July 25, 2023

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Idaho National Laboratory

# AGR-3/4 PIE and Data Analysis

**DOE ART Gas-Cooled Reactor (GCR) Review Meeting**
Virtual Meeting
July 25 – 27, 2023

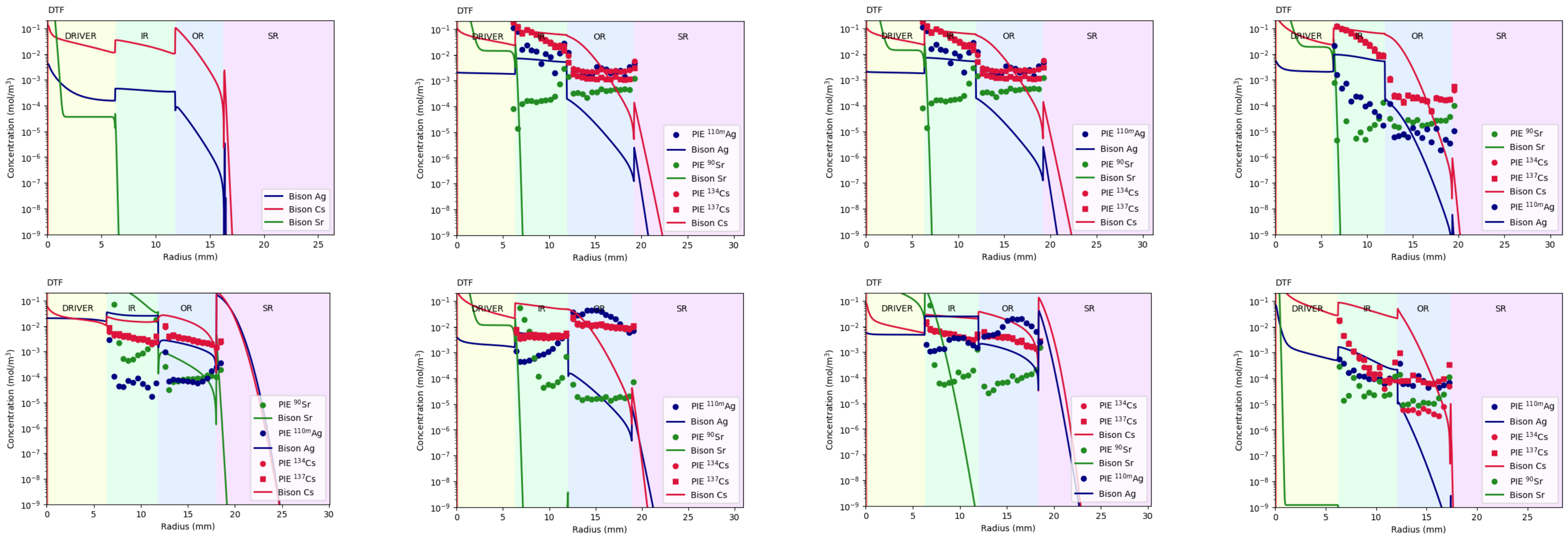
ART
Advanced Reactor Technologies

# BISON Improvements

- Freundlich isotherm model now built into BISON
- Working with NEAMS team to incorporate a model explicit in the gas phase which can be used to model vapor-phase transport
- TRISO particle improvements

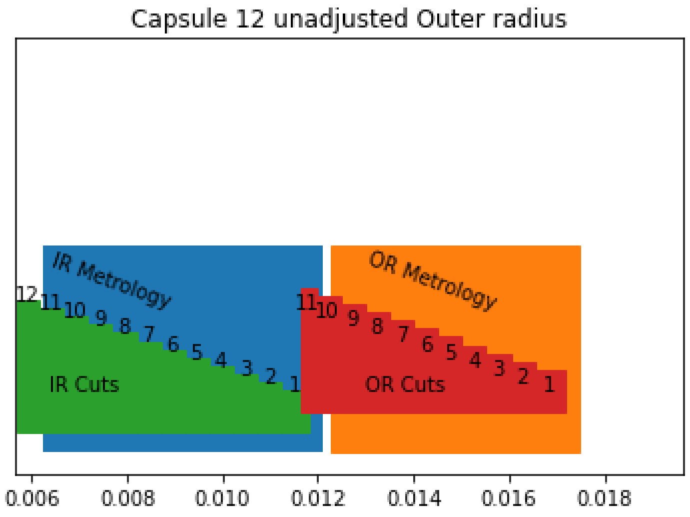
# BISON Assessment Case Development

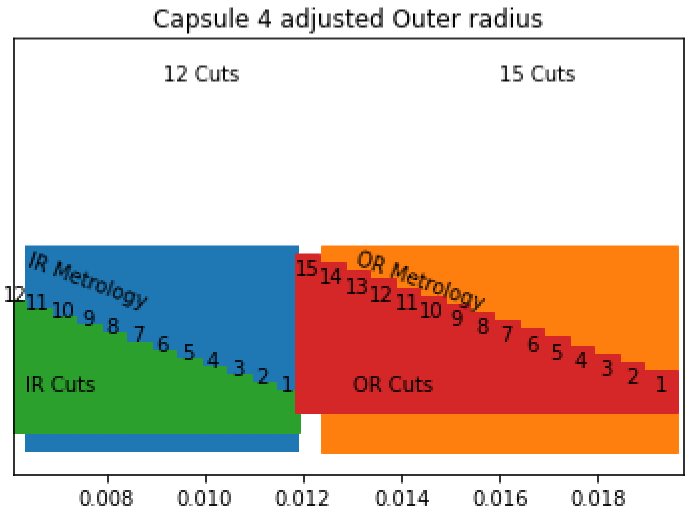
- Worked with BISON team to refine the AGR 3/4 TRISO Assessment case model and add measurements from capsule 4 inner and outer rings

