



Idaho State
University

Characterization of a HALEU-Fueled AGN-201M Reactor for Benchmark Evaluation

Dr. Mary Lou Dunzik-Gougar, Theodore Pollock, Maruf Anwarul, Matthew W. Lambert, Kyler Johnson, Jude Milloway and Angela Trejo

ROAR



Benchmarking Project

- The goal of this project is to conduct an International Criticality Safety Benchmark Evaluation Project (ICSBEP) evaluation of the AGN-201M reactor in collaboration with Oak Ridge National Laboratory.
- To prepare a high-fidelity model of the AGN-201M, the reactor was fully disassembled and each component was characterized with high precision and the results documented
- Upon reassembly, various operational data will be documented.
- Uncertainty quantification will be performed.



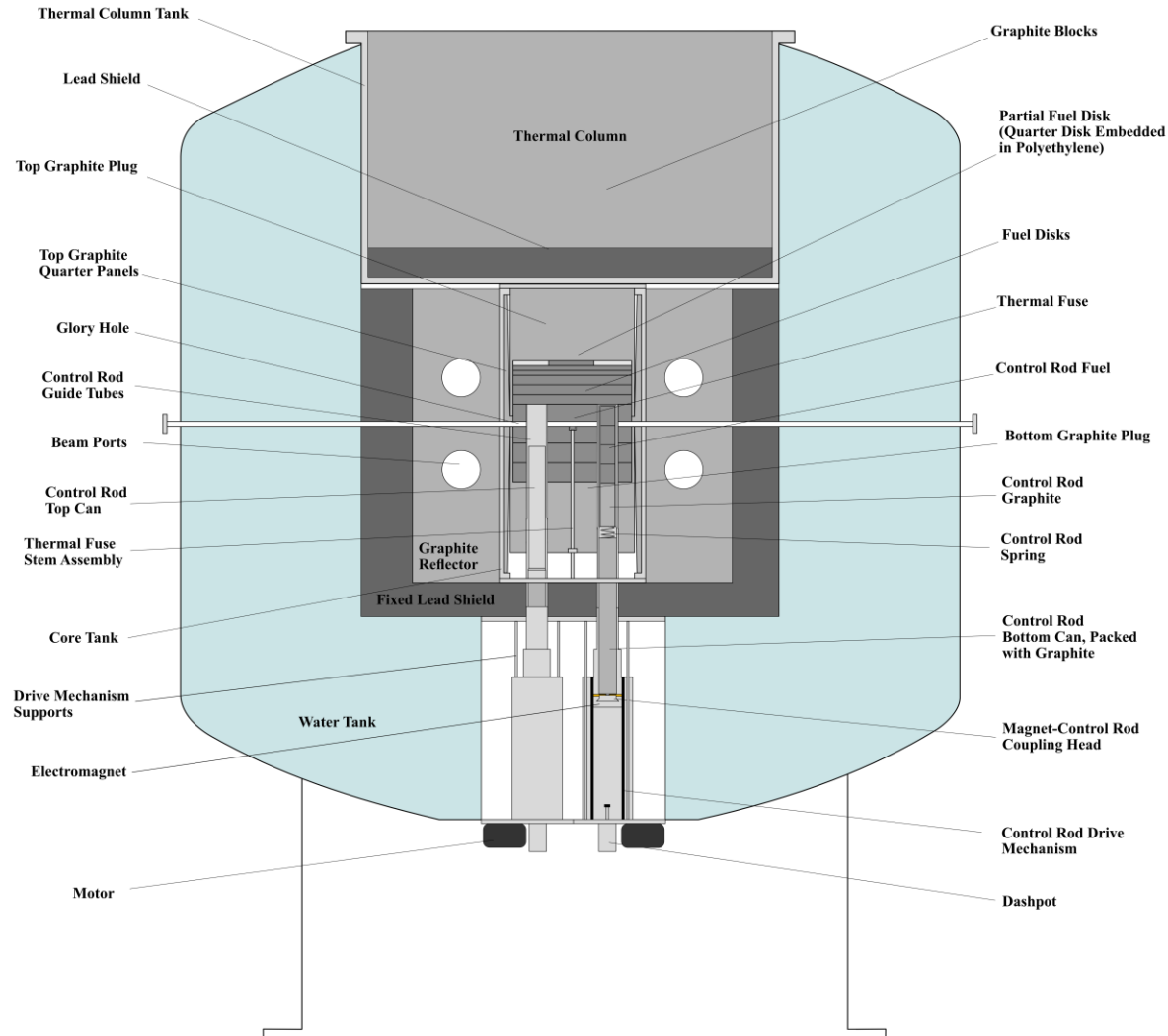
Why this reactor?

