

## Installation Overview

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## INSTALLATION SEQUENCE:

0. Internal Cryogenic pipes, Temporary Construction Floor and CRB
1. FTs Installation
2. CRP- 3X3 m<sup>2</sup>
3. Top Cabling Inside Cryostat
4. Field Cage Installation
5. Cathode and Groundgrid ( in parallel with last parts of Field Cage)
6. Removal of Temporary Construction Floor
7. PMTs and Groundgrid
8. Closure of the TCO

Detector installation schedule depends directly on the installation sequences in the cryostat:

- CRP
- Field Cage and Cathode
- PMTs

The CRP assembly depends on LEM and anode production strategy  
(and LAS = LEM + Anode Sandwich assembly)

- The default planning 4 weeks ago was based on the start of the full LEM production (160) by 2 firms on April 2017. This has evolved during last weeks

Main changes are:

- The t0 to start the first LEM production has moved by 6 weeks; due to administrative treatment + cumulated problem of a fire in one of the 2 firms
- Start the production of 80 LEM+anode enough to build at least the two first CRP as soon as the tender are signed
- Go on rapidly with the second firm in the following weeks

# ProtoDUNE-DP

Version 15/04/2017

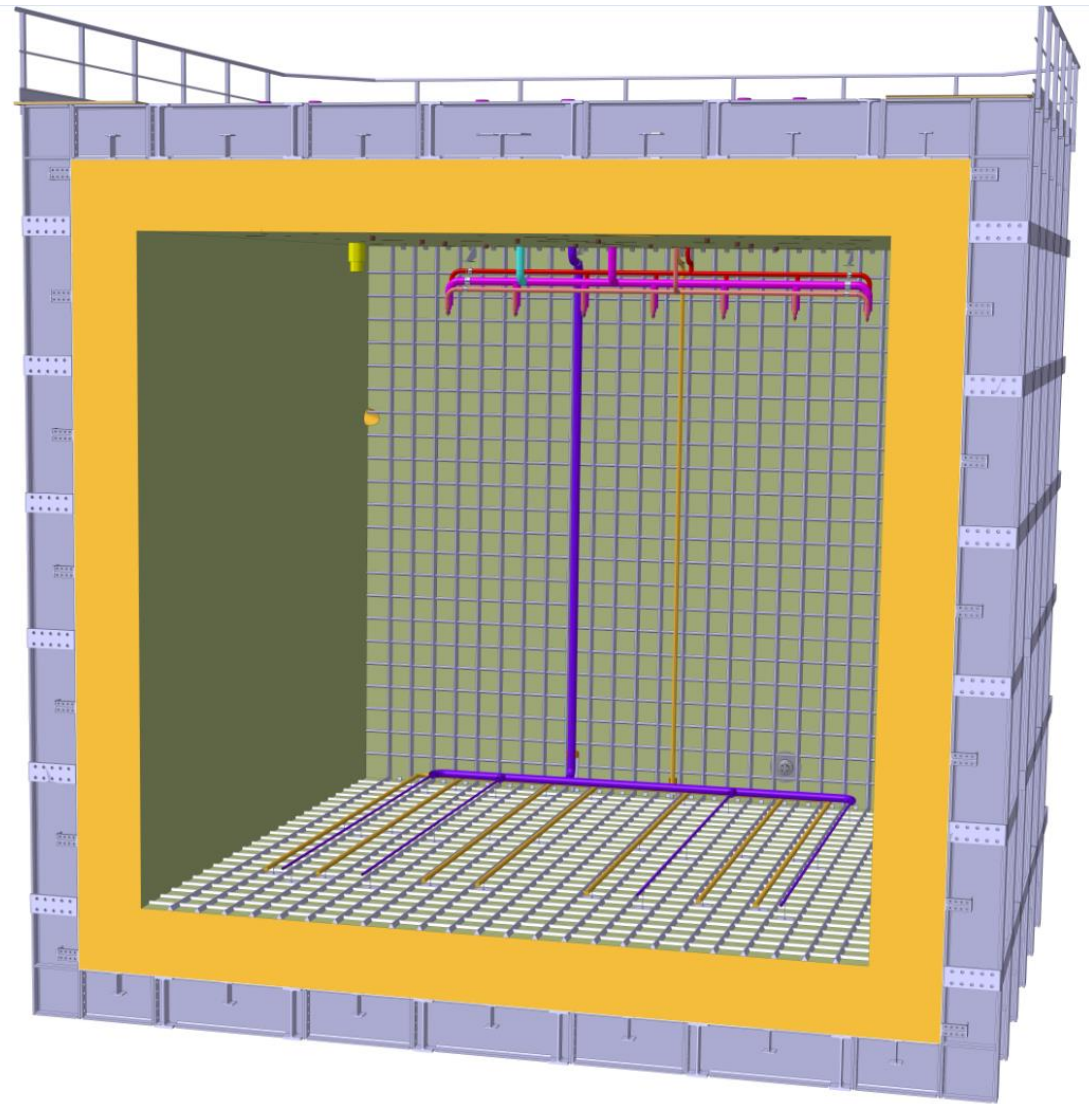
Task name	Duration (days)	Start date (dd//mm/yy)	Finish date (dd//mm/yy)
ProtoDUNE-DP	343 days	01/12/2016	09/04/2018
Cryostat preparation	93 days	08/03/2017	14/07/2017
CRP Production & Installation	193 days	10/04/2017	17/01/2018
Chimneys and feedthroughs	80 days	05/06/2017	22/09/2017
Drift Cage Production and Installation	235 days	01/05/2017	06/04/2018
Beam plug installation	5 days	26/02/2018	05/03/2018
HV system	10 days	08/02/2018	22/02/2018
PMT and Light Read Out System	340 days	01/12/2016	04/04/2018
Lower the Ground grid to its final position	2 days	04/04/2018	06/04/2018
Front End electronics	90 days	25/09/2017	09/02/2018
Slow control	30 days	06/11/2017	15/12/2017
Purity monitor	15 days	05/03/2018	26/03/2018
Ready to seal TCO & cryostat	1 day	06/04/2018	09/04/2018
Large Area Trigger Counters	30 days	13/11/2017	22/12/2017

The end of installation is April 6, 2018



## 0) Internal Cryogenic Pipes

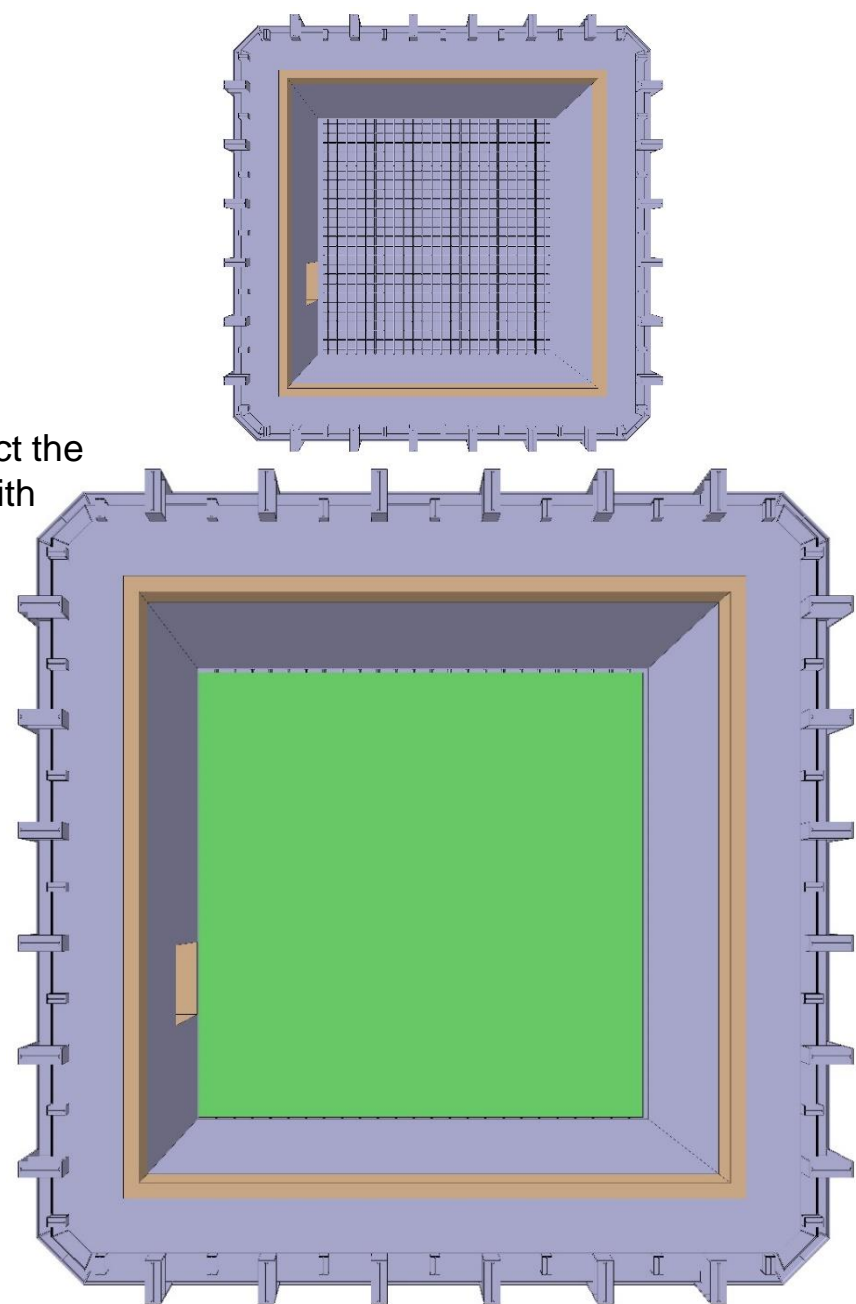
- Internal Cryogenic Pipes will be installed before the Temporary Construction Floor.



3 weeks from end of June 2017

## 0) Temporary Construction Floor

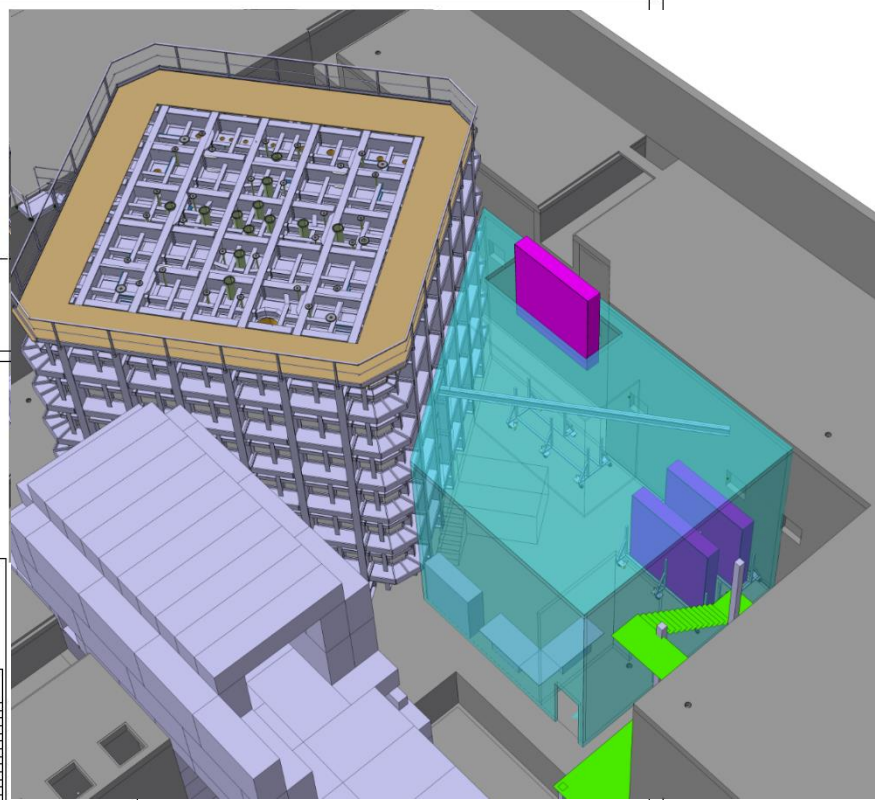
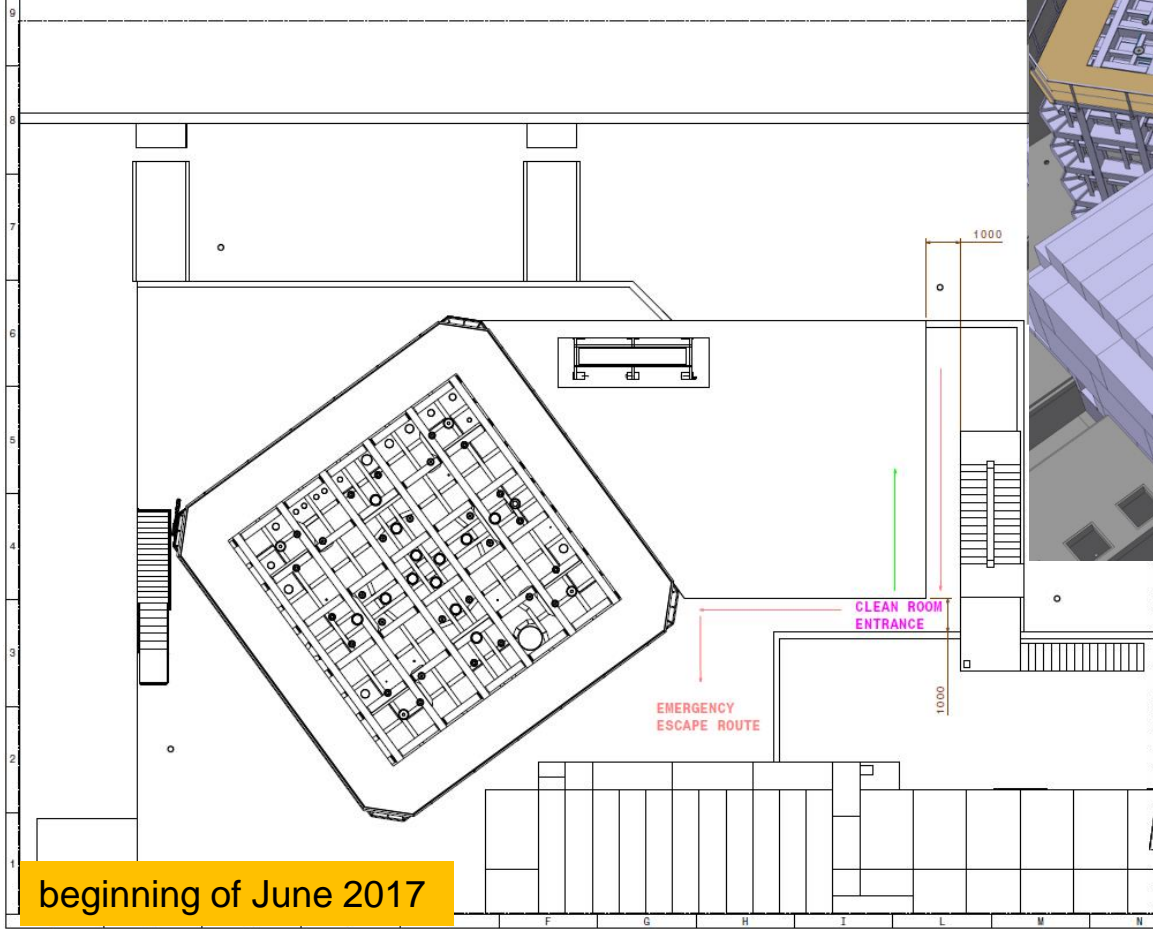
- Cryostat is used as a clean Room
- Field Cage, CRP are installed inside
- Temporary construction floor is needed to protect the bottom membrane and be able to work inside with personnel lift
- Floor will be at the level of the TCO height



mid-July 2017

# 0) CRB – Clean Room Buffer

- Roof Hatch at the Top for lowering the various Boxes. (**MAX Size: 3,2x3,2x0.5 m**)
- Clean air from Manhole keeping the cryostat in overpressure  
→ prevent dirty air to go inside the Cryostat

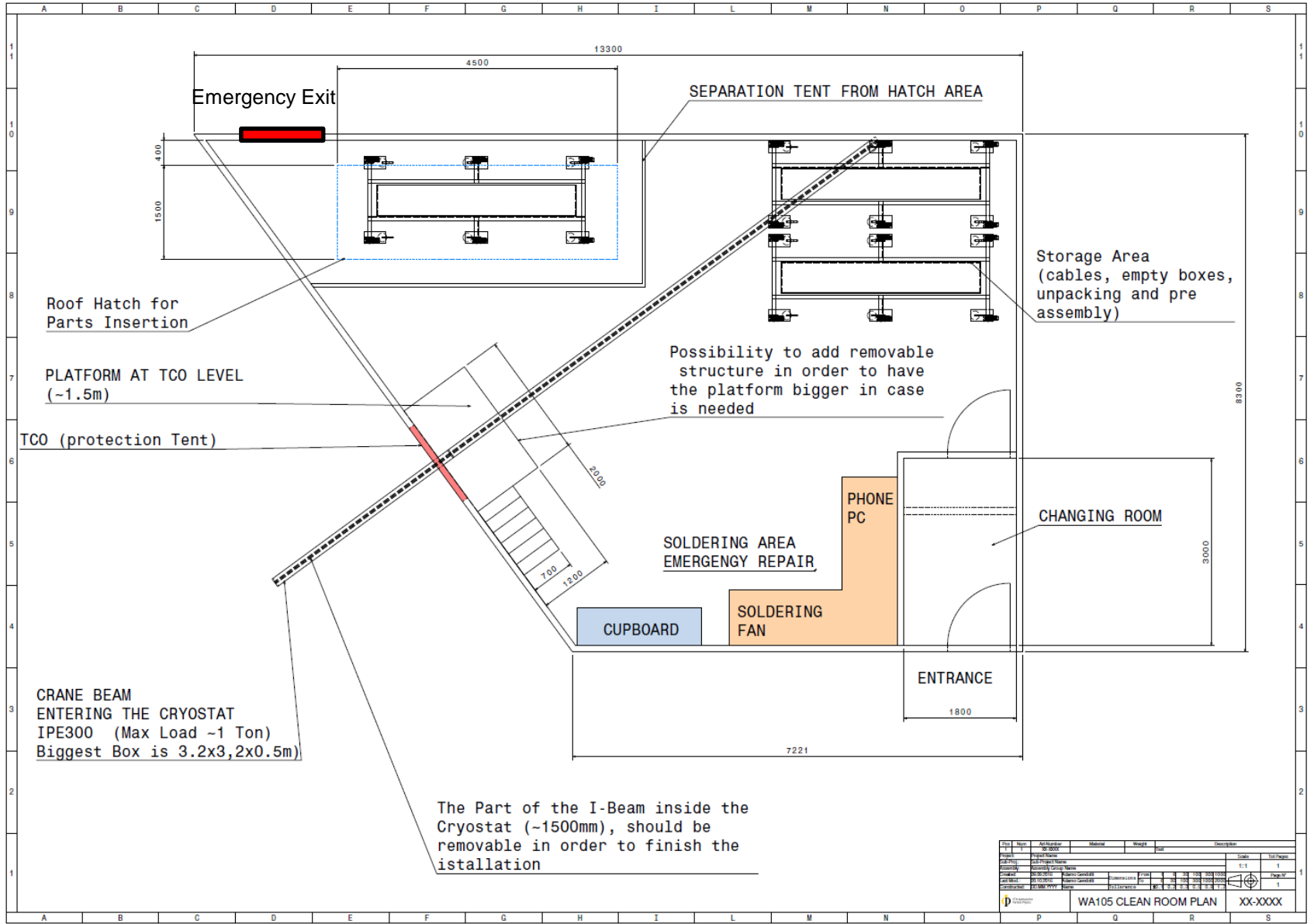


Item	Sign	Alt Number	Material	Weight	Unit	Description	Scale	Sur Degree
1		1000					1:1	5
2		1000					1:1	5
3		1000					1:1	5
4		1000					1:1	5
5		1000					1:1	5
6		1000					1:1	5
7		1000					1:1	5
8		1000					1:1	5
9		1000					1:1	5

ETH-Zürich OVERVIEW IN EHN1 XX-XXXX

# 0) CRB – Clean Room Buffer

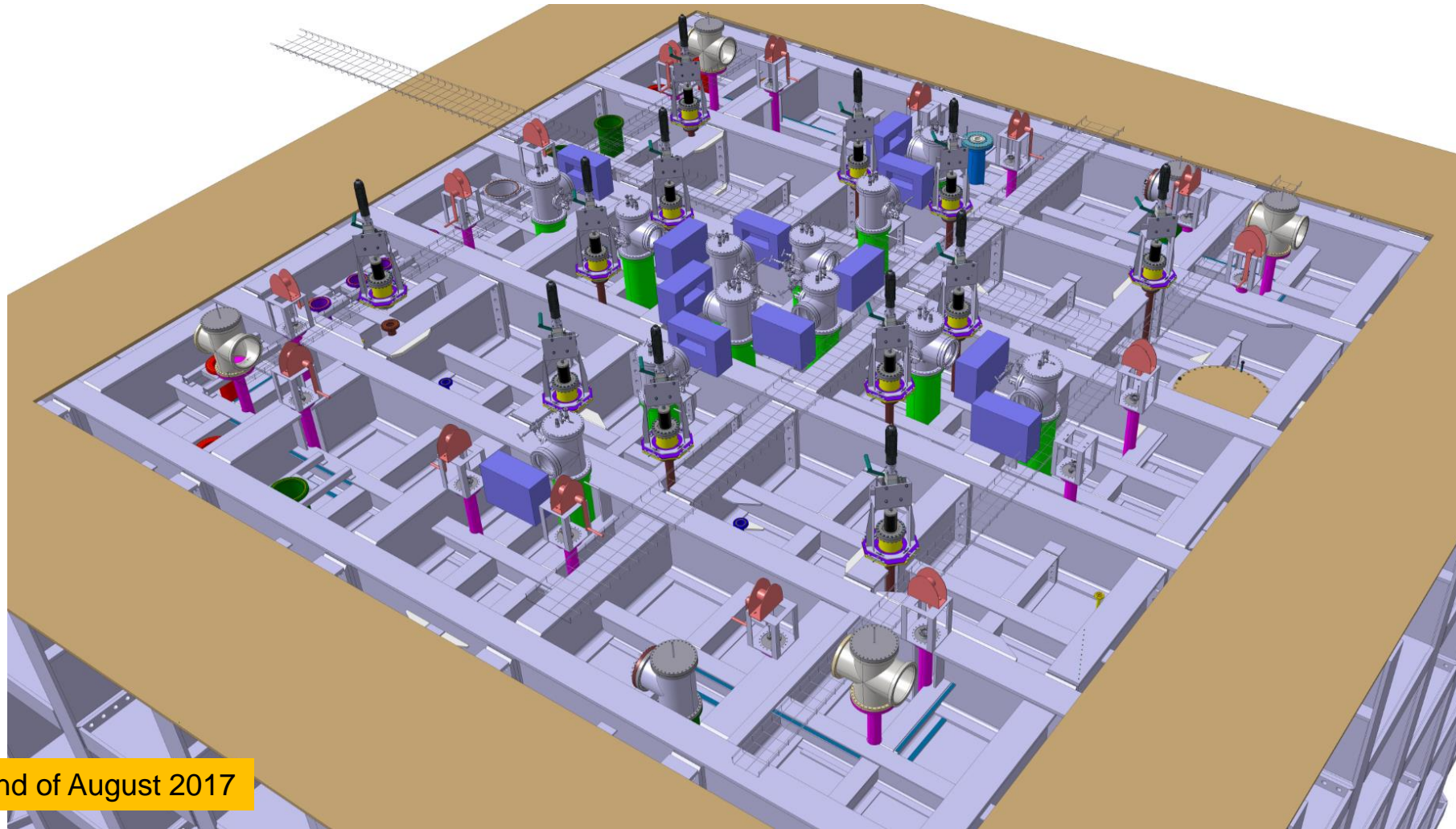
- CRB internal layout proposal





# 1) FTs Installation

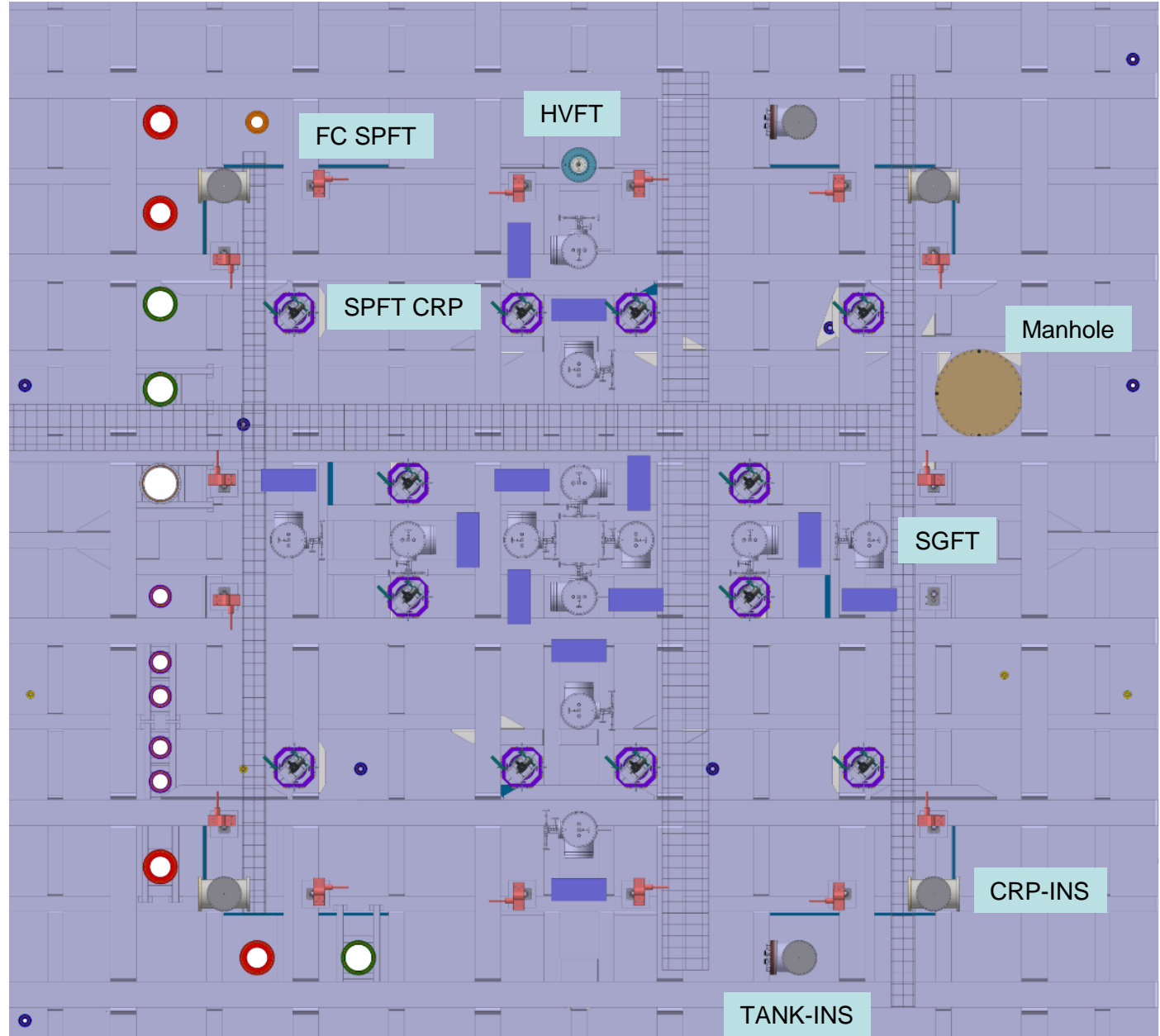
- SGFT, SPFT-CRP, CRP-INS FTs and TANK-INS needs to be there at the beginning
- SPFT-FC are for the Field Cage installation
- HVFT during the FC Installation



