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Doc No:	LA-UR-03-2827	Release Date:	5/05/03

Title:	University Programs of the U.S. Advanced Fuel Cycle Initiative
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Approved for Release

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LA-UR-03-2827

Title: UNIVERSITY PROGRAMS OF THE U.S. ADVANCED FUEL CYCLE INITIATIVE

May 2003

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Submitted to: Sixth International Meeting on the Nuclear Applications of Accelerator Technology (AccApp 03), a Topical Meeting imbedded with the 2003 Annual Meeting of the American Nuclear Society, San Diego, CA, June 1-5, 2003.

University Programs of the U.S. Advanced Fuel Cycle Initiative

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Abstract–*As the Advanced Accelerator Applications (AAA) Program, which was initiated in fiscal year 2001 (FY01), grows and transitions to the Advanced Fuel Cycle (AFC) Program in FY03, research for its underlying science and technology will require an ever larger cadre of educated scientists and trained technicians. In addition, other applications of nuclear science and engineering (e.g., proliferation monitoring and defense, nuclear medicine, safety regulation, industrial processes, and many others) require increased academic and national infrastructure and even larger student populations. Because of the recognition of these current and increasing requirements, the DOE began a multi-year program to involve university faculty and students in various phases of these Projects to support the infrastructure requirements of nuclear energy, science and technology fields as well as the special needs of the DOE transmutation program. Herein I summarize the goals and accomplishments of the university programs that have supported the AAA and AFC Programs during FY02, including the involvement of 120 students at more than 30 universities in the U.S. and abroad. I also highlight contributions to academic research from LANL, which hosted students from and sponsored research at more than 18 universities by more than 50 students and 20 faculty members, investing about 10% of its AFC budget.*

I. INTRODUCTION

Students and faculty alike view P&T--Partitioning of used nuclear fuel and Transmutation of its resultant wastes--as an exciting and ripe area for academic research. Large-scale research for P&T technology began in the U.S. in the early 1990s as a Laboratory Directed Research and Development (LDRD) Project at the Los Alamos National Laboratory. Researchers at LANL first examined molten-salt fueled and cooled systems for Accelerator-driven Transmutation of Waste (ATW), and later investigated liquid-metal-cooled, metal-fueled ATW concepts. The National Academy of Sciences reviewed ATW concepts as a means of managing used nuclear fuel in the mid-1990s,[1] and the Department of Nuclear Engineering at the Massachusetts Institute of Technology reviewed the ATW LDRD project of LANL again in 1998. Following the MIT review the U.S. Congress recognized the potential of this technology for managing a large legacy of used nuclear fuel; they then authorized the DOE Office of Environmental Management (Office of Civilian Radioactive Waste Management-OCRWM) to develop a technology and deployment roadmap for ATW in FY99. The Congress then funded an ATW research program within the Office of Nuclear Energy, Science and Technology (DOE-NE) in FY00.

A year after the completion of the ATW Roadmap, the Advanced Accelerator Applications (AAA) Program was initiated as a multi-laboratory research program in collaboration with a number of universities, including the University of Nevada, Las Vegas, the University of California at Berkeley, the University of Michigan, and the University of Texas at Austin. The primary mission of the AAA Program was the development of technology for transmutation of nuclear waste and demonstration of its practicality and value for long-term waste management. Other goals were to help revitalize the U.S. nuclear infrastructure and for the U.S. to resume an international leadership role in nuclear technologies. This new science and technology will require a large cadre of educated scientists and trained technicians in addition to that required for our broader national nuclear infrastructure.[2, 3] The AAA program is now transitioning to a new program called the Advanced Fuel Cycle Initiative (AFCI or AFC), with a larger goal of integration and management of nuclear materials in the entire fuel cycle. This larger program will require an even larger involvement of academia and students than did the ATW and AAA projects.

