ATLAS PATCH PANEL 01 (PP1), SERVICES, MECHANICS & EDDY CURRENT EFFECTS

INFN-LNF

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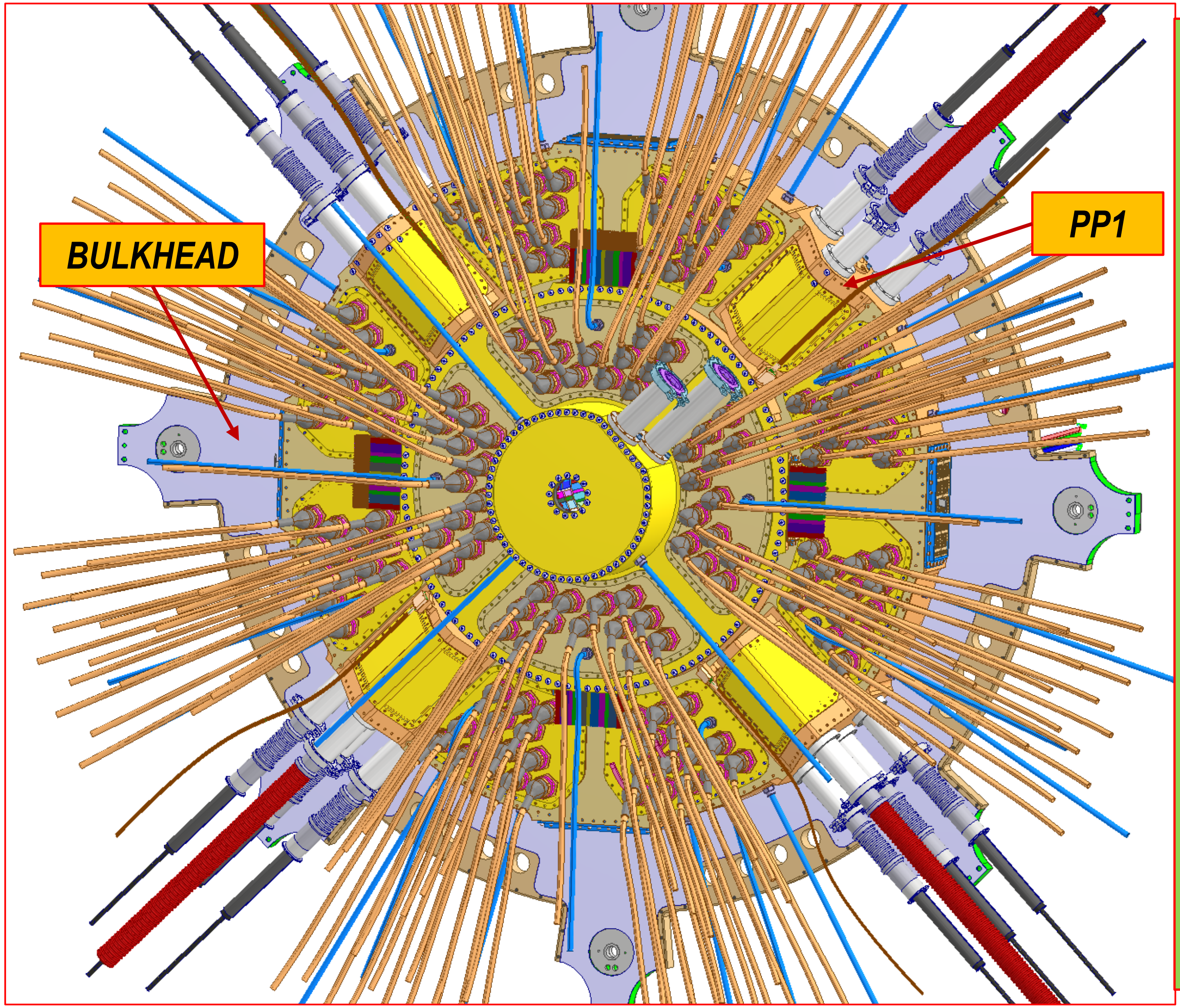
https://indico.cern.ch/event/1017981/overview

Outline

- PP1 MECHANICS
- INTEGRATION SEQUENCE
- DATA CABLE FEEDTHROUGH
- EDDY CURRENT EFFECTS
- CONCLUSIONS

PP1 OVERVIEW

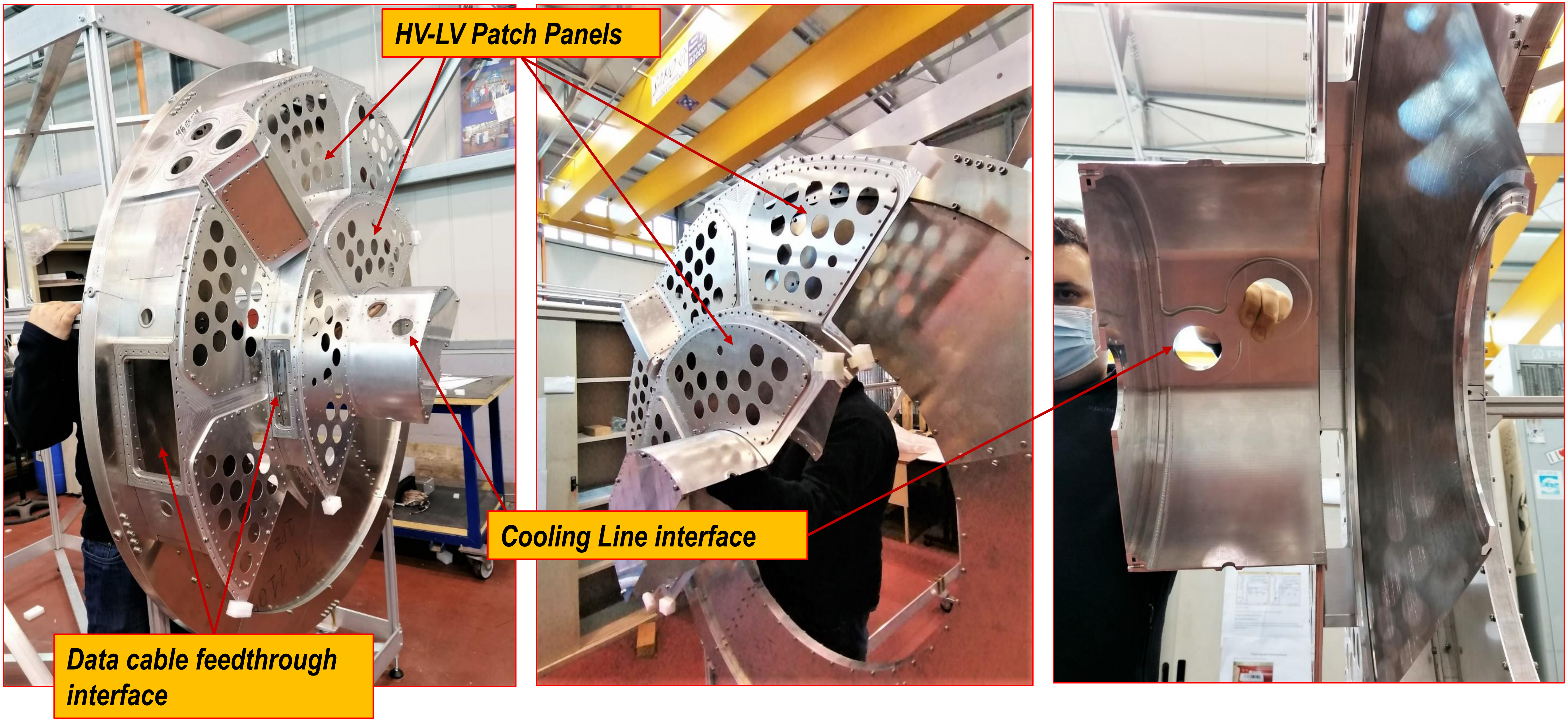


MAIN FEATURES :

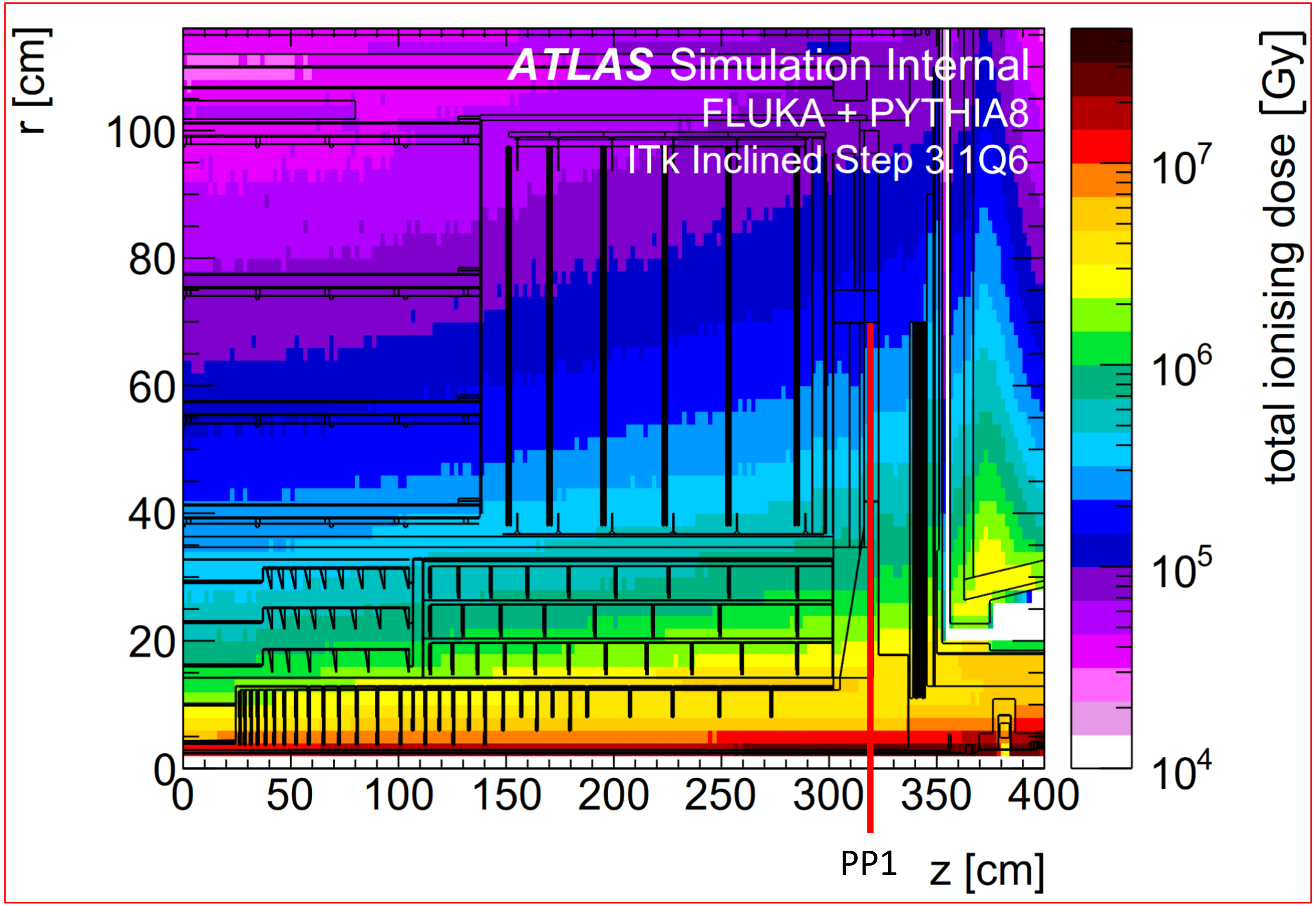
- ***Faraday Cage closure***
- *Data cable Feedthrough:* - ***8488 Twinax Cables*** *(Outer System)*
  - ***4604 Twinax Cables*** *(Inner System)*
- *HV –LV Connectors:* - ***112*** *(Outer System)*
  - ***52*** *(Inner System)*
- *Cooling line feedthrough:* - ***14 lines*** *(Outer System)*
  - ***2 lines*** *(Inner System)*
- *Internal Nitrogen Overpressure:* ***4 mbar***
- *Internal Dew Point temperature:* ***< -60°C***
- *External Dew Point:* ***< -30°C***
- ***Heaters on the body to avoid condensation***

PP1 FULL SCALE MOCK-UP

PP1 FULL SCALE MOCK-UP



SEALING: RADIATION MAP

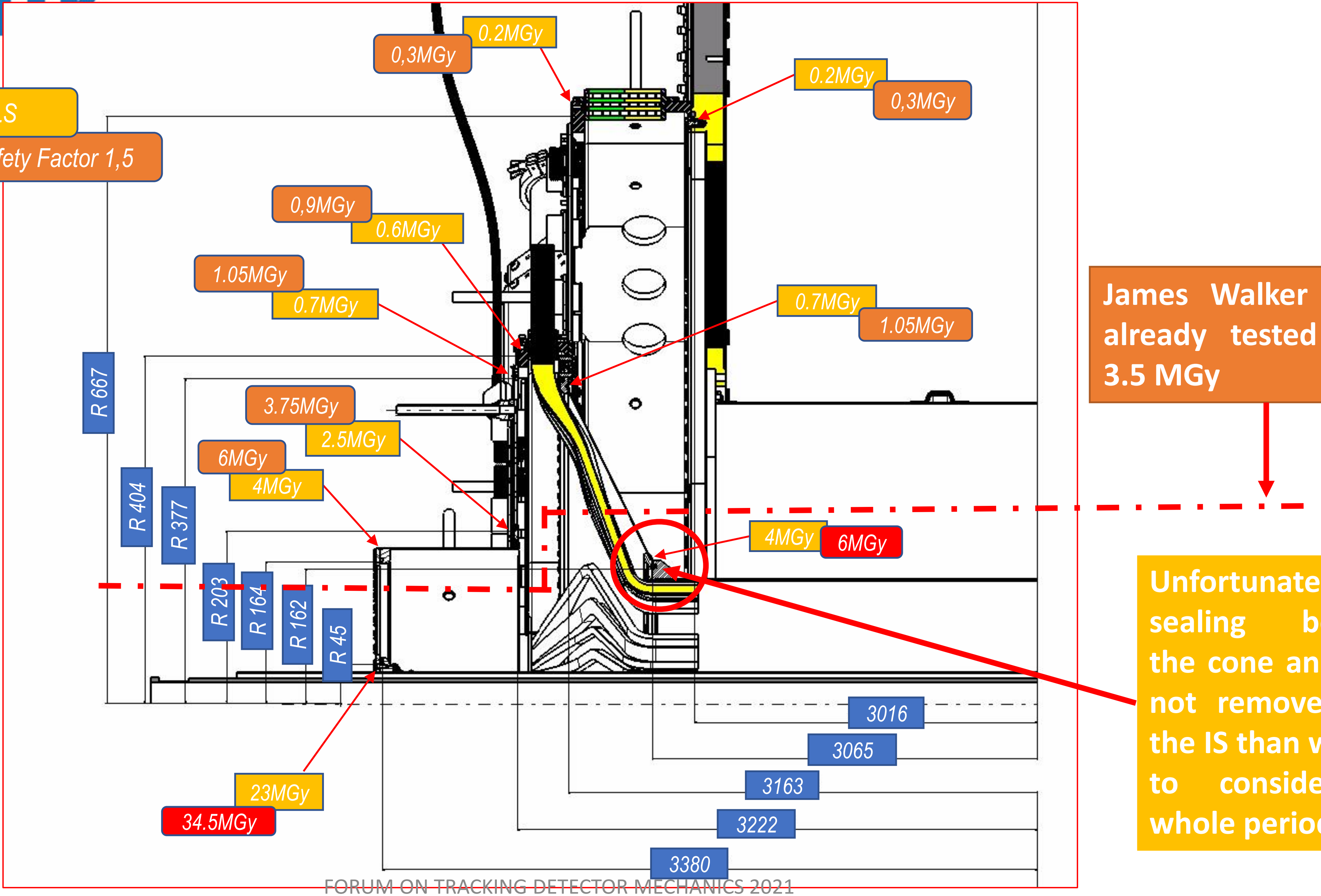


Computed radiation dose @ 4000 fbarn^-1

SEALING: RADIATION MAP

COMPUTED RAD LEVELS

Values With Safety Factor 1,5



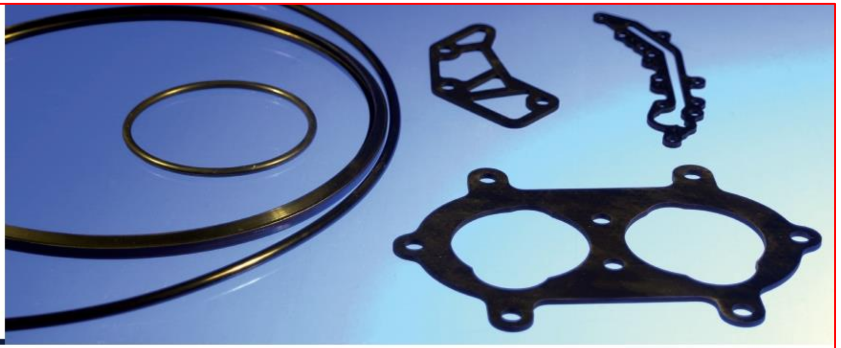
James Walker O-rings already tested up to 3.5 MGy

Unfortunately the sealing between the cone and IST is not removed with the IS than we have to consider the whole period dose.

SEALING: RUBBER LIKE MATERIAL

Shieldseal®
663

EPDM elastomer with nuclear application life of up to 40 years



MECHANICAL PROPERTIES (TYPICAL)

HARDNESS
(nominal): 80 IRHD.

TENSILE STRENGTH:
18 MPa

ELONGATION AT BREAK:
200%

COMPRESSION SET
(70h @ 125°C): 10.5%

TEMPERATURE CAPABILITY

Min - 40°C
Max +125°C constant
+150°C intermittent

Can survive very short exposures to higher temperatures (consult James Walker)

General properties

Specifically formulated to offer a long service life of up to 40 years in applications where ionizing radiation is present, particularly where the elastomer is in contact with:

- Air
- Hot water
- Steam

This elastomer is also suitable for long-term contact with a wide variety of media associated with nuclear waste, including:

- Dilute acids and alkalis
- Ketones
- Lower alcohols
- Silicone oils and greases

Leachable ion content

Shieldseal 663 contains a very low level of leachable ions such as Cl- and SO42-, to ensure that items made of this material do not contribute to corrosion in metalwork.

Water soluble contents of sulphate and chloride are at levels below 3 ppm.

Radiation/thermal resistance

Third-party tests carried out in accordance with international standards show that Shieldseal 663 has good generic radiation resistance up to a dose of 1600 kGy in radiation conditions that include elevated temperatures up to 70°C.

Thermal pre-ageing of the samples did not significantly alter the end-of-life ageing characteristics.

Third-party testing by AMEC

Samples of initially un-aged and thermally pre-aged Shieldseal 663 from two different batches were irradiated at a dose rate of 1 kGy.h-1 up to 1000 kGy in a Co-60 irradiation facility. A number of samples were also irradiated at 70°C to assess synergistic effects.

Samples were then exposed to a further 600 kGy, at room temperature, to simulate additional radiation from a Design Basis Event (DBE) such as a loss of coolant accident (LOCA).

Levels of degradation were monitored periodically during radiation/thermal ageing by compression set measurement of button samples. Tensile test samples were aged in the same manner and tested at James Walker Technology Centre for hardness, elongation at break, and tensile strength.

Mechanical testing of aged Shieldseal 663 dumbbell samples showed that, overall, the hardness, elongation at break and tensile strength for both the initially un-aged and the thermally pre-aged samples were similar for each test condition.

Elongation at break test results

Showed that the generally accepted end-of-life condition, defined as 50% elongation at break, was reached at a dose of 1600 kGy. (Typical elongation at break value for an un-aged, un-irradiated sample of Shieldseal 663 is 200%.)

