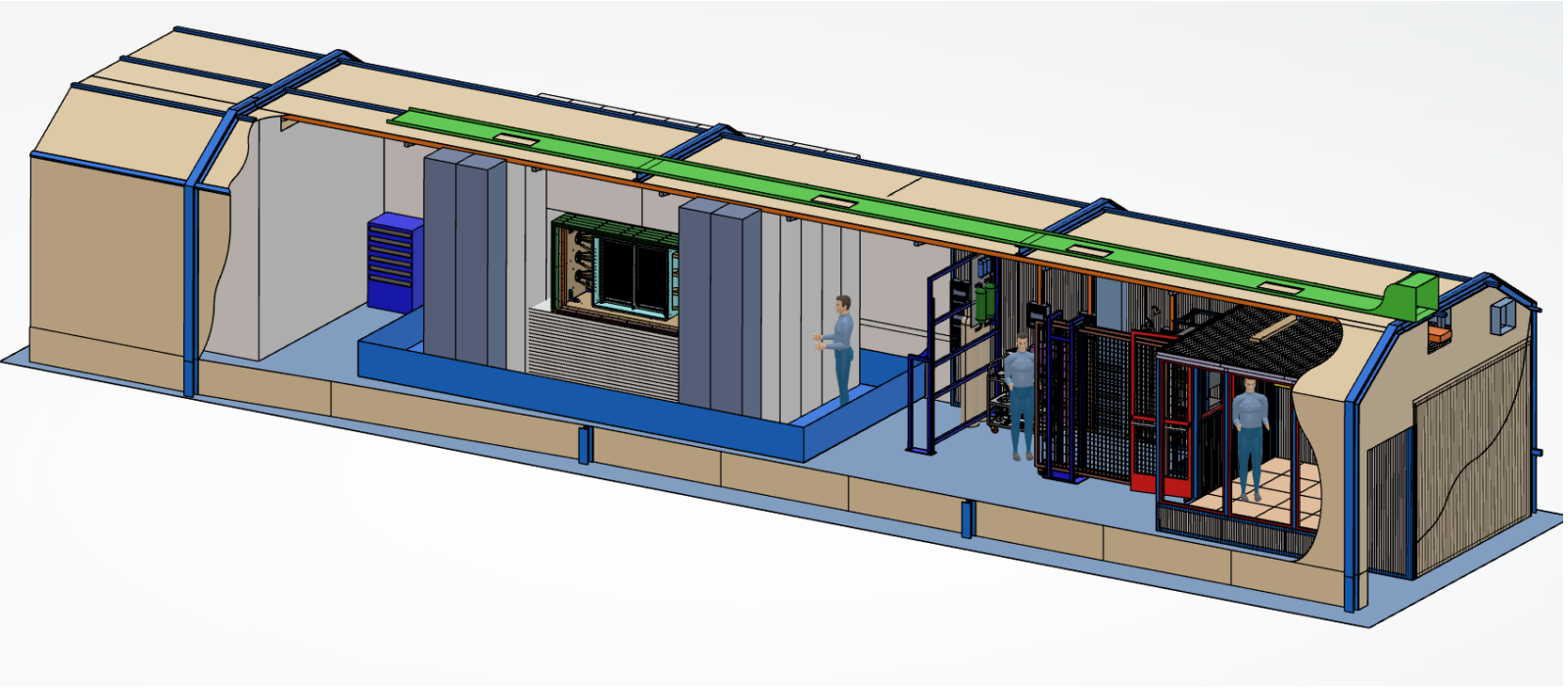
CYGNO
Mechanical Design
Mechanics-Integration-Maintenance



Cygno Collaboration Meeting

Cagli

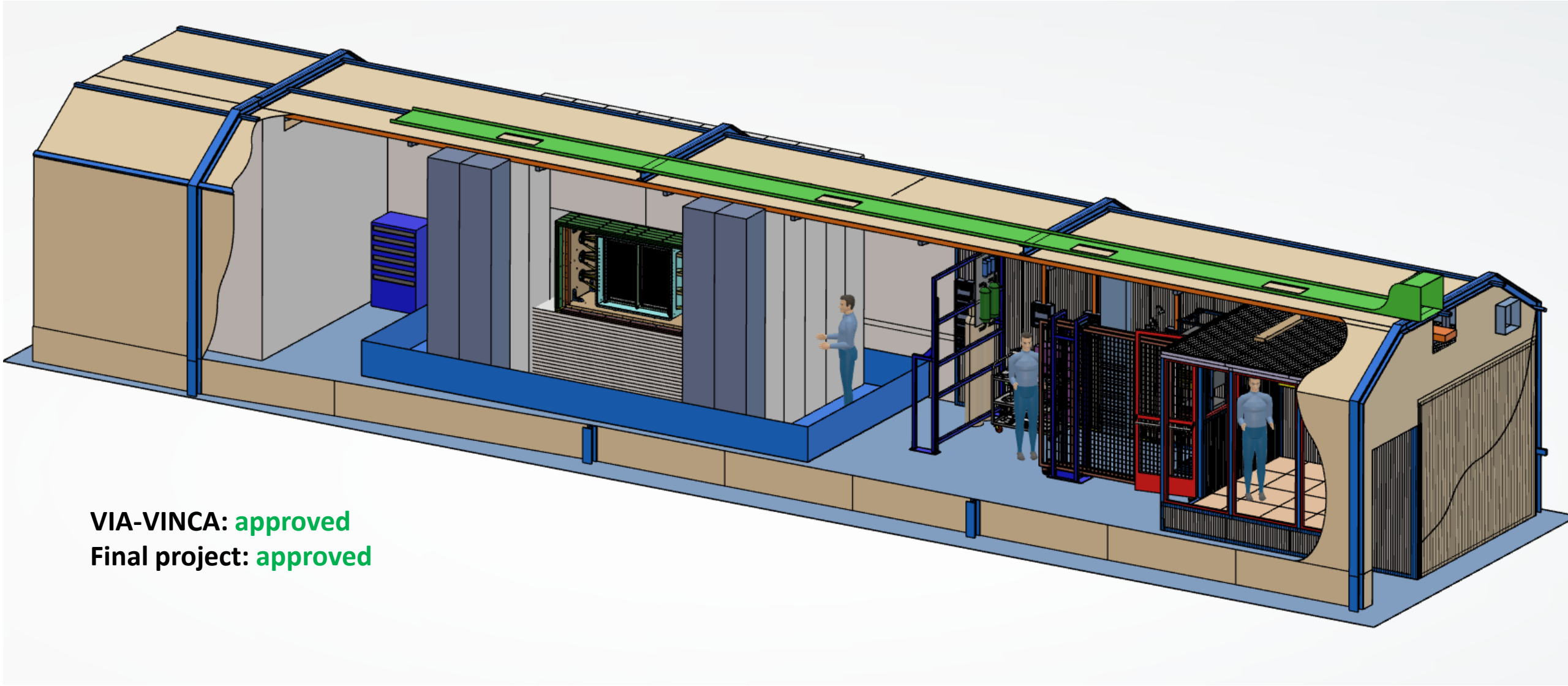
November 28th 2024

S. Tomassini

Outline

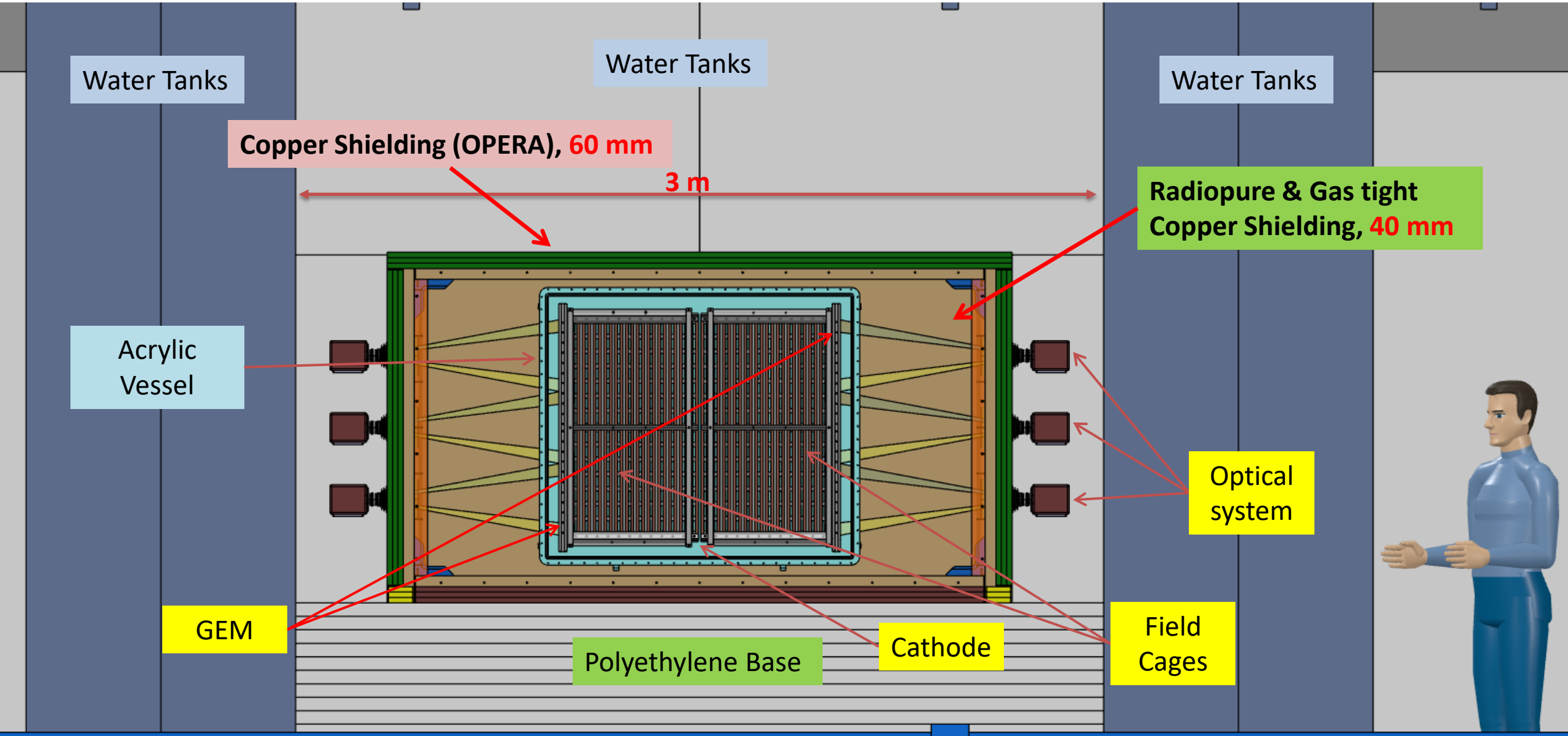
- Cygno general layout
- Copper shielding Design
- PMMA vessel design and material qualification
- Field cage design (Engineering aspects)
- Setup Integration
- Neutron shielding design and procurement
- Conclusions

CYGNO @ LNGS Hall F

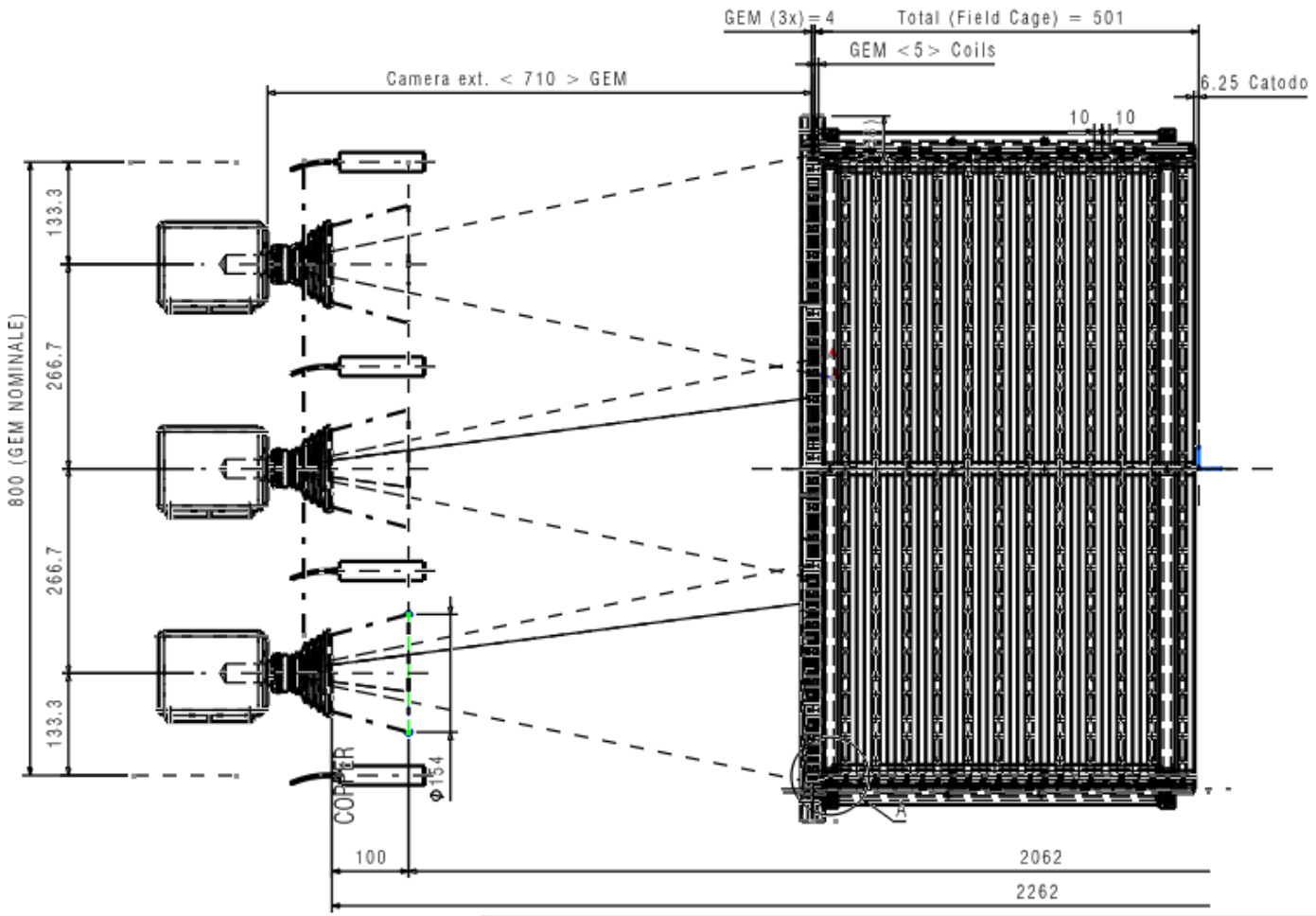


VIA-VINCA: approved
Final project: approved

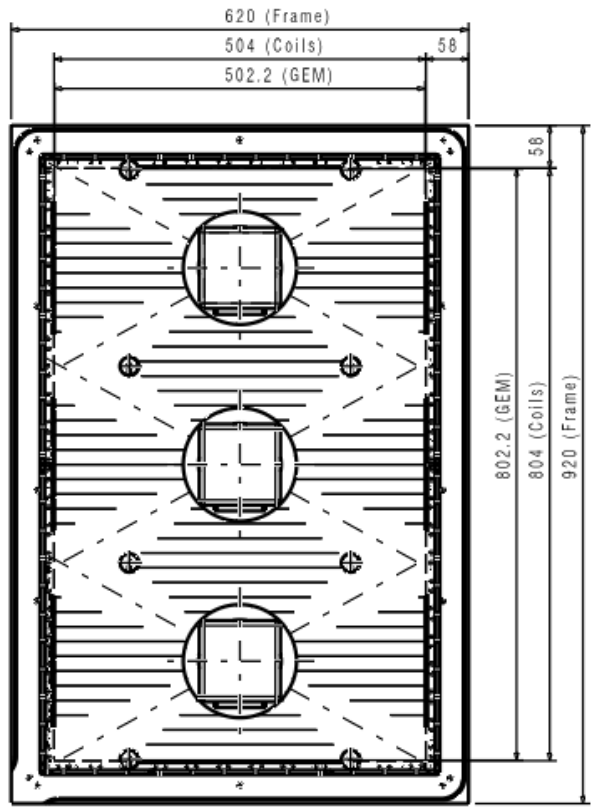
Mechanical Layout



Internal Positioning



Capoccia - Croce



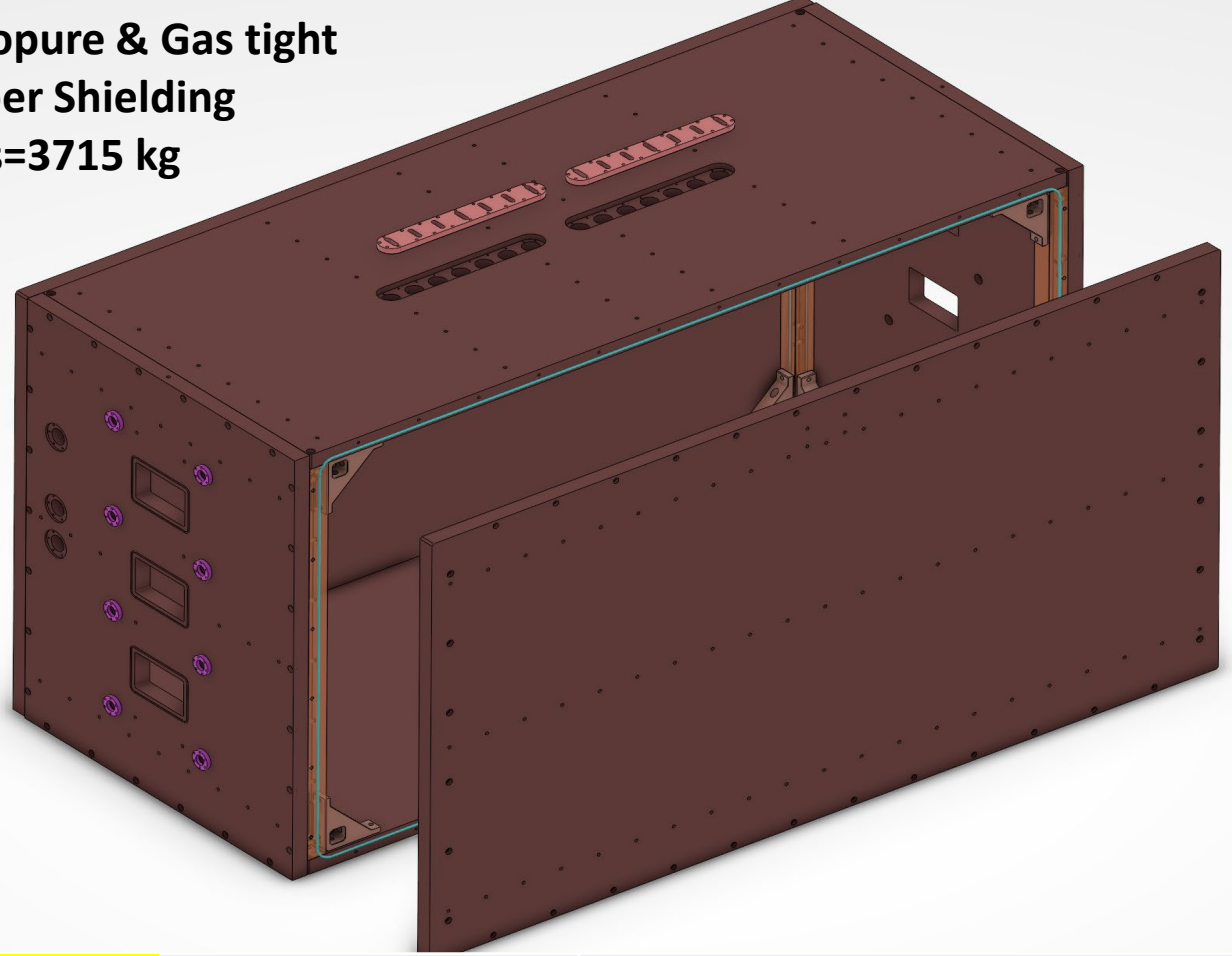
COPPER SHIELDING

Calibrating source mover

Green plate: OPERA copper

Brown plate: radiopure copper

Radiopure & Gas tight
Copper Shielding
Mass=3715 kg



Leak rate

Leak rate spec: **1 sccm = 0.0168 mbar*l/s**

O-ring length=
6.3*2+4*2+0.57*6+0.050*16+.2*6=**26m**

O-ring diam= 6.3 mm

Compression= 30%

Roughness = 0.8 micron

Δp= +0.5 mbar

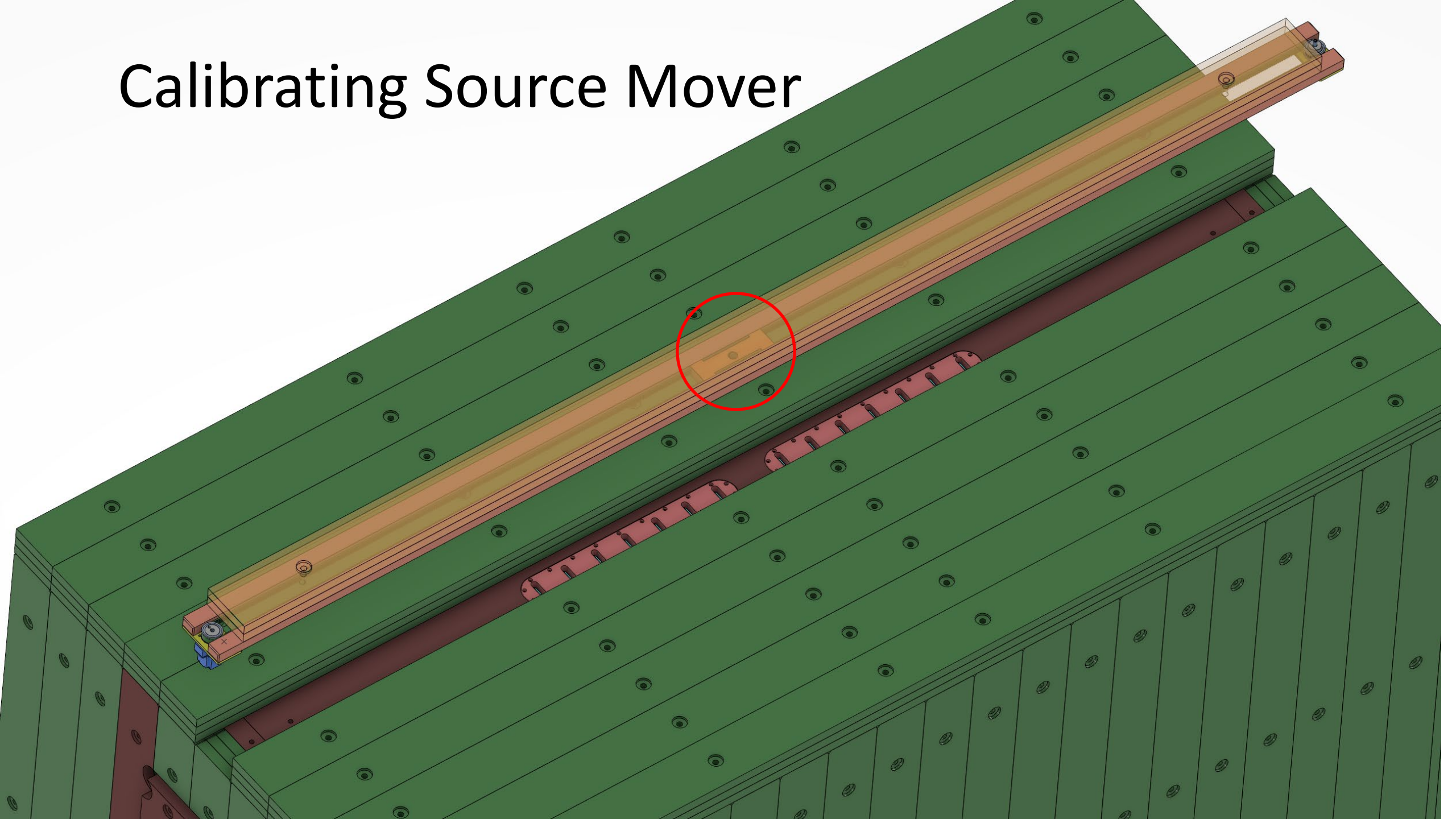
Mixture = helium

NOT A VACCUM CHAMBER!

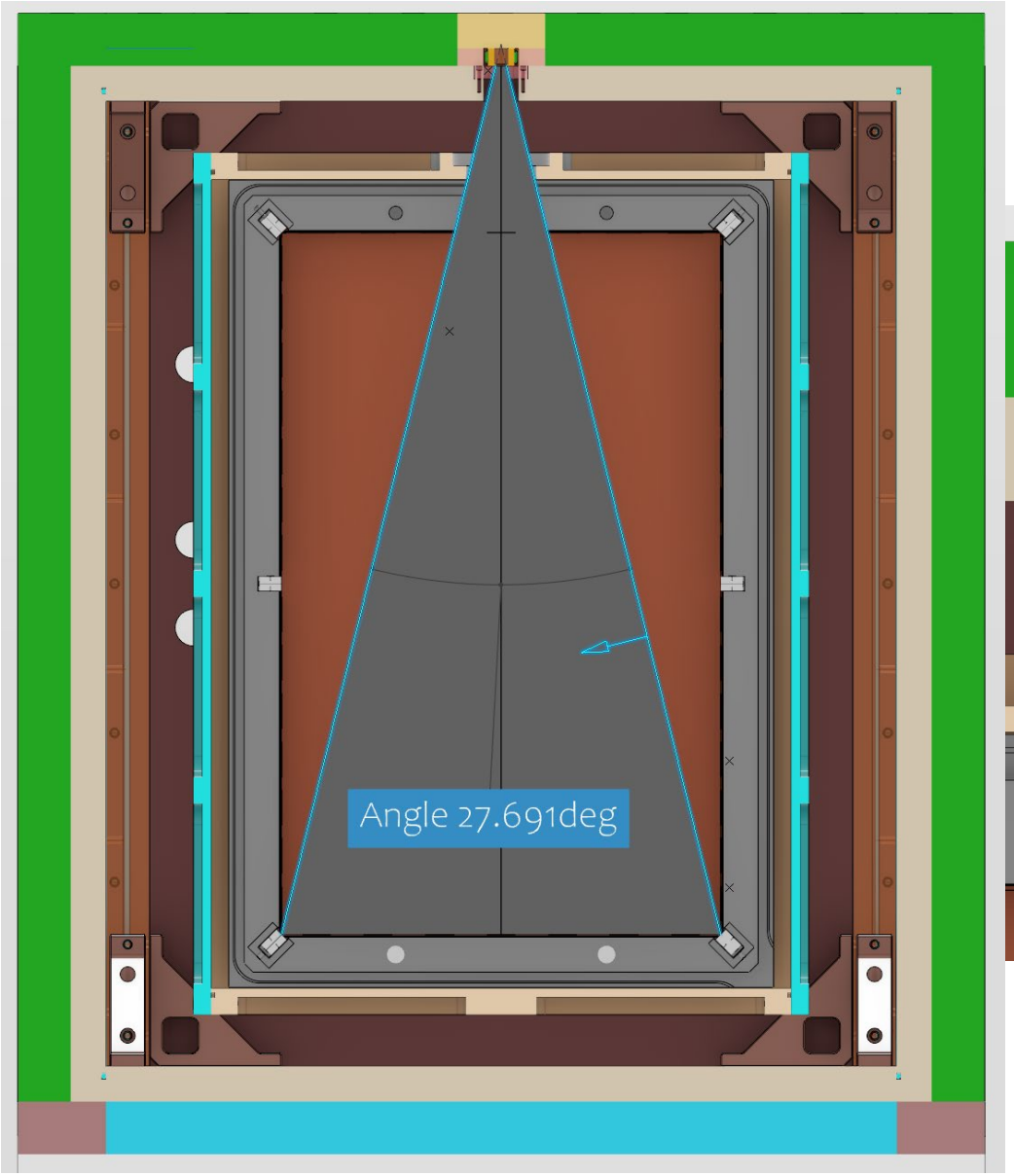
2.81E-06	mbar *l/s
	with safety fact=10

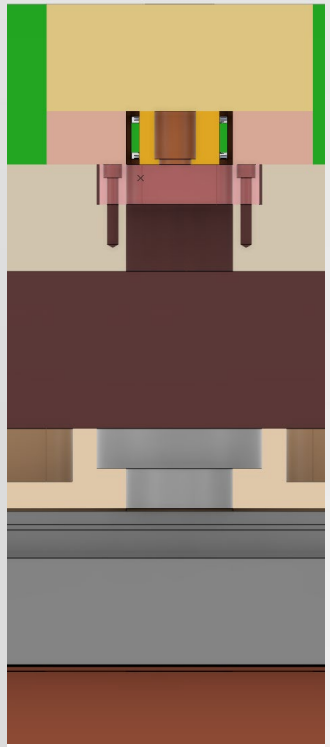
L = 0.7 F D P Q (1-S)2
Where:
L = Approximate leak rate of the seal, std. cc/sec.
F = Permeability rate of the gas through the o-ring elastomer at the expected operating temperature, (std. cc cm/cm2 sec bar) x 10-8
D = contact length of the O-ring, inches (rectangular or square type).
P = Pressure differential across the o-ring seal, lb/in2
Q = Factor based on the percent squeeze and whether the O-ring is lubricated or dry.
S = Percent squeeze on the O-ring cross section expressed as a decimal. (i.e., for a 20% squeeze, S = .20)

