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Radiation Measurement Scientist

Modernization of Radiation Measurement Methods in Support of the Ongoing Advanced Test Reactor Mission

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

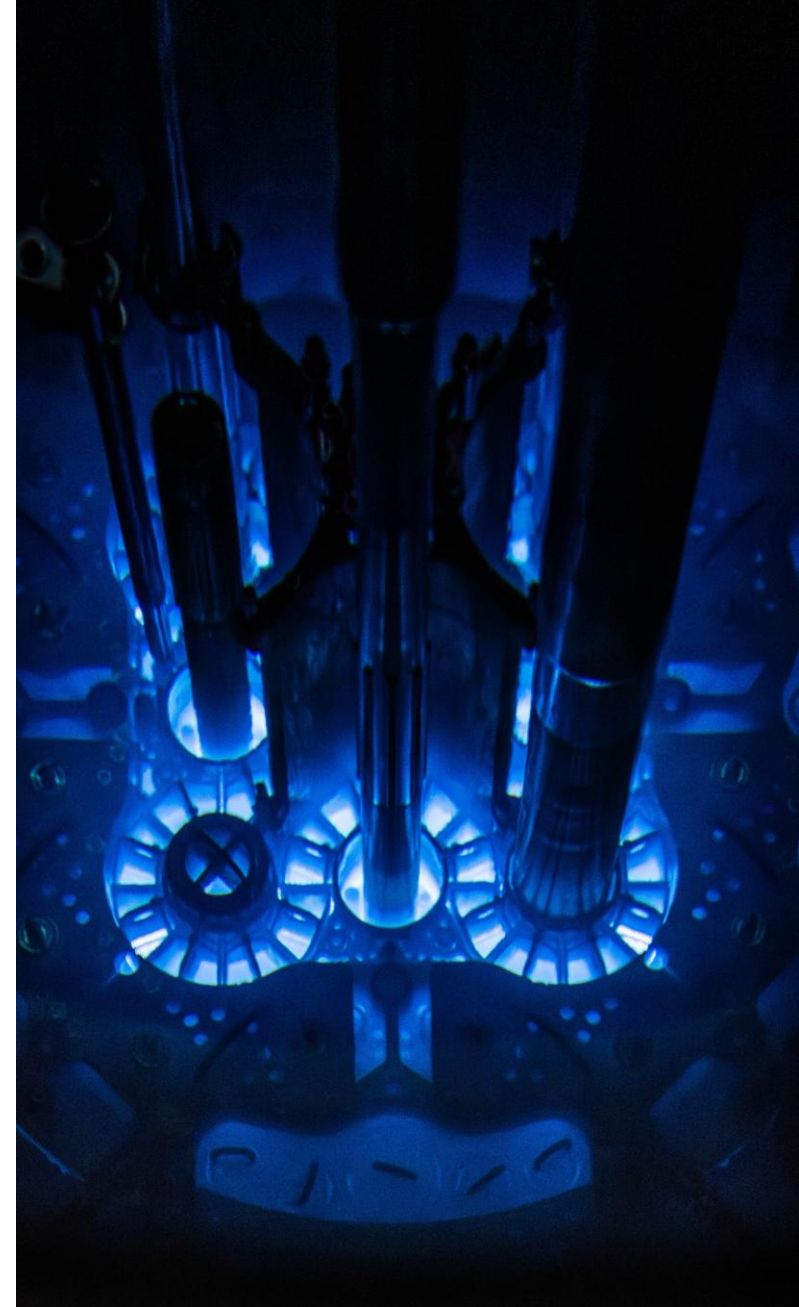


Idaho National Laboratory

The Advanced Test Reactor (ATR)

- Light Water Cooled; Beryllium Moderated
- Nominal thermal power capacity: 250 MW
- Max Thermal Neutron Flux: $1.0 \times 10^{15} \text{ n} \cdot \text{cm}^{-2} \cdot \text{s}^{-1}$
- Max Fast Neutron Flux: $5.0 \times 10^{14} \text{ n} \cdot \text{cm}^{-2} \cdot \text{s}^{-1}$
- Flux Traps: 9
- Fuel Assemblies: 40
- Fuel Plates per Assembly: 19
- Length of Assembly: 1.2 m (4 feet)
- Operating Pressure: 2.5 Mpa (360 psig)
- Design Temperature: 115°C (240°F)

