

# PIERRE AUGER OBSERVATORY

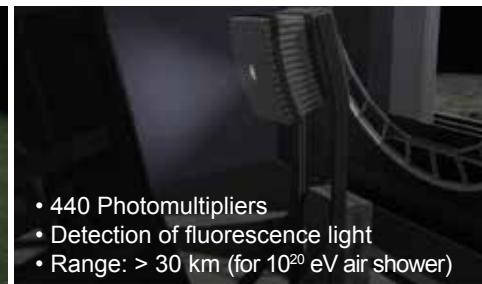
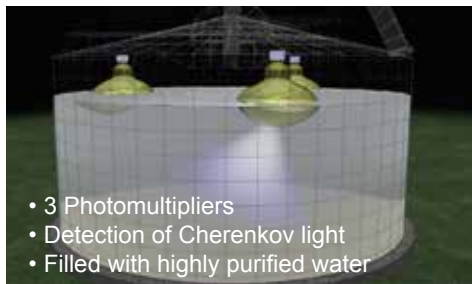
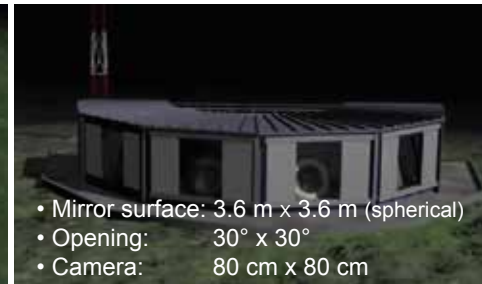
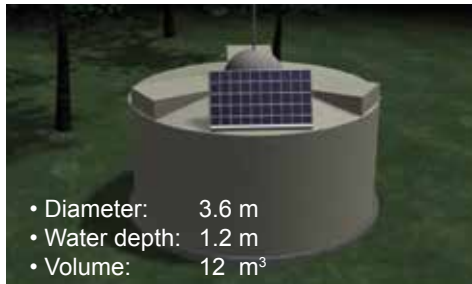
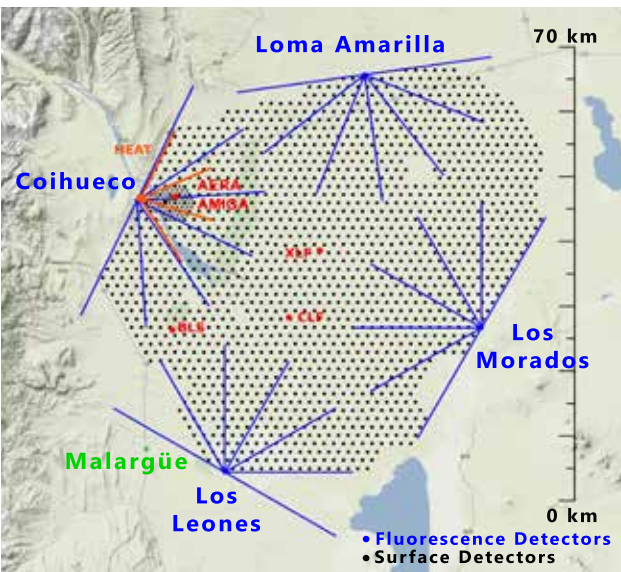
## The Pierre Auger Observatory

On the vast plain known as the *Pampa Amarilla* in western Argentina, the Pierre Auger Observatory is studying the highest-energy particles in the Universe, which hit the Earth from all directions, so-called cosmic rays. Cosmic rays with low to moderate energies are well understood, while those with extremely high energies remain highly mysterious. By detecting and studying these rare particles, the Pierre Auger Observatory is tackling the enigmas of their origin and existence.

**Area: 3,000 km<sup>2</sup>**  
(30 times the size of Paris)

**Surface Detector**  
1,660 surface detector stations  
(1,500 m apart from each other)

**Fluorescence Detector**  
27 fluorescence telescopes  
(in 4 different places)



## The Pierre Auger Collaboration

- ~ 500 scientists
- ~ 90 institutes
- 16 countries
- construction budget: US\$ 54 million
- 60 published peer-reviewed papers
- > 7,000 citations

### Location:

Malargüe, Province of Mendoza, Argentina

### Main Goals:

Determination of the energy, direction and mass composition of cosmic rays with energies above 10<sup>18</sup> eV to better understand the universe.

