Early Cosmic-Ray Research in Argentina

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The 1950s were a decade of political and economic difficulties in Argentina. Still, university students could carry out a modest research program.

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In March 1949, a group of us studying natural science and mathematics at the University of Buenos Aires gathered to hear teaching assistant Estrella Mathov talk about her trip to Brazil. Estrella had just returned from a scientific conference that had been attended by many great cosmic-ray physicists, including Cecil Powell, Beppo Occhialini, and Brazil's own Cesar Lattes. With great enthusiasm, she was telling everybody about the new projects and techniques that were just emerging in cosmic-ray research. Since Estrella was already working with Geiger counters, she encouraged the few physics majors, including me, to get involved with particle detection using nuclear photographic emulsions.[1] That new technique was particularly attractive because it did not require complex and costly electronic equipment.

Estrella had brought home emulsion plates from Brazil; some were still unexposed. She managed, somehow, to pilfer a microscope and then commanded us, "Let's get to work!" Hers was a revolutionary concept for an Argentine university at that time. Students were supposed to go to the university to attend classes, and professors were supposed to teach. But research? And research involving lower-division students at that?

Baby steps

Four of us followed Estrella's exhortation: Beatriz Cougnet, Hans Kobrak, Pedro Waloschek, and me. Hans was a chemistry major; the rest of us were majoring in physical–mathematical sciences. Beatriz, my high-school sweetheart, has now been my wife for 50 years.

With great reluctance, the physics department gave us a space that would serve as our office and laboratory for the next three years. It was a tiny room, without windows or ventilation, under the scaffolding of an old lecture hall. We installed the microscope and, with pots and pans, improvised a laboratory for developing nuclear-emulsion plates.

At first, Estrella put us to work with radioactive materials. We soaked the emulsions with weak solutions of thorium and uranium salts, then studied the tracks made by the alpha particles from their radioactive decay. We got good enough statistics to separate overlapping Gaussian distributions of track length and to calibrate the range–energy relation for alphas in the emulsions. We wrote a report and, despite being only sophomores, dared to present it in person to the department head, the venerable Teófilo Isnardi.

At that time, researchers were using cosmic radiation as a source of high-energy particles to study nuclear reactions and properties of the newly discovered π and μ mesons. To interpret their data, however, researchers needed to know what was coming in. In particular, they needed to know how the flux of cosmic rays varies with magnetic latitude (the latitude determined by Earth's magnetic dipole axis, as opposed to its geographic axis) and to understand the mechanisms for cosmic-ray propagation and diffusion through the atmosphere. As a place to investigate those questions, no better country existed than Argentina, with a 3000-km-long north–south stretch of the Andes and peaks that soared to 7000 m. Nor, we felt in our exuberant enthusiasm, was there a better group to carry out that study than Estrella's undergraduates.

We contacted the University of Cuyo in the Andean province of Mendoza. Fernando Cruz, rector of the university and a forward-looking science enthusiast, was establishing a research center there, the department of scientific investigations (DIC). He invited us to Mendoza and promised to help us with local logistics.

With financial support from Estrella (from her own pocket, as far as I remember), I traveled to Mendoza in July 1949 with a package of the emulsions she had brought from Brazil. Personnel from the DIC accompanied me to Puente del Inca, a spa in the middle of the Andes at 2700 m altitude. From there, we climbed a relatively low and easy peak, the Banderita Norte (see figure 1), about 3400 m high, to expose the nuclear emulsions. After a week, we went up again to retrieve them. In the interim, I spoke with DIC secretary Pérez Crivelli, a mountain expert who strongly encouraged us to plan a more ambitious program of exposures on the slopes of Mount Aconcagua. That mountain, the highest peak in the Western Hemisphere, loomed above and 35 km to the north of Puente del Inca. Again, the University of Cuyo promised local logistic support. The idea of following up our "feasibility study" with an expedition to the Aconcagua was, not unexpectedly, received with great enthusiasm by my colleagues.

