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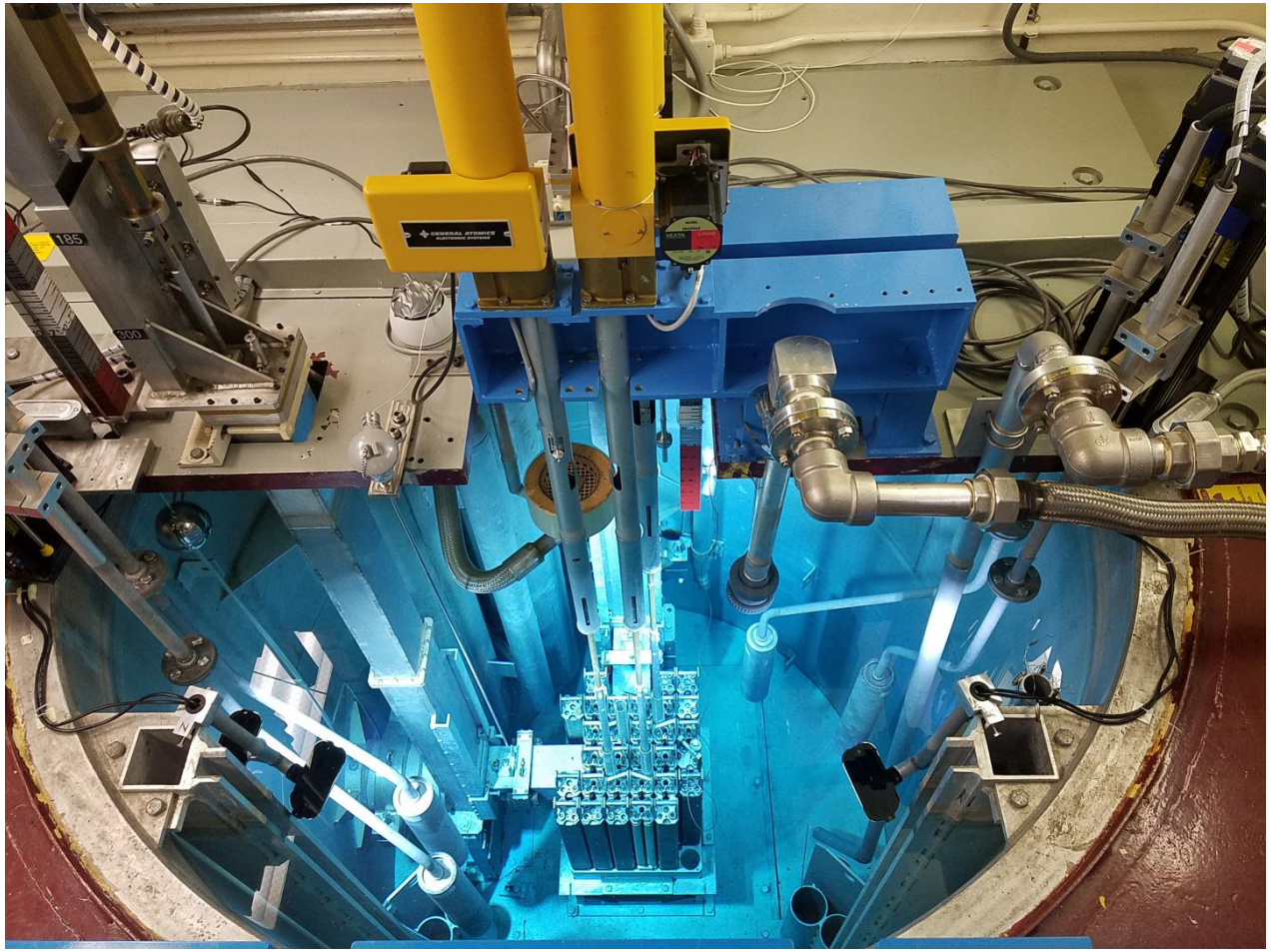
NRAD Beamline Upgrades

Battelle Energy Alliance manages INL for the
U.S. Department of Energy's Office of Nuclear Energy

