Temperature Dependent Experiments using SPRF/CX

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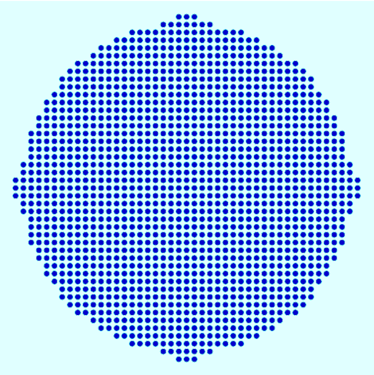
Goals

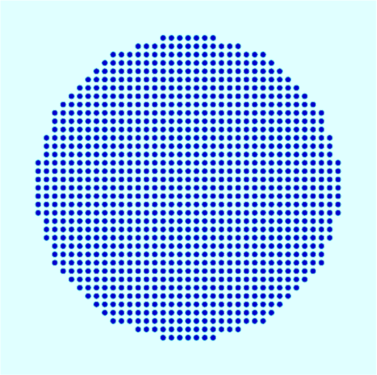
- Currently there is a lack of LCT experiments at temperatures other than 25 °C
  - Important for fuel storage applications
  - Ability to test codes and data off of nominal conditions
- Establish standard critical benchmarks through approach on number of rods.
  - Goal to work with IER-452 ITC inversion temperature experiments
- Provide flexibility for SNL staff in arrays that are ultimately chosen for experiments
- Provide input to component modifications that are necessary

Nuclear Design

- Examined a variety of arrays for 7uPCX and BUCCX fuels
  - Either in ICSBEP handbook or from SNL ANS paper
- Generated ENDF/B-VII.1 library with TSL data ever 5 °C
- Ran cases that included water temperature and density and fuel temperature to select
  - Most positive temperature response
  - Most negative response
  - Minimum temperature response
- Using the above cases
  - Separate effects calculations
  - Regional water calculations
  - Sensitivity and estimated experimental uncertainty calculations

