sPHENIX INTT

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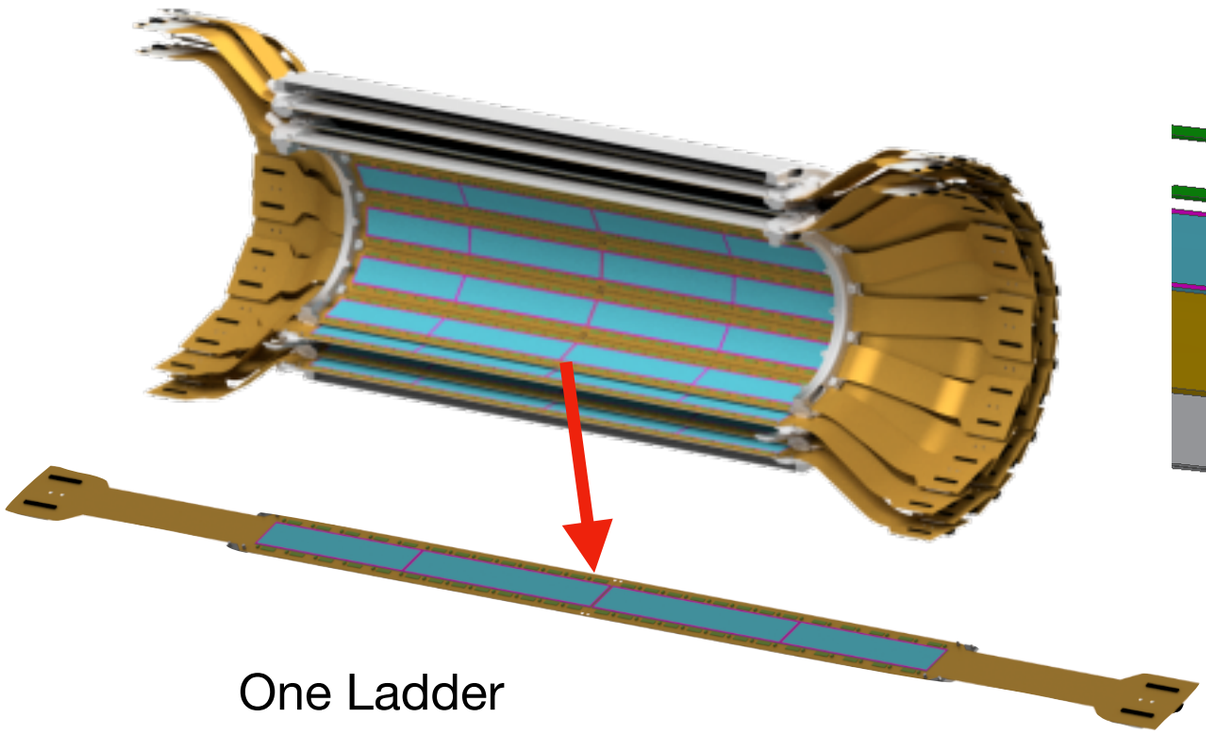
RIKEN/RBRC : Takahito Todoroki, Itaru Nakagawa

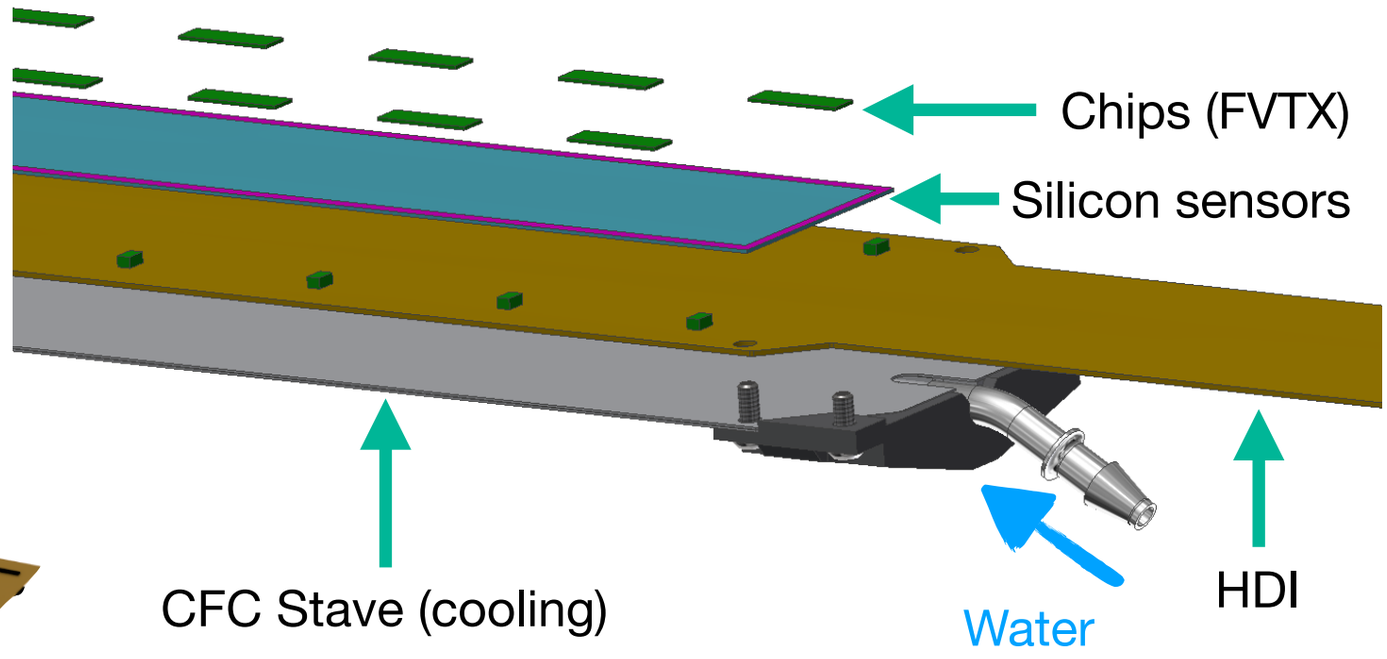
2021/01/22

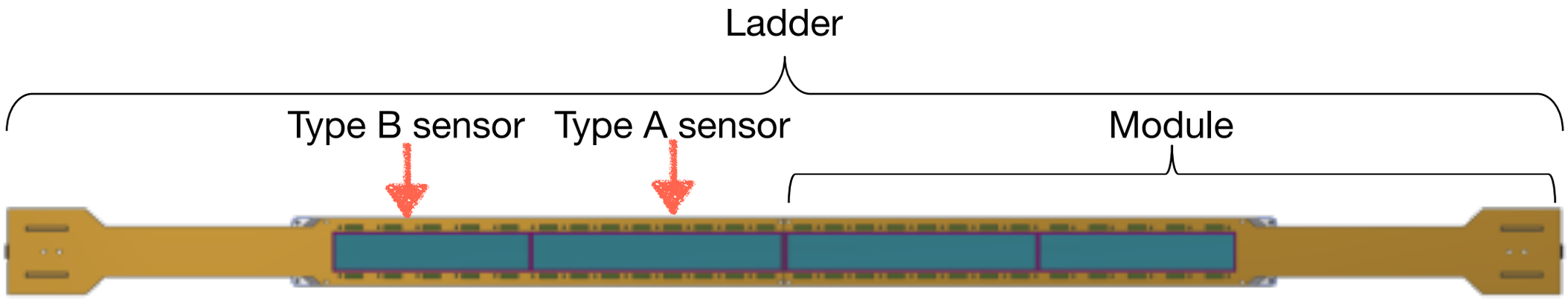
INTermediate Tracker (INTT)

2 layers of silicon strip detector



Module = 1 HDI + 26 Chips + 2 Silicon sensors
Ladder = 2 Modules + 1 CFC Stave





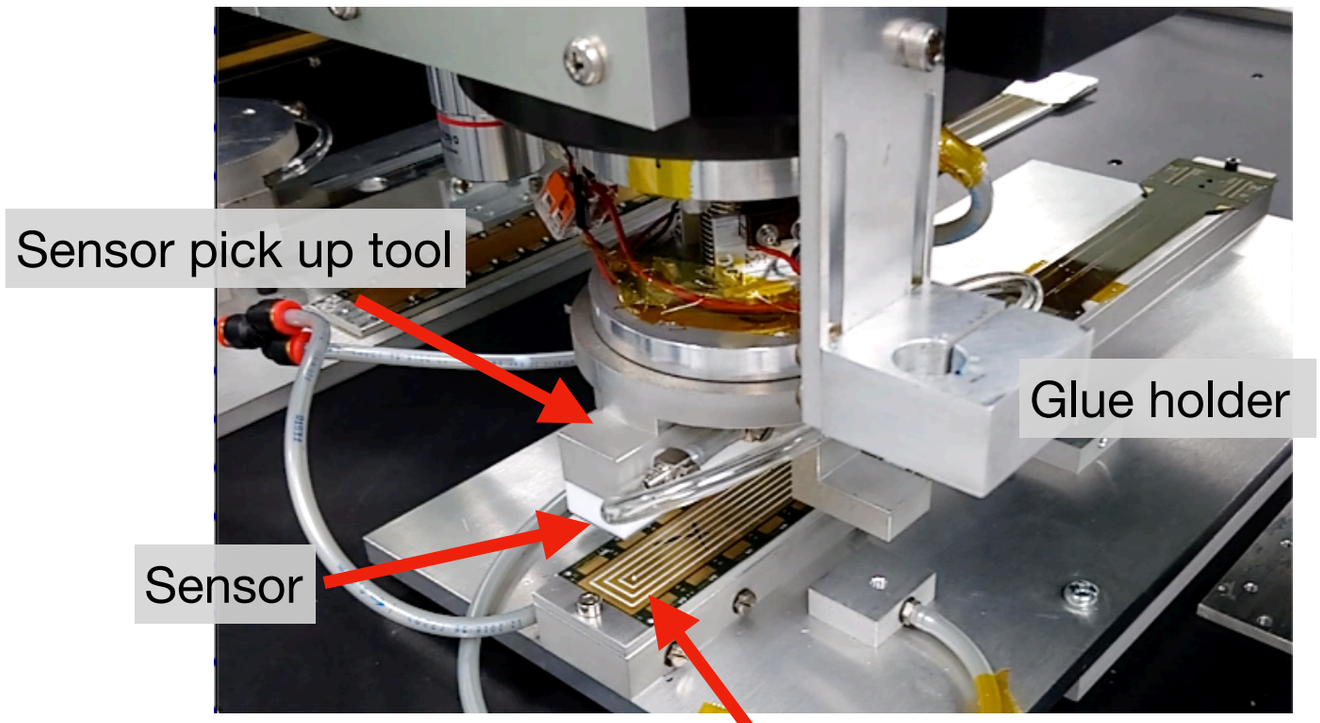
INTT : 56 Ladders + 64 spares = 120 Ladders -> 40 Ladders in Taiwan

INTT assembly introduction

Assembly Unit : Module

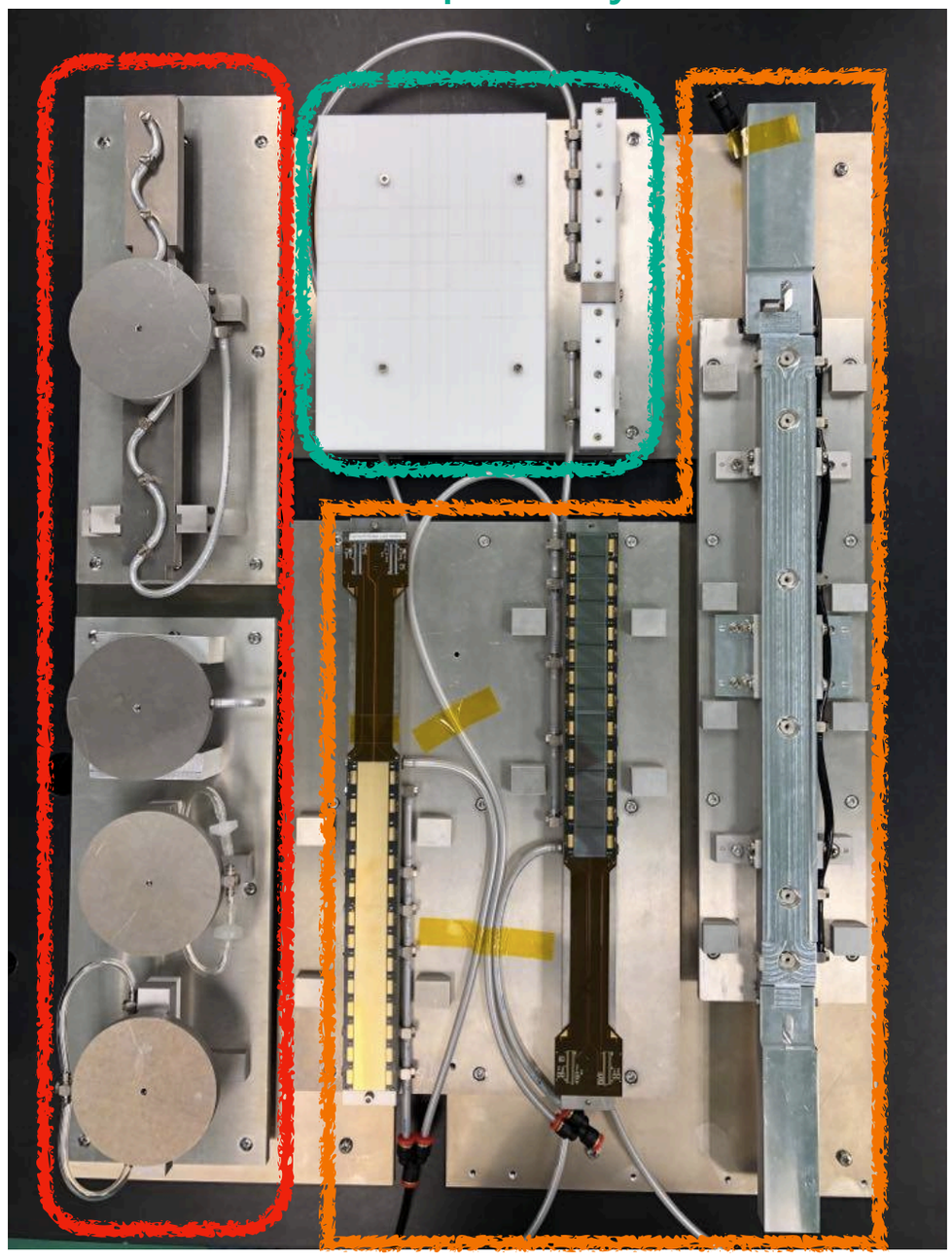
- Module assembly procedures :
  1. Chips to HDI
  2. Sensors to HDI
  3. Encapsulation glue to HDI
  4. Thermal cycle test
- Ladder assembly procedures :
  - Modules to Stave

Assembly requirements : Sensor placing error < 50 μm



INTT assembly family on Gantry

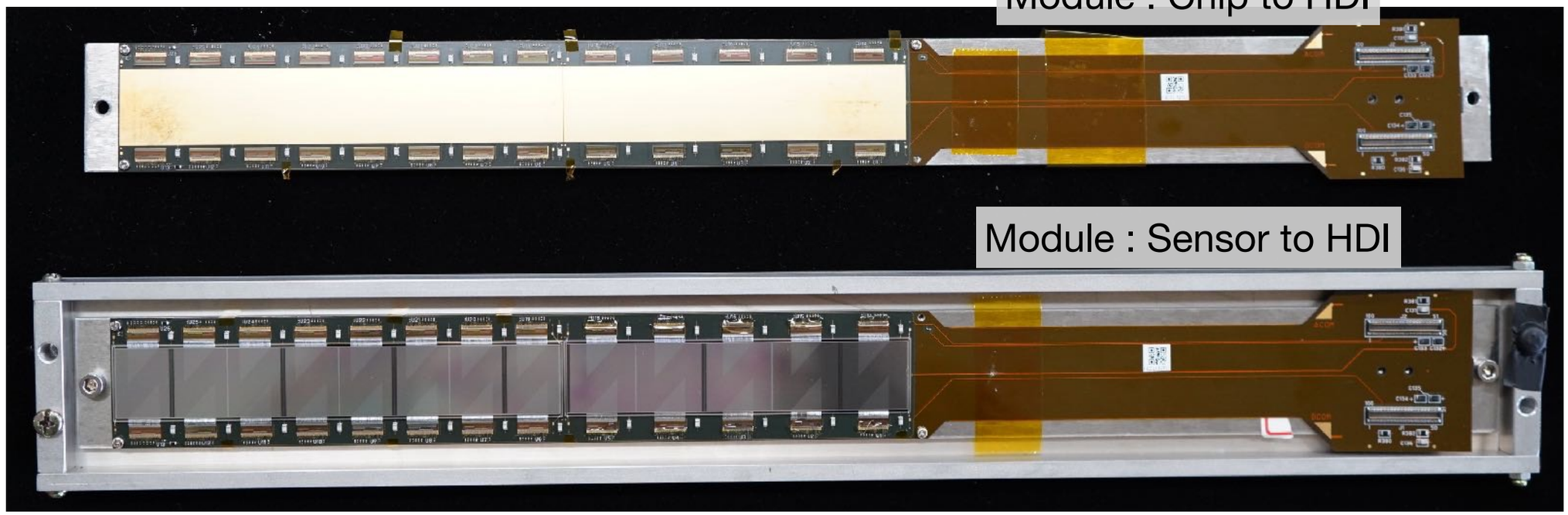
Sample tray



Pick up tools Assembly tray

INTT assembly results

Module



X axis

Y axis

Average sensors placing error

	Type A	Type B
X axis (um)	—14.13	-9.99
Y axis (um)	-36.27	-54.73
Rotation (rad)	-7.07E-05	1.66E-04

