PROCEEDINGS OF SCIENCE

Cosmic Ray Physics in Argentina

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We discuss the history of Cosmic Ray research in Argentina, from the pioneering works in the 1940's to the active participation in the Auger Observatory. We review the earliest evidences for research in the field, the emergence of systematic studies on Cosmic Rays and how these developments were intimately connected to the creation of new research groups and institutions. A new impetus to this domain was given by the construction of the Auger Observatory, offering to the Argentinean community the opportunity to take part in important contributions.

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1. Introduction

Since their discovery by Victor Hess in 1912 [1], the study of Cosmic Rays (CRs) has been a very exciting research field. Seeking to understand the properties and origin of CR, scientists have climbed mountains, flown in balloons, and traveled to the far corners of the earth in their quest to understand the nature and behavior of these particles. At the early times, before the construction of large particle accelerators, cosmic rays were the main and natural source for the discovery of new particles. In 1932, Carl Anderson, observing the trajectory of CRs in a cloud chamber discovered the positron [2], fulfilling the predictions made by Paul Dirac [3]. Four years later, the muon, which was originally called mesotron (since its mass is between that of the electron and the proton) was discovered by Carl Anderson and Seth Neddermeyer also using a cloud chamber [4]. One year before, Hideki Yukawa postulated the existence of a particle of similar mass, the pion, to explain certain nuclear processes. The discovery of this particle was made in 1947 by the Brazilian physicist Cesar Lattes, through the study of CRs, by using photograpic plates with nuclear emulsions[1] that he exposed in Chacaltaya, Bolivia [5].

In 1939, by studying the coincidences between Geiger-Müller counters separated by hundreds of meters, Pierre Auger discovered the existence of extensive air showers [18] produced by the interaction of the primary CR with the atmosphere. Auger assumed that these events were caused by particles of up to 10^{15} eV, with an energy so large that "it is really impossible to imagine a single process capable of impairing it". Following this discovery, a series of experiments to extend the known spectrum of cosmic rays at high energies by several orders of magnitude began to be designed and constructed. The energy spectrum that emerged from these experiments was shown to follow a power law with an energy dependence of $\sim \mathrm{E}^{-3}$. Therefore, the cosmic ray flux has very low values for the highest energies, reaching of the order of one particle per km^2 per century per steradian for energies about 10^{20} eV. Thus, large arrays of detectors are required for the study of cosmic rays at the highest energies.

In 1963, John Linsley with the Volcano Ranch experiment, in USA, detected the first high energy event with an estimated energy above 10^{20} eV [7]. At about the same time, Arno Penzias and Robert Wilson discovered the Cosmic Microwave Background (CMB) radiation with a temperature of 2.7 K [8]. As a consequence of this CMB, Kenneth Greisen and independently, Vadim Kuz'min and Georgy Zatsepin, showed that the highest energy CRs would interact with the CMB photons and degradate their energy. This became known as the GZK-cutoff effect, which sets a maximum distance of about 100 Mpc from which CRs with energies above 5×10^{19} eV [9] may have propagated to the Earth.

It is natural to expect that activities related to the study of CRs in Argentina followed the international events mentioned above and this is what will be described in this contribution, which is based on the research made by Adrian Rovero, from the IAFE (Instituto de Astronomía y Física

[1] Nuclear plates are photographic plates with special emulsions that when revealed show traces of electrically charged particles that transversed during exposure as a row of silver beads. The observation technique is to stack multiple plates with emulsion and expose them tangential to the CR flux, protected from sunlight for a long time, from days to weeks. After processing the plates, they must be analyzed with microscopes powerful enough to detect silver grains of less than one micron thick, which form the image of the trajectory of a charged particle, and thus to identify the "stars", or centers produced by nuclear reactions in the plates during exposure. From the analysis of the shape of each trace on the plate one can deduce the type of particle that produced it.

del Espacio, CONICET-UBA) published in reference [10]. In section 2, we discuss the first evidences of CRs studies that somehow marked the start of this topic in Argentina. In section 3, some systematic studies of the CR response to altitude and geomagnetic latitude is presented which was accompanied by the creation of a solid group that have taken an important role on the development of new institutions and new research areas. Also, we will see how this initial group followed the international events and how it split in to two groups, one dedicated to the Elementary Particles Physics research and another dedicated to building CR instruments to be launched in balloons and rockets for the CR characterization (section 4). Finally, in section 5, we discuss the last 15 years with the rebirth of the CR physics at the highest energies with the construction and operation of the Pierre Auger Observatory.

