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ATRC MC21 Validation

SIPT & LIPT Experiments

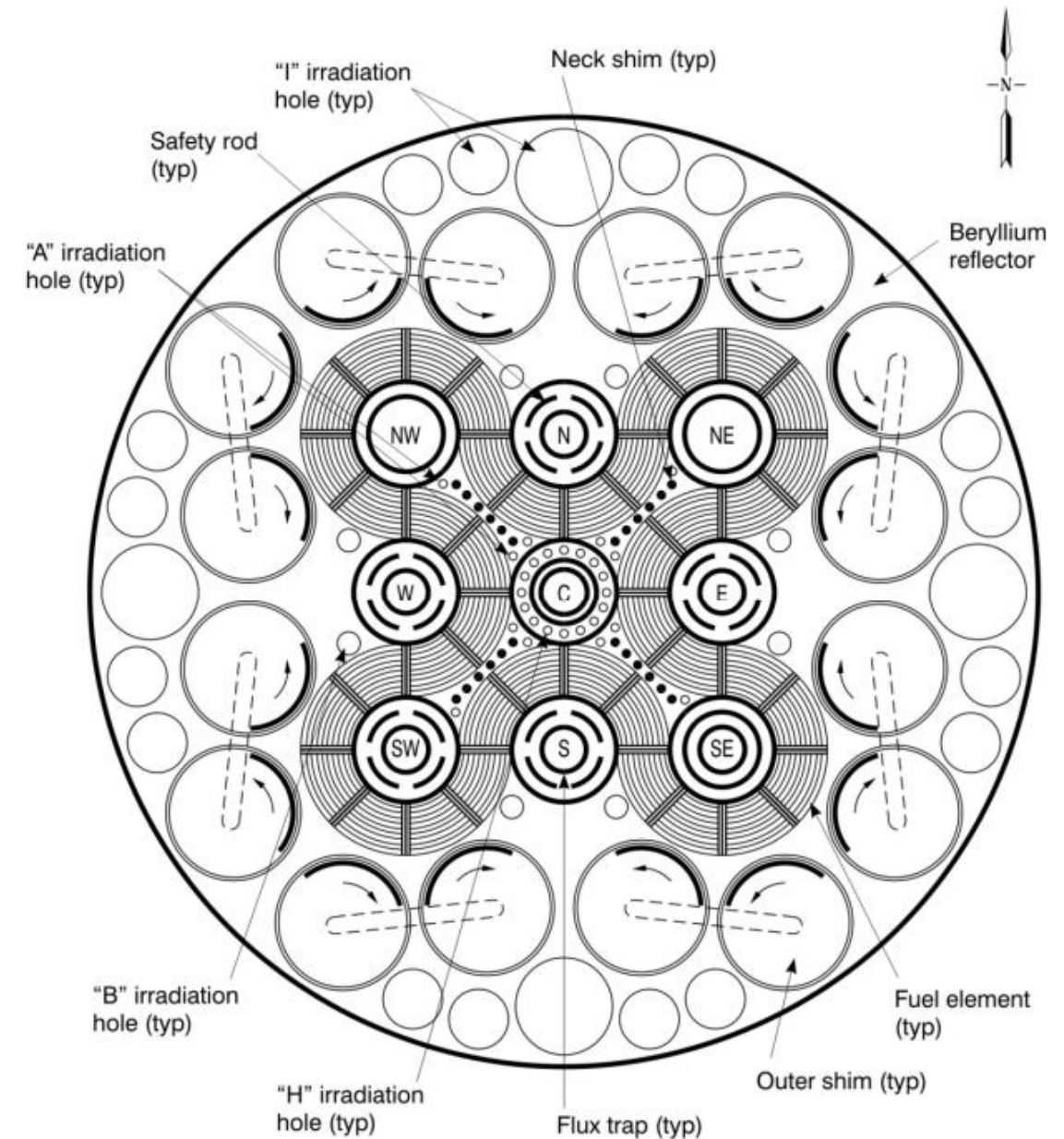