Idaho National Laboratory

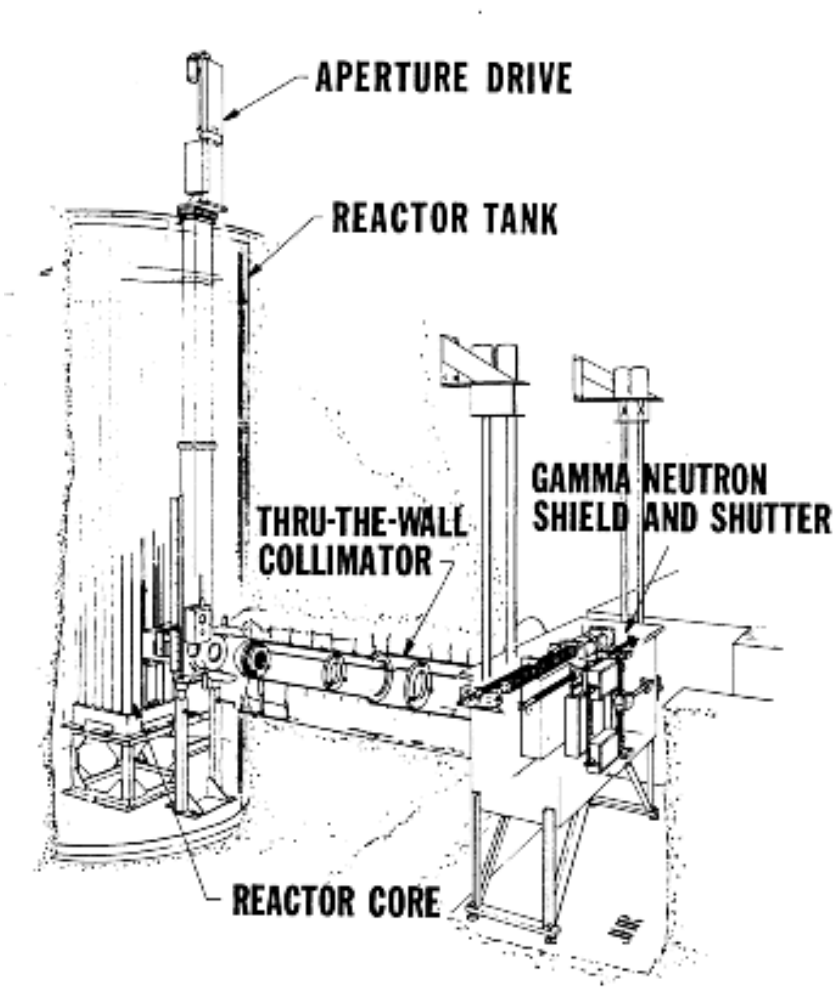
NRAD Basics

- NRAD is a 250kW LEU TRIGA
- **Underneath the largest inert atmosphere hot cell in USA**
- Two radial beamlines – NRS and ERS
- Current capabilities include
  - Neutron radiography
  - Neutron tomography
  - Neutron beam experiment
  - In-core irradiations
  - Operator training



Current NRS Configuration

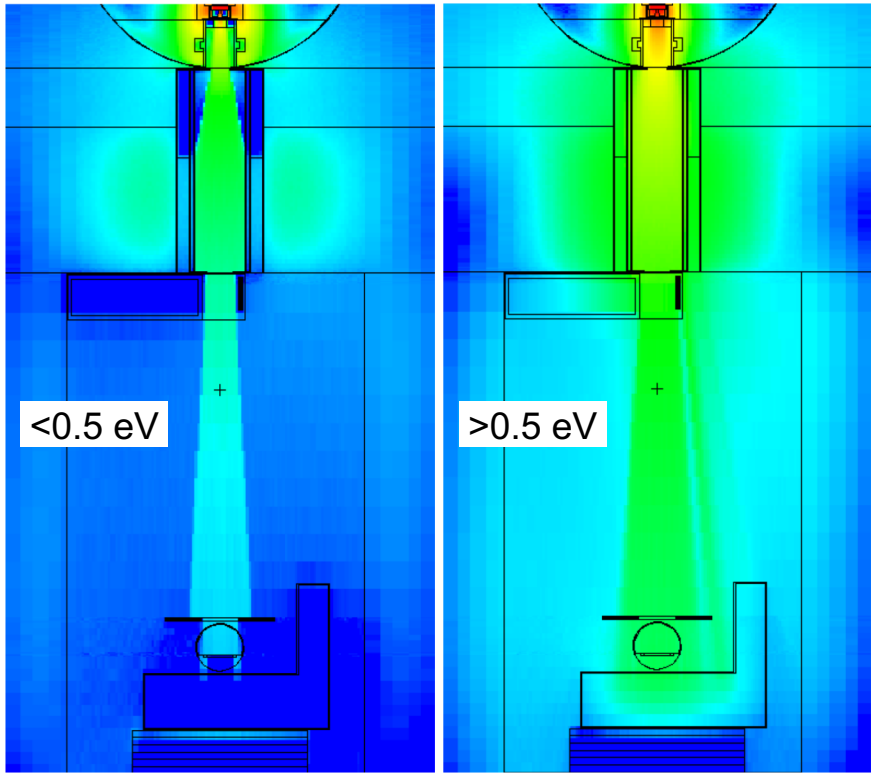
- Beamline components:
  - In tank beam chamber
  - In tank aperture – sets L/D ratio
  - Through-the-wall collimator (TWC)
  - Neutron shutter and gamma shield
  - Shapers and scrapers



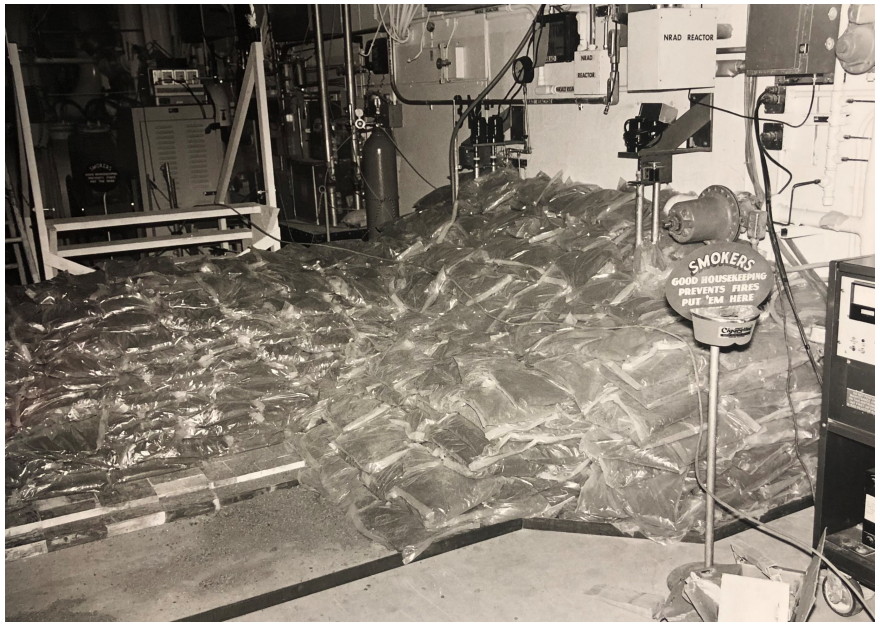
NRAD Current Modernization and Upgrade Efforts