- Existing power reactors use Low Enriched Uranium fuel (LEU) (3-5% uranium-235)
- Many advanced reactors plan to use High-Assay Low Enriched (HALEU) fuel (5-20% U-235) which will require evaluation of fuel transport containers
- More analysis of upset conditions involving moderator intrusion during advanced reactor fuel fabrication is necessary
- The AGN-201 is an optimally-moderated, HALEU-fueled, graphite-reflected system!
- Reactor is small and simple; easy to take apart
- All components can be handled with minimal PPE



Idaho State
University

ISU AGN-201 Reactor



*Drawing not to scale

- Aerojet General Nucleonics Model 201
- Training, research, testing reactor
- 1 of 5 left, 1 of 4 operating
- Very low power, max 5 W

ROAR



Idaho State
University

ISU's AGN-201 in Life Magazine (1950s)



ROAR



Idaho State
University

ISU's AGN-201 in the present day





Idaho State
University

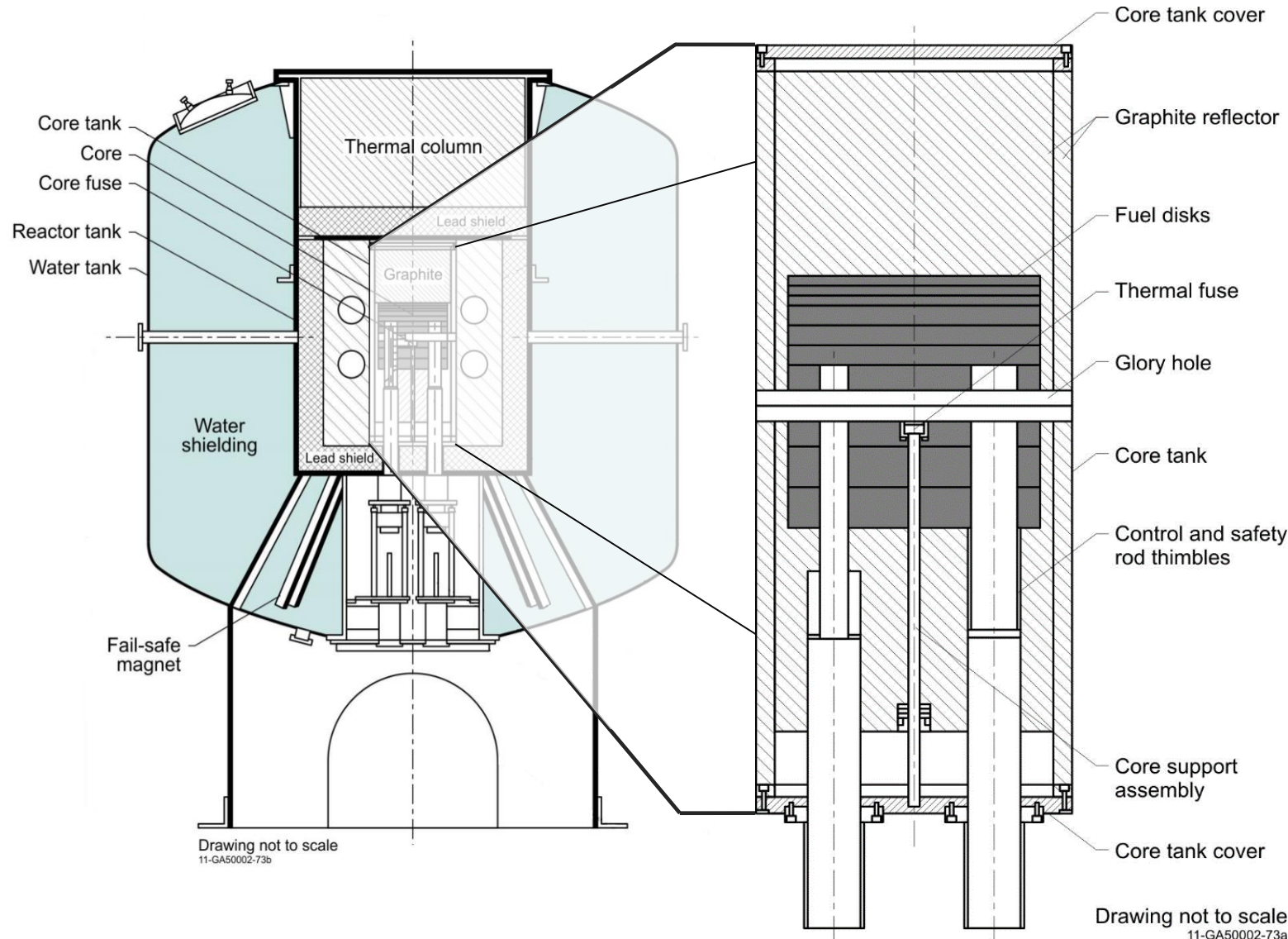
Aerojet-General Nucleonics Brochure



ROAR



AGN-201 Specifications

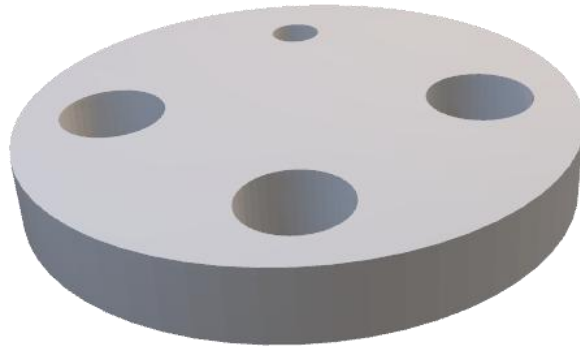


- Cylindrical core about the size of a 5-gallon bucket
- HALEU-fueled, 19.75% ^{235}U
- UO_2 fuel in polyethylene disks
- Fueled control rods enter from bottom



