Advanced Reactors Infrastructure and Research at the PULSTAR Reactor

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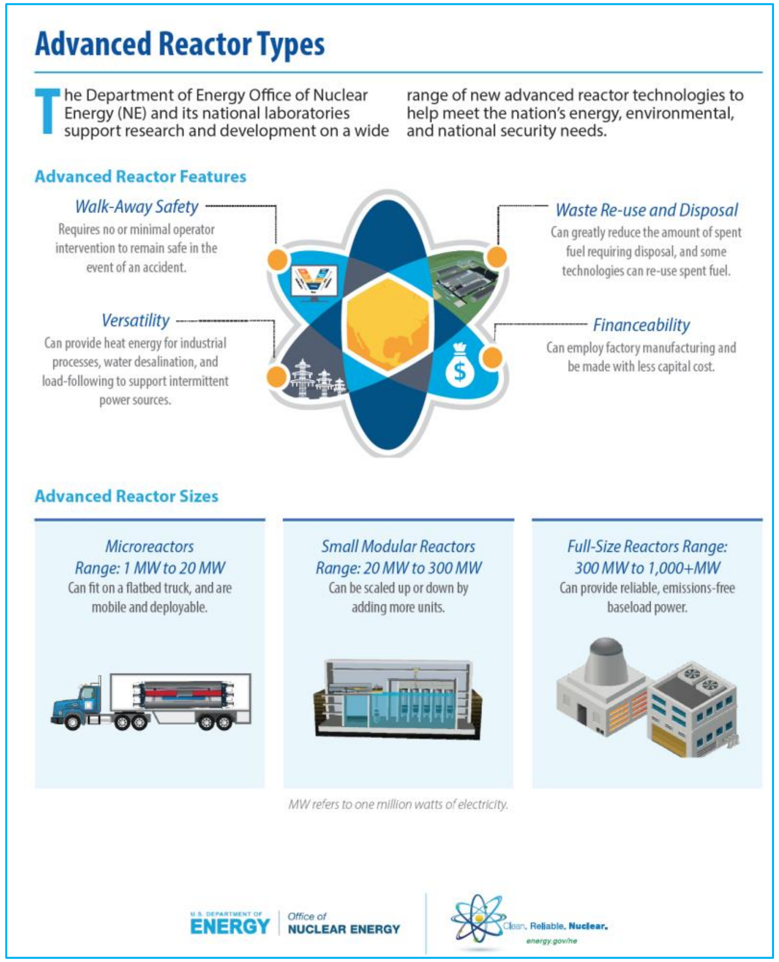
TRTR 2021, October 17 – 21, 2021, Zoom meeting
Raleigh, North Carolina, USA

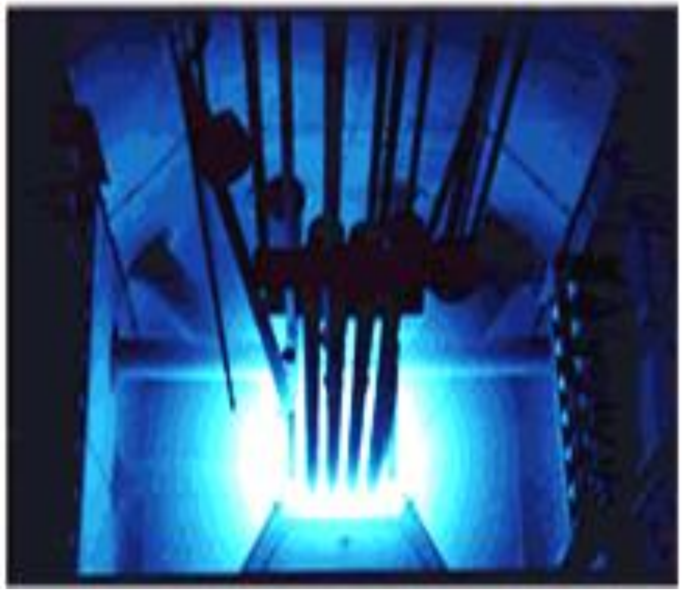
Motivation

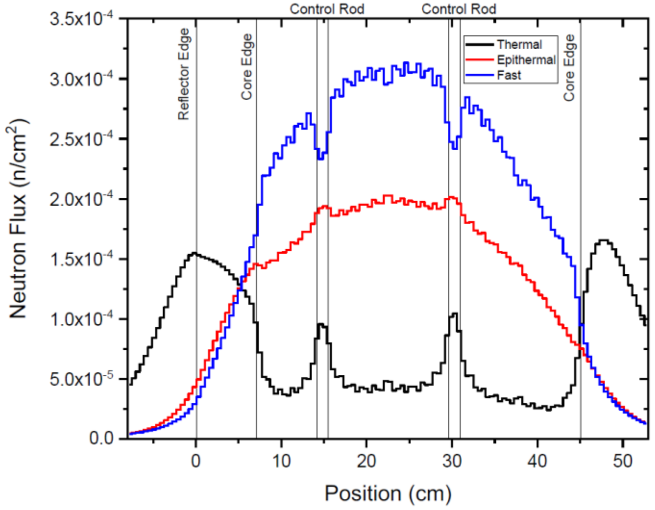
- **Support the national mission of implementing advanced reactors**
  - **Fuel testing experiments** – monitor various species production and release under neutron irradiation and as a function of temperature
  - **Molten Salt Irradiation Experiment (MSIE)** – monitor various species production and release under neutron irradiation and as a function of temperature
  - **Develop, implement and test advanced instrumentation concepts** – e.g., digital and ML technology
  - **Develop, implement and test pre and post irradiation capabilities** – e.g., using samples irradiated in a corresponding environment