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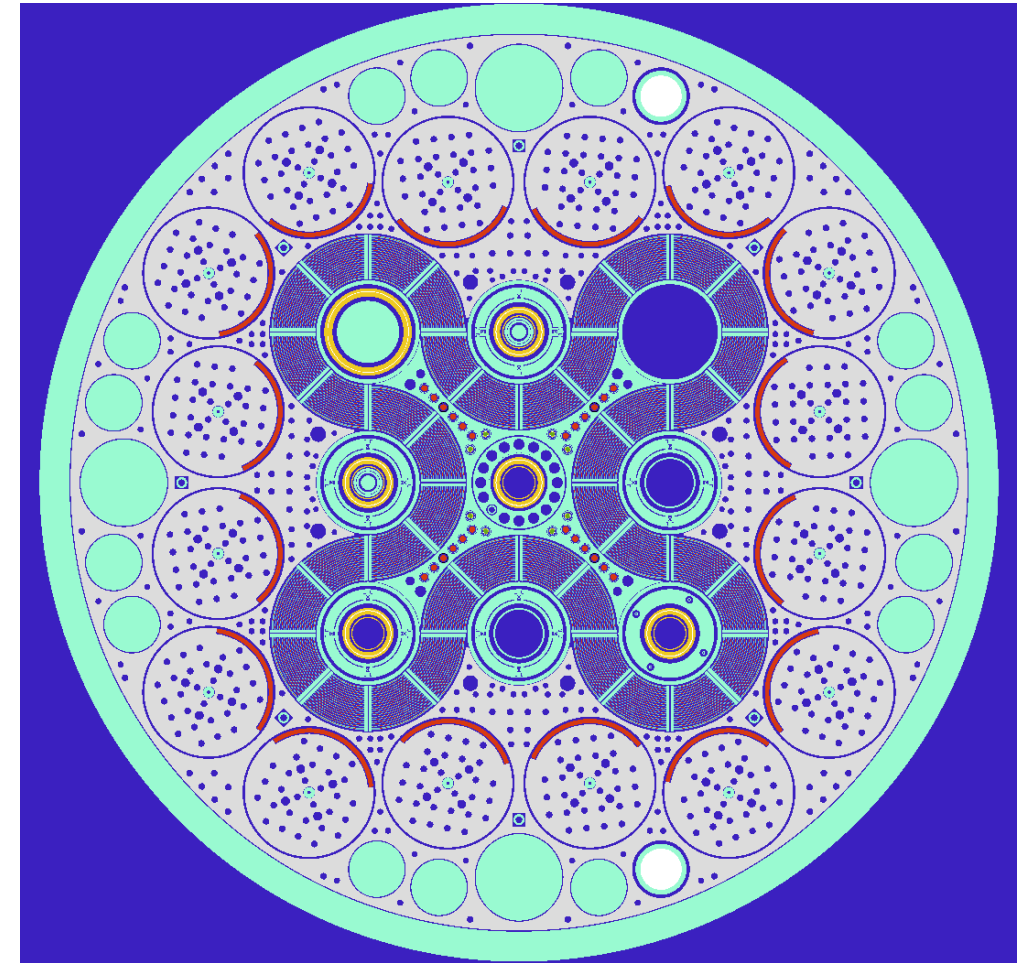
Overview – Advanced Test Reactor Critical (ATRC) Facility

