



**FUSION
FOR
ENERGY**



IBERDROLA
Ingeniería y Construcción



ASG
Superconductors



**ELYTT
ENERGY**

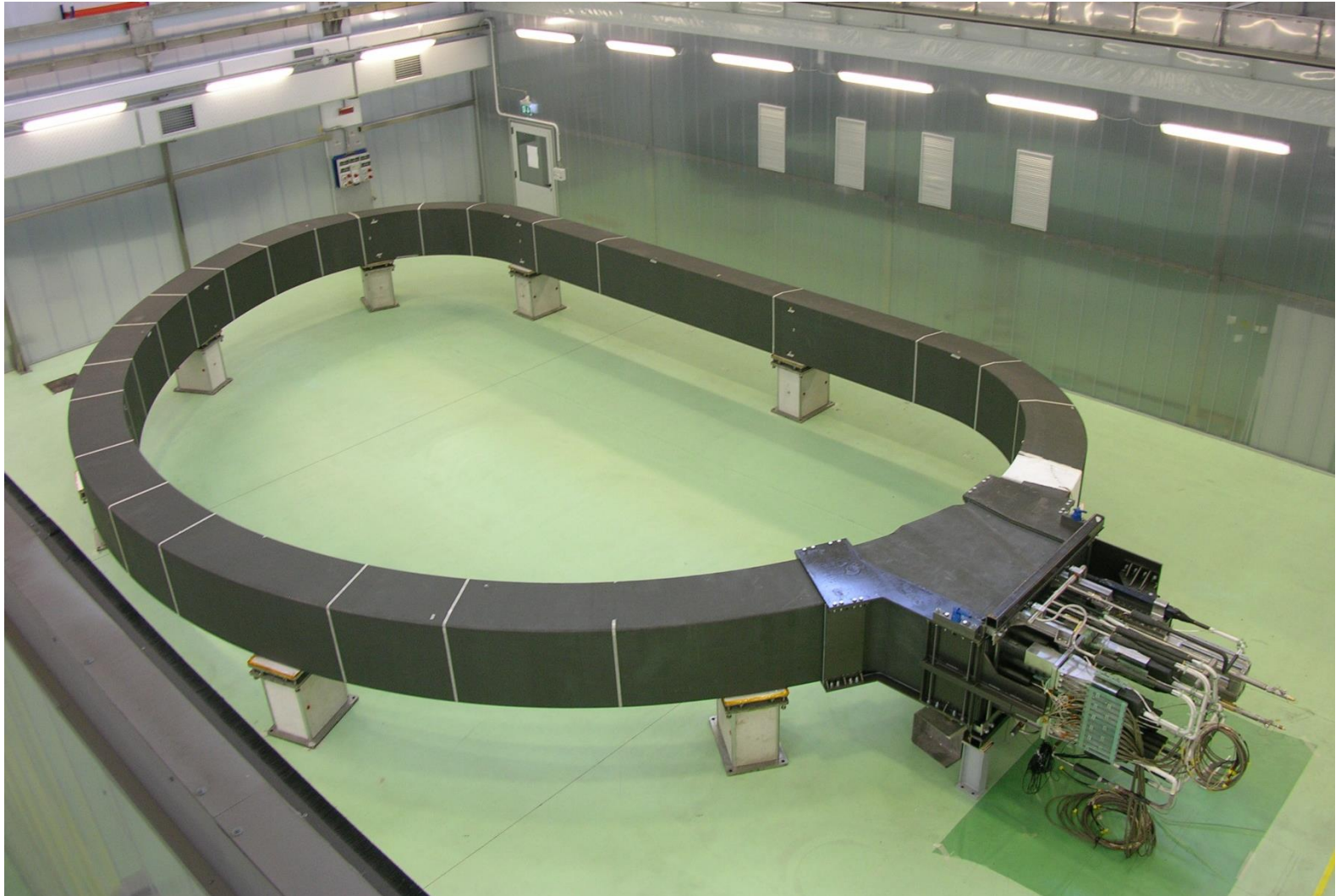


Manufacturing the European superconducting TF Winding Packs for ITER

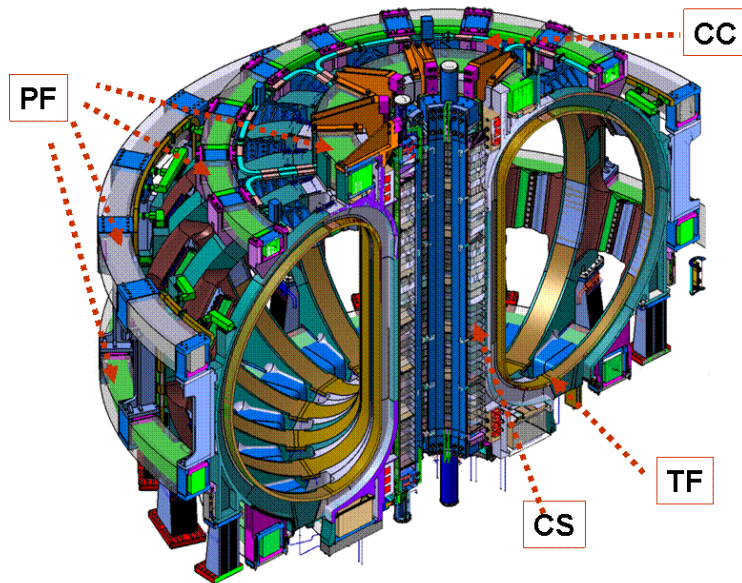
M. Cornelis, P. Aprili, B. Bellesia, A. Bonito-Oliva, E. Boter Rebollo, P. Casas Lino, J. Cornella Medrano, M. Damone, R. Harrison, A. Hernandez Sanchez, M. Jimenez, C. Kostopoulos, K. Libens, N. Pellicer Sabadi, L. Poncet, S. Tarrago, E. Viladiu Martinez, J. Silva Ribeiro, P. Barbero, A. Felipe, S. Pittaluga, O. Dormicchi

