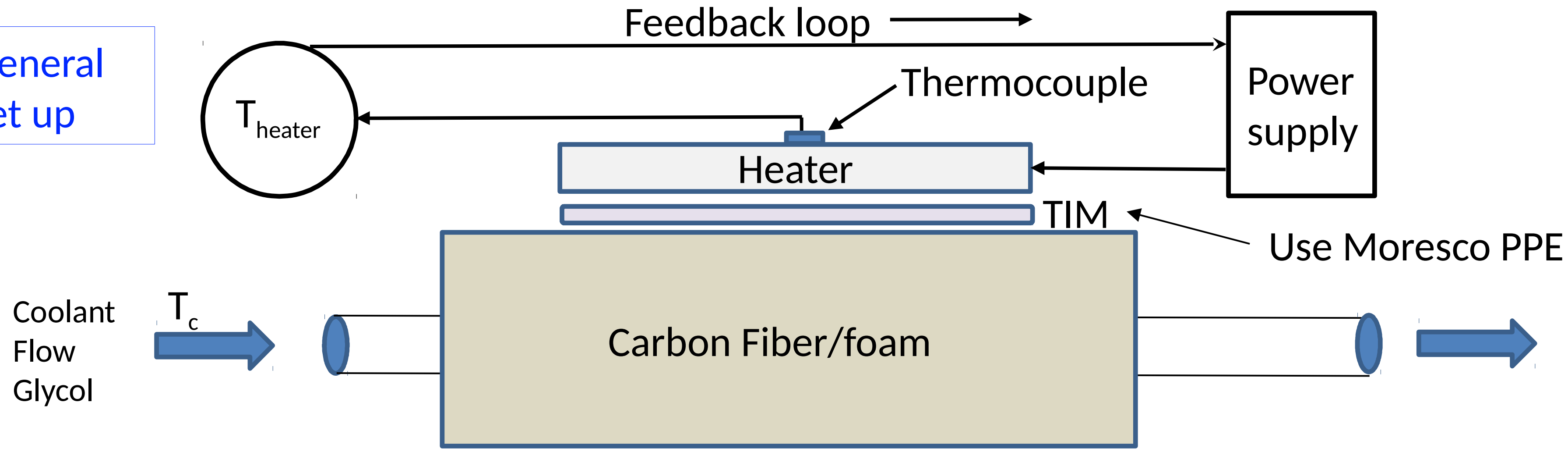
Strategy for runaway emulation

TFPIX Cornell U. team

Strategy for runaway emulation

General set up



Specific goal

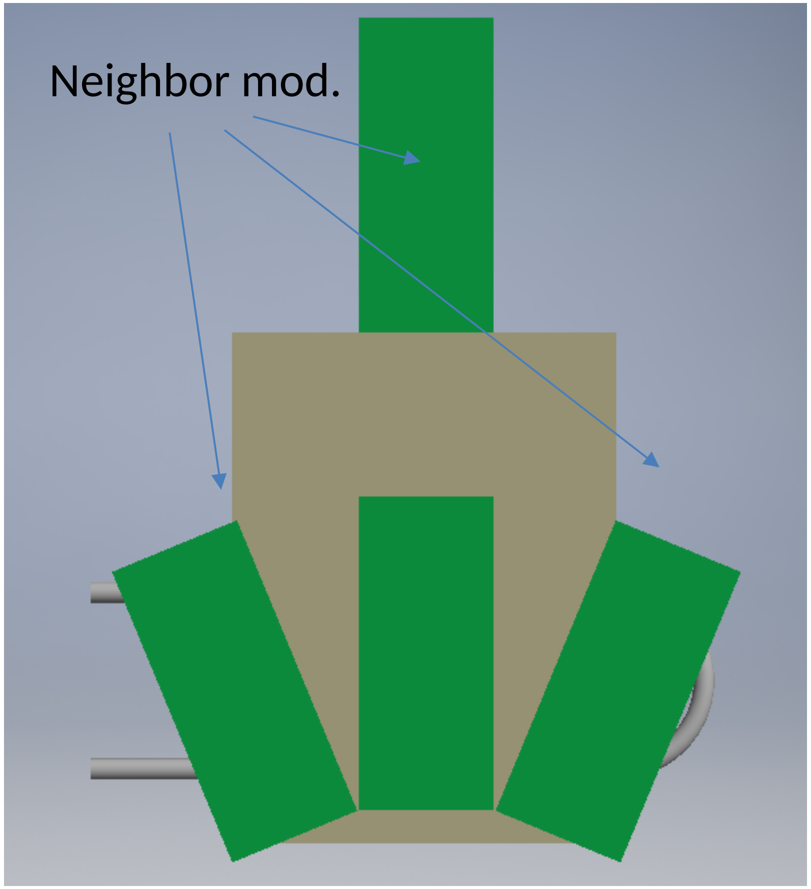
Measure the difference between the heater temperature (T_h) and coolant temperature (T_c) as a function of the coolant temperature, i.e.

