

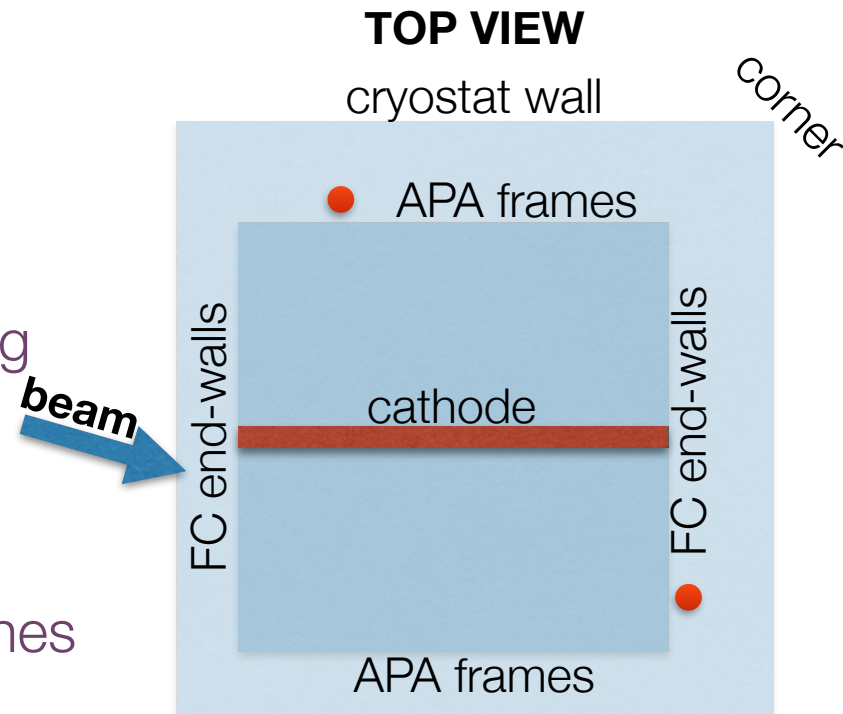
# “Other” temperature sensors inside the ProtoDUNE-SP cryostat

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# Motivation

- T-gradient monitors cover two fix XY positions only (red dots ●)
- Complement them with other sensors of the same precision to provide a 3D map as precise as possible
  - Particularly interesting are the regions near the LAr inlets (bottom)
  - Sensors in the cathode region could be also interesting since this is not covered at all by T-gradient monitors
- Locations investigated:
  - APA frames: no space (wires everywhere)
  - FC end-walls: need shielding (an overkill)
  - cryostat walls: not possible to weld anything
  - **cryostat corners**: OK, they are reinforced
  - **ground planes**: OK, no field beyond them
  - **cryogenic pipes**: OK, beyond ground planes