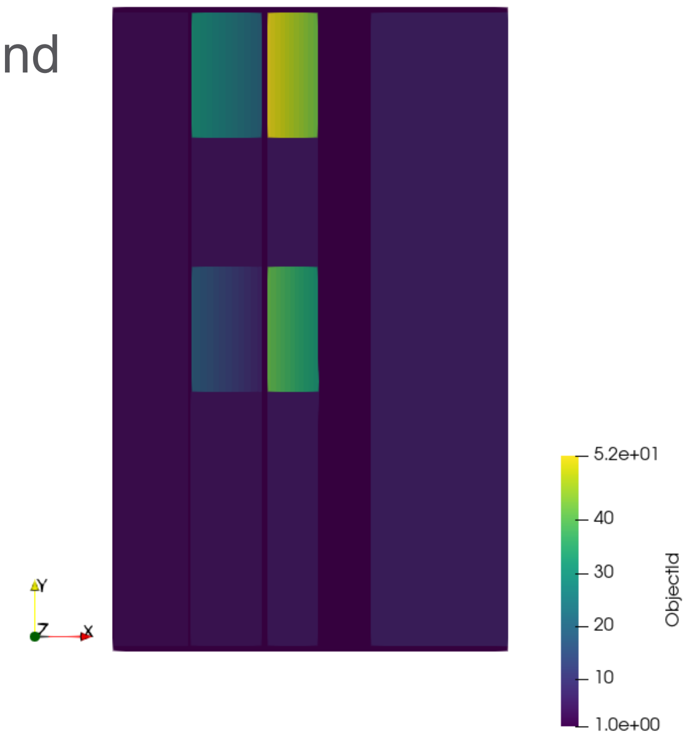


# 2D Model Creation

- Extracted axial temperature profiles from as-run ABAQUS thermal analysis results
- Uses measurements from post-irradiation metrology where available
- Some uncertainty due to discrepancies between metrology and destructive analysis measurements
- Developed to test theory of short-circuit gas-phase diffusion around compacts

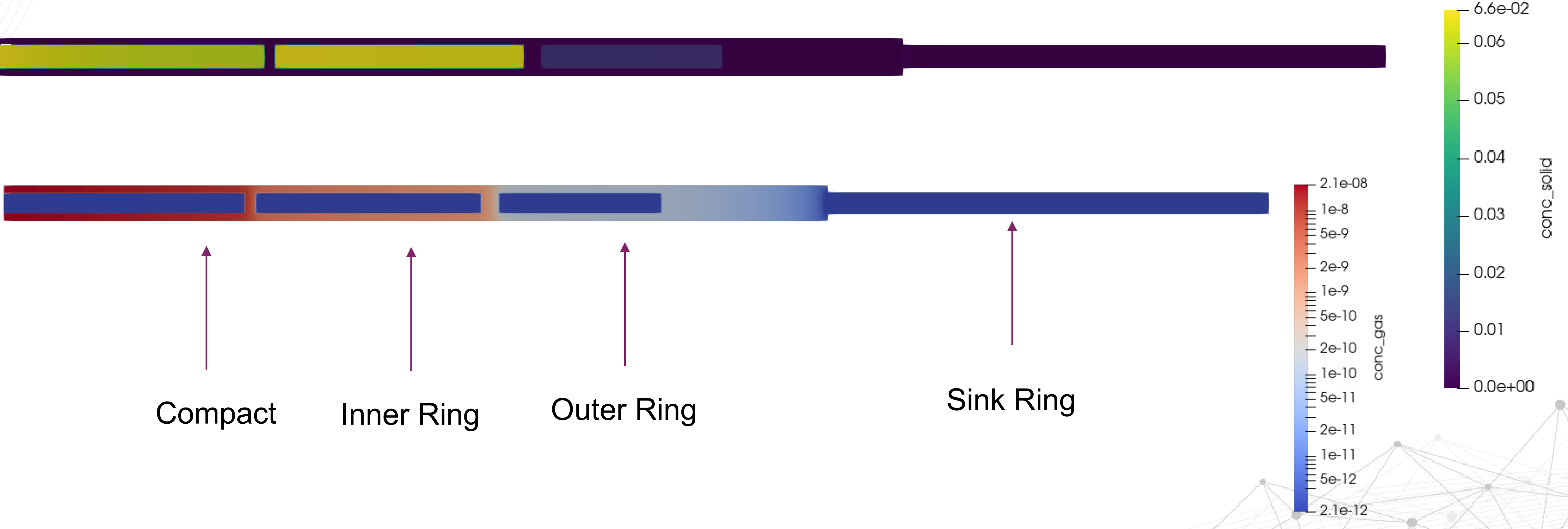


# 2D Model Proof-of-concept

- Modeling sorption across gaps explicitly
- Plans for a parametric study of 2D effects of gap sizes (short-circuit transport), axial distribution profiles
- No short-circuit pathway allowed through the sink ring



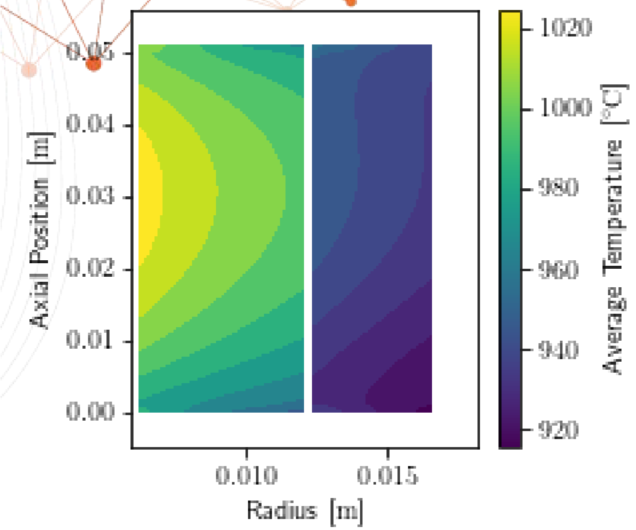
# 2D Model Limitations

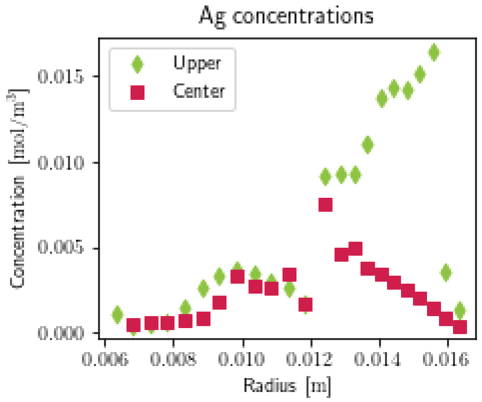
- No available data for sorption isotherms of isotopes (and concentrations) of interest
- Correlation approach; Narrow gap sizes make full CFD calculations computationally expensive
- Solubility/trapping information also missing

