Activities at BNL:
Answering to the Recommendation #5 for the Review:

An Interim Design Review of the INTT electronics (July 28, 2021)

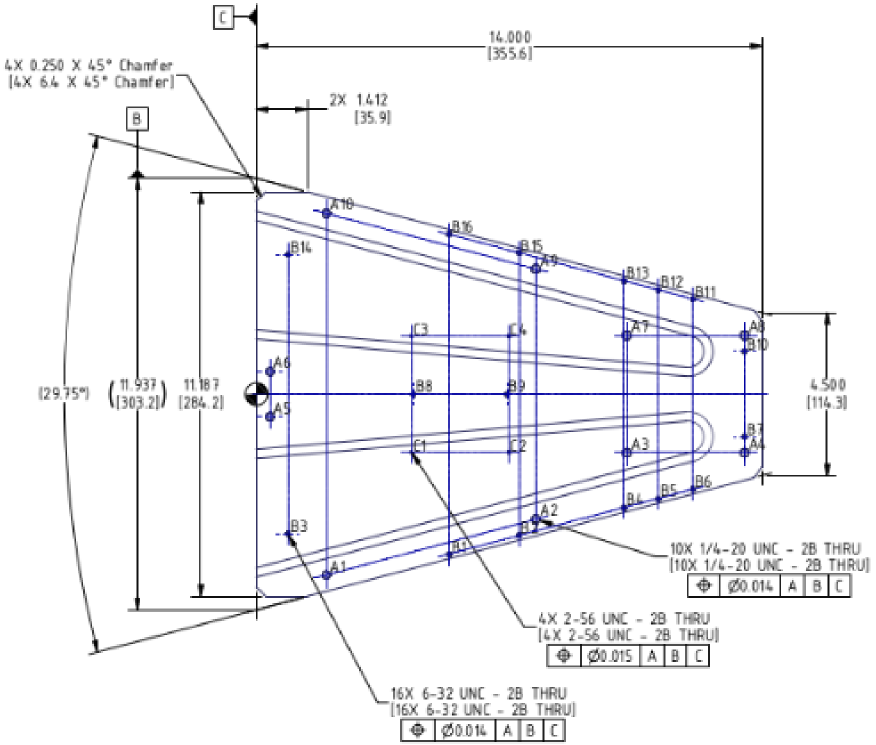
Recommendation #5. Complete the FEA of the cooling of the ROC.

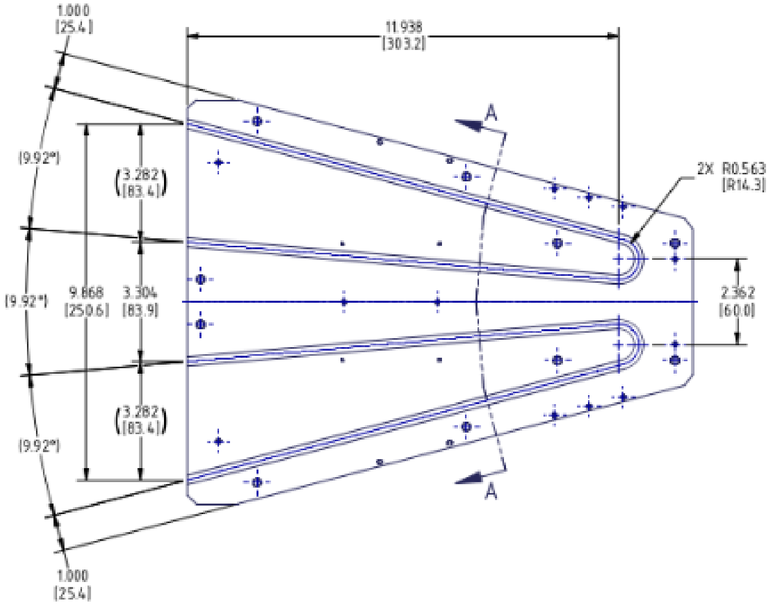
Robert Pisani, Dan Cacace and Rachid Nouicer

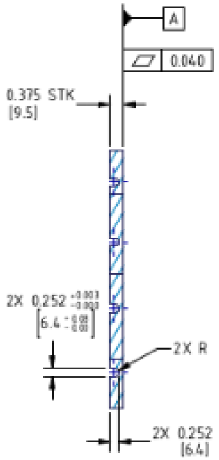
October 28th, 2021

REVISION HISTORY					
REV	ECN NUMBER	ZONE	DESCRIPTION	DATE	APPROVED
A					

NOTES:
1. MATERIAL: Aluminum 6061-T6
2. UNTOLERANCED DIMENSIONS ARE BASIC ⌓ 0.020 | A | B | C
3. DRAWING MAY BE USED WITH MODEL " - REV 2 - INTT - ROC Cooling Plate.STP" AND VALUES QUERIED FROM 3-D DIGITAL MODEL ARE BASIC.
4. FINISHED ARTICLE SHALL BE FREE OF OILS, LUBRICANTS AND OTHER CONTAMINANTS.







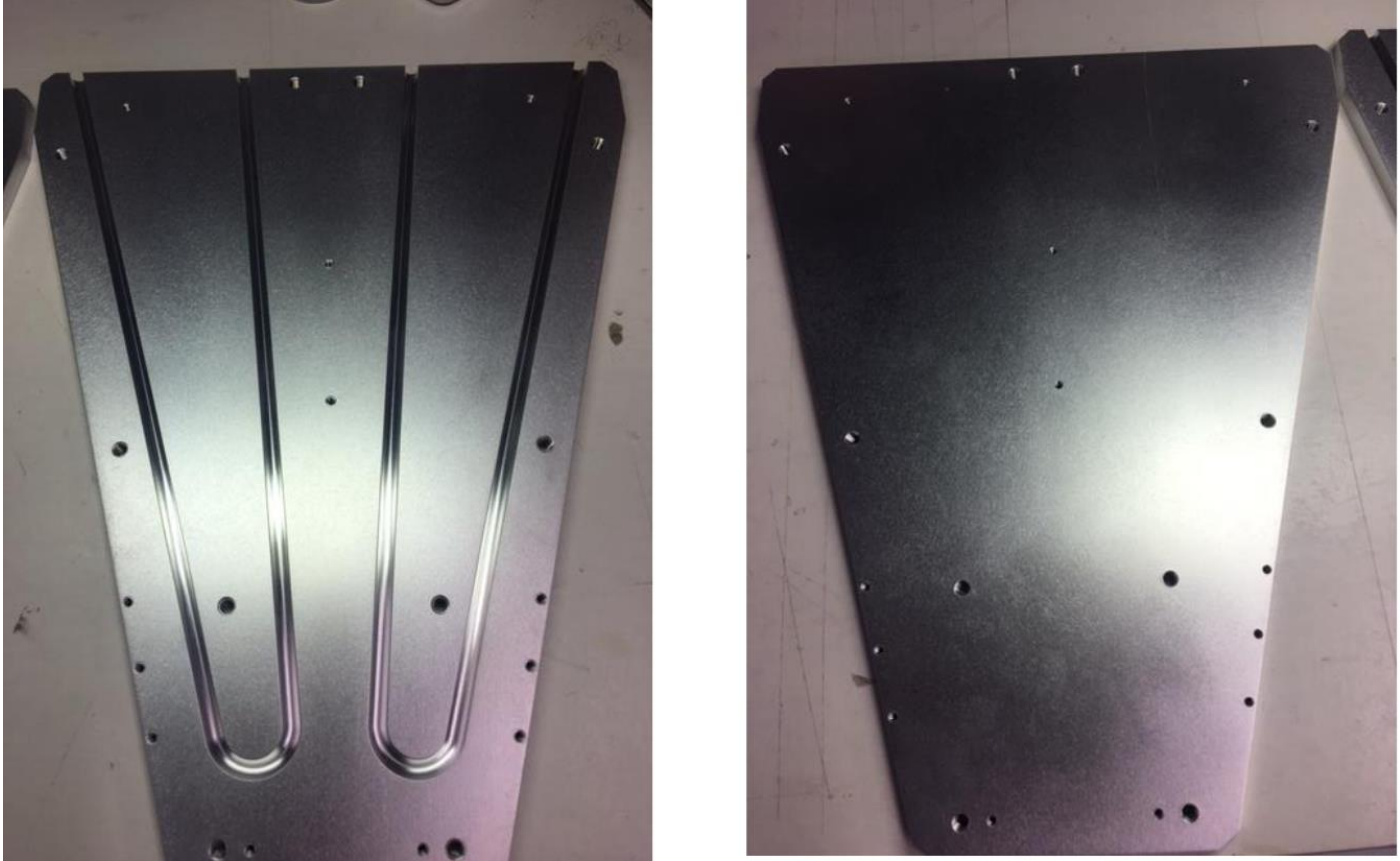
SECTION A-A
SCALE 1 / 2

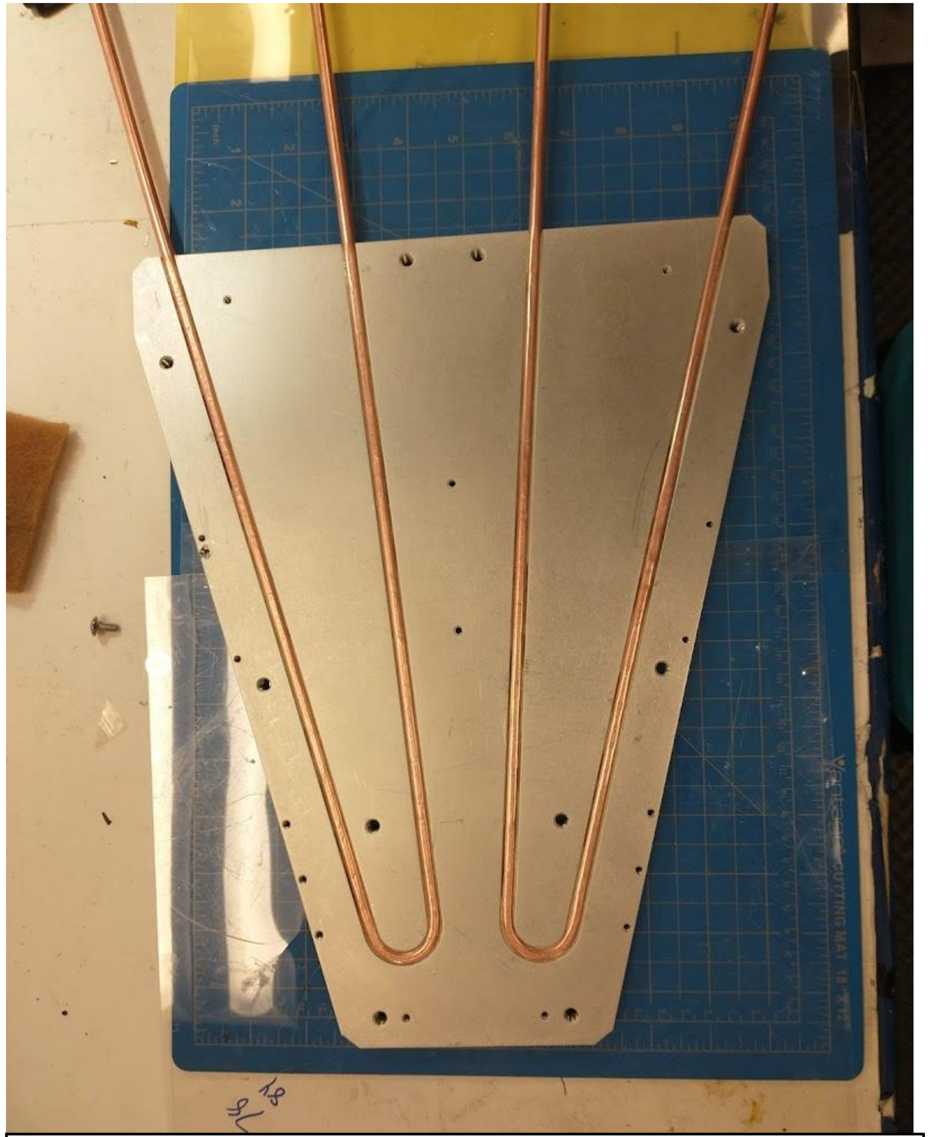
Hole Table			
HOLE	XDIM	YDIM	DESCRIPTION
A1	1.933	-5.002	1/4-20 UNC - 2B THRU [1/4-20 UNC - 2B THRU]
A2	7.732	-3.462	1/4-20 UNC - 2B THRU [1/4-20 UNC - 2B THRU]
A3	10.250	-1.625	1/4-20 UNC - 2B THRU [1/4-20 UNC - 2B THRU]
A4	13.500	-1.625	1/4-20 UNC - 2B THRU [1/4-20 UNC - 2B THRU]
A5	0.375	-0.625	1/4-20 UNC - 2B THRU [1/4-20 UNC - 2B THRU]
A6	0.375	0.625	1/4-20 UNC - 2B THRU [1/4-20 UNC - 2B THRU]
A7	10.250	1.625	1/4-20 UNC - 2B THRU [1/4-20 UNC - 2B THRU]
A8	13.500	1.625	1/4-20 UNC - 2B THRU [1/4-20 UNC - 2B THRU]
A9	7.732	3.462	1/4-20 UNC - 2B THRU [1/4-20 UNC - 2B THRU]
A10	1.933	5.002	1/4-20 UNC - 2B THRU [1/4-20 UNC - 2B THRU]
B1	5.333	-4.423	6-32 UNC - 2B THRU [6-32 UNC - 2B THRU]
B2	7.266	-3.909	6-32 UNC - 2B THRU [6-32 UNC - 2B THRU]
B3	0.872	-3.860	6-32 UNC - 2B THRU [6-32 UNC - 2B THRU]
B4	10.165	-3.139	6-32 UNC - 2B THRU [6-32 UNC - 2B THRU]
B5	11.117	-2.886	6-32 UNC - 2B THRU [6-32 UNC - 2B THRU]
B6	12.069	-2.634	6-32 UNC - 2B THRU [6-32 UNC - 2B THRU]
B7	13.500	-1.181	6-32 UNC - 2B THRU [6-32 UNC - 2B THRU]
B8	4.342	0.000	6-32 UNC - 2B THRU [6-32 UNC - 2B THRU]
B9	6.933	0.000	6-32 UNC - 2B THRU [6-32 UNC - 2B THRU]
B10	13.500	1.181	6-32 UNC - 2B THRU [6-32 UNC - 2B THRU]
B11	12.069	2.634	6-32 UNC - 2B THRU [6-32 UNC - 2B THRU]
B12	11.117	2.886	6-32 UNC - 2B THRU [6-32 UNC - 2B THRU]
B13	10.165	3.139	6-32 UNC - 2B THRU [6-32 UNC - 2B THRU]
B14	0.872	3.860	6-32 UNC - 2B THRU [6-32 UNC - 2B THRU]
B15	7.266	3.909	6-32 UNC - 2B THRU [6-32 UNC - 2B THRU]
B16	5.333	4.423	6-32 UNC - 2B THRU [6-32 UNC - 2B THRU]
C1	4.287	-1.600	2-56 UNC - 2B THRU [2-56 UNC - 2B THRU]
C2	6.987	-1.600	2-56 UNC - 2B THRU [2-56 UNC - 2B THRU]
C3	4.287	1.600	2-56 UNC - 2B THRU [2-56 UNC - 2B THRU]
C4	6.987	1.600	2-56 UNC - 2B THRU [2-56 UNC - 2B THRU]

