ANNUAL REPORT

September 1, 2005 – August 31, 2006

NUCLEAR ENGINEERING AND RADIOLOGICAL SCIENCES

University of Michigan

MichiganEngineering

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Contents

Summary of Activities

This is the eleventh Annual Report of the Department of Nuclear Engineering and Radiological Sciences (NERS) at the University of Michigan. The report was assembled for the purpose of providing a record of teaching, research and service activities of the faculty, staff and students of the department.

The department taught a total of 29 (including two special topics) courses during AY 2005-2006. Independent study and projects courses (NERS 499, 599 and 799) had enrollments totaling 62. In addition to the NERS courses, NERS faculty taught two sections of the first-year course ENG 101, *Introduction to Computers and Programming*, averaging 220 students per section. The enrollments for NERS 211, *Introduction to Nuclear Engineering and Radiological Sciences*, offered as an elective for engineering students outside the department, had 200 total students last year for the Fall and Winter sections.

The Fall 2005 term enrollments totaled 74 (NERS) and 16 (Eng Physics) undergraduate students and 78 graduate students. During AY 2005-2006, the department awarded 38 BSE-NERS and 8 BSE-Eng Physics degrees, 21 MS/MSE and 7 PhD degrees.

The undergraduate and graduate students were again successful in winning numerous awards this past year. Seventeen undergraduates were recipients of the National Academy for Nuclear Training (NANT) scholarships, seven received American Nuclear Society (ANS) awards, and twenty-four were recipients of U.S. Department of Energy (DoE) scholarships. Graduate students won seven fellowships from DoE, five from the Department of Homeland Security (DHS), one from NANT, thirteen fellowships from other federal agencies and professional societies, and six scholarships from ANS. In addition, nine graduate students won college or department fellowships. This outstanding record of student accomplishments in attracting fellowships and scholarships will continue: 100 awards have already been made to undergraduate and graduate students for academic year 2006-2007.

Our faculty are also being recognized for their achievements: Rod Ewing was elected Fellow of the American Association for the Advancement of Science and was awarded the Dana Medal from the Mineralogical Society of America; Lumin Wang received the CoE Department Faculty Award for Outstanding Achievement; John Lee received the NERS Award for Outstanding Teacher; Ron Gilgenbach was elected IEEE Fellow and received the IEEE Outstanding Professional Award; and Mark Hammig received the Rackham School of Graduate Studies Distinguished Dissertation Award.

The faculty supervised a total of 55 research projects with expenditures of almost $6.2M. The NERS research projects included four DoE NEER grants and ten DoE NERI and

I-NERI grants. The NERS faculty published 72 articles in archival journals in calendar year 2005.

The ANS student chapter was awarded the Elaine Harden Award as the best student professional society in the College of Engineering for their leadership and service. This award follows on the heels of the 2005 Samuel Glasstone Award from the American Nuclear Society, presented to the student ANS chaper for "accomplishing the most notable achievements in public service and the advancements of nuclear engineering." The department salutes the student ANS chapter for their outstanding achievement in winning prestigious awards two years in a row for their dedication and service as a professional society.

The department received a six-year accreditation from the Accreditation Board for Engineering and Technology (ABET) and will be accredited through 2011.

Faculty Awards and Honors

Rodney C. Ewing

- American Association for the Advancement of Science
  Fellow
- Mineralogical Society of America
  Dana Medal

Ronald M. Gilgenbach

- Institute of Electrical and Electronics Engineers
  IEEE Fellow
  Outstanding Professional Award

Mark Hammig

- Horace H. Rackham School of Graduate Studies and UMI Dissertation Publishing/ProQuest Information and Learning
  Distinguished Dissertation Award (2005)

John C. Lee

- Nuclear Engineering and Radiological Sciences
  Award for Outstanding Teacher (Selected by NERS students)

Lumin Wang

- U-M College of Engineering
  Department Faculty Award for Outstanding Achievement

Student Organizations

ALPHA NU SIGMA SOCIETY

The objective of the Alpha Nu Sigma Society is "to recognize high scholarship, integrity, and potential achievement in applied nuclear science and nuclear engineering among outstanding students by means of membership in the Society."

Additionally, the Michigan Alpha Chapter provides tutoring for students both in and outside the department taking NERS courses. This tutoring is offered for students five days a week in one-on-one tutoring sessions. Since 1993, the Chapter has recognized a faculty member for contributions to undergraduate and graduate education. Professor John C. Lee was selected by the students as the 2005-06 recipient of the NERS Award for Outstanding Teacher.

Alpha Nu Sigma established a tutoring schedule to help students with classes. Any student within the department or taking a departmental course is eligible to use the tutoring services. At least one tutor is available five days a week to help answer questions. This service has the ability to evolve according to students' needs.

Alpha Nu Sigma's laptop borrowing program continues to be popular. Last year, the laptops were checked out by numerous students for use on NERS projects and presentations. These laptops are available on a first-come, first-serve basis for undergraduate and graduate students alike.

AMERICAN NUCLEAR SOCIETY

Last year it was the ANS Samuel Glasstone Award. This year the University of Michigan Student Chapter of the American Nuclear Society (U-M ANS) has been awarded the 2006 Elaine Harden Award. This award is given to the University of Michigan student society that best exemplifies the ideal of Epeians, an Engineering society that recognizes dedicated leaders, develops and motivates leadership, and encourages service.

Driven by the growing enrollments in NERS, the U-M ANS has increased its membership and its activities over the last few years. The chapter works very hard to maintain the goals of the national society and to represent the NERS Department. In addition to maintaining excellent academic records, the members of U-M ANS participate in service, outreach, social, and professional development activities.

This year the officers of U-M ANS set a series of goals with the overall aim of establishing continuity for the future. Some of the goals over the past couple of years have included: holding regular monthly interactive meetings, assisting with recruitment and retention of students in NERS, educating elementary, middle, and high school students about nuclear technologies, continuing involvement with the Michigan section of the ANS, increasing U-M ANS involvement with the National ANS, and encouraging flexibility and creativity in U-M ANS leadership opportunities.

Being involved in service, outreach, professional development and social activities is important to the members of U-M ANS. Some of these activities included:

SALINE MIDDLE SCHOOL CLASSROOM VISITS

A U-M ANS graduate student visited Saline Middle School to teach four science classes about basic quantum theory, radioactive decay, nuclear power plants, nuclear weapons, and medical applications of nuclear sciences.

SOUTHEAST MICHIGAN SCIENCE FAIR JUDGING

U-M ANS members served as volunteer judges for the annual Southeast Michigan Science Fair, part of the Intel International Science and Engineering Fair. There were over 200 junior division (seventh and eighth grade) and 45 senior division (high school) projects.

DETROIT AREA PRE-COLLEGE ENGINEERING PROGRAM (DAPCEP)

U-M ANS members served as instructors and teachers' assistants for DAPCEP. Over a dozen seventh and eighth graders gave up their Saturdays to attend the "Glow Blue" sessions hosted by our U-M ANS student members. The DAPCEP students learned about isotopes and radiation, detectors, fission and power plants, plasmas and fusion, nuclear waste, and safety of spent fuel casks. Students also toured laboratories in the NERS Department and visited the Ann Arbor Hands-On Museum. In addition, they constructed and tested egg drop devices, which represented the drop tests performed on spent fuel transportation casks.

CLEARING THE FOG

The Engineering Advising Center of the College of Engineering introduced this program in 2006 as a way to help undeclared first-year engineering students. A U-M ANS member spoke with students who were interested in nuclear engineering and radiological sciences, as well as many who were unsure what this field of study was about.

MICHIGAN SECTION ANS STUDENT PRESENTATIONS

Michigan Section ANS holds an annual meeting at which U-M ANS members give presentations on their undergraduate or graduate research or class projects. This meeting is an opportunity for students to showcase their work to industry representatives.

WELCOME DAYS

The College of Engineering sponsors two welcome days for new students. U-M ANS prepared exhibit tables to distribute information about ANS and the NERS Department. These events are a great opportunity to meet the incoming students and tell them about the nuclear engineering field.

TECH DAY

Tech Day is one of the College of Engineering's largest annual recruitment programs. Over 1000 high school students and their parents visit campus, tour the various engineering departments, and meet representatives from student societies during this one-day event. U-M

ANS prepared an exhibit booth to share information about the department, organization, and nuclear engineering in general.

The U-M ANS also brings members together for fun events. Some of the fun events that are sponsored by the student society include: spring and fall picnics, pizza parties, holiday lunch, ice cream social, ice skating, bowling, reflecting pool races, and intramural sports.

HEALTH PHYSICS SOCIETY

The University of Michigan Student Branch of the Health Physics Society was among the charter groups of student branches formed in 1992. The Health Physics Society is dedicated to the development, dissemination, and application of both the scientific knowledge of and the practical means for radiation protection, with an emphasis on protection of people and the environment from unnecessary exposure to radiation. The student branch has been involved in a number of professional activities, parties, seminars, and public relations activities, including tours, teacher training workshops and visits to high schools for the dissemination of basic information about radiation and radiation health effects.

Curriculum

The NERS program goals and objectives were modified this year, based on input from students, faculty and the NERS advisory board. The changes represent no significant change in our mission, but bring the goals and objectives in closer alignment to the requirements of the Accreditation Board for Engineering and Technology (ABET).

Goals

The program provides students with:

- skills and tools necessary for industrial, medical, governmental and environmental applications of nuclear processes and radiation; and
- insights and skills that will prepare them to be leaders in research and the practice of nuclear engineering and radiological sciences.

Objectives

Upon graduation, our students are:

- prepared for entry-level professional practice in industry, government or health care practice, where they will be performing analysis and measurements related to radiation and radiation interactions with matter, including nuclear power system and health physics design and analysis;
- prepared to pursue graduate studies and earn M.S. or Ph.D. degrees in nuclear engineering and related fields;
- prepared for successful careers and eventual leadership roles because of their strong background in fundamental engineering analysis, teamwork and communications skills, and ability to engage in life-long learning and the continual improvement of their skills and knowledge.

Course Changes

- NERS 471, *Introduction to Plasmas*, was changed from 4 to 3 credit hours.
- The titles of NERS 250, 490, 499 and 590 were changed to include "Radiological Sciences."
- The prerequisites for NERS 250, *Fundamentals of Nuclear Engineering and Radiological Sciences*, were changed to include differential equations and physics through electro-magnetic phenomena.
- In addition, the prerequisites for NERS 315, *Nuclear Instrumentation Laboratory*, were changed to include electronic circuits.
- Several inactive courses were dropped.

New Courses

NERS 585 *Transportation of Radioactive Materials*
Prerequisite: Junior status in engineering. Senior or graduate status in any field
Analysis of risks and consequences of routine transportation of radioactive materials and of transportation accidents involving these materials; history and review of regulations governing radioactive materials, overview of packaging design and vulnerabilities, and current issues and concerns involving radioactive materials transportations. Essays and quantitative analysis both included.

NERS 586 *Applied Radiological Measurements*
Prerequisite: NERS 484, NERS 515 or equivalent
Instrumentation and applied measurements of interest for radiation safety, environmental sciences, and medical physics. Dosimeters, radon gas, *in situ* gamma ray spectroscopy, skin dose, bioassay, internal dose evaluation, alpha detection, applied instrumentation, and other selected medical physics and health measurements. Includes analytical modeling and computer simulation for comparison with several physical experiments. Lectures and laboratory.

COURSES OFFERED*

COURSE NO.	COURSE TITLE	TERM	CREDIT HRS
NERS 211	Intro to Nuclear Engineering & Radiological Sciences	I, II	4
NERS 250	Fundamentals of Nuclear Engineering & Radiological Sciences	II	4
NERS 311	Elements of Nuclear Engineering & Radiological Sci I	I	4
NERS 312	Elements of Nuclear Engineering & Radiological Sci II	II	4
NERS 315	Nuclear Instrumentation Laboratory	II	4
NERS 421	Nuclear Engineering Materials	I	3
NERS 425	Applications of Radiation	II	4
NERS 441	Nuclear Reactor Theory I	I	4
NERS 442	Nuclear Power Reactors	II	4
NERS 462	Reactor Safety Analysis	I	3
NERS 471	Introduction to Plasmas	I	4
NERS 472	Fusion Reactor Technology	II	2
NERS 481/BioE 481	Engineering Principles of Radiation Imaging	II	2
NERS 484/BioE 484	Radiological Health Engineering Fundamentals	I	4
NERS 490	Special Topics in Nuclear Engineering & Radiological Sciences	All	TBA
NERS 499	Research in Nuclear Engineering & Radiological Sciences	All	1-3
NERS 511	Quantum Mechanics in Neutron-Nuclear Reactions	II	3
NERS 512	Interaction of Radiation and Matter	II	3
NERS 515	Nuclear Measurements Laboratory	I	4
NERS 518	Advanced Radiation Measurements and Imaging	I	2 Alt Yrs
NERS 521	Radiation Effects in Nuclear Materials	I	3
NERS 522	Nuclear Fuels	II	3 Alt Yrs
NERS 531	Nuclear Waste Management	II	3 Alt Yrs
NERS 543	Nuclear Reactor Theory II	I	3
NERS 551	Nuclear Reactor Kinetics	II	3
NERS 554	Radiation Shielding	II	4

* Roman numeral indicates term(s) the course will be offered, and number in parentheses indicates credit hours.
Fall term, I; Winter term, II; Spring/Summer terms, III A/B

COURSE NO.	COURSE TITLE	TERM	CREDIT HRS
NERS 561	Nuclear Core Design and Analysis I	II	3
NERS 562	Nuclear Core Design and Analysis II	IIIA	3
NERS 571	Intermediate Plasma Physics I	I	3
NERS 572/ AppPhy 672	Intermediate Plasma Physics II	II	3
NERS 575/EECS 519	Plasma Generation and Diagnostic Laboratory	II	4
NERS 576	Charged Particle Accelerators and Beams	I	3 Alt Yrs
NERS 577	Plasma Spectroscopy	I	3 Alt Yrs
NERS 578/EECS 517	Physical Processes in Plasmas	II	3 even Yrs
NERS 579/EHS 692	Physics of Diagnostic Radiology	II, IIIA	3
NERS 580/BioE 580	Computation Projects in Radiation Imaging	II	1
NERS 582/BioE 582	Medical Radiological Health Engineering	II	3
NERS 583/EHS 683	Applied Radiation Dose Assessment	II	4
NERS 585	Transportation of Radioactive Waste	I	2 Alt Yrs
NERS 586	Applied Radiological Measurements	II	4
NERS 587	Internal Radiation Dose Assessment	II	3
NERS 588	Radiological Health Engineering Practicum	All	1-12
NERS 590	Special Topics in Nuclear Engineering & Radiological Sciences II	All	TBA
NERS 599	Master's Project	I, II, IIIA-B	1-3
NERS 621	Nuclear Waste Forms	I	3 Alt Yrs
NERS 622/ MSE 622/Mfg 622	Ion Beam Modification and Analysis of Materials	II	3 Alt Yrs
NERS 644	Transport Theory	I	3
NERS 671	Theory of Plasma Confinement in Fusion Systems I	I	3 Alt Yrs
NERS 672	Theory of Plasma Confinement in Fusion Systems II	II	3 Alt Yrs
NERS 673	Electrons and Coherent Radiation	II	3
NERS 674/ AppPhy 674	High Intensity Laser-Plasma Interactions	I	3
NERS 799	Special Projects	All	1-6
NERS 990	Dissertation/Pre-candidate	I, II , III IIIA-B	2-8 1-4
NERS 995	Dissertation/Candidate	I, II, II, IIIA-B	8 4

COURSE ENROLLMENTS

COURSE	TITLE	Fall '05	W '06	Sp/Su '06
NERS 211	Introduction to Nuclear Engr and Radiological Sci	86	114	
NERS 250	Fundamentals of Nuclear Engr and Radiological Sci		37	
NERS 311	Elements of Nuclear Engr and Radiological Sci I	24		
NERS 312	Elements of Nuclear Engr and Radiological Sci II		23	
NERS 315	Nuclear Instrumentation Laboratory		23	
NERS 421	Nuclear Engr Materials	18		
NERS 425	Applications of Radiation		31	
NERS 441	Nuclear Reactor Theory I	27		
NERS 442	Nuclear Power Reactors		20	
NERS 462	Reactor Safety Analysis	31		
NERS 471	Introduction to Plasmas	22		
NERS 481	Engr Principles of Radiation Imaging (BioE 481)		14	
NERS 484	Radiological Health Engr Fundamentals (BioE 484)	17		
NERS 499	Research in Nuclear Engr & Radiological Sci	11	10	
NERS 515	Nuclear Measurements Laboratory	9	3	
NERS 518	Advanced Radiation Measurements and Imaging		32	
NERS 522	Nuclear Fuels		16	
NERS 543	Nuclear Reactor Theory II	10		
NERS 551	Nuclear Reactor Kinetics		18	
NERS 554	Radiation Shielding	15		
NERS 561	Nuclear Core Design and Analysis I		12	
NERS 571	Intermediate Plasma Physics I	9		
NERS 572	Plasma Physics II		7	
NERS 575	Plasma Generation and Diagnostics Lab (EECS 519)		15	
NERS 587	Physics Processes in Plasmas		7	
NERS 579	Physics of Diagnostic Radiology		1	
NERS 580	Computation Proj in Radiation Imaging (BioM 580)		14	
NERS 586	Applied Radiological Measurements		5	
NERS 588	Radiation Safety and Medical Physics Practicum		1	
NERS 590	Special Topics in Nuclear Engr & Radiological Sci II	26	10	
NERS 599	Master's Project	4	7	2
NERS 644	Transport Theory		12	
NERS 799	Special Projects	11	15	2
NERS 990	Dissertation-Precandidate	11	19	1
NERS 995	Dissertation-Candidate	29	28	3

