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STATUS OF U.S. PLANS FOR AN ADVANCED ISOL FACILITY A BRIEF REPORT

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A brief discussion is provided of the current status of plans to build an advanced ISOL radioactive ion beam facility in the United States. Designs for this new facility, which was recommended as the next major construction project of the DOE Nuclear Physics Program Office, have been proposed by two U.S. national laboratories, Argonne National Laboratory and Oak Ridge National Laboratory. The new facility will provide orders-of-magnitude higher radioactive beam currents than existing facilities of this type and will cost in the range of $250 million.

Over the past decade one of the most rapidly developing fields of study in nuclear physics has been that of radioactive ion beam (RIB) physics. Measurements using RIBs are now carried out at what may be appropriately called first-generation facilities at several nuclear physics laboratories around the world. In 1989, the United States Nuclear Science Advisory Committee (NSAC) that advises both the DOE and the NSF nuclear physics programs wrote that, "Wholly new vistas would be opened by a radioactive nuclear beam accelerator." In this case the authors of the Long Range Plan were considering the growing interest in the field and suggesting that a next-generation facility would be of great interest to the community. Their prophecy has held true.

Radioactive ion beams are produced primarily by two methods, by fragmentation and by the isotope separator on line (ISOL) technique. In the fragmentation technique a beam of high-energy ($\gtrsim$ 100 MeV/nucleon) heavy ions bombards a target and the ensuing fragmentation of the beam and target produce nuclei far from stability. Those nuclei are collected and mass analyzed to form a radioactive ion beam. Some advantages to this technique are the ability to produce very short-lived isotopes or radionuclides and the production of higher-energy RIB beams that are desirable for nuclear reaction studies. On the other hand, this technique produces low-intensity and low-quality beams. In the ISOL technique a high-intensity (tens of microamps) beam of generally light ions is used to bombard a target to produce nuclei far from stability. Those radioactive atoms are evaporated from the target, ionized in an ion source, and accelerated to about 250kV and then

mass separated and further accelerated to energies (up to a few MeV/nucleon) useful for nuclear structure and nuclear astrophysics studies. This technique has the advantage of producing higher-intensity beams with the very high beam quality generally needed for low-energy nuclear physics studies.

Research using RIB beams produced by fragmentation is being carried out at several facilities such as Michigan State University's (MSU) National Superconducting Cyclotron Laboratory (NSCL), the GSI in Germany, the RIKEN facility in Japan, and the GANIL facility in France. The ISOL technique to produce RIBs was pioneered at the CERN ISOLDE facility. The recent addition to the ISOL technique is to accelerate the RIBs to higher energy for use in nuclear structure physics. Such interest has led several facilities around the world that have access to two accelerators to reconfigure their accelerators to produce accelerated RIBs by the ISOL method. An example of such a facility is the Holifield Radioactive Ion Beam Facility (HRIBF) at the Oak Ridge National Laboratory. This facility is currently fully operational and carries out RIB research programs in nuclear structure and nuclear astrophysics.

Following the 1989 recommendation by NSAC, a users group was formed to pursue the construction of an advanced high-intensity ISOL facility. This group, known as the Isospin Laboratory Users Group, held several meetings and workshops to discuss the physics to be done with the facility and to discuss the parameters for the facility. In 1991, the ISL group produced a report that made a strong scientific case for the need for a new ISOL accelerator. That report served as a catalyst for the growing interest in this area of research.

The Long Range Plan for Nuclear Science prepared by NSAC in 1996 recommended that following the completion of the RHIC accelerator the next construction project for the DOE Nuclear Physics Program Office be an advanced ISOL facility. The recommendation reads:

> The scientific opportunities made available by world-class radioactive beams are extremely compelling and merit very high priority. The U.S. is well-positioned for a leadership role in this important area; accordingly
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> - We strongly recommend the immediate upgrade of the MSU facility to provide intense beams of radioactive nuclei via fragmentation.
> - We strongly recommend development of a cost-effective plan for a next-generation ISOL-type facility and its construction when RHIC construction is substantially complete.

The U.S. National Science Foundation that funds the MSU NSCL has provided funding for the upgrade of that facility, and the work is well under way. The U.S. DOE has embraced the NSAC recommendation for the construction of an advanced ISOL facility and is moving forward on that project. The rest of this report discusses recent progress on the DOE advanced ISOL facility project.

