Lattes at the Berkeley Cyclotron in March 1948

THE PHYSICIST WHO SAW A BIGGER PICTURE

César Lattes' studies were based on experiments with cosmic rays and the use of accelerators in particle physics

Marcos Pivetta

July 11 of this year marks the 100th anniversary of the birth of physicist Cesare Mansueto Giulio Lattes (1924–2005). Born in Curitiba to a wealthy immigrant couple from northwestern Italy, César Lattes, as he was best known, was a unique character in Brazilian science. While living in the city of São Paulo, he managed to stand out from a very young age among a generation of brilliant physicists and mathematicians trained at the newly founded University of São Paulo (USP) in the 1930s and 1940s, including Marcello Damy (1914–2009), Mário Schenberg (1914–1990), and Oscar Sala (1922–2010).

The work he conducted shortly after the end of the Second World War advanced two related fields that use different approaches to study the origin and role of subatomic (smaller than an atom) particles: research on cosmic rays that reach Earth and particle (accelerator) physics.

As an investigator of the tiny world hidden inside the atom, he proposed an improvement to nuclear emulsions, a special type of photographic plate used to detect fleeting subatomic particles that last for only fractions of a microsecond. His idea was to increase the sensitivity of the emulsions, allowing him to see phenomena that others could not.

In 1947, while working at the University of Bristol in the United Kingdom, Lattes co-discovered a new type of subatomic particle produced by cosmic rays hitting Earth: the pi meson (now known as a pion). The primary function of the pion is to hold the atomic nucleus together and thus prevent protons and neutrons from escaping. The improved emulsion plates made it possible to observe traces of the particles in records obtained in France and Bolivia. The following year, Lattes was the first to observe the pion itself, this time produced artificially inside a particle accelerator at the University of California, Berkeley (*see page 40*). In 1950, the head of his former laboratory in Bristol, the British physicist Cecil Powell (1903–1969), won the Nobel Prize in Physics for improvements to the photographic particle detection method and identification of the pion.

Although he did not receive the Nobel Prize himself, Lattes quickly gained respect and fame. His practical ingenuity led to his meteoric rise, and the research he conducted in his early career had repercussions at home and abroad. At the height of his popularity, he was a scientific celebrity in Brazil in the same mold as the public health doctors Carlos Chagas (1879–1934) and Oswaldo Cruz (1872–1917). He was the subject of a samba show and was pictured on magazine covers.

With his scientific prestige, he helped found the Brazilian Center for Physics Research (CBPF) in 1949 and supported the creation of the Brazilian National Council for Scientific and Technological Development (CNPq) in 1951—and he did all this before turning 27. "There is no book on the history of physics in the last century that does not mention the importance of Lattes's work with the pion," says the physics historian Olival Freire Junior of the Federal University of Bahia (UFBA), currently the scientific director of the CNPq. "Lattes is considered a genius much the same way mathematician John Nash [1928–2015] was."

Like his American colleague, who won the 1994 Nobel Prize in Economics for his contribution to game theory, Lattes suffered from mental illness. Nash had schizophrenia, a condition that caused hallucinations and at times alienated him from reality. Lattes alternated between episodes of extreme depression and euphoria, a condition that today would likely be diagnosed as bipolar disorder. "He was hospitalized several times due to his mental health, which hindered his career. He might have done more if he had not suffered from this problem," says Antonio Augusto Passos Videira, a philosopher and science historian from Rio de Janeiro State University (UERJ) and collaborating researcher at the CBPF. "But that takes nothing away from the merit of his work."

Lattes was an enthusiast of experimental physics and often a critic of mathematicians and theorists (Albert Einstein was one of his favorite targets throughout his life). "The only thing that matters is what you can detect or what you can infer from what you detected," he said in an unpublished interview that is part of the physicist's collection at the University of Campinas (UNICAMP), the last place he worked. "Lattes mastered scientific know-how," explains Heráclio Duarte Tavares, a science historian from Mato Grosso State University (UNEMAT) who has been studying the physicist's career.

Although he was one of the first scientists to show the potential of particle accelerators for discoveries about the subatomic world, Lattes dedicated most of his career to studies of cosmic rays. This was the field in which he began and ended his scientific career.