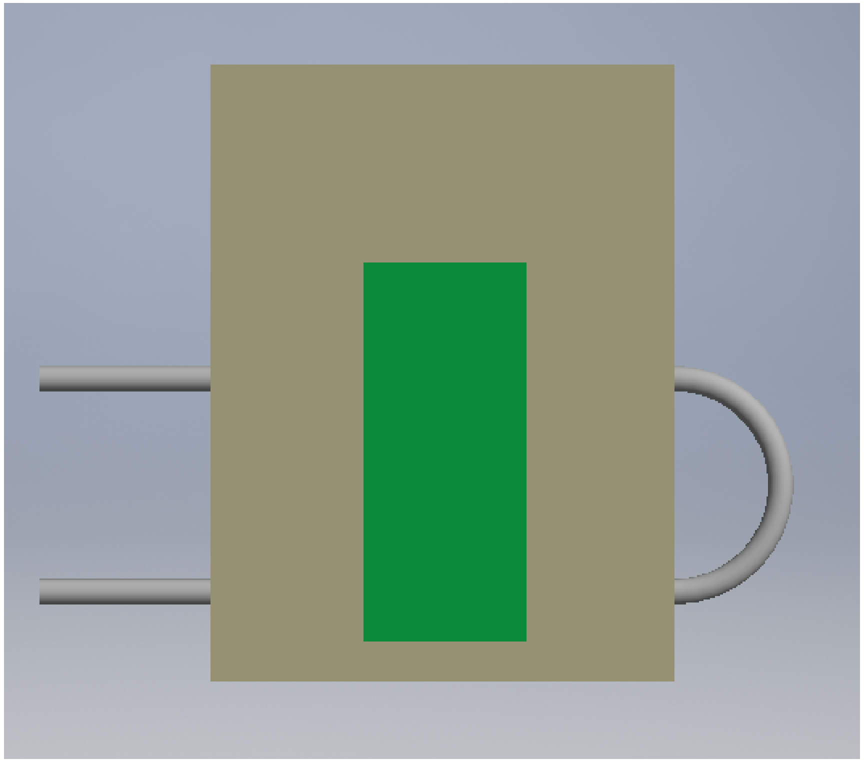
$$T_h - T_c \quad vs \quad T_c$$

Unit cell sample (ucs)