X axis ~-15 μm, Y axis : ~ -40 μm (has improved)

Ladder

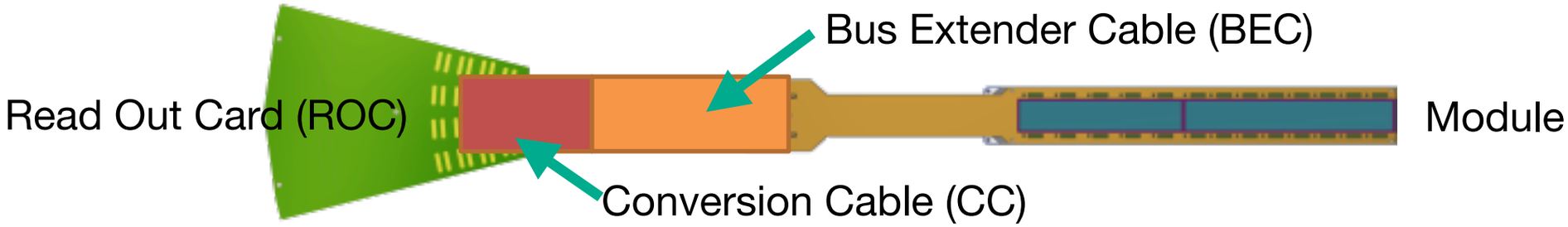
Module placing error on Stave

X axis (um)	< 5
Y axis (um)	<10
Rotation (rad)	< 1E-4

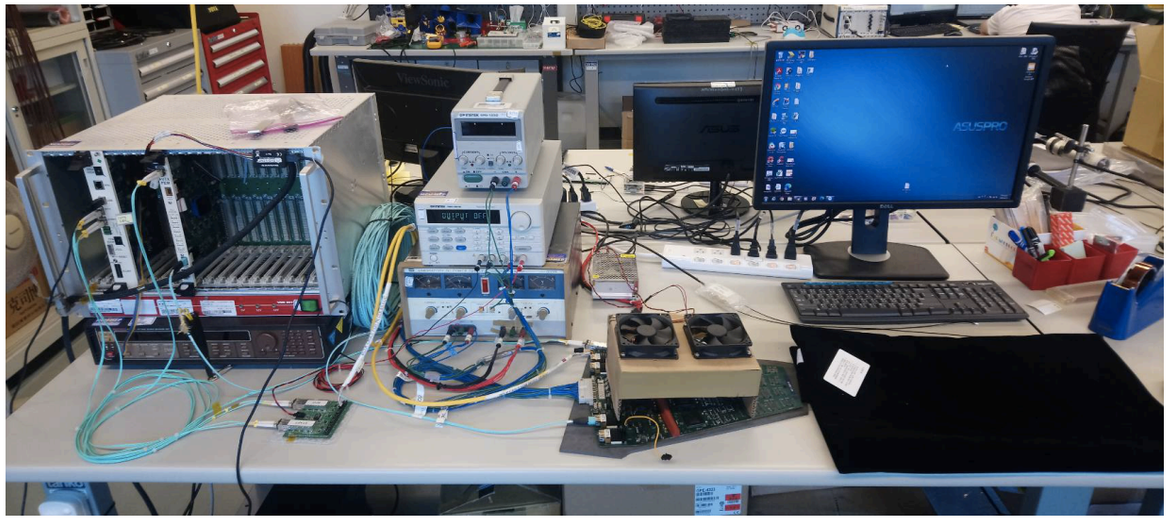
Assembly dry run : verified

To do : real Ladder assembly

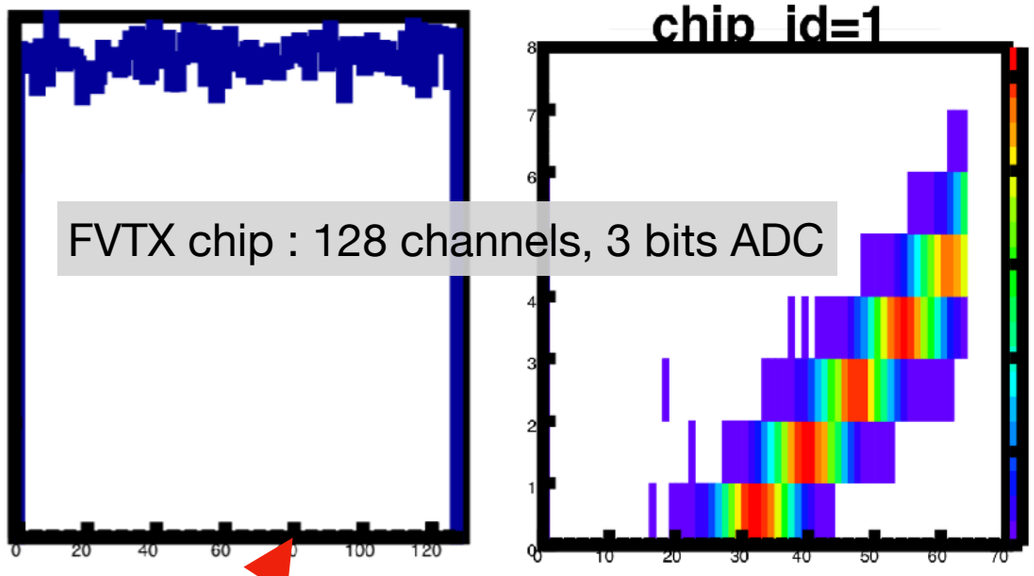
INTT DAQ system

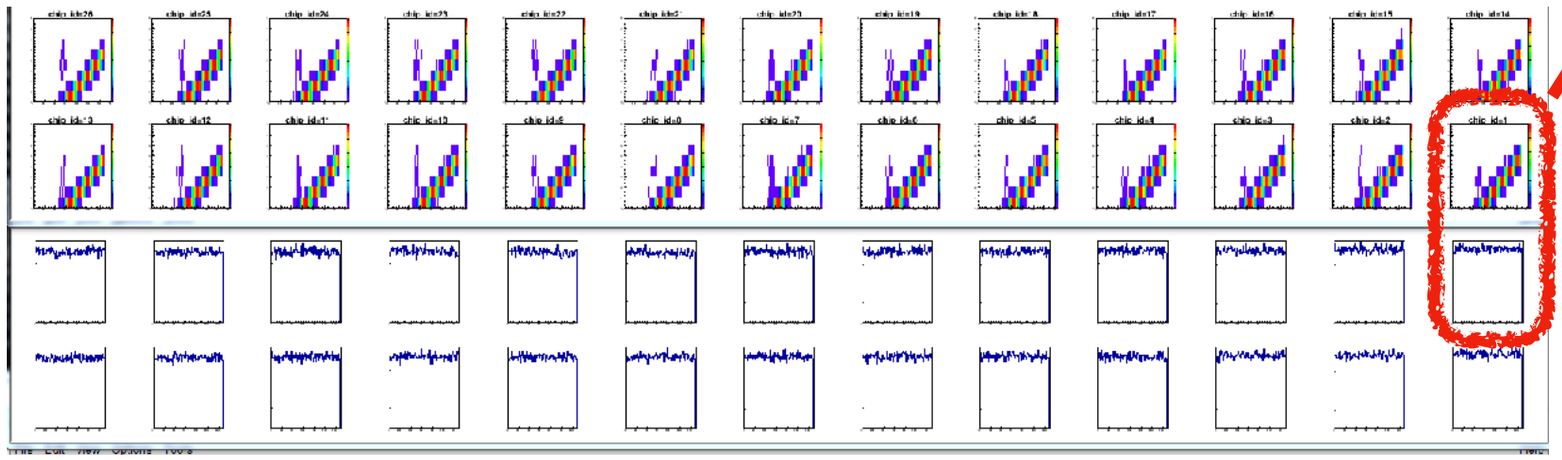


TestBench in NTU



Capabilities : chips responses test, source test





Calibration results

- Upper row :
  - X axis : amplitude of inject pulse
  - Y axis : chip response
- Bottom row :
  - X axis : chip channels
  - Y axis : entries of events

For problematic modules : several debug methods are performed

Summary

- Module assembly
  - 17 modules are assembled, yield : 10/17 ~ 59%
    - Problematic modules -> debugging in progress
  - Sensor placing error < 15 μm, meeting with the assembly requirement.

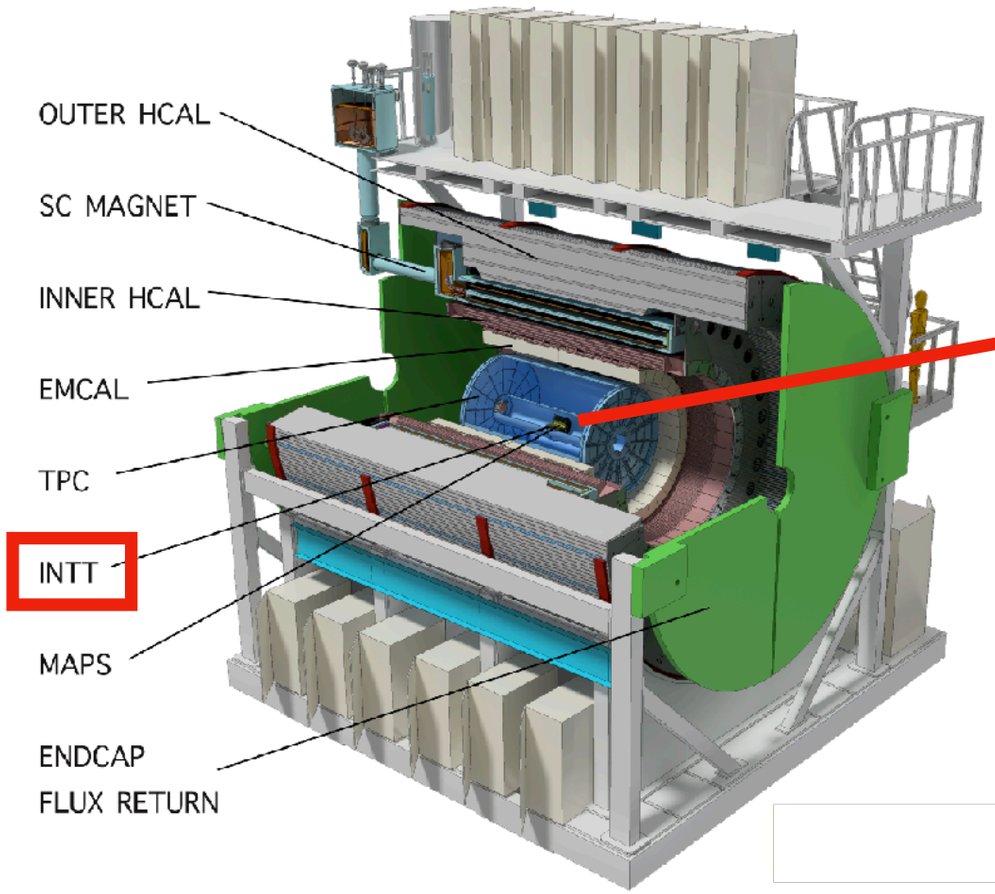
- Ladder assembly
  - Assembly procedures are verified

- To do list :
  - Stave quality tests : flatness test & leakage test
  - First Ladder assembly
  - Set up source test for INTT Module & Ladder

