ANNUAL REPORT

September 2004 - August 2005

NUCLEAR ENGINEERING AND RADIOLOGICAL SCIENCES

University of Michigan

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September 1, 2004 – August 31, 2005

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University of Michigan

MichiganEngineering

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Contents

Summary of Activities

This is the tenth Annual Report of the Department of Nuclear Engineering and Radiological Sciences 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 31 courses during AY 2004-2005. In addition to the NERS courses, NERS faculty taught three sections of the freshman 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, continue to increase with over 200 total students last year for the Fall and Winter sections.

Enrollments and graduations continue to increase. The Fall 2004 term enrollments increased by nearly 10% for both the undergraduate and graduate programs over the Fall 2003 terms, totaling 72 and 84 students respectively. During AY 2004-2005, the department awarded 16 BSE, 34 MS/MSE and 16 PhD degrees.

The graduate and undergraduate students were again successful in winning numerous awards this past year. Graduate students won nine fellowships from the U.S. Department of Energy (DOE), two from the National Academy for Nuclear Training (NANT), 11 fellowships from other federal agencies and professional societies, and seven scholarships from the American Nuclear Society (ANS). In addition, eight graduate students won college or department fellowships. Fourteen undergraduates were recipients of NANT scholarships, six received ANS awards, and 23 were recipients of DOE scholarships. This outstanding record of student accomplishments in attracting fellowships and scholarships will continue; 91 awards have already been made to undergraduate and graduate students for AY 2005-2006.

Our faculty are also being recognized for their achievements: Zhong He received the NERS Faculty Award for Outstanding Achievement, Bill Martin the NERS Outstanding Teacher Award, and Gary Was the Outstanding Achievement Award from the Materials Science and Technology Division of the American Nuclear Society. On the occasion of his 60th birthday, Ed Larsen was honored by a special symposium at the U-M in recognition of his outstanding career achievements. Two of our emeritus faculty also garnered awards: Ziya Akcasu was honored for his career achievements by the U-M Macromolecular Science and Engineering Program on the occasion of his 80th birthday, and Terry Kammash was given the ANS Special Award for his achievements in space nuclear power.

The faculty supervised a total of 62 projects with an annual budget of almost $6.3M, about the same as last year. The NERS research projects include four NEER grants and 11 NERI and I-NERI grants. The NERS faculty published a total of 153 articles in archival journals, conference proceedings, technical books, or technical reports in calendar year 2004.

The American Nuclear Society recognized the exceptional achievements of the ANS student chapter with the 2005 Samuel Glasstone Award, given to the outstanding student section in the U.S. for “accomplishing the most notable achievements in public service and the advancements of nuclear engineering.”

Awards and Honors

FACULTY AWARDS AND HONORS

Zhong He
Associate Professor

- Nuclear Engineering and Radiological Sciences
  Faculty Merit Award for Outstanding Achievement

Terry Kammash
Stephen S. Attwood Professor Emeritus

- American Nuclear Society Special Award – Space Nuclear Power

William R. Martin
Professor and Chair

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

Gary S. Was
Professor and Associate Dean for Research

- American Nuclear Society, Materials Science and Technology Division
  Outstanding Achievement Award

Ruth F. Weiner
Adjunct Professor

- American Nuclear Society
  ANS Fellow

STUDENT AWARDS, HONORS, AND FELLOWSHIPS FOR ACADEMIC YEAR 2004-2005

Graduate

Fellowships and Scholarships

- American Nuclear Society Graduate Awards
  M. Coselmon, A. Garner, J. Hayward, N. Jordan, S. Kiff, S. Sepke, B. Toth
- Applied Materials
  Nick Jordan
- Center for the Education of Women
  Maryanne Stasko, Carrie Beck
- Dean's/Named Fellowship (College of Engineering)
  Bryan Toth, Adrienne Lehnert
- Department of Homeland Security
  W. Geoff West
- 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
- Los Alamos National Laboratory
  Mathieu Brener
- National Academy for Nuclear Training Nuclear Engineering Fellowship
  Health Physics: Rachel Gunnett
  Nuclear Engineering: Shane Rye
- National Physical Science Consortium
  Trevor Strickler
- National Science Foundation
  Scott Kiff (renewed)
- Rackham Engineering Award I (Minority) Fellowship
  Tiberius Moran; Johari Moore and Martha Coselmon (renewed)
- Regent's Fellowship
  John Harvey
- U.S. Department of Energy Computational Science Graduate Fellowship
  Heath Hanshaw, Greg Davidson, Allan Wollaber
- U.S. Department of Energy Fusion Fellowship
  Richard Kowalczyk
- U.S. Department of Energy Naval Nuclear Propulsion Fellowship
  David Griesheimer, Troy Becker, Micah Hackett, Bryan Toth

- U.S. Department of Energy University Research Alliance
  Neal Ham
- U.S. Navy
  Stephen Dewey
- Westinghouse/CNNC Fellowship
  Qun Yu, Yidan Yuan

Honors and Awards

- American Nuclear Society, Hetcore6: A Nuclear Power Plant Design for Wolverine Point
  Jeremy Conlin, Chris Kirby, Kevin Lynn
- Institute for Nuclear Materials Management Annual Meeting, Best Student Paper Award
  Brandon O'Donnell
- *Medical Physics* Journal Cover Article, **32**, 5 (2005)
  Martha Coselmon (with Professors Moran, Radawski, and Fraass)
- Microscopy Society of America Presidential Student Award, Microscopy and Microanalysis 2005
  Tianhua Ding
- Society of Nuclear Medicine Computer and Instrumentation Young Investigator Award
  Sang-June Park
- U-M College of Engineering:
  Distinguished Achievement Award – Graduate
  David Jordan
  Distinguished Leadership Award – Graduate
  David Jordan
  Ivor K. McIvor Award
  Mark Hammig

Undergraduate

Scholarships

- First Year Merit Scholarships
  Gregory Bastin, Lacey Bierlein, Robert Chokley, David Coviak, Eric Falstad, Allen Fisher, Noah Krzan, Kathryn Masi, Kevin Mulder, Matthew Schiefer, Emily Yaich
- NERS Continuous Scholarship
  Douglas Barritt, Douglas Fynan
- Second Year Undergraduate Merit Scholarship
  Jeffrey Adams, Lindsey Baumgarten, Amy Coffer, Nicholas Krupansky, Anree Little, Stephen Rice, Christopher Tien, Mark VanSumeren
- Kikuchi Scholarship
  Robert Reed
- American Nuclear Society Undergradaute Scholarship Award
  Douglas Fynan, Anree Little, Matthew Thomas, Christopher Tien, Brandon Weatherford, Jacob Zier
- U.S. Department of Energy Nuclear Engineering Undergraduate Scholarship
  Douglas Fynan, Matthew Gomez, Andrew Gerlach, Derek Granzow, John Harvey, Bryan Hayden, Maha Jawad, Andrew Kalchik, Joel Kulesza, Anree Little, Aaron Muncey, Janelle Penisten, Michael Seely, Stephen Rice, Jennifer Schlicht, Matthew Thomas, Christopher Tien, Brian Wagner, Brandon Weatherford, Zachary Whetstone, Danielle Worthy, Jiali Wu, Jacob Zier
- National Academy for Nuclear Training Scholarship
  Jonathan Dreyer, Douglas Fynan, Matthew Gomez, Andrew Gerlach, Derek Granzow, Jason Haas, Andrea Kritcher, Michael Seely, Christopher Tien, Matthew Thomas, Brandon Weatherford, Danielle Worthy, Jiali Wu, Jacob Zier

Honors and Awards

- Outstanding Undergraduate Student Award (Engineering Physics)
  Phillip Szepietowski
- Outstanding Undergraduate Student Award (Nuclear Engineering and Radiological Sciences)
  Jacob Zier
- Distinguished Leadership Award
  Alberto Lopez, Janelle Penisten
- Mildred and Steele Bailey Prize
  Janelle Penisten
- Dr. Arthur D. Robinson Scholarship Award
  Matthew Studenski
- Roger M. Jones Poetry Prize
  Jennifer Schlicht

Graduate Internships (2002-2005)

Tiberius Moran	General Atomics	CA
Wei Ji	General Atomics	CA
Troy Becker	Knolls Atomic Power Laboratory	NY
Bryan Toth	Knolls Atomic Power Laboratory	NY
Emily Wolters	Knolls Atomic Power Laboratory	NY
Nicholas Jordan	L-3 Communications - Electron Devices	CA
Sy Stange	Lawrence Livermore National Laboratory	CA
Jesse Cheatham	Los Alamos National Laboratory	NM
Jeremy Conlin	Los Alamos National Laboratory	NM
Gregory Davidson	Los Alamos National Laboratory	NM
Allan Wollaber	Los Alamos National Laboratory	NM
Ryan McClarren	Sandia National Laboratories	NM
Janelle Penisten	Sandia National Laboratories	NM
Trevor Strickler	Sandia National Laboratories	NM
Dustin Gress	Upstate Medical Physics	NY
Shenjie Gu	Westinghouse	PA
Xiaoping Li	Westinghouse	PA
Tong Liu	Westinghouse	PA
Yawei Mao	Westinghouse	PA
Rui Shu	Westinghouse	PA
Qun Yu (Annie)	Westinghouse	PA
Yidan Yuan	Westinghouse	PA

Undergraduate Internships (2005)

Jason Haas	Bettis Atomic Power Laboratory	PA
Yevgeney Vinogradskiy	Beaumont Hospital	MI
Nicholas Krupansky	Compuware	MI
Robert Reed	DC Cook Power Plant	MI
Matthew Thomas	DC Cook Power Plant	MI
Andrew Caldwell	Delphi	MI
Bryan Hayden	DTE Energy	MI
Natallia Pinchuk	Eli Lilly	IN
Andrew VanSumeren	GE Health Care	WI
Brian Kitchen	INEEL	ID
Michael Seely	INEEL	ID
Benjamin Kevern	Knolls Atomic Power Laboratory	NY
Joel Kulesza	Knolls Atomic Power Laboratory	NY
Alexander Lazarides	L-3 Communications	CA
Jonathan Dreyer	Lawrence Livermore National Laboratory	CA
Andrew Gerlach	Lawrence Livermore National Laboratory	CA
Derek Granzow	Lawrence Livermore National Laboratory	CA
Brian Wagner	Lawrence Livermore National Laboratory	CA
Jacob Zier	Lawrence Livermore National Laboratory	CA
Gregory Fischer	Los Alamos National Laboratory	NM
Joshua Kinig	Los Alamos National Laboratory	NM
Sara Seamans	Palisades Power Plant	MI
Thomas Dow	Sandia National Laboratories	NM
Matthew Gomez	Sandia National Laboratories	NM
Danielle Worthy	Sandia National Laboratories	NM
Jiali Wu	Sandia National Laboratories	NM
Brandon Weatherford	Savannah River Research Laboratory	SC
Virinder Sandhu	Southwest Research Laboratory	TX
Osvaldo Font	University of California – Davis	CA
Maha Jawad	University of Michigan Hospitals	MI

Deepak Mangla	University of Michigan Bioelectromagnitism Laboratory	MI
Brock Palen	University of Michigan Center for Advanced Computing	MI
Elaine West	University of Michigan High Temperature Corrosion Laboratory	MI
Stephen Marin	University of Michigan Mathematics Department	MI
Shikha Prasad	University of Michigan NERS Department	MI
Jennifer Schlicht	University of Michigan Radiological Health Engineering Laboratory	MI
Zachary Whetstone	University of Michigan Radiological Health Engineering Laboratory	MI
Benjamin Hammargren	University of Michigan Radiological Health Engineering Laboratory	MI
Andrew Kalchik	University of Michigan Radiological Health Engineering Laboratory	MI
Crystal Thrall	Westinghouse Corporation	PA

Award Decisions Made in 2005 for Academic Year 2005-2006

- American Nuclear Society Awards - National
  - Graduate 7
  - Undergraduate 5
- American Nuclear Society Awards – Michigan Section 2
- Dean's/Named Fellowship (College of Engineering) 2
- Directed Energy Professional Society 1
- Kikuchi Scholarship 1
- Marshall Space Flight Center, Graduate Student Research Program (GSRP) 1
- Merit Scholarships – First Year Undergraduate 6
- Merit Scholarships – Second Year Undergraduate 4
- National Physical Sciences Consortium 1
- National Science Foundation 1
- National Academy for Nuclear Training Scholarships/Fellowships
  - Graduate
    - Nuclear Engineering 1
  - Undergraduate 17
- NERS Continuous Undergraduate Merit Scholarship 2
- Rackham/Engineering Graduate Award I (Minority) 2
- Rackham/Engineering Graduate Award Continued 2
- Regents Fellowship (College of Engineering) 1
- Robert S. Landauer, Sr. Fellowship in Health Physics 1
- Department of Energy Graduate and Undergraduate Fellowships
  - Computational Sciences 2
  - Naval Nuclear Propulsion 2
  - Nuclear Engineering/Health Physics Graduate Fellowship 1
  - Nuclear Engineering Undergraduate Fellowship 25
- Department of Defense
  - National Defense Science and Engineering 1
- Department of Homeland Security 1
- Westinghouse/CNNC Fellowship 2

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 William Martin was selected by the students as the 2004-05 recipient of the Outstanding Teacher Award.

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 (ANS)

The University of Michigan Student Branch of the American Nuclear Society (U-M ANS) has several goals: to facilitate connections between the students and members of the nuclear industry, to provide accurate information about the applications of nuclear technology to the campus and community, and to promote interaction among NERS students, faculty, and staff. There were additional goals established for the 2004-05 by the officers which included: establish ANS as a recognized organization with the CoE community, assist with recruitment and retention of students in the NERS Department, and increase emphasis on professional development and employment opportunities.

