IFIC, 03/05/2017

Temperature measurements in ProtoDUNE-SP

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IFIC - (CSIC & Univ. Valencia)

review

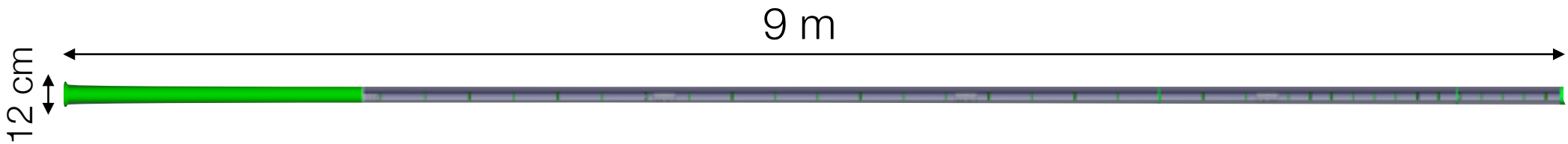
Recommendations

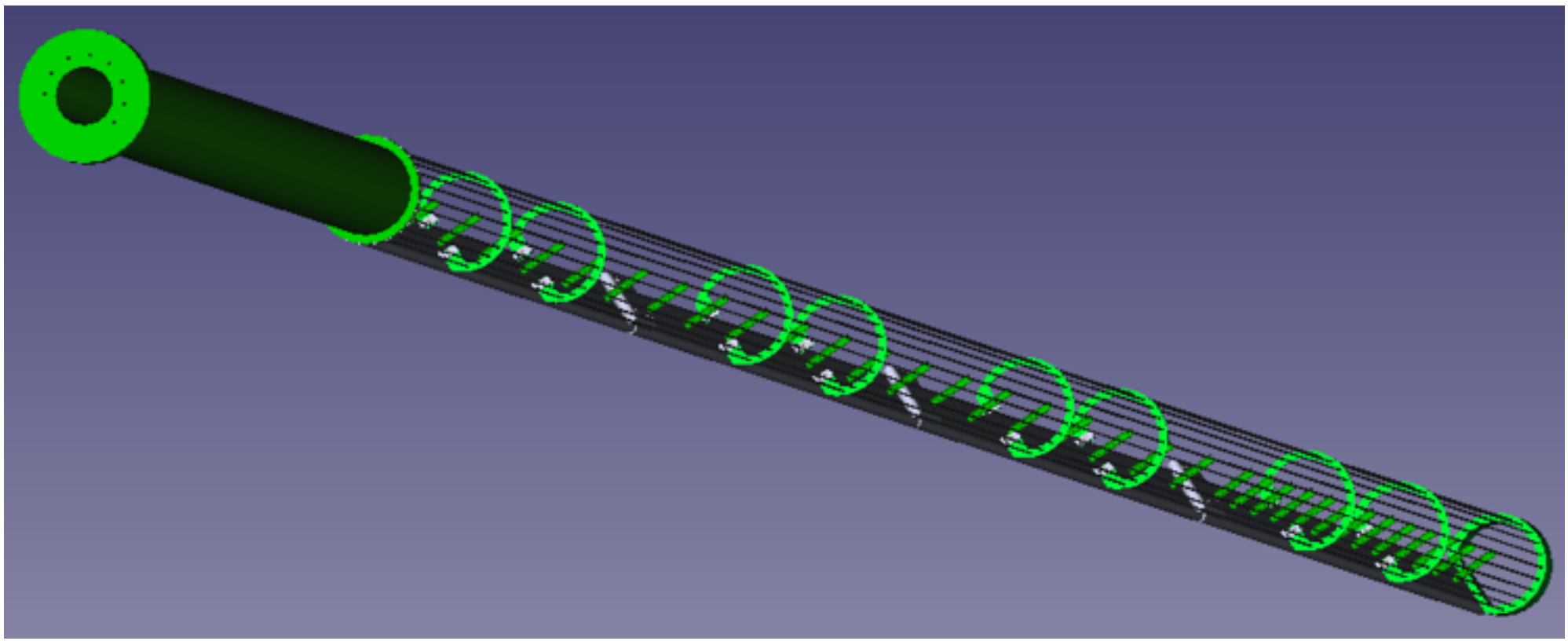
- **A full thermal analysis of the Temperature Gradient Monitors** should be performed by end of this summer and the results discussed within the Collaboration**.**
- **3D computation of the field in the structure** is required to be sure that no point exceeds the maximum allowed value.
- **Procedures for installation** have to be defined not later than end of July 2017.
- **Define the installation procedure so that it is viable with all the constraints form the other detector components and the facility (for instance the crane height).**
- **Integration in the general installation planning** should be done not later than end of July 2017.
- The definition of the **integration in the slow control system** has to be finalized by end of 2017.
- The **choice of 100 Ohm** is not yet definitive. There are advantages in increasing the resistance at least to 1k. Check this option.
- Sensor PCB are long because the probe must sense the temperature of liquid argon, and not being biassed by the temperature of the surrounding material. Where the field is high, reducing this dimension may be critical. Evaluate the minimum distance with CFD computations.
- Details of the **mechanisms how to fix the bottom of the pillars** are not defined

T-gradient monitor

preliminary 3D cad model

- 9 meters long and 12 cm diameter cylinder hanging from port 14.4 (14 cm diameter)





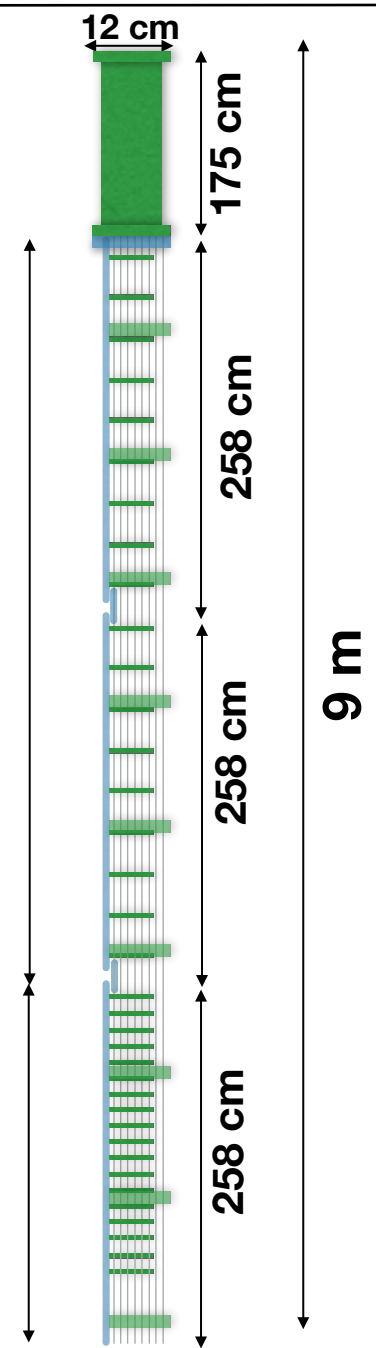
Baseline configuration

- 3 aluminum plates of 258 cm each
- 3 FR4 disks per plate
- 18 sensors separated 12 cm in the bottom plate
- 18 sensors, separated 30 cm in the other two plates

18 sensors separated 30 cm

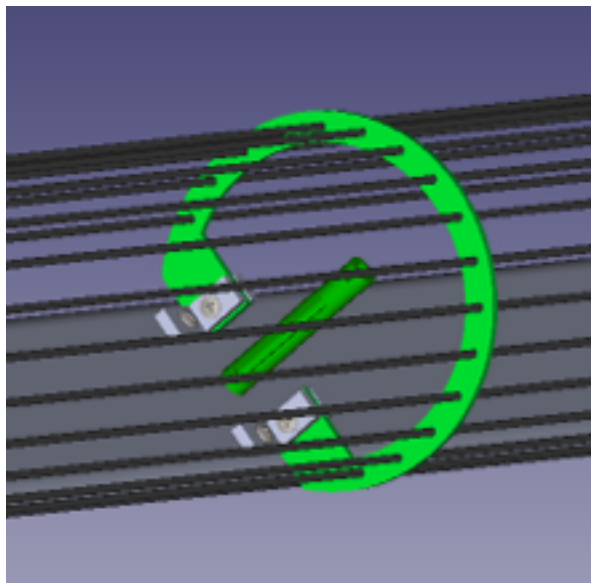
The reviewers suggested to put more sensors at the top

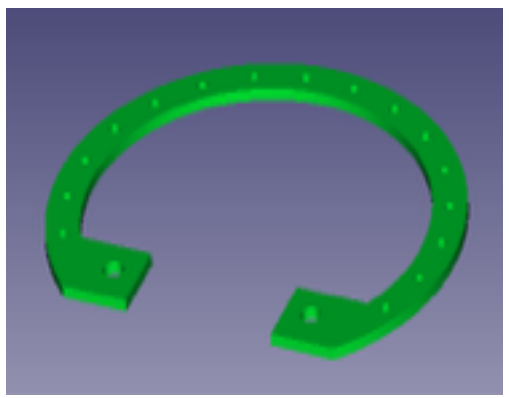
18 sensors separated 12 cm

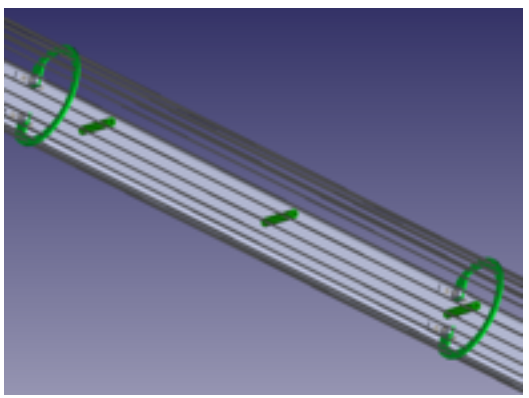


Shielding grid

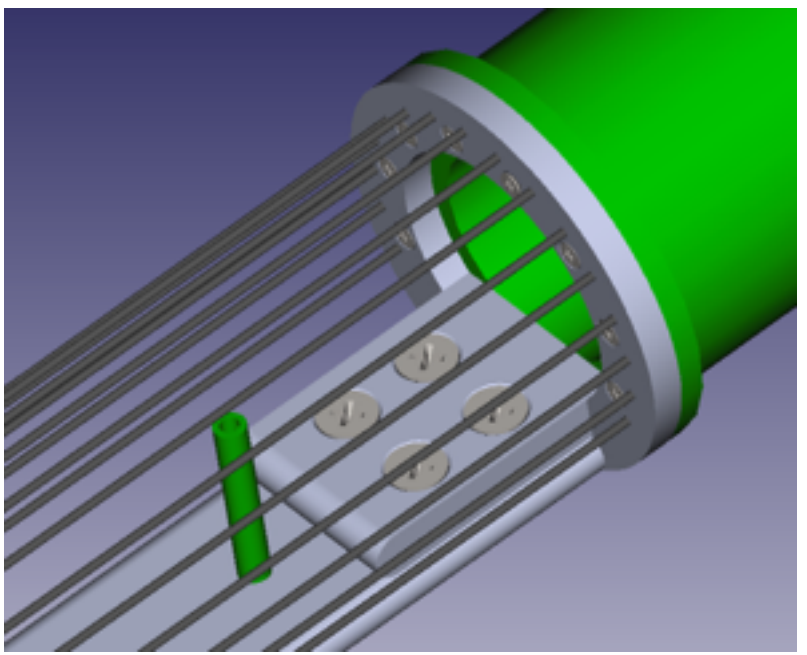
- FR4 disks keep the 3 mm diameter stainless still rods vertical and at a fix distance





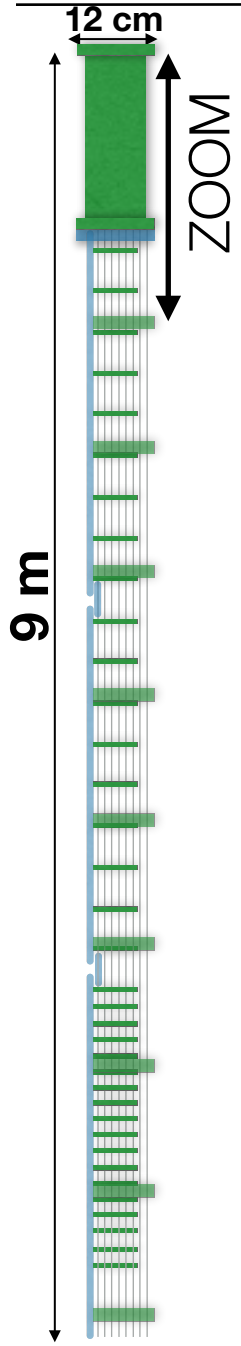


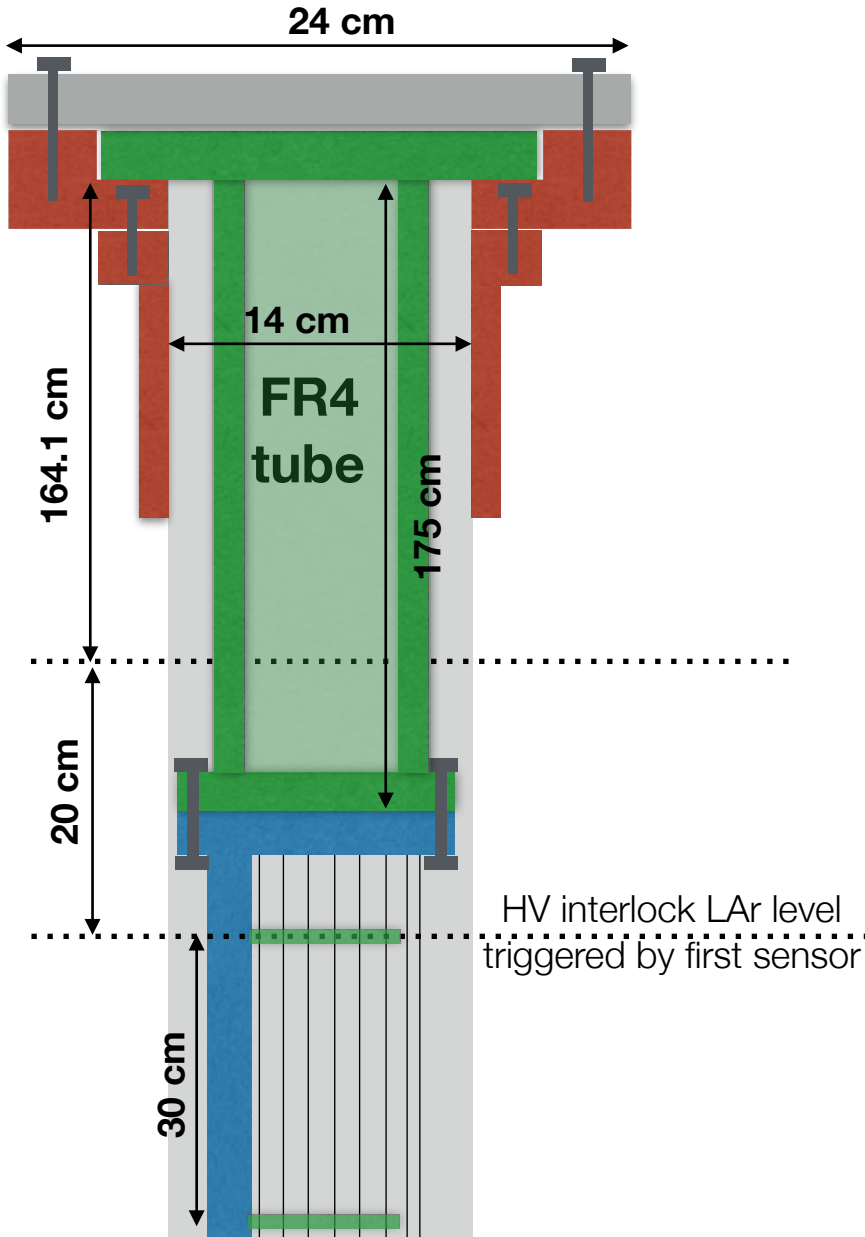
- Stainless still rods are screwed onto the aluminum disk, which is screwed to the FR4 tube and the aluminum plate