7uPCX Fuel Arrays Considered


LCT-102-001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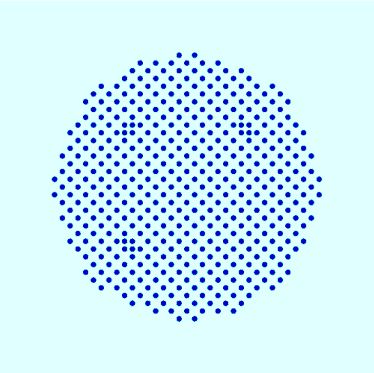
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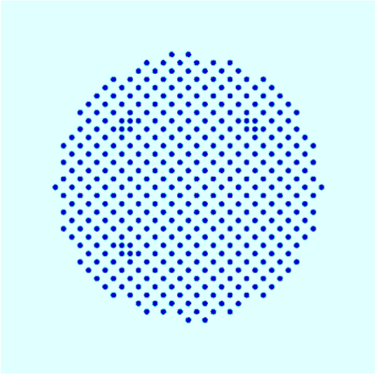
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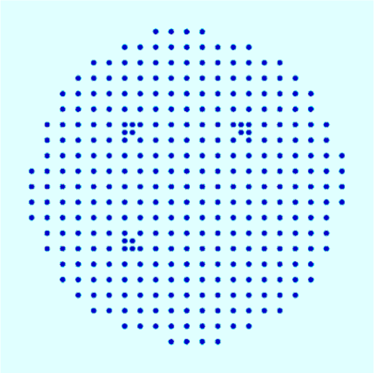
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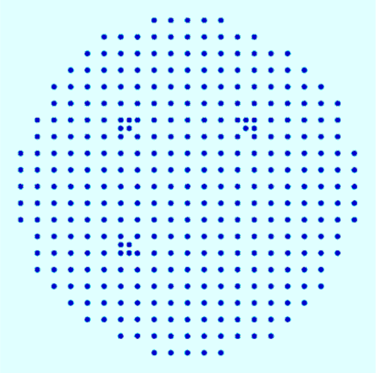
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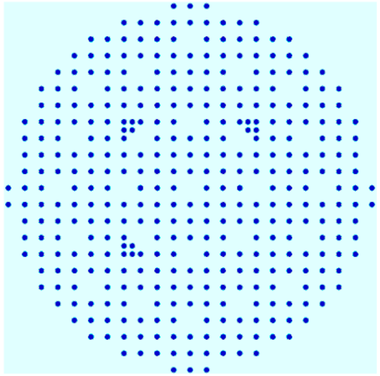
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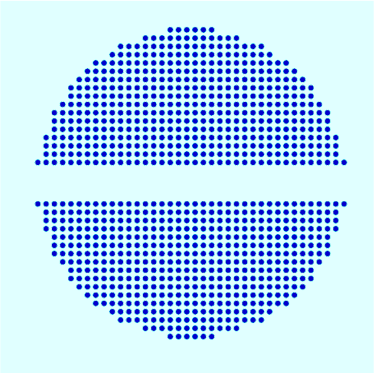
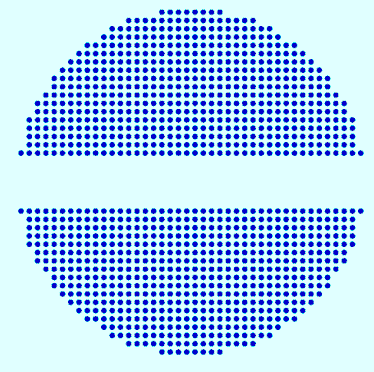
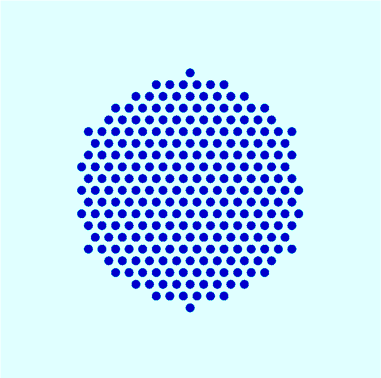
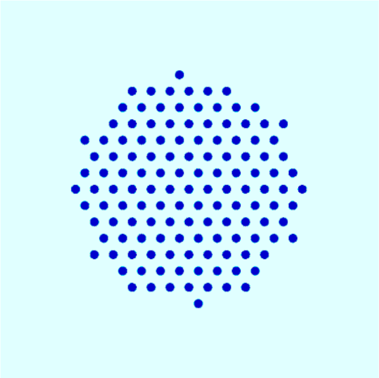

0.855 cm pitch
4 Row Channel


0.855 cm pitch
6 Row Channel

BUCCX Fueled Arrays Considered



LCT-079-001



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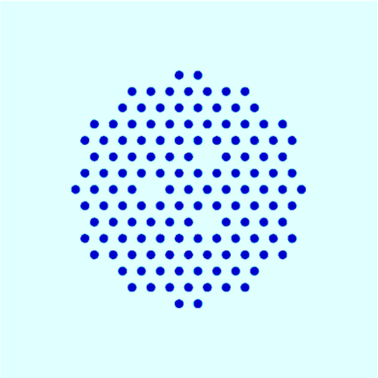
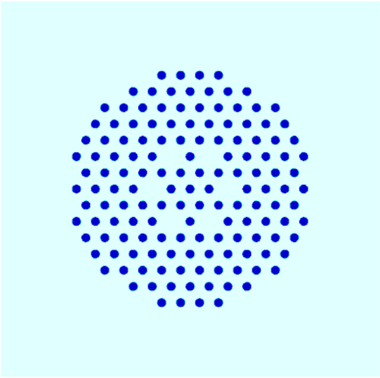
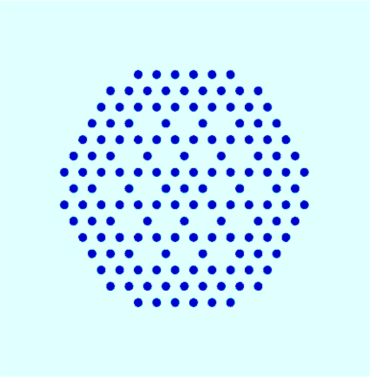