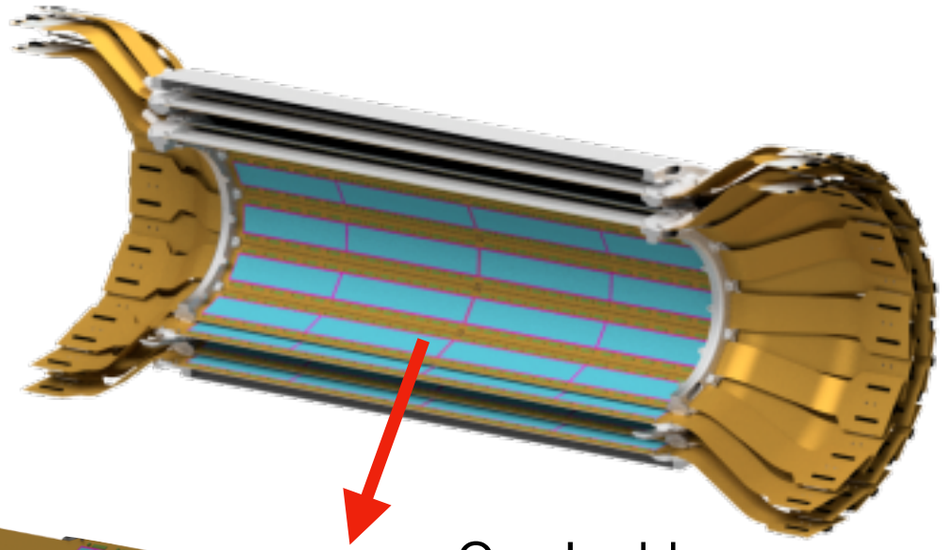
Back up

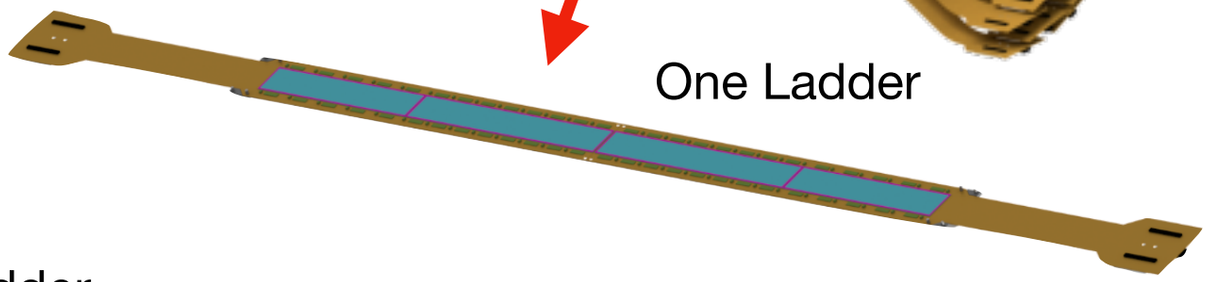
Where is INTT

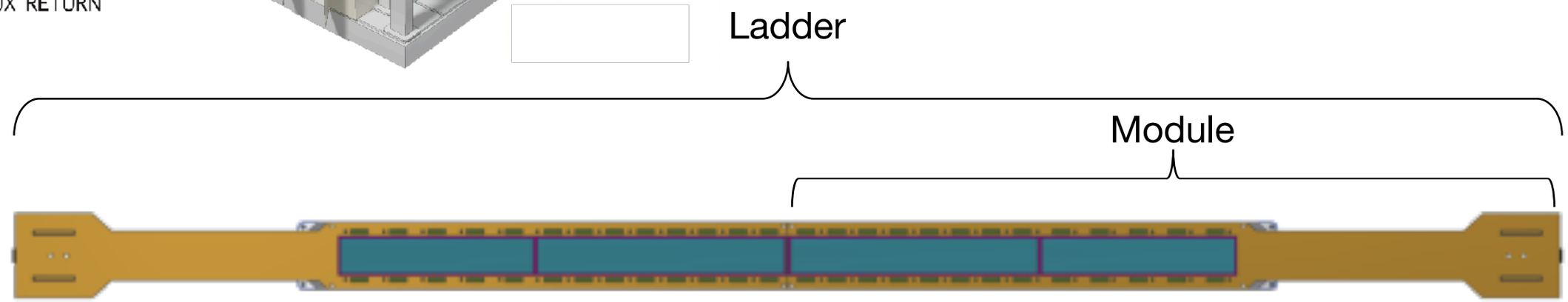
sPHENIX experiment



2 layers of silicon strip detector







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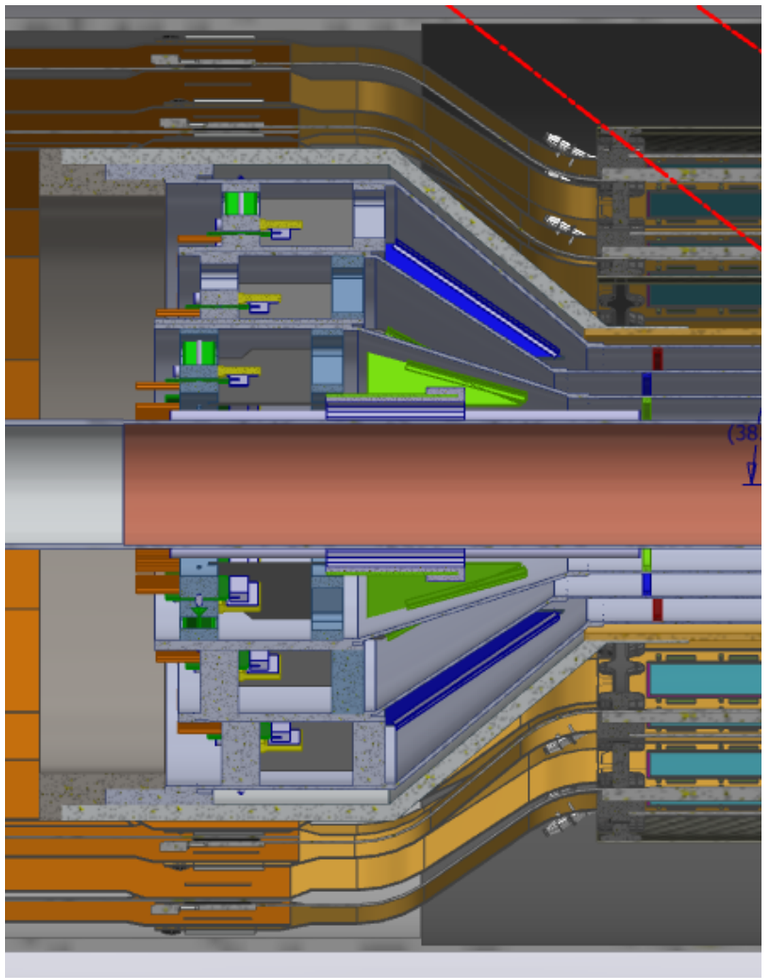
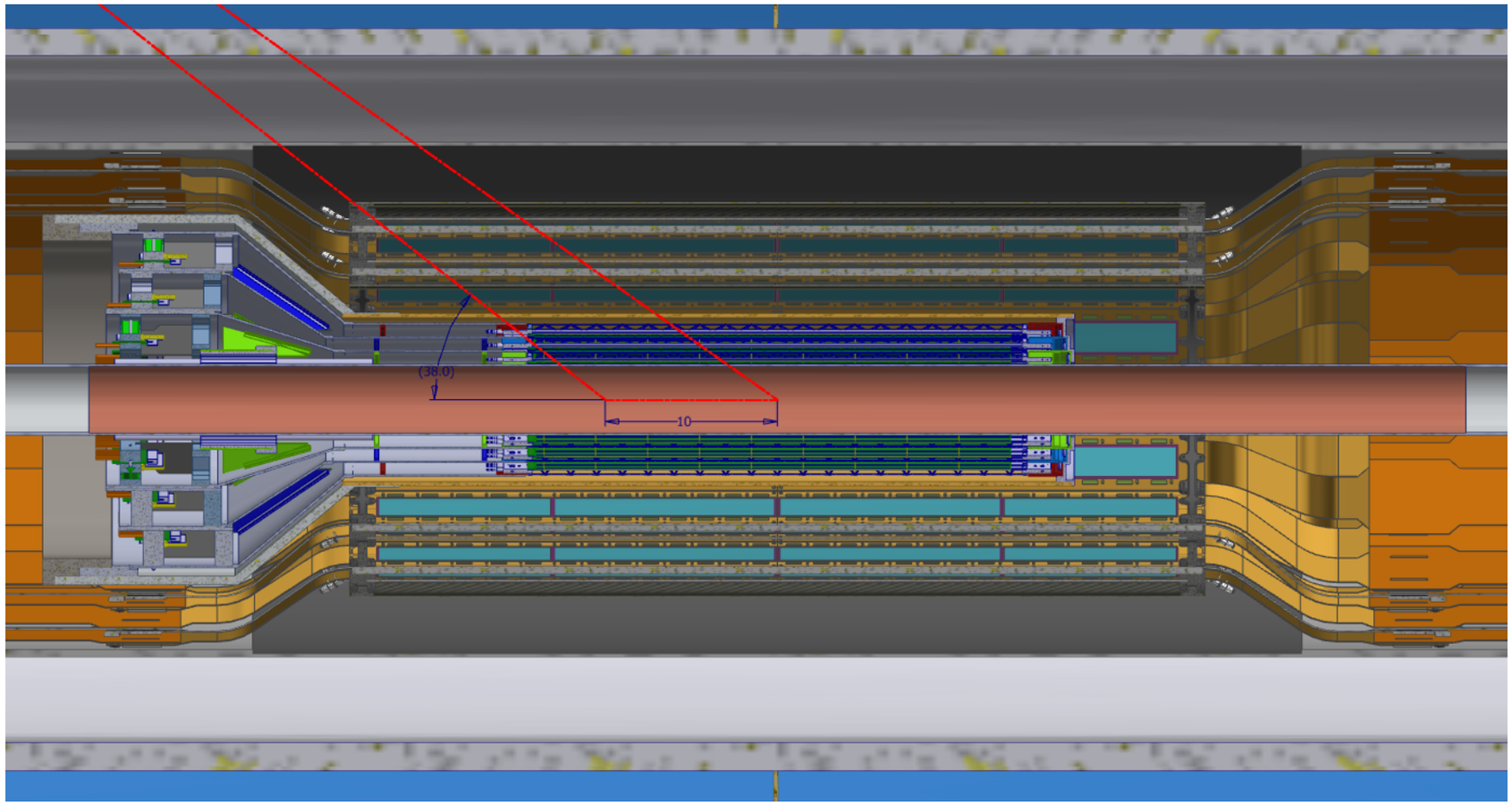
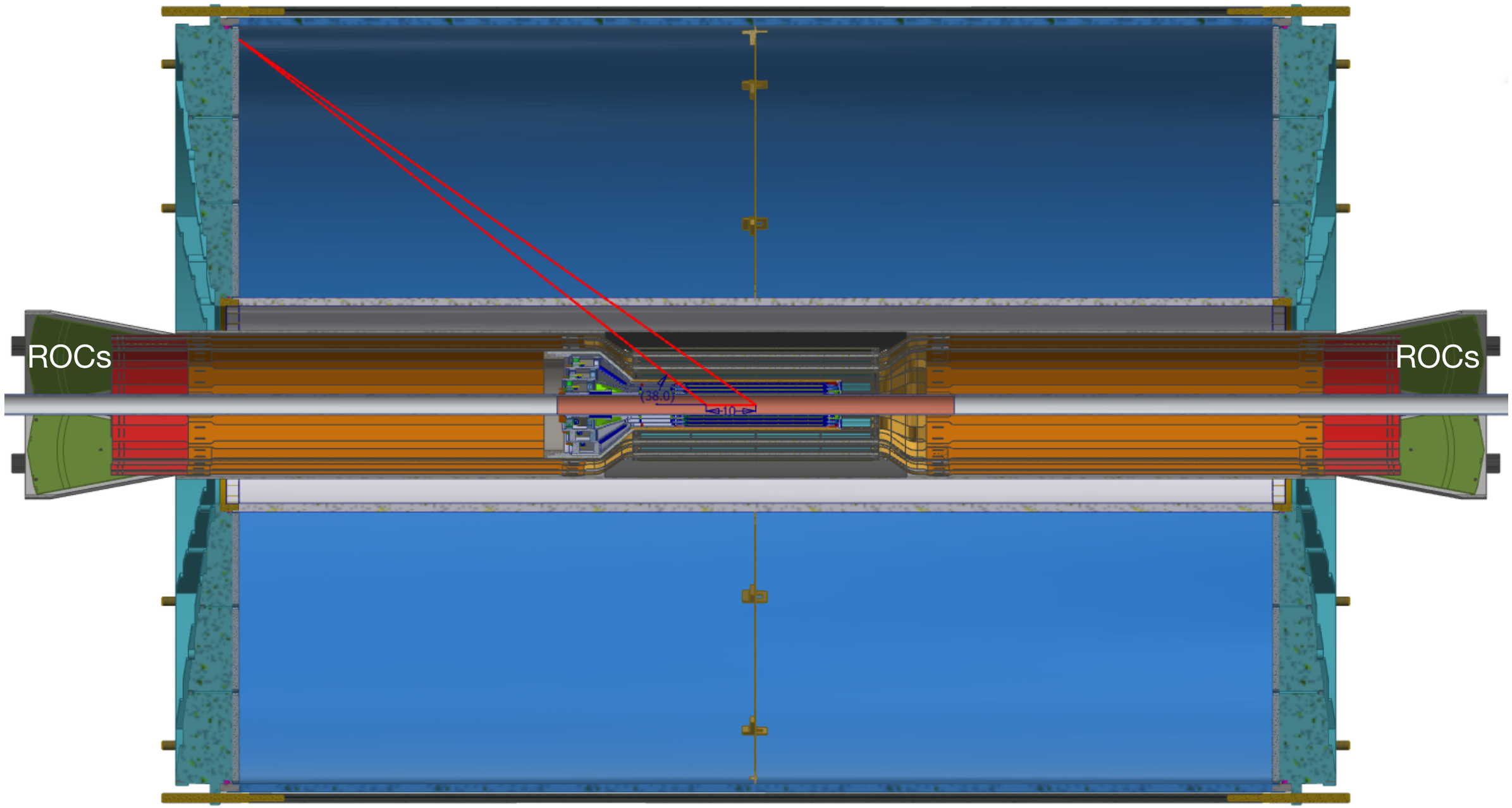
INTT and MVTX



