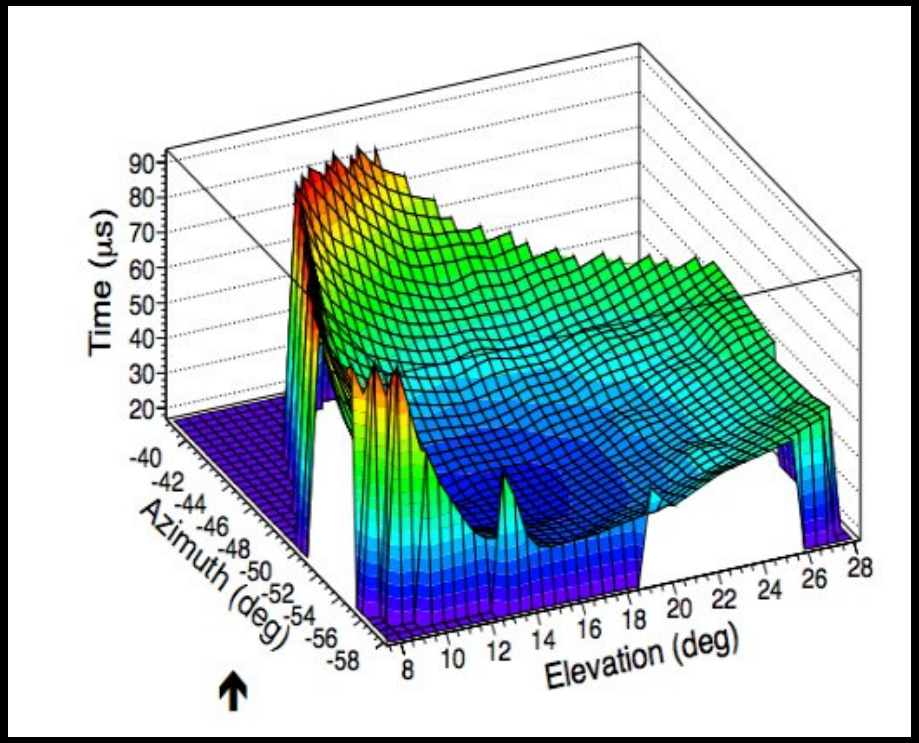
- Auger has high sensitivity to NEUTRINOS
- Auger can identify high energy PHOTONS
- Arrival directions of cosmic rays correlated with sources (if magnetic deflections low)
- MULTIMESSENGER ASTRONOMY



COLATERAL RESULTS



SOLAR PHYSICS (background signals)
ATMOSPHERIC SCIENCE ("Elves" and ionospheric effects)
LIGHTNINGS



COLATERAL RESULTS

HIGH ENERGY PARTICLE INTERACTIONS !
p-Air cross section at sqrt(s) = 57 TeV
Phys. Rev. Lett. 109, 062002 (2012)
Phys. Rev. D (2014)