Task 3: Humidity Chamber

NMI3-Soft Matter JRA-WP20

Matt Barrett

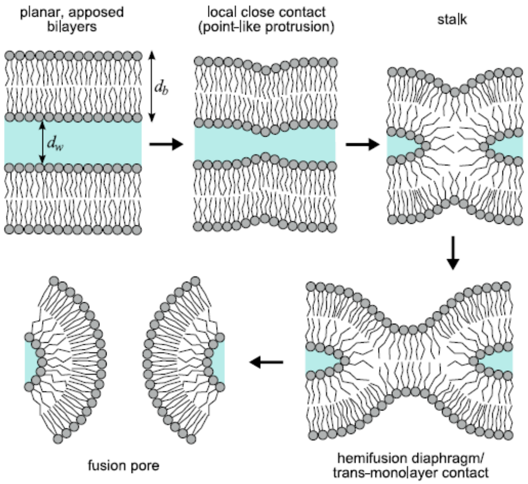
21.06.2013 - Berlin

In this talk…

- Project Overview
- Current Design
- Simulations

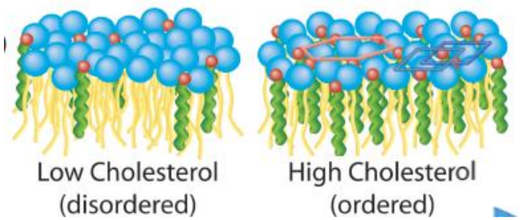
Motivation: Scientific Interests

- Stalk formation in membranes
  - Tuneable humidity facilitates phase transition from bilayer to stalk, normally protein facilitated

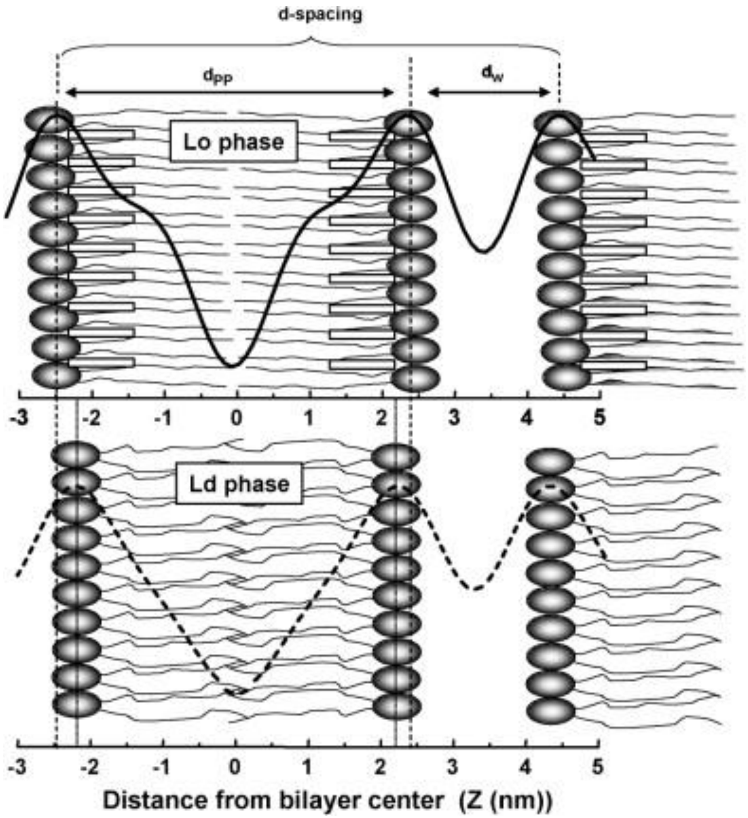


Aeffner, 2012.

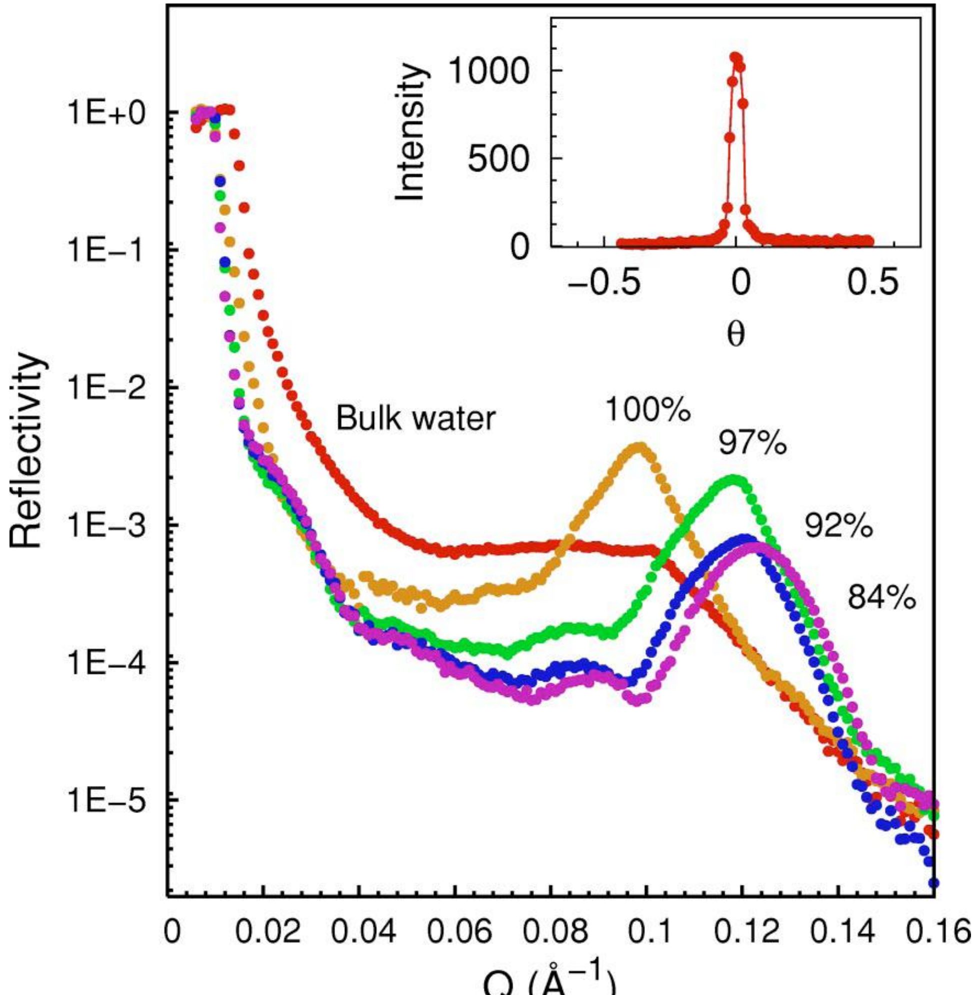
- Cholesterol solubility in DMPC membranes
  - Determine cholesterol solubility limit when approaching physiological conditions (high humidity)



Toward 100% RH, no condensation



Tessier, J. Colloid and Interface, 2008



Harroun, Rev. Sci. Instruments, 2005

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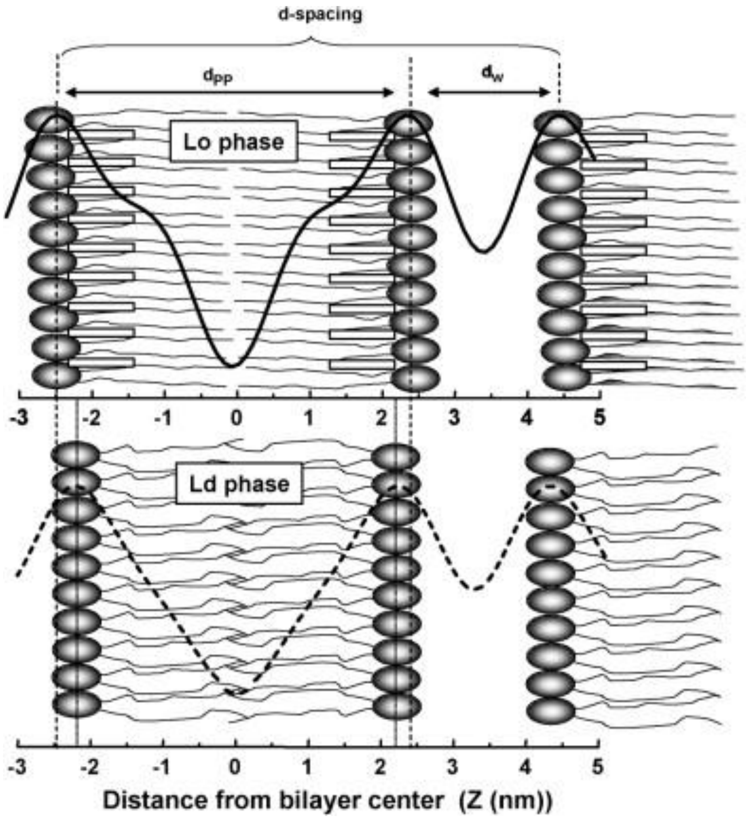

