



RFD – Cryogenic Instrumentation

CRG WP9 working review #2

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General information – production strategy

Reminder: we will have 5 DQW+5 RFD modules fabricated for LHC (8 operational and 1+1 spares).

Apart of above before series production for LHC there are 2 prototypes of CC:

- 1 DQW (already in SPS) – CERN fabrication
- 1 RFD (production starting) – Daresbury UK

Series production and instrumentation strategy:

5 RFD to be produced by TRIUMF Canada

4 DQW to be produced by Daresbury UK

1 DQW to be produced by CERN

Instrumentation strategy: 2 prototypes and 3 series modules (one module from each producer) will be fully equipped with instrumentation.

Remaining 7 series modules will be equipped with reduced instrumentation.

Thermometers summary table – RFD proto.

The thermometers quantity/cryomodule. Table 1 shows proposal for RFD prototype. Table 2 for HL-LHC series cryogenic needs (to be agreed with BE-RF).

Table 1:

type	regulation (nominal)				c-d regul.				interlock				monitoring				total				total
	Lhe	vac 5 K	vac 50 K	air	Lhe	vac 5 K	vac 50 K	air	Lhe	vac 5 K	vac 50 K	air	Lhe	vac 5 K	vac 50 K	air	Lhe	vac 5 K	vac 50 K	air	
CERNOX	2	2				4								14	6		2	20	6		28
PT100												2			4				4	2	6

Table 2:

type	regulation (nominal)				c-d regul.				interlock				monitoring				total				total
	Lhe	vac 5 K	vac 50 K	air	Lhe	vac 5 K	vac 50 K	air	Lhe	vac 5 K	vac 50 K	air	Lhe	vac 5 K	vac 50 K	air	Lhe	vac 5 K	vac 50 K	air	
CERNOX	2	2				4								14	6		2	6			8
PT100												2			2/4				2	2	4

Delivery dates:

First batch for one cryomodule will be needed in October 2020. The remaining part shall be available during 2021 (9 cryomodules to be fabricated 4+1 DQW and 4 RFD with 1 proto as a spare).

Remarks:

- Installation definition for specific TTs is under definition (screwed or glued), required cable length will be 4 m.
- Detailed specification of instrumentation will be sent in May 2020 at latest.
- In KB opinion a few PT100 are missing to cover monitoring+interlock on tuners and blades (installed in air).

Thermometers summary table – RFD proto.

Full version (per module):

28 cernox is confirmed (27 channels, 1 redundant TT included)

- 8 for regulation (7 channels needed, 1 redundant TT included)
- 19 for monitoring

At least 4 cernox are to be precisely calibrated (LHe and BS)

21 PT100 is confirmed (19 channels, 4 redundant TTs included)

- 16 for regulation (12 channels, 4 redundant TTs included)
- 5 for monitoring

Reduced series version (per module):

13 cernox is confirmed (12 channels, 1 redundant TT included)

- 8 for regulation (7 channels needed, 1 redundant TT included)
- 5 for monitoring

At least 4 cernox are to be precisely calibrated (LHe and BS)

16 PT100 is confirmed (12 channels, 4 redundant TTs included)

- 16 for regulation (12 channels, 4 redundant TTs included)

Sum calculation for TTs

Full version:

28 cernox * 4 modules = 112
(16 of 112 precisely calibrated)

21 PT100 * 4 modules = 84

Reduced series version:

13 cernox * 7 modules = 91

16 PT100 * 7 modules = 112

Total:

Cernox: $112 + 91 = 203$
(16 of 203 precisely calibrated)

PT100: $84 + 112 = 196$

Delivery dates:

First batch for one cryomodule will be needed in October 2020. The remaining part shall be available during 2021.

Next steps

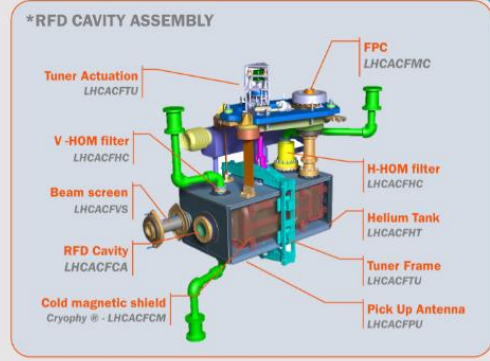
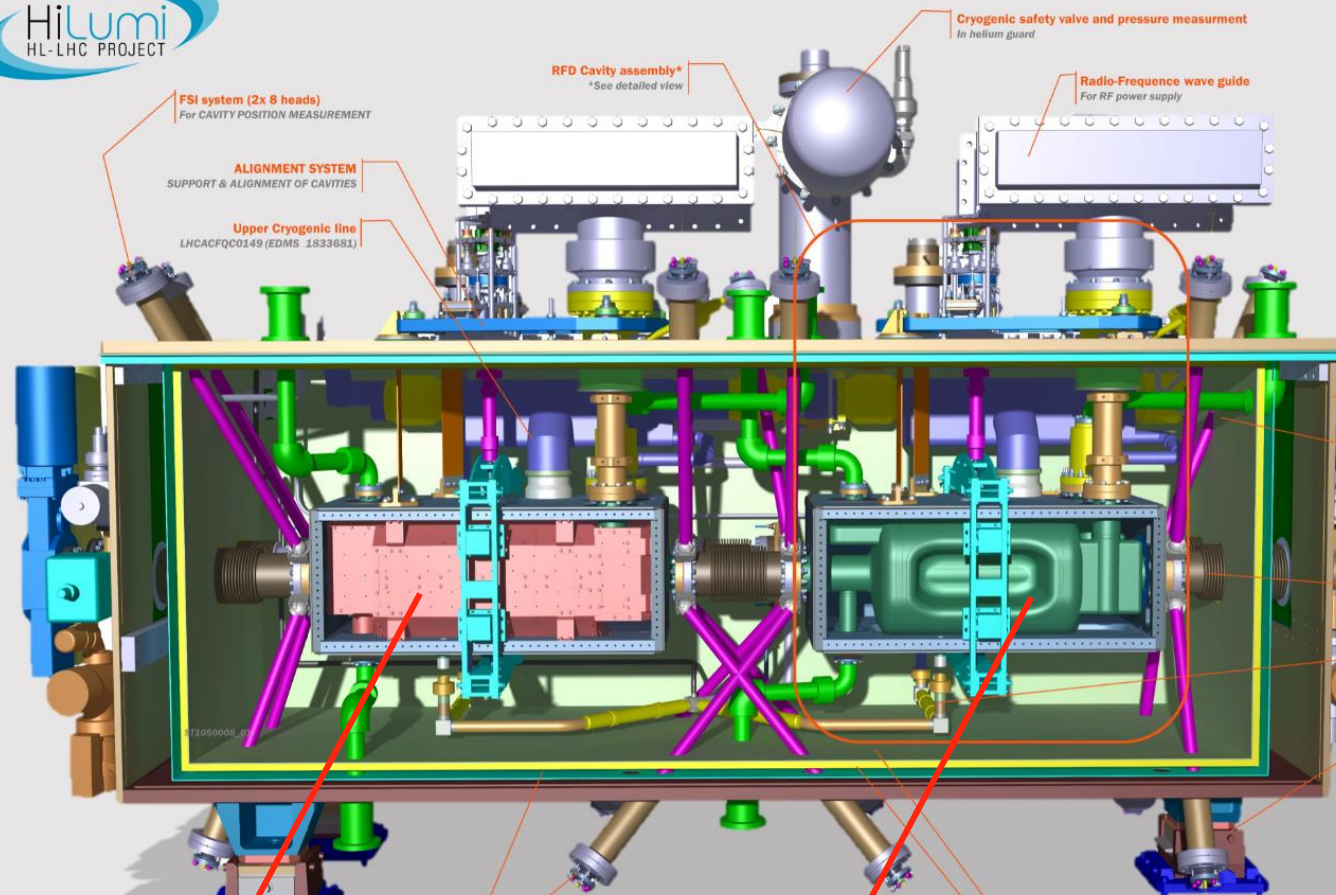
- Definition of installation method with CERN design office (May 2020)
- Preparation of PIDs for full and reduced versions (to be started asap by CRG)
- Filling of request to CI – “big table of Juan” (~June 2020)
- Review of installation method with CRG-CI (~June 2020)
- Delivery of first batch to Daresbury in October 2020
- Visit to Daresbury for installation training end of 2020/ beginning of 2021
- Remaining deliveries and trainings in 2021
- SM18 test of RFD proto in September 2021 (com. channels to be ready)

Back up slides

type	regulation (nominal)				c-d regul.				interlock				monitoring				total				total
	Lhe	vac 5 K	vac 50 K	air	Lhe	vac 5 K	vac 50 K	air	Lhe	vac 5 K	vac 50 K	air	Lhe	vac 5 K	vac 50 K	air	Lhe	vac 5 K	vac 50 K	air	
CERNOX	2	2				4								14	6		2	20	6		28
PT100												16			5				16	5	21

type	regulation (nominal)				c-d regul.				interlock				monitoring				total				total
	Lhe	vac 5 K	vac 50 K	air	Lhe	vac 5 K	vac 50 K	air	Lhe	vac 5 K	vac 50 K	air	Lhe	vac 5 K	vac 50 K	air	Lhe	vac 5 K	vac 50 K	air	
CERNOX	2	2				4								2	3		2	8	3		13
PT100												16								16	16