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César Lattes (*without a jacket*) poses with his brother Davide, his mother Carolina, and his father Giuseppe (*above*). Portrait of Lattes aged 19 at his graduation from the physics program at USP in 1943 (*right*)

Before settling in São Paulo in the early 1930s, the Lattes family lived in Curitiba and Porto Alegre in addition to spending six months in Turin, Italy. In São Paulo, César Lattes completed the equivalent of high school at Colégio Dante Alighieri in 1938. This traditional private school founded by Italian immigrants exists to this day. Through family connections, Lattes was able to secure a place in USP's nascent undergraduate course in physics at just 15 years of age.

His father Giuseppe was a foreign exchange manager at Banco Francês e Italiano in São Paulo. One of his clients was Gleb Wataghin (1899–1986), a Ukrainian-Italian physicist who moved to São Paulo in 1934 to implement the physics course at USP's School of Philosophy, Sciences, Languages, and Literature (FFCL)—the predecessor of what is now the School of Philosophy, Languages and Literature, and Human Sciences (FFLCH). The bank where Giuseppe worked was responsible for handling the salary of Wataghin, who studied cosmic rays.

One day, Lattes Sr. asked the physicist if he would talk to his son, who was interested in science. The young Lattes, who had even considered becoming an elementary school teacher, spoke with Wataghin, and the two hit it off. The rules for enrolling at university were less strict at the time, and after passing several academic tests, he was accepted into the course. Another Italian account holder at the bank, Giuseppe Occhialini (1907–1993), who also taught physics at USP, soon became an inspiration for Lattes Jr.

Lattes was a precocious talent, graduating in 1943 at the age of 19. He did not defend a doctoral

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Members of the HH Wills Physics Laboratory at the University of Bristol, headed by Powell (*sitting on the left in a suit and tie*). Lattes is fourth from the left in the second row

thesis, but that did not hold him back. In 1948, after his discovery of the pion, USP awarded him an honorary PhD. After graduating, Lattes spent some time studying cosmic rays in field experiments with two Italian colleagues who also studied physics at USP: Ugo Camerini (1925–2014) and Andrea Wataghin (1926–1984), Gleb's son. In 1946, he traveled to the United Kingdom and joined Occhialini, who was already conducting research with Powell's group at the University of Bristol.

