Electrical and grounding connections review
CERN, 26/09/2017

T-gradient monitor II
and
“other” T sensors

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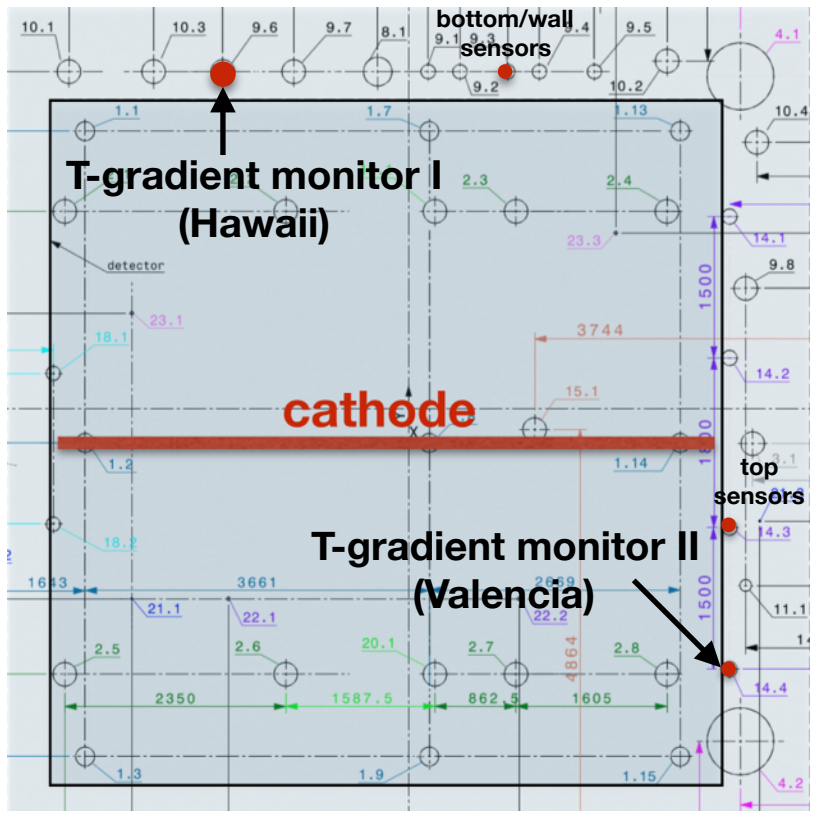
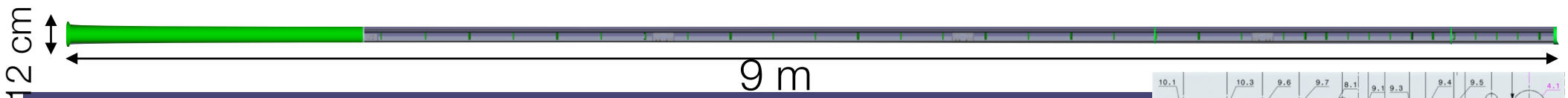
Motivation

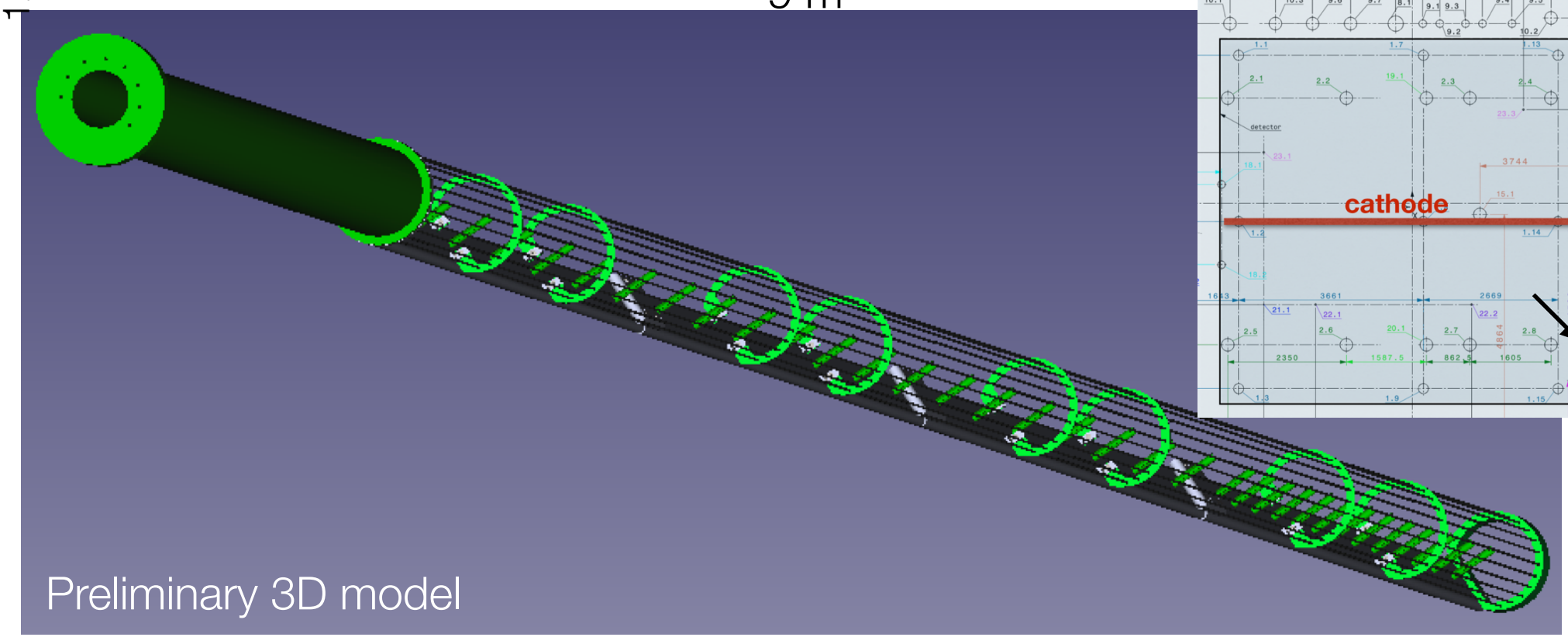
- precise (<5 mK) **3D temperature map** to validate fluid dynamic simulations and ensure a good understanding of the cryogenics system
  - **T-Gradient monitors**: detailed (10-30 cm) vertical profile at two **different XY** locations
  - Complement with **other sensors** of the same precision at other XY locations to provide a 3D map as detailed as posible
- standard sensors (~0.1 K) on the **membrane** to monitor cryostat behaviour during cool-down and filling
  - some of them on the **floor** to check that LAr is getting everywhere when filling starts



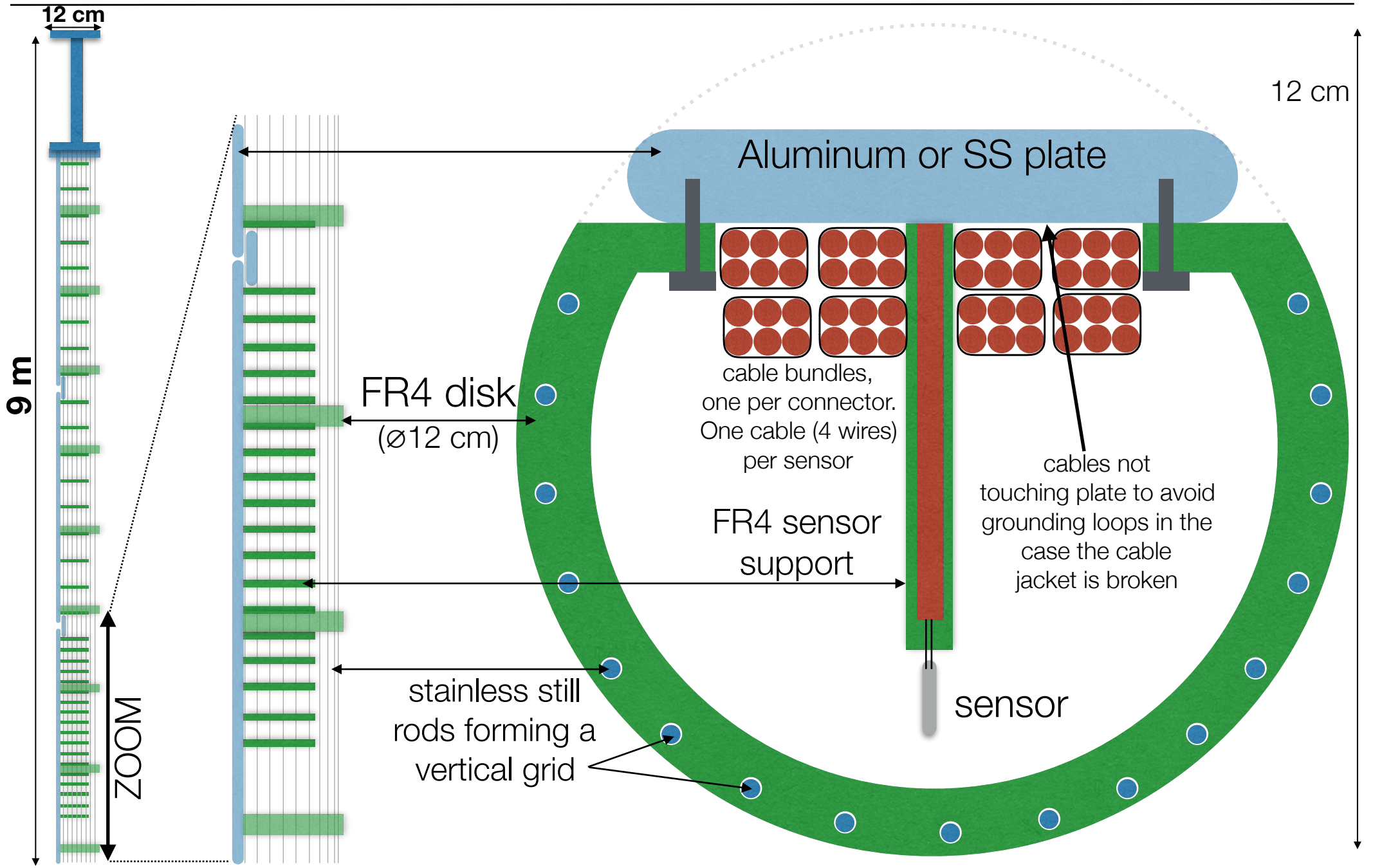
T-Gradient monitor II

- 9 meters long and 12 cm diameter cylinder hanging from port 14.4 (14 cm inner diameter)
- 48 sensors cross-calibrated in the lab
- Needs electric field shielding: sensors and cables inside faraday cage