During the next decade, the nation will need additional nuclear scientists and engineers for national security programs that include counter-proliferation, global monitoring, stewardship of our nuclear stockpile, and naval nuclear propulsion. We will also need more college graduates for design and federal regulation of Generation IV reactors and advanced fuel cycles, [4] and we will need young people for nuclear medicine and medical research using radioisotopes. We will need still more young scientists and engineers for expanding industrial radiation applications such as manufacturing, oil and gas exploration, and irradiation to sterilize hundreds of consumer products and most medical equipment. In addition, we ll need a larger nuclear workforce to design and operate irradiation facilities to eliminate pathogens like Listeria and E. coli from our food, Hoof-and-mouth from our feed stocks, and Anthrax from our mail.

Because of the requirements for educated scientists and engineers in a wide variety of nuclear- and accelerator-related fields, multi-year programs involved university faculty and students in various phases of the ATW, then the AAA, and the AFC projects. This report describes ongoing university programs and new initiatives that are supporting both the research needed for transmutation and the national nuclear infrastructure. Since the inception of the LANL-funded ATW project, LANL has taken the lead in these programs in funding, coordinating, and collaborating on research involving faculty and students. These past programs included research projects at the University of Michigan, the University of California at Berkeley, and the University of Texas at Austin; a University Participation Program (AAA UPP) at the University of Nevada, Las Vegas (UNLV), and a University Fellowship Program (AAA UFP). Current programs include ongoing LANL-funded university research, including four more universities that were added last year, the UNLV program, which has been renamed the UNLV Transmutation Research Program (TRP), the AFC Fellowship Program, and a new project at the Idaho Accelerator Center, a research center at the Idaho State University. This report begins with a description of student support during the year. More detailed descriptions of research programs at the universities are in other papers in this Proceedings.

II. AAA STUDENT SUPPORT

A significant aspect of these Programs is that they have supported more than one hundred U.S. students. During FY02 120 students were supported through the University Fellowship Program, the UNLV TRP, research contracts with 10 universities, and internship programs at national laboratories. Last year, both FY01 and FY02 AAA funding was used, and students worked on transmutation-related research with support from other DOE programs (special student programs, other research projects, etc.). Table I. is a summary of the different categories of student support, and the following sections briefly describe the programs. The universities students worked at or came from to work at the national laboratories are included in Table II.

Table I. Summary of FY02 AAA Student Support

UNLV Transmutation Research Program	49	(26 graduate and 23 undergraduate students)
ISU-IAC Program	20	(10 graduate and 10 undergraduate students)
University Fellowship Program	20	(10 FY01 and 10 FY02)
Directed University Research Programs	16	
Laboratory interns	21	(includes students also in other categories)
Seaborg Transactinium Science Institute Summer School	2	

Table II. FY02 AAA Universities*

Allegheny College
Arizona State University
Brigham Young University
Ecole des Mines de Nantes
Georgia Institute of Technology
Idaho State University
Imperial College of London
Iowa State University
Massachusetts Institute of Technology
North Carolina State University
New Mexico Institute of Technology
Ohio State University
South Dakota School of Mines & Technology
Tbilisi University (Republic of Georgia)
Texas A&M University
University of Arizona
University of California Berkeley
University of California Davis
University of California San Diego
University of Cincinnati
University of Florida
University of Illinois at Chicago
University of Illinois at Urbana-Champaign
University of Massachusetts
University of Michigan
U of Nevada LasVegas
University of New Mexico
University of Tennessee Knoxville
University of Texas-Arlington
University of Texas-Austin
Vanderbilt University

*Students worked at these universities or came from these universities to work as graduate research assistants at the national laboratories during Fiscal Year 2002.

III. UNLV TRANSMUTATION RESEARCH PROGRAM (TRP)

The UNLV TRP was designed to benefit the National AAA Project and the University s goals to enhance student-focused and internationally recognized research programs. In accordance with the public law that established the AAA Project and the UNLV funding, the UNLV TRP included research and development of technologies for economic and environmentally sound refinement of used nuclear fuel. In its first year, 12 research projects were initiated, and that list expanded to 16 during FY02. In addition, substantial improvements to infrastructure at the UNLV are underway.[5] More than 50 students [currently 26 graduate (Masters and Ph.D.) and 23 undergraduate] have been employed at UNLV in research projects and as support to the project administrators in the Harry Reid Center for Environmental Studies. These students represent several colleges at UNLV, including Health Sciences, Engineering, and Sciences, and several departments within those colleges. A complete discussion of the sixteen approved research projects is in the first TRP annual report. The research projects at UNLV are highly interdisciplinary, cutting across departments and even colleges. With the UNLV TRP now in its third year with more than 30 faculty and research staff, the UNLV has become the lead U.S. university for transmutation research.