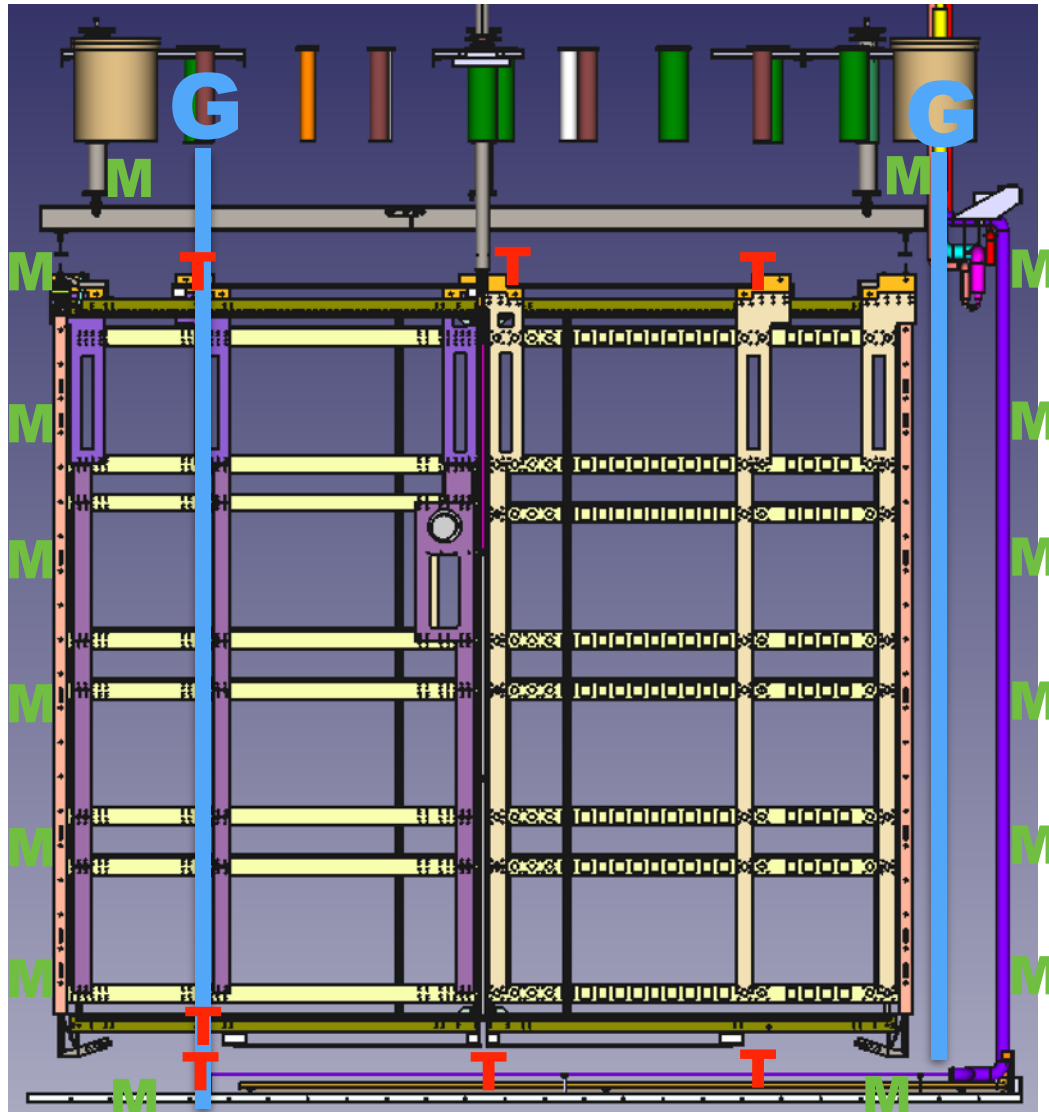
# Sensor map

**T** Top-bottom

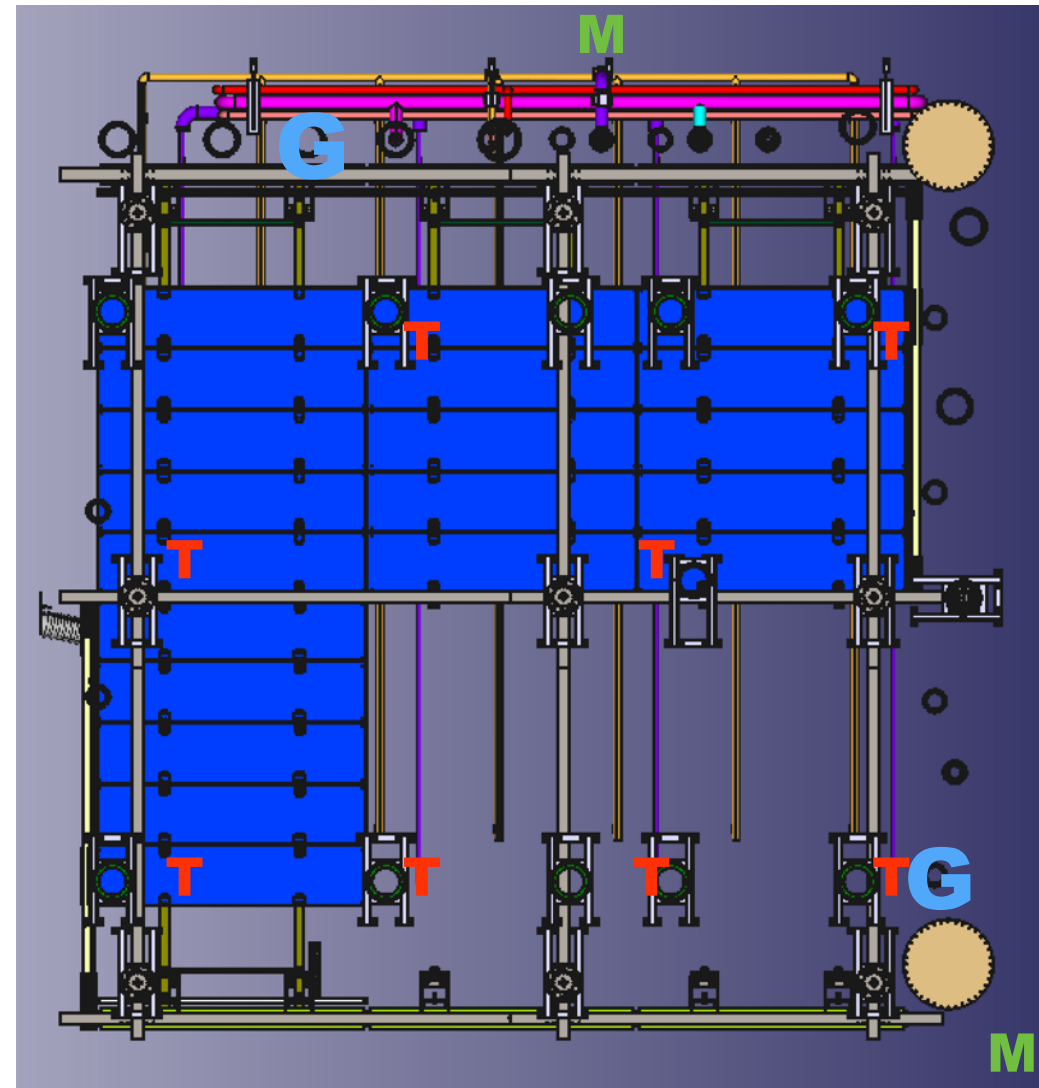
**G** T-Gradient monitors

**M** Cryostat wall

**SIDE view**



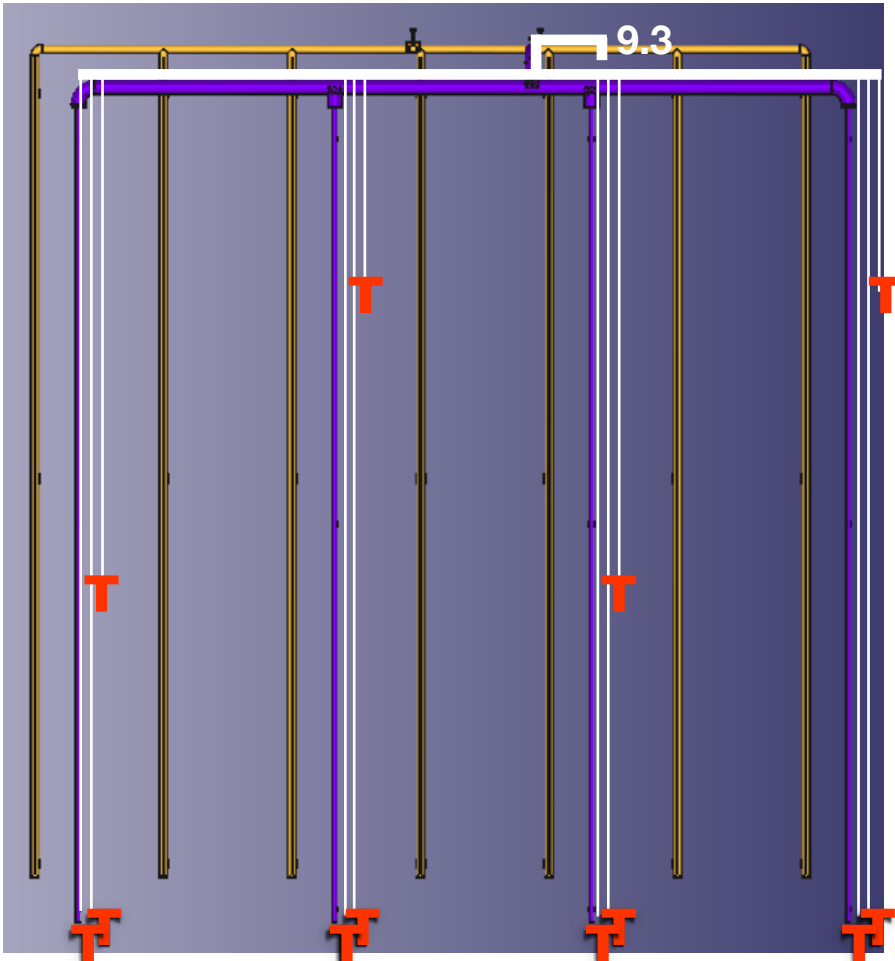
**TOP view**



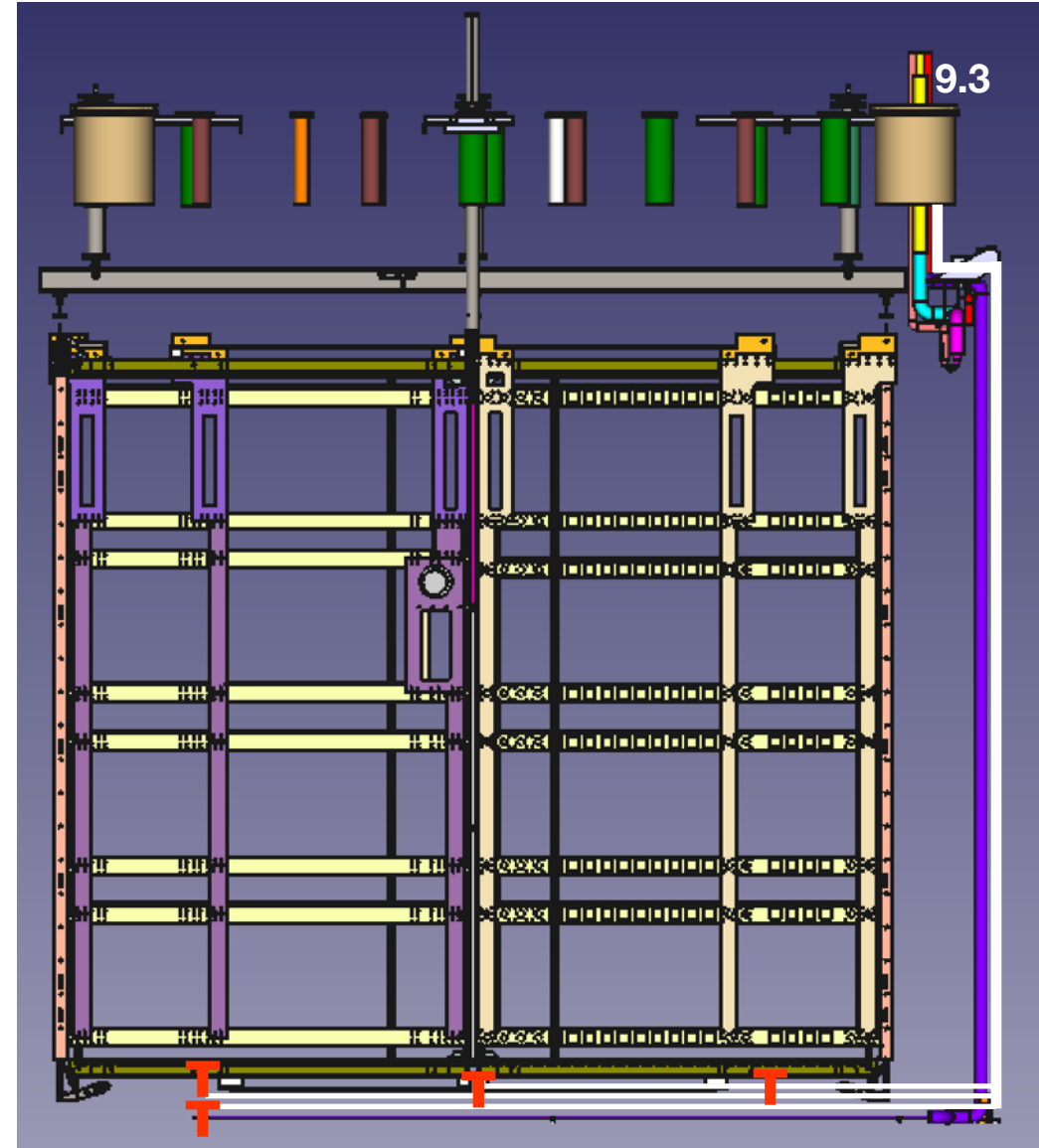
# Cabling for pipes

- Cables can run attached to the pipes all the way to port 9.3
- Pipes in purple, cables in white

