Thermo-mechanical aspects of LC vertex detectors

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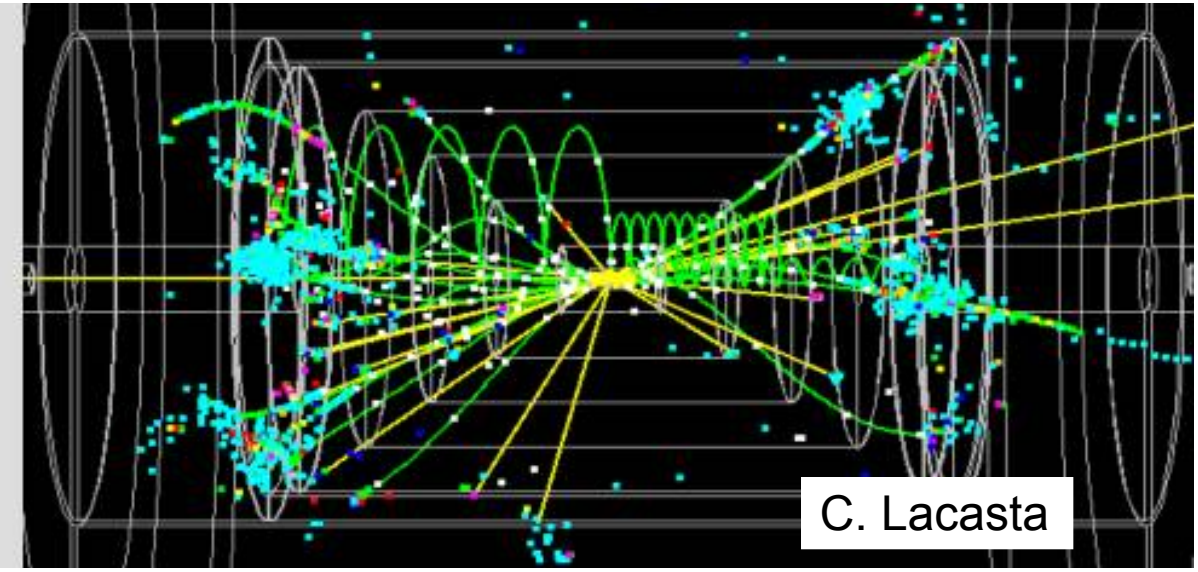
M. Perelló (2), I. Vila (4), M.A. Villarejo (2), M. Vos (2)

(1) (2) (3) (4) (5)

Introduction

What physicists imagine...



Introduction

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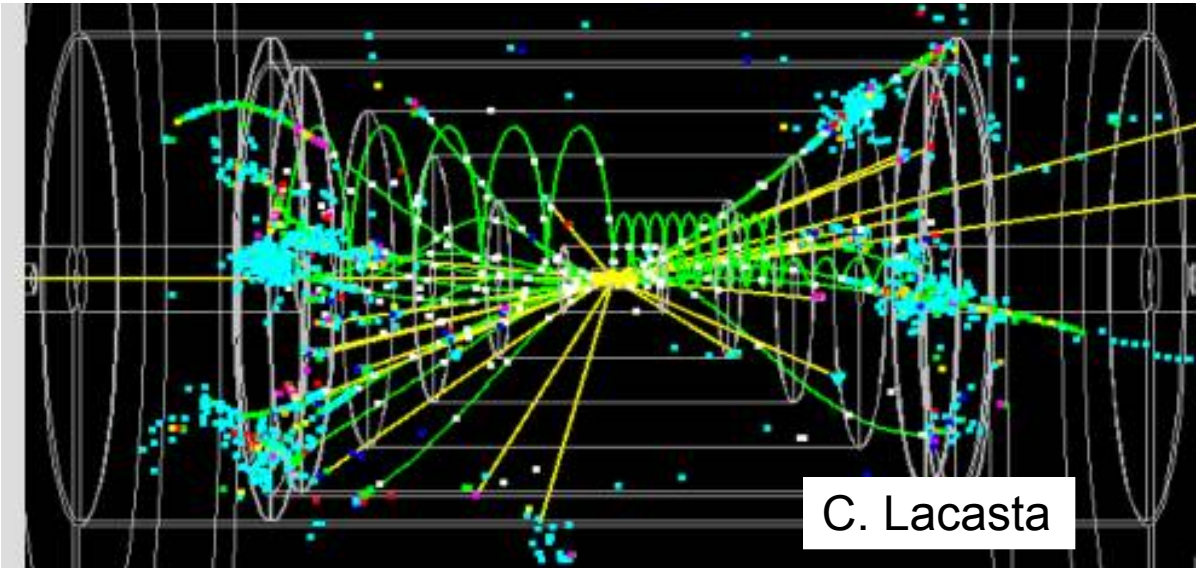
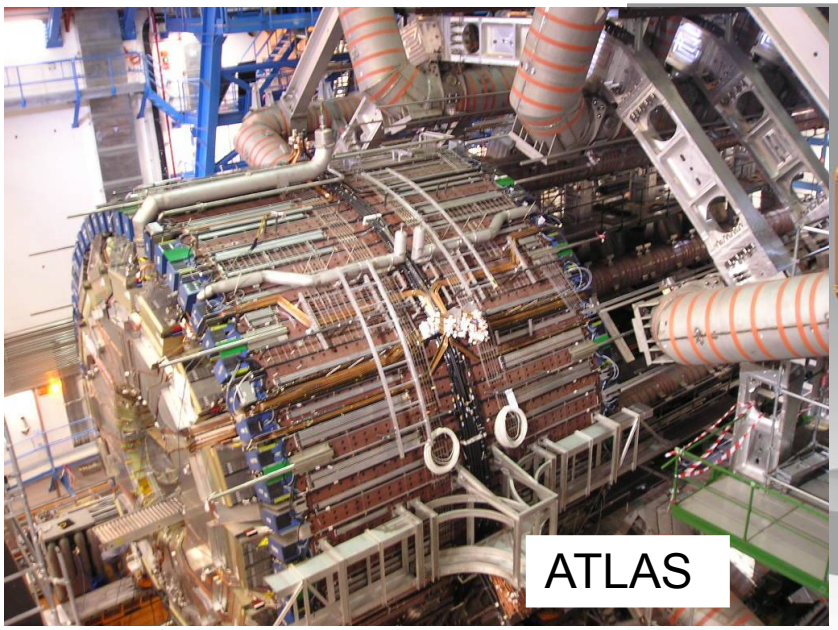
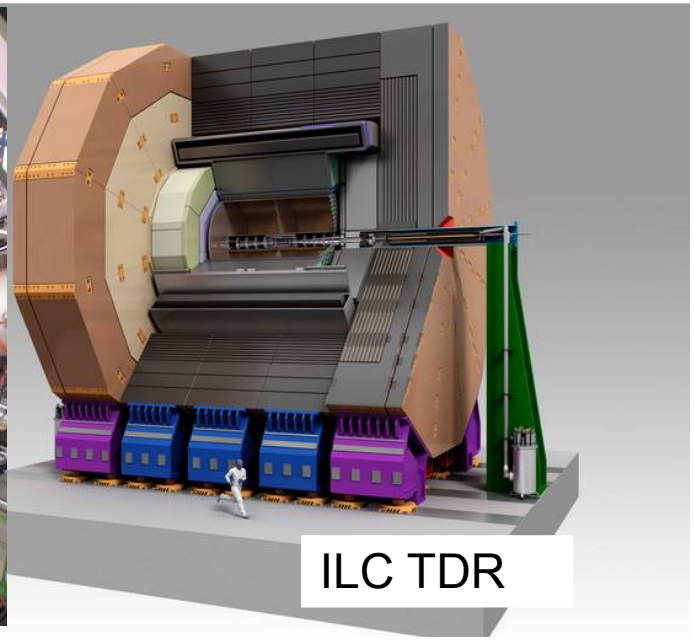
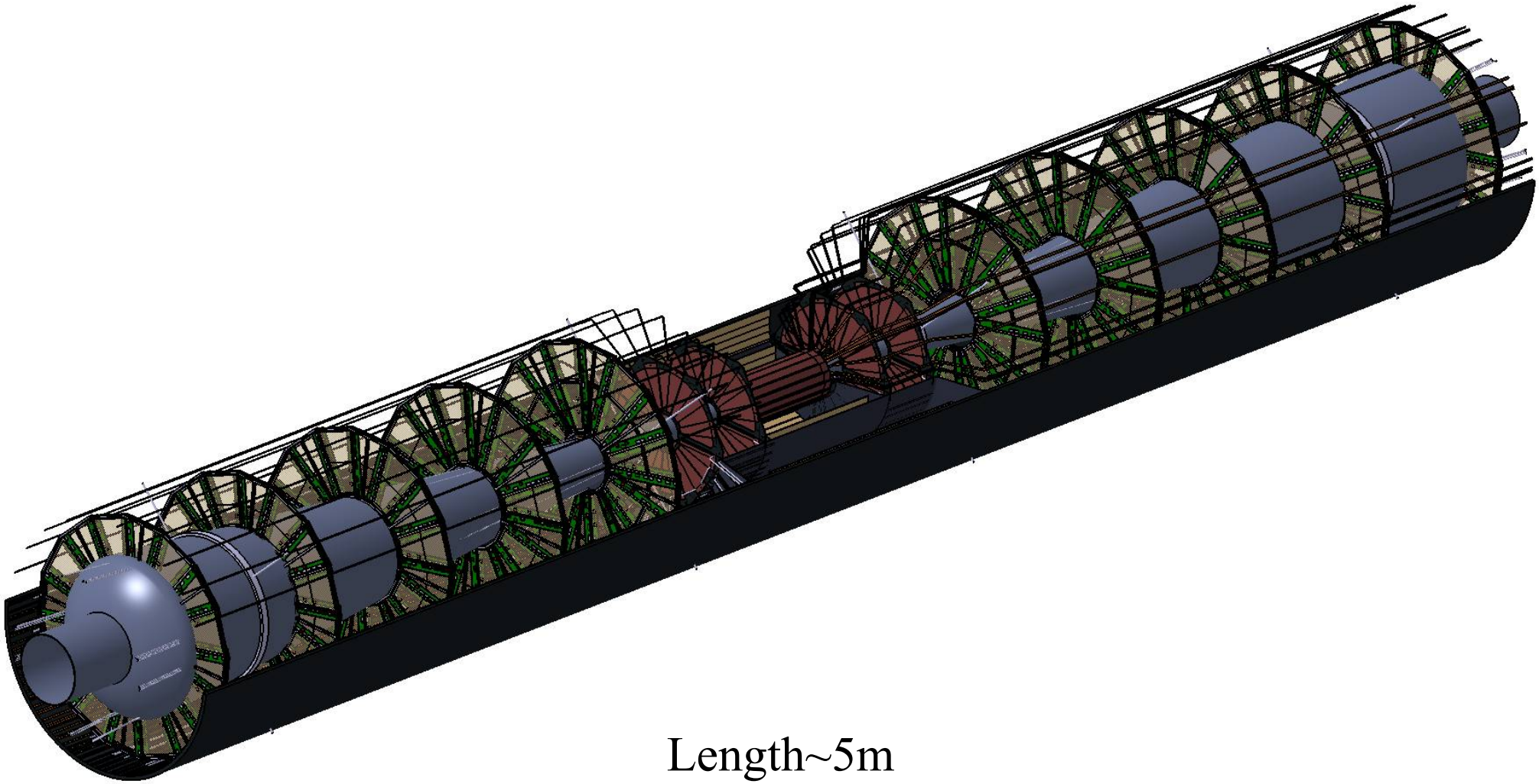


What engineers imagine...





