Thermal Analysis of Electronics Cabinet

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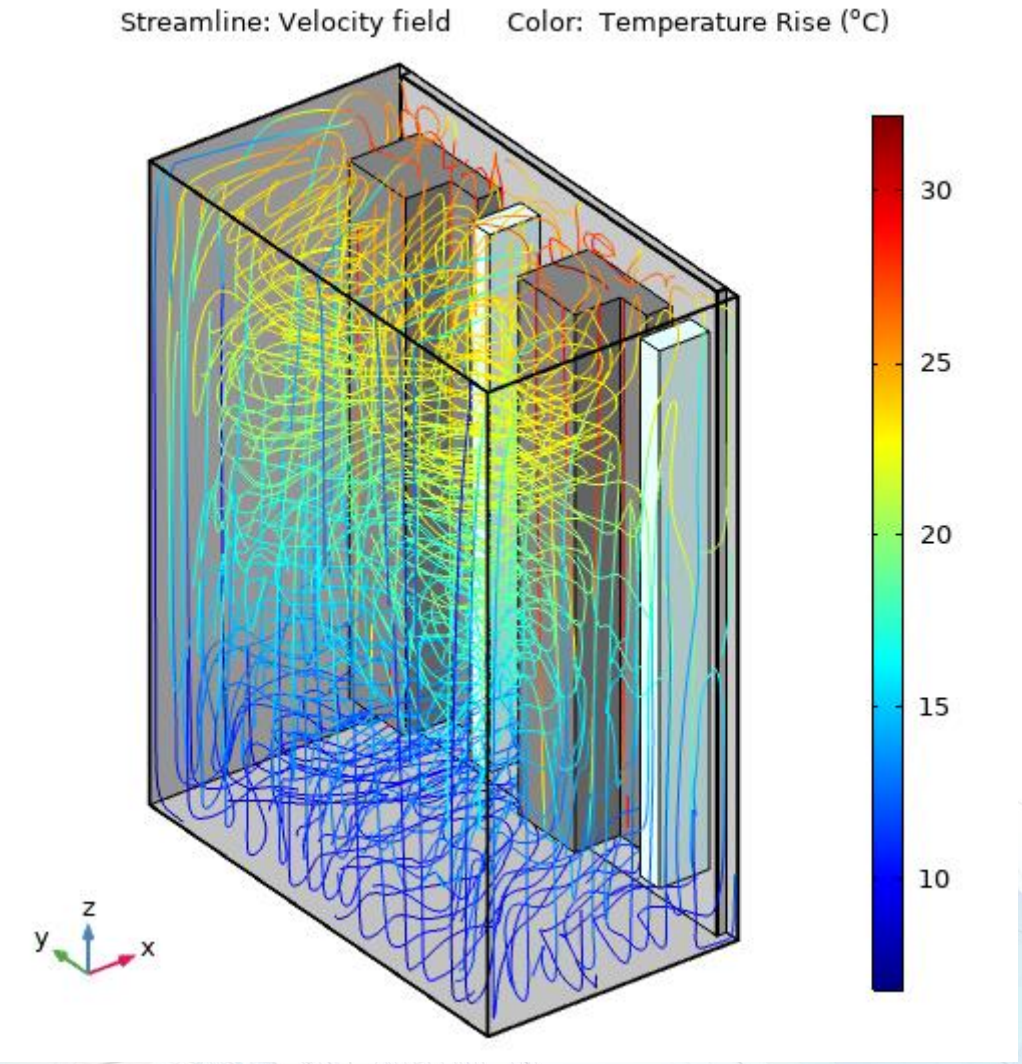
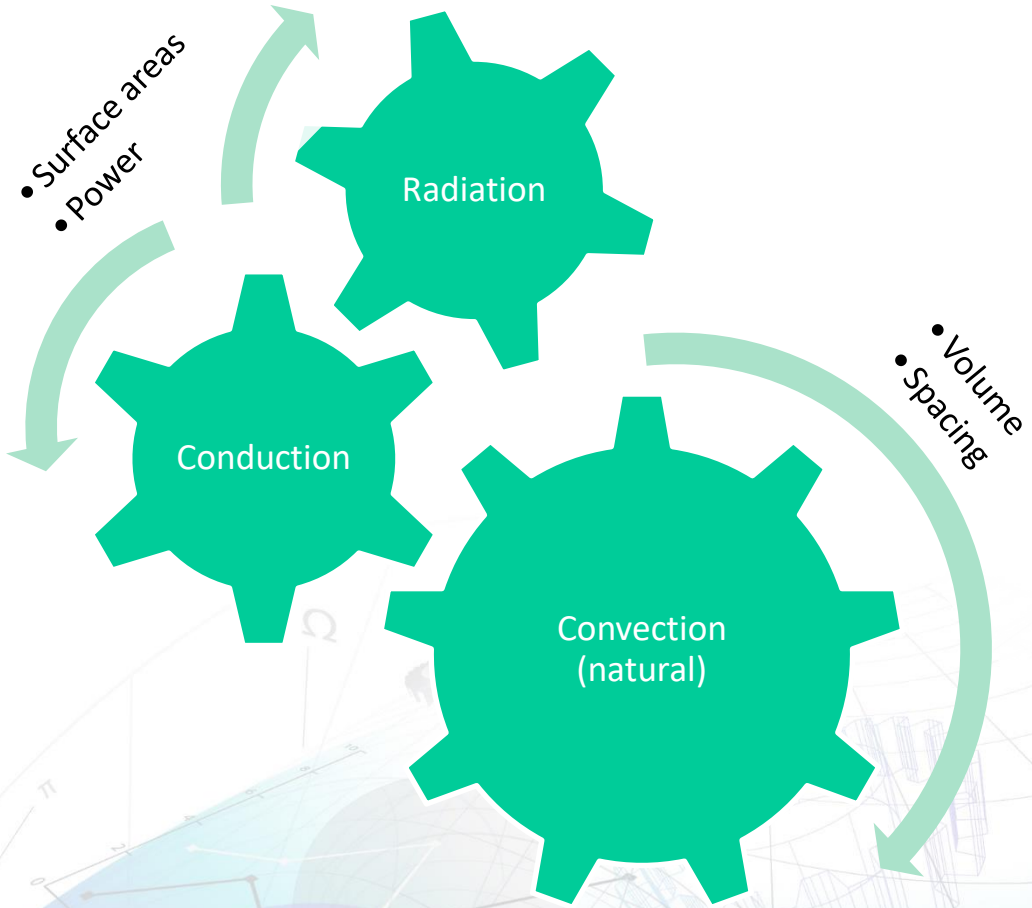
Outline

