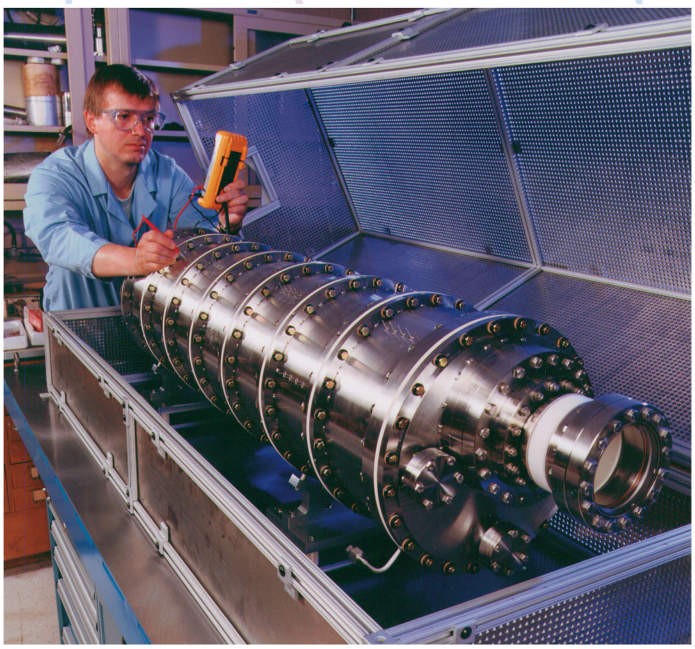
ARGONNE NATIONAL LABORATORY

Pioneering Science and Technology

THE RARE ISOTOPE ACCELERATOR PROJECT

A Rare Isotope Accelerator (RIA) would produce and accelerate very short-lived nuclei (rare isotopes). Examination of these isotopes and their reactions will answer important questions in nuclear physics and astrophysics, and the study of fundamental interactions at low energy. Such studies require yields of radioactive isotopes far in excess of what are currently available, a fact long recognized by the international physics community and reflected by investment in that field around the world. The U.S. nuclear physics community recognizes the importance of such studies and recommended in its 2002 long-range plan that a next-generation facility, RIA, be the highest priority for new construction in nuclear physics.



This "gas catcher cell" developed at Argonne for the Rare Isotope Acclerator provides a new way to generate intense beams of short-lived, exotic nuclear isotopes for basic research in nuclear physics and other sciences. The device magnetically separates energetic exotic ions produced in thin targets and brings them to rest in a catcher cell filled with pressurized helium. This new separation technology will give physicists high-quality exotic beams of any element in the periodic table.

RIA would accelerate unstable nuclei (rare isotopes) and direct the resulting beams into targets. Examination of the impact will address important open questions that concern our own origins and our understanding of cosmic events. It will provide critical information previously impossible to obtain on such topics as nucleosynthesis during and shortly after the Big Bang, energy generation in stars, heavy-element production in supernovas, nuclear structure effects in nuclei far from stability, and nuclear decay, reactions, and structure.

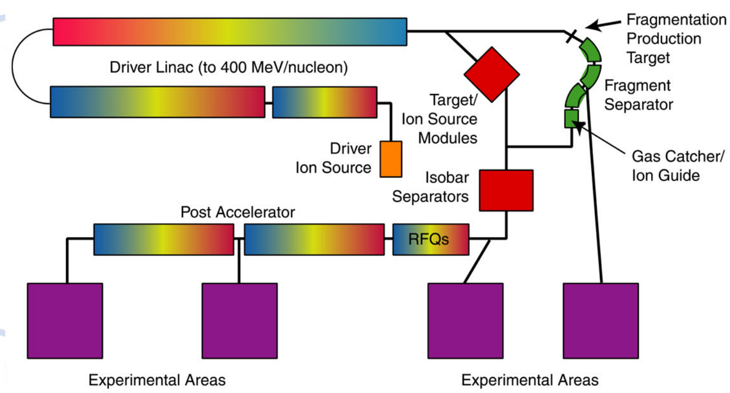
RIA has important applications in other fields, such as medical and industrial radiology, and an important national security role in support of the science-based stockpile stewardship program.

Concept

Existing facilities have not been able to reach required high yields of radioactive ions because of limitations in production and extraction mechanisms, and in beam power available. The RIA facility evolved from an Argonne concept incorporating new technologies that overcome these limitations and will make it significantly more powerful than any related facilities.

How It Works

The RIA facility combines the best isotope-production and in-flight fragmentation technology with novel approaches to handle high primary-beam power and remove existing limitations in the extraction of short-lived isotopes. A versatile primary accelerator allows using



Schematic layout of the RIA complex.

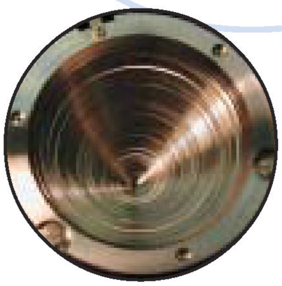
various production and extraction schemes to optimize production of specific isotopes.

In particular, a novel approach — in which radioactive isotopes produced by fragmentation of a fast heavy-ion beam are stopped and cooled in a high-purity helium gas cell and then extracted by electromagnetic fields as singly charged thermal ions — provides huge increases in efficiency for very short-lived isotopes, making them available for further study.

Both the driver and post-accelerators make extensive use of the superconducting radiofrequency technology developed at Argonne for its existing heavy ion accelerator, the Argonne Tandem-Linac Accelerator System (ATLAS). If sited at Argonne, RIA could incorporate ATLAS and its associated experimental equipment and infrastructure.

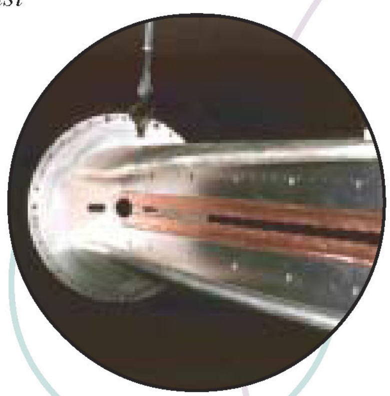
Research and Development

The RIA concept involves numerous new technologies, including new extraction mechanisms based on the guiding of ions thermalized in ultra-high-purity helium, production targets using two-step production mechanisms to allow handling of higher primary power, flowing liquid lithium targets, low-velocity accelerator structures, medium-velocity superconducting cavities, and multiple-charge-state acceleration. These technologies were developed through a vigorous R&D program initiated at Argonne that now involves groups at the Thomas Jefferson National Accelerator Facility; the National Superconducting Cyclotron Laboratory (at Michigan State University); the Texas A&M Cyclotron Institute; Colorado School of Mines; and Los Alamos, Lawrence Berkeley, Lawrence Livermore, Oak Ridge and Brookhaven national laboratories. These R&D efforts have demonstrated the feasibility and effectiveness of the proposed facility.



Conical electrodes near the extraction aperture of the prototype fast gas catcher.

A 2-spoke superconducting resonator recently developed and tested for RIA.



One pair of vanes of the prototype CW 12-MHz RFQ.

RIA technologies.

Design and Construction

Argonne is a strong candidate to be the site of the RIA facility because of its leadership role in developing the overall concepts; its proven track record in the design, construction, and operation of large-scale U.S. Department of Energy (DOE) facilities; and the cost-effectiveness of employing extensive existing scientific and support infrastructure. The RIA project will be carried out by a nationwide consortium of laboratories and universities. Following approval by DOE and Congress, the full facility could be completed in 7 years.

Sponsor

U.S. Department of Energy, Office of Nuclear Physics

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