Neutron Beams Need Upgrades

- Problem: The neutron beams were designed for thermal neutrons but *most* are not thermal

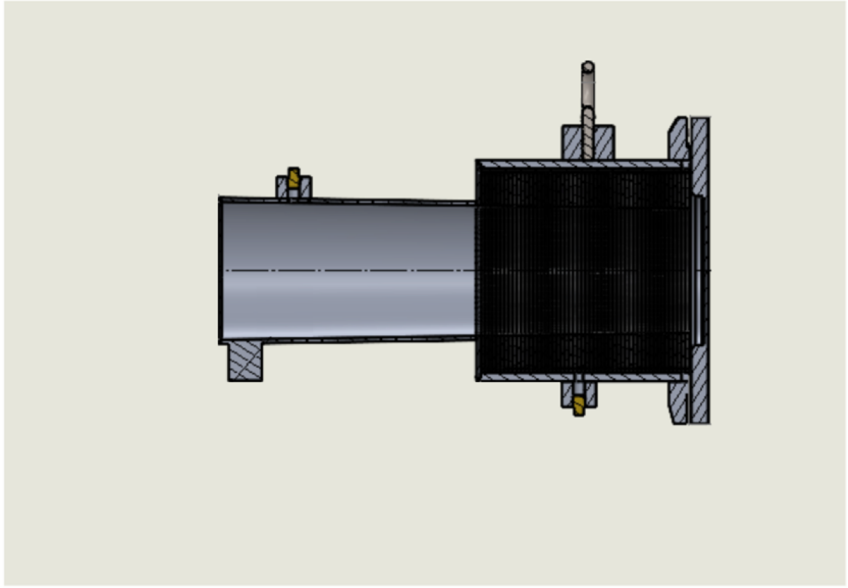


Radiation transport models showing thermal neutrons (left) and higher energy neutrons (right) in the ERS.