The Director of the UNLV TRP has provided quarterly reports, has submitted overview reports to national conferences,[6] and has given presentations at reviews and national meetings that describe the vision and implementation of this rapidly maturing program. These presentations and reports include descriptions of the research projects that were underway in the first two years of the program, important decision points, and a new paradigm in research collaborations with national laboratories that is exemplified by the program. A brief description of each of the projects illustrates the breadth of ongoing transmutation research at UNLV (numerals coincide with UNLV Task numbers):

1. Melt casting of metallic fuel pins incorporating volatile actinides.
2. Modeling, fabrication, and optimization of niobium accelerator cavities.[7]
3. Experimental investigation of steel corrosion in lead bismuth eutectic.[8]
4. Hydrogen-induced embrittlement of candidate target materials.[9]
5. Modeling corrosion in oxygen controlled LBE systems with coupling of chemical kinetics and hydrodynamics.[10]
6. Neutron multiplicity measurement for target/blanket materials.[11]
7. An intercollegiate project to develop dose conversion coefficients for radionuclides produced in spallation neutron sources.
8. Systems engineering modeling of chemical separations.[12]
9. Design and evaluation of remote processes for fuel fabrication.
10. Development of a mechanistic understanding of the high-temperature deformation of alloy EP-823.[13]
11. Nuclear criticality analyses for transmuter fuel fabrication and separations.
12. Radiation transport modeling of beam-target experiments.[14]
13. Developing a sensing system for the measurement of oxygen concentration in liquid Pb-Bi eutectic.[15]
14. Use of positron annihilation spectroscopy for stress-strain measurements (a collaboration with Idaho State University).[16]
15. Immobilization of fission iodine by reaction with a fullerene containing carbon compound and insoluble˚natural organic matrix to help develop waste forms for the back end of fluorine-based separations processes.
16. Evaluation of fluorapatite as a waste-form material.

IV. IDAHO STATE UNIVERSITY--IDAHO ACCELERATOR CENTER (ISU-IAC)

Part of the growth of university programs of the AFC project was the addition this year of a new program at the Idaho Accelerator Center (IAC) of the Idaho State University (ISU). The ISU-IAC AAA Program was designed to benefit the National AAA Project and the University s goals to enhance accelerator infrastructure and research. The AFC program at ISU-IAC supported twenty students, including two from Tbilisi University in the Republic of Georgia who are studying at ISU. This project also included three collaborations with UNLV, and one UNLV student worked in the IAC last summer. Three research projects are described briefly below.

<u>Positron Annihilation for Materials Stress Analysis</u>: A new technique for determination of residual stress in materials is being developed at the IAC. These new techniques for Accelerator-based Gamma-induced Positron Annihilation Spectroscopy (AG-PAS)[17] use highly penetrating gamma-rays (bremsstrahlung from high-energy electrons) to create positrons inside the material via pair production. Researchers at the IAC have also synchronized bremsstrahlung pulses with intense laser irradiation pulses to study dynamic structural changes in material as a result of thermally induced stress, where they have successfully measured stress/strain in engineering samples of several-cm thickness. These measurements have been completed on Steel, Aluminum, Zirconium and Silicon. In addition, they have developed another method using (p,gamma) reactions from a 2-MeV

proton beam, which induce coincident gamma rays to perform positron life-time spectroscopy.

Accelerator Driven Neutron Source: Staff and students at the IAC have developed and tested an electron accelerator-driven neutron source for performing dynamic reactivity measurements in multiplying and non-multiplying assemblies. The accelerator will provide a pulsed neutron fluence of about 10^{11} neutrons per pulse and an average of 10^{13} neutrons per second. Building modifications on the IAC building are underway and will provide space for this facility that will be operational in early 2003. Photo-neutron production calculations and benchmark experiments have been performed for a number of accelerator target configurations.[18, 19] Students determined that a high-Z cylindrical target with a beam cavity, so the electron beam strikes the interior of the target, would provide the maximum neutron yield. This produced a factor of ~2 increase in yield compared to surface bombardment.