Student Academics and Employment

AWARDS AND HONORS

Undergraduate

Scholarships

- First Year Merit Scholarships
  Jennifer Everhart, Curtis Dauw, Ryan Penney, Conor O'Bryan, Scott Pfeffer, Scott Wagner
- NERS Continuous Scholarship
  Jonathan Fritz, Douglas Fynan, Justin Lamy
- Second Year Undergraduate Merit Scholarship
  Allen Fisher, Kelsey Hanson, Kathryn Masi, Yanbo Zhu
- Kikuchi Scholarship
  Jonathan Fritz
- American Nuclear Society Undergraduate Scholarship Award
  Allen Fisher, Andrew Haefner, Maha Sada Jawad, Natallia Pinchuk, Robert Reed
- American Nuclear Society Undergraduate Scholarship Award – Michigan Section
  Yevgeney (Jenia) Vinogradskiy, Danielle Worthy
- U.S. Department of Energy Nuclear Engineering Undergraduate Scholarship
  Douglas Fynan, Andrew Gerlach, Derek Granzow, Bryan Hayden, Maha Sada Jawad, Joel Kulesza, Anree Little, Kyle Patterson, Natallia Pinchuk, Robert Reed, Stephen Rice, Jennifer Schlicht, Sara Seamans, Matthew Thomas, Christopher Tien, Nicholas Touran, Stephen Troyer, Yevgeney (Jenia) Vinogradskiy, Patricia Voss, Brian Wagner, Brandon Weatherford, Zachary Whetstone, Danielle Worthy, Jiali Wu
- National Academy for Nuclear Training Scholarship
  Thomas Briley, Adam Dow, Allen Fisher, Douglas Fynan, Andrew Gerlach, Derek Granzow, Jason Haas, Andrew Haefner, Sara Seamans, Christopher Tien, Nicholas Touran, Matthew Thomas, Patricia Voss, Brandon Weatherford, Zachary Whetstone, Danielle Worthy, Jiali Wu
- Joseph B. and Florence V. Cejka Scholarship
  Kelsey Hanson
- Ziegler Family Scholarship
  Stephen Rice
- Class of 1931E Scholarship
  Douglas Fynan
- William J. Olcott Fund
  Kaya Zhu

- Bernard J. and Ronni S. Lacroute Scholarship
  Patricia Voss
- GE Scholarship
  Christopher Tien

Honors and Awards

- Outstanding Undergraduate Student Award (Engineering Physics)
  Michael McDonald
- Outstanding Undergraduate Student Award (Nuclear Engineering and Radiological Sciences)
  Virinder Sandhu
- Distinguished Leadership Award
  Maha Sada Jawad, Robert Reed, Danielle Worthy
- Mildred and Steele Bailey Prize
  Danielle Worthy
- MEPO Undergraduate Achievement Award
  Michelle Baca, Anree Little
- MEPO Undergraduate Rising Student Achievement Award
  Osvaldo Font
- Elaine Harden Award
  American Nuclear Society
  President – Danielle Worthy
  Vice-President – Maha Sada Jawad
  Treasurer – Sara Seamans
  Secretary – Jennifer Schlicht
  Faculty Advisor – Zhong He

Graduate

Fellowships and Scholarships

- American Nuclear Society Graduate Awards
  Martha Coselmon, Nicholas Jordan, Bryan Toth, Emily Wolters, Jacob Zier, Janelle Penisten, Micah Hackett
- Applied Materials
  Nicholas Jordan
- Center for the Education of Women
  Maryanne Stasko
- College of Engineering Dean's/Named Fellowship
  Jacob Zier, Emily Wolters

- College of Engineering Regent's Fellowship
  Matthew Gomez
- Directed Energy Professional Society
  Brad Hoff
- Health Physics Society
  2004 Richard J. Burk Jr. Fellowship - Adrienne Lehnert
  2005 Robert S. Landauer, Sr. Memorial Fellowship – John Harvey
- NASA Graduate Student Research Program
  Jason Hayward
- National Academy for Nuclear Training Fellowship
  Nuclear Engineering: Andrew Kalchik
- National Physical Science Consortium
  Trevor Strickler
- National Science Foundation (renewal)
  Scott Kiff
- Rackham Engineering Award Fellowship
  Elaine West, Alejandro Perez-Bergquist
  Renewals: Tiberius Moran; Johari Moore & Martha Coselmon
- U.S. Department of Energy Civilian Radioactive Waste Management Fellowship
  Janelle Penisten
- U.S. Department of Energy Computational Sciences Fellowship
  Gregory Davidson, Allan Wollaber
- U.S. Department of Energy Naval Nuclear Propulsion Fellowship
  Troy Becker, Micah Hackett, Bryan Toth
- U.S. Department of Homeland Security
  Adrienne Lehnert
- U.S. Department of Energy Nuclear Engineering/Health Physics Fellowship
  Emily Wolters
- U.S. Department of Defense National Defense Science and Engineering
  Allen Garner
- U.S. Navy
  Stephen Dewey
- University Research Alliance
  A. Neal Ham
- Westinghouse/CNNC Fellowship
  Yongping Qiu, Zhi Wang

AWARD DECISIONS MADE IN 2006 FOR A/Y 2006-2007

Undergraduate

Scholarships

- First Year Merit Scholarships
  John Bergsma Jr., David Genevich, Archis Joglekar, Ryan Orizondo, Dane Reggia, Charles Sullivan, Andrew Till
- NERS Continuous Scholarship
  Jonathan Fritz, Douglas Fynan, Justin Lamy, Christopher Pigeon
- Second Year Undergraduate Merit Scholarship
  Ian Faust, James Laird II, Justin Lamy, Scott Pfeffer, Christopher Tobin
- Kikuchi Scholarship
  Benjamin Betzler, Yvan Boucher
- American Nuclear Society Undergraduate Scholarship Award
  Allen Fisher, Hamdi Franzi, Jonathan Fritz, Douglas Fynan, Justin Lamy, Natallia Pinchuk, Robert Reed, Christopher Tien
- American Nuclear Society Undergraduate Scholarship Award – Michigan Section
  Robert Reed
- U.S. Department of Energy Nuclear Engineering Undergraduate Scholarship
  Scott Ambers, Benjamin Betzler, Yvan Boucher, Thomas Briley, Amy Coffer, Jennifer Dolan, Ian Faust, Allen Fisher, Jonathan Fritz, Matthew Franzi, Douglas Fynan, Andrew Haefner, Nicholas Krupansky, Justin Lamy, Diana Li, Kathryn Masi, Jeffrey Neumann, Kyle Patterson, Natallia Pinchuk, Scott Pfeffer, Robert Reed, Ian Rittersdorf, Christopher Tien, Stephen Troyer, Patricia Voss, Scott Wagner
- U.S. Department of Homeland Security
  Allen Fisher
- National Academy for Nuclear Training Scholarship
  Scott Ambers, Thomas Briley, Ian Faust, Allen Fisher, Jonathan Fritz, Douglas Fynan, Andrew Haefner, Kelsey Hanson, Eric Miller, Robert Reed, Christopher Tien, Patricia Voss
- GE Scholarship
  Christopher Tien

Graduate

Fellowships

- American Nuclear Society Graduate Awards
  Jason Hayward, Nicholas Jordan, Bryan Toth, Christopher Wahl, Brandon Weatherford, Emily Wolters
- College of Engineering Dean's/Named Fellowship
  Brandon Weatherford, Christopher McGuffey
- College of Engineering Regent's Fellowship
  Shikha Prasad
- Directed Energy Professional Society
  Brad Hoff
- Graduate Student Research Program, Marshall Space Flight Center
  Jason Hayward
- Health Physics Society
  Robert S. Landauer, Sr. Fellowship: Zachary Whetstone
  Robert Gardner Fellowship: Nathan Haverland
  Healthy Physics Student Fellowship: Benjamin Hammargren
- National Academy for Nuclear Training in Nuclear Engineering Fellowship
  Bryan Hayden
- Rackham Barbour Fellowship
  Yan Cao
- Rackham Engineering Award Fellowship
  Andrew Gerlach
- Rackham Engineering Award Fellowship (renewal)
  Martha Coselmon, Tiberius Moran, Elaine West, Alejandro Perez-Bergquist
- Rackham Predoctoral Fellowship
  Phongphaeth Pengvanich
- U.S. Department of Energy Computational Sciences Fellowship
  Allan Wollaber
- U.S. Department of Energy Naval Nuclear Propulsion Fellowship
  Troy Becker, Micah Hackett
- U.S. Department of Energy Nuclear Engineering/Health Physics Fellowship
  Emily Wolters
- U.S. Department of Energy Office of Civilian Radiation Waste Management
  Kelly Prater, Nathan Haverland
- U.S. Department of Defense National Defense Science and Engineering
  Christopher Wahl, J. Michaela Flak
- U.S. Department of Homeland Security
  Adrienne Lehnert, Zachary Whetstone, William Kaye
- University Research Alliance; Advanced Fuel Cycle Initiative
  Jason Haas

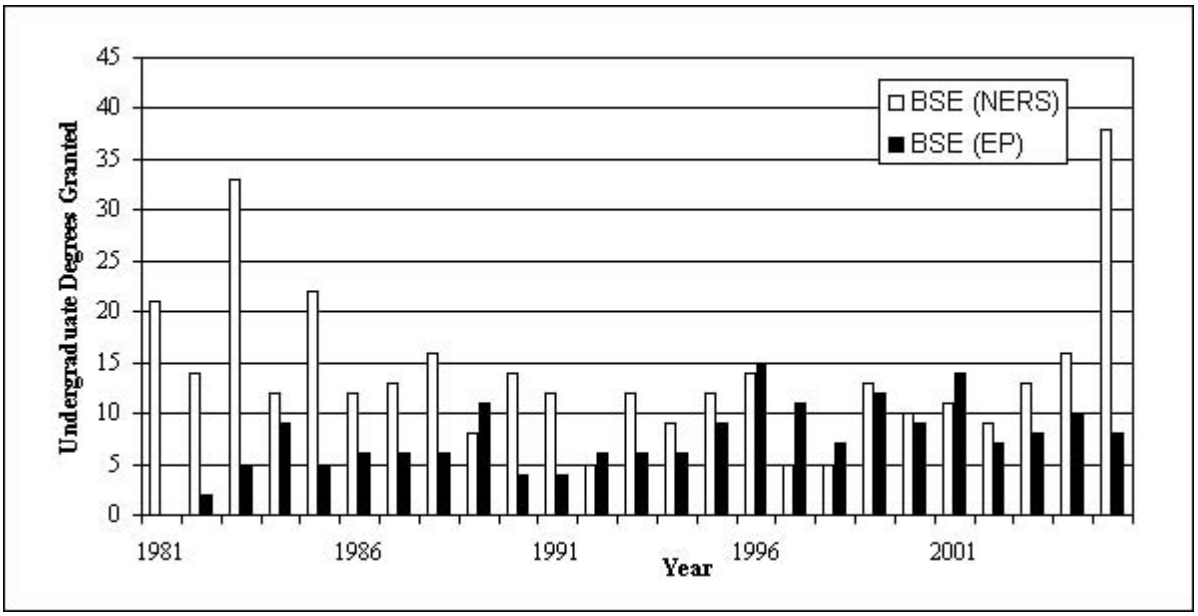
Honors and Awards (Graduate)

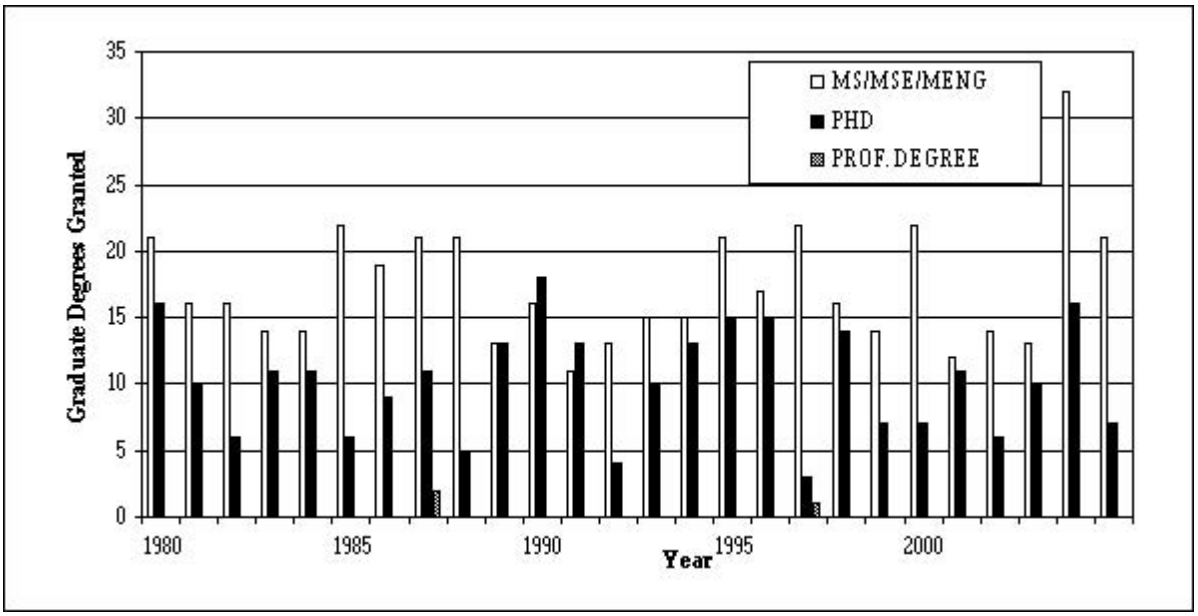
- College of Engineering 2006 Distinguished Achievement Award
  Allen Garner
- Rackham School of Graduate Studies Distinguished Dissertation Award of 2005
  Mark Hammig
- Best Student Paper, ANS Math and Computation Topical Conference,
  Avignon, France (Sept. 2005)
  Allan Wollaber

DEGREES AWARDED BY ACADEMIC YEAR

September 2005 through August 2006

Degree	Number
BSE in Nuclear Engineering and Radiological Sciences	38
BSE in Engineering Physics	8
MSE and MS in Nuclear Engineering and Radiological Sciences (including 10 students continuing in doctoral program)	21
PhD in Nuclear Engineering and Radiological Sciences, and in Nuclear Science	7
Professional Degree (Nuclear Engineer)	0





DOCTORAL THESES TITLES

For Degrees Conferred September 2005–August 2006

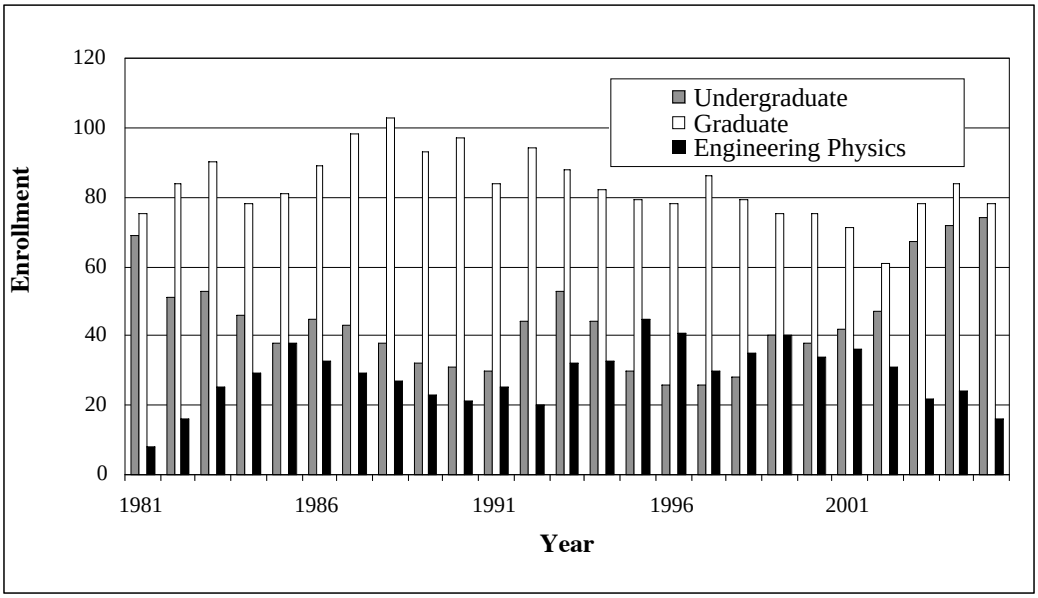
STUDENT	TITLE	ADVISOR
Dewey, Steven	Novel Methods of Gamma Ray Spectrometry	K. Kearfott
Garner, Allen	Electrical Pulse Induced Biological Effects Using Dielectric Spectroscopy and Mathematical Models	Y. Y. Lau
Hidaka, Yoshiteru	Experimental and Simulation Studies of a Large Area Plasma Source as Electric Propulsion Neutralizer	R. M. Gilgenbach Y. Y. Lau
Strickler, Trevor	Azimuthal Wire Motion and Ablation Dynamics in Z-pinches	R. M. Gilgenbach Y. Y. Lau
Tyagi, Neelam	IMRT Dose Delivery Effects in Radiotherapy Treatment Planning Using Monte Carlo Methods	I. Chetty A. Bielajew
White, William	RF Priming of a Long Pulse Relativistic Magnetron	R. M. Gilgenbach
Xu, Dan	Gamma-Ray Imaging and Polarization Measurement Using 3D Position-Sensitive CdZnTe Detectors	Z. He

Doctoral Theses in Progress for Academic Year 2006-2007

STUDENT	TITLE	ADVISOR
Alpay, Bulent	Degradation Monitoring Using Probabilistic Inference	J. P. Holloway
Ding, Tianhua	*In Situ* TEM Study Of Self-Organization Process of Three-Dimensional Void Superlattice Formation In Electron Irradiated Caf2	L. M. Wang
Hayward, Jason	Characterization of a Double-Sided Strip HPGe Detector	D. K. Wehe
Kiff, Scott	Coplanar Anode Implementation in Compressed-Xenon Ionization Chambers	Z. He
Ji, Wei	Neutronic Analysis of Particle Fuel for High Temperature Gas Reactors	W. R. Martin
Lee, Wonho	A Dual and Hybrid Collimation Gamma Camera Using LaCI3 and CsI Scintillator	D. K. Wehe
McClarren, Ryan	Practical Spherical Harmonics Methods for Nonlinear Radiation Transport	J. P. Holloway
Sorensen, Reuben	Systematic Method for Optimizing Plutonium Transmutation in LWRs	J. C. Lee
Sturm, Benjamin	Gamma-Ray Spectroscopy Using Coplanar Grid CdZnTe Semiconductor Detectors	Z. He
Tchou, Philip	2AFC Assessment of Noise Perception Using Medical LCD Monitors	E. W. Larsen M. Flynn
Wollaber, Allan	A Monte Carlo-Deterministic Method for Global Time-Dependent Photon Transport Calculations	E. W. Larsen

FALL ENROLLMENT

Year	Undergraduate	Graduate	Engineering Physics
1980	68	88	0
1981	69	75	8
1982	51	84	16
1983	53	90	25
1984	46	78	29
1985	38	81	38
1986	45	89	33
1987	43	98	29
1988	38	103	27
1989	32	93	23
1990	31	97	21
1991	30	84	25
1992	44	94	20
1993	53	88	32
1994	44	82	33
1995	30	79	45
1996	26	78	41
1997	26	86	30
1998	28	79	35
1999	40	75	40
2000	38	75	34
2001	42	71	36
2002	47	61	31
2003	67	78	22
2004	72	84	24
2005	74	78	16