Fuel Disks

- Bottom disks have holes for control rods
- Top disks have no penetrations





Idaho State
University

Central fuel (with glory hole cut out)

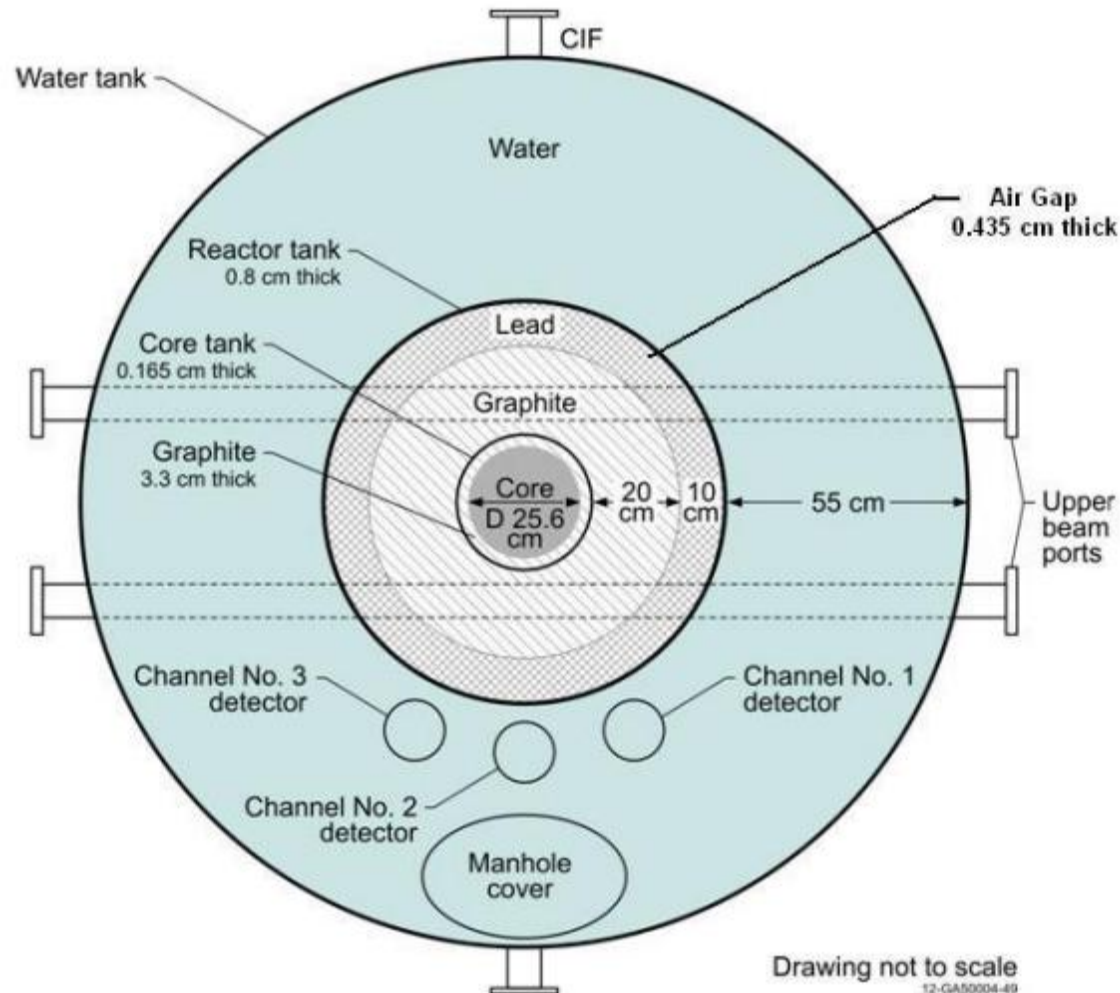


ROAR



Plan View

- Graphite reflector
- Lead & water shielding





Idaho State
University

Reactor Disassembly

- Disassembly conducted in June 2025
- Assisted by 3 undergraduate students, 2 graduate students and an ISU alumni
- First time the reactor has been fully disassembled at ISU



ROAR



Idaho State
University

The Team



ROAR



Idaho State
University

Disassembly



Assembled core tank



Upper fuel disk
20438



Idaho State
University

Disassembly



Lower fuel disk 20432



Control rod thimbles and
graphite shells

ROAR



Idaho State
University

Disassembly



Lower graphite reflector



Upper graphite panel



Idaho State
University

Disassembly



Outer graphite reflector



Outer lead shielding



Idaho State
University

Reactor Characterization

Instruments

- Professionally calibrated
- Calipers, balances, feeler gauges, and 3-dimensional scanner

Over 3,000 individual physical measurements taken including masses, diameters, thicknesses, etc.