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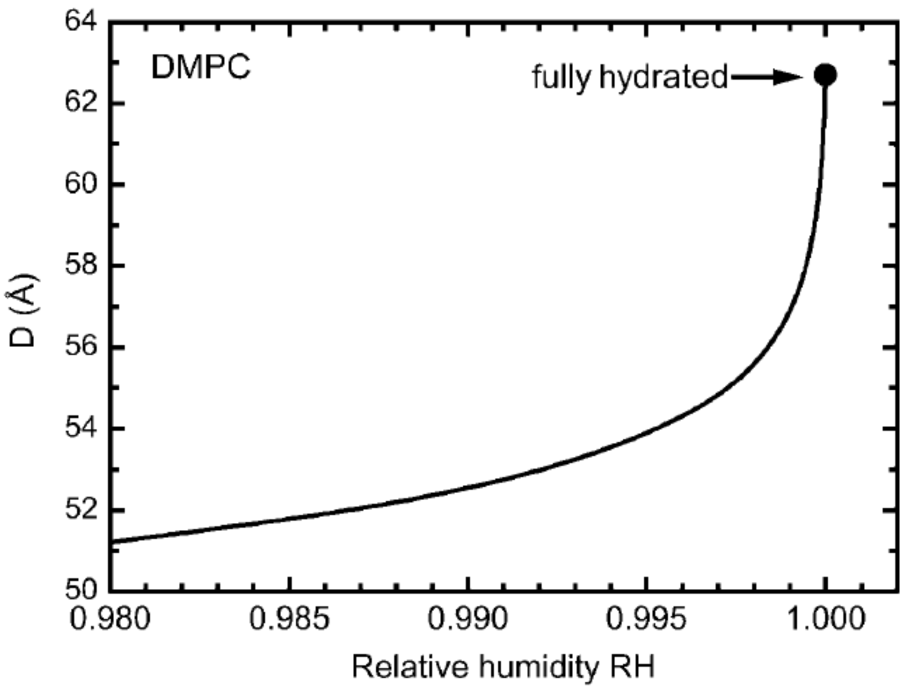


Kučerka, Biophysical Journal, 2005

Project goal

Develop a humidity chamber which has:

- faster and better controlled temperature and humidity response
- the ability to access large a T and RH range
- adaptability to different neutron instrument geometry
- option for multi-sample holder

Timeline

Year 1:

Review the existing systems determine the specifications of the next-generation chambers (proposal suggested goal of 10 mK stability in T and 0.1% stability in RH)

Year 2:

Produce drawings

Year 3:

Build and commission chamber

Participants

Task Leader

HZB Helmholtz Zentrum Berlin

Partners

ILL Neutrons for Science Institut Laue-Langevin

Jülich Forschungszentrum

Observers

Science & Technology Facilities Council

Technische Universität München

cea energie atomique • energies alternatives

McMaster University

HZB Helmholtz Zentrum Berlin

Past Meetings

- 22nd October – Berlin (JRA kick-off)
- 7th December – Garching (NMI3 General Assembly – aux. meeting)
- 28th January – Paris (Work-package meeting)
- 6th March – Berlin/Grenoble (Video)
- 26th March – Berlin/Grenoble (Video)
- 14th May – Berlin/Grenoble (Video)

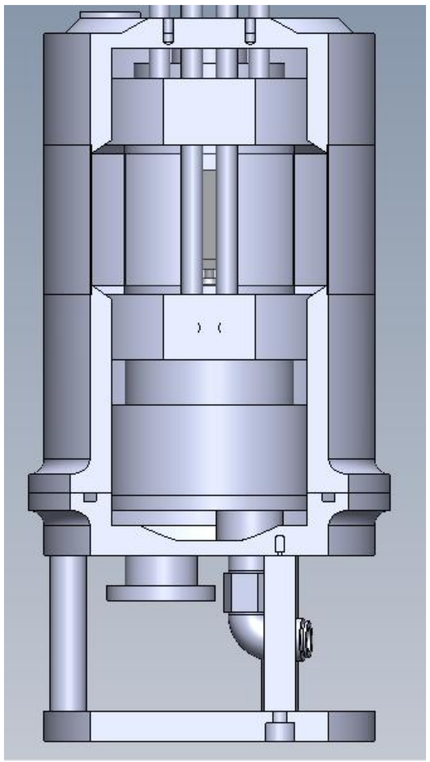
Humidity control techniques

	Humidity ceiling (at 25 C)	Humidity Stability	Automation for RH change	Equilibration time (after RH change)	Contrast variation (H_20/D_20)
Gas flow	~95%	~0.1% (or better?)	MFCs	minutes	Bubble through mix
Saturated salt	98% (discrete steps)	Weak temperature dependence	Syringe pumps (Sat. and distilled)	hours	Change of sample/ flow into reservoir
Temperature controlled	≤100%	~0.01% (or better?)	Peltier/water bath temp	hours	Flow liquid into reservoir
Fixed humid	Same as salt	No regulation	X	X	Change of sample
Bulk water	Saturated	Stable	X	X	Flow into bulk volume

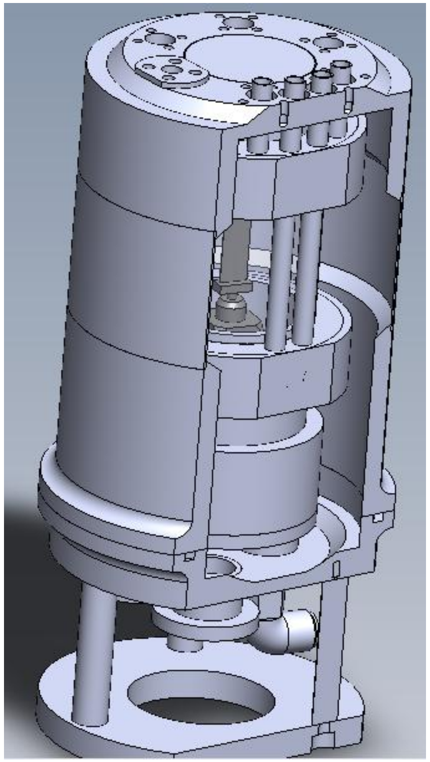
Current Design

- A. Perkins and ILL sample environment group
  - through discussions with HZB sample environment group
  - Scientific input from Bruno Demé, Thomas Hauß and Maikel Rheinstädter

Current Design



- Double walled (evacuated) Al
- Total size=240xØ110
- Inner cell=122xØ50
- Wide angular scanning range possible (~300°)
- Simple sample change



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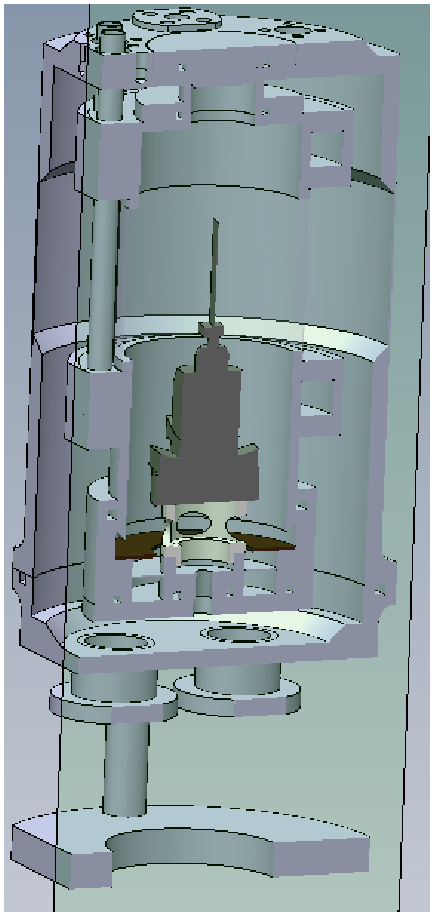
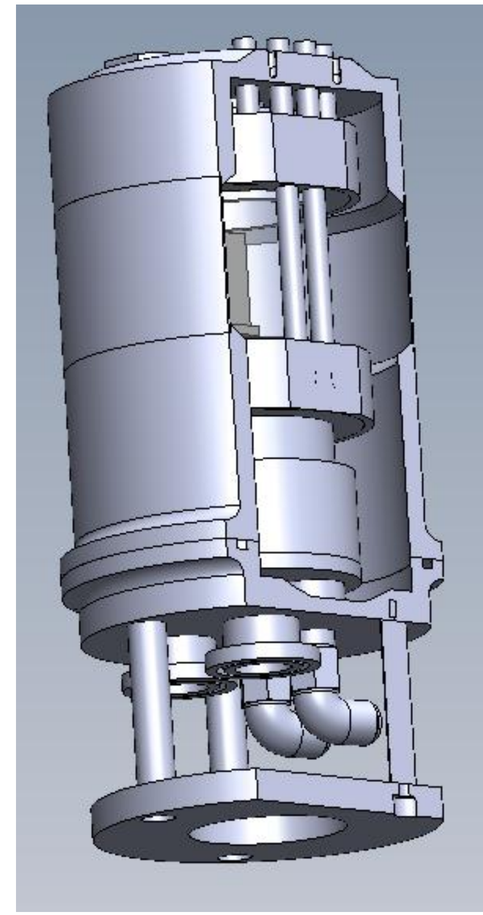
Current Design