EMPLOYMENT STATISTICS
AND CONTINUING EDUCATION

Place of First Employment of Graduates
September 2005 – August 2006

EMPLOYER	BSE STUDENTS
Advent Engineering	Sara Seamans
Armed Forces	Michelle Baca
	Francis DeCambra
	Anree Little
Dominion	Crystal Thrall
Schlumberger	Rebecca Wright
Shonka Research and Associates	Aaron Kelley
U-M Center for Advanced Computing	Brock Palen
Westinghouse	Gregory Fischer
	Joel Kulesza
	Thomas Richard

EMPLOYER	MS/MSE STUDENTS
China National Nuclear Corporation	Zhi Wang
Duke Power	Maryanne Stasko
Duke Power	Janelle Penisten
First Energy Nuclear Operating Company (David-Besse Nuclear Station)	A. Neal Ham
General Atomics	Jessie Crozier
National Nuclear Security Administration	Michael Reim
National Nuclear Security Administration	Adam Boyd
Shanghai Nuclear Engineering Research and Design Institute	Yongping Qiu
Westinghouse	Michael Seely
Xoran Technologies	Jonathan Alspaugh
Unknown	Andrew Kalchik

EMPLOYER	PhD STUDENTS
Brooks Air Force Base	Steven Dewey
General Electric Research Center	Allen Garner
General Electric Global Research	Dan Xu
Massachusetts Institute of Technology	Yoshiteru Hidaka
K-Tech	William White
Princeton Plasma Physics Lab	Trevor Strickler
University of Michigan Hospitals Radiation Oncology	Neelam Tyagi

Continuing Graduate Studies

UNIVERSITY	BSE STUDENTS
Kansas State University (Mechanical Eng)	Matthew Thomas
San Diego State University (Physics)	Jordan Vela
University of California – Berkeley (Nuclear Eng)	Joshua King
University of Michigan (Aerospace)	Michael McDonald
University of Michigan (Applied Physics)	Prashant Padmanabhan
University of Michigan (Mathematics)	Stephen Marin
University of Michigan (Mechanical Eng)	Alberto Lopez
University of Michigan, Medical School	M. Sada Jawad
University of Michigan	Edward Cruz
(Nuclear Engineering and Radiological Sciences)	T. Adam Dow
	Andrew Gerlach
	Jason Haas
	Benjamin Hammargren
	Bryan Hayden
	Benjamin Kevern
	Shikha Prasad
	Virinder Sandhu
	Nicholas Touran
	Brian Wagner
	Brandon Weatherford
	Jiali Wu
University of Michigan, School of Education	Peter Diemer
University of Texas of Biomedical Sci (Medical Phys)	Yevgeney Vinogradskiy
Western Michigan University	Anat Cohen
Wayne State University (Medical Phys)	Danielle Worthy

UNKNOWN	BSE STUDENTS
	Edward Fortunate
	Derek Granzow
	Joey Pawlak
	Alexis Talwar
	Kaya Zhu

UNIVERSITY	MS/MSE STUDENTS
University of Michigan	Mat Brener
(Nuclear Engineering and Radiological Sciences)	Jesse Cheatham
	Shu-Hui Hsu
	Rojano Kashani
	Hao Jiang
	Sy Stange
	Bryan Toth
	Haori Yang
University of Florida	Matthew Studenski
University of Pennsylvania	Kevin Gralewski

INTERNSHIPS

Undergraduate

Andrea Wenstrup	Arrogant Frog Winery	France
Kathryn Masi	Boulevard Hills Assisted Living	MI
Anat Cohen	Dana Farber Cancer Institute	MA
Natallia Pinchuk	DC Cook Power Plant	MI
Andrew Caldwell	Delphi	MI
Kristine Matten	Duke Energy Catawba Nuclear Station	NC
Danielle Worthy	Eli Lilly	IN
Shikha Prasad	General Atomics	CA
Allen Fisher	Idaho National Laboratory	ID
Nicholas Touran	Idaho National Laboratory	ID
Brandon Weatherford	L-3 Communications	CA
Amy Coffer	Lawrence Livermore National Laboratory	CA
Andrew Gerlach	Lawrence Livermore National Laboratory	CA
Robert Reed	Lawrence Livermore National Laboratory	CA
Joshua King	Los Alamos National Laboratory	NM
Benjamin Yee	Los Alamos National Laboratory	NM
David Sumpter	Los Animas Road and Bridge Department	CO
Osvaldo Font	Nuclear Regulatory Commission	MD
Crystal Thrall	Nuclear Regulatory Commission	MD
Patricia Voss	Nuclear Regulatory Commission	IL
Brian Wagner	Nuclear Regulatory Commission	MD
Christopher Tien	Pacific Northwest National Laboratory	WA
Matthew Franzi	Palisades Power Plant	MI
Ian Rittersdorf	Palisades Power Plant	MI
Brock Palen	University of Michigan Center for Advanced Computing	MI
Najeb Abdul-Jabbar	University of Michigan Michigan Ion Beam Laboratory	MI
Fariz Hamdi	University of Michigan Michigan Ion Beam Laboratory	MI
Stephen Marin	University of Michigan Michigan Ion Beam Laboratory	MI

Scott Pfeffer	University of Michigan Michigan Ion Beam Laboratory	MI
Christopher Chwasz	University of Michigan Radiation Detection Laboratory	MI
Andrew Haefner	University of Michigan Radiation Oncology	MI
Jiali Wu	University of Michigan Radiation Oncology	MI
Zachary Whetstone	University of Michigan Radiological Health Engineering Laboratory	MI
Heather Wittaniemi	University of Michigan Radiological Health Engineering Laboratory	MI
Ian Faust	University of Missouri Research Reactor	MO

Graduate

Emily Wolters	Argonne National Laboratory	IL
Yan Cao	Argonne National Laboratory	IL
Bryan Toth	Bettis National Laboratory	PA
Gokhan Yesilyurt	General Atomics	CA
Jessie Crozier	General Atomics	CA
Bulent Alpay	Idaho National Laboratory	ID
Micah Hackett	Knolls Atomic Power Laboratory	NY
Troy Becker	Knolls Atomic Power Laboratory	NY
Tiberius Moran	Los Alamos National Laboratory	NM
Steven Anderson	Los Alamos National Laboratory	NM
Mark Shaver	Pacific Northwest National Laboratory	WA
Adrienne Lehnert	Pacific Northwest National Laboratory	WA
Tianhua Ding	The rSmart Group, Inc.	AZ
Matthew Gomez	Sandia National Laboratories	NM
Yongping Qiu	Westinghouse	PA
Zhi Wang	Westinghouse	PA

Employment Patterns of Graduates September 2005 – August 2006

	BS	*MS/MSE*	*PhD*	*Prof*
Federal Government				
Department of Defense				
United States Navy	3			
United States Air Force			1	
Department of Energy				
Bechtel Bettis				
Brookhaven National Laboratory				
Knolls Atomic Power Laboratory				
Los Alamos National Laboratory				
Pacific Northwest National Laboratory				
Sandia National Laboratories				
National Nuclear Security Administration		2		
Nuclear Regulatory Commission				
Other Industrial and Medical Organizations				
Advent Engineering	1			
General Atomics		1		
General Electric Research Center			1	
General Electric Global Research			1	
K-Tech			1	
Schlumberger	1			
Shonka Research and Associates	1			
U-M Hospitals Radiation Oncology .			1	
Westinghouse		1		
Xoran Technologies		1		
Nuclear Utilities				
DTE Energy				
Duke Power		2		
First Energy Nuclear Operating Company		1		
Nuclear Reactor Manufacturers				
China National Nuclear Corporation		1		
Dominion	1			
Shanghai Nuclear Engineering R & D Institute		1		
Westinghouse	3			
Academic Institutions: Grad, Post Doc, and Faculty				
Kansas State University (Mechnical Engr)	1			
Massachusetts Institute of Technology			1	
Princeton Plasma Physics Lab			1	

San Diego State University	1			
University of California – Berkeley (Nuclear Engr)	1			
University of Florida		1		
University of Michigan (Aerospace)	1			
University of Michigan (Applied Physics)	1			
University of Michigan (Cntr for Adv Computing)	1			
University of Michigan (Mathematics)	1			
University of Michigan (Mechanical Engr)	1			
University of Michigan (Medical School)	1			
University of Michigan (NERS)	13	8		
University of Michigan (School of Education)	1			
University of Pennsylvania		1		
University of Texas of Biomedical Sci (Medical Physics)	1			
Wayne State University	1			
Western Michigan University	1			
Unknown	5	1		
TOTALS	41	21	7	

Employment Patterns of Graduates
36-Year Summary: August 1970 - July 2006

	BS	*MS*	*MEng*	*PhD*	*Prof*
Federal Government					
Department of Commerce				7	
Department of Defense					
Armed Forces	63	22	1	8	
Civilian Employees	3	3		15	
Department of Energy	10	40	3	90	
Department of Transportation				2	
Environmental Protection Agency			2		
NASA		1			
Nuclear Regulatory Commission	5	2	1		1
Waste Management Federal Services		1			
Electrical Utilities	69	35	1	8	
Nuclear Reactor Manufacturers	37	49		21	1
Architecture-Engineering Firms	18	29	1	5	
Consulting Firms	4	5	3	9	
Other Industrial & Medical Organizations	23	40	4	55	
Foreign Governments	1	11		12	3
Academic Institutions					
Faculty and Staff	7	6	2	52	
Graduate School and Postdoctoral Work	325	339	10	48	
Employment Outside the Profession	14	10		2	
Returned to Home Country and Unknown	84	38	7	29	3
Fulbright Award	1				
TOTALS	664	631	35	364	8

NERS Colloquia Fall 2005

DATE	SPEAKER	TITLE
Sept. 23	William R. Martin U-M NERS	Departmental Welcome
Sept. 30	John Foster NASA Glenn Research Center	Into the Future with Ion Propulsion: Pushing the Lifetime Barrier
Oct. 7	John Vandenkieboom Los Alamos National Laboratory	Nuclear Weapon Fundamentals and Stewardship Issues
Oct. 14	Douglas C. Wood Advent Engineering Services, Inc.	The Yucca Mountain Surface Facility: The Forgotten Component of the National High-Level Waste Solution
Oct. 21	Kurt Sickafus Los Alamos National Laboratory	Layered Atom Arrangements in Oxides
Oct. 28	Wei Lu U-M Electrical Engineering and Computer Science Department	One-Dimensional Transport in Nanowire Heterostructures
Nov. 4	Industry Forum Career Fair Recruiters	Job Opportunities and Current Activities for NERS Graduates
Nov. 11	David Ampleford Sandia National Laboratories	Tailoring Wire Array Implosions to Explore Z-Pinch Physics and Laboratory Astrophysics Applications
Nov. 18	Massimo Salvatores Argonne National Laboratory and CEA-Cadarache	Impact of Nuclear Data Uncertainties on Core Neutronics
Dec. 2	Harold Ing Bubble Technology, Inc.	Neutron Measurements in Connection with Dosimetry of Atomic Radiation Workers and Security of Civilians and Military Personnel
Dec. 9	Mike Hartman National Institute of Standards and Technology (NIST)	Ultrashort Electrical Pulses Open a New Gateway into Biological Cells

NERS Colloquia Winter 2006

DATE	SPEAKER	TITLE
Jan. 6	Thomas Johnson Colorado State University	Power Lines, Politics and Pulses
Jan. 13	Karl Krushelnick Blackett Laboratory, U. of London	Laser-Plasma Interactions Using Petawatt Lasers
Jan. 20	David Chichester Sandia National Laboratories	Sealed Neutron Tube Generators: Technology and Applications
Jan. 27	Eric Smith Pacific Northwest National Lab	Nuclear Science in Homeland Security
Feb. 3	Gerald Fishman Marshall Space Flight Center	Techniques and Observations In High-Energy Astrophysics
Feb. 10	Edward A. Parson U-M School of Law & School of Natural Resources & Environment	Global Climate Change: What Do We Know, and How Well Do We Know It?
Feb. 17	Thomas Zurbuchen U-M Atmospheric, Oceanic and Space Sciences Department	Breakthrough Science Enabled by Nuclear Technology in Space
Feb. 24	Neelan Tyagi, Dan Xu and Micah Hackett, U-M NERS	NERS Student Presentations
Mar. 10	Regis Babinet Embassy of France, Washington, DC	Nuclear Energy Policy in France: European Context and Environmental Issues
Mar.17	Jim Wiggins Nuclear Regulatory Research Office	The Future of Nuclear Regulatory Research – A Perspective
Mar. 24	Jerry Shapiro Consultant	Planning the Rebirth of Nuclear Power in the U.S.
Mar. 31	Viswanath Krishnamoorthy Qynergy Corporation	Betavoltaic Technology – Potential Implications for Long-Lasting Power
April 14	Alexander Kostinski Physics Department Michigan Tech	The Texture of Atmospheric Clouds and Implications for Radiative Transfer

Research Activities

FISSION SYSTEMS AND RADIATION TRANSPORT

Development of Time-Dependent Pn Solver for ALEGRA

J. P. Holloway, PI
Sandia National Laboratories
$120,827/3 yrs

The long term goal of this project is to develop new radiation transport capabilities for ALEGRA. Under this contract the University of Michigan is working with Dr. Thomas Brunner of Sandia National Laboratories on exploratory work to develop a new thermal radiation transport module compatible with the ALEGRA framework. We envision a spherical harmonics based angular discretization with an implicit-in time Riemann solver. The treatment of the closure for the spherical harmonics expansion will consider a general approach that supports standard Pn truncation, extensions of variable Eddington factor closures to higher order, as well as using closure moment data from external (higher-order) computations. Closures ensuring positivity of the flux will be investigated.

R. McClarren, J. P. Holloway, T. Brunner and T. Mehlhorn, "A Quasi-Linear Implicit Riemann Solver for the Time-Dependent Pn Equations," *Nuclear Science and Engineering*, to appear (2006). (Invited)

R. McClarren, J. P. Holloway, T. Brunner and T. Mehlhorn, "An Implicit Riemann Solver for the Time-Dependent Pn Equations," *Proceedings of the International Topical Meeting on Mathematics and Computation: Supercomputing, Reactor Physics and Nuclear and Biological Applications* (2005).

R. McClarren, J. P. Holloway and T. Brunner, "Establishing an Asymptotic Diffusion Limit for Riemann Solvers on the Time-Dependant Pn Equations," *Proceedings of the International Topical Meeting on Mathematics and Computation: Supercomputing, Reactor Physics and Nuclear and Biological Applications* (2005).

T. Brunner and J. P. Holloway, "Two Dimensional Time Dependent Riemann Solvers for Neutron Transport," *Journal of Computational Physics*, **210**, 386-399 (2005).

R. McClarren, T. Brunner, J. P. Holloway and T. Mehlhorn, "Implicit Riemann Solvers for the Pn Equations," presented at the Computational Methods in Transport Workshop (2004).

Model Based Transient Control and Component Degradation Monitoring in Generation IV Nuclear Power Plants

J. P. Holloway, PI and J. C. Lee, Co-PI
U.S. Department of Energy/NERI
$1,382,504/42 mos

This project involving the University of Michigan, Westinghouse and Sandia National Laboratories supports the development of advanced nuclear power technology. The project is developing advanced and integrated methodologies for constructing model based control systems for fission power systems. The project is also developing an advanced model-based approach to monitoring nuclear plant systems for degradations. These two tasks are united by their reliance on sensor networks that map sensor signals to plant state information through the use of plant system models. This plant sensor information is used to connect models of plant state to the actual plant state. Nonlinear state-space control algorithms are being developed to provide robust and automatic plant control in a wide variety of plant transient maneuvers, including startup, shutdown, and load follow maneuvers, including large or total load rejections. By providing smooth transient control without reactor trip these control systems can greatly improve both plant safety and economics. The quest for long-life cores in highly integrated and modular reactor designs places great demands on the already difficult maintenance systems of nuclear power stations. Advanced degradation monitoring will allow nuclear plant operators to optimize plant maintenance subject to both safety and economic factors. Recent effort included testing the unscented Kalman filter for monitoring power plant components with full nonlinear representation of system dynamics.

S. E. Aumeier, B. Alpay and J. C. Lee, "Adaptive Kalman Filtering for Diagnosis of Multiple Component Degradations," *Trans. Am. Nucl. Soc.*, **91**, 127 (2004).

J. P. Holloway, "State Identification in Nonlinear Systems," *Proceedings of Space Technology and Applications International Forum – STAIF 2005*, edited by M. El-Genk (2005).

S. Bragg-Sitton and J. P. Holloway, "Autonomous Reactor Control Using Model Based Predictive Control for Space Propulsion Applications," *Proceedings of Space Technology and Applications International Forum – STAIF 2005*, edited by M. El-Genk (2005).

S. E. Aumeier, B. Alpay and J. C. Lee, "Probabilistic Techniques for Diagnosis of Multiple Component Degradations," to appear *Nuclear Science and Engineering* (2006).

Advanced Variance Reduction for Global k-Eigenvalue Simulations in MCNP5

E. W. Larsen, PI and W. R. Martin, Co-PI
U.S. Department of Energy/NEER
$299,982/3 yrs

The goal of this project is to develop and implement new advanced variance reduction strategies for practical, continuous-energy k-eigenvalue and eigenfunction simulations in the Monte Carlo particle transport code MCNP5. This FORTRAN-90 version of MCNP, developed at Los Alamos National Laboratory and recently released by RSICC, contains new features–in particular, a multigroup cross section generator and a dual mesh which overlays the computational mesh–that allow MCNP5 to employ the automatic variance reduction method AVATAR for source-detector problems. The implementation of these features in MCNP5 will greatly facilitate the implementation and testing of more advanced variance reduction techniques that require the same multigroup cross sections and dual mesh.
In this project, we will implement in MCNP5 the Variational Variance Reduction (VVR) method for enhancing the Monte Carlo simulation of k-eigenvalue problems, In this recently-developed technique, a variational functional, which requires estimates of both forward and adjoint k-eigenfunctions, is evaluated to estimate k. This functional is more expensive to evaluate than the standard Monte Carlo functional, which requires only an estimate of the forward k-eigenfunction. However, because the variational functional is more accurate, a significant gain in the figure of merit is achieved.

The VVR method has been developed in preliminary work at the University of Michigan during the past six years and has undergone successful but very limited testing. The extension of this method to continuous-energy Monte Carlo simulations, its implementation in MCNP5, and its testing on difficult, realistic problems, is the essence of this proposed research.