Compression set test results

These showed that the generally accepted end-of-life value of 90% was reached at 1600 kGy. Irradiation at 70°C made

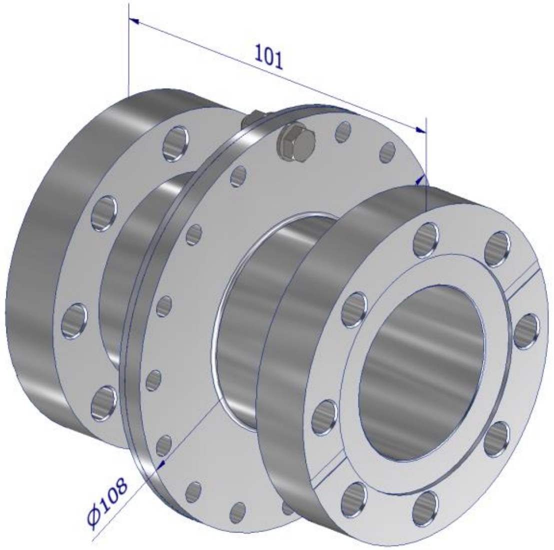
BATCH A

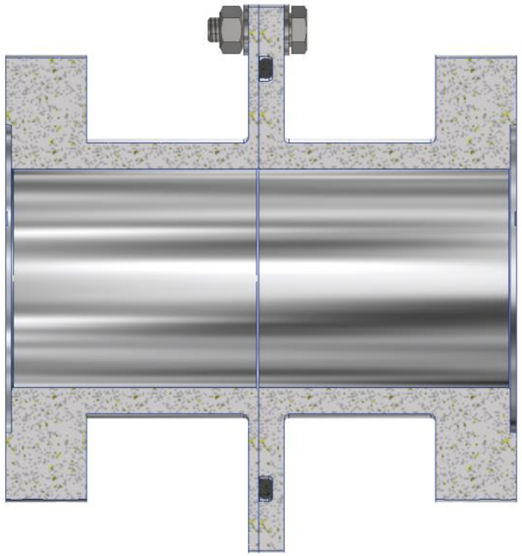
BATCH B

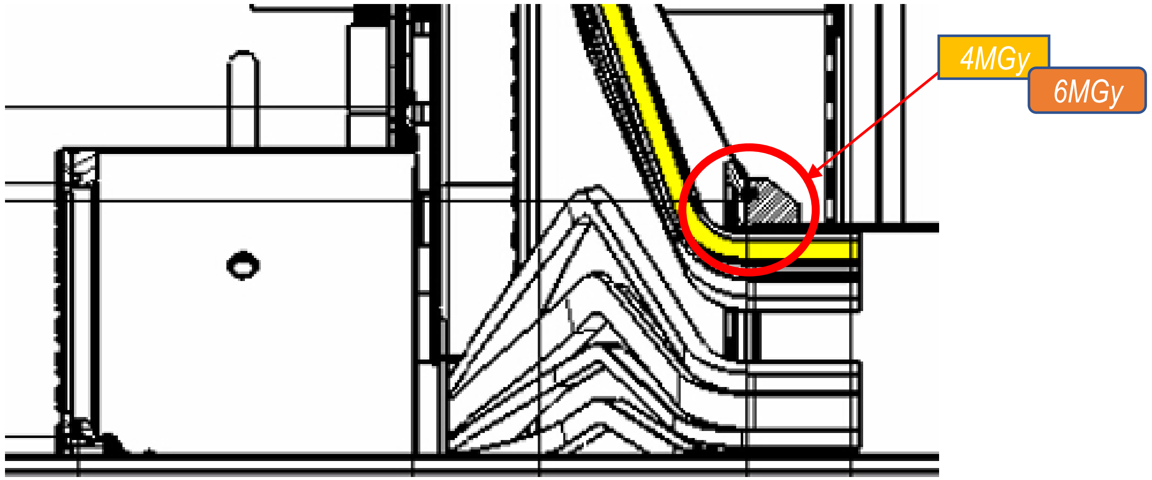
The O-Rings material is SHIELDSEAL® 663 (EPDM Family) provided by James Walker and certified up to 1.6 MGy .
We divided the ten O-rings in two batches of five gaskets each:

- ***One batch (A) was tested without irradiation.***
- ***The other one (B), was tested after the radiation dose of 3.5 MGy (350 Mrd). .***

O-RING QUALIFICATION UP TO 6 MGy



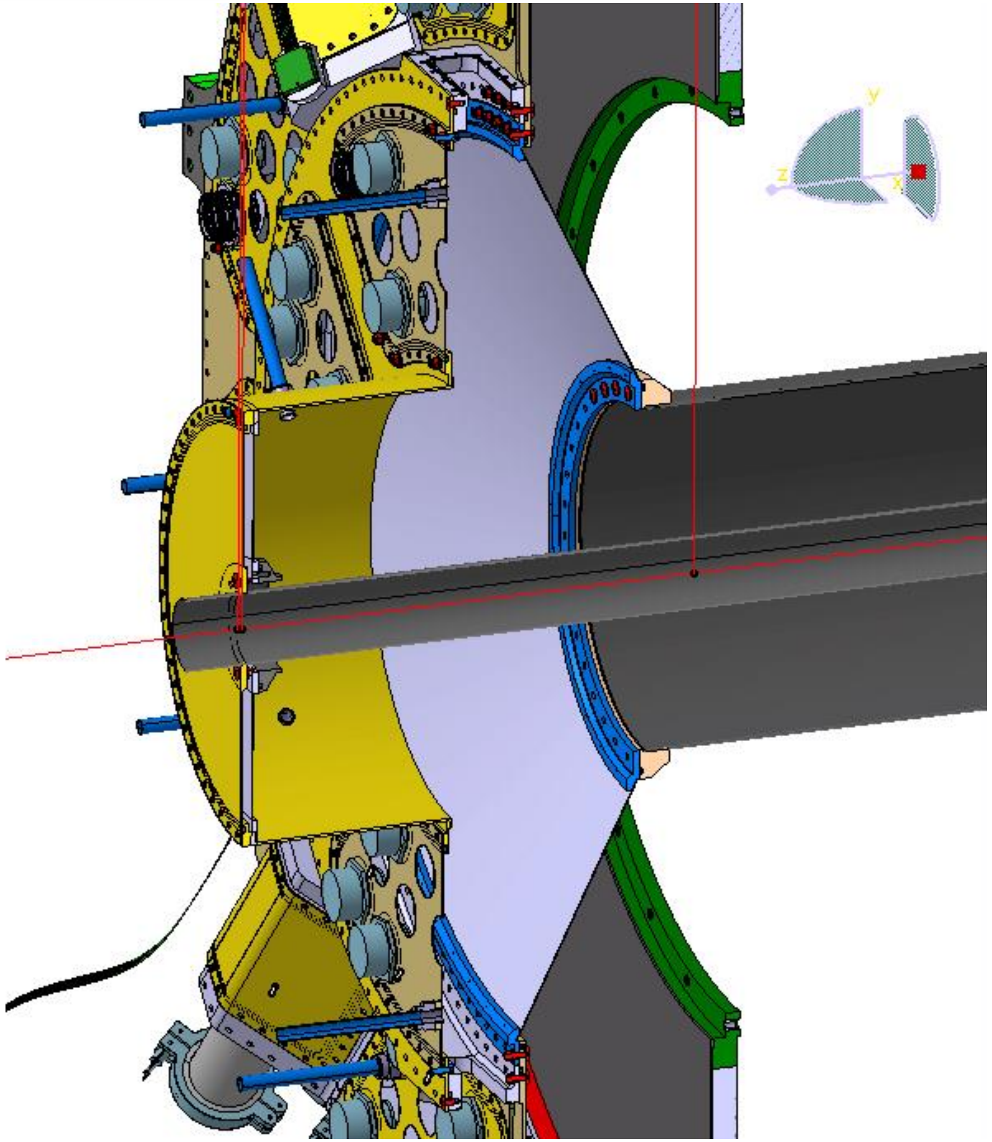




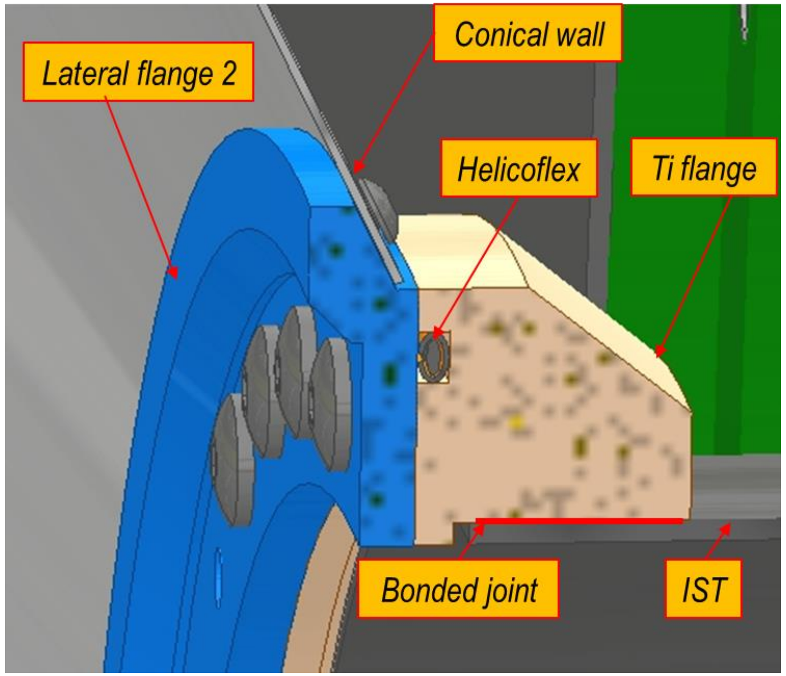
Three new specimens were designed to test a new batch of compressed JW O-ring, up to 6 MGy.
O-rings will remain mounted in the specimen after irradiation to be leak tested at different operative conditions (rad dose).

TO BE TEST YET

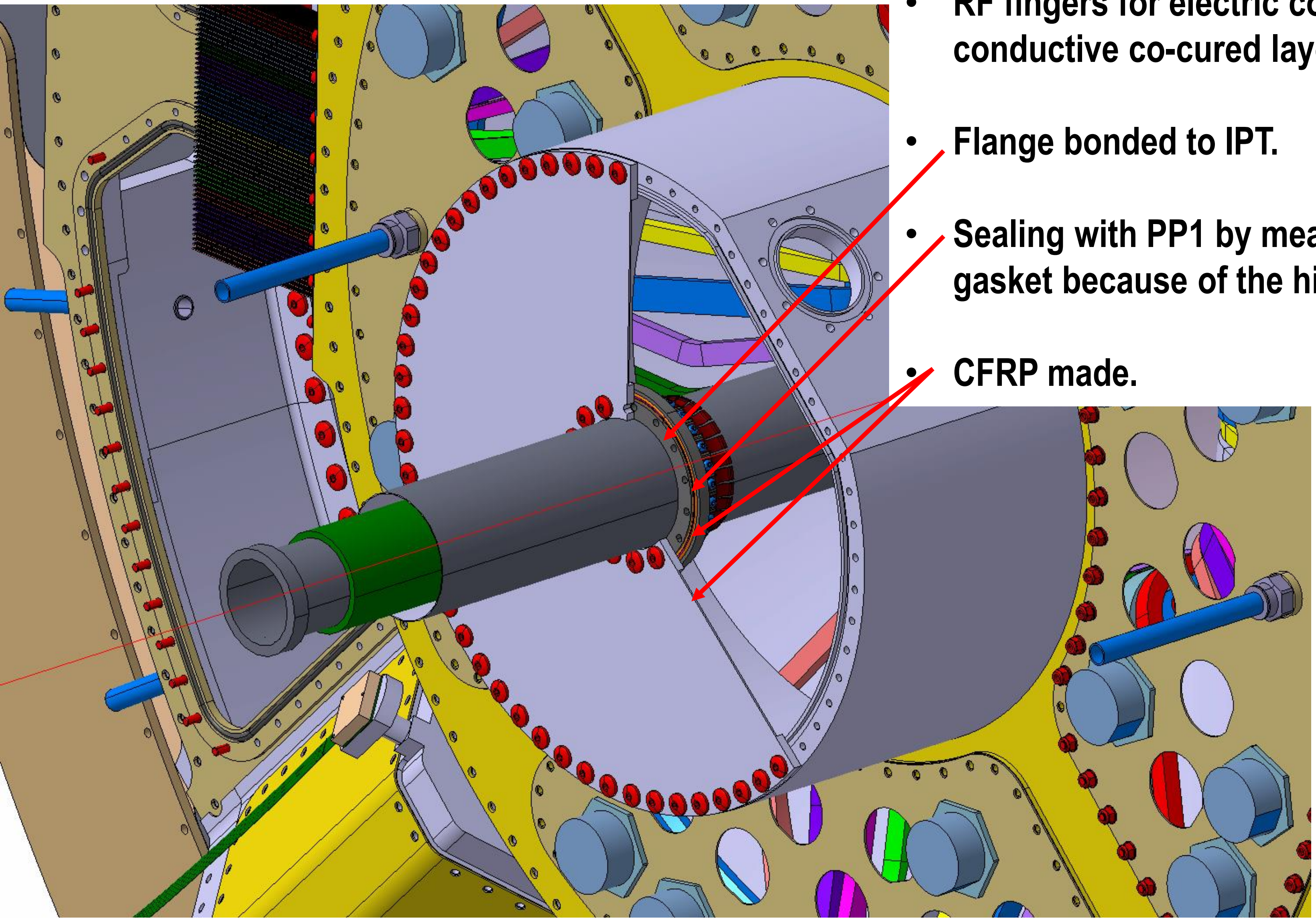
PP1-IST INTERFACE



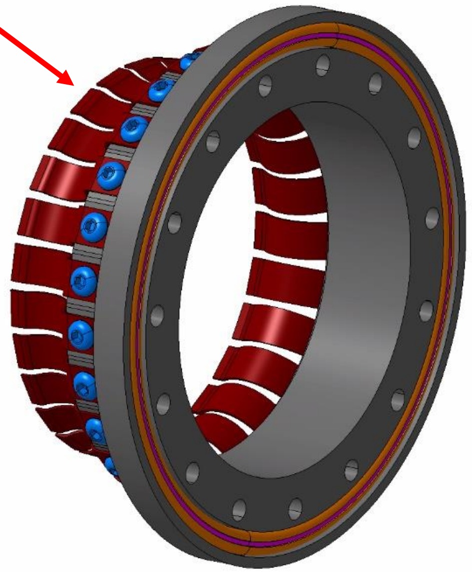
- The interface flange is bonded to the IST pipe.
- The diaphragm is bolted and bonded to the interface flange (the blue one).
- Possibility to make the cone with CFRP.
- Sealing between the two flanges by means of a metal gasket because of the high radiation dose foreseen. WIP

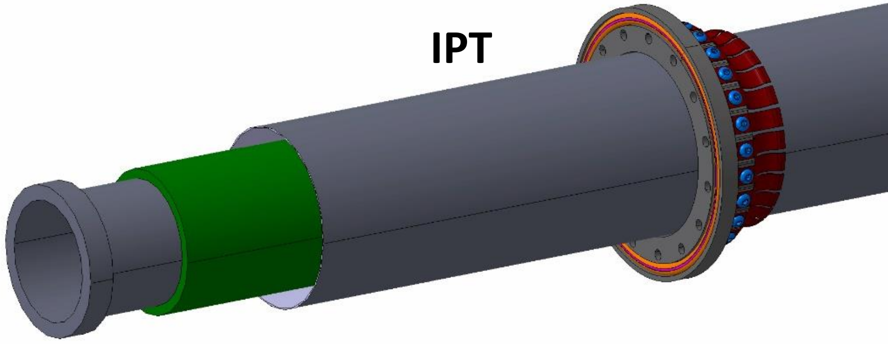


PP1-IPT INTERFACE

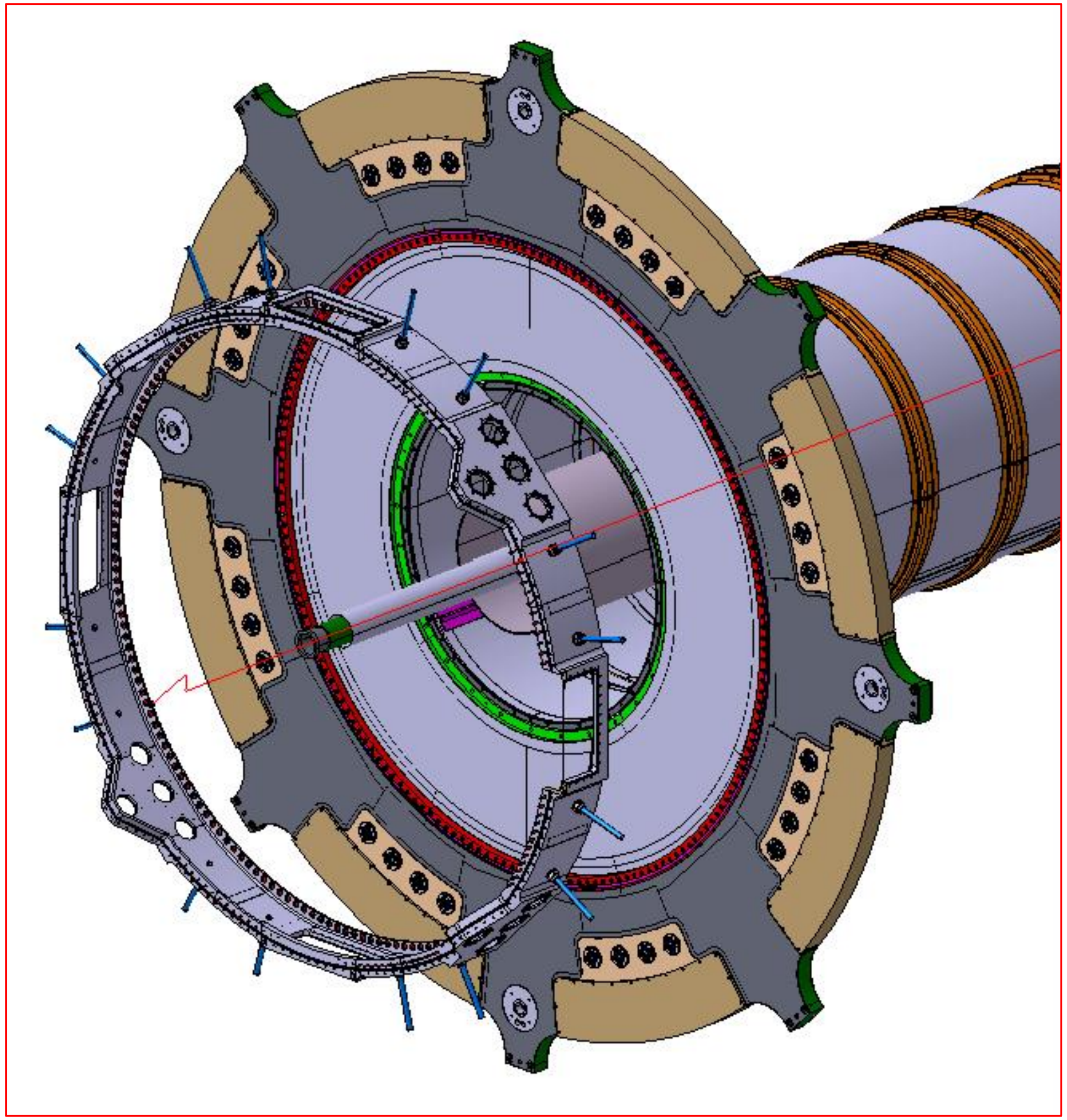


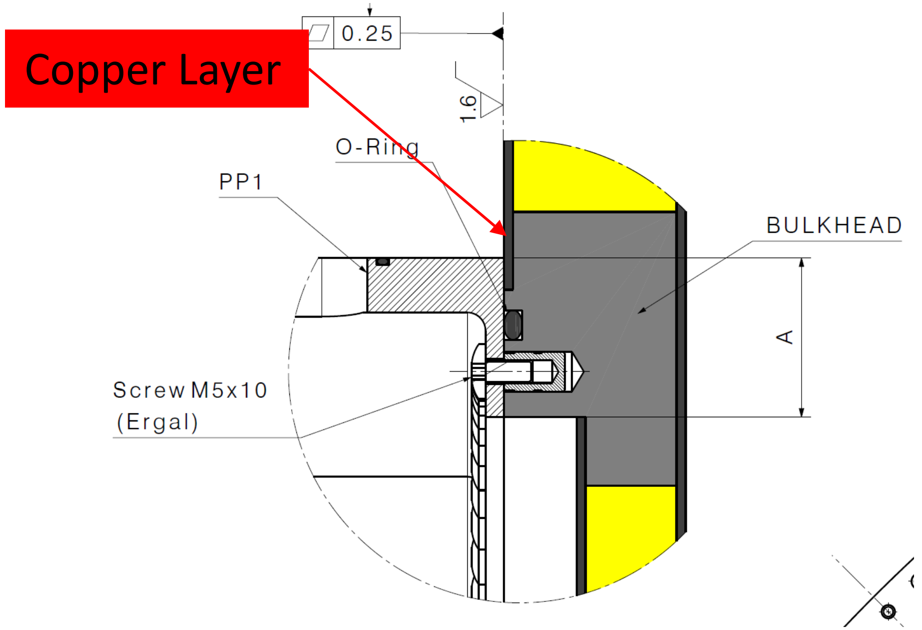
- RF fingers for electric continuity with the conductive co-cured layer on IPT.
- Flange bonded to IPT.
- Sealing with PP1 by means of a metal gasket because of the high radiation dose
- CFRP made.





