Progress on R&D at INFN-Pisa

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on behalf of the INFN Pisa mechanical studies group

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004761.

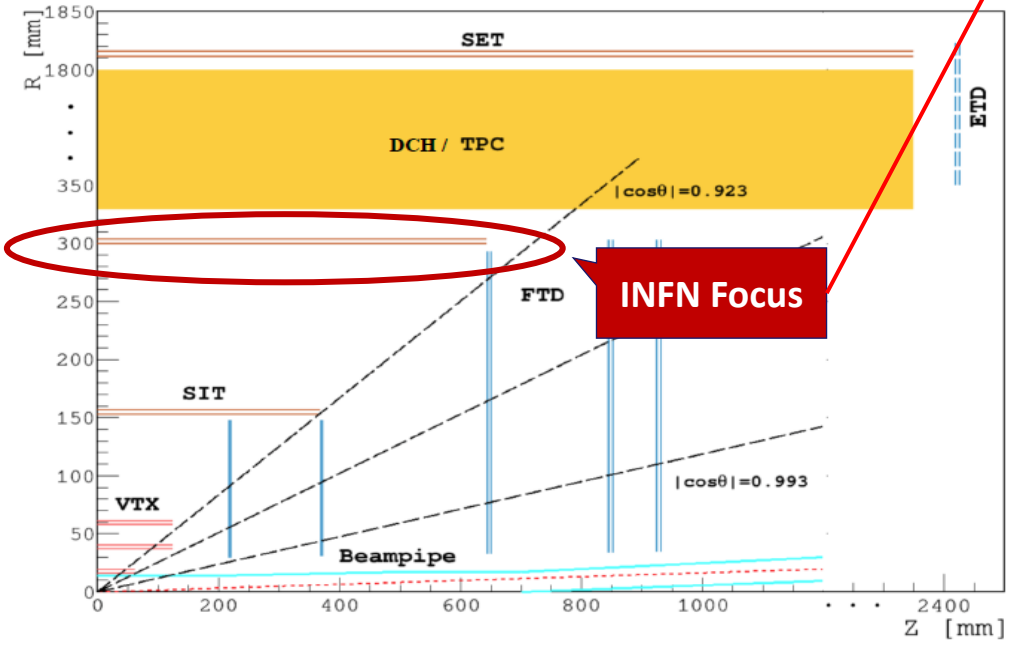
- Light structure for CEPC
- Light structure for Belle 2 DMAPS VTX Upgrade
- Conclusions

CepC Tracker

Baseline tracker design: TPC

and 3 layers / 5 disks of silicon sensors,

50 m² (33 w/o ETD) if built in CMOS pixels (strips default)



Detector		Radius R [mm]	$\pm z$ [mm]	Material budget [X_0]
SIT	Layer 1	153	371.3	0.65%
	Layer 2	300	664.9	0.65%
SET	Layer 3	1811	2350	0.65%
		R_{in}	R_{out}	
FTD	Disk 1	39	151.9	220	0.50%
	Disk 2	49.6	151.9	371.3	0.50%
	Disk 3	70.1	298.9	644.9	0.65%
	Disk 4	79.3	309	846	0.65%
	Disk 5	92.7	309	1057.5	0.65%
ETD	Disk	419.3	1822.7	2420	0.65%

Physics process	Measurands	Detector subsystem	Performance requirement
$ZH, Z \to e^+e^-, \mu^+\mu^-$ $H \to \mu^+\mu^-$	$m_H, \sigma(ZH)$ $\mathrm{BR}(H \to \mu^+\mu^-)$	Tracker	$\Delta(1/p_T) =$ $2 \times 10^{-5} \oplus \frac{0.001}{p(\mathrm{GeV})\sin^{3/2}\theta}$

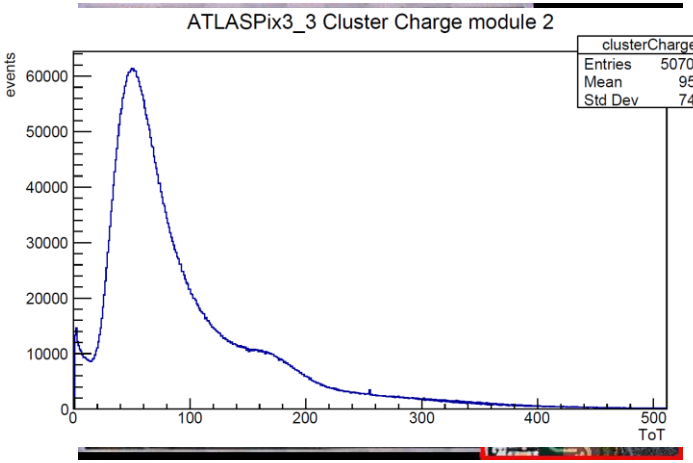
$\sigma_{r\phi} \approx 7\mu m$

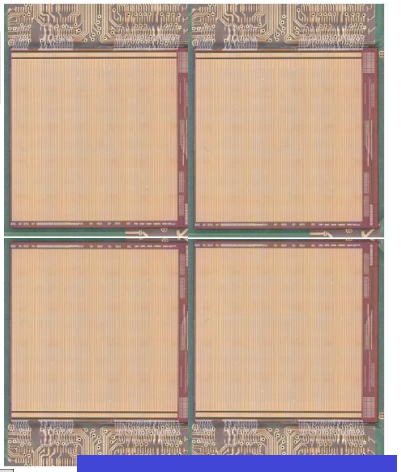
AtlasPix3

DETECTOR

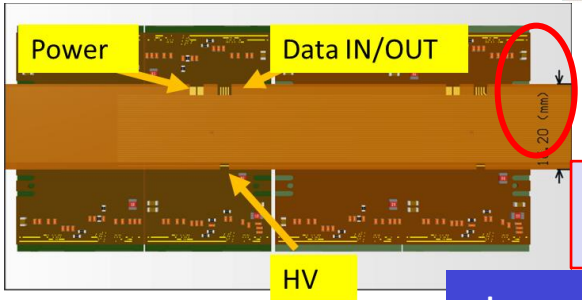
Total thickness 372 µm
Total copper 36 µm

- Based on ATLASPIX3 R&D
  - 50 x 150 µm2
  - Up to 1.28 Gb/s downlink
  - TSI 180 nm process
  - 132 columns of 372 pixels
- Active length (r-phi x z)
  - 18.6 mm x 19.8 mm
- Module is made of 2x2 chips
- Power goal 100 mW/cm^2 (175 now)
- Module tested on beam (DESY)