- Objective
- Geometry
- Physics
- Spacing sensitivity



OBJECTIVE

Use multiphysics modeling to understand passive energy dissipation in electronics cabinets



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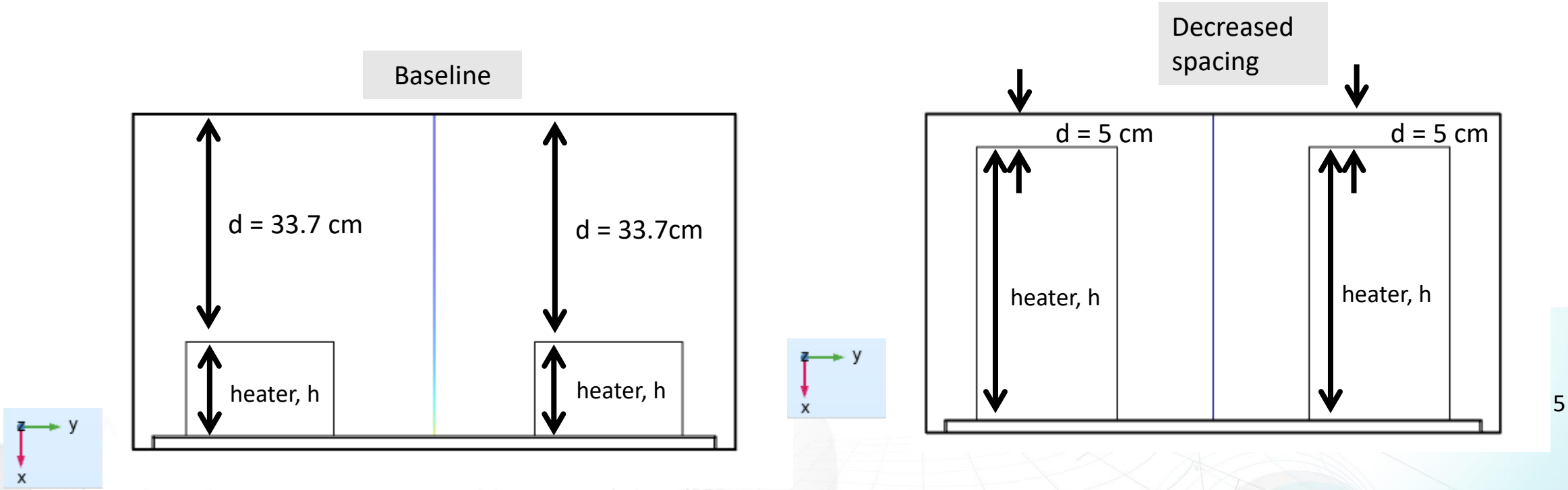
Specifically, we seek to understand effect of spacing parameter on maximum temperature rise



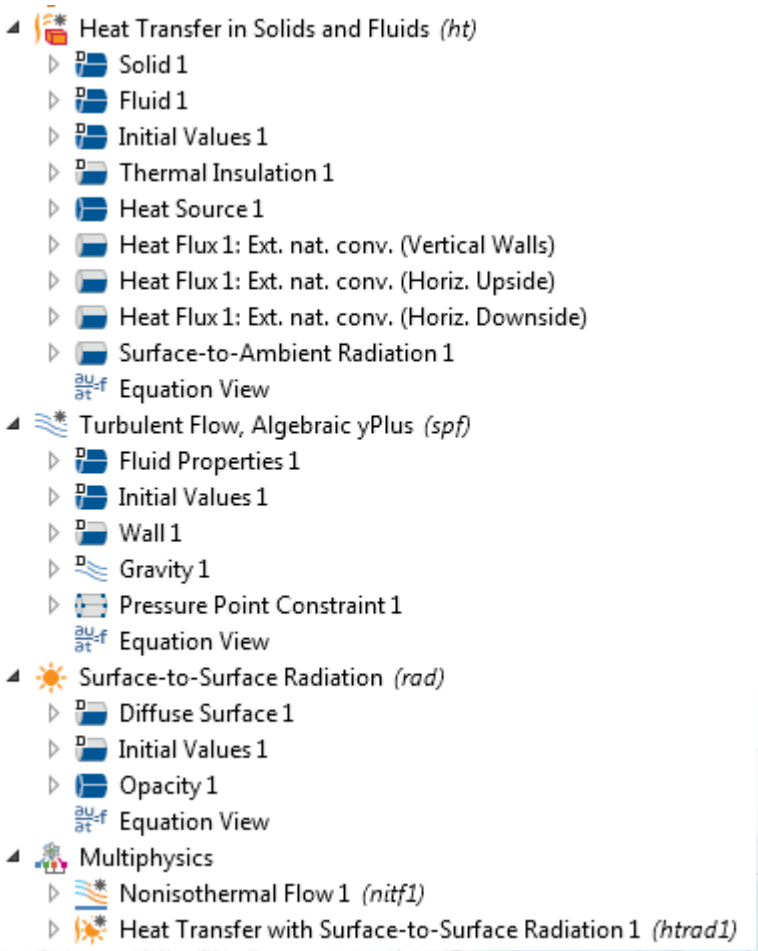
PHYSICS

Conjugate heat transfer with radiation

- Intimately coupled, multiphysics analysis
- Solids
  - Heat equation
  - Surface-to-surface radiation
  - Fluid
  - Conservation of mass, momentum, and energy
  - $\rho(T,p)$
- Non-default solver strategy