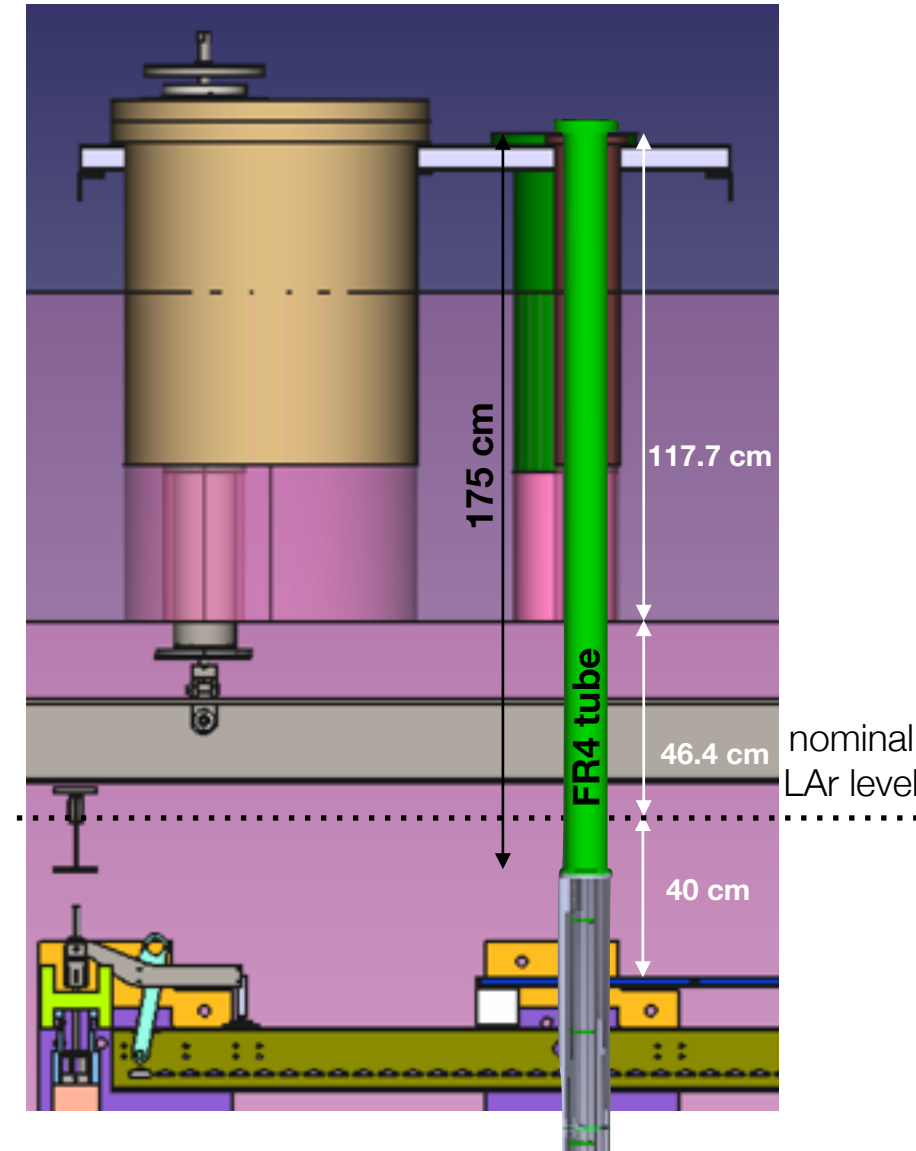


Top section

- A FR4 tube with only cables inside, to insulate aluminum structure from flange



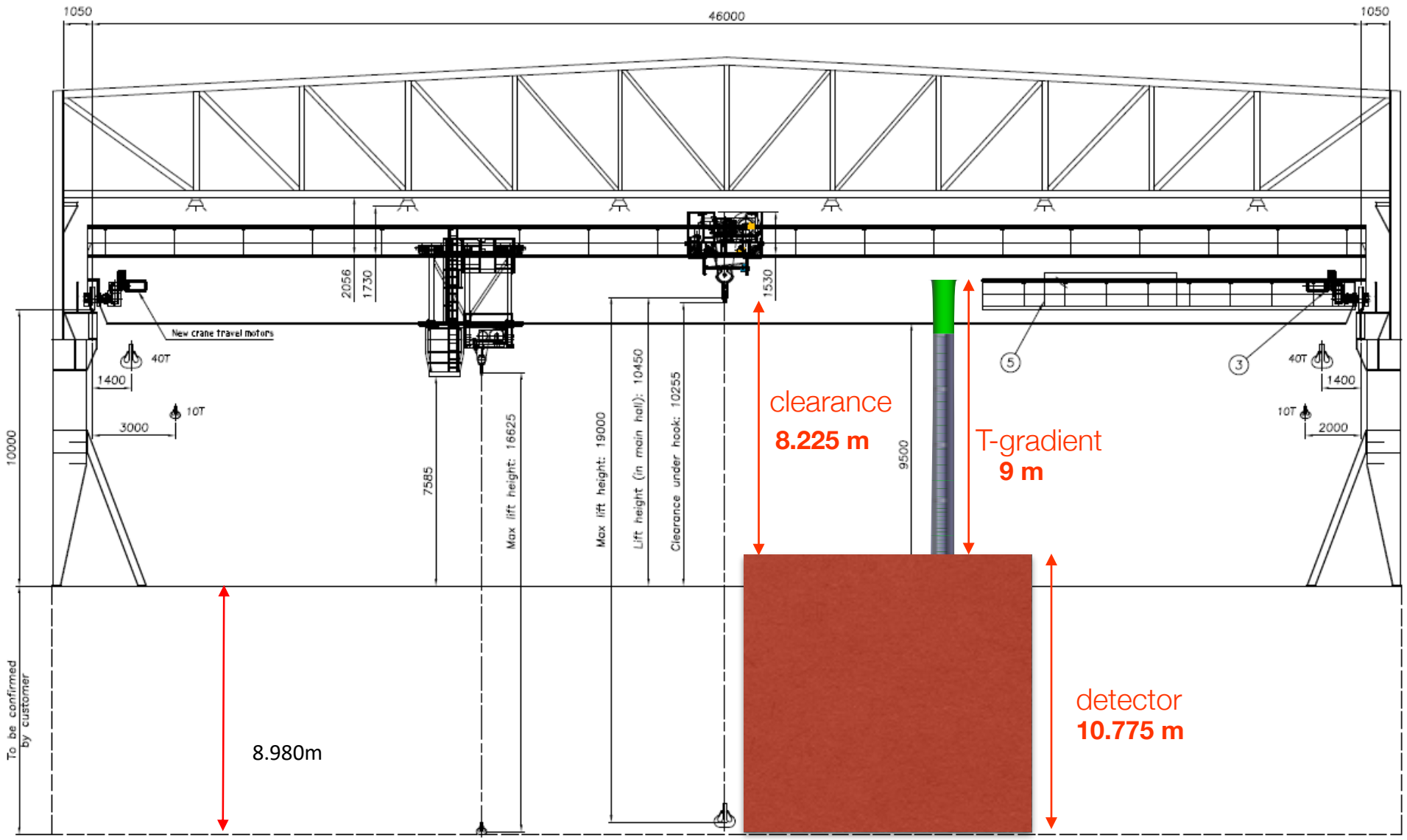




Clearance for installation

GIROT Sylvain CLERC Vi
NESSI Marzio CHAMIZ

CRANE

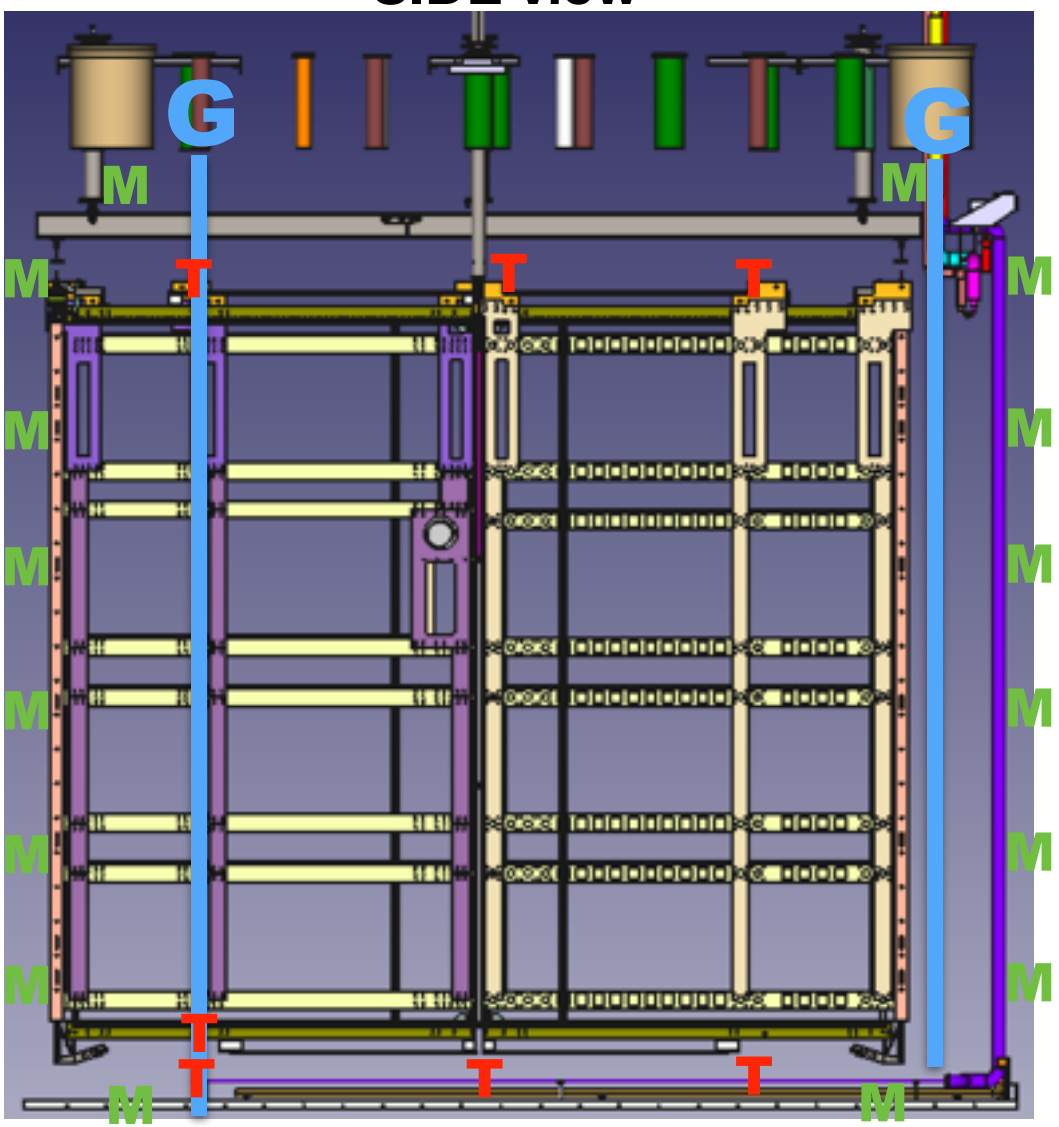


other sensors

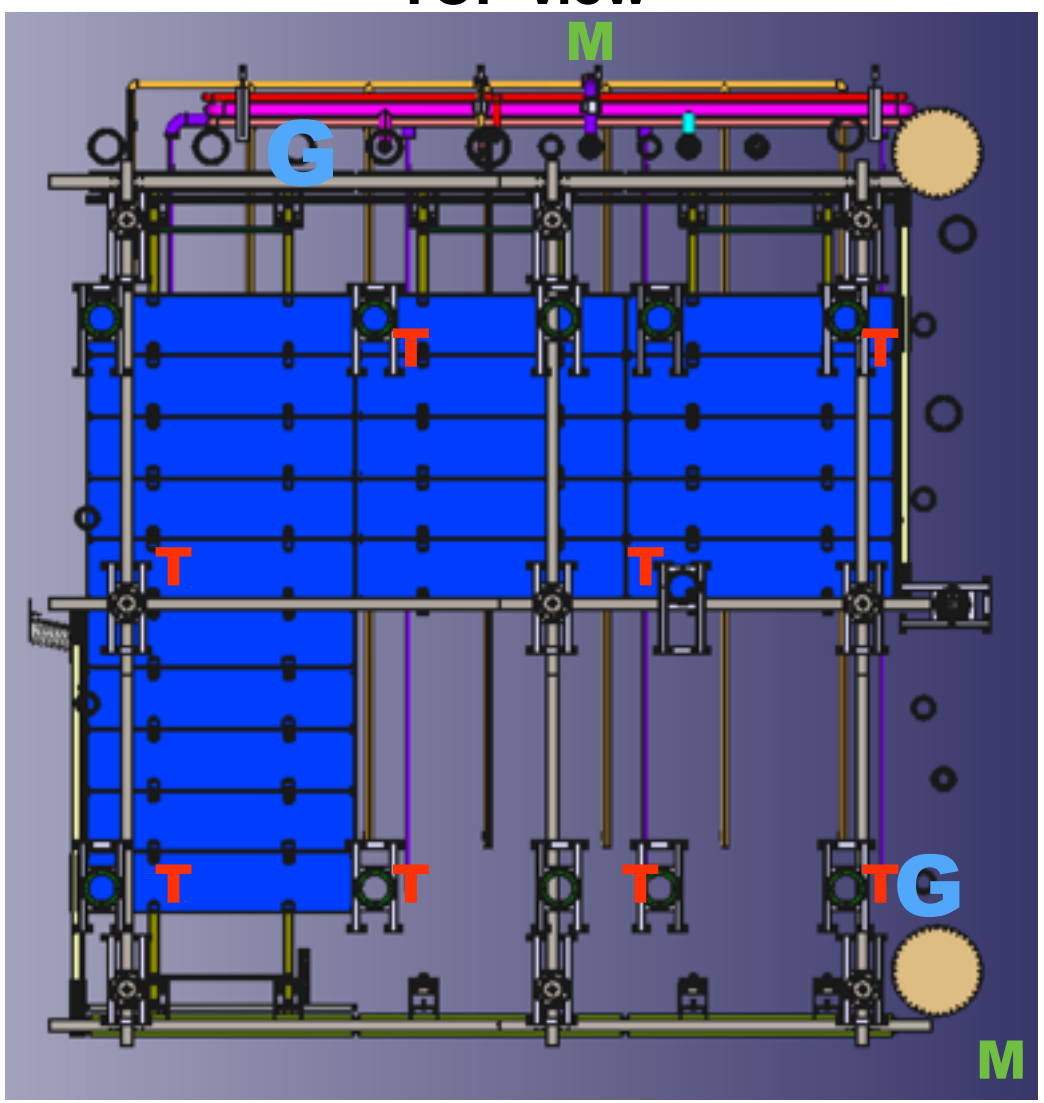
Sensor map

T Top-bottom **G** T-Gradient monitors **M** Cryostat wall