The U-M ANS increased activities in many areas:

- Presentations by companies/national laboratories (Los Alamos National Labs, Knolls Atomic Power Lab, Big Rock Nuclear Power Facility, DTE Energy, and the University

of Nevada at Las Vegas) at ANS meetings were scheduled throughout the year. In additional a tour of D.C. Cook Nuclear Power Plant in Bridgman, MI was arranged.

- Community Service activities included: Salvation Army Thanksgiving Canned Food Drive, America Reads Children's Book Drive, SAFE House Volunteering, Penny War to raise funds for the tsunami relief efforts, and Ronald McDonald House.
- Social activities included: Fall Picnic, Holiday Party, Ice Skating at Yost Ice Arena, Graduate Students Pizza Party, Bowling, Spring Picnic, Reflecting Pool Races and Intramural Sports.
- Fundraising activities included: Pop and Candy Fund and ANS T-shirts.
- College and University involvement included: Graduate Student Welcome Day, CoE Welcome Day, Tech Day, Engineers Week Movie Night (received "Best Student Society E-Week Event with a $100 monetary gift).

As a result of the increased involvement of students and increased activities, the U-M ANS received first place for the Glasstone Award (monetary gift of $1,000). The full Glasstone report submitted to National ANS can be found on the NERS Department website (www.ners.engin.umich.edu).

HEALTH PHYSICS SOCIETY

The Student Chapter of the Health Physics Society at the University of Michigan works to bring students, professionals, and members of the public together in order to promote understanding and the proper use of radiation and radioactive materials. The most visible and effective manner of accomplishing this goal has been the maintenance of a web page that continues to reach out to thousands of visitors per week. This web page contains a plethora of information ranging from teaching materials to professional links to employment opportunities in the field of health physics.

In addition to web-related activities, many members participate in both state and national meetings and conferences of the Health Physics Society. For instance, many of the student members presented scientific papers and technical posters at the 2005 Annual Meeting of the Health Physics Society in Spokane, WA, and many secured prestigious health physics internships at national laboratories and private corporations during the summer session. Many exciting professional and social activities are planned for the coming school terms. In the past, these events have resulted in the enrichment not only of our own members, but also members of other Health Physics Society groups and of the general public as well.

Curriculum

On March 11, 2005, NERS faculty developed a new set of course requirements for the doctoral degree, comprising a Laboratory Course Requirement and a Breadth Requirement, as detailed below. In addition, students take extensive course work in their option to prepare for their option-specific candidacy exam and to support their dissertation research.

Laboratory Requirement

All Ph.D. students must take NERS 515, Nuclear Measurements Laboratory, and obtain a grade of B (5.00) or better. Students who have taken NERS 315 as an undergraduate must instead take one of the following: NERS 425, NERS 575 or NERS 583. The department executive committee must approve any other variances.

Breadth Requirement

All Ph.D. students must take and obtain a grade of B (5.00) or better in 6 credit hours of NERS courses selected from outside the student's option, as defined by the following list of courses. Courses not listed do not satisfy this requirement; the department executive committee must approve any variances. The purpose of this requirement is to ensure the breadth of nuclear engineering and radiological science education of our Ph.D. students and to ensure that the student is exposed to the quantitative analytical methods used in other specialties in the field. A laboratory course used to satisfy this breadth requirement cannot be used to satisfy the laboratory requirement (above).

Breadth Requirement Courses and Option Classification

Fission Systems and Radiation Transport:

NERS 441, 543, 551, 554, 561

Materials:

NERS 521, 522

Radiation Measurements and Imaging:

NERS 481, 518, 580

Plasmas and Fusion:

NERS 471, 571, 572, 575, 576

Radiation Safety, Environmental Sciences, and Medical Physics:

NERS 484, 531, 582, 583, 585, 587

COURSES OFFERED*

COURSE NO.	COURSE TITLE	TERM	CREDIT HRS
NERS 100	Radiation and the Environment	II	2
NERS 211	Intro to Nuclear Engineering & Radiological Sciences	I, II	4
NERS 250	Fundamentals of Nuclear Engineering	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 400	Elements of Nuclear Energy	I, II	2
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 445	Nuclear Reactor Laboratory	II, IIIA	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 482/BioE 482	Fundamentals of Ultrasonics with Medical Applications	II	2
NERS 484/BioE 484	Radiological Health Engineering Fundamentals	I	4
NERS 490	Special Topics in Nuclear Engineering	All	TBA
NERS 499	Research in Nuclear Engineering	I, II, IIIA-B	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

* 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 543	Nuclear Reactor Theory II	I	3
NERS 551	Nuclear Reactor Kinetics	II	3
NERS 554	Radiation Shielding	II	4
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/EHS 672	Radiological Assessment and Risk Evaluation	I	3
NERS 587	Internal Radiation Dose Assessment	II	3
NERS 588	Radiological Health Engineering Practicum	All	1-12
NERS 590	Special Topics in Nuclear Engineering II	All	TBA
NERS 599	Master's Project	I, II, IIIA-B	1-3
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

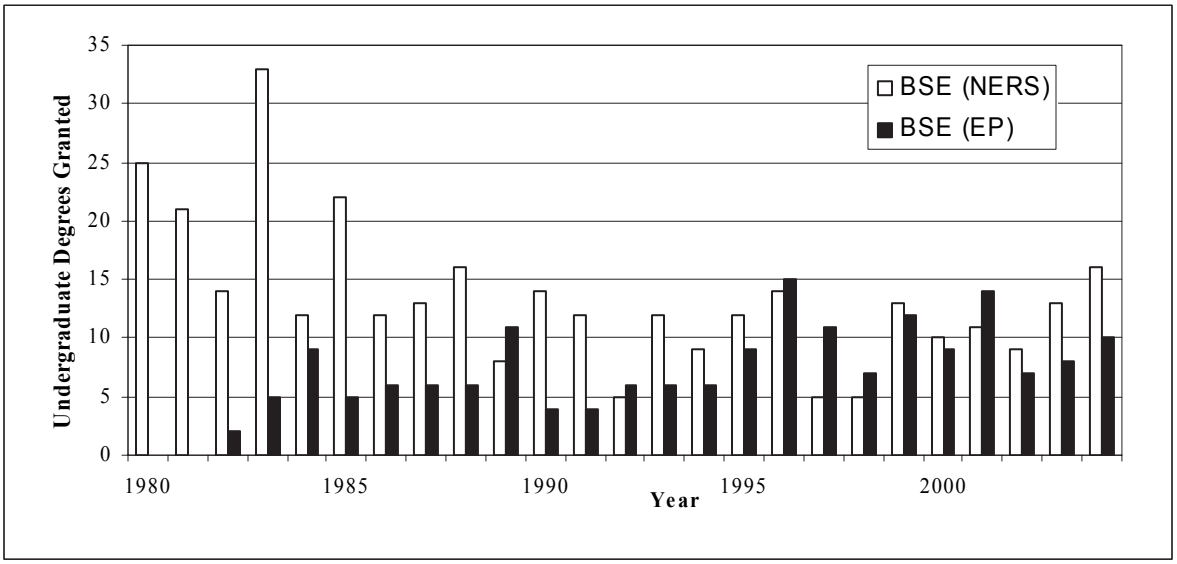
COURSE	TITLE	ENROLLMENT		
		Fall '04	Winter '05	Sp/Su '05
NERS 211	Introduction to Nuclear Engr and Radiological Sci	83	119	
NERS 250	Fundamentals of Nuclear Engr		30	
NERS 311	Elements of Nuclear Engr and Radiological Sci I	34		
NERS 312	Elements of Nuclear Engr and Radiological Sci II		30	
NERS 315	Nuclear Instrumentation Laboratory		28	
NERS 421	Nuclear Engr Materials	11		
NERS 425	Applications of Radiation		27	
NERS 441	Nuclear Reactor Theory I	30		
NERS 442	Nuclear Power Reactors		16	
NERS 462	Reactor Safety Analysis	9		
NERS 471	Introduction to Plasmas	14		
NERS 481	Engr Principles of Radiation Imaging (BioE 481)		34	
NERS 484	Radiological Health Engr Fundamentals (BioE 484)	19		
NERS 490	Special Topics in Nuclear Engr I		10	
NERS 499	Research in Nuclear Engr	7	7	1
NERS 515	Nuclear Measurements Laboratory	16	1	
NERS 531	Nuclear Waste Management	24		
NERS 543	Nuclear Reactor Theory II		8	
NERS 551	Nuclear Reactor Kinetics	7		
NERS 554	Radiation Shielding		23	
NERS 561	Nuclear Core Design and Analysis I		8	
NERS 571	Intermediate Plasma Physics I	21		
NERS 572	Plasma Physics II		12	
NERS 575	Plasma Generation and Diagnostics Lab (EECS 519)		14	
NERS 576	Charged Particle Accelerators	26		
NERS 579	Physics of Diagnostic Radiology			5
NERS 580	Computation Proj in Radiation Imaging (BioM 580)		13	
NERS 583	Applied Radiation Dose Assessment		6	
NERS 588	Radiation Safety and Medical Physics Practicum	2	2	
NERS 590	Special Topics in Nuclear Engr II	15	68	
NERS 599	Master's Project	2	2	
NERS 622	Ion Beam Modification and Analysis of Materials		5	
NERS 799	Special Projects	17	17	3
NERS 990	Dissertation-Precandidate	12	11	
NERS 995	Dissertation-Candidate	33	31	5

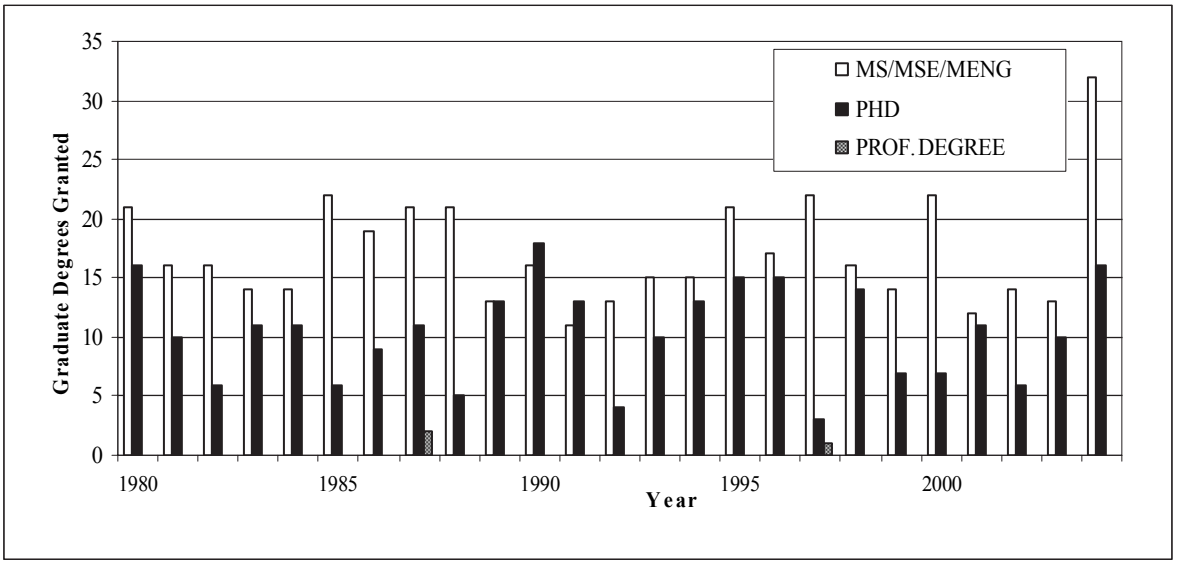
Students

DEGREES AWARDED

August 2004 through July 2005

Degree	Number
BSE in Nuclear Engineering and Radiological Sciences	16
BSE in Engineering Physics	10
MSE and MS in Nuclear Engineering and Radiological Sciences (including 19 students continuing in doctoral program)	32
PhD in Nuclear Engineering and Radiological Sciences and in Nuclear Sciences	16
Professional Degree (Nuclear Engineer)	0





DOCTORAL THESES TITLES

For Degrees Conferred August 2004–May 2005

STUDENT	TITLE	ADVISOR
Capell, Brent	Intergranular Stress Corrosion Cracking and Selective Internal Oxidation of Ni-Cr-Fe Alloys in Hydrogenated Steam	G. S. Was
Griesheimer, David	Functional Expansion Tallies for Monte Carlo Simulations	J. P. Holloway W. R. Martin
Hammig, Mark	Mechanical Radiation Detection via Sub-Brownian Level Deflections	D. K. Wehe
Hanshaw, Heath	The Multidimensional Multiple Balance Method for S_N Radiation Transport	E. W. Larsen
Hartman, Michael	Investigation of the Crystalline Structure of Ettringite with *In Situ* Measurement of Its Evolution During Formation and Thermal Decomposition	M. Atzmon R. R. Berliner
Jones, Michael	Cathode Priming of a Relativistic Magnetron using Multi-Emission Zones on Projection Ablation Lithography Cathodes	R. M. Gilgenbach
Jordan, David	Ultrawideband Electrochemotherapy	R. M. Gilgenbach M. Uhler
Kowalczyk, Richard	A Klystron Study: Intermodulation Supression and Beam Loading of Cavities	Y. Y. Lau
Kulik, Viktoriya	Space-Time Analysis for Reactivity Determination in Source-Driven Subcritical Systems	J. C. Lee
Neculaes, V. Bogdan	Magnetron Magnetic Priming for Rapid Startup and Noise Reduction	R. M. Gilgenbach
Park, Sang-June	A Very High Resolution Small Animal PET used on the Compton PET Concept	D. K. Wehe W. L. Rogers

