



Molten Salt Thermal Batteries: Uncertainty Quantification

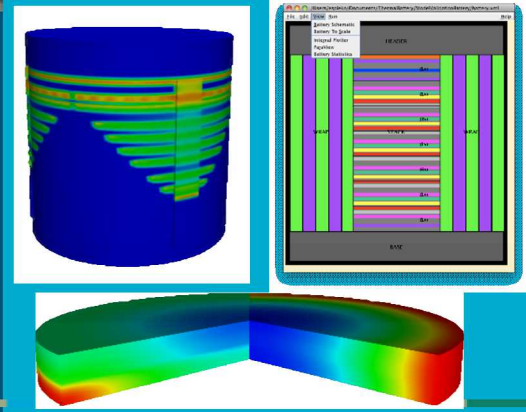


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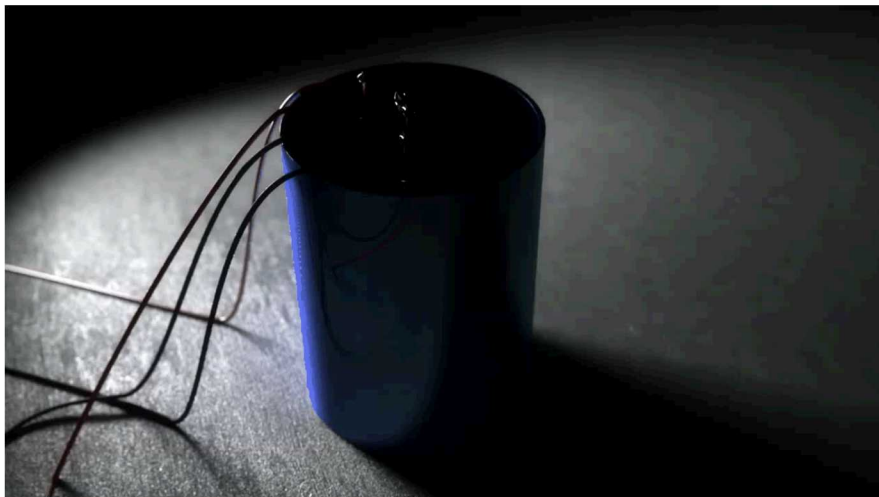
Project Mentors: Scott Roberts & Ben Schroeder

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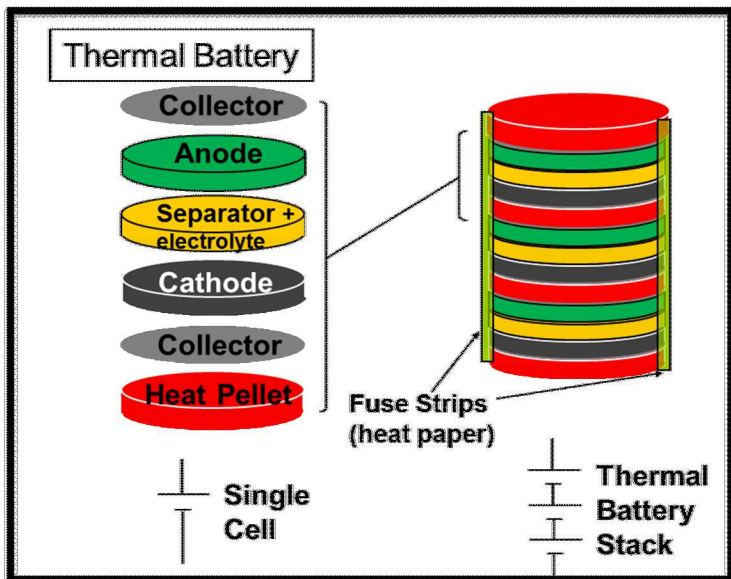
Midshipman 3/C Lillian N. Usadi



What are Molten Salt (Thermal) Batteries?



