# IER-499: TEX-Cl Experimental Measurements

Chlorine Validation to Support NNSA Operations

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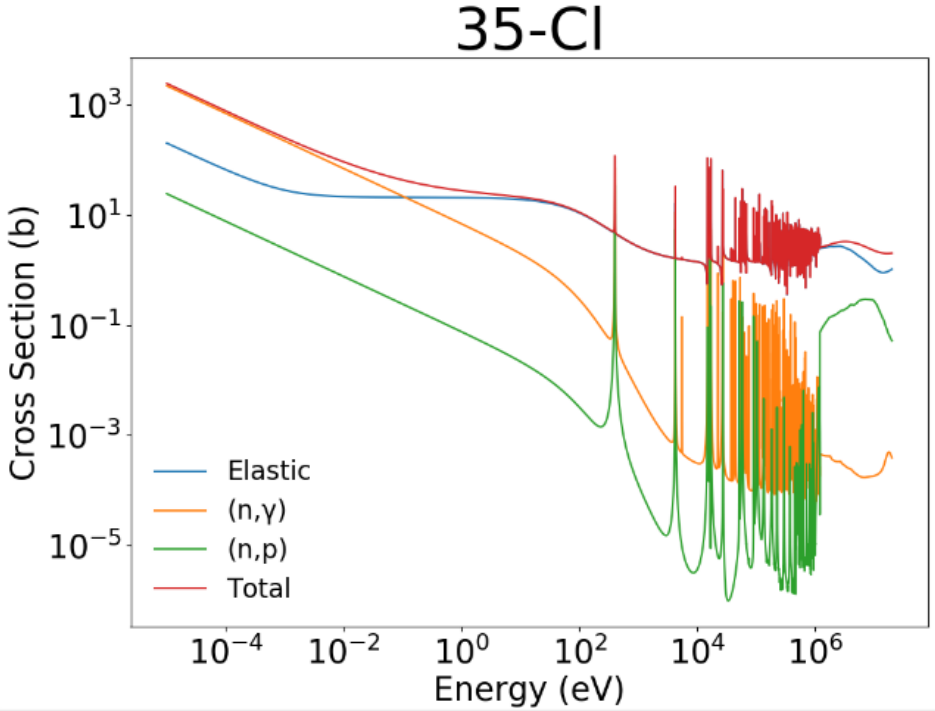
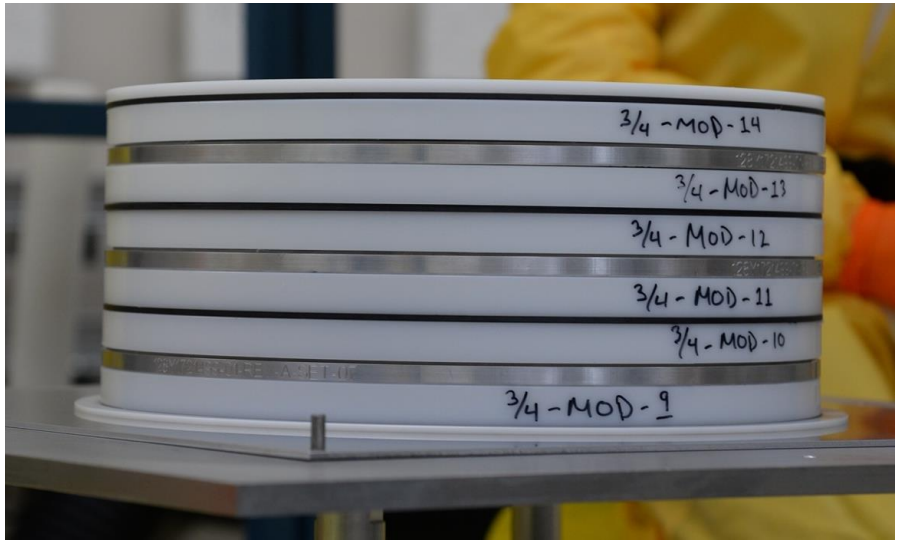
# Need for Chlorine Experiments

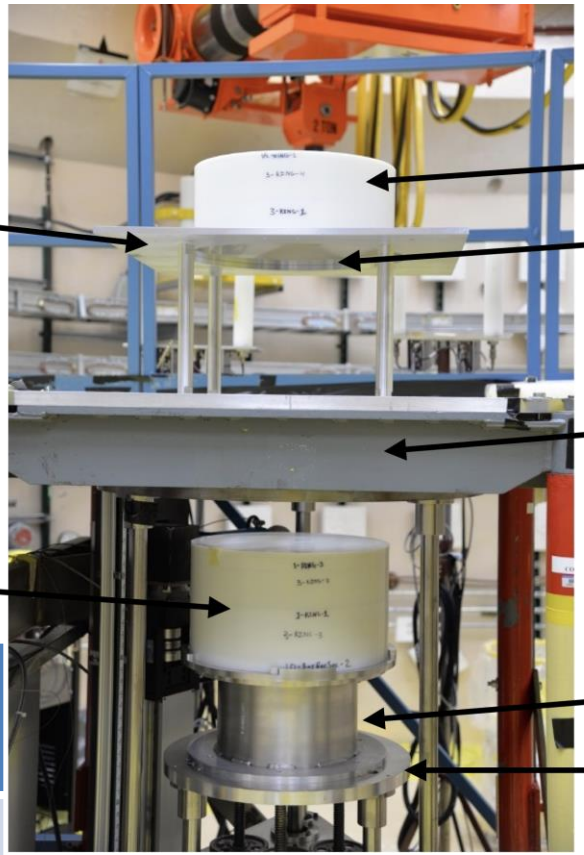
- What are the needs for a chlorine benchmark?
  - Y-12 electrorefining operations which credit $^{35}Cl$ as a neutron absorber
  - Idaho National Lab / Terrapower for Molten Chlorine Reactor Experiments (MCRE) fuel fabrication
  - Los Alamos National Laboratory for their aqueous plutonium chloride systems
  - $^{35}Cl(n,p)$ for nuclear data needs
    - The cross section is believed to have a significant uncertainty
    - Interest has been expressed by both domestic and international entities
  - IRSN and SRNS, amongst others, have also expressed interest in this benchmark



