ILLINOIS

Nuclear, Plasma & Radiological Engineering

GRAINGER COLLEGE OF ENGINEERING

FACULTY & FACILITIES

Fall 2019

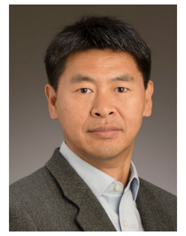
216 Talbot Laboratory, MC 234 | 104 S. Wright St. | Urbana, IL 61801

Research programs in Nuclear, Plasma, and Radiological Engineering at the University of Illinois at Urbana-Champaign can be broadly classified into five areas:

- **Nuclear Power** (reactor physics, thermalhydraulics, fuel cycle, radiation transport, I&C)
- **Plasma and Fusion** (modeling, plasma-material interactions)
- **Radiological Sciences** (detectors, imaging, health physics, medical applications)
- **Material Science** (nuclear fuels, structural materials
- **Risk and Policy** (PRA, safety, energy, arms controls, disarmament, security)

Professors

Brent Heuser



Ling-Jian Meng

David Ruzic

Jim Stubbins

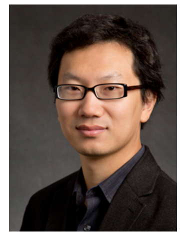
Rizwan Uddin

Associate Professors

Davide Curreli

Tomasz Kozlowski

Magdi Ragheb



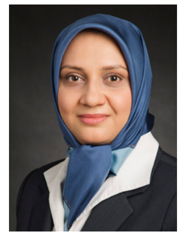
Yang Zhang

Assistant Professors

Caleb Brooks

Angela Di Fulvio

Kathryn Huff



Zahra Mohaghegh

Research Faculty/Scientist

Daniel Andruczyk

Seyed Reihani

Brent J. Heuser

Associate Head, Undergraduate Programs

Research: Nuclear materials, nuclear fuels performance modeling, microanalytical analysis techniques, neutron scattering, hydrogen in metals including Zr-based alloys for LWR applications.

positron.npre.illinois.edu

Education: BS, Nuclear Engineering, The University of Michigan, 1983; MS, Nuclear Engineering, The University of Michigan, 1989; PhD, Nuclear Engineering, The University of Michigan, 1990.

Ling-Jian Meng

Research: Radiation detection and imaging.

radimg.npre.illinois.edu

Education: BS, Modern Physics, University of Science and Technology of China, 1995; PhD, Detector Physics, University of Southampton, United Kingdom, 2001.

David N. Ruzic

Abel Bliss Professor of Engineering

Research: Plasma-material interactions; liquid metals for fusion; etching and deposition for plasma processing; EUV lithography sources; atmospheric-pressure plasmas for cleaning, adhesion, and film deposition; magnetron sputtering applications.

cpmi.illinois.edu

Education: BS, Physics/Applied Mathematics, Purdue University, 1979; MA, Physics, Princeton University, 1981; PhD, Physics, Princeton University, 1984.

James F. Stubbins

Donald Biggar Willett Professor of Engineering

Research: Nuclear power; materials.

materials.npre.illinois.edu

Education: BS, Nuclear Engineering, University of Michigan, 1970; MS, Nuclear Engineering, University of Cincinnati, 1972; PhD, Materials Science, University of Cincinnati, 1975.

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Rizwan Uddin

Department Head

Research: Nuclear engineering education; virtual reality; computational biology; nonlinear dynamical systems; reactor thermal hydraulics and computational fluid dynamics; homogenization techniques; nuclear reactor theory; computational methods.

verl.npre.illinois.edu

Education: BS, Mechanical Engineering, Middle East Technical University, 1980; MS, Nuclear Engineering, University of Illinois, 1983; PhD, Nuclear Engineering, University of Illinois, 1987.

Davide Curreli

Research: Plasma edge and PMI modeling; plasma physics and fusion.

curreli.npre.illinois.edu

Education: BS, Aerospace Engineering, University of Padua (Italy), 2004; MS, Aerospace Engineering, University of Padua (Italy), 2007; PhD, Sciences, Technologies and Measures for Space, University of Padova (Italy), 2011.

Tomasz Kozlowski

Research: Advanced reactor designs; multi-physics modeling and simulation; nuclear power; reactor analysis methods; reactor physics; reactor thermal-hydraulics; reactor transient and accident analysis; verification, validation and uncertainty methods.

arts.npre.illinois.edu

Education: BS, Nuclear Engineering, Purdue University, 2000; MS, Nuclear Engineering, Purdue University, 2004; PhD, Nuclear Engineering, Purdue University, 2005; Docent Habilitation, Nuclear Power Safety, Royal Institute of Technology (Sweden), 2011.