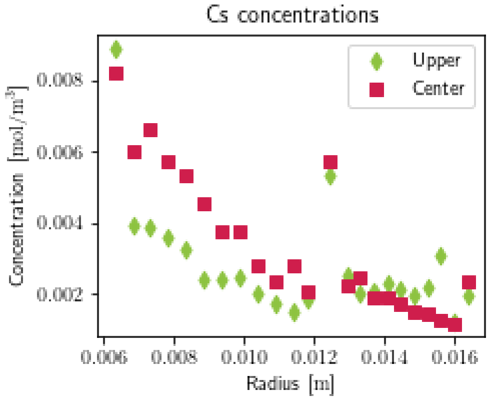
# Axial thermal profile calculations

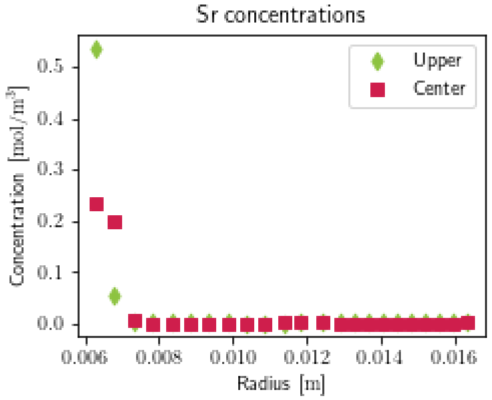
- Full 2D thermal profile is calculated using time-dependent axial temperature distributions at compact and ring boundaries from As-Run Thermal Analysis (Hawkes 2016) as boundary conditions
- Temperature transients are not expected to significantly impact transport
  - Total time of transient is approximately 15 minutes
  - Instantaneous inventory of fission products in the gas phase (outside of rings) is small enough to be negligible
- Not explicitly modeling the grafoil on top/bottom of ring (which is modeled in the As-run analysis) except via temperature at the inner/outer boundary
  - Grafoil is thermally anisotropic (>10x) and accounts for some of the axial thermal variations