ROAR



Idaho State
University

Characterization



Measuring fuel plate mass



Fuel disk diameter
measurement



Idaho State
University

Characterization

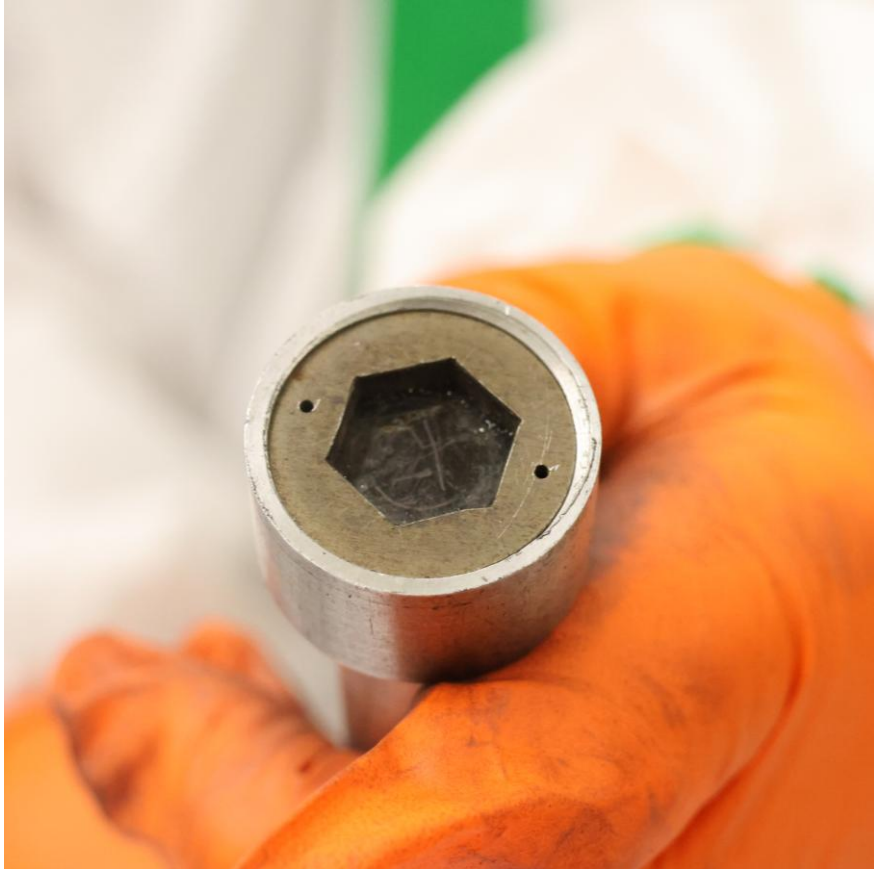


Measuring graphite panel



Measuring upper graphite reflector

Characterization



Thermal fuse and fuse
thimble



Safety Rod 1 fuel and graphite



Idaho State
University

Characterization



Using a Coordinate Measuring Machine to model a fuel disk



Graphite from thermal column



Idaho State
University

Put up your hands!



ROAR



Discoveries

- Manufacturing damage to fuel plate
 - Fuel plate 20432 has a section missing from the edge of a control rod penetration
- Core tank thickness is less than previously thought
 - Original AGN documentation lists a core tank thickness of 0.065 in, measured thickness was 0.051 in
- Graphite panels cut radially into sections
 - Radially cut panels are difficult to remove from core tank