# TEX-Cl Configurations

- Three configurations have been executed

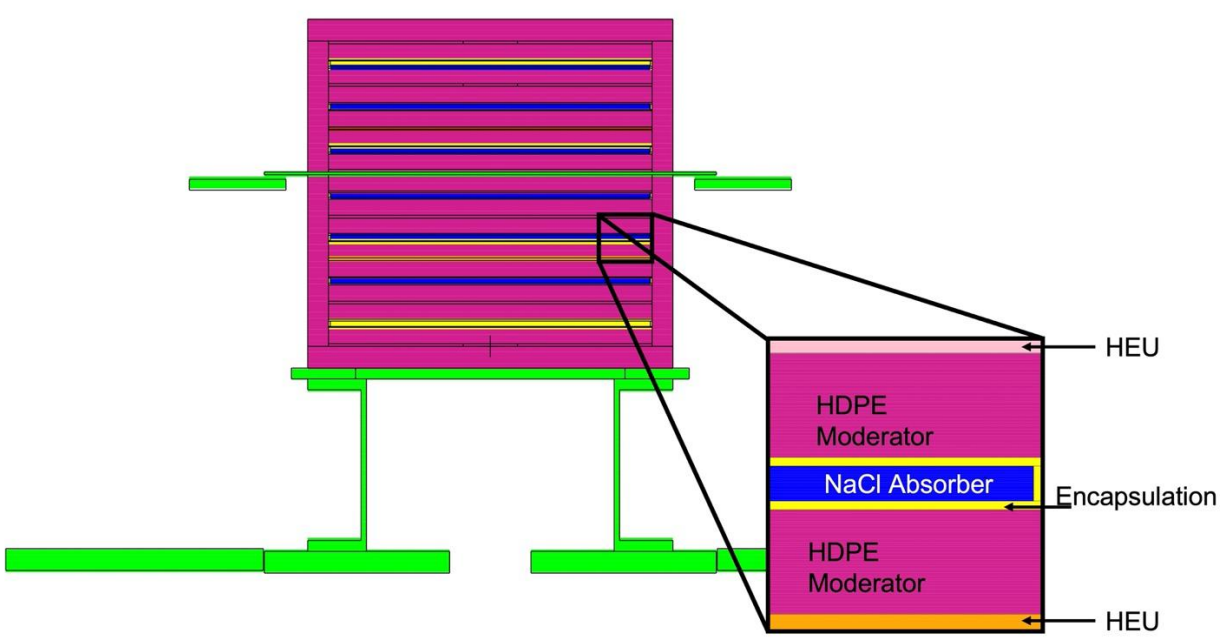


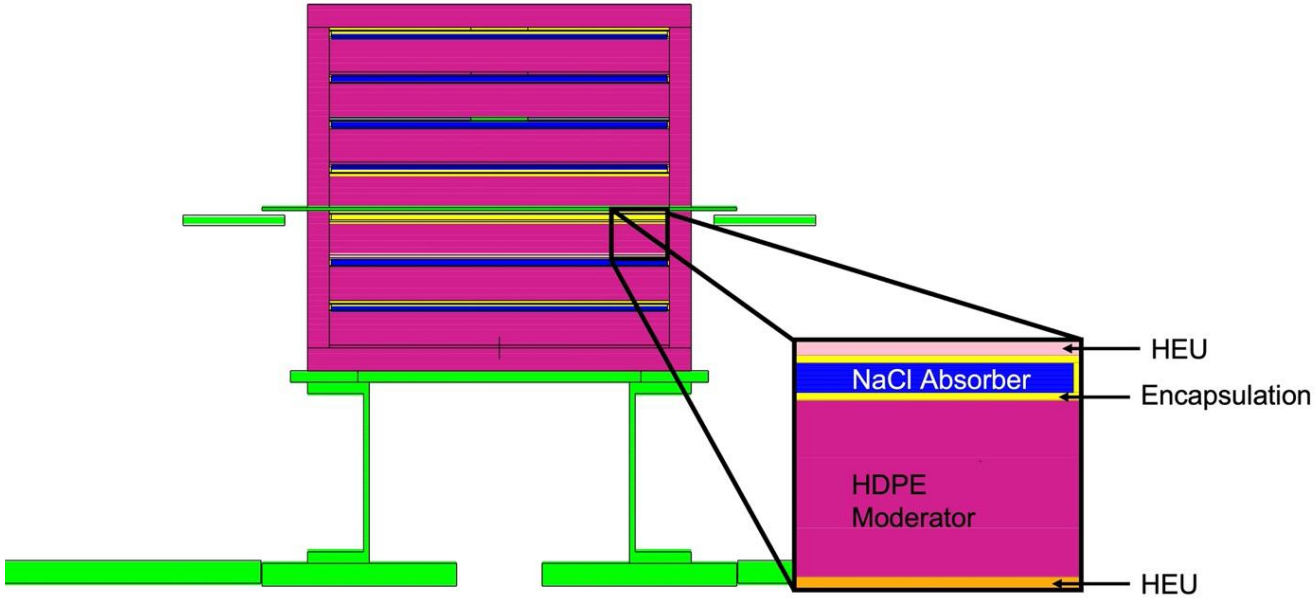




| Configuration | Thermal Fission Fraction (%) | Intermediate Fission Fraction (%) | Fast Fission Fraction (%) |
|---|---|---|---|
| 8-Layer Sandwich | 58.1 | 30.2 | 11.8 |
| 8-Layer Standard | 62.9 | 25.5 | 11.6 |
| 18-Layer Standard | 13.7 | 51.8 | 34.6 |

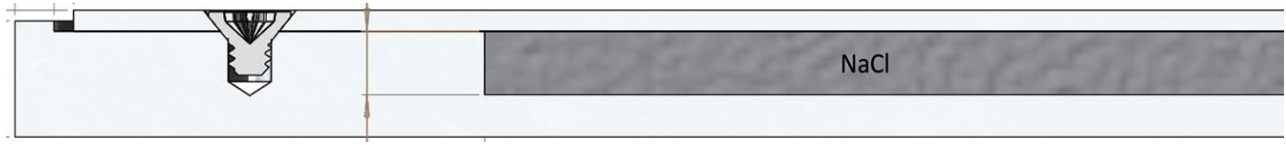
# Configurations

- Two types of configurations: Sandwich (left) and Standard (right)

