

**Combined**  
**2009-2010 Annual Report**  
**and**  
**Final Report**  
**Western Nuclear Science Alliance**  
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## **Summary**

The Western Nuclear Science Alliance (WNSA) was formed at Oregon State University (OSU) under the DOE Innovations in Nuclear Infrastructure and Education (INIE) program in 2002.

The primary objective of the INIE program is to strengthen nuclear science and engineering programs at the member institutions and to address the long term goal of the University Reactor Infrastructure and Education Assistance Program, namely, to “Enable, by 2015, the Nation’s nuclear engineering universities to achieve a stable national undergraduate enrollment of approximately 1,500 to meet the Nation’s need for trained nuclear scientists and engineers.”

WNSA has been very effective in meeting these goals. The infrastructure at several of the WNSA university nuclear reactors has been upgraded significantly, as have classroom and laboratory facilities for Nuclear Engineering, Health Physics, and Radiochemistry students and faculty. Major nuclear-related education programs have been inaugurated, including considerable assistance by WNSA universities to other university nuclear programs. Research has also been enhanced under WNSA, as has outreach to pre-college and college students and faculty.

The INIE program under WNSA has been an exceptional boost to the nuclear programs at the eight funded WNSA universities. In subsequent years under INIE these programs have expanded even further in terms of new research facilities, research reactor renovations, expanded educational opportunities, and extended cooperation and collaboration between universities, national laboratories, and nuclear utilities.

## **I. Annual Report for 2009-2010**

Activities during this time period were limited to the writing of reports and collecting of data for this final report. As such, the activity was limited to only OSU.

## **II. Cumulative Final Report**

### **A. Educational Enhancements**

**OSU Distance Education Program.** OSU is now in its eighth year of its Radiation Health Physics distance education program. The program has grown considerably during this time period. All of the Radiation Health Physics courses, including two laboratory courses taught in one-week sessions on-campus, have now been taught multiple times now. Most importantly, the number of distance students matriculating is climbing.

**New OSU Graduate Degree Program.** The OSU Department of Nuclear Engineering and Radiation Health Physics now offers a non-thesis Master of Health Physics degree. This is a professional graduate degree that emphasize fundamental learning and professional development. The degree will direct students toward professional licensing, e.g., the Certified Health Physicist license. The major objective is to provide an applied, professional degree for those individuals wishing the Master's credential, but not requiring a research focus for their planned profession. This is especially applicable to distance students.

**New UCD Nuclear Courses.** "Introduction to Nuclear Science and Engineering" and "Neutron Inspection Techniques" have been offered to UCD graduate students. These entry level courses prepare engineering students to pursue research applications using neutrons in their own professional fields. UCD graduate students are using MNRC's neutron imaging capabilities to study organics in rocks, nutrient and moisture distribution in healthy and diseased grapevines, and macroscopic quantification of water flow and contaminant transport in soils. They are also using instrumental neutron activation analysis to study pottery and clay samples from archaeological sites to understand trading routes between tribes.

**WSU Curriculum Development.** The WSU Nuclear Radiation Center in conjunction with the WSU Department of Chemistry, utilizing WNSA support, developed and taught a two credit summer course for K-12 science teachers in Nuclear and Radiochemistry.

**ISU Nuclear Engineering Education.** Support from the INIE program has focused on enhancing nuclear engineering education at ISU by providing undergraduate and graduate students unique opportunities to use laboratory facilities and equipment at other WNSA institutions. ISU students and faculty visit these facilities to gain direct, hands-on experience in nuclear engineering experiments and nuclear reactor operations by conducting experiments and engaging in research using the infrastructure at other WNSA institutions not available at ISU. There is also interest in developing support mechanisms for student involvement in research at other WNSA facilities. In addition, ISU has developed closer ties

with the University of New Mexico and Texas A&M AGN reactor facilities to share operational and technical experience to contribute to the continued successful operation of these facilities.

An agreement with INL has been made that allows the ISU Nuclear Engineering Program to use INL facilities, including the Advanced Test Reactor, the Advanced Test Reactor Critical Facility, the Radiation Measurements Laboratory, and the Advanced Test Reactor simulator, at the Reactor Technology Complex (RTC) for teaching undergraduate and graduate laboratories. This development is a major accomplishment that allows ISU access to state-of-the-art national laboratory facilities for use in nuclear engineering education.

Much of the focus of recent WNSA-related projects involved replacement of the ISU AGN-201 reactor control console. Funds provided through WNSA were used to purchase needed components and to pay students working on different tasks associated with the project. The overall system integration, testing and implementation was done by a masters-level graduate student. This student also received a Reactor Operator license from the NRC. Another graduate student completed a thesis that involved the design and testing of a new system for measuring and displaying control rod position using state-of-the-art absolute encoder devices coupled to the control rod drive assemblies. In addition, four undergraduate students from two colleges helped with various aspects of the project, and have gained valuable experience in reactor control and safety systems design and reactor operating characteristics. In related projects, one graduate student has completed a thesis that provided the design for a new reactivity oscillator system for the AGN reactor, and another master's student is working on the design of a new pneumatic sample transfer system.