Dose Conversion Coefficients: Faculty and students in the Health Physics program at ISU are participating in this intercollegiate project with UNLV and other universities (see Task 7 of the UNLV section of this report). The PI for this portion of the project is ISU Prof. Richard Brey, who is a member of the DCC working group. Several students are calculating dose coefficients and DCCs.

V. LANL-DIRECTED UNIVERSITY PROJECTS

In FY00 the Accelerator-driven Transmutation of Waste (ATW) Project began as a $9M effort following a decade of laboratory-funded research at Los Alamos National Laboratory. During the ATW Project, Los Alamos National Laboratory contracted with three universities the University of California-Berkeley, the University of Michigan, and the University of Texas-Austin to support ongoing research in transmuter design and analysis, in planning for experiments, and in assessing proliferation-resistance attributes of separations and transmutation technologies. Research projects at these three universities have continued, and they have employed undergraduate and graduate students during several years. In FY02 LANL added two more university programs at North Carolina State University and the University of Illinois at Urbana Champaign, and other ongoing research at Arizona State and the Imperial College of London was folded into the AFC research program. LANL initiated purchase requests for research support from the University of Florida and the Georgia Institute of Technology. In all, LANL supported 14 students at 7 universities.

V.A. University of California at Berkeley

Faculty and students at the University of California-Berkeley have conducted research to evaluate designs of transmuters and to optimize the destruction of neptunium (the isotope of primary concern for long-term storage).[20] Conclusions of analyses of molten-salt[21] and other transmutation reactors are discussed in a paper that was presented at the Nov. 2001 Winter Meeting of the American Nuclear Society in Reno, NV.[22] In addition, several students have worked on code systems that have directly benefited AAA research needs while supported by funding from other programs, such as the Nuclear Energy Research Initiative (NERI), the Nuclear Engineering Education Research program (NEER), and Generation IV roadmap and reactor studies projects.[23] One example of this synergy was a project to compare lead-bismuth-cooled and sodium-cooled transmuter systems,[24] and another was a project to evaluate a modular, pebble-bed-type gas-cooled reactor as a transmuter.[25]

V.B. University of Michigan

At the University of Michigan, several faculty and students have supported the ATW, AAA, and AFCI Projects with studies for the design of integral experiments as well as evaluations of a variety of technical issues. Faculty members have acted as honest brokers to provide comments and advice during systems studies, reactor studies, and the development of concepts for future experiments. In addition, students have completed considerable work and thesis studies. In one study, mono-energetic neutron sources of sufficiently high energy (e.g. 14 MeV) to contribute to the science of accelerator-driven transmutation in lead and bismuth moderators have been shown to produce flux depressions just below the source energy, such that they would contribute marginally to physics measurements and benchmarking in the energy regime of the depression.[26] This work continued in FY02 with the examination of the ability of standard fast spectrum analysis techniques to capture the details of neutron slowing down in heavy moderators such as Pb and Bi.[27] In another project neutronics tools were compared to validate design methods.[28]

As one of the major tasks for the AAA project at the University of Michigan, they have been studying dynamic behavior of accelerator-driven subcritical reactor (ADS) systems. This has involved the development of dynamic models for simulating multiple pulses of spallation neutron sources and methods for determining the reactivity in ADS systems. Their emphasis has been on developing computational tools that can accurately and efficiently represent the localized nature of spallation sources in determining the power distribution and reactivity in transient conditions. A Michigan student developed numerical algorithms based on a two-dimensional time-dependent diffusion theory code that can accurately account for step changes in localized sources in time to establish a space-dependent dynamic model for simulation of ADS transient behavior.[29, 30] This involves separate treatments for the shape-function and amplitude-function calculations that can represent prompt space-time variations in neutron flux within the quasi-static formulation. These studies continued in the development of methods to account for the spatial dependence in reactivity measurements.[31] Other work at Michigan has included the development of a linear reactivity model[32] and extrapolation algorithms for equilibrium cycle analysis of transmutation systems, integral experiments for fuel reaction rate, and advice on the prioritization of research requirements.