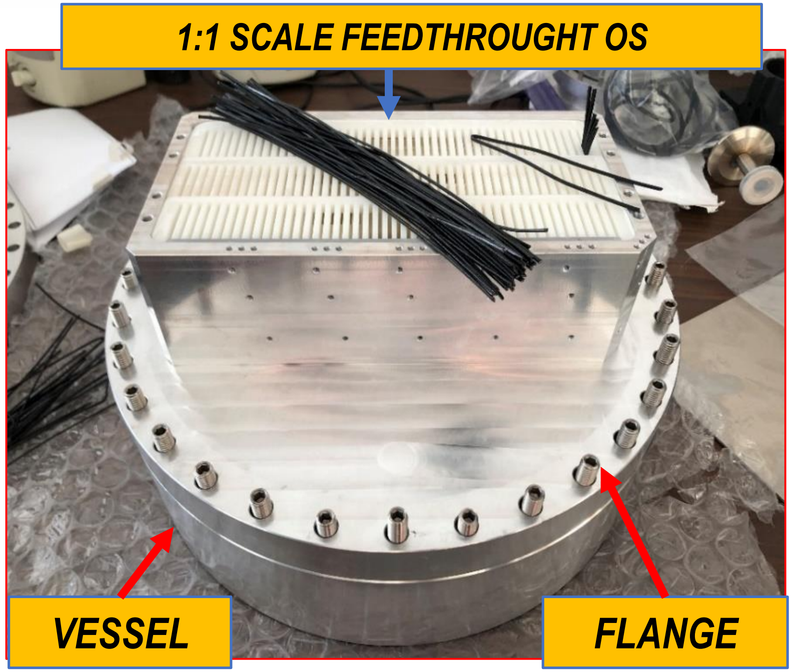
PP1-BULKHEAD INTERFACE

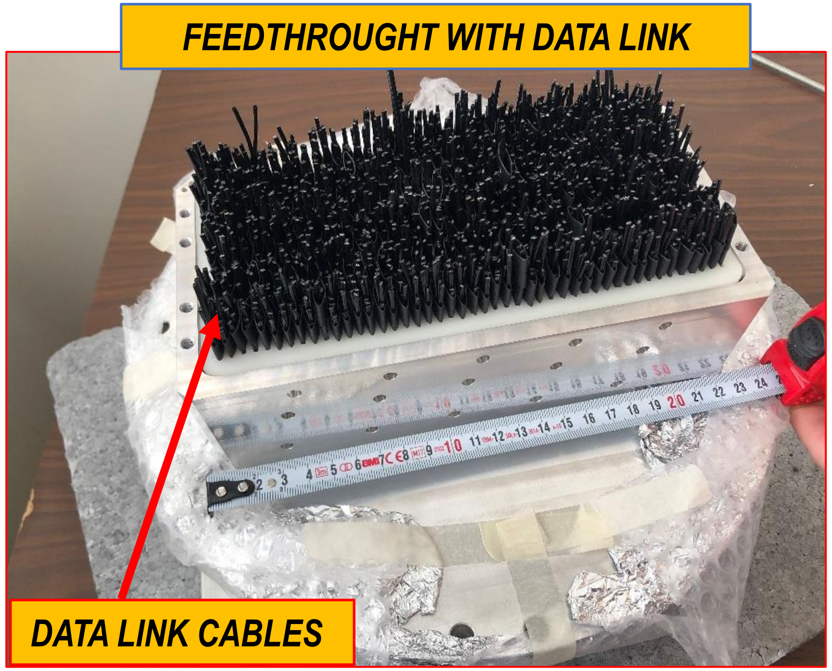


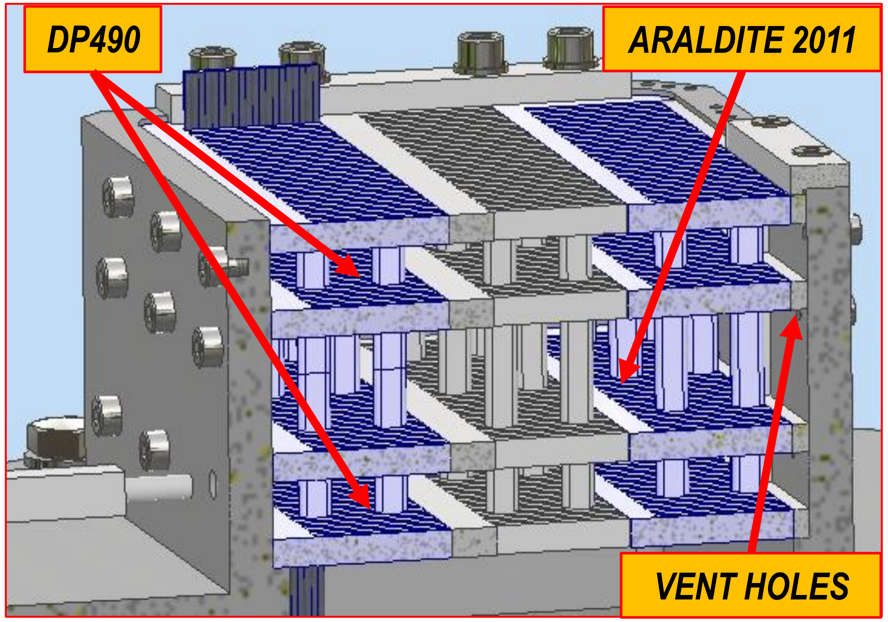


- The interface flange is bolted to the bulkhead.
- In the bulkhead there is a Peek insert with a groove for O-ring sealing.
- Sealing between the two flanges by means of a rubber O-ring because of low radiation dose foreseen.
- Copper layer for electric continuity with PP1 (Faraday cage).

OUTER SYSTEM DATA CABLES FEEDTHROUGH

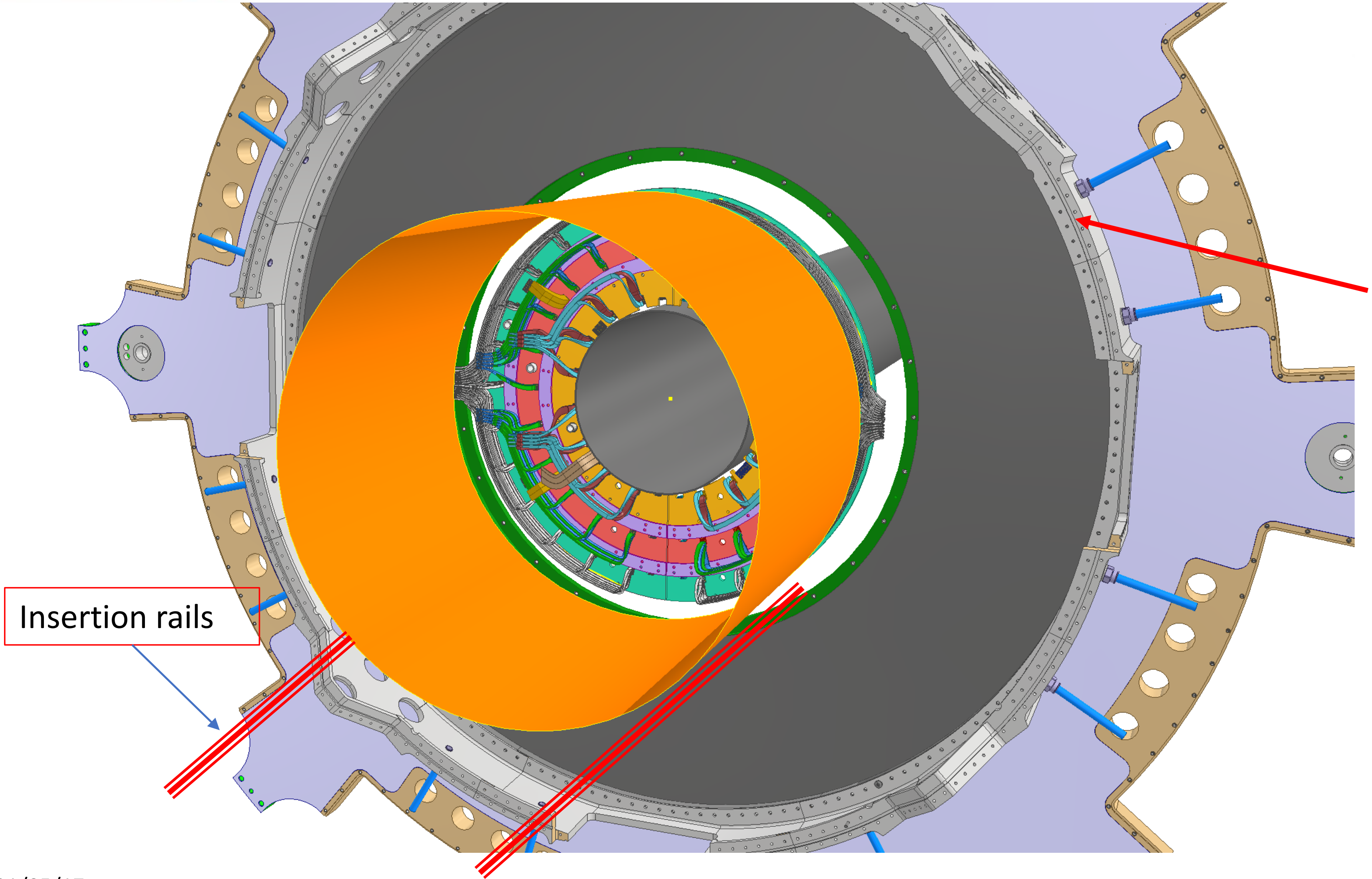






- Two full scale DFTs were produced and fully populated with Twinax cables.
- The prototypes will be used to measure the leakage of Outer System DFT.
- We will test the resin filling process, in horizontal and vertical position, with the two flanges. This to simulate the sealing at different locations in PP1.

INTEGRATION SEQUENCE



THIS IS A SIMPLIFIED PICTURE JUST AFTER THE PIXEL DETECTOR INSERTION INTO PST

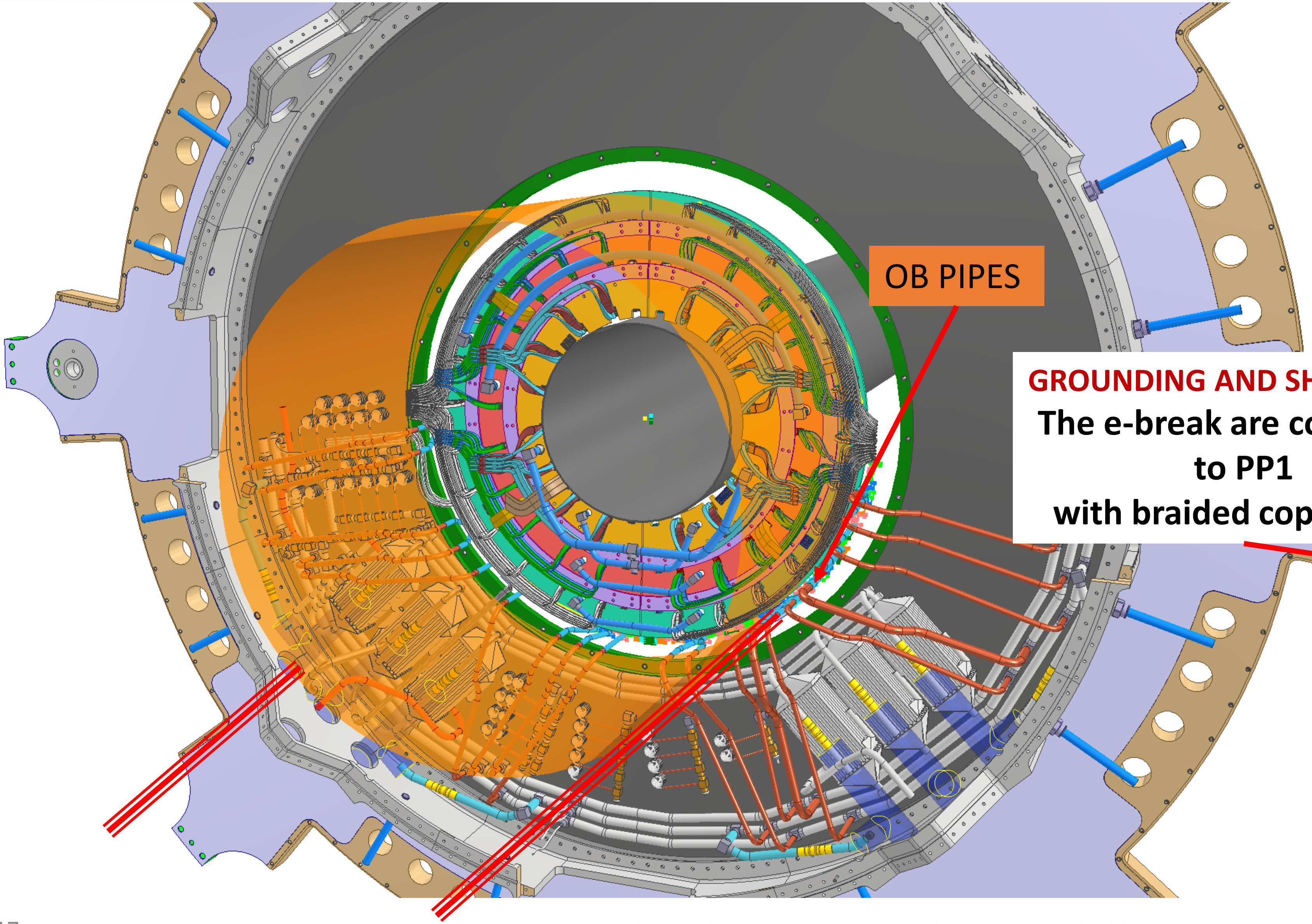
THE PP1 INTERFACE FLANGE IS INSTALLED BEFORE THE PIXEL INSERTION

ALL THE CABLES ARE STORED ON THE INTEGRATION TROLLEYS

THE ORANGE CYLINDER SHOWS THE TROLLEY ENVELOPE

Services routed inside the orange cylinder are not shown in the picture

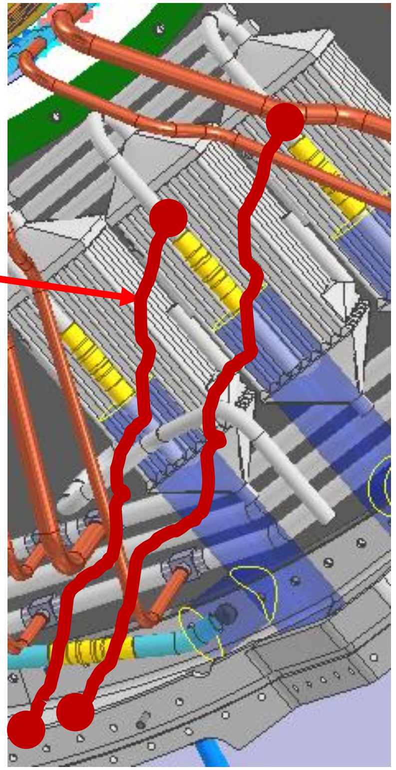
INTEGRATION SEQUENCE: FIRST OB MANIFOLD



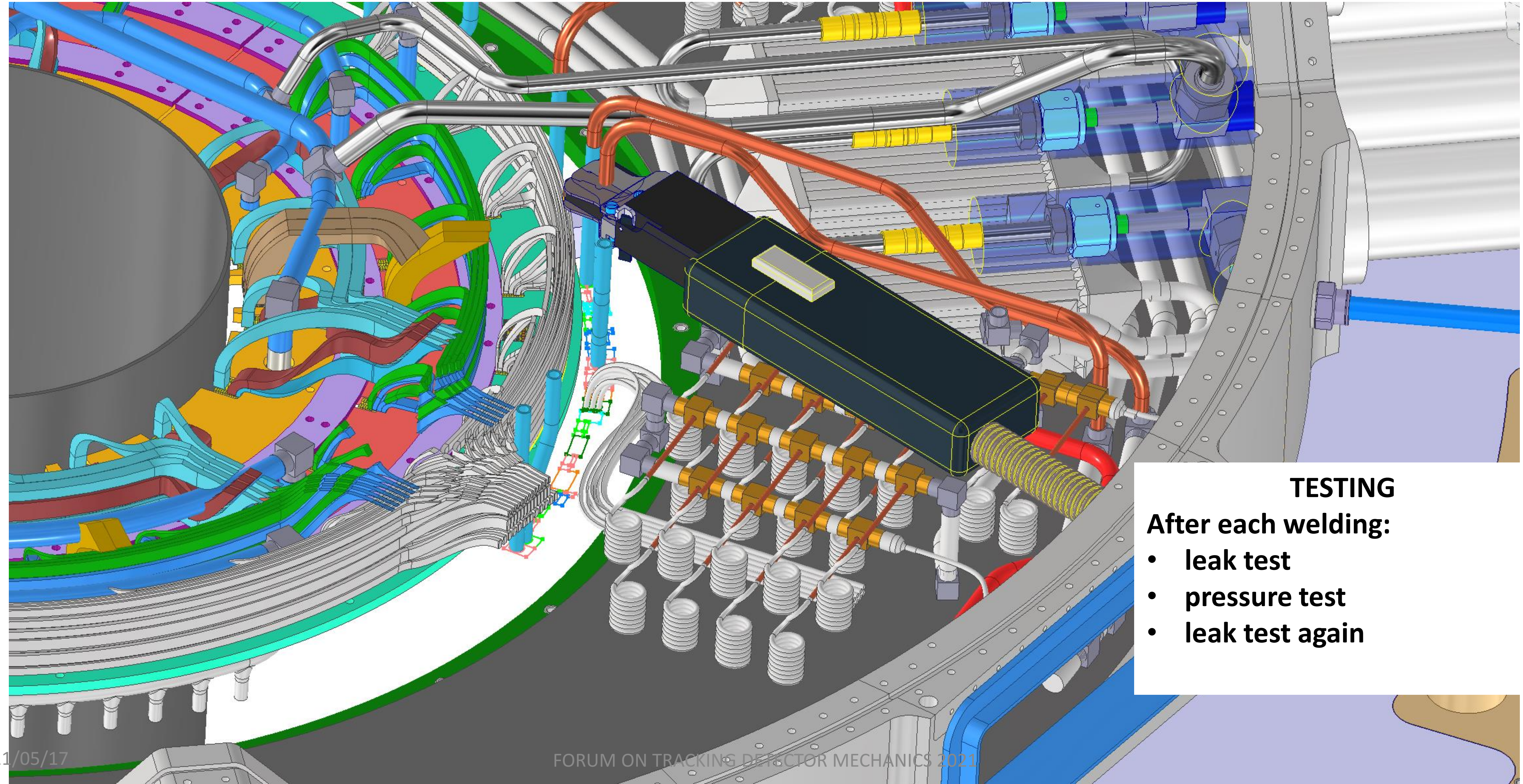
THE FIRST OB MANIFOLD, ALREADY PRODUCED, PRESSURE TESTED AND LEAK TESTED IN THE WORKSHOP, IS INSTALLED IN THE PP1 ENVELOPE AND PREPARED TO BE WELDED TO THE OB PIPES

GROUNDING AND SHIELDING

The e-break are connected to PP1 with braided copper wire



INTEGRATION SEQUENCE: ORBITAL WELDING INSIDE PP1

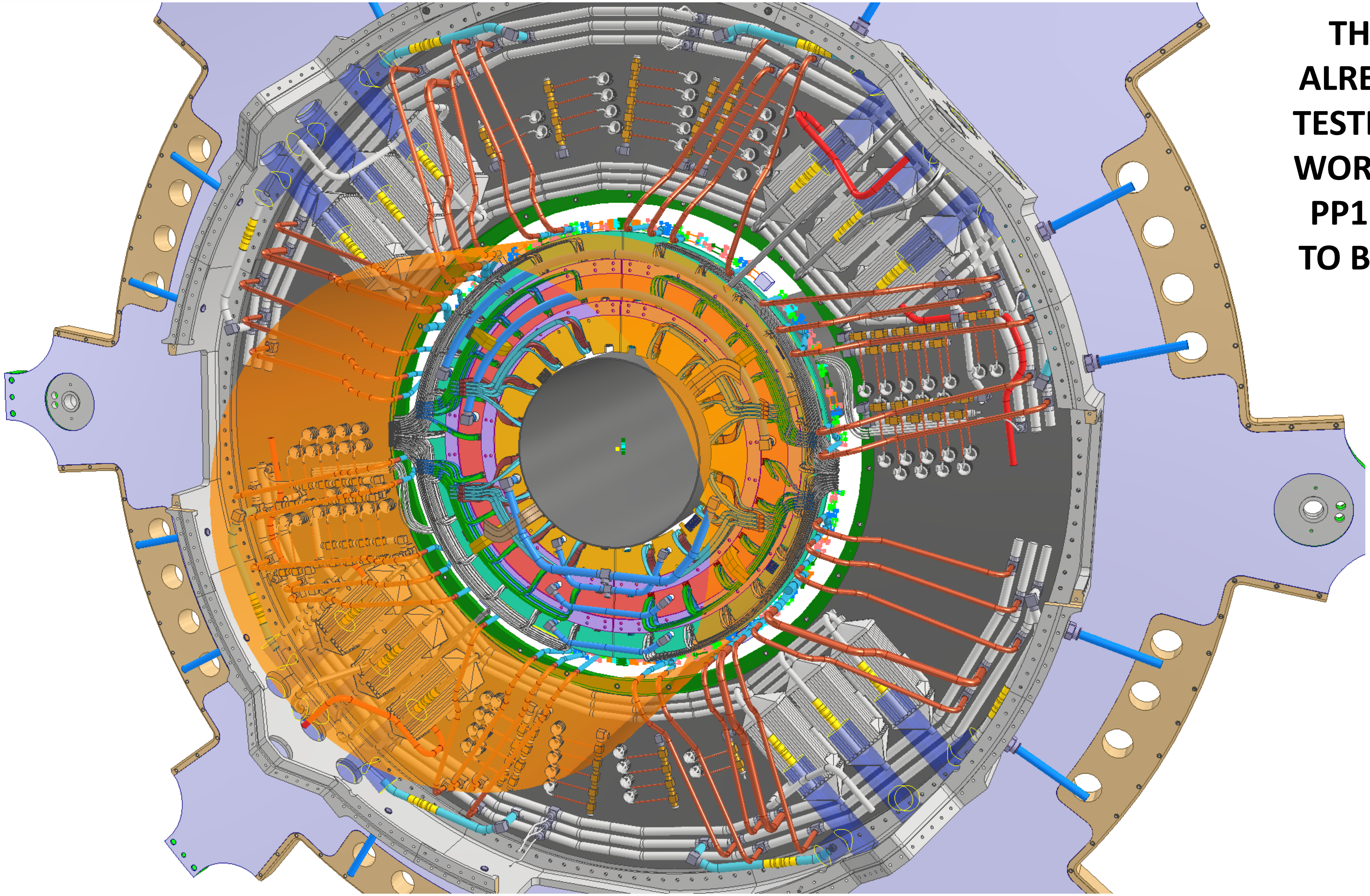


TESTING

After each welding:

- **leak test**
- **pressure test**
- **leak test again**

INTEGRATION SEQUENCE: OB MANIFOLDS



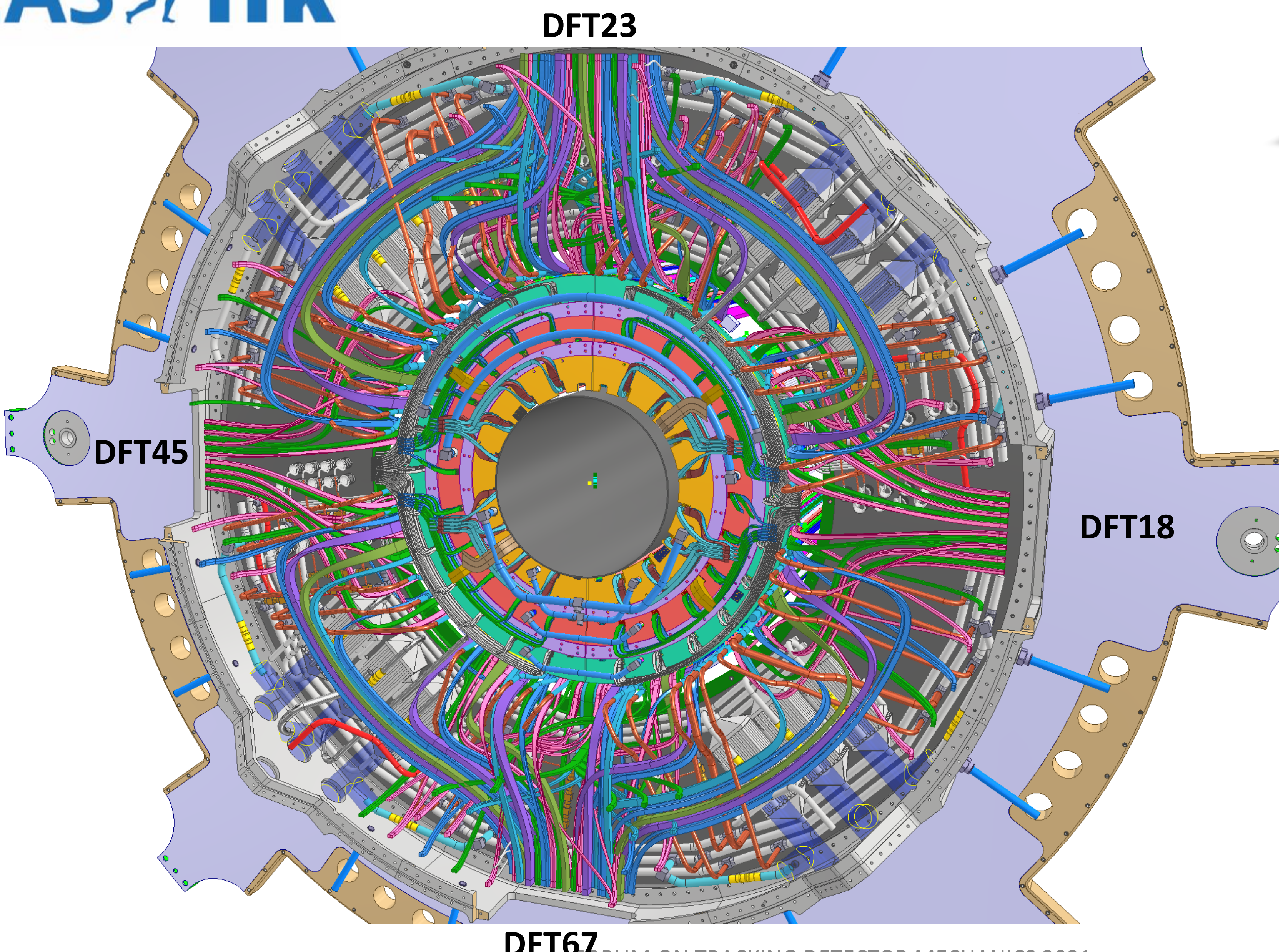
THE SECOND OB MANIFOLD, ALREADY PRODUCED, PRESSURE TESTED AND LEAK TESTED IN THE WORKSHOP, IS INSTALLED IN THE PP1 ENVELOPE AND PREPARED TO BE WELDED TO THE OB PIPES

TESTING

After each welding:

- **leak test**
- **pressure test**
- **leak test again**

INTEGRATION SEQUENCE: OB CABLING

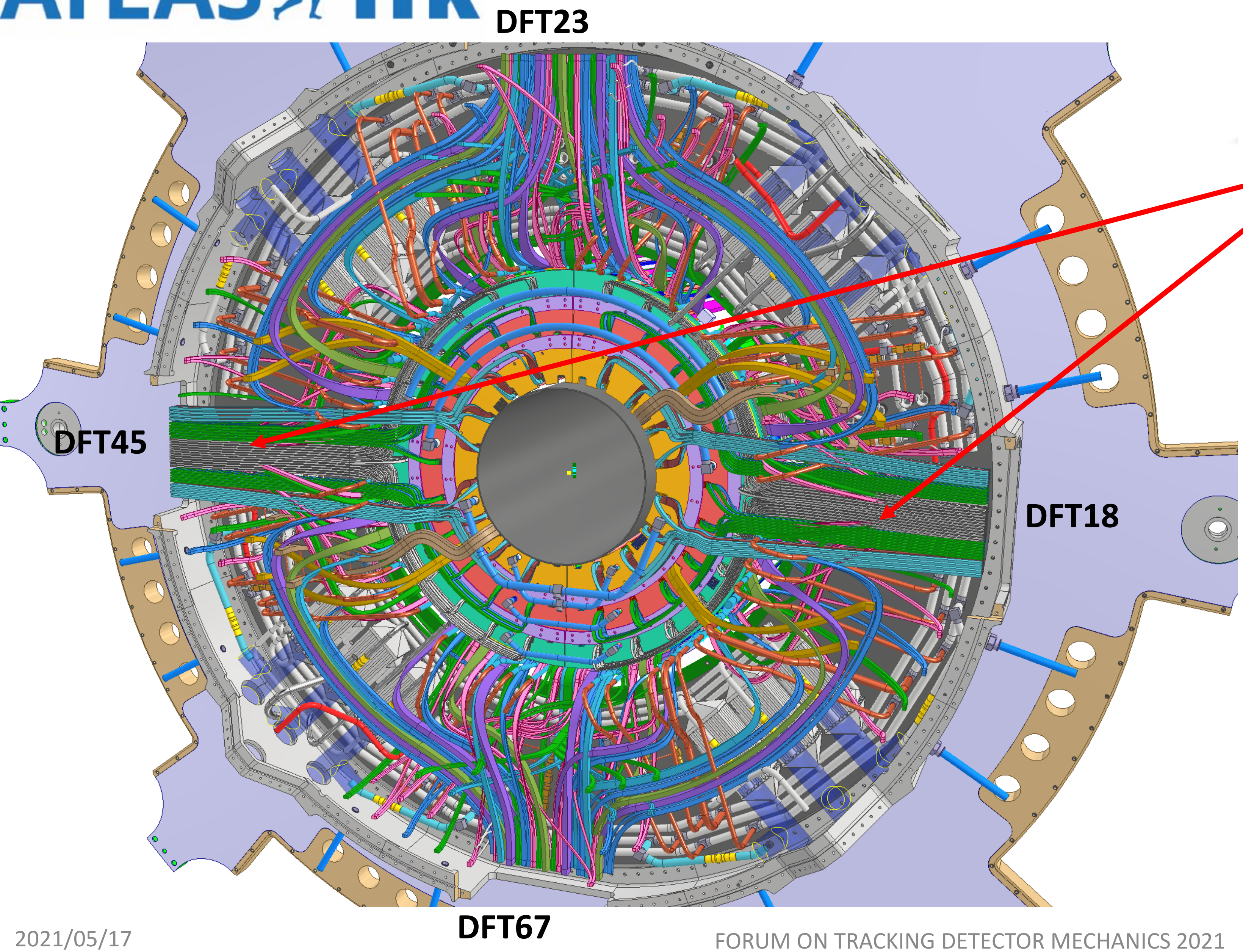


DATA CABLES ARE ROUTED IN THE PP1 VOLUME AND DRESSED IN THE RELATIVE DFT.

- DFT23 & 67 ARE FULLY POPULATED WITH OB CABLES
- DFT18 & 45 ARE PARTLY POPULATED WITH OB CABLES

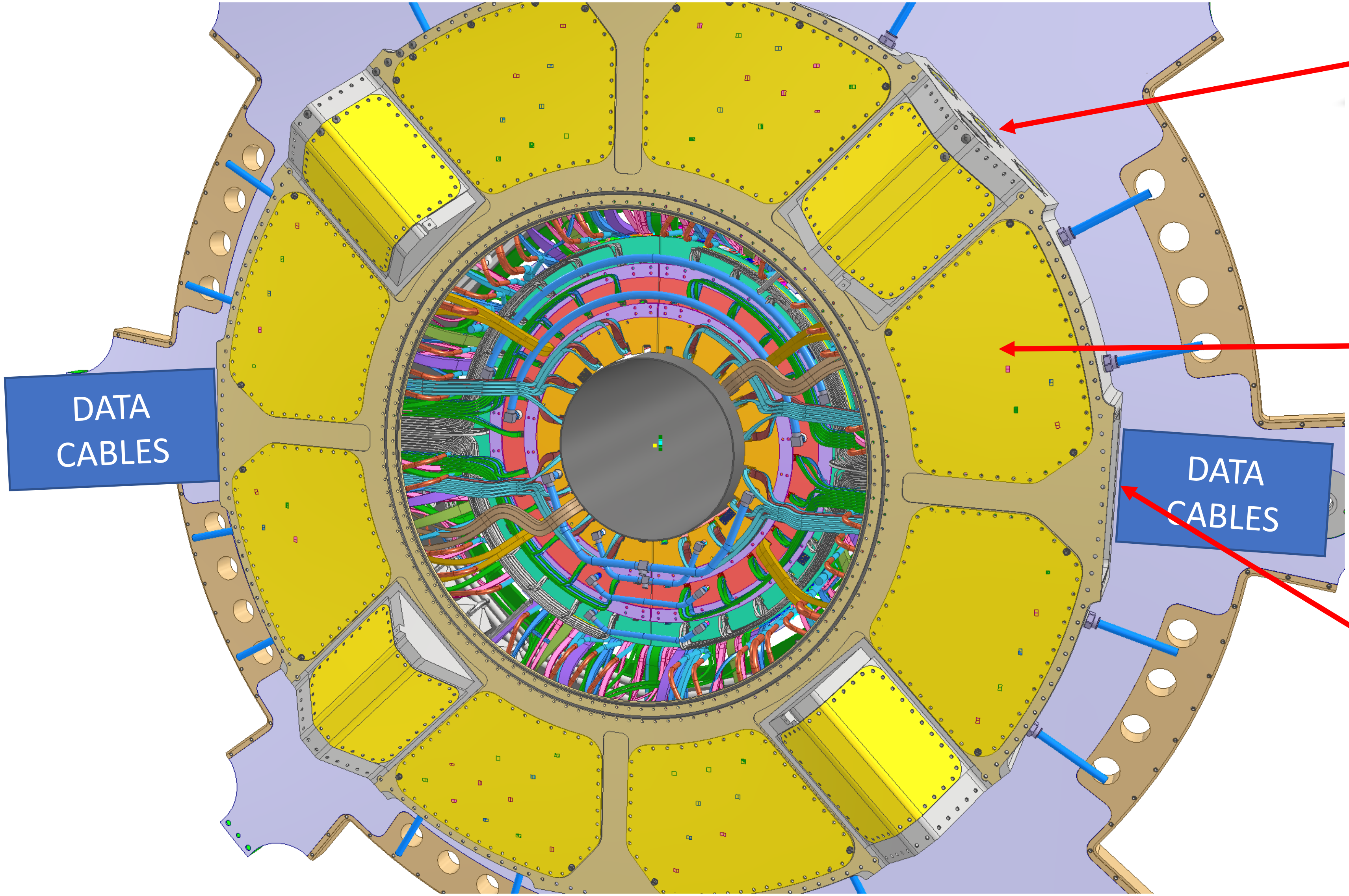
EC CABLES ARE STILL STORED ON THE INSERTION TROLLEYS AND PACKED ALONG Z

INTEGRATION SEQUENCE: EC CABLING



THE EC CABLES, FIRST THE DATA AND THAN THE NON DATA, ARE ROUTED IN THE PP1 VOLUME AND DRESSED IN THE DFT18 & 45.

INTEGRATION SEQUENCE: PP1 OUTER VOLUME CLOSING

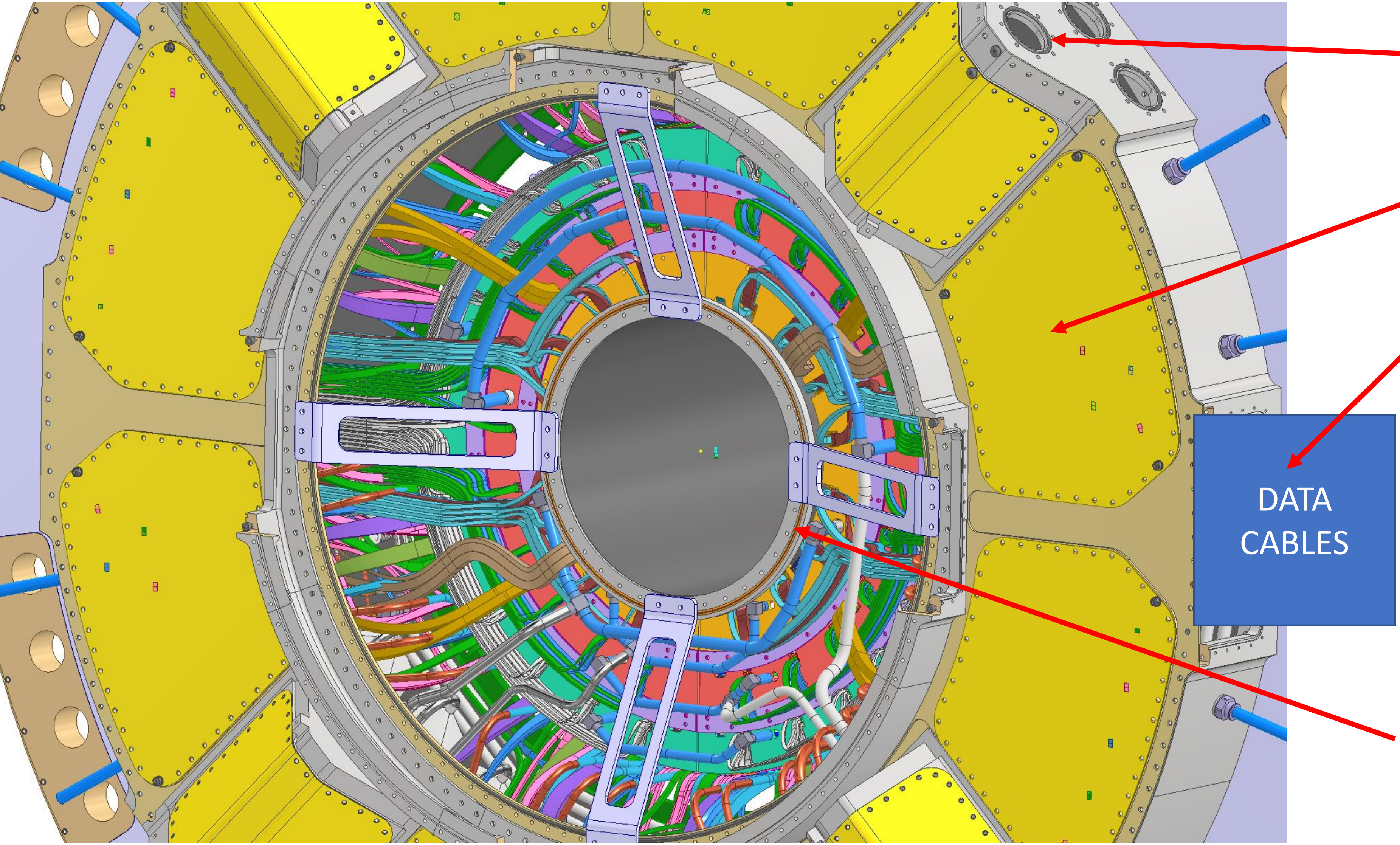


BLANK FLANGES ARE INSTALLED TO CLOSE THE FLEX LINE PORTS

BLANK PANELS ARE INSTALLED TO SEAL PP1

FEEDTHROUGHS HAVE BEEN SEALED WITH RESIN

INTEGRATION SEQUENCE: IST FLANGE BONDING



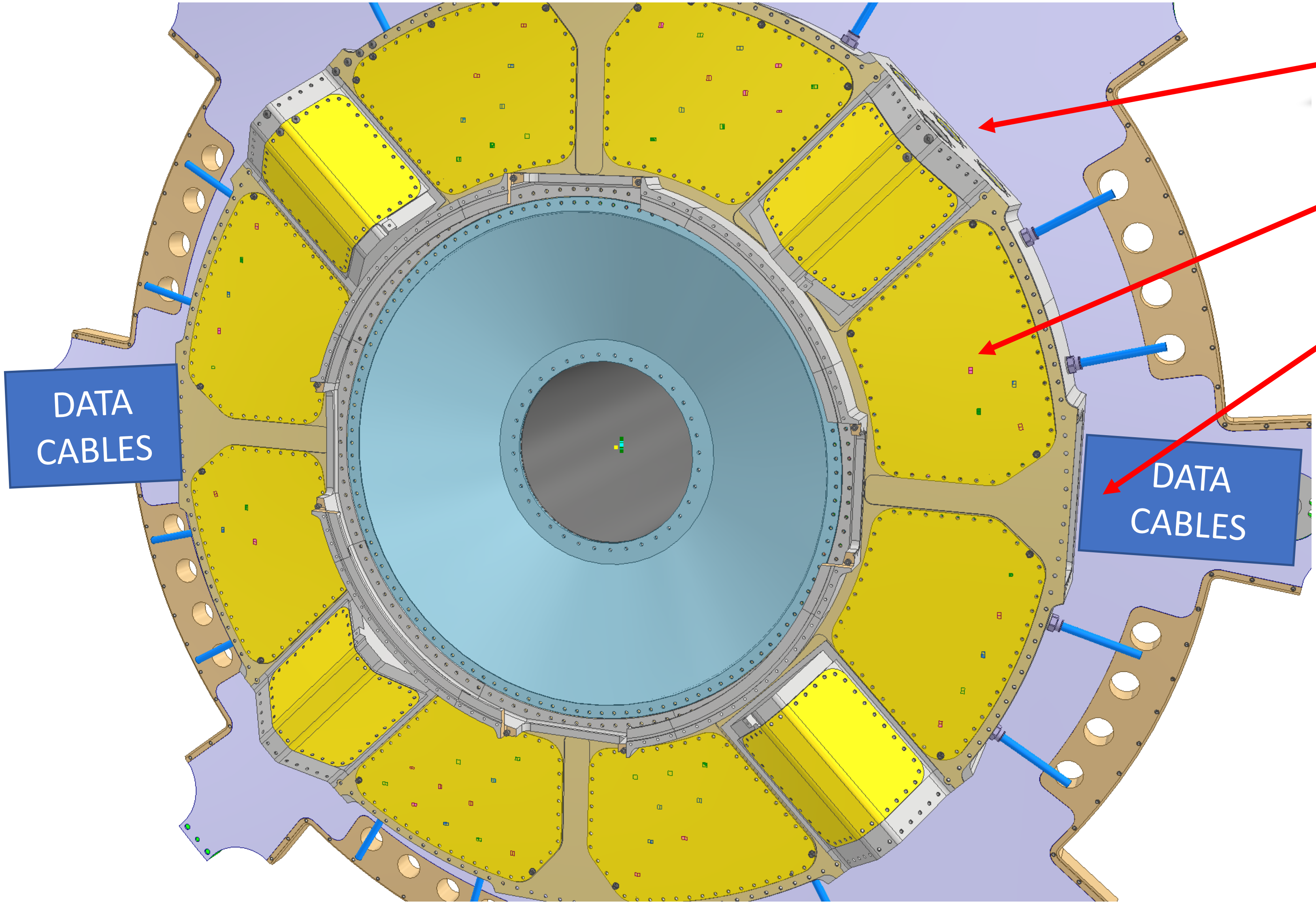
BLANK FLANGES ARE INSTALLED TO CLOSE THE FLEX LINE PORTS