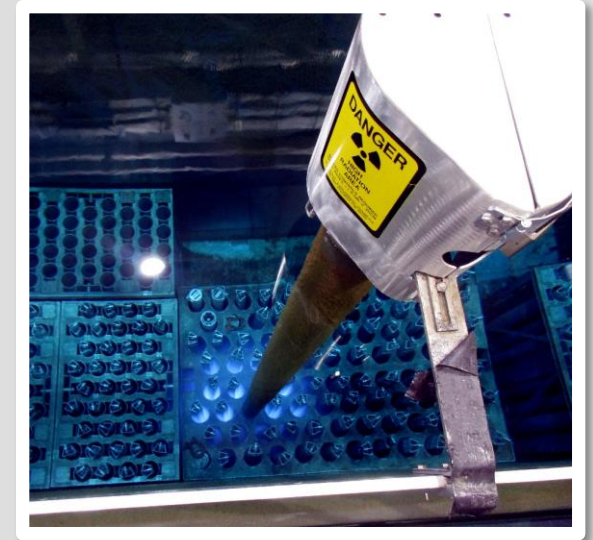
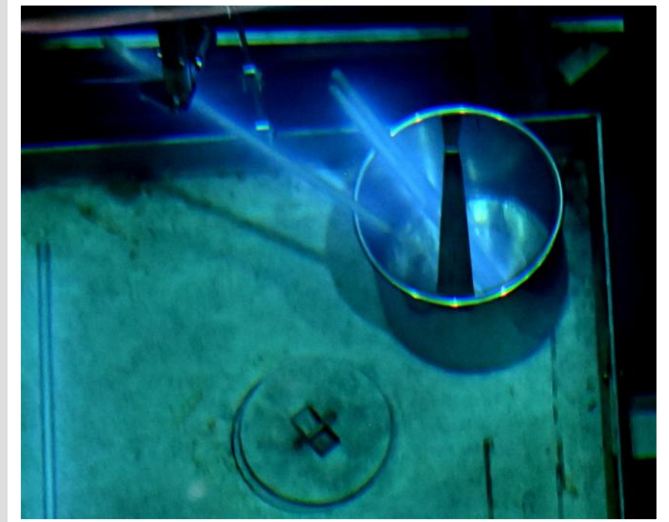
Information from Campbell, Joseph L. ATR User Guide. United States: N. p., 2021.



Radiation Measurement Laboratory (RML)

Analytical Research Laboratory

- ATR Cycle Neutron Dosimetry
- Gamma Spectroscopy
- Gross α/β
- Fission-Rate Monitor Measurements
- High dose ion chamber measurements
- Environmental Reporting
- NDA of Suspect Radiological Material
- Emergency Response



ATR Neutron Dosimetry

Heterogeneous Neutron Flux Profile¹

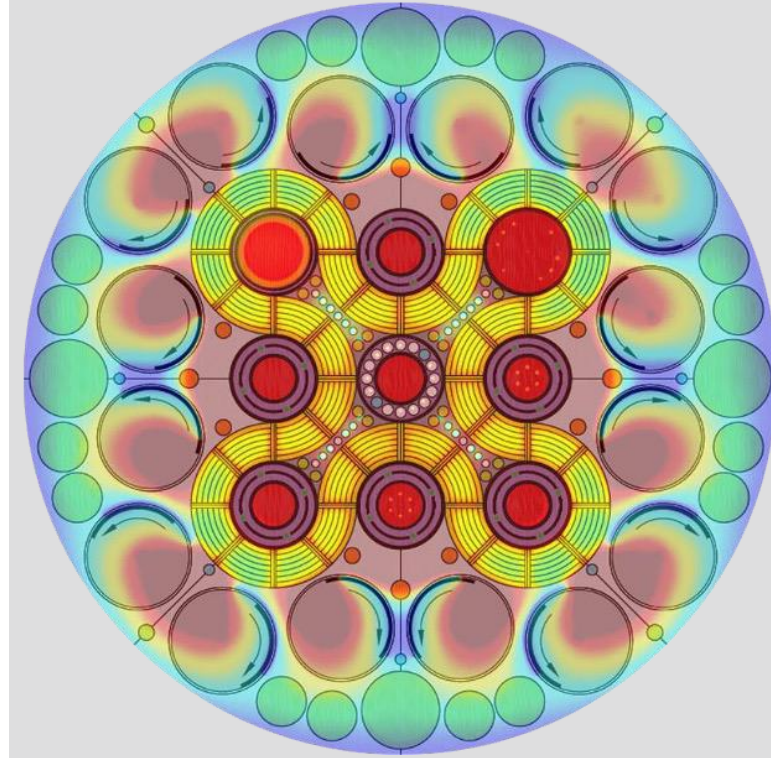
Radioactivation of material

- $^{58}\text{Ni}(n,p)^{58}\text{Co}$ reaction [fast]²
 - 99.7% Pure ^{58}Ni
 - 0.5mm diameter
- $^{59}\text{Co}(n,\gamma)^{60}\text{Co}$ reaction [thermal]³
 - 0.1% ^{59}Co by mass - Al
 - 0.5% ^{59}Co by mass – Al
 - 0.8 mm diameter