SIDE view



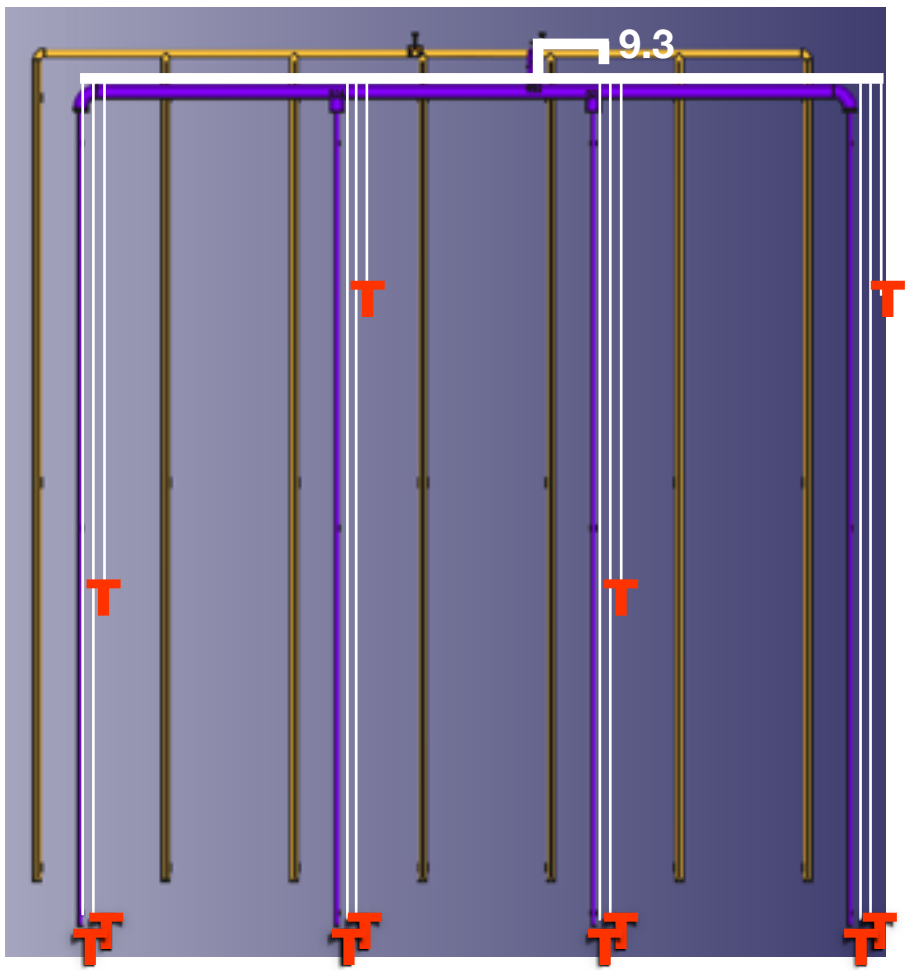
TOP view



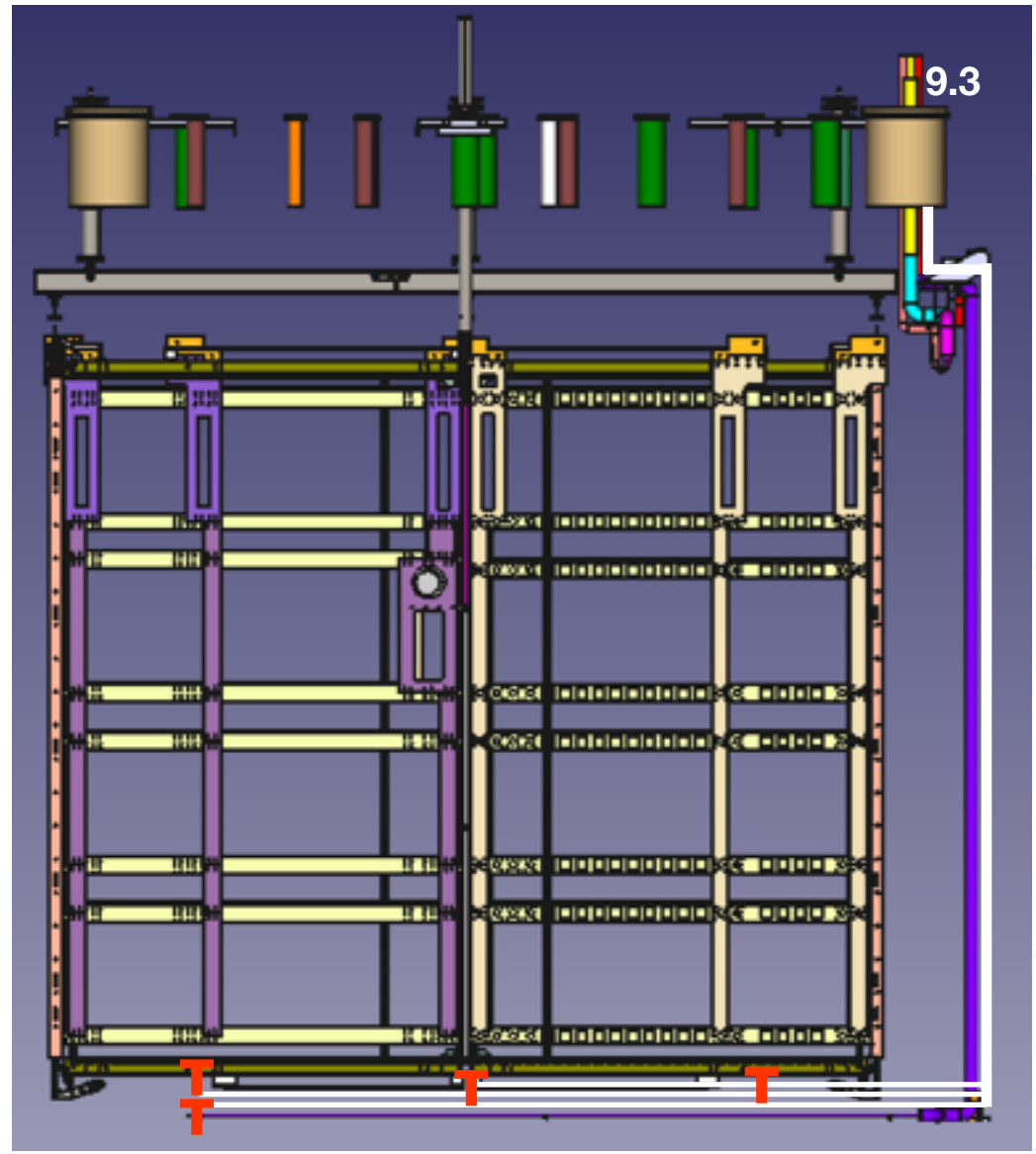
Cabling for pipes

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

TOP view

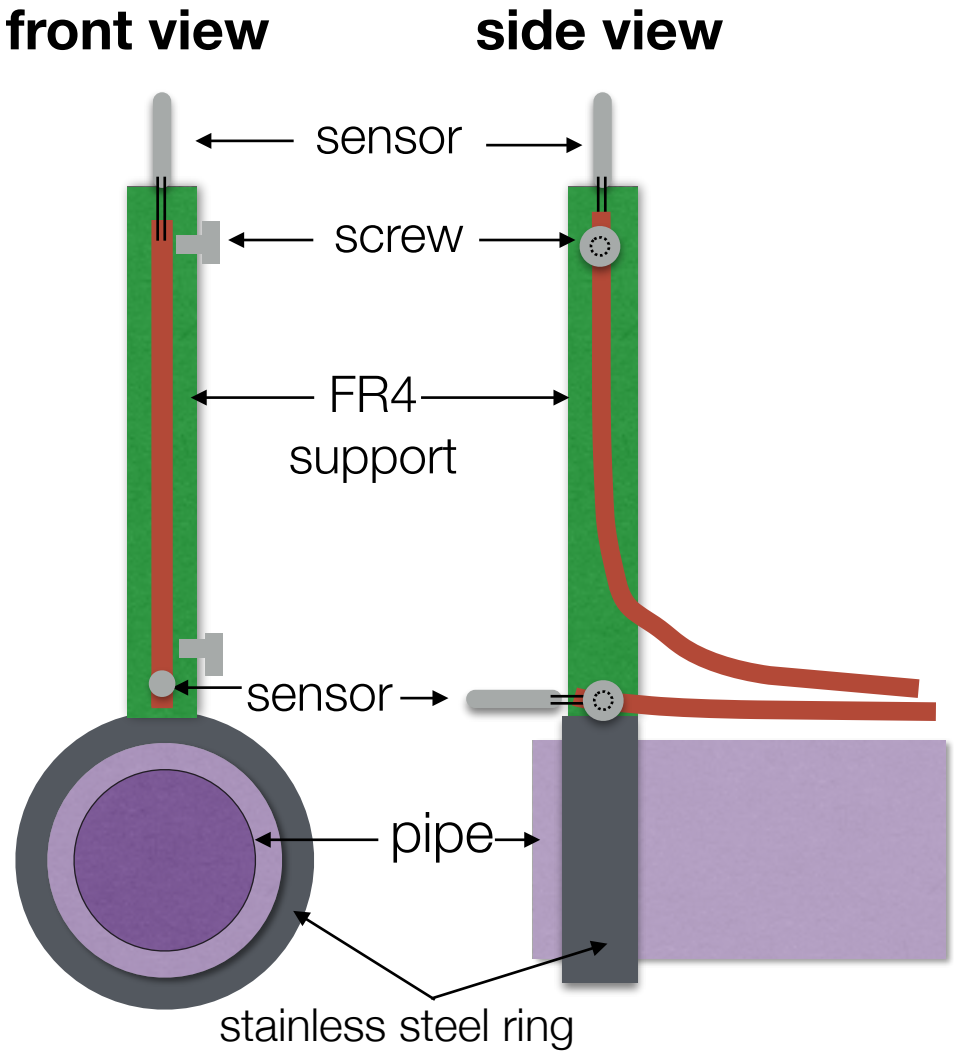


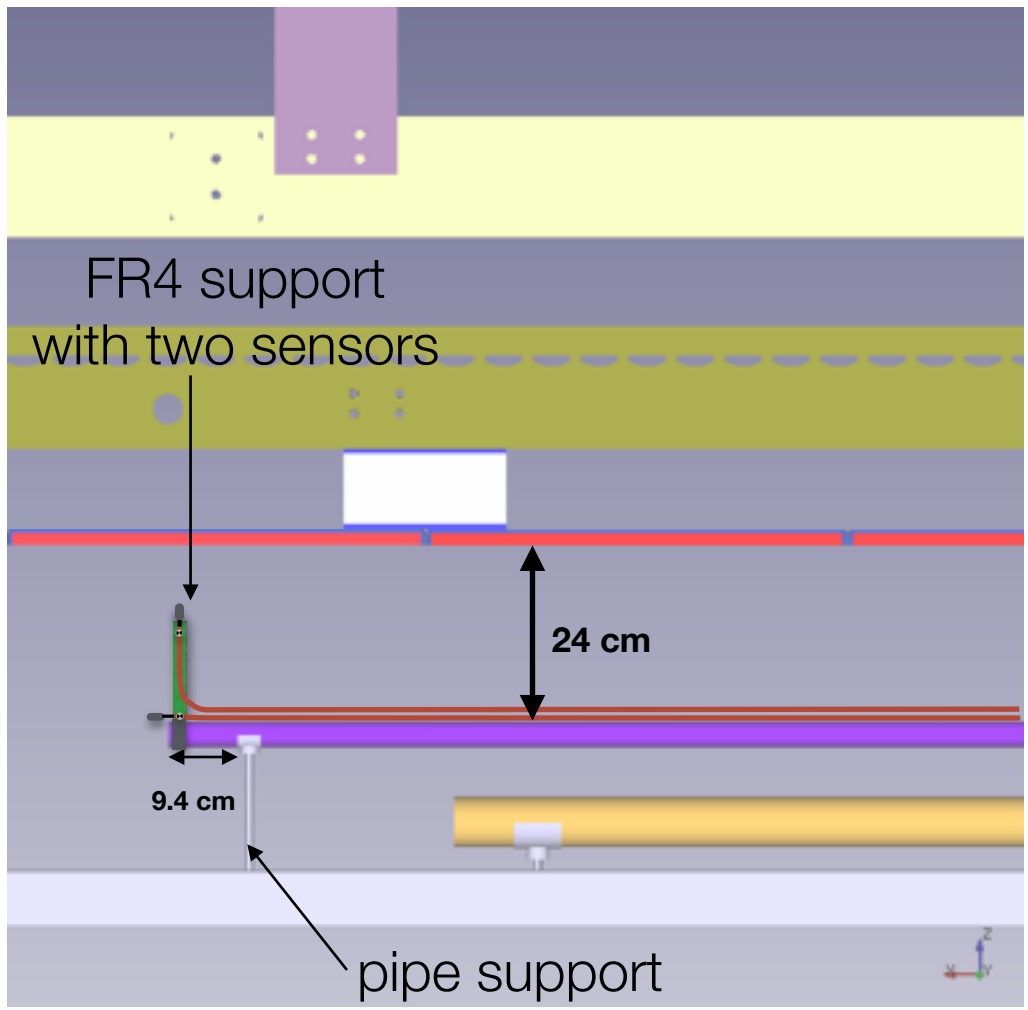
SIDE view



Sensor's support

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





Hawaii sensor's support

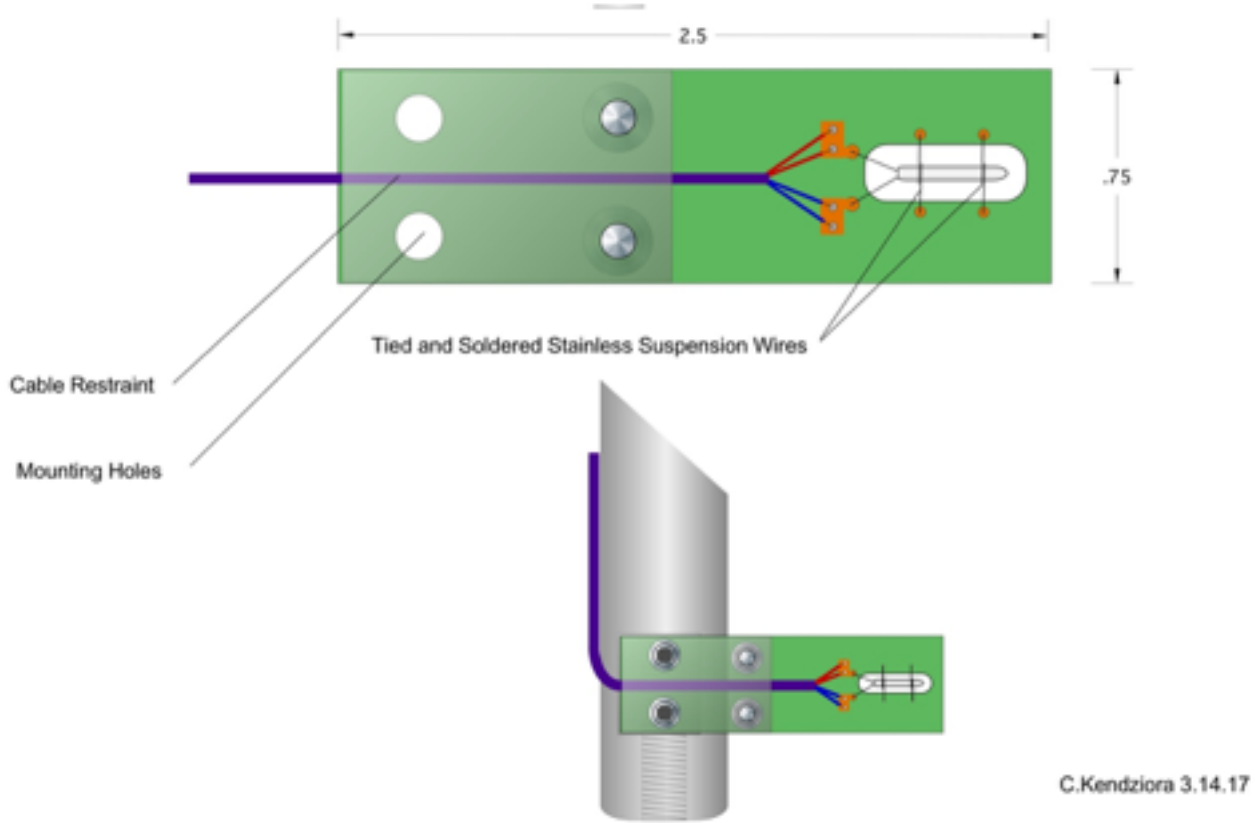