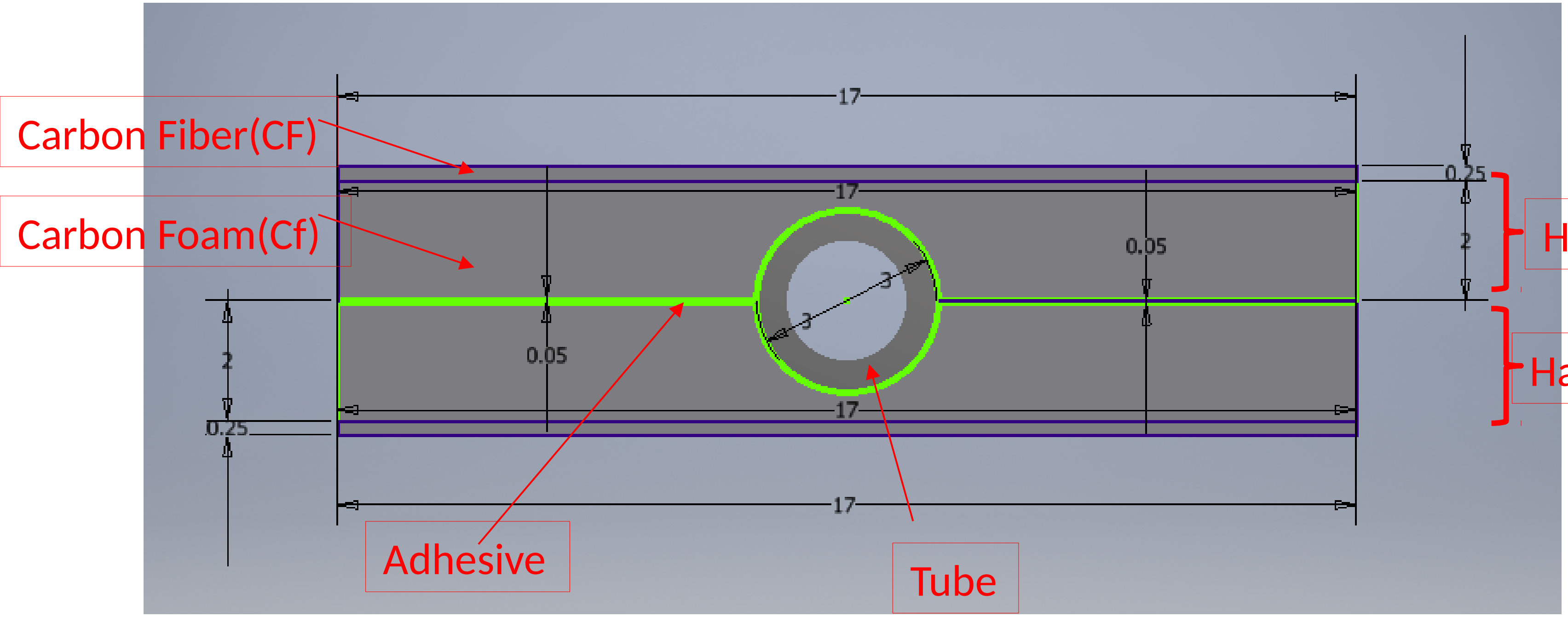
"One module space-region"

- Dimensions according to location of Neighbor modules, Cooling circuit.
- Gluing according to single tube testing



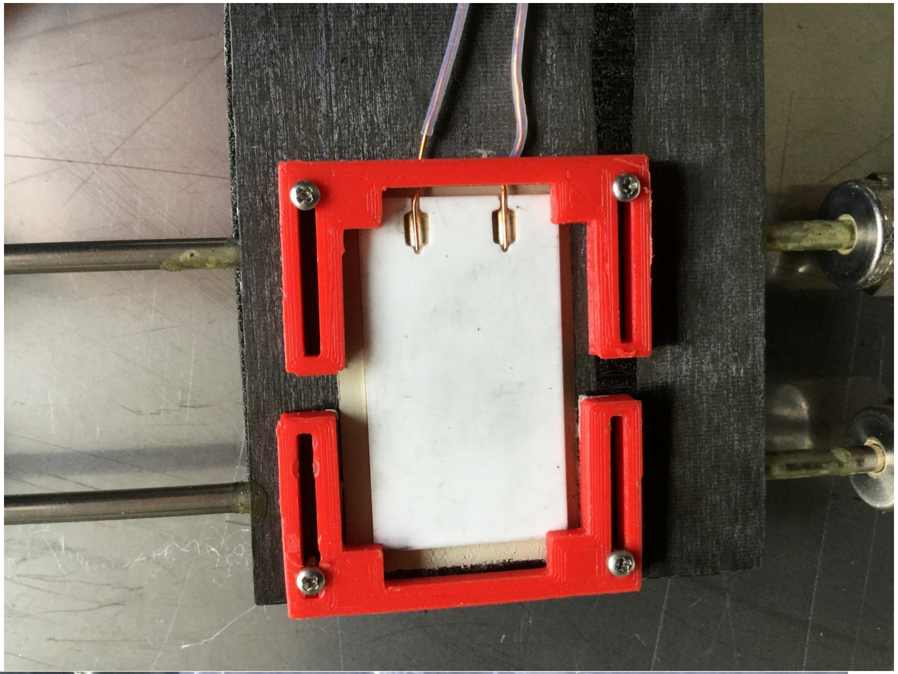


Single tube sample view



- Adhesive: Hysol EA 9396 (**Phase I BPix**), CVD loaded, Graphite loaded, others.
- Tubing: Stainless steel => OD=3mm, ID 2.5 mm

Sample preparation



- Vacuum -> aiming for uniform pressure on the heater and uniformity of the TIM layer
- Red clip-> hold in place the heater. Minimal pressure

Thermal runaway(TRA) simulation

$$Q_{sens}(T) = I(T_{\mathrm{ref}})\, V_{\mathrm{bias}} \left(\frac{T}{T_{\mathrm{ref}}}\right)^2 e^{T_A\left(\frac{1}{T} - \frac{1}{T_{\mathrm{ref}}}\right)}$$