- ATRC is a low-power (~600 W) nuclear mockup of the ATR
- Contains 40 fresh fuel elements that are beryllium reflected and water moderated
- ATRC provides a method of establishing an experiment's estimated reactivity and axial profile
- Measurements are often needed to ensure ATR safety requirements are protected
- ATRC is identical to ATR w/ exception of fuel loading, reactivity control poisons, and non-pressurized loops



Overview - ATRC Monte Carlo for the 21st Century (MC21) Model

- High-fidelity 3-dimensional MC21 model of the ATRC core
- Uses ENDF/B-VIII.0 cross section libraries
- Explicitly models all fuel elements, experiment positions, and reactivity control elements.
- Experiment Configurations:
 - Standard In-Pile Tubes (SIPTs) located in N, W, C, SW, and SE flux traps
 - Large In-Pile Tube (LIPT) located in NW flux trap
 - Irradiation housings in NE, E, and S flux traps
- Model structure allows for quick changes to flux trap configurations or fuel loading



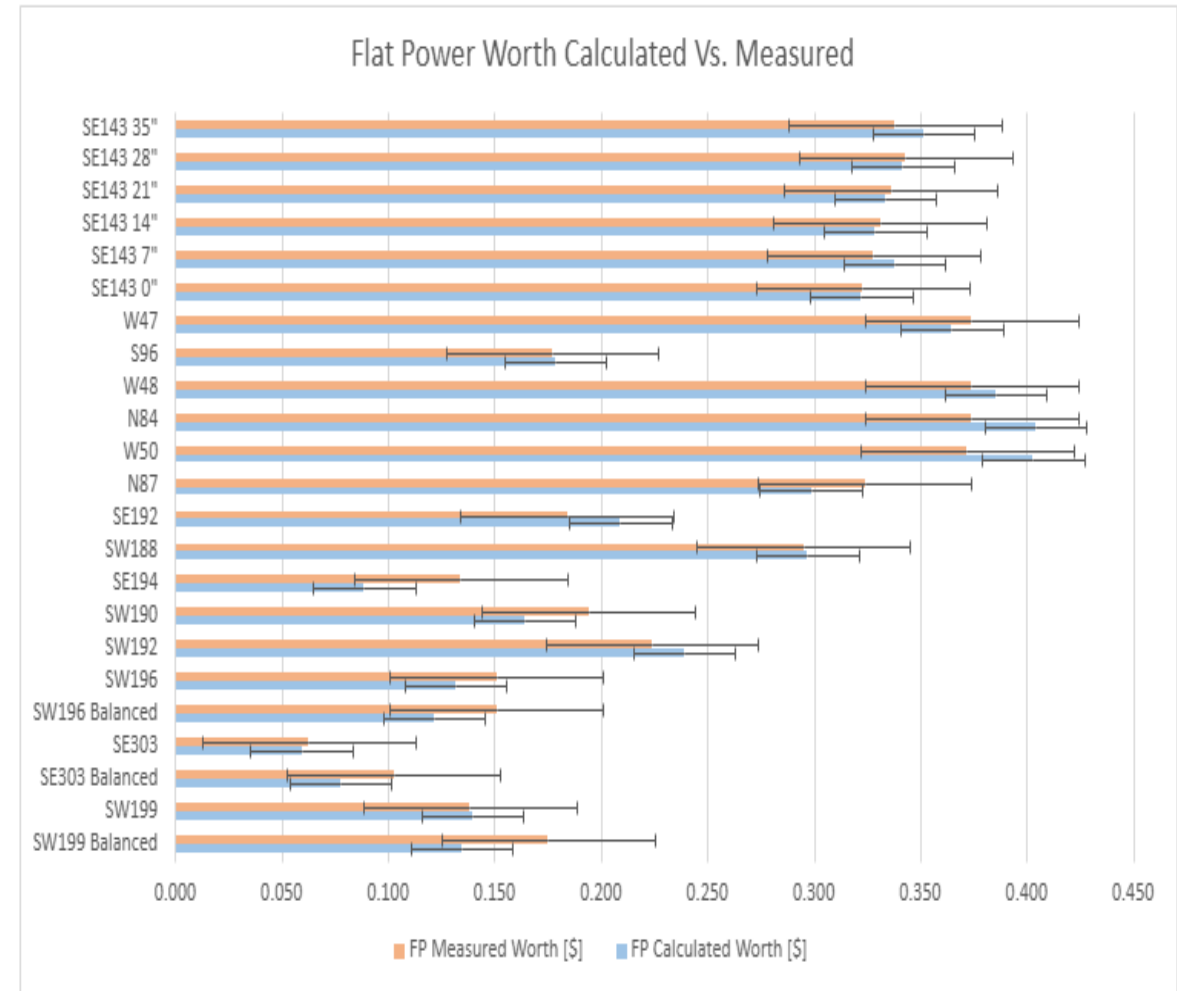
Midplane cross section of ATRC MC21 model

Experimental Measurement Method and Acceptance Criteria

- Experiment reactivities are measured following:
 1. A base/reference core is taken to critical and Outer Shim Control Cylinder (OSCC) positions are recorded
 2. Total core reactivity is estimated using previously measured shim worth curves
 3. Experiment is inserted and reactor taken to critical with the new OSCC positions recorded
 4. The reactivity difference between the core loadings is calculated
 5. The reactivity worth is then power-weighted based on core relative power relationships to be used for the ATR Core Safety Assurance Package (CSAP).
 - Measured uncertainty of $\pm 0.05\%$ is historically accepted
 - Calculated uncertainty is standard error (only considered eigenvalue uncertainty in this work)
- Both calculated and measured quantities have uncertainties; confidence in validation acceptance will be present in overlapping uncertainty intervals

