Charge Readout Planes

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LAPP

Outline:

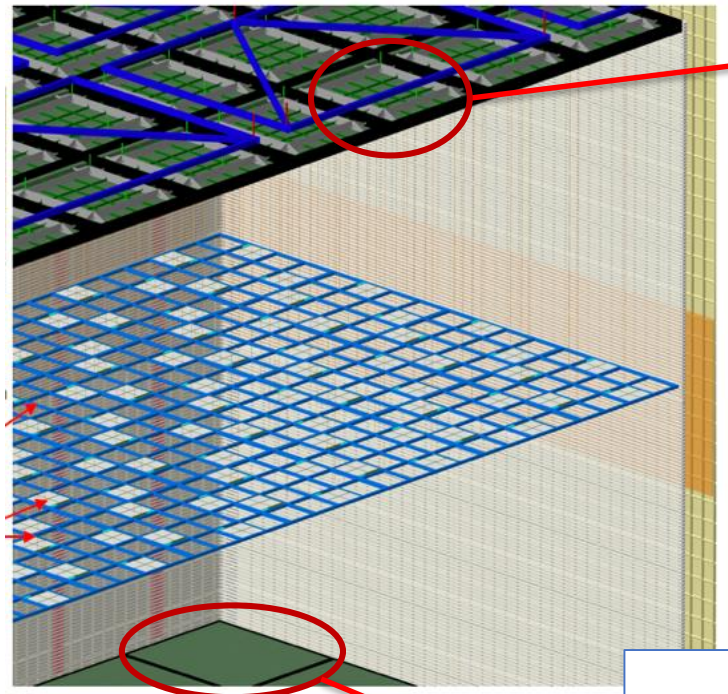
- Brief description
- Mechanical activities
- Preparation and assembly for first CRP in cold box
- Summary

LAPP mechanical team: B. Aimard, G. Deleglise, N. Geffroy, F. Peltier

Charge Readout Plane

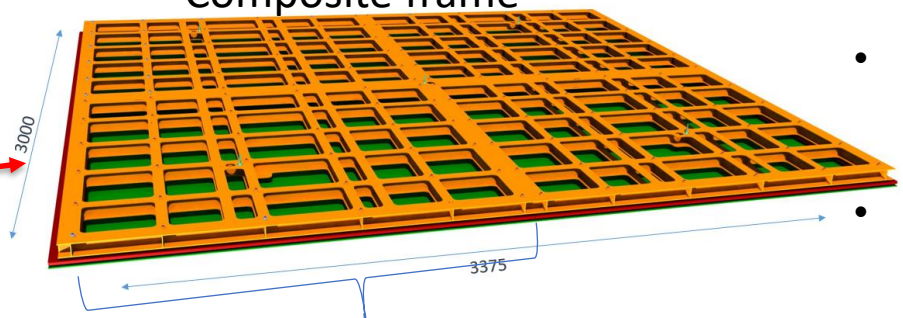
✓ 160 CRP units (80 on top, 80 on the bottom)

Readout by DP electronics



Readout by CE

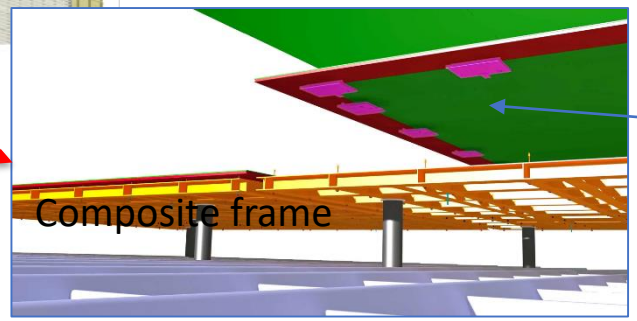
Composite frame



1 CRP = 3000 x 3375 mm^2

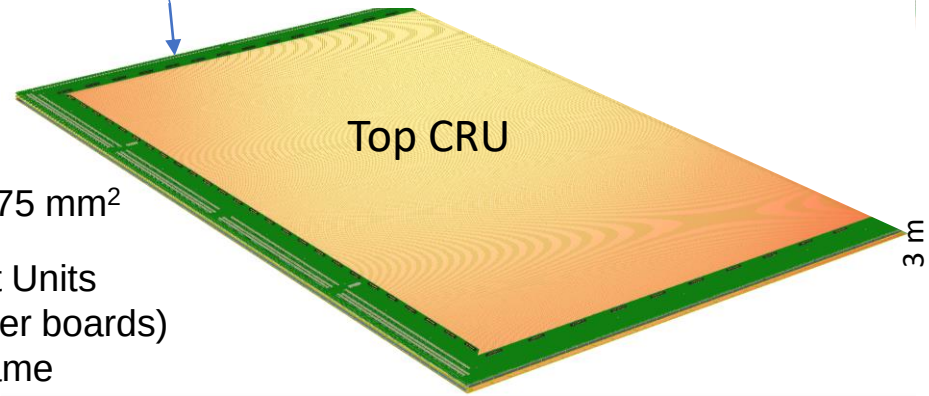
✓ Charge Readout Units (anodes + adapter boards)

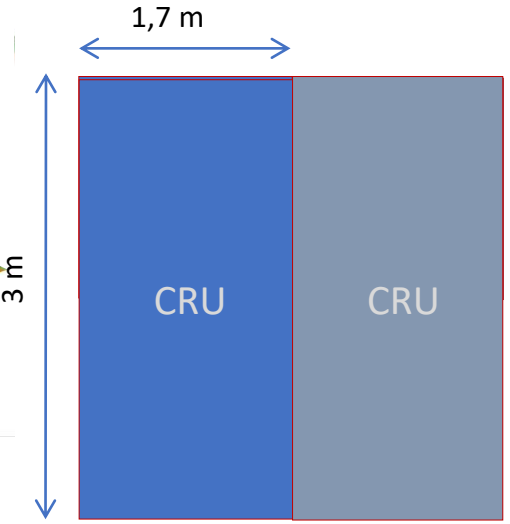
✓ 1 mechanical frame

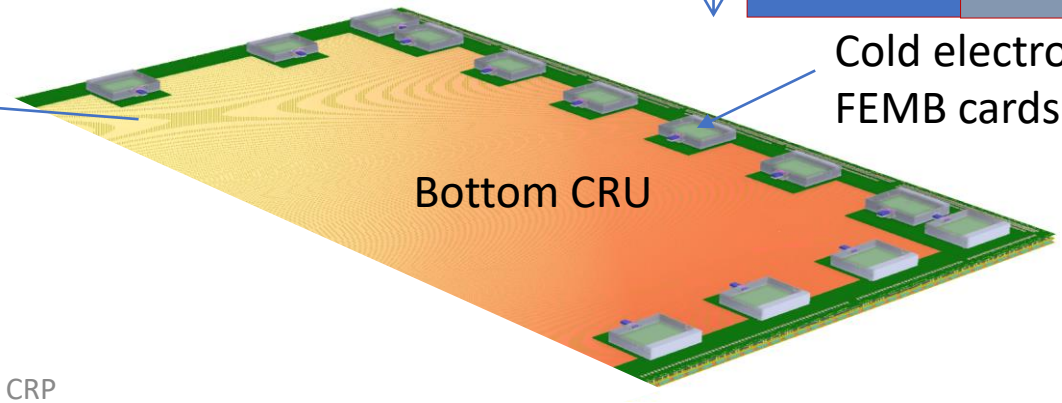


Readout geometry foreseen: Identical for top and bottom:

- An anode PCB unit is 3 m x 1.7m in size, constructed by bonding several PCBs side by side.
- A CRP is made of 2 CRU

