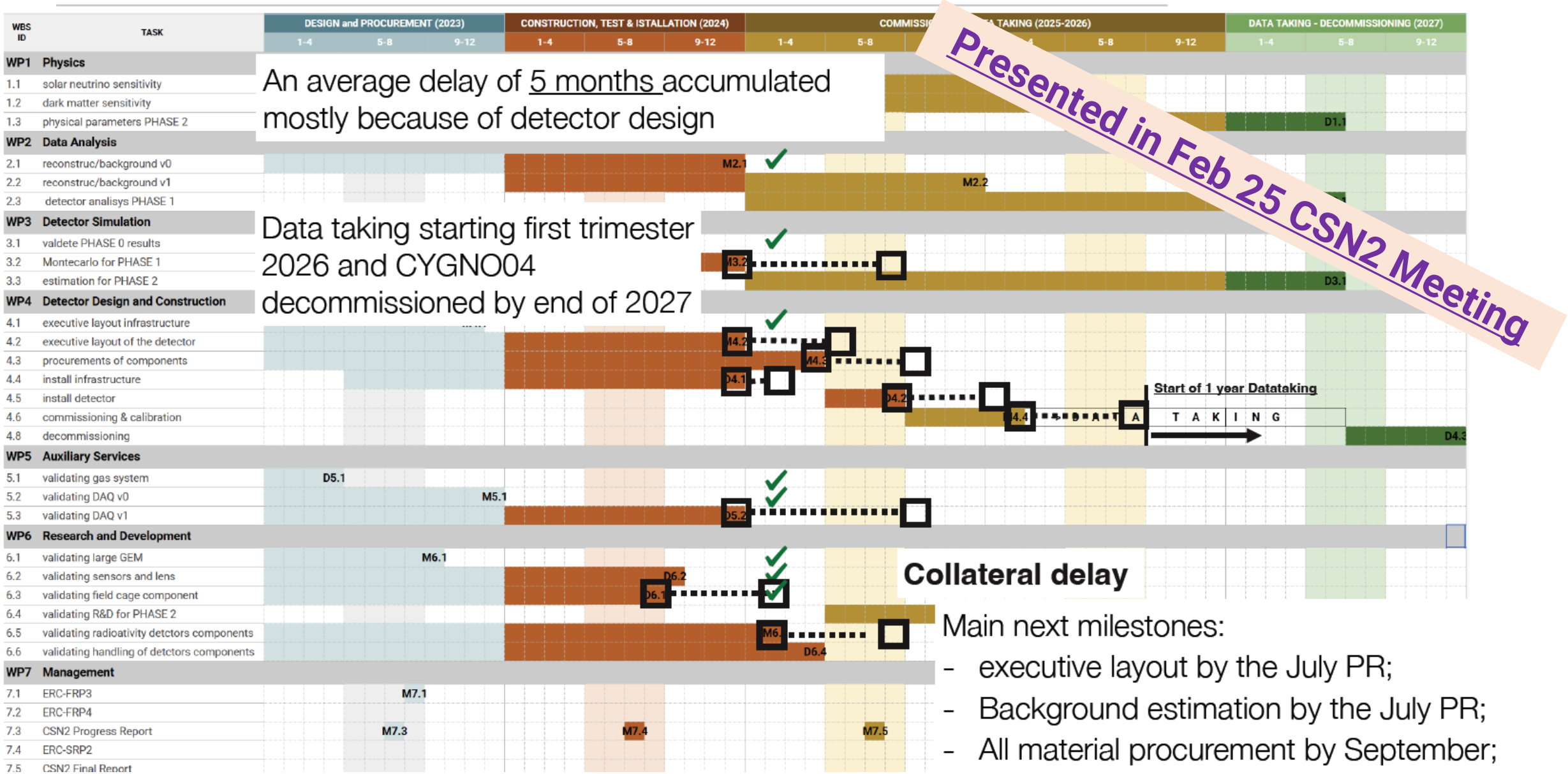
# CYGNO04
# Technical Coordinator Report

Davide Fiorina – GSSI & INFN LNGS

# CYGNO04 Gantt




An average delay of 5 months accumulated mostly because of detector design

Data taking starting first trimester 2026 and CYGNO04 decommissioned by end of 2027

Presented in Feb 25 CSN2 Meeting

**Collateral delay**

Main next milestones:

- executive layout by the July PR;
- Background estimation by the July PR;
- All material procurement by September;

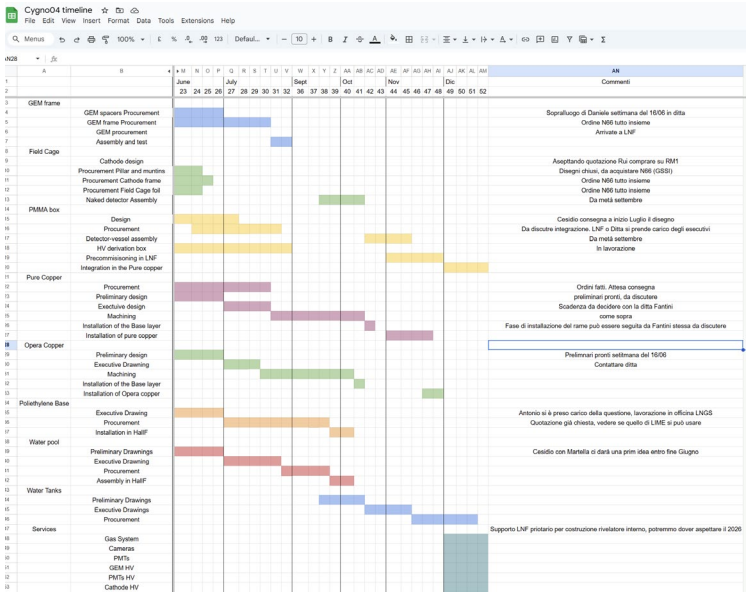
# CYGNO04 Gantt

**CYGNO relies on LNF services for design and installation.**

- LNF placed CYGNO as a 2nd priority in the first semester of 2025 (3-month person).
  - Patched with 3 month-person from LNGS mechanic service
- Work in **design** proceeded slowly because of higher priority experiments (LNF) and a lack of familiarity (LNGS)

**Given the progress made by the work and the explicit will of the LNF to complete it successfully**

- For the second semester, we got **3 months-person at 1st priority** @ LNF, we now foresee proceeding fastly




Day-by-day updated timeline to monitor progress

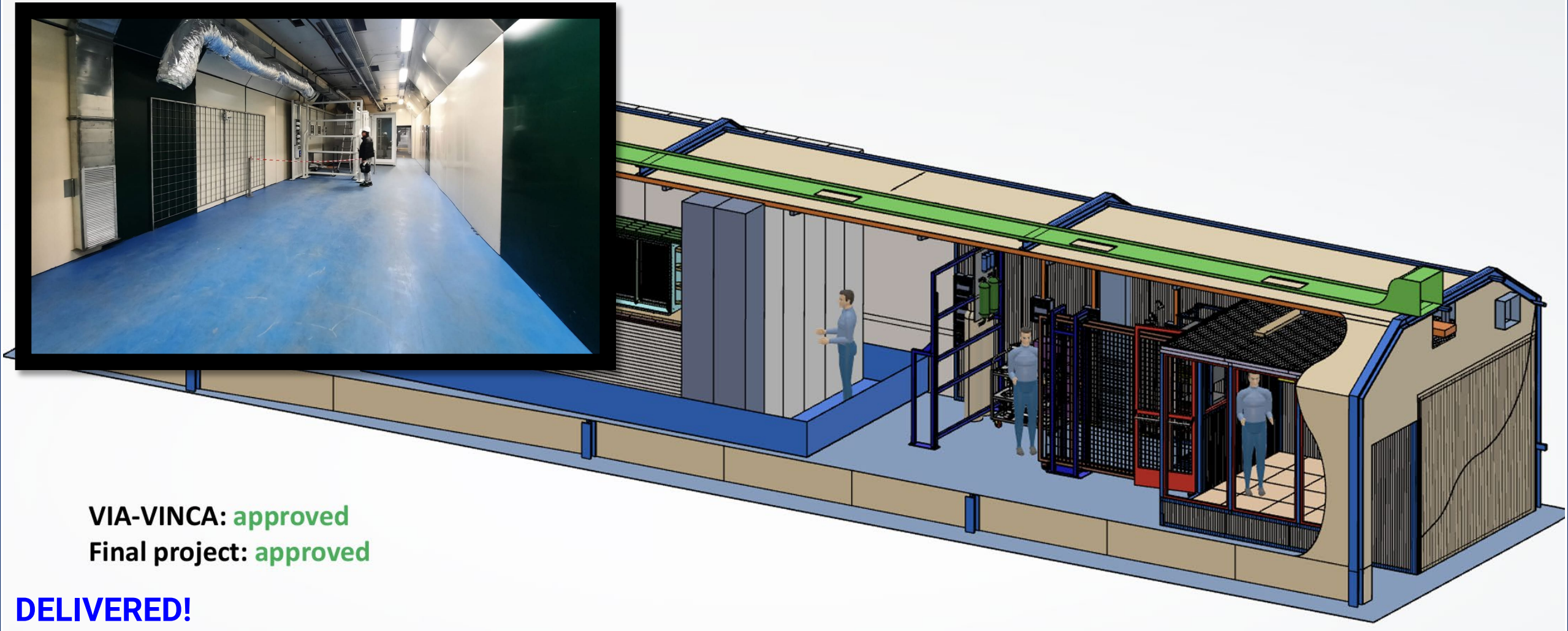
We are now on the correct path to deliver the detector in the **first trimester of 2026**.
Commissioning will last 6 months with one year of data taking, decommissioning is foreseen at the end 2027.

La commissione apprezza il lavoro di analisi compiuto dalla collaborazione su LIME ma invita la collaborazione a finalizzare la realizzazione di CYGNO-04 non oltre i primi mesi del 2026, recuperando, ove possibile i ritardi. La CSN2 raccomanda alla collaborazione un adeguato periodo di presa dati prima del *decommissioning* previsto nel 2027. La commissione inoltre puntualizza che la maggior parte delle spese di costruzione costruzione e caratterizzazione di CYGNO-04 devono essere sostenute su fondi ERC e si impegna a dare supporto all'esperimento secondo il piano finanziario esposto nel CDR a fronte del raggiungimento delle *milestone* di progetto, che saranno puntualmente verificate dai Referee.

September 24

# HallF Infrastructure

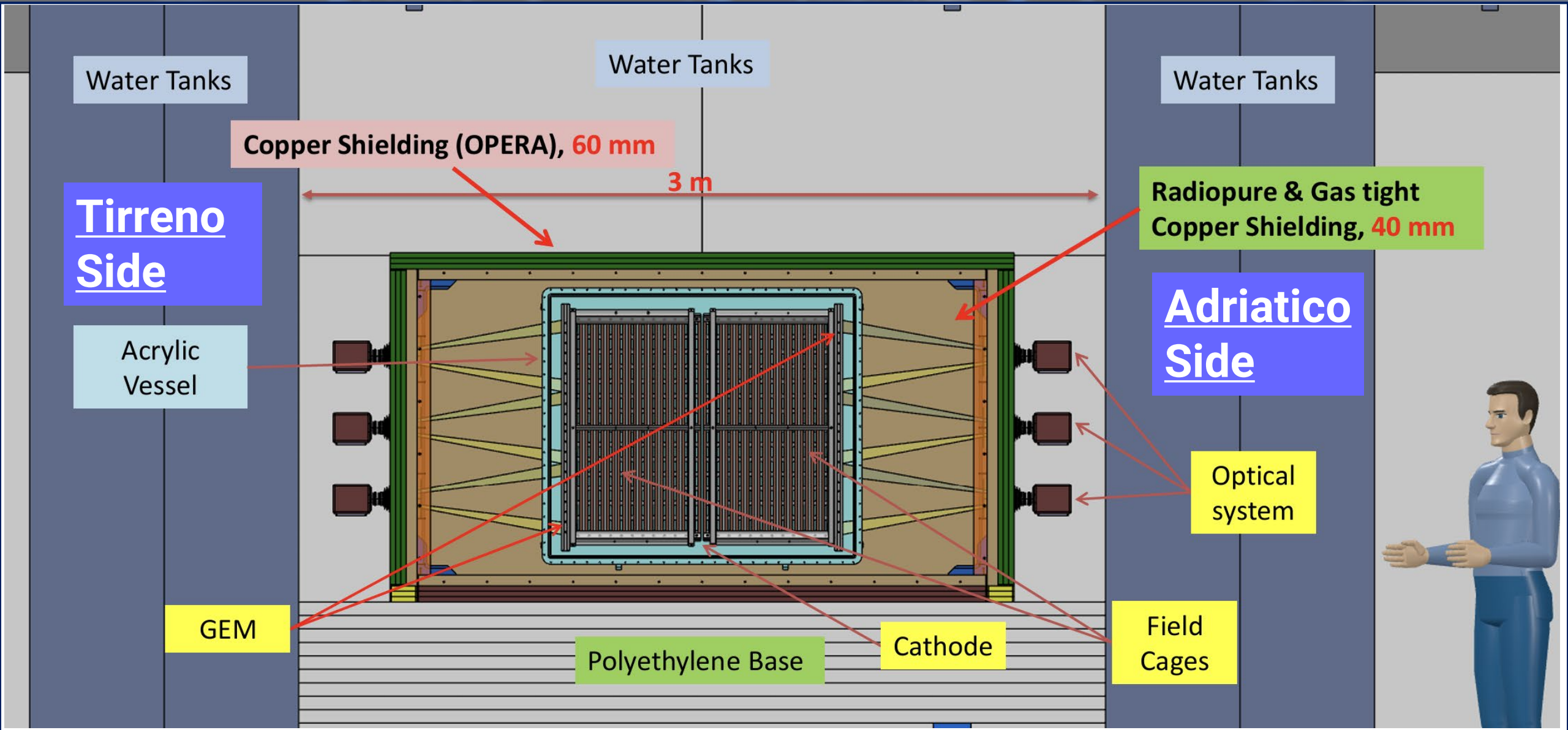




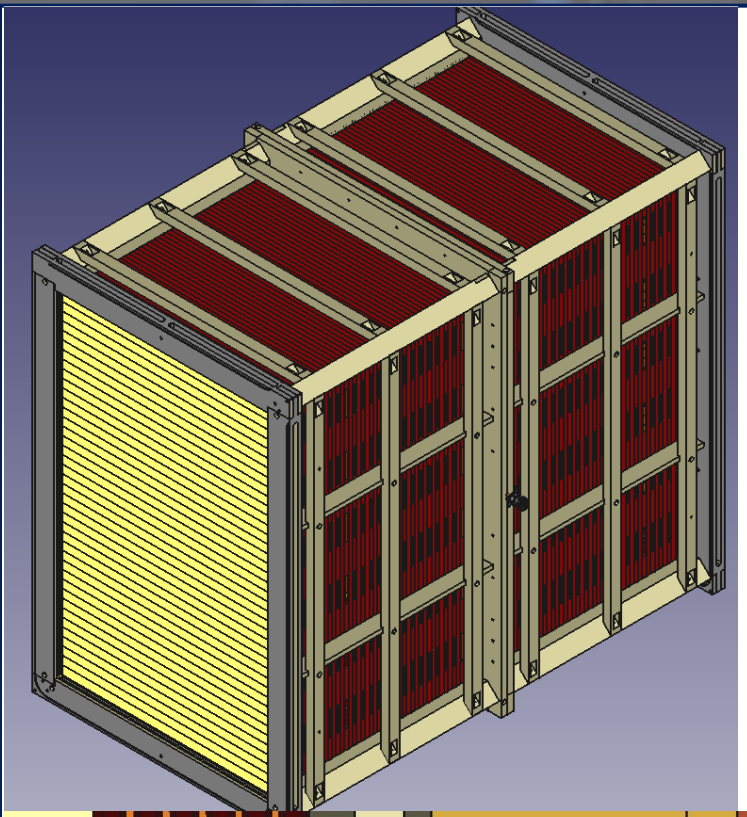
VIA-VINCA: approved
Final project: approved

