Summary

- A remind of goals of Straw activities.
- Status of the straw prototype 1200X800mm.
- Additional FEM analysis on the CF structure.
- Dry test at CERN (12-13 October 2023).
- Problems encountered.
- Final assembly (06-17 November 2023)
- Conclusions.

The goals of the activities are to demonstrate that the DUNE STT tracker design is feasible in time and technology with the required level of reliability.

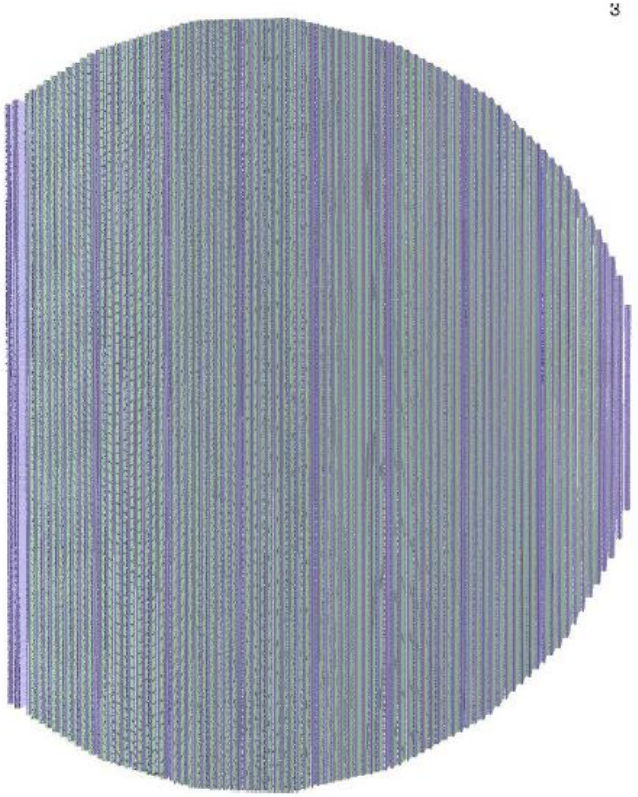
Straw detector geometry.

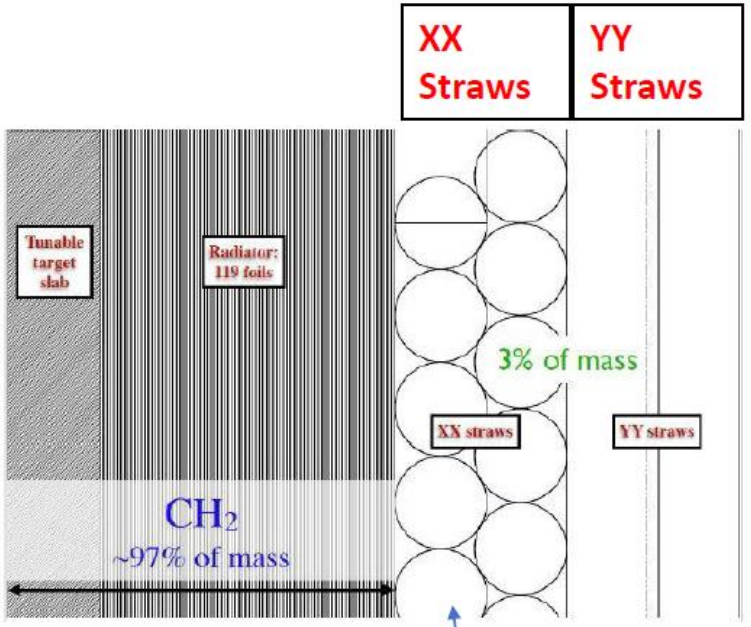
STT FOR SAND

70 CH_2 modules
8 C modules
6 tracking modules

~220,000 straws
average straw length 3.2 m
maximal straw length 3.8 m
internal gas volume ~14 m^3
nominal gas pressure ~2 bar

FV mass:
~4.7 t CH_2
~600 kg C





Straw tube diameter 5mm

Status of the straw prototype 1200x800mm.

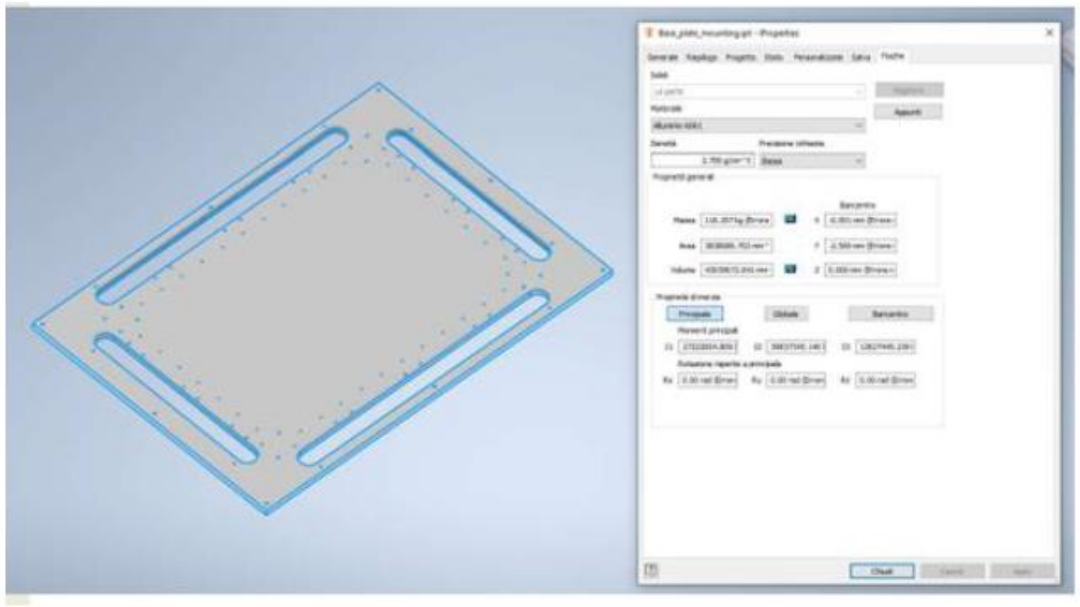
Connection of straws to common collector keeping uniform overpressure and gas leak tests

The preparation activities starts in August 2023 at CERN.
Straw must be pressurized for the assembly at 2 bar.
Straws must be cut in four groups at the proper length.
All straw are plugged in one end and connected in group to a common manifolds and retain valves.

Status of the straw prototype 1200x800mm.

In the same time in Pisa we were preparing the assembly tooling surveying all parts.

Aluminum reference plate



Aluminum plate 5083-0 1200x1700x25mm. Mass: 116 Kg. Expected final flatness: 0.1 mm

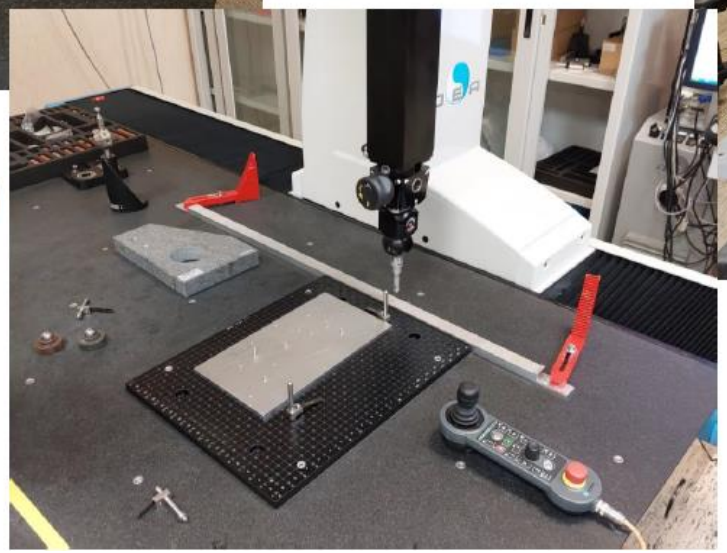
Status of the straw prototype 1200x800mm.

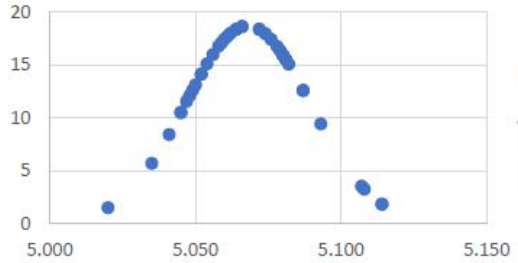
CF assembly tooling

tool for straw alignment

Straw Assembly tooling.

Survey with CMM
Pitch very precise level of accuracy of CMM.
Holder diameter Distribution. Standard deviation 20 μm

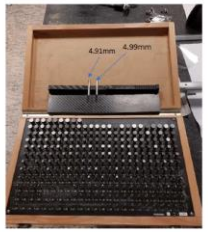


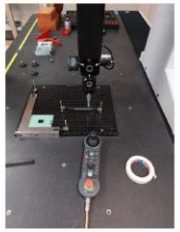


Diameter tolerance.
5mm 0/+0.012

Status of the straw prototype 1200x800mm.
Carbon fibers frame survey with CMM

Update production CF frame (2/2)





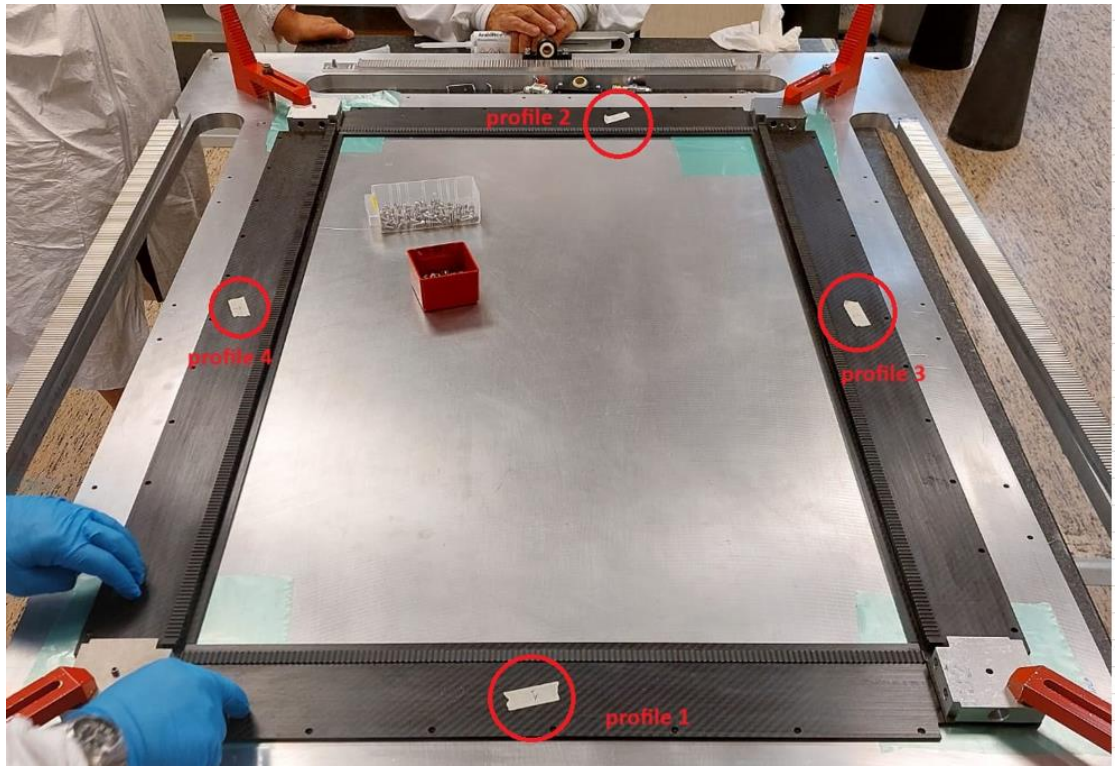
D_nominale	Misure	Scarto		P_nominale	Misure	Scarto
5.000	4.876	0.124		5.000	4.97	0.030
5.000	5.002	-0.002		5.000	5.022	-0.022
5.000	4.948	0.053		5.000	5	0.000
5.000	4.921	0.079		5.000	4.989	0.011
5.000	4.927	0.073		5.000	5.01	-0.010
5.000	4.96	0.040		5.000	4.997	0.003
5.000	4.953	0.047		5.000	5.001	-0.001
5.000	4.964	0.036		5.000	4.995	0.005
5.000	4.992	0.008		5.000	4.953	0.047
5.000	5.043	0.043				
media	4.9586				4.993	
dev_standard	0.0465861				0.02064	