See AltaSim Tips & Tricks Article

http://www.altasimtechnologies.com/



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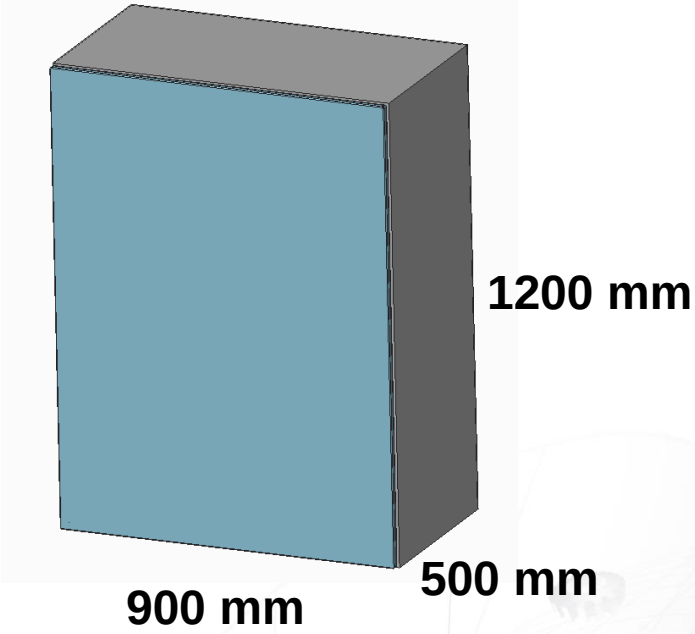
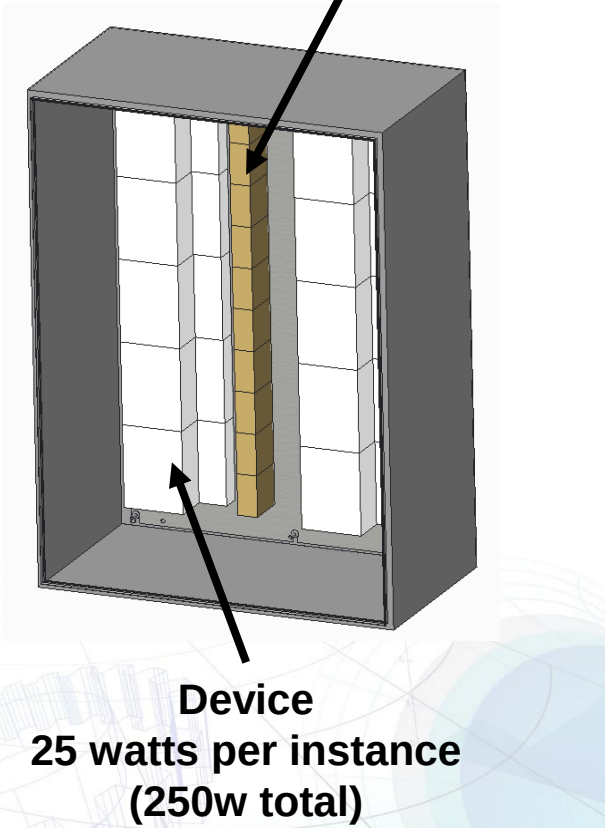
GEOMETRY

Geometry simplified for parametric studies





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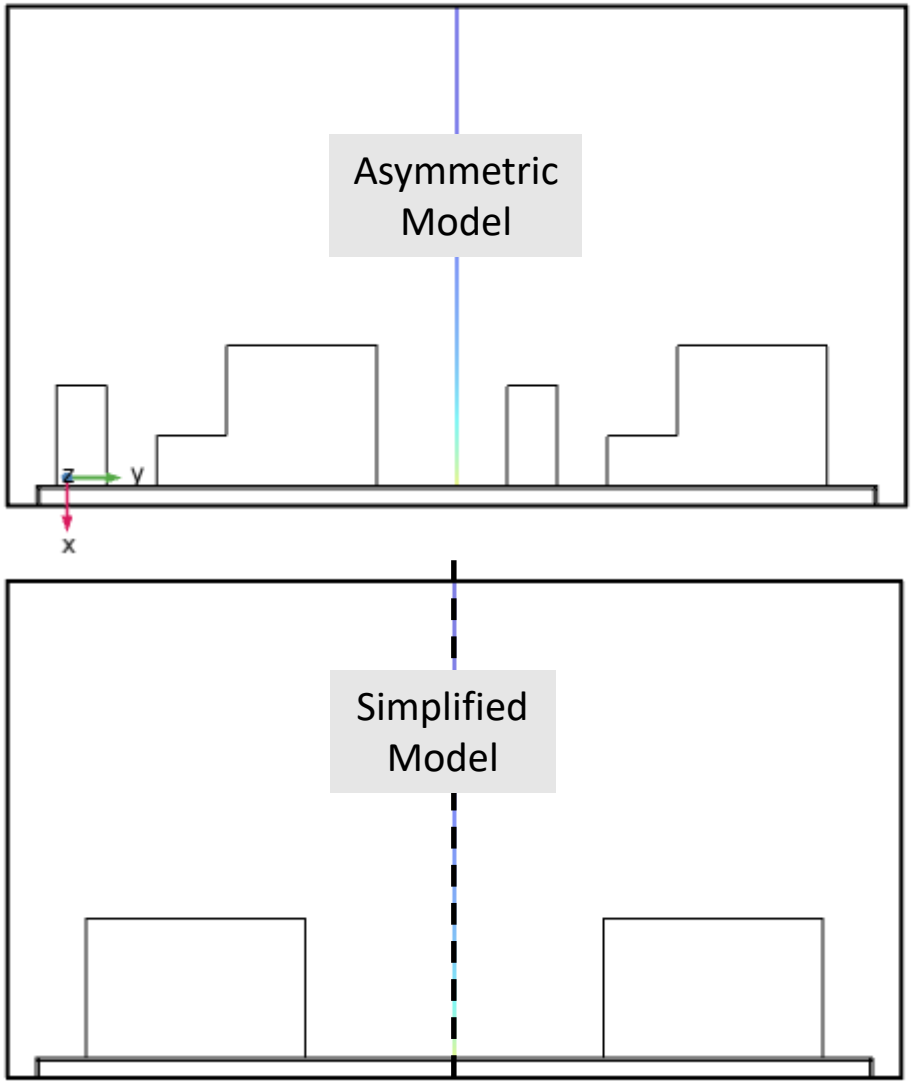
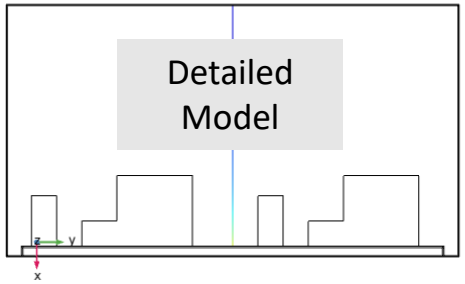
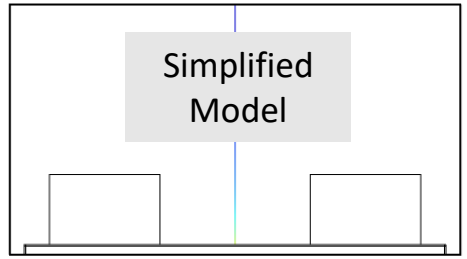
Simplification for half symmetry

