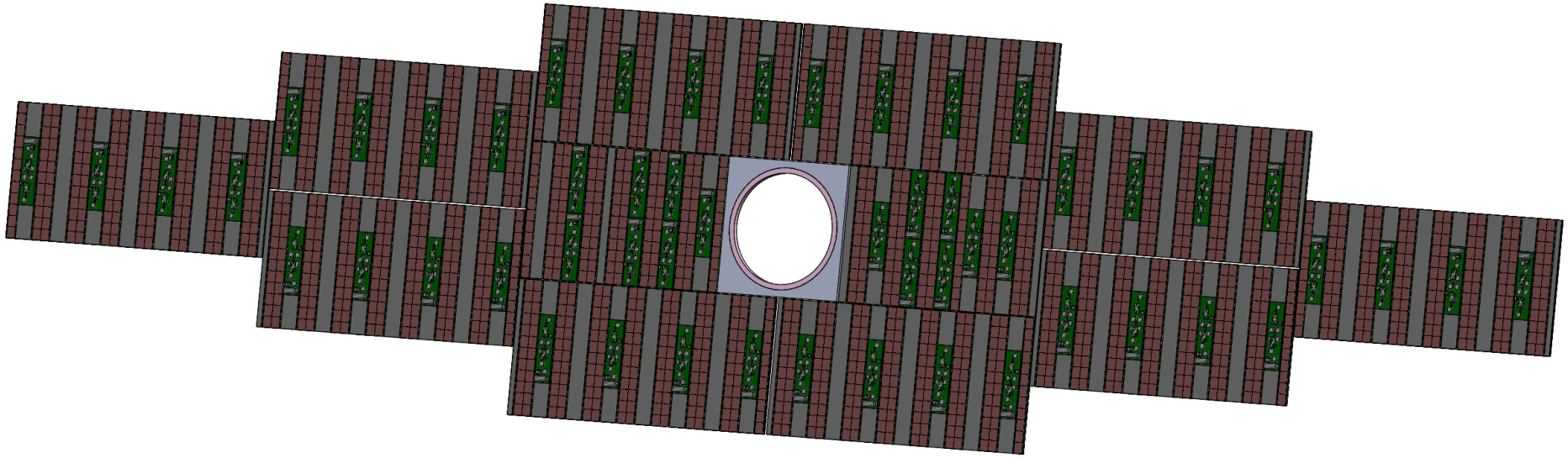
Mighty Tracker – Pixel Module Mechanics and Electronics

Overall Design, Pixel Module Design, Chip Matrix, and more…

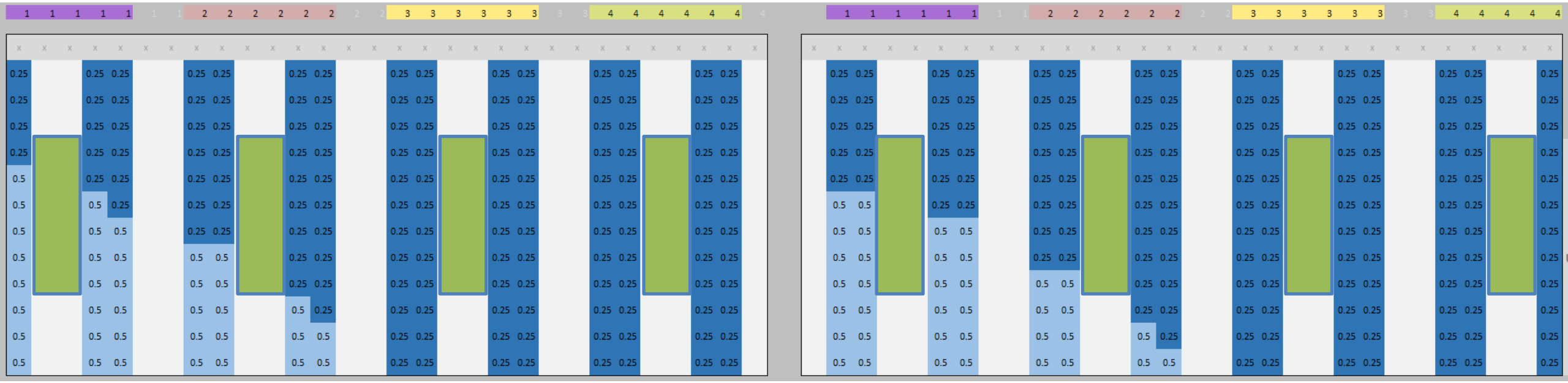


Alex Bitadze

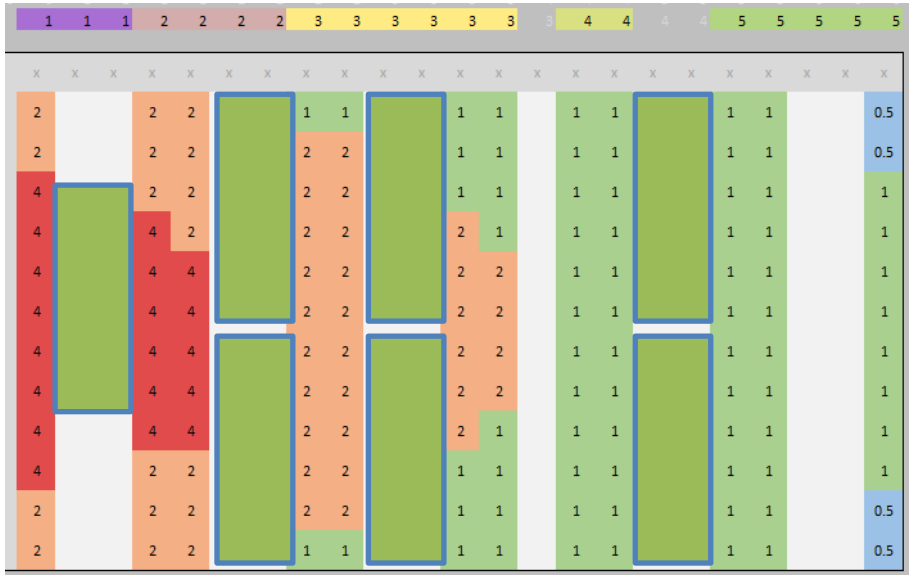
On behalf of the MT Mechanics & Modules team.

Side A (30 x 12 Chips)

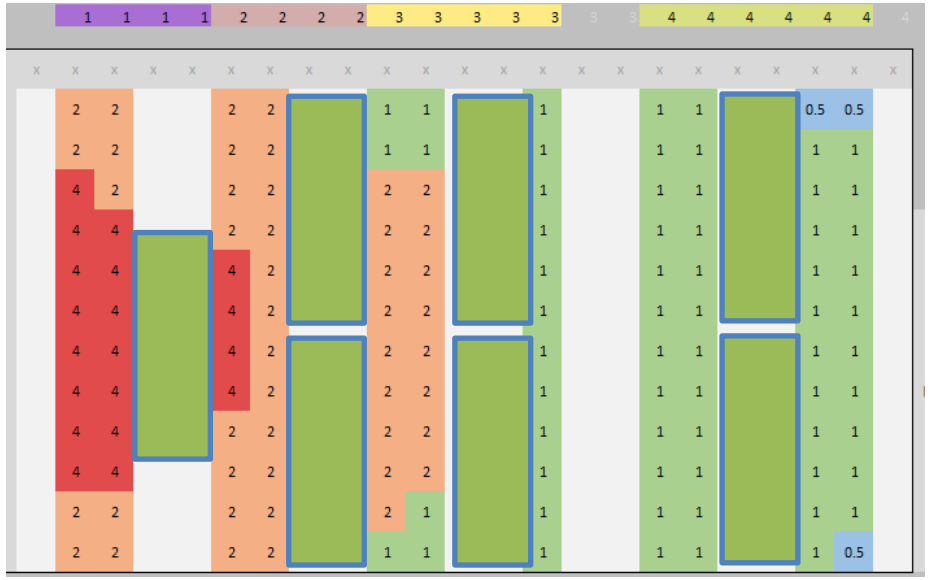
Side B (30 x 12 Chips)
(Reversed)



Side A (23 x 12 Chips)

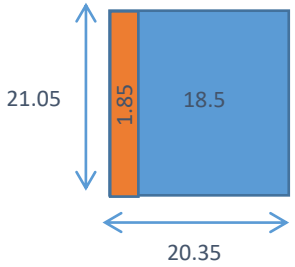


Side B (23 x 12 Chips)
(Reversed)