LANL technical staff initiated a new project at U of Michigan in FY02. This project involves the use of proton irradiation to simulate spallation-neutron radiation damage in accelerator-driven systems. This work began with an investigation of the effect of higher gas production at significant doses (several displacements per atom or dpa) to lay a foundation for a full-scale irradiation campaign. It was followed by development of a detailed description of the irradiation campaign (temperatures, dose rates, doses, and He-implantation levels), and finally by conducting irradiation testing on steels at various dpa levels. The first campaign is almost finished, with proton irradiations of HT-9 and T-91 steels at 3.0, 7.0, and 10.0 dpa having been completed.[33]

V.C. University of Texas at Austin

In one of the two research projects that are ongoing at UT-Austin, proliferation resistance and security metrics have been quantified for separations, fuel fabrication, transmutation, and disposal.[34, 35] They developed of a set of high-level metrics by consulting a number of experts in the field. Last year they added time-dependence to the methodology as well as uncertainty estimates. A product of this work is an initial comparison of the security metric from transmutation with that from the once-through fuel cycle.[36] In another project, UT-Austin is preparing to conduct and analyze the results from a set of cross-section measurement experiments at the LANSCE facility at LANL.

V.D. North Carolina State University

A new participant in the international collaborations for the AAA Program was added in the latter part of the year. North Carolina State University is calculating radiation damage, including production of displacements, helium, hydrogen, and heavier transmutation products, and energy deposition in targets for generation of high-energy spallation neutrons. They are examining response in target materials, containment structures, and entrance windows of the target assemblies for the SINQ spallation neutron sources that are under design and development at the Paul Scherrer Institute (PSI). These targets include the Mark II and Mark III designs.[37] In addition, they will examine less obvious (and less well studied) mechanisms for the transfer of energy to the irradiated materials and hence the production of displacements. These mechanisms include recoil-atom damage and other interaction products. Finally, they will analyze the effects of the calculated radiation damage on mechanical and other property changes and assess reasonable and safe lifetimes for radiation-damaged components. Much work has been completed in the short time since the initiation of this project.[38]

V.E. University of Illinois at Urbana Champaign

A 2001 AAA Fellow at UIUC has begun a thesis project to investigate impedance spectroscopy as a feasible method of measuring the effects and rates of lead-bismuth corrosion on structural materials while DELTA-Loop research staff members at LANL provide advice and collaboration.[39] Through a contract with LANL, UIUC will purchase components for and construct a container/piping system to investigate issues related to corrosion in high-temperature liquid lead-bismuth eutectic (LBE). In this impedance spectroscopy technique, alternating electric currents of various frequencies will be used to measure the electrical impedance of a surface corroded by lead-bismuth. UIUC will construct a lead-bismuth loop (piping, connections, thermocouples, pump(s), heating element(s), lead-bismuth, and experimental section) at the Materials Research Laboratory (UIUC MRL), and will conduct controlled experiments to take impedance spectroscopy measurements on corroding steel samples.

V.F. University of Florida

Technical staff at Los Alamos initiated another new intercollegiate collaboration to investigate the effects of intense proton and neutron irradiation on the oxide layers that are formed on steels in high-temperature LBE systems. One graduate student will be working with the University of Michigan to irradiate samples that have been oxidized in the DELTA Loop at LANL.

VI. UNIVERSITY FELLOWSHIP PROGRAM

The University Research Alliance, which is a consortium of Texas universities (URA is located in Amarillo, Texas), manages the AFC University Fellowship Program (AFC UFP) for the DOE/NE. The University Fellowship Program is intended to support top students across the nation in a variety of disciplines that will be required to support transmutation research and technology development in the coming decade. The program was described in detail at the 2001 Winter

Meeting of the ANS.[40] In the first two years twenty Fellows were selected from highly qualified applicants. The Fellowships were awarded in April of 2001 and 2002 to students who would attend graduate school at 16 universities. The AAA and AFCI Fellows work on a variety of topics as they conduct research for their Masters theses and degrees.