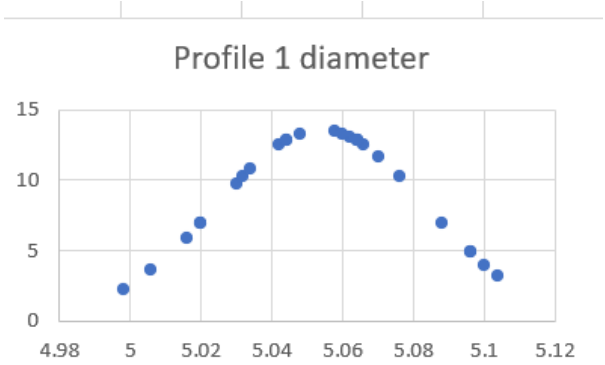
Diameter

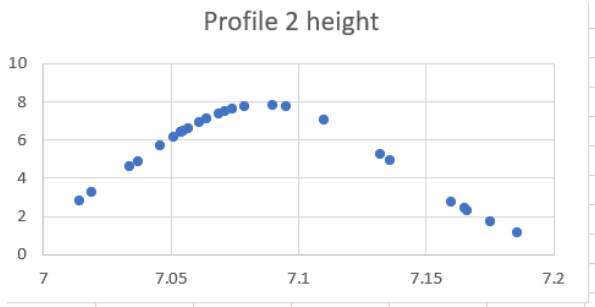
mean	5.054	4.988	5.019	4.949
st.dev.	0.029	0.026	0.027	0.028
max	5.104	5.08	5.112	4.986
min	4.998	4.958	4.979	4.846

Heigth

mean	7.127	7.087	16.609	16.560
st.dev.	0.050	0.051	0.281	0.280
max	7.26	7.186	17.341	17.221
min	7.062	7.014	16.394	16.3







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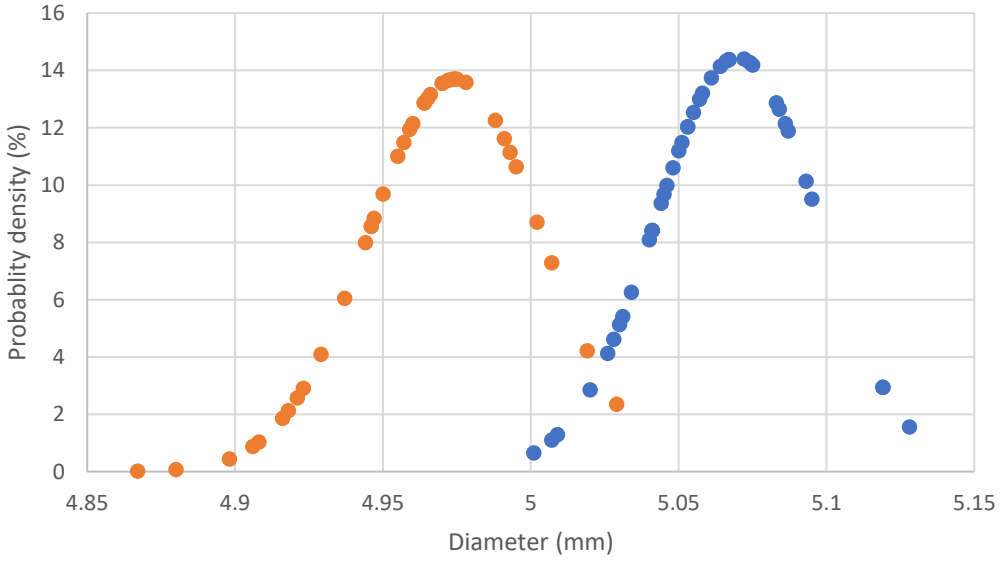
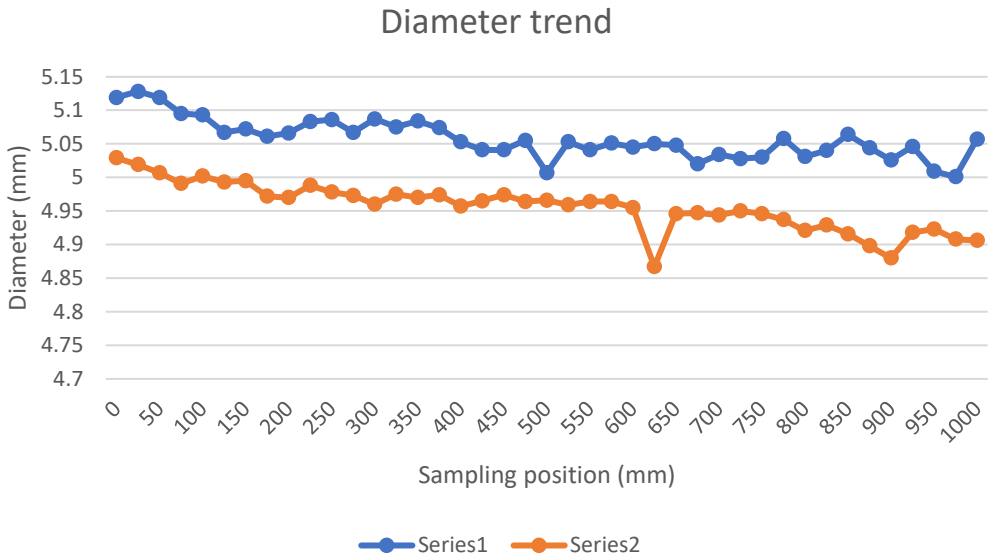
Measurements on upper holders with CMM

All on diameter of long top holders





Nominal value: 5 mm -0.00/+0.016mm (H7)
Mean: 5.07 mm (blue), 4.97 mm (orange)
Sigma: 0.03 mm (blue), 0.03 mm (orange)

Slight dependance on the position

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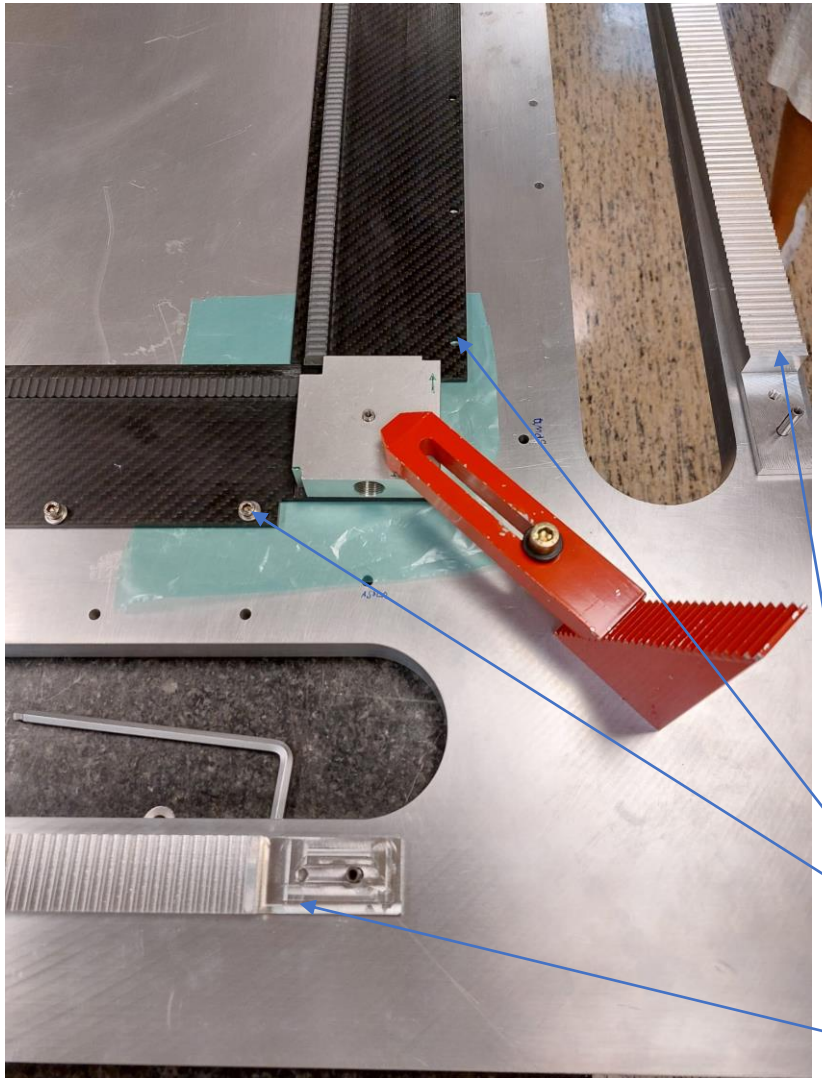
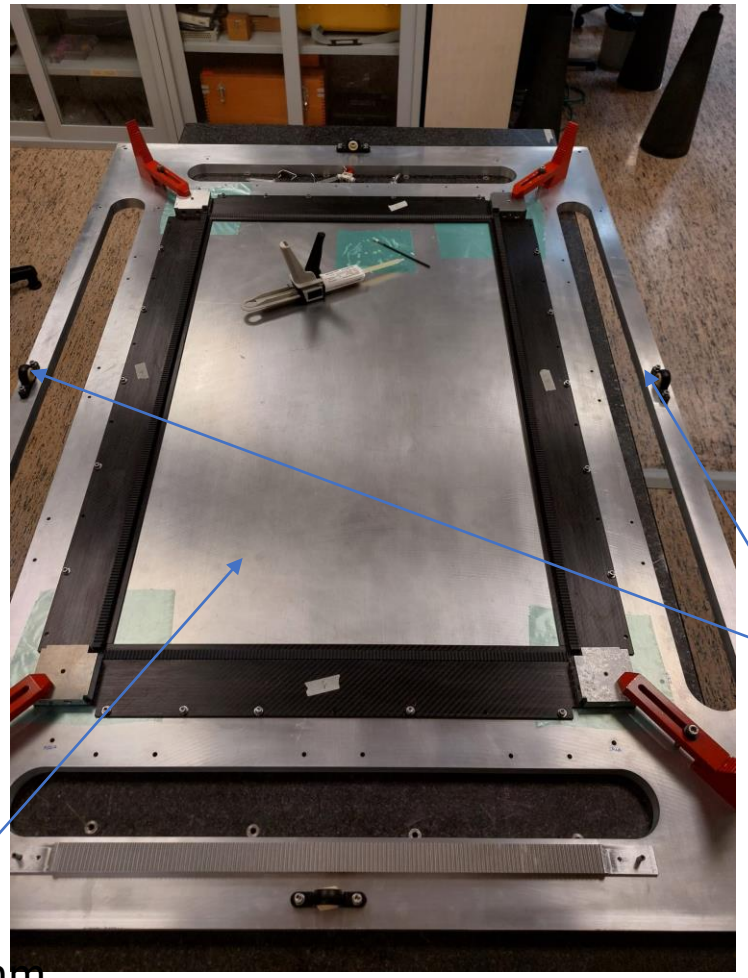
The tooling must be used to assembly the structural parts of the CF frame with the require precision.