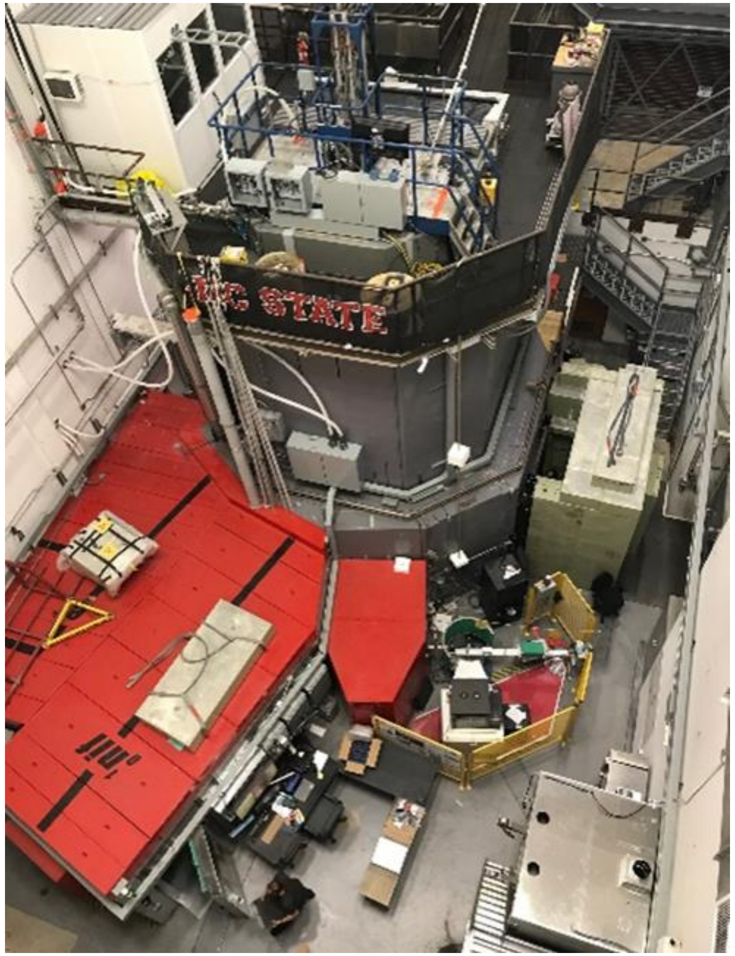
PULSTAR Reactor

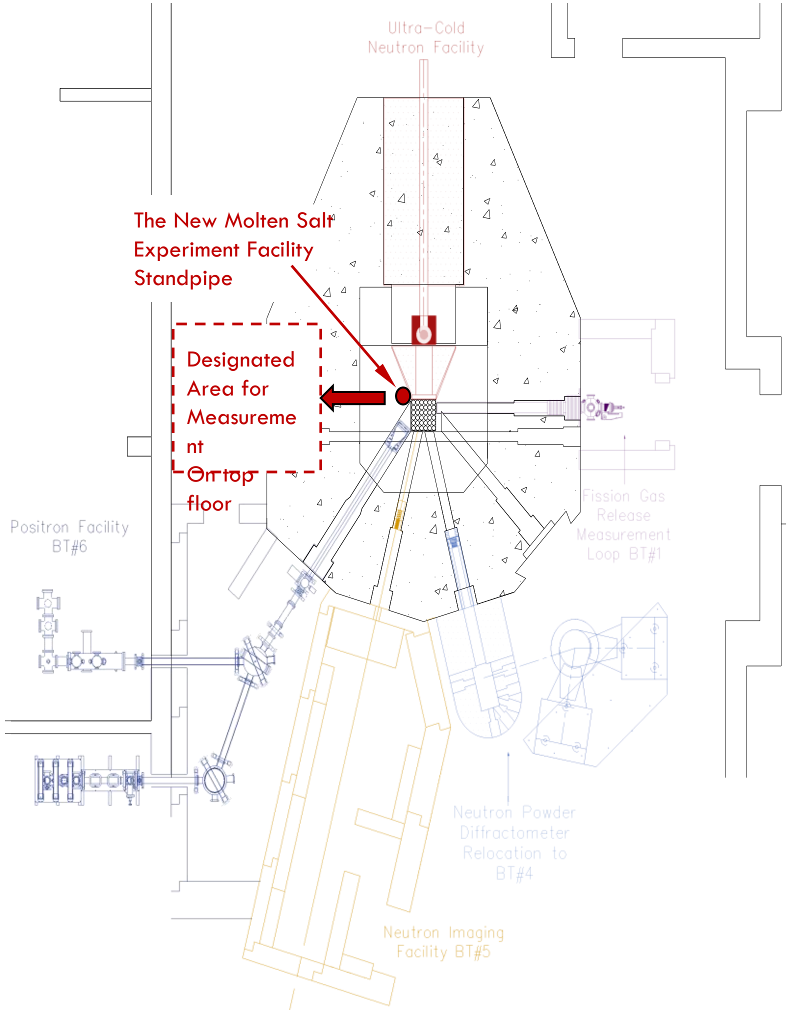
- 1-MW power
- Open pool/tank
- Light water moderated and cooled
- 5 x 5 array of fuel assemblies
- 5 x 5 array of pins
- Sintered UO_2 pellets
- 4% and 6% enriched





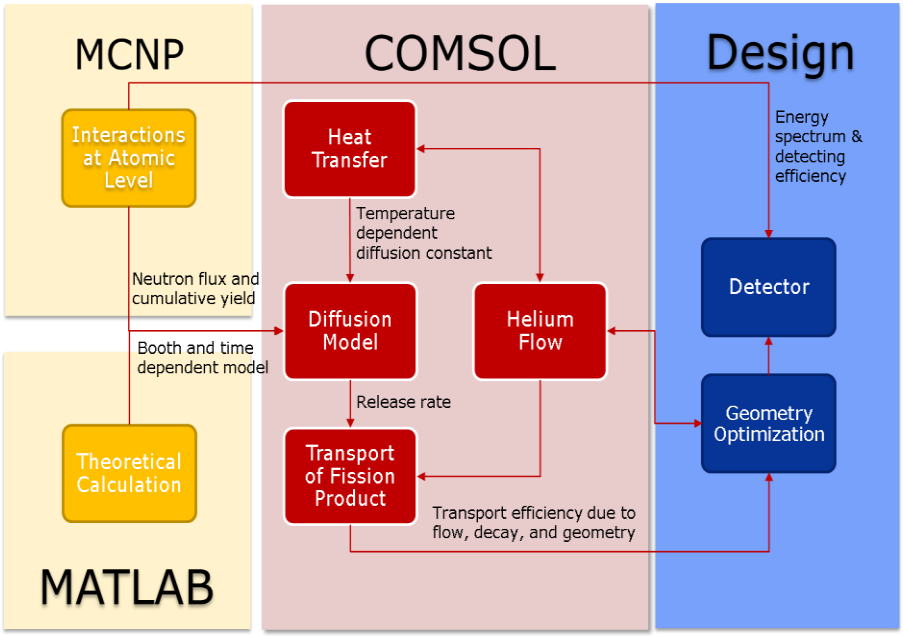
PULSTAR Capabilities
Advanced Reactor Research