Development of TRU Transmuters for Optimization of the Global Fuel Cycle

J. C. Lee, PI and R. F. Fleming, Co-PI
U.S. Department of Energy/NERI
$611,465/36 months

The project aims to develop advanced fuel cycles for the transmutation of transuranic (TRU) elements in irradiated nuclear fuel from light water reactor (LWR) power plants. The research will focus on developing fast-spectrum nuclear reactors that could efficiently transmute long-lived TRUs, thereby significantly reducing the radioactivity of the irradiated fuel. We have developed an equilibrium fuel cycle methodology to consistently compare the performance of LWR transmuters with that of other transmuters. We have studied ways to implement thorium in reload fuel cycles for both pressurized water rectors (PWRs) and sodium-cooled fast reactors (SFRs) for efficient transmutation of TRUs. Recent effort has

focused on the development of general optimization algorithms that can systematically and efficiently optimize a multitude of fuel cycle parameters for PWRs and SFRs, while rigorously satisfying operational constraints including the peak power density. The optimization algorithm has been successfully implemented and tested for 2-D optimal fuel loading pattern searches for the AP600 and other PWR configurations. Effort is continuing to implement the fuel cycle optimization algorithm for full 3-D optimization of SFR configurations including heterogeneous core designs and TRU transmutation targets.

J. C. Davis and J. C. Lee, "Comparison of Monte Carlo and Deterministic Depletion Codes for LWR Fuel Cycle Analysis," *Trans. Am. Nucl. Soc.*, **92**, 651 (2005).

R. T. Sorensen and J. C. Lee, "LWR Equilibrium Cycle Search Methodology for Assembly-Level Fuel Cycle Analysis," submitted for publication in *Nuclear Science and Engineering*.

R. T. Sorensen and J. C. Lee, "LWR Equilibrium Cycle Search Methodology for Global Fuel Cycle Analysis," *Trans. Am. Nucl. Soc.*, **93**, 622 (2005).

R. T. Sorensen, J. C. Davis and J. C. Lee, "Thorium-based Fuels for Enhancing Plutonium Transmutation in Light Water Reactors," *Trans. Am. Nucl. Soc.*, **94**, 87 (2006).

J. C. Davis, R. T. Sorensen, J. C. Lee and R. F. Fleming, "Transmutation Characteristics of Thorium-Based Fuel in a Multiple-Tier Fuel Cycle," *Trans. Am. Nucl. Soc.*, **94**, 89 (2006).

R. T. Sorensen, J. C. Davis and J. C. Lee, "Systematic Method for Optimizing Plutonium Transmutation in LWRs," to be presented at the ANS Conference in November 2006.

Neutronic Analysis for the Very High Temperature Gas-Cooled Reactor

J. C. Lee, PI and W. R. Martin, Co-PI
U.S. Department of Energy/Idaho National Engineering & Environmental Laboratory/I-NERI
$340,000/36 mos

This is an I-NERI project involving INEEL, Korea Advanced Institute of Science and Technology, Seoul National University, and the NERS Department. The focus of the project is to develop neutronic methodology for the Very High Temperature Gas-Cooled Reactor (VHTGR), which has been selected as a key concept in the Generation IV Roadmap. The neutronic methodology will focus on accurate determination of power distributions that account for thermal-hydraulic feedback effects for the transient and safety analysis of the VHTGR. We have developed MCNP5 models to represent material heterogeneities inherent in the microsphere fuel particles and fuel compacts for a GT-MHR design. We have also

performed coupled nuclear-thermal/hydraulic (NTH) analysis to obtain self-consistent global power and temperature distributions using a homogenized global model for MCNP5 and three-ring core model for the RELAP5-3D/ATHENA code. This effort included the development of a "pseudo-material" scheme, which results in an effective fuel material at an arbitrary temperature *T* that is a mixture of fuel with cross sections that were generated at two temperatures that bracket *T*. This scheme will allow Monte Carlo calculation of resonance integrals at arbitrary temperatures rather than at the discrete set of temperatures that happen to be in the MCNP5 library. We have compared heterogeneous and homogeneous representations of the microsphere and fuel compact cells, and have established the importance of heterogeneities on the overall VHTGR neutronics analysis. Effort has been also made to perform whole-core VHTGR depletion calculations using the MONTEBURNS code combining the MCNP5 and ORIGEN2.2 codes.

F. B. Brown, W. R. Martin, W. Ji, J. L. Conlin and J. C. Lee, "Stochastic Geometry and HTGR Modeling with MCNP5," *Proc. Monte Carlo 2005 Topical Meeting*, Chattanooga, Tennessee (2005).

W. Ji, J. L. Conlin, W. R. Martin, J. C. Lee and F. B. Brown, "Explicit Modeling of Particle Fuel for the Very-High Temperature Gas-Cooled Reactor," *Trans. Am. Nucl. Soc.*, **92**, 236 (2005).

J. L. Conlin, W. Ji, J. C. Lee and W. R. Martin, "Pseudo Material Construct for Coupled Neutronic-Thermal-Hydraulic Analysis of VHTGR," *Trans. Am. Nucl. Soc.*, **92**, 225 (2005).

H. No, C. H. Oh, J. H. Kim, G. Park, J. C. Lee, W. R. Martin, H. S. Lim, E. S. Kim, M. O. Kim, J. L. Conlin and W. Ji, "Very-High-Temperature Gas-Cooled Reactors: Progress and Challenges," *Proc. International Congress on Advances in Nuclear Power Plant* (2005).

W. Ji, J. L. Conlin, G. Yesilyurt, W. R. Martin, J. C. Lee and F. B. Brown, "Neutronic Analysis to Support Validation of Safety Analysis Codes for the VHTR," *Trans. Am. Nucl. Soc.*, *93*, 931 (2005).

G. Yesilyurt, W. R. Martin and J. C. Lee, "Preliminary Analysis of VHTR Decay Heat Source," to be presented at the ANS Conference in November 2006.

Reactor-Accelerator Coupling Experiments (RACE) Project

J. C. Lee, PI
U.S. Department of Energy/Idaho State University
$65,000/15 months

As an integral part of the DOE Advanced Fuel Cycle Initiative, we have been collaborating with the Idaho State University (ISU) to develop an international program to perform accelerator-driven subcritical systems (ADSS) experiments. In the initial phase of the Reactor-Accelerator Coupling Experiments (RACE) project, we have performed reactor physics simulations of an ISU subcritical reactor configuration driven by an electron linear accelerator. The simulation effort focused on 3-D ERANOS kinetics study of the RACE configuration following the injection of a neutron source generated by photo-neutron reactions in a Cu-W target. Effort will continue to perform simulations of pulsed source experiments performed at ISU as well as at the RACE configurations at the University of Texas and Texas A&M University.

V. V. Kulik, J. C. Lee and D. E. Beller, "Dynamic Analysis of Space-Time Effects in the ISU RACE Configuration," *Proc. AccApp05 Conference*, Venice, Italy (2005).

V. V. Kulik and J. C. Lee, "Application of Modal-Local Method for Modeling of Pulsed Source Experiments," *Trans. Am. Nucl. Soc.*, **92**, 561 (2005).

V. V. Kulik and J. C. Lee, "Space-Time Correction for Reactivity Determination in Source-Driven Subcritical Systems," *Nucl. Sci. Eng.,* **153**, 69 (2006).

Y. Cao, T. Zhou, I. I. Al-Qasir, A. I. Hawari, R. F. Fleming and J. C. Lee, "MCNP5 Simulations of ZrH Scattering Experiments," *Trans. Am. Nucl. Soc.*, **94**, 603 (2006).

An Advanced Neutronic Analysis Toolkit with In-line Monte Carlo Capability for VHTR Analysis

W. R. Martin, PI and J. C. Lee, Co-PI
U.S. Department of Energy/NERI
$600,000/3 yrs

The goal of this project is to develop, implement, and test a lattice physics code for very high temperature reactor (VHTR) neutronic design and analysis. This code is based on a production-quality lattice physics code used in LWR analysis and is augmented by Monte Carlo capability to treat resonance absorption in TRISO particle fuel. The approach takes advantage of the highly developed capabilities available for light water reactor neutronic

analysis, in which lattice physics codes generate effective cross sections at the assembly level. These cross sections can be used in nodal codes to allow efficient calculation of global flux/power distributions and keff as a function of fuel depletion and temperature.

This project will incorporate the capability of the nodal Monte Carlo code, MCNP5, directly into the lattice code, CPM-3, to establish "proof-of-principle." Code linking will be accomplished through an interface that will enable the MCNP5 capability to be extensible to other cross-section generation codes as well. This capability will be demonstrated by linking MCNP5 to CASMO-4. The resultant package will inherit the substantial downstream capabilities of CASMO-SIMULATE, including cross-section generation for global nodal analysis and depletion, systematic preparation of cross-section sets for accident analysis, and efficient fuel cycle analyses and assessment of alternative fuel management schemes. The final result will be a validated neutronics methodology for VHTR design and analysis, including cross-section generation, global reactor analysis, depletion, and fuel management.

Collaborating Organizations: Studsvik of America, Idaho National Laboratory, Los Alamos National Laboratory, General Atomics, Oak Ridge National Laboratory, and TransWare Enterprises, Inc.

Global Monte Carlo Simulation with High Order Polynomial Expansions

W. R. Martin, PI and J. P. Holloway, Co-PI
U.S. Department of Energy/NEER
$300,000/3 yrs

This is a research project involving the development of a computational methodology to predict the global neutron scalar flux and thermal power profiles throughout a nuclear reactor. This methodology is based on the utilization of high order polynomials within a Monte Carlo algorithm to accelerate Monte Carlo fission source iterations for loosely coupled reactor systems. Preliminary work has demonstrated the feasibility of using high order polynomials to estimate spatially and angularly varying quantities such as the scalar flux distribution within a lattice or the interface current distribution on a boundary. This work has also led to a second approach based on imbedding this methodology into a response matrix formalism, allowing one in principle to estimate high order response matrices that could be used to estimate global flux and power distributions with improved accuracy and efficiency compared with conventional Monte Carlo methods. These methods should improve the convergence of Monte Carlo fission source iterations for loosely coupled systems.

D. P. Griesheimer, J. Cheatham, J. P. Holloway and W. R. Martin, "Improving Monte Carlo Source Convergence with the Functional Expansion Technique," accepted for presentation at the American Nuclear Society Annual Conference, Washington, DC, November 2005.

D. P. Griesheimer, W. R. Martin and J. P. Holloway, "A Functional Expansion Method for Monte Carlo Eigenvalue Calculations," *Proc. Monte Carlo 2005 Topical Meeting*, American Nuclear Society, Chattanooga, TN, April 17–21, 2005, on CD-ROM, American Nuclear Society, LaGrange Park, IL (2005).

MATERIALS

Structure, Properties and Relaxation of Shear Bands in Metallic Glasses

M. Atzmon, PI
A. Ganuza, Graduate Student; K. Rajulapati, Research Fellow
National Science Foundation, Division of Materials Research
$426,898/4 yrs

In crystalline solids, the atomic scale structure has been understood for a long time. On the other hand, the structure of some nonequilibrium materials is still the subject of current research. In amorphous materials, the density is variable and is a function of the thermomechanical history. Structural relaxation has a significant effect on the properties. Since mechanical deformation introduces shear bands whose density is lower than that of the matrix, it is important to understand their structure and effect on mechanical and transport properties. A similar issue exists in nanocrystalline metals. The structure of grain boundaries is a function of the sample history, and it affects the mechanical properties. In this work, the effect of thermomechanical treatment on the hardness and strain-rate sensitivity is being studied. Modern high-resolution transmission-electron microscopy methods are used to explain the observed property changes.

D. Jang and M. Atzmon, "Grain-Boundary Relaxation and its Effect on Plasticity in Nanocrystalline Fe," *Journal of Applied Physics,* **99**, 083504 (2006).

W. H. Jiang and M. Atzmon, "Plastic Flow of an Amorphous/Nanocrystalline $Al_{90}Fe_5Gd_5$ Composite Formed by Rolling," *Intermetallics,* **14**, 962 (2006).

W. H. Jiang and M. Atzmon, "Mechanically-Induced Nanocrystallization and Defects in Amorphous Alloys: a High-Resolution Transmission Electron Microscopy Study,"*Scripta Materialia,* **54**, 333 (2006). (Invited)

D. Jang and M. Atzmon, "The Contribution of Grain-Boundary Activity to Plasticity in Nanocrystalline Fe - the Effect of Grain-Boundary Relaxation," *Journal of Metastable and Nanocrystalline Materials,* **24-25**, 555 (2005).

W. H. Jiang, F. E. Pinkerton and M. Atzmon, "Mechanical Behavior of Shear Bands and the Effect of their Relaxation in a Rolled Amorphous Al-Based Alloy,"*Acta Materialia,* **53**, 3469 (2005).

W. H. Jiang and M. Atzmon, "Mechanical Strength of Nanocrystalline/Amorphous $Al_{90}Fe_5Gd_5$ Composites Produced by Rolling," *Applied Physics Letters,* **86**, 151916 (2005).

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Structural Relaxation and Properties of Planar Defects in Amorphous and Nanocrystalline Metals

M. Atzmon, PI; D. Jang, Graduate Student
National Science Foundation, Division of Materials Research
$365,000/3 yrs

In crystalline solids, the atomic scale structure has been understood for a long time. On the other hand, the structure of some nonequilibrium materials is still the subject of current research. In amorphous materials, the density is variable and is a function of the thermomechanical history. Structural relaxation has a significant effect on the properties. Since mechanical deformation introduces shear bands whose density is lower than that of the

matrix, it is important to understand their structure and effect on mechanical and transport properties. A similar issue exists in nanocrystalline metals. The structure of grain boundaries is a function of the sample history, and it affects the mechanical properties. In this work, the effect of thermomechanical treatment on the hardness and strain-rate sensitivity is being studied. Modern high-resolution transmission-electron microscopy methods are used to explain the observed property changes.

Nanoparticle-Environment Interfaces: Interactions in Natural Systems

R. C. Ewing and L. M. Wang, Co-PIs (with U. Beker, Geological Sciences)
N. Pavenayotin, Graduate Student; S. Zhu, Research Fellow
National Science Foundation, Nanoscale Interdisciplinary Research Team (NIRT) program
$1,499,000/4 years

Recent developments in surface analysis, computer simulations using quantum mechanical and empirical methods, and advanced techniques in electron microscopy now allow the accurate characterization and modeling of interface properties between nanoparticles and their immediate atomic-scale environment. These properties encompass the structural relationships between both phases, the stability of nanomaterials in their respective hosts, the chemistry in and near the interface, electron transfer mechanisms across the interface, and magnetic ordering in the nanoparticle, as well as in the near-interface region of the host matrix. In this research program, we apply the combination of newly-developed experimental and theoretical capabilities to a variety of research topics that collectively focus on the important role of nanoparticle interfaces in natural systems, such as the formation of metal particles on sulfide and oxide surfaces and their incorporation into the bulk, transport of metal-bearing nanoparticles in atmospheric particulates and groundwater colloids, and to biomineralization processes. A number of undergraduate and graduate students from different disciplines, such as mineralogy, geology, nuclear engineering, materials science, and chemical engineering are involved in the proposed projects.

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Particle-Induced Amorphization of Complex Ceramics

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W. Li, Grad. Student (MSE), J. Lian and S. Utsunomiya, Research Fellows (GeoSciences)
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$853,201/3.5 yrs

The crystalline-to-amorphous (c-a) phase transition is of fundamental importance. Particle irradiations provide a highly controlled means of investigating this phase transformation and the structure of the amorphous state. The interaction of heavy-particles (alpha-recoil nuclei, fission fragments and implanted ions) with ceramics is complex because these materials have a wide range of structure types, complex compositions, and because chemical bonding is variable (not only from structure-type to structure-type, but also within a single structure). Radiation damage and annealing can produce diverse results, but most commonly, single crystals become aperiodic (the metamict state) or break down into a polycrystalline aggregate (sometimes not the same as the original phase). In this research program, the transitions from the periodic to aperiodic state of various nonmetallic materials (both natural and synthetic) are studied by detailed x-ray diffraction analysis, *in-situ* transmission electron microscopy, high resolution transmission electron microscopy, x-ray photoelectron spectroscopy, extended x-ray absorption fine structure spectroscopy/x-ray absorption near edge spectroscopy and other spectroscopic techniques. A theoretical model is also being developed to predict the relative susceptibility of ceramic materials to radiation-induced amorphization based on the experimental results.

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Self-Organized 3-D Array of Nanostructures Under Irradiation

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S. Zhu, Res. Fellow, T. H. Ding, A. Perez-Bergquist and Q. Wei (MSE), Graduate Students
U.S. Department of Energy; Office of Basic Energy Sciences
$580,335/3.5 yrs

The main goal of this research project is to obtain better scientific understanding of a spectacular phenomenon induced by radiation effects, i.e. the formation of 3-D ordered arrays of nanoclusters for the advancement of nanoscience and technology. The phenomenon was first observed over 30 years ago as void lattice in irradiated pure metals,

but the nanocluster in the array can also be interstitial plates (dislocation loops), gas bubbles or metal colloids (in multiple component nonmetals). These arrays are considered as nanostructures not only because the clusters in the array are nanometer in diameter, but also because the "lattice parameters" of the array are also in the nanoscale. *In situ* and high resolution TEM are used to reveal the process of the nanostructure formation during ion beam irradiation. State of the art facilities that link modern TEMs with ion accelerators at Argonne National Laboratory and in Japan are used for the study.

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Accelerator-Based Study of Irradiation Creep of Pyrolytic Carbon Used in TRISO Fuel Particles for Very High Temperature Reators (VHTR)

L. M. Wang, PI and G. S. Was (Co-PI)
Rongsheng Zhou, Post-doctoral scholar
U.S. Department of Energy, Nuclear Energy Research Initiative (NERI)
$616,851/3 yrs

Pyrolytic carbon (PyC) is one of the structural materials in the TRISO fuel particles which will be used in the next generation of gas-cooled very-high-temperature reactors. When the TRISO particles are under irradiation, creep of the pyrocarbon layers can cause radial cracking leading to catastrophic particle failure. Therefore, a fundamental understanding of the creep behavior of PyC during irradiation is required to predict the overall fuel performance.

The primary objective of this project is to characterize the creep behavior of PyC through a systematic program of accelerator-based proton irradiation and *in-situ* measurements under stress at various temperatures between 400°C and 1,200°C. Test data will be analyzed to determine creep coefficients, which will then be correlated to existing coefficients measured under neutron irradiation. In addition, initial experiments on the transport of select fission products (e.g., Ag and Sr) in PyC under irradiation and stress will be conducted by implanting ions into the sample surface. The PyC microstructure will be studied with advanced analytical transmission electron microscopy (TEM).