THIRD ANGLE PROJECTION

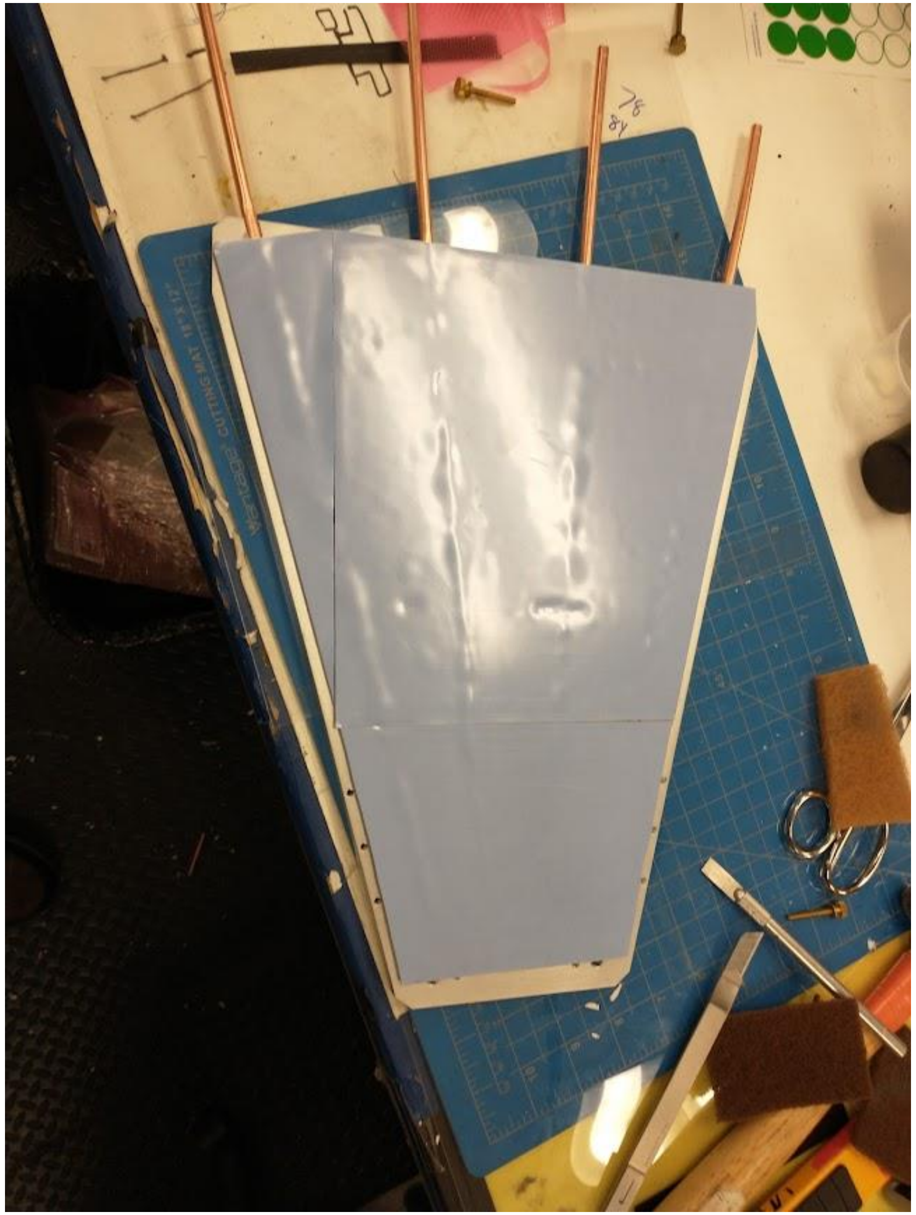
BROOKHAVEN NATIONAL LABORATORY
BROOKHAVEN SCIENCE ASSOCIATES
UPTON, NY 11973

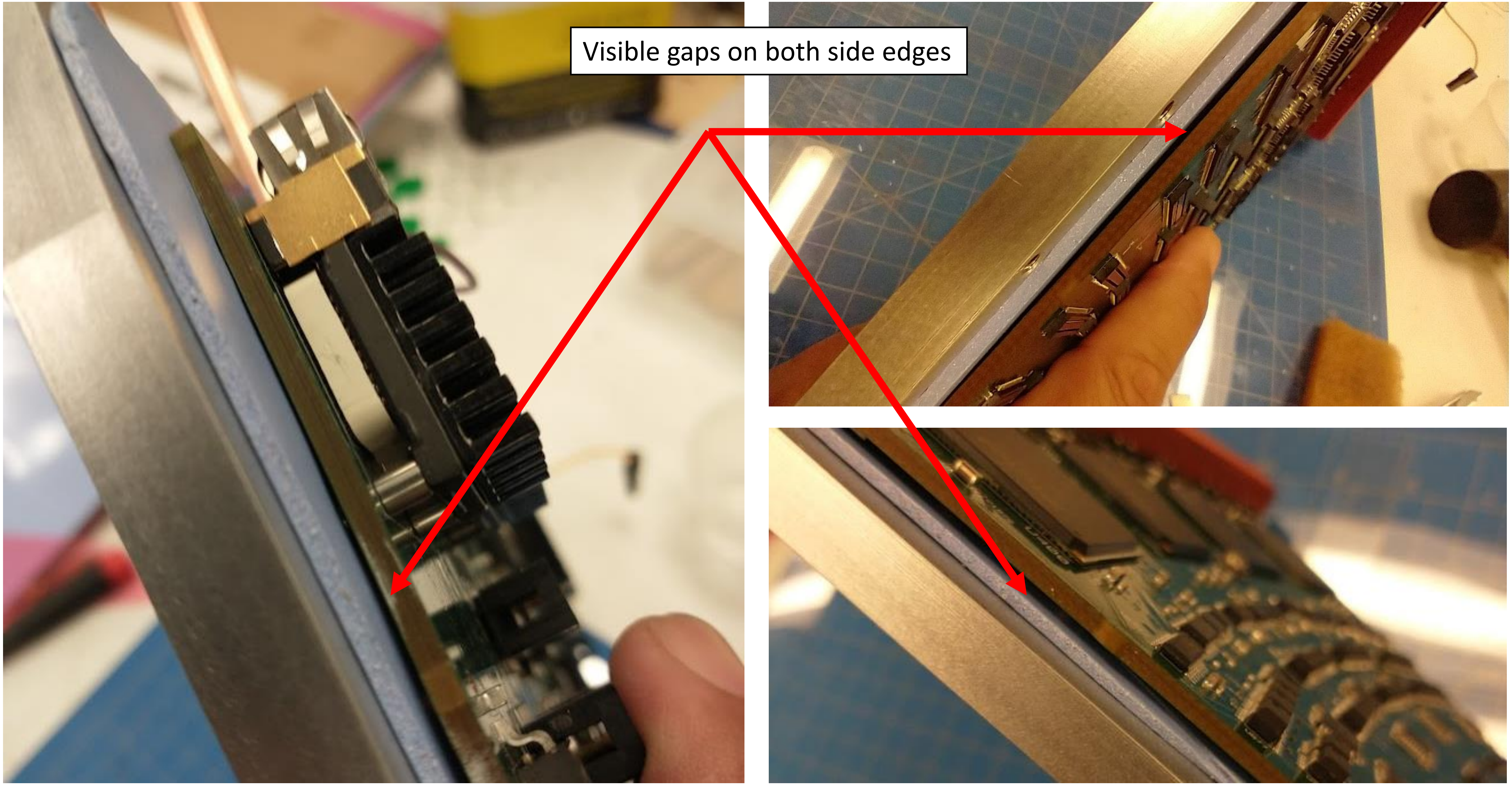
INTT
ROC Cooling Plate



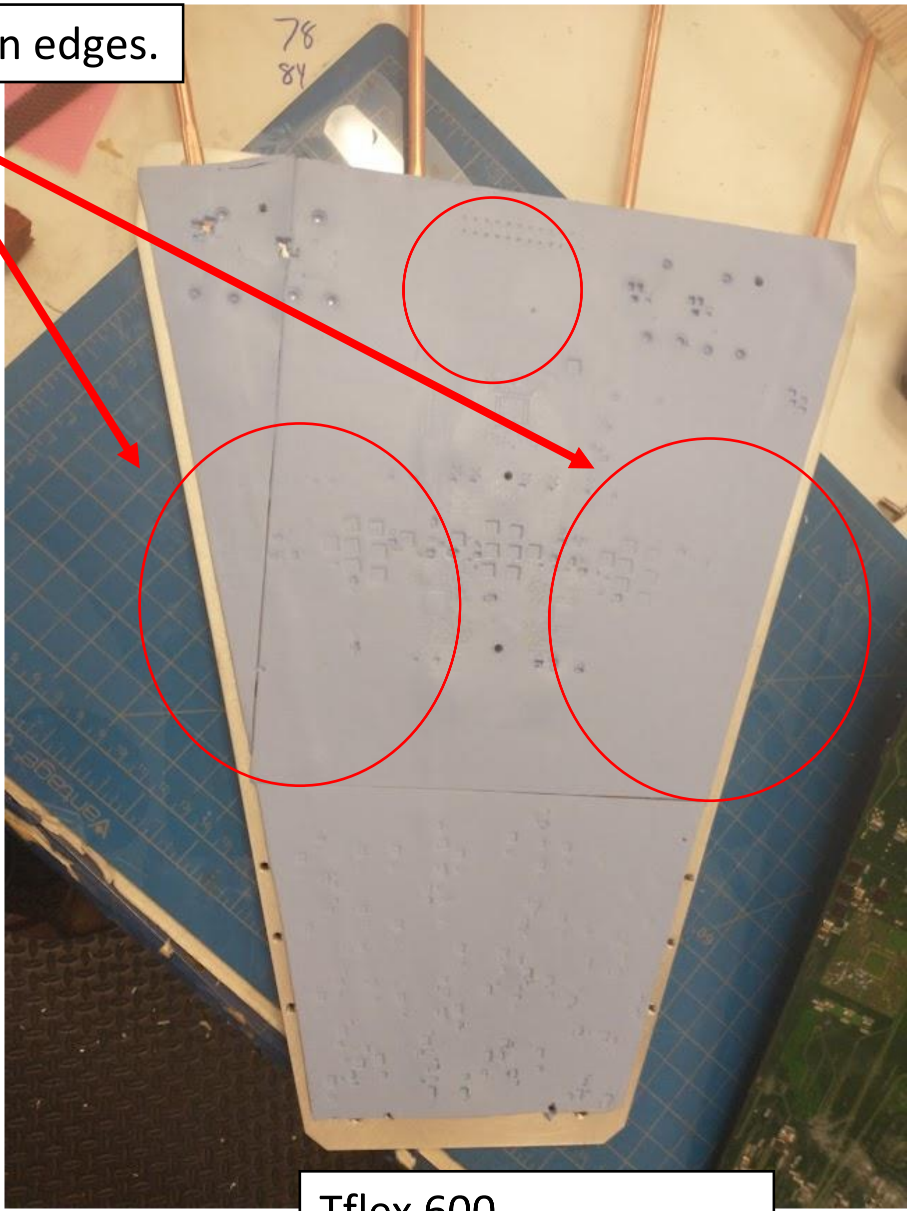


First try pressing copper tubing into channel



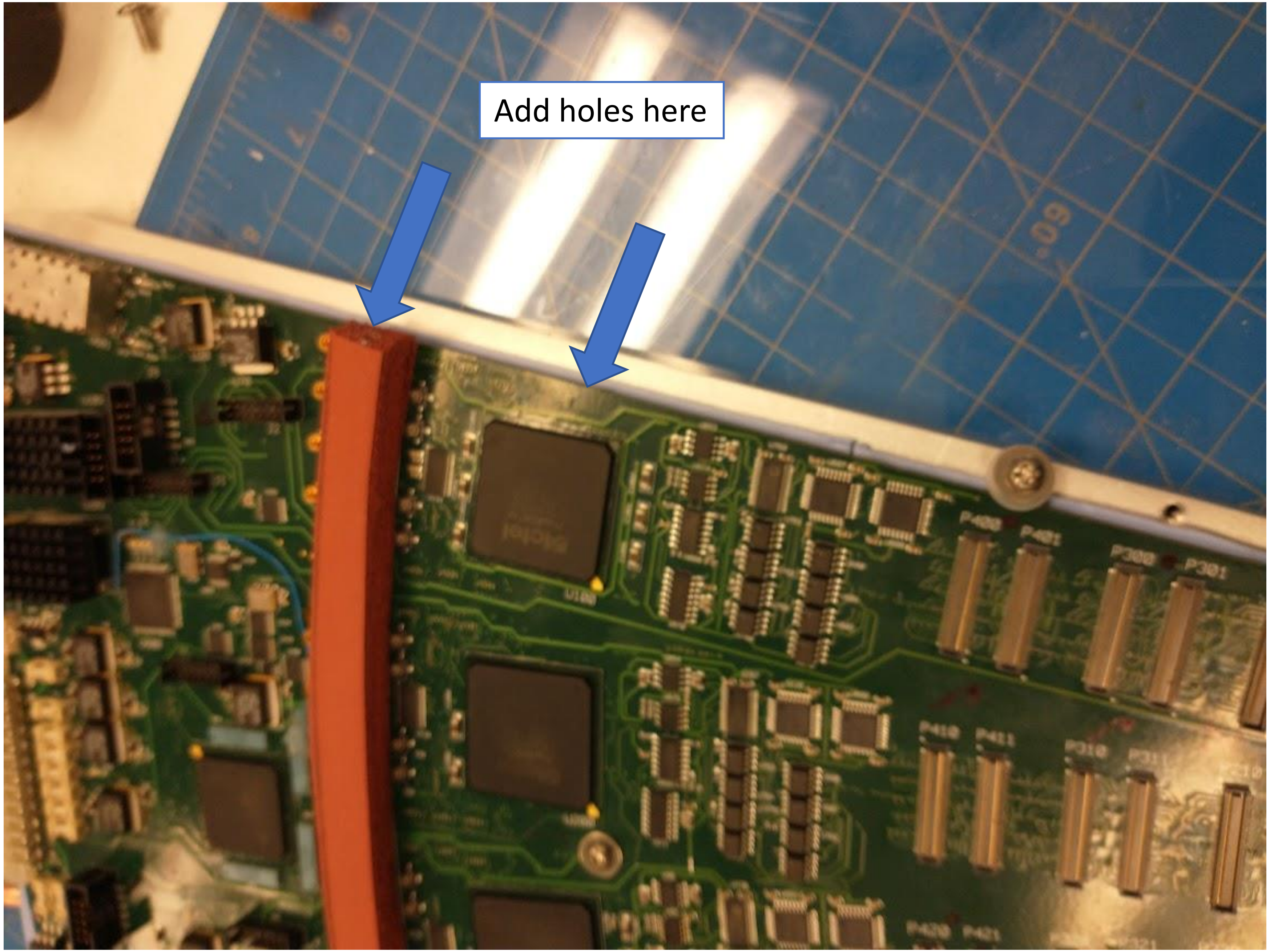


Visible gaps on both side edges

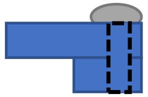