Scientific mountaineering

Hans took responsibility for organizing the expedition. Through the good offices of the DIC, he established contact with the Argentine air force and army. The Aeronautics Ministry offered a DC-3 cargo plane to transport us and our equipment to Mendoza. The Ministry of War provided the necessary base-camp equipment, which came

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Figure 1. The author poses with nuclear emulsions (in the white box) at Cerro Banderita Norte, in this 1949 photograph. Located near Puente del Inca in Mendoza, this was the site of a study that established the low-cost logistic feasibility of exposing nuclear emulsions in the Argentine Andes. (All photographs by the author.)

from the High-Altitude Mountain Regiment in Uspallata and included five large tents, five soldiers, an experienced commander, a cook, and a dozen mules trained in terrain up to 6000 m altitude.

We had to work on Isnardi to obtain financial support for food and lodging and, above all, to secure his permission for something unheard of in that old-fashioned physics department—a handful of young, inexperienced lower-division students organizing and conducting a scientific expedition to the highest peak of the Americas. Permission was granted, but with the proviso that, on the ascent route, we never go beyond a certain point called "Nido de Cóndores" (Condors' Nest), situated at about 5500 m altitude. The summit itself was strictly off limits. As I see it now, that was a very reasonable judgment. But at the time, we were furious!

At the end of 1949, our group split into three parts. Hans and I went to Mendoza to conduct the expedition. Beatriz went to Germany on a business-and-family trip: The business was to visit Werner Heisenberg's Max Planck Institute (MPI) for Physics in Göttingen and learn about the work of their nuclear-emulsion laboratory, which was headed by Martin Teucher. Pedro accompanied us to Mendoza to help get the expedition started. His main task, though, was to take a summer job at the University of Cuyo and help to build a high-altitude laboratory on the flanks of Cerro Laguna, 150 km south of the Aconcagua. The laboratory was named, not surprisingly, Estación de Altura Perón, after Argentina's president and dictator Juan Perón.

Our expedition spent 45 days at the Plaza de Mulas base camp during January and February 1950 (see figure 2). We placed one package of emulsions at the base camp and another under 10 m of ice in the Horcones glacier, adjacent to the camp. Then, on 12 January, we began our ascents to deposit the remaining emulsions on the west flank of the Aconcagua (see figure 3). Practically everything was carried up by the mules. Those extraordinary animals had an incredible carrying capacity, especially considering the very difficult and dangerously steep terrain of loose rock, snow, and sometimes glacier ice.