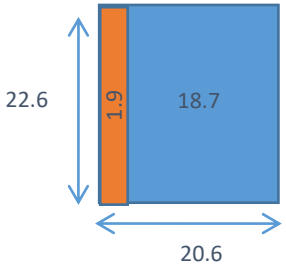


** All values in mm*

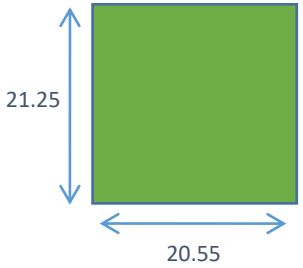
ASIC

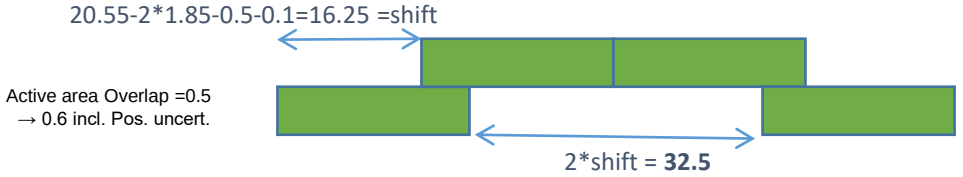


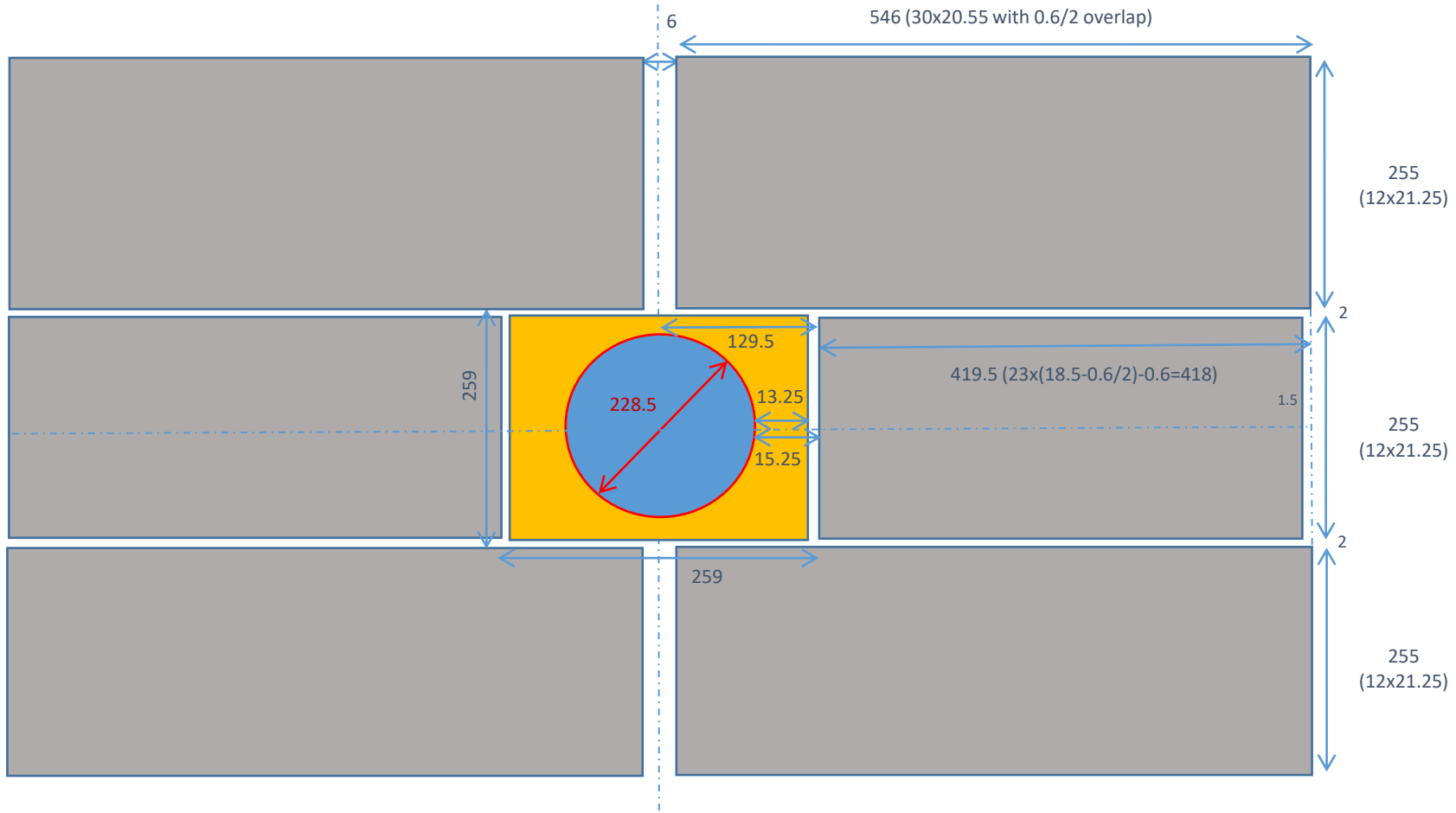
MAX ASIC

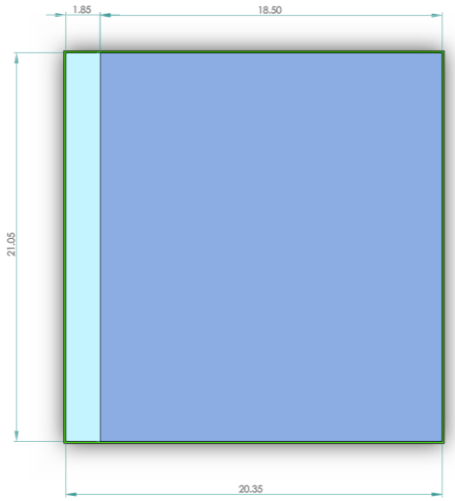


Real ASIC Footprint

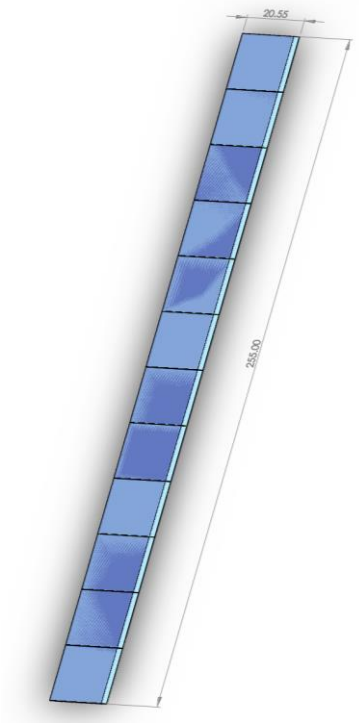




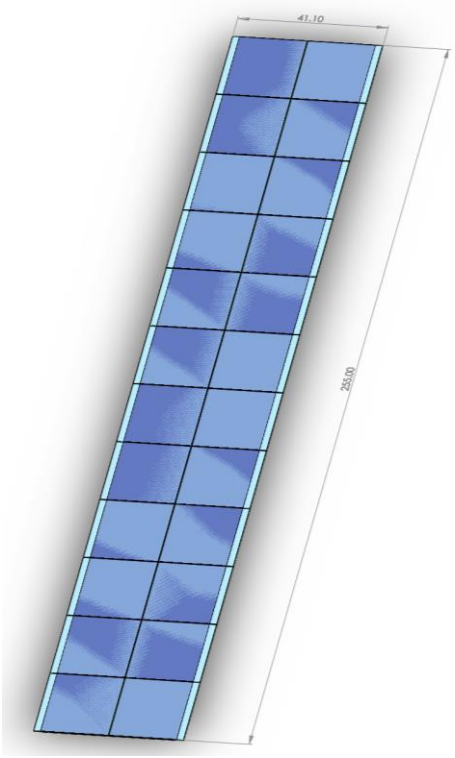




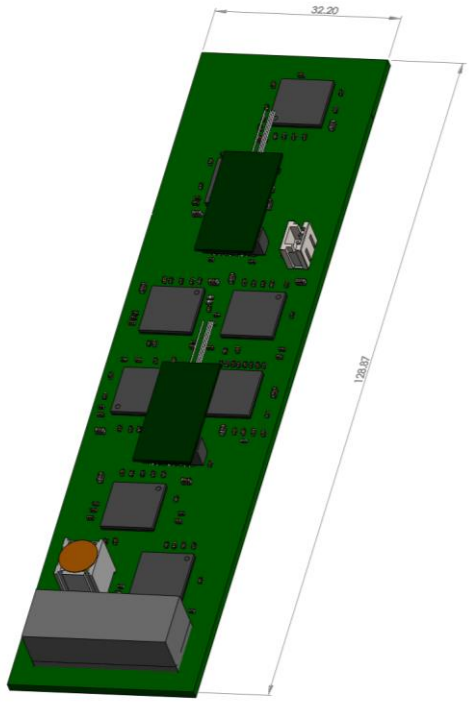
** Footprint: +200 µm*



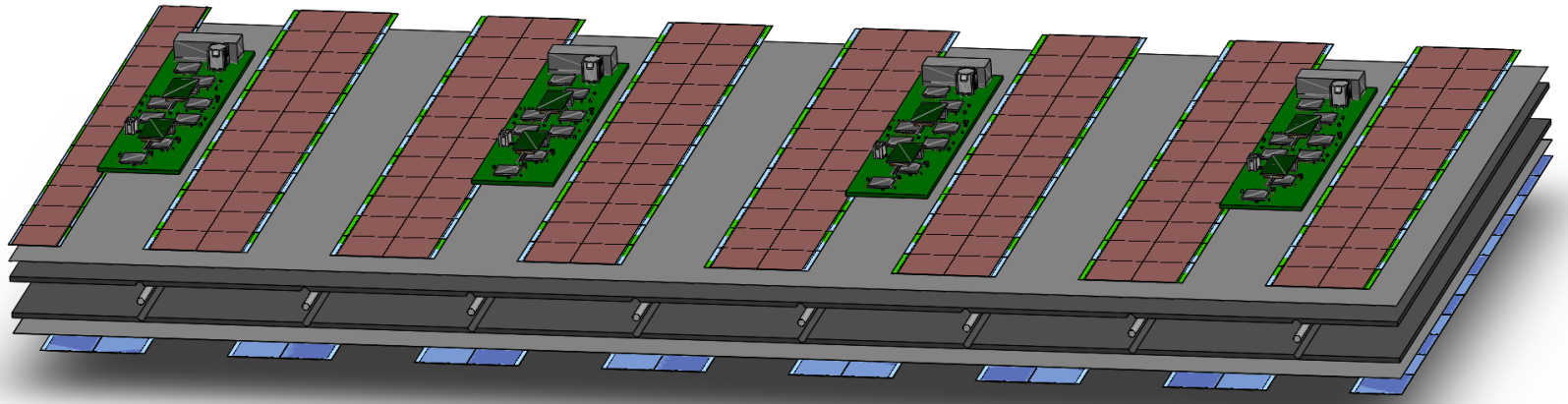
1 x 12 Flex Assembly

