Implementation of a Research & Education Program at the PULSTAR Reactor

Ayman I. Hawari

Distinguished Professor & Director

Nuclear Reactor Program
Department of Nuclear Engineering
North Carolina State University
Raleigh, North Carolina, USA

TRTR 2021, October 17 – 21, 2021, Zoom meeting
Raleigh, North Carolina, USA

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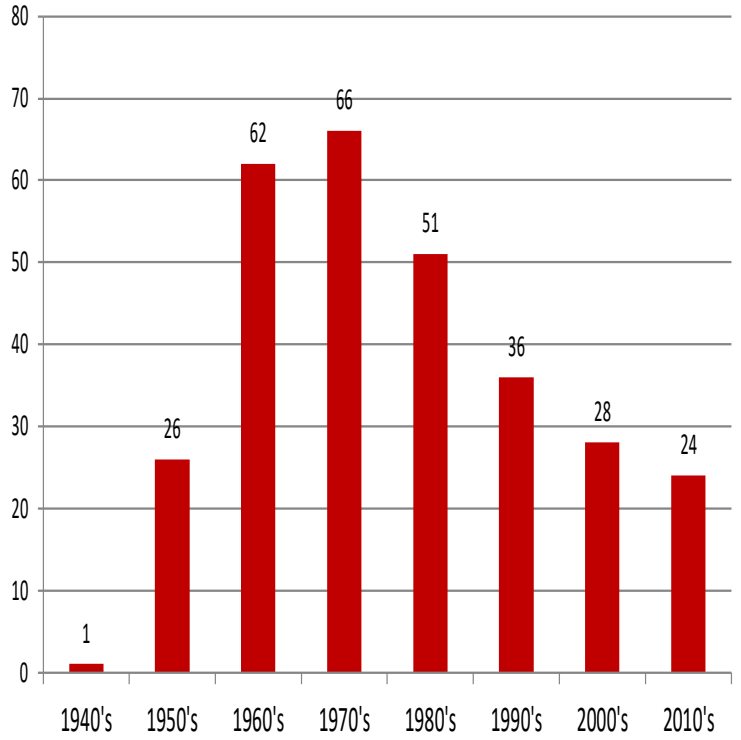
What is a Research Reactor?

- **A Research reactor is a source of radiation**
  - It primarily produces neutrons and gamma-rays
    - Using this primary radiation secondary radiation can also be produced
  - The produced radiation can be used for performing studies either in the core of the reactor or can be guided to be used in ex-core experiments
- While the reactor does not usually produce electricity, it can be used to understand the fundamental concepts that are relevant to the safe operation and control of electricity producing reactors



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Mission

- **Education / Training**
  - Provide a hands-on understanding of the physics and operations of nuclear reactors to the next generation of nuclear engineers
  - Serve as a multi-disciplinary education center in the area of radiation physics applications
  - Provide training in support of nuclear power development
- **Scientific applications and research**
  - Develop state-of-the-art facilities for understanding and applying the principles of radiation interaction with matter
    - Includes in-pool and ex-pool studies
- **Outreach, extension and service**
  - Support the national infrastructure through the use of nuclear methods in various aspects including medical and industrial

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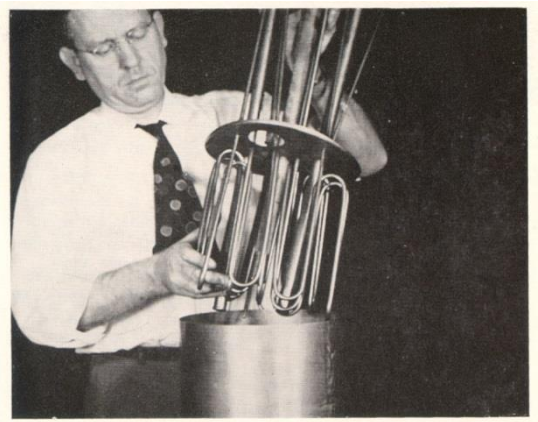
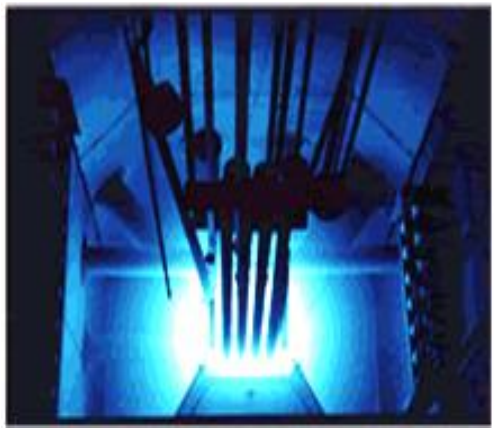
Nuclear Reactor Program
Board of Governors Center

- The first open access nuclear reactor in the world (envisioned 1949, operated 1953) was the R-1 reactor at NC State University