- **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 (MSIE)**

Multiphysics Design Infrastructure



- Neutronics
  - MCNP, Serpent
- Heat transfer
  - COMSOL, OpenFoam
  - solid, liquid, and gas environment
  - Proof of furnace concept
- Two-Phase Fluid Flow
- Transport of Fission Products
  - Diffusion in two-phase system
  - Particle tracing in gas - aerosol
- Highly Coupled System
  - Non-isothermal, non-equilibrium flow with production & decay

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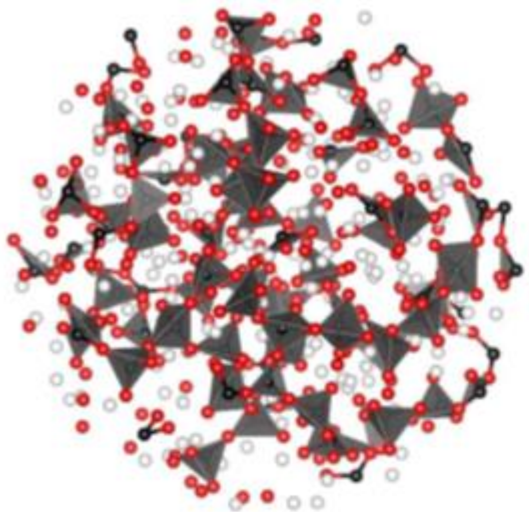
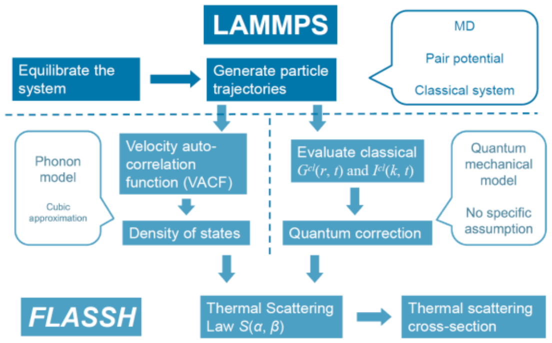
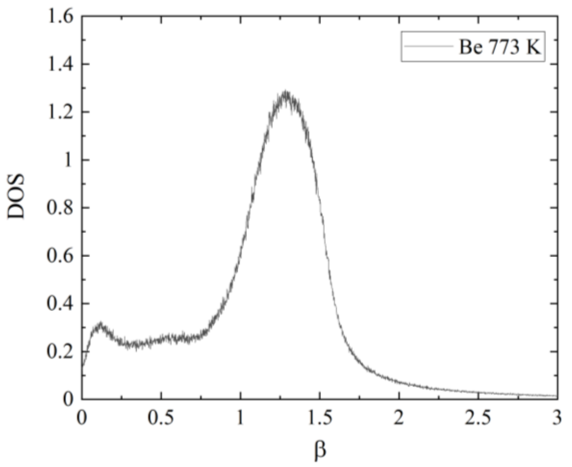
Advanced Neutronics

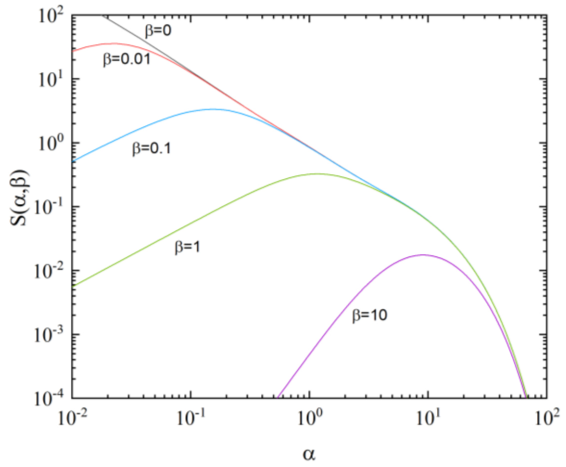
Molten salt FLiBe
Molecular Dynamics
Models

