Argonne’s Accelerator Science and Technology

Argonne’s accelerator science and technology (S&T) research is critical to the improvement of the nation’s accelerator-driven scientific user facilities, and contributes to accelerator technology used in societal applications. The APS Upgrade, along with upgrades of Argonne facilities in high energy and nuclear physics, leverage the accelerator research activities. Argonne has notable accelerator design and development expertise of strategic importance to the accelerator S&T community in the United States and abroad. For accelerator-based x-rays, Argonne has significant expertise in modeling, design, and operation of both electron accelerators and free electron lasers; undulator design, fabrication, and measurement; control systems; and vacuum chamber design and construction. Codes developed at Argonne for x-ray facility design are used worldwide. Argonne is continuing development of a strong and unique R&D effort in support of x-ray optics, a critical need given the increasing number of hard x-ray sources, including the APS Upgrade. Furthermore, the APS has, within its existing organization, a strong accelerator R&D capability.

For high-energy physics, Argonne plays a significant R&D role for linear collider challenges, and is exploring application of advanced concepts to hard x-ray free electron lasers (X-FELs). The Argonne Advanced Wakefield Accelerator is the only facility in the world where two-beam acceleration techniques and dielectrically loaded structures (a promising concept for linear colliders and X-FELs) are being developed. Nuclear physics applications include the creation, acceleration, and manipulation of beams of rare isotopes and the development of high-performance, low-velocity superconducting accelerating structures. End-to-end simulations for hadrons and heavy ions are carried out with new codes that take advantage of the Laboratory’s ALCF and will be further enabled by its upgrades.

Argonne is a U.S. leader in the processing of superconducting radio-frequency cavities by techniques developed for ATLAS and its upgrades. There is considerable interest, in the United States and abroad, in applications of this technology to high-current hadron linear accelerators with energies in the MeV–GeV range, including the FRIB at Michigan State University.

Argonne’s goal is not only to continue the activities noted above, but to further leverage unique Laboratory strengths to address accelerator S&T challenges. This goal has led Argonne to (1) concentrate on “cavity”-based accelerating structures; (2) use materials science and other expertise at Argonne to understand surface phenomena that currently limit performance; (3) improve surfaces by both standard surface treatments and new materials synthesis technologies such as atomic layer deposition (ALD); (4) explore new techniques for cavity construction combining ALD and x-ray lithography; and (5) explore the technological challenges associated with the acceleration and manipulation of very high-intensity, high-power beams. These activities are possible because of Argonne’s interdisciplinary character and its materials and chemical science expertise. Examples include the application of Wakefield Accelerator developments to photon science needs for an FEL driver, and the work performed on accelerator-driven systems for the transmutation of spent nuclear fuel.

Argonne, along with Fermilab, has developed a seminal program for introducing undergraduates to accelerator S&T to help meet the overall needs of the DOE/SC community and ensure development of the nation’s future accelerator scientists.

Funding for this core capability comes primarily from DOE/SC program offices that use accelerators for research, namely BES, HEP, and NP. DOD and international laboratories also provide some funding. Future plans are being evaluated for other synergistic accelerator R&D activities, including those in assembly and testing of superconducting rf cavities.