# Half Shell cycling and testing in Frascati. (equipment, specs and approaches)

# Half Shell Clamping in Frascati, Cycling and testing (all Layers)

Marianna Testa LNF-INFN

OEC Integration Workshop 1 February 2024

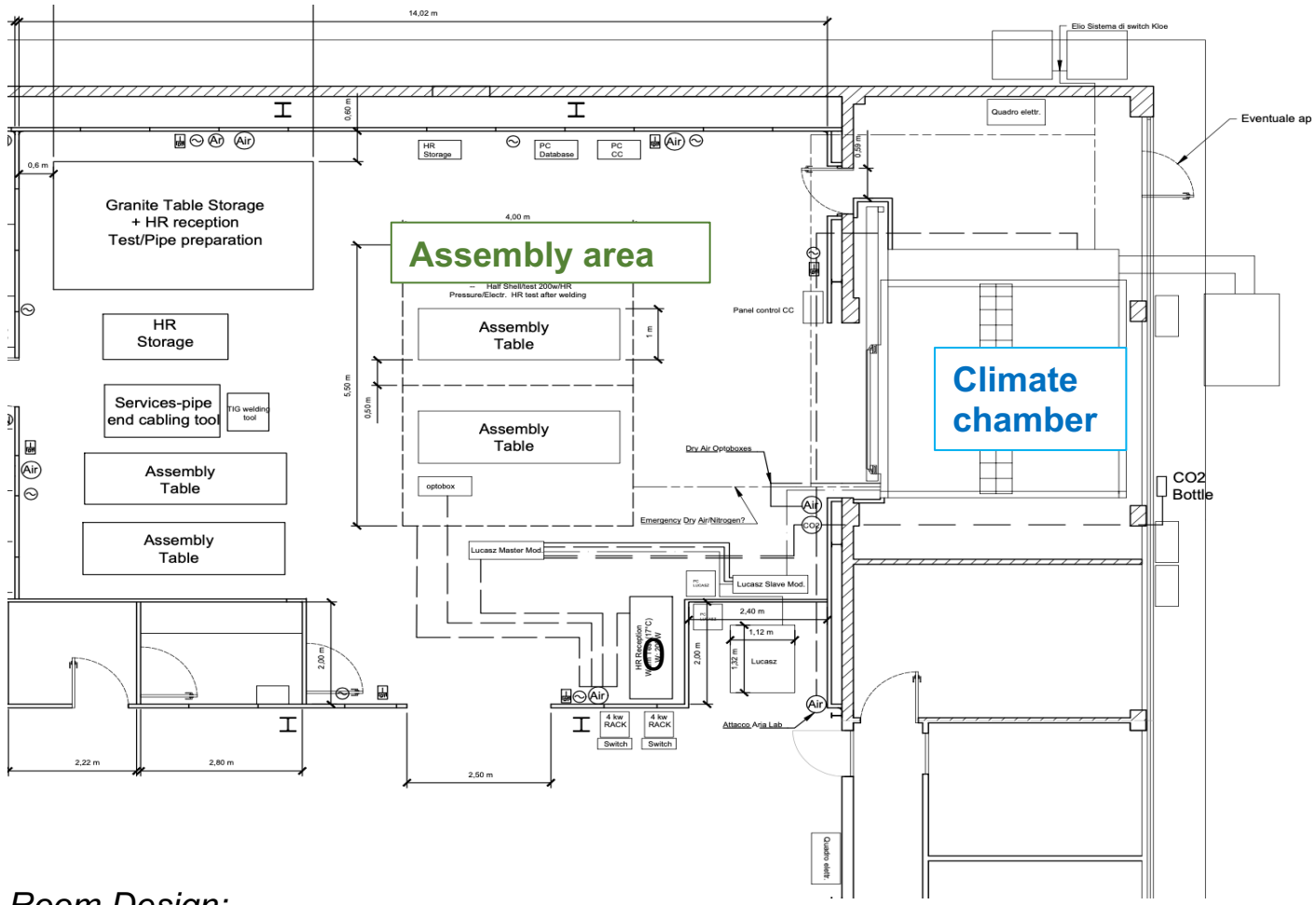
With contributions from

Z. Chubinidze, B.Buadze, L.Vannoli, P. Albicocco

Thanks to C. Gemme for useful discussion and suggestions

# EC Testing during Integration

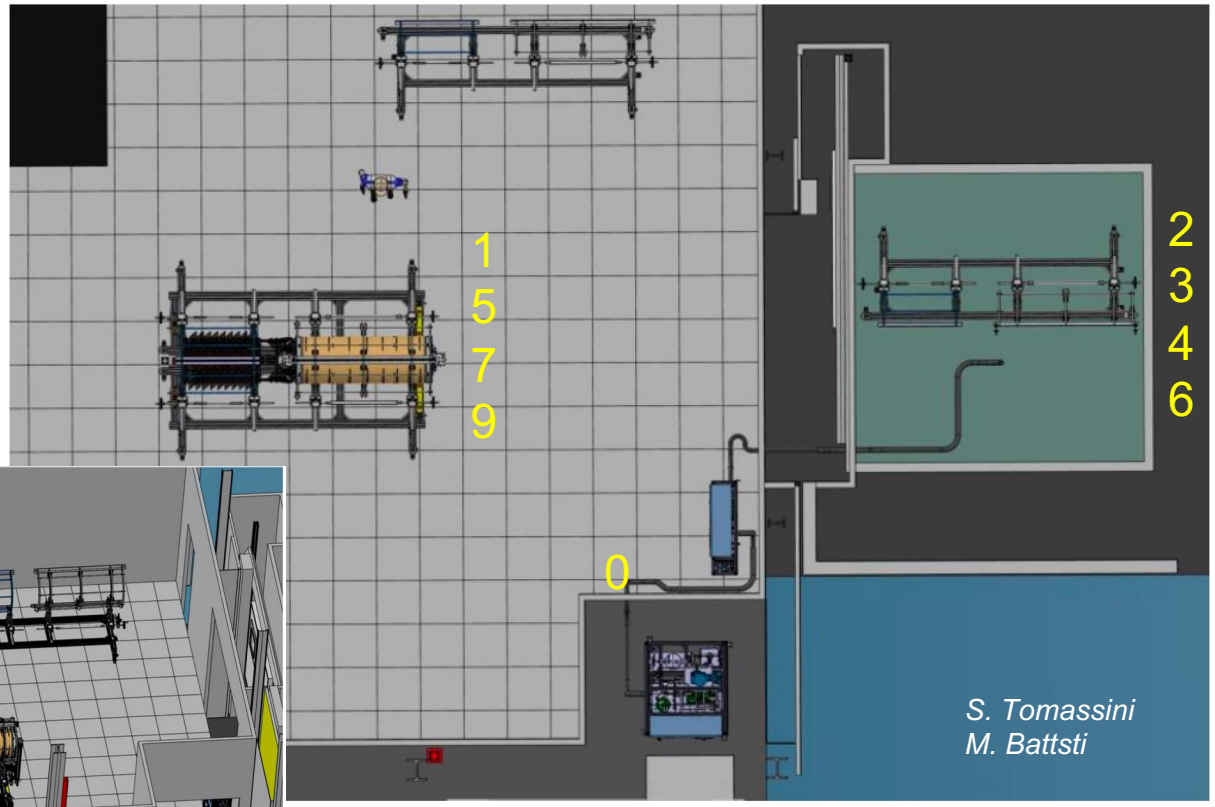
Baseline as described in
[ITkPixelIntegration-ElectrialEquipment-v10_docx_cpdf.pdf]




*Clean Room Design:*
*E. Dane', M. Testa*

0. Half-ring reception test
1. insertion of services – cooling lines, data/pwr cable - and test
2. Insertion of half-ring with silicon modules
3. Low Power mode connectivity test
4. Testing connectivity with cold $CO_2$.
5. Thermo-cycles test with detector Off
6. Testing again connectivity with cold $CO_2$
7. Mating couple of half-shells to form a layer
8. Testing connectivity of complete layer cooling with Lp mode /warm CO2
9. Bring layer on platform
10. Repeat for the three layers
11. Final test on transport box

# EC Testing during Integration





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[ITkPixelIntegration-ElectrialEquipment-v10_docx_cpdf.pdf]

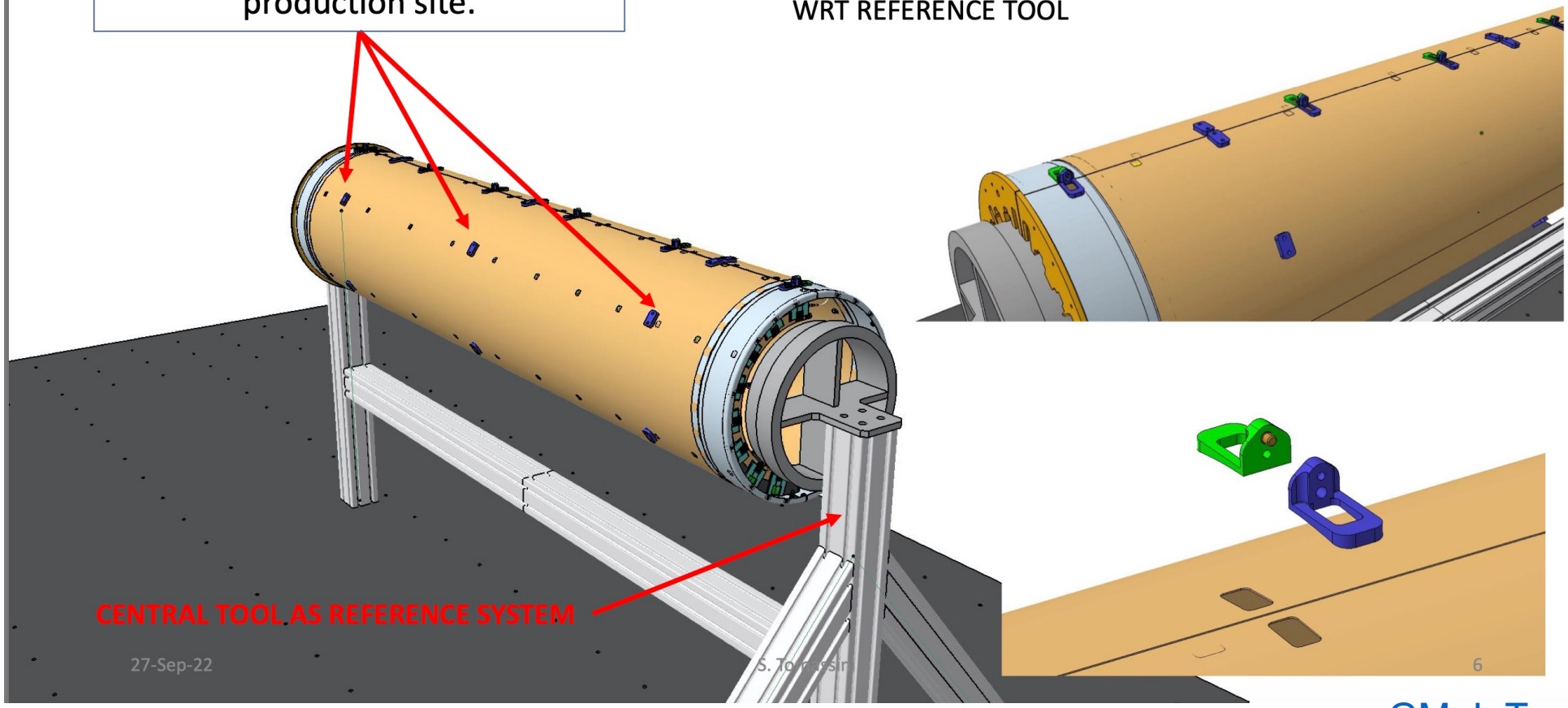
# HS and tooling preparation - 1

**Integration Sequence**

L2_L3_L4 - Interface Plates (n.12)

already glued on CF shells at the production site.