**DELIVERED!**
**Services installation ongoing: Network (ongoing), Compressed Air (OK)**
**DAQ, HV and gas system moving from LIME, ready for end of June**

# Mechanical Layout

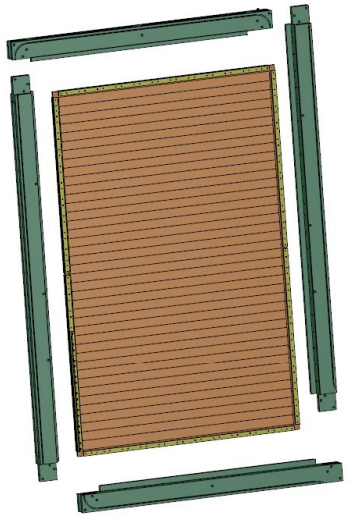


# Inner Detector

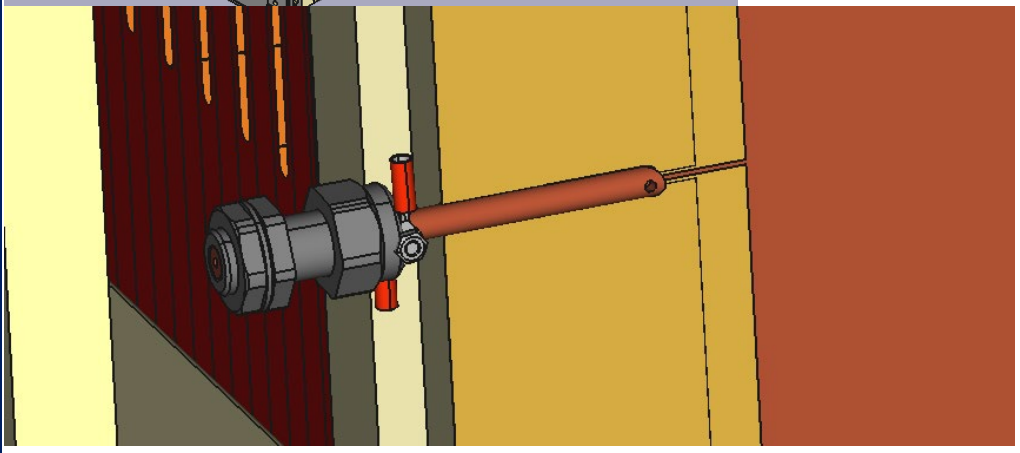


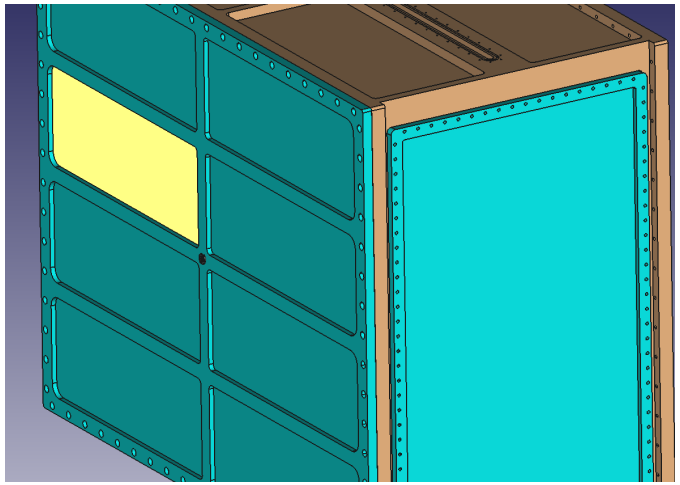
Drawings completed and frozen

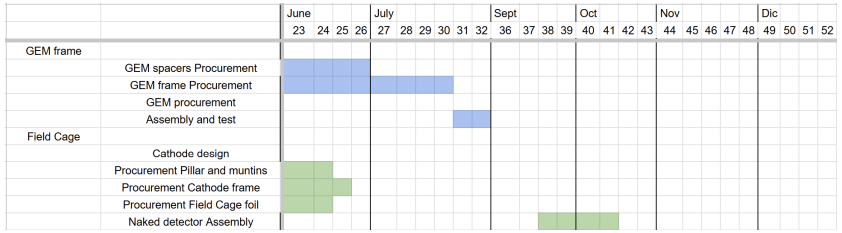
- GEMs procured and tested
- All material is Nylon66, non hygroscopic low radioactivity
  - GEM external frame under production (13.6k€) *Technoalarm*
  - Order for all N66 ongoing (3-4k€) *Lucioli Plast*
  - Quote requested for N66 machining *Technoalarm*
  - Cathode procurement ongoing (2x 1.5k€) *CERN*
  - Field cage quote requested *SeriGroup*
- Copper pin silver glued on a cathode pad for external connection, cable gland to ensure gas thightness on the PMMA



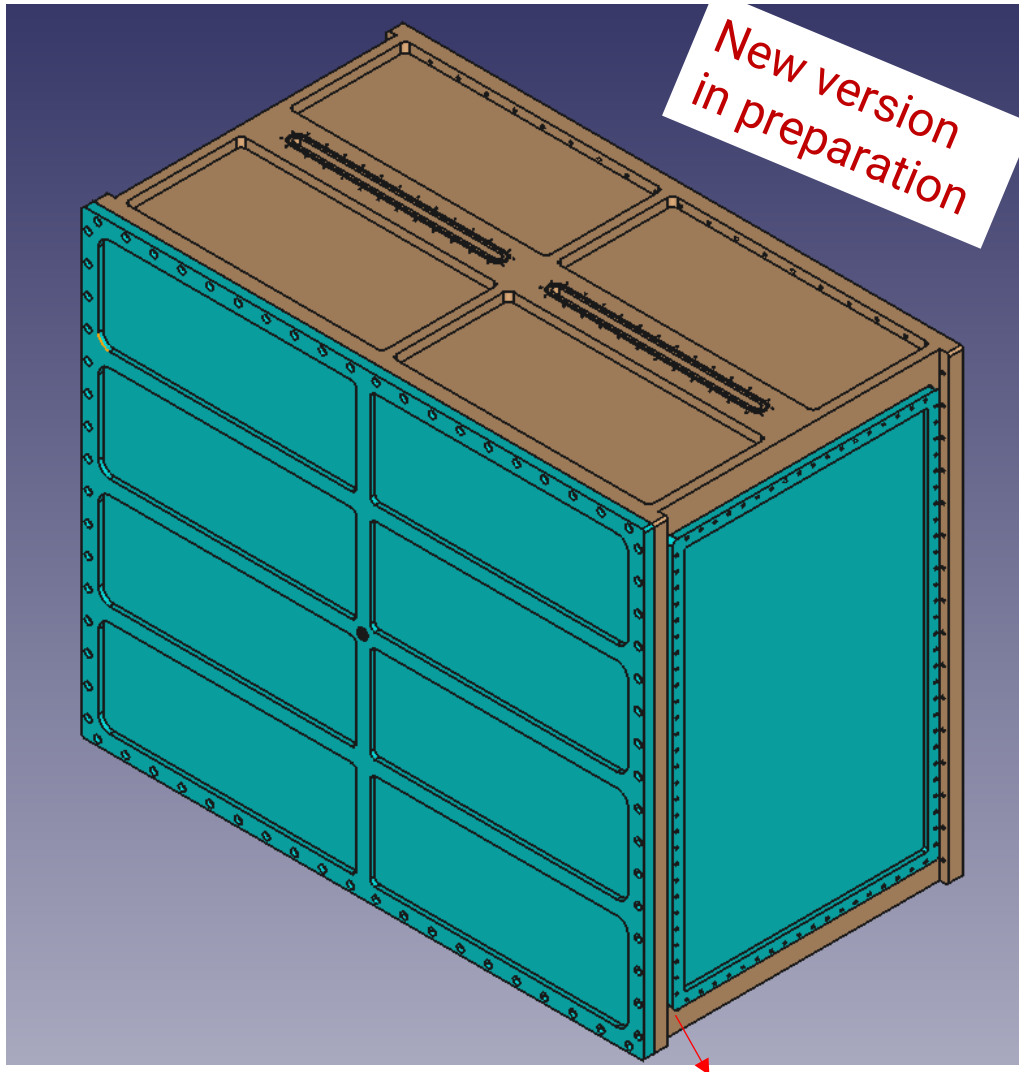
**Frascati Clean Room and technicians are secured from mid-September for assembly and test**





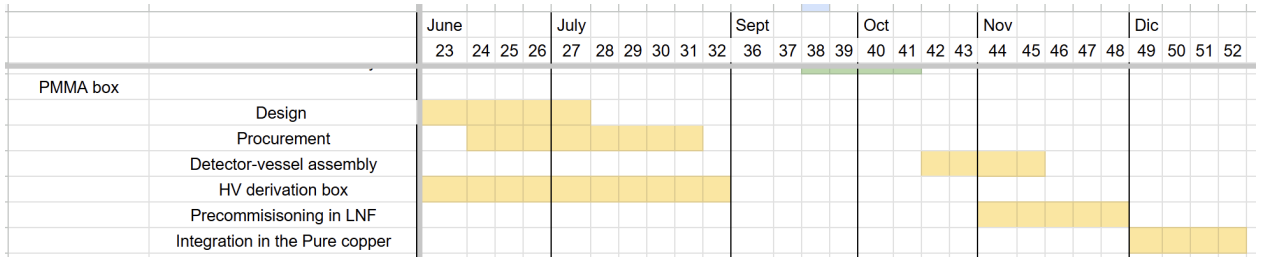


# PMMA vessel

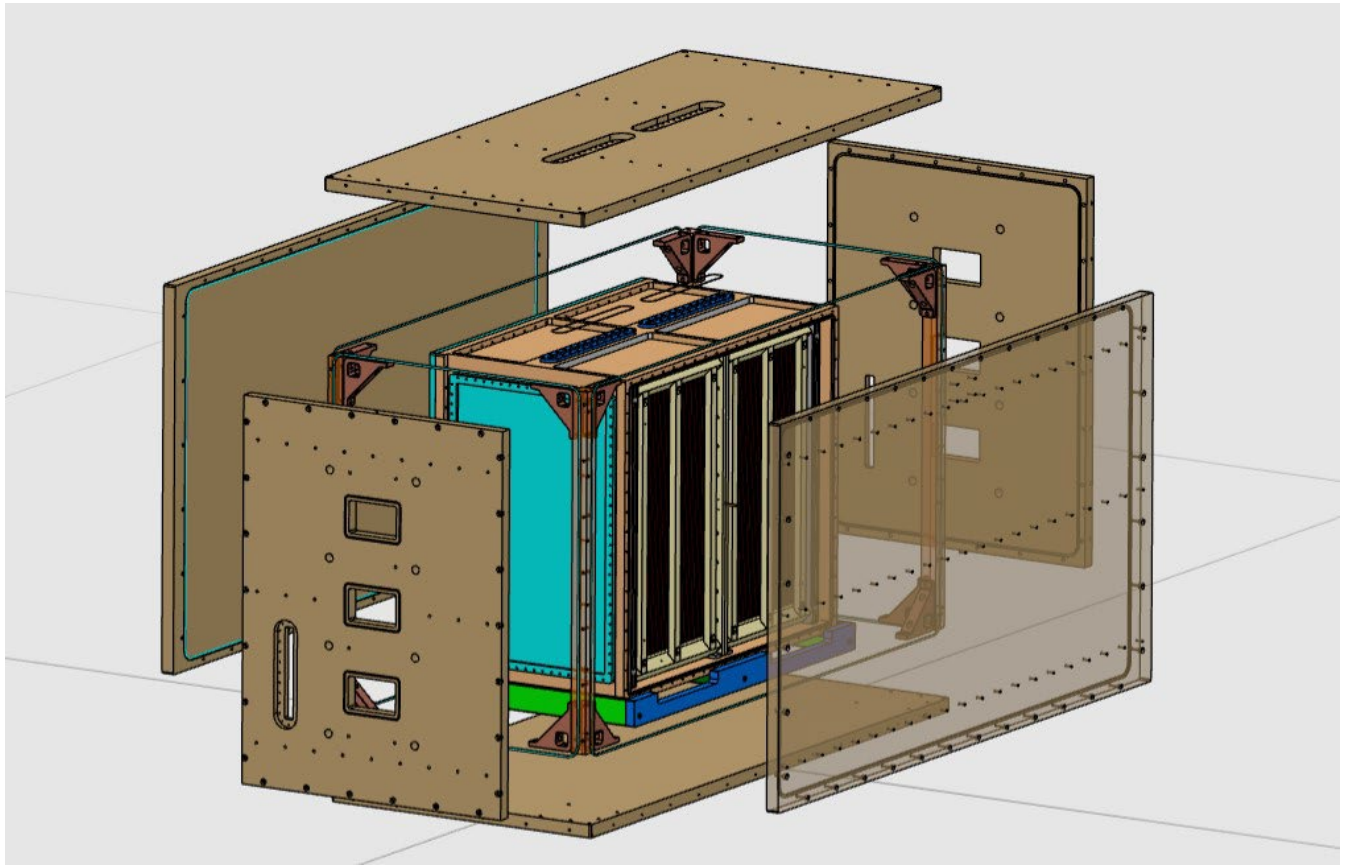



## PMMA vessel

- Dimension Defined
- Last FEM calculations with a 50mbar overpressure (10 times more than design)  relaxed our mechanical constrain
- A new simplified version of the PMMA box without Ribs i.e., plain slabs, is under design (expected for the end of the month)
  - Simpler, cheaper, with similar mass
  - Design service can provide only preliminary drawnings: contructing and exectutives tbd by LNGS service (if request is accepted), as a backup, the company (*Bussetti e Mazza*) is available to take only the 3D file and complete the work
- 6x 6mm inlet for each side, 3x 10mm outlet near cathode for gas
- Only HV cables should go inside
  - Cathode (50kV) through copper pin and cable gland
  - GEM HV (6pin+2spare) pass-though pins soldered with liquid PMMA