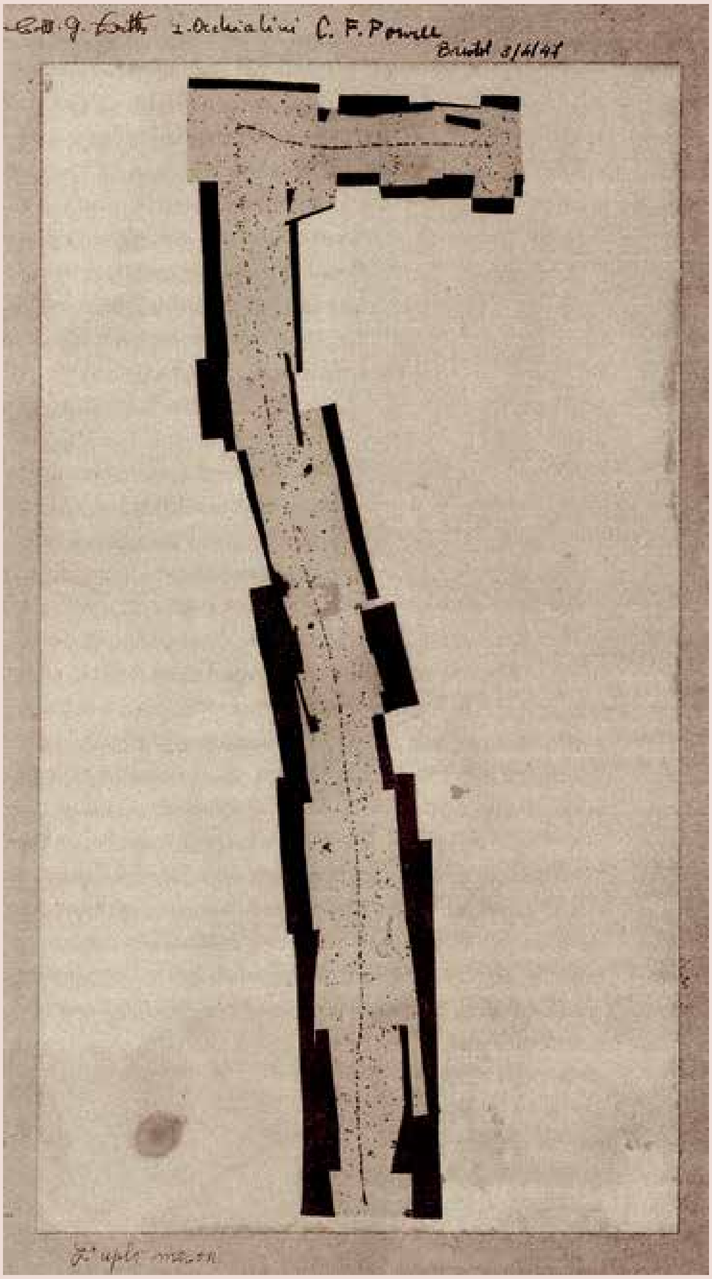
It was the Italian's second time in the UK. Between 1931 and 1934, he worked at the respected Cavendish Laboratory in the University of Cambridge's Department of Physics, which was led by Patrick Blackett (1897–1974) at the time. Together they helped to improve the Wilson chamber or cloud chamber, a closed container that uses supersaturated vapor to show the path of ionizing radiation, such as particles from cosmic rays. The pair used the improved device to confirm the existence of the positron, a positively charged antielectron. In 1948, Blackett alone won the Nobel Prize in Physics for this work. An interesting aside: during a stay in Cambridge in the mid-1920s, a young Robert *Oppenheimer* (1904–1967), who suffered from depression, allegedly left a poisoned apple on the desk of Blackett, who was then his supervisor. Whether fictional or real, the scene appears at the beginning of the 2024 Oscar-winning biopic Oppenheimer, which tells the story of the American physicist who was dubbed the "father of the atomic bomb."

It was the relationship Lattes established with Occhialini at USP that made it possible for him to visit Bristol in 1946. In the UK, the Brazilian had the chance to observe nuclear emulsions exposed to cosmic rays obtained by Occhialini on a 2,800-meter mountain in the French Pyrenees called Pic du Midi. The most sensitive photographic plates seemed to capture trails produced by particles of the meson class. To be certain of his discovery, Lattes proposed a similar experiment at a higher location in the Bolivian Andes. He believed that on Mount Chacaltaya, at an altitude of 5,421 meters, the chance of recording these particles from cosmic rays with the best-suited version of the photographic plates would be much greater. He was right.

However, a little-known episode almost put an early end to Lattes's ascending career. In April 1947, on his way to Bolivia to carry out the field experiment, Lattes had to pass through Brazil. Because the trip was funded by the British, he was advised to buy a plane ticket from a state-owned company, British South American Airways (BSAA). It would be a long and tiring flight that would take more than a day. After departing from London, there were stops in Lisbon, Dakar, and Natal before arriving in Rio de Janeiro, the final destination.

Lattes did not follow the advice. An official at the Brazilian embassy in London told him that the British aircraft were adapted war bombers and that the in-flight service left much to be desired. "His contact suggested he travel with the Brazilian airline Panair because they had brand new planes, good food, and attractive flight attendants," said the journalist Cássio Leite Vieira

PHOTOS 1 AND 2 CÉSAR LATTES'S PERSONAL ARCHIVE **3** UNIVERSITY OF BRISTOL



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Traces left by mesons (*above*) observed on photographic plates (*below*) by the Bristol group

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in the book *César Lattes – Arrastado pela História* (César Lattes – Carried by History), a brief biography published by CBPF in 2017 that can be downloaded for free online. The Brazilian physicist flew by Panair and probably escaped death: the British plane crashed in Dakar. "There are reports that there were no survivors," wrote Leite Vieira.