**TOP view**



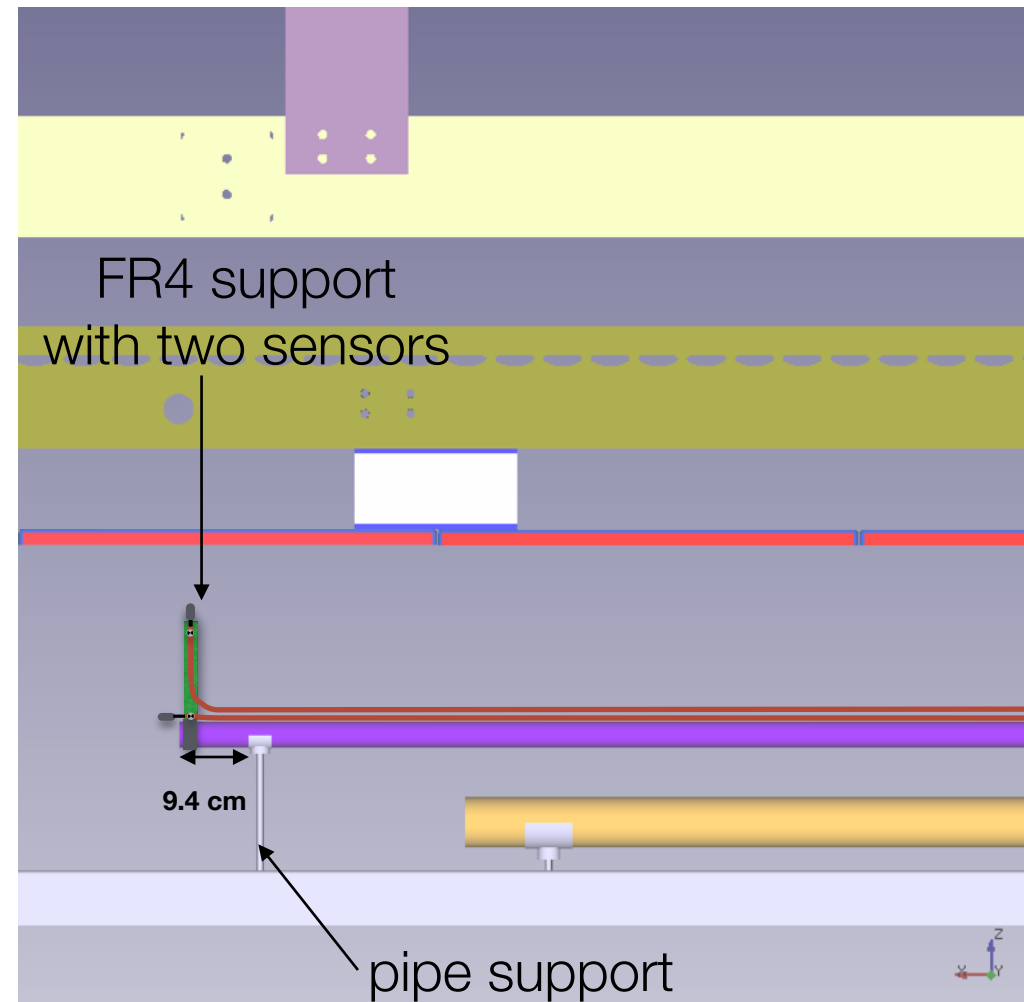
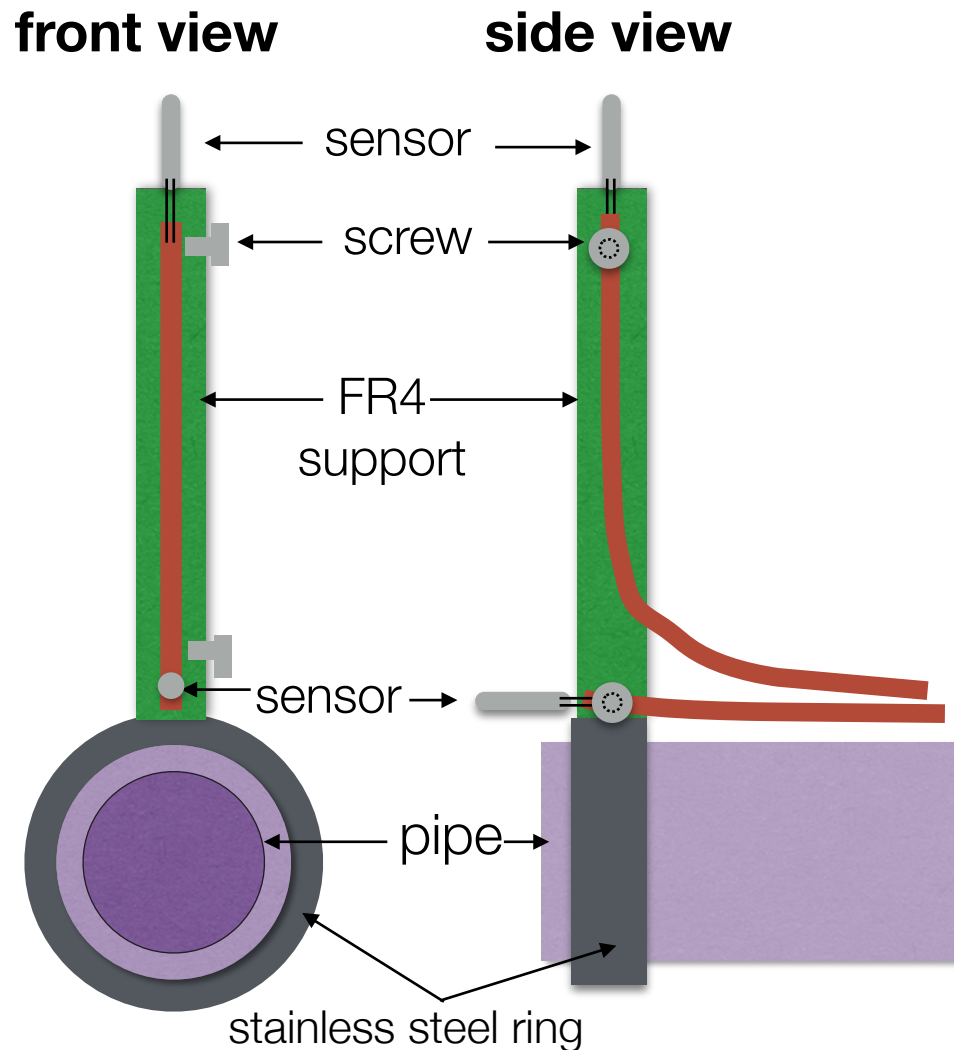
**SIDE view**