End of August 2017

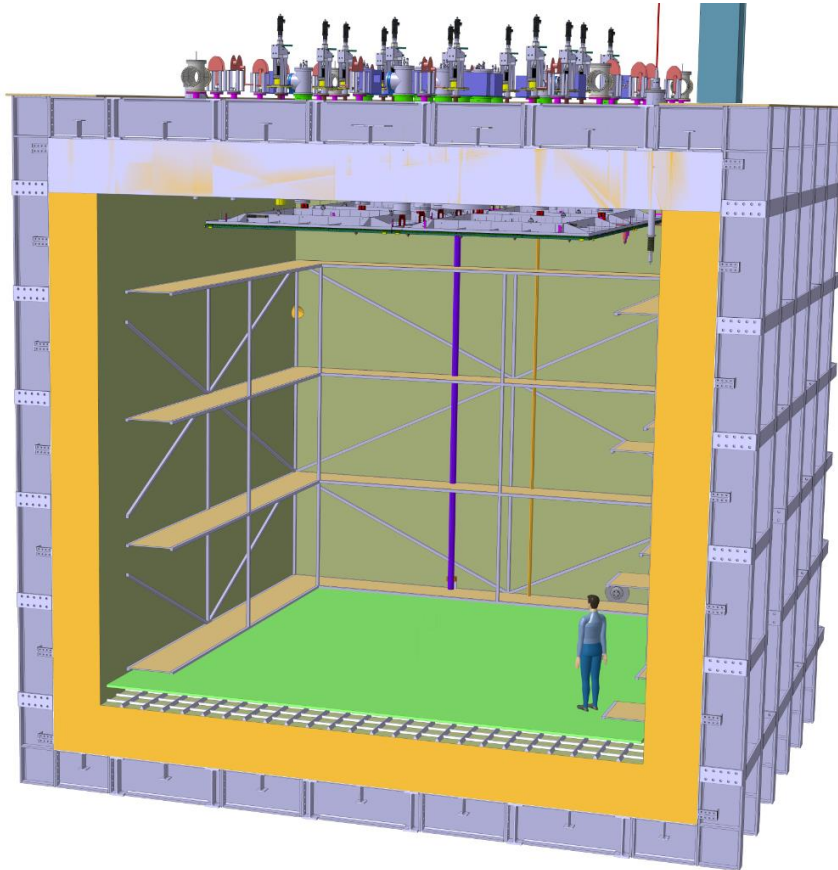
# 1) FTs at the Cryostat

- 12 x SGFT +  $\mu$ TCA
- 12 x SPFT CRP
- 16 x FC SPFT
- 4 x CRP-INS
- 2 x TANK-INS
- 1 x HVFT

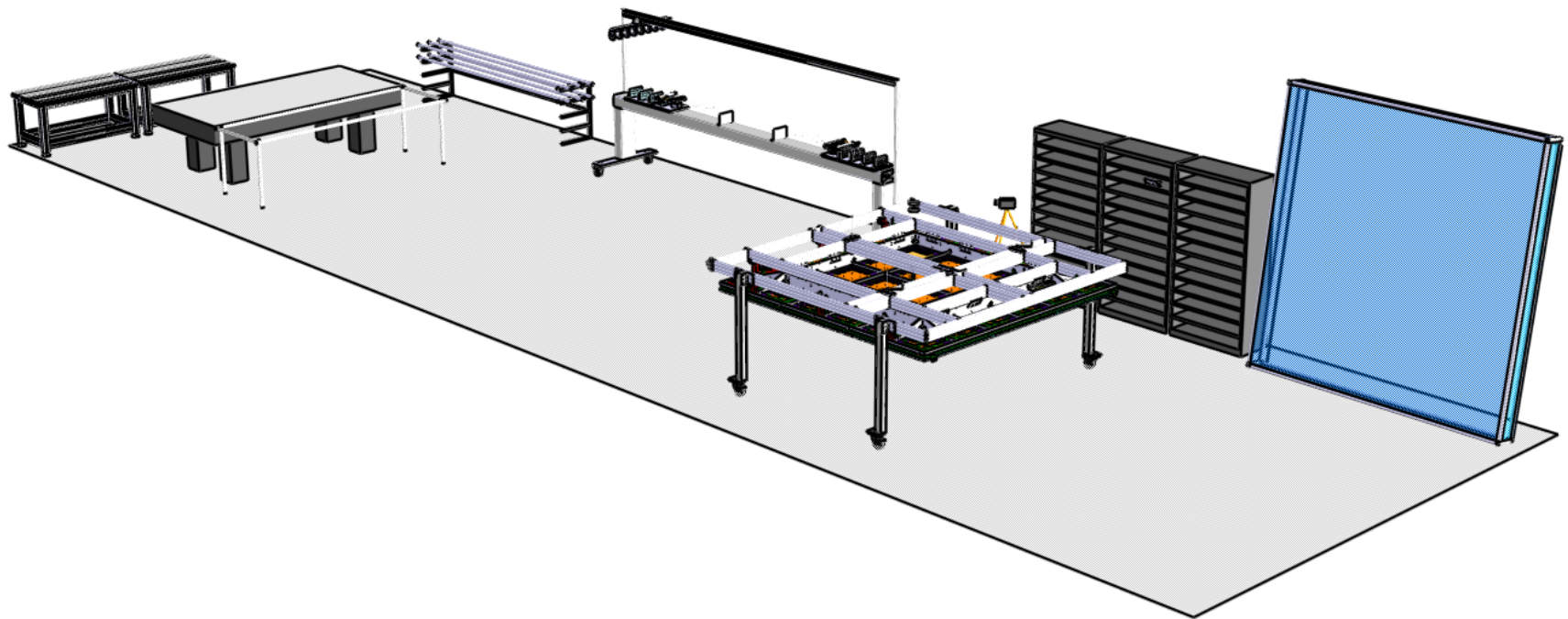


# Equipment needed Inside the Cryostat

- Max Height 6.5 m
- Scaffolding all around ~80cm (no need to be anchored at the membrane)
- Movable scaffolding inside the the Cryostat ( with possibility to secure it to the external scaffolding)



## Assembly in Clean Room 185



See B. Aimard Talk - *CRP Production, QA*

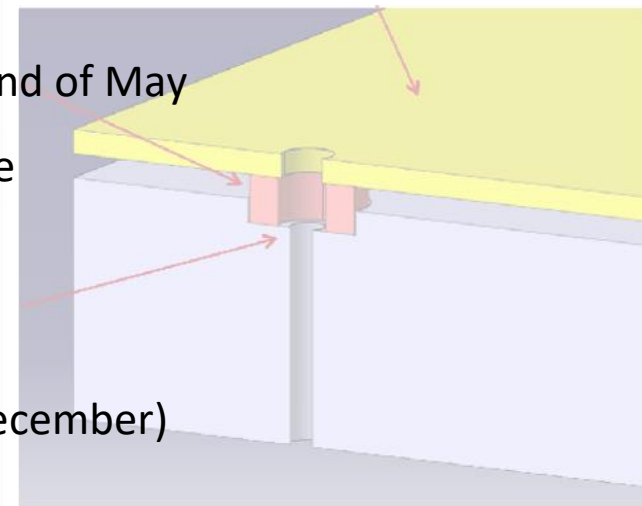
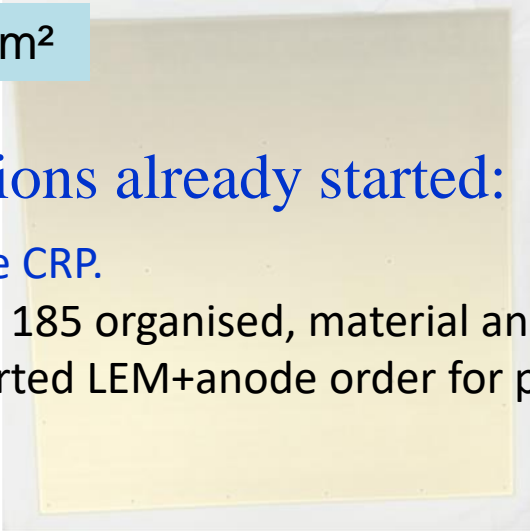
## CRP : Actions already started:

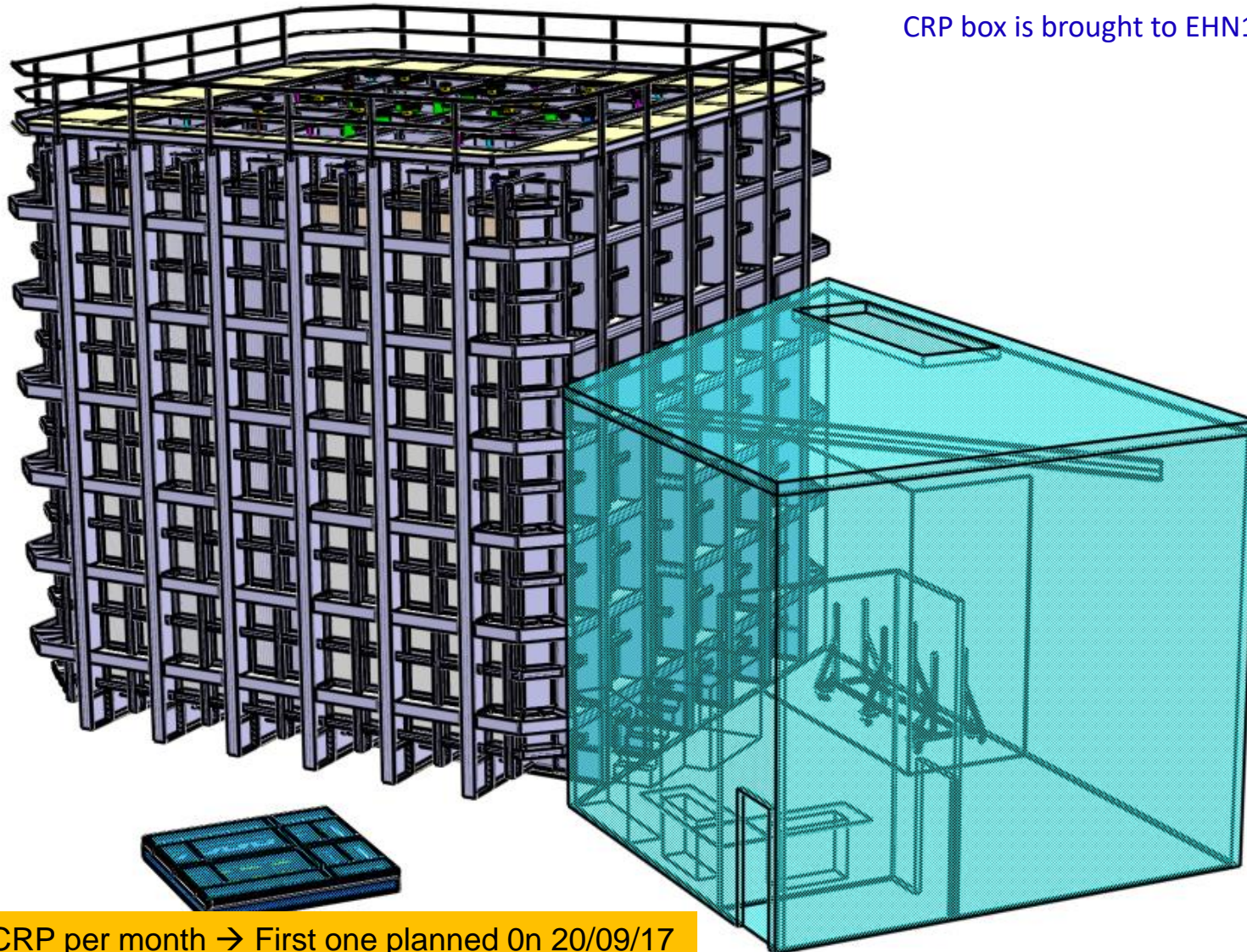
### To build the CRP.

- get 185 organised, material and tooling have been ordered beginning of April
- started LEM+anode order for production on April 18<sup>th</sup>

### Key dates:

- 185 CR equipped with tooling and ready to start construction end of May
- start of first CRP frame construction in CR185 beginning of June
- reception of first 12 LAS batch beginning of July.
- 1st CRP completed by mid september
- After that CRP construction rate = 1 per month (last one mid December)



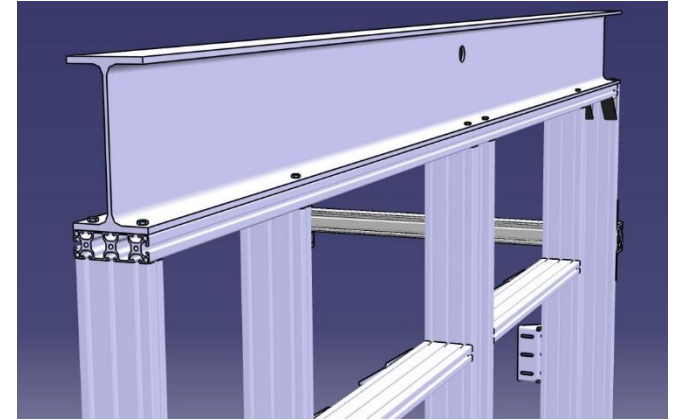
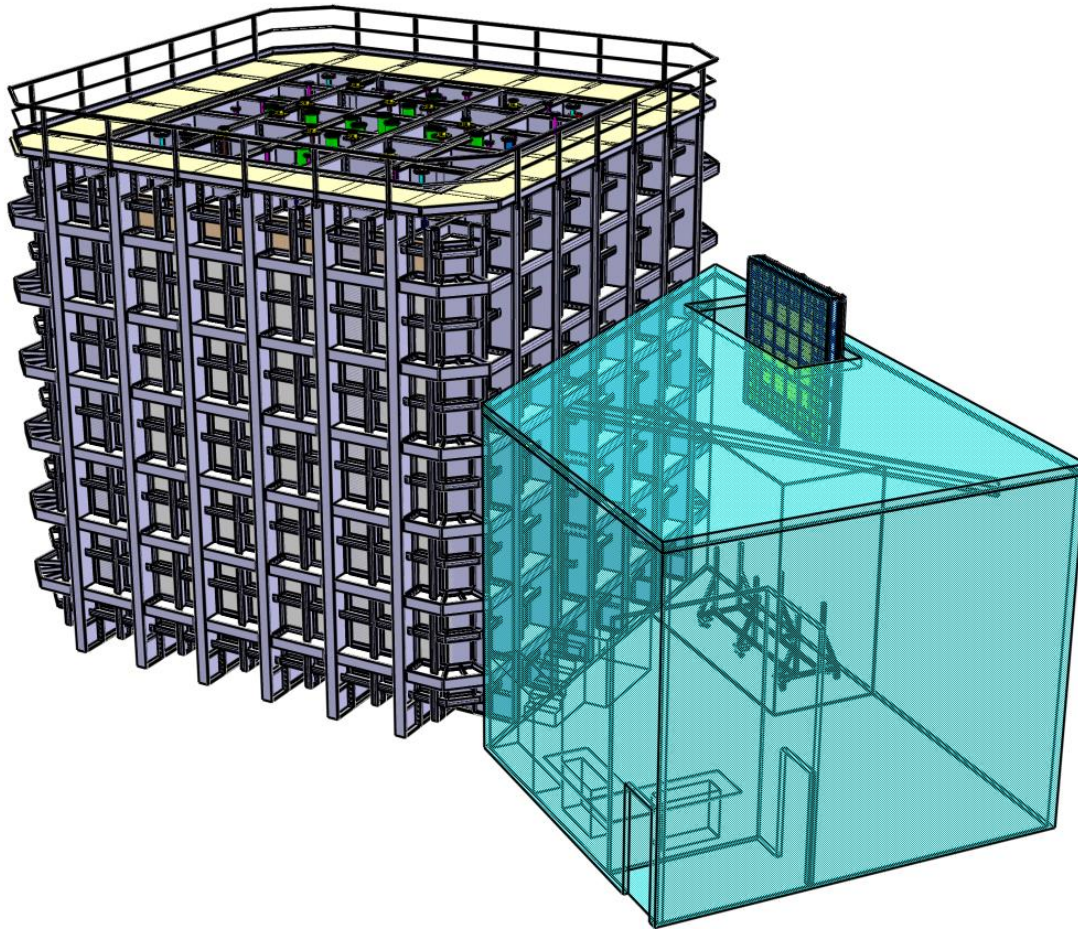


CRP box is brought to EHN1 from CR185

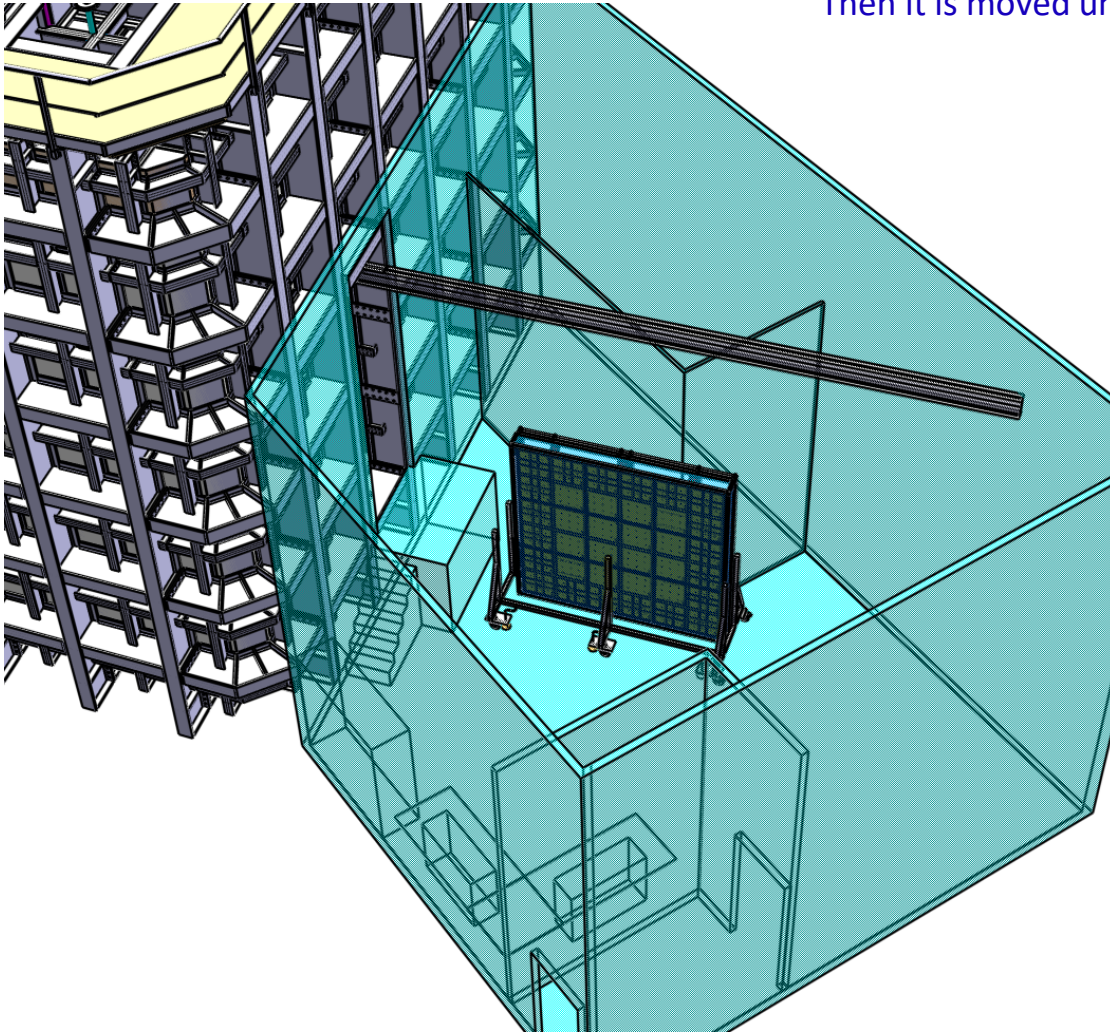
1 CRP per month → First one planned on 20/09/17

The box is inserted in the CRB thanks to the Hall's crane

- *The box is suspended by a special handling IPE stiffener*

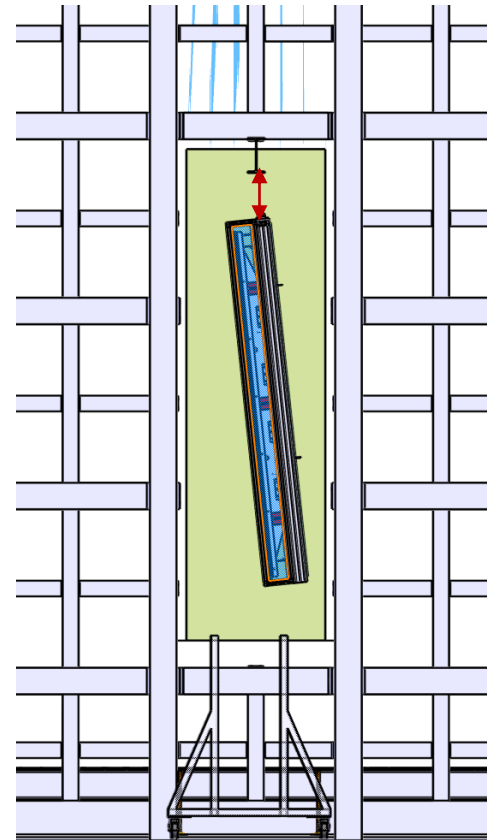
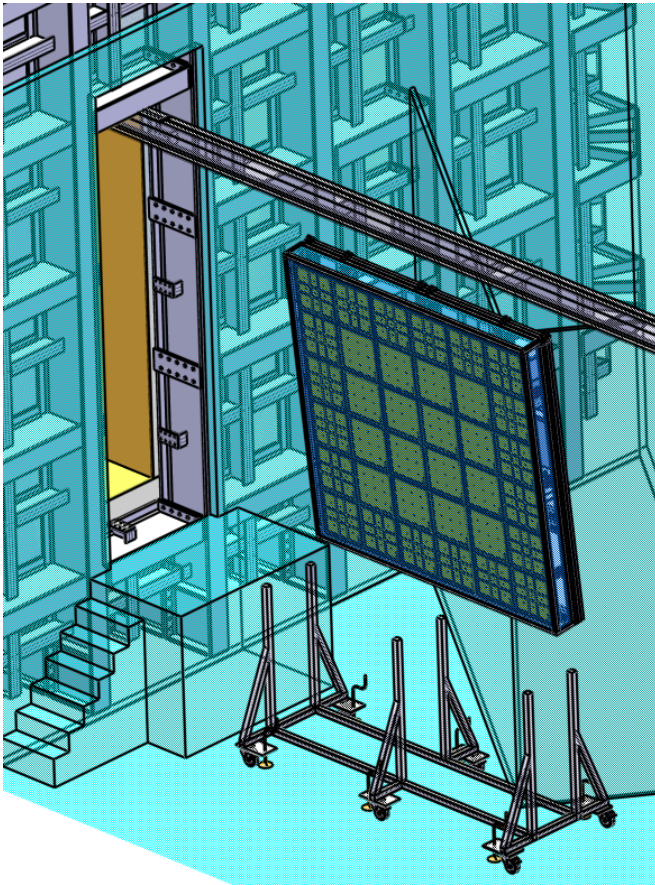


The box is « unfilmed » to preserve CRB cleanliness  
Then it is moved under the rail to be lifted