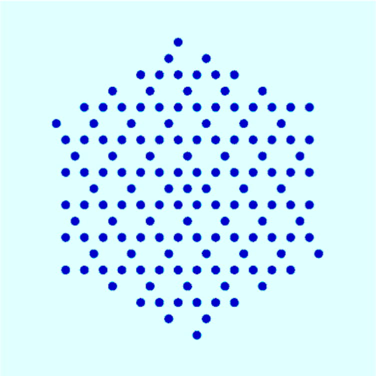
2.8 cm pitch
3 holes



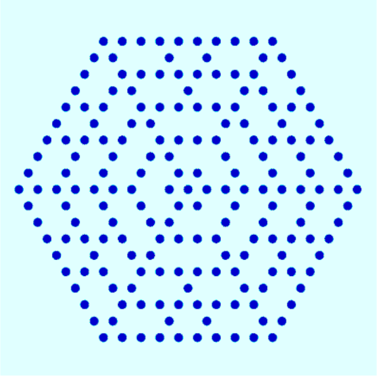
2.8 cm pitch
6 holes



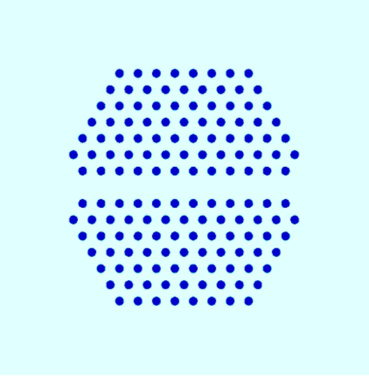
2.8 cm pitch
18 holes



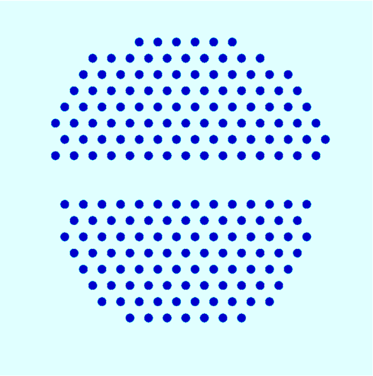
2.8 cm pitch