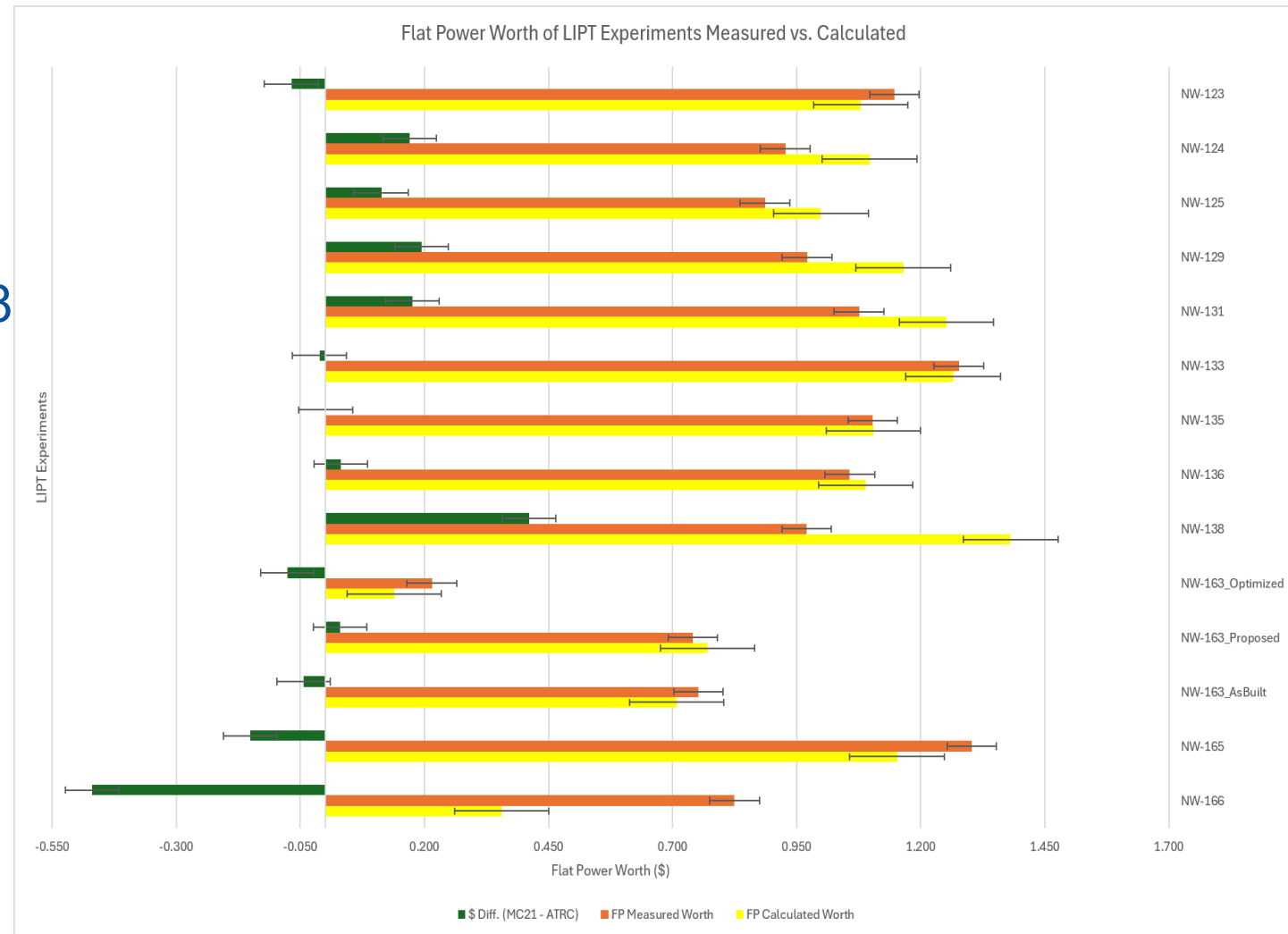
Validation – SIPT Reactivity Worth

- All the calculated experiment worths are within uncertainty overlap of measured values
 - Measured Uncertainty $\pm 0.05\$$
- Largest difference in SE-194 calculation overestimates by 0.045\$
- Even split between overpredicting and underpredicting measured values



