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IMPROVING THE NEUTRON FLUENCE RATE MONITOR MEASUREMENT SYSTEM AT THE ADVANCED TEST REACTOR

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- The existing fluence monitor wire scanning system (FMWS) at the Advanced Test Reactor (ATR) was installed in 1958.
- This system in the ATR canal is utilized after every reactor cycle by the ATR Radiation Measurements Laboratory (RML) to assess the activation of cobalt and nickel dosimeter wires during the cycle.
- A scoping study was performed to develop a base-line design to ensure that existing capabilities could be replaced with a new system.
- The proposed new hardware will enable automated measuring of several flux monitor holders without necessitating the removal of the flux wires.
- An electronically cooled High-Purity Germanium (HPGe) detector will be used along with a new collimator housing to provide high-resolution gamma-ray measurements.

A pre-conceptual design was developed at INL for a Submersible ATR Gamma Examination (SAGE) Scanner. The purpose of the SAGE scanner is to replace the existing flux wire monitoring scanning station so that higher resolution gamma-ray energy data can be obtained more quickly and with reduced personnel radiation exposure. One fundamental design constraint was the ability to measure both the activated Co/Al wire and the activated Ni wire simultaneously. This is made possible using a HPGe detector which can easily distinguish between the energies of the associated gamma-rays.

The SAGE scanner will include a receiver for a sample-holding magazine that is designed to accommodate scanning of all the existing FMWH designs. Furthermore, the design of the magazine will provide guidance to experimenters wishing to incorporate new FMWH designs. The magazine will hold multiple FMWHs, enabling the ability to automatically measure the activity from several holders in sequence; a dramatic improvement over the existing system that can only measure one wire at a time.

Another improvement over the existing system is the ability to calibrate the SAGE scanner with a model to determine specific activity directly instead of requiring a 2-step measurement (NaI + ionization chamber). The use of a calculated efficiency for will also enable the ability to expand to other reactor dosimeter reactions instead of being limited to only ^{60}Co and ^{58}Co as is presently the case. A wide range of activities can be accommodated by incorporating a vertical axis which can move the activated wire further from the collimator face if the activity is too high. However, the typical specific activity for activated wires is between 1E4 and 1E10 Bq/mg. Finally, the system will be capable of higher spatial resolution, down to 0.5-mm in the axial direction.