Cryomodule preview



Cavity #1

Cavity #2



HL-LHC-WP04—CRAB CAVITIES RFD CRYOMODULE FOR SPS TESTS

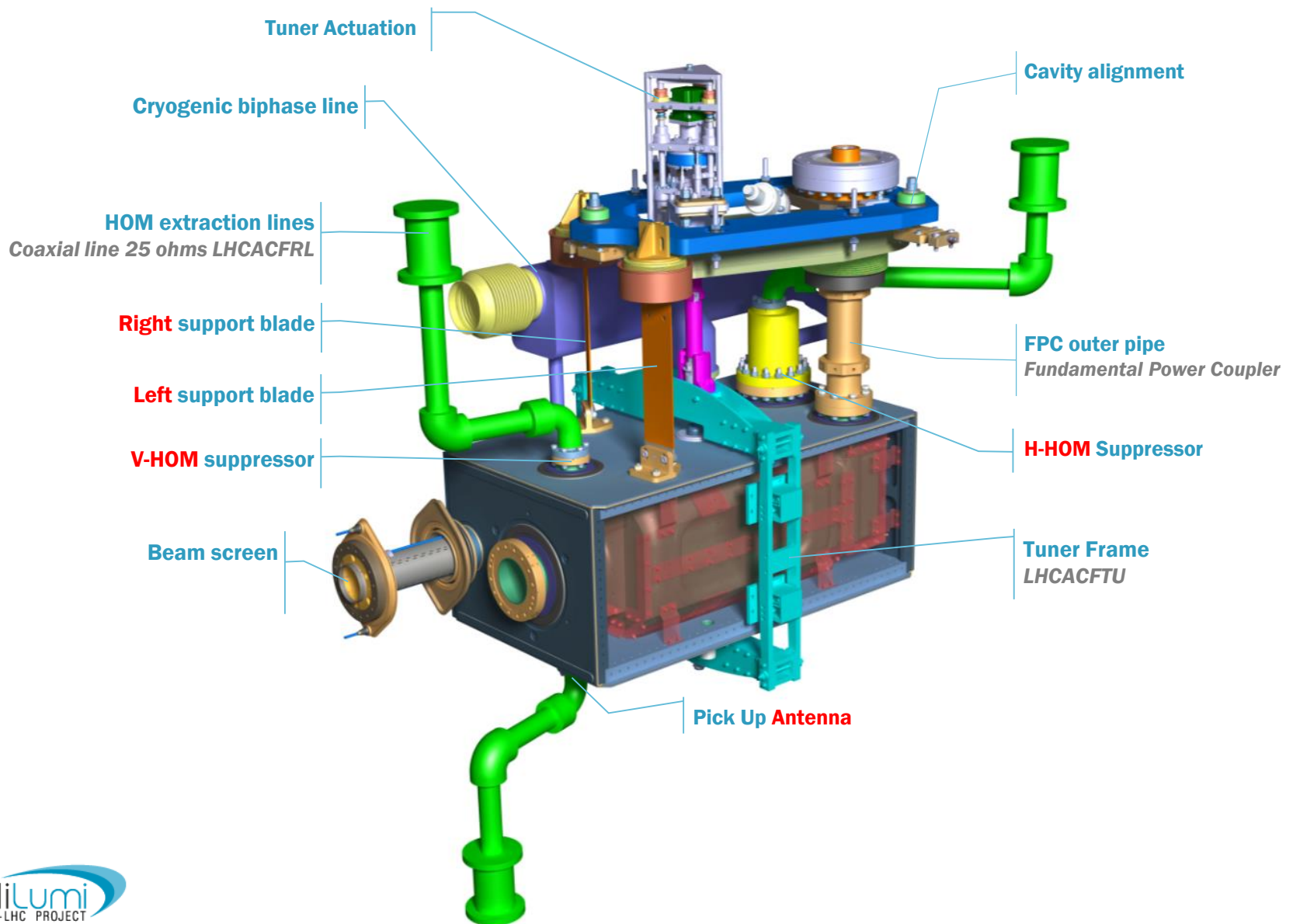
Information about RFD cryomodule

- Overall dimensions (L/l/h): 3350/950/1900mm
- Mass : ~3900kg (estimation 05-2019)
- Cavities : RFD (2x)
- HOM filters : 4 pces (2 per cavity)
- Pick Up Antenna : 2 pces (1 per cavity)
- Tuner : 2 unit (1 per cavity)
- RF Gate valves : 4 pces
- FSI Heads : 16 ports (8 per cavity)