September 19th, 2017

First European Winding Pack

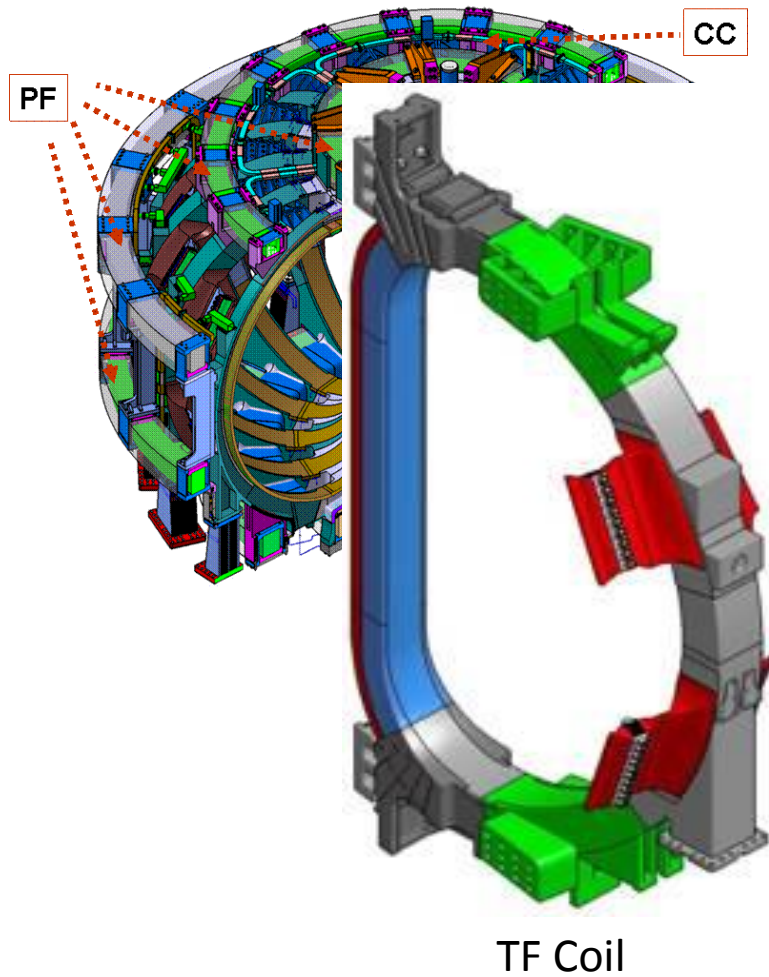


Winding Pack: composition