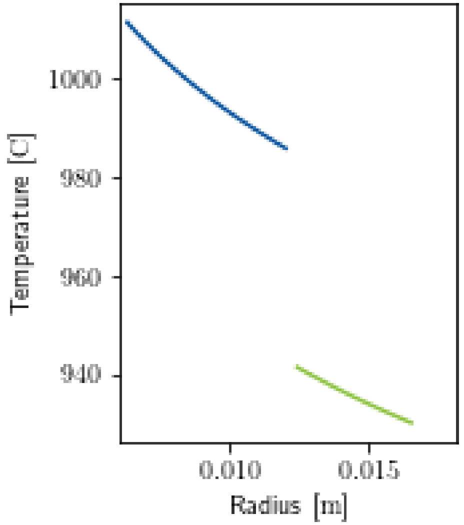
# Capsule 3

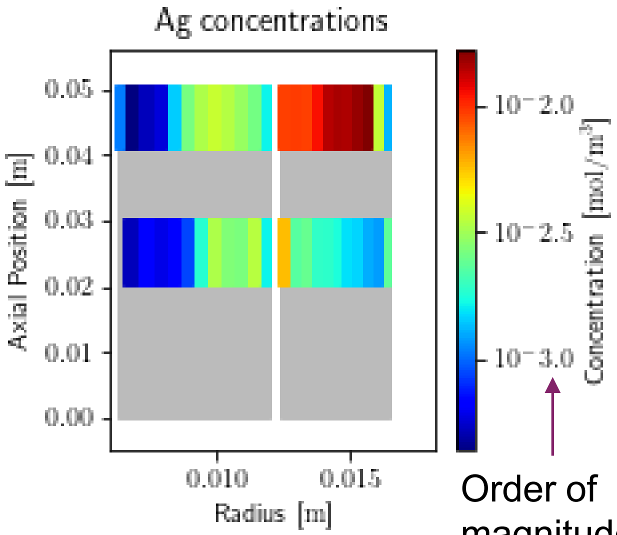


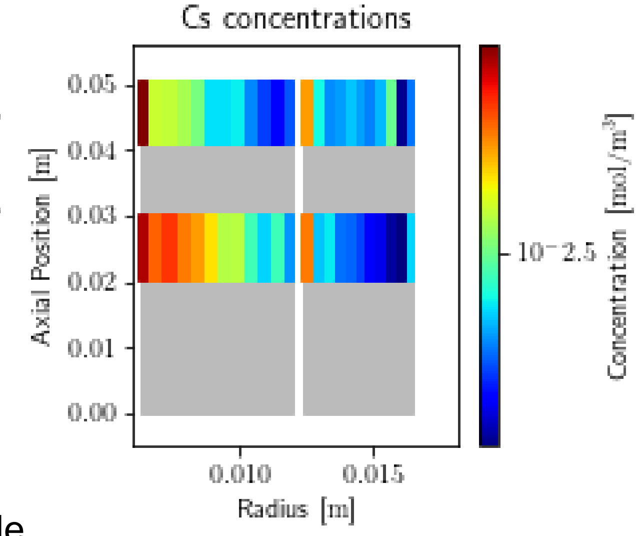



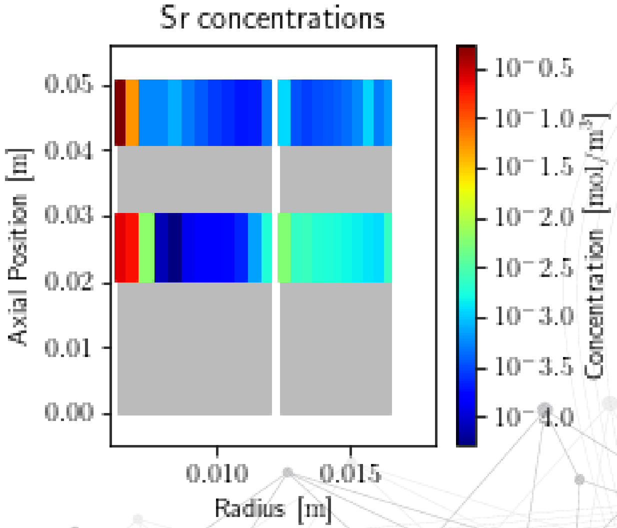



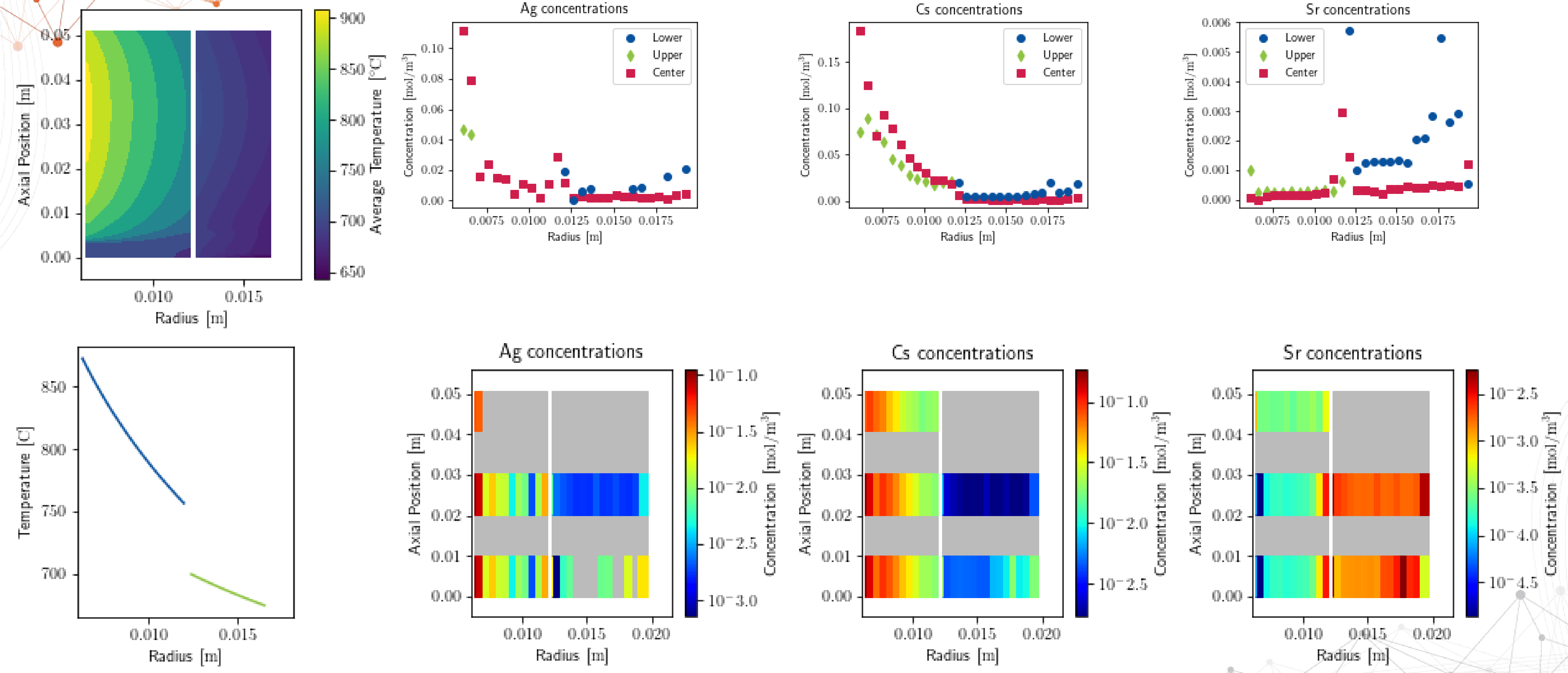




Order of magnitude (superscript)



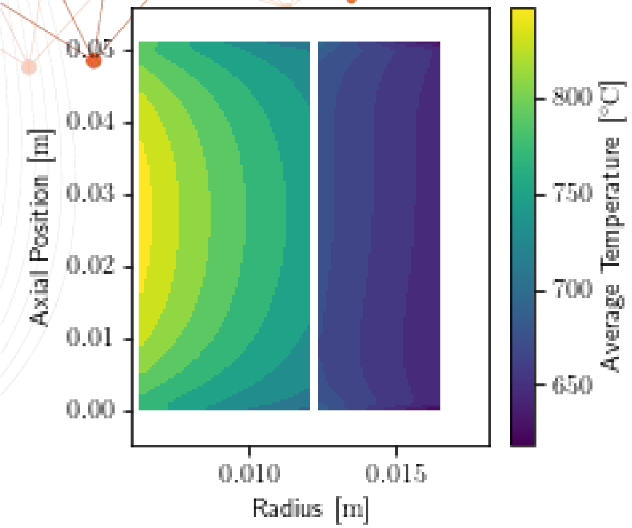



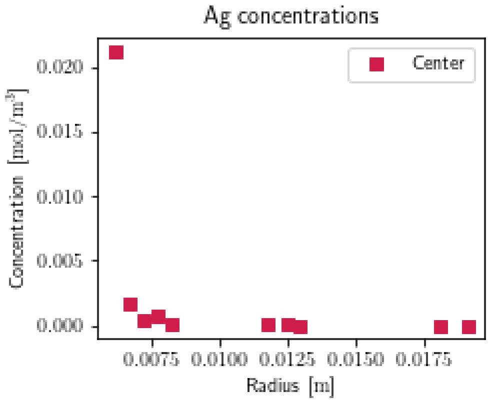
# Capsule 4

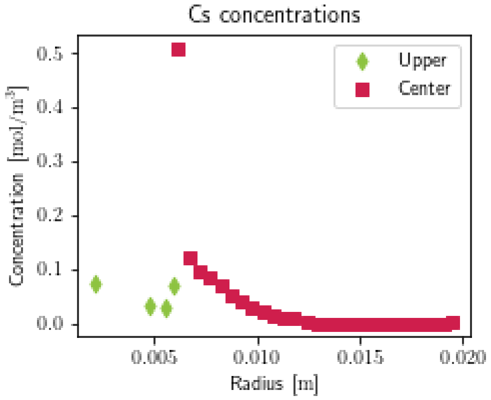


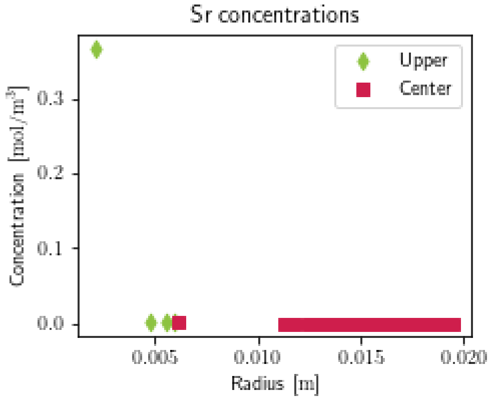
Axial Position [m]
Radius [m]
Average Temperature [°C]
Ag concentrations
Cs concentrations
Sr concentrations
Lower
Upper
Center
Concentration [mol/m³]
Temperature [C]