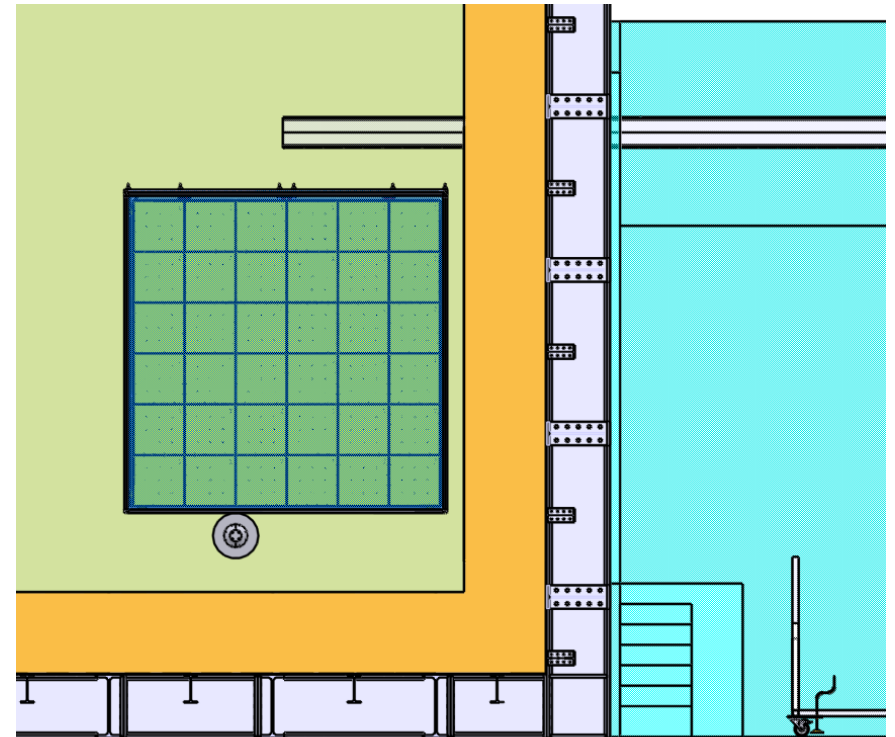
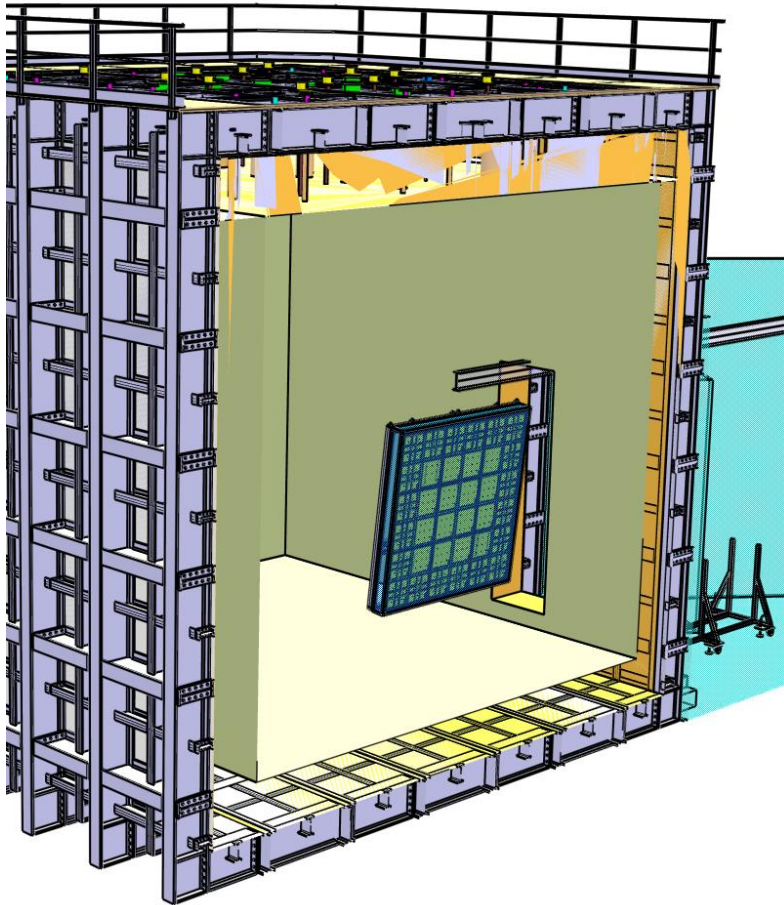




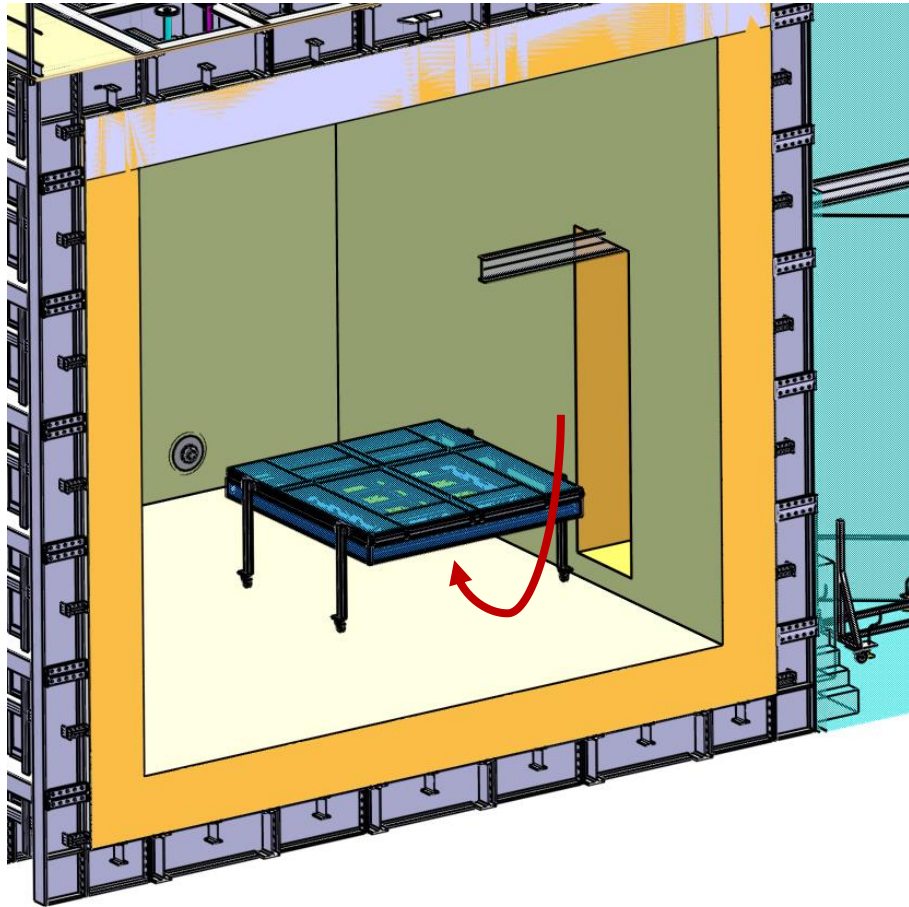
The box is lifted under the rail



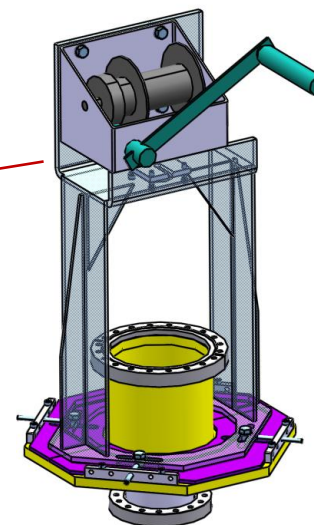
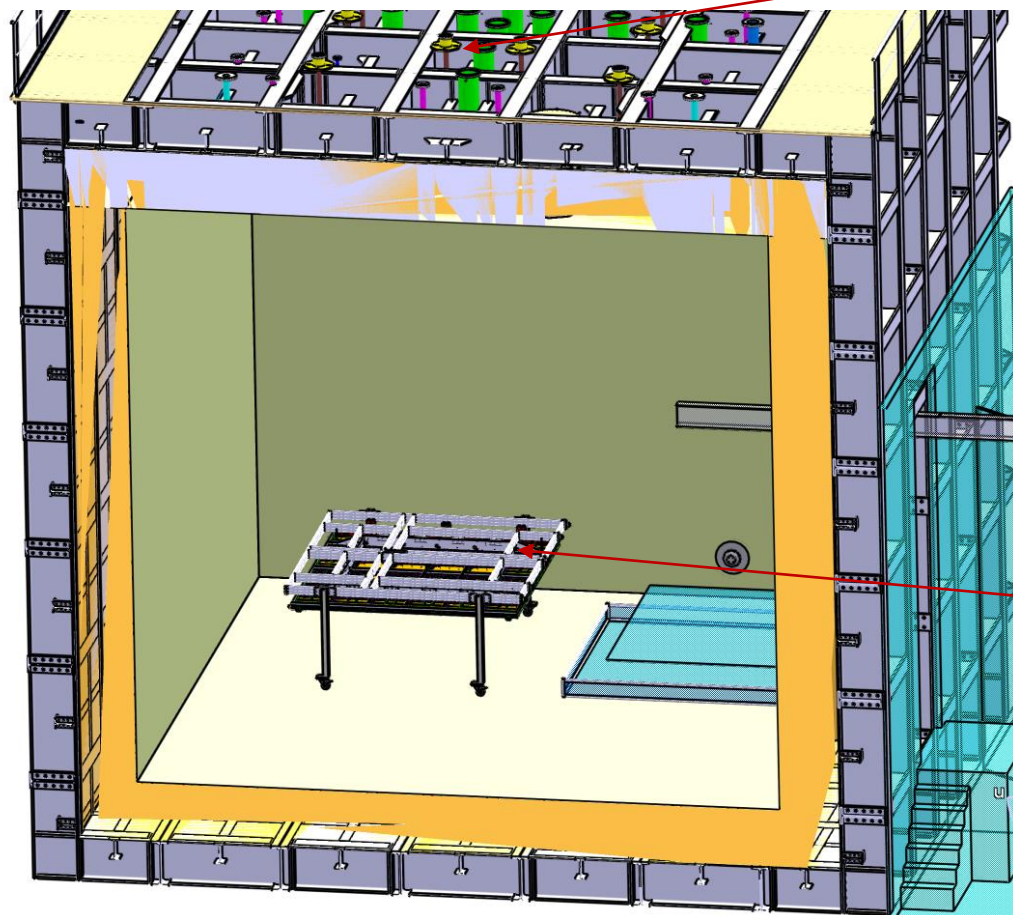
The box is inserted inside the cryostat through the rail



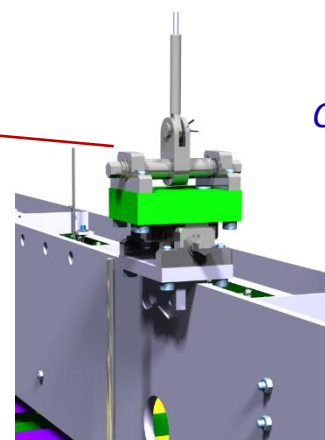
The feet of the box are replaced, the box is lowered and rotated, then placed on its wheels



The box is placed below its SPFT chimneys  
 The top and the bottom of the box are removed  
 Cables from the SPFT are connected to the module



*SPFTs are equipped with special winches at this time*

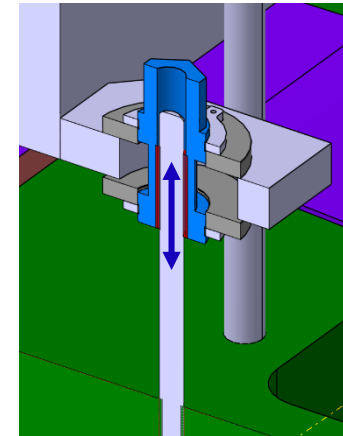
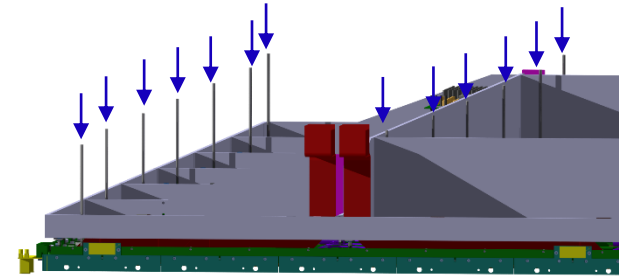
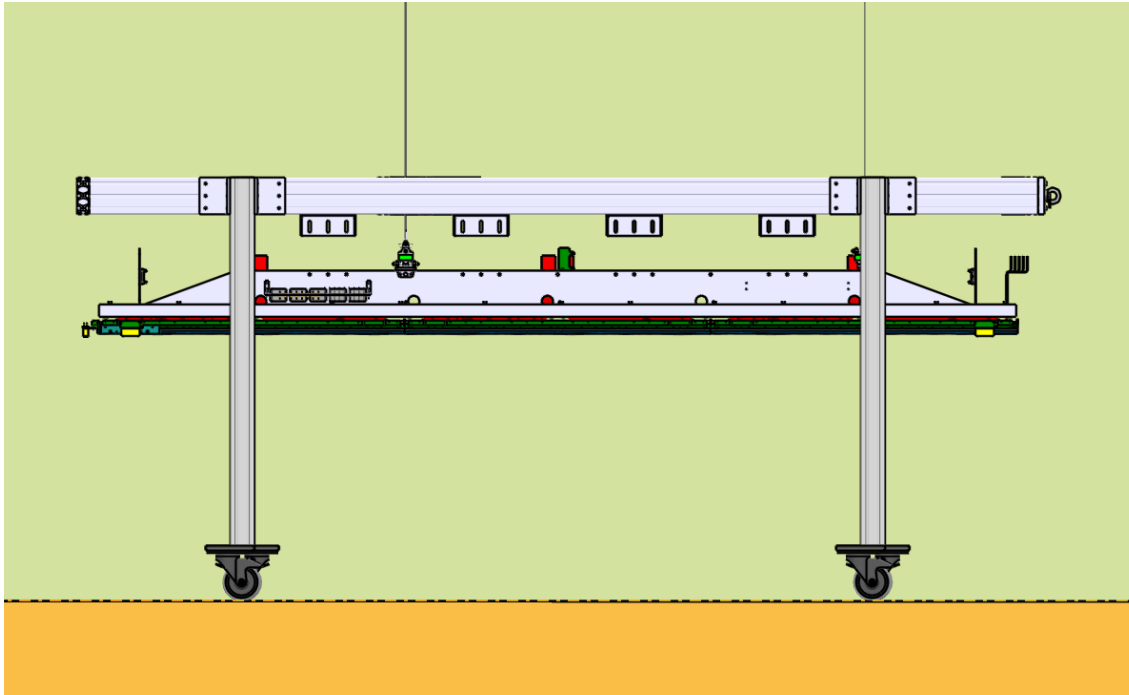


*CRP suspension systems*

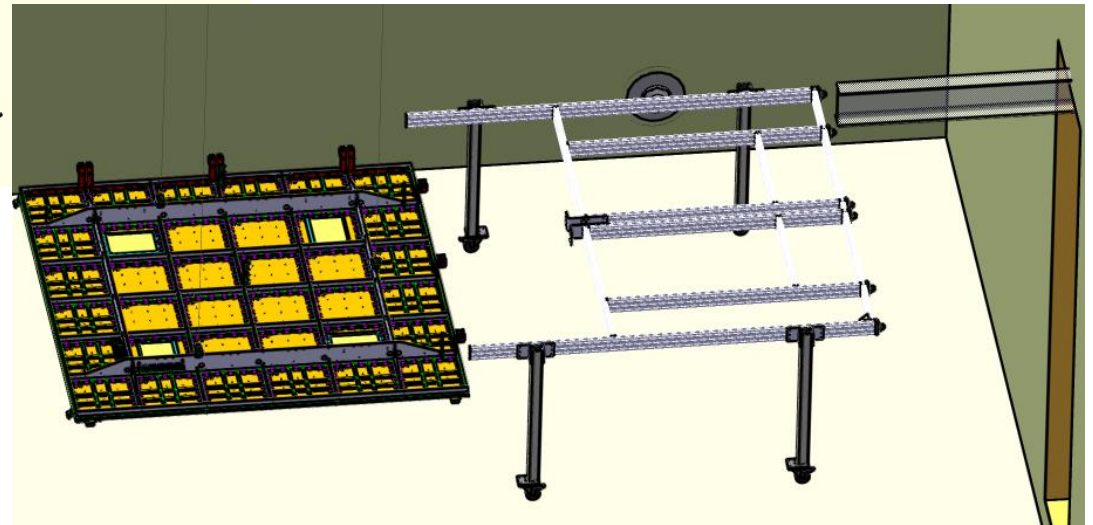
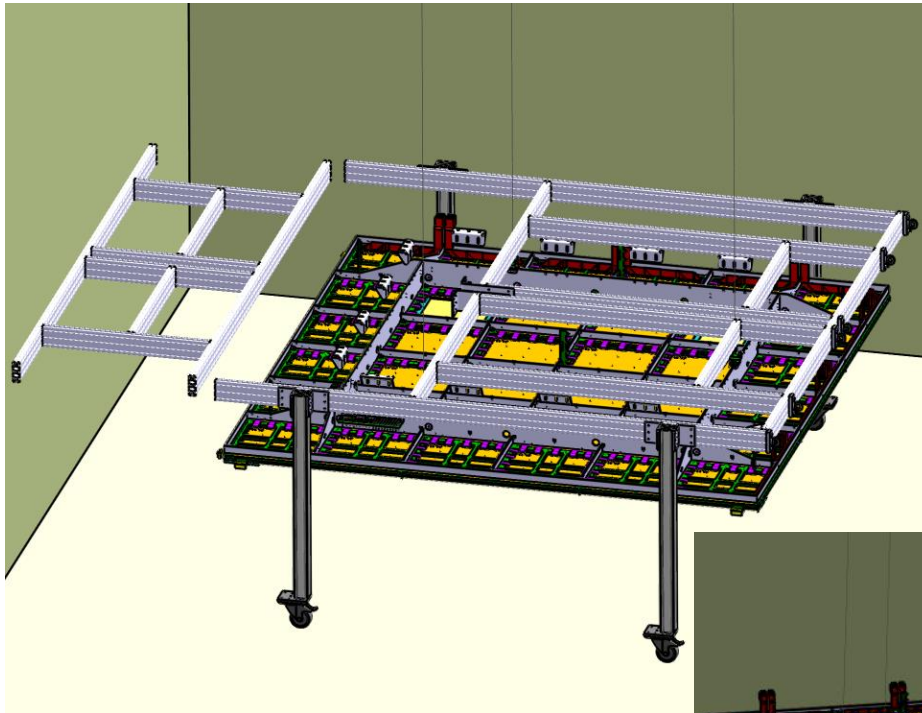
Once the module is suspended, it can be detached from the structure

All the supporting squares for transport are removed

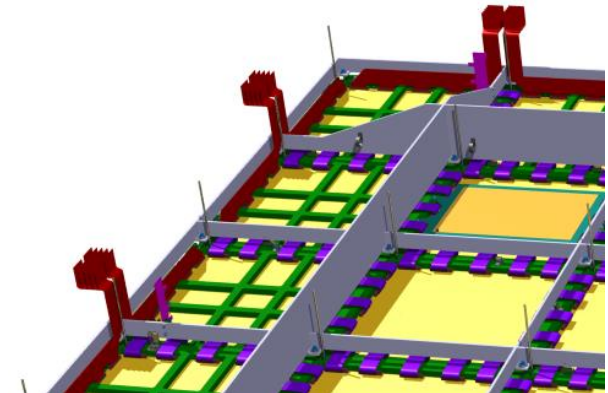
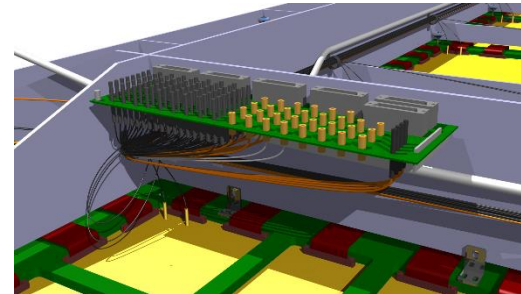
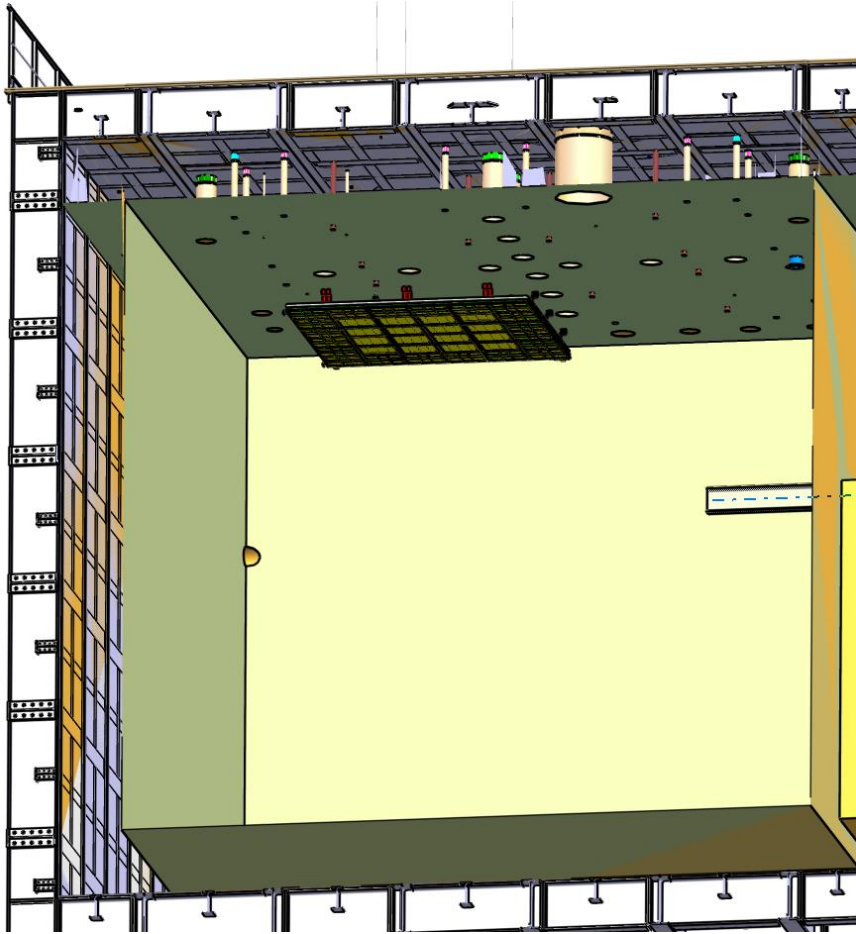
The planarity is checked thanks to laser-tracker or optical level



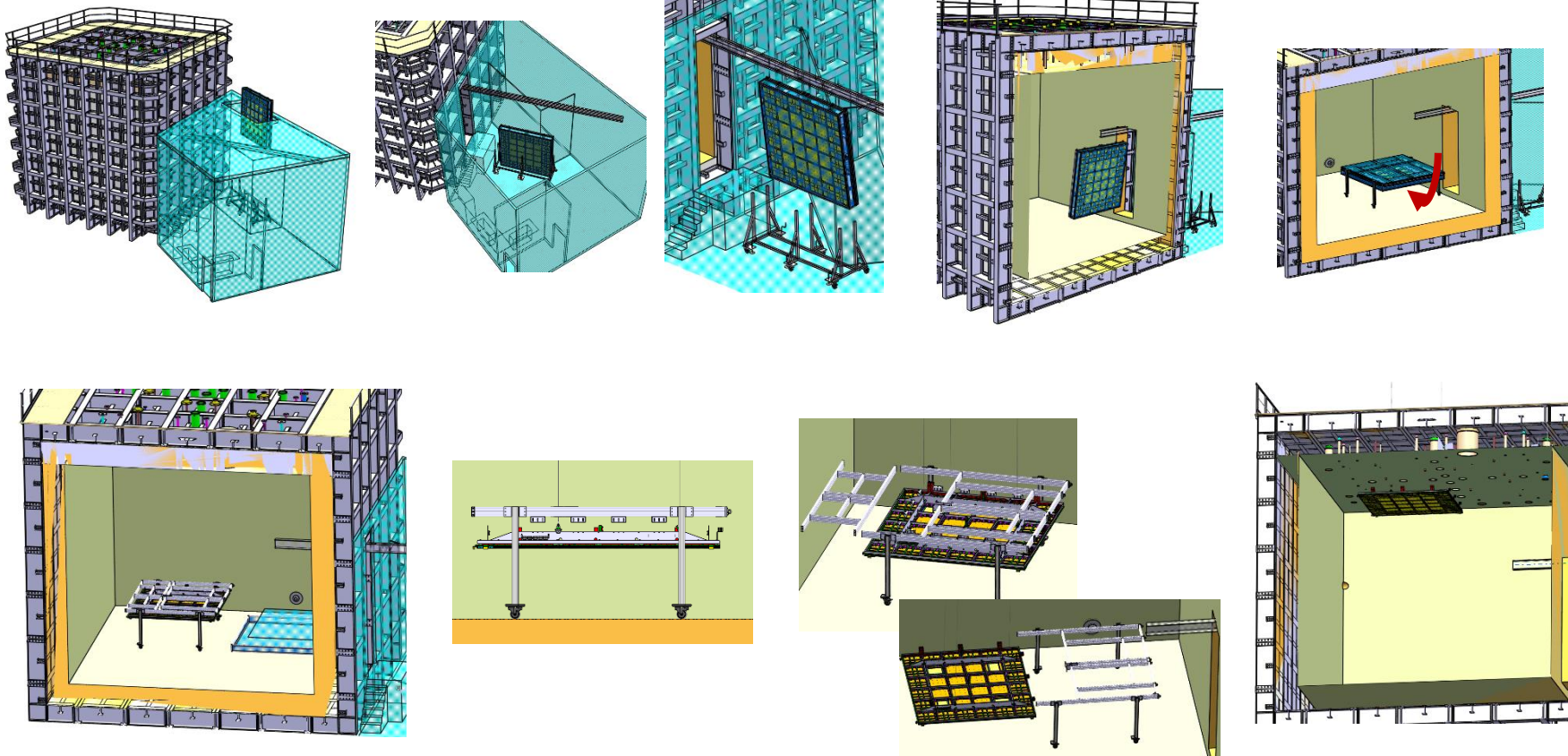
The structure is then removed in two parts



The module is lifted to the roof, and connected to chimneys (signal, HV, control...)