Introduction

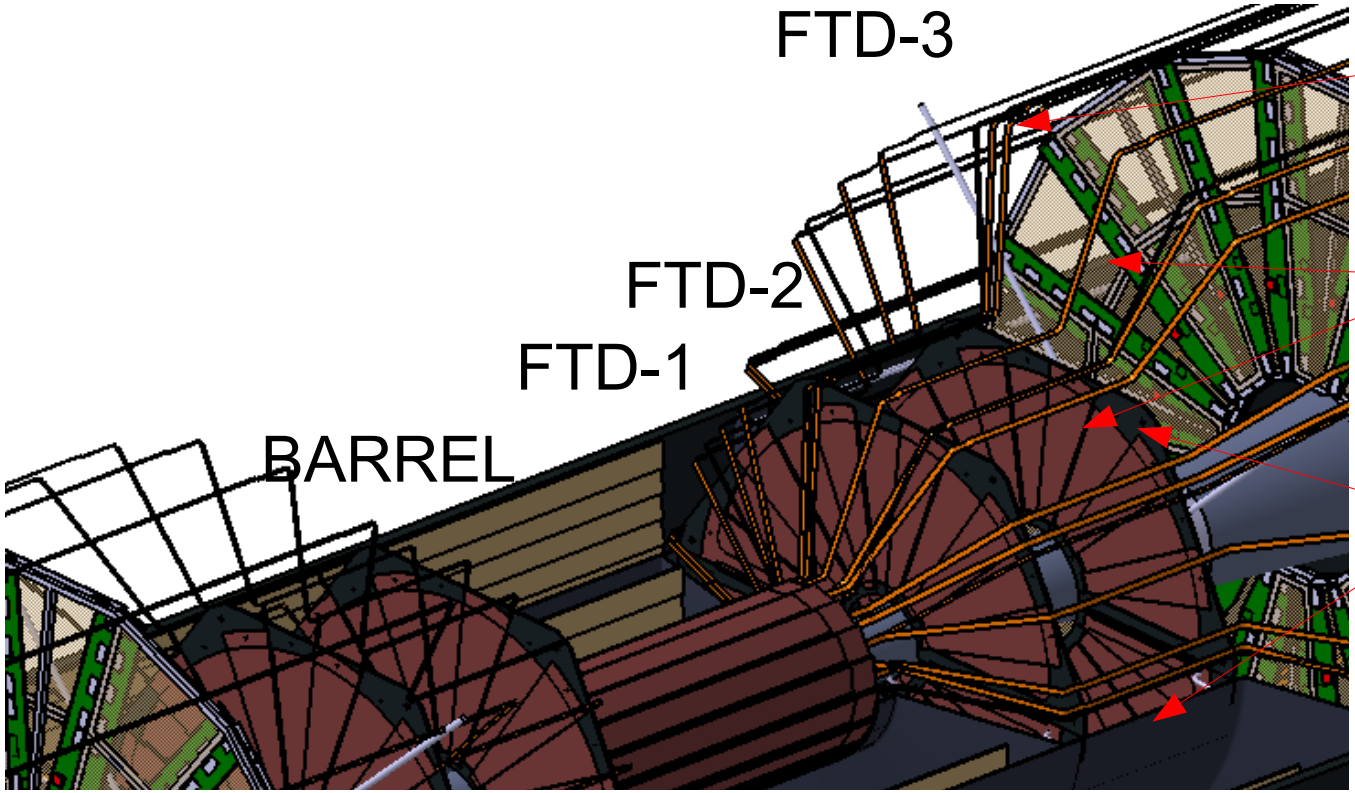


Length~5m

Diameter~0,64m

As light and rigid as possible

Introduction



Services

Electronics

Mechanical support structure

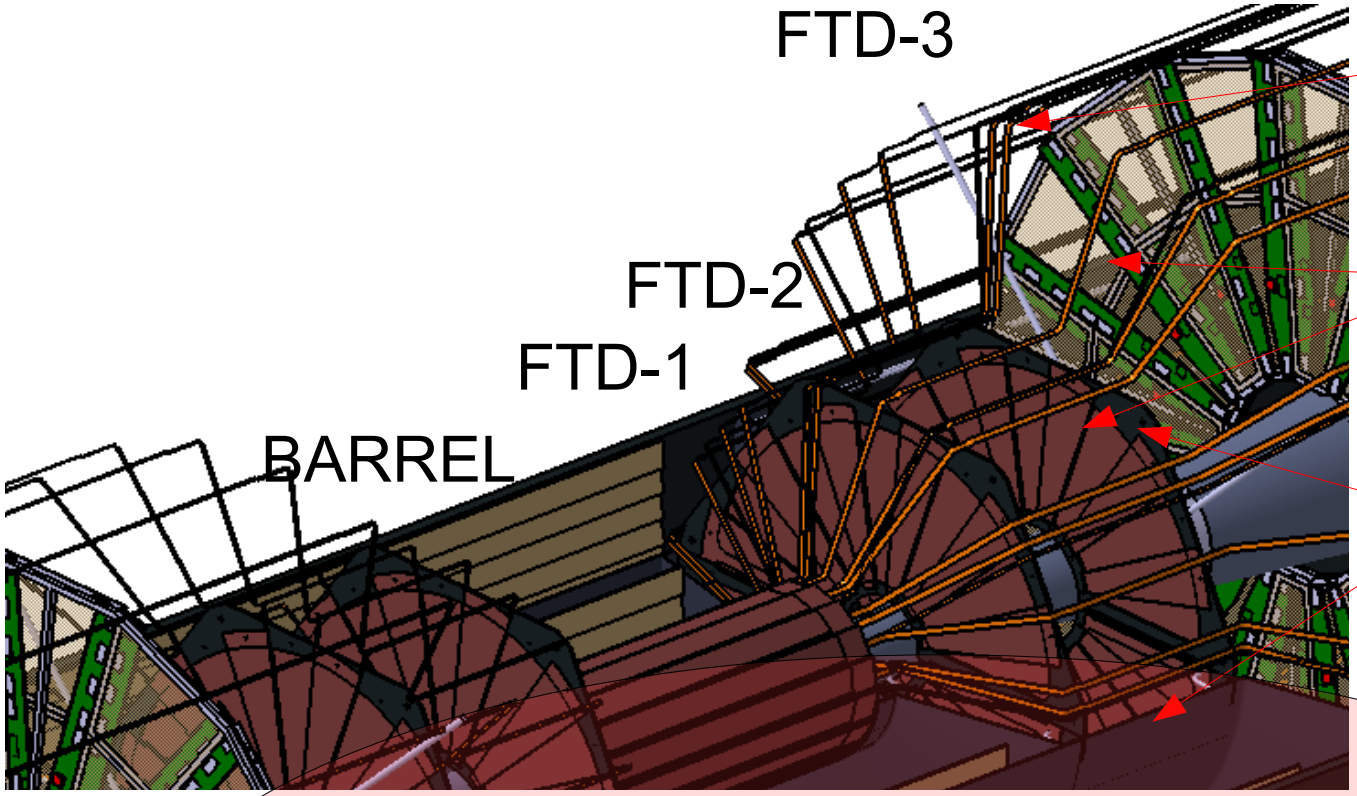
Integration ⟷ **Materials**

- Radiation length
- Mechanical properties
- Joints
- New materials
- ...

Services

- Power to deliver
- Cooling strategy
- Layout
- ...

Introduction



Services

Electronics

Mechanical support structure

Integration ↔ **Materials**

- Radiation length
- Mechanical properties
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- ...

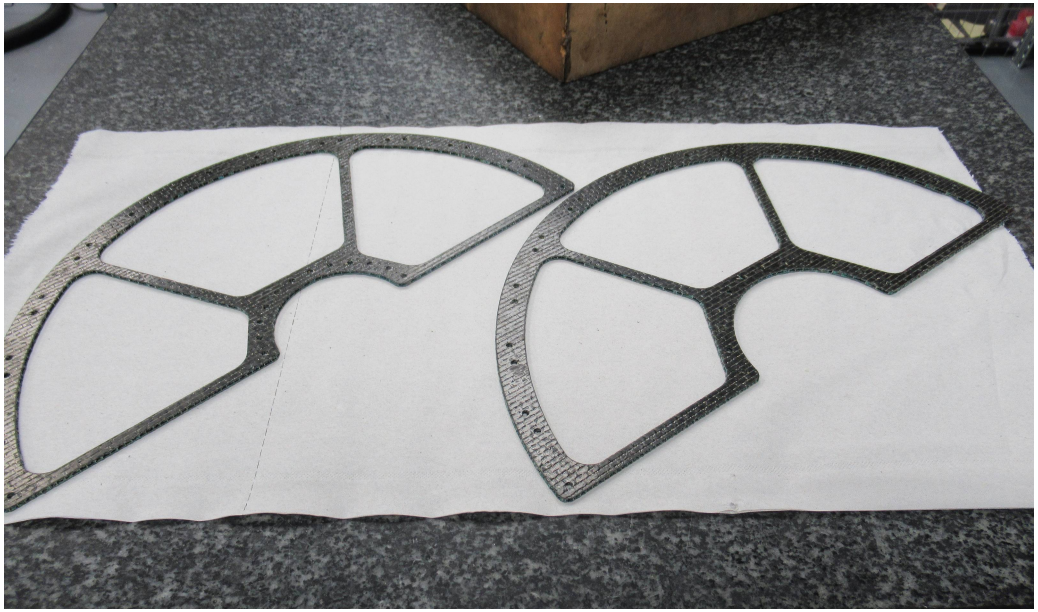
QA/QC

Services

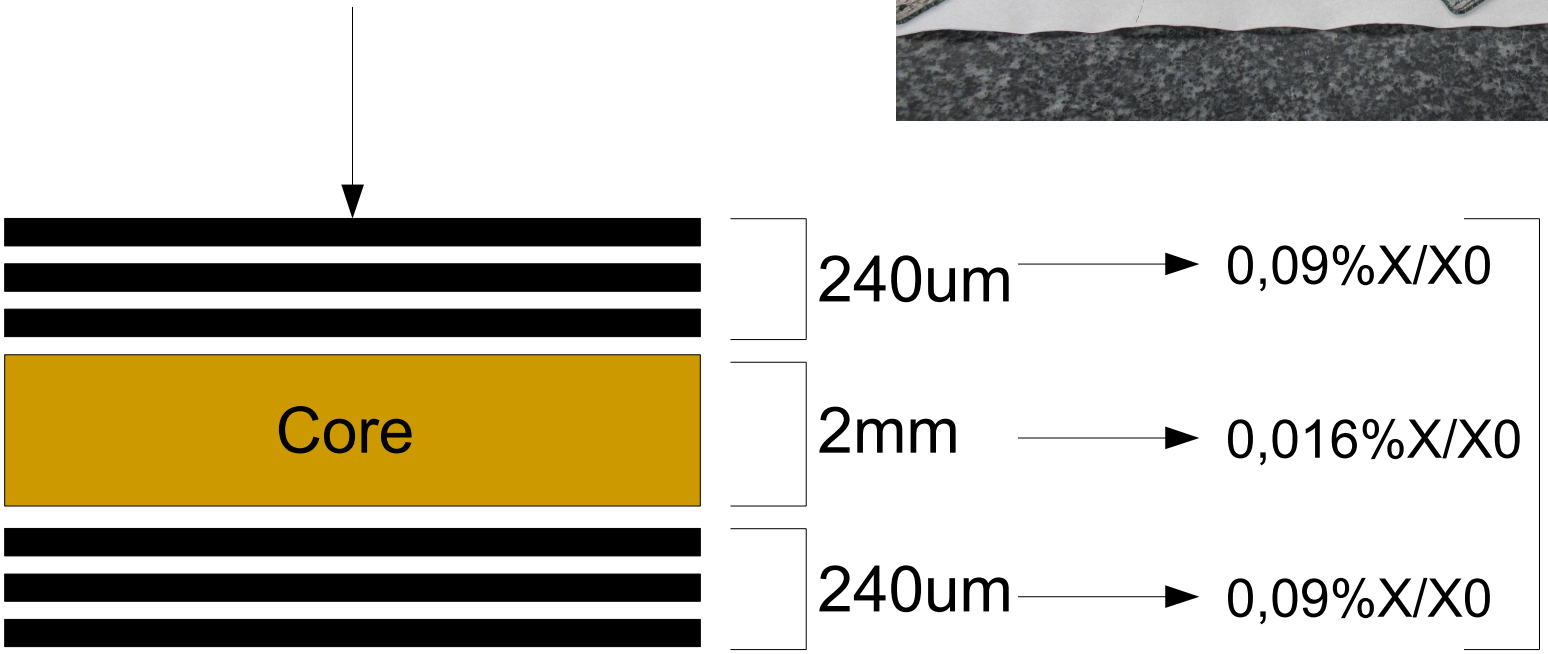
- Power to deliver
- Cooling strategy
- Layout
- ...

Materials: radiation length

Materials
- Radiation length
- Mechanical properties
- Joints
- New materials
- ...



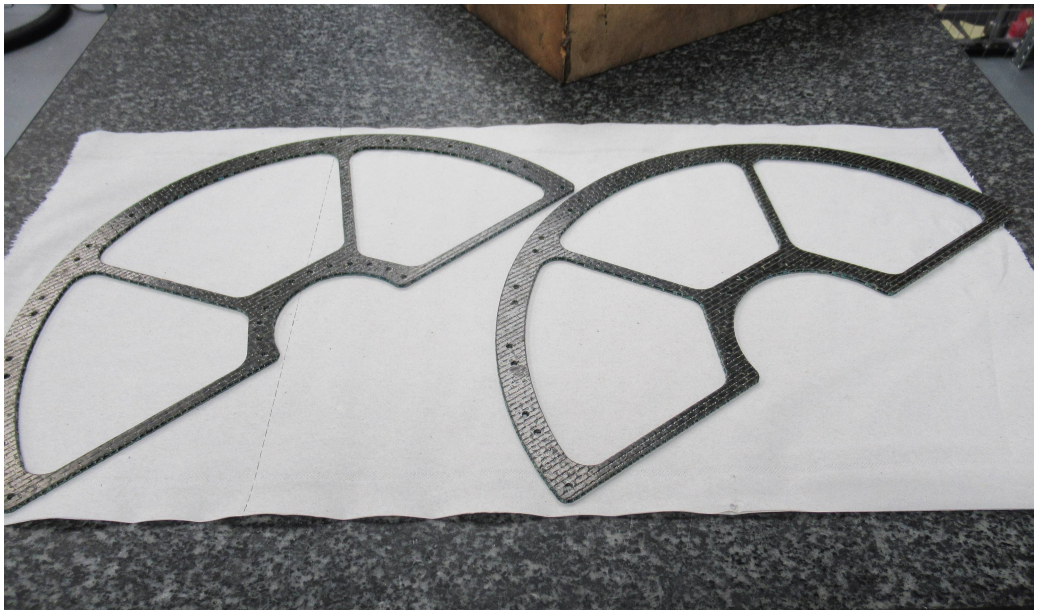
Carbon fiber



0,06%X/X0 (Averaged because of holes & 1st Endcap layer, passive material is out of sensor region)

Materials: mechanical properties

Materials
- Radiation length
- Mechanical properties
- Joints
- New materials
- ...

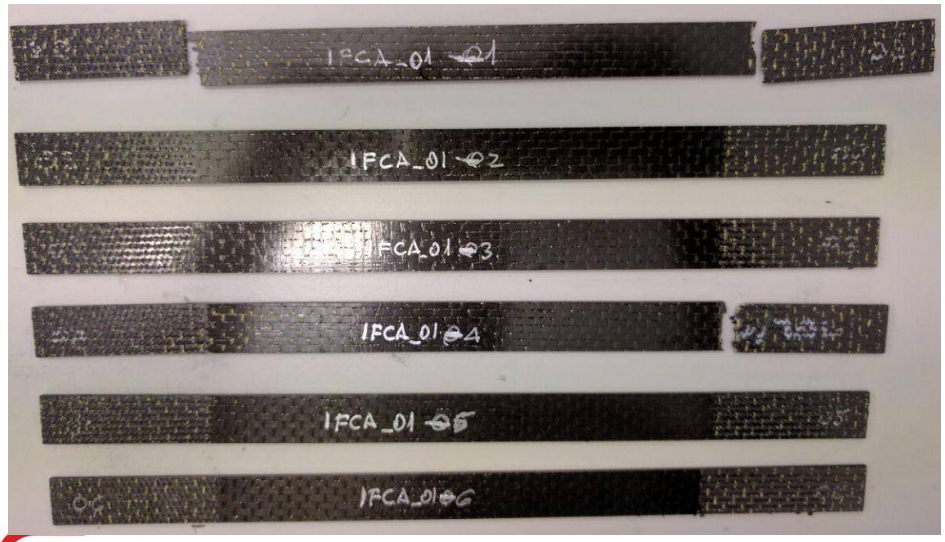


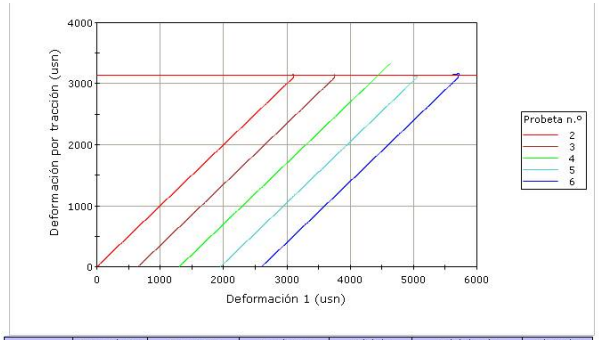
E_t=289,9 GPa

E_c=259,4 Gpa (tipically E_c<E_t)