Restrain thread holes

Wide aluminum external saddles

Ref. Plane
Flatness 0.1mm

Features for rotation

The tooling must be allows all the assembly and test operations.

A bit of history of tooling to assembly the straw prototype.

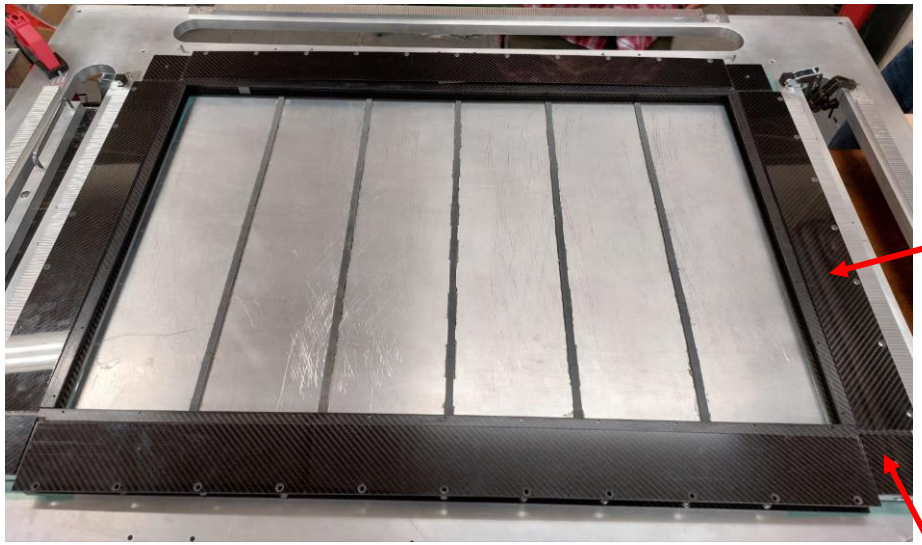
- Tooling concepts:

1. The tooling must be used to assembly the structural parts of the CF frame with the require precision.
2. The tooling must keep align the straw to be glued to the frame.
3. The tooling must allow all the operations necessary to complete the prototype. (test, sealing, etc)

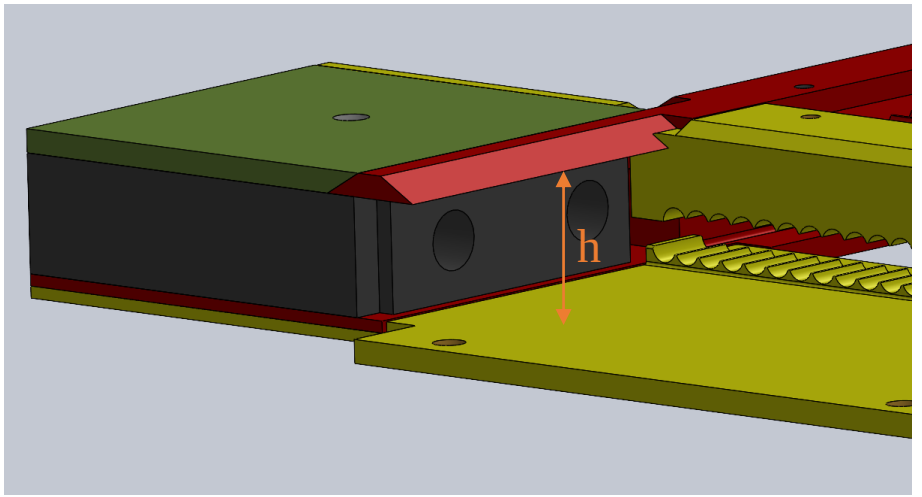
Tooling features

- The tooling has a good reference plane with a flatness of 100 μm in the mounting area.
- The tooling has precision holes to position the CF with pins parts and thread hole to restrain the CF parts.
- The tooling have aluminum machining external wider saddle to positioning the four straw layers.
- The tooling has a feature to rotate the plane for stycast sealing
- The tooling will restrain the temporary top cover to seal the straw volume.

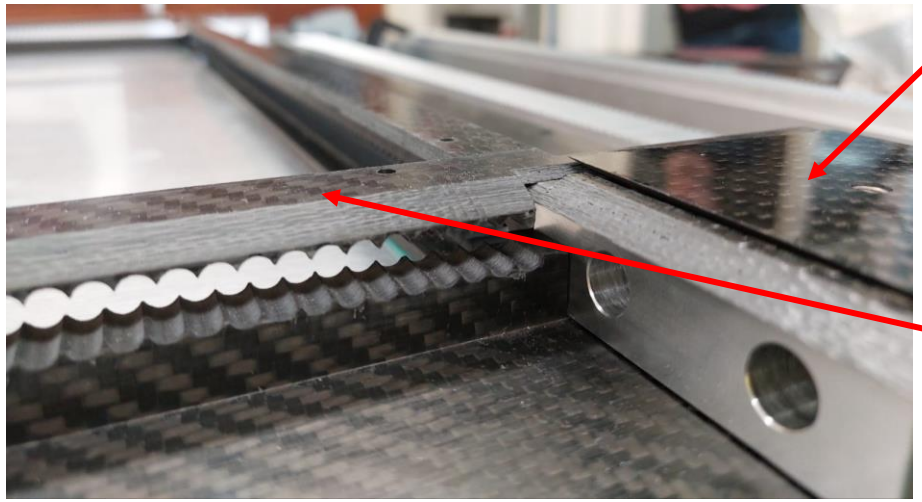
Mechanical integration of top cover



cover (4)



CF corners (4)



top
holder (4)

We need to check:

- height h for sealing
- position of the straw tubes

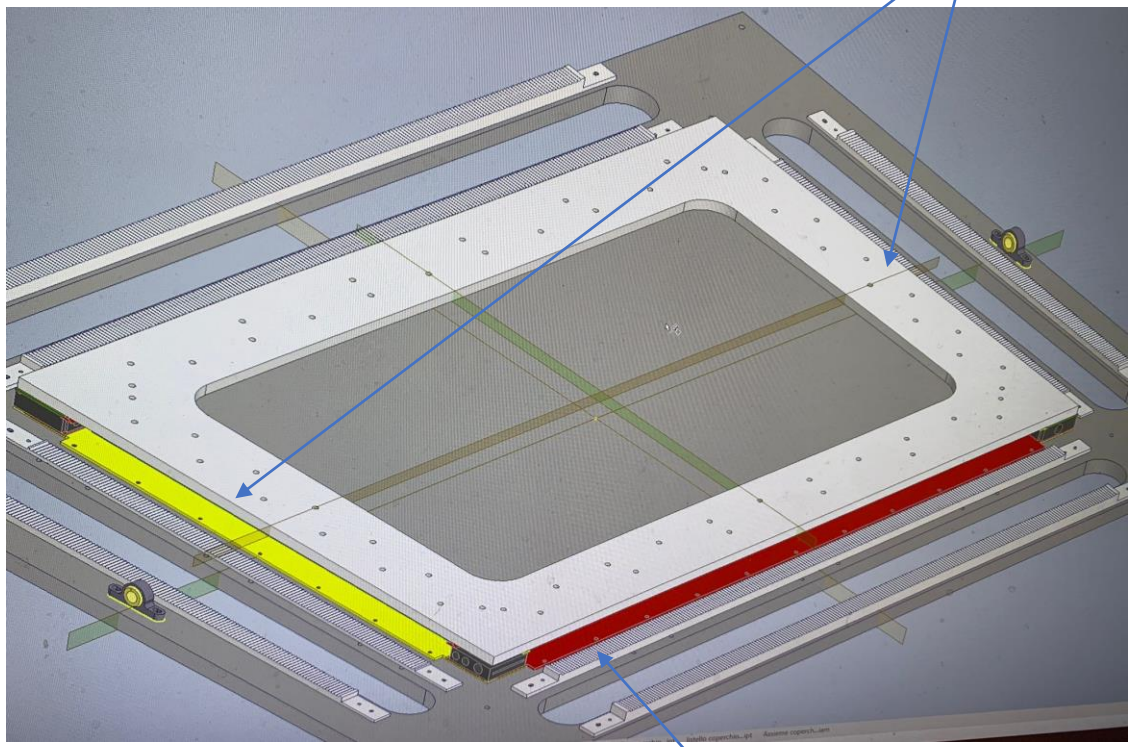
Next steps (1/3)