EN Engineering Department



Cavity Layout



Instrumentation layout

Cryomodule internal dimensions

- Distances in the cryomodule for informations

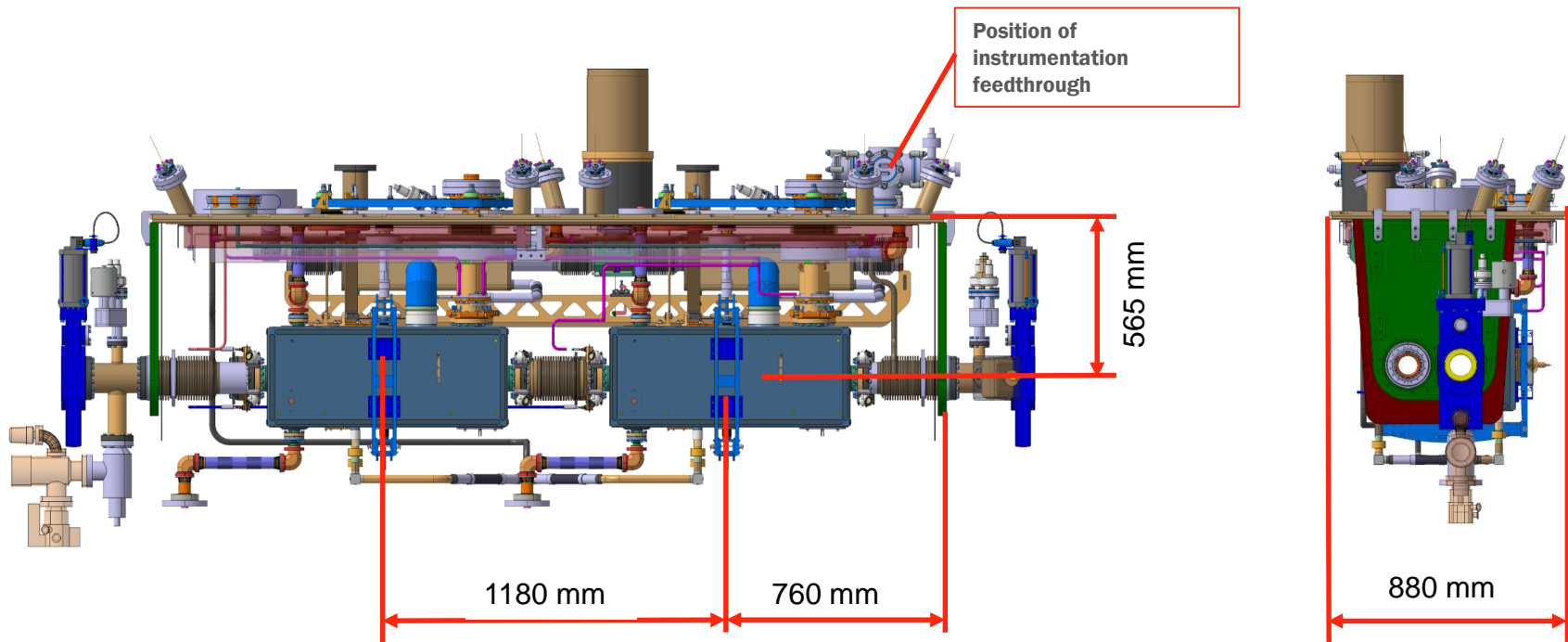


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# ref	Type	Location	Temp (K)	Range of Measurmen t	Connexion	Time of assembly
#010	cernox	Helium tank 1- bottom in liquid He	2 K	300 – 1.5 K	Inside liquid He glued on level gauge	Operation Lhe temperature (calibrated, tol. 5 mK at cold)
#020	cernox	Helium tank 1-middle height	2 K	300 – 1.5 K	Bolted with copper support	Cool down speed regulation, tol. 2 K at warm
#030	cernox	Helium tank 1 top	2 K	300 – 1.5 K	Bolted with copper support	Cool down speed regulation, tol. 2 K at warm
#040	cernox	Helium tank 2 – bottom in liquid He	2 K	300 – 1.5 K	Inside liquid He glued on level gauge	Operation Lhe temperature (calibrated, tol 5 mK at cold)
#050	cernox	Helium tank 2 – middle height	2 K	300 – 1.5 K	Bolted with copper support	Cool down speed regulation, tol. 2 K at warm
#060	cernox	Helium tank 2 – top	2 K	300 – 1.5 K	Bolted with copper support	Cool down speed regulation, tol. 2 K at warm
#070	PT100	H-HOM cavity 1 coaxial line "warm"	150 K	300 – 100 K	Glued on Ø41mm	RF requested – monitoring
#080	cernox	H-HOM cavity 1 coaxial line "thermalisation 50K"	70 K	300 – 40 K	Glued on Ø41mm	RF requested - monitoring
#090	cernox	H-HOM cavity 1 coaxial line "Thermalisation 20K"	30 K	300 – 10 K	Glued on Ø41mm	RF requested - monitoring
#100	cernox	H-HOM CF35 "Feedthrough" on HOM FT flange Cav 1	-4 K	300 – 3 K	Collar monted on CF40 FLANGE	RF requested - monitoring
#110	cernox	H-HOM CF100 "cavity" on cavity 1 HOM flange	2 K	300 – 1.5 K	Collar monted on CF100 FLANGE	RF requested - monitoring
#120	cernox	H-HOM CF35 "Feedthrough" on HOM FT flange Cav 2	-4 K	300 – 3 K	Collar monted on CF40 FLANGE	RF requested - monitoring
#130	cernox	H-HOM CF100 "cavity" on cavity 2 HOM flange	2 K	300 – 1.5 K	Collar monted on CF100 FLANGE	RF requested - monitoring
#140	PT100	V-HOM cavity 1 coaxial line "warm"	150 K	300 – 100 K	Glued on Ø41mm	RF requested - monitoring
#150	cernox	V-HOM cavity 1 coaxial line "thermalisation 50K"	2 K	300 – 1.5 K	Glued on Ø41mm	RF requested - monitoring
#160	cernox	V-HOM cavity 1 coaxial line "thermalisation 20K"	2 K	300 – 1.5 K	Glued on Ø41mm	RF requested - monitoring
#170	cernox	VHOMS CF40 "cavity" on cavity 1 flange	2 K	300 – 1.5 K	Collar monted on CF FLANGE (same that therm)	RF requested - monitoring
#180	cernox	VHOMS CF40 "cavity" on cavity 2 flange	2 K	300 – 1.5 K	Collar monted on CF FLANGE (same that therm)	RF requested - monitoring
#190	cernox	Pick up antenna cav. 1 - Antenna flange	2 K	300 – 3 K	Collar monted on CF40 FLANGE	RF requested - monitoring
#200	cernox	Pick up antenna cav. 2 - Antenna flange	2 K	300 – 3 K	Collar monted on CF40 FLANGE	RF requested - monitoring
#210	PT100	FPC "warm" cavity 1	300 K external	300 – 220 K	Collar to be designed	RF requested – monitoring – EH regulation
#220	cernox	FPC "Thermalization 50K" cavity 1	70 K	300 – 40 K	Collar to be designed	RF requested – monitoring – cryo interested
#230	cernox	FPC "Thermalization 20K" cavity 1	50 K	300 – 30 K	Collar to be designed	RF requested – monitoring – cryo interested
#240	cernox	FPC "cavity" cavity 1 (Flange of FPC pipe)	4 K	300 – 2 K	Collar monted on CF63 FLANGE	RF requested – monitoring – cryo interested
#250	PT100	FPC "warm" cavity 2	300 K external	300 – 220 K	Glued on pipe	RF requested – monitoring – EH regulation
#260	cernox	FPC "Thermalization 50K" cavity 2	70 K	300 – 40 K	Glued on pipe	RF requested – monitoring – cryo interested
#270	cernox	FPC "Thermalization 20K" cavity 2	50 K	300 – 30 K	Glued on pipe	RF requested – monitoring – cryo interested
#280	cernox	FPC "cavity" cavity 2 (Flange of FPC pipe)	4 K	300 – 2 K	Collar monted on CF63 FLANGE	RF requested – monitoring – cryo interested
#290	PT100 flex	CW cavity 1 crab line "Thermalisation 50K"	70K		Bolted on screen ? To be checked	RF requested - monitoring
#300	cernox	CW cavity 1 crab line "C COLD" - on chamber flange	10K		Collar to be designed	RF requested - monitoring
#310	cernox	CW cavity 1 beam screen "BS COLD" - on chamber flange	20K		Collar to be designed	BS regulation (calibrated, tol. 0.1 K at cold)
#320	PT100 flex	CW cavity 2 crab line "Thermalisation 50K"	70K		Bolted on screen ? To be checked	RF requested - monitoring
#330	cernox	CW cavity 2 crab line "COLD" - on chamber flange	10K		Collar to be designed	BS regulation (calibrated, tol. 0.1 K at cold)
#340	cernox	CW cavity 2 beam screen "BS COLD" - on chamber flange	20K		Collar to be designed	RF requested - monitoring

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# ref	Type	Location	Temp (K)	Range of Measurement	Connexion	Time of assembly
#350	Pressure trans.	Safety port	30 mbara	2 bara – 10 mbara	Installed in Helium guard	
#360	Level gauge	Helium tank 1	2 K (30 mbara)	0 – 100%	RFD L= ??	
#370	Level gauge	Helium tank 2	2 K (30 mbara)	0 – 100%	RFD L= ??	
#380	Resistive glued printed foil	Helium tank 1	4.5 K	100 W	Max 160x250 mm	
#390	Resistive glued printed foil	Helium tank 2	4.5 K	100 W	Max 160x250 mm	
#400	Cartridge x4	FPC flange cavity 1	~250-300 K	75 W	Diam 6.5 mm, length 23 mm	
#410	Cartridge x4	FPC flange cavity 2	~250-300 K	75 W	Diam 6.5 mm, length 23 mm	
#420	Cartridge	Level port cavity 1	~250-300 K	75 W	Diam 6.5 mm, length 23 mm	
#430	Cartridge	Level port cavity 2	~250-300 K	75 W	Diam 6.5 mm, length 23 mm	
#440	Cartridge	TUNER cavity 1	~250-300 K	75 W	Diam 6.5 mm, length 23 mm	
#450	Cartridge	TUNER cavity 2	~250-300 K	75 W	Diam 6.5 mm, length 23 mm	
#460	Cartridge	BLADE left cavity 1	~250-300 K	75 W	Diam 6.5 mm, length 23 mm	
#470	Cartridge	BLADE right cavity 1	~250-300 K	75 W	Diam 6.5 mm, length 23 mm	
#480	Cartridge	BLADE left cavity 2	~250-300 K	75 W	Diam 6.5 mm, length 23 mm	
#490	Cartridge	BLADE right cavity 2	~250-300 K	75 W	Diam 6.5 mm, length 23 mm	
#500	Cartridge x2	Crab line CW cavity 1	~250-300 K	75 W	Diam 6.5 mm, length 23 mm	
#510	Cartridge x2	Second line CW cavity 1	~250-300 K	75 W	Diam 6.5 mm, length 23 mm	
#520	Cartridge x2	Crab line CW cavity 2	~250-300 K	75 W	Diam 6.5 mm, length 23 mm	
#530	Cartridge x2	Second line CW cavity 2	~250-300 K	75 W	Diam 6.5 mm, length 23 mm	
#550	Cartridge x2	Safety port	~250-300 K	75 W	Diam 6.5 mm, length 23 mm	
#560	Cartridge x2	RF feedthrough coax H-HOM cavity 1	~250-300 K	75 W	Diam 6.5 mm, length 23 mm	
#570	Cartridge x2	RF feedthrough coax V-HOM cavity 1	~250-300 K	75 W	Diam 6.5 mm, length 23 mm	
#580	Cartridge x2	RF feedthrough coax Antenna cavity 1	~250-300 K	75 W	Diam 6.5 mm, length 23 mm	
#590	Cartridge x2	RF feedthrough coax H-HOM cavity 2	~250-300 K	75 W	Diam 6.5 mm, length 23 mm	
#600	Cartridge x2	RF feedthrough coax V-HOM cavity 2	~250-300 K	75 W	Diam 6.5 mm, length 23 mm	
#610	Cartridge x2	RF feedthrough coax Antenna cavity 2	~250-300 K	75 W	Diam 6.5 mm, length 23 mm	
#620	Cartridge rotfil	Beam screen cooling circuit entre FPC et BS	5-60K		See drawing	
#630	Thermocouple J	Inside heating cartridge #460			in cartridge	
#640	Strain gauge	Blade left cavity 1			Glued on blade	
#650	Strain gauge	Blade right cavity 1			Glued on blade	
#660	Strain gauge	Blade left cavity 2			Glued on blade	
#670	Strain gauge	Blade right cavity 2			Glued on blade	
#680	Strain gauge	FPC outer pipe cavity 1			Glued on blade	
#690	Strain gauge	FPC outer pipe cavity 2			Glued on blade	

Instrumentation layout

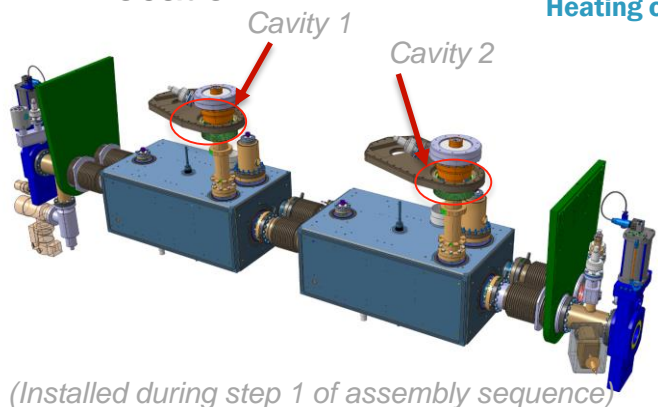
HEATERS 1/7

FPC HEATERS (8x – 4/FPC)