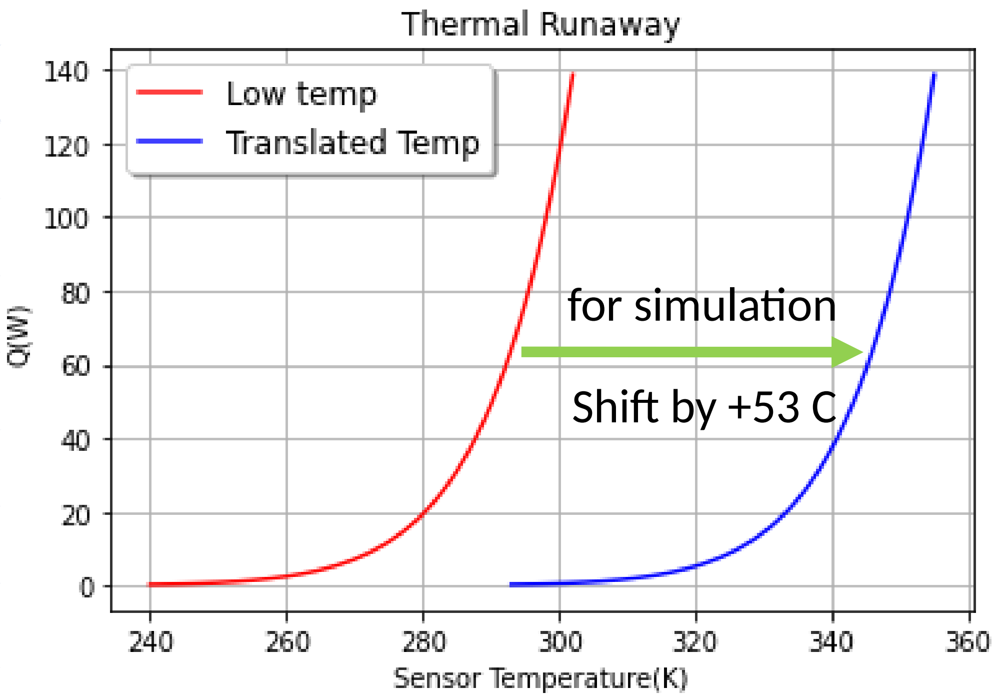
with

Fluence

sensor volume

$$I(T_{\mathrm{ref}} = 20^\circ C) = 4.28 \times 10^{-17} \left(\frac{A}{cm}\right) \times \Phi\ (cm^{-2}) \times V_{sens}\ (cm^3)$$

Value	Parameter
$2.1*10^{16}$ neq/cm^2	Fluence
h=4.4 cm	length of the sensor
l=1.8 cm	width of the sensor
dd=$100*10^{-4}$ cm	depletion depth
Vb=800 V	bias voltage
To=293 C	Tref
Ta=7000 C	T_A