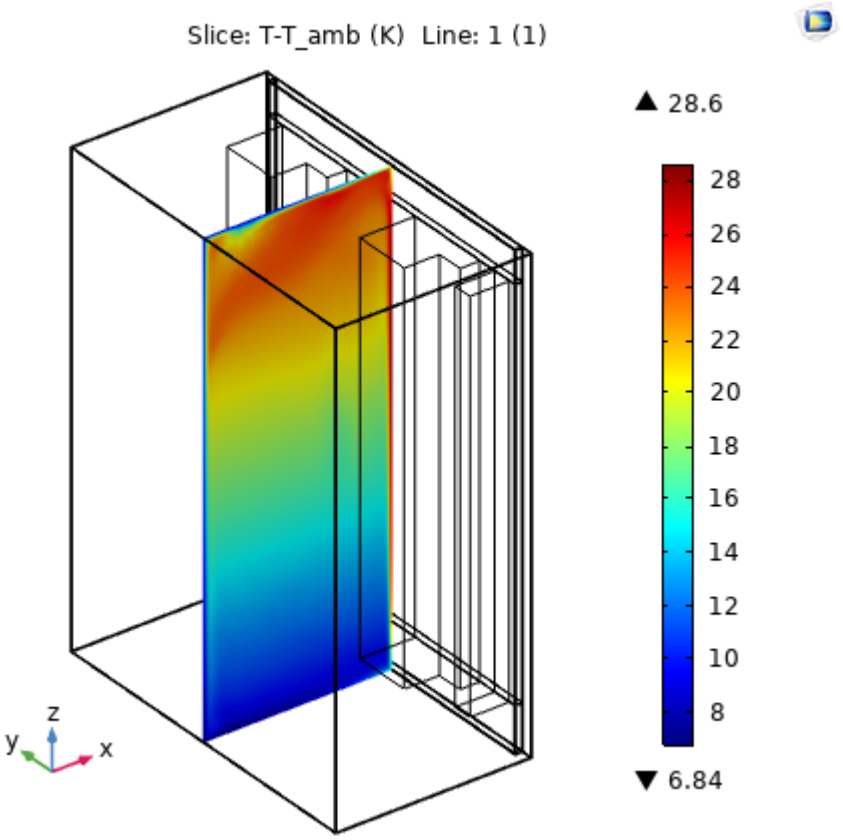
- Heater geometry simplified
- Wire troughs removed
- Half symmetric

