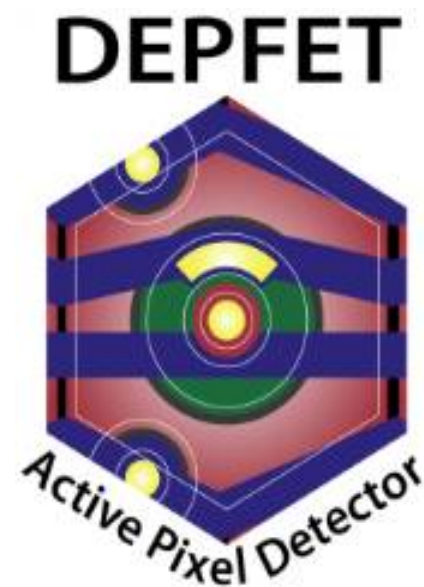


Update of the DEPFET technology applied for future applications: thermo-mechanical mockup for ILC and microchannels cooling



L. Andricek(1) , J.V. Civera (2), M.A de la Torre (3), M. Frovel (3),
J. Fuster (2), I. Garcia (2), P. Gomis (2), D. Moya (4), C. Marinas (5),
M. Perelló (2), I. Vila (4), M.A. Villarejo (2), M. Vos (2)



(1)



(2)



(3)



(4)



(5)

Official motivation

- 1- Mockup for a detector inner region with DEPFET silicon dummies
 - Cooling according to the baseline design
 - Geometry according to the baseline design
- 2- Microchannel cooling for DEPFET sensors
 - Thermal tests
 - Qualification process
 - Lessons learned (for a mechanical and non-mechanical engineer)

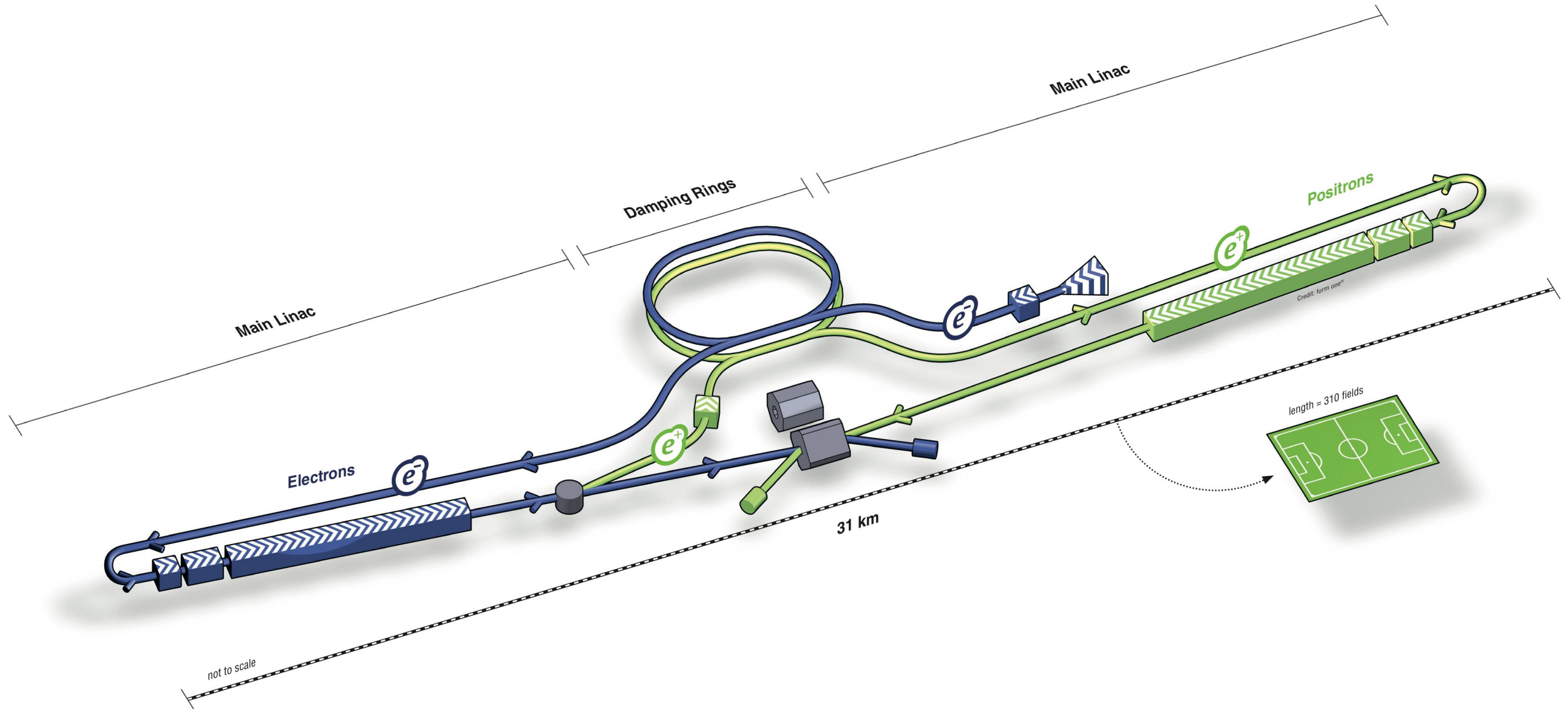


Real motivation

- ~~1- Mockup for a detector inner region with DEPFET silicon dummies~~
 - ~~- Cooling according to the baseline design~~
 - ~~- Geometry according to the baseline design~~
- ~~2- Microchannel cooling for DEPFET sensors~~
 - ~~- Thermal tests~~
 - ~~- Qualification process~~
 - ~~- Lessons learned (for a mechanical and non-mechanical engineer)~~
- 3- Take it as a motivational talk: from the thermo-mechanical point of view, DEPFET is a real possibility for the ILC
- 4- I want to give and receive input from the DEPFET community to know new issues that would affect to all of us
- 5- R&D is possible even from the thermomechanical point of view:
mcc!!



Introduction



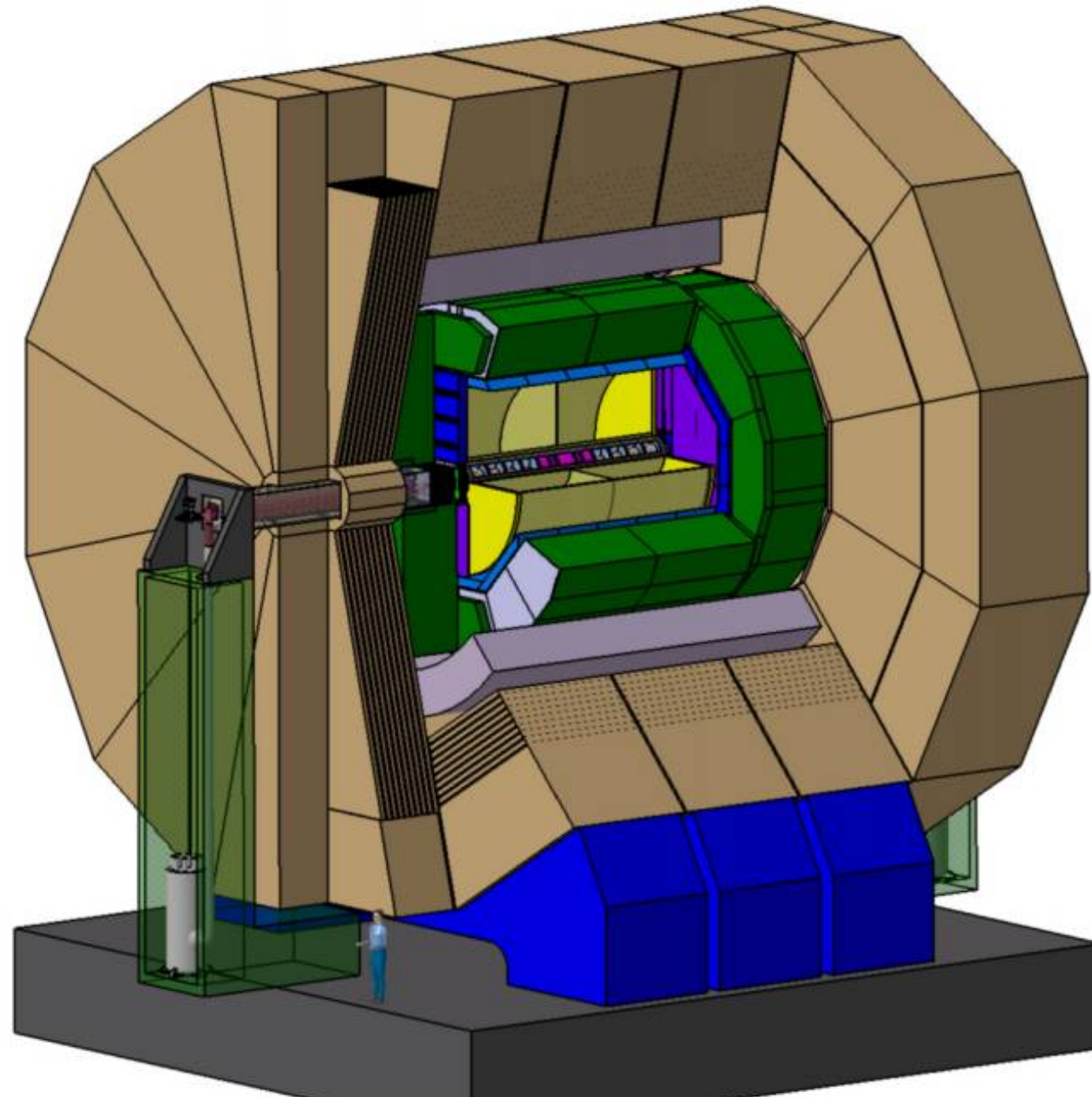
Linear $e^- e^+$ accelerator

Complement of the LHC at CERN

It will contribute to explore the physics beyond the Standard Model



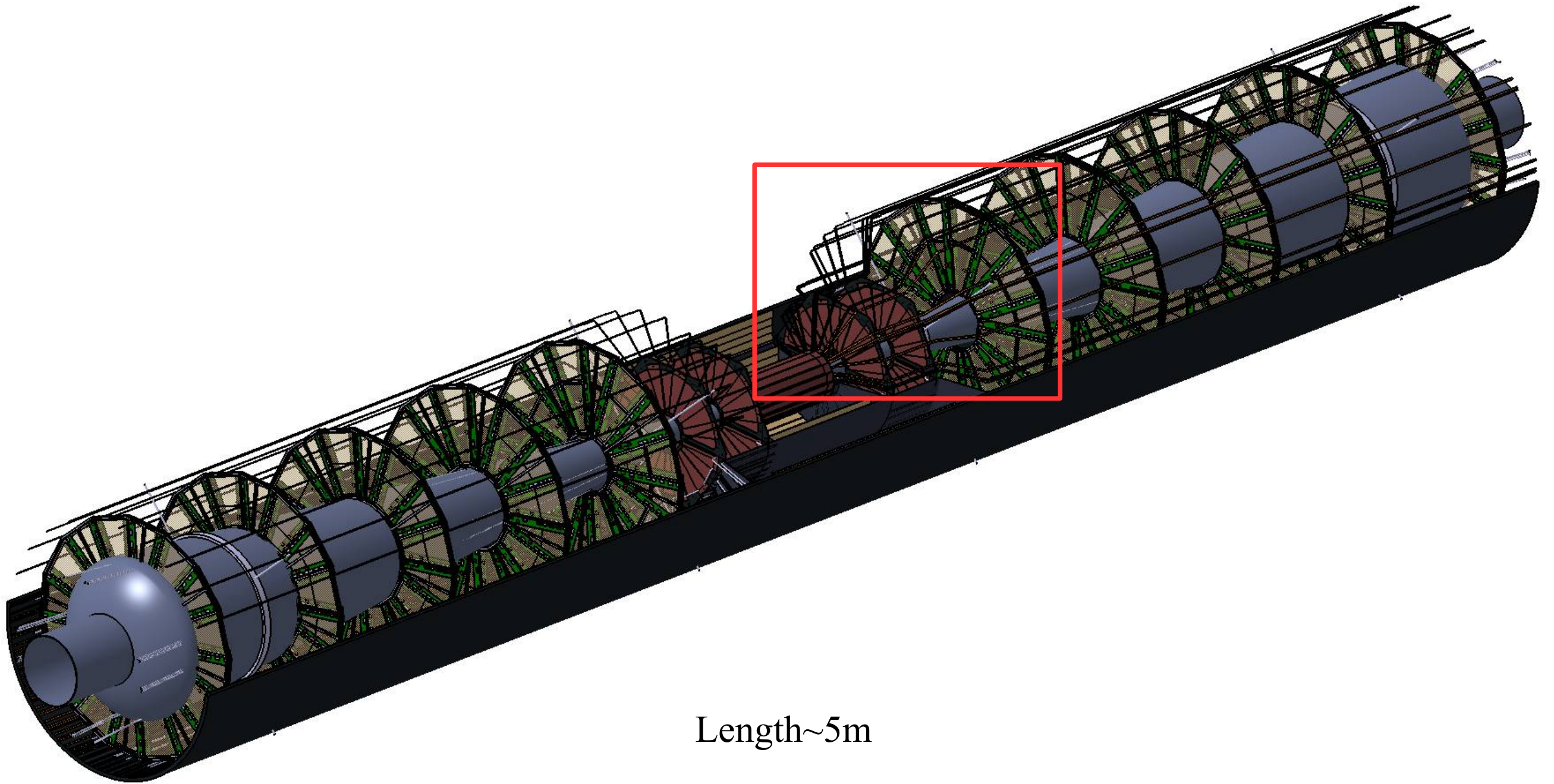
Introduction



The ILD detector systems have many layers surrounding the point where the beams collide

We will focus in the inner most region (the first layer)