BLANK PANELS ARE INSTALLED TO SEAL PP1

FEEDTHROUGHS HAVE BEEN SEALED WITH RESIN

TOOL INSTALLED TO KEEP IN PLACE THE FLANGE DURING BONDING TO IST

INTEGRATION SEQUENCE: CONICAL DIAPHRAM SEALING



BLANK FLANGES ARE INSTALLED TO CLOSE THE FLEX LINE PORTS

BLANK PANELS ARE INSTALLED TO SEAL PP1

FEEDTHROUGHS HAVE BEEN SEALED WITH RESIN

PRESSURE TEST UP TO 4 mbar

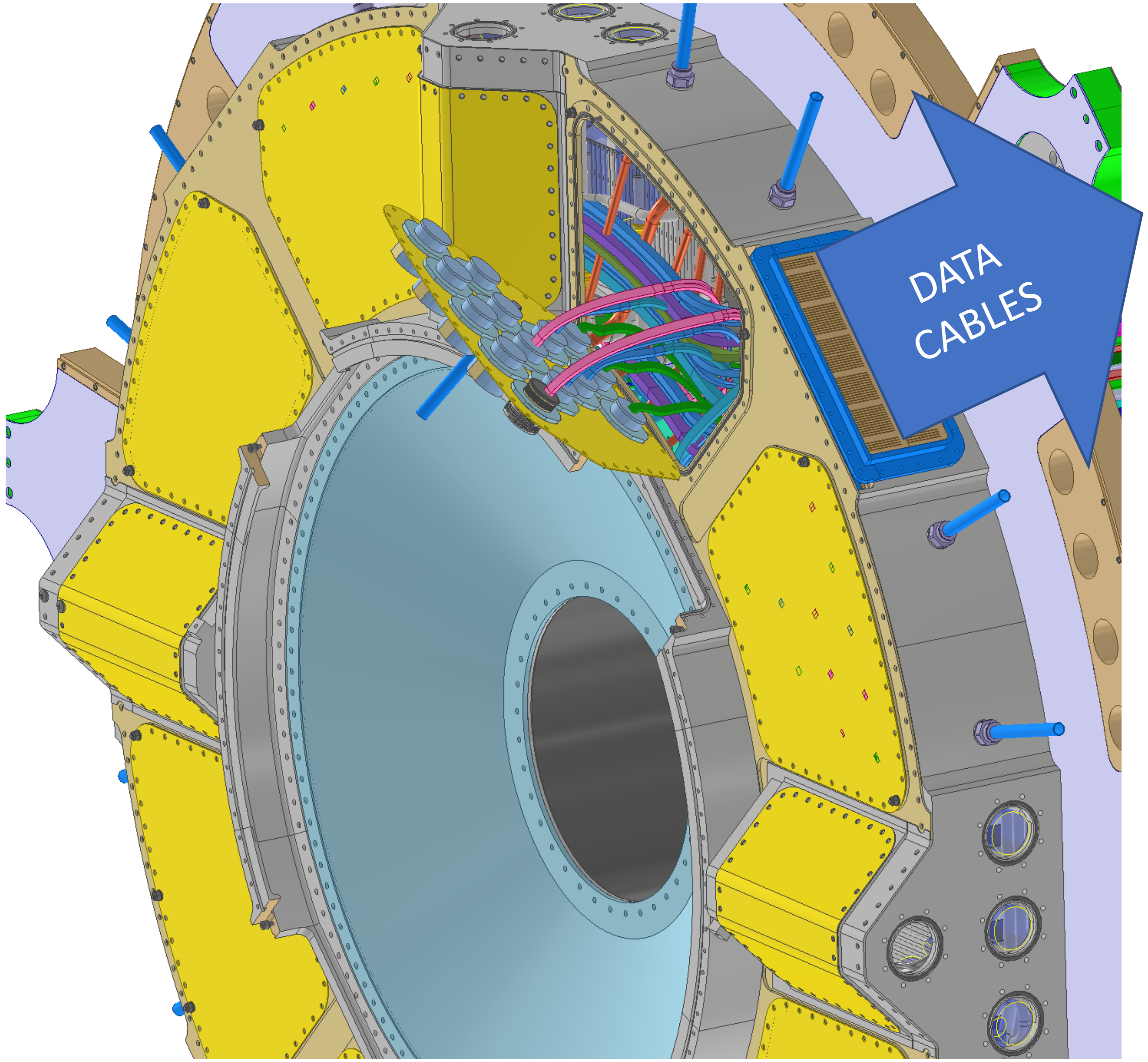
LEAK TEST:

- **-PRESSURE DROP OVER TIME**

OR

- **-TRACING GAS (FREON)**

INTEGRATION SEQUENCE: CONNECTOR INSTALLATION



IF THE PRESSURE TEST IS OK (MAX 4 mbar)

⇩

IF LEAK TEST IS OK

⇩

THAN

⇩

REMOVE ONE BLANK PANEL

⇩

PULL THE HV/LV CONNECTORS OUT

⇩

MOUNT AND SEAL THE CONNECOTRS ON THE PANEL

⇩

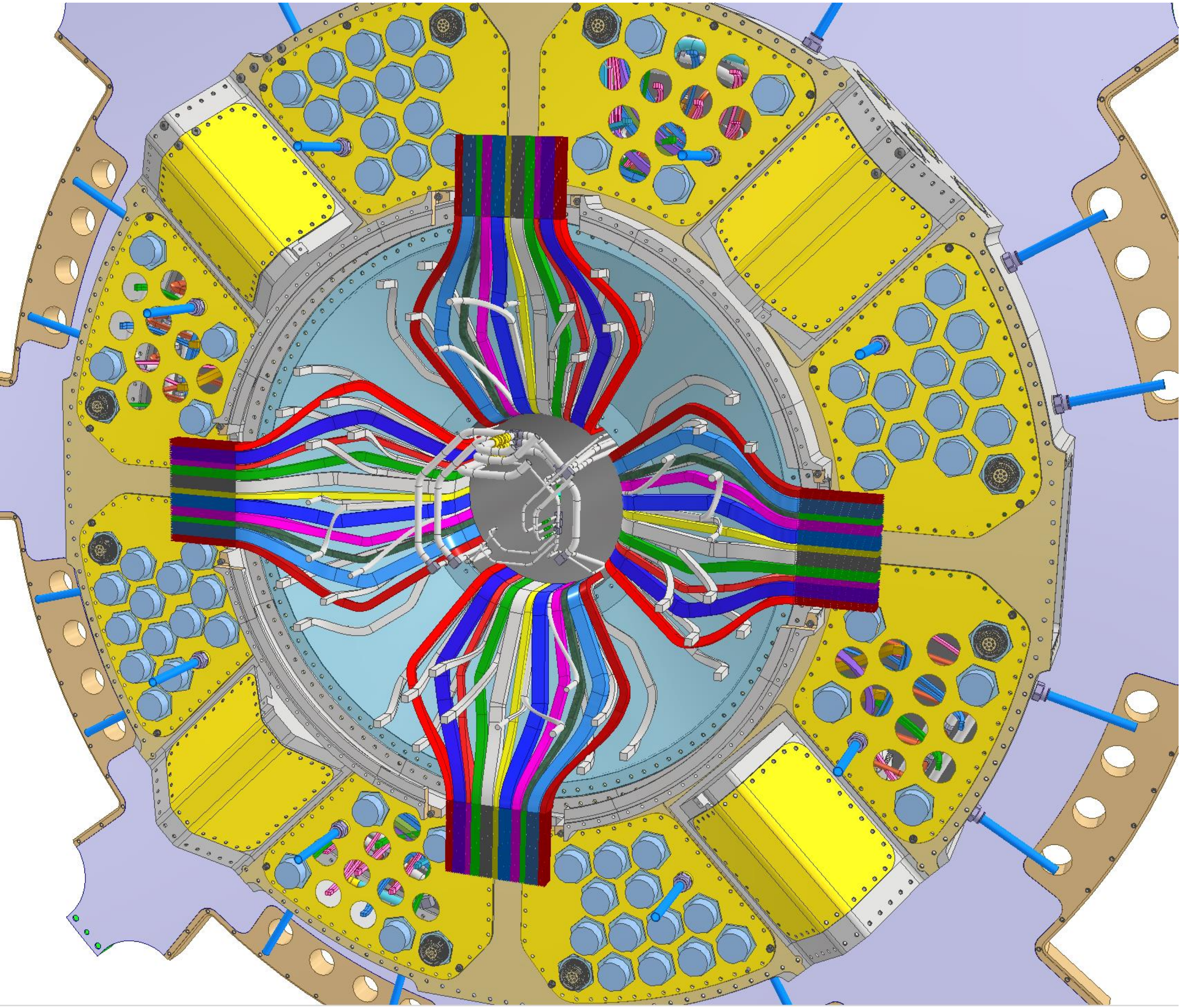
SEAL THE PANEL

⇩

LEAK TEST

Nb: THE PREVIOUS TASKS MUST BE DONE IN PARALLEL ON BOTH SIDES OF THE DETECTOR (A & C)

INTEGRATION SEQUENCE: IS CABLE DRESSING



ONCE THE OUTER VOLUME PANELS ARE ALL INSTALLED, SEALED AND LEAK TESTED

THE INNER SYSTEM CAN BE INSERTED

THE "IS" ENTER THE DETECTOR WITH THE MANIFOLD ALREADY INSTALLED, PRESSURE TESTED AND LEAK TESTED

DATA CABLES ARE ROUTED IN THE PP1 VOLUME AND DRESSED IN THE FEEDTHROUGHS

NON DATA CABLES ARE ROUTED IN THE VOLUME AS WELL

EDDY CURRENT EFFECTS ON PP1 SHELL

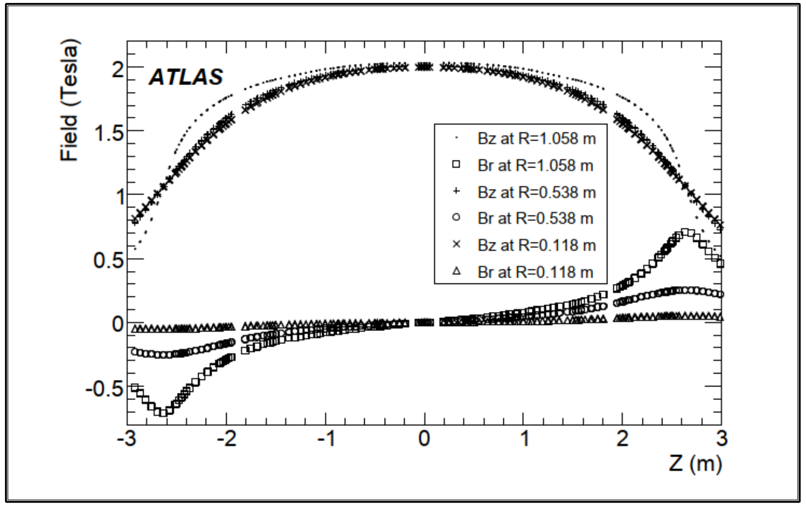
A complete presentation can be found here:

https://indico.cern.ch/event/953539/

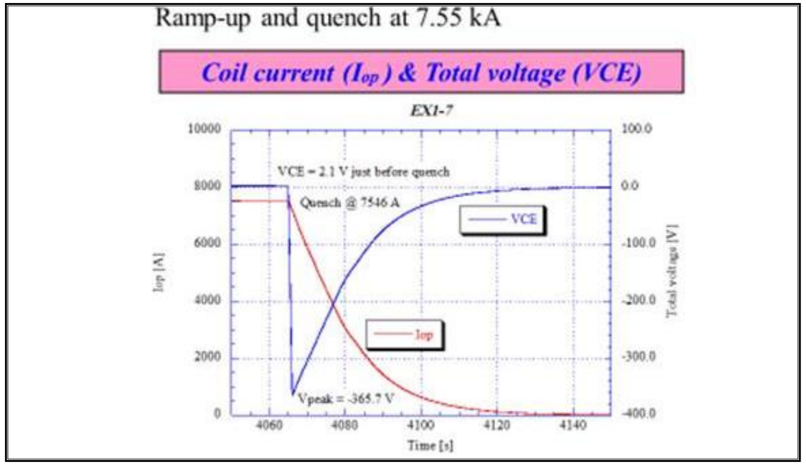
EDDY CURRENT EFFECTS

A detailed FEA can be downloaded here: **https://indico.cern.ch/event/953539/**

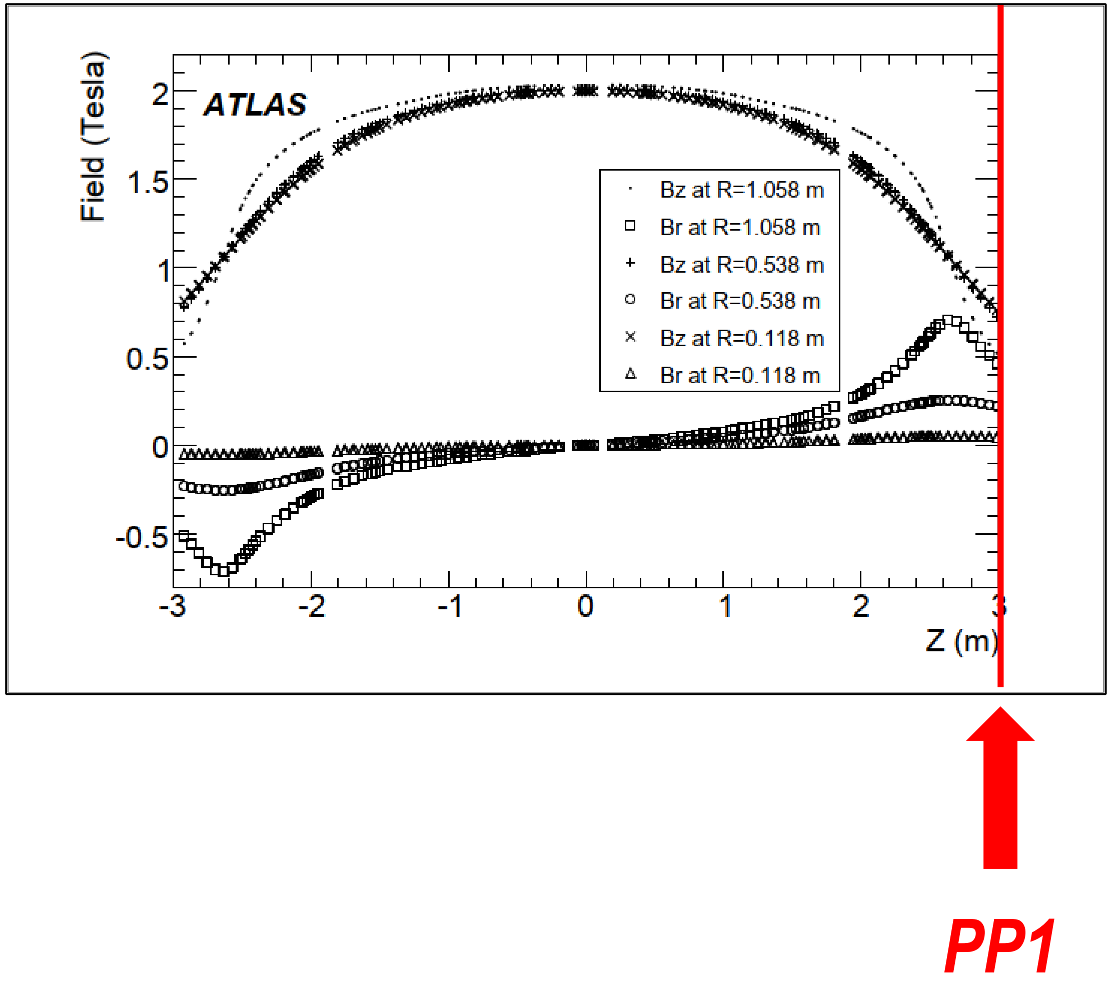
- The solenoid on the cryostat bore is superconductive @ 2T.
- The map of the B-field is available and it gives Bz and Br vs three different radii
- When the magnet quenches a current is induced in any coil that sees a dB/dt with a no-zero cross section.

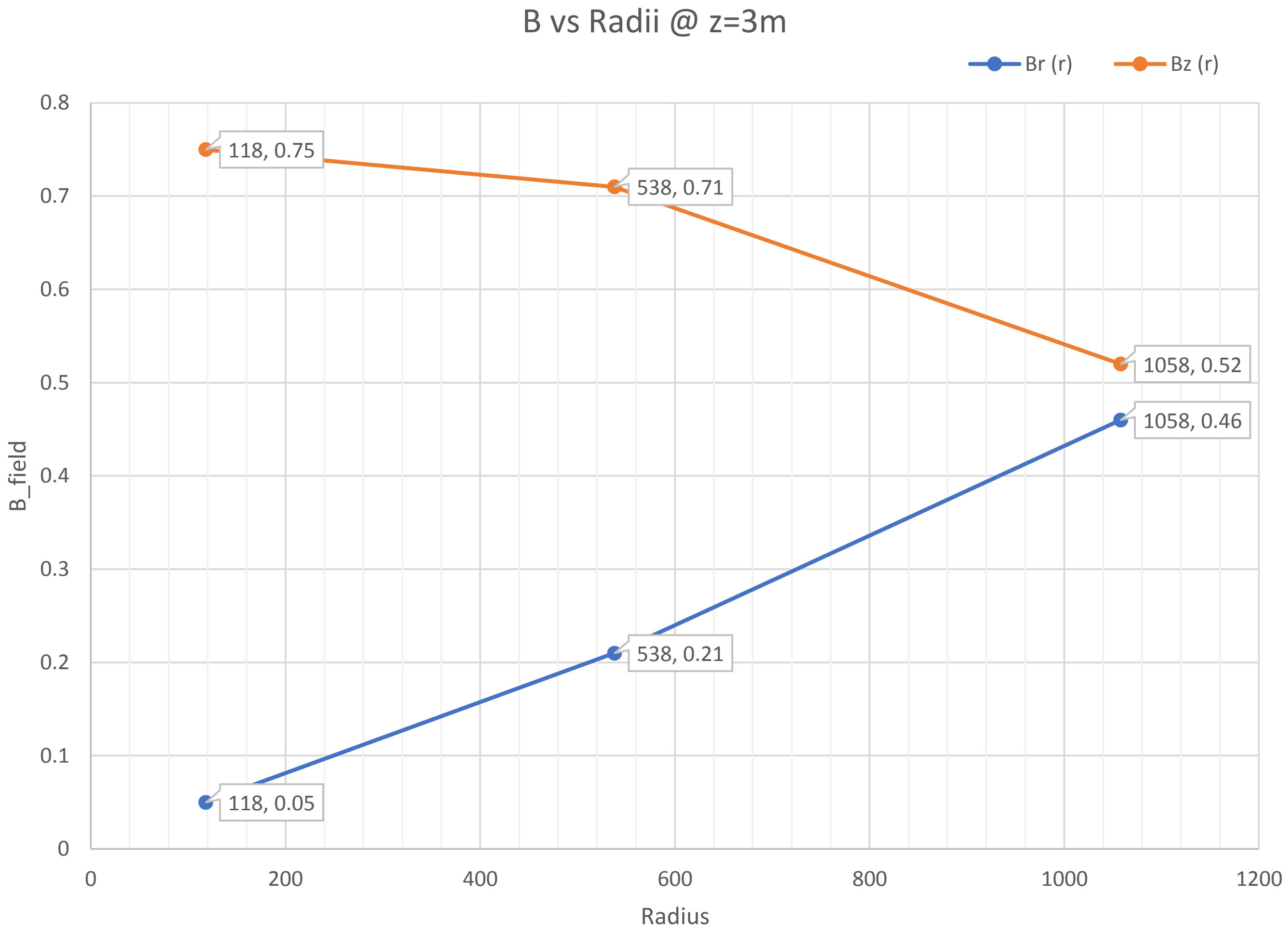


- This is a generic issues for all the components inside the detector. However, at PP1, it is really relevant:
  - dB/dt (as estimated from the plot above) is high: 1T in 10sec ➔ 0.1 T/s
  - PP1 is a low-resistance coil-like structure
  - B-field has a relevant radial component (~ 0.7 T) that can induce an axial force during the quenching. <u>This would tend to ‘push” the PP1 toward IP</u>
  - The Z-component of the B-field induces a radial “NON buckling” force on PP1 cage, indeed

