Collaboration seeks to enhance accelerator technology, lower costs

September 27 2016

The University of Chicago is part of a collaboration that has been awarded $23 million by the National Science Foundation to increase the intensity of beams of charged particles, while lowering the costs of key accelerator technologies. This Science and Technology Center will contribute to scientific advances in many disciplines, including physics, chemistry and mathematics, by enhancing accelerator capabilities.

Particle accelerators generate powerful X-ray and electron beams that reveal the structure of biological molecules and materials, produce collisions that replicate conditions in the early universe or reveal the structure of the proton, and serve critical functions in manufacturing.

"Beam science enables these devices, but questions in beam science require a new approach," said Ritchie Patterson, the lead researcher of the Center for Bright Beams at Cornell University, which is leading the collaboration. "To realize the full potential of beams for science and industry, we need to combine the expertise of accelerator physicists with the knowledge and tools of scientists and mathematicians from a wide range of disciplines."

CCB proposes to do just that, with experts in physical chemistry, materials science, condensed matter physics, plasma physics and mathematics to strengthen accelerator scientists from around the country.

The center's overarching research goal is to increase the intensity

(brightness) of charged particle beams by a factor of 100, enabling ultra-fast electron imaging for materials science and biology, extending the reach of particle colliders, and offering new tools to the semiconductor industry for the creation and inspection of integrated circuits.

Leveraging experience, transferring knowledge

"Our vision is to develop the fundamental knowledge that is required to improve the performance and lower the costs of accelerator technologies," said Steven Sibener, the Carl William Eisendrath Distinguished Service Professor in Chemistry at the University of Chicago. "We will leverage the diverse experience available at universities and national labs and will transfer the knowledge and technology back to them."The new center will investigate three inseparable themes from particle accelerators: beam production, beam acceleration, and beam transport and storage.

"Accelerator science is an emerging and exciting field," said Young-Kee Kim, the Louis Block Professor in Physics at UChicago. "Chicagoland has a great deal of accelerator expertise, along with large and complex accelerator facilities at Fermi National Accelerator Laboratory and Argonne National Laboratory. The multi-disciplinary approach of the center and UChicago will be different from the focuses at Fermilab and Argonne, yet synergistic. Together we can create a much stronger accelerator research program in Chicagoland."

Kim and Sibener both serve on the center's executive committee. Sibener is co-coordinator of the beam acceleration research theme, which encompasses new materials and concepts for accelerator design. Kim is co-coordinator of the beam transport and storage research theme, and also education director for the center. The latter role relates to another of the center's missions, to educate the next generation of leaders in this forefront field of science and technology.

Two other faculty members from UChicago's accelerator science program will participate in the new center's work: Amie Wilkinson, professor in mathematics; and Sergei Nagaitsev, chief accelerator officer at Fermilab and professor in physics.

The project includes researchers and collaborators at the University of California Los Angeles, University of Florida, University of Maryland at College Park, Brigham Young University, Morehouse College, Clark Atlanta University and Chicago State University. Scientists at Lawrence Berkeley National Laboratory, the University of Toronto and TRIUMF (Canada's national laboratory for particle and nuclear physics) also will contribute their expertise.

Particle beam beneficiaries

For years, scientists have increased beam brightness through clever design of devices for beam production, acceleration and transport, and through largely trial-and-error improvements in materials processing. This strategy yielded significant advances but is now reaching its limits. As a result, scientists do not control or even understand all of the factors that contribute to surface resistance, which drives both the length of an accelerator and its energy efficiency, and similar questions remain for other key accelerator technologies. Answering the open questions in beam science requires a new approach.

Approximately 10,000 U.S. researchers rely on beams of electrons or photons for physics, chemistry materials science, biology and medicine. By enhancing the capabilities of the accelerators essential to research in these fields, the Center for Bright Beams will improve the performance of small laboratory instruments and industrial tools as well as large colliders and X-ray sources.

The center's industrial partners will incorporate their inventions into

instruments for manufacturing integrated circuits, producing medical radioisotopes, and developing new pharmaceuticals. The center will transfer its bright beam technology to market leaders in accelerator components, electron microscopy, photolithography and semiconductor inspection.

Provided by University of Chicago