Magdi Ragheb

Research: Nuclear power.

npre.illinois.edu/directory/profile/mragheb

Education: BS, Nuclear Engineering, University of Alexandria, 1970; MS, Nuclear Engineering, Science Centre for Postgraduate Studies, University of Alexandria, 1973; MS, Nuclear Engineering, University of Wisconsin-Madison, 1974; PhD, Nuclear Engineering/Computer Sciences, University of Wisconsin-Madison, 1978.

Yang Zhang

Research: Physics and chemistry of liquids, especially under extreme/interfacial/non-equilibrium conditions; Accelerated atomistic simulation methods; Neutron and X-ray experiments; Long timescale phenomena and rare events; Soft robotics, human-compatible machines, and wearable human-enhancing devices.

zhang.engineering.illinois.edu

Education: BS, Electrical Science and Technology, University of Science and Technology of China, 2004; PhD, Nuclear Science and Engineering, Massachusetts Institute of Technology, 2010.

Caleb Brooks

Research: Advanced reactor designs; interfacial area transport; nuclear power; reactor thermal-hydraulics; reactor transient and accident analysis; two-phase flow and heat transfer.

mtdl.npre.illinois.edu

Education: BS, Nuclear Engineering, Purdue University, 2008; MS, Nuclear Engineering, Purdue University, 2012; PhD, Nuclear Engineering, Purdue University, 2014.

Angela Di Fulvio

Research: Neutron detection, spectroscopy, dosimetry, and imaging; Detection systems and algorithms for safeguards and nonproliferation.

npre.illinois.edu/directory/profile/difulvio

Education: BS, Electronic bioengineering, University of Pisa, Italy 2005; MS, Bioengineering, University of Pisa, Italy 2007; PhD, Nuclear Engineering, University of Pisa, Italy, 2011.

Kathryn D. Huff

Research: Advanced reactor designs; nuclear fuel cycles; nuclear power; multi-physics modeling and simulation; scientific computing.

arfc.npre.illinois.edu

Education: BA, Physics, University of Chicago, 2008; PhD, Nuclear Engineering, University of Wisconsin-Madison, 2013.

Zahra Mohaghegh

Research: Probabilistic Risk Assessment for conventional nuclear power plants and advanced reactors.

soteria.npre.illinois.edu

Education: BS, Mechanical Engineering, Shariff University of Technology (Tehran, Iran), 1996; MS, Reliability Engineering, University of Maryland, 2006; PhD, Reliability Engineering, University of Maryland, 2007.

Daniel Andruczyk

Research: Nuclear Fusion, plasma physics, plasma diagnostics, plasma material interactions, fusion materials.

npre.illinois.edu/directory/profile/andruczy

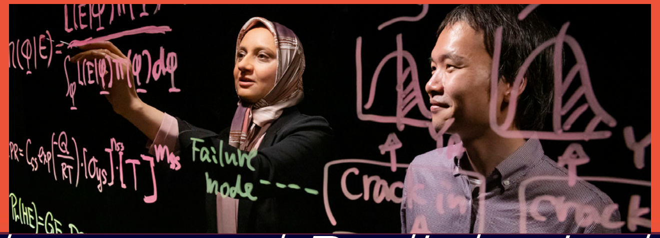
Education: BS, Physics, University of Queensland, 1998; BS (hons), University of Queensland, 1999; MS Plasma Physics, University of Sydney, 2001; PhD, University of Sydney, Plasma Physics, 2005.

Seyed A. Reihani

Research: Probabilistic physics of failure analysis; Reactive transport modeling; Reactive surface modeling and characterization

npre.illinois.edu/directory/profile/sreihani

Education: BSc, Mechanical Engineering, Sharif University of Technology (Tehran, IRAN), 1989; MSc, Mechanical Engineering, University of Tehran (Tehran, IRAN), 1992; PhD, Mechanical Engineering, University of Maryland, College Park, 2005



NPRE Laboratory Facilities

Talbot Laboratory, 104 S. Wright St.