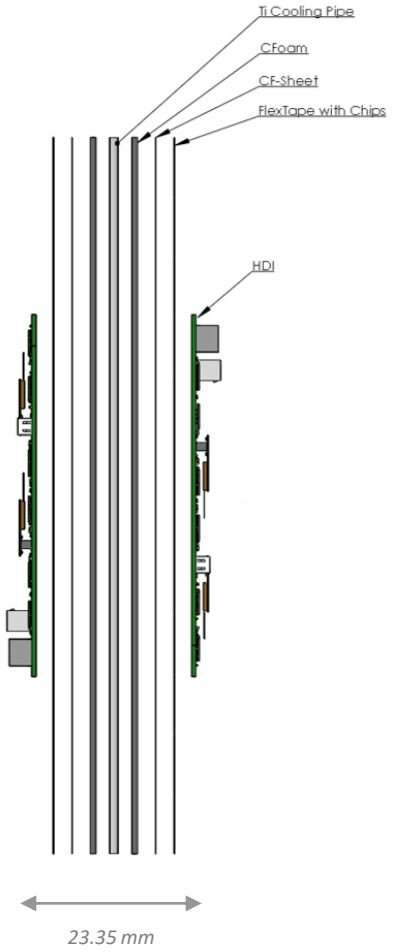


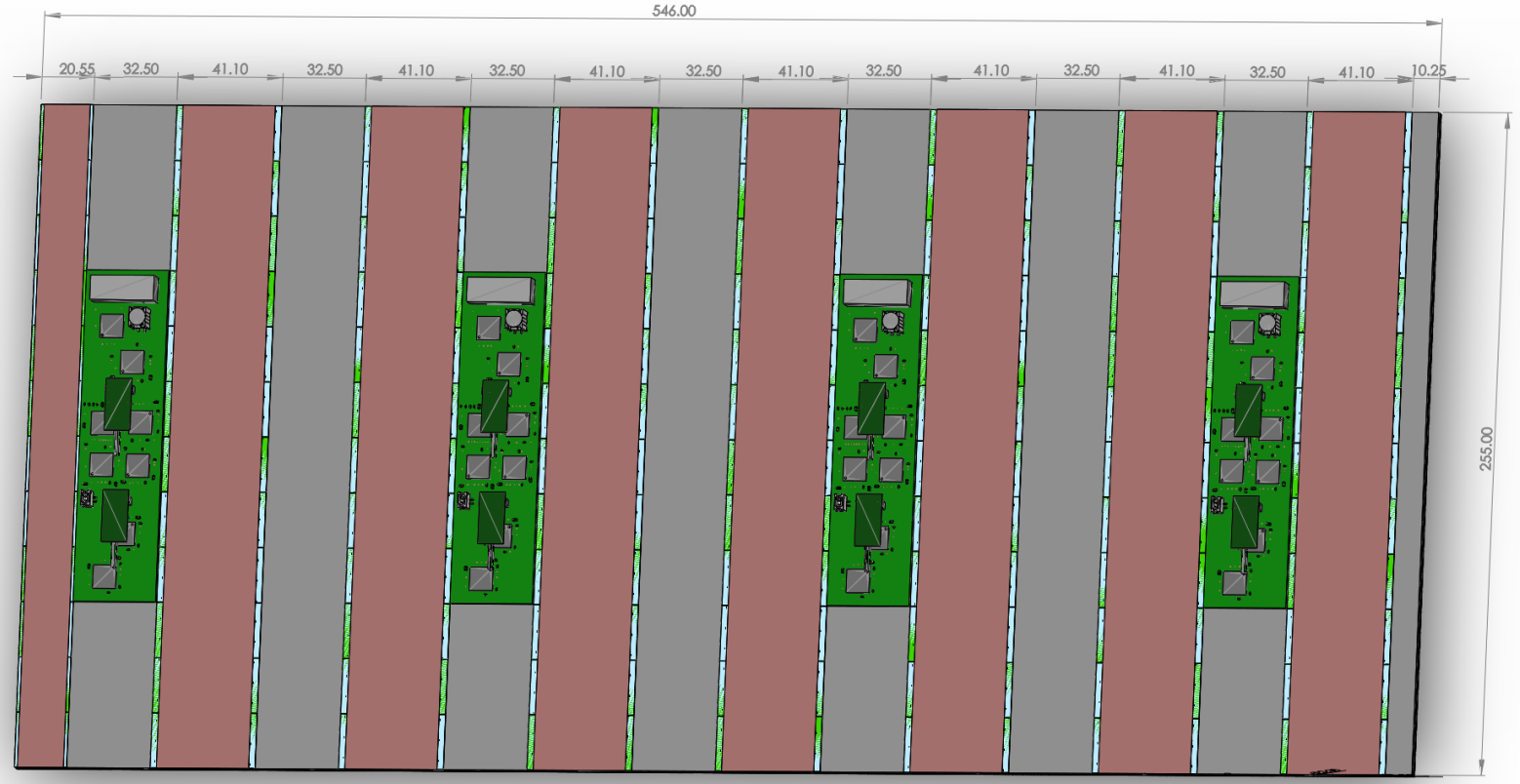
2 x 12 Flex Assembly

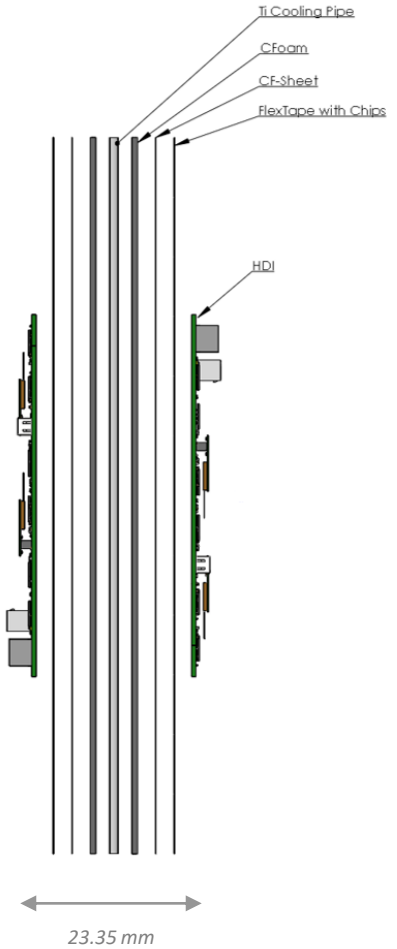


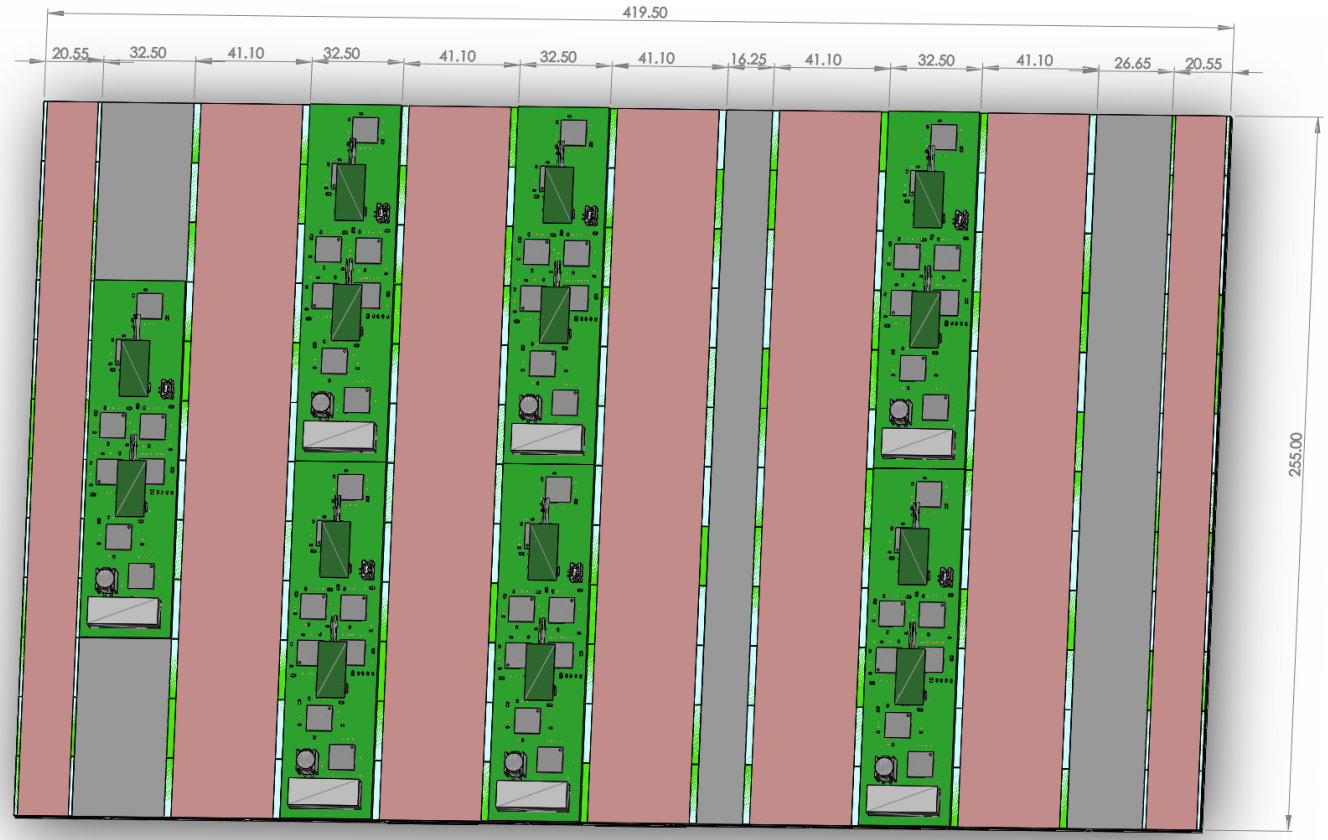
HIGH DENSITY
INTERCONNECT (HDI) PCB

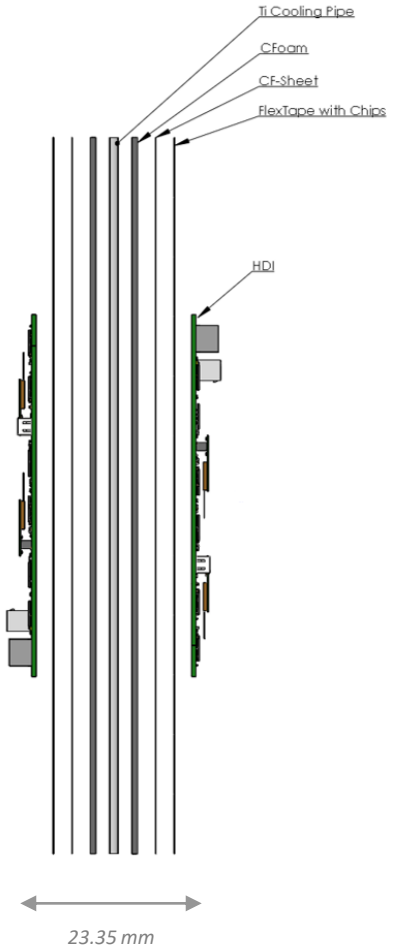


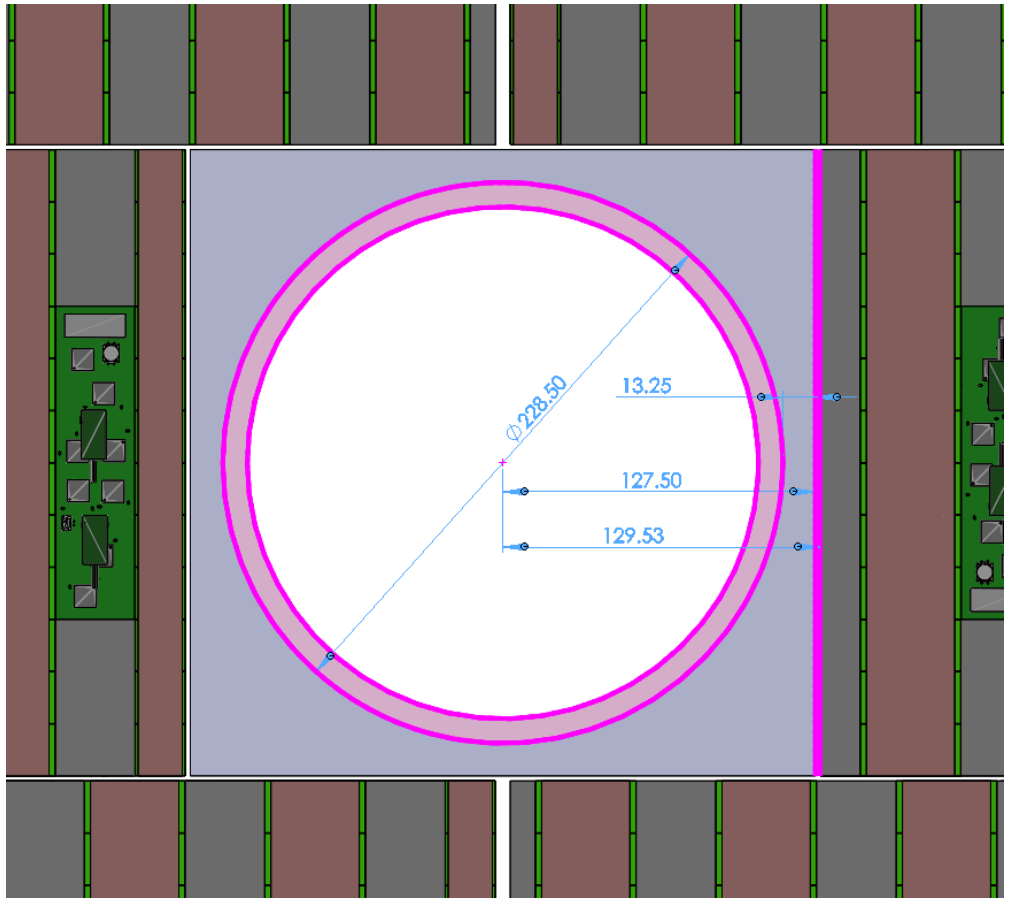

Ti Cooling Pipe
CFoam
CF-Sheet
FlexTape with Chips
HDI
23.35 mm


546.00
20.55
32.50
41.10
32.50
41.10
32.50
41.10
32.50
41.10
32.50
41.10
32.50
41.10
32.50
41.10