## Auger Spokespersons / Contact Persons



**Karl-Heinz Kampert** (kampert@uni-wuppertal.de)  
Spokesperson of the Pierre Auger Observatory.  
Professor of physics and chair of astroparticle physics at the Bergische Universität Wuppertal, Germany.



**Antonio Bueno** (a.bueno@ugr.es)  
Co-spokesperson of the Pierre Auger Observatory.  
Professor of physics at the Universidad de Granada, Spain.

## Founding Fathers of Auger



**Jim W. Cronin**  
Spokesperson Emeritus of the Pierre Auger Observatory.  
Professor Emeritus at the University of Chicago, USA.  
Nobel Prize in Physics in 1980 together with Val L. Fitch, for their discovery of the asymmetry in the behaviour of matter and antimatter.



**Alan A. Watson**  
Spokesperson Emeritus of the Pierre Auger Observatory.  
Professor Emeritus at University of Leeds, United Kingdom.  
Fellow of the Royal Society since 2000.



More information at  
[www.auger.org](http://www.auger.org)

# PIERRE AUGER OBSERVATORY



## Timeline

- 1992** Jim W. Cronin and Alan A. Watson suggest building a giant air shower array with much greater collecting power than had ever been considered previously.
- 1995**  
Jan 30 - Jul 31 Production of a design report – reference design and cost estimate – by the Design Group for the Auger Project hosted by Fermilab, Illinois, USA. This becomes the basis for funding proposals in 17 participating countries.
- 1995**  
Nov A meeting is held in Paris to form the collaboration. It chooses the site of Mendoza, Argentina in the Southern Hemisphere. The Observatory is named after the French physicist Pierre Victor Auger.
- 1999**  
Mar Signature of the International Agreement in Mendoza.
- 2000** Beginning of the construction of the observatory.
- 2001** The Engineering Array – a full-scale prototype of the first 32 SD stations and a single fluorescence telescope – is operated for 6 months. It is later integrated into the main setup and used for more detailed design choices and calibration.
- 2003** The Observatory becomes the largest detector in the world for the detection of ultra-high energy cosmic rays.
- 2004** First physics results are reported from more than 100 surface detector stations.
- 2007**  
May Release of 1% of the data to the public for outreach purposes. The data can be explored at the website of the Public Event Display ([www.auger.org/event-display](http://www.auger.org/event-display)).



## AugerPrime

The upgrade will consist of enhanced surface detector stations (SSD), faster electronics, dedicated underground muon detectors and optimized operations for the fluorescence telescopes.

Ten more years of operation is planned to double the data set and to particularly study:

- The origin of the flux suppression at ultra-high energy,
- The proton contribution at highest energies ( $E > 6 \cdot 10^{19}$  eV), leading to a so-called “particle astronomy”
- New particle physics beyond the reach of the LHC

What is it made of?  
How does it get to us?  
Where does it come from?  
How does the airshower of billions of particles develop?  
How does it get 100,000,000 times the energy of a proton in the LHC?

Key questions addressed by the Observatory

How can we improve the detector?

Preliminary results indicate that the directions of origin of the 27 highest-energy events are correlated with the locations of active galactic nuclei (AGNs). **2007**  
Nov

Observation of the energy spectrum of cosmic rays confirms that the flux is strongly suppressed above  $4 \cdot 10^{19}$  eV as predicted by the GZK theory. **2008**

Best present limits are set on the detection of photons with an energy of  $10^{18}$  eV. **2009**

Observations of the depth of the maximum of air-shower profiles above  $10^{18}$  eV give first hints on the composition of cosmic rays at ultra-high energy. **2010**

Solar physics with the Auger Observatory. **2011**

Measurement of the proton-proton cross section at a centre-of-mass energy of 57 TeV, complementing results from the LHC – always below 14 TeV. **2012**

Best present limits on the detection of neutrinos with an energy of  $10^{18}$  eV. **2013**

Observation of large-scale anisotropies: Arrival directions of cosmic rays are not evenly distributed, giving hints on the origin – whether galactic or extragalactic – of cosmic rays at ultra-high energy. **2015**

Observations of a deficit in the number of muons in air showers challenge predictions from hadronic interaction models. **2015**