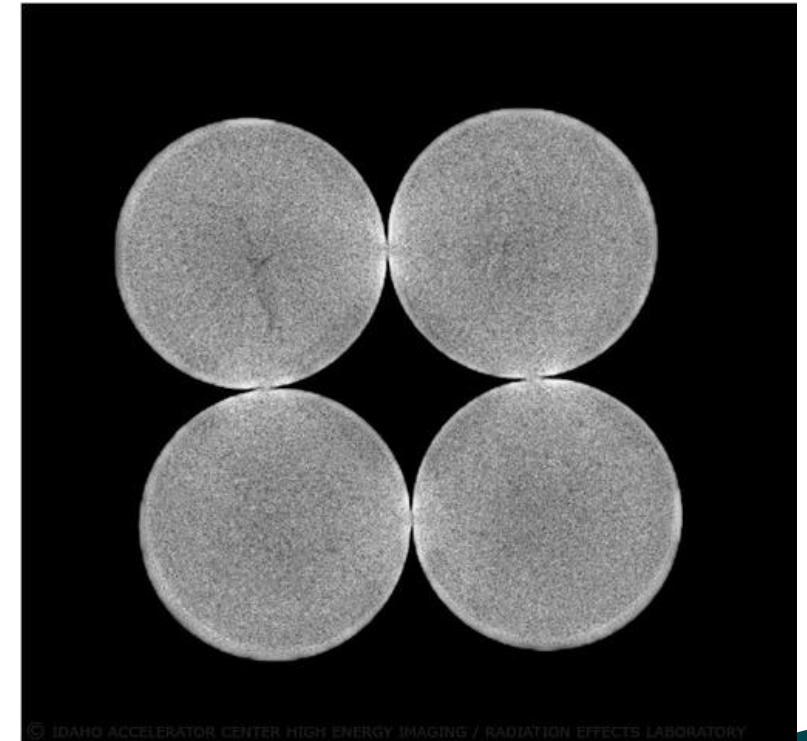
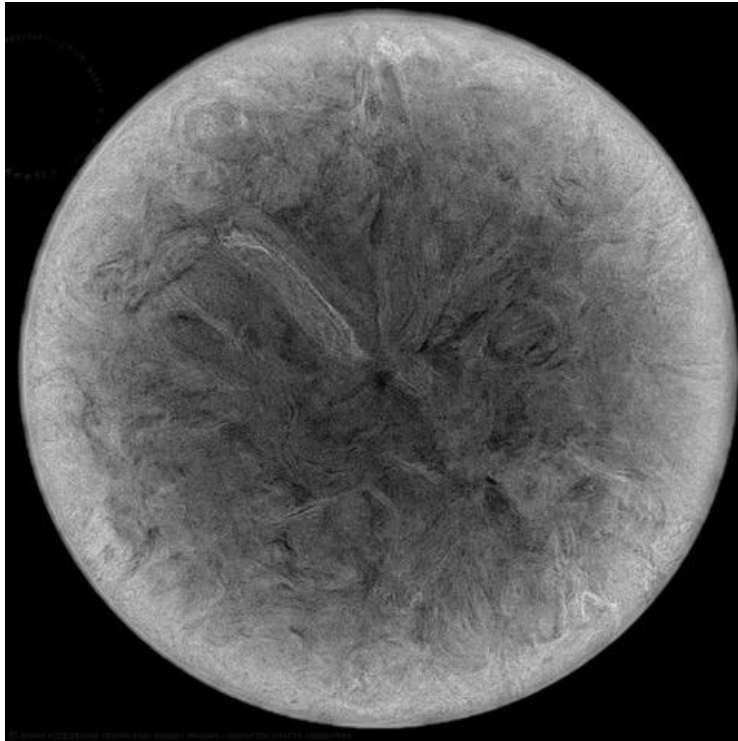
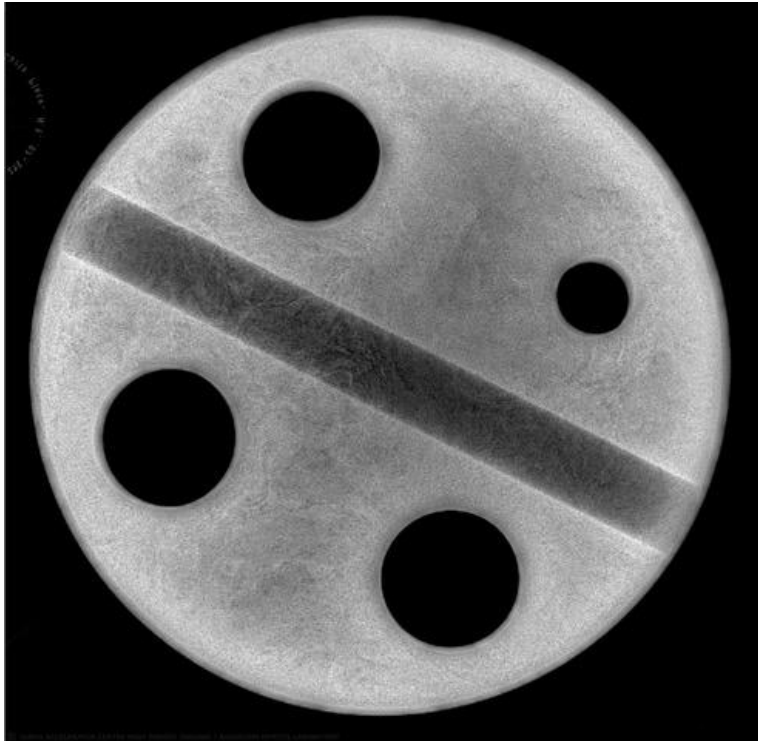




Idaho State
University

Discoveries

Each fuel disk and fuel rod was radiographed by Mike Smith at the Idaho Accelerator Center to examine the distribution of uranium within the plastic disks.