42 holes



2.8 cm pitch
81 holes



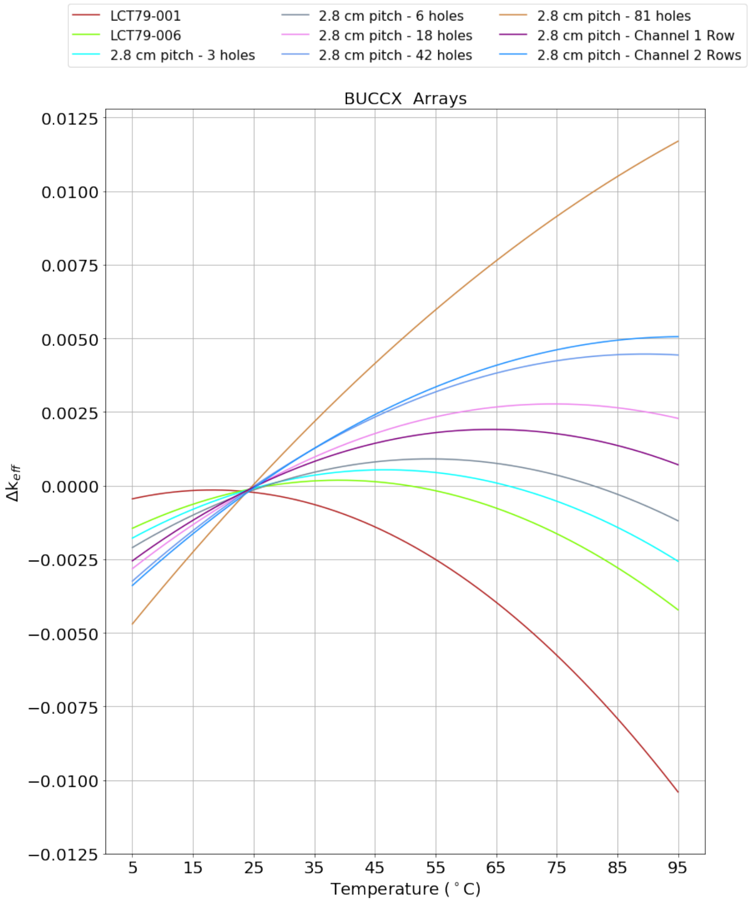
2.8 cm pitch
1 row channel

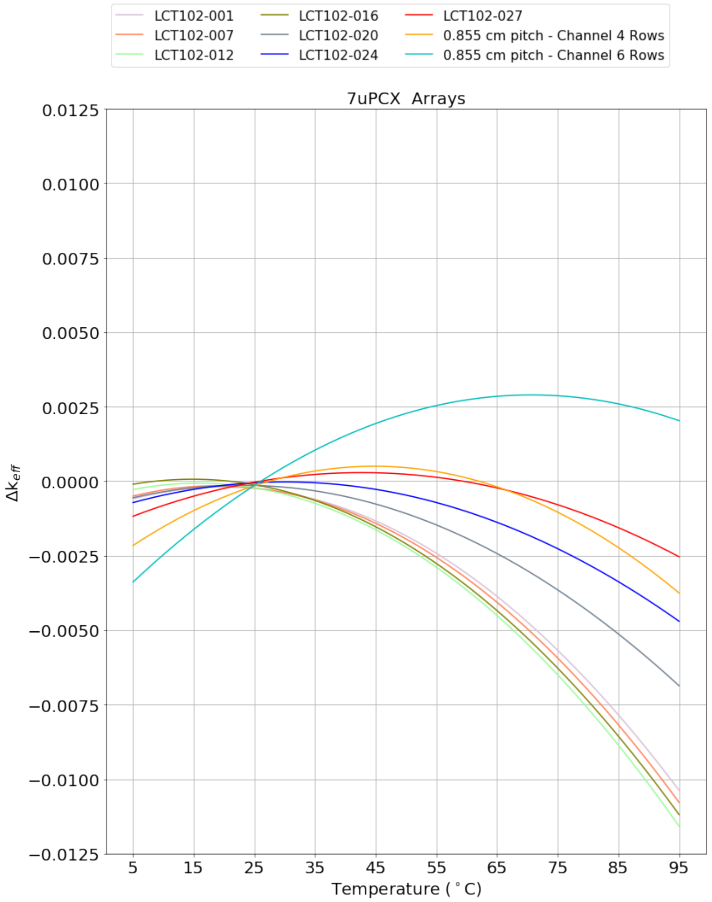


2.8 cm pitch
2 row channel

Full Effects Cases

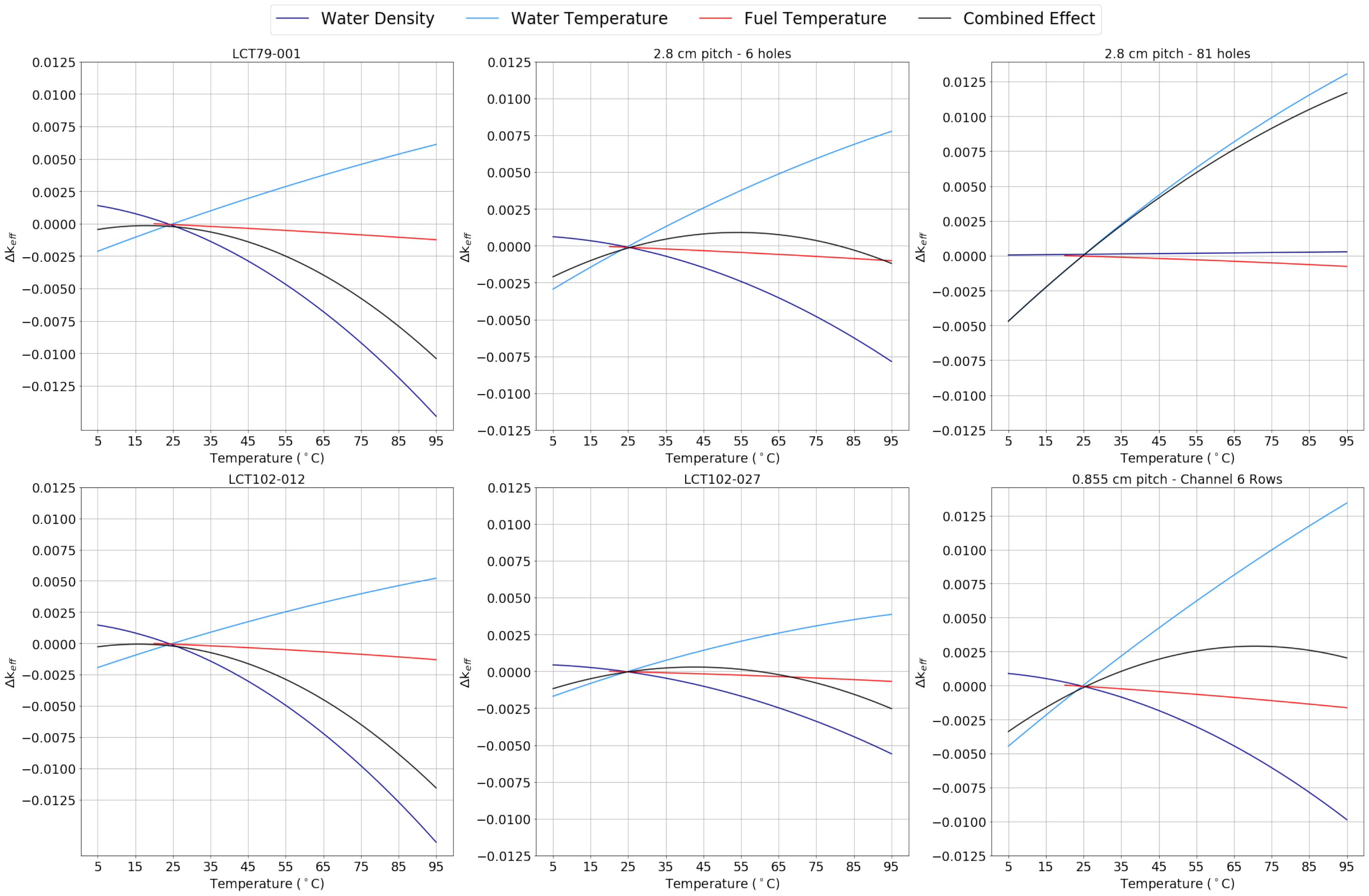
- 7uPCX
  - NTR - LCT-102-012
  - PTR – 6 Row Channel
  - MTR – LCT-102-027
- BUCCX
  - NTR – LCT-079-001
  - PTR – 2.8 cm – 81 holes
  - MTR – 2.8 cm – 6 holes
- Both fuels generate similar NTR cases, PTR appears to be easier to achieve with BUCCX