# Copper Vessel

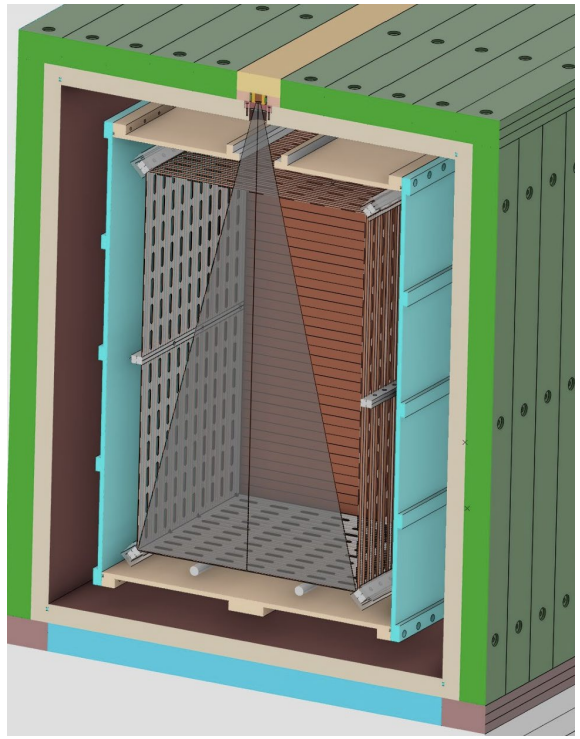


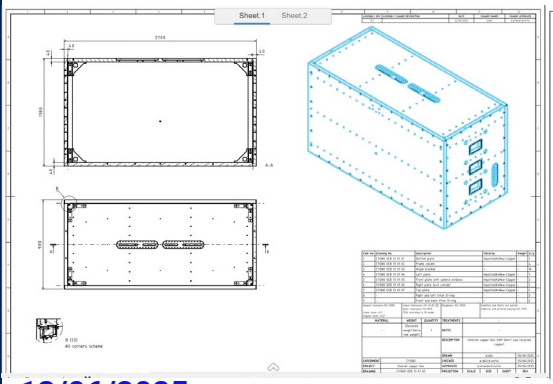
## Gas Thigh Radiopure Vessel

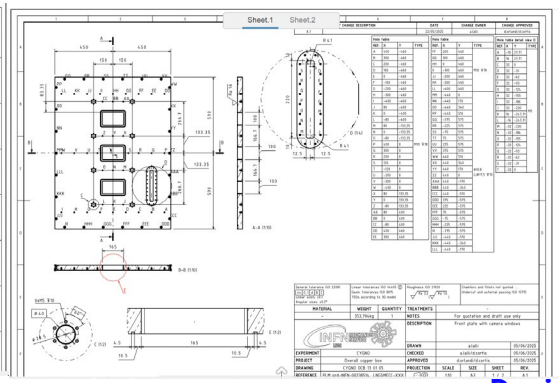
- Function as a second gas volume
- Copper delivery is foreseen for mid-July, directly to the company
  - Company *Fantini* meeting for next week to discuss the first quote + possibility for them to follow the installation underground

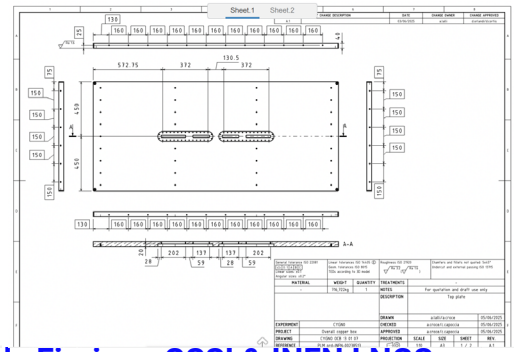
**Preliminary drawnings ready!**
**final 3D expected by end of June**

Feedthrough similar as PMMA with cable gland to ensure gas thightness

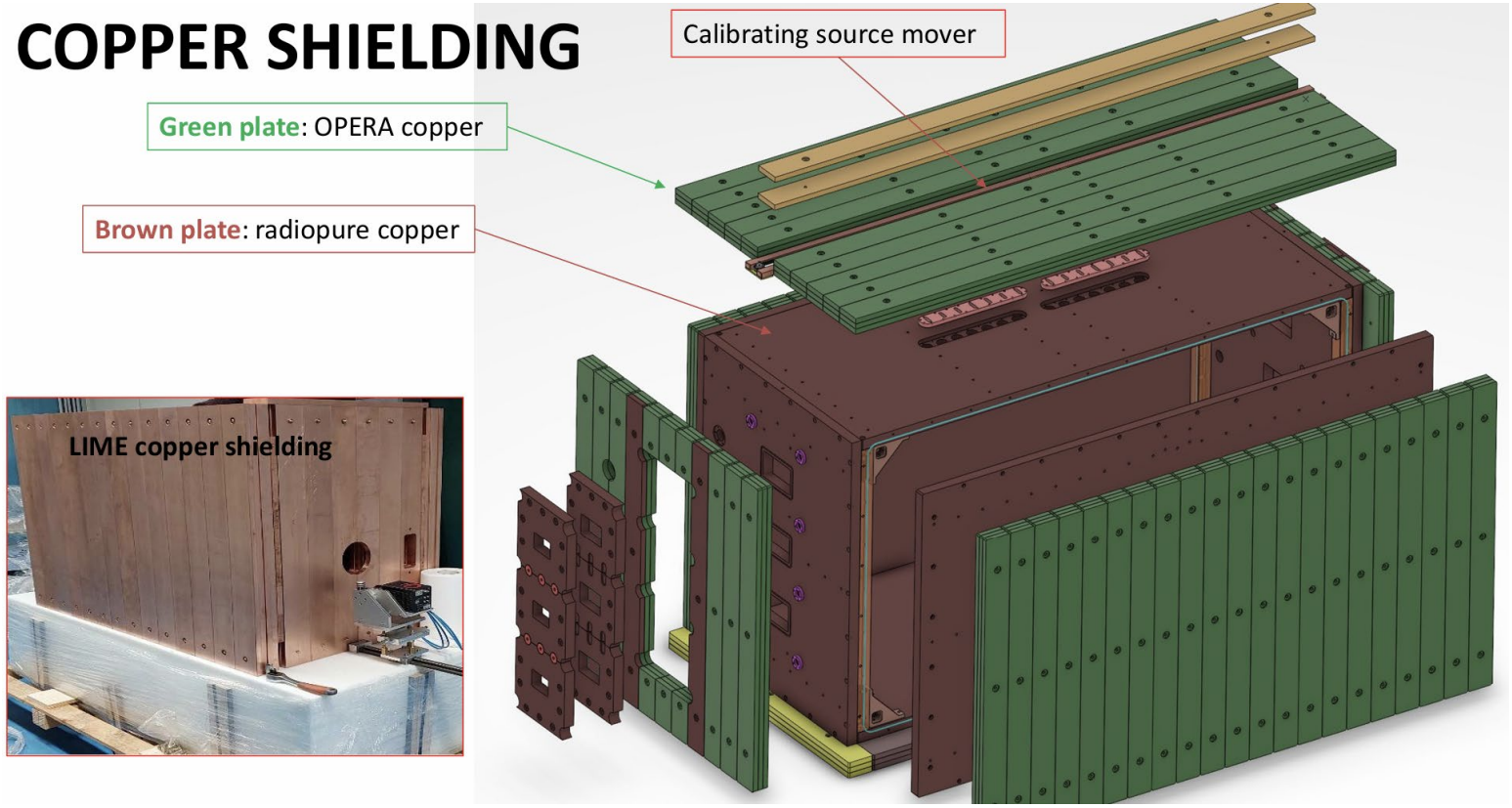








# Copper shielding



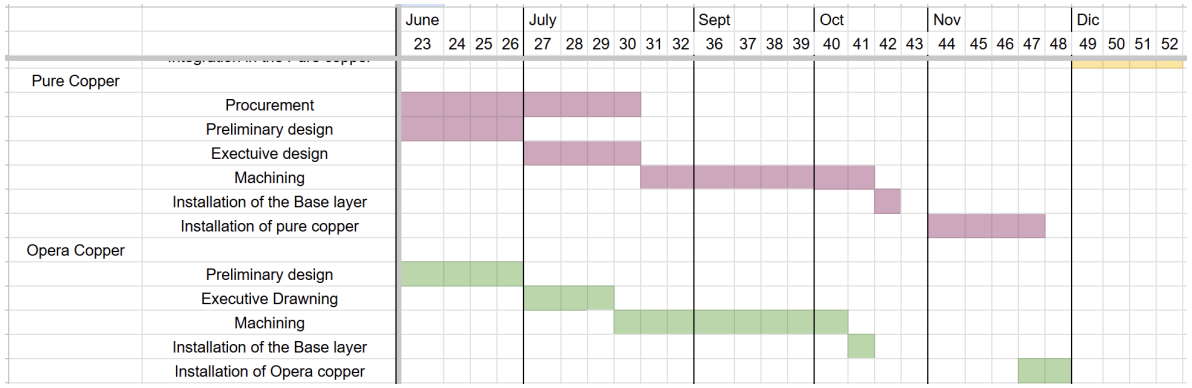

**OPERA Copper**

87 bars (flat 100x20) 2945 mm long, weighing approximately 52 kg each for **4.5 tons.**

Additional **3 tons** secured from the Ptolemy experiment

Company to machine Opera slabs available (same as LIME, *MeccanicaDP*)