- Three water channels for precise independent temperatures
- Sample cell thermally isolated (plastic post, steel supports)
- Access for wiring above and below sample (T or RH sensors, Peltier element)

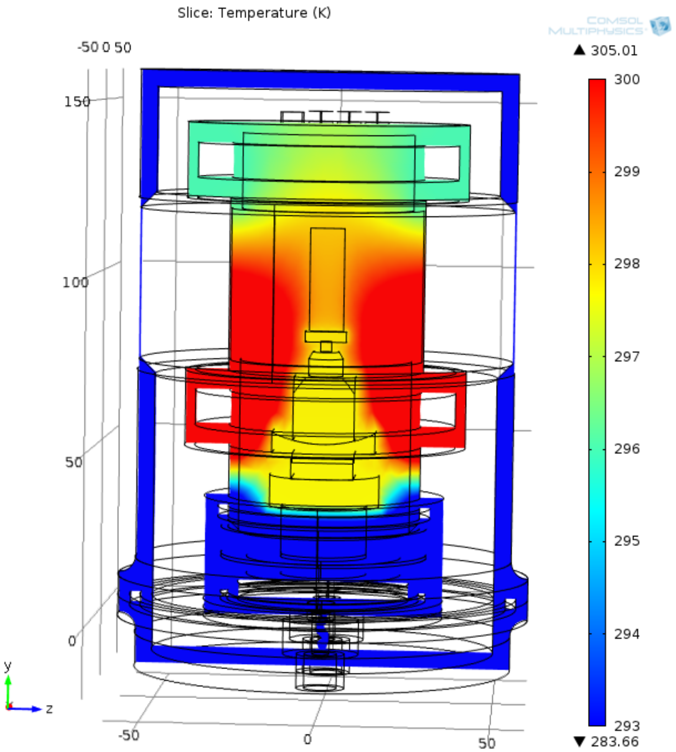


Relative Humidity Parameters

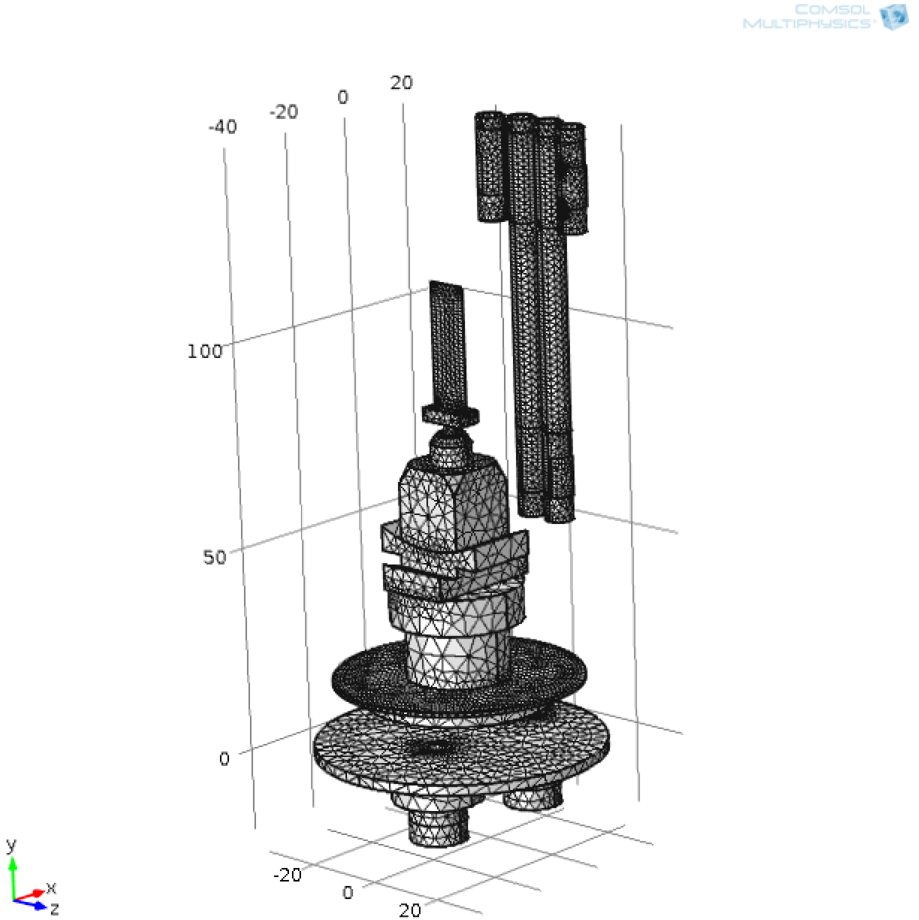
( )

Bridgeman and Aldrich, 1964

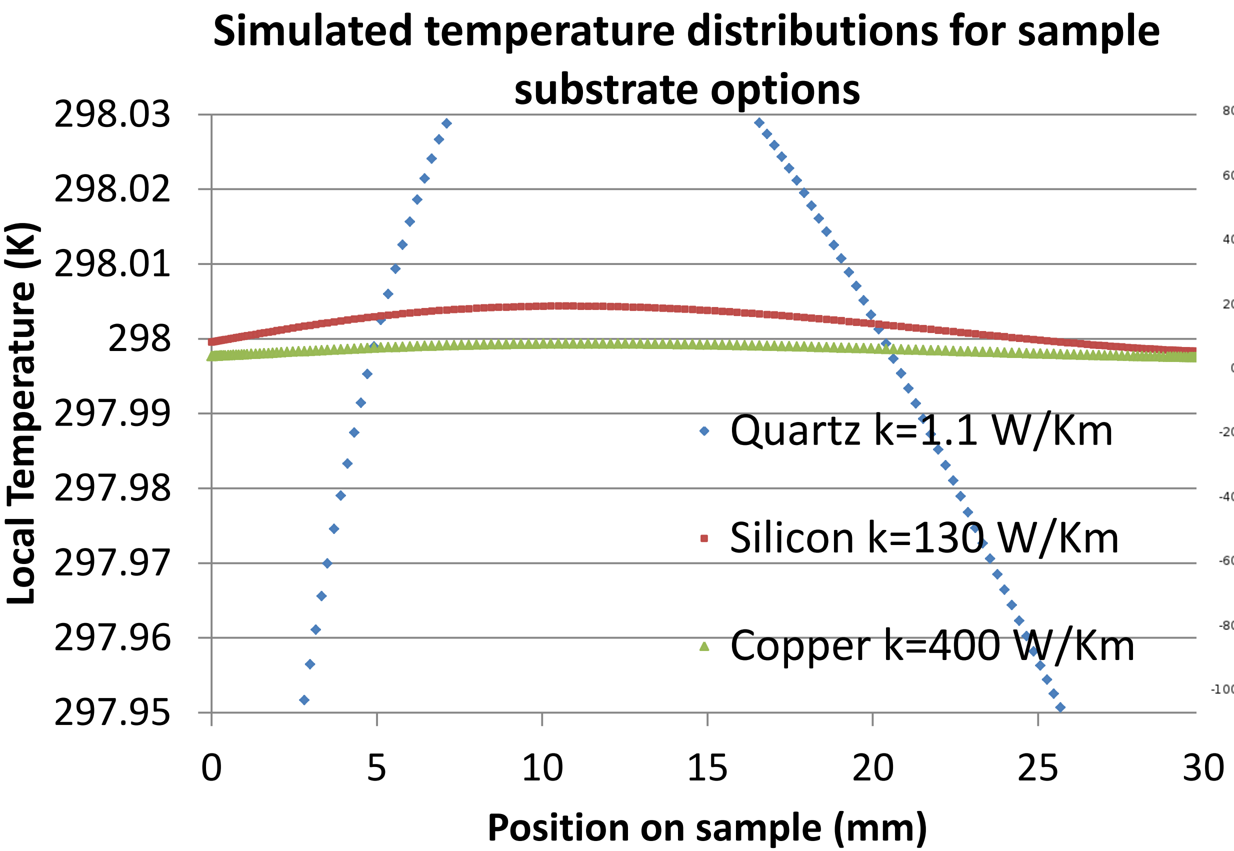
r.h. (%) sample at 298 K	P_{needed} (mbar)	$T_{water\ bath}$ (K)
100	31.42	298
98	30.8	297.7
90	28.3	296.3
75	23.6	293.2
40	12.6	283.5