No contact on edges.

Tflex 600



Add holes here



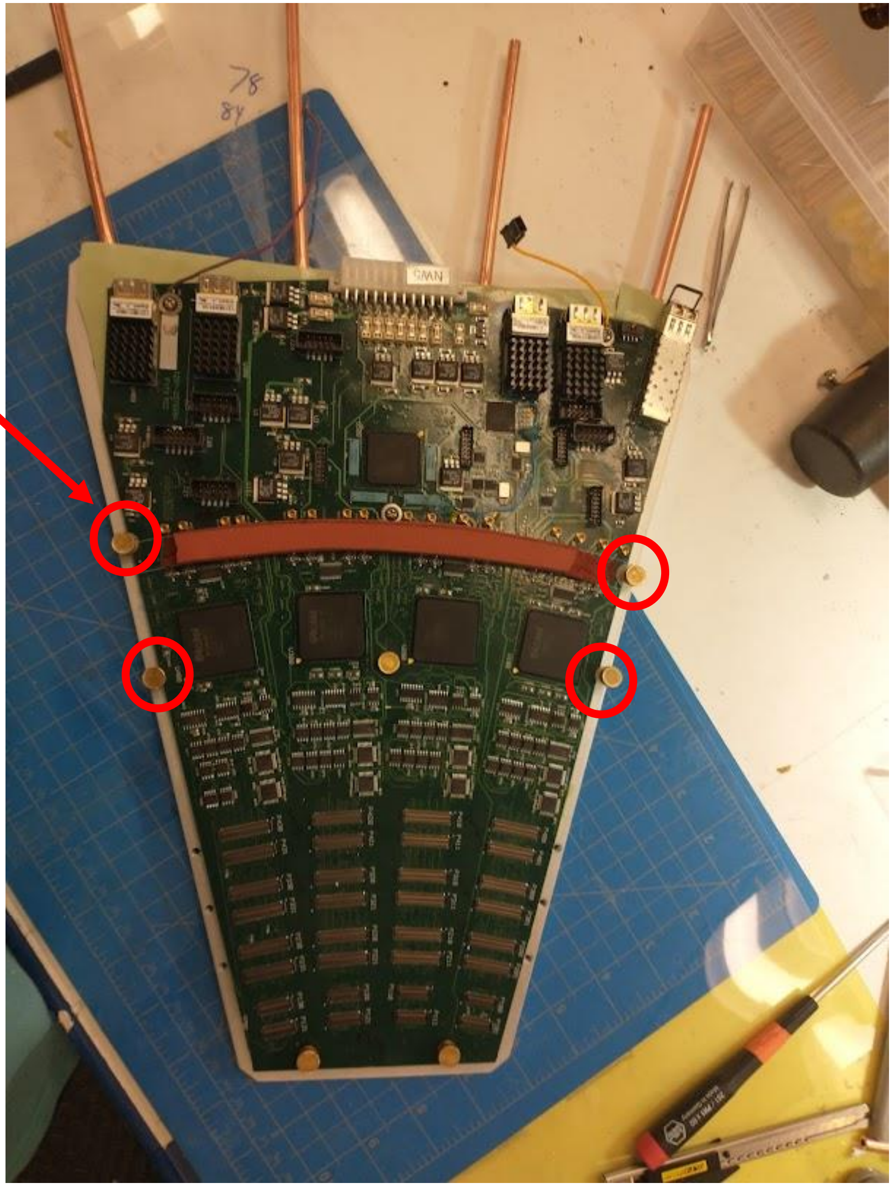
Added four 6-32 holes on edge

All mounting screws have nylon washers under them to prevent shorts.

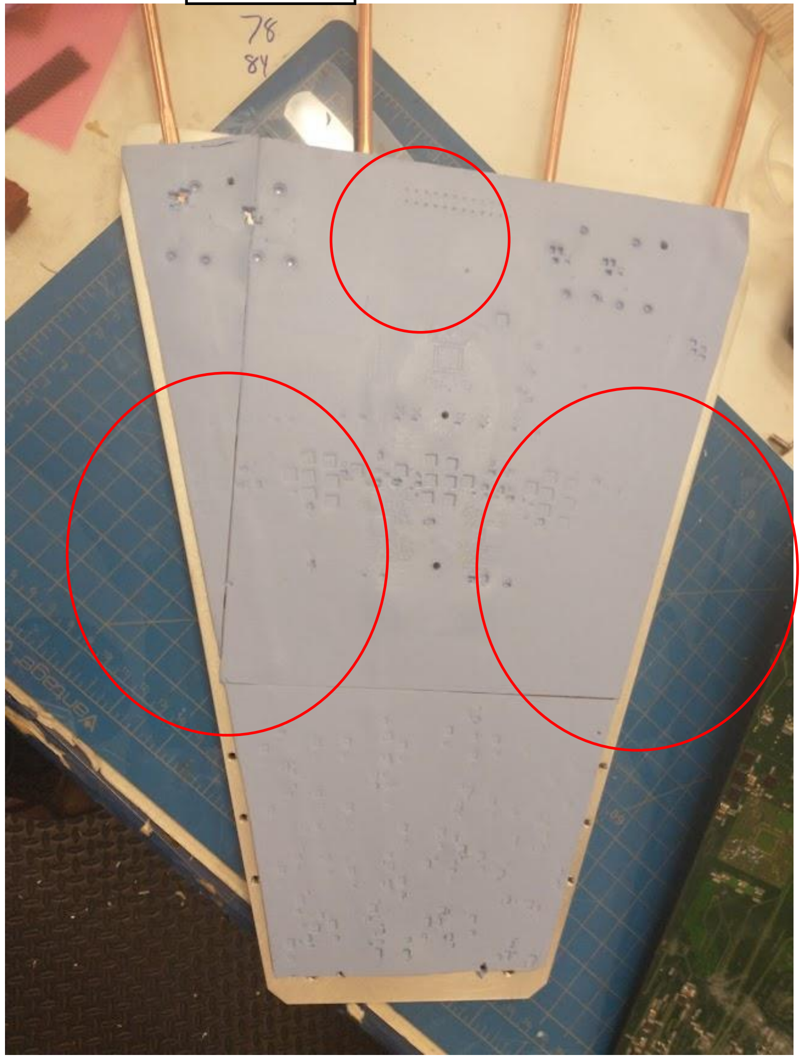
Green →Gap Pad Tflex 300
A little softer
1.2W/m-K
$12 a sheet

Blue →Gap Pad Tflex 600
Very soft
3.0W/m-K
$125 a sheet

We will test with Tflex 300 first.