Both the FY01 and FY02 Fellows collaborated directly with technical staff at the National Laboratories to formulate their Masters thesis topics so that they will directly benefit the AFC Project. To facilitate selection of thesis topics, a summary of research topics that were appropriate for M.S.-level research was developed.[41] During the summer of 2002, seven of the Fellows chose to work as graduate research assistants (GRA) at five different National Laboratories: Los Alamos, Argonne, Argonne-West, Oak Ridge, and Sandia. GRAs worked on a variety of projects, for instance: at LANL conducting an experiment to measure neutron multiplicity in lead and lead-bismuth targets for high-energy proton accelerators;[14] at ANL-West on a project to develop fabrication technology for transmutation fuels;[42] at ANL on separations of used fuel using pyro-chemistry technology; and at ORNL on fabrication of coated-particle fuels. Selection of new students for FY03 Fellowships was suspended because of a shortfall in funding and a delay in the passage of the FY03 budget.

VI.A. Laboratory Intern Students

The national laboratories employ students, from undergraduate to Ph.D., to provide administrative assistance and to conduct critical scientific research. Most interns conduct research during the summer, however, several students are supported during other portions of the year, and Ph.D. students may work at the laboratories year-round.[43] Four of the AFC National Laboratories supported 21 undergraduate and graduate students directly during the past year (6 at ANL, 2 at ANL-West, 10 at LANL, 2 at LLNL, and 3 at ORNL). This total includes four of the AAA Fellows who were mentioned previously in the AAA UFP Students section. The two students who were at LLNL attended Summer School in the Glenn T. Seaborg Institute for Transactinium Science (GTS-ITS).

VII. OTHER.

VII.A. Argonne National Laboratory (ANL)

In addition to the major LANL-directed university programs, ANL technical staff conducted research through two universities in FY02 and supported GRAs as previously mentioned. ANL assumed some of the reactor-based transmutation studies that LANL initiated at the University of Michigan. They also began a one-year project at the Massachusetts Institute of Technology.

VII.B. Celebrity Visit Provides AAA-AFC Visibility

In February of 2002, author/historian Richard Rhodes suggest to actor and philanthropist Paul Newman that he contact me to ask what we could do with used nuclear fuel (Rhodes was technical advisor on the movie *Fat Man and Little Boy*, in which Newman played Gen. Leslie Groves). I explained to Newman that many options had been explored and described several that are still open, like storage at an interim site such as the Goshute Reservation in Utah, disposal in a permanent repository such as Yucca Mountain, and recycling and transmutation. During one of several subsequent telephone calls, I mentioned a joint UNLV-DOE project to develop a public transit bus that is propelled by electricity from a hydrogen-fueled internal combustion engine (hydrogen generation is a current application of nuclear generated electricity). The opportunity to hear about the UNLV transmutation project, to see the hydrogen-fueled big-block V-8 engine (he s also a racecar driver and team owner), and to visit Yucca Mountain was irresistible. In March, Mr. Newman and Raymond Lamontagne (the Chairman of the Board of his Hole In the Wall Gang Camps for cancer-stricken children) spent two days in Southern Nevada. The Director and co-Director of the UNLV TRP gave presentations on nuclear waste disposal and on transmutation. They then visited the College of Engineering to learn about the hydrogen project and the racing engine shop where the engine was being tested on a dynamometer. On the second day of their visit, the Chief Scientist of the Yucca Mountain contractor and the Mayor of Caliente took Newman and Lamontagne on a personal guided tour of Yucca Mountain. This visit provided many opportunities to publicize the AAA and TRP projects, because it was reported in the monthly newsletter of the UNLV Dean for Research, by the Nuclear Energy Institute, and by the American Nuclear Society. Subsequent follow-up activities and discussions provided further exposure for the program, including a dinner-nuclear debate that Newman and his wife, actress Joanne Woodward, organized for senior representatives from network and public television, prominent newspapers, and newsmagazines. I assembled the pro-nuclear side of this lively discussion, Environmental Defense organized the skeptics, and last May we gathered in the living room of their Fifth Avenue New York apartment to talk about disposition of used fuel and the future of nuclear power.