4 chip module

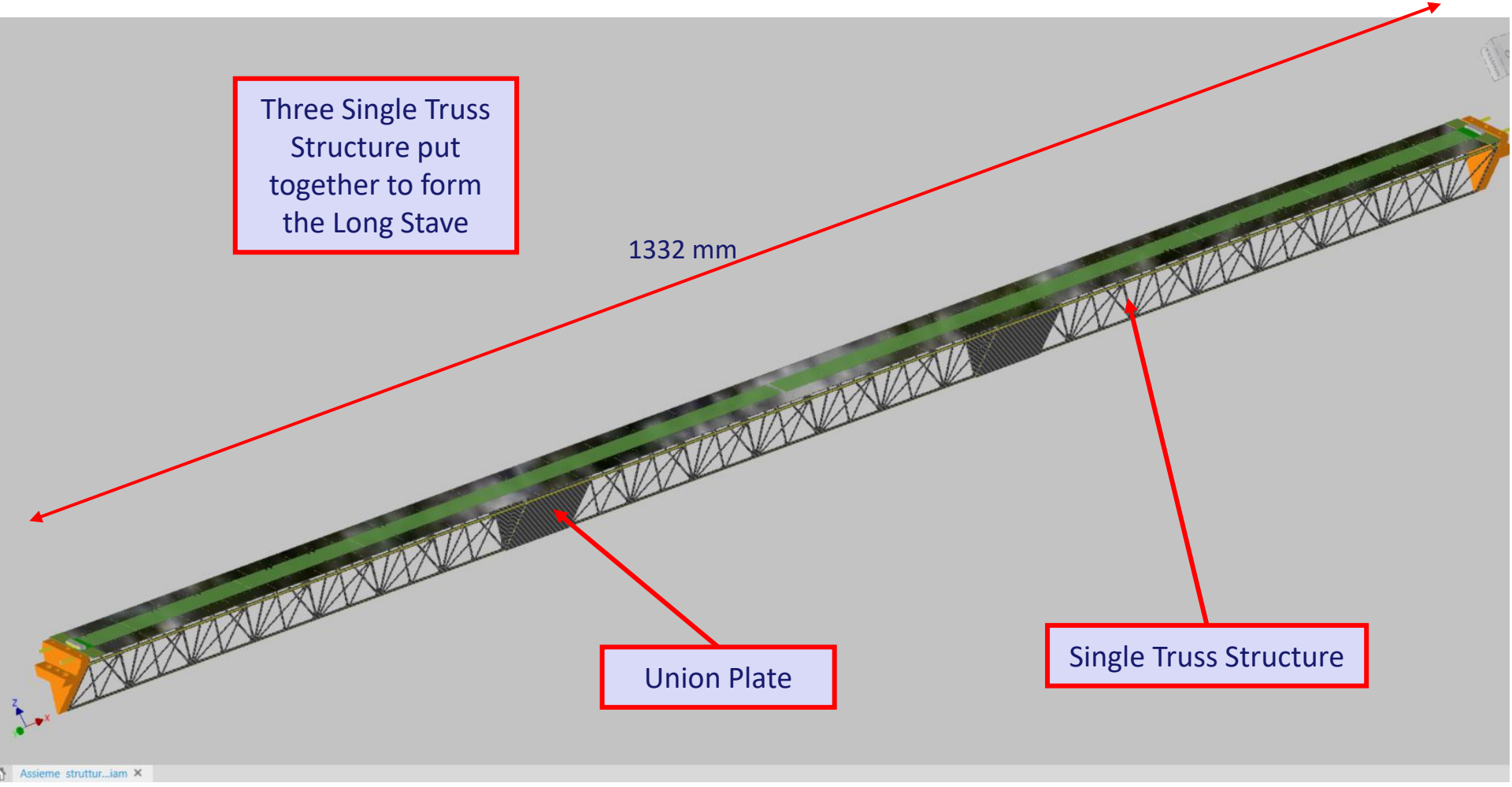


stave

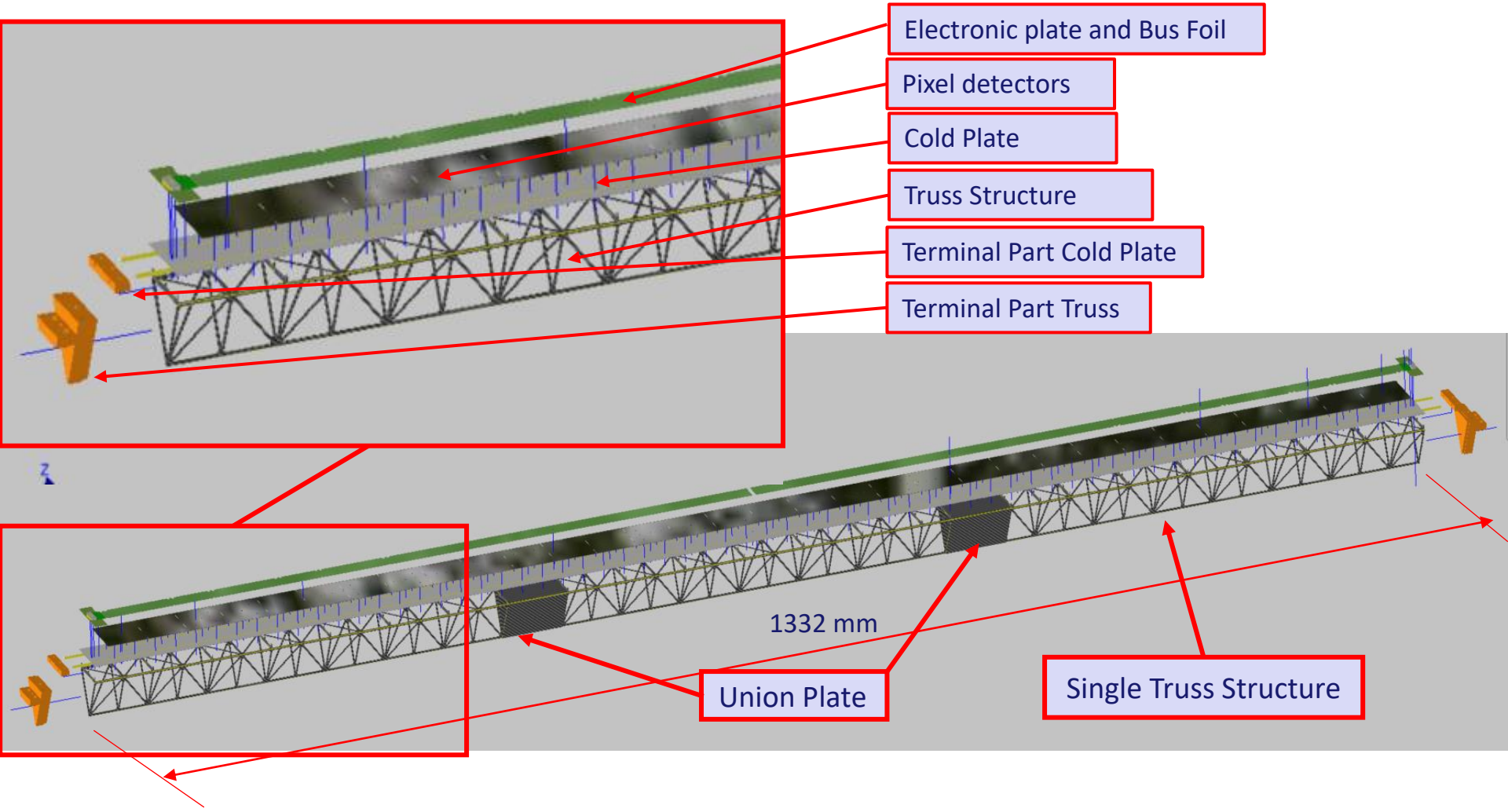
Attilio Andreazza Group
INFN Milano

Collaboration: INFN, IHEP, KIT, Liverpool

Long Stave for the Outer Tracker of the CEPC Experiment