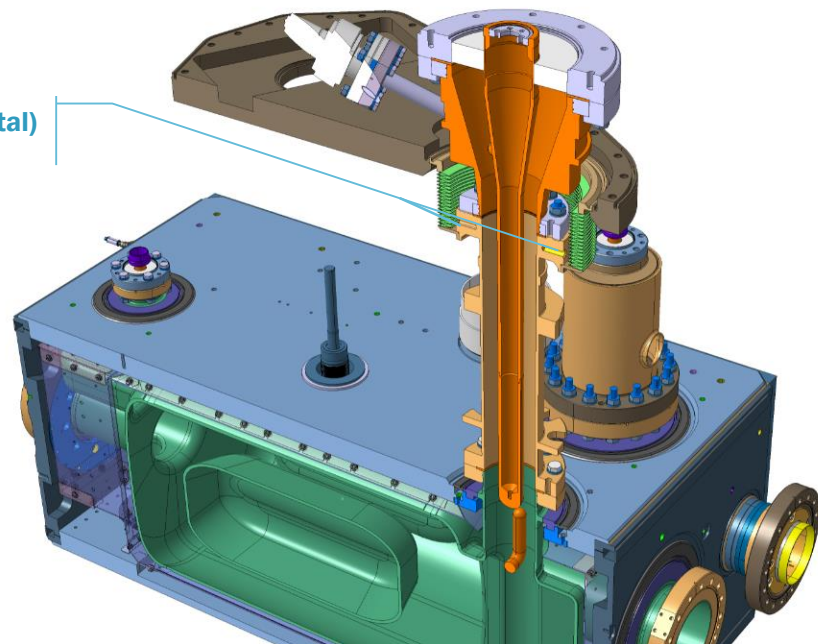
Ø6.5mm – L25mm – 75W

Installed outside of the cryomodule

- Location

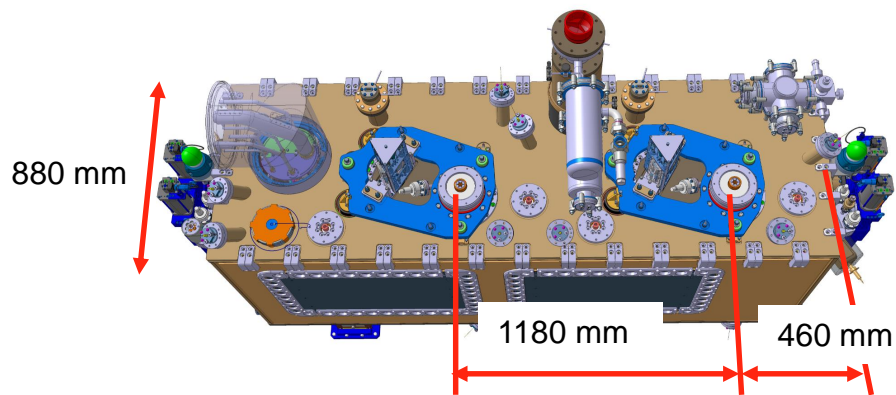


Heating cartridge (x4/FPC – 8 in total)



(Installed during step 1 of assembly sequence)

- Labels : #400 & #410
- Distance on the top plate :

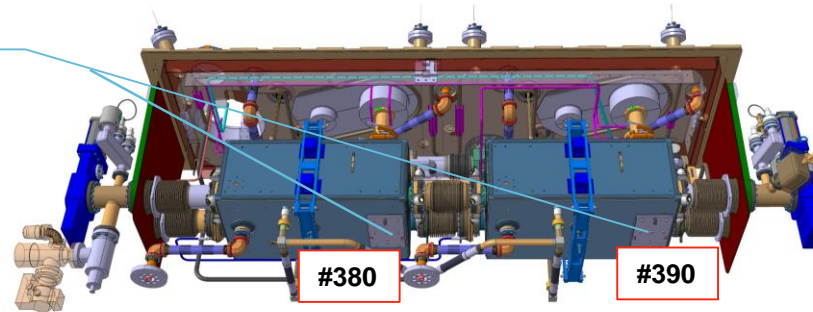


Instrumentation layout HEATERS 2/7

Helium tank HEATERS (2x – 1/Cavity)

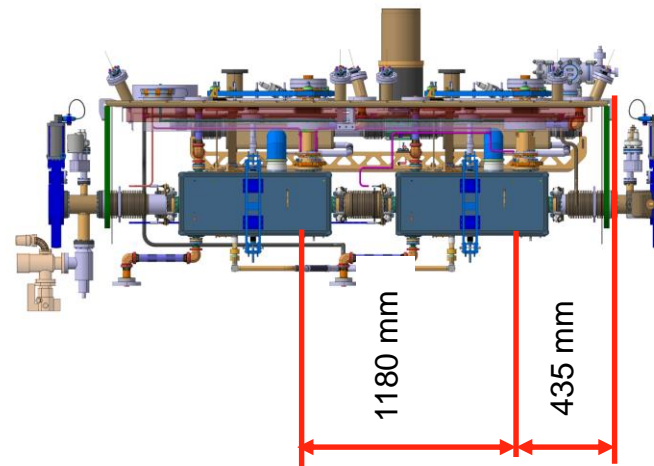
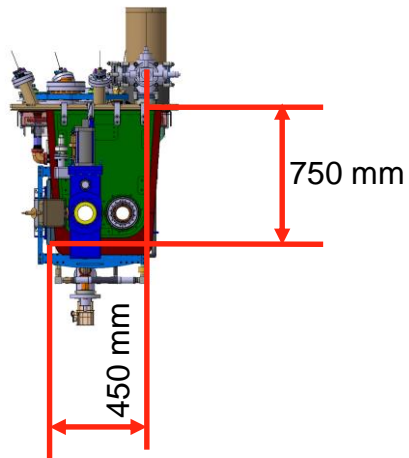
- Location

Resistive glued printed foil
100W



Installed during step xx of assembly sequence

- Labels : #380 & #390
- Distances in the cryomodule



Instrumentation layout

HEATERS 3/7

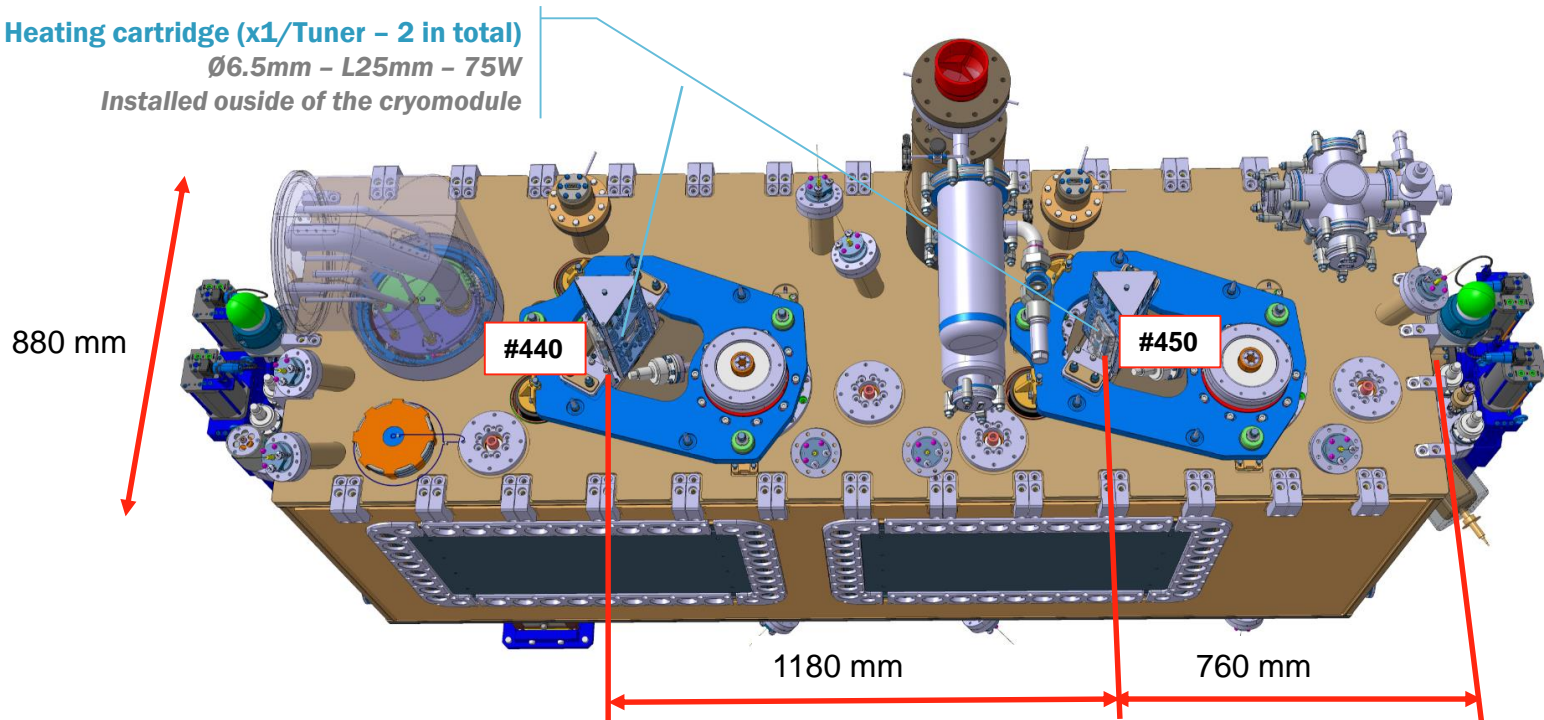
Tuner HEATERS (2x – 1/Tuner)