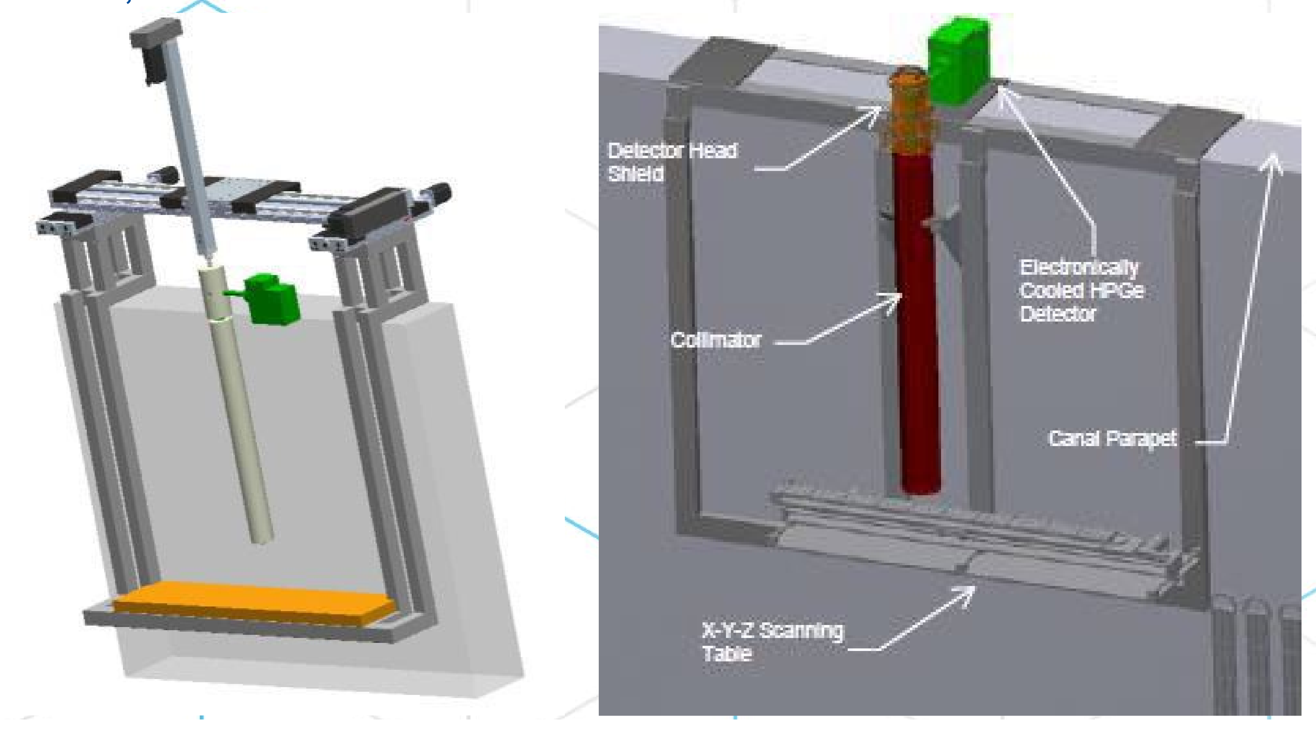

Figure 3. Two control systems are proposed for SAGE, one that moves the detector and collimator above the water (LEFT) and one that moves the sample table underwater (RIGHT)

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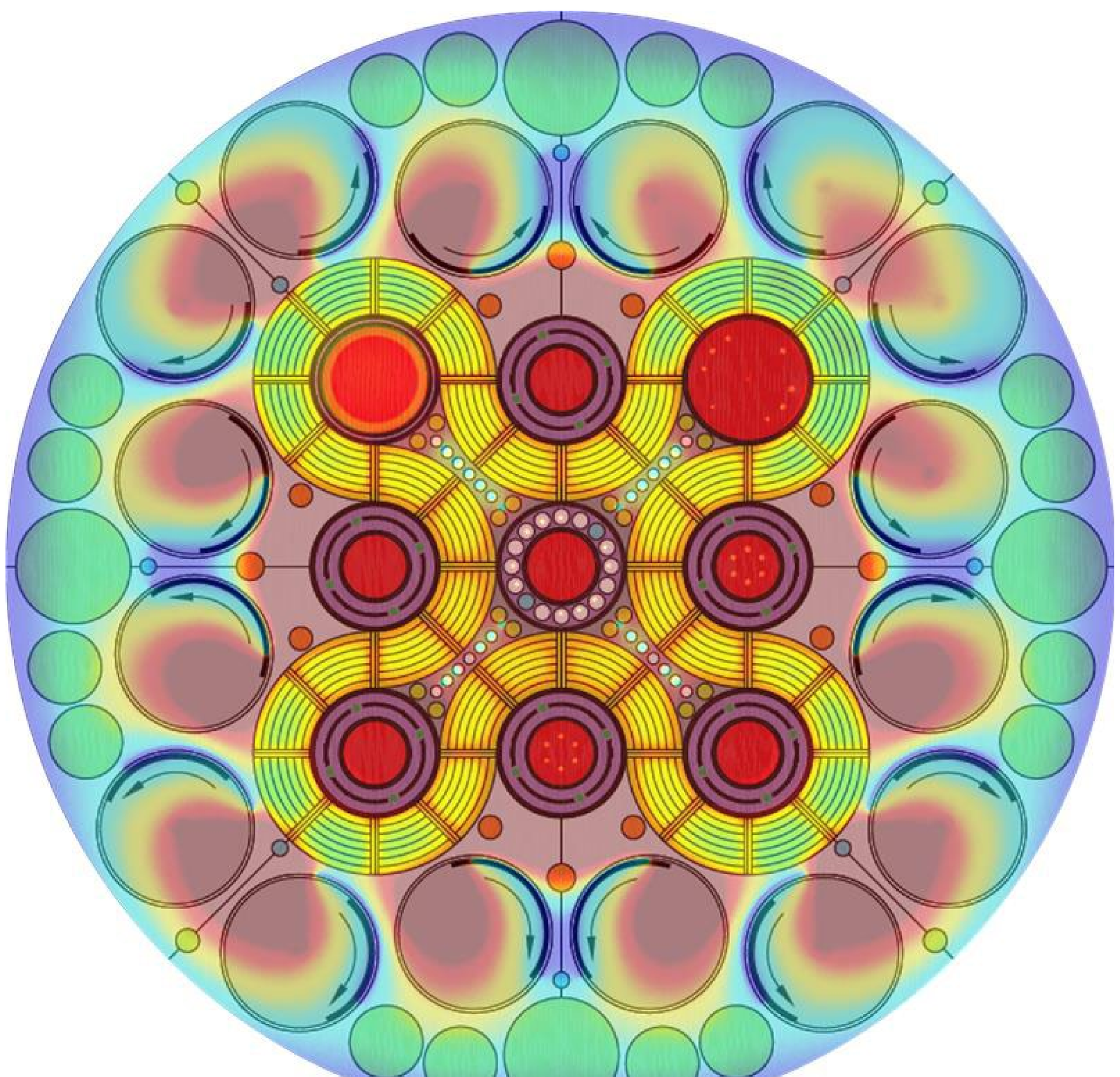