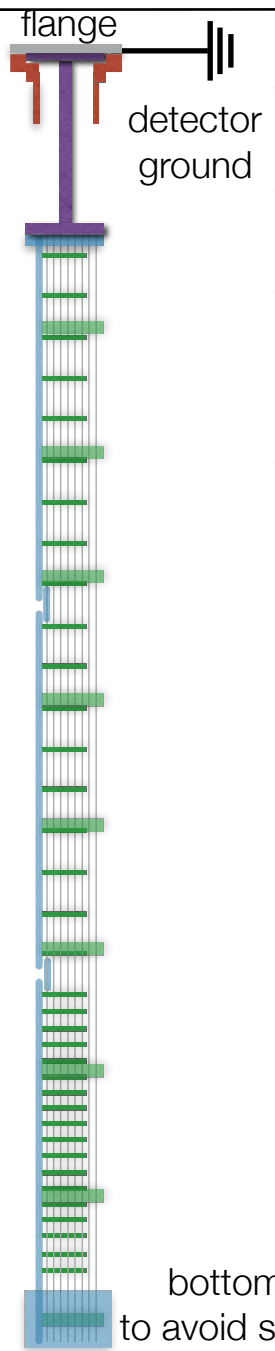




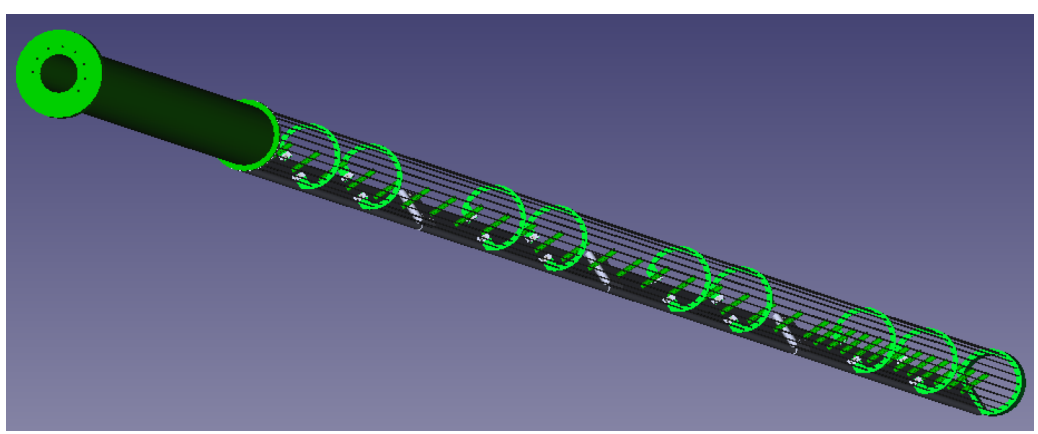
Conceptual design



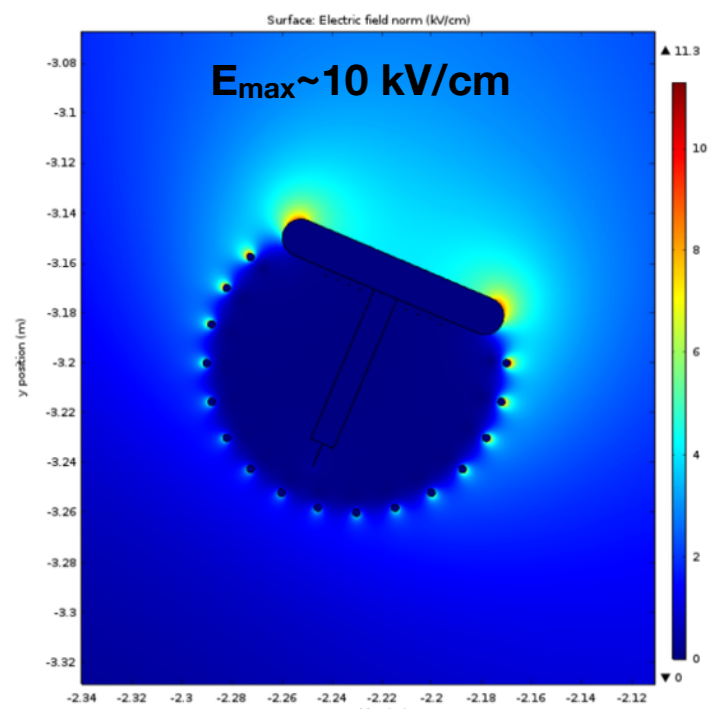
Electric field shielding



- 20 cm away from field cage end wall at -60 kV
- Cage connected to ground
- Two options, shield (grid + vertical plate) can be connected either to flange or to bottom cup
- Flange preferred. In this case must use non conductive cup or isolate cup from T-gradient