$E_{theoretical}$=298 Gpa

- **IMPORTANT FOR MEC. STABILITY**



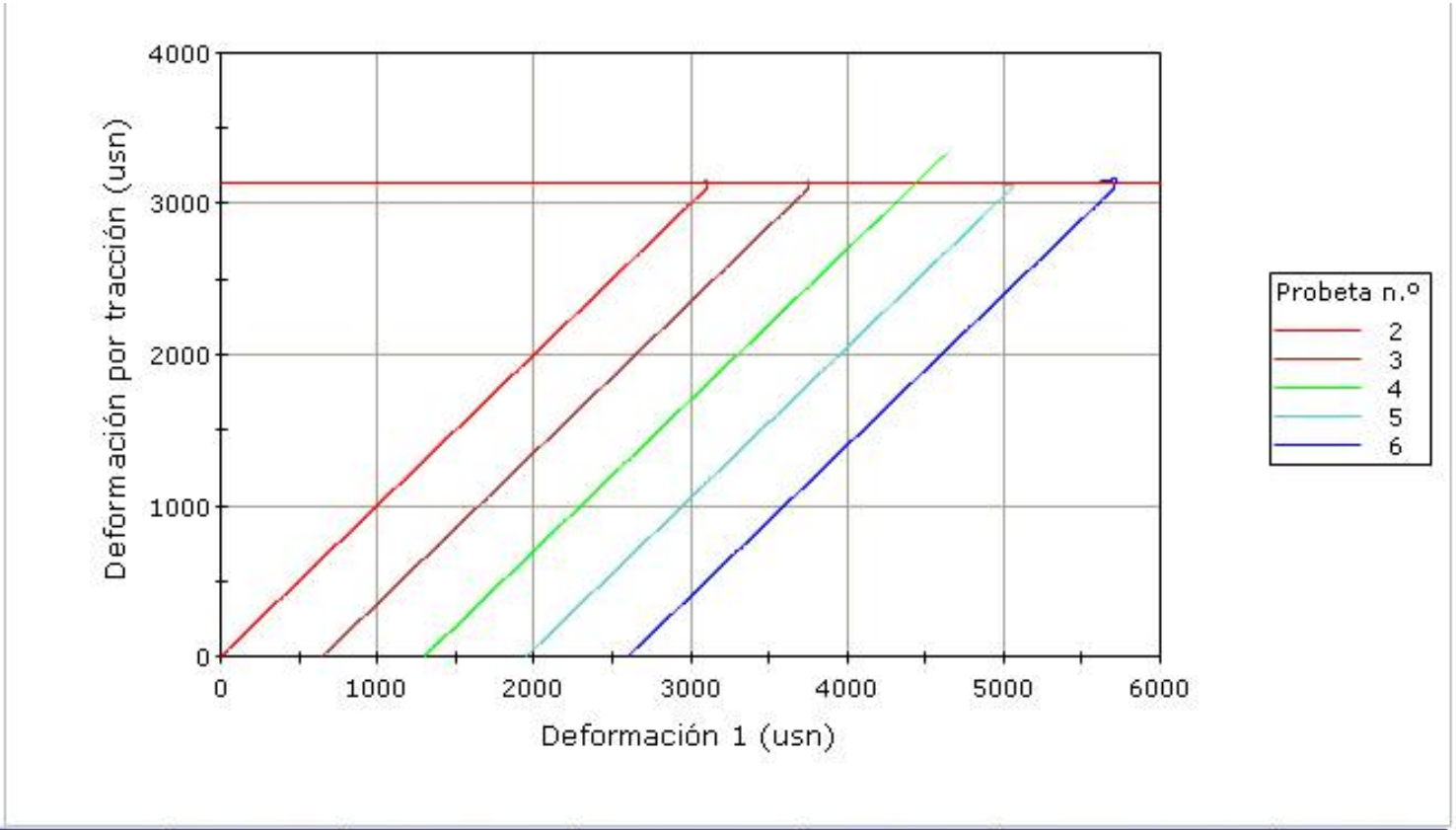


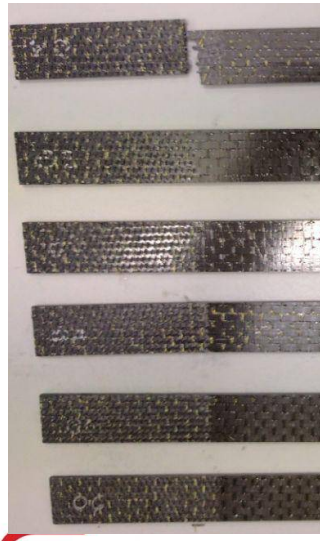
	ID probeta	Espesor (mm)	Anchura (mm)	Módulo Elástico (GPa)	Módulo de Poisson ()	Tipo de rotura
2	IFCA-02	1.575	14.98	298.6	0.257	
3	IFCA-03	1.572	14.98	287.6	0.316	
4	IFCA-04	1.579	14.99	280.2	0.265	
5	IFCA-05	1.530	14.96	293.4	0.261	
6	IFCA-06	1.547	15.00	289.8	0.239	
Máx.		1.579	15.00	298.6	0.316	
Mín.		1.530	14.96	280.2	0.239	
Media		1.561	14.98	289.9	0.268	
D.S.		0.02	0.01	6.84	0.03	
C.V.(%)		1.36	0.10	2.36	10.70	

Materials: mechanical properties

Materials

E_t=289,
E_c=259
$E_{theoretical}$





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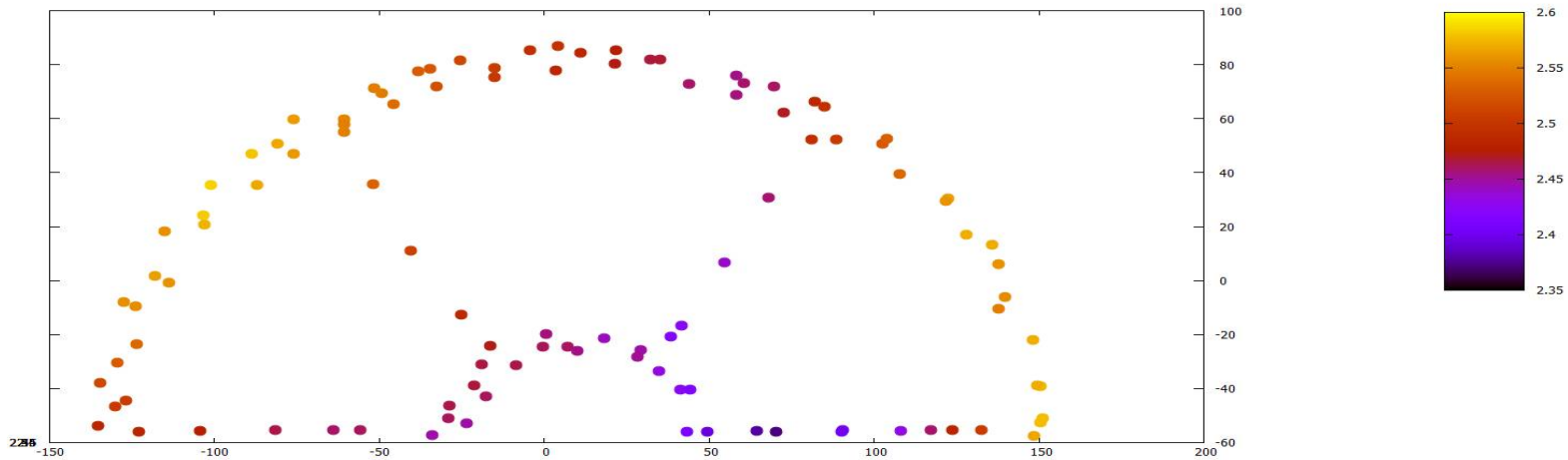
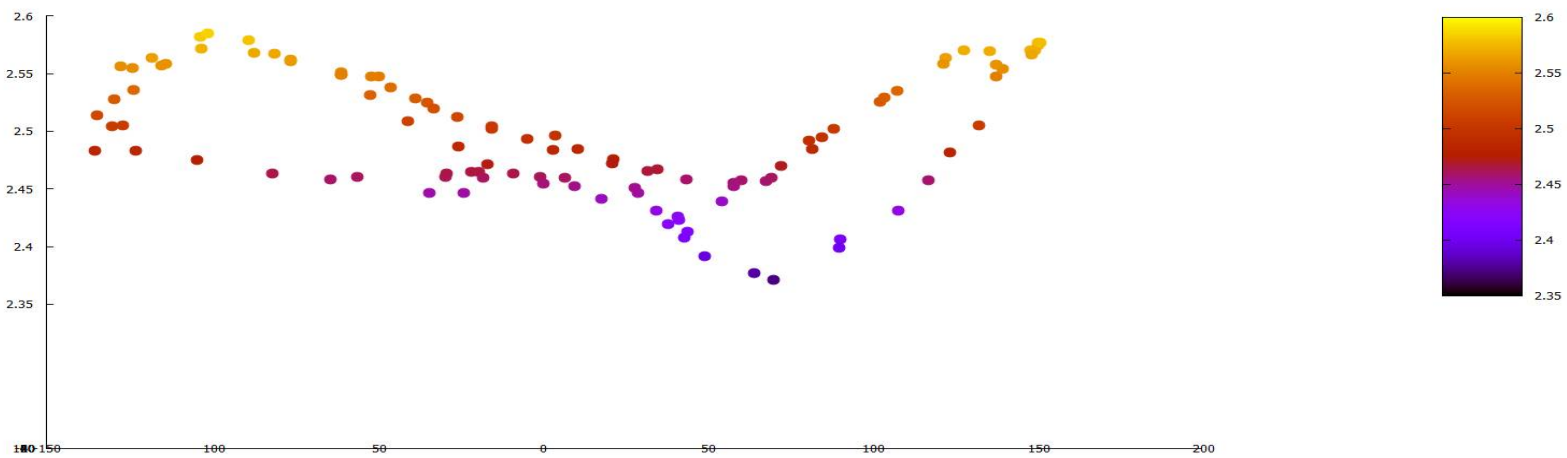
Materials: mechanical properties

Materials
- Radiation length
- Mechanical properties
- Joints
- New materials

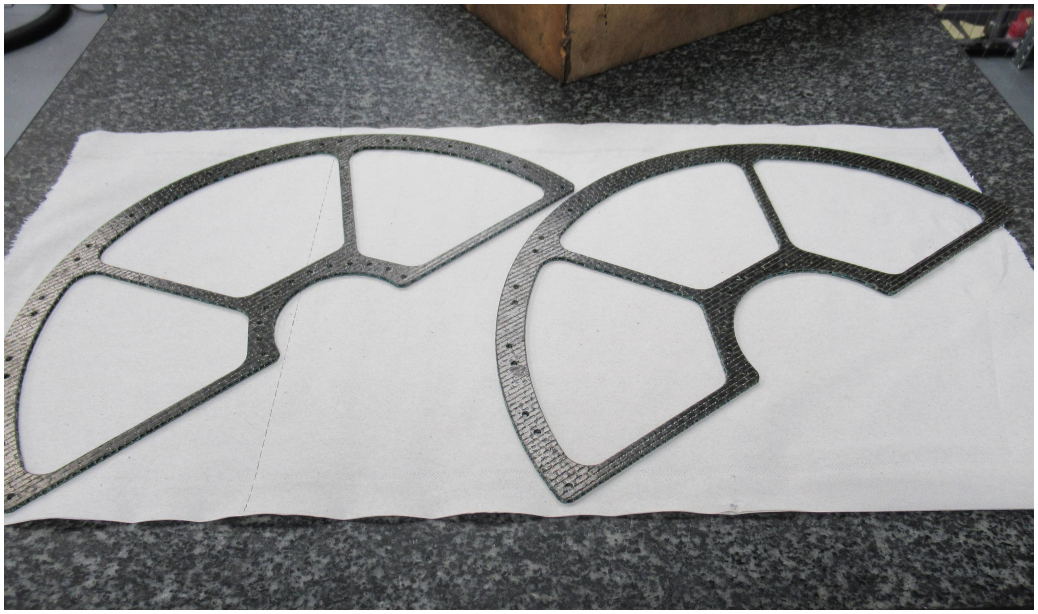




Worst scenatio possible: planarity of 150 um

Materials: joints

Materials
- Radiation length
- Mechanical properties
- Joints
- New materials
- ...

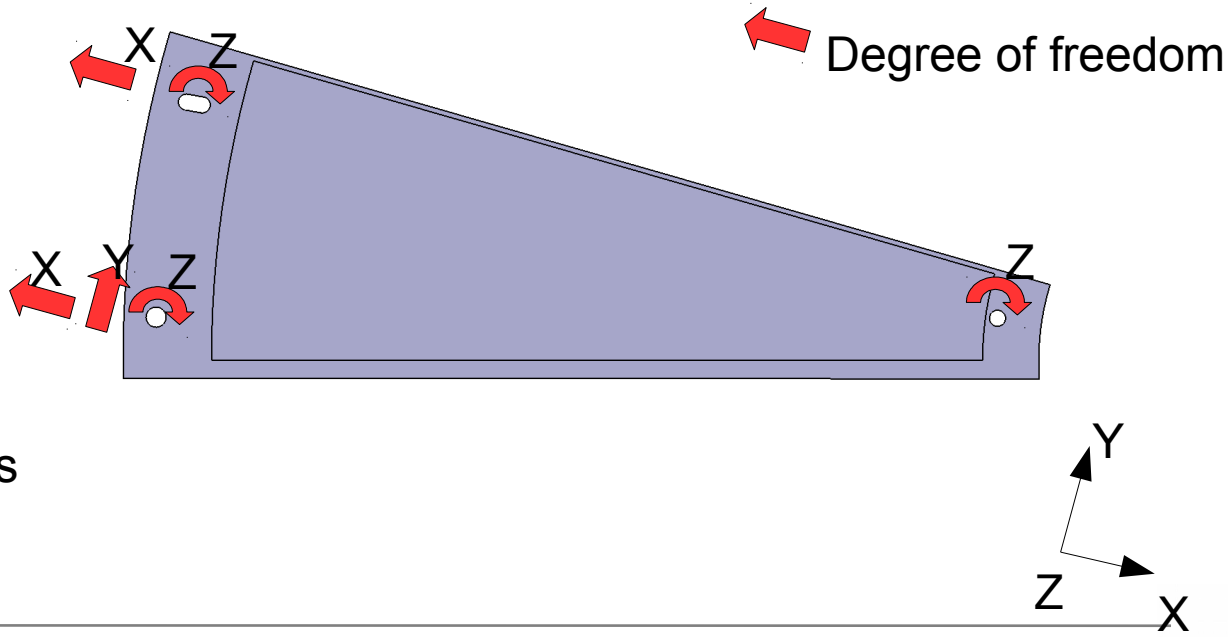


Kinematic in the plane:

- No deformations out of plane due to thermal expansion

- No mechanical/electronical failure due to in plane loads:

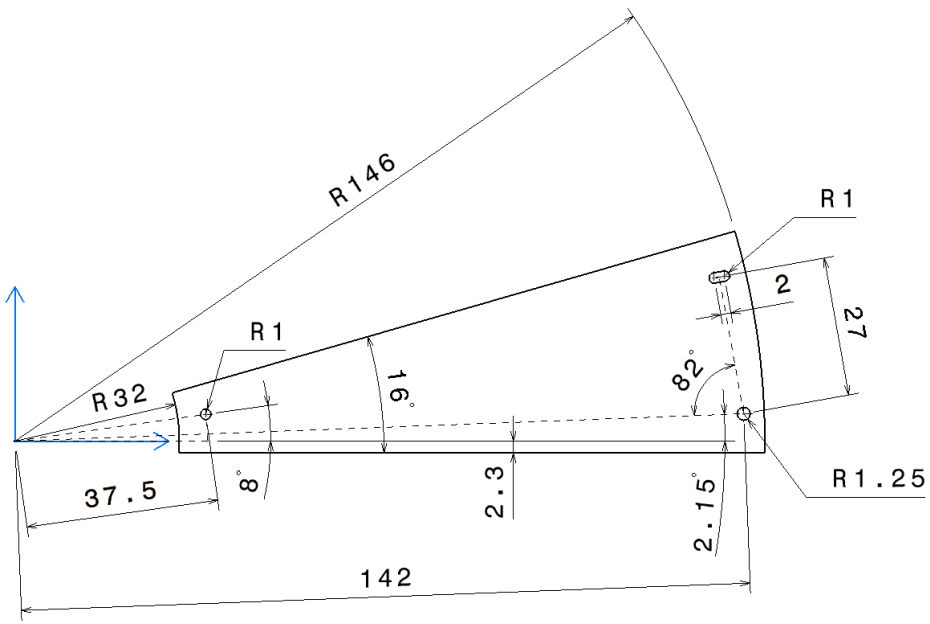
  - Insertion of the assembly
  - Earthquakes
  - Stresses related to services



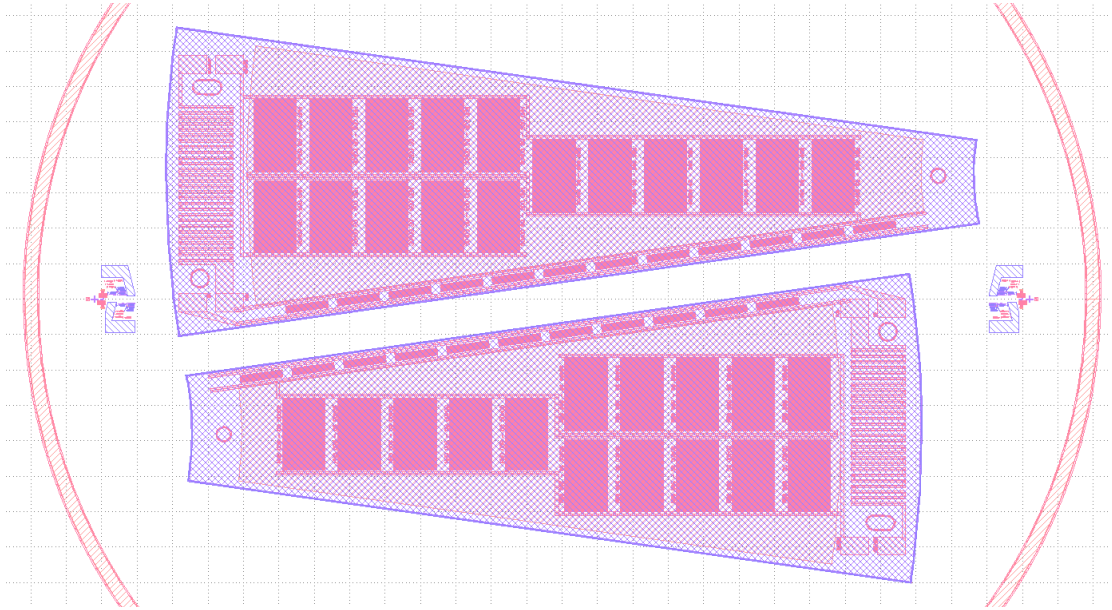
Materials: joints

Materials
- Radiation length
- Mechanical properties
- Joints
- New materials
- ...