10.25
255.00


Ti Cooling Pipe
CFoam
CF-Sheet
FlexTape with Chips
HDI
23.35 mm

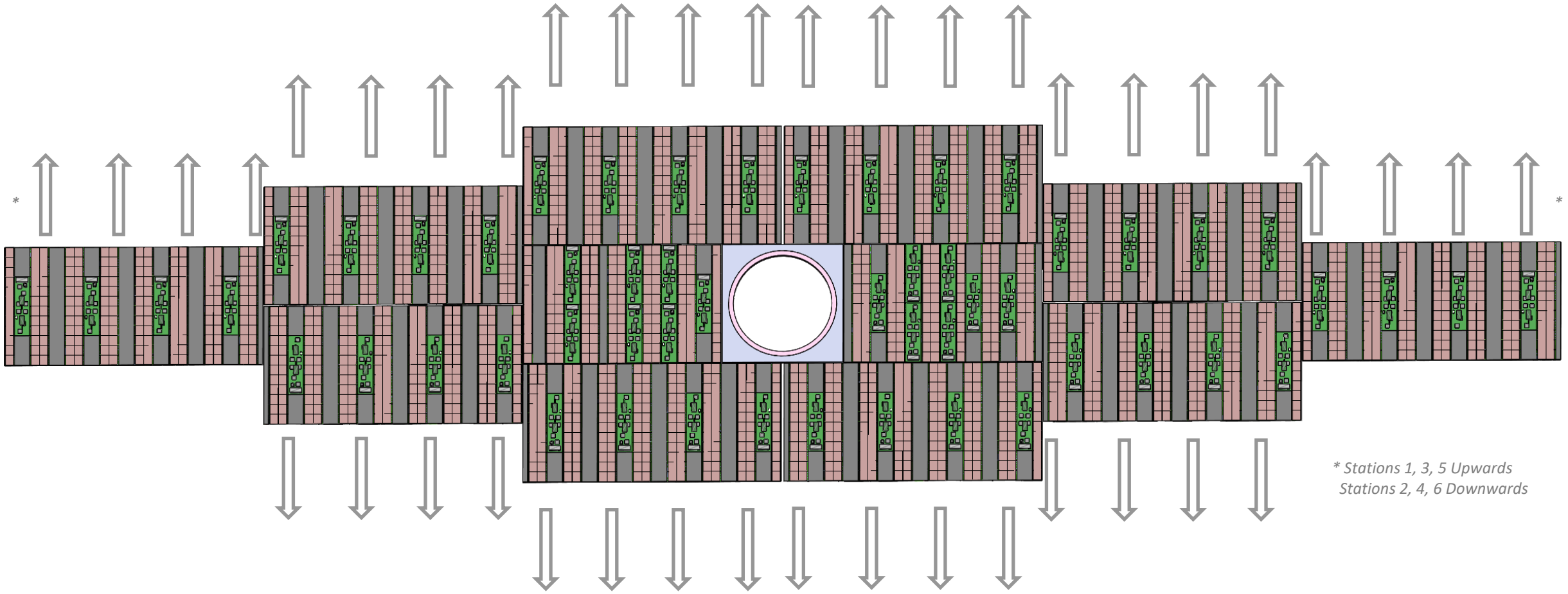

419.50
20.55
32.50
41.10
32.50
41.10
32.50
41.10
16.25
41.10
32.50
41.10
26.65
20.55
255.00


Ti Cooling Pipe
CFoam
CF-Sheet
FlexTape with Chips
HDI
23.35 mm


Ø228.50
13.25
127.50
129.53

***Front** View*

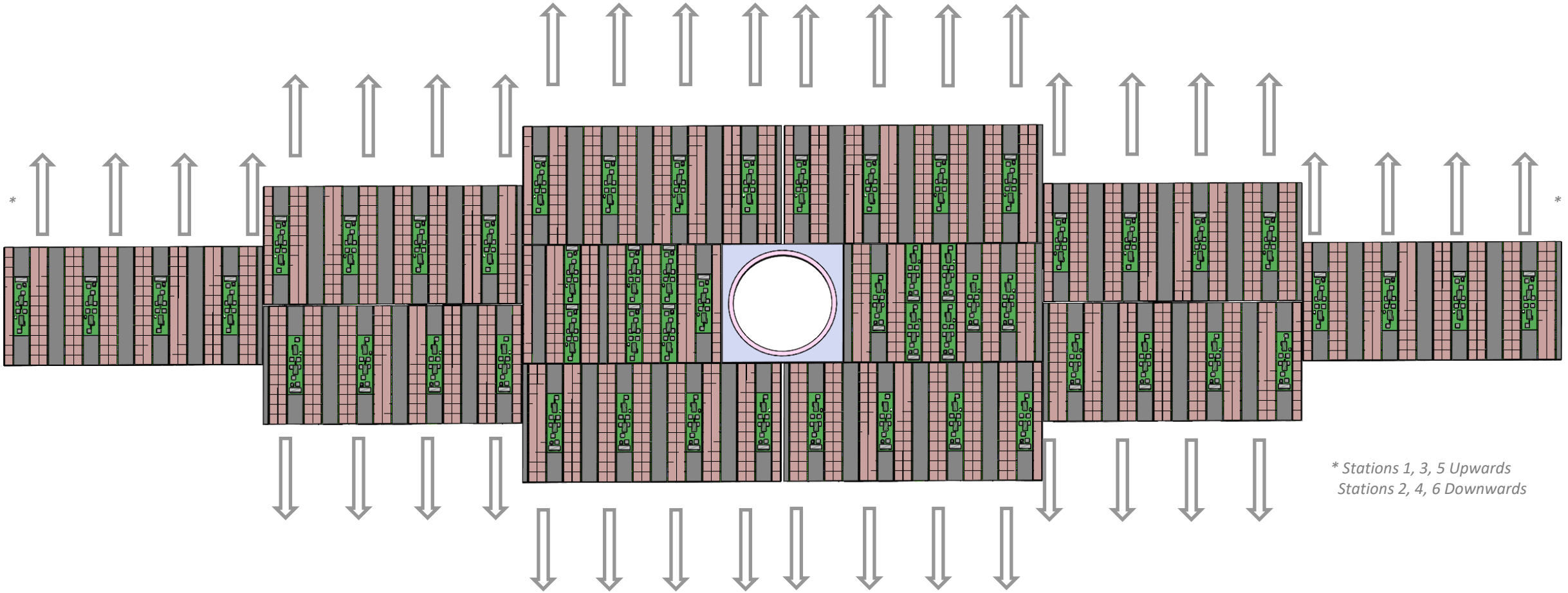
Long Module Services – Front & Back - Same Direction
Short Module Services – Front & Back - Opposite Direction