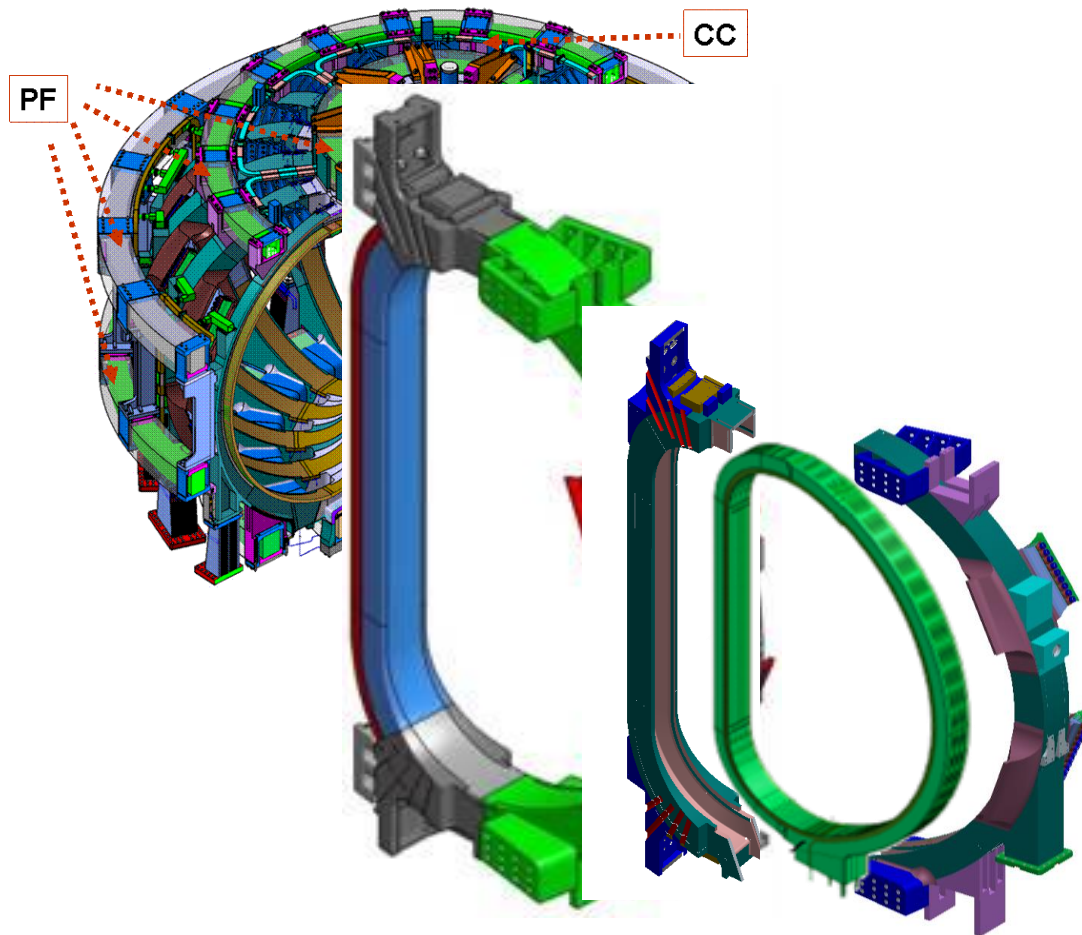


ITER Magnet System

Winding Pack: composition