Advanced Reactors & Fuel Cycles Group

118 Talbot, arfc.npre.illinois.edu, Katy Huff

The ARFC group seeks to advance the safety and sustainability of nuclear energy production through improved reactor designs, fuel cycle strategies, and waste management techniques. In the area of advanced reactors, our work focuses on extending current simulation tools with features essential to advanced reactor multiphysics. In the context of the broader nuclear fuel cycle, the ARFC group emphasizes modeling, simulation, and analysis of the global nuclear fuel cycle, with an emphasis on sustainability. A crosscutting theme of our research is an emphasis on advancing methods and software for computational nuclear engineering. Accordingly, the ARFC group is proud to affiliate with the University of Illinois National Center for Supercomputing Applications and its Blue Waters computing facility.

Functional X-ray Imaging Lab

225F Talbot, radimg.npre.illinois.edu, Ling-Jian Meng

FXIL consists of a walk-in closet equipped with four different X-ray sources, a wide variety of X-ray imaging and spectroscopic detectors, an optical photon imaging camera based on state-of-the-art intensified EMCCD detectors, and potentially a regular emission tomography system integrated ion beam line. The facility offers highly unique X-ray imaging techniques for a wide range of biomedical imaging applications, including micro X-ray computed tomography (CT), X-ray florescent CT (XFCT), X-ray luminescent CT (XLCT) and nanobeam therapy. The equipment can be used in microbiology and nano-medicine, potentially novel bio-imaging technologies, and to monitor cancer micro-biology.

High Temperature Corrosion Lab

220, 209 Talbot, positron.npre.illinois.edu, Brent J. Heuser

A recirculating loop autoclave with load frame capability is housed in this laboratory. This system is used to simulate LWR primary coolant conditions under applied load to study hydrothermal corrosion and other phenomenon such as stress corrosion cracking. A simultaneous thermal analyzer with combined thermogravimetric and differential scanning calorimetry function is also part of this laboratory. A Zeiss AXIOscope A! material microscope and Mettler Toledo analytical balance are available for preliminary sample characterization.

High Temperature Nuclear Materials Lab

209A, B, C Talbot. materials.npre.illinois.edu, James F. Stubbins This laboratory focuses on materials characterization research on the effects of high temperatures, corrosive atmospheres, mechanical loading and radiation in advanced nuclear materials. This includes in situ creep and creep-fatigue experiments at high temperatures, high temperature aging and exposure to controlled corrosive atmospheres, microstructure and radiation damage evaluation using scanning, transmission, and scanning-transmission electron microscopes (SEM, TEM and STEM) located in the Materials Research Laboratory, and mechanical property studies with micro-tensile tests using load frames located in the AMTEL Laboratory. This laboratory is equipped with sample preparation and thermo-mechanical testing instruments including a mechanical polisher, vibratory polisher, and a fume hood equipped with twin jet-polishers for scanning electron microscopy (SEM) and TEM sample preparation, as well as high temperature gas control systems and gas chromatography for elevated temperature materials exposure.

Magnetron Sputtering Lab

220, 209 Talbot, positron.npre.illinois.edu, Brent J. Heuser

A reactive gas magnetron sputtering tool dedicated to the growth of thin films for nuclear applications is housed in this laboratory. This system can deposit uranium-based compounds using reactive gases such as oxygen and nitrogen. The sample stage can be heated to 800 C for single crystal growth. The system employs three sputter gun for co-sputtering to achieve a wide range of compositions. A calibrated thickness monitor, gas flow control, and a precision leak valve are part of this system. Past projects include mass transport studies in urania and coatings for accident tolerant nuclear fuel.

Multiphase Thermo-fluid Dynamics Lab

11 Talbot, mtdl.npre.illinois.edu, Caleb Brooks

This laboratory performs experiments related to thermal hydraulics and multiphase flow. Phenomena studied include boiling, condensation, critical heat flux, natural circulation, two-phase flow instabilities, bubble dynamics, and two-phase transport. Utilizing advanced instrumentation, data from these experiments are used in model development and validation of computational tools.

Soft Robotics & Artificial Intelligence Lab

220B Talbot, http://zhang.engineering.illinois.edu, Yang Zhang

The lab works on the design, manufacture, and intelligent control of soft robots, human-compatible machines, and wearable human-enhancing devices using advanced soft materials and sensors. These soft robotic devices have demonstrated promising capabilities that could enable a wide range of unique applications not possible with traditional robots.

