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Nuclear Requalification of the ATR Core

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Changing the World's Energy Future

Andrew Kelsey Prince

Idaho National Laboratory

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Idaho National Laboratory
Idaho Falls, Idaho 83415

http://www.inl.gov

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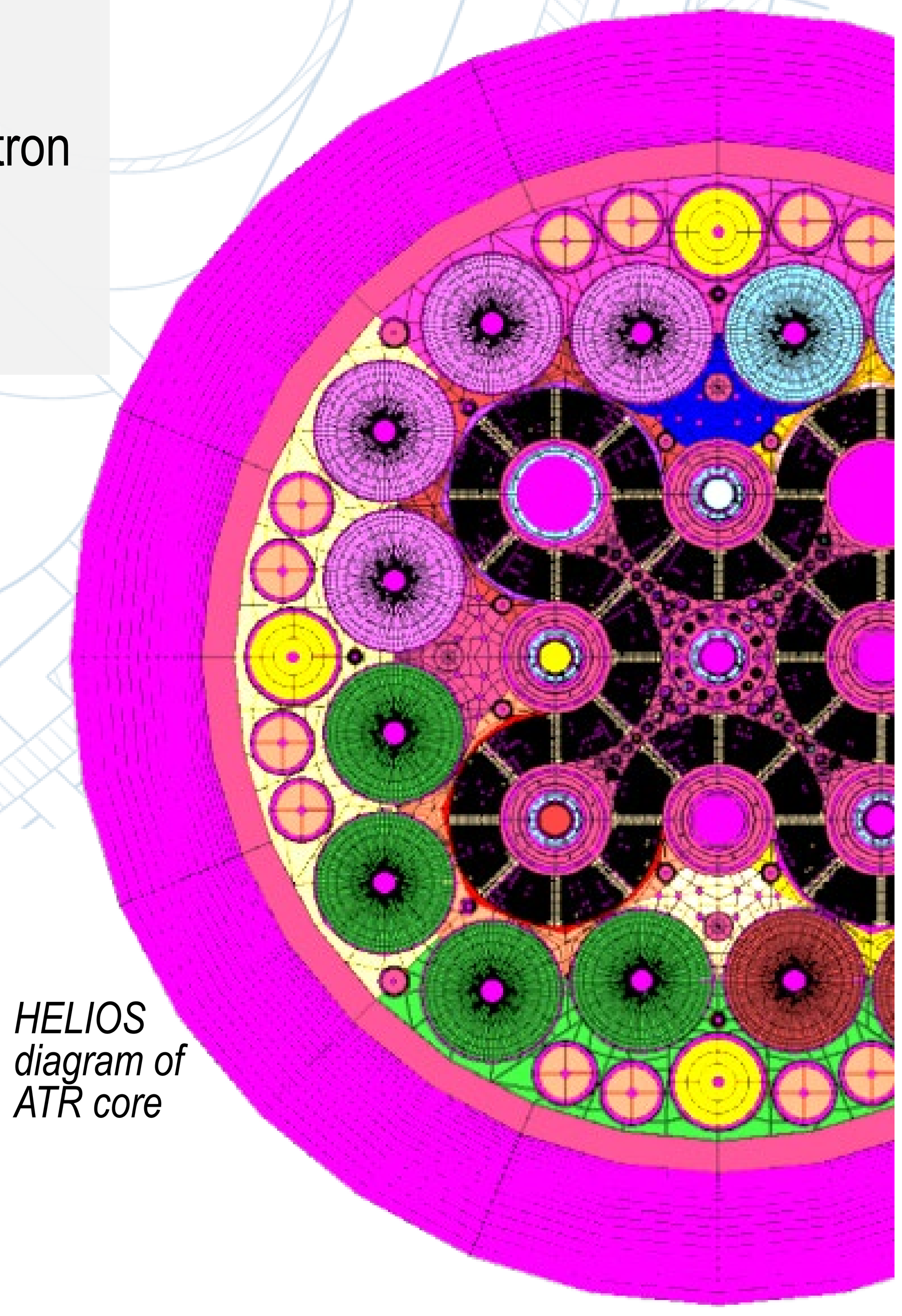
An Independent Review of Criticality Predictions for Core Internals Changeout VI Nuclear Testing

BACKGROUND

The Advanced Test Reactor (ATR) was designed with a clover-serpentine fuel arrangement to create a very high neutron flux that is utilized for materials and fuels testing. The high neutron flux causes neutron embrittlement to the beryllium reflector requiring it to be replaced during a reactor Outage. Concurrently, a piece-for-piece replacement of the core internals is performed to maintain reactor functionality. This is called a Core Internals Changeout (CIC).