After confirming the discovery of the pion in the experiment in Bolivia and then at the Berkeley accelerator in 1948, Lattes returned to Brazil with a high reputation. After his involvement in the creation of the CBPF and CNPq, he remained in Rio de Janeiro for most of the 1950s. Between 1955 and 1957, he spent time at the University of Chicago and the University of Minnesota in the U.S. "He didn't publish much during this period—probably due to his mental health problems, marked by episodes of depression," Leite Vieira explained in his book.

In 1960, Lattes returned as professor to the place where his career began: USP. Two years later, he began a major international research project called the Brazil-Japan Collaboration (CBJ), which studied cosmic rays for four decades, primarily at a physics lab in Chacaltaya, Bolivia. "Lattes could have stayed abroad," says Climério Paulo da Silva Neto, a science historian from the UFBA Physics Institute. Always a nationalist, however, he wanted to develop Brazilian science, and he prioritized partnerships with South Americans and countries outside Europe and the U.S.

His return to the institution that trained him was not permanent, however. In 1967, after spending a year at the University of Pisa in Italy where he worked more closely with geochronology, Lattes transferred to UNICAMP, which had been founded the previous year. He chose to leave USP because of a disagreement over a position as a full professor. He moved to Campinas and took his CBJ research with him. The new university, located in the interior of São Paulo, was where Lattes spent most of his time as a professor and researcher until he retired in 1986. He died in 2005 at the age of 80.

Although he came from a wealthy family, Lattes was always seen as a down-to-earth and approachable person. He loved animals. In interviews, he said he would have liked to have been a veterinarian if he had not become a physicist. There are many stories about one of his dogs, Gaúcho, a pointer who was like his shadow at UNICAMP in the 1970s and 1980s. The dog participated in his classes, attended his lab, and accompanied him on journeys in the car. "My hus-

PHOTOS 1 REPRODUCTION NATURE 2 ALICIA IVANISSEVICH 3 CÉSAR LATTES' PERSONAL ARCHIVES band [José Augusto Chinellato, a professor at UNICAMP] defended his doctoral thesis with Gaúcho in the room," recalls the physicist Carola Dobrigkeit Chinellato with a smile. Chinellato, a professor at the same university, was also supervised by Lattes during her PhD, and like her husband, she went on to investigate cosmic rays.

Friends and colleagues say that although Lattes was generally kind and humble, he was not always an easy person to be around. At times he could be harsh and even unfair. One historic episode was his public attempt to debunk Albert Einstein's (1879–1955) theory of relativity in 1980. "I remember him calling me and saying he wanted to hold a conference to criticize Einstein's work," says the physicist Roberto Leal Lobo, director of the CBPF between 1979 and 1982. "I thought the phone call was strange. But there was no way to refuse the request from Lattes, who was the founder of the center."

Lattes presented his controversial ideas at the CBPF, and he invited the press to the event. In an article published in the newspaper *Jornal do Brasil* on June 15, 1980, Lattes said, "He [Einstein] just got lucky. I think he was mentally ill. But the mentally ill sometimes see things that other people don't see. He made two lucky guesses: his theory on the photoelectric effect and his theory on black-body radiation, the basis of quantum mechanics. But in everything else, I think he's clueless."

In a presentation at the Brazilian Academy of Science (ABC), the physicist Jayme Tiomno (1920–2011), then at the Pontifical Catholic University of Rio de Janeiro (PUC-Rio), defended Einstein's ideas. "Lattes regretted this whole situation later," says the physicist Edison Shibuya, a retired professor from UNICAMP who was supervised by the pion discoverer during his PhD and then studied cosmic rays and worked alongside him for almost four decades. "Lattes saw that the measurements he used to test relativity could have been affected by the equipment."