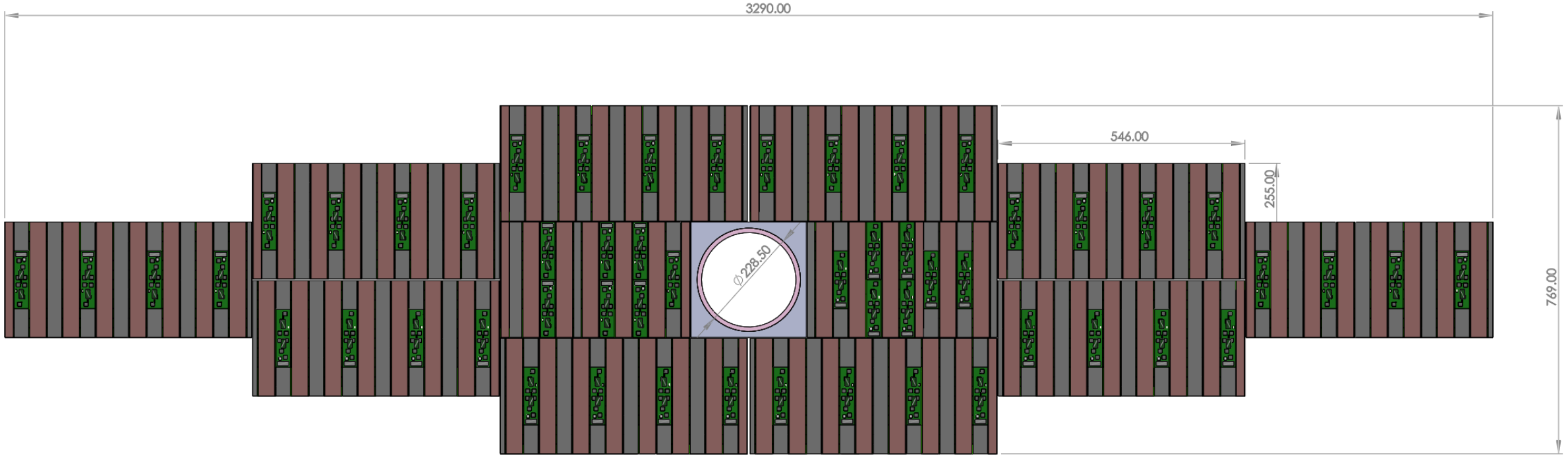
** Stations 1, 3, 5 Upwards*
Stations 2, 4, 6 Downwards

***Back** View*

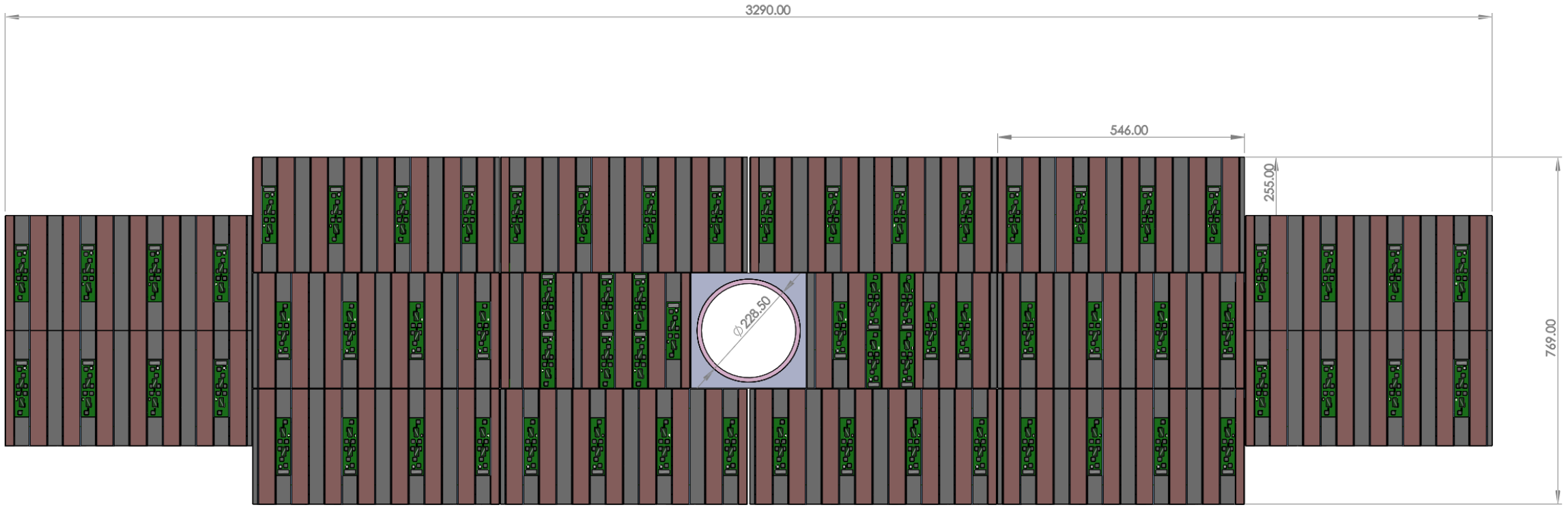
Long Module Services – Front & Back - Same Direction
Short Module Services – Front & Back - Opposite Direction



** Stations 1, 3, 5 Upwards*
Stations 2, 4, 6 Downwards


3290.00
546.00
255.00
Ø228.50
769.00


2194.00
546.00
255.00
769.00
Ø228.50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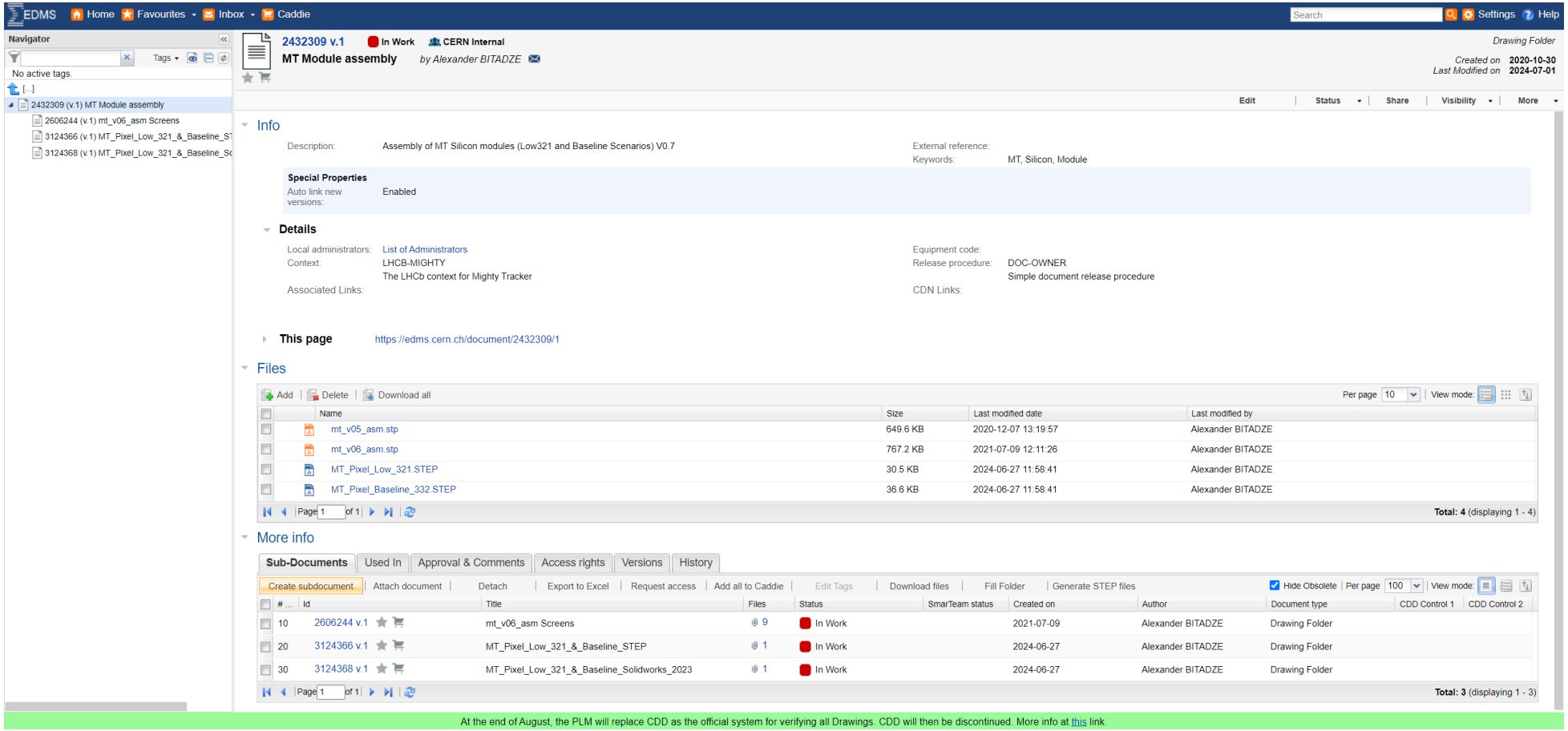
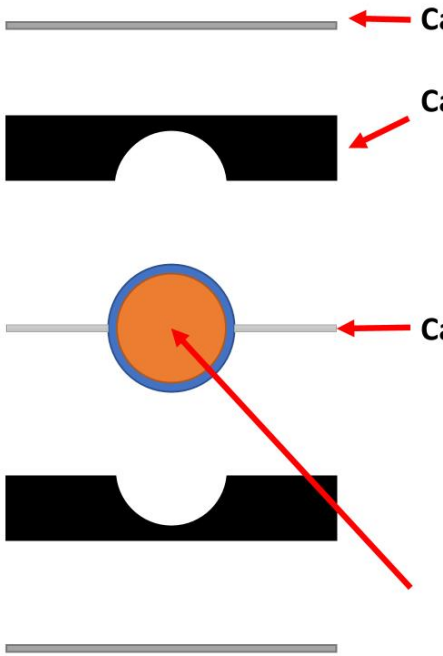
https://edms.cern.ch/document/2432309/1



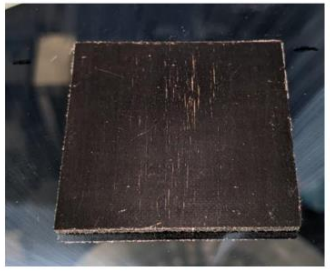
Base module exploded view



Carbon fibre - Cocuring in Liverpool (~150um)

Carbon foam available for small samples

- 2 mm thick
- Two Poco HTC foam plates in-house
- Negotiation on going with Lockheed Martin



Carbon veil + Glue (Hysol + graphite)