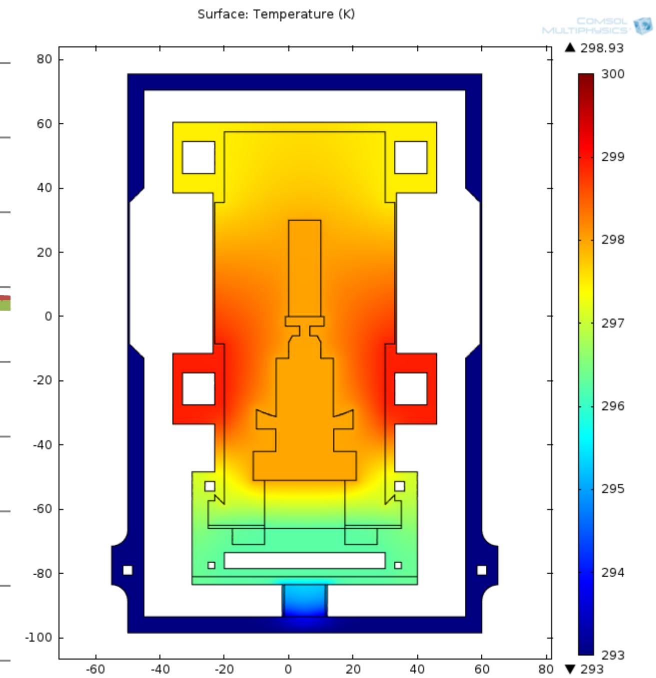


Finite Elements Simulation

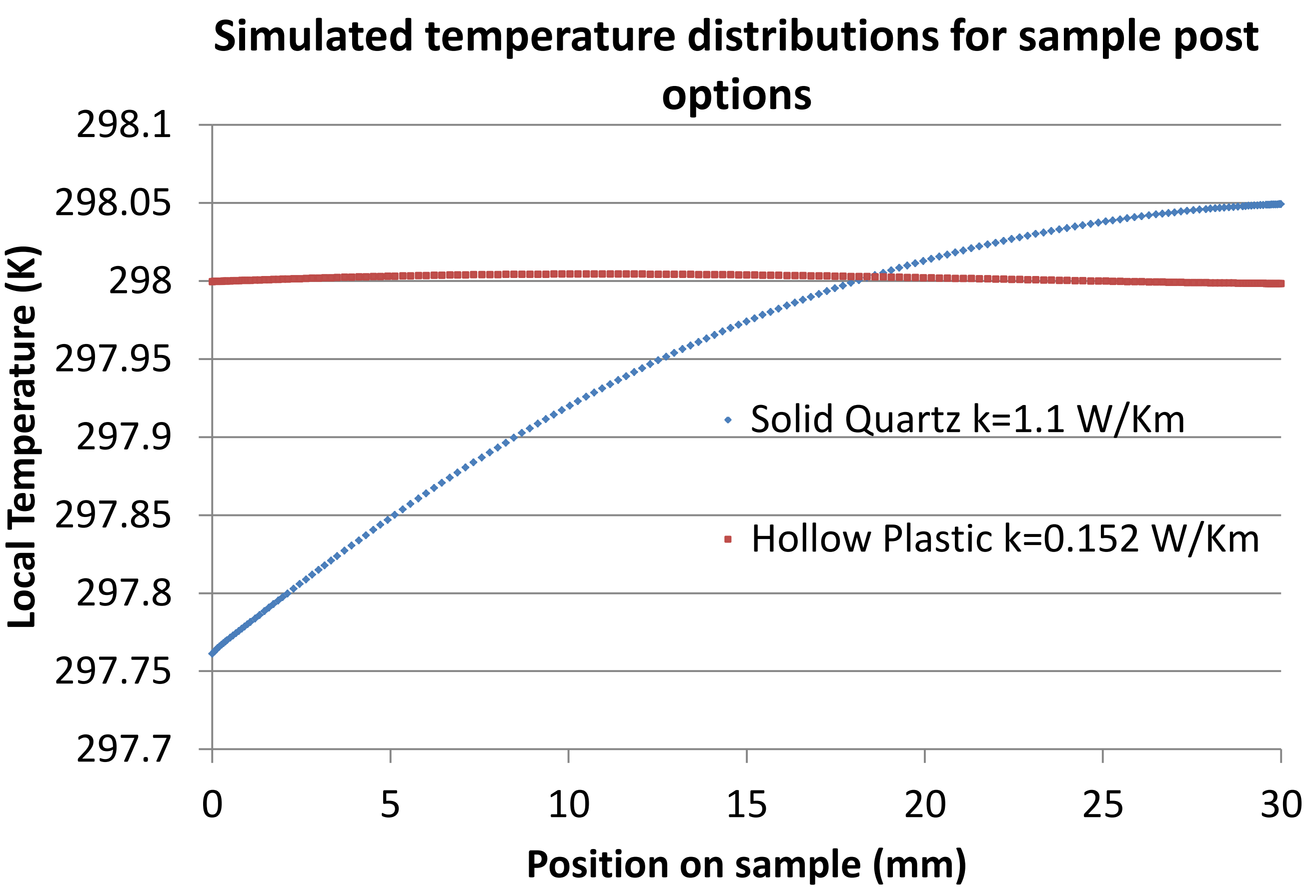


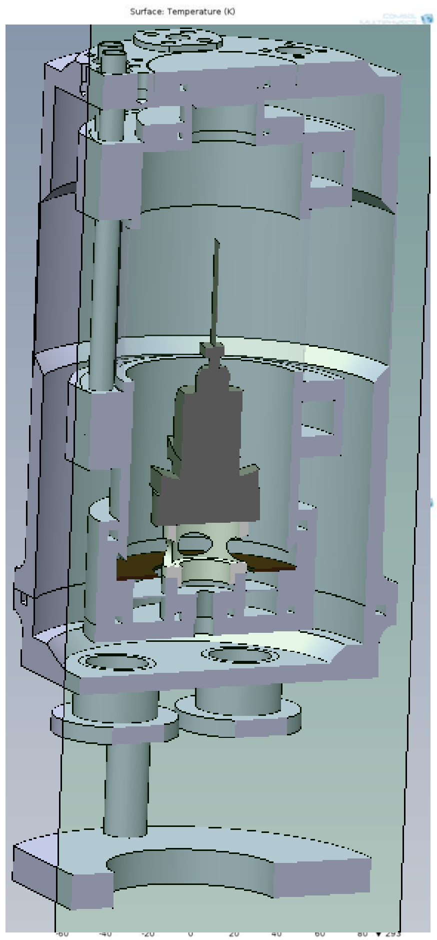
Substrate options



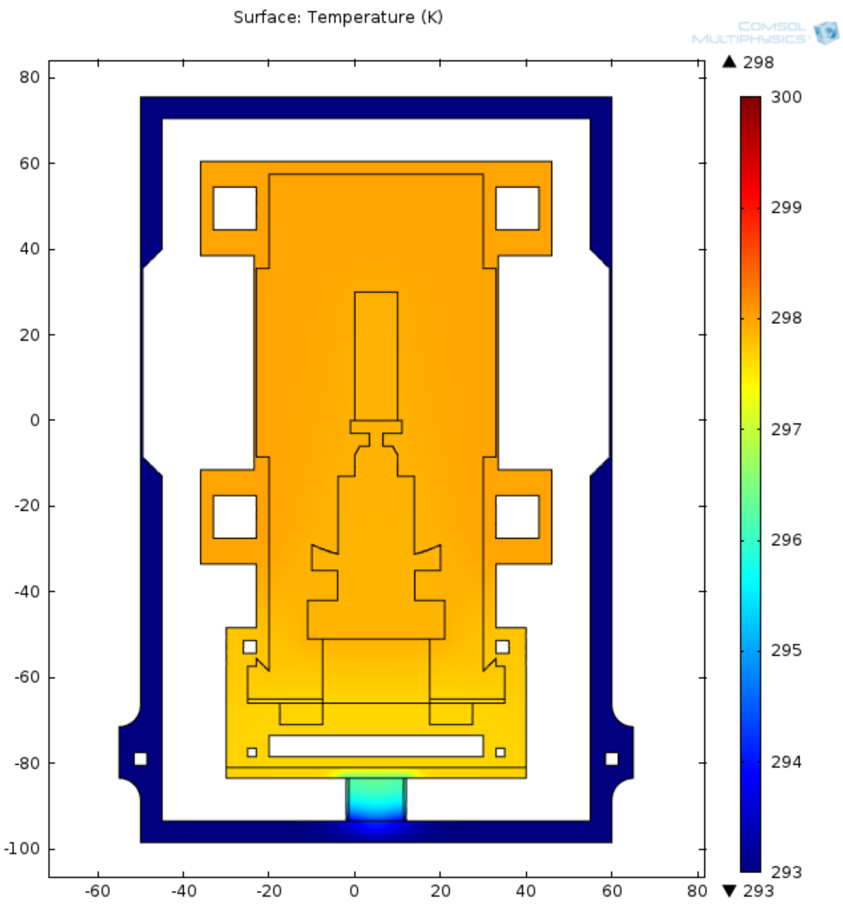