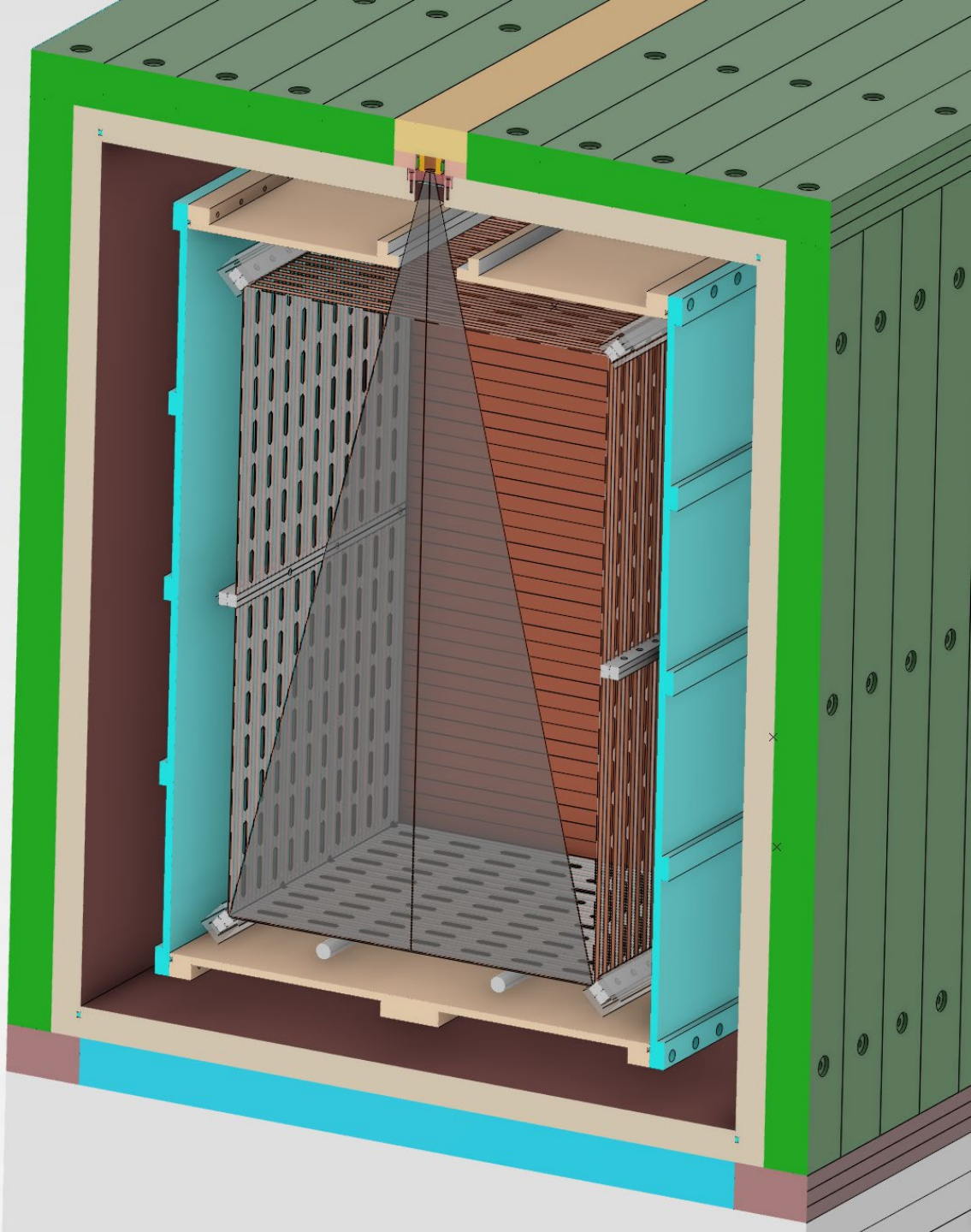
Calibrating Source Mover



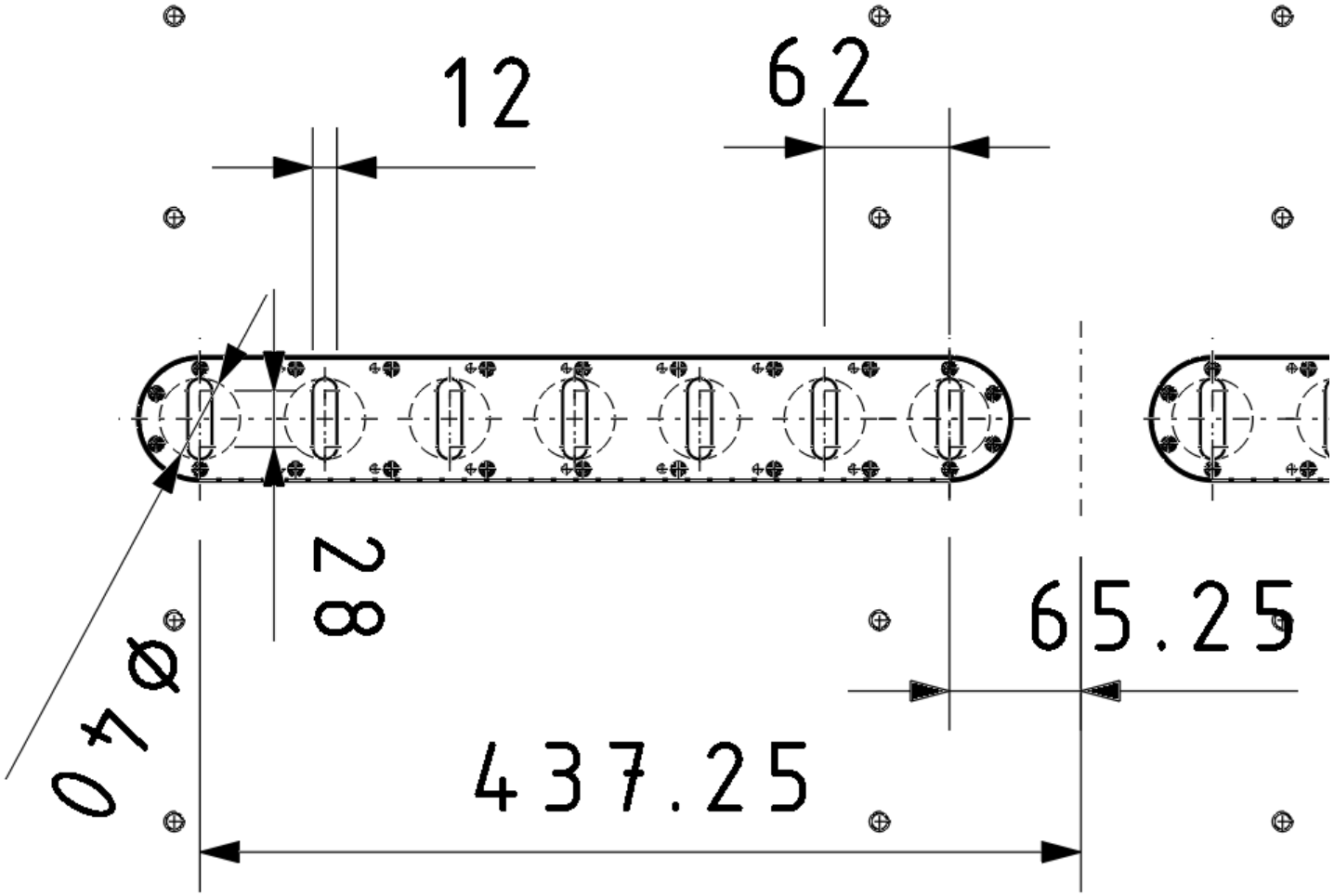
Calibrating Source Mover

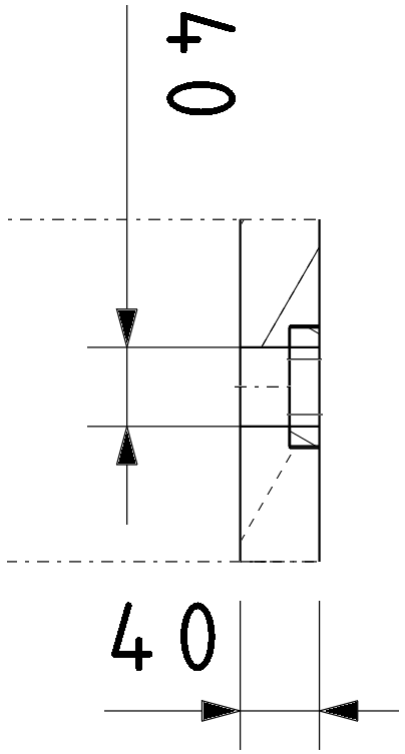






Hole and slot Positions for Calibrating Source





Radiopure Copper Cleaning

According to the CUORE documentation, a **simplified** treatment to clean the copper shielding for Cygno is the **PLASMA CLEANING**

After a first contact with an Italian company (Plasonic), it was recommended the following procedure:

A) Plasma cleaning of surfaces -> Oxygen

B) Plasma cleaning of surfaces -> Hydrogen

C) Passivation

D) Packaging for transportation

PLASONIC srl

- **The company is in Turin**
- **The Cygno components, because of the dimensions and mass, can be processed in Germany**
- **Plan for qualification: clean few samples like copper pieces, PMMA samples and copper screws and than measure at LNGS (January)**

DO WE REALLY NEED?

PMMA Vessel

Very preliminary design… however I do not see any criticality… Important is to give the green light for the optical window position

The total mass is about 100 kg

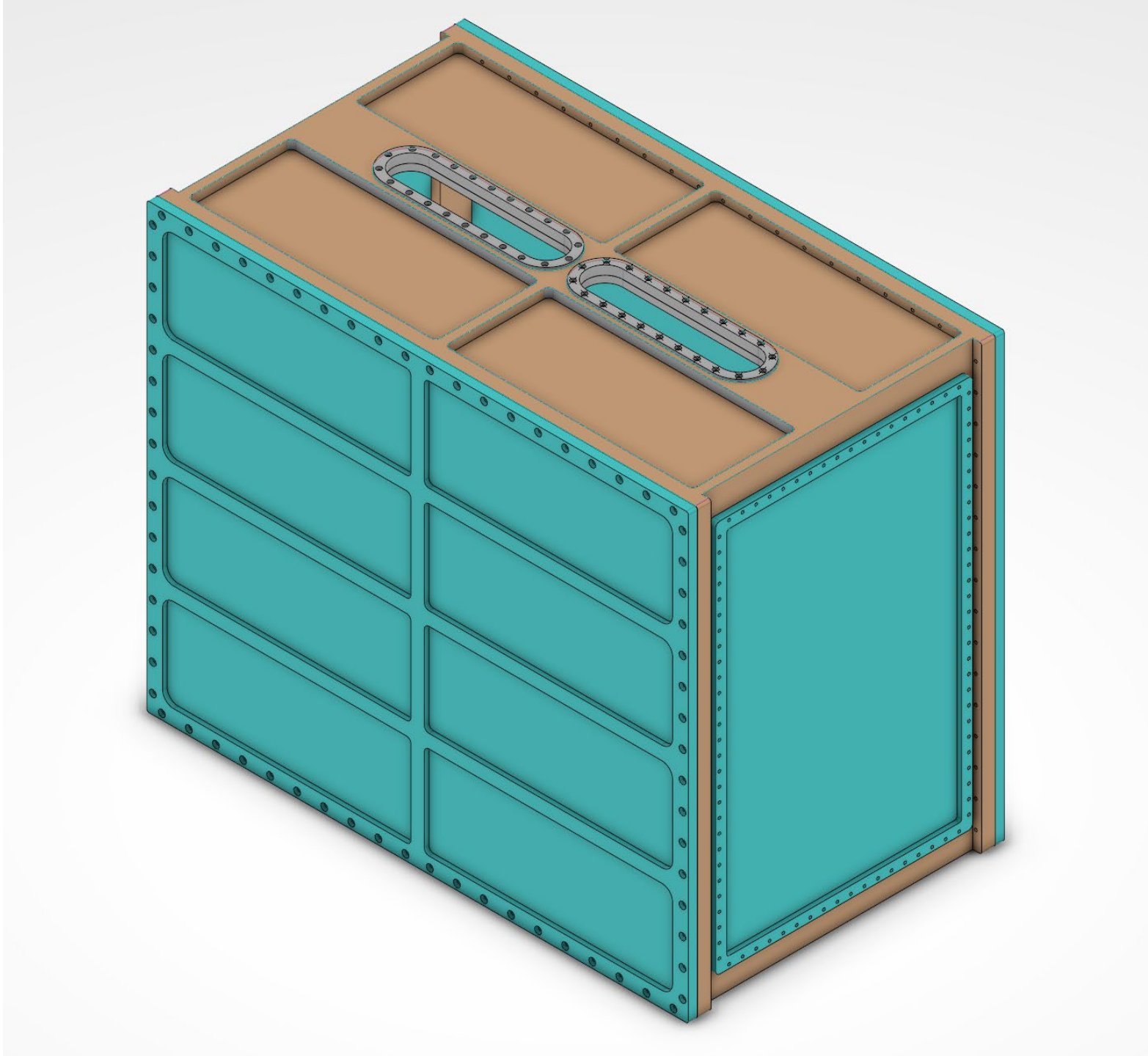
The optical windows design is not fixed yet because of the reflection issue on the GEM

The gas flow simulation?

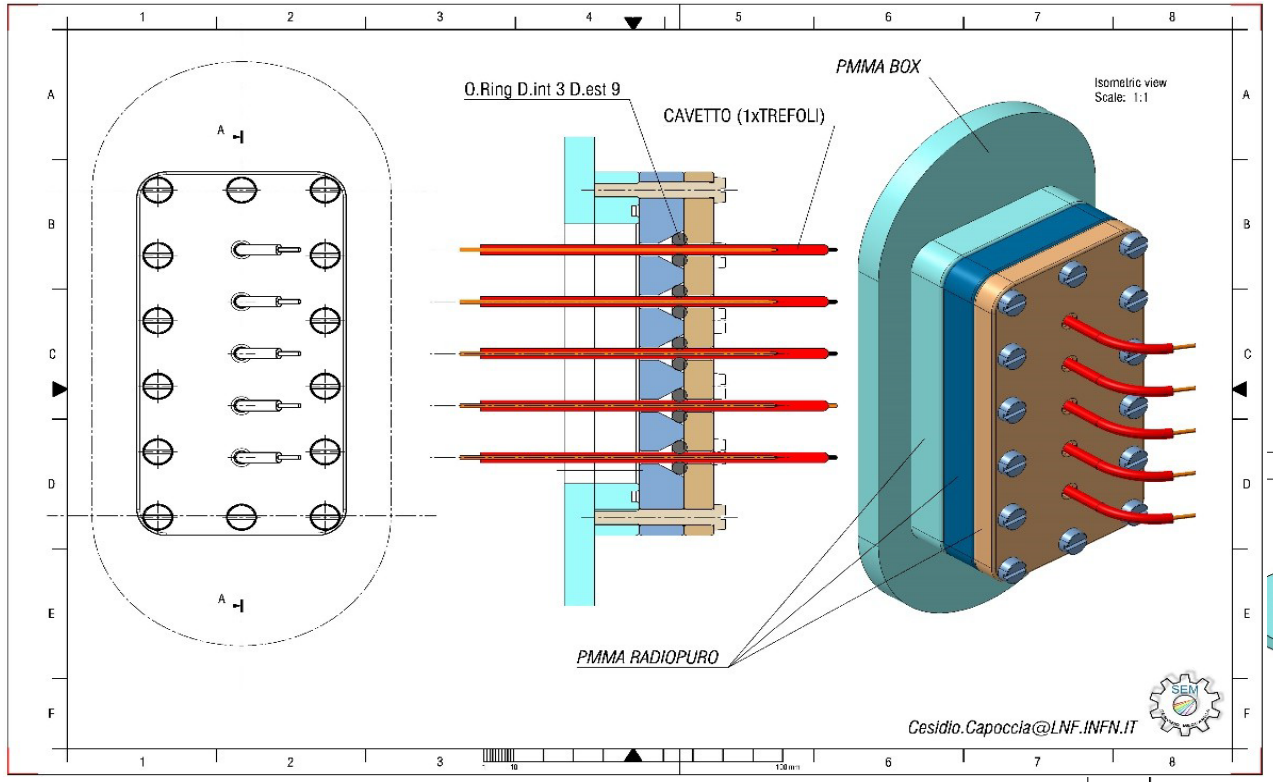
The feedthroughs for the signal cables and for the pipes: some conceptual were developed but not finalized yet (see next two slides)

The flanges for the calibrating source are 80x380 mm

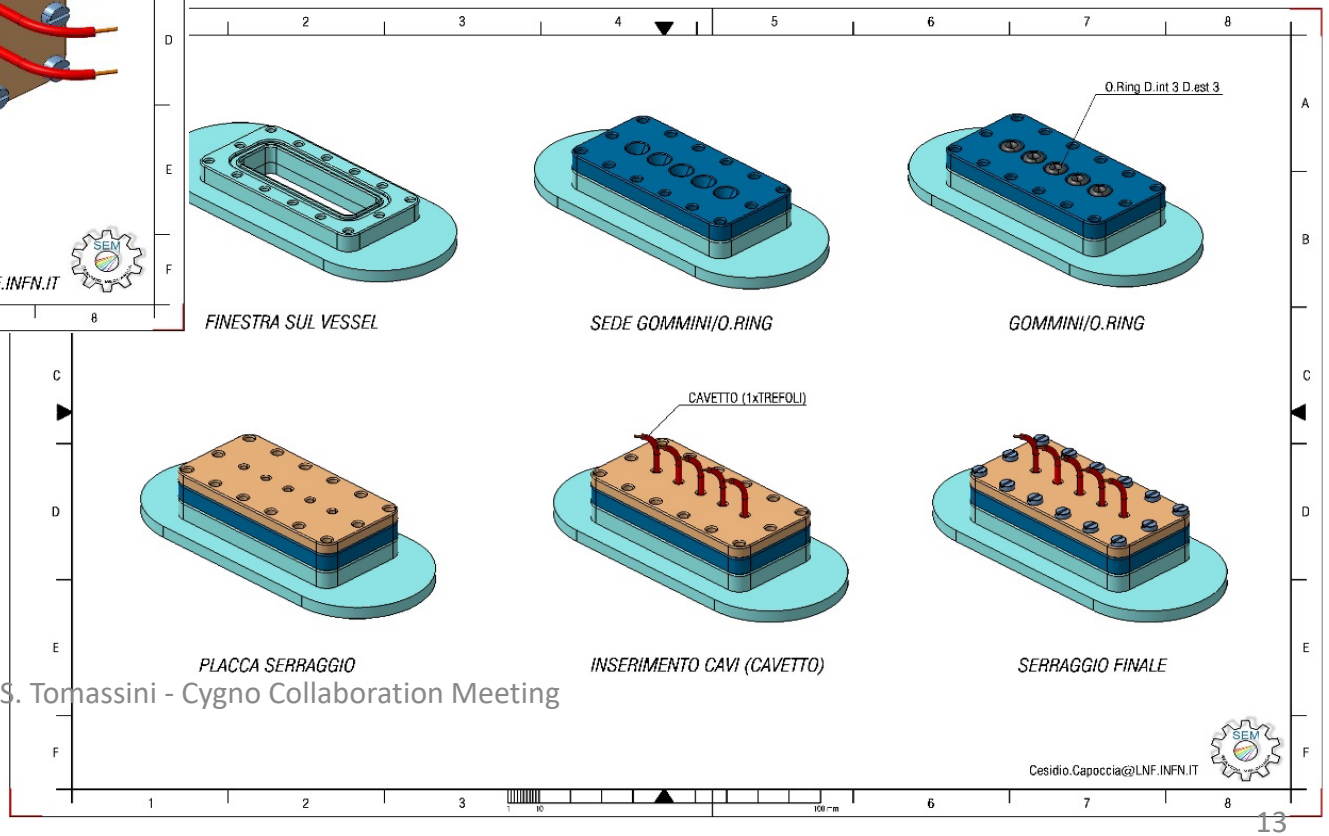
ETFE sheets, 125 microns, are foreseen to close the volume in a sandwich mode



FEEDTHROUGHS: Cables & Pipes



THIS IS A SCHEMATIC DESIGN OF A DOABLE MULTI-CORE CABLE FEEDTHROUGH USING RADIOPURE PMMA AND O.RINGS ALL COMPRESSED WITH NYLON SCREWS. ALSO DOABLE WITH "DOUBLE CONE" (TWO O.RINGS FOR EACH CABLE)



BESIDE THERE IS THE INTEGRATION SEQUENCE

THE BEST PERFORMANCE IS EXPECTED WITH SOLID PIPES.

THE SAME DESIGN CAN BE USED FOR THE GAS PIPES.

Contacts for radiopure PMMA vendors

VinkItalia.
The PMMA is produced in Germany

Two samples are on the way to Frascati
PLEXIGLAS GS 0F00

Angelo Acocella

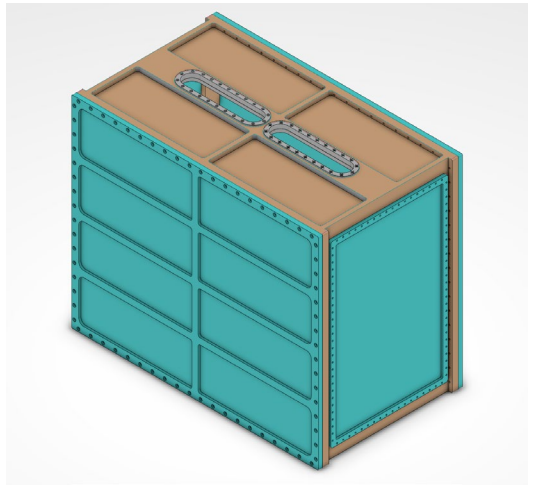
POLYCAST Sheet, Rod & Tube
SPARTECH
69 Southfield Ave.
Stamford, CT 06902
Web: www.spartech.com
Angelo.Acocella@spartech.com

1. UVT-Ultra violet transmitting
2. Polycast standard

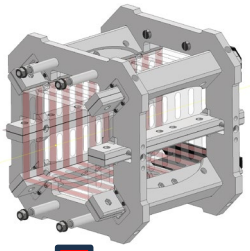
I can send you a 12”x12” sample of .500” of both of them.

Thaddeus Paddock

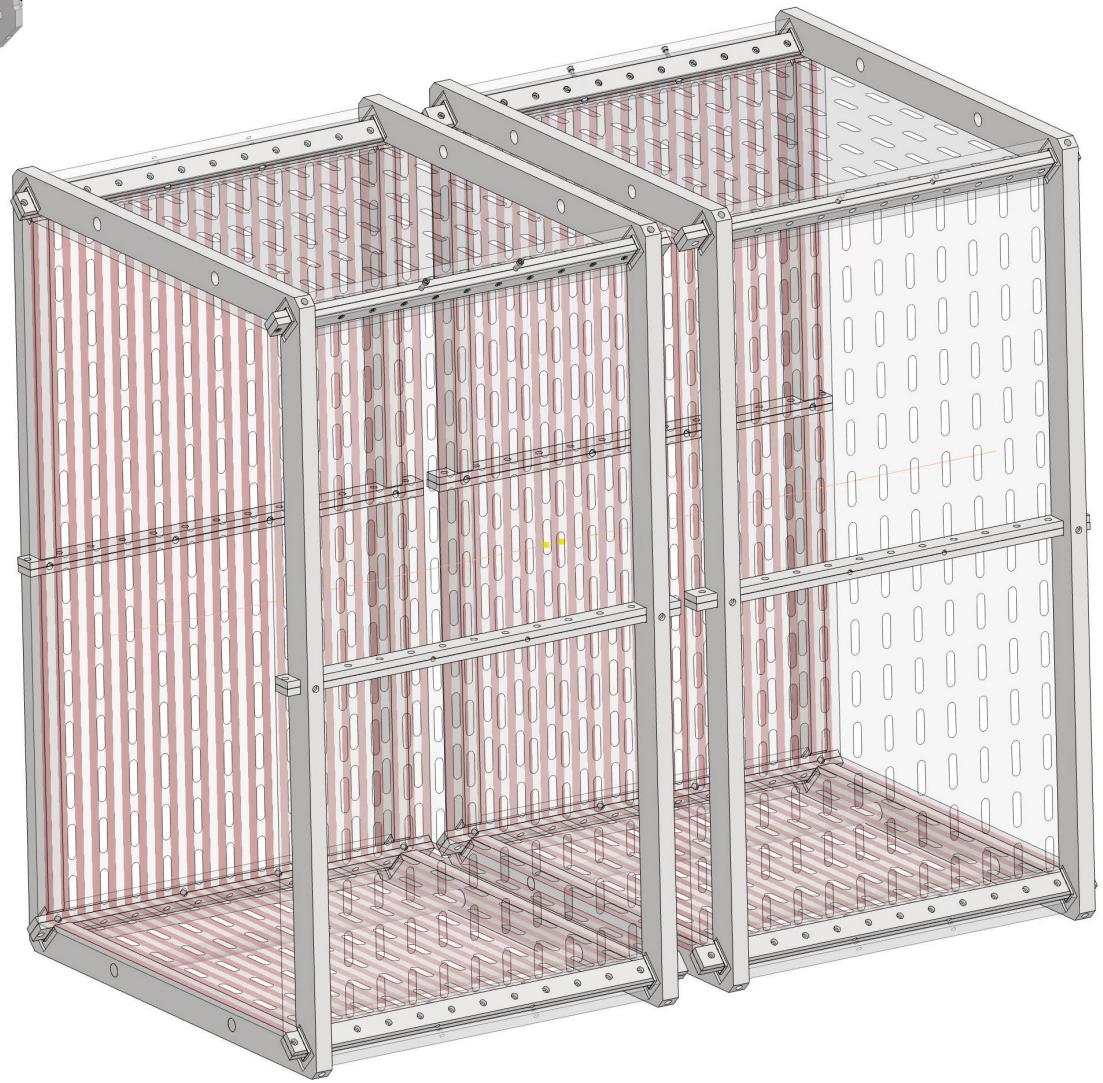
Reynolds Polymer Technology, Inc.
teamrpt@reynoldspolymer.com