- **Regular Batteries** (liquid electrolyte)
- **Thermal Batteries** (solid electrolyte)
 - Burn heat pellet
 - Molten salt → liquid electrolyte
- **Longer shelf life**
- **Applications:** one use weapons (e.g. missiles)

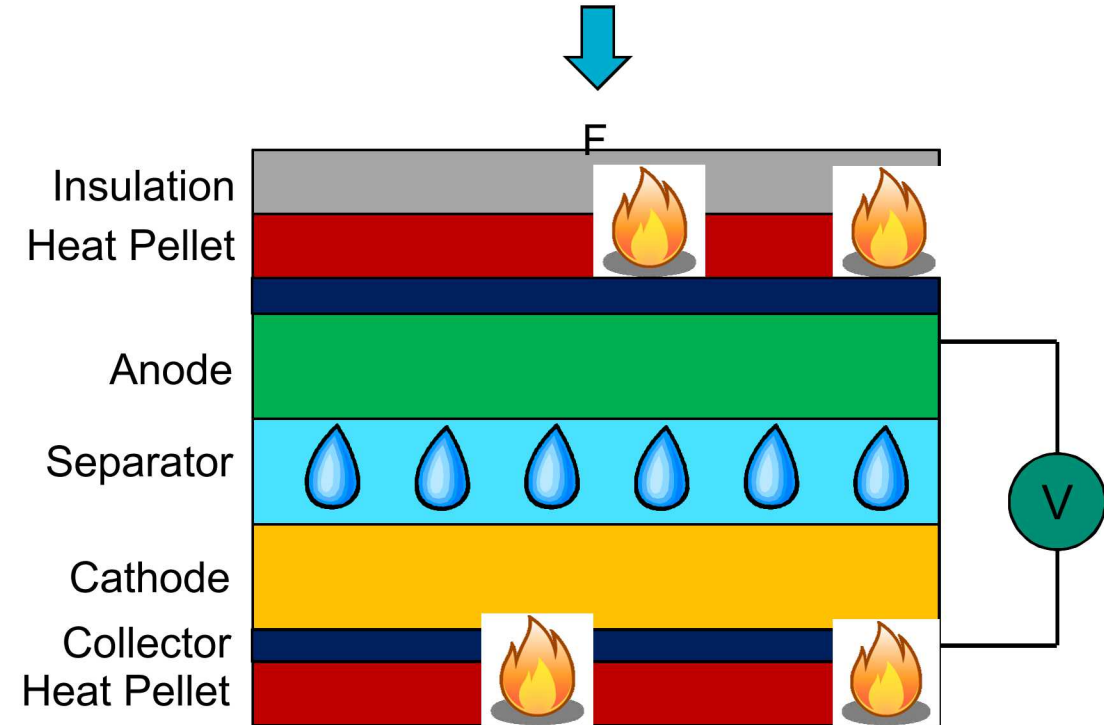


Reference:

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Stages of Molten Salt (Thermal) Batteries

1. Heat pellet burning
2. Thermal diffusion
3. Melting of the electrolyte
4. Deformation of the separator
5. Rebound of the insulation
6. Flow of the electrolyte
7. Activation