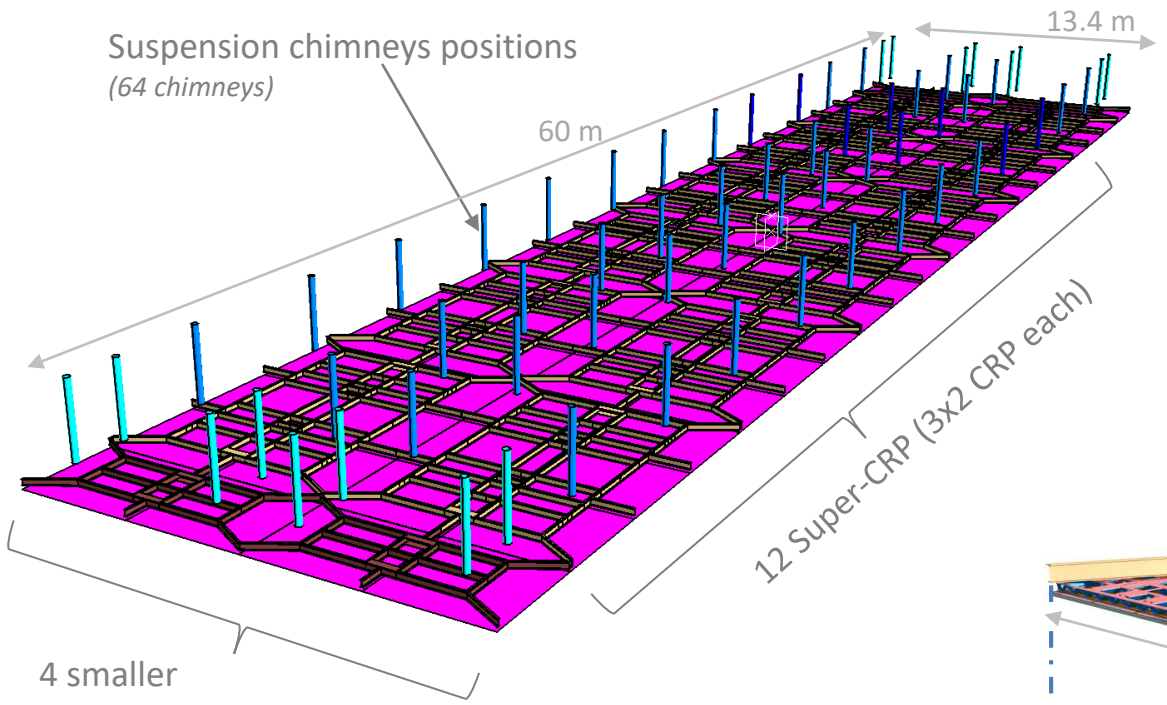




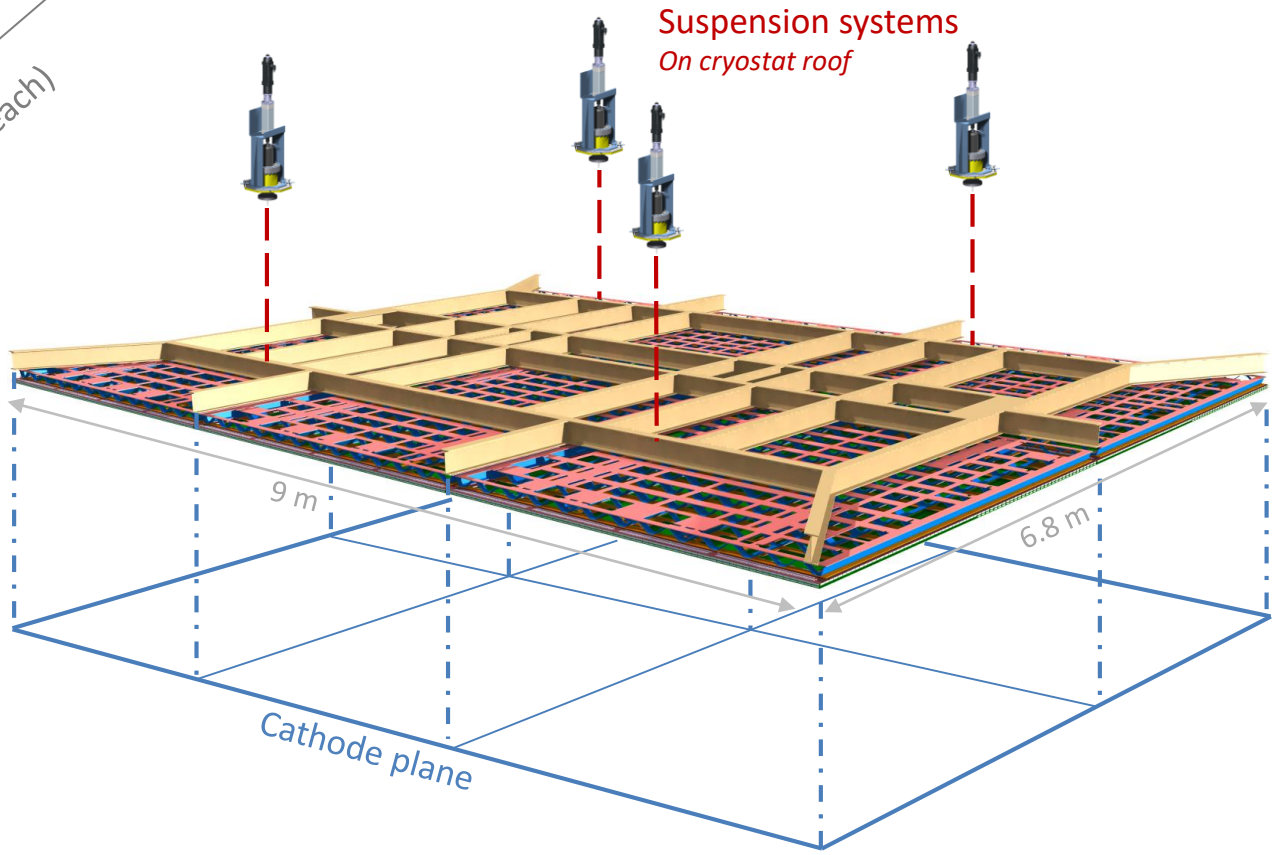


Cold electronic FEMB cards

Top CRP plane layout



Each superstructure suspended by 4 cables and position controlled from the top of the cryostat like for Dual Phase

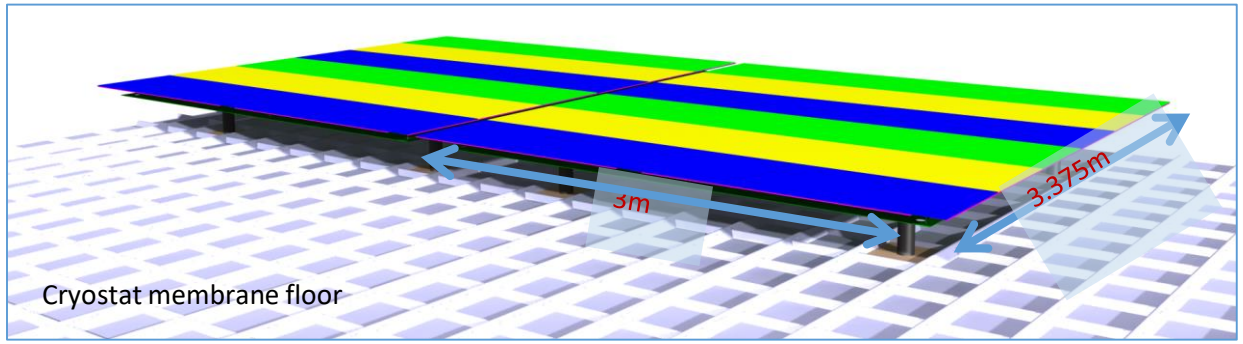


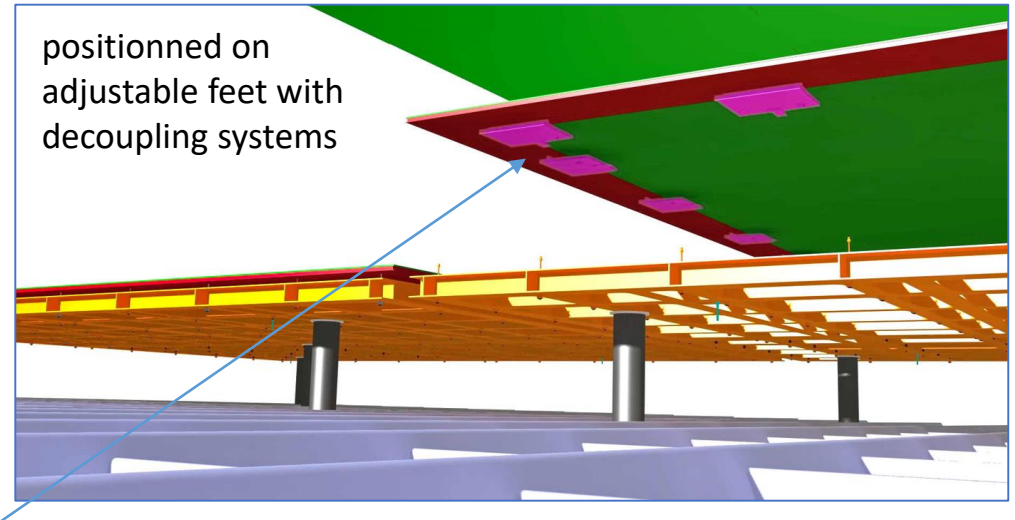
Top plane: 80 CRPs

Anode planarity specification : <10 mm @ cold

6 cathode units suspended to 1 SuperCRP by 12 points with insulating dyneema ropes (detailed design being worked)

Bottom CRP Plane Layout



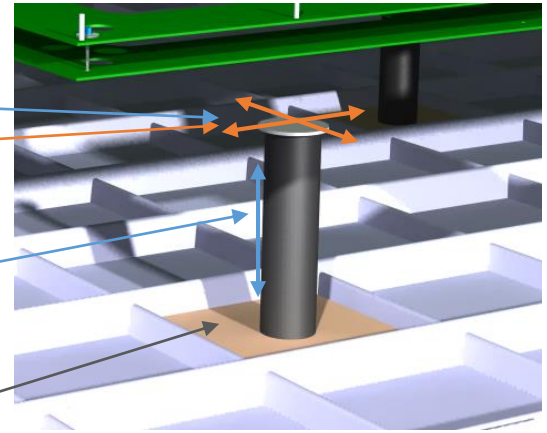


Design of the bottom CRP frame:
No metallic frame, only composite frame

With the bottom CE boxes attached below the anode plane + planarity can be controlled by the supporting feet to keep each anode plane within the 5 mm deformation range