Acquisition of a Research Grade Ion Implanter for Research and Education in Ion Beam Modification of Materials

G. S. Was, PI
National Science Foundation
$864,288/2 yrs

A new and highly versatile ion implanter will provide greatly expanded capabilities to the University's research programs, attract new research projects and foster the training of graduate and undergraduate students in ion-solid interactions. The 400 kV ion implanter made by National Electrostatics Corporation consists of an ion source and lens system, a gas supply system, a 90° analyzing magnet, a mass defining slit, beam position monitor, accelerator tube, and electrostatic quadrupole triplet lens, a beamline with a Faraday cup, neutral beam trap and raster-scanner, and a target station capable of 6 inch (150 mm) wafer handling, a four-position faraday cup arrangement for dose measurement and target temperature control from LN_2 temperature to 800°C, and an ion source (Danfysik model 921A) for the production of high current and high brightness ion beams. Its versatility is due to its ability to ionize materials that have a low vapor pressure by using an oven to heat the

charge materials to several hundred degrees, giving it the capability of making ions from a large fraction of the periodic chart. The implanter will be utilized immediately in research programs encompassing a wide range of scientific disciplines and focusing on nanoparticle formation in metals and ceramics, semiconductor nanostructures and heterostructures, atomic and molecular structure modification, and biomedical device materials. Examples of some of the novel uses of this facility are the formation of 3-D arrays of nanostructures to enhance physical and mechanical properties of materials, semiconductor nanopatterning by seeding the formation of nanometer-sized arrays of semiconductor structures, synthesis of bipolar quantum dot thermoelectric devices, femtosecond laser-assisted molecular beam epitaxy, refractive index patterning and the improvement of photoactive devices via ion implantation, and improved adherence of polymer coatings used in next-generation embolization coils for treating neurovascular defects, such as aneurysms and brain tumors. It will also play the lead role in providing surface modification capability to users of the NSF National Nanotechnology Infrastructure Network (NNIN) at the Michigan node. Overall, this implanter will provided a critical resource to 14 active research programs encompassing the work of 28 faculty in 9 departments at Michigan and representing over $22M of active or pending research programs, and will provide a unique resource to surrounding and partner schools. A significant role of the implanter will be to promote the teaching, training and education of graduate, undergraduate students and post-docs in surface modification and materials at the nanoscale, through research projects and formal classes, and to provide special programs for undergraduate students and K-12 outreach.

Alloys for 1000°C Service in the Next Generation Nuclear Plant

G. S. Was, PI (with J. W. Jones and T. Pollock)
D. Kumar and J. Kim, Graduate Students
U.S. Department of Energy, Nuclear Energy Research Initiative (NERI) ($873,912/3 yrs)
Idaho National Laboratory
$181,000/3 yrs

The objective of the proposed research is to define strategies for the improvement of alloys for structural components, such as the intermediate heat exchanger and primary-to-secondary piping, for service at 1000°C in the He environment of the NGNP. Specifically, we will investigate the oxidation/carburization behavior and microstructure stability and how these processes affect creep. While generating this data, the project will also develop a fundamental understanding of how impurities in the He environment affect these degradation processes and how this understanding can be used to develop more useful life prediction methodologies. Our initial studies will focus on the mechanisms controlling the high temperature degradation of nickel-base alloy 617. Understanding the degradation mechanisms will allow us to predict long-term behavior (to extrapolate lab results to long-

term service performance) and to identify an effective approach to modify existing alloys for improved performance. To achieve the latter, we will also investigate two material modification strategies; alloy modifications that provide additional solid solution strengthening and reduce interdiffusion (and therefore creep), and grain boundary engineering to reduce creep. The alloy selection and materials requirements will be based on the Next Generation Nuclear Plant Materials Selection and Qualification Program Plan (INEEL/EXT-03-01128) and the research plan will be closely integrated with, and designed to complement ongoing and planned studies on alloy 617 at INEEL and ORNL. The research will also provide a platform for educating students in the area of nuclear reactor materials and related issues.

BWRVIP Highly Irradiated Stainless Steel Crack Growth

G. S. Was, PI
S. Teysseyre, Assistant Research Scientist
General Electric
$50,000/2 yrs

This program focuses on post-test fracture surface examination of CGR samples in a scanning electron microscope (SEM) in a hot cell, in support of a larger program being conducted by General Electric for the Electric Power Research Institute. The microscope we will be using is a Philips Quanta-HiVac SEM. This instrument is ideal for hot cell applications as the vacuum and column system can be separated from the computer control. So, the instrument can be moved into the hot cell when needed while the computer control is located outside. Further, this instrument has a large specimen chamber and sample mounting system, both easing SEM use within a hot cell. The Quanta SEM uses operating voltages between 1 and 30 kV, allowing for analysis on a wide range of materials and excitation of the x-rays from all elements of interest. Energy dispersive x-ray spectrometry and a back-scatter detector will provide compositional analysis of irradiated specimens.

Each sample fracture surface will be examined to verify the straightness of the crack front and also to verify that the crack mode was indeed intergranular. Fracture surfaces will also be used to calibrate the DCPD results. The fracture mode during crack growth will be characterized in terms of the degree of intergranularity and to characterize secondary cracking. Both halves of the CT sample will be examined.

Candidate Materials Evaluation for the Supercritical Water-Cooled Reactor

G S. Was, PI

R. Zhou, Post-doctoral scholar; E. West, Graduate Student

U.S. Department of Energy, Nuclear Energy Research Initiative (NERI)

$486,250/3 yrs

The supercritical-water-cooled reactor (SCWR) system is being evaluated as a Generation IV concept because it and builds on currently proven light water technology to provide for high thermal efficiency and plant simplification. Development, testing, and selection of suitable materials for cladding and internal components are central to the development of a SCWR. Supercritical water presents unique challenges to the long-term performance of engineering materials. Corrosion and stress corrosion cracking (SCC) in particular have been identified as critical problems because the temperature and the oxidative nature of supercritical water may accelerate the corrosion kinetics and induce stress corrosion cracking. In addition, the presence of radiation can influence corrosion and SCC both by altering the material microstructure and by accelerating corrosion and SCC due to the generation of oxygen and other free radicals via radiolysis. The existing database on the corrosion and stress corrosion cracking of materials in supercritical water is very sparse. Data on the behavior of irradiated alloys is non-existent.

The objective of the proposed research is to investigate degradation of materials in the supercritical water environment. First, representative alloys from the important classes of candidate materials will be studied for their corrosion and stress-corrosion cracking resistance in supercritical water. These will include ferritic-martensitic steels, austenitic stainless steels, and Ni-base alloys. Corrosion and SCC tests will be conducted at various temperatures and exposure times, as well as in various water chemistries. Second, emerging plasma surface modification and grain boundary engineering technologies will be applied to modify the near surface chemistry, microstructure, and stress-state of the alloys prior to corrosion testing. Third, the effect of irradiation on corrosion and stress-corrosion cracking of alloys in the as-received and modified/engineered conditions will be examined by irradiating samples using high-energy protons and then exposing them to supercritical water. All these tests will be performed in close coordination with, and as a complement to, the Generation IV testing programs on radiolysis corrosion/SCC of neutron irradiated materials in supercritical water. The research program will be performed by the University of Wisconsin and the University of Michigan. Both these institutions have a proven infrastructure for successfully implementing all aspects of the proposed research. The research will have a strong educational component with several graduate and undergraduate students participating.

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Constant Extension Rate Testing of Alloy 690 in Supercritical Water

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S. Teysseyre, Assistant Research Scientist
$25,000/1 yr

Stress corrosion cracking susceptibility of Alloy 690 has been assessed by crack growth rate tests at temperatures just below and above the critical limit of water in an effort to obtain accelerated test data and to assess the likelihood of SCC occurring in primary water conditions. Results have produced IGSCC in alloy 690 and slow but stable crack growth rates [recent unpublished data by Jacko and Andresen]. Constant extension rate experiments on a different heat of alloy 690 in 400°C pure SCW containing less than 10 ppb O_2 produced IGSCC, indicating a susceptibility to crack initiation under these conditions [Was, 12th Env. Deg.]. A set of CERT experiments are proposed to 1) determine the SCW conditions under which alloy 690 is susceptible to IGSCC in SCW, 2) whether the cracking depends on water density, 3) whether it is the same as that in subcritical water, and possibly 4) whether hydrogen additions can affect cracking.

High Temperature Materials for the Gas-Cooled Fast Reactor

G. S. Was, PI
G. Gupta, graduate student
Idaho National Laboratory
$50,000/1 yr

Both France and the United States have a shared interest in the development of advanced reactor systems that employ inert gas as a coolant. Currently, insufficient physical property data exist to qualify candidate materials for gas-cooled fast reactor (GFR) designs. The overall goal of the GFR materials qualification program is to establish candidate metallic and ceramic materials for GFR designs and to evaluate the mechanical properties, dimensional stability, and corrosion resistance.

As part of the GFR evaluation of metallic components, a study is underway to determine if grain boundary engineering techniques can improve the high temperature creep strength of candidate metals by optimizing grain boundary structural orientations. As part of this study, the focus of our work is in the following areas: 1) grain boundary engineering of T91 and HT-9, 2) tests to understand the thermal stability of treatments developed to optimize the grain boundary structure of T91, 3) creep testing of alloy T91 in both the as-received and optimized conditions, 4) characterization of the microstructure in the as-received, aged, crept and optimized alloy T91, and 5) grain boundary engineering of nickel-base alloy 617.

Localized Deformation as a Primary Cause of Irradiation Assisted Stress Corrosion Cracking

G. S. Was, PI (with J. T. Busby, ORNL – collaborator)
G. Jiao, Postdoctoral Scholar
U.S. Department of Energy, Nuclear Engineering Education Research Program (NEER)
$300,000/3 yrs

The purpose of this project is to establish that localized deformation in irradiated LWR core internals is a primary factor in irradiation assisted stress corrosion cracking (IASCC). This mode of degradation is a continuing problem in existing LWRs and is expected to be a more serious problem in advanced LWRs and water-cooled Generation IV concepts such as the supercritical water reactor. Progress in understanding the mechanism driving IASCC has been slow due to the difficulty in unfolding the various contributions to the irradiated microstructure that may contribute to IG cracking. However, data from both unirradiated and irradiated austenitic alloys point toward slip localization in the form of intense, dislocation channels as a common factor in the cause of IG cracking in these alloys. The plan of work seeks to establish the role of localized deformation using a series of carefully chosen alloys and a systematic set of experiments designed to quantify the degree of slip localization as a function of alloy stacking fault energy (SFE) and dislocation channeling following irradiation. Experiments in BWR normal water chemistry will provide the link between slip localization and IASCC susceptibility. A primary outcome of the project is to provide guidance for the development of mitigation measures for IASCC.

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A Mechanistic Basis for Irradiation Assisted Stress Corrosion Cracking

G. S. Was, PI
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$60,000/2 yrs

Irradiation assisted stress corrosion cracking (IASCC) refers to intergranular stress corrosion cracking that is accelerated under the action of irradiation in light water reactor core components. It is referred to as "assisted" because irradiation enhances, or accelerates the IGSCC process over the unirradiated state. IASCC has been a problem in the nuclear industry for the last 30 years and continues to occur due to a lack of understanding of its underlying mechanism. It is the single most important problem in core component cracking in boiling water reactors (BWR) [1] and is of growing importance in pressurized water reactors (PWR). Understanding the mechanism of IASCC is required in order to provide guidance for the development of mitigation strategies.

The IASCC problem has taken on new urgency with the proposal of more advanced water reactor concepts under the Generation IV program [2], such as the supercritical water reactor (SCWR). The SCWR represents a more demanding environment than LWRs in temperature, irradiation dose and the corrosiveness of the media itself. As such, there is an even more pressing need to develop a solution to the IASCC problem. However, in order to do so, the underlying mechanism must first be understood. This proposal aims to establish such an understanding, which will lead directly to mitigation strategies for current and future reactors. The objective is to determine whether deformation mode is a primary factor in the mechanism of irradiation assisted intergranular stress corrosion cracking of austenitic alloys in light water reactor core components.

Stress Corrosion Cracking and Corrosion of Candidate Alloys for the Supercritical Water Reactor Concept

G. S. Was, PI
S. Teysseyre, Assistant Research Scientist
U.S. Department of Energy, International Nuclear Energy Research Initiative (INERI)
$1,033,207/3 yrs

Supercritical water presents unique challenges to the long-term operation of engineering materials. The generation of oxygen and hydrogen gas by radiolysis and the high solubility of these gases in supercritical water may result in higher corrosion and stress corrosion cracking rates than experienced with other reactor designs. In addition, radiation may accelerate or assist the stress corrosion cracking in the reactor region, and stress corrosion cracking and accelerated corrosion may occur in the preheat and cool-down sections of the circuit. The existing data base on the corrosion and stress corrosion cracking of austenitic stainless steel and nickel based alloys in supercritical water is very sparse. Data on the behavior of irradiated alloys is non-existent. Therefore, the focus of this work will be stress-corrosion-cracking behavior of candidate fuel cladding and structural materials in the unirradiated and irradiated conditions. Two high-temperature autoclave systems have been built to test the SCC and corrosion behavior of unirradiated and proton-irradiated materials. Proton irradiation is used as a surrogate for neutron irradiated material in order to get a first look at the response of candidate alloys to irradiation, and also to cover alloys for which there are currently no neutron irradiated samples for testing. A third high-temperature autoclave coupled to a loading system, and capable of straining up to four tensile samples in constant extension rate mode or one compact tension sample in crack growth rate mode is being built and operated at the University of Michigan (U-M). This system is being constructed for conducting experiments on neutron-irradiated materials. The resulting data will be used to further narrow the list of promising materials and develop appropriate stress-corrosion-cracking correlations. The capability to conduct both crack growth rate and constant extension rate tensile experiments on neutron-irradiated samples will constitute the first facility capable of assessing SCC of neutron irradiated alloys in supercritical water.

The work plan for this three year (FY05-FY07) program consists of four principal tasks; 1) the completion of a facility to conduct crack growth rate and constant extension rate tensile tests on highly radioactive, neutron irradiated samples in supercritical water, 2) constant extension rate tests and crack growth rate tests of candidate alloys in supercritical water, 3) proton irradiation and constant extension rate tests of proton-irradiated samples in supercritical water and 4) constant extension rate tests and crack growth rate tests of candidate neutron-irradiated alloys in supercritical water.

S. Teysseyre, Q. Peng, C. Becker and G. S. Was, "Facility for Stress Corrosion Cracking of Irradiated Specimens in Supercritical Water," *J. Nucl. Mater*. (In press)

G. S. Was and S. Teysseyre, "Challenges and Recent Progress in Corrosion and Stress Corrosion Cracking of Alloys for Supercritical Water Reactor Core Components," *Proc. 12th International Conference on Degradation of Materials in Nuclear Power Systems – Water Reactors*, The Minerals, Metals and Materials Society, Warrendale, PA. (In press)

G. S. Was and S. Teysseyre, "Corrosion of Austenitic Alloys in Supercritical Water," submitted to *Corrosion*.

S. Teysseyre and G. S. Was, "Stress Corrosion Cracking of Austenitic Alloys in Supercritical Water," submitted to *Corrosion*.

G. S. Was, S. Teysseyre, Z. Jiao and J. McKinley, "Oxidation and Stress Corrosion Cracking of Austenitic Alloys in Supercritical Water," *Proc. NACE International Annual Conference, Corrosion 2005*, paper #05397, Houston, TX (2005).

G. S. Was and P. L. Andresen, "Stress Corrosion Cracking of Alloys in Aggressive Nuclear Reactor Core Environments," *Proc. NACE International Annual Conference, Corrosion 2005*, paper #05RTS5, Houston, TX (2005).

G. S. Was and T. R. Allen, "Time, Temperature and Dissolved Oxygen Dependence of Oxidation of Austenitic and Ferritic-Martensitic Alloys in Supercritical Water," *Proc. ICAPP2005*, paper #5690, Seoul, S. Korea, American Nuclear Society, LaGrange Park, IL (2005).

G. S. Was, S. Teysseyre and J. McKinley, "Corrosion and Stress Corrosion Cracking of Iron- and Nickel-base Austenitic Alloys in Supercritical Water," *Proc. NACE Annual Conference, Corrosion 2004*, paper #04492, New Orleans, LA (2004).

S. Teysseyre, J. McKinley, G. S. Was, D. B. Mitton, H. Kim, J-K Kim and R. M. Latanision, "Corrosion and Stress Corrosion Cracking of Austenitic Alloys in Supercritical Water," *Proc. 11th Int'l Conf. Environmental Degradation of Materials in Nuclear Power Systems – Water Reactors*, 63-72, American Nuclear Society, La Grange Park, IL (2004).

PLASMAS AND FUSION

Electron Cyclotron Plasma Sources

R. M. Gilgenbach, PI and Y. Y. Lau, Co-PI
National Aeronautics and Space Administration
$106,000/1 yr

This project explores a new type of plasma rocket that uses a microwave plasma electron cyclotron resonance.

Yoshitera Hidaka, "Experiments and Simulations of a Large Area ECR Source as an Electric Propulsion Neutralizer," Doctoral Dissertation, University of Michigan, Ann Arbor (2005).

Experimental and Theoretical Studies of Wire Z-Pinches

R. M. Gilgenbach, PI and Y. Y. Lau, Co-PI
U.S. Department of Energy/Sandia National Laboratories
$300,000/yr

The purpose of this work is to perform detailed diagnostics on expanding plasma ionization dynamics of a new z-pinch plasma experiment built at the University of Michigan.

T. Strickler, Y. Y. Lau, R. M. Gilgenbach, M. E. Cuneo and T. A. Mehlhorn, "Azimuthal Clumping Instability in a Z-Pinch Wire Array," *Phys. Plasmas*, **12**, 052701 (2005).

T. Strickler, "Azimuthal Wire Motion and Ablation Dynamics in Z-Pinches," Doctoral Dissertation, University of Michigan, Ann Arbor (2006).

DURIP Equipment Grant: Versatile Ultrawideband Generator and Antenna System

R. M. Gilgenbach, PI and Y. Y. Lau, Co-PI
U.S. Department of Defense/Air Force Office of Scientific Research
$205,000/1 yr

This is supplementary funding for equipment purchase for ultrawideband generator and antenna for biological applications.

Industrial Affiliates Program (L-3 Communications)
R. M. Gilgenbach, PI and Y. Y. Lau, Co-PI
L-3 Communication Electron Devices
$10,000/yr

This gift from L-3 Communications facilitates communication with researchers in the U-M Intense Energy Beam Interaction Laboratory.

Industrial Affiliates Program (Northrop Grumman)
R. M. Gilgenbach, PI and Y. Y. Lau, Co-PI
Northrop Grumman Corporation
$10,000/2 yrs

This gift from the Northrop Grumman Corporation facilitates communication with researchers in the U-M Intense Energy Beam Interaction Laboratory.

