

Training the 21st Century Nuclear Workforce at South Florida's Public Research University

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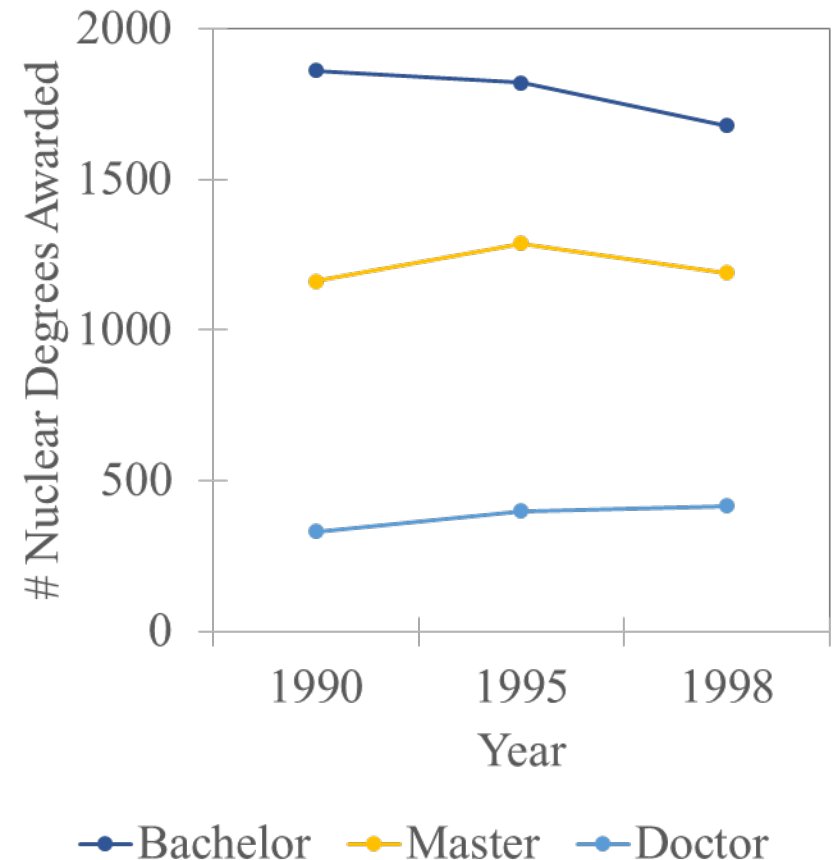


- I. Nuclear Workforce Needs and Challenges
- II. FIU: Its growth and current status as a public research university
- III. FIU's developing Radiochemistry, Health Physics, and Applied Radiological Sciences degree programs
- IV. FIU's Nuclear Research Areas of Emphasis



A Nuclear Workforce Crisis?

- **Retirement wave** has led to recent expertise shortage
- **Radiochemistry and Physics** were specifically identified as “high future demand”
- Few programs are in minority-serving institutions with limited access to research
- **Number of programs and graduates of Nuclear & Radiochemistry/Nuclear Physics have been consistently decreasing over the past 20 years**



OECD/NEA “Nuclear Education and Training: Cause for Concern?” (2000)

Blue Ribbon Commission on America’s Nuclear Future, Report to the Secretary of Energy (2012)
http://www.nei.org/corporatesite/media/filefolder/BRC_FinalReport_Jan2012.pdf



Both Traditional Nuclear Chemistry and Physics Programs in Prolonged Decline

Chem. Subfield	1999-2004	2005-2009
Analytical	1957	1861
Pharmaceutical	333	333
Nuclear	36	n/a
Organic	3232	3207
Polymer	636	600
Physical	1754	1652
Total Chemistry	12232	11457

Physics Subfield	1999-2004	2005-2009	Growth
Atomic, Molecular and Chemical	529	687	30%
Condensed Matter	1729	2363	37%
Particle	888	1405	58%
Nuclear	448	471	5%
Polymer	120	157	31%
Total Physics	7060	10385	47%

Note: Nuclear Chemistry was not included on the surveys of doctoral students in 2005 – 2009