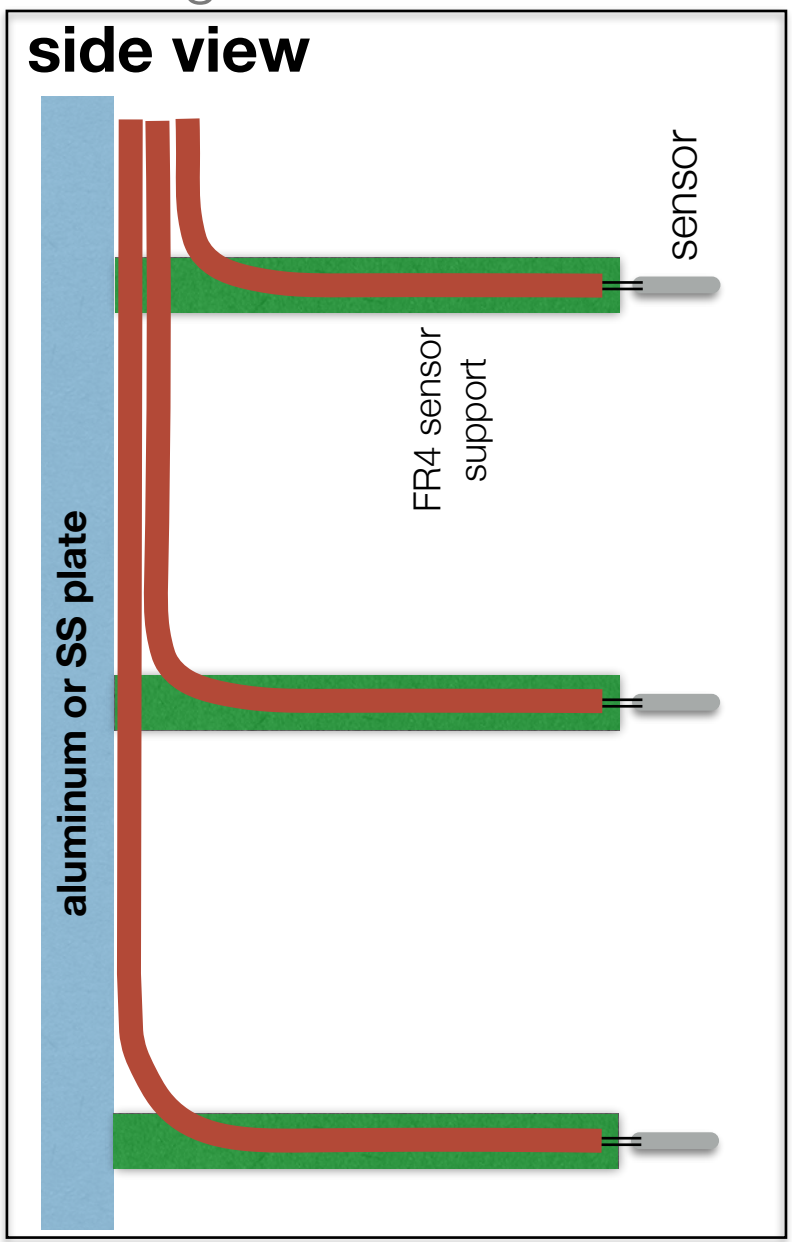


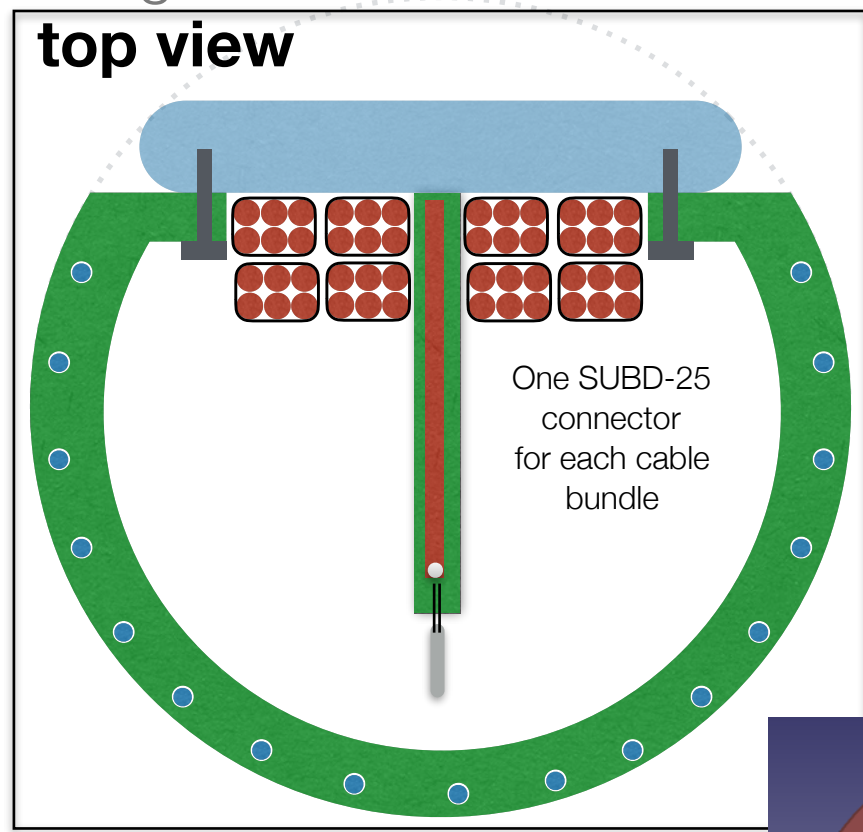
electrostatic simulation



Cables and connectors

- Single 4-wires cables from flange to sensor

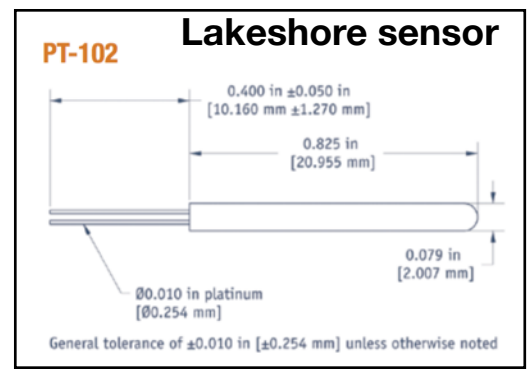


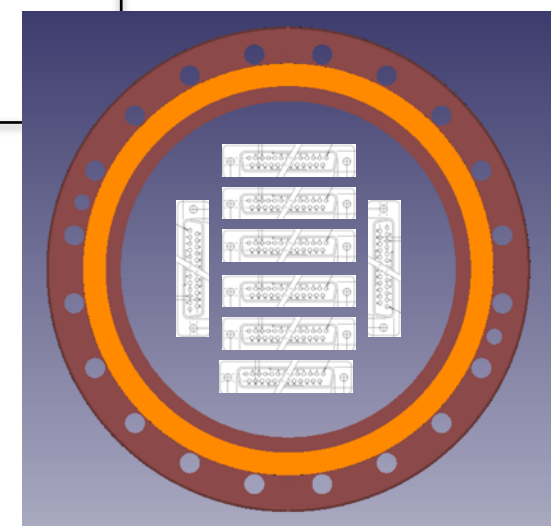


8 SUB-D 25 pin

48 sensors

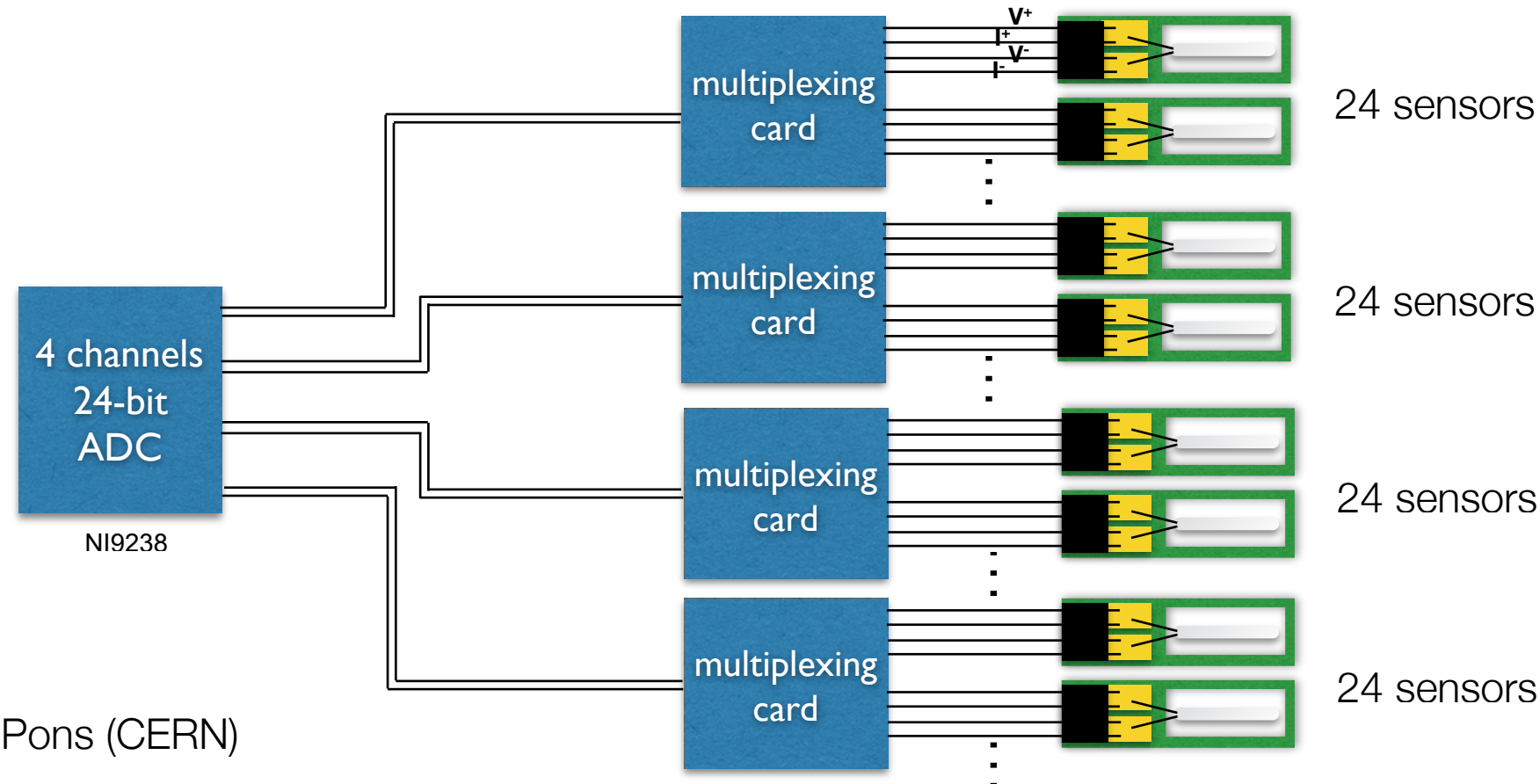
192 wires





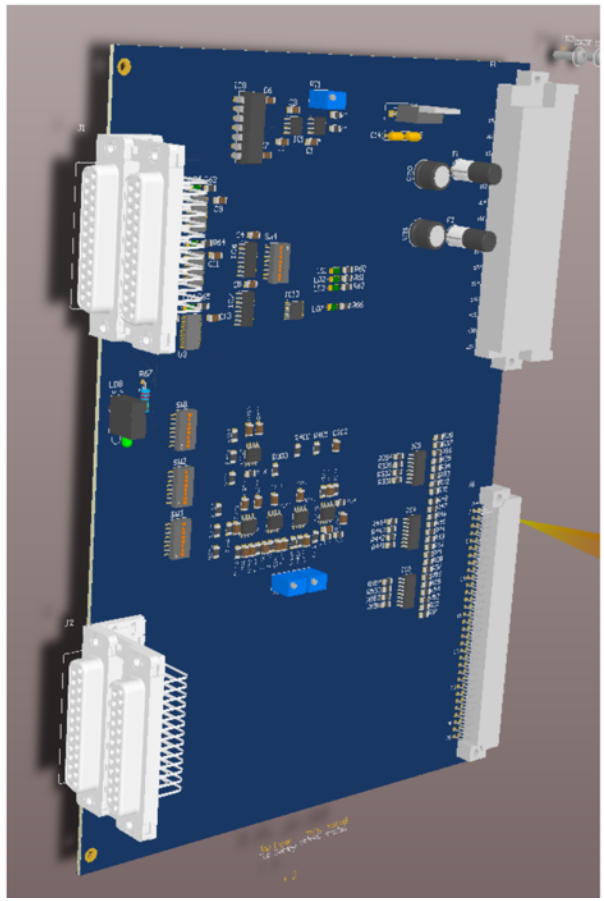
Readout

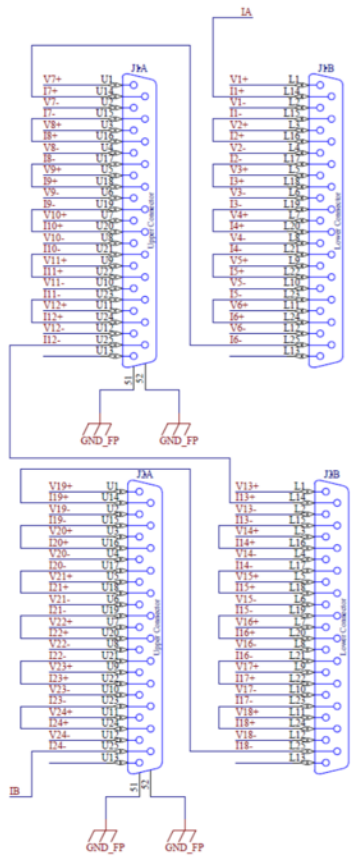
- 4 channels 24-bit (0-1 V range) ADC from National Instruments NI9238
- **1 mA DC** current source in the multiplexing card with all 24 sensors in series
- **4-wires system**: 2 for current excitation and 2 for voltage signal



Multiplexing board

- Able to read 24 sensors (6 per SUBD-25) with a single ADC channel
- Possibility to multiplex several multiplexing boards:
  - Needed if the final number of sensors is more than 96





6U size PT100 multiplexing board

2x2 SUB-D 25 pin female dual stacked connector

Dualport 25p F/F

D- Sub 25p, oben F / unten F / Güteklass

Manufacturer:	FCT Electronic
Fabricant prod no.:	FDT-25SG2M
Série:	FD

Voir la série

Current switch

- Reversing the current has been found very useful to disentangle sensor and readout channel offsets
- Although readout channel offsets can be computed using fix resistors, those offsets depend on the current source and ADC temperatures. Using an automatic current switch, the readout offsets are removed automatically
- **Question**: would a fast change between +1 and -1 mA induce some undesired noise on other systems ? The switch would be done every ~10”

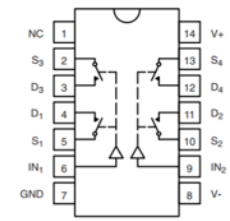
Current source polarity reversing using the circuit DG302B

Vishay Siliconix

FUNCTIONAL BLOCK DIAGRAM

DG302B

Plastic DIP



Top View

TRUTH TABLE	
Logic	Switch
0	OFF
1	ON

Logic “0” ≤ 0.8 V
Logic “1” ≥ 4 V

Cables

CABLE COMPOSITION

1- PTFE fillers for roundness

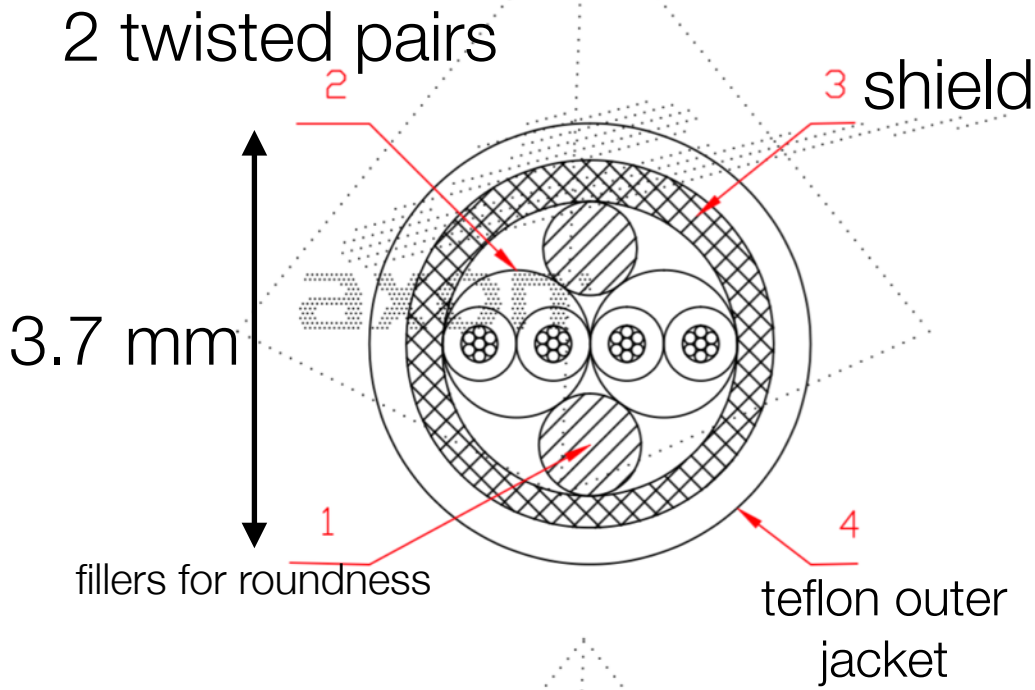
2- 2x twisted pairs ref. 2x PT2807
Description of one wire PT2807 SPC - ref. P556951
Conductor
Material: Silver plated annealed copper
Composition: AWG28 or 7x0.127mm nom
Diameter: 0.381 mm nom
Section: 0.088mm² nom
Resistance: 20 Ω/100m nom @ 20°C
Insulation
Material: Extruded PFA
Diameter: 0.70mm MAX.
Colors: Red/Black and Violet/Orange

3- Braided shield
Material: Nickel plated annealed copper
Strand diameter: 0.127mm nom

4- Outer jacket
Material: Extruded PFA
Color: White

MAIN DATA

Outer dimensions: 3.70 mm nom.
Temperature rating: -200°C/+200°C
Voltage rating: 250V AC MAX.
Approximative weight: 28 g/m nominal



UNLESS OTHERWISE SPECIFIED DIMENSIONS : MM ANGLES : d.

KEY CHARACTERISTICS
C : 0

CUSTOMER N°
IFIC

FILE N°
S566986AA.dwg

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

TITLE :
PT2807 StP2x2

SIZE
A4

SCALE : N.D.

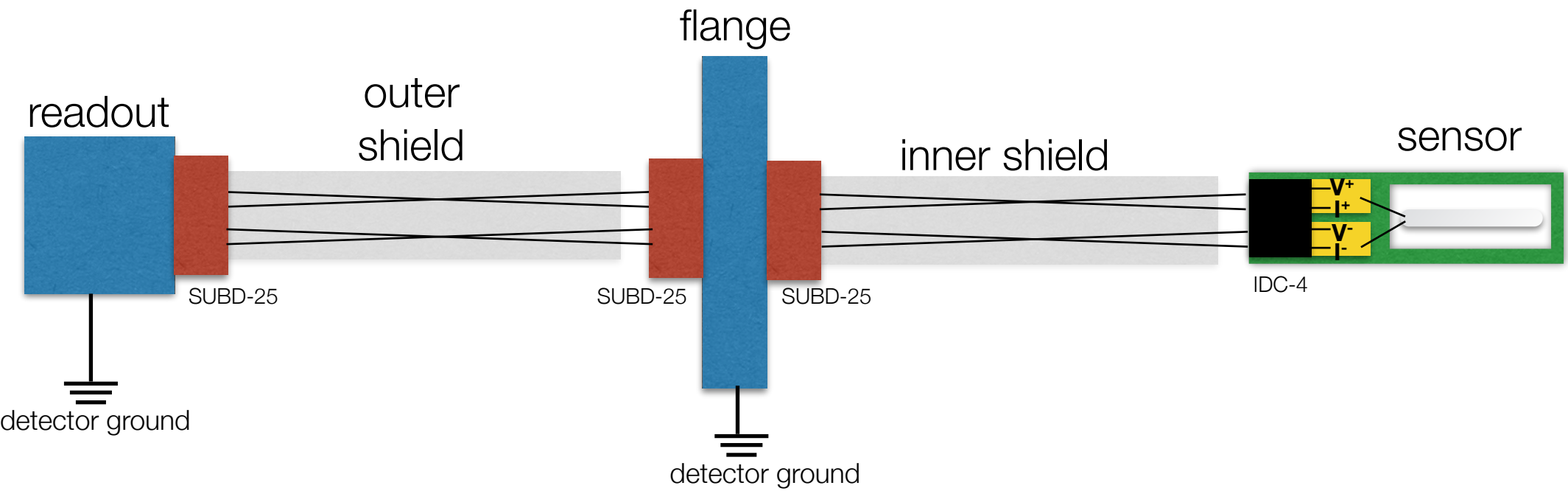
AXON'SA N°
P566986

REV
A
Prod. | Doc.