2. Pioneering Cosmic Ray studies in Argentina

2.1 First evidences

As Adrian Rovero pointed out in his article [10], there are reports that show that Pierre Auger went to Argentina in 1933. This fact is mentioned in the obituary of Louis Leprince-Ringuet, who worked with Pierre Auger [11]. Also, in a book written by Pierre Auger about Cosmic Rays in 1941, it is mentioned that an experiment to study the variation of the number of cosmic ray particles with the geomagnetic latitude was performed. This experiment was done using Geiger-Müller counters that ran continuously during a boat trip that made the journey Le Havre - Buenos Aires, roundtrip [12]. These measures confirmed the decrease in the flux of particles near the Equator.

There are records that during the 1940's Enrique Gaviola organized informal meetings at the El Condor hotel, in Pampa de Achala, Córdoba province, Argentina, while leading the National Astronomical Observatory, in this province [13]. It is known that these meetings dealt mainly with issues of theoretical physics, but also the first cosmic ray experiments were performed. These meetings began with the arrival to Argentina of Guido Beck in 1943 and lasted at least until 1949 (as can be deduced from the written comments on the hotel guestbook).

According to Rovero's research [10], there is historical material at the Astronomical Observatory in Córdoba that testify that exposures of plates were done at this institution, although it is unclear whether they were performed using nuclear emulsions. The reference date is around 1945. Also, some notes from an unknown author were found that explicitly refere to Pampa de Achala (the same place where the informal meetings mentioned above were done) and the conditions of the plates revealing as well as the location where they were taken (figure 1). Rovero concludes that this material could be part of the work performed by Damián Canals-Frau, Guido Beck's student, based on a private communication with Pedro Waloscheck in 2009 [10], and on the review published in "Ciencia y Tecnología" magazine by Canals-Frau in 1949 [14] together with a presentation in the annual meeting of the Argentinean Physics Society (AFA) that same year. In some of the figures of the review, Canals-Frau exemplified a "star", which allow one to conclude that these plates were analyzed with microscopes. These presentations were made before 1947 and, therefore, would be the first indication that there were studies of nuclear reactions with CRs in Argentina. Since the material is not well documented and taking into account the type of publications done, it is believed that these studies were not considered relevant at that time.

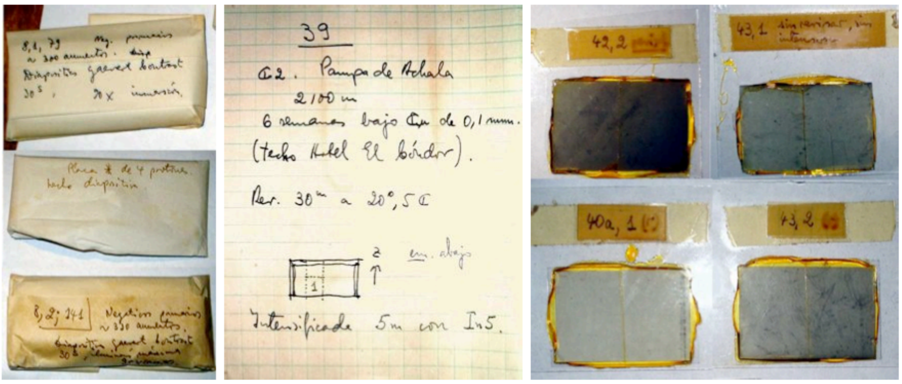

Figure 1: Picture of some of the historical materials at the Astronomical Observatory in Córdoba extracted from reference [10]. *Left:* Envelopes that contain the plates; *Center:* Unknown author notes included with the material; *Right:* Some plates with labels.

2.2 High altitude Cosmic Ray Observatory

At the end of the 1940's, the National University of Cuyo (UNC), in Mendoza, took the initiative to promote itself and created the Pure Science department, forerunner of the Scientific Research Department, whose program had two specific objectives: building an Astronomical Observatory in San Juan province and a Cosmic Ray Observatory in Mendoza province. The latter was named "Estación de Altura Juan Perón", whose construction was immersed in the national politics of the time with some civic-military expeditions. Although the station was built, it never worked as a Cosmic Ray Observatory, nor contributed to the goal of forming a center for the development of basic research in the region. This part of the history reconstructed by Rovero [10] is based on previous work done by Pablo Pacheco [15].

As a member of the Scientific Research Department, the Swiss-Italian Giovanni Pinardi, doctor of chemistry, who arrived in Argentina in 1946 and was professor at UNC since 1948, had the commitment to build the Cosmic Ray Observatory. The original idea was to place the observatory nearby Maipo Volcano, at 5100 m altitude, but then, for logistical reasons, it ended up being built at 3900 m, near Laguna del Diamante in Laguna mountain. Pinardi carried out the construction of the building, which was finished by mid of 1950 (figure 2). The design of this high altitude station was based on the italian station Testa Grigia built in the Alps, where Pinardi worked together with Enrico Fermi before coming to Argentina.