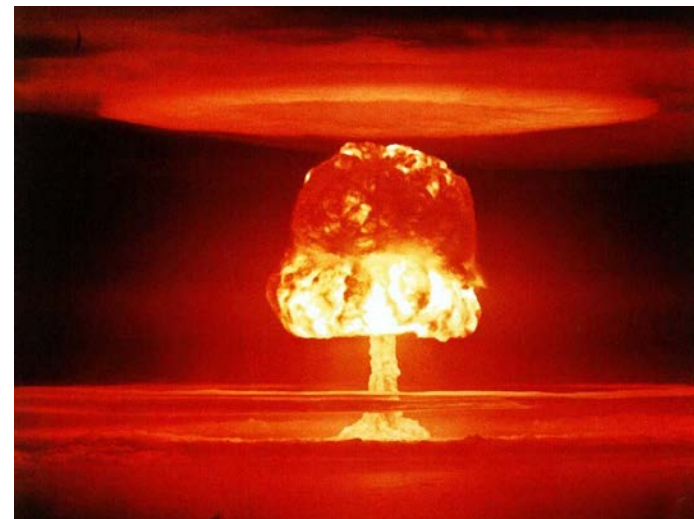


US NRC identified

- **Radiochemistry** and **Health Physics** as areas of strong future growth in US workforce
- Large shortages in underrepresented minority participation in current nuclear workforce and in university nuclear programs

University Goals

- To attract high quality students into nuclear career degree programs
- To meet future staffing requirements of US nuclear workforce
- To develop new or update aging research facilities



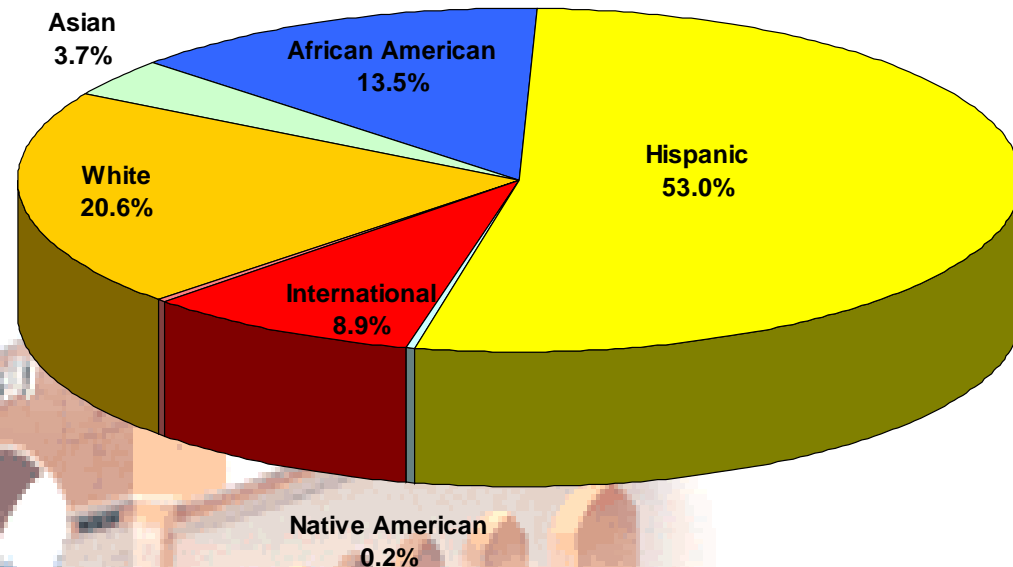
1972 opening: 6,000 students



- ~55,000 students
- 10th largest university in the nation
- *Washington Monthly* ranked 17th in the nation for top universities
- Multi-campus university on 579 acres



- **Top producer of Hispanic graduates in the U.S.**
- **Third ranked producer of minority undergraduate degrees**
- **Ninth ranked producer of minority graduate degrees**
- **Highest level Carnegie Doctoral Comprehensive Research Institution rating**



- > **30 research centers** and institutes at FIU
- > **420 laboratories**, high bays or other research spaces
- The Applied Research Center (ARC) is a soft money center at FIU