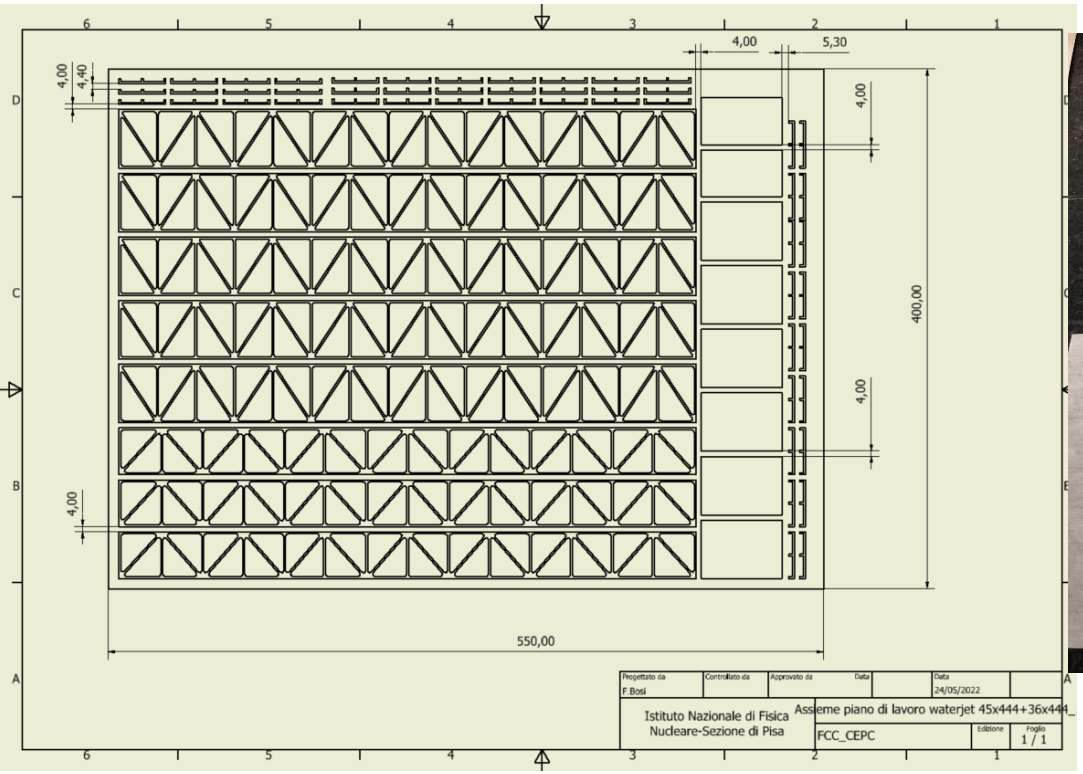


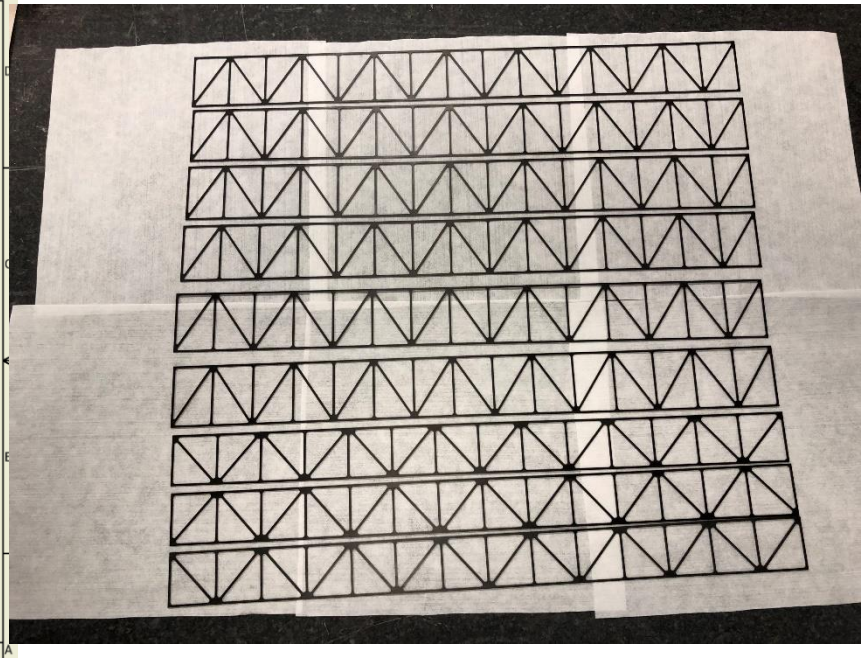
Long Stave Exploded View



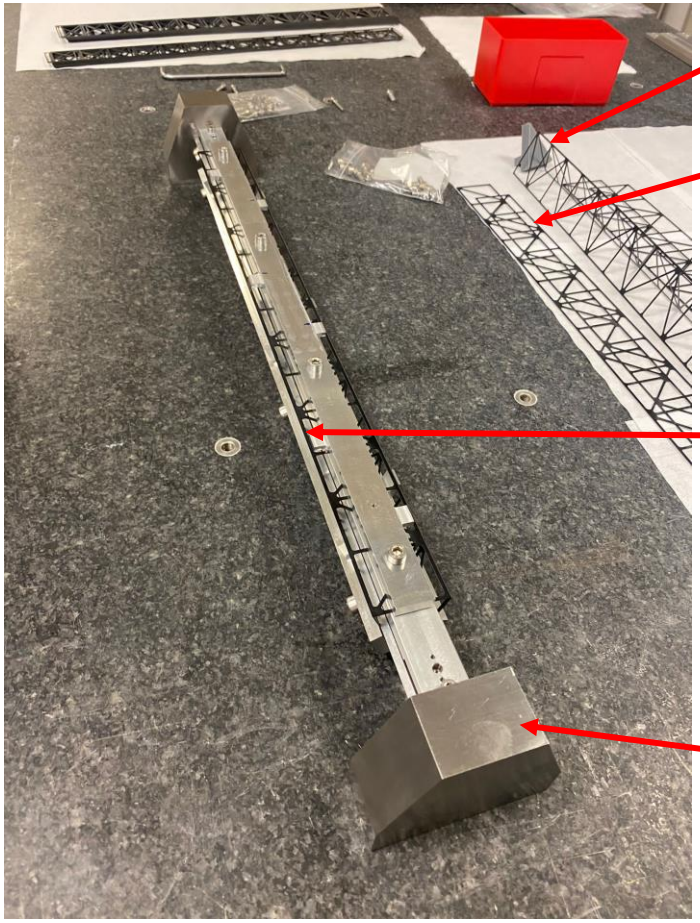
SINGLE SHORT TRUSS STRUCTURE

- LAMINATED FOIL
- Th=0.5 mm of 550x460 mm^2
- Carbon Fiber MJ46



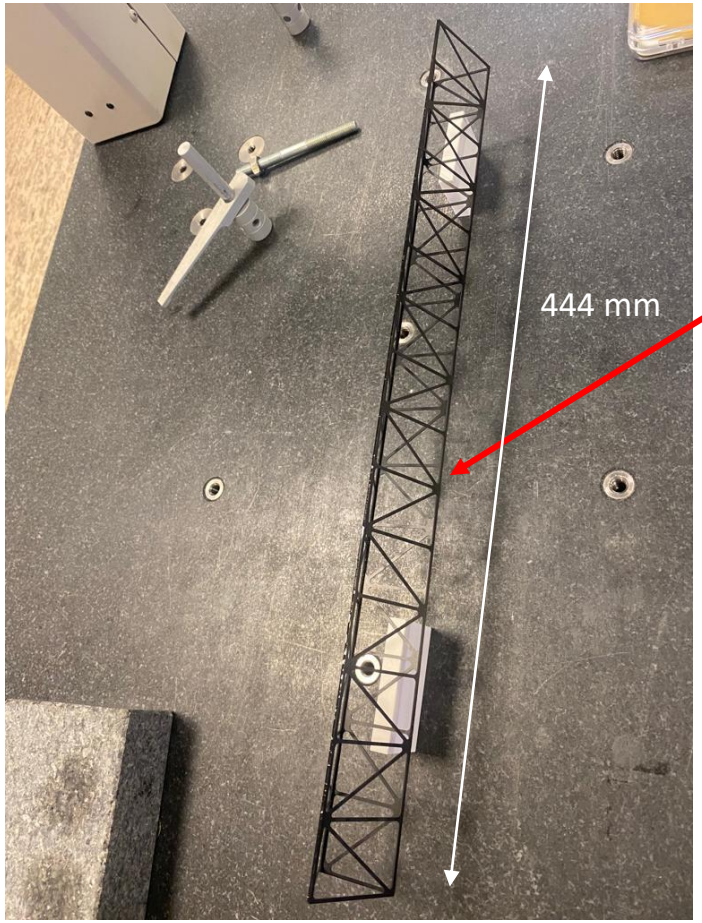