ROAR



Reassembly

- A leak in a shield tank pipe was repaired by replacing the corroded section.
- The shield water was flushed.
- Lifting hardware was installed in the lead shielding and graphite reflector.
- The reactor core was reassembled.
- The material loadings in the beam ports were standardized.
- Proportional counters and NIM equipment were configured for approach-to-critical.
- Reassembly completed on November 7th, 2025.





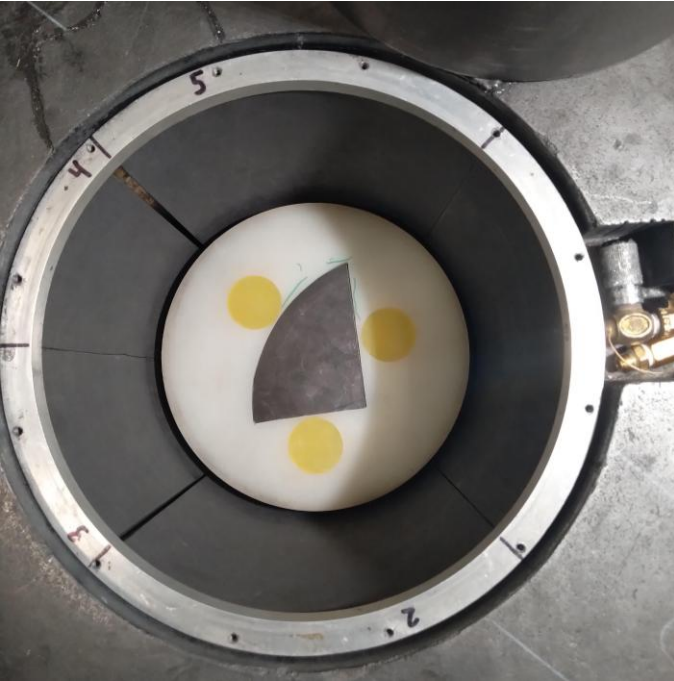
Approach-to-critical

- A partial fuel disk, sometimes called the “franken-disk”, is located on top of the core.
- It was believed that this reactivity-adding disk may no longer be necessary because a gap between the core halves had been closed upon reassembly.
- Disk was intentionally left out of core, and approach-to-critical was attempted on 11/07/25 but criticality could not be achieved.
- Franken-disk was placed back in the core and a successful approach-to-critical occurred on December 18th, 2025.
- UNM AGN-201 does not require this reactivity addition and maintains a higher excess reactivity.
- Reactor was returned to service where it will be used to train operators.