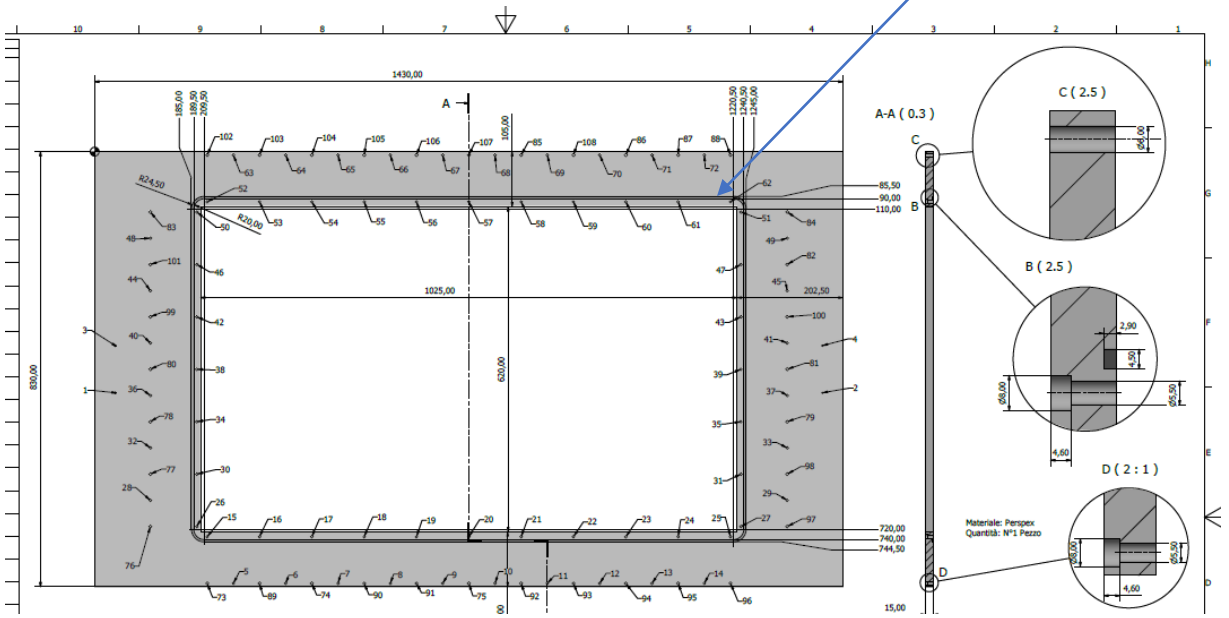
Temporary cover

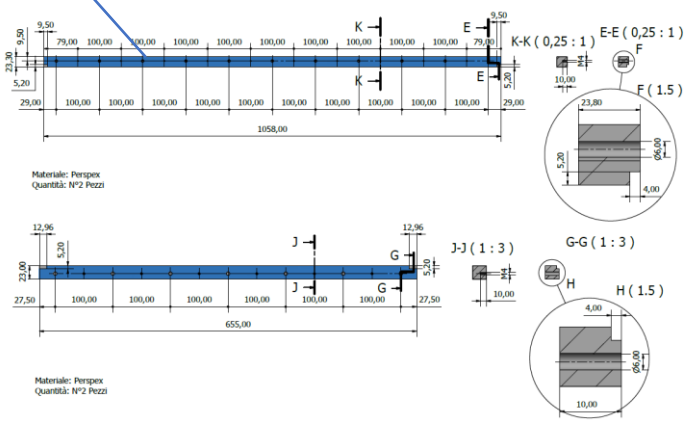
- easily removable
- constrained to the plate
- guarantee module sealing.

O-ring groove

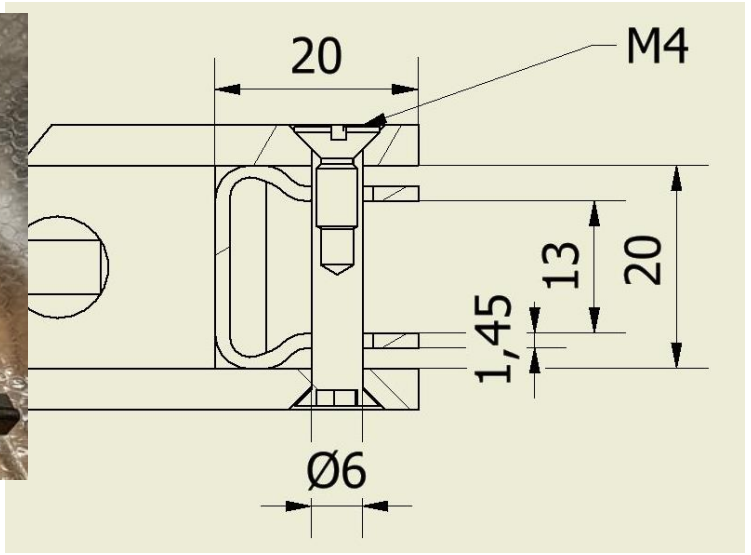
Handles attachments

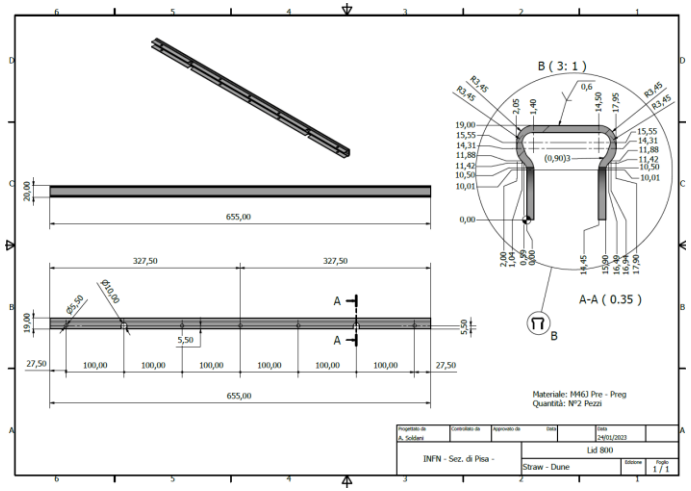


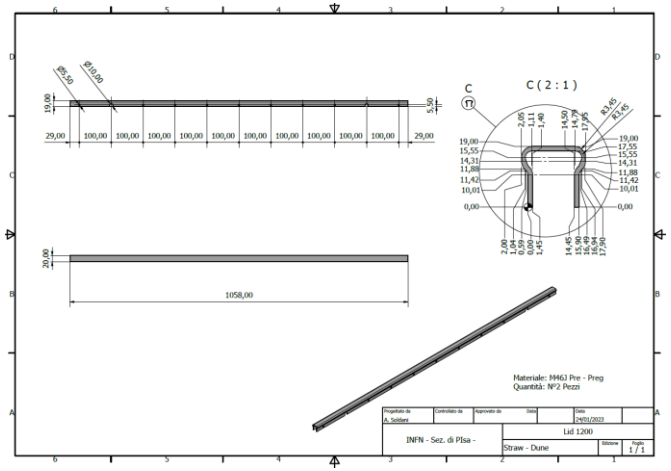




Next steps (2/3)