1. BARE SHELLS ARE INSTALLED AND CLAMPED ON THE REFERENCE TOOL
2. THE CILYNDER IS ALIGNED WRT REFERENCE TOOL

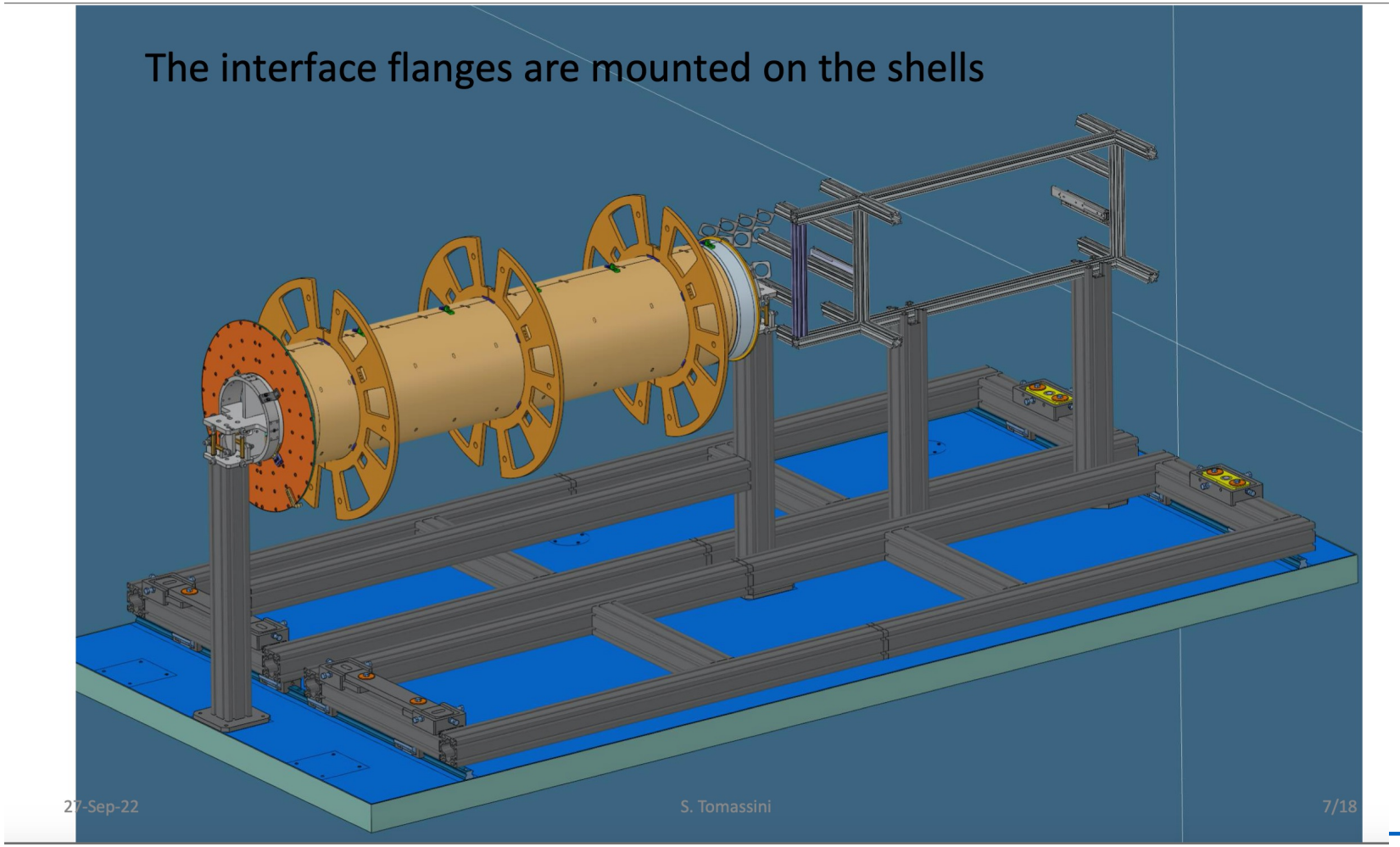






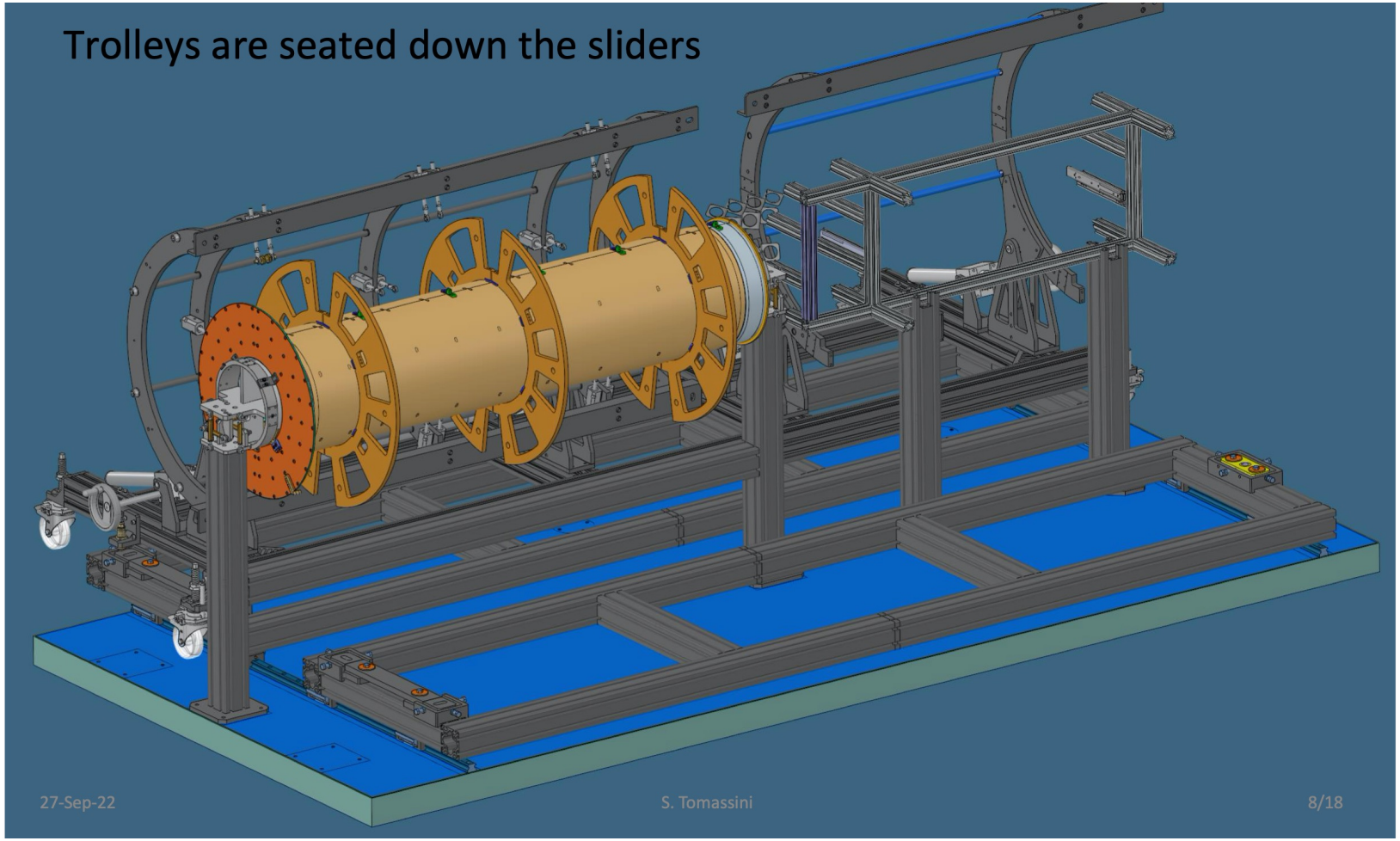

GM_I_Tomassini_27Nov2022 talk

# HS and tooling preparation - 2




_Tomassini_27Nov2022 talk

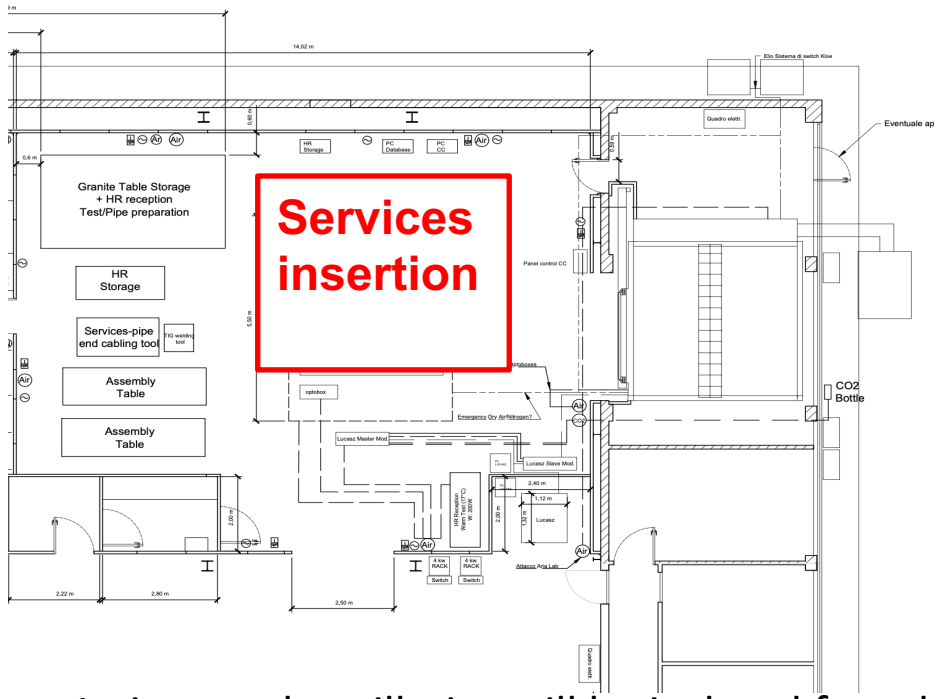
# HS and tooling preparation - 3

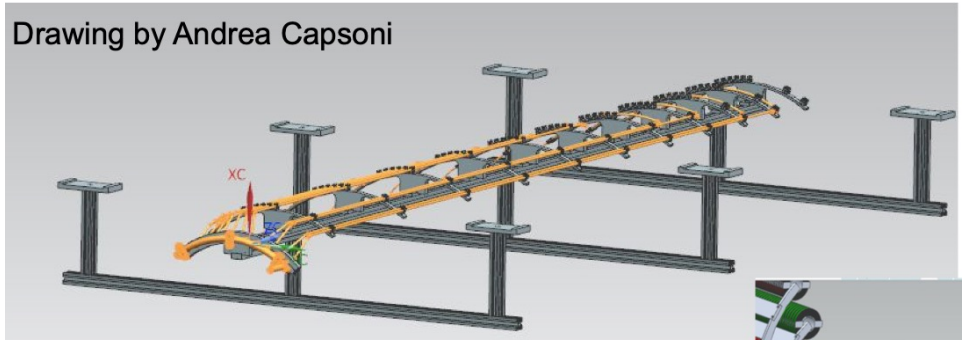


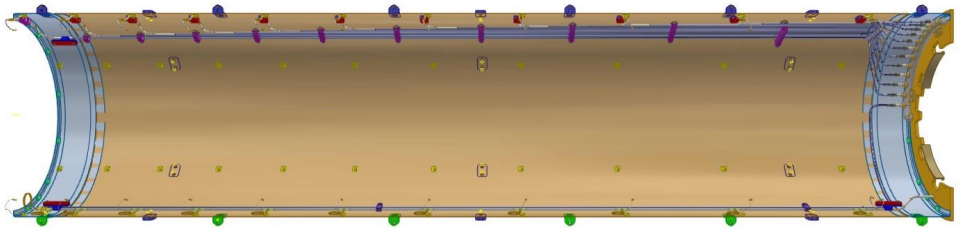

GM_I_Tomassini_27Nov2022 talk

# Insertion of cooling type-1 services





- Type 1 pipes and capillaries will be isolated from half-shells or any other conductive surface using ULTEM clip
- The resistance to the support structure will be measured and recorded to ensure compliance with the grounding and shielding including ground fault monitors specifications

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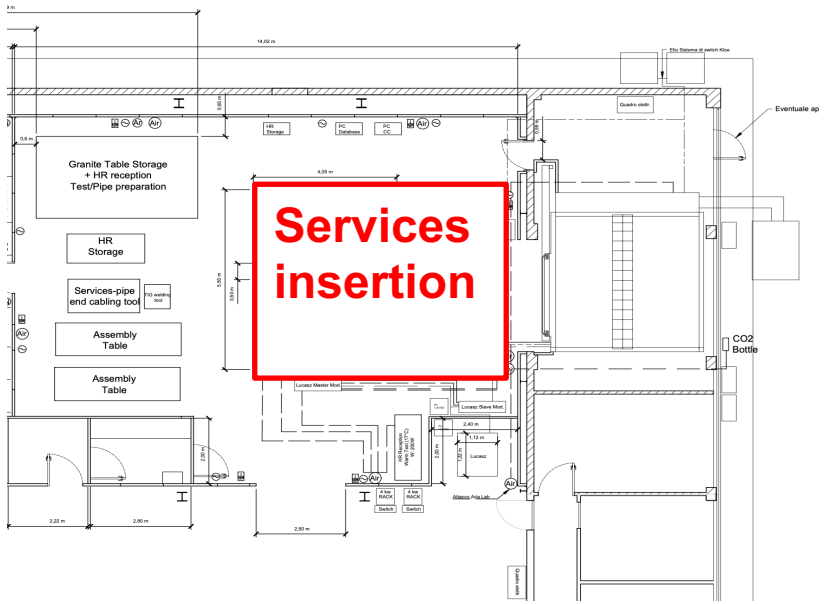
# Insertion of data/pwr and env type-1 services

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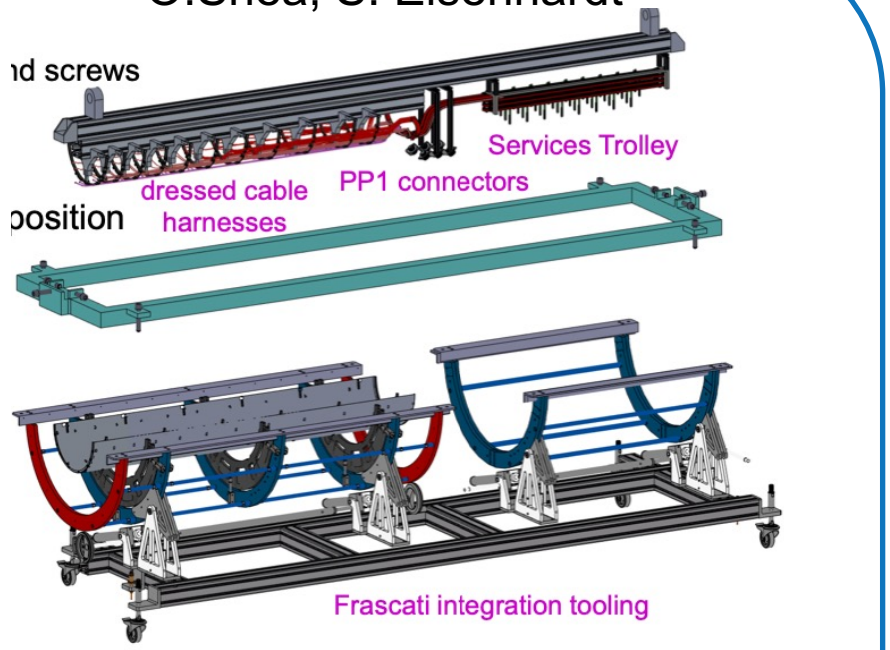
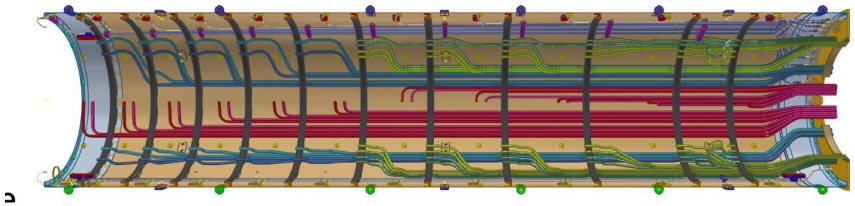
O.Shea, S. Eisenhardt



- Electrical **continuity** of HV-,LV-, Tilock-, CANbus and VCAN-lines, env. bundle, from terminations PCB to **PP1 connectors**
- Localized heat input / 'cold-spray' will be used to make sure the sensors respond appropriately (check on humidity  sensors TBD).
- **Mapping** of pwr and env bundls PP2/PP3 and PSU
- Electrical continuity of **data** cables from firefly to **termination boards**
- **Mapping** of twinax cables with

# Insertion of Half-Rings & connection to Electrical services

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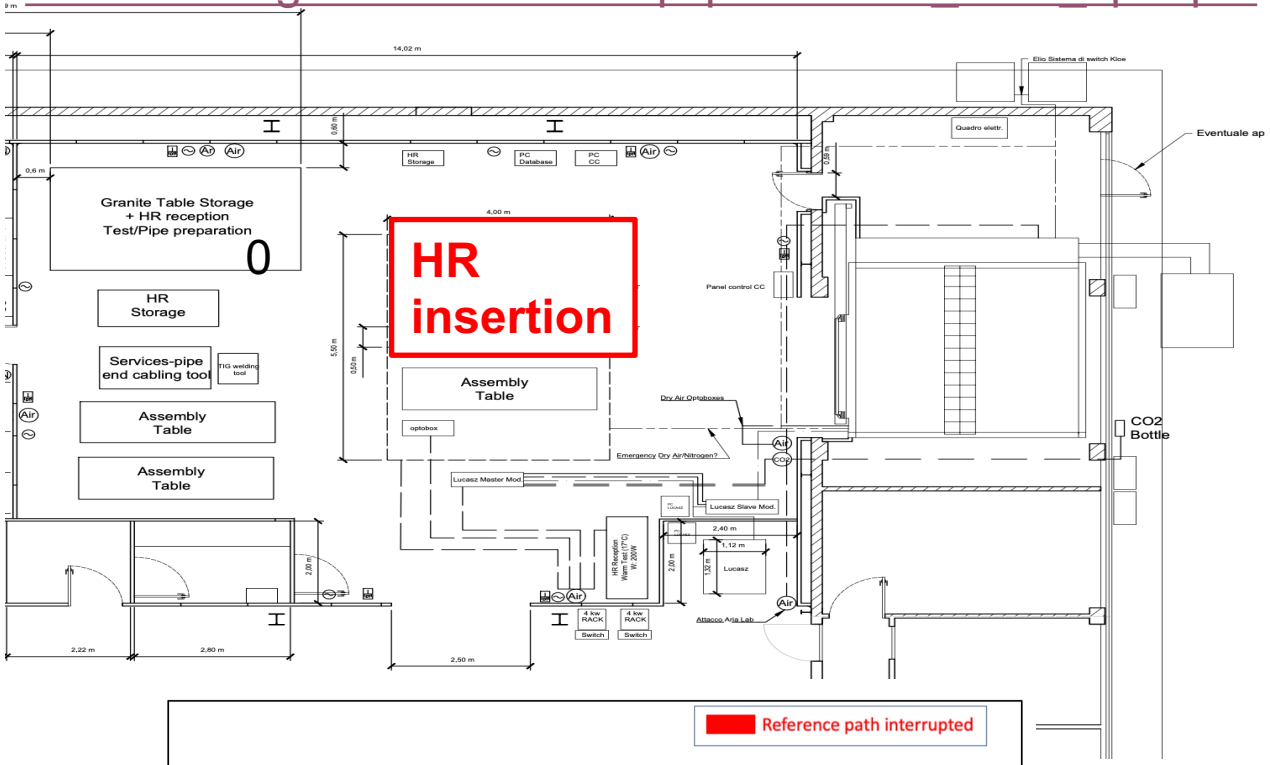
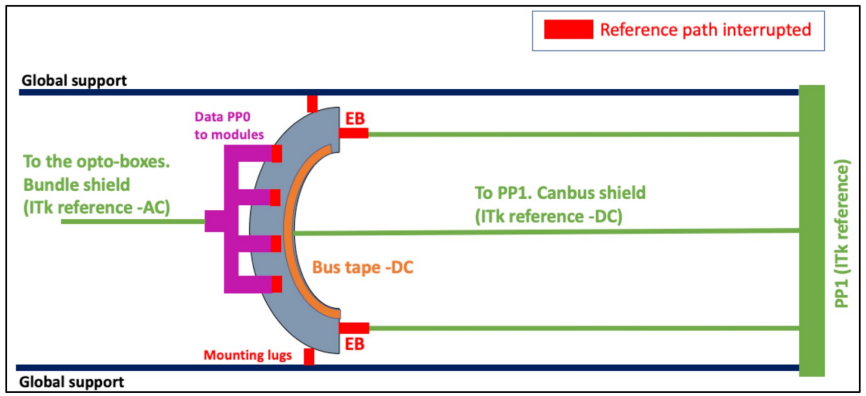
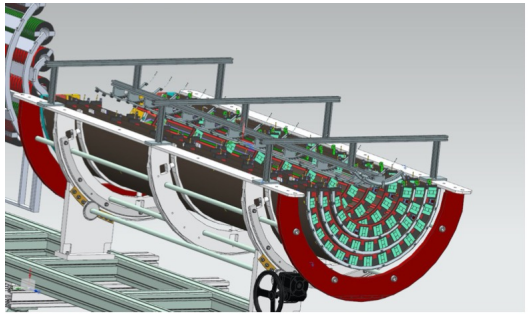


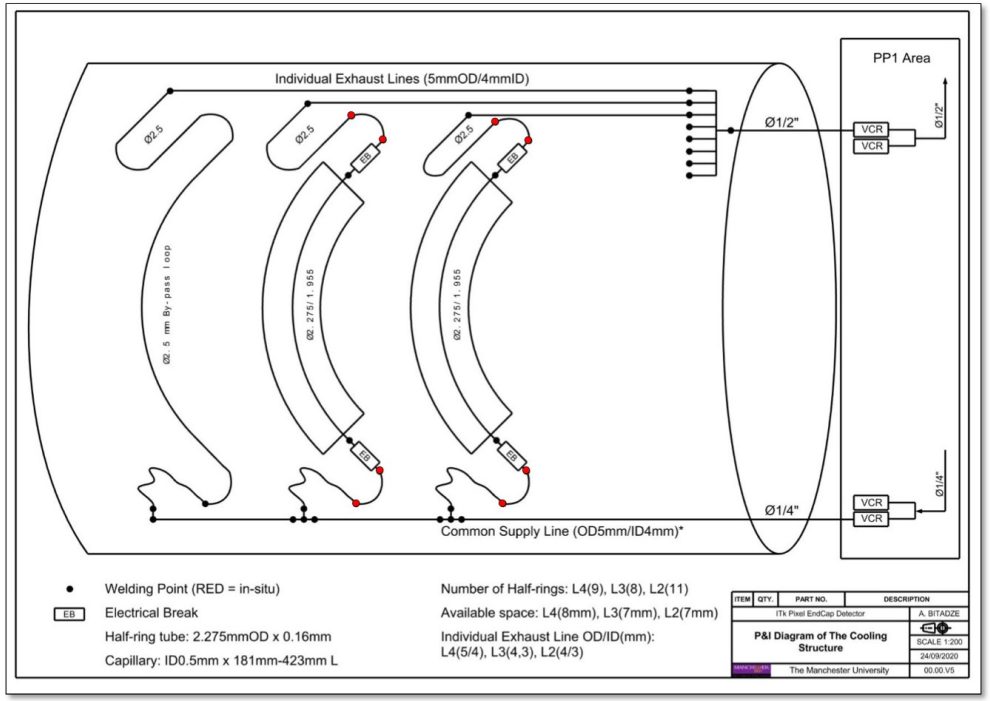
- Insertion of Half-ring
- **G&S check**: isolation between HR and HS
  - The isolation resistance between ground pads on HV EoS on the half-ring to the Type-1 cooling manifolds and the the half-cylinder will be recorded.
- Connection with **services"**
  - From here HR is at the ITk ground via Canbus shield
- HR tested in **low power mode**
- Need of convective cooling fans, according to tests ( shown later)

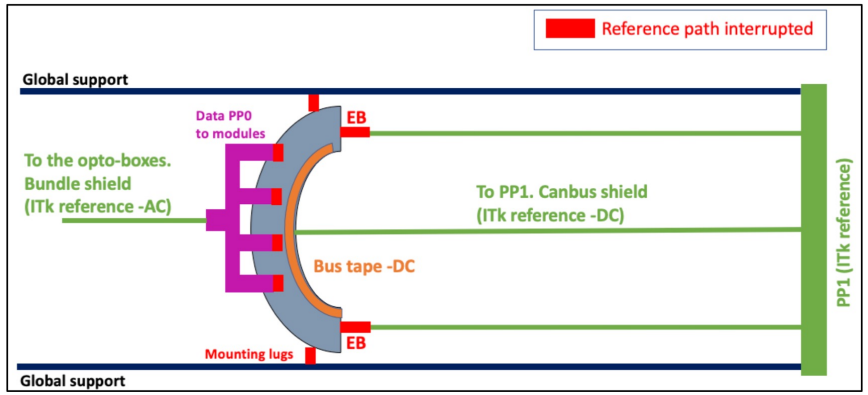
# Welding

- 4 welds per HR
  - Leak test
  - Pressure test 162 bar
  - Leak test
  - Next slides about gas ( Ar in SR1 )

- Re-test with low power mode
  - Check no damage on modules/services

- Repeat until Half-shell is populated



# Welding

- In SR1 Argon is used:
- https://edms.cern.ch/ui/file/2913775/1/Procedure_document_-_SR1_weld_proof_test_DRAFT_V1x_docx_cpdf.pdf. ?

Since the presence of traces of water in the ITk on-detector cooling distribution system is highly undesirable, a hydrostatic proof test cannot be applied. The ITk on-detector cooling system welded joints proof test is a pneumatic test. The use of Nitrogen as a proof test fluid is undesirable, as it does not allow to use a sniffer to find leaks if necessary. Both Argon and Helium are preferred for the Proof test, but since **Argon** is cheaper, it is chosen as the Proof test fluid.

Information from C. Degeorge (thanks!)

- At the very beginning of the high pressure test we put 25% of the operational pressure, so, in our case 32,5 bar.

→ Possible to find a leak which can be invisible during a vacuum leak test.

- Under this pressure (32,5 bar) the tested manifold is officially accessible and a leak can be found using the Argon sniffer. This is not possible with Nitrogen or Air

# Connectivity Test on each HR after welding with Low Power Mode

# Connectivity Test with Low Power Mode

| | Electrical Connectivity | |
|---|---|---|
| | **Already Tested** | **To beTested** |
| | Bus Tape-EoS (HV,LV, Vcan,Canbus, T-ilock) | Type1 bundle - EoS connection |
| | Type-1 pwr cable and connectors | |
| | PP1 connectros, Type2, Type3 cables (all off-detector cables) | |
| | Mapping | |

- **Granularity:** one Type1 bundle per time
- **Connectivity of HV/LV/Canbus/Vcan/ T-lock lines**
  - Switch on modules. Record T,V, I
  - Threshold scan specifically for HV connection
    - Check noise from s-curve
    - TBC: threshold scan with LP mode possible?