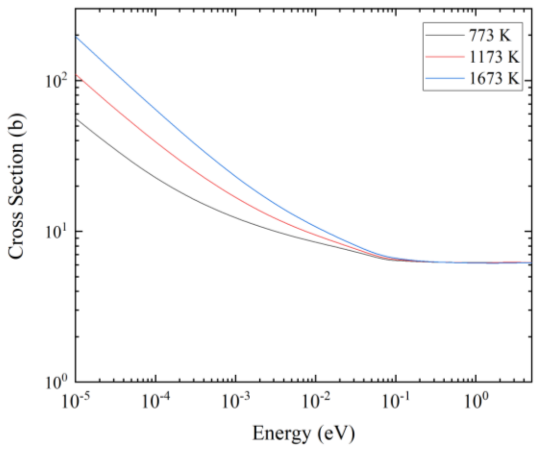




Input to MC simulations
For source term
estimation







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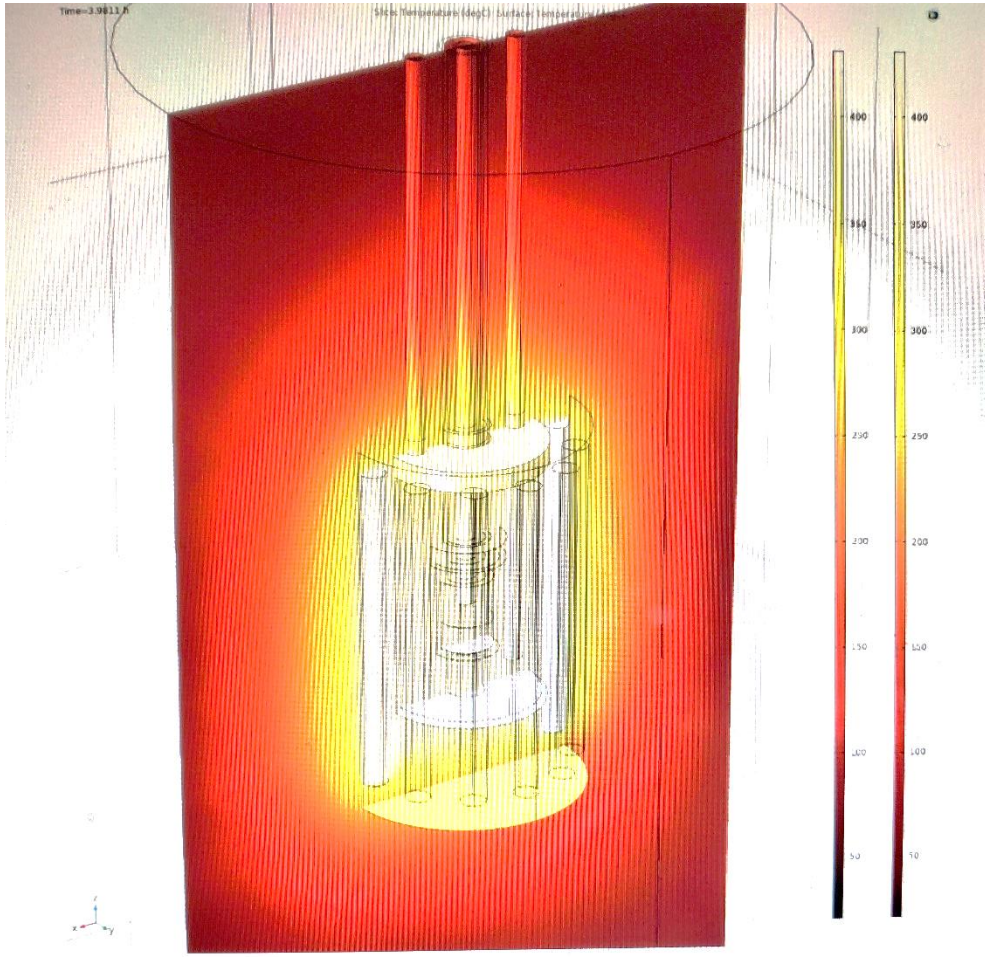
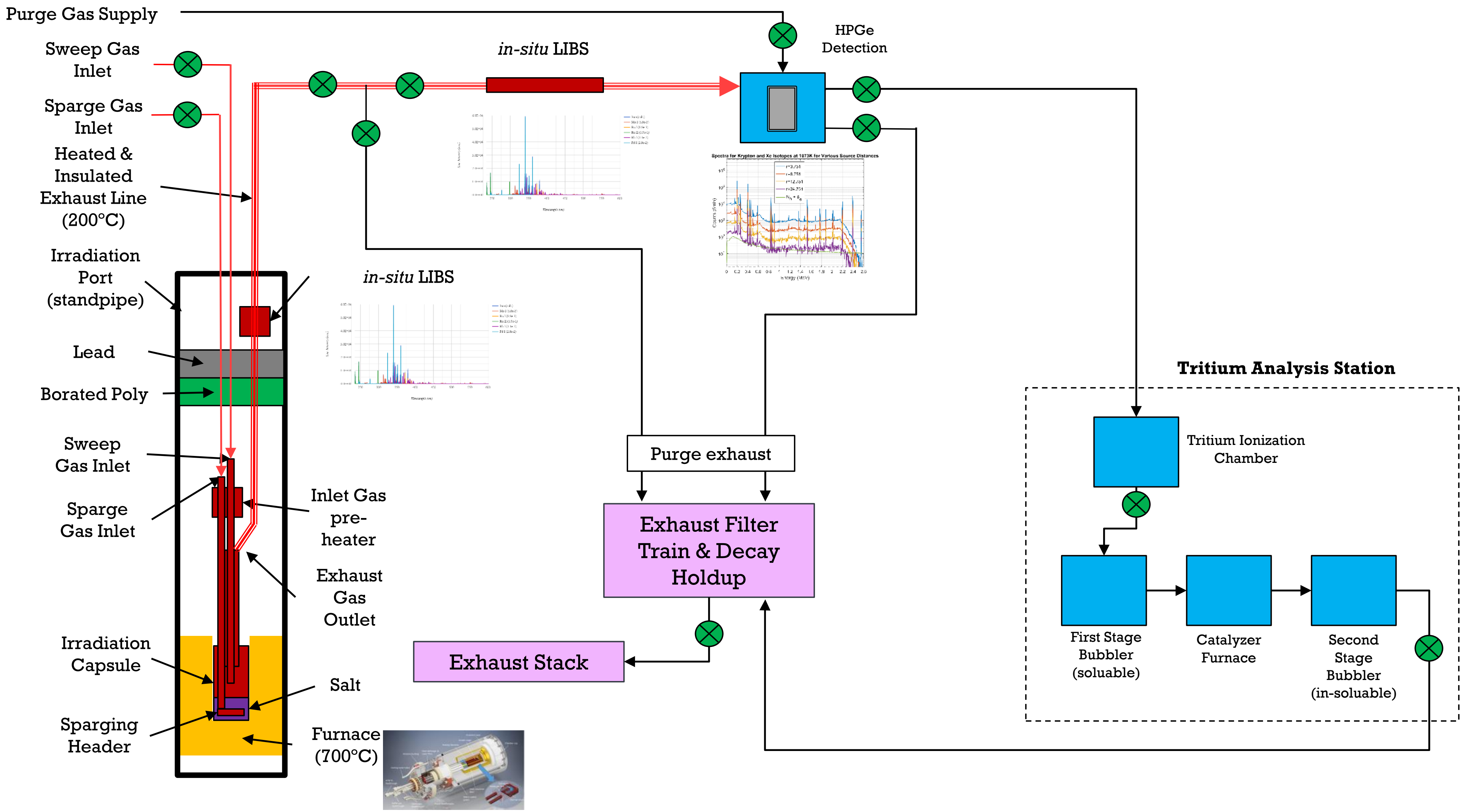
Heat Transfer in COMSOL Multiphysics