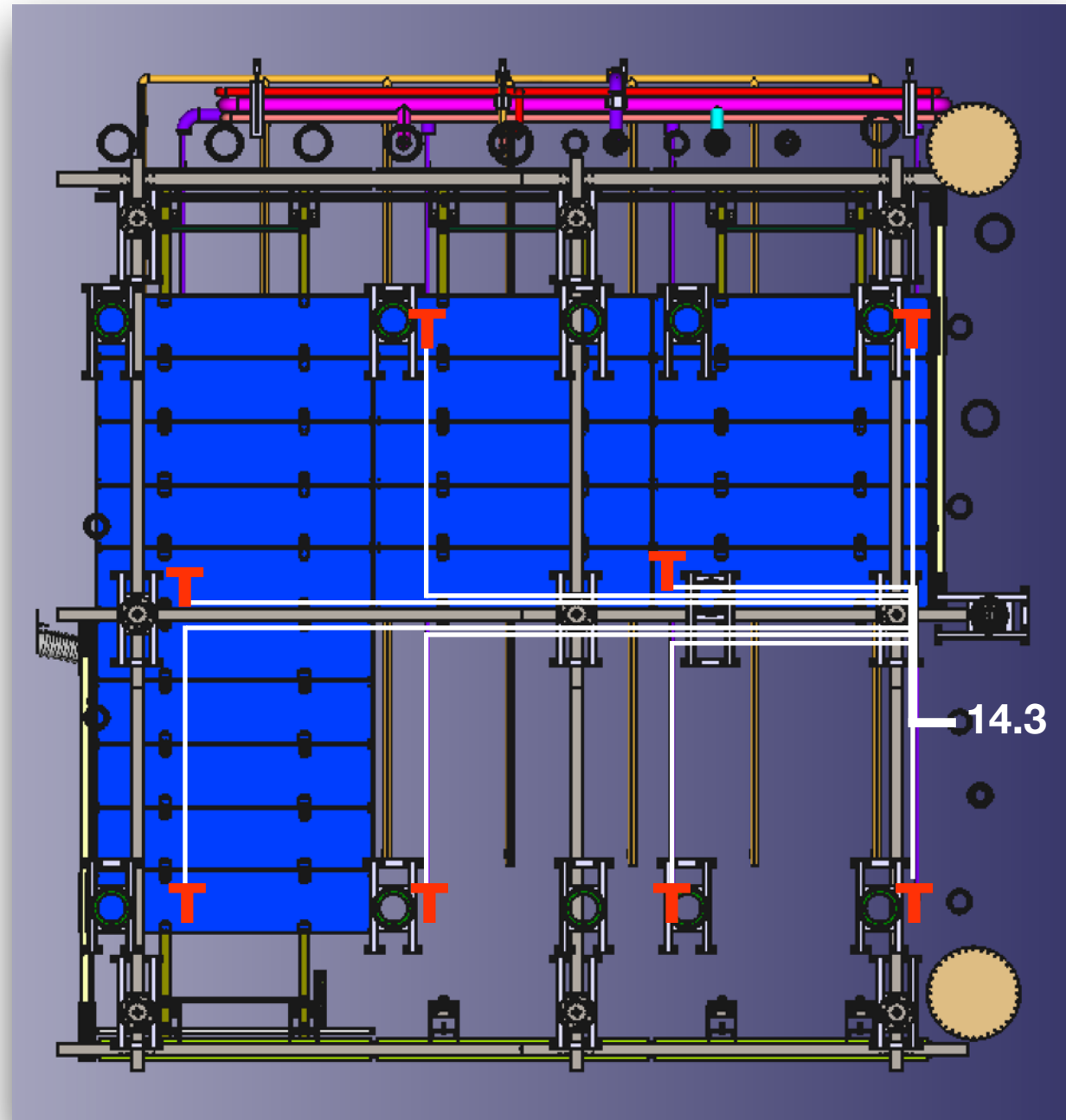
# Sensor's support

- Needs to be designed (two weeks)
- Depending on false floor height it may need to be temporarily rotated

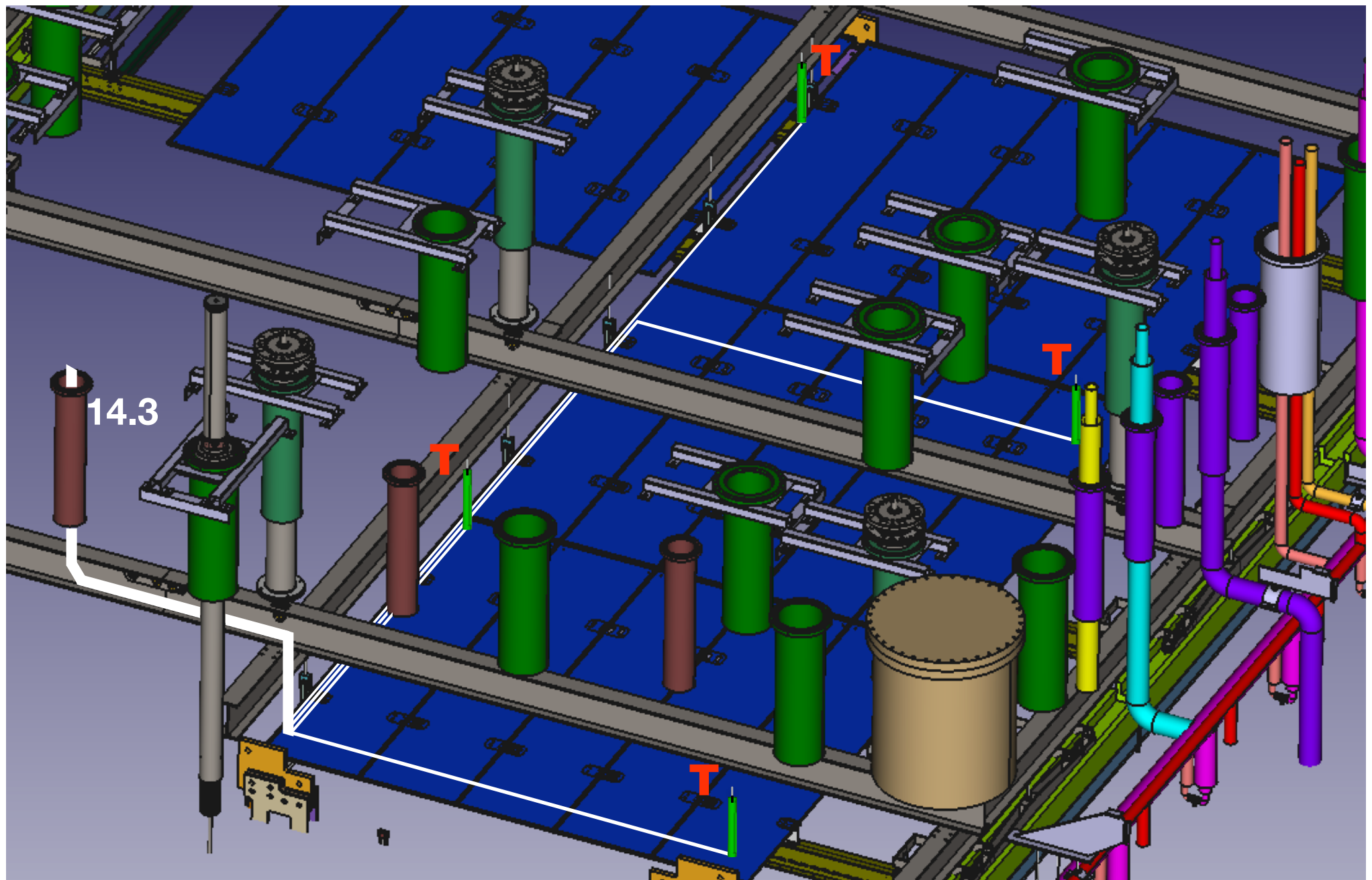


# TOP sensors and cabling

- Same map as at the bottom
- All sensors at the same height
- Need to understand system to hold the cables
- This might be an option