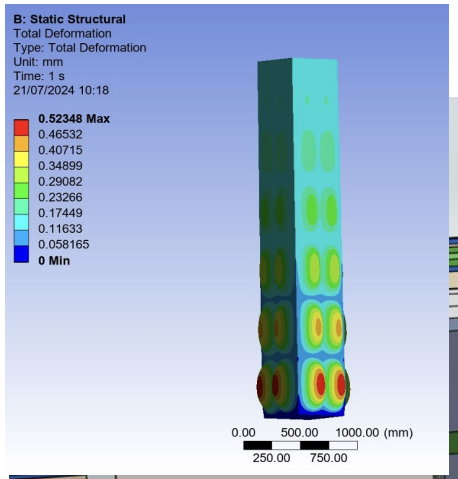
In principle no need to use LIME copper

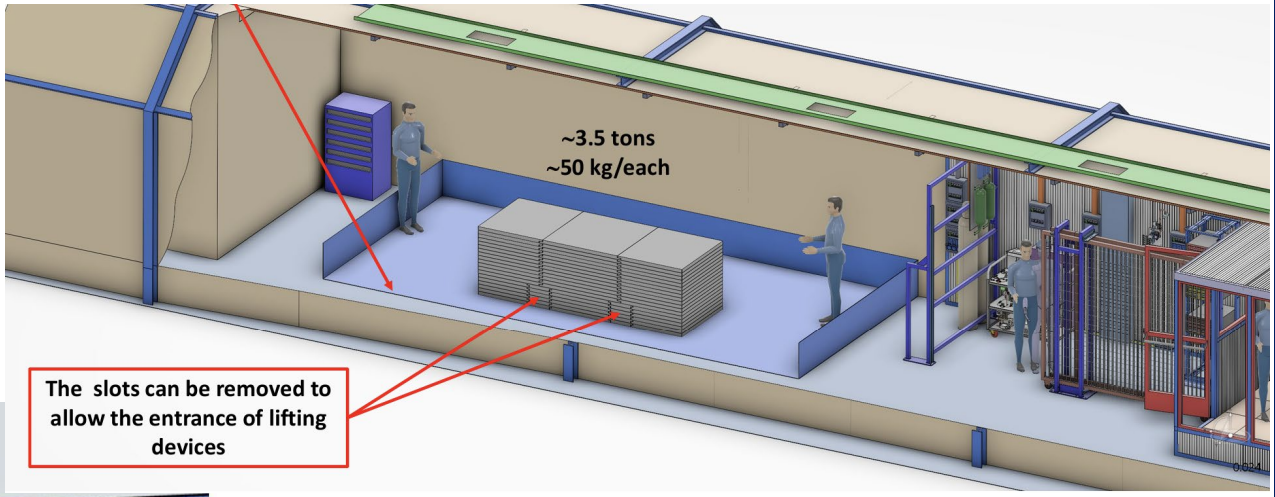


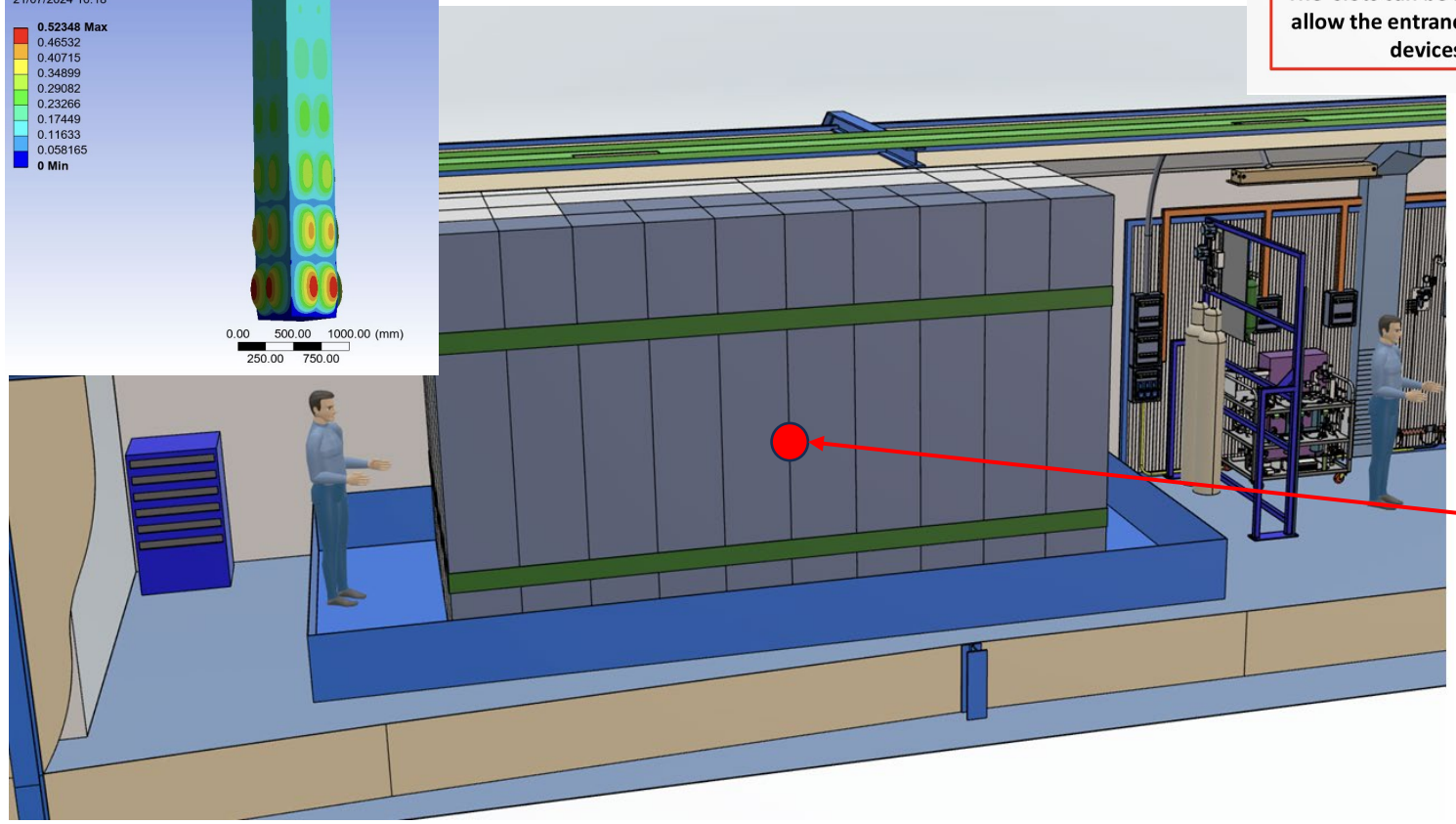

# Water shielding

## Polyethylene base

- Quote obtained from *Palazzi*, cross-check to see how much from LIME we can save.
- Then proceed with slabs procurement
- Machining can be done in LNGS



## 100cm Water Shielding

- Profiting from LIME experience the idea is already in place, lowest priority in design

## Safety Pool

- Critical point for installation
- Preliminary drawing before July to be validated by LNGS technical coordinators

# Recap

**Given the significant progress made and the firm commitment of LNF to complete this work, we have secured 3 person-months at the highest priority for the design service at LNF for the second semester, which will significantly accelerate the project's advancement.**
**LNF also agreed to assign technicians for the inner detector assembly with the highest priority, 3.5 months-person**

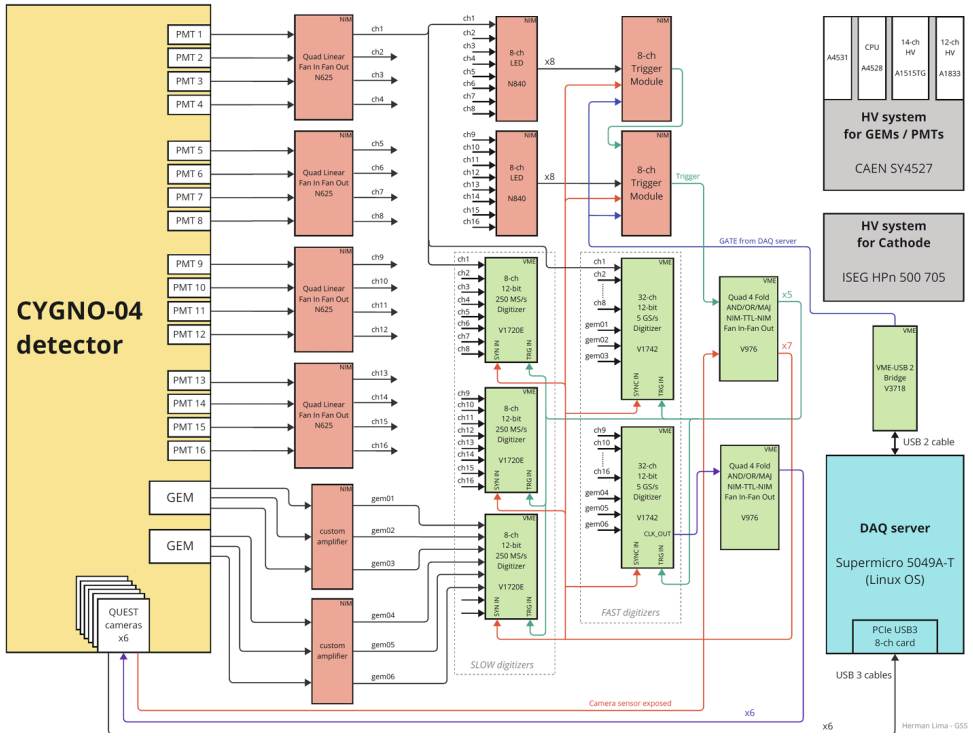
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| *CYGNO/INITIUM (G.Mazzitelli)* | *3* | *23%* | *3* | *23%* | *1* | *1* | *Seguire il procurement del vessel di PMMA (no) , Finalizzare i disegni esecutivi rame radiopuro, Seguire i lavori in ditta rame radiopuro, Completare i disegni esecutivi rame esterno (Opera), Seguire i lavori in ditta rame esterno, Disegni esecutivi per la piscina contenitiva, Disegni esecutivi water tanks. Sviluppo dei disegni esecutivi di CYGNO 04, Supporto alla stesura dei capitolati tecnici per gli acquisti di CYGNO 04, Supporto alle successive installazioni di CYGNO 04 (rif.Shielding in coll.LNGS) .* |

- **Inner Detector:**
  - 3D frozen
  - Procurement in progress (end before summer)
  - Resources and spaces secured for assembly (starting from mid-September)
- **PMMA vessel:**
  - New design with fewer constraints under development (3D before the end of June)
  - Procurement expected to start before summer, timeline depending on resources (LNGS or company)
  - Deliver requested for the beginning of October for integration in LNF
- **Copper shielding**
  - Radiopure copper delivery before the end of July
  - Preliminary drawings ready
  - Meeting with the company next week (discuss also the installation of the box in LNGS)
    - Deliver expected in November
  - Opera copper preliminary is ready next week
    - Start quotation with nearby companies before the end of the month
- **Polyethylene base:**
  - Quote requested
  - Possible machining in LNGS because of low effort
- **Water Pool**
  - Rising in priority since it’s constraining installation and works in the area
  - Beginning of July, first drawing to discuss with LNGS tech coordination and SPP
- **Water shielding**: least priority for now

Riunione di programmazione II semestre 2025 (9 June 2025) · Agenda (Indico)

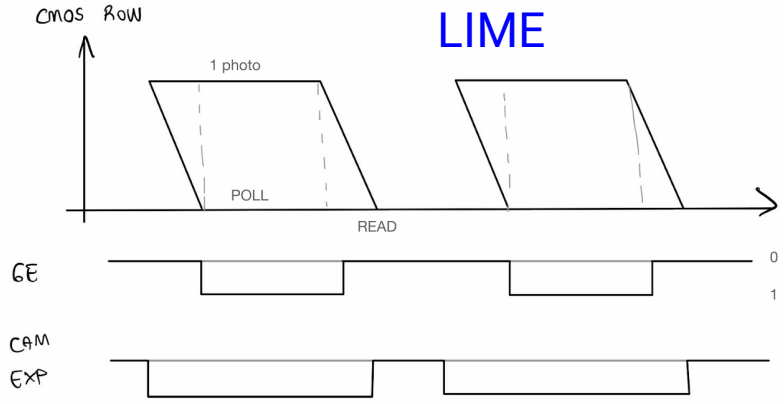
| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| cygno | Mazzitelli | 2 mu per assemblaggio del rivelatore nudo in CR a LNF | 1,5 | high | Tesauro | 30% | D.D.Unit | 1,5 | 1 | sept - dec 2025 |
| | | 1 mu per integrazione rivelatore nudo nella box di PMMA in CR a LNF | 1,5 | high | Paoletti | 30% | D.D.Unit | 1,5 | 1 | |
| | | 1 mu per pre-commissioning nella CR a LNF | 1,0 | high | Pierluigi | 20% | D.D.Unit | 1,0 | 1 | |

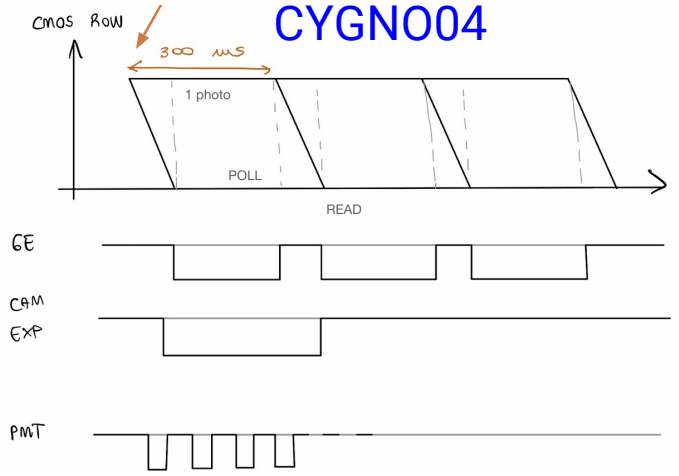
# DAQ

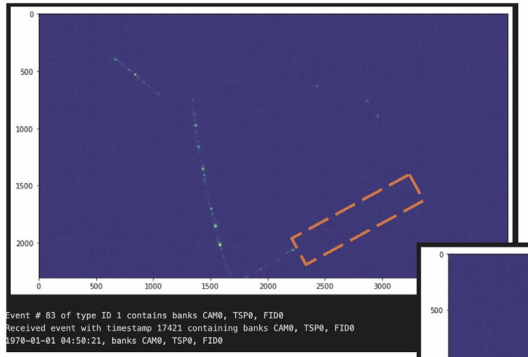


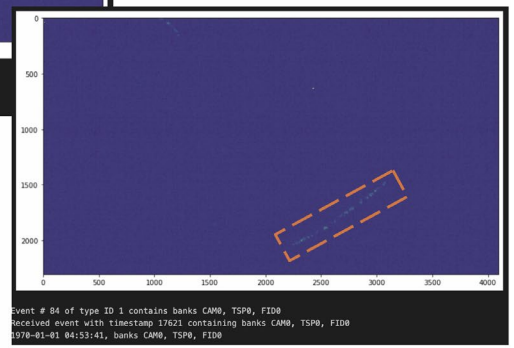

## DAQ:

- All hardware procured! Missing ≈50% of the consumable for installation
- Design two independent data acquisition paths that can also run in a ‘combined mode’.
- Wrt LIME change the camera operation mode from ‘software trigger’ to External Trigger mode
- Both the exposure and readout of the camera are made by the external trigger, reducing the deadtime.
  - → Deadtime is reduced form ≈30% to <1%
  - → Possibility to recover cut tracks
  - → Tested and working in the LIME infrastructure
  - → Daq v1 needs to extend this framework to 6 cameras 16 PMTs collaboration effort ongoing to have it before the end of the year

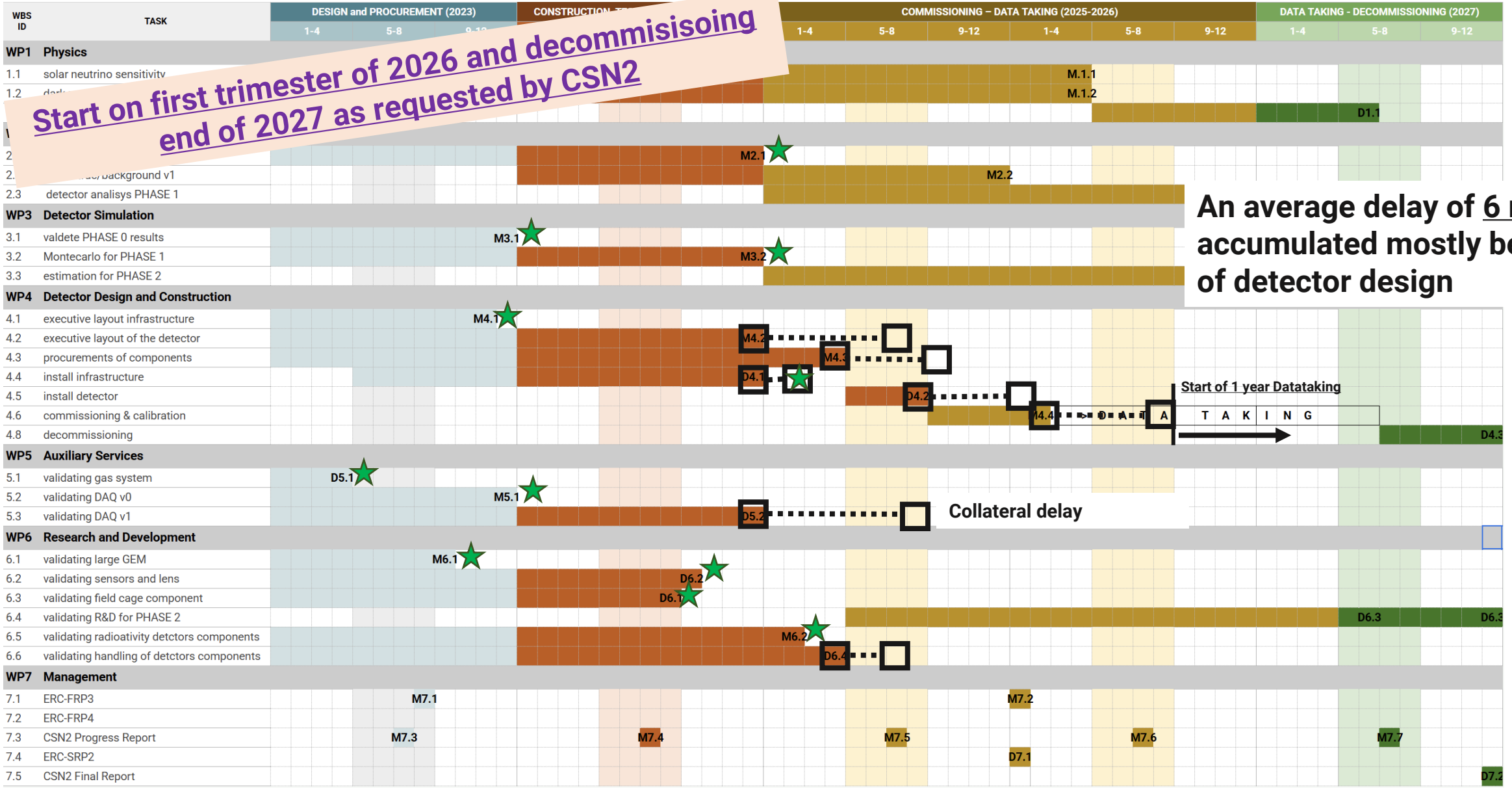


# CYGNO04 Gantt




Start on first trimester of 2026 and decommisisoing end of 2027 as requested by CSN2