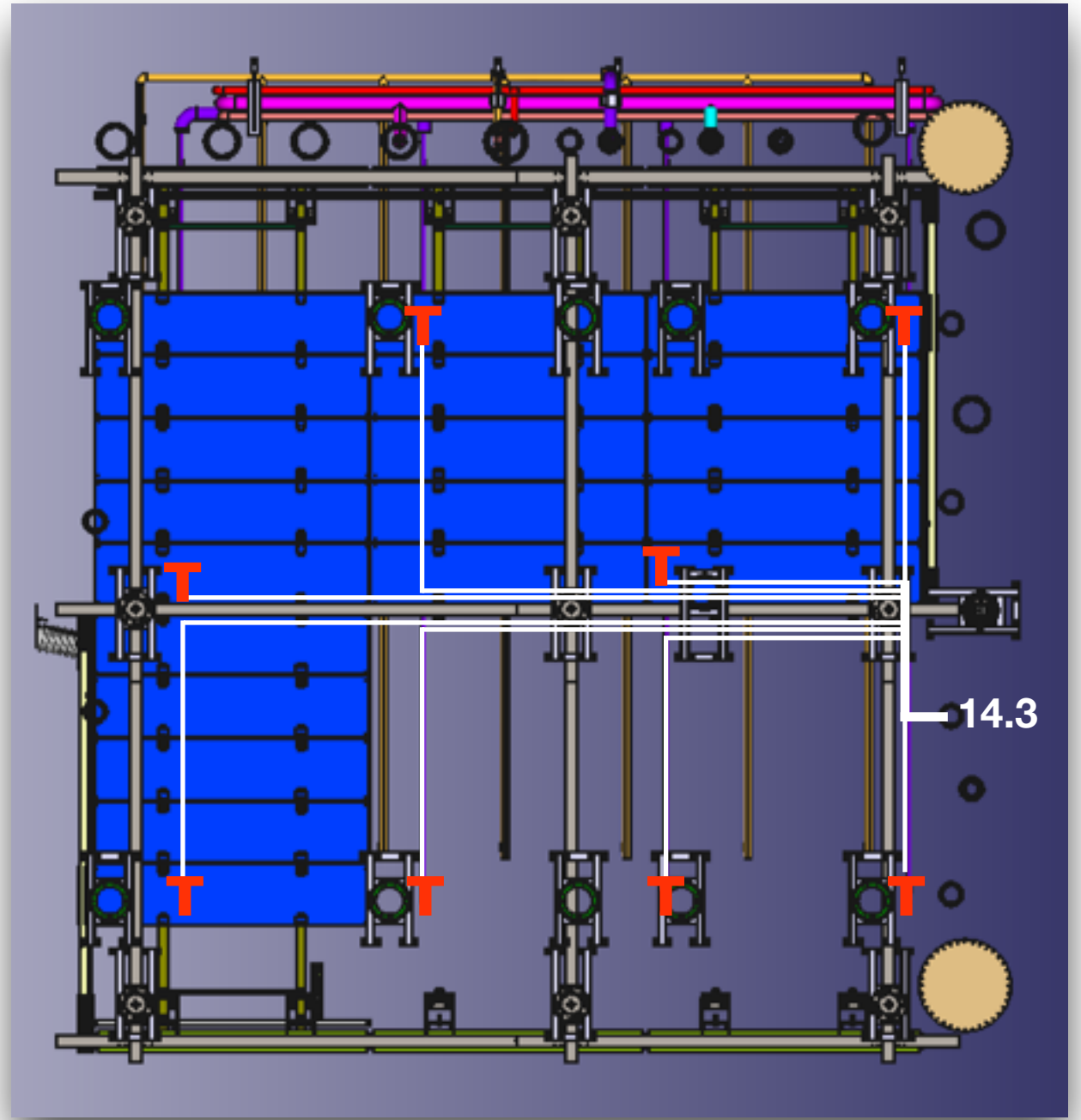


Fig. A2.2. Details of the sensor mount and PCB mount on the rod are shown along with the dimensions of the PCB.

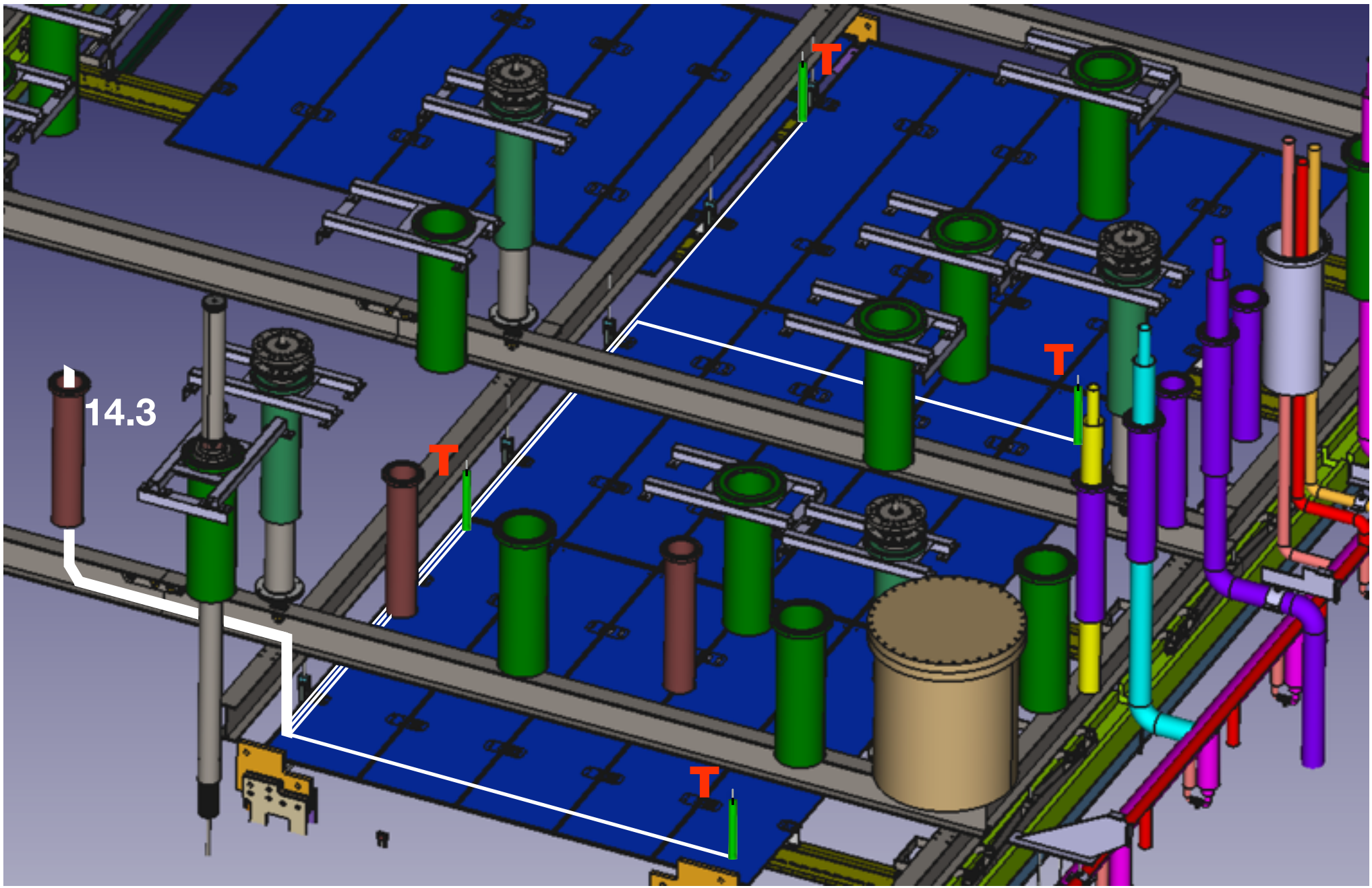
Fig. A2.3. Details of the cable restraining system at the sensor are shown. By sandwiching the cable between the PCB and stainless steel rod mount, the sensor soldering joints are tension free during construction and installation.