Lattes was married and had four daughters, three of whom are still alive. None studied physics or became scientists. He also had a brother, Davide, who owned a construction company. At the universities he attended, in addition to his scientific work, he left hundreds of academic descendants: researchers whose master's or doctoral studies were supervised by him and who, in turn, trained new postgraduate students. There is no greater legacy for a master than the success of his or her pupils. In April 2024, the Presidency of the Brazilian Republic included Lattes in the *Livro dos Heróis e Heroínas da Pátria* (Book of National Heroes). ■

Lattes arriving in Brazil in 1948

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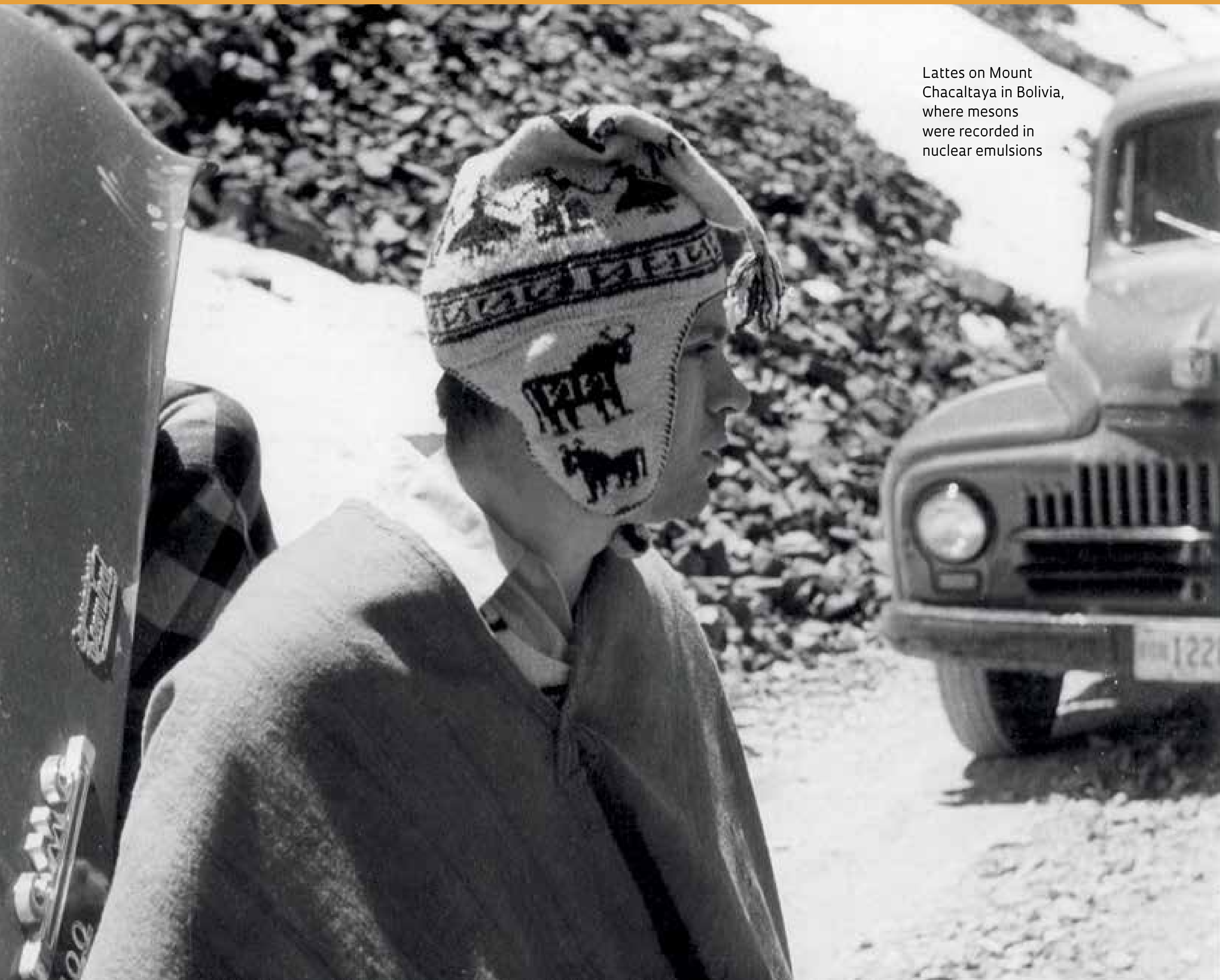
A MAJOR CONTRIBUTION



Lattes on Mount Chacaltaya in Bolivia, where mesons were recorded in nuclear emulsions

The discovery of the pion led to a greater understanding of the cohesion of the atomic nucleus

Marcos Pivetta

Seventy-five years ago, when César Lattes played a decisive role in the discovery of the pion, one could count the number of subatomic particles known to science on one hand. At the time, three basic constituents of the atom were identified: electrons in 1897, protons in 1919, and neutrons in 1932. However, our knowledge of the inside of the atom did not go much further than that.

