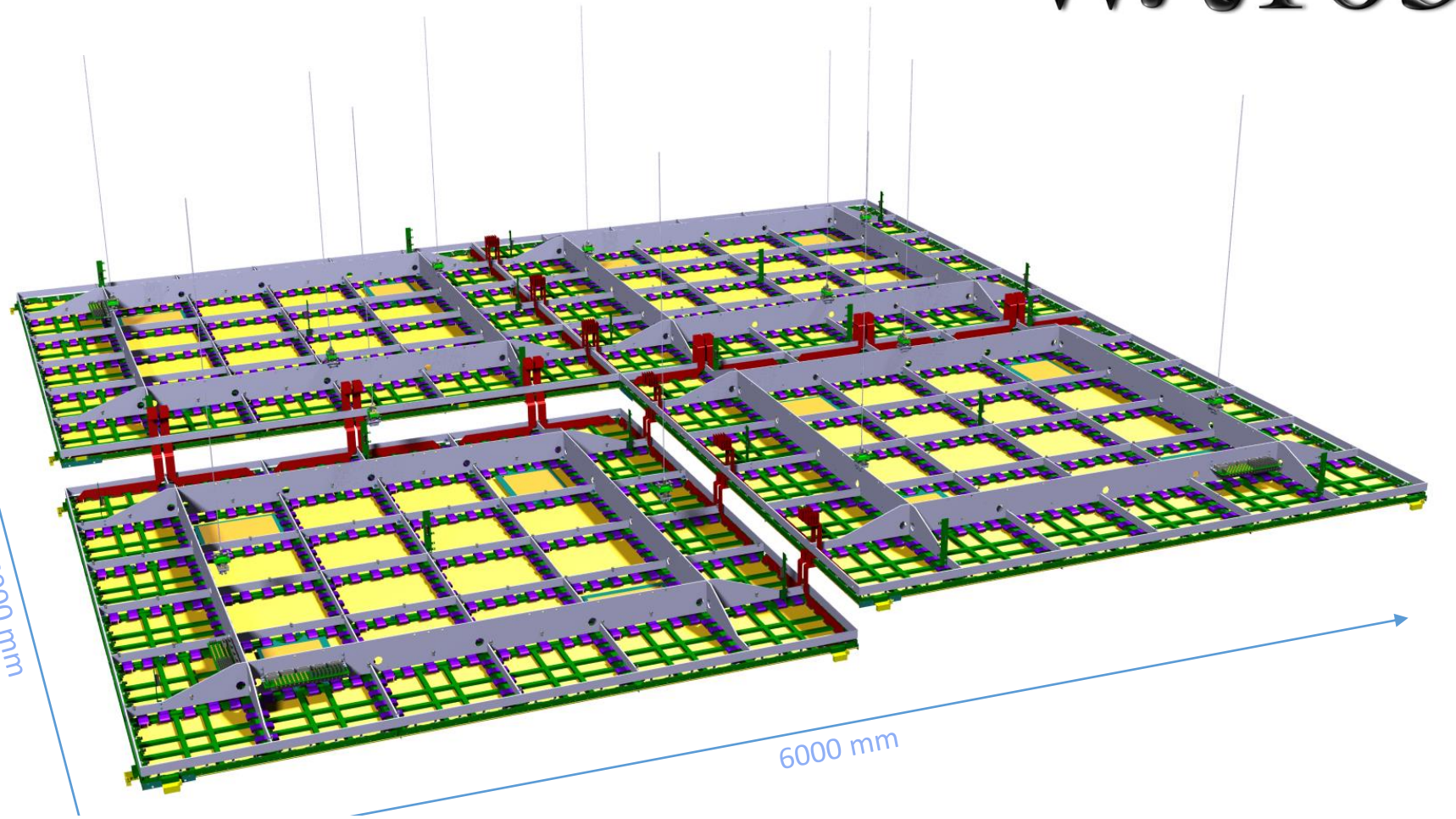


DRAFT presentation for DP ProtoDUNE Design Review 24th April 17

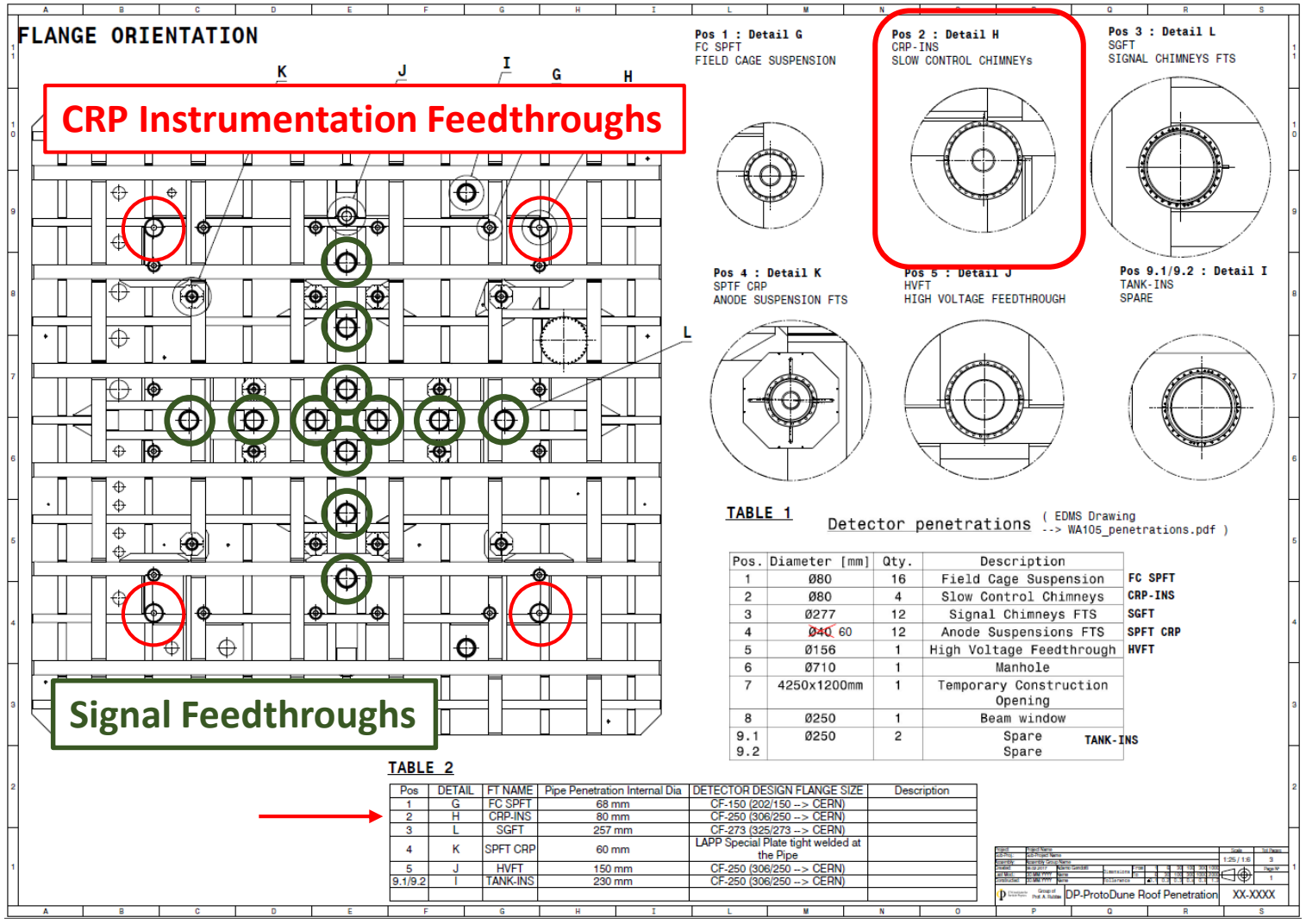
C.Cantini on behalf of ETHZ Group

Instrumentation: from 311 Detector to protoDUNE DP

- Temperature probes
  - Insulation space
  - Inner vessel
- Instrumentation flanges, connectors internal cabling
- Distribution of sensors on Charge Readout Plane
- Patch panel
- Calibration system
- Level meter system
- Middle HV system

DP protoDUNE instrumentation/slow control design is profiting a lot from commissioning of 311 Detector.
Continued prototyping efforts toward multi Kton Det.

CRP Instrumentation Feedthroughs



Based on new sensors list and previous experience with 311 Detector, preliminary design for Flanges hosting CRP INS.

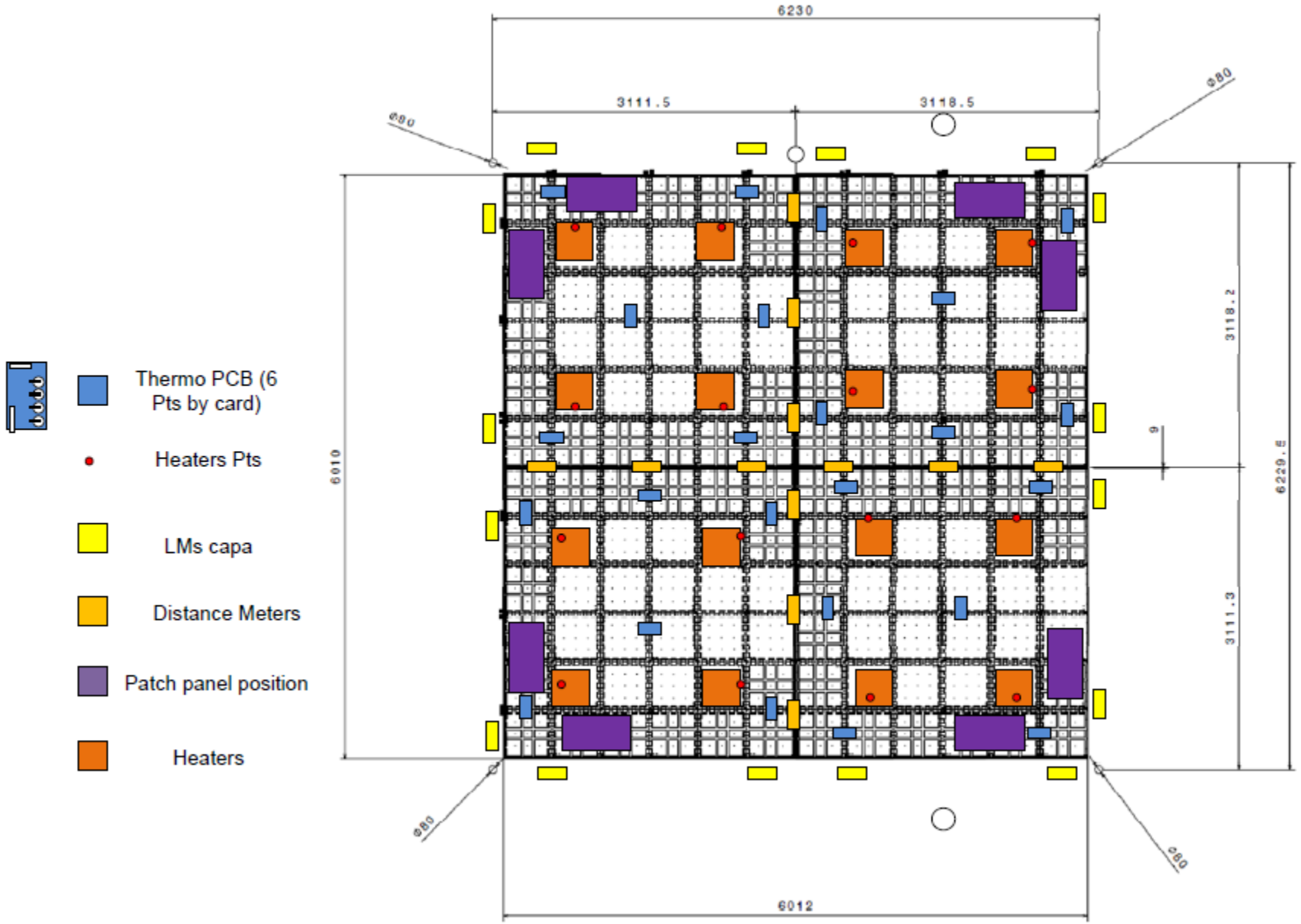
4 x CRP INS flange dedicated to:

- Slow control signals (temperatures, LAr level meters, pressure…)
  - Connectors as 311 Detector
  - Improving internal cabling
- Middle High Voltage (10 kV rated channels)
- Pulsing system: under consideration

Penetrations already defined: 80 mm dia, CF250 flange for CRP INS.