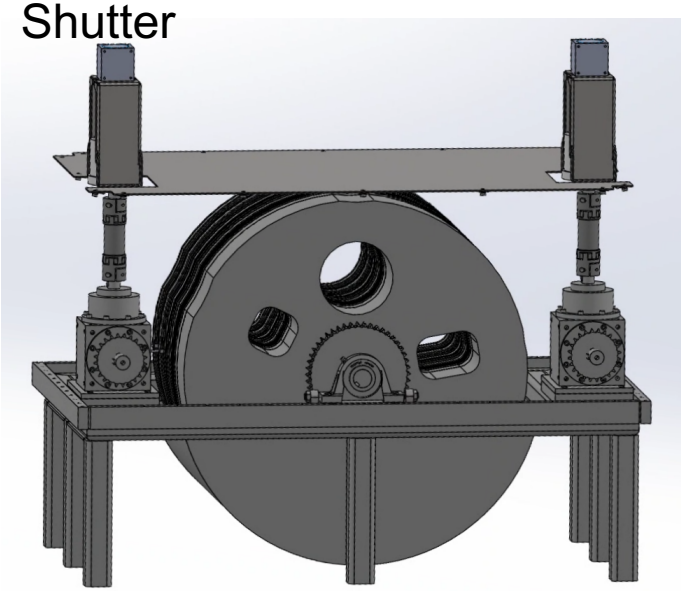


NRS Modifications

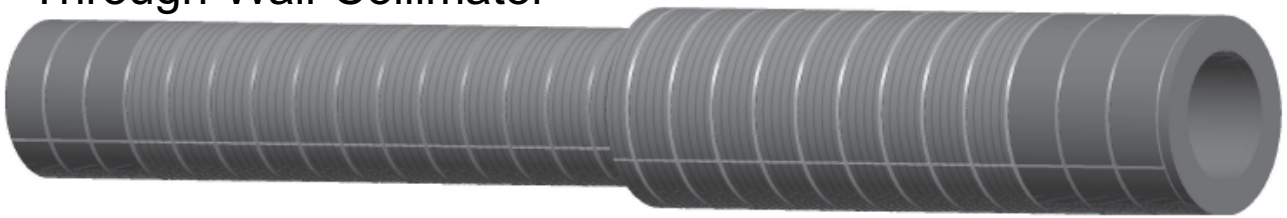
Beam Chamber



Shutter



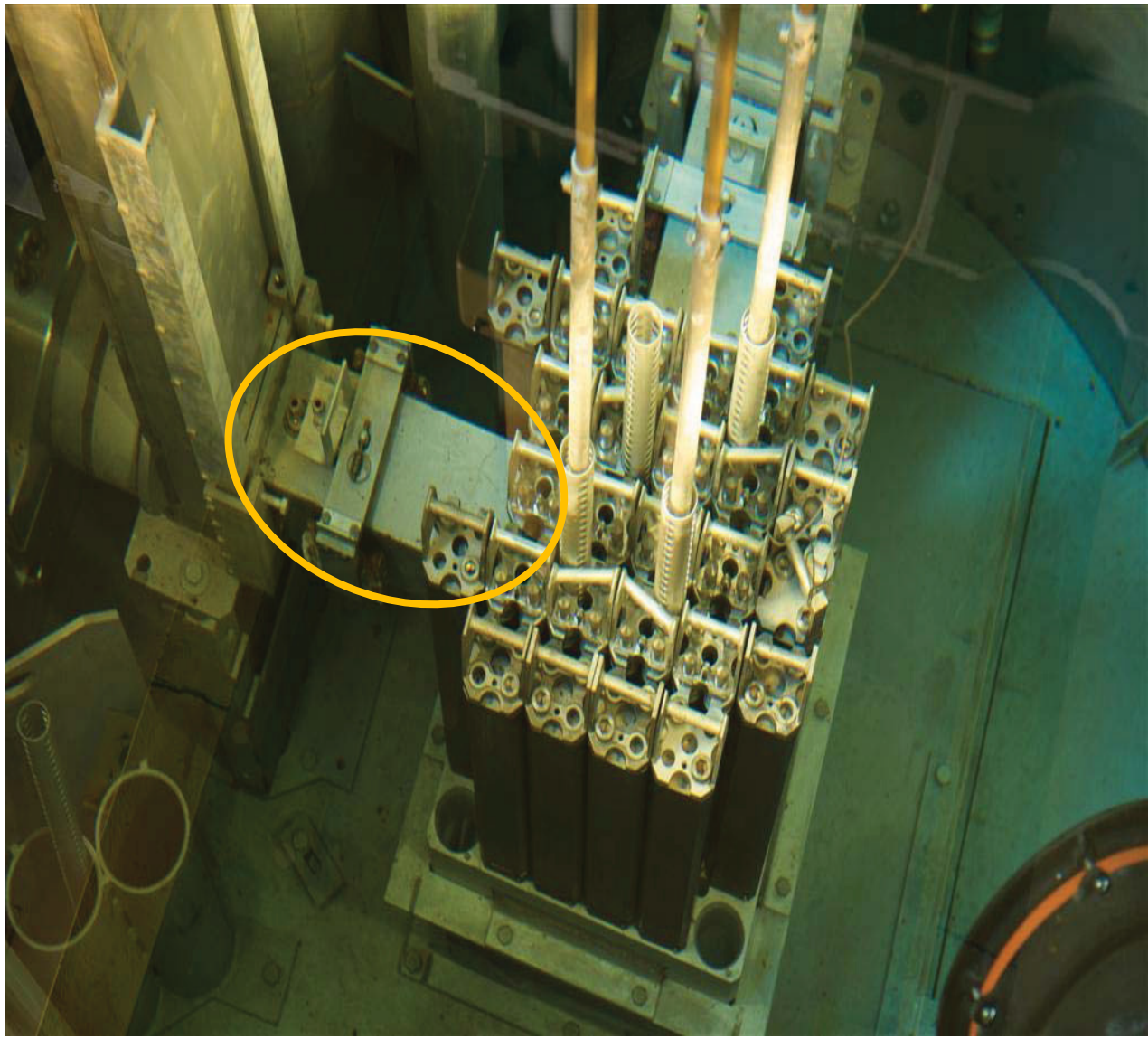
Through-Wall-Collimator



In Tank Beam Chamber

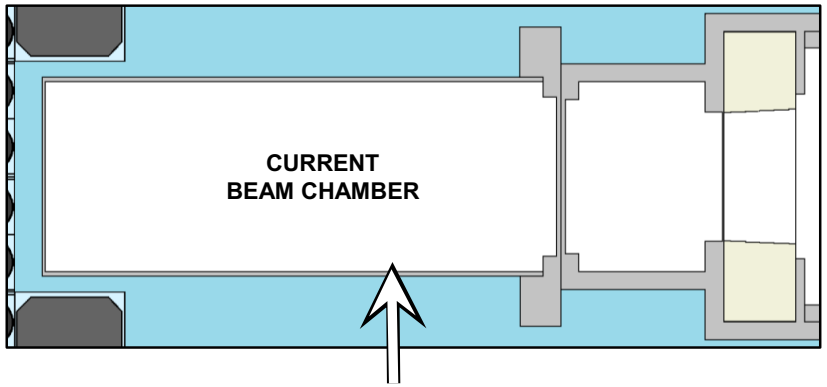
- Current design: Aluminum box filled with helium
- New design: Tapered aluminum box, with borated steel on downstream side, filled with helium

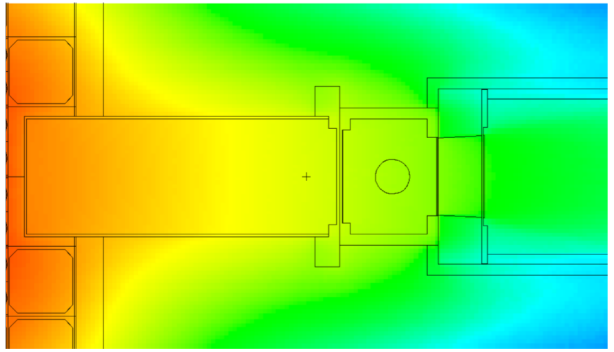
- Pre-collimate beam onto the fixed aperture
- Attenuate uncollimated neutrons and gammas
- Increase core excess reactivity