At the end of 1934, Japanese physicist Hideki Yukawa (1907–1981) of Osaka University proposed a theory about what holds the atomic nucleus together. The integrity of the structure, which contains 99.9% of the mass of an atom, was a mystery. Formed by neutrons with no electrical charge and positive protons, the atomic nucleus should theoretically break apart due to electromagnetic forces. Because they have the same charge, the protons should repel each other, tearing the nucleus apart.

Since this is not what happens, Yukawa hypothesized that there must be a particle with an intermediate mass between that of the proton and the electron that transmits a force (now referred to as the strong nuclear force) capable of negating the electromagnetism and ensuring that the nucleus remains intact. According to the Japanese physicist's calculations, this hypothetical particle, which would later be named the meson, has a mass between 200 and 300 times greater than the electron and 6 to 9 times smaller than the proton. "Yukawa's ideas were largely forgotten for a few years," says Antonio Augusto Passos Videira, a philosopher and science historian from Rio de Janeiro State University (UERJ) and collaborating researcher at the Brazilian Center for Physics Research (CBPF).

In 1936, while carrying out measurements of cosmic rays, American physicists Carl David Anderson (1905–1991) and Seth Neddermeyer (1907–1988), from the California Institute of Technology (Caltech), discovered a particle with approximately 200 times the mass of an electron. It was originally called a mu meson, now known as the muon. Within a few years, however, other experiments showed that the muon was not related to the cohesion of the atomic nucleus and was not the meson predicted by the Japanese physicist.

The mystery only began to become clearer after the end of the Second World War, with the arrival on the scene of a scientist who was not from any of the traditional great international physics institutions, that is, the young César Lattes in his early twenties. Between 1946 and 1948, this Brazilian scholar was the first physicist to observe experimental evidence of trails produced by mesons both in nature in a shower of cosmic rays and "artificially" inside a particle accelerator. The particle identified by Lattes was originally called the pi meson. Later, it came to be known as the pion.

The pion was discovered after the use of a special photographic plate referred to as a nuclear emulsion film, which began to replace Wilson cloud chambers in cosmic ray experiments that sought evidence of unstable subatomic particles. Compared with the previous technique, the new plates were capable of much more refined results. At the University of São Paulo (USP), Lattes worked with cloud chambers, which are

PHOTO CBPF

closed containers that use supersaturated vapor to show the trails produced by electrically charged particles. The person who trained him, Italian physicist Giuseppe Occhialini, was one of his mentors during the years he taught at USP from 1907–1993. The trajectory of the particles appears in the form of lines in the image produced by this technique.

In the mid-1940s, Lattes had the chance to see nuclear emulsions sent to Brazil by Occhialini, who at the time was working at the HH Wills Laboratory of the University of Bristol, UK, headed by Cecil Powell (1903–1969). The Brazilian researcher was amazed by the possibility of new photographic plates, which are far more sensitive because they contain approximately ten times more silver salts (silver bromide). He later accepted an invitation to work on the other side of the Atlantic, leaving for Bristol in 1946.

It was at this point in history that the key moment in identifying the pion occurred. Upon arriving at Bristol, Lattes asked the Ilford laboratory—which manufactured nuclear emulsions alongside Kodak—to produce photographic plates with an additional element in its gelatin, namely, boron. The introduction of boron increased the retention time of the images in the emulsions and extended the sensitivity period of the plates. The modification enabled the visualization of extremely fast and fleeting subatomic particles, such as pi mesons. When an ionized particle passes through an emulsion, the silver and bromine are separated. "This produces the traces we see on the plate," explains Carola Dobrigkeit Chinellato, a physicist from the University of Campinas (UNICAMP) who performed her PhD under Lattes' supervision and studied cosmic rays.