Introduction

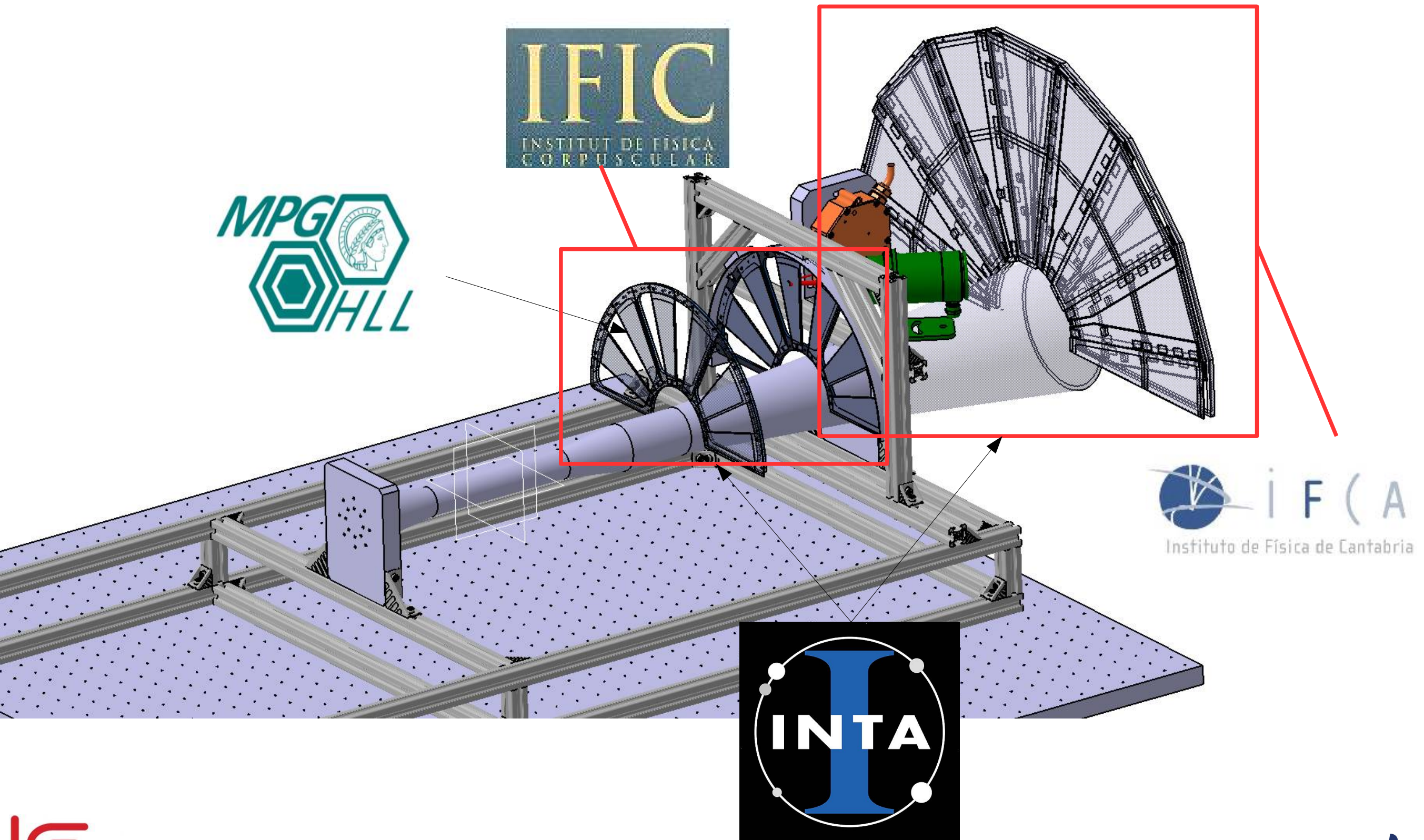


Length~5m

Diameter~0,64m

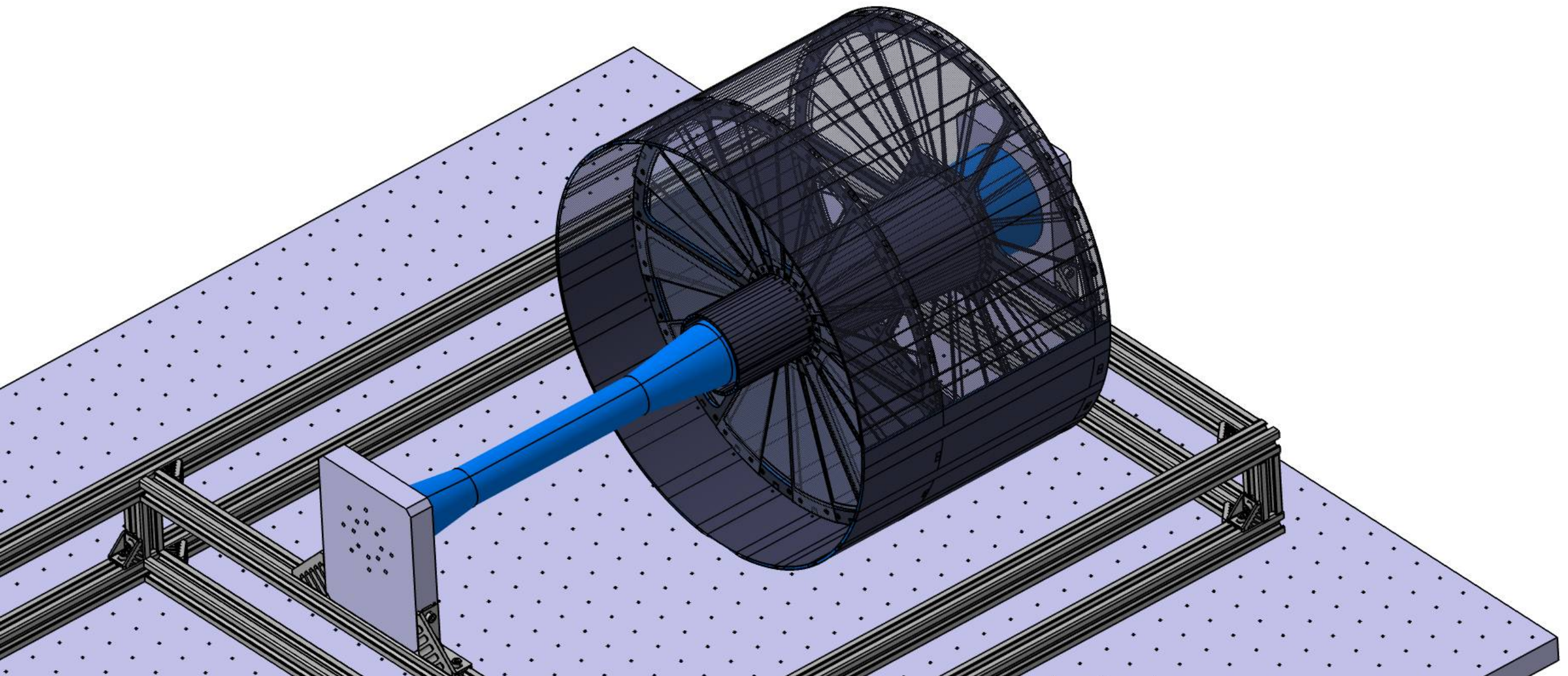
As light and rigid as possible

FTD Mock-up

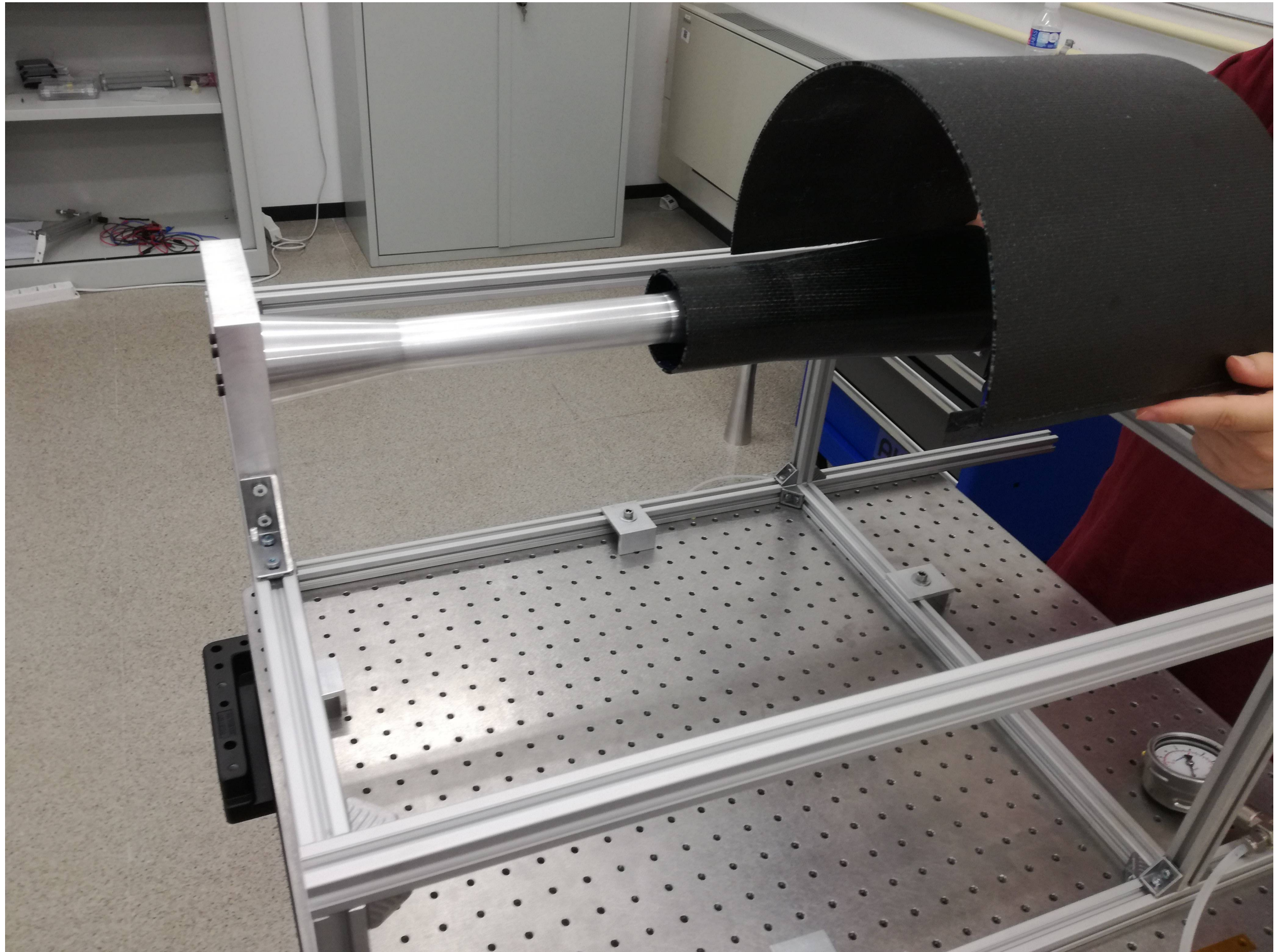


FTD Mock-up

- Objectives:
- Carbon fiber experience (materials, joints)
 - Integration studies
 - Services studies (cooling and cabling)
 - Thermal studies through air cooling (baseline)
 - Mechanical studies for future specs.
 - Good reasons for baseline changes