FTD1: design

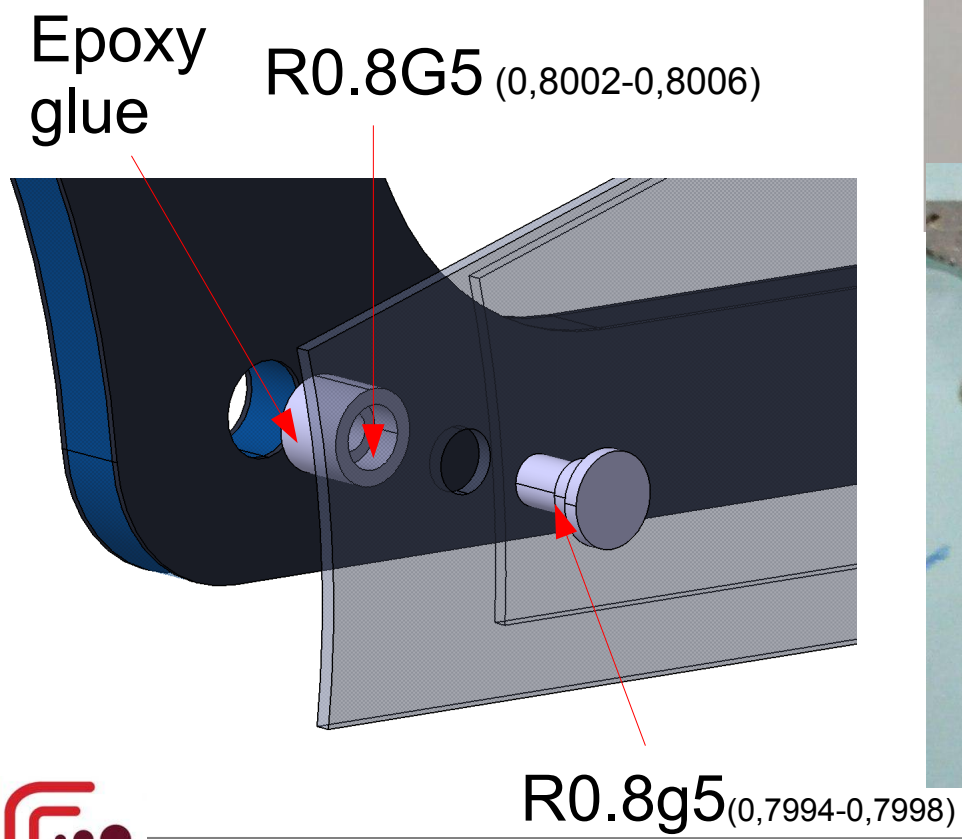


FTD1&2: .gds for manufacturing



Materials: joints

Materials
- Radiation length
- Mechanical properties
- Joints
- New materials
- ...



Materials: joints

Materials
- Radiation length
- Mechanical properties
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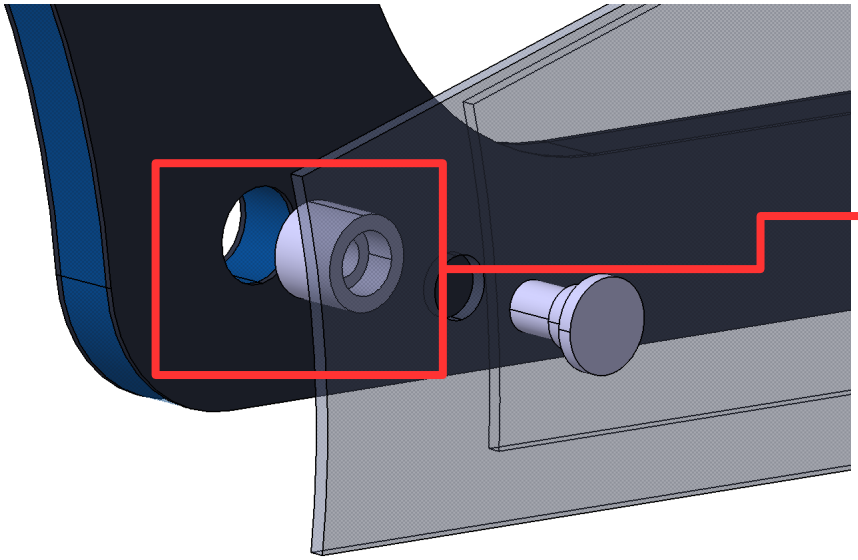
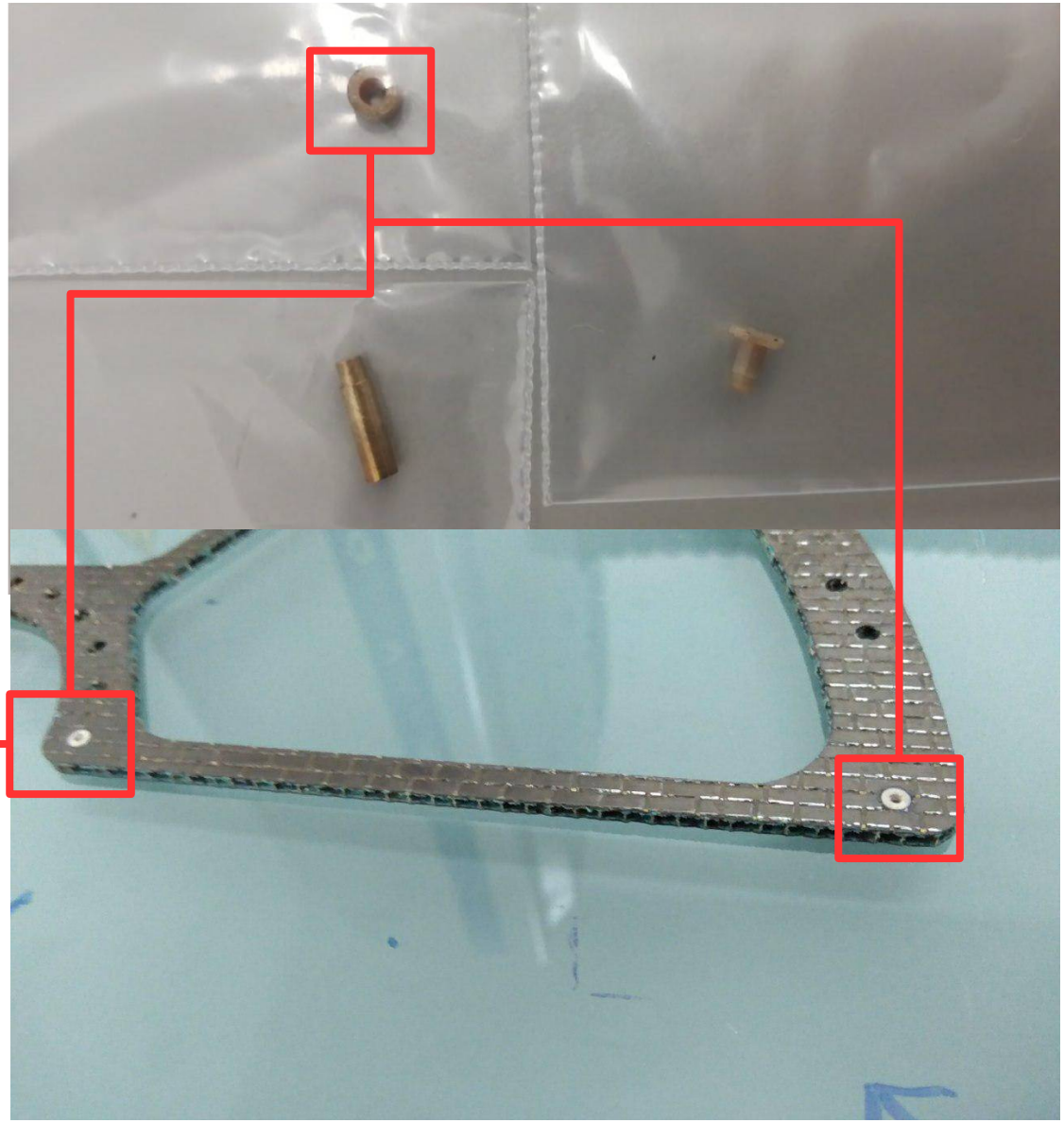
- New materials
- ...





Materials: joints

Materials
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- ...

Materials: joints

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- Radiation length
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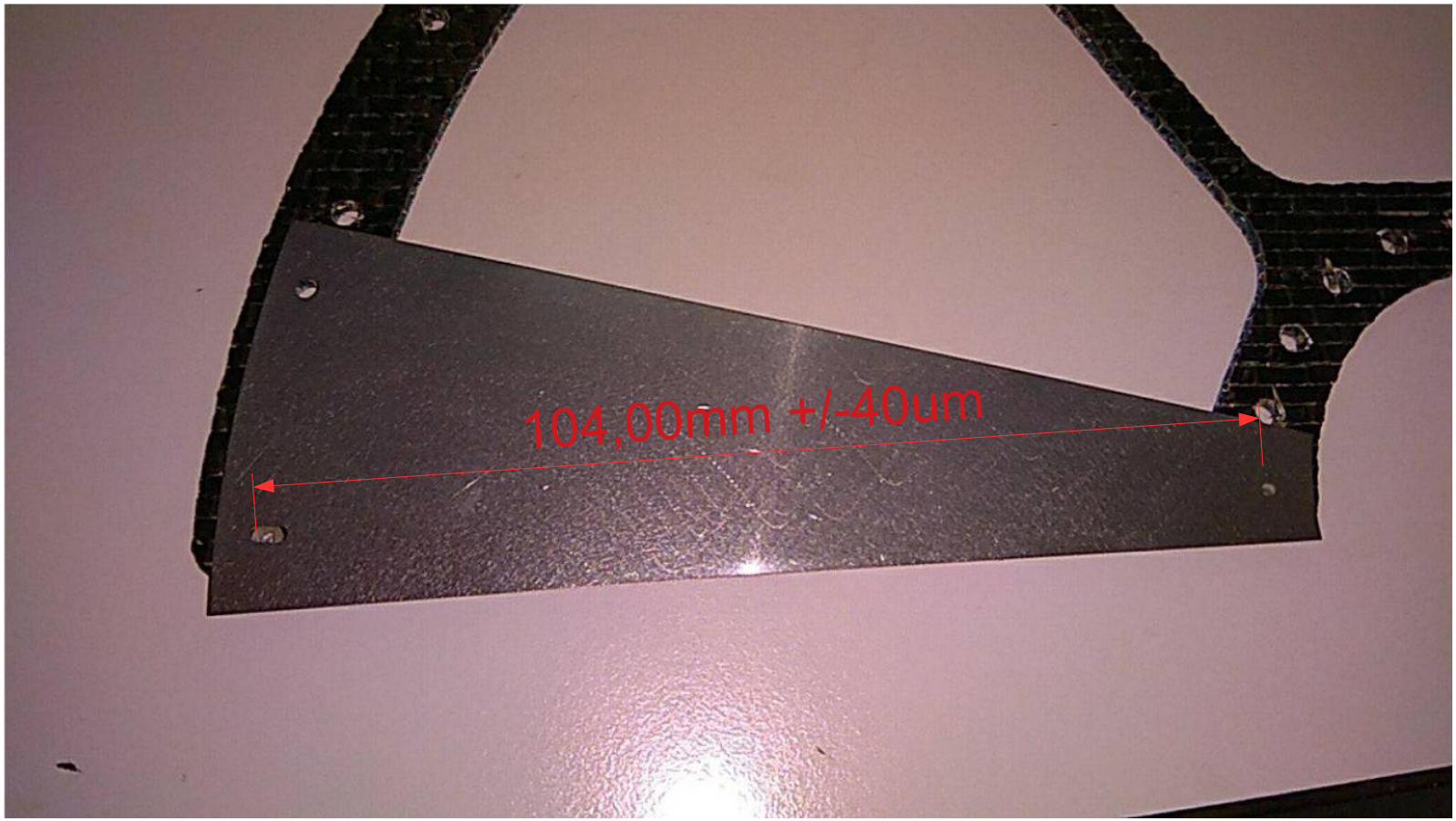
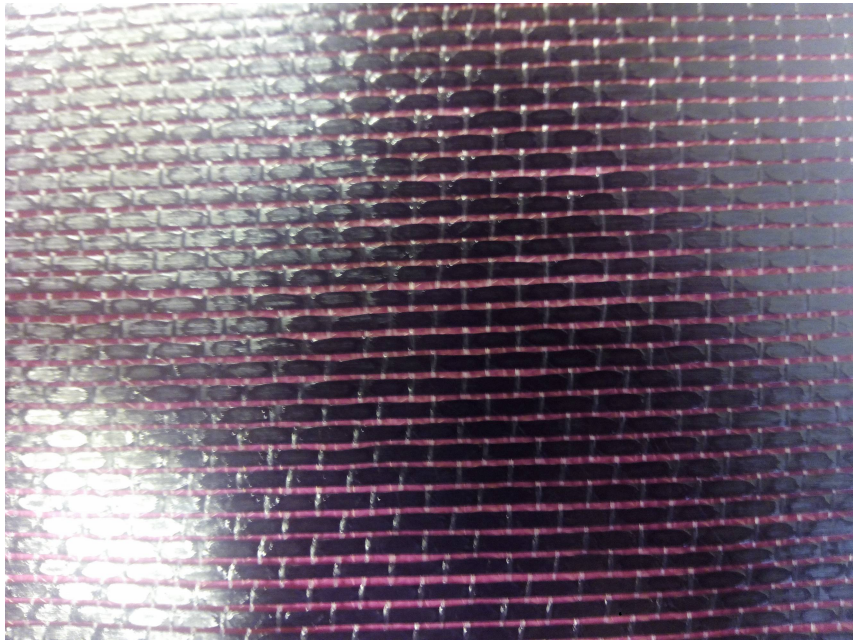
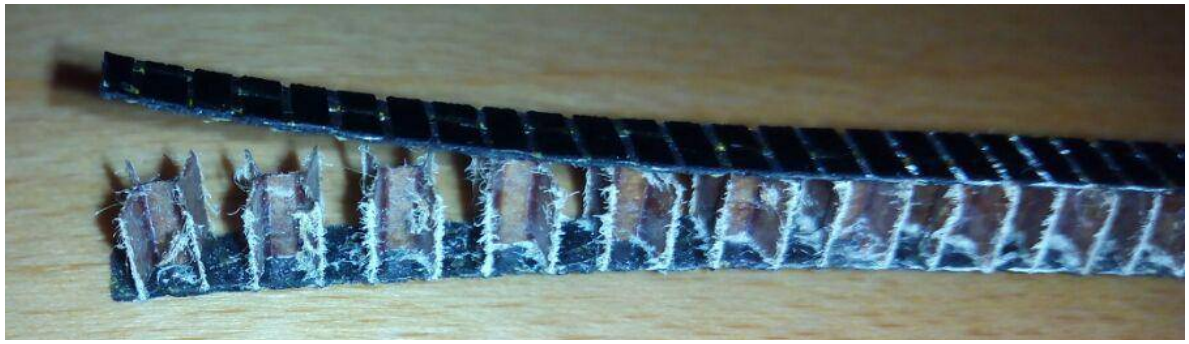
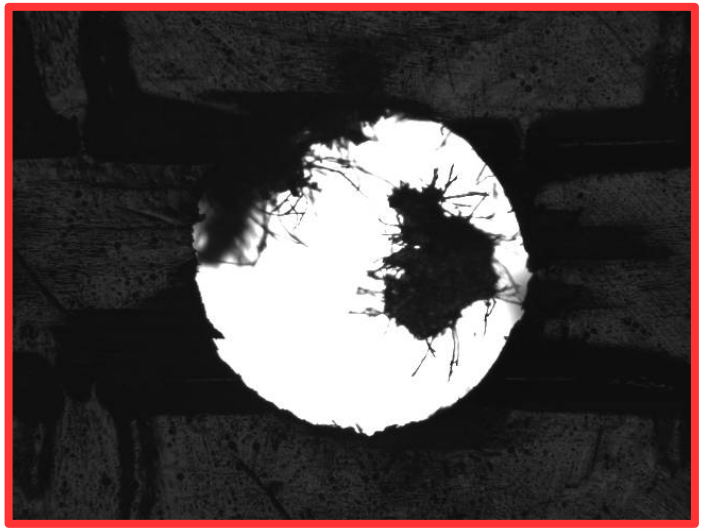


Materials: new materials and ...