One new tenure-track assistant professor and two research associate faculty, one of whom is a radiochemist and the other a nuclear metallurgist, have been hired by ISU nuclear engineering. The two research faculty have joint appointments with INL. These latest hires are expected to collaborate with faculty from the ISU chemistry and physics departments.

## **B. Research Innovations**

**OSU Radiochemistry.** Research innovations in the OSU radiochemistry program included (1) a project on speciation chemistry of plutonium and other actinides in UREX+ processes, funded under the DOE NERI program in collaboration with UNLV and ANL; (2) collaborative projects with OSU Veterinary Medicine on Tc-labeled proteins and metabolism of explosives; (3) collaborative projects with OSU Chemistry on nanoparticles for radiochemical, biological, and environmental applications; and (4) collaborative projects with CH<sub>2</sub>M-Hill on column experiments with <sup>90</sup>Sr sorptive media.

**UCD/UU Nuclear Forensics.** This project involved collaboration between UCD and UU to quantify and qualify samples with minute plutonium uptake through Neutron-induced Autoradiography (NIAR). NIAR is being used to measure <sup>239</sup>Pu in hard and soft tissue samples. Initial NIAR samples from UU have been irradiated and analyzed. Existing irradiation facilities are being improved with new beam parameters to improve clarity of the

NIAR images.

**UCD Vulnerability and Survivability of Materials.** The exposure vessel has been modified to further reduce potential thermal neutron leakage. Radiation dosimetry was performed to calibrate this renovated irradiation facility. A study was conducted to better correlate radiation dosimetry and Monte Carlo simulation.

**UCD Instrumental Neutron Activation Analysis** of pottery samples. Pottery, clays, and other raw materials used in the production of ceramics originating from archaeological sites in Nevada have been analyzed for studies of trading routes between tribes.

### **C. Infrastructure Improvements**

**OSU OSTR Beam Port #4 Improvements.** The development of a highly collimated neutron beam for use in PGNA and neutron depth profiling was completed in 2009, complimentary to the new neutron radiography beam line completed in 2005. It is anticipated that these beams will increase utilization of the reactor by researchers from across university campus and the across the nation. The beams are operational without interfering or otherwise negatively affecting the present operation and research demands. The new facility was described in the Journal of Radioanalytical and Nuclear Chemistry **283**, pp 359-369 (2010).

**OSU OSTR Secondary System Replacement.** Problems associated with the carbon steel secondary system piping had reached a maximum in 2007. In 2008 and into 2009 all the secondary piping was replaced with stainless steel. This was in addition to the purchase of variable speed drives, pumps and heat exchangers.

**OSU Gamma Spectroscopy Instrumentation Replacements.** The instrumentation replaced included digital spectroscopy systems, spectroscopy software, and installation costs. Taking advantage of the digital signal process has allowed us to completely automate three sample changers and network two rooms containing a total of eight detector systems. These improvements have made these two labs much more user friendly for both students and researchers. Although we are anticipating future changes in the room, the instrumentation purchased will likely be utilized for the next 15-20 years.

**UCD Neutron Radiography/Tomography Techniques.** UCD/MNRC's neutron tomographic facility in Bay 3 has been completely upgraded with a new set of radiation shielding and imaging instrumentation and equipment. The system includes an adjustable lithiated-polyethylene neutron beam collimator, a reconditioned robot and new sample stage, a new neutron scintillation conversion screen and mirror assembly, a mixed-field-shielded high-performance CCD camera, and an image data acquisition computer. Initial testing of the system was successfully completed. The image resolution is improved to approximately 200 microns.

**UU Vertical Beam Port.** MCNP calculations have been conducted to validate the beam port design. Neutron and photon fluxes have been calculated. Several types of beam port designs, including a changeable aperture, have been considered to get reasonable results and minimize cost.

#### **D. Partnerships with DOE labs, colleges and universities, utilities, and other public/private entities**

The following collaborative radiochemistry projects have concluded or continue to be ongoing at **OSU**: (1) Argonne National Laboratory (Chemical Engineering Division) on separation processes for the Advanced Fuel Cycle Initiative; (2) INL (Radioanalytical Division) on alteration of spent nuclear fuel forms; (3) PNNL (Radiochemistry) on plutonium complexation and separation chemistry; and (4) Colleges and high school in the region, including a project on arsenic monitoring and mobility in the soils in the Sweet Home, OR region, which involves application of neutron activation analysis, soil leaching experiments on bioavailability of As, and plant uptake experiments.