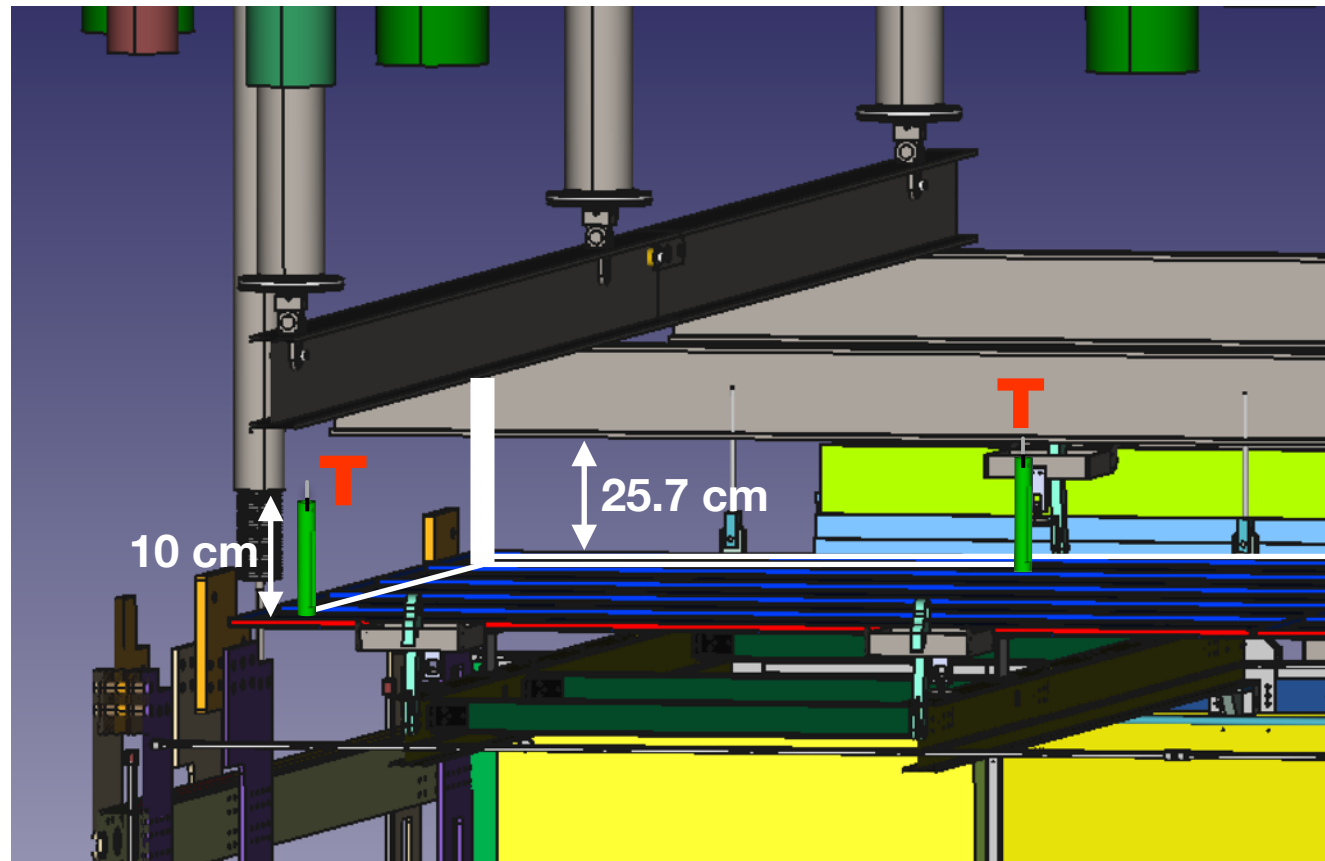
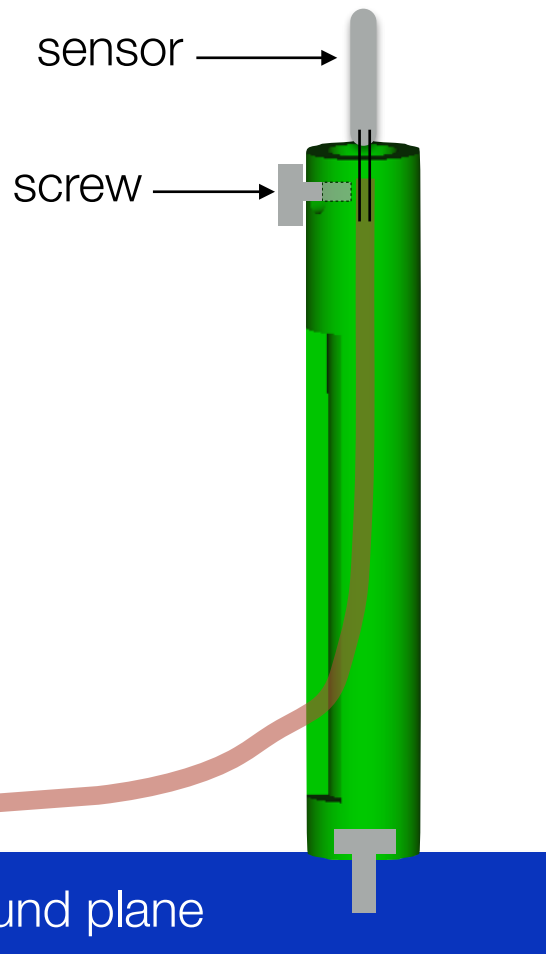


# TOP ground plane cabling



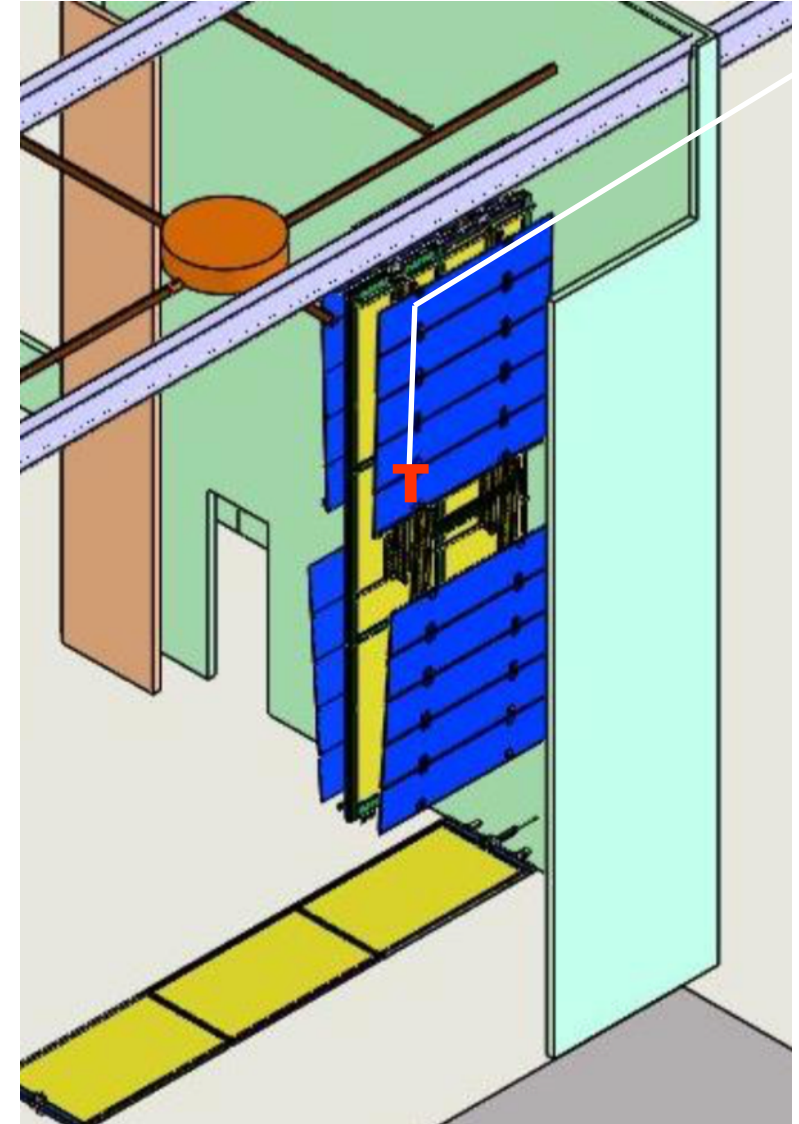
# Sensor's support

- To minimise the temperature bias produced by ground planes keep sensors at some distance from them ( $\sim 10$  cm)
- The support needs to be designed (two weeks)