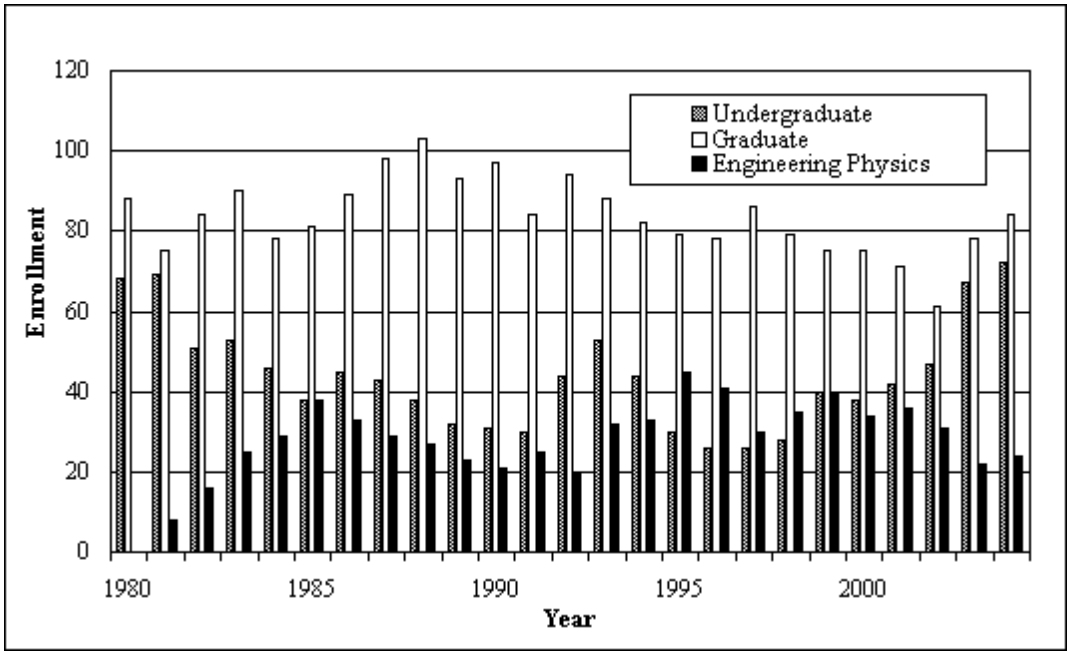
Pollack, Samuela	Contour-Guided Denoising of Radiological Dose Profiles	A. F. Bielajew
Rosu, Mihaela	Dose Computation in Conformal Radiation Therapy Including Geometric Uncertanties: Methods and Clinical Implications	A. F. Bielajew R. K. Ten Haken
Sepke, Scott	Theory and Applications of Intense Laser Plasma Interactions	D. P. Umstadter
Valenzuela, Anthony	Relativistic Free Electrons in an Intense Laser Field: Experimental Observations of Optically-Induced Deflection of an Electron Beam	D. P. Umstadter
Zhang, Feng	Events Reconstruction for 3-D Position Sensitive CdZnTe Gamma-Ray Spectrometers	Z. He

For Doctoral Theses in Progress

STUDENT	TITLE	ADVISOR
Ding, Tianhua	Self-Ordering Process of Voids in Electron Beam Stimulated CaF_2	L. M. Wang
Garner, Allen	An Analysis of Electrical Pulse Induced Biological Effects Using Dielectric Spectroscopy and Mathematical Biology	R. M. Gilgenbach
Hidaka, Yoshiteru	Extraction of Electron Current from the U-M Large Area, ECR Plasma Neutralizer	R. M. Gilgenbach
Liang, Liang	Dosimetry in Lungs: A Random Medium Study	E. W. Larsen
Pengvanich, Pongphaeth	A Study of Magnetron Phenomena	Y. Y. Lau
Strickler, Trevor	Ionization Dynamics of Z-Pinches and X-Pinches	R. M. Gilgenbach
Tchou, Philip	2AFC Assessment and Analysis of Noise Thresholds for Mammography Using LCD Displays	E. W. Larsen M. Flynn
Tyagi, Neelam	Investigation of IMRT Delivery Techniques in Hetrogeneous Media	A. F. Bielajew I. Chetty
West, W. Geoffrey	A Method and Apparatus for Time-Resolved Optically Stimulated Luminescence Radiation Detection	K. J. Kearfott
White, William	Radio Frequency Priming of a Long Pulse Relativistic Magnetron	R. M. Gilgenbach
Xu, Dan	4pi Compton Imaging Spectrometer using 3D Position Sensitive CdZnTe Detectors	Z. He

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



EMPLOYMENT STATISTICS
AND CONTINUING EDUCATION

Place of First Employment of Graduates
September 2004 – August 2005

EMPLOYER	PhD STUDENTS
Bechtel Bettis	Brent Capell
	David Griesheimer
Brookhaven National Laboratory	Sang-June Park
Commissariat a l'Energie Atomique (CEA)	Viktoriya Kulik
General Electric Research Center	V. Bogdan Neculaes
L-3 Communications	Richard Kowalczyk
Los Alamos National Laboratory	Anthony Valenzuela
	Samuela Pollack
Medical Physics Consulting	David Jordan
National Institute for Standards and Technology	Michael Hartman
Sandia National Laboratories	Michael Jones
	Heath Hanshaw
U-M NERS	Mark Hammig
	Feng Zhang
U-M Hospitals Radiation Oncology	Mihaela Rosu
University of Nebraska	Scott Sepke

EMPLOYER	MS/MSE STUDENTS
Advent Engineering	Rachel Gunnett
Bechtel Bettis	Eric Gartner
	Christopher Kirby
	Johari Moore
Beijing Institute of Nuclear Engineering	Yidan Yuan
Knolls Atomic Power Laboratory	Jason D'Haene
Nuclear Power Institute of China	Rui Shu
Nuclear Power Qinshan Joint Venture Co., Ltd.	Xiaoping Li
Nuclear Regulatory Commission	John Lehning, III
Pearl Harbor Naval Shipyard	Shane Rye
Upstate Medical Physics	Dustin Gress
University of Massachusetts Health System	I-Lin Kuo
Zhejiang Sanmen Nuclear Power Co., Ltd.	Qun Yu (Annie)

EMPLOYER	**BSE STUDENTS**
DTE Energy	Larry Hu
Tacom	Joseph Schneider
United States Navy	John Halahan

UNKNOWN	**BSE STUDENTS**
	Heejung Hong
	Rodrigo Palma
	Ann Paulson
	Ted Thorbeck

Continuing Graduate Studies

UNIVERSITY	**MS/MSE Students**
University of Michigan	Troy Becker
(Nuclear Engineering and Radiological Sciences)	Jeremy Conlin
	Yan Cao
	Gregory Davidson
	Weijiang Duan
	Micah Hackett
	John Harvey
	Jason Hayward
	Yoshiteru Hidaka
	Brad Hoff
	Haori Jiang
	Adrienne Lehnert
	Lee-Cheng Peng
	Miesher Rodrigues
	Trevor Strickler
	Wilken Tang
Rensselaer Polytechnic Institute	Bryan Bednarz

UNIVERSITY	**BSE STUDENTS**
McGill University	Katherine Woch
University of California – Berkeley	Jonathan Dreyer
	Andrea Kritcher
University of Michigan (Applied Physics)	James Glownia
University of Michigan (Mechanical Eng)	Issei Sugimoto
University of Michigan (Medical School)	Aaron Muncey
University of Michigan (NERS)	Adam Boyd
	Jesse Crozier
	Matthew Gomez
	Andrew Kalchik
	Janelle Penisten
	Michael Reim
	Michael Seely
	Matthew Studenski
	Elaine West
	Jacob Zier
University of Michigan (Physics)	Phillip Szepietowski

UNKNOWN	**BSE STUDENTS**
(Graduate School)	Joseph Lucido III

Employment Patterns of Graduates September 2004 – August 2005

	BS	*MS/MSE*	*PhD*	*Prof*
Federal Government				
Department of Defense				
United States Navy	1	1		
Department of Energy				
Bechtel Bettis		3	2	
Brookhaven National Laboratory			1	
Knolls Atomic Power Laboratory		1		
Los Alamos National Laboratory			2	
Sandia National Laboratories			2	
Nuclear Regulatory Commission		1		
Other Industrial and Medical Organizations				
Advent Engineering		1		
Commissariat a l'Energie Atomique (CEA)			1	
General Electric Research Center			1	
L-3 Communications			1	
Medical Physics Consulting			1	
Tacom	1			
University of Massachusetts Hospital		1		
U-M Hospitals, Radiation Oncology			1	
Upstate Medical Physics		1		
Nuclear Utilities				
DTE Energy	1			
Nuclear Reactor Manufacturers				
Beijing Institute of NE		1		
Nuclear Power Institute of China		1		
Nuclear Power Qinshan Joint Venture		1		
Zhejiang Sanmen Nuclear Power Co.		1		
Academic Institutions: Grad, Post Doc, and Faculty				
McGill University	1			
National Institute for Standards and Technology			1	
Rensselaer Polytechnic Institute		1		
University of California – Berkeley	2			
University of Michigan (Mechanical Eng)	1			
University of Michigan (Medical School)	1			
University of Michigan (NERS)	10	18		
University of Michigan (NERS) Post Doc			2	
University of Michigan (Physics)	2			
University of Nebraska			1	
Unknown Graduate School	1			
Unknown	4			

Employment Patterns of Graduates
35-Year Summary: August 1970 - July 2005

	BS	*MS*	*MEng*	*PhD*	*Prof*
Federal Government					
Department of Commerce				7	
Department of Defense					
Armed Forces	60	22	1	7	
Civilian Employees	3	3		15	
Department of Energy	10	38	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	32	1	6	
Nuclear Reactor Manufacturers	33	49		21	1
Architecture-Engineering Firms	18	28	1	5	
Consulting Firms	3	5	3	8	
Other Industrial & Medical Organizations	21	38	4	54	
Foreign Governments	1	9		12	3
Academic Institutions					
Faculty and Staff	6	6	2	52	
Graduate School and Postdoctoral Work	301	329	10	46	
Employment Outside the Profession	13	10		2	
Returned to Home Country and Unknown	79	37	7	29	3
Fulbright Award	1				
TOTALS	623	610	35	356	8

NERS Colloquia Fall 2004

Date	Speaker	Title
Sept. 17	William R. Martin University of Michigan (NERS)	Departmental Welcome
Sept. 24	Randy Lott Westinghouse	Materials Research in the Commercial Nuclear Power Industry
Oct. 1	Kai Vetter Lawrence Livermore National Lab	High-Sensitivity Gamma-Ray Imaging for Homeland Security Applications
Oct. 8	Tom Mehlhorn Sandia National Laboratories	Fusion Neutron Production from ICF Target Implosions by Z-Pinch Radiation Sources: A Quest that Began in NE-312 in 1973
Oct. 15	Joe Schumer Naval Research Laboratory	Advanced Energetics Using Nuclear Isomers
Oct. 22	John Wagner Oak Ridge National Laboratory	Automated Variance Reduction for Monte Carlo
Oct. 29	Ronald Hockey Pacific Northwest National Lab	Nondestructive Characterization of TRISO Coated Particle Fuel
Nov. 5	NERS Industry/Career Fair Forum	Job Opportunities and Current Activities for NERS Graduates
Nov. 12	Larry Foulke Bettis Atomic Power Laboratory	Jupiter Icy Moons Orbiter (JIMO) Project
Nov. 19	Fred Becchetti Physics Department, U-M	Magnetic Confinement of Radiotherapy (Electron and Proton) Beams
Nov. 26	Thanksgiving Break	No Colloquium
Dec. 3	Martin Molecke Sandia National Laboratories	International Spent Fuel Sabotage – Aerosol Measurement Test Program at Sandia National Laboratories
Dec. 10	Juergen Kolb Old Dominion University	Ultrashort Electrical Pulses Open a New Gateway into Biological Cells

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NERS Colloquia Winter 2005

Date	Speaker	Title
Jan. 14	Fei Gao Pacific Northwest National Lab	Multi-Scale Computer Simulations of Irradiation Damage in Ceramics
Jan. 21	Robert Singleterry NASA-Langley Research Center	Space Radiation Engineering and Design
Jan. 28	Leon Shohet University of Wisconsin	The Effects of Vacuum Ultraviolet Radiation on the Processing of Electronic Materials
Feb. 4	Robert S. Averback University of Ilinois	Ion Beam Induced Nanostructures in Metal Thin-Films
Feb. 11	Hatice Akkurt Schlumberger	Using Neutrons for Oil Well Logging
Feb. 18	Min Hu Cornell University	Plasma Dynamics, Mass Ablation, Charge State, and Instabilities in Linear Array Z-Pinches
Feb. 25	Ryan McClarren, Ben Sturm, Wei Ji NERS, University of Michigan	NERS Student Presentations
Mar. 11	Peggy Christenson Sandia National Laboratories	Hybrid Plasma Simulation Techniques
Mar. 18	Ken Struve and Mike Mazarakis Sandia National Laboratories	Studies of the ZR Upgrade: New Machine Capabilities; and Progress in Developing LTDs (Linear Transformer Drivers)
Mar. 25	Daniel B. Bullen, Chicago, IL; Rodney Ewing and Kim Kearfott (Moderator), University of Michigan	Yucca Mountain as a Geological Repository for High-Level Waste
April 1	Reza Moridi Radiation Safety Institute of Canada	Personal Alpha Dosimetry in the Canadian Uranium Industry
April 8	Michael Nastasi Los Alamos National Laboratory	Determining the Mechanisms of Cleavage in Hydrogen Ion Implanted Si
April 15	Charles Barnes NASA-JPL (Jet Propulsion Laboratory)	Recent Radiation-Effects Activities at Jet Propulsion Laboratory

Research Activities

FISSION SYSTEMS AND RADIATION TRANSPORT

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.