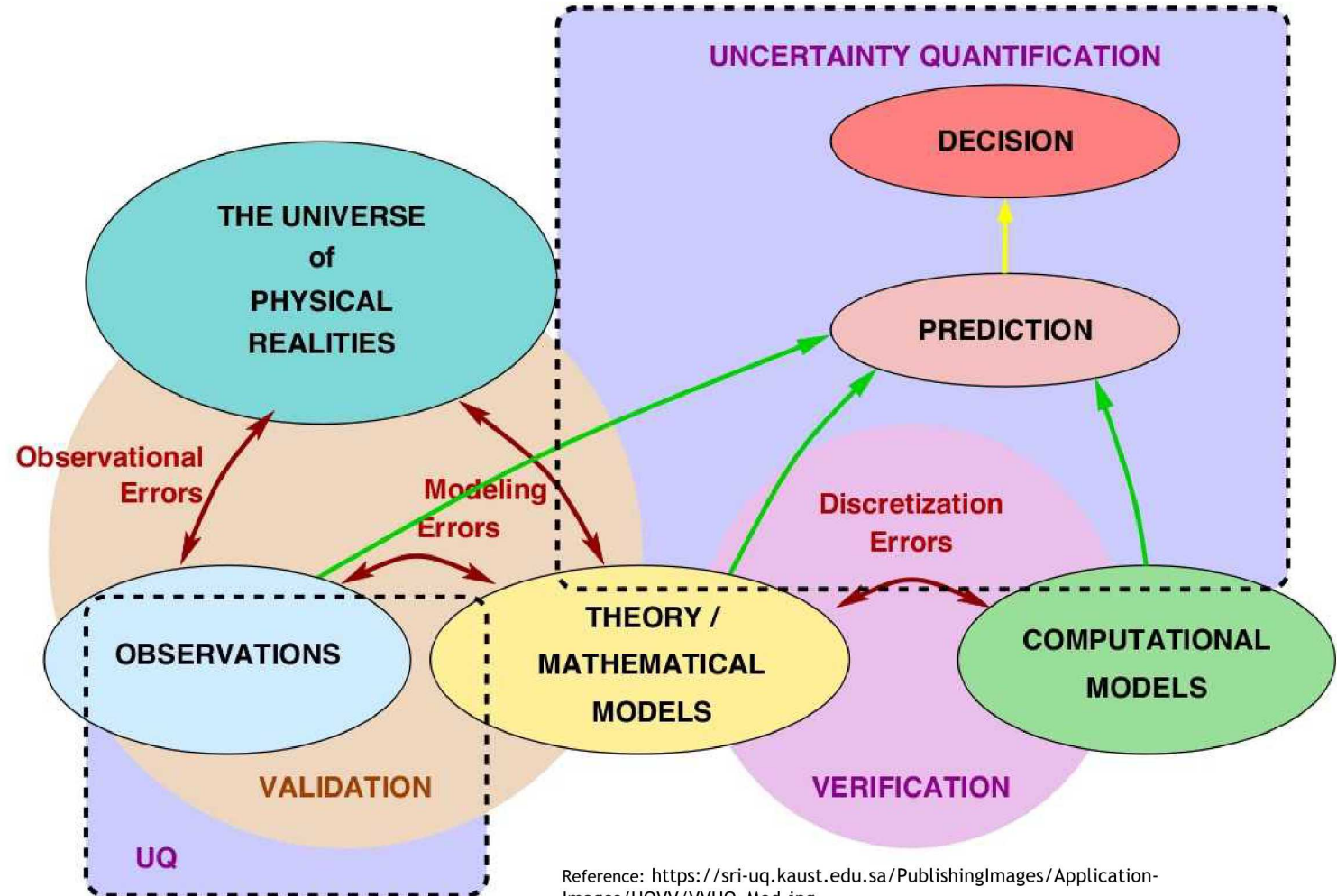
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How do we measure the validity and accuracy of our model?

Verification, & Validation, & Uncertainty Quantification (V&V&UQ)