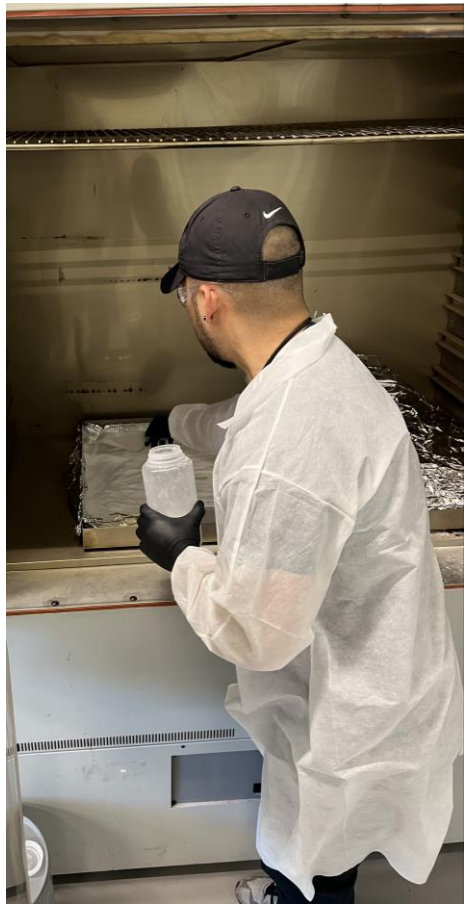


# Chlorine Absorber Design - Filling



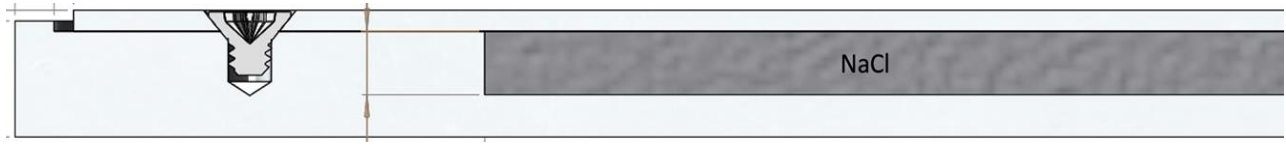

Salt (≥99.5% pure lab grade sodium chloride) was dried in an oven over night



Salt was poured into the aluminum encapsulation

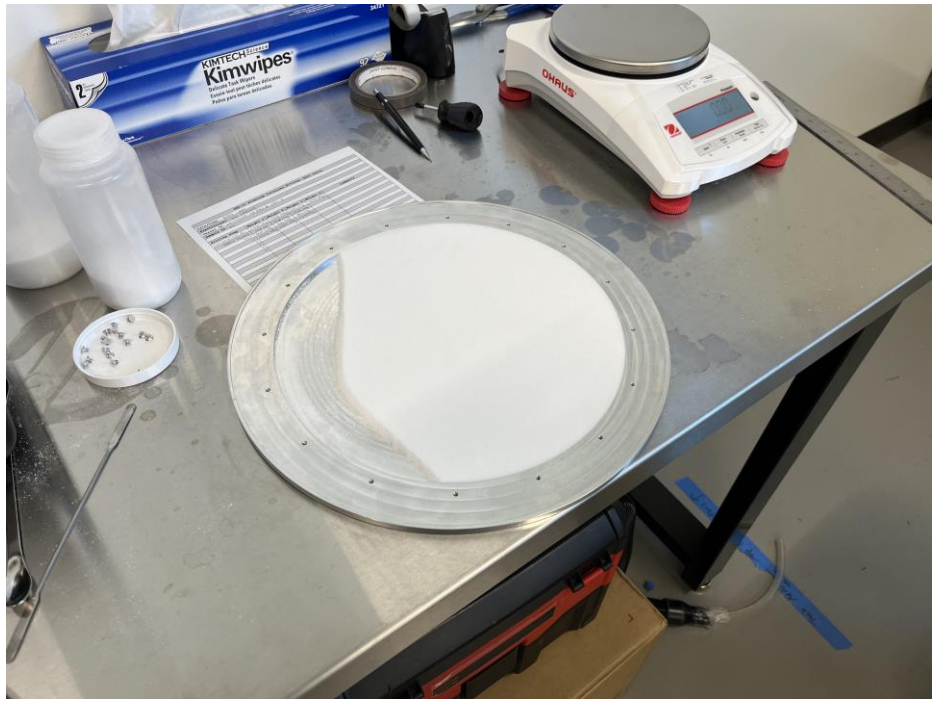

The interfaces were cleaned before the lid was installed

# Chlorine Absorber Design - Filling



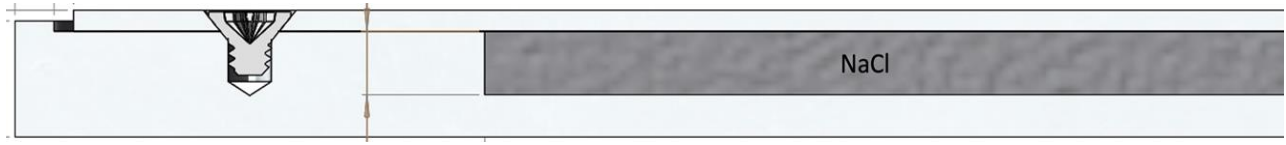

Salt was vibro-packed on its side

A void formed on the ‘top’ of the plate



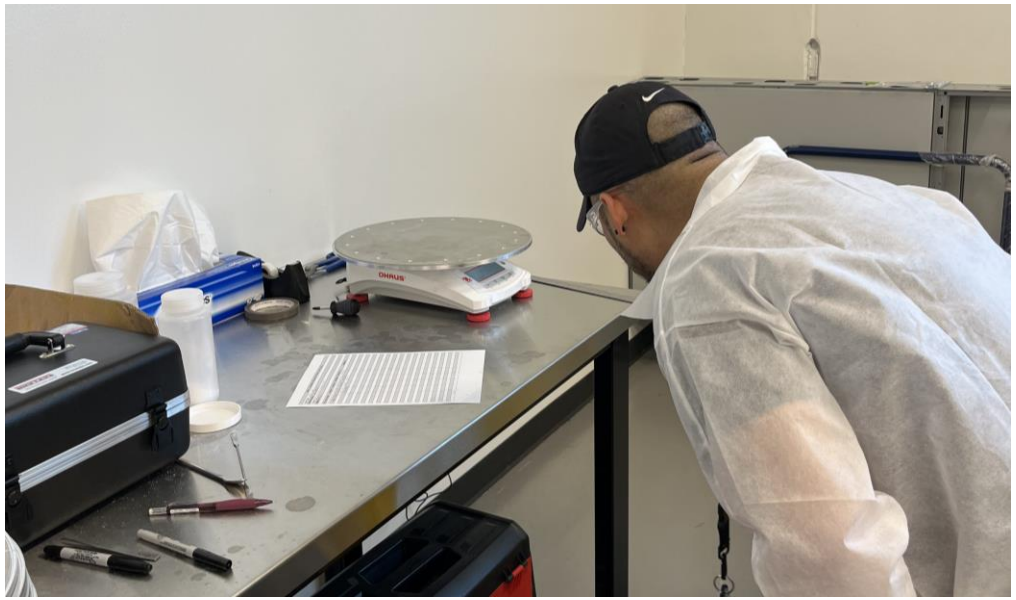

The void was filled and the process started over again

# Chlorine Absorber Design - Filling

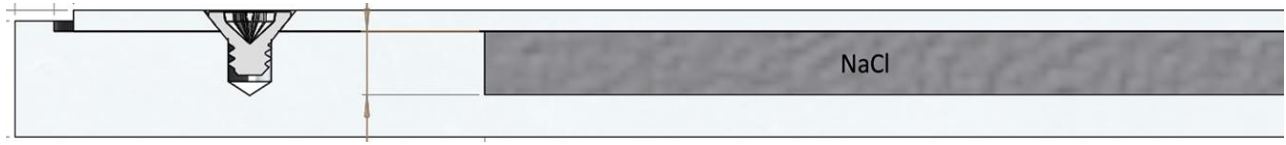



Salt was vibro-packed on its side

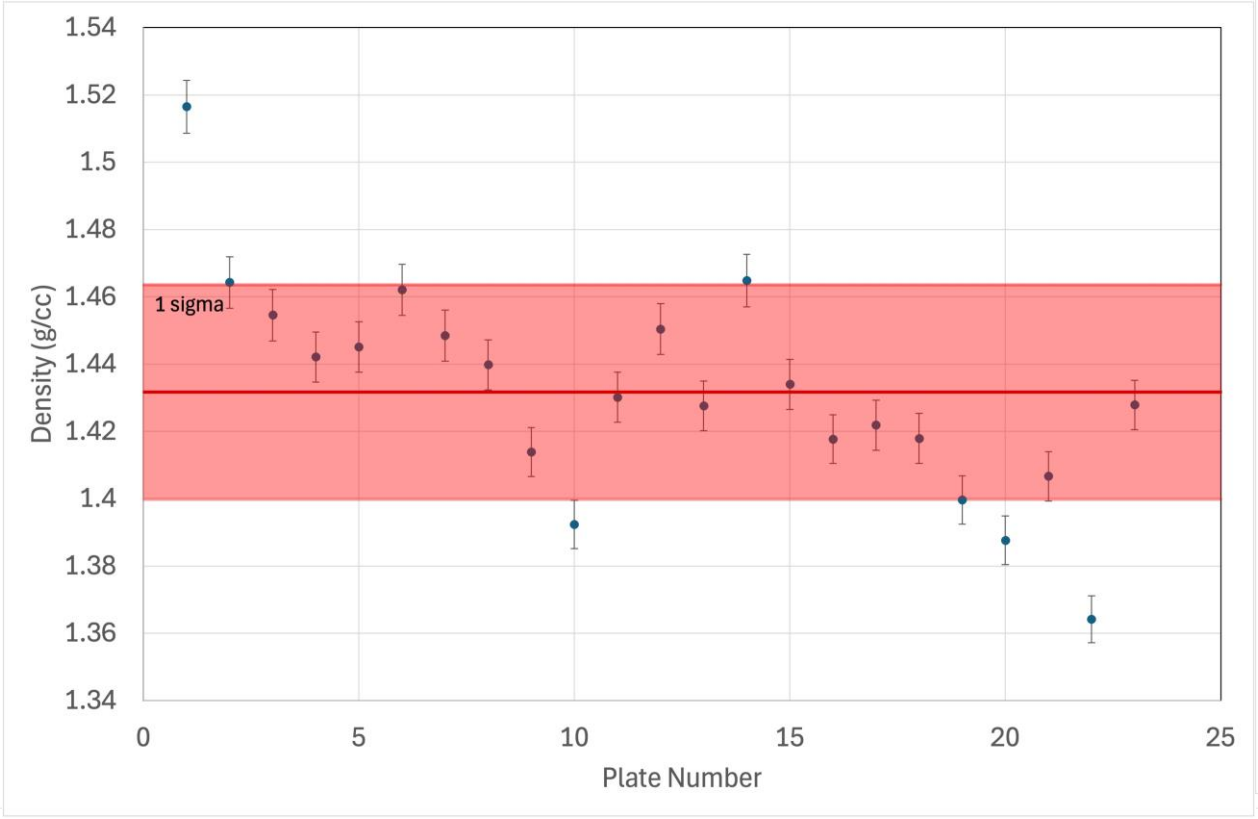
- The filling procedure was modified to be more efficient
  - A thicker lid, used only for filling, was fabricated with a hole at the top
  - The hole allowed a funnel to be placed, so that salt could be added without having to remove the lid
  - This increased filling efficiency tremendously

