University Currents

A Newsletter For and About the University Nuclear Engineering and Science Community

U. S. Department of Energy *Fall 2006*

World Nuclear University Summer Institute

This year, 89 young people from 34 countries spent six weeks in Sweden and France at the World Nuclear University Summer Institute exchanging knowledge with one another and top leaders from the nuclear industry. Applications for next year's Summer Institute, to be held in Korea were accepted through November 30, 2006.

Fellows, mentors and organizers tour a high-level radioactive waste storage facility at La Hague, France

The 2006 World Nuclear University Summer Institute started with a visionary address from the University's President, John Ritch: "Between now and 2050, as world population swells from 6.4 billion toward 9 billion, mankind will consume more energy than the combined total used in all previous history. Under current patterns of energy use, the results will prove calamitous. Let it be said clearly and with confidence: If we are to meet expanding worldwide human need without destroying our planetary environment, this must become a nuclear century."

It is the role of the World Nuclear Univer-sity's flagship project, the annual Summer Institute, to accelerate the development of these people: increase and anchor their knowledge of environmental science, nuclear medicine, safety, the global nuclear power industry and nuclear arms control while building a worldwide network for years to come.

The second Summer Institute took place in July and August 2006 at the Royal Park Hotel outside of Stockholm, Sweden. Five of the course's six weeks were spent in Stockholm, the other taking in an exhaustive tour of France's nuclear facilities. In addition, a weekend trip took Summer Institute Fellows to Sweden's Oskarshamn to tour leading used fuel management and final disposal facilities.

Jeremy Gordon and Daniel Westlén enjoy a reception at Stockholm City Hall

In collaboration with the WNU, the 2006 Summer Institute was hosted by the Swedish Centre for Nuclear Technology (SKC), the Swedish Royal Institute of Technology (KTH) and France's Commissariat a l'Energie Atomique (CEA). The second Summer Institute built on the success of the first at Idaho Falls, Idaho the previous year, and, circling the globe, the 2007 Summer Institute is scheduled for July 14-August 24, 2007, at Daejeon, South Korea, to be hosted by the Korea Atomic Energy Research Institute and Korea Hydro and Nuclear Power.

With the continued support of the World Nuclear Association, International Atomic Energy Agency, Nuclear Energy Agency and World Association of Nuclear Operators, it is hoped that the Summer Institute will be just one of the WNU's projects, accelerating the development of nuclear skills around the world.

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(WNUSI)

Over the course of six weeks…

From the first day's introductions and team building, Fellows lived and worked as a family, and after spending six weeks working, playing, eating and drinking together it is no exaggeration to say it really felt like that. Fellows made each other's acquaintance on an equal footing as people, rather than on the basis of qualification or status, and that made for a congenial atmosphere of mutual respect and cooperative learning. But despite the wide spectrum of personal background and experience, there's one thing that unites Summer Institute Fellows – a belief in nuclear energy. So besides friendly chatting about the weather, each other's countries and each other's lives, Fellows were immersed in a global nuclear culture constantly fed by the Summer Institute's work program.

Some of the most interesting moments during the lecture component came from question sessions. Fellows had the opportunity to ask questions of the speakers – again on a very equal footing. And in fact, the breadth of perspectives meant that quite often the lecturers themselves were learning. There were also chances to have more private discussions with speakers over lunch and many of the speakers attended a few days of the SI, giving even more chances to gain familiarity.

The same was true of the 'distinguished speakers' that covered evening sessions with the Fellows. At these informal events, well-known individuals were given a freer reign to talk about their personal development during their careers. These inspiring sessions were each followed by informal buffet receptions. But these were no awkward occasions of polite atomic small talk. True familiarity was built between fellows, lecturers, and speakers, who all visibly enjoyed the mutual inspiration of open conversation. The Summer Institute's excellent organizers and mentors – themselves rather distinguished – were also always on hand for guidance, insight and discussion.

Greater than the sum of its parts

The mentors came into their own during the other major component of the Summer Institute. Fellows were assigned to mentor groups of about ten to conduct a whole variety of group work. Carrying out lecture discussions, group presentations and reports, each group became like a family unit: advising, supporting, learning from and joking with one another. The mentors ensured that everyone had a role to play and everyone's voice was heard - even when agreement was impossible – and it was during these afternoon sessions that the sheer depth of expertise present was experienced by the Fellows.

The Summer Institute is a collaborative process involving some of the widest-reaching institutions, the leading companies, and the leading scientists and executives within those bodies. Each of those also get back what they put in, but the most important resource input, output, processed or enriched by the Summer Institute is the potential of the young people that attend it.

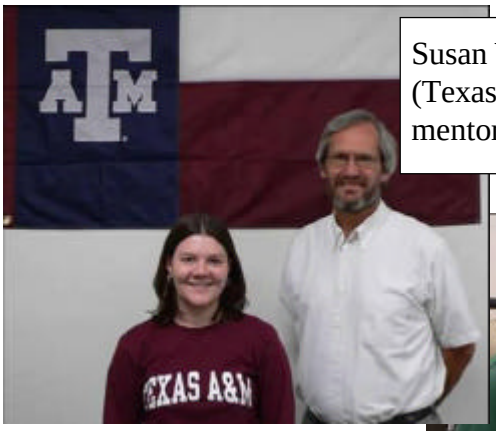
New Radiation Detection Laboratory at Georgia Tech

In recent years Georgia Tech has experienced tremendous growth in the Nuclear and Radiological Engineering and Medical Physics Programs. The programs have grown from an undergraduate and graduate total of 106 students in 2001 to a total of 225 students registered for the current semester. The 2006-2007 senior class has 18 students with future classes having up to 30 students. These larger undergraduate classes, a growing number of graduate students, and the new medical physics program made it necessary to update and expand the academic radiation detection laboratory.

In the spring semester of 2005, 38 undergraduate and graduate NRE/MP students took the radiation detection class and completed their laboratory work in the newly created Areva radiation detection laboratory. The new laboratory consists of a larger laboratory space to accommodate the increased class sizes and five brand new experimental stations consisting of the radiation detection equipment necessary to complete the laboratories. Additional laboratory stations are planned as the size of the classes continues to grow. Funding for the upgraded laboratory was obtained from Areva which provided a total of $100,000 over five years for the purchase of the new experimental equipment and stations with matching funding from the Georgia Tech technology fees. With the funds available a final laboratory consisting of 8-10 stations is planned. The final setup will be able to accommodate up to 30 students per class section.