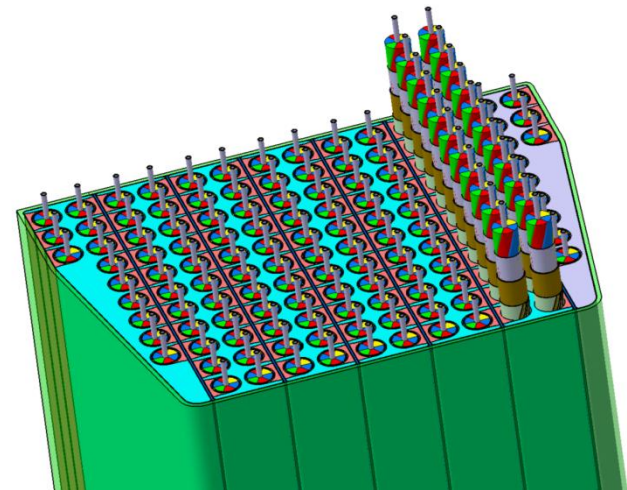
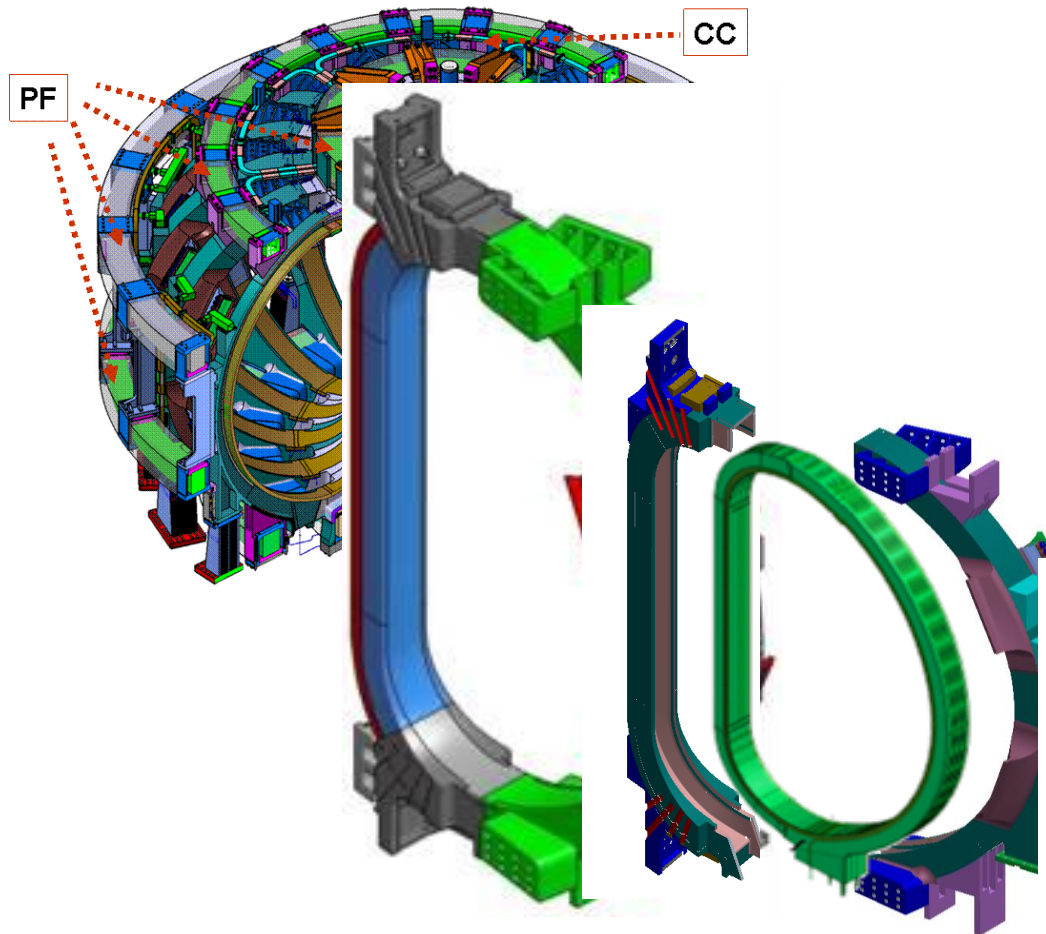


Winding Pack: composition