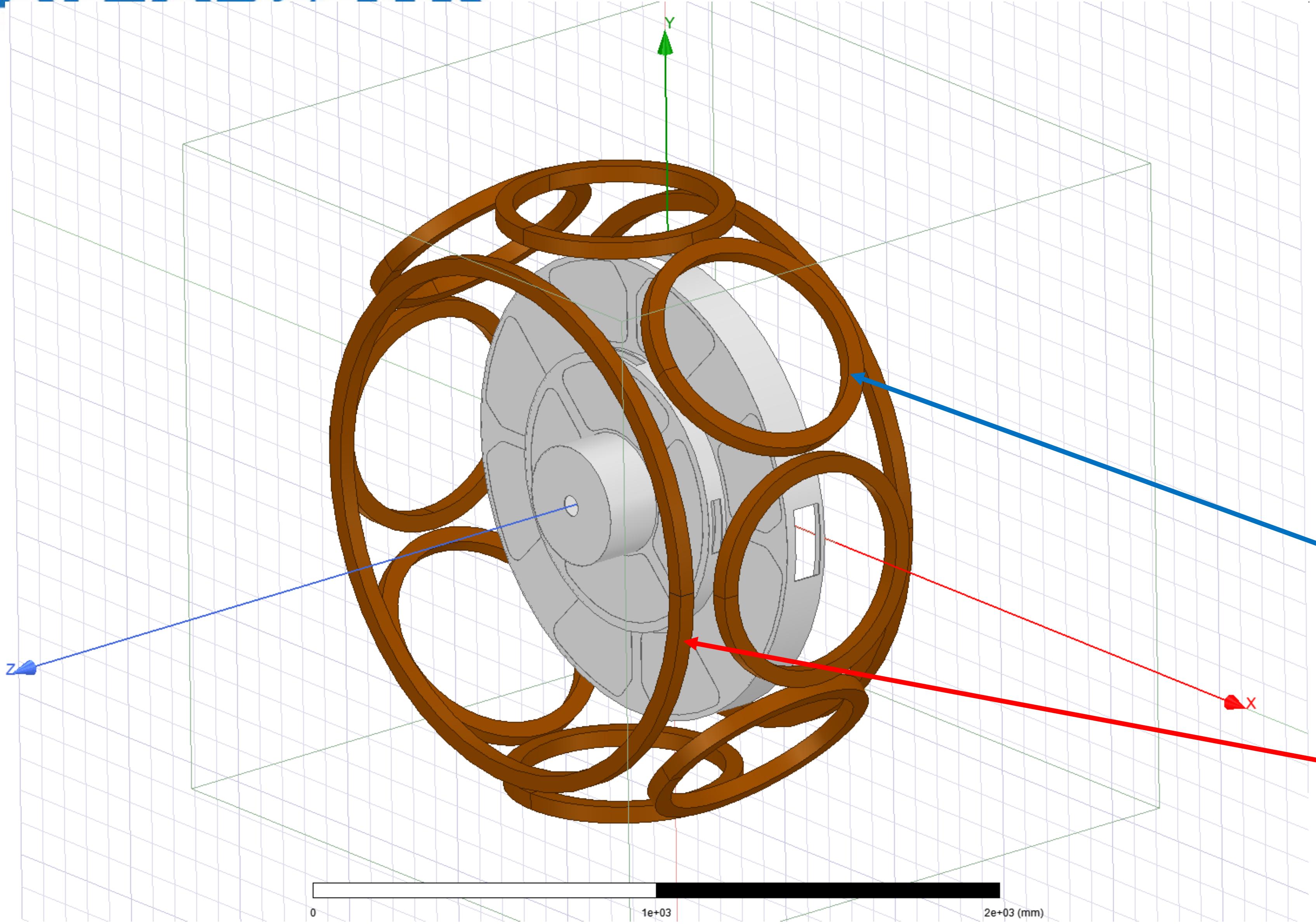


MEASURED ATLAS B_field @ PP1





MAGNETOSTATIC ANALYSIS



The question is:

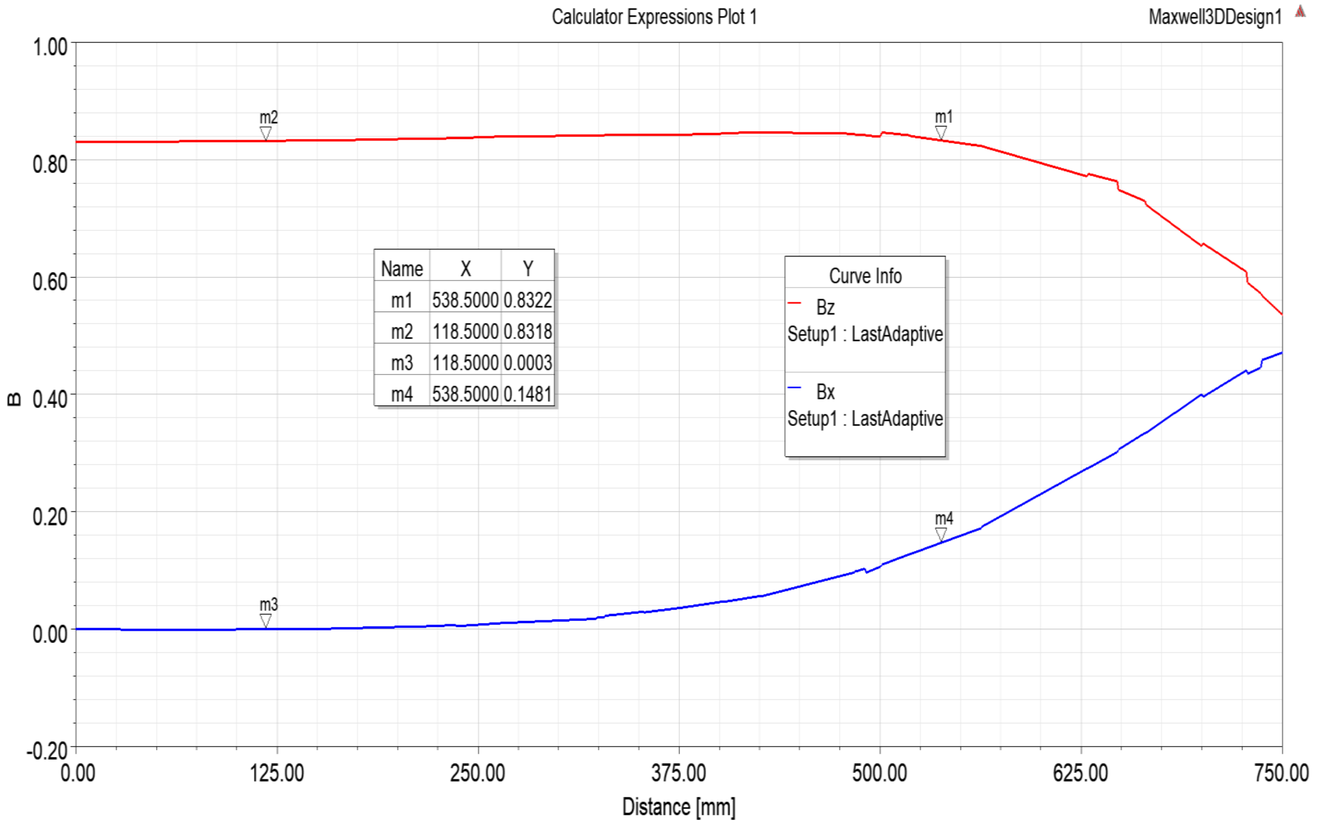
Which current is needed in the coils to have the same B_field map @ PP1?

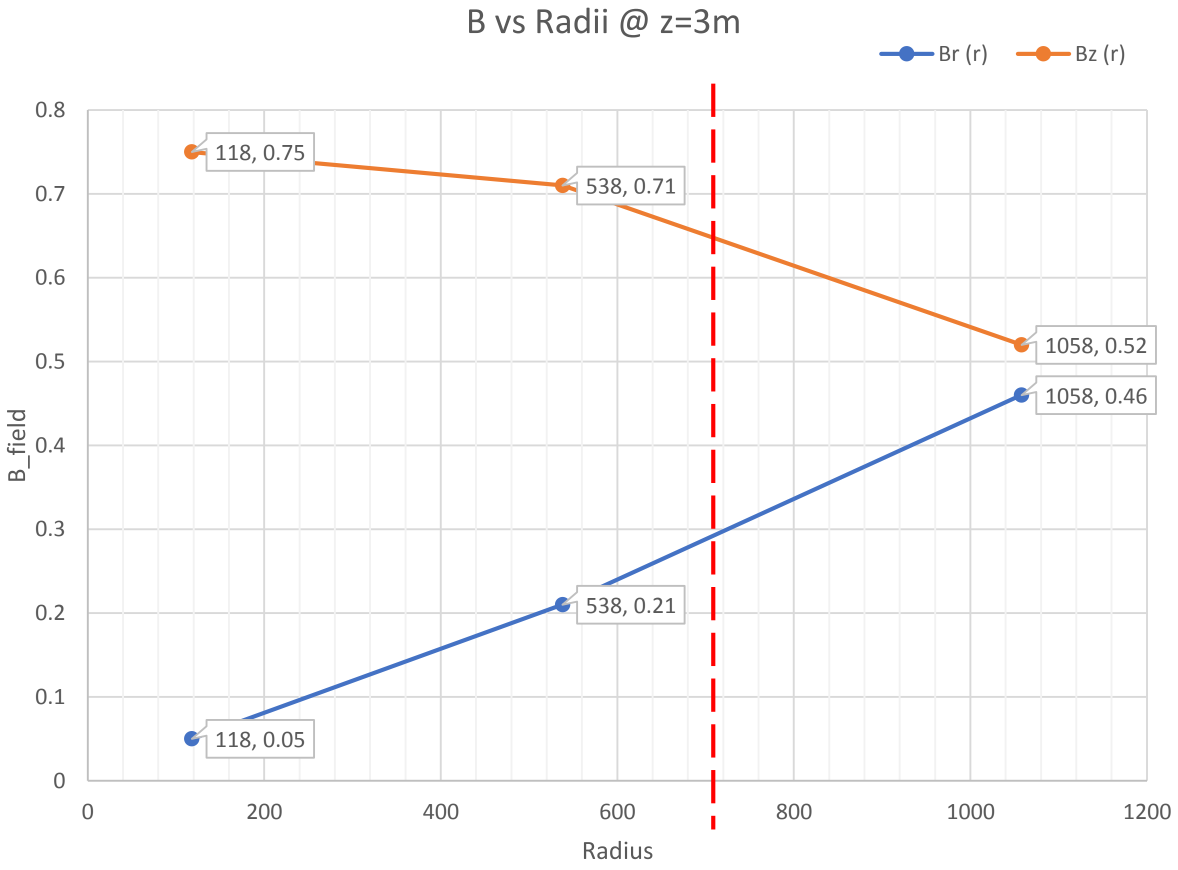
The coil setup is able to generate a magnetic field equivalent to the magnetic field measured inside ATLAS @ Z=3000 mm

8 coils to generate the radial component of B_field (Br)

2 coils to generate the axial component of B_field (Bz)

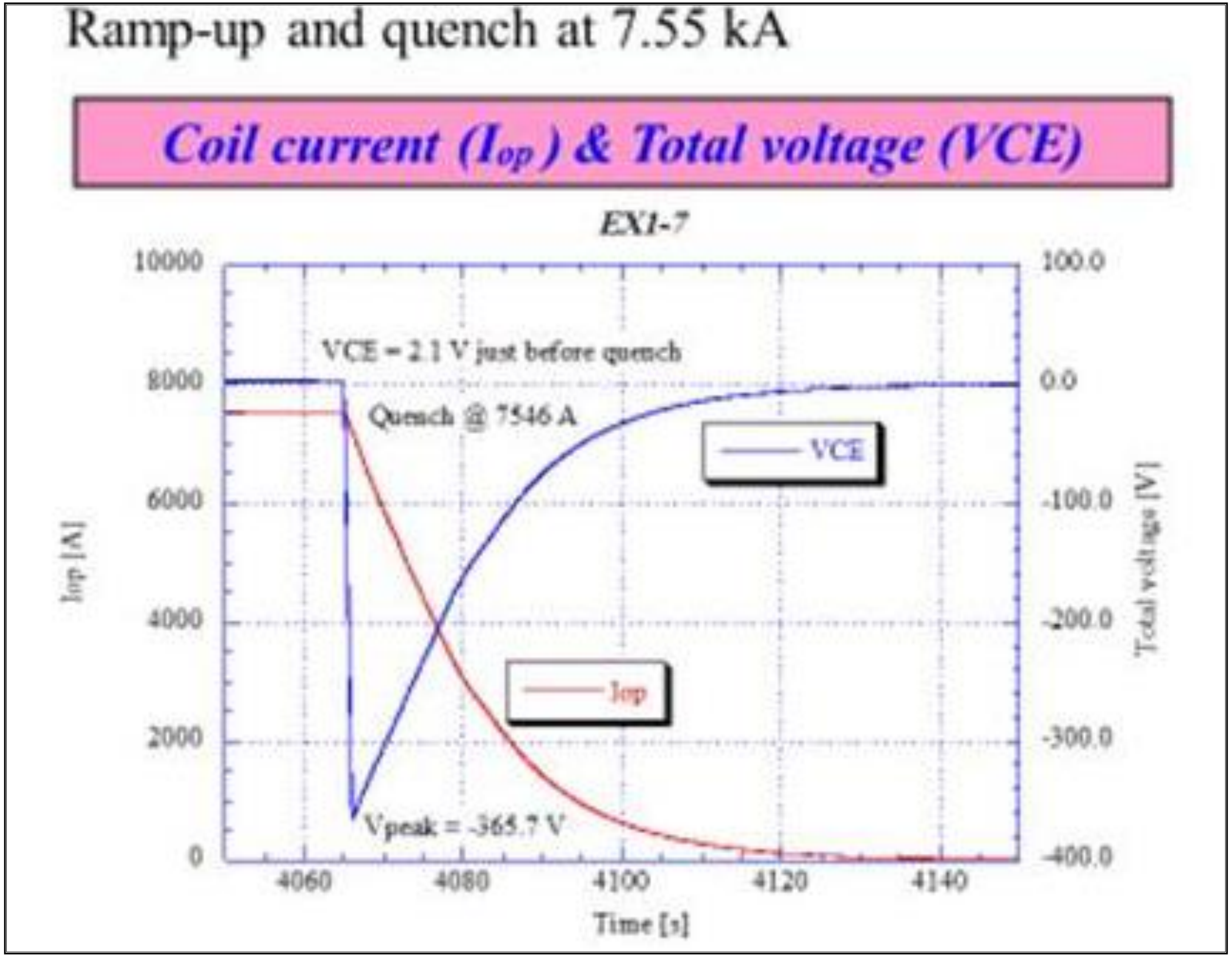
MAGNETOSTATIC ANALYSIS: RESULTS





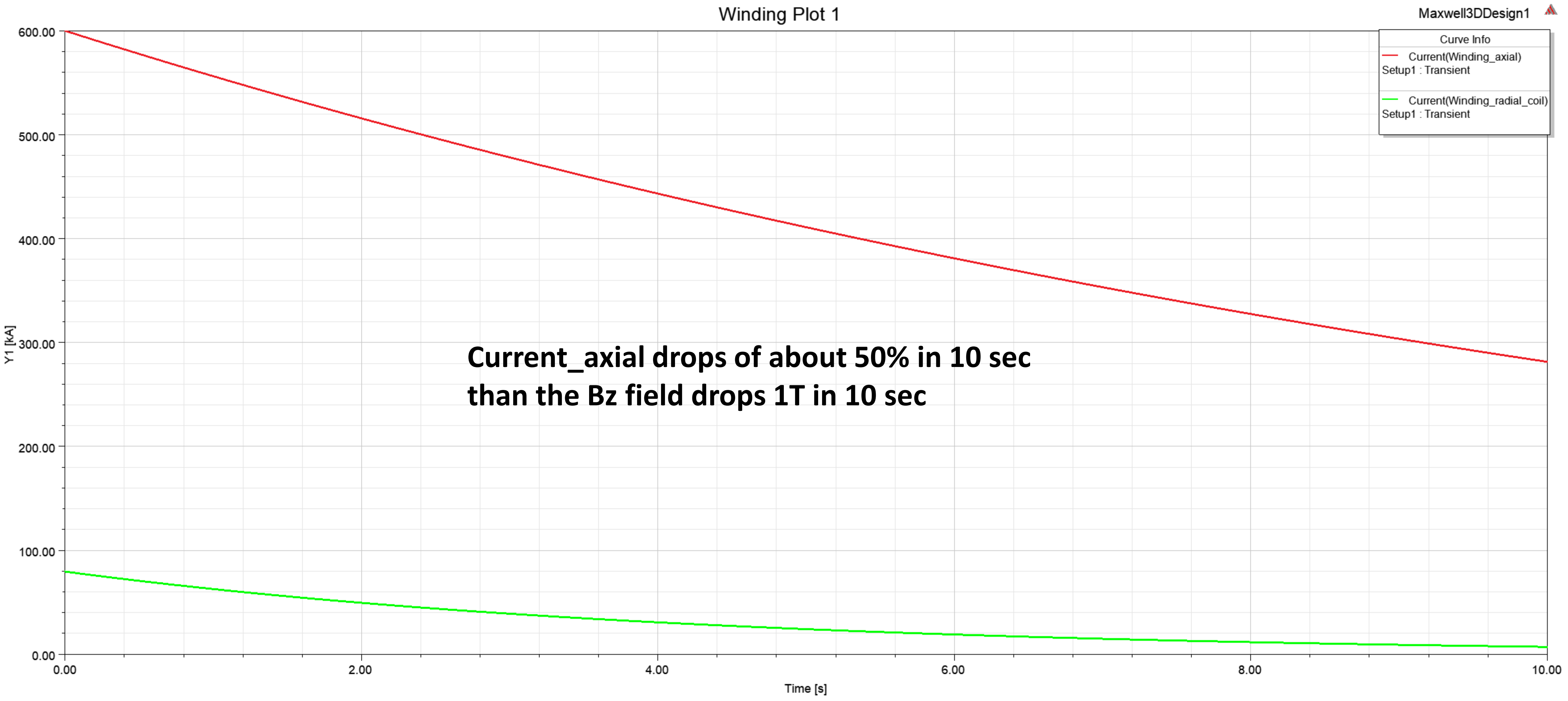
The field distributions above are used as initial conditions in a transient analysis

MAGNET QUENCHING

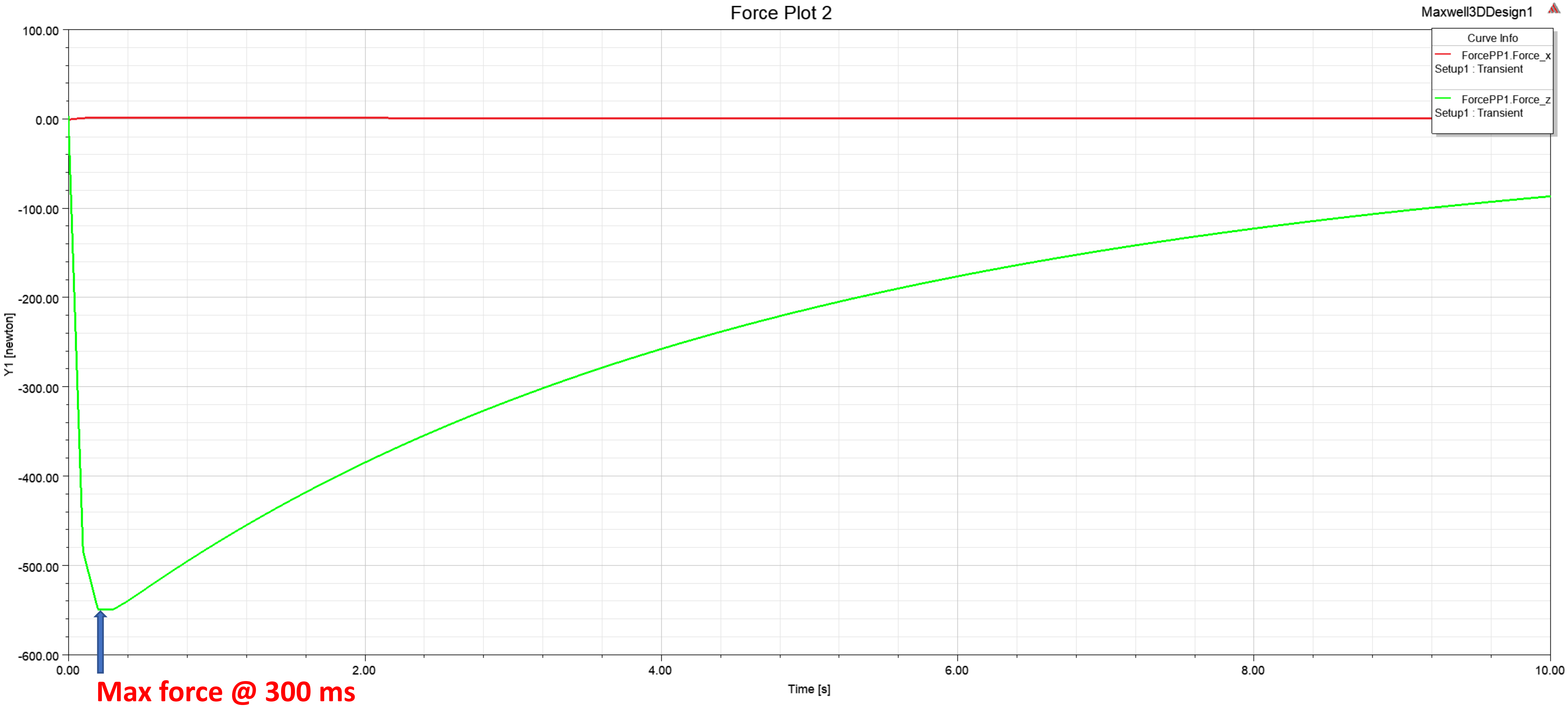


- **During quench the current drops from the maximum to about zero in about 40 sec.**
- **The coils behave like an RL circuit**
- **A time constant $\tau = \frac{L}{R} = 40s$ was considered in the FEA model**
- **The Bz field drops of about 1T in about 10 sec. This is confirmed by the current drop in the next slide.**