ARC Mission Statement

- Solve complex issues in environmental stewardship, energy security, nuclear, cyber security and defense technology through innovative, cooperative research
- Apply entrepreneurship in serving our clientele and ensuring sustainability and growth
- Provide unique mentoring and internship opportunities to the students of FIU
- Develop and maintain an internationally-recognized, proficient and diverse workforce



FIU's Nuclear Research Interdisciplinary Program (NRIP)

- Spearheaded by the Applied Research Center (Dave Roelant): working across departments and colleges and creating collaborations
- Includes the following: **ARC, Chemistry, Physics, Biomedical Engineering, and the Medical School**
- Bridges FIU strengths with societal and workforce needs
- **External Nuclear Board of Advisors** chaired by Dr. Nils Diaz with 16 member organizations including LANL, SRNL, ORNL, U. Mich, MIT, Columbia, AREVA, Southern Co., Westinghouse, Hitachi
- Holds **monthly business development meetings** on RFPs, proposal development, client engagement, client needs, and aligning FIU to win future awards



- **Established June 2011** by 5 researchers from 5 FIU departments (ARC, Physics, Chemistry, Biomedical Engineering, and Medical School) which grew to > 35 researchers by July 2015
- **Niche technical areas:** 1.) Radiochemistry, 2.) Health Physics/Radiation Measurements, 3.) Nuclear Forensics
- Has growing **funding from MSI and STEM** program development funds to build FIU R&D and academic programs with scope aligned to nuclear topics of the funding agencies
- Secured over **\$1.5M of NRC funding for development** of nuclear programs and capabilities (curricula development, faculty development, undergrad scholarships, graduate fellowships)



Vision By July 2018

- **Grow external nuclear funding to \$1M/yr** (50% R&D; 50% academic support)
- **Improve high quality nuclear education** while maintaining FIU as the lowest cost and most affordable university (*US World News Report*)
- Support FIU's College of Arts and Sciences to establish and **develop an Applied Radiological Sciences degree program** consisting of tracks in Radiochemistry, Health Physics, and Nuclear Forensics with over 60 students in dedicated BS, MS or PhD programs
- **Increase involvement of faculty & staff** in interdisciplinary nuclear research; and radiochemistry, forensics, and health physics students performing nuclear R&D.



Radiochemistry (RC) Track in Chemistry Ph.D. Program

- **Curricula development** over 2013-2014 (with support from US-NRC)
- Approved in Summer 2015 as **a track within the chemistry Ph.D. Program**
 - Already recruited its first student (minority Hispanic female).
- **Current US-NRC support through nuclear fellowships grants** [\$684,000 to support 6 graduate students per year until 2018]
- **New Assistant Professor** to be hired (from recently awarded US NRC Junior Faculty Development Grant)
- Ultimate goal to move track into an Applied Radiological Sciences (ARS) degree program in CAS combining with Health Physics track
 - Expected launch date: Fall 2017



Health Physics (HP) Track in Physics

- **Proposal for BS Physics with Specialty in Health Physics** submitted to undergrad curricula comm. Sept. 2015; remaining approvals by Aug. 2016; launch Fall 2016 (4 Nuclear Physics professors championing the program)
- **Ph.D. Health Physics (HP) possible in 2017** if FIU is awarded \$450K in July 2016 for hiring a professor in Health Physics specialization on NRC Faculty Development grant
 - Ph.D. HP Curricula was developed over 2013-2014. New hire HP professor would enable quick planning and approval of a HP track Physics PhD degree.
- Based upon primary recommendation of FIU's Nuclear Board, combining radiochemistry and health physics into a CAS degree program administered by Physics & Chemistry Departments would greatly enhance funding and multidisciplinary nature of R&D.