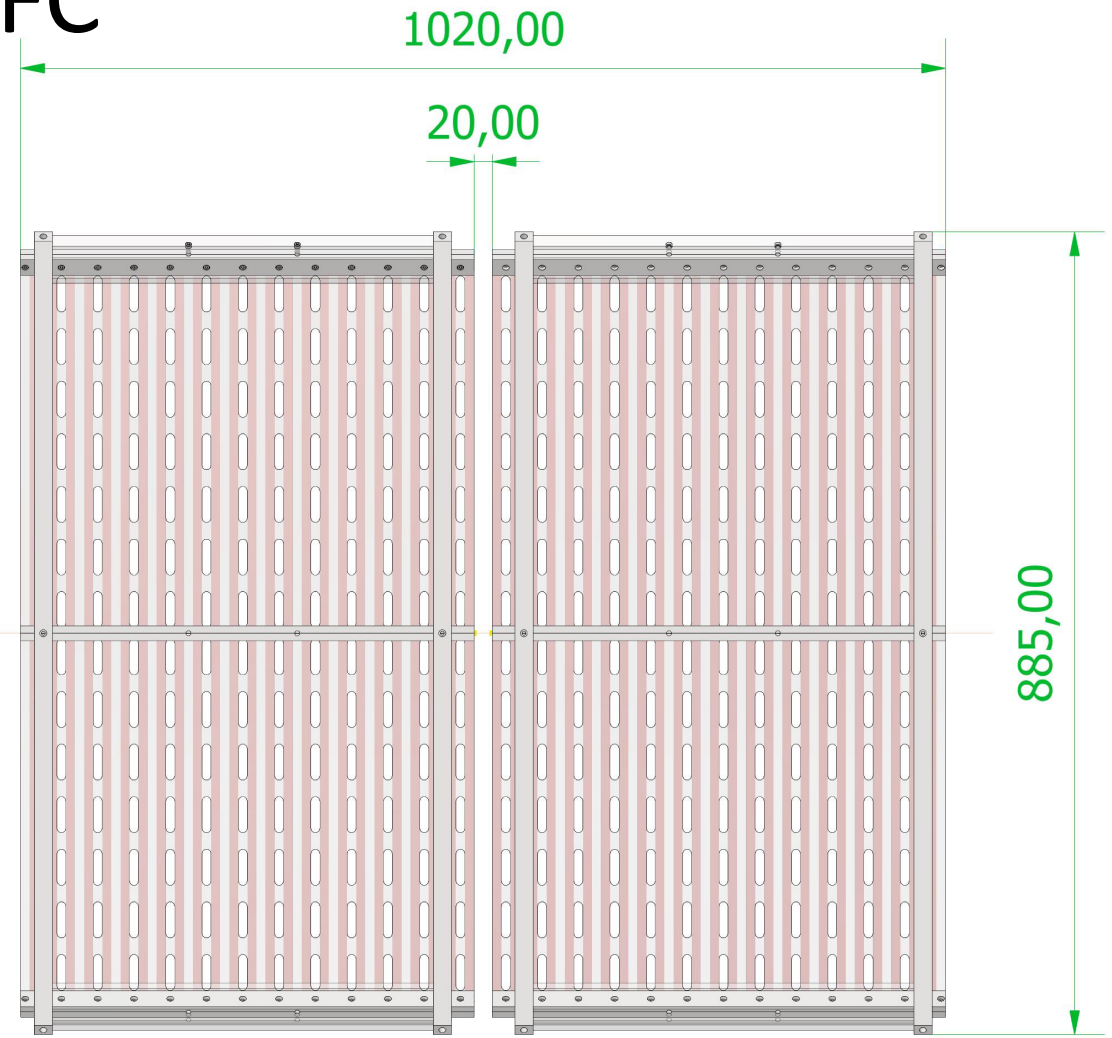


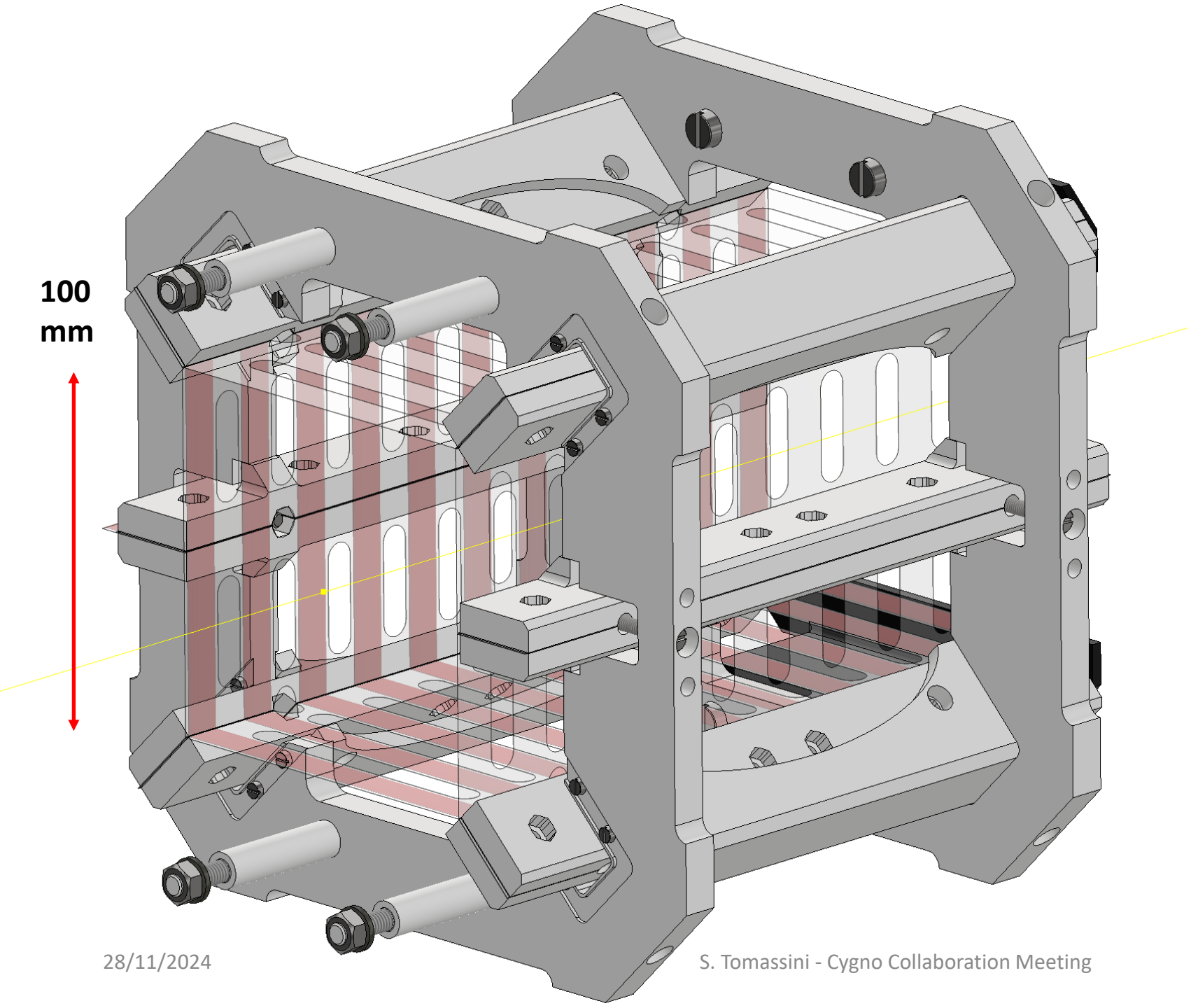
CYGNO - FC



GIN

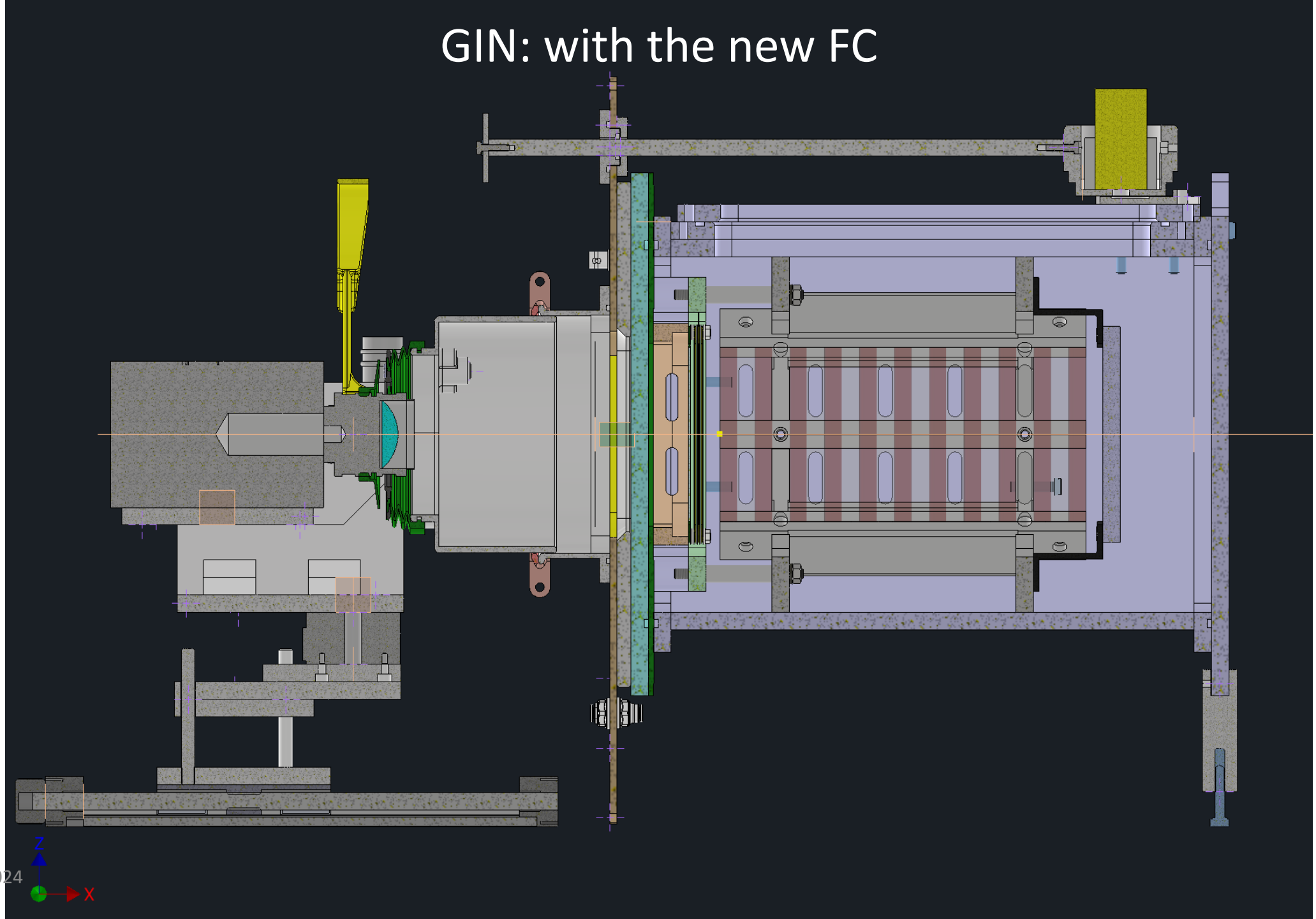




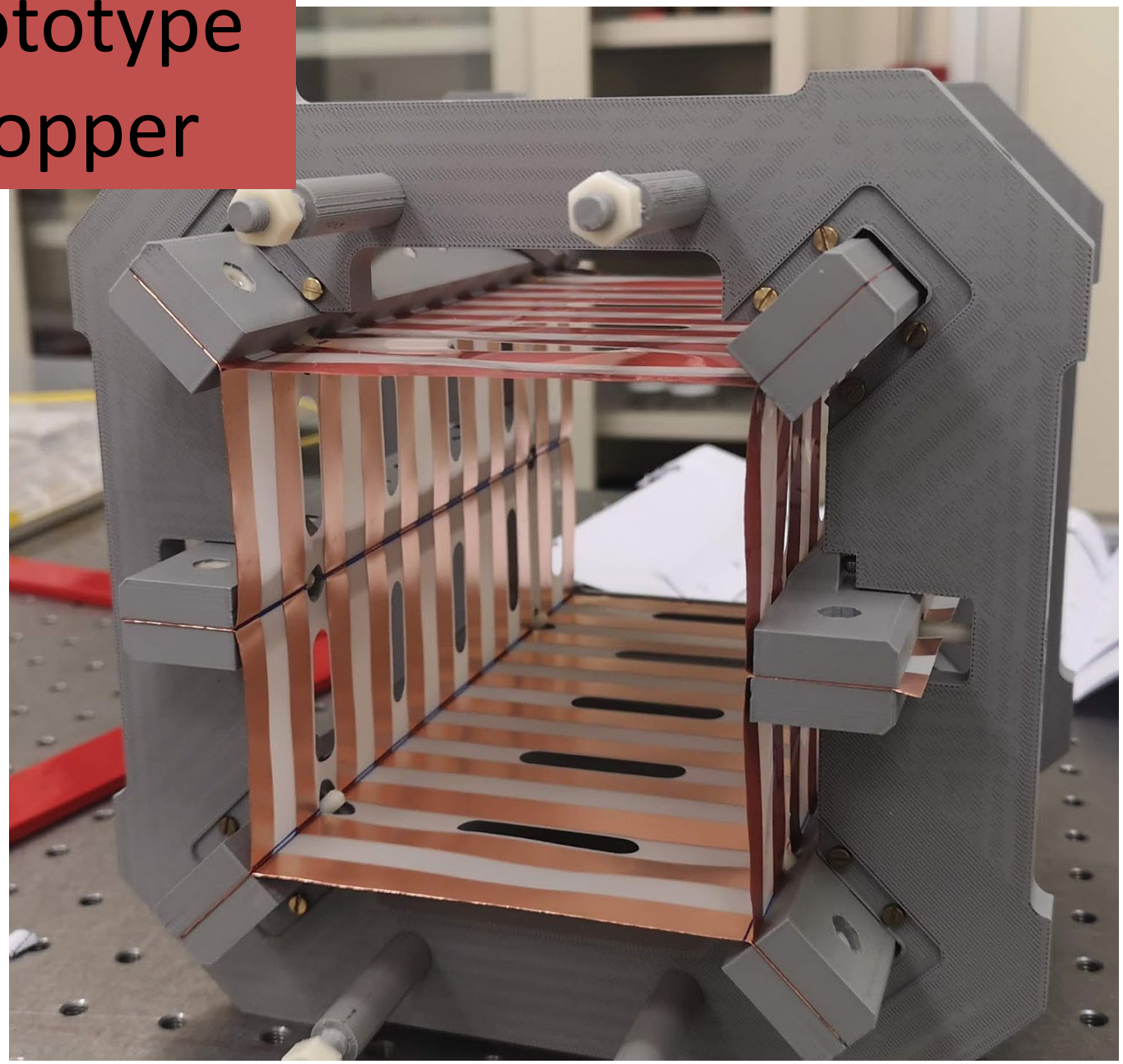


FC OPTIMIZED FOR THE GIN SETUP. All the components can be machined as acrylic material

GIN: with the new FC



The Prototype PET-Copper

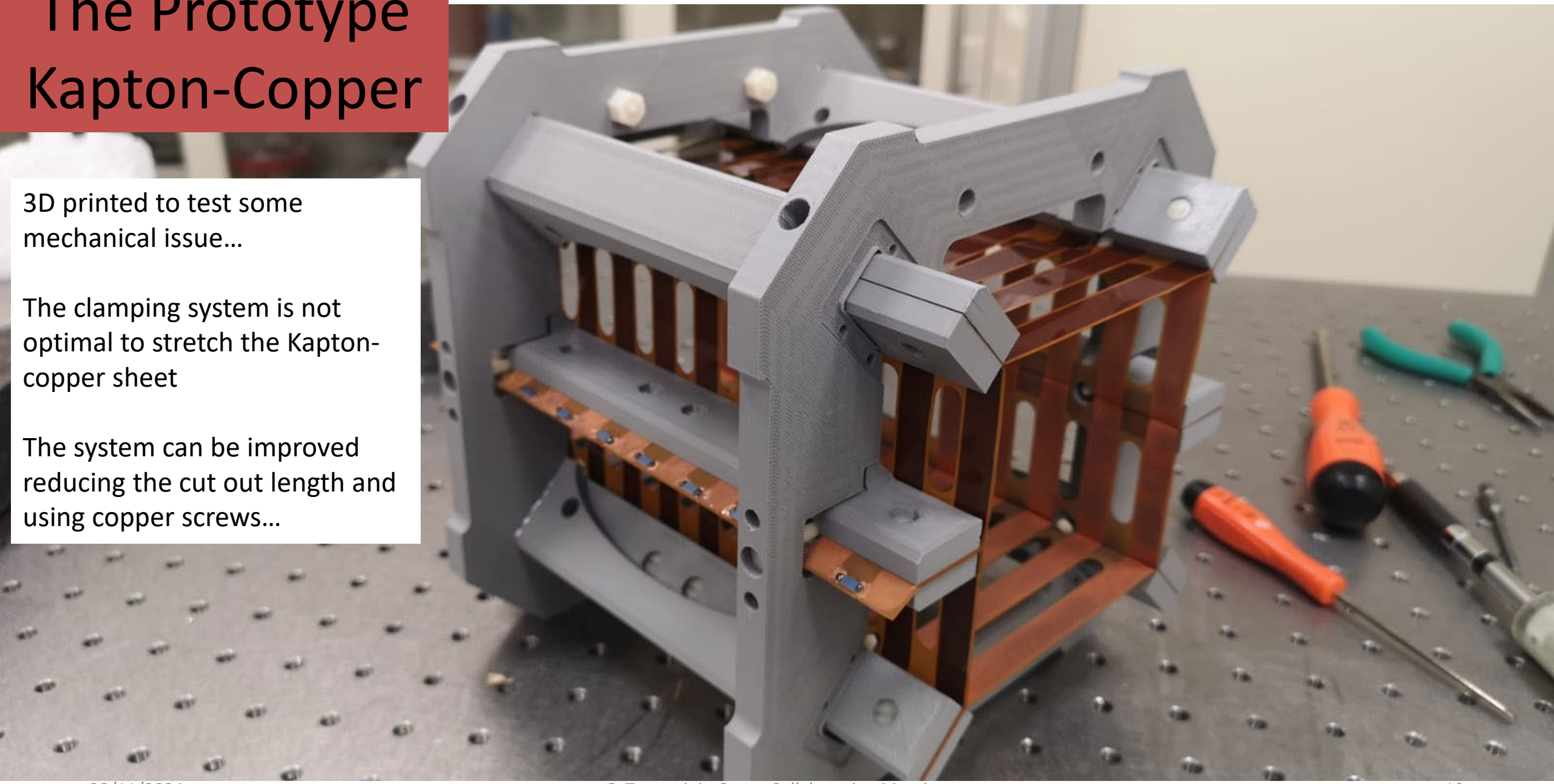


3D printed to test some mechanical issue…

The clamping system is not optimal to stretch the PET-copper sheet

The cutting edge of the foil was not well cut…

The Prototype Kapton-Copper

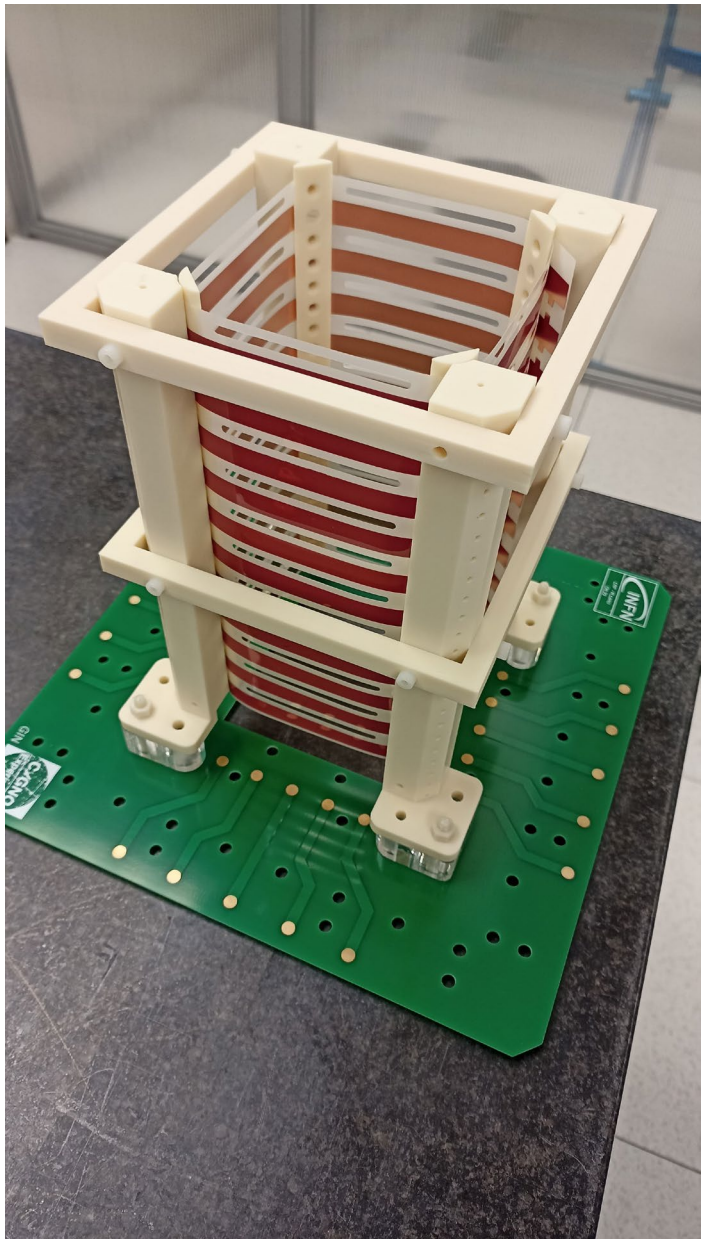


3D printed to test some mechanical issue…

The clamping system is not optimal to stretch the Kapton-copper sheet

The system can be improved reducing the cut out length and using copper screws…

The Prototype 2 PET-Copper



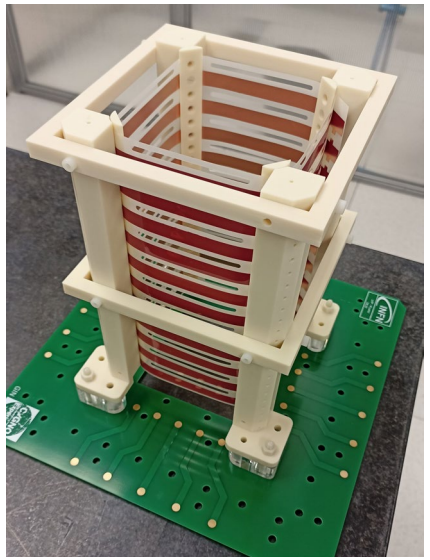
Designed by Pierluigi,Russo, Paoletti, Tesauro, Mazzitelli and Benussi…

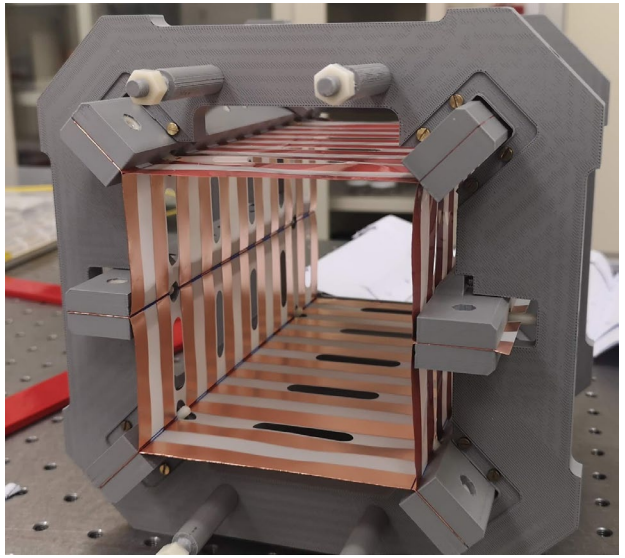
Currently under test with GIN…

It seems the field is distorted around a corner…

It is promising even though the design must be optimized for the real scale design (800x500) instead of 100x100 mm

What is the design to choose for the full scale FC?

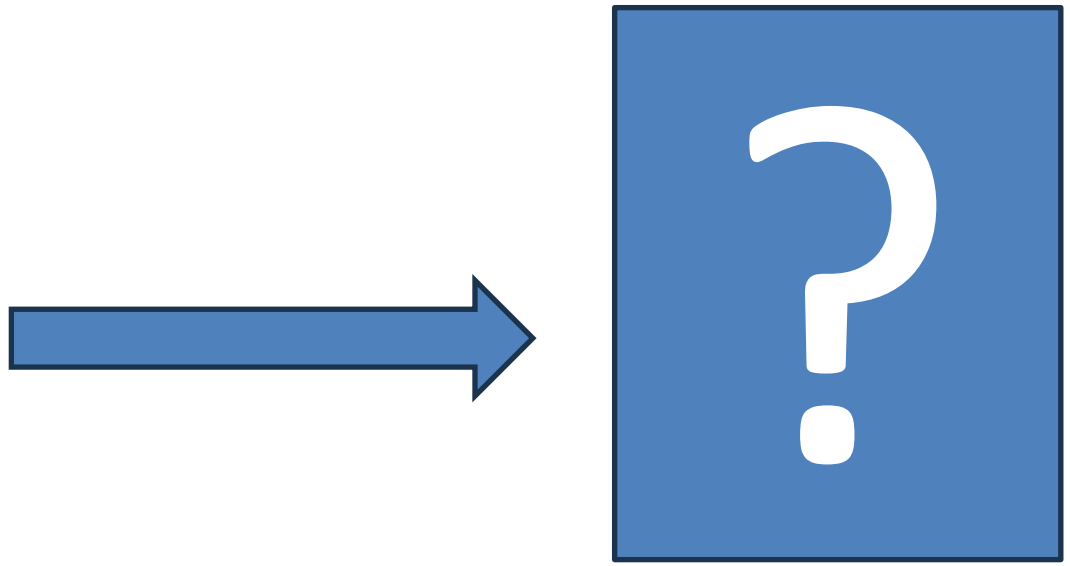




It is urgent to make a choice to finalize the mechanical design of the FC, PMMA vessel, the interface with GEM…

Cathode?

In the current design is a 800x500x2.5 mm copper sheet… The material was procured with the radio-pure copper for the shielding production

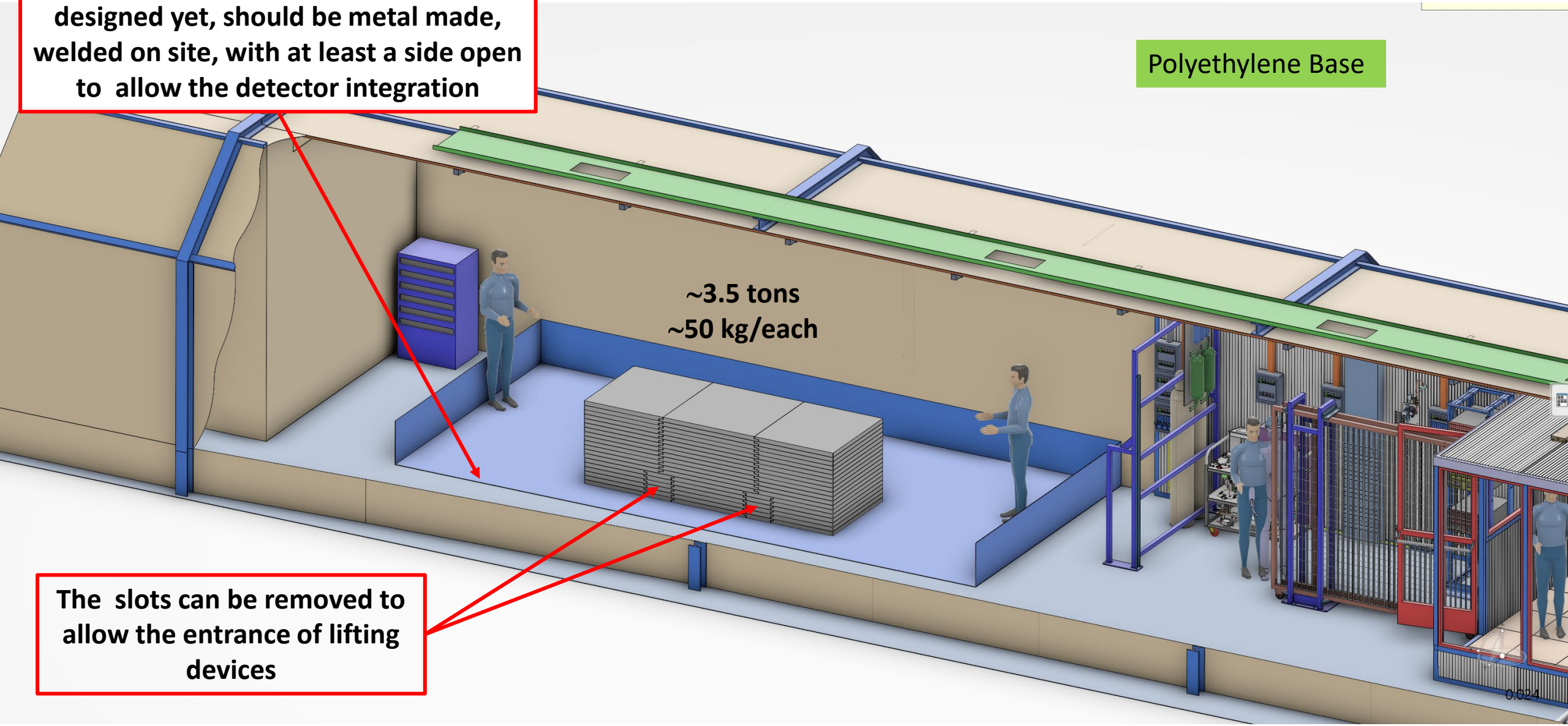


Do we have any other idea?

INTEGRATION

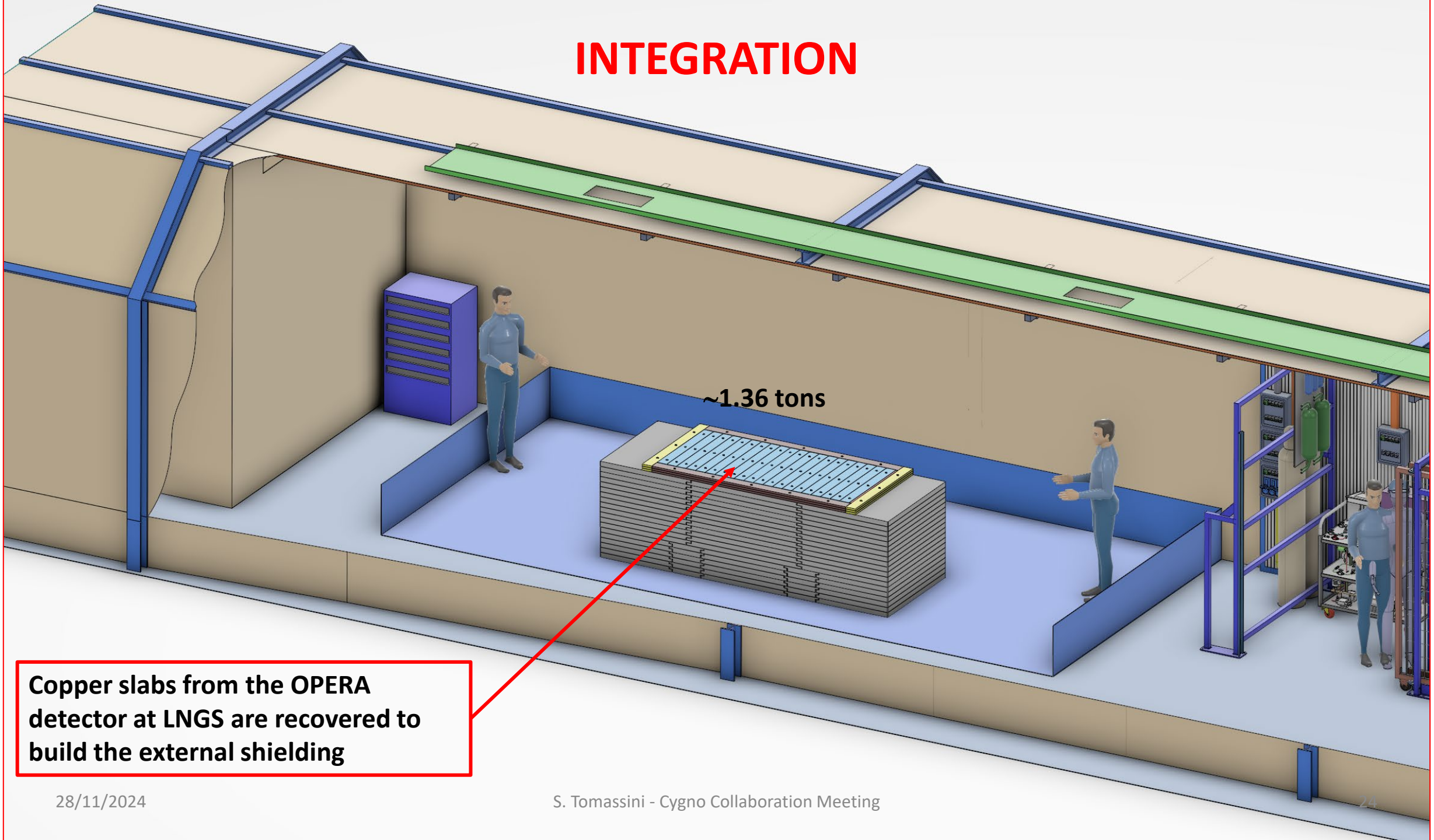
The safety pool (base tank), not designed yet, should be metal made, welded on site, with at least a side open to allow the detector integration

Polyethylene Base



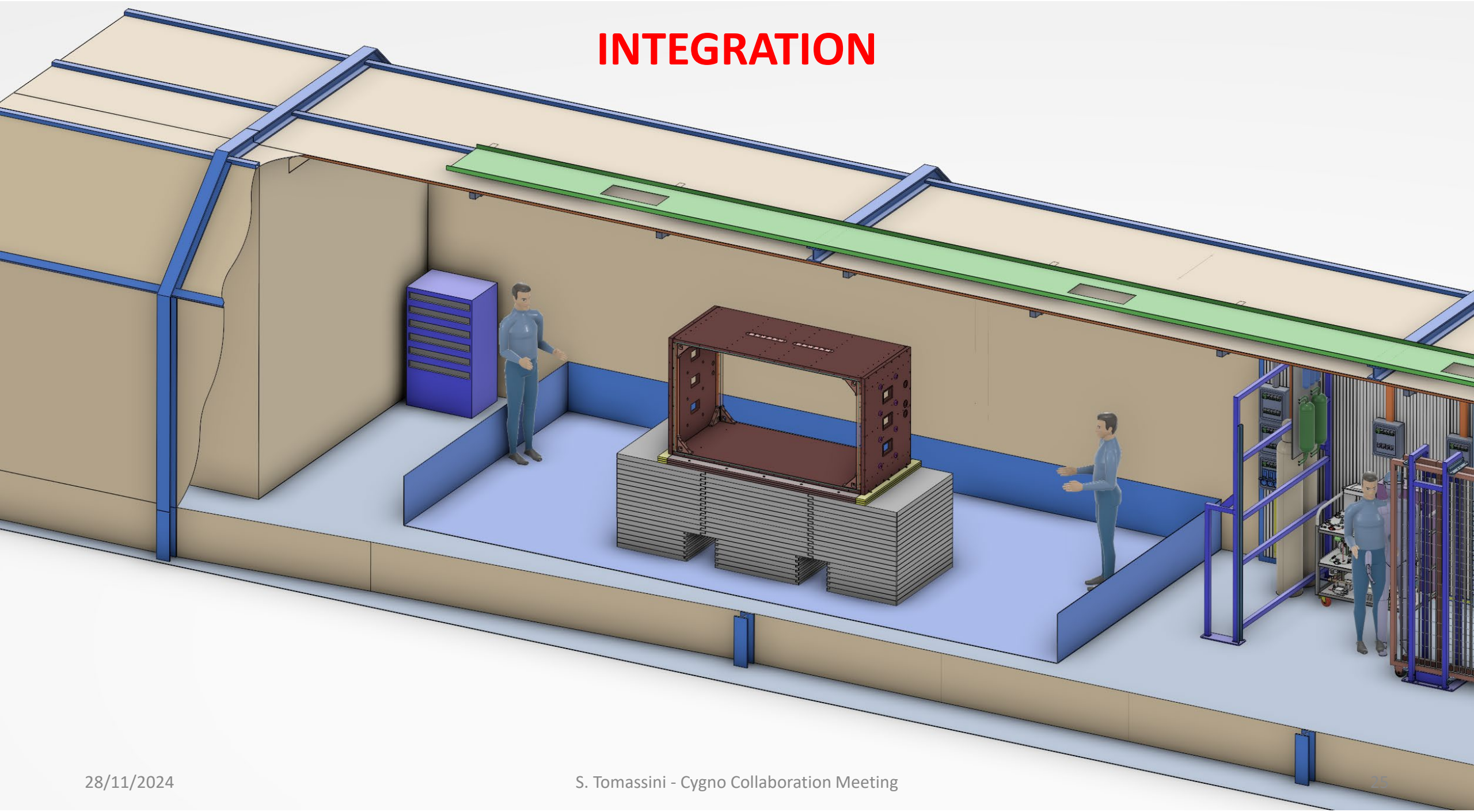
The slots can be removed to allow the entrance of lifting devices

INTEGRATION

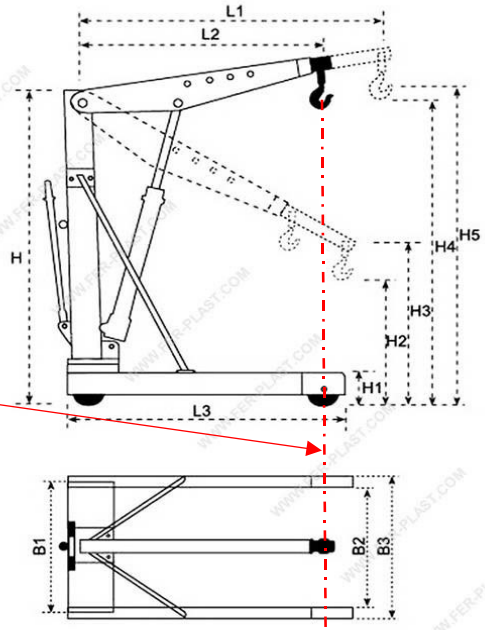


Copper slabs from the OPERA detector at LNGS are recovered to build the external shielding