SHEET 1 of 1

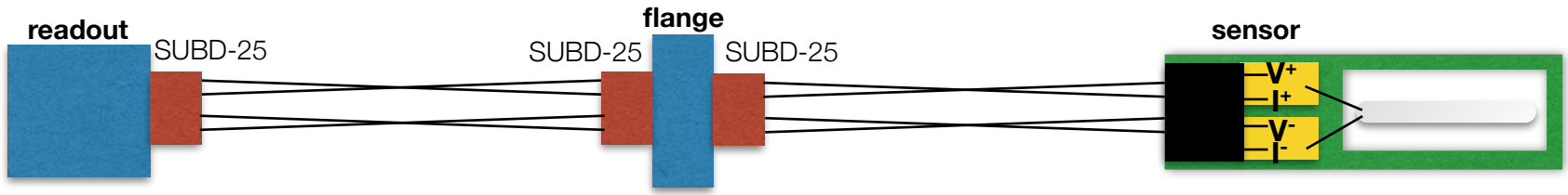
Electrical connections

- **4-wires system**: 2 for current excitation and 2 for voltage signal
- 2 twisted pairs, one for + (V and I) and one for -
- Cable metallic shield connected to ground as shown below:
  - the shield of six cables connected to the external shield of the SUB-D 25 connector

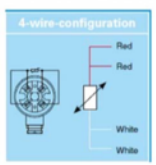


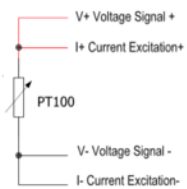
- To avoid a grounding loop the outer cable shield cannot be connected to flange

SUBD-25 channel mapping

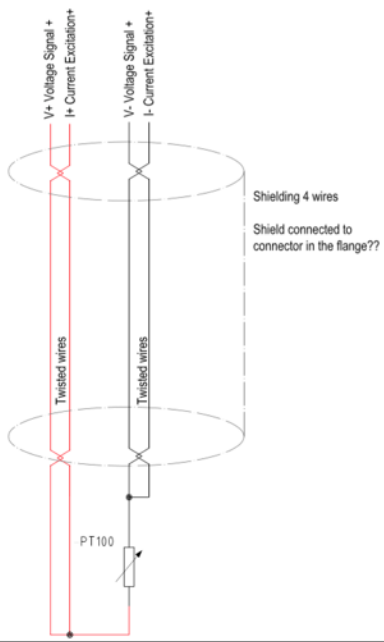


Pt100 RTD Colour codes IEC 60751

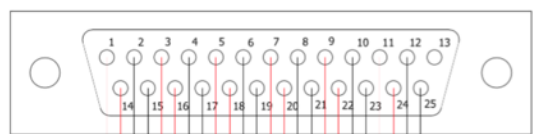




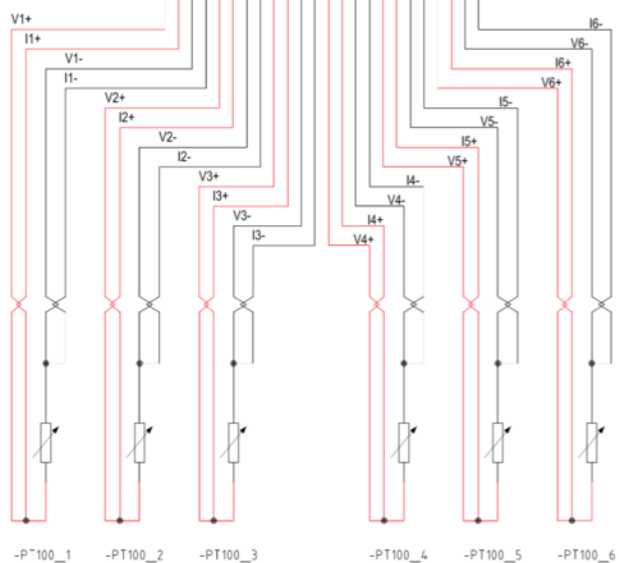
PT100 TWISTED WIRES CONVENTION



DB25 MALE CONNECTOR ON FLANGE
PT100 PIN ASSIGNEMENT
SHIELDING IS NOT REPRESENTED



DB25 MALE Connector
Front View



draft for discussion

DB25 CONNECTOR - PT100 PIN ASSIGNEMENT

PIN	TAG	DESCRIPTION
1	V1+	Voltage Signal + PT100_1
14	I1+	Current excitation + PT100_1
2	V1-	Voltage Signal - PT100_1
15	I1-	Current excitation - PT100_1
3	V2+	Voltage Signal + PT100_2
16	I2+	Current excitation + PT100_2
4	V2-	Voltage Signal - PT100_2
17	I2-	Current excitation - PT100_2
5	V3+	Voltage Signal + PT100_3
18	I3+	Current excitation + PT100_3
6	V3-	Voltage Signal - PT100_3
19	I3-	Current excitation - PT100_3
7	V4+	Voltage Signal + PT100_4
20	I4+	Current excitation + PT100_4
8	V4-	Voltage Signal - PT100_4
21	I4-	Current excitation - PT100_4
9	V5+	Voltage Signal + PT100_5
22	I5+	Current excitation + PT100_5
10	V5-	Voltage Signal - PT100_5
23	I5-	Current excitation - PT100_5
11	V6+	Voltage Signal + PT100_6
24	I6+	Current excitation + PT100_6
12	V6-	Voltage Signal - PT100_6
25	I6-	Current excitation - PT100_6
13	NC	Not connected

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CH-1211 GENEVA, 23
SWITZERLAND

DEEP UNDERGROUND NEUTRINO EXPERIMENT

NP - 04 DETECTOR
protoDUNE SP
SLOW CONTROLS

Project Name: Gradient Monitor

Designer: X.PONS | Created On: 15/06/2017
Checked: G.LEHMANN – S.PORDES – A.CERVERA | Modified On: 16/06/2017
Scale: 1 /ECH | File Name: DWG_FILE.DWG | Back File Name: FDP_FILE.DWG | Version: 2.0

Drawing Name: PT100 sensor connection mapping at the flange DB25 pin male connector.

EDMS Number: EDMS | Drawing Number: 1 Of 1

Labelling

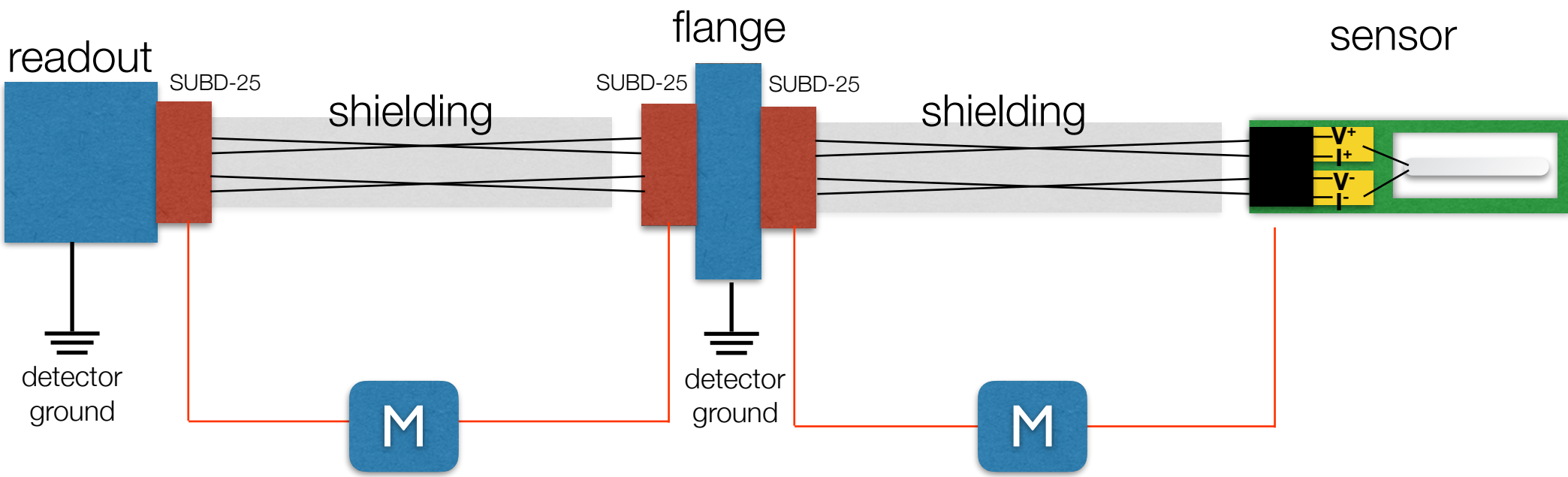
- All sensors and cables should be correctly labelled.
  - Sensors have a serial number (e.g. 43140, 43141, …) visible on the sensor itself
  - Outer cables and connectors will be always labeled
  - Inner cables and connectors will be labelled temporarily until all connections are done and verified
- Examples of bookkeeping and labelling for T-gradient monitor (48 units) and bottom pipe (12 units) sensors

position in T-gradient	elevation	flange	SUBD-25 in flange	position in SUBD-25	sensor	multiplexing card	SUBD-25 in card	position in SUBD-25	channel number
1-48	0-7000 mm	10.4	1-8	1-6	43140	1-2	1-4	1-6	1-48

pipe	position in pipe	flange	SUBD-25 in flange	position in SUBD-25	sensor	multiplexing card	SUBD-25 in card	position in SUBD-25
1-4	1-3	9.3	1-2	1-6	43140	3	1-2	1-6