It is believed that Pinardi exposed nuclear plates at different altitudes in the areas explored for the construction of the Observatory, following the international context of the discovery of the pion using photographic plates with nuclear emulsions. There is also evidence that Pinardi made several public presentations on the subject of CRs. However, there are no reports of these studies on either national or international scientific circles.

Immediately after completion of the construction, Pinardi "presented his resignation tired of the envy and the hostile political environment at the University" [15]. There are evidences that during the next few years after construction and before being completely abandoned, the high altitude station operated as a Meteorological Observatory. Thus, the initial objectives set by the UNC were never achieved. However, the station would soon become useful for the logistic of other

Figure 2: Picture of the high altitude Cosmic Ray Observatory, extracted from reference [10]. *Left and Center:* Building finished in the middle of 1950; *Right:* G. Pinardi standing among the workers.

CR experiments.

3. First Systematic Research on Cosmic Rays in Argentina

3.1 First measurements

At the beginning of 1949, at the University of Buenos Aires (UBA) a group of students was formed to systematically study the CRs. This group was the first to produce scientific results in Argentina to contribute to the knowledge in this area. They were also pioneering in creating institutions and training human resources in CR and Particle Physics. The initiative started with the return of Estrella Mazzoli de Mathov from a scientific meeting in Brazil, where she had learned about the new modern techniques to study CRs. Estrella was, at that moment, assistant professor in Elementary Physics in the Faculty for Natural and Exact Science (FCEN) at UBA and was doing her PhD thesis using Geiger-Müller counters. The initial group was formed by the undergraduate students, Beatriz Cougnet, Hans Kobrak, Juan Roederer, and Pedro Waloschek coordinated by Estrella Mazzoli. They started to learn this new technique of detecting cosmic ray particles using the emulsion plates brought from Brazil. For that they equiped an small laboratory with a microscope and a system to reveal the plates.

They proposed to characterize the cosmic radiation, in particular to study its dependence on altitude and geomagnetic latitude in a systematic way. To this end, they organized a first expedition to the Andes with the available plates they had. In July 1949 Roederer went to Banderita mountain at 3200 m of altitude to leave the plates for a week. They went there invited by Pinardi, who helped with the expedition sending one of the persons from his group, Edmundo Pérez Crivelli. It is fair to say that this was the first measurement of CRs with nuclear emulsions perfectly registered in Argentina (figure 3).

During this expedition, they planned a new expedition for the summer of 1949-1950 to make systematic measurements at various points in the west side of the Aconcagua mountain. The measurements were made between Plaza de Mulas at 4325 m altitude and the top of the mountain. The total length of the expedition was 45 days. From the base camp they went by mule to place the

Figure 3: Juan Roederer in Banderita mountain at 3200 m altitude, in Mendoza province during the exposition of the nuclear emulsion plates, extracted from reference [10].

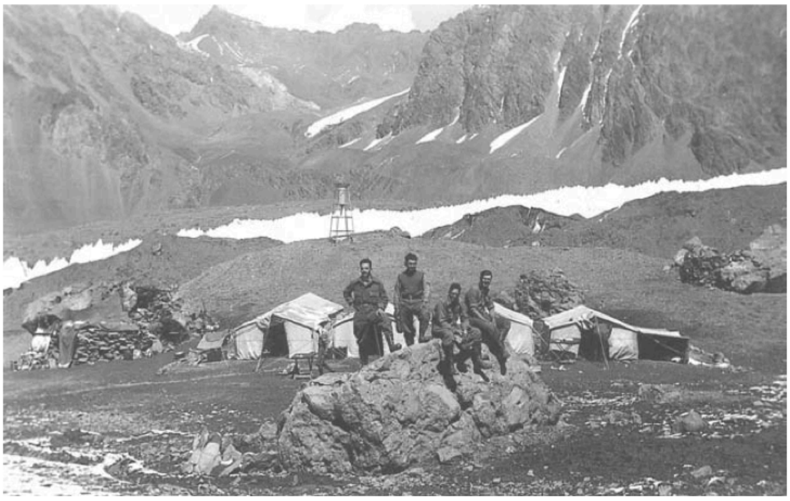

Figure 4: Picture of the camp at Plaza de Mulas, extracted from reference [16]. Soldiers that participated on the expedition together with the Director of Physic Department at UBA, J.J. Giambiagi (third to the left). The tent on the far left worked as an office and revealing lab.

plates at three different altitudes, of which only two could be recovered. The plates were revealed and checked with a microscope at the base camp at Plaza de Mulas (figure 4), although the final scanning was performed in the laboratory in Buenos Aires.

Unfortunately, the group failed when it came to the data analysis. According to Roederer, they made an error of principle, with the group putting much effort, man power and material capital to collet data, without much dedication in the analysis of data and their interpretation. As they were undergraduate students, they did not have time to analyse the data while taking courses. So they could not make a systematic scanning of the plates and never published any scientific results of significance on this expedition. However, they made a presentation at the annual meeting of the AFA.