Work in progress: Details will come when equipment will be availabe

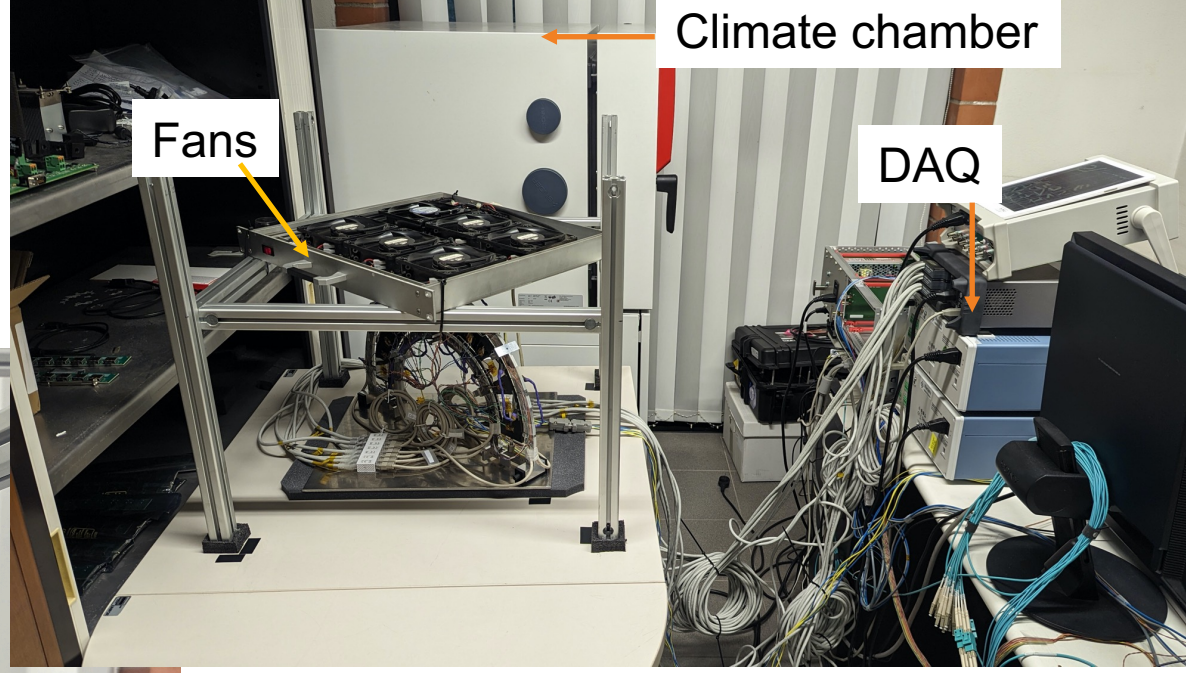
# Connectivity Test with Low Power Mode

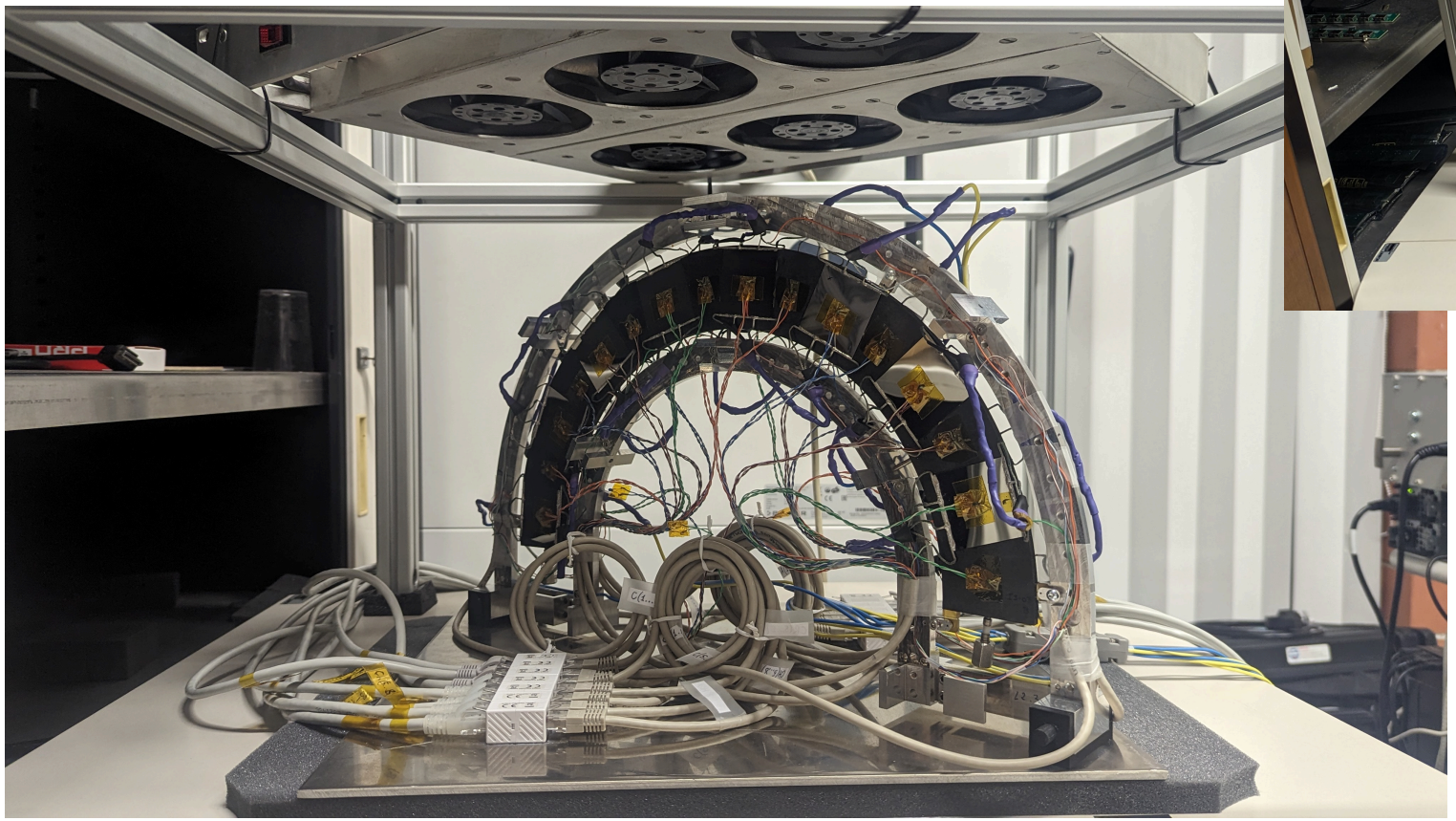
| Data Connectivity | |
|---|---|
| **Already Tested** | **To be Tested** |
| Module-PP0 | Twinax – PP0 |
| Twinax bundle terminations | |
| Extension- twinax bundle | |
| Fibers & their connectors | |
| Mapping optoboards-twinax cables | |

- **Granularity:** one PP0-twinax-extension per time
- **DAQ Felix-Module** basic connectivity :
  - Optical and electrical alignment
- **Downlink** checks from Felix to Modules:
  - Configure a FE in each module
- **Uplink** check: digital scans

Work in progress: Details will come when equipment will be availabe

# Low Power Mode on Thermal Half Rings



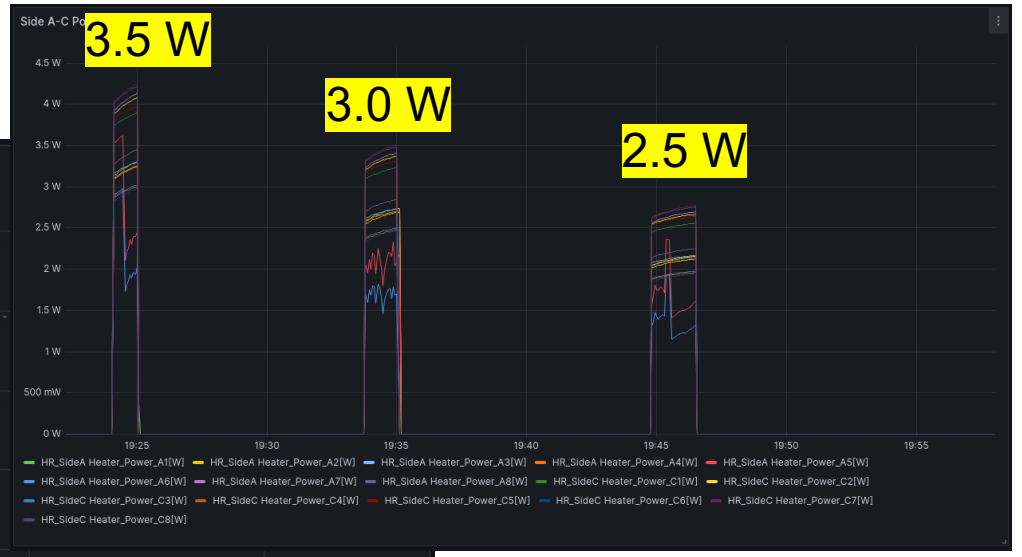



Thanks a lot to Manchester group
( Ben, Jo, Paki, Juliette)
for providing the thermal HR
and making possibility to start this activity !

Z. Chubinidze, B. Buadze

# Low Power Mode on Thermal Half Rings: no Fan

Reach 40 C in ~ 1min

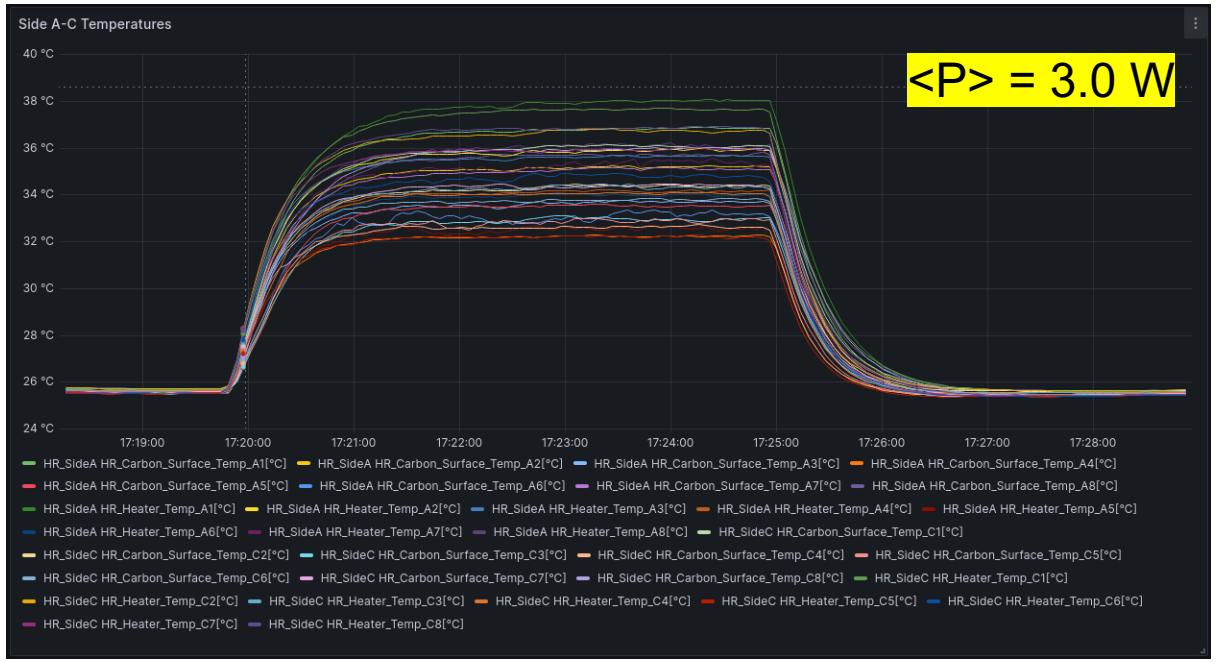




Average power values among heaters

Z. Chubinidze

# Low Power Mode on Thermal Half Rings using Fans

| Heaters with P>3W | C7 | C8 | A7 | C2 | C5 | C6 |
|---|---|---|---|---|---|---|
| Air velocity m/s | 3.3 | 3.2 | 3.6 | 5.3 | 4.2 | 4.3 |



**air velocity >= 3.2 m is enough to maintain T<40 C**

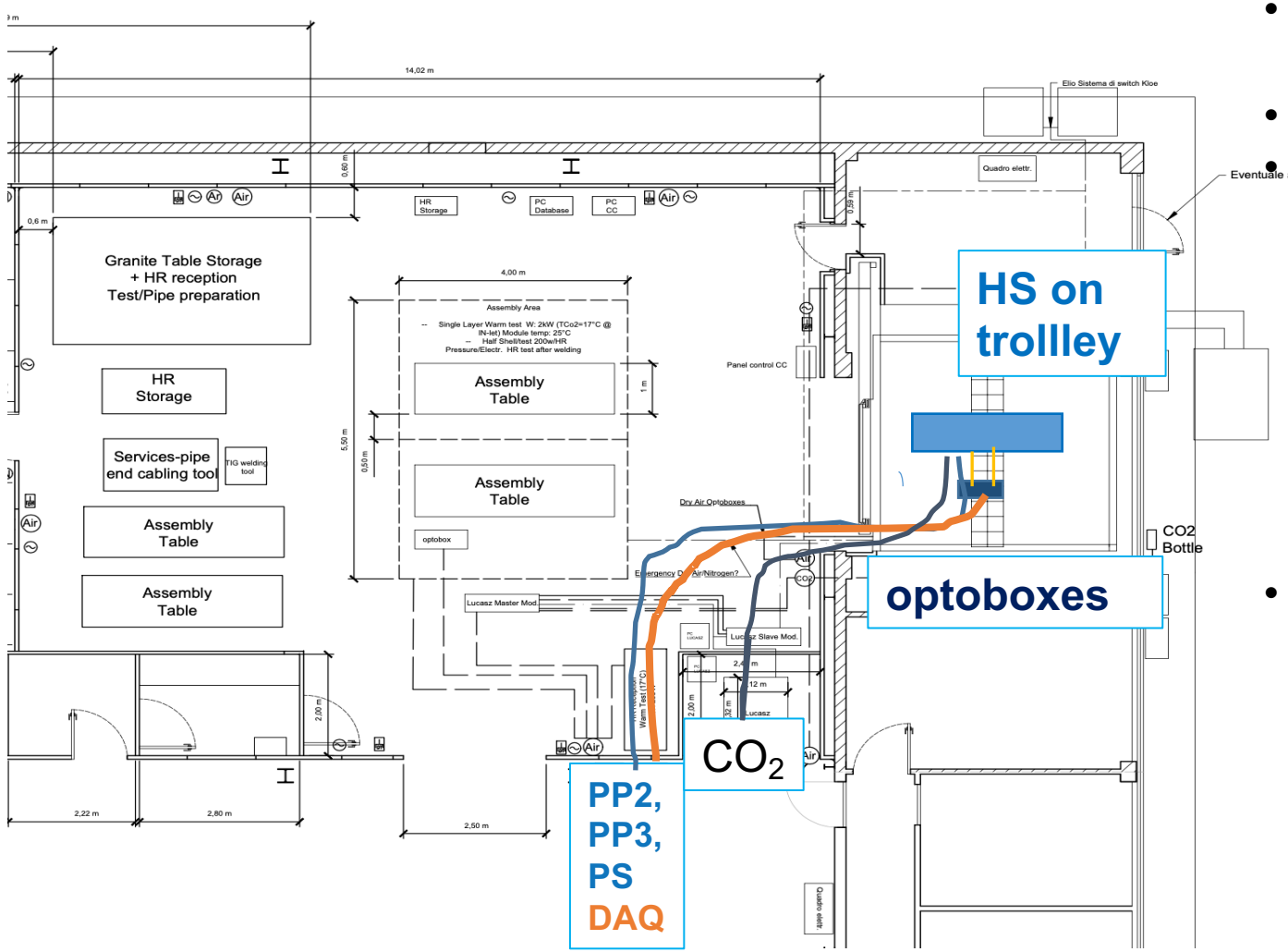
Z. Chubinidze

# Functional and Connectivity test on populated HS with cold $CO_2$

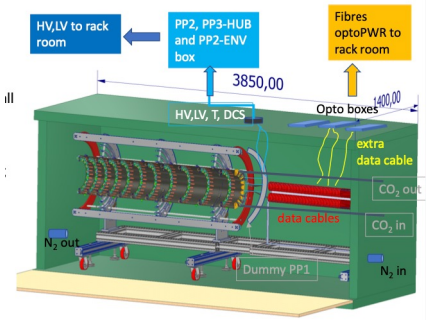
# Functional test on populated Half-Shell

| Previous Step: connectivity of individual HRs with LP mode | Current Step: populated HS |
|---|---|
| Electrical and Data connectivity for each HR | • $CO_2$ Cooling<br>• GS cooling<br>• Overall connectivity at low T<br>• Thermal cycles<br>• Post-thermal cicle connectivity at low T |

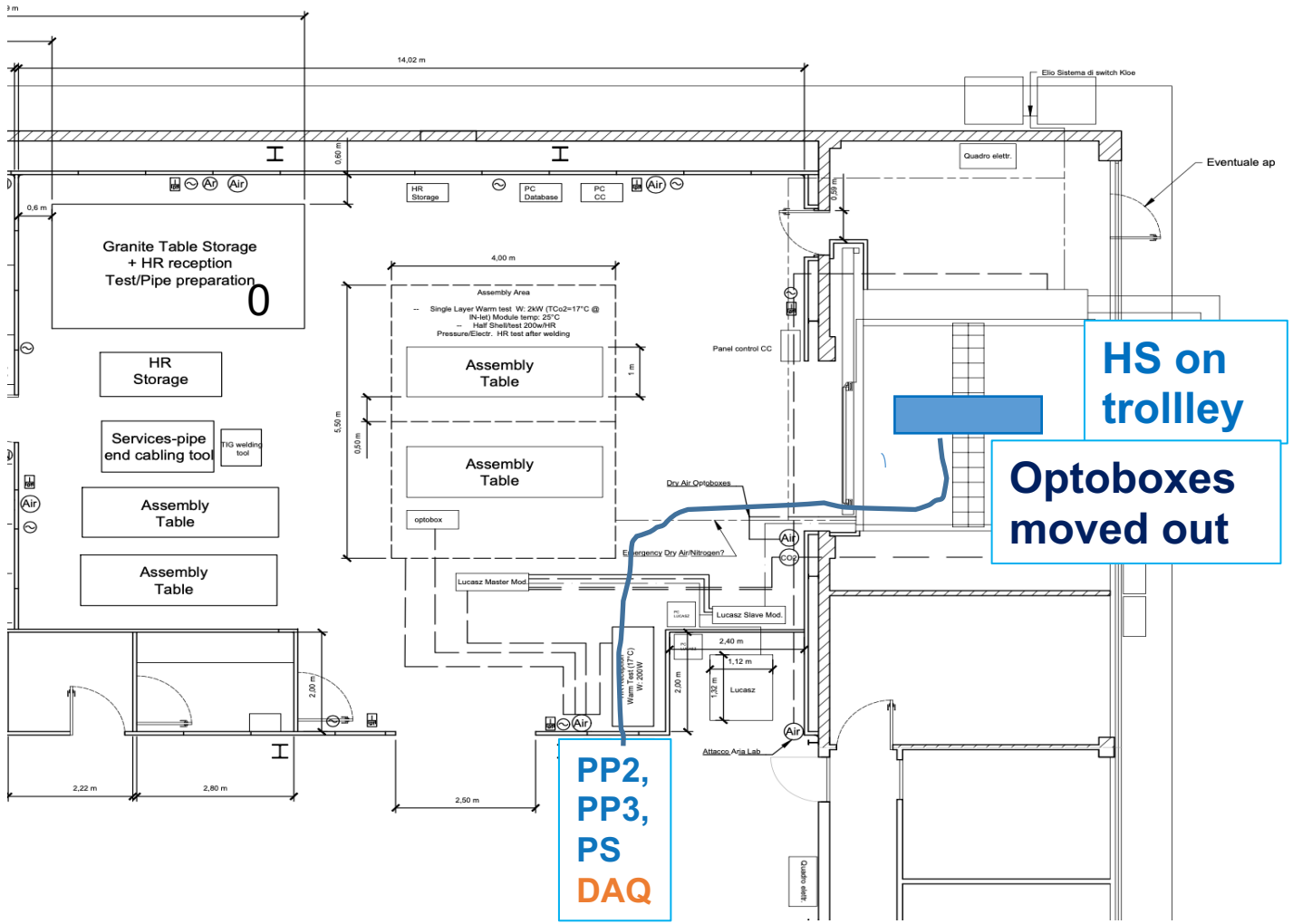
# Functional test on populated Half-Shell – pre thermal cycle



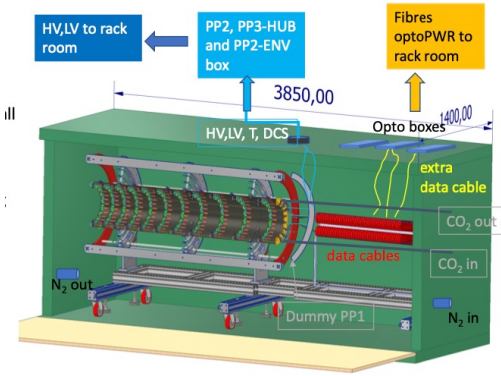

- Functional cold test with $CO_2$ at $T_{ev}$ ~ -15 C of populated HS
- DP < - 60 C
- Baseline: in Climate Chamber
  - T_CC ~ +20C a
    - Could be lower to help cooling due to limited $CO_2$ flow from the plant
    - Bonus running at low T_CC: easier to reach low DP and more precise measurement from viasala DP sensor
- All the services are connected up to $PP_2$ and PP3