We exposed the nuclear

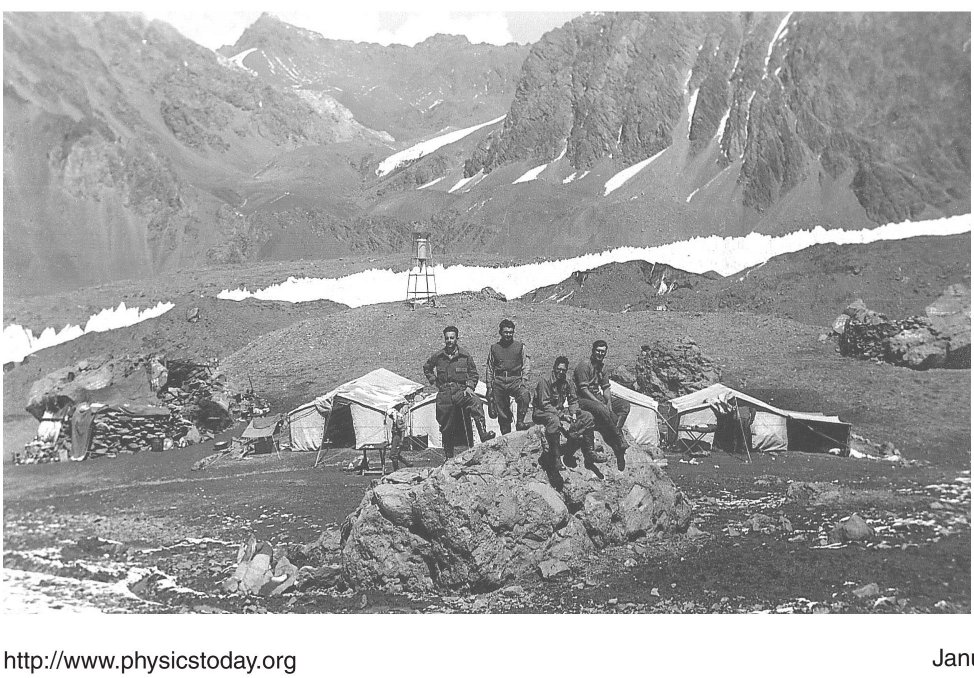

Figure 2. Plaza de Mulas base camp, at the foot of Mount Aconcagua. Juan J. Giambiagi, from the University of Buenos Aires (third from left), is accompanied by soldiers of the High-Altitude Mountain Regiment. His brief stay at the camp, on behalf of the physics department head, was to check on our well-being. In the picture's background are the Horcones glacier and Cerro Bonete.

plates at two places on the ascent route. The highest exposure point was located somewhat above Refugio Plantamura, a small, solid, wooden structure, at about 6000 m altitude, that served as a departure point for the final assault of the summit. At about 6100 m altitude, that exposure point violated Isnardi's prohibition—but only slightly! In fact, the Nido de Cóndores was way off the new ascent route.

The weather got a lot worse after our initial ascents. For two weeks, it snowed every morning. When the time came to retrieve the plates, we had to traverse slopes that had more than a meter of new snow. One of the packages of plates could not be retrieved, and may still be lying there.

At Plaza de Mulas, we developed all our plates during the night, in a tent. It was quite an adventure. The temperature in the tent was never much above −10°C, but the various solutions had to be kept lukewarm at specified, constant temperatures. We had a microscope at Plaza de Mulas, but used it only to check on the quality of development. The systematic scanning was supposed to be done in our tiny quarters at the physics department in Buenos Aires.

And that's where we failed. We had made a fundamental planning mistake by devoting too much attention and resources to the acquisition of data and not enough to data analysis and interpretation. Sound familiar? Our many student obligations precluded a systematic scanning of the plates exposed on the Aconcagua. Nonetheless, our expedition had several elements that, as I look back on it, I find commendable. We undertook a modest research project and experienced the excitement and the frustrations of research, both at a very early stage in our scientific careers. I'd recommend experimental work for any student's beginning efforts, even if the student is inclined toward theory. Our expedition allowed us to interact with the "real world," both in terms of the work we did and the people with whom we had to deal.