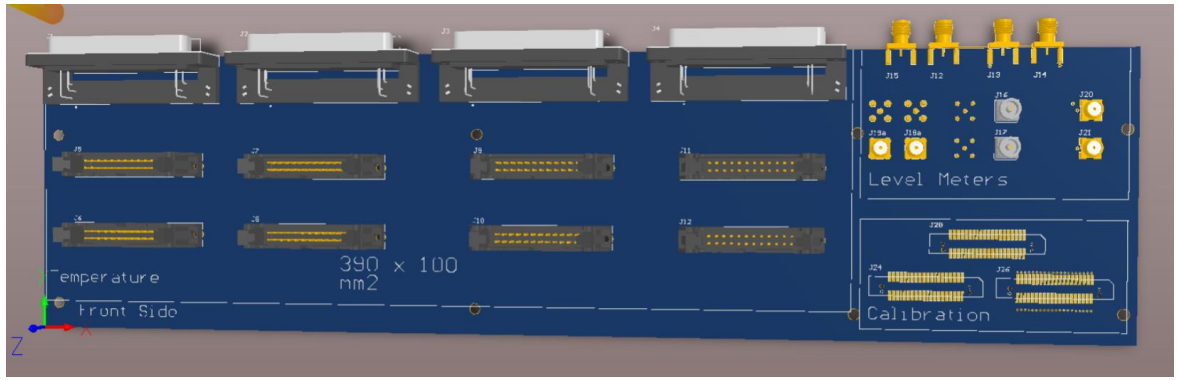
A tee or cross will be needed, similarly to TANK INS Flanges

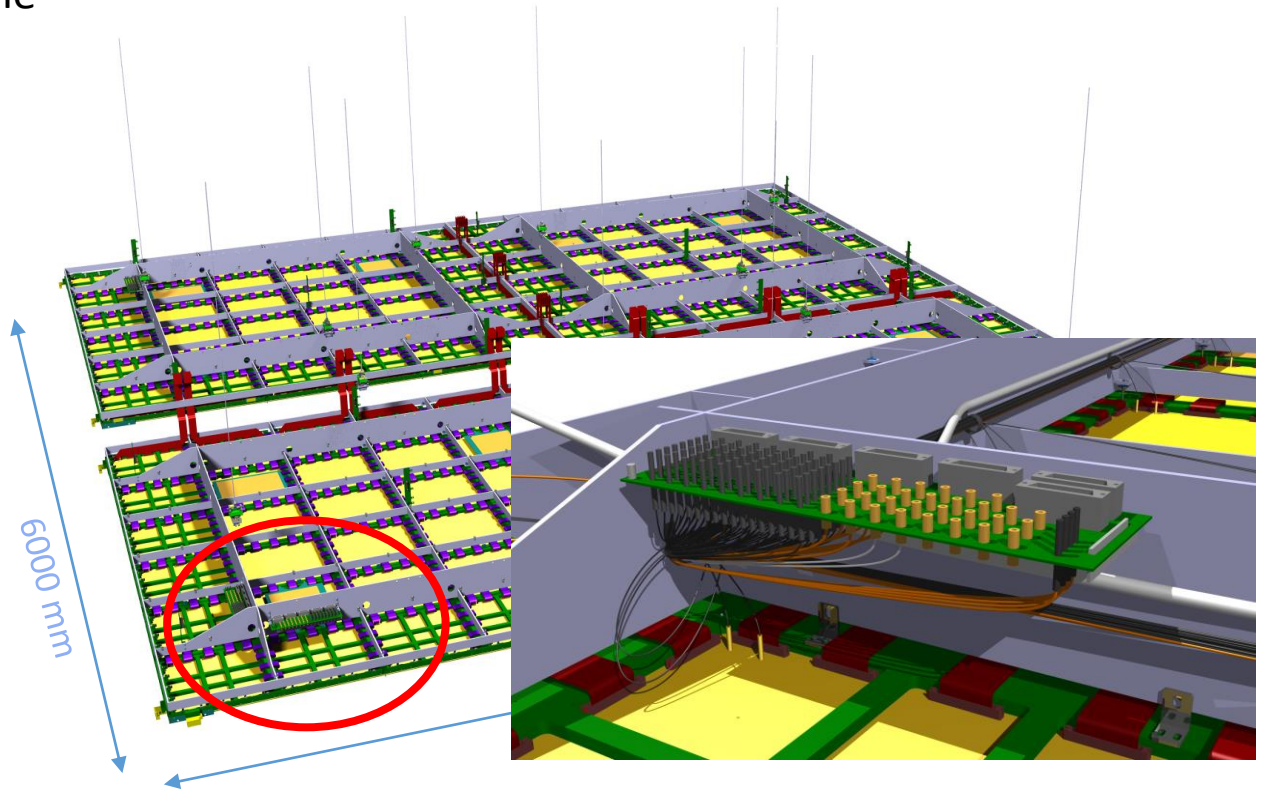
Distribution of temperature sensors and level meter



A patch panel as interface in the vessel for sensors

- PCB panel fixed on Charge Readout Plane – each module has one
- Purpose of the panel is to ease installation and cabling
  - Temperature sensors distributed on CRP
  - Liquid argon level meter for CRP positioning and distance meter for relative alignment of modules
  - Pulsing system
- A second patch panel for LEM biasing – under development

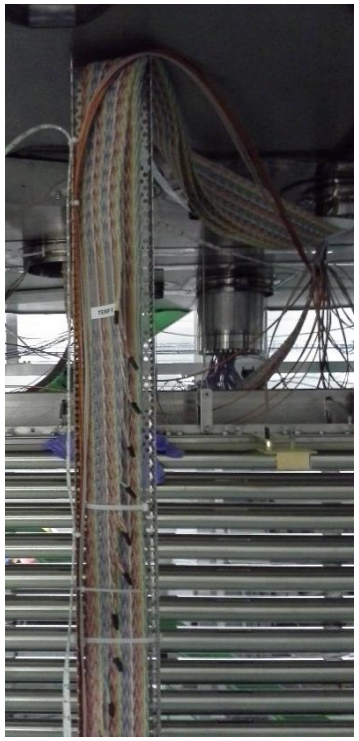


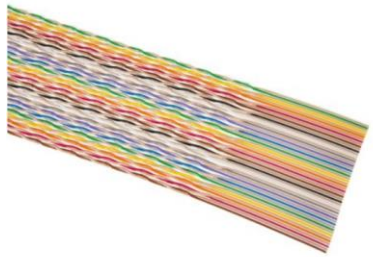


HV patch panel: design still pending, it depends on HV Flange

Cabling in collaboration with Confectronic, Allectra and other workshops at CERN for custom made assemblies.

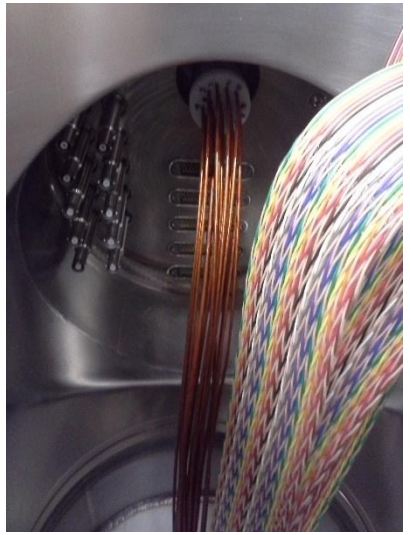
Temperature probes





- 311 Detector has o(90) temperature probes distributed in main vessel, soldered on ribbon cable, spaced by 4 cm or arranged on “thermometers”
- 311 Detector has 45 temperature probes in the insulation space
- 4 wires method everywhere
- Pt interfaced to NI9219 modules outsides in racks

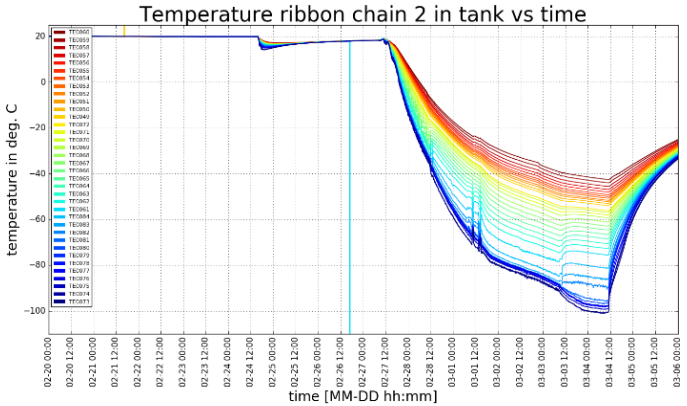
- 666 Detector o(150) temperature sensors, distributed between CRP INS flange and TANK INS flange
- Proposing same platinum sensors, same company - demonstrated <0.1 K error at TLAr, CLASS Y resistors
  - Considering low outgassing rate cables (Cicoil)
  - Compare outgassing for 2 solutions t.b.d.
- Automated calibration procedure is being considered



Baseline choice for cable >

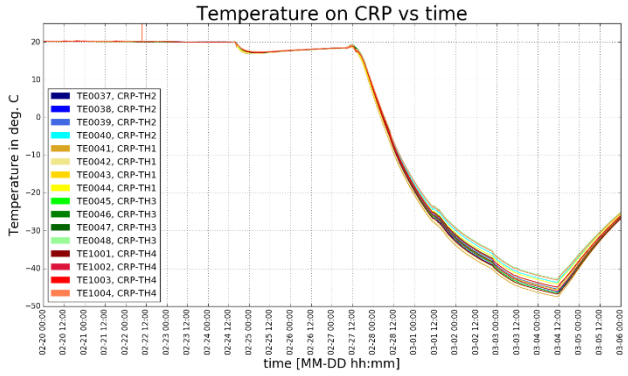
- 3M 50 way Twisted Ribbon Cable, 1.27 mm pitch, AWG 28
- Used for resistive level meter and thermometers
- Intermediate interface at the patch panel
- Interfaced through SUBD50 weldable connectors on CRP INS flange to acquisition system

Temperature probes

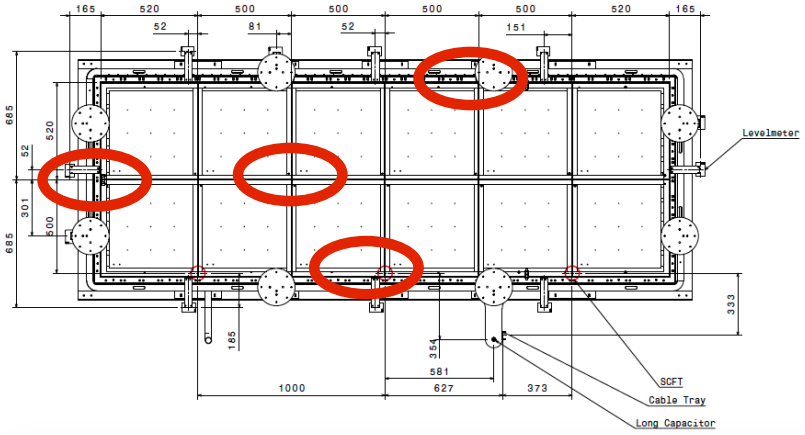


Resistive chain (4) covered by TANK INS flange

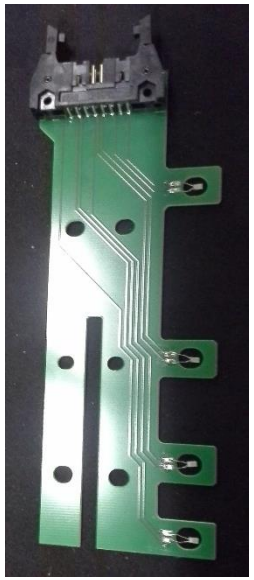
In 311 detector we monitor the temperature of the gas on top of the anode at different heights thanks to several PCBs where 4 Pt sensors are soldered (thermometers).
For 666 a new version with 6 Pts was designed.

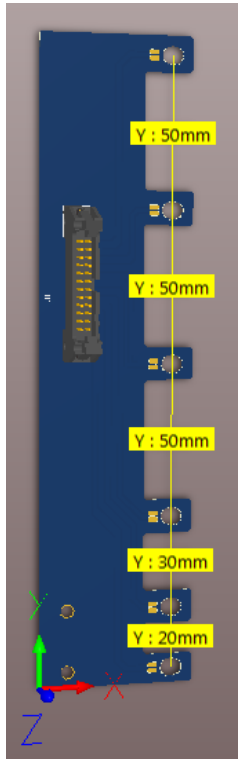


Thermometers 311 Det: 4 Pts
4 installed on CRP in gas phase



Thermometers 311

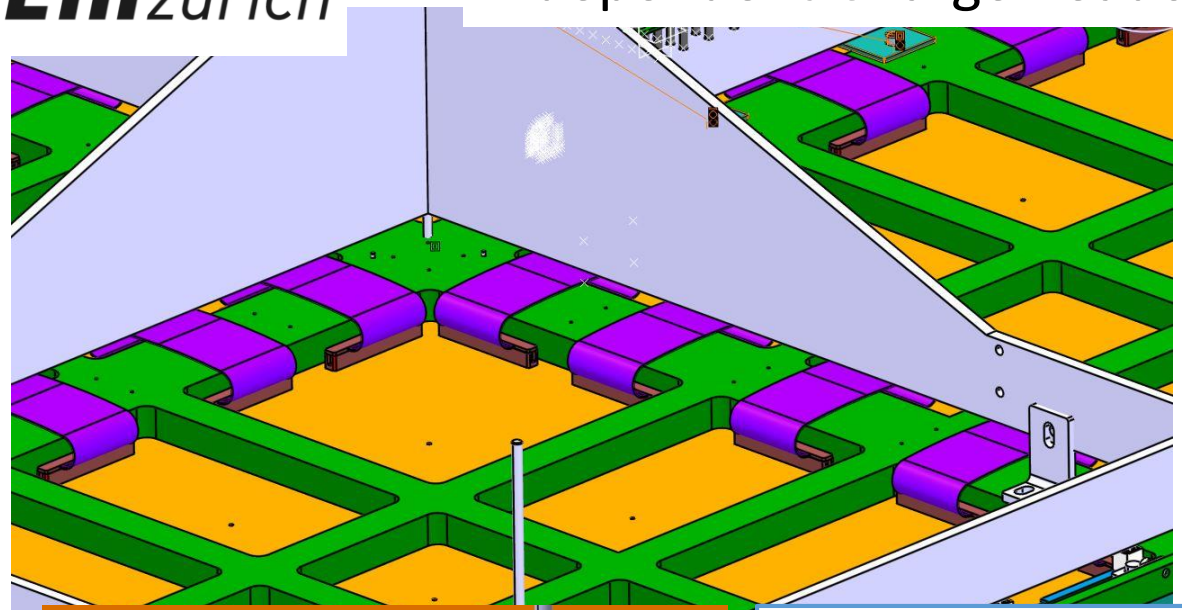


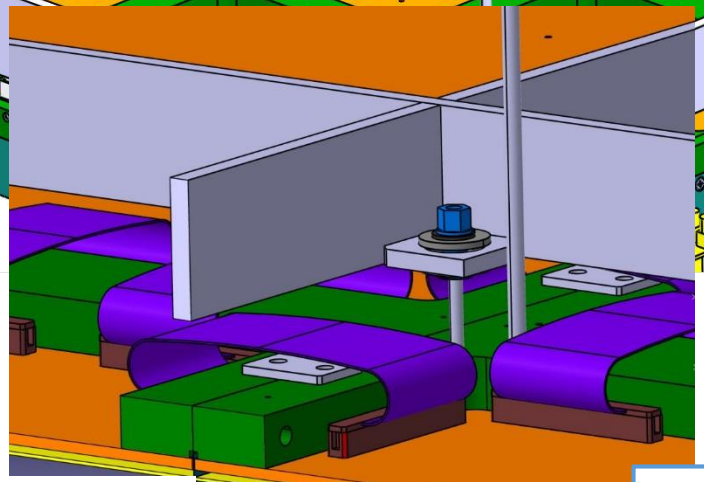


Thermometers new version: 6 Pts

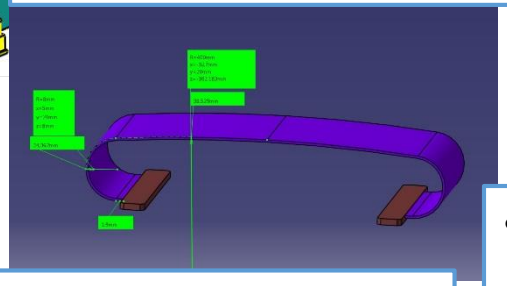
Better fixation
Integrated already in CRP design