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," submitted for publication in *Nuclear Science and Engineering*.

Development of Time-Dependent Pn Solver for ALEGRA

J. P. Holloway, D. P. Umstadter, and W. R. Martin, Co-PIs
Sandia National Laboratories
$73,404/2 yr

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

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 a 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).

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 NCNP5, and its testing on difficult, realistic problems, is the essence of this proposed research.

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. We have found that linearly interpolating the mixture with the square root of T gave excellent results, which is consistent with the fact that tabulated resonance integrals are essentially linear with the square root of the fuel temperature. 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. Finally, 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.

W. Ji, J. L. Conlin, W. R. Martin, and J. C. Lee, "Reactor Physics Analysis of the VHTGR Core," *Trans. Am. Nucl. Soc*., **91**, 556 (2004).

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); also LA-UR-04-8668, Los Alamos National Laboratory (2004).

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," to be presented at the ANS Conference, November 2005.

OSMOSE - An Experimental Program for Improving Neutronic Predictions of Advanced Nuclear Fuels

J. C. Lee, PI
U.S. Department of Energy/Argonne National Laboratory (I-NERI)
$165,000/3 yrs

In collaboration with Argonne National Laboratory and the French CEA (Commissariat á l'Energie Atomique), this International Nuclear Energy Research Initiative (I-NERI) project aims at determining the integral reaction rates of various actinides, including uranium, thorium, and transuranic nuclides. The reaction rate data will play a major role in assessing burnup credits for the storage and disposal of spent nuclear fuel and in the design analysis for transmutation systems. The program centers on performing oscillation tests involving small TRU samples in the French MINERVE reactor, where a calibrated control rod compensates for reactivity perturbations induced by the oscillating samples. Our effort has focused on neutronic modeling of the MINERVE core both with the MCNP5 Monte Carlo code and the WIMS-DIF3D deterministic codes. Effort has been made to simulate the reactivity worths of small UO_2 calibration samples measured through control rod oscillation tests.

Y. Cao, G. Perret, R. T. Klann, and J. C. Lee, "Reactor Physics Analysis of the MINERVE Reactor for the OSMOSE Project," *Trans. Am. Nucl. Soc*., **91,** 725 (2004).

R. T. Klann, J. P. Hudelot, G. Perret, N. Drin, J. C. Lee, and Y. Cao, "Final Report of the International Nuclear Energy Research Initiative OSMOSE Project (FY01-FY04)," ANL-04/25, Argonne National Laboratory (2005).

Support to the AAA Program in Nuclear Engineering and Nuclear Physics

J. C. Lee, PI; J. P. Holloway, R. F. Fleming, and G. S. Was, Co PIs
U.S. Department of Energy/Los Alamos National Laboratory
$435,000/28 mos

The project began in May 2000 as part of the multi-institutional ATW (Accelerator Transmutation of Waste) program to develop accelerator-driven subcritical reactors for the purpose of transmuting transuranics, including neptunium, plutonium, americium and curium, and long-lived fission products. The program shifted somewhat away from the accelerator-based focus toward multi-tier critical transmuter approaches, as the national program evolved into the Advanced Accelerator Applications (AAA) and more recently the Advanced Fuel Cycle Initiative (AFCI). Our effort included study of coupled accelerator-core dynamics and transuranics transmutation in both thermal and fast reactors. The project also included an experimental program studying the effects of irradiation on reactor structural components in the Pb-Bi coolant using proton irradiation.

V. V. Kulik and J. C. Lee, "Space-Time Correction in Reactivity Determination for Subcritical Systems," *Proc. AccApp'03 Conference* (2004).

V. V. Kulik and J. C. Lee, "Applications of Modal-Local Analysis for Source-Driven Subcritical Systems," *Proc. PHYSOR 2004 Conference* (2004).

R. T. Sorensen and J. C. Lee, "LWR Lattice Physics Model for Equilibrium Fuel Cycle Analysis," *Trans. Am. Nucl. Soc*., **90**, 590 (2004).

V. V. Kulik, J. C. Lee, G. Aliberti, G. Imel, and G. Palmiotti, "Determination of Reactivity for MUSE-4 SC0 Configuration," *Trans. Am. Nucl. Soc*., **90**, 547 (2004).

G. S. Was, J. T. Busby, T. R. Allen, and J. Gan, "Assessment of Materials for Accelerator Applications using Proton Irradiation and Corrosion Experiments," *Proc. AccApp'03 Conference* (2004).

J. C. Davis, J. C. Lee, and R. F. Fleming, "Denatured Thorium in Fast Reactors Employing a Closed Fuel Cycle," *Trans. Am. Nucl. Soc*., **90**, 86 (2004).

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," to appear in *Nuclear Science and Engineering*.

Cross-Validation of Transmutation and Fuel Cycle Codes

J. C. Lee, PI and R. F. Fleming, Co-PI
U.S. Department of Energy/Los Alamos National Laboratory
$60,000/12 mos

As part of the DOE Advanced Fuel Cycle Initiative, we performed a study comparing Mote Carlo fuel cycle calculations with deterministic lattice physics calculations for representative light water reactor (LWR) fuel configurations. Our study has focused on the cross-validation of both MCNP5-ORIGEN2.2 (MONTEBURNS) and MCNPX-CINDER90 with the CASMO-3 collision probability code. We additionally compared the Monte Carlo depletion codes with the Westinghouse PHOENIX-P code and the EPRI CPM-3 code. Our study has indicated that, with due attention paid to key attributes of Monte Carlo depletion algorithms, we are able to achieve acceptable agreement between the Monte Carlo and deterministic fuel cycle calculations.

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).

Reactor-Accelerator Coupling Experiments (RACE) Project

J. C. Lee, PI
U.S. Department of Energy/Idaho State University
$100,000/18 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 the actual pulsed source experiments planned at ISU as well as at the RACE configurations to be established 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," to be presented at the AccApp05 Conference, Venice, Italy (2005).

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 will develop equilibrium fuel cycle methodology to consistently compare the performance of LWR transmuters with that of other transmuters. A key objective of the project is to develop simplified analytical fuel cycle methods that could provide physical insights into the overall performance of an integrated nuclear energy and fuel cycle economy.

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," to be presented at the ANS Conference, November 2005.

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).

D. P. Griesheimer, W. R. Martin, and J. P. Holloway, "Convergence Properties of Monte Carlo Functional Expansion Tallies," submitted to *Journal of Computational Physics*, November 2004.

D. P. Griesheimer, W. R. Martin, and J. P. Holloway, "Estimation of Fluence Distributions with Monte Carlo Functional Expansion Tallies," *Proc. Tenth International Conference on Radiation Shielding (ICRS-10)*, Madeira, Portugal, May 2004.

D. P. Griesheimer and W. R. Martin, "Two Dimensional Functional Expansion Tallies for Monte Carlo Simulations," *Proc. American Nuclear Society Topical Conference*, PHYSOR-2004, Chicago, Illinois, April 2004.

F. B. Brown, D. P. Griesheimer, and W. R. Martin, "Continuously Varying Material Properties and Tallies for Monte Carlo Calculations," *Proc. American Nuclear Society Topical Conference*, PHYSOR-2004, Chicago, Illinois, April 2004.

National Partnership for Advanced Computational Infrastructure (NPACI)

W. R. Martin, PI; Quentin Stout (EECS) and Ed Borbely (CPD), Co-PIs
National Science Foundation
$1.2M/yr

The NPACI (National Partnership for Advanced Computational Infrastructure) project is an NSF-funded grant that supports infrastructure (facilities, staff, and equipment) for high performance computing, including data-intensive computing. The lead institution in the NPACI partnership is UCSD, which operates the San Diego Supercomputer Center. In addition to UCSD and the University of Michigan, the other major resource partners are Caltech, UC Berkeley, and the University of Texas. The U-M is a "mid-range" site, operating and maintaining a mid-sized parallel computing facility (four computational clusters totaling nearly 700 cpus, including a 134 cpu AMD Athlon cluster, a 256 cpu Athlon cluster, a 400 cpu AMD Opteron cluster, and a 128 cpu Apple G5 cluster) that provides computational cycles, data resources, and expert consultation to the users at the U-M as well as the national community. The NSF funds provide support for the parallel computing facility, the data intensive facility, and five full time staff, including three systems programmers and two expert user consultants. The actual parallel computing facility is operated by the Center for Advanced Computing (CAC). Students, staff, and faculty at the U-M are welcome to use the parallel computing facility. Please see http://cac.engin.umich.edu/ for more information.

MATERIALS

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.

X. T. Zu, M. Atzmon, L. M. Wang, L. P. You, F. R. Wan, G. S. Was, and R. B. Adamson, "Effect of Ion Irradiation on Microstructure and Hardness of Zircaloy -4," *J. ASTM International*, **1**, JAI11316 (2004).

X. T. Zu, K. Sun, M. Atzmon, L. M. Wang, L. P. You, F. R. Wan, J. T. Busby, G. S. Was, and R. B. Adamson, "Effect of Proton and Ne Irradiation on the Microstructure of Zircaloy 4," *Philosophical Magazine*, **85**, 649 (2005).

W. H. Jiang and M. Atzmon, "Deformation-Induced Nanocrystallization - a Comparison of Two Amorphous, Al-Based Alloys," *Journal of Materials Research,* **20**, 696 (2005).

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Nanoparticle-Environment Interfaces: Interactions in Natural Systems
R. C. Ewing and L. M. Wang, co-PIs (with U. Beker, Geological Sciences)
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.

Particle-Induced Amorphization of Complex Ceramics
R. C. Ewing, PI and L. M. Wang, Co-PI
J. Lian, Graduate Student; S. Utsunomiya, Research Fellow
U.S. Department of Energy, Office of Basic Energy Sciences
$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

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Self-Organized 3-D Array of Nanostructures Under Irradiation

L. M. Wang, PI
T. H. Ding, Graduate Student; S. Zhu, Research Fellow
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.

X. Xiang, X. T. Zu, S. Zhu, and L. M. Wang, "Optical Properties of Metallic Nanoparticles in Ni-Ion-Implanted α-Al_2O_3 Single Crystals," *Applied Physics Letters*, **84**, 1, 52-54 (2004).

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Development of Tool Materials for Friction Stir Welding
L. M. Wang, PI
Jian Chen, Research Fellow
General Motor Corporation
$150,506/2 yrs

The main objective of this research project is to select and develop durable tool materials for the newly developed process of friction stir welding (FSW). The feasibility of using wear resistant coatings and ceramic materials for long lasting pinhead, as well as optimum FSW process parameters for aluminum alloy welding with the new types of pinhead will be determined. Study of the microstructure changes of the pinhead and the metallic materials (aluminum alloys and steels) welded by FSW will also be conducted. The deliverables of this study include recommendations on FSW tool materials for welding both aluminum alloys and steels, optimum processing FSW parameters as well as the prediction of lifetime of the FSW tool materials. The overall goal of this research project is to provide a solid foundation for GM R&D to develop a larger scale research program for the industrial application of FSW on GM assembly lines. The FSW technique may also be applied for sealing the canisters containing high-level nuclear waste.

Evaluation of Radiation Effects in Icosahedral Borides
L. M. Wang, PI
S. Zhu, Research Fellow
U.S. Air Force (a subcontract from Qynergy Corporation)
$100,000

The objective of this research project is to evaluate the electron irradiation effects in candidate materials for application in nuclear batteries using beta-decay sources. Transmission electron microscopes at the Electron Microbeam Analysis Laboratory are used to conduct the research.

Advanced Corrosion-Resistant Alloys for High Burnup and Generation IV Applications
G. S. Was, PI; M. Atzmon, co-PI, and J. Busby, Collaborator (with A. Motta, Penn State University, Y. H. Jeong, Korea Atomic Energy Research Institute, R. Comstock, Westinghouse Electric Co. and Y. S. Kim, Hanyang University – Korea)
U.S. Department of Energy, International Nuclear Energy Research Initiative (NERI)
$466,304/3 yrs

This project is a collaboration uniting scientists and capabilities from five separate organizations in two countries to study the corrosion of zirconium-based alloys. The main research goals are to develop and demonstrate a technical basis for improving the corrosion resistance of zirconium-based alloys in aqueous reactor coolants. The approach will be to study the microstructure of oxides formed in a series of model alloys that is specially fabricated and designed to highlight and isolate the effects of individual parameters on the corrosion process. This knowledge will

then be used to develop new alloys with enhanced corrosion resistance for high burnup applications. We will also test model alloys at the temperatures relevant for the Supercritical water reactor (SCWR), to discern the viability of Zr alloys for use in SCWR and to identify potential operating temperature ranges.

Y. H. Jeong, J. Y. Park, H. G. Kim, J. T. Busby, E. Gartner, M. Atzmon, G. S. Was, R. J. Comstock, Y. S. Chu, M. Gomes da Silva, A. Yilmazbayhan, and A. T. Motta, "Corrosion of Zirconium-Based Fuel Cladding Alloys in Supercritical Water," 12th International Conference on Degradation of Materials in Nuclear Power Systems – Water Reactors, The Minerals, Metals and Materials Society, Warrendale, PA, in press.