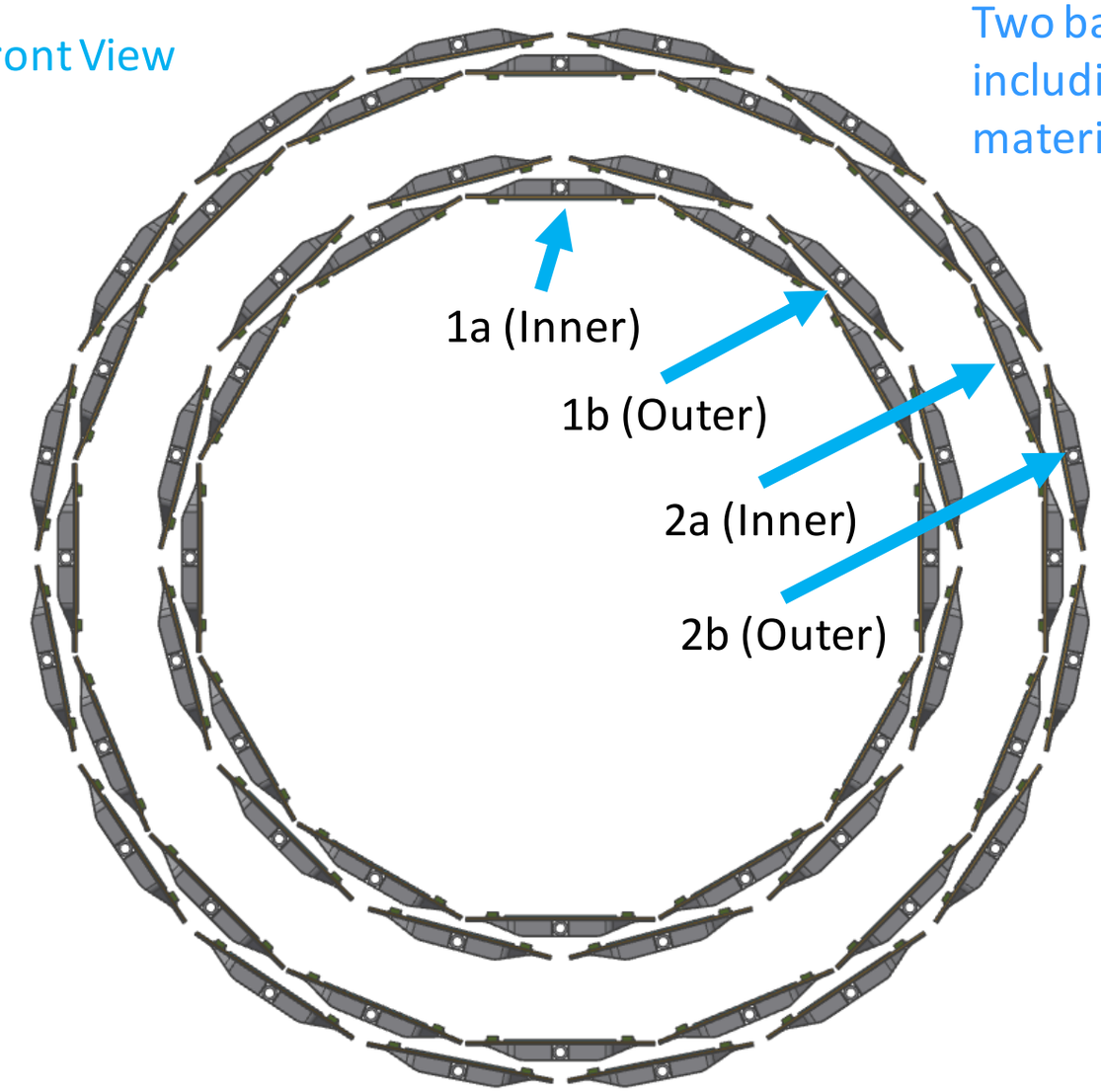


INTT, MVTX and TPC

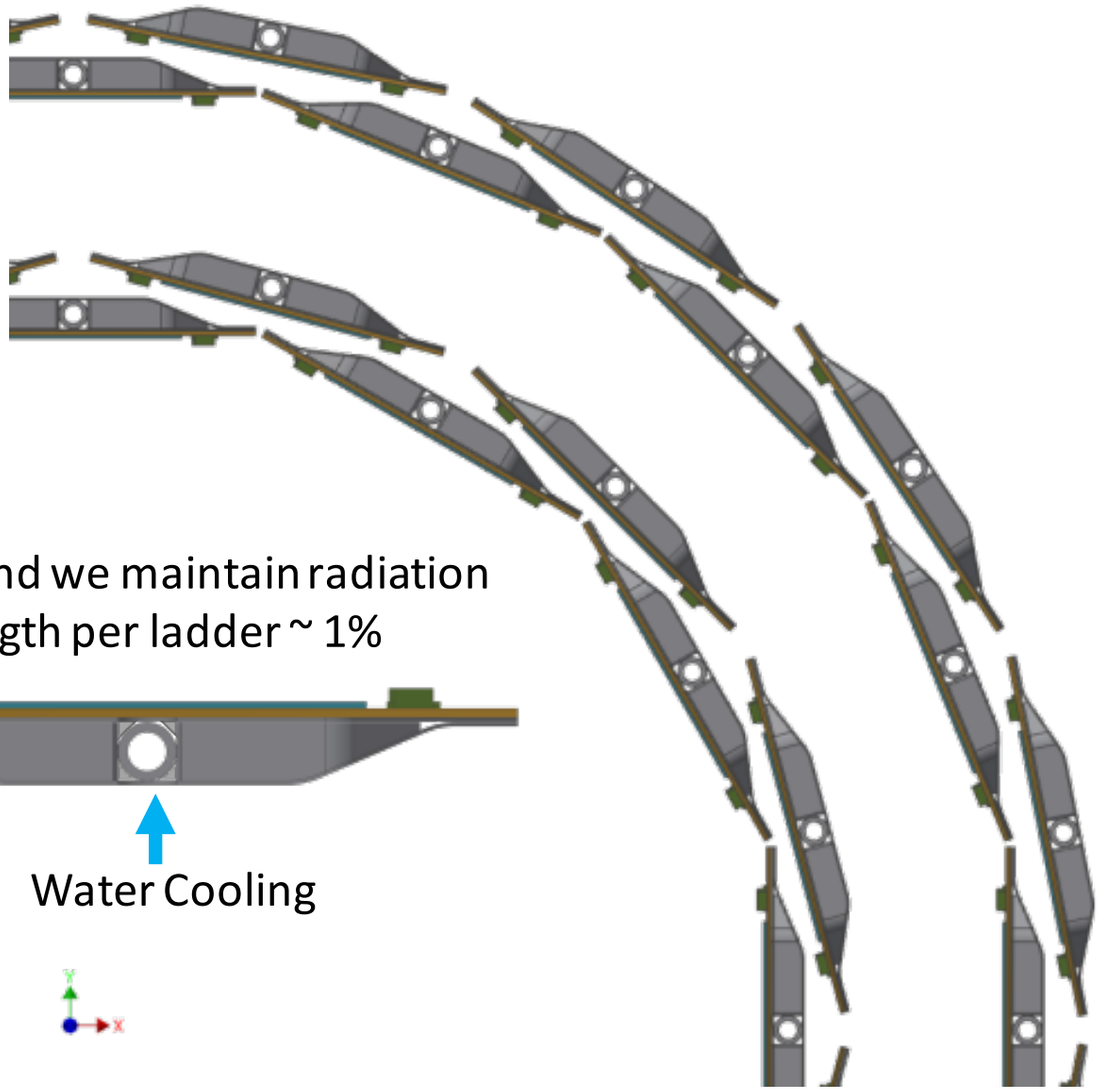


INTT Barrels Layout

Front View

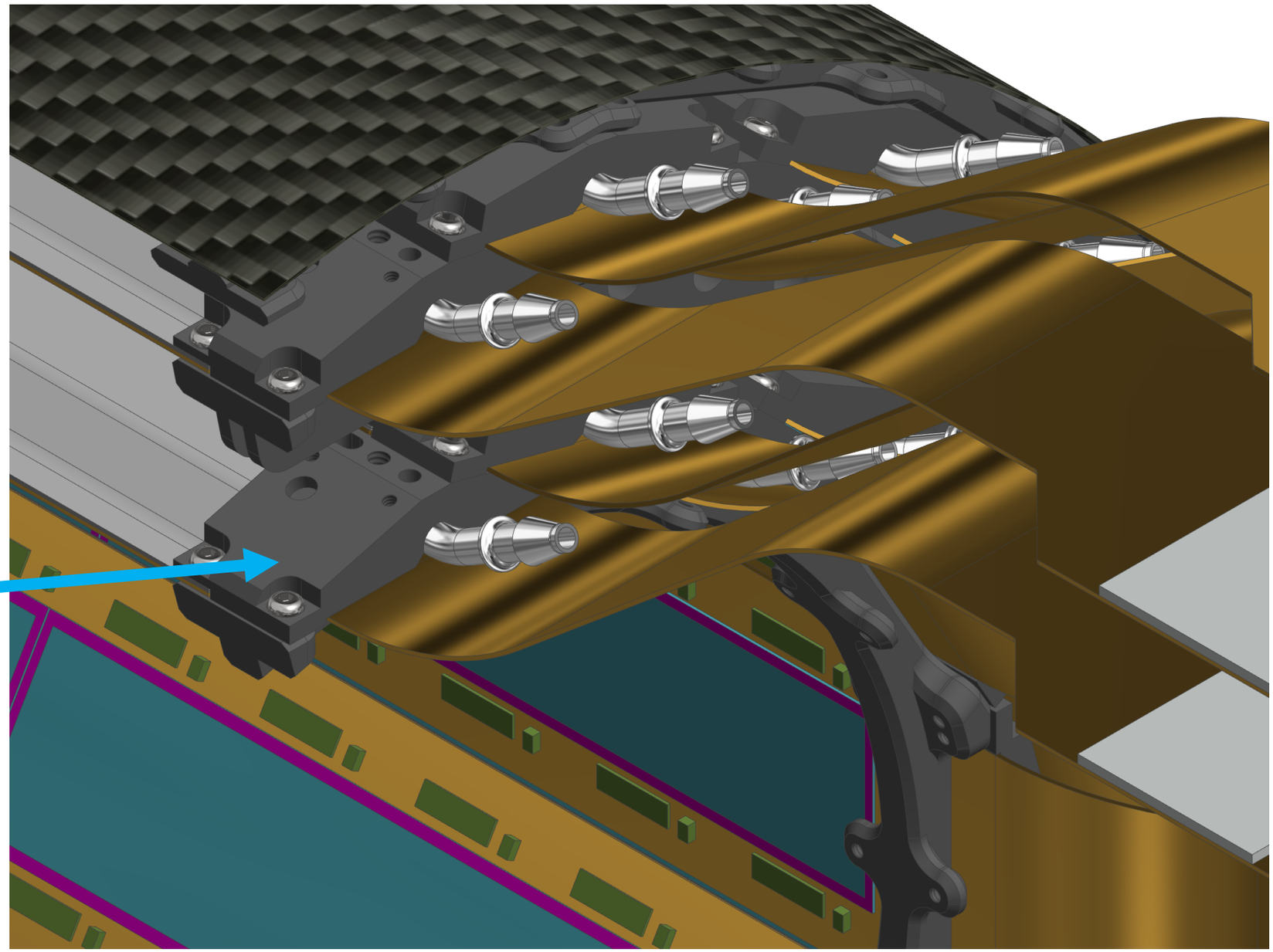


Two barrels including all materials



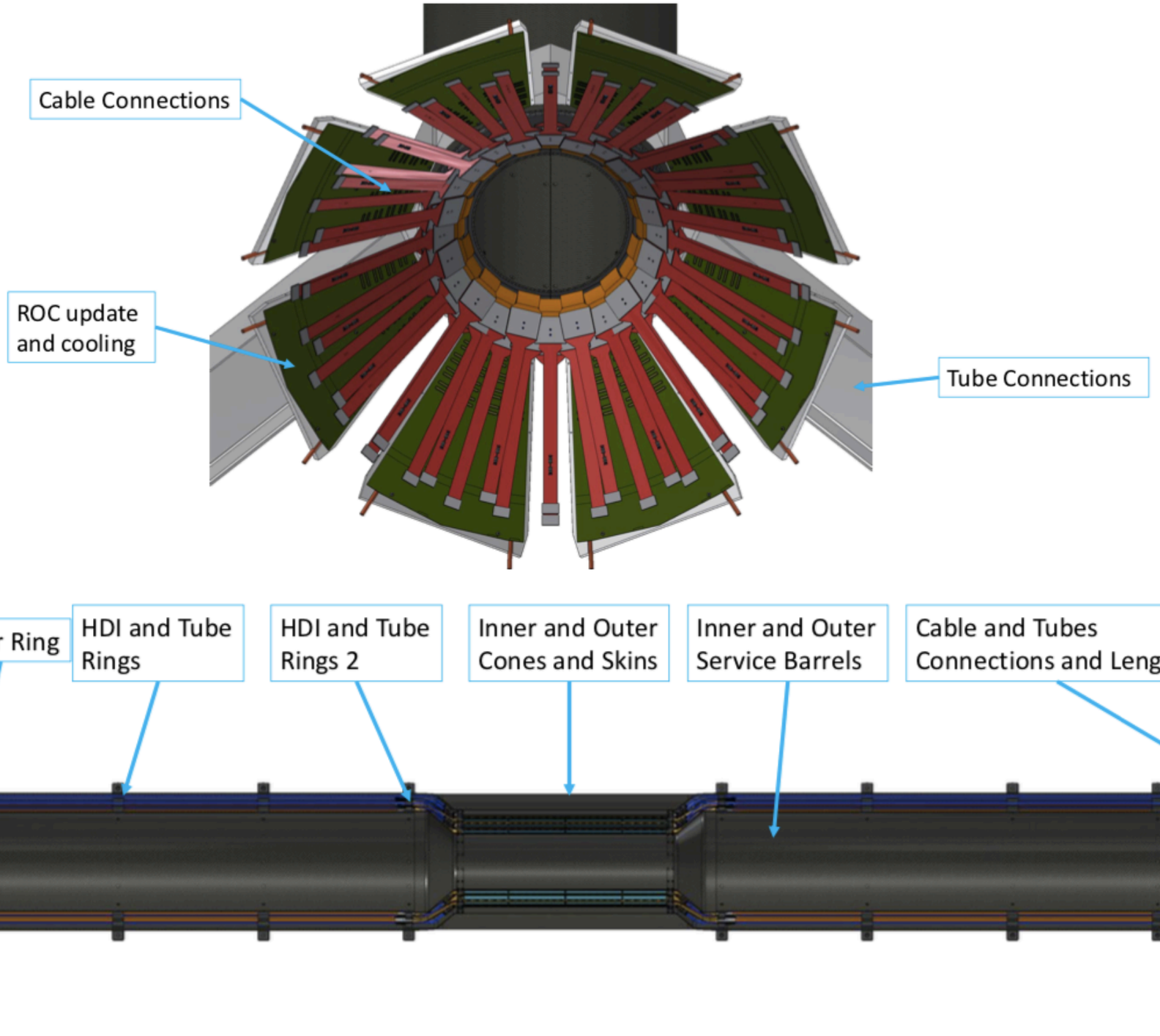
Water and we maintain radiation length per ladder ~ 1%

INTT Barrel Layout

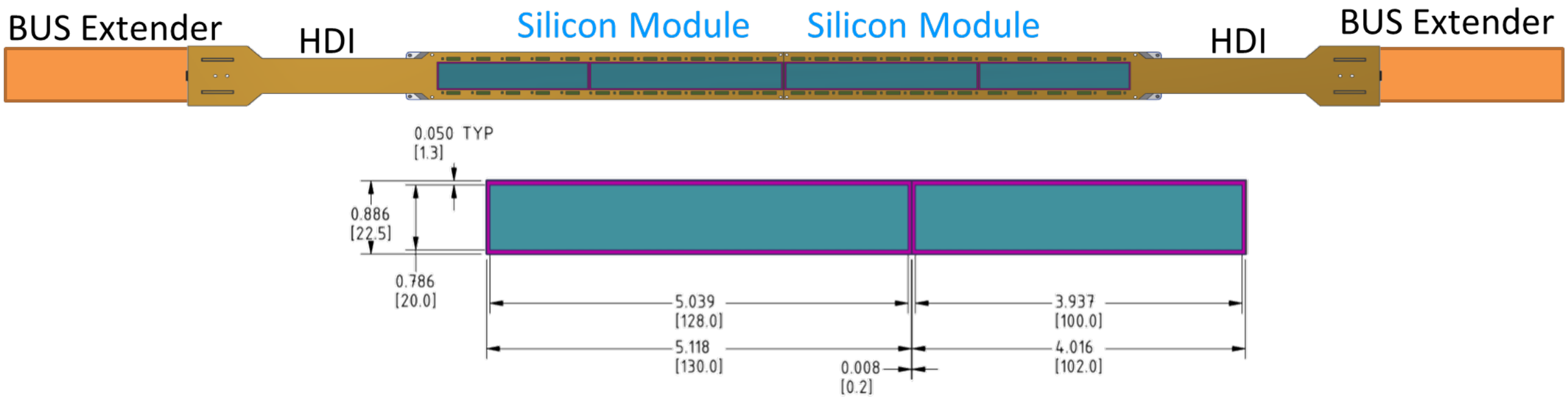


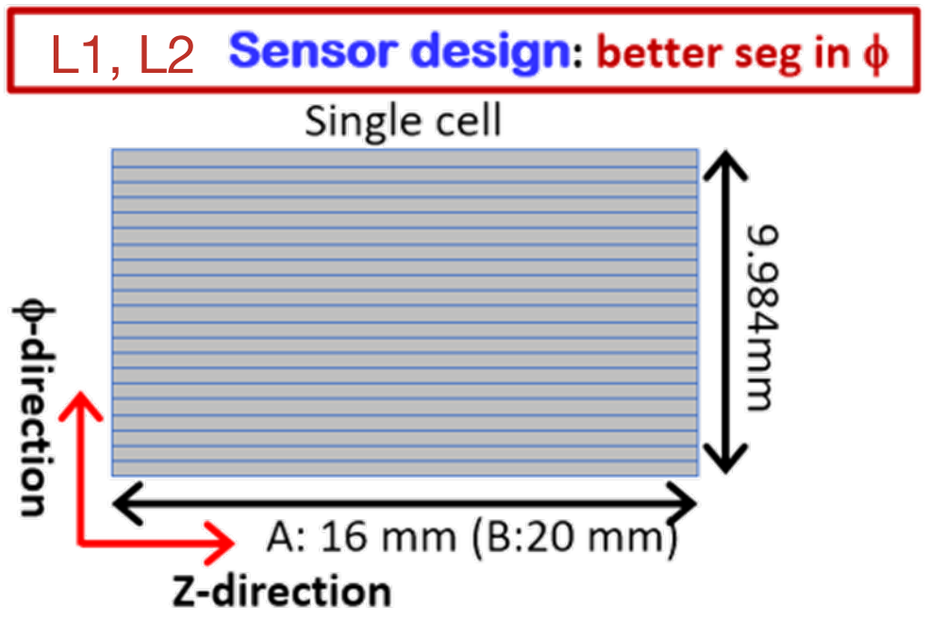
Stave Endcap
(Carbon PEEK)

INTT in sPHENIX



INTT sensor specification





Type A: Single sensor = 8 x 2 cells
Type B: Single sensor = 5 x 2 cells

Thickness: 320 um
Pitch: 9.984 mm/128 = 78 um
Φ-length (single sensor) = 22.5 mm
F-length (active area) = 20.0 mm
Z-length type-A (single sensor) = 130.0 mm
Z-length type-A (active area) = 128.0 mm
Z-length type-B (single sensor) = 102.0 mm
Z-length type-B (active area) = 100.0 mm

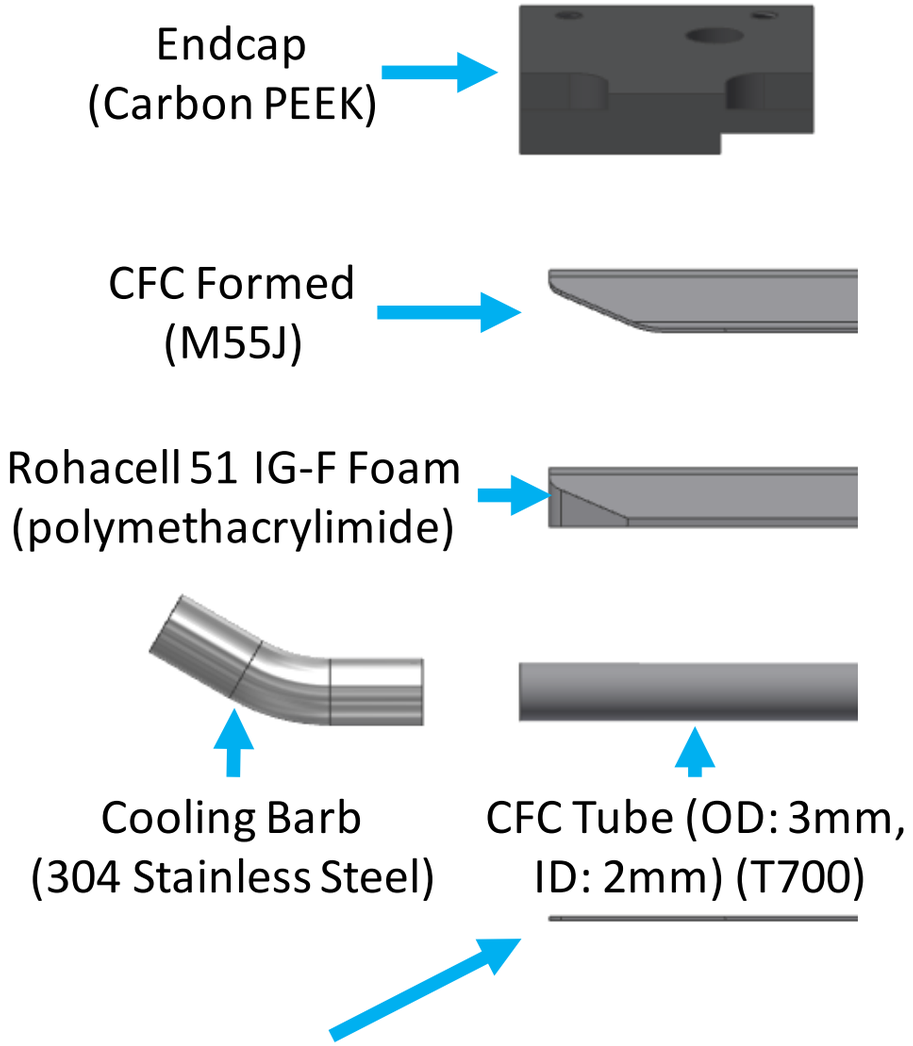
INTT single Ladder Radiation Length

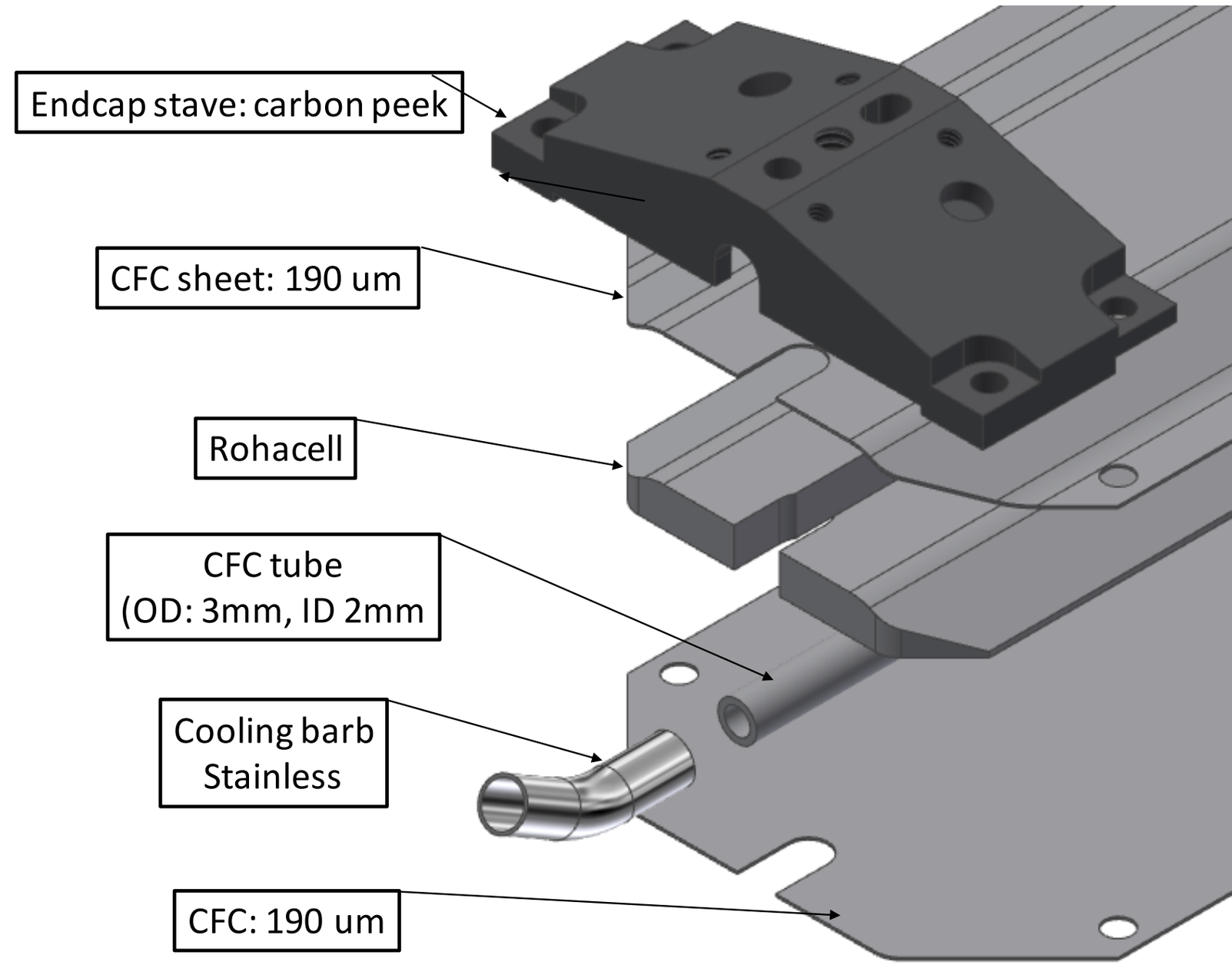
Material	Thickness [μm]	X/X_0
Silicon	320	0.34%
HDI	473	0.49%
Stave	3500	0.25%
Total	4293	1.08%