Independent Charge Readout Plane 3x3 m2 module

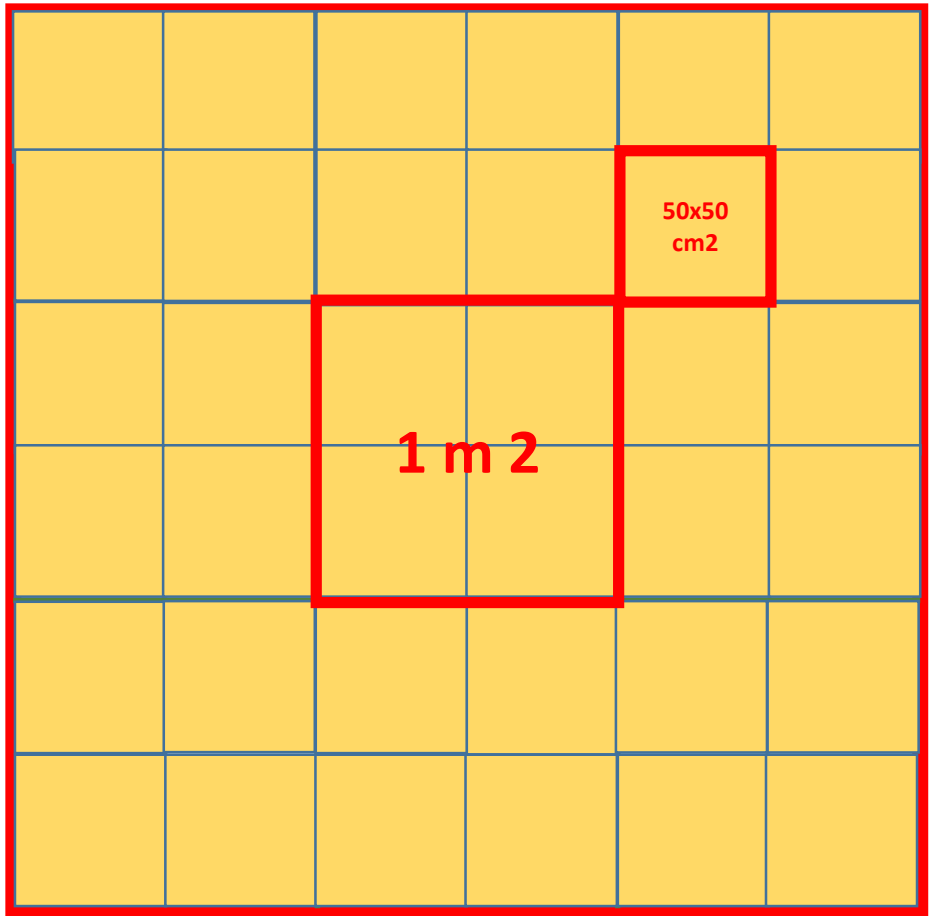




Bridge needed to electrically connect adjacent 50x50 cm2 anodes

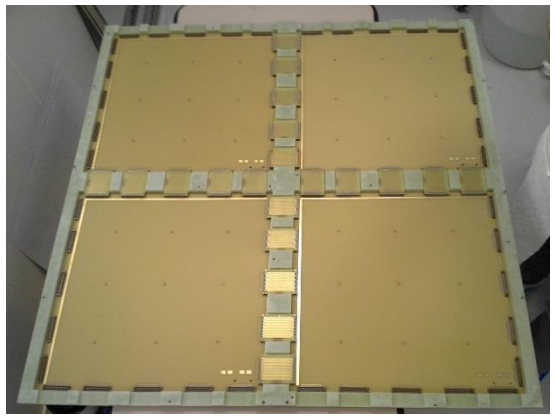


20 cm long flat cable 68c, 0.635 mm pitch, 30 AWG



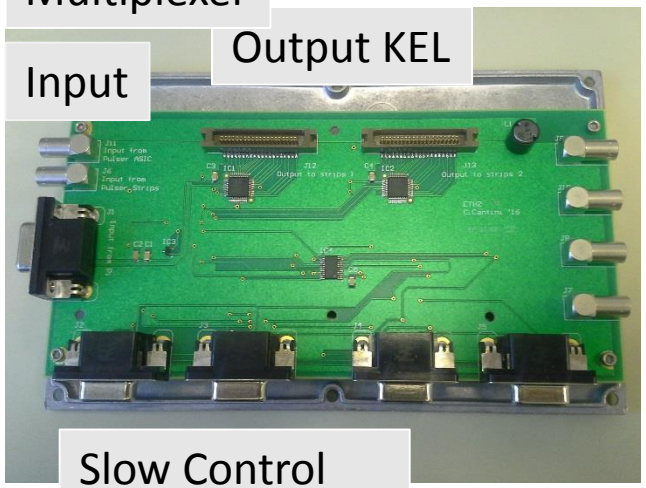
- 300 bridge per 9m2 module needed
  - Several options under consideration – see backup
- 600 KEL 8925E-068-179-F (receptacles to be crimped on cable)
- 720 KEL 8913-068E/R-178MS-A-F (smd connectors for anode)

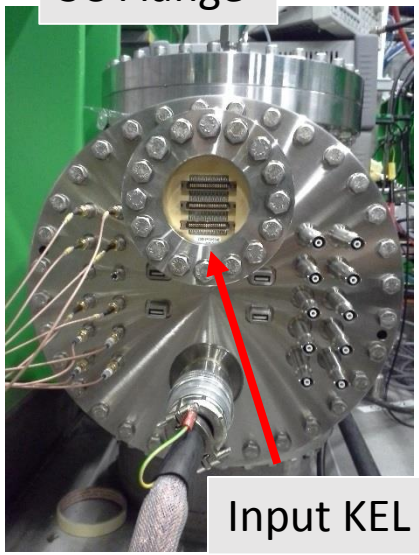
Pulsing system for electronics

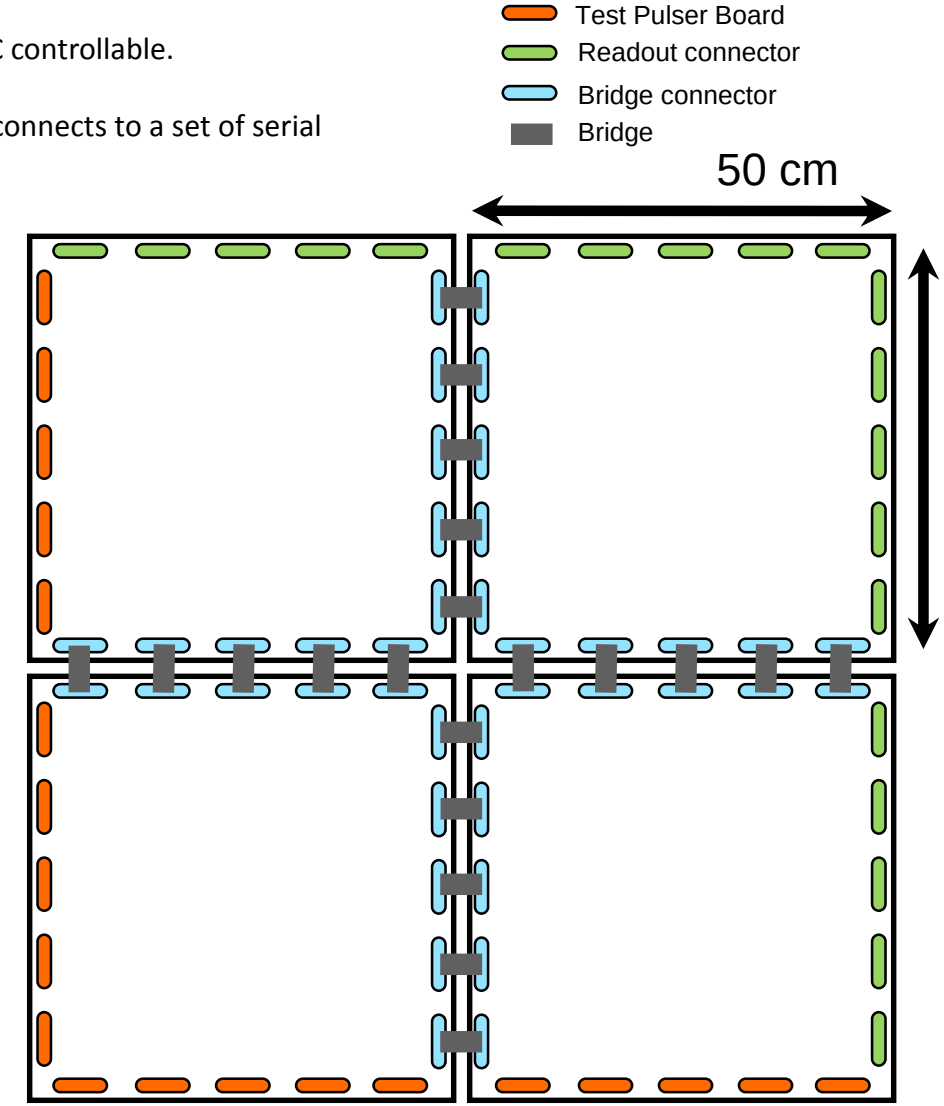


Controlled distribution of calibration pulses throughout the entire CRP. I2C controllable.
Good way of testing continuity also.
It connects to a flange on slow control chimney 2, then each twisted pair connects to a set of serial 32 SMD Capacitors on one end of Anode. Pulses 32 channels at once.

For DP ProtoDune:
Same concept.
Pulsing can be done through CRP INS Feedtru.
Differentiating boards' design completed.
Some ideas of improving cabling under consideration with Ken Sakashita.
Developing a systematic QC system on capacitors.

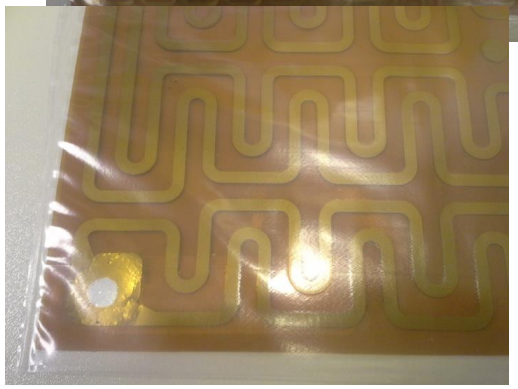


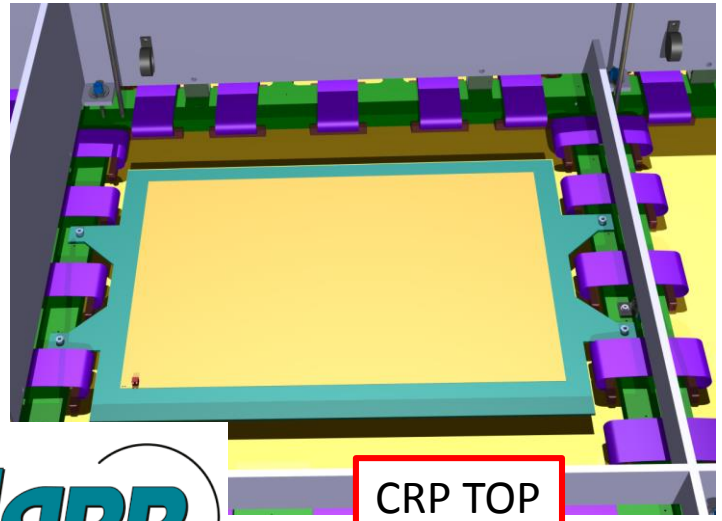


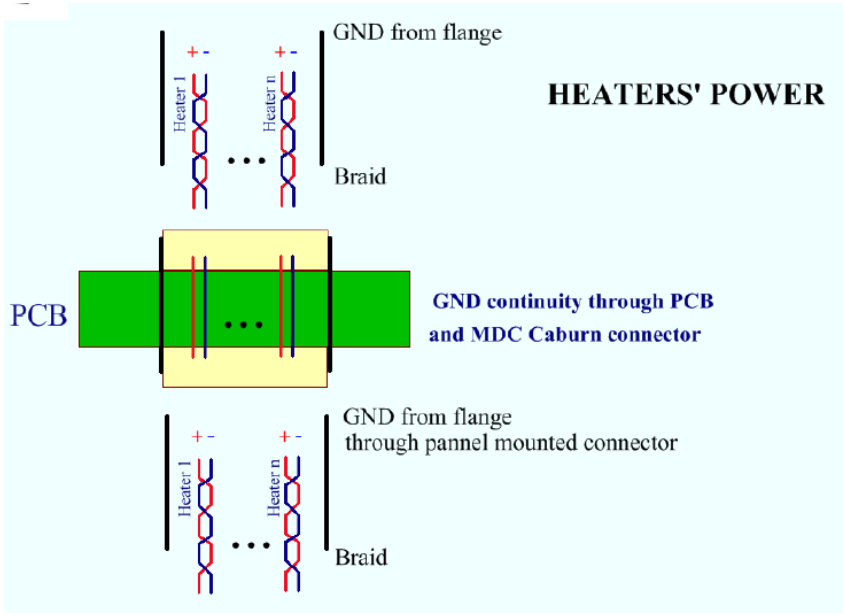


Heaters

Favour the outgassing
Avoid GAr stratification during cool down
Kapton Insulated Flexible Heaters by Omega or Alectra
Custom made heaters foils, from few W up to hundreds each
Foreseen on top of CRP and on membrane floor (to be defined)