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

G. S. Was, PI (with J. W. Jones and T. Pollock)
Deepak Kumar and Jinuk Kim, Graduate Students
U.S. Department of Energy, Nuclear Energy Research Initiative (NERI)
$873,912/3 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
Sebastien Teysseyre, Research Investigator
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
Elaine West and Vladimir Bubulac, Graduate Students
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

Design of Radiation-Tolerant Alloys for Generation IV Nuclear Power Systems

G. S. Was, PI (with T. Allen, U. Wisc. and S. Bruemmer, PNNL)
Micah Hackett and Gaurav Gupta, Graduate Students
U.S. Department of Energy, Nuclear Energy Research Initiative (NERI)
$564,584/3 yrs

Under the Generation IV Reactor initiative, revolutionary improvements in nuclear energy system design in the areas of sustainability, economics, and safety and reliability are being pursued. To meet these goals, advanced nuclear energy systems demand materials that minimize resource use, minimize waste impact, improve proliferation resistance, extend component lifetime, and reduce uncertainty in component performance, all while potentially operating in higher temperature environments, to greater radiation dose, and in unique corrosion environments compared to previous generations of nuclear energy systems. The irradiation performance of structural materials will likely be the limiting factor in successful nuclear energy system development. Based on experience, materials not tailored for irradiation performance generally experience profound changes in virtually all important engineering and physical properties because of fundamental changes in structure caused by radiation damage.

This project will develop and characterize the radiation performance of materials with improved radiation resistance. Material classes will be chosen that are expected to be critical in multiple Generation IV technologies. The material design strategies to be tested fall into three main categories: (1) alloying, by adding oversized elements to the matrix; (2) engineering grain boundaries; and (3) microstructural/nanostructural design, such as adding matrix precipitates.

The materials to be examined include both austenitic and ferritic-martensitic steels, both classes of which are expected to be key structural materials in many Generation IV concepts. The irradiation program will consist of scoping studies using proton and heavy-ion irradiations of key alloys and tailored alloy condition and examination of materials irradiated in BOR-60 to confirm charged particle results. Examinations will include microstructural characterization, mechanical properties evaluation using hardness and shear punch, and stress corrosion cracking.

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R. B. Dropek, G. S. Was, J. Gan, J. I. Cole, T. R. Allen, and E. A. Kenik, "Bulk Composition and Grain Boundary Engineering to Improve Stress Corrosion Cracking Behavior of Proton Irradiated Stainless Steels," *Proc.11th Int'l Conf. Environmental Degradation of Materials in Nuclear Power Systems – Water Reactors*, 1132-1141, American Nuclear Society, La Grange Park, IL (2004).

Developing and Evaluating Candidate Materials for Generation IV Supercritical Water Reactors

G. S. Was, PI (with J. Cole, ANL; J. Jang, KAERI; J. Rempe, INEEL;
and M. Corradini, U. Wisconsin)
P. Ampornrat, Graduate Student
U.S. Department of Energy, Nuclear Energy Research Initiative (I-NERI)
$430,000/3 yrs

The goal of this project is to establish candidate materials for supercritical water reactor designs and to initiate the evaluation of the mechanical properties, dimensional stability, and corrosion resistance. To overcome the principal technical and scientific obstacles to the long-term future use of nuclear energy, new reactor designs must offer enhanced safety and reliability, sustainability and economics. To meet these goals, Generation IV (GEN IV) reactor designs must incorporate advanced materials for cladding and structural components. Currently, insufficient physical property data exist to qualify candidate materials. In many cases, candidate materials have not even been identified. For all Generation IV designs, significant materials property data must be obtained to license future reactor designs.

To meet the goals of the GEN IV Reactor research initiative, international collaborations are critical in terms of shared resources and shared expertise. Because of the significant costs associated with nuclear systems research an international cost sharing approach will provide maximum value for the limited research dollars. Both the Republic of Korea (ROK) and the United States (US) have a shared interest in the development of advanced reactor systems that employ supercritical water as a coolant.

Supercritical water reactors (SCWR) are one of the more promising Generation IV nuclear systems concepts due to enhanced thermal efficiencies and relative compactness when compared to current light water reactor (LWR) technology. The relatively mature alloy development programs for supercritical fossil plants (SC-FP) can be used as a baseline for the development of fuel cladding and structural materials in a SCWR. The SC-FP alloys have known corrosion resistance properties but have not been evaluated relative to degradation in radiation fields. Additionally, materials developed for the fast reactor programs, which operated in similar temperature regimes as SCWR, will also be evaluated for SCWR applications. These alloys have known radiation resistance, but the corrosion performance is unknown. To understand the relative materials compatibility, a comprehensive research program is proposed that initially evaluates state-of-the-art SC-FP and fast reactor materials for application in SCWR, and expands on these alloys to produce materials optimized for SCWR fuel cladding and core internal structures.

P. Ampornrat, C. B. Bahn, and G. S. Was, "Corrosion and Stress Corrosion Cracking of Ferritic-Martensitic Alloys in Supercritical Water," *Proc 12th International Conference on Degradation of Materials in Nuclear Power Systems – Water Reactors*, The Minerals, Metals and Materials Society, Warrendale, PA, in press.

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P. Ampornrat, G. Gupta and G. S. Was, "Corrosion and SCC of Ferritic-Martensitic Steels in Supercritical Water," *Proc. American Nuclear Society Annual Meeting*, June 2005, American Nuclear Society, LaGrange Park, IL.

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.

Z. Jiao, J. T. Busby, R. Obata, and G. S. Was, "Influence of Localized Deformation on Irradiation-Assisted Stress Corrosion Cracking of Proton-Irradiated Austenitic Alloys," *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, "Recent Developments in Understanding Irradiation Assisted Stress Corrosion Cracking," *Proc. 11th Int'l Conf. Environmental Degradation of Materials in Nuclear Power Systems – Water Reactors*, 965-985, American Nuclear Society, La Grange Park, IL (2004).

Radiation Effects in Candidate Materials for Spallation Neutron Environments
G. S. Was, PI; Neal Ham, Graduate Student
Los Alamos National Laboratory
$372,018/3 yrs

The objective of this project is to investigate the effect of proton irradiation on the microstructure, microchemistry and subsequent corrosion and stress-corrosion cracking behavior of ferritic-martensitic (F-M) steels for application in spallation neutron environments. A second objective will be the evaluation of the low-MeV proton damage state relative to that produced in a prototypical spallation (600-800 MeV protons and neutrons) environment.

G. S. Was, J. T. Busby, T. R. Allen, and J. Gan, "Assessment of Materials for Accelerator Applications using Proton Irradiation," *Proc. Sixth Int'l Meeting on Nuclear Applications of Accelerator Technology (AccApp'03)*, 864-873, American Nuclear Society, La Grange Park, IL (2004).

Stress Corrosion Cracking and Corrosion of Candidate Alloys for the Supercritical Water Reactor Concept
G. S. Was, PI
S. Teysseyre, Research Scientist and Q. Peng, Postdoctoral Scholar
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 4 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 (UM). 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. The tasks are described in the following sections.

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. The tasks are described in the following sections.

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).

Use of Proton Irradiation to Determine IASCC Mechanisms in Light Water Reactors

G. S. Was, PI and Jeremy Busby, Co-PI
Electric Power Research Institute
$677,000/3 yrs

The objective of this research project is to identify the specific metallurgical conditions that control IASCC using proton irradiation and constant extension rate testing (CERT) in relevant environments. This project will provide guidance in the selection of the most important metallurgical conditions for subsequent testing of neutron irradiated alloys to confirm the conditions of greatest impact to IASCC. It will also provide guidance on the selection of specific alloys with solute additions that should be irradiated in reactor for subsequent testing. This approach follows the broad CIR-II plan to examine 20 single-variable conditions spanning 14 alloys in order to isolate the metallurgical variables (microchemistry, microstructure, hardening, etc.) that control IASCC susceptibility of austenitic alloys and to determine the IASCC mechanism. Successful completion of this project is expected to result in the identification of specific metallurgical variables that most strongly impact IASCC, and hence, a better understanding of the IASCC mechanism as well as a direction for modeling and mitigation.

J. T. Busby and G. S. Was, "Effect of Metallurgical Conditions on Irradiation-Assisted Stress Corrosion Cracking of Commercial Stainless Steels," *Proc. 12th International Conference on Degradation of Materials in Nuclear Power Systems – Water Reactors*, The Minerals, Metals and Materials Society, Warrendale, PA, in press.

J. T. Busby, E. A. Kenik, and G. S. Was, "Effect of Single Solute Additions on Radiation-Induced Segregation and Microstructure of Model Austenitic Alloys," submitted to *J. Nucl. Mater*.

G. S. Was and J. T. Busby, "Role of Irradiated Microstructure and Microchemistry in Irradiation Assisted Stress Corrosion Cracking," *Phil. Mag*., **85**, 4-7, 443-465 (2005).

J. T. Busby, M. M. Sowa, G. S. Was, and E. P. Simonen, "Post-Irradiation Annealing of Small Defect Clusters," *Phil. Mag*., **85**, 4-7, 609-617 (2005).

J. T. Busby, M. C. Hash, and G. S. Was, "The Relationship Between Hardness and Yield Stress in Irradiated Austenitic and Ferritic Steels," *J. Nucl. Mater*., **336**, 267-278 (2005).

J. T. Busby, M. M. Sowa, and G. S. Was, "The Role of Fine Defect Clusters in Irradiation-Assisted Stress Corrosion Cracking of Proton-Irradiated 304 Stainless Steel," *Proc. Effects of Radiation on Materials: 21st International Symposium, ASTM STP*, edited by M. L. Grossbeck, T. R. Allen, R. G. Lott, and A. S. Kumar, 78-91, American Society for Testing and Materials, West Conshohocken, PA (2004).

M. C. Hash, L. M. Wang, J. T. Busby, and G. S. Was, "The Effect of Hardening Source in Proton Irradiation-Assisted Stress Corrosion Cracking of Cold-Worked Type 304 Stainless Steel," *Proc. Effects of Radiation on Materials: 21st International Symposium, ASTM STP*, edited by M. L. Grossbeck, T. R. Allen, R. G. Lott and A. S. Kumar, 92-104, American Society for Testing and Materials, West Conshohocken, PA (2004).

J. I. Cole, T. R. Allen, G. S. Was, and E. A. Kenik, "The Influence of Pre-irradiation Heat Treatments on Thermal Non-Equilibrium and Radiation-Induced Segregation Behavior in Model Austenitic Stainless Steel Alloys," *Proc. Effects of Radiation on Materials: 21st International Symposium, ASTM STP*, edited by M. L. Grossbeck, T. R. Allen, R. G. Lott and A. S. Kumar, 540-552, American Society for Testing and Materials, West Conshohocken, PA (2004).

B. H. Sencer, G. S. Was, F. A. Garner, G. M. Bond, M. Sagisaka, and Y. Isobe, "Proton-Induced Microstructural Evolution of Solution Annealed 304 and Cold-Worked 316 Stainless Steels Irradiated at 300 and 340^{o}C," *Proc. 11th Int'l Conf. Environmental Degradation of Materials in Nuclear Power Systems – Water Reactors*, 665-674, American Nuclear Society, La Grange Park, IL (2004).

Y. Isobe, M. Sagisaka, B. H. Sencer, G. S. Was, F. A. Garner, H. Yuya, A. Nishikawa, and Y. Sugita, "Proton-Induced Relaxation of Surface Stresses Resulting from Heavily Cold-Worked 304 Stainless Steels," *Proc. 11th Int'l Conf. Environmental Degradation of Materials in Nuclear Power Systems – Water Reactors*, 930-939, 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.

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
$600,000/yr for 2 yrs

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).

M. D. Johnston, "Ionization Dynamics of a Single Wire Z-Pinch," Doctoral Dissertation, University of Michigan, Ann Arbor (2004).

Industrial Affiliates Program

R. M. Gilgenbach, PI and Y. Y. Lau, Co-PI
L-3 Communication Electron Devices
$10,000/1 yr

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

Industrial Affiliates Program

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.

Microwave Vacuum Electronics
R. M. Gilgenbach, P.I. and Y. Y. Lau, Co-PI
U.S. Department of Defense/Air Force /University of Wisconsin
$802,894/5 yrs

This concerns vacuum microwave sources, particularly klystrons and crossed-field devices.

M. C. Jones, V. B. Neculaes, Y. Y. Lau, R. M. Gilgenbach, and W. M. White, "Cathode Priming of a Relativistic Magnetron," *Appl. Phys. Lett*., **85**, 6332 (2004).

R. Kowalczyk, Y. Y. Lau, and R. M. Gilgenbach, "Effects of a Finite Axial Magnetic Field on the Beam Loading of a Cavity," *IEEE Trans. Electron Devices*, **51**, 1522 (2004).

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.

M. C. Jones, V. B. Neculaes, R. M. Gilgenbach, W. M. White, M. R. Lopez, and Y. Y. Lau, "Projection Ablation Lithography Cathode for High-Current, Relativistic Magnetrons," *Rev. Sci. Instrum.*, **75**, 2976 (2004).

L. K. Ang, Y. Y. Lau, and T. J. T. Kwan, "Simple Derivation of Quantum Scaling in Child-Langmuir Law," *IEEE Trans. Plasma Sci.,* **32**, 410 (2004).

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

M. C. Jones, R. M. Gilgenbach, B. Qi, Y. Y. Lau, and G. L. Doll, "Ablation Plasma Ion Implantation Using a DC Power Supply," *Appl. Phys. A,* **79**, 969 (2004).

Priming of Relativistic Magnetron
R. M. Gilgenbach, PI and Y. Y. Lau, Co PI
U.S. Department of Defense/Air Force Office of Scientific Research
$600,000/3 yrs

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

M. C. Jones, V. B. Neculaes, W. White, Y. Y. Lau, and R. M. Gilgenbach, "Simulation of Rapid Startup in Microwave Magnetrons with Azimuthally Varying Axial Magnetic Fields," *Appl. Phys. Lett*., **84**, 1016 (2004).