Idaho State
University

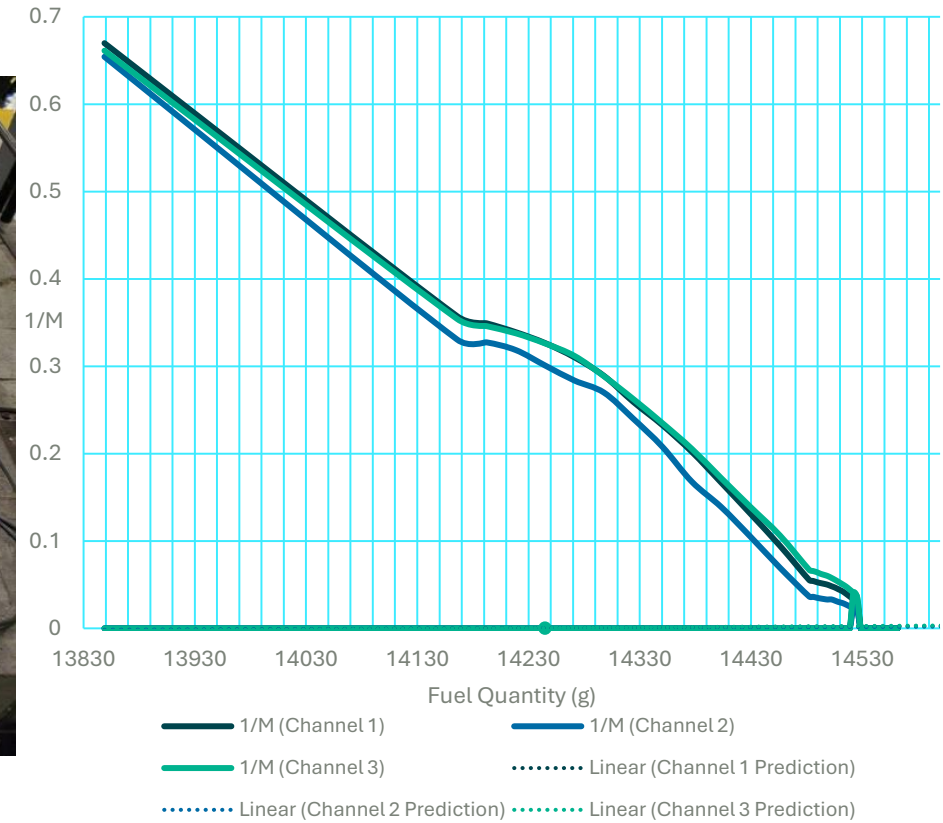
Approach-to-critical



Franken-disk



Approach-to-critical instrumentation

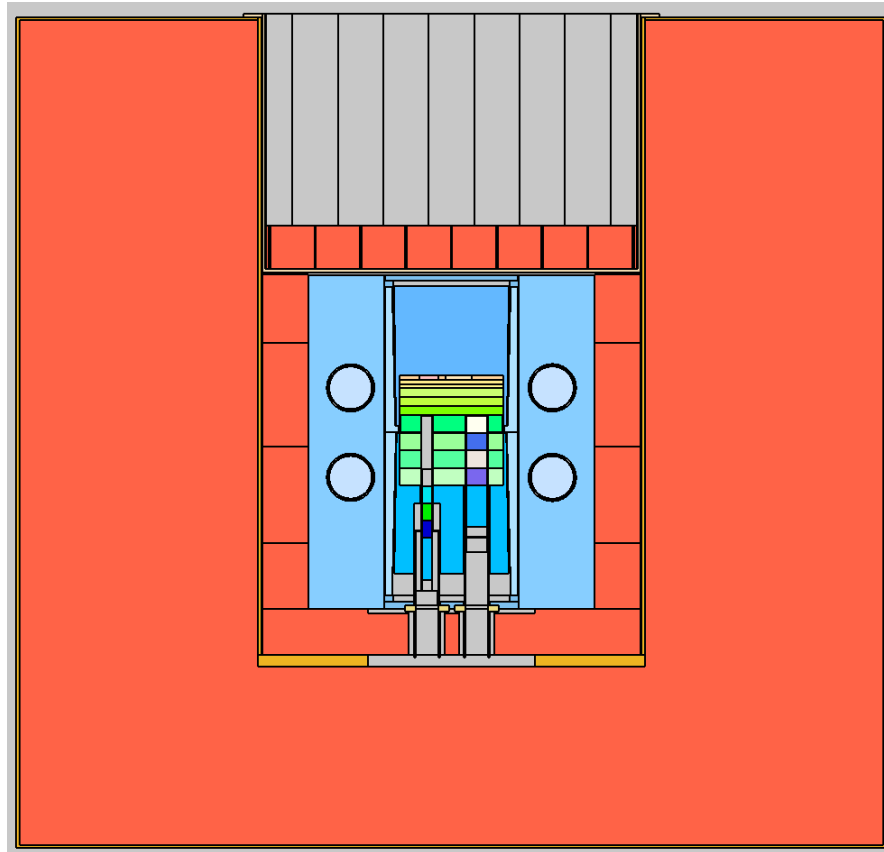




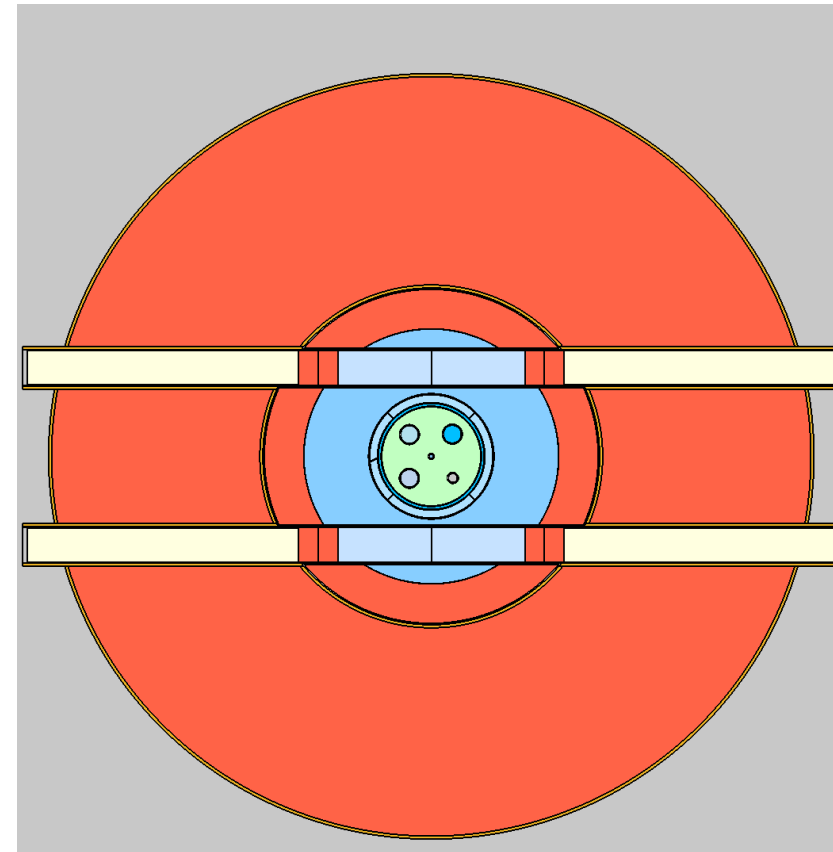
Idaho State
University

Detailed AGN-201 Model

SCALE 6.3 CSAS6 input is currently 1348 lines and 39 unique material compositions