Nuclear Engineering Students Enjoy Summer at Oak Ridge National Laboratory (ORNL)

A total of 30 nuclear engineering (NE) students spent 10-12 week internships at ORNL in summer 2006. The students participated in research with staff from the Nuclear Science and Technology Division (NSTD), Material Science and Technology Division (MSTD) and the Spallation Neutron Source (SNS). The NE students represented University of Florida, University of Tennessee, Pennsylvania State University, University of Illinois, University of Wisconsin, Georgia Institute of Technology, Massachusetts Institute of Technology, Purdue University, Kansas State University, University of New Mexico, University of Missouri-Rolla, Texas A&M and Prairie View A&M. **Many of the interns are supported by DOE's Office of Nuclear Energy.** The students had successful poster sessions, where they presented their research work at the end of their appointments. They also had several opportunities to attend a seminar series and interact with laboratory management and researchers. The local Oak Ridge/Knoxville chapter of the American Nuclear Society hosted a reception for the summer interns at the American Museum of Science and Energy. The summer 2006 seminar series included the following talks.



Susan Williams (Texas A&M) with mentor Don Mueller

Martin Ohmes (Kansas State University) with mentor Zane Bell

Date	Speaker	Title
August 4, 2006	B.D. Ganapol, University of Arizona	A New Analytical Solution to the Multigroup Diffusion Equation in One-Dimensional Plane Geometry
August 3, 2006	Prof. Jim Morel, Dept of Nuclear Engineering, Texas A&M	A Preconditioned Krylov Method for Thermal Radiation Transport Calculations
July 26, 2006	Don Copinger, Reactor & Facility Safety, ORNL	Overview of GE's New Plant Design - the ESBWR
July 20, 2006	Prof. Tom Downar, Purdue University	Coupled Codes for Multi-Physics Simulation of Nuclear Reactors
July 19, 2006	Randy Belles, Advanced Reactor Systems, ORNL	Overview of Westinghouse's New Plant Design - the AP-1000
July 12, 2006	Kevin Clarno, Reactor Analysis, ORNL	Terascale Computing for Nuclear Energy"
June 28, 2006	Mark Williams, Criticality & Shielding Methods & Applications, ORNL	Cross Section Processing and Nuclear Data
June 22, 2006	John Gutteridge, DOE/NE Director of University Programs	University Nuclear Engineering Support: A Decade of Progress
June 21, 2006	Ian Gross, Reactor Analysis Group, ORNL	Application of ORIGEN for Spent Fuel Analysis, Safety, and Nuclear Safeguards"
June 14, 2006	J. L. McDuffee, Thermal Hydraulics & Irradiation Engineering, ORNL	Materials Irradiation within the Nuclear Science and Technology Division
June 15, 2006	Charles W. Forsberg, ORNL	The Advanced High-Temperature Reactor
May 31, 2006	Valmor de Almeida, Separations and Material Research Group, ORNL	SciDAC Tools for Nuclear Energy

Training Missouri's Workforce

Linn State Technical College programs offered at the Advanced Technology Center (ATC) in Mexico, are preparing the students of today to become the trained workforce of tomorrow.

The Advanced Technology Center is a cooperative effort among the City of Mexico, industry, and higher education institutions including Linn State, Moberly Area Community College and the Missouri University Extension.

Linn State Technical College offers three degree programs through the ATC:

- Laser and Photonics Technology
- Automation and Robotics Technology
- Nuclear Technology

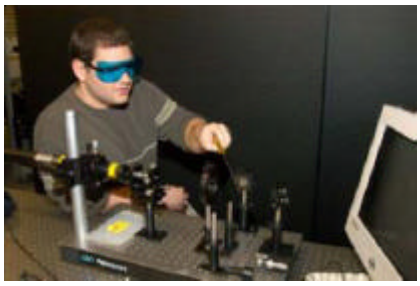
All ATC programs have advisory councils made up of representatives from some of the largest corporations in Missouri, which helps insure that the ATC's curriculum remains at the cutting edge of the needs of industry.

Sen. Christopher "Kit" Bond did the honors at the ribbon cutting ceremony for the Advanced Training Center's new annex. Bond secured federal funding for construction of the addition, which includes classrooms and labs.

"We try to get industry involved in every aspect of the educational process here," said Randy Etter, executive director of the ATC. "Industry is the only reason why we are here."

The Nuclear Technology Program, for example, was developed collaboratively by Linn State, the University of Missouri Nuclear Science Engineering Institute (NSEI), Missouri University Research Reactor (MURR) and AmerenUE Callaway Nuclear Power Plant.

The program offers students a state-of-the art education and training that allows them to seek radiation protection/ nuclear technician positions.



The Linn Tech/ATC laser and photonics program offers students a unique opportunity to learn how to operate, maintain and repair lasers and optical equipment. Laser and optical technicians are in high demand in manufacturing, research, medical, communications and entertainment industries.

The Linn State ATC Laser and Photonics Technology program is one of only 20 programs in the United States. These schools must meet the growing need for that special training. Currently there are approximately 10,000 photonics companies in the United States.

Graduates of all of the Linn State/ATC programs find jobs, said Etter. Many decide to stay in Missouri, but companies from other states often recruit new graduates.

"We have a placement rate of 95 percent," said Etter. "The reason we don't hit 100 percent is because some students chose to pursue a different career after they graduate."

In August, Sen. Christopher "Kit" Bond returned to his hometown of Mexico to cut the ribbon on a new addition at the Advanced Technology Center, which has been named the Christopher S. Bond Annex.

The addition – which was funded with federal, state and private funds – adds 16,000- square-feet for classes and lab instruction.

"The ATC is giving Missourians the skills they need to be sought after by companies to fill the high-paying jobs they offer," said Bond. "That is a win-win-win: for our workers, for industries and for our communities."

University of Idaho/INL NERI Investigates Enhancements to High Temperature Irradiation-Resistant Thermocouples for GEN IV and GNEP Tests

University of Idaho students are not only gaining laboratory experience as they pursue their degrees, but they are also helping to provide instrumentation needed for the Department of Energy's Office of Nuclear Energy (DOE-NE) testing of Generation IV (GENIV) and Global Nuclear Energy Partnership (GNEP) fuels and materials. Recently, successful efforts by the Idaho National Laboratory have led to high temperature irradiation resistant thermocouples that will be used in an upcoming gas reactor fuel test at INL's Advanced Test Reactor Dr. Joy Rempe, who is leading INL's effort to develop high temperature instrumentation for test reactor applications, notes that the "thermocouples that we've developed are the only available temperature sensors that can withstand the high temperature radiation conditions proposed for these gas reactor fuel tests and tests to evaluate proposed fuels for transmutation." As part of a recently awarded University Nuclear Energy Research Initiative (UNERI), "Enhancements to High Temperature In-Pile Thermocouple Performance," UI Mechanical Engineering Professor John Crepeau and Dr. Rempe are mentoring students as they investigate options associated with fabrication techniques, geometry, and alloys, to further enhance the performance of these thermocouples at INL's High Temperature Test Laboratory (HTTL). "To date, INL research has demonstrated the long duration (over 4000 hours) performance of these thermocouples at temperatures up to 1400 ºC, and preliminary INL data show that these thermocouples are viable up to 1600 ºC. UNERI funding is allowing us to investigate options that we believe will lead to an optimized design that is viable for even higher temperatures and prepare students for high temperature experimental research."