Nanophysics of Electron Emission and Breakdown for High Power Microwaves
R. M. Gilgenbach, PI and Y. Y. Lau, Co-PI
U.S. Department of Defense/Air Force/Univ. CA-Davis
$350,000/5 yrs

This project concerns several issues in microwave generation from vacuum electron microwave devices.

R. J. Umstattd, C. G. Carr, C. L. Frenzen, J. W. Luginsland and Y. Y. Lau, "A Simple Physical Derivation of Child-Langmuir Space-Charge-Limited Emission Using Vacuum Capacitance," *Am. J. Phys.,* **73**, 160 (2005).

W. Tang, H. Bosman, Y. Y. Lau and R. M. Gilgenbach, "Ohmic Heating of Particulates in a Lossless Medium," *J. Appl. Phys.* **97**, 114915 (2005).

K. Jensen, Y. Y. Lau and N. Jordan, "Emission Nonuniformity Due to Profilimetry Variation in Thermionic Cathodes," *Appl. Phys. Lett*., **88**, 164105 (2006).

L. K. Ang, W. S. Koh, Y. Y. Lau and T. J. T. Kwan, "Space-Charge-Limited Flow in the Quantum Regime," *Phys. Plasmas*, **13**, 056701 (2006). (Invited paper)

Phase Locking of Commercial Magnetrons

R. M. Gilgenbach, PI and Y. Y. Lau, Co-PI
U.S. Office of Naval Research/University of New Mexico
$370,000/3 yrs

This project is to study mode locking of high power microwave devices, in collaboration with the University of New Mexico.

Relativistic Magnetron Priming Experiments and Theory

R. M. Gilgenbach, PI and Y. Y. Lau, Co-PI
U.S. Department of Defense/Air Force Office of Scientific Research
$1,856,000/5 yrs

This research is to provide novel methods of priming relativistic magnetron for generating 100's MW microwave pulses.

V. B. Neculaes, P. Pengvanich, Y. Hidaka, Y. Y. Lau, R. M. Gilgenbach, W. White, M. C. Jones and H. Bosman, "Rapid Kinematic Bunching and Parametric Instability in a Crossed-Field Gap with a Periodic Magnetic Field," *IEEE Trans. Plasma Sci.*, **33**, 654 (2005).

M. C. Jones, V. B. Neculaes, W. White, Y. Y. Lau, R. M. Gilgenbach, J. W. Luginsland, P. Pengvanich, N. M. Jordan, Y. Hidaka and H. Bosman, "Simulation of Magnetic Priming in a Relativistic Magnetron," *IEEE Trans. Electron Device*, **52**, 858 (2005).

V. B. Neculaes, M. C. Jones, R. M. Gilgenbach, Y. Y. Lau, R. M. Gilgenbach, J. W. Luginsland, B. W. Hoff, W. M. White, N. M. Jordan, P. Pengvanich, Y. Hidaka and H. Bosman, "Magnetic Perturbation Effects on Noise and Startup in DC-Operating Oven Magnetrons," *IEEE Trans. Electron Devices*, **52**, 864 (2005).

P. Pengvanich, V. B. Neculaes, Y. Y. Lau, R. M. Gilgenbach, M. C. Jones, W. M. White and R. D. Kowalczyk, "Modeling and Experimental Studies of Magnetron Injection Locking," *J. Appl. Phys.,* **98**, 11, 114903 (2005).

M. C. Jones, V. B. Neculaes, Y. Y. Lau, R. M. Gilgenbach, W. M. White, B. W. Hoff and N. M. Jordan, "Magnetron Priming by Multiple Cathodes," *Appl. Phys. Lett.*, **87**, 081501 (2005).

R. M. Gilgenbach, Y. Y. Lau, H. McDowell, K. L. Cartwright and T. A. Spencer, "Crossed-Field Devices," in *Modern Microwave and Millimeter-Wave Power Electronics*, edited by R. J. Barker, J. H. Booske, N. C. Luhman and G. S. Nusinovich, Ch. 6, IEEE Press, Piscatway, NJ (2005).

W. M. White, R. M. Gilgenbach, M. C. Jones, V. B. Neculaes, Y. Y. Lau, P. Pengvanich, N. Jordan, B. W. Hoff, R. Edgar, T. A. Spencer and D. Price, "Radio Frequency Priming of a Long-Pulse Relativistic Magnetron," *IEEE Trans. Plasma Sci.*, **34**, 627 (2006).

Ultra-Wideband RF Enhanced Electroporation for Chemotherapy

R. M. Gilgenbach, PI; Y. Y. Lau and M. Uhler (Medical School), Co-PIs
U.S. Department of Defense/Air Force Office of Scientific Research
$900,000 for 6 years

This is an innovative new research project that explores the fundamental interactions of non-ionizing RF radiation with biological cells. The goal is to combine ultra-wideband radiation with chemotherapy treatment of tumor cells. A factor of 1,000 improvement in chemotherapy drug effectiveness has been demonstrated by the application of high electric fields to cells.

D. W. Jordan, M. D. Uhler, R. M. Gilgenbach and Y. Y. Lau, "Enhancement of Cancer Chemotherapy *in vitro* by Intense Ultrawideband Electric Field Pulses," *J. Appl. Phys.*, **99**, 094701 (2006).

A. L. Garner, Y. Y. Lau, M. D. Uhler, D. W. Jordan and R. M. Gilgenbach, "Incorporating Spatial Dependence into an Ontogenetic Multicellular Tumor Spheroid Growth Model," *J. Appl. Phys.*, **98**, 124701 (2005).

A. L. Garner, Y. Y. Lau, D. W. Jordan, M. D. Uhler and R. M. Gilgenbach, "Implications of a Simple Mathematical Model to Cancer Cell Population Dynamics," *Cell Prolif.*, **39**, 15 (2006).

Intergovernmental Personnel Act (IPA) Assignment at Air Force Research Laboratory

Y. Y. Lau, PI
U.S. Department of Air Force
$79,135/9 months

This is to support the 2005-2006 sabbatical leave with work in high power microwaves.

Study of Plasma Dynamics in the GDM Plasma Thruster
T. Kammash, PI
NASA – GSRP
$48,000/2 yrs

Plasma confined in the Gasdynamic Mirror (GDM) can be heated to sufficiently high temperatures to serve as a thruster when the plasma is ejected from one of the mirrors to generate thrust. Several conditions must be satisfied in order for this to be achieved, including adequate confinement, generation of the accelerating electrostatic potential and stability for the duration of this confinement. This study is aimed at addressing the various plasma phenomena that impact these conditions.

T. Kammash, R. Tang and B. Cassenti, "A Bi-Model Fusion Propulsion System for He-3 Mining of the Planets," *Trans. American Nuclear Society*, **94**, 4-8 (2006).

T. Kammash, "Antiproton-Driven Gas Core Fission Rocket," *J. British Interplanitary Society,* **59**, 23-26 (2006).

T. Kammash, "Nuclear Powered Laser Driven Plasma Propulsion System," *J. British Interplanetary Society*, **58**, 407 (2005).

T. Kammash, "Antiproton Induced Fission for Nuclear Rocket Propulsion," *Proc. 53rd JANNAF Propulsion Meeting*, Monterey, CA, December 5-8, 2005.

T. Kammash and R. Tang, "Propulsive Capability of Assymmetric GDM Propulsion System," *Paper #AIAA-2006-4391*, 42nd Joint Propulsion Conference, Sacramento, CA, July 9-12, 2006.

T. Kammash and R. Tang, "Antiproton Driven Bi-Model Fusion Propulsion System," *Paper #AIAA-2006-4394*, 42nd Joint Propulsion Conference, Sacramento, CA, July 9-12, 2006.

RADIATION MEASUREMENTS AND IMAGING

Increased Range Neutron Response High Explosives Detection

M. D. Hammig, PI
U.S. Department of Defense, Air Force (subcontract)
$98,359/9 months

A depth-sensitive Compton camera based on fast inorganic scintillators is being developed as a means to rapidly image high explosives and other organic materials in three dimensions at intermediate to long ranges. When coupled with an intense pulsed neutron source, the fast response and sizable detection areas of BaF_2 scintillators permit the rapid imaging of the environment in both depth and angle. This project, a collaboration between the University of Michigan and a small business concern, includes the development of novel position sensing techniques within the volume of a scintillation material and the further advance of fast timing techniques.

M. D. Hammig and B. T. Wells, "Development of a Depth and Angular-Sensitive Gamma-Camera for Imaging Neutron-Interrogated Materials," presented at 2006 IEEE Nuclear Science Symposium, San Diego, CA.

Gamma Ray Array for Passive Detection of Hidden Objects

M. D. Hammig, PI
U.S. Department of Defense, Army (subcontract)
$98,224/6 months

During this project, we are determining the optimal means by which one may use the natural background radiation to see hidden objects in buildings and below ground. To that end, we are building a gamma-ray detector array, based primarily on semiconductor devices composed of silicon, to image deviations in the angular distribution of the incident gamma-rays. One of the goals of this business-university collaboration is to extend both the carrier and spatial sensitivities of position-sensing semiconductor devices.

Constructing 3D CdZnTe Polaris II Isotope Identifier

Z. He, PI
U.S. Department of Energy/Battelle Pacific Northwest Laboratories
$724,728/3 yrs (started March 2006)

This project develops the first array system using 3-dimensional position-sensitive CdZnTe gamma-ray spectrometers for isotope identification. This system will employ 18 1.5×1.5×1 cm^3 modular detectors, having a total detection volume of 40.5 cm^3. The expected energy resolution is about 1% FWHM or better at 662 keV gamma-ray energy and angular resolution less than 20 degrees within a 4π solid angle. The applications are for nuclear non-proliferation and homeland security.

Fast Neutron Imaging Spectrometers

Z. He, PI; G. F. Knoll and D. K. Wehe, Co-PIs
U.S. Department of Energy/NEER
$336,756/3 yrs

The remote sensing of nuclear materials is important for DOE programs in national security and international arms control, especially after the tragic events of September 11. The detection of fast neutrons is important in these applications. The sensitivity of such measurements can be greatly enhanced if information is also gained on the direction of the incoming radiation. Systems for the imaging of gamma ray sources are under development at a number of laboratories. We are interested in extending this imaging capability to fast neutron measurements.

The goal of this project is to develop a fast neutron spectrometer design that is capable of localizing the incident direction of each detected neutron without the use of collimation. The principle is based on a parallel approach to Compton scatter imaging for gamma rays. The effective detection efficiency of such a system can be orders of magnitude higher than that for a collimated system, and the large mass and imperfect angular selection of a fast neutron collimator are avoided. The approach can also provide an unambiguous measurement of the incident neutron energy that may be exploited to differentiate between various possible sources of neutrons.

Miniature Neutron-Alpha Activation Spectrometer

Z. He, PI; J. P. Holloway and R. F. Fleming, Co-PIs
National Aeronautics and Space Administration/Johns Hopkins
$400,000/2 yrs ($131,772 comes to U-M)

The purpose of this project is to develop a miniature (under 1 kg) instrument to be used on a lander or Rover type vehicle to Mars. The instrument will provide *in situ* whole-sample composition covering a wide range of elements in the periodic table, including the identification of elements present in water and biological materials. The Miniature Neutron-

Alpha Activation Spectrometer (MiNAAS) will extend the range and penetration depth of current Rutherford backscattering spectrometers by incorporating neutron activation techniques in order to enable whole-rock determination of chemical species. MiNAAS will use neutron bombardment and detection of the resultant gamma emissions to complement and augment the composition information achieved with an alpha-based spectrometer. Novel to this approach is the development and use of a switching neutron source and a small high-resolution gamma-ray detector. By adding a capability for neutron activation analysis to the traditional APX instrument, elemental composition coverage will be complemented and extended. Lighter but abundant elements crucial to determine petrologic rock type (e.g. oxygen, carbon, hydrogen, sodium) and nickel and rare earths will be detected, providing diagnostic information on the state of planetary differentiation, the history of igneous activity, and the identification of chemical substances that may reveal either the existence or potential for the enviroment to sustain life. It may also feasible to use MiNAAS as the front end for an instrument suite (including possibly a core driller and mass or infrared spectrometers), to select promising samples from the vast array of candidates on the planet surface and hereby avoid wasting resources.

The University of Michigan group focuses on the development of small high-resolution gamma-ray spectrometers based on depth-sensing coplanar-grid CdZnTe detectors.

Detection of Shielded Uranium and Plutonium

Z. He, PI
Department of Defense, Defense Threat Reduction Agency (DTRA)
$2,800,000/2 yrs (started in March 2006)

This project is to develop unprecedented array systems using 3-dimensional position-sensitive CdZnTe and HgI_2 gamma-ray imaging spectrometers, which will have total detection volume of more than 100 cm^3 per system. These systems will be tested against real special nuclear materials at the end of the project.

Advanced Radiation Detector Development in Support of National Security Needs

Z. He, PI
U.S. Department of Energy/NA-22 Office
$1,320,000/4 yrs (started November 2005)

The goal of this research project is to develop compact radiation detectors which can be useful in non proliferation applications. The project supports exciting research in room temperature detectors using semiconductors such as CZT.

Development of Pixellated Mercuric Iodide Gamma-Ray Detectors

Zhong He, PI
Constellation Technology Corporation
$149,718/2 yrs (started September 2005)

This project develops thick (1cm) pixellated prototype HgI_2 gamma-ray spectrometers with energy resolution of about 1% FWHM at 662 keV.

Test of a 2x2x2 Array of 1.5 cm Thick CdZnTe Detectors and Study of their Internal Backgrounds in High-Altitude Balloon and Space Environment

Zhong He, PI
NASA
$97,343/1 yr (2005 – 2006)

This project is developing a 2×2 array system using 2×2×1.5 cm^3 CdZnTe 3-dimensional position-sensitive detectors for astrophysics applications.

For publications of Professor Zhong He's group, see website at:
http://czt-lab.engin.umich.edu

Very High Resolution SPECT/CT System

L. J. Meng, PI
National Institute of Health
$1,151,172/4 yrs

This project is developing an ultra-high resolution SPECT/CT system for molecular imaging research. This system is based on intensified EMCCD sensors and has an imaging spatial resolution of 100 micron or better in vivo. The system provides an unmatched capability for monitoring tiny features inside test animals that relate to abnormal radiotracer uptake. The applications of this system include monitoring the growth of tiny tumor tissue inside small animals such as mice, developing new drugs for cancer treatment based on animal models.

L. J. Meng, "Design of a Single Photon Emission Microscope for Small Animal I-125 Imaging," presented at the 52nd SNM Annual Meeting in Toronto, June 2005.

Integration of Electron Tracking into Compton Imaging for the Advanced Compton Telescope

D. K. Wehe, PI
National Aeronautics and Space Administration (NASA)
$24,000/1 yr

This project seeks to understand the significance of the Compton recoil electron direction in enhancing the images produced by electronically collimated gamma ray imagers. As position sensing capabilities continue to improve with finer pitch electrodes, it may be possible by looking at bystander signals to not only determine sub-pitch lateral resolution, but also to infer some information as to the electron's initial direction.

Mobile Robotics and Sensing – University Research Program in Robotics

D. H. Wehe, PI
U.S. Department of Energy
$852,500/yr

The University of Michigan extends the capabilities of current mobile robots to provide increased autonomy of remote operations, so that sensors and other technologies can be quickly and safely delivered to interior and outdoor environments of large expanses. The University of Michigan also develops advanced radiation sensing technologies for use in DOE environments. Current projects include the development of hybrid gamma ray imagers, development of unique digital pulse processing techniques, active interrogation for surveillance and monitoring, and micro-mechanical radiation detectors.

Radionuclides: Radiation Detection and Quantification

D. H. Wehe, PI (with W. L. Rogers)
NIH/U-M Nuclear Medicine (subcontract)
$214,933/3 yrs

This project involves the development of electronically collimated gamma ray imagers for nuclear medicine applications, including SPECT, and combined PET+SPECT for small animal imaging. NERS students work with researchers in nuclear medicine to develop the prototype imaging systems and the algorithms for interpreting the data.

RADIATION SAFETY, ENVIRONMENTAL SCIENCES, AND MEDICAL PHYSICS (REM)

Better Correlation of Outcomes with MC Dose Calculation

Alex Bielajew, PI
NIH/U-M Radiation Oncology
$8,785/1 yr

The purpose of this investigation is to see if clinical outcomes correlate better with dose calculations performed by the Monte Carlo method. The Monte Carlo method is acknowledged to be the most accurate dose calculation method. However, it is not yet resolved that using this method, which involves significant computational overhead, would improve radiotherapy delivery significantly.

Corrosion of Spent Nuclear Fuel: The Long-Term Assessment

R. C. Ewing, PI
U.S. Department of Energy, Yucca Mountain Science and Technology Program
$500,000/3 yrs

Applied Environmental Radiation Measurements Laboratory

K. J. Kearfott, PI
U-M Elizabeth Caroline Crosby Research Award
$64,000

A new facility has been established which focuses on the measurement of small amounts of radiation in the environment and in laboratory samples. Unique, practical capabilities to solve actual industrial, medical, nuclear power, and national laboratory radiation safety challenges are to be developed through applied research. A variety of specific projects, relating to nuclear facility decommissioning, nuclear power plant emissions verification, geological research, radiotracer experiments, responses to radiological terrorists events, and the clean-up of contaminated environments are possible. Capabilities include alpha spectroscopy, portable and laboratory gamma and X-ray spectroscopy with HPGe and NaI, integrative and temporal radon and radon progeny measurement, and thermoluminescent dosimetry.

S. C. Dewey, C. P. Henley, K. J. Kearfott and S. M. Bernal., "Design of an Inexpensive, Flexible, Shielded Cave for Environmental Radioactivity Measurements," *Operational Radiation Safety, Health Physics,* **88** (Supplement 5), S110-S114 (2005).

K. J. Kearfott, L. W Parker and D. A. Cusumano, "An Integrated Photon, Neutron and Beta Calibration Phantom and Storage System for Thermoluminescent Detectors (TLDs)," *Health Physics Journal,* **89**, 1, S65 (2005).

S. C. Dewey and K. J. Kearfott, "Improving the Numerical Stability of an *In-Situ* Gamma Ray Spectroscopy Method using Multiple Measurements for the Determination of Activity Concentration as a Function of Depth," *Health Physics Journal,* **89**, 1, S9-10 (2005).

Detection of Concealed Conventional Bulk Explosives

K. J. Kearfott, PI
nPoint, LLC
$305,000/yr

Several different neutron-based methods for detecting explosives are possible, all based upon detection of the excess nitrogen found in explosives. This project has as its goals the investigation of several new approaches, as well as the combination of existing approaches for improved sensitivity and specificity. The grant focuses upon the development of an experimental facility for studying these approaches.