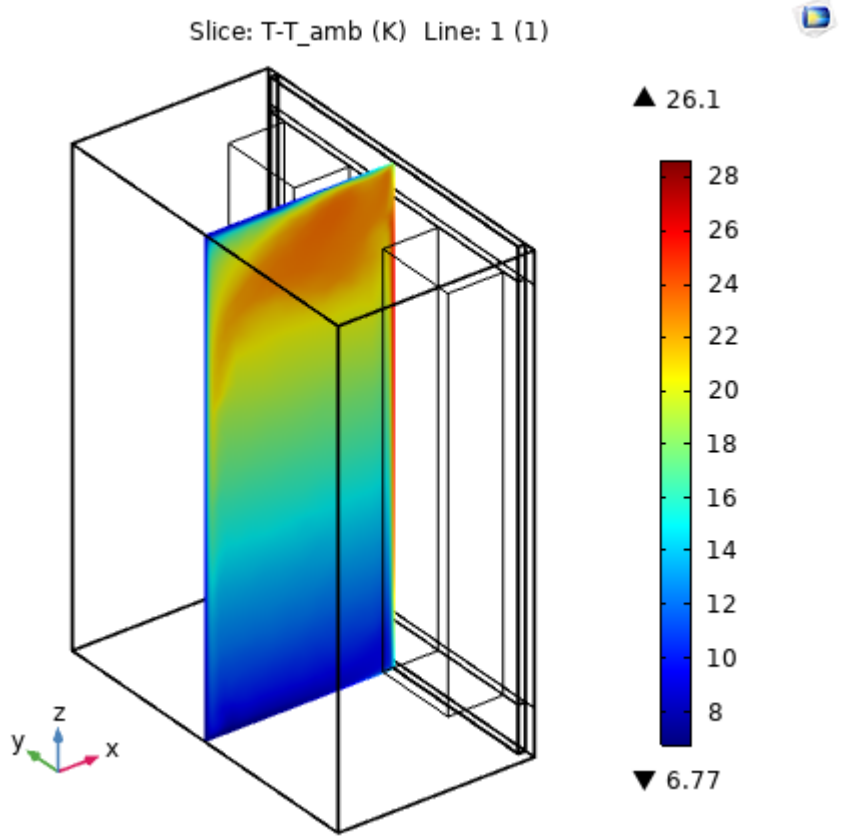


Confirm simplified model is representative







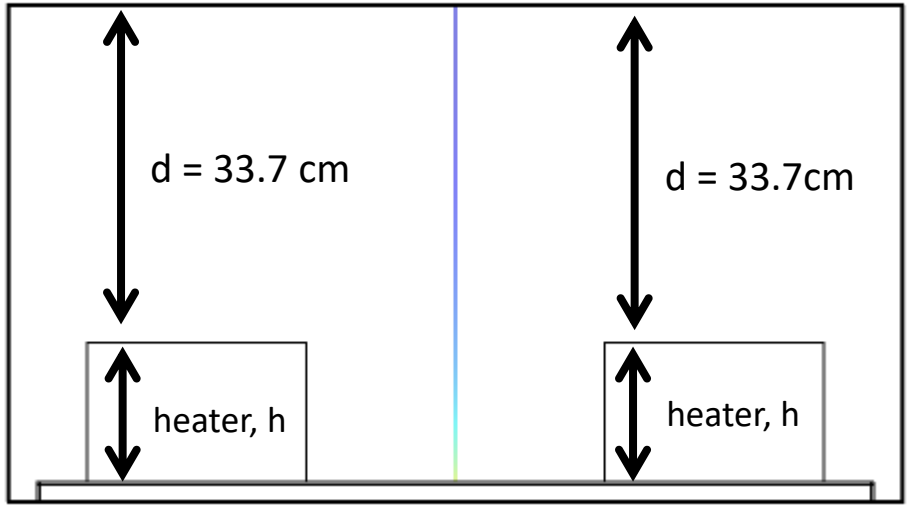


SPACING “GAP” SENSITIVITY

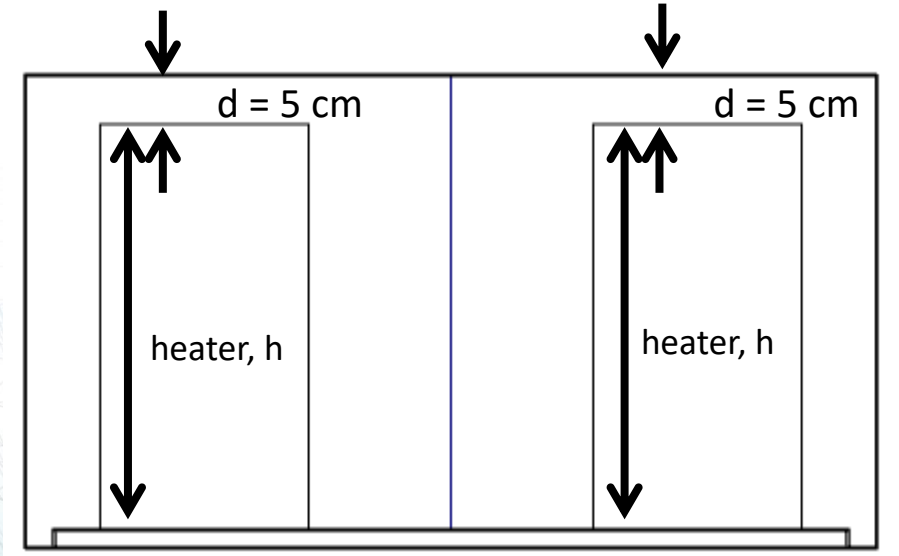
Spacing geometric parameter

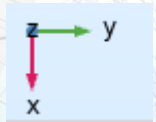
- Spacing between heater and front face of cabinet, d
- Decrease d by increasing heater size, h
- Keep power the same at 250 W

Baseline

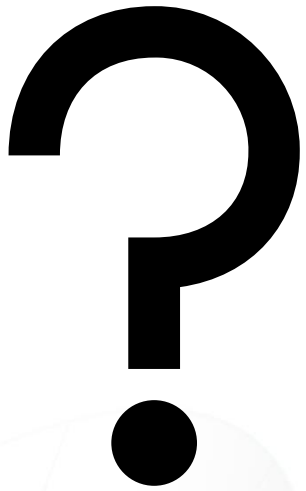


Spacing, d = 5 cm





What effect will decreasing the spacing have on the peak temperature?



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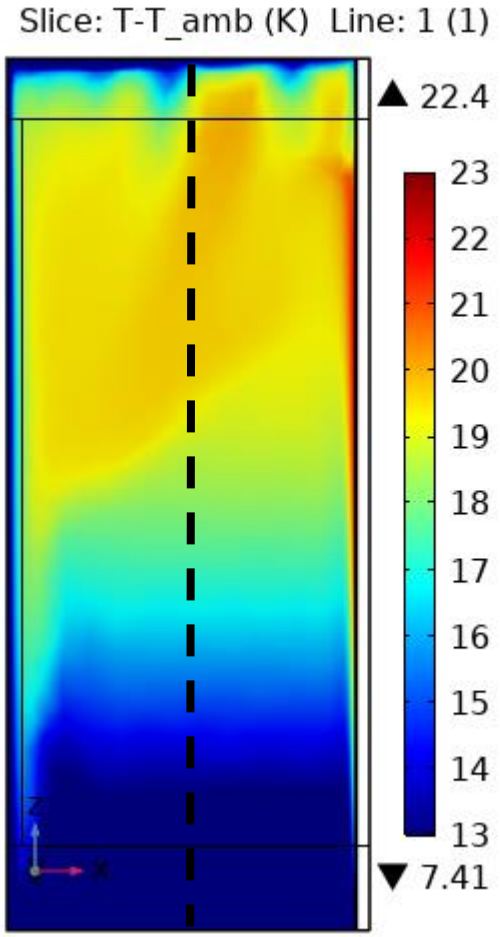
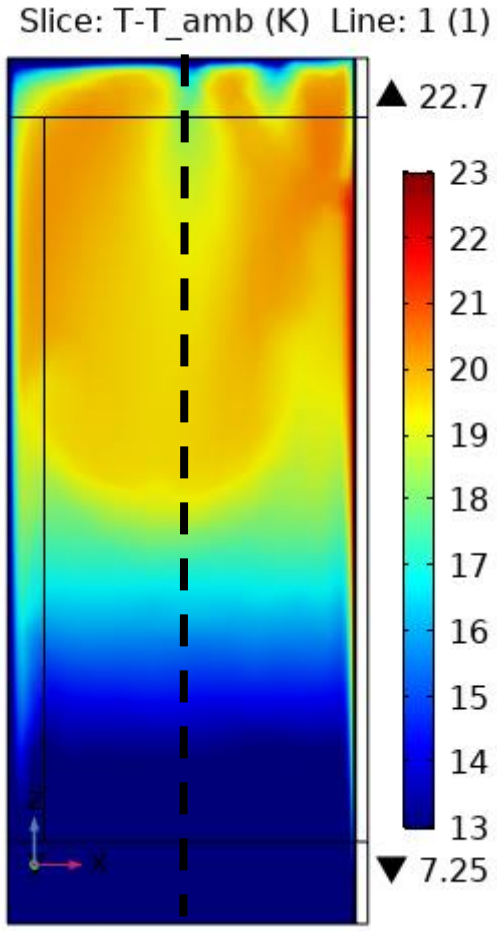
Temperature variation: Effect of spacing