Materials
- Radiation length
- Mechanical properties
- Joints
- New materials
- ...





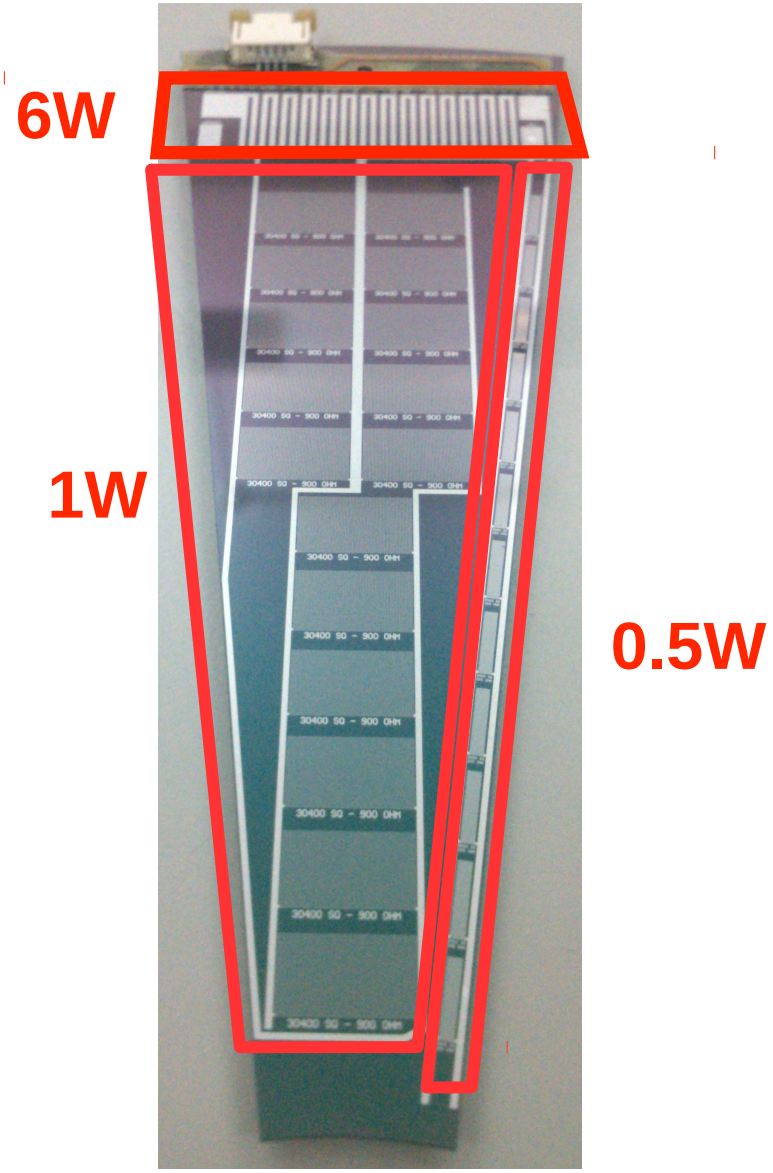


Services: power to deliver

Services
- Power to deliver
- Cooling strategy
- Layout
- ...

VTX Barrel

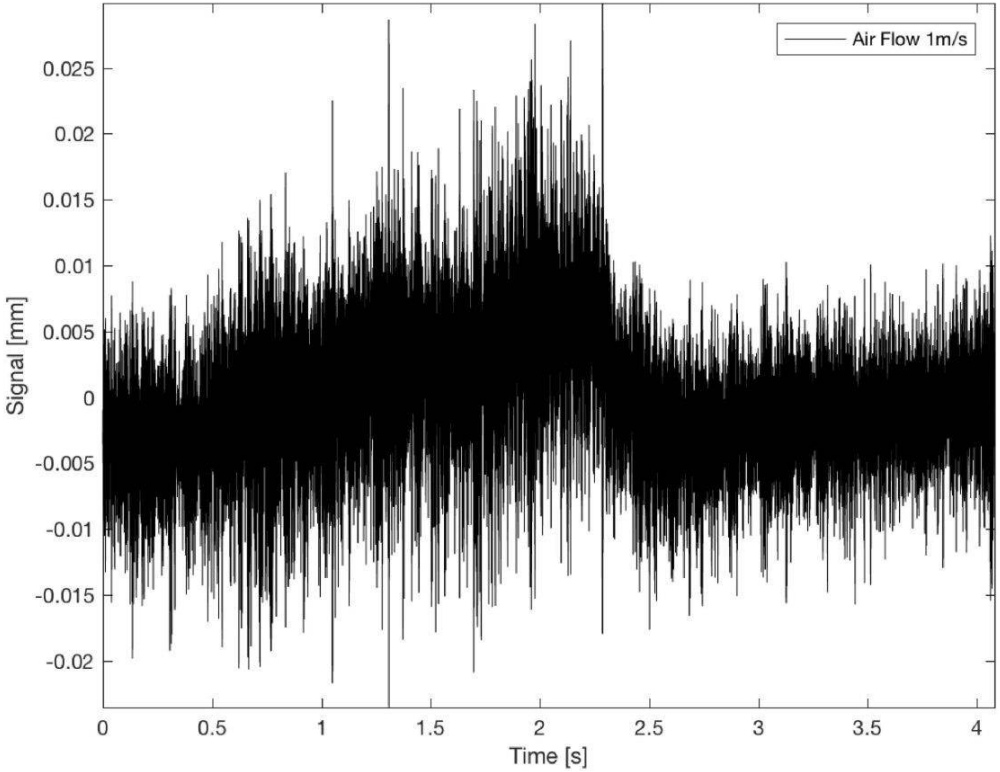
VTX Endcap

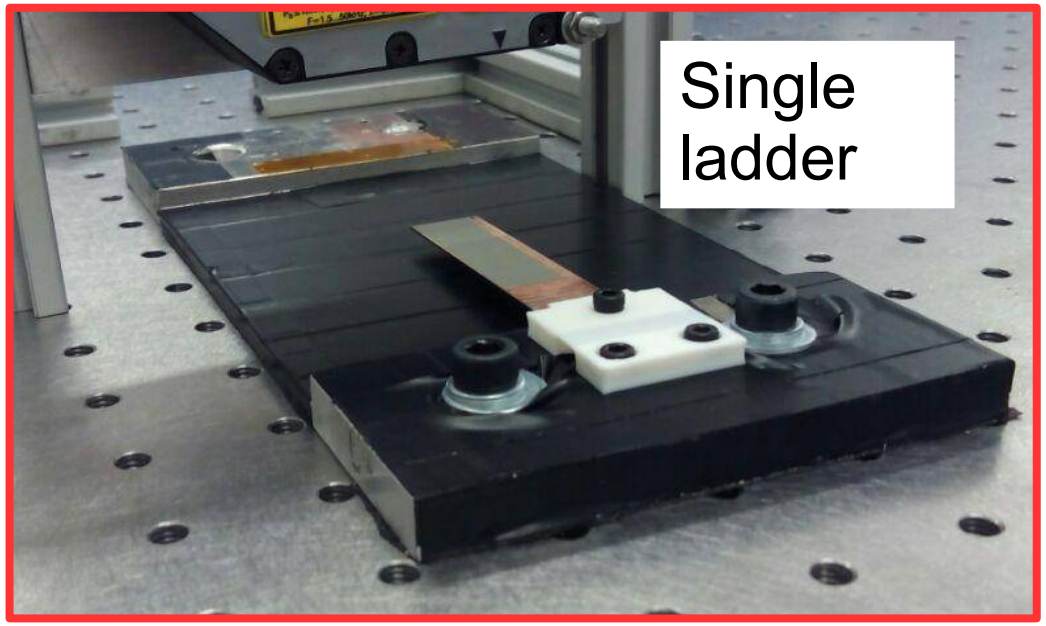


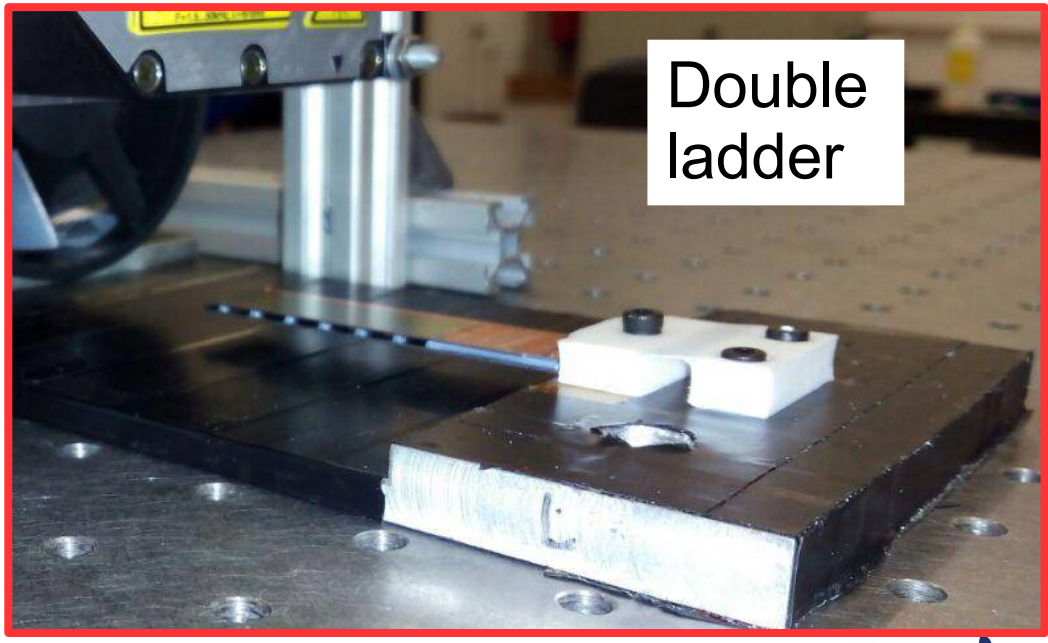
Based on DEPFET technology:
- Power distribution
- Material
- Mechanical stiffness

But take it as an example that may be applied to other technologies, just take the overall idea...

Services air cooling: Barrel



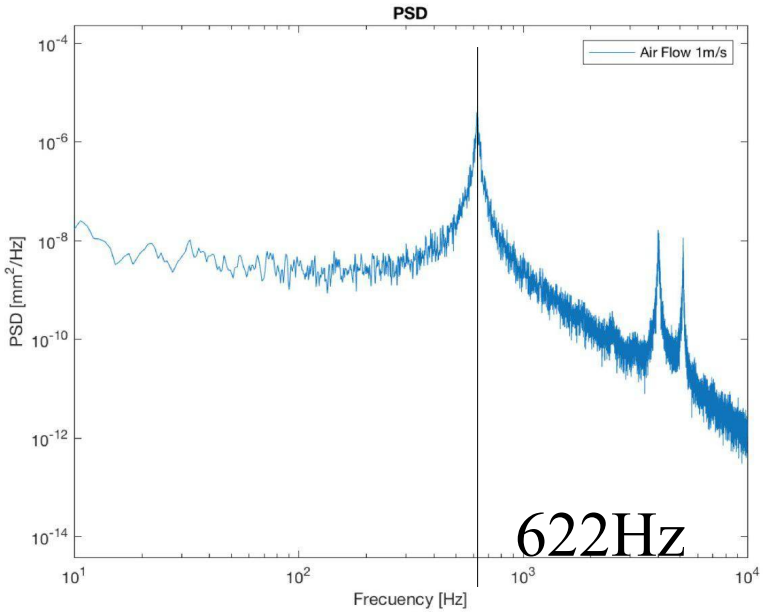


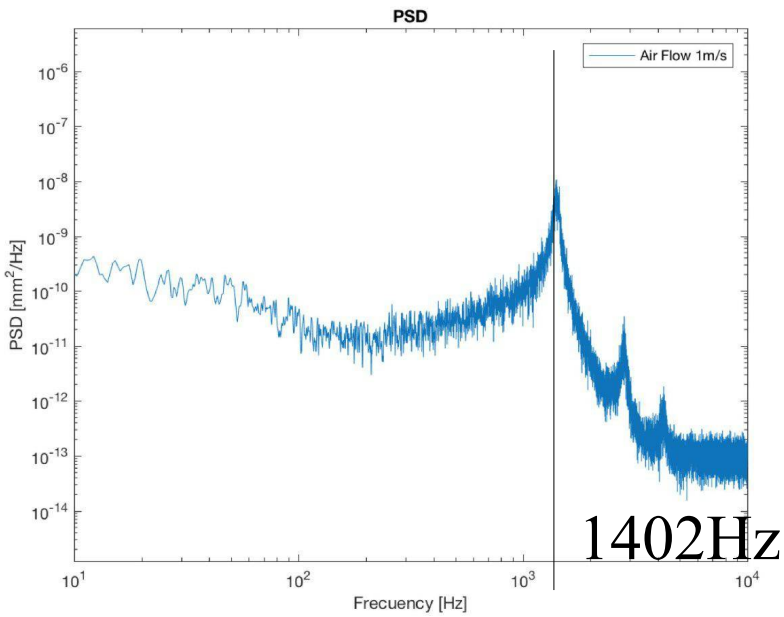


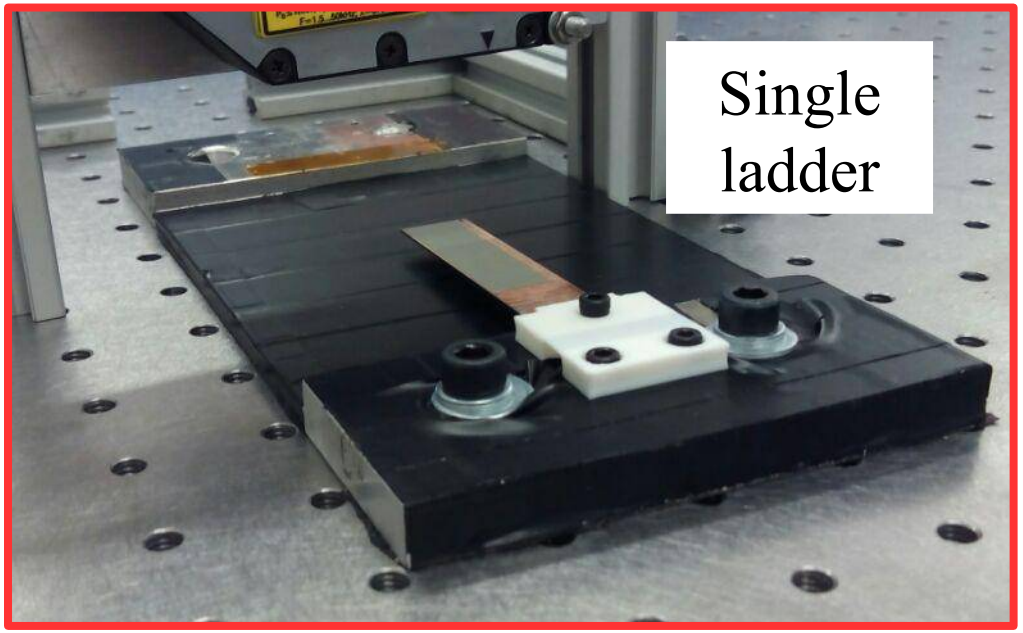
v=1m/s	Peak2Peak	RMS
Single ladder	68um	7,2um
Double ladder	8,1um	2,2um