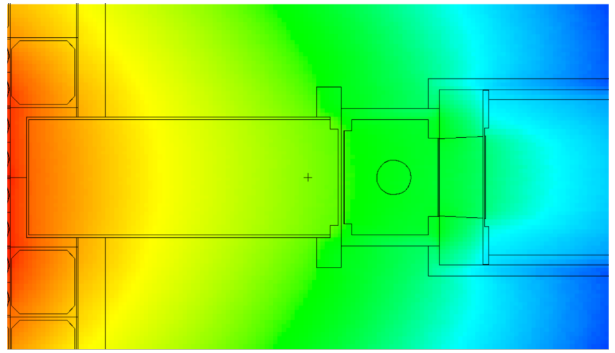


NRAD Current Modernization and Upgrade Efforts

Upgrading the North Neutron Beam





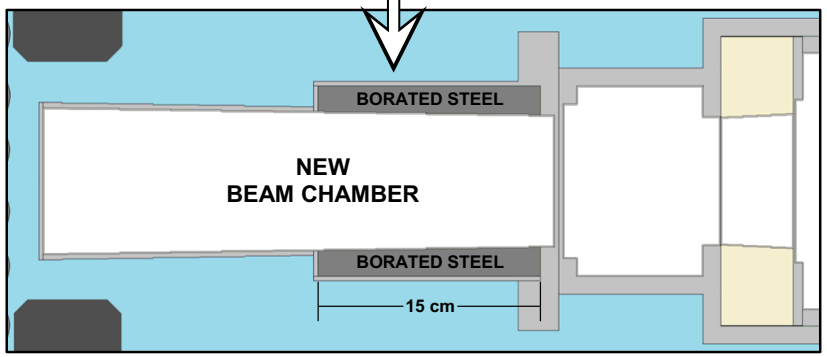


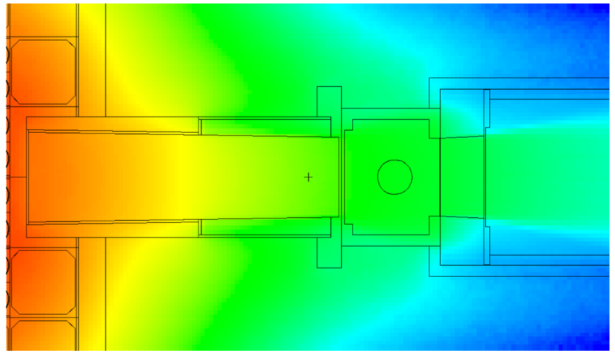
W
N

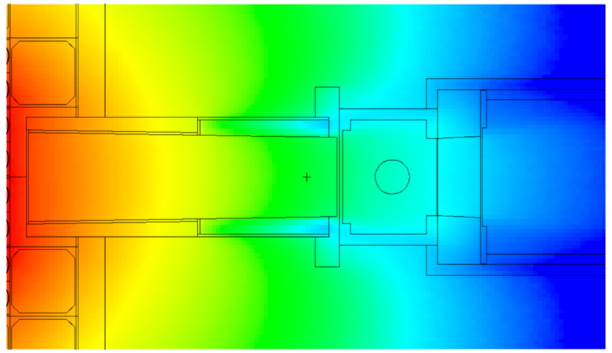
CURRENT
NEW

NEUTRON
FLUX

GAMMA
FLUX







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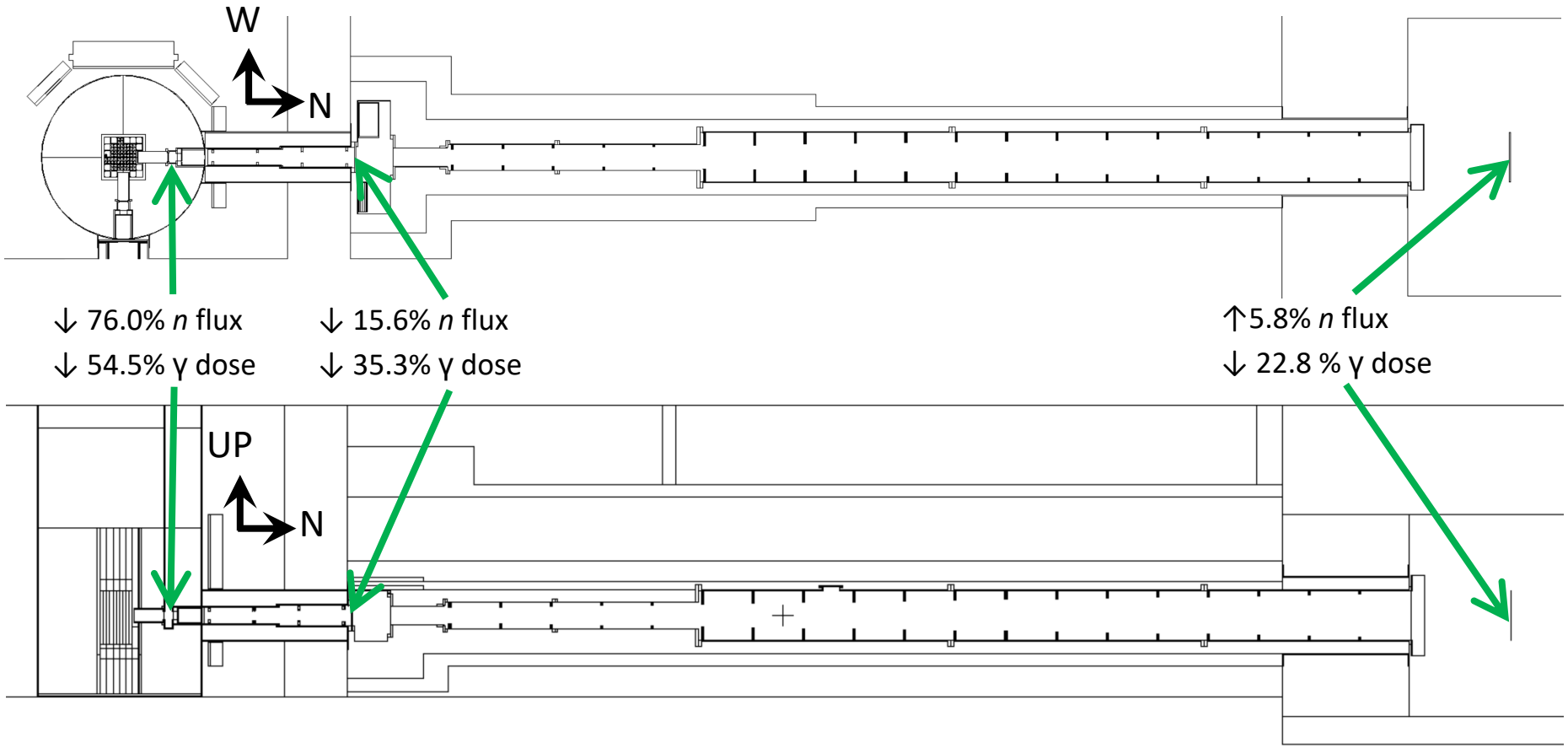
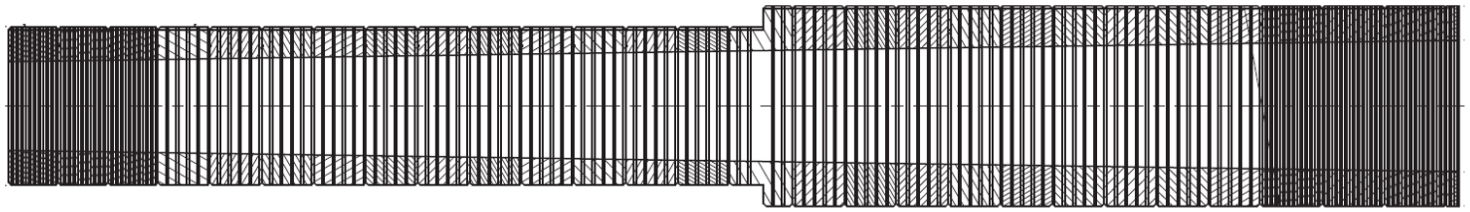


Through-Wall-Collimator

- Current design: Helium filled tube with four attenuator rings for thermal neutrons