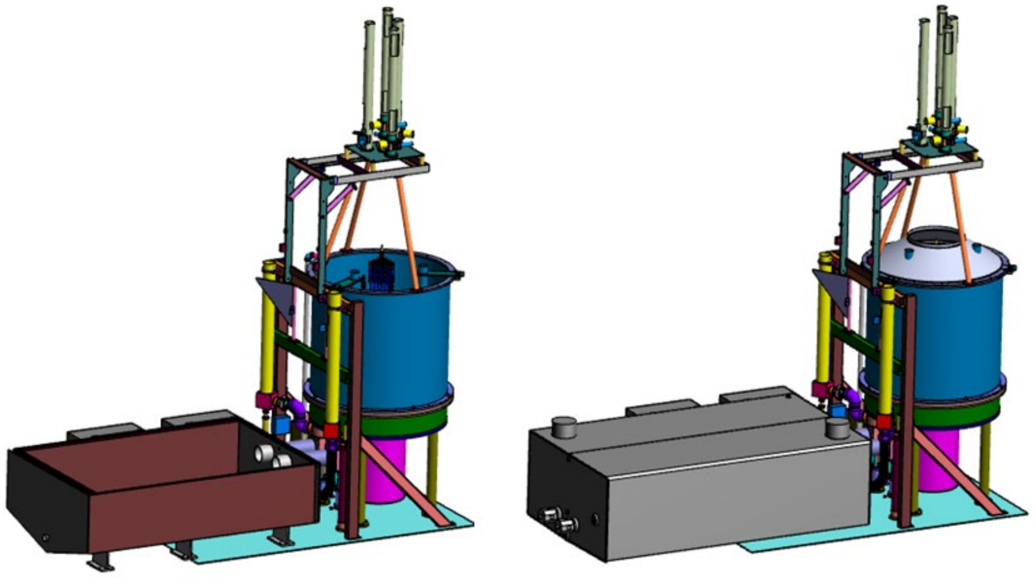
Separate Effects Calculations

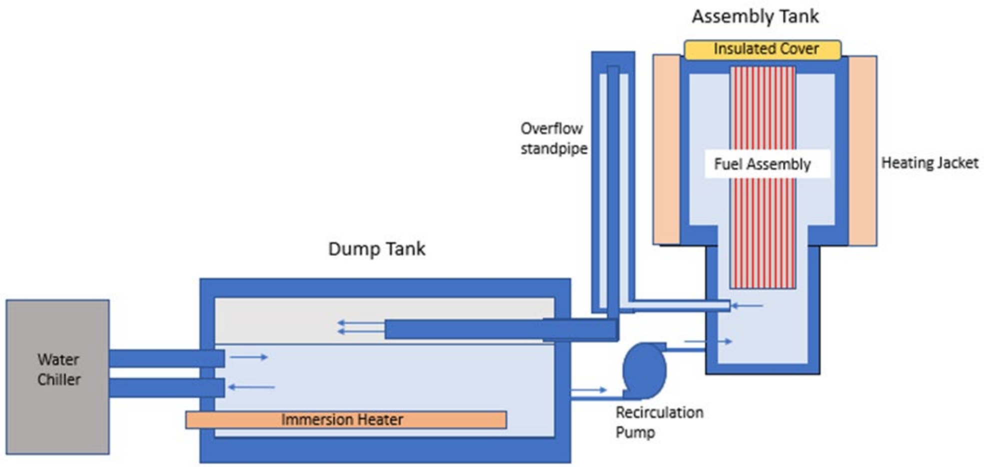
- Water temperature positive effect in all cases
  - Primarily due to reflector effect
- Water density primarily negative effect
  - Primarily due to moderator region
- Fuel temperature effect is minimal (~100 pcm max)



Thermal Analysis

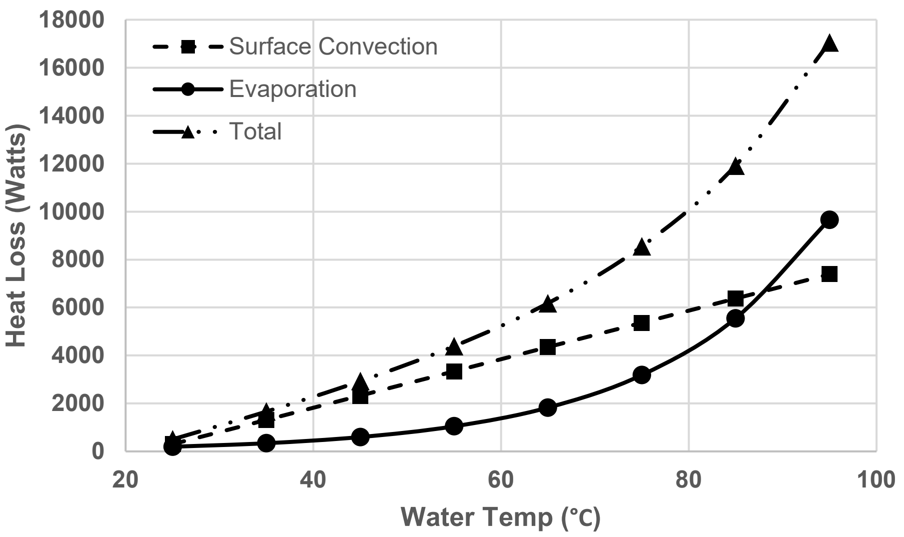
- Heat loss through the sides and tops of the tanks was calculated to inform insulation and heating requirements for high temperature operation.
- The thermal equilibrium time was calculated for two different fuel assemblies.
- The impact of water evaporation on heat and mass losses was analyzed.
- Cooling requirements were calculated to inform chiller sizing.