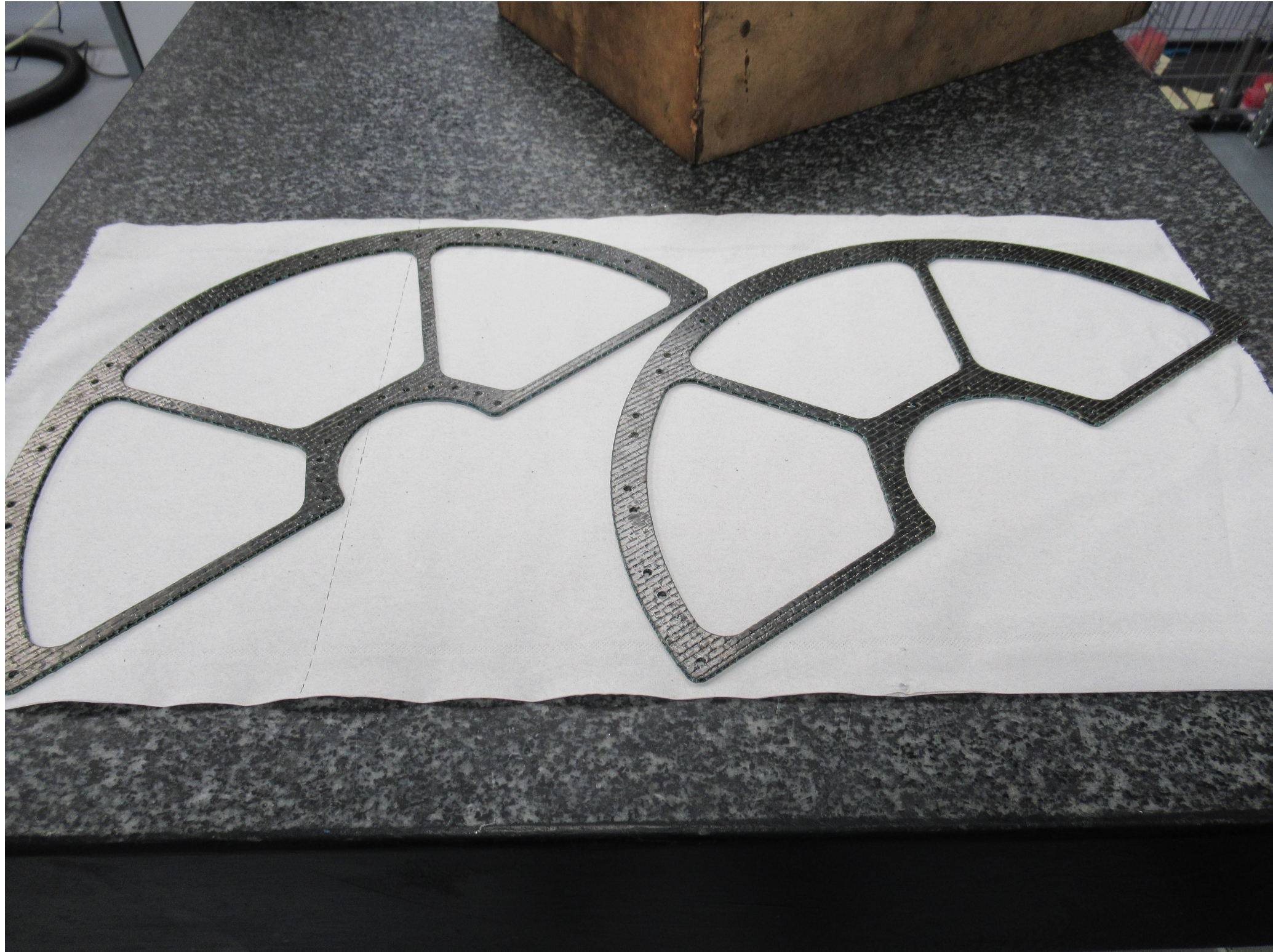
FTD Mock-up



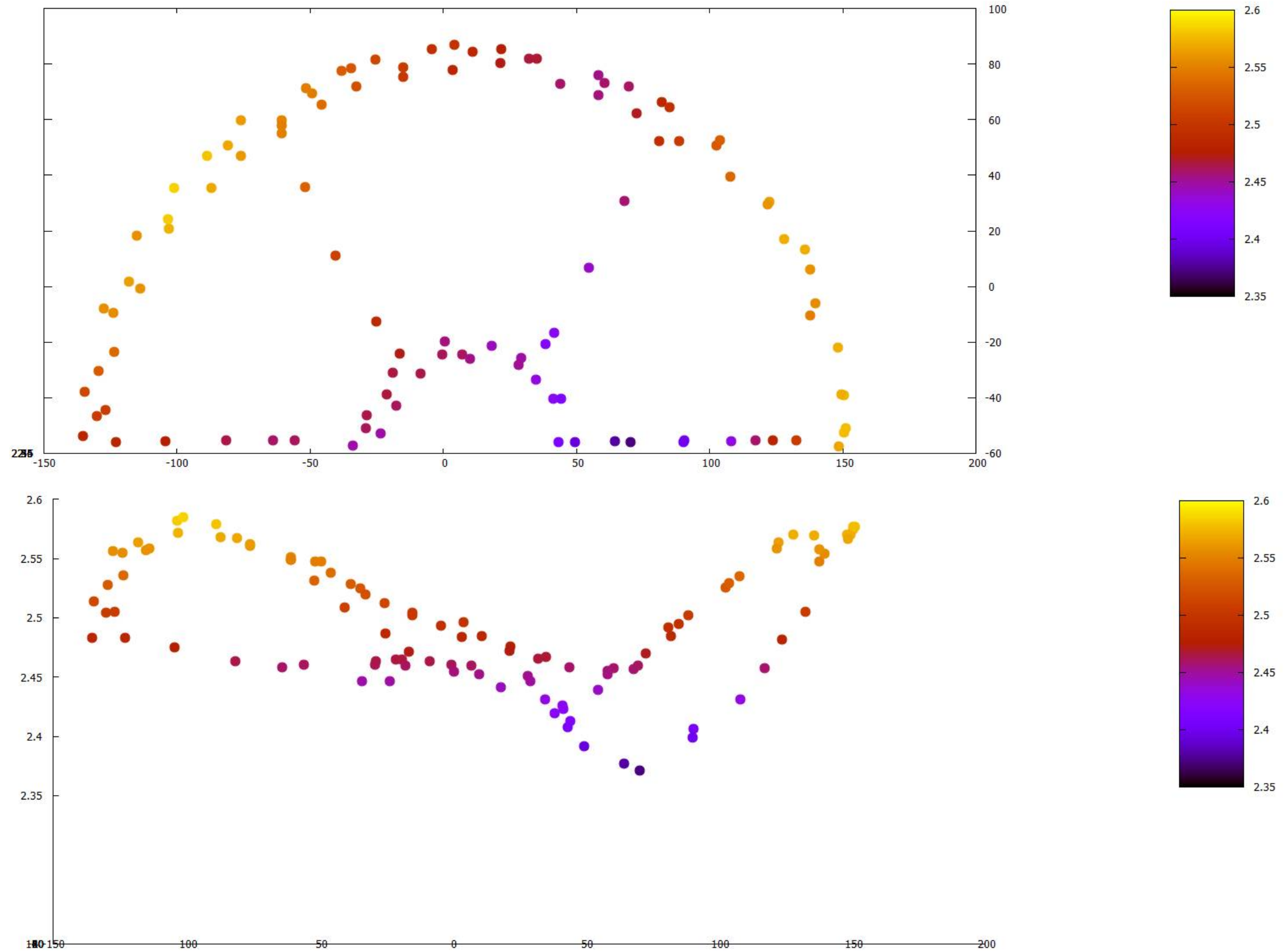
FTD Mock-up



FTD Mock-up



FTD Mock-up



Worst scenario possible: planarity of 150 μm

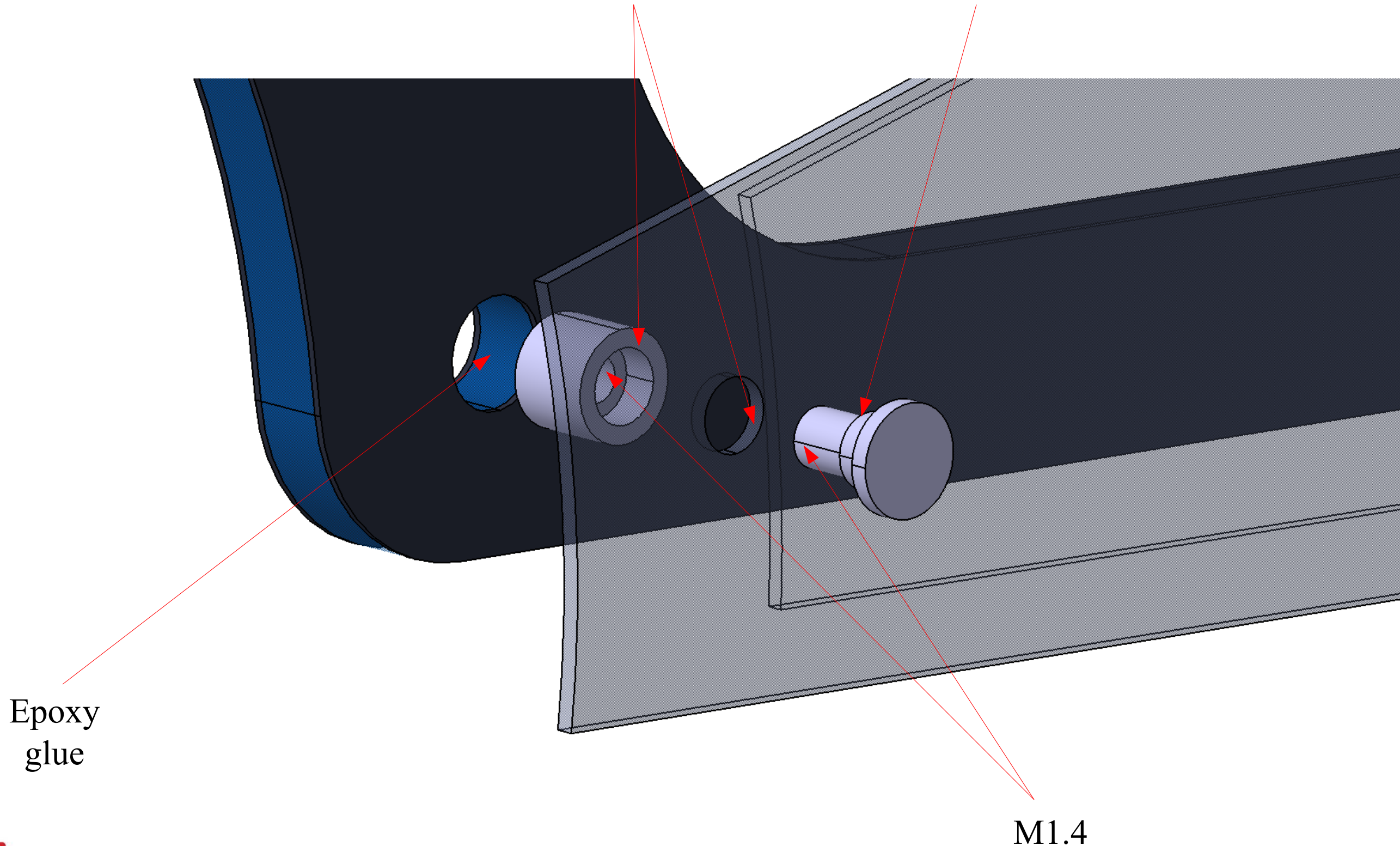


FTD Mock-up



FTD Mock-up

2H3 (2,000-2,002 mm) 2g3 (1,996-1,998 mm)

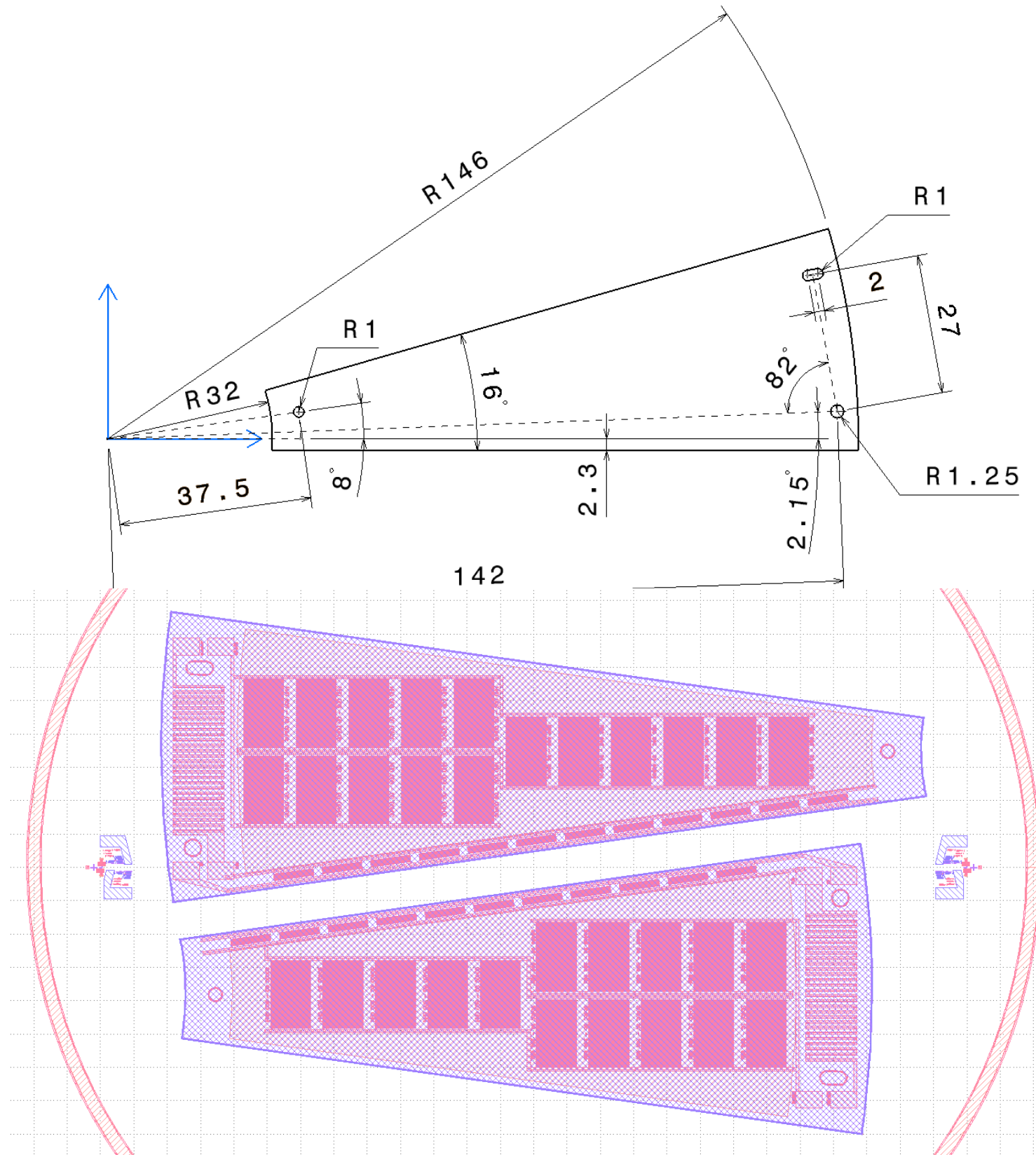


Epoxy
glue

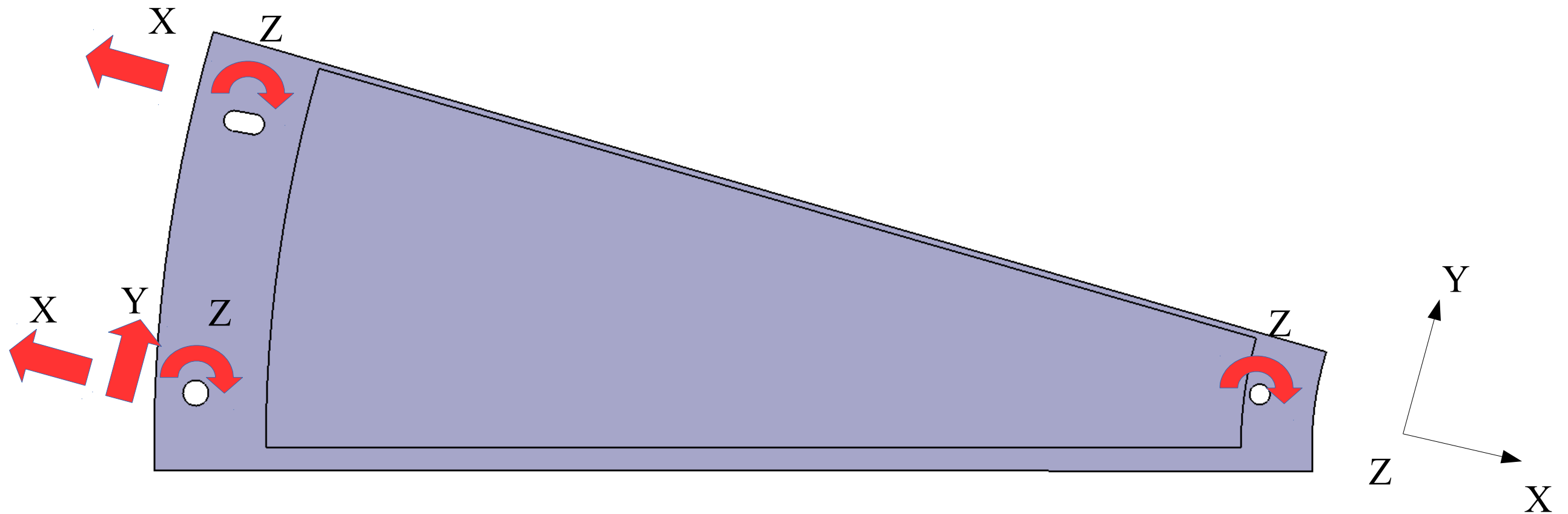
M1.4



FTD Mock-up

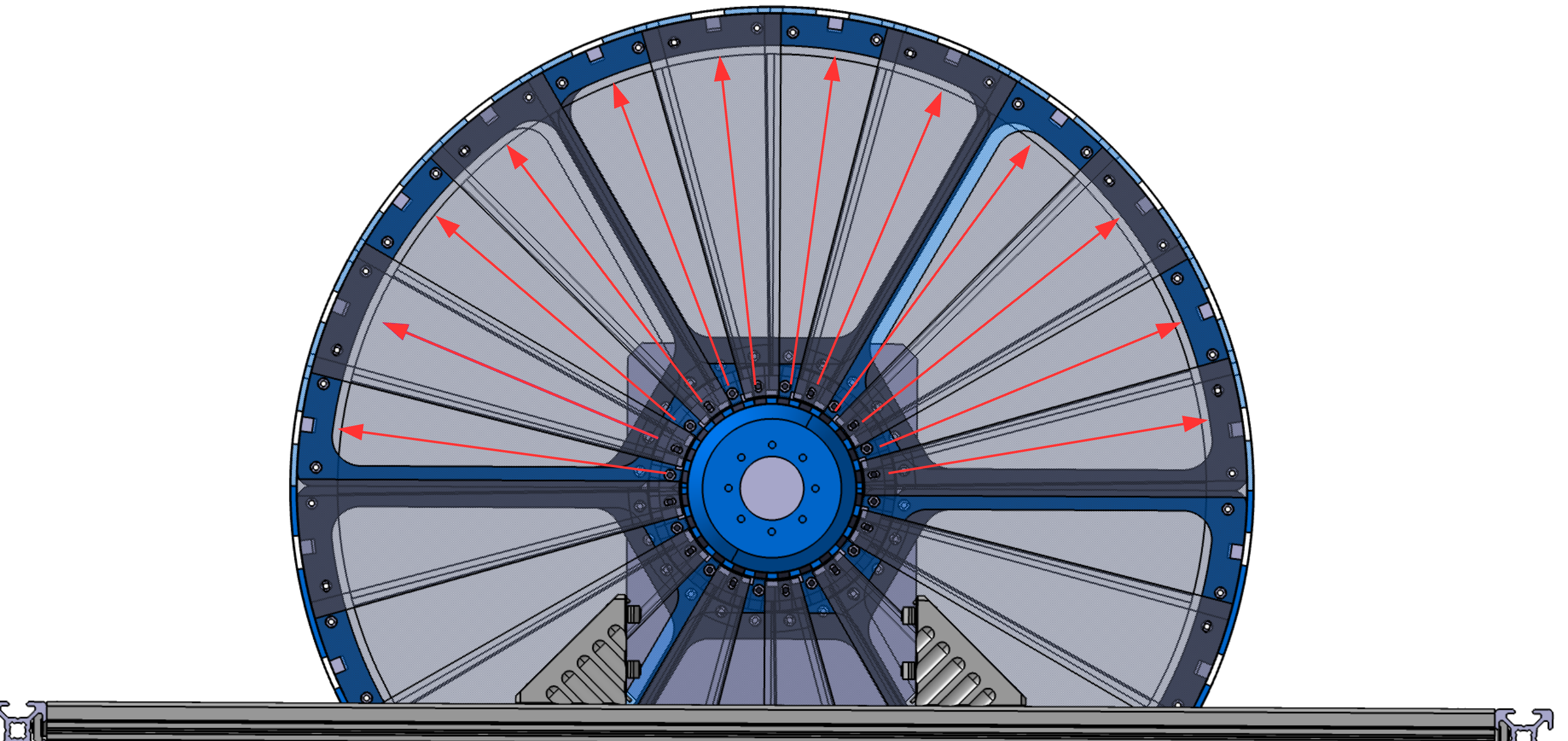


FTD Mock-up

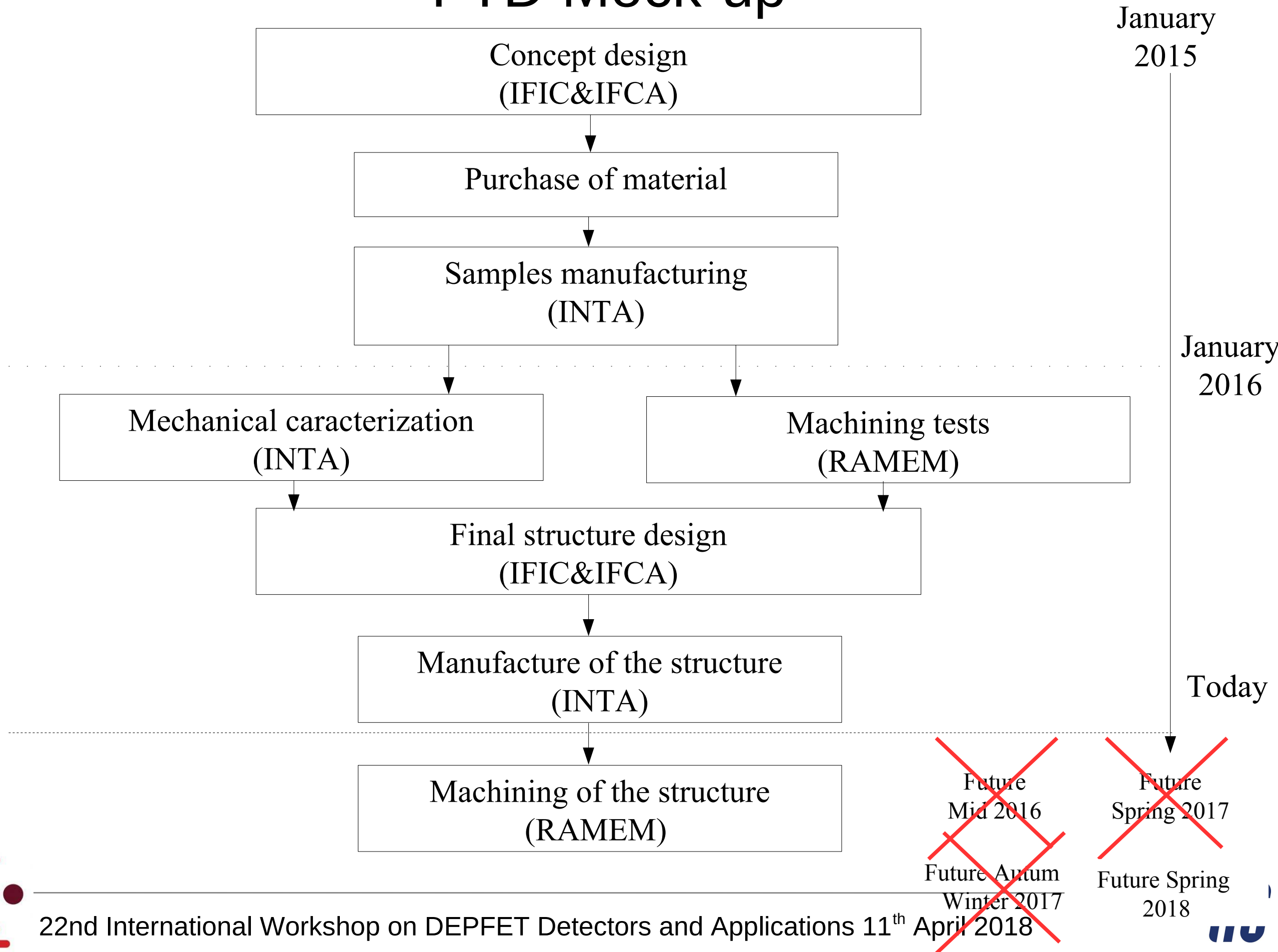


Kinematic joints!! :
- no thermal deformation out of plane (in principle)
- no deformation out of plane due to the structure deformation, just a position change