INL researcher, Darrell Knudson, and UI student, Patrick Greene, prepare thermocouples for calibration runs in a tube furnace at INL's High Temperature Test Laboratory.

University of Idaho Student, Josh Daw, and Idaho National Laboratory researcher, Joy Rempe, discuss an x-ray of a thermocouple obtained from the real-time x-ray imaging system located at INL's High Temperature Test Laboratory.

This project benefits both the UI and the INL. Students are using this project for their graduate degrees and at the same time preparing for INL staff positions. "This is a unique opportunity for students to work directly with engineers at the INL," says Crepeau. "Our students are doing important research which directly contributes to the state-of-the-art work that is done at the INL, and has both near and long term applications."

Cermonies Commemorate Conversion of University Research Reactors to Low-enriched Uranium

WASHINGTON, D.C. — The Department of Energy's Office of National Nuclear Security Administration (NNSA) and the Office of Nuclear Energy (NE) working with the Nuclear Regulatory Commission (NRC) and two universities have converted the 1-megawatt TRIGA research reactor at Texas A&M University and the 100 Kw training reactor at the University of Florida from the use of highly enriched uranium to low enriched uranium.

As a part of its nonproliferation mission, NNSA converts research reactors in the U.S. and around the world from operating on highly enriched uranium (HEU) to low enriched uranium (LEU) fuel. LEU is not suitable for use in a nuclear weapon and is not sought by terrorists or criminals. The conversion is part of the Bush administration's efforts to minimize the use of highly enriched uranium in civil applications around the world.

"Decreasing the use of highly enriched uranium in the United States and around the world is a priority for this administration. Converting these domestic reactors at the University of Florida and Texas A&M University further demonstrates our commitment to limiting the spread of nuclear material. This domestic reactor conversion will also help us significantly as we work with others to convert research reactors as part of our global effort to minimize the use of HEU in civilian nuclear applications around the world," said Secretary Samuel W. Bodman.

HEU is primarily used in research reactors to produce isotopes for medical applications, and early reactor technology used HEU fuel because it was more difficult to achieve comparable power levels using LEU. However, modern reactor designs can use newer high-density LEU fuels while maintaining comparable power levels, making conversion an attractive option for limiting the availability of HEU nuclear material.

NNSA worked closely with NE, the U.S. Nuclear Regulatory Commission, Texas A&M University, and the University of Florida to complete these reactor conversions. Officials from NNSA, NE, and NRC joined others at Texas A&M in College Station on October 13th and at the University of Florida in Gainesville on October 18th to commemorate the successful fuel conversion of the reactors.

Under the 2005 North American Security and Prosperity Partnership, the United States, Mexico, and Canada agreed to convert civil HEU reactors on the North American continent to LEU fuel by 2011, where such LEU fuel is available. These two reactors are the first of six domestic research reactors the United States will convert. Mexico will convert its one research reactor in Mexico City, and Canada will convert three research reactors.

These reactor conversions also support the 2005 Bratislava Joint Statement on Nuclear Security Cooperation issued by President Bush and Russian President Vladimir Putin. Under the statement, the United States and Russia agreed to work together to convert more than 30 U.S. and Russian-supplied research reactors around the world from the use of HEU to LEU.

The Global Threat Reduction Initiative's (GTRI) mission includes returning and securing nuclear fuel, and converting research reactors around the world. Currently, GTRI is working to convert 59 more reactors around the world from HEU to LEU by 2014.

Georgia Tech Engineering in Top Ten for Hispanics

Atlanta (October 5, 2006) — Hispanic Business magazine ranked the College of Engineering at the Georgia Institute of Technology as one of the nation's top ten engineering graduate schools for Hispanic students. Tech's engineering school held the number three spot this year.

"The College of Engineering is working harder than ever to ensure that Hispanic students can excel at Georgia Tech," said Don Giddens, dean of the College of Engineering. "With programs such as The Goizueta Foundation fellowships and scholarships, Georgia Tech maintains its long-standing commitment to the Hispanic community."

The ranking cited Tech's reputation as one of the nation's premier research universities and the rapidly growing enrollment of Hispanic students, as well as female and other minority students in preparing them to enter a multicultural workforce.

Tech is one of the largest producers of Hispanic engineers in the country, a status it achieved not only through the high quality and reputation of its engineering programs, but also through targeted recruitment and retention for Hispanic students. The linchpin to these efforts is The Goizueta Foundation, established by the late CEO and chairman of the board of directors of The Coca-Cola Company, Roberto C. Goizueta.

Since 2001, The Foundation has contributed more than $6.5 million to boost recruitment and retention of Hispanic students at the graduate and undergraduate levels through scholarships and fellowships, as well as endowing a faculty chair and a rotating chair position for junior faculty. Since Tech does not use racial or ethnic preferences to determine admissions, student recruiting is central to the Institute's efforts to increase diversity. Support from The Goizueta Foundation in 2004 allowed Tech to hire a program director, Jorge Breton, to support Hispanic recruiting and administer the scholarships. This fall, Tech has awarded 53 Goizueta Foundation-funded scholarships and fellowships to the tune of $220,578.

But, if recruitment efforts get students in the door, it's the quality of education, the faculty and student support organizations that keep them at Tech. Essential to these efforts are The Goizueta Foundation Faculty Chairs. Both Santamarina and the Junior Rotating Faculty Chair, Rigoberto Hernandez of the School of Chemistry and Biochemistry, use their funding both for long-term academic initiatives and to mentor students.

The ranking also cited student support organizations such as the Spanish Speaking Organization, La Unidad Latina, Lambda Theta Alpha Latin Sorority, the new Hispanic Scholarship Fund and the Society of Hispanic Professional Engineers (SHPE). These organizations ensure that Hispanic students have the support they need to be successful at Tech and in their careers.

"I am honored to be part of an institution that is valued not only for its academic excellence but for being a great place for Hispanics," said Lucas Posada, president of Georgia Tech SHPE. "I think that every single student that comes to Georgia Tech has tremendous potential," said Santamarina. "It's my goal to help them realize that potential."