- Synergy with the local Atlas end-caps production

Glue application to the veil

Polyimide tubes

Lewvac, 2.822mm OD, 76µm wall thickness

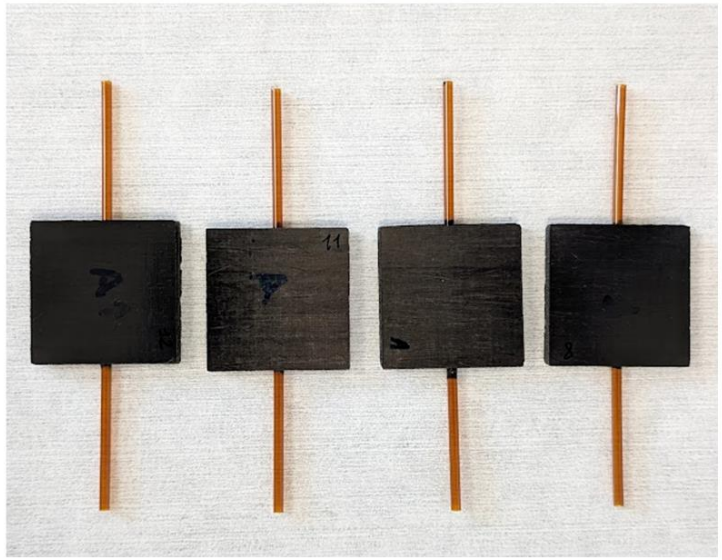
Microlumens can provide longer lengths (55” 2.54mm OD)

[Mode details in Stefano’s talk]

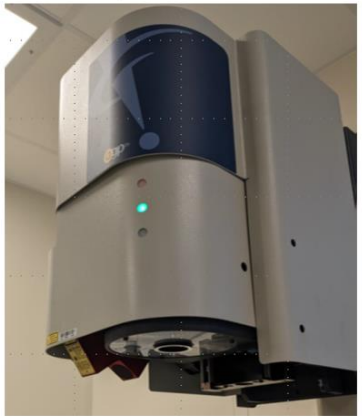
Baby modules

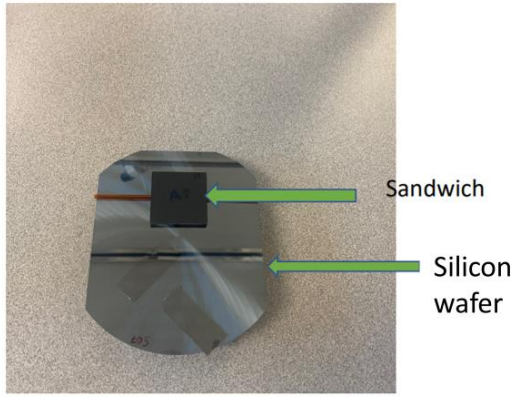
[Metrology presentation]

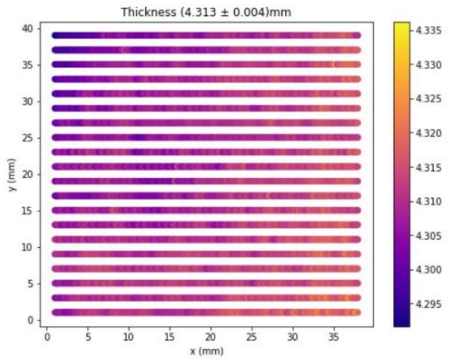
Four samples assembled

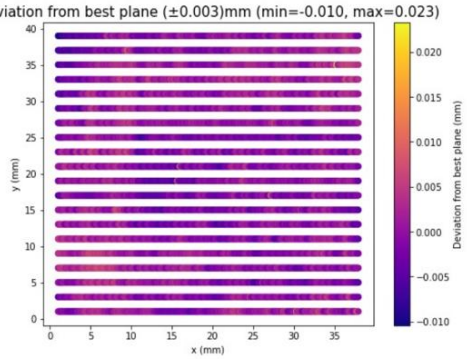


Smartscope measurements









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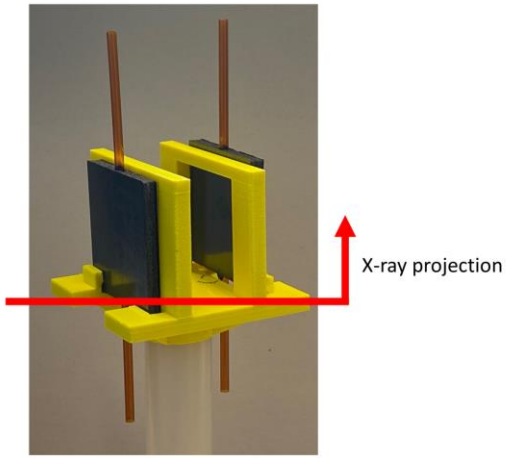
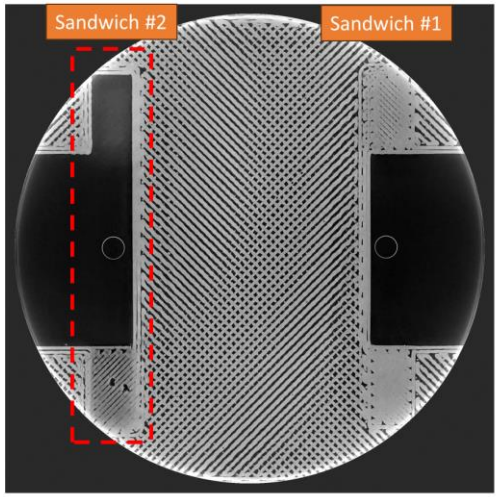
X-ray Tomography (NXCT UK)





X-ray Analysis

Simple pattern recognition based in python (opencv, ndimage)

- It can still be improved (ongoing)

Initial approach to try to identify the basic features of the baby module:

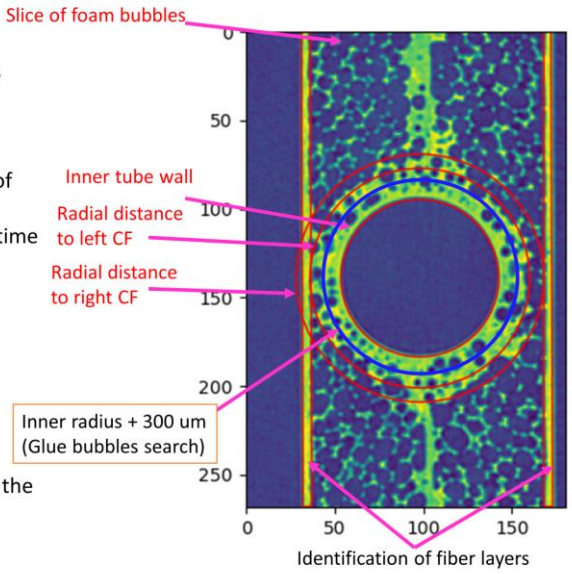
- Focus on the region around the tube for the time being
- Inner wall of the Kapton tube
- Carbon fiber layers

Inner circle: Kapton inner diameter

CF identification:

- Outer part is easier to identify (flat surface)
- Inner module part has the contribution from the resin penetration

The pixel size corresponds to roughly 30um x 30um



Comparison between FEA and Simplified

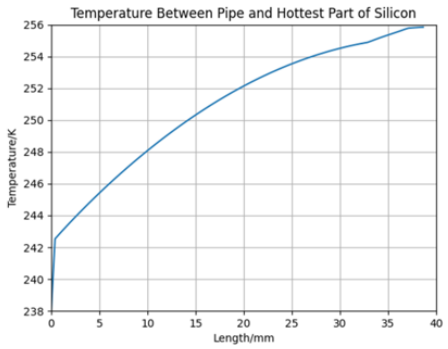
Model with 2 chips distance (simplified geometry)

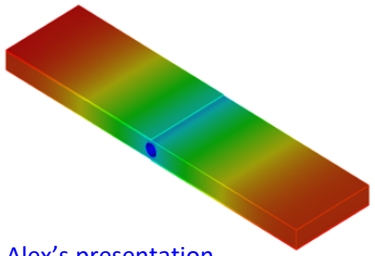
FEA (FreeCad)	$\Delta T = 18°C$
Simplified Python	$\Delta T = 20°C$

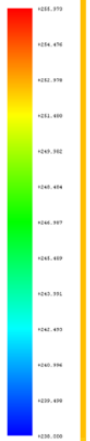
Difference of 2°C, python code is a fast tool for feasibility studies and better understanding of the complete FEA

FEA (FreeCad)