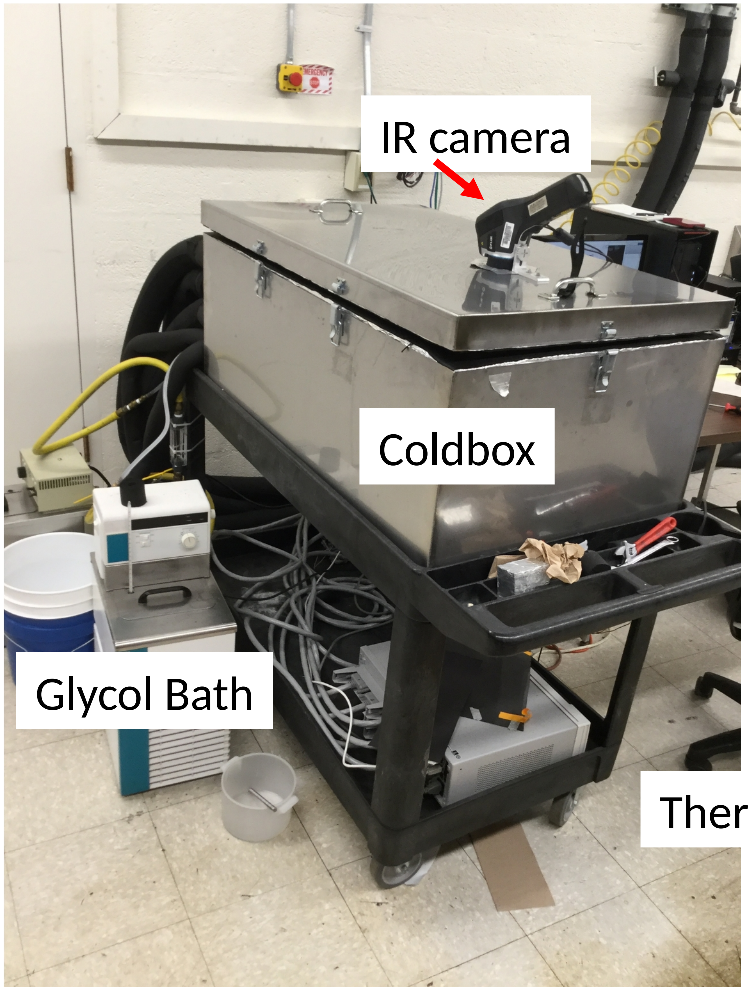
TRA data taking- setup

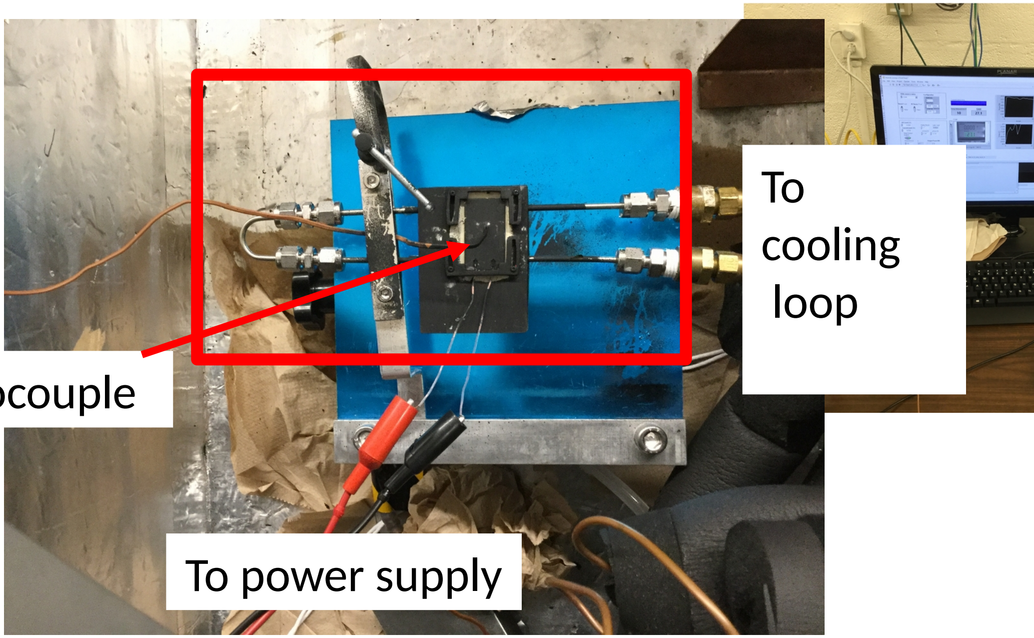
LabVIEW

Power supply

Webcam

multimeter





TRA data taking-procedure

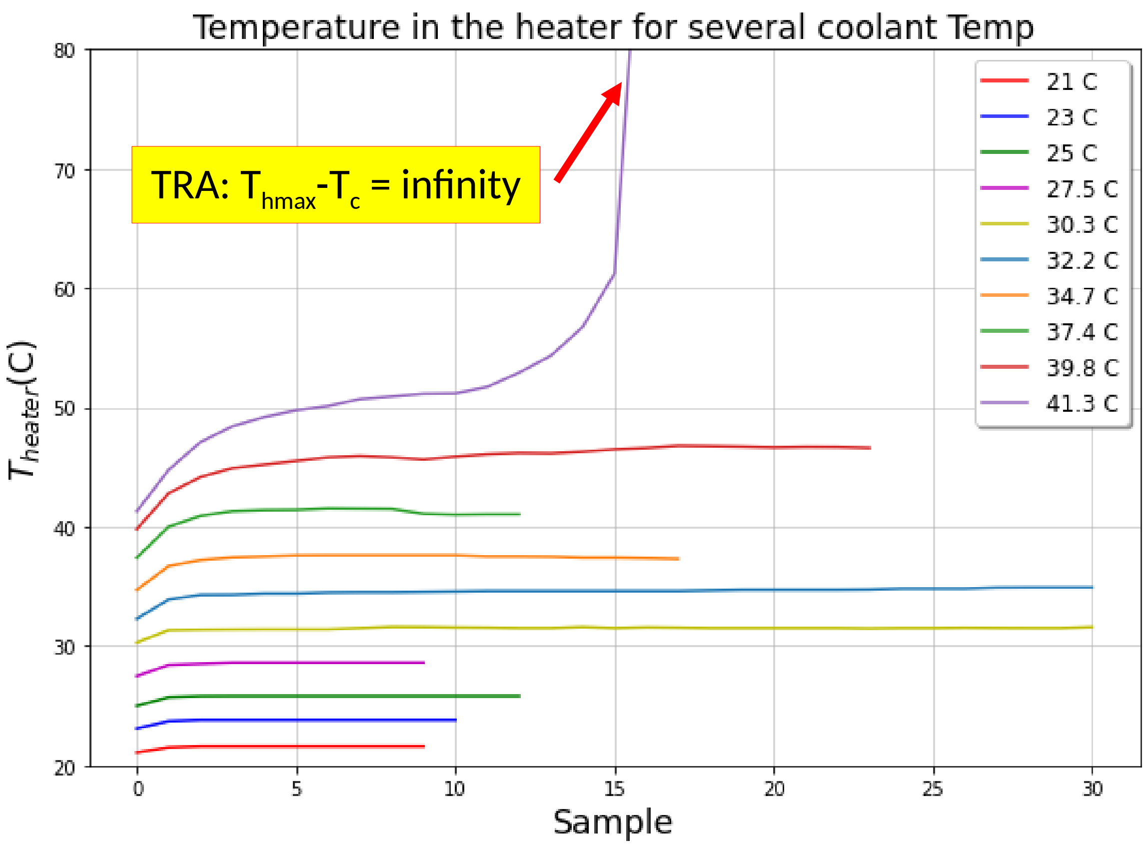
- Set coolant temperature T_c
- Set P=0 W, wait 3 min. then read T_h (which should be = T_c).
- Initiate the feedback loop to control power supply by setting $P(T_h)$.

- Wait 3 minutes. Then read device temperature T_h.
- Next iteration: Raise power level to $P(T_h)$. T_h will increase…

- Continue iterating until temperature plateaus …or thermal runaway occurs

Reminder: testing is done at 20 degC < T < 110 degC while the effects we are trying to simulate actually will take place at around -30 degC. (the 53 degC shift would be reversed).