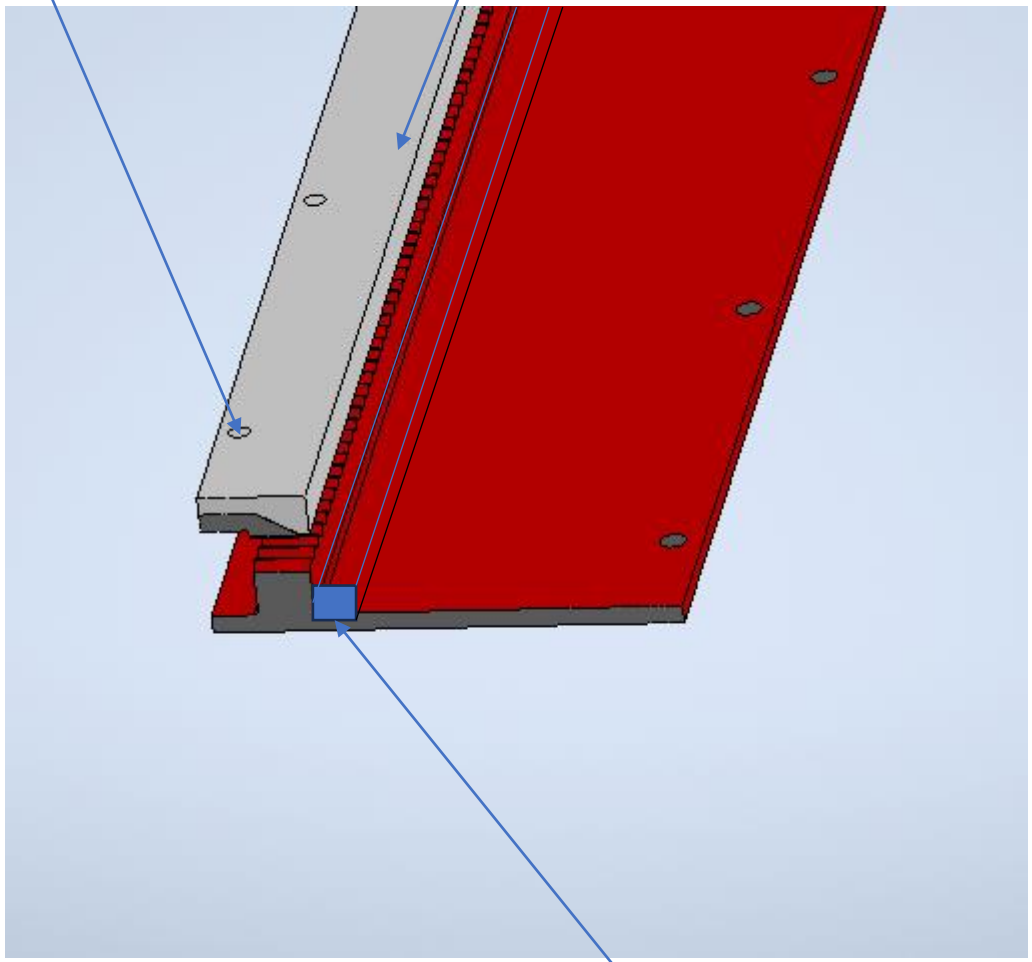




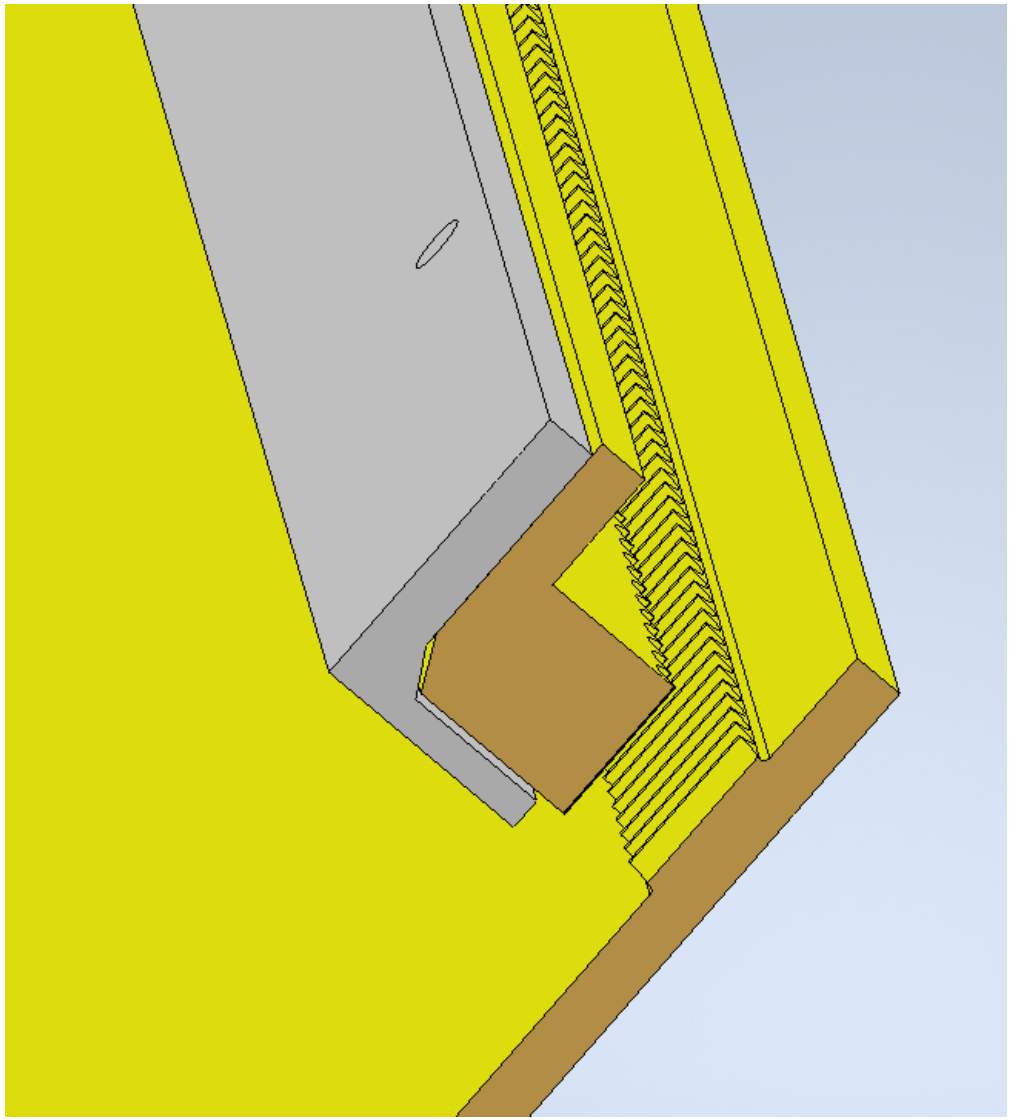
Stycast molding

Teflon profile to Seal ends with stycast

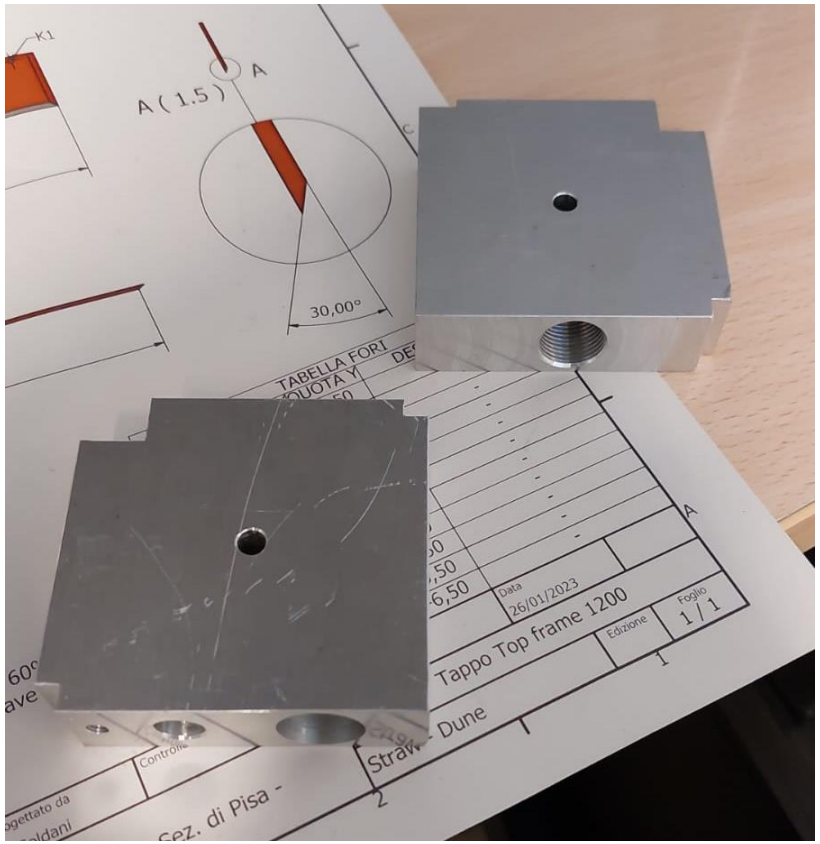
M4 insert

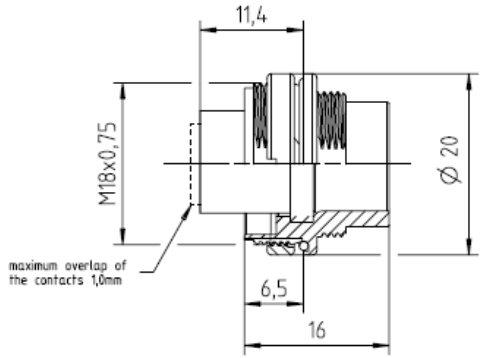


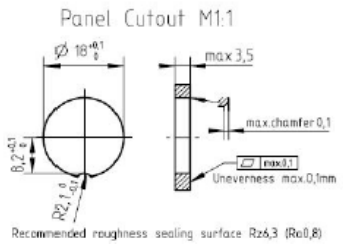
Additional Teflon profile

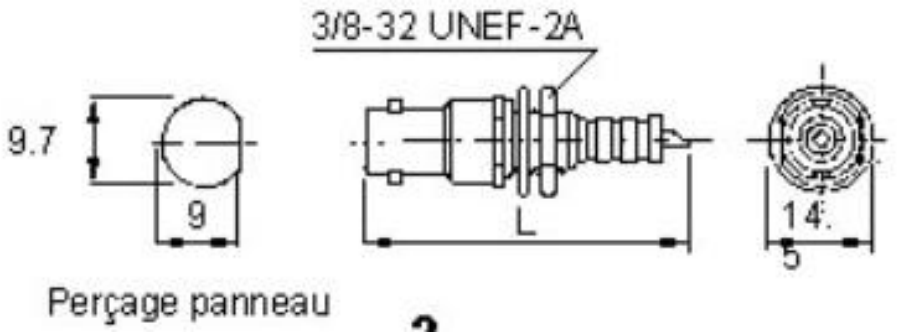


Next steps (3/3)

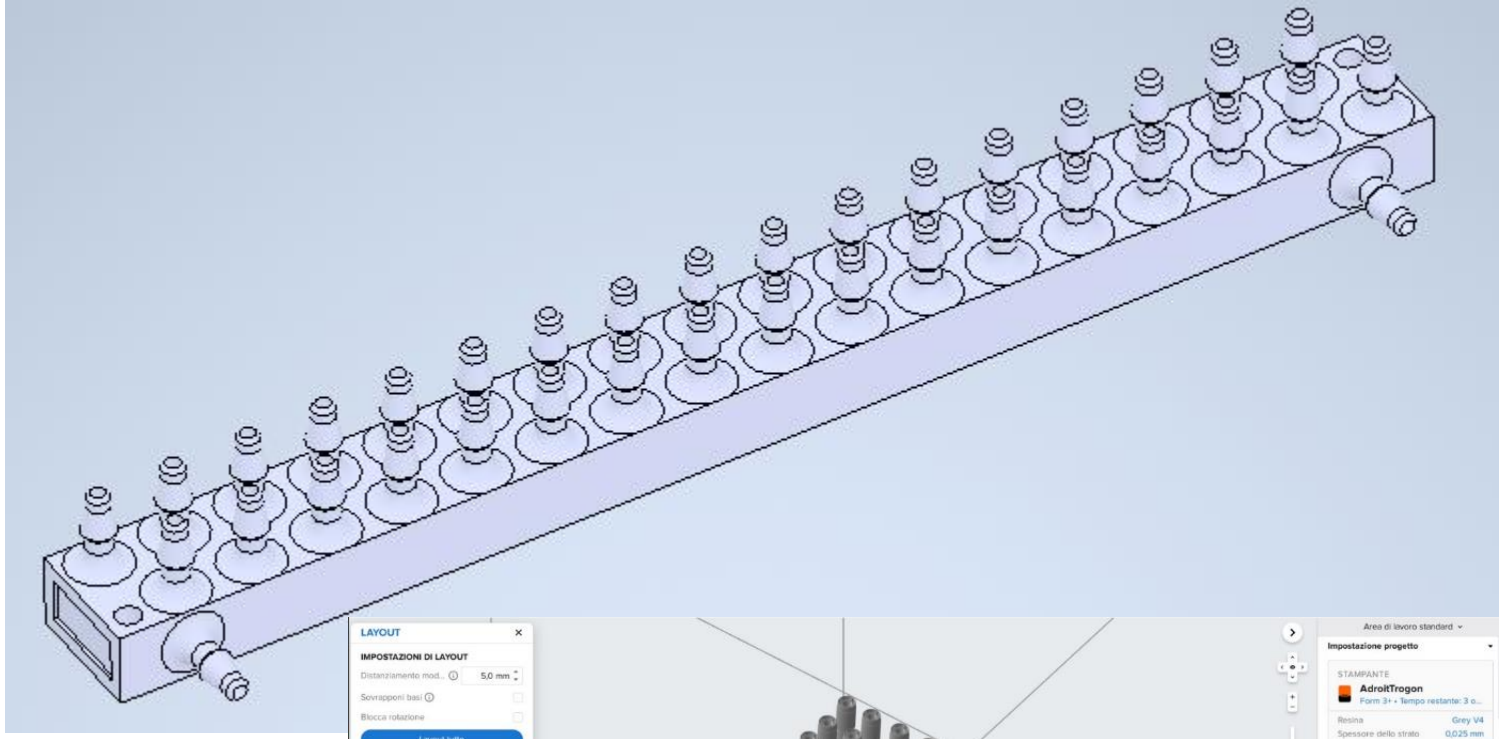


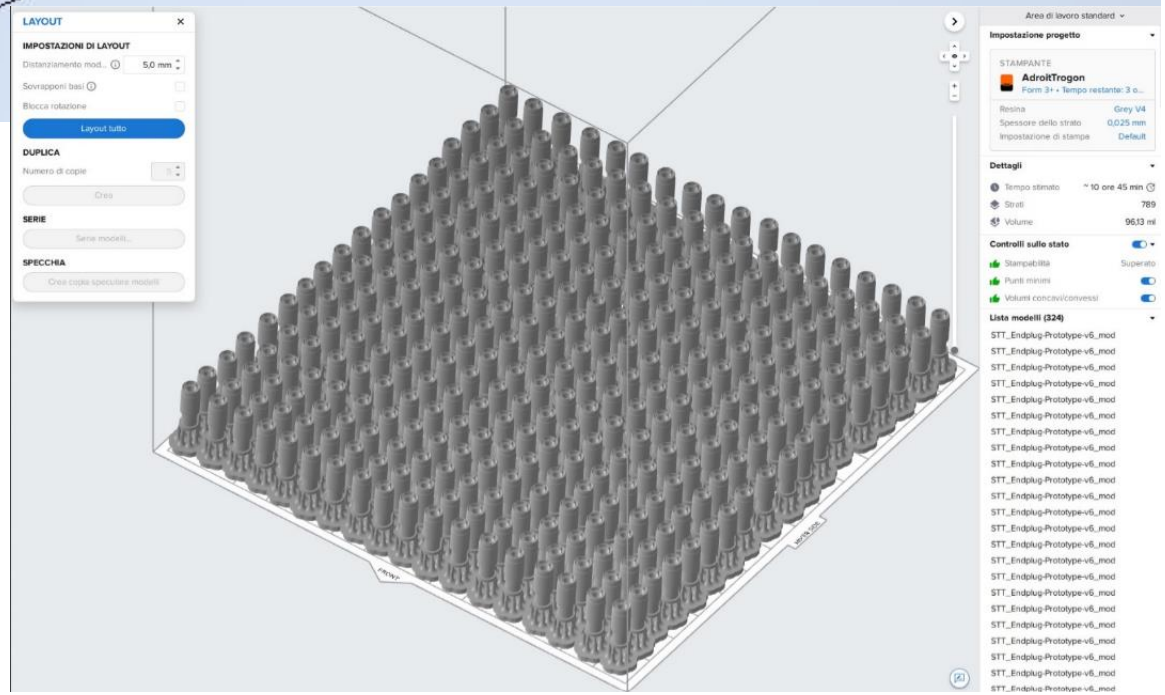






Add thread for connectors (both gas and electronics)