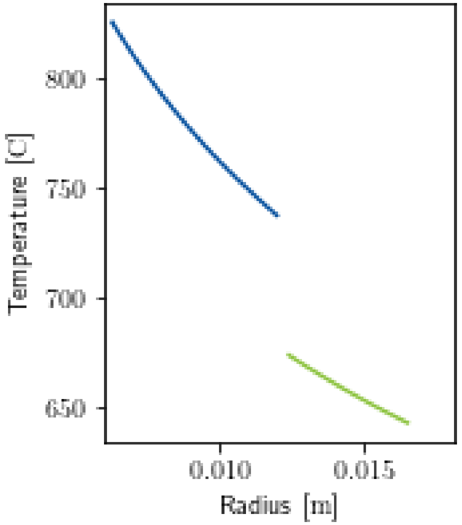
# Capsule 5

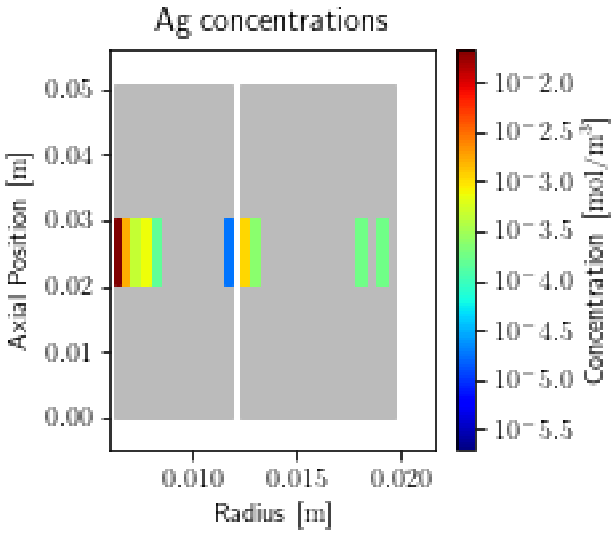


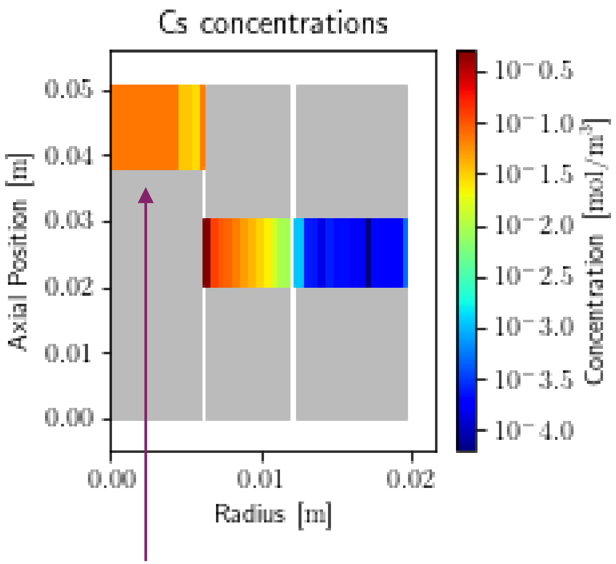



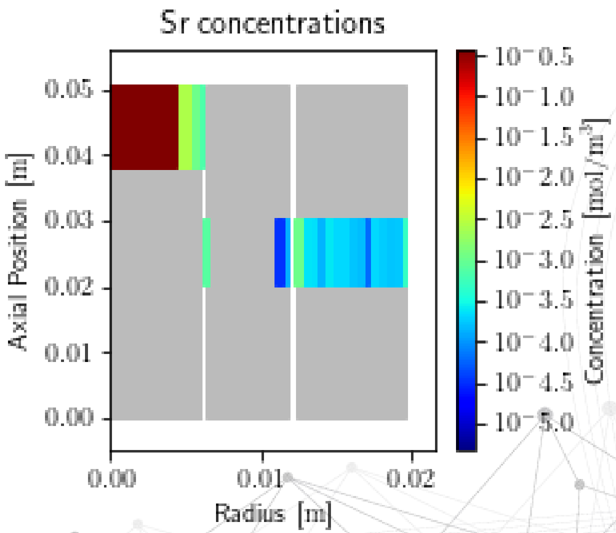



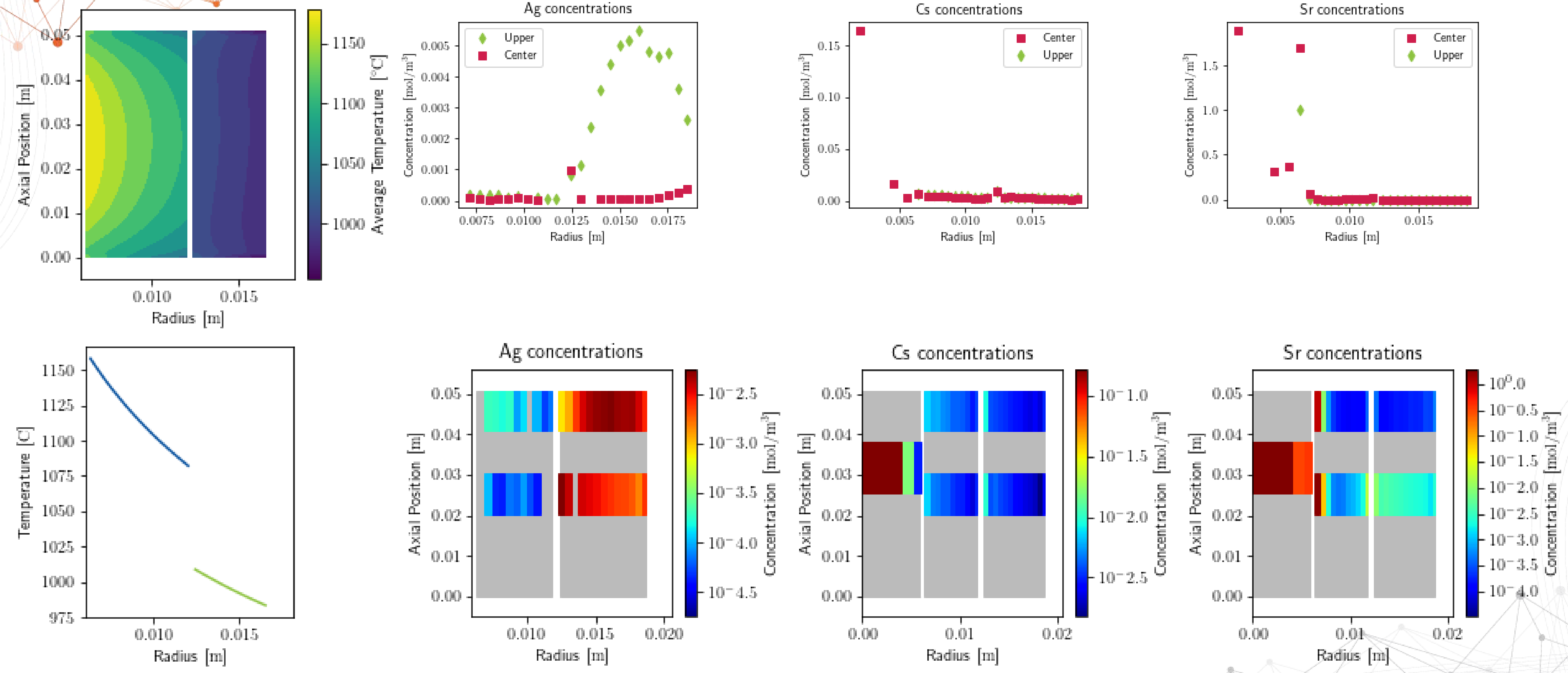




Compact concentration profile

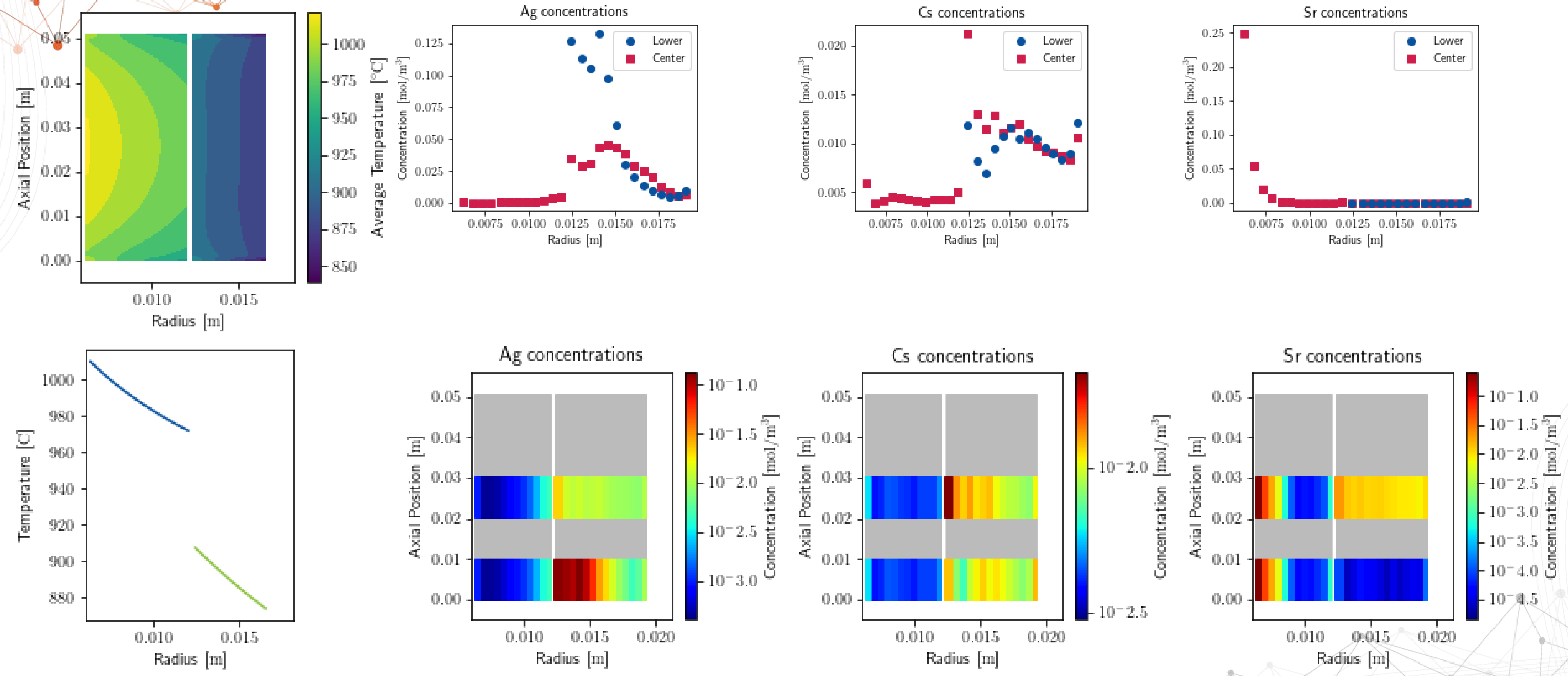


# Capsule 7



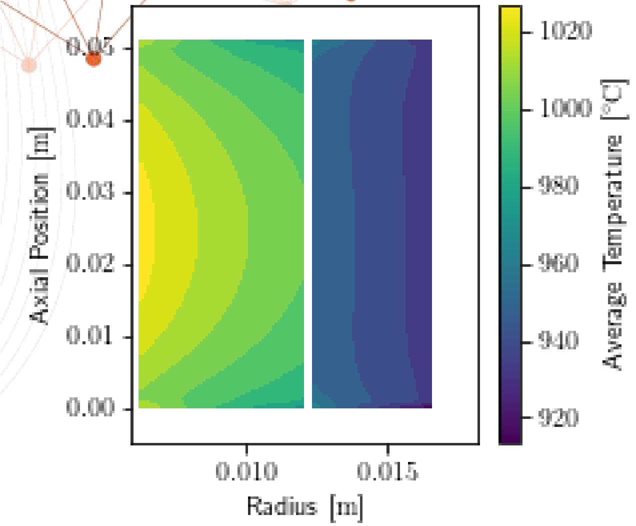
Axial Position [m]
Radius [m]
Average Temperature [°C]
Ag concentrations
Upper
Center
Concentration [mol/m³]
Radius [m]
Cs concentrations
Center
Upper
Concentration [mol/m³]
Radius [m]
Sr concentrations
Center
Upper
Concentration [mol/m³]
Radius [m]
Temperature [C]
Radius [m]
Ag concentrations
Axial Position [m]
Concentration [mol/m³]
Radius [m]
Cs concentrations
Axial Position [m]
Concentration [mol/m³]
Radius [m]
Sr concentrations
Axial Position [m]
Concentration [mol/m³]
Radius [m]