Figure 1. This heat-map of the neutron population in a typical ATR cycle illustrates the dramatic variations throughout the reactor and reflector due to the heterogeneous nature of the core (adapted from [1]).

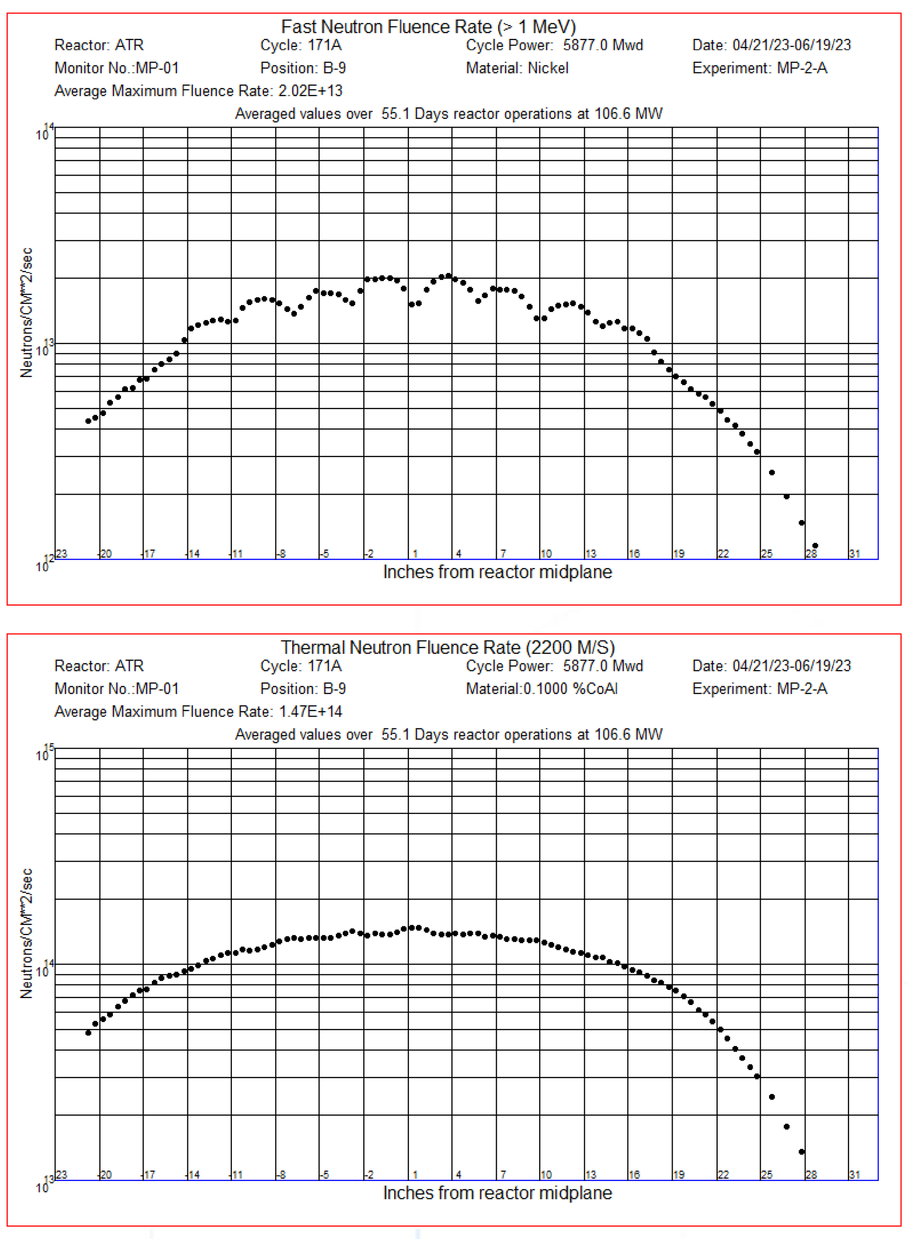

Figure 2. An example of the average fast and thermal neutron fluence rates measured by the existing FMWS system [6]. Cobalt and nickel dosimeter wires are activated according to ASTM standards E481 and E264 [2, 3]. SAGE must replace existing capacity and proposes to improve system resolution.

- The increasing risk of unrecoverable loss of data from a failure of the existing wire scanning system at ATR drove SAGE design.
- The conceptual design of the SAGE scanner has led to the development of two viable replacements for an aging FMWS system.
- Many advantages can be realized with the new system including:
  - Higher fidelity measurements,
  - Greater flexibility in material selection,
  - Higher resolution scanning,
  - Reduced operator dose, and,
  - Improved personnel efficiency.

[1] Idaho National Laboratory, "ATR Core Cross Section Diagrams, DWG-606000," 2013.
[2] ASTM Standard E481, "Standard Test Method for Measuring Neutron Fluence Rates by Radioactivation of Cobalt and Silver," 2016. [Online]. Available: https://www.astm.org/e0481-16.html.
[3] ASTM International Standard E264, "Standard Test Method for Measuring Fast-Neutron Reaction Rates by Radioactivation of Nickel," 2019. [Online]. Available: https://www.astm.org/e0264-19.html.
[4] M. B. E. D. N. Soppera, " JANIS 4: An Improved Version of the NEA Java-based Nuclear Data Information System," Nuclear Data Sheets, vol. 120, pp. 294-296, 2014.
[5] A. Trkov, P. Griffin, S. Simakov, L. Greenwood, K. Zolotarev, R. Capote, D. Aldama, V. Chechev, C. Destouches, A. Kahler, C. Konno, M. Kostal, M. Majerle, E. Malambu, M. Ohta, V. Pronyaev, V. Radulovic, S. Sato and M. Schulc, "IRDFF-II: A New Neutron Metrology Library," Special issue of Nuclear Data Sheets, vol. 163, pp. 1-108, 2019.
[6] B. Walker and M. Reichenberger, "Measured thermal and fast neutron fluence rates ATR Cycles 171A MP-2 Rev. 2 4/21/23 thru 6/19/23," Idaho National Laboratory, Idaho Falls, ID, 2024.