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

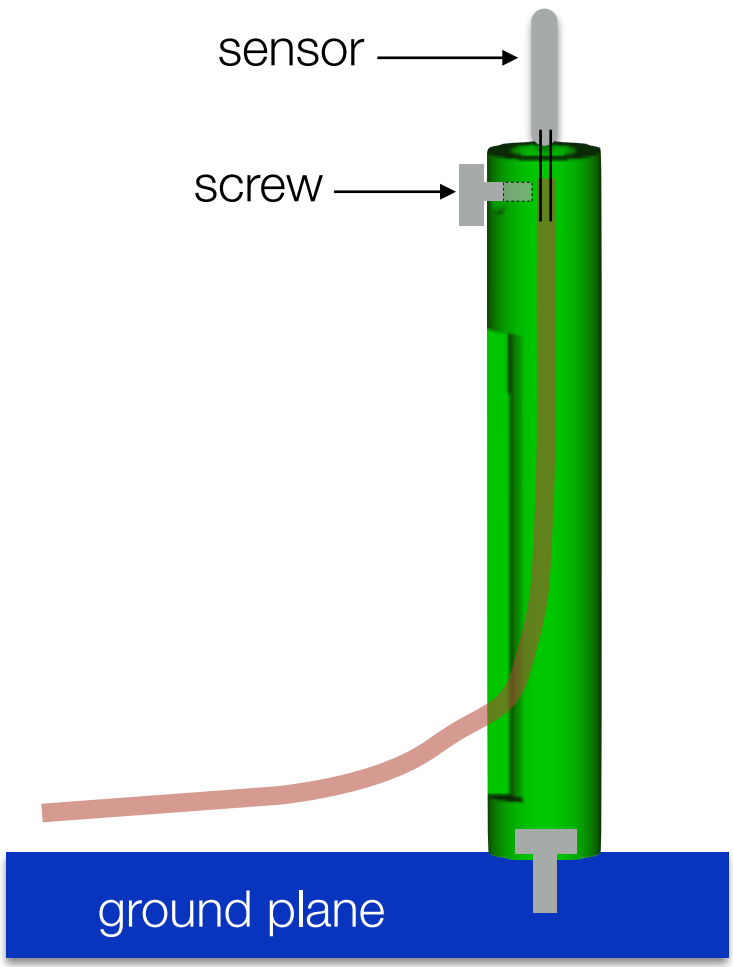


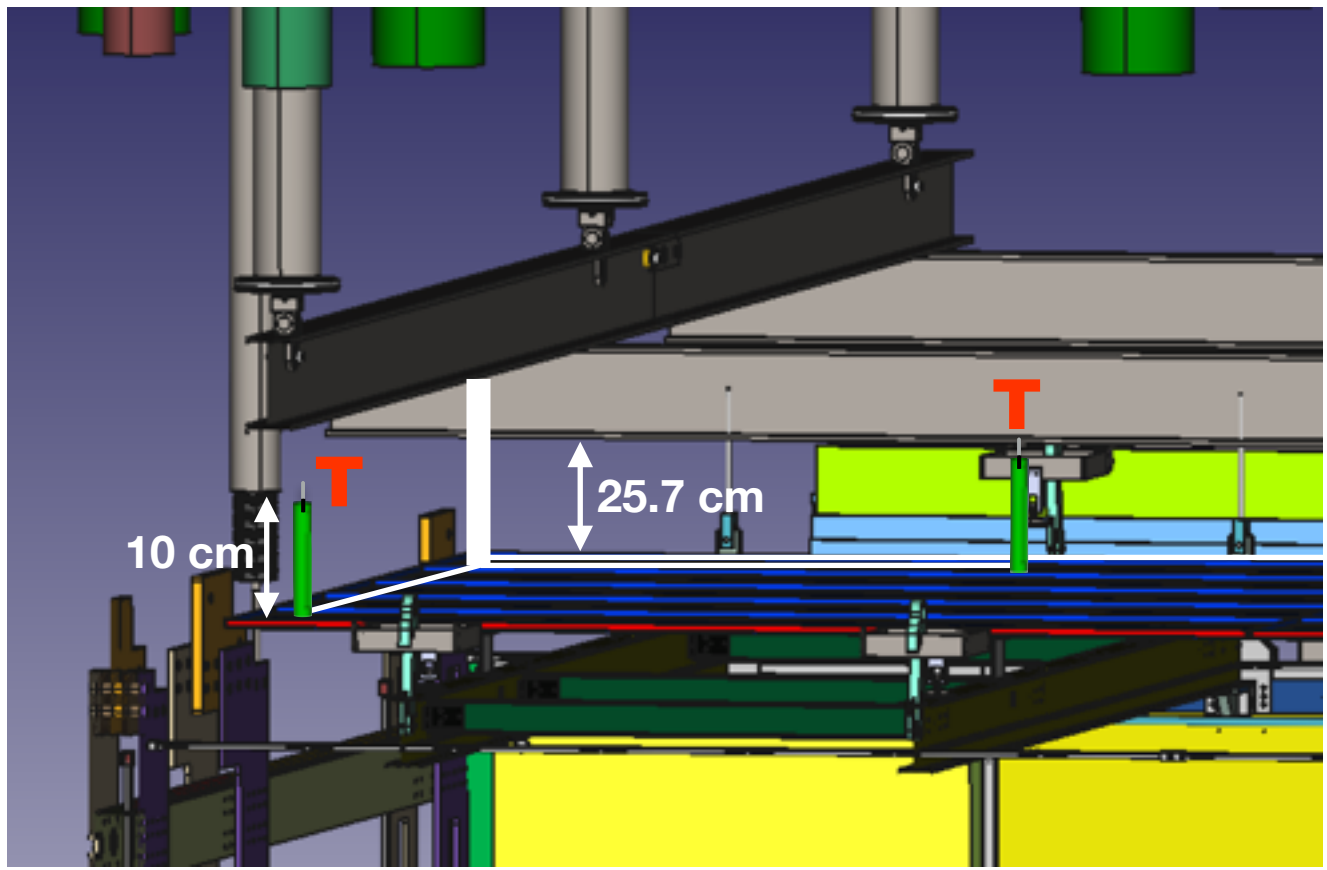
TOP ground plane cabling



Sensor's support

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



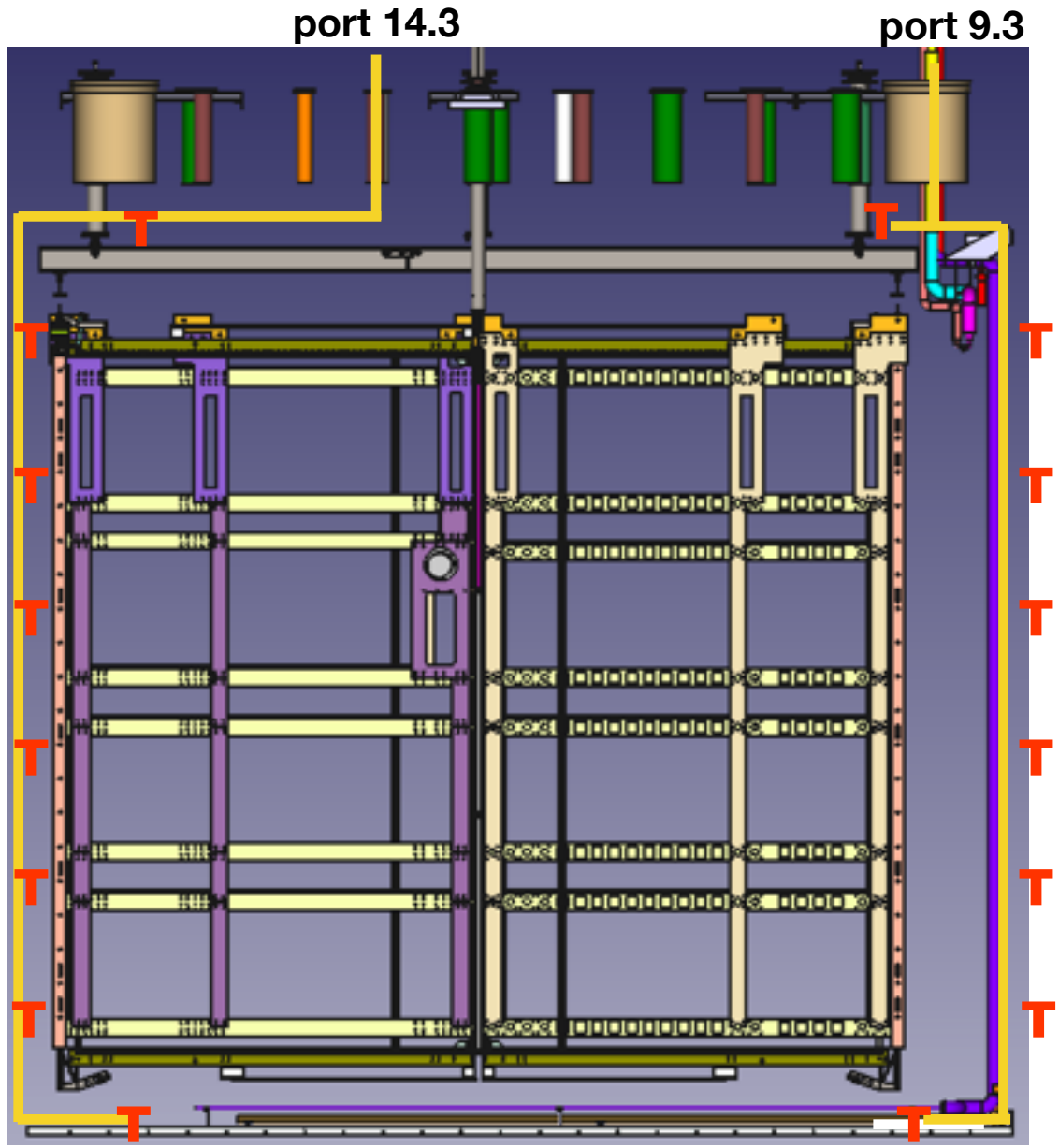


Sensors on cryostat walls

- 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

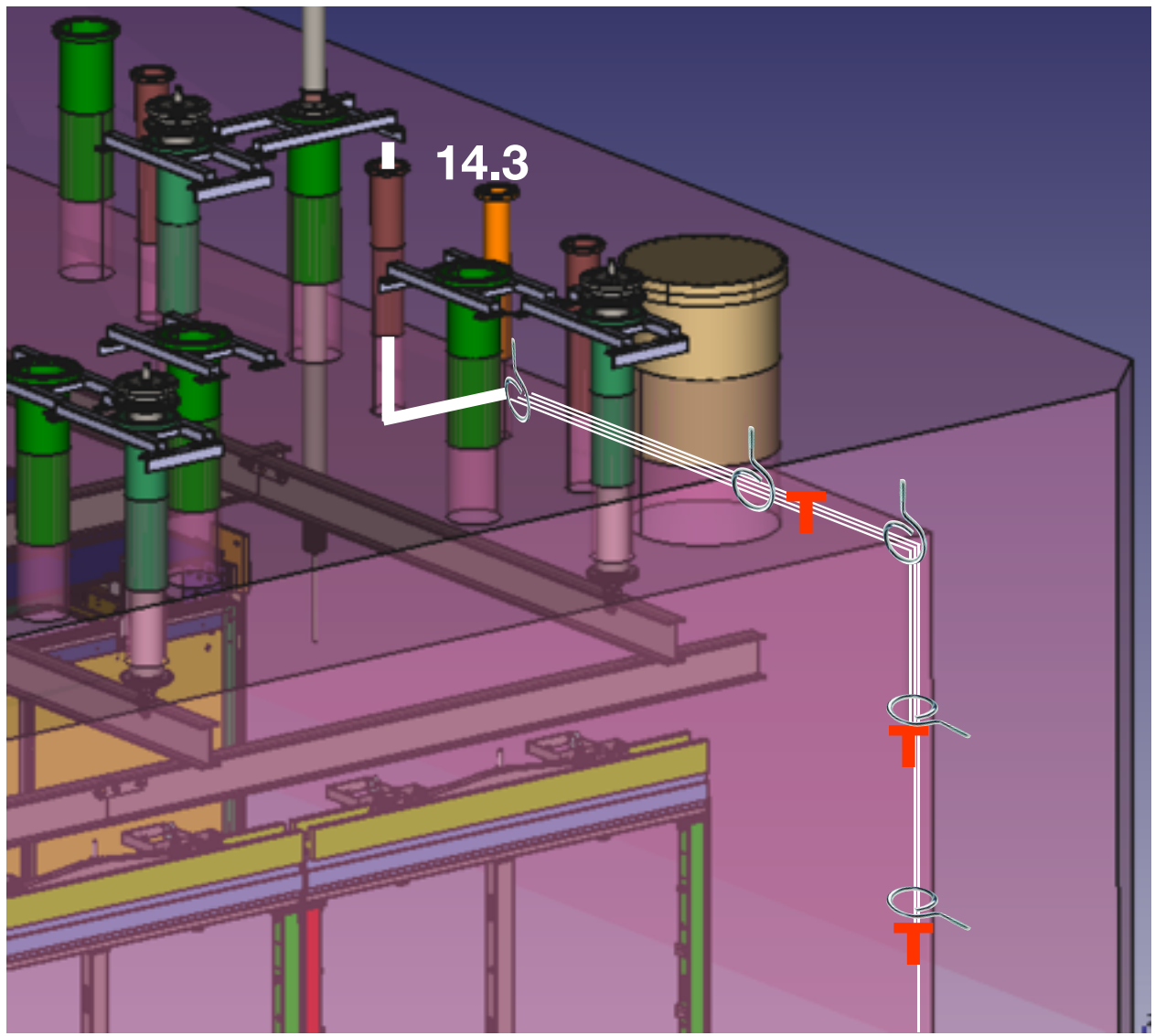
seen from downstream



Cabling for membrane: south

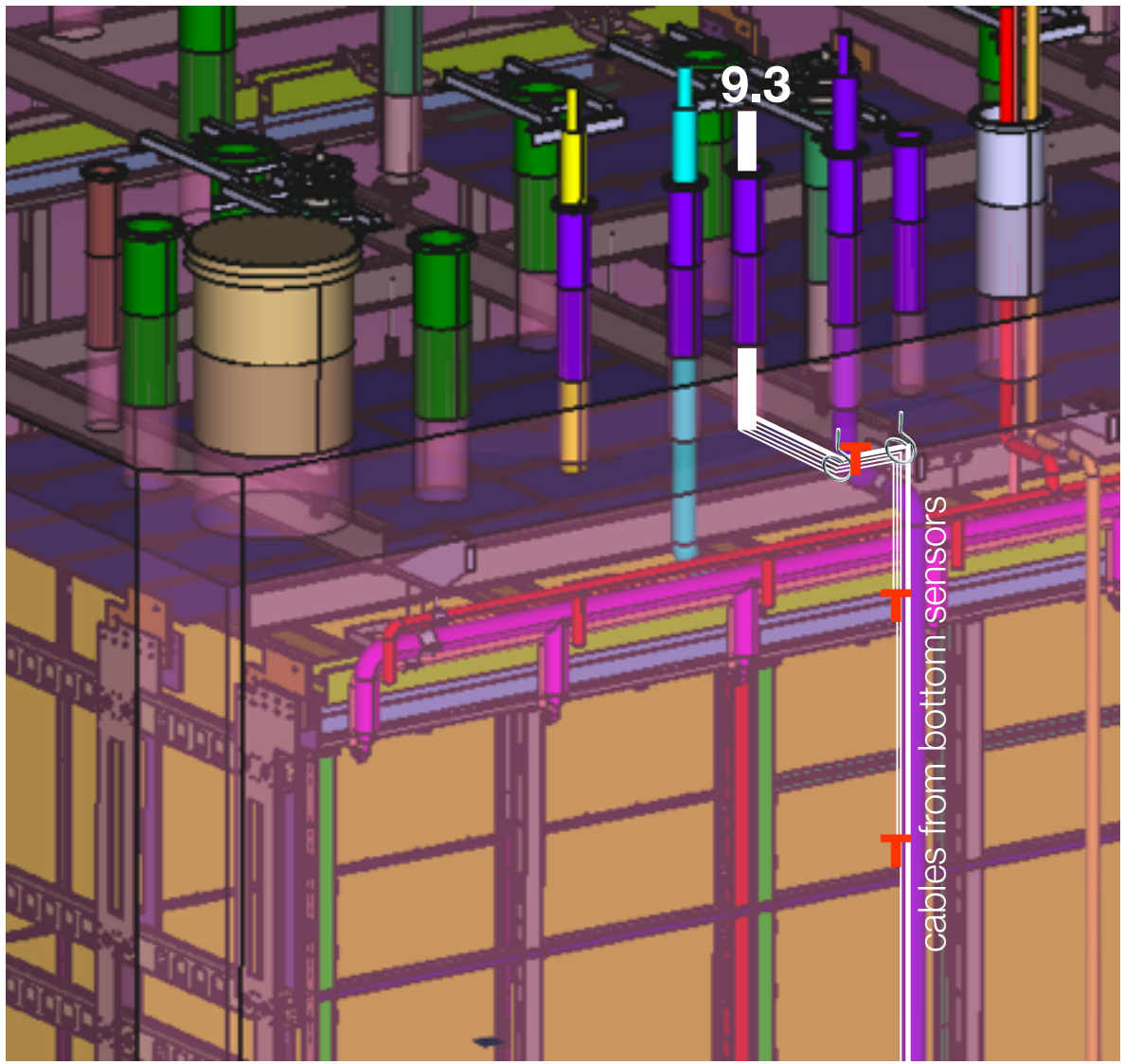
- Weld bridle rings to the joint between two walls

- 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



cables

Cables

- In order to maximize the precision of the temperature measurements and at the same time to guarantee **good behaviour in cold and low outgassing** the following requirements have been identified:
  - 4 wires per sensor
  - Teflon jacketed (FEP, PTFE) cables
  - Twisted pair wires
  - EMC shielding every two pairs
- Three models under consideration:
  - Alpha Wire
  - Belden
  - Axon-cable
- We will chose next week and ask for the derogation

In farnell

- too thick AWG<25

3300 $/Km

ALPHA WIRE

Multipair Screened Cable, Communication, Slate, 2 Pair, 24 AWG, 1000 ft, 304.8 m

Technical Data Sheet (130.99KB) EN
RoHS compliant

Jacket Colour	**Slate**
No. of Pairs	**2 Pair**
Wire Gauge	**24AWG**
Conductor Area CSA	-
Reel Length (Imperial)	**1000ft**
Reel Length (Metric)	**304.8m**
No. of Max Strands x Strand Size	**7 x 0.2mm**
Voltage Rating	**150V**
Jacket Material	**FEP**
Conductor Material	**Tinned Copper**
External Diameter	**4.318mm**
Product Range	-

2000 $/Km

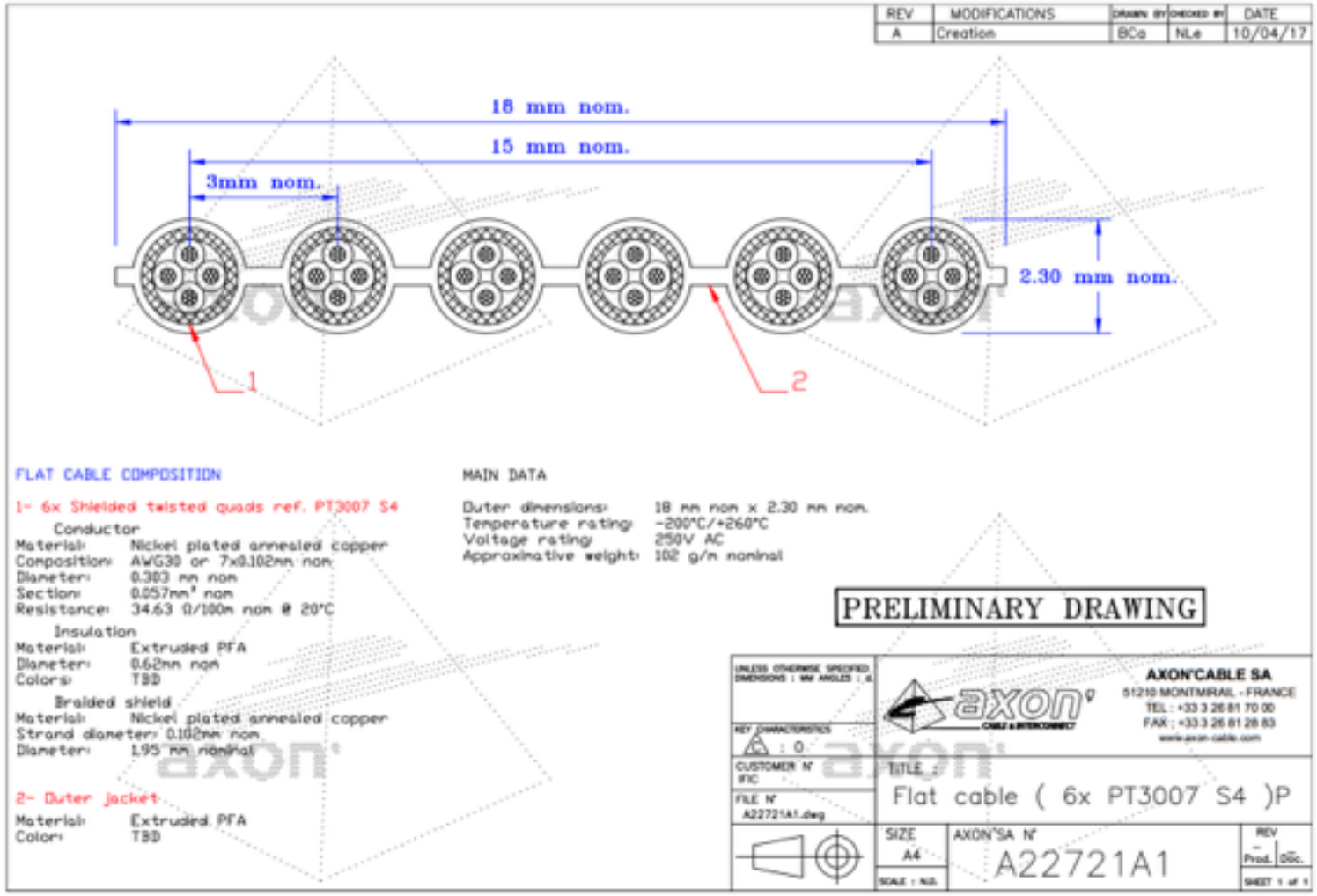
BELDEN

SHIELDED CABLE MULTIPAIR, 2PAIR, 1000FT, 22AWG, 300V, RED

Technical Data Sheet (94.39KB) EN
RoHS compliant

Jacket Colour	**Red**
No. of Pairs	**2 Pair**
Wire Gauge	**22AWG**
Conductor Area CSA	-
Reel Length (Imperial)	**1000ft**
Reel Length (Metric)	**304.8m**
No. of Max Strands x Strand Size	**7 x 30AWG**
Voltage Rating	**300V**
Jacket Material	**FEP**
Conductor Material	**Tinned Copper**
External Diameter	**3.759mm**
Product Range	-