Single truss structure realized by WataJet Company
Special process waterjet technology (precision 50 µm)



Single truss structure mask assembled and glued on the mask

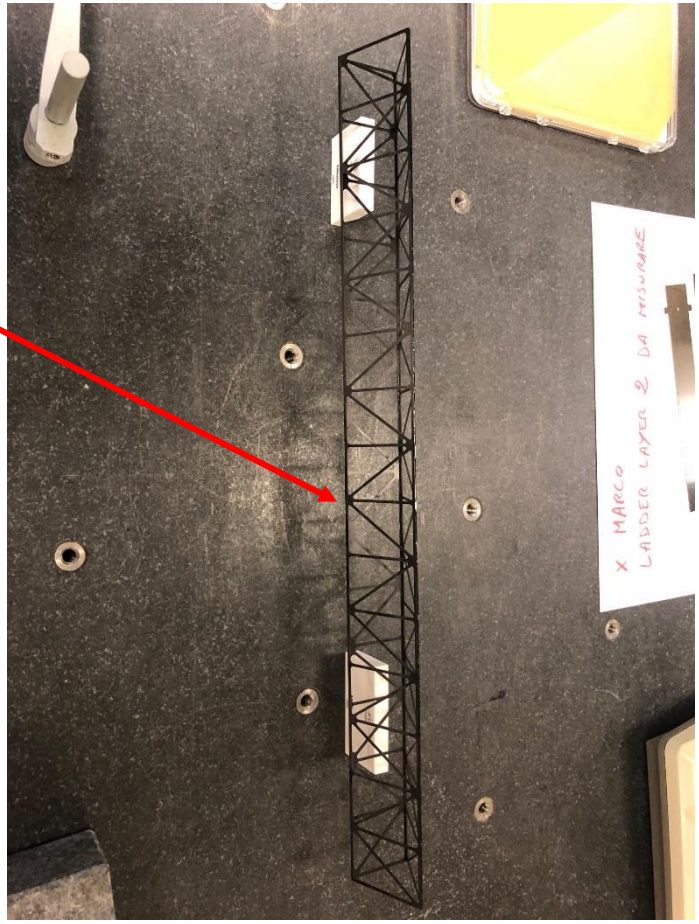
SINGLE SHORT TRUSS STRUCTURE BY SHORT MASK