FTD Mock-up



FTD Mock-up



January
2015

January
2016

Today

~~Future
Mid 2016~~

~~Future
Spring 2017~~

~~Future Autumn
Winter 2017~~

~~Future Spring
2018~~

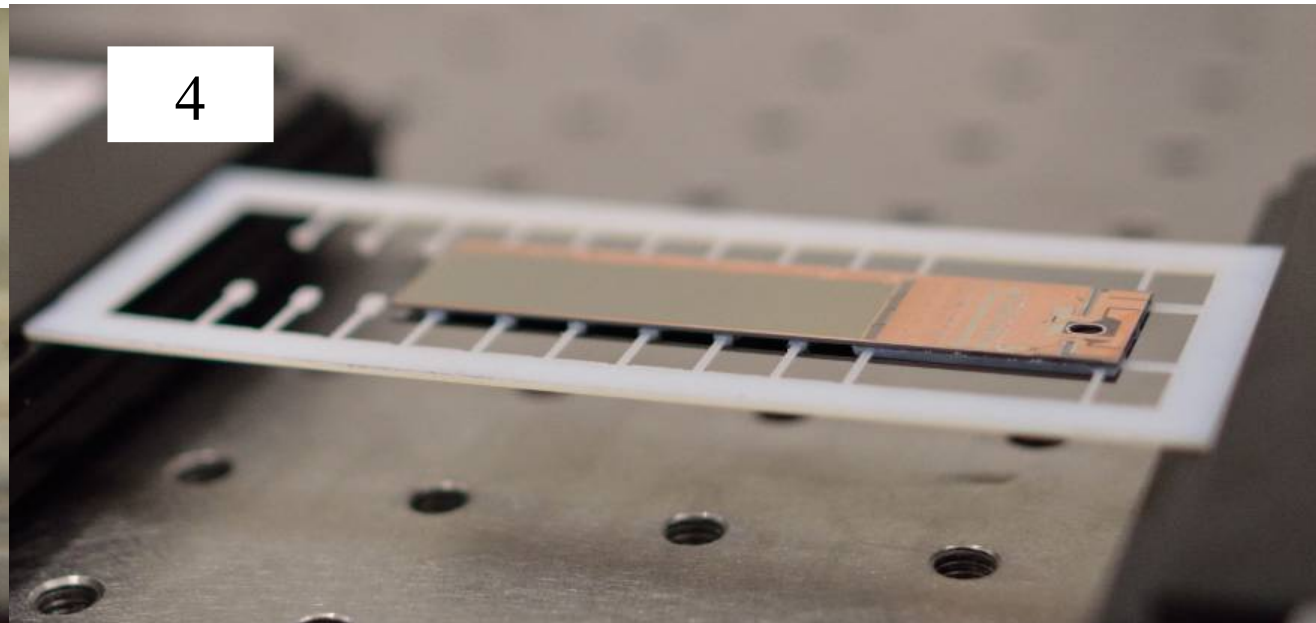
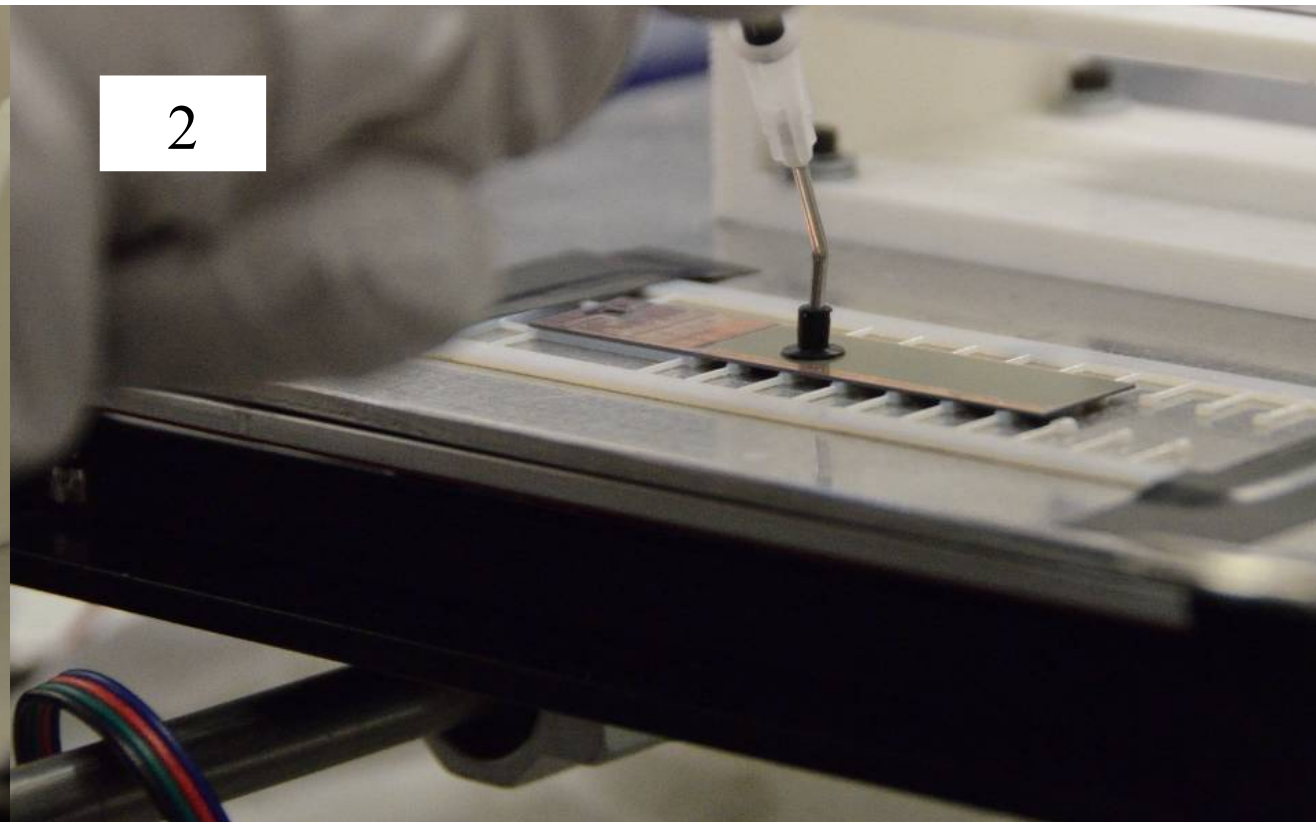
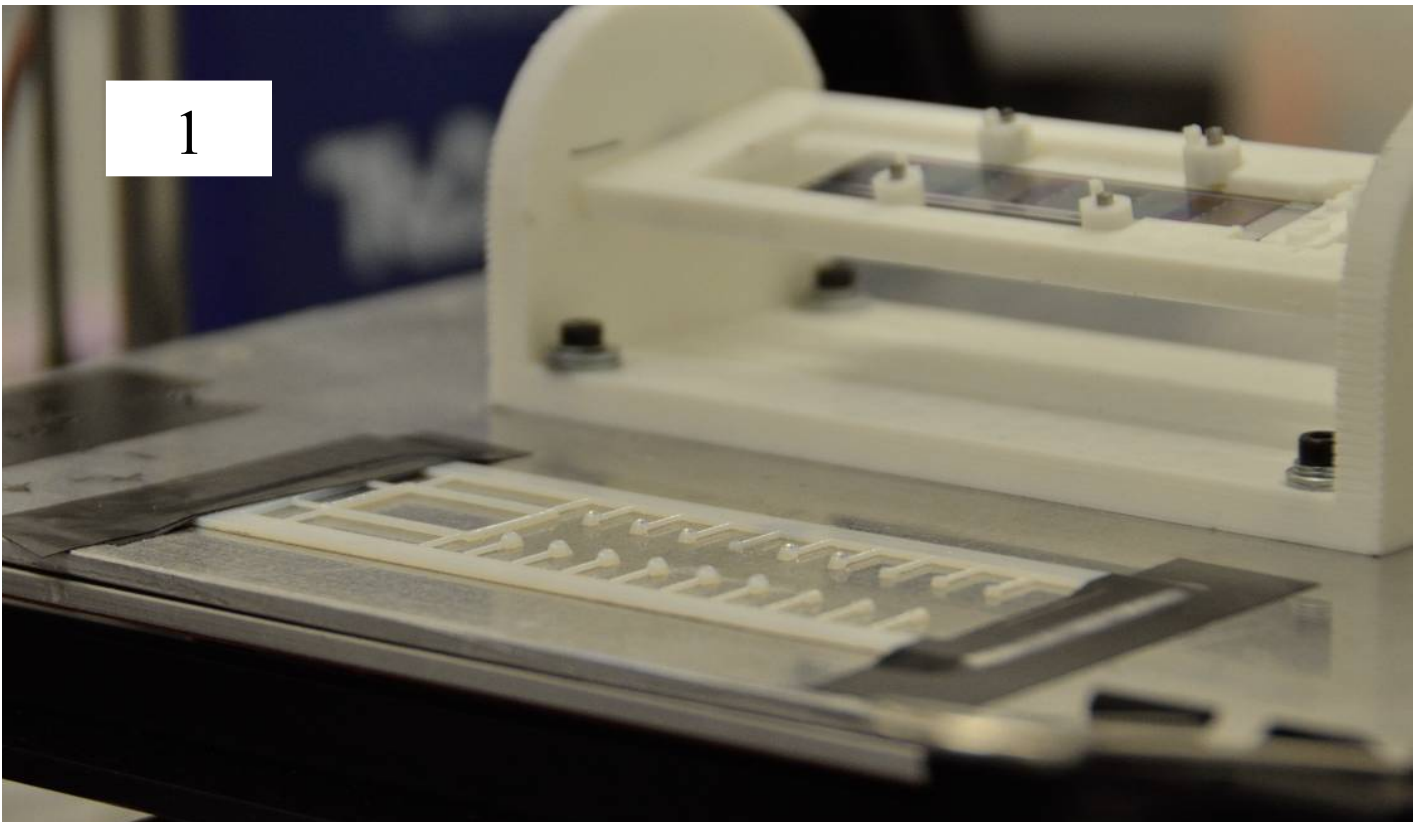


Mock-up summary

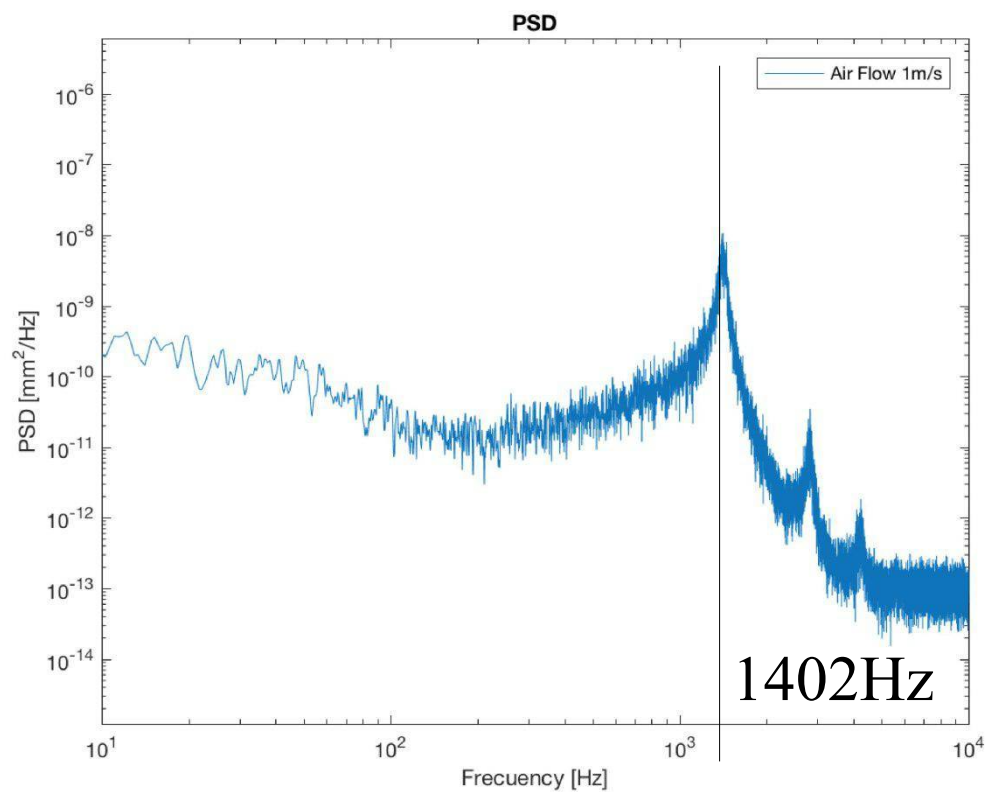
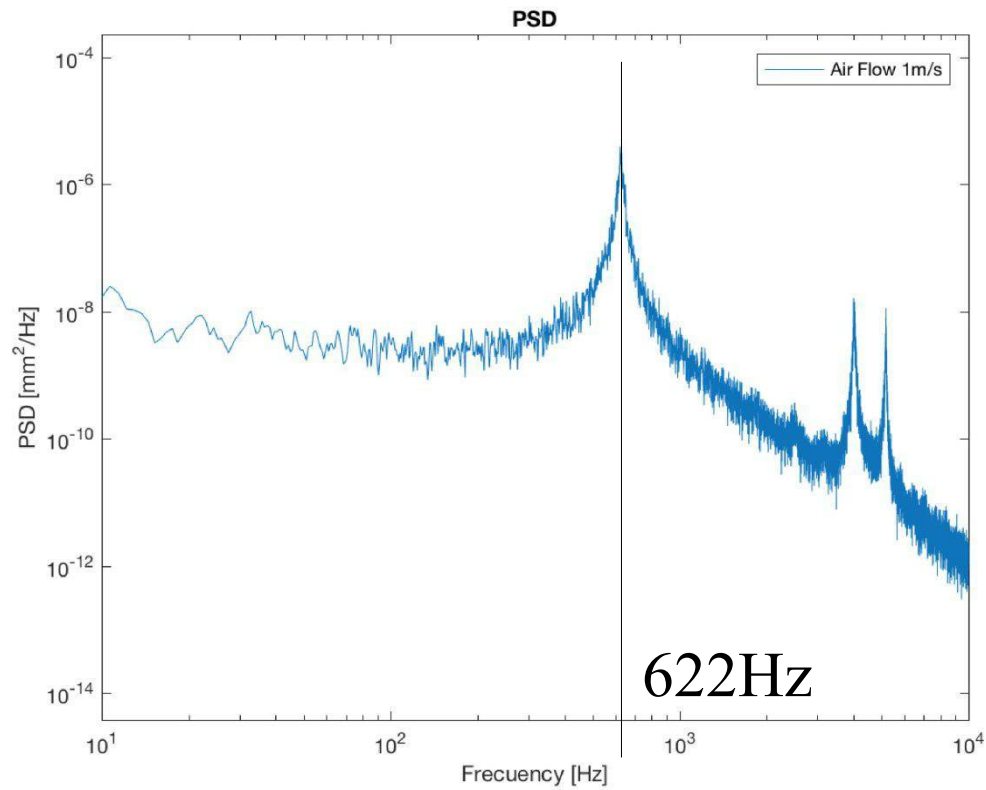
- Objectives:
- Carbon fiber experience (materials, joints)
 - Integration studies
 - Services studies (cooling and cabling)
 - Thermal studies through air cooling (baseline)
 - Mechanical studies for future specs.
 - Good reasons for baseline changes
-
- Even without test results, some of the objectives have been achieved
 - Aircooling for a single petal demonstrated in previous mockup, we expect the same good results for a mockup with 2 complete disks
 - Optimistic feedback for DEPFET layout silicon dummies: possible solution for the ILC from the thermomechanical point of view
 - Near to zero mechanical-purpose-material in the active DEPFET region