Flat cable from Axon



No	Reference	Designation		Qty	Leadtime	Unit price	Line total	Comments
1	A22721A1	FLAT CABLE (6*PT3007 S4) P		0.05 KM	TBD	80 737.00 € / KM	4 036.85 €	
2	PRESTATIONSERVICE	SET UP TOOLNG	***	1 P	2 WEEKS	325.00 € / P	325.00 €	Set up tooling along with line 1 : A22721A1
3	A22721A2	CABLE (PT3007 STE4) P6		0.65 KM	TBD	30 305.00 € / KM	19 698.25 €	

cylindrical cable from axon

REV	MODIFICATIONS	DRAWN BY	CHECKED BY	DATE
A	Creation	BCa	NLe	10/04/17

CABLE COMPOSITION

1- 6x Shielded jacketed twisted quads ref. PT3007 StE4

Conductor
Material: Nickel plated annealed copper
Composition: AWG30 or 7x0.102mm nom
Diameter: 0.303 mm nom
Section: 0.057mm² nom
Resistance: 34.63 Ω/100m nom @ 20°C

Insulation
Material: Extruded PFA
Diameter: 0.62mm nom
Colors: TBD

Braided shield
Material: Nickel plated annealed copper
Strand diameter: 0.102mm nom
Diameter: 1.95 mm nominal

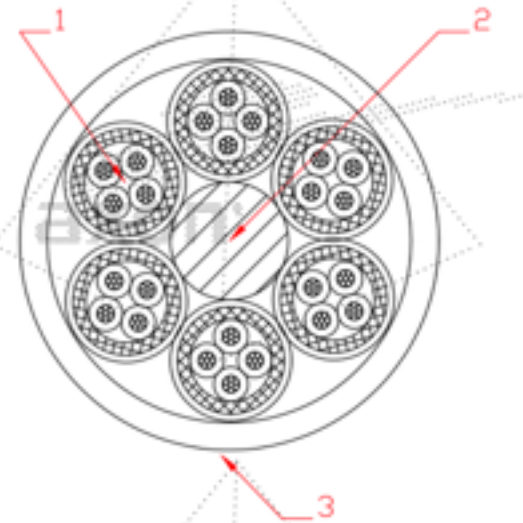
Insulation wrapped and sintered PTFE tape
Color: White
Diameter: 2.20 mm nominal

2- Filler for roundness

3- Outer jacket
Material: Extruded PFA
Color: TBD

MAIN DATA

Outer diameter: 7.60 mm nom
Temperature rating: -200°C/+260°C
Voltage rating: 250V AC
Approximative weight: 102 g/m nominal



PRELIMINARY DRAWING

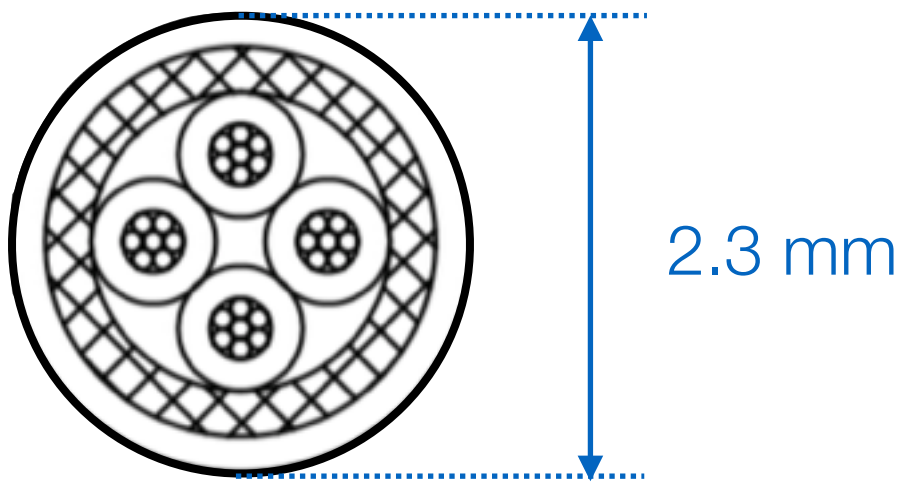
AXON'CABLE SA
51210 MONTMIRAIL - FRANCE
TEL : +33 3 26 81 70 00
FAX : +33 3 26 81 28 83
www.axon-cable.com

KEY CHARACTERISTICS : 0
CUSTOMER N° IFIC
FILE N° A22721A2.dwg
TITLE : Cable (PT3007 StE4)P6
SIZE A4
AXON'SA N° A22721A2
REV – Prod. – Doc.
SHEET 1 of 1

No	Reference	Designation		Qty	Leadtime	Unit price	Line total	Comments
1	A22721A1	FLAT CABLE (6*PT3007 S4) P		0.05 KM	TBD	80 737.00 € / KM	4 036.85 €	
2	PRESTATIONSERVICE	SET UP TOOLNG	***	1 P	2 WEEKS	325.00 € / P	325.00 €	Set up tooling along with line 1 : A22721A1
3	A22721A2	CABLE (PT3007 STE4) P6		0.65 KM	TBD	30 305.00 € / KM	19 698.25 €	

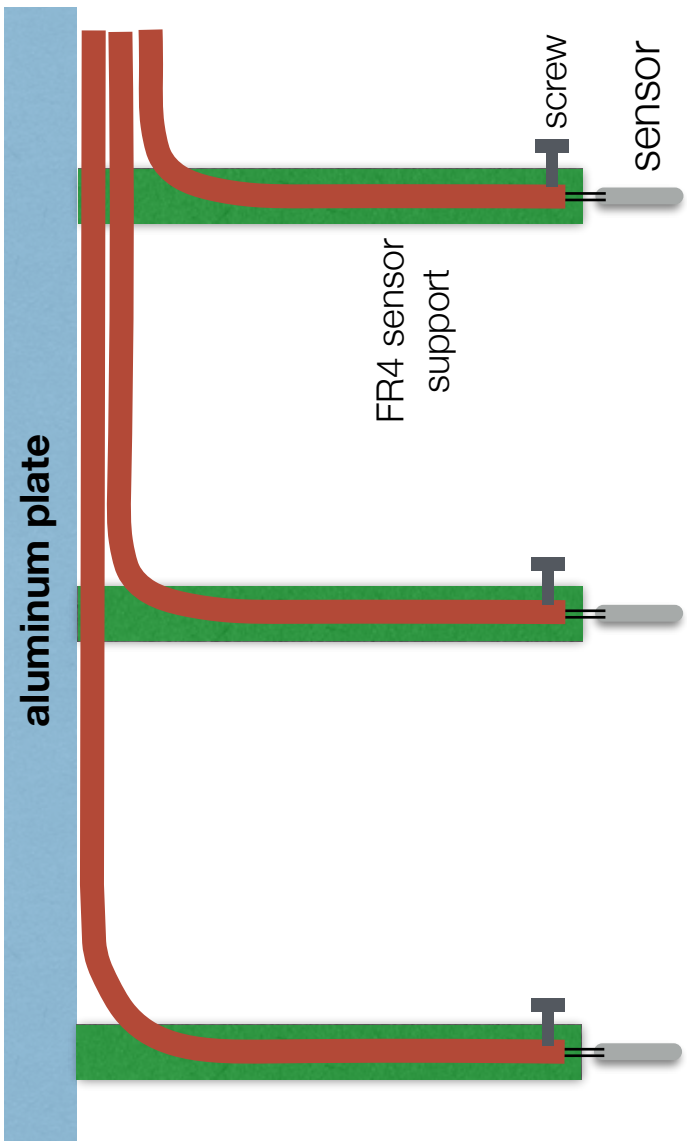
Individual cables

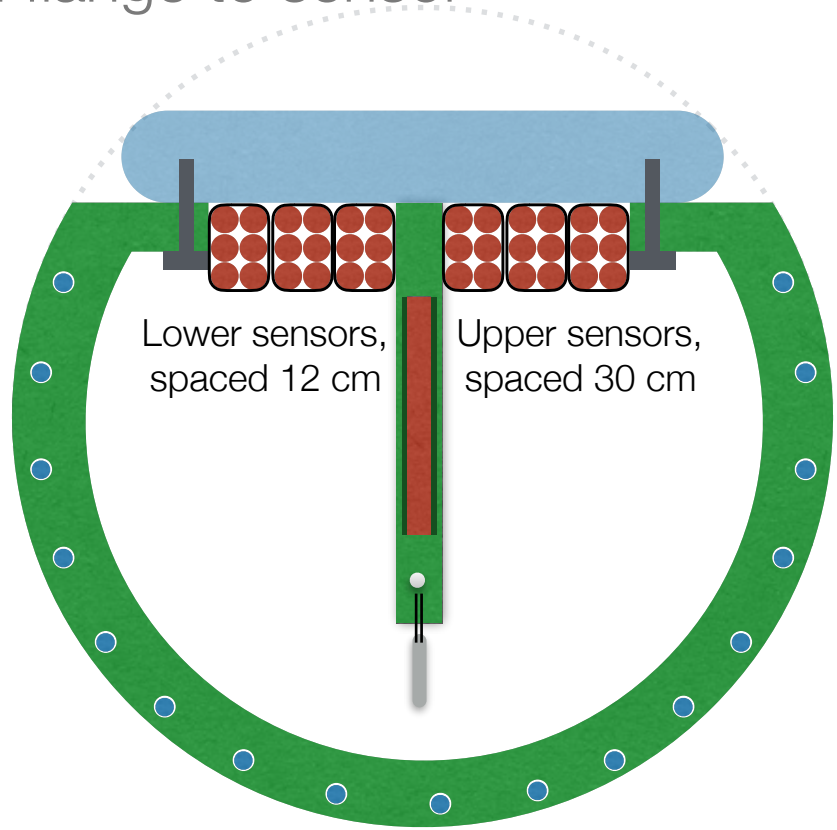
- I’ve asked Axon to explore the option of individual cables
- I would expect this cable to cost about 10000 $/Km
- We need about 500 m for “other sensors”
- We need about 250 m for T-gradient monitor



Cables and sensors

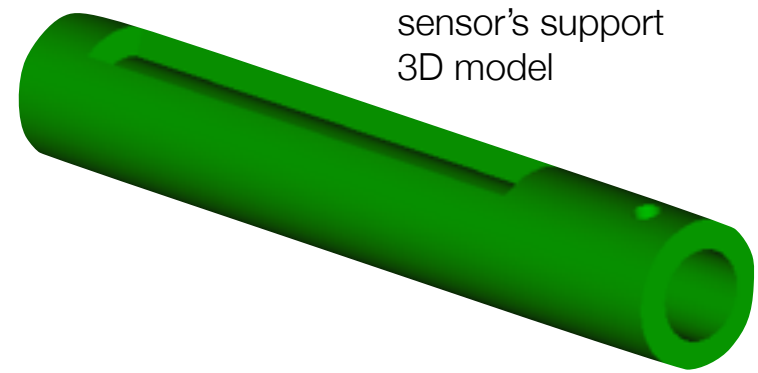
- Single 4-wires cables from flange to sensor





One SUBD-25 connector for each cable bundle

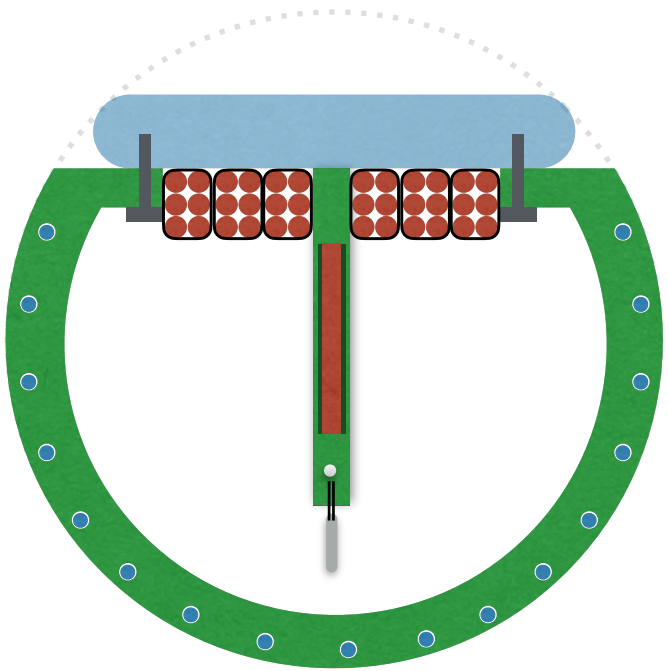
sensor's support 3D model



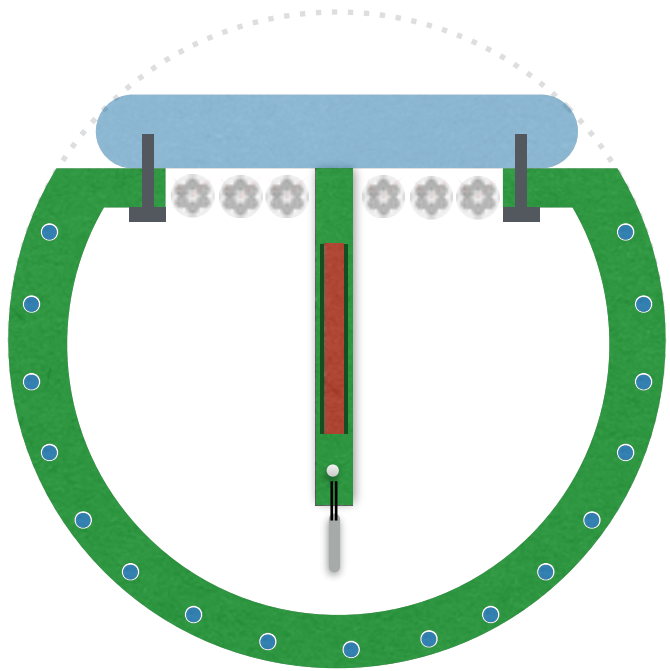
Cable options

- I can see three options:
  - Individual four wires cables, distributed in bundles by us
  - cylindrical bundles of six 4-wires cables with outer teflon jacket
  - flat cables with six cables of 4-wires with outer teflon jacket
- There are probably more options. Open to new ideas !!!!