Boxes of equipment outside the CBPF headquarters, ready to be dispatched on an expedition to the Bolivian Andes in the early 1950s

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Later, in 1946, Occhialini traveled to Pic du Midi, a 2,800-meter mountain in the French Pyrenees, to record particles originating from cosmic rays via nuclear emulsions, both with and without boron. The idea for this test is attributed to Lattes. Back in Bristol, the pair found evidence of two types of unstable particles in the boron plates, that is, the pi meson, whose name originated from the fact that it is the primary particle, the decay of which gives rise to the mu meson (muon). At the time, the muon was believed to be a meson (a nuclear particle with intermediate mass), but it was later determined that it is a lepton—a heavy relative of the electron. To verify the discovery made at Pic du Midi, Lattes proposed a repeat of the experiment at a much higher location on a mountain in the Bolivian Andes. "The number of cosmic particles on Chacaltaya, at 5,500 meters, is 100,000 times greater [than in Pic du Midi]," recalled Lattes in a 1995 interview published in the magazine *Ciência Hoje*.

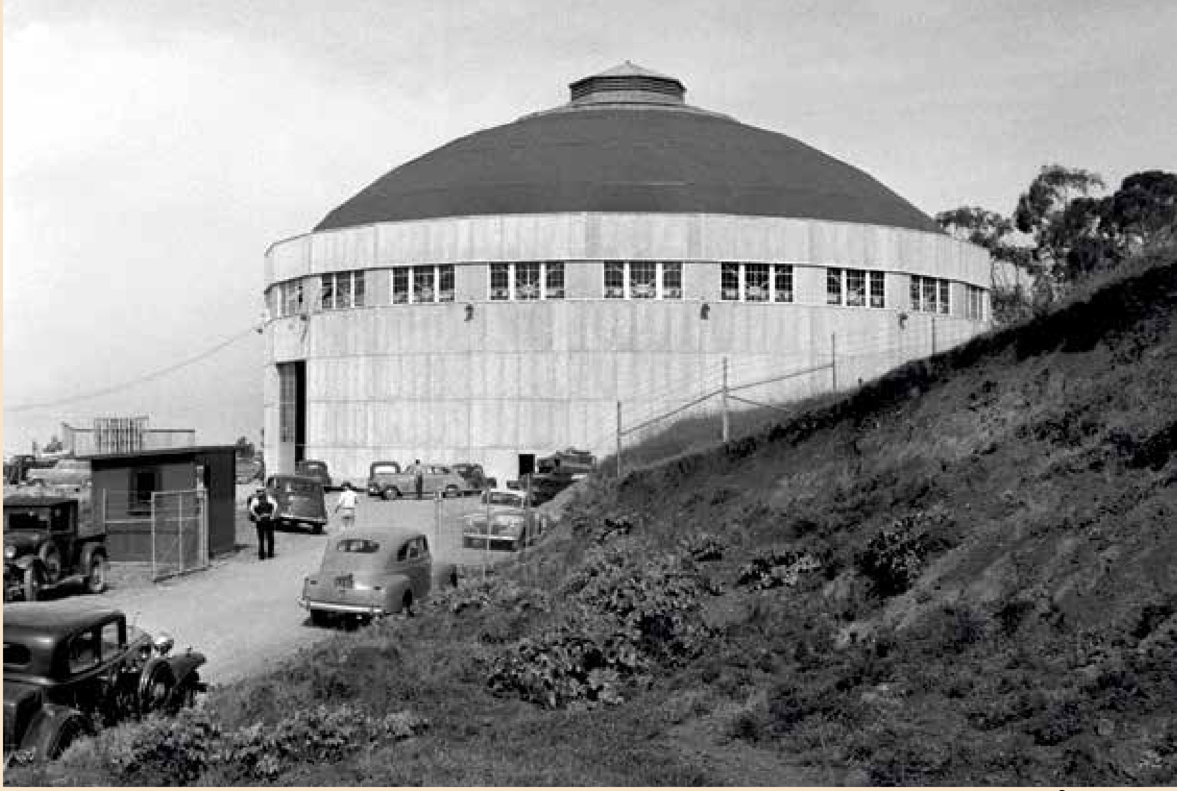
The expedition to the Andean mountain left from Brazil, with Lattes taking the emulsions to the neighboring country, where he achieved his objective. A series of articles in the journal *Nature* describing the results from Pic du Midi and Chacaltaya confirmed the discovery of the pi meson on the basis of the observation of cosmic rays. In 1947, Lattes went to the University of California, Berkeley.

