OBITUARIES

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James Watson Cronin

James Watson Cronin, a visionary leader in the fields of particle physics and astrophysics, passed away unexpectedly on 25 August 2016 from complications of a fall.

Jim was born on 29 September 1931 in Chicago, where his father was a PhD student in Greek language and literature. The family moved to Dallas when Jim's father became a professor of classics at Southern Methodist University. Jim attended SMU and graduated with a degree in physics and mathematics in 1951. He did his graduate work in experimental nuclear physics under Samuel Allison at the University of Chicago and received his PhD in 1955.

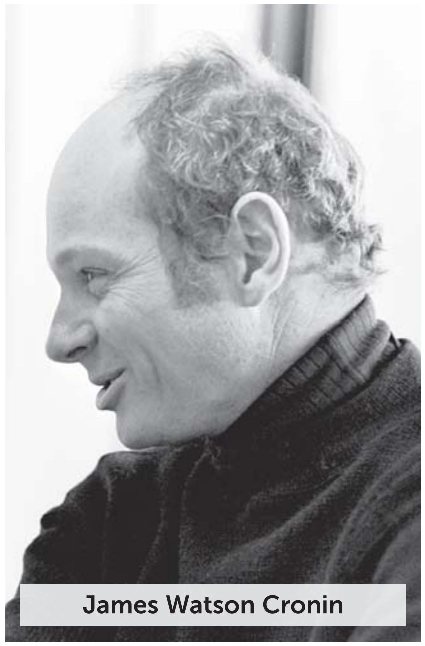
Jim joined the group of Rodney Cool and Oreste Piccioni at Brookhaven National Laboratory as a postdoc, and he worked at the Cosmotron and Bevatron on early measurements of parity violation in hyperon decays. There he met Val Fitch, who brought him to Princeton University as part of the physics faculty in 1958.

At Princeton, Jim made seminal contributions to detector technology. His development of spark chambers allowed high-resolution measurements of the trajectories of charged particles for rare processes.

Those detectors were the basis of the apparatus he used at Brookhaven's Alternating Gradient Synchrotron in 1963 with James Christenson, Fitch, and René Turlay. They observed a small but unmistakable signal for the rare decay $K_L \to \pi^+\pi^-$. It was unexpected evidence for *CP* violation and led to the 1980 Nobel Prize in Physics for Jim and Fitch. In subsequent experiments, Jim measured the *CP*-violating decay $K_L \to \pi^0\pi^0$ to elucidate the source of *CP* violation.

In 1971 Jim returned to the University of Chicago as a University Professor of Physics. The year before, in the early days of the Fermilab program and in the development of the parton model, Jim and Pierre Piroué of Princeton proposed a simple but elegant experiment to measure the production of single particles at high transverse momentum at angles close to 90° in the center-of-momentum frame. Fermilab was delayed, so the discovery of the spectrum's power-law behavior, the first indication of parton–parton scattering, was made at CERN's Intersecting Storage Rings contemporaneous with but ahead of the Chicago–Princeton results.

FERMILAB



James Watson Cronin

Jim had foreseen that the new energy regime would be an opportunity to search for hitherto unknown particles with lifetimes that were short compared with those of pions and kaons. His insightful hand-drawn plots—which he made for all his experiments throughout his career—were the basis of the discovery of "direct muons," later identified as the muonic decays of particles containing charm quarks.

In the mid 1980s, Jim became fascinated by the acceleration mechanism and composition of ultra-high-energy (UHE) cosmic rays (energy greater than 100 TeV). Several experiments suggested that the particles come from point sources, but the statistics were poor. Jim knew that a definitive answer would require a very large detector. His efforts led to the CASA–MIA gamma-ray experiment, which consisted of more than 1000 detectors covering 0.25 km^2 in Utah. Although CASA–MIA definitively ruled out point sources as a significant contributor to UHE cosmic rays, it paved the way for Jim's next, even larger cosmic-ray experiment.

Jim turned his attention to the diffuse continuum of cosmic rays. If they were extragalactic protons, they should have an energy cutoff at about 5×10^{19} eV, where they would interact with the cosmic microwave background and produce excited baryons. Since such energetic cosmic rays have a flux of a few per square kilometer per century, a truly enormous detector—what would eventually become the 3000 km^2 Pierre Auger Observatory in Argentina—was required.