3.2 International publication

As the second expedition was being undertaken another member of the group, Beatriz Cougnet was in Germany and had stablished contact with the group of nuclear plates of the Max Planck Physics Institute in Göttingen, in particular with Karl Wirtz, codirector of the Institute. Wirtz visited the group of students at Buenos Aires and committed to provide nuclear emulsion plates for the next expedition that the group was planning, this time to the high altitude station that Pinardi had just finished to build. The main objective this time was to register some nuclear reaction involving a pion, which was recently discovered [5] and raised a lot of scientific interest at that moment.

At the beginning of 1951, Pedro Waloscheck and Juan Roederer traveled again to Mendoza, to the high altitude station and they exposed the plates at the top of Laguna mountain at 5030 m altitude. The plates were revealed and scanned with success, and two "stars" that they were looking for were found. This led them to wrote their first international scientific publication of Argentina on this subject [17]. In figure 5 one of the two nuclear reactions published by the group is shown.

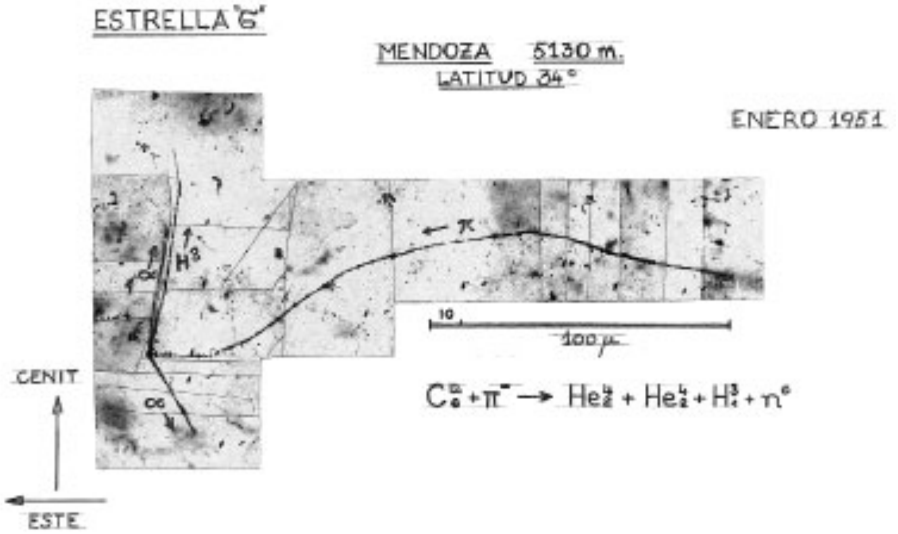

Figure 5: Micrograph of a pi meson capture by carbon nuclei in a nuclear emulsion exposed at Laguna mountain, extracted from reference [16].

In the same year of the publication, the group was very active and planning the next expedition, this time with the objective of studying the absorption of the nucleonic component of cosmic radiation at low geomagnetic latitude. For this sake, they chose to expose the plates in the Aconquija mountain, in Tucumán province, in the north of Argentina. This expedition was done in collaboration with the Physic Deparment of National University of Tucumán (UNT). The plates were placed by Cougnet and Roederer between 2600 m and 5330 m of altitude, revealed in a laboratory of the UNT and scanned in Germany, according to the agreement with Wirtz. The results were quickly published and were also part of Roederer's PhD thesis. This was the beginning of a productive collaboration with the UNT.

According to Roederer [16], in 1953 they did what he called "the last in the series" for the nuclear emulsion exposure. This time, following the objective to study the dependence of CR with the latitude, they planned what would be the last expedition to the Lanin volcano. After the expedition and back to Buenos Aires, they did not dedicate so much to this data analyses due to the several issues, although some results were used in future publications.

4. New laboratory at the National Commission of Atomic Energy

Towards the end of 1952, the High Energy division at the National Comision of Atomic Energy[2] (CNEA) was created and a group of Cosmic Radiation started to be formed. A Laboratory of Nuclear Plates was created and Pedro Waloscheck was hired to help to construct it. Waloscheck hired several persons. Most of them would have important roles in different groups and institutions that were created later, such Emma Pérez Ferreira (which became president of the CNEA), Horacio Ghielmetti (which later became president of IAFE) and Adulio Chiccini (director of the CR measurements in Bariloche). Also, Beatriz Cougnet, Alicia Díaz Romero and Juan Roederer were part of the group. Since this group covered different aspects of the cosmic radiation, this Laboratory of Nuclear Plates was transformed in the High Energy Division, directed by Roederer with two different laboratories: Elementary Particle Laboratory, also directed by Roederer and Cosmic Ray Laboratory directed by Ghielmetti.