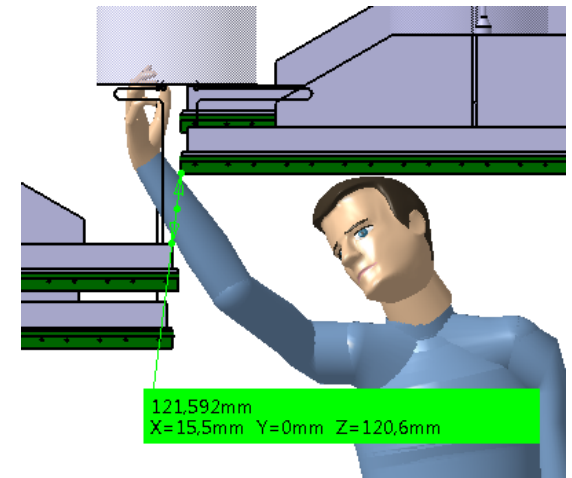
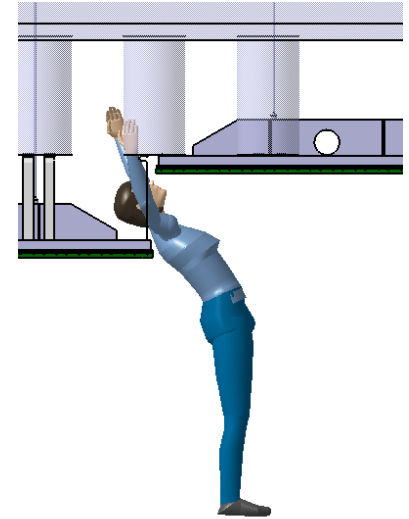
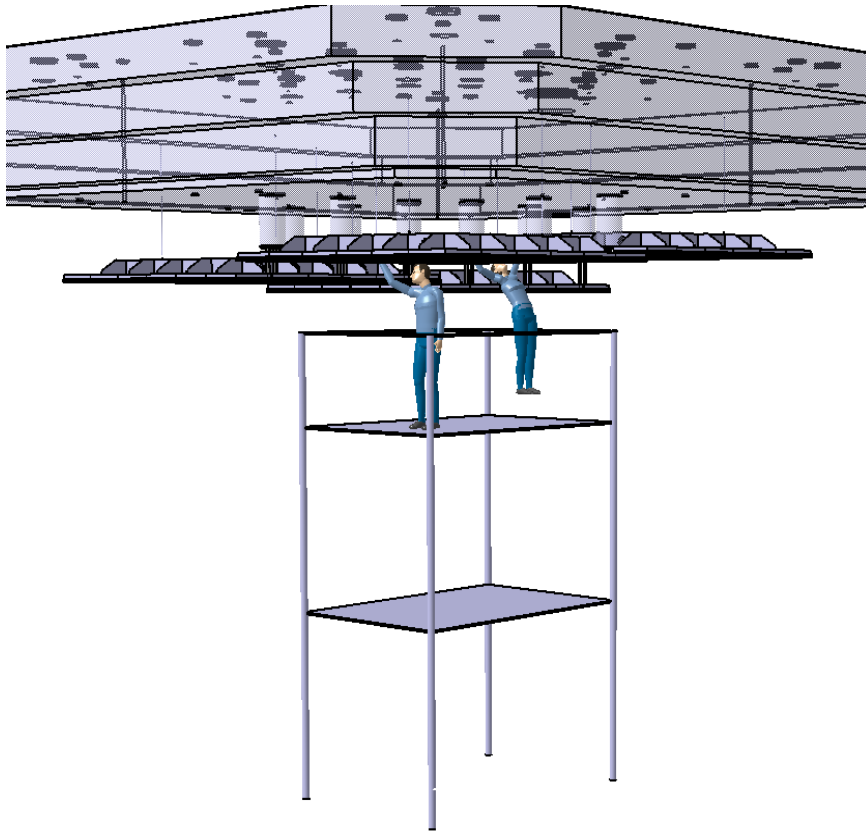


The operation is then repeated to insert the other modules ...



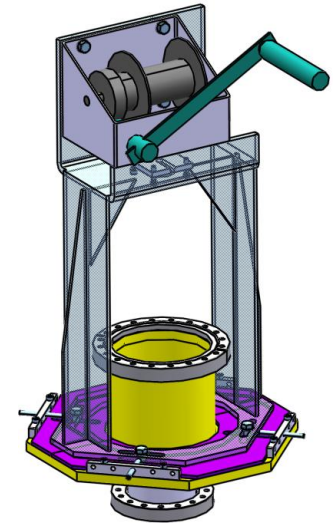
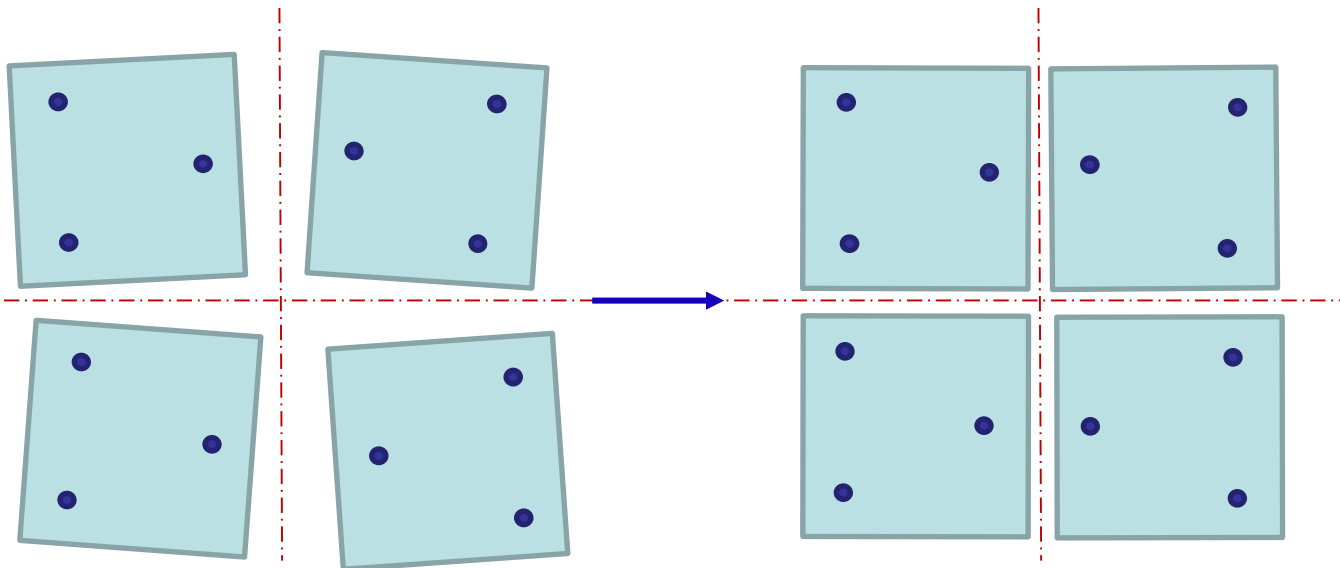
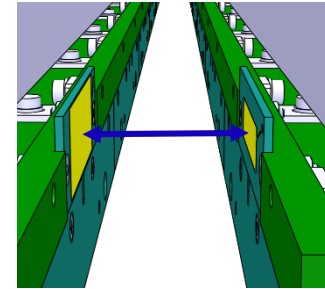


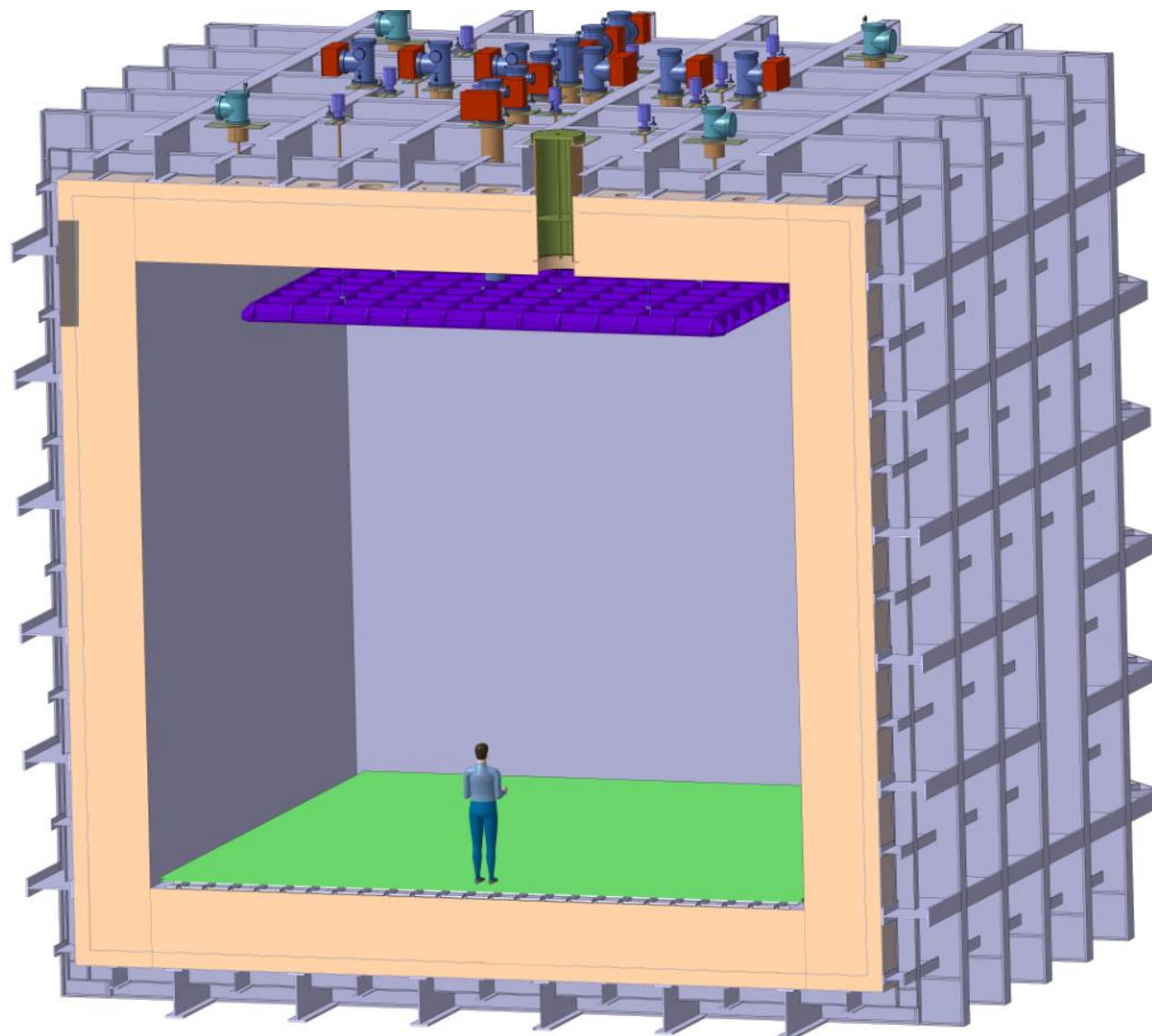
To connect plugs between modules, the modules are vertically shifted



Modules' alignment is made from the roof

- *Distance-Meters* to get information on relative position
- *SPFT system* to translate modules

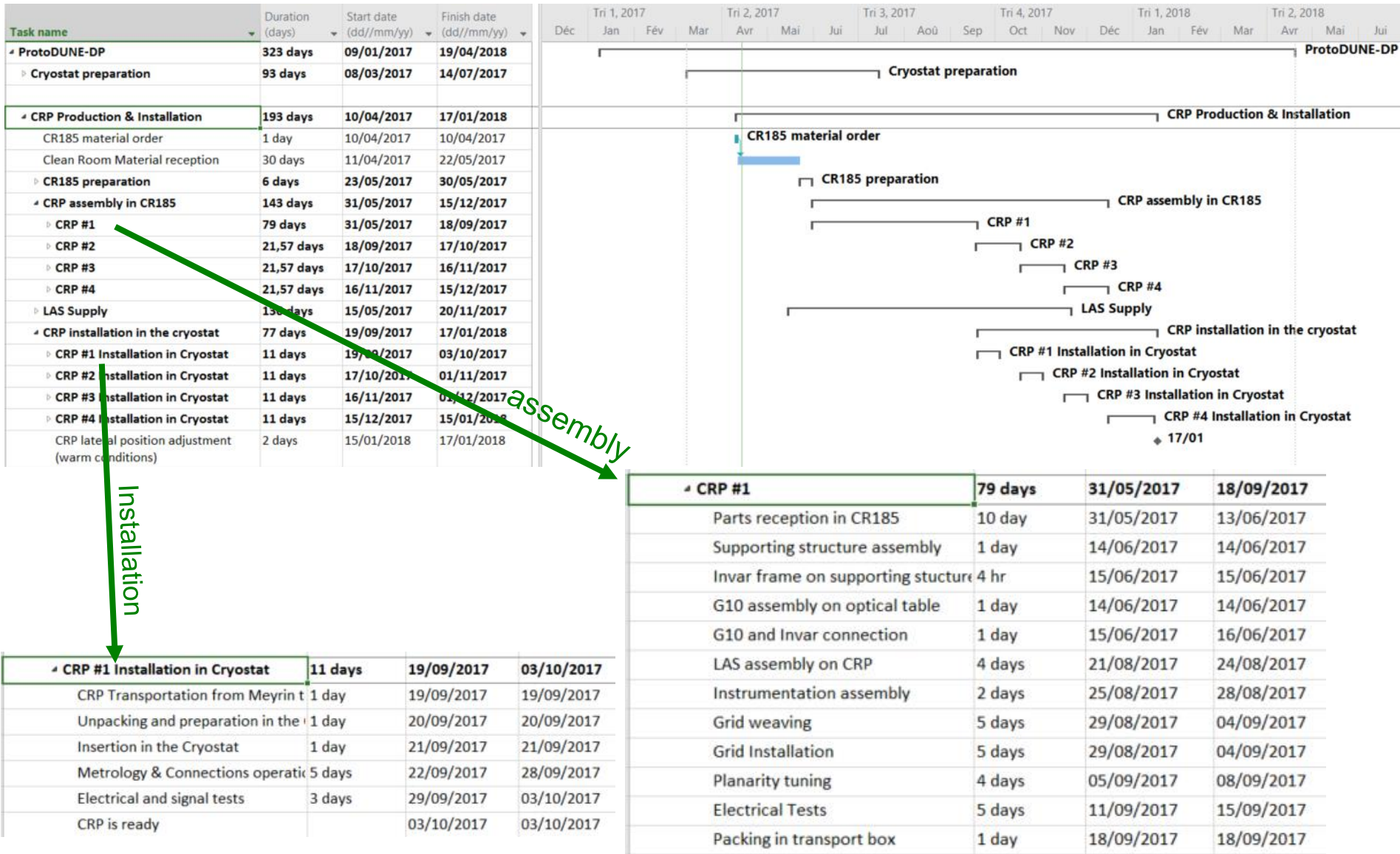




- All CRPs fixed on nominal Position

Mid January 2018

# CRP Production and Installation

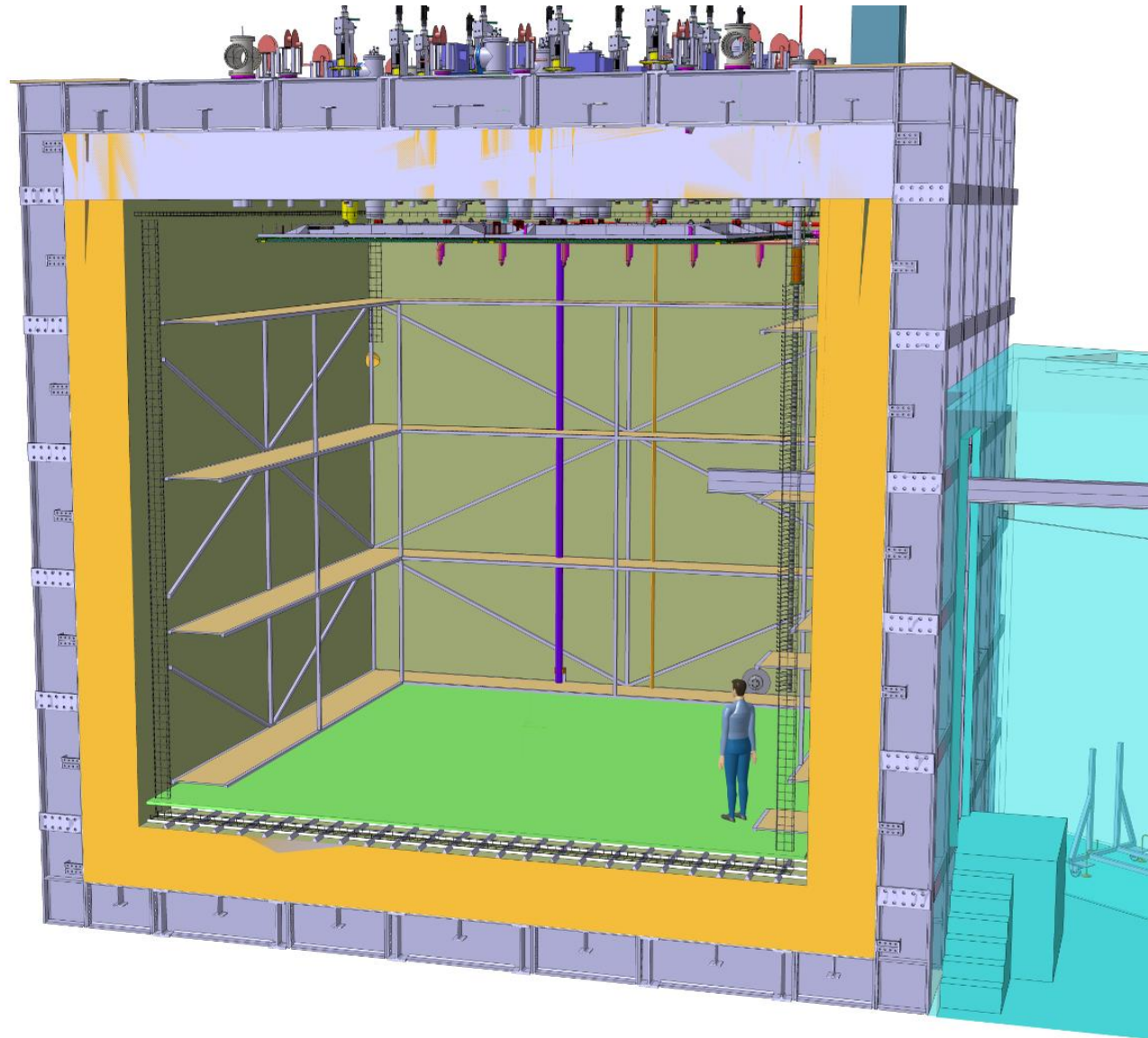


Installation

assembly

### 3) Scaffolding Cable trays and cabling

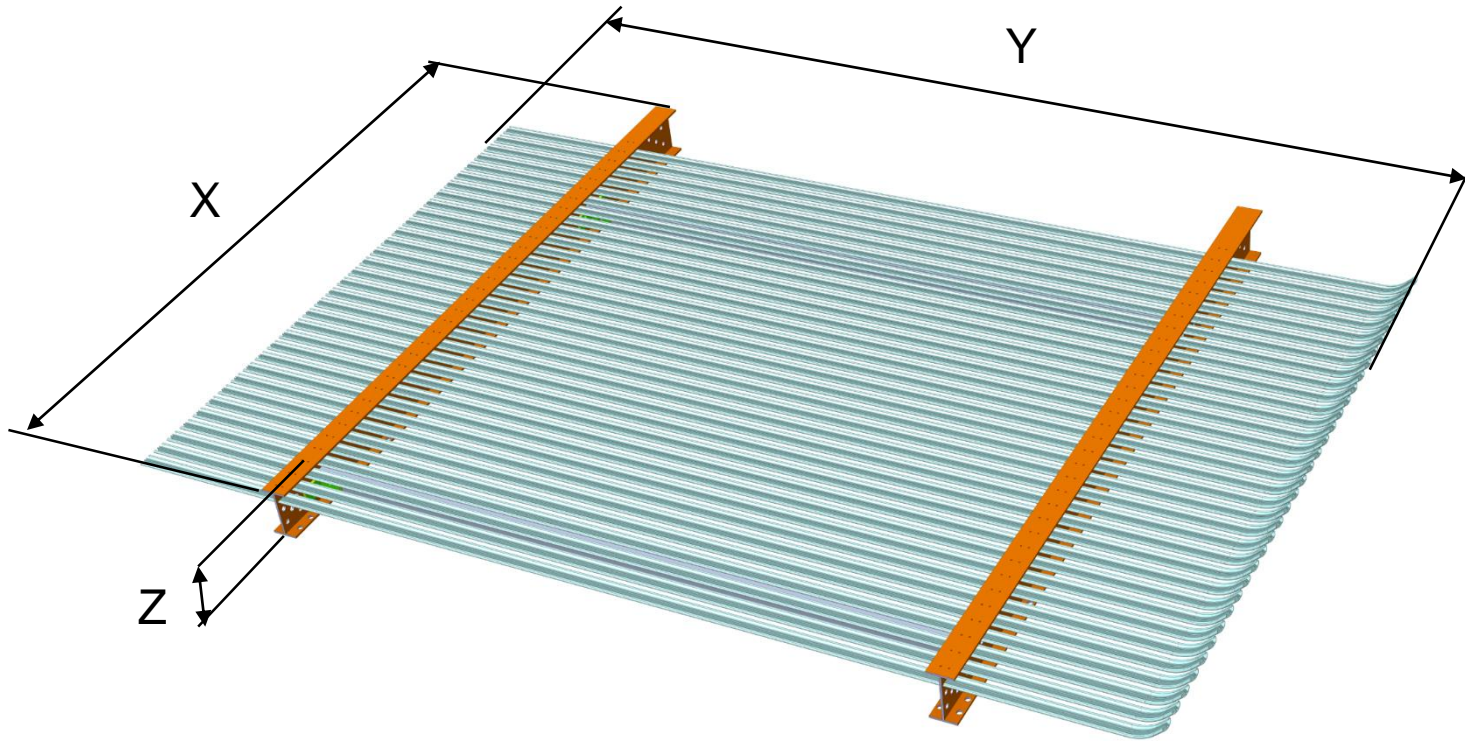
- Scaffolding all around
- Cable trays at the corner of the Cryosat
- Cables can already be pulled from the Feedthroughs to the Temporary floor



## 4) Field Cage

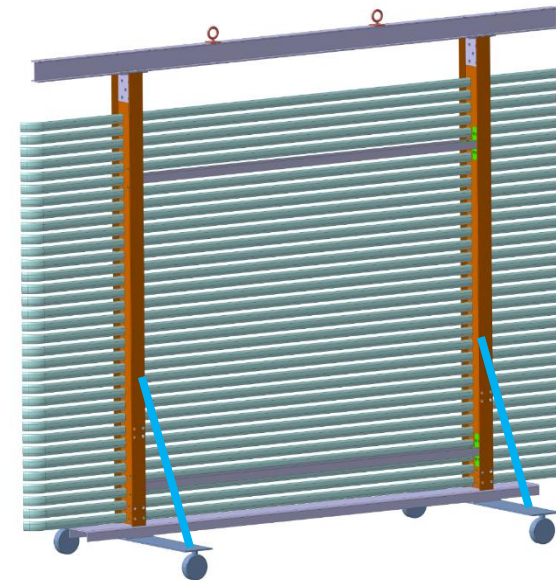
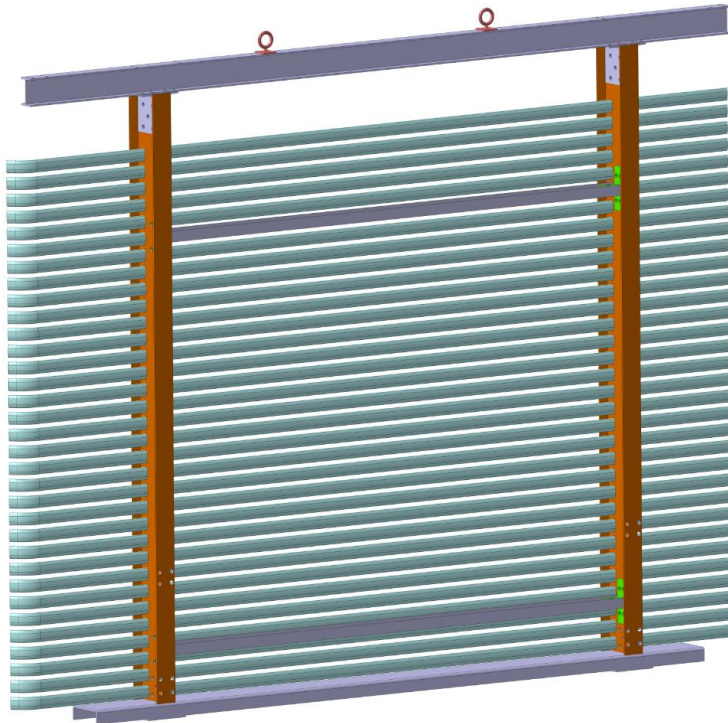
- Sub-Modules of the Field Cage

Sub Module	X	Y	Z
1st Sub-Module	2180	3050	165
2nd Sub-Module	1980	3050	165
3rd Sub-Module	1980	3050	165



## 4) Field Cage

- Assembly of the Sub Modules inside the CRB horizontally → 2 Person for 1 Sub-modules per day
- Steel reinforcement on top and bottom in order to rotate it vertically, lift it and bring it inside the Cryostat
- Transfer of the Sub Modules inside the Cryostat without Box: Reinforcement is needed.