V. B. Neculaes, R. M. Gilgenbach, Y. Y. Lau, M. C. Jones, and W. White, "Low- Noise Microwave Oven Magnetrons with Fast Start-Oscillation by Azimuthally Varying Axial Magnetic Fields," *IEEE Trans. Plasma Sci*., **32**, 1152 (2004).

J. W. Luginsland, Y. Y. Lau, V. B. Neculaes, M. H. Frese, J. J. Watrous, R. M. Gilgenbach, and M. C. Jones, "Three-Dimensional Particle-in-Cell Simulations of Rapid Startup in Strapped Magnetrons due to Variation in the Insulating Magnetic Field," *Appl. Phys. Lett*., **84**, 5425 (2004).

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).

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 ultimate goal is to combine ultra-wideband radiation and chemotherapy treatment of tumor cells.

D. W. Jordan, R. M. Gilgenbach, M. D. Uhler, L. H. Gates, and Y. Y. Lau, "Effect of Pulsed, High-Power Radiofrequency Radiation on Electroporation of Mammalian Cells," *IEEE Trans. Plasma Sci.*, **32**, 1573 (2004).

Analysis of Multipactor Discharge
Y. Y. Lau, PI
U.S. Department of Energy
$273,610/3 yrs

The general theory of particulate heating, by the rf electric field and rf magnetic field in an electromagnetic pulse of arbitrary pulse shape is developed, together with scaling laws.

H. Bosman, W. Tang, Y. Y. Lau, and R. M. Gilgenbach, "Heating of a Particulate by RF Electric and RF Magnetic Fields," *Appl. Phys. Lett*., **85**, 3319 (2004).

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).

H. Bosman, Y. Y. Lau, and R. M. Gilgenbach, "Power Absorption By Surface Films on Microwave Windows," *IEEE Trans. Plasma Sci*., **32**, 1292-1297 (2004).

Effect of the Ambipolar Potential on the Propulsive Performance of the GDM Plasma Thruster
T. Kammash, PI
National Aeronautics and Space Administration (NASA) – STTR (Phase II)
$196,000/2 yrs

The Gasdynamic Mirror (GDM) Plasma Thruster utilizes a magnetic mirror configuration to confine the plasma while being heated by external means. The rapid escape of the electrons gives rise to a positive electrostatic potential that accelerates the ions while slowing down the electrons until both species exit at equal rates, giving rise to a charge-neutral plasma beam that provides the thrust. This project is to deduce mathematically an expression for such a potential and to calculate the escape energies of the electrons and ions of the plasma.

S. Jahshan and T. Kammash,"Multimegawatt Nuclear Reactor Design For Plasma Propulsion Systems," *Journal of Propulsion and Power*, **21**, 3, 385-391 (2005).

T. Kammash, "Antiproton Powered Gas Core Fission Propulsion System," *Proc. Space Nuclear Conference*, ANS, San Diego, CA (June 2005). CD-ROM.

T. Kammash, "The Gasdynamic Mirror Fusion Propulsion System – Revisited," *Proc. STAIF 2005*, AIP Conference, **746**, Albuquerque, NM (February 2005).

T. Kammash, "JIMO Mission with Antiproton Powered Gas Core Fission Rocket," AIAA Joint Propulsion Conference, Tucson, AZ (July 2005). Paper # AIAA 2005-4322.

T. Kammash and D. Kirtley, "Wall Protection For the MICF Fusion Propulsion System," AIAA Joint Propulsion Conference, Tucson, AZ (July 2005). Paper # AIAA 2005-4139.

T. Kammash and R. Tang, “Antiproton Driven Propulsion Systems – Fission or Fusion,” AIAA Joint Propulsion Conference, Tucson, AZ (July 2005). Paper # AIAA 2005-4137.

T. Kammash and R. Tang, “Electrodeless Plasma Thruster with Self-Generated Electric Field,” AIAA Joint Propulsion Conference, Tucson, AZ (July 2005). Paper # AIAA 2005-4121.

RADIATION MEASUREMENTS AND IMAGING

Development of 3-D Advanced CZT Detectors

Z. He, PI
U.S. Department of Energy/Battelle Pacific Northwest Laboratories
$149,089/yr

This project develops 3-dimensional position-sensitive CdZnTe gamma-ray spectrometers and imaging devices, which could offer energy resolutions of 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.

J. E. Baciak and Z. He, "Long-Term Stability of 1 cm Thick Pixelated HgI_2 Gamma-Ray Spectrometers Operating at Room Temperature," *IEEE Transactions on Nuclear Science*, **51**, 4, 1886-1894 (2004).

R. Gonzalez, J. M. Perez, and Z. He, "Efficiency at Different Interaction Depths in Large Coplanar CdZnTe Detectors," *Nuclear Instruments and Methods in Physics Research A,* **531,** 544-559 (2004).

K. Hitomi, L. J. Meng, and Z. He, "Evaluation of Pixellated HgI_2 Detectors," *Conf. Record of 14th International Workshop on Room-Temperature Semiconductor X and Gamma-ray Detectors*, October 16 – 22, 2004, Rome, Italy.

C. E. Lehner, Z. He, and F. Zhang, "4π Compton Imaging Using a 3-D Position-Sensitive CdZnTe Detector via Weighted List-Mode Maximum Likelihood," *IEEE Transactions on Nuclear Science*, **51**, 4, 1618-1624 (2004).

C. E. Lehner and Z. He, "Image Artifacts Resulting from Gamma-Ray Tracking Algorithms Used with Compton Imagers," submitted to 2004 IEEE Nuclear Science Symposium, Rome, Italy.

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.

S. D. Kiff, Z. He, and G. Tepper, "A New Coplanar-Grid High-Pressure Xe Gamma-Ray Spectrometer," submitted to *IEEE Transactions on Nuclear Science*.

Miniature Neutron-Alpha Activation Spectrometer

Z. He, PI; J. P. Holloway and R. F. Fleming, Co PIs
National Aeronautics and Space Administration
$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.

Pixellated Detector Development
Z. He, PI
Department of Defense, Defense Threat Reduction Agency (DTRA)
$248,106/2 yrs

The focus of this project is to develop ASIC electronic readout systems for advanced 3-dimensional position-sensitive CdZnTe and HgI_2 gamma-ray spectrometers which could offer energy resolutions of 1% FWHM or better at 662 keV gamma-ray energy.

Advanced Radiation Detector Development in Support of National Security Needs
Z. He, PI; D. K. Wehe and G. F. Knoll, Co-PIs
U.S. Department of Energy/NN
$950,000/4 yrs

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. One of the more unusual detectors being developed involves tiny cantilever beams which deflect when radiation interacts in them. Much like a diving board, the beams vibrate at a natural frequency from the impact and the amplitude is dependent upon the momentum absorbed. These tiny beams have deflection amplitudes which are comparable to those naturally present from thermal motion, making meaningful signals difficult to extract. If successful, this would be the first detector which senses radiation from mechanical motion. Another project being initiated involves the development of a fast neutron imager. The idea here is to use the physics of Compton imaging applied to fast neutron scattering.

F. Zhang, Z. He, D. Xu, G. F. Knoll, D. K. Wehe, and J. E. Berry, "Improved Resolution for 3D Position Sensitive CdZnTe Spectrometers," *IEEE Transactions on Nuclear Science*, **51**, 5, 2427 – 2431 (2004).

F. Zhang, Z. He, and D. Xu, "Analysis of Detector Response using 3-D Position Sensitive CZT Gamma-Ray Spectrometers," *IEEE Transactions on Nuclear Science*, **51**, 6, 3098–3104 (2004).

D. Xu and Z. He, "Detection of Gamma Ray Polarization Using a 3D Position Sensitive CdZnTe Detector," accepted for publication in *IEEE Transactions on Nuclear Science,* 2005.

F. Zhang, Z. He, G. F. Knoll, D. K. Wehe, and J. E. Berry, "3D Position Sensitive CdZnTe Spectrometer Performance using Third Generation VAS/TAT Readout Electronics," accepted for publication in *IEEE Transactions on Nuclear Science*, 2005.

L. J. Meng and Z. He, "Exploring the Limiting Timing Resolution for Large Volume CZT Detectors with Waveform Analysis," *Nuclear Instruments and Methods in Physics Research A*, **550,** 435-445 (2005).

B. W. Sturm and Z. He, "Evaluation of CdZnTe Detectors using Crystals Grown by the Modified Vertical Bridgeman Technique," submitted to *IEEE Transactions on Nuclear Science*.

B. W. Sturm, Z. He, E. Rhodes, T. H. Zurbuchen, and P. L. Koehn, "Coplanar Grid CdZnTe Detectors for Space Science Applications," accepted for publication in *Nuclear Instruments and Methods in Physics Research A*, 2005.

Development of Pixellated Mercuric Iodide Gamma-Ray Detectors
Zhong He, PI
Constellation Technology Corporation
$79,756/year

This project develops thick (1cm) pixellated prototype HgI2 gamma-ray spectrometers with energy resolution of about 1% FWHM at 662 keV.

L. J. Meng and Z. He, "Estimate Interaction Timing in a Large Volume HgI_2 Detector using Cathode Pulse Waveforms," *Nuclear Instruments and Methods in Physics Research A*, **545**, 234-251 (2005).

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, etc.

L. J. Meng, N. H. Clinthorne, and W. L. Rogers, "Aperture Design for I-125 Small Animal Imaging Using A Very High Resolution Scintillation Camera," presented at the Second Annual Meeting of the Society of Molecular Imaging, San Francisco, August, 2003.

L. J. Meng, "Design of a Single Photon Emission Microscope for Small Animal I-125 Imaging," presented at the 52nd SNM Annual Meeting at 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 Outcome 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 does calculation method. However, it is not yet resolved that using this method, which involves significant computational overhead, would improve radiotherapy delivery significantly.

Applied Environmental Radiation Measurements Laboratory

K. J. Kearfott, PI
National Science Foundation with 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.

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.

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.

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.

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 focusses upon the development of an experimental facility for studying these approaches.

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.

External Research Support

SUMMARY OF RESEARCH ACTIVITIES
ACTIVE SEPTEMBER 1, 2004 – AUGUST 31, 2005

Name of Project	Funding Organization	Project Director	Budget
Structural Relaxation and Properties of Planar Defects in Amorphous and Nonocrystalline Metals	NSF	Atzmon	$365,000/3 yrs
Better Correlation of Outcomes with MC Dose Calculation	NIH/Radiation Oncology	Bielajew	$8,785
Acquisition of a Focused Ion Beam Workstation for Multidisciplinary Materials Research at the University of Michigan	NSF	Ewing	$500,000/3 yrs
Applied Materials Gift Fund	Applied Materials	Gilgenbach	$57,000/2 yrs
Cut-Cathode High-Power Microwave (HPM) Magnetron Experiments & Theories	AF/U-NewMexico	Gilgenbach/Lau	$80,000/1 yr
Electron Cyclotron Plasma Sources	NASA	Gilgenbach/Lau	$106,485/1 yr
Ionization Dynamics of Wire Z-Pinches	DOE/Sandia	Gilgenbach/Lau	$579,075/2 yrs
Microwave Vacuum Electronics	DOD/AF/U-Wisc	Gilgenbach/Lau	$777,815/5 yrs
Nanophysics of Electron Emission and Breakdown for High-Power Microwaves	DOD/AF/U-Wisc	Gilgenbach/Lau	$310,031/5 yrs
Northrop Grumman Gift	NorthropGrumman	Gilgenbach/Lau	$5,000/yr
Relativistic Magnetron Experiments and Theory	DOD/AF	Gilgenbach/Lau	$1.8M/5 yrs
Support for University Research in Vacuum Electronics (Gift)	L-3 Communication	Gilgenbach	$10,000/1 yr