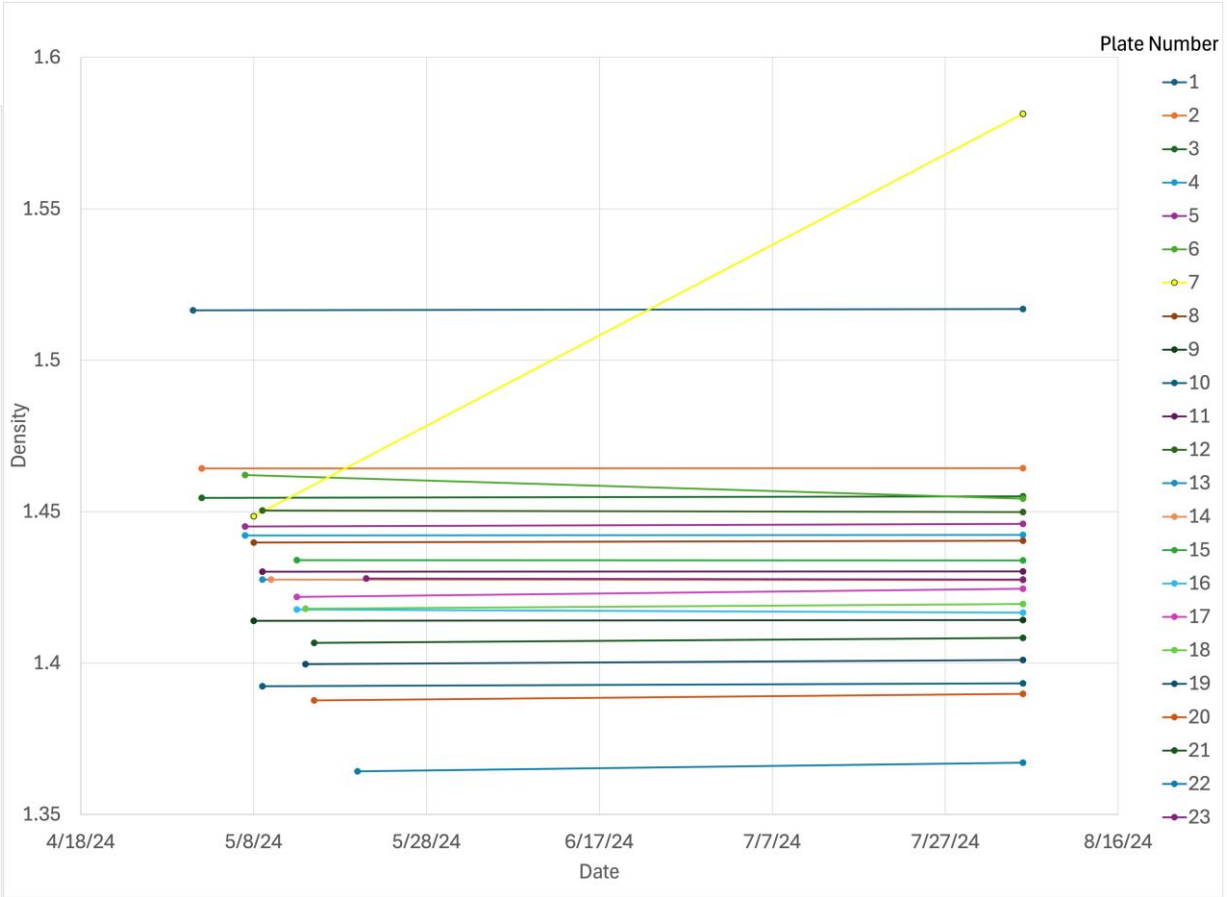


# Chlorine Absorber Design - 3/16”

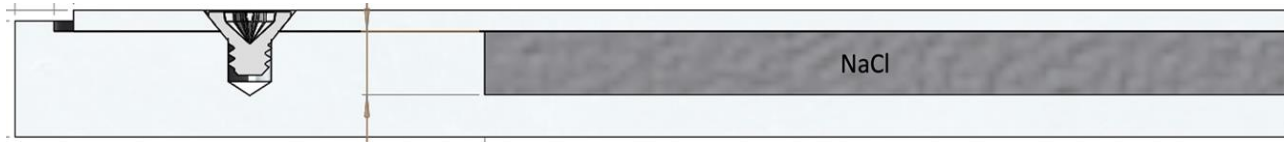



- Absorber plates were weighed at fill, before shipment to NCERC, and after experiment
- Anomalous plates were not used



# Chlorine Absorber Design – 1/4”

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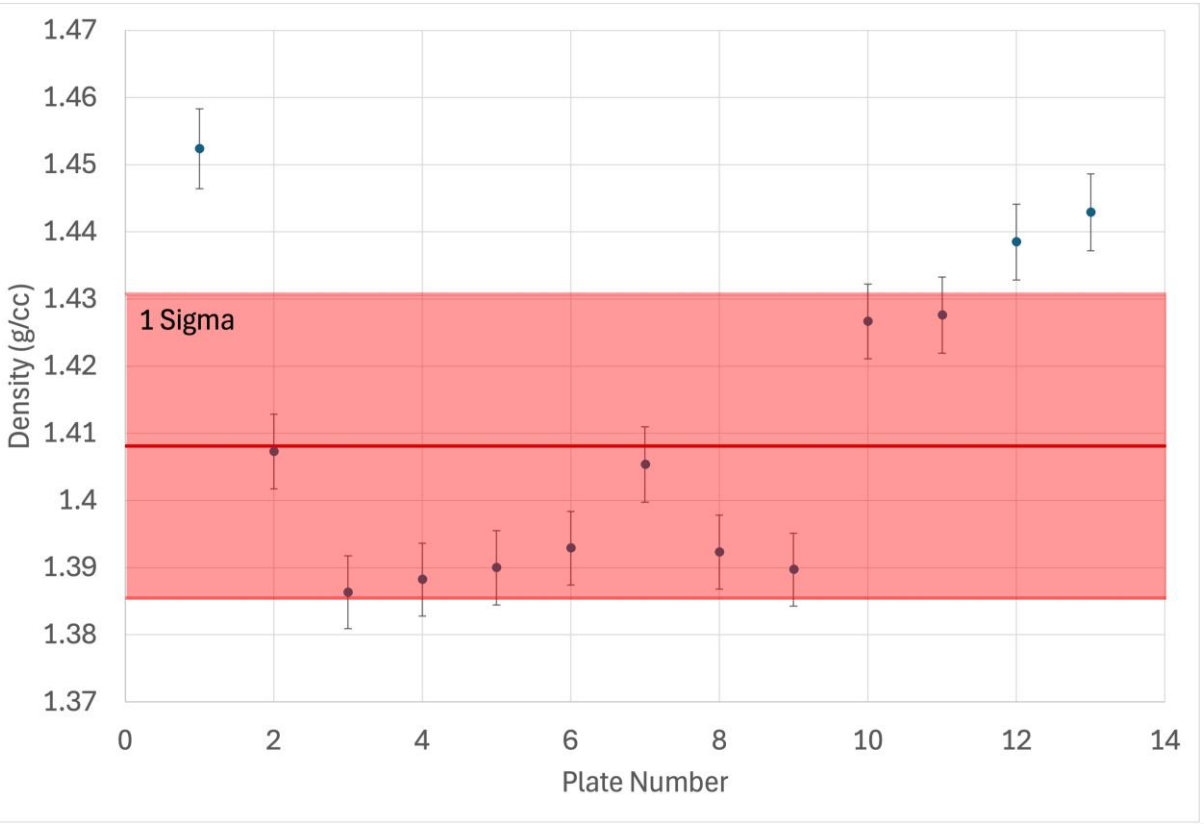