- Location and distances

Heating cartridge (x1/Tuner – 2 in total)

Ø6.5mm – L25mm – 75W

Installed outside of the cryomodule



Installed during step xx of assembly sequence

- Labels : #440 & #450

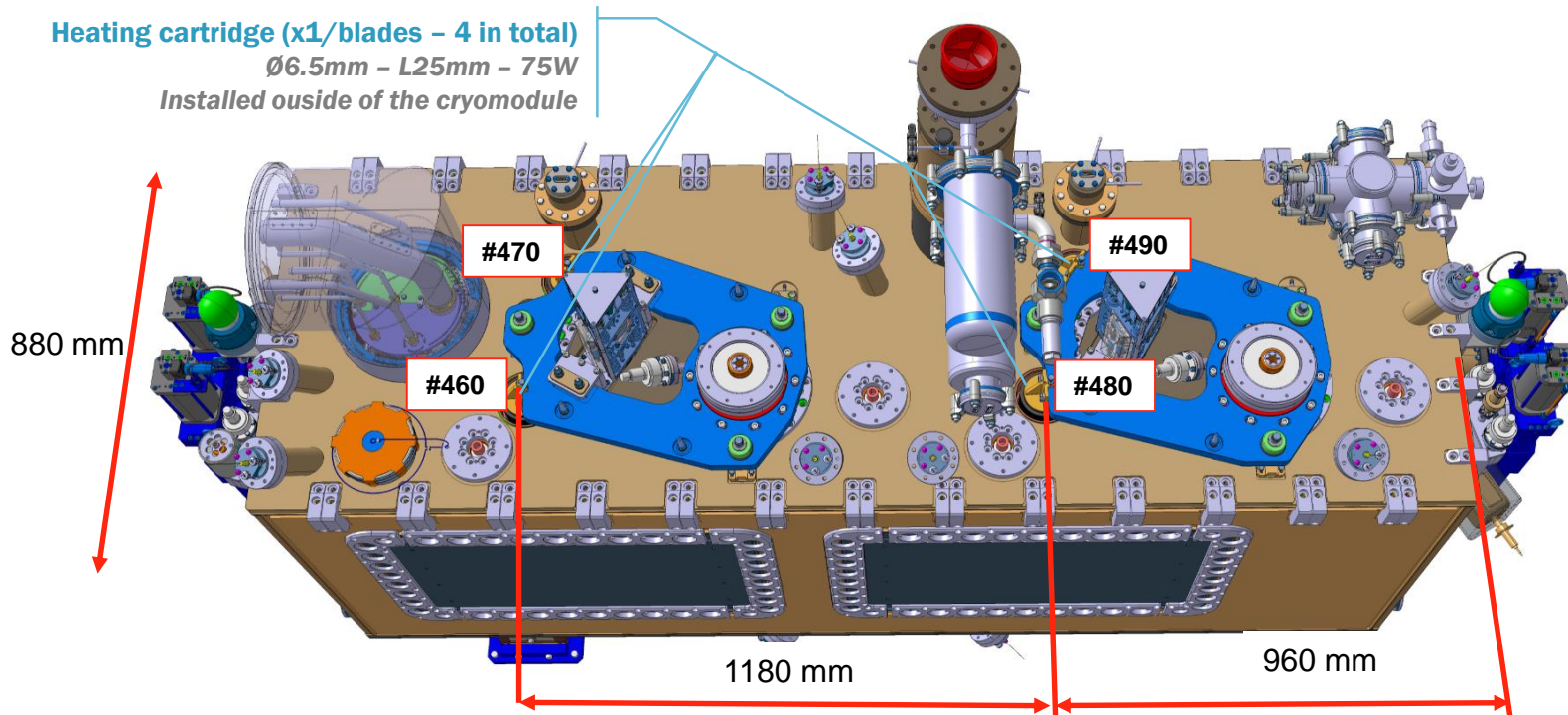
Instrumentation layout

HEATERS 4/7

Blade HEATERS (4x – 1/Blade)

- Location and distances

Heating cartridge (x1/blades – 4 in total)
Ø6.5mm – L25mm – 75W
Installed outside of the cryomodule



Installed during step xx of assembly sequence

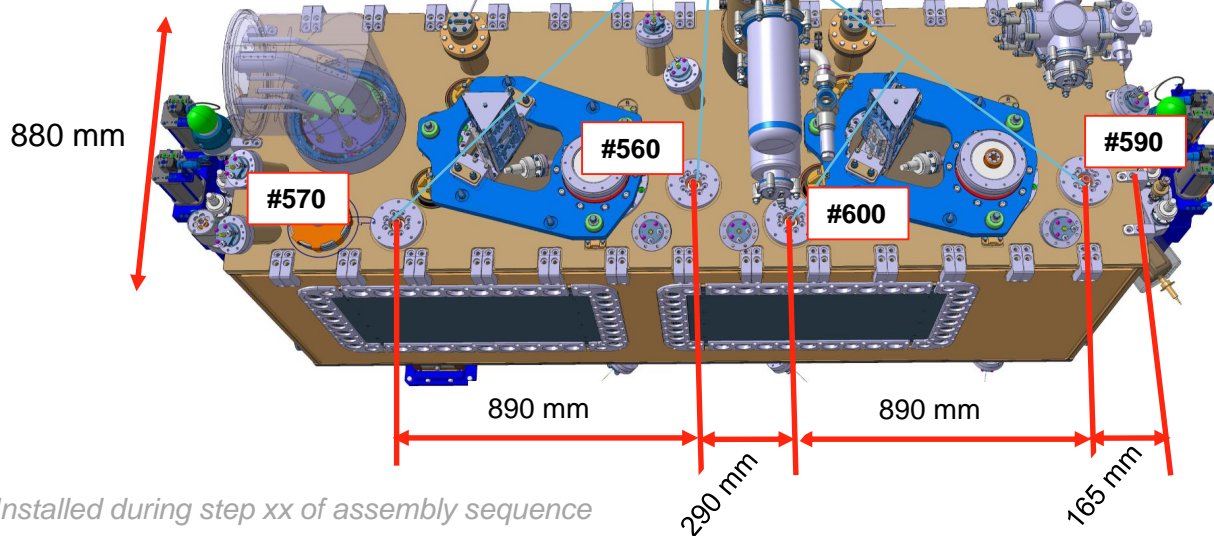
- Labels : #460, #470, #480 & #490

Instrumentation layout HEATERS 5/7

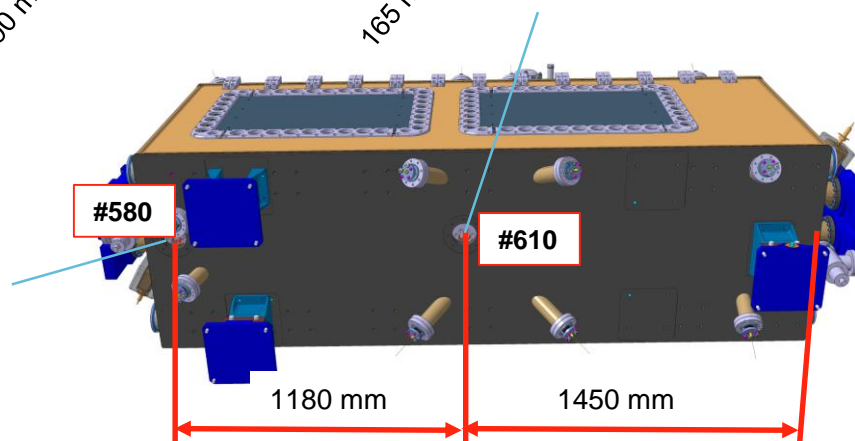
RF coaxial feedthrough HEATERS (6x – 1/line)

- Location and distances

Heating cartridge (x1/FT – 6 in total)
Ø6.5mm – L25mm – 75W
Installed outside of the cryomodule