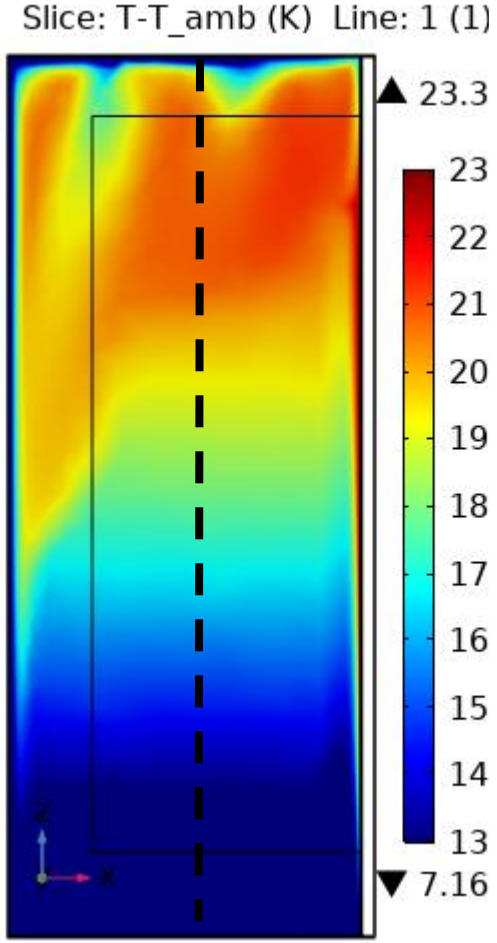
2 cm



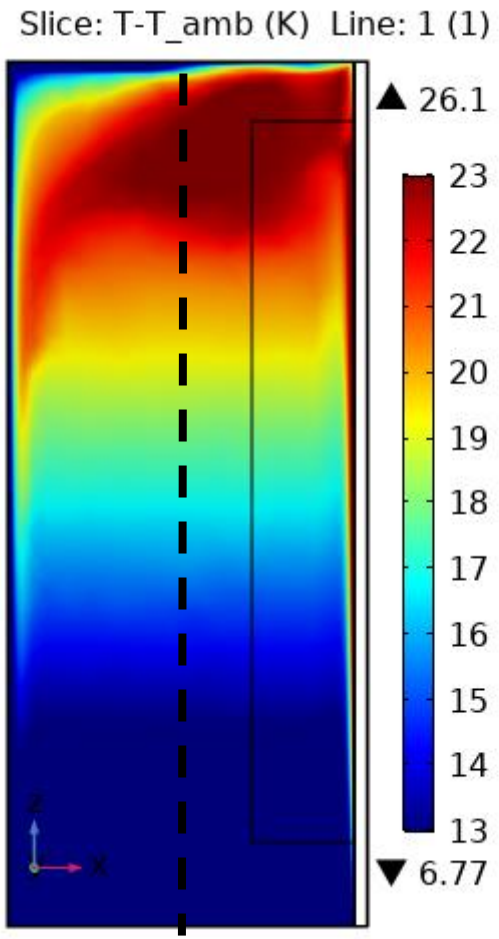
5 cm



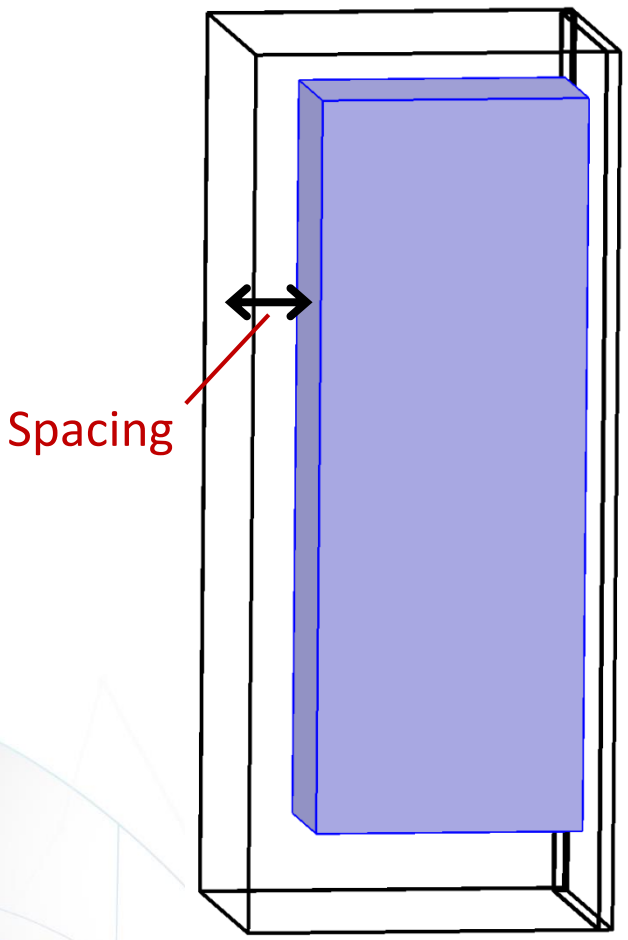
11.3 cm

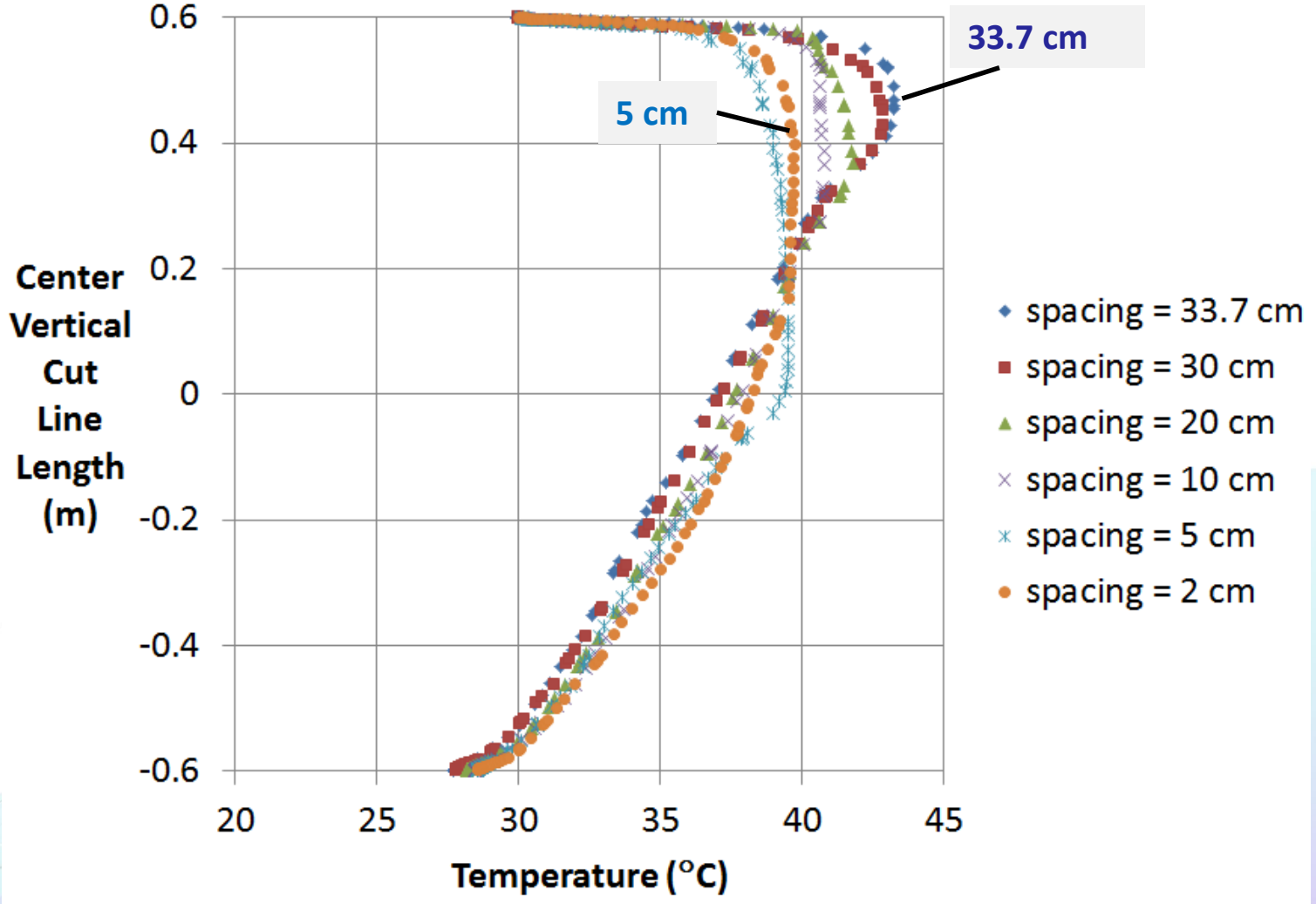


33.7 cm