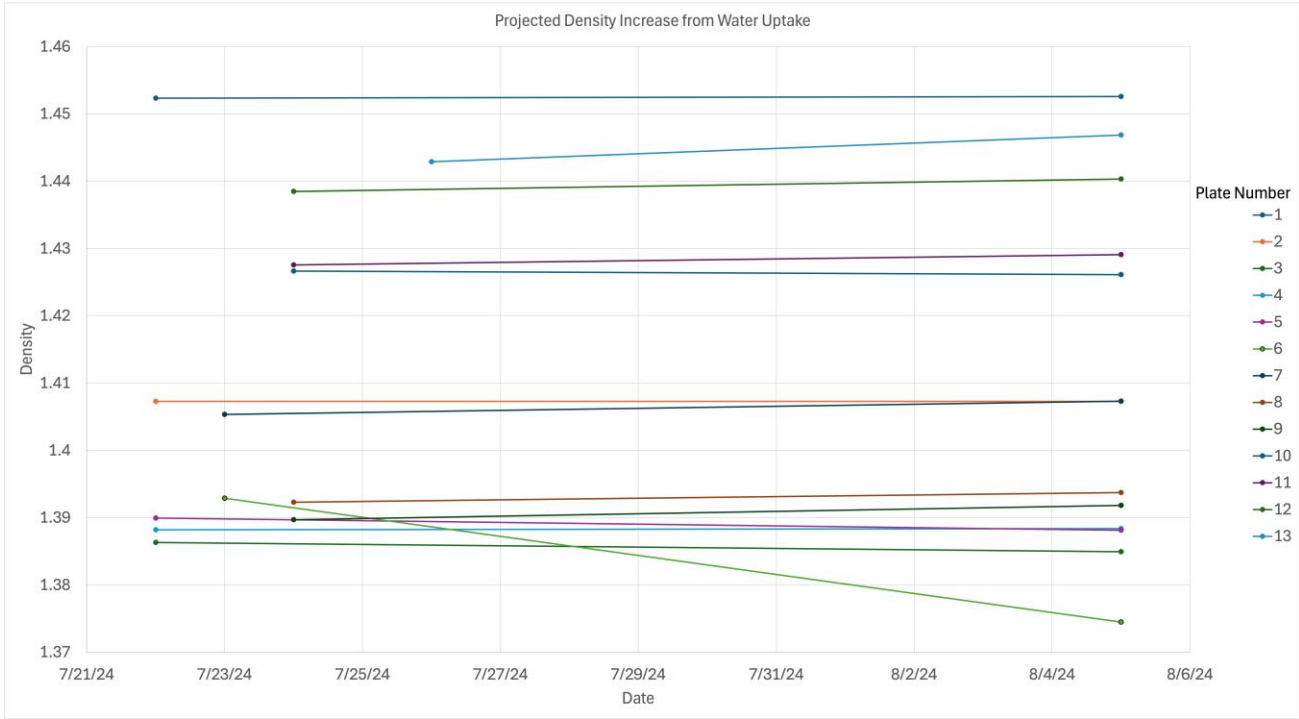

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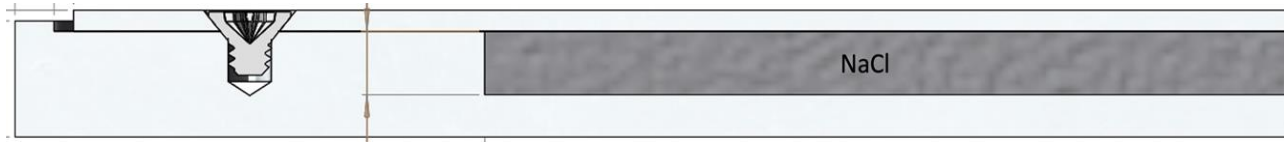
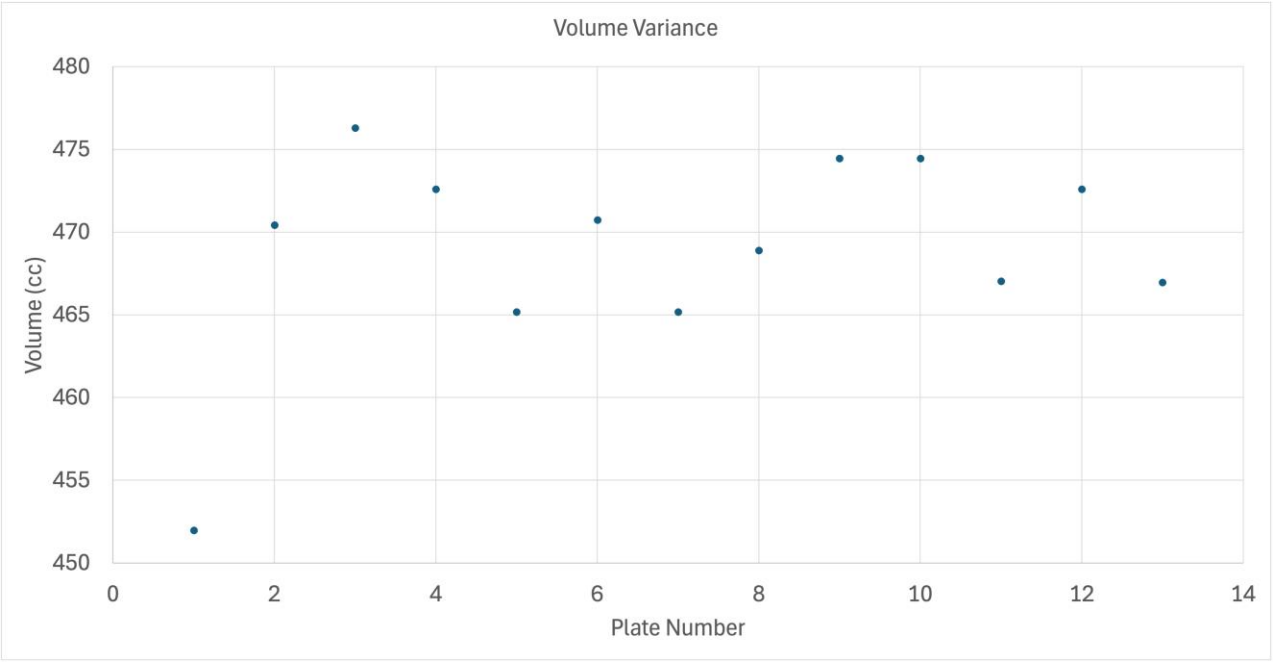
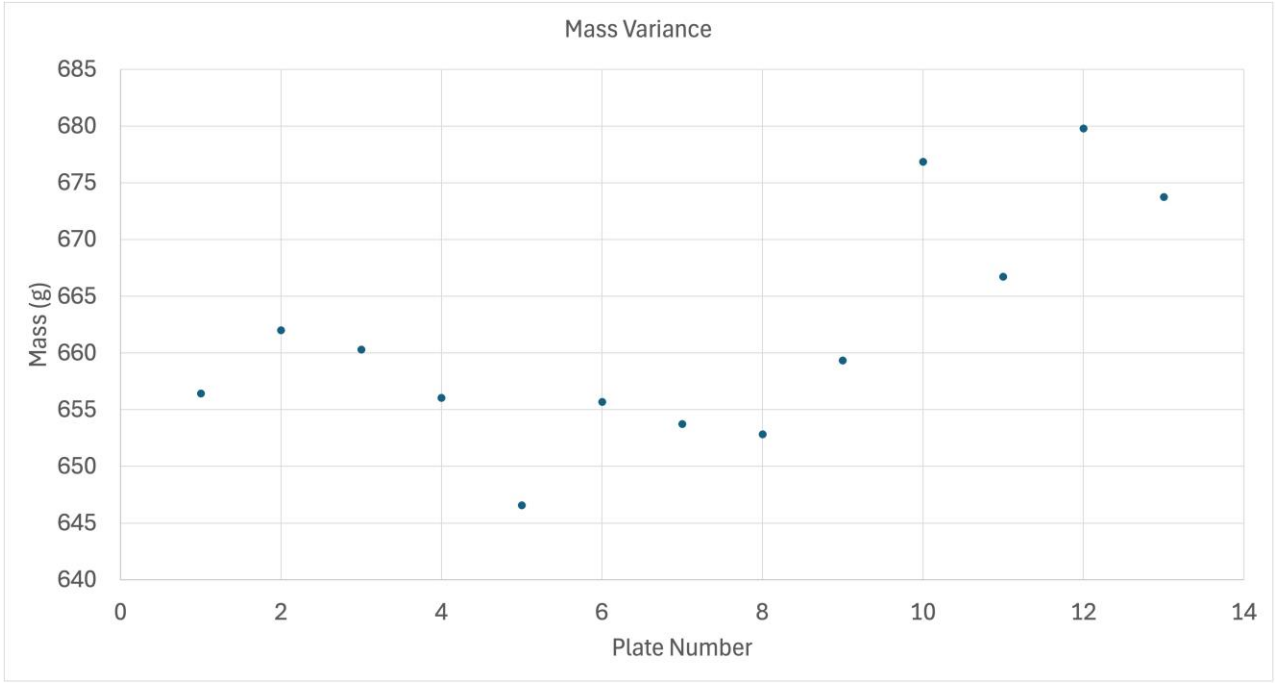
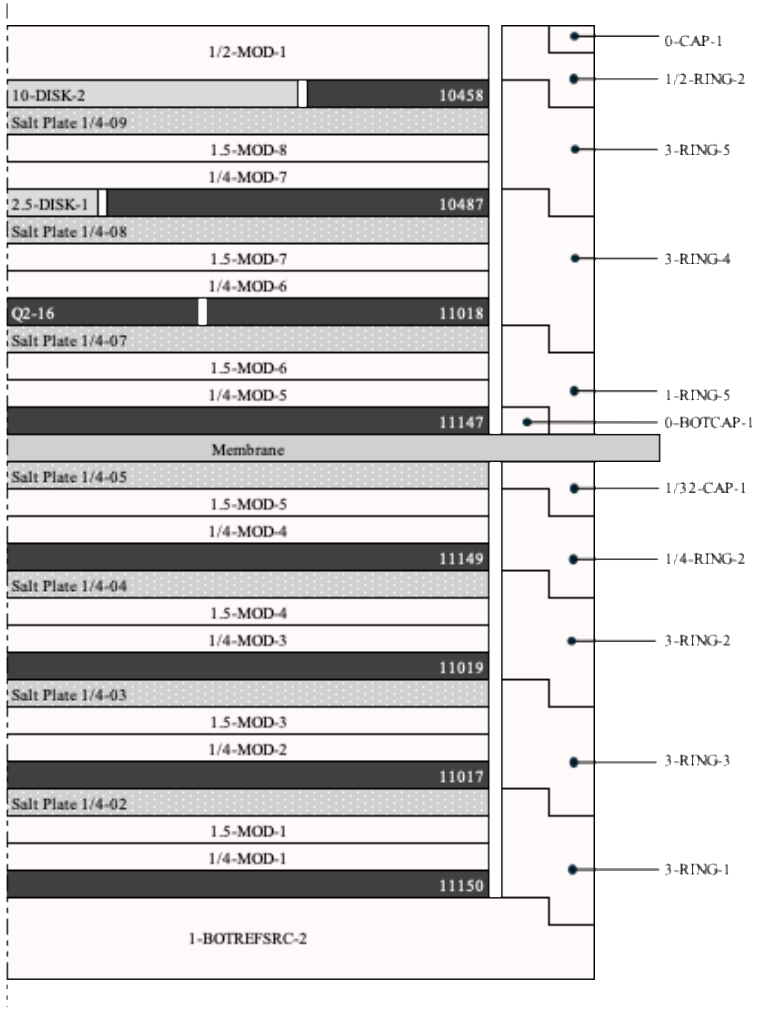