The Elementary Particle Laboratory studied the nuclear reactions using the cosmic radiation. This Laboratory followed its own path and abandoned the study of CRs when the modern accelerators started to be built. On the other hand, the Cosmic Radiation Laboratory followed another path developing different kinds of detectors starting with muon and neutron detectors to the construction of X-ray and gamma-ray detectors mounted in aerostatic balloons and rockets, and also to the development of instrumentation for satellites. This ultimately lead to the creation of IAFE and latter with the CONAE (National Commission of Space Activities).

4.1 The International Geophysical Year

For the maximum of the Solar Activity Cycle, several activities were planned under the International Geophysical Year (IGY) organized by the International Council of Scientific Unions. Argentina joined the several activities including the study of cosmic radiation. For the IGY, instrumentation was installed in three observatories: Mina Aguilar in Jujuy province, Villa Ortúzar in Buenos Aires city, and Ushuaia and latter the Ellsworth station in Antarctic was added. In particular, the station Mina Aguilar was chosen by Roederer and Waloscheck in 1953 searching for a site at high altitude ($\sim$ 4000 m) but at low geomagnetic latitude and under the responsibility of

[2] The CNEA was recently created in May 1950.

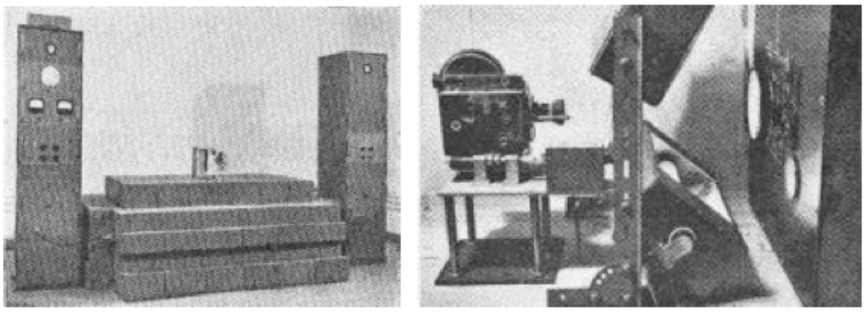

Figure 6: Neutron monitors used in the International Geophysical Year, 1957-1958, extracted from reference [10]; *Left.* Counters under the lead and paraffin shield with its electronics; *Right.* The camera to register the events.

the UNT group. The main characteristics of this station was its easy access and the appropriate infrastructure to harbor the equipment and the persons to operate the instruments for long periods of time.

For the IGY, the project was coordinated in Argentina by Ghielmetti and Cicchini and each observatory had different types of detector, including muon telescopes to monitor the flux of particles and a neutron monitor to study the modulation caused by the fluctuations of the magnetic field due to solar activities. The neutron monitor consisted in six proportional counters of BF_3 covered by lead and paraffin (figure 6). Since it was important to guarantee that the equipment worked continuously, two monitors in each station were placed. The data was recorded mechanically (perforated paper) and also photographically with a camera that took one shot each 15 minutes in normal conditions or each minute if there was some alarm related with the solar activity.

The muon telescope (figure 7) consisted of nine blocks with twelve Geiger-Müller counters mounted in a turntable working in coincidence. In this way, each time that a muon particle crossed the detectors, the coincidence circuit gave a register and counting the number of registers per time unit it was possible to determine the flux at different directions according to the counter orientation. Also they had a "cubic telescope" required by the IGY, composed of three blocks of Geiger-Müller counters in coincidence. This muon telescope was also duplicated in each station to guarantee continuity in the muon flux monitoring.

According to Rovero [10], the commissioning and data taking during the AGY produced a big impact in Argentina, in particular for the division of High Energies. This was the opportunity to provide a significant contribution to the international scientific community and to establish possible cooperations with international renamed institutions. As a consequence a very important Cosmic Rays Conference was organized in Bariloche in 1959 and this research domain expanded to different centers in Argentina. In particular, Roederer started a group in Córdoba University, where some years later they performed several observations with neutron monitors between the years 1964 and 1970.