HDI Material	Thickness [μm]	X/X_0
Copper*	52	0.36%
Polyimide	380	0.13%
Total**	432	0.49%

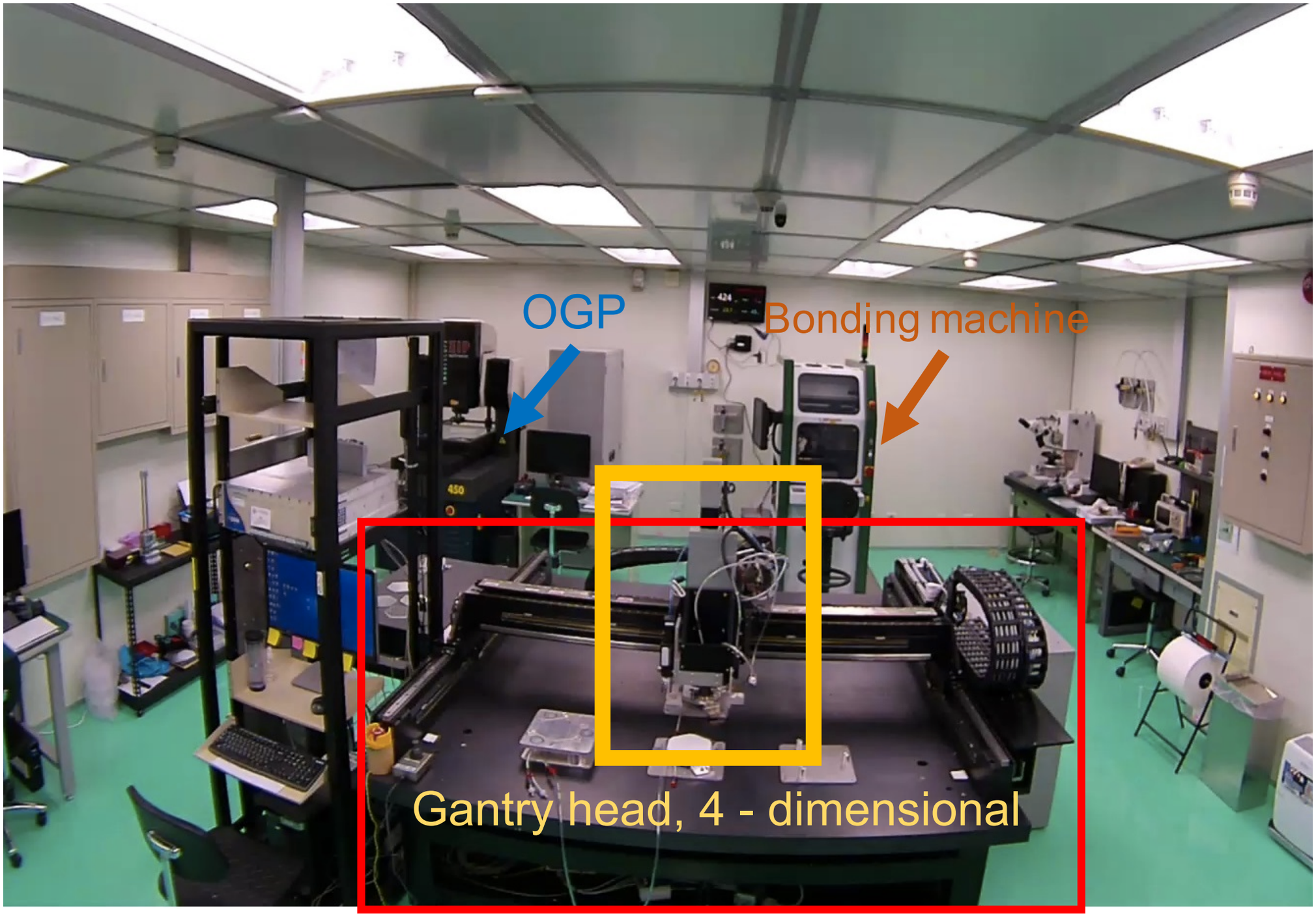
*Copper thickness is not physical thickness, but effective thickness.
**Total thickness is not 473μm, because of copper effective thickness.

INTT prototype stave design



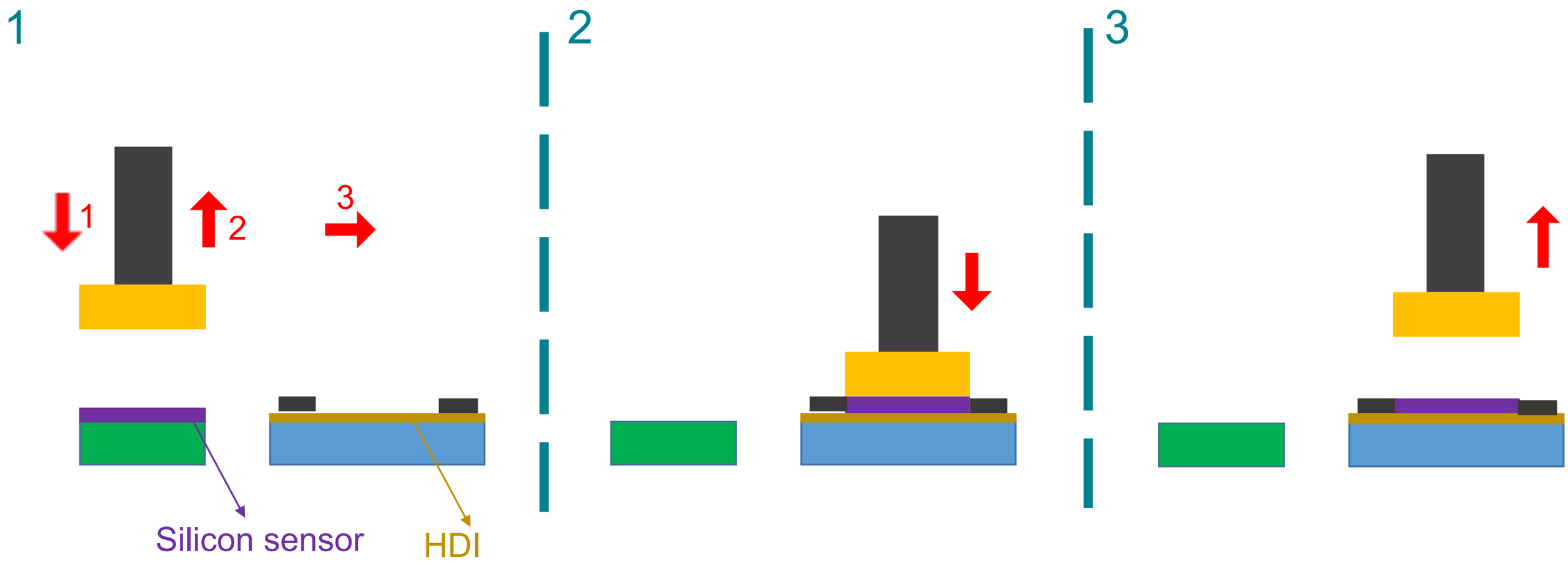


Taiwan Silicon Detector Facility (TSiDF)

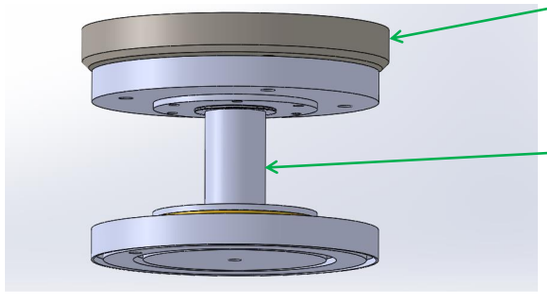


Assembly method

: Gantry head
: Module assembly tray
: Silicon sensor sample tray
: Pick up tool



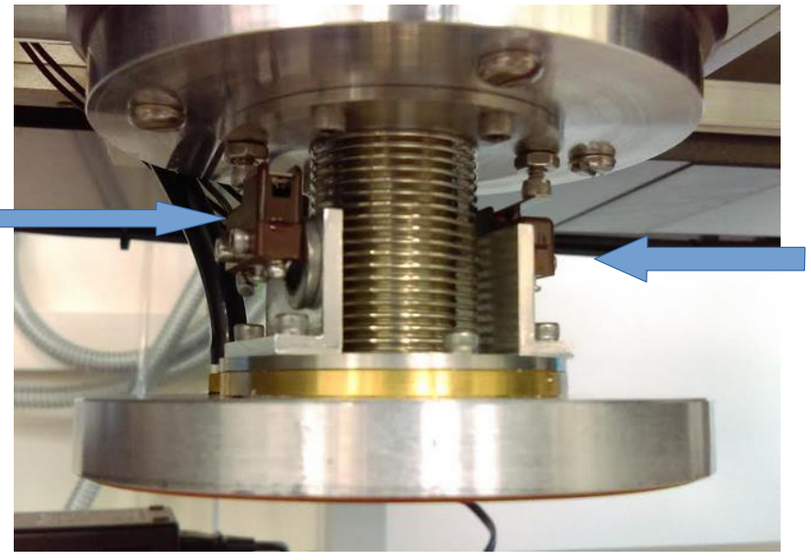
Gantry head



Aerotech Gantry rotational stage.

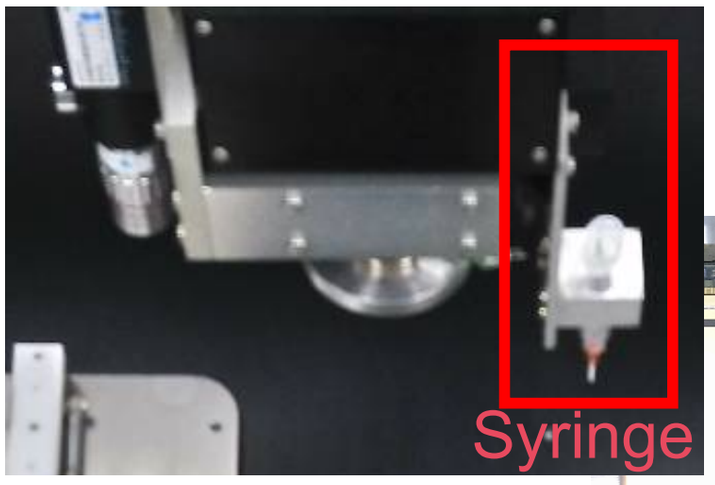
Compressible pickup head that is permanently mounted on the gantry.

Compression Switches



INTT assembly : glue pattern

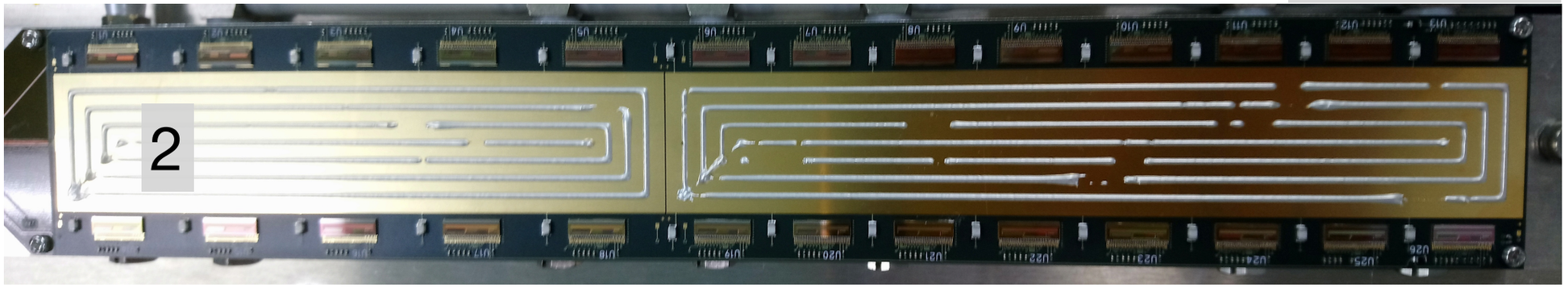
Gantry head



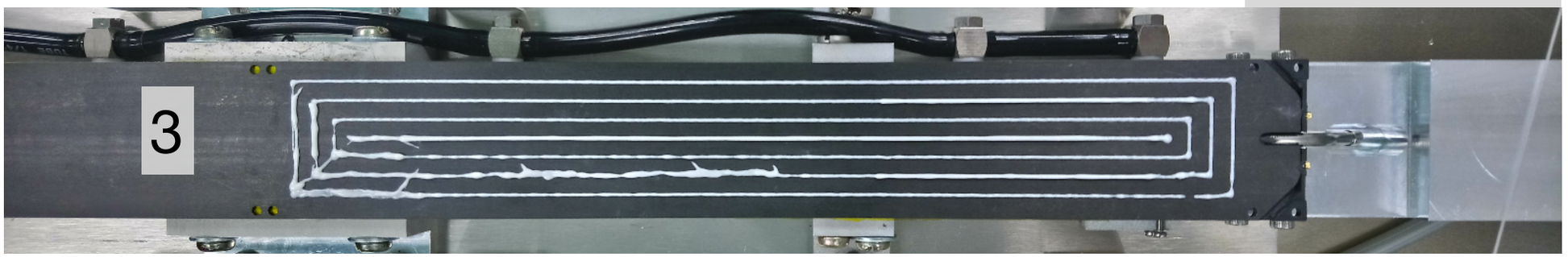
1, 2 : silver epoxy
3 : thermal conductive glue

Chip to HDI

Sensor to HDI



Module to Stave

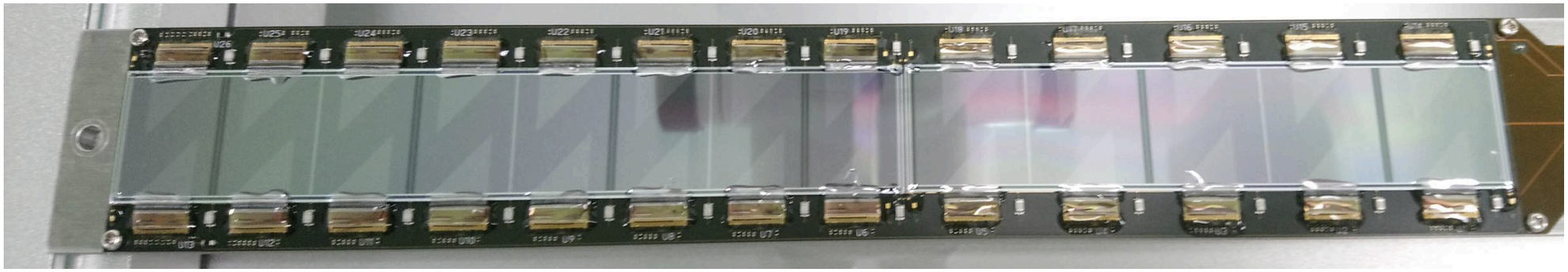


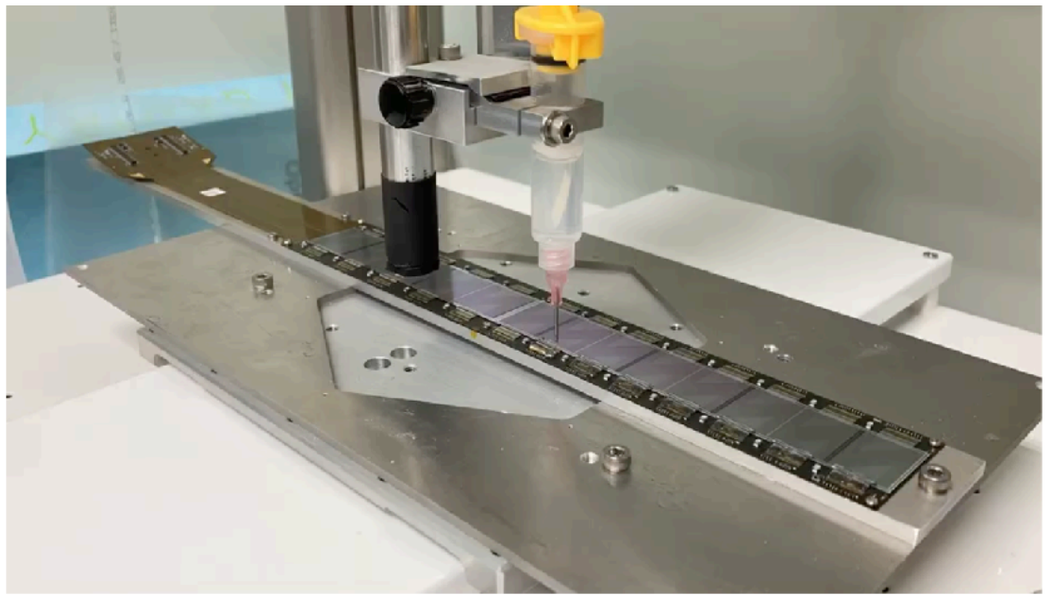
Encapsulation glue application

Work done by 連勝

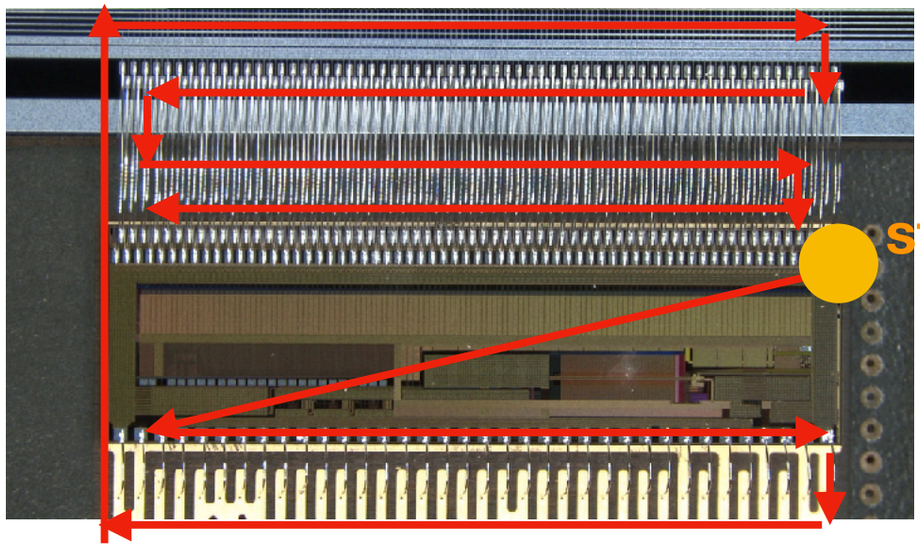
Mini Gantry in NTU

Test with pre production 001





Sylgard 186 is used
Needle size of syringe : 0.6 mm
Waiting time : 30 ~ 40 mins after mixing