At the institution's 184-inch cyclotron particle accelerator, Lattes observed meson trails just 10 days after his arrival, something his hosts had been unable to do. The theorized artificial mesons, produced inside an accelerator rather than by cosmic rays, also became a reality. The discovery was attributed to Lattes and the American physicist Eugene Gardner (1913–1950), a student of the American nuclear physicist Ernest Lawrence (1901–1958).

NO NOBEL PRIZE

A question that always arises when recounting Lattes' career is whether the Brazilian should have won the 1950 Nobel Prize in Physics for his central role in the discovery of the pion. British scientist Cecil Powell, head of the Bristol group, received honor alone. The Royal Swedish Academy of Sciences awarded him the Nobel Prize "for his development of the photographic method of studying nuclear processes and his discoveries regarding mesons made with this method." The 1949 Nobel Prize in Physics was also awarded to a scientist studying these particles: Japanese theoretical physicist Hideki Yukawa, who predicted the existence of mesons.

Lattes was nominated for the prize seven times, but not in 1950, according to files published on the official Nobel website. In 1949 and 1952, he was



The Berkeley cyclotron in the 1940s, where artificial mesons were observed

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nominated twice (by two different people). In 1951, 1953, and 1954, he was recommended once.

Occhialini, who taught Lattes at USP and worked alongside him in Bristol, is another name that was apparently overlooked by the Nobel Prize Committee in 1950. With the Italian researcher, however, there was an additional factor: he had already missed out on the 1948 Nobel Prize in Physics, which was awarded to the British physicist Patrick Blackett of the University of Cambridge for his development of the cloud chamber method and discoveries in nuclear physics and cosmic radiation. Between 1936 and 1969, Occhialini was nominated the Nobel Prize 32 times but never won it.

"The Nobel Prize reinforces inequalities in research," says Climério Paulo da Silva Neto, a science historian from the Federal University of Bahia (UFBA). "The honor tends to be given to scientists from renowned institutions or those who already have great public recognition." The selection of famous names amplifies the impact of the award and feeds a cycle that promotes scientific notoriety for the Nobel Prize and its recipients. Silva Neto analyzed documents from the Swedish Academy, including letters of recommendation for Lattes, and is working on a paper about the Brazilian physicist and the Nobel Prize.

For decades, there were rumors that the Danish physicist Niels Bohr (1885–1962), who won the Nobel Prize in Physics in 1922 for his studies on atomic structure and radiation, had written a letter to the Swedish academy with harsh criticism of its choice not to honor Lattes. The letter was supposedly set to be published in 2012, half a century after Bohr's death, but if it does exist, it has never come to light.

Soon after the Bristol group observed the pions, the renowned Danish physicist invited the Brazilian scholar to Copenhagen to give a series of lectures about his work. The two appeared to be compatible. However, according to Nobel's public records, Bohr never even nominated Lattes for the prize. The person who recommended the Brazilian for the award three years in a row (in 1952, 1953, and 1954) was Croatian-Swiss chemist Leopold Ružička (1887–1976), winner of the Nobel Prize in Chemistry in 1939.

Interestingly, in the first 50 years of the Nobel Prize between 1901 and 1950, the physics prize was awarded to just one scientist alone 35 times, to a duo eight times, and to three people once. On six occasions, the honor was not awarded because of the two world wars. Lattes repeated several times that he was glad that he did not win the Nobel Prize, since if he had, he would have spent the rest of his life writing letters of recommendation for researchers. However, on some occasions, he took a different stance. In a statement published in the *Jornal da Unicamp* newspaper in 2004, he said he was "robbed twice," a reference to missing out on the prize for his work at Bristol and at Berkeley. In an interview with the magazine *Superinteressante*, published after he died in March 2005, Lattes said that the Nobel Prize should have gone to Occhialini and criticized the award: "These grand prizes don't help science." ■

PHOTOS 1 CBPF 2 LAWRENCE BERKELEY NATIONAL LABORATORY