INTEGRATION



NELLA BASE DI POLIETILENE VANNO PREVISTE DELLE ‘’NICCHIE” PER PERMETTERE ALLE RUOTE ANTERIORI DELLA GRU DI ‘’ENTRARE” SOTTO LA COPPER BOX



Model		Capacity	Position 1	Position 2	Position 3	Position 4	Net Weight
FPSA1000	kg	1000	1000	900	800	700	103

Dimensions		L1	L2	L3	H1	H2	H3	H4	H5	H	B1	B2	B3
FPSA1000	mm	1360	1060	1395	155	470	705	2225	2475	1595	925	840	1000

FPSA 1000 M	Gruetta idraulica per Europallet - Prodotto montato	~~1.700,00 €~~ 1.445,00 €

6. **Quali apparecchi di sollevamento non richiedono la verifica periodica da parte dell’INAIL?**

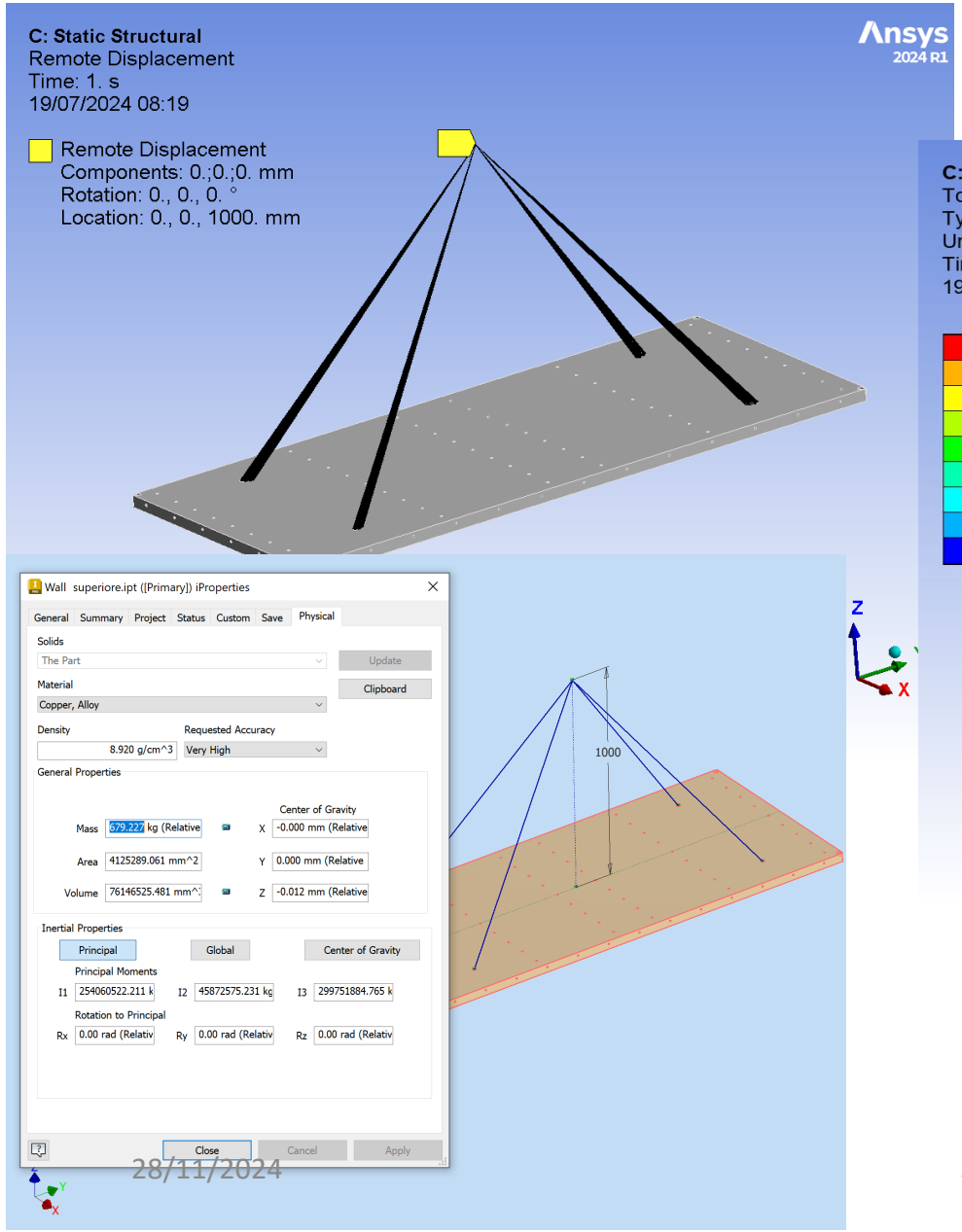
Qualsiasi apparecchio per il sollevamento che rientra in uno dei seguenti casi *non* richiede la verifica periodica:

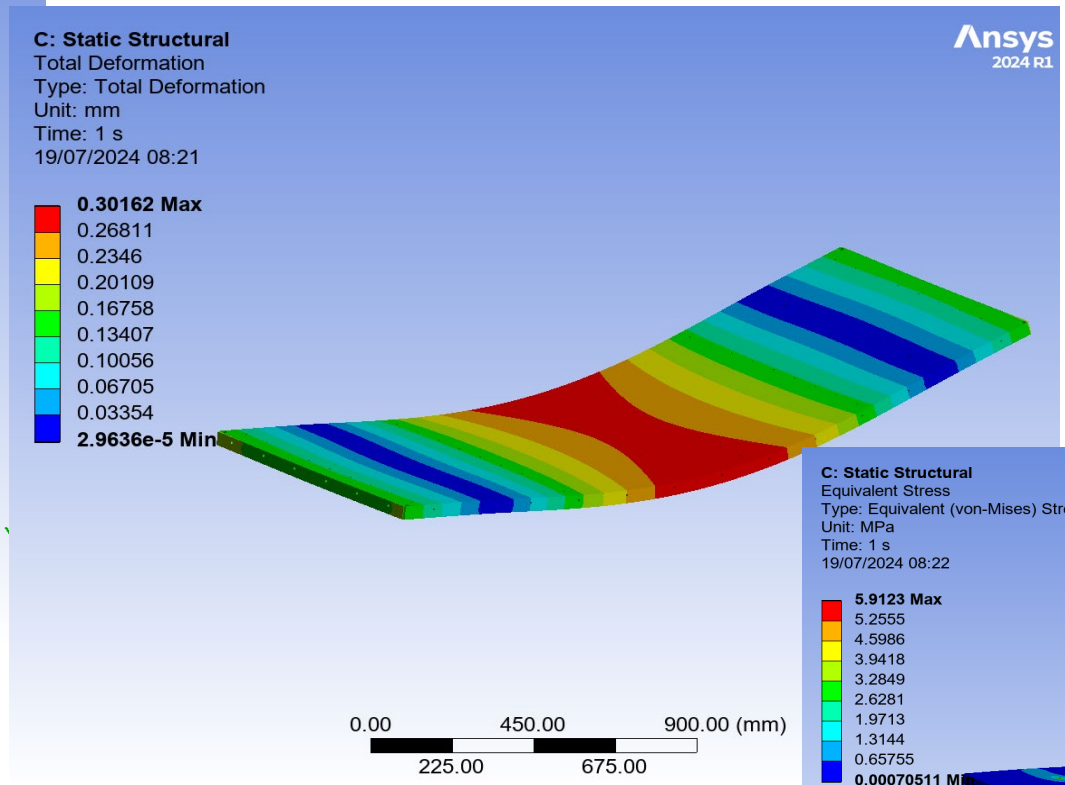
- Impianto di sollevamento motorizzato che *non supera i 200 kg. di portata massima*;
- Impianto di sollevamento ad *azionamento manuale* per qualsiasi portata.

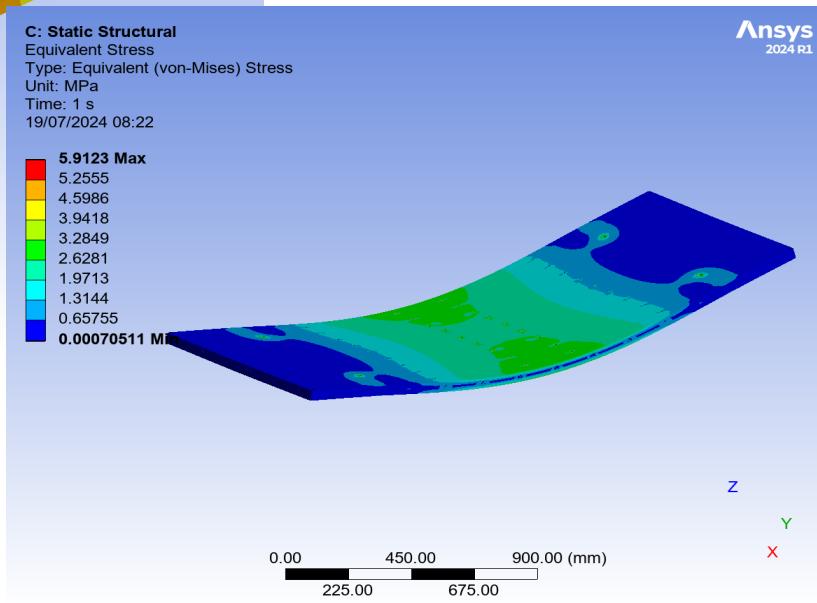
Hydraulic crane for pallets, with the large forks it allows to fit around the pallet

Copper Plate handling

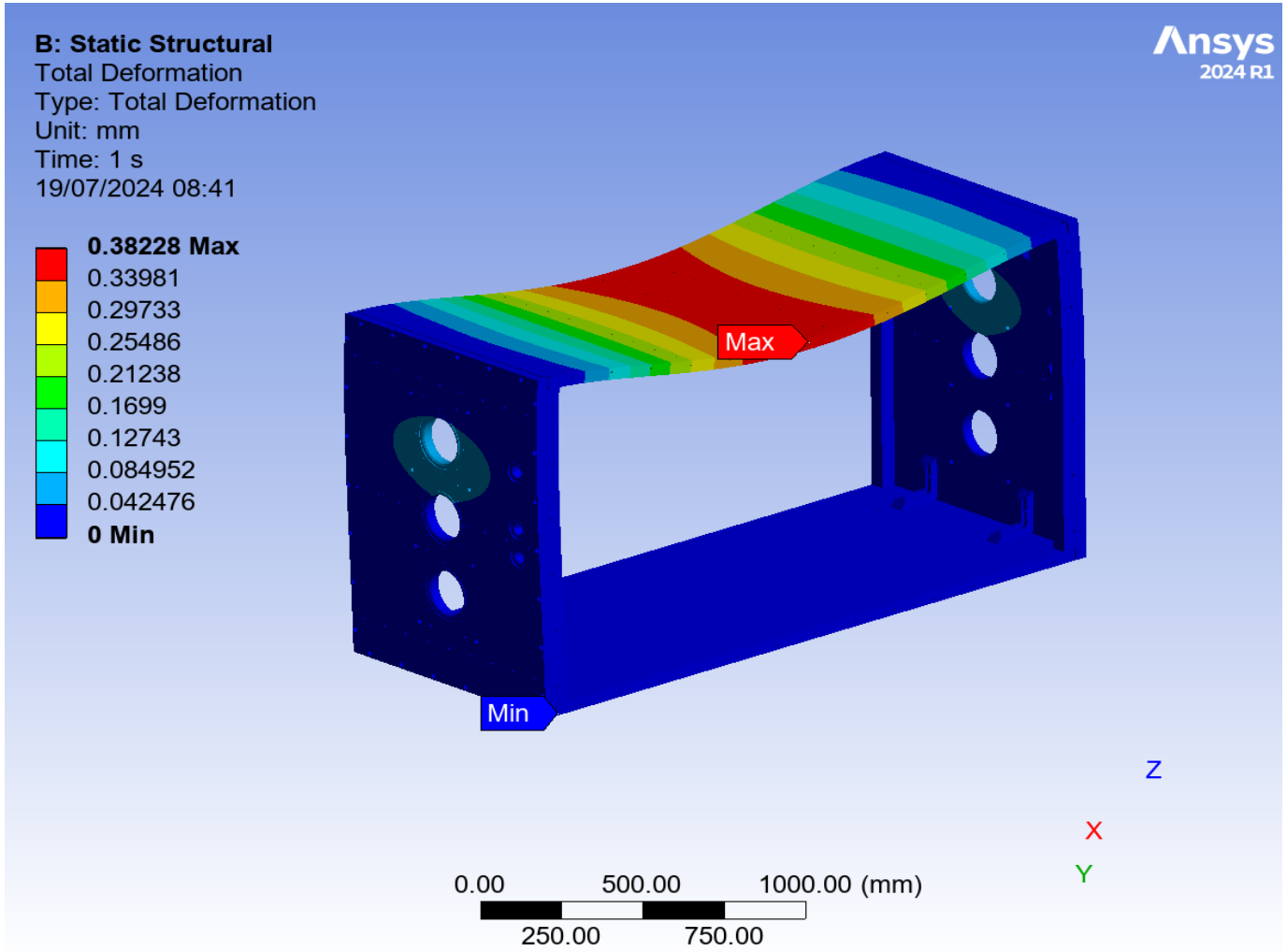
The copper plate can be safely handled with four straps and a lifting device (crane or equivalent). Four Swivel eye-bolts M20 are required.



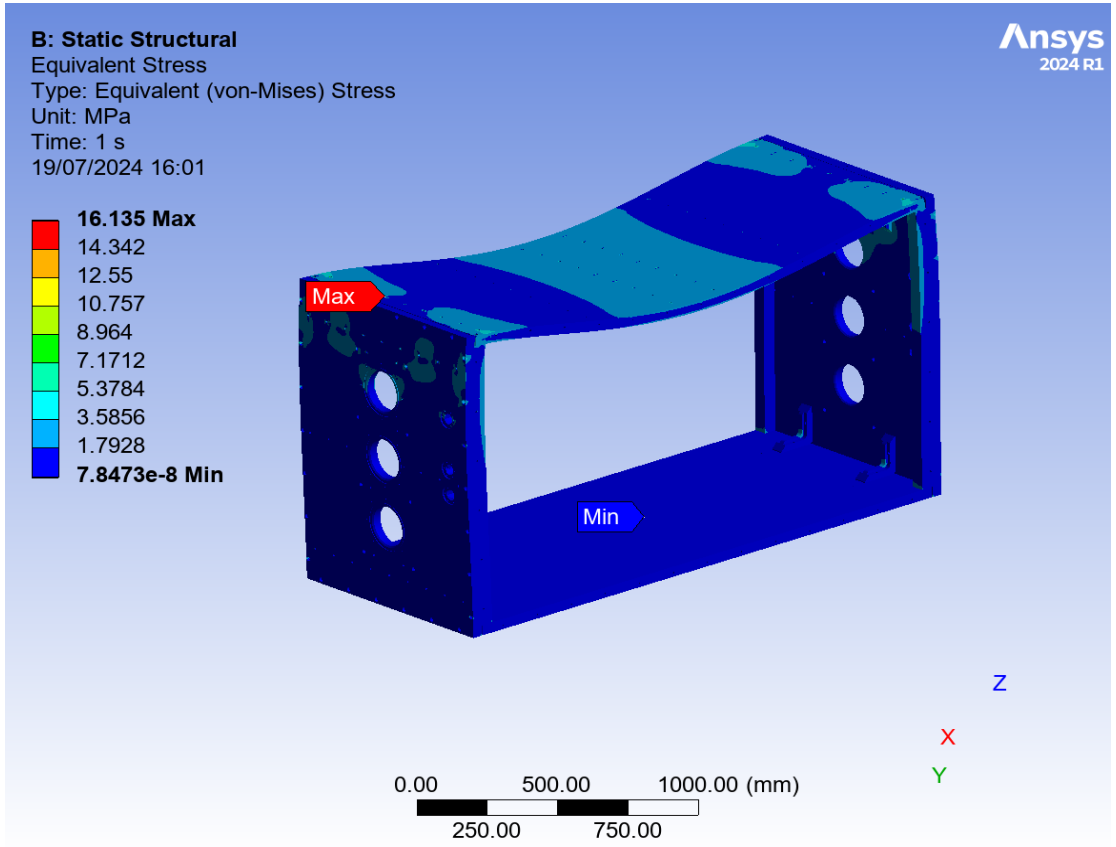




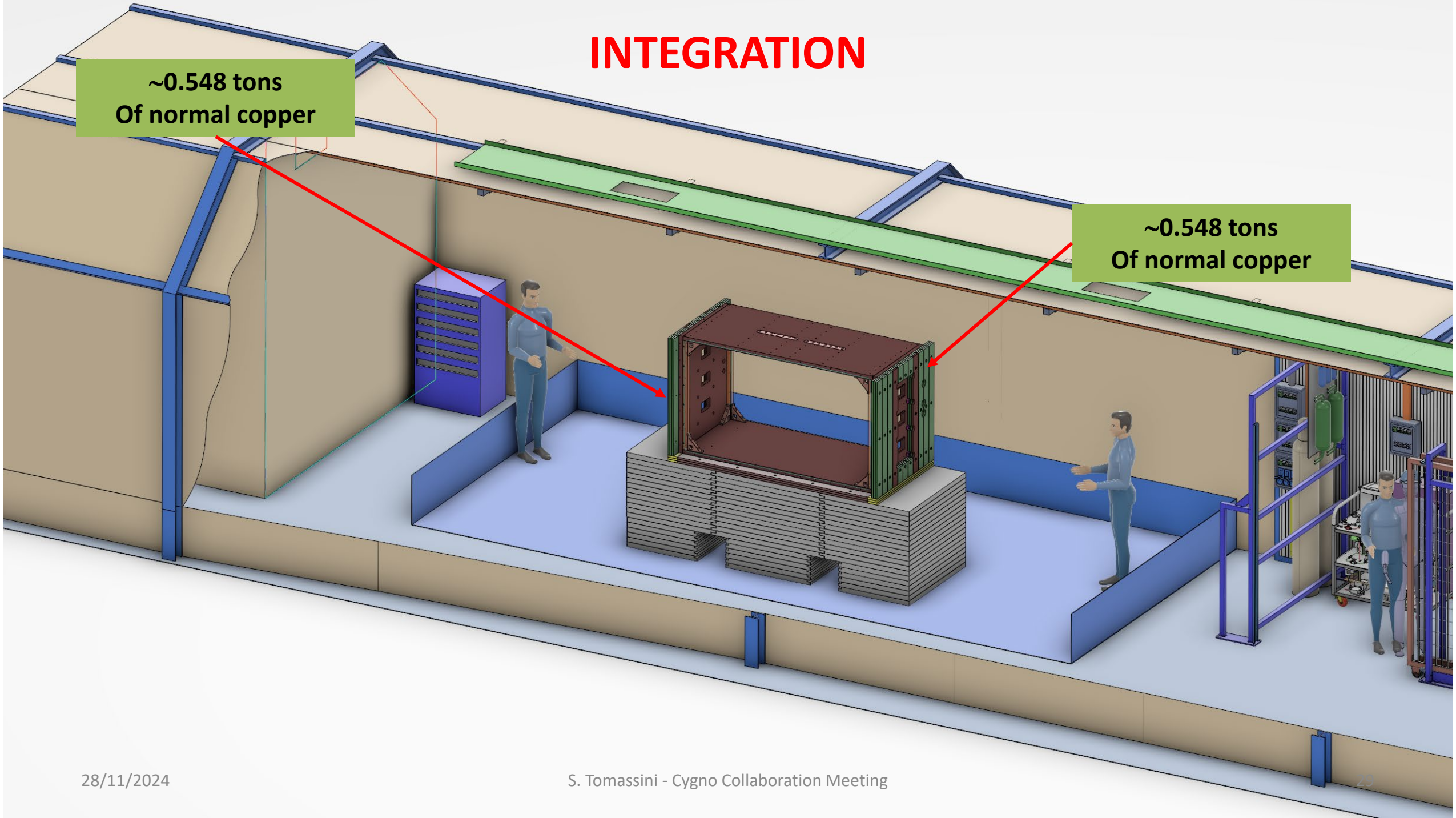
Copper box Integration cont’



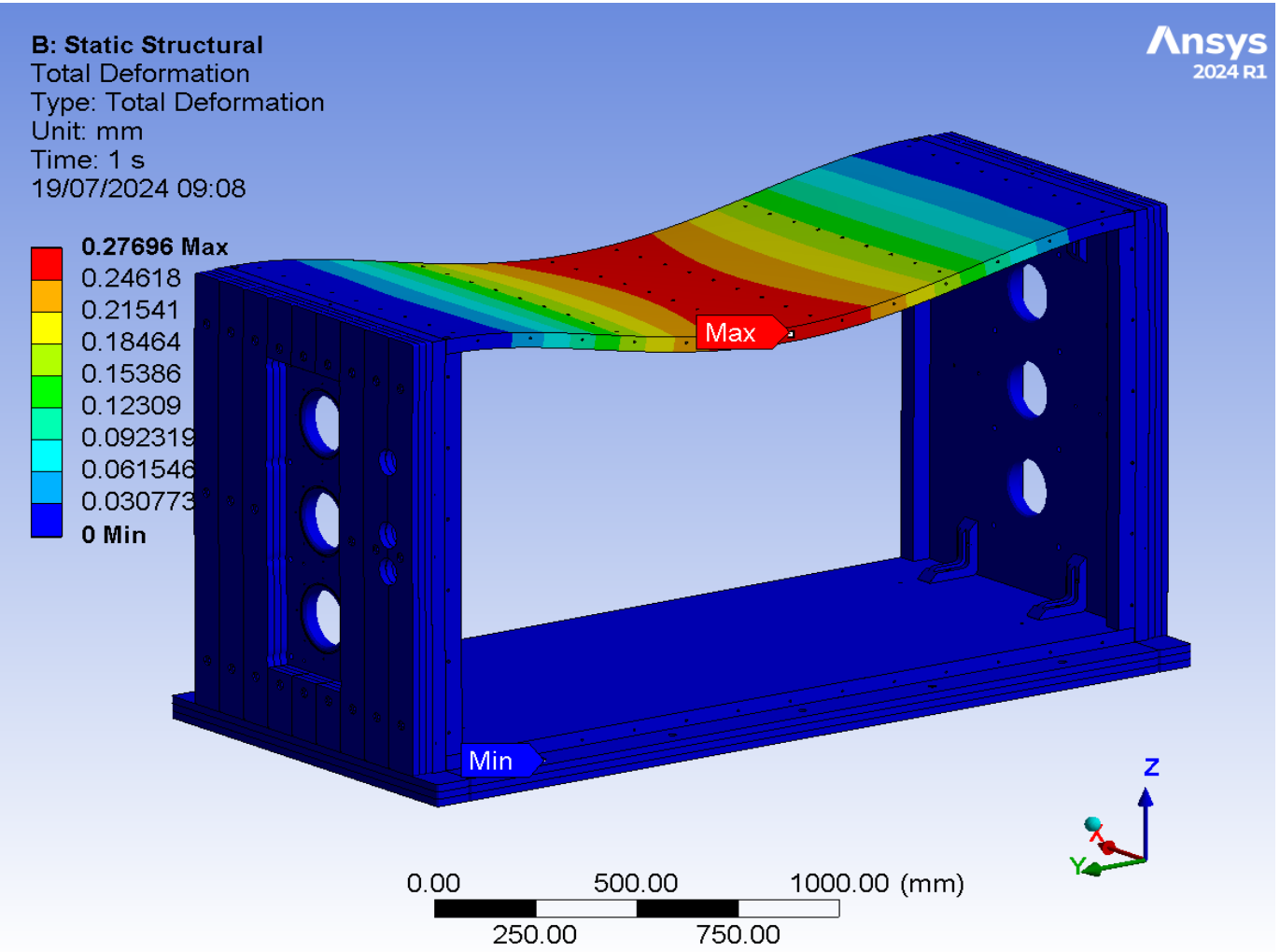
Since deformations of the top panel occur during integration, for this phase a strong-back is still required to stiffen the panel and allow the integration of the copper slabs on the external layer.



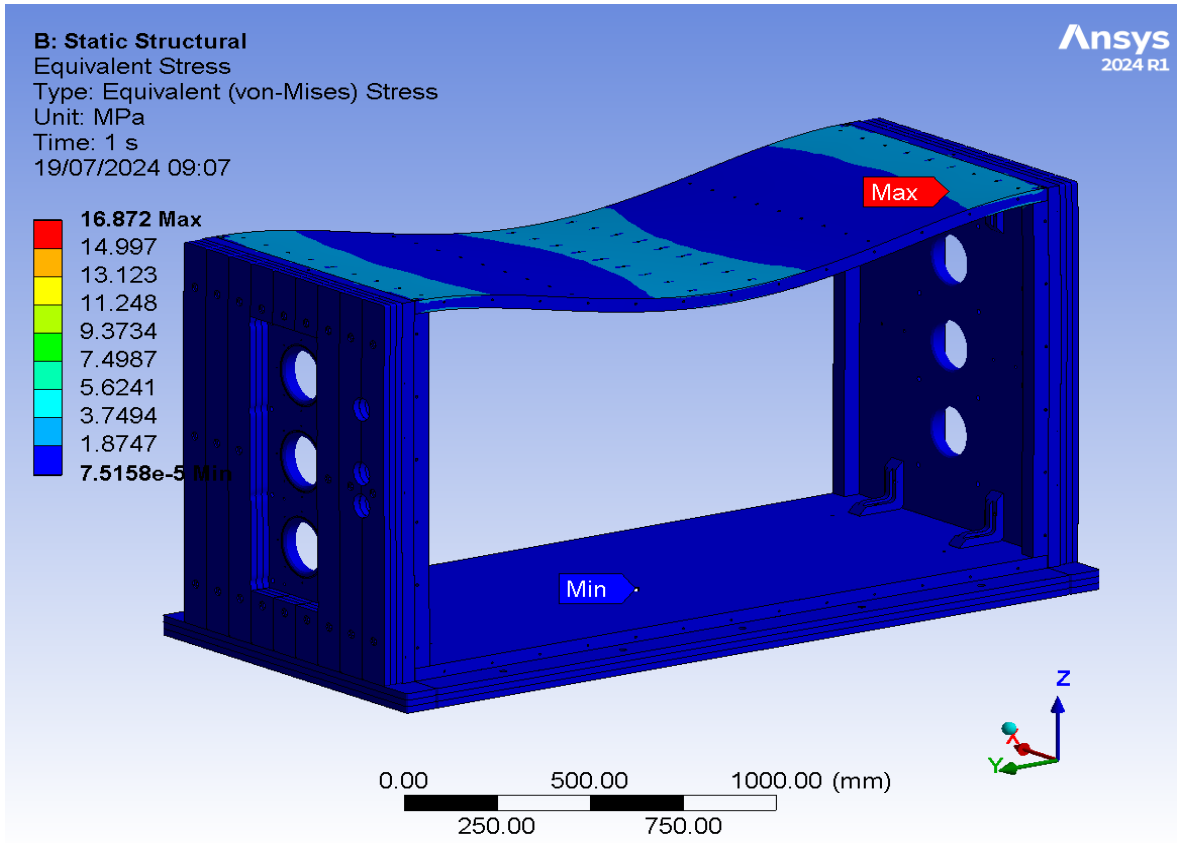
INTEGRATION



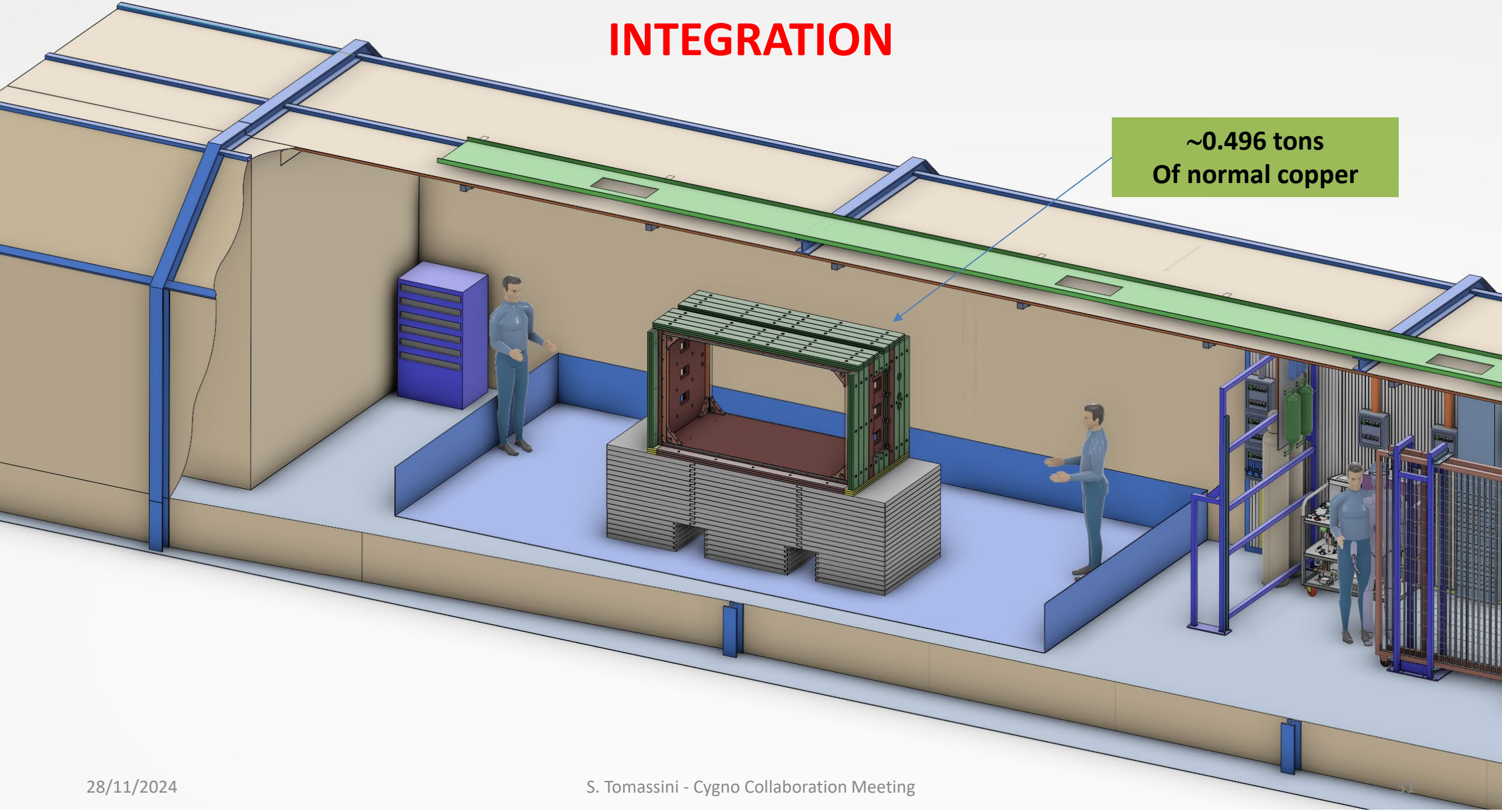
Copper box Integration cont’



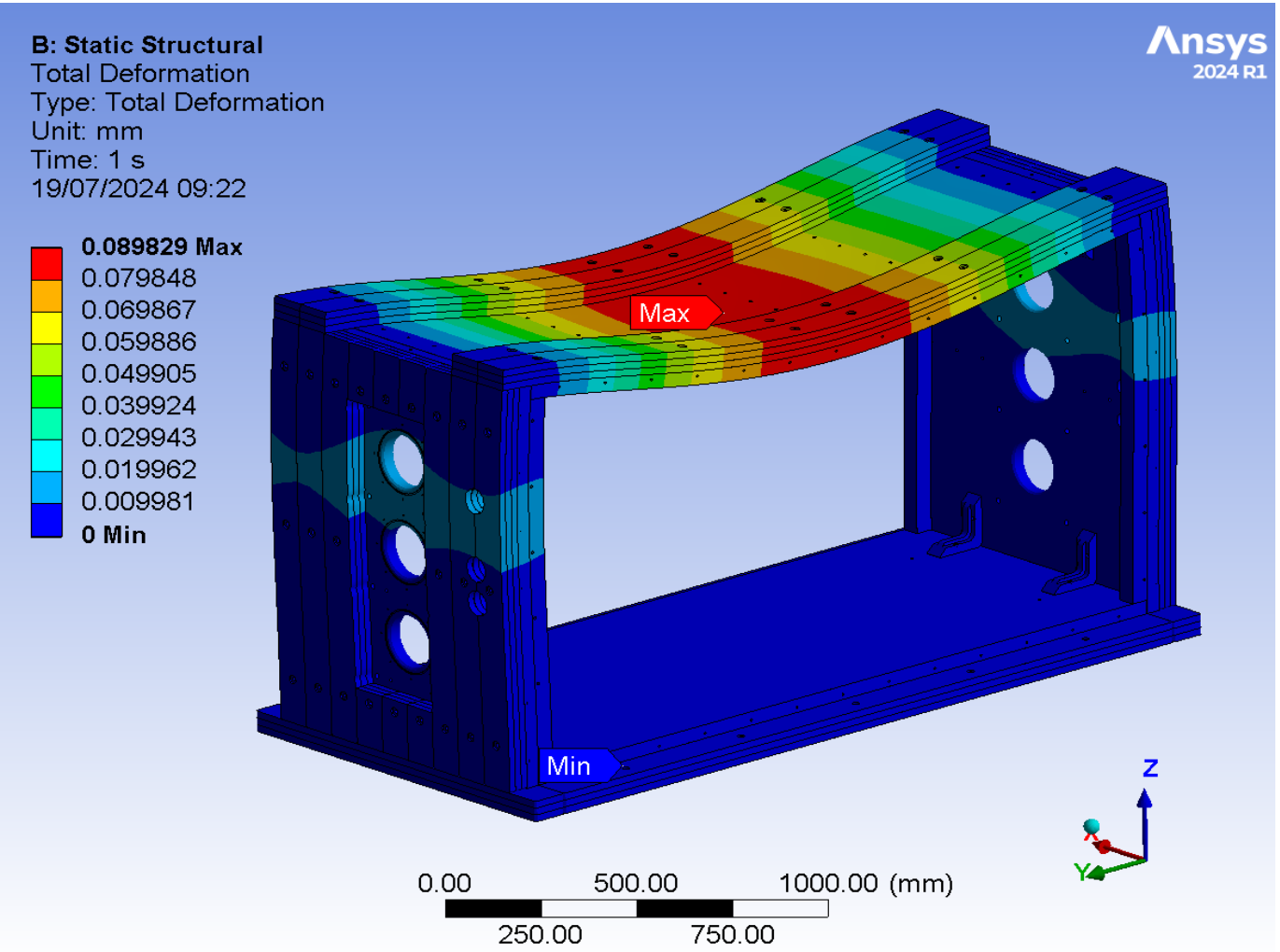
In this phase a strong-back is still required to stiffen the panel and allow the integration of the copper slabs on the external layer.