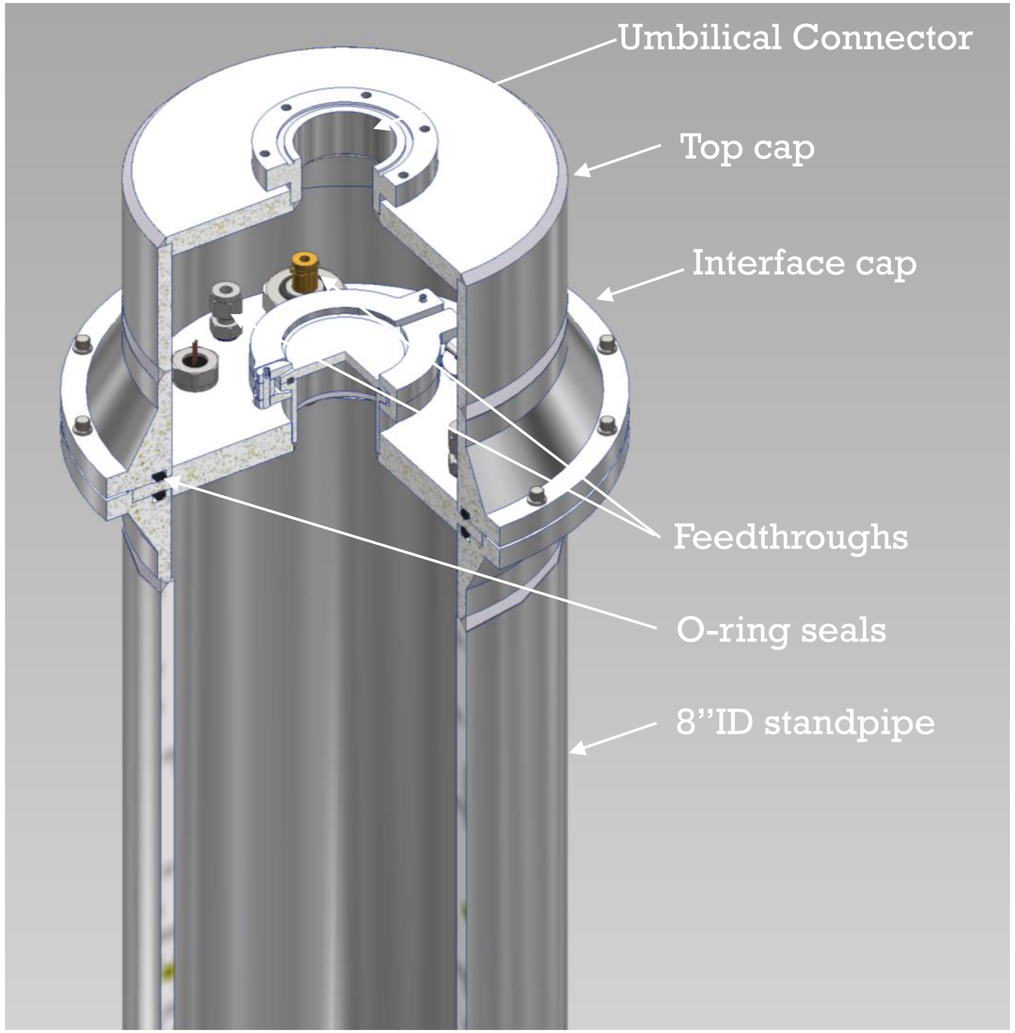
Time dependent study - temperature of the furnace model

- Furnace Model
  - Alumina layer in a standpipe
  - Molybdenum heating rods
  - Double encapsulated sample holder
  - Purging and sweeping gas
- Proof of furnace concept
  - Fixed input power
  - Coupled with gas flow
  - Heating rate and uniformity
  - Thermal insulation check