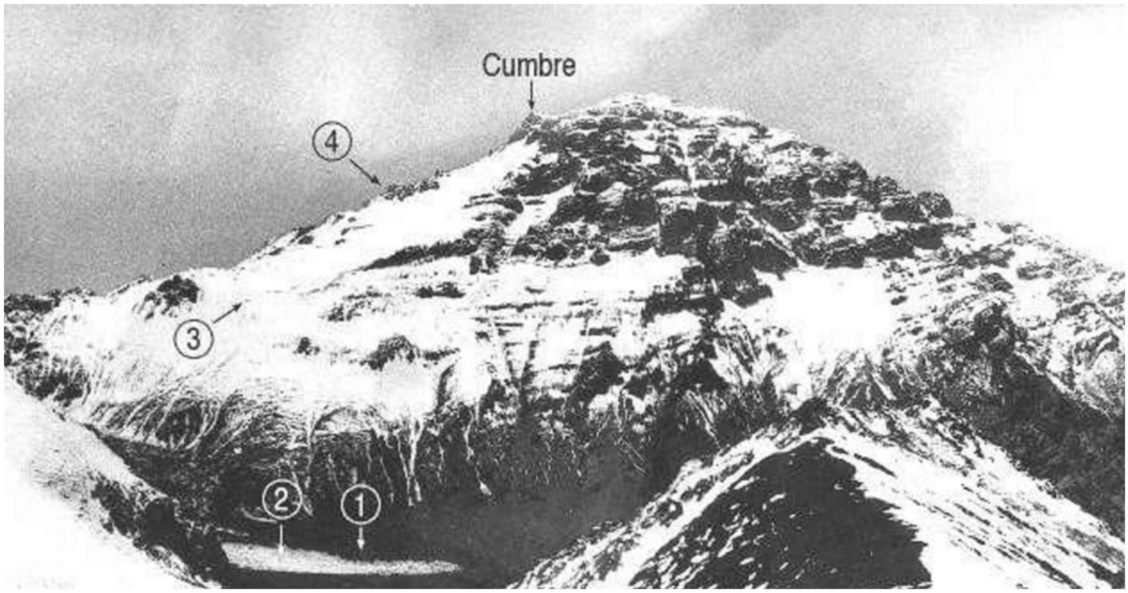

Figure 3. Mount Aconcagua's west flank as seen from the summit of Cerro Bonete. The numbers indicate nuclear-emulsion exposure sites: (1) the Plaza de Mulas base camp at 4350 m; (2) the Horcones glacier at 4300 m; (3) on the ascent route at 5200 m; and (4) near Refugio Plantamura at 6100 m, the highest point at which nuclear emulsions had ever been exposed on the ground. ("Cumbre" means summit.)

Sigma stars

Beatriz returned from Europe very excited about her visit to the MPI. There she had met Karl Wirtz, one of the institute codirectors. It happened that he was planning to visit Argentina later in 1950.

Indeed, one day, Wirtz did show up in our little cubicle at the university, and was quite impressed with the ingenious system that Pedro had built for developing nuclear emulsions. On several occasions during Wirtz's visit, we four students had the opportunity to discuss with him our future plans. He promised that the MPI would provide emulsions for exposure at the Estación de Altura Perón in Mendoza, and he invited me to spend some time at the MPI to work on the results.

Wirtz was impressed with our group and said as much to the leaders of the National Atomic Energy Commission (CNEA, now CONEA). Perón was in the process of setting up the CNEA as the federal agency assigned to deal with nuclear affairs. Its dual mission was to seek, enlist, and train young Argentine scientists in nuclear energy and to administer the infamous Huemul Atomic Project. That fusion energy project, conceived and directed by Austrian physicist and con artist Ronald Richter, was being developed in absolute secrecy on Isla Huemul, a small island on Lake Nahuel Huapí in the breathtaking southern mountain resort of Bariloche. Even at the project's early stages, some high-level members of Perón's entourage had serious doubts about Richter's sincerity and the soundness of his ideas. The doubters discreetly sought the advice of scientists from advanced countries—a risky move because of Perón's initial blind support of Richter. Wirtz was one such adviser, hence his visit to Argentina.

Shortly after Wirtz's visit, one of the doubters, Otto Gamba, an engineer at the University of Cuyo and, later, deputy director of the CNEA, called us to the CNEA's new offices just across the street from the "Pink House," Argentina's presidential residence. Gamba told us of CNEA's ambitious plans to support nuclear-physics and engineering research, and its intention to hire young scientists, even university students. We had, of course, heard rumors about the Huemul project, but Gamba assured us total independence from anything going on in Bariloche.

Taking advantage of Gamba's interest, we again enlisted the help of the University of Cuyo and, on 6 January 1951, Pedro and I departed for Mendoza. Our base camp was the Estación de Altura, and our expedition exposed a package of nuclear emulsions on the summit of Cerro Laguna, at 5230 m altitude. Once the emulsions, made by the Ilford company and provided courtesy of the MPI, had left England, it took only five days to place them at the top of the Laguna. Of great help were a special import license personally signed by Perón, Pedro's hair-raising jeep trip from the Mendoza airport to the Estación de Altura, and my record-breaking 4.5-hour solo ascent to the summit. (Mules cannot be used in that terrain.)