[1] Reichenberger, M.A., McCary, K.M., Ottaway, D.G, "Advanced Test Reactor Neutron Dosimetry Report - Cycle 175A-1.", Oct. 2025. <https://doi.org/10.2172/3022277>

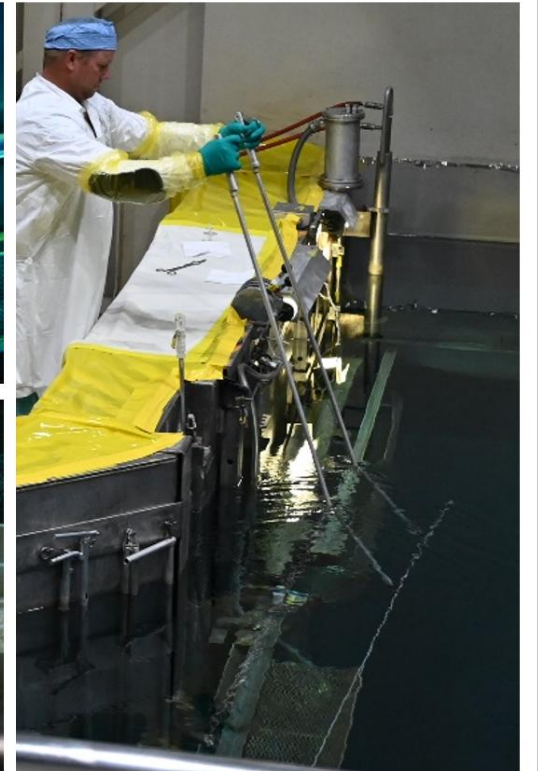
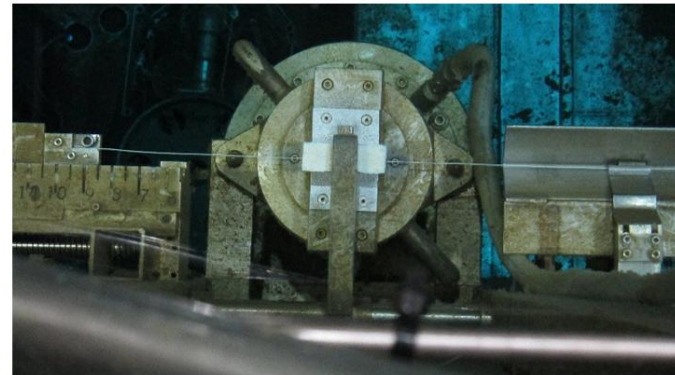
[2] ASTM International Standard E262, "Standard Test Method for Determining Thermal Neutron Reaction Rates and Thermal Neutron Fluence Rates by Radioactivation Techniques," 2017.

[3] ASTM International Standard E264, "Standard Test Method for Measuring Fast-Neutron Reaction Rates by Radioactivation of Nickel," 2019



Disassembly & Measurement in ATR Canal

- Dosimetry is removed after irradiation.
- Count Rates measured on NaI detector at designated elevations.
- 1/8 in (3mm) snippet is removed for measurement at RML.
- Single point failures.



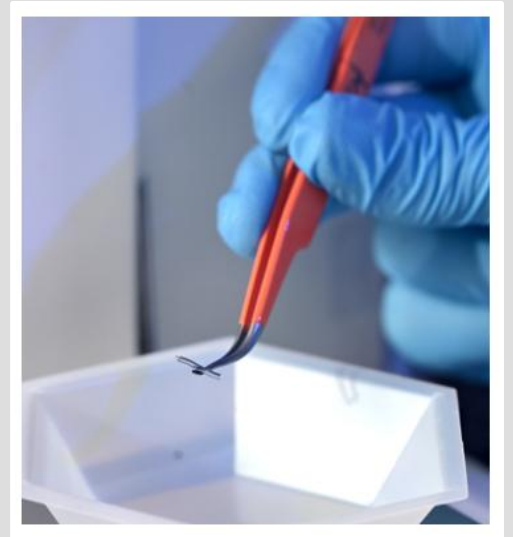
Activity quantification at RML

Previous:

- High pressure 4π Ion chamber to determine activity.
- Snippets are then weighed to account for source isotope concentrations.
- Legacy hardware issues.