Before

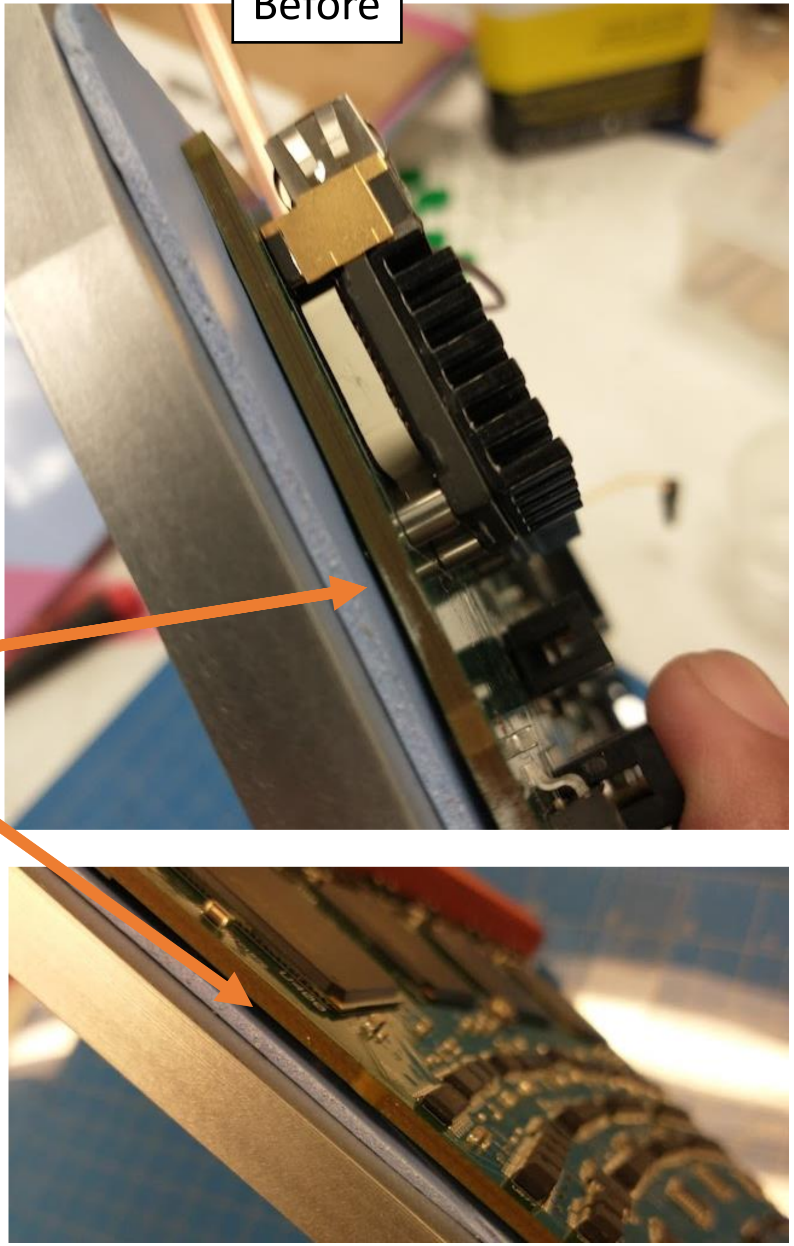


Tflex 600

After adding extra screws

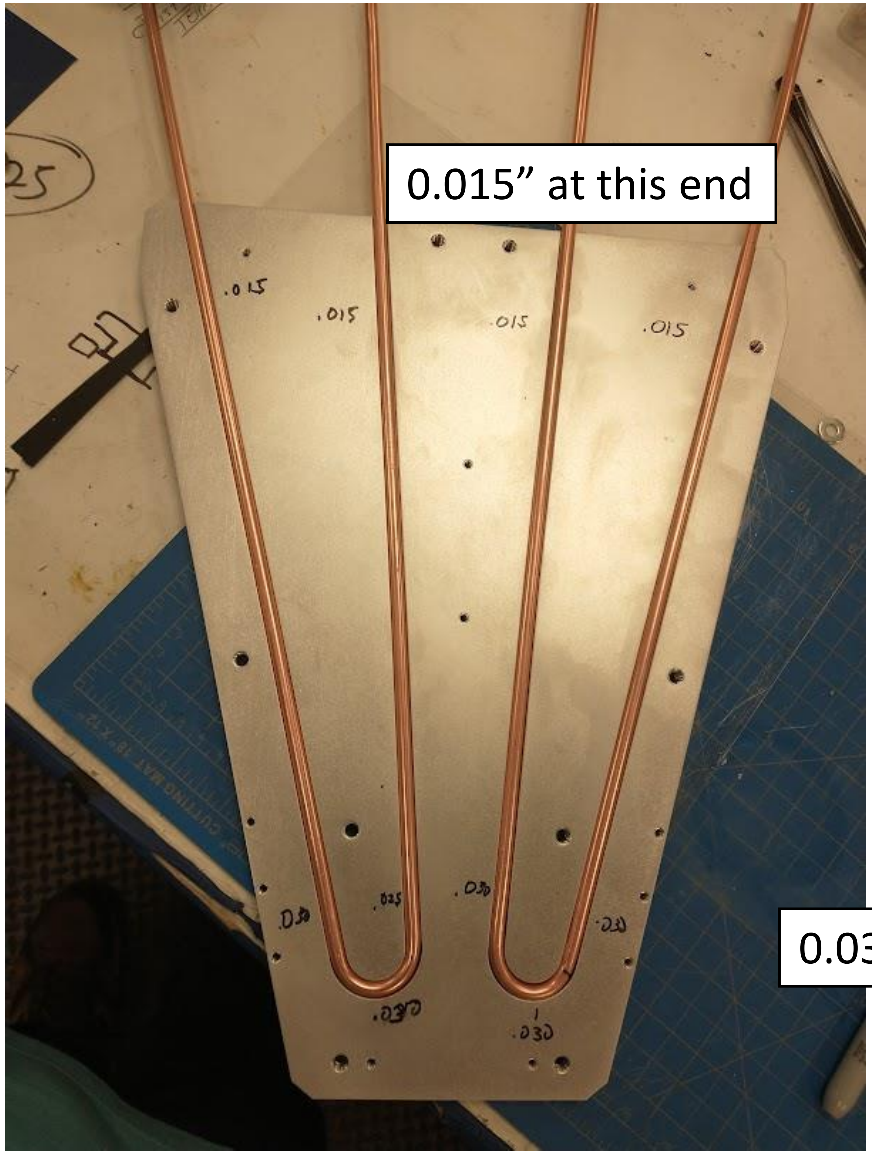
Switched to Tflex 300

Before



Gap No Contact

Gap Gone



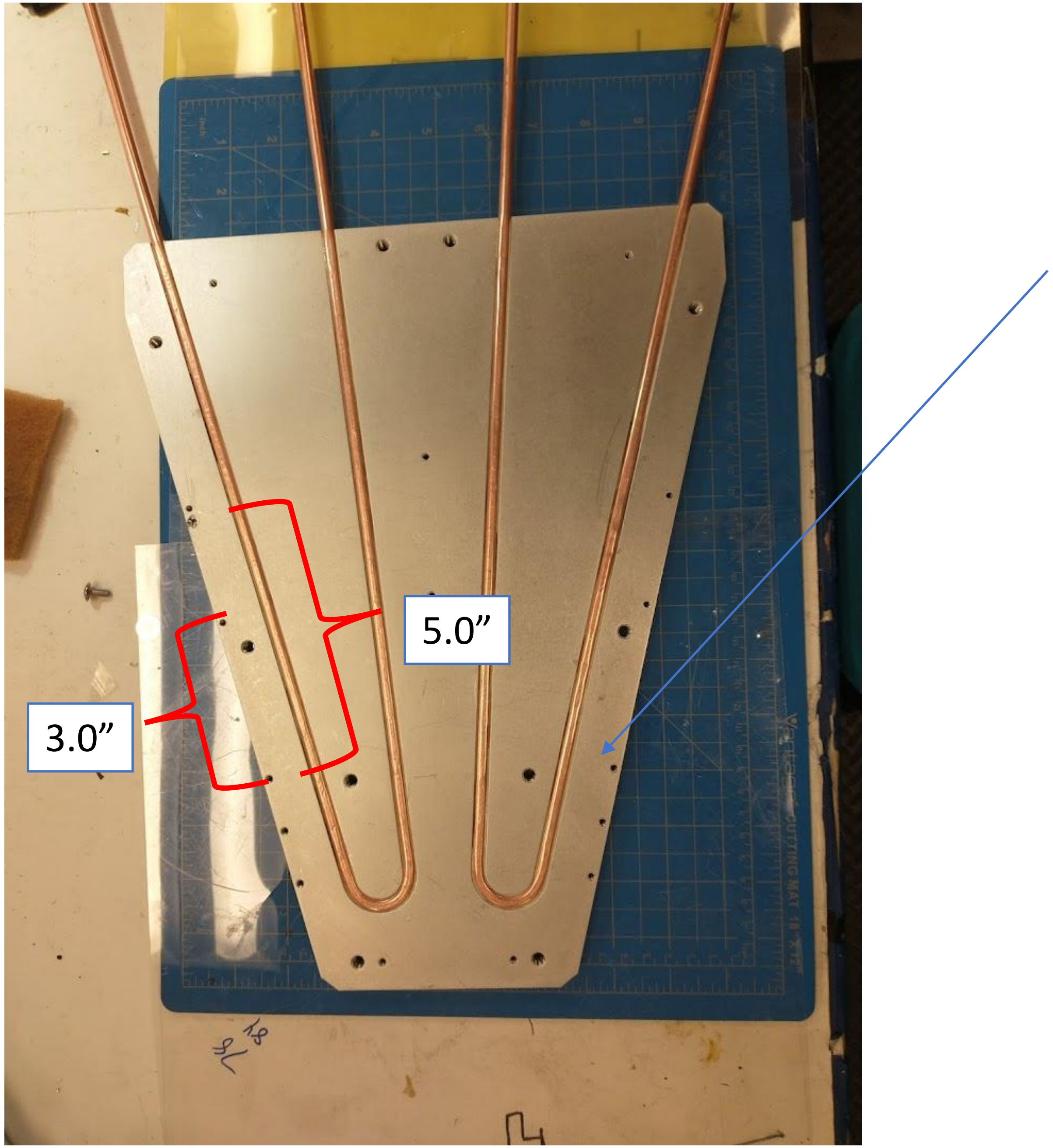
0.015” at this end

0.030” at this end

Amount tube sticks out above Al Plate

0.015 side is fine.

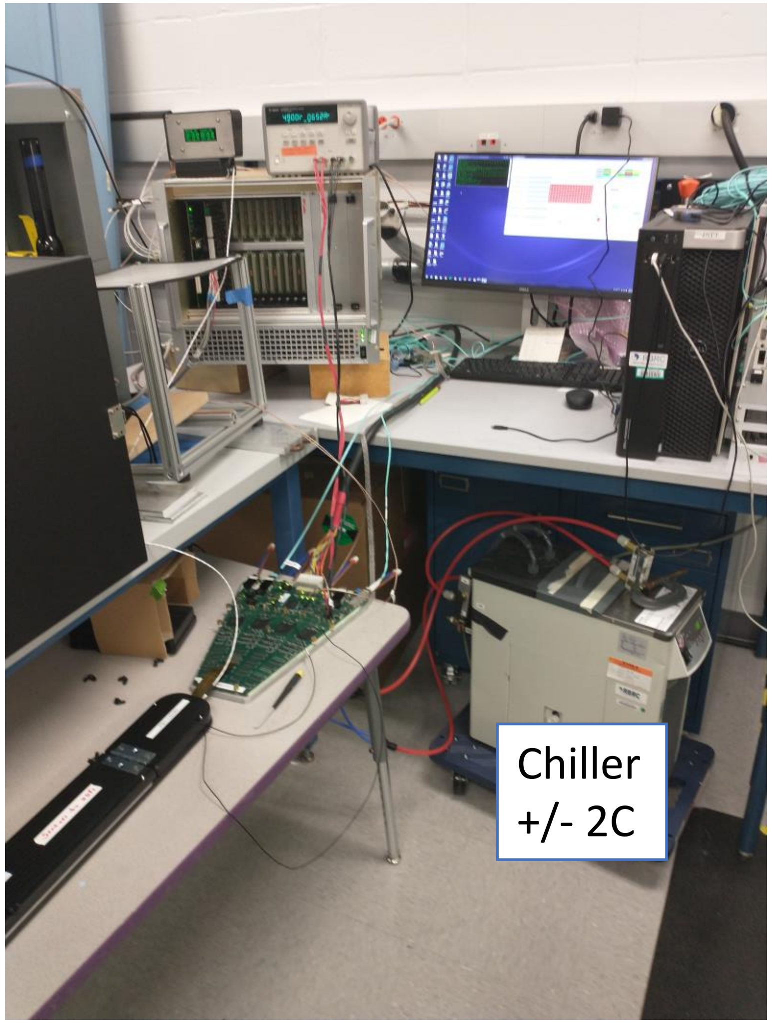
May make a mod to design to make the channel 0.015” deeper.



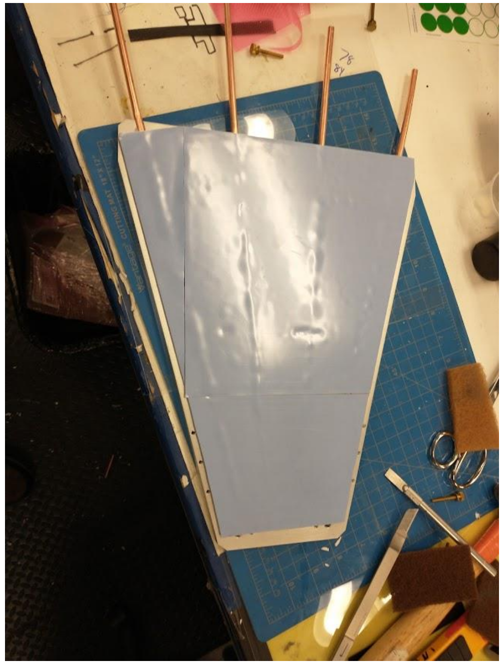
Placement of 4 new holes.