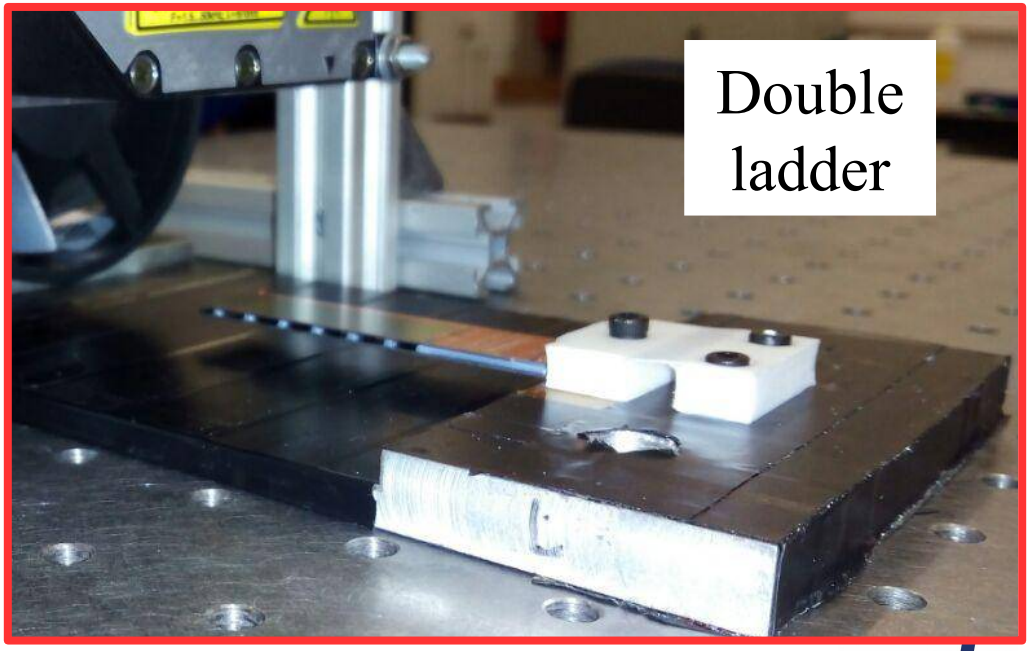
3D printed spacer: 0,01%X/X0 per ladder → **0,01%X/X0 are 9um of Si aprox.**