Single truss structure realized

glueing with Araldite 2011 and Cyanacrlilate

Until now three truss structures realized

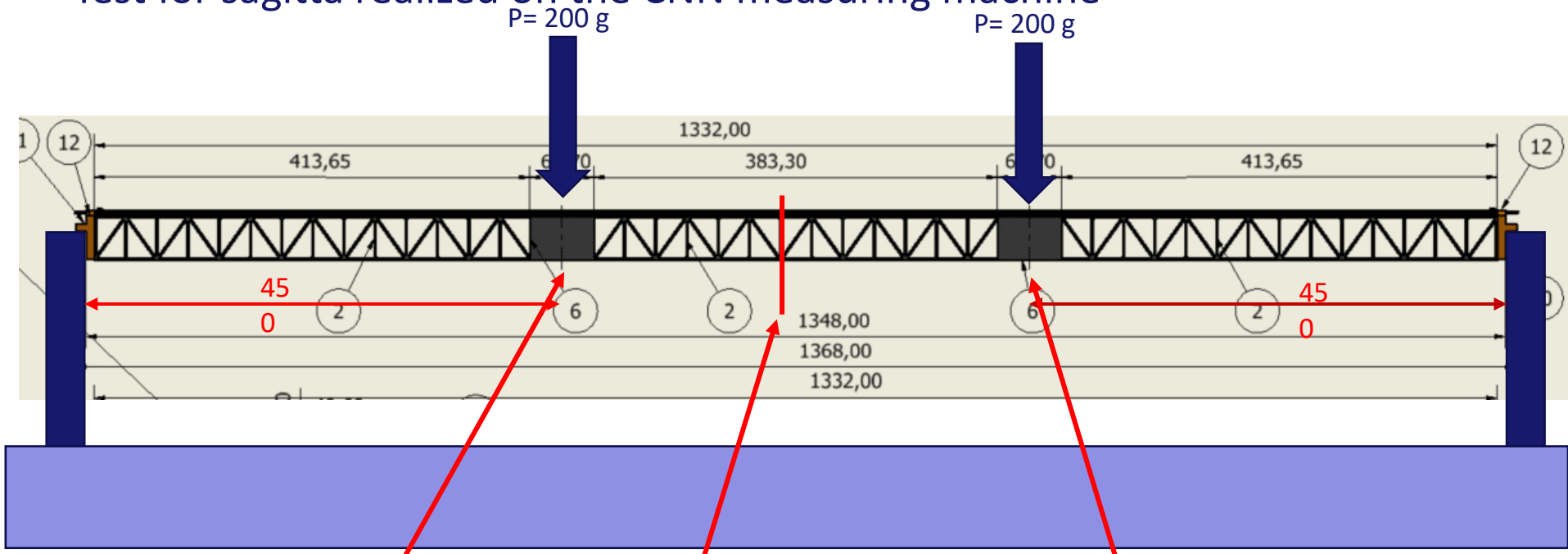


SINGLE LONG TRUSS STRUCTURE BY LONG MASK

- One sample realized until now

EXPERIMENTAL TEST FOR THE SAGITTA VALUE OF SUPER WEIGHT LOAD

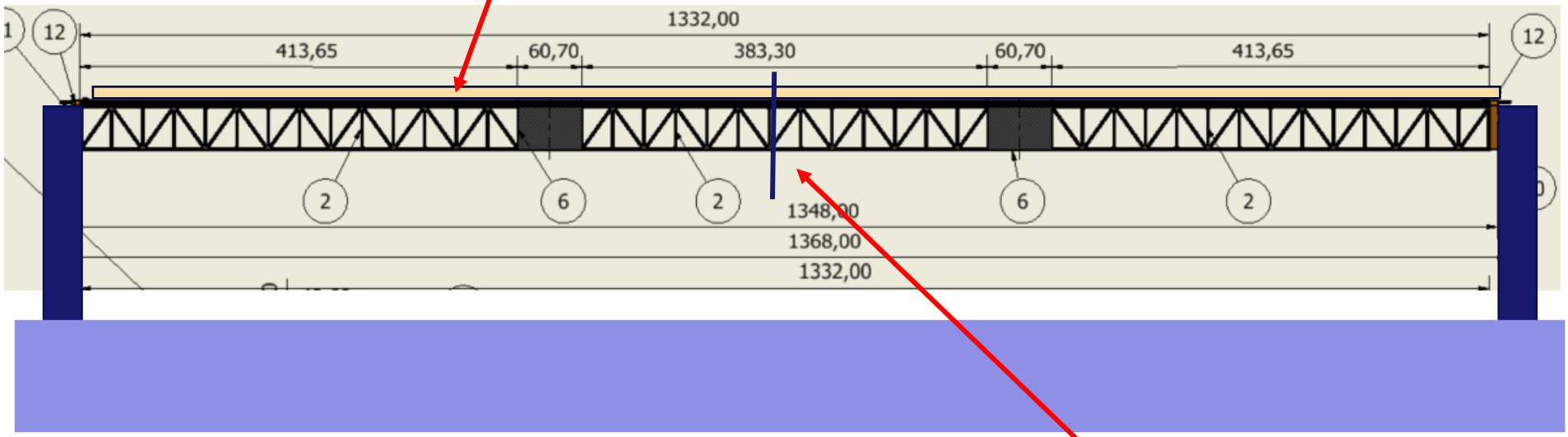
- Test for sagitta realized on the CNN measuring machine



Sagitta measured at the center and at the point where applied the load

EXPERIMENTAL TEST FOR THE SAGITTA VALUE OF THE REAL WEIGHT

Equivalent weight uniformily distribuited of the detector + electronic + Power Bus + Cold Plate= 164,85 g



Test for sagitta realized on the CNN measuring machine

Sagitta measured at the center of the truss

TRUSS STRUCTURE UNDER MEASURING MACHINE

- Truss Structure positioned under the 3D CNN Measuring Machine Hexagon DEA GHIBLI
- Volume measured 3500x1500x1800 mm^3
- Precision X,Y,Z axis 4,5 micron

RESULTS

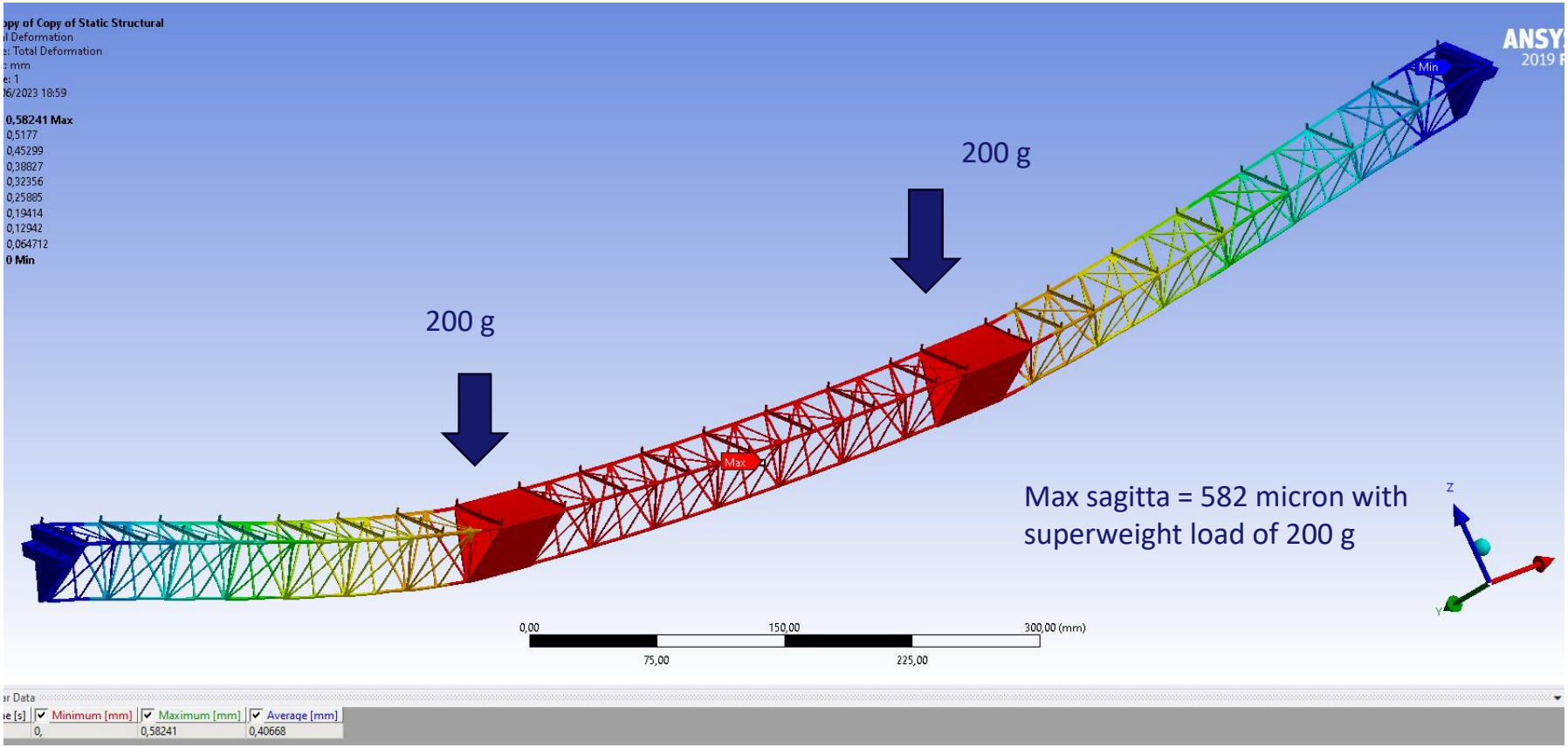
Super Weight Test

- Concentrated load 200 g at 450 mm from each edge
- Sagitta at 450 mm from the edge = 800micron
- Sagitta at the center of the structure = 900 micron