Nuclear R&D Funding Goals

- **5 key federal government clients** (DOE NEUP, NRC, DHS, NNSA, & DTRA) identified in 2012 as funding multi-disciplinary, nuclear R&D relevant to INRP.
- Smaller funding from industry (Cabrera, FPL, AREVA, etc.) is of strategic importance and is being pursued
- **\$1M per year** in external funding (50% R&D/ 50% Academic)



Current Nuclear Research Programs:

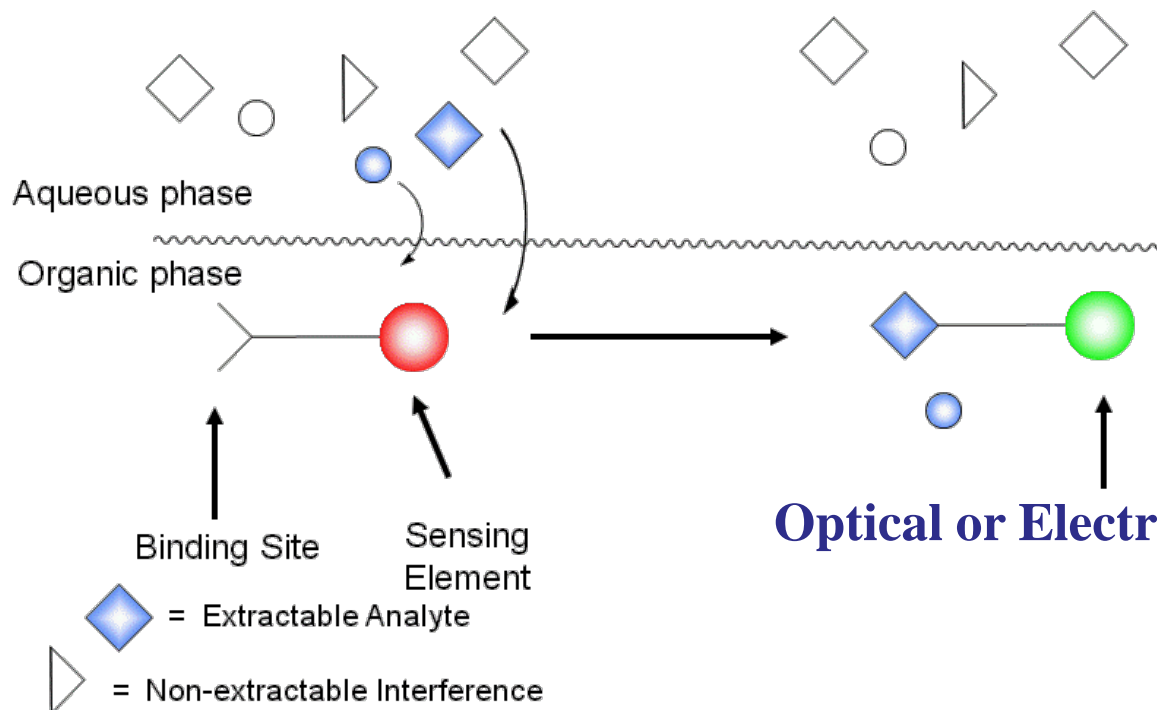
- Nuclear physics research at U.S. Dept. of Energy's Jefferson Laboratory (Physics, DOE Office of Science, \$0.5M/yr)
- Separations chemistry for nuclear fuel and high-level radioactive waste (Chemistry & ARC, DOE EM funded via SRNS contract for \$0.3M/yr)
- Cleanup of soil, groundwater, facilities and waste contaminated with radioactivity (ARC, DOE-EM funded at \$4.5 M/yr)
- Consulting contracts: Vector, Inc (for WIPP-related research) and ISM (for HLW consulting)



- **CSS Professors:**
 - Konstantinos Kavallieratos, Alexander Mebel, Raphael Raptis, Francisco Fernandez-Lima, Bruce McCord
- **CSS Group** is designing ligands and sensors for targets of nuclear security and nuclear fuel cycle and high-level waste separation applications based on coordination and supramolecular chemistry principles:
 - Metals and Nuclear Materials
 - Explosives
 - Chemical Warfare Agents
 - Nuclear Fuel Processing



Combining solvent extraction and ion exchange with coordination offers opportunities for 1) **Selective Sensing of Ion-pair combinations**, of importance to Nuclear Security and 2) **Nuclear Fuel Cycle and High-Level Waste Separation Applications**.