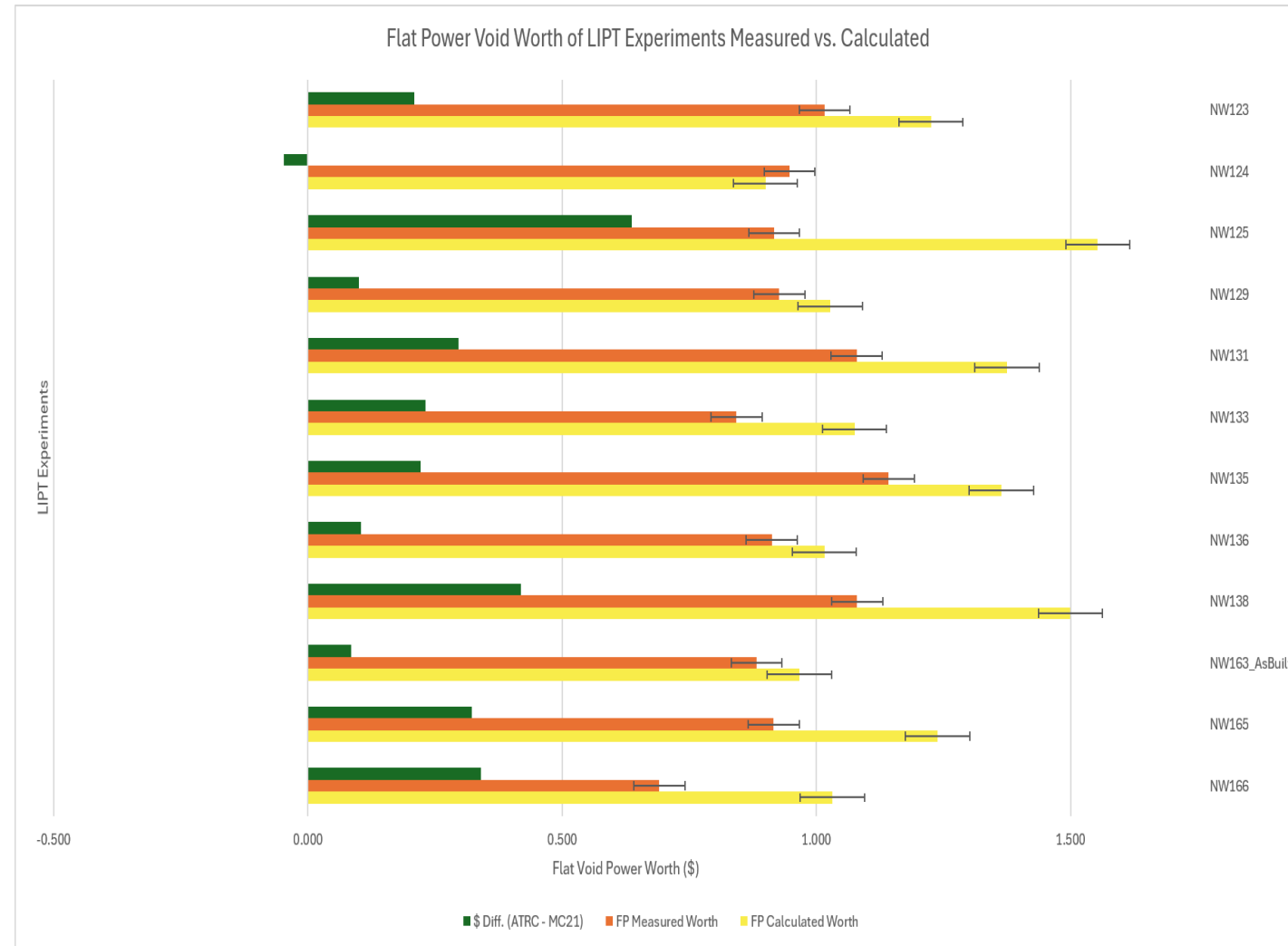
Validation – LIPT Reactivity Worth

- 8/14 models within uncertainty overlap
 - Measured uncertainty +/-0.05\$
- Largest error in NW-166 and NW-138 at -0.47\$ and +0.41\$ respectively
 - All other experiments below +/- 0.20\$
- Eigenvalues are not as reflective of differences in reactivity
- ATRC measurements for LIPT voiding are required as the legacy computational methods did not include LIPT voiding in analysis and relied on measured data



Validation – LIPT Void Reactivity Worth

- 4/12 models within uncertainty overlap
 - Measured uncertainty +/-0.05\$
- Largest error in NW-166 (+0.34\$), NW-165 (+0.32\$), NW-138 (+0.42\$), and NW-125 (+0.63\$)
 - All other experiments below +/- 0.30\$
- Eigenvalues are not as reflective of differences in reactivity
- Calculated values are almost entirely consistent in conservatively estimated void worth



Conclusions & Next Steps

- Differences likely due to method of measurement (not empirical) and how MC21 calculates reactivity
- Incorporate more experiment validation and axial fission profile analysis
- Incorporate flux runs in ATRC testing moving forward to capture flux distribution
- Open ATRC to Lab Directed Research Directives (LDRDs)

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