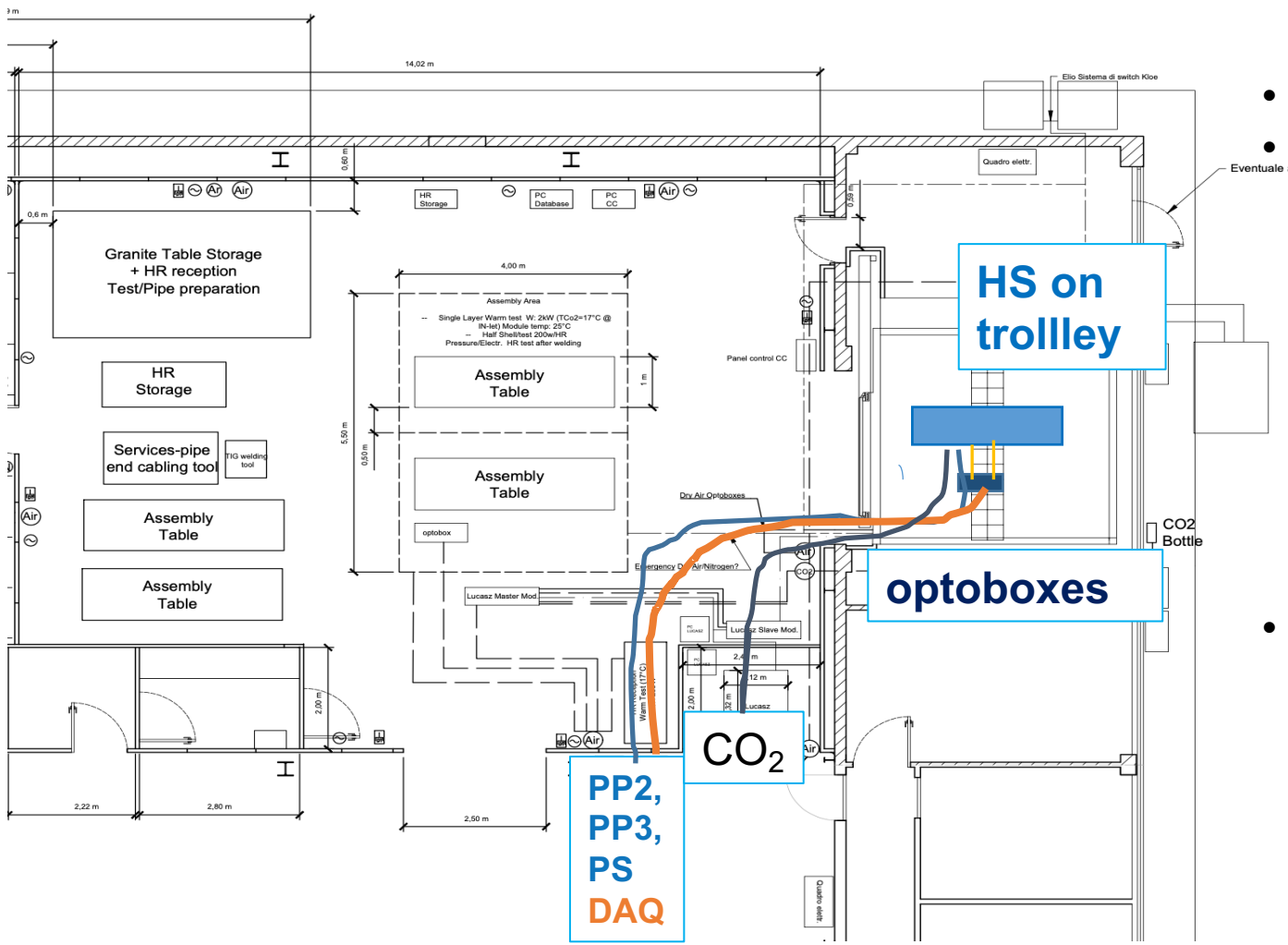
# Thermal Cycle populated Half-Shell




- Thermal cycle [+40 – 45C ] in the Climate Chamber with detector **off**
- DCS (box sensors) on
- Interlock (box sensors) on
- DP < -60 C
- Optoboard out



# Functional test on populated Half-Shell – post thermal cycle

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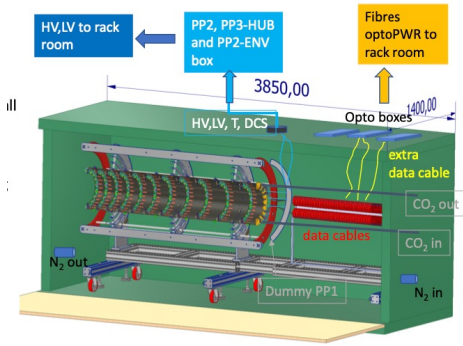


# Equipment

Full equipment for EC integration in ITkPixelIntegration-ElectrialEquipment-v10_docx_cpdf.pdf

*Table 2: Table of testing steps for one half-shell of layers 2, 3 and 4 of one EC.*

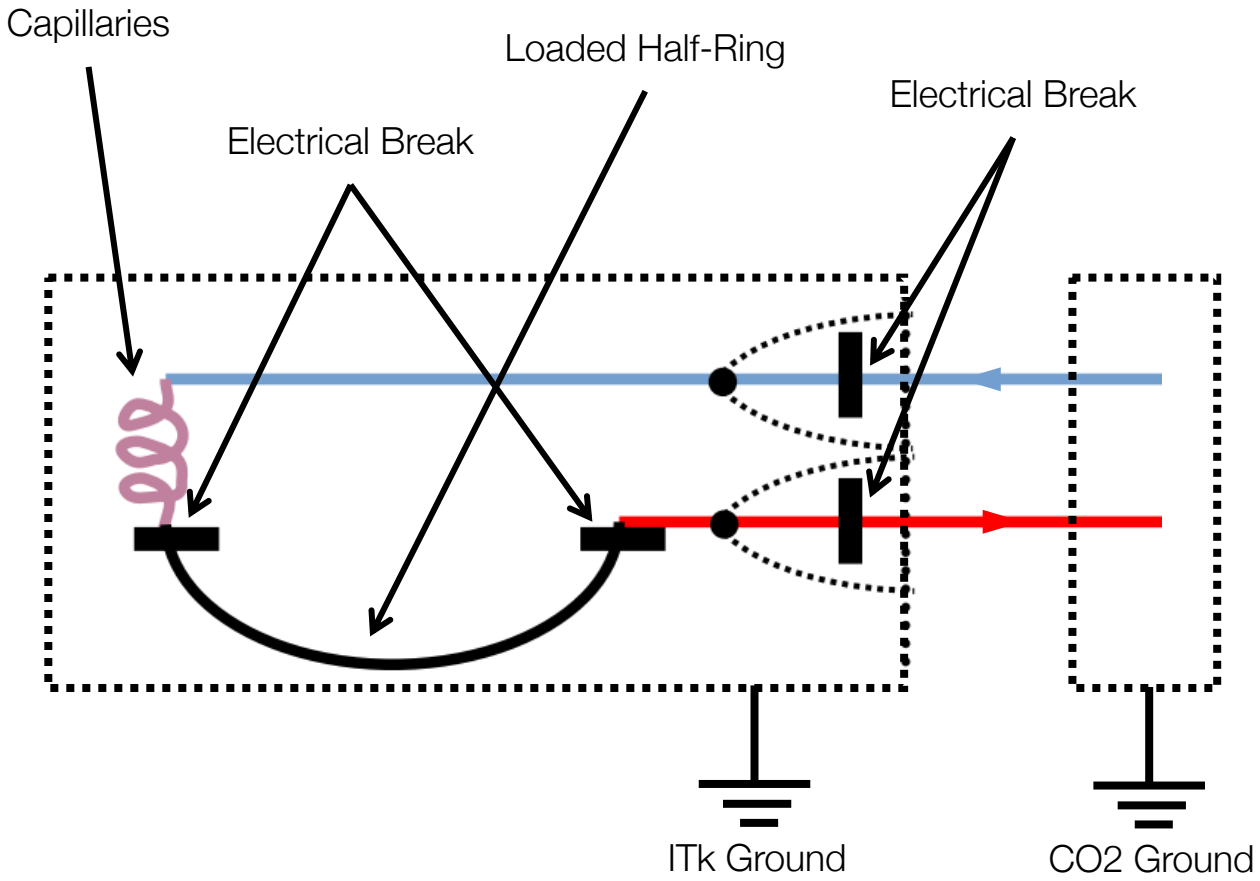
| Test step | Detector Tested Section | Number of Serial Power Chains | Number Data (Up/Down) Links |
|---|---|---|---|
| 1/6 | 5 HR L2 (0.5 link/FE) left/right | 10 | 160/80 |
| 2/7 | 6 HR L2 (1 link/FE) left/right | 12 | 384/96 |
| 3/8 | 8 HR L3 (0.5 link/FE) left/right | 16 | 352/176 |
| 4/9 | 4 HR L4 (0.25 link/FE) left/right | 8 | 104/104 |
| 5/10 | 5 HR L4 (0.5 link/FE) left/right | 10 | 182/130 |

The largest testing step and thus required equipment is step 3.

- 4 PP1 connector,  4 type-2 cables,
- 1 Env-terminal PP1 connector (2 wire T-sensor), 1 Extra Env PP1 connector, 2 Env. Type-2 cable
- 2(4) LV(HV) PSU
- 32 twinax bundles, 3 trunk fibers
- …

# Functional test on populated HS:  G&S. Cooling scheme

- When  testing with CO2 , proper G&S scheme should be adopted



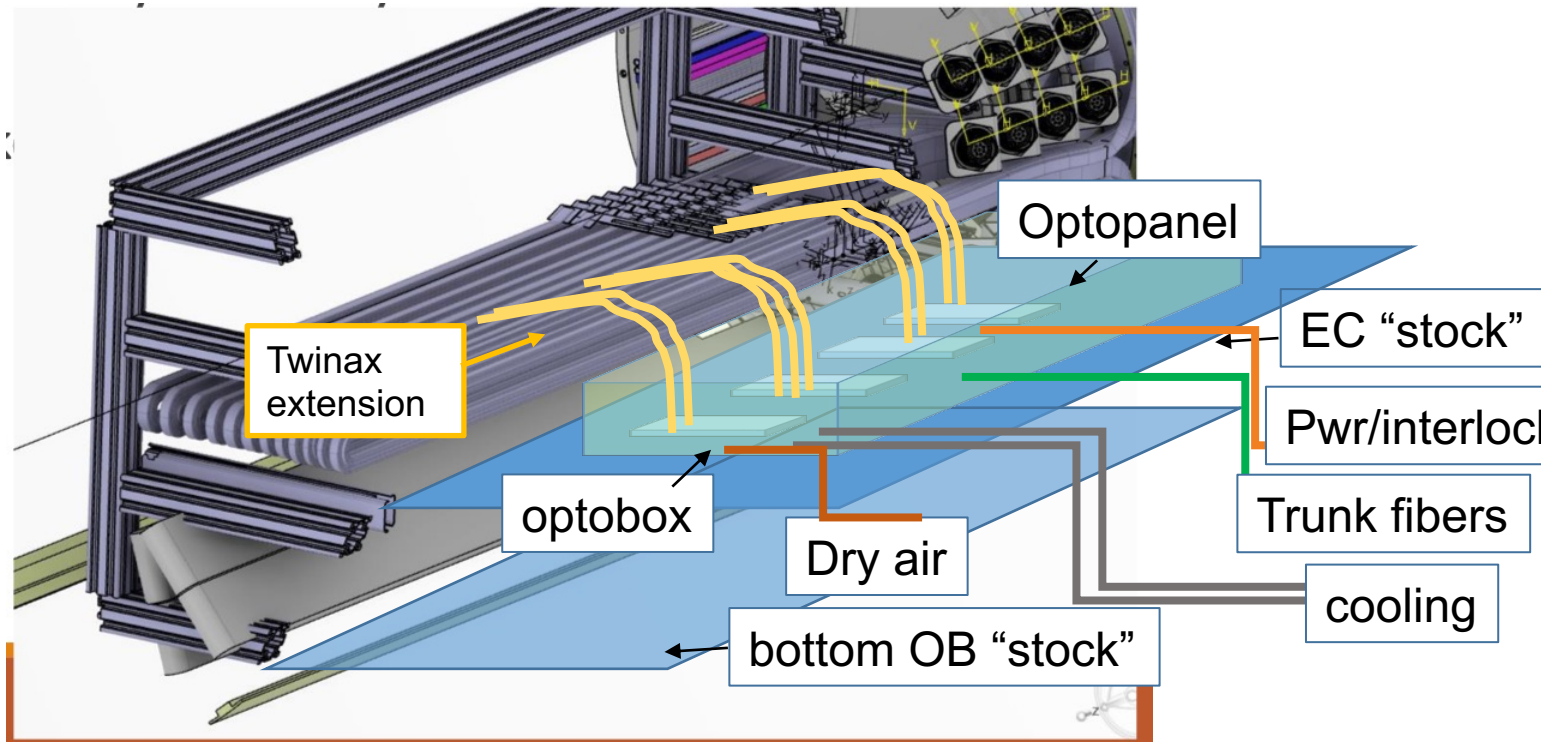

From Slice Test in SR1

- Need EB between cooling transfer lines from lucasz plant and on-detector cooling pipes to reduce noise fr

Details in Leonardo's slide

# Trolley for Optopanel during integration / surface tests

O.Shea, S. Eisenhardt, E. Vigeolas




- Conceptual sketch; not in scale

- Extenal inputs needed. Design of
  - optopanel and holding structures for data extension
  - Termination boards position and holding structures for data extension on trolley

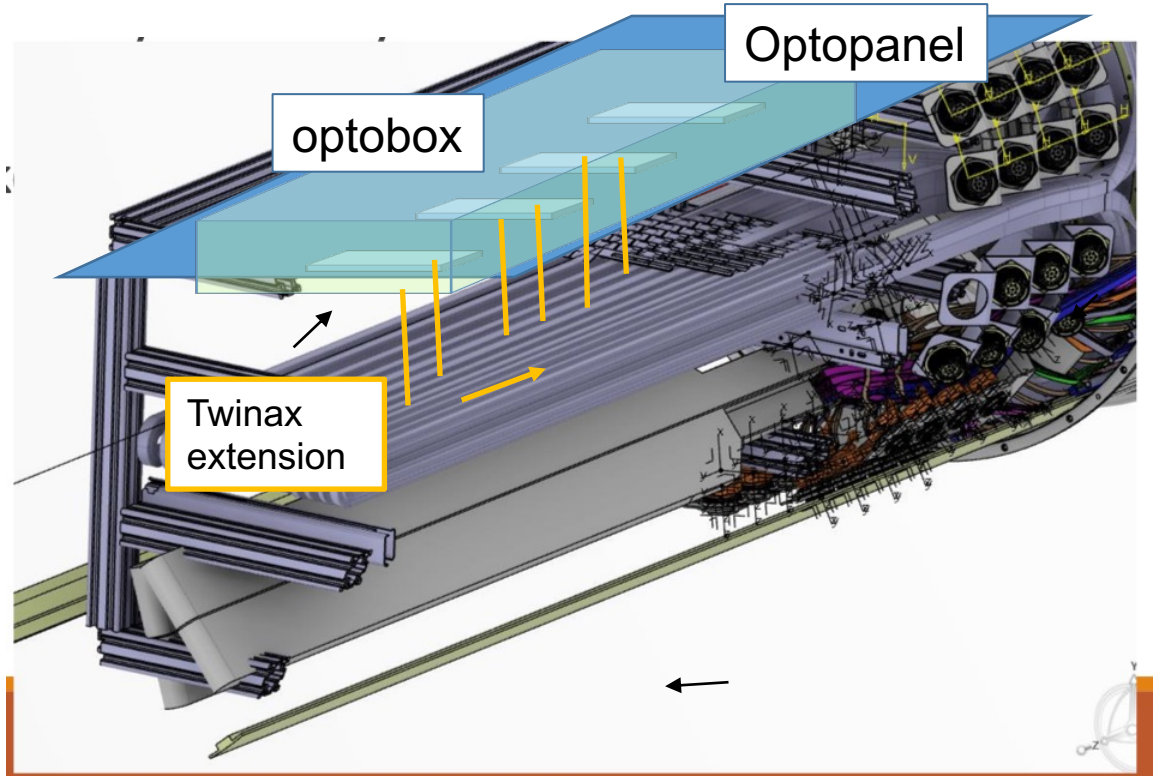
- As close as possible to the termination boards
  - twinax extension will be ~ 2m long, TBC if more.
- Baseline geometry
  - 4 Ooptoboards s in one row
- Movable
  - away during EC thermal cycyle
- Both for individual test of EC,OB and combined test

- Optoboxes should be (de)mountable
  - Normal and Mirrored type
- Preferably Inside the test box
  - less feedthroughs for trunk cable wrt twinax extensions

→ Dimension of test box large enough

# Trolley for Optopanel during EC testing

O.Shea, S. Eisenhardt, E. Vigeolas




Equipment:
4(3) Type M(N) optoboxes , 4 type-2 Opto-MoPS cable, 7 type-2 Vopto cable, 3 trunk fibers,…
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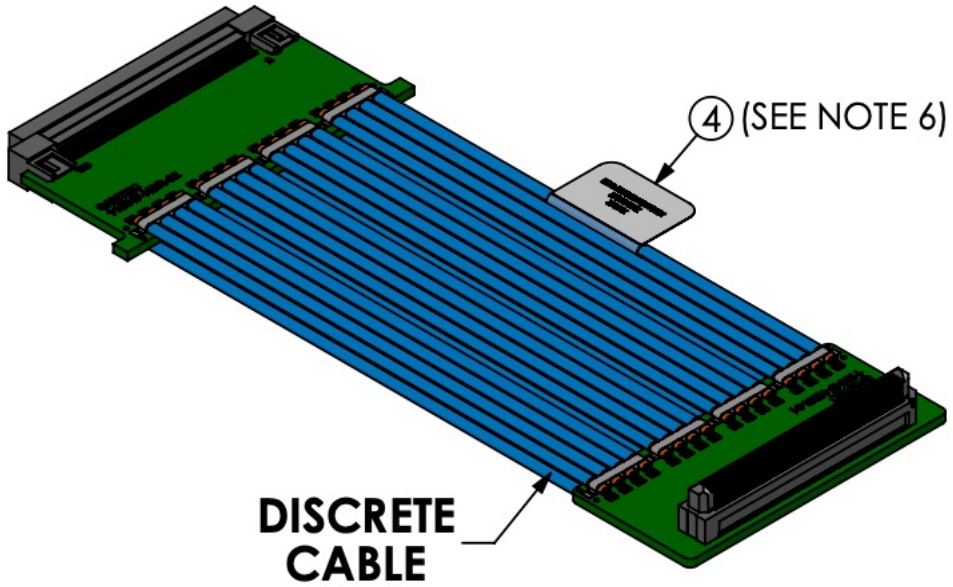
- For EC to save space in the test box, possible to place the optopanel in the envelope for OB services
- We will get 4(3) Type M(N) optoboxes
- Possible to keep always Type M optoboxes if reconfigured software-wise for the test of different detector region
- G&S:
  - Finale System: shield around the twinax bundles to extended the faraday cage to optopanel
  - In integration side:
    - Optopanel in contact with the service trolley which has the ITk ground