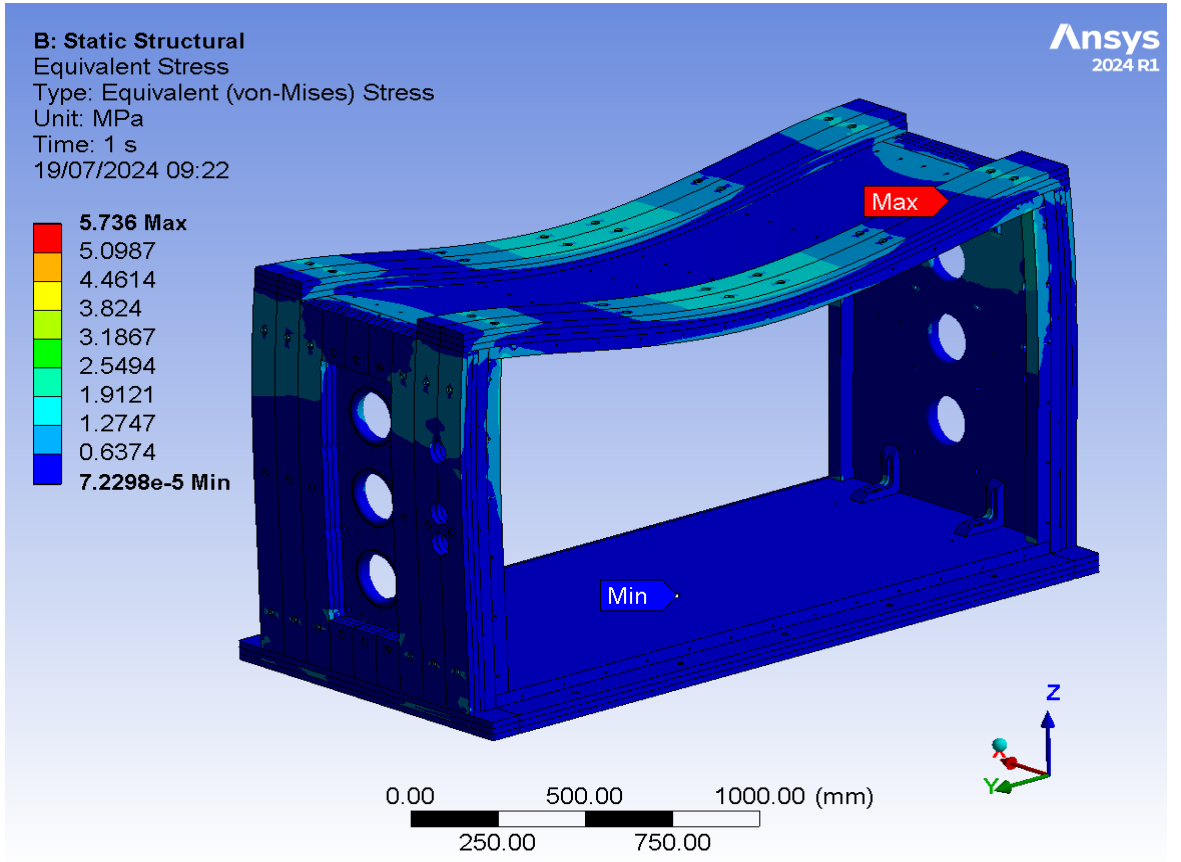
INTEGRATION



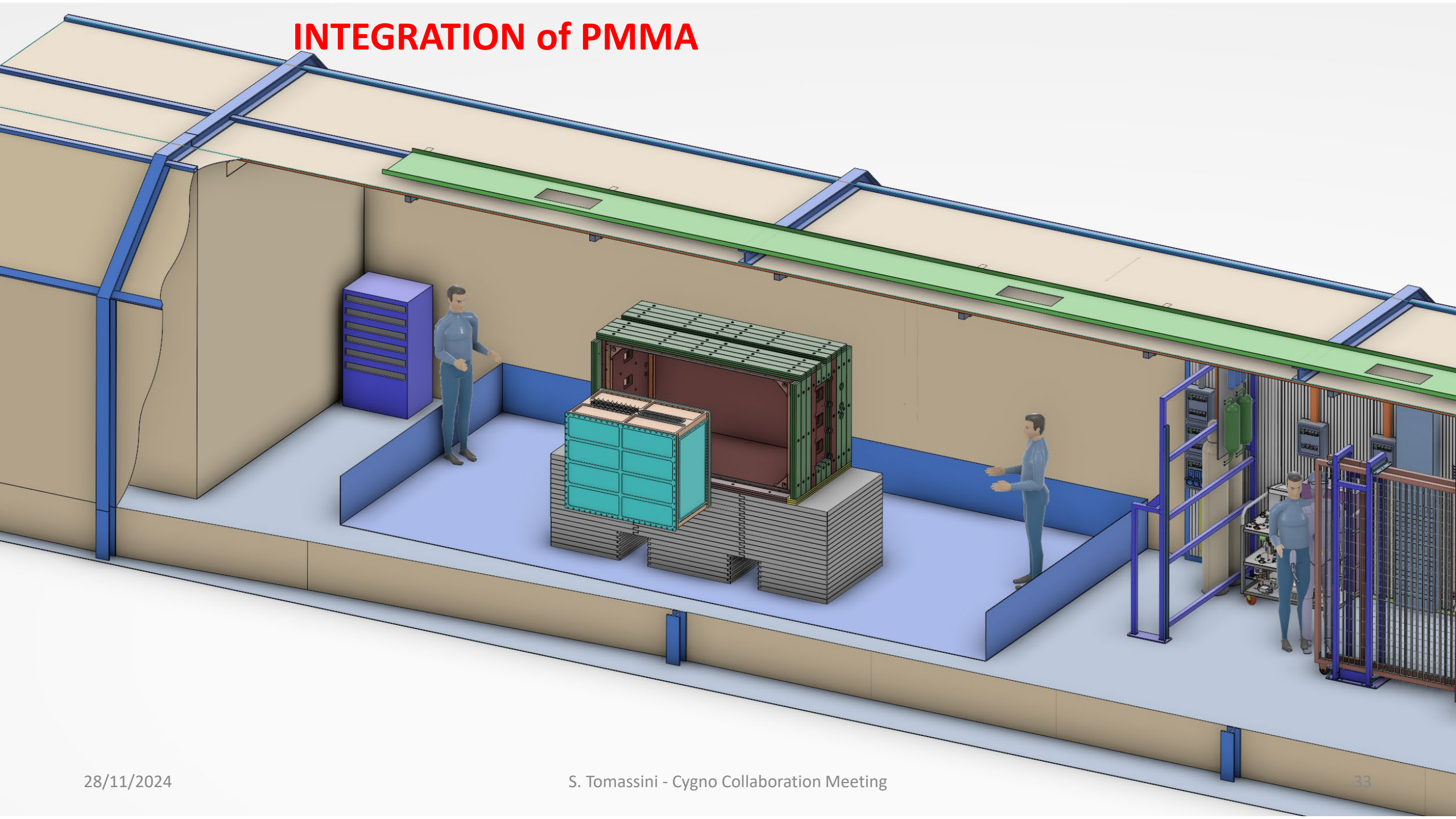
Copper box Integration cont’



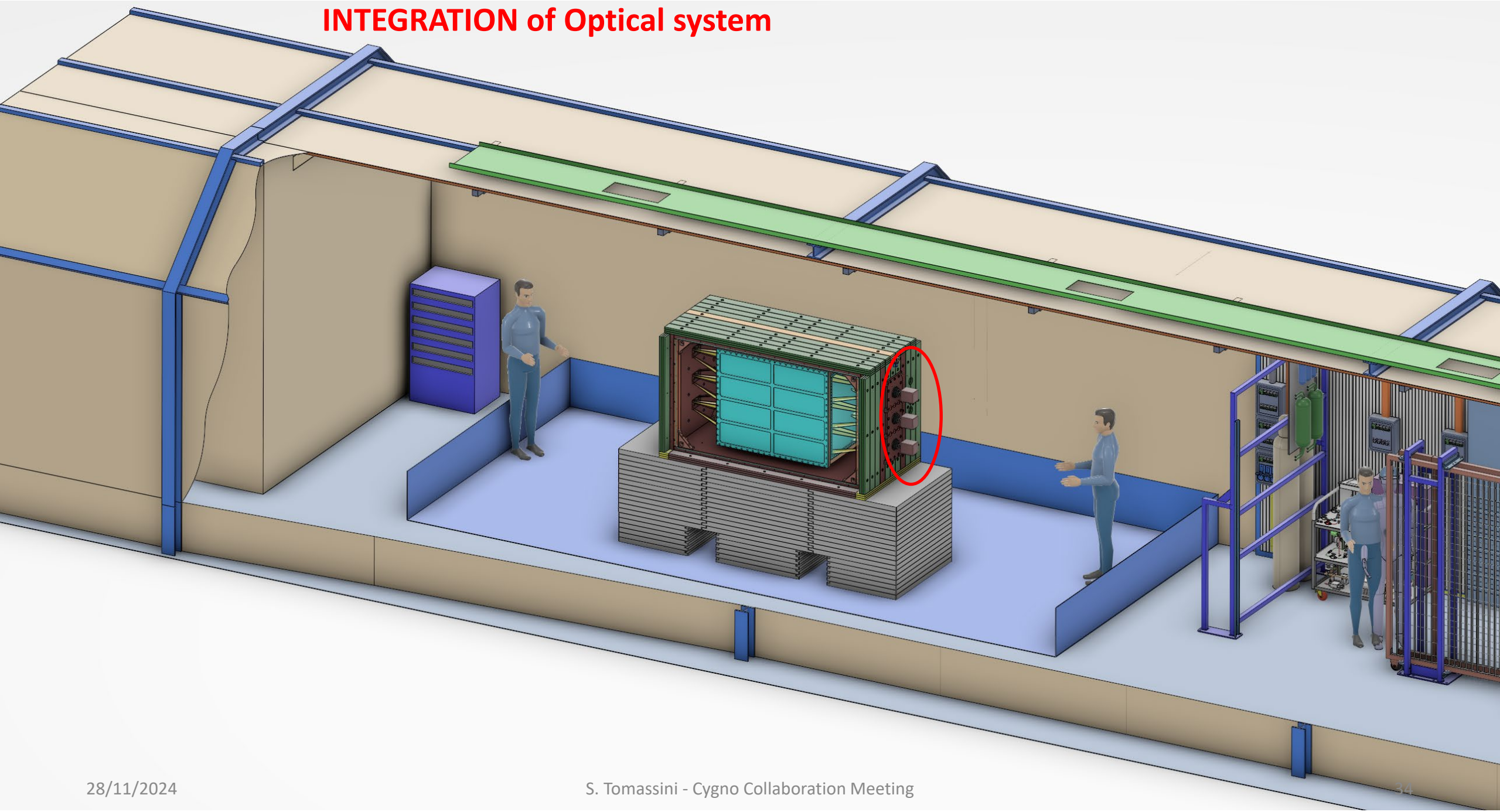
In this phases, after the integration and the tightening of 12 slabs on the top panel, the strong-back can be removed since the deformation of the top plate itself is below 0.1 mm



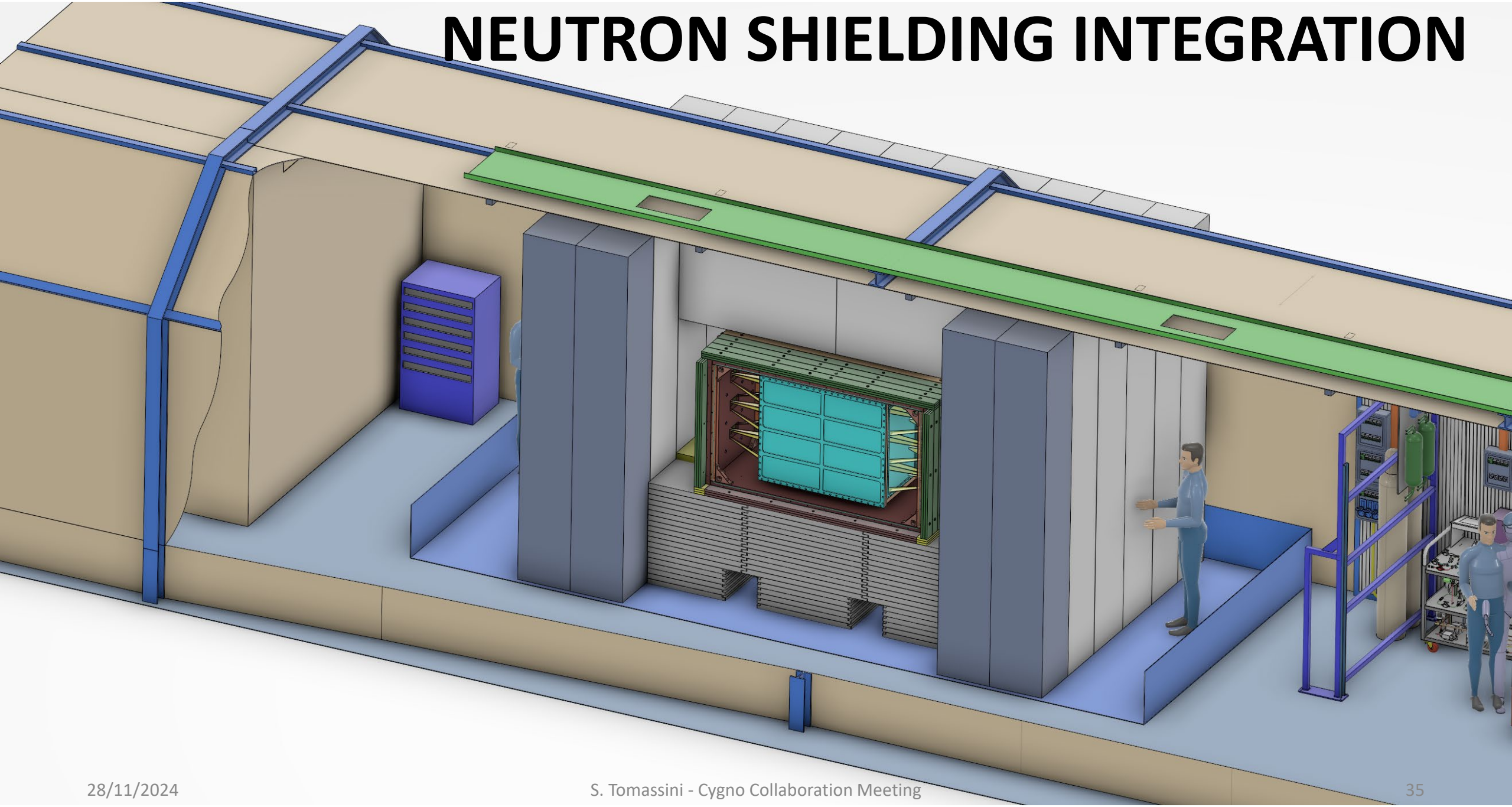
INTEGRATION of PMMA



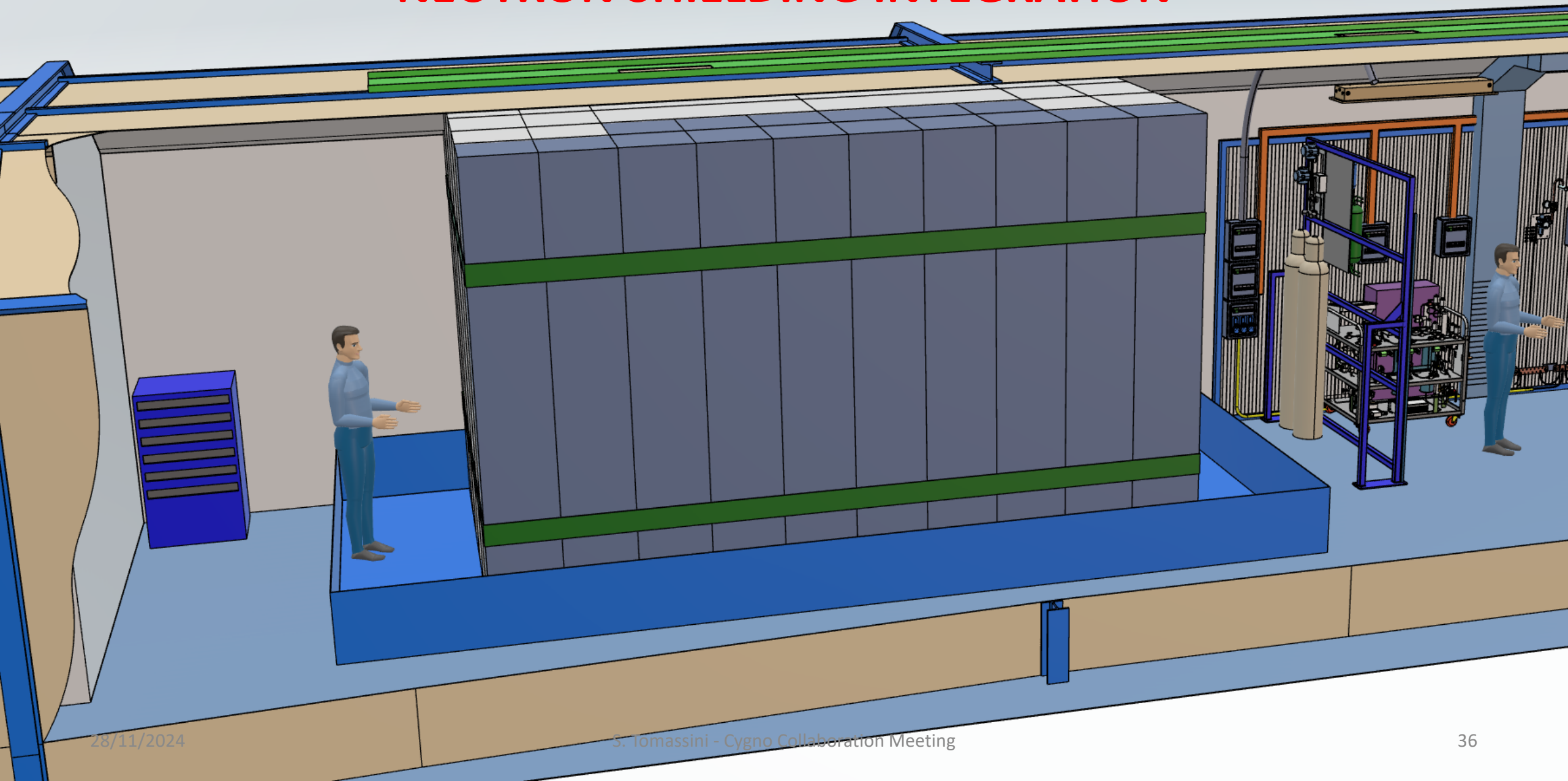
INTEGRATION of Optical system



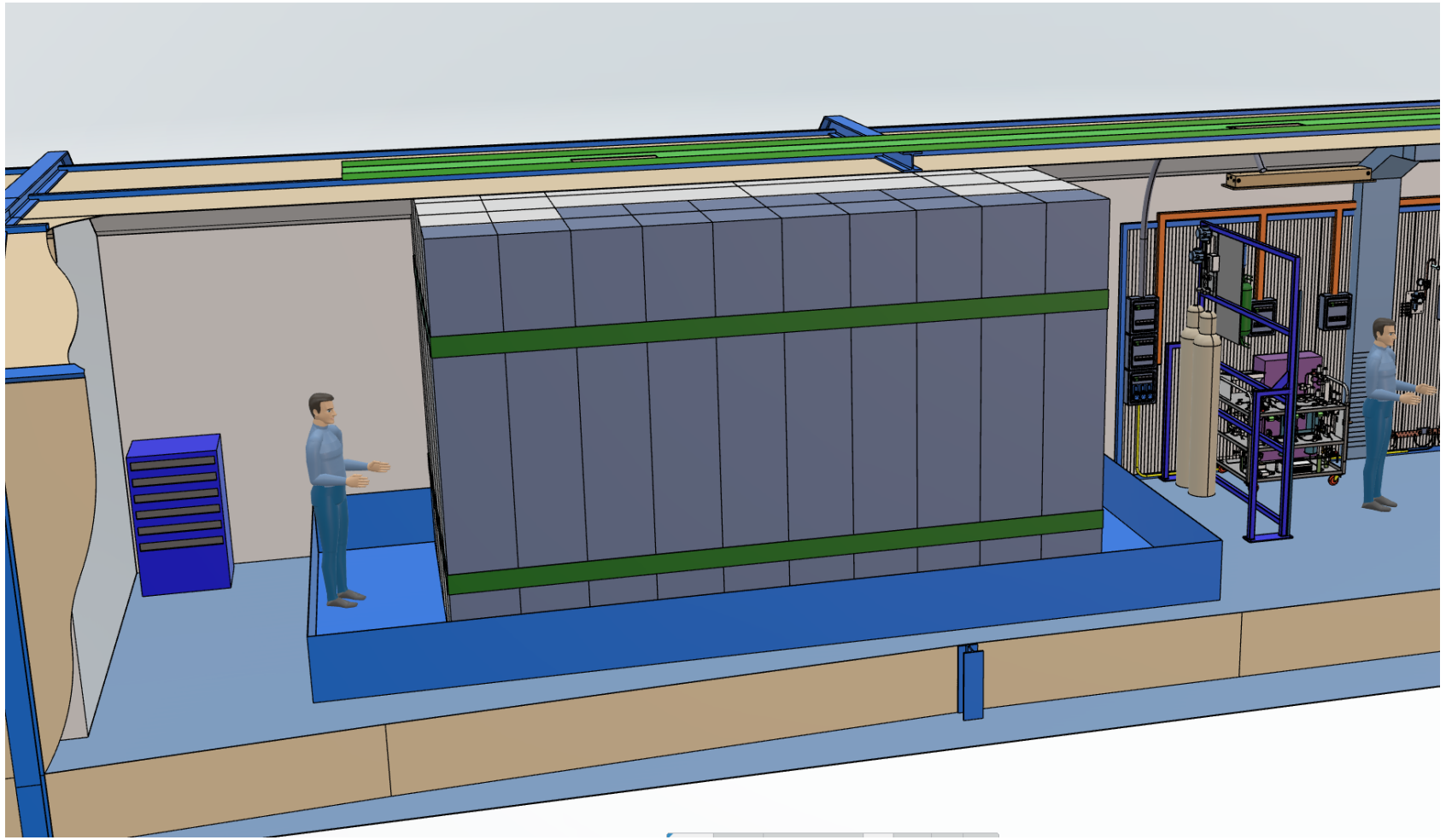
NEUTRON SHIELDING INTEGRATION



NEUTRON SHIELDING INTEGRATION



Neutron shielding: design and procurement



…Profit of the LIME experience…

The company gave the green light for the production of bigger tanks (private discussion with Cesidio)

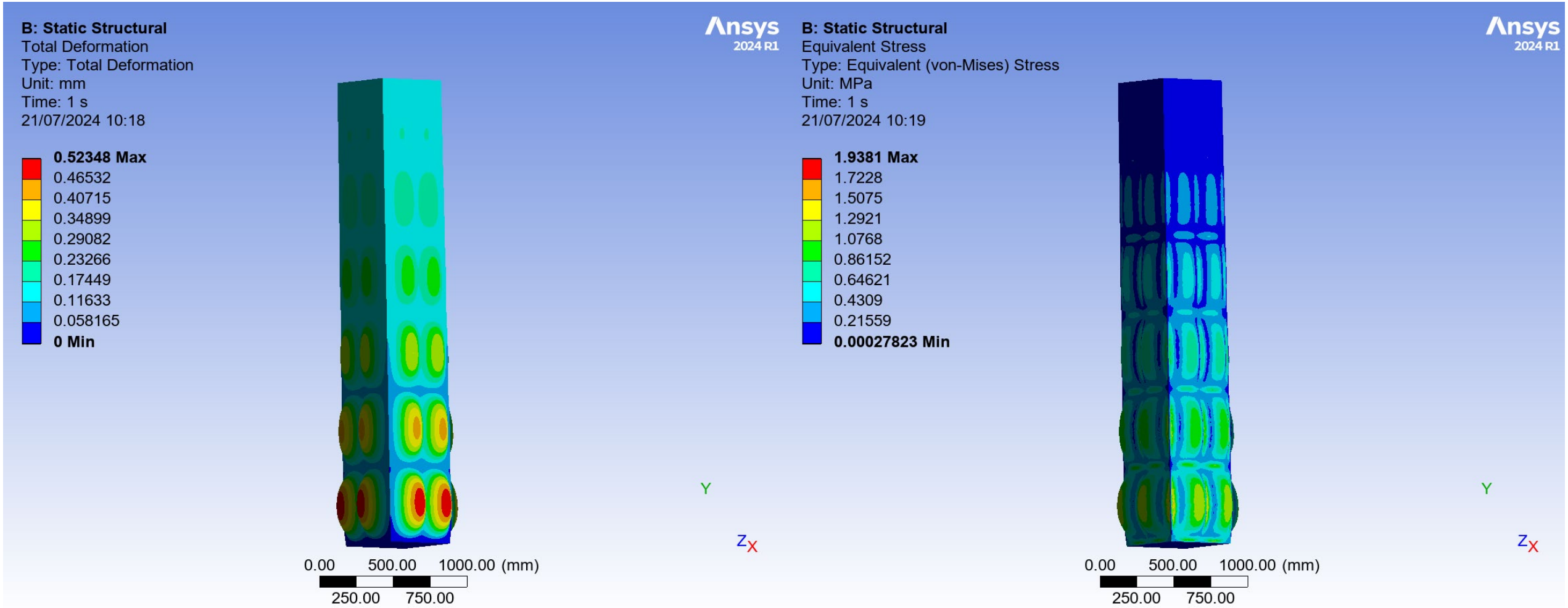
By the end of March we have to order…

CONCLUSIONS

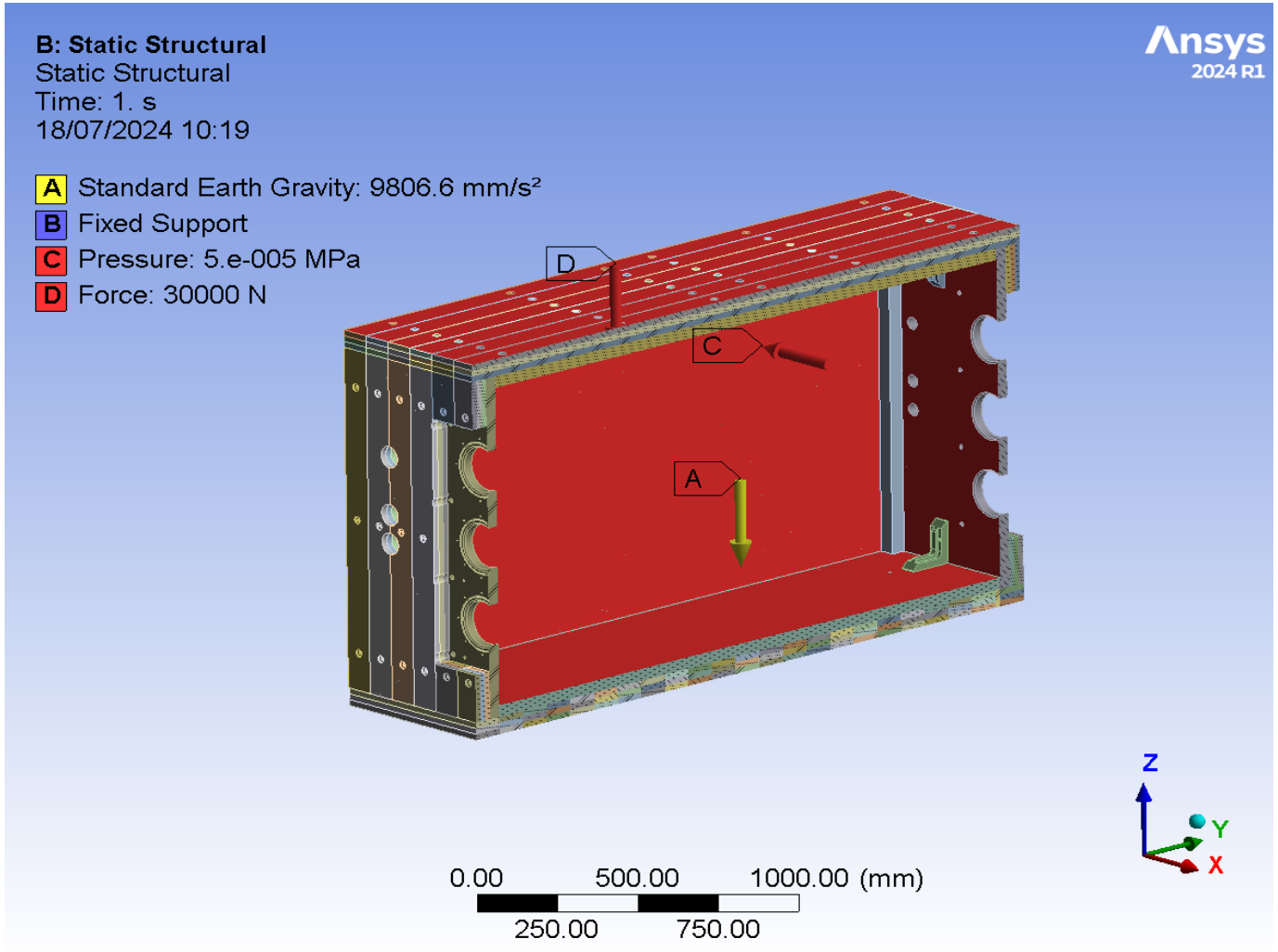
- The service project at LNGS was prepared by an external professional and approved by the LAB. The services installation started on November 20th 2024.
- The procurement of radiopure raw copper plate was awarded. The lead time for the copper plate delivery is 18 weeks.
- The recovery of copper slabs from OPERA is well understood.
- The mechanical design of copper shielding (radiopure and OPERA) must be finalized to precede soon with the order for production
- The cleaning method (IF REALLY NEEDED) for copper and PMMA must be decided and the order must be awarded soon because it will be time consuming and expensive
- The design of the field cage is progressing. Small FC prototypes have been built for the GIN detector. Results are expected soon. More optimizations must be considered for the FC after the first tests.
- The acrylic vessel design is ongoing provided the limit of 135 kg mass. Windows for the test source have been designed. Samples of material from two different vendors have been requested, a first bunch should be available shortly for measurements…
- The procurement of Polyethylene base must be done.
- The Neutron shielding design is ongoing. A smaller shielding has been built and installed for the LIME detector. Some other work must be done in the coming months…
- The integration sequence is well understood and for some points was tested for the LIME setup… some integration tools must be designed and procured
- The safety pool (base tank) must be designed and procured urgently since without it we cannot start the integration