Jim and Alan Watson of the University of Leeds organized a design workshop at Fermilab that attracted scientists from 40 institutions in 15 countries. The detector consists of 1660 water Cherenkov tanks and 27 fluorescence telescopes. Jim traveled around the world to meet with leaders of science agencies and heads of state. His persuasiveness, charm, and Nobel stature enabled the collaboration to obtain the needed funding.

The Auger Observatory, a collaboration of more than 400 scientists, definitively observed the energy cutoff and obtained important information about the composition of the highest-energy cosmic rays. In addition to the scientific results it has obtained, the collaboration has significantly raised the profile of basic science in Latin America.

Jim loved good data, and he remained a keen competitor in analyzing them, even in later highly complex experiments. We often found him logged onto the university's computers, from which he continued to evaluate data from the Auger Observatory up until his death.

In addition to the Nobel Prize, Jim's many honors included the US Department of Energy's Ernest Orlando Lawrence Award in 1976 and the National Medal of Science in 1999. He had many cherished colleagues in France, where he received the country's Legion of Honor.

In 2004 Jim published *Fermi Remembered* (University of Chicago Press), a collection of essays and reminiscences by colleagues and material from Fermi's notebooks. Jim put the book together after a symposium he organized to celebrate the 100th anniversary of Fermi's birth.

Jim was a deeply dedicated educator. One of the honors he valued most was Chicago's Quantrell Award for Excellence in Undergraduate Teaching in 1994. He also took exceptional responsibility for undergraduate instructional labs, in which he would spend long hours working with the students. His interest extended to early education in science as well; his infectious love of learning led to the creation of the James Cronin School for the children of Malargüe, Argentina.

In addition to establishing the highest standards in his current field, Jim was an extraordinary mentor to several generations of physicists and astrophysicists. We count ourselves exceptionally lucky to have been among them. His foresight and style shaped the experimental fields of precision kaon physics and cosmic rays and made a lasting impact on PhD students worldwide.

Jim will be remembered as much for his generosity, warmth, drive, and impeccable honesty as for his seminal contributions to scientific knowledge. He had a deep intellectual interest in the workings of the universe and possessed the remarkable ability to elevate any enterprise he took on. He was wonderful to work with and a wonderful man.

Henry J. Frisch
James E. Pilcher
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Vera Cooper Rubin

Vera Cooper Rubin, who transformed our understanding of the universe by confirming the existence of dark matter, passed away on 25 December 2016 in Princeton, New Jersey. A trailblazing astronomer, a passionate champion of women in science, and an inspiring role model to generations of scientists, Rubin was loved and admired by her many colleagues and friends.

Born in Philadelphia on 23 July 1928, Rubin moved with her family to Washington, DC, when she was 10. She developed her love for astronomy at an early age as she watched the stars go by, built a telescope, and wondered about the mysteries of the universe. She graduated with a bachelor's degree in astronomy from Vassar College in 1948. That year, at 19, she married Robert Rubin, a chemistry PhD student at Cornell University, and joined him there for her master's degree in astronomy.

MARK GODFREY

Vera Cooper Rubin

In 1951 they moved back to DC, where Rubin began her PhD at Georgetown University with legendary physicist George Gamow. Her thesis explored the spatial distribution of galaxies. She found that the galaxy distribution was clumped rather than randomly distributed in space—a surprising and important result whose significance took years to fully appreciate. Rubin earned her PhD in 1954 and remained at Georgetown to teach.

In 1965 she joined the department of terrestrial magnetism (DTM) at the Carnegie Institution of Washington. Rubin thrived at the DTM for the rest of her career. She carried out her seminal work there and mentored generations of budding astronomers. Said current Carnegie president Matthew Scott, "Vera Rubin was a national treasure as an accomplished astronomer and a wonderful role model for young scientists."

Rubin's groundbreaking scientific contribution was establishing the flat rotation curves of spiral galaxies: She showed that stars orbit the galactic center with velocities that remain constant (flat) out to the outer parts of galaxies rather than decline with distance, as expected from Newtonian gravity. The higher-than-expected velocity at the outskirts implies more mass than can be