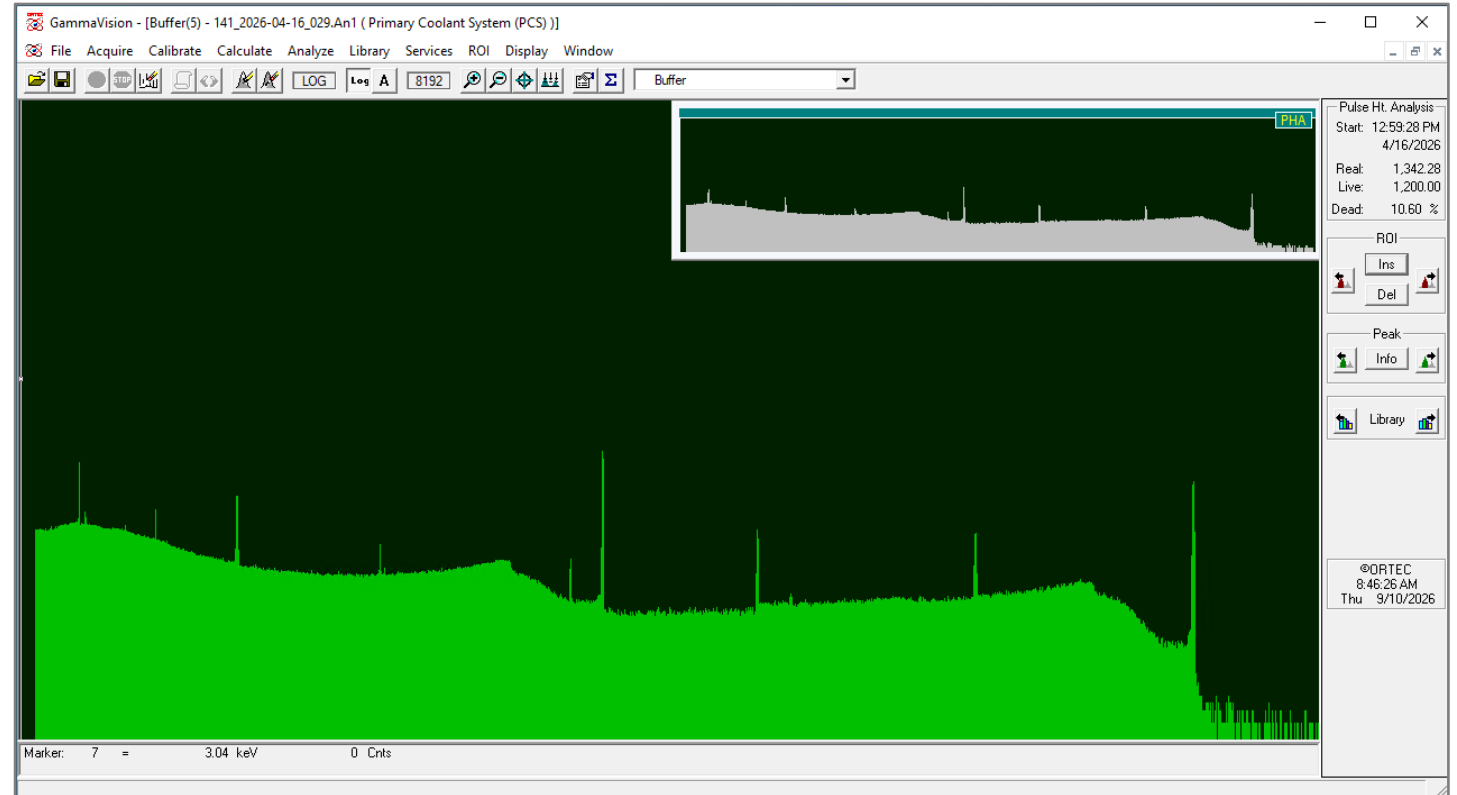
Now:

- Snippets are weighed
- Secured to sample cards
- Activity measured by HPGe Detectors



Gamma Spectroscopy

- 12 HPGe detectors
 - 5 traditional dewars
 - 7 newer recyclers
 - Stack Effluent Monitor
- Flexible sample geometry positioning
 - Sample matrix
 - Activity considerations
- Complex spectra