⇒ Bottom frame can be made more transparent than top frame and
⇒ Lighter thanks to the adaptable supporting feet distribution

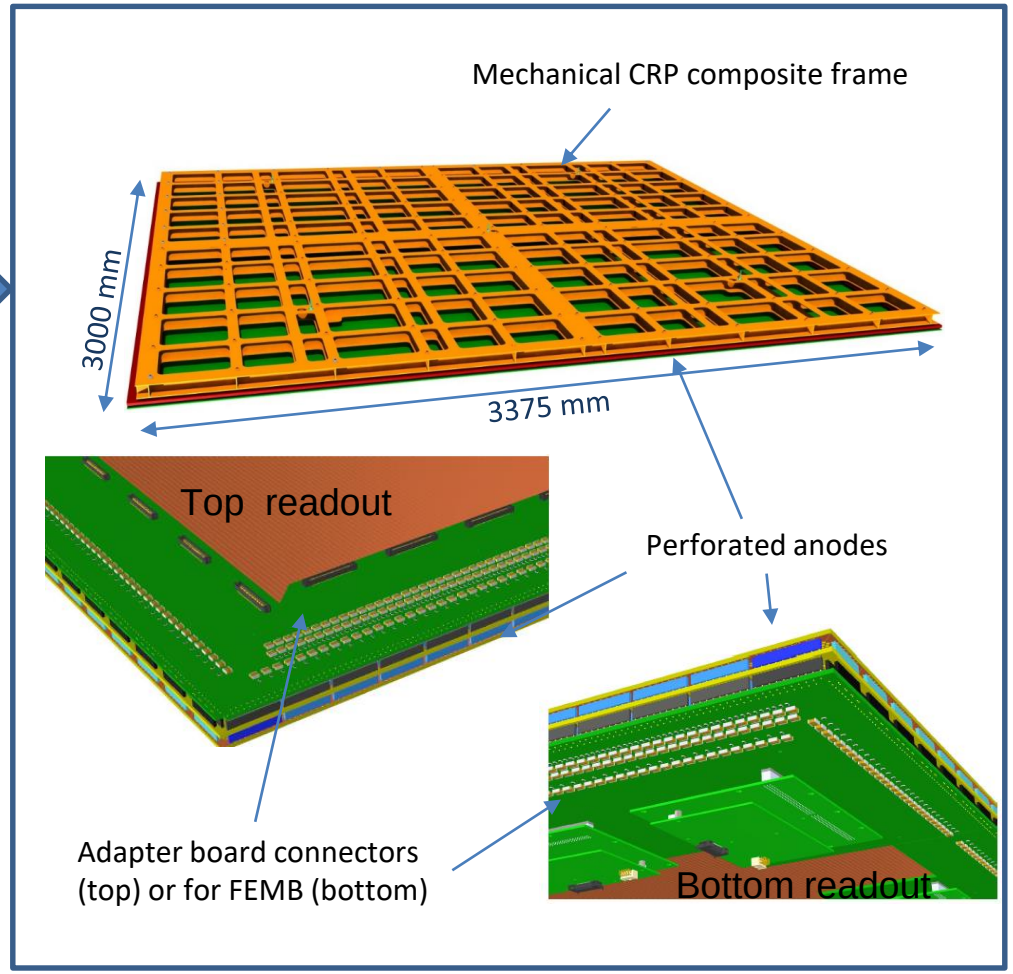
The bottom CRPs will be positioned on adjustable feet



CRP Scope:

Blue: activities at LAPP
Red: not yet covered

- ❑ CRP components:
  - Anodes
  - Adapter boards for electronics
  - **Mechanical frames**
  - Instrumentation and cabling (sensors)
- ❑ CRP support structure:
  - **Superstructure for top detector**
  - **Top suspension system and position control**
  - Support systems for bottom detector
- ❑ CRP transport system and box:
  - **Design and fabrication**
  - **Integration in CRP factories**
- ❑ Assembly site
  - **Design and construction**
  - **CRP production**



- ❑ Tests and design validations (sequential process 2021 - 2023)
  - Small scale (50L)
  - **Cold box**
  - **NP02-module 0**

Anode material properties and thermal shrinkage

Material characterisation :

- measurement of material properties (CTE, deformations) of several samples for composite material and structure
- Validate material properties

Perforated anode characterisation :

Reference equivalent **Young modulus** for simulations :

Full Plate : 24600 MPa *(24500-27500 MPa)*

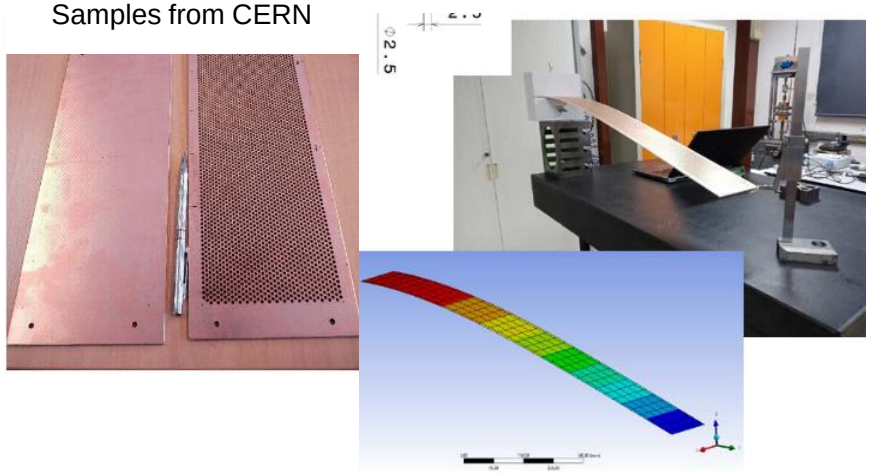
Drilled Plate : 10000 MPa *(8800-11700 MPa)*

Reference equivalent **density** for simulations:

Full Plate : 1845,5 kg/m³

Drilled Plate : 804 kg/m³

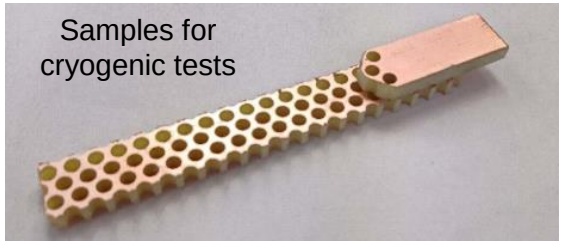
Perforated PCB
Samples from CERN



- Use the measured material characteristics to input the simulation and optimise design

- *1 layer of 3m x 1,68m drilled/plated PCB : 13 kg*
- *For 1 CRP: 2 layers of 3 x 3,4m drilled/plated PCB : 52 kg*

Samples for
cryogenic tests



Coefficients of Thermal Expansions (CTE) measured by Cryolab (CERN)

- on **Anode material** and **Glass fiber** from composite frame manufacturer,
- along **two orthogonal directions**

- $\alpha_{FG\ composite\ structure} = 8{,}9 \cdot 10^{-6}\ K^{-1}$
- $\alpha_{Anodes} = 11{,}0 \cdot 10^{-6}\ K^{-1}$

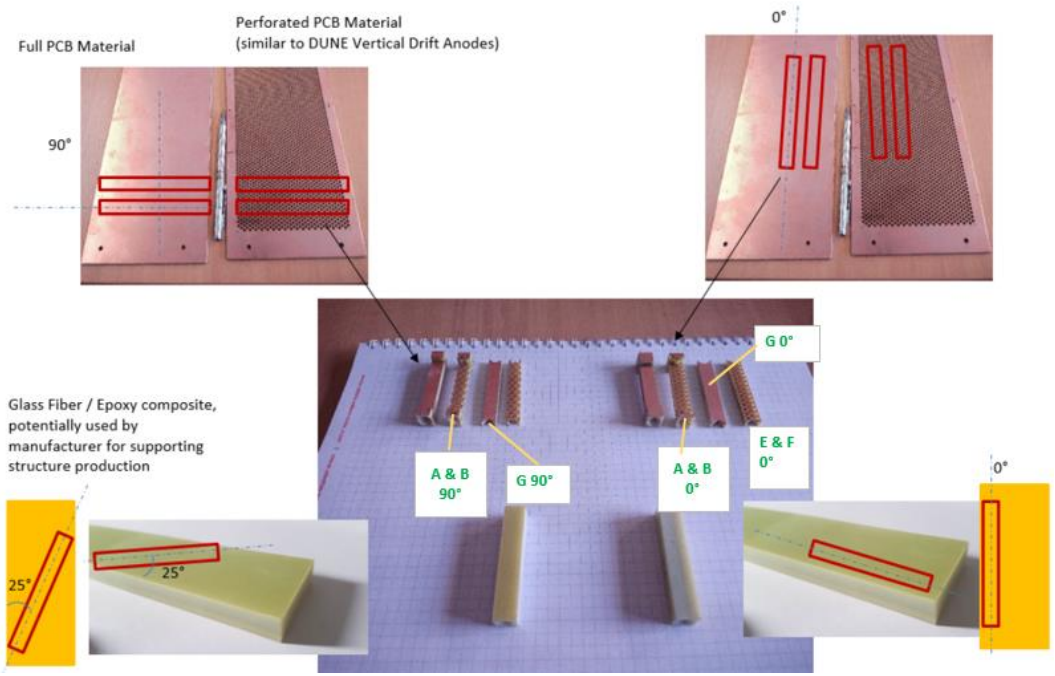
- ➢ PCB perforation has negligible effect on CTE (< $0{,}2.10^{-6}K^{-1}$)
- ➢ Glass-Fiber, as built from the manufacturer, is almost isotropic in plane