# Data extender prototypes

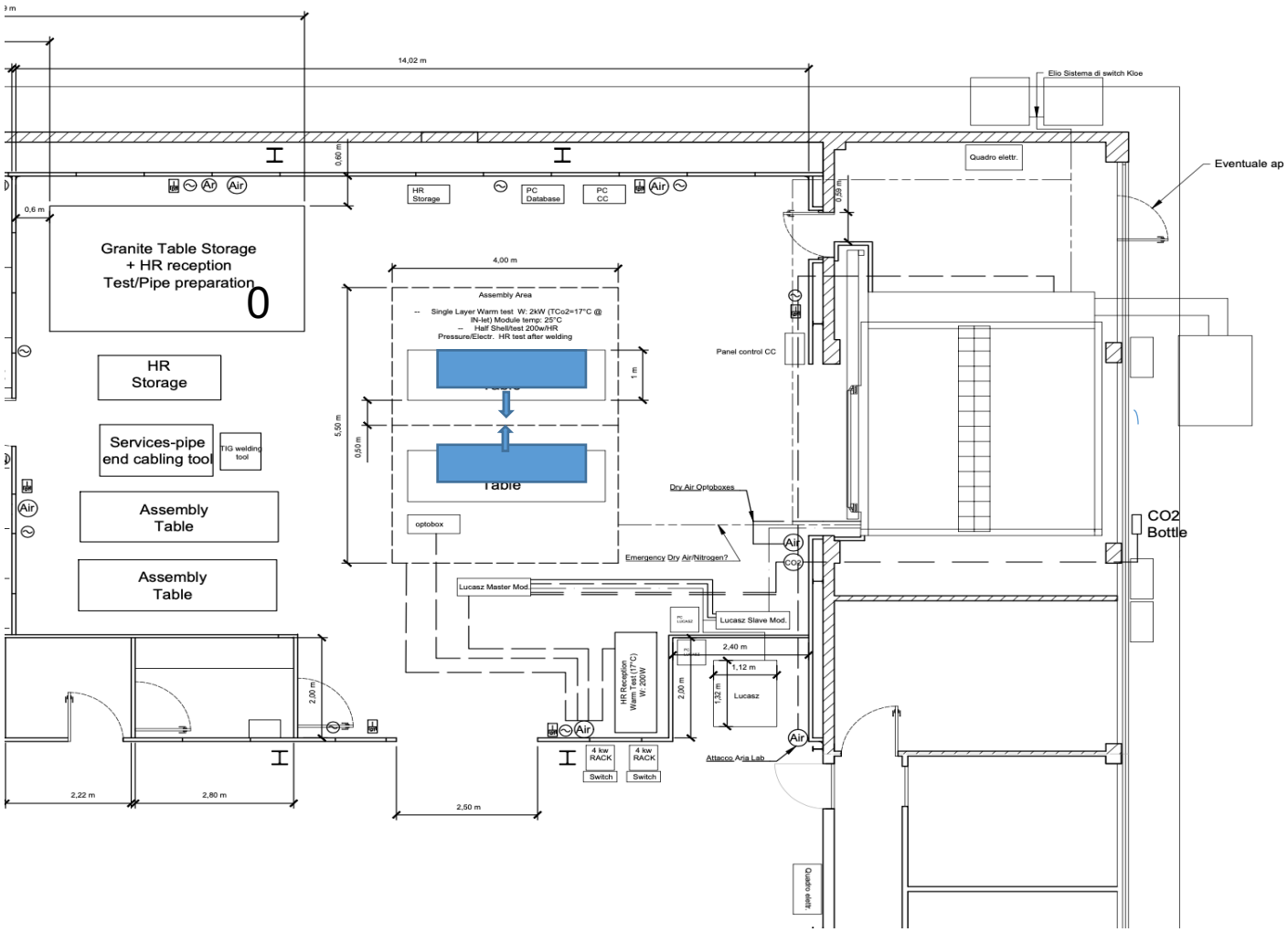
P.Albicocco

- Ordered 6x data extender prototypes for electrical test
  - 3x 2m, 3x 3m
- Prototypes expected in ~2months

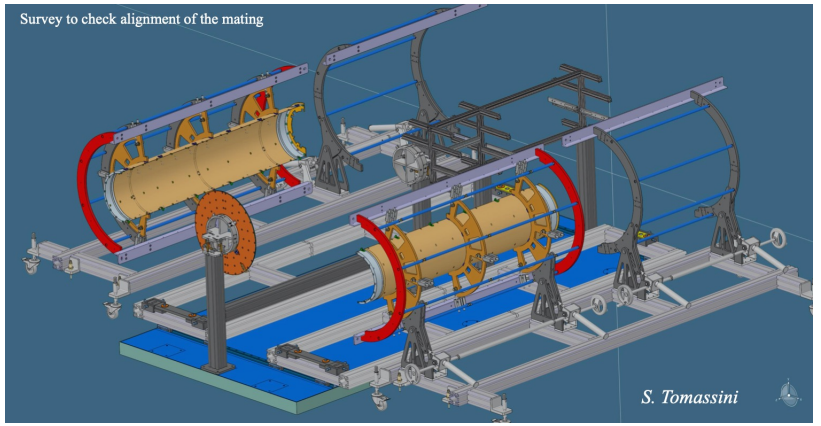



- Mechanical aspects are still to be evaluated:
  - the definition of the termination boards position and orientation on trolley are not available

# Mating of Half-shell

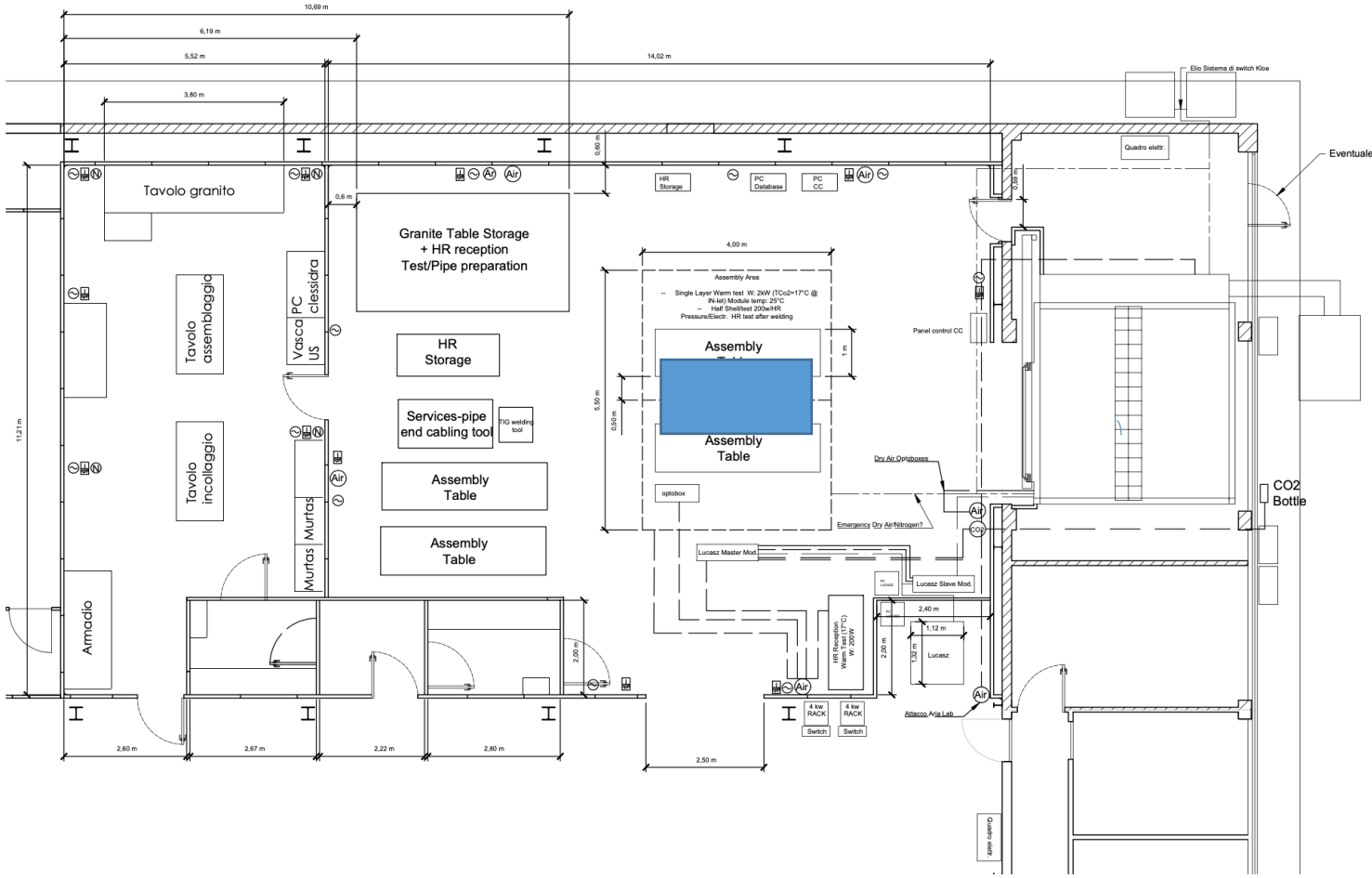



- Move the trolley in mating area
- Redo operation for the twin HS
- Mating couple of half-shells to form a layer
- Check alignimenti with laser track



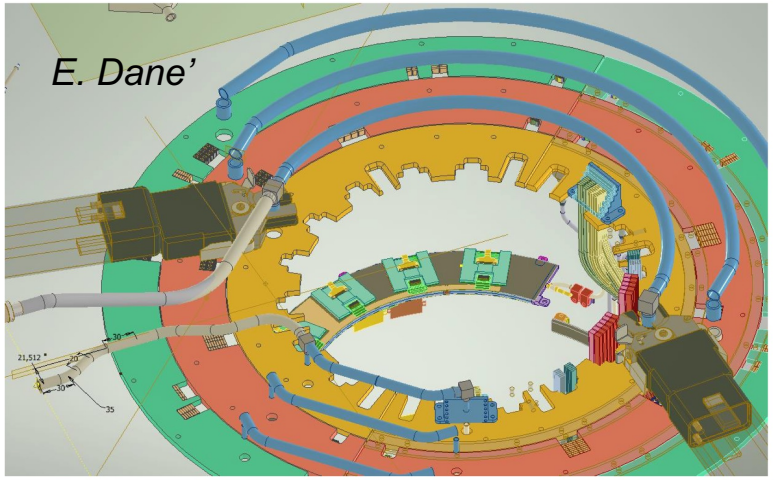

**Now the struture is almost closed**
**( small holes on low Z flange )**
**Convection cooling not enough**

# Complete layer ready




- Move trolley in the mating area
- Weld the manifolds of the individial HS here
- Leak test
- Pressure test 162 bar
- Leak test

**TBD**: connectivitt tests before or after (preferred) welding welding of manifolds?

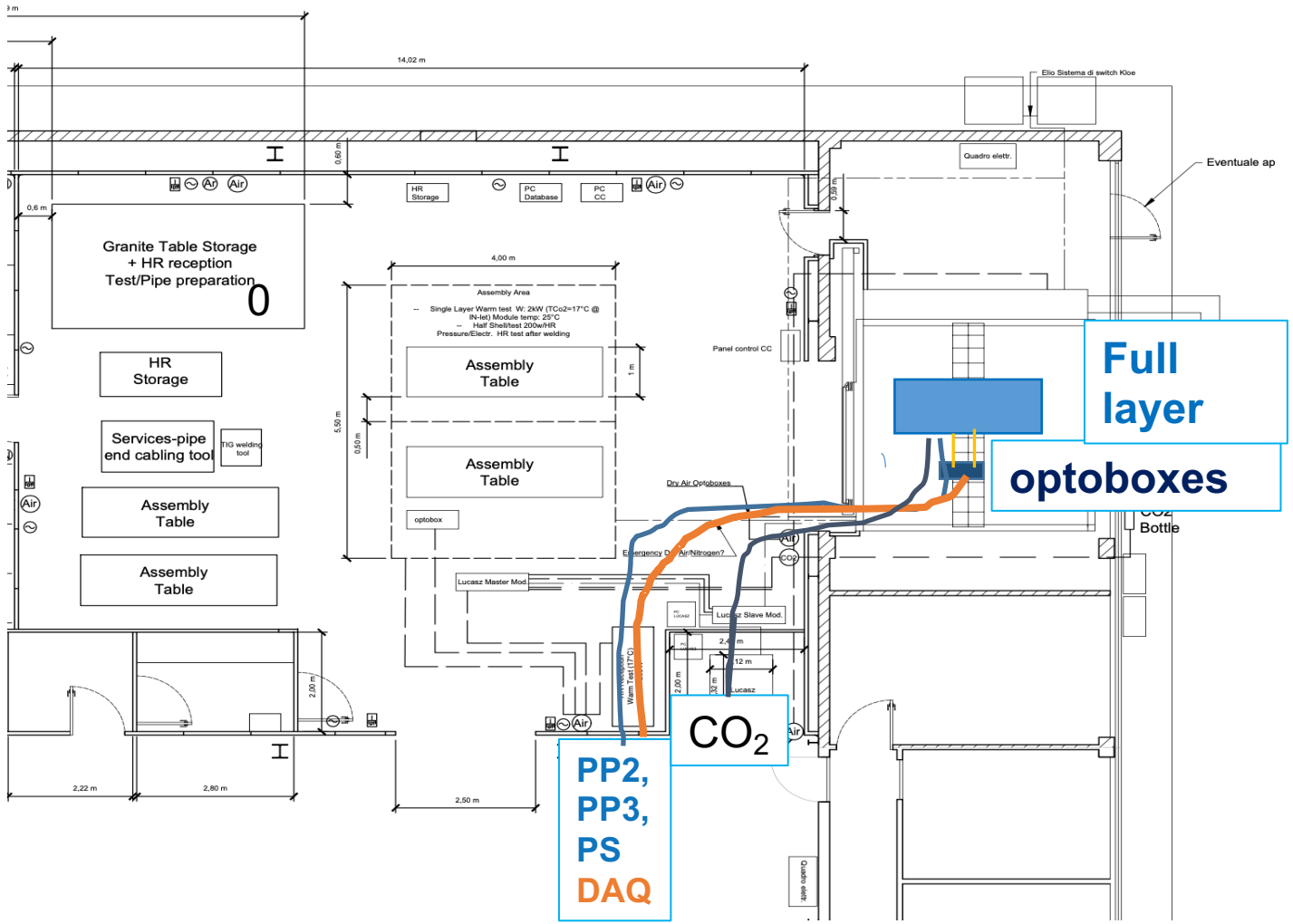


# Connectivity test on complete layer

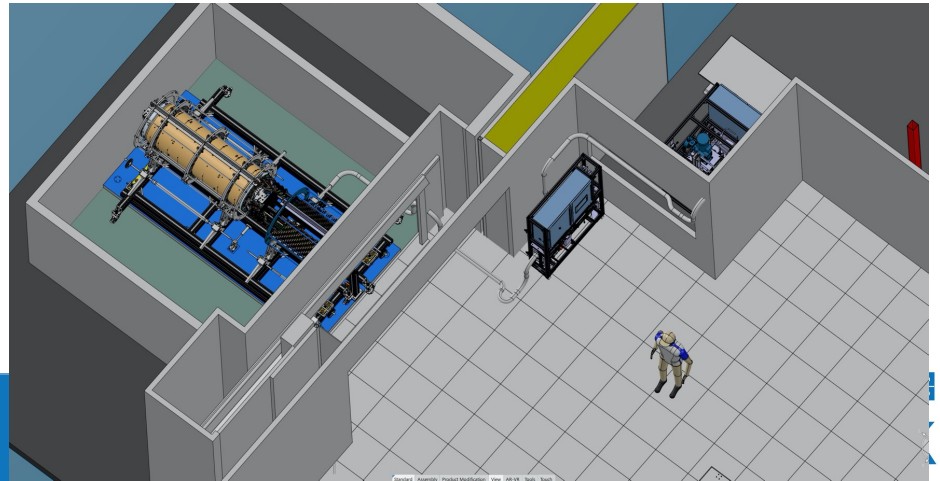
# Connectivity test on completed layers

| Previous Step: tests on HS | To be tested | How? |
|---|---|---|
| • Overall connectivity at low T pre and after thermal cycle on individual HS<br>• $CO_2$ Cooling | Connectivity of complete layer after mating | **Pending:**<br>• tests before or after (preferred) welding of manifolds<br>• **Granularity** same as for individual HS<br>• **Cooling options**<br>  • Low pow mode in climate chamber<br>  • Nominal (Small) flux $CO_2$ + low power mode if manifolds are not ( are) welded<br>  • Nominal (Small) flux $CO_2$ + low power mode in climate chamber if manifolds are not ( are) welded<br>**Test:**<br>• Short connectivity test: configure one module per SP chain all return data lines with digital scan or electrical&optical alignment |

# Connectivity test on complete layer

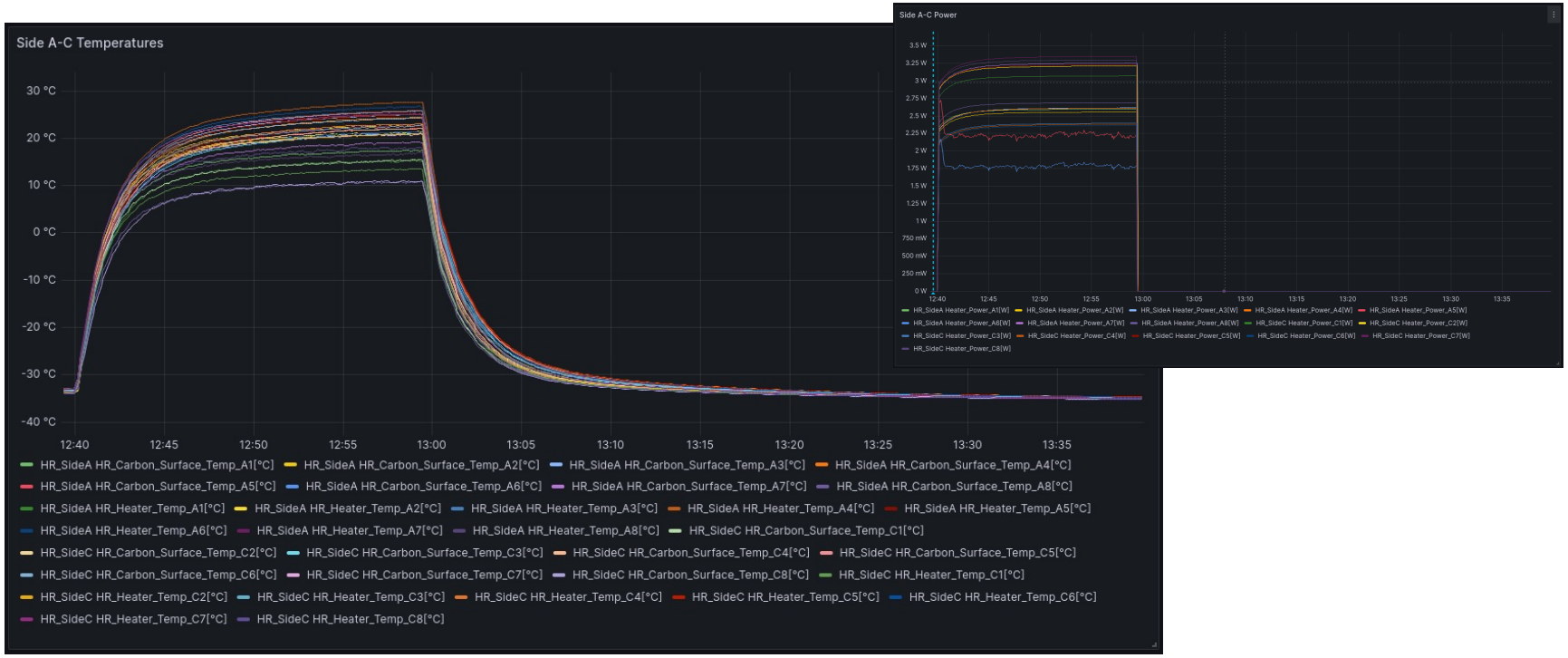



- Baseline:
  - Move the trolley with the complete layer the climate chamber
- Cooling options:
  1. with $CO_2$ at $T_{ev}$ ~ +15 C
  2. Low power mode in climate chamber
  3. Both CO2 and Low power mode
- *In both cases: temperature inside climate chamber could be lowered to help cooling*
- DP < -60 C if $CO_2$ running
- Bonus running at low T_CC:
  easier to reach low DP and more precise measurement from viasala DP sensor



# Test on Thermal HR in small climate chamber

- Preliminary, work in progress
- Rough enclosure to emulate low air conduction regime







Further tests will come with $CO_2$ flux (*) and correlation with environment T

(*) Thanks to Ian, Jo, Alex,Paki for providing us the Fred-fittings!