M. T. Studenski, N. P. Haverland and K. J. Kearfott, "Simulation, Design, and Construction of a ^{137}Cs Irradiation Facility," *Health Physics Journal, Operational Radiation Safety,* submitted May 2006.

M. T. Studenski and K. J. Kearfott, "Design and Simulation of a Neutron Facility," *Health Physics Journal, Operational Radiation Safety*, submitted June 2006.

Explosives Detection Using Neutrons

K. J. Kearfott, PI
U.S. Dept. of Army, TACOM
$99,999/yr

Simulations are to be performed to fully characterize the interrogation of objects and the environment for the detection of explosives. The simulations should lead to an understanding

of the best approach for the detection of explosives. The problems of land mines, improvised explosive devices, car bombs, and large amounts of explosives held in shipping containers are to be addressed separately.

NERS 585 Laboratory Development

K. J. Kearfott, PI
U-M Department of NERS and College of Engineering
$150,000

A new laboratory is being developed for applied radiation measurements, featuring practical laboratory exercises of relevance to radiation safety, environmental sciences, and medical physics. The laboratory will also feature a combination of physical measurements with computational simulations.

J. A. Moore and K. J. Kearfott, "A Radon Chamber for Educational Purposes," *Operational Radiation Safety, Health Physics*, **89** (Supplement 5) S78-S84 (2005).

M. S. Jawad, D. K. Worthy, L. R. Baumgarten, J. A. Moore and K. J. Kearfott, "Environmental Factors Influencing Temporal Indoor Radon Concentration," *Health Physics Journal*, **89**, 1, S17 (2005).

K. J. Kearfott, J. A. Harvey, S. C. Dewey, M. L. Rodrigues, R. B. Gunnett and A. L. Lehnert, "A New Laboratory Course in Applied Radiological Measurements," *Health Physics Journal,* **89**, 1, S9 (2005).

J. A. Moore, A. L. Lehnert, S.-H Hsu and K. J. Kearfott, "A Simple Radon Chamber for Educational Usage," *Health Physics Journal,* **89**, 1, S18 (2005).

J. G. Dreyer, W. G. West, E. Wagner, K. J. Kearfott, "The University of Michigan Student Health Physics Society's Radiation and Health Physics World Wide Web Site," *Operational Radiation Safety, Health Physics*, **88** (Supplement 5), S115-S120 (2005).

Radiation Dosimeter Development

K. J. Kearfott, PI
PreSense, LLC
$285,000/yr

Illicit nuclear materials for atomic or nuclear weapons or for use in radiological dispersive devises (dirty bombs) have become of great national interest since September 11. This research project has as its goals the investigative of optically stimulated and thermally stimulated materials for use to detect such materials through the integration and read-out of signals in unique ways. New materials with specific temporal properties are also being investigated.

W. G. West, K. J. Kearfott and S. M. Bernal, "The Sunlight Optically Stimulated Luminescent (OSL) Response of a Commercially Available α-Al_2O_3:C Personnel Dosimetry Material," *Radiation Protection Dosimetry*, accepted 2004.

W. G. West, K. J. Kearfott and A. F. Kalchik, "An Affordable Optically Stimulated Luminescent Dosimeter Reader," *Health Physics Journal*, **89**, 1, S7-S8 (2005).

M. L. Rodrigues, S.-H. Hsu, K. J. Kearfott, J. E. Schlicht, M. T. Sami and T. A. Lebeis, "Temporal Sensitivity Changes and Signal Fading of LiF: Tl, Mg Under Controlled Environmental Conditions," *Health Physics Journal*, **89**, 1, S8 (2005).

L. W. Parker, J. A. Moore, S.-H. Hsu, A. L. Lehnert, M. L. Rodrigues and K. J. Kearfott, "Doses Delivered to Thermoluminescence Detectors (TLDs) Due to Radon Gas," *Health Physics Journal,* **89**, 1, S67-S68 (2005).

M. L. Rodrigues, K. J. Kearfott, S.-H. Hsu, J. E. Schlicht, L. R. Baumgarten and L. W. Parker, "The Effect of the Time-Temperature Heating Profile Design on the Precision and Accuracy of Thermoluminescent (TL) Glow Curve Peak Areas for LiF: Mg, Ti," *Health Physics Journal,* **89**, 1, S8 (2005).

R. B. Gunnett, K. J. Kearfott and J. E. Schlicht, "Experimental Verification of a Method for Obtaining Temporal Dose Information from Thermoluminescent Dosimeters (TLDs) Using a Simple Collimator with a Mechanical Rotating Mechanism," *Health Physics Journal,* **89**, 1, S8-S9 (2005).

T. A. Lebeis, W. G. West, M. L. Rodrigues, A. F. Kalchik and K. J. Kearfott, "The Thermoluminescent Properties of G-200 Feldspar in a Pressed Potassium Bromide (KBr) Matrix," *Health Physics Journal*, **89**, 1, S68 (2005).

Radioactive Materials Risk Transportation

K. J. Kearfott, PI
Sandia National Laboratories
$31,000/yr

This work involves the analytical and experimental study of the radiation exposures that result from the compromise in the lead liner of a high level waste (nuclear fuel) shipping cask. Analytical models based upon point spread functions are to be developed for incorporation into the risk analysis code RADTRAN. Verification of this equation is to be accomplished using MCNP as well as a down-scaled experimental model.

R. M Weiner, J. J Penisten and K. J. Kearfott, "Atmospheric Dispersion Model for RADTRAN," Electronic Proceedings, Institute of Nuclear Materials Management 46th Annual Meeting (2005).

Fiscal Year 2006 Research Expenditures

Total Research Expenditures Attributed to an External Sponsor and Other Sponsored Activity

Project Director	Sponsor	Project Title	Project Grant	Expenditures
Atzmon	NSF	Structural Relaxation and Properties of Planar Defects in Amorphous and Nanocrystalline Metals	F008643	75,424
Berliner	NSF	The Durability of Concrete: The Crystal Chemistry for the Calcium Aminosulfate Hydrates and Related Compounds	F004994	4,000
Gilgenbach	DoD/AF	Ultrawideband Radio Frequency (RF) Enhanced Electroporation for Chemotherapy	F006493	39,722
Gilgenbach/ Lau	DoE/Sandia National Labs	Ionization Dynamics of Wire Z-Pinches	F009898	300,941
Gilgenbach/ Lau	NASA	Electron Cyclotron Plasma Sources	F010185	21,228
Gilgenbach/ Lau	DoD/AF/U-Wisc.	Nanophysics of Electron Emission and Breakdown for High Power Microwaves	F010707	25,500
Gilgenbach/ Lau	DoD/AF	Relativisic Magnetron Priming Experiements and Theory	F012088	371,727
Gilgenbach/ Lau	DoD/AF	Cut-Cathode High-Power Microwave (HPM) Magnetron Experiments & Theories	F012908	80,970
Gilgenbach/ Lau	DoD/AF	UWB Microwave Antenna Research for Biological Applications	F013633	58,059
Gilgenbach	Applied Materials, Inc.	Applied Materials Gift Fund	G001636	24,688
Gilgenbach	L-3 Communi-cations	Support for University Research in Vacuum Electronics	N006404	4,646

Hammig	DoD/AF/ Galt LLC	Depth and Angular Imaging via a Compton Camera Using Fast Inorganic Scintillators	F015209	3,082
He	DoE	Advanced Radiation Detector Research in Support of National Security Needs	F005479	111,829
He/Knoll/ Wehe	DoE (NEER)	Fast Neutron Imaging Systems	F006740	30,430
He	NASA/ Johns Hopkins U.	Miniature Neutron-Alpha Activation Spectrometer	F009071	20,803
He	DoD/DTRA	Development of Pixellated Mecuric Iodide Gamma-Ray Detectors	F011651	15,350
He	DoD/DTRA/ Constella. Technology	Evaluation and Testing of 3D Pixellated Mecuric Iodide Gamma-Ray Detectors	F013948	67,748
He	DoE	Development of Advanced 3-D CdZnTe (Cadmium Zinc Telluride) Detector Arrays	F014259	144,550
He	NASA/ Wash. U. St. Louis	Test of 2x2x2 Array of 1.5cm Thick CdZnTe Detectors and Study of Their Internal Backgrounds in High-Altitude Balloon and Space Environments	F014439	28,582
He	DoE/SBIR Phase I	Monte Carlo Simulations of CdZnTe Strip Detectors for PET Application	F014599	7,375
He	DoE/Batelle Pacific NW Labs	Constructing 3D CdNzTe Polaris II Isotope Identifier	F015043	75,922
He	DoD/Alion Sci & Tech	Detection of Shielded Uranium and Plutonium	F015358	11,776
Holloway/ Lee/Martin	DoE (NERI)	Model-Based Transient Control and Component Degradation Monitoring in Generation IV Nuclear Power Plants	F007323	171,954
Holloway	DoE/Sandia	Development of Time-dependent Pn Solver for Alegra	F009881	44,434
Kammash	NASA/ Reisz Engineers	Effect of Ambipolar Potential on Propulsive Performance of the GOM Plasma Thruster (Phase 1 and 2)	F013022	100,942

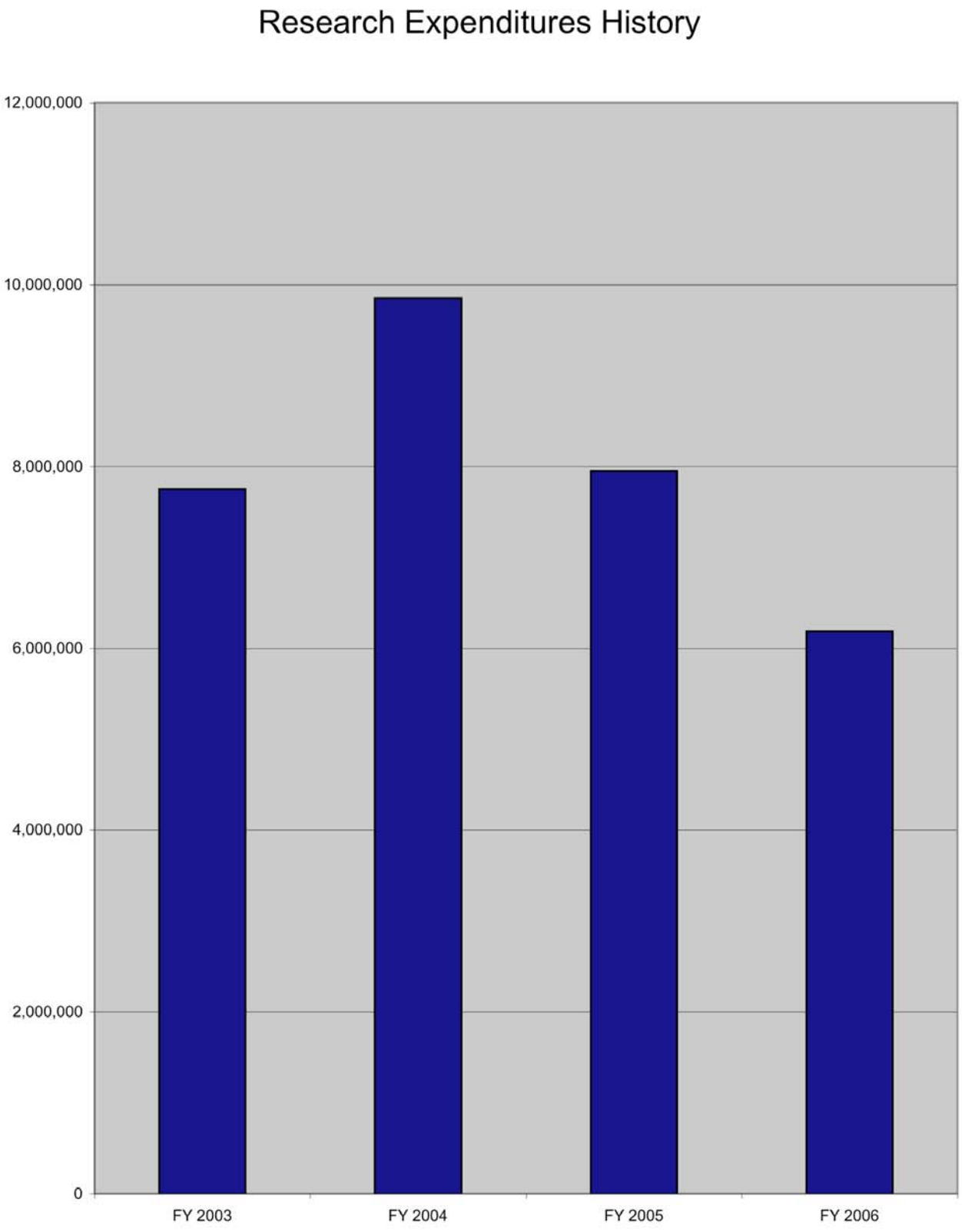
Kammash	NASA	Study of Plasma Dynamics in the Gasdynamic Mirror Plasma Thruster	F013312	22,774
Kearfott	NANT	Graduate Fellowships in Health Physics	C375114	(737)
Kearfott	DoE/Sandia	Radioactive Materials Transportation Risk Analysis	F011682	9,083
Kearfott	DoD/Army/ Battelle	Explosives Detection Using Neutrons	F013093	90,665
Kearfott	NPoint, LLC	Detection of Concealed Conventional Bulk Explosives	N006629	58,037
Kearfott	NPoint, LLC	Radiation Dosimeter Development	N006630	180,340
Knoll	Elsevier Science B. V.	Editorial Services, Nuclear Instruments and Methods in Physics Research	C391987	(11,620)
Knoll	Elsevier Science B. V.	Editorial Services, Nuclear Instruments and Methods in Physics Research	N007321	32,662
Larsen	DoE/U-CA	ASCI Research Contract	F009833	34,173
Larsen/ Martin	DoE (NEER)	Advanced Variance Reduction for Global k-Eigenvalue Simulations in MCNP5	F011419	182,559
Lau	DoE	Analysis of Multipactor Discharge	C036858	3,254
Lau	DoD/AF	Intergovernmental Personnel Act (IPA)	F014573	45,219
Lee/Martin/ Holloway	DoE (I-NERI)	Development of Safety Analysis Codes and Experimental Validation for a Very High Temperature Gas-Cooled Reactor	F008698	65,180
Lee	DoE/ Penn State Univ.	Proposal for the Establishment of the Neutron Science Lab	F011912	9,554

Lee/Fleming	DoE (NERI)	Development of TRU Transmuters for Optimization of the Global Fuel Cycle	F012345	164,952
Lee	DoE/Idaho State Univ.	U-M Participation in the AFCI RACE Project	F013911	65,218
Martin	NSF/SubK	National Partnership Advanced Computational Infrastructure	C036576	(402,422)
Martin	DoE (Dept)	Support Nuclear Engineering Education and Research at U of M	F006895	(5,328)
Martin/ Holloway	DoE (NEER)	Global Monte Carlo Simulation with High Order Polynomial Expansions	F011333	115,554
Martin/Lee	DoE (NERI)	An Advanced Neutronic Analysis Toolkit with Inline Monte Carlo Capability for NGNP Analysis	F015010	39,318
Martin	Institute of Nuclear Power Operations	Advanced Fellowships in Nuclear Engineering	C341676	14,000
Meng	NIH	Very High Resolution SPECT/CT System	F011301	60,875
Meng	NIH	Very High Resolution SPECT/CT System	F013652	166,950
Umstadter	DoE	Atomic Processes in High-Energy Density Plasmas	C034986	349
Umstadter	NSF	Physics Frontiers Center FOCUS: Frontiers in Optical Coherent and Ultrafast Science (FOCUS) – Sub of F004935	F008614	(463)
Umstadter	NSF	Ion Acceleration with High Intensity Lasers	F011502	(1,131)
Wang	DoE	Self-Organized 3-D Array of Nanostructures Under Irradiation	F007316	189
Wang	DoE	Self-Organised 3-D Array of Nanostructures Under Irradiation	F007316	156,831

Wang	DoD/AF/ Qynergy Corp	Effects of Irradiation on Icosahedral Borides	F011866	27,937
Wang	DoE	Particle-Induced Amorphization of Complex Ceramics	F012220	83,917
Wang	NSF	Nanoparticle-Environmental Interfaces	F012244	10,560
Wang	Southwest Res. Institute	Analytical Transmission Electron Microscopy of Ion Beam Modified Materials for Aerospace Applications	N007279	10,000
Was	EPRI	Use of Proton Irradiation to Understand IASCC in LWR Cores	C375524	(6,917)
Was	DoE	Random Grain Boundary Network Connectivity as a Predictive Tool for Intergranular Stress Corrosion Cracking	F005795	(665)
Was	DoE/Idaho Nat Lab (I-NERI)	Developing and Evaluating Candidate Materials for Generation IV Supercritical Water Reactors	F008346	146,215
Was	DoE/Penn State Univ. (I-NERI)	Advanced Corrosion-Resistant Zirconium (ZR) Alloys for High Burn-up and Generation IV Applications	F008451	148,182
Was	DoE/U-CA	Radiation Effects in Candidate Materials for Spallation Neutron Environments	F008517	61,337
Was	DoE/U-Wisc (NERI)	Design of Radiation-Tolerant Structural Alloys for Generation IV Nuclear Energy Systems	F009731	60,710
Was	DoE/ Subcontract (I-NERI)	Stress Corrosion Cracking of Candidate Alloys for the Supercritical Water Reactor Concept	F011832	178,521
Was	DoE (NERI)	Strategies for Alloy Development for 1000°C Service in the NGNP	F012633	175,965
Was	DoE/U-Wisc	Candidate Materials Evaluation for the Supercritical Water-Cooled Reactor	F012819	119,769
Was	DoE (NEER)	Localized Deformation as a Primary Cause of Irradiation-Assisted Stress Corrosion Cracking	F013324	46,760

Was, et al.	NSF	Acquisition of a Research Grad Ion Implanter for Research and Education in Ion Beam Modification of Materials	F013349	257,109
Was	DoE/Idaho Nat Lab	High Temperature Metallic Materials for GFR	F014870	8,670
Was	Electric Power Res Inst (EPRI)	Use of Proton Irradiatin to Understand IASCC in LWR Cores	N001979	4,019
Wehe	DoE	Applied Research in Support of the Robotics Technology Development Program	C023431	102,346
Wehe	NIH/U-M Nuclear Medicine	Radionuclides:Radiation Detecection and Quatification	F007618	4,441
Wehe	DoE	Mobile Robotics and Sensing-Univ Research Prog in Robotics	F010788	1,128,693
Wehe	NASA	Integration of Electron Tracking into Compton Imaging for the Advanced Compton Telescope	F013569	31,475
		Sub Total		**5,404,154**

Total Research Expenditures Attributed to an External Sponsor	5,404,154
Other Sponsored Activity (Costshare / Tuition / Fees)	132,606
Sub Total	**5,536,760**
Other Research Expenditures	**648,749**
GRAND TOTAL	**6,185,509**


Research Expenditures History
12,000,000
10,000,000
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6,000,000
4,000,000
2,000,000
0
FY 2003
FY 2004
FY 2005
FY 2006

Publications

(January 1, 2005 – December 31, 2005)

FISSION SYSTEMS AND RADIATION TRANSPORT

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T. Brunner and J. P. Holloway, "Two Dimensional Time Dependent Riemann Solvers for Neutron Transport," *Journal of Computational Physics,* **210**, 386-399 (2005).