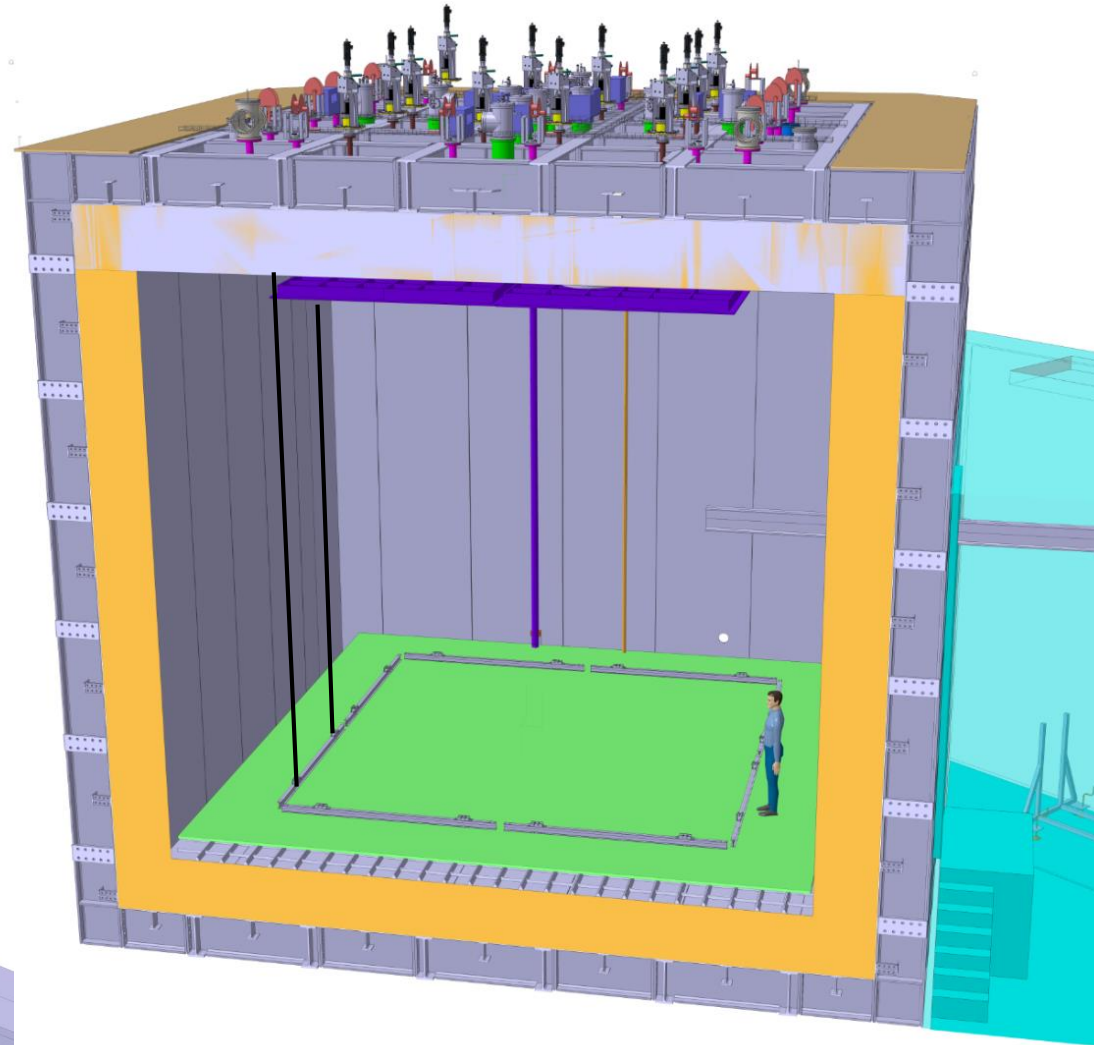
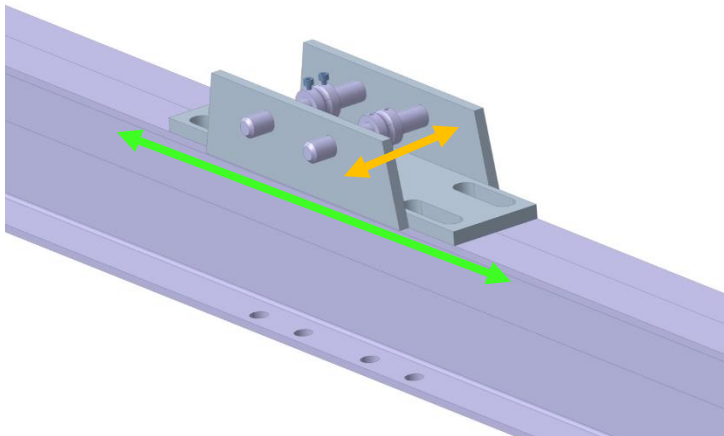


- Once inside, wheels on bottom reinforcement will be mounted in order to move the sub module on place.

Starts when last CRP is inserted in the Cryostat: 20/12/2017

## 4) Field Cage

- Accordingly to the position of the CRP  
→ Mark the position of the field cage on the construction floor
- Position the SS I-Beam (hanging system) in the right position
- Lower the hanging SS wire and connect to the I-Beam → Connection point centered at the wire



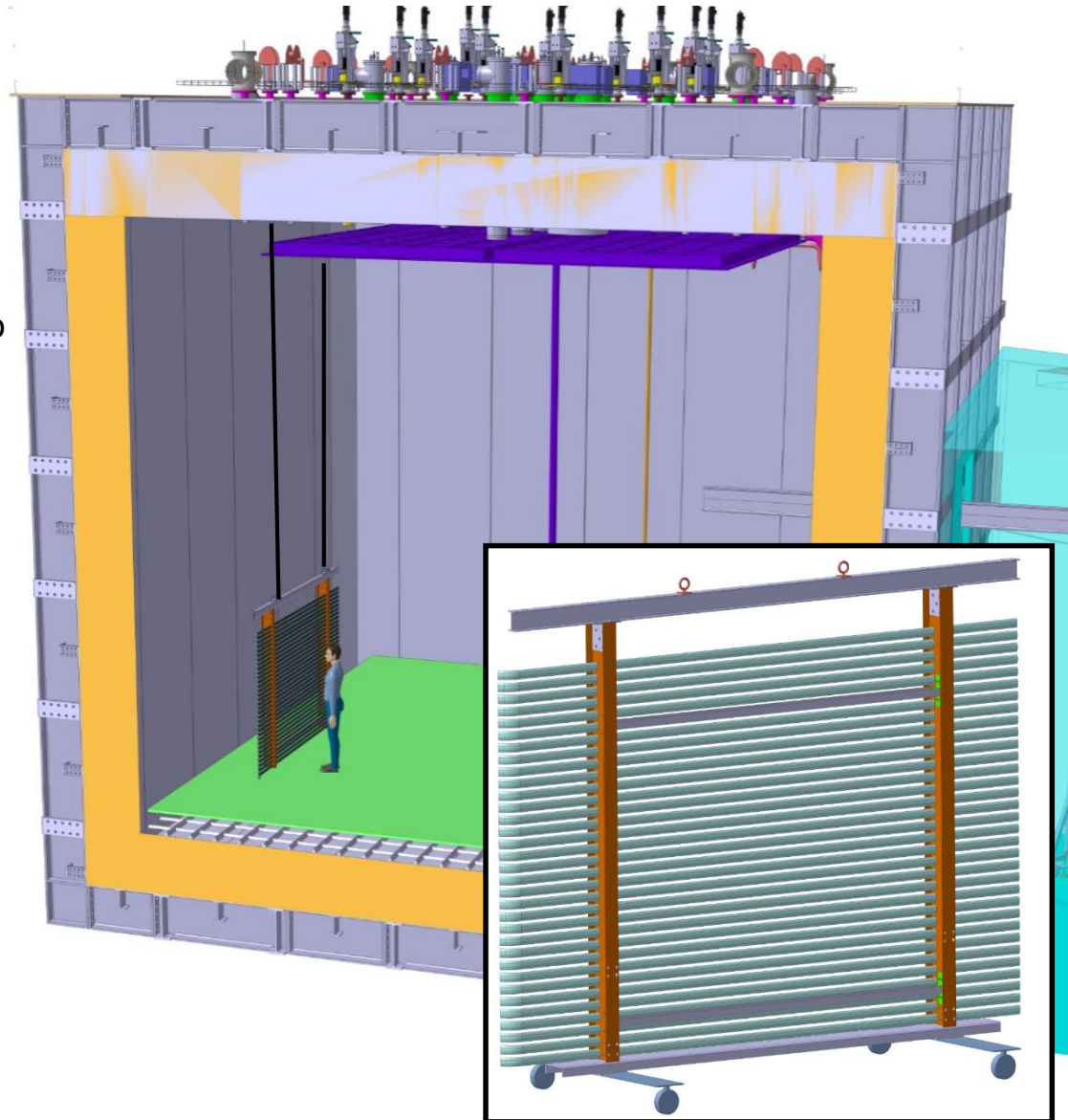


## 4) Field Cage

- Lift the I-Beam ~2.5 m
- Bring in first sub modules and connect to hanging system
- Already install the PCB boards of the HV divider (if it's needed in module)

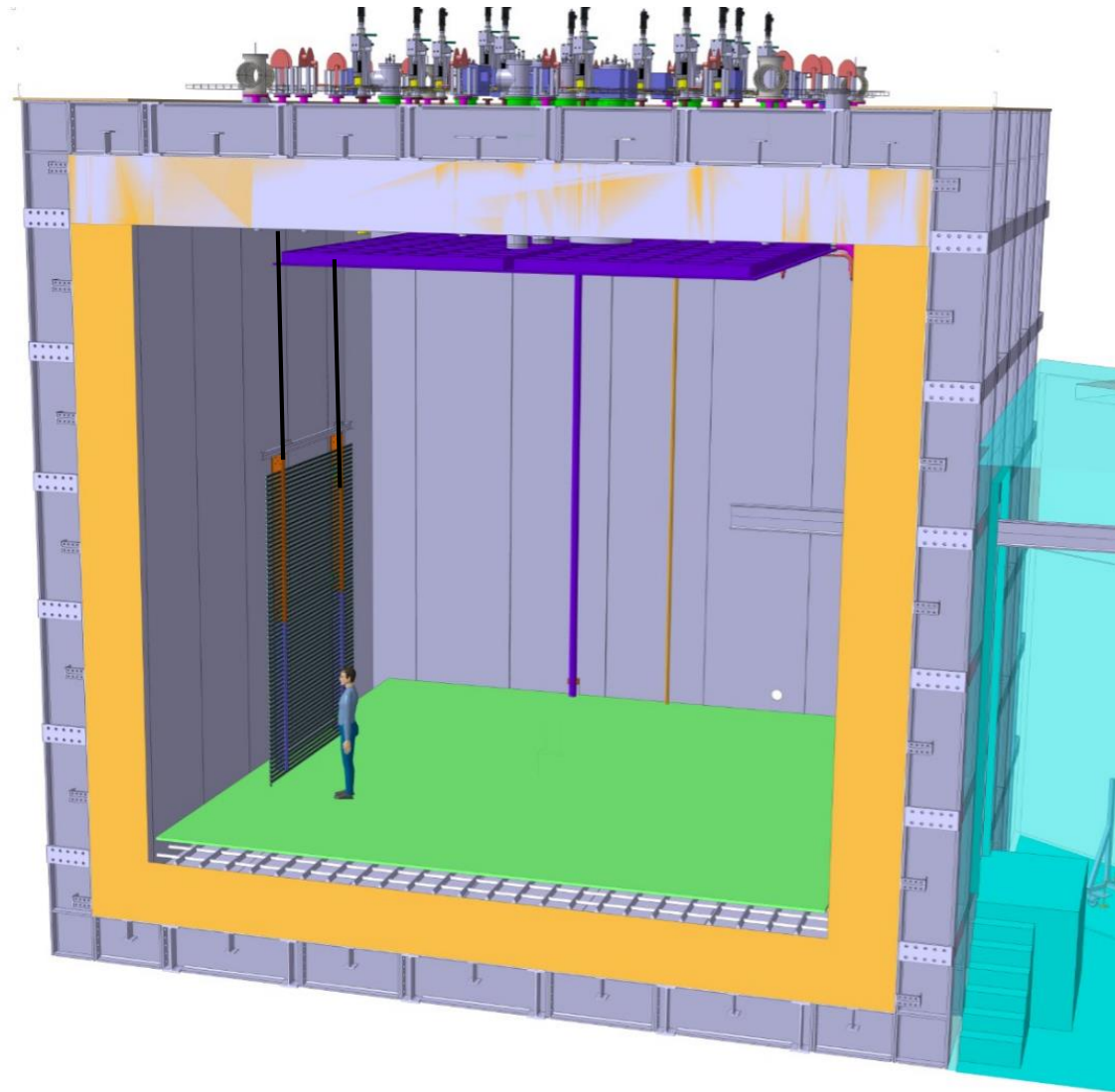
### Sub module Installation:

- 2 Person on Top Lifting
- 2 Person inside the Cryostat



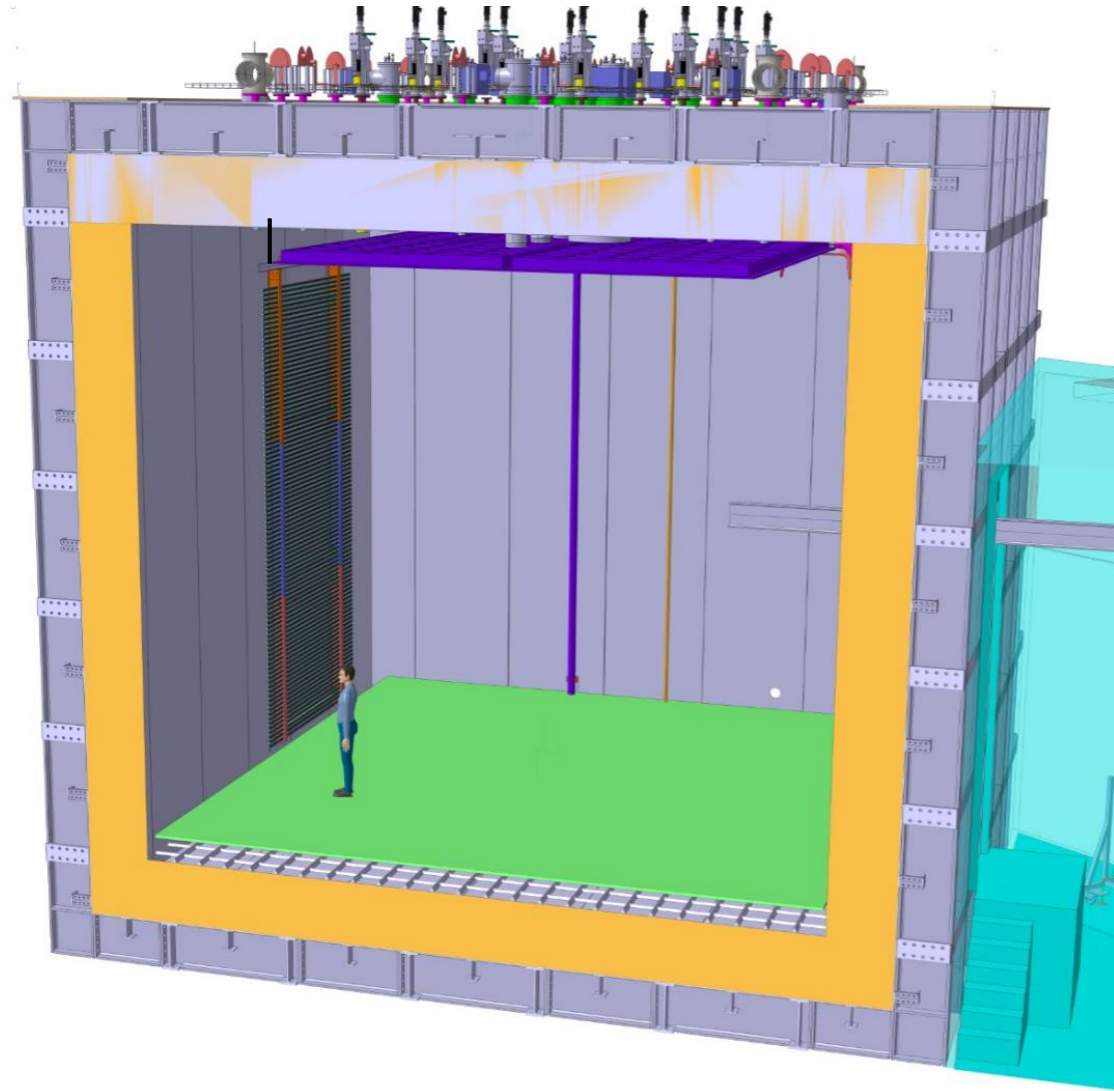
## 4) Field Cage

- Same for 2nd sub module
- Already install the PCB boards of the HV divider (if it's needed in module)
- Lift for another 2.5m



## 4) Field Cage

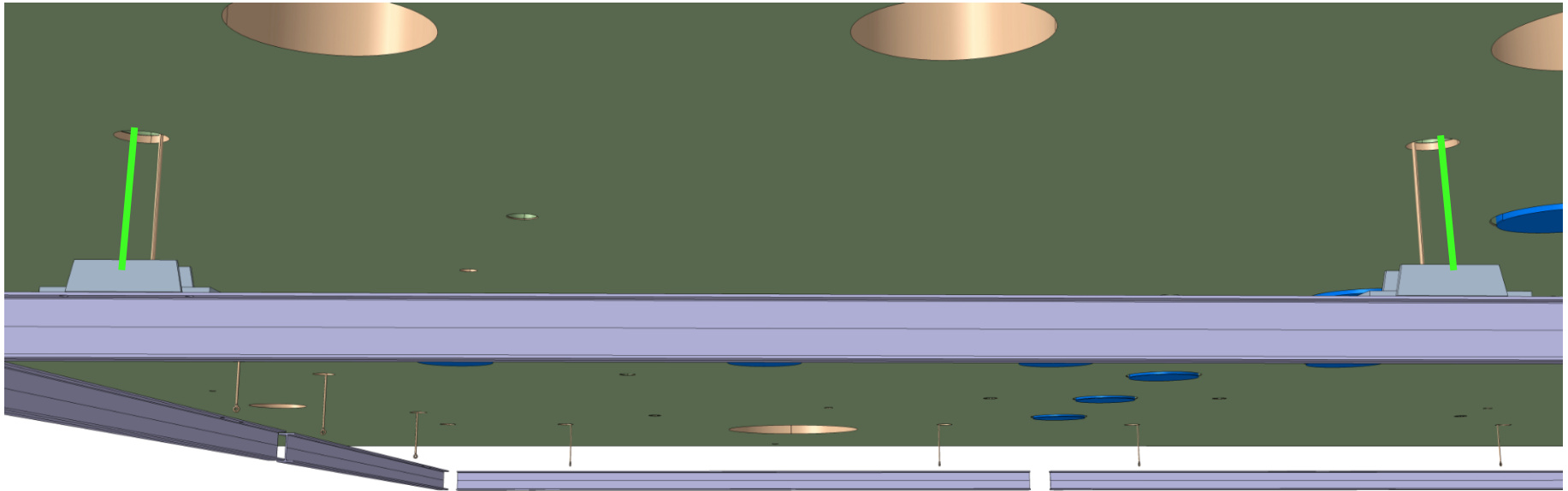
- 3rd sub module
- Lift the entire module at his nominal position



## 4) Field Cage



- When the module is in nominal vertical position the additional final hanging wire can be installed
- Final wires are installed with possibility to fine tune the length
- Installation wires can be then removed



## 4) Field Cage

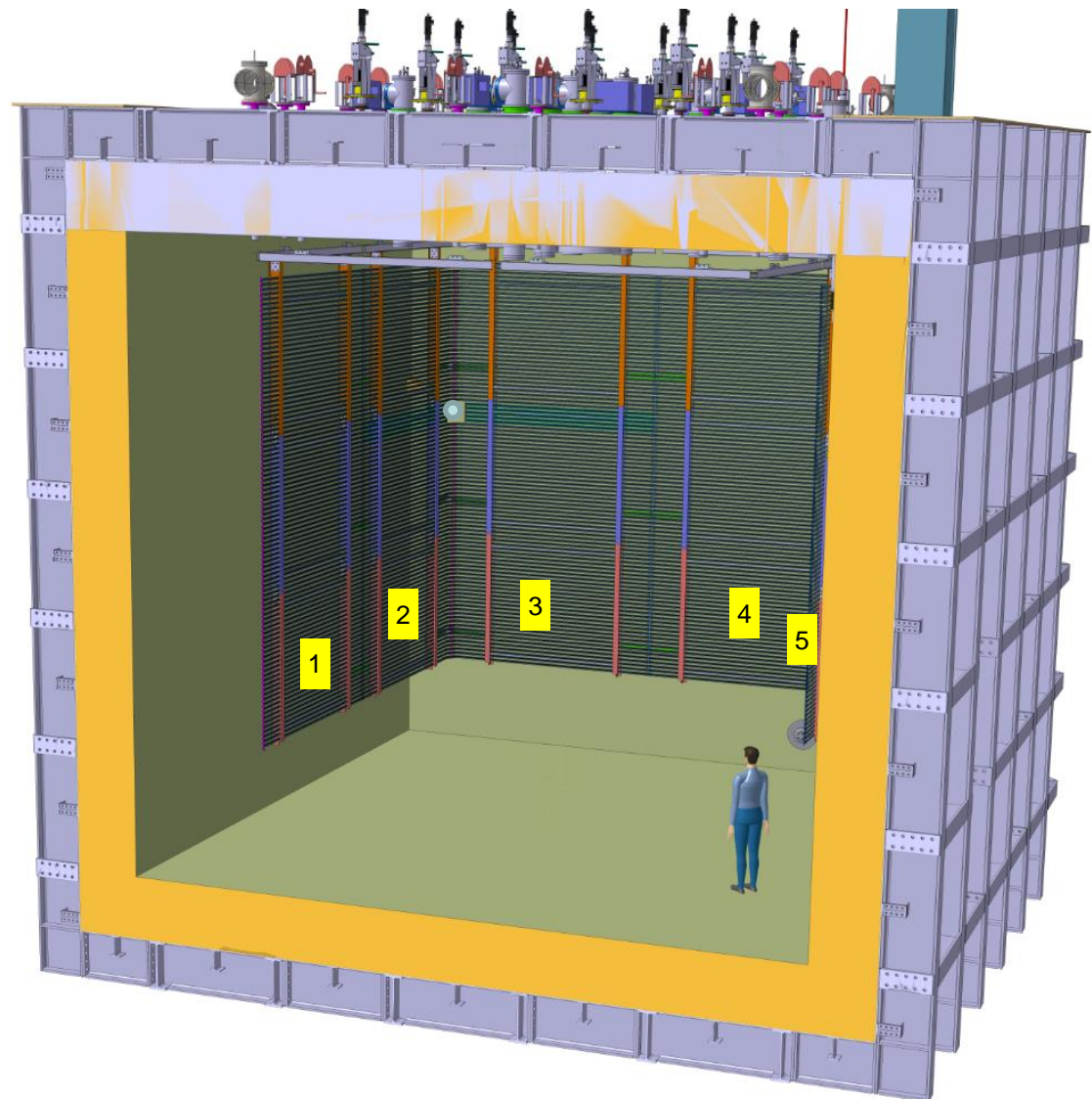
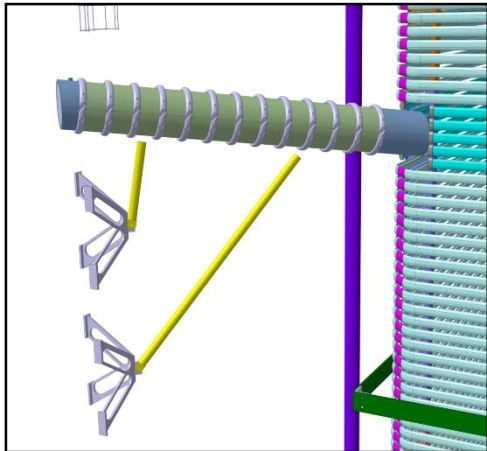
- 5 modules complete
- Clips and reinforcement between these modules can be already installed
- On Modules 1 and 5 already install during assembly the PCB Boards

Clips and Reinforcement Installation :

- 1 Person Inside the field cage
- 1 Person Externally of the field cage

At this configuration:

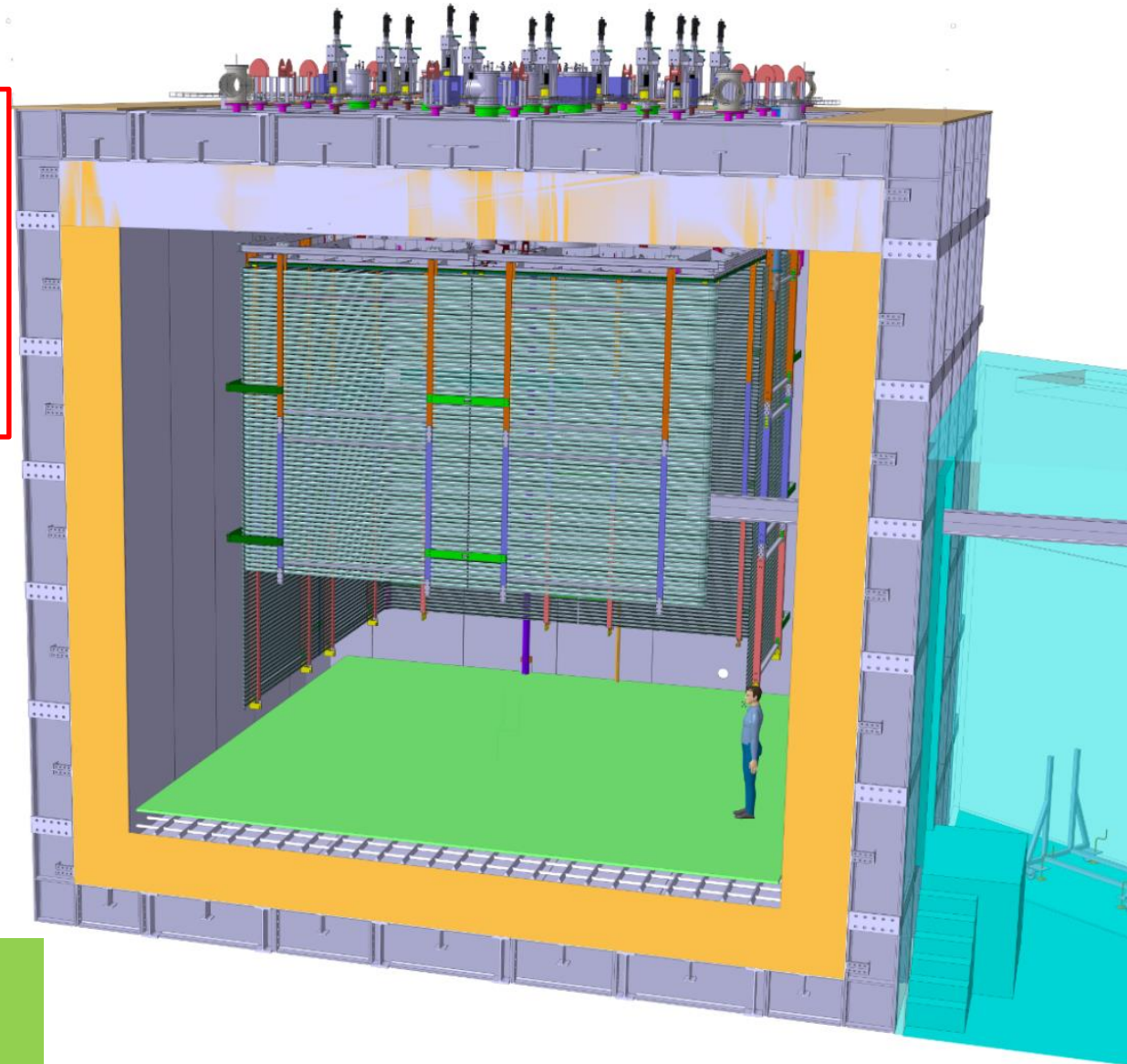
- Beam Plug can be installed



mid-February 2018

## 4) Field Cage

- 2 x Modules 2/3 completed
- 1 Module missing (TCO Side)
- Install where is possible Clips and reinforcement.