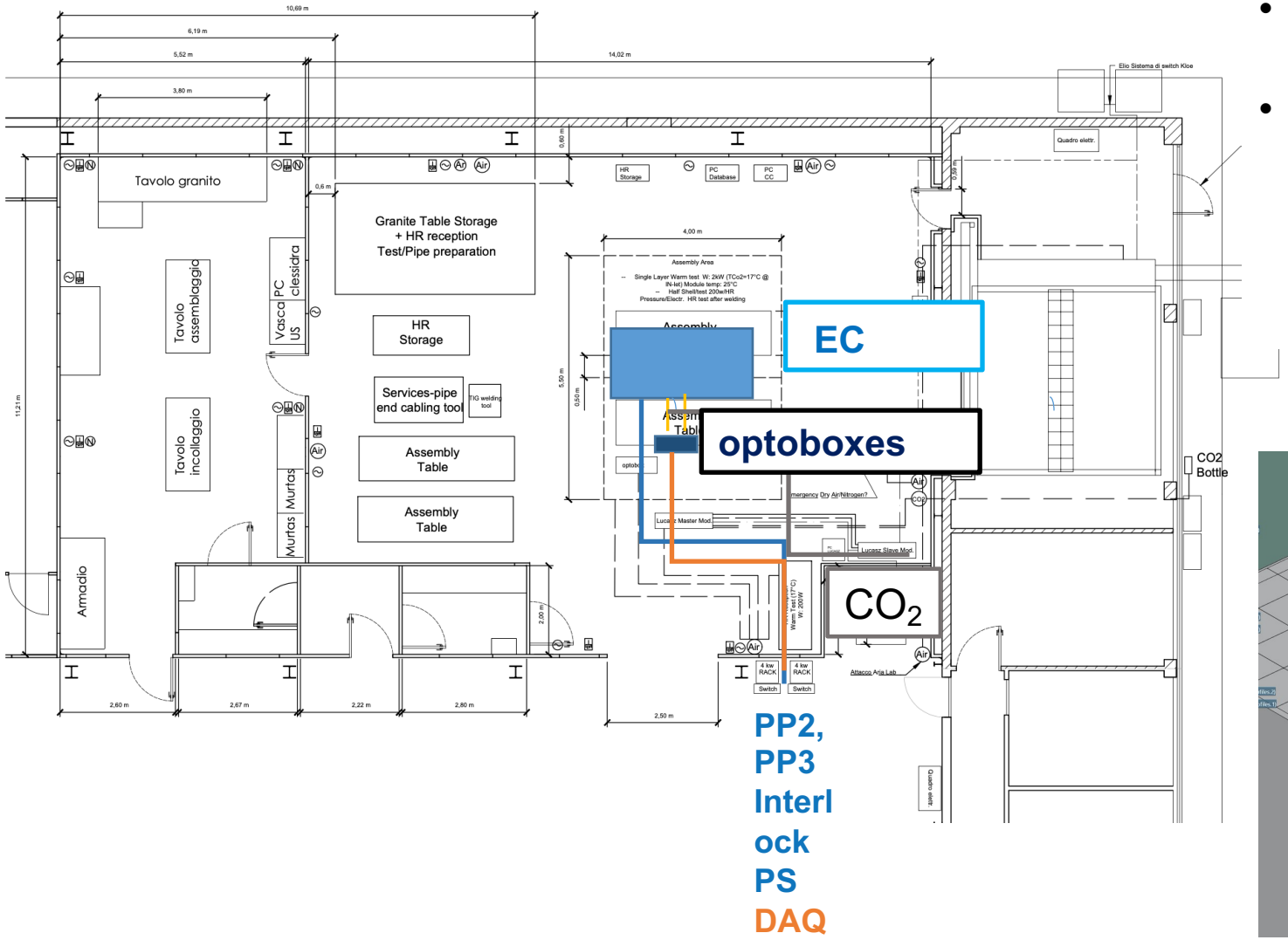
Z. Chubinidze, B. Buadze

# Connectivity test on complete endcap

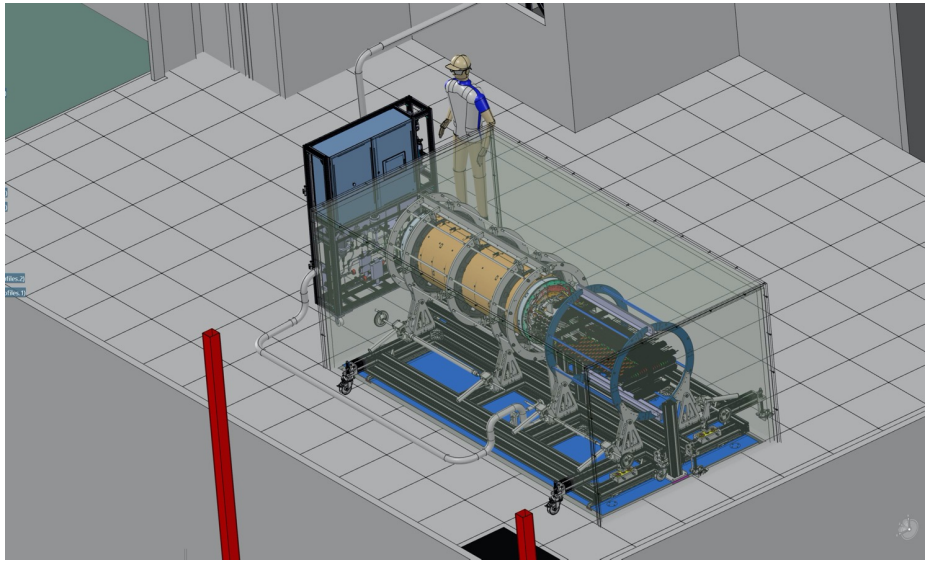
# Connecivity  test on complete endcap

| Already checked in previous steps | To be tested | How |
|---|---|---|
| | | |
| Overall connectivity<br>• For HS at low T $CO_2$<br>• For completed layer at high T $CO_2$ and/or LP mode | • Full endcap connectivity<br>• Final Comissioning Test<br>• Reference for SR1 post-shipment test | **Granularity** same as for individual HS<br><br>**Where**: TBD in shipping box or climate chamber<br><br>**Cooling options**<br>• Low pow mode in climate chamber<br>• Small flux $CO_2$ + low power mode<br>• Small flux $CO_2$ + low power mode in climate chamber<br><br>**Test:**<br>• Short connectivity test: configure one module per SP chain all return data lines with digital scan or electrical&optical alignment |

# Completed Endcap




- All mainfolds are welded →CO2 flux reduced by 2
- Final reference warm test to be compareted with reception test at SR1
- **Cooling Options**
  - Low pow mode in climate chamber
  - Small flux $CO_2$ + low power mode
  - Small flux $CO_2$ + low power mode in climate chamber



# Reception Test at SR1

- Same Testing step and
- Same Equipment used in Integration site

ITkPixelIntegration-ElectrialEquipment-v10_docx_cpdf.pdf

*Table 2: Table of testing steps for one half-shell of layers 2, 3 and 4 of one EC.*

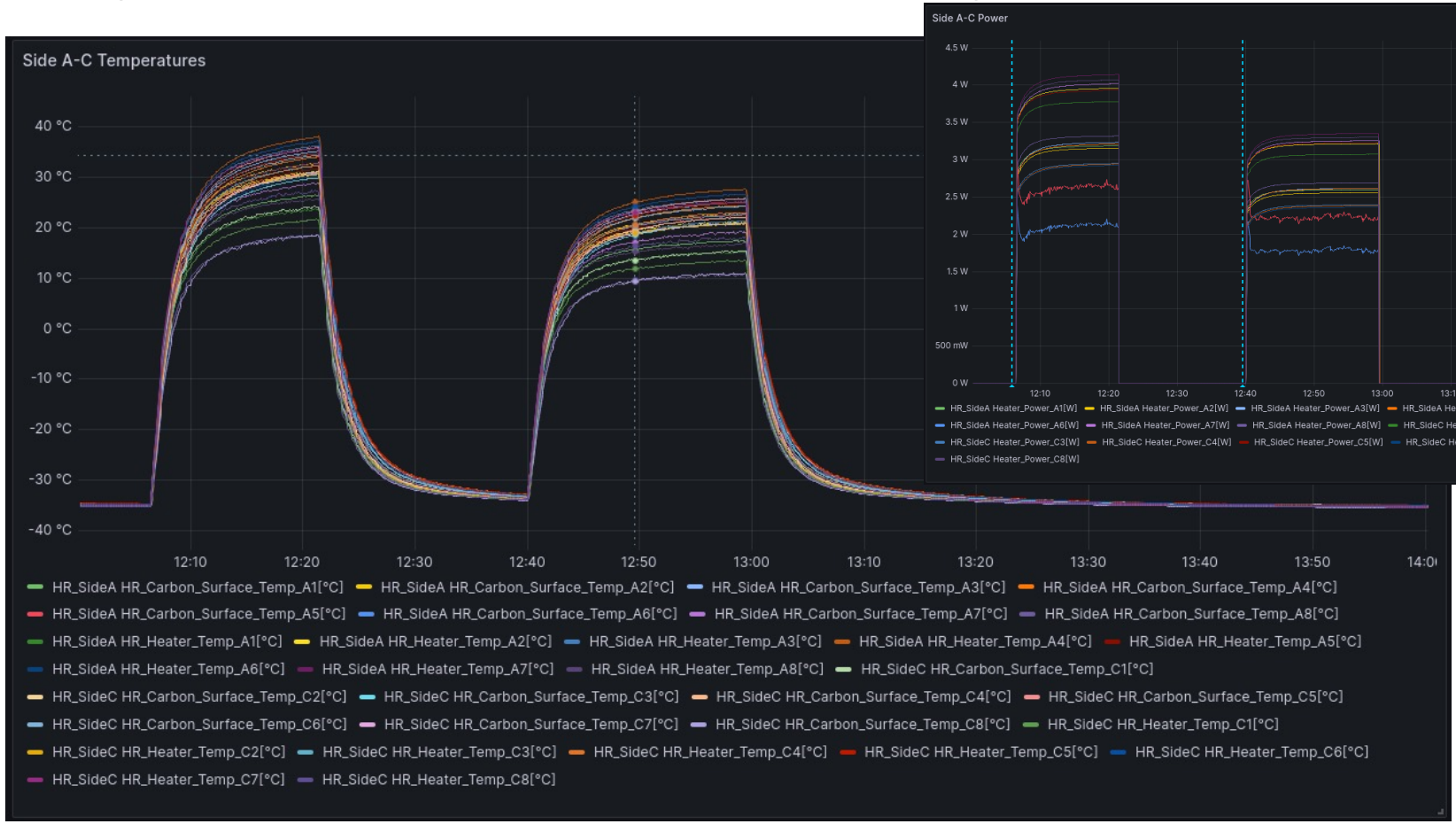
| Test step | Detector Tested Section | Number of Serial Power Chains | Number Data (Up/Down) Links |
|---|---|---|---|
| 1/6 | 5 HR L2 (0.5 link/FE) left/right | 10 | 160/80 |
| 2/7 | 6 HR L2 (1 link/FE) left/right | 12 | 384/96 |
| 3/8 | 8 HR L3 (0.5 link/FE) left/right | 16 | 352/176 |
| 4/9 | 4 HR L4 (0.25 link/FE) left/right | 8 | 104/104 |
| 5/10 | 5 HR L4 (0.5 link/FE) left/right | 10 | 182/130 |

- At SR1 no cooling limitation
- We may have a test with CO2 there instead of a LP mode for the final tests in integration site

# Backup

# Test on Thermal HR in small climate chamber

- Preliminary, work in progress
- Rough enclosure to emulate low air conduction regime



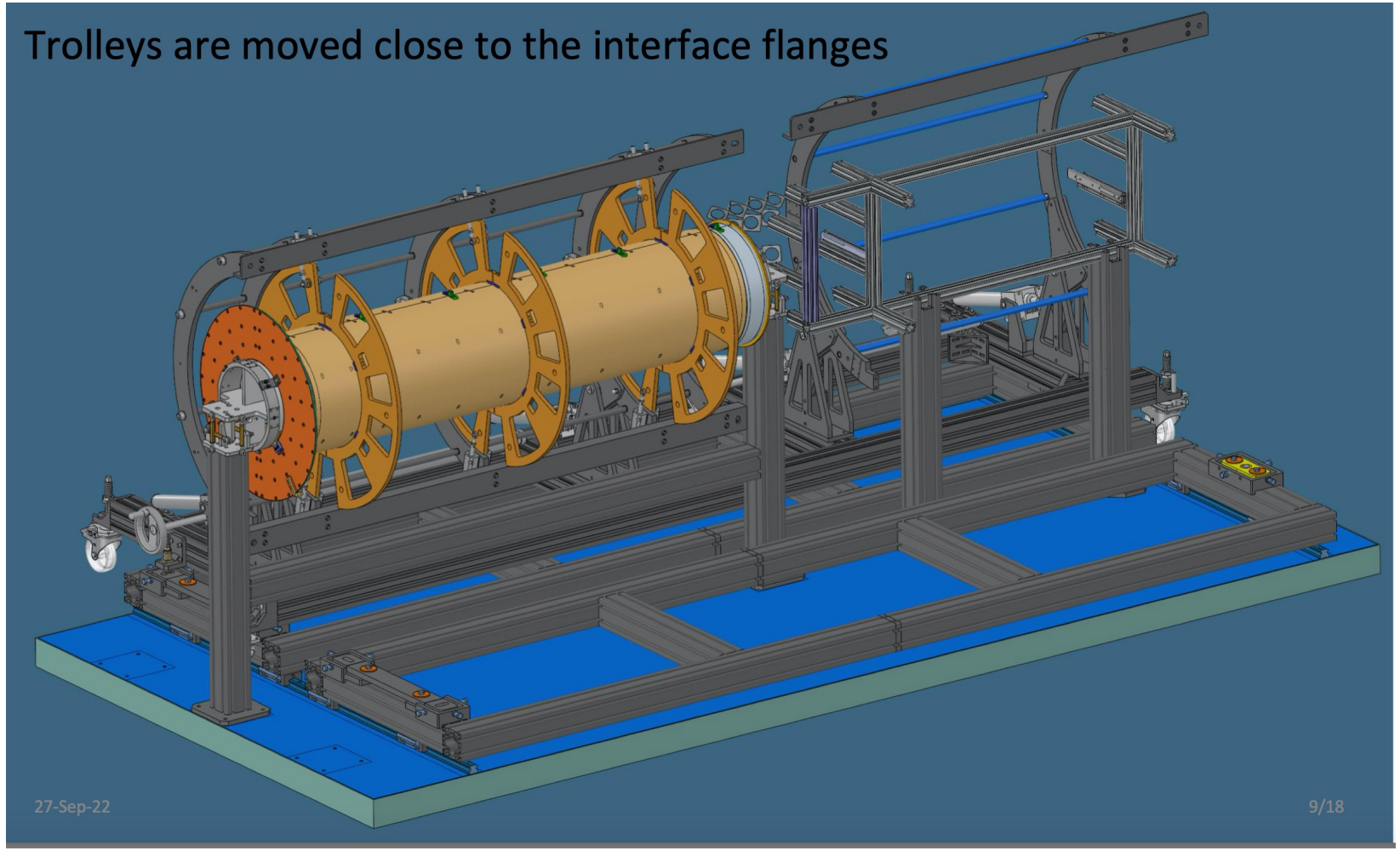




Further tests will come with CO2 flux

Z. Chubinidze, B. Buadze

# HS and tooling preparation - 4

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# HS and tooling preparation - 6

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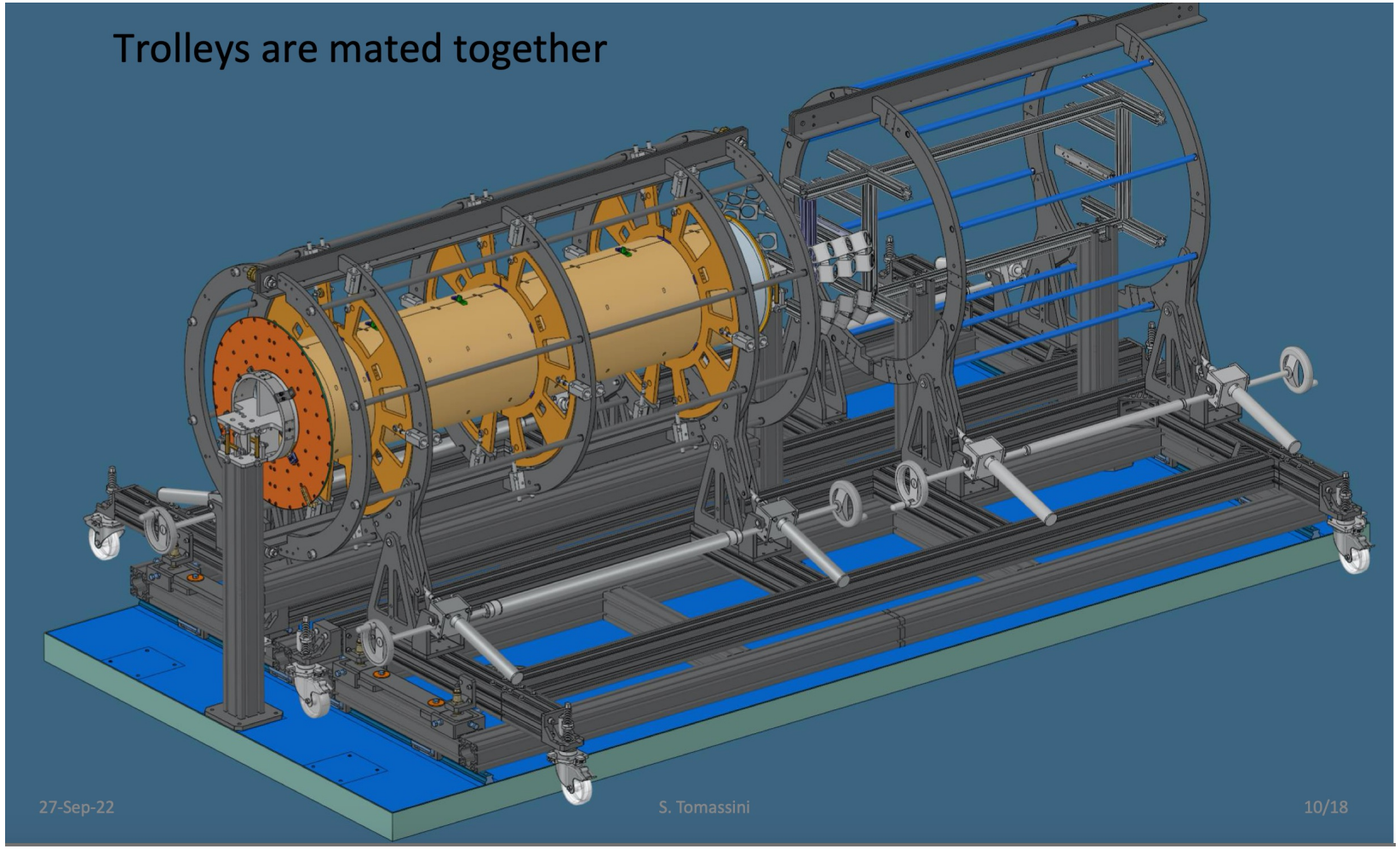
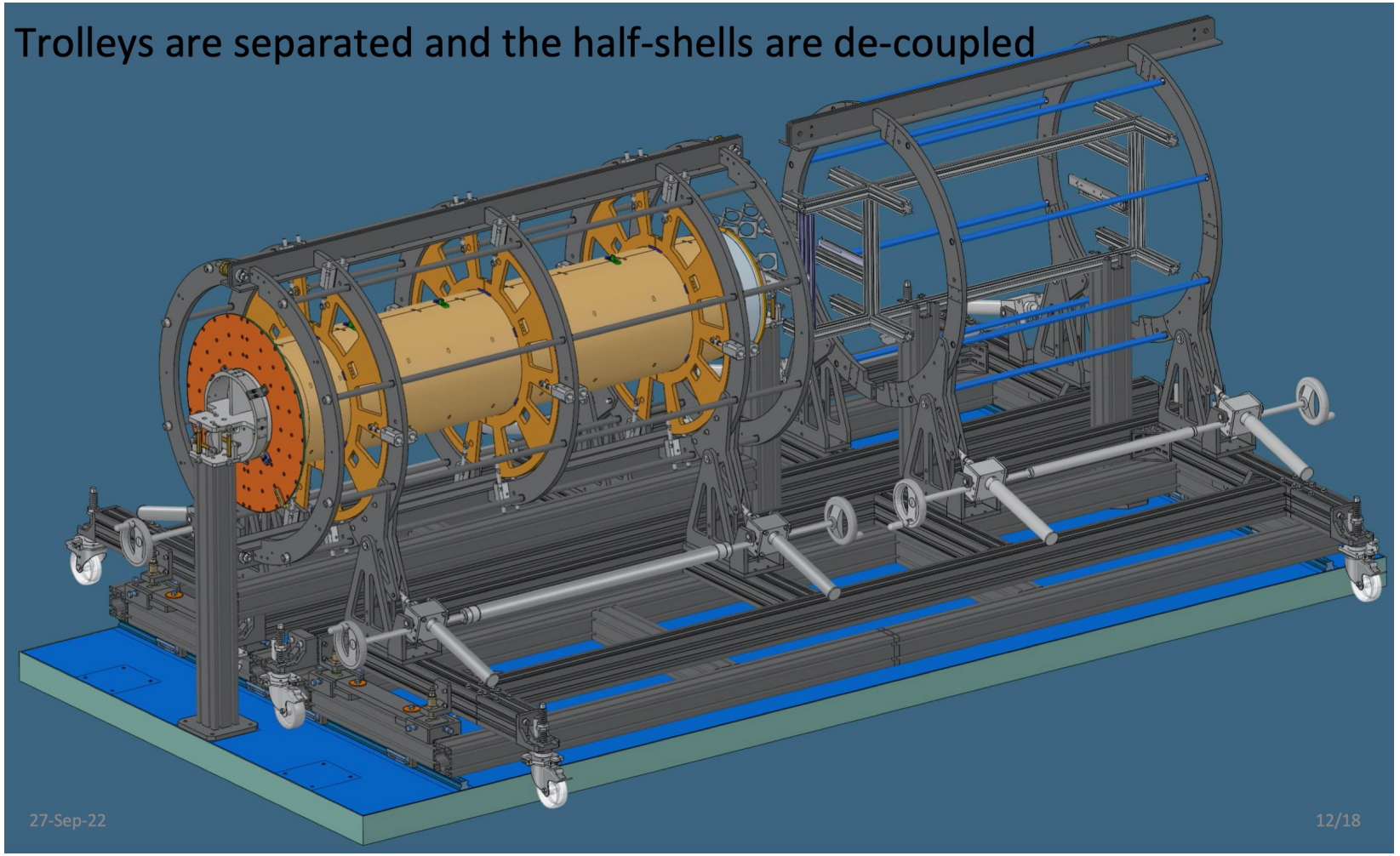