(Some difference with the simulation value attributable to a non conformal CFRP material: to be optimized)

Real Weight Test

- Uniformily load distributed of 164,85 g
- Sagitta at 450 mm from the edge =210 micron
- Sagitta at the center of the structure = 280 micron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mm
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/6/2023 18:59
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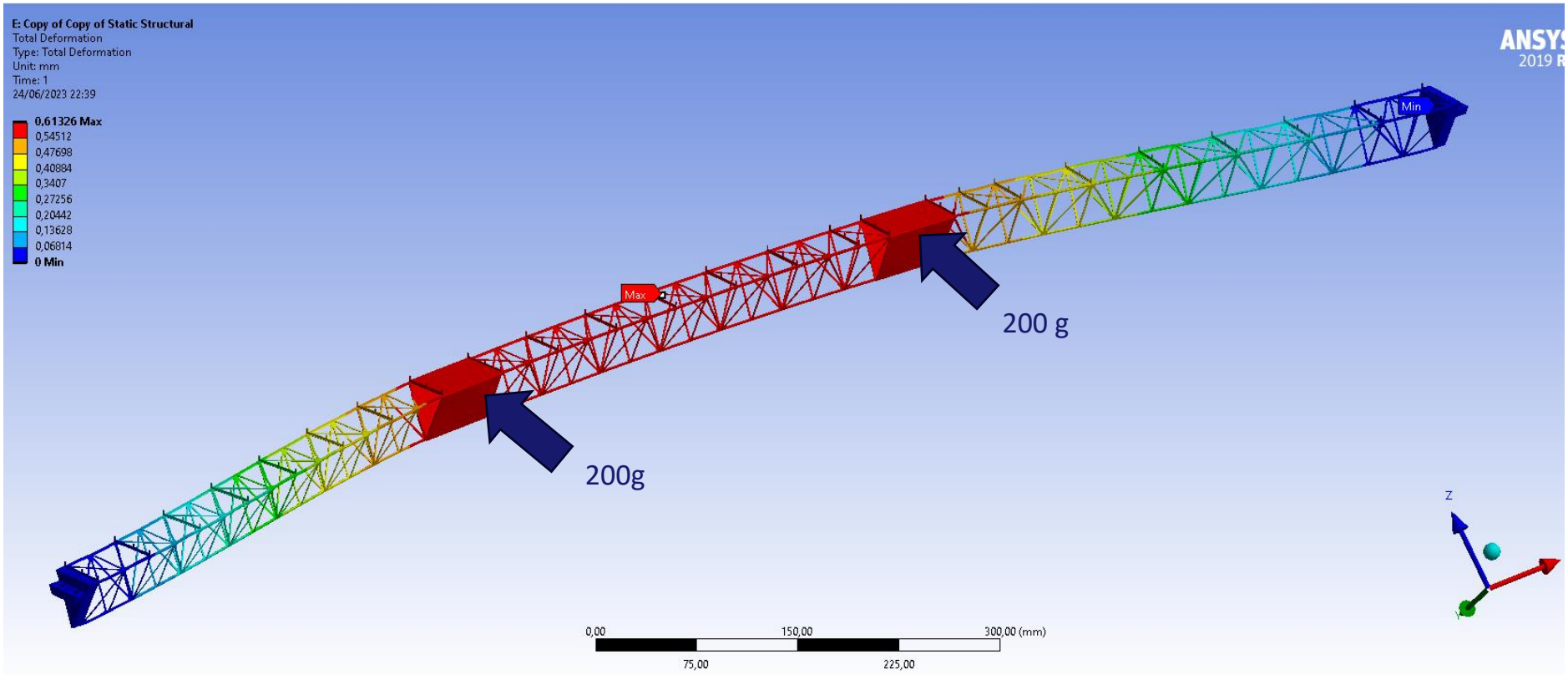
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0,54512
0,47698
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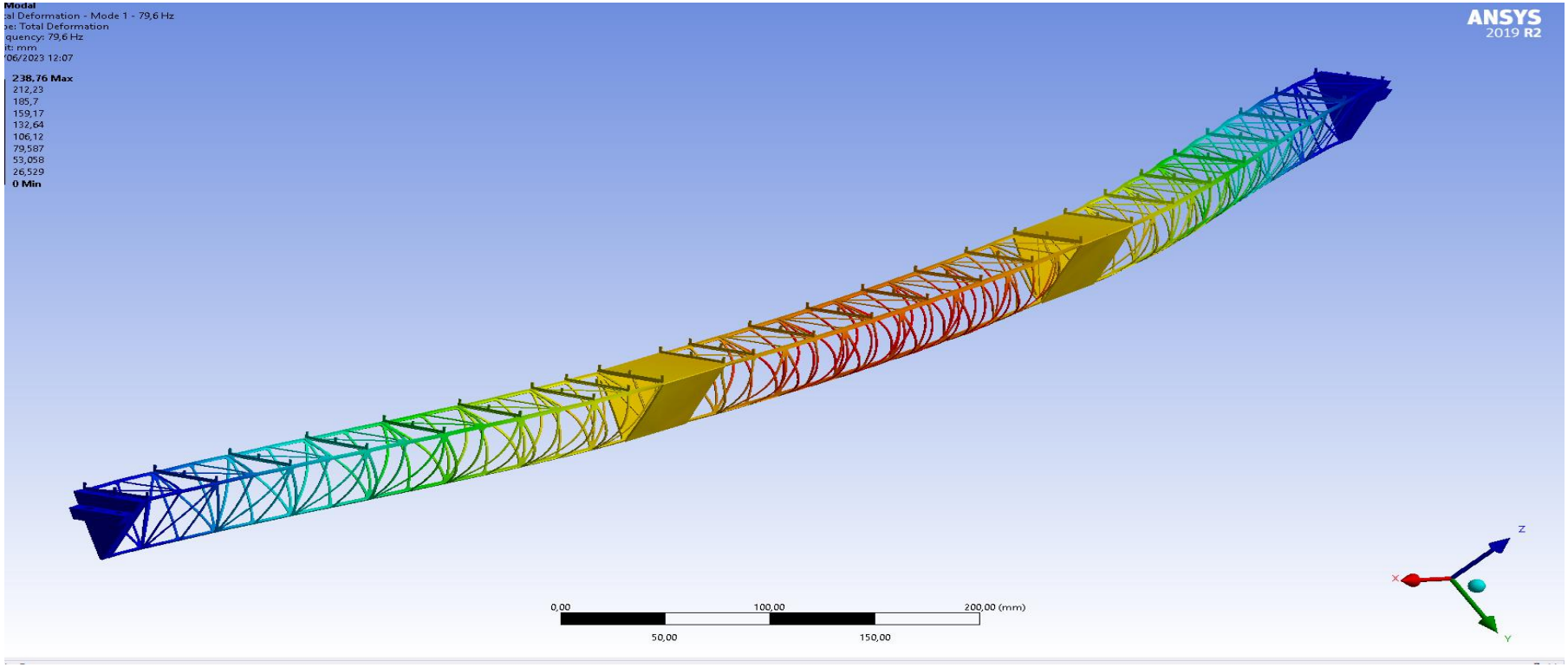
- First Frequency of resonance = 79,6 Hz
- Second frequency of resonance = 81,4 Hz
- Third Frequency of resonance = 166,6 Hz