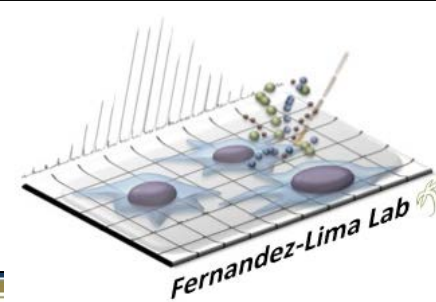
Potential for co-extraction/
combined sensing of multiple
species through ion pairing

Optical or Electrochemical Response

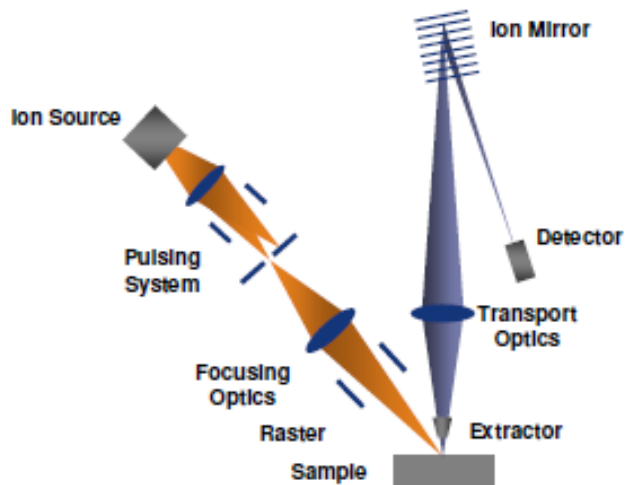


- Synthesis, including inert atmosphere
- NMR spectroscopy (600 and 400 MHz)
- Mass Spectrometry including ICP-MS, APCI-MS and ESI-MS
- UV-Vis and Fluorescence Spectroscopy
- FT-Infrared Spectroscopy
- Electrochemistry
- Calorimetry
- X-ray Crystallography
- Computational methods

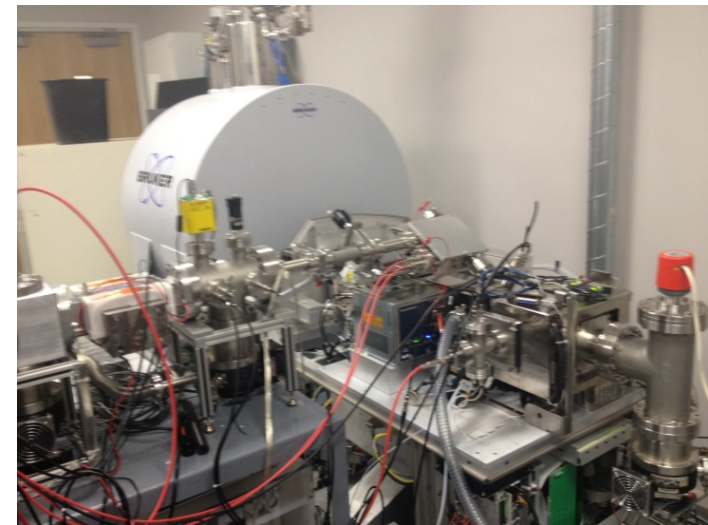




Structural and compositional characterization of metal oxide pellets and oxides using surface-based mass spectrometry.



Dual beam Bi_3 and Ar_{1000} 3D profiling coupled to a TOF SIMS

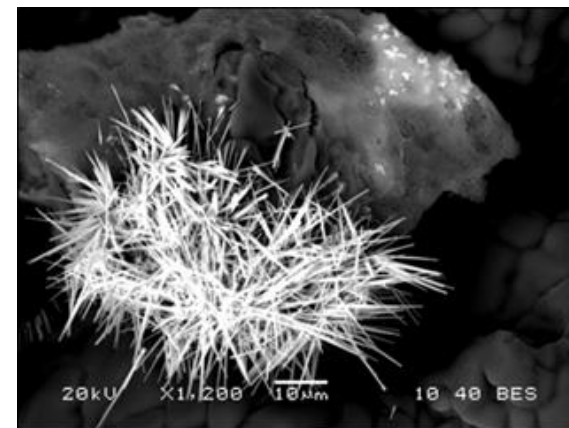


NP beam coupled to FTICR-SIMS instrument developed at Dr. Fernandez-Lima laboratory



Collaboration with DOE's **Hanford Site** and **Savannah River Site** for Uranium remediation in F/H area seepage basins.