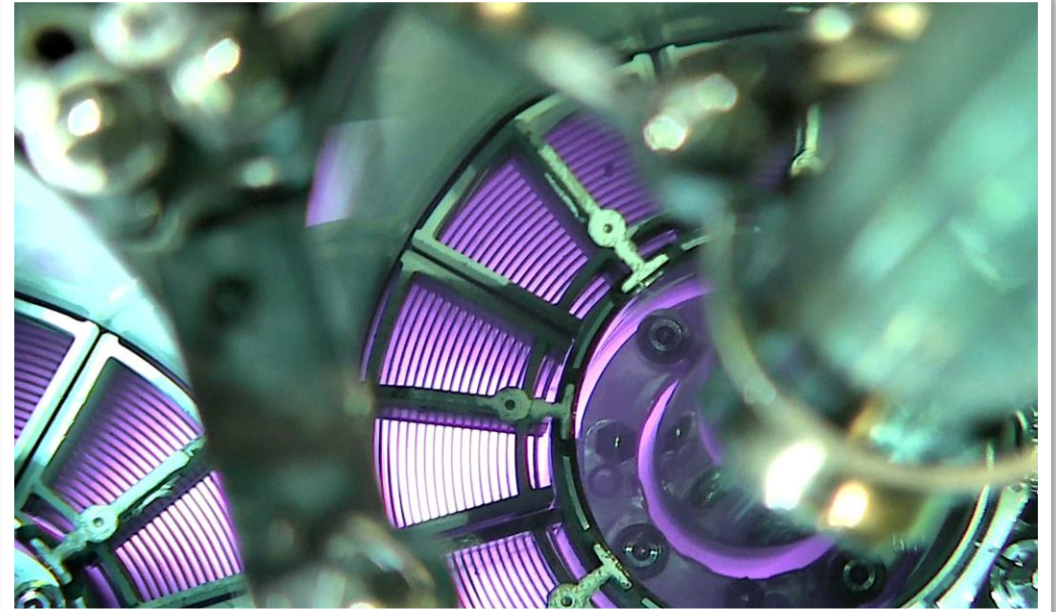


From PC-GAP to GammaVision

Personal Computer Gamma-ray Analysis Package

- FORTRAN complications
- Force fits/false positives
- Modern OS compatibility
- Flexibility
- Commercial support
- Industry Standards

Divisive disclaimer: This is the opinion of one researcher at one facility. I understand this is a sensitive and complicated topic and subject to much debate among INL colleagues. This is how RML has elected to proceed at the direction of our technical authority.

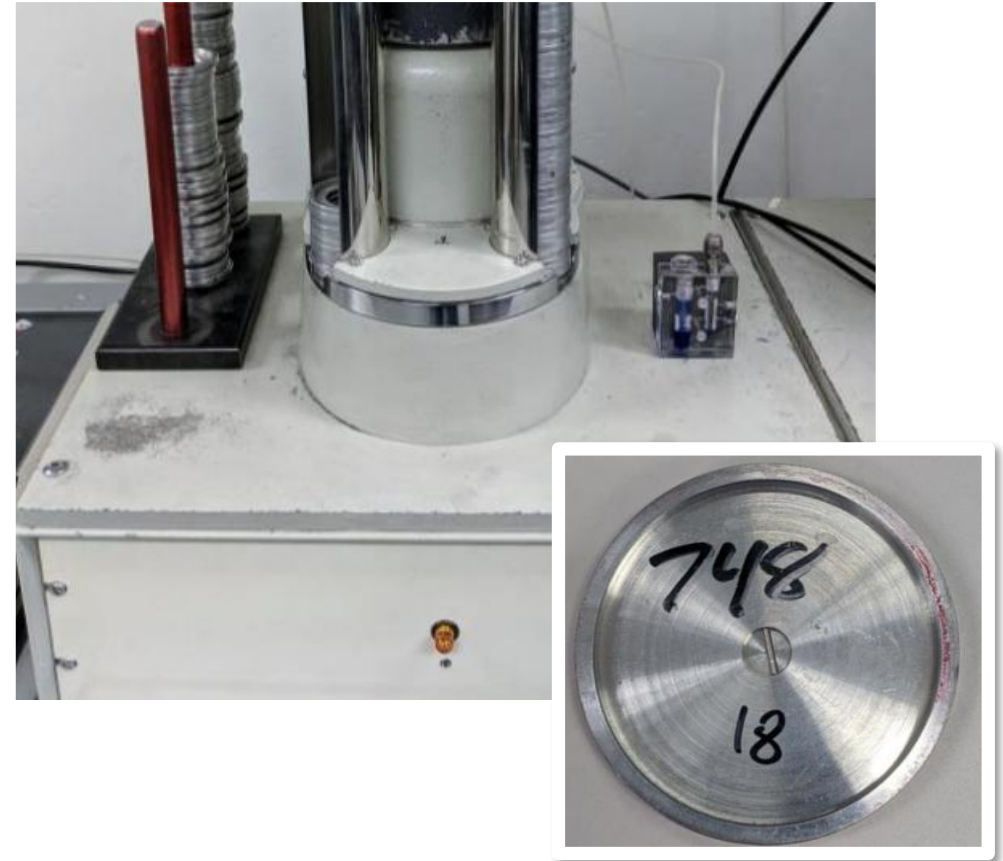


Several fuel elements within the ATR Core. Some camera sensors make the Cherenkov effect appear purple. Image used courtesy of INL Photography