The DMAPS Upgrade of the

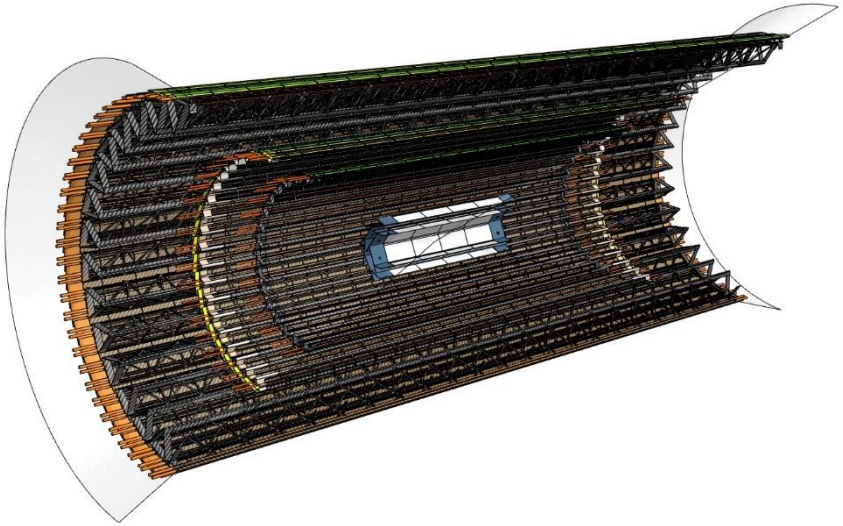
The SuperKEKB collider is planning a major upgrade of the I.R. to reach the design luminosity.

- **All-layer monolithic** vertex detector upgrade (**VTX**) to be installed in LS2 in ~2028:
  - More performant and resilient against higher machine backgrounds
  - Defined target spec's in terms of material budget, spatial resolution and integration time window
  - Baseline chip technology TJ180 nm, evolving from TJ-Monopix2:

    OBELIX: First steps towards a Belle II CMOS sensor, **submission in 2024**

- Realization of prototypes of inner/outer layers ongoing, submitted to the mechanical, thermal and electrical characterization.

- In the finalization phase the CDR of the Belle II Upgrade.



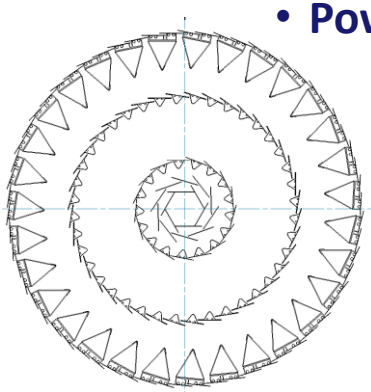
- **Low material budget** (~50 µm thin sensors):
  0.1% X0 (L1-2), 0.3-0.5% X0 (L3-4), 0.8% X0 (L5)

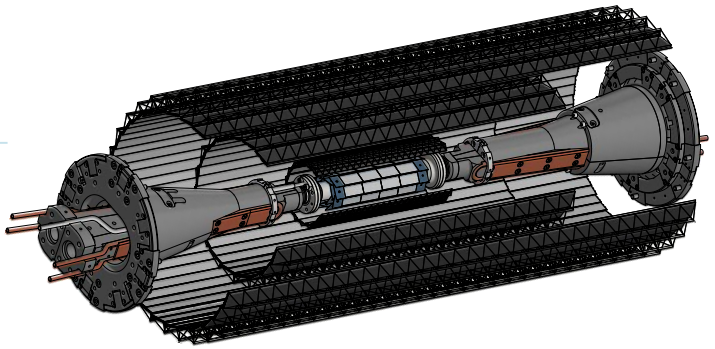
- **Requirements**:
  - Radiation levels for L1 (r=1.4 cm)
    - TID: ~100 Mrad
    - NIEL: ~5∗10^14 n_eq/cm^2
  - Hit-rate up to 120 MHz/cm^2
  - Resolution < 15 um
  - Fast integration time 50-100 ns
  - Operation simplicity and reduced services

- **Depleted monolithic active CMOS pixel sensors**
  - Chip size: 2x3 cm^2
  - Moderate pixel pitch 33 µm^2

- 5 straight **fully pixelated** barrel layers
- **Same sensor chip for all layers**
- **iVTX**: Inner 2 layers

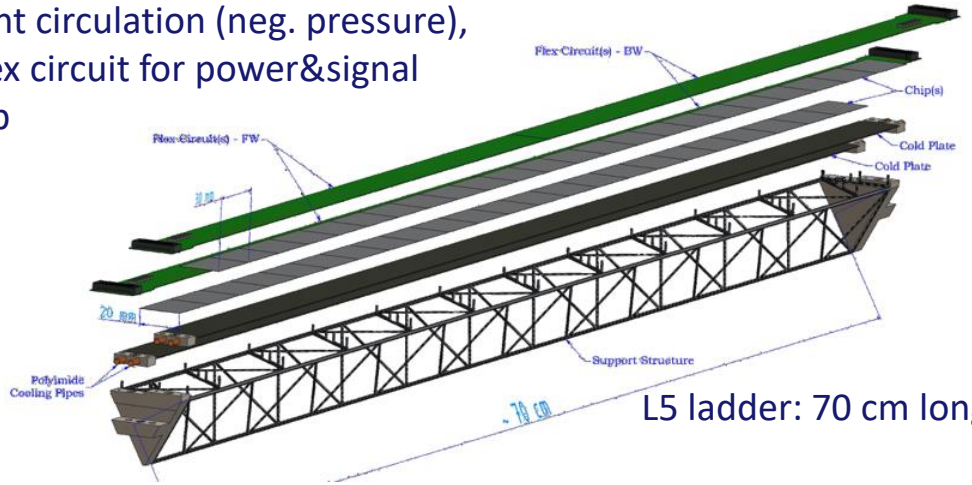
  see Marcel Vos' talk
- **oVTX**: Outer sections (3 layers), CF structure, water cooled
  - L3@3.9 cm (alternative @6.9 cm)
  - L4@90 cm, L5@13.5 cm
- **Power dissipation** $\sim 200\ \mathrm{mW/cm^2}$