TRANSIENT ANALYSIS: COIL CURRENT vs TIME

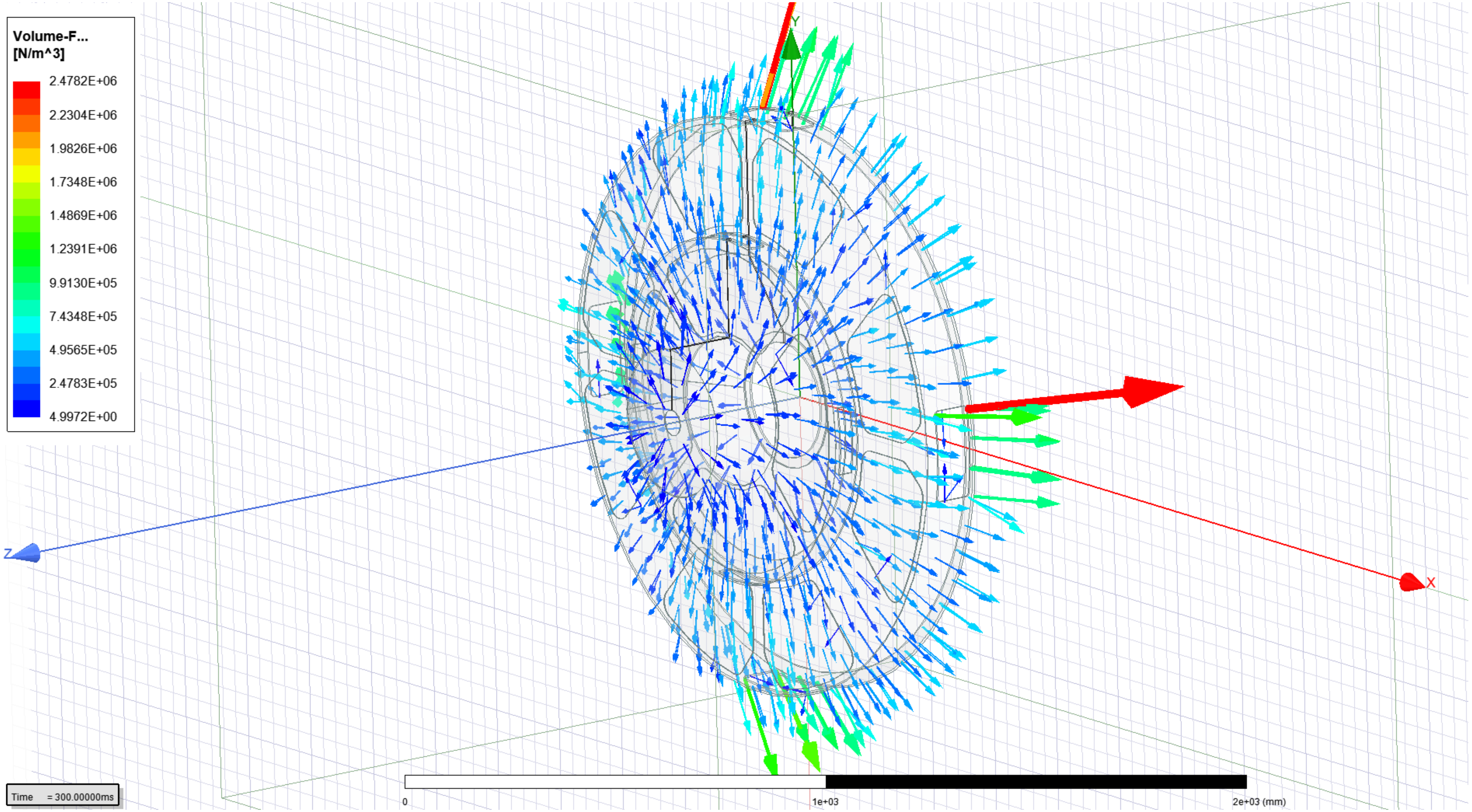


TRANSIENT ANALYSIS: EDDY FORCES



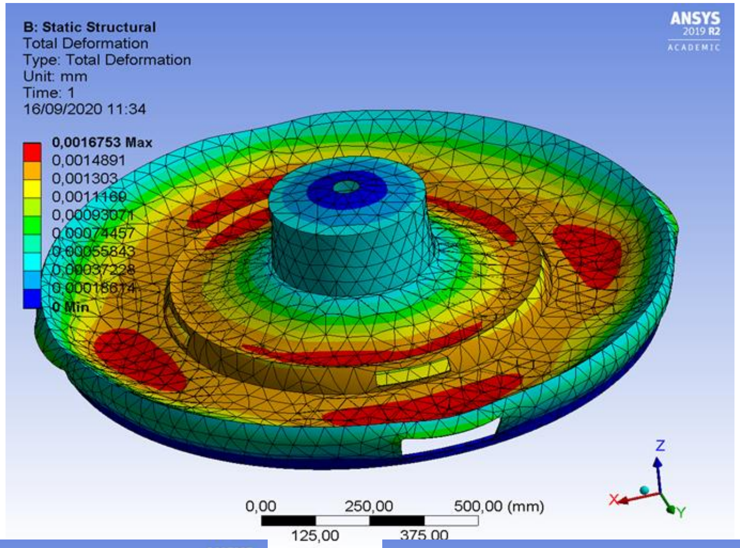
Max force @ 300 ms

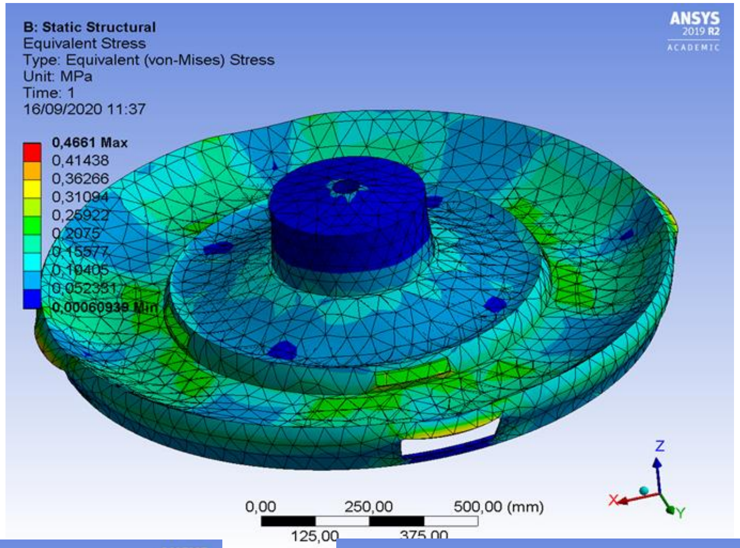
TRANSIENT ANALYSIS: VOLUME FORCE

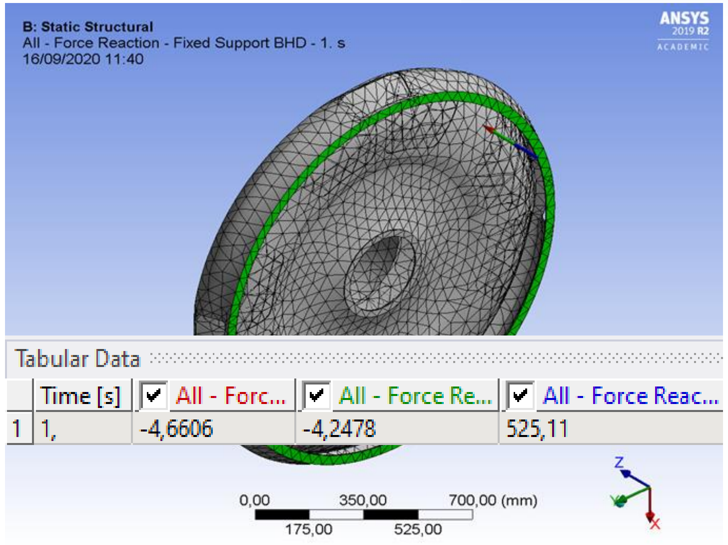


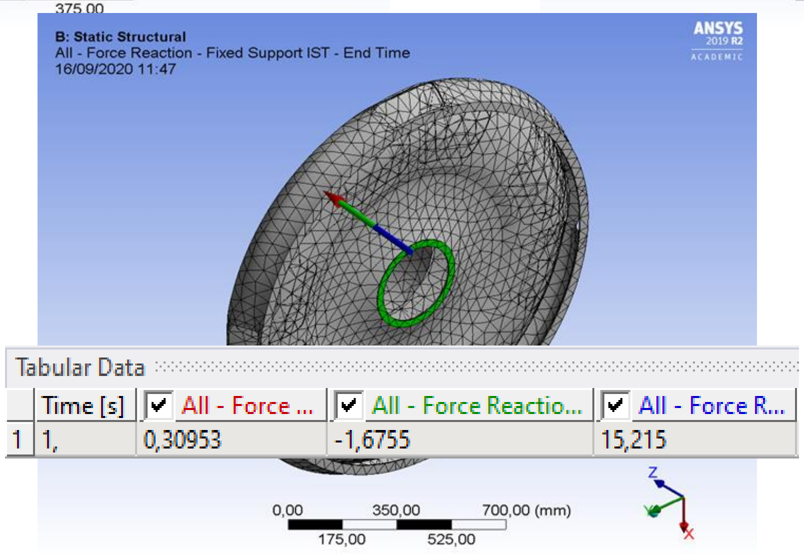
STRESS AND REACTION FORCES @ IPT, IST, BULKHEAD

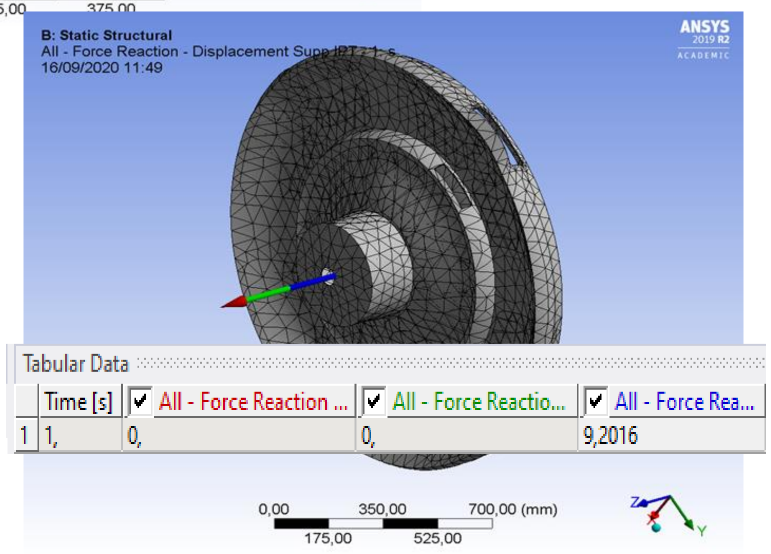
FORCE: [N]
STRESS: [Mpa]
DISPL.: [mm]



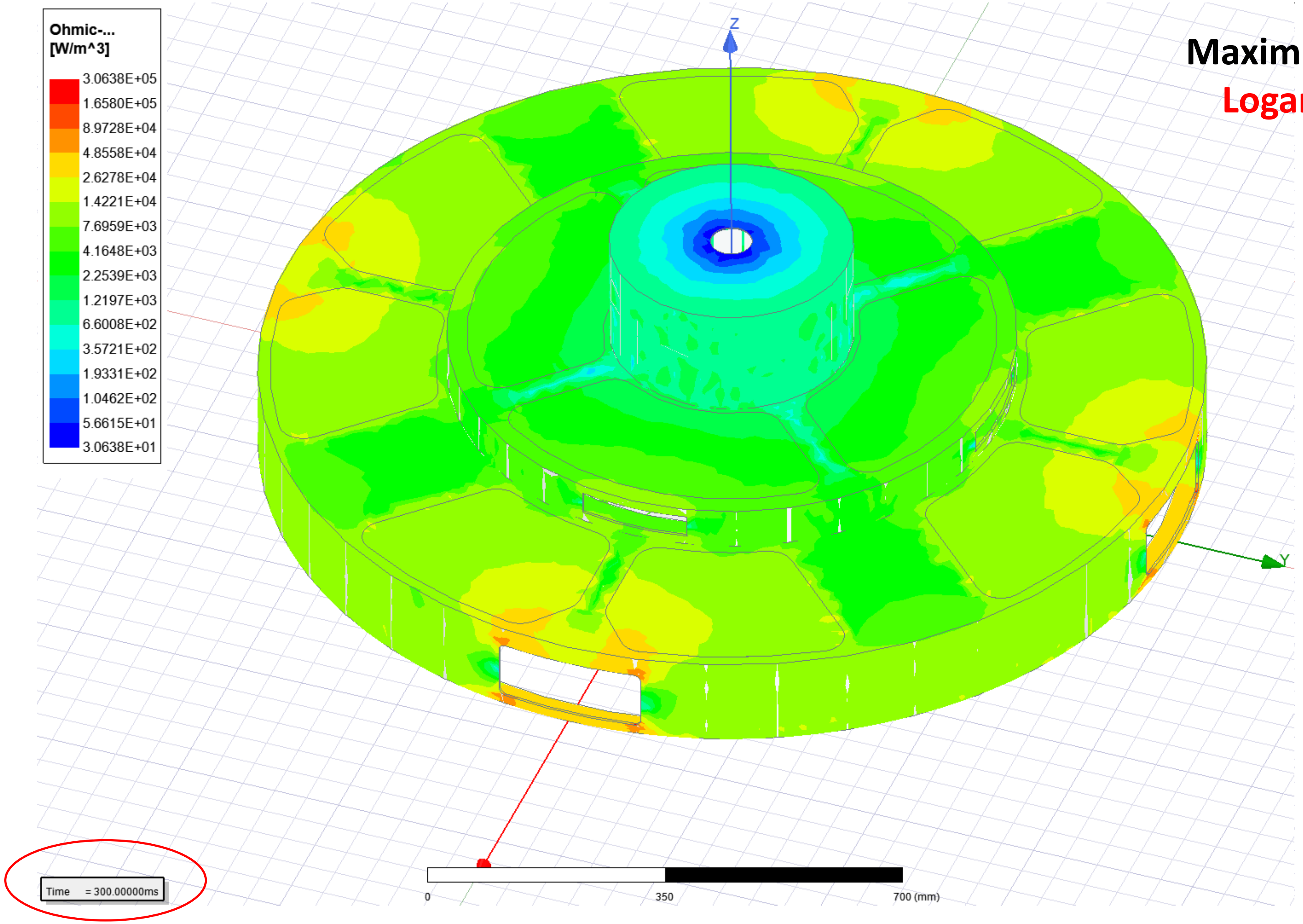








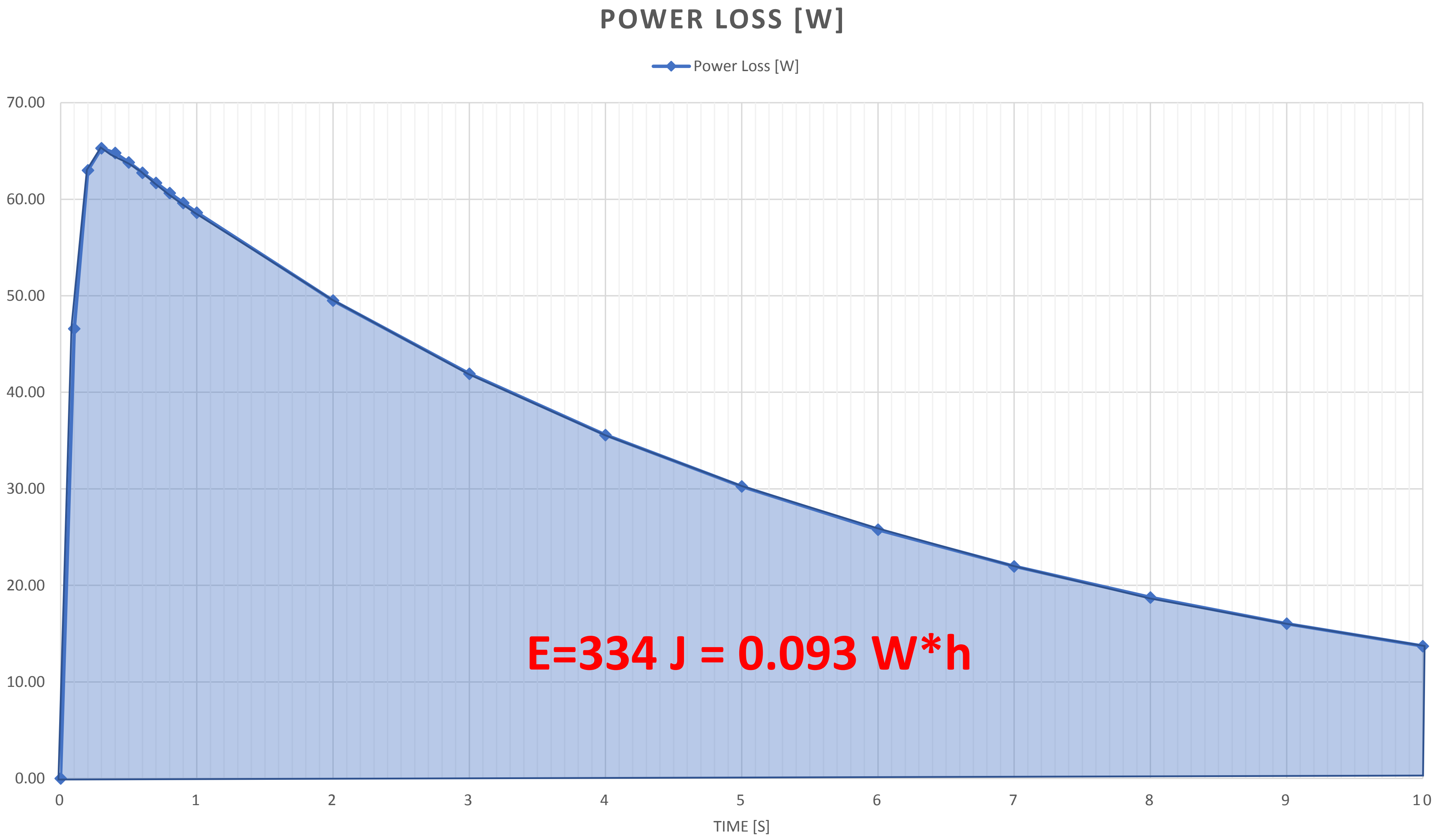
MAXIMUM OHMIC LOSS



Maximum Ohmic loss
Logarithmic scale

POWER LOSS vs TIME

time [s]	Power Loss [W]	ENERGY (J)
0	1.09E-08	
0.1	46.6	2.33E+00
0.2	63	5.48E+00
0.3	65.3	6.42E+00
0.4	64.8	6.51E+00
0.5	63.83	6.43E+00
0.6	62.76	6.33E+00
0.7	61.7	6.22E+00
0.8	60.65	6.12E+00
0.9	59.63	6.01E+00
1	58.62	5.91E+00
2	49.51	5.41E+01
3	41.93	4.57E+01
4	35.58	3.88E+01
5	30.25	3.29E+01
6	25.76	2.80E+01
7	21.97	2.39E+01
8	18.75	2.04E+01
9	16.03	1.74E+01
10	13.71	1.49E+01
		3.34E+02



CONCLUSIONS

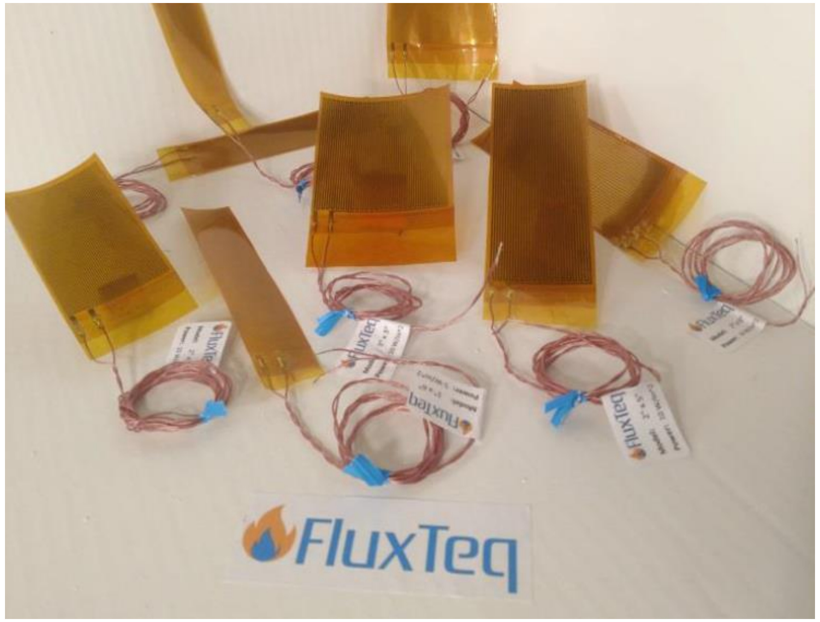
- The Engineering design of PP1 and the services is well developed
- PP1 Integration sequence is well understood
- Additional integration tests will come within the fall using the PP1 mock-up
- Welding process inside PP1 will be tested on the PP1 mock-up
- Major prototypes have been manufactured
  - PP1 real scale Mock-up
  - Data feedthrough full scale mock-up
- The PP1 eddy current effect simulated: heat load and eddy force are well understood
- The feedthrough sealing and leak measurement to be tested on a full scale mock-up is ongoing