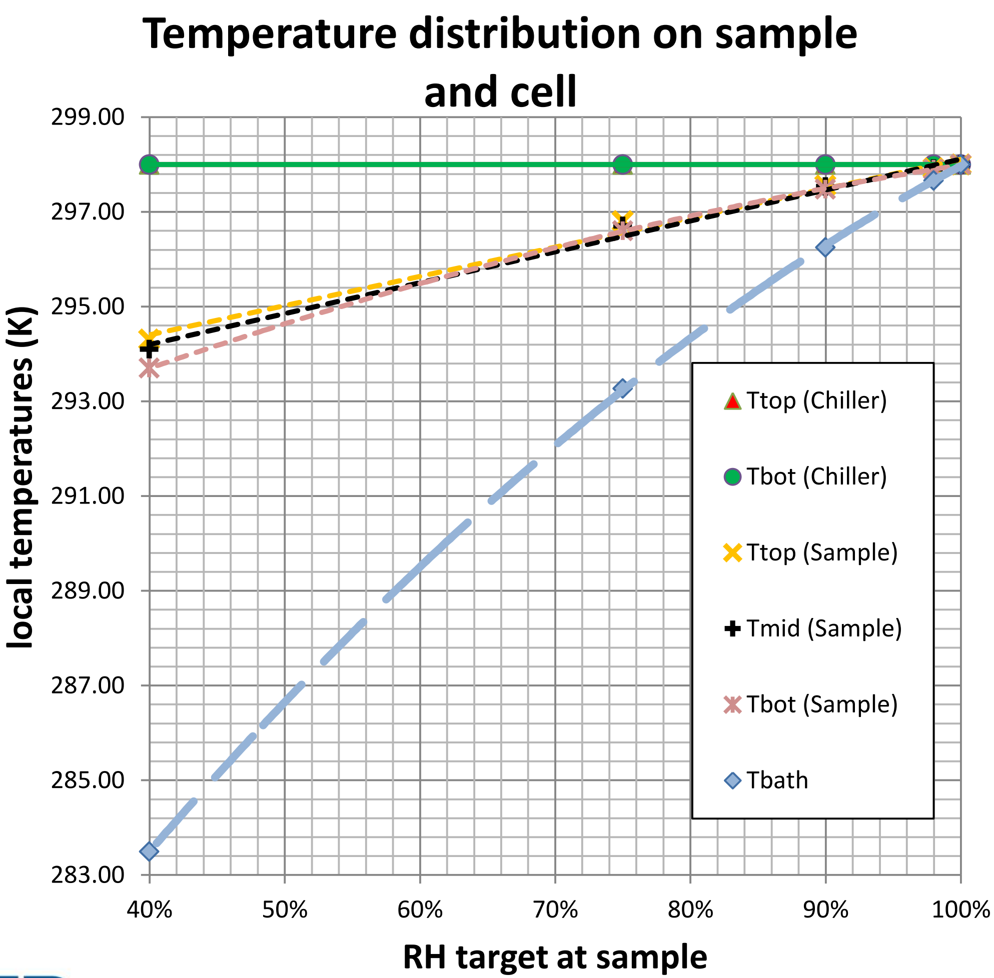
Sample post material





Simulation Results: Ttop=Tbot=298K





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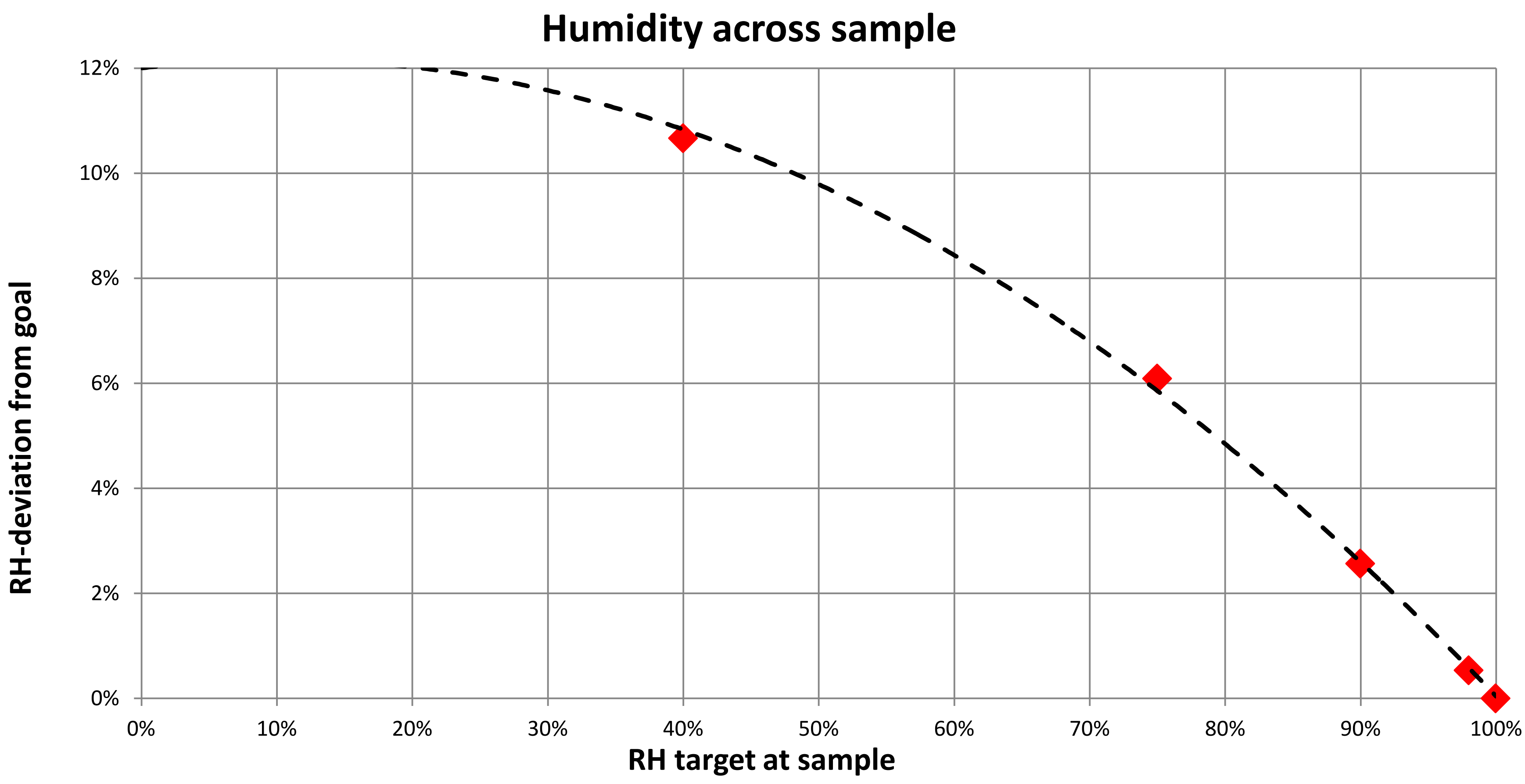