$T\ Pipe = -35\ °C$
$T\ Hottest = -17\ °C$
$\Delta T = 18\ °C$



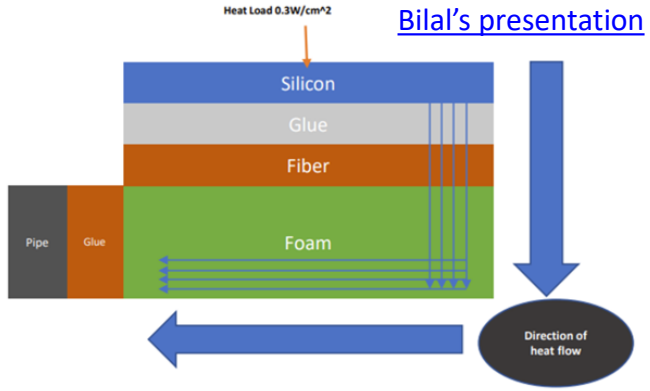




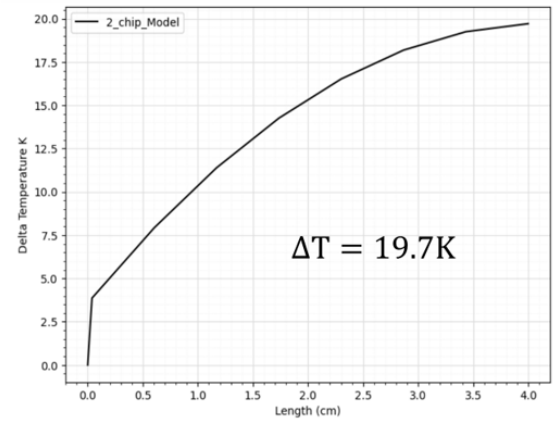
Alex's presentation

Simplified Python

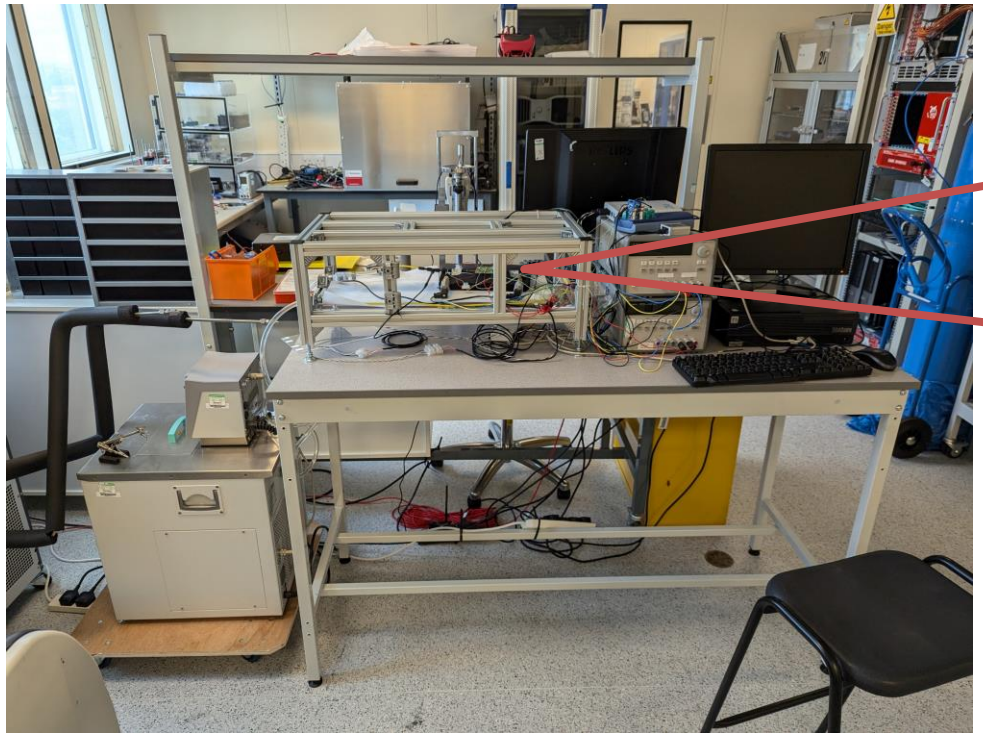
Bilal's presentation

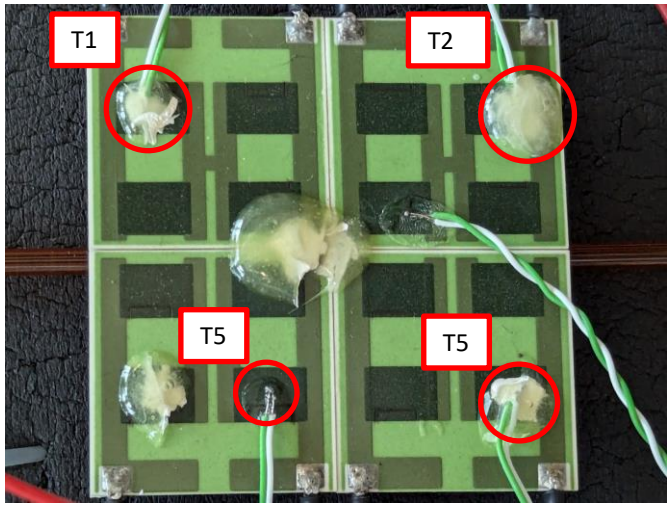


ΔT for 2 chips

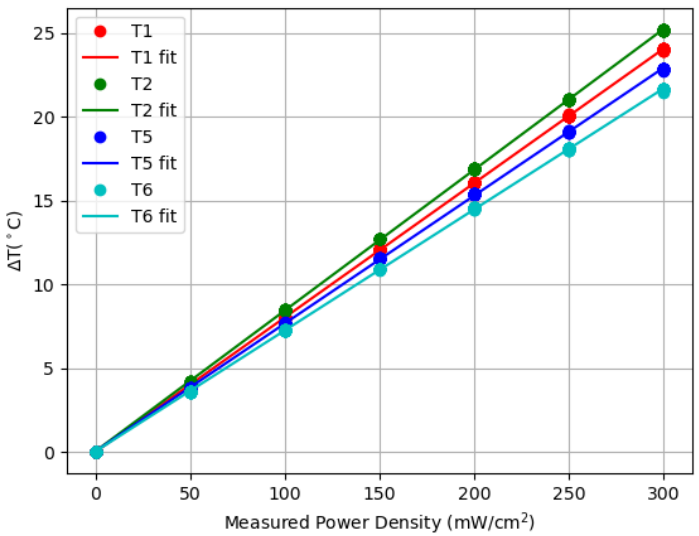


Experimental set-up

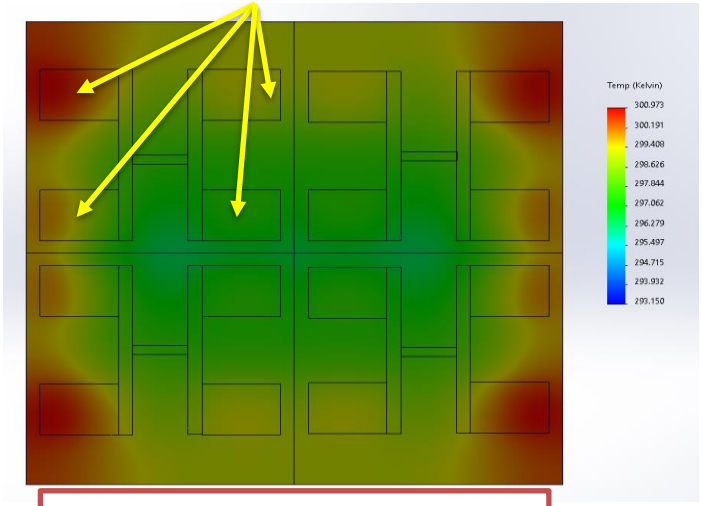




Some of the probes detached

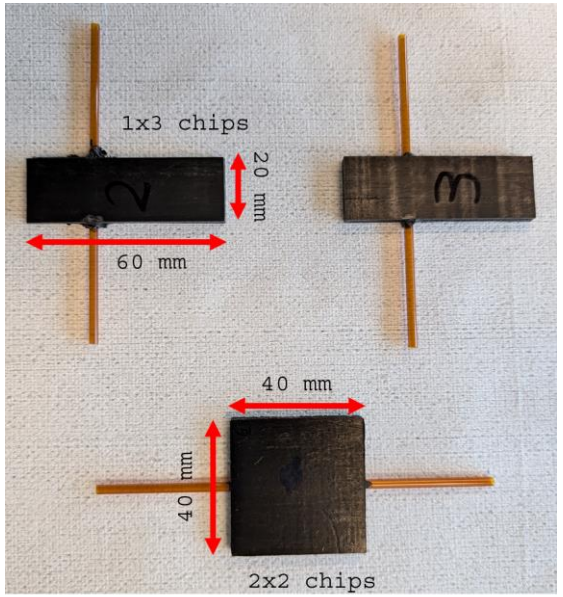


FEA (0.3W per block – 1.2W per chip)



Difference in glue thickness not included!!!
(Heaters tilting)

1. FEA
   1. Convection is not included
   2. Heater tilting not included
   3. Assuming temperature inside the cooling line at $0°C$
   4. 1.2W per heater ($192 mW/cm^2$)
   5. $\Delta T_{initial} \sim 28°C$
2. Measurement
   1. Largest convection estimated as 1.6W ($25 W/m^2K$ at $\Delta T \sim 25°C$) -> loss of additional $62 mW/cm^2$ (link)
   2. Effective power -> $254 mW/cm^2$
   3. $\Delta T_{initial} \sim 21°C$ ($254 mW/cm^2$)
   4. $\Delta T_{initial} \sim 25°C$ ($300 mW/cm^2$)



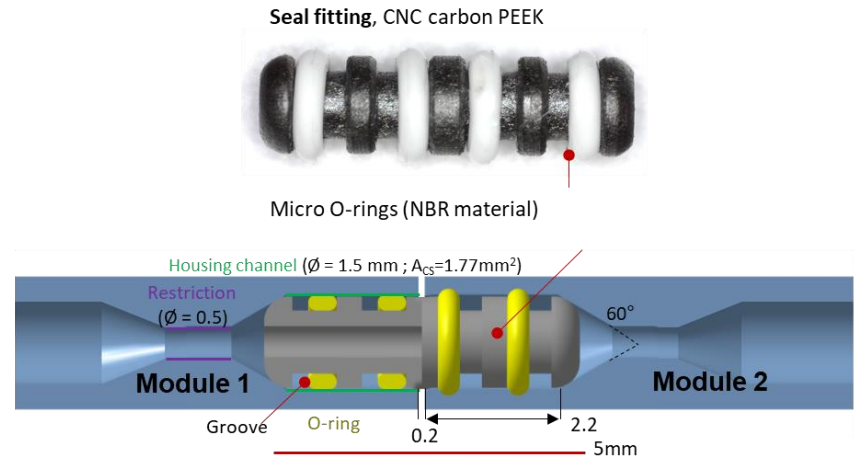
- ✓ First cooling performance results obtained and compared to FEAs
- ✓ Intermediate upgrade to HFE7100 soon
- ✓ Upgrade to CO2 evaporative cooling in the coming month or so (Ti tubes prototypes)

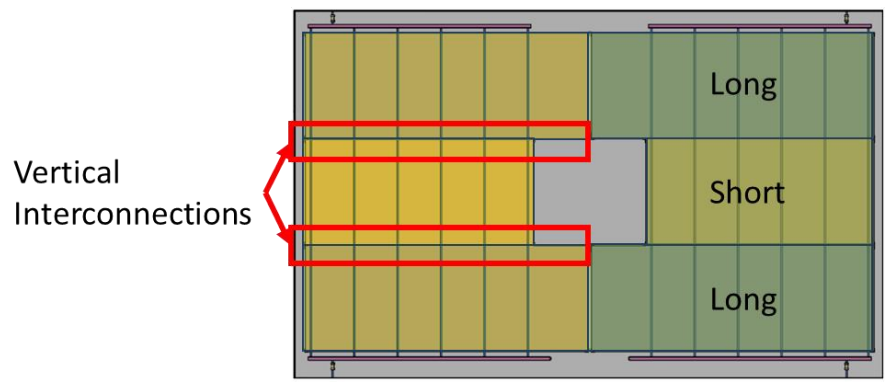
- ✓ New samples 1x3 chips size will allow us to estimate the cooling performance for 1 and 2 chips cooling spacing
  - 2 Kapton tube samples assembled
  - Titanium sample will also be assembled
  - Comparison
- ✓ Custom-made heaters coming
  - 20mm x 20mm (~10 working days)