The purpose of the Laguna expedition was not to study

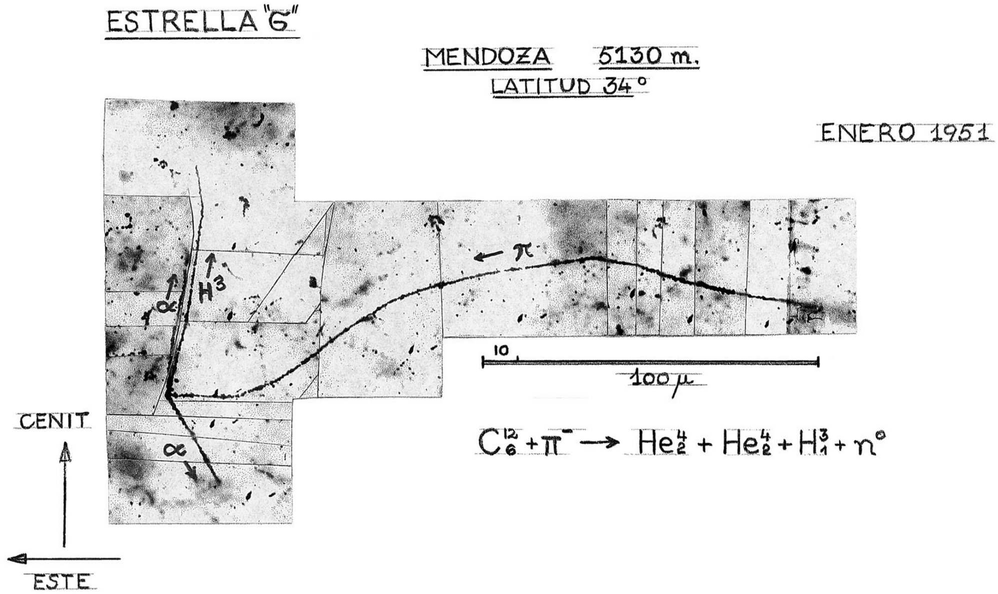

Figure 4. Micrograph composite showing a sigma star event recorded in a nuclear emulsion exposed at Cerro Laguna. The particle tracks are made of silver grains; by measuring the length, grain density, and scattering of the tracks, one can determine the electric charge, mass, and energy of the corresponding particles. The event shows the capture of a π^- meson by a carbon nucleus. This and a similar event led to the first Argentine paper on cosmic rays in an international journal (B. Cougnet, J. Roederer, P. Waloschek, *Zeitschrift Für Naturforschung A*, volume 7, page 201, 1952).

absorption in the atmosphere. Rather, it was to use cosmic rays in the study of high-energy nuclear reactions and, we hoped, to create a few mesons, particles that were then at the center of interest in physics. Thus, we did not need additional intermediate altitude exposures. The plates were exposed at the summit for just five days. After we retrieved them, we brought the emulsions to Buenos Aires and developed them in our cubicle. Our efforts this time were well rewarded: We found two events (a lot at the time) in which emulsion nuclei captured π^- mesons and then disintegrated into several fragments that could be fully identified. Figure 4 shows one of those "sigma star" events.

"The Argentine scientist Richter"

On 24 March 1951, shortly after our return from Cerro Laguna, Perón startled the world with his announcement that "the Argentine scientist Richter"—who couldn't speak a word of Spanish—had achieved the controlled release of nuclear-fusion energy.[2] Not one real Argentine physicist was participating in the Huemul project, and not one in the entire country believed in the truth of Perón's announcement. But 20 months would pass and 62 million pesos would be wasted before CNEA president Pedro Iraolagoitía could, with Perón's tacit and reluctant approval, intervene with a paramilitary operation and put an end to Richter's near-absolute authority.

Perón's bombshell announcement didn't affect our plans, consistent with Gamba's pledge that the more serious scientific plans of the CNEA would be independent from the Richter affair. Beatriz and I were organizing yet another expedition, this time a study of the atmospheric absorption of cosmic radiation's nucleon component at low geomagnetic latitude. Again, the help of the MPI proved crucial. In particular, Wirtz agreed that the exposed plates could be scanned in the Göttingen lab, which was well-equipped with expert scanners and was, by that time, under the direction of Klaus Gottstein. The services of those "popsies," as nuclear-emulsion scanners were called in Europe, and the emulsion package provided by the MPI for the Laguna expedition were the only material assistance we received from outside Argentina during all of our investigations.