Back up slides

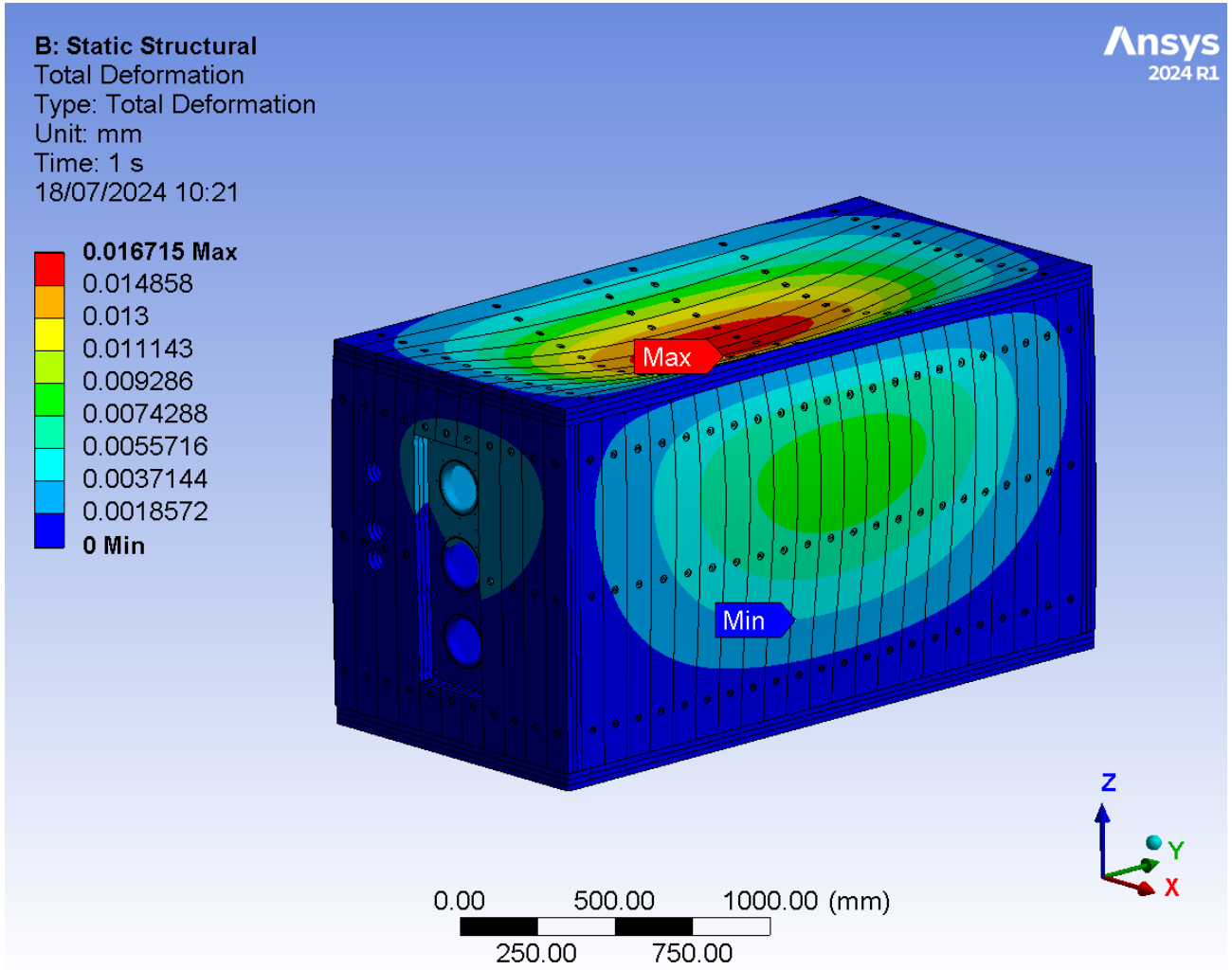
PE tanks

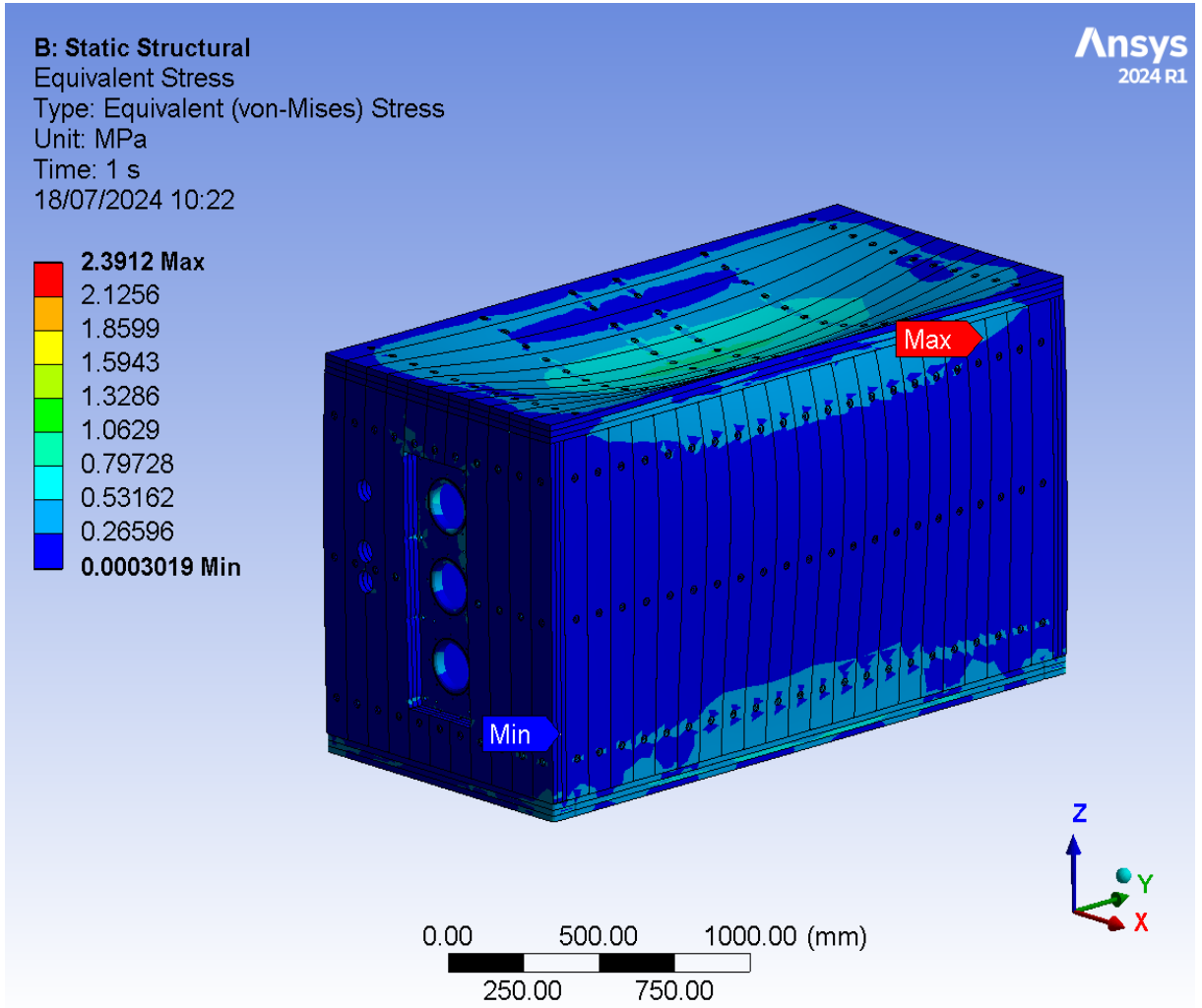

B: Static Structural
Total Deformation
Type: Total Deformation
Unit: mm
Time: 1 s
21/07/2024 10:18
0.52348 Max
0.46532
0.40715
0.34899
0.29082
0.23266
0.17449
0.11633
0.058165
0 Min
Ansys
2024 R1
0.00
500.00
1000.00 (mm)
250.00
750.00
Y
Z
X
B: Static Structural
Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: MPa
Time: 1 s
21/07/2024 10:19
1.9381 Max
1.7228
1.5075
1.2921
1.0768
0.86152
0.64621
0.4309
0.21559
0.00027823 Min
Ansys
2024 R1
0.00
500.00
1000.00 (mm)
250.00
750.00
Y
Z
X