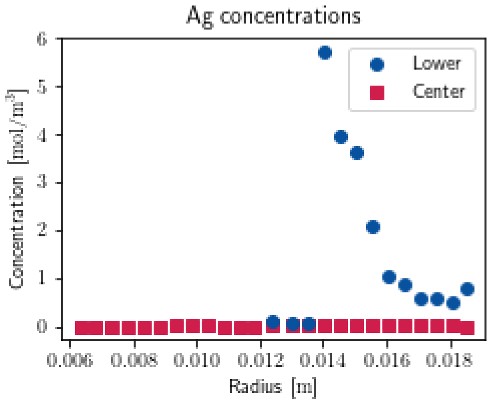
# Capsule 8

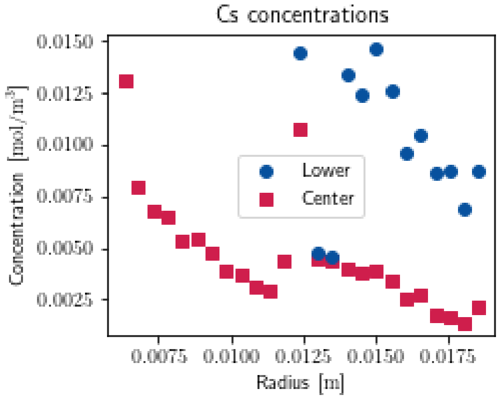


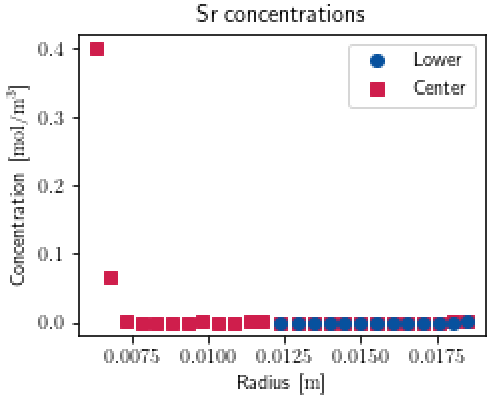
Axial Position [m]
Radius [m]
Average Temperature [°C]
Ag concentrations
Cs concentrations
Sr concentrations
Lower
Center
Concentration [mol/m³]
Temperature [C]

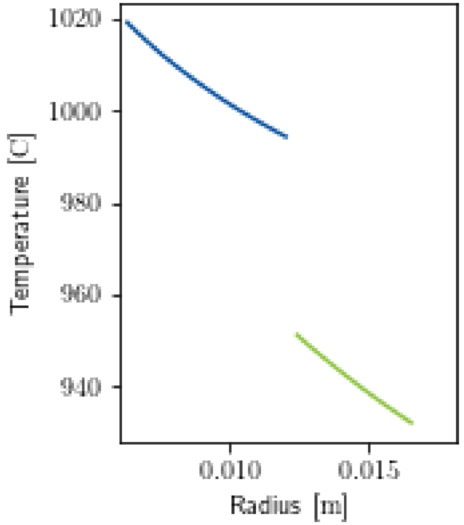
# Capsule 10

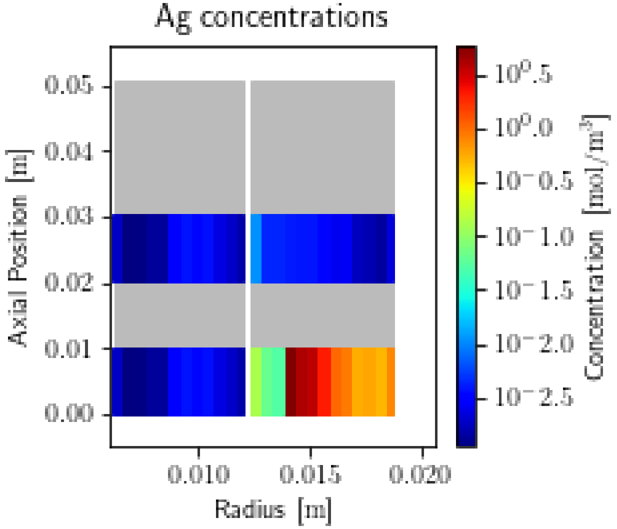

Axial Position [m]
Radius [m]
Average Temperature [°C]

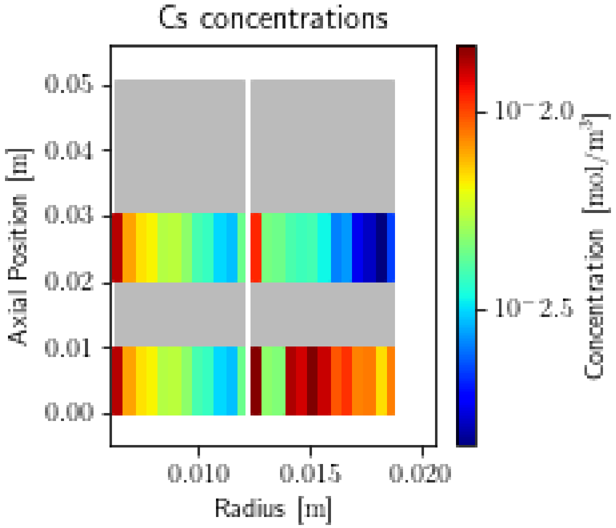

Ag concentrations
Lower
Center
Concentration [mol/m³]
Radius [m]

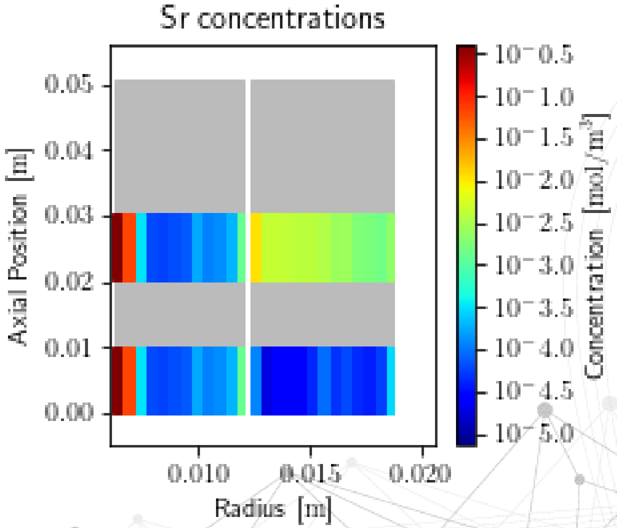

Cs concentrations
Lower
Center
Concentration [mol/m³]
Radius [m]


Sr concentrations
Lower
Center
Concentration [mol/m³]
Radius [m]

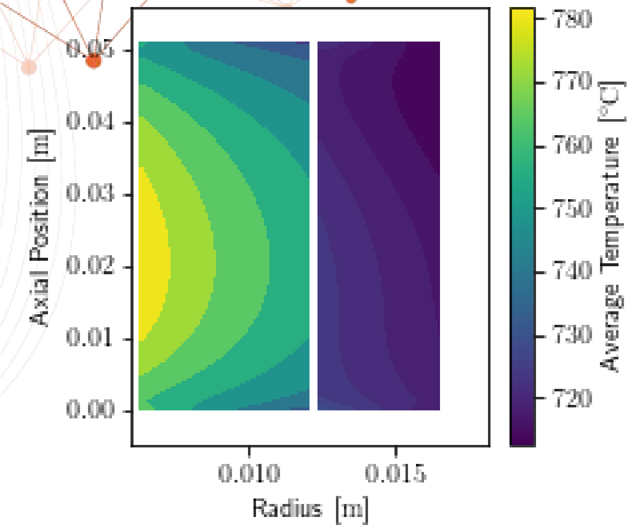

Temperature [C]
Radius [m]