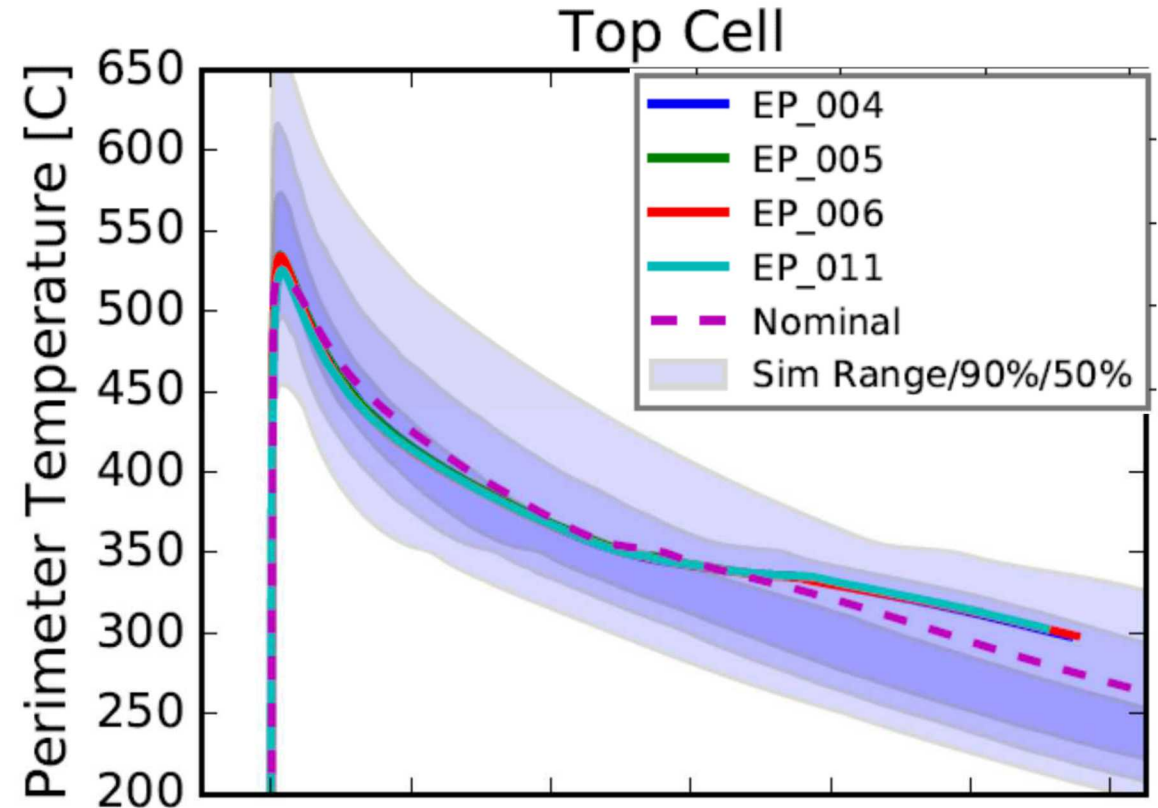
- **Verification**: How do you know if the computational code matches mathematical model?
- **Validation**: How do the model results compare with the experimental results?
- **Uncertainty quantification**: How does parameter uncertainty affect the uncertainty of our model? Do we have the ability to quantify this uncertainty?



Quantities of Interest (QoI)

What do we want to study?

- **Rise Time** : battery to melt
 - **Life Time**: battery freezes out
 - Maximum cathode/anode temperatures
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- Parameters have inherent uncertainties (variable thickness, thermal conductivity, etc.)
 - **Uncertainty Quantification**: Study of how uncertainty of parameters affect uncertainty of QoI



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What I did

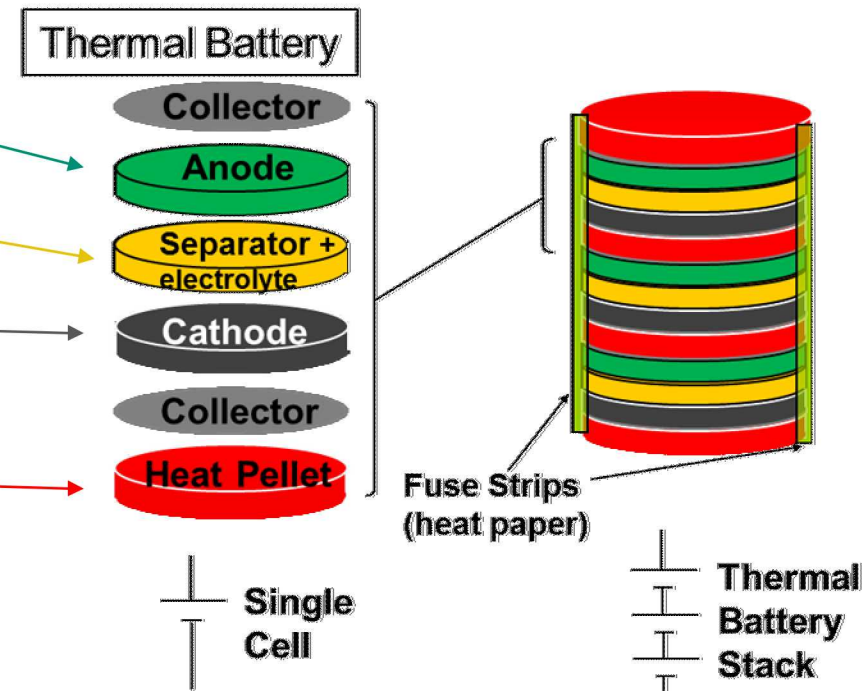
- **Previously:** Run simulations changing thermal properties of battery (thermal conductivity, specific heat, etc.)
- **Currently:** Run simulations changing geometric properties of battery

