Having married Maurice Goldhaber, who was then a physics professor at the University of Illinois, she immigrated to the US in 1939 and became a research physicist in the same department as her husband. There, in 1942, she discovered that spontaneous fission is associated with the emission of neutrons—a discovery kept secret until World War II ended. In 1948, she and Maurice established the identity of beta particles with atomic electrons.

That same year, she was made a research assistant professor. However, her further advancement was blocked by the university's antinepotism rules. To avoid them, she and Maurice moved in 1950 to BNL. An associate physicist at first, she was promoted to physicist in 1958 and senior physicist in 1962.

From the early 1950s onward, Trude directed her scientific research toward systematizing the properties of nuclear levels across the entire periodic table. It was a time of rapid development in both experimental techniques and nuclear structure theory. Independent particle and collective motion models were proposed to describe nuclear excitations, but the regions of applicability of each class of model were largely unknown. For instance, the Mayer–Jensen shell model appeared to contradict what was known about the short-range saturated nuclear forces, with their implied pronounced nucleon clustering. There was speculation that the forces that were known to act between free nucleons were somehow modified in dense nuclear matter and that shell structure existed only for ground states. Evidence for shell closures in heavier nuclei lacked experimental evidence.

Trude's research at that time was devoted to resolving these apparent contradictions. In 1953, she demonstrated the existence of shell structure in excited nuclear states by conducting a detailed and comprehensive survey of the energy of the first excited states of even–even nuclei as a function of neutron number. Her conclusions included the important finding that the excitation energy increases strongly at the shell closures. A few years later, she and Joseph Weneser noted that the ratio of excitation energy of the second excited state to the first in nuclei in the region where $38 < N < 88$ significantly differs from that in the adjacent region where $90 < N < 108$. The value in the lower region is near the ratio of 2 identified with phonon excitation in spherical nuclei, whereas the value in the upper region is near $10/3$, which signals an abrupt change in the spacing of excited states characteristic of rotating deformed nuclei.

GERTRUDE SCHARFF GOLDHABER

In 1957, Trude reported the remarkable isomerism in the deformed nucleus, hafnium-180, with its implied retardations of 10^{16} and 10^9 for the E1 and E3 transitions, respectively, thereby dramatically verifying the predictions of K forbiddenness in electromagnetic transitions of deformed nuclei.

Over many of the following years, Trude with various collaborators developed the phenomenological variable moment of inertia model and was able to smoothly parameterize the energy ratio of the first 4^+ to 2^+ states of the even–even nuclei over most of the periodic table with values ranging from about 2.2 to $10/3$.

Taken as a whole, Trude's work played an integral part in unfolding the story of nuclear structure, alerting experimentalists to important regions of the periodic table and confronting theorists with the realities of nature. For her contributions to nuclear physics, she was elected to the National Academy of Sciences in 1972 (becoming only the third female physicist so elected).

In addition to her science, Trude also had a major impact on life at BNL. In 1960, she started the Brookhaven lecture series, which continues today to introduce BNL scientists and others to research by their lab colleagues. She was a founding member of Brookhaven Women in Science in 1979, and she often lent her energies to education and to attracting women to the sciences.

Having retired in 1977, Trude continued her association with BNL as a research collaborator until 1990. She also held adjunct professorships at Cornell University and Johns Hopkins University in the 1980s. She served on several committees, including the American Physical Society's committee on the status of women in physics, the National Research Council's human resources committee on the education and employment of women in science and engineering and the National Academy of Sciences' committee on human rights.

Trude made important contributions to science and was an inspiration to many women as a pioneer in a field dominated by men. She was devoted to improving science education at all levels, and was an avid hiker, swimmer, tennis player and skier. Her contributions to both BNL and the science community were important and long lasting.

PETER D. BOND
CHELLIS CHASMAN
Brookhaven National Laboratory
Upton, New York

John Reginald Richardson

John Reginald Richardson, who, over his long career, was one of the dominant figures in cyclotron development, died in Fremont, California, on 25 November 1997 after a lengthy illness. He was 85. His many achievements include the first demonstration of phase stability, the first synchrocylotron and the first sector-focused cyclotron.

Born in Edmonton, Alberta, Reg lived in Vancouver, British Columbia, until he reached the age of 10, when his family immigrated to the US. He took his bachelor's degree at UCLA, where Glenn Seaborg remembers him as the top physics student of their class of 1933.

Reg then went to the University of California's Berkeley campus, where, as Ernest Lawrence's last graduate student, he received his PhD in physics in 1937. After a year as a National Research Council fellow at the University of Michigan, he was appointed an assistant professor of physics at the University of Illinois—in both places continuing his PhD studies of nuclear structure and bringing his Berkeley expertise to bear on the two universities' newly constructed cyclotrons.

In 1942, after the US entered World War II, Reg returned to Berkeley to develop calutrons for the electromagnetic separation of uranium for the Manhattan Project.

When the principle of phase stability was discovered independently by Vladimir Veksler in 1944 and Edwin McMillan in 1945, it was thought at first that its application to cyclotrons required moderately high energy ion injection. However, exploiting his calutron experience, Reg was able to show that 1–5% of the ions emerging from an ion source could be captured

John Reginald Richardson

in the stable bucket. In 1946, he led an *ad hoc* group consisting of Ed Lofgren, Ken MacKenzie, Bernard Peters, Fred Schmidt and Byron Wright in converting the fixed-frequency 37-inch cyclotron at Berkeley to FM operation as the first synchrocyclotron. This success not only provided the first demonstration of the phase-stability principle (Frank Goward and D. E. Barnes's first operation of a synchrotron followed a few months later), but also confirmed the feasibility of converting the 184-inch cyclotron from a classical cyclotron to a synchrocyclotron.