- New design: A solid steel collimator to attenuate all neutron energies.
- Will reduce:
  - Unnecessary activation
  - Dose to personnel
  - Need for supplemental shielding

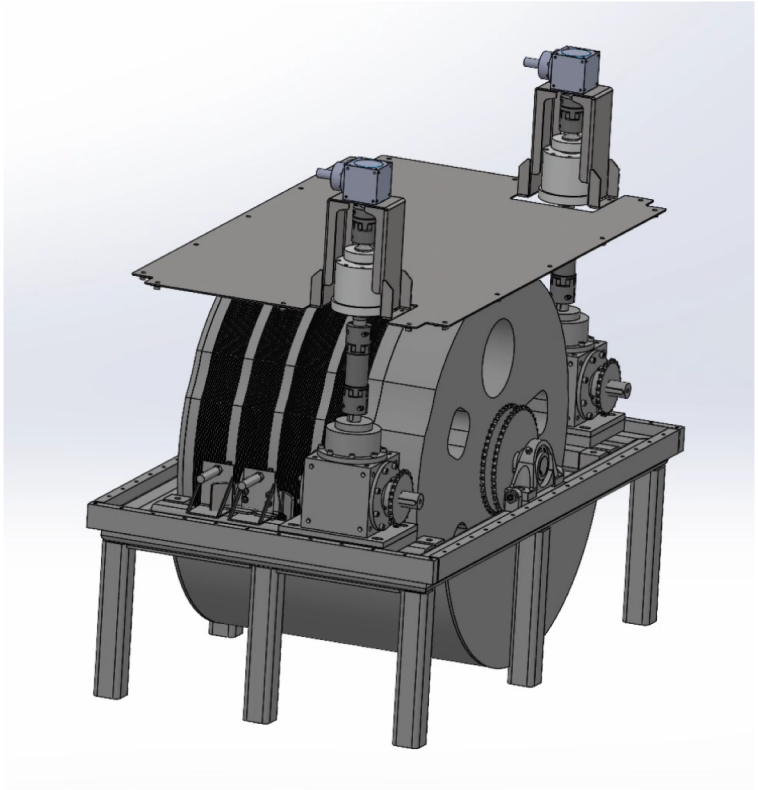


Radiation Shielding

- The current beamline design does not adequately shield against epithermal and fast neutrons
- Requires significant amount of shielding material
- A supplemental shielding “hump” was installed to reduce the radiation levels
- The new in-tank beam chamber and TWC will reduce the shielding required