- Anode thickness

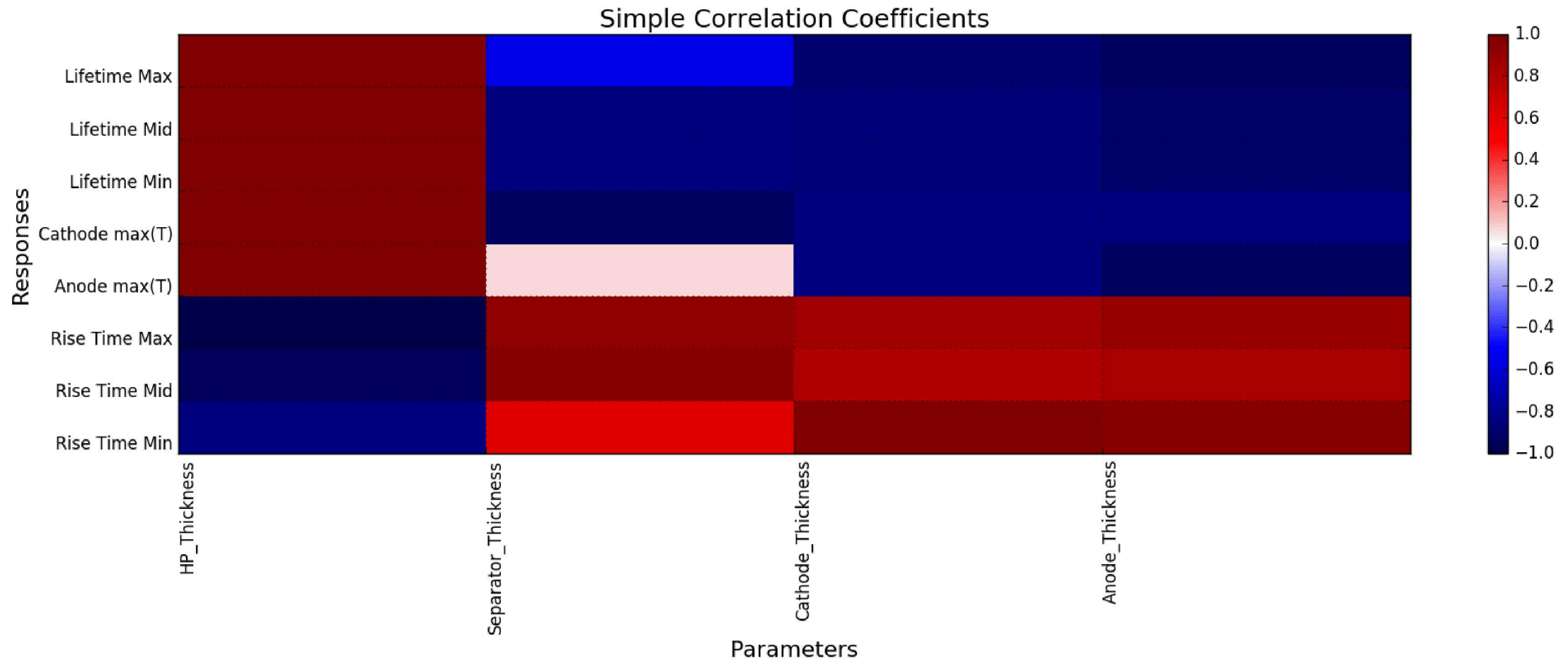
- Separator Thickness

- Cathode Thickness

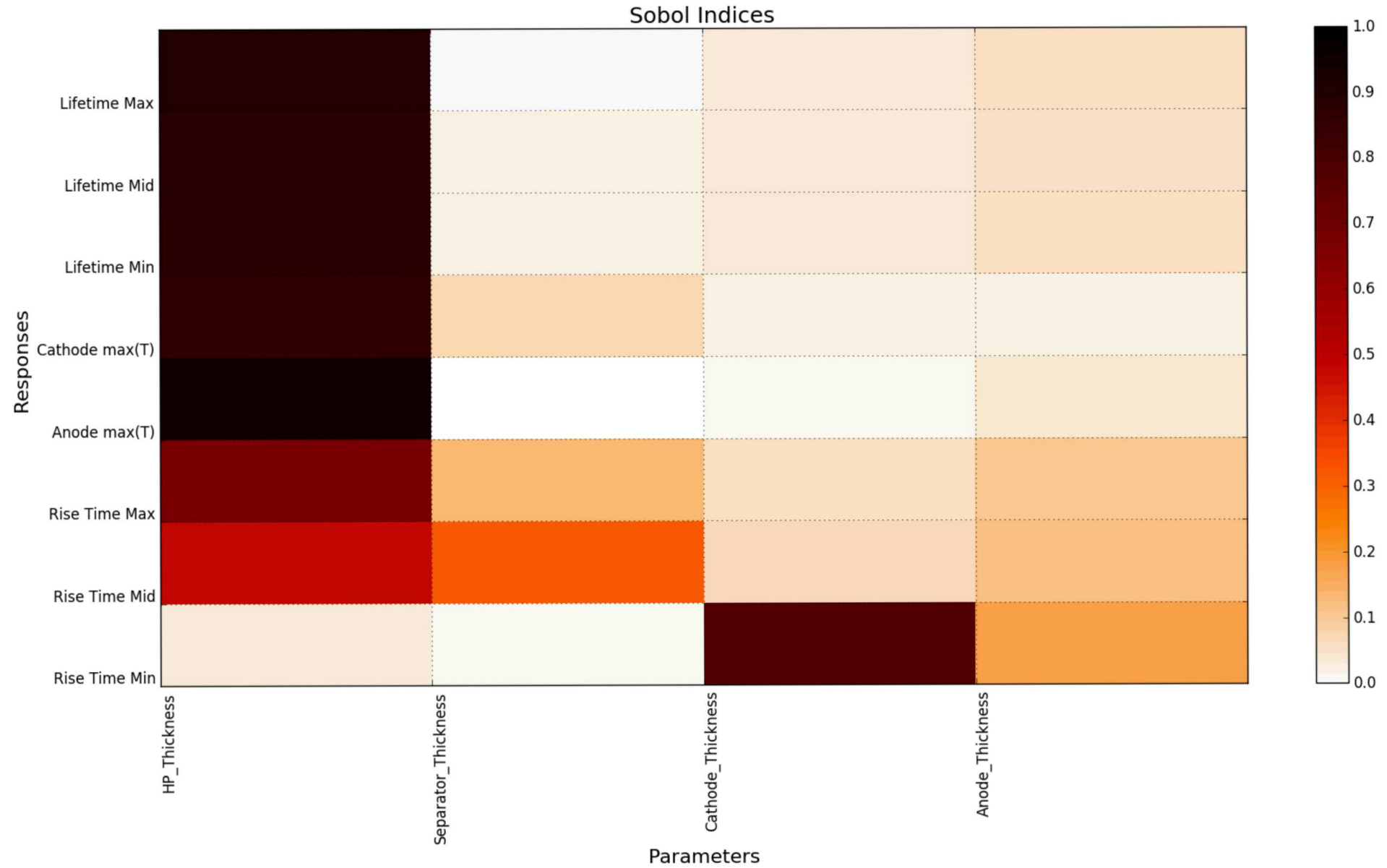
- Heat Pellet Thickness



Results: Simple Correlation Coefficients



Result: Sobol Indices



So what?

- Heat pellet had the largest impact on uncertainty
 - Density is constant
 - Added to energy in the system
- **Going forward:**
 - Altering thickness while changing density
 - Run simulation with ~500 samples (currently 100)

What I Learned

- Basic modeling/Running simulations
- Python, Linux, Virtual machines
- Real science is messy.