As the site of our expedition, we chose a mountain range in the province of Tucumán. The Nevados del Aconquija, 1100 km northwest of Buenos Aires, are geologically independent of the Andes but also quite high. Our sponsors were the CNEA and the University of Tucumán; the local organizer and expedition chief was Orlando Bravo. A teaching assistant in Tucumán, Bravo would later become a member of the CNEA's cosmic-ray laboratory and a doctoral student of mine. We exposed our plates between 19 July and 8 August 1951 at various altitudes, ranging from 2600 m to 5330 m at the summit of Mount Tipillas de los Cerrillos (see figure 5). The plates were developed at the University of Tucumán's well-equipped radiochemical lab and immediately sent to Göttingen for scanning. Shortly after our return to Buenos Aires, the four of us received an offer from the CNEA for employment as part-time student investigators. We were among the first half-dozen scientists—or would-be scientists—employed by the CNEA.

In December 1951, I went to Göttingen with a stipend from the CNEA. Thanks to the scanning work already in progress, I could begin analyzing and interpreting data right away. Visitors came from all over the world, and seminars were held almost daily; in that enormously stimulating atmosphere, it was easy to obtain interesting results from the start. I determined the absorption and diffusion characteristics of the nucleon component in various energy ranges. After comparing my results with those obtained earlier by Teucher in the Alps, I was able to accurately determine the latitude effect at those energies. Some of the results were published very quickly.[3] It was important work, at least to me. In time it became the subject of my doctoral thesis at the University of Buenos Aires.

Last expeditions

When I returned from Germany in September 1952, I found that the CNEA had moved. Their new building included a functioning nuclear-emulsion laboratory equipped with new microscopes, a photographic development lab, big windows, and good ventilation. The CNEA's new quarters had been expropriated from a large private pharmaceutical firm, allegedly because the firm did not "donate" enough money to the Eva Perón Social Foundation. At the beginning of the year, Beatriz, Pedro, and Hans had left the dark cubicle at the university for the CNEA laboratory. Several new people joined the laboratory during the year, including Emma Pérez Ferreira, who, many years later, would serve as CNEA president for the Alfonsín government. From the very beginning, two clear branches of research were emerging: a space branch that focused on the galactic and solar origins of cosmic rays and the modulation of their flux by the interplanetary magnetic field, and a nuclear branch that used cosmic-ray particles to study high-energy nuclear reactions and elementary particles.

In early 1953, about a month after Iraolagoitía's paramilitary intervention at Huemul, Beatriz and I, married by that time, embarked on another expedition, the last of the series. Our goal was to expose emulsions farther south, that is, at higher geomagnetic latitude, on the slopes of Lanín Volcano near Bariloche. While in Bariloche preparing for the expedition, we stayed at a hotel that belonged to the CNEA. The only other guests were the top authorities of the CNEA, three captains whom we called the naval Basque trio: Iraolagoitía, Joaquín Urretabizkaya, and Mario de Ugarriza.

The trio was in Bariloche for a mopping-up operation, the last act of the Richter fiasco. We had the chance to join them in one of their visits to Isla Huemul to examine what could be salvaged from that absurd and costly project. Richter's equipment, though, was mostly useless. He had built a powerful electric arc system in open air, extended across the gap of a huge electromagnet. He would inject lithium and hydrogen, which—surprise!—always exploded with a big bang. An array of Geiger counters nearby monitored the gamma rays from what was supposed to be a fusion reaction, and Richter would declare the counters' response to be definite proof of success. But once he'd had to relinquish command of his project, it became evident that the counter system responded efficiently to the large electromagnetic fields present whenever the arc was on, whether or not there was lithium and hydrogen.[2]

During our expedition, we found our bosses rather nervous. Richter was still in Bariloche, and the trio feared that some of his bodyguards would attempt to cause them harm. That fear was no joke: During the endless evening "Truco" card games the trio played with Beatriz, security chief Ugarriza always had his Colt 45 loaded and ready, plainly visible on the table.