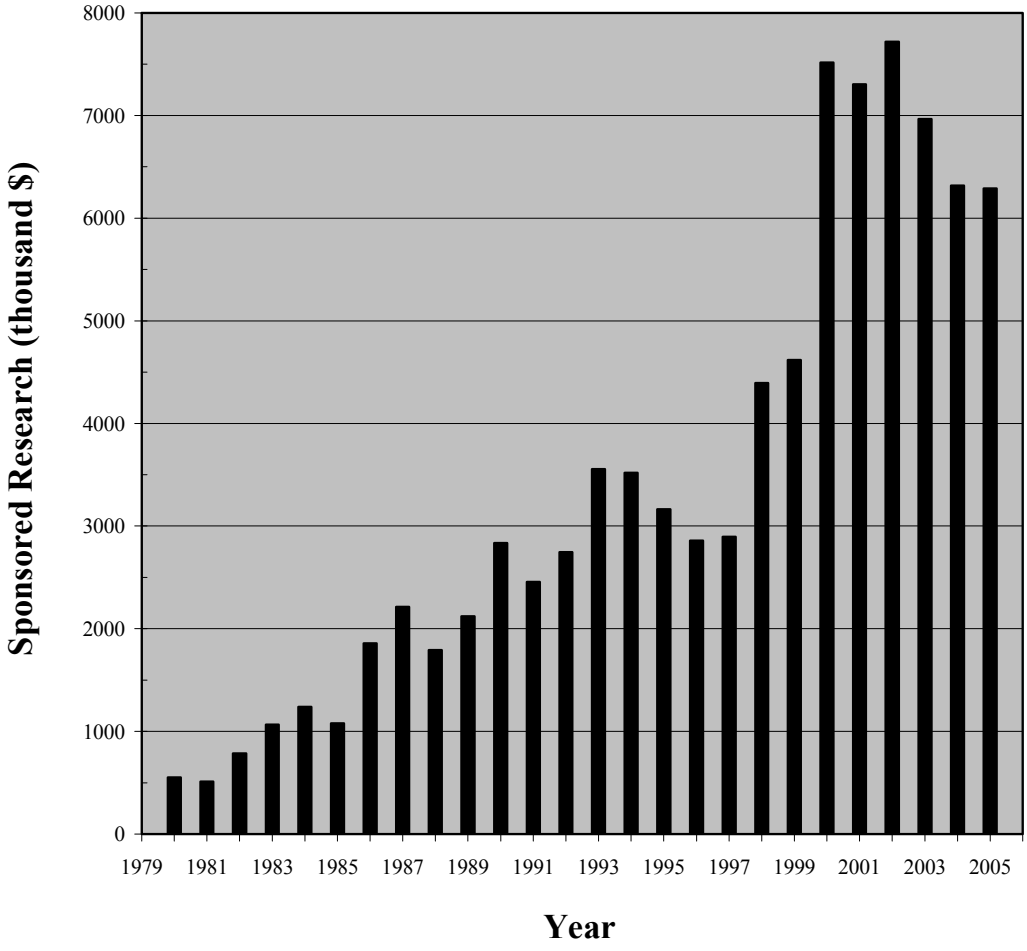
Ultrawideband Radio Frequency (RF) Enhanced Electroporation for Chemotherapy	DOD/AF	Gilgenbach/Lau/ Uhler	$450,000/3 yrs
Advanced Radiation Detector Research in Support of National Security Needs	DOE	He/Wehe/Knoll	$965,000/4 yrs
Development of Thick Pixellated Mercuric Iodide Gamma-Ray Detectors	Constellation Tech Corporation	He	$78,756/1 yr
Fast Neutron Imaging Systems	DOE/NEER	He	$336,756/3 yrs
Miniature Neutron-Alpha Activation Spectrometer	NASA/Johns Hopkins Univ.	He	$79,912/2 yrs
Pixellated Detector Development	DOD/DTRA	He	$248,106/2 yrs
Development of Time-Dependent Pn Solver for Alegra	DOE/Sandia	Holloway	$73,404/2 yrs
Hewlitt-Packard Gift for Project with MEPO	Hewlitt-Packard	Holloway	$35,000
Model-Based Transient Control and Component Degradation Monitoring in Generation IV Nuclear Power Plants	DOE/NERI	Holloway, Lee, Martin	$1,022,504/3.5 yrs
Effect of Ambipolar Potential on Propulsive Performance of the GOM Plasma Thruster (Phase 2)	NASA/Reisz Engineers	Kammash	$196,000/2 yrs
Study of Plasma Dynamics in the Gasdynamic Mirror Plasma Thruster	NASA	Kammash	$24,000/yr
Detection of Concealed Conventional Bulk Explosives	Npoint, LLC	Kearfott	$305,000/18 mos
Explosives Detection Using Neutrons	U.S. Army/Battelle	Kearfott	$90,378/1 yr
Radiation Dosimeter Development	Npoint, LLC	Kearfott	$285,000/18 mos
Radioactive Materials Transportation Risk Assessment	DOE/Sandia	Kearfott	$31,000/1 yr

ASCI Research Contract	DOE/U-CA	Larsen	$135,993/2 yrs
Advanced Variance Reduction for Global k-Eigenvalue Simulations in MCNP5	DOE/NEER	Larsen	$197,559/yr
Analysis of Multipactor Discharge	DOE	Lau	$646,185/7 yrs
Cross-Validation of Transmutation and Fuel Cycle Codes	DOE/U-CA	Lee	$59,508/1 yr
Development of Safety Analysis Codes and Experimental Validation for a Very High TemperatureGas-Cooled Reactor	DOE/I-NERI	Lee/Martin/ Holloway	$340,000/3 yrs
Development of TRU Transmuters for Optimization of the Global Fuel Cycle	DOE/NERI	Lee	$175,000/1 yr
An Experimental Program for Improving Neutronic Predictions of Advanced Nuclear Fuels (OSMOSE)	DOE/Argonne/ I-NERI	Lee	$165,000/3 yrs
Proposal for the Establishment of the Neutron Science Laboratory	DOE/Penn State U.	Lee	$150,000/1 yr
DOE/Industry Matching Grant	Industry	Martin (Dept)	$51,000/2 yrs
Global Monte Carlo Simulation with High Order Polynomial Expansions	DOE/NEER	Martin	$197,765/2 yrs
Graduate Fellowships in Nuclear Engineering – Inst of Nuclear Power Operations (NANT)	NANT	Martin (Dept)	$42,000/ 3 yrs
National Partnership for Advanced Computational Infrastructure (NPACI)	NSF	Martin	$1.2M/yr
Support of Nuclear Engineering Education and Research at U-M (DOE Matching Grant)	DOE	Martin (Dept)	$70,000/3 yrs
Westinghouse CNNC Fellowship Program	Westinghouse	Martin (Dept)	$645,000/5 yrs
Very High Resolution SPECT/CT System	NIH	Meng	$1,151,172/4 yrs

Effects of Irradiation on Icosahedral Borides	DOD/AF/Qynergy Corp	Wang	$100,000/1 yr
Material Characterization Support for GM Research and Development	GM Corp	Wang	$55,614/1 yr
Nanoparticle-Environmental Interfaces	NSF	Wang	$41,292/1 yr
Particle-Induced Amorphization of Complex Ceramics	DOE	Wang	$113,000/1 yr
Process of Friction Stir Welding and Materials for its Tool	GM Corp	Wang	$162,056/2 yrs
Self-Organized 3-D Array of Nanostructures under Irradiation	DOE	Wang	$578,056/3.5 yrs
Advanced Corrosion-Resistant Zirconium (ZR) Alloys for High Burn-up and Generation IV Applications	DOE/Penn State U./I-NERI	Was	$466,304/3 yrs
Acquisition of a Research Grad Ion Implanter for Research and Education in Ion Beam Modification of Materials	NSF	Was, et al.	$596,088/2 yrs
Candidate Materials Evaluation for the Supercritical Water-Cooled Reactor	DOE/U-Wisconsin/NERI	Was	$486,250/3 yrs
Design of Radiation-Tolerant Structural Alloys for Generation IV Nuclear Energy Systems	DOE/U-Wisconsin/NERI	Was	$564,584/3 yrs
Developing and Evaluating Candidate Materials for Generation IV Supercritical Water Reactors	DOE/Idaho Nat Lab (I-NERI)	Was	$430,000/3 yrs
Localized Deformation as a Primary Cause of Irradiation-Assisted Stress Corrosion Cracking	DOE/NEER	Was	$100,000/1 yr
Radiation Effects in Candidate Materials for Spallation Neutron Environments	DOE/U-CA	Was	$201,250/2 yrs
Random Grain Boundary Network Connectivity as a Predictive Tool for Intergranular Stress Corrosion Cracking	DOE/LLNL (NERI)	Was	$272,657/3 yrs

Strategies for Alloy Development for 1000°C Service in the NGNP	DOE/NERI	Was	$250,000/1 yr
Stress Corrosion Cracking of Candidate Alloys for the Supercritical Water Reactor Concept	DOE/INERI	Was	$449,829/18 mos
Use of Proton Irradiation to Understand IASCC in LWR Cores	EPRI	Was	$677,525/3 yrs
Integration of Electron Tracking into Compton Imaging for the Advanced Compton Telescope	NASA	Wehe	$24,000/yr
Mobile Robotics and Sensing – University Research Program in Robotics	DOE	Wehe	$852,500/yr
Gamma Ray Imaging for Medical Applica-tions (subcontract) - Radionuclides: Radiation Detection and Quantification	NIH/Nuclear Medicine	Wehe (with W. L. Rogers)	$214,933/3 yrs

SPONSORED RESEARCH BUDGET HISTORY



OTHER PROJECTS

Applied Environmental Radiation Measurements Laboratory	NSF and U-M Crosby Research Award	Kearfott	$64,000
Graduate Fellowships in Health Physics – Inst of Nuclear Power Operations (NANT)	NANT	Kearfott (Dept)	$42,000/3 yrs
Graduate Fellowships in Health Physics MUSC	U.S. DOE Special Programs Office	Kearfott (Dept)	~$53,850/ student/year
Editorial Services, *Nuclear Instruments and Methods in Physics Research A*	Elsevier Science	Knoll	$232,532/8 yrs
Homeland Security Graduate Fellowship	U.S. Dept of Homeland Security Sci & Technology	Kearfott (Dept)	$116,813/3 yrs
Office of Civilian Radioactive Waste Management Graduate Fellowship Program	U.S. DOE	Kearfott (Dept)	~$53,850/ student/year
Summer Undergraduate Research Awards	COE, Assoc Dean for Academic Affairs	Kearfott	$4,500 for 3 undergrads

Publications

(January 1, 2004 – December 31, 2004)

FISSION SYSTEMS AND RADIATION TRANSPORT

Journal Articles

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*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," *Proceedings Fourteenth International Conference on Solid State Dosimetry*, New Haven, CT, June 25-July 2, 2004.

S. J. Wilderman, *R. B. Gunnett, K. J. Kearfott, and Y. K. Dewaraja, "Fast CT/SPECT Derived 3D Monte Carlo Dose Computations for I-131 Internal Emitter Therapy," *Proceedings 2004 IEEE Nuclear Science and Medical Imaging Conference*, Rome, Italy, October 16-22, 2004. (CD)

Patents

R. R. Benke, K. J. Kearfott (primary inventor), and D. S. McGregor, "Method and System for Determining Depth Distribution of Radiation-Emitting Material Located in a Source Medium and Radiation Detector System for Use Therein," issued April 27, 2004.

*C. J. Branch-Sullivan, K. J. Kearfott (primary inventor), B. Stojadinovic, and D. S. McGregor, "Method and System for High-Speed, 3D Imaging of Optically-Invisible Radiation," issued October 19, 2004.

D. S. McGregor (primary inventor) and K. J. Kearfott, "Method and System for Detecting Ionizing Radiation," issued October 19, 2004.

Service

(January 1, 2004 – December 31, 2004)

Service to the College of Engineering

Member, MSE Graduate Committee	Atzmon
Member, Engineering Undergraduate Admissions Committee	Atzmon
Program Advisor, Engineering Physics	Atzmon
Member, Engineering Faculty Advisory Committee	Bielajew
Liaison, LSA and CoE Science	Bielajew
Member, CoE Faculty Admissions Committee	Gilgenbach
Chair, CUOS Search Committee	Gilgenbach
Professor, Engineering 195	Gilgenbach
College Representative for two EECS Hiring Committees	Gilgenbach
Member, CoE Strategic Planning Implementation Committee on Excellence in Engineering Education and First Year Programs	Holloway
Member, CoE Faculty Honors and Awards Committee	Holloway
Member, CoE Curriculum Committee	Holloway
Course Coordinator, Engineering 101–administrative/academic support	Holloway
Member, Engineering Teaching Academy	Holloway
Member, CoE Environmental Technology Council	Kearfott
Member, U-M Engineering College Discipline Committee	Larsen
Director, Center for Advanced Computing (CAC)	Martin
Member, Tenure Committee for Sherif El-Tawil (CEE)	Martin
Member, Scholarship Committee	Martin
Member, Reappointment Committee for Russell Green	Martin
Member, CoE Nominating Committee	Martin
Member, CoE Honors and Awards Committee	Martin
Participant, Faculty, Academic Careers in Engineering & Sciences (ACES)	Martin
Member, Strategic Planning Advisory Committee	Wang
Member, Engineering Corporate Relations Board	Was
Member, CoE ERC Center Review Committee	Wehe

Service to the University

Member, SACUA Library Committee	Bielajew
Member, Natural Sciences Division Committee, Promotion Review	Ewing
Member, Applied Physics Executive Committee Engineering Education	Gilgenbach
Member, U-M Radiation Policy Committee	Kearfott

Member, U-M Radioactive Drug Research Committee (RDRC) Subcommittee on Human Use of Radiosotopes (SHUR), Dosimetrist	Kearfott
Advisor, U-M Health Physics Society Student Branch	Kearfott
Director, Acting, Michigan Grid Research and Infrastructure Development (MGRID) Center	Martin
Member, Grievance Review Board Chairs Panel	Martin
Member, FNR Safety Review Committee	Martin
Member, OVPR Review Committee	Martin
Member, Executive Committee for Electron Microbeam Analysis Laboratory	Wang
Member, Rules Committee of Senate Assembly	Wang
Member, UMTRI Executive Committee – OVPR	Was
Member, fMRI Advisory Committee – OVPR	Was
Member, Conflict of Interest/Conflict of Commitment Committee - Provost/OVPR	Was
Member, PML/FNR Space Use Committee – OVPR	Was
Member, Hydrogen Initiatives & MMPP Committee – OVPR	Was
Co-Chair, UMTRI Director search committee – OVPR	Was
Member, NRC Assessment of Doctoral Programs – Provost	Was
Member, Science and Technology Policy Committee – Duderstadt	Was