HELIOS diagram of ATR core

NUCLEAR TESTING SIGNIFICANCE

Upon core replacement, nuclear instrumentation and monitoring systems must be recalibrated to the new unirradiated neutronic environment of the fresh core. Using previous data and modeling software, criticality analysis can be conducted for the new components of ATR's core. After testing the analysis for accuracy, it allows safety, power control, and scientific testing systems to be operated with confidence.

PREVIOUS CIC DATA

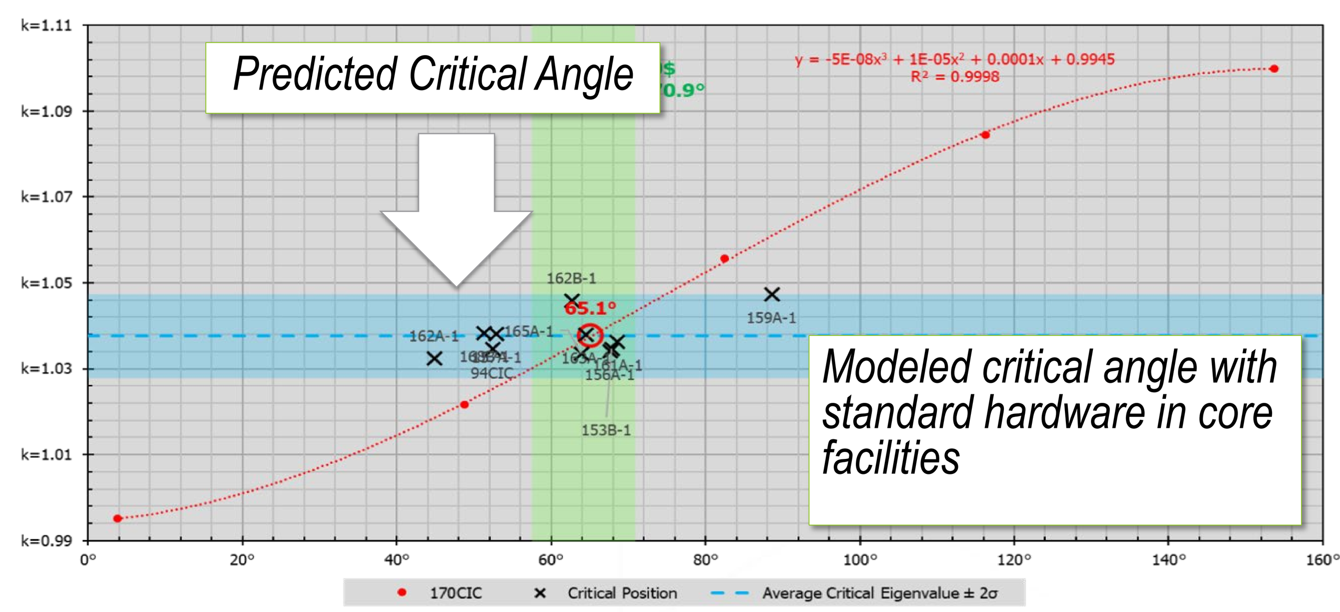
Previous CIC reports portray information in various manners and fashions. This makes data difficult to relate between years and information that may prove useful for the process may not have not been carried over to official reports.