Fission-Rate Monitor Measurements

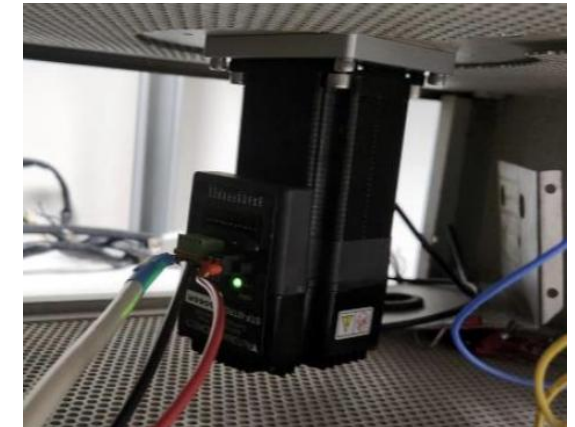
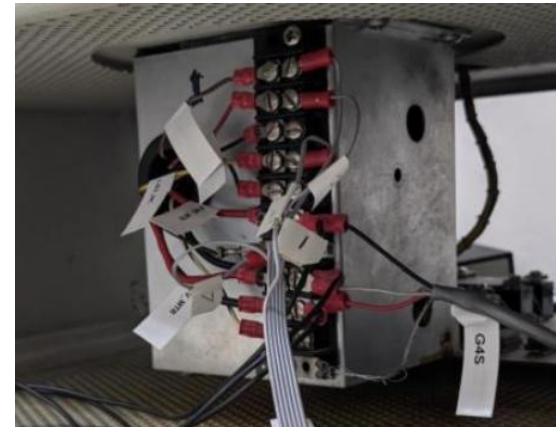
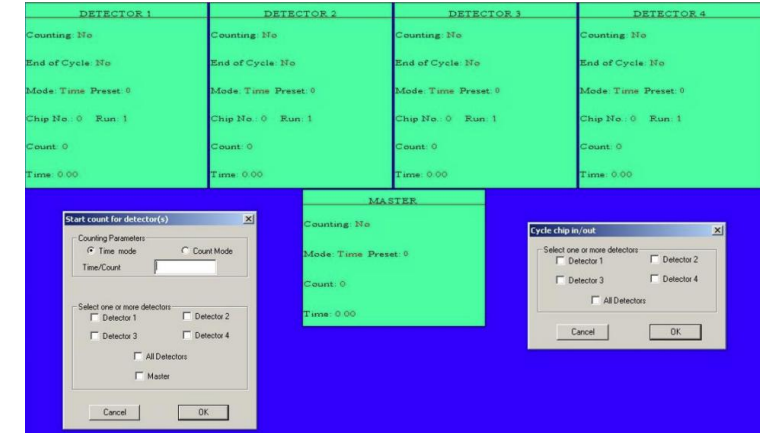
- U-Al wires in ATR-C core (min. 340)
- Simultaneous Gross β count on 4 channels
- Analog decay correction
- Custom built system
- Develop fission rate map of ATR-C
- Simulation/Model Verification

B. W. Howes, C. H. Hogg and L. D. Weber, "Use of U235 Wire as a Fission Rate and Thermal Flux Monitor PTR-759," National Reactor Testing Station, US Atomic Energy Commission, Idaho Falls, ID, 1965.