In line with these holes

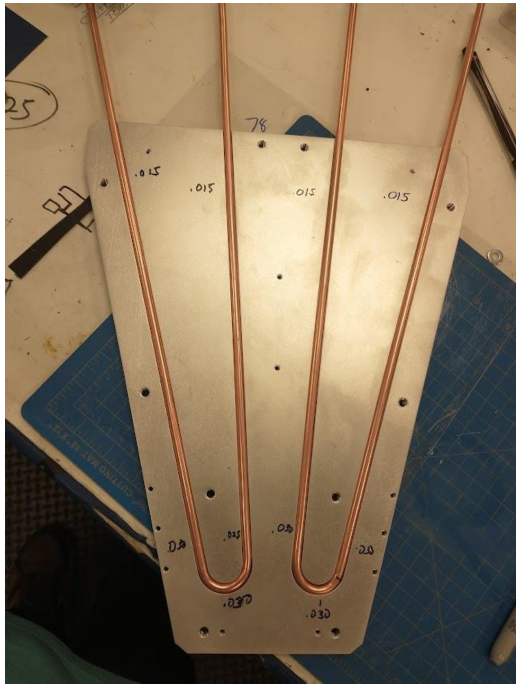
Setup



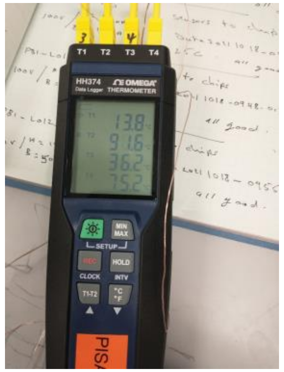
Chiller
+/- 2C

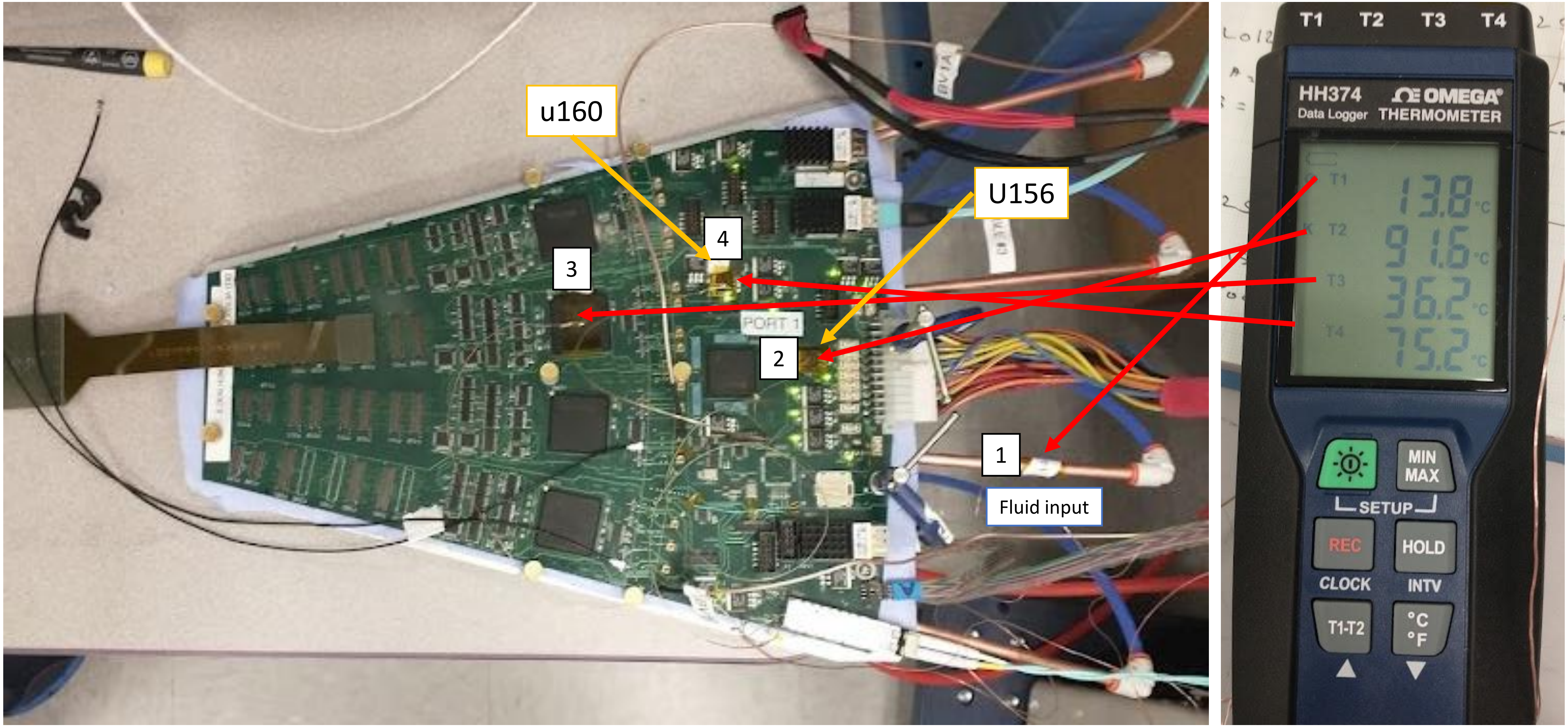


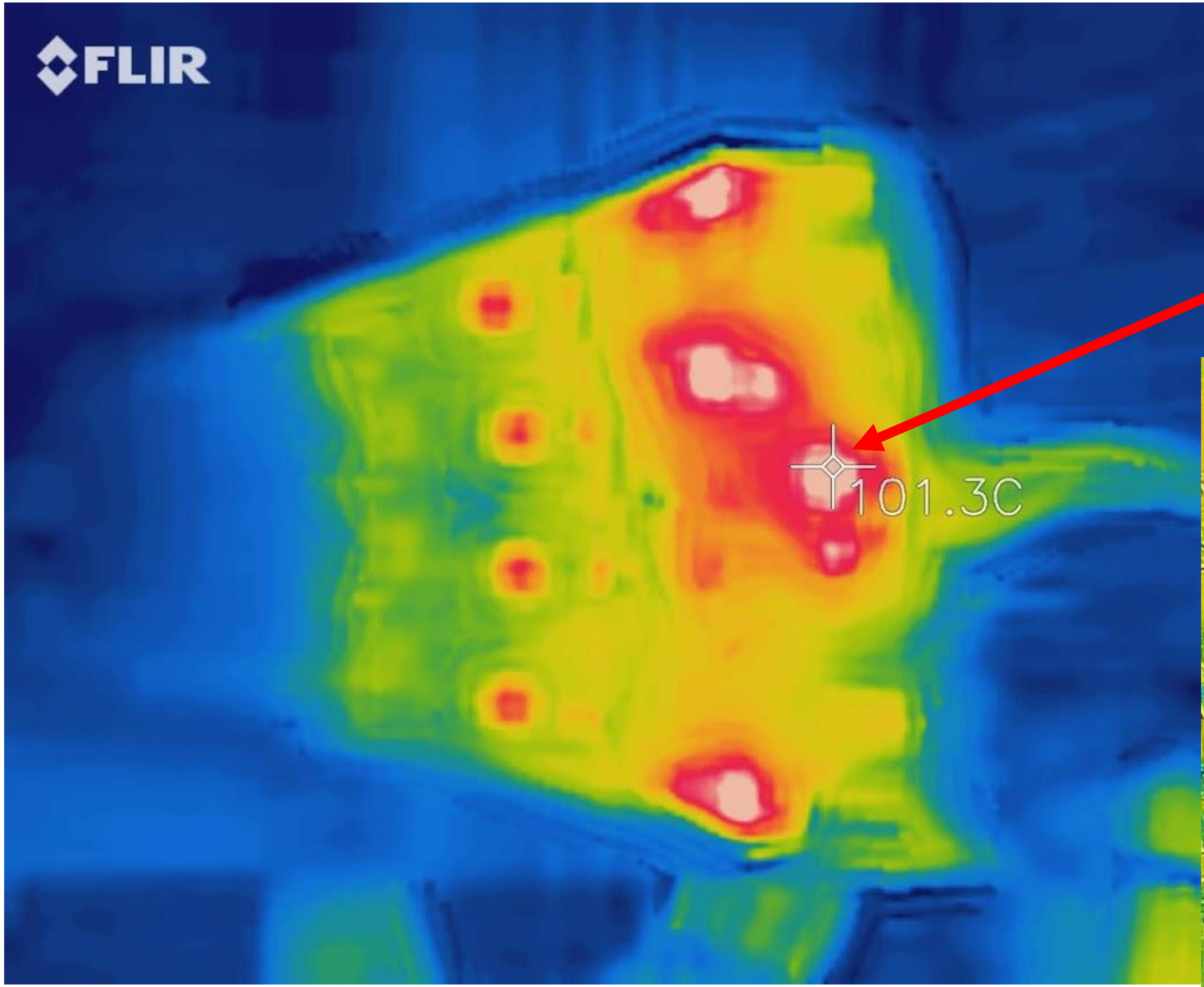
Using TFLEX 600 gap pad



We are using 4 K type thermocouples to monitor the temperature at a few locations on the ROC board.




u160
U156
4
3
2
1
Fluid input
T1
T2
T3
T4
HH374
Data Logger
OMEGA
THERMOMETER
T1 13.8 °C
T2 91.6 °C
T3 36.2 °C
T4 75.2 °C
MIN MAX
SETUP
REC
HOLD
CLOCK
INTV
T1-T2
°C °F



Cooling with just the plate.

There are 4-5 regulators running at 90-100C (White on picture). U156 is the worst in terms of temp.
C-Grade rating 125C MAX
Lt1585 cm 9266368

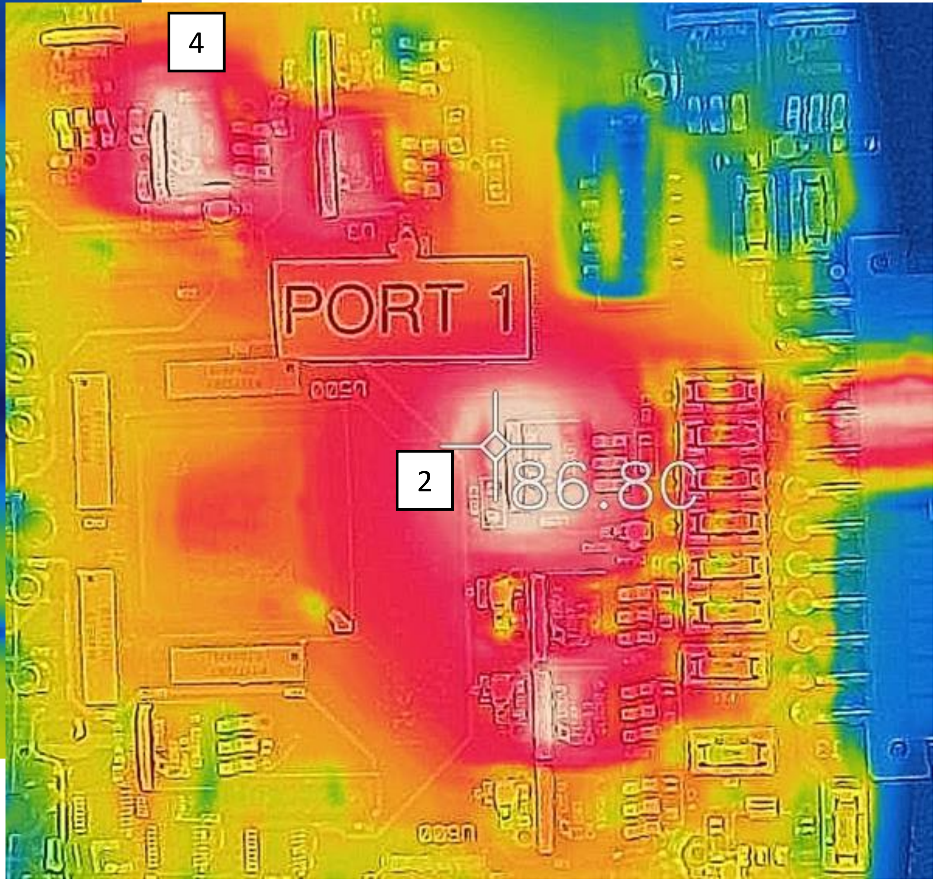
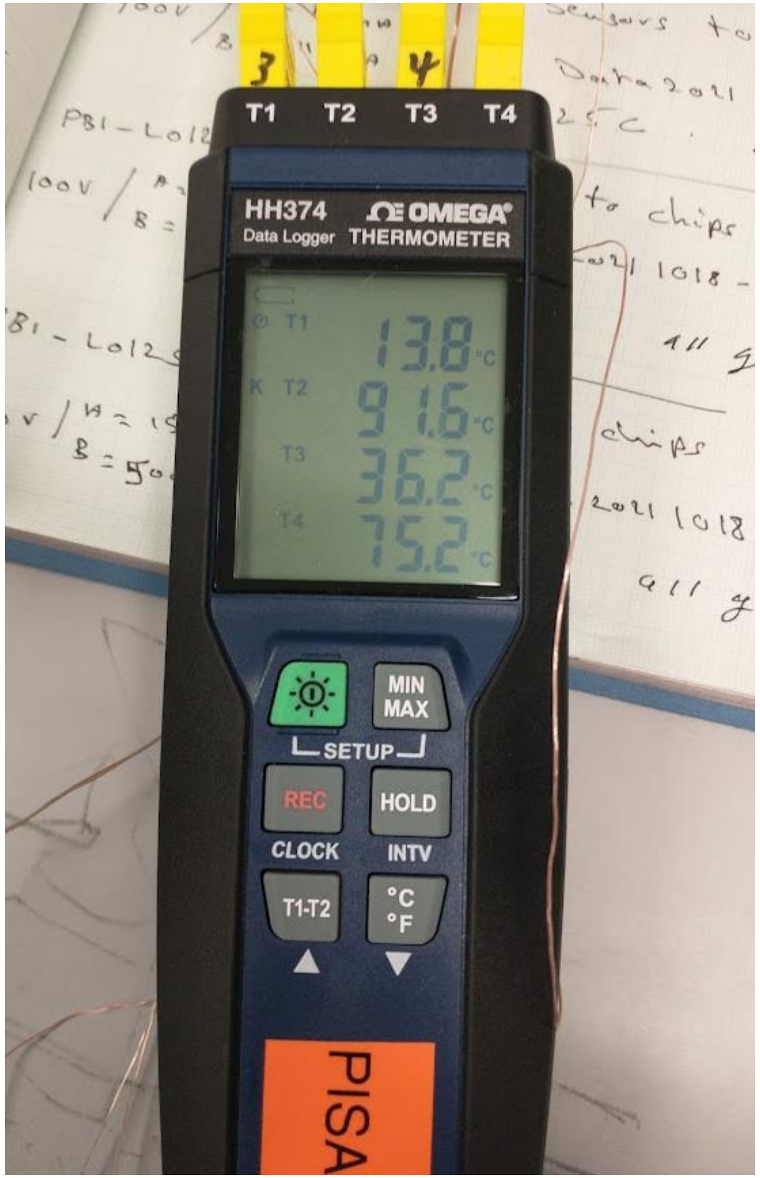
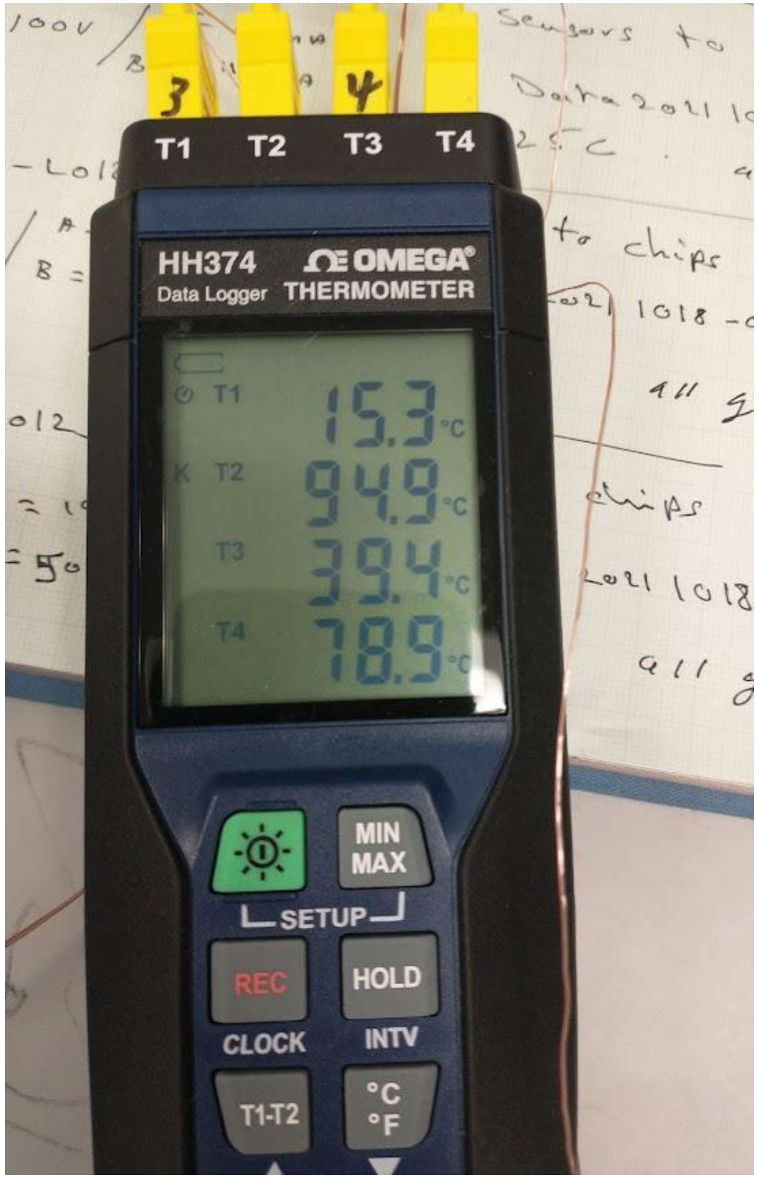