MSIE Conceptual Schematic



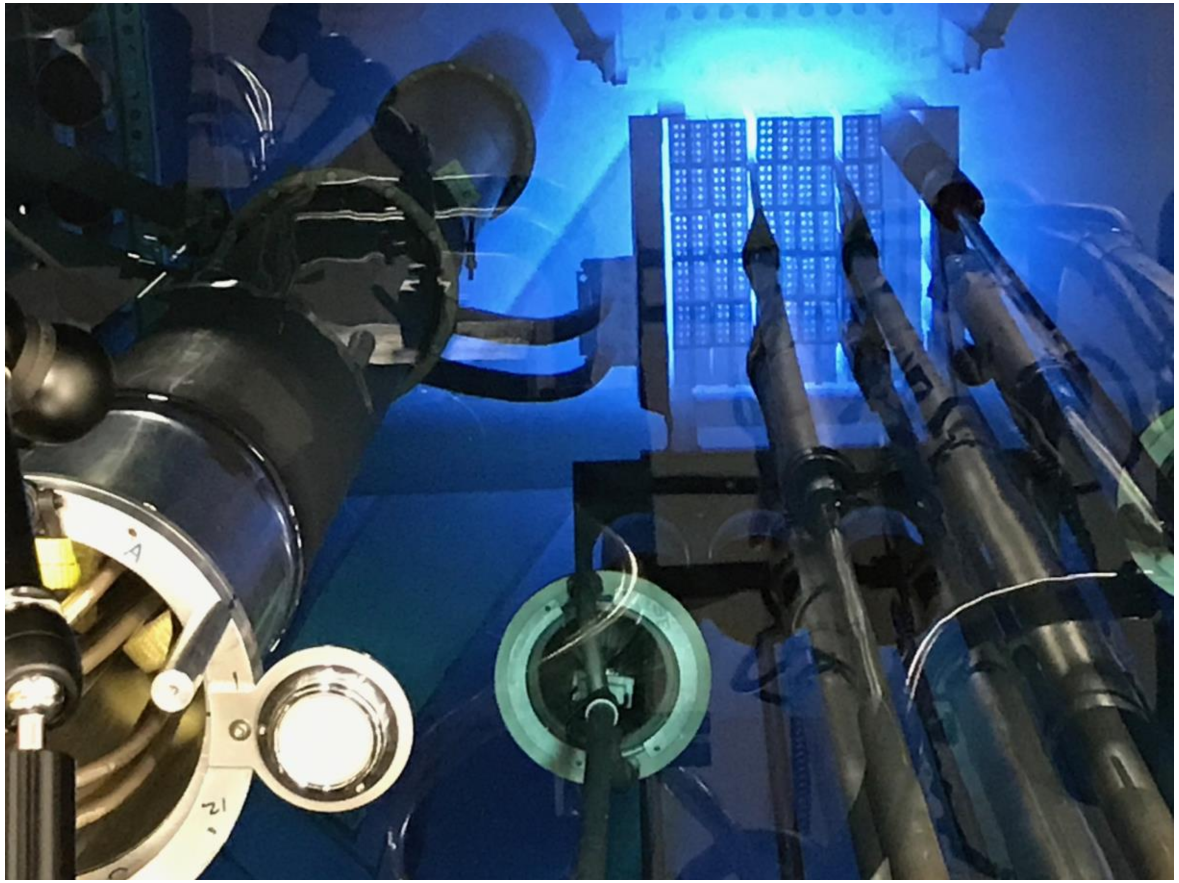
Design of the Dry Well (Standpipe)



- Located Between BT#1 & BT#6
- 6061 Al with Viton O-rings
- Movable on a bottom track to engage and disengage
- Design of the interface

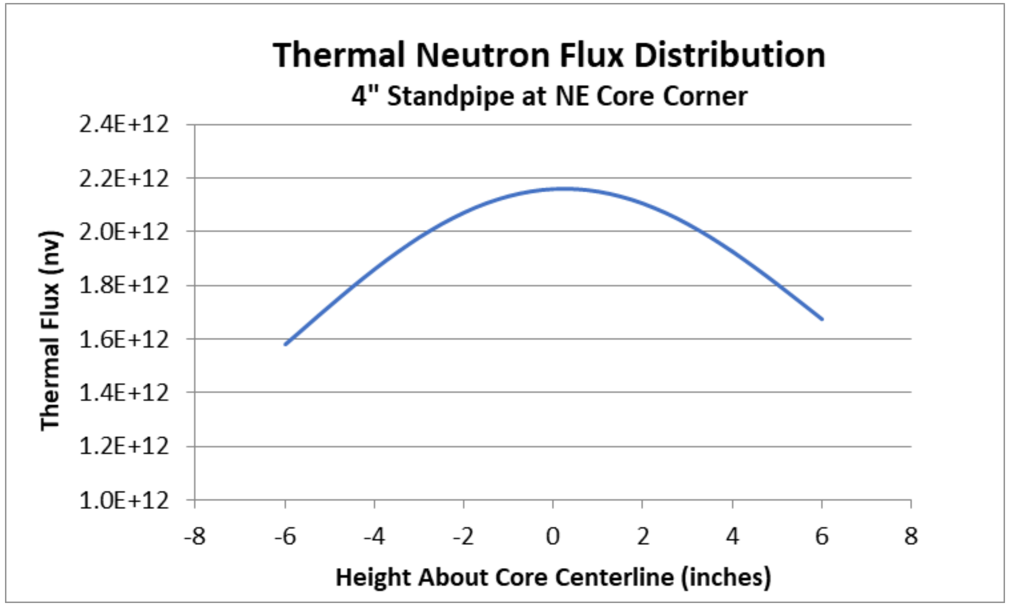
Feedthru Type	Size	No.	use
Gas	1/4"	1,2	Outer chamber
	1/4"	3	Inner chamber, in
	1/2"	4	Inner chamber, out
	1/2"	5,6	Standpipe flushing/pumping
Thermocouple	center	TC1,2	Inner chamber temp
	center	TC3,4	Outer chamber temp
	1/2"	TC5-12	Heated line temp gradience
Power	center	P1-P4	Furnace - multipin
	center	P5-P8	Heated line heating tape
Measurement	1/2"	O1-4	LIBS