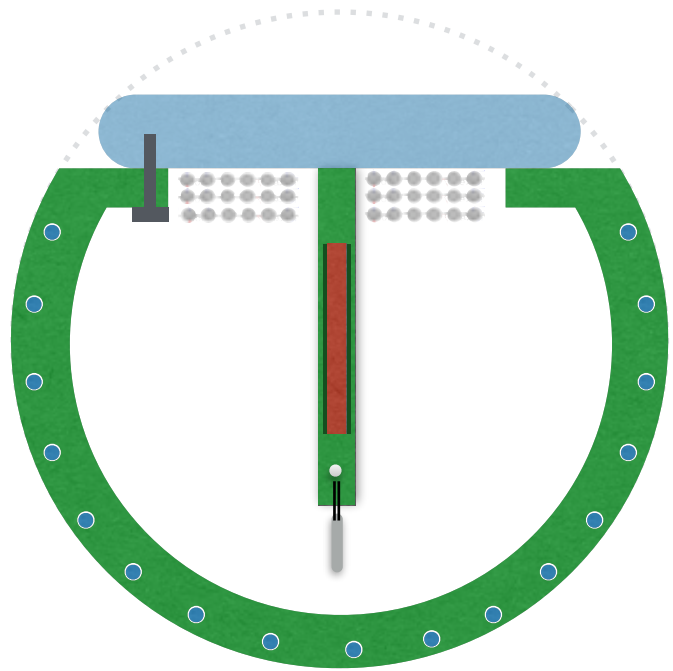
individual 4-wires cables



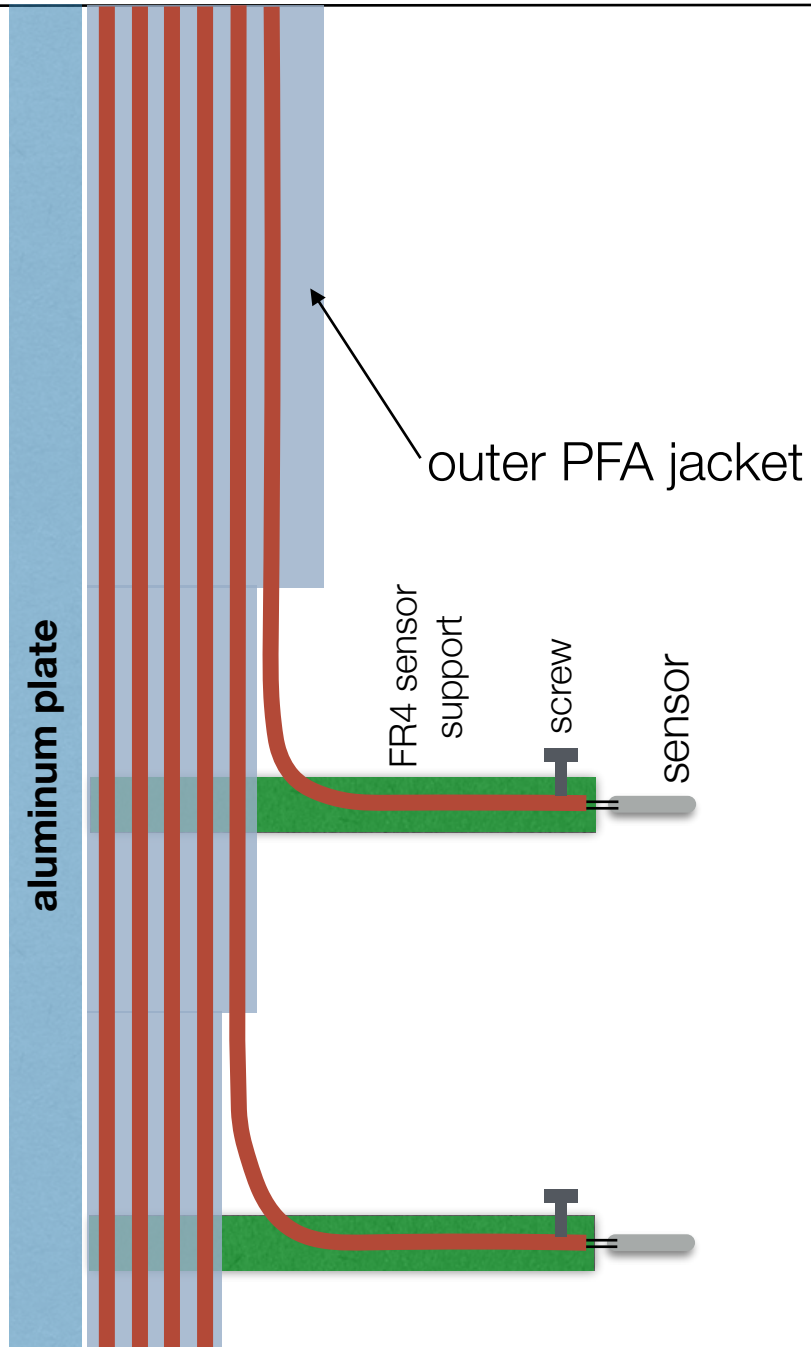
cylindrical 6-cables



flat 6-cables

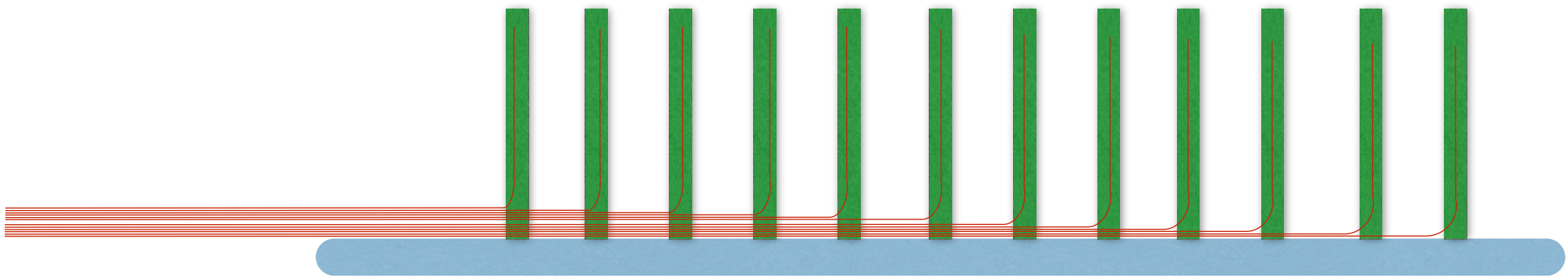


Outer jacket



- In the case we use an outer PFA jacket, this should be terminated at different distances
  - There are 18 sensors spaced 30 cm and another 18 spaced 12 cm
- I guess this is not posible for the cylindrical option since cables would have to be rearranged inside

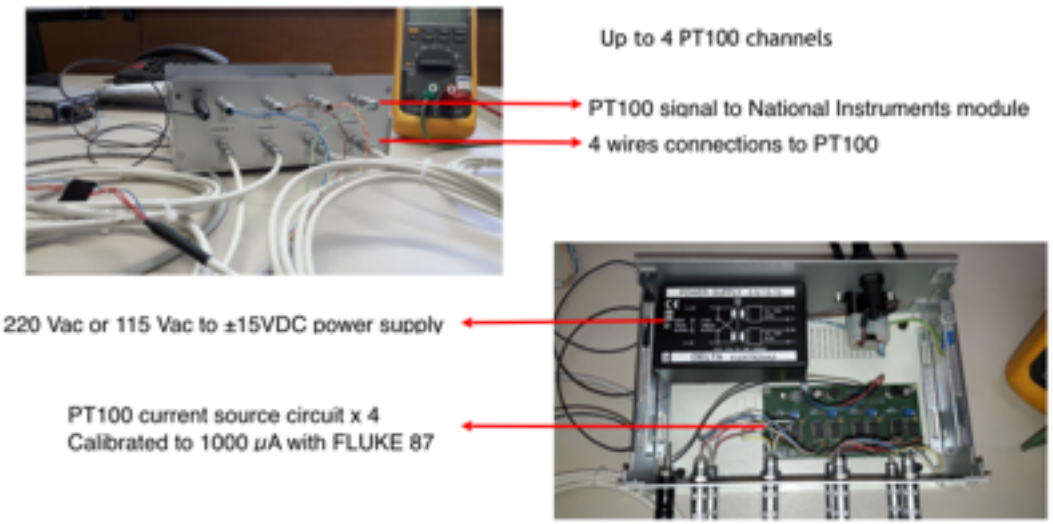
- Side view for two 6-cables bundles



calibration

Readout and slow controls

- Developed by CERN EP-DT department (Xavier Pons). Three parts:
  - An accurate current source for PT100 excitation, implemented by a compact electronic circuit using high a precision voltage reference from Texas Instruments.
  - A multiplexing circuit based on an ADG707 Analog Device multiplexer electronic device;
  - A high resolution and accuracy voltage signal readout module based on National Instruments NI9238, which has 24 bits resolution over 1 Volt range. This module is inserted in a National Instruments Ethernet DAQ backplane, which will distribute the temperature values to the main Slow Control Software through the standard protocol, OPC UA. The Ethernet DAQ will include also the multiplexing logic

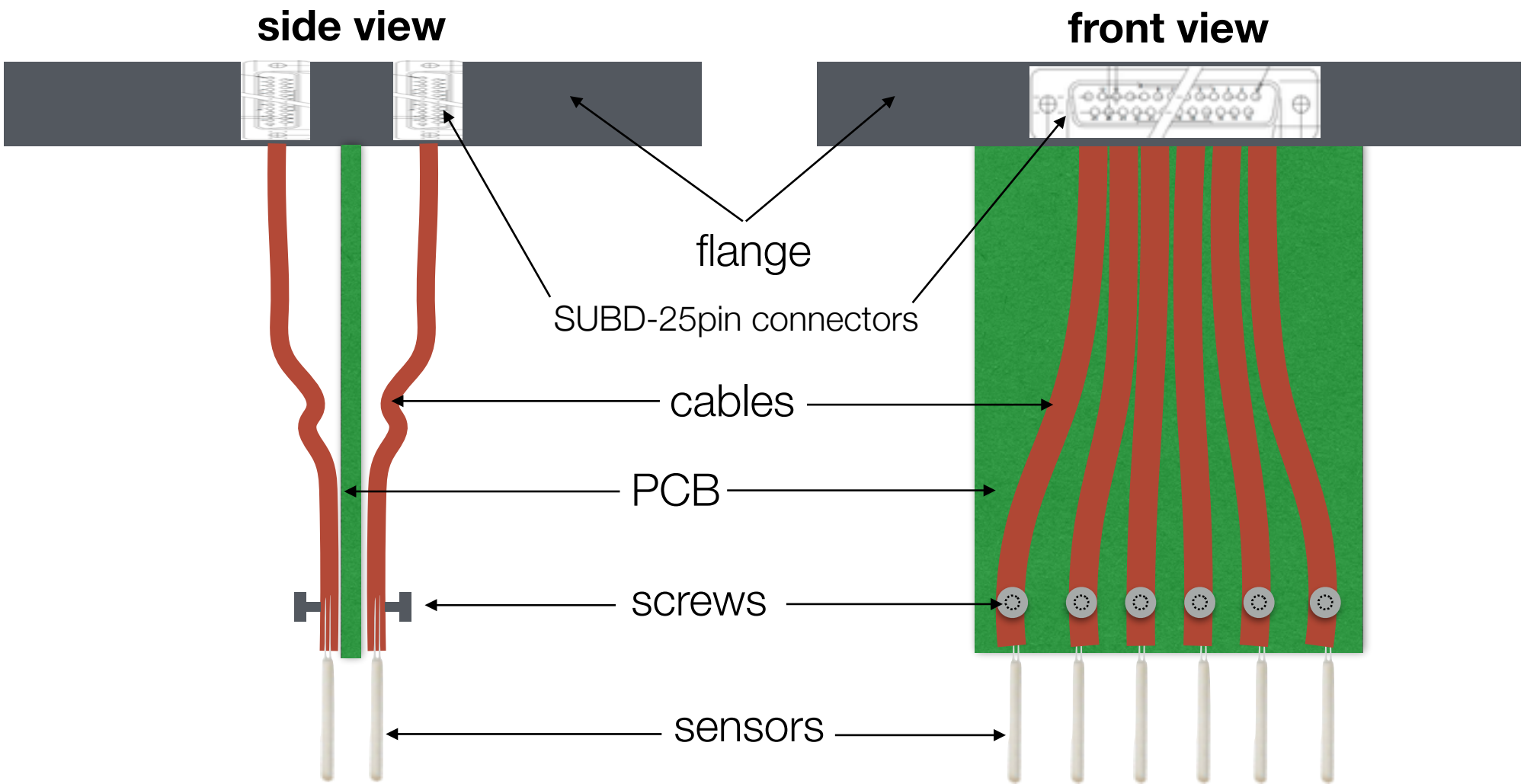


current source calibrated to 3 nA

Sensor calibration

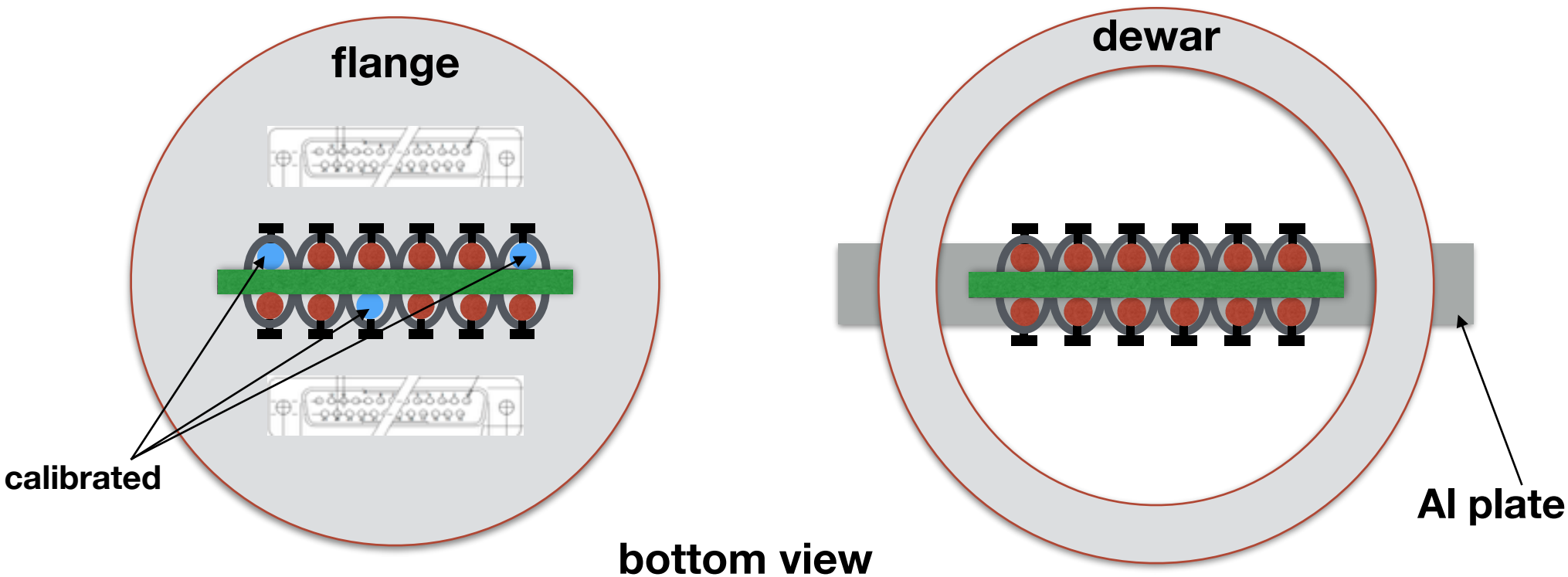
- Lakeshore calibrated sensors are 5 times more expensive (>500 €)
- A small dewar (16 cm opening) available in Valencia (up to 15 atm)
- The idea is to use LAr as bulk
- Use LN2 and a heater to vary slightly the temperature (±5 K)
- The flange and the system to hold the sensors needs to be designed
- Initial tests with no flange will begin next week