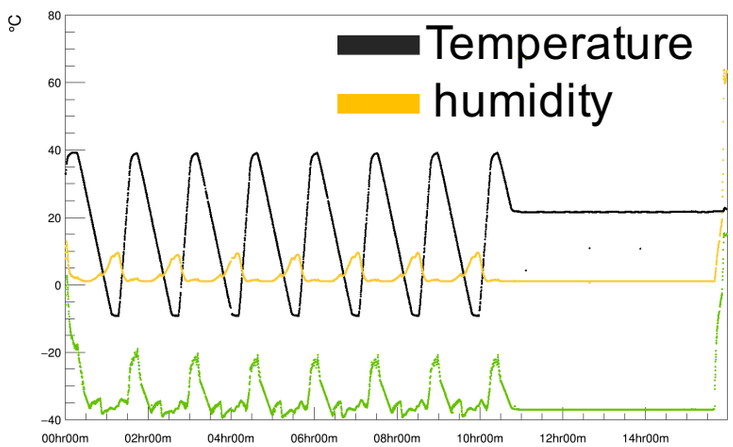
Thermal cycle test

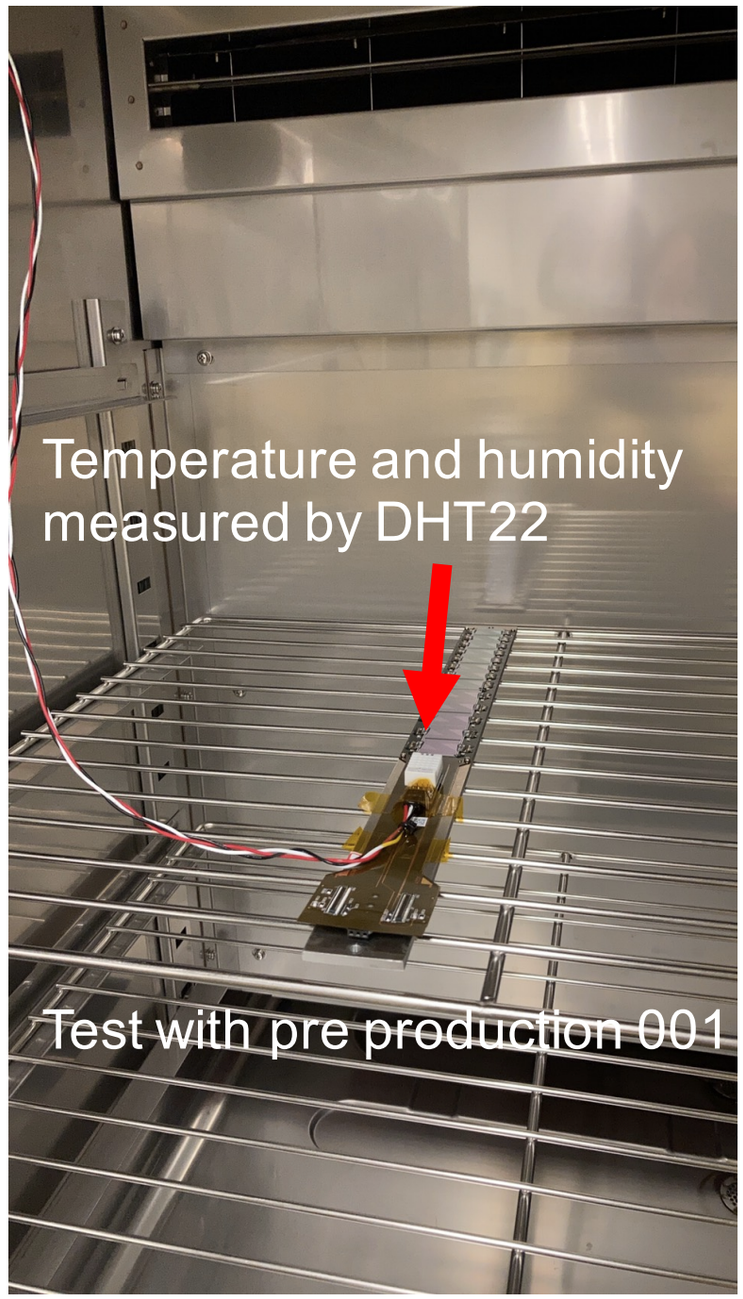
$$\mathrm{AccelerationFactor} = \left(\frac{\Delta T_{test}}{\Delta T_{use}}\right)^{m},\ \ m = 3$$

$$\frac{AF * cycles}{cycles/day} = \mathrm{Lifetime(day)}$$

- ΔT_{use} = 20°C, assuming detector runs on 5°C and warms up to 25°C
- ΔT_{test} = 50°C, thermal cycles between -10°C and 40°C
- AF = $(50/20)^3$ = 15.625
- Assuming one cycle for every 10 days, 3 year of lifetime test needs 3*365*0.1/15.625 = 7 cycles

Temperature : -10 ^0C ~ 40 ^0C
Heating time : 17 mins
Cooling time : 50 mins
Repeat : 7 times





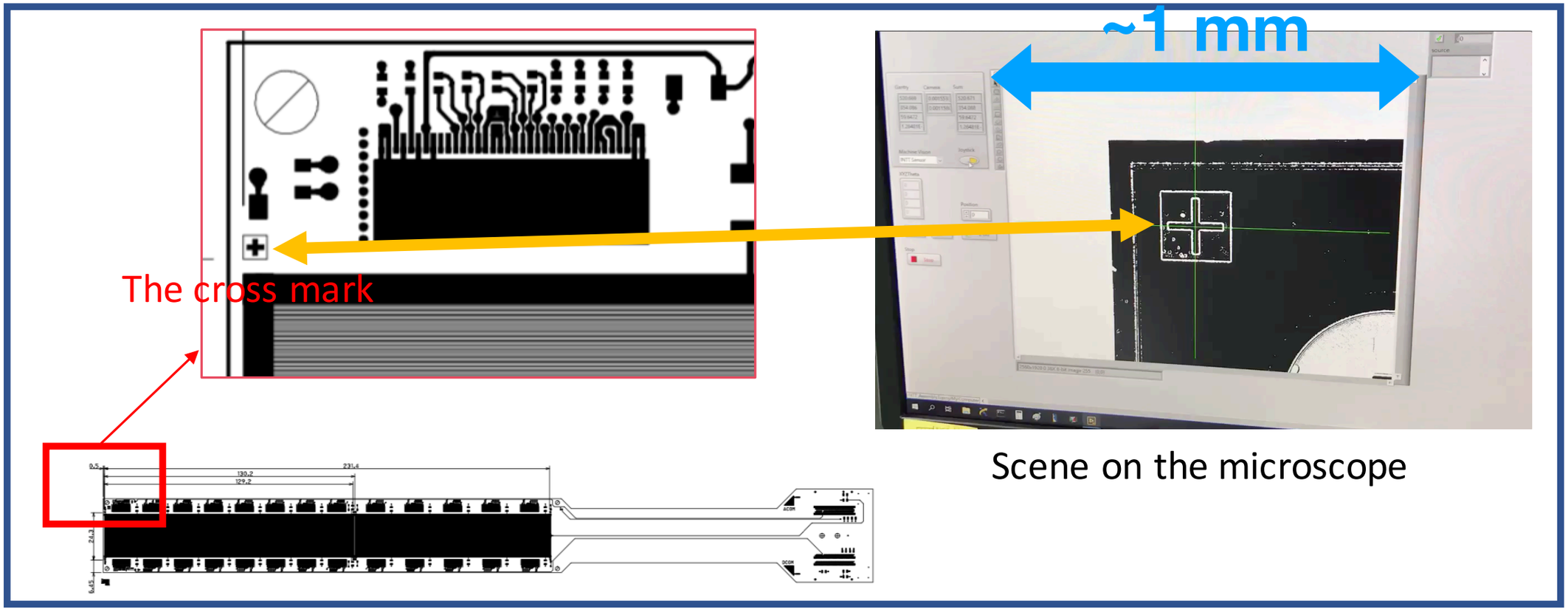
The calibration test result after thermal cycle is consistent with the case before thermal cycling

Stave holes measurement

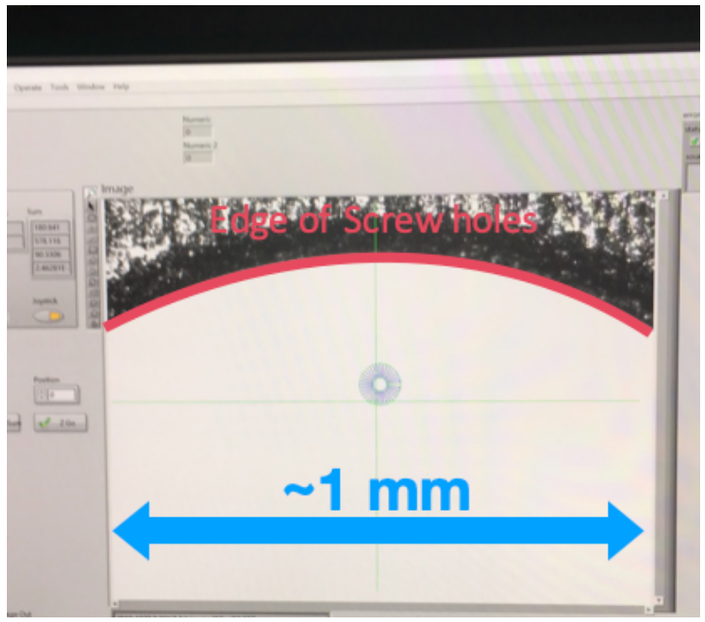
The measurement of the cross mark of HDI and sensor by using microscope is to get their center position

size of the camera window : ~ 1 mm

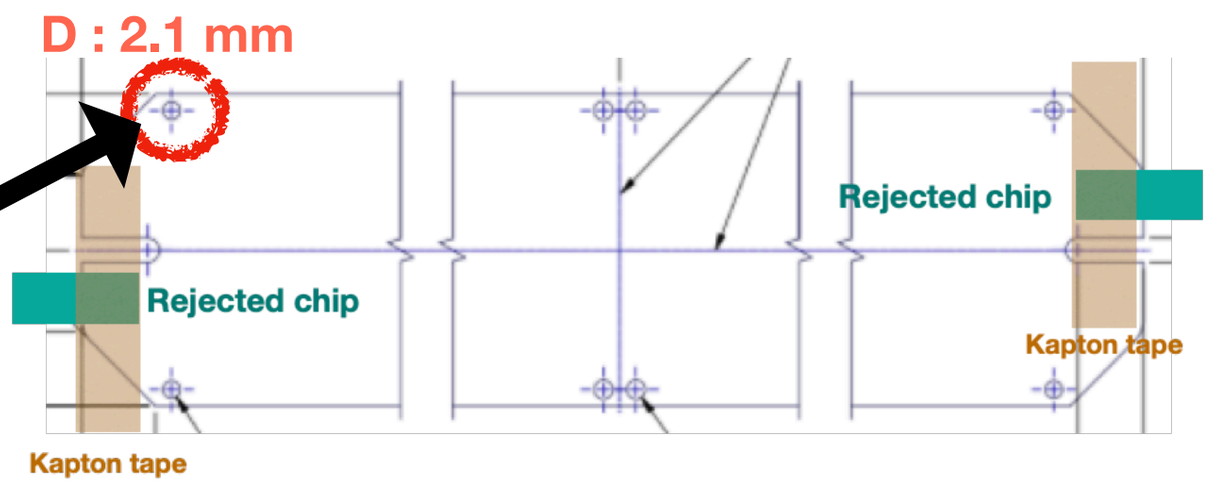
Demonstration of cross marks measurement

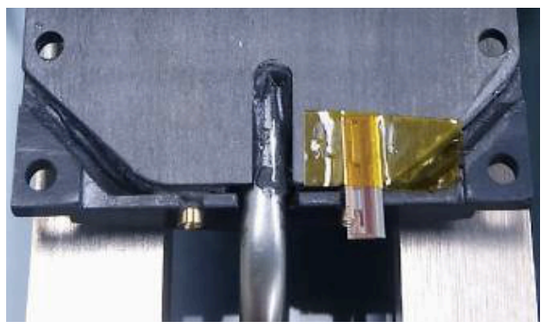


Stave holes measurement



Original method to fix chips on stave

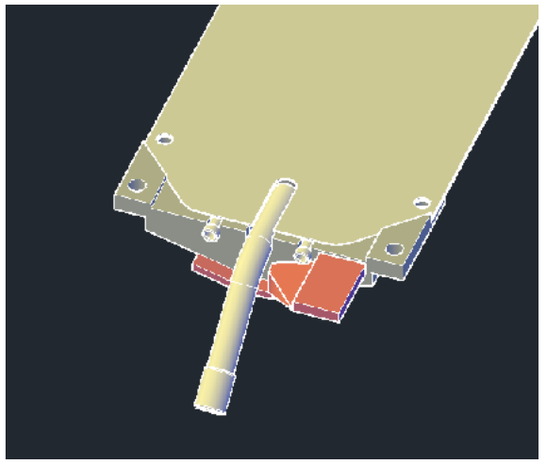


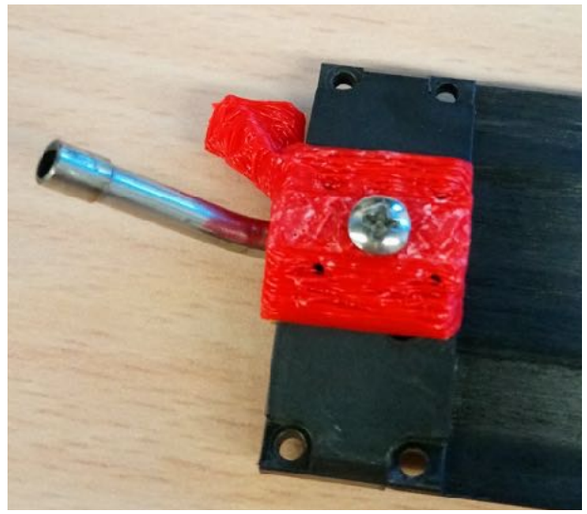


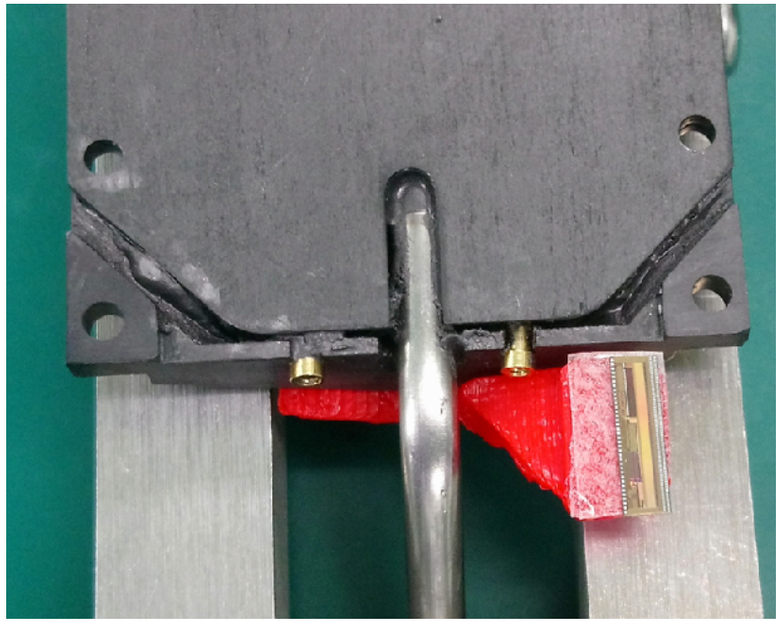
1. fix rejected chip on each edge of stave
2. measure cross marks of chips by OGP
3. measure the holes of staves by OGP → Obtain stave's relative position
4. move stave back to gantry
5. measure the cross marks of chips by gantry camera
6. By step 2, 3 and 5 -> obtain stave position