In 1997, the DOE requested that Argonne National Laboratory (ANL) and Oak Ridge National Laboratory (ORNL) hold a workshop to discuss the scientific opportunities for the advanced ISOL facility. The workshop, held at Ohio State University in the summer of 1997, was attended by about 200 scientists. The conclusions from that meeting were published in a "white paper" which showed the need and enthusiasm for the construction of the advanced facility. Using the report from the Ohio State meeting, the DOE established a general cost and time line for the project. The cost was set at about $250 million. The project would receive major funding around the year 2002-2003, and the project would take about four years to complete, making start of operation around the year 2007.

Two U. S. national laboratories, ANL and ORNL, have provided concepts for the construction of this new facility. It is not the intent or scope of this report to present the details of the designs. The Argonne proposal is to construct a new driver accelerator to produce RIBs and to use the existing ATLAS facility to accelerate the radioactive ions. The new driver for the Argonne proposal would be a superconducting linac capable of accelerating a variety of particles including 100-MeV protons, 200-MeV deuterons, and heavy ions up to about 100 MeV/nucleon. The ORNL proposal is to use a small fraction of the 1-milliamp, 1-GeV proton beam from the linac of the recently funded Neutron Spallation Source as the driver for production of the radioactive ions. The ORNL proposal would build a new superconducting linac to accelerate the RIBs, and new experimental areas for research.

In 1998, the DOE requested that NSAC establish a task force to "perform a technical study and evaluation of the options for a next-generation facility in the United States for beams of radioactive nuclei, based on the Isotope-Separator-On-Line (ISOL) technique." That Task Force has been established with Herman Grunder (Thomas Jefferson Laboratory) as the chairman. Other Task Force members are: Jim Beene (ORNL), Dick Boyd (Ohio State), Rick Casten (Yale), Stan Kowalski (MIT), Claude Lyneis (LBNL), Jay Marx (LBNL), Jerry Nolen (ANL), Helge Ravn (ISOLDE/CERN), Paul Schmor (TRIUMF), Brad Sherrill (MSU), and Konrad Gelbke (MSU), ex officio member.

The Task Force is charged with preparation of an interim report by April 1999 and a final report by October of 1999. The group meets every month and has heard presentations of the ORNL and ANL techniques. As of this time there is no schedule for the selection process beyond the scheduled date for the report of the technical Task Force. However, in order to meet a construction start of 2002, it could be expected that a call for proposals would be issued not long after the results are known from the technical study.

In closing, it is important to note that this brief report was concerned only with the construction of an advanced ISOL facility in the United States. However, there are several advanced ISOL projects under way or proposed in other countries. Of those projects, the ISAC project at TRIUMF in Vancouver, B.C., Canada, is nearing full operation. That project, which uses 500-MeV protons as the driver beam for RIB production, has reached the stage of initial beam production. Accelerated RIBs (1-2 MeV/nucleon) will be available in another year, and a proposal has been submitted by the ISAC group to the Canadian funding authorities to increase the acceleration energy to a few MeV/nucleon. Both Europe and Japan have plans for the construction of advanced ISOL facilities based on use of high-energy proton beams.

It is clear that the low-energy nuclear physics community has fully embraced research with radioactive ion beams, and such research will be a strong component of nuclear physics research for decades to come.

For further details of facilities and topics discussed in this report, see the following Web sites:

ISOL Task Force information, www.srfsrv.jlab.org/isol/

Scientific Opportunities with an Advanced ISOL Facility (Nov. 1997)
(5 MB pdf), www.er.doe.gov/production/henp/isolpaper.pdf

ANL–ATLAS Exotic Beam Facility | "Yellow Book (Feb. 1995),"
www.phy.anl.gov/div/rib/index.html
www.phy.anl.gov/div/origins/yellow-book/

CERN–ISOLDE, www.cern.ch/ISOLDE/frames/isoframe.html

GANIL–SPIRAL (France), www.ganil.fr/spiral/

GSI–ISOL (Germany), clri6f.gsi.de/~msep/isol.html

NSCL–K1200 Cyclotron/A1200 Beam Analysis System, www.nscl.msu.edu/

ORNL–Holifield Radioactive Ion Beam Facility | NISOL Facility at the SNS,
www.phy.ornl.gov/hribf/hribf.html
www.phy.ornl.gov/nisol/index.html

RIKEN–RIKEN RI Beam Factory (Japan), www-ribf.riken.go.jp/ribf_e.html
TRIUMF–ISAC, www.triumf.ca/isac/lothar/isac.html

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