Conceptual design



Conceptual design

- **9 sensors** can be **calibrated at once** using as **reference 3 sensors calibrated by Lakeshore**. Perform several combinations of locations to disentangle possible spacial variations of temperature
- The flange will arrive later, so we need some temporary solution
  - We should be able to screw the PCB holding the sensors either to the flange or to an Aluminum plate at the top of the dewar

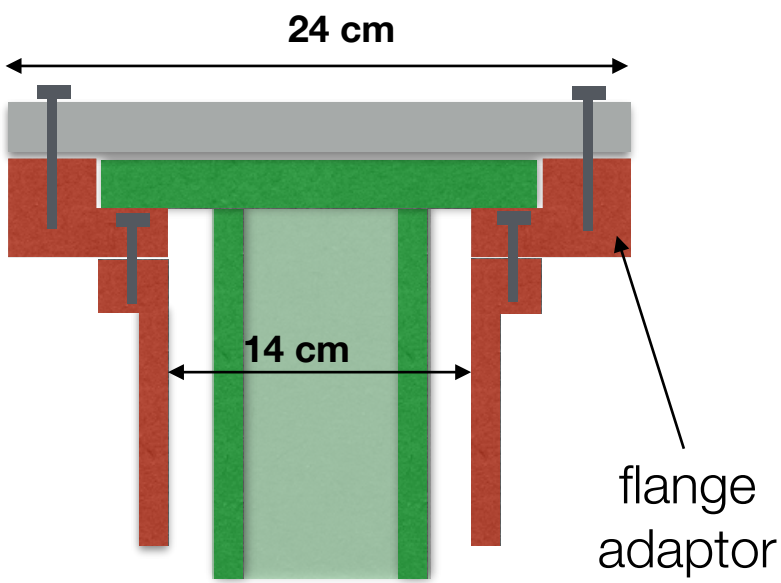


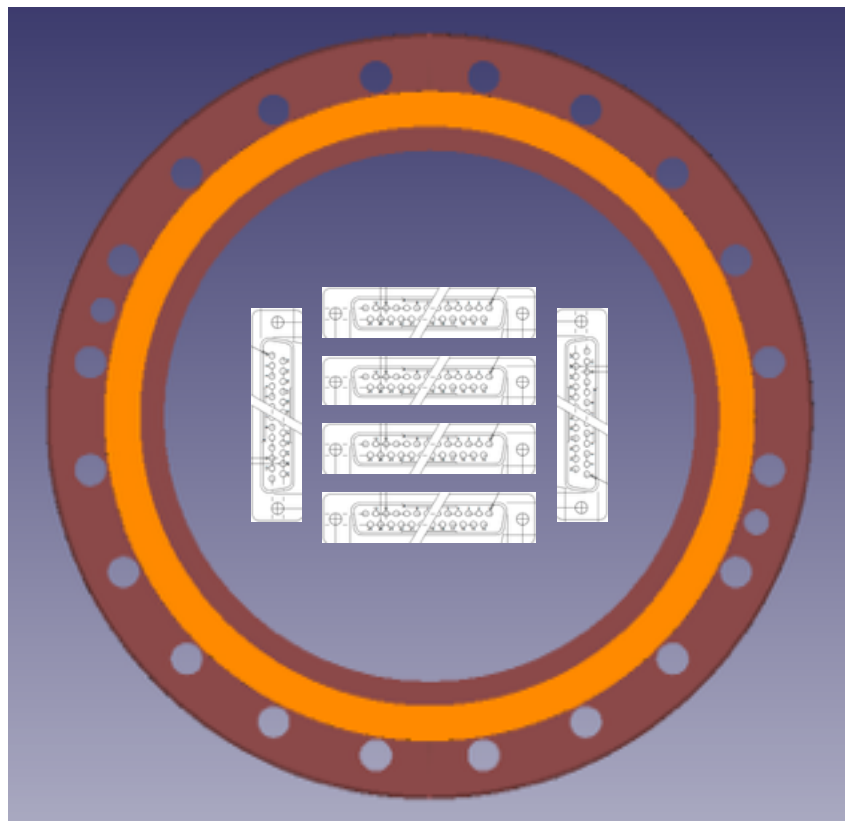
backup

Flange area

- The FR4 tube rests on top of the chimney (use a flange adaptor) in this way the T-gradient monitor and the flange are independent
  - We could for example open the flange to check the connections

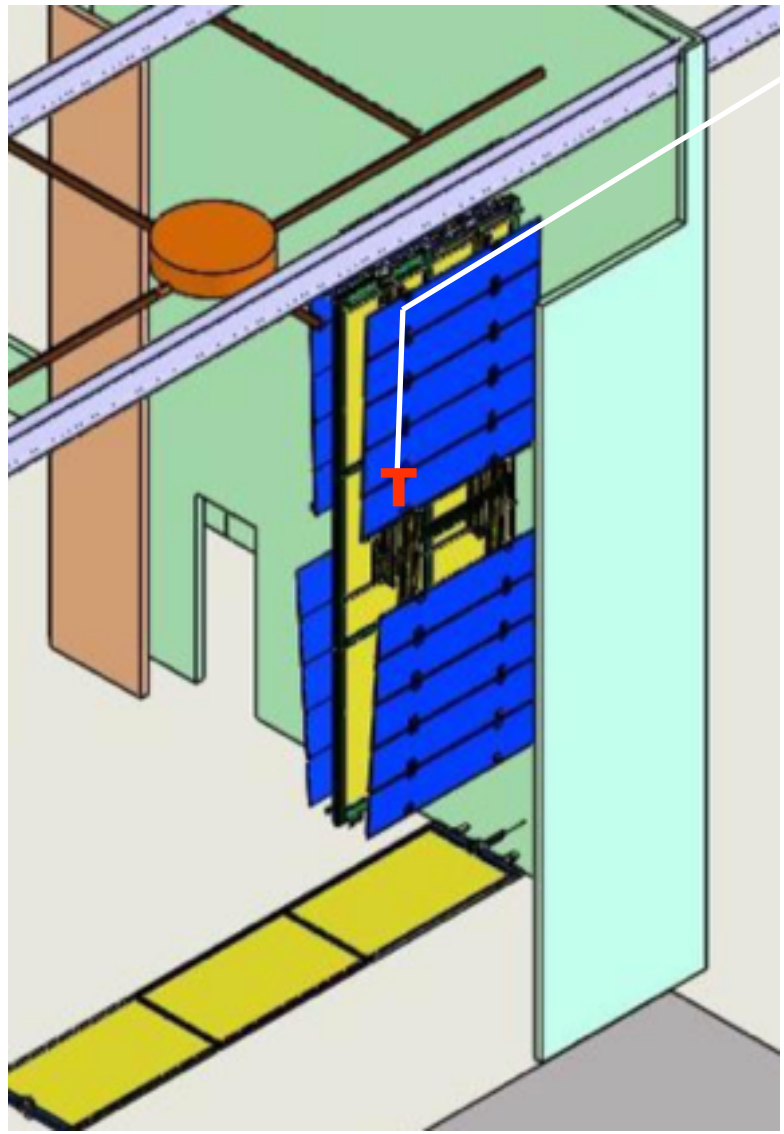
6 SUB-D 25 pin
36 sensors
144 wires





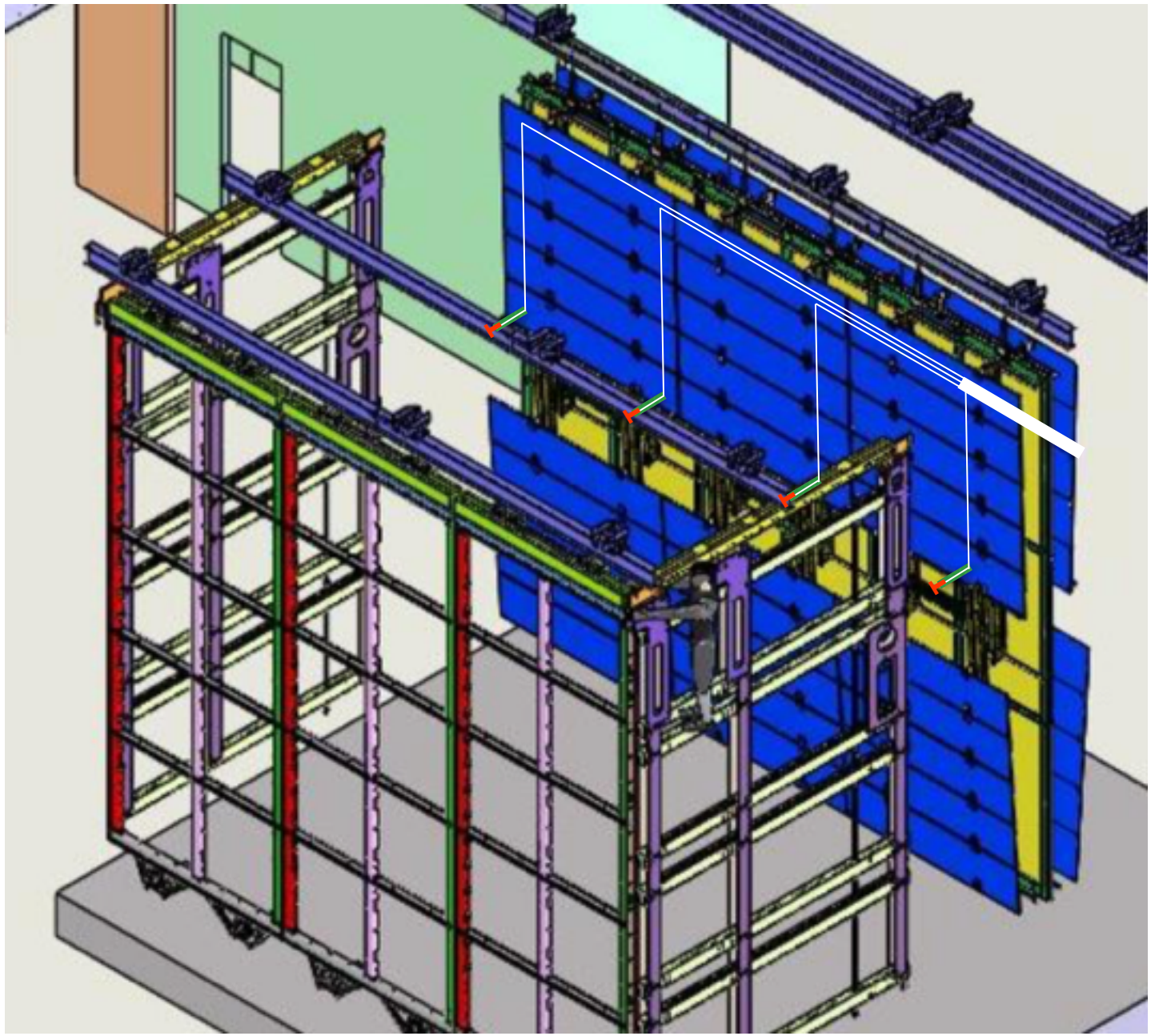
Installation in clean room

- **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)



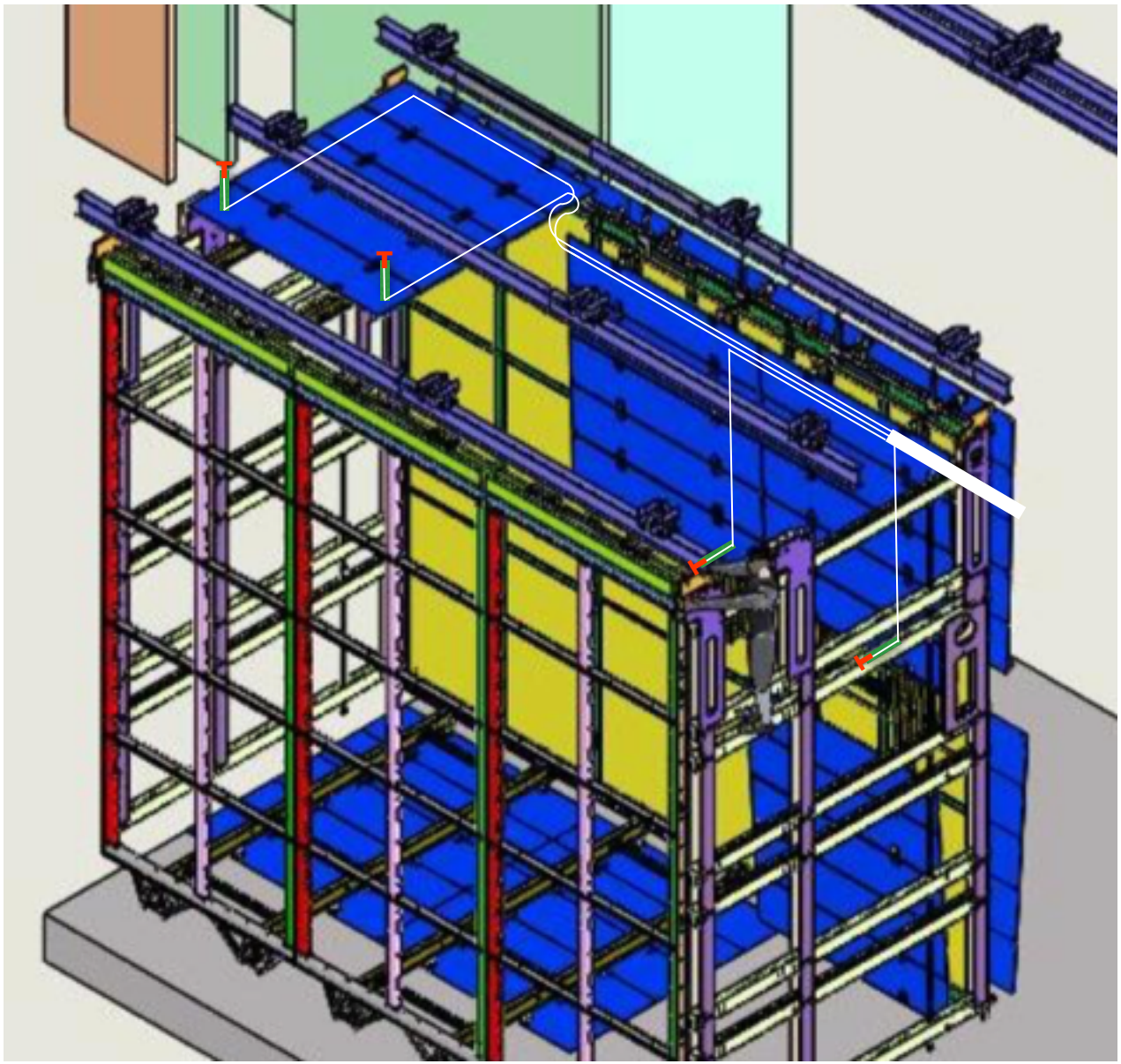
Moving GP into cryostat

- **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



Cryostat ports