- Labels : xx

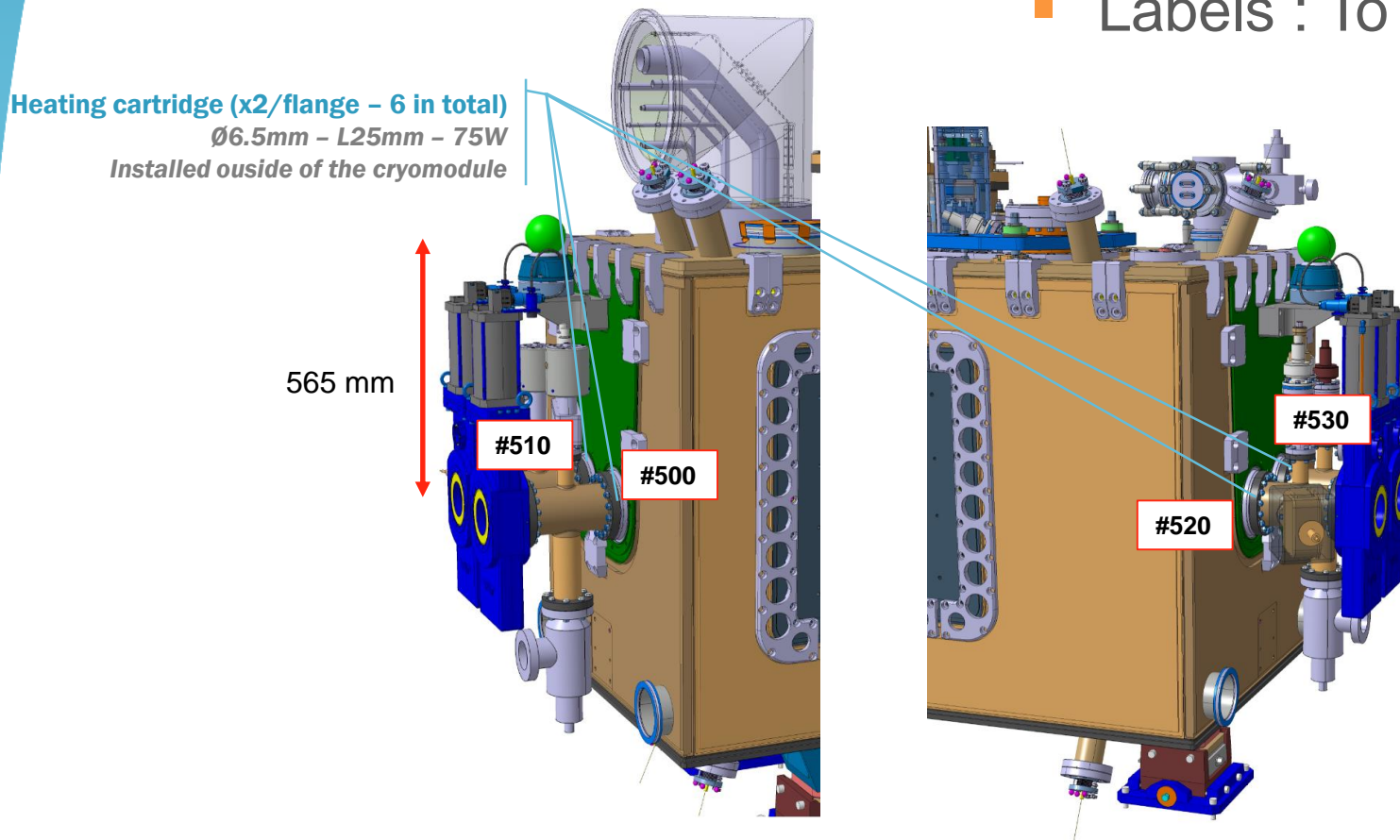


Instrumentation layout

HEATERS 6/7

Cold warm transition HEATERS (8x – 2/line)

- Location and distances
- Labels : To be defined



Installed during step xx of assembly sequence

Instrumentation layout

HEATERS 7/7

Cryo ports HEATERS (4x)

- Location and distances

Heating cartridge (level gauges port -1/port)

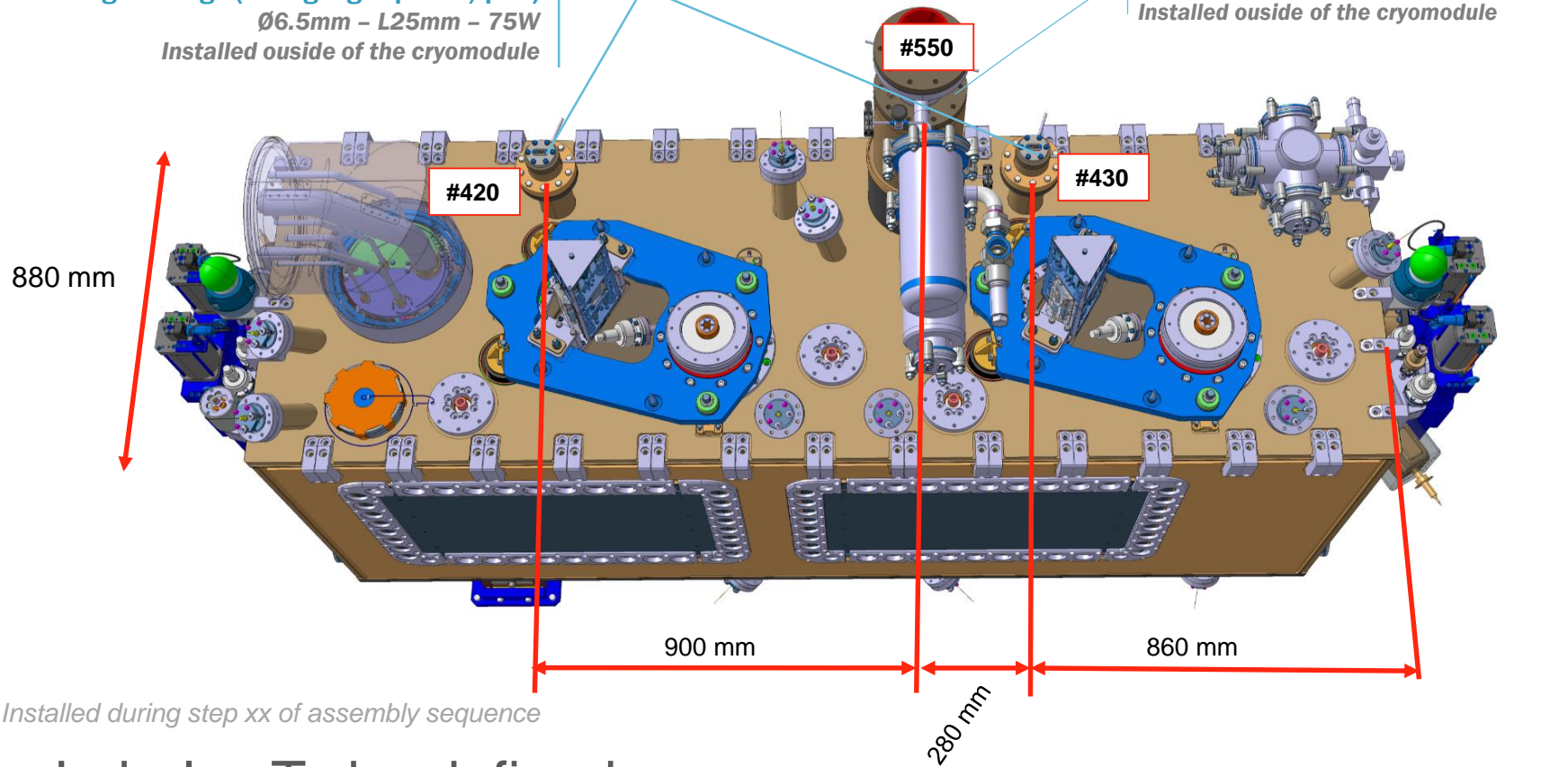
Ø6.5mm - L25mm - 75W

Installed outside of the cryomodule

Heating cartridge (safety port - 2/port)