STATIC STRUCTURAL LOADS: DATA TAKING

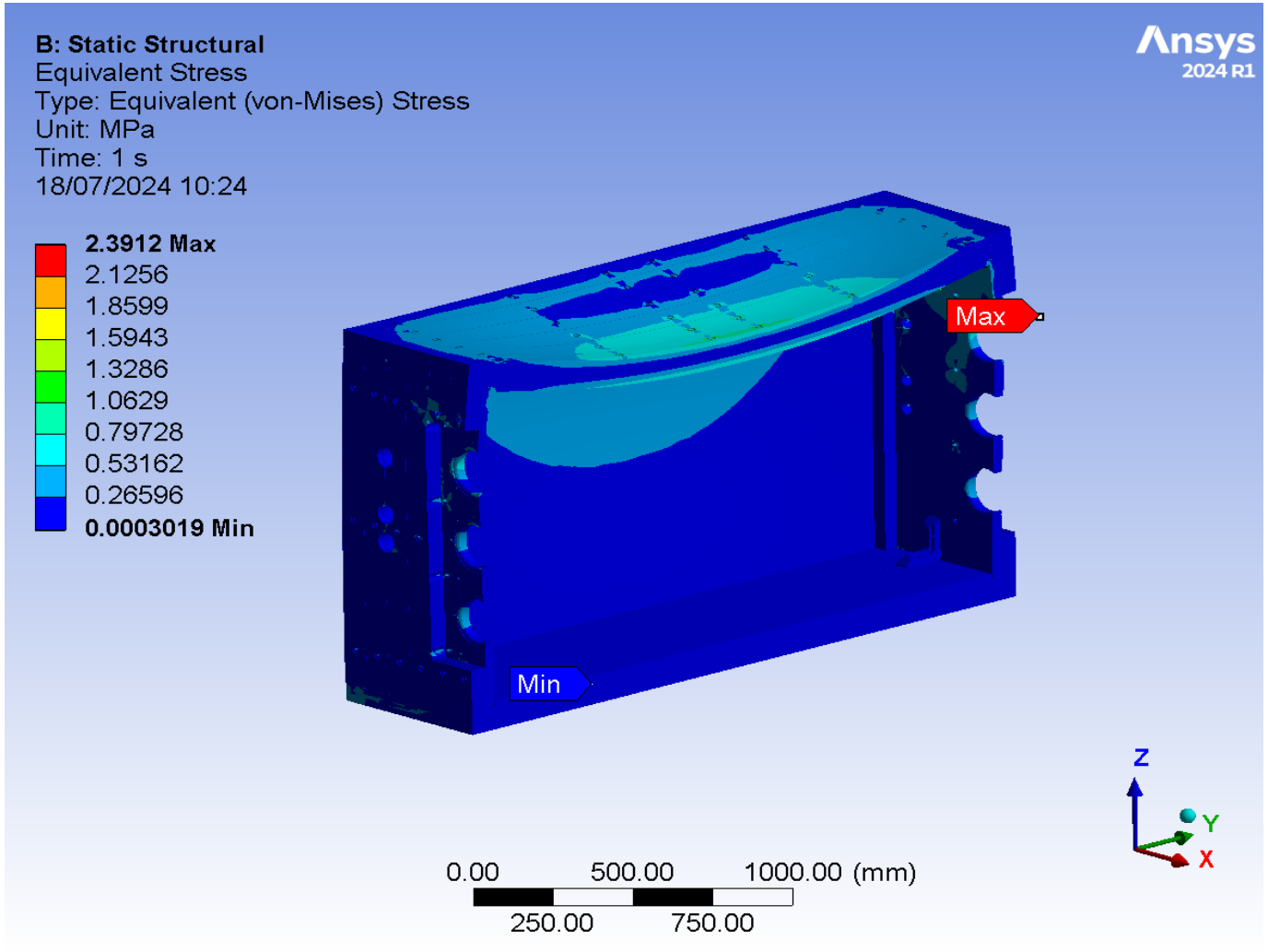


STATIC STRUCTURAL: DATA TAKING

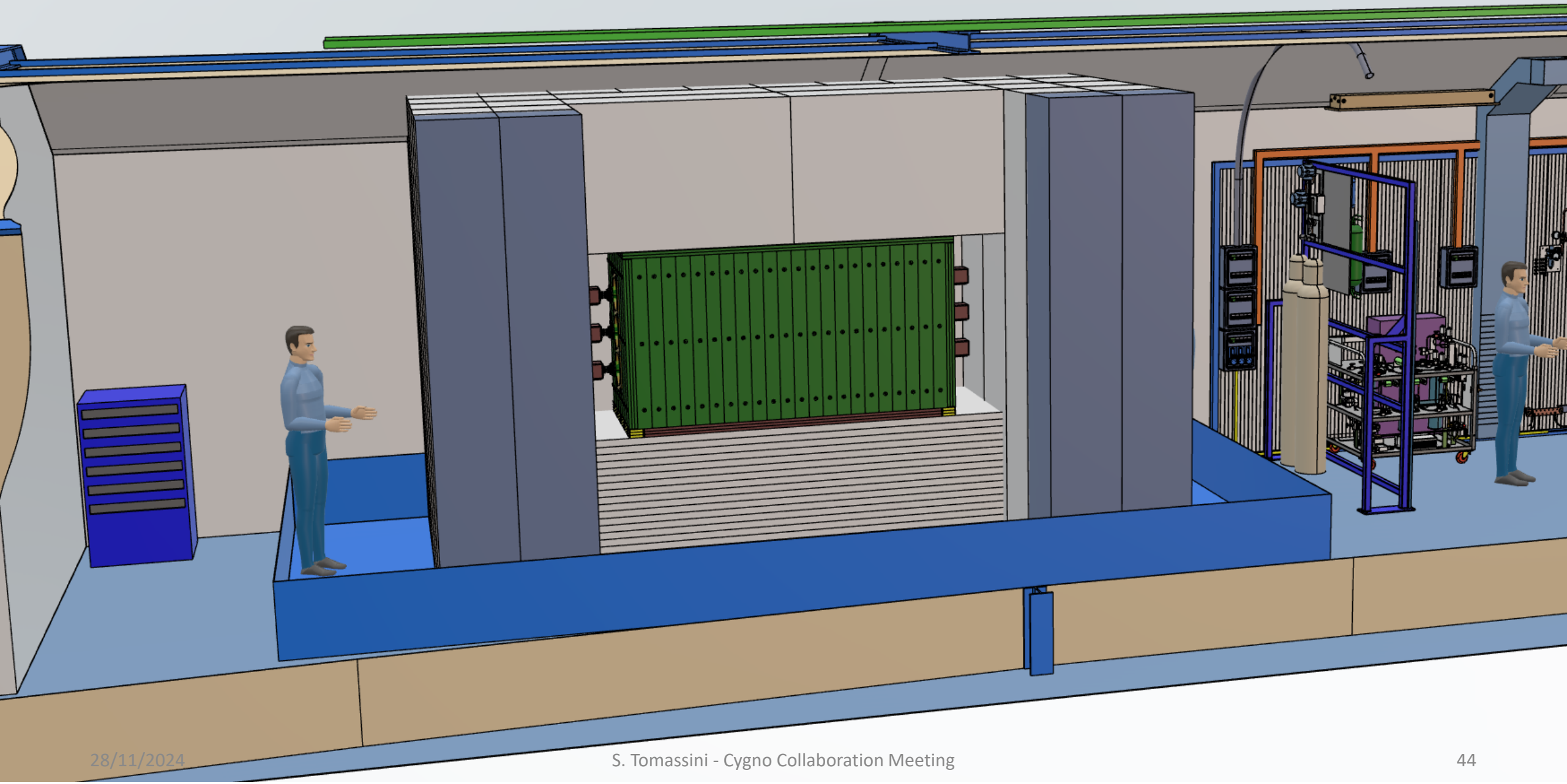




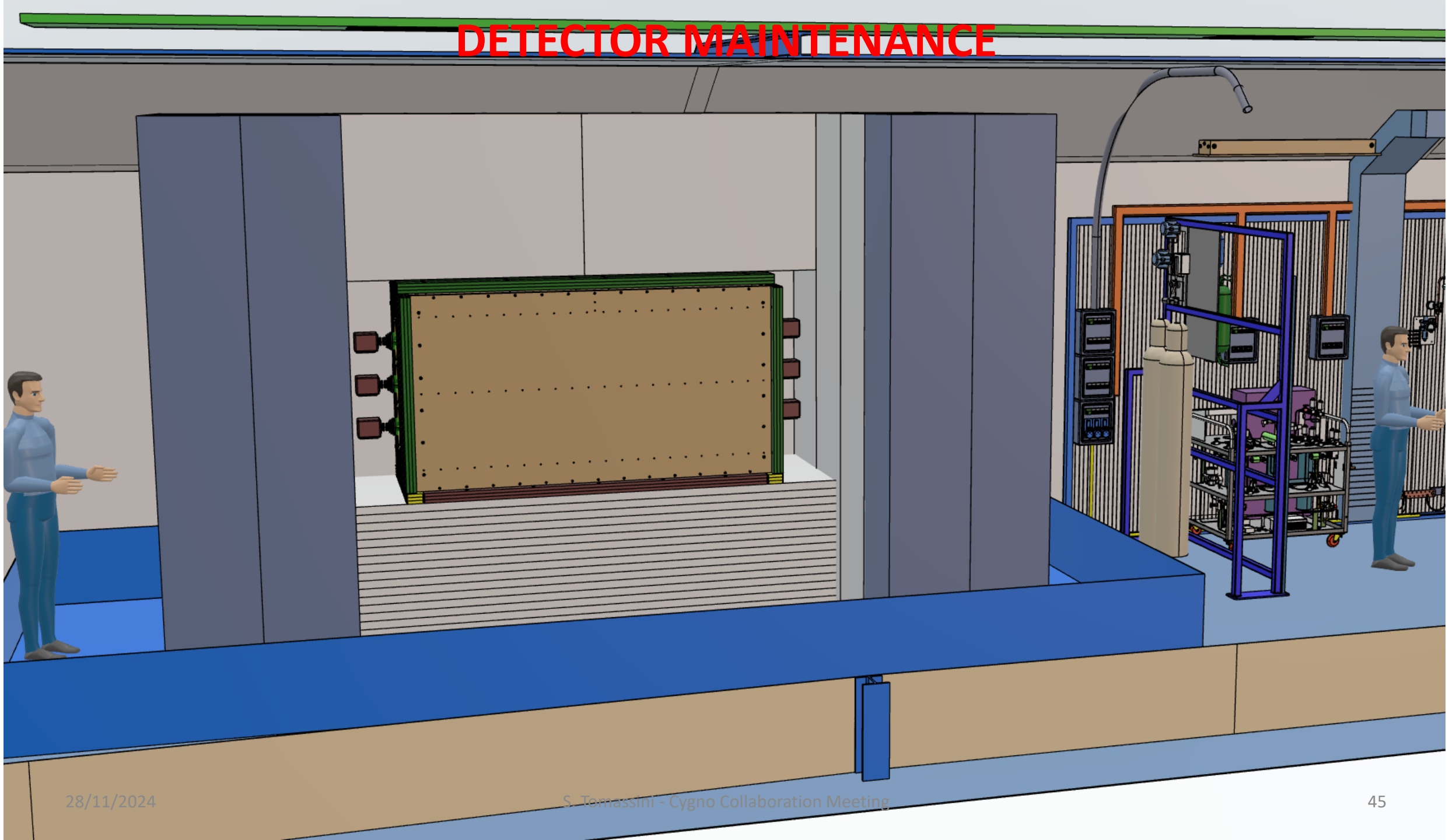
STATIC STRUCTURAL: DATA TAKING



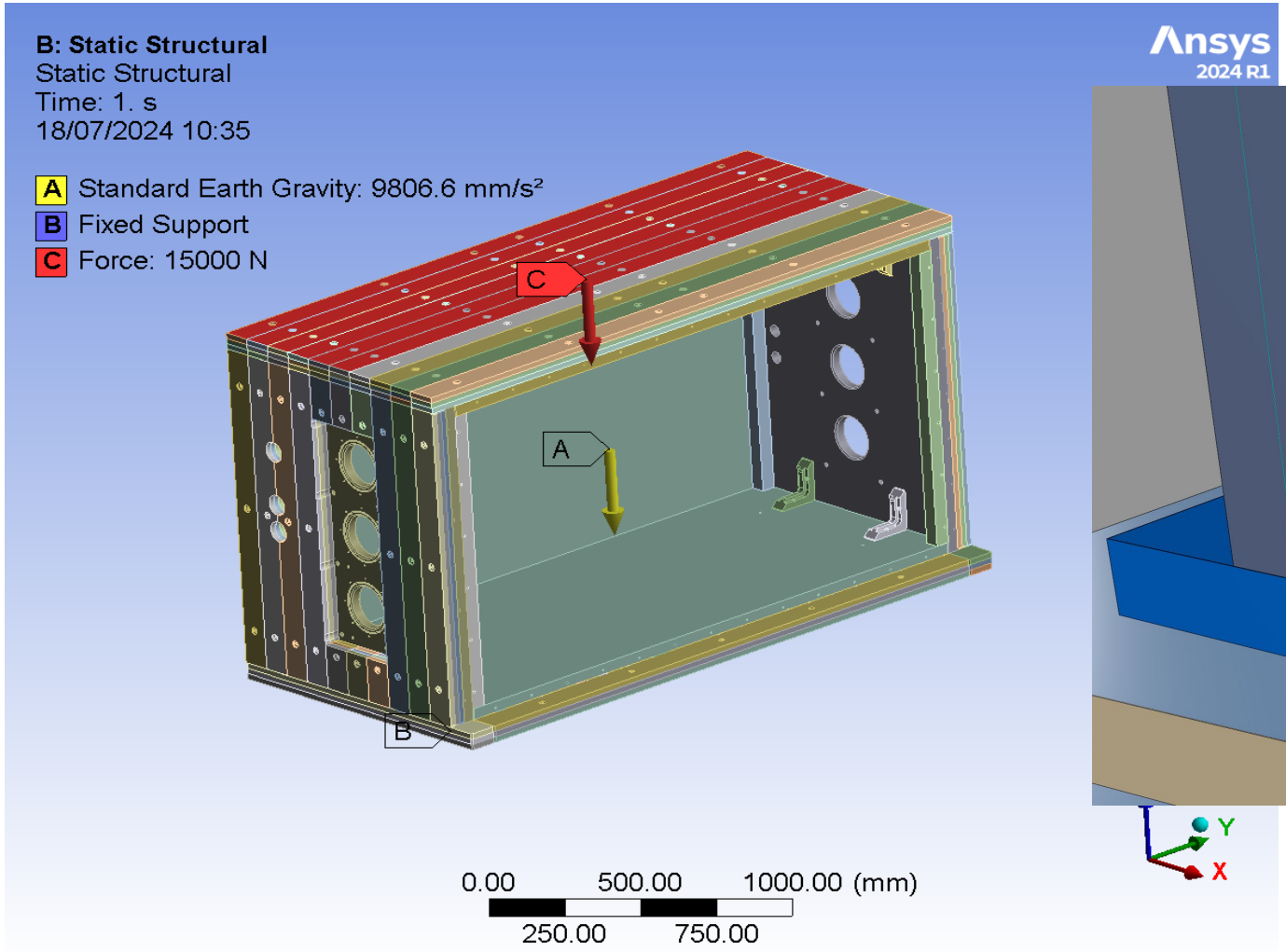
DETECTOR MAINTENANCE

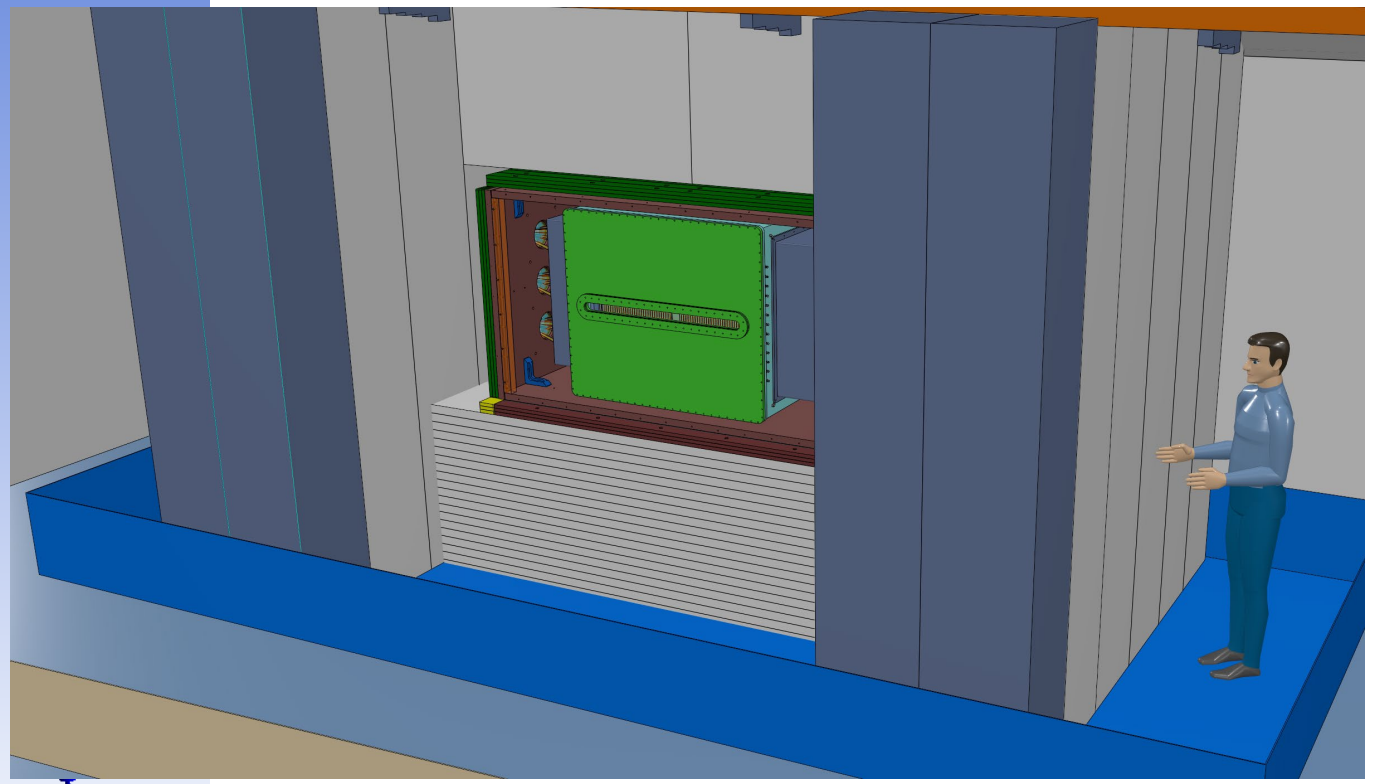


DETECTOR MAINTENANCE

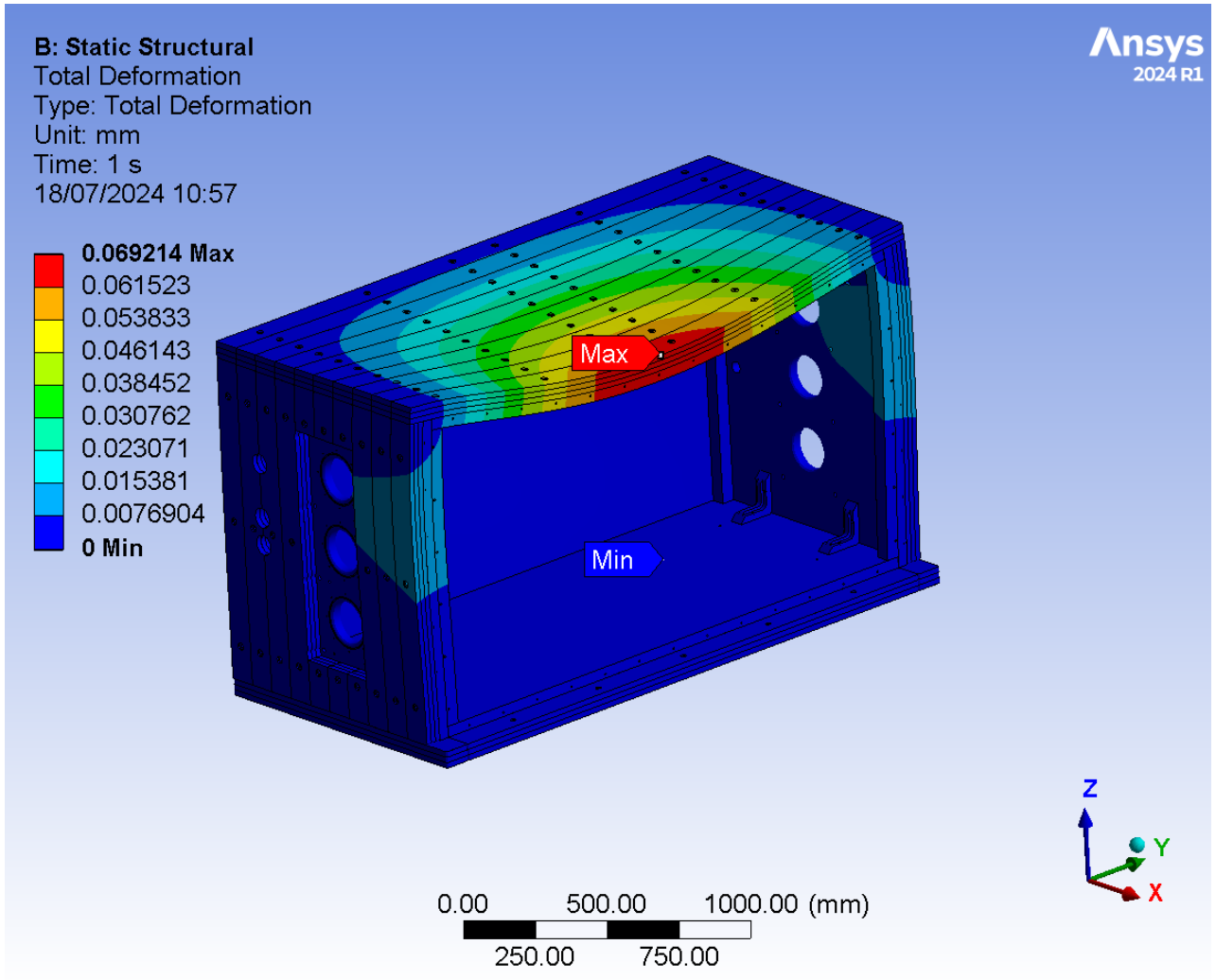


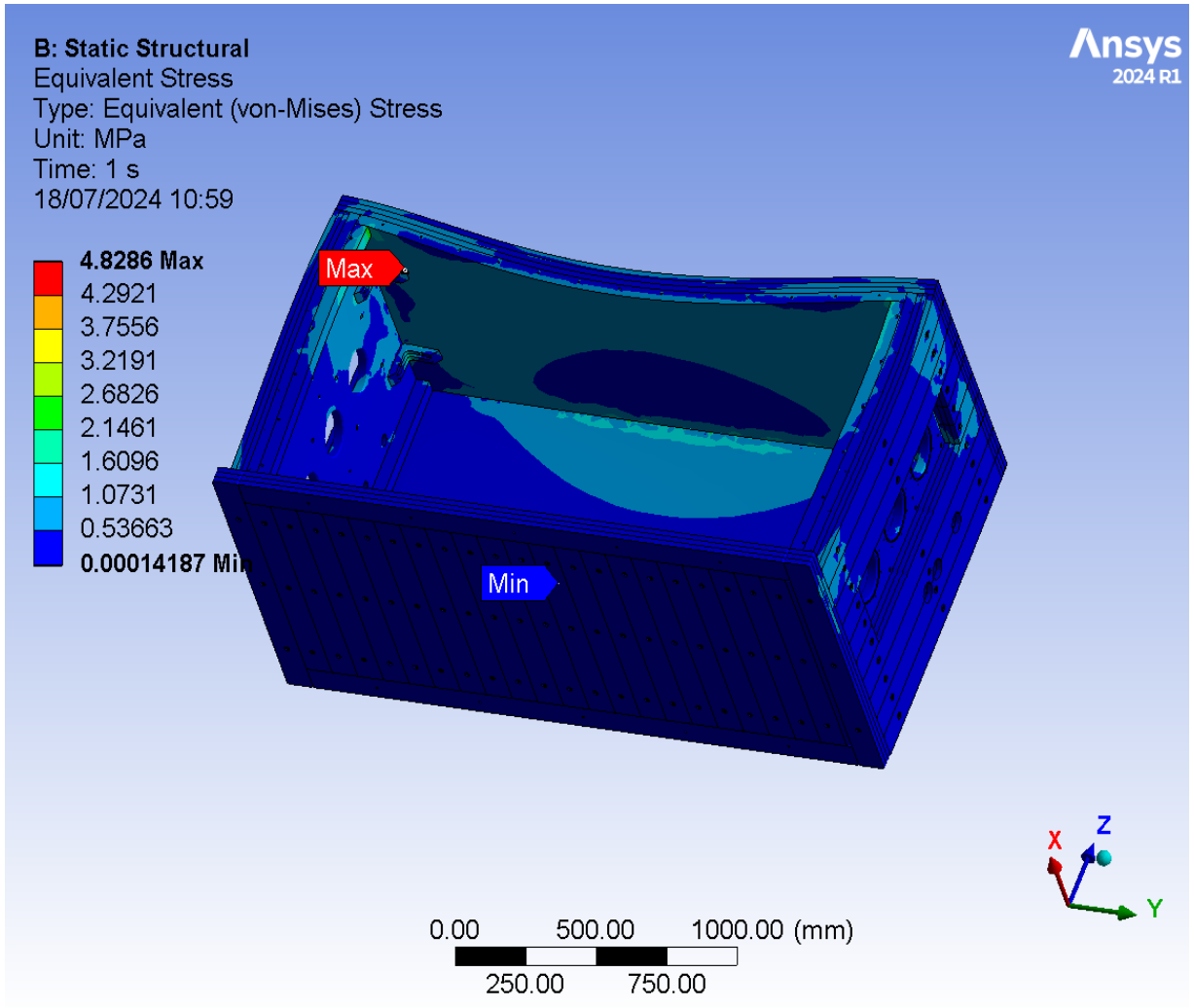
STATIC STRUCTURAL: DETECTOR MAINTENANCE



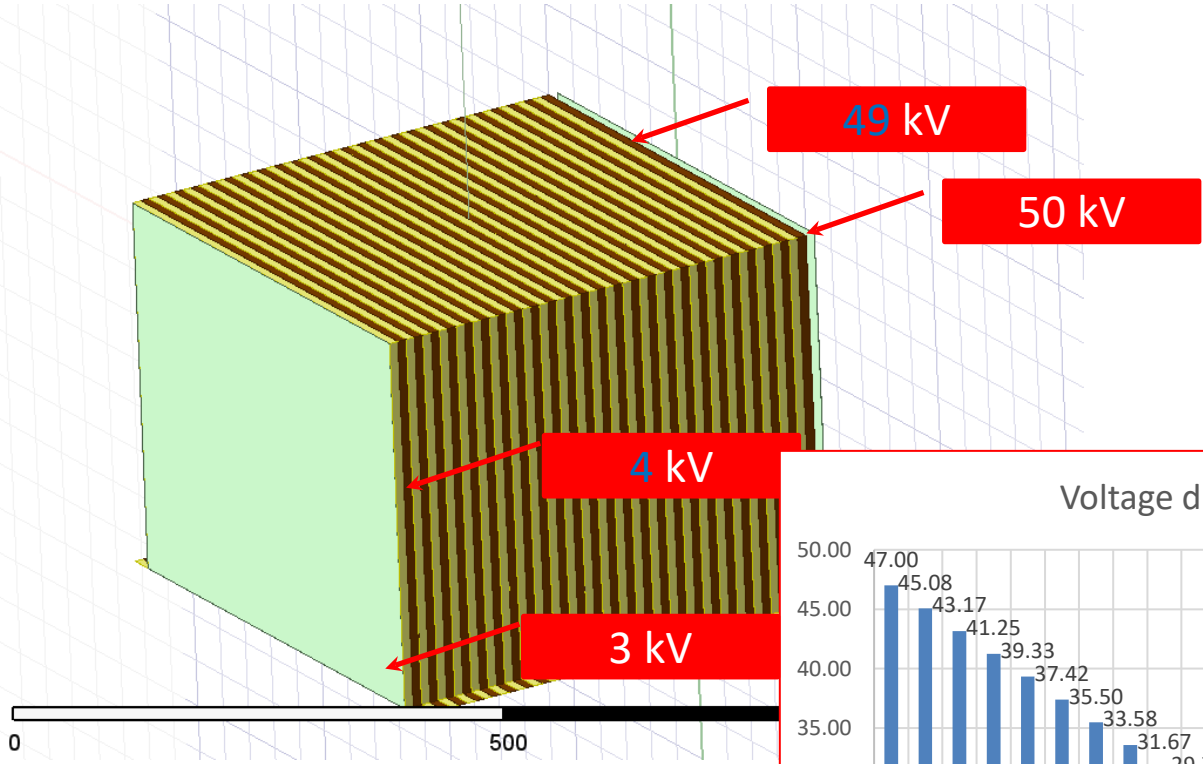


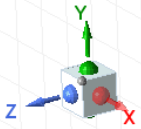
STATIC STRUCTURAL: DETECTOR MAINTENANCE

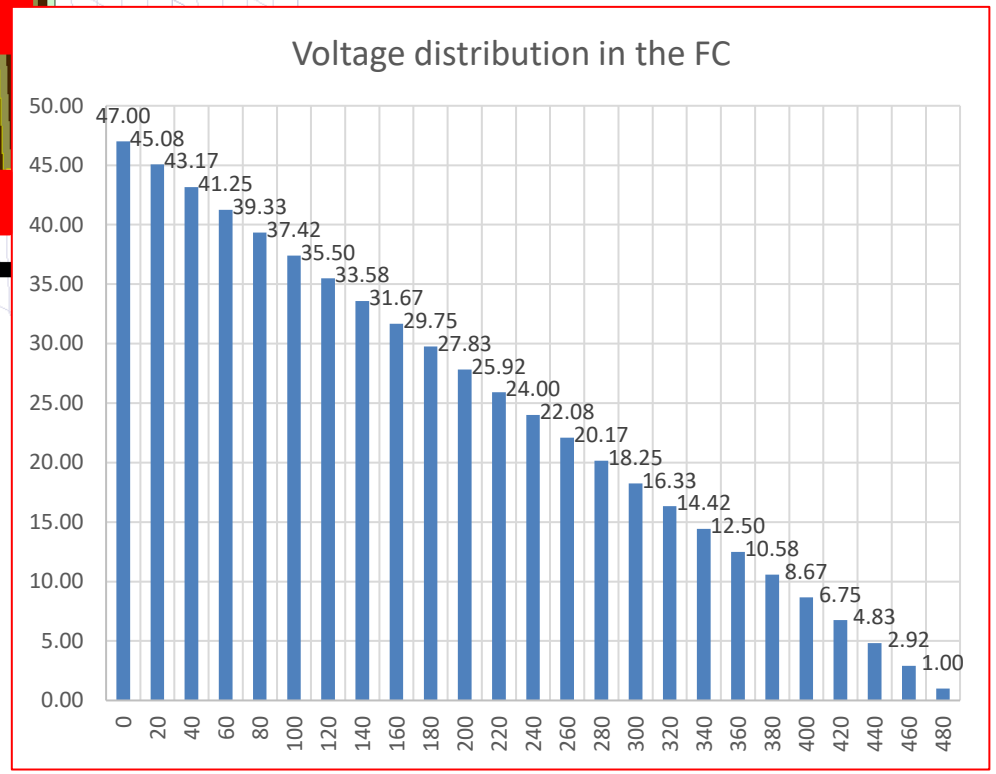




FC: 47 kV to 1 kV







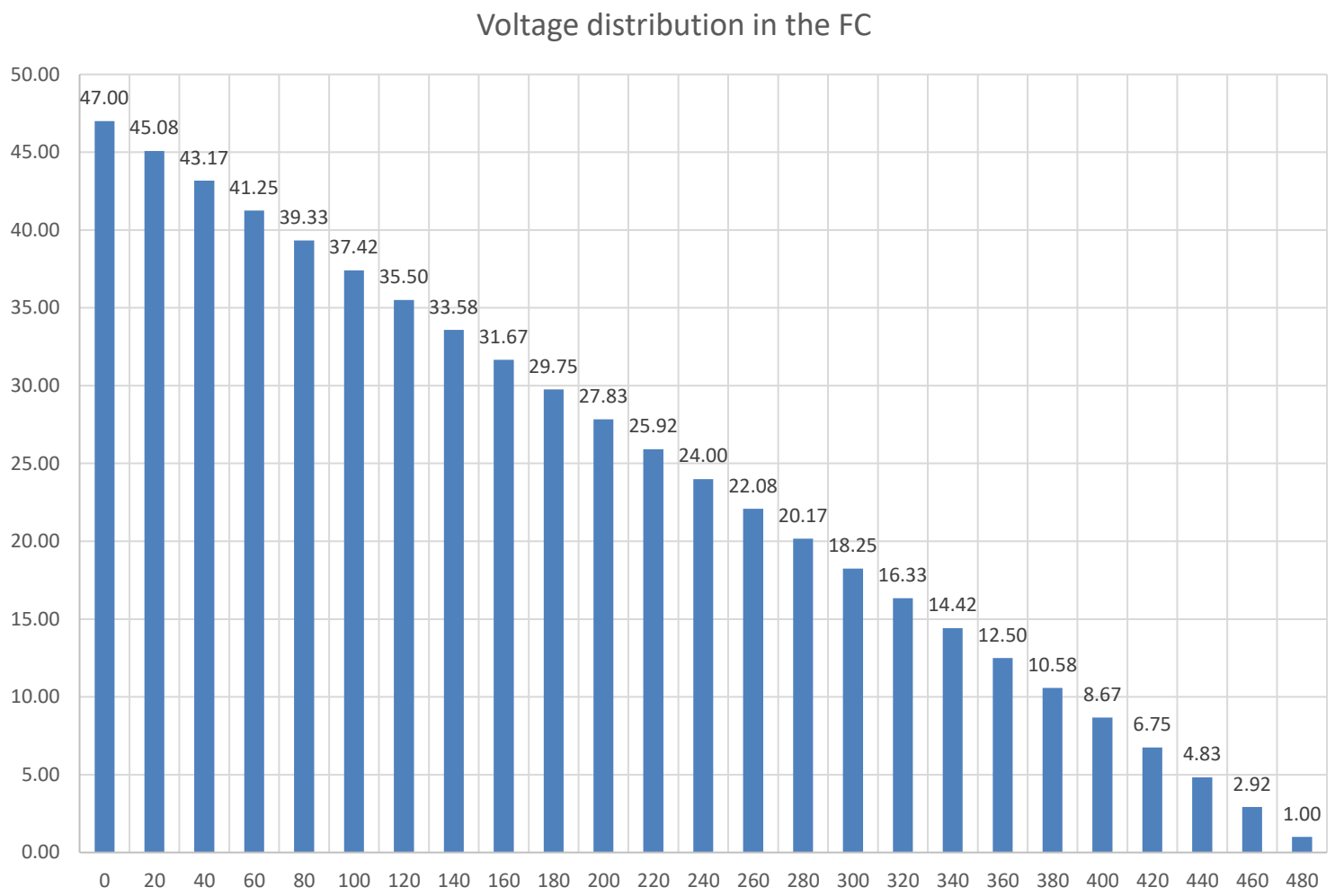
Voltage distribution in the FC

The first turn close to the Cathode is at **10 mm**

The last turn distance from the GEM is **10 mm**

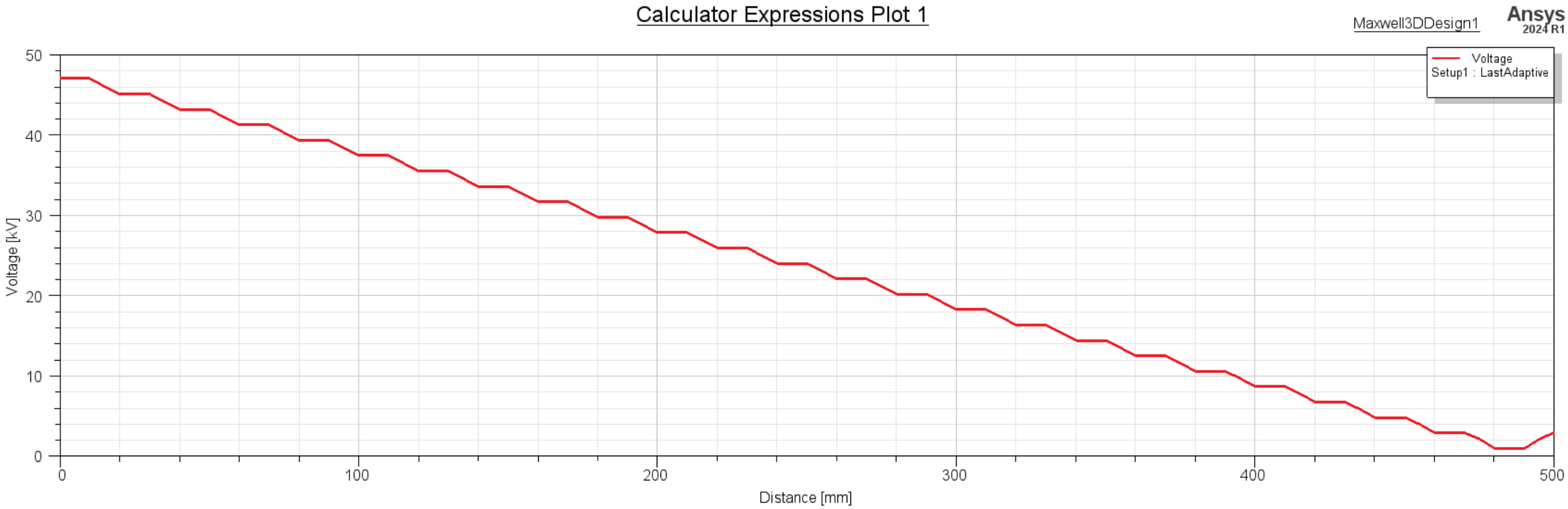
The cathode is at 50 kV

The GEM is at 3 kV

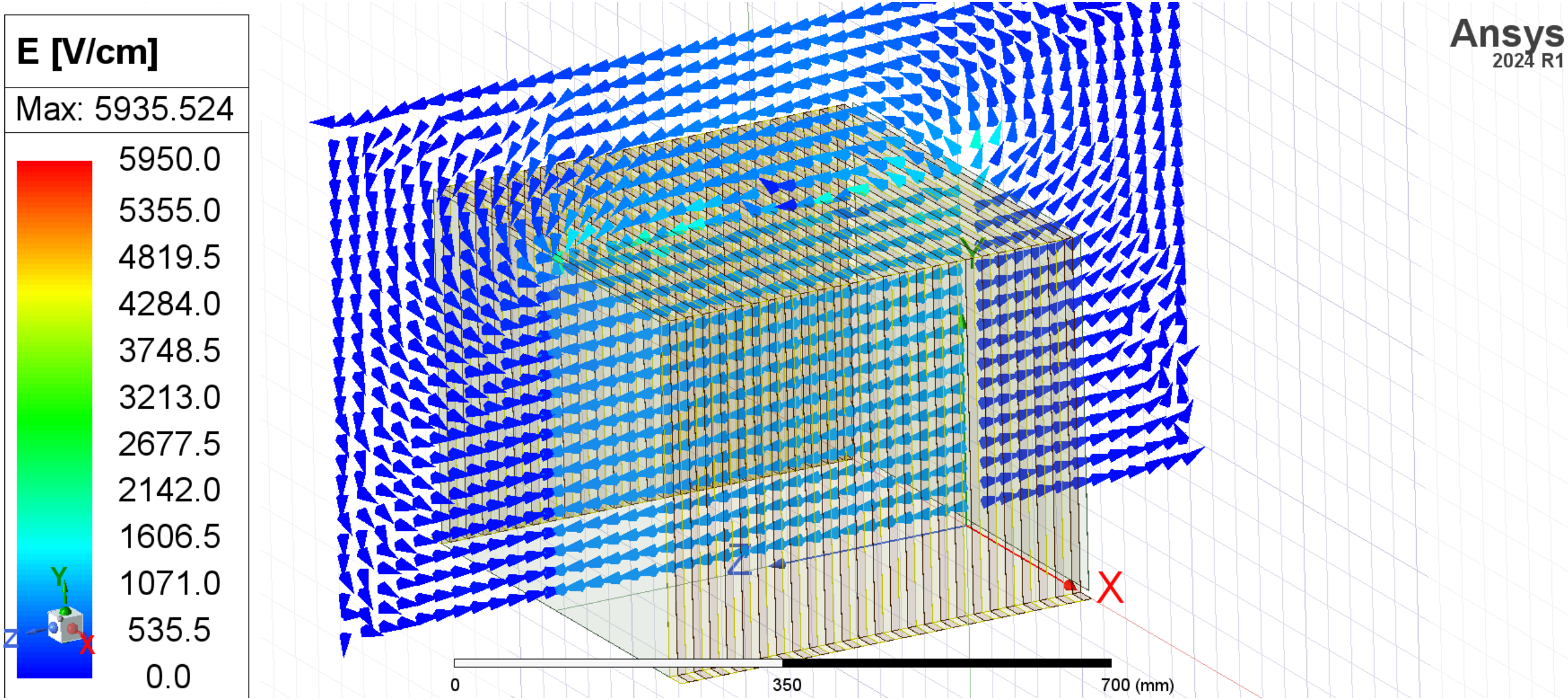


Voltage distribution applied to the FC

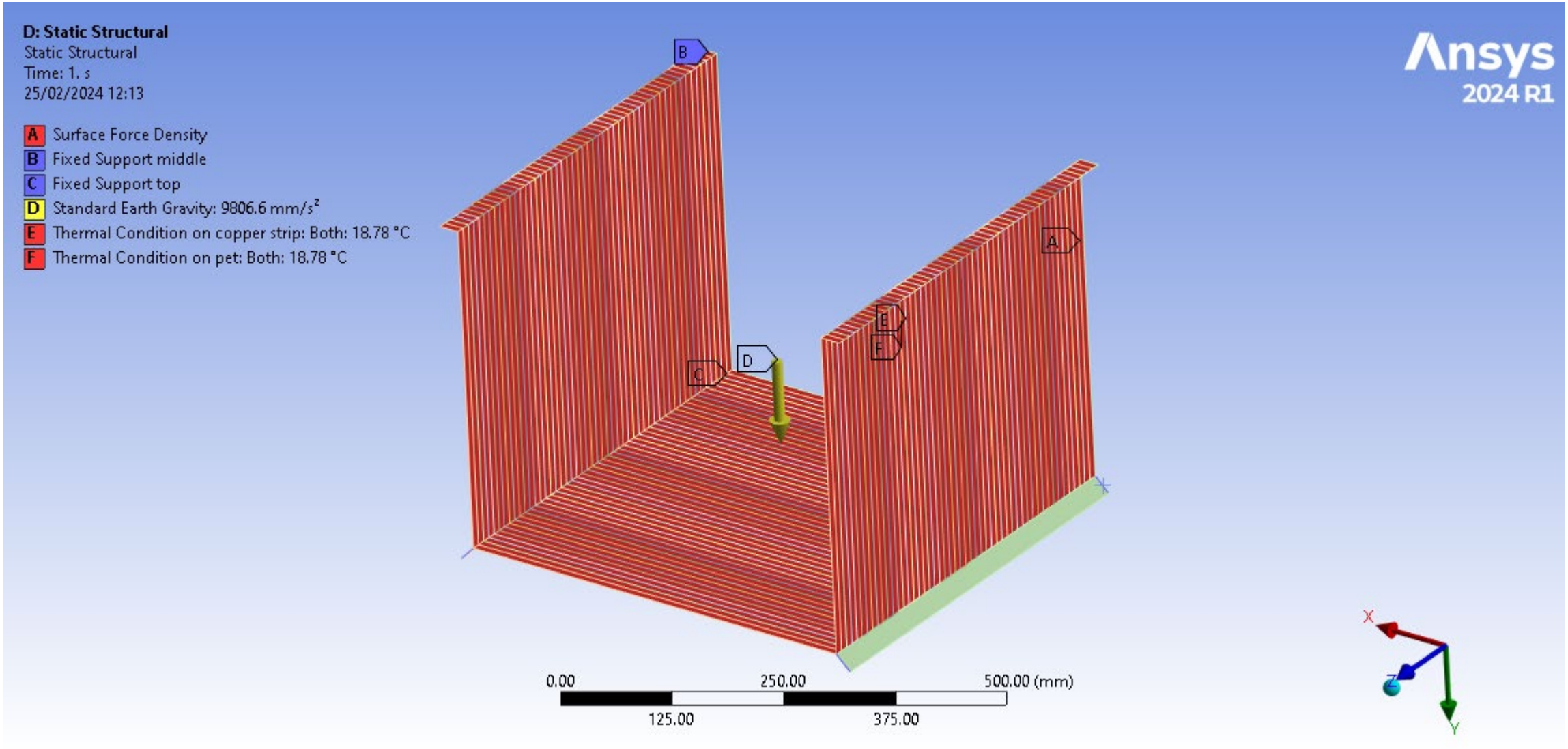
- The first turn close to the Cathode is at **10 mm**
- The last turn distance from the GEM is **10 mm**
- **The cathode is at 50 kV**
- **The GEM is at 3 kV**



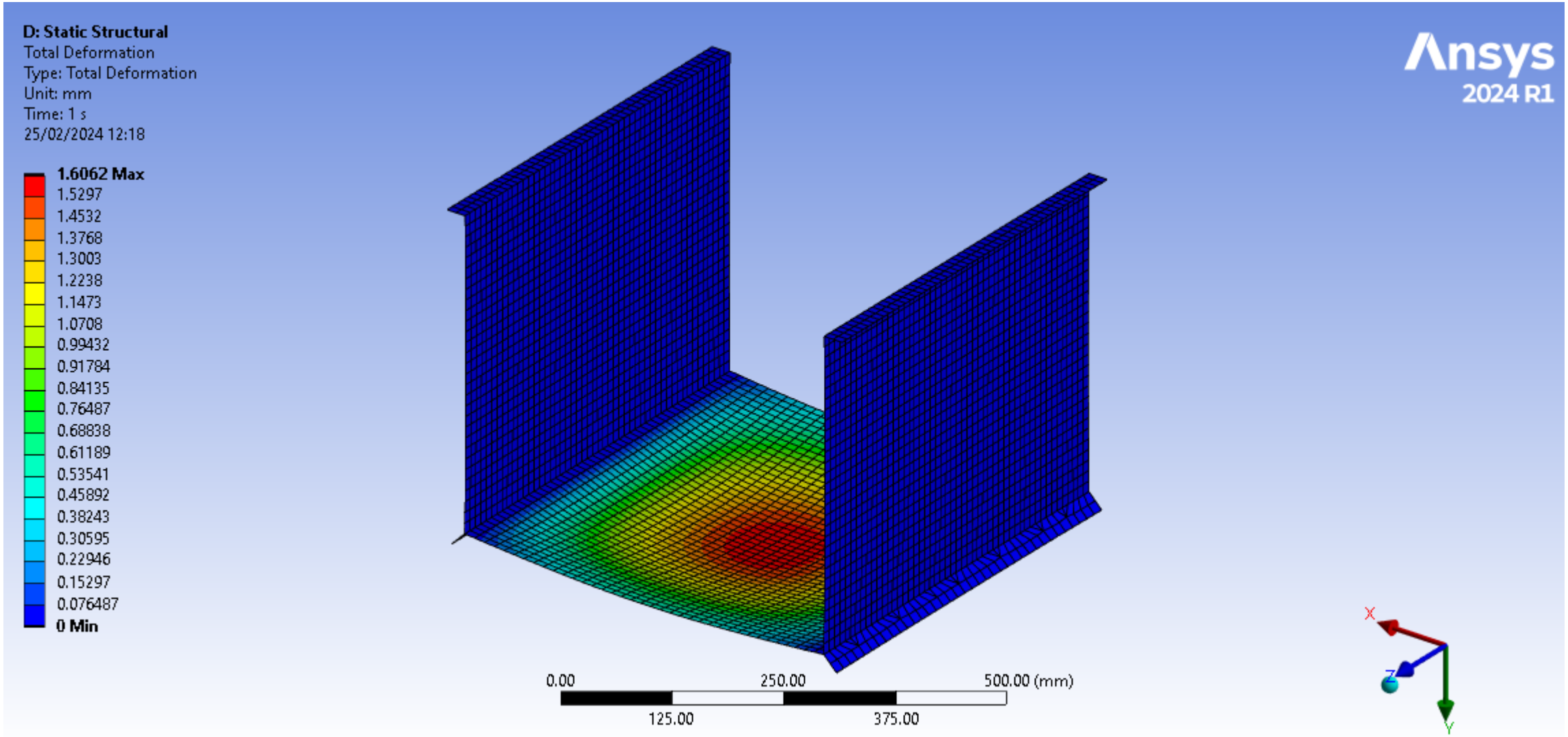
FC: 47 kV to 1 kV



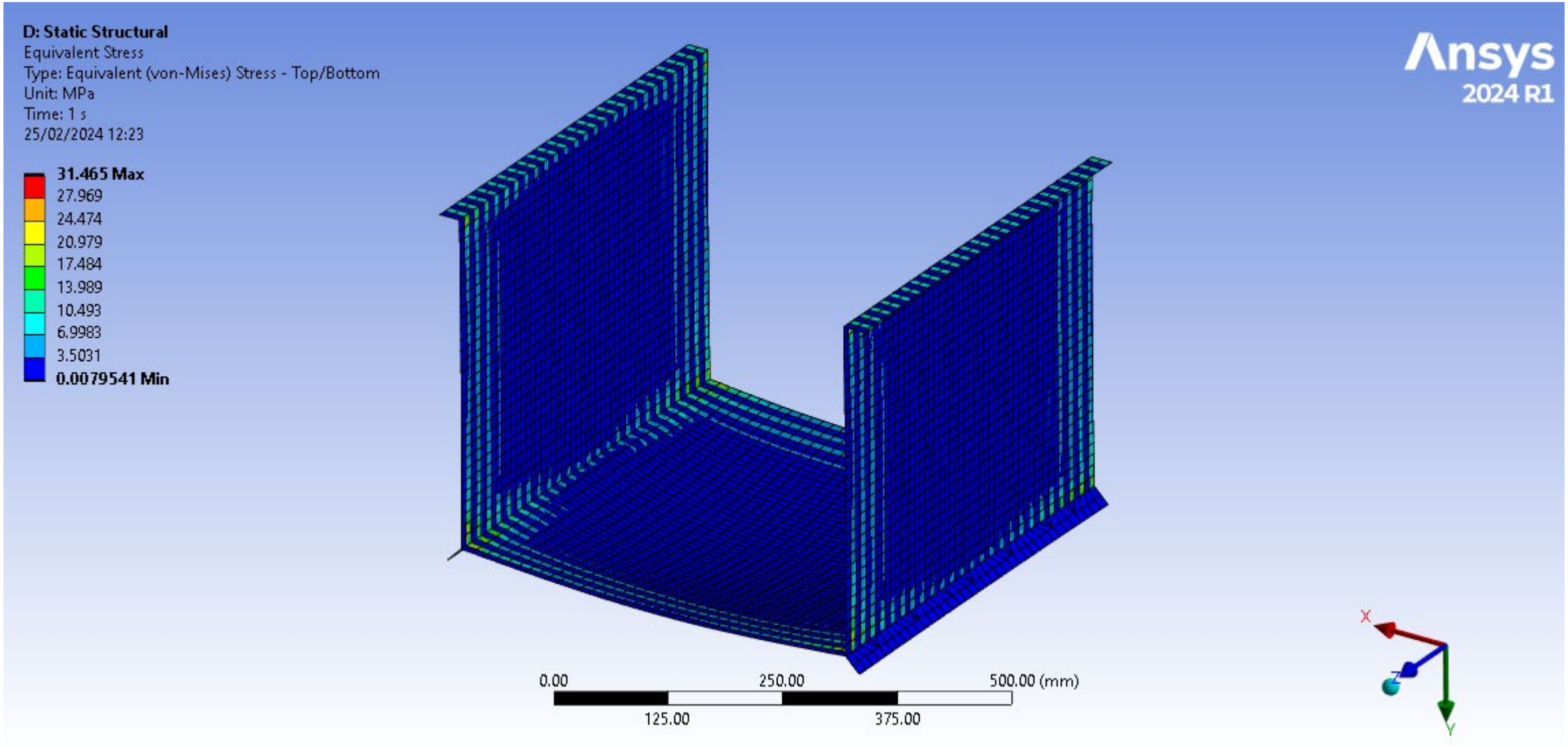
Bottom: Loads with 30 N Stretching Force