# HS and tooling preparation - 8

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# Mating of Half-shell

FARO Laser Tracker Vantage:
Measurement of the target position
(contact measurement)


## Point to Point Accuracy***


**In-Line Distance Measurement**

| | Length | 2-5m (6.6-16.4ft) | 2-10m (6.6-32.8ft) | 2-20m (6.6-65.6ft) | 2-30m (6.6-98.4ft) | 2-40m (6.6-131.2ft) | 2-60m (6.6-196.9ft) | 2-80*m (6.6-262.5ft) |
|---|---|---|---|---|---|---|---|---|
| | Distance | 3m (9.8ft) | 8m (26.2ft) | 18m (59ft) | 28m (91.9ft) | 38m (124.7ft) | 58m (190.3ft) | 78m (255.9ft) |
| ADM | MPE | 0.018mm (0.0007") | 0.022mm (0.0009") | 0.030mm (0.0012") | 0.038mm (0.0015") | 0.046mm (0.0018") | 0.062mm (0.0025") | 0.078mm (0.0031") |
| ADM | Typical | 0.009mm (0.0004") | 0.011mm (0.0004") | 0.015mm (0.0006") | 0.019mm (0.0008") | 0.023mm (0.0009") | 0.031mm (0.0012") | 0.039mm (0.0015") |

**Horizontal Scale Bar Measurement (2.3m, 7.55ft)**

| | Range | 2m (6.6ft) | 5m (16.4ft) | 10m (32.8ft) | 20m (65.6ft) | 30m (98.4ft) | 40m (131.2ft) | 60m (196.9ft) | 80*m (262.5ft) |
|---|---|---|---|---|---|---|---|---|---|
| ADM | MPE | 0.044mm (0.0017") | 0.064mm (0.0025") | 0.099mm (0.0039") | 0.170mm (0.0067") | 0.240mm (0.0095") | 0.311mm (0.0122") | 0.453mm (0.0178") | 0.594mm (0.0234") |
| ADM | Typical | 0.022mm (0.0009") | 0.032mm (0.0013") | 0.049mm (0.0019") | 0.085mm (0.0033") | 0.120mm (0.0047") | 0.156mm (0.0061") | 0.226mm (0.0089") | 0.297mm (0.0117) |

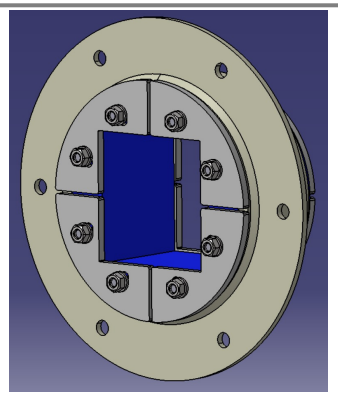
*With selected targets. **Product complies with radiation performance standards under the food, drug, and cosmetics act and international standard IEC 60825-1 2001-08. ***MPE and all accuracy specifications are calculated per ASME B89.4.19-2006. Variation in air temperature is not included. Specifications, descriptions, and technical data may be subject to change. ****With integrated weather station.
Protected by U.S. patents: 7,327,446 7,352,446 7,466,401 7,701,559 8,040,525 8,120,780

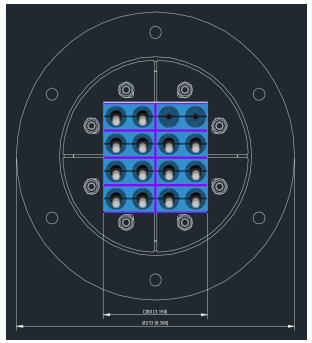
# Status of datase extenders extension

- Ordered 6x data extender prototypes for electrical test
  - 3x 2m, 3x 3m
- Prototypes expected in ~2months
- Mechanical aspects are still to be evaluated:
  - the definition of the termination boards position and orientation on trolley are not available
  - Tehcnical design and mapping in backup slides

# Feedthrough Options

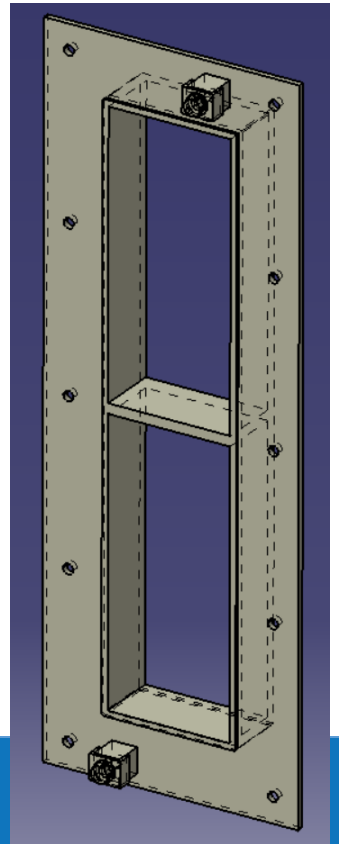
## (1)



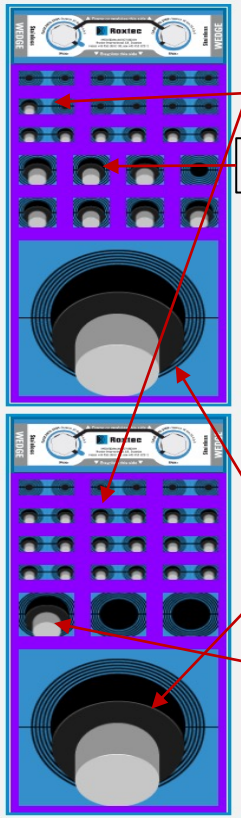


Optoboxes

- AISI316
- Packing space (mm) 80 x 80
- Aperture dimension Ø (mm) 144 - 144
- Weight (kg) 3.4



- AISI316
- Frame openings 2
- Packing space (mm) 120 x 240
- External dimensions
- WxHxD (mm) 252.5 x 698 x 93
- Aperture dimensions WxH (mm) 148(+5/-5) x 595(+5/-5)
- Weight (kg) 9.8



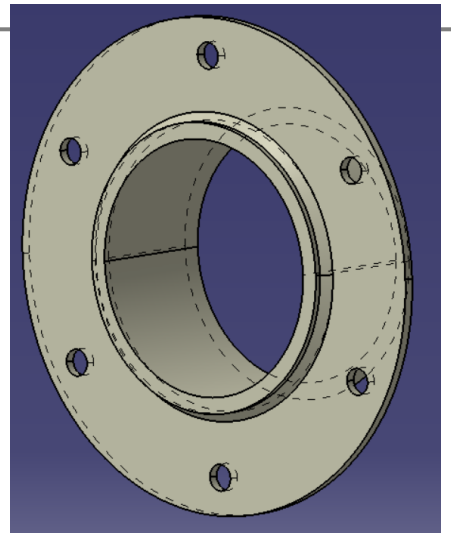
Sensors

Type II

$CO_2$

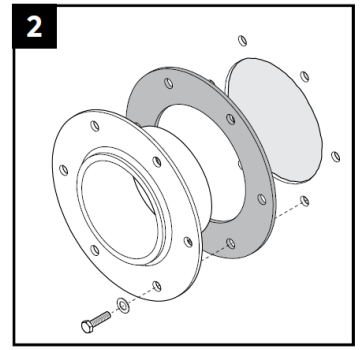
$N_2$ emergency

## (2)

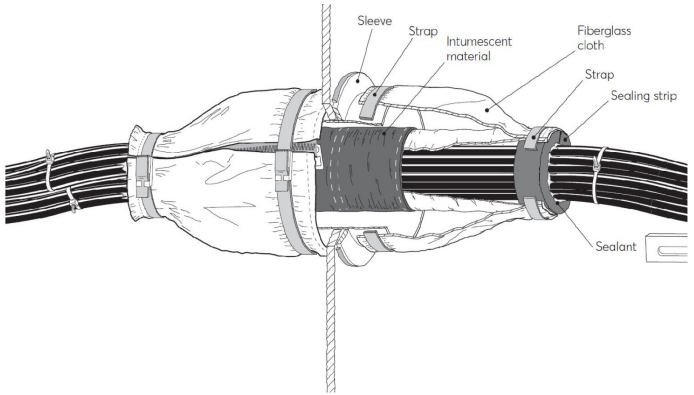


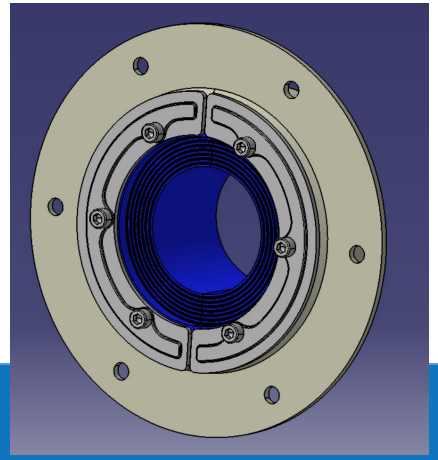
Lighter (AISI316 1.6 kg)- to be used for sensor cables, for Type II ones and for those of the optoboxes (multiplicity to be defined)

Sleeve gasket




Round sleeve with pre-punched gasket.

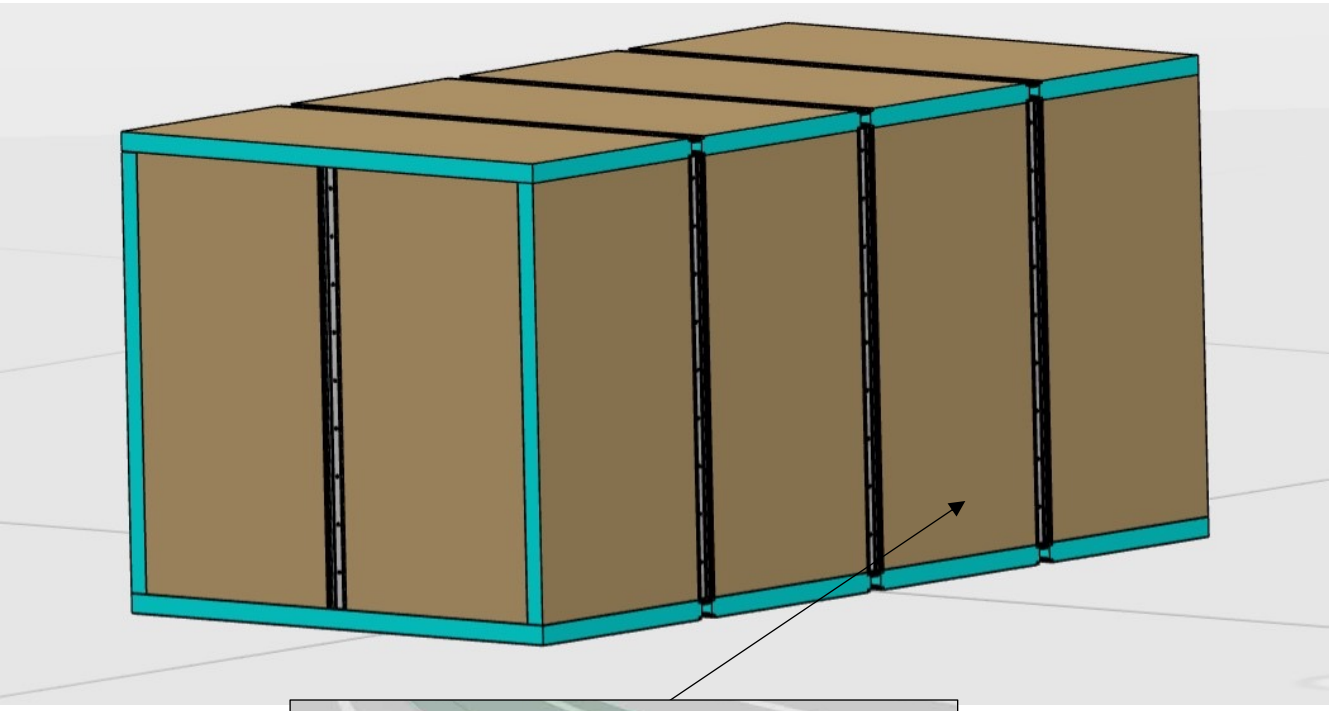


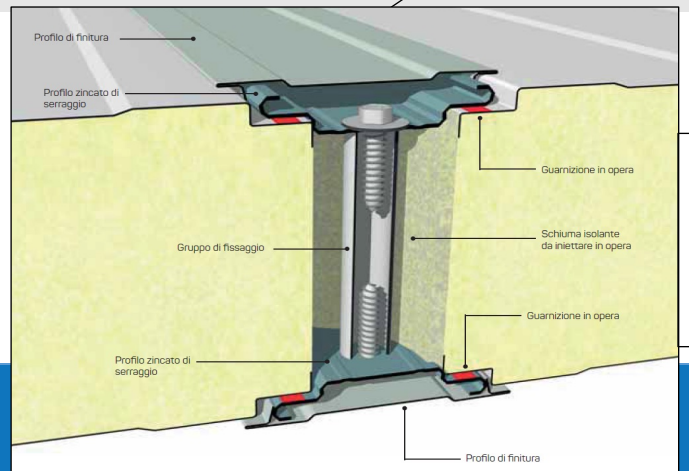



Feedthrough for single $CO_2$ line (AISI316 – Φ 66-98 mm – 3.6 kg)

# Reception Test and Transport Box

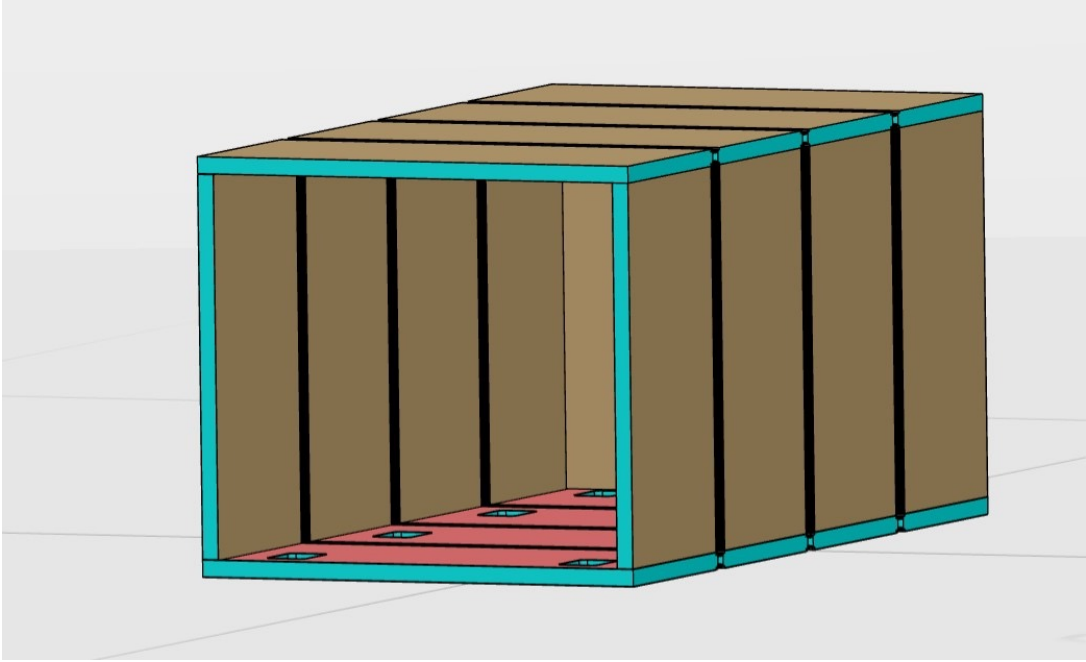
- Preliminary design: L x W x H = 4250 mm x 2200 mm x 2000 mm
- To be checked: space for optopanel trolley
- Note: The width of the door in SR1 is slightly more than 3000mm

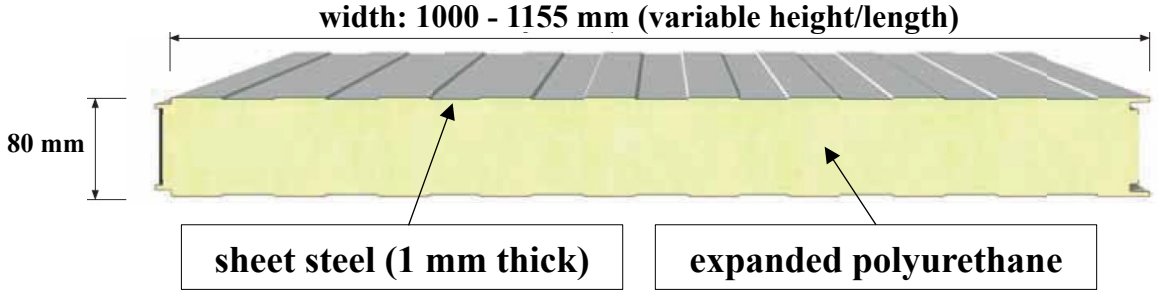





A. Croce,
G. Cesarini

Injected joint with insulating foam to be injected on site (Average Thermal Transmittance U = 0.119 W/m$^2$K)






| Nominal Panel Thickness mm | 100 | 120 | 150 | 200 |
|---|---|---|---|---|
| Thermal Transmittance U (W/m$^2$K) | 0.22 | 0.18 | 0.15 | 0.11 |
| Annex A.10 of the European standard EN 14509 | | | | |

# Test of pwr bundles on trolley

| | | | | | | |
|---|---|---|---|---|---|---|
| 4) harness dressing on EC/trolley jig: | | | | | | |
| | routing & fixation on loom: | | | | | |
| | | mounting of EoS connectors | | | | |
| | | cable routing within EC, with CTE expansion loops | | | | |
| | | cable routing around EC endflange | | | | |
| | | cable looming between endflange and PP1 (to remain after assembly) | | | | |
| | | cable routing towards trolley & storage/coiling of excess cabling | | | | |
| | | PP1 connector mounting/adjustment (in extended trolley position) | | | | |
| | test of transition of trolley configuration between expanded and retracted position | | | | | |
| 5) post dressing QC testing: | | | | | | |
| | connection of non-data cables (both sides) | | | | | |
| | non-data cable harness connectivity test (LV) | | | | | |
| | disconnection of non-data cables (both sides) | | | | | |
| | analysis / QC decision & documentation non-data cables | | | | | |

Stolen from S. Eisenhardt harnesses timeline

# Test of env. bundles on trolley

Stolen from S. Eisenhardt harnesses timeline

| | | | | | |
|---|---|---|---|---|---|
| 4) harness dressing on EC/trolley jig: | | | | | |
| | routing & fixation on loom: | | | | |
| | | mounting of volume T-sensors (2-wire) | | | |
| | | cable routing within EC, with CTE expansion loops | | | |
| | | cable routing around EC endflange | | | |
| | | (transport compatible) mounting of cooling loop T-sensors (2-wire) | | | |
| | | cable routing within EC, with CTE expansion loops | | | |
| | | cable routing around EC endflange | | | |
| | | (transport compatible) mounting of manifold T-sensors (2-wire & 4-wire) | | | |
| | | cable routing around EC endflange | | | |
| | | cable looming between endflange and PP1 (to remain after assembly) | | | |
| | | cable routing towards trolley & storage/coiling of excess cabling | | | |
| | | PP1 connector mounting/adjustment (in extended trolley position) | | | |
| | test of transition of trolley configuration between expanded and retracted position | | | | |
| 5) post dressing QC testing: | | | | | |
| | connection of env cables (PP1 side) | | | | |
| | non-data cable harness connectivity test (LV) | | | | |
| | disconnection of env cables (PP1 side) | | | | |
| | analysis / QC decision & documentation env cables | | | | |

Cooling temperature and environmental sensors are installed. Electrical connectivity tests will be made to ensure that those sensors and their associated cabling are free from damage. Localized heat input / ‘cold-spray’ will be used to make sure the sensors respond appropriately (need to understand how best to check humidity sensors).