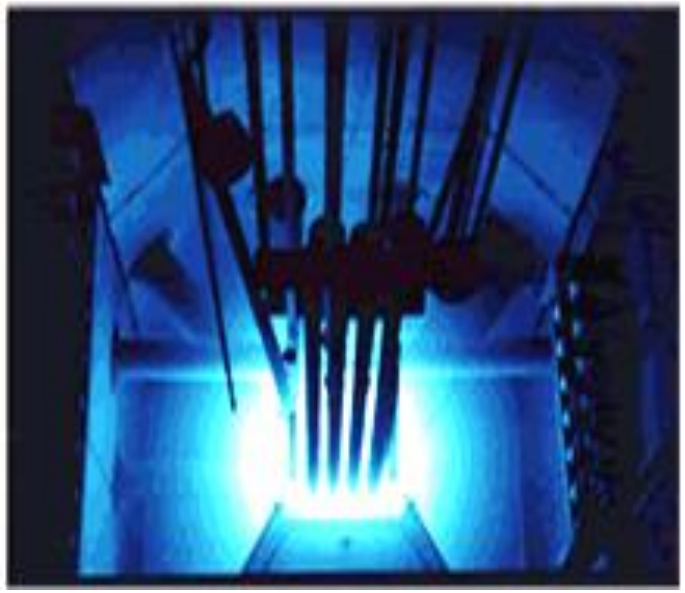
Uranyl sulfate homogenous core

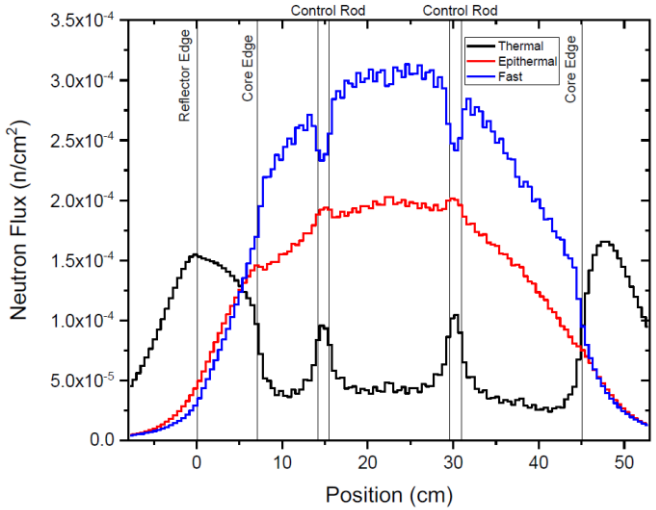
PULSTAR Reactor 1972 1-MW

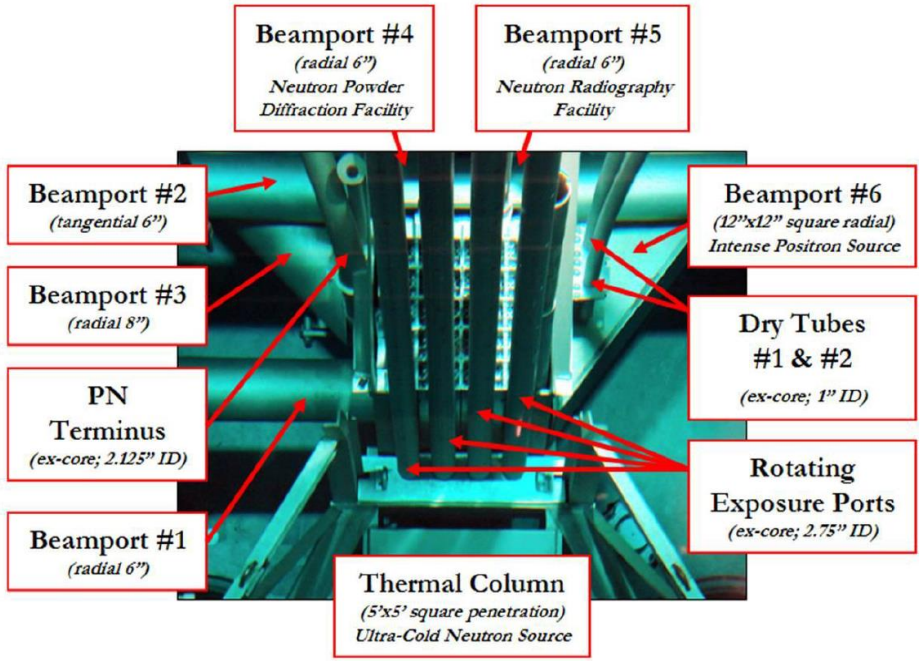


PULSTAR Reactor

- 1-MW power
- Open pool/tank
- Light water moderated and cooled
- 5 x 5 array of fuel assemblies
- 5 x 5 array of pins
- Sintered UO_2 pellets
- 4% and 6% enriched







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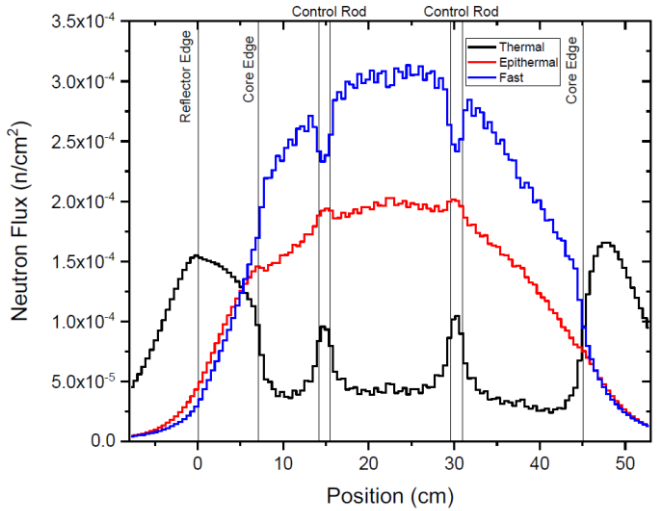