That same year, Reg took up a faculty appointment at UCLA and was soon joined by MacKenzie and Wright, and also by David Saxon. Together, they formed a strong nuclear physics group and brought the 37-inch cyclotron from Berkeley. The conversion of this machine to a 20 MeV synchrocyclotron provided not only a leading research facility, but also an essential tool for the many graduate students attracted there.

The many higher-energy synchrocyclotrons built in the ensuing years, along with electron synchrotrons, made secondary beams of pions and muons available and inaugurated the era of accelerator-based particle physics. But the pulsed operation of those machines limited beam intensities to about 1 microamp, so the need for intense 200–300 MeV deuteron beams led to the construction of the 60-foot-diameter Mark I linear accelerator. Reg championed a more modest alternative—a CW cyclotron based on Llewellyn H. Thomas's prewar suggestion of using a magnetic field that increased radially to maintain fixed-orbit frequency into the relativistic regime, while varying azimuthally to provide axial focusing. He had kept his Berkeley connections, and there, in 1950, he led David Judd, John Jungerman, Elmer Kelly, Robert Pyle, Robert Thornton and Wright in building the first sector-focused cyclotron—an electron model that achieved v/c values of 0.5.

Such cyclotrons are harder to tune than synchrocyclotrons and require a very accurately tailored magnetic field. Such precision could not be achieved by shaping the iron alone, but required the adjustment of over 50 trimming coils, using the beam as a probe. Reg's skill and perseverance in bringing the beam to full energy led one of the engineers, who normally classified experimental physicists as "2-knob men" or "4-knob men" according to their tuning ability, to concede that here was a "10-knob man."

This work remained classified until 1955, but once the secret was out, sector-focused cyclotrons rapidly proliferated. Back at UCLA, Reg led the design and construction of a 50 MeV cyclotron that took full advantage of Donald Kerst's spiral sector focusing and Wright and Martin Rickey's H^- ion acceleration concept to provide clean beam extraction at variable energy. Completed in 1962, the cyclotron greatly increased the range of experiments available. Reg was determined to show that a small lab could be the first to produce relativistic protons at high intensity and, in fact, won the race by a year.

His 1963 proposal for a 750 MeV H^- cyclotron "meson factory"—a term he coined—was unsuccessful at UCLA, but adopted in Canada in a downsized version that led to the construction of the 520 MeV, 200 μA TRIUMF cyclotron in Vancouver. Reg presided over TRIUMF's construction and commissioning with great effectiveness as the facility's second director from 1971 until 1976.

In his supposed retirement, he initiated the drive for the KAON Factory at TRIUMF and, always out ahead, was already working on the 100 GeV extension before the ink was dry on the 30 GeV proposal!

Throughout his career, Reg continued to participate in nuclear and particle physics experiments. Most notable, perhaps, were the experiments that resulted in the introduction of the Kurie plot for determining β-decay energies, the first measurement of the charged pion's lifetime (surely one of the last papers to report the measurement of a fundamental particle property by a single author!) and the elucidation of nucleon–nucleon scattering from 14 MeV through to 520 MeV.

His greatest legacy, however, must be the more than 200 sector-focused cyclotrons now in operation worldwide, whose intense beams have had a major impact on nuclear and particle physics, condensed matter physics, chemistry and medicine. Reg was awarded the American Physical Society's Wilson Prize in 1991.

Reg will be remembered not only for his monumental achievements and his impact on generations of nuclear and accelerator physics students, but also for his elegant style and for the warm hospitality that he and his family bestowed on so many of his colleagues.

David J. Clark
Lawrence Berkeley National Laboratory
Berkeley, California
Michael Craddock
University of British Columbia and TRIUMF
Vancouver, British Columbia, Canada

Norman Carroll Koon

On 29 December 1997, the magnetism and condensed matter physics community lost one of its outstanding researchers: Norman Carroll Koon, a physicist at the US Naval Research Laboratory (NRL) in Washington, DC, was killed in a skiing accident while vacationing at White Tail ski resort in Pennsylvania.

Born on 8 July 1938, in Sheridan, Arkansas, Koon was educated at the Georgia Institute of Technology, where he received a bachelor's degree in engineering in 1960 and a PhD in physics in 1970 for research on the Mössbauer effect.

Soon after joining NRL in 1969, Koon and Arthur Clark of the Naval Surface Warfare Center (NSWC), who was working independently, discovered the large magnetostrictive properties of the (rare earth) Fe_2 Laves-phase class of materials that are now used in magnetostrictive transducers. Over several years, Koon intensively researched those systems, with the aim of understanding their exchange, magnetic anisotropy and magnetoelastic properties.

From the early results of their magnetization studies, Koon and Conrad Williams developed $Ho_{0.58}Tb_{0.20}Dy_{0.22}Fe_2$, a low-anisotropy, high-magnetostrictive material.

Koon also developed the technique for producing high-quality single crystals of rare earth compounds. That success enabled Koon and me (I was then at the National Institute of Standards and Technology) to study the exchange and anisotropy directly with inelastic neutron scattering. As our research progressed, Koon not only became rapidly expert at determining spin wave dispersion, but also devel-