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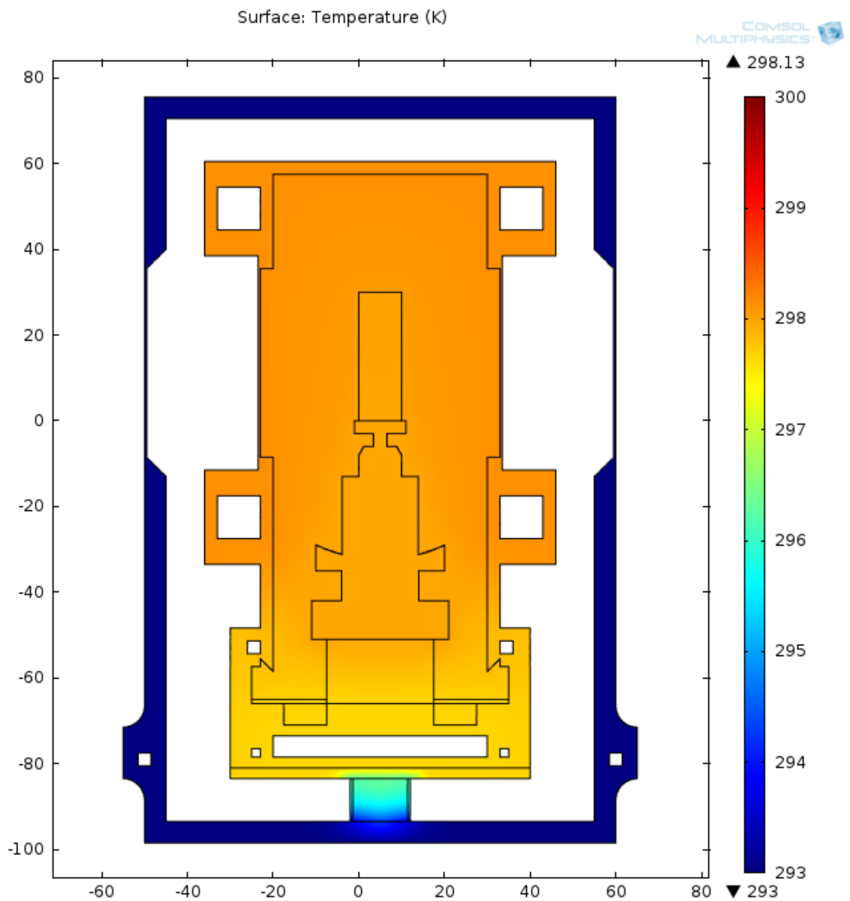
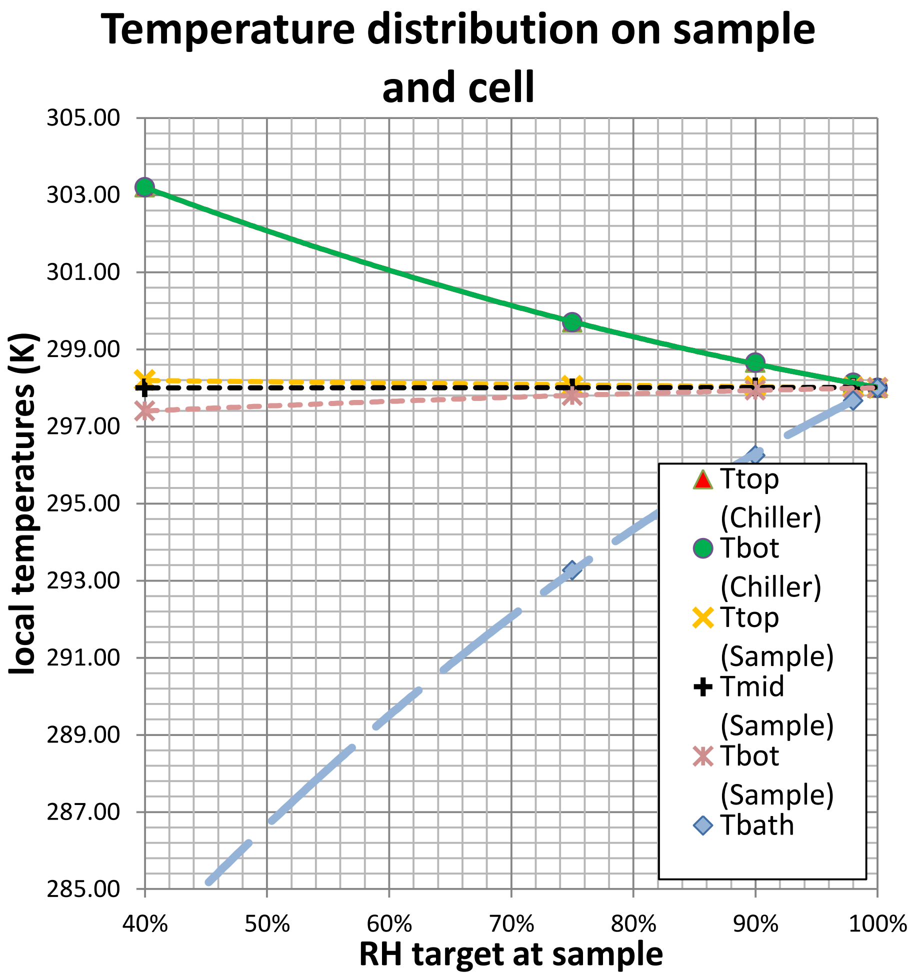
Simulation Results: Ttop=Tbot=x





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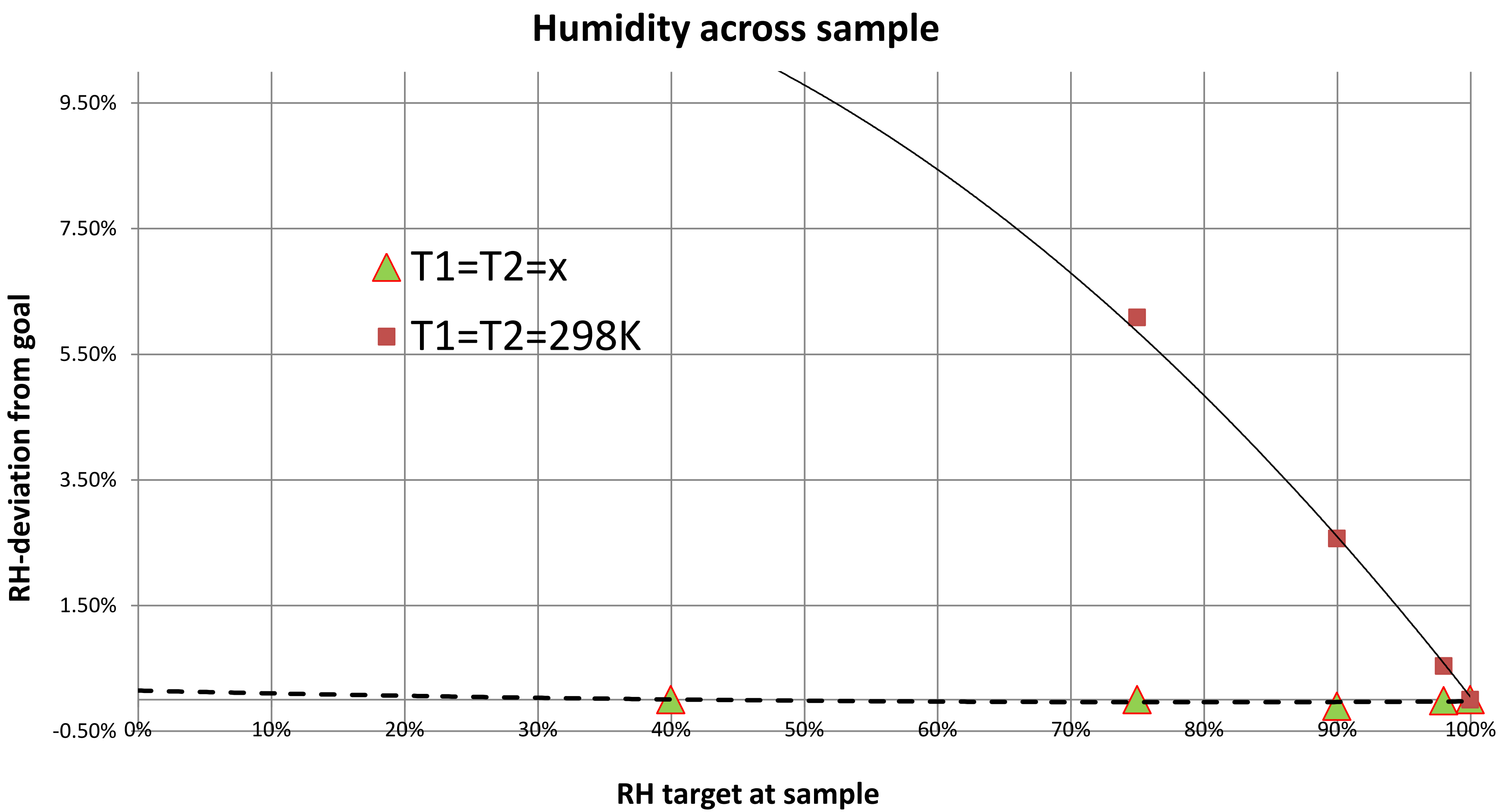