Hands On Learning

The Nuclear Technology program offered by the Linn State Technical College at the Advanced Training Center is the only one of its kind in Missouri and one of only a handful in the nation. It was developed cooperatively with the Missouri University Nuclear Research Reactor, the University of Missouri Nuclear Science and Engineering Institute and AmerenUE Callaway Nuclear Power Plant, all leaders in the nuclear industry.

The core curriculum is designed to follow training guidelines established by accrediting organizations for training and qualification of radiological protection technicians and the curriculum also includes courses that prepare the graduate for work in nuclear plant operations. An eight-week internship at an approved company is included as a part of the curriculum in the second year.

Technicians with the educational background this program provides are in high demand. The present demand for radiation protection professionals is 130 percent of those with the required training. The demand is expected to increase 160 percent over the next five years.

Jack Carpenter To Give The 2006 Distinguished Technical Lecture

On December 7, Dr. Jack Carpenter, technical director at Argonne National Laboratory's Intense Pulsed Neutron Source, was the 2006 Nuclear Engineering Technical Lecturer at North Carolina State University. Carpenter is known for his groundbreaking work in the development of neutron sources and instrumentation; receiving the 2006 Clifford G. Shull Prize from the Neutron Scattering Society of America.

The Clifford G. Shull Prize in Neutron Science is named in honor of Clifford G. Schull, who shared the Nobel Prize in physics in 1994 with Bertram Brockhouse for pioneering developments in neutron science.

Through the generous contributions of NC State's Department of Nuclear Engineering, and the College of Engineering Foundation supporters, North Carolina State's Nuclear Engineering Distinguished Technical Lecture Series was launched in 2002. Special thanks must be given to the Washington Group for their contributions to the 2006 lecture.

Department of Energy's Harnessed Atom Initiative Receives Support From General Electric – Global Nuclear Fuel

***The Harnessed Atom* is a science educational curriculum extension covering energy and nuclear physics. The U.S Department of Energy originally offered the program in 1986. Today, it is being revised as an honors program for high school physics and chemistry students, and is being re-introduced as a multi-region field test.** Following the field test, results will be reported and final recommended revisions identified prior to a national rollout. North Carolina State's Nuclear Engineering Department, with the generous financial contributions of General Electric – Global Nuclear Fuel, will be one of the field test regions.

Young Investigators operating atmospheric plasma device

Jack Carpenter, upcoming 2006 Distinguished Technical Lecturer

The curriculum provides a focused study of energy science in a ten-day educational module that provides factual information and discussions of topics important to today's social and political realities. It allows students to explore nuclear science and engineering topics in an interesting and educationally valid way.

Provost and New College of Engineering Dean Take Note of Nuclear Engineering

NC State's Provost Larry Nielsen and the new Dean of Engineering Louis Martin-Vega visited the department in September. Discussions centered around the success of NC State's nuclear engineering academic program, the PULSTAR reactor, and various research initiatives. Drs. Nielsen and Martin-Vega expressed their support for current and future projects. They were particularly interested in such initiatives

Dr. Hawari discusses PULSTAR reactor research initiatives; Dean Martin-Vega and Provost Nielsen second and third from right

as the **Multi-University Southeast INIE Consortium (IME)** and Idaho National Laboratory's Nuclear University Consortium (NUC). North Carolina State University is one of five leading research universities making up NUC.

The new dean of engineering, Dr. Martin-Vega, joins us from the University of South Florida. He has served as the acting head of the Engineering Directorate at the National Science Foundation (NSF), and as the director of NSF's Division of Design, Manufacture and Industrial Innovation.

Dr. Robin P. Gardner Appointed to The National Academy of Science Committee on Radiation Source Use and Replacement

Dr. Robin P. Gardner, professor of nuclear and chemical engineering at North Carolina State University, has been appointed to the National Academy of Science Committee on Radiation Source Use and Replacement. The 15-month appointment runs through October 31, 2007.

Dr. Robin Gardner

The principal task of this twelve-person committee is "to review the current industrial, research, and commercial (including medical) use of radiation sources to identify uses for which:

1. The radiation source can be replaced with an equivalent (or improved) process that does not require the use of radioisotopes; or
2. The radiation source can be replaced with another radiation source that poses a lower risk to public health and safety if it is involved in an accident or used in a terrorist attack."

Dr. Gardner is also the Director of the Center for Engineering Applications of Radioisotopes and an Alumni Distinguished Graduate Professor at North Carolina State University.

Senior university administrators visit the nuclear engineering department

Success With Science Teachers And High School Students

NC State's *Science Teachers' Workshop in Nuclear Technology* was held at the end of June. Local teachers were provided with instruction and curriculum material to enhance in-class lessons on radiation detection, biological effects of radiation, along with industrial radiation and radioisotope measurement applications. Labs included instruction on neutron activation analysis and the exponential law of radiation detection.

Dr. Mohamed Bourham meets with teachers for program evaluation

On the second day, Progress Energy's Shearon Harris Nuclear Power Plant, provided additional lectures and tours of environmental facilities.

For three weeks in July, the *Young Investigators' Summer Program in Nuclear Technology and Its Applications* hosted high school rising juniors, rising seniors and graduating seniors. They were taken through a series of lectures, seminars, labs, and small group projects. They also participated in industrial field trips. Sites visited included AREVA Training Center, PET Net Pharmaceuticals, and the Radiology Division of NC State's College of Veterinary Medicine.

Idaho National Laboratory -- Summer Interns -- Vital to Nation's R&D

Audrey Roman's pipette-tipped syringe slowly fills with solution as she removes the top phase of her liquid separation. For the second consecutive summer, she's working with top-notch radiochemists and believes her summer job is second to none. Audrey Roman is an intern at Idaho National Laboratory.

Two years ago, this Caldwell native never imagined herself competing with older students for such a contested opportunity, to work at the nation's lead nuclear energy lab. Simply sending her resume was one of the best choices she ever made.

"I came out here and it's been a great experience. I learned a lot more than I would have anywhere else. I talked with one of my classmates and she didn't even know about the things I'm working on," said Roman, a soon-to-be junior at the University of Idaho in Moscow, Idaho.

University of Idaho junior Audrey Roman performs a chemical test during her second summer internship at the Idaho National Laboratory

She and her mentor, INL radiochemist Cathy Riddle, are working on the development of Fission Product Extraction (FPEX). The FPEX process allows scientists to simultaneously separate two very important long-lived fission products from spent nuclear fuel. Riddle began research on the FPEX process in 2003 for her master's thesis. In 2004, FPEX was nominated for R&D Magazine's R&D 100 awards as one of the nation's top research developments.