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*B. Alpay and J. P. Holloway, "Segmenting Space Shields," *Proceedings Space Nuclear Conference 2005*, San Diego, CA, June 5-9, 2005.

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*Publication of work done as a student in the Department of Nuclear Engineering and Radiological Sciences at the University of Michigan

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MATERIALS

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T. R. Allen, L. Tan, Y. Chen, K. Sridharan, M. T. Machut, J. Gan, *G. Gupta, G. S. Was and S. Ukai, "Corrosion and Radiation Response of Advanced Ferritic-Martensitic Steels for Generation IV Application," *Proceedings of Global 2005*, Paper IL001, Tsukuba, Japan Oct. 9-13 (2005).

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Service

(January 1, 2005 – December 31, 2005)

Service to the College of Engineering

Member, CoE Undergraduate Admissions Committee	Atzmon
Member, Engineering Faculty Library Advisory Committee	Bielajew
College Science Liaison to LSA	Bielajew
Member, CUOS Director Search Committee	Gilgenbach
Member, CoE Curriculum Committee	He
Course Coordinator, Engineering 101	Holloway
Member, CRLT North Advisory Board	Holloway
Member, CoE Midterm Course Evaluation System	Holloway
Member, Casebook Committee for Mark Brehob (EECS)	Holloway
Member, U-M College of Engineering, Environmental Technology Council	Kearfott
Member, U-M Engineering College Honors & Awards Committee	Larsen
CoE Nominating Committee	Wehe
CoE Curriculum Committee	Wehe

Service to the University

Member, SACUA Library Committee	Bielajew
Member, Natural Sciences Division Committee	Ewing
Member, Nanoscale Science & Engineering Initiative Steering Committee, Office of the Vice-President of Research, 2004 to present	Ewing
Search Advisory Committee for the Provost and Executive Vice-President for Academic Affairs	Ewing
Member, Executive Committee, Geological Sciences	Ewing
Chair, Earth Systems Science Search Committee	Ewing
Member, Applied Physics Executive Committee	Gilgenbach
Member, Provost's Steering Committee on Multidisciplinary and Team Teaching	Holloway
Member, Institutional Cooperation Academic Leadership Program Fellow	Holloway
Member, U-M Radiation Policy Committee	Kearfott
Member, U-M Radioactive Drug Research Committee (RDRC) Subcommittee on Human Use of Radioisotopes (SHUR), Dosimetrist	Kearfott
Chair, Ford Nuclear Reactor Safety Review Committee	Martin
Member, Rackham Appeals Panel	Martin
Member, Rules Committee for Senate Advisory Committee on University Affairs (SACUA), University of Michigan	Wang
Director, Electron Microbeam Analysis Laboratory (EMAL)	Wang

Service to the Nation

Hill and Knowlton, Participant in Survey for University of Illinois at Urbana-Champaign Concerning Programs and Impacts	Kearfott
Member, two review panels for Sandia National Laboratories: Accelerated Scientific Computing (ASC) Radiation Effects Sciences (RES)	Larsen
Member, review panel for Los Alamos National Laboratory: CCS Division Review Committee	Larsen
Co-Chair, ASCI Prototype Hostile Environment Simulation Review Panel, Sandia National Laboratories	Martin
Chair, University of Chicago Review Panel for ASCI Level I Center (DoE) (Flash Center for Astrophysical Flashes)	Martin
Member, ASCI Predictive Science Panel (DoE)	Martin
Chair, DoE Workshop on Advanced Simulations for Future Fuel Cycle, Lawrence Livermore National Laboratory, December 2005	Martin
Congressional testimony for support of DoE University programs	Wehe
Member of DoE's National Attribution Panel for Nonproliferation and Arms Control	Wehe

Service to the Profession

President, International Mechanochemical Union (a member society in the International Union of Pure and Applied Chemistry)	Atzmon
Member, Steering Committee, International Symposium on Metastable, Mechanically Alloyed and Nanocrystalline Materials (held annually)	Atzmon
Co-organizer, Symposium on Neutron Scattering in Materials Research, held at the TMS 2005 Annual Meeting in San Francisco	Atzmon
Lecturer, *Microscopic Radiation Physics, Macroscopic Radiation Physics, Photon Dose Calculation Models, Electron Dose Calculation Models, Air Kerma Calibration of Ionization Chambers,* Umea, Sweden	Bielajew
Vice-Chair of IEEE Plasma Science and Applications Technical Committee	Gilgenbach
Member, Maxwell Prize Committee, APS Division of Plasma Physcis	Gilgenbach
Peer Review Panel, NASA Astronomy and Physics Research and Analysis (APRA) program, Potomac, MD	He
Program committee member, IEEE Nuclear Science Symposium and Medical Imaging Conference, San Juan, Puerto Rico.	He
Program Committee member, SPIE International Symposium on Optical Science, Engineering, and Instrumentation. Program on Hard X-Ray and Gamma-Ray Detector Physics, Optics, and Applications.	He
Division Vice President & Division Chair for the 2006 American Society of Engineering Education	Holloway

Secretary/Treasurer & Glenn Murphy Award Chair, American Society of Engineering Education, Nuclear & Radiological Engineering Division	Holloway
Member, American Nuclear Society Scholarship Policy and Coordination Committee	Holloway
Member, American Nuclear Society Graduate Scholarship Selection Committee	Holloway
Member, Divisions of American Nuclear Society: Radiation Protection and Shielding; Education and Training; Biology and Medicine; Isotopes and Radiation; Decommissioning, Decontamination and Reutilization; Nuclear Criticality Safety; Operations and Power	Kearfott
Member, Executive Committee, Michigan Local Section of American Nuclear Society	Kearfott
Member, Planning Committee American Nuclear Society	Kearfott
Conference Session Chair, American Nuclear Society, Radiation Protection and Shielding Division, Biennial Topical Meeting (Carlsbad, NM), Session on "Radiological and Environmental Dosimetry and Assessment."	Kearfott
Faculty advisor to the Student Health Physics Society	Kearfott
Consultant to Girardi and Keefe, Patent Infringement Lawsuit	Kearfott
Consultant Brinks, Hofer, Gilson, and Lione, Expert Witness, Patent Infringement Lawsuit	Kearfott
Member, Technical Review Committee for the Mathematics & Computation Division of the American Nuclear Society	Larsen
Chair, Board of Visitors, Institute for Computational Engineering and Science, University of Texas at Austin	Martin
Member, Advisory Board, Department of Nuclear Engineering, University of Tennessee	Martin
Vice-Chair and Chair-elect, Mathematics and Computation Division, ANS	Martin
Member, Program Committee, Mathematics and Computation Division, ANS	Martin
Member, Technical Committee NACE Annual	Teysseyre
Co-Chair, "Corrosion in Supercritical System" symposium for "Corrosion 2007" (2005-2006)	Teysseyre
Member, TMS Nuclear Materials Committee and TMS Corrosion and Environmental Effects Committee	Was
Member, MRS, Special Programs Committee	Was
Member, AFCI/GenIV Materials Working Group, LANL	Was
Member, Organizing Committee, International Conference on Environmental Degradation of Materials in Light Water Reactors	Was
Board of Directors, Engineering Research Council, American Society for Engineering Education	Was
Executive Committee, Accelerator Applications Division, American Nuclear Society	Was

Co-Chair of session on "Management of Materials Degradation in the Current LWR Fleet," 2005 ANS Annual Meeting, San Diego	Was
Chair, Eleventh Radiation Measurements and Applications Conference	Wehe
Member, IEEE Radiation Instrumentation Steering Committee	Wehe
Chair, IEEE Awards Committee	Wehe
Chair, Eleventh Radiation Measurements and Applications Conference	Wehe
Member, IEEE Radiation Instrumentation Steering Committee	Wehe
Chairman of the IEEE Awards Committee.	Wehe

Editorial Services

Associate Editor, *Physics of Plasmas*	Gilgenbach
Associate Editor, *Transport Theory and Statistical Physics*	Holloway
Associate Editor, *Health Physics Journal*	Kearfott
Member, Editorial Board, *Transport Theory and Statistical Physics*	Larsen
Associate Editor, *Physics of Plasmas*	Lau
Associate Editor, *Journal of Computational Physics*	Martin
Advisory Editor, *Nuclear Science and Engineering*	Martin
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Member, Editorial Board, *Metallurgical Transactions A.*	Was

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PhD (Applied Physics) California Institute of Technology, 1985
Thermodynamics of materials, diffusion of solids, amorphous metal alloys, ion beam modification of materials

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PhD (Theoretical Physics) Stanford University, 1982
Theory of electron and photon transport, Monte Carlo theory and development, radiation dosimetry theory, radiotherapy treatment planning algorithms

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President Emeritus, University of Michigan
University Professor of Science and Engineering
Director, The Millennium Project
PhD (Engineering Science and Physics) California Institute of Technology, 1967
Nuclear systems, computer simulation, science policy, higher education

Rodney C. Ewing
Professor
Also Professor, Materials Science and Engineering
and Professor, Geological Sciences
PhD (Mineralogy/Geology) Stanford University, 1974
Nuclear waste management, radiation effects in glasses

Ronald F. Fleming
Professor
PhD (Nuclear Engineering) University of Michigan, 1975
Neutron activation analysis, materials analysis using nuclear techniques, radiation measurements

John E. Foster
Associate Professor
PhD (Applied Physics) University of Michigan, 1996
Low-temperature plasma physics including applications in the areas of space propulsion plasmas, environmental plasmas, space and atmospheric plasma phenomena, energy conversion plasmas, and processing plasmas

Ronald M. Gilgenbach
Professor
Also Professor, Applied Physics Program
Director, Intense Energy Beam Interaction Laboratory
PhD (Electrical Engineering) Columbia University, 1978
Plasmas, fusion, lasers, electron beams, interaction of intense laser and particle beams with plasmas and materials

Mark Hammig
Assistant Research Scientist
PhD (Radiation Measurements) University of Michigan, 2004
Development of miniature sensors that use mechanical rather than electrical signals to detect ionizing radiation

Zhong He
Associate Professor
PhD (Physics) University of Southampton, United Kingdom, 1993
Room-temperature semiconductor and scintillation detectors for x-ray imaging and spectroscopy

James Paul Holloway
Professor
PhD (Engineering Physics) University of Virginia, 1989
Kinetic theory (plasmas, radiation), inverse problems

Kimberlee J. Kearfott, CHP
Professor
ScD (Nuclear Engineering) Massachusetts Institute of Technology, 1980
Radiation detectors, dosimetry, radiation protection policy, dose assessments, digital mammography, image reconstruction and analysis for nuclear medicine images

Karl M. Krushelnick
Professor
Associate Director, Center for Ultrafast Optical Science
PhD (Physics) Princeton University, 1994
Plasma physics, ultra-high intensity laser system development, inertial confinement fusion, compact laser-based particle accelerators and applications

Edward W. Larsen
Professor
PhD (Mathematics) Rensselaer Polytechnic Institute, 1971
Analytic and numerical methods for nuclear reactor theory, neutron transport, non-linear radiative transfer, electron and photon transport

Yue-Ying Lau
Professor
Also Professor, Applied Physics Program
PhD (Electrical Engineering) Massachusetts Institute of Technology, 1973
Plasma physics, physics of charged particle beams, radiation sources, vacuum microelectronics

John C. Lee
Professor
PhD (Nuclear Engineering) University of California, Berkeley, 1969
Nuclear reactor physics, reactor safety analysis, dynamics and control of nuclear power plants, nuclear fuel cycle

William R. Martin
Professor and Chair
PhD (Nuclear Engineering) University of Michigan, 1976
Computational methods development for the solution of the Boltzman transport equation, including utilization of advanced computer architectures

Sebastien Teysseyre
Assistant Research Scientist
PhD Ecole Nationale Superieure des Mines de Saint Etienne, France, 2001
Expertise in corrosion stress corrosion cracking and irradiation assisted stress corrosion cracking. In high temperature, aqueous environments including supercritical water

Lumin Wang
Professor
PhD (Materials Science) University of Wisconsin-Madison, 1988
Ion beam modification of materials, transmission electron microscopy, monocrystalline materials, and nuclear materials

Gary S. Was
Professor
Also Professor, Materials Science and Engineering
Director, Michigan Ion Beam Laboratory (MIBL)
Director, Michigan Memorial Phoenix Energy Institute (MMPEI)
ScD (Nuclear Materials Engineering) Massachusetts Institute of Technology, 1980
Radiation effects on materials, ion beam modification of materials, hydrogen embrittlement, stress corrosion cracking, nuclear fuels

David K. Wehe
Associate Professor
PhD (Nuclear Engineering) University of Michigan, 1984
Gamma ray imaging, neutron physics, radiation spectroscopy, artificial intelligence and robotics applications, power plant reliability

Feng Zhang
Assistant Research Scientist
PhD (Nuclear Engineering & Radiological Sciences) University of Michigan, 2004
Room-temperature semiconductor detectors, ASIC readout systems and reconstruction of radiation interactions, 4th-generation 3-D position sensitive CdZnTe detector array system.

EMERITUS FACULTY

A. Ziya Akcasu
Professor Emeritus
Also Professor Emeritus, Macromolecular Science and Engineering
PhD (Nuclear Engineering) University of Michigan, 1963
Dynamics of polymer solutions and blends, stochastic differential equations, reactor physics, kinetics

Terry Kammash
Stephen S. Attwood Professor Emeritus of Engineering
Professor Emeritus
PhD (Nuclear Engineering) University of Michigan, 1958
Fusion reactor physics and engineering, plasma physics, physics of intense charged particle beams, space applications of fusion energy

William Kerr
Professor Emeritus
PhD (Electrical Engineering) University of Michigan, 1954
Reactor safety analysis, probabilistic risk analysis, radiation protection, reactor shielding, energy production

John S. King
Professor Emeritus
PhD (Physics) University of Michigan, 1953
Neutron spectroscopy, neutron physics

Glenn F. Knoll, PE
Professor Emeritus
PhD (Nuclear Engineering) University of Michigan, 1963
Radiation measurements, neutron cross sections, nuclear measurements, radiation imaging

Dietrich H. Vincent
Professor Emeritus
Dr. Rer. Natl. (Physics) Universität Göttingen, Germany, 1956
Gases in metals, ion beam analysis, radiation effects on materials

ADJUNCT FACULTY

Jeremy Busby
Adjunct Assistant Professor
PhD (Nuclear Engineering and Radiological Sciences) University of Michigan, 2000
Radiation effects on materials, stress corrosion cracking, electron microscopy

Frederick W. Buckman
Adjunct Professor
PhD (Nuclear Engineering) Massachusetts Institute of Technology, 1970
Chairman and CEO of Trans-Elect
Formerly CEO of PacifiCorp and Consumers Power Company,
Nuclear plant design and nuclear reactor safety

Michael J. Flynn
Adjunct Professor
PhD (Nuclear Engineering) University of Michigan, 1975
Senior Staff Scientist, Henry Ford Health System
Medical imaging, image analysis, bioengineering, radiation detection

Mitchell M. Goodsitt
Adjunct Professor
PhD (Nuclear Physics) University of Wisconsin, Madison, 1982
Professor of Radiological Sciences, Radiology, University of Michigan
Professor of Radiological Health, University of Michigan

Randall K. Ten Haken
Adjunct Professor
PhD (Nuclear Physics) University of Wisconsin, 1978
Professor, Radiation Oncology, University of Michigan
Assoc. Professor, Environmental and Industrial Health, University of Michigan

Ruth Weiner
Adjunct Professor
PhD (Chemistry) Johns Hopkins University, 1962
Sandia National Laboratories
Member, Advisory Committee on Nuclear Waste

VISITING FACULTY

Kun-Dar Li
Visiting Research Scientist
Hsing-Kuo University of Management, Taiwan

Tiecheng Lu
Visiting Research Scientist
Sichuan University, Sichuan Province, People's Republic of China

Rongsheng Zhou
Visiting Research Scientist
Shanghai Jiao Tong University, People's Republic of China

Weilie Zhou
Visiting Research Scientist
Electron Microscopy Facility, University of New Oreleans

Xiaotao Zu
Visiting Research Scientist
China University of Electronic Science and Technology

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Scott Wilderman, Senior Research Fellow
Haiyan Xiao, Research Fellow
Sha Zhu, Research Fellow

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James Berry, Mechanical Engineer
Edward A. Birdsall, Facilities Infrastructure Manager
Malik Gibbons Hansen, Research Project Engineer
Russell Miller, Engineering Technician
Fabian Naab, Research Lab Specialist Associate
Mark Perreault, Senior Electronics Technician, Plasma Experimental Bay
Victor Rotberg, Senior Research Specialist – retired 5/31/06, now Lab Assistant (temp)
Ovidiu Toader, Research Area Specialist Lead, Michigan Ion Beam Laboratory

Administrative Support Staff

Ann Bell, Senior Secretary
Donna Constant, Secretary Intermediate
Cherilyn Davis, NERS Graduate Program Secretary
Pam Derry, Academic Advisor/Counselor
Amber French, Secretary (temp)
Peggy Jo Gramer, Senior Graduate Program Coordinator
Caroline Joaquin, Department Administrator
Pat Moore, Office and Editorial Assistant – retired 1/7/06, now Editorial Assistant (temp)
Shannon Thomas, Accountant Associate

Advisory Board

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Simon Labov	Director, Radiation Detection Center Lawrence Livermore National Laboratory Livermore, CA
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Thomas A. Mehlhorn	Sandia National Laboratories Albuquerque, NM
Edward L. Nickoloff	Department of Radiology Columbia University New York, NY
William T. O'Connor, Jr.	Vice President, Nuclear Generation DTE Energy – Fermi 2 Newport, MI
Robert L. Sindelar	Manager, Materials Applications and Process Technology Savannah River National Laboratory Aiken, SC
Thomas A. Spencer	Deputy Division Chief Air Force Research Lab/DEH Kirtland AFB, NM