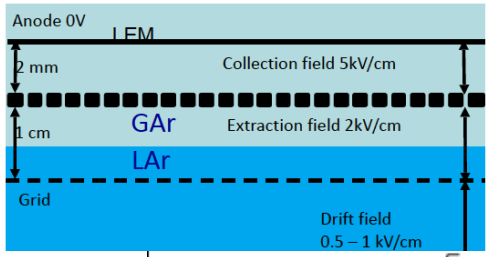




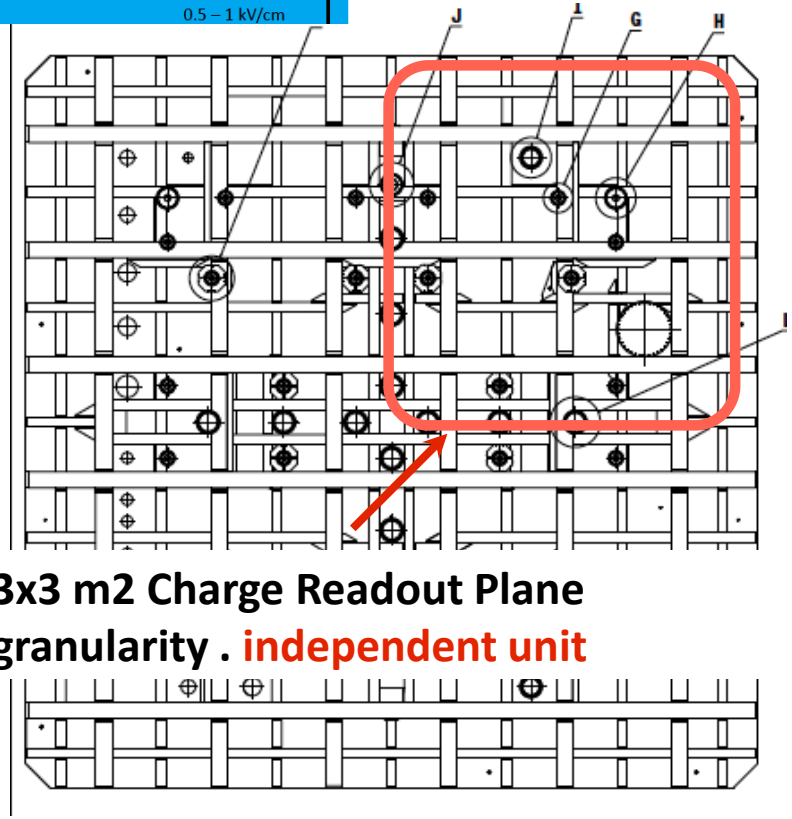
Mounted on FR4 plate on top
of CRP or glued on membrane

- Caburn multi pin panel mounted connector
- Shielded cable (to be identified)
- Connected internally to CRP INS flange(s)

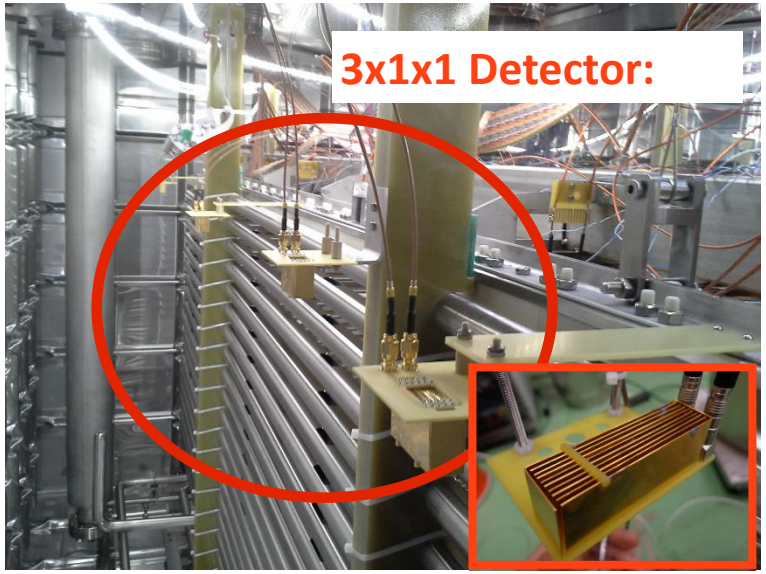
Position of level meter in 666 Detector



LEM



3x3 m2 Charge Readout Plane granularity . independent unit



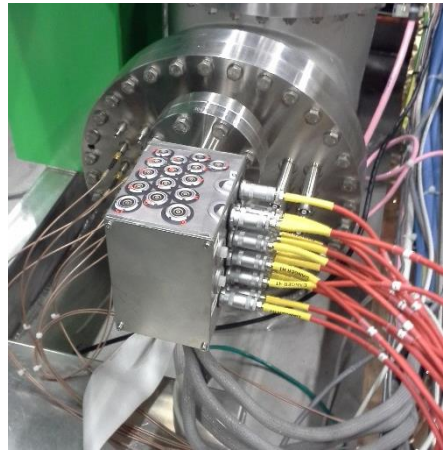
We can control relative position of CRP to LAr level measuring **capacitance between Grid and LEM's bottom electrode**.

- distributed measure
- It has to be **tested** in 3x1x1 Detector
- Some switches between

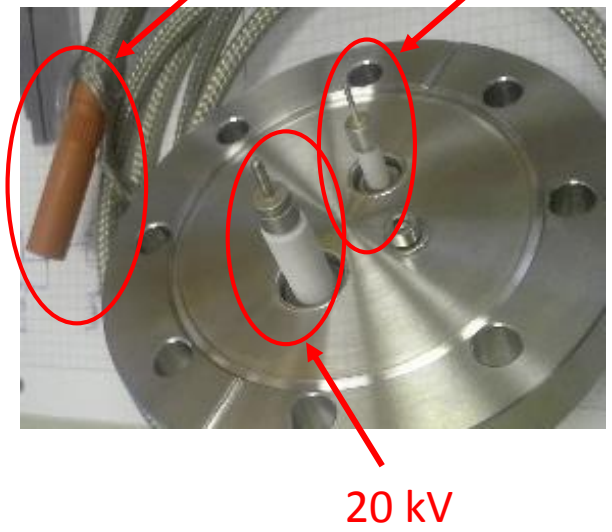
- Solution adopted for the 311 Detector is not fully scalable
- 3x3 modules will have 4 LM like those on edges
- To have finer resolution on CRP position a different approach is proposed

Middle high voltage fro LEM biasing

- Solution implemented for 311 Detector is custom made, filled with glue
  - Tested in Gar, Air, vacuum
  - Perfect isolation (E-12 Atm*cm3/s)
  - Perfect dielectric performances, no leak current (less than 1 nA) above 10 kV
  - Reproducible results
  - Still a possibility



- For DP ProtoDune
- High Voltage
  - TOT 288 channels, split on 4 Flanges
  - O(80) per CRP INS FT
  - NO commercial available solutions
  - Experimented several..
- Collaboration with Allectra to develop a weldable connector, single sided, working (no discharge, no leak current) in GAr up to 10 kV



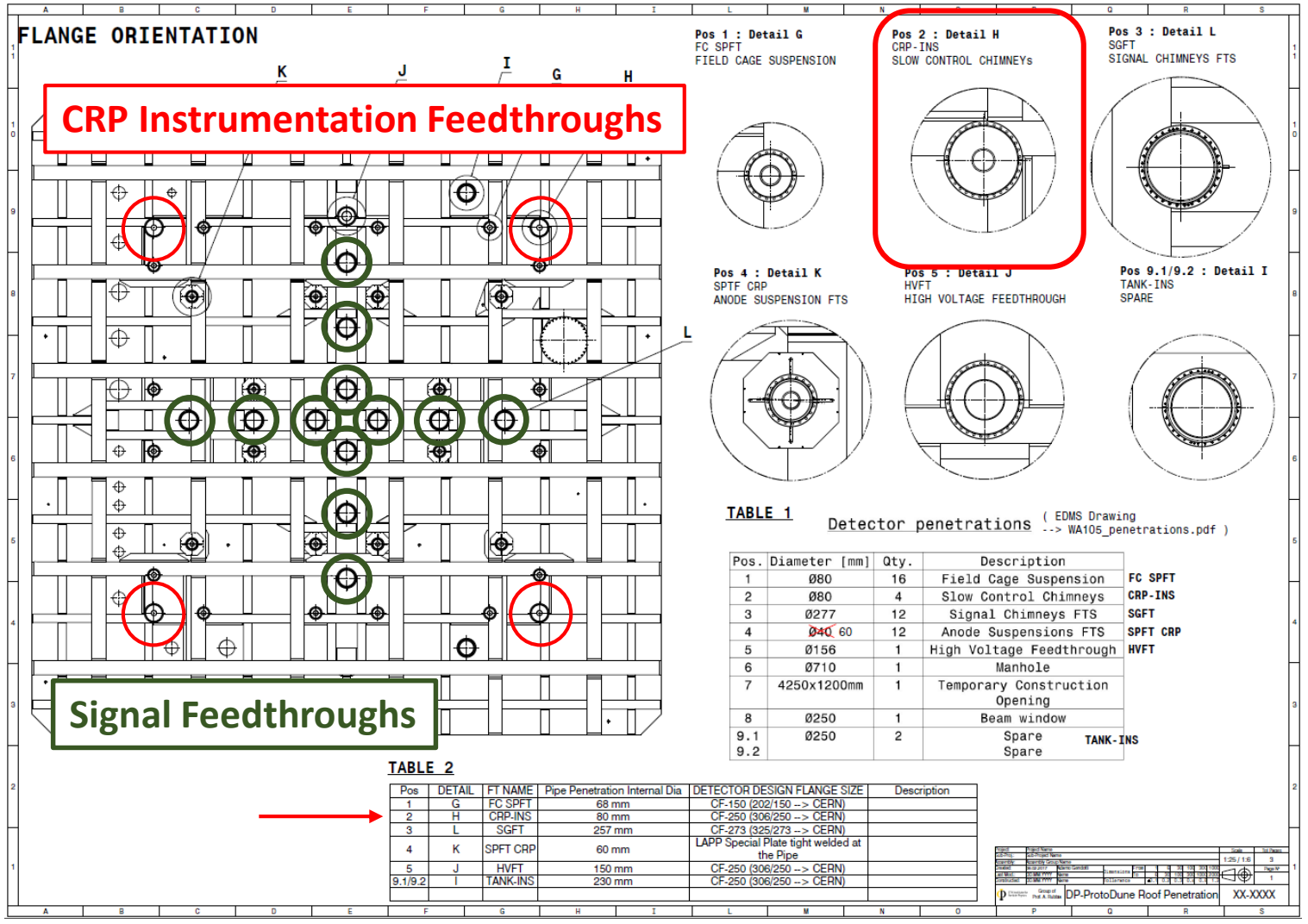
<u>Test flange, with 2 custom made single sided connectors</u>
Special silicon cable (”power glove”).
Only available for 20 kV version.
Tested successfully up to 20 kV in Air, GAr and Vacuum.
Thinner cable under consideration, hence higher density on flange.
Dedicated flange on CRP INS flange

Conclusions and outlook

- Design of 6x6x6 Instrumentation is an activity involving many items (sensors, vacuum flange, connectors, cabling…)
- It has benefit a lot from the experience developed with past smaller scale activities and with 3x1x1 Detector it has scaled up to industrial dimensions
- It is a collaborative activity among us, CERN and external suppliers
- A fully scalable system based on National Instruments cards has been developed, installed and tested – see talk by Yann – in the context of 311, it is being scaled up already for 6x6x6 Detector (many racks will be same)
- Documentation is now needed to keep track of numerous items we have inside main vessel
- Finalize the instrumentation flanges (few points to decide on, like HV)
- Start purchasing material

Back up slides

CRP Instrumentation Feedthroughs



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4 x CRP INS flange dedicated to:

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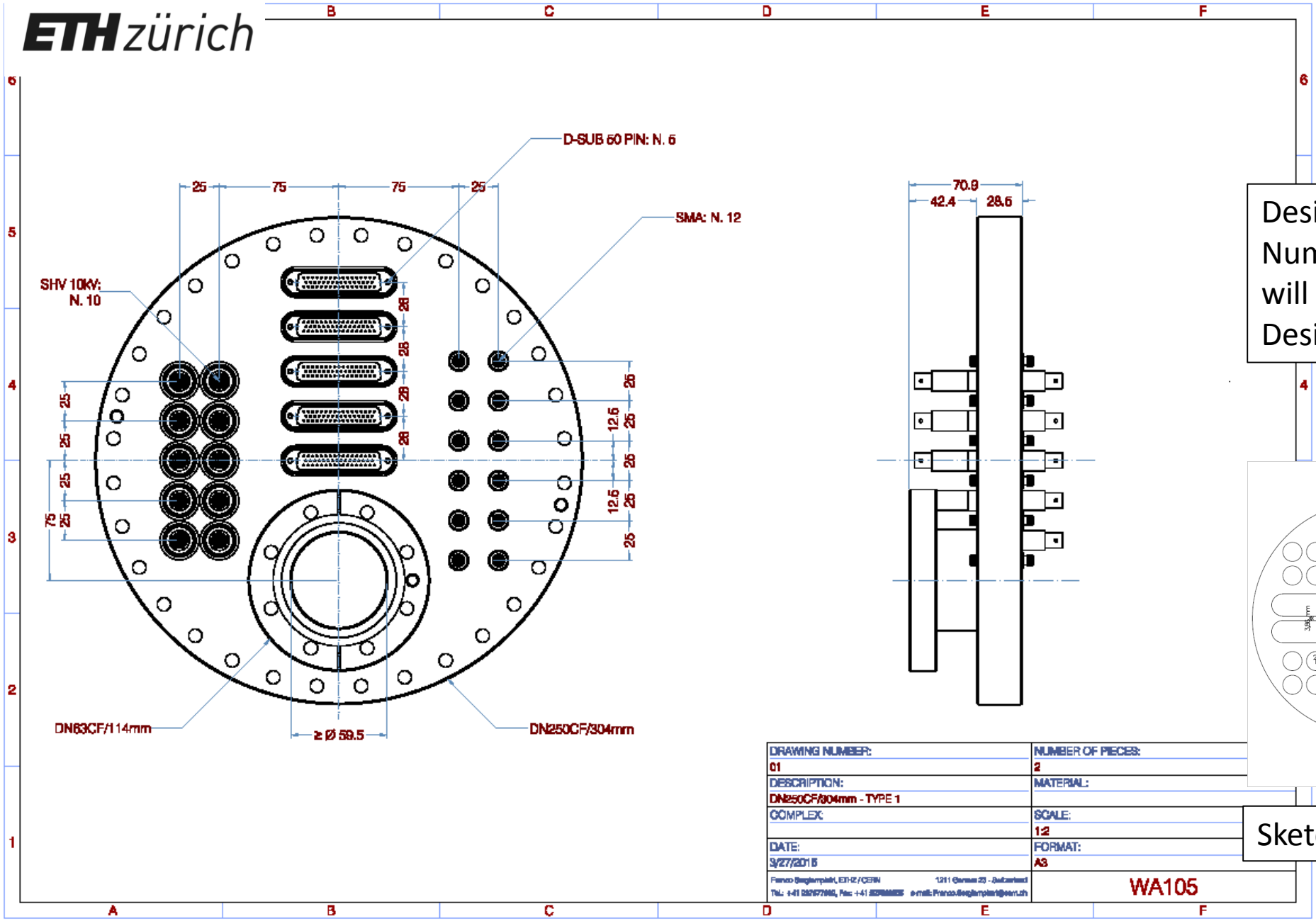