Putting down the test tubes and taking off the safety glasses reveal Riddle and Roman as more than professional researchers, but as friends. Armed with friendly connections in the professional work force has given Audrey more focus, much the same way it helped Riddle as a student.

"I started here at the lab in much the same way as Audrey is now. I have come full circle in that I was the intern seven years ago and now I am the mentor," said Riddle. "I have seen great changes in Audrey this year compared to last. She has another year of university under her belt and her competency as a researcher, as well as her confidence, have improved considerably."

Jeff Larson writes notes with his mentor, Curtis Clark

A summer haven for college students, INL's internship program, which is **heavily supported by the Department of Energy's Office of Nuclear Energy**, invited more than 240 interns this summer, representing 72 U.S. colleges and 14 local high schools. Every year, students come from all over the country seeking hands-on experience, the lifeblood of the college degree and the stepping stone to putting textbook knowledge into action.

"At my university, I've been studying heat transfer and this gives me the opportunity to see both sides, much more of the computational and program side of it. It was the best opportunity for me to see the other side of what I'm interested in. It's always better to see both sides of the coin," said Justin Talley, a junior nuclear engineering student at University of Missouri-Rolla.

Another intern-influenced program at the lab is the Reduced Enrichment Research and Test Reactors (RERTR) Program. Jeff Larson, also an INL veteran intern, bonds aluminum cladding and different metals with

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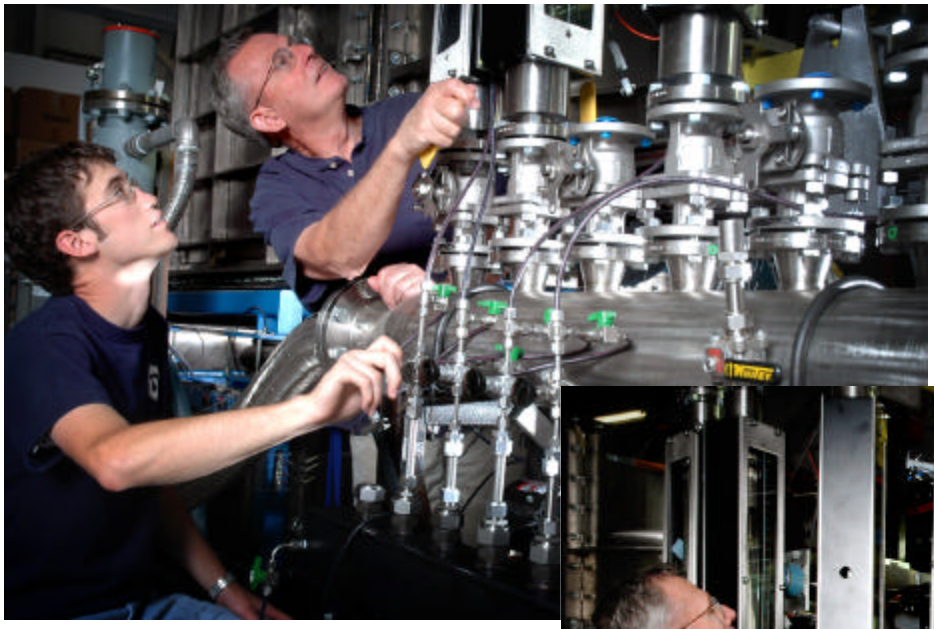
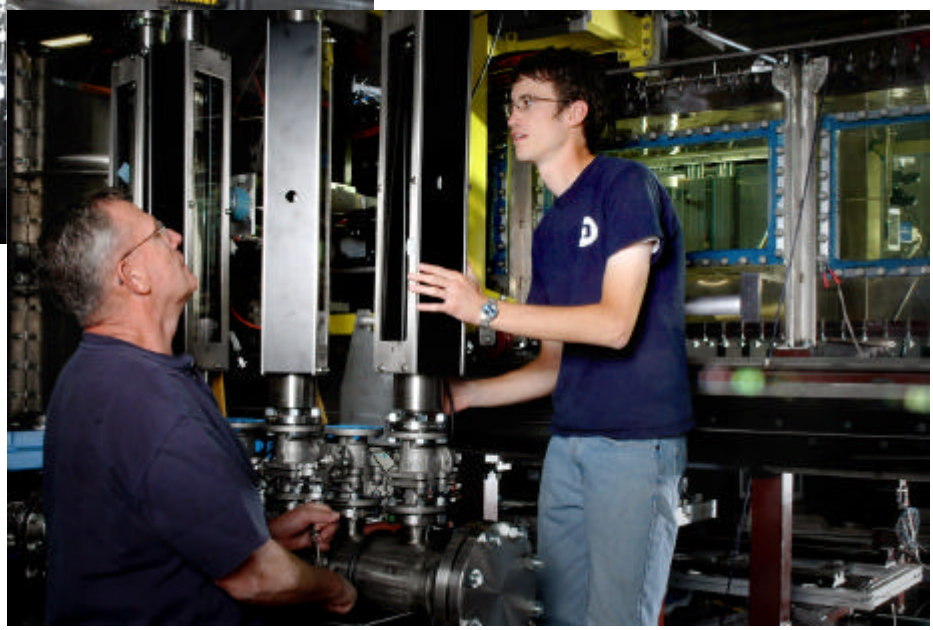
(Summer Interns)

his mentor, materials engineer Curtis Clark. They're developing new fuels that allow more research reactors to operate with low-enriched uranium fuel, further reducing proliferation risks.

"I've enjoyed this internship, it's so versatile. As a student, you're looking for *real* hands-on experience. I've been able to actually build a few things and design some things here at INL," said Larson, a recent graduate of Brigham Young University.





Dan Christensen with Hugh McIlroy

With a heavy focus on nuclear fuels, INL provides a wide range of learning as well as the instrumental hands-on experience necessary for edging out competitors in the job market. Mentors motivate, teach and guide students. Delegating responsibilities and projects to students gives students a sense of ownership and responsibility for their work.

Dan Christensen, from Utah State University, is working on the organization, display and analysis of data collected from a model of the lower plenum for the Very High Temperature Reactor (VHTR), a next-generation reactor aimed at broadening the uses of nuclear power. The lower plenum, an area under the reactor core, channels hot coolant gas from the reactor cooling conduits to the outlet and then to other systems to produce electricity and hydrogen. His mentor, retired Marine Lt. Col. Hugh McIlroy, Ph.D., delegated the organization and display of the data set to Dan to enable a detailed analysis of the complicated flow.

"We've studied these things in class and then to actually use that knowledge has been a real eye-opener. It's not so vague anymore. It's even got me interested in research now," said Christensen.