# Installation in clean room

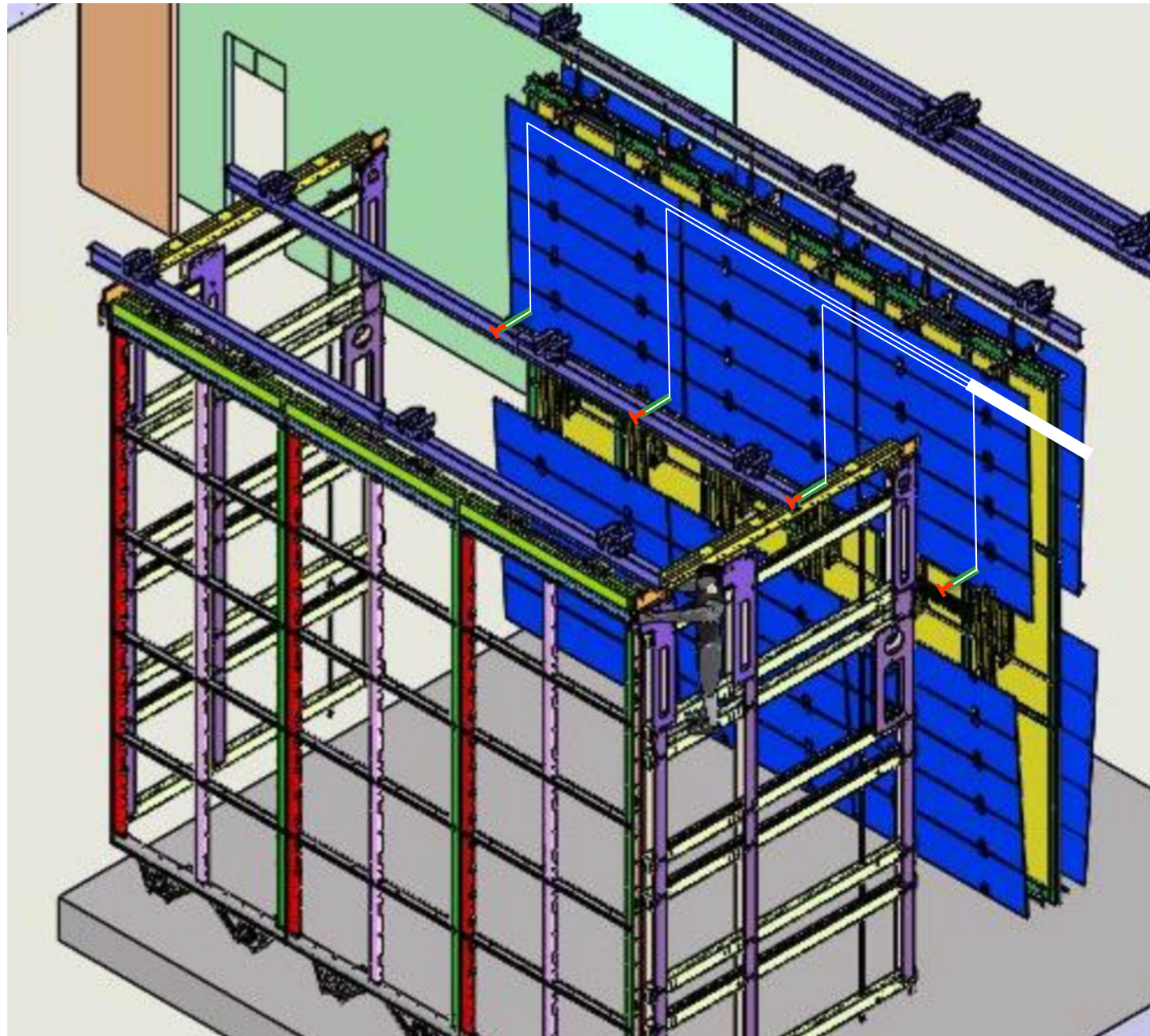
- **Nov 7, 2017 - Jan 5, 2018**
- For each CPA module, sensors/cables in the 2 associated top GP modules are installed in the clean room
- The cable exceeding the GP dimensions is attached to the modules beside, once they are put together (in the cryostat, see next slide)





# Moving GP into cryostat

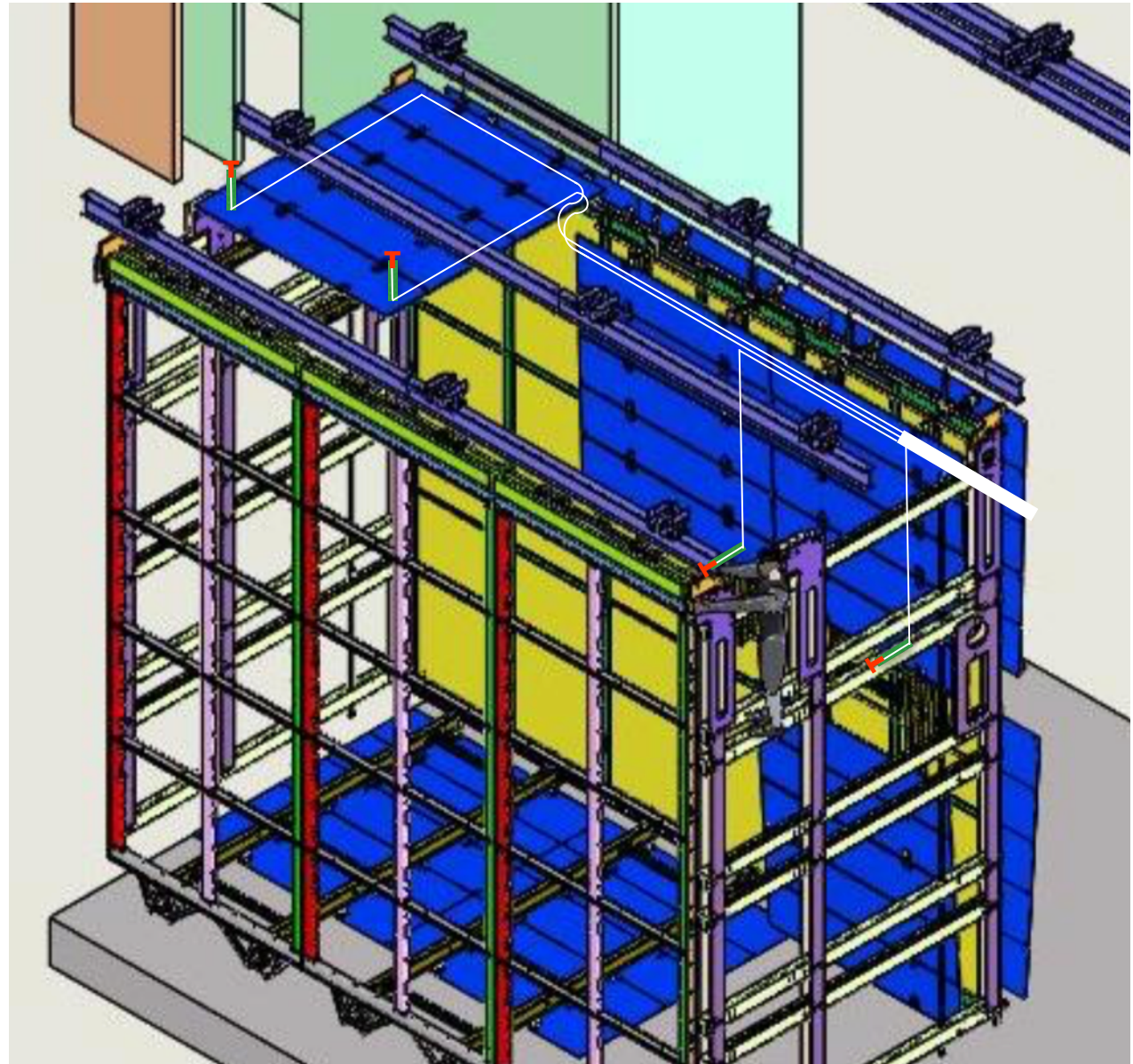
- **Nov 7, 2017 - Jan 5, 2018**
- The three CPA modules and corresponding FCs and GPs are put together once in the cryostat
- So cables in each GP module should be attached to nearby GP modules at that point