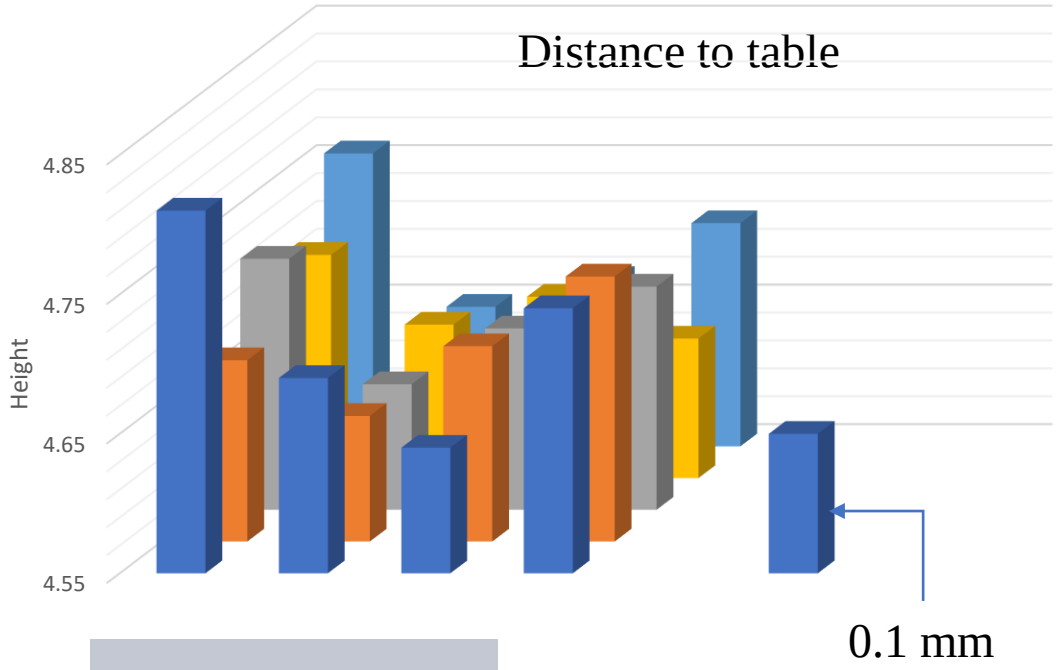


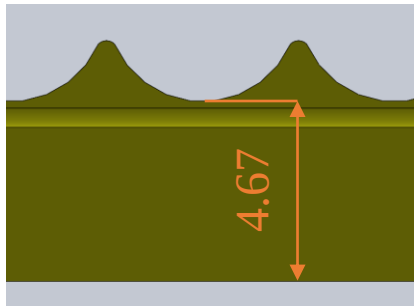


3D resin printing

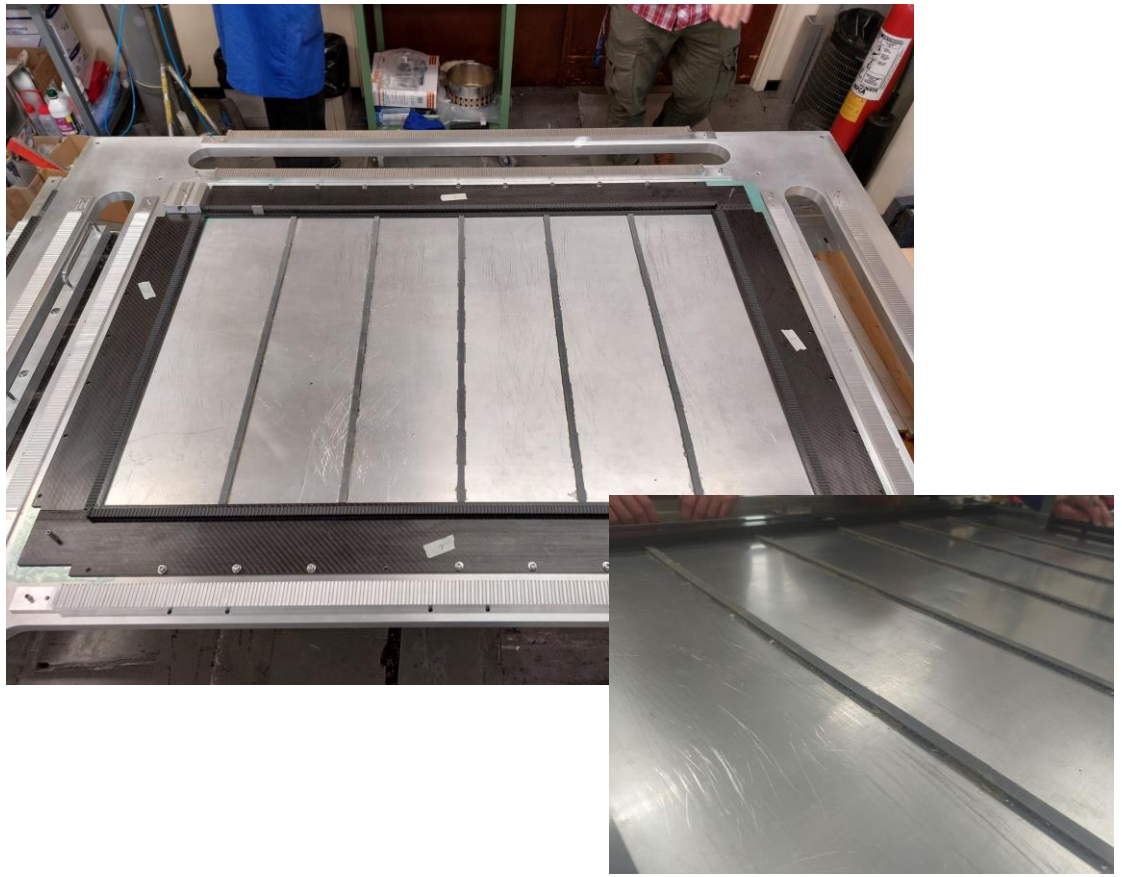
Dry test: new spacers (1/1)

We realized immediately, that the pressurized straw, supported by the external saddle sag under gravity. Furthermore they do not stay straight. The corrective actions ware to provide underneath and lateral space supports.





Nominal value: 4.67 mm



Dry test: straw layers (1/2)

First layer assembly

Lateral spacer for the external straws

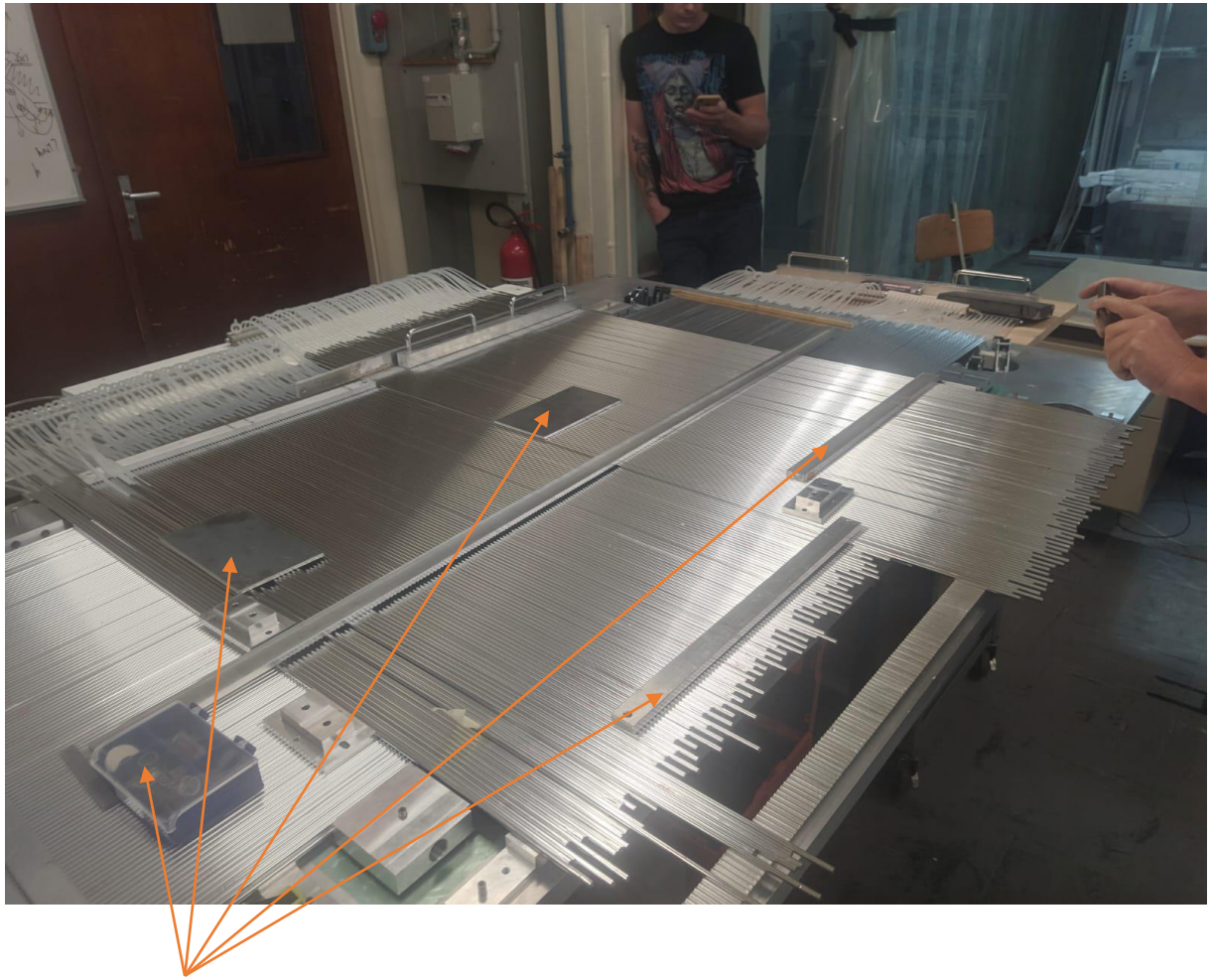
Procedure:

- Connection of the straws to common manifold
- Preparation of spacers to support first straw
- Start assembling from one end

We learn how to handle straw with manifolds to achieved a better straw placemenents

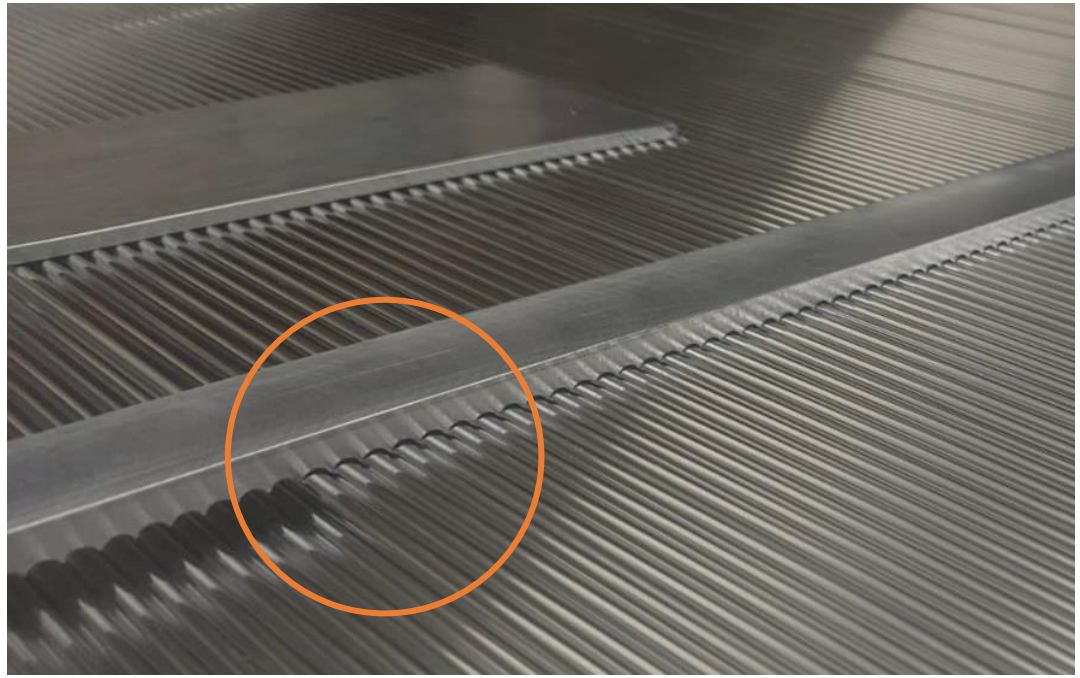
Dry test: straw layers (2/2)

Bridges allow alignment of straws without force

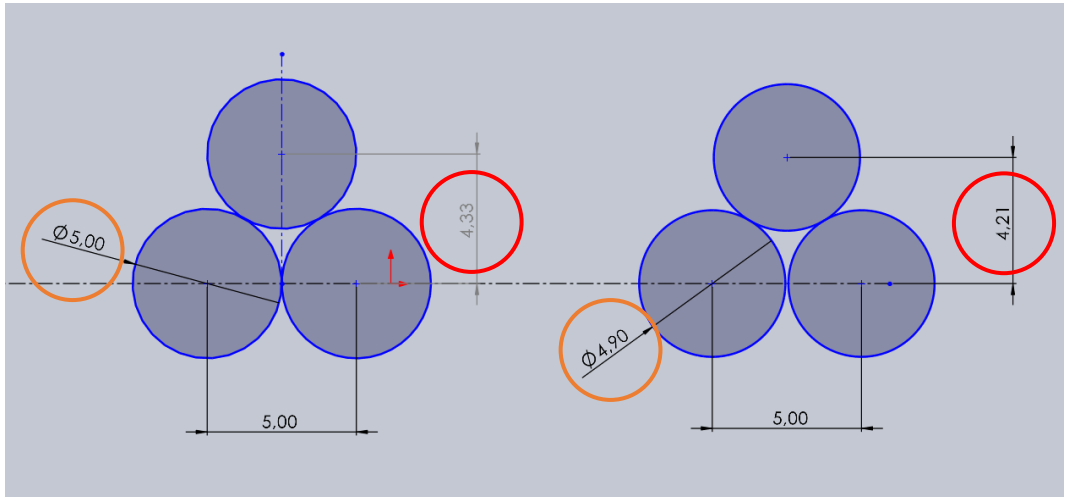


Weight keep in position straw tubes during assembly

Problems during dry-test (1/2)

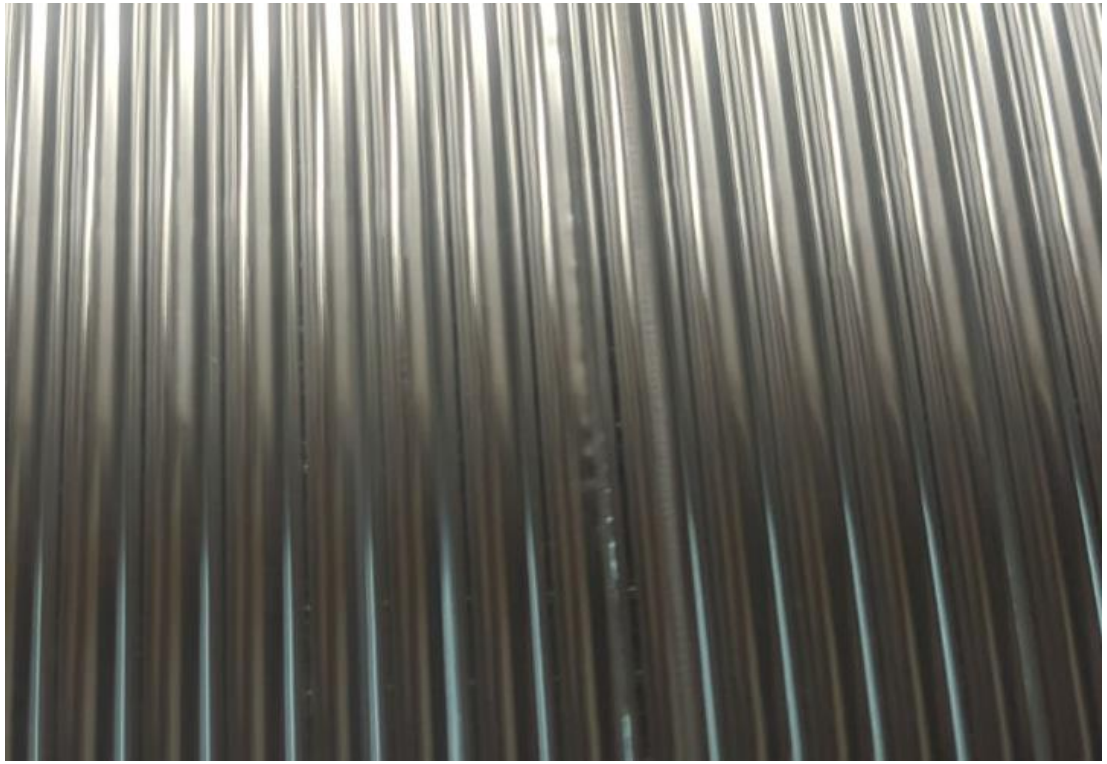


gap



Influence of diameter value on center height
(pitch value is given by the frame)

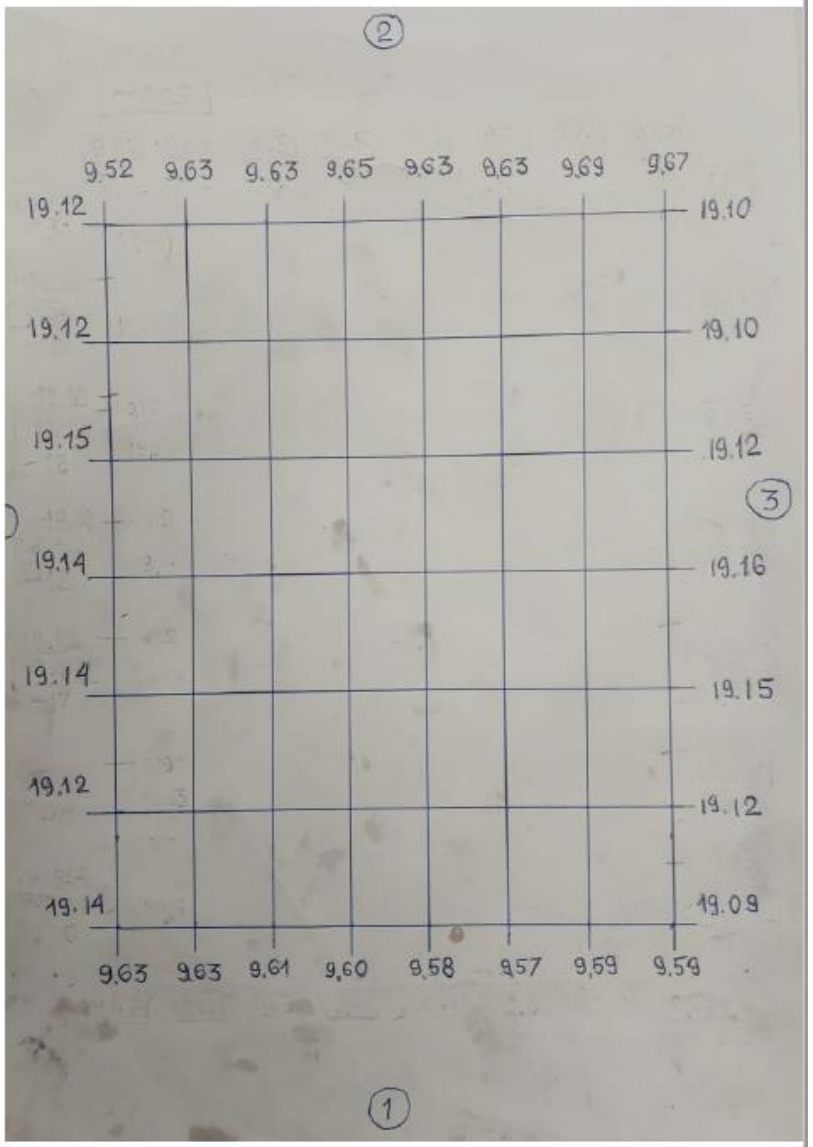
Problems during dry-test (2/2)