Having ownership of projects and experiments gives students a sense of self and empowers them to see their own potential.

"It has always been the excitement about the science that has encouraged me to continue on to advanced degrees. Learning is a journey. You never know what will be around the next corner unless you keep going!" said Riddle.

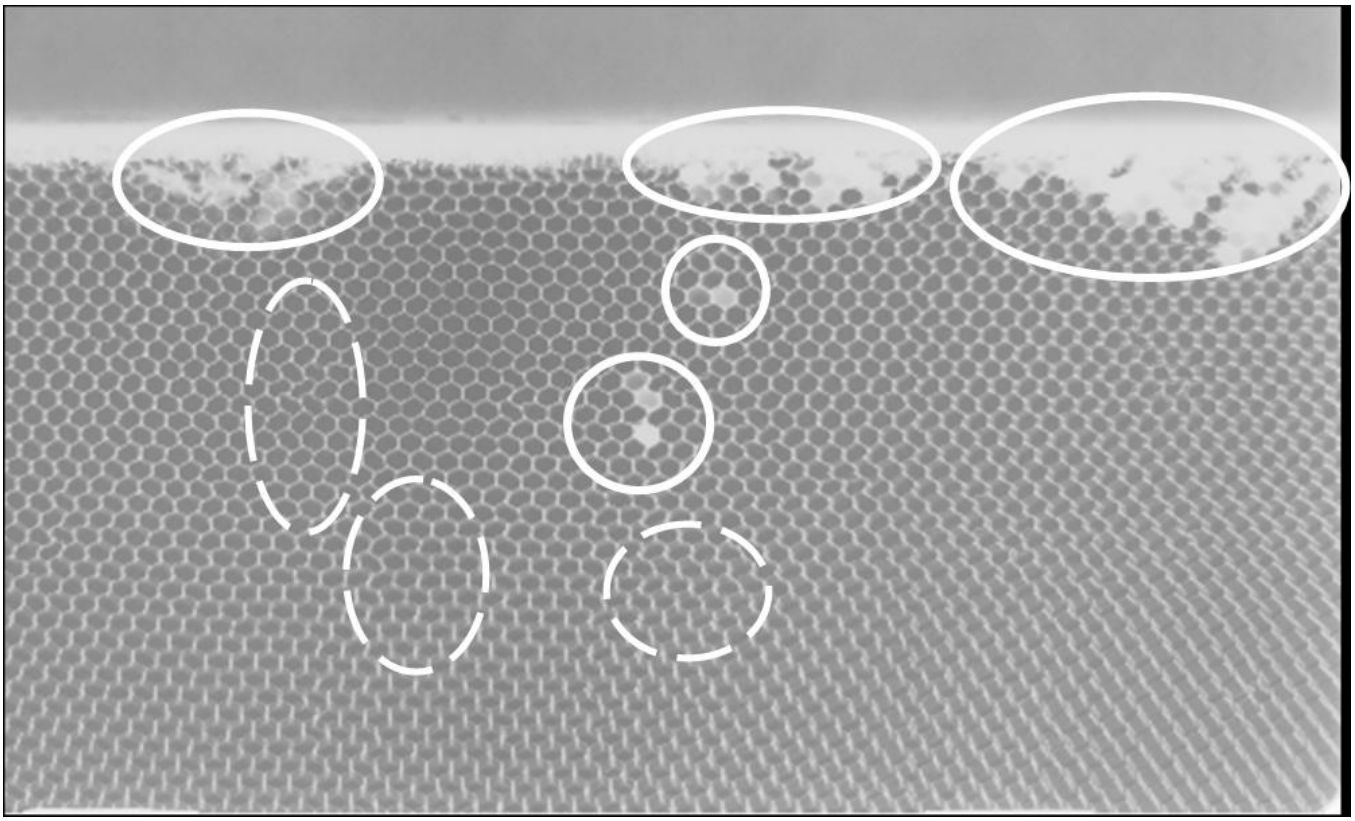
Most interns only see a small piece of a research puzzle during their summer here, but the impact they have on the entire research is often just as important as what they learn from it.

The University of California, Davis

Concerns about the production of graduates in nuclear science and engineering as well as the status of research reactors on campuses led DOE to develop the Innovations in Nuclear Infrastructure and Education (INIE) program. Similarly, the current climate in the aircraft industry is characterized by increasing maintenance costs and older aircraft, which together threaten safety. To guard against failure, the industry requires robust diagnosis, maintenance, repair, and long-term resolution of technically complex issues arising from aging. On the other hand, while academia is engaged in research which directly affects the aviation industry, it is not producing enough engineers with the skills and knowledge required by industry to address and mitigate structural aging, especially in the area of nondestructive evaluation (NDE).

The University of California, Davis (UCD) participates in INIE through the Western Nuclear Science Alliance (WNSA). UCD is now developing a consortium to drive innovations that address technologies related to structural aging through three workgroups: scientific researchers (from UC Davis and the Center for Nondestructive Characterization at the Lawrence Livermore National Laboratory [LLNL]), education/outreach personnel (those involved in the proposed research, as well as local community colleges), and end-users (aerospace companies, regulatory agencies, research laboratories, local and state government agencies, and organizations supporting entrepreneurship, innovation, and economic development). The Consortium will assist in focusing the research questions, integrating the research results, and encouraging changes in the research and education process as required to meet the needs of the end-users. A central component of this effort is the research capabilities of the UC Davis McClellan Nuclear Radiation Center, defined by the LLNL researchers as a "world-class neutron-based inspection facility."

An example of the inspection capability is shown in the accompanying neutron radiograph. Anyone interested in learning more about this effort can contact Dr. Robert Flocchini, Director of the MNRC at 916-614-6200 or rjflocchini@ucdavis.edu.



Neutron radiograph of a rotor blade. Solid ellipses and dashed ellipses indicate respectively water and some crushed (i.e. damaged) honeycomb cells. The distance between the two flat sides of a honeycomb cell is 3/16 in (4.76 mm). Courtesy of Dr. R. Flocchini, Director of UC Davis MNRC.

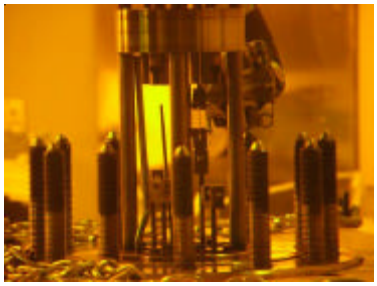
Neutron Irradiated Materials Testing Capability at the University of Michigan

The University of Michigan has recently developed a one-of-a-kind capability for studying the effect of neutron irradiation on materials. Through Department of Energy funding, Research Scientist Sébastien Teysseyre and Professor Gary S. Was of the Nuclear Engineering and Radiological Sciences Department designed and completed a facility for studying stress corrosion cracking of neutron-irradiated materials in high-temperature (600°C), high-pressure (30 MPa) supercritical water to support the Supercritical Water Reactor, SCWR, concept.