Verifying connections

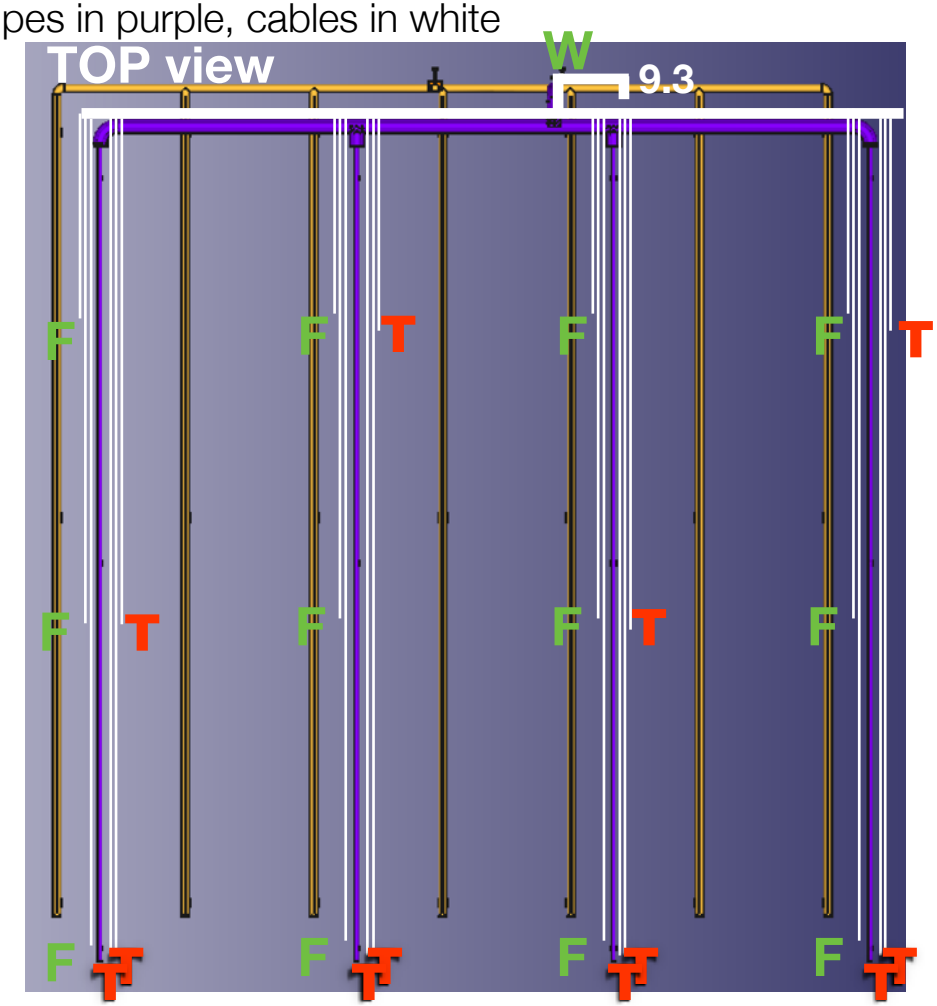
- Once installed, for every sensor we should verify that
  - **it works correctly**: shows ambient temperature. If possible use a small box with LN2 to test response in cold
  - **it is connected to the right readout channel**: heat/cool-down sensors individually and check that temperature changes for the expected readout channel
- Grounding connections should be also verified: use multimeter (M) to check the resistance between relevant elements

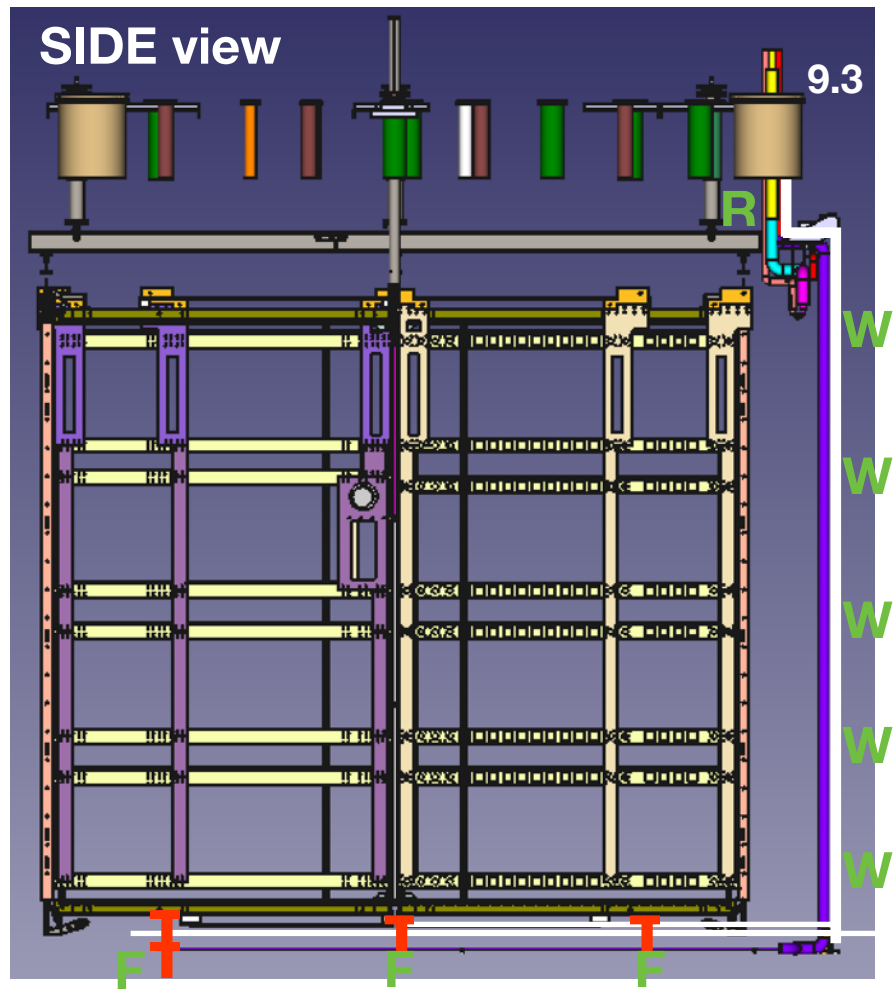


Bottom/membrane sensors

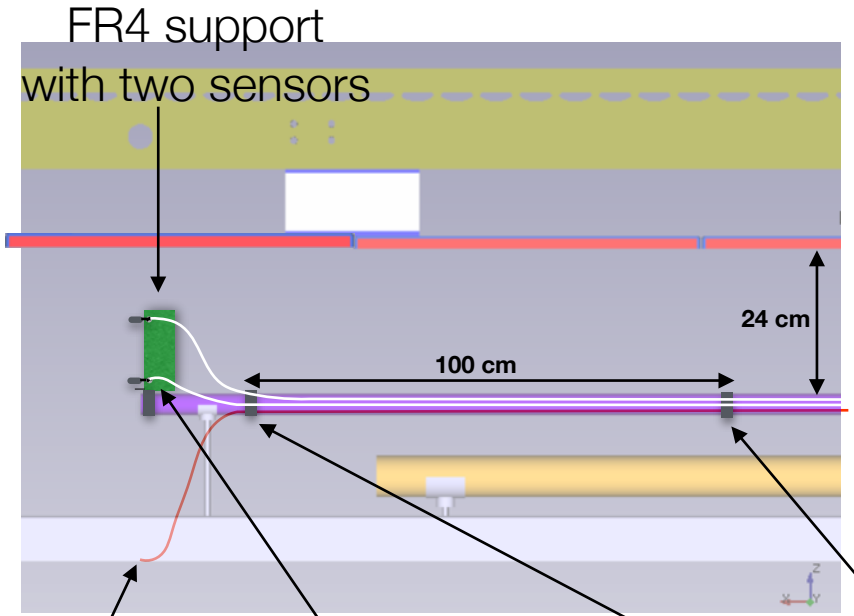
- 12 high precision sensors mounted on the bottom pipes (**T**)
- 12 standard sensors on the floor (**F**), 5 on the wall (**W**) and 1 on the roof (**R**)
- Cables run attached to the pipes all the way to port 9.3

Pipes in purple, cables in white

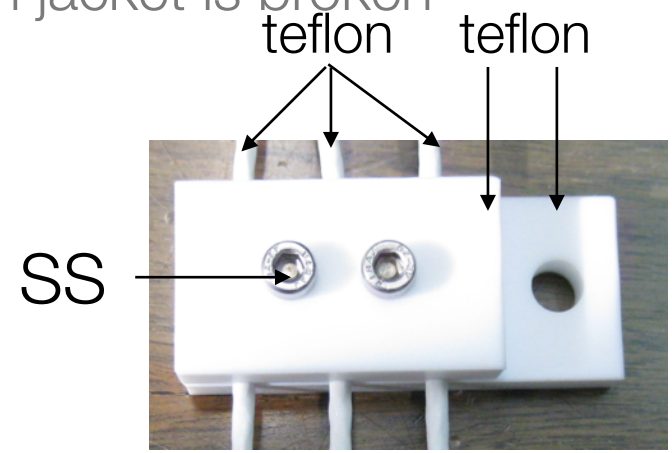


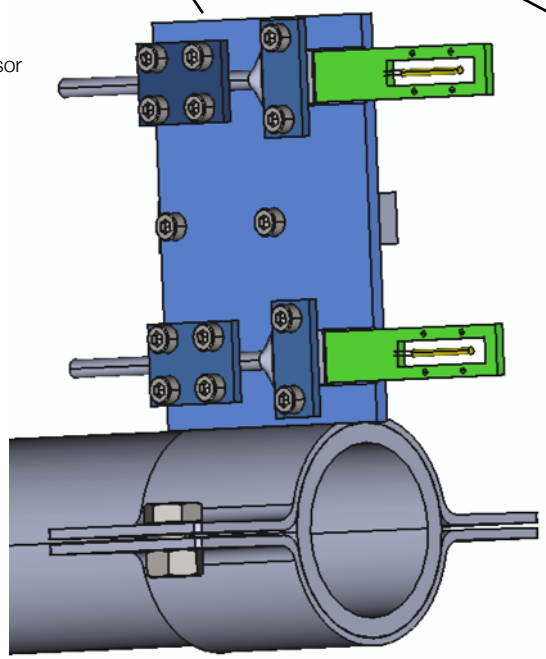


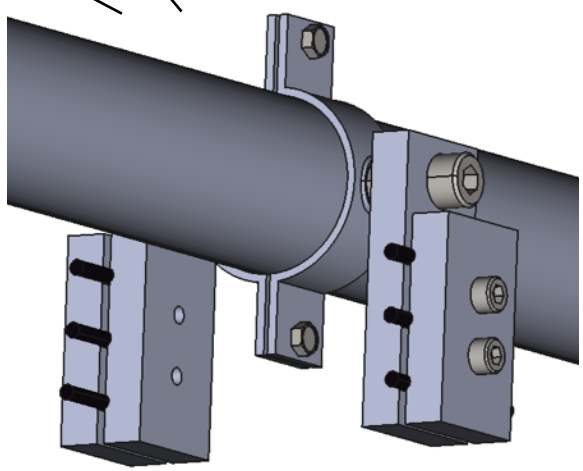
bottom sensor/cable supports



- Cables and grounding scheme is the same as for the T-gradient
- We have put special care in guarantying that the **cable does not touch any metallic element** to avoid grounding loops in the case the outer teflon jacket is broken