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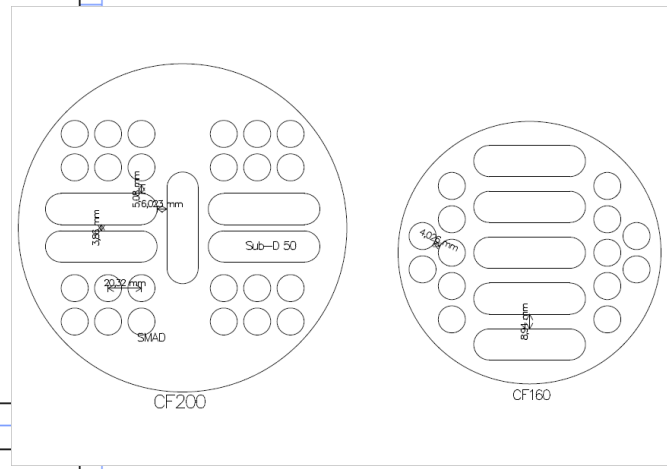
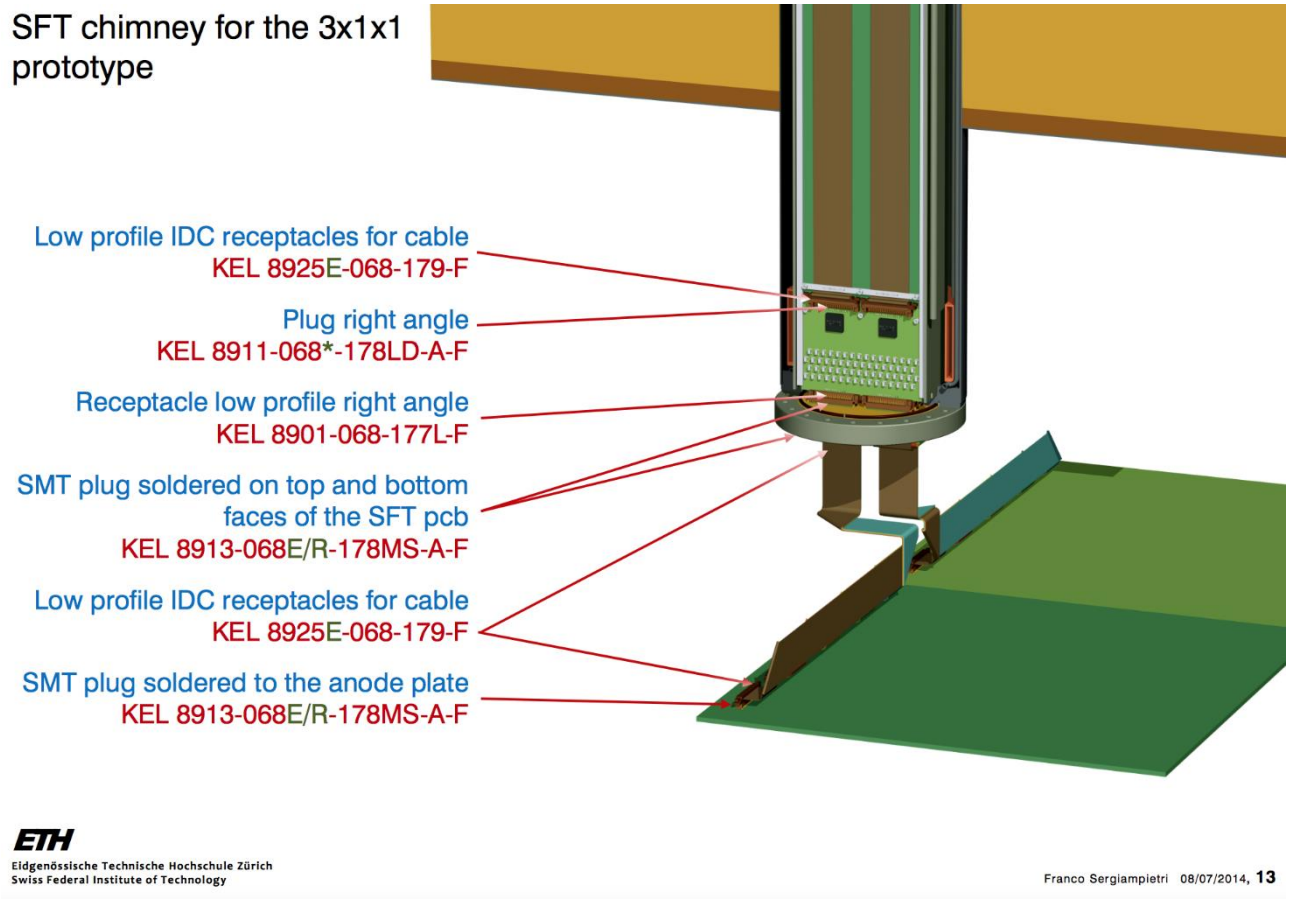
COMPLEX:	SCALE: 1:2
DATE: 3/27/2015	FORMAT: A3
Franco Sergiampietri, ETH-IZ / CERN 1211 Geneva 23 - Switzerland Tel.: +41 [redacted], Fax: +41 [redacted] e-mail: Franco.Sergiampietri@cern.ch	WA105

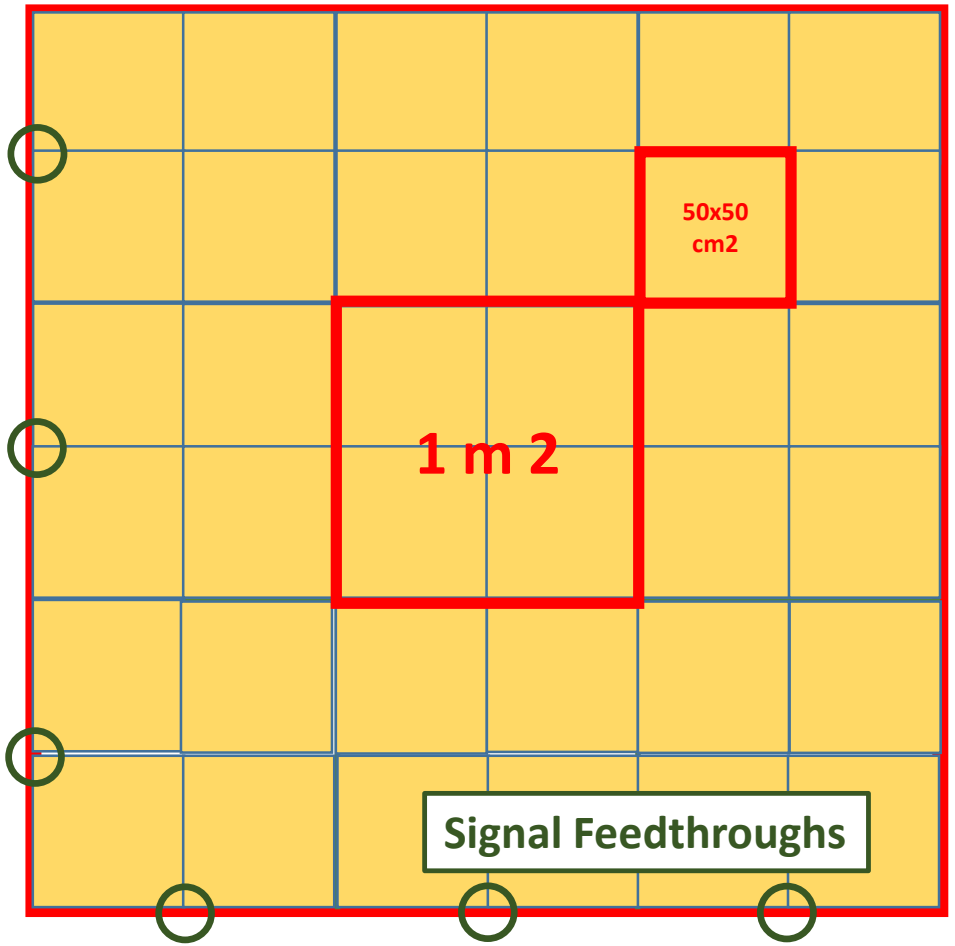
Design of SC Flange 311 by Franco.
Number of connectors on CRP INS will be similar to the ones for 311.
Design in progress.



Sketch for CRP INS flange 6x6x6

Connectors and cable for electronics

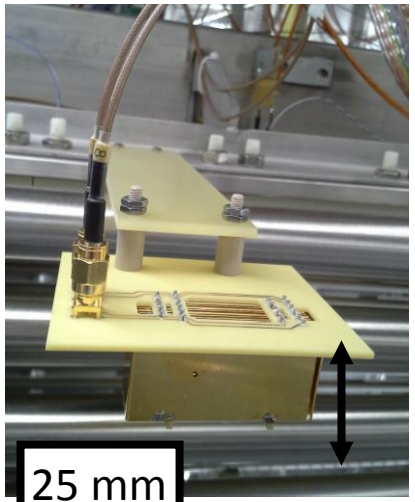


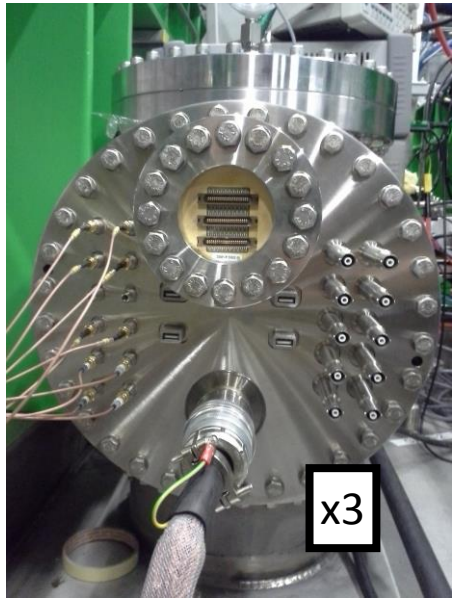


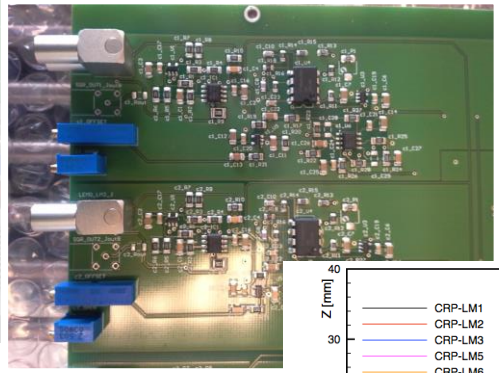
Electronics: each 9 m2 CRP module
Hitachi 68 c twisted pairs 0.635 mm pitch
Automated continuity test procedure during installation will be implemented