Our exposure of nuclear emulsions on Lanín Volcano went without a hitch. Unfortunately, we were, once again, so busy with other projects after we returned to Buenos Aires that not much science came out of our expedition. More successful was a trip Pedro and I took to the far north to look for a place for a permanent high-altitude cosmic-ray observatory. We identified Mina Aguilar, an American lead mine, as the ideal spot: It was at the right altitude (4000 m) and geomagnetic latitude, had a building available for staff and equipment, and was supplied with electric power. We wrote a recommendation to the CNEA president, and a few years later, Mina Aguilar was part of the Argentine observatory chain for the International Geophysical Year (IGY).

Figure 5. Orlando Bravo, with a package of nuclear emulsions that were exposed at the summit of Mount Tipillas de los Cerrillos. The data obtained from the expedition led by Bravo allowed the first detailed determination of the magnetic-latitude effect and atmospheric absorption characteristics of the cosmic-ray nucleon component. The sign gives the initials of the National University of Tucumán and warns, "Danger. Don't touch." Bravo and colleagues didn't want any mountain climbers ruining their experiments.

Cosmic-ray laboratory

In November 1953, Beatriz and I flew to Göttingen with our new baby. We worked at the MPI until August 1955. In the summer of 1954, I participated in the Varenna summer school in Italy (see figure 6). Enrico Fermi's lectures there—his last—influenced me both as a physicist and as a teacher, and helped impress upon me how important it is for scientists from developing countries to interact with great physicists in both formal and informal settings. While we were in Europe, the cosmic-ray laboratory at the CNEA began preparing for the IGY, scheduled to start in mid-1957. Our group had lost Pedro and Hans, who had left for Germany and the US, respectively, but new blood and brains had arrived in the form of young postgraduates from the University of Tucumán.

When we returned from Germany, three observatories were being built under the direction of Horacio Ghielmetti and Adulio Cicchini. One was in Mina Aguilar, as Pedro and I had recommended a couple of years earlier; a second was in Buenos Aires; and the third was in Ushuaia, the southernmost city on the South American continent. The CNEA now had a division of high energy, whose directorship I assumed upon my return. The division included a cosmic-ray laboratory, headed by Ghielmetti, and a laboratory of elementary particles, led by me. Two weeks after our return, a revolution toppled the Perón regime and opened the way for a democratic government. Except for