Ø6.5mm - L25mm - 75W

Installed outside of the cryomodule

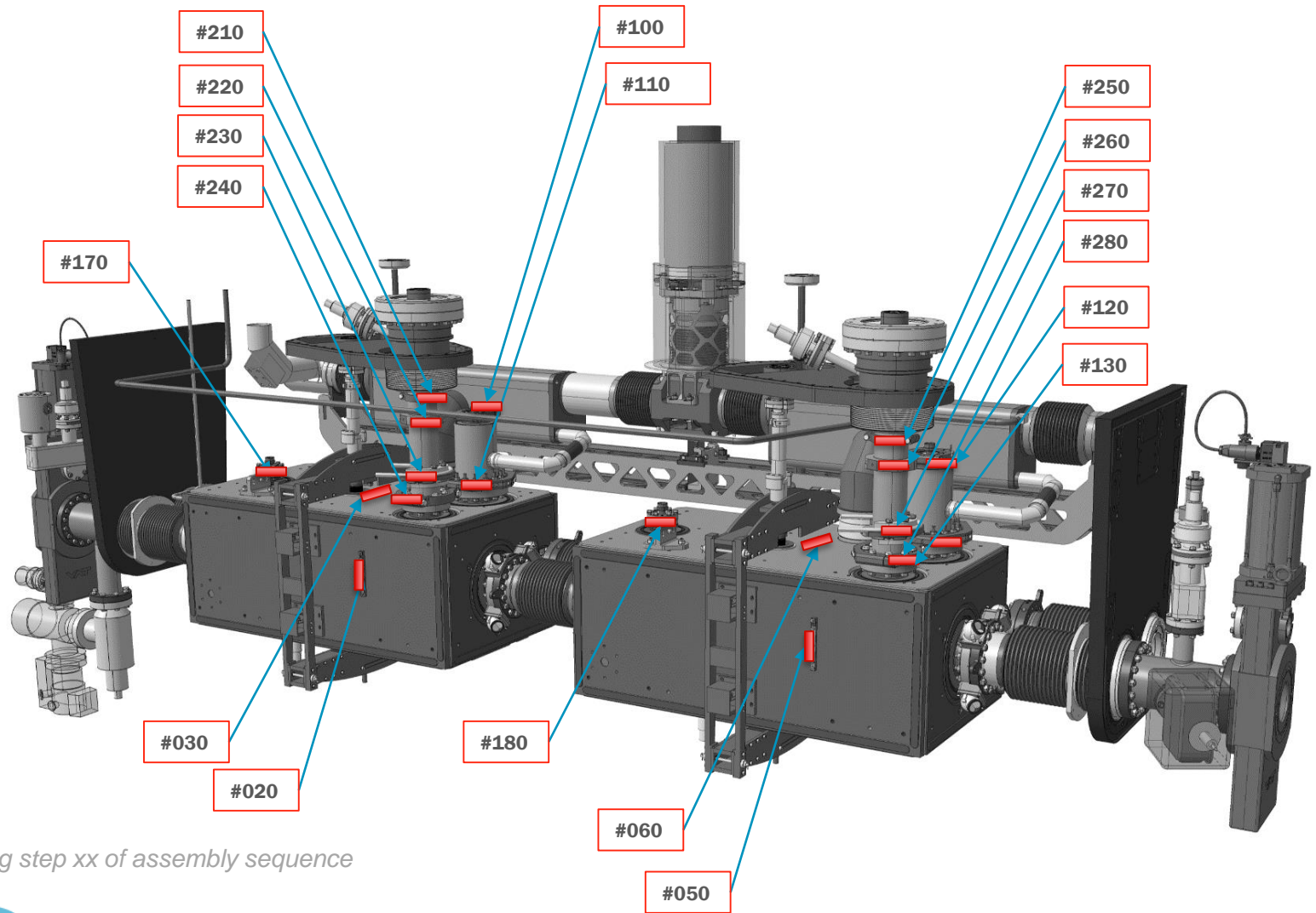


Installed during step xx of assembly sequence

- Labels : To be defined

Instrumentation layout

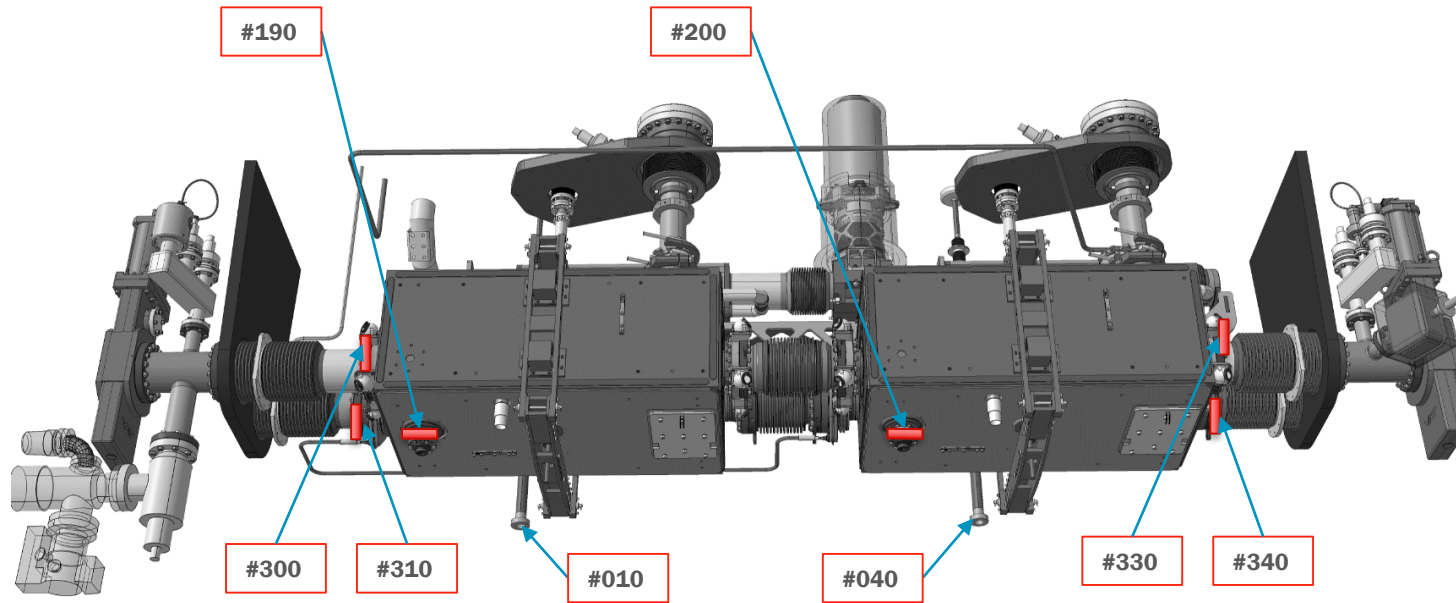
Temperature sensors 1/4



Installed during step xx of assembly sequence

Instrumentation layout

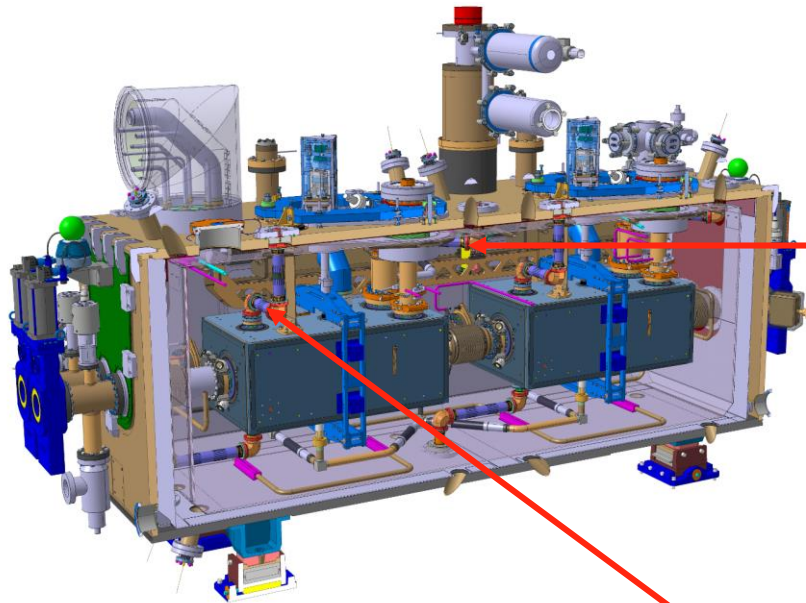
Temperature sensors 2/4



Installed during step xx of assembly sequence

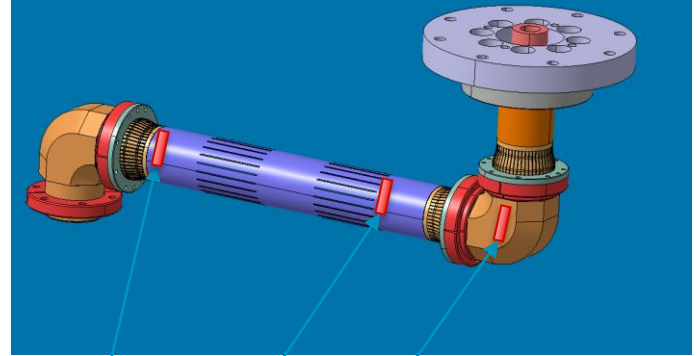
Instrumentation layout

Temperature sensors 3/4



Installed during step xx of assembly sequence

H-HOMS coaxial line cavity 1
Line to be reviewed !!!!! Just for illustration

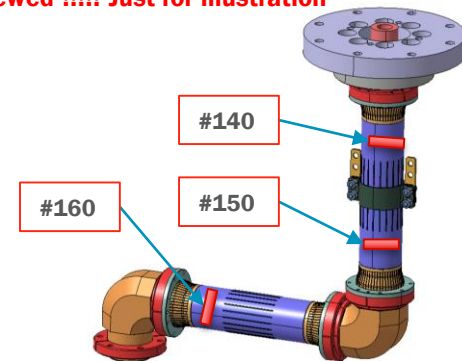


#090

#080

#070

V-HOMS coaxial line cavity 1