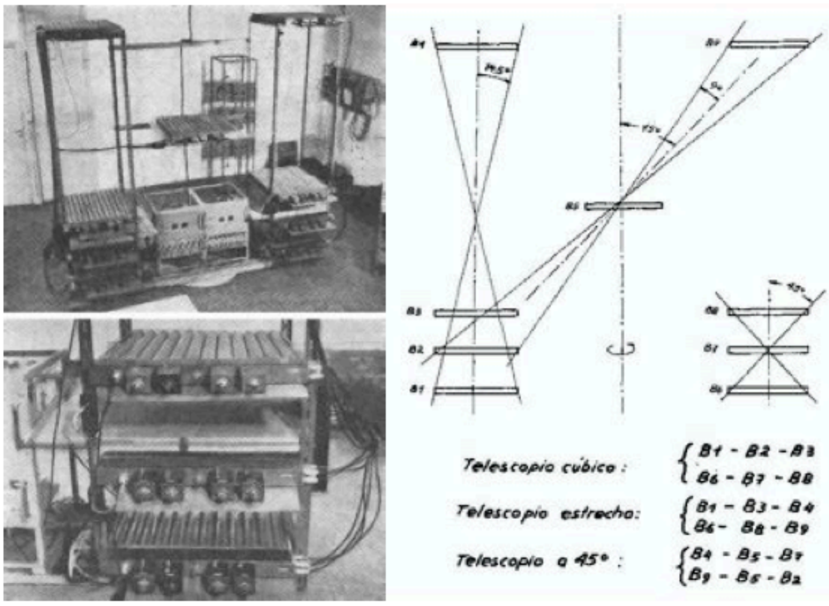

Figure 7: Muon telescopes used in the IGY, 1957-1958, extracted from reference [10]; *Up-Left.* Set of nine blocks with twelve Geiger-Müller counters and its associated electronics; *Down-Left.* Cubic telescope with three blocks of twelves counters, required by the AGY; *Right.* Scheme of the 9 blocks configuration with their logic combinations.

4.2 Space Physics to study Cosmic Rays

From the activities performed for the IGY, another group started to undertake activities devoted to Space Physics. In 1958, James Van Allen discovered the belt of trapped particles in Earth's atmosphere. Due to the asymmetry of the magnetosphere, there is a region where the belt is a few hundred kilometers above the Earth surface, and where the charged particles could precipitate. This is known as South Atlantic Anomaly (SAA). In particular, this precipitation of relativistic electrons should produce X-radiation. Due to its location, Argentina is a place privileged to study the SAA. This motivated a group coordinated by Ghielmetti that started to perform balloon observations.

From early 1962 to late 1963 they performed more than 30 balloon launches in Buenos Aires and in the Atlantic at 1500 km East of Buenos Aires. All the balloons were equiped with Geiger-Müller counters and a few of them had also X-ray detectors operating in three energy bands (20-60 keV, 60-150 keV and larger than 150 keV). The total load did not exceed 1.5 kg and a few liters of volume. According to Rovero [10], the published papers do not mention explicitly what kind of balloons were used, but he assumes they were meteorological balloons. There were several news in journals of that time, and in one of them, the creativity of the Argentineans for doing relevant science with very cheap material and constructing homemake equipments is highlighted.

At that moment, the Laboratory of Cosmic Radiation, part of the CNEA, was more and more dedicated to Space Physics rather than to nuclear energy. Because of that, in 1962, the Laboratory made an agreement with the UBA in which their activities were supported by the FCEN. Two years

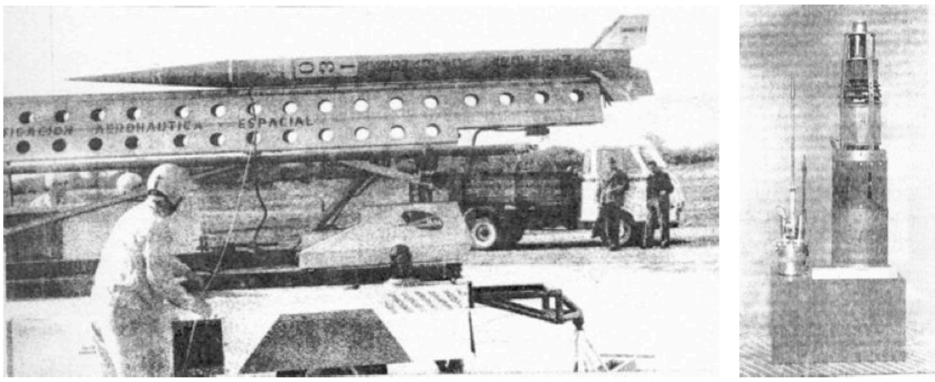

Figure 8: Launch of instrumentation mounted in the Orion rocket, extracted from reference [10]; *Left.* Preparations before the launch; *Right.* Ogive with Geiger-Mïller counters and scintillator material for X-Ray measurements.

later, an agreement was signed between CNEA, UBA and CONICET (National Council of Scientific and Technical) to create the National Center for Cosmic Radiation (CNRC). The first director of the CNRC was Juan Roederer, although he was more interested in the Van Allen particles than in the detection of the cosmic radiation. In 1966, Roederer was succeeded by Horacio Ghielmetti.

4.3 From CNRC to IAFE

At the same time that CNRC was created, a new international event was organized, motivated by the minimum of the Solar Cycle, the International Quiet Sun Year (IQSY). Several Argentinean Institutions participated on this event. An international network of neutron monitors, to study cosmic radiation was proposed, but this time with more sensitivity. The detection principle remained the same than the ones used for the IGY, but the collection area of each detector was larger. In Argentina, these monitors were installed in Buenos Aires, Ushuaia and Mina Aguilar. The data was registered in punched tapes. The group of the UNT also participated in the IQSY, since this group was active and with good international contacts. In particular they took care of the site in Mina Aguilar and some of their results were presented in the "VI Interamerican Seminar of Cosmic Radiation" in La Paz, Bolivia, in 1970.