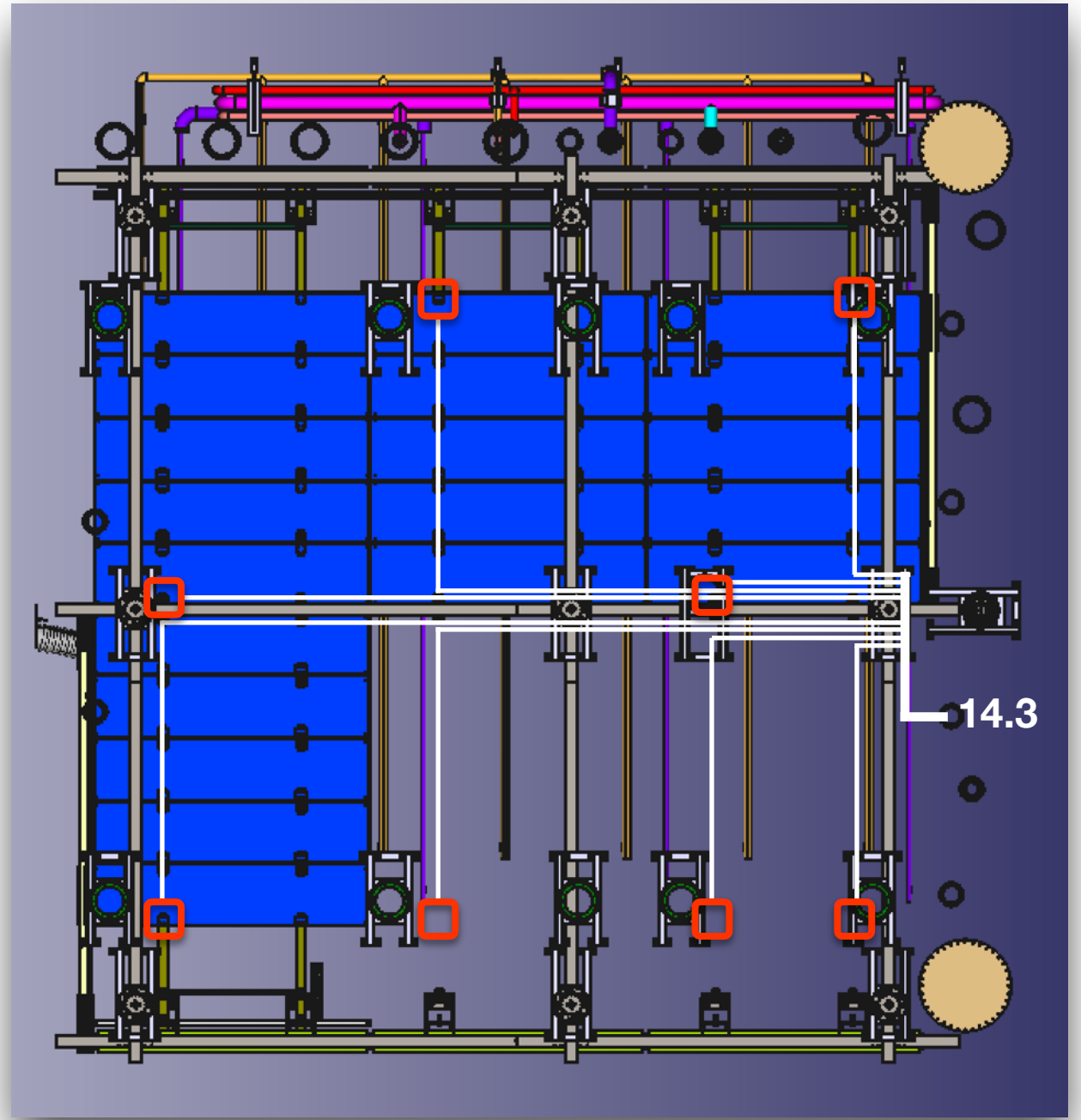






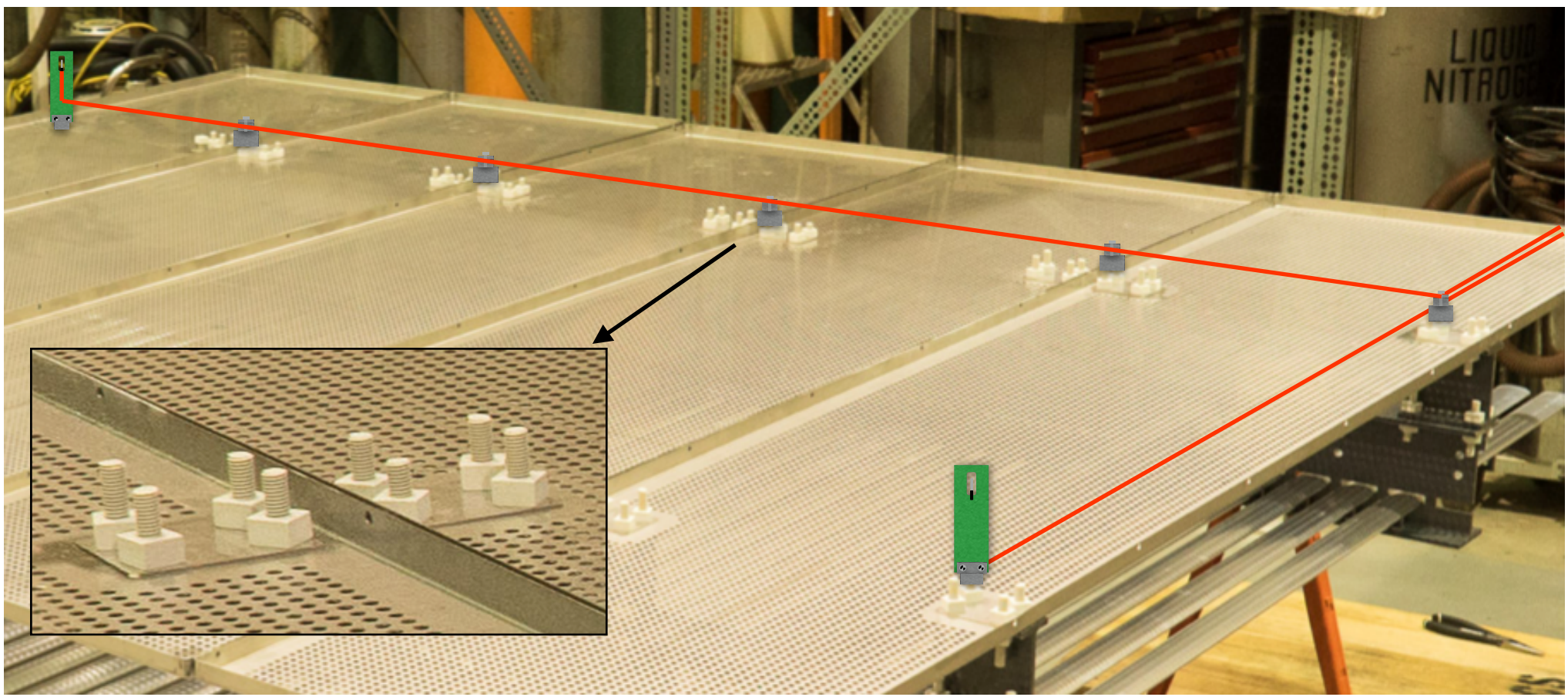
top sensors

- 8 high precision sensors above the ground planes
- Cables and grounding scheme is the same as for the T-gradient



sensor/cable supports

- Use the FR4 screws foreseen to connect two GP modules (see image) as anchoring point for cables and sensor's support. Supports not yet designed but should be similar to the ones at the bottom
- **Cables will not touch the ground planes**



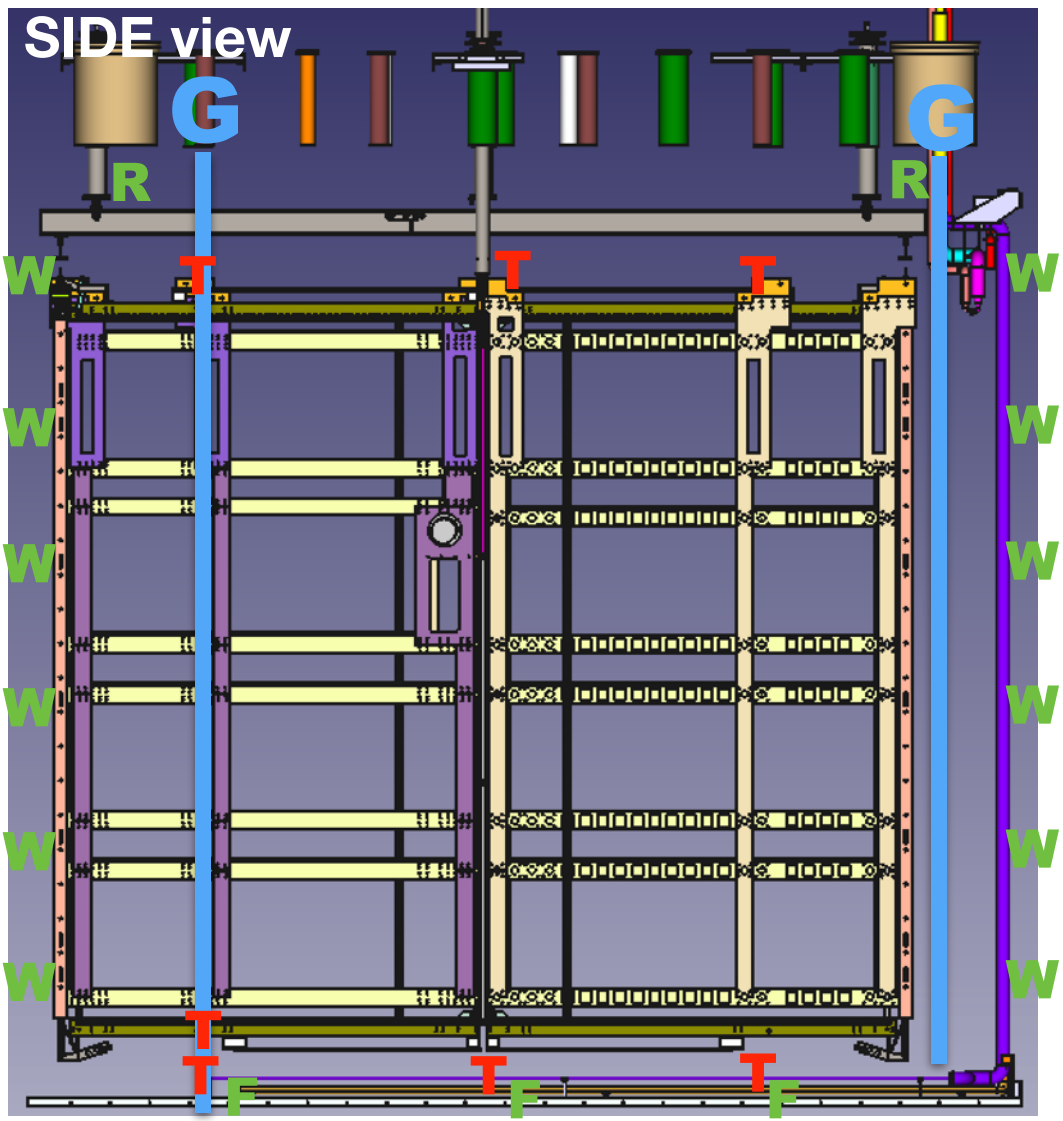
backup

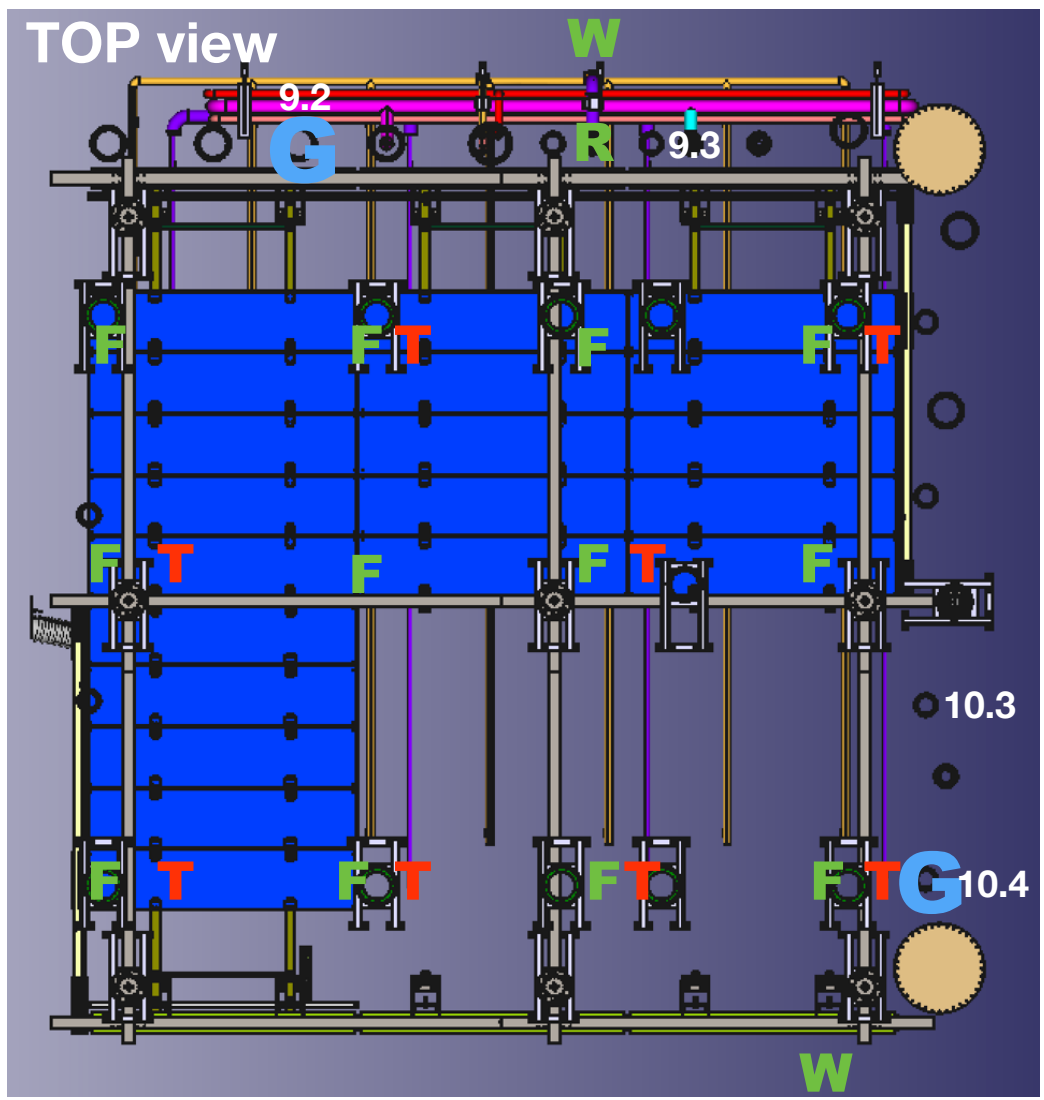
Sensor map

high precision (< 5 mk) **T** Top-bottom

high precision (<5 mk) **G** T-Gradient monitors
ports 10.3 and 9.