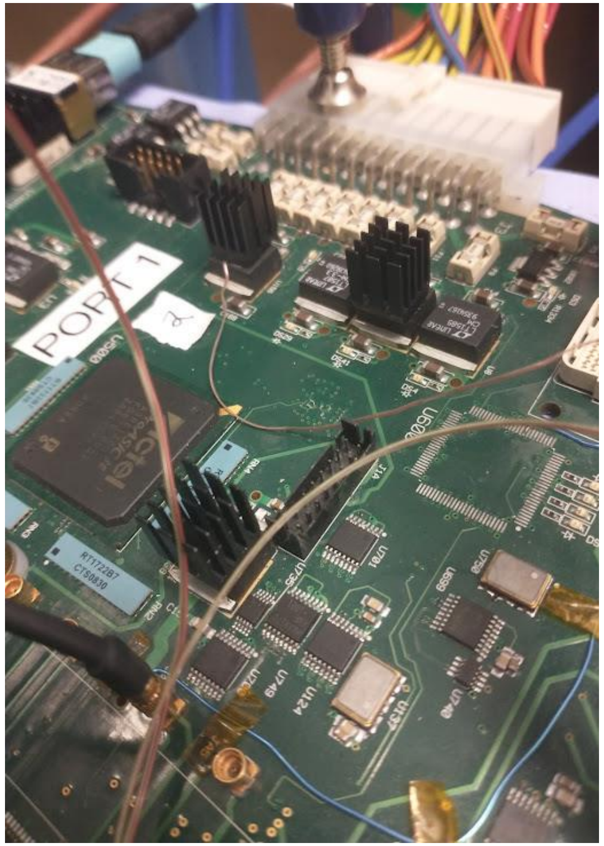
Plate is doing something. You can see temps change as the cooling fluid temp changes (T1). As T1 goes up a little, the other 3 components follow.

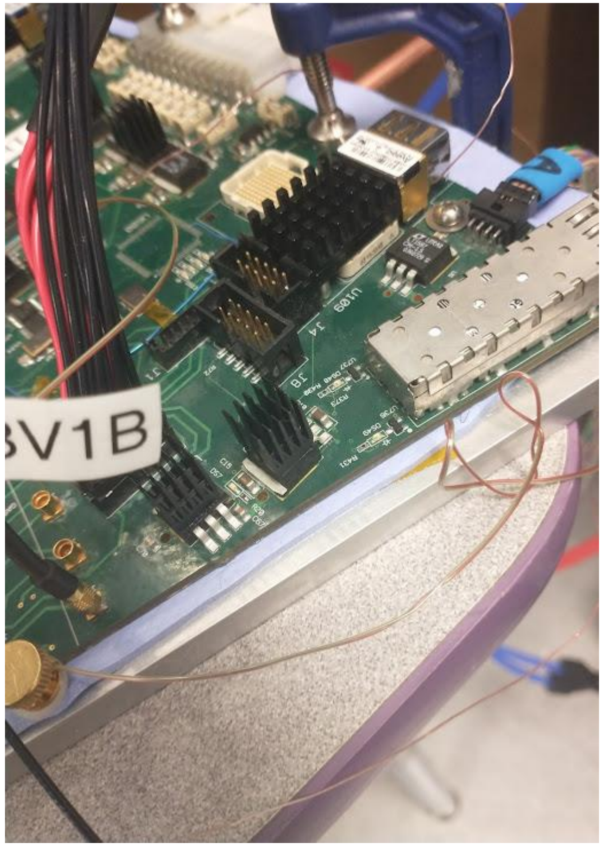
The ROC board is not designed to pull heat efficiently from the regulators through the back.

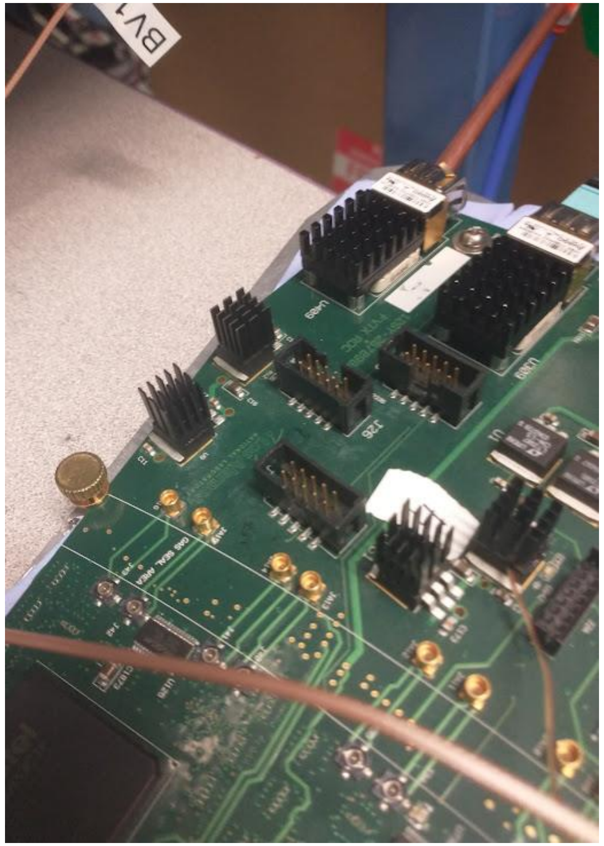
We will need to cool them directly.