3x3 m2 = 9 m2 unit
36 anode 50x50 cm2

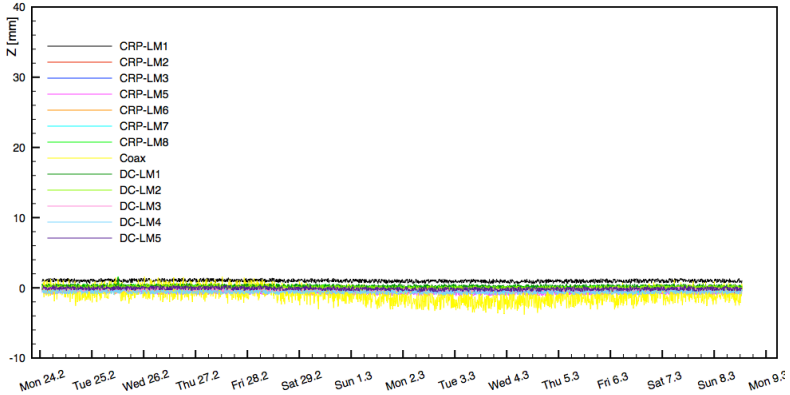
LAr level meter system in 311 Detector

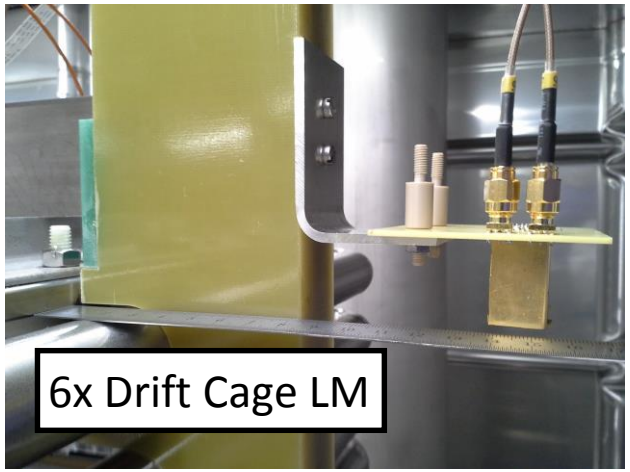


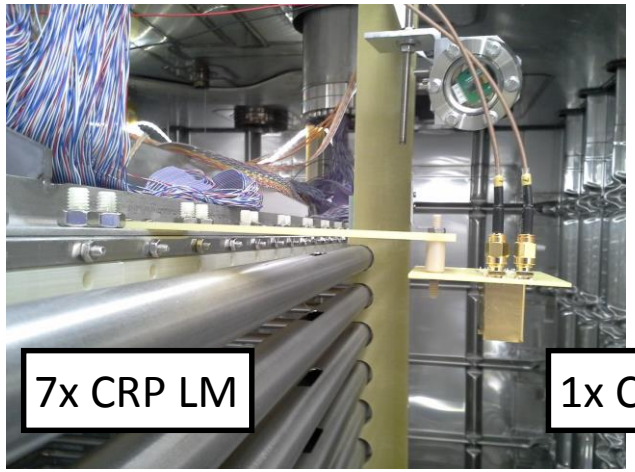




Custom sensing elements
Custom electronics

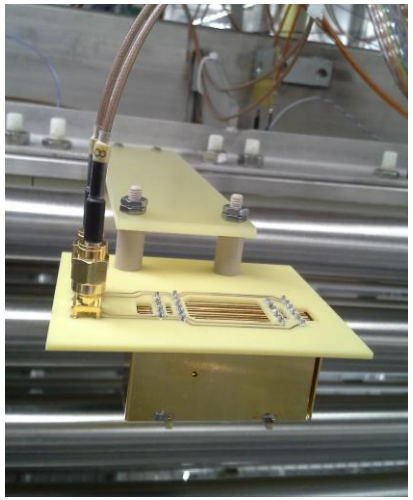


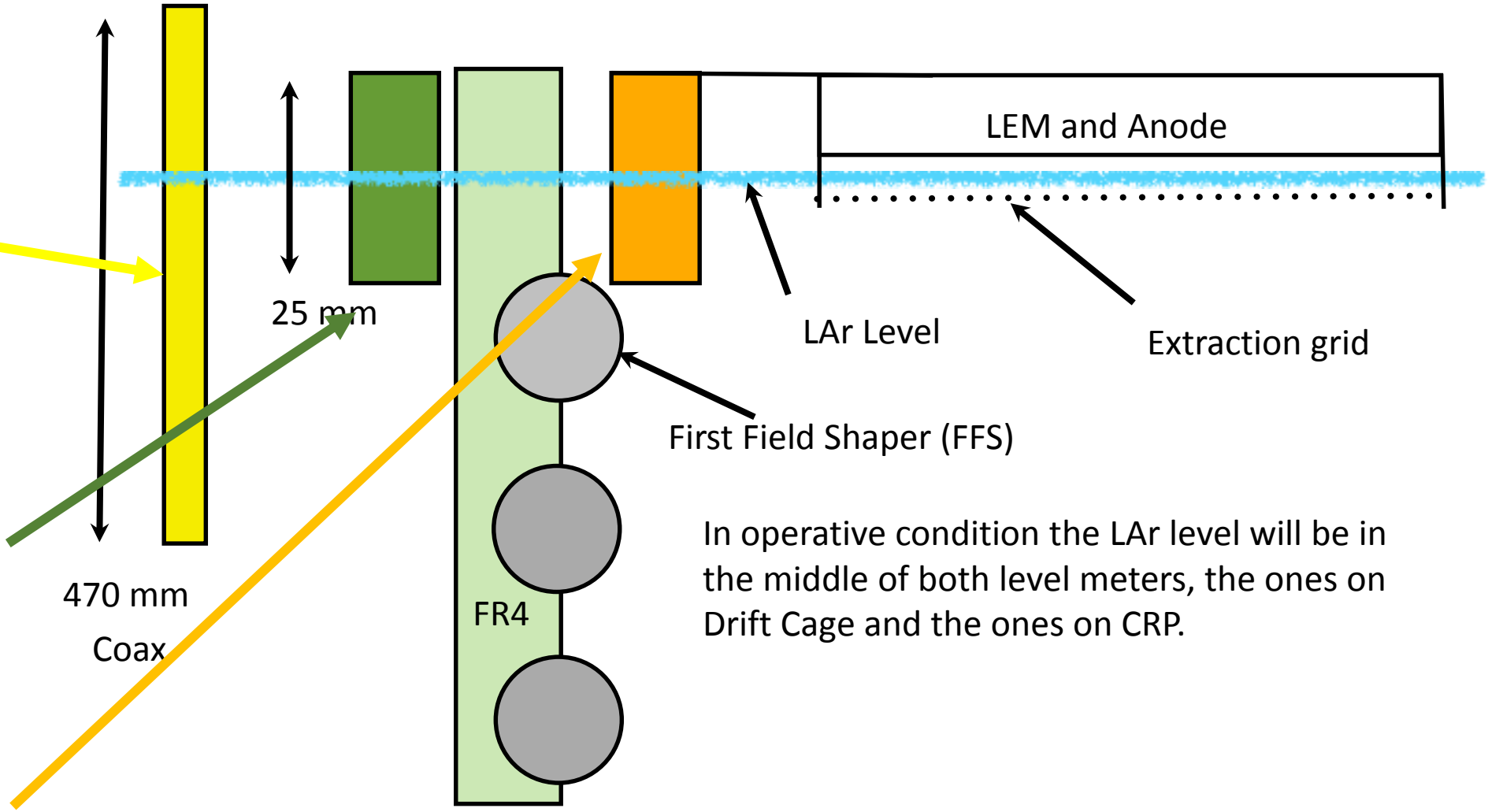




Currently all sensors in GAr atmosphere

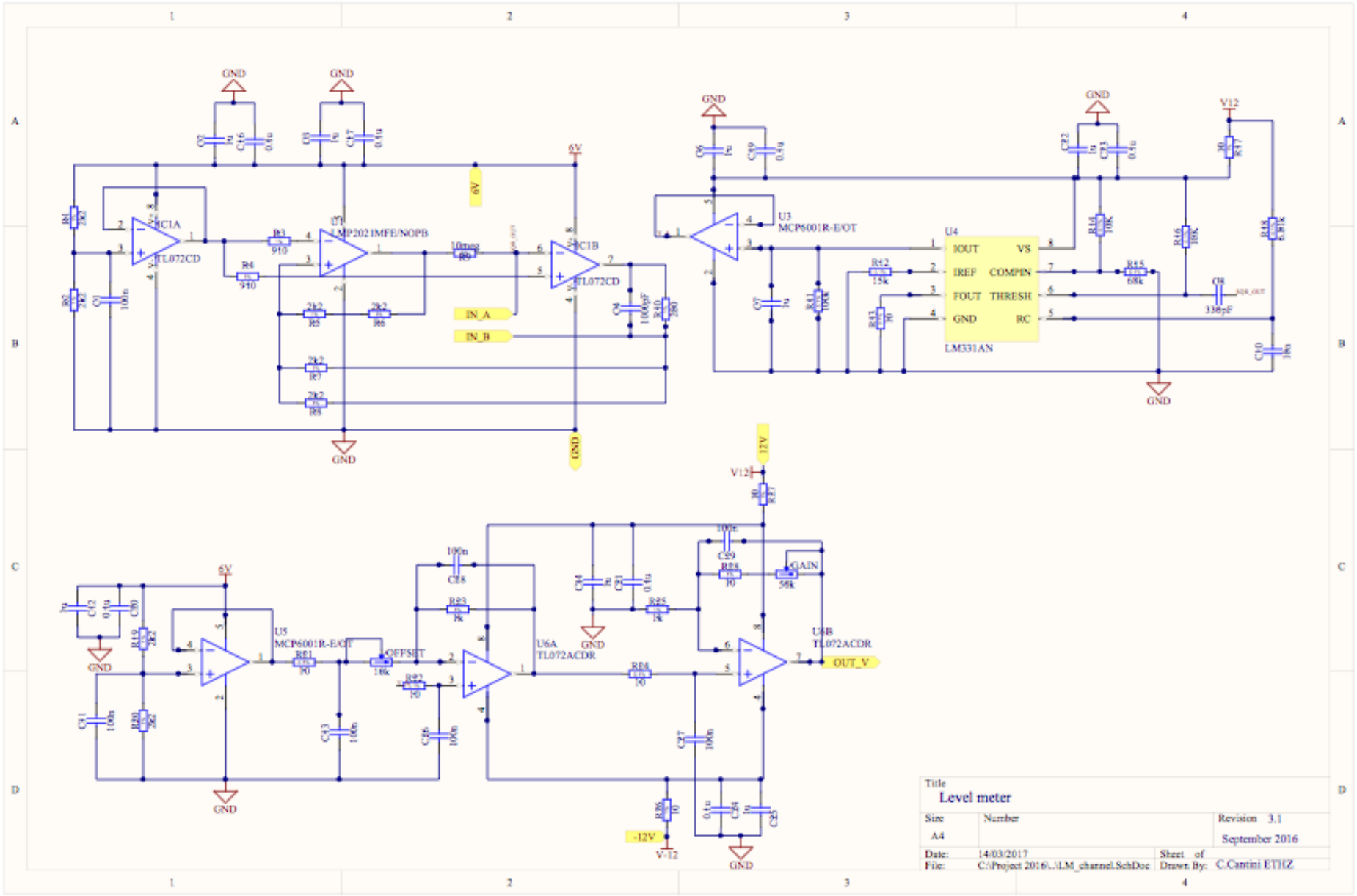
Position of level meter in 311 Detector





In operative condition the LAr level will be in the middle of both level meters, the ones on Drift Cage and the ones on CRP.

Electronics for LAr level meter



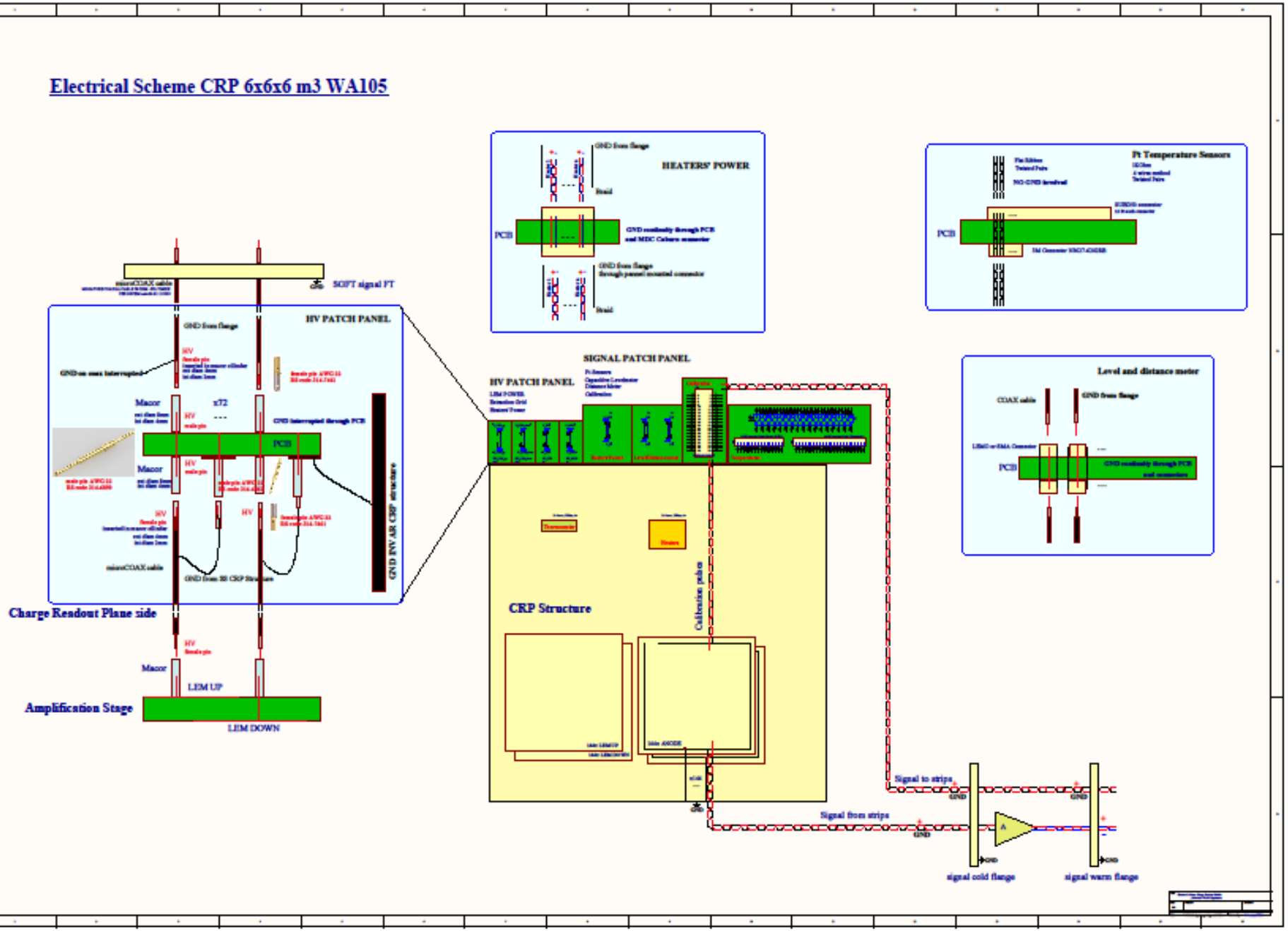
Cable for LAr level meter

Coaxial Cable, FEP Sheath RG316/U

Bedea - RG316/U

Characteristic resistance	50 Ω
Attenuation per 100 m	
100 MHz:	37 dB
200 MHz:	47 dB
1000 MHz:	102 dB
Internal conductor:	Silver-plated steel strand 7 x 0.17 mm
Dielectric:	PTFE Ø 1.52 mm
Shield braiding:	Silver-plated copper
Sheath:	FEP, brown
Outer diameter:	Ø 2.5 ±0.1 mm
Temperature range:	-70 °C → +200 °C
Weight approx.:	0.5 kg / 25 m coil
	2.1 kg / 100 m coil

Used inside and outside the detector to connect sensors to flanges and then to electronics



Elementary but comprehensive view of all the electrical parts on the CRP.
Important also to keep track of internal reference to GND.

WA105

ETH zürich

Alternative 1 for bridge

RIBBON CABLE

PITCH: 0.635mm

SPECIFICATIONS

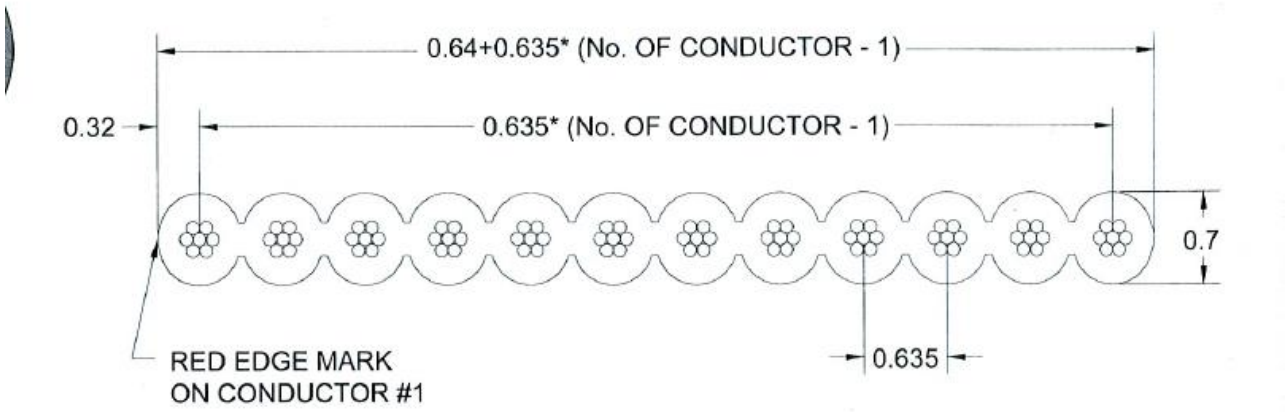
UL File No. : E162690
UL Style : 2678
Operating Temperature : -20˚C to +105˚C
Flammability Rating : UL-VW-1
Voltage Rating : 150V

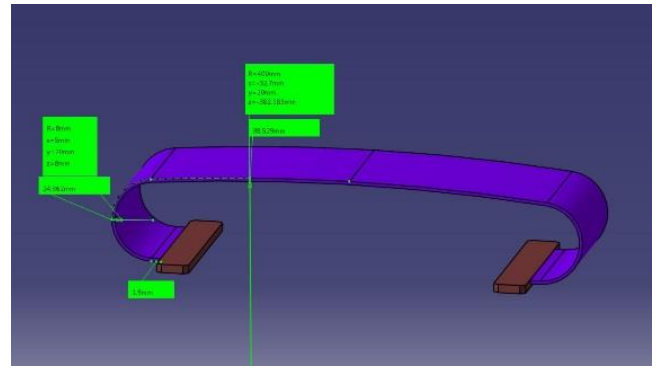
Physical

Insulation Material : Polyvinyl Chloride (PVC)
Conductor : #30AWG (7*0.102) Stranded Tinned Copper
Color : Grey With Red Edge

Electrical

Impedance : 75Ω (Unbalanced)
Capacitance : 22.5 pF/ft. 70 pF/m
Inductance: .317 uH/ft
Propagation Delay : 1.7 ns/ft.
Insulation Resistance : 1GΩ /M min.