Peak temperature increases as spacing increases





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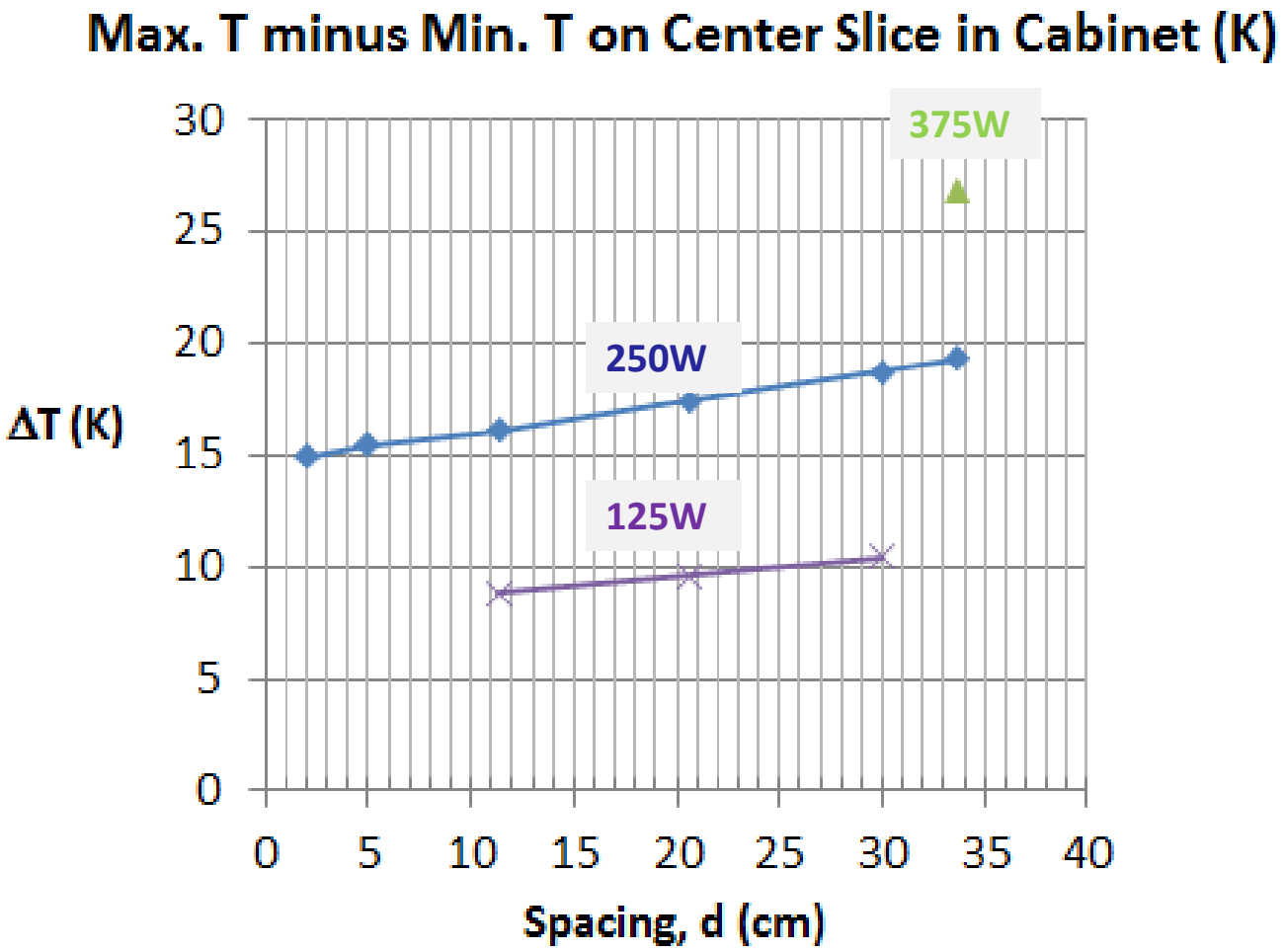
ΔT top to bottom: Effect of spacing and power