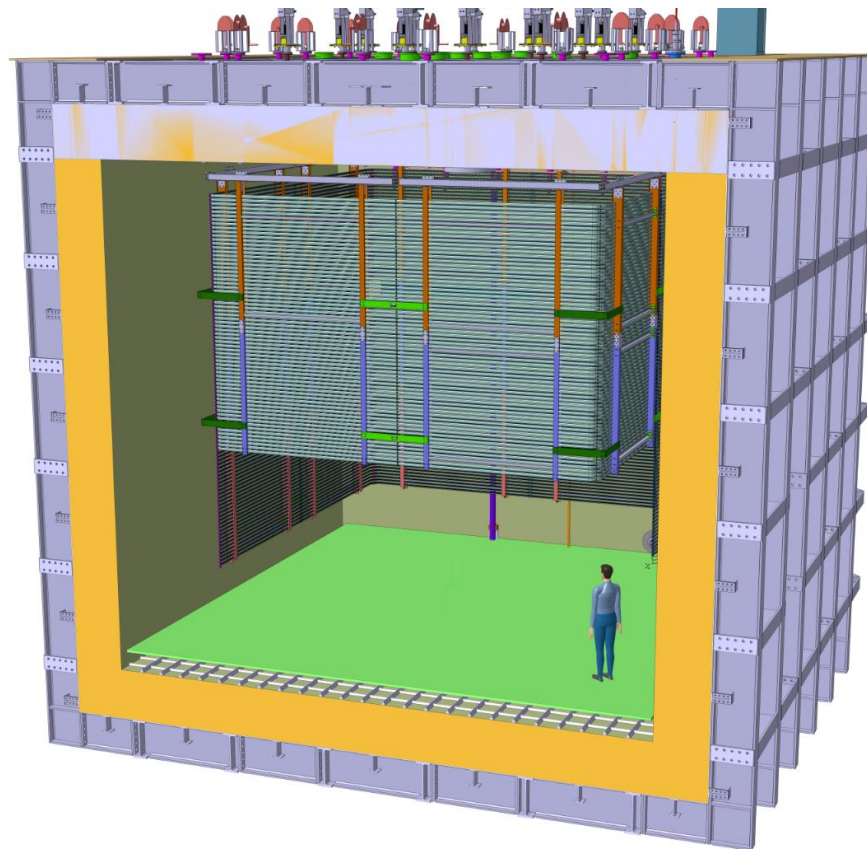


### Clips and Reinforcement Installation :

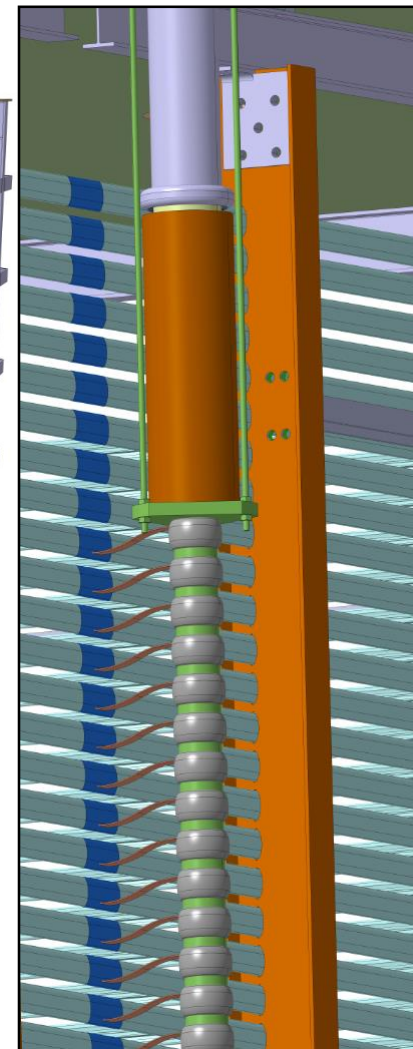
- 1 Person Inside the field cage
- 1 Person Externally of the field cage

## 5) Cathode and Groundgrid

- Bring in the 5 x FC Sub Modules left and place them vertically at the side of the Cryostat
- Bring in Cathode and Ground Grid Modules
- Dismantle the crane I-Beam
- Assemble 2/3 of the module in front of the TCO
- Connect missing clips and Reinforcement
- Assemble first 2/3 of the HV degrader.
- HVFT can be already inserted
- Bring out Movable scaffolding

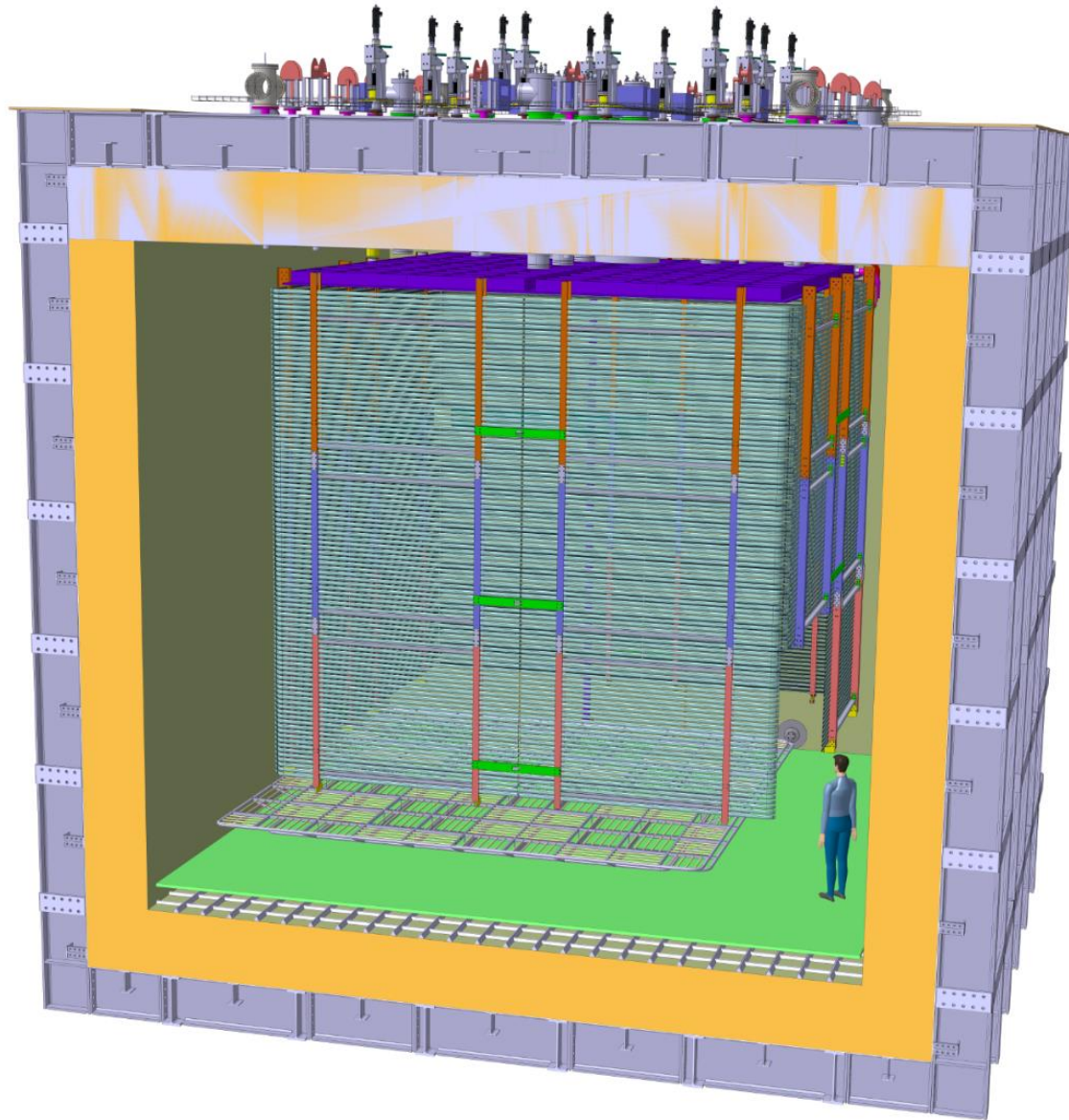


Cables of HV degrader connected with the clips



## 5) Cathode and Groundgrid

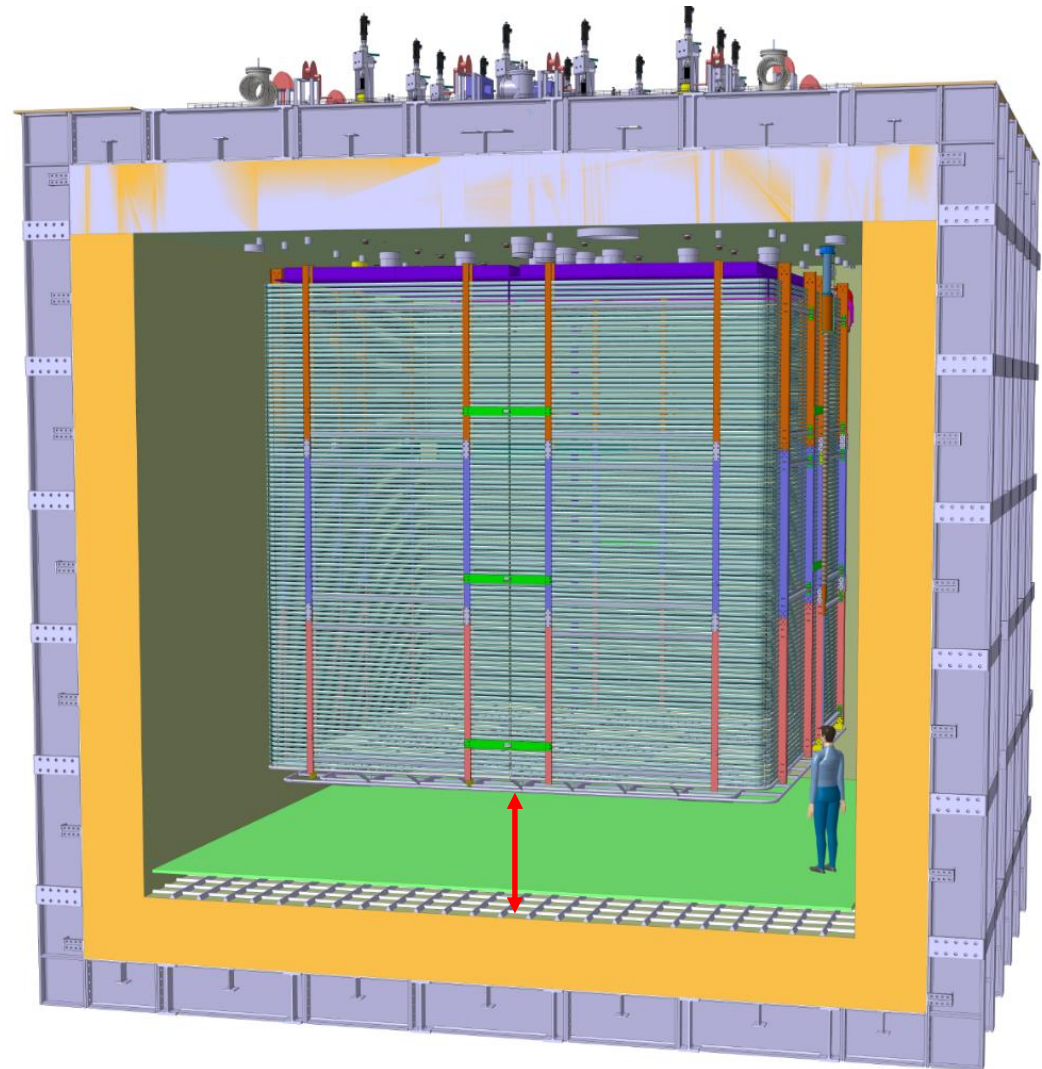
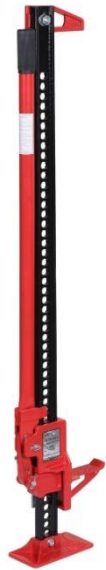
- Assemble Cathode and Ground Grid connected together on wheels supports and move it to a corner
- Install 3 last Sub modules
- Last sub-module to be installed → in front of the TCO
- Complete installation of the Reinforcement, clips and HV degrader
- For the last Row of sub modules is sufficient a movable stairs inside the Drift Cage (~1.5m height)





## 5) Field Cage, Cathode and Groundgrid

- Lift the Cathode+Groundgrid and fix it to the field cage (manual lifter)



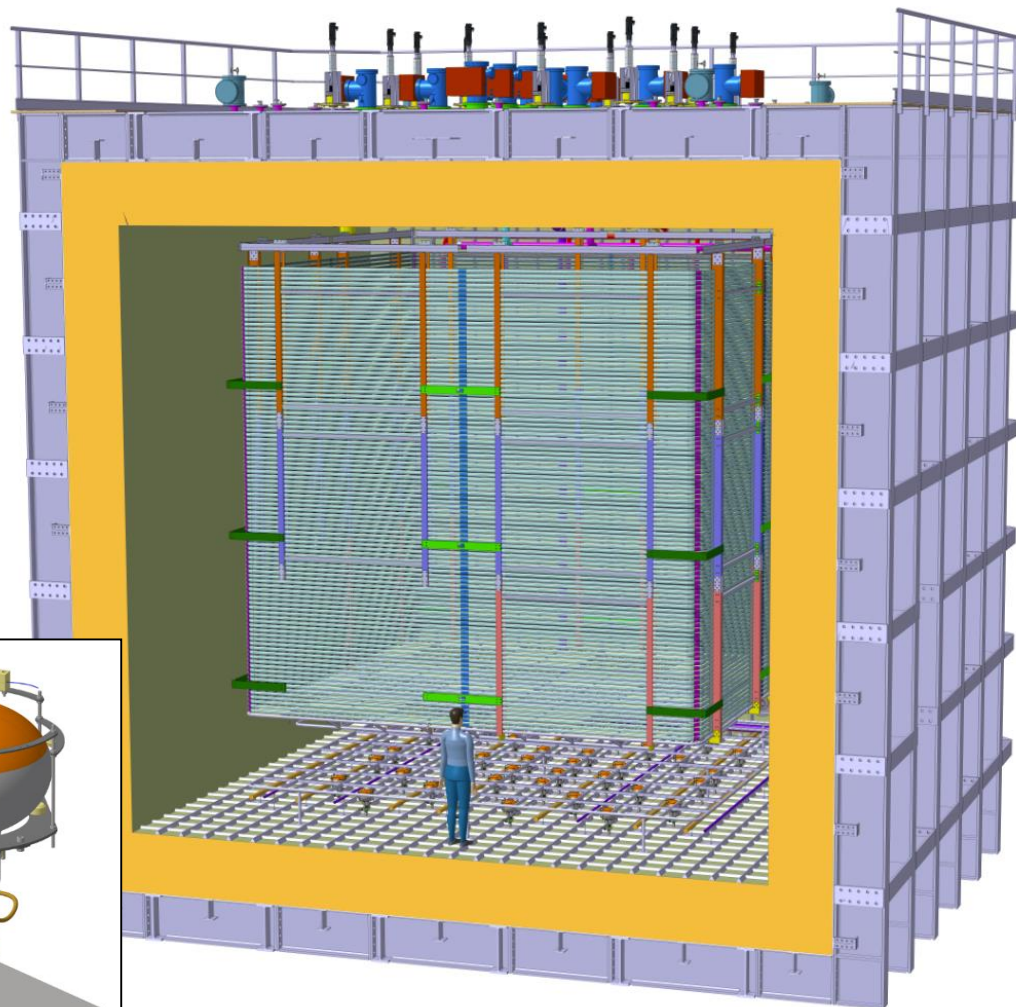
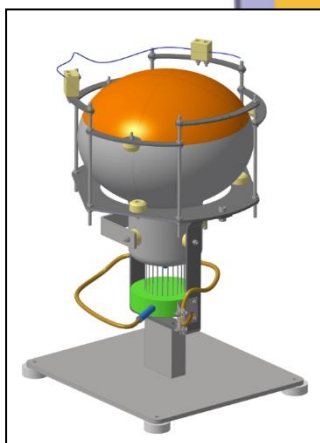
Membrane - Ground Grid distance: ~1.2m

## 6-7) Removal of Construction Floor Groundrid and PMTs

From 15/03/2018

- Removal of the scaffolding and construction floor
- Installation of the PMTs  
→ ~1.2m flat membrane to Groundgrid  
See A.Verdugo Talk - *PMT system production, QA and installation*
- PMTs cabling on cryostat floor
- Positioning of the Groundgrid pillars
- Lowering of the Ground Grid

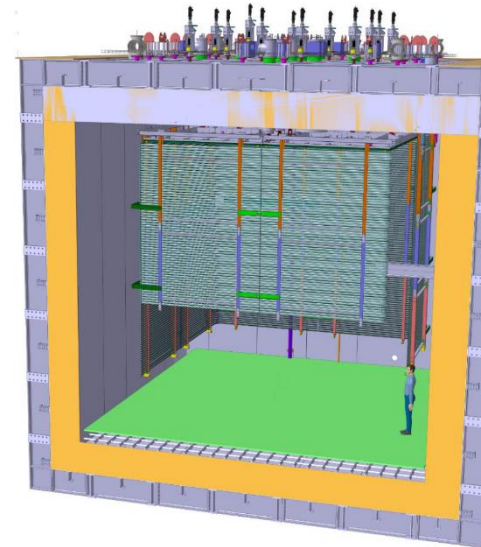
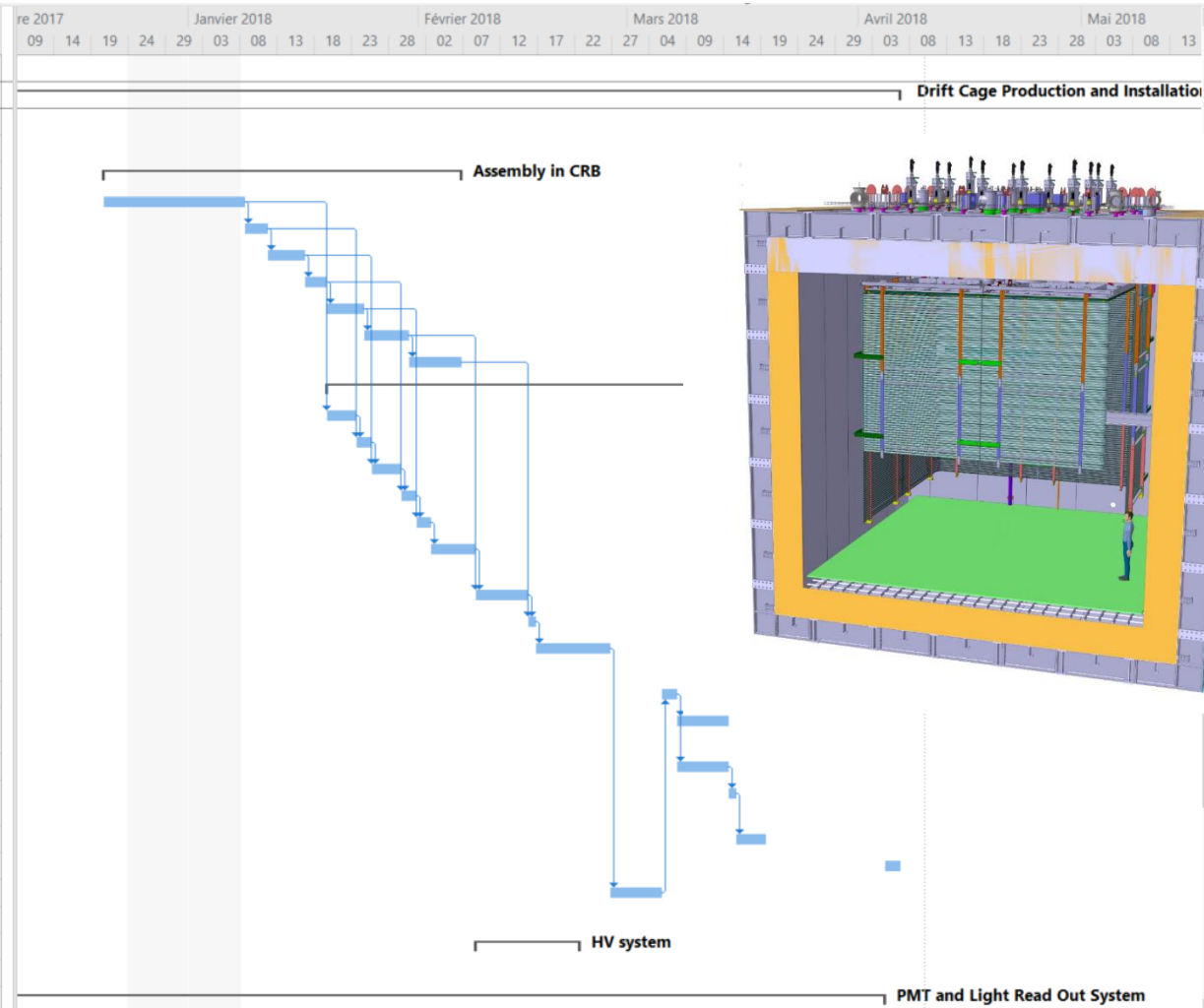
End of March 2018



# Field Cage Installation

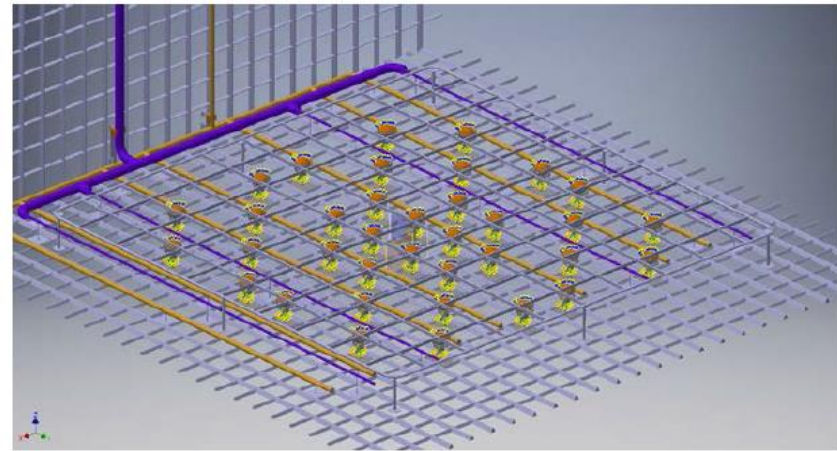
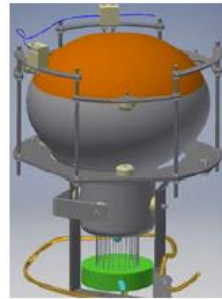
- New assembly procedure in the cryostat to take into account, space, logistics etc....

Task name	Duration (days)	Start date (dd/mm/yy)	Finish date (dd/mm/yy)
<b>Drift Cage Production and Installation</b>	<b>235 days</b>	<b>01/05/2017</b>	<b>06/04/2018</b>
Mechanical Test assembly in UTA	89 days	01/05/2017	31/08/2017
PCB production and testing in cold	87 days	01/06/2017	29/09/2017
<b>Assembly in CRB</b>	<b>24 days</b>	<b>20/12/2017</b>	<b>06/02/2018</b>
3 submodules of column 1	3 days	20/12/2017	08/01/2018
3 submodules of column 2	3 days	08/01/2018	11/01/2018
3 submodules of column 3	3 days	11/01/2018	16/01/2018
3 submodules of column 4	3 days	16/01/2018	19/01/2018
3 submodules of column 5	3 days	19/01/2018	24/01/2018
4 submodules of column 6 and 7	4 days	24/01/2018	30/01/2018
5 submodules to install last	5 days	30/01/2018	06/02/2018
<b>Installation in cryostat</b>	<b>55 days</b>	<b>19/01/2018</b>	<b>06/04/2018</b>
Assemble First column	2 days	19/01/2018	23/01/2018
Assemble Second column	2 days	23/01/2018	25/01/2018
Assemble Third column	2 days	25/01/2018	29/01/2018
Assemble Fourth column	2 days	29/01/2018	31/01/2018
Assemble Fifth column	2 days	31/01/2018	02/02/2018
Fix clips and contacting dividers and reinforcements	4 days	02/02/2018	08/02/2018
Assemble 2/3 of columns 6 and 7	5 days	08/02/2018	15/02/2018
Bring last 5 submodules on the side	1 days	15/02/2018	16/02/2018
Bring and assemble cathode and GND grid modules	6 days	16/02/2018	26/02/2018
Remove Crane I-Beam inside the	2 days	05/03/2018	07/03/2018
Install 4 of the last FC submodules + missing reinforcement clips	5 days	07/03/2018	14/03/2018
HVFT and degraders	5 days	07/03/2018	14/03/2018
connect cathode and ground grid to the FC	1 day	14/03/2018	15/03/2018
Remove floor and scaffoldings	2 days	15/03/2018	19/03/2018
Lower the ground grid	2 days	04/04/2018	06/04/2018
Beam plug installation	5 days	26/02/2018	05/03/2018
<b>HV system</b>	<b>10 days</b>	<b>08/02/2018</b>	<b>22/02/2018</b>
<b>PMT and Light Read Out System</b>	<b>340 days</b>	<b>01/12/2016</b>	<b>04/04/2018</b>