**An average delay of 6 months accumulated mostly because of detector design**

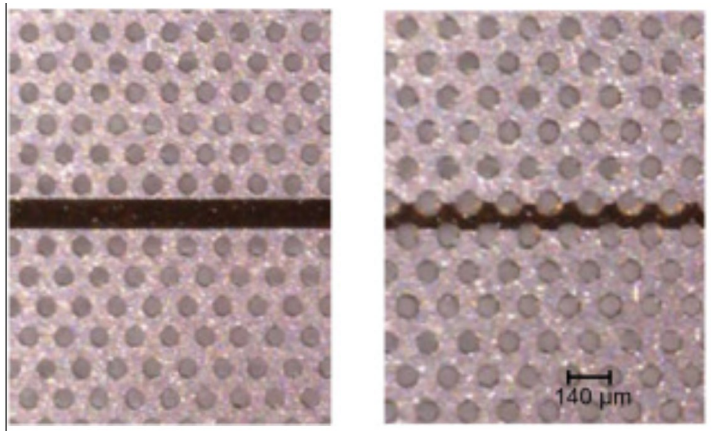
# BACKUP

# GEM foils

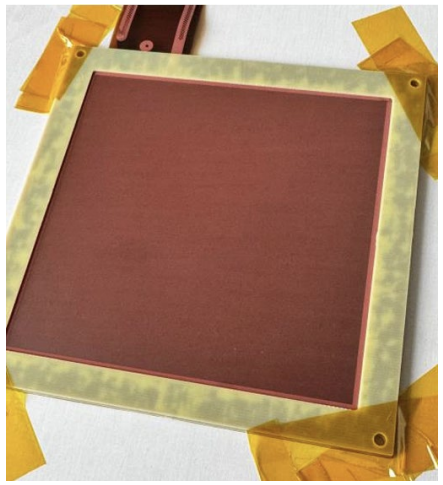
CYGNO needs 6 GEM foils, we bought 8 foils

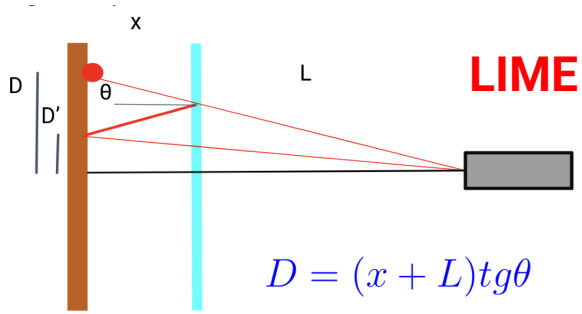
- 4 foils with random segmentation (one is oxidized)
- 4 foils with standard segmentation (one is oxidized)

**Random segmentation** should reduce the dead area while maintaing the operational stability (tested by CMS-GEM)




**Oxidized GEM** made by corrugation of copper plus deposition of O(nm) copper polymer makes the GEM opaque avoiding reflection of large light emission on hte PMMA window as observed in LIME



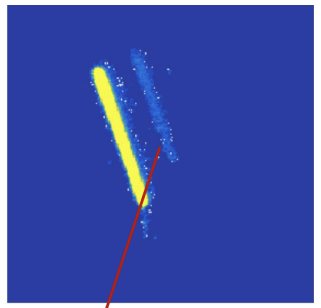



**LIME**

$$D = (x + L)tg\theta$$

$$D - D' = 2xtg\theta$$

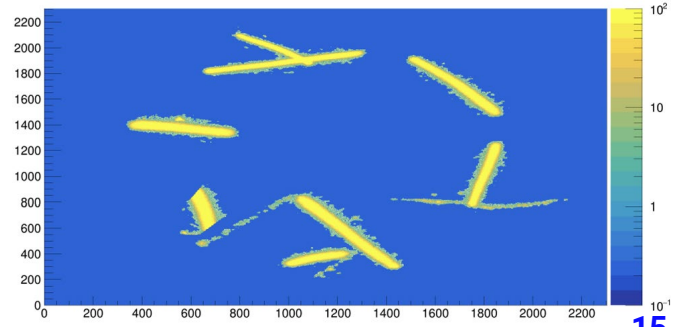
Distance of the shadow



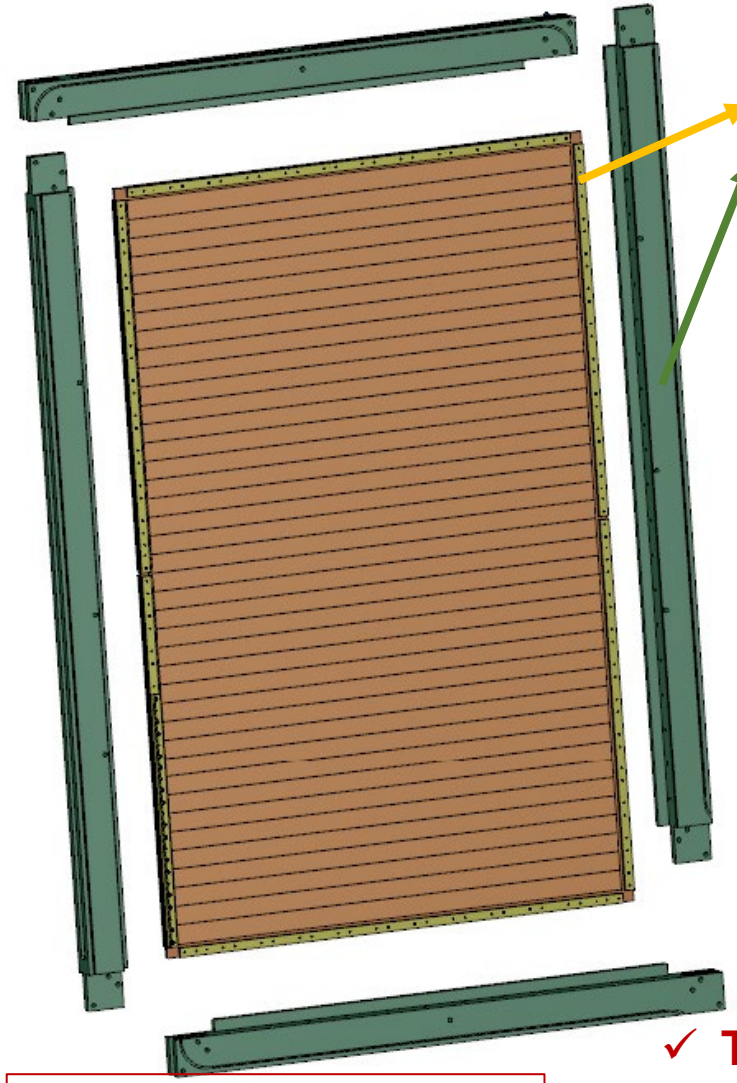
Theory and measurement agree

**GIN- Frascati Proto**

Oxided GEM large light



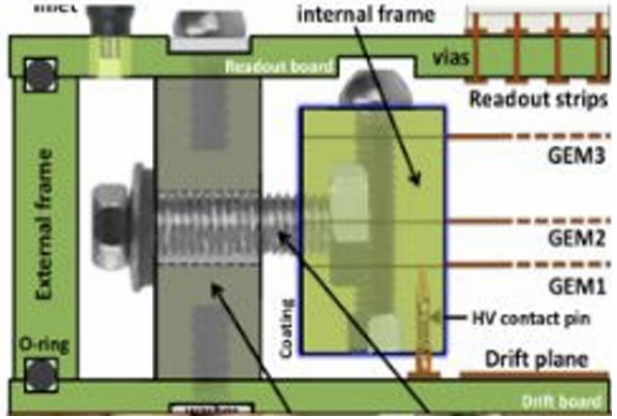
# GEM Frame

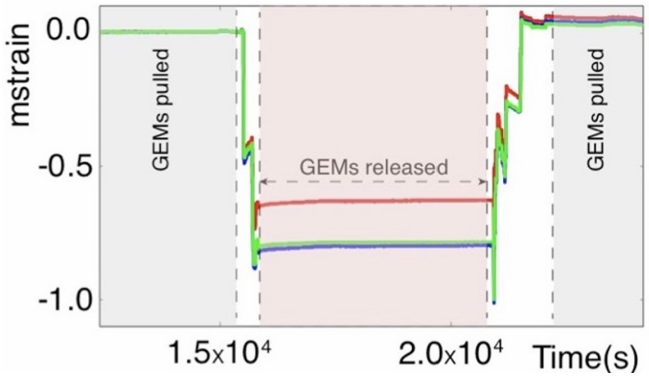


**Work Carried out by LNF** GEM foils are mounted à-la CMS

- Stretching system and HV powering through pogo-pins on the internal frame
- External Frame guarantees the tensile strength and it is part of the detector structure
- Both frames in Nylon66
  - Non-igrospoic (different from Nylon6)
  - Good mechanical proprieties
  - Lower background wrt PMMA

External Frames may host Fiber Bragg Grating (FBG) for tensile deformation monitoring



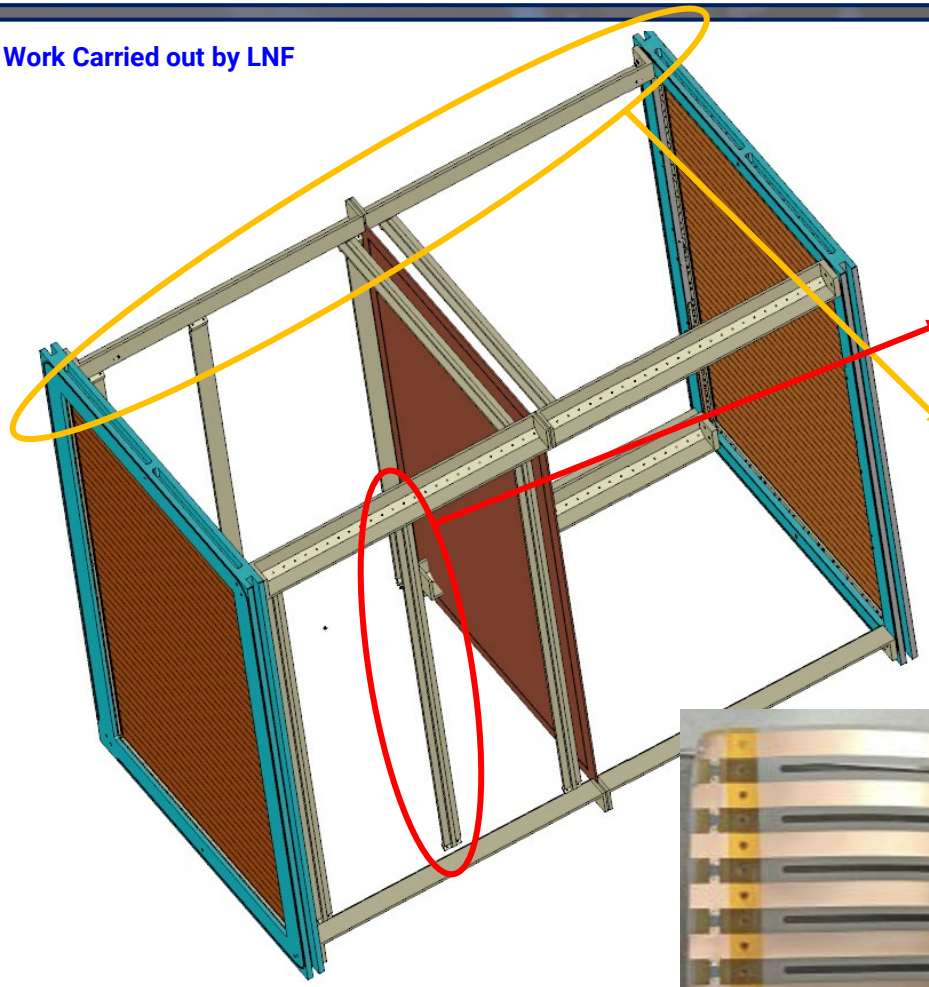




**To be integrated in the 3D model**

- ✓ **The two GEM frames are in production (1 month delivery+1 month GEM stack conditioning and test)**
- ✓ **Integration in the 3D model ongoing**