TRA data taking- Th vs Tc



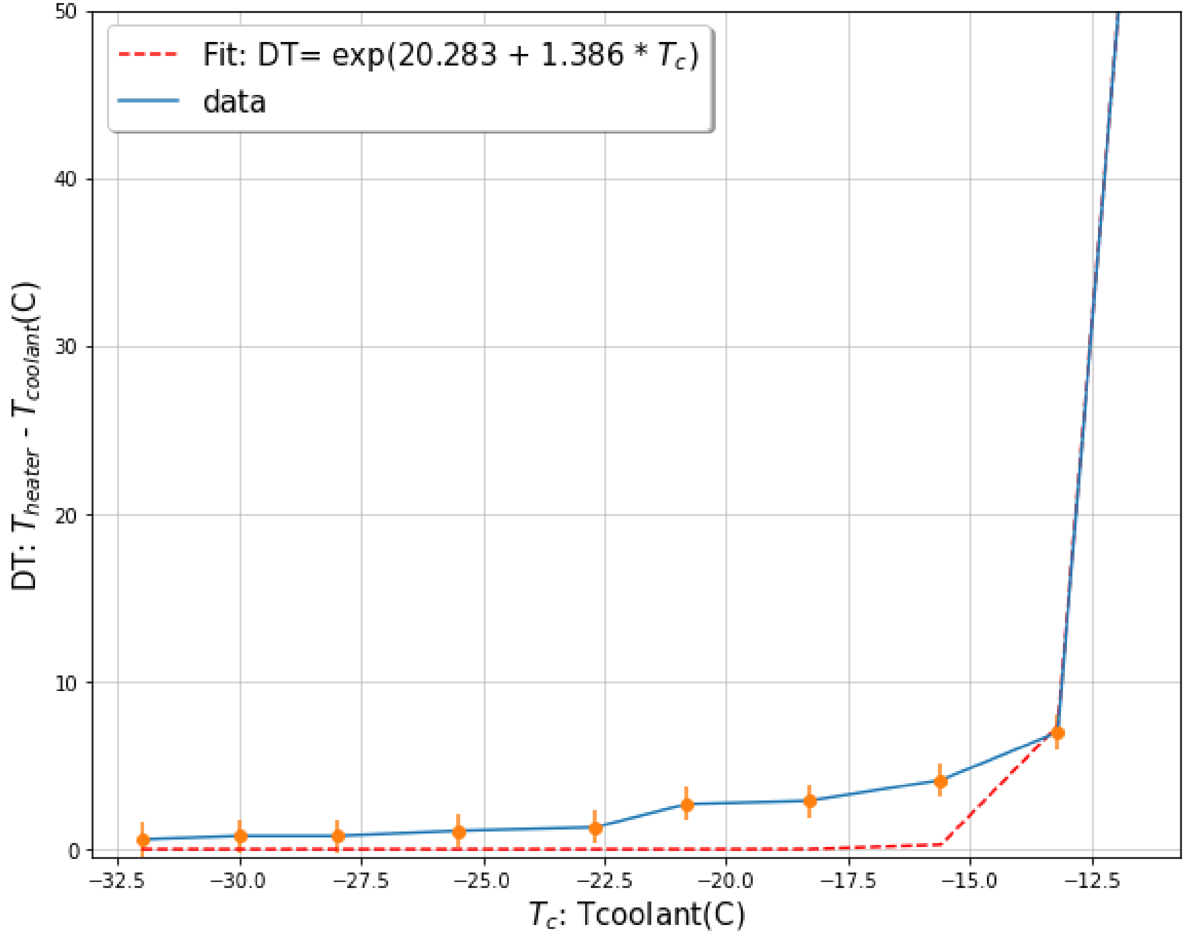
Increasing T_c would induce TRA* ; we are interested maximum change in temperature, i.e.

$$DT = T_{hmax} - T_c$$

If no TRA then $T_{hmax} = T_{plateau}$

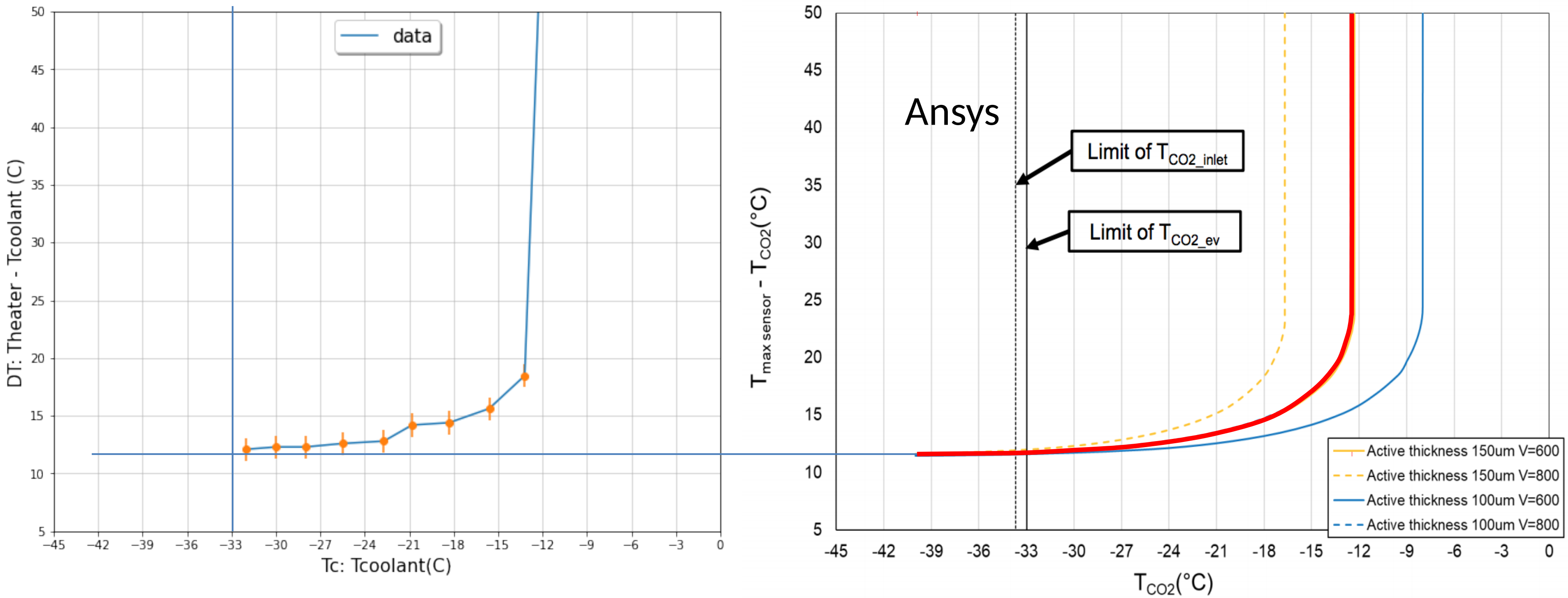
* Increase in fluence and/or TIM performance will also induce TRA but we concentrate in one effect at a time.