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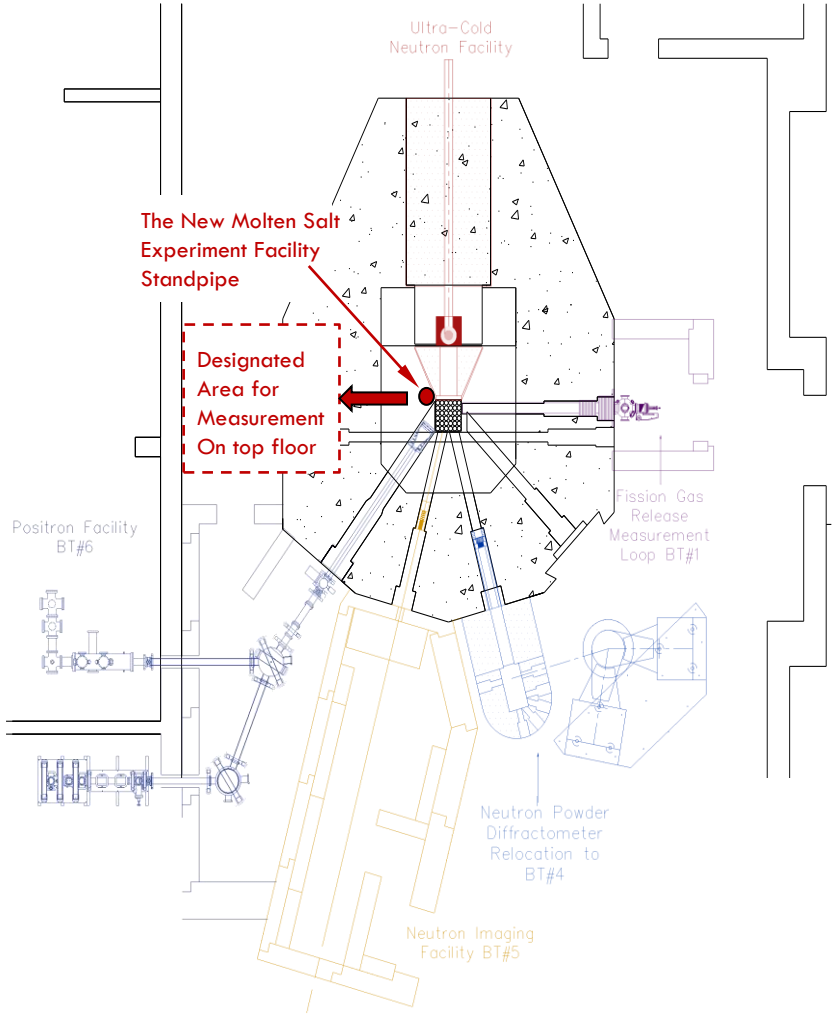
Development Strategy

Development Strategy

- **Capabilities**
  - Enhance neutron flux at all irradiation locations
- **Sustainability**
  - Ensure long term operation of reactor
- **Institutional mission**
  - **Multidisciplinary facility**
    - Instrument the reactor for a wide user base

PULSTAR Capabilities



- **Major Capabilities**
  - **Neutron powder diffractometer**
  - Neutron imaging
  - **Intense positron beam**
  - Ultracold neutron source (under testing)
  - **Fission gas release and measurement loop**
  - Neutron activation analysis
  - In-pool irradiation testing facilities
    - **Molten Salt Irradiation Experiment**

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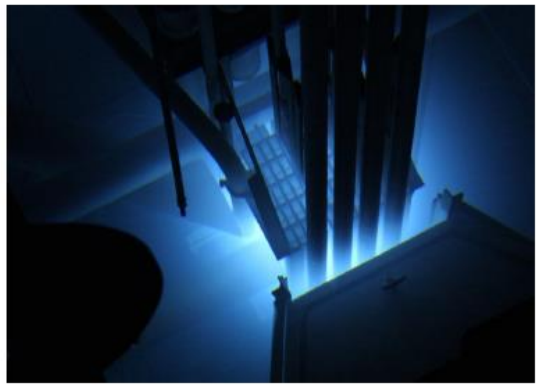
LICENSE AMENDMENT

FOR THE USE OF 6% ENRICHED FUEL

Nuclear Reactor Program

NORTH CAROLINA STATE UNIVERSITY

RALEIGH, NORTH CAROLINA 27695



LICENSE NO. R-120

DOCKET NO. 50-297

March 12, 2015

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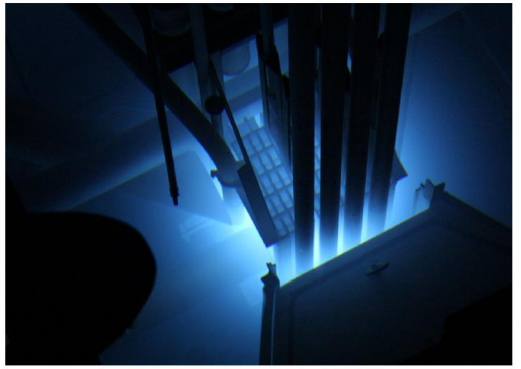
PULSTAR REACTOR