- Mass and volume measurements of each plate were compared
  - Masses were initial fill masses

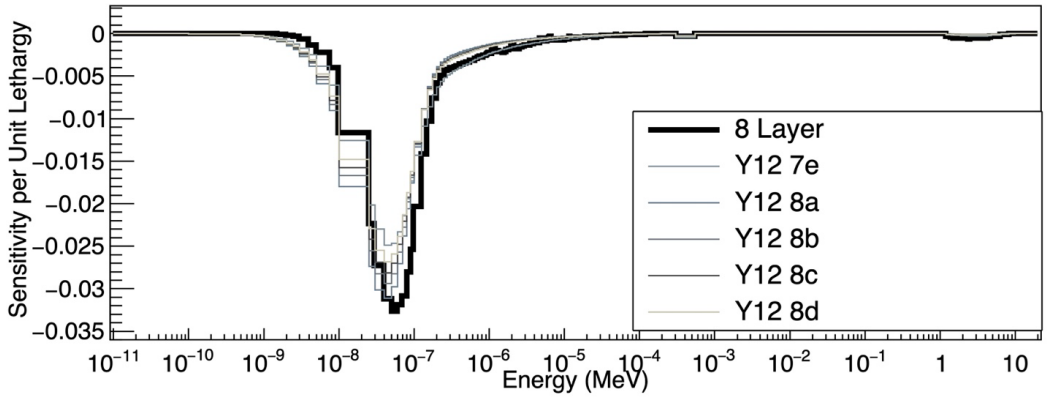


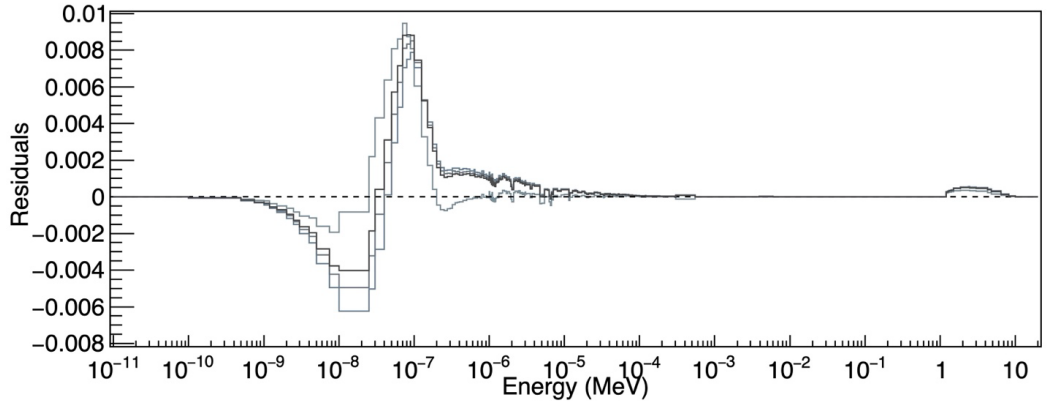



# 8-Layer Standard Configuration



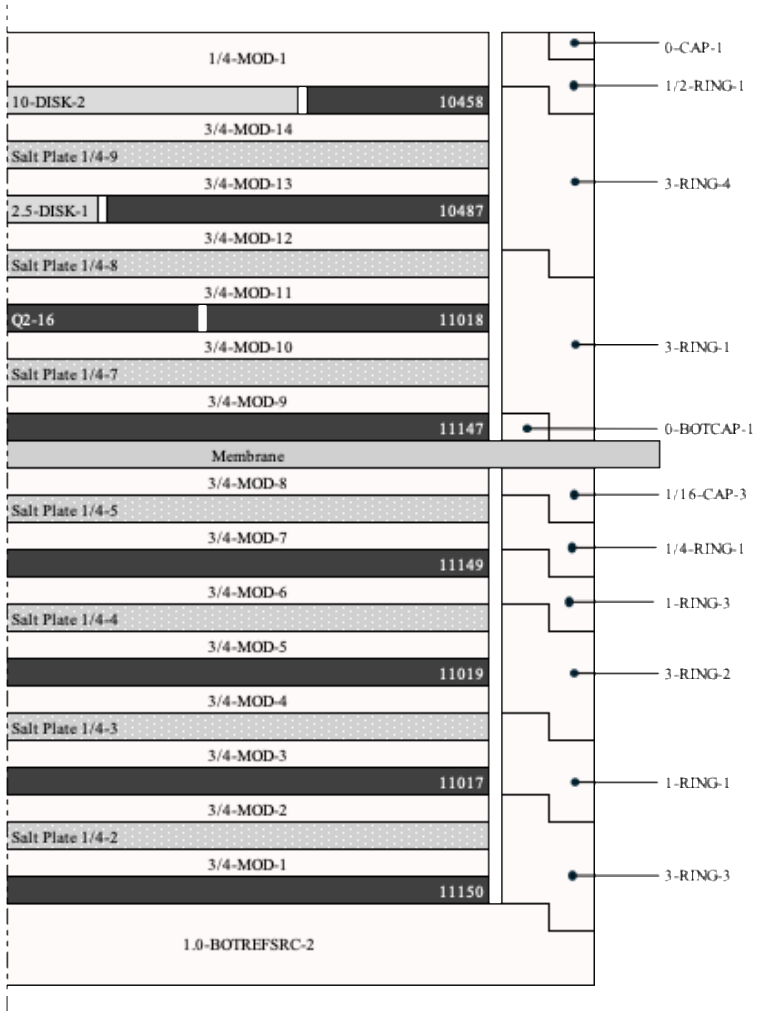

- 8-Layer Standard Config:
  - 0.25” NaCl Absorbers
  - 1.75” HDPE Moderators
  - 0.5” Upper Reflector
  - 8 HEU plates
    - Total = 48.6 kg