Neutron Shutter

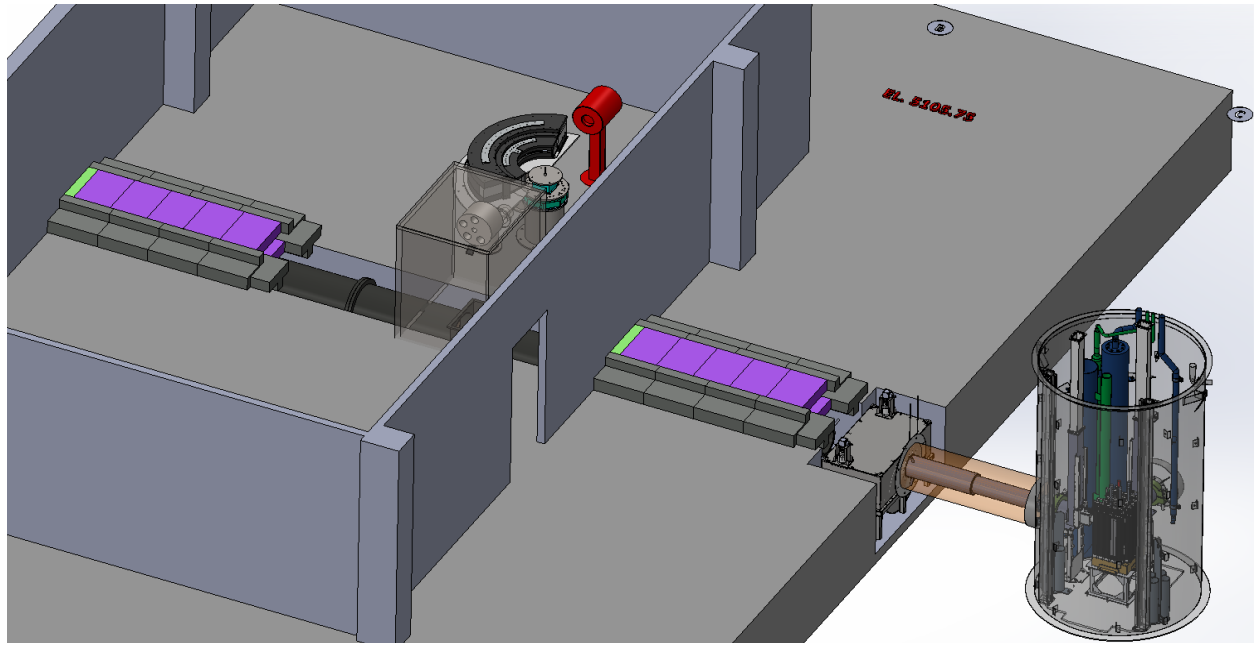
- Current design: Separate gamma shield and neutron shutter contained within the housing box. Beam conditioning with “shapers”
  - Access to NRS restricted while reactor is operating
- New design: Modern rotating drum type shutter.
  - Allows access to NRS at full power

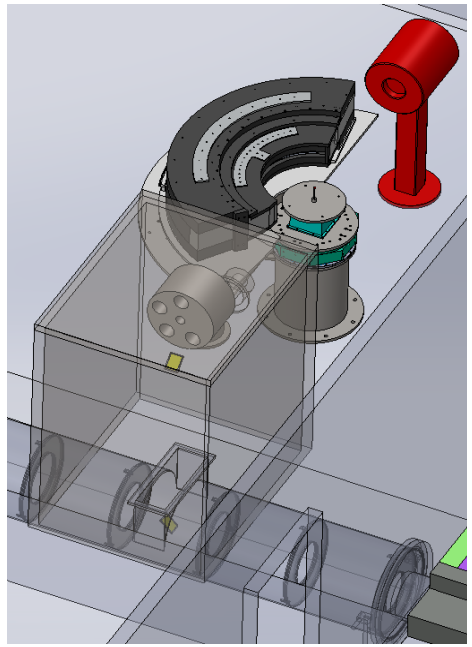


Potential New Capabilities

Neutron Scattering / Diffraction

- Neutron Tomography in the NRS
  - New imaging system is in development to expand application space
- Neutron Diffraction
  - Fundamental understanding of irradiated fuels & materials behavior
  - Fuels behavior for fuel qualification