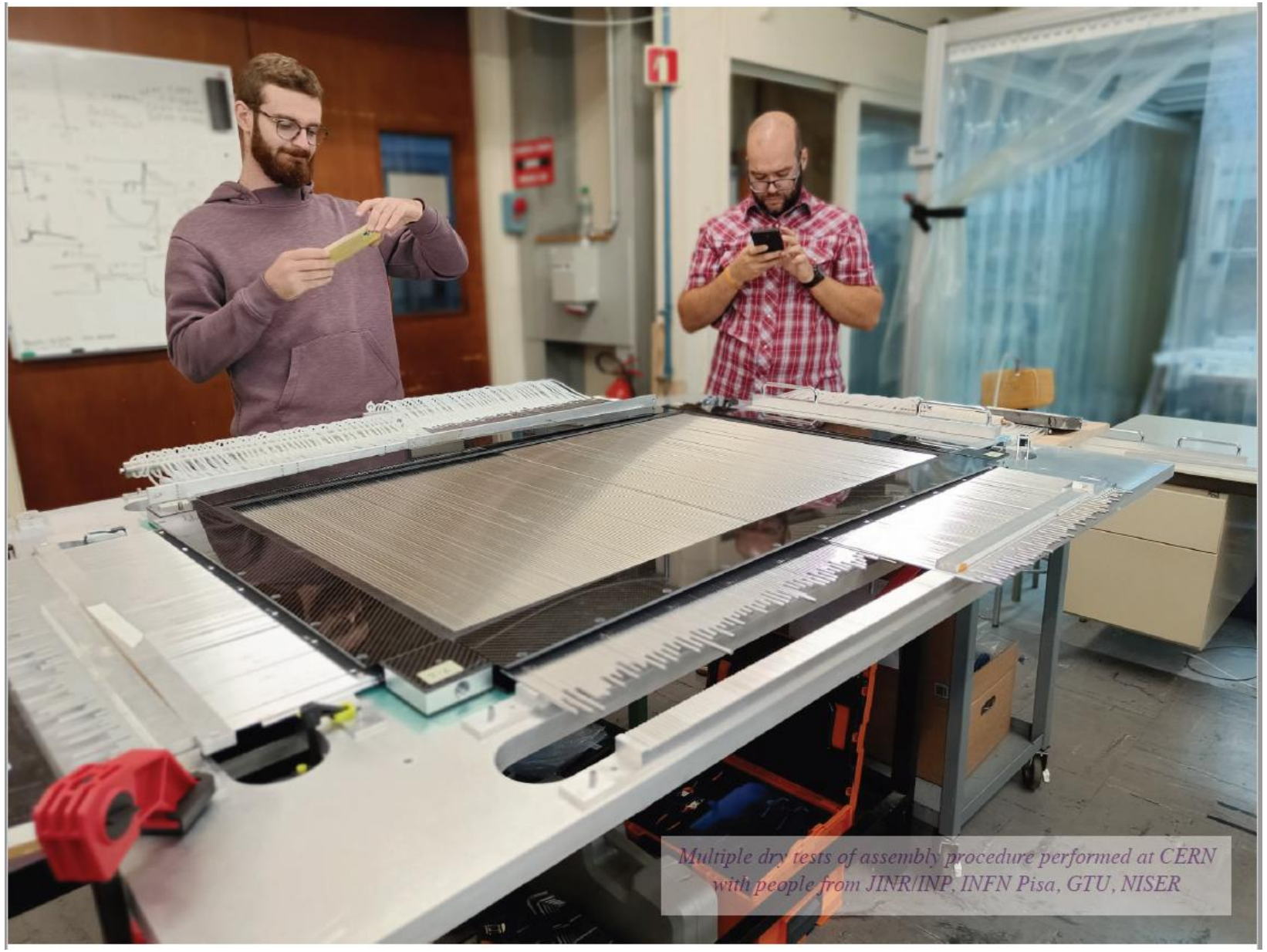
- space between straw tubes
- detection method

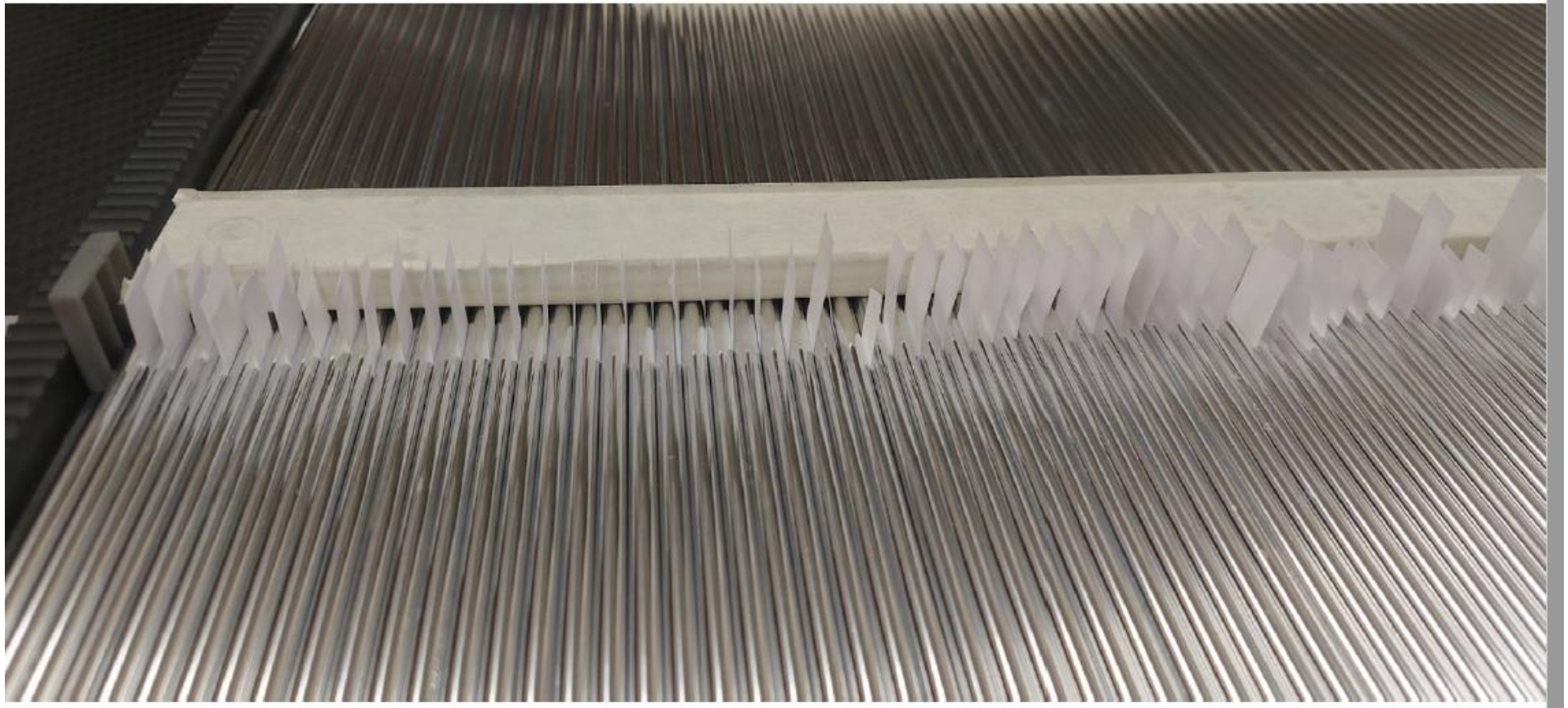
Measure distance of straw holders from mounting table to guarantee correct alignment after adjustments

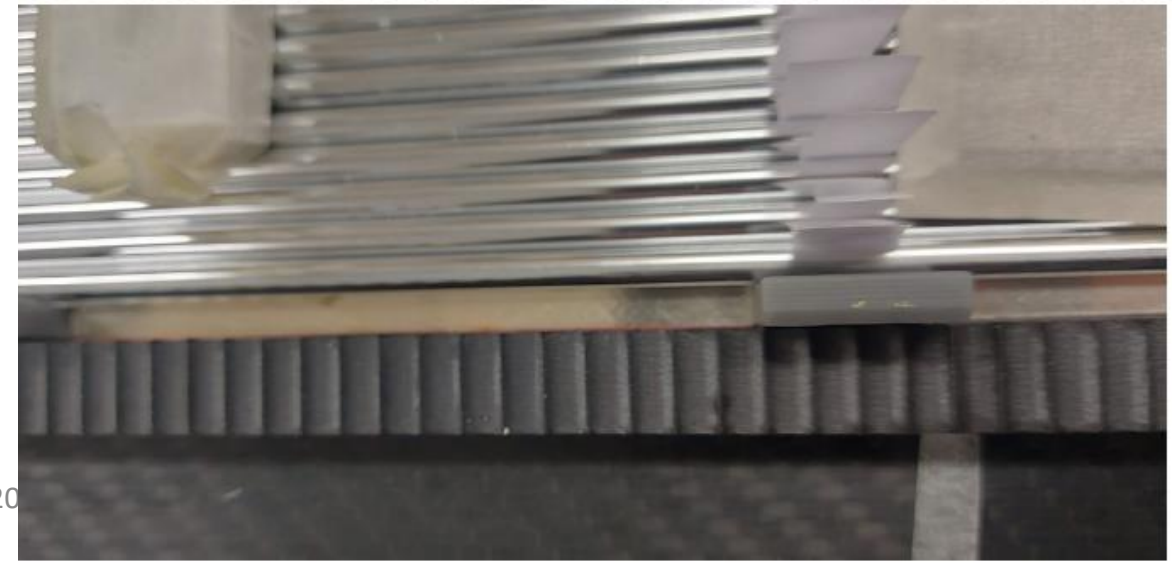
(table flatness <100µm)



Dry test at CERN (12-13 October 2023).



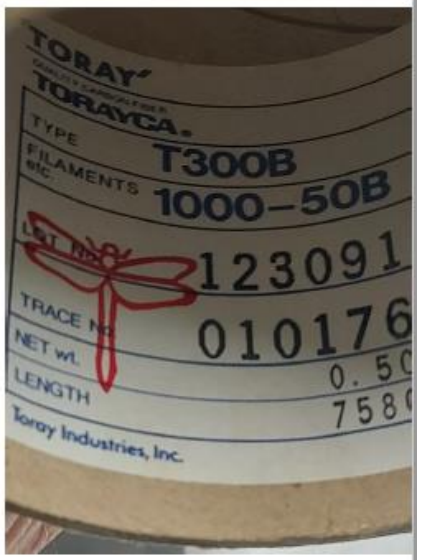




Insert paper spacers to keep uniform straw spacing (pressurized at 2 bar) + plastic spacers (3D printed) to align straws with frame

(increase slightly straw diameter in future)

Consider gluing
C-fiber wire (~50μm)
for straw alignment



- *Preparation for assembly completed at CERN*
- *Activity at CERN currently suspended until beginning of November*
- *Gluing of straws to the frame from 7-8 November*
- *Plan to complete prototype assembly including wiring of straws by end of November*

Various measuring tools borrowed from CERN

Final assembly (06-17 November 2023)

- We have all materials to do the straw assembly; parts and glues.
- We have to do a dry test and take the final decision how to proceed with the assembly.
- Same test we will do today and tomorrow on the gluing of the corner bocks.

Conclusion.

- We have already identified improvements to be applied to the tooling. This has been implemented.
- After the first Prototype is done we will measure with laser scanner before and after the prototype has been realized from the mounting table.
- We are going to implement in the second prototype all we learn for this first assembly procedure.
- We have a plan to improve the CF Flatness with different method of production.
- We are start thinking about real size prototype. what will be the accuracy for the tooling and the CF structure. (Theoretical accuracy ISO standard H7 size 3000mm 0.3-0.2mm)(no temp. variation)