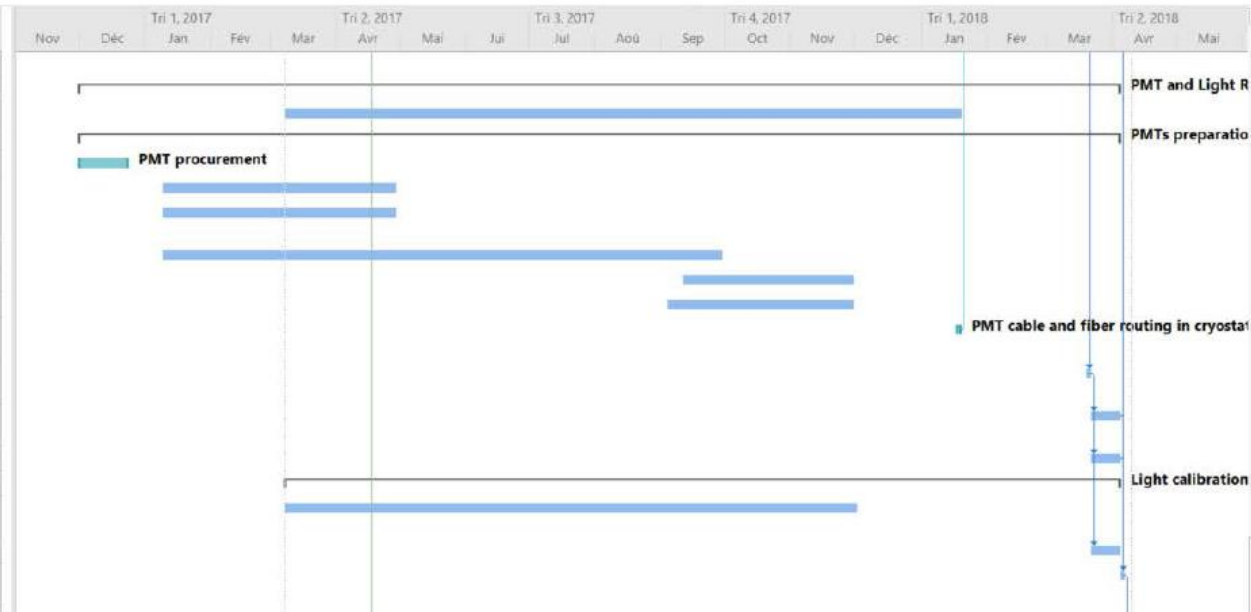


10/01/2017

# Light Readout System



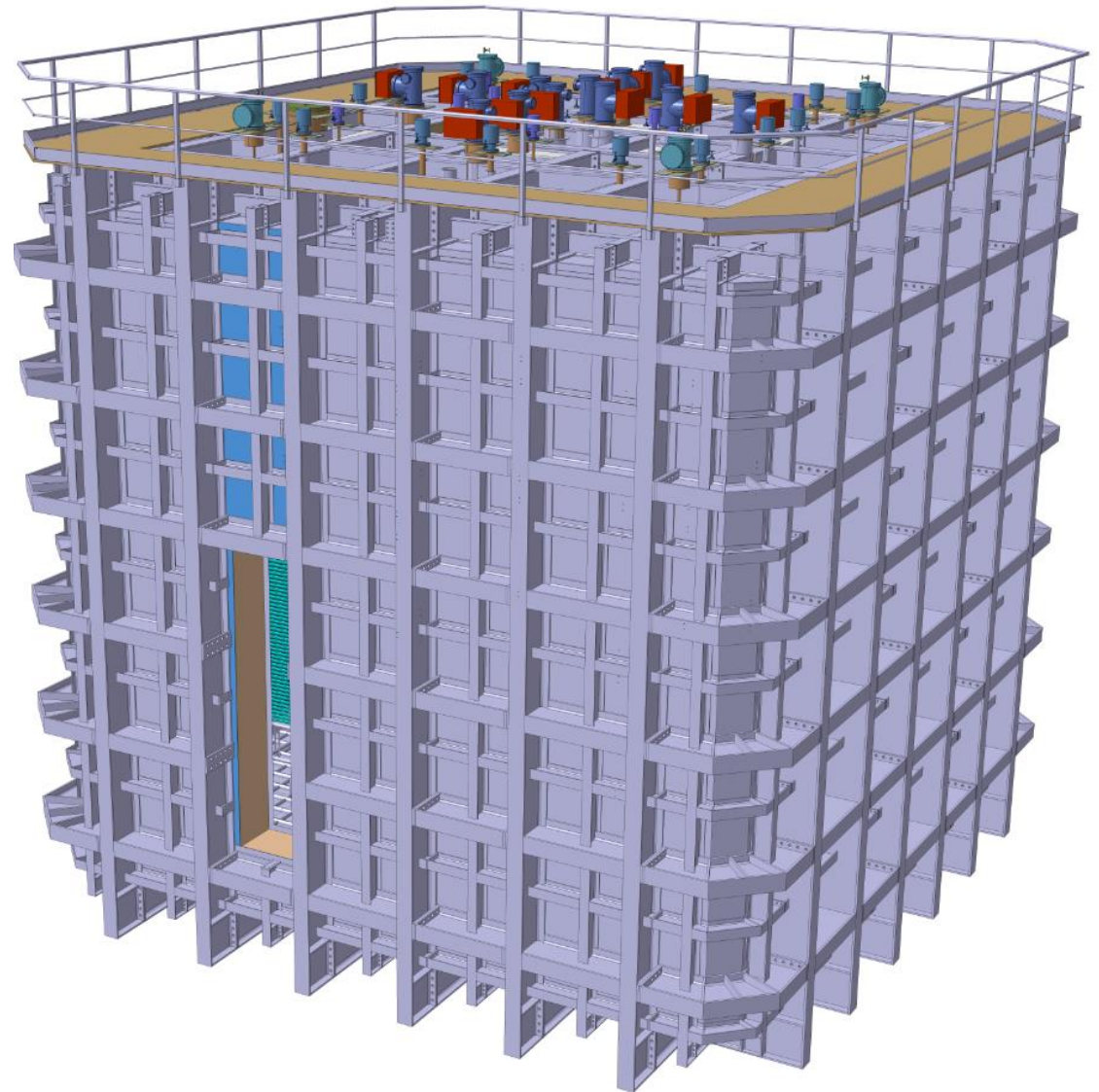
Task name	Duration (days)	Start date (dd/mm/yy)	Finish date (dd/mm/yy)
<b>• PMT and Light Read Out System</b>	<b>340 days</b>	<b>01/12/2016</b>	<b>04/04/2018</b>
LRO electronics	218 days	08/03/2017	19/01/2018
<b>• PMTs preparation and installation</b>	<b>340 days</b>	<b>01/12/2016</b>	<b>04/04/2018</b>
PMT procurement	17 days	01/12/2016	23/12/2016
PMT base design and manufacturing	80 days	09/01/2017	28/04/2017
PMT support structure production and assembly	81 days	09/01/2017	28/04/2017
PMTs characterization	190 days	09/01/2017	29/09/2017
TPB coating	59 days	11/09/2017	30/11/2017
Splitter production and tests	64 days	04/09/2017	30/11/2017
PMT cable and fiber routing in cryostat from flange to bottom	2 days	17/01/2018	19/01/2018
PMT support installation on the membrane	2 days	19/03/2018	21/03/2018
PMT testing, installation in cryostat and cabling	10 days	21/03/2018	04/04/2018
Splitter installation	10 days	21/03/2018	04/04/2018
<b>• Light calibration system</b>	<b>271 days</b>	<b>08/03/2017</b>	<b>04/04/2018</b>
Fibers, light source tests and procurement	193 days	08/03/2017	01/12/2017
Fiber calibration system installation	10 days	21/03/2018	04/04/2018
Lower the Ground grid to its final position	2 days	04/04/2018	06/04/2018



Installation and cabling in cryostat in March 2018

# 10) Closure of the TCO

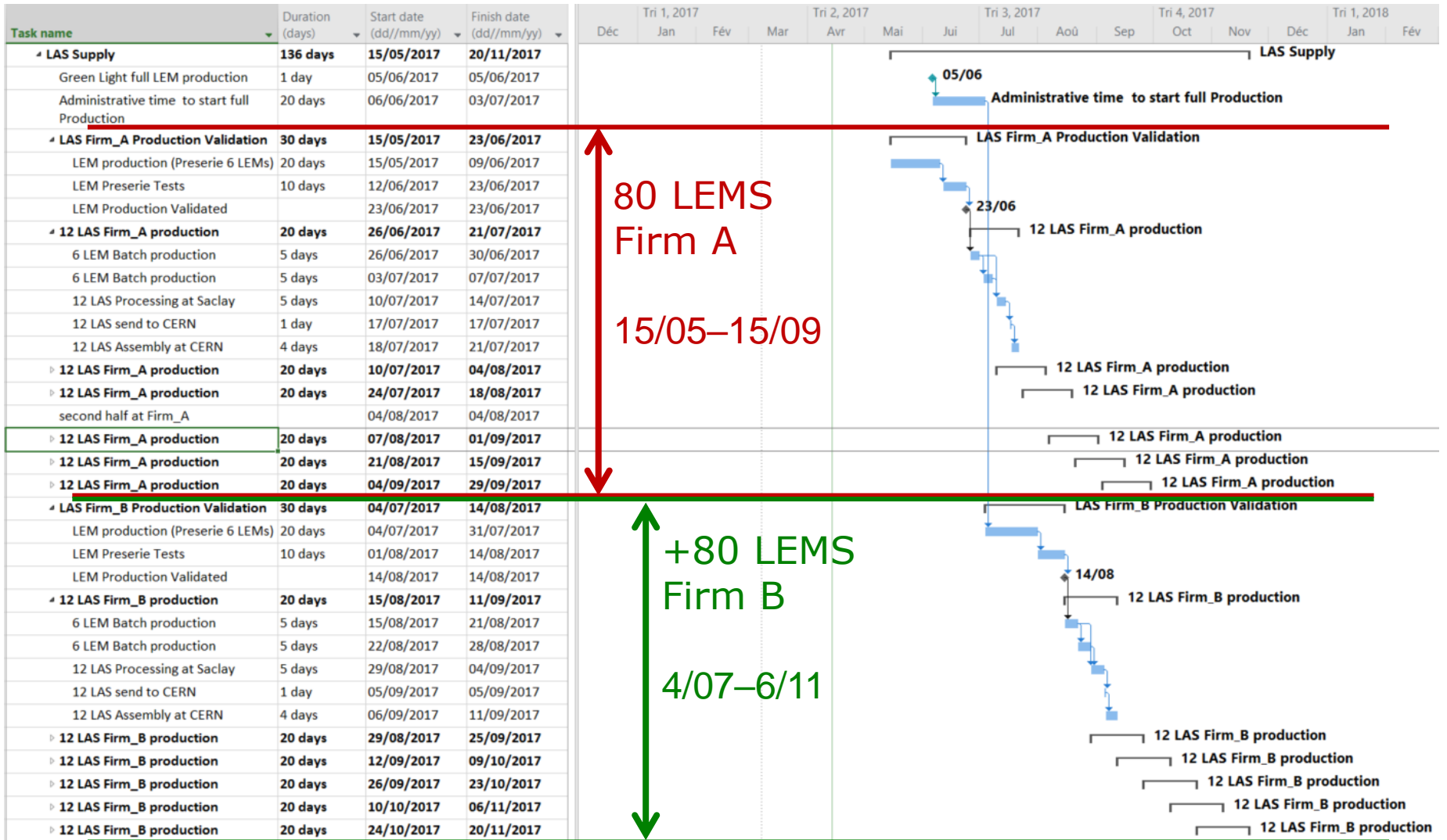
- TCO closure



April 6th 2018

Thank you

# LEM Anode Sandwich production



# Alternative Equipment needed Inside the Cryostat



- 2x personnel lift

- 2 x Movable stair (demountable)
- Max Height ~1.5/1.7 m
- Installation of the last parts (personnel lift already out)

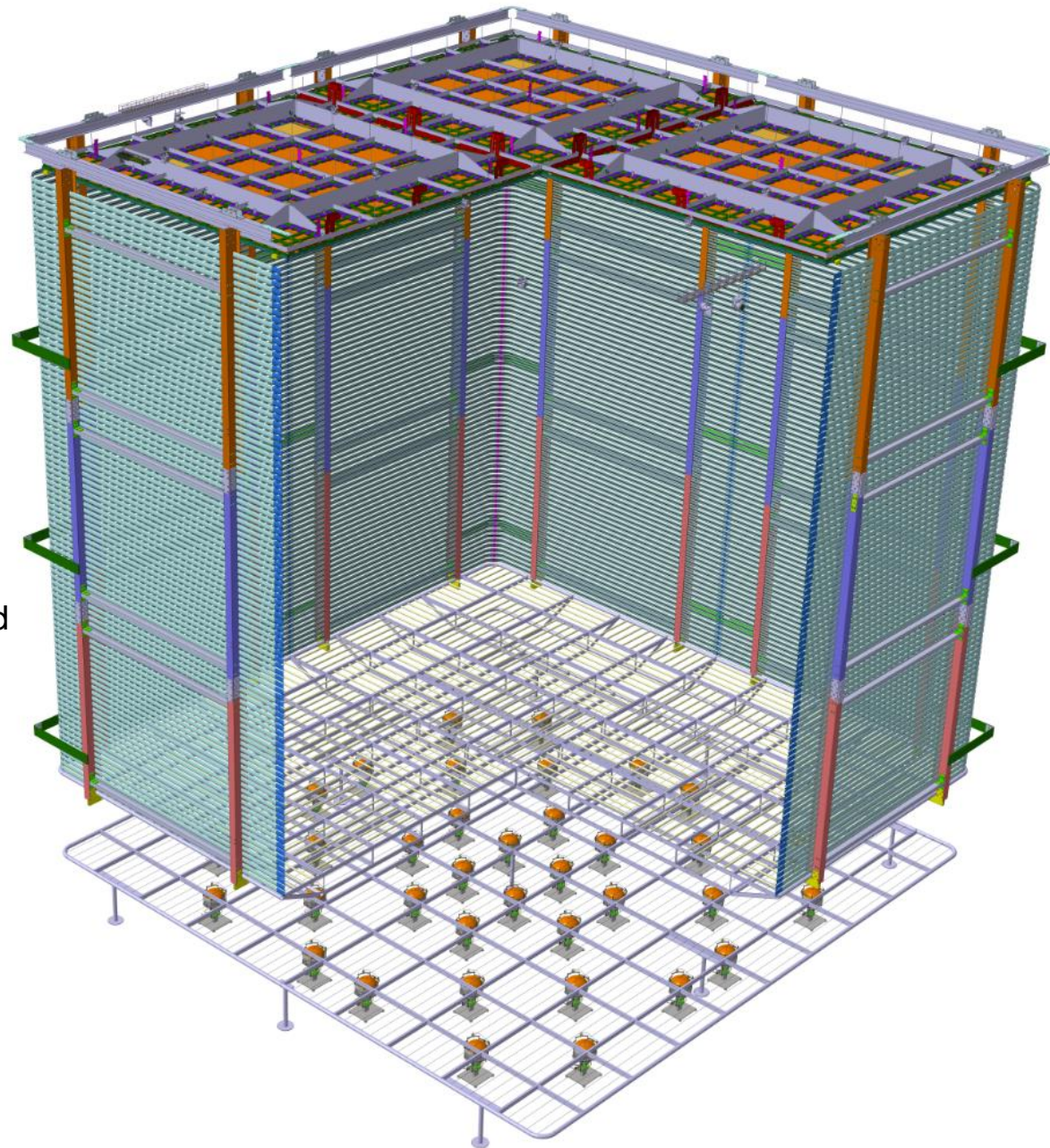
Max Height 6.5 m



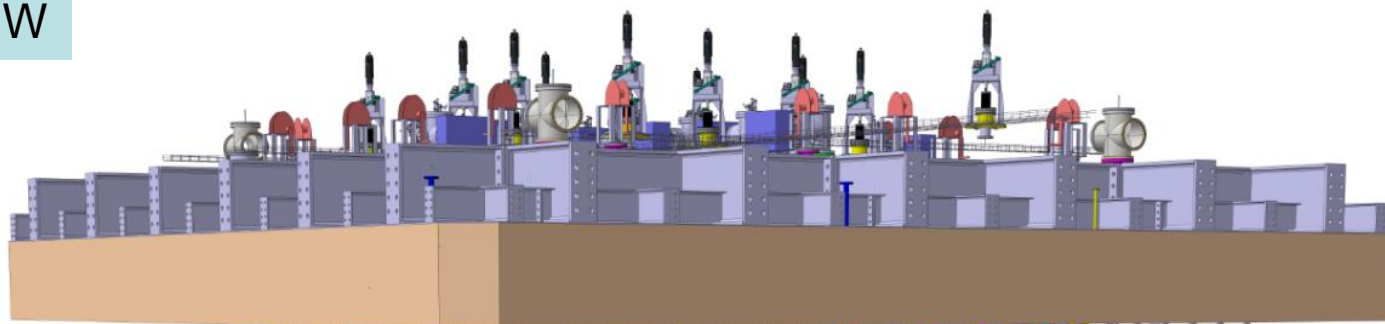
< 1m - In order to fit between FC and Cryostat walls



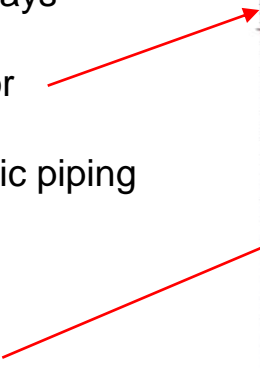
- 4x CRP Modules 3x3m<sup>2</sup>
- Field Cage (8x Modules)
- Cathode (4x Modules)
- GroundGrid (4x Modules)
- 36 x PMTs → 2 Layouts, both compatible with Internal Cryogenic and actual design of the Groundgrid



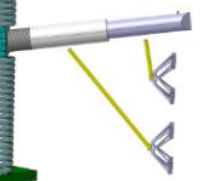
# DETECTOR OVERVIEW



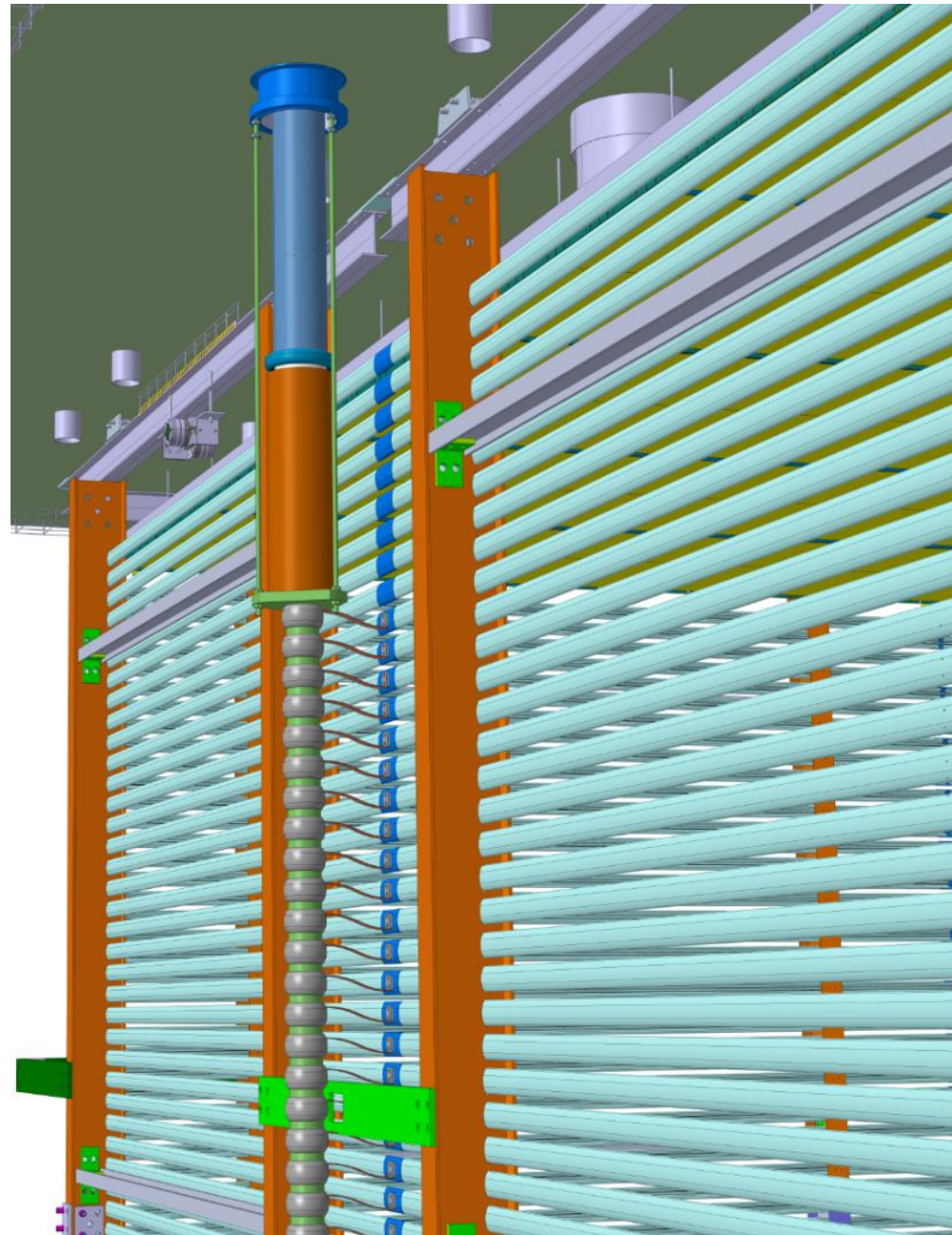
- Top FTs
- Internal Cable Trays
- 4 x Purity Monitor
- Internal Cryogenic piping
- Beam Plug
- HVFT degrader



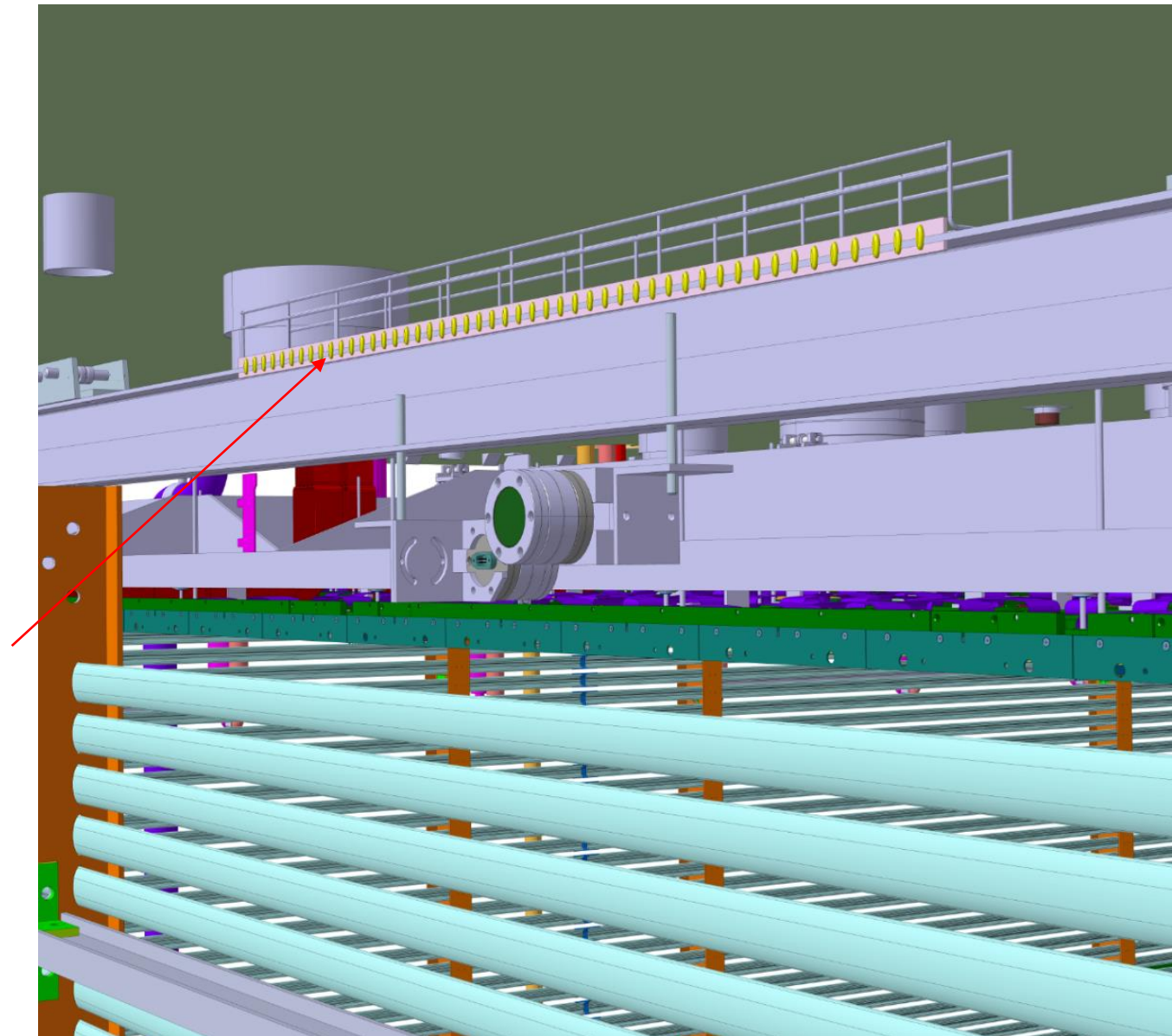
Beam Plug



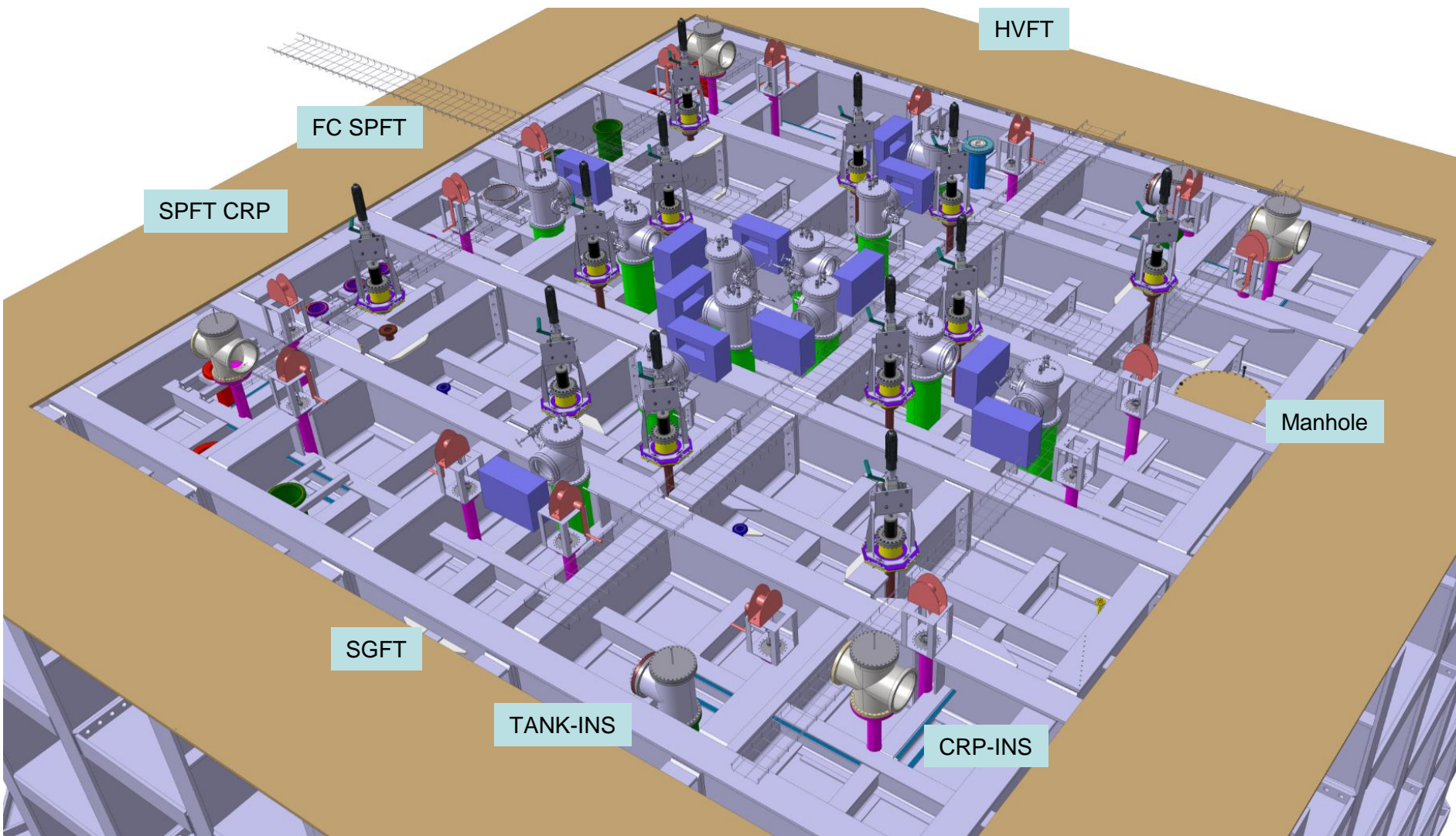
- HV Degrader decoupled from the HVFT
- Hung at the HV Crossing Pipe
- Stainless Steel Rings connected to the Field Cage Alu rings