VII.C. Publications and Presentations

In the short time that the ATW and AAA university programs have existed, many papers have been published and many presentations have been made. Some of these have been mentioned herein, while many others are cited in the references listed in the bibliography. University Programs presentations were made at the 2001 Winter

Meeting of the ANS in Reno, Nevada[44] and at the 2002 Annual Meeting of the ANS in Hollywood, Florida.[45] Another presentation was made as part of a panel discussion on management of used nuclear fuel at the ANS Annual Meeting.[46] Colloquia were presented at The Ohio State University, University of Tennessee at Knoxville, University of Pittsburgh, ISU, Washington State University, and UNLV. University programs of the AAA project were also highlighted in a newsletter of the Accelerator Applications Division of the ANS.

VIII. FUTURE GROWTH

Expansion of academic collaborations for the AFC Project next year (FY04) and beyond depends on projected budgets. An increased budget may allow these programs to expand and others to be added. A University Consortium for Transmutation Research (UCTR) is another new program that is being formed for. UNLV, ISU, and URA are leading a national effort to form the UCTR with cooperation from many prominent universities as well as international participants. The UCTR is intended to develop a strong university-run program to continue research and development of accelerator-driven transmutation, to become the national lead for this technology, and to plan for the eventual construction of a test facility. This test facility, if constructed, will be operated by the UCTR as an international user facility for academic research on transmutation of waste from the nuclear fuel cycle.

With growth in the UNLV TRP, ISU-IAC, AFC Fellowships, and Directed University Research, along with initiation of the UCTR, university collaborations could reach the order of $10 million or much more per year by or before FY04.

IX. MEETING THE GOALS

In the introduction I described the goals of the AAA Project: to develop transmutation technology, to revitalize nuclear infrastructure, to provide a test-bed for advanced nuclear projects, and to resume an international leadership role. With the transition to the Advanced Fuel Cycle Program (AFC), our University research supports all of these goals while expanding on and leveraging other DOE/NE programs such as the Nuclear Energy Education Research Program (NEER), the Nuclear Energy Research Initiative (NERI) as well as International NERI (I-NERI), and reactor research programs such as Generation IV. Much of the research and development that is being conducted for the AFC Project will support the development of Generation IV concepts and nuclear systems. With more than 115 students supported this year, and the expectation of even more in 2003, the contribution to the U.S. nuclear infrastructure is obvious. In addition, U.S. participation in international conferences will increase substantially as a result of the many research projects supported by AAA funding. This will demonstrate to the international community an expanding major role for the U.S. in this technology. As a prime example, the Student Mini-Conference that was held in conjunction with the Winter Meeting of the ANS in Reno, Nevada in November 2001 was dominated by AAA-supported student presentations (more than half of the oral papers were for AAA-sponsored research). We believe that AFC University Programs will continue to strongly support the mission and goals of the AFC Project.

X. SUMMARY

The Advanced Fuel Cycle (AFC) Program will require a large cadre of educated scientists and trained technicians in the next decade or more. Other applications of nuclear science and engineering also require increased academic and national infrastructure and student populations. The AFC Program includes university faculty and students in various phases of the Project to support the infrastructure requirements of nuclear energy, science and technology fields as well as the special needs of the DOE transmutation program. These AFC University Programs complement other DOE-NE programs such NEER, NERI and I-NERI, and reactor research programs like Gen-IV by connecting students to nuclear research projects in a wide variety of academic disciplines. In this paper we described university programs that have supported the AAA Project and that are supporting the R&D necessary for the AFC Project. These ongoing programs include the University Fellowship Program, the UNLV Transmutation Research Program, the Idaho Accelerator Center at the Idaho State University, Directed University Research, and other efforts. The AFC Project is well poised to contribute to the future education of nuclear scientists and engineers while conducting research that is essential to the success of the project. We expect AFC University Programs to grow substantially in the coming years.

Acknowledgement–The Office of Nuclear Energy, Science and Technology of the U. S. Department of Energy has supported or is supporting all of the work reported herein through the ATW, AAA, and Advanced Fuel Cycle Programs.

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