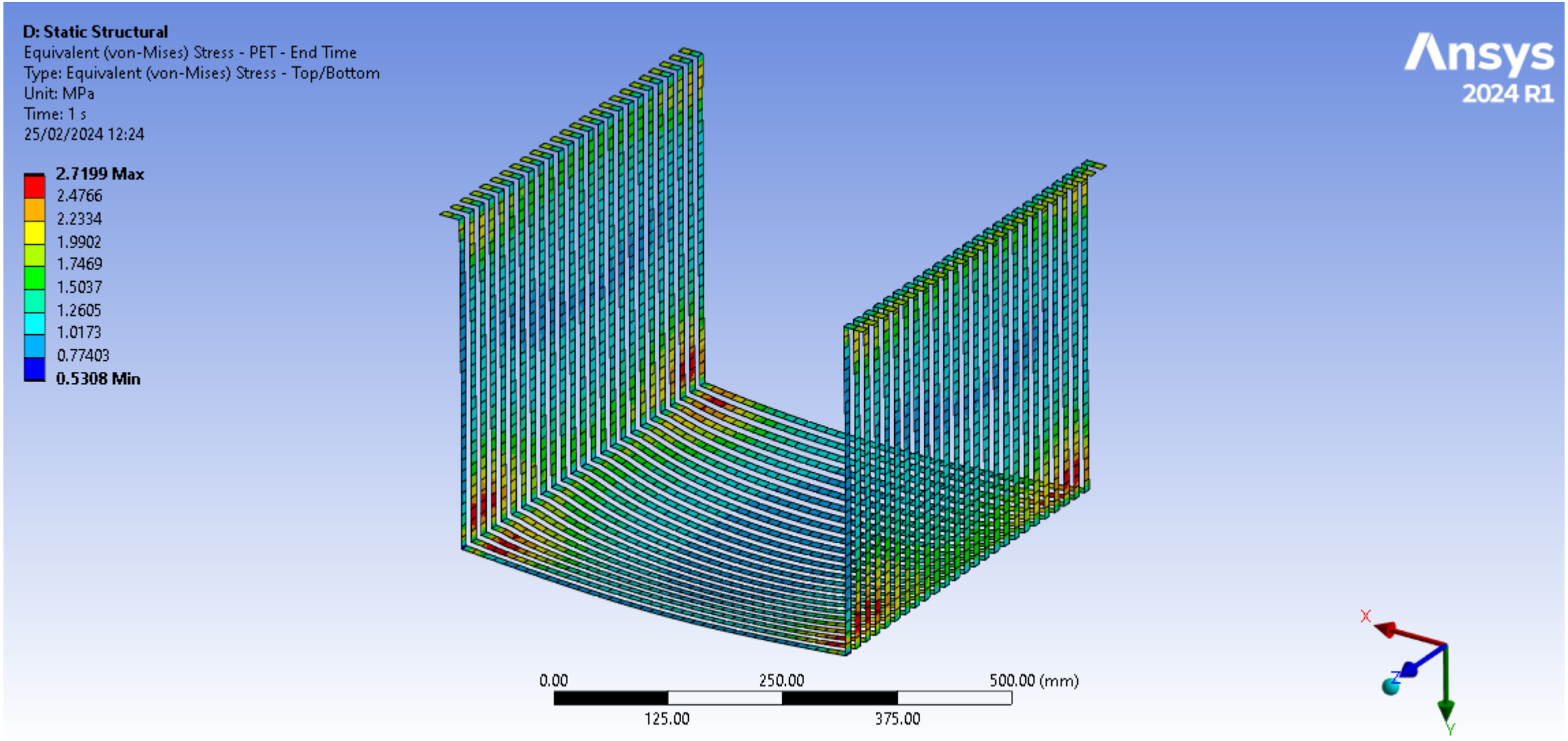
Bottom: Total deformation with 30 N Stretching Force



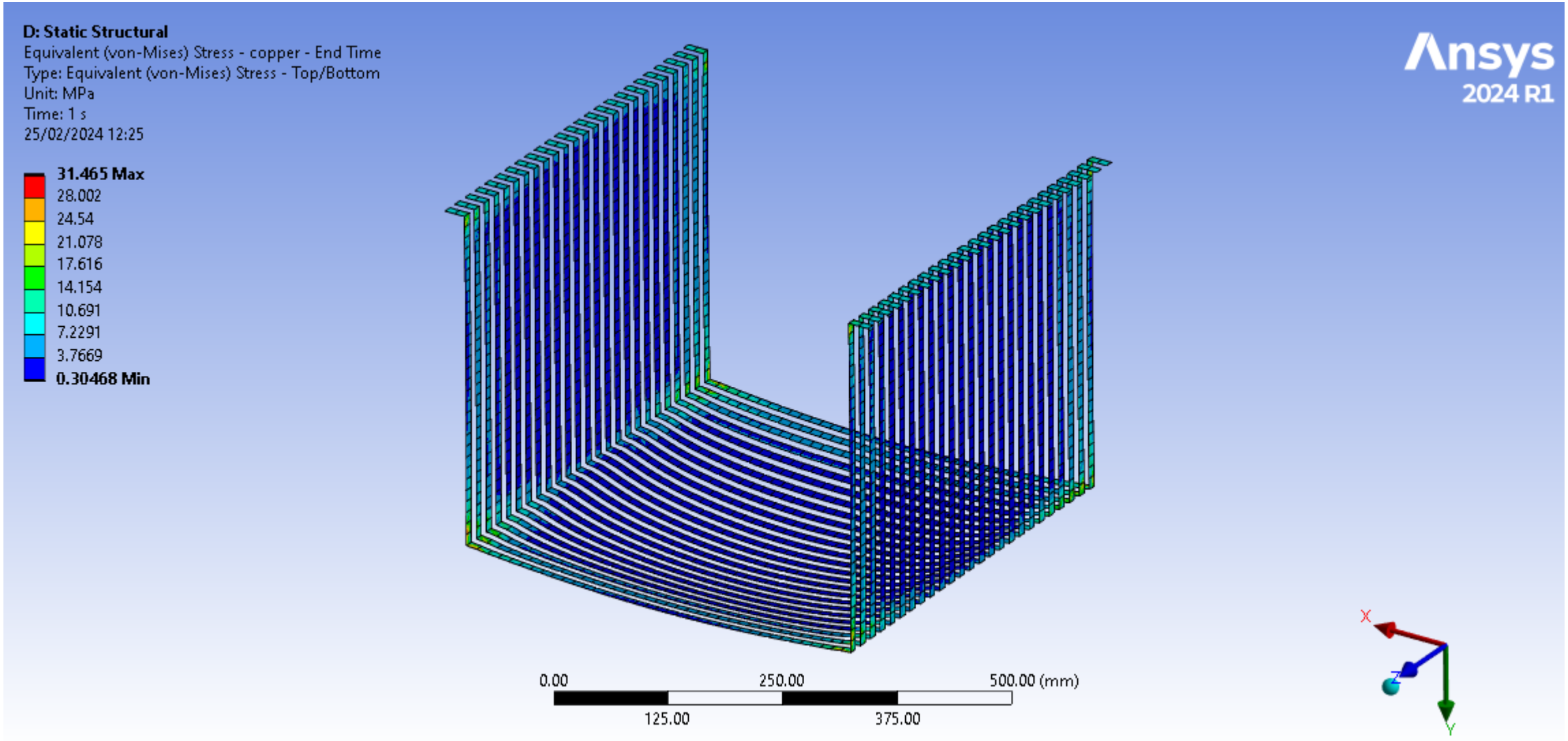
Bottom: Von Mises with 30 N Stretching Force



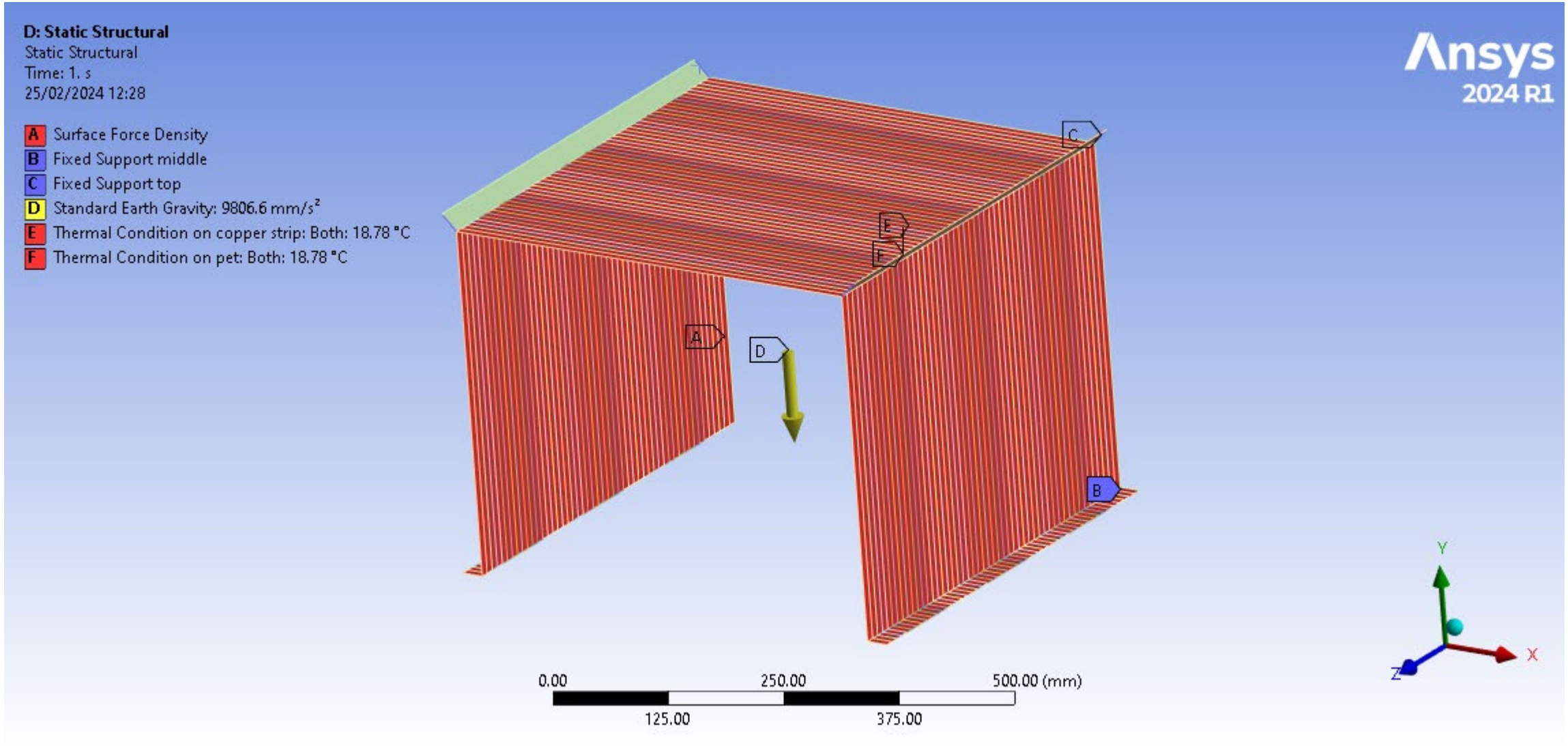
Bottom: Von Mises with 30 N Stretching Force (PET)



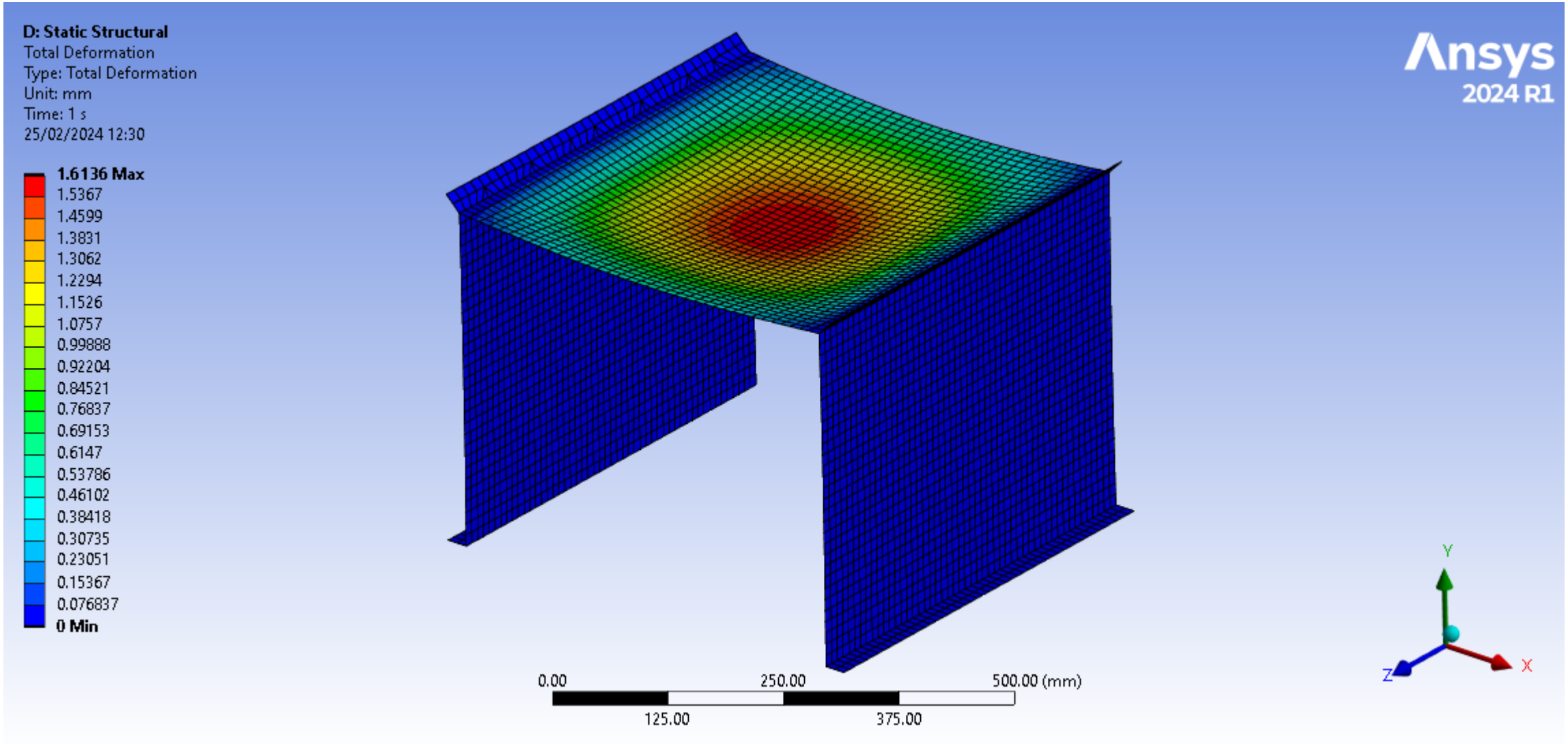
Bottom: Von Mises with 30 N Stretching Force (Cu)



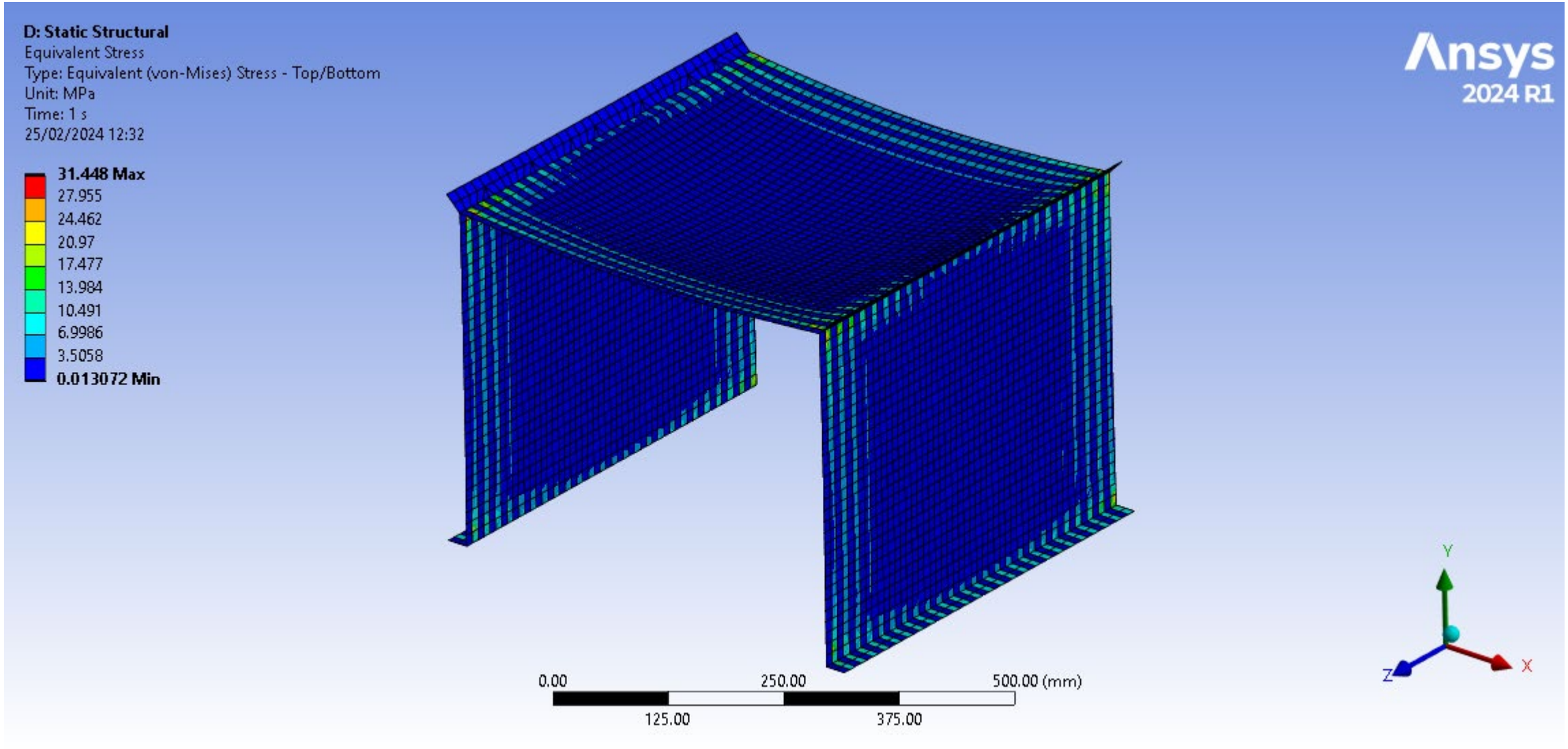
TOP: Loads with 30 N Stretching Force



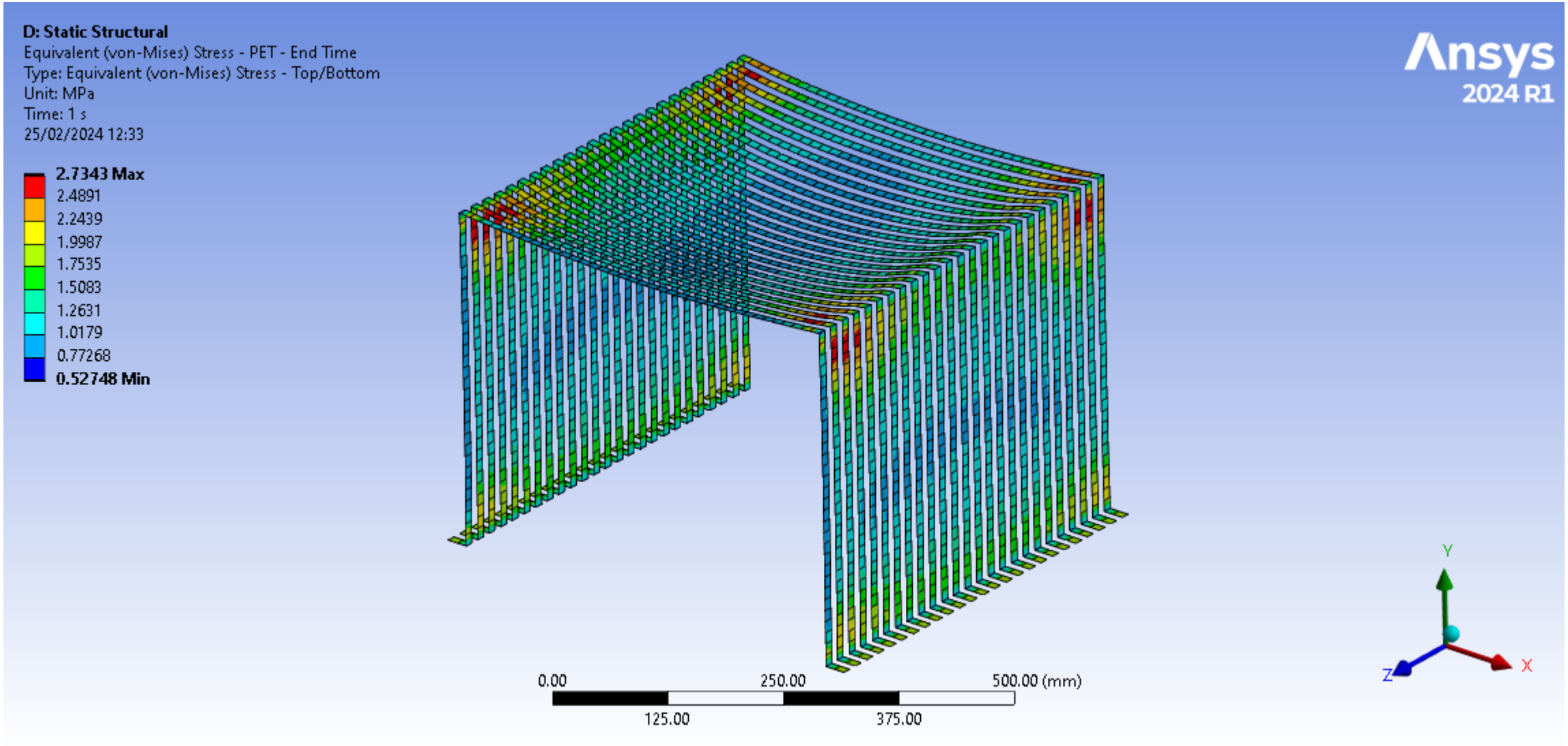
Top: Total deformation with 30 N Stretching Force



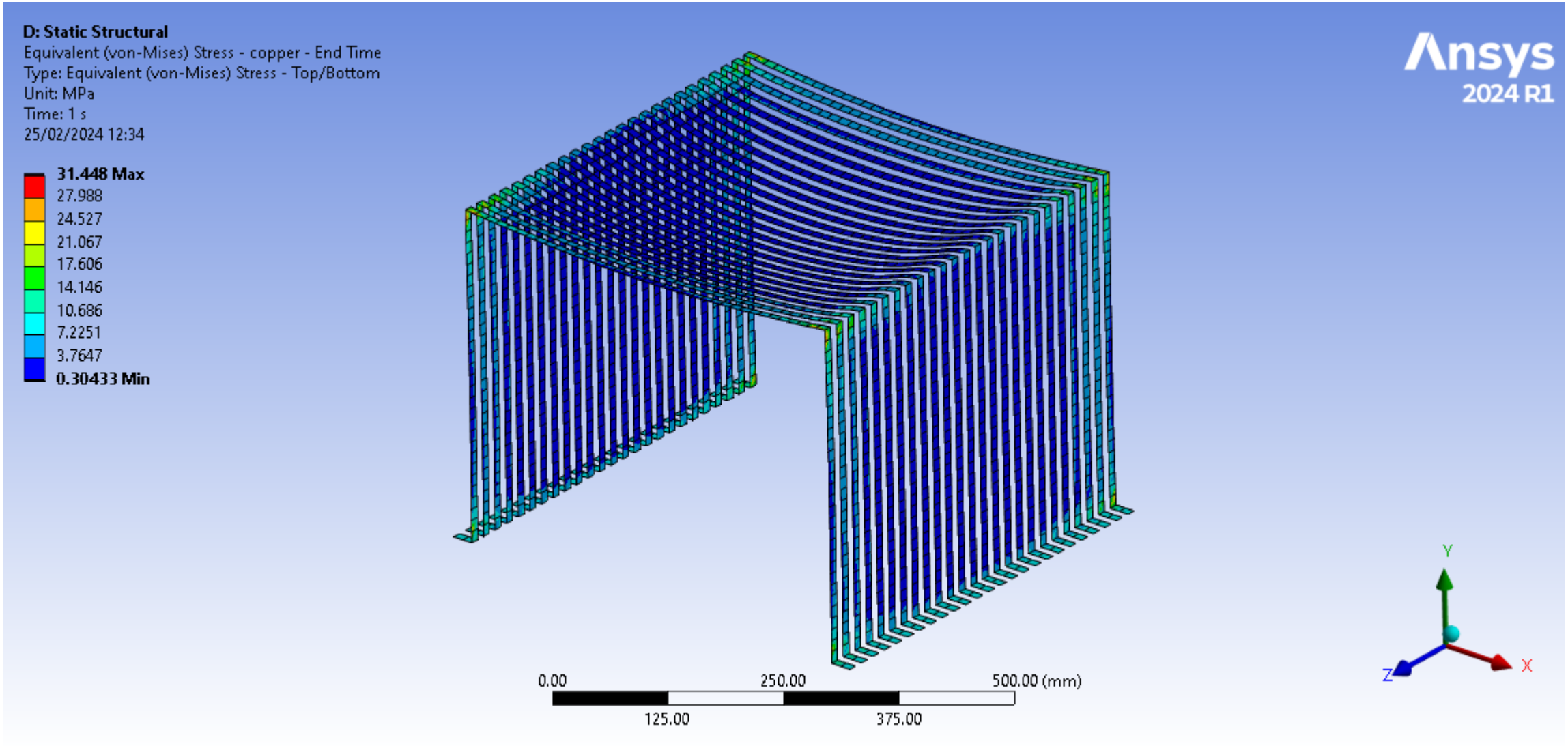
Top: Von Mises with 30 N Stretching Force



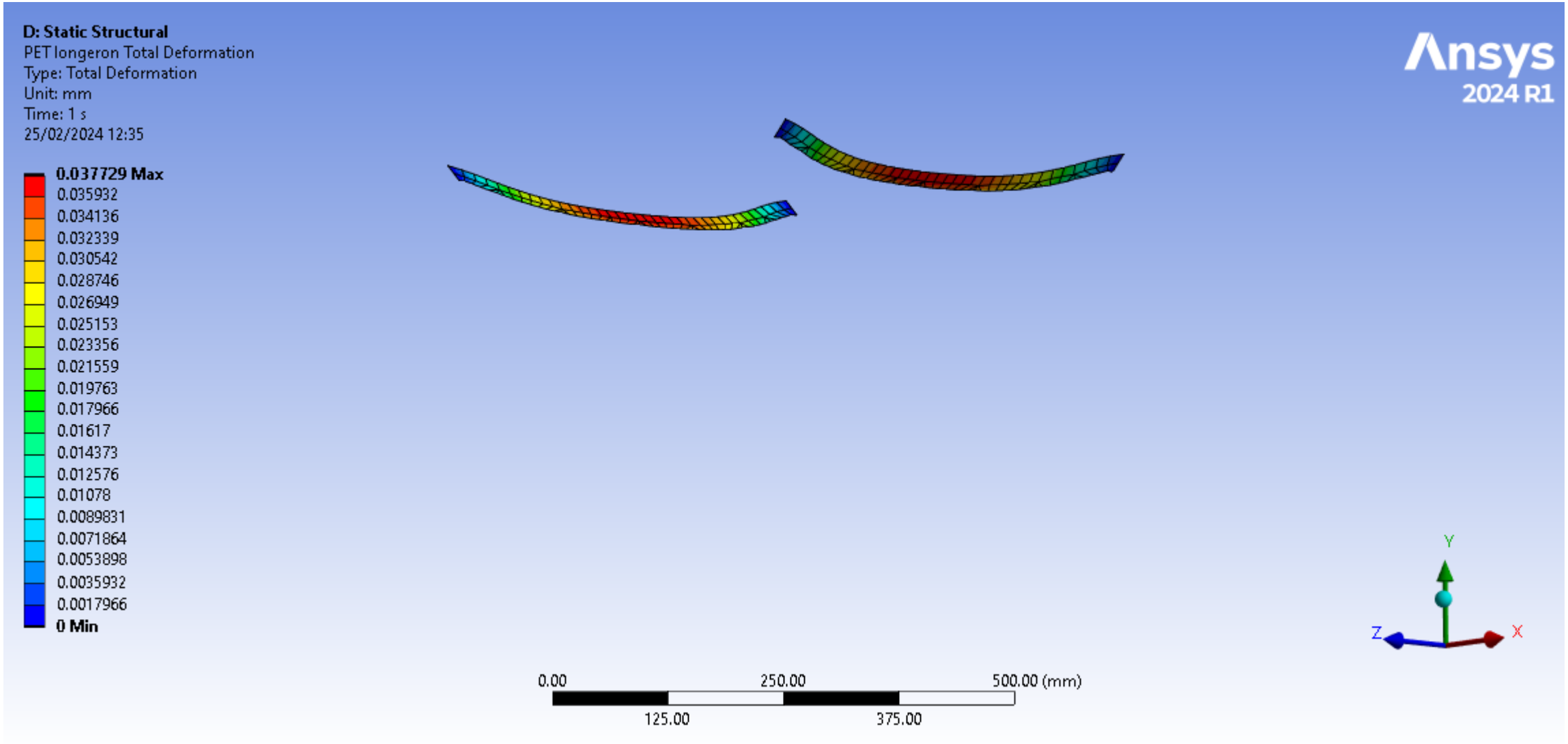
Top: Von Mises with 30 N Stretching Force (PET)



Top: Von Mises with 30 N Stretching Force (Cu)



Top: Total deformation with 30 N Stretching Force (Longeron)



Top: Von Mises with 30 N Stretching Force (Longeron)