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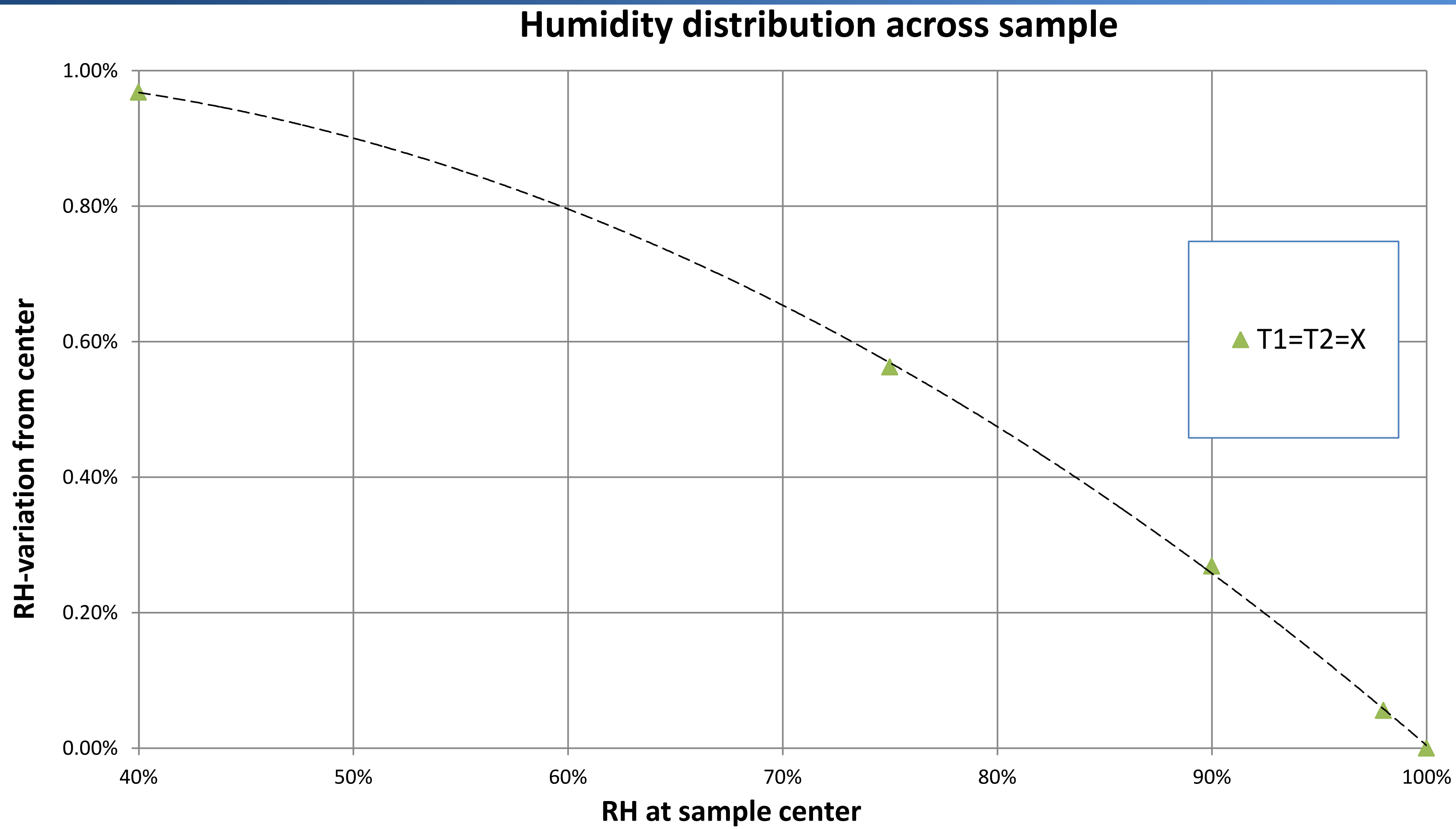
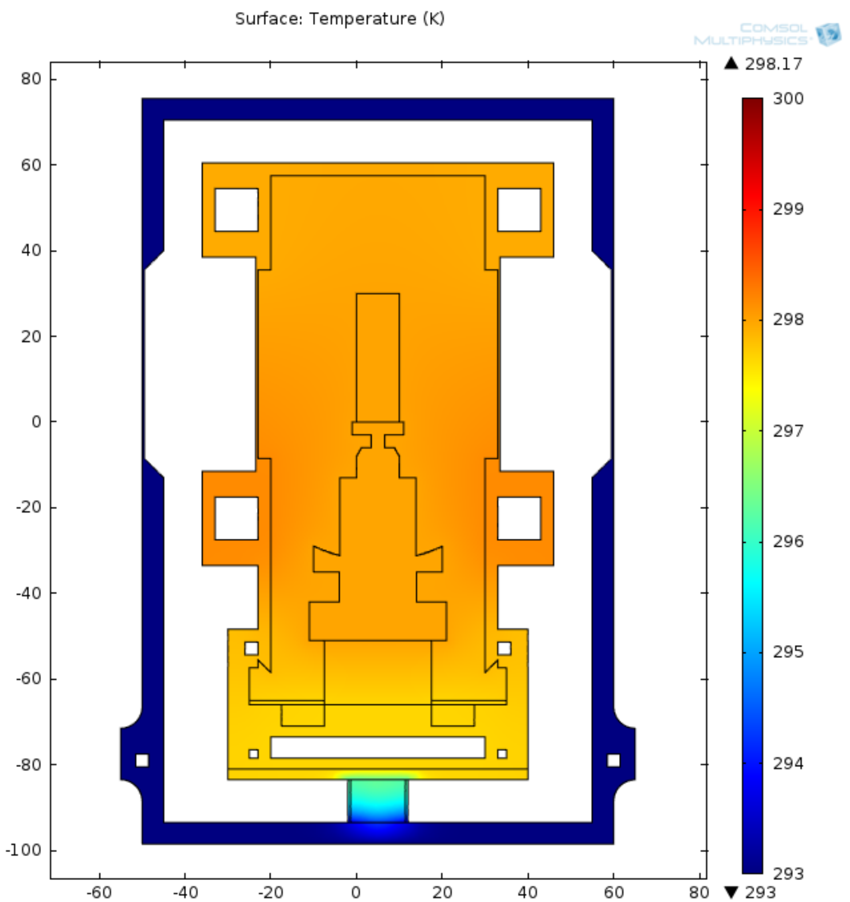
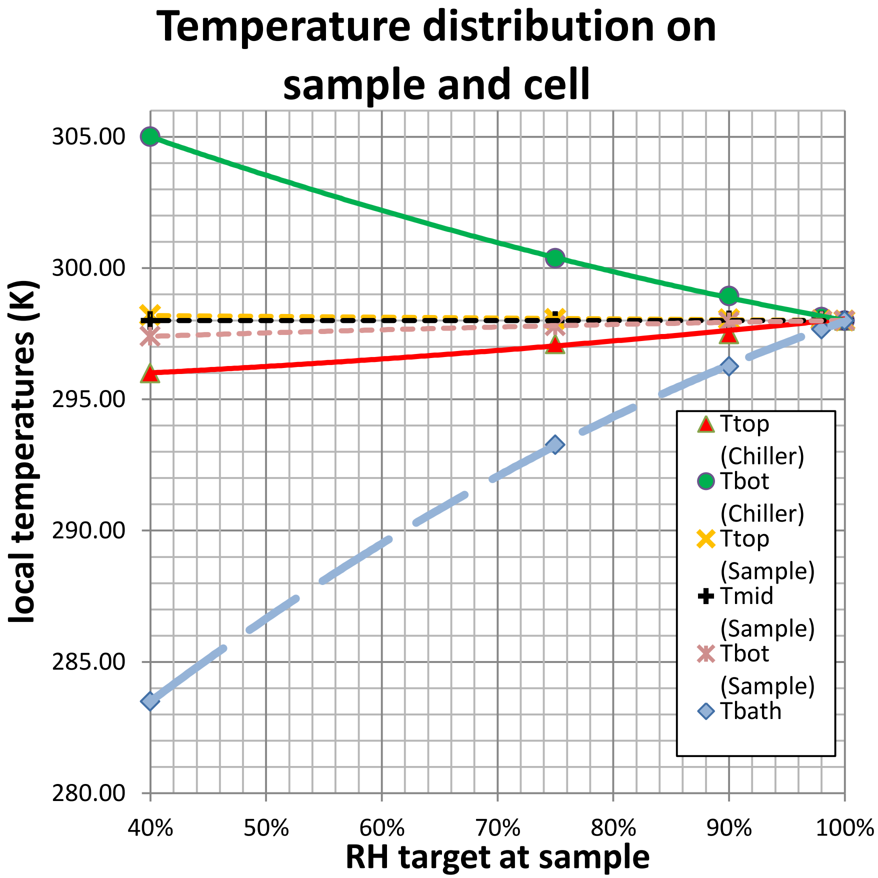