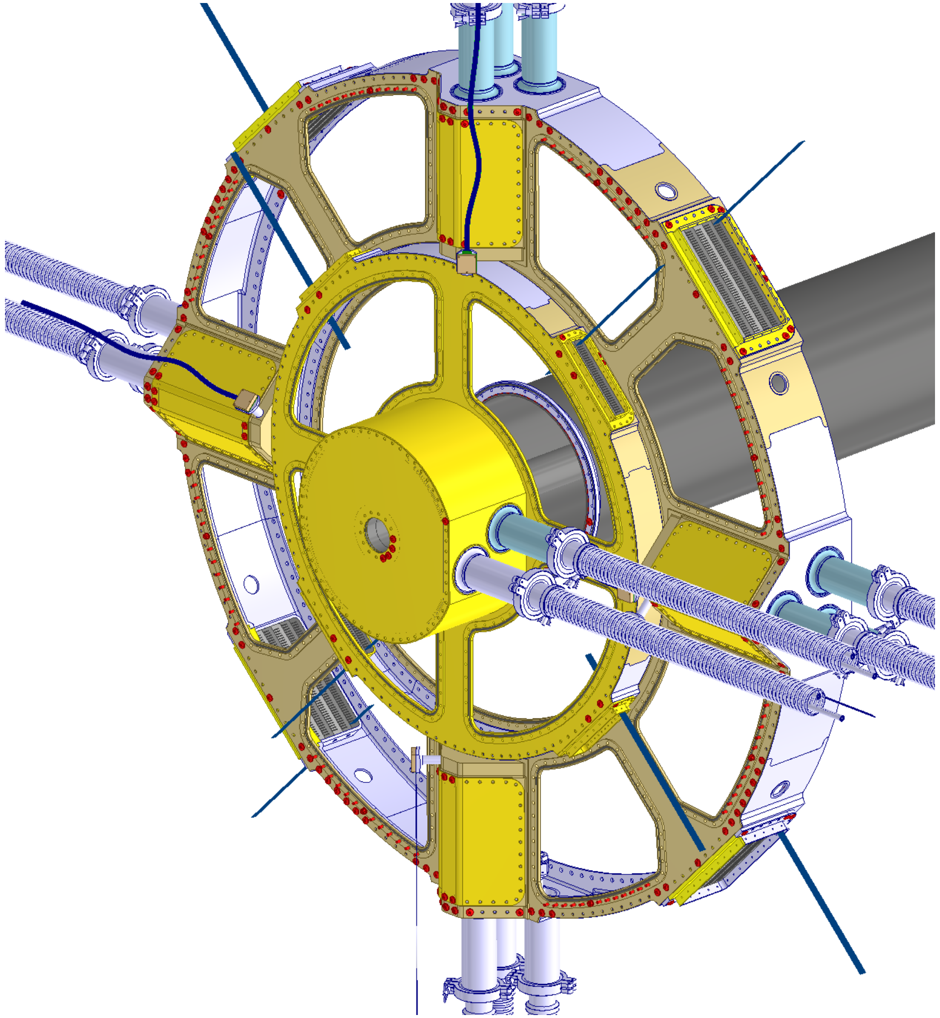
BACKUP SLIDES

TEMPERATURE DISTRIBUTION AT PP1 LEVEL

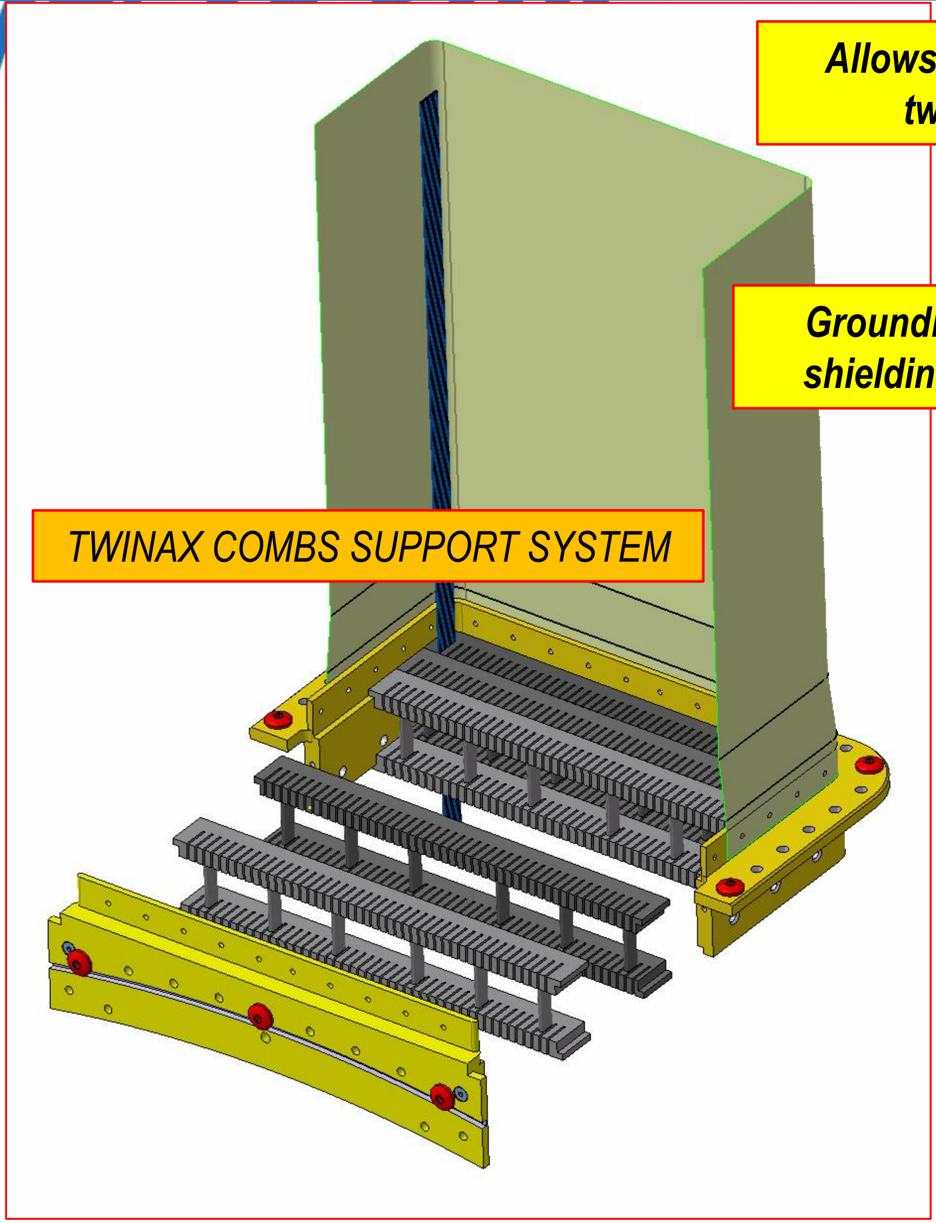
17	6	At the level of the PP1 transition assess the temperature distribution and possible heat transfer between the services and the cooling pipes	X	3	Danilo/Sandro		Setup PP1 group and review this action, prepare a report of current status and plans for PDR follow-up. Report results at FDR		Recommend

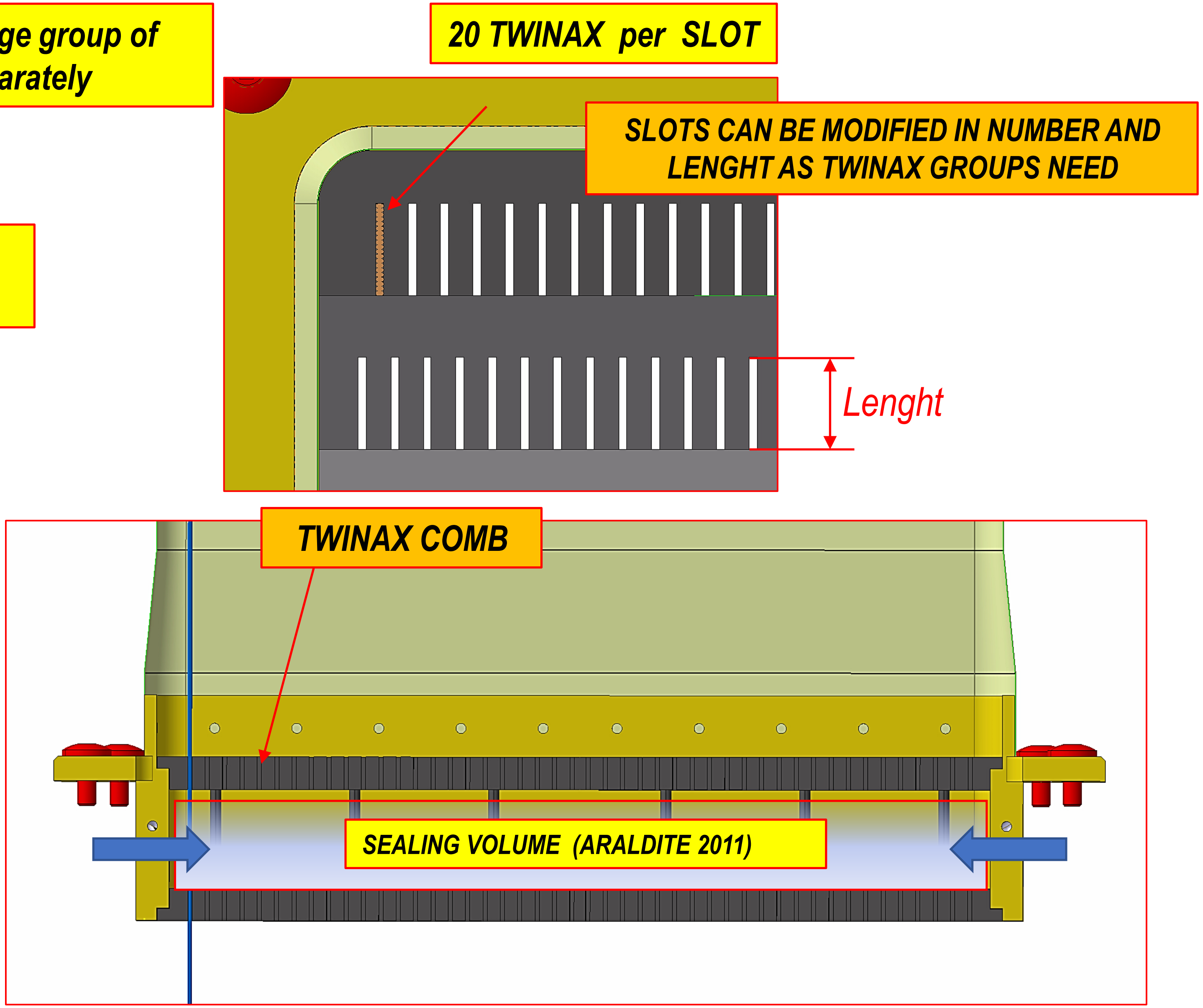
- **Minimum temp inside PP1, in case of system failure, -55 °C**
- **Naked pipes inside PP1, Max Temp inside PP1 without any power dissipation in the cables -38°C**
- **Outside PP1 dew point Temp -30 °C**
- **In case of CO_2 system failure, the temperature of the external shell of PP1 might go under the -30 °C creating condensation.**
- **Kapton Heaters are laminated on the external surface of PP1**





PP1 - DATACABLE FEEDTHROUGH 2/2



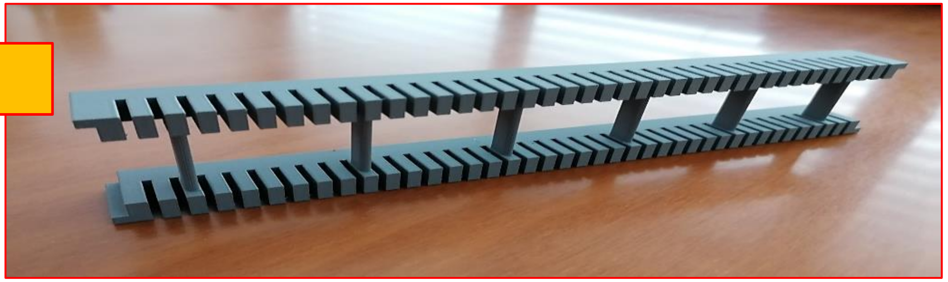


DATACABLE FEEDTHROUGH MOCKUPs

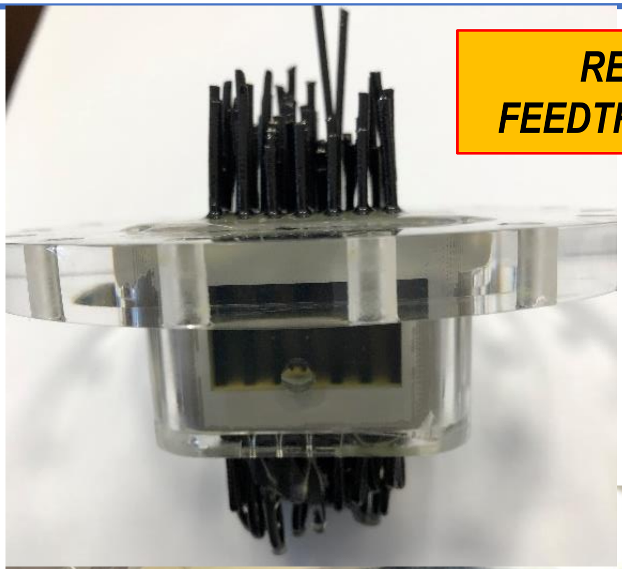
REAL SCALE DATACABLE FEEDTRHOUGH MOCKUP

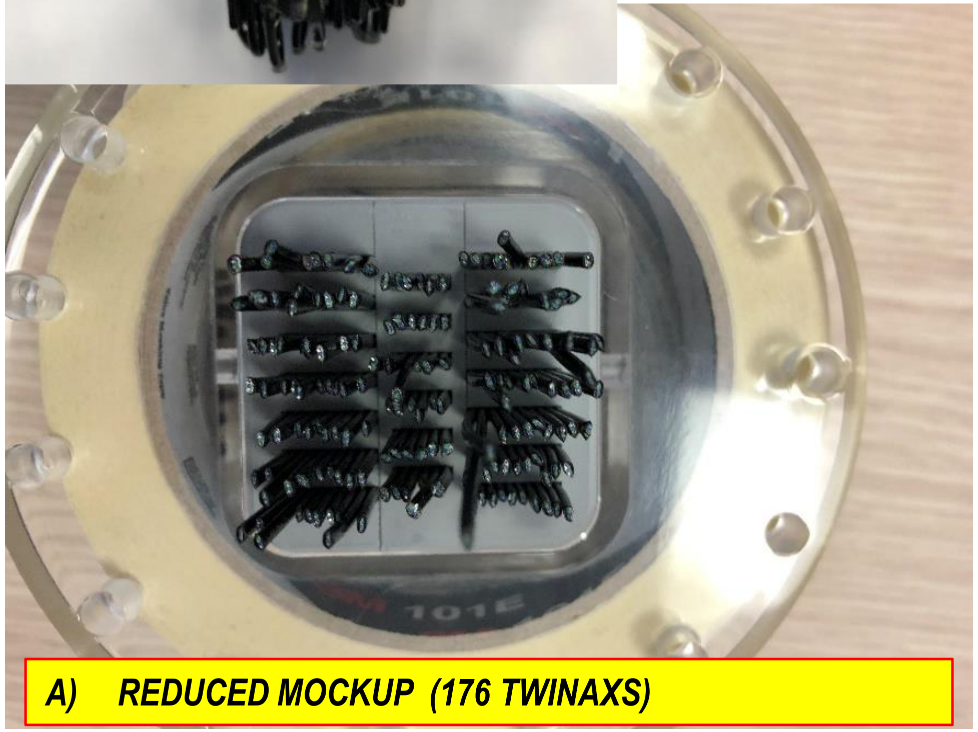
A) FULL SCALE MOCKUP TO CHECK THE TWINAX STACKING
B) ACRYLIC MADE TO CHECK THE FILLING PROCESS

COMB



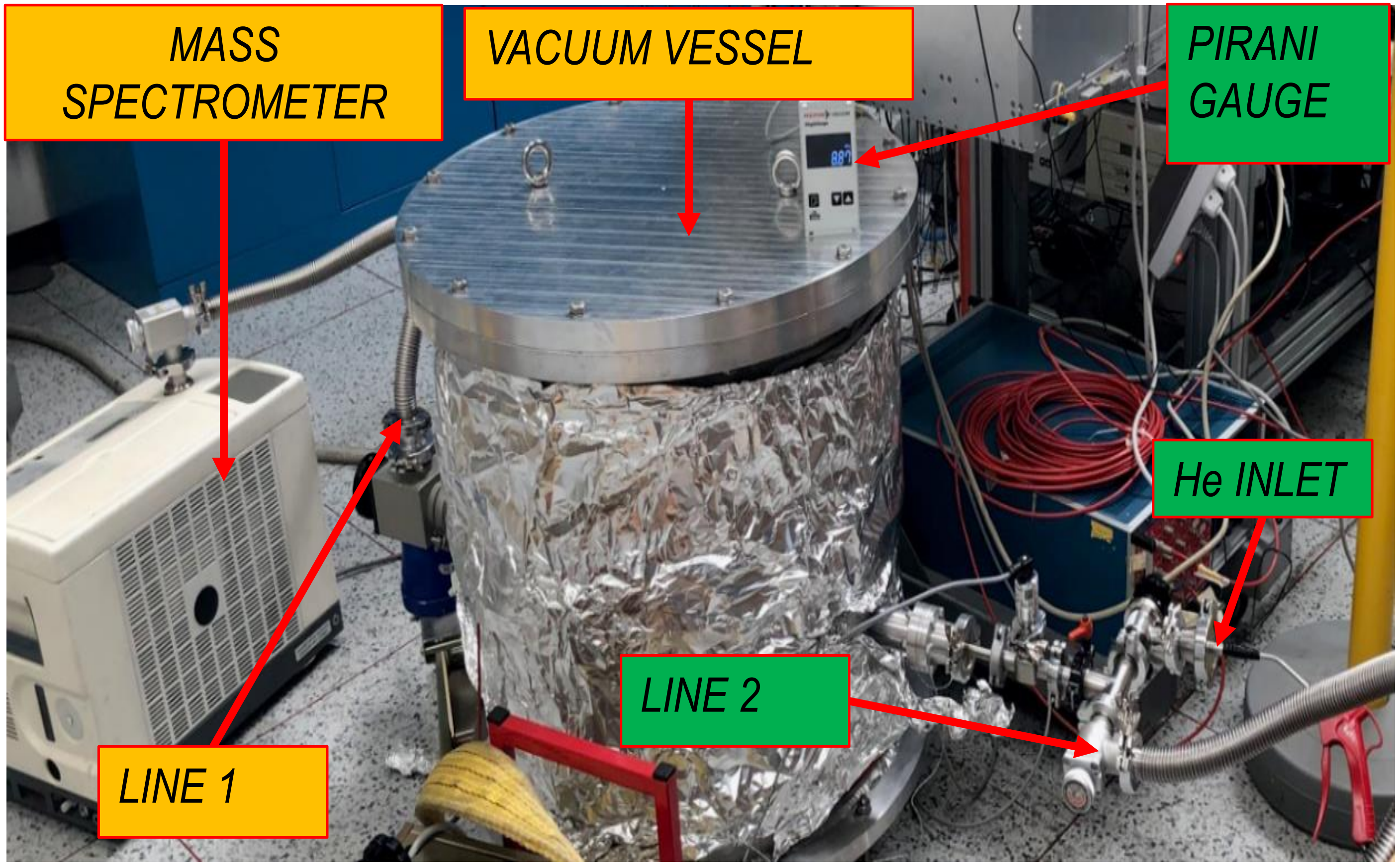
REDUCED DATACABLE FEEDTRHOUGH FOR LEAK TEST

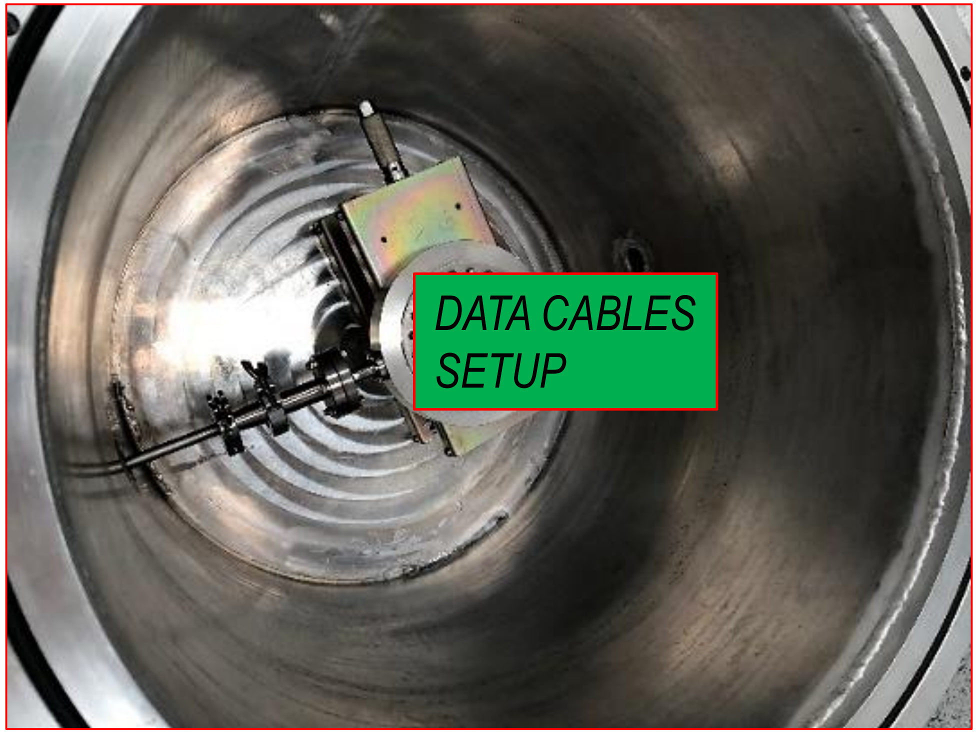




A) REDUCED MOCKUP (176 TWINAXS)

FULL SCALE DFT MOCKUP AND LEAK RATE MEASUREMENTS





THE LEAK RATE OF FEEDTHROUGH WILL BE MEASURED WITH THE HELIUM DETECTION METHOD:

1. ***Vacuum on both lines.***
2. ***Flushing Helium at 1 bar in line 2 (inside the data cables setup).***
3. ***Read the leak rate on mass spectrometer (line1).***