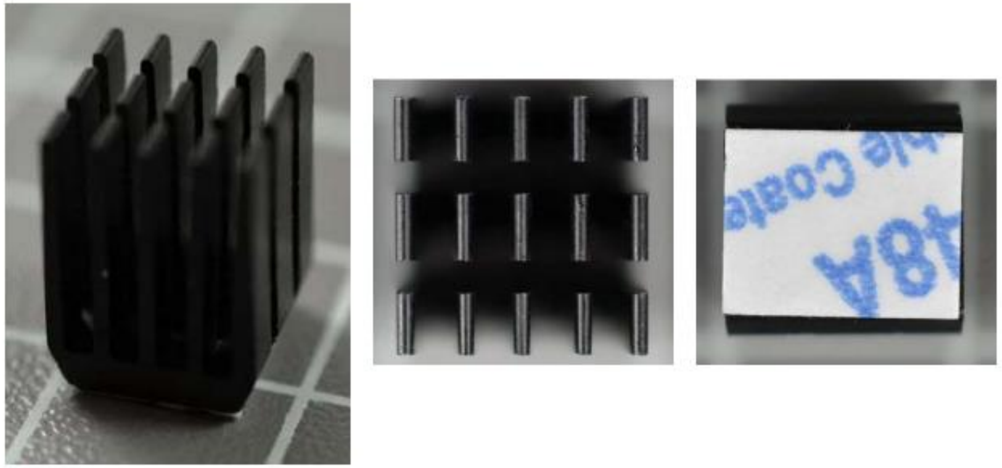



PORT 1
2


BV1B

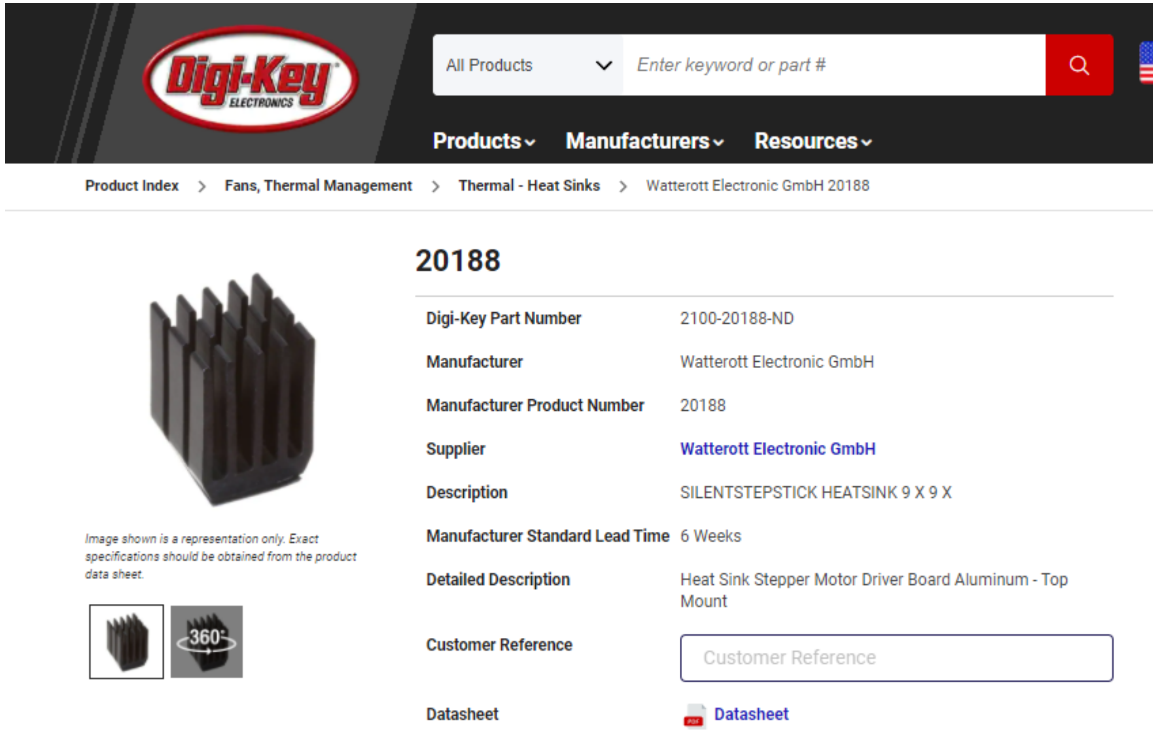

BV1

Heat Sink Part Number



SilentStepStick Heatsink 9 x 9 x 12

Item number: 20188



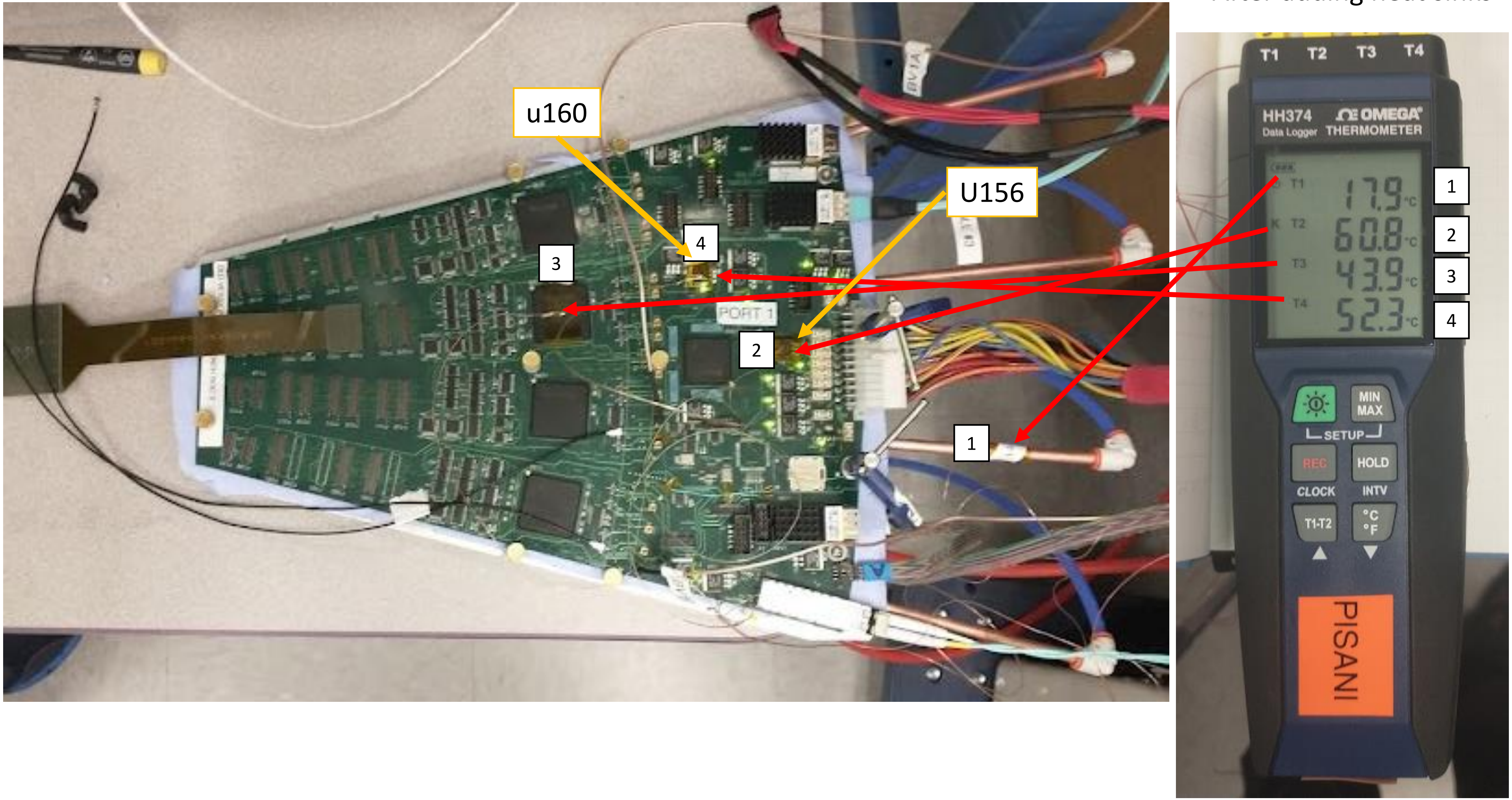
Product Index > Fans, Thermal Management > Thermal - Heat Sinks > Watterott Electronic GmbH 20188

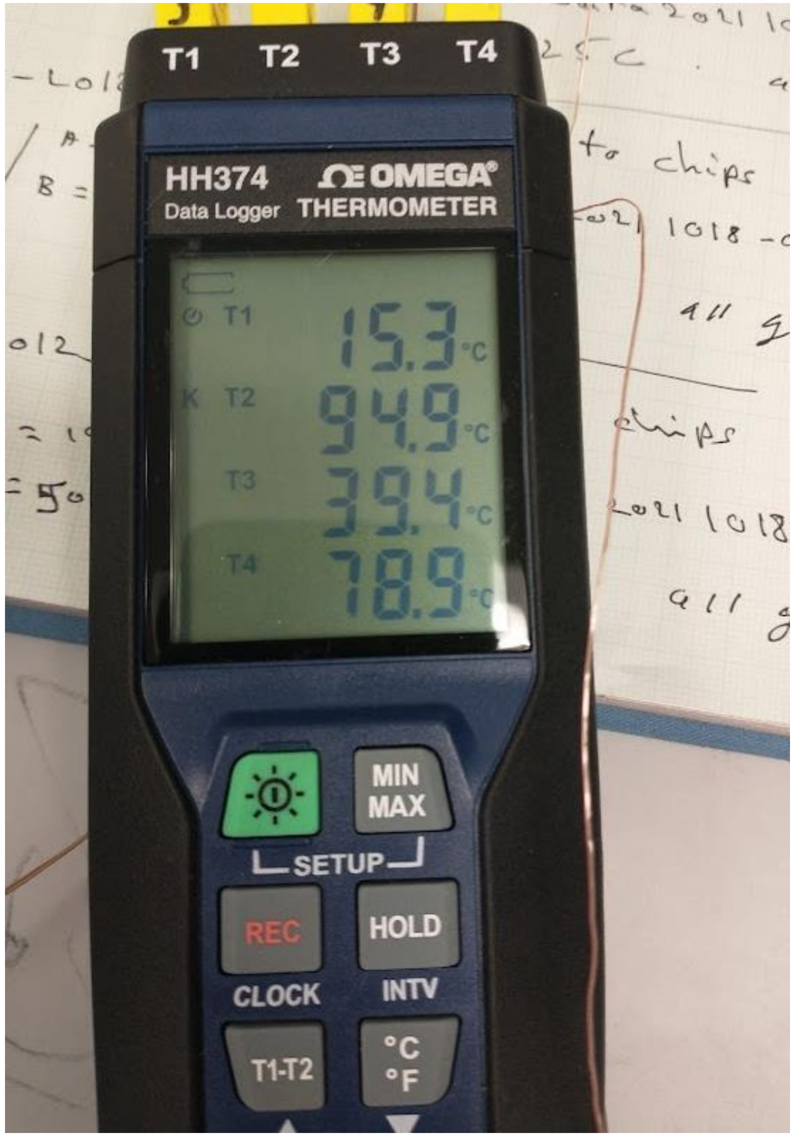
20188

Image shown is a representation only. Exact specifications should be obtained from the product data sheet.

Digi-Key Part Number	2100-20188-ND
Manufacturer	Watterott Electronic GmbH
Manufacturer Product Number	20188
Supplier	Watterott Electronic GmbH
Description	SILENTSTEPSTICK HEATSINK 9 X 9 X
Manufacturer Standard Lead Time	6 Weeks
Detailed Description	Heat Sink Stepper Motor Driver Board Aluminum - Top Mount
Customer Reference	Customer Reference
Datasheet	Datasheet

After adding heat sinks



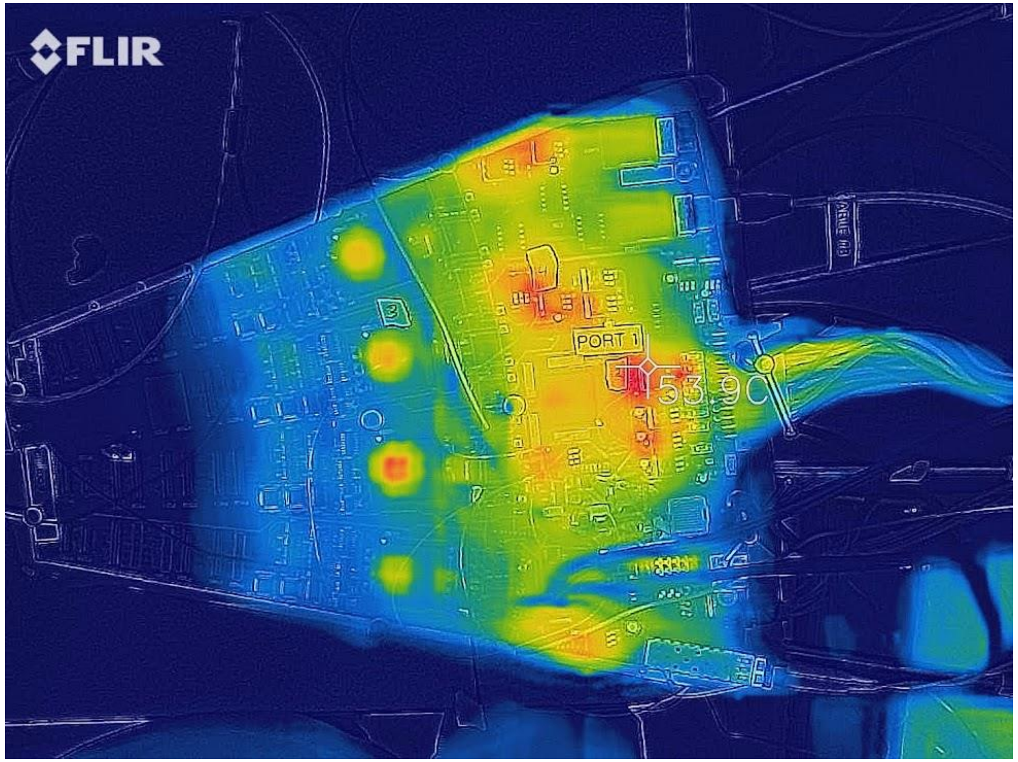


After adding heat sinks

2 regulators are 35C cooler. Note T1 is 3 degrees higher.

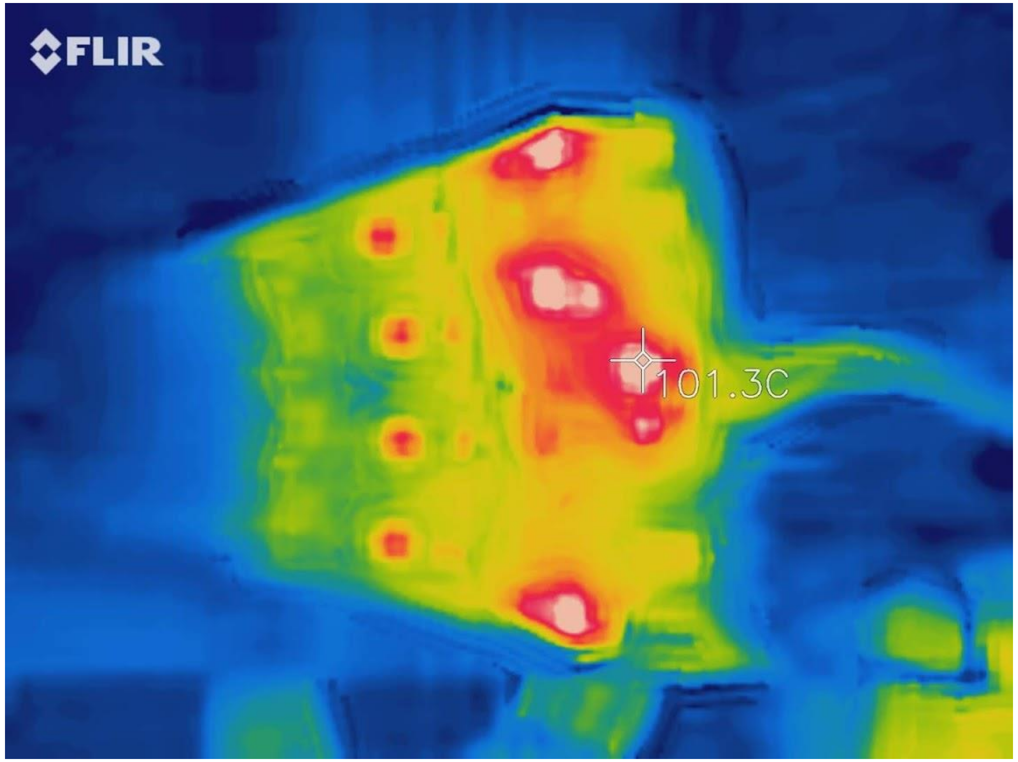
Note: Temp of cooling fluid (T1) is 18C so FPGA (T3) temp went up 3 degrees following the fluid temp.