Stave holes measurement

Stave chip holder
Can be fixed by screw

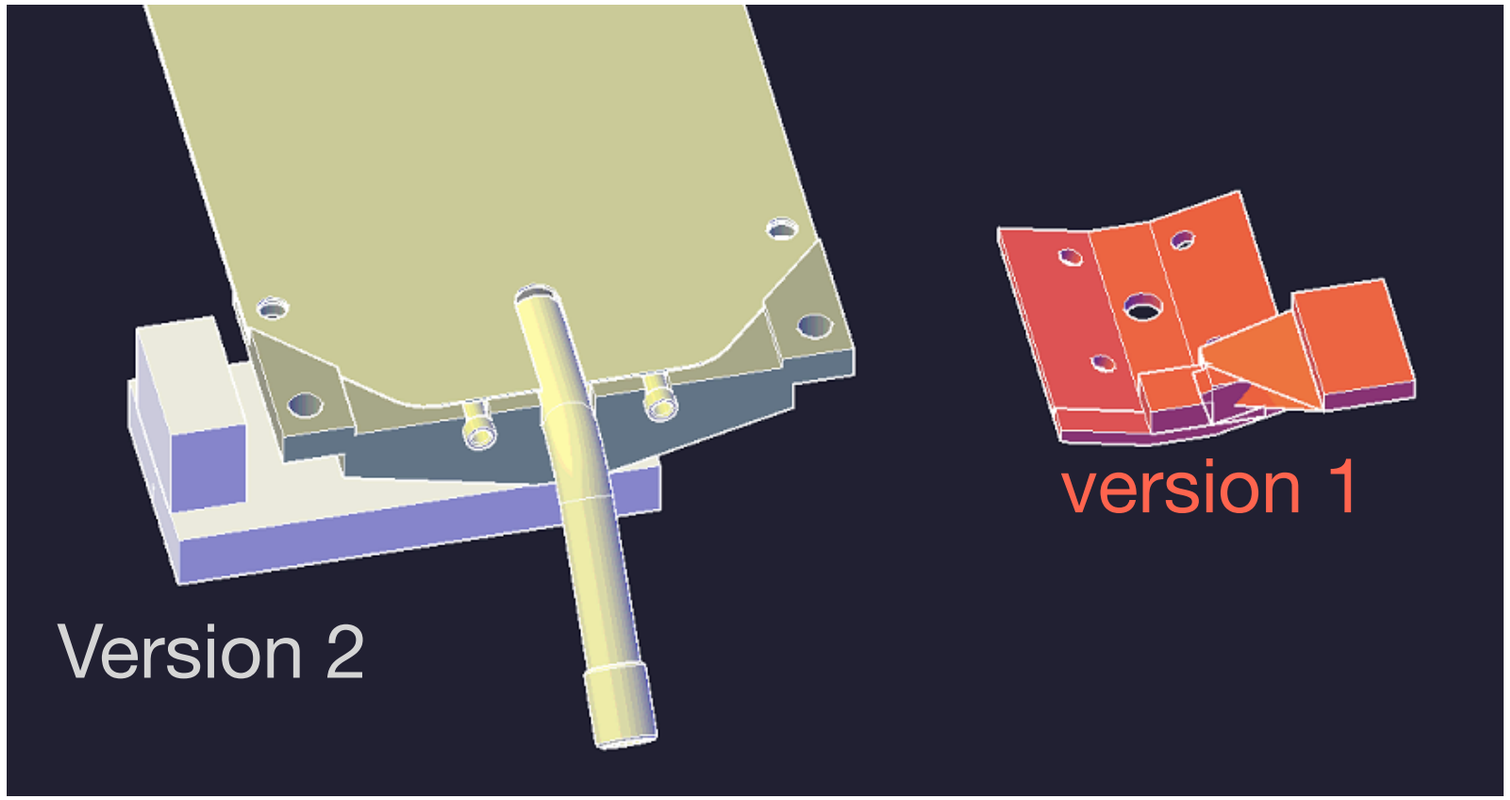






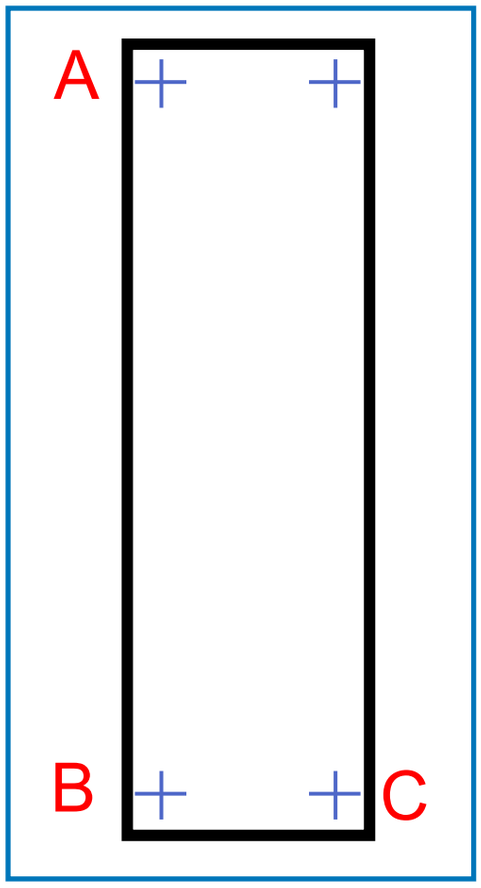
The order of version 2 has been sent to AS CNC

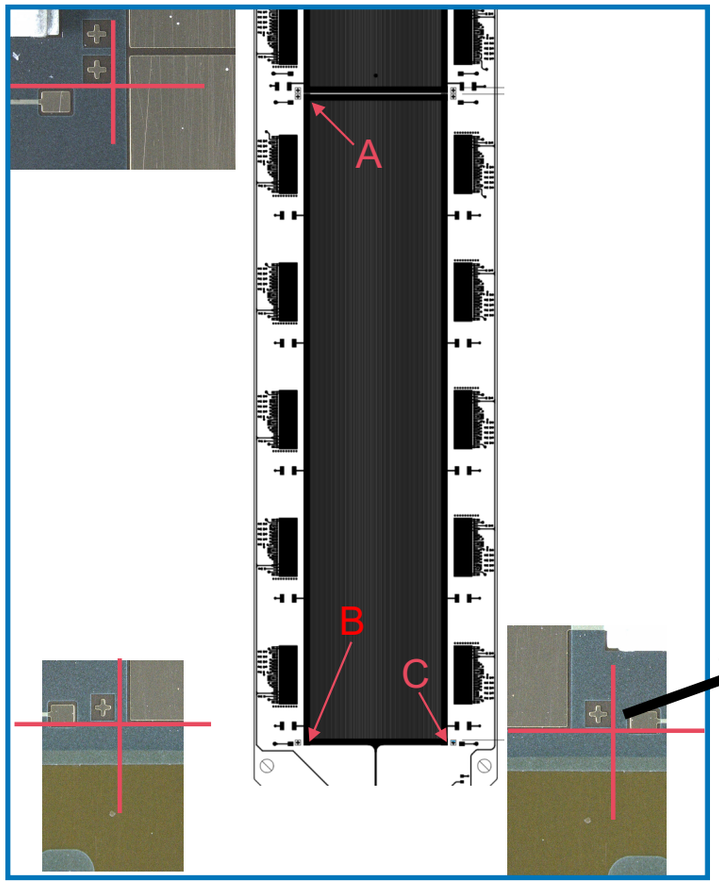
Material : stainless steel or aluminum

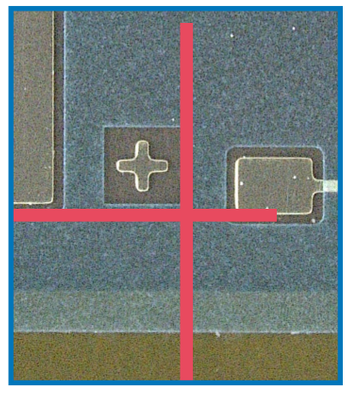


HDI position/rotation measurement

Point A - B : rotation
Point A - C : position



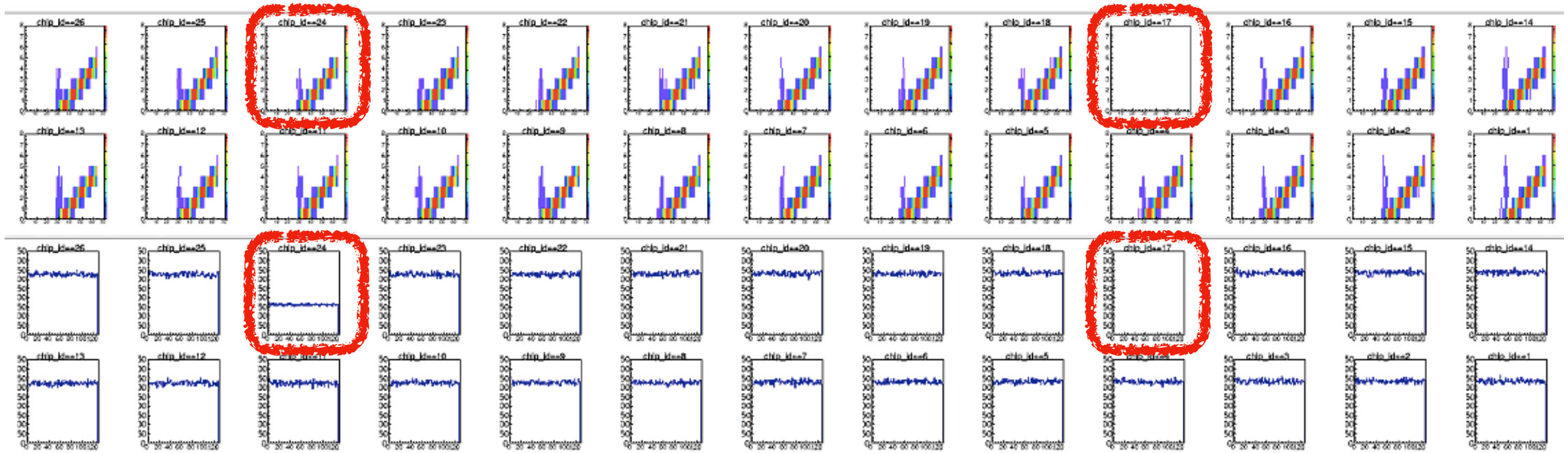




sensor :
measure cross mark

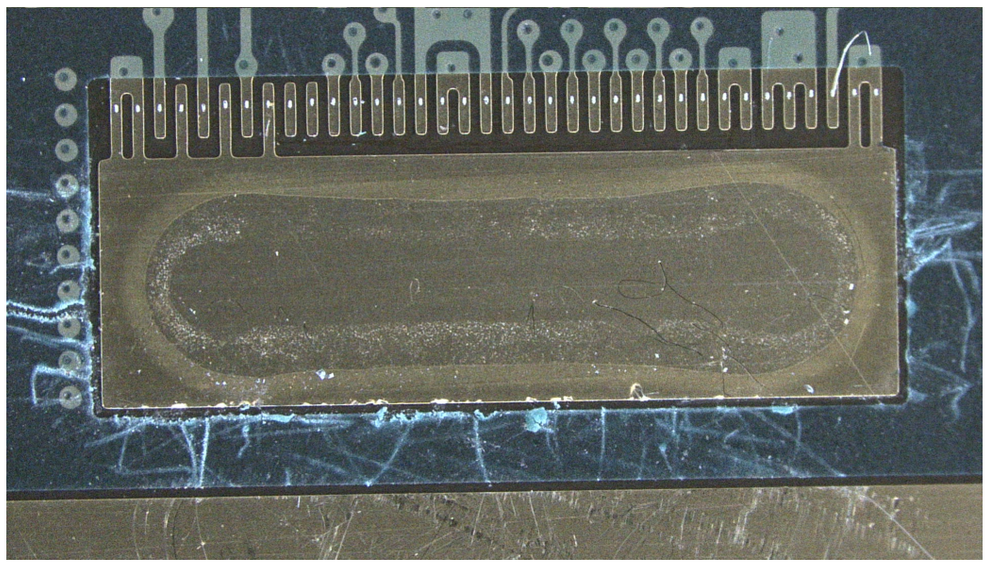
HDI :
measure the corner of the square of cross mark

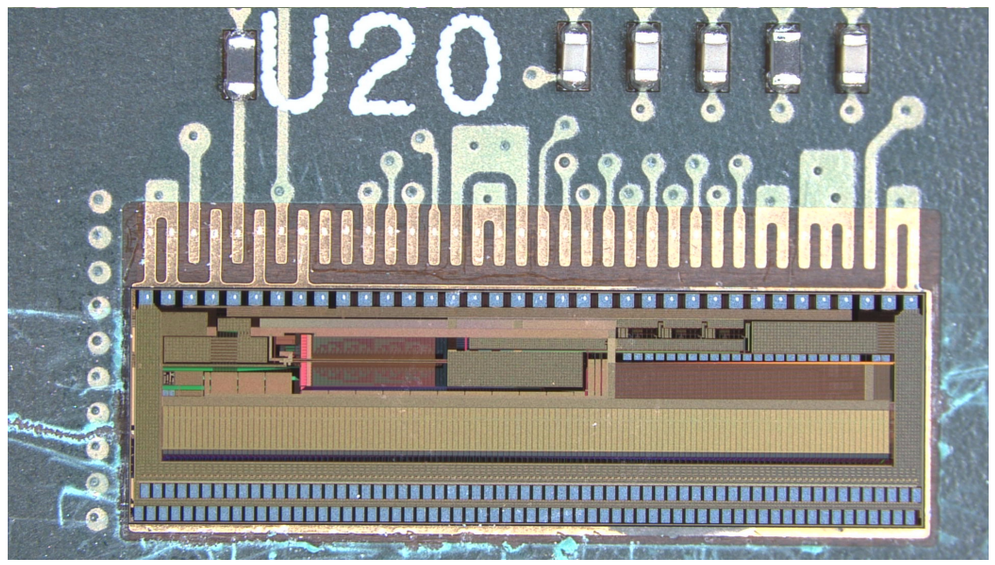
INTT DAQ debug method



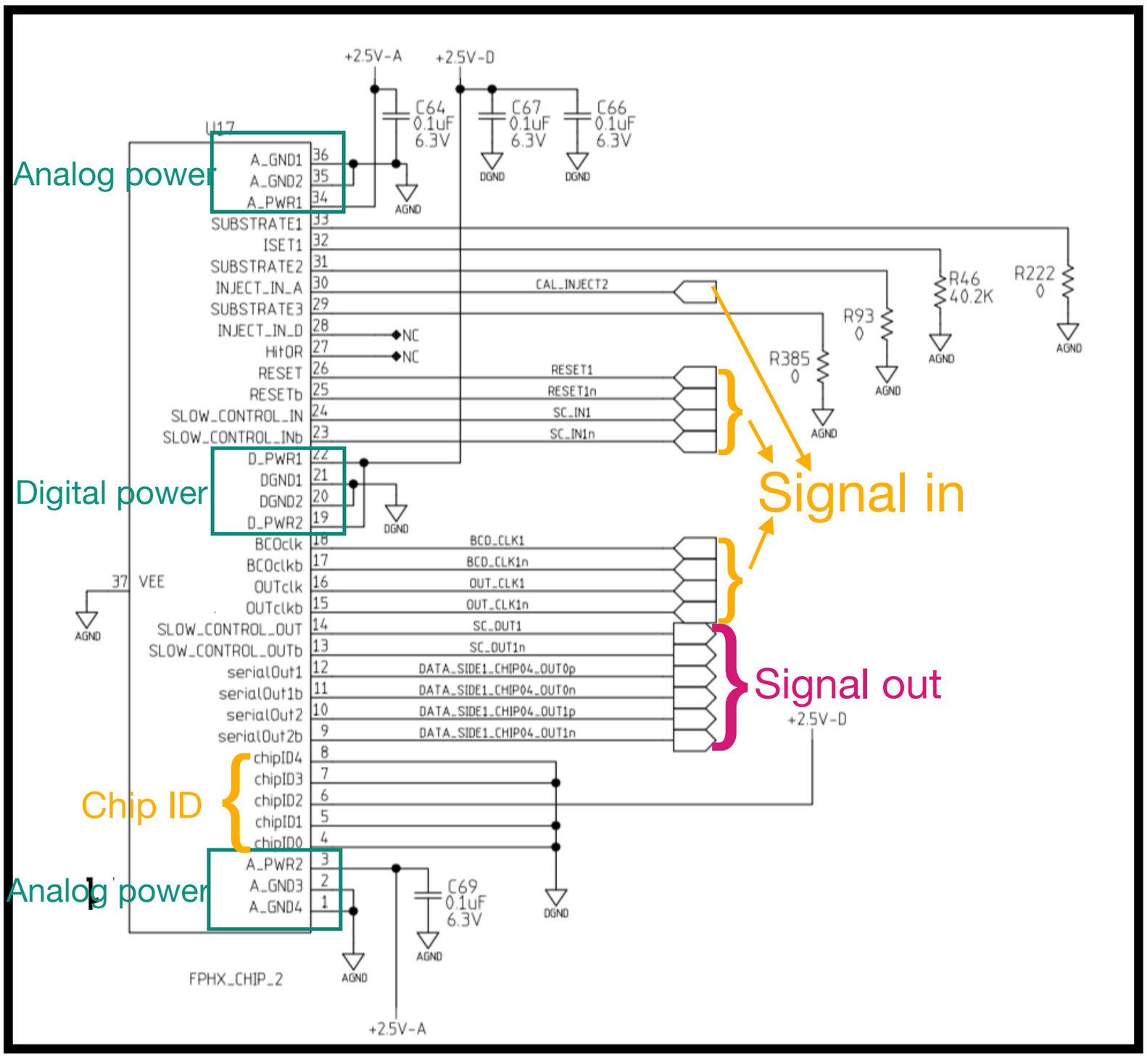
Problematic module example : Module 047, chip to HDI