Sensitivity Profiles compared to Y-12 application cases

# 8-Layer Sandwich Configuration

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  - 8 HEU plates
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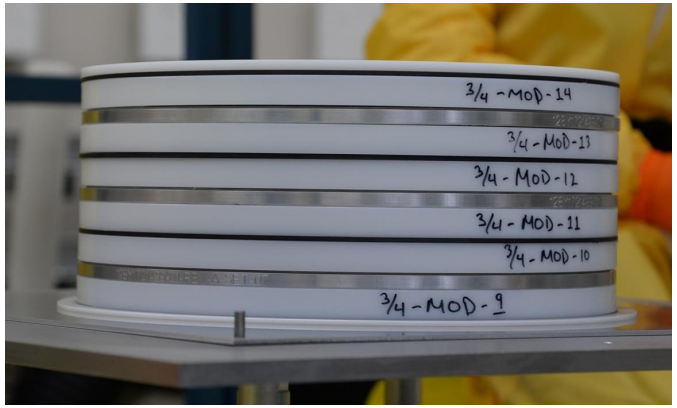
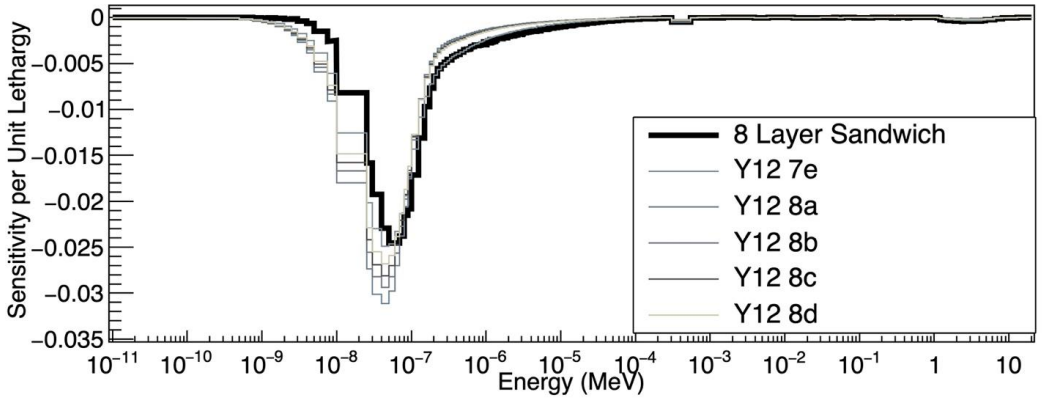
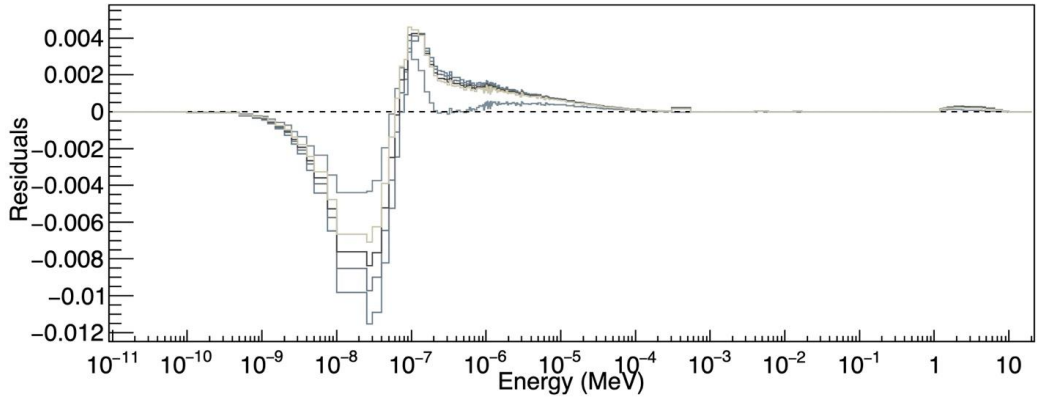


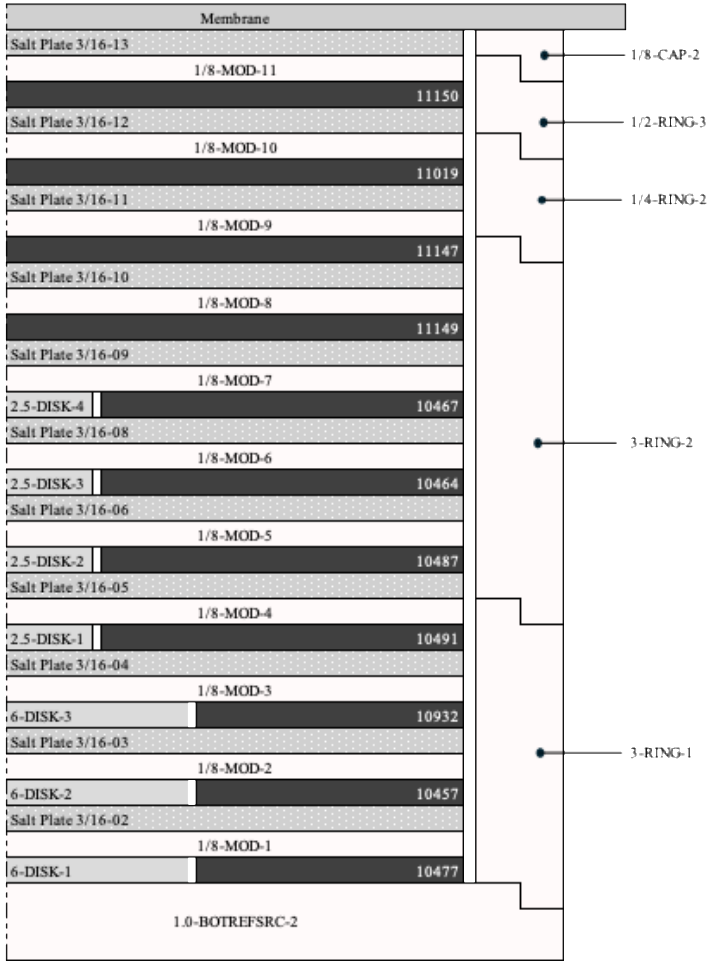



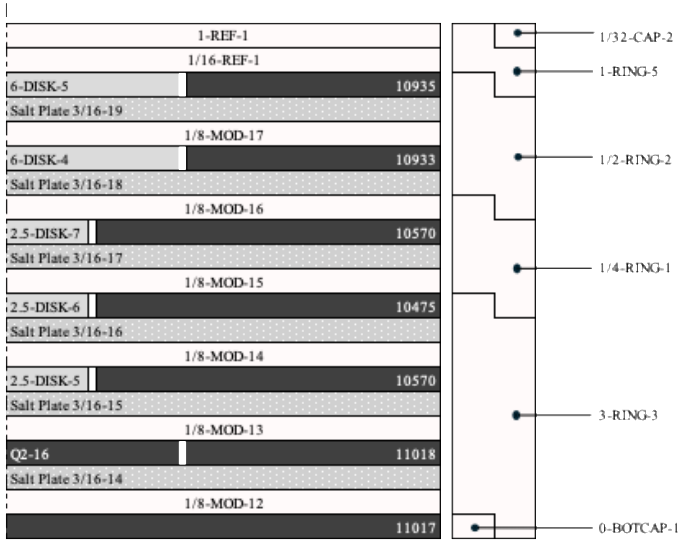

Sensitivity Profiles compared to Y-12 application cases

# 18-Layer Standard Configuration

Lower Stack

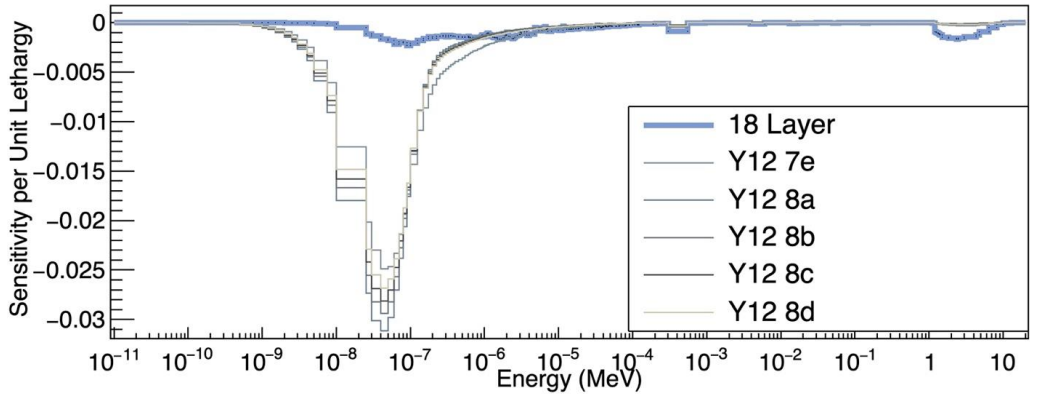


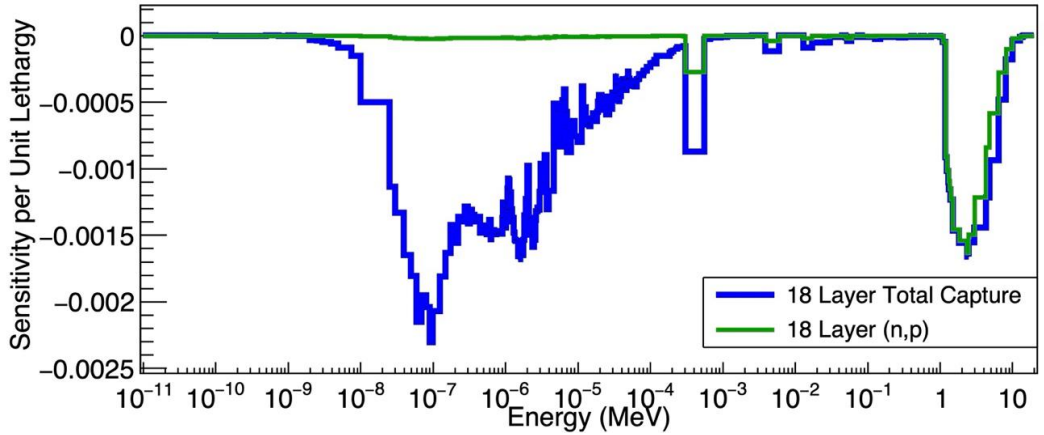

- 18-Layer Standard Config:
  - 0.1875” NaCl Absorbers
  - 0.125” HDPE Moderators
  - 1.0625” Upper Reflector
  - 18 HEU plates
    - Total = 109.2 kg