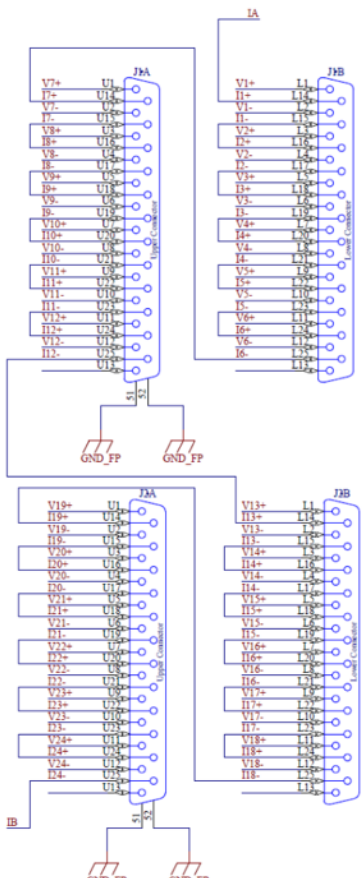
low precision (~0.1 K) **W/F/R** Cryostat wall/floor/roof

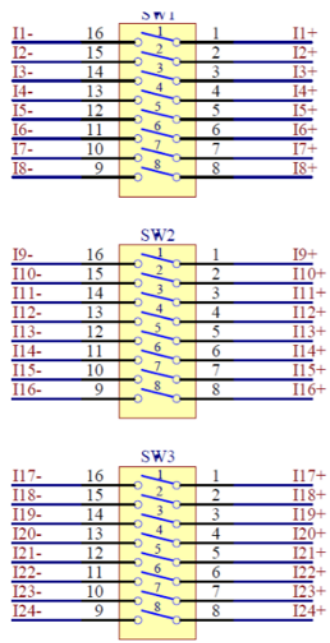


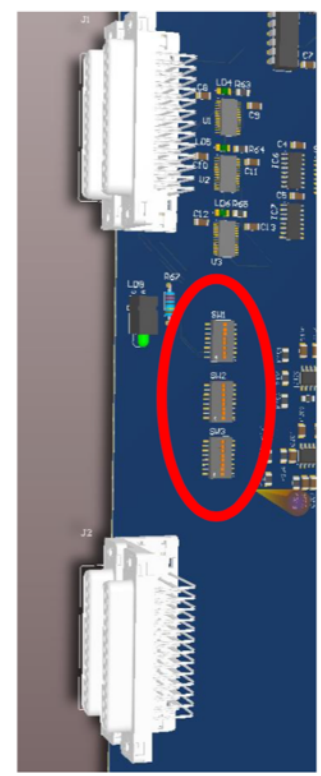


By-passing unused PT100 channels

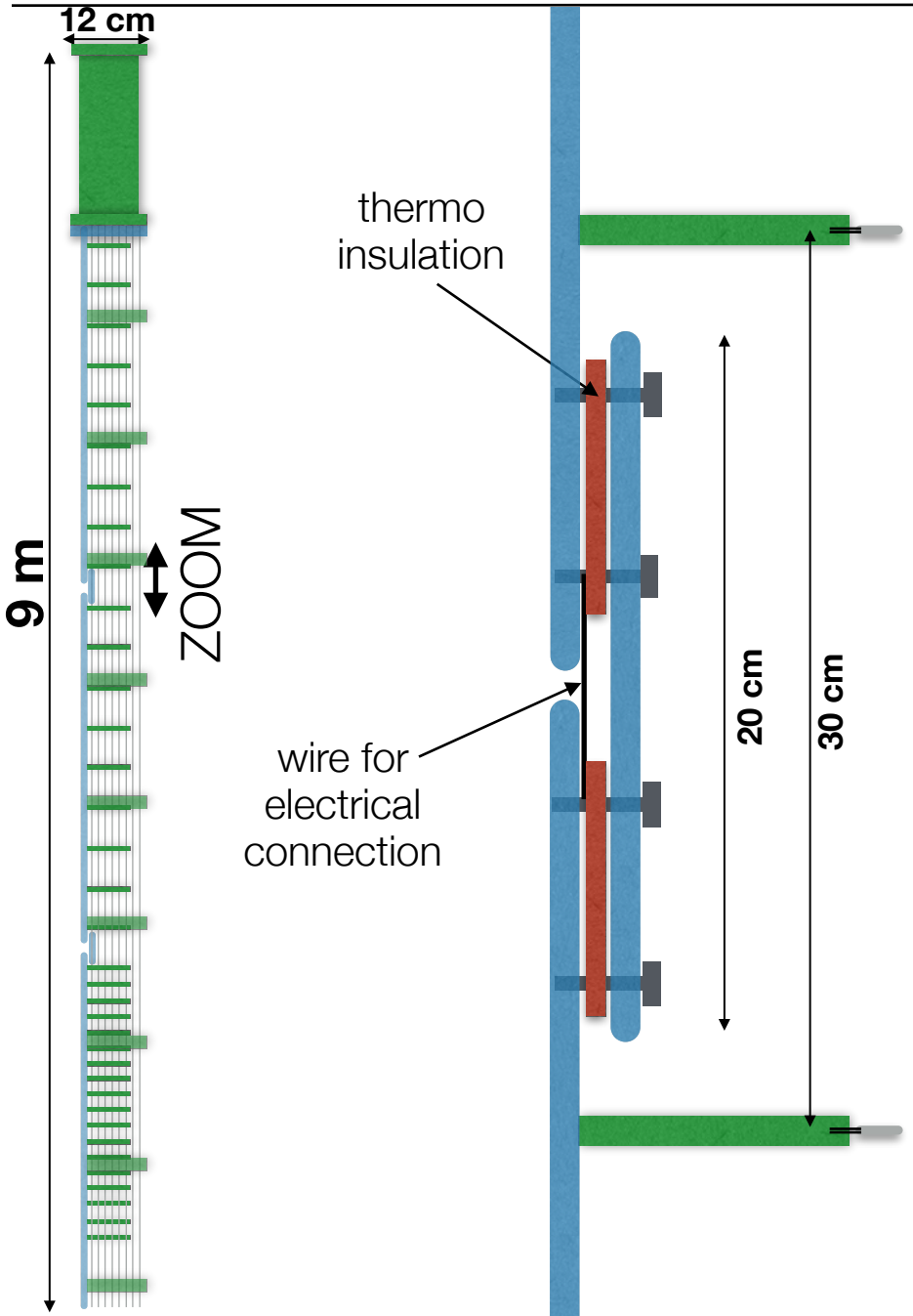
As the current source is connected in serial in case of an unused PT100 sensor the current source for that channel has to by bypassed by means of switch



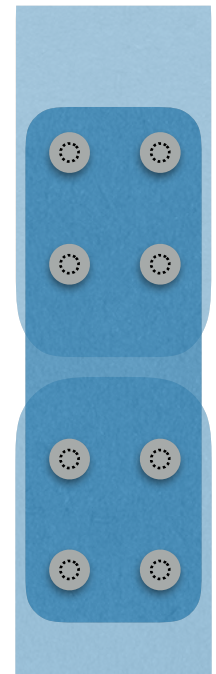




Connection between sections



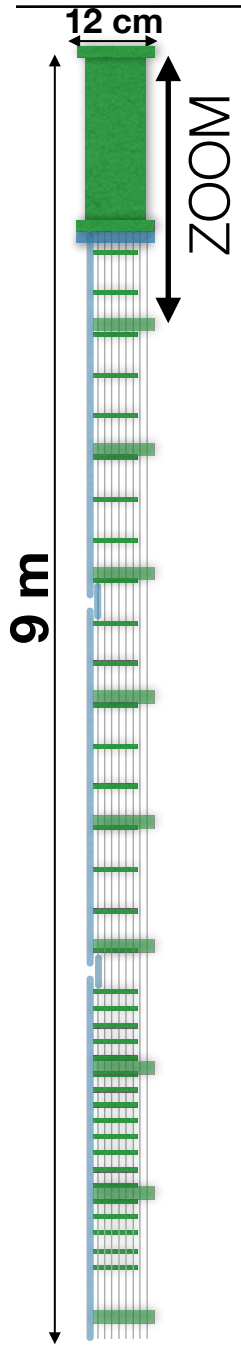
- We probably need **insulation** between plates to avoid thermal coupling, or a FR4 connection instead of aluminum
- If **two screws** are used vertically in each side we have to be **careful with shrinking**
- An **electrical connection** to guaranty all plates are at **ground**
- We need a proper design with rigidity studies