Chip replacement

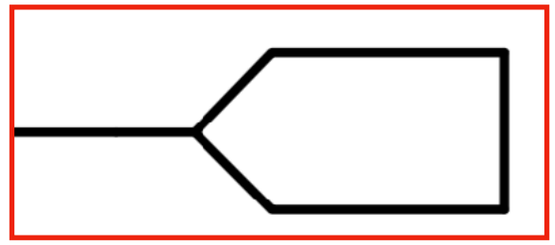




INTT DAQ Debug method



Signal from ROC to HDI



Signal to ROC from HDI

Check the continuity of inner circuit of HDI

Analog power

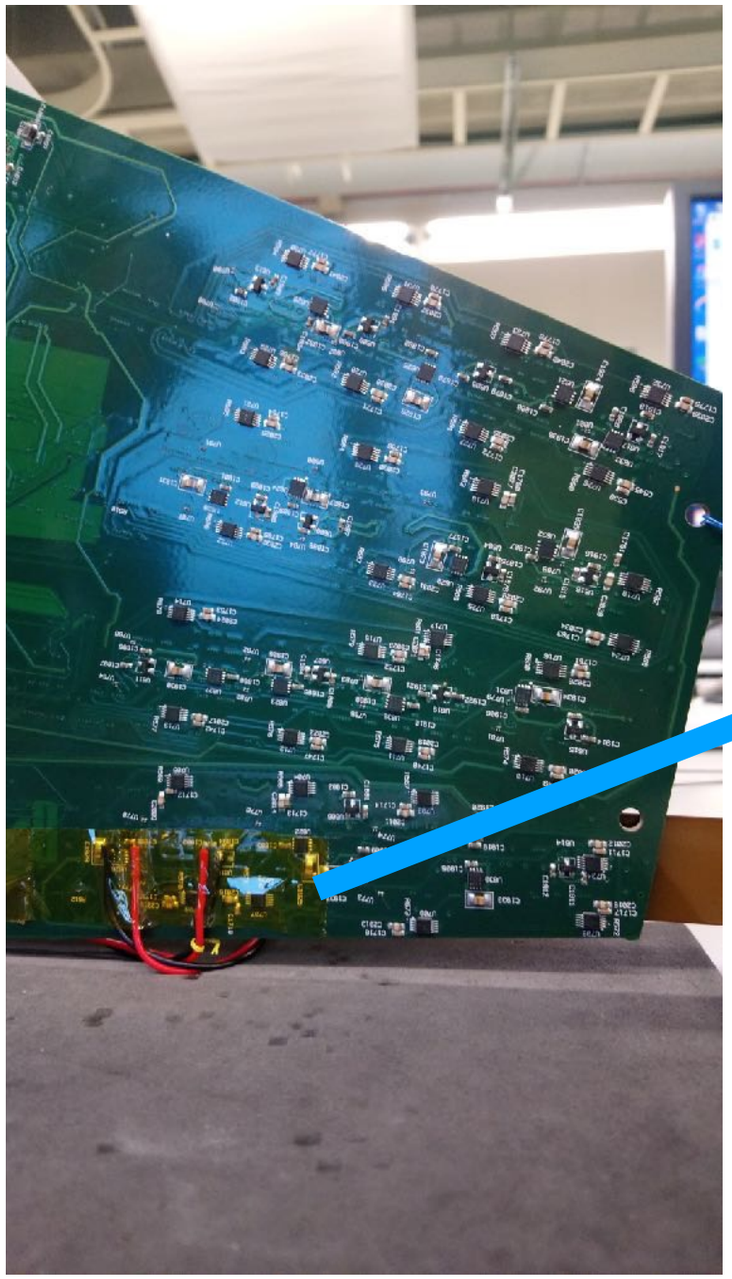
Digital power

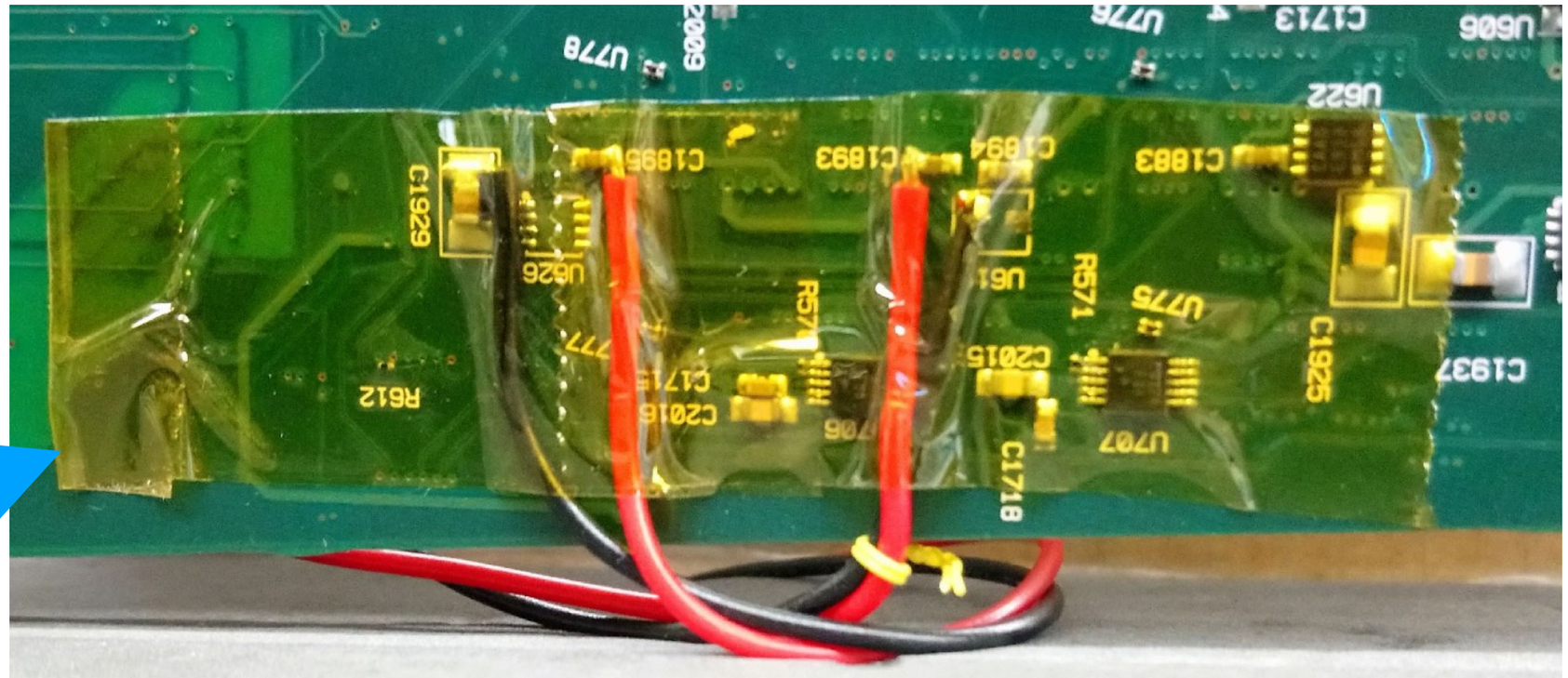
Signal out

9 signal in

Chip ID

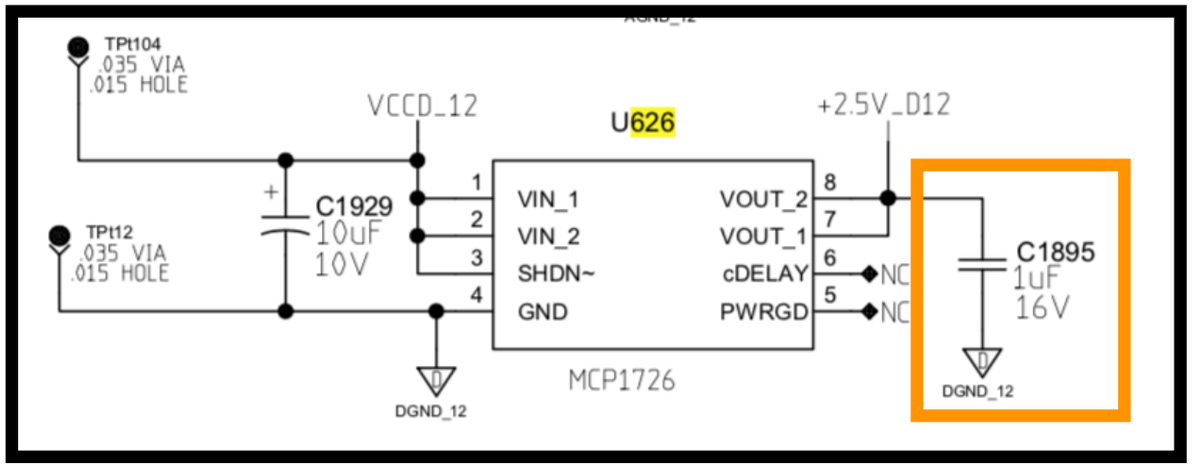
Regulators replacement of P400 401





Digital power

The regulator to supply digital power to P400 401

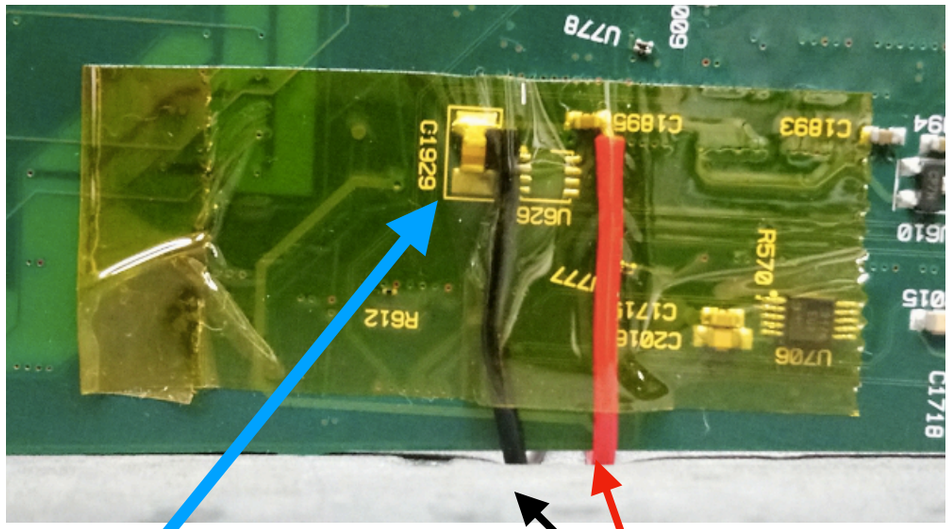


Voltage drop

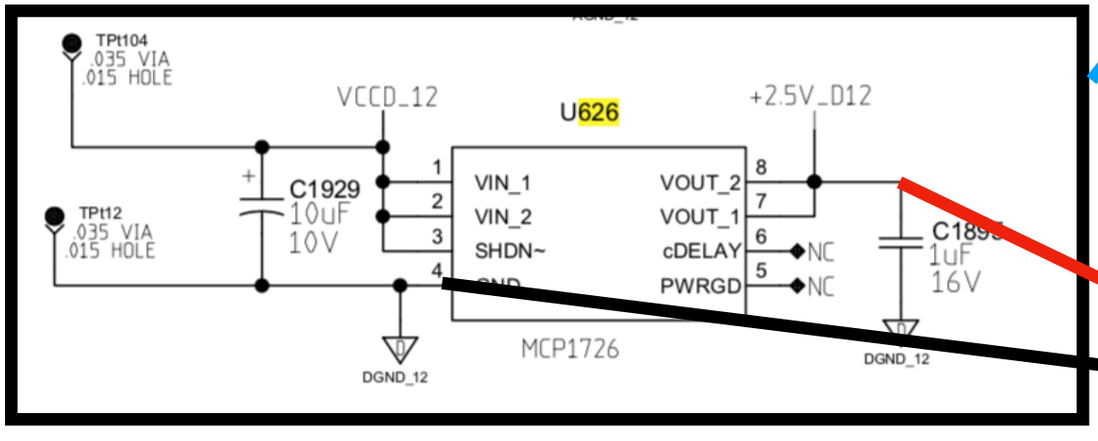
LVDS setting	3 (2mA)	255 (2mA)
C1895 voltage	2.427	2.184

On drawing : 2.5V

The regulator U626 is removed



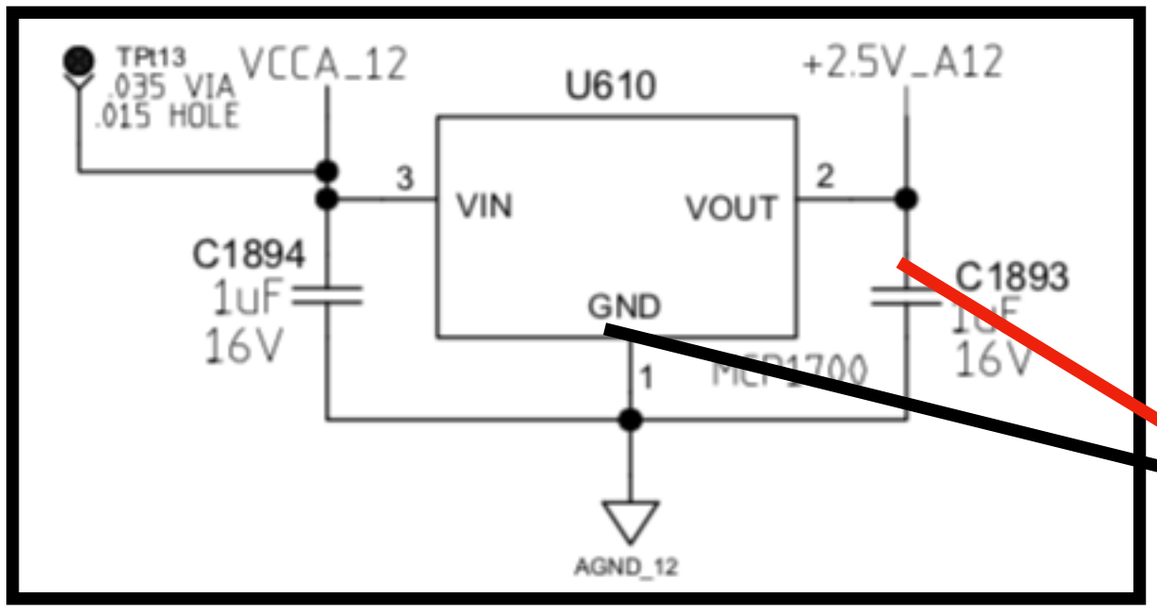
LVDS setting	3 (2mA)	255 (2mA)
Power supply voltage	2.64V	2.71V



Red cable to C1895
Black to pin 4 of U626

Power supply

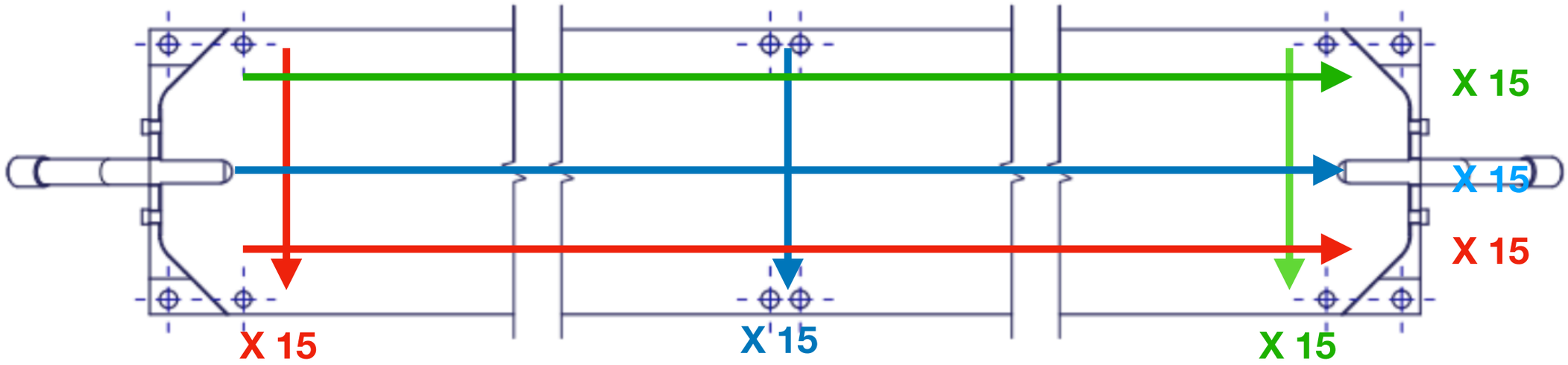
Analog power



Red cable to C1893
Black to ground of U610

power source	analog	digital
supply voltage	2.564 V	2.655V
current	0.185A	0.349A

Stave flatness measurement



Transverse / Longitudinal directions : 45 measurements

PP : pre production
P : production

ID	PP7	P1	P5	P6	P10
Longitudinal	266um	187um	80.5um	150 um	94.8um
Transverse	251um	99.3um	32.9	69.5um	36.2um

Original flatness requirement : <100 um

Measurements done by OGP

Stave flatness measurement