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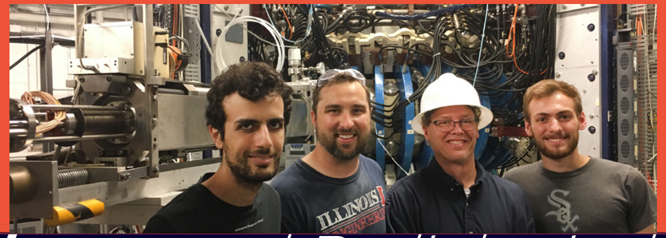

Nuclear, Plasma and Radiological

Radiation Detection & Imaging Lab

220C Talbot, radimg.npre.illinois.edu, Ling-Jian Meng

The Radiation Detection and Imaging Lab focuses on developing non-invasive imaging technology for use in preclinical medical research. Many of our current endeavors focus on developing semiconductor Single Photon Emission Computed Tomography (SPECT) and Positron Emission Tomography (PET). These works challenge the current state of the art for spatial resolution and system sensitivity. The use of highly pixelated CdTe detectors has driven our work to break into a spatial resolution on the order of 300 microns for both PET and SPECT. Our work in SPECT has also challenged the limits of aperture sensitivity through the engineering of the compound-eye aperture.

Radiological Instrumentation Lab

225D Talbot, ril.npre.illinois.edu,

RIL focuses on research and development of new radiation detection and instrumentation for imaging and sensing applications. This includes the development of novel detector technology and imaging techniques, data processing, experimental validation, modeling, computational problem solving, and quantitative characterization of biological processes.

Socio-Technical Risk Analysis Lab

127 Talbot, soteria.npre.illinois.edu, Zahra Mohaghegh

The SoTeRiA Laboratory provides scientific and innovative research solutions to complex and real-world problems of safety, reliability, security, and profitability. SoTeRiA is advancing Probabilistic Risk Assessment (PRA) for risk-informed design and regulation of conventional nuclear power plants and advanced reactors by contributing to two key areas of theoretical and methodological development: (1) spatio-temporal causal modeling of social and physical failure mechanisms in PRA and (2) the fusion of big data analytics with PRA. The lab's on-going research projects on organizational risk analysis, sponsored by the National Science Foundation (NSF); on systematic enterprise risk management for utilities, funded by the Department of Energy (DOE); on probabilistic physics of failure analysis for Advanced Water Cooled Reactors, supported by the International Atomic Energy Agency (IAEA); and the projects led by the nuclear industry can be found on the SoTeRiA Lab website.

Virtual Education & Research Lab

135 Talbot, verl.npre.illinois.edu, Rizwan Uddin

The goals of VERL span research, teaching, service and outreach. Tools used are innovative and mostly computer-based. From fundamental advances in numerical methods; advanced modeling and simulation of different aspects of scientific and engineering problems; to virtual, 3D models for training, education and outreach; this laboratory focuses on developing and using new methods and tools to address fundamental scientific and applied engineering problems.

Micro/Nano Technology Laboratory, 208 N. Wright St.

Radiation Surface Science & Engineering Lab

1302 MNTL, rssel.engineering.illinois.edu,

The RSSEL group designs self-organized nanostructures and mesostructures with directed irradiation synthesis and directed plasma nanosynthesis to enable multi-functional and multi-scale properties at surface and interfaces of dissimilar material systems (e.g. polymer and metals, ceramics and biomaterials). Research areas include: advanced functional biointerfaces, advanced fusion interfaces, multi-scale computational irradiation surface science, nanostructured functional materials, sustainable nanomanufacturing, and in-situ, in-operando diagnostics.

Computing Applications Building, 605 E. Springfield Ave.

Computational Plasma Physics Lab

129 CAB, curreli.npre.illinois.edu, Davide Curreli

The Computational Plasma Physics Group develops theoretical and computational models for a variety of Plasma Physics applications ranging from fusion edge plasmas to industrial plasmas and nuclear forensic, utilizing advanced, predictive simulation capabilities on high-performance computing machines, and multi-physics multi-scale models.

Digital Computer Laboratory, 1304 W. Springfield Ave.

Neutron Metrology Lab

L538 DCL, npre.illinois.edu/directory/profile/difulvio, Angela Di Fulvio

This lab is currently under construction and, once completed, will be a neutron experimental facility for both NPRE students and researchers in NPRE and elsewhere. The lab is equipped with a Cf-252 source and a D-T neutron generator with an emission rate of ~1E7 and ~1E8 neutrons/s, respectively. The neutron flux density is well-characterized in energy and intensity employing various instruments, including multisphere spectrometers, ionization chambers, long counters, and scintillators, calibrated to primary reference standards, which enable the detection of neutrons via scattering of protons or via fission of uranium nuclei.