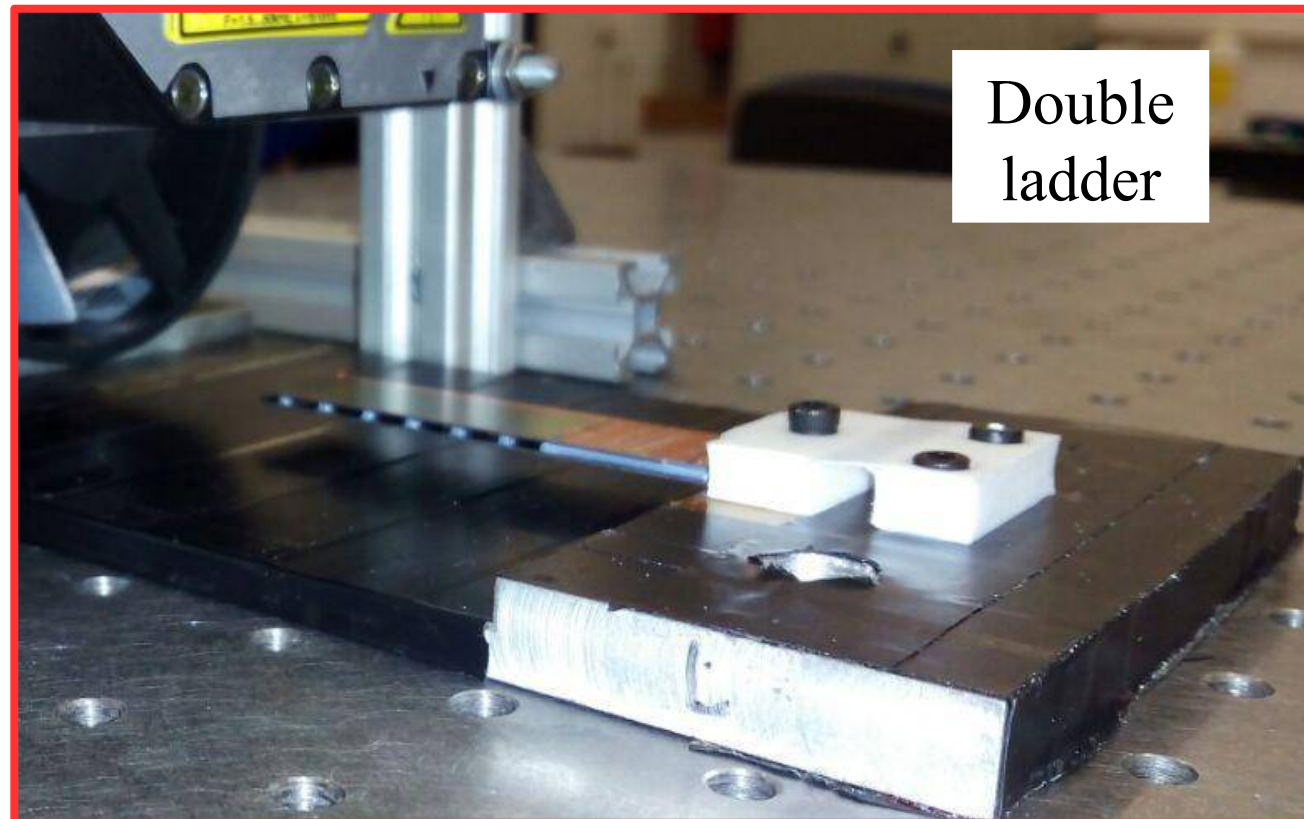
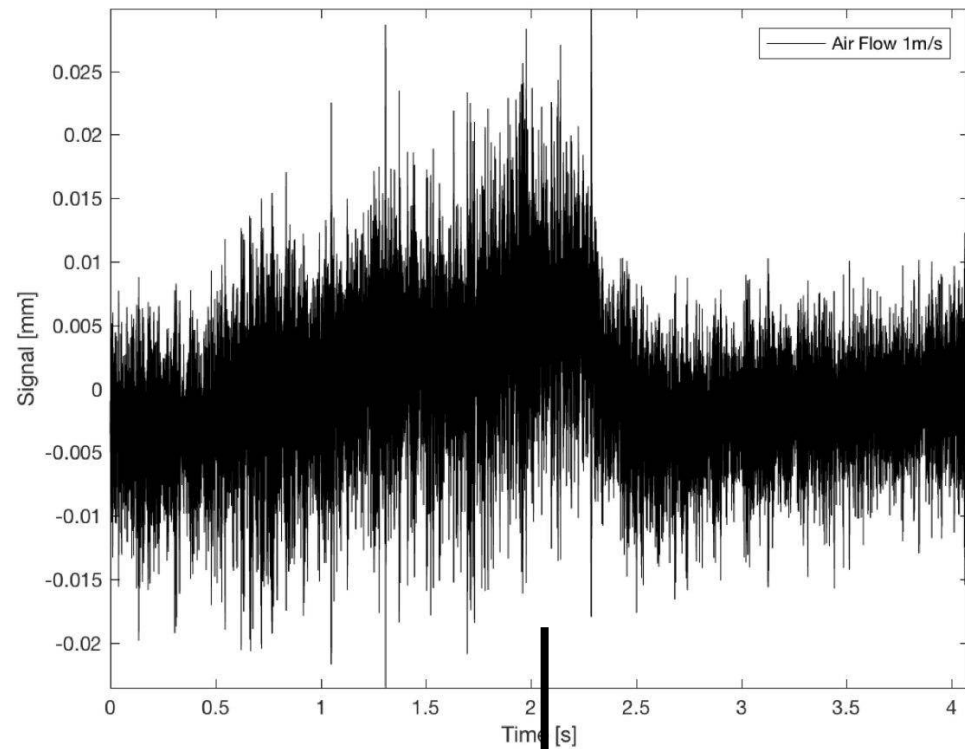
Mock-up: bonustrack



Mock-up: bonustrack



Mock-up: bonustrack



$v=1\text{m/s}$	Peak2Peak	RMS
Single ladder	68 μm	7,2 μm
Double ladder	8,1 μm	2,2 μm

**3D printed spacer:
0,01% X/X_0 per ladder**



**0,01% X/X_0
are 9 μm of Si
aprox.**

Mock-up summary bonustrack

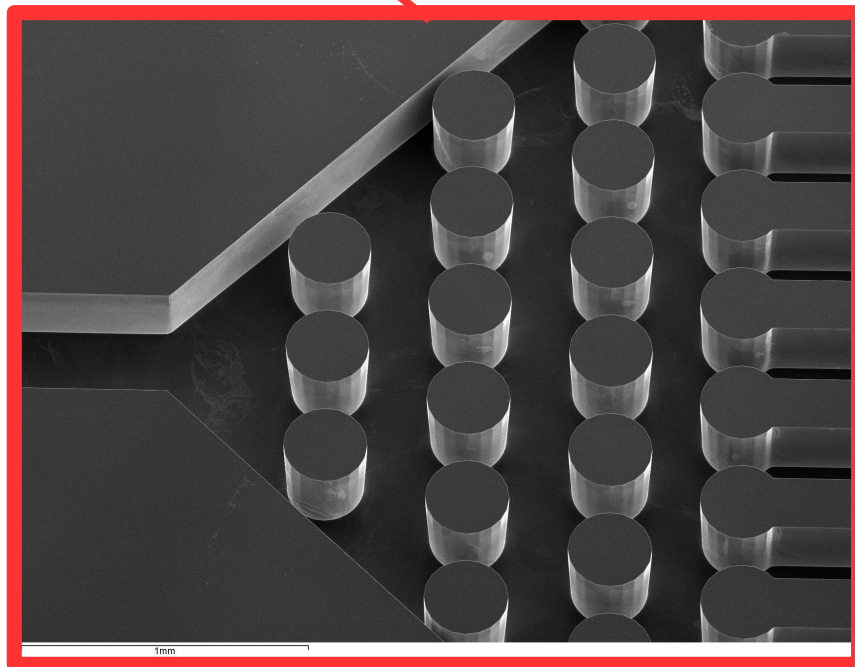
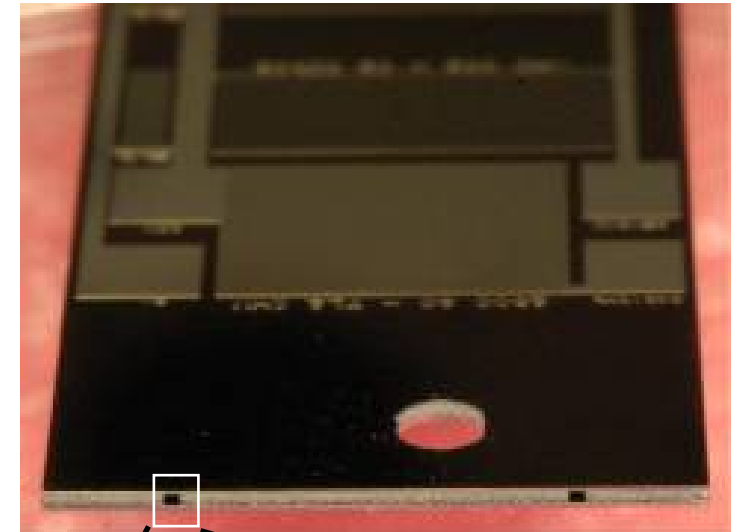
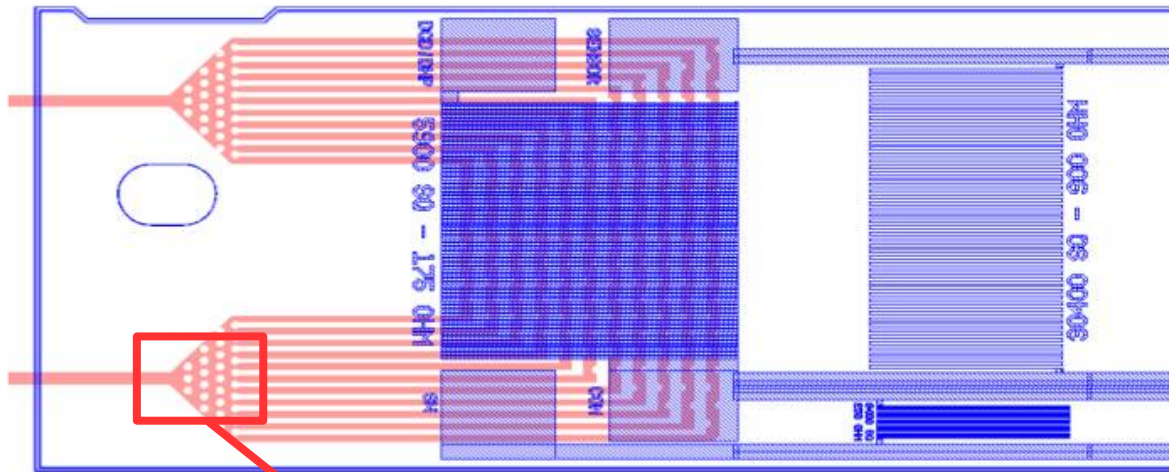
- Objectives:
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- Optimistic feedback for DEPFET layout silicon dummies: possible solution for the ILC from the thermomechanical point of view
- Near to zero mechanical-purpose-material in the active DEPFET region
- **With low addition of material budget, with double ladder but greater stiffness properties**

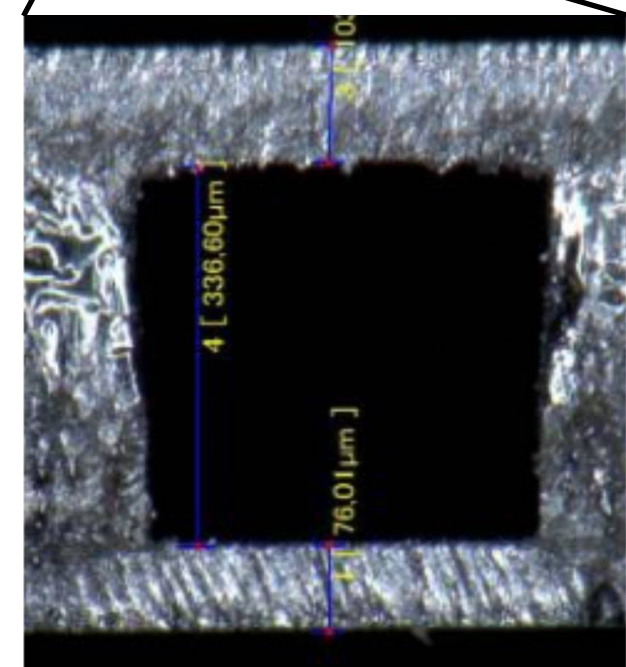


Introduction

The resistive dummies with integrated micro-channels based in DEPFET layout design:

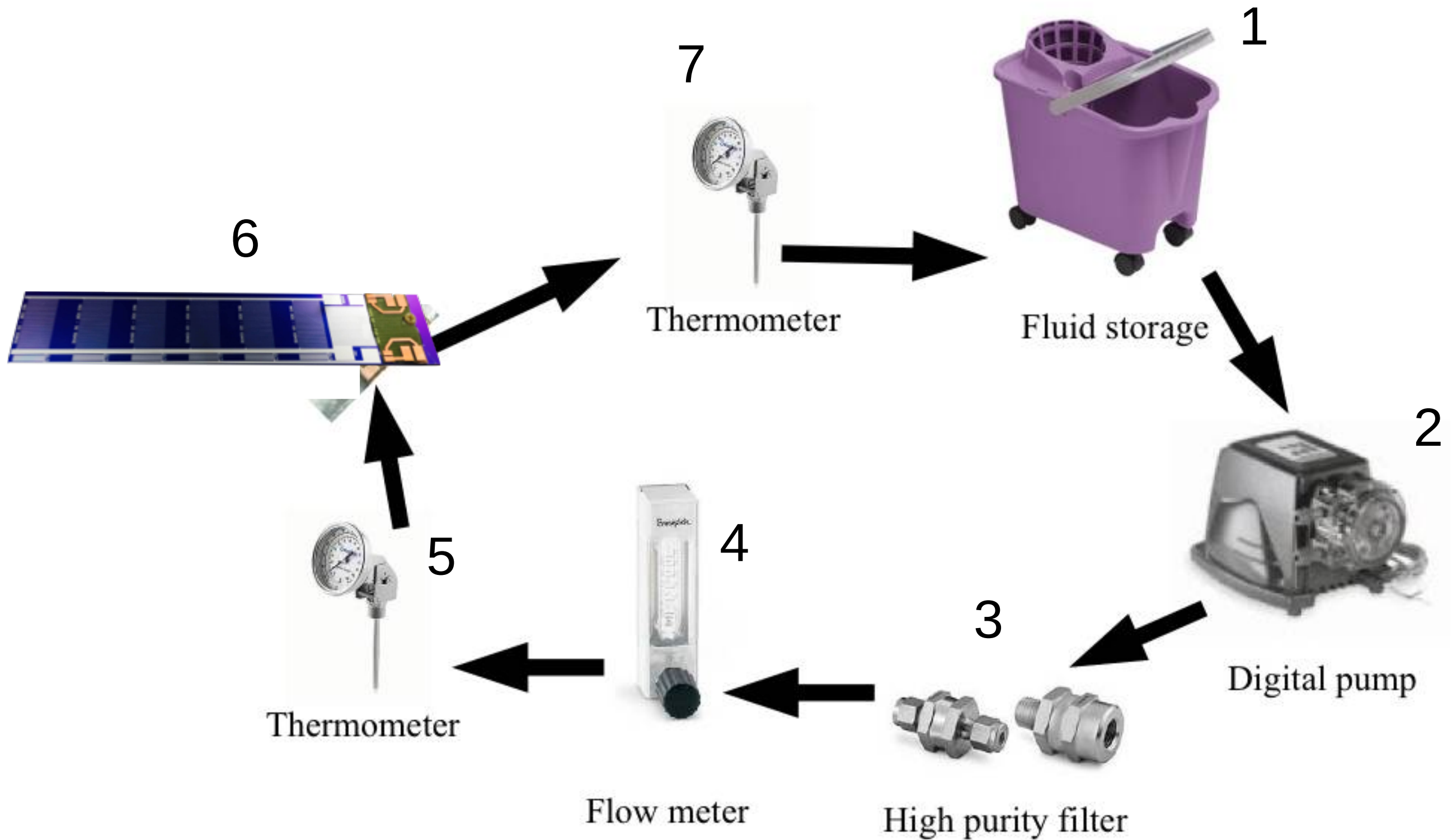


Micro-channel pattern in handle wafer

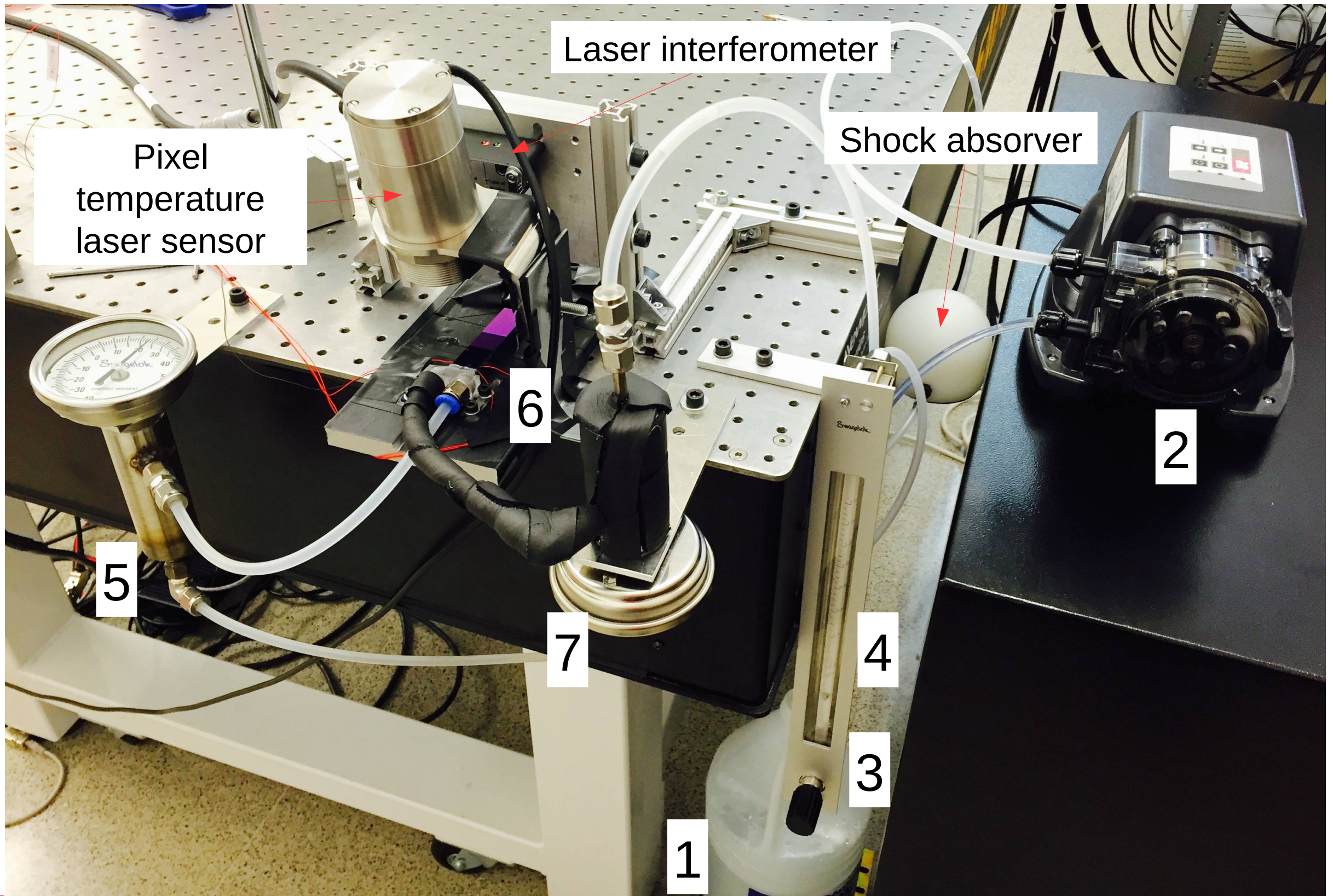


Inlet and outlet: ~380 x 340 μm

Introduction

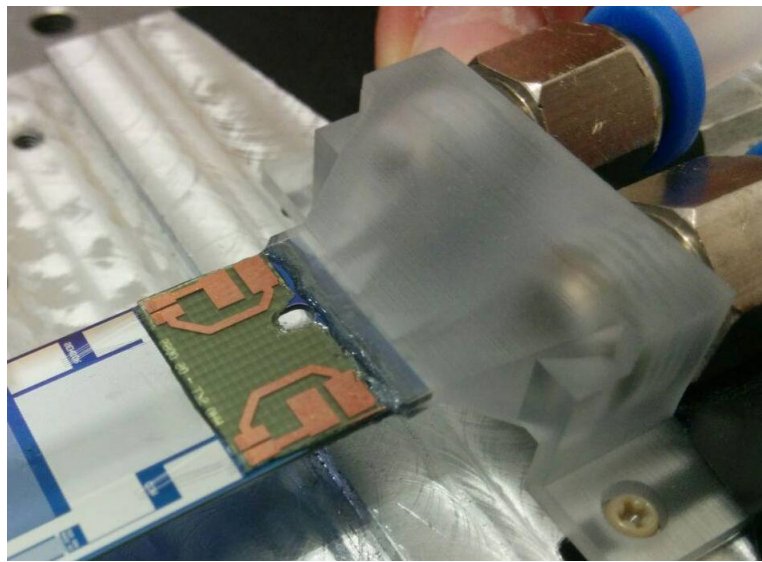
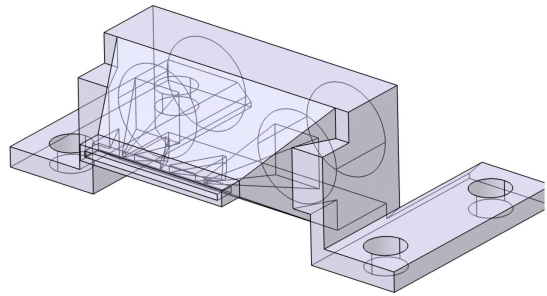


Introduction

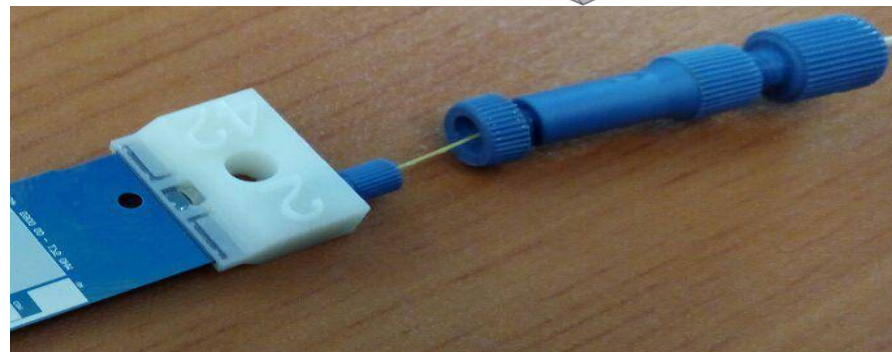
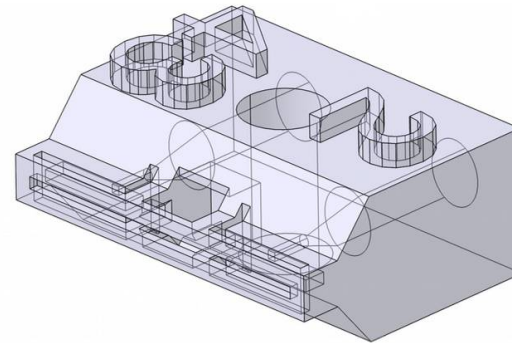


MCC: material budget fitting

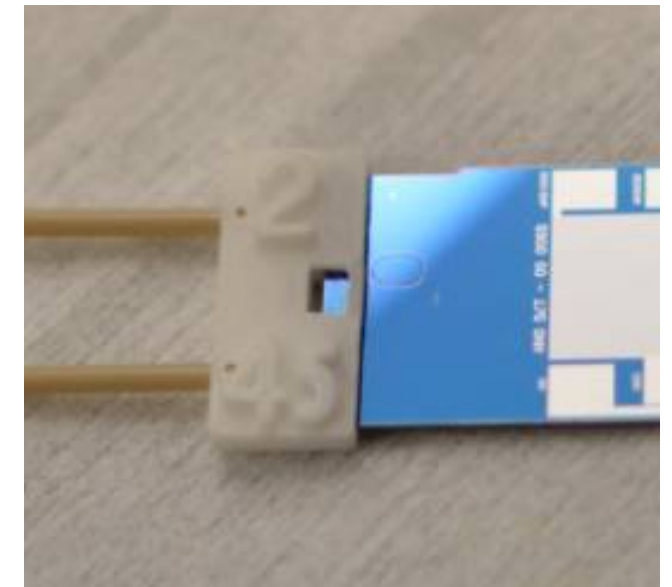
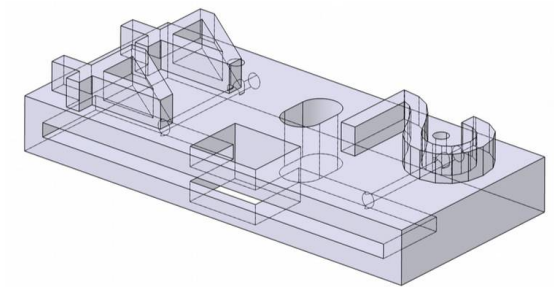
Past (A long time ago,...)
(0.81% X/X₀)



Past (A not so long time ago)
(0.2% X/X₀)



Present
(0.05% X/X₀)

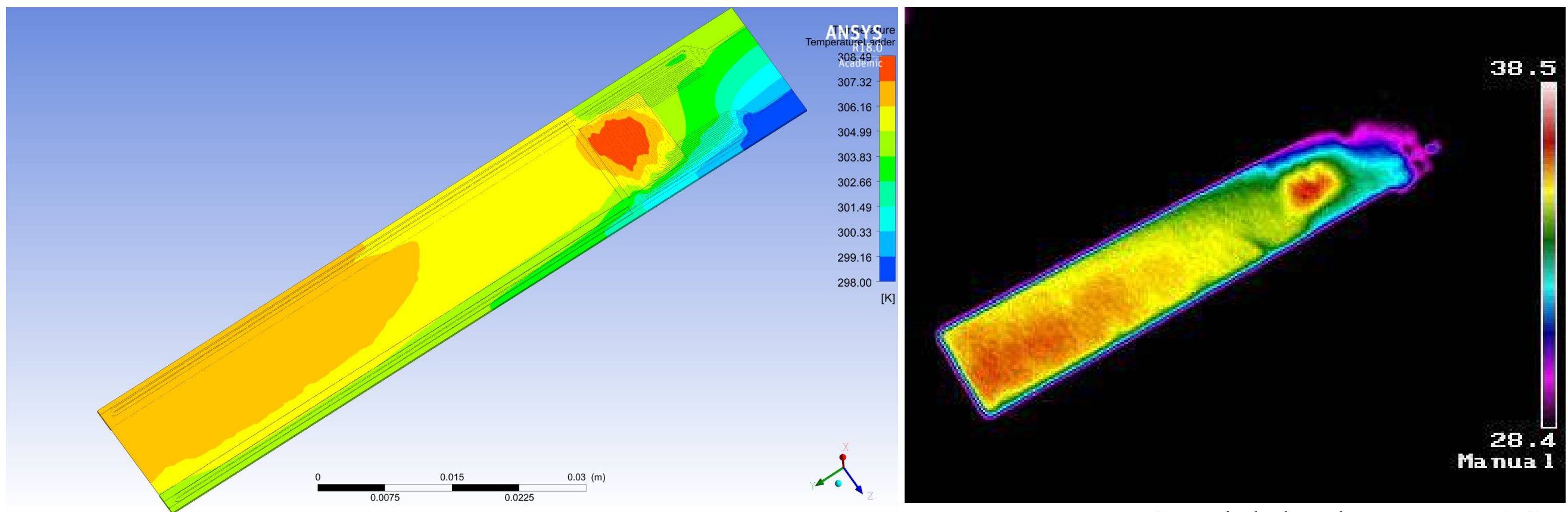
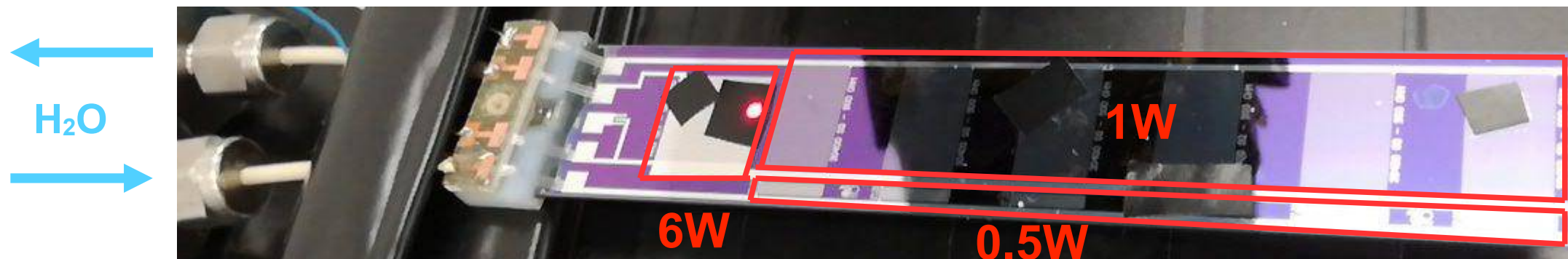


- First successful attempt
- Huge amount of material used: connector and metal fittings
- Mechanical fitting
- Non high performance glue

- Low amount of material used: connector and peek fittings
- Mechanical fitting
- High performance glue Araldite 2020 → low viscosity → clogging

- Low amount of material used: connector and peek fittings
- Chemical fitting
- High performance glue Araldite 2011 → high viscosity → no clogging

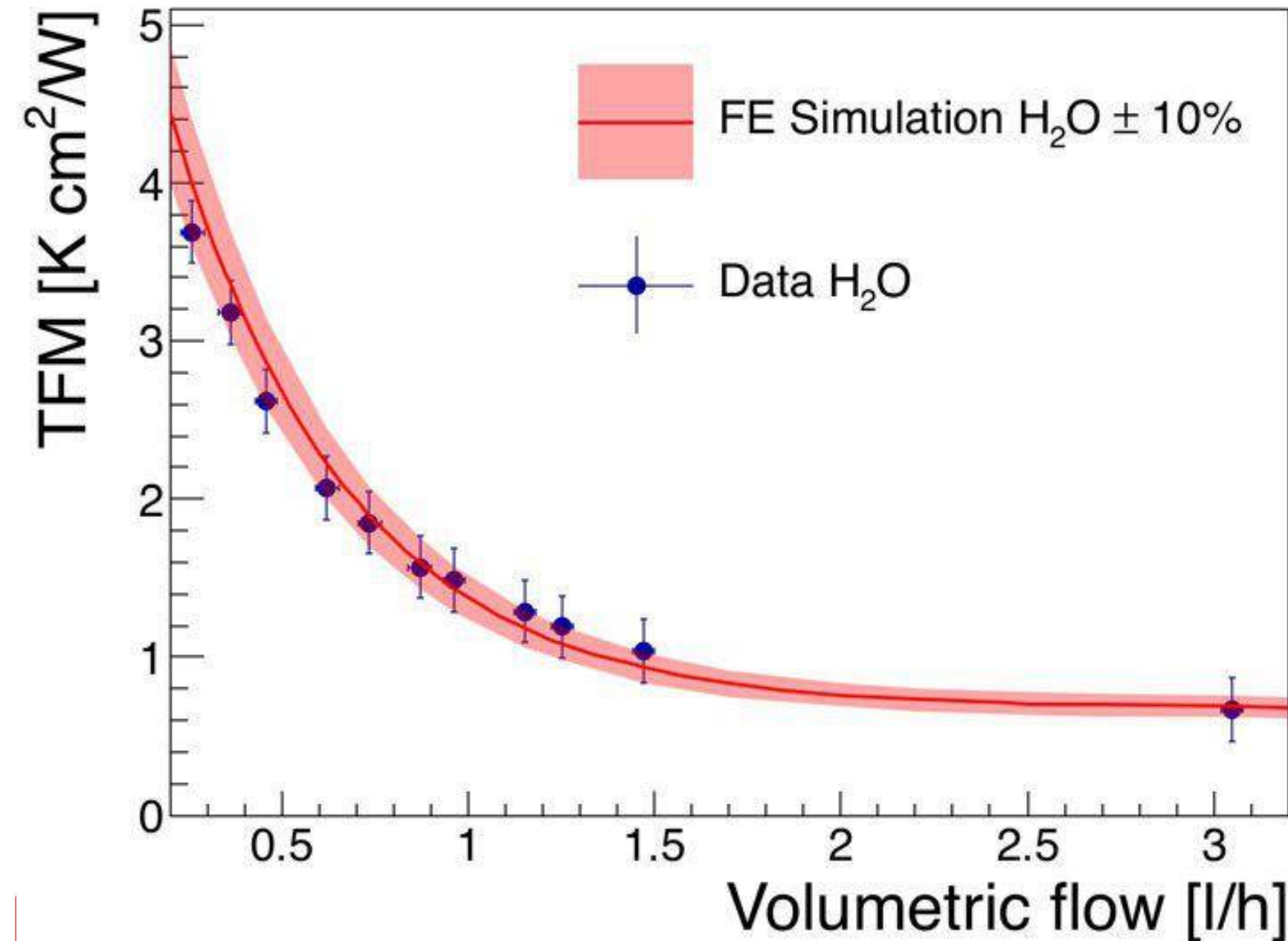
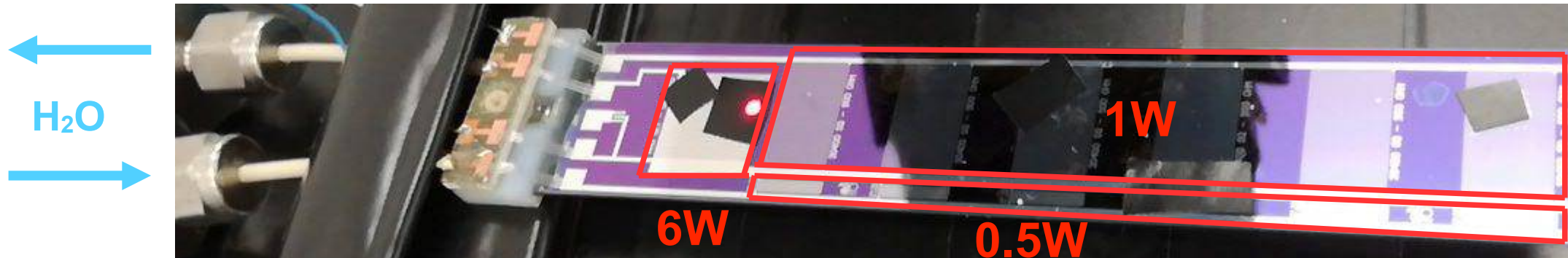
MCC: thermal power dissipation