Gary Was (left) and Sébastien Teysseyre (right) next to the load frame during a stress corrosion cracking experiment on samples irradiated in the fast flux test facility

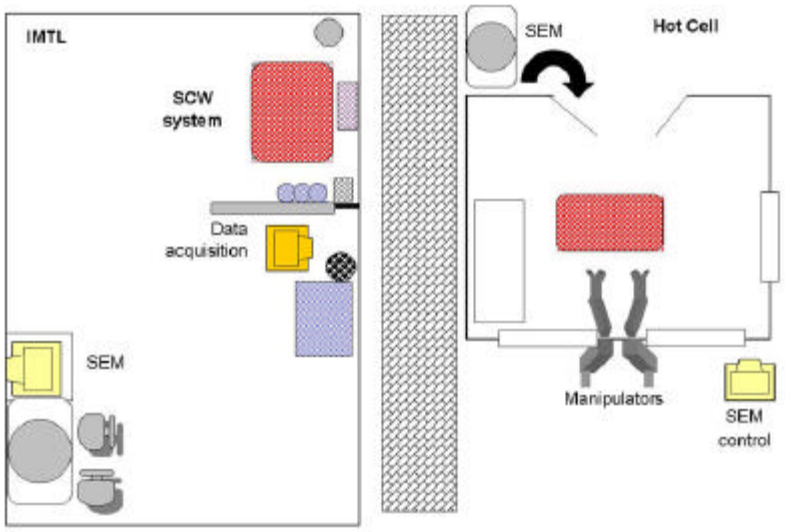
The feasibility of many GenIV concepts, such as the SCWR, rests on the development of materials that can withstand the aggressive environments inherent to those designs. Experience with light water reactors has shown that irradiation assisted stress corrosion cracking is a life-limiting failure mode that must be addressed to ensure the integrity of the core. While surrogates for neutron-irradiation (proton, heavy ion irradiation, etc.) have contributed greatly to our understanding of irradiation effects, irradiation with neutrons is required to confirm the role of in-core irradiation on crack initiation and crack growth in candidate alloys. However, the lack of such facilities has prevented the study of stress corrosion cracking of irradiated materials under supercritical water conditions.

The Irradiated Material Testing Laboratory (IMTL) was designed to provide Constant Extension Rate Tensile (CERT) or Crack Growth Rate (CGR) testing of neutron-irradiated specimens in supercritical water, and for post-test analysis of the fracture behavior by scanning electron microscopy (SEM). The heart of the laboratory is a mobile load frame that contains the autoclave and the loading system. The load frame is rolled into the hot cell adjacent to the laboratory for specimen loading, autoclave closure, shield installation and pressure testing in preparation for the experiment. The autoclave is then rolled back into IMTL, where either CERT experiments or CGR experiments are conducted. Once the experiment is completed, the autoclave is rolled back in the hotcell for unloading of the specimens, and an SEM column is rolled into the hotcell for analysis of the fracture behavior of the samples. The testing and analysis capabilities provide a novel capability for assessment of neutron irradiation effects in highly aggressive, aqueous environments.



Loading of tensile samples into the internal load frame using manipulators in the hot cell.

To date, both CERT tests and CGR tests have been conducted up to 500°C. The first results indicate that indeed, neutron irradiation of austenitic stainless steels causes severe intergranular failure in supercritical water.



Schematic of the Irradiated Material Testing Laboratory and hot cell #1 at the University of Michigan

Summer 2006 Missouri University Undergraduate Research Scholars in Nuclear Science and Engineering Fields

During the summer of 2006, the MU campus and the University of Missouri Research Reactor Center hosted seven undergraduate students who participated in nuclear science and engineering research studies. Financial support came from various sources. The U.S. Department of Energy Innovations in Nuclear Infrastructure and Education grant to the Midwest Nuclear Science and Engineering Consortium provided direct scholarship support for four of the students, along with analytical support and services for all the students.

The students brought additional energy and enthusiasm to MURR for the eight intensive week session, from June 12 to August 4, 2006. They attended lectures, conducted research, wrote abstracts, and prepared posters and presentations, while also finding time for some summer fun. The summer program was coordinated by MURR along with other summer research groups managed by the MU Office of Undergraduate Studies and the MU Graduate School.

The MURR students and the programs that financially supported them are:

U.S. Department of Energy Innovations in Nuclear Infrastructure and Education (DOE INIE)

- Alejandro D. Barilari-Serres, a sophomore in Mechanical Engineering at the Polytechnic University of Puerto Rico, worked on "Prompt Gamma Neutron Activation Analysis of Alternative Sensor Materials for Planetary Exploration," under mentors William Miller, John Miles, David Robertson and Joe Kyger (Alejandro's research scholarship was co-sponsored by the National Aeronautics and Space Administration (NASA) Missouri Space Grant Consortium).
- Magen Coleman, a senior in Chemistry at the University of Mary Washington, studied "Provenancing Obsidian Samples from Peru Using XRF Analysis," under mentors Mike Glascock, David Robertson and Joe Kyger.
- Ian C. Faust, a sophomore in Nuclear Engineering at the University of Michigan, investigated "Flux Growth of Singular $Li_xM_2O_4$ for use in testing the Quantum Critical Point (QCP)," under mentors Keary Schoen, Wouter Montfrooij and Joe Kyger.
- Ivan J. Rivera-Hernandez, a junior in Electrical Engineering at the Polytechnic University of Puerto Rico did an "Engineering Review and Calibration of Devices to Measure Coolant Flow Through Irradiation Positions at MURR," under mentors William Miller, Michael Flagg, Matt Sanford, and Joe Kyger.

National Science Foundation / National Institute of Health's Research Experience for Undergraduates (NSF REU) in Radiochemistry

- Eric P. Brueckner, a junior majoring in Chemistry and minoring in Physics at Westminster College, did a "Computational Evaluation of LEU Conversion for Production of Tc-99m" under mentors William Miller, Dave Robertson, Jason Rothenberger and Joe Kyger; hosted by MURR.

Stevens' Fellows Program in Chemistry, a Life Sciences Undergraduate Research Opportunity Program

- Nicole C. Bodkin, a sophomore at MU in Biology, "The Impact of Methyl Mercury on the Distribution of Selenium in Various Tissues," with Kimberly Griswold, under mentors David Robertson and Joe Kyger; hosted by MURR.