Upper Stack

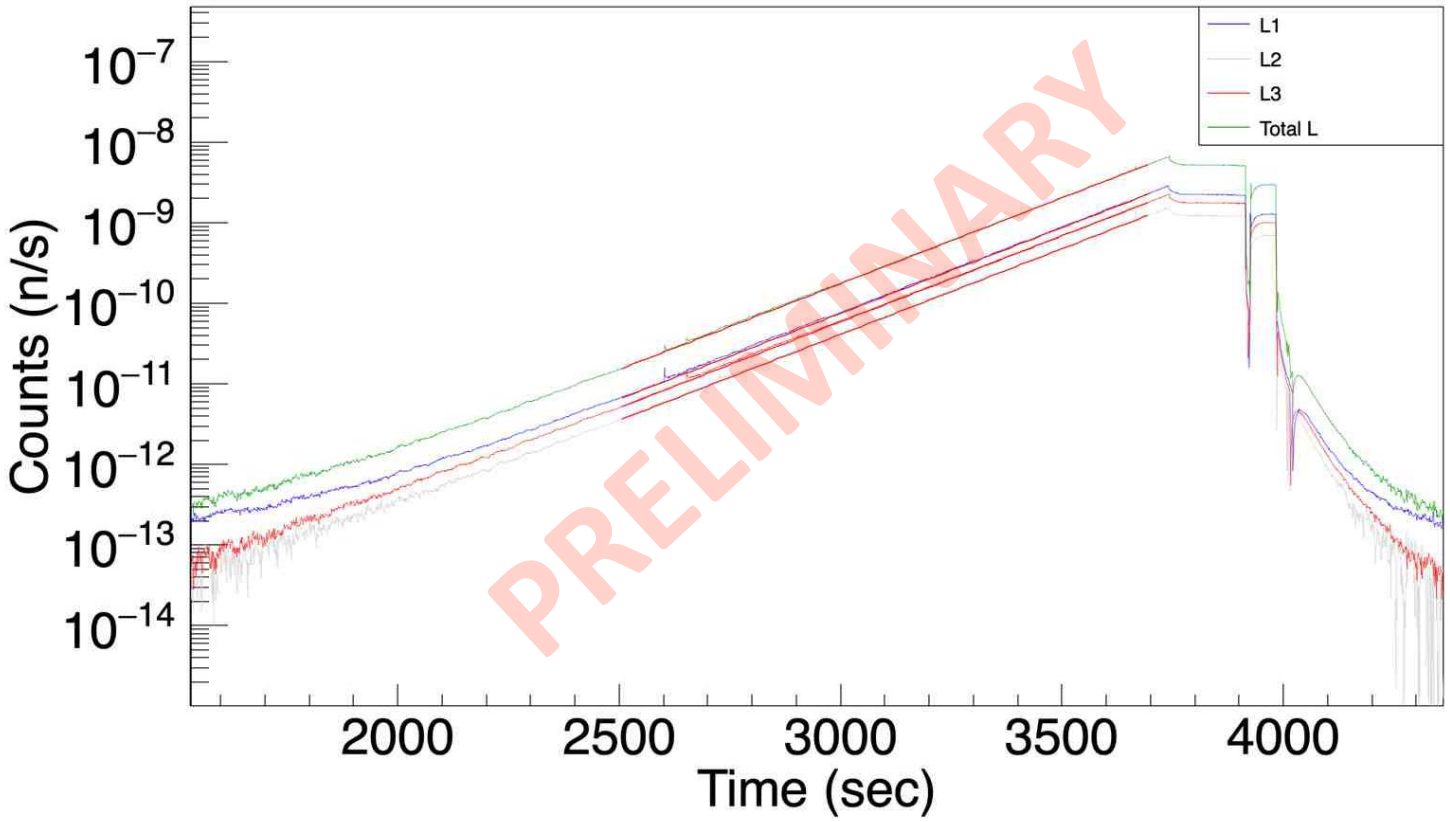
Sensitivity Profiles compared to Y-12 application cases



# Period Measurements

- **Preliminary** experimental period and reactivity measurements
- **Comparing to CED-2 calculations
  - Not the benchmark models
  - Uses CED-2 Delayed Neutron Parameters

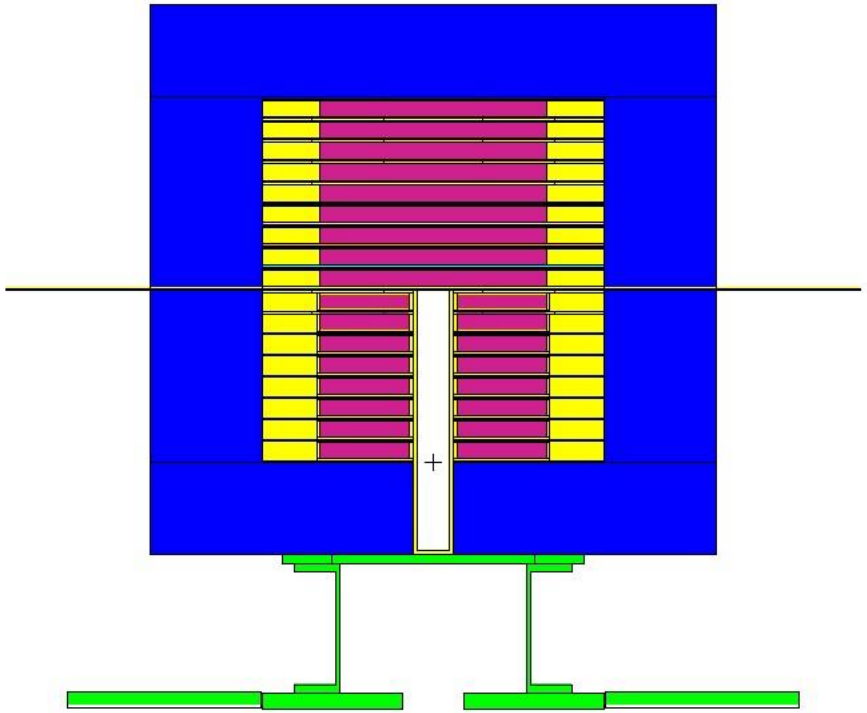



| Configuration | MCNP6.2 – ENDF/B-VIII.0 $k_{eff}$ | MCNP6.2 – ENDF/B-VIII.0 Reactivity (¢) | Preliminary Experimental $k_{eff}$ | Preliminary Reactivity (¢) |
|---|---|---|---|---|
| 8-Layer Sandwich | 1.00011(7) | 1.50(2) | 1.00041(2) | 5.59(23) |
| 8-Layer Standard | 1.00057(7) | 8.09(8) | 1.00063(3) | 8.90(36) |
| 18-Layer Standard | 1.00135(7) | 17.42(18) | 1.000137(6) | 17.67(71) |

PRELIMINARY

# TEX-Cl Timeline and Future

- Benchmarking in progress – Anticipated at the next ICSBEP Technical Review Group (TRG)
- Funding acquired for additional configurations
  - Focuses on INL and TerraPower application cases
  - Designed to address $^{35}Cl(n,p)$
  - Three additional configurations identified:
    - Two following the same TEX-HEU format as the TEX-Cl campaign
    - One following the ZEUS copper reflector format
      - Copper reflectors instead of the HDPE
      - Lower stack requires alignment mechanism, either tube or sheath



# Conclusions

- TEX-Cl experiments have been completed (July-August 2024) at NCERC
  - Three configurations were performed
- Novel salt plate designs worked flawlessly
- TEX-Cl experiment benchmarking is underway and expected to be completed for the next TRG


We would like to acknowledge and thank the NCSP for funding this work.

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