Special thanks to ATLAS group

- Inlet in the simulation is the outlet in the test
- Thermal camera inside black box
- Simulation $\Delta T=10,5K$ and test $\Delta T=10,1K$

MCC optimization: new channels layout



Test accuracy:

- Vol. Flow: +/- 0.04 l/h
- Temperature: +/- 1K
- Power: +/- 1% W

Simulation accuracy:

- No radiation
- Infrarated HTC
- Positioning of the measuring point

Mcc dummy cooled non-stop for 2 days with no leaks and no clogging

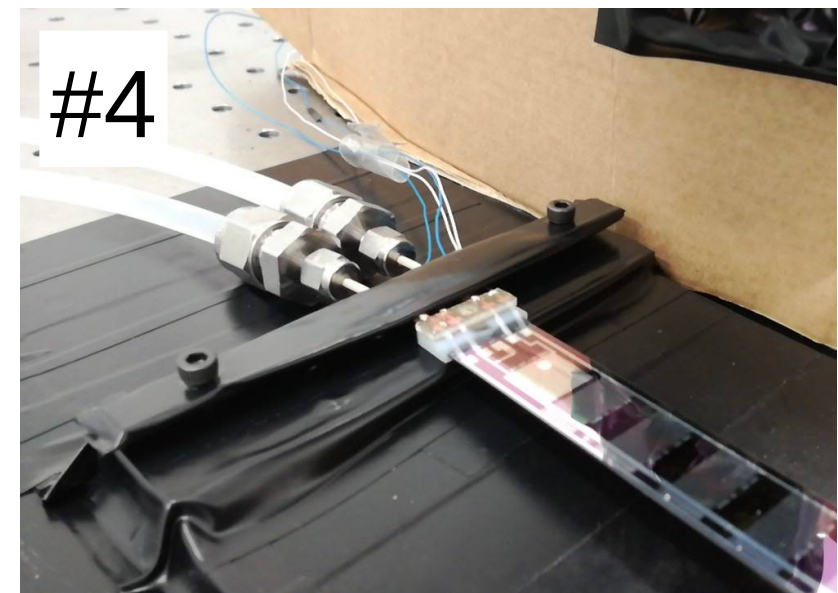
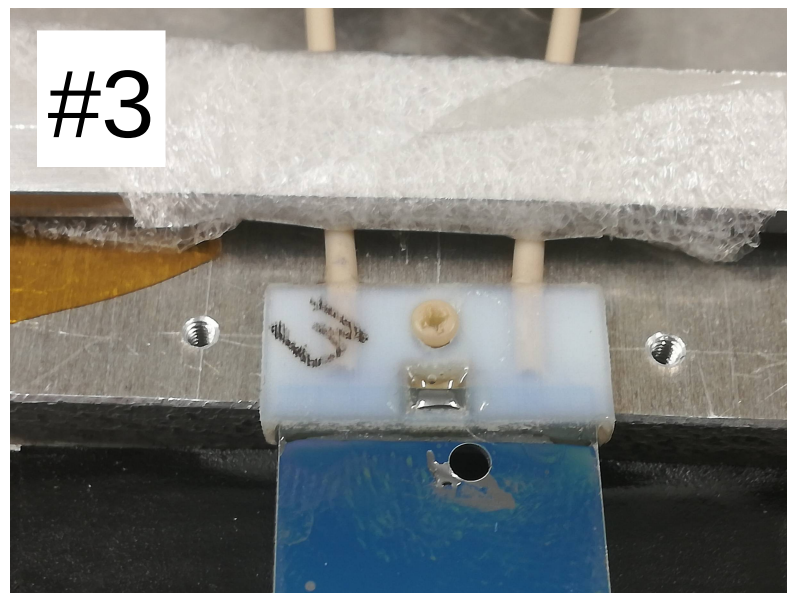
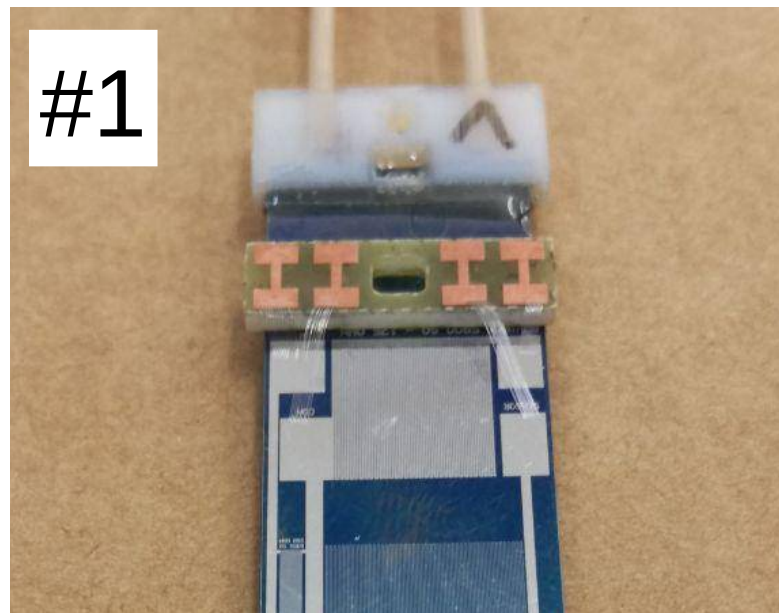
Good agreement with FE simulation within 10% error

In low Vol. Flow, tests are very sensitive to the Vol. Flow error

In high Vol. Flow, test are very sensirive to the Temp. error

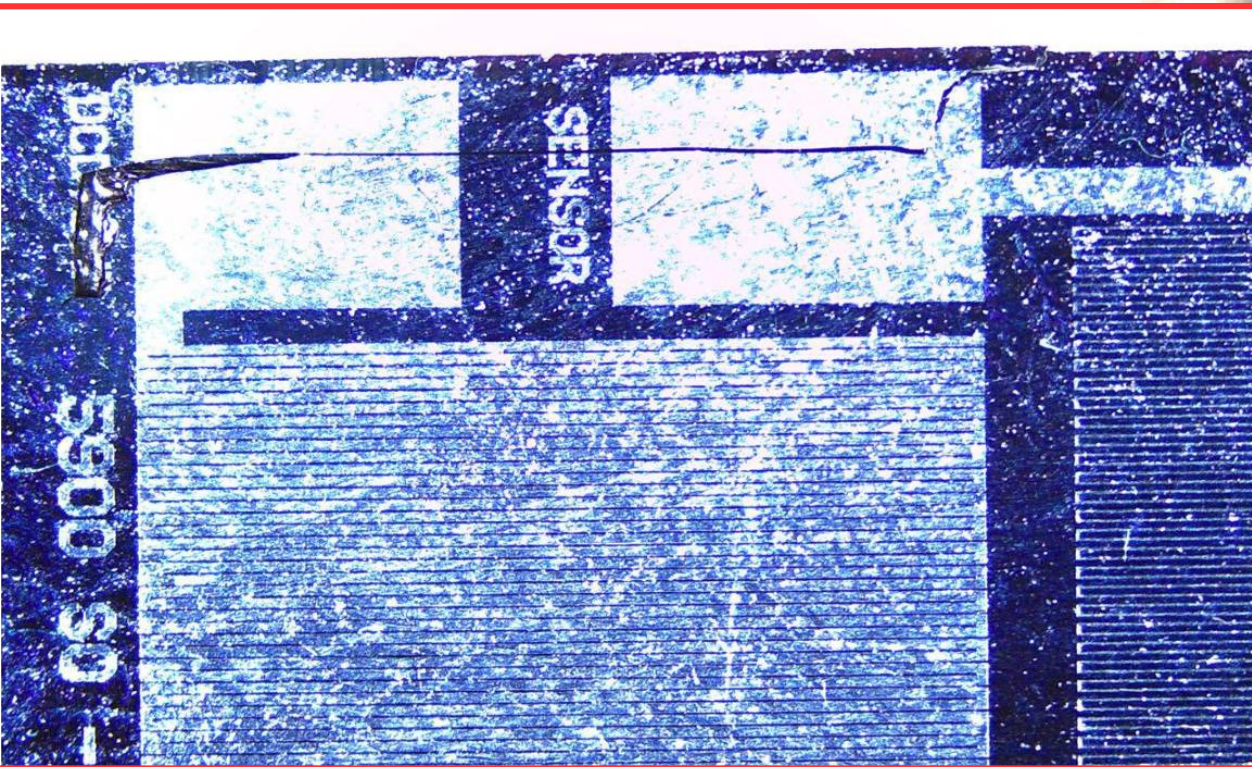
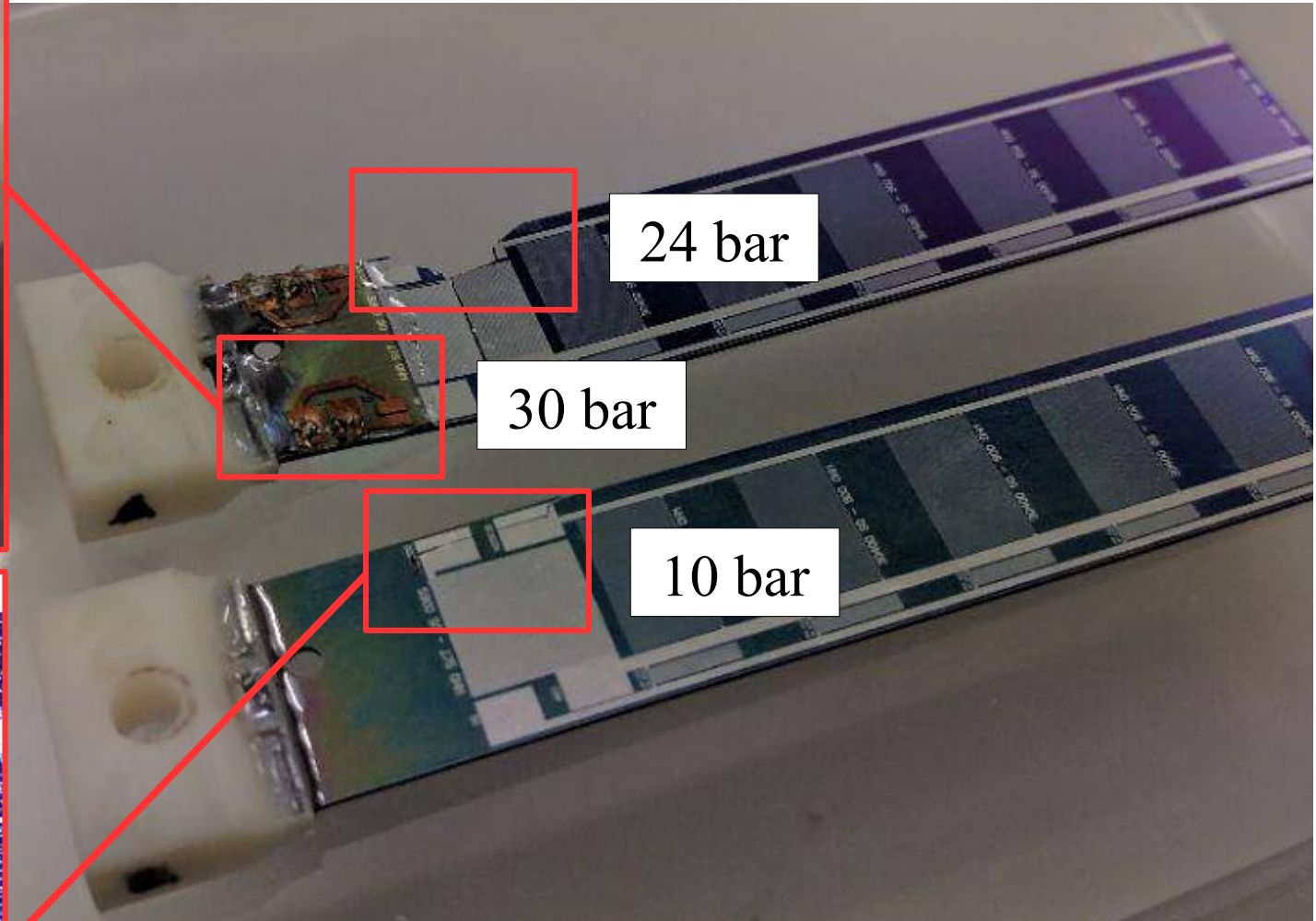
MCC qualification: Vacuum test

Sample number	#1	#2	#3	#4
Vacuum test [mbar l/h]	$5,5e^{-9}$	$9,0e^{-9}$	$8,6e^{-9}$	$6,1e^{-9}$