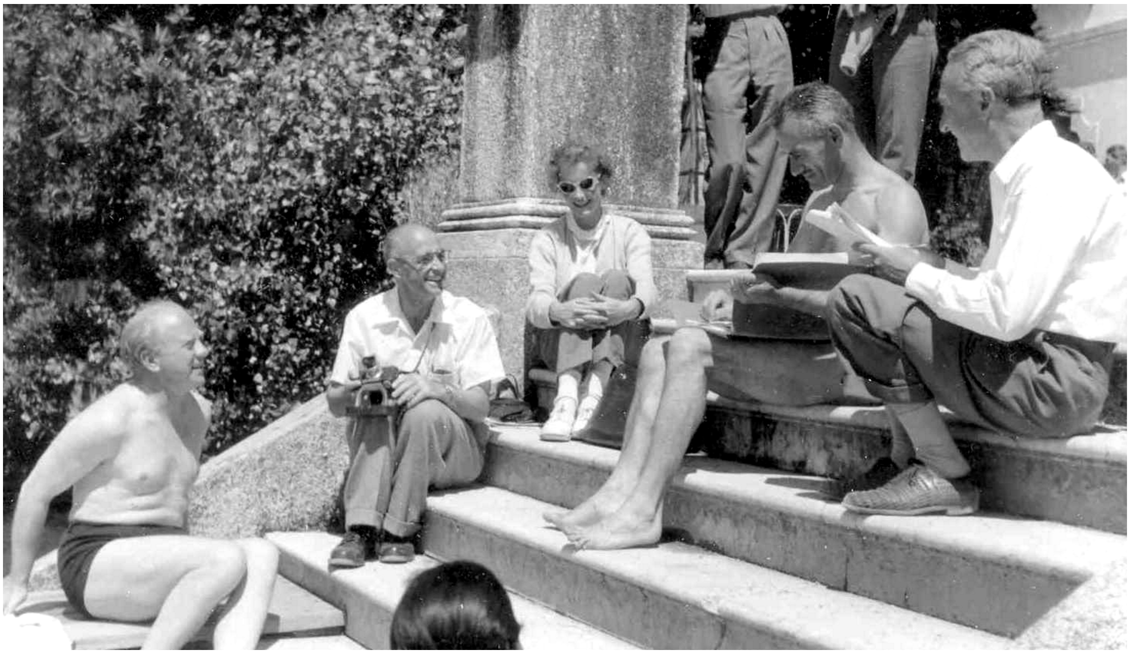

Figure 6. Informal gatherings were a part of the charm of the 1954 Varenna Summer School in Italy. Pictured from left to right are Werner Heisenberg, Enrico Fermi, M. Bruin, Louis Leprince-Ringuet, and Bruno Rossi.

changes in the top echelons, the impact on the CNEA was minimal compared to other governmental institutions. The reason was that most of the scientific and technical personnel of the CNEA supported the revolution. Thanks to the shrewd policy of the CNEA's leaders, the organization had always closed its eyes to the political orientation of its staff. Occasionally, it even offered "scientific asylum" to scientists fired for political reasons from universities and other institutions.

In 1957, the CNEA was the seat of an international symposium on physics of elementary particles, jointly organized by Juan J. Giambiagi, then the head of the physics department at the University of Buenos Aires, and me. Many top scientists participated from developing and advanced countries alike. Toward the end of the year, I spent some time at the Bevatron in Berkeley, California. As part of my research, I exposed a stack of emulsions to a high-energy beam and studied the resulting high-energy neutron interactions and K^0 meson pair creation. My work at the Bevatron illustrates why elementary-particle and cosmic-ray research were gradually separating: The great accelerators were replacing cosmic rays as a far more efficient and controllable source of high-energy particles. The divorce between the two fields led to an increasing independence of the two components of the CNEA's high-energy division.

The cosmic-ray laboratory also prospered. Its three observatories began functioning about a year after the mid-1957 start of the IGY, and thereafter provided a continuous record of the intensities of various components of cosmic radiation. Indeed, the greatest impact of the IGY was the stimulus and opportunity it provided scientists from developing nations to carry out world-class research with data obtained locally and from the new world data centers created through the IGY. Argentine physicists were able to make fundamental contributions, in particular toward understanding how solar-flare protons propagate through interplanetary space and how the galactic and solar components of cosmic radiation are affected by coronal mass ejections (then called "magnetic bottles"). Several colleagues and I published a series of papers[4] that marked a shift in the cosmic-ray laboratory's interest toward space physics, a new branch of physics born during the IGY.

The Ellsworth Station in Antarctica was transferred by the US to Argentina in 1958, and our cosmic-ray laboratory was put in charge of the neutron monitor there. Now we were operating one of the largest and best-equipped cosmic-ray chains of the entire IGY program. As had happened after our Aconcagua expedition, we were again flooded with data. But this time, thanks to a good team of young and eager scientists, those data provided material for studies, papers, and theses for years to come, and laid the basis for future experiments with balloons and rockets. In January 1959, the cosmic-ray laboratory, with support from UNESCO, organized a Latin American course on cosmic rays, which was held in Bariloche and had considerable international repercussions (see the article by Serge A. Korff and Robert L. Chasson, PHYSICS TODAY, July 1959, page 32). In summary—we were well on our way!

This article is based on my review "Las Primeras Investigaciones de Radiación Cósmica en la Argentina 1949–59: Un Relato Personal," published in 2002 in Ciencia Hoy*, volume 21, page 38. I thank the Argentine members of the International Project Pierre Auger, a program that is reviving the interest of Argentine physicists in cosmic-ray research, for inviting me to write a personal account of those early years.*

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