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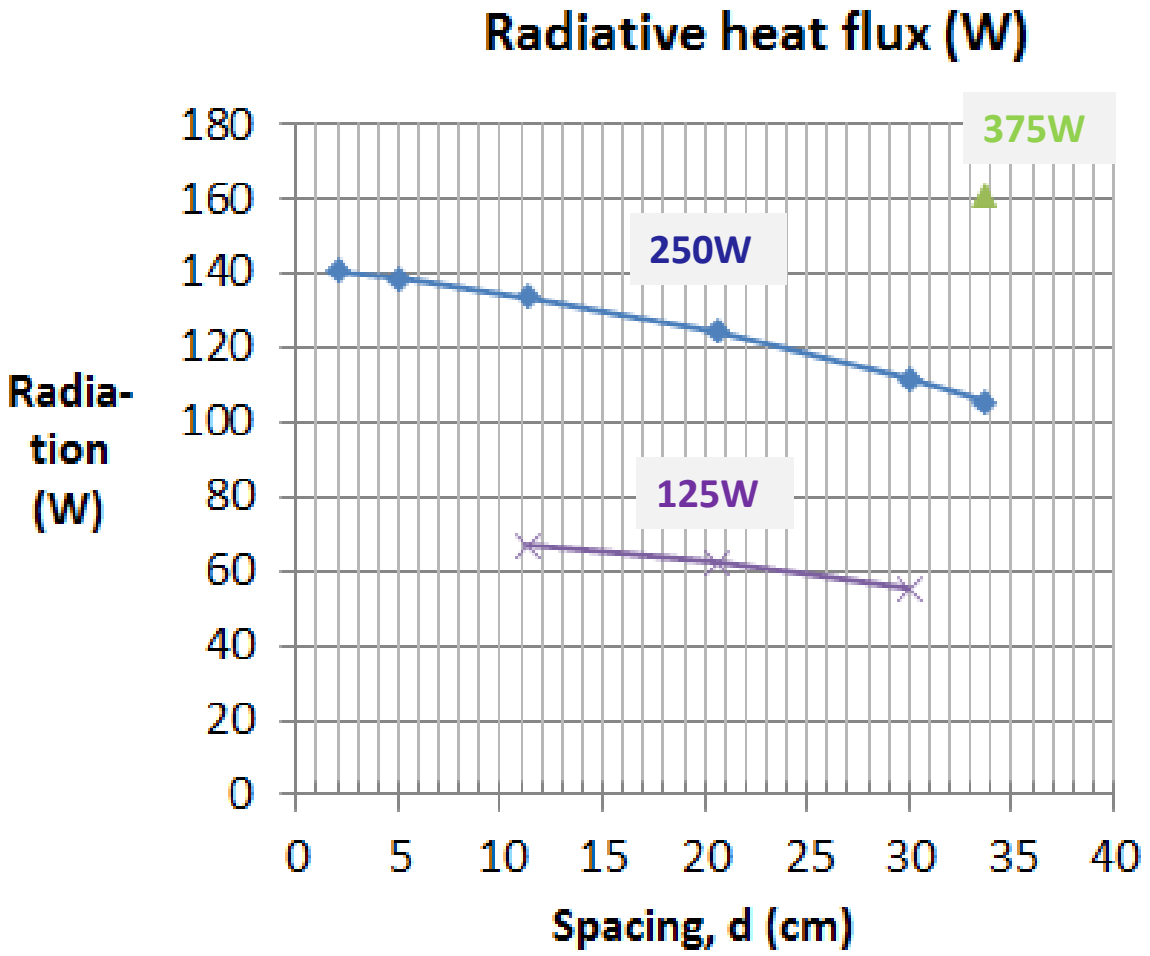
Radiative heat flux: Effect of applied power



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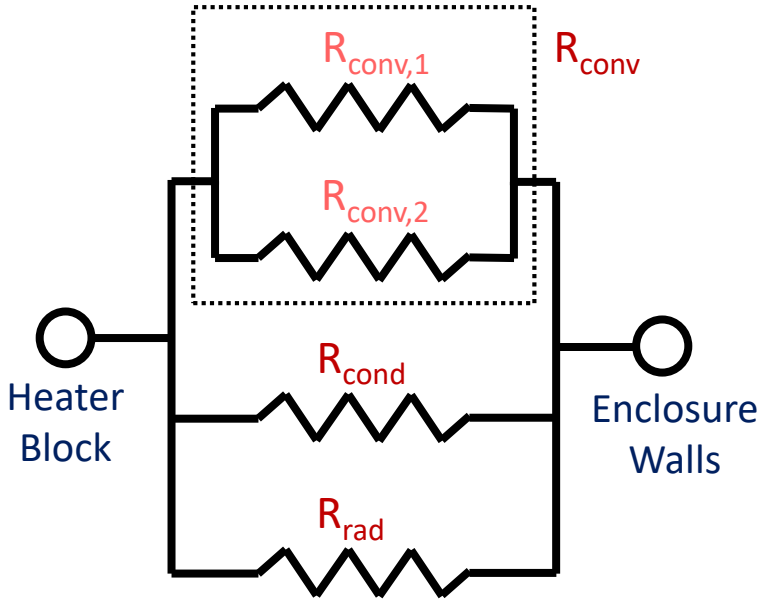
Effect of spacing on thermal resistances in cabinet model



Thermal Resistances (°C/W) at 250 W							
		Thermal Path					R_{total}
		R_{rad}	R_{cond}	R_{conv}	$R_{conv,1}$	$R_{conv,2}$	
Spacing (cm)	**11.3**	0.119	0.322	0.238	1.345	0.289	0.063
	20.7	0.143	0.316	0.260	1.182	0.333	0.071
	30.0	0.183	0.301	0.291	1.074	0.399	0.082

R_{rad}: Radiation from heating block to enclosure walls
R_{cond}: Conduction from heating block into back plate
R_{conv}: Total convection from heating block to enclosure walls
$R_{conv,1}$: Convection from "front" face of heating block
$R_{conv,2}$: Convection from all other faces of heating block

Convective resistance from front face does indeed go down as spacing increases.

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Proportion of heat transfer mode versus spacing

	Mode of Heat Transfer		
Spacing (cm)	Convection	Conduction	Radiation
11	26%	21%	54%
21	26%	24%	50%
30	28%	27%	45%

Lessons learned

- Generally:
  - Radiation effect (even at “low” temperatures) is important due to relatively low convection and conduction fluxes
- Specifically:
  - Negative effect of chocking of natural convection from front face not as important as positive effect of increasing surface area for radiation improvement and convection from other side faces

Further reading

- August 2019 - AltaSim COMSOL Tips Tricks - Solver Speed-up for Conjugate Heat Transfer with Radiation

- https://www.comsol.com/blogs/the-importance-of-thermal-radiation-in-your-models/

- https://www.comsol.com/offers/Predicting-the-Thermal-Performance-of-Electronic-Devices

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