TRA: DT vs Tc



Note the Tc scale was shifted back to low temperature range.
Error bars corresponds to an estimate of 1 degC

TRA Lab simulation vs Ansys

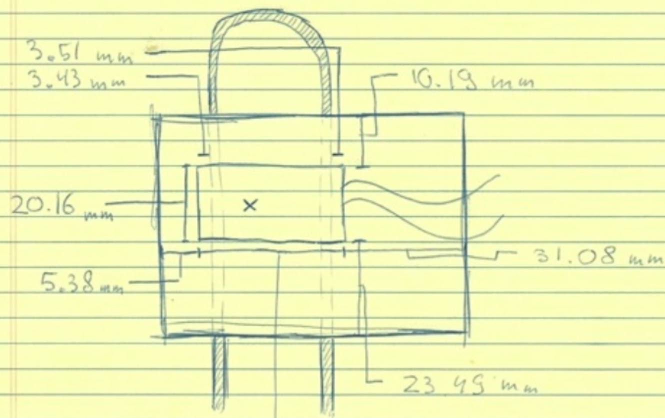


We are interested in the Ansys thermal simulation of our sample

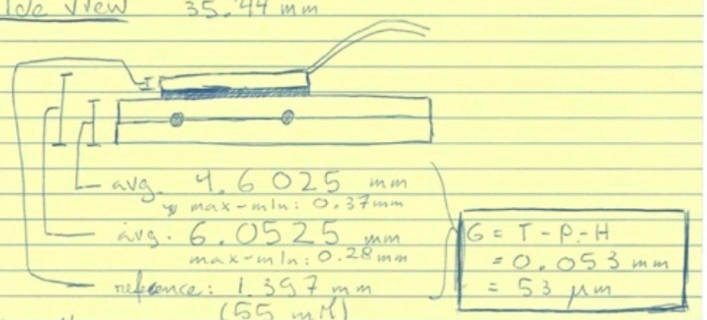
Sample features and schematic I

1

Plaquette: top view



Side view

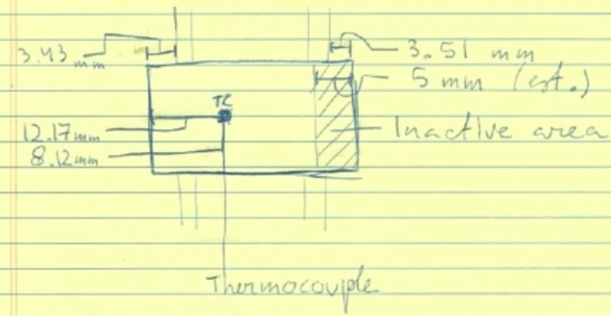


Plaquette area:

	measured total:
5.38 + 35.44 + 31.08 = 71.90 mm	72.83 mm
10.19 + 20.16 + 23.49 = 53.84 mm	53.58 mm

2

Heater: top view



Heater area: 35.44 mm × 20.16 mm
= 714.47 mm²

However, the bottom part of the heater does not contribute to the heating. Based on ~~the~~ thermal images of the heater at various power settings, this inactive area was estimated to be 0.5 mm wide.

The area used for the 'active heater' is 20 mm × 30 mm = 600 mm².

One might additionally want to discount thin strips along the other edges; however, I do not think this necessary.

Sample features and schematic II

3

Tube measurements.

Outer tube to outer tube:

: 27.91 mm

: 27.96 mm

, : 3.13 mm, 3.29 mm
(diff. from 3.0 probably due to paint)