# Rotating FC/GP

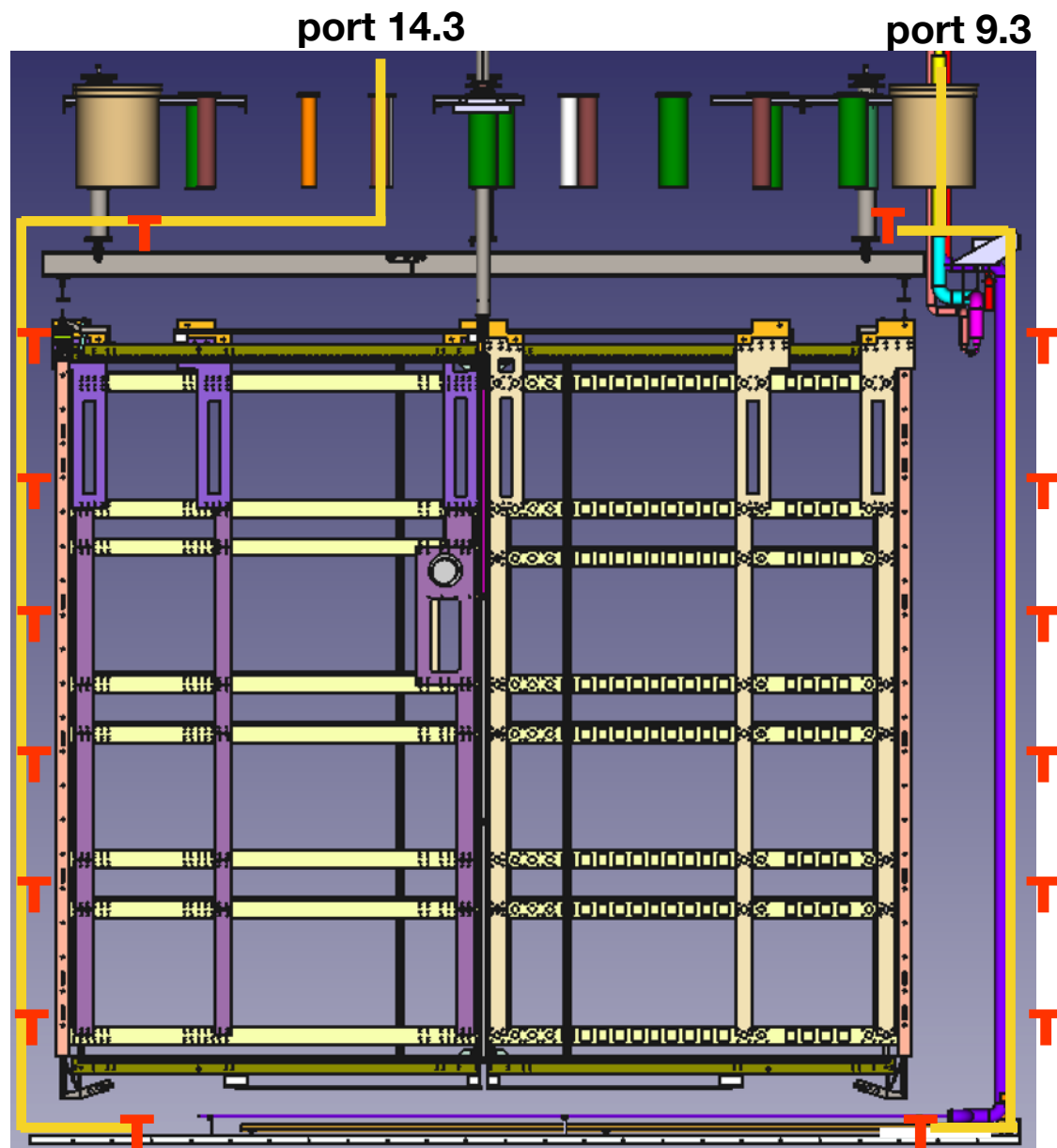
- **Jan 5, 2018 - Jan 10, 2018**
- Cables should be loose between GP modules to allow rotation of one with respect to the other
- They will be tighten once the three modules are in their final positions



# Sensors on cryostat walls

- To monitor cryostat walls' temperature during cool-down and filling
  - Can use standard sensors
  - Behind APAs to avoid shielding
- 
- 16 sensors in total
  - Corrugation step is 34 cm
  - Put sensors every 4 corrugations (136 cm)
    - 6 sensors
  - + top and bottom