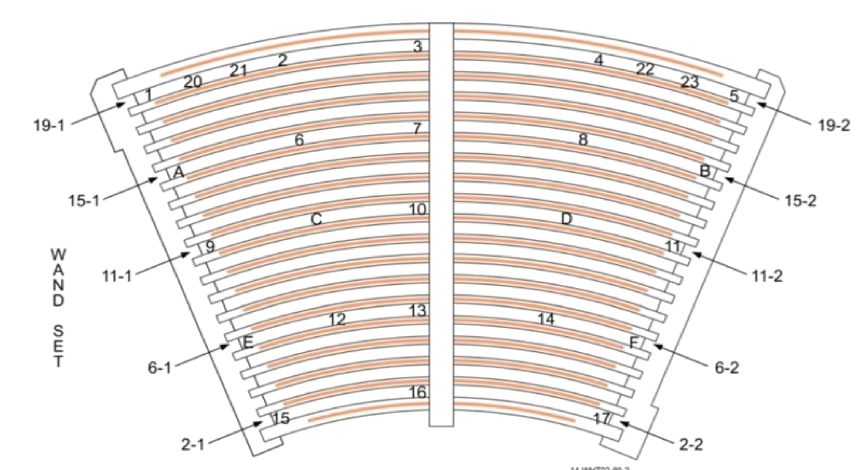
- Only one common software used, PDQ
- Inconsistent portrayal of similar data
- Diagrams not always labeled with units for represented data
- Important trends mentioned in text often with no visual

MODELING

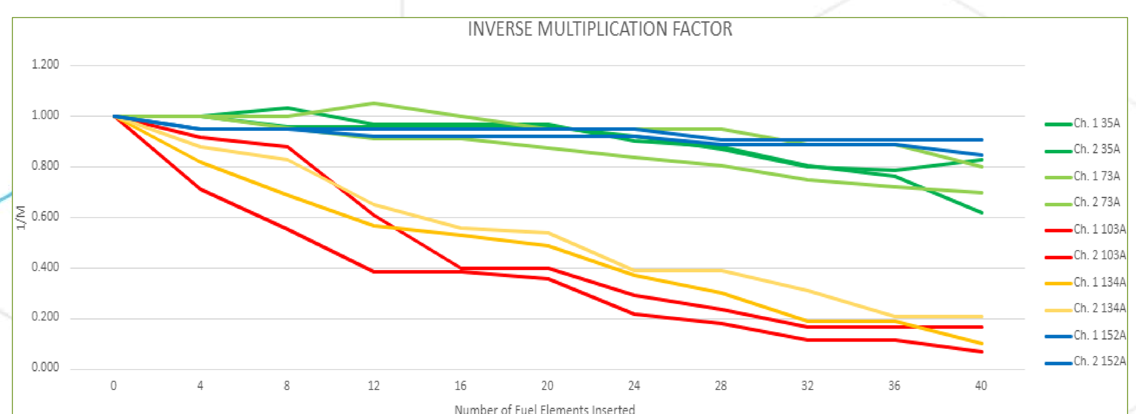
CIC VI will utilize several new Monte Carlo-based neutronics modeling software allowing for safe initial criticality predictions of ATR with its fresh core components.

- Predictive estimates for criticality allow for safe reactor start-up
- Comparison to previous core loadings and software results
- Multiple software results give clearer range of error





Flux wand insertion points on ATR fuel element



ATR inverse multiplication factor trend during CIC loadings with start-up source (lower) and no start-up source (upper)

TESTING

Once initial criticality is completed, further validation or correction of the modeled values is performed using various irradiation tests and comparisons to the ATR Critical Facility (ATRC). This is followed by calibration of nuclear instrumentation