# Field Cage and Cathode

Work Carried out by LNF

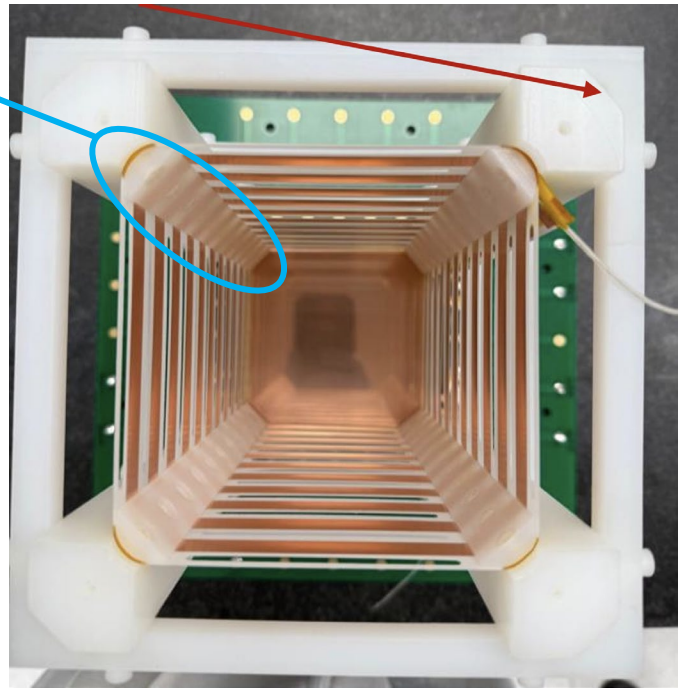


**The cathode** will be a Kapton foil copper clad on both sides (50um+5um)

- Integration ongoing, the design of the support/frame will follow the same as the GEM one
- Backup solution, full copper plate

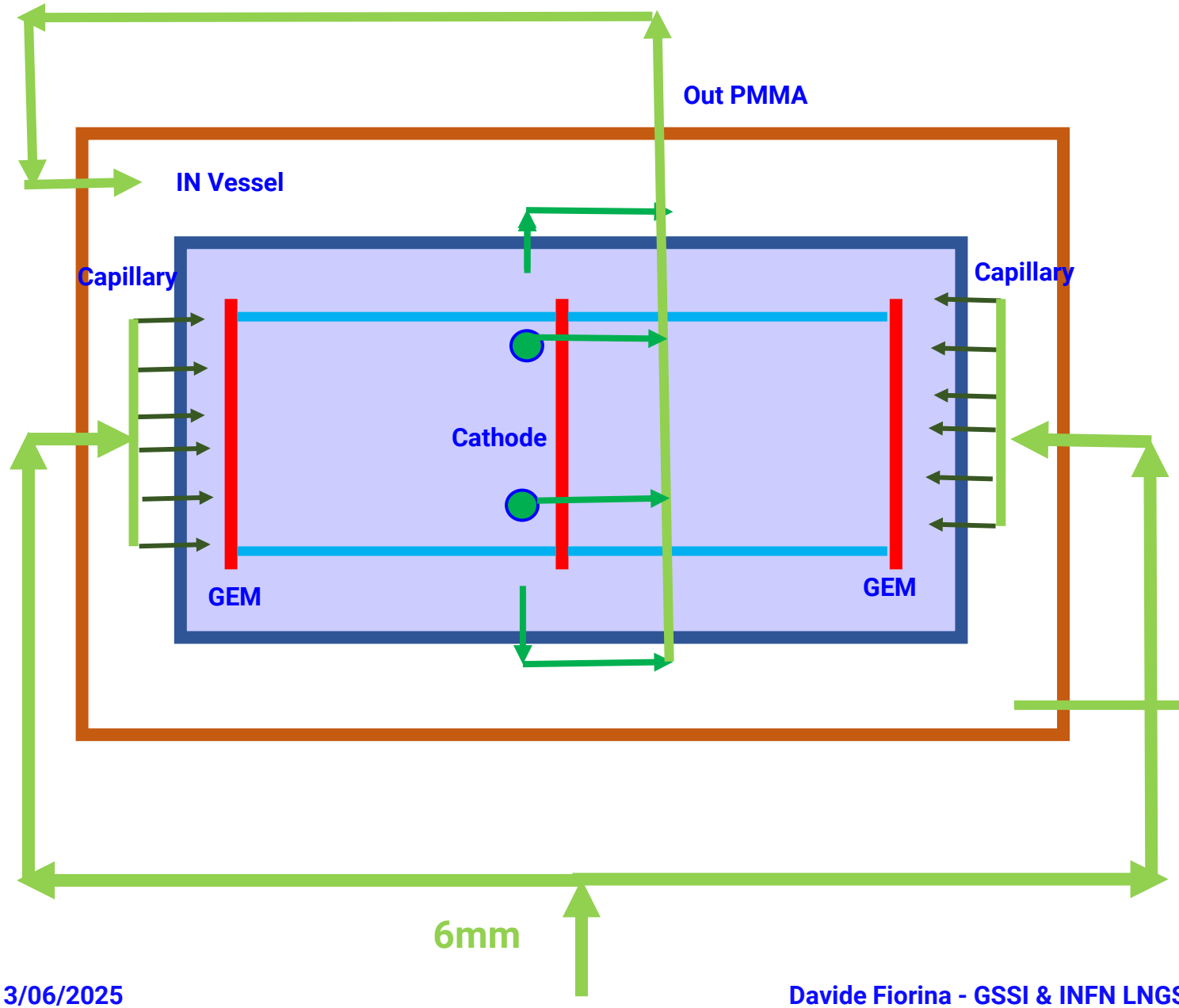
**Field Cage** Structure in Nylon66

- Probably no need for supporting structures (structural checks to be done)
- Field rings made by copper strips on Kapton (PET as backup)
- Resistors soldered on one side
- Field Cage held by countersink N66 screws. Tests indicate no need to use an additional N66 strip



**To be integrated in the 3D model**

# Gas distribution

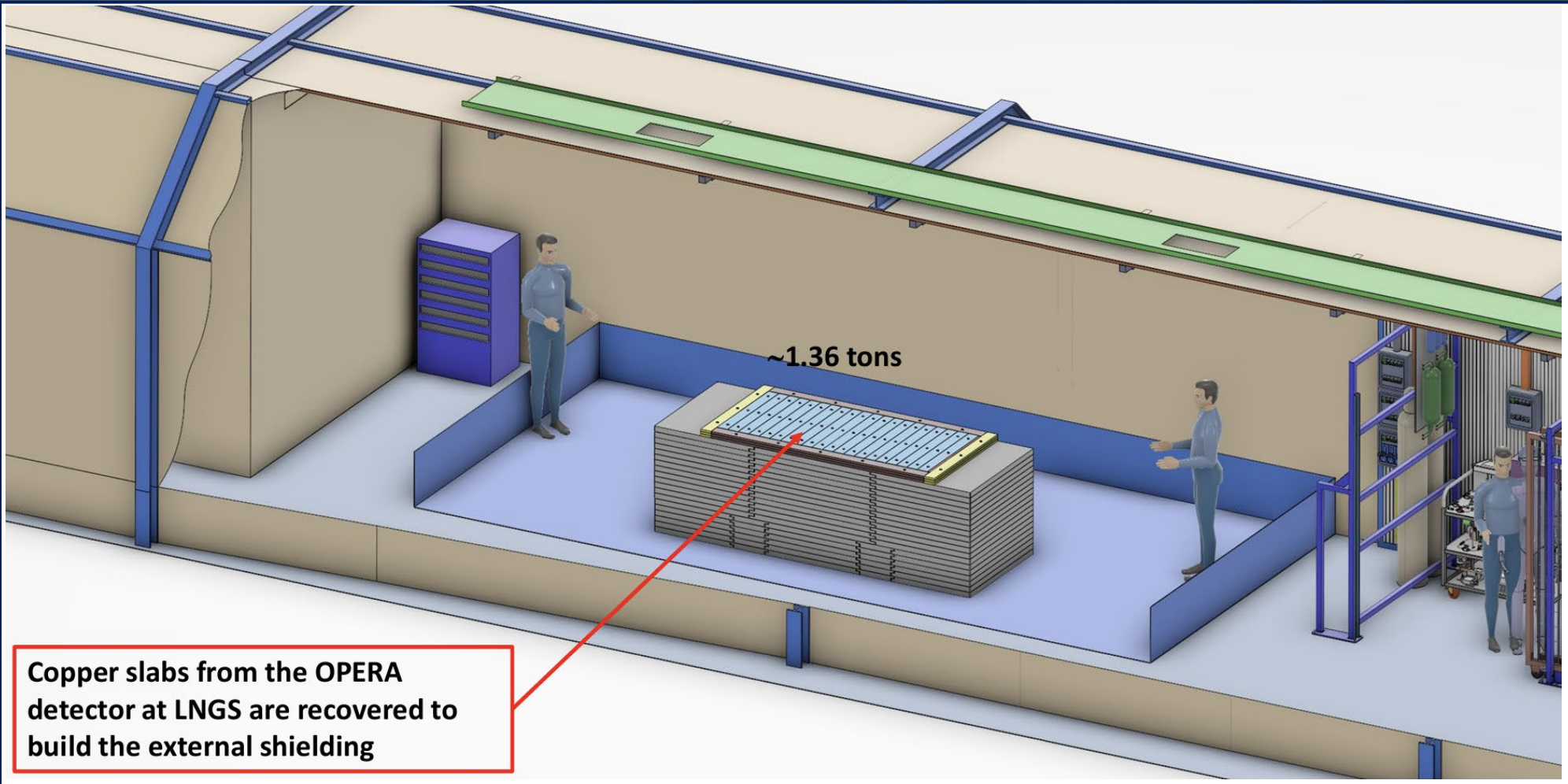



## Gas System

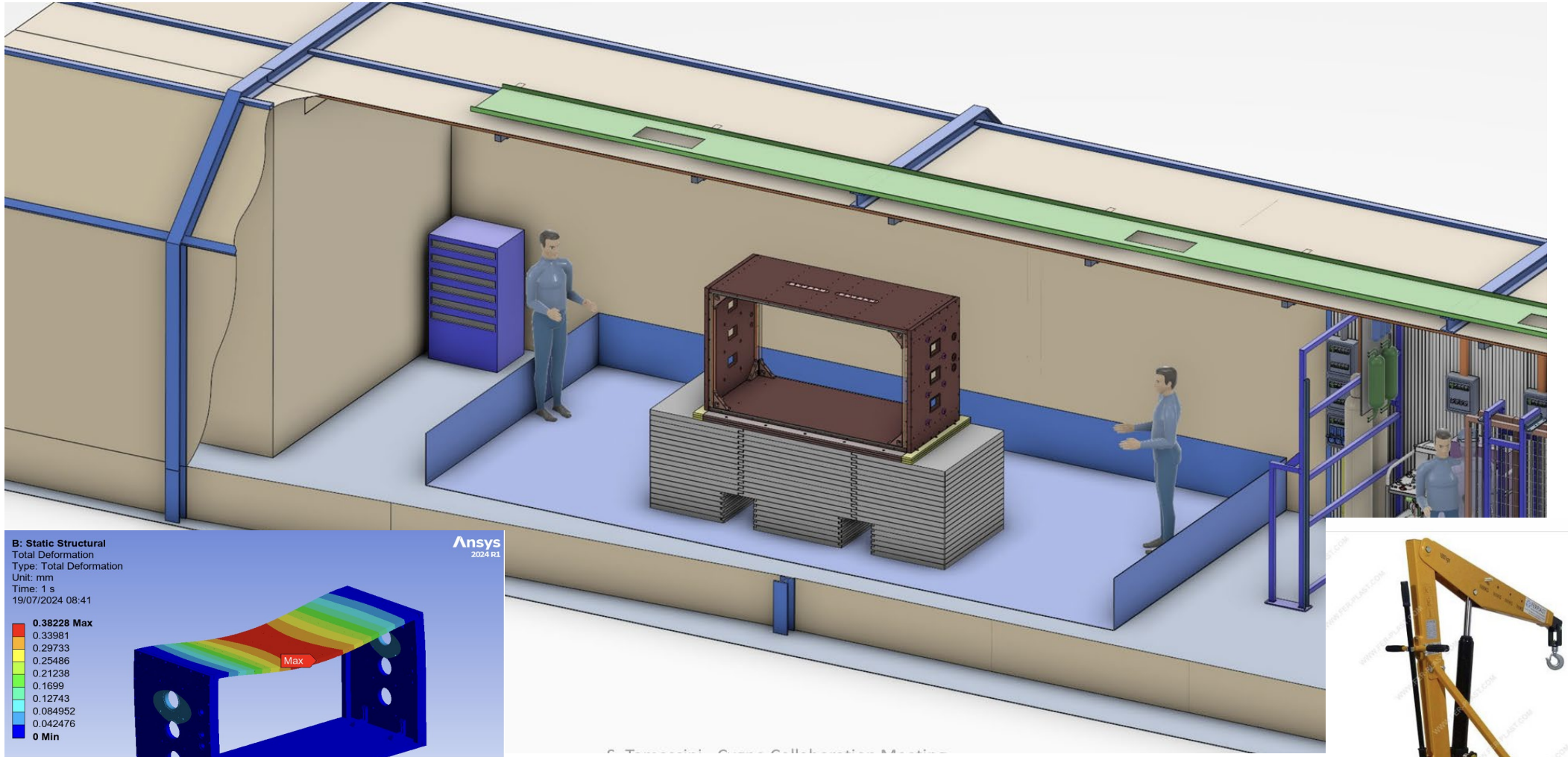
- The core of the gas system is the one from LIME (built for CYGNO04)
- All pipes in SS or eventually copper
- Main gas line 12mm inside the copper vessel splitting in 12 (6 per side) 6mm pipes supplying the PMMA vessel on the 2 GEM sides
- Return placed in the center of the PMMA vessel 6x 6mm pipes converging outside the vessel in 1x 12mm pipe
- Main 12mm pipe is flushing the copper vessel cavity and then returning