- 4 x Cryocameras
- Same design of the 3x1x1
- Fixed at the Top SS I-Beam of the Field Cage modules
- LEDs

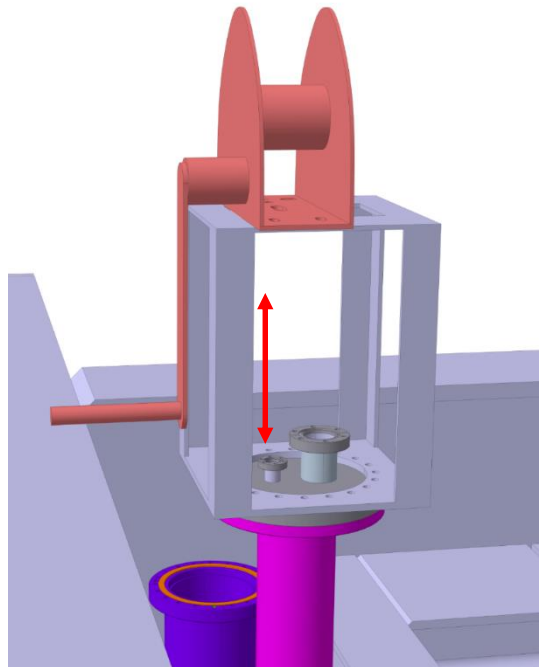


# TOP FEEDTHROUGH



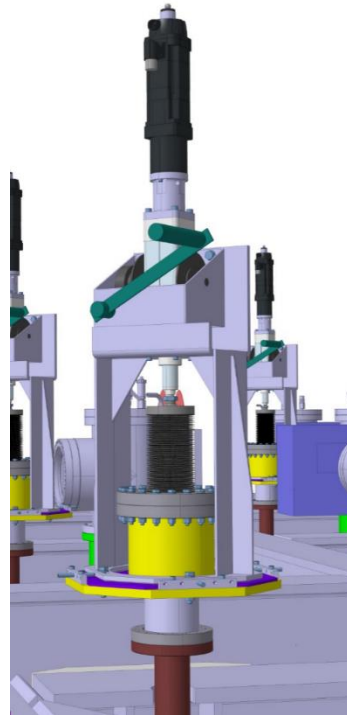
## 12 x FC SPFT

- CF160 with 2 Small Chimney
- CF40 Field Cage Lifting
- CF16 Field Cage fixing



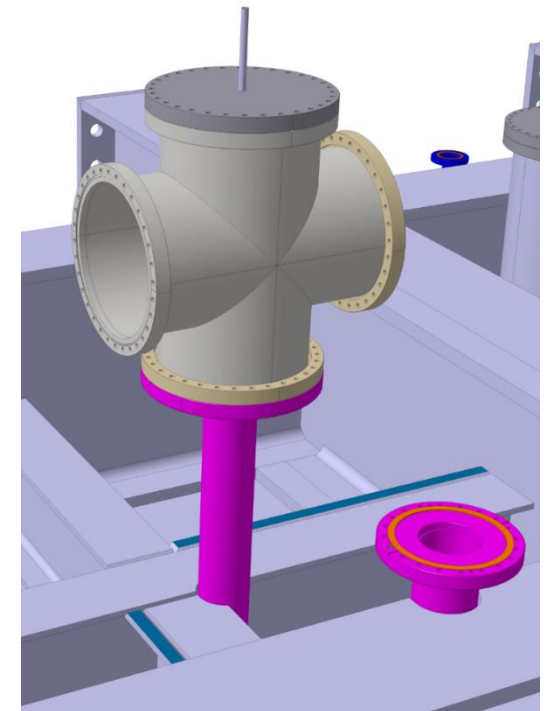
## 12 x SPFT CRP

- CF100 at the Crossing pipe
- Motor for vertical regulation
- X-Y Manual Regulation
- Manual Lifter for CRP Installation



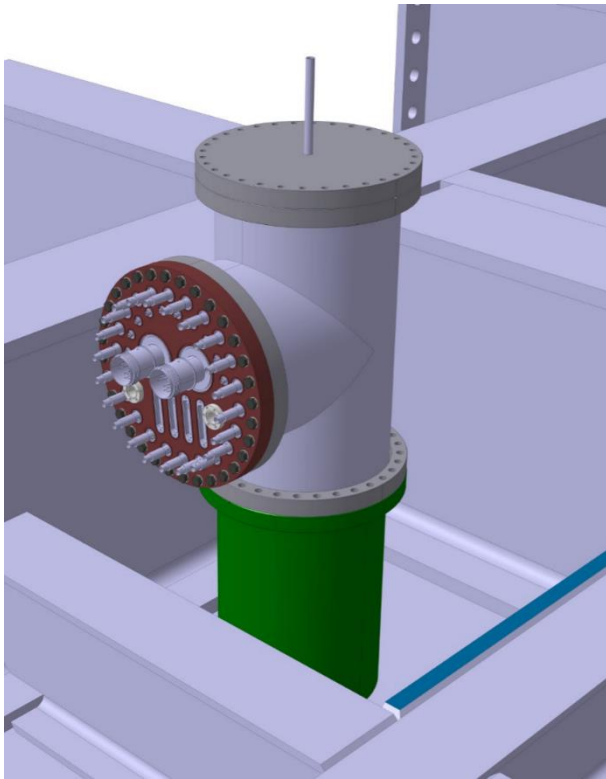
## 4 x CRP-INS

- CF250 Cross
- Flange with connectors not yet integrated



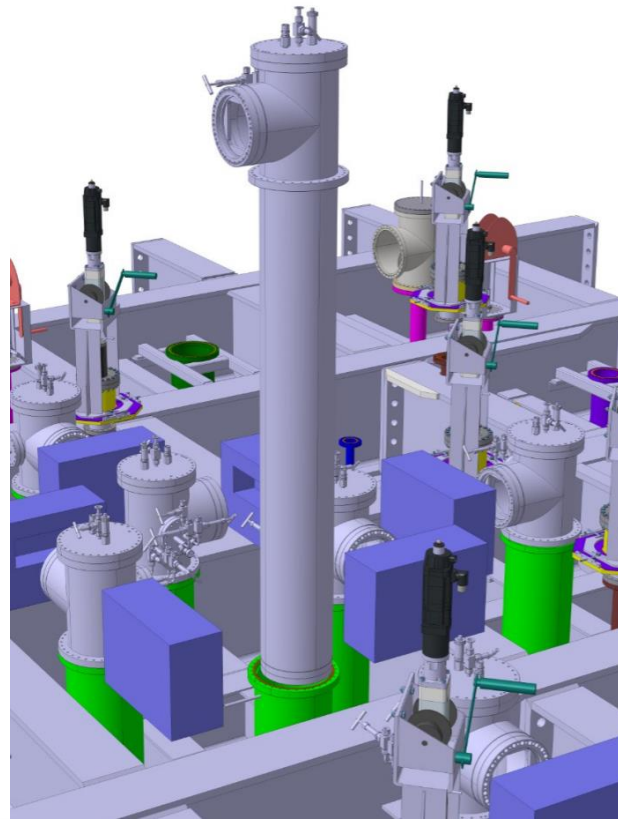
## 2 x TANK-INS

- CF250 Tee
- CF250 with connectors



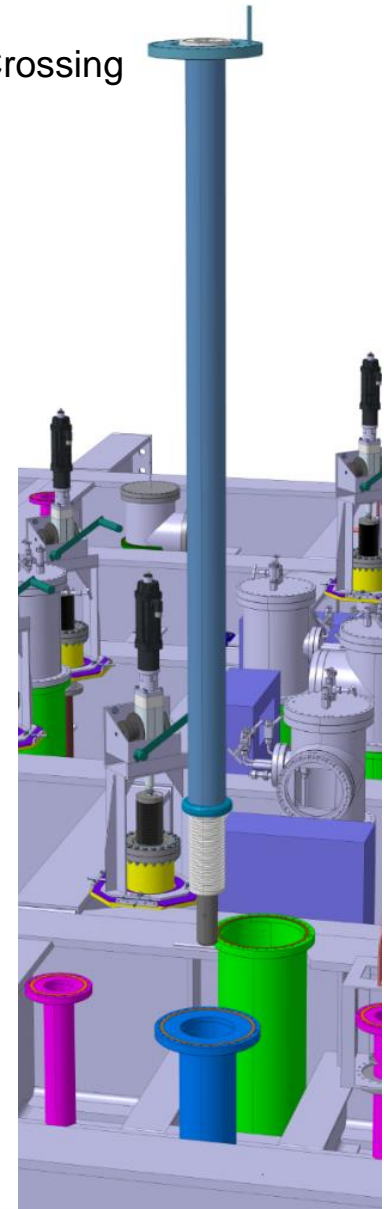
## 12 x SGFT

- CF250 Tee

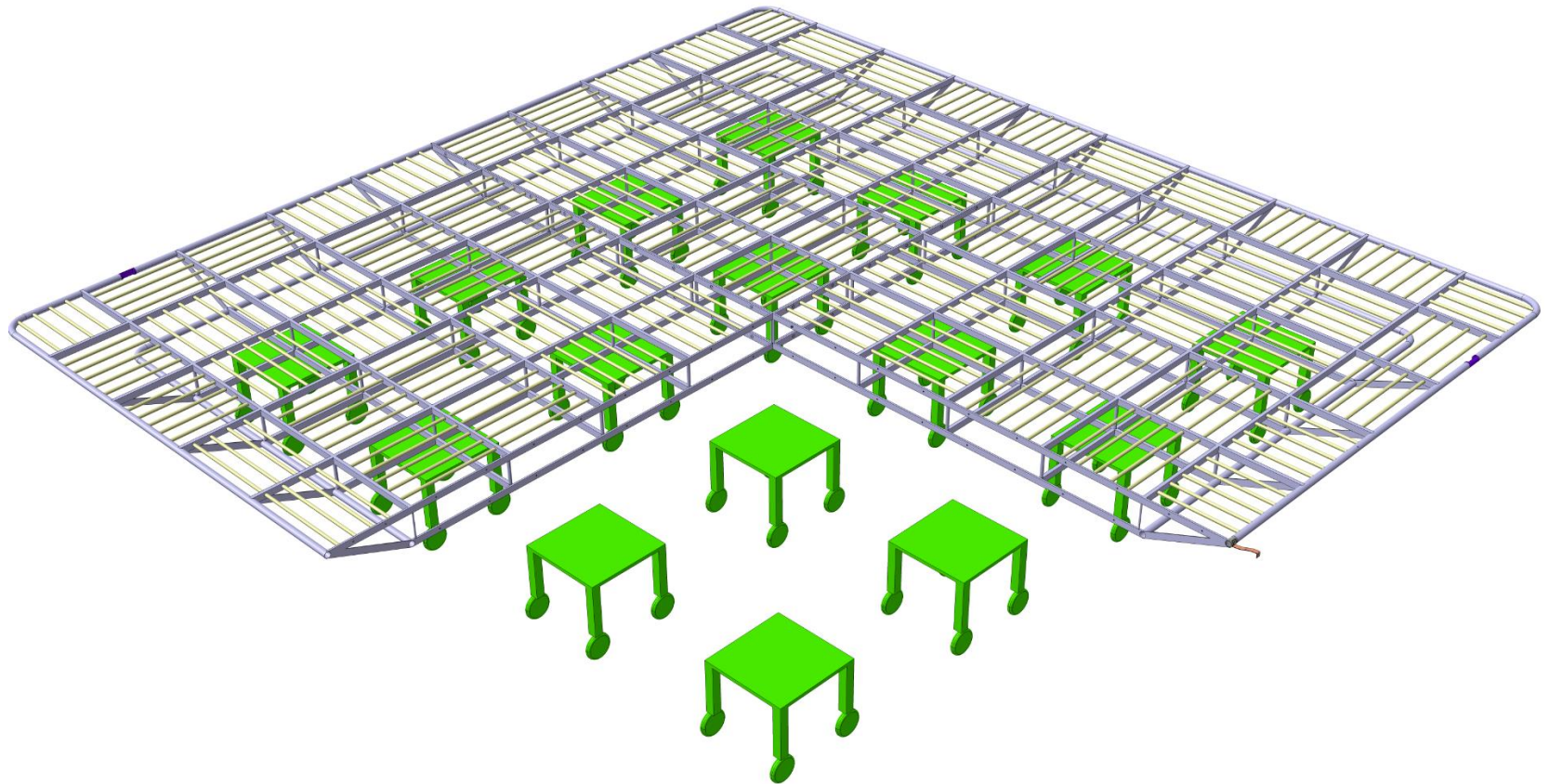


## 1 x HVFT

- CF250 at the Crossing Pipes



- 4 modules needs to be placed on Tables wheels at least 50 cm height

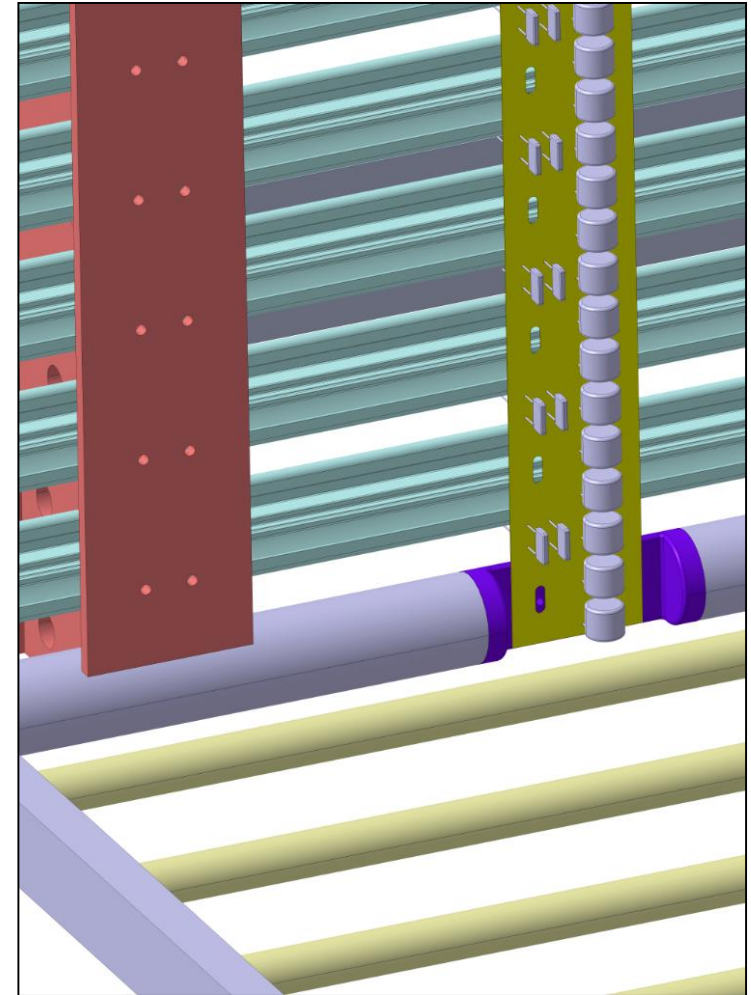
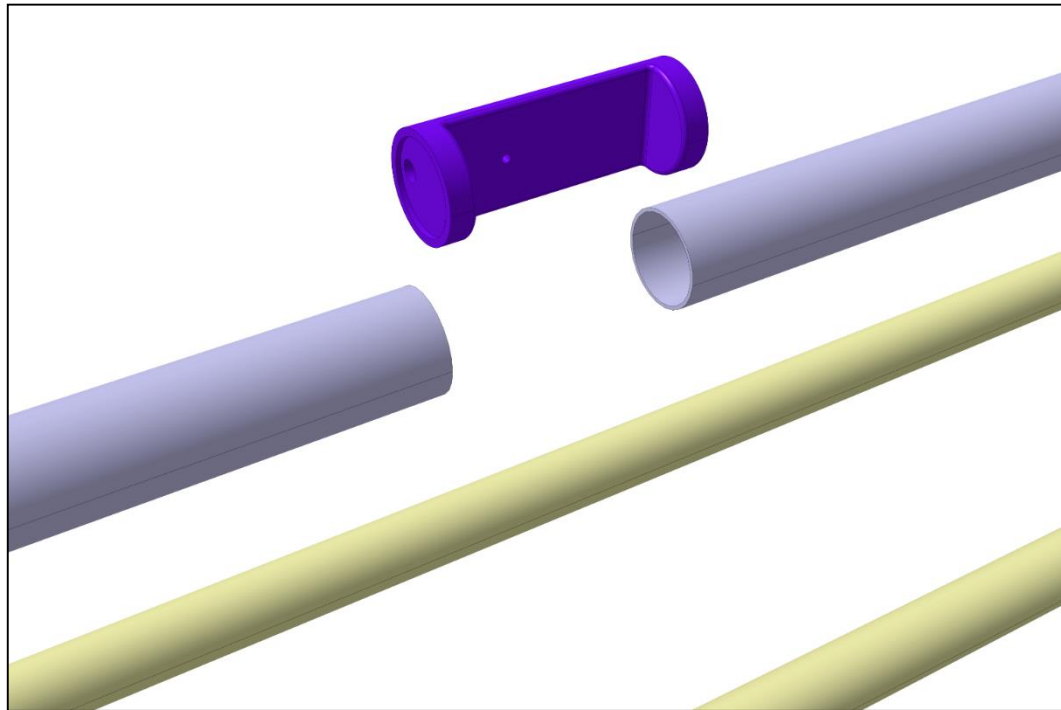


- Access for the connection for the first 3 modules is simple
- For the last module is needed to insert and tight the screws from below

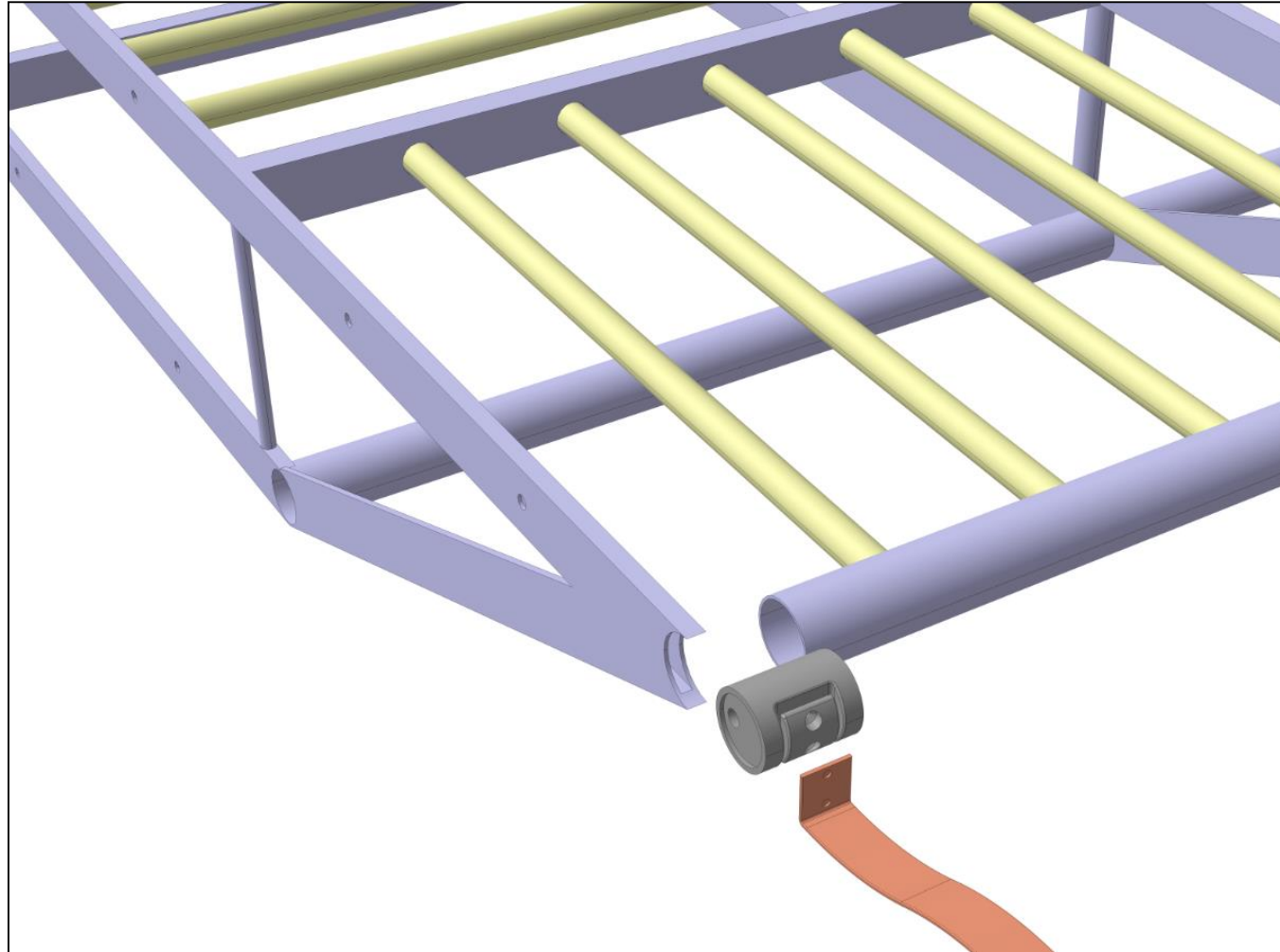


# PCB Board Voltage divider connection

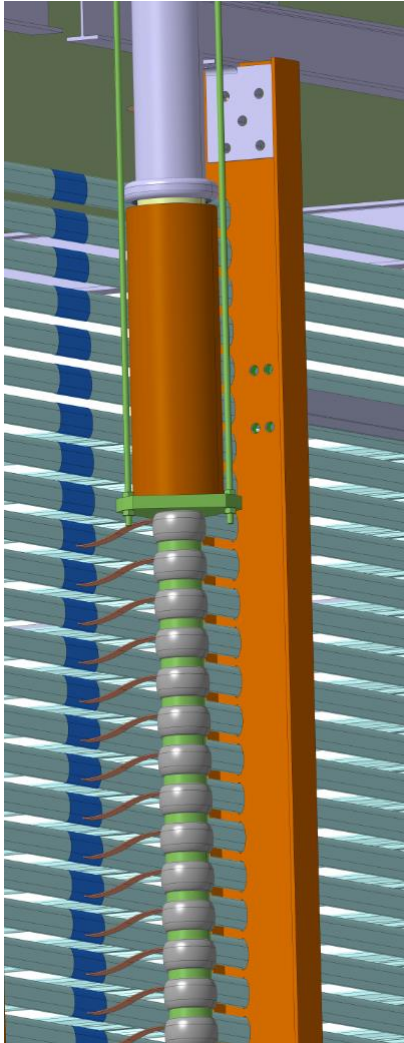
- 2 modules have special connection for the PCB Board
- Full rod (dia 40mm) insert of 100mm length machined in order to accomodate the PCB Board



- 1 Module have a special connection for the HV degrader
- Full rod (dia 40mm) insert with «cap» of 50mm length machined for cable fixing



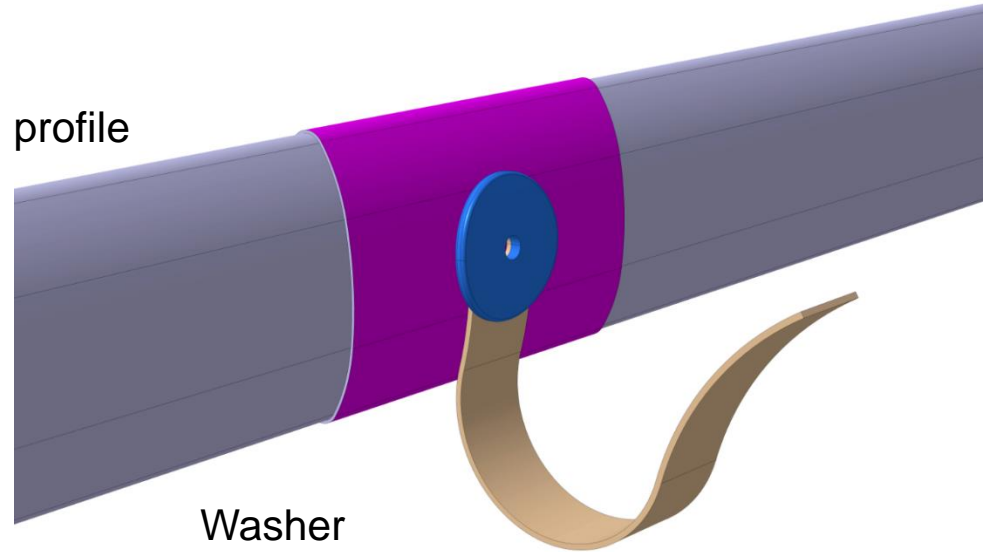
HVFT



HV degrader

Clip

Alu profile



Washer

Cable

See L. Molina Bueno Talk - *HV system design*