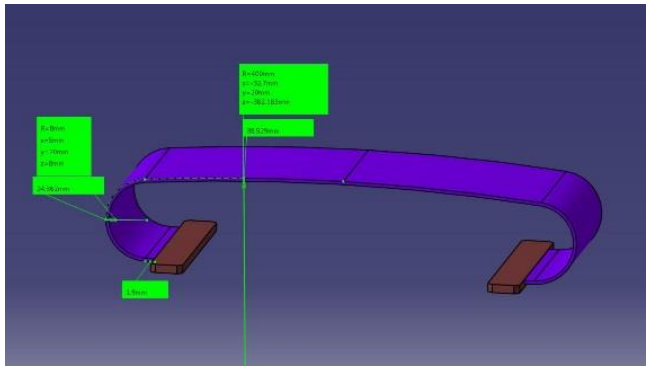
+ CONNECTOR KEL 8925E-179F
2 CHF piece / 6-12 weeks delivery

3.85 CHF/m / 12-14 weeks delivery

Assembly and electrical test possible here at CERN

Alternative 2 for bridge

RADIATION SIGN : 5.3
CONDUCTOR : Tinned copper - 30 AWG multi. 7 x 0.102 mm (KLASING)
CROSS-SECTION 0.057 mm2
DISTANCE BETWEEN CONDUCTOR AXES : 0.635 mm
INSULATION : Polyolefine
SPECIFICATIONS : TEST VOLTAGE 250 V a.c.
OPERATING TEMPERATURE -50 to +105°C
RESISTANCE (D.C.) 354 Ohm/km
IMPEDANCE 110 Ohm
CAPACITANCE 60pF/m
RATED PROPAGATION TIME 4.10 ns/m
INDUCTANCE 0.85 µH/m
FIRE RESISTANCE : IEC 60332-1



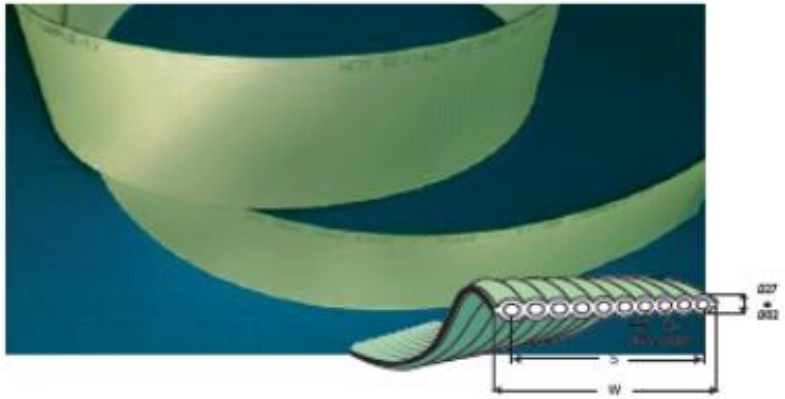
+ CONNECTOR KEL 8925E-179F
2 CHF piece / 6-12 weeks delivery

CERN Catalogue 04.21.21.068.4
8.1 CHF/m
Assembly and electrical test possible here at CERN

Sample to be tested for continuity in cold and outgassing

Alternative 3 for bridge

Solid Microzip — Low Smoke Zero Halogen (LSZH) 0.025 inch (0.635 mm)



UL Style: 20930 (Pending)	CSA Style: AWM I A/B FT- 1
UL Voltage Rating: 30V	CSA Voltage Rating: 30V
UL Temp: 105°C	CSA Temp: 105°C

Pitch 025 (0.635 mm) ± 0.0016".

Low smoke zero halogen polyolefin thermoplastic

ECO friendly

APPLICATIONS Ultra ATA 33, 66, 100 and 133. Internal wiring of electronic equipment

REACH and RoHS 2 compliant

PHYSICAL CONSTRUCTION DESCRIPTION This Microzip consists of 30 AWG solid bare copper. Each leg of copper is pulled in parallel and fully extruded. A polarity stripe is co-extruded into position number one for easy identification. Color is green with black polarity.

Pitch: 0.025 in (0.635 mm)

- XX - P - 00YYY
- Conductor AWG: 30 1/30 AWG BC
- Insulation: LSZH
- Conductor Resistance ohms/1000 ft (ohms/Km): 104 (341.12)
- Capacitance Ground-Signal (G-S) pF/ft (pF/m): 12.5 (41.01)
  - (G-S-G) pF/ft (pF/m): 22.0 (72.17)
- Impedance (G-S-G) SE - Single End: 80 ohms
  - (G-S) Differential: 130 ohms
- Propagation Delay Nanoseconds/ft (ns/m): 1.60 (5.25)
  Maximum Skew ns/ft (ns/m): 0.060 (0.196)

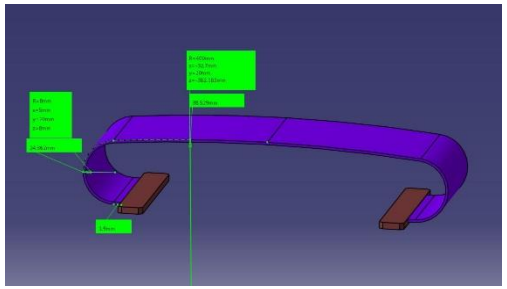
Other conductor counts and put-ups available upon request. All data is for reference only and is subject to change.

	Part Number	# of Conductors	Put-Up	Width "W" Span "S"
Example 1	68 - P - 00400	68	400 ft 121.92 m	Width: 1.700 in (43.18 mm)
				Span" 1.675 in (42.54 mm)
Example 2	80 - P - 00400	60	400 ft 121.92 m	Width: 1.500 in (38.10 mm)
				Span: 1.475 in (37.46 mm)

Building a Part Number

Part Number Format	XX - P - 00YYY	XX	00YYY	Width: XX * .050 in
				Span: XX* .050 in - .050

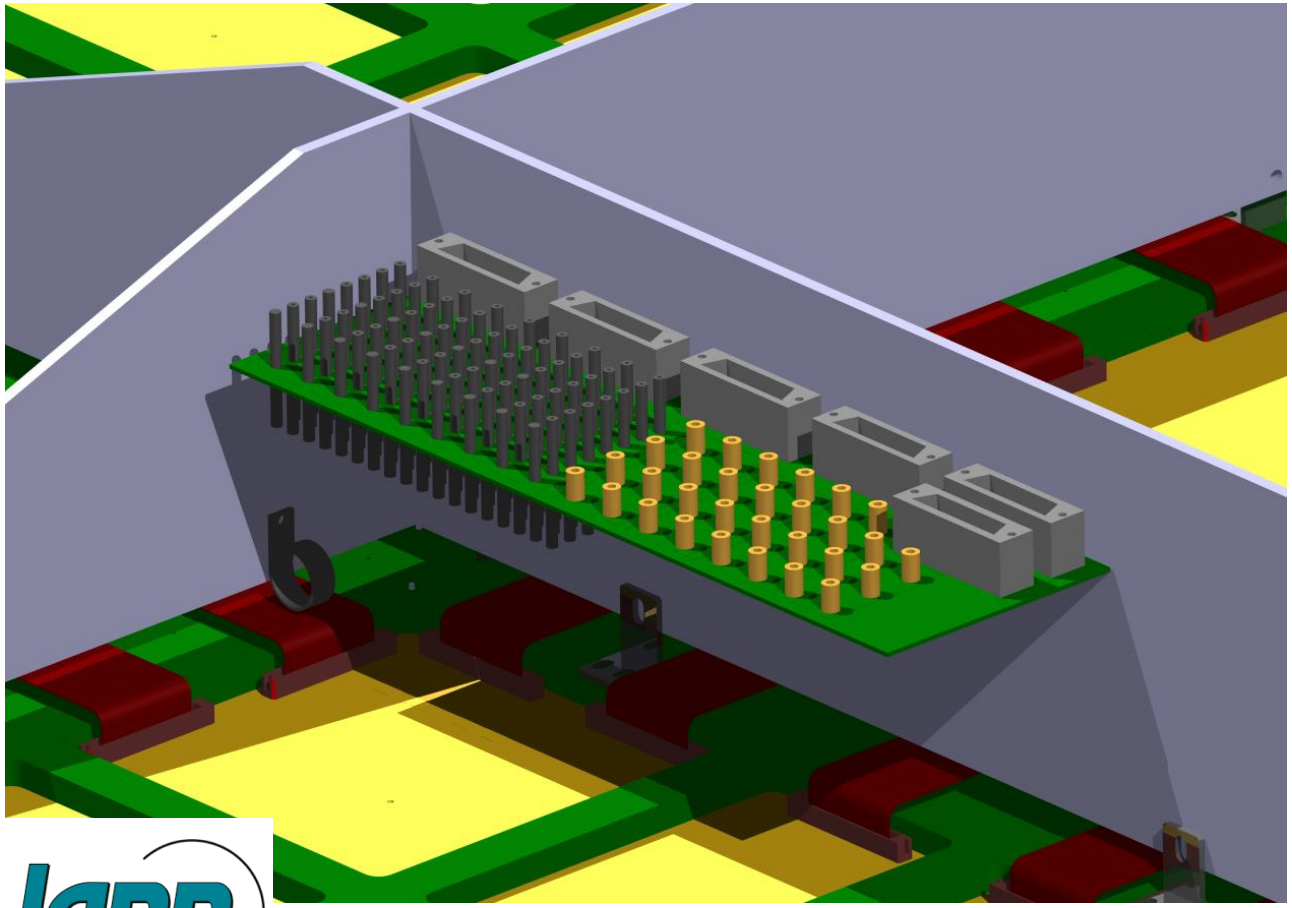
XX= No. of conductors: other conductor counts available upon request
YYY = Put-Up (ft.): 400

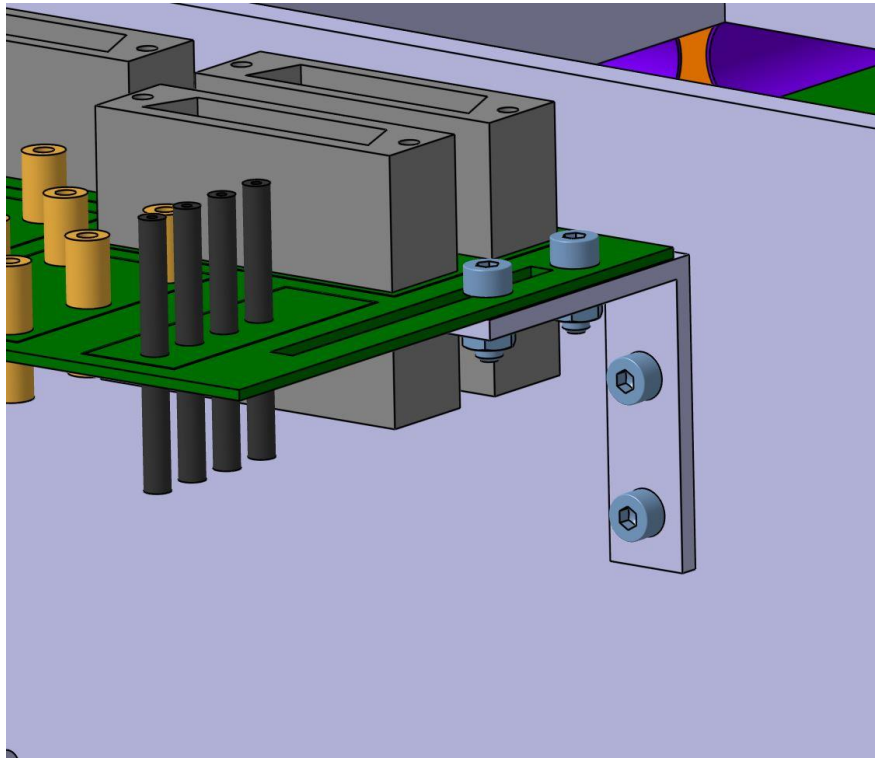


+ CONNECTOR KEL 8925E-179F
2 CHF piece / 6-12 weeks delivery

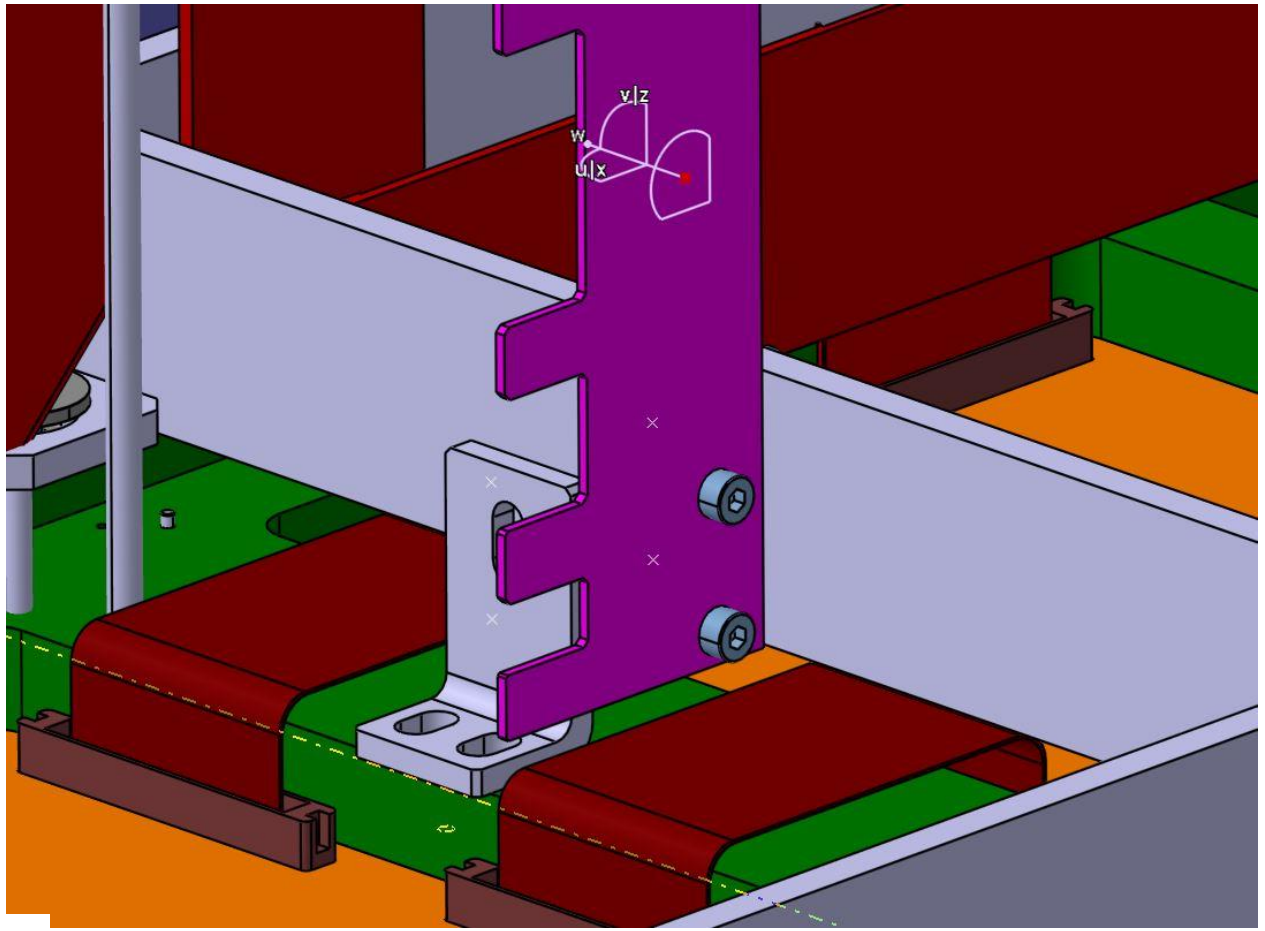
Minimum order 2 Km , 12.7 CHF/m / 12-14 weeks delivery