Implementation of MSIE

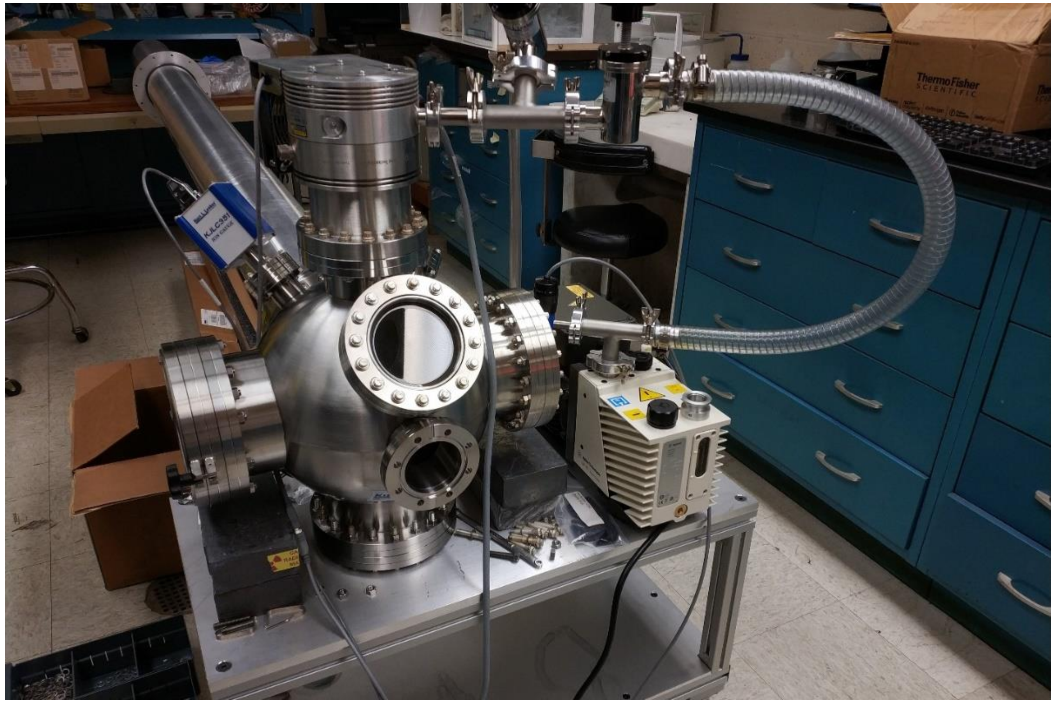


8" ID MSIE tube project at north-east PULSTAR core position

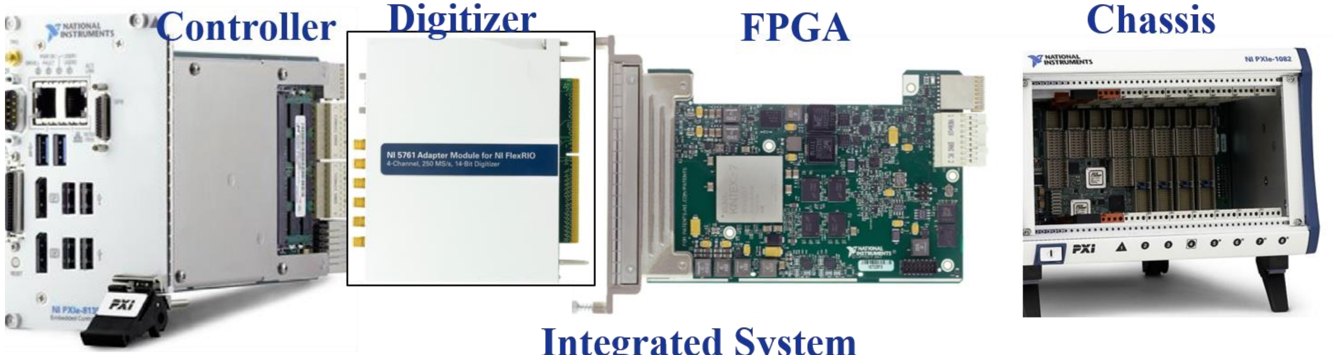
Thermal neutron flux as a function of the vertical position relative to the center of the core



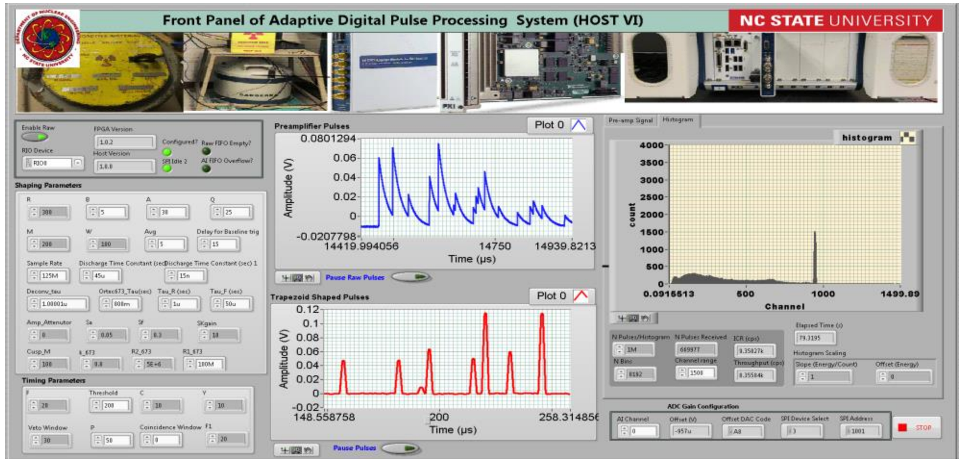
Fission Gas Release Measurement Facility



Advanced Instrumentation – Online Assay



Integrated System



Holistic digital gamma-ray spectroscopy methods and instrumentation for high-throughput high-resolution applications
Patent number: 11029416
Abstract: Method of real-time adaptive digital pulse signal processing for high count rate gamma-ray spectroscopy applications includes receiving a preamplifier signal at a pulse deconvolver, the preamplifier signal including resolution deterioration resulting from pulse pile-up. The method further includes generating a deconvoluted signal, by the pulse deconvolver, from the preamplifier signal, the deconvoluted signal having less resolution deterioration as compared to the received preamplifier signal. The method furthermore includes shaping of the deconvoluted signal by a trapezoid filter, the shaping comprising adjusting a shaping parameter of the trapezoid filter for an incoming signal based on a time separation from a subsequent incoming signal.
Type: Grant
Filed: February 19, 2020
Date of Patent: June 8, 2021
Assignee: North Carolina State University
Inventors: Ayman I. Hawari, Shefali Saxena

Patent 2021

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Pre and Post Irradiation Examination