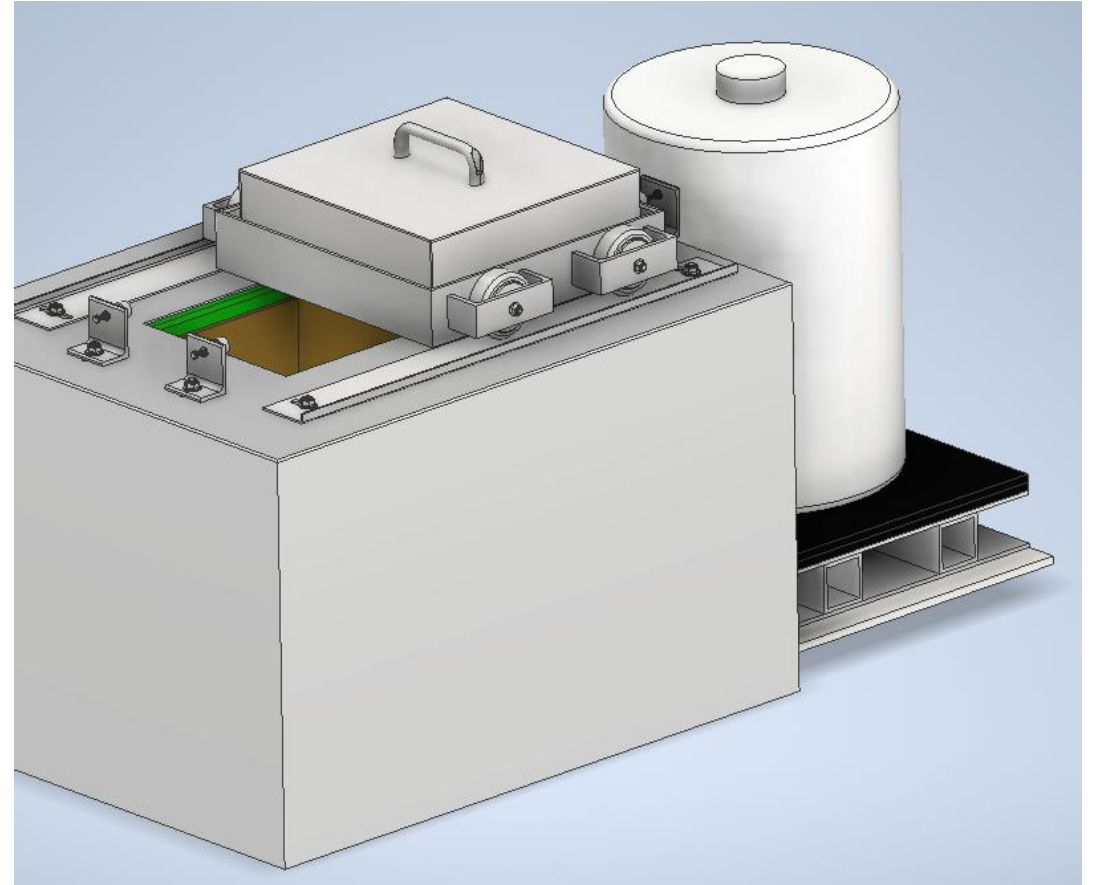
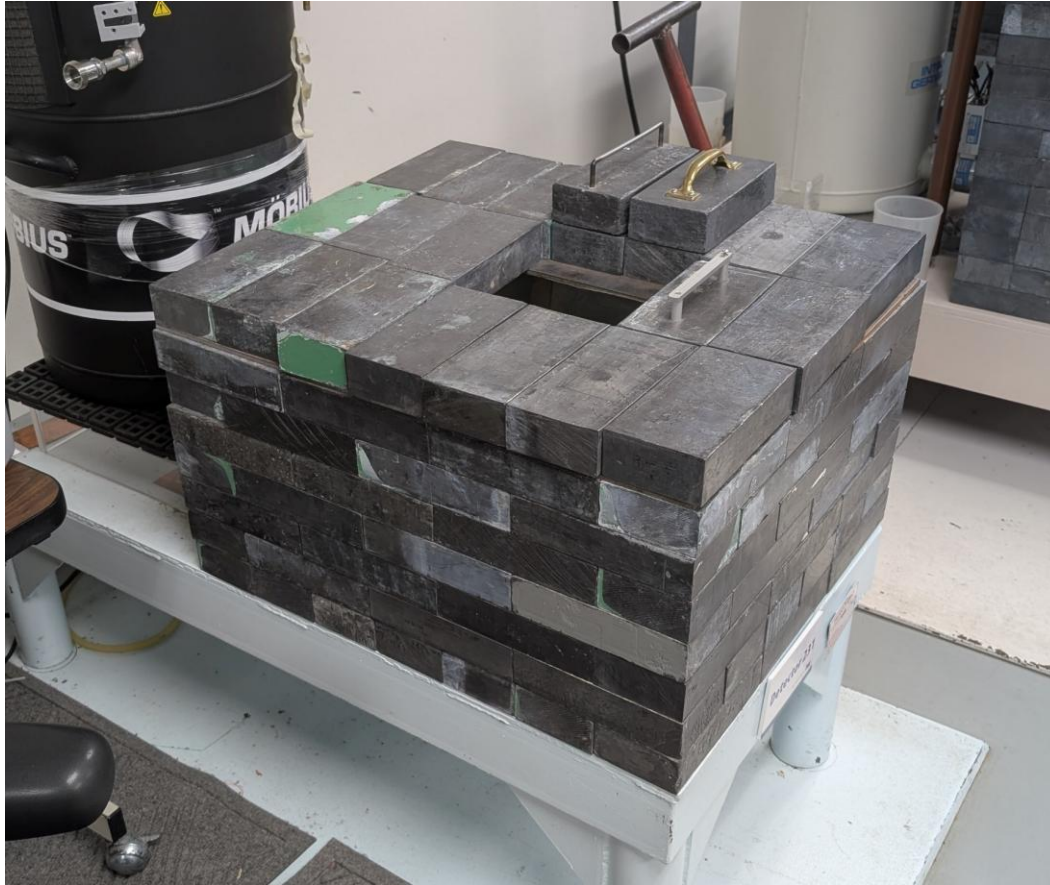