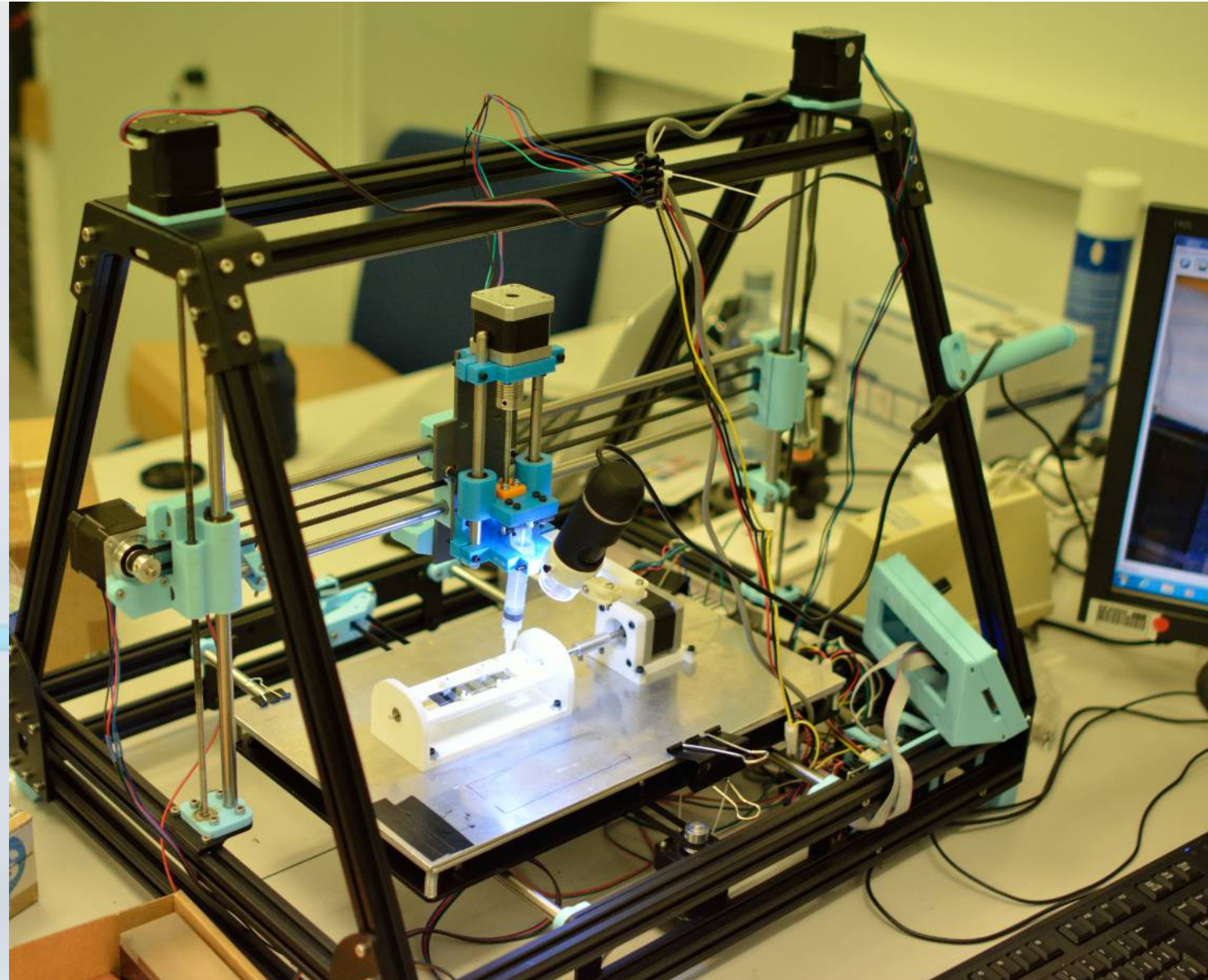
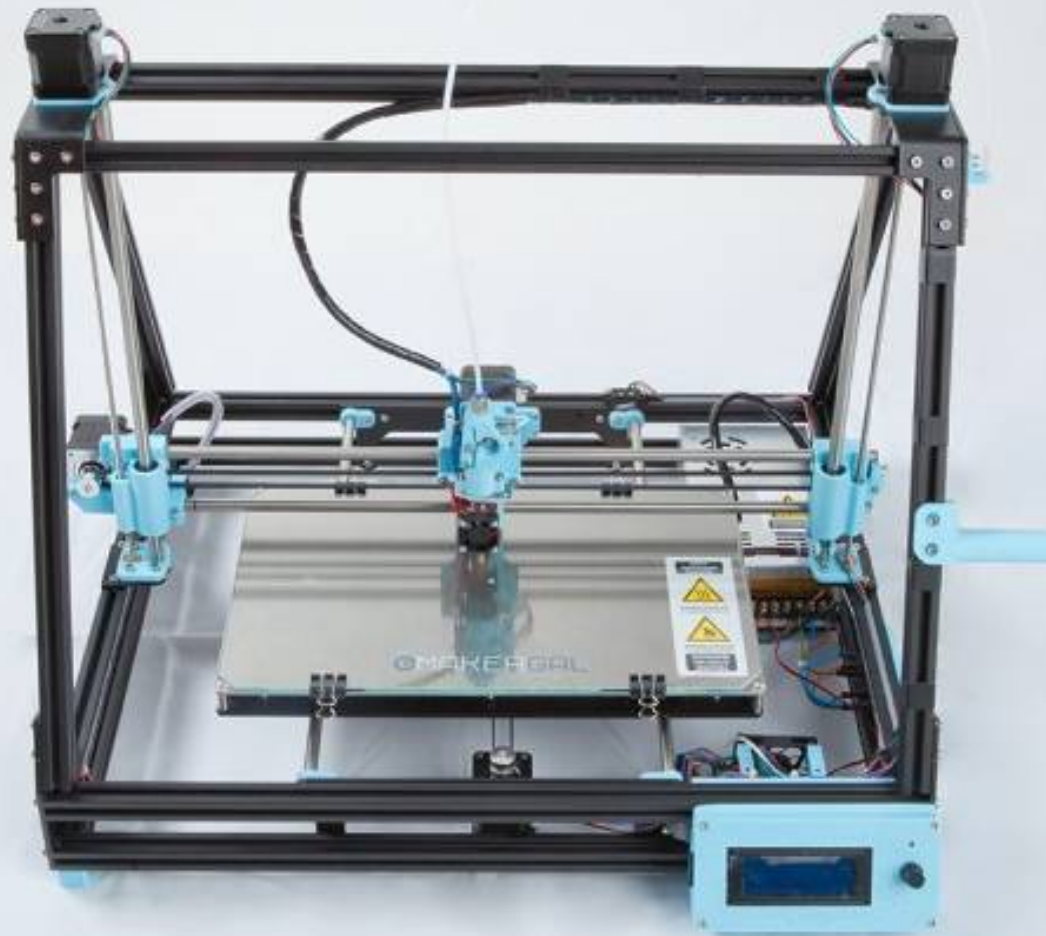
Special thanks to IFIMED

MCC qualification: pressure test



MCC qualification: gluing automatization

Mendel Max 3D XL



- Low cost machine
- Open hardware and software
- Needing to adapt tooling for needle and glue syringe

MCC qualification: radiation resistance

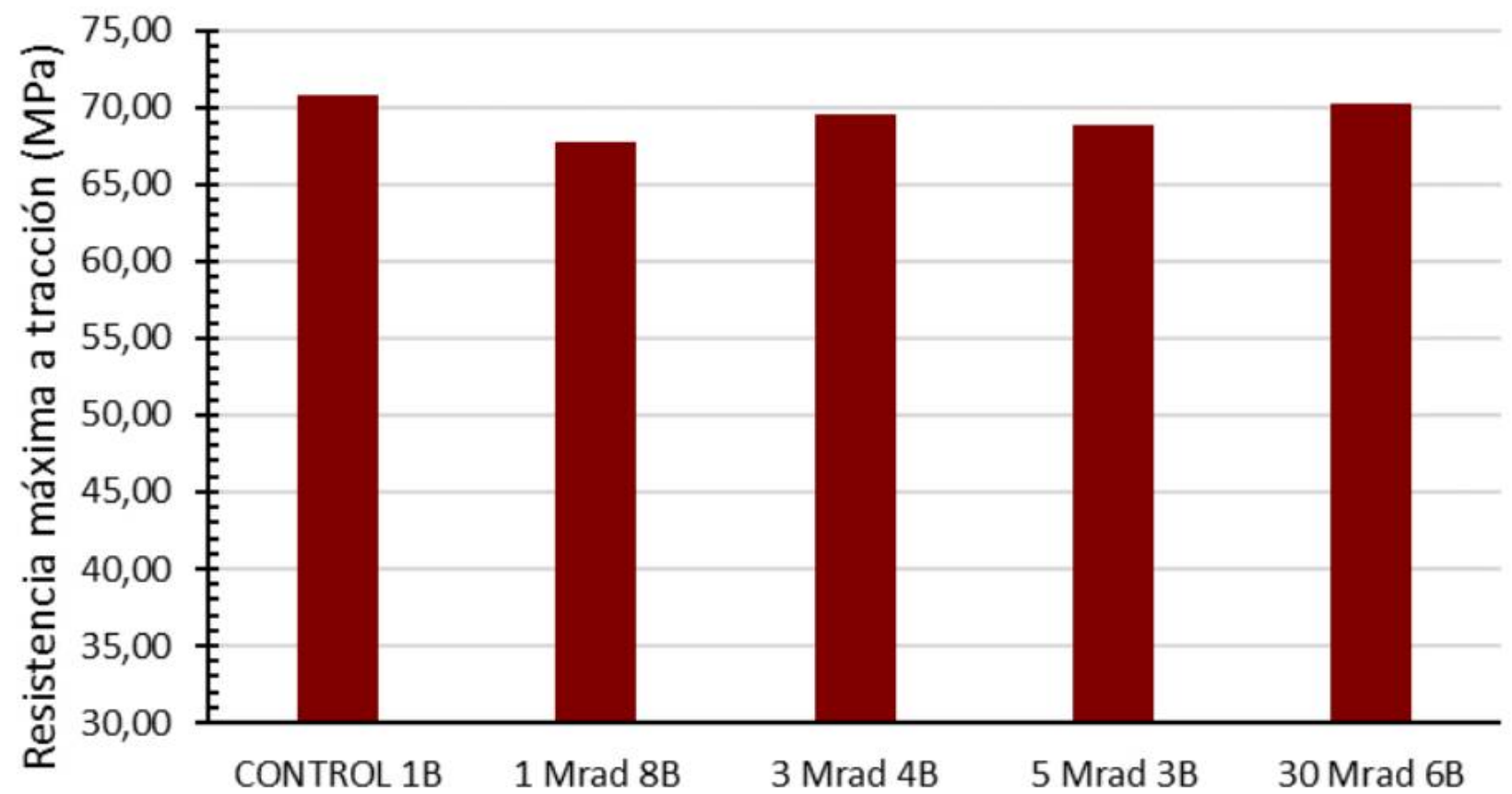
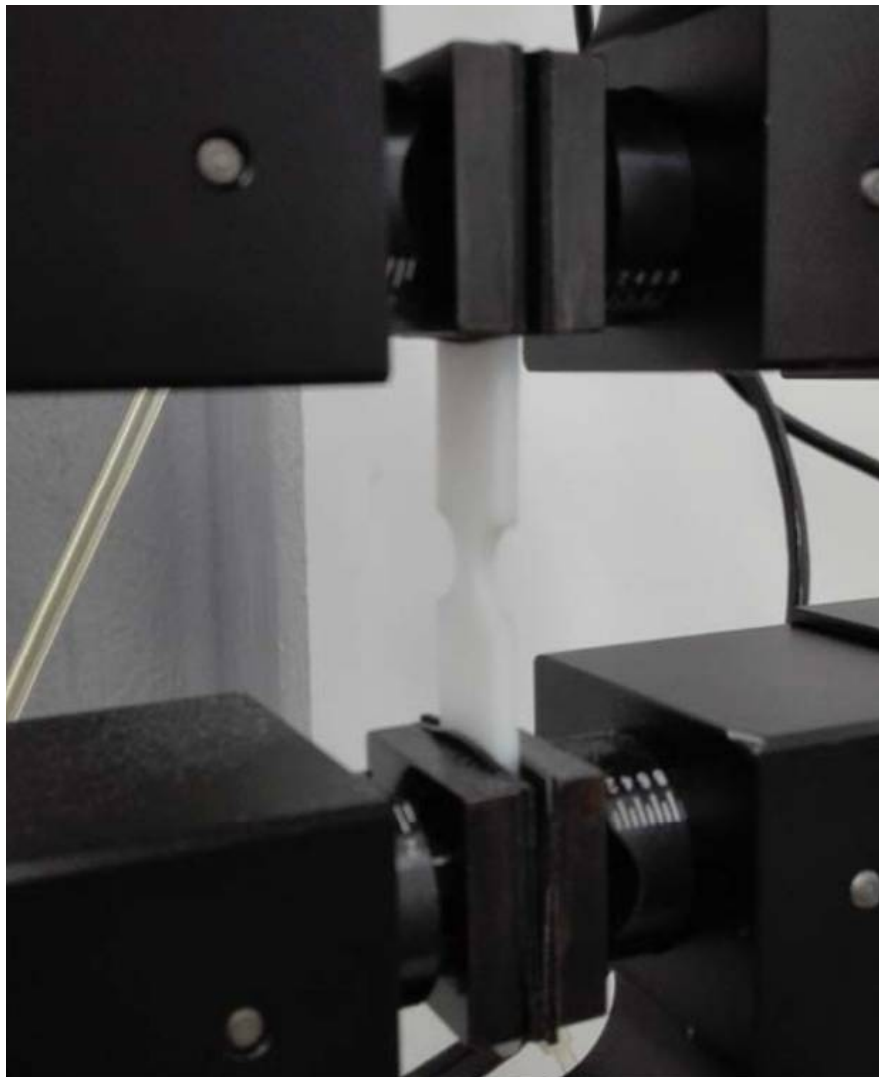


Different radiations levels

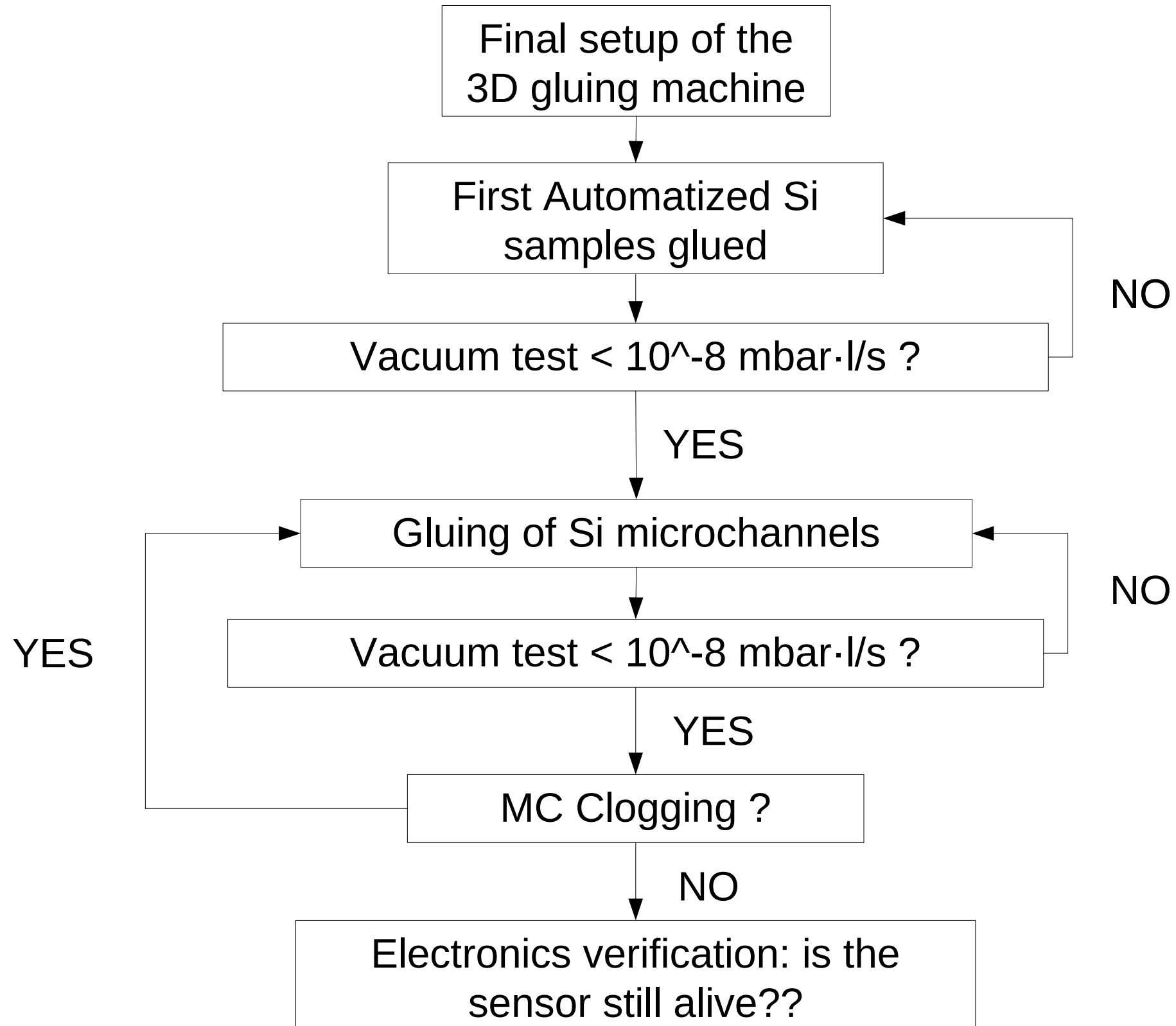
Two type of radiation:

- Neutrons
- **X-Rays**

MCC qualification: radiation resistance



MCC qualification process



Future work

- MCC with bumpbonded asics: different resistive layers added and testing of the computer model
- MCC tooling upgrade for gluing: from mechanical joints to vacuum ones.
- Manifold for MCC ladders
- ??



MCC summary

- Qualification of MCC mostly done: leak tests, thermal tests, mechanical tests, material optimization: glues, 3D printing materials...
- Simulation model verified by lab measurements: computer optimization is possible
- First mcc silicon dummy connected in the plane sensor direction: saving of space
- MCC is a strong candidate as a future cooling method:
 - No vibrations
 - High “power removal” capacity
 - Very low amount of material added
- If you are interested in thermo-mechanical problems/solutions, you are kindly invited for the [Forum on Tracker Detector Mechanics 25-27 June](#).