Those properties are included in FE analysis and impacts on stress and planarity are evaluated

Material characterisation :

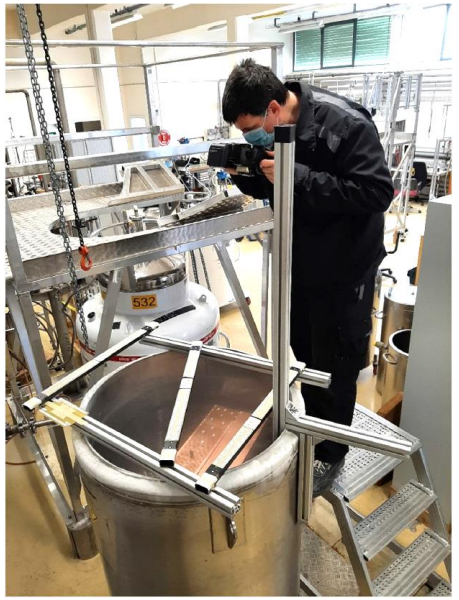
Coefficients of Thermal Expansions (CTE) measured by Cryolab (CERN)

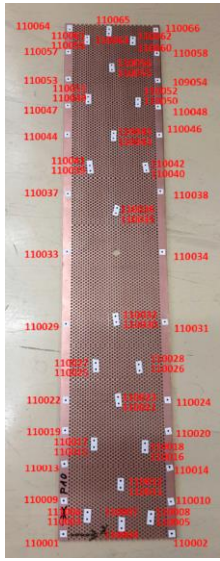
- on **Anode material** and **Glass fiber** from manufacturer,
- along **two orthogonal directions**



Sample preparation

CTE for Anode material measured by photogrammetry by CERN metrology team.



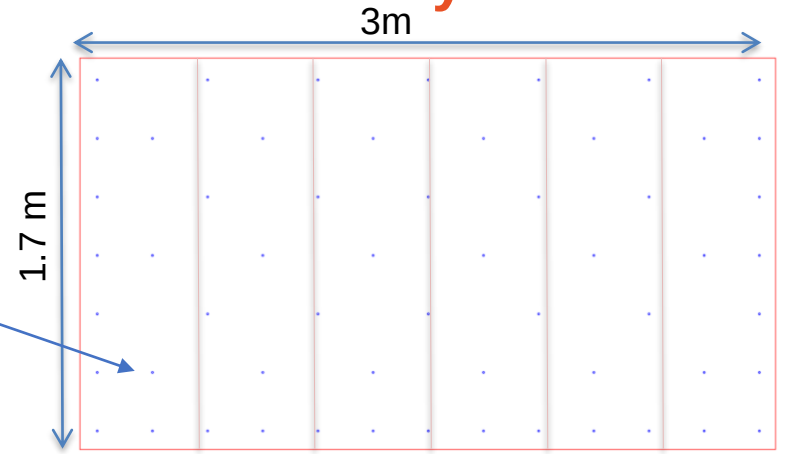


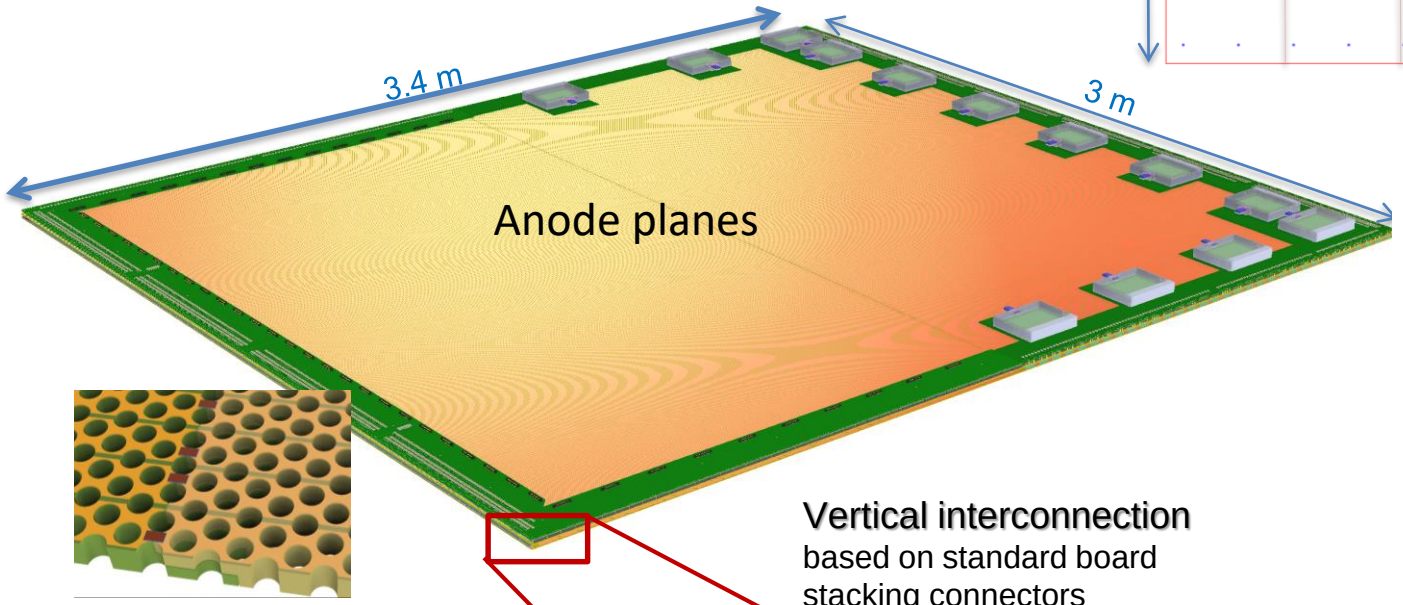
Design of First CRP for Cold Box

First CRP 3-View Design : 2 CRU mechanical assembly

On each CRU: 58 holes (4mm) designed into the anode PCBs and the adapter boards as mechanical support points to be attached to the composite frame to keep the PCBs flat and aligned.

Positions have been optimized by FE simulation to minimize deformations

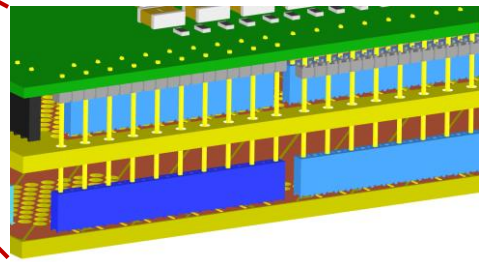




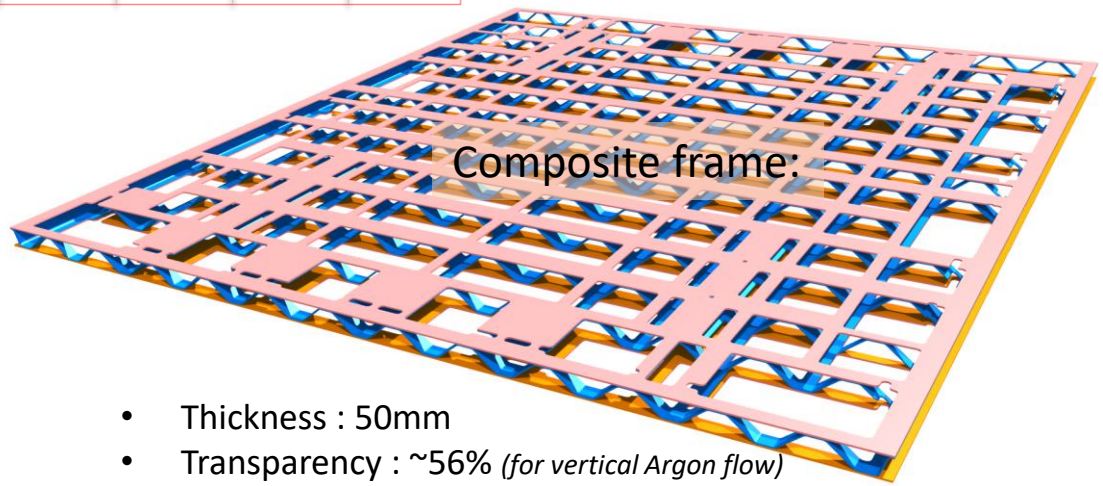
Horizontal anode interconnection:

-Join 6 pieces of 1.7m x 0.5m PCBs into a single assembly using a half lap joint technique.
-Screen-printed conductive ink patches bridge the strips across the gap

Vertical interconnection
based on standard board stacking connectors



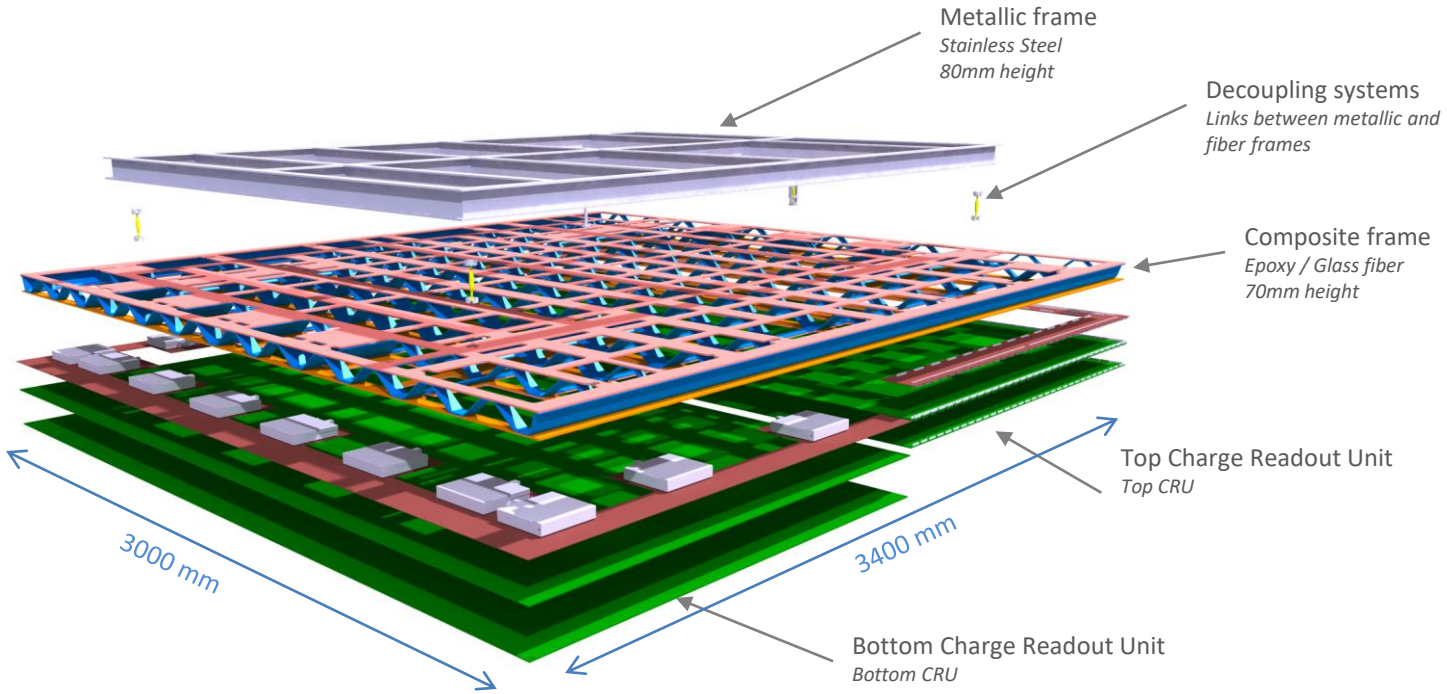
Hybrid solution to combine the 2 types of readout electronics in a suspended CRP configuration



- Thickness : 50mm
- Transparency : ~56% *(for vertical Argon flow)*
- Mass : 100kg
- Material : Epoxy / Glass fiber
- Molded omega-structure used for high Stiffness/Mass ratio
- Openings are CNC machined
- Can be assembled in 2 or 3 parts

For the CRPs to be constructed and tested in 2022:
design will be optimized specifically for Top and Bottom planes as for the FD

First CRP for cold box:



Mechanical simulation

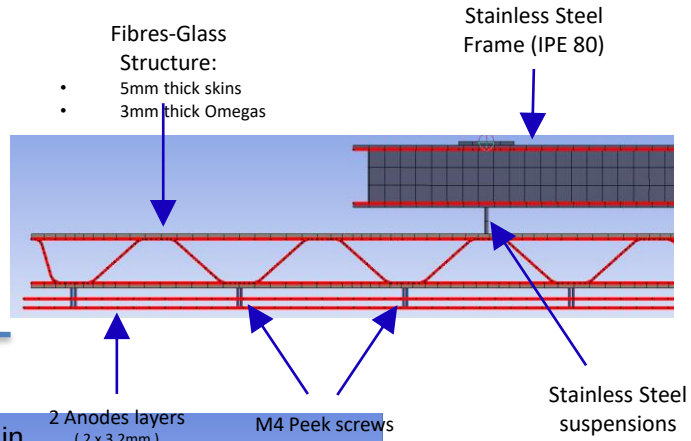
Model :

- *Metallic/composite frame, anodes, CE-boxes*
- *Fours suspension cables (off-centered)*

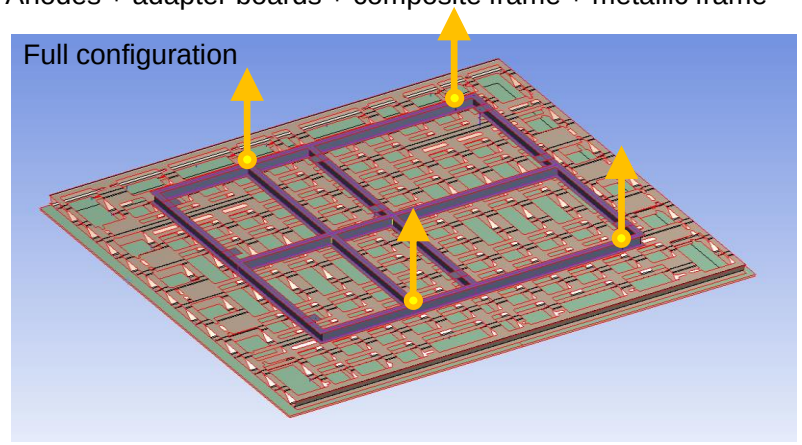
Boundary conditions :

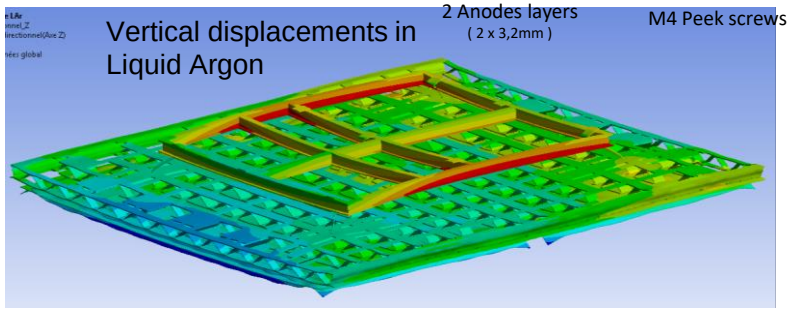
- *Gravity (in Air/in Argon)*
- *Thermal loads*

- $\alpha_{\text{Stainless Steel}} = 13{,}2 \cdot 10^{-6}\ K^{-1}$
- $\alpha_{\text{FG composite structure}} = 8{,}9 \cdot 10^{-6}\ K^{-1}$
- $\alpha_{\text{Anodes}} = 11{,}0 \cdot 10^{-6}\ K^{-1}$