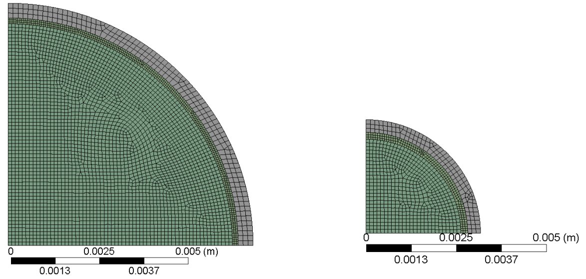


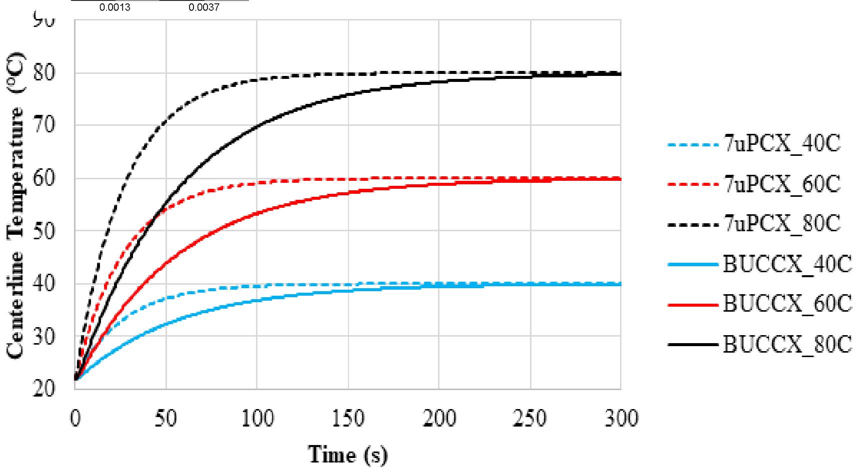


Thermal simulations

- Thermal insulation on tank and dump tank needed to mitigate convective losses
- Lid for evaporative losses
- Results in line with hot tub energy consumption
- ANSYS calculations for centerline fuel temperature
- Time to heat centerline of rod to equilibrium temperature
  - ~4.5 min for BUCCX and ~2 min for 7uPCX



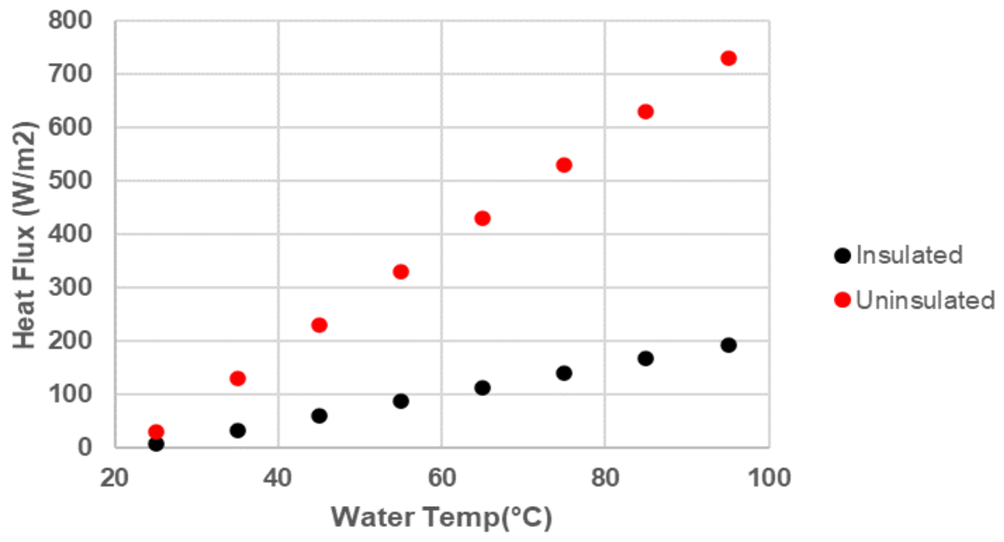




Potential Upgrades

- List of hardware upgrades were suggested using the results of thermal analyses
  - Larger capacity dump tank
  - Immersion heater and controller
  - Fiberglass insulation jackets
    - Optional heated jacket on assembly tank
  - Recirculation chiller
  - Custom assembly tank cover
- Material cost* estimate determined
    - *Excluding labor

Impact of 2" fiberglass insulation



Item	Approximate Cost
Temperature instrumentation	$6,000
Dump tank	$3,000
Heating and insulation	$13,000
Cooling	$15,000
Cover fabrication	$2,000
Dehumidifier	$2,000

Conclusions

- A range of fuel arrays has been examined for both fuel types and representative arrays were selected
- Temperature dependent calculations were performed to show the performance of the arrays
- Modification to the SPRF/CX facility have been proposed to aid SNL staff in the execution of temperature dependent experiments