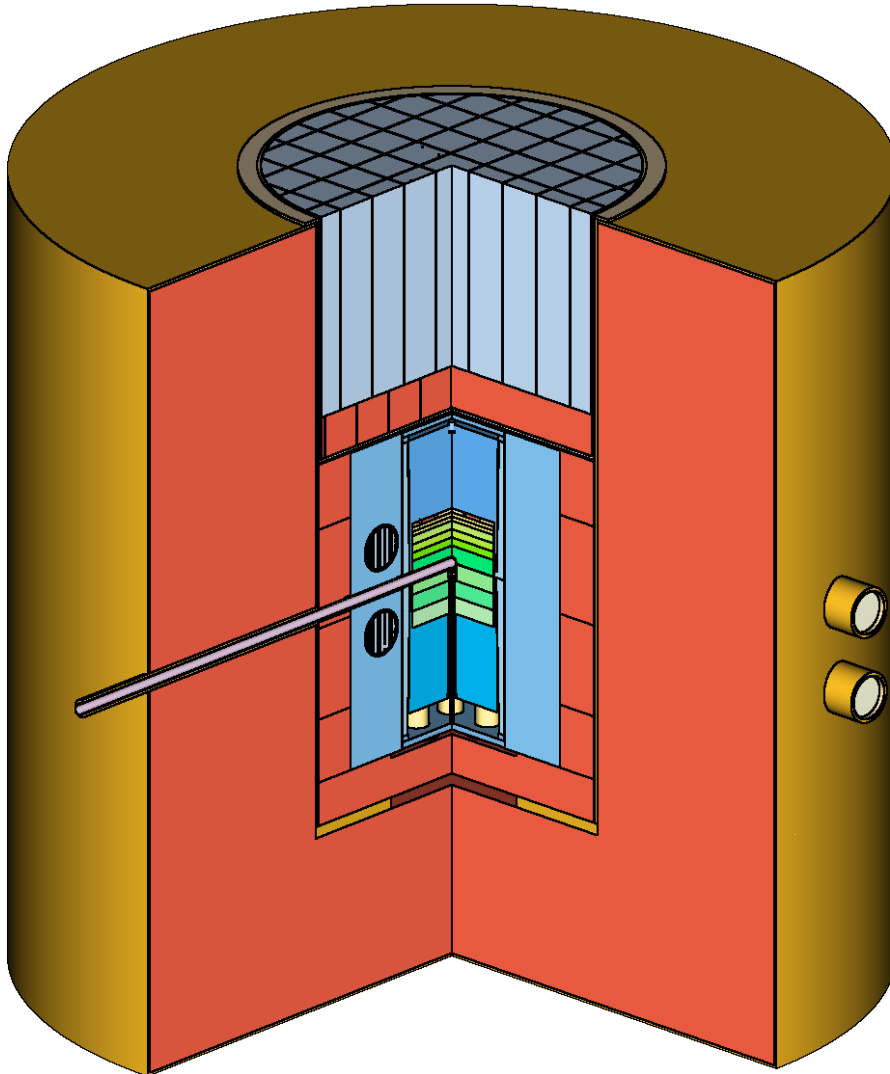
X-Z elevation view at midplane



X-Y plan view at midplane



3D View



- Model construction is still ongoing.
- Detailed MCNP model being constructed in parallel.
- Some additional measurements are required.



Uncertainty Quantification

- All measurements have uncertainties which must be incorporated into the benchmark models.
- Type A uncertainty is derived from taking repeated measurements of a component.
- Type B uncertainties are often derived from the measurement methods, such as calibrated instruments.
- Of great concern to the benchmark is the fuel enrichment and homogeneity. The actual value of fuel enrichment will vary from the value in the reactor technical specifications. And the distribution of fuel in the plastic may not be uniform.



Notable Updates

- Isotopic analysis conducted on fuel samples by Idaho National Laboratory's Analytical Laboratory, showing enrichments near 19.9% for all fuel components.
- Team is locating a laboratory that can conduct impurity analysis of graphite components.
- Critical rod height experiments were conducted August 24th-28th.
- These experiments were designed to investigate fuel homogeneity by rearranging the position of the 6 upper stack plates in the core. Data is still being processed from these experiments.