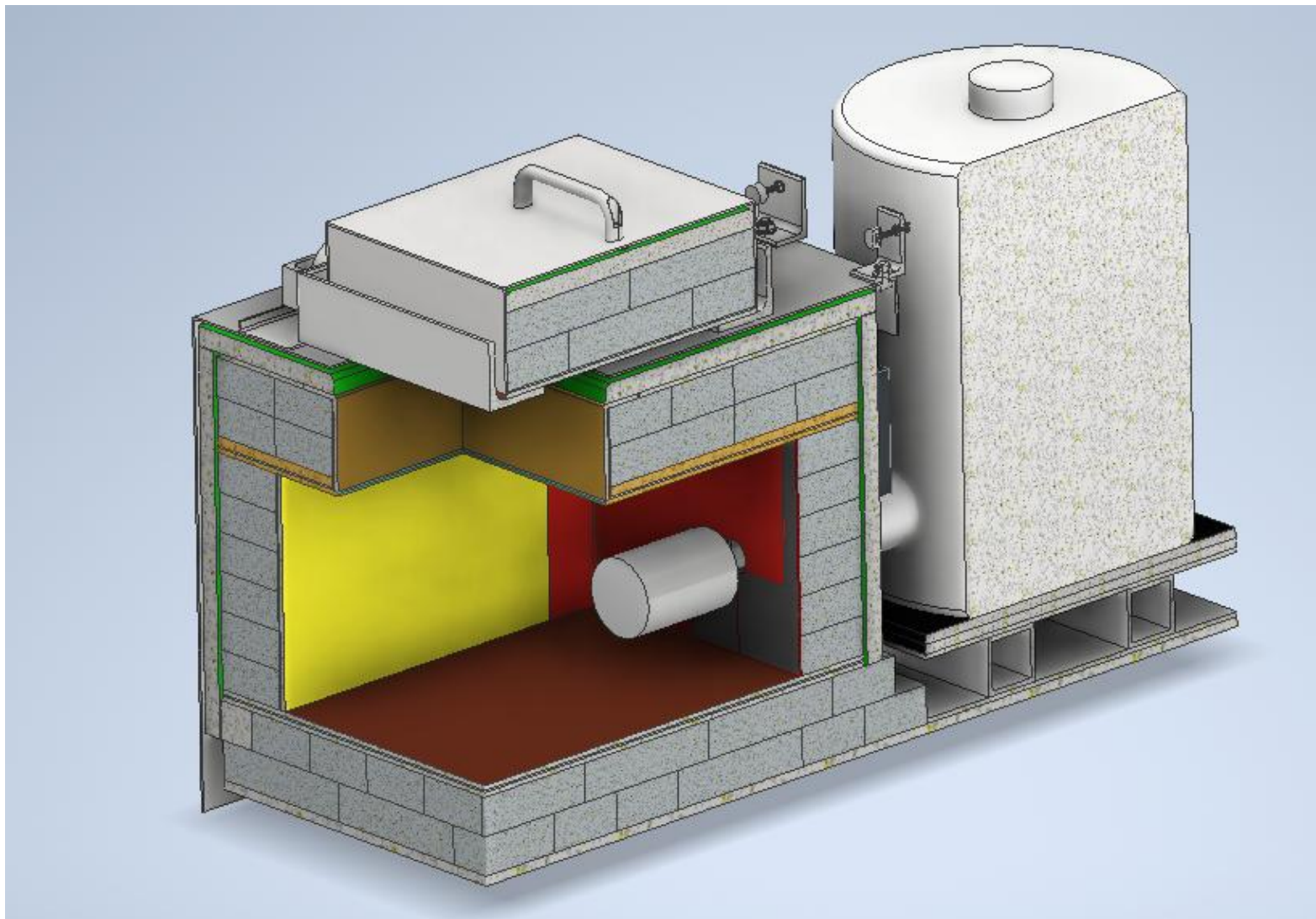
Fission Rate Measurement System (FRMS)

- Replaced custom gas flow proportional counters with off the shelf commercially available scintillators and preamps.
- Updated motor hardware for reliable sample changing
- Software updates – software crashes
- Pause button
- Gamma spec to provide fission-rate conversion factor



Detector Cave Updates





Questions/Contacts

Please send any follow up questions or comments to Dani Ottaway: dani.ottaway@inl.gov

Special thank you to INL Photography for use of images, and RML Personnel: M.A. Reichenberger, K.M. McCary, B.J. Walker, and B.A. Page.

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