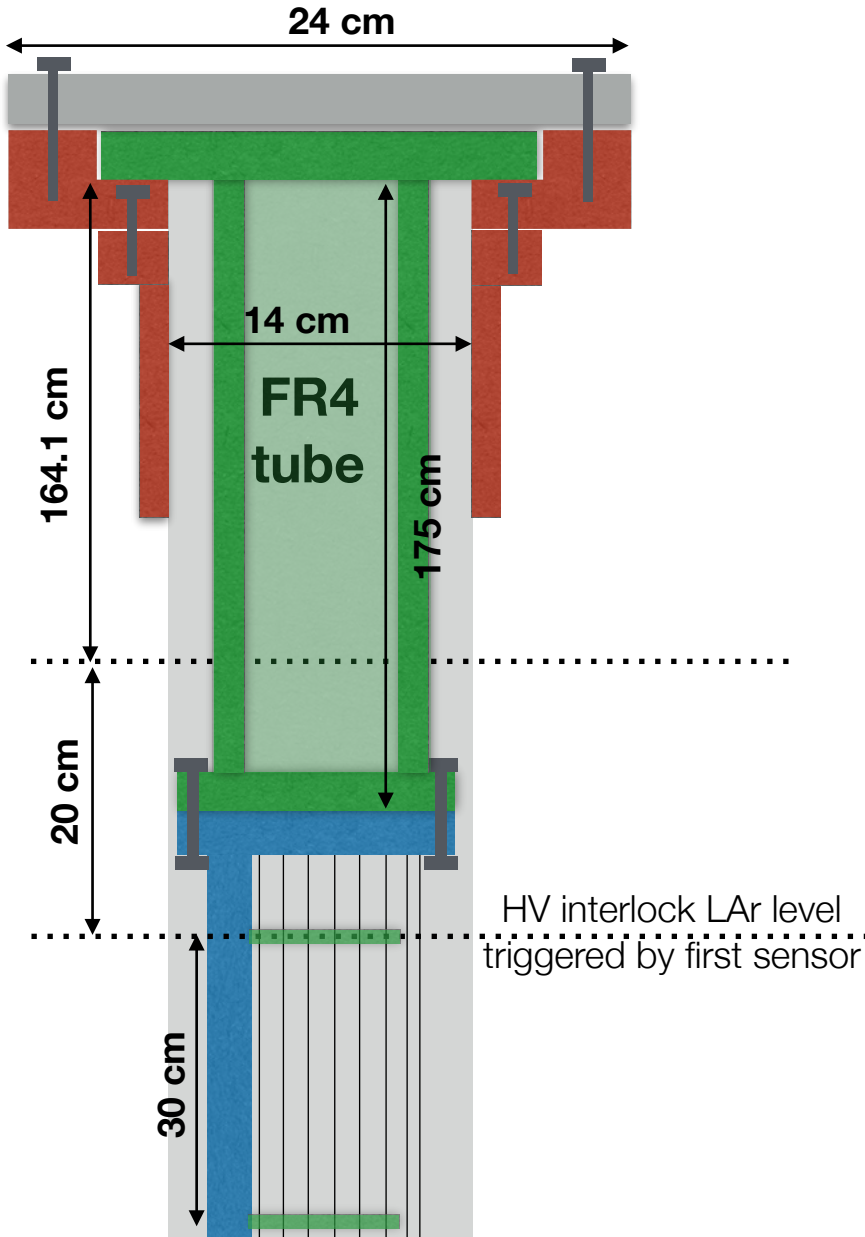


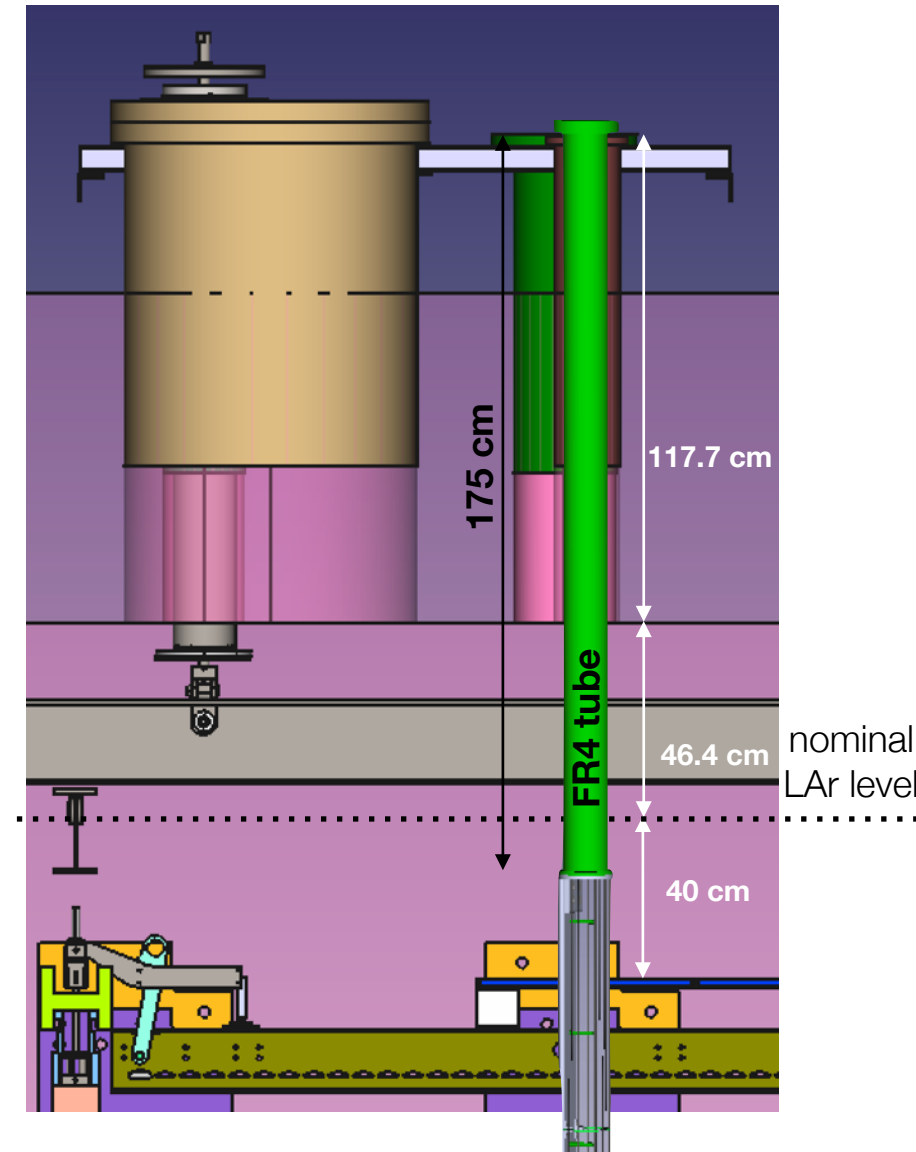
front view

Top section

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

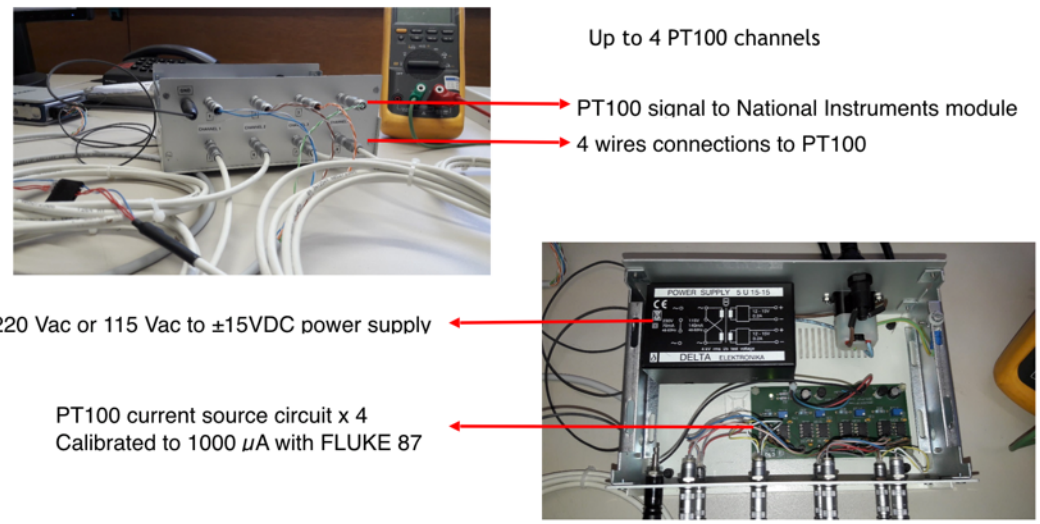






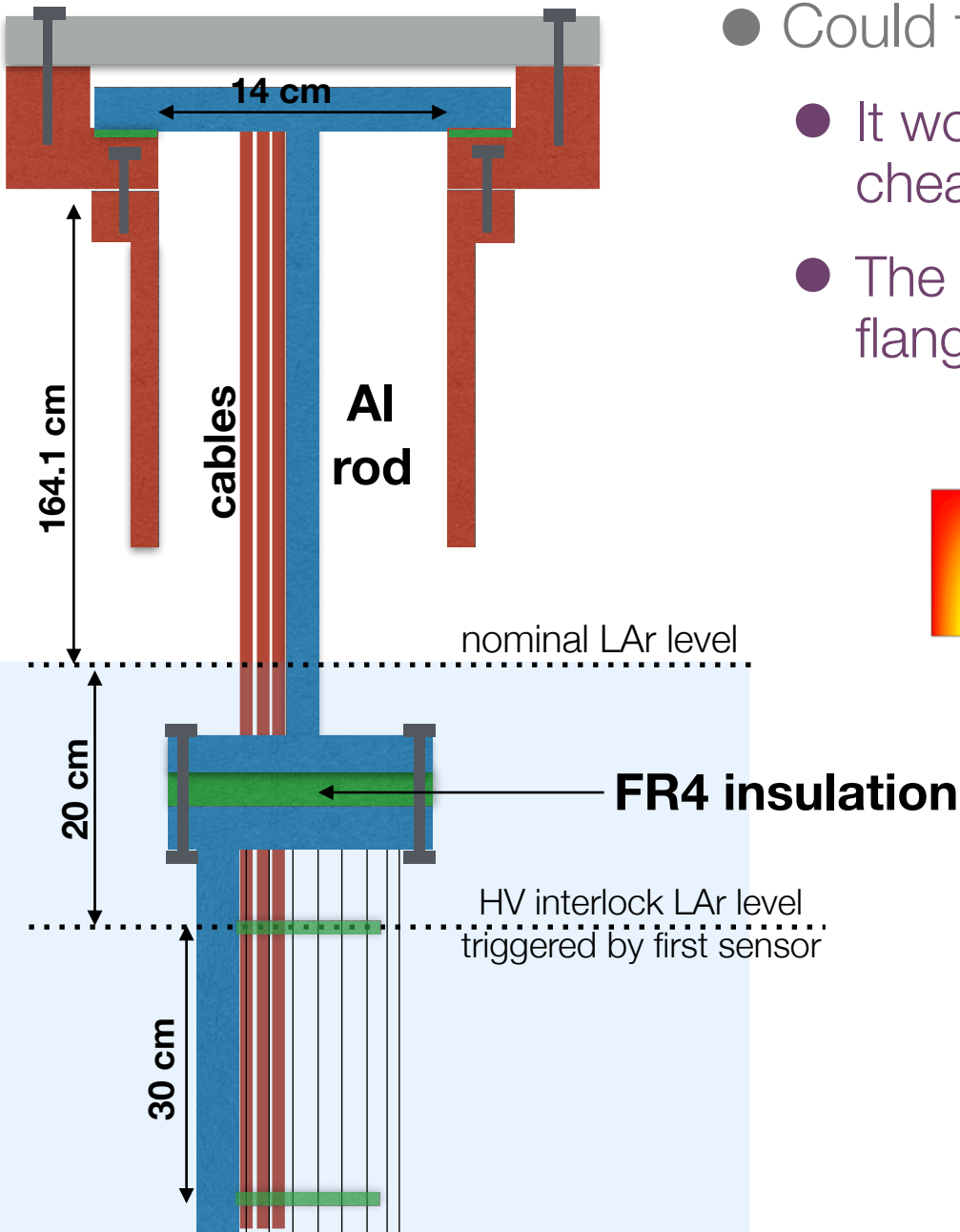
Readout and slow controls

- 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

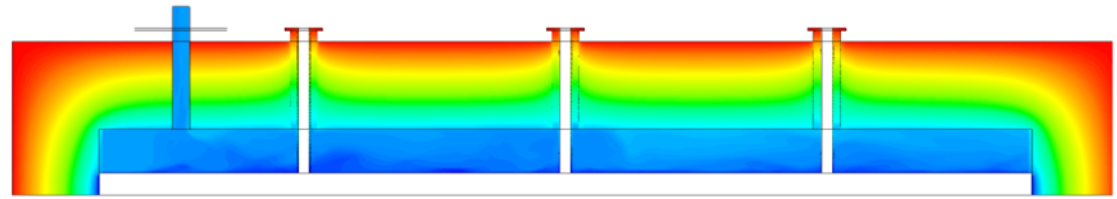


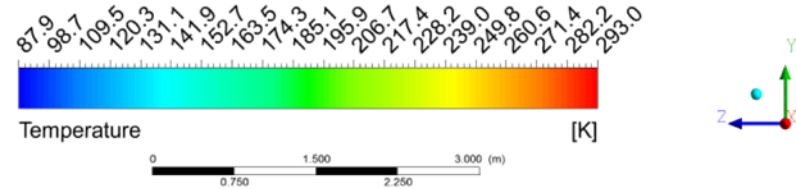
current source calibrated to 3 nA

Question ?



- Could the top tube be made of aluminum ?
  - It would be much easier to machine and cheaper
  - The issue could be the heat flux from the flange (at room temperature) to the LAr





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