Flux Wands / U-Al Fission Monitors

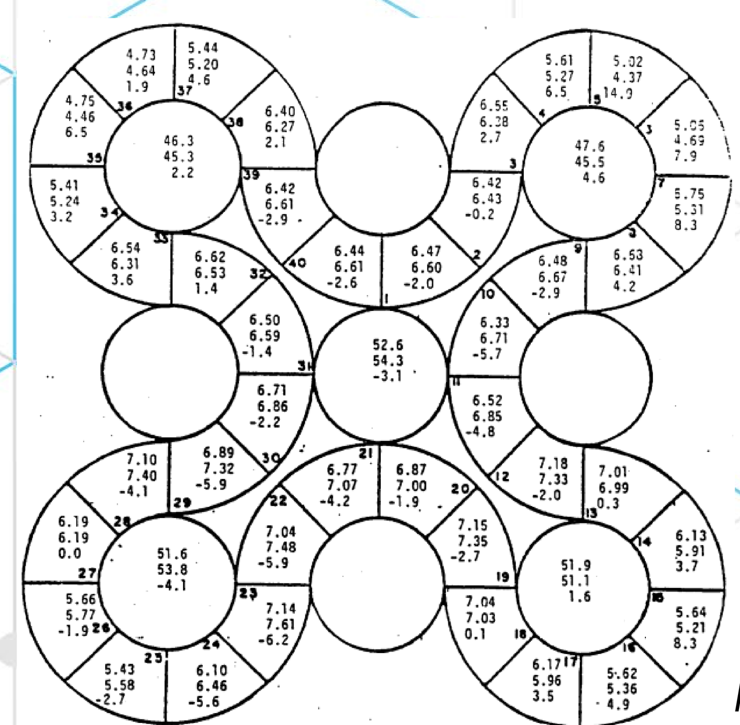
- Neutron activation of fission monitors to map flux and power data
- Standard mapping method for ATR and ATRC

ATRC

- ATR's sister core
- Mockup ATRC to compare ATR core measurements

Silver Wire / N-16 Testing

- Activation of silver wires for N-16 monitoring system calibration



1986 CIC core power scheme

Same kind of data

+

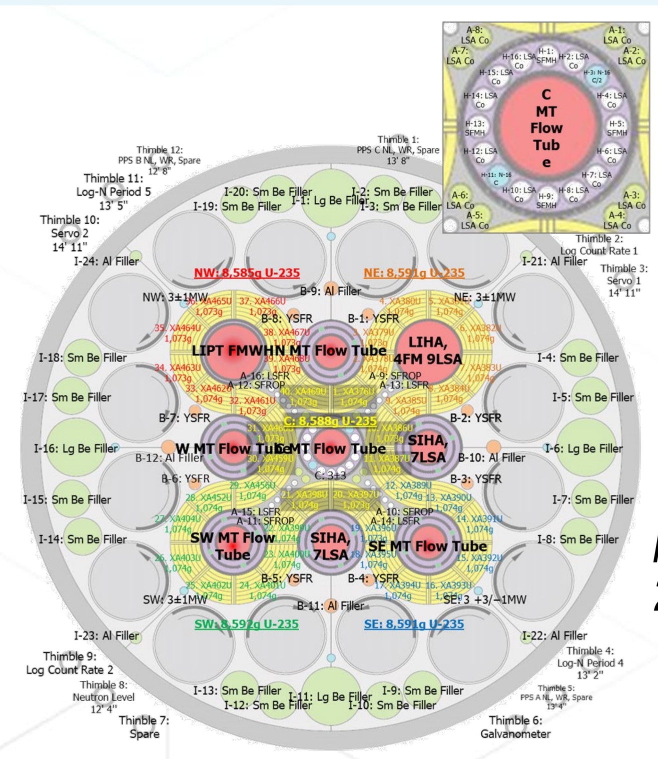
Inconsistent Layout

and 19 of all forty fuel element positions have been compared. All reported data are normalized to a core power of 250 watts. Note that the ATR measured

Table NT-3-1. Comparison of relative power divisions from ATR, ATRC, and PDQ

Data Source	NW LIPT Lobe (MW)	NE LIHA Lobe (MW)	C SIHA Lobe (MW)	SW SIPT Lobe (MW)	SE SIPT Lobe (MW)
ATR NT-3[a]	44.5	40.0	58.6	52.8	54.2
ATRC 94-3	44.7	41.4	57.3	54.3	52.2
PDQ	43.3	40.2	58.6	53.6	54.3

1994 CIC lobe power results



Modeled core layout for 2021 core power tests

CONCLUSIONS

- **CIC IV predictions follow closely with modeled values and currently documented trends**
- **Accurate prediction of reactor critical position provides strong safety margin for re-start of ATR**
- **Create a standard for CIC data reporting in official reports**

FUTURE WORK

- Conduct CIC VI requalification testing and safely bring ATR back to normal operation
- Index previous CIC data into standardized formats for ease of reference
- Update any trend data and present it visually

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