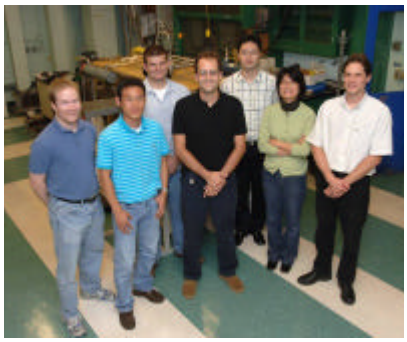
Louis Stokes Missouri Alliance for Minority Participation (LS-MoAMP) Summer Research in Science, Technology, Engineering and Mathematics (STEM), MU Graduate School

- Kimberly Griswold, a junior in Chemistry at Alabama A&M, did research on "The Impact of Methyl Mercury on the Distribution of Selenium in Various Tissues," with Nicole Bodkin, under mentors David Robertson and Joe Kyger.

Back Row: Alejandro Barilari-Serres, Ivan Rivera-Hernandez, Eric Brueckner, Ian Faust. Front Row: Magen Coleman, Nicole Bodkin, Kimberly Griswold

M.I.T. Nuclear Science and Engineering -- Nanofluid Applications in LWRs

Can the nuclear industry take advantage of the latest advances in nanotechnology? Jacopo Buongiorno, assistant professor of nuclear science and engineering at MIT, and Lin-wen Hu, associate director of the MIT nuclear reactor laboratory, believe it can. Their group is studying heat transfer in 'nanofluids', to boost power density and safety margins in LWRs. Nanofluids are engineered colloidal suspensions of nanoparticles in a base fluid, typically water. "We get dramatic enhancements of the Critical Heat Flux (CHF), up to 100%, with the nanoparticles at concentrations of 10^{-5}", notes Buongiorno. "It's almost magical." Since CHF is the chief thermal limit for LWRs, their thermal performance could be greatly improved by the use of nanofluids. The nanoparticles currently used in the MIT studies are mostly oxides such as alumina, silica and zirconia, but other types of nanoparticles are also being tested. Buongiorno and Hu believe the CHF enhancement is correlated to the boiling-induced precipitation of a thin layer of nanoparticles on the heated surface. Experiments conducted in their lab showed that such a layer dramatically improves the wettability of the surface, thus improving CHF.



The nanofluid heat transfer group at the Nuclear Science and Engineering Department of MIT. From left to right: graduate students Wesley Williams, Sung Joong Kim and Tim Lucas, Prof. Jacopo Buongiorno, post-doc associate Dr. In Cheol Bang, research scientists Dr. Lin-wen Hu and Dr. Tom McKrell.

The first nuclear-plant applications of nanofluids may not be as day-to-day coolants but as replacements for the emergency core coolant, or for reactor cavity flooding during severe accidents. The use of nanofluids as circulating coolants will have to await careful studies of whether they might be incompatible with current LWR coolant chemistry control practices. Assuming those studies pan out, though, the potential is great. There are more than 400 nuclear plants worldwide and, in principle, most of them could be retrofitted to handle nanofluids.

The newly-founded Center for Nanofluids Technology at MIT (http://mit.edu/nse/nanofluids) has a sophisticatedly instrumented pool boiling facility to study the CHF enhancement mechanism, and a loop to measure flow CHF. The group is also planning to run irradiation tests. "Although preliminary results from experiments conducted utilizing an irradiation facility at MIT's 5 MW research reactor have proven to be very promising, additional testing to determine how these highly specialized nanofluid particles will react under the harsh radiation environment of a power plant will have to be conducted," says Hu.

Besides Buongiorno and Hu, the nanofluid group includes five graduate students, four undergrads, a post-doc and a research scientist. The work is sponsored by the **DOE Innovations in Nuclear Infrastructure and Education Program**, AREVA, the Idaho National Laboratory and the Nuclear Regulatory Commission. Various US and international universities collaborate including the University of Florida, the Rensellaer Polytechnic Institute, the Polytechnic of Milan and the University of Leeds.

MIT students participate in the 2006 Summer Fellowship Program at the Center for Space Nuclear Research.

MIT Students Matthew Everson (NSE) and Joe Yurko (AA) made presentations at Idaho National Laboratory's Center for Nuclear Space Research detailing what they accomplished over the summer on their UROP projects. INL sponsors a summer space fellows program to which the MIT students were invited by Dr. Steven Howe, INL's Director of Space Research. The MIT student presentations were based on UROP projects sponsored by Prof. Kadak who accompanied them to INL. The INL Fellows worked on developing new fuels for space reactors, power transmission systems, and comparing nuclear thermal rockets (NTRs) to current chemical rocket technology. The MIT projects were in the same general area.

Joe's background is in chemical rockets. He has built solid rocket motors using similar fuels to the solid rocket boosters on the shuttle. He has always been a supporter of using solid rocket technology. However, the results presented by the Fellows have changed his mind that not only is nuclear propulsion the future of rocketry but that NTRs are cost effective for use today.

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(Nanofluid)

The most striking result was that by using an NTR powered transfer stage, nearly 33% more mass could be delivered to the Moon, using the current NASA plan for the return. Space travel is all about mass, and the fact that an NTR can improve performance that much is beyond impressive. The Fellows gave a real argument that NASA should be using nuclear power to take us back to the Moon, and this time to stay.

Matthew learned a lot about Nuclear Thermal Propulsion. The presentation given by the CSNR Fellows helped him understand the basics and the major advantages of this propulsion system and advanced space nuclear reactor fuels. He was impressed by how thorough and in-depth the Fellows' research had been conducted. The overall goal of the presentations were to provide for a present day effective mode of transportation to the moon of future lunar base components and astronauts and a source of electrical power for successful missions. The CSNR Fellows reinforced the need for a reliable and low maintenance nuclear power reactor to provide such a lunar base with electrical power.

Matthew's presentation introduced the idea of using direct energy conversion (DEC) systems, in which heat is converted directly into electricity with little or no moving parts, in a lunar surface reactor. After researching various forms of DEC systems, he found that thermionic power generation, using heat to "boil" electrons off a metal surface and collect them on opposing metal surface, is the best DEC system at present to be used on the lunar surface. The low mass radiator and power to mass ratio of a thermionic power system makes it superior to any other present day DEC system he researched and makes it feasible for use in a space nuclear reactor.

Joe Yurko, Matthew Everson and Prof. Andrew Kadak at Idaho National Laboratory

Important Dates to Remember

2007

- CONTE, Jacksonville, Florida
  February 4-7, 2007
- ICONE-15, Nagoya, Japan
  April 22-26, 2007

For Additional Information Please Contact

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