Working with Adelphi Technology, **UCD** has tested Adelphi's compound reflective lens for thermal neutron focusing in MNRC's Bay 4. A separate system working with Nova Scientific's micro channel plate as an imaging system has been tested and proven to work. A permanent fixture and station was designed and is being built for this system to be used in Bay 4 to support further research applications.

Funds have been used at **ISU** to travel to the two other AGN reactor facilities (Texas A&M University and the University of New Mexico) to review maintenance/operating procedures and discuss control rod cladding failures that occurred recently at ISU. As a result, ISU has developed a close working relationship with these other AGN facilities, who are both members of the INIE Southwest Consortium, which will allow all these universities to address common operational problems and maintenance issues and to jointly fabricate additional control rod capsules for use as spare components should additional occurrences of cladding failures occur. As part of the INL Idaho University Consortium, ISU has partnered with Boise State University and the University of Idaho to establish the Institute of Nuclear Science and Engineering at ISU. ISU maintains close ties with INL, which provides many opportunities for collaboration in research and instruction. ISU has joined with the University of Idaho in jointly offering Nuclear Engineering courses and is investigating the use of INL reactor facilities for teaching undergraduate and graduate laboratories. ISU is involved in the OSU Academic Center of Excellence in Thermal Fluids. ISU has also established ties with AREVA and Energy Northwest.

**Reed College** has worked collaboratively with Pacific University in their Modern Physics course and on informal levels with OSU and Portland Community College. Reed also assists with chemistry and physics classes at Concordia University.

#### **E. University Commitment**

The **OSU** Radiation Center and the Department of Nuclear Engineering and Radiation Health Physics currently have their most active support from the College of Engineering and upper university administration in their 50 year histories. On behalf of the Radiation Center and Department, the University, among other things, continues supporting a major building campaign, adding new faculty positions, raising funds for endowed chairs, and including the Center and the department in the capital campaign for the university.

**UCD** is committed to the INIE program and the MNRC research reactor; including committing matching funds for research participation.

Since 2002 **WSU** has pledged its support and commitment to the WSU reactor and its continued operation, including approximately \$1,000,000 in facility repairs and upgrades that directly impact reactor operations. WSU has proposed spending an additional \$500,000 during 2006-2008 in replacing or upgrading the building heating and air conditioning systems. During this same time period WSU has doubled the number of its combined Nuclear Radiation Center and Department of Chemistry radiochemistry faculty.

**UCB** has offered strong support for the continued excellence of its Nuclear Engineering Department. Prime examples of this support include recurrence of a faculty position with permission to recruit for a new professor in the field of applied nuclear physics or nuclear chemistry, funding the construction of a new Nuclear Imaging Laboratory, appointment of a chaired professorship within the department, special startup funds for a new faculty member, and an increase in the quota for acceptance of new graduate students in the department.

**ISU's** participation in the WNSA consortium has greatly strengthened the nuclear engineering program at ISU, enhanced the education experience and opportunities of its students, and has also contributed to the start up of a new baccalaureate degree program in nuclear engineering in the ISU College of Engineering.

**Reed College** is helping to fund the research facility for prompt gamma measurements due to INIE funding for the germanium detectors. The College is investing in facility improvements for reactor relicensing in 2007.

**UCI** continues to support maintenance of reactor operation at the present level, including supplies and upgrade expenses for its laboratory course in Radioisotope Techniques.

**UU** WSNA funds were used to enhance/improve current research capabilities. For those graduate students funded through research contracts, including WSNA, the UU Graduate School provided full tuition.

## **F. INIE Impact**

The INIE program has been the impetus for improved relationships between the WNSA universities and national laboratories, resulting in increased cooperation and resource sharing. This has served as a catalyst for many positive changes in the university nuclear programs. Furthermore, the INIE program has had a tremendous impact on the university departments of nuclear science and engineering and on university research reactors around the country. Enrollments have increased to a level of stability, research reactors have been significantly upgraded, new research programs have been initiated, and nuclear departments have attained increased status and support within the universities.

As one specific example, at OSU several important factors have recently coalesced into elevating the status of the Department of Nuclear Engineering and Radiation Health Physics and the Radiation Center within the University, nationally, and internationally, namely OSU's internationally recognized \$13+ million thermal hydraulics facilities and research program, becoming a lead institution for an INIE grant, being a top ten ranked graduate Nuclear Engineering program, and OSU's selection as a member of the National University Consortium of the Idaho National Laboratory. These factors have reinforced each other wherein success has bred more success. As a result, the OSU Radiation Center and Department of Nuclear Engineering and Radiation Health Physics are currently being showcased by the University for a major building upgrade, establishment of an additional sponsored faculty chair position, and new faculty positions. The INIE grant has been an important focal point in achieving this status.