**AugerPrime** – Celebrate 15 years of achievements and signature ceremony of a new International Agreement for the next ten years ([www.auger.org/augerprime](http://www.auger.org/augerprime)). **2015**  
Nov





## Enhancements and further developments to the Observatory



### HEAT – High Elevation Auger Telescopes

- 3 FD telescopes with elevated field of view – being tilted by 29°
- designed to cover the elevation range from 30° to 58°, which lies above the field of view of the standard FD telescopes
- extends the energy range of cosmic air-shower measurements down to  $10^{17}$  eV

### AMIGA – Auger Muons and Infill for the Ground Array

- an infilled area of 61 surface detector stations, deployed on a 750 m triangular grid of 23.5 km<sup>2</sup>, each paired in the future with a 30 m<sup>2</sup> plastic scintillator and buried 2.3 m underground
- first 7 stations with muon detectors have been deployed in an engineering array called the Unitary Cell (UC), completed in Feb. 2015
- measures the muon content of air showers



### AERA – Auger Engineering Radio Array

- 153 radio detection stations spread on an area of 17 km<sup>2</sup>
- radio-station array completed in April 2015
- detects the radio emission from cosmic-ray showers in the frequency range of 30-80 MHz
- measures the cosmic-ray composition beyond  $3 \cdot 10^{18}$  eV

## Funding agencies

### Argentina

Comisión Nacional de Energía Atómica  
 Agencia Nacional de Promoción Científica y Tecnológica (ANPCyT)  
 Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET)  
 Gobierno de la Provincia de Mendoza  
 Municipalidad de Malargüe  
 NDM Holdings and Valle Las Leñas, in gratitude for their continuing cooperation over land access

### Australia

The Australian Research Council

### Brasil

Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq)  
 Financiadora de Estudos e Projetos (FINEP)  
 Fundação de Amparo à Pesquisa do Estado de Rio de Janeiro (FAPERJ)  
 São Paulo Research Foundation (FAPESP)  
 Ministério de Ciência e Tecnologia (MCT)

### Czech Republic

Ministry of Education, Youth and Sports  
 Czech Science Foundation

### France

Centre de Calcul IN2P3/CNRS  
 Centre National de la Recherche Scientifique (CNRS)  
 Conseil Régional Ile-de-France  
 Département Physique Nucléaire et Corpusculaire (PNC-IN2P3/CNRS)

Département Sciences de l'Univers (SDU-INSU/CNRS)  
 Institut Lagrange de Paris (ILP) within the Investissements d'Avenir Programme

### Germany

Bundesministerium für Bildung und Forschung (BMBF)  
 Deutsche Forschungsgemeinschaft (DFG)  
 Helmholtz-Gemeinschaft Deutscher Forschungszentren (HGF)  
 Ministerium für Wissenschaft und Forschung, Nordrhein Westfalen  
 Ministerium für Wissenschaft, Forschung und Kunst, Baden-Württemberg

### Italy

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 Istituto Nazionale di Astrofisica (INAF)  
 Ministero degli Affari Esteri e della Cooperazione Internazionale (MAE)  
 Ministero dell'Istruzione dell'Università e della Ricerca (MIUR)

### Mexico

Consejo Nacional de Ciencia y Tecnología (CONACyT)

### Netherlands

Ministerie van Onderwijs, Cultuur en Wetenschap  
 Nederlandse Organisatie voor Wetenschappelijk Onderzoek (NWO)  
 Stichting voor Fundamenteel Onderzoek der Materie (FOM)

### Poland

National Science Centre  
 National Centre for Research and Development

### Portugal

Portuguese national funds and FEDER funds within Programa Operacional Factores de Competitividade through Fundação para a Ciência e a Tecnologia (COMPETE)

### Romania

Minister of National Education and Scientific Research  
 Romanian Authority for Scientific Research and Innovation ANCSI CNDI-UEFISCDI  
 Programme for research - Space Technology and Advanced Research (STAR)

### Slovenia

Slovenian Research Agency

### Spain

Comunidad de Madrid  
 FEDER funds  
 Ministerio de Educación y Ciencia  
 Xunta de Galicia

### USA

Department of Energy  
 National Science Foundation  
 The Grainger Foundation

### International

European Particle Physics Latin American Network  
 European Union 7<sup>th</sup> Framework Program  
 UNESCO



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