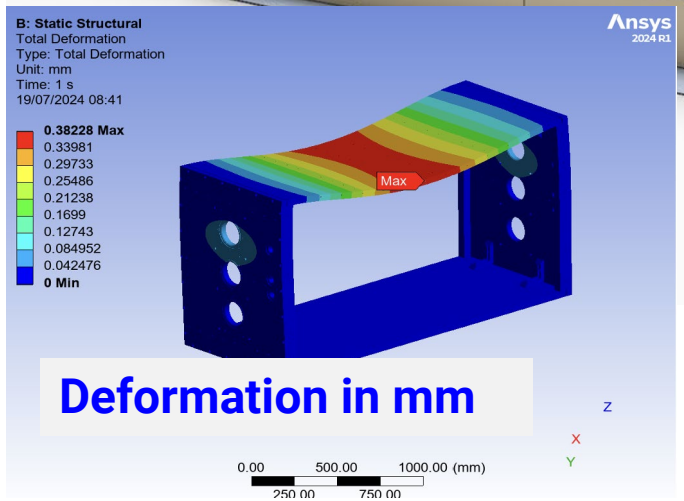
**To be integrated in the 3D model**

# Installation



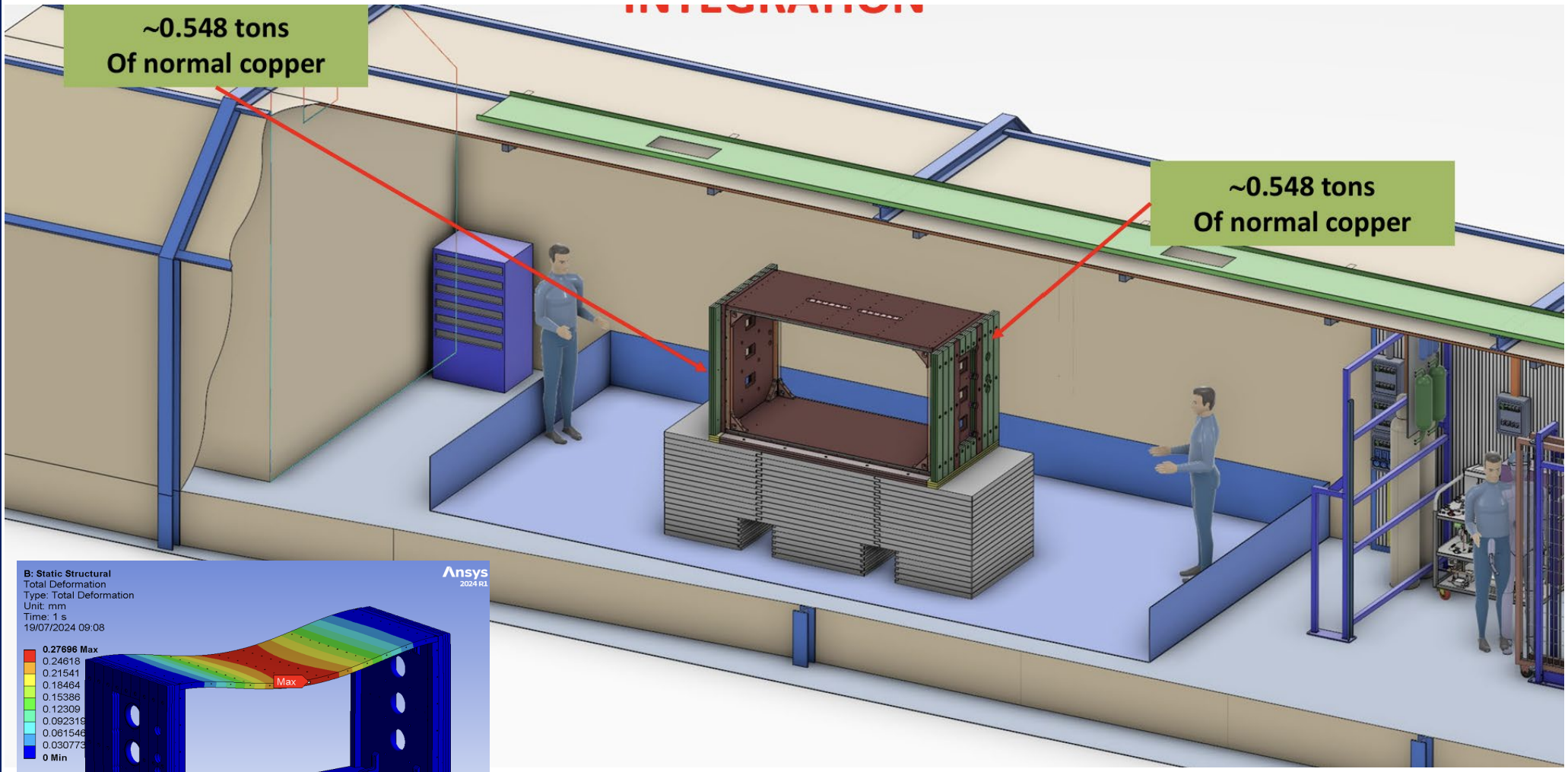
# Installation

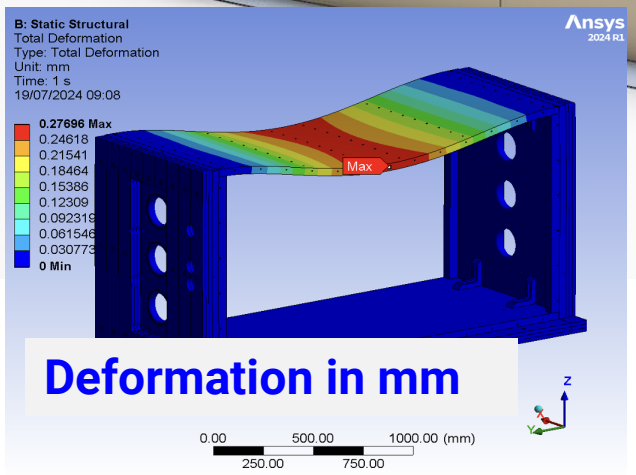




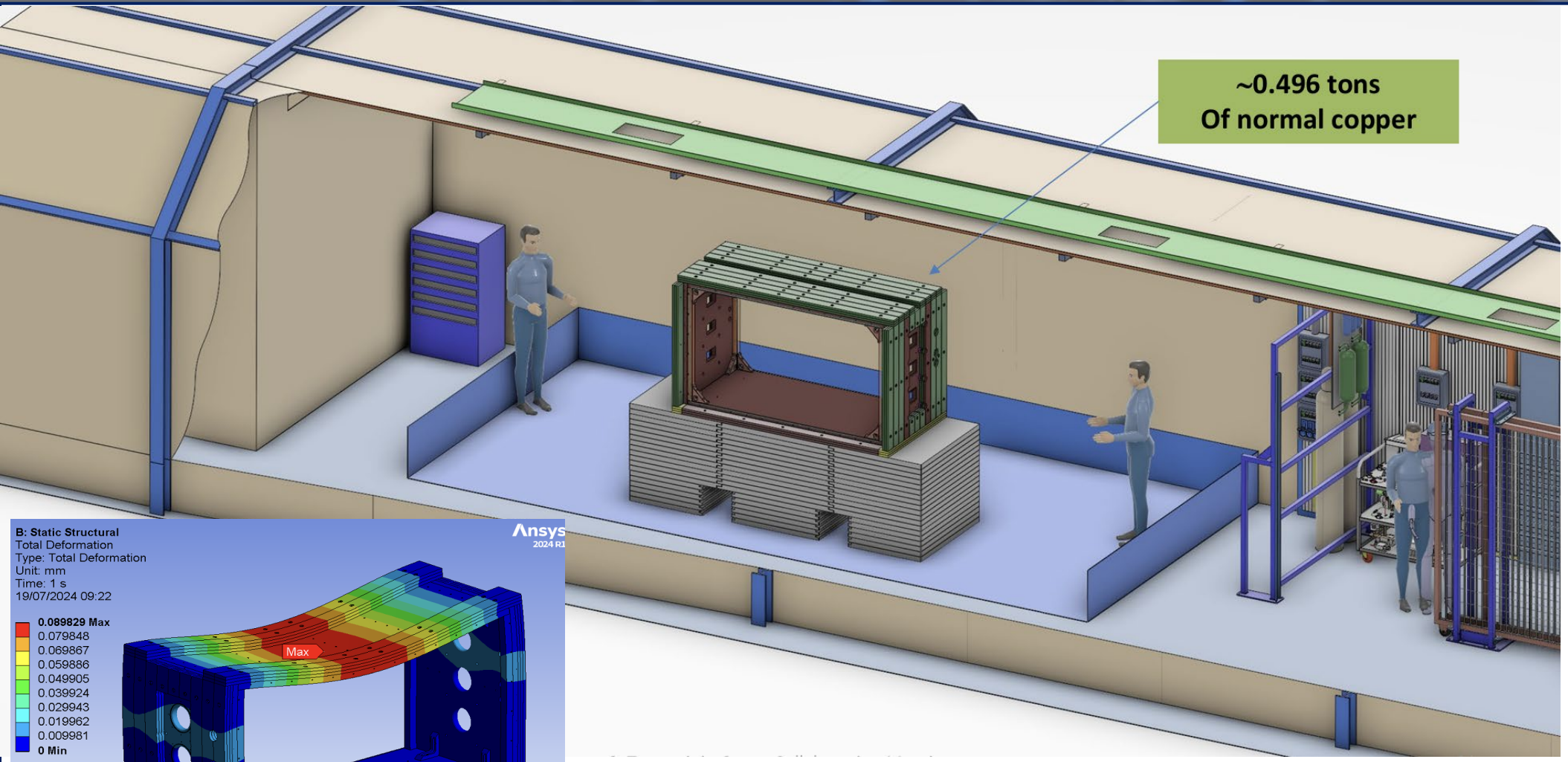

NELLA BASE DI POLIETILENE VANNO PREVISTE DELLE "NICCHIE" PER PERMETTERE ALLE RUOTE ANTERIORI DELLA GRU DI "ENTRARE" SOTTO LA COPPER BOX