UPDATED

SAFETY ANALYSIS REPORT

NORTH CAROLINA STATE UNIVERSITY

RALEIGH, NORTH CAROLINA 27695



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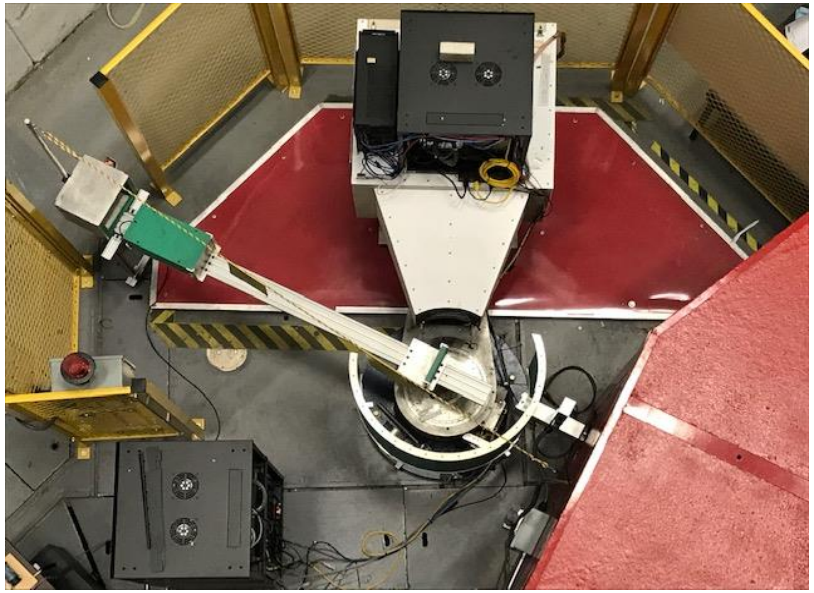
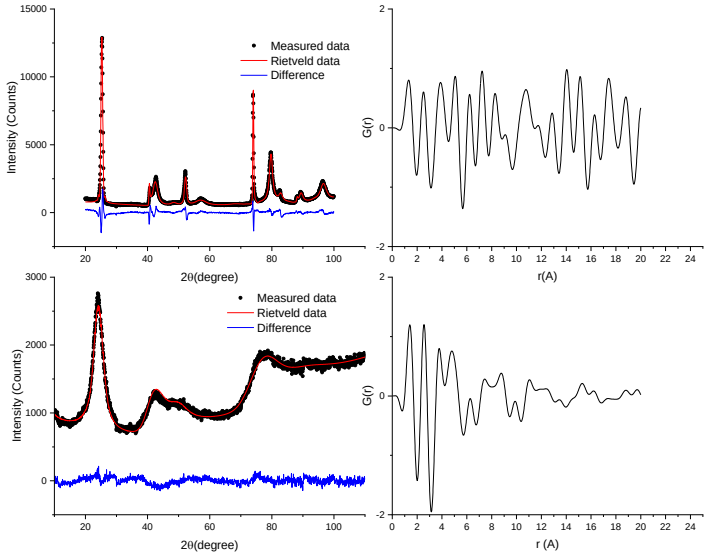
29-MARCH-2017

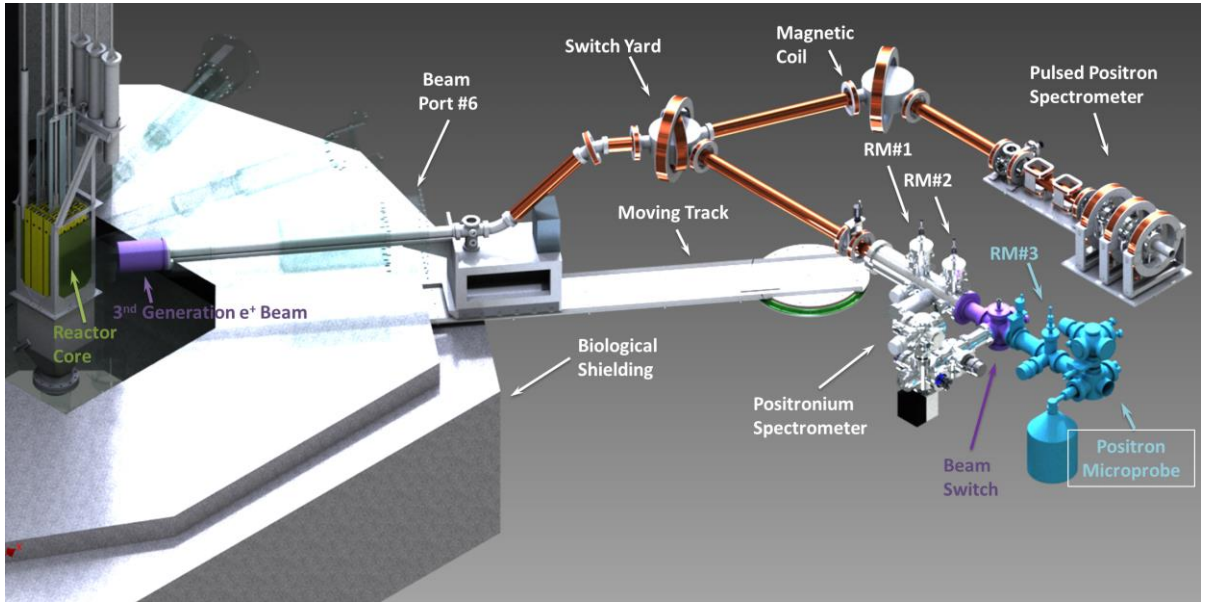
Neutron Scattering
PULSTAR Powder Diffractometer

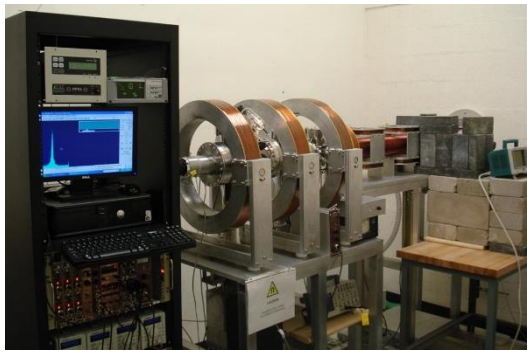
- Beam Tube 4 – two 3” sapphire fast neutron filters.
- Si bent perfect crystal focusing monochromator – 1.479 Å beam at sample position.
- Large area position sensitive neutron detector array 15” by 24” spanning 20º for high resolution.
- Detector rotates on air pad supports.