Services air cooling: Barrel

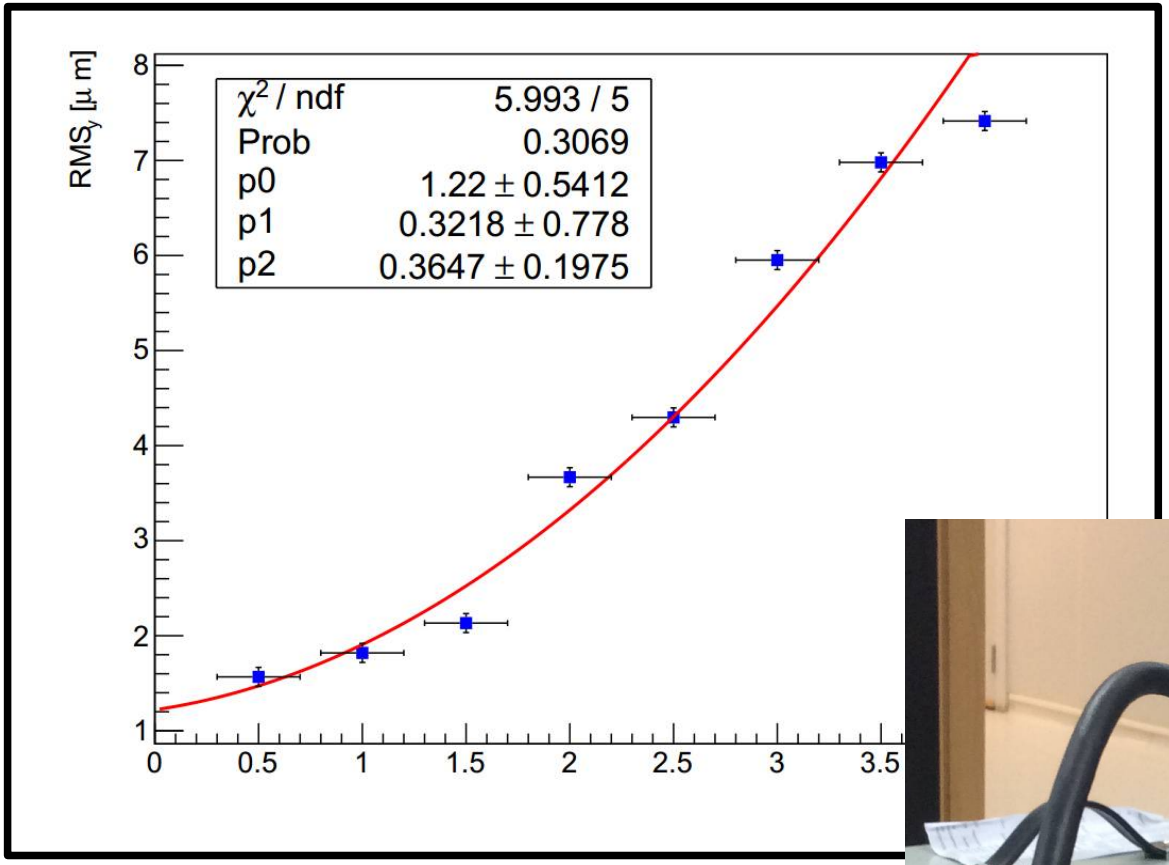


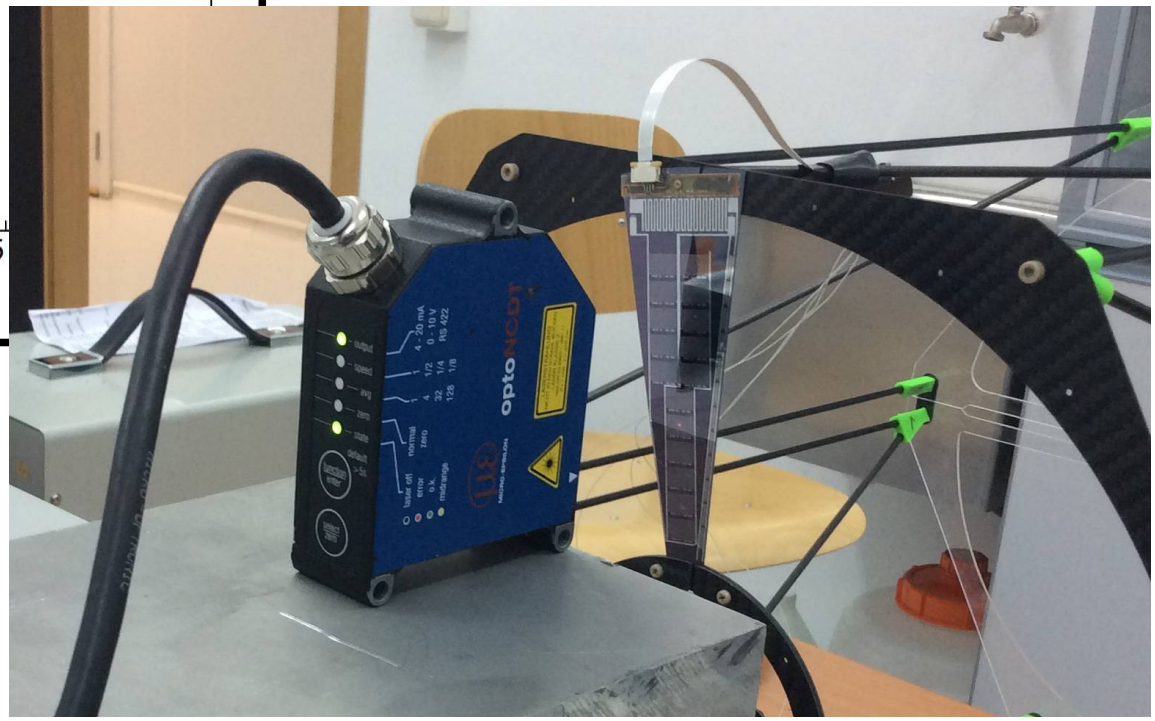




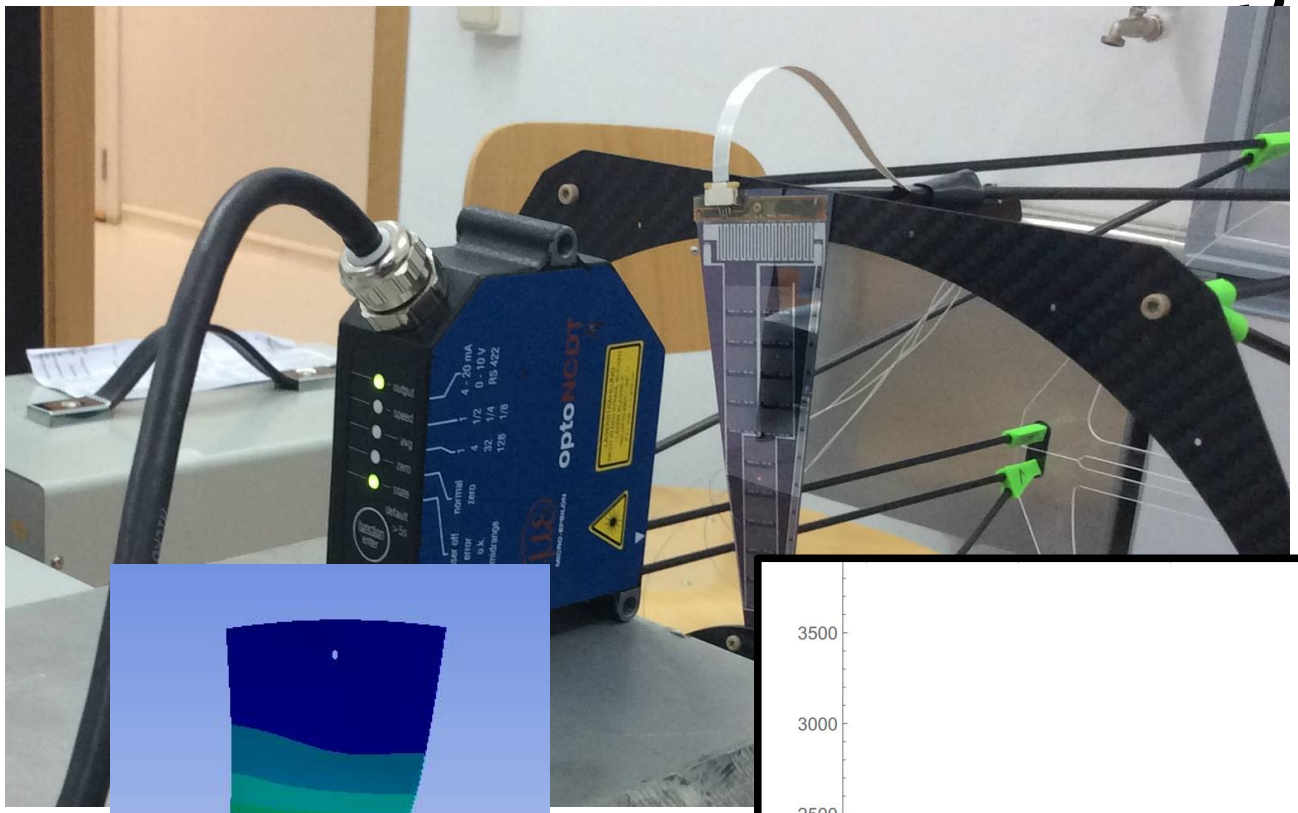


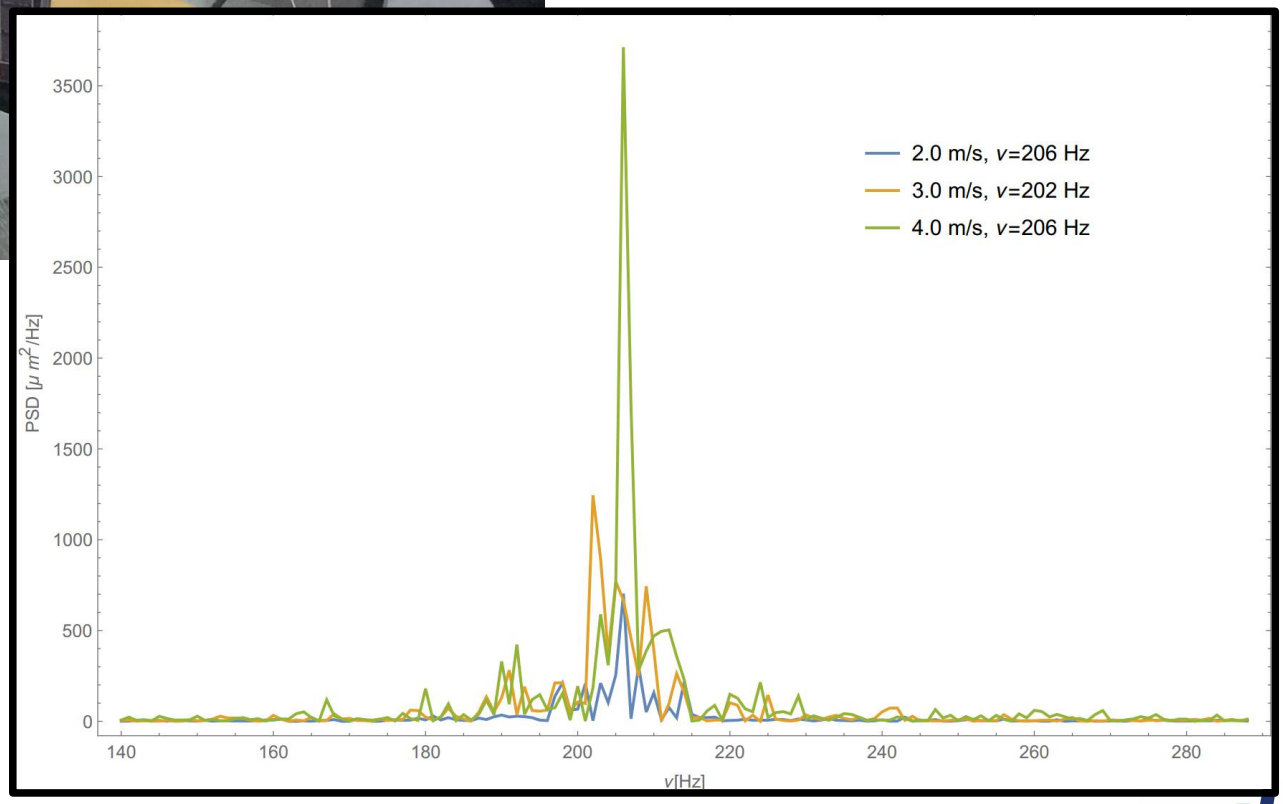
Services air cooling: Endcap





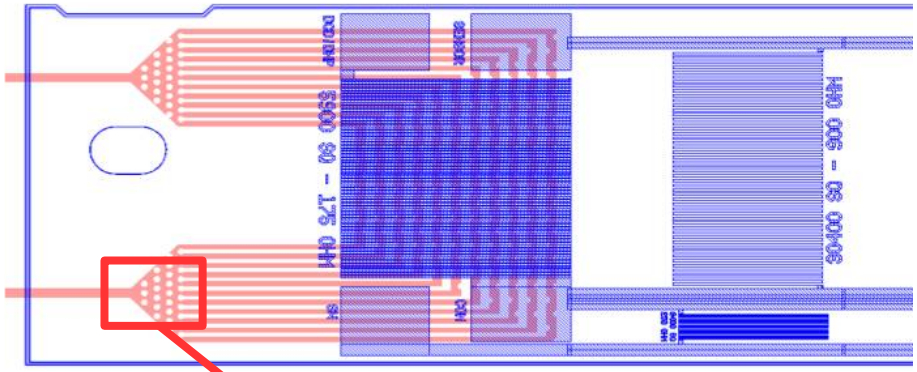
Services air cooling: Endcap

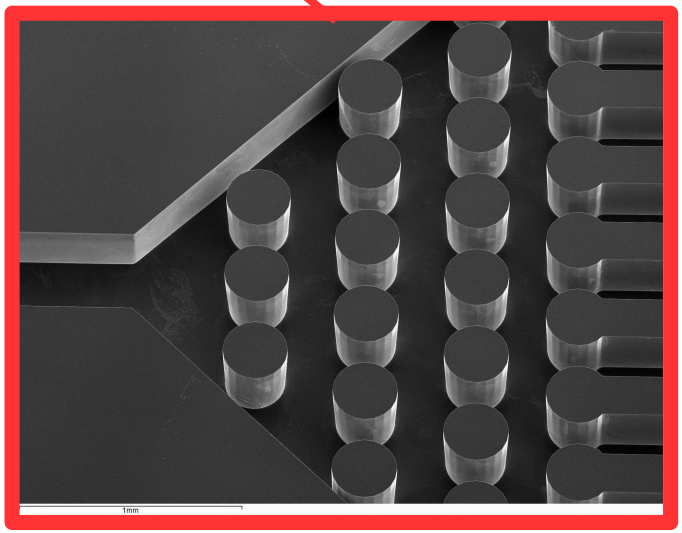




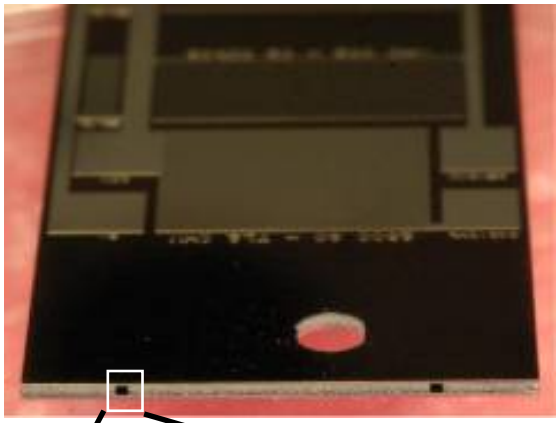
Services mcc: barrel

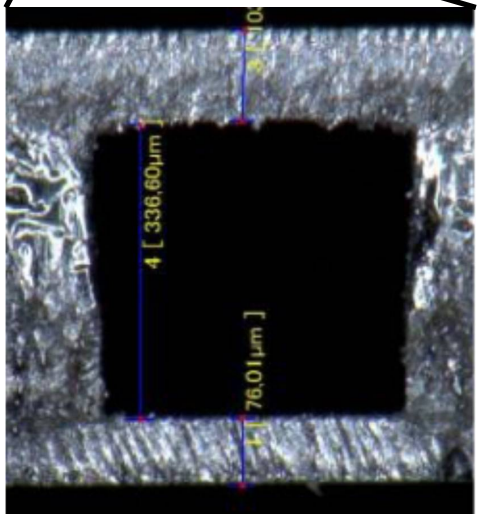
The resistive dummies with integrated micro-channels based in DEPFET layout design:





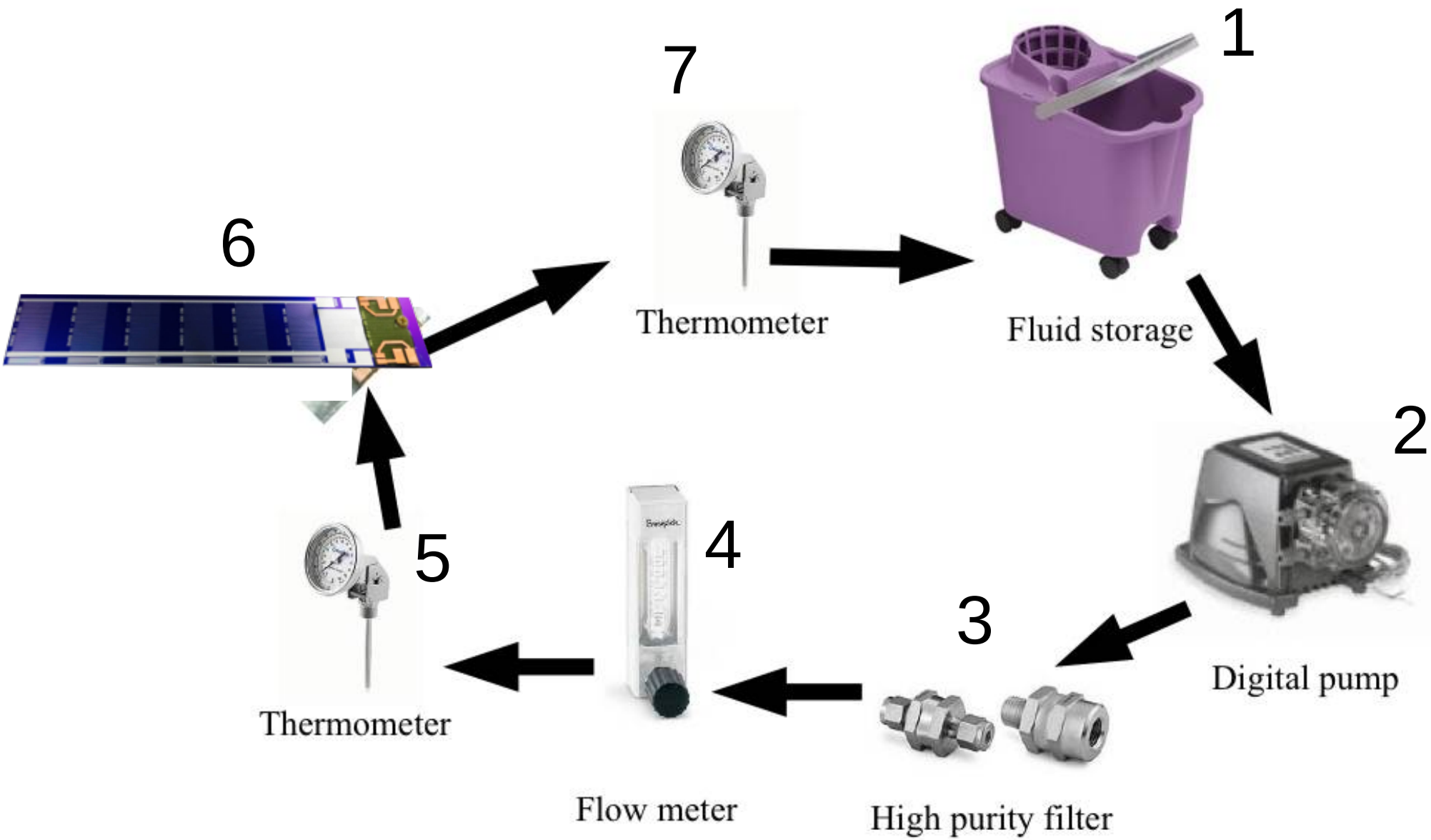
Micro-channel pattern in handle wafer



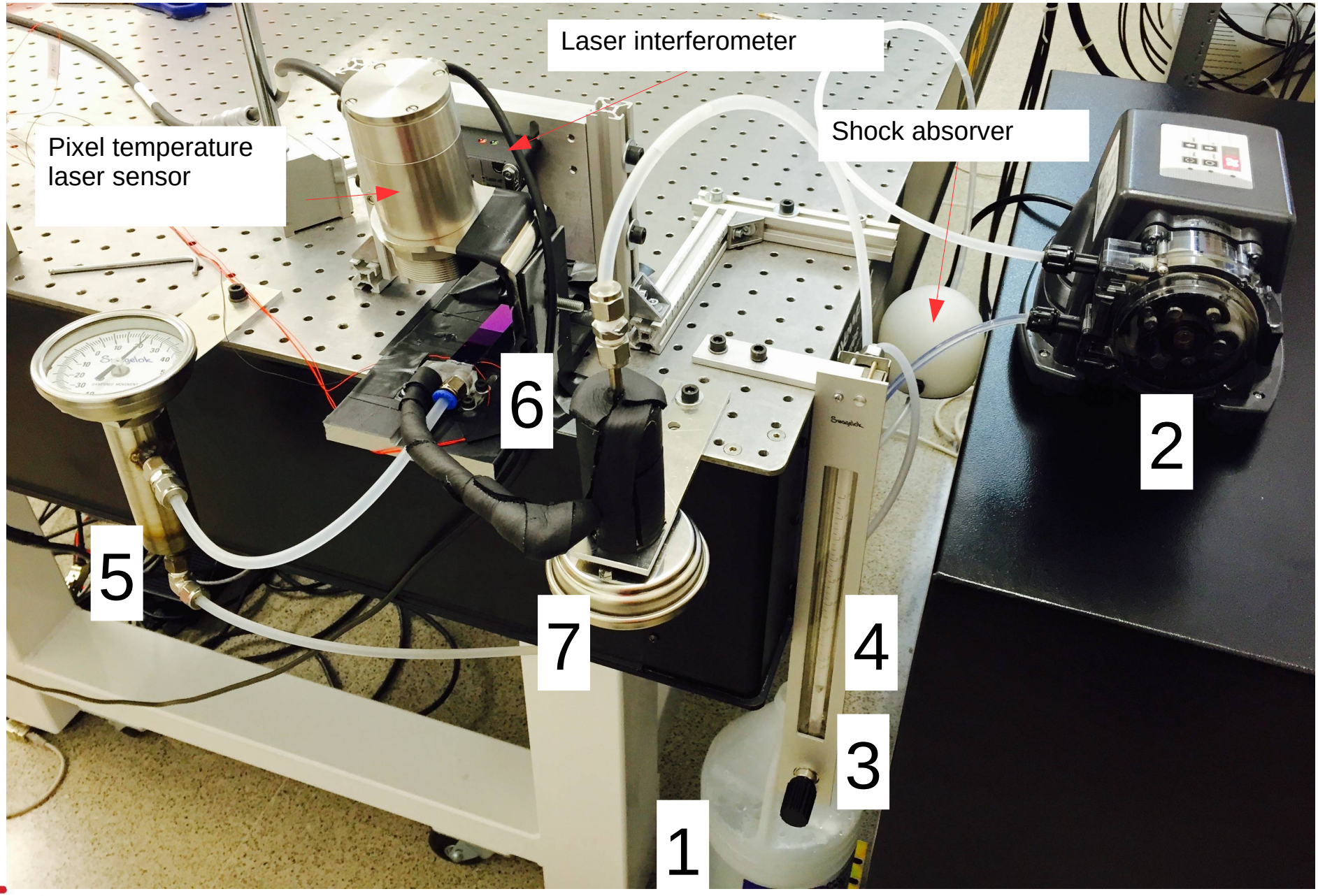


Inlet and outlet: ~380 x 340 µm

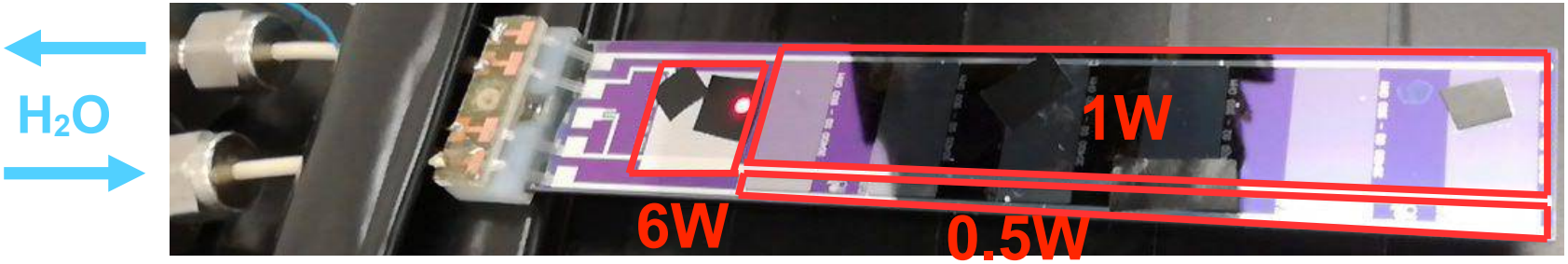
Services mcc: barrel

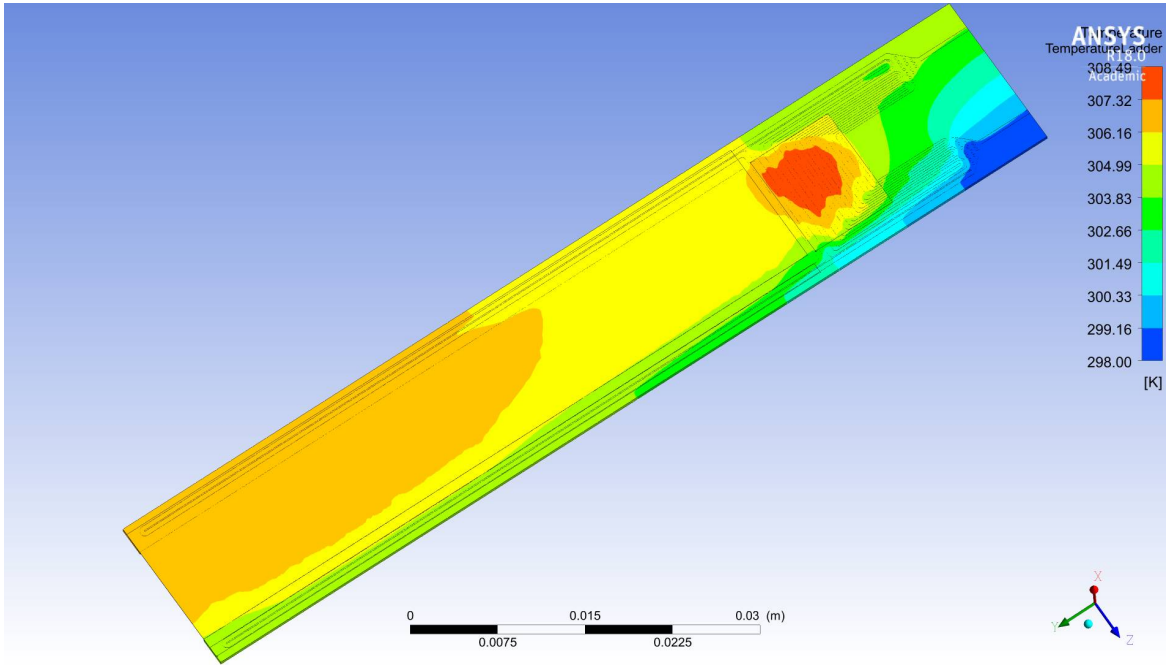


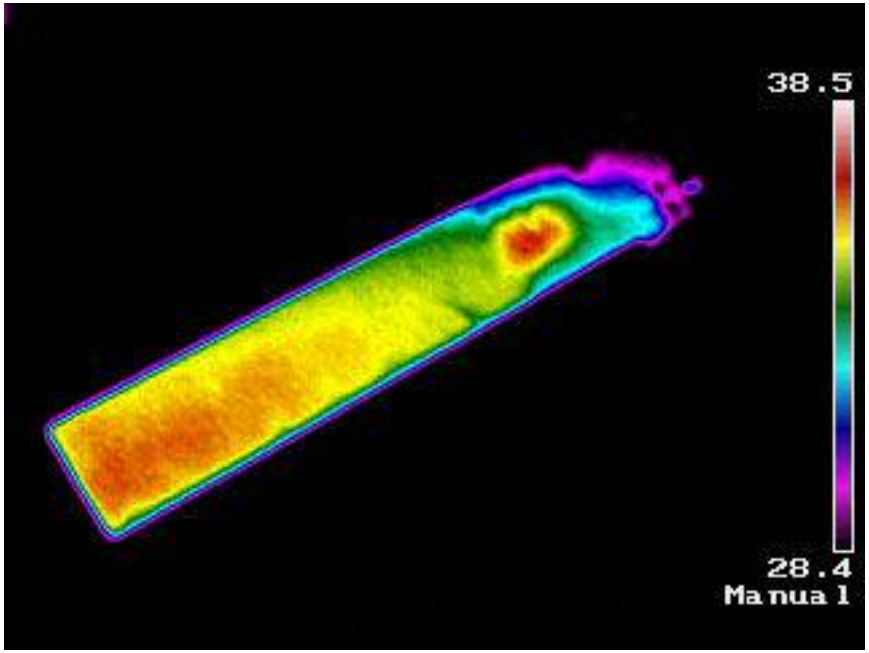
Services mcc: barrel



Services mcc: barrel





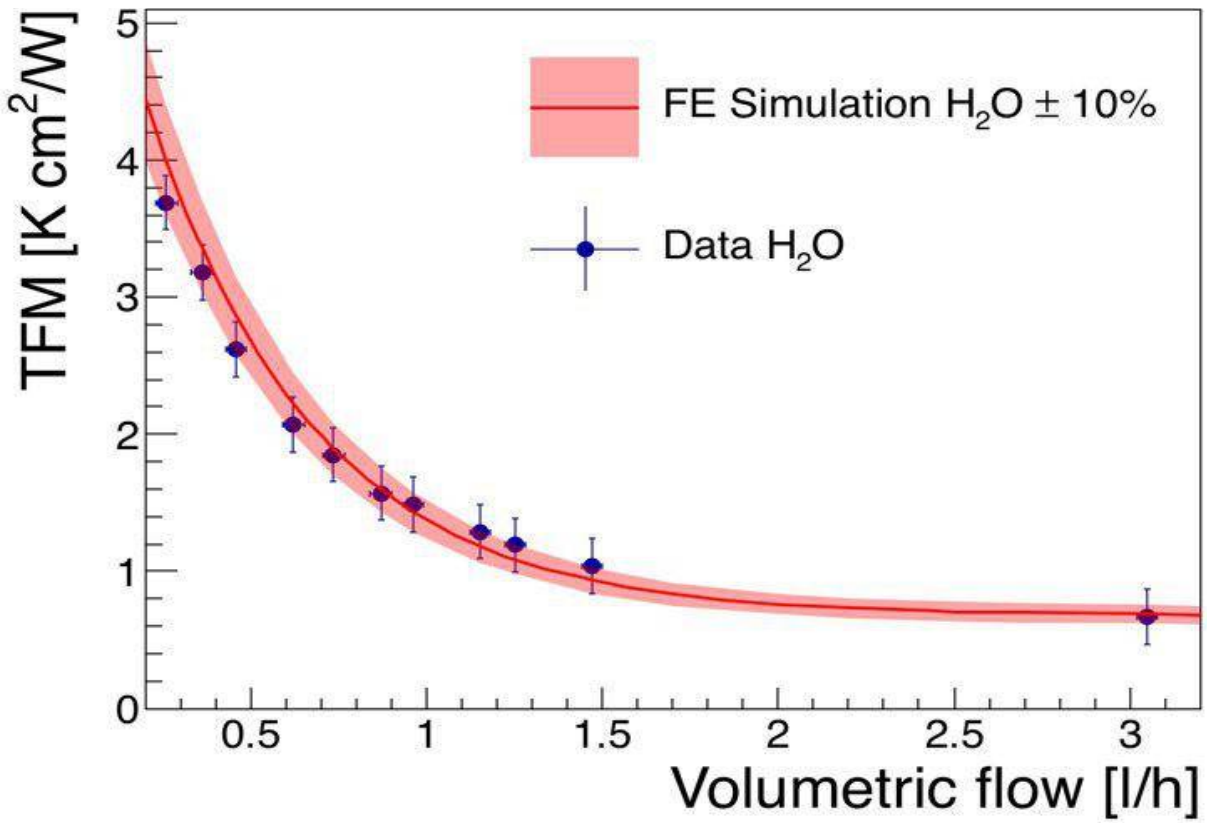


- Inlet in the simulation is the outlet in the test
- Thermal camera inside black box
- Simulation ΔT=10,5K and test ΔT=10,1K

Services mcc: barrel

Services

- Power to deliver
- Cooling strategy
- 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

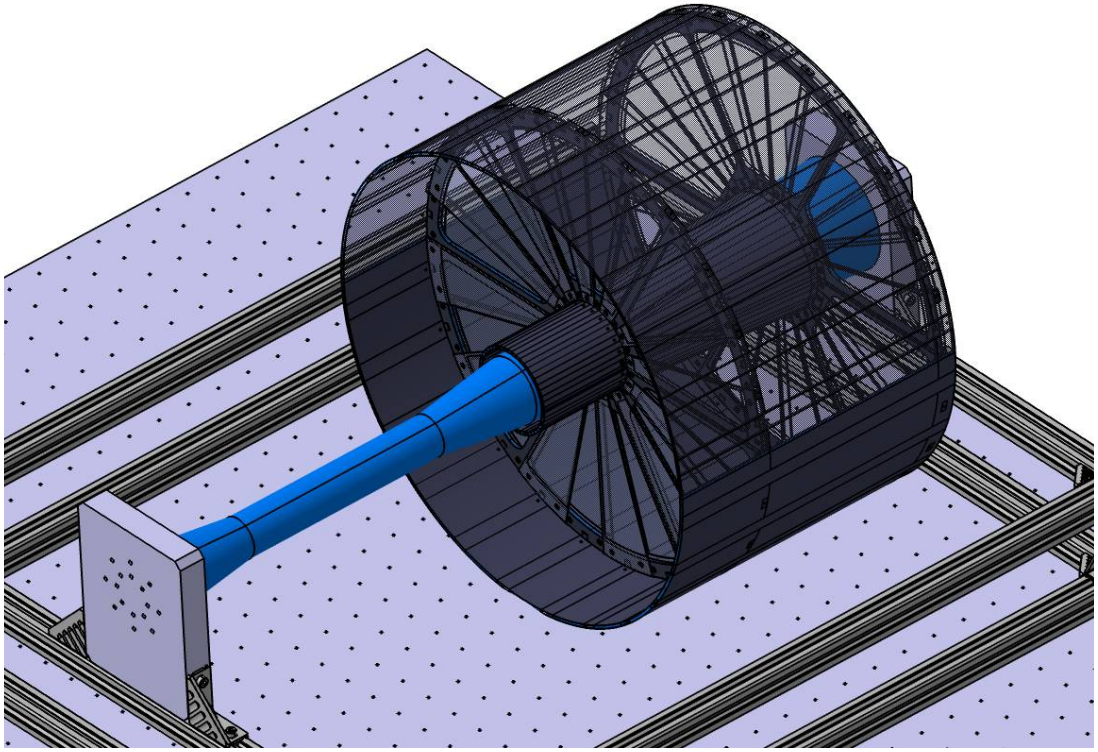
Good agreement with FE simulation within 10% error

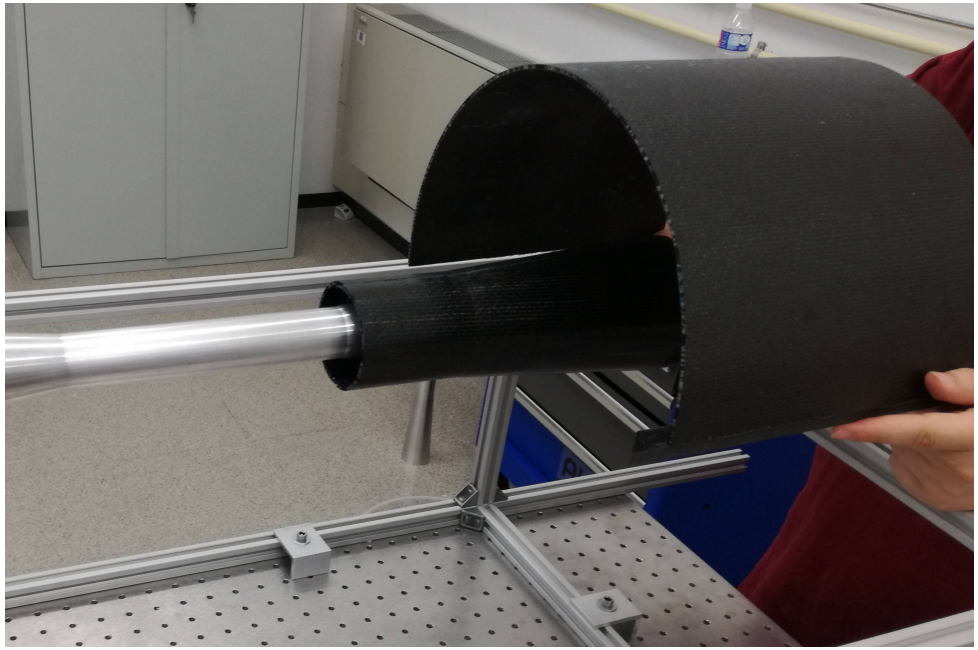
In low Vol. Flow, tests are very sensitive to the Vol. Flow error

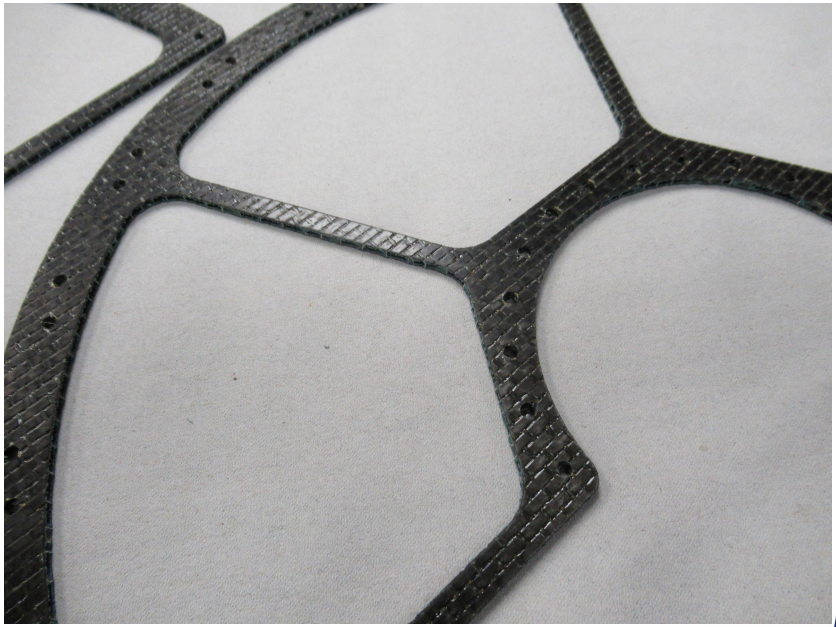
In high Vol. Flow, test are very sensirive to the Temp. error

Integration

Integration

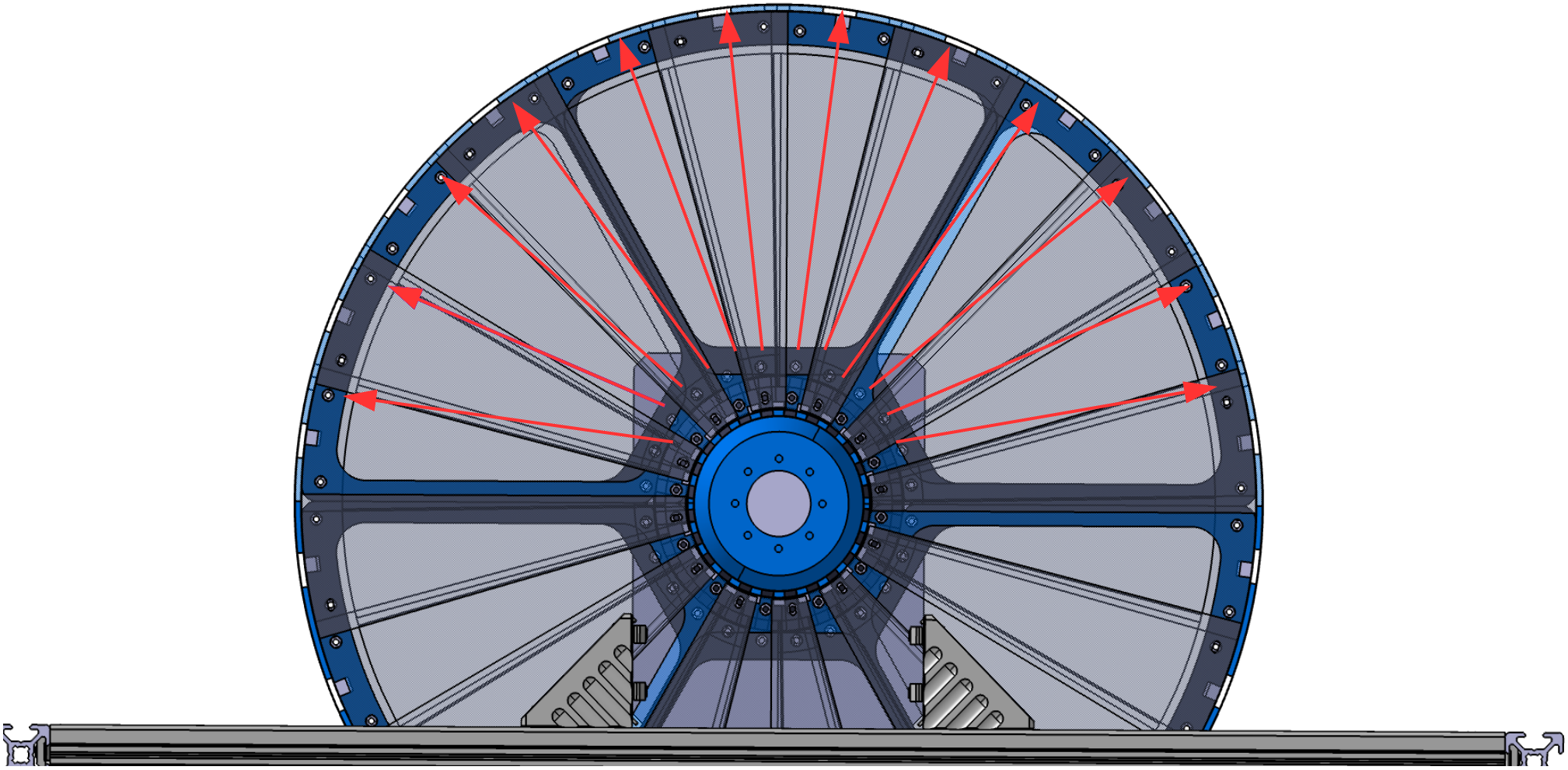






Integration

Integration



Summary

- Presented some steps for mechanical characterization for sensors structures

- Presented some real problems that engineers have to deal with when building VTX detectors and some of their solutions: joints, integration, …

- Too many variables: layout, materials, cooling strategy, sensor technology, … so it is needed clear and very detailed specifications made by physicists thinking in Physics (but also in real possibilites)

- Siingle ladders vs double ladders?

- Air vs mc cooling?

- MCC is not the baseline but has been demonstrated to be a competitive solution: mcc qualification for more information