Anodes + adapter boards + composite frame + metallic frame

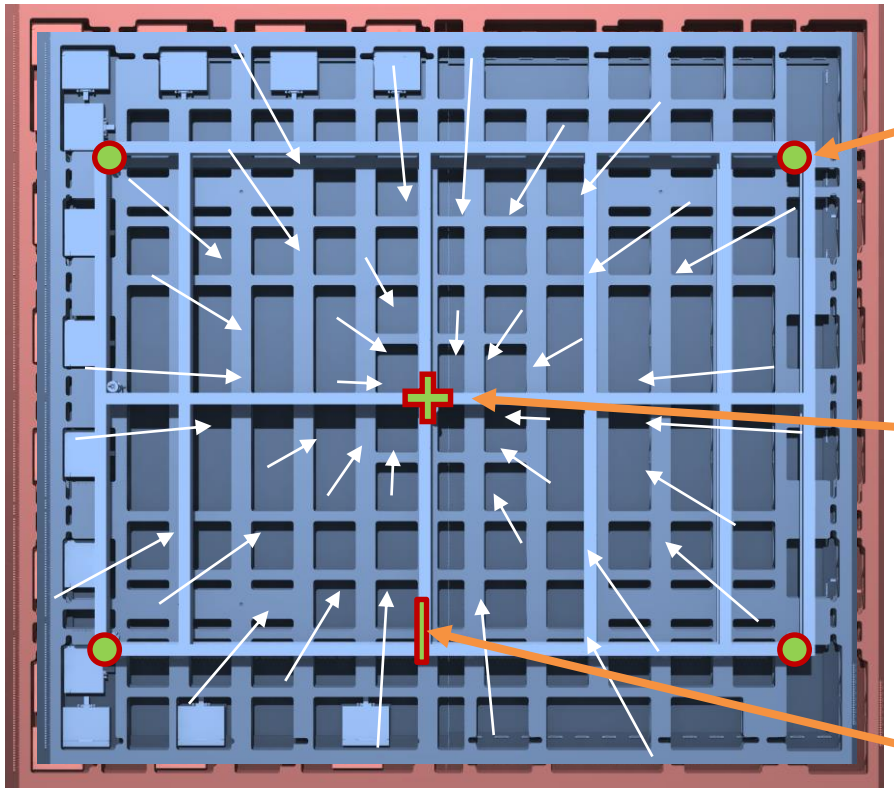




➢ Max local relative displacement between anodes < 0,5mm and anode plane deformation <1mm

Decoupling system:

Thermal shrinkage towards 1 fixed point to control the lateral position of the panel :

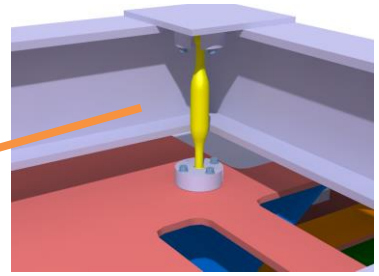


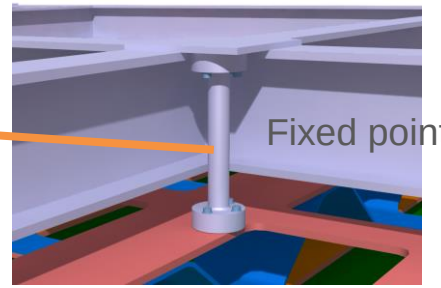
Double ball-joints, to insure vertical position while allowing lateral sliding

One direction sliding, to avoid panel rotation

Links between metallic and composite frames :

Double ball-joint

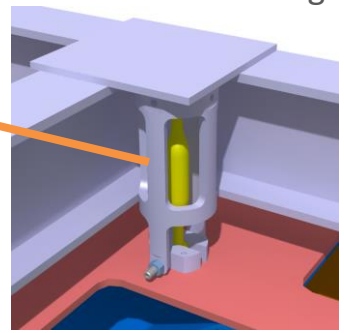


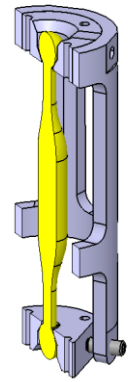


Fixed point

- Those parts will be machined at LAPP
- Tests in Liquid Argon and fine tuning are foreseen

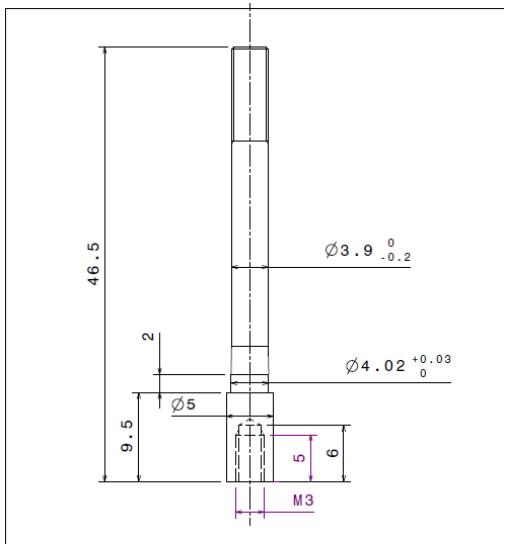
One direction sliding

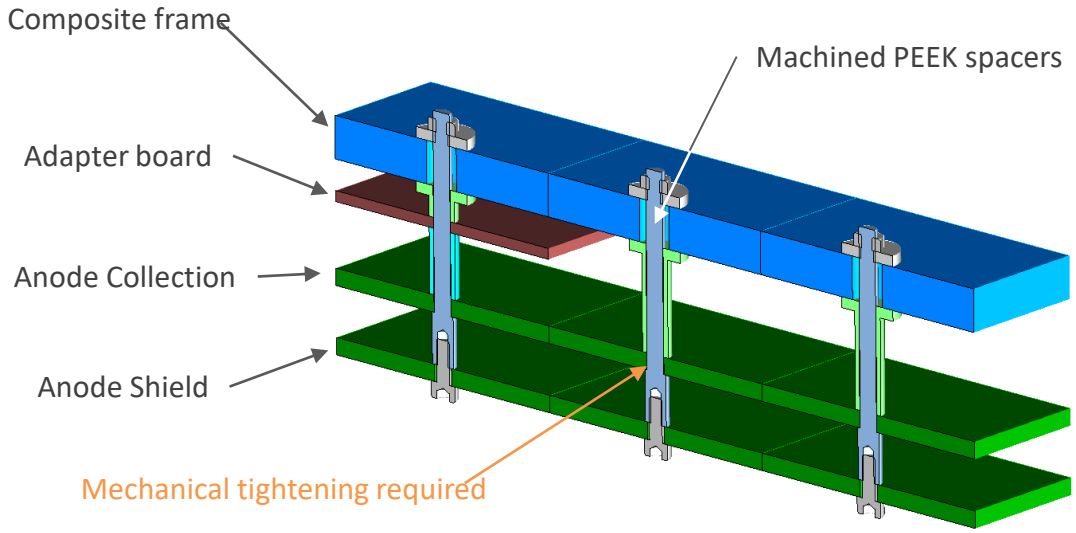




Assembly aspects:

Spacers geometry



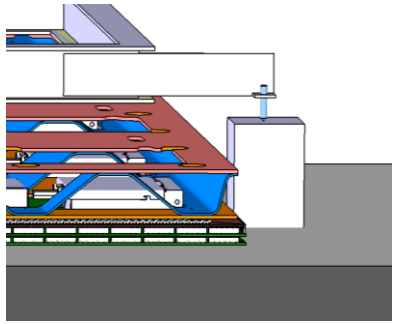


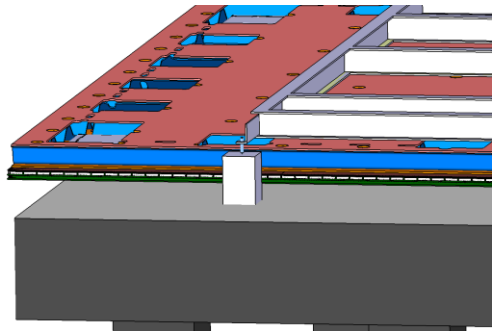
➢ Specific Spacer design allows quick, accurate and clean assembly (no glue)

Assembly procedure:

The tasks are being defined and detailed for the first CRP construction in 2021

=> Serve as input to the CRP factories task definition and optimization

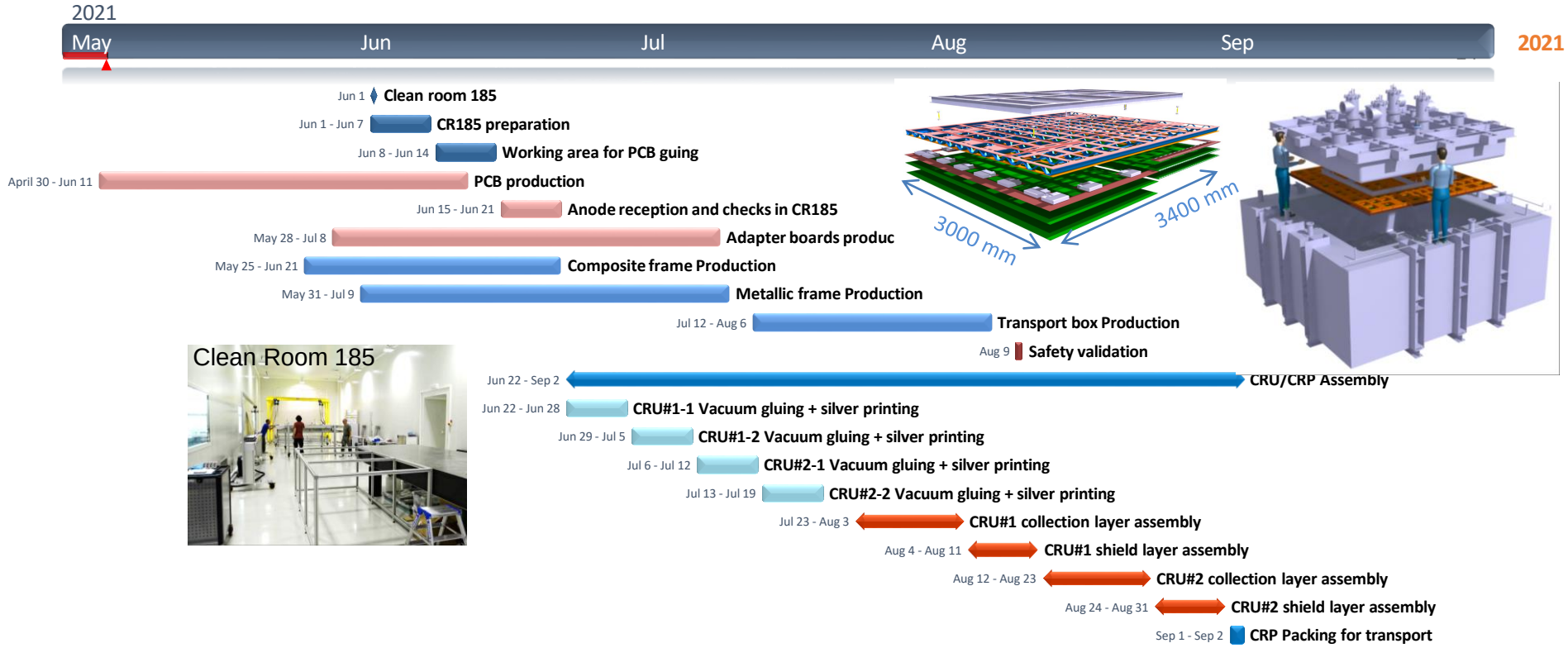




Schedule for first CRP construction:

- The Clean Room 185 will be available beginning of June
- The anodes will be the first components to be received in the clean room by end of June
- The assembly of the first CRP should last about 2 months