seen from downstream



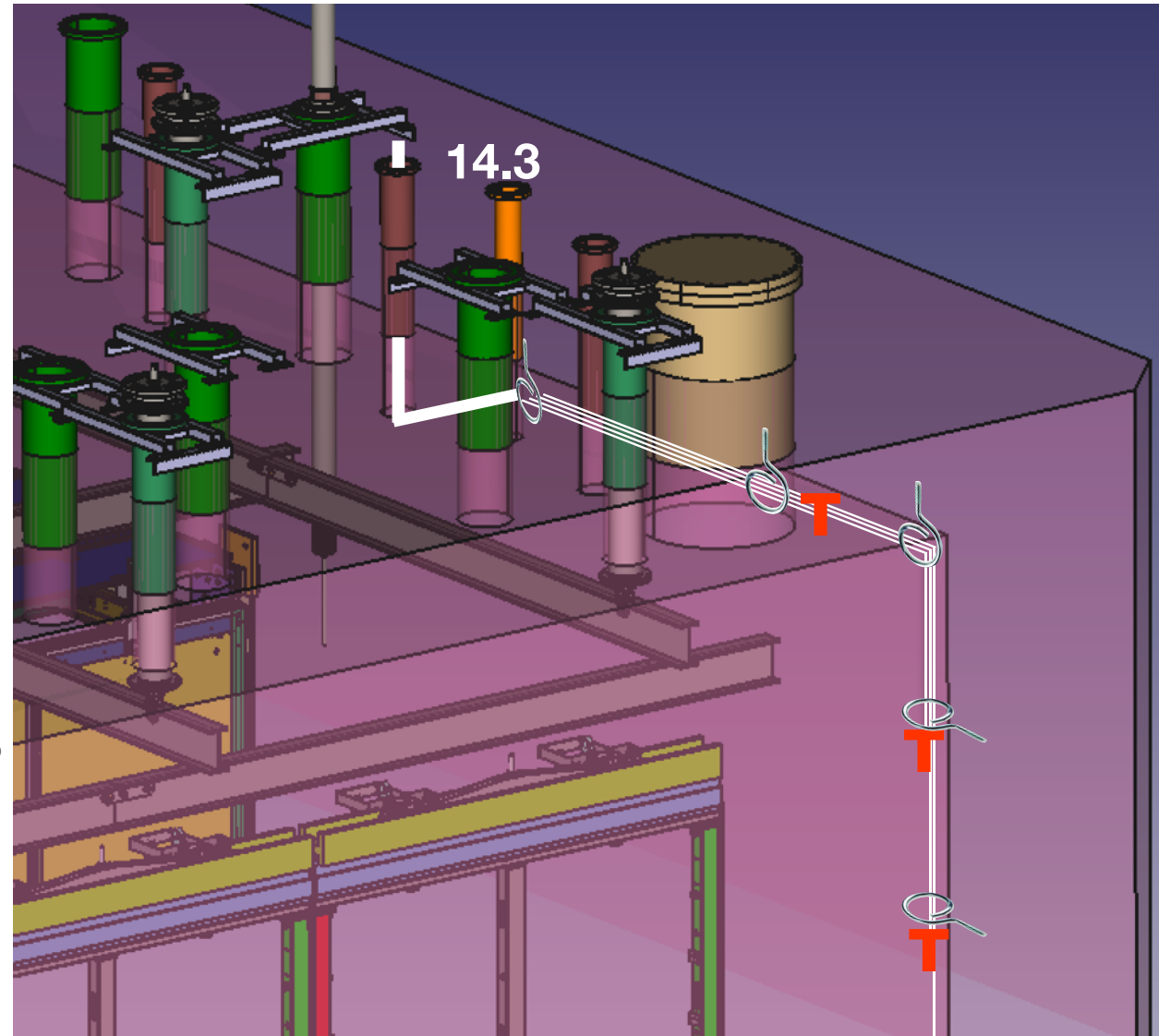


# Cabling for membrane: south

- Weld bridle rings to the joint between two walls

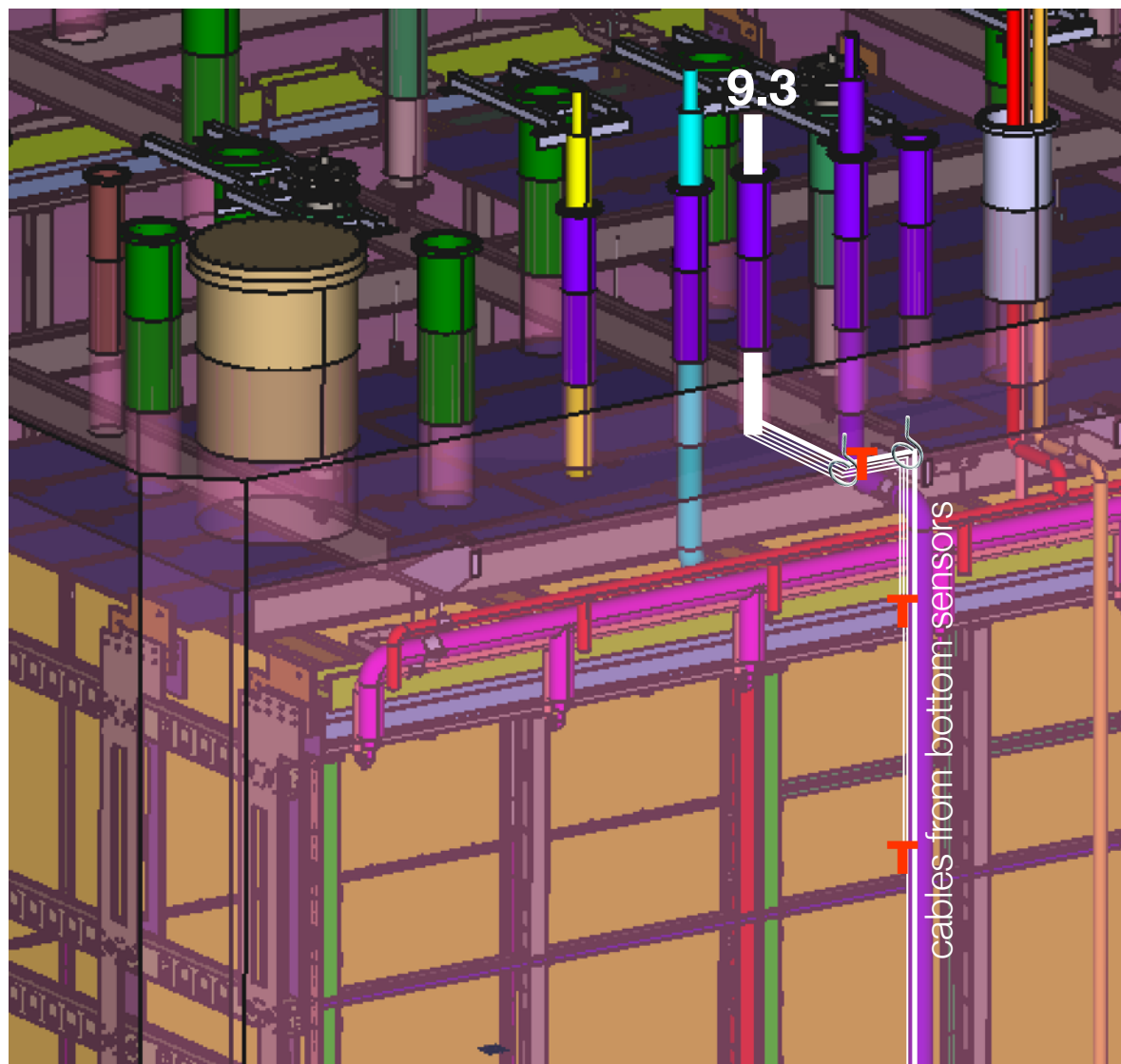


- Sensors epoxied into walls



# Cabling for membrane: north

- Use the vertical LAr pipe as for the the bottom sensors
- Need to understand how to fix the cables to the pipes
- Sensors epoxied to walls



# Installation plan

## pipes

- End of June, beginning of July: Pipes are mounted on the cryostat

## bottom sensors

- Install sensors (12 sensors) on the **bottom pipes** and route cables from sensors to the bottom of the vertical section of the LAr pipe

- Install sensors on the **cryostat floor** (2 sensors)

## false floor

- Install false floor

- Once false floor is installed the scaffolding can be used to route cables from the bottom of the vertical section of the LAr pipe to port 9.3

## wall/roof sensors

- Sensors/cables can be also installed on the lateral walls and roof of the cryostat. North cables will go to port 14.3 and south ones to port 9.3

## top GP sensors

- For each top GP module in the clean room, sensors and cables are installed (8 sensors in total)

- CPA/FC/GP modules are move sequentially into the cryostat. As they arrive there we route the cable to modules beside

- south GPs are rotated and cables between GP modules are tighten and routed towards port 14.3

- north GPs are rotated and cables between GP modules are tighten and routed towards port 14.3

end July-Sep 27

Nov 7-Jan 5

Jan 5-20

# Other

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- Readout system, calibration system and cables are the same as for the T-gradient monitor
- **QC/QA:** All sensors will be calibrated with their final cables at IFIC. During the calibration process all kind of tests will be carried out to check the accuracy and the reproducibility of the measurements. If possible sensors will be calibrated at CERN with the final readout
- **Slow controls:** Same as for T-gradient monitor
- **Development towards DUNE:**
  - Sensors' map and cabling is different for DUNE, but some lessons can be probably learned
  - Better sensors and cables could be probably found by the time DUNE is built
  - The readout and calibrations system can be also improved

# Critical items

- Bottom sensors must be installed between August and September
- Most critical items:
  - **cable derogation**: must apply next week if possible
  - **sensor calibration**: will start next week

	2017									2018				
	Apr	May	Jun	Jul	Aug	Set	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Conceptual design	x													
Engineering design		x												
Prototyping		x	x											
Design calibration system	x													
Calibration system commissioning		x												
Sensor calibration			x											
Cable preparation and sensor-cable calibration				x										
<b>Installation of bottom sensors</b>					x	x								
Installation of membrane sensors					x	x								
Installation of top sensors								x	x					
Deployment of GPs										x	x			

**backup**

# Cryostat ports

## Hawaii T-gradient monitor

## other T- sensors

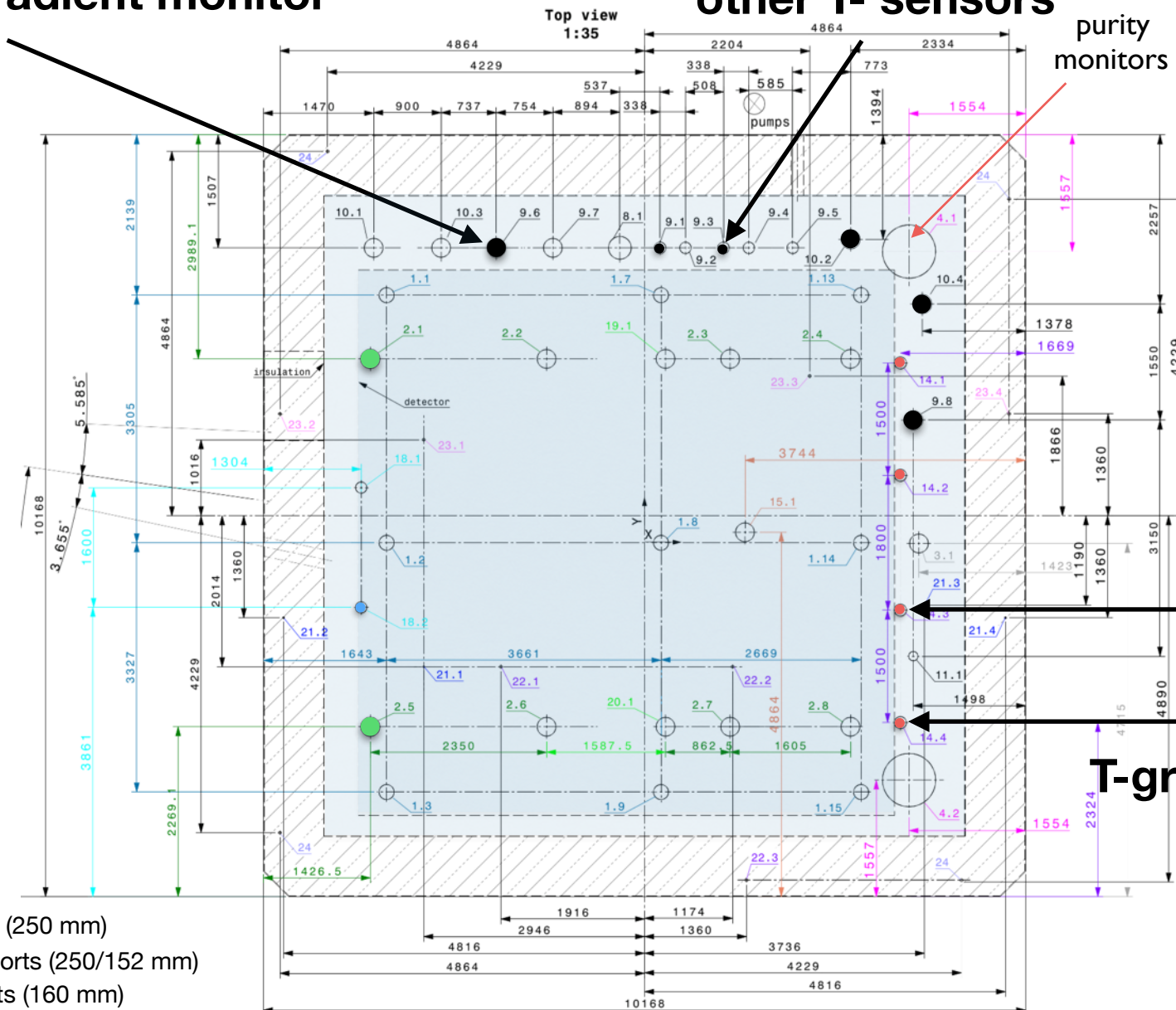
purity monitors

beam

LAr  
FC

9.1 to be shared

- Spare signal ports (250 mm)
- Spare cryogenic ports (250/152 mm)
- Unused Laser ports (160 mm)
- Spare (150 mm)



other T- sensors

Valencia T-gradient monitor