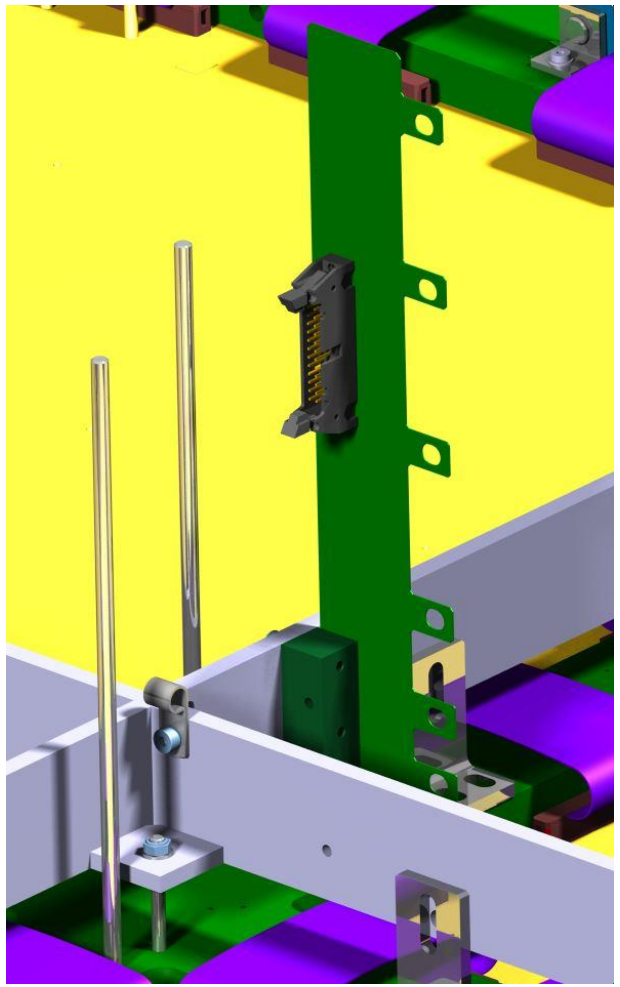
Fixation patch panels



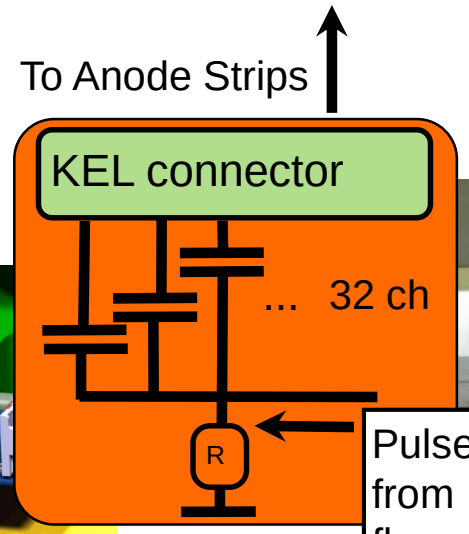


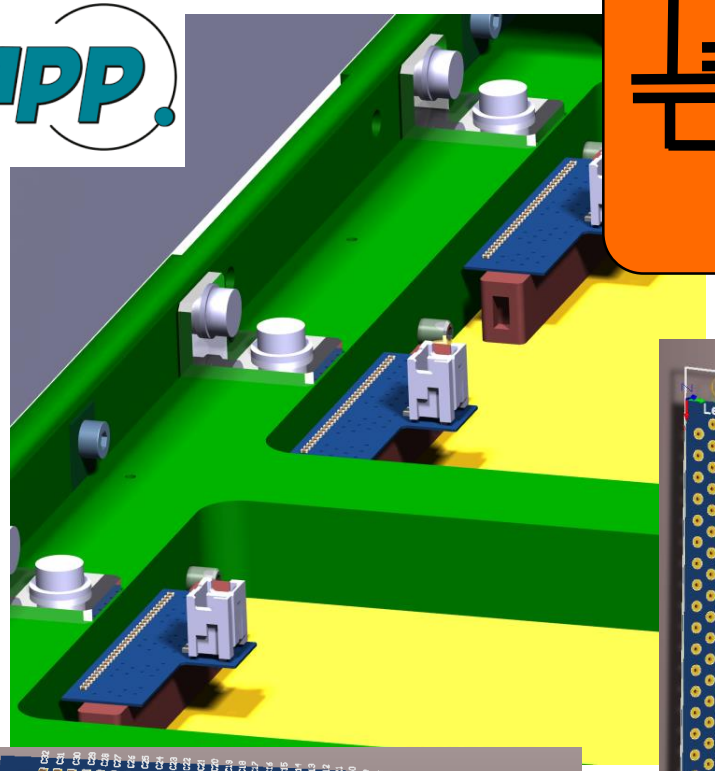
Fixation Thermometers

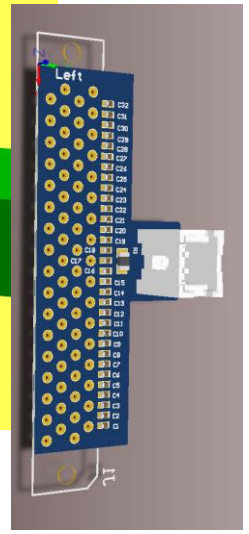


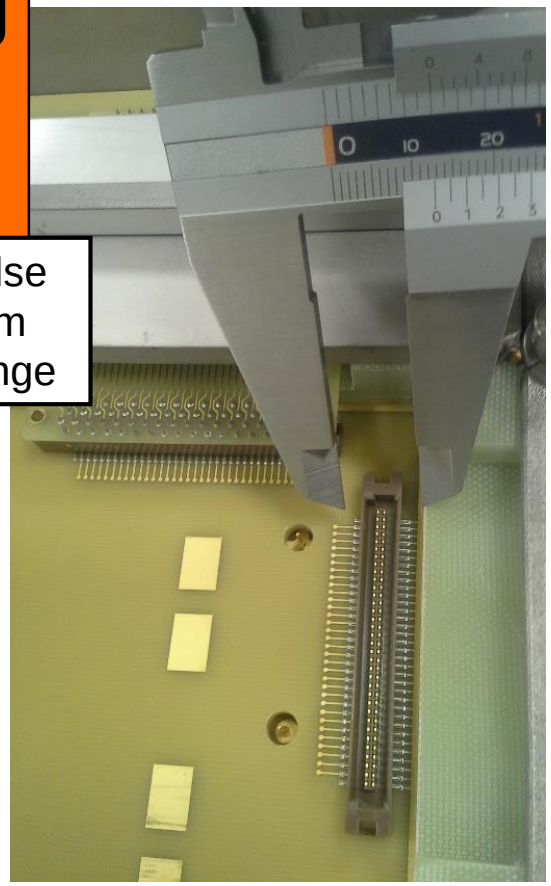


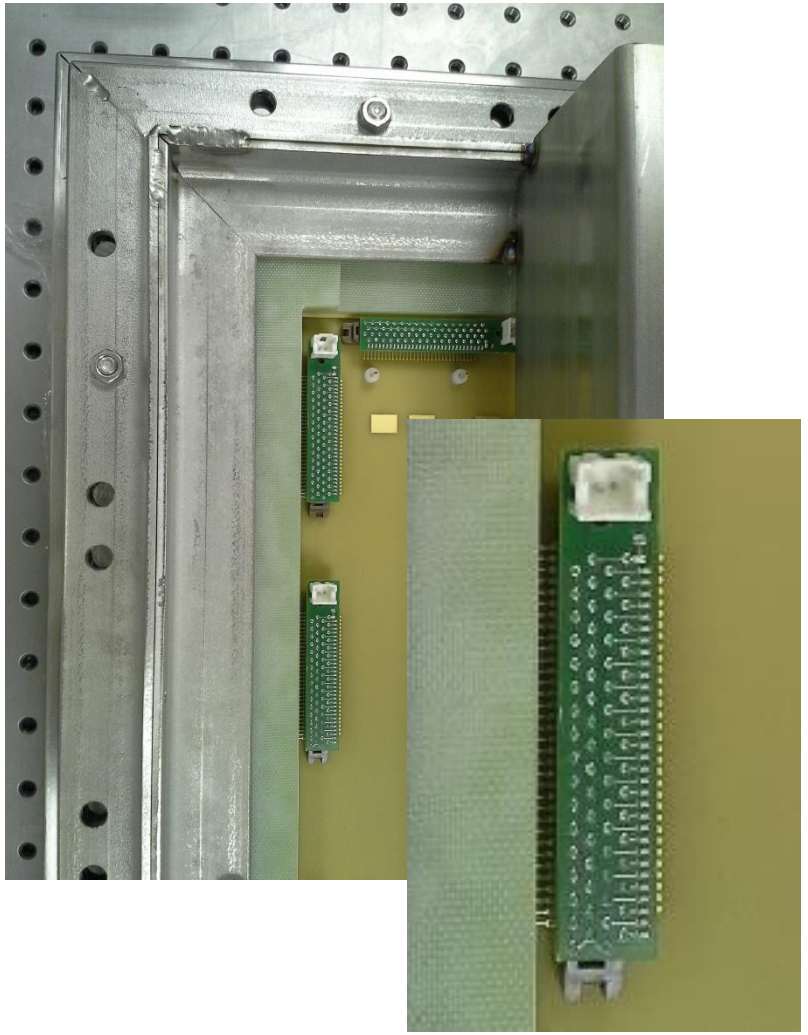
Details PCB for pulsing





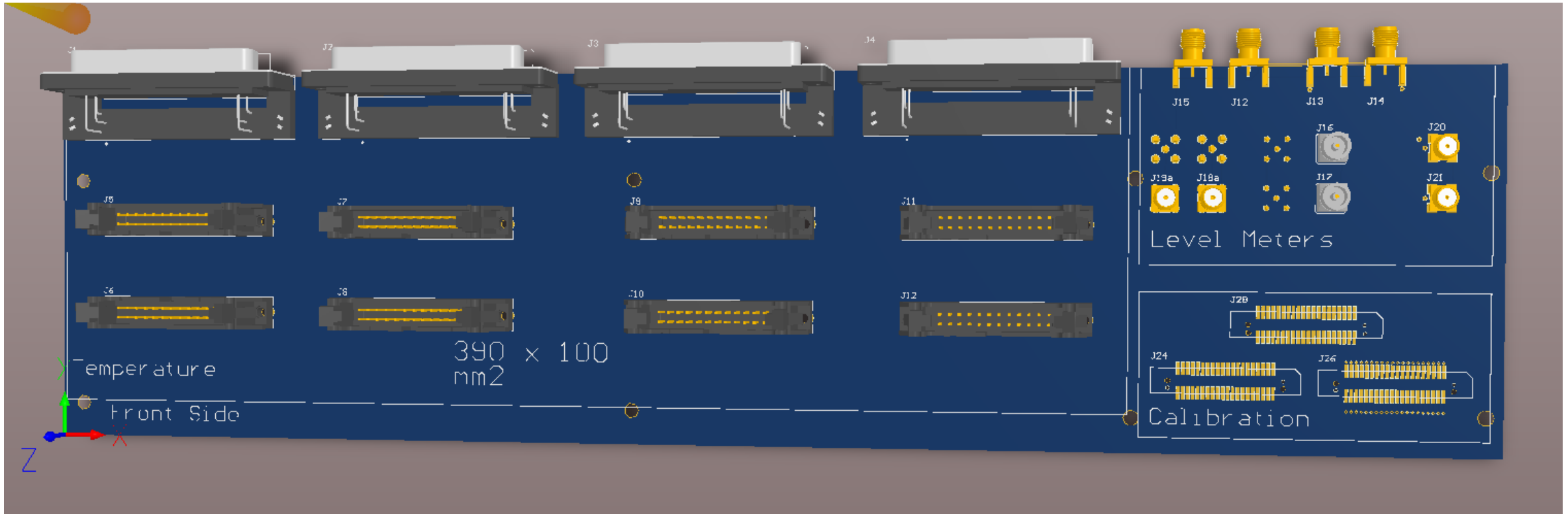






Details patch panel

Prototype hereafter. Based on sensor_list_666, numbers of connectors may slightly vary.
3M connectors matching Thermometers connectors, SUBD50 towards flanges
Dimension 390x100 mm2 – can be adapted as needed
Fixation holes – or any other fixation system to be discussed



Details patch panel for high voltage

Prototype to test spark free connections in argon gas arranged in multipin
Makor cylinder technique – two macor cylinders inserted one into the other to provide isolation
Dimension here is 10 cm OD