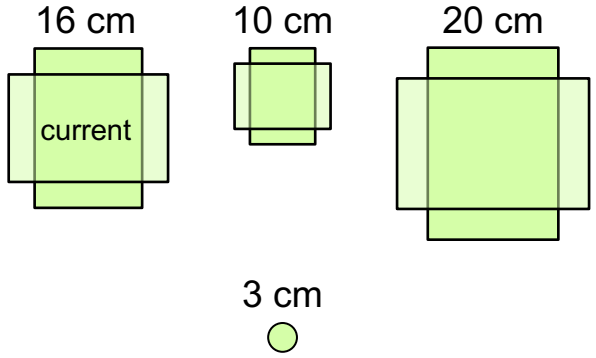


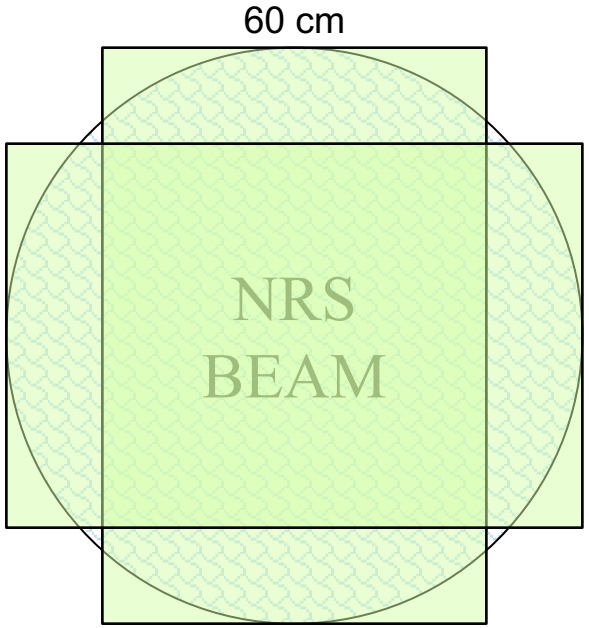


Potential New Capabilities

Neutron Tomography in the NRS

- Neutron Tomography in the NRS
  - New imaging system is in development to expand application space
- Applications:
  - TRISO compacts
  - Fuel rods/rodlets, elements/bundles
  - Advanced moderators
  - Pyroprocessing materials
  - Transient experiment loops
  - Engineering scale experiments
  - Furnace experiments
  - Water propagation in materials
  - Non-nuclear INL mission (e.g. batteries, biofuels)
  - Paleontology & cultural heritage
  - Model V&V using realistic geometry



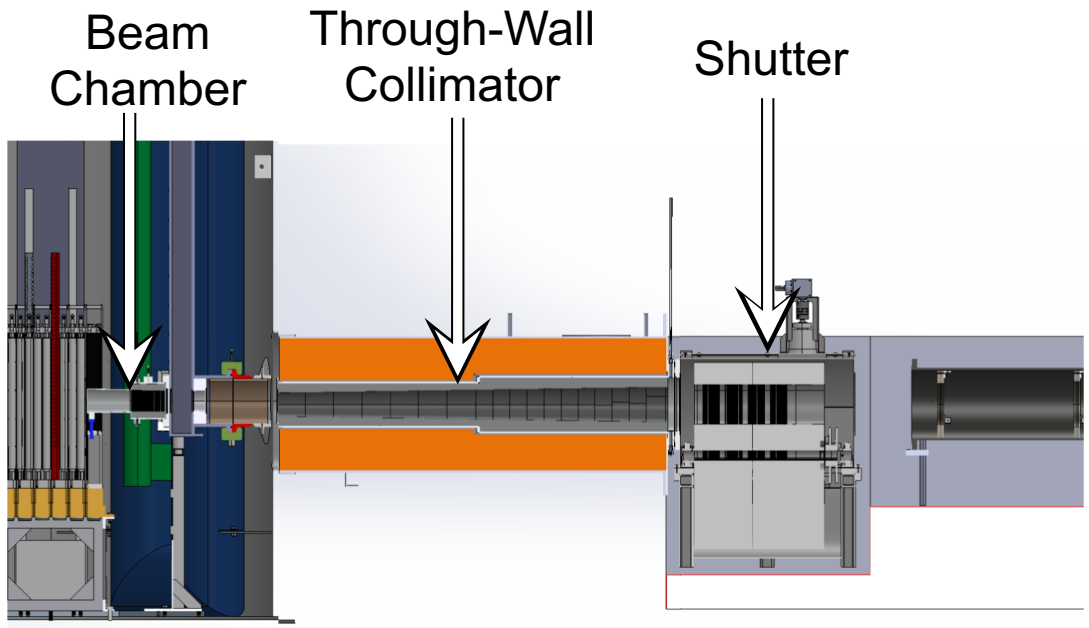


Capability Overview

Current NRAD	Next-Level NRAD
ERS • Radiography (film and image plates) NRS • Radiography (film and image plates) • Digital radiography and tomography In-core • Wet-tube and dry-tube positions • Cask/container transfer only	ERS • Radiography (film and image plates) • **Digital computed tomography** NRS • Radiography (film and image plates) • **Upgraded** digital radiography and tomography **North Beam Hall** • **Neutron scattering/diffraction** **Sample Analysis Laboratory** • **Neutron Activation Analysis (NAA)** • **Sample and experiment preparation** In-core • Wet-tube and dry-tube positions • Cask/container transfer • **Pneumatic sample transfer system** • **In-core furnace and rotating irradiator**

Overall Benefits

- Increased excess reactivity (beam chamber)
- Reduced dose to personnel and unnecessary activation (beam chamber & TWC)
- Minimize or eliminate supplemental shielding hump (beam chamber & TWC)
- Improved access to NRS cell during operations (shutter)
- Improved beam conditioning for current and future experiments (all)



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Battelle Energy Alliance manages INL for the U.S. Department of Energy's Office of Nuclear Energy. INL is the nation's center for nuclear energy research and development, and also performs research in each of DOE's strategic goal areas: energy, national security, science and the environment.