Vertical interconnection

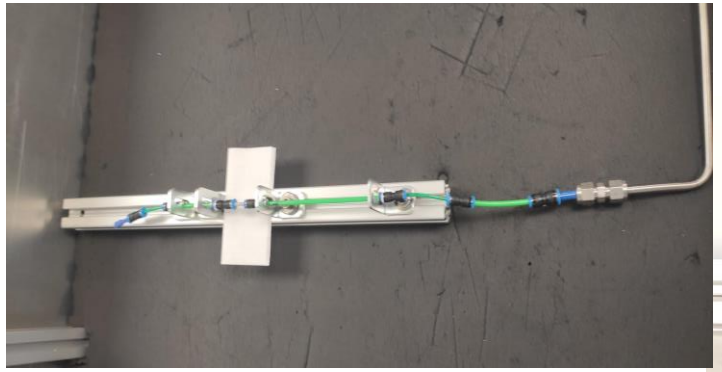
- Reliable hydraulic and mechanical interconnection (CERN EP-DT)
- Very compact
  - Seal fitting is 5 mm long and has 1.5 mm OD
- Proposal to solve the vertical integration of the modules
  - Module can still be replaced
  - Near seamless
- Radiation hardness of O-rings being investigated

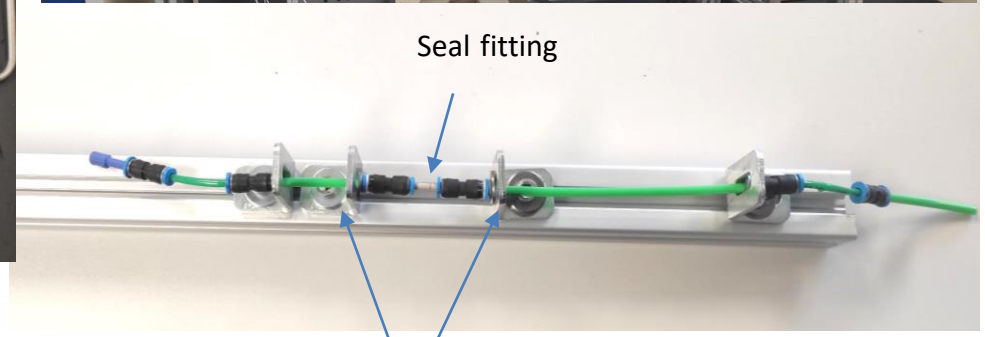
[EP-DT day meeting]





We used a compact reinforcement test stand to assess the seal fitting. During the procedure, we incrementally raised the pressure to detect any potential leaks or tube ruptures.





At approximately **40 bar** of pressure, there were no observable leaks detected. Upon surpassing the 40 bar threshold and reaching around 50 bar, leaks remained undetected. However, there was noticeable deformation in the plastic tubes, eventually leading to tube rupture

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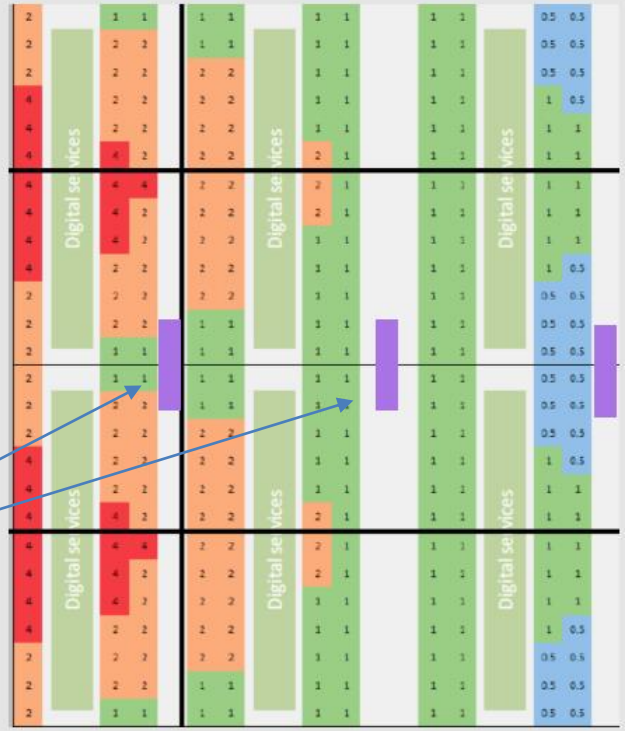
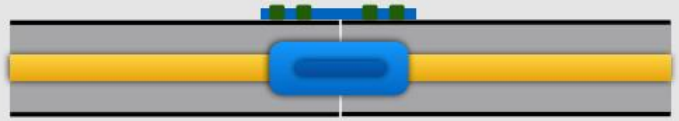
[Marco's presentation]

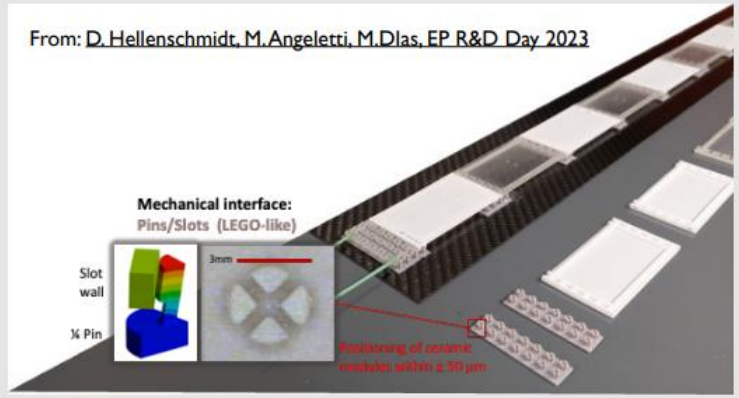
Potential position of connectors

Front



- Connectors clamp modules in a column

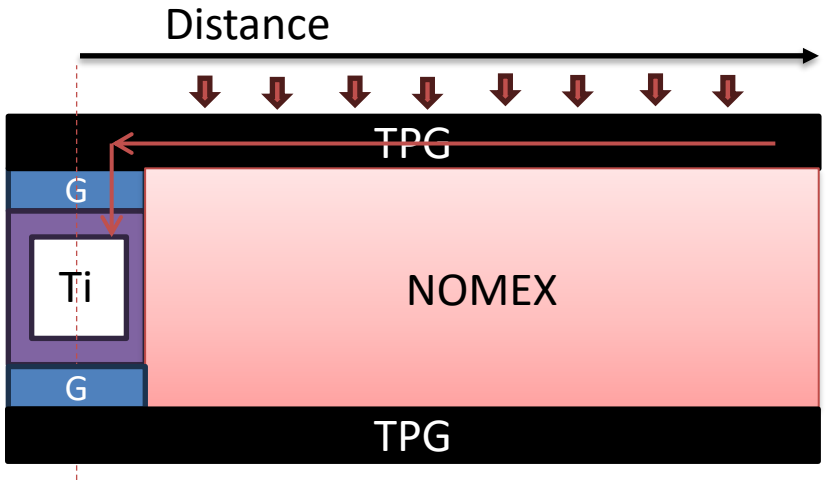


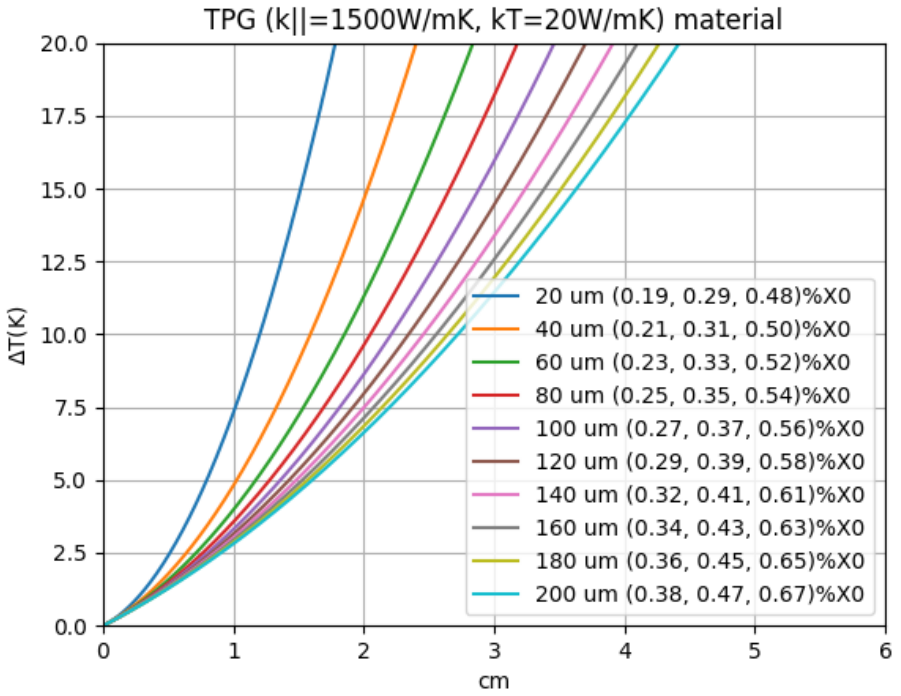


Fixation points in between modules in empty columns

5

No Foam alternatives (TPG calculation)





3mm titanium squared tube (250um wall)

TPG: k||=1500W/mK, kT=20W/mK, X0=19.23cm
G: kT=1W/mK, X0=35.5cm
Ti: k=16W/mK, X0=3.56cm

X0 calculated averaging the Ti tube over 8 cm, 4cm and 2cm respectively (one cooling line every 4, 2 and 1 chip columns)

Ongoing activities and plans

- ✓ Implement cooling connection fittings into the CAD
- ✓ Implement module interconnection clamps into the CAD
- ✓ Finalise the 3D CAD Design for the Pixel Module Assembly
- ✓ Cooling connection fittings pressure tests / Reliable interconnection design
- ✓ Thermal test setup (FEA validation) – New sample tests - Novec HFE7100 and CO_2
- ✓ Validate the on-detector cooling system (DT)
- ✓ FEA Analyses for No Foam solutions (New Materials)
- ✓ FEA Analyses for Full assembly (thermal box / support structures) for Gravitational sag and vibrations
- ✓ Define QA/QC procedure for chips/flexes assemblies, along with the implementation of proper reworkability procedures
- ✓ Define Pixel module assembly serviceability and maintenance procedures after installation