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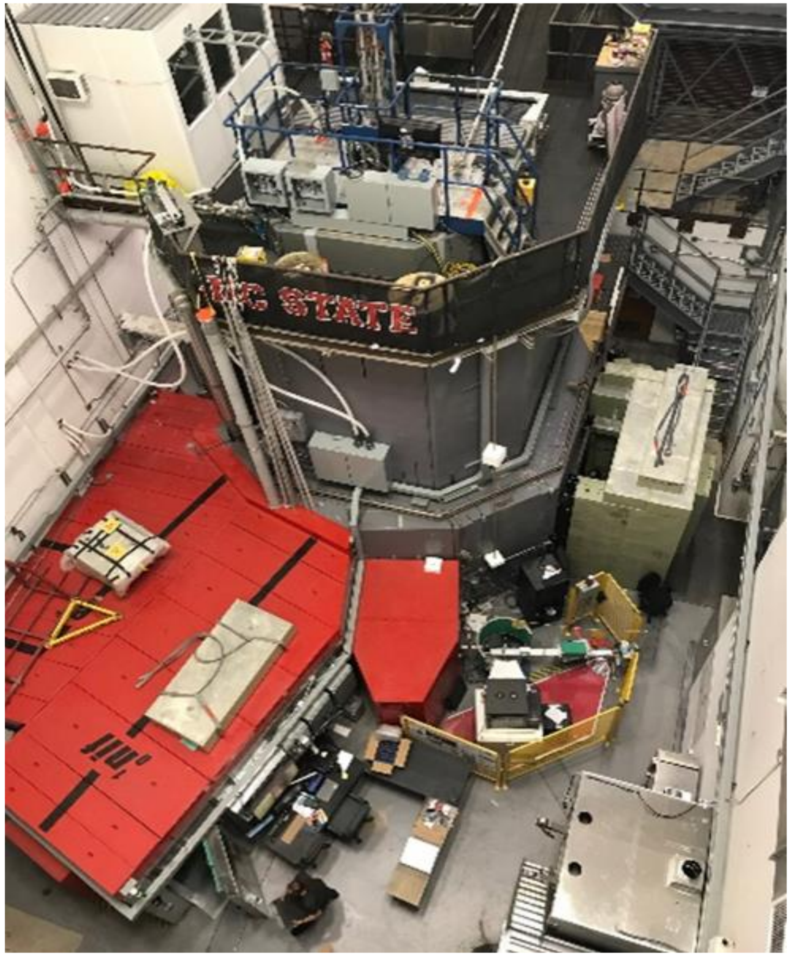

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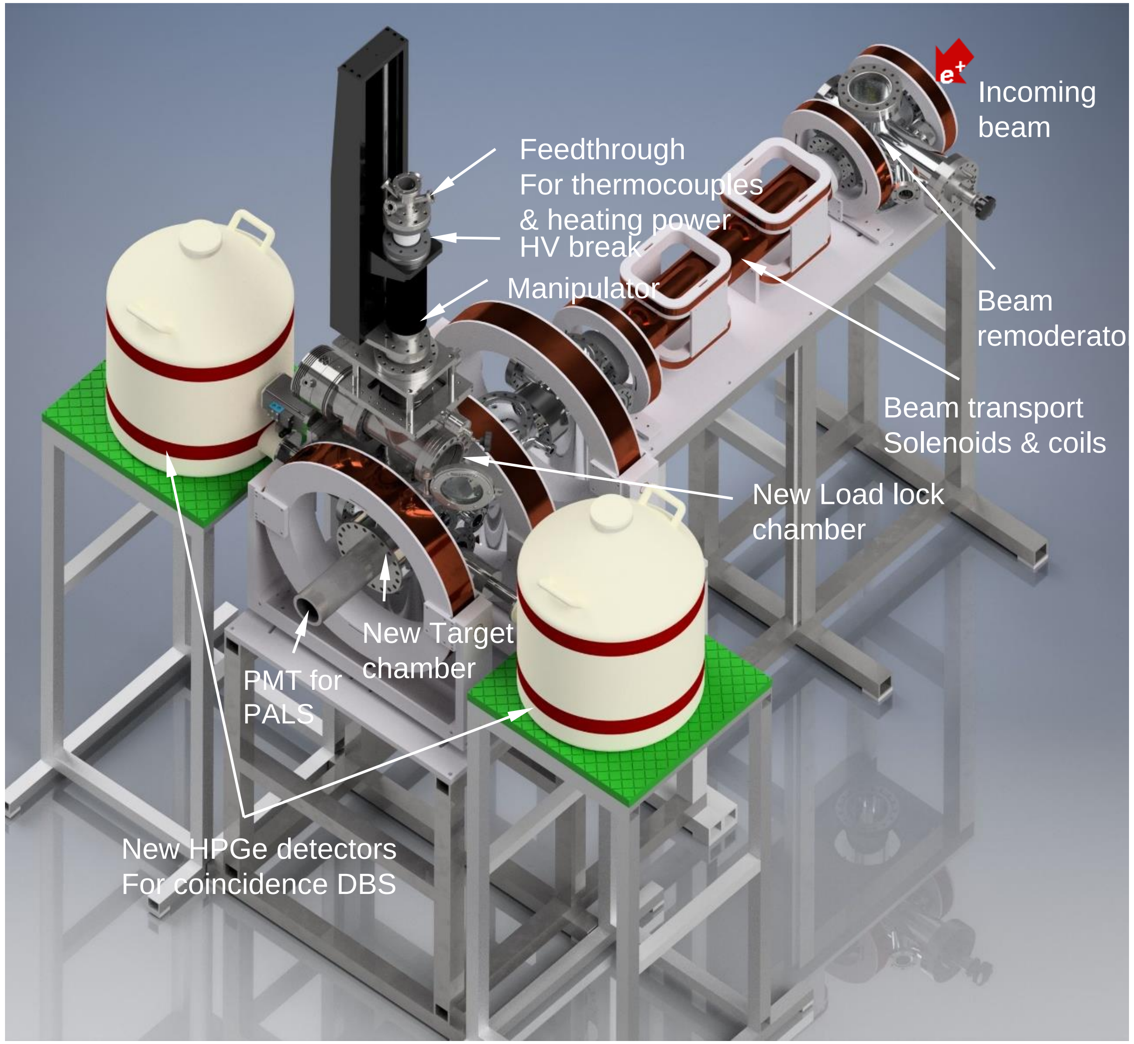
PAS Measurements



- Upgrade of the Positron Beam Facility
  - New load lock design for faster sample changing
  - New sample stage for multi-sample heating/cooling measurement
  - Coincidence capability
- Possible measurement
  - Corrosion on surfaces
  - Deposition/contamination of fission products on surfaces

Summary

- The PULSTAR reactor is hub with modern infrastructure in support of Advanced Reactors implementation research

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Thank You

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