Following the international events, in 1965, the CNRC started to measure the cosmic radiation with instrumentation aboard rockets built by the Institute of Aeronautic and Spacial Research (IIAE) created in 1961 by the Air Force. Using these rockets, they wanted to go above 38 km high, that was the maximum altitude reached by the balloons. The need of going higher was related to the different residual X-ray components in the atmosphere that complicate the discrimination of the radiation produced by the supposed precipitation of electrons near the SAA. Going higher not only the residual component would be attenuated but also, the X-rays would not be so much attenuated by the atmosphere. According to Rovero's research based on references in the literature [10], there were two launches with this objective, one in December 1967 with an Orion 24 rocket, which reached an altitude of about 90 km and another in August 1969, also with the Orion 31 Rocket that reached 80 km (figure 8). Both of them were equiped with the same kind of instrumentation. The data collected by the Orion 24 launch were not able to be interpreted since the altitude was not established with enough precision. The data of Orion 31 was not useful either since there was a problem in the launch hindering X-ray measurements. In spite of this, comparing the two measurements, the the fluxes measured with the counters were comparable. There are registers that also the group in UNT did some launches aiming to study Galactic X-rays.

As a consequence of all the work done with balloon and rocket launches, a new Institution dedicated to the Astrophysics was needed. In 1971, the Institute of Astronomy and Space Physics (IAFE) was created, and latter, this institution helped with the creation of the National Commission of Space Activities (CONAE). Concerning the high energies, in the 1970's, IAFE was focused on instrumentation mounted in aerostatic balloons, but their results were published only in the 1990's. The experimental group dedicated much of the time to the instrumentation of the satellites. One decade after, the institution started in Argentina a new history with the gamma ray astronomy and more than two decades latter, they returned to CRs physics through to the Pierre Auger project, on which more Argentinean institutions were involved.

5. Ultra High Energy Cosmic Rays Research in Argentina

In 1992, given the need to build a giant cosmic ray observatory in order to understand the origin of highest energy particles that reach the Earth, three people began to conceive the idea of what is now the Pierre Auger Observatory [18]. These pioneers were James Cronin (from Chicago University and Nobel laureate in Physics in 1980), Alan Watson (from Leeds University) and Murat Boratav (from Paris University). They planed to construct a giant Observatory to study the Ultra-High Energy Cosmic Rays (UHECRS) with an unprecedented statistic to resolve the controversy raised by the two experiments of that time, AGASA[3] [19] and HiRes[4] [20] on the existence or not of the GZK-cutoff [9]. This project was initially called Giant Array Project (GAP), but later was changed to Pierre Auger Project to honor the discoverer of extensive air showers.

5.1 Joining the Pierre Auger project

Two years after these three pioneers started the idea of the Pierre Auger Observatory, the project idea arrived to Argentina through Luis Masperi. He was organizing in Atomic Center of Bariloche (CNEA) the "VI Argentinean Symposium of Theoretical Physics on Particles and Fields", where James Cronin was invited. During one of the AFA annual meetings, Masperi commented this idea with Alberto Etchegoyen (TANDAR-CNEA), who showed interested. At the same time, independently, Alberto Filevich (TANDAR-CNEA) also learned about Cronin's ideas to build a cosmic ray observatory. Both aware of these news, they decided to contact Jim Cronin to invite him to give a talk at the TANDAR Laboratory. Finally, Cronin visited TANDAR in early 1995 and gave a talk about the necessity of building a giant observatory and of searching for a site with

[3] AGASA consists of 111 scintillators of 2.2 m^2 separated by 1 km or more, covering a total area of 100 km^2 with 27 muon counters, located in Akeno in Japan. It was in operation from 1990 to 2002 with a total exposure of 670 km ^{2} sr year. Reported the detection of 11 high-energy events.

[4] HiRes is a fluorescence binocular telescopes stationed in Utah, USA. The first set of detectors was called Fly's Eye and then these were improved in resolution and aperture, which gave the name of HiRes (high resolution). The total exposure was estimated at $\sim$ 600 km^2 sr year in monocular mode and $\sim$ 170 km^2 sr year in stereo mode.

Figure 9: First International Auger Collaboration Meeting in Argentina, extracted from reference [10].

specified characteristics to be defined during a six month meeting at same year. Hence, Filevich and Etchegoyen together with Masperi and Colomb (CONAE) started to organize the participation of the Argentineans in this project.