- Investigating **Microbial-Meta-Autunite Interactions** - Effect of Bicarbonate and Calcium Ions
- Behavior of **humate and sodium silicate** in the F/H Area subsurface [possible options for Uranium remediation]
- **Uranium Immobilization by NH₃ Gas injection** at the Hanford 200 Area Vadose Zone
 - Deliquescence behavior and Precipitate formation
 - Uranium sorption to relevant minerals in the presence of NH₃
 - Mineral dissolution and precipitation



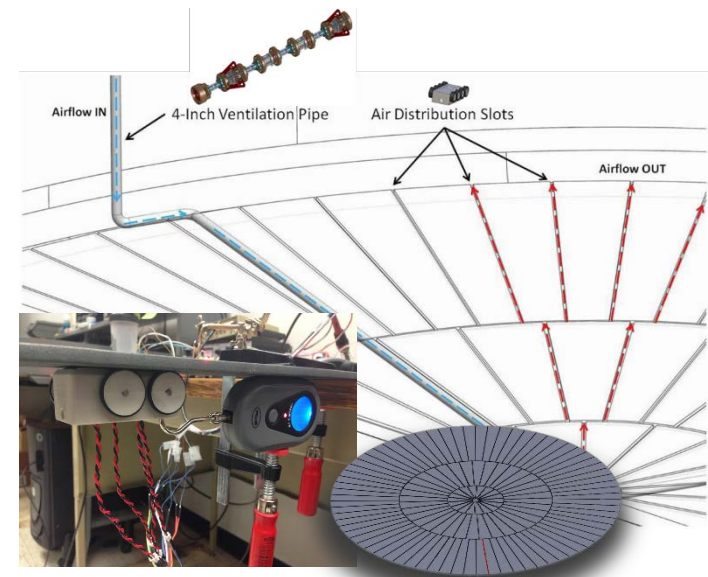
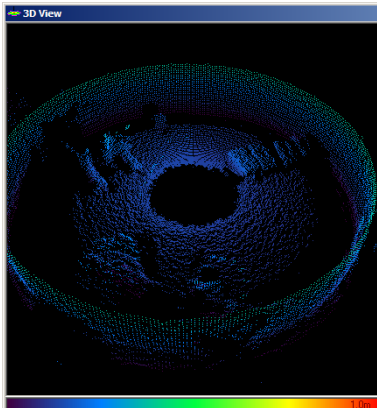
Crystalline
uranium phases



Over 250 technologies developed and tested at FIU ARC since 1995

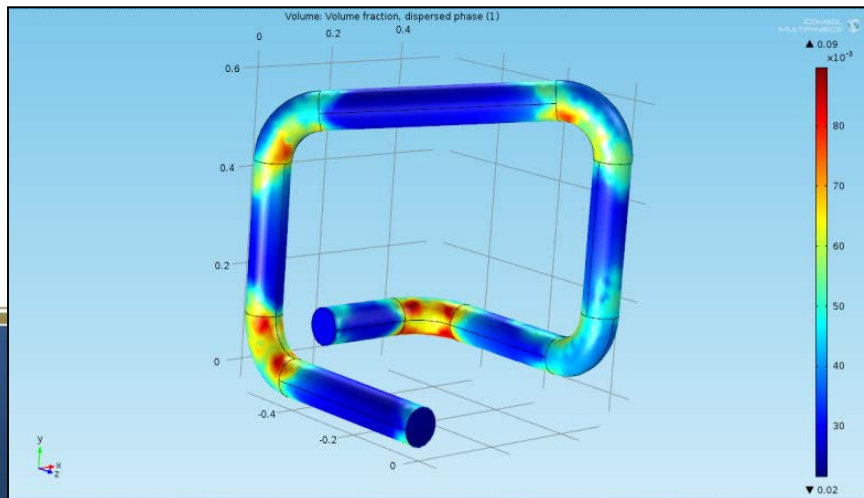
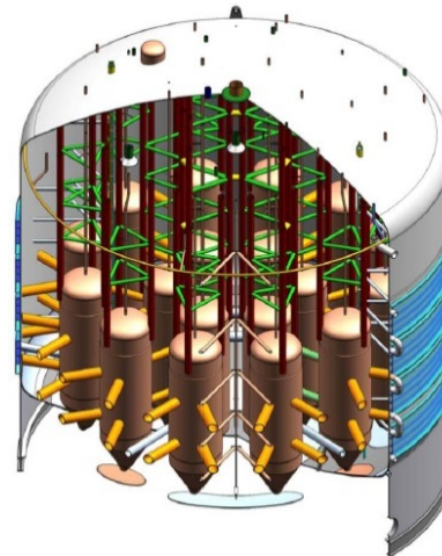
Current technology development:

- Pipeline unplugging technologies
- Sensor systems for pipeline integrity analysis
- Inspection tools for double shell tanks
- Sensor evaluation for tank mixing and settling



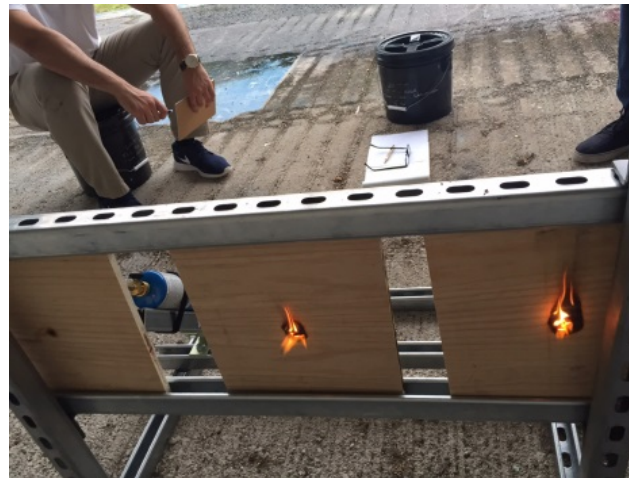
Additional tasks have focused on the modeling and experimental analysis of HLW

- CFD modeling of plug formation in HLW lines - effects of pipeline geometry
- Modeling of non-Newtonian fluids and multiphase flows for the evaluation of mixing processes in HLW tanks
- Experimental analysis of gas retention properties



Intumescent Coating and Fixative testing:

- Mitigate/prevent radionuclide release in the event of a fire by adding an intumescent coating to fixatives
- Fixative degradation begins at 200 – 400°C
- Testing from 100 – 1000°C



Laboratories host a wide variety of specialized equipment including:

- 4 Gamma Spectrometers
- Permacon Facility with HEPA filters
- 20+ Alpha Spectrometers
- Liquid Scintillation Counter
- KPA Uranium Detector
- ICP-OES in radiological facility
- Radiochemistry Lab
- Multiport Glovebox
- 10+ Dosimeters



Multiport glovebox facility (**left**) housed in a 20'x24' Permacon Rad facility (**right**) with 3 stage HEPA filters.



- FIU is working to address nuclear workforce shortages
- Radiochemistry and Health Physics are emerging academic and R&D areas at FIU
- Over 70 researchers and labs now perform nuclear-related R&D (under a broad radiation license with the State of Florida that can handle numerous elements and isotopes)
- FIU students are eager for additional radiological internships and career opportunities



The U.S. Nuclear Regulatory Commission Educational Development Grants:

NRC NRC-HQ-13-G-38-0017 (Scholarships)

NRC-HQ-84-14-G-0040 (Fellowships)

NRC-HQ-84-15-G-0043 (Faculty Development)

NRC-HQ-12-G-38-0079 (Curriculum Development)

The Department of Energy's Office of Environmental Management (DOE EM) for Cooperative Agreement, DE-EM0000598, "Rapid Deployment of Engineered Solutions for Environmental Problems"

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THANK YOU

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