# Test of data bundles on trolley

| | | | | | | |
|---|---|---|---|---|---|---|
| 4) harness dressing on EC/trolley jig: | | | | | | |
| | routing & fixation on loom: | | | | | |
| | | mounting of data pigtail connectors | | | | |
| | | cable routing withing EC, with CTE expansion loops | | | | |
| | | cable routing around EC endflange | | | | |
| | | cable looming between endflange and PP1 (to remain after assembly) | | | | |
| | | cable routing towards trolley & storage/coiling of excess cabling | | | | |
| | | optoboard adaptor mounting/adjustment (in extended trolley position) | | | | |
| | test of transition of trolley configuration between expanded and retracted position | | | | | |
| 5) post dressing QC testing: | | | | | | |
| | connection of data cables (both sides) | | | | | |
| | data cable harness connectivity test (CON) | | | | | |
| | disconnection of data cables (both sides) | | | | | |
| | analysis / QC decision & documentation data cables | | | | | |

Stolen from S. Eisenhardt harnesses timeline

# Infrastructures at LNF for EC Integration

Dryer -70C dew point

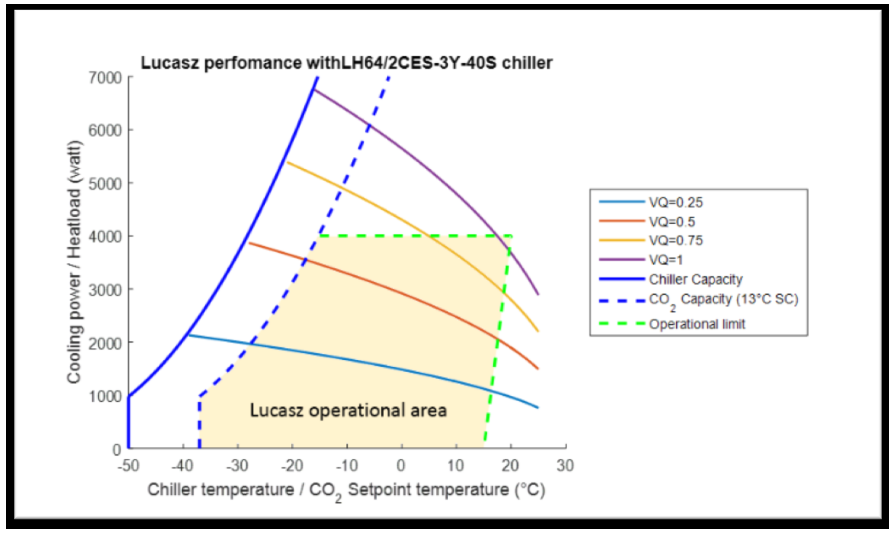
Climate Chamber functional
To do: Need feedthough for cables and $CO_2$ lines

$CO_2$ Lucasz commissioned plant a LNF
To do : Merging of lines from master and slave boxes to reach 20 g/s

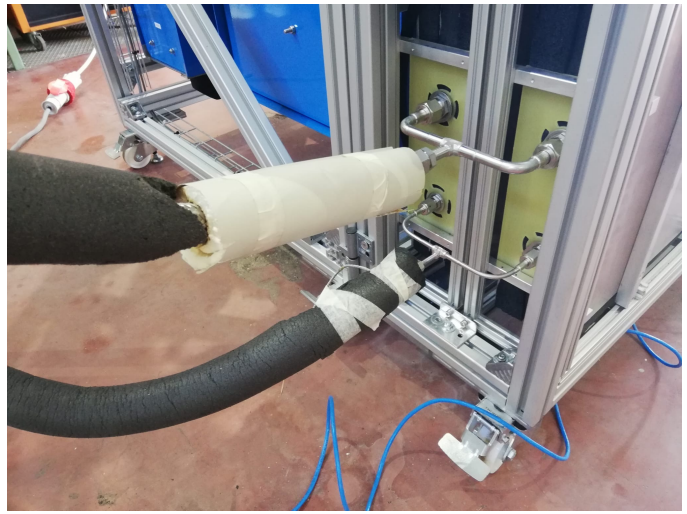
| Start point inside Test Box | End point Outside TB | Type | Quantity | Dimensions (mm) |
|---|---|---|---|---|
| Optoboxes (4) | Small $H_2O$ cooling plant | Cooling pipes | 2 | 8 / 10 |
| | Rack: Felix board | Trunk fiber bundle | 2 | 10 check |
| | Rack: power supply | Power cables | 4 | 14 |
| | Rack: PP3 | VCAN cables | 4 | 7 |
| | Dry air net | Dry air pipes | 2 | 8 |
| Half-shell | LUCASZ $CO_2$ plant | $CO_2$ transfer lines | 2 | 8 / 12 |
| | Rack: PP2 | Type II cables | 6 (4 power supply + 2 environmental) | 20 |
| Inlet-Middle-Outlet of CO2 flow | Rack: DCS and interlock | PTC | 11 | 3.5 |
| Test Box environment | Rack: DCS and interlock | Humidity sensors | 2 | 3.5 |
| | Rack: DCS and interlock | Dew point sensors | 6 | 5.7 |
| | Rack: DCS and interlock | Flow meters | 2 | 5.7 |
| | Rack: DCS and interlock | Pressure sensors | 2 | 5.7 |
| | Rack: DCS and interlock | Light sensors | 2 | 5.7 |
| | Rack: DCS and interlock | Emergency nitrogen pipe | 1 | 25.4 |

# Status Infrastrucure: Lucasz Plant at LNF

C. Ligi, G. Cesarini



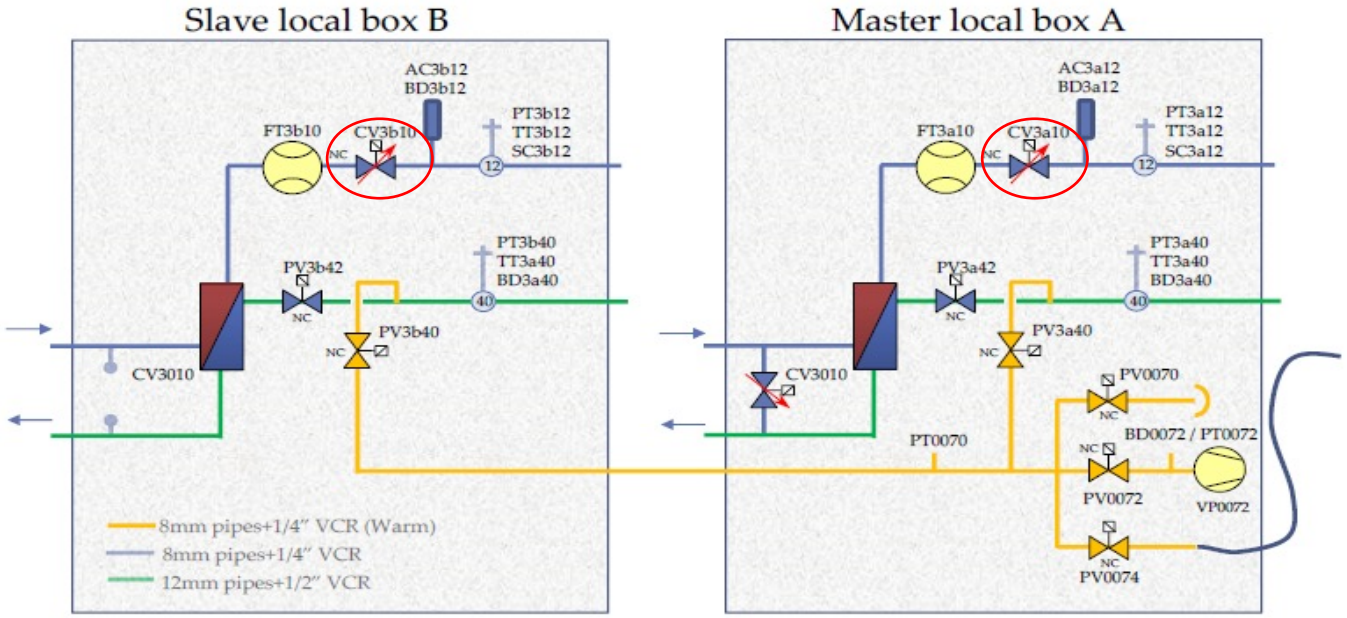

| Feature | Performance |
|---|---|
| Cooling loop maximum flow | 10g/s per loop ✓ |
| Total plant flow | 20g/s ✓ |
| Min evaporating T | -30°C, depending on heat load, see graph ✓ |
| Max evaporating T | +18°C ✓ |
| Number of cooling loops | #2 |
| Max DP across cooling loop | <15 Bar ✓ |
| Cooling loop max power | 2000 W ✓ |
| Dimensions (LxWxH) | 1125/1475* x 1300 x 1820 *Lite/Full version |



- Merging of lines to reach 20 g/s
- With VP = 0.5 proposal:
  - $T_{C02\ evap}$ -15 C for cold test
  - $T_{C02\ evap}$ +15 C for warm test

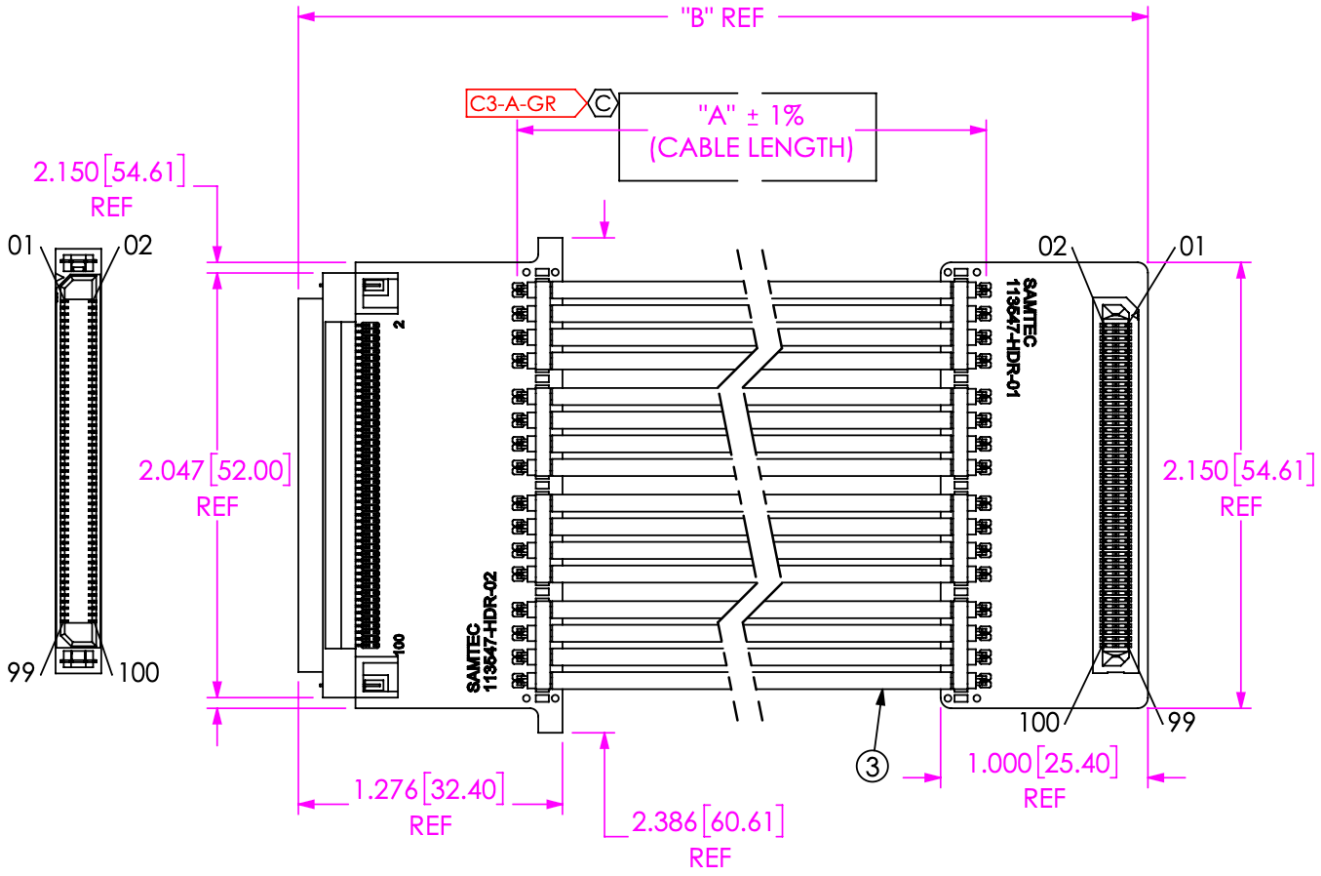
G. Cesarini,
C. Ligi

| | $T_{setpoint}$ = -20 °C | | | |
|---|---|---|---|---|
| Local Boxes | CV3a10 Valve (%) | CV3b10 Valve (%) | Dummy Load (kW) | Flow rate (g/s) |
| Master | 83.2 | / | 2 | 10.5 |
| Slave | / | 84.2 | | 10.5 |
| Merging | / | | | 21 |
| Master | 100 (non-operational condition) | / | 2 | 12.2 |
| Slave | / | 100 (non-operational condition) | | 10.9 |
| Merging | / | | | 23.1 |

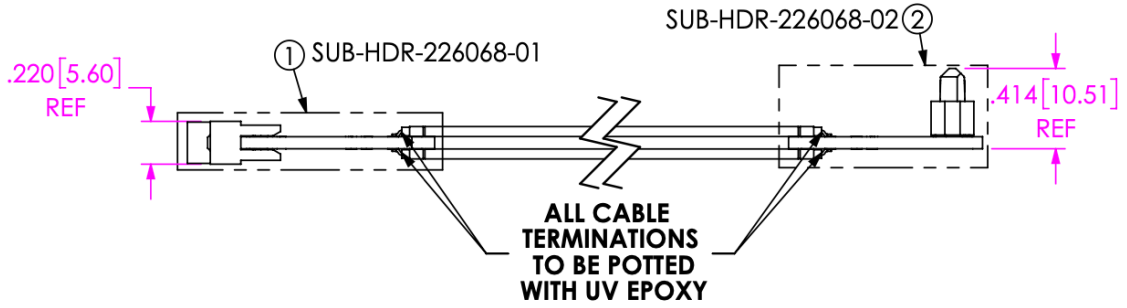



pump stroke set to 15 mm

# Data ewxtenders prototypes




| TABLE 1 | | |
|---|---|---|
| **PART #** | **"A"** | **"B"** |
| HDR-226068-01-ERDP | 40.00 [1,016.0] | 41.83 [1,062.5] |
| HDR-226068-02-ERDP | 80.00 [2,032.0] | 81.83 [2,078.5] |
| HDR-226068-03-ERDP | 200.00 [5,080.0] | 201.83 [5,126.5] |
| HDR-226068-04-ERDP | 120.00 [3,048.0] | 121.83 [3,094.5] |



# Pin mapping

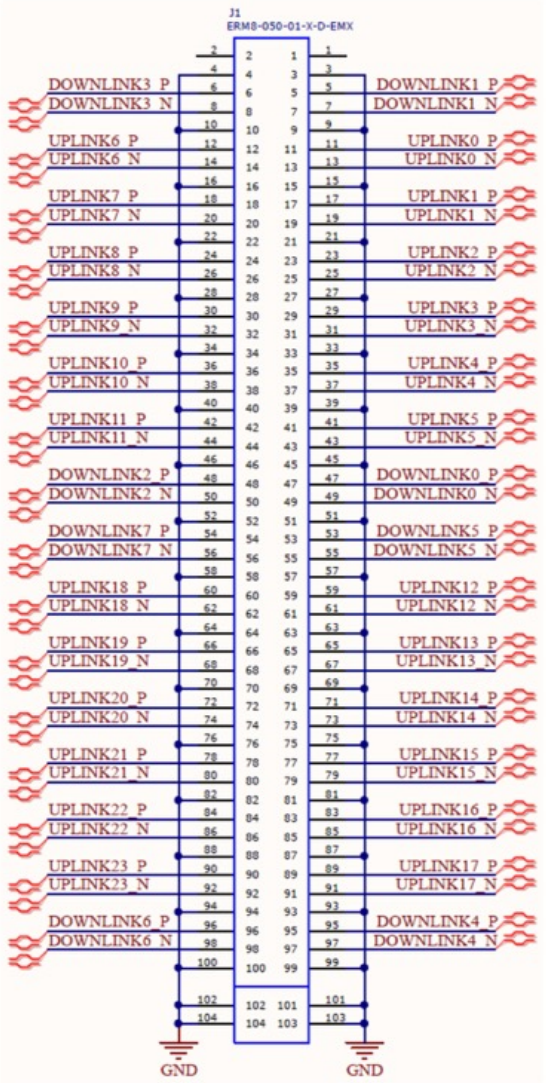



**TABLE 2**

**SIGNAL MAPPING**

| J1 | NAME | J2 | J1 | NAME | J2 | J1 | NAME | J2 | J1 | NAME | J2 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | NC | 1 | 51 | GND | 51 | 2 | NC | 2 | 52 | GND | 52 |
| 3 | GND | 3 | 53 | DP | 53 | 4 | GND | 4 | 54 | DP | 54 |
| 5 | DP | 5 | 55 | | 55 | 6 | DP | 6 | 56 | | 56 |
| 7 | | 7 | 57 | GND | 57 | 8 | | 8 | 58 | GND | 58 |
| 9 | GND | 9 | 59 | DP | 59 | 10 | GND | 10 | 60 | DP | 60 |
| 11 | DP | 11 | 61 | | 61 | 12 | DP | 12 | 62 | | 62 |
| 13 | | 13 | 63 | GND | 63 | 14 | | 14 | 64 | GND | 64 |
| 15 | GND | 15 | 65 | DP | 65 | 16 | GND | 16 | 66 | DP | 66 |
| 17 | DP | 17 | 67 | | 67 | 18 | DP | 18 | 68 | | 68 |
| 19 | | 19 | 69 | GND | 69 | 20 | | 20 | 70 | GND | 70 |
| 21 | GND | 21 | 71 | DP | 71 | 22 | GND | 22 | 72 | DP | 72 |
| 23 | DP | 23 | 73 | | 73 | 24 | DP | 24 | 74 | | 74 |
| 25 | | 25 | 75 | GND | 75 | 26 | | 26 | 76 | GND | 76 |
| 27 | GND | 27 | 77 | DP | 77 | 28 | GND | 28 | 78 | DP | 78 |
| 29 | DP | 29 | 79 | | 79 | 30 | DP | 30 | 80 | | 80 |
| 31 | | 31 | 81 | GND | 81 | 32 | | 32 | 82 | GND | 82 |
| 33 | GND | 33 | 83 | DP | 83 | 34 | GND | 34 | 84 | DP | 84 |
| 35 | DP | 35 | 85 | | 85 | 36 | DP | 36 | 86 | | 86 |
| 37 | | 37 | 87 | GND | 87 | 38 | | 38 | 88 | GND | 88 |
| 39 | GND | 39 | 89 | DP | 89 | 40 | GND | 40 | 90 | DP | 90 |
| 41 | DP | 41 | 91 | | 91 | 42 | DP | 42 | 92 | | 92 |
| 43 | | 43 | 93 | GND | 93 | 44 | | 44 | 94 | GND | 94 |
| 45 | GND | 45 | 95 | DP | 95 | 46 | GND | 46 | 96 | DP | 96 |
| 47 | DP | 47 | 97 | | 97 | 48 | DP | 48 | 98 | | 98 |
| 49 | | 49 | 99 | GND | 99 | 50 | | 50 | 100 | GND | 100 |

ALL GROUNDS COMMON AND TIED TO CABLE SHIELD