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Nuclear, Plasma and Radiological

Nuclear Radiation Laboratory, 201 S. Goodwin Ave.

Center for Plasma-Material Interactions

NRL, cpmi.illinois.edu, David N. Ruzic

The primary objective of CPMI is studying plasma-material interactions relevant to fusion, semiconductor manufacturing, and plasma processing through computational and experimental means. CPMI has facilities for the study of fusion materials, High Intensity Pulsed Magnetron Sputtering (HIPMS), liquid metals, Extreme Ultraviolet Lithography (EUVL), laser-material interactions, and more. Government and commercial partners support projects to further application and knowledge of plasma physics.

Hybrid Illinois Device for Research & Applications (HIDRA)

NRL, cpmi.illinois.edu/2016/04/26/hidra-hybrid-illinois-device-for-research-and-applications, Daniel Andruczyk

The Hybrid Illinois Device for Research and Applications (HIDRA) is a toroidal plasma device at Illinois, formerly known as WEGA when operated in Greifswald. The HIDRA vacuum vessel has a circular cross section and a major radius of R = 0.72 m and a minor radius a = 0.19 m, with a steady state toroidal magnetic field BT < 0.5 T. A limiter can be used with reduced plasma minor radius between 0.10 – 0.15 m. Since HIDRA has the ability for long pulse steady state operation via the classical stellarator configuration, HIDRA has an actual toroidal magnetic field, just like a tokamak. HIDRA also has the capability to operate as a tokamak and thus a pulsing capability during steady operation allows simulation of transient events. Initial plasmas will use 2.45 GHz magnetron heating up to 26 kW and should achieve Te ~ 20 eV and ne ~ 1×1018 m-3. Even though these plasma parameters are much lower than that of larger devices like EAST, the plasma and magnetic fields at the first wall are very close to those produced in HIDRA. The steady state and pulsed capabilities of HIDRA make it an ideal test bed for liquid Li science and technology, where flow, ejection and recycling can be assessed.

Nuclear Engineering Laboratory, 100 S. Goodwin Ave.

Fusion Studies Lab

104 NEL, fsl.npre.illinois.edu, George H. Miley

Condensed phases of hydrogen in metals is the primary interest of this laboratory. The properties of trapping sites at defect structures are currently being investigated in thin films and nanoparticles. Current experiments include characterizing the effects of plasma treatments, cryo-milling, and hydride cycling on the creation of these defect structures. COMSOL modeling is also done for metal hydride chemisorption and heat transfer in porous media. Various equipment: Thermal Desorption Spectroscopy (TDS) unit, liquid N2 stainless-steel ball mill, dual use high-pressure/high-vacuum systems, and a DC HV plasma apparatus. These studies are relevant to Inertial Confinement Fusion, hydrogen storage, and High Temperature Superconductivity.

College of Engineering/Campus

Beckman Institute for Advanced Science and Technology, 405 N. Mathews Ave., beckman.illinois.edu. Beckman is an interdisciplinary research institute devoted to leading-edge research in the physical sciences, computation, engineering, biology, behavior, cognition, and neuroscience.

Coordinated Science Laboratory, 1308 W. Main St., csl.illinois.edu. CSL is a premier, multidisciplinary research laboratory focusing on information technology at the crossroads of circuits, computing, control, and communications. CSL uses these innovations to explore critical issues in defense, medicine, environmental sciences, robotics, life-enhancement for the disabled, and aeronautics.

Frederick Seitz Materials Research Laboratory, 104 S. Goodwin Ave., mrl.illinois.edu. MRL fosters interdisciplinary research at the forefront of materials science. MRL brings together world-class faculty and students in condensed matter physics, materials chemistry, and materials science in a highly collaborative research environment.

Micro and Nanotechnology Laboratory, 208 N. Wright St., mntl.illinois.edu. MNTL faculty and students are conducting research advancing a broad range of applications, including high-speed data communications, high-efficiency lighting, solar power, flexible electronics, biosensors for drug discovery, biomedical imaging, disease diagnostics, vaccine delivery strategies, environmental monitoring, and novel microelectronics/photonics concepts for next-generation computing architectures.

National Center for Supercomputing Applications, 208 N. Wright St., ncsa.illinois.edu. NCSA is a hub of transdisciplinary research and digital scholarship where faculty, staff, students, and collaborators unite to address research grand challenges. NCSA provides integrated cyberinfrastructure – computing, software, data, networking, and visualization resources and expertise essential to the work of scientists, engineers, and scholars at Illinois and across the country.

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