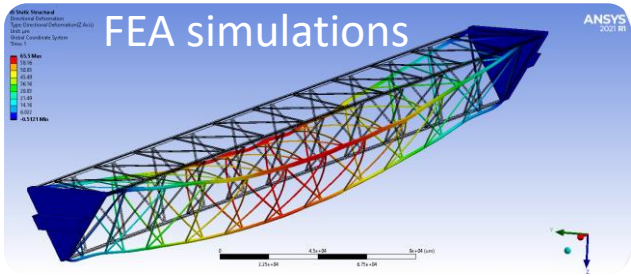


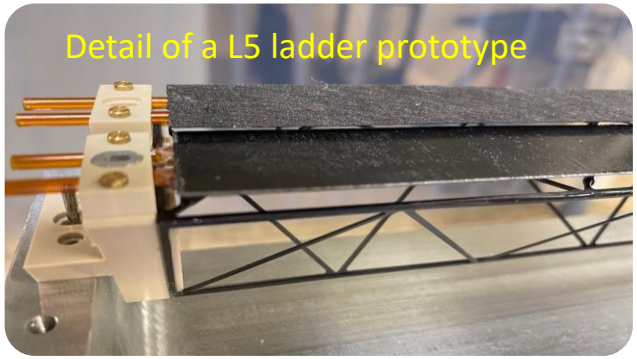
Outer VTX

Ladder structure design inspired by ALICE ITS2, composed of:
CF support structure (truss), cold-plate with pipes for liquid coolant circulation (neg. pressure),
Chip and Flex circuit for power&signal glued on top



L5 ladder: 70 cm long



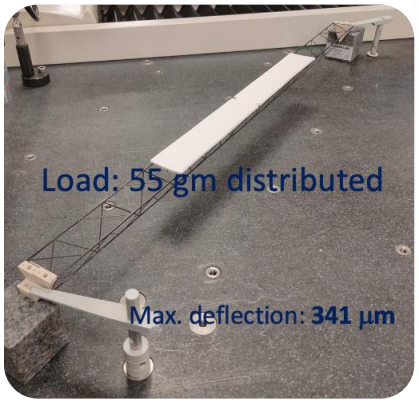


Performed mechanical characterization of the L5 prototype:

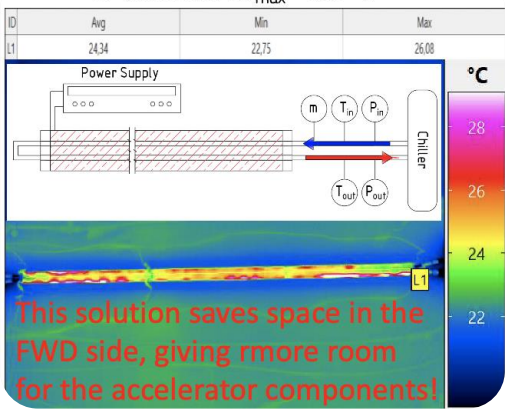
- Distortion: measurements of sagitta (~340 um)
- Vibration: 1st resonance frequency ~250 Hz (>>earthquake f.)

Thermal characterization:

- Used Kapton heaters, inlet (T=10°C) and outlet on one side
- Uniform temperature along the ladder ΔT max=3.3 °C

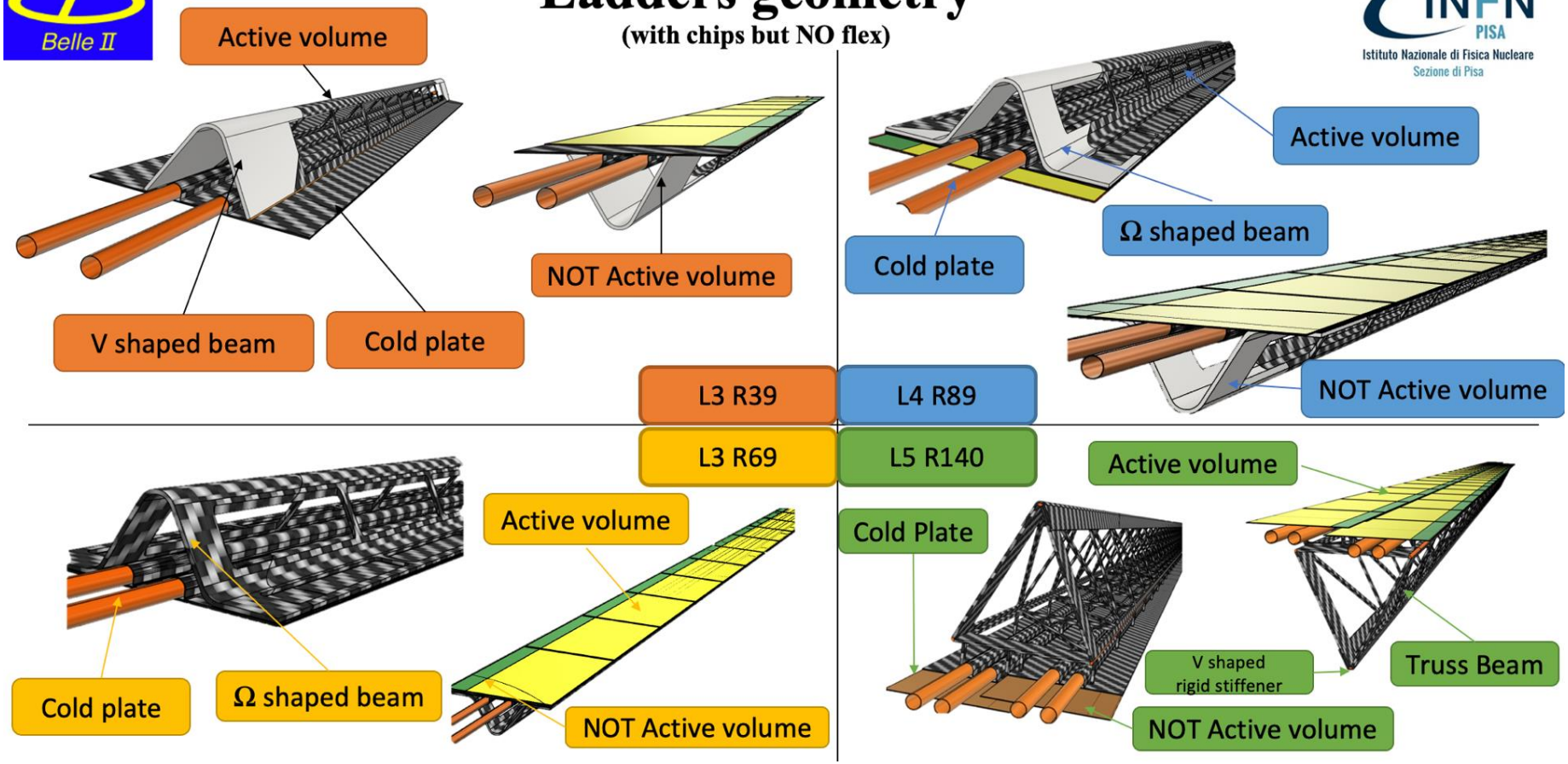


U-turn flow ΔT_{max}= 3.3 °C



Ladders geometry

(with chips but NO flex)



Thanks for the attention