Ag concentrations
Axial Position [m]
Radius [m]
Concentration [mol/m³]

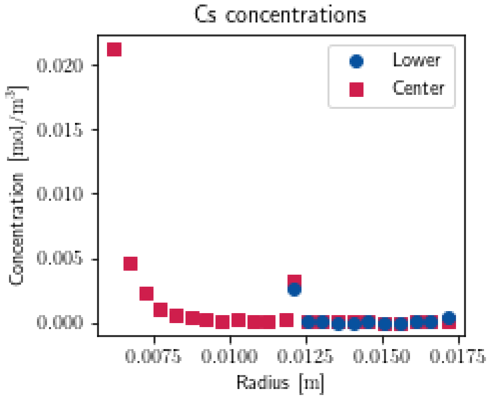

Cs concentrations
Axial Position [m]
Radius [m]
Concentration [mol/m³]


Sr concentrations
Axial Position [m]
Radius [m]
Concentration [mol/m³]

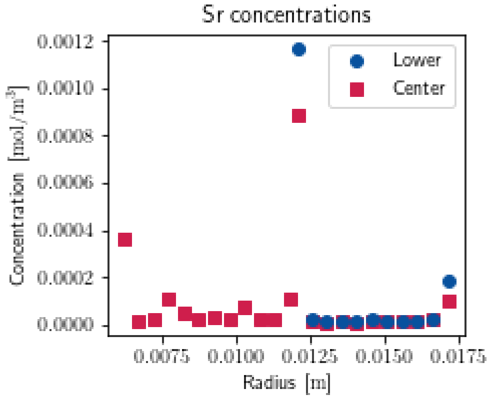
# Capsule 12



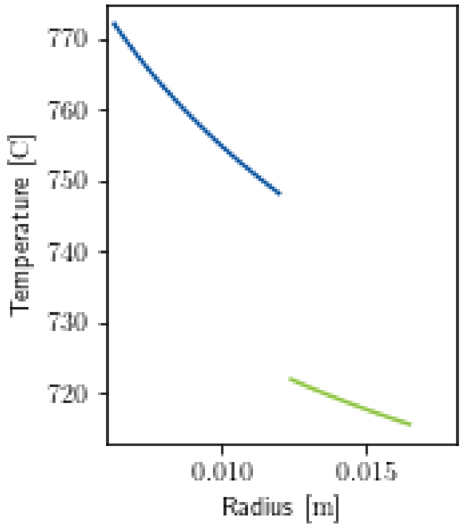
Axial Position [m]
Radius [m]
Average Temperature [°C]

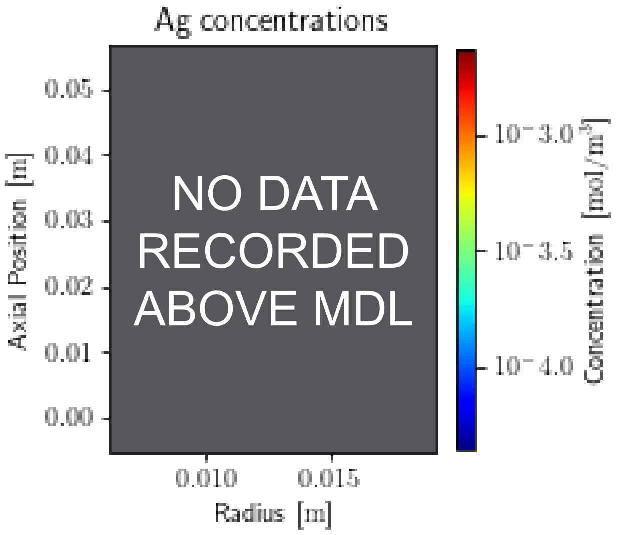
Cs concentrations
Lower
Center
Concentration [mol/m³]
Radius [m]

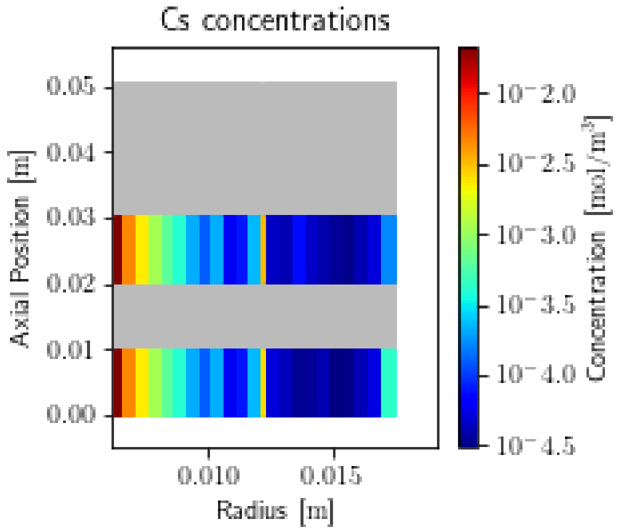
Sr concentrations
Lower
Center
Concentration [mol/m³]
Radius [m]

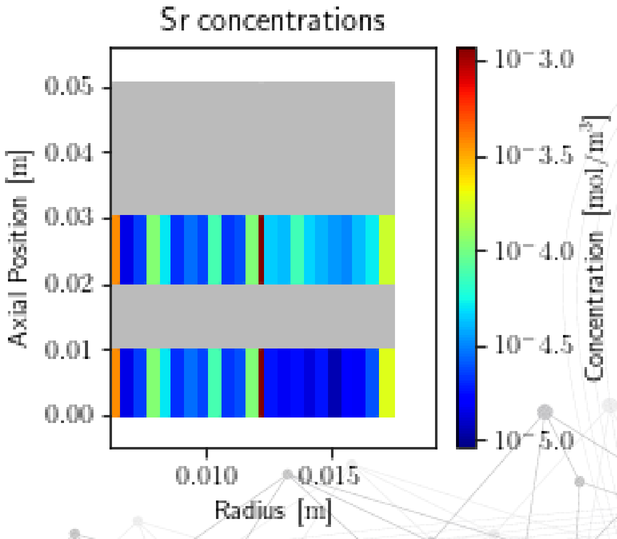
Temperature [C]
Radius [m]

Ag concentrations
NO DATA RECORDED ABOVE MDL
Axial Position [m]
Radius [m]
Concentration [mol/m³]

Cs concentrations
Axial Position [m]
Radius [m]
Concentration [mol/m³]

Sr concentrations
Axial Position [m]
Radius [m]
Concentration [mol/m³]

# Further Work Planned

- 2D Air-gap explicit full model
  - Natural convection effects
- Sorption-based activity coefficient model
  - Does not address Eu-154 diffusion
- Gas permeation model (related to sorption-based activity coefficient)