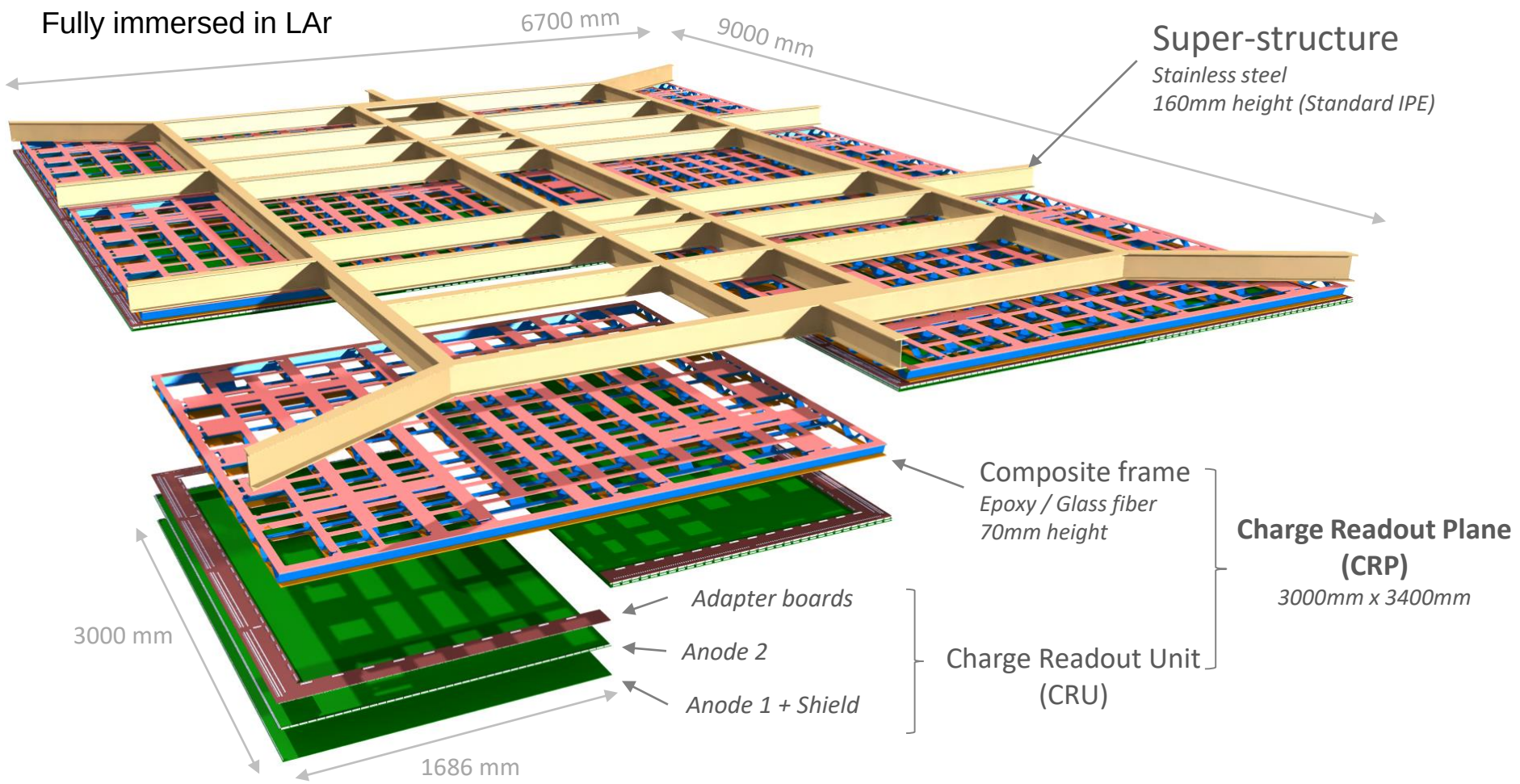
Component production and CRP assembly



The target date for the completion of the CRP assembly is beginning of September

Superstructure design and mechanical simulations

Top mechanical structure design

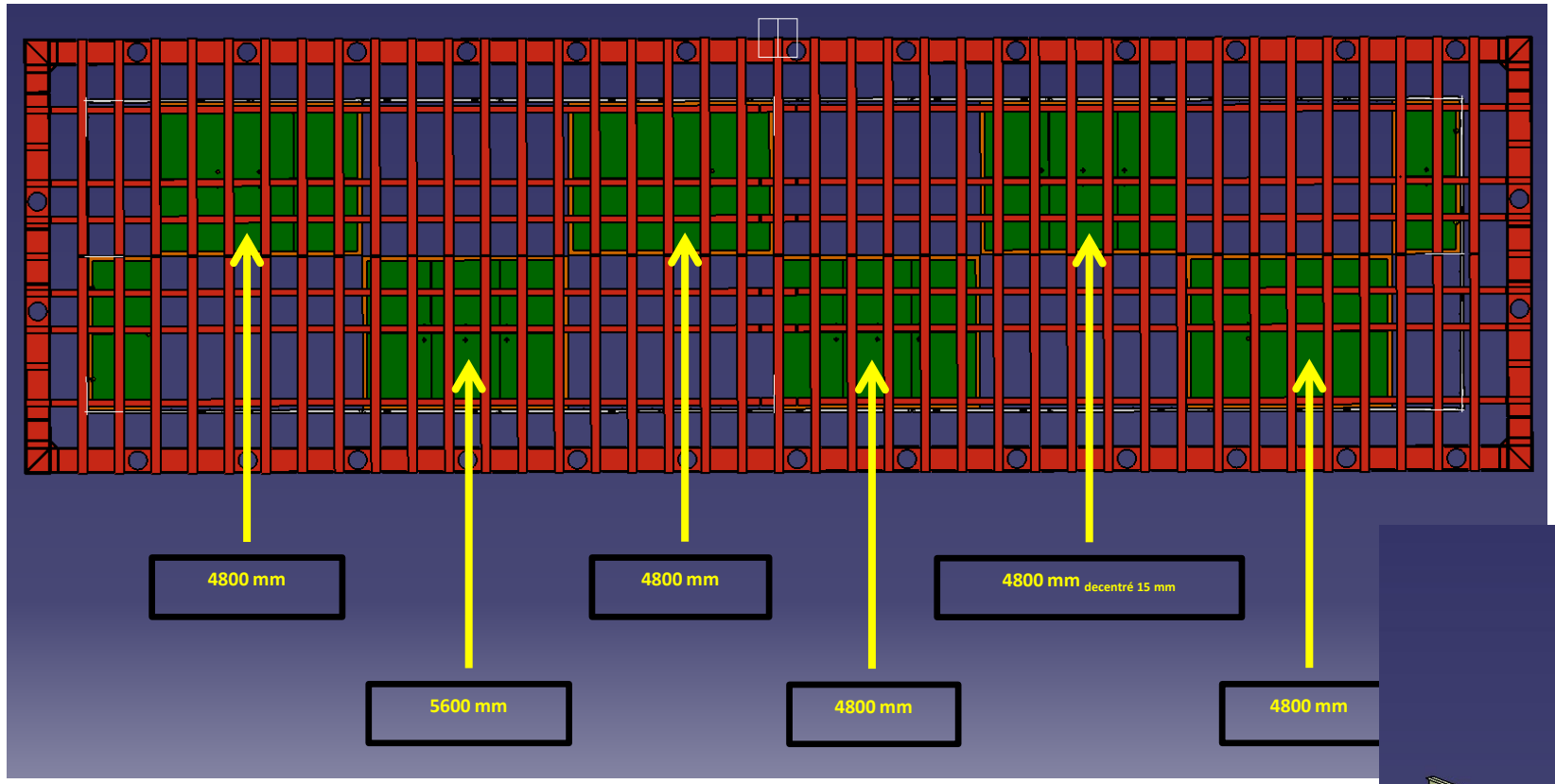


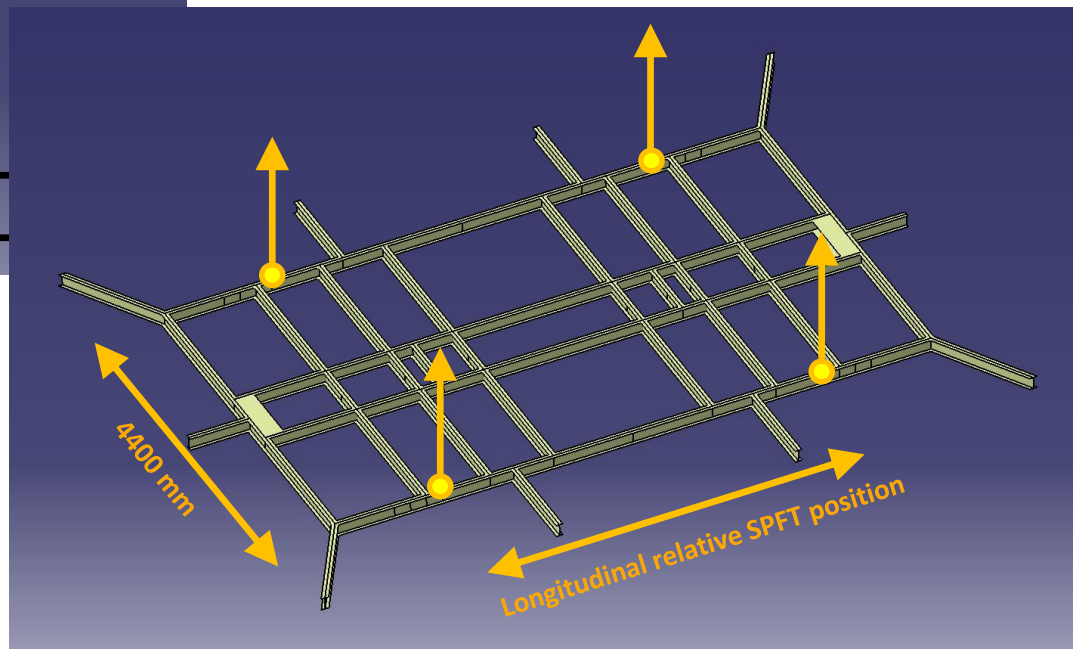
Composite frames
Brings primary stiffness to electronic PCB
Thermo-mechanical behaviour close to PCB
*Thermal shrinkage : **5,5mm** over 200°K and 3 meters*

Metallic frame
Brings general stiffness
*Thermal shrinkage : **25mm** over 200°K and 9 meters*

Anodes
*Thermal shrinkage : **6mm** over 200°K and 3 meters*

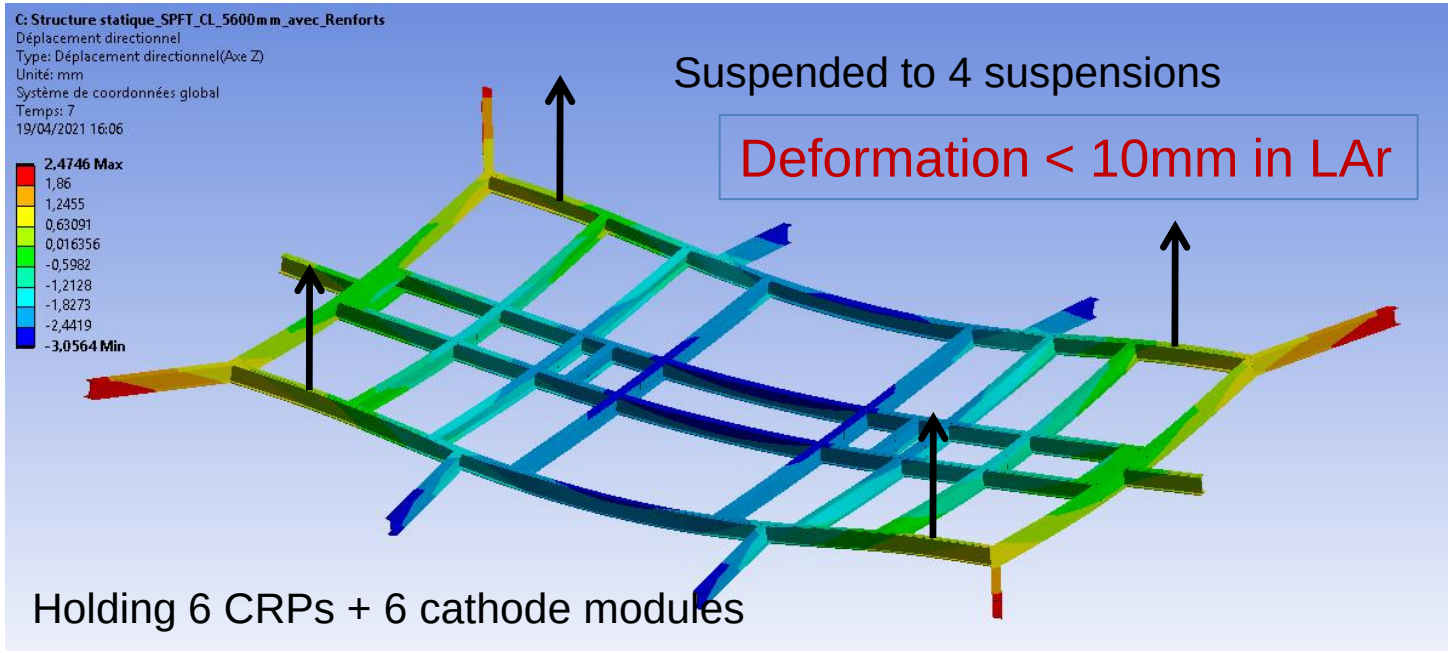
Superstructure suspension position optimisation





Superstructure mechanical simulation

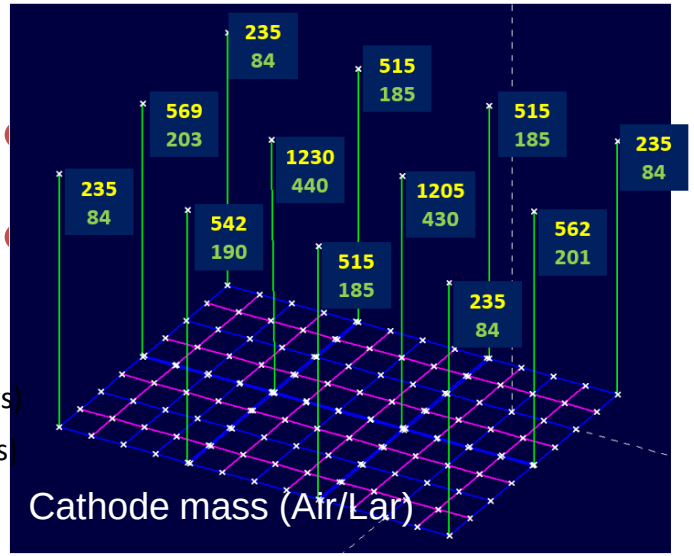
Suspension distance: 5600mm



	Temps [s]	Minimum [mm]	Maximum [mm]
Entire structure in AIR	1,	-2,0875	1,5894
	2,	-4,5314	3,7174
	3,	-6,8956	3,8981
	4,	-1,7118	1,3033
Entire structure in LAr	5,	-2,5107	1,999
	6,	-3,057	2,055
	7,	-3,0564	2,4746

Δz_{Air} = 10,8 mm

Δz_{LAr} = 5,53 mm…



Step 4 : Gravity on SuperStructure alone in LAr (1000 kg)

Step 5 : same + 6 CRPs mass in Lar (68 kg on four points)

Step 6 : same + cathode mass in LAr (236 kg on 12 points)

Step 7 : same + Thermal shrinking (22°C → -186°C)

Summary:

- Since January a lot of activities on CRP definition and developments took place on :
  - Design of the CRP composite frame and anode attachment system
  - Definition of the assembly procedures for the anodes and the mechanical structures
  - Design of the metallic frame and suspension system for the cold box integration and test
  - Design of the top CRP superstructure started => to be continued with interface of the cathode system
  - Continuous activity of optimisation for top and bottom CRP structures
  - Coming steps: production and assembly of the first CRP at CERN

- Several activities related to Far Detector design, prototyping and construction phases still to be developed