Simulation Results: Ttop≠Tbot





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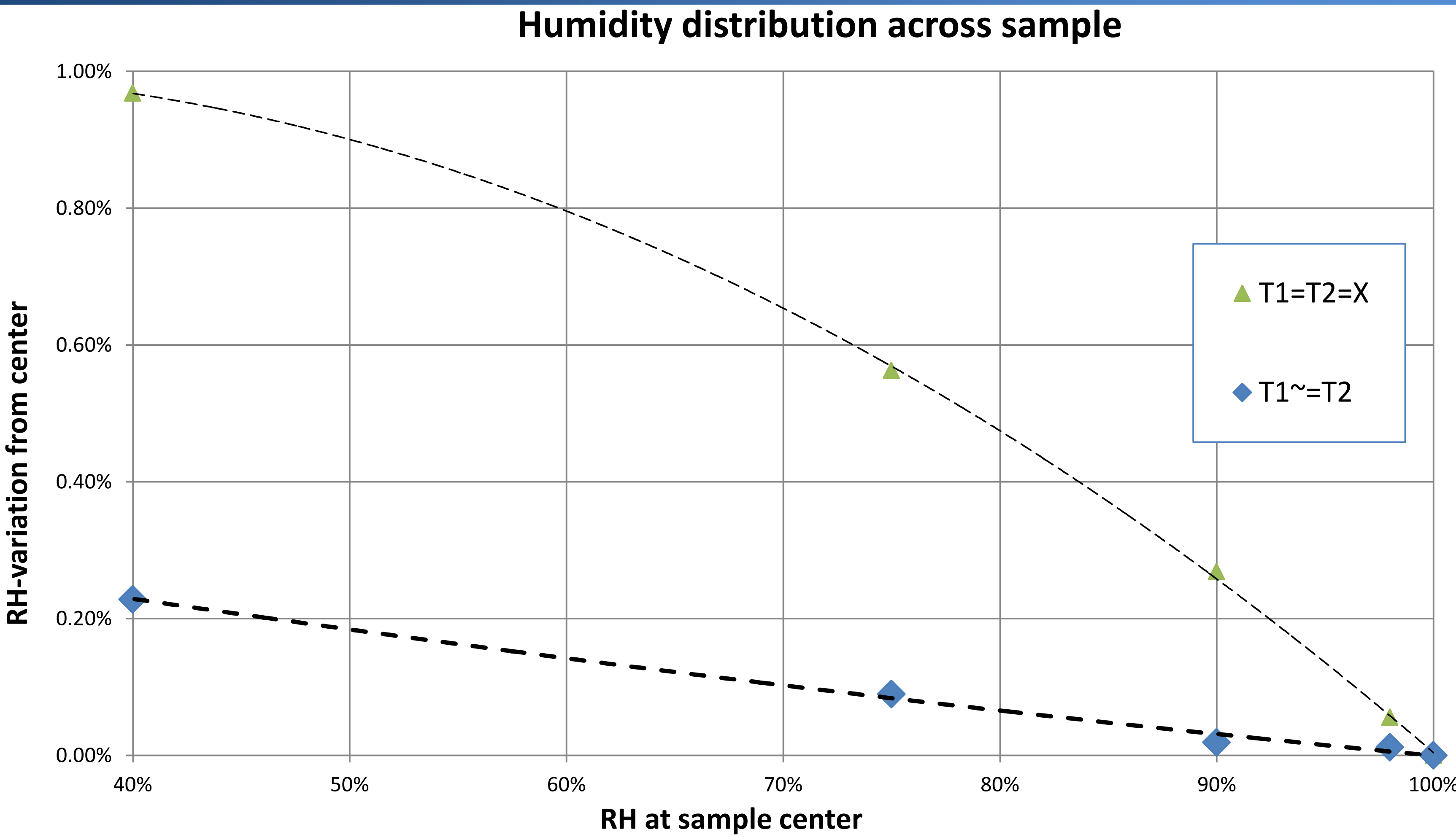

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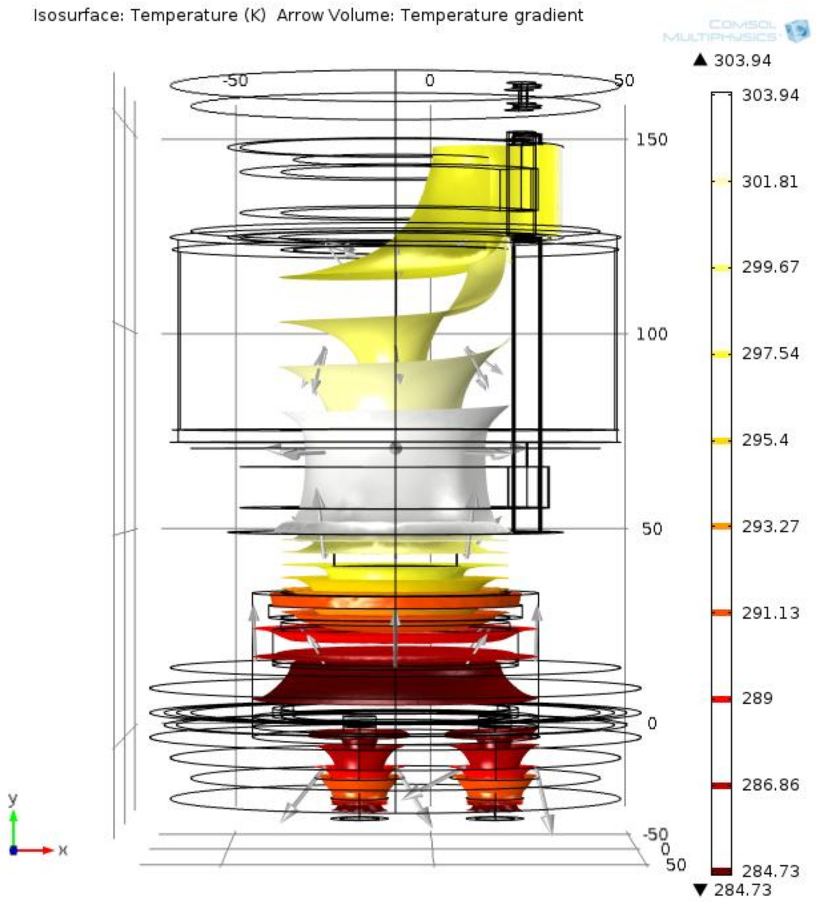
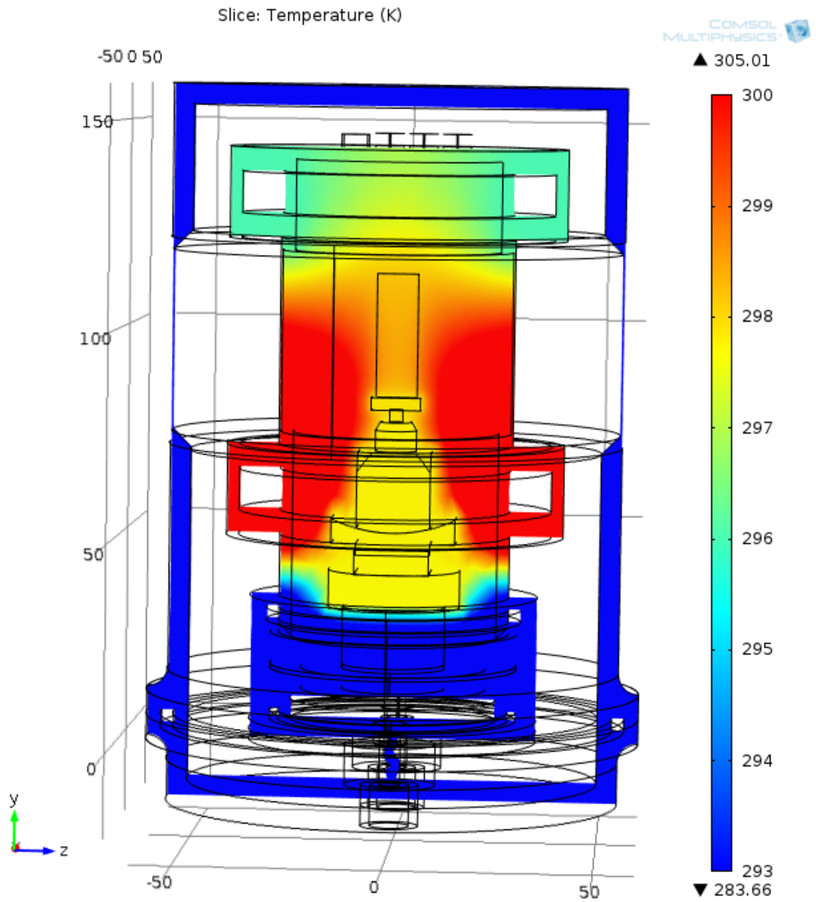
Problems with current design





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Next steps in design

- Addition of fan above sample to allow air circulation (faster equilibration)
- Baffels above water bath to hide low bath temperature from sample
- Water bath solution change without opening cell (D2O/H2O or salt)

Summary

- Current Design
  - details, features and next steps
- Finite Element Simulations
  - Minimize temperature variation over sample