Service to the Nation

Proposal Reviewer, U.S. Civilian Research & Development Foundation	Atzmon
Proposal Reviewer, National Science Foundation	Atzmon
Proposal Reviewer, Department of Energy	Atzmon
Proposal Reviewer, Puerto Rico EPSCoR Scholarly Productivity Award	Atzmon
Reviewer, ISMANAM	Atzmon
Chair, Review Panel for NSF Nanoscale Interdisciplinary Research Team	Atzmon
Member, Committee to review "Risk Based Approaches for the Disposition of Transuranic and High-Level Radioactive Waste" for the BRWM of the National Research Council	Ewing
Member, Committee to review "The Effects of Nuclear Earth-Penetrator Weapon and Other Weapons" for Division of Engineering and Physical Sciences of the National Research Council	Ewing
Participant, Consortium with U-Wisconsin, MIT, U-New Mexico, U-Nevada, Reno to study nanophysics of cathodes and windows for high power microwave generation	Gilgenbach
Reviewer, BiNational Science Foundation	Gilgenbach

Peer Review Panel, NASA Astronomy and Physics Research and Analysis (APRA) program	He
Panel Reviewer, U.S. National Laboratory Program Review, Office of Research and Development, Science and Technology Directorate, Department of Homeland Security	He
Program Review, Department of Energy NA-22 Office, Oak Ridge National Laboratory	He
Proposal Reviewer for Department of Energy	He
Proposal Reviewer, NASA (Gamma-ray astronomy)	He
Reviewer, Department of Energy Nuclear Engineering Education Research (NEER) Program, Radiological Engineering Area	Kearfott
Reviewer, U.S. Civilian Research and Development Foundation (CRDF) for the Independent States of the Former Soviet Union Center & Research Proposals.	Kearfott
Reviewer, U.S. Army Corp of Engineers, Engineer Research and Development Center's (ERDC) basic research proposals	Kearfott
Member, ASCI Prototype Hostile Environment Simulation Review Panel, Sandia	Larsen
Reviewer for Department of Energy	Larsen
Consultant, Naval Research Laboratory	Lau
Member, Department of Energy University Working Group	Lee
Member, Review Committee for the NRC's Oversight of the Davis-Besse Nuclear Power Station, U.S. General Accounting Office	Lee
Visiting Professor, Korea Advanced Institute of Science and Technology	Lee
Chair, ASCI Prototype Hostile Environment Simulation Review Panel, Sandia	Martin
Chair, University of Chicago Review Panel for ASCI Level I Center (Flash Center for Astrophysical Flashes)	Martin
Member, ASCI Primary and Secondary Burn Code Review Panel (DoE)	Martin
Member, ASCI Predictive Science Panel (DoE)	Martin
Reviewer for Department of Energy	Martin
Reviewer for National Science Foundation	Martin
Proposal Reviewer, Department of Energy, Basic Energy Sciences Program	Wang
Proposal Reviewer, Department of Energy, Small Business Innovation Research Program (SBIR)	Wang
Proposal Reviewer, National Science Foundation, Nano-Science and Technology Initiative Program	Wang
Member, Materials Review Committee for the Materials Program Plan for the NGNP, INL	Was
Member, AFCI/GenIV Materials Working Group, LANL	Was

Consultant to GAO investigation and report on PRA at Davis-Besse Reactor	Was
Reviewer, Department of Energy SBIR Phase I and Phase II Proposals	Wehe
Congressional testimony for support of Department of Energy University Programs	Wehe
Member, Department of Energy National Attribution Panel for Nonproliferation and Arms Control	Wehe

Service to the Profession

President, International Mechanochemical Union	Atzmon
Book reviewer for the Institute of Physics Publishing	Atzmon
Member, Steering Committee, International Symposium on Metastable, Mechanically Alloyed and Nanocrystalline Materials	Atzmon
Member, Chemistry and Physics of Materials Committee, TMS.	Atzmon
Consultant, Golder Associates, Inc.	Ewing
Consultant, Dade Moeller & Associates, Inc.	Ewing
Member, Board of Visitors, Institute for Computational Engineering And Science (University of Texas at Austin)	Martin
Adjunct Visiting Professor, Department of Physics, Sichuan University, Chengdu, China	Wang
Adjunct Visiting Professor, Department of Applied Physics, University of Electronic Science and Technology, Chengdu, China	Wang
Consultant, Qynergy Corporation on the evaluation of radiation effects on borides for nuclear battery applications	Wang
Board of Directors, Engineering Research Council – ASEE	Was
Member, IEEE Radiation Instrumentation Steering Committee	Wehe

Service to Professional Societies

Member, Materials Research Society Ad Hoc Committee for the Symposium on the Scientific Basis for Nuclear Waste Management	Ewing
Member, Materials Research Society Program Committee of the Twenty-Ninth International Symposium on the Scientific Basis for Nuclear Waste Management, Ghent, Belgium	Ewing
Member, American Nuclear Society Executive Committee of the Environmental Sciences Division	Ewing
Member, Maxwell Prize Committee, APS Division of Plasma Physics	Gilgenbach

Member, Program Committee of SPIE International Symposium on Optical Science, Engineering, and Instrumentation. Program on Hard X-Ray and Gamma-Ray Detector Physics, Optics and Applications	He
Secretary/Treasurer American Society of Engineering Education, Nuclear Engineering Division Executive Board/Chair Glenn Murphy Award	Holloway
Member, American Nuclear Society Scholarship Policy and and Coordination Committee	Holloway
Member, ANS President's Blue Ribbon Task Group on Workforce Needs	Kearfott
Member, Executive Committee, Michigan Local Section of ANS	Kearfott
Reviewer, Radiation and Protection Shielding Division (RPSD) Annual Meeting Abstracts	Kearfott
Reviewer, Education and Training Division (ETD) Annual Meeting Abstracts	Kearfott
Member, Pacific Basin Nuclear Conference (PBNC) 14, Honolulu, Hawaii	Kearfott
Member, Program Committee, American Nuclear Society, Pacific Basin Nuclear Conference, Honolulu, Hawaii	Kearfott
Treasurer, Mathematics and Computation Division, ANS	Martin
Vice-Chair/Chair-Elect, Mathematics and Computation Division, ANS	Martin
Member, Program Committee, Mathematics and Computation Division, ANS	Martin
Member, Board of Directors, Engineering Research Council – ASEE	Was

Service to Technical Journals

Reviewer, *Acta materialia*	Atzmon
Reviewer, *Applied Physics Letters*	Atzmon
Reviewer, *Journal of Electrochemistry*	Atzmon
Reviewer, *Journal of Materials Research*	Atzmon
Reviewer, *Materials Science and Engineering*	Atzmon
Reviewer, *Materials Transactions*	Atzmon
Reviewer, *Philosophical Magazine*	Atzmon
Reviewer, *Physical Review E*	Atzmon
Reviewer, *Physical Review Letters*	Atzmon
Reviewer, *Scripta Materialia*	Atzmon
Editor, *Physics in Medicine and Biology*	Bielajew
Guest Associate Editor, *Medical Physics*	Bielajew
Reviewer, *Medical Physics*	Bielajew
Reviewer, *Physics in Medicine and Biology*	Bielajew
Founding Editor, Mineralogical Society of American, *Elements*	Ewing

Member, Editorial Board, *Mineralogia Polonica*	Ewing
Reviewer, *IEEE Transactions Plasma Science*	Gilgenbach
Reviewer, *Physics of Plasmas*	Gilgenbach
Reviewer, *Applied Physics Letters*	Gilgenbach
Reviewer, *Journal of Applied Physics*	Gilgenbach
Reviewer, *Bioelectromagnetics*	Gilgenbach
Reviewer, *Nuclear Instruments and Methods in Physics Research A*	He
Reviewer, *IEEE Transactions on Nuclear Sciences*	He
Reviewer, *Journal of Computational Physics*	Holloway
Associate Editor, *Transport Theory and Statistical Physics*	Holloway
Reviewer, *Nuclear Science and Engineering*	Holloway
Reviewer, *Nuclear Instruments and Methods A*	Holloway
Associate Editor, (Operational Topics), *Health Physics Journal*	Kearfott
Reviewer, *Journal of Nuclear Medicine*	Kearfott
Reviewer, *Health Physics Journal*	Kearfott
Reviewer, *I.E.E.E. Transactions on Medical Imaging*	Kearfott
Reviewer, *Medical Physics*	Kearfott
Reviewer, *Nuclear Instrumentation and Methods Physics Research A*	Kearfott
Associate Editor, *Physics of Plasmas*	Lau
Reviewer and Adjudicator, *Physical Review Letter*	Lau
Reviewer and Adjudicator, *Applied Physics Letter*	Lau
Reviewer and Adjudicator, *Journal of Applied Physics*	Lau
Reviewer and Adjudicator, *IEEE Transactions Plasma Science*	Lau
Reviewer and Adjudicator, *IEEE Transactions Electron Devices*	Lau
Reviewer and Adjudicator, *Nuclear Instruments and Methods A*	Lau
Reviewer and Adjudicator, *Electron Device Letters*	Lau
Reviewer, *Nuclear Science and Engineering*	Lee
Reviewer, *Nuclear Technology*	Lee
Reviewer, *IEEE Transactions on Nuclear Science*	Lee
Reviewer, *Nuclear Instruments and Methods*	Lee
Reviewer, *PHYSOR*	Lee
Editor, Associate, *Journal of Computational Physics* (Academic Press, Inc)	Martin
Editor, Advisory, *Nuclear Science and Engineering*) (American Nuclear Society)	Martin
Member, Editorial Board, *Transport Theory and Statistical Physics* (Marcel Dekker)	Martin
Reviewer, *Applied Physics Letters*	Wang
Reviewer, *American Mineralogist*	Wang
Reviewer, *Journal of Applied Physics*	Wang
Reviewer, *Journal of Nuclear Materials*	Wang

Reviewer, *Nuclear Instruments and Methods in Physics Research B*	Wang
Reviewer, *Physical Review B*	Wang
Associate Editor, *Nuclear Instruments and Methods B*	Was
Editorial Board, *Metallurgical Transactions A*	Was
Manuscript Reviewer*, Journal of Nuclear Materials*	Was
Manuscript Reviewer, *Nuclear Science and Engineering*	Was
Manuscript Reviewer, *Nuclear Instruments and Methods*	Was
Manuscript Reviewer, *Materials Science and Engineering A Corrosion*	Was
Manuscript Reviewer, *Journal of Applied Physics*	Was
Editor, *IEEE Transactions on Nuclear Science*	Wehe
Reviewer, *IEEE Transactions on Nuclear Science, Instrumentation and Methods A*	Wehe

Workshops and Conferences

Co-Organizer, Symposium on Neutron Scattering in Materials Research	Atzmon
Organizer, 12th International Conference on Environmental Degradation of Materials in Nuclear Power Systems–Water Reactors, Stevenson, WA	Was
Conference Chair, Eleventh Radiation Measurements and Applications Conference	Wehe

Personnel

(As of September 2005)

FACULTY

Michael Atzmon
Associate Professor
Also Associate Professor, Materials Science and Engineering
PhD (Applied Physics) California Institute of Technology, 1985
Thermodynamics of materials, diffusion of solids, amorphous metal alloys, ion beam modification of materials

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

James J. Duderstadt
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
Chair 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

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

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

Ling-Jian Meng
Assistant Research Scientist
PhD (Physics & Astronomy), University of Southampton, UK, 2001
Radiation detectors, medical imaging instruments

Sebastien Teysseyre
Research Investigator
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
Also Professor, Materials Science and Engineering
Director, Electron Microbeam Analysis Laboratory (EMAL)
PhD (Materials Science) University of Wisconsin-Madison, 1988
Ion beam modification of materials, transmission electron microscopy, nanocrystalline materials, and nuclear materials

Gary S. Was
Professor
Also Professor, Materials Science and Engineering
Director, Michigan Ion Beam Laboratory (MIBL)
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

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

Russell E. Stoller
Adjunct Associate Professor
PhD (Chemical Engineering) University of California, 1987
Oak Ridge National Laboratory
Theoretical modeling of fast reactor fuel performance, fuel pin thermal performance, fission gas release

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

Xiaofeng Duan
Visiting Research Scientist
Institute of Physics, Chinese Academy of Sciences, Beijing, China

Zhili Dong
Visiting Research Scientist
Nanyang Technological University, Singapore

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

Wenhui Jiang
Visiting Professor
Shenyang University of Technology, People's Republic of China

Wei Zhou
Visiting Research Scientist
Nanyang Technological University, Singapore

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

STAFF

Research Staff

Jian Chen, Senior Research Fellow
Zhijie Jiao, Research Fellow
Qunjia Peng, Research Fellow
Xiangcheng Sun, Research Fellow
Tan Tong Tat, Visiting Research Investigator II
Scott Wilderman, Senior Research Fellow
Feng Zhang, Research Fellow
Sha Zhu, Research Fellow

Technical Support Staff

Edward A. Birdsall, Facilities Infrastructure Manager
Malik Gibbons Hansen, Research Project Engineer
Mark Perreault, Senior Electronics Technician, Plasma Experimental Bay
Victor Rotberg, Senior Research Specialist, Michigan Ion Beam Laboratory
Ovidiu Toader, Research Specialist, Michigan Ion Beam Laboratory

Administrative Support Staff

Ann Bell, Senior Secretary
Cherilyn Davis, NERS Graduate Program Secretary
Pam Derry, Academic Advisor/Counselor
Peggy Jo Gramer, Senior Graduate Program Coordinator
Caroline Joaquin, Department Administrator
Emily Koopmann, Academic Secretary
Linore Latham, Accountant (Temporary)
Pat Moore, Office and Editorial Assistant
Shannon Thomas, Accountant Associate

Advisory Board

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James A. Fici	Senior Vice President Westinghouse Electric Company Pittsburgh, PA
James D. Kurfess	Naval Research Laboratory Washington, DC
Simon Labov	Director, Radiation Detection Center Lawrence Livermore National Laboratory Livermore, CA
Randy G. Lott	Science and Technology Department Westinghouse Electric Company Pittsburgh, PA
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