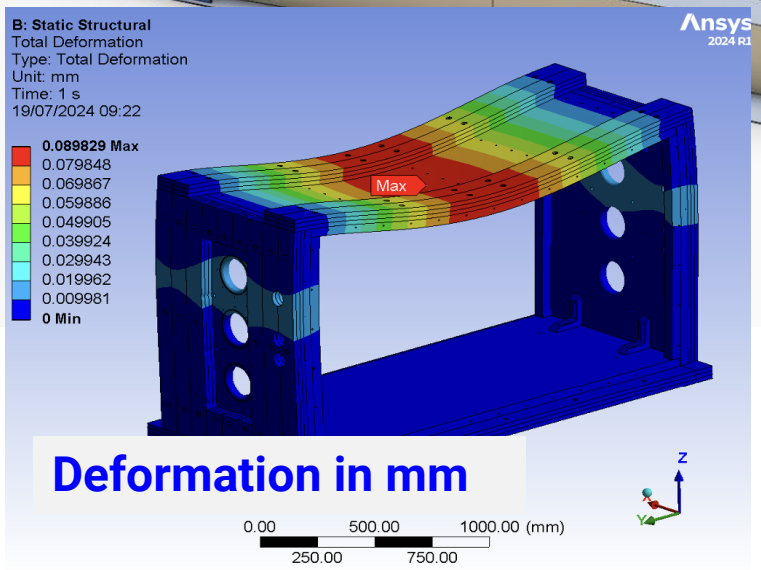
# Installation



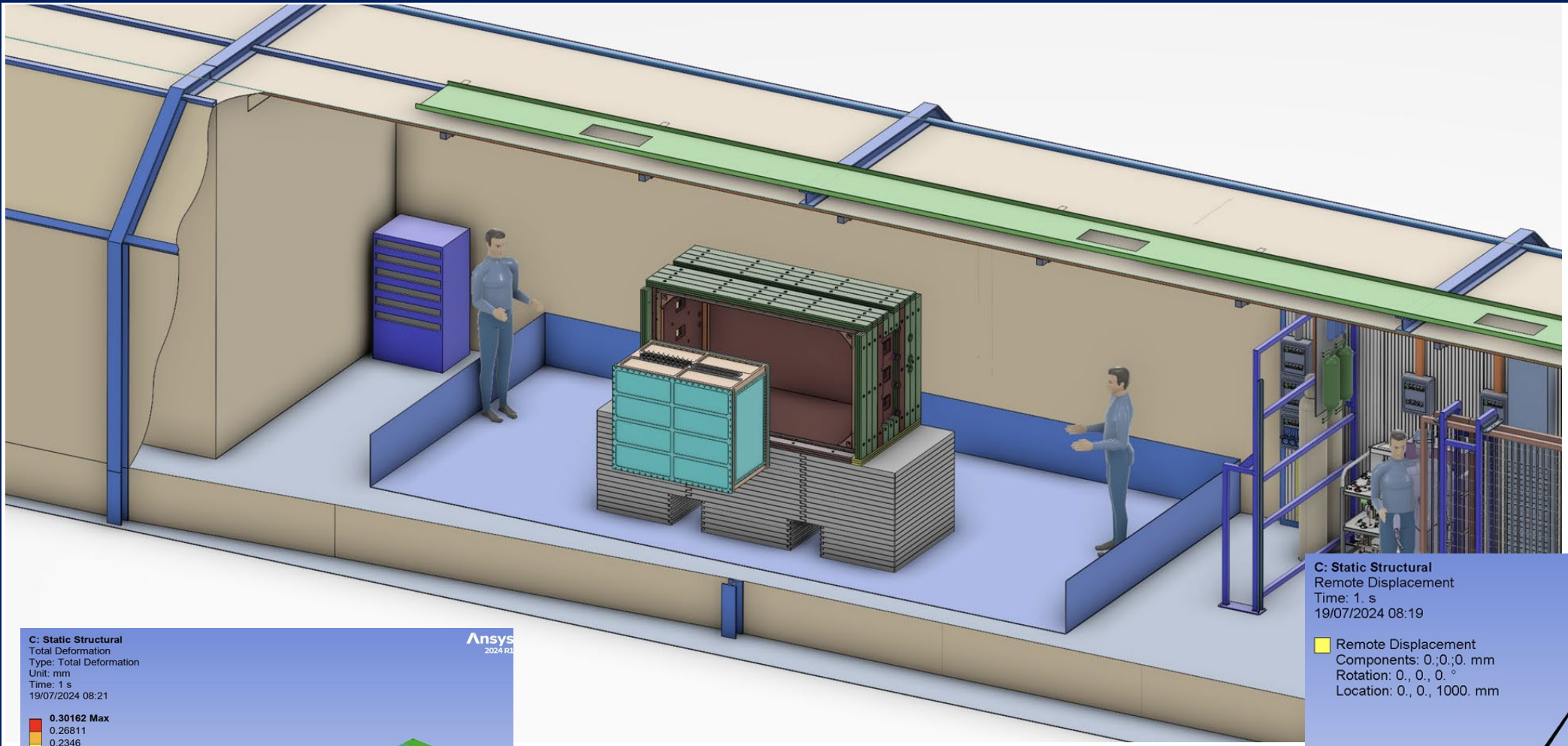



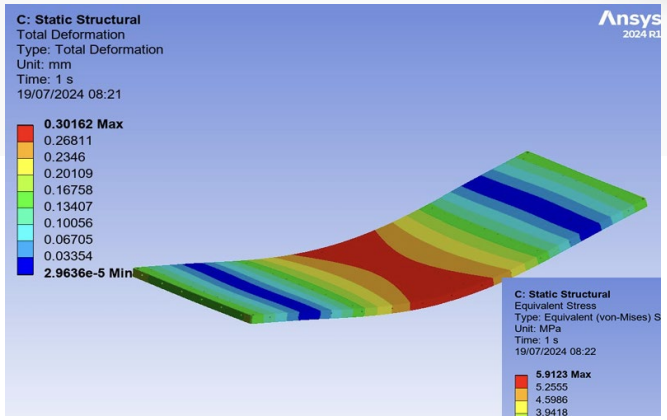
# Installation

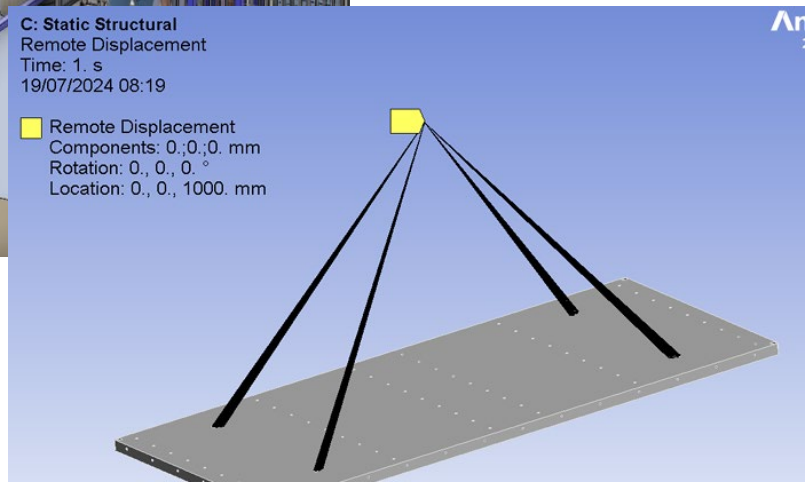


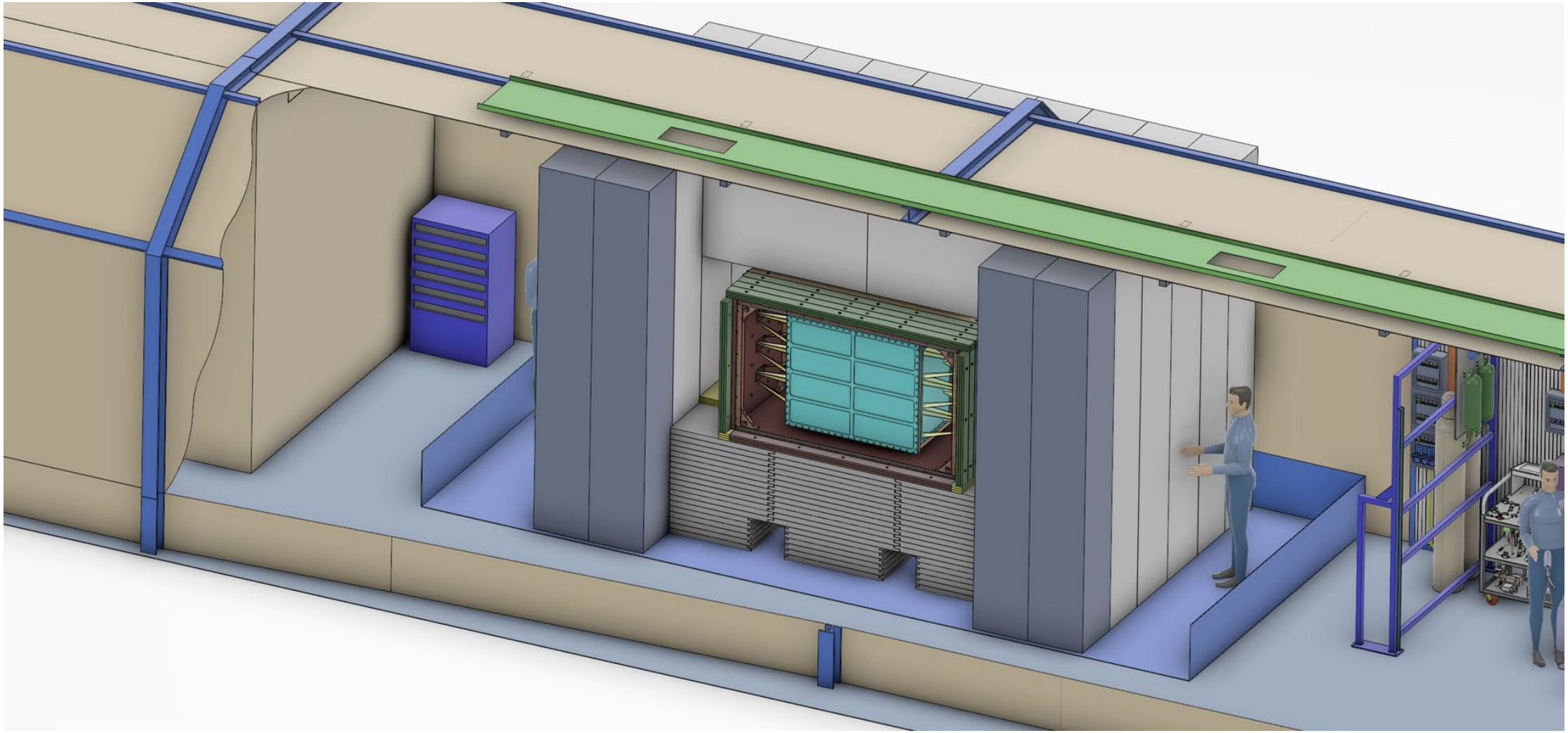
# Installation





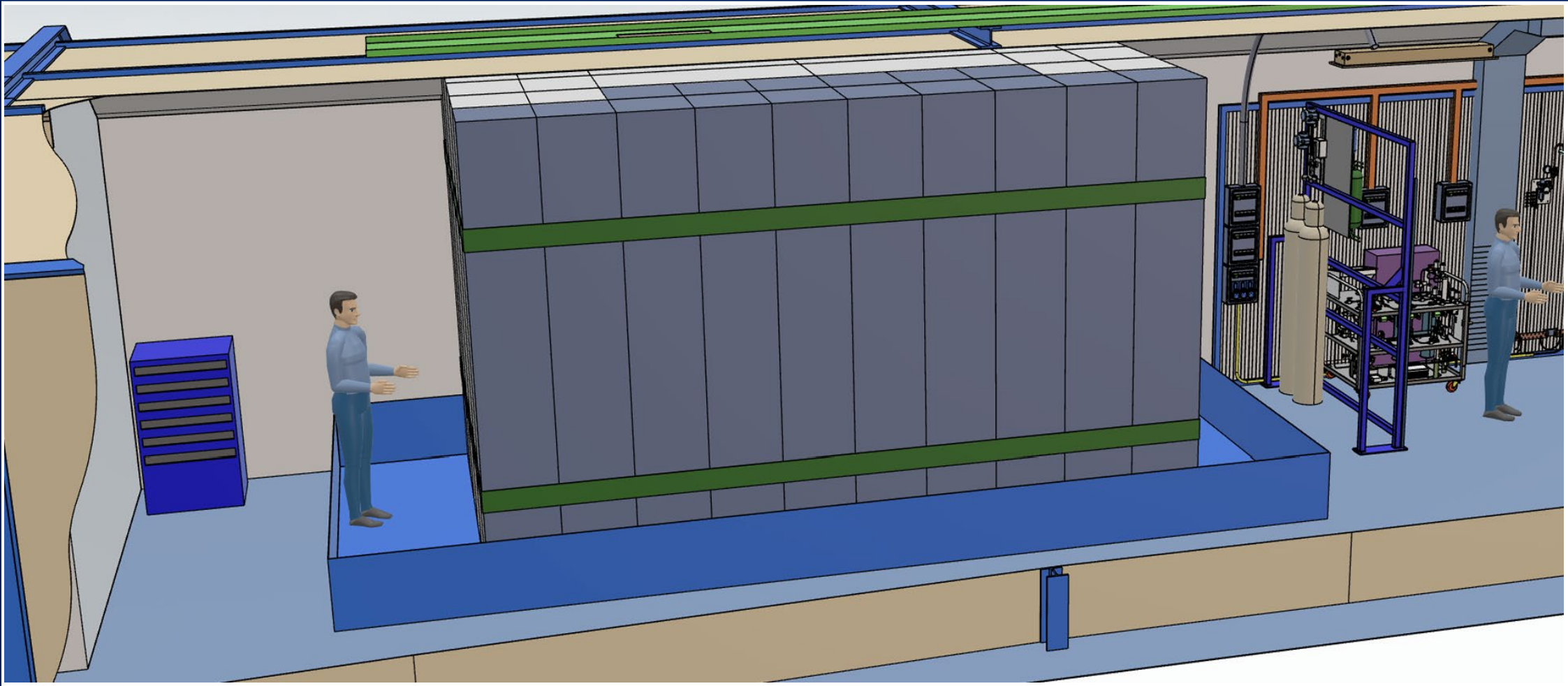



# Installation



**MAINTAINANCE CONFIGURATION**

# Installation



**Data Taking Configuration**

We should be able to swap from **Data taking** to **Maintenance** in ***O(1day)***

# DAQ

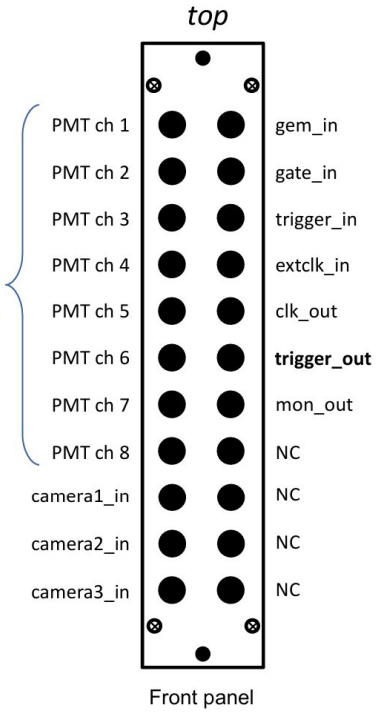
Version 1.0 of DAQ will inherit the same trigger logic of LIME using only the PMTs signals to trigger (version 2.0 discussed by Giorgio)

- Trigger will be generated by a custom made FPGA+rasperryPi module fully customizable

- All the necessary modules procured
- Procuring of consumables is ongoing (procured ≈50%)

| | GROUP | DESCRIPTION | Model | Manufact. | Need | Available | TO ORDER | Notes |
|---|---|---|---|---|---|---|---|---|
| 1 | NIM module | Quad Linear Fan In Fan Out | N625 | CAEN | 4 | 4 | 0 | 1 available at LNF and 2 ordered |
| 2 | NIM module | 8-ch Discriminator | N840 | CAEN | 2 | 2 | 0 | 1 available at LNF |
| 3 | ~~NIM module~~ | ~~4-ch Fast Amplifier~~ | ~~N978~~ | ~~CAEN~~ | ~~2~~ | ~~4~~ | ~~4~~ | D. Pinci said there is a custom amplifier design going on and this module won't be used in CYGNO04 (21/10/24). |
| 4 | NIM module | 8-ch Trigger Module | TM v2 | GSSI | 2 | 1 | 1 | under development / estimated delivery of new comps. mid Dec |
| 5 | NIM crate | 12-slots standard NIM crate | | CAEN | 1 | 3 | -2 | 1 available at LNF and 1 at LNGS |
| 6 | VME module | 8-ch, 250MSPS Digitizer | V1720E | CAEN | 3 | 3 | 0 | 2 available, need 1 more because of the GEMs (28/10/24) |
| 7 | VME module | 32-ch, 5GSPS Digitizer | V1742 | CAEN | 1 | 3 | -2 | 1 available at LNF and 1 at LNGS |
| 8 | VME module | Quad 4 fold Logic, NIM-TTL-NIM | V976 | CAEN | 2 | 1 | 1 | 1 fanout of the Trigger signal and 1 Clock to cameras |
| 9 | VME module | VME-USB2 Bridge | V3718 | CAEN | 1 | 1 | 0 | 1 available at LNF (accord. to Francesco Renga) |
| 10 | VME crate | 4U, 8 slots, VME64 std crate | VME8008B | CAEN | 1 | 1 | 0 | 8 slots used / I said to D. Pinci that it is safer to replace by a 21-slot standard crate (21/10/24). Ex: CAEN VME8100 |
| 11 | HV module | 12-ch for the PMTs | A1833 | CAEN | 1 | 1 | 0 | |
| 12 | HV module | 14-ch HV for Triple-GEMs | A1515BTG | CAEN | 1 | 1 | 0 | |
| 13 | HV crate | Universal Multichannel Power Supply System | SY4527 | CAEN | 1 | 1 | 0 | |
| 14 | HV system | AC/DC High-Voltage Power Supply | HPn 500 705 | ISEG | 1 | 1 | 0 | |
| 15 | Computing | 8-ch, USB3-PCIe interface card | PCIe-U308 | ADLINK | 1 | 0 | 1 | 1 unit ordered by GSSI / estimated delivery mid December |
| 16 | Computing | Graphics Processing Unit (GPU) | ??? | ??? | 1 | 1 | 0 | according to D. Pinci (21/10/24) one (maybe 2) GPU is already installed in LIME DAQ Server. |
| 17 | Computing | USB 2 cable (Type-A to Type-C connectors) | | | 1 | 0 | 1 | check if available at LNF |
| 18 | Computing | USB 3 long cable | | | 6 | 0 | 6 | |
| 19 | Computing | Xeon processor workstation (DAQ server - Linux) | 5049A-T | Supermicro | 1 | 1 | 0 | |
| 20 | Computing | Computer (Windows OS) | | | 1 | 1 | 0 | |
| 21 | Sensor | Orca Quest qCMOS camera | C15550-20UP | Hamamatsu | 6 | 1 | 5 | 5 new cameras ordered by GSSI (nov/24) |
| 22 | Sensor | Photomultiplier Tube (PMT) | R7378 | Hamamatsu | 16 | 4 | 12 | ordered? |

** Minimum Requirements.*



Front panel


Trigger Module v2 under development.

**DAQ v1 will be ready well in time before CYGNO04 installation**