At this time, a special team composed by Antoine Letessier-Selvon (France) and Kenneth Gibbs (USA), was looking for candidates for the sites where the Observatory would be built. Argentina was a candidate country and the local collaboration pre-selected some candidates to be visited by the official searching group. Also, the Argentinean Collaboration was consolidated as such in 1995 with the first national meeting that took place in Bariloche during the annual AFA meeting. The participants of this Argentinean Auger meeting included Watson, Cronin, and some Brazilians collegues [5], who also were interested in the project, Ronald Shellard (Brazilian Center to Physics Research, CBPF) and Carlos Escobar (University of São Paulo).

At the end of this same year, Argentina was selected as the South Site for the Auger Observatory during a meeting at the UNESCO in Paris. Argentina was competing with Australia and South Africa. At this meeting the Argentinean team presented a summary of the characteristics of the different possible sites and agreed to study in detail some sites for the final decision of where the Observatory would be constructed. At that time the study of CRs in Argentina restarted to be a major subject.

In early 1996 the Argentinean Collaboration met in the Physics Department of University of La Plata, another of the member institutions of the project. At this meeting the group was consolidated and the distribution of the different tasks of the project started. They also started to organize the First International Auger Collaboration Meeting in Argentina, held in San Rafael, Mendoza province (figure 9).

During the following years, several studies for candidate sites in Argentina were performed. It was also time of intense political activities, where the Argentinean Collaboration ignored the political pressure, giving support for the project to continue despite the twists and turns that affected the country. In August 1997, James Cronin, spokeperson at that time, signed together with the Secretary of Science and Technology a letter of intent. This letter was the starting point to obtain the financial support needed to fulfill Argentina's commitment for building the Observatory. Finally, in

1998 Malargüe was chosen as the site where the Observatory. One year later, and with the arrival of a new national government, the project obtained full support in Argentina. An Engineering Array started to be constructed to check the design parameters and study its functionality. After this phase, the final construction was started in 2002 and completed in mid 2008.

The Pierre Auger collaboration has more than four hundred researchers and engineers from seventeen countries and is collecting data in a stable form since January 2004. It already produced important results for understanding UHECR such as the determination of the extra galactic origin and the anisotropic distribution of the highest energy events, the suppression in their flux (compatible with the GZK-cutoff), and several limits on the photon and neutrino fluxes [21].

5.2 The Argentinean Collaboration

During the stage of detector design in the TANDAR Laboratory, one of the first prototype Water Cherenkov detectors (WCDs) was built. A WCD is mainly formed by a tank with pure water that contains photomultiplies (PMTs) to detect the Cherenkov light generated by charged particles that go throught. This prototype had a number of flexible configurations in order to study the response of the detector to different PMTs positions inside the tank, the effective height of the water volume, among others [22]. Also, this prototype was externally triggered by scintillator plates to identify muons crossing the WCD at different zenith angles allowing for a careful characterization of the response of the detector used for the calibration purposes and to validate the simulation codes [23]. This prototype not only gave the Argentineans the possibility to contribute to the international collaboration but also allowed to train human resources and involve new students in the project. One of the major contributions was the idea of the current calibration method of the WCD of the Auger Observatory, that was performed and tested in this prototype and adapted to the detectors of the Engineering Array [24].

Also, this prototype was part of a unit cell formed by 3 WCD in a triangle configuration ~ 250 m appart with a smaller WCD in the middle of the triangle, named TANGO (TANdar Ground Observatory). This array gave the opportunity to study CRs at energies around 10^{15} eV for the first time in Argentina [25, 26]. Later, the array was dismantled and the prototype was used for teaching and training purposes.

In parallel, the La Plata group, led by Sergio Sciutto, was focussing on the shower simulations. They wrote a code, named AIRES [27, 28], which became very popular in the cosmic ray community and is used by several groups from Auger Collaboration as well as from other experiments. The code is very easy to install, to use and is very fast to run. These characteristics make it unique from the rest of the others.

The contributions described above represent a few examples of the degree of development achieved by several groups in Argentina, which are now qualified to work in most aspects of the Auger Observatory. At present, the engagement of the Argentinean groups in the Collaboration is very important and they have key responsibilities, from the maintenance of the Observatory to the data analysis. They are also taking the lead in several enhancements of the detectors.

6. Final Comments

This contribution represents an effort to recount the history of Cosmic Ray research in Argentina, which is largely ignored by most physicists inside and outside the country. We show how the will of a small group to unveil the mysteries of these particles persisted even in an unstable and sometimes hostile environment. Despite the lack of a strong research tradition, these pioneering initiatives led to the creation of new institutions and to a more sustained investigation on the field, which later conducted to the research in particle, nuclear, and space physics. The research on Ultra High Energy Cosmic Rays, triggered by the construction of the Pierre Auger Observatory, promoted a renovation in the field and the establishment of competitive groups covering this various aspects of the experiment.

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