Within WNSA new research reactor facilities, such as OSU's Neutron Radiography Facility, have been built. Funds for this facility would never have been attained without the INIE grant. Likewise, the neutron radiography facilities at UCD's McClellan Nuclear Radiation Center have been upgraded to be the finest such university facilities in the country, capable of doing groundbreaking research in agriculture, geology, engineering, and many other fields with its neutron tomography/microscopy capabilities. Classroom teaching facilities have been upgraded at OSU, UCB, and UCD with WNSA funds. Again, these improvements would not have been possible without the INIE grant. Furthermore, a new academic Nuclear Engineering program at UCD and a new Department of Nuclear Engineering at ISU have been created directly or indirectly because of WNSA.

WNSA has taken the lead in implementing new courses that are not taught in existing U.S. Nuclear Engineering curricula. Two summer courses, the first being the forerunner for the INIE Nuclear Summer Institute, have been taught by WNSA national laboratory personnel on nonproliferation issues. Expertise for energy and security programs is mutually reinforcing; both benefit from strong academic and research agendas at the universities. The national laboratories are concerned about a dearth of graduate students in the academic pipeline with backgrounds suitable for a variety of national security careers at the laboratories, in government, in industry, and academia. INIE sponsorship provided the impetus for the LLNL two-week 2005 INIE Nuclear Summer Institute course "Analytic Methods for Nuclear Non-proliferation and National Security," for which LLNL was able to considerably leverage a \$64,000 INIE contribution by providing about \$200,000 of additional laboratory funds for the course.



Because of INIE, a number of WNSA university students were able to travel to other WNSA university reactors to perform laboratory experiments not available on their own campuses. Innovations by WNSA, such as inter-institutional technical forums to bring university and national laboratory researchers together, have been a positive impact on the WNSA universities and national laboratories alike. The WNSA INIE grant has been used as significant leverage of other funds for equipment purchases, establishment of new faculty positions, and obtaining grants that would not have been possible without the INIE grant.

There remains a desire among the nine university, the four national laboratory, and the three industry WNSA members to maintain the inter-institutional collegiality and programs that have been established because of the INIE grant. Many of these fine programs came into existence because of INIE funding and would regress strongly or cease altogether in the absence of INIE funding. For example, students at universities without a reactor would no longer be able to travel to other WNSA universities with reactors to perform experiments. Also there would not be adequate funds to maintain the facility upgrades that have been established under INIE nor the faculty supported on the INIE grant. Specifically, both the WSU and OSU radiochemistry positions would be lost, since these positions are totally funded by WNSA, in the process severely hampering the efforts to address manpower pipeline and research issues in radiochemistry that are of so much interest to the DOE national laboratories.

INIE has added a component of support for universities that helps bridge the gap between "hard" baseline university funding and totally "soft" (and increasingly difficult to obtain) 3-year grants such as NEER and NERI. The INIE program helps to bridge this gap with "firm" longer-term funding that can be depended upon almost as a baseline, assuming that the program is continued on an extended basis, while still requiring measurable results and progress in specific R&D activities.

In summary, among other programs, the WNSA INIE grant has enabled the construction of state-of-the-art research facilities at WNSA university reactors, increased collaboration between university and national laboratories, the development of significant distance education programs in health physics, and the establishment of a viable regional radiochemistry program. None of these programs would have been possible without the INIE grant.

## Appendix

### Acronyms Used

ISU	Idaho State University
OSU	Oregon State University
Reed	Reed College
UCB	University of California Berkeley
UCD	University of California Davis
UCI	University of California Irvine
UNLV	University of Nevada Las Vegas
UU	University of Utah
WSU	Washington State University
INL	Idaho National Laboratory
LANL	Los Alamos National Laboratory
LLNL	Lawrence Livermore National Laboratory
PNNL	Pacific Northwest National Laboratory
MNRC	McClellan Nuclear Radiation Center
NE&RHP	Nuclear Engineering and Radiation Health Physics
OSTR	Oregon State TRIGA Reactor
INIE	Innovations in Nuclear Infrastructure and Education
WNSA	Western Nuclear Science Alliance
PI	Principal Investigator
NAA	Neutron activation analysis

## **WNSA Non-University Organizational Members (Representative)**

### **National Laboratories**

Idaho National Laboratory (Dave Nigg)  
Lawrence Livermore National Laboratory (Tom Isaacs)  
Los Alamos National Laboratory (Paul Lisowski)  
Pacific Northwest National Laboratory (Jim Buelt)

### **Industry**

Energy Northwest (Dale Atkinson)  
Entergy Nuclear (Dan Keuter)  
Exelon (Jeff Benjamin)