Line to be reviewed !!!!! Just for illustration



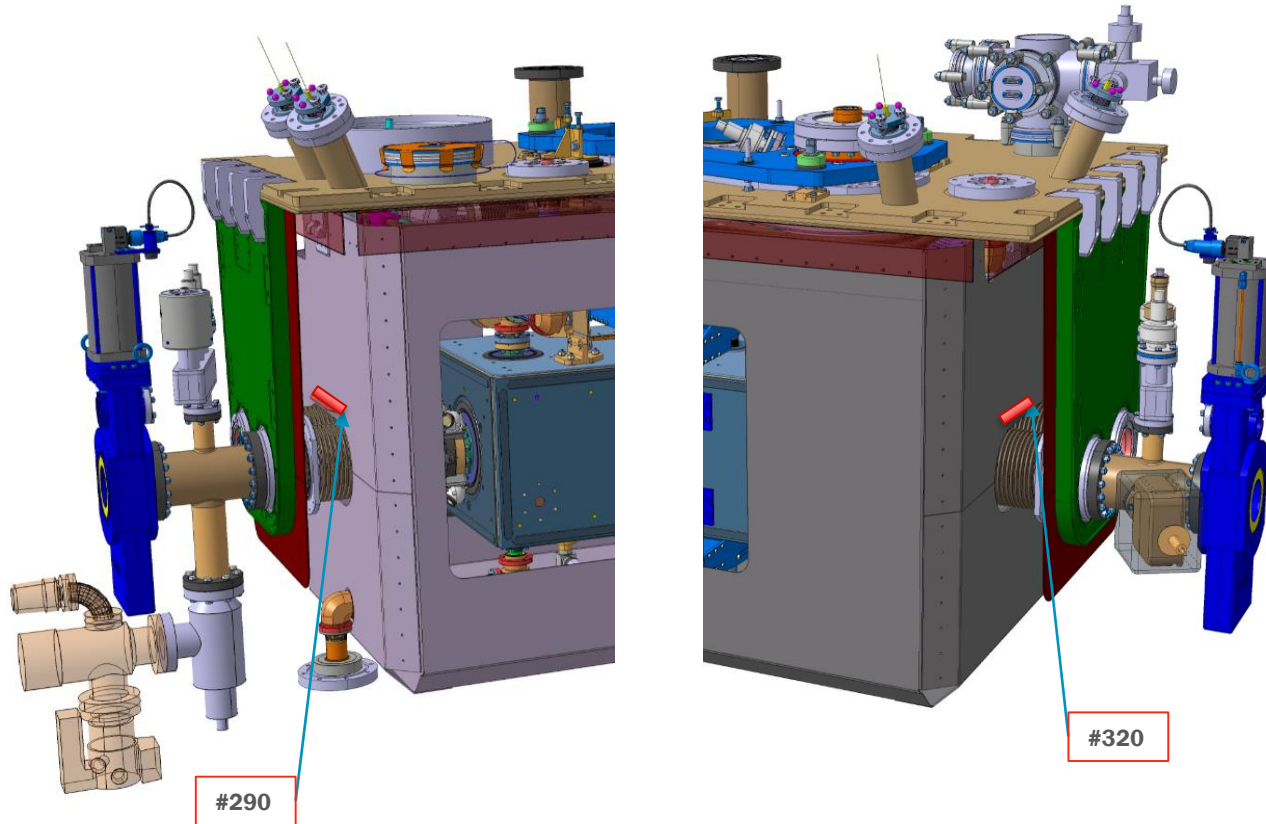
#140

#160

#150

Instrumentation layout

Temperature sensors 4/4



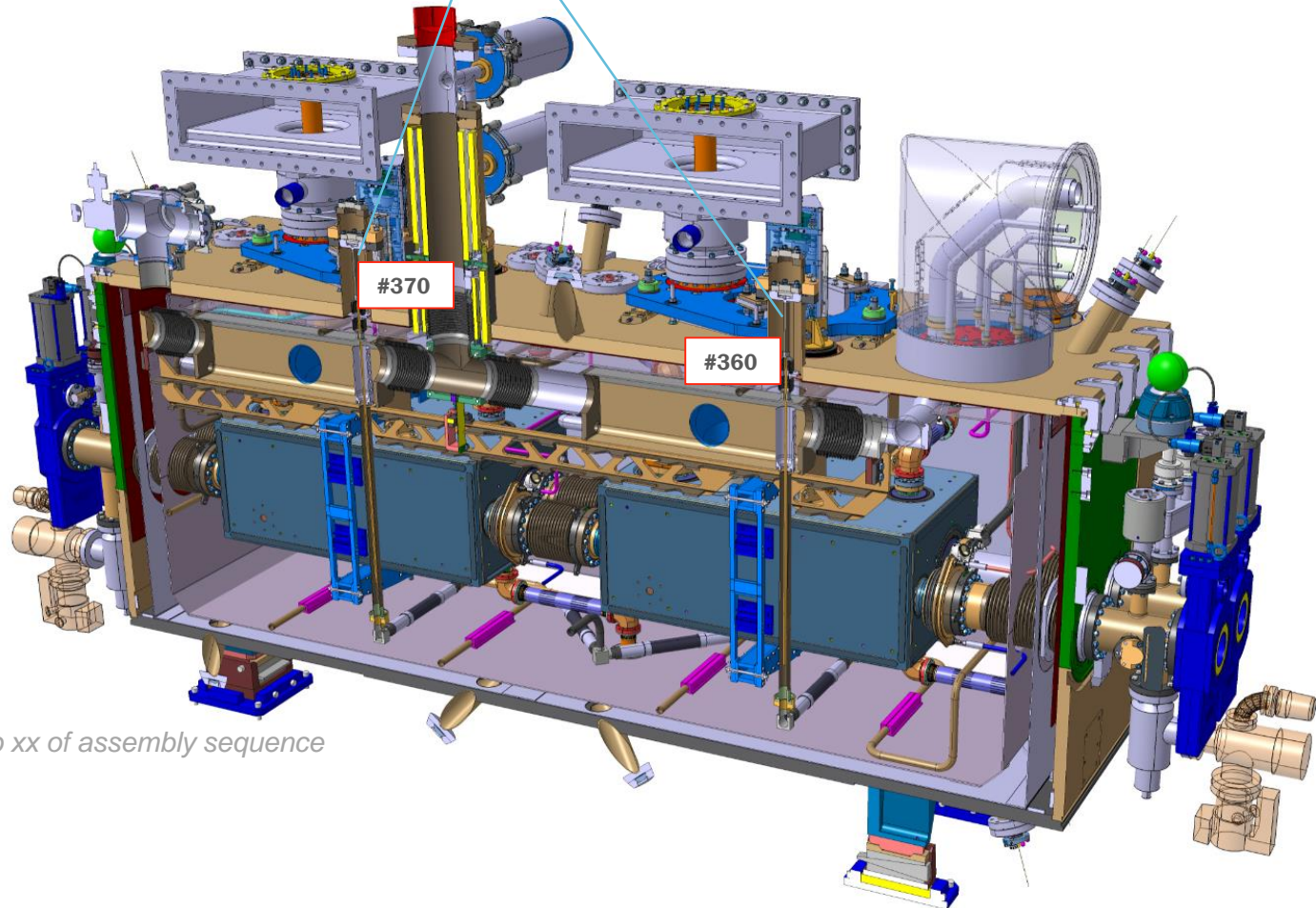
Installed during step xx of assembly sequence

Level gauges

Level gauges - 1/port
AMI Helium Level Sensor
Sensor Diameter : 1/4"
Active Length : 30"
Overall Length : 31"

Supplier : American Magnetics Inc.

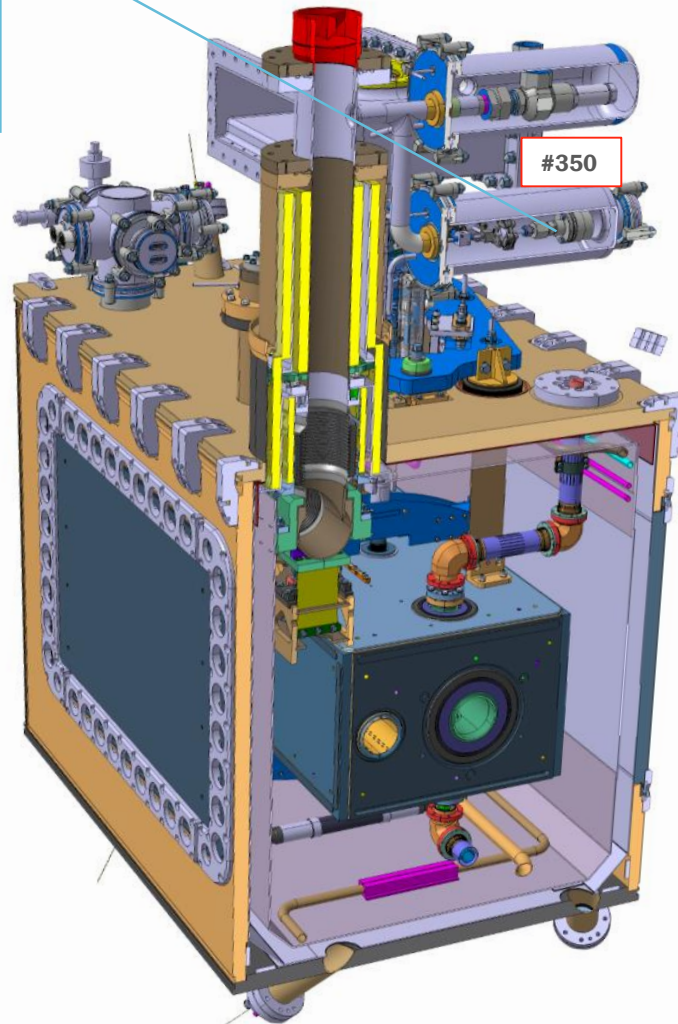
Reference : HS-1/4-RGD-30/31in-4LdCp-LL6-S



Installed during step xx of assembly sequence

Pressure transmitter

Gauge Pressure Transmitter
266GST (NPT MALE) ABB - Dismantled
Gauge 266GST, version male threaded NPT 1/2
Supplier : ABB
Reference : 266GST (NPT Male)



Installed during step xx of assembly sequence