With Heat Sinks



Highest temp around 60C

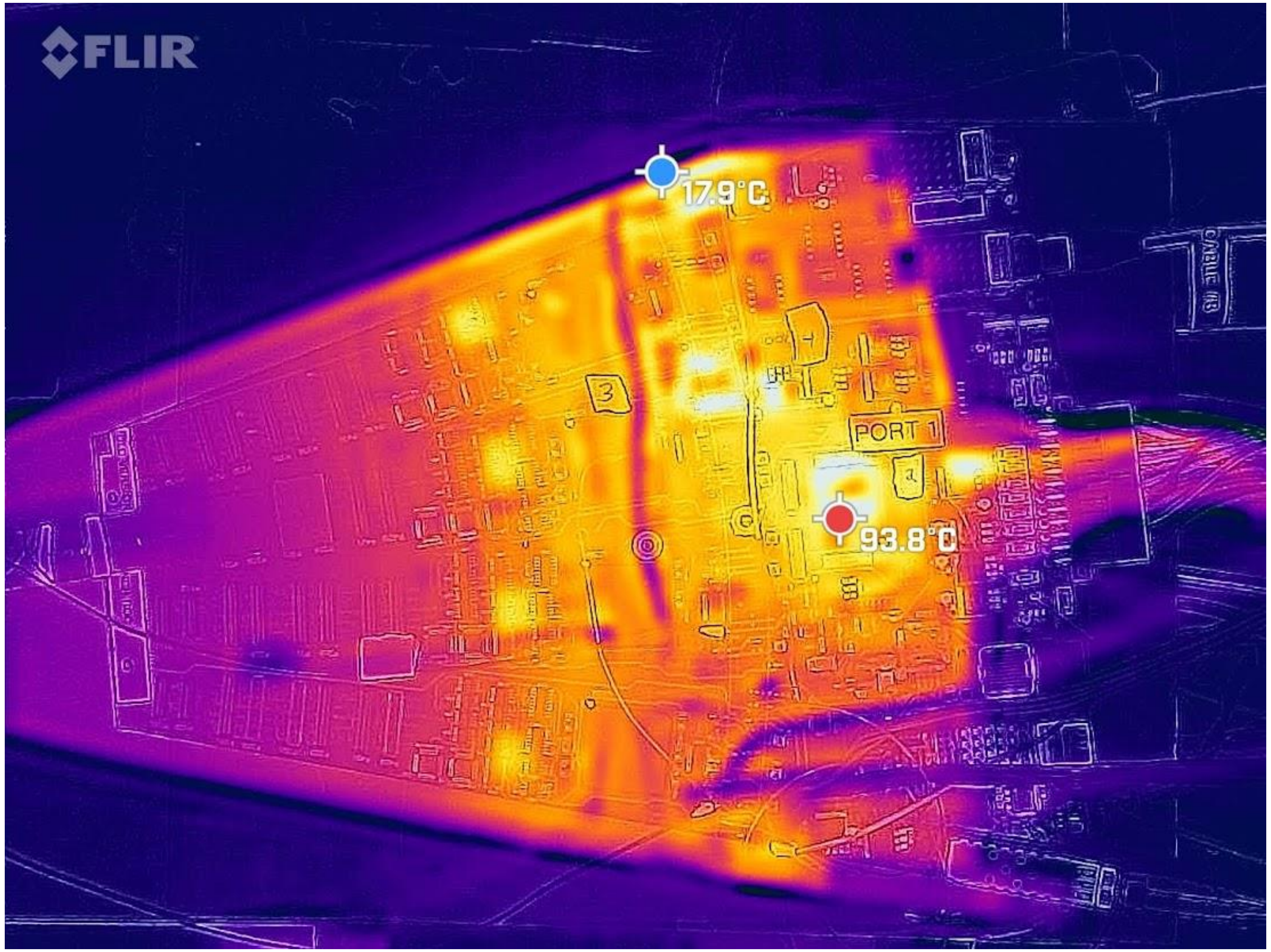
Without Heat Sinks



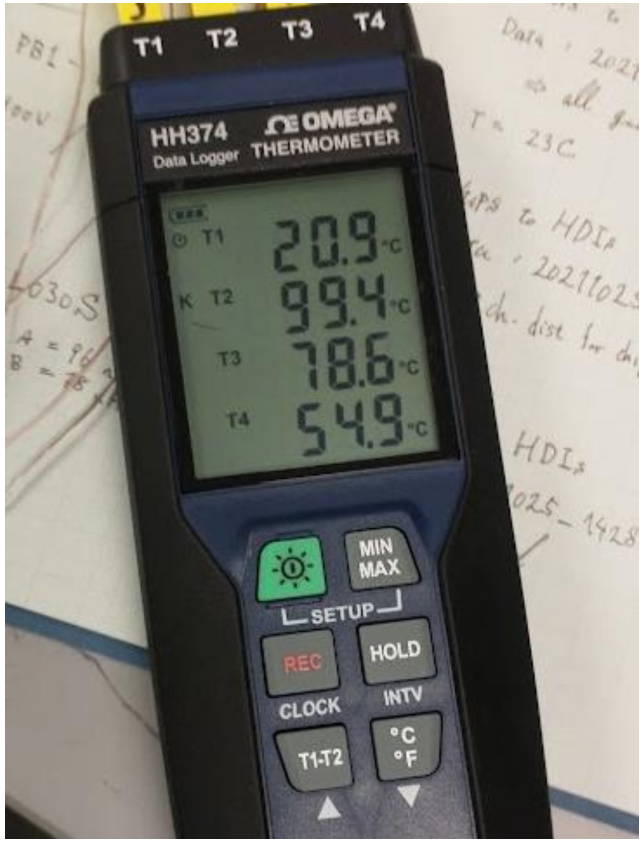
Highest temp around 105C

Next Step: Try adding heat sink to FPGA

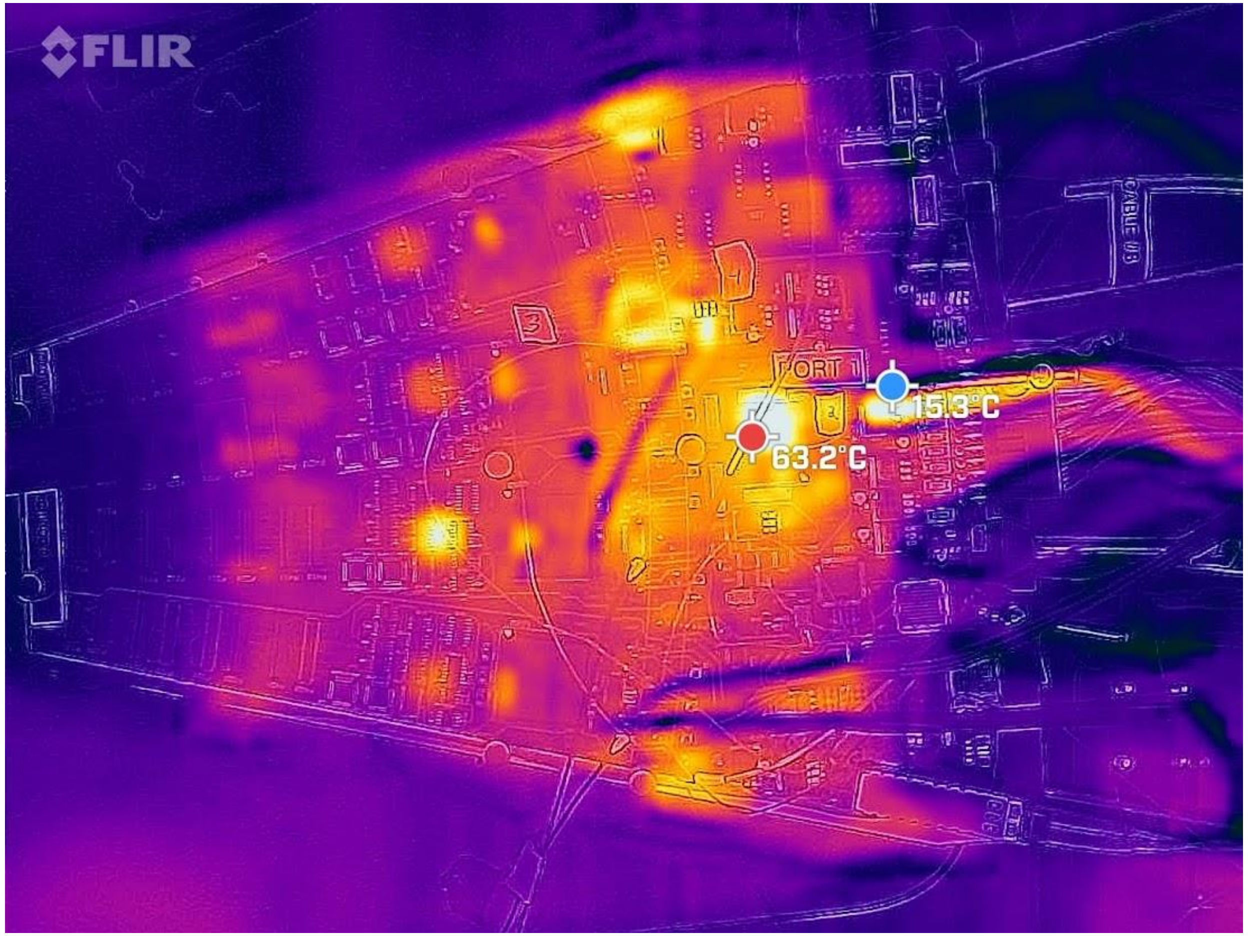
Testing with cold plate.



ROC without cooling plate connected.. Floating. No Fan. Still has heat sinks on regulators. Wanted to test how much heat the cold plate is removing.



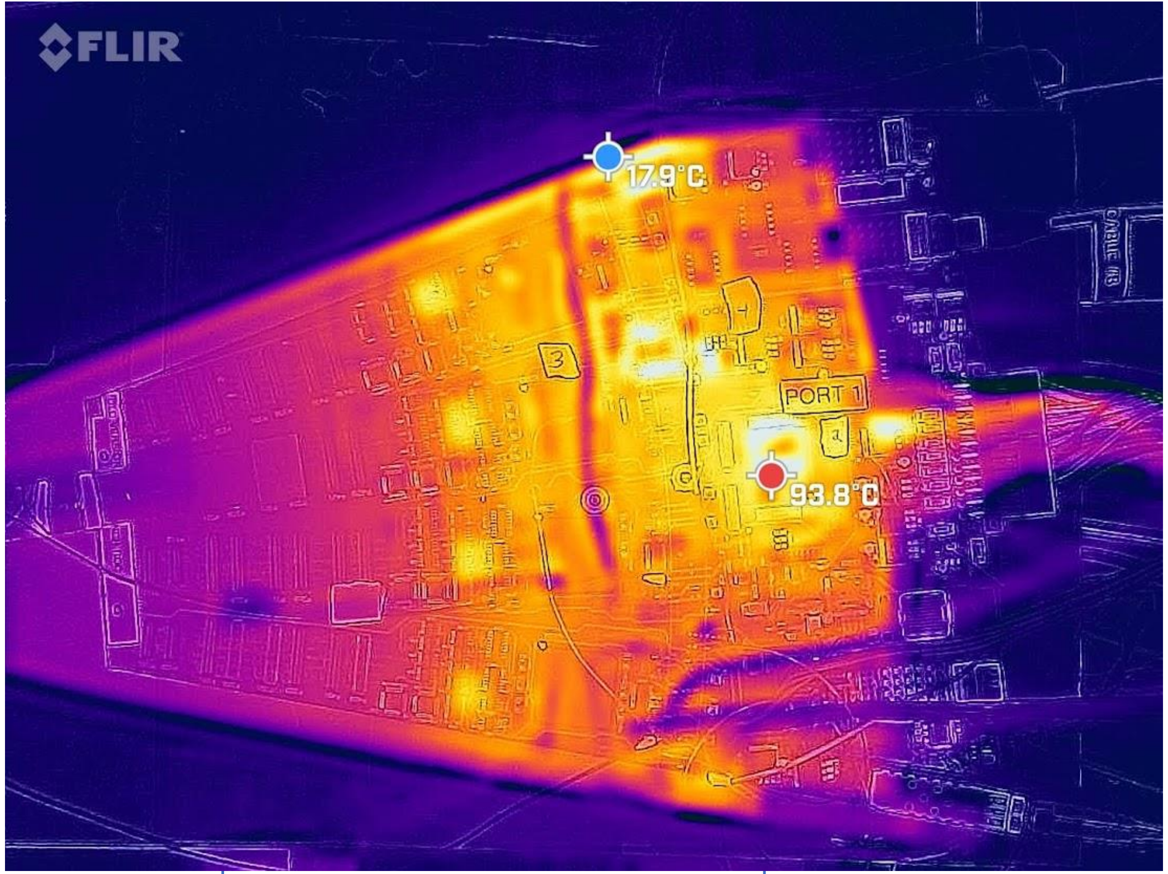
Was still going up but stopped the test since there was no cooling. Regulators still have heat sink.



Attached cooling plate and turned the chiller on.

Stable again. Went back to the previous numbers. Cold plate drops the temp of the regulators by 35-40C

Without Cooling Plate



Highest temp around 95C

With Cooling Plate

Highest temp around 60C

Summary

- Recommendation #5. Complete the FEA of the cooling of the ROC.

  Answer: instead to do the FEA analysis, we built the really ROC Aluminum plate support with cooling embedded and we did thermal studies:

- To ensure normal operation of the ROC during data taking we need following:
  - a) Thermal plate with cooper cooling tubes embedded (two inputs and two output)
  - b) Cooling sets at 18 degree Celsius
  - c) heat sinkers are needed and they are mounted on the regulators of the ROC front side ($1 each heat sinker)
    - Under these conditions:
      - a) the regulators are operating at 60 degree C (instead of 105 degree C during FVTX operation)
      - b) the FPGA chips are operation at 38 degree C