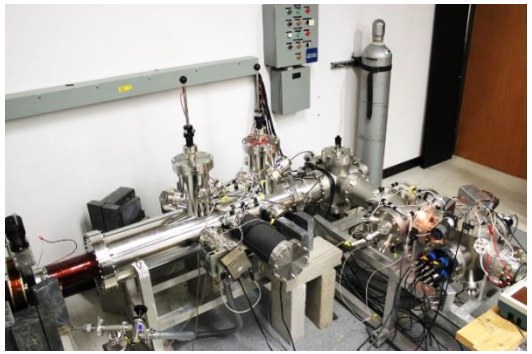


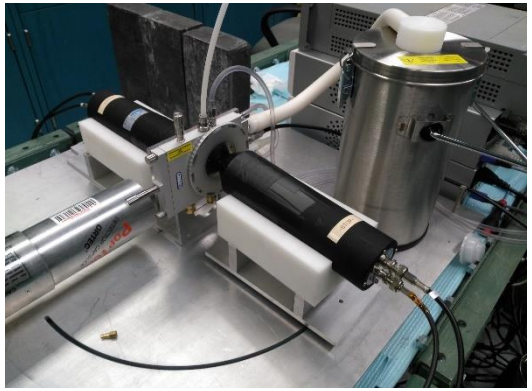


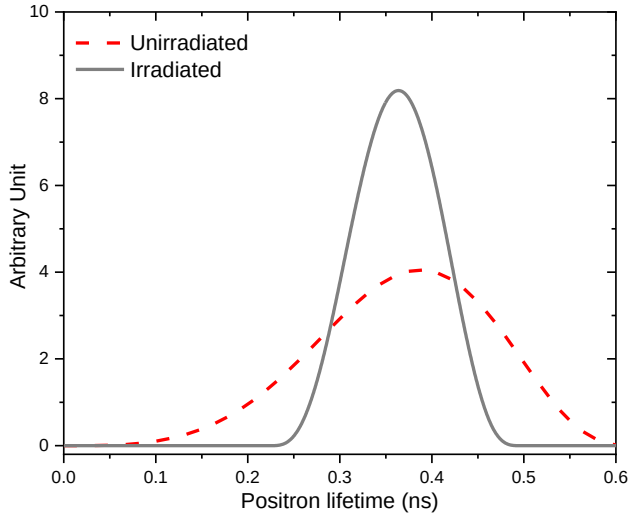
Intense Positron Beam Facility



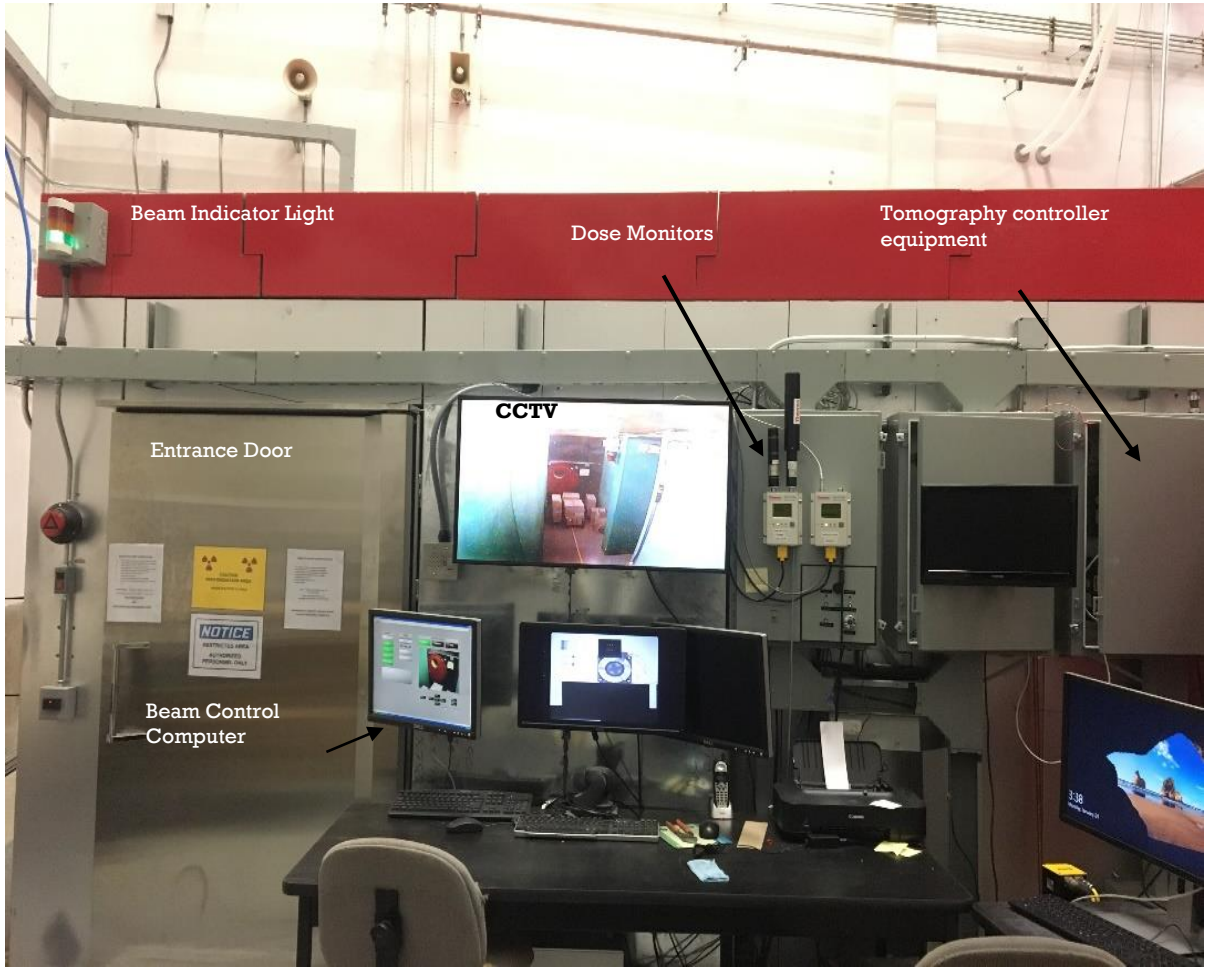


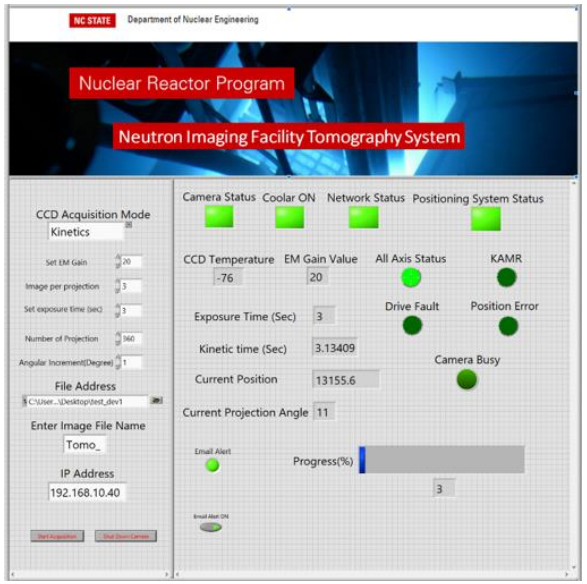


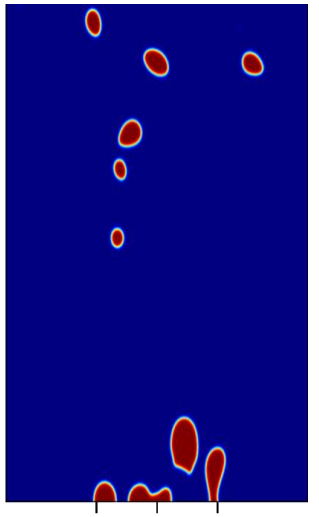


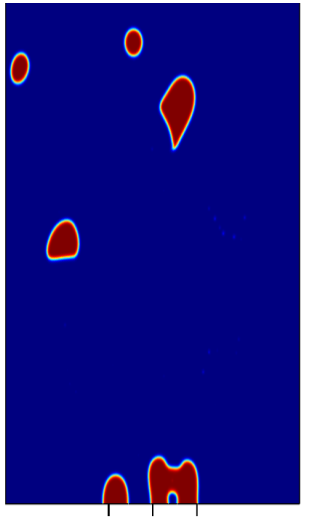


Thermal Neutron Imaging









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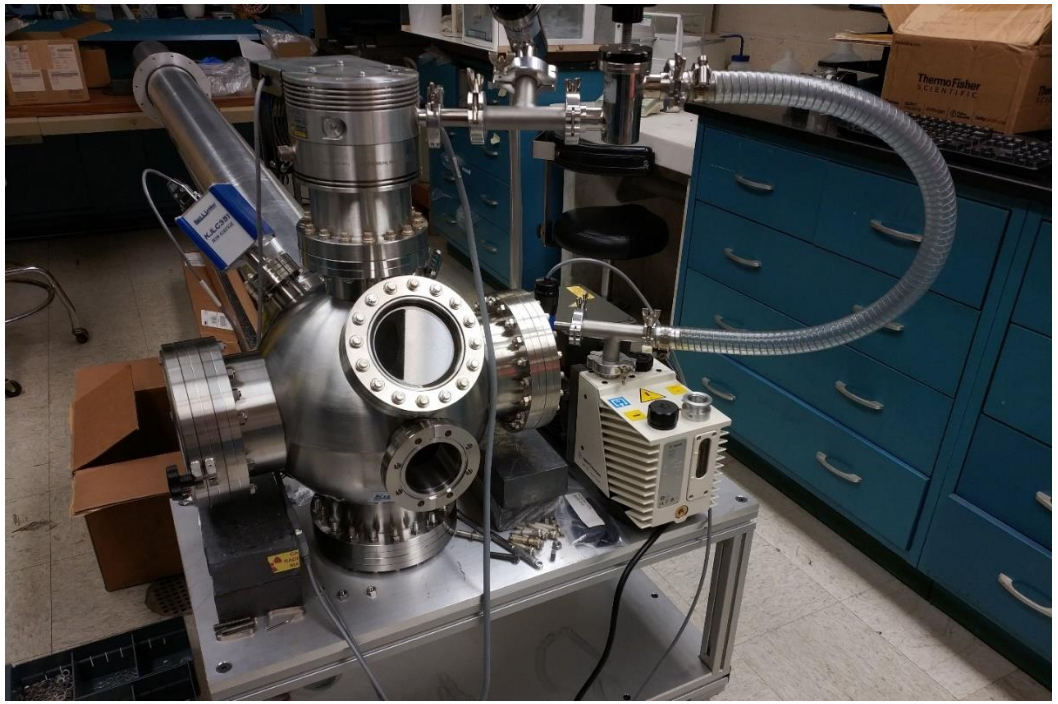
Fission Gas Release Measurement Facility



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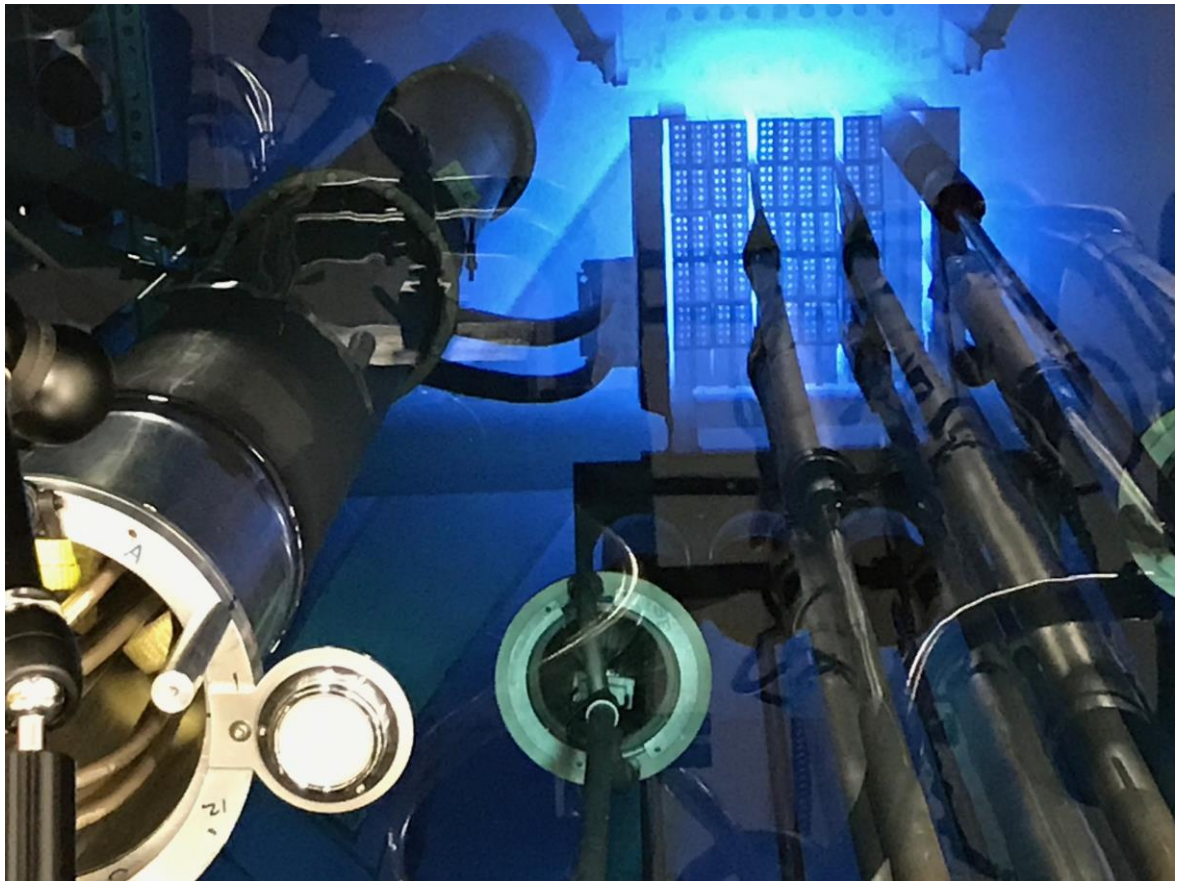
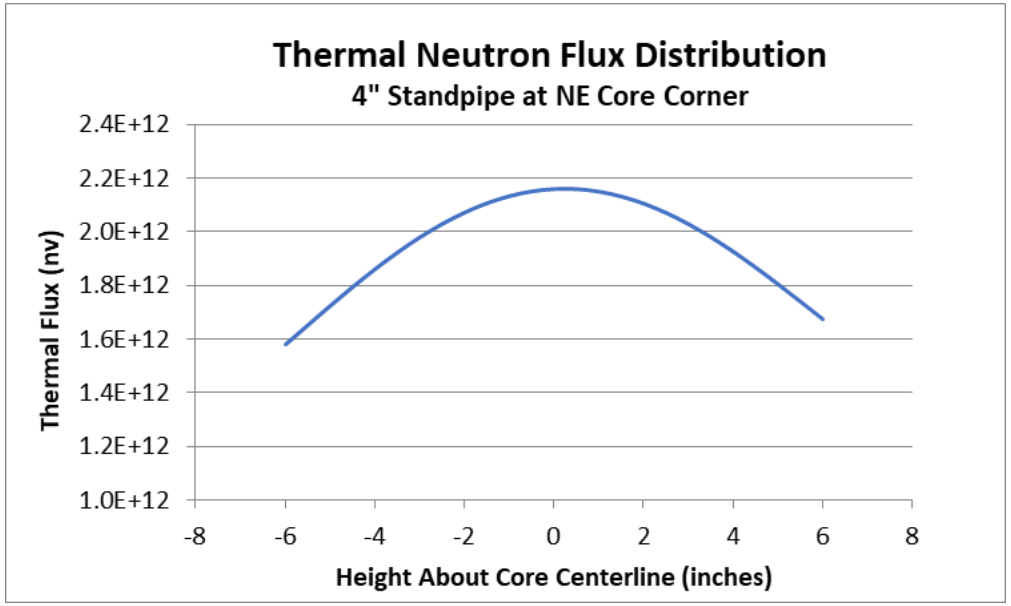
Molten Salt Irradiation Experiment

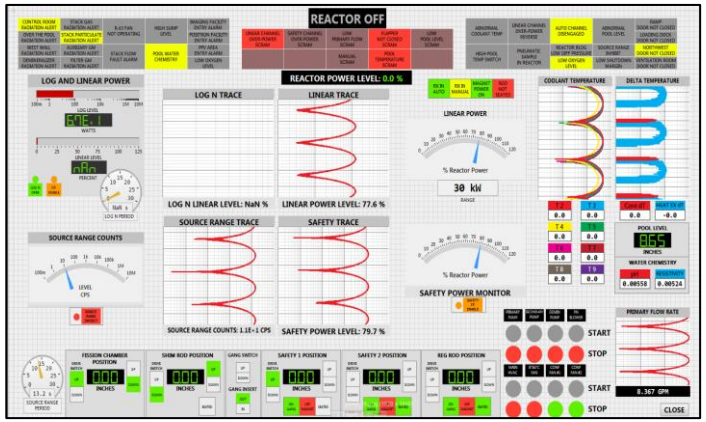


8’’ ID MSIE tube project at north-east PULSTAR core position

Thermal neutron flux as a function of the vertical position relative to the center of the core



Education – Internet Reactor Laboratory



IAEA's Internet Reactor Laboratory expands access to training

Posted on **January 9, 2017** by **ansnuclearcafe** — **1 Comment ↓**

The Internet-based remote learning tool is being used to train nuclear engineering students.
By Dick Kovan

The International Atomic Energy Agency established its Internet Reactor Laboratory (IRL) program as one solution for a country that has a research reactor to provide practical reactor operating experience to nuclear engineering students, usually—but not always—in IAEA member states that do not have a research reactor.

The IRL concept was originally developed by a U.S. Department of Energy–funded research reactor consortium in which North Carolina State University (NCSU) successfully demonstrated that an Internet computer link could deliver practical experiments from its PULSTAR reactor to students at other universities in the United States. The next step—to develop the concept internationally—grew from an existing relationship between NCSU and the Jordan University of Science and Technology (JUST), which had set up the country's first nuclear engineering program in 2007 to supply Jordan's nuclear energy program with fully qualified nuclear engineers. The IRL project was inaugurated at JUST's Department of Nuclear Engineering in November 2010.

The White House
Office of the Press Secretary
For Immediate Release

May 24, 2016

FACT SHEET: Enhancing U.S.-Vietnam Civil Nuclear Clean Energy Cooperation

Complement Vietnamese university nuclear curriculum programs with the Department of Energy supported remote reactor training from North Carolina State University.

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Partnerships

- National and International partnerships
  - Partner in the DOE/INL NSUF
    - Experiments conducted at PULSTAR
  - Partner with DOE and DOS to develop international educational programs
    - New international internet reactor lab offering
  - Partner in NSF's RTNN (Research Triangle Nanotechnology Network)
  - Lead of CSEWG and OECD/NEA WPEC data groups
  - Member International Group on Research Reactors (IGORR)
  - Collaborate with IAEA in various activities

All the above resulted in increasing utilization

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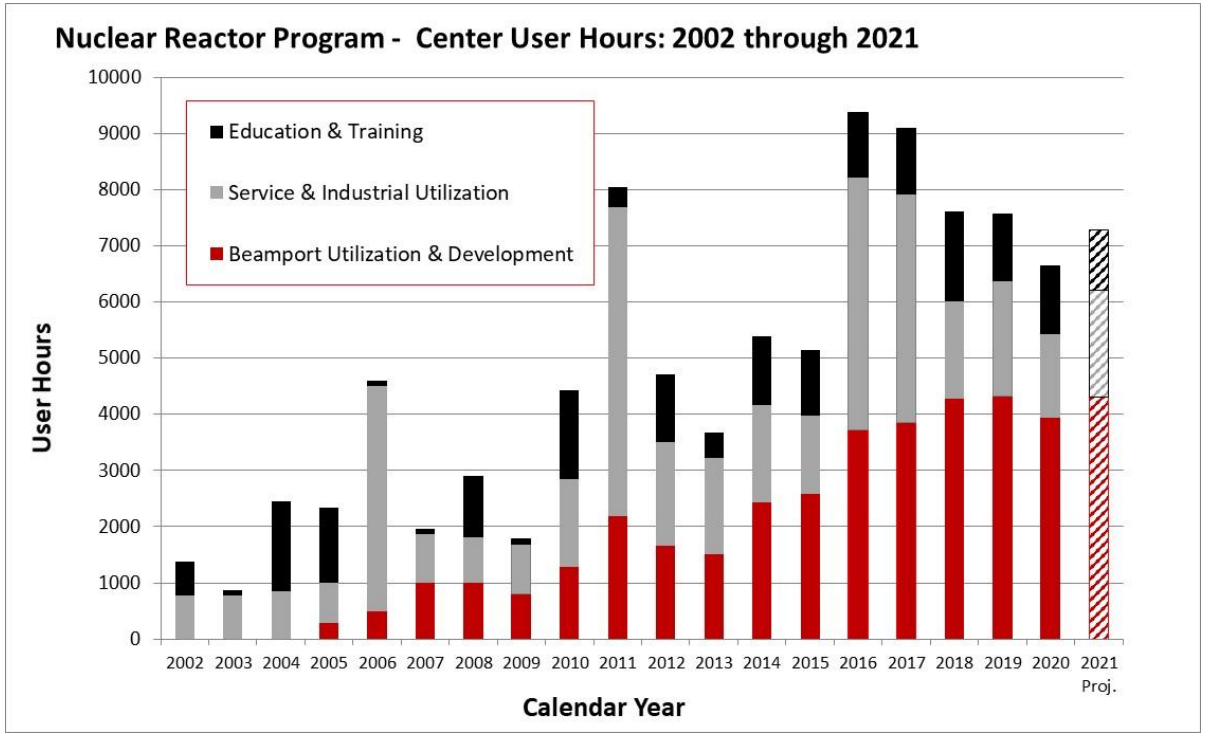
Utilization Metrics

- UNC system "Board of Governors Center"
  - Instrumented to be multidisciplinary
- Annually 5000 – 10000 user hours
  - 40% external to UNC system
- Academic users 52%
  - 40% nuclear engineering
- Non academic users 48%



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Summary

- The Nuclear Reactor Program and the PULSTAR reactor implemented a utilization program that serves the educational education and research mission of NC State University
- The program is based on the development of state-of-the-art in-pool and ex-pool irradiation facilities
- The utilization is enhanced through key partnerships and national and international engagement

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Acknowledgement

- Funding for the development of infrastructure at the PULSTAR reactor has been received through

  - DOE-NE NEUP R&D and Infrastructure programs
  - NNSA Nuclear Criticality Safety program (NCSP)
  - Naval Reactors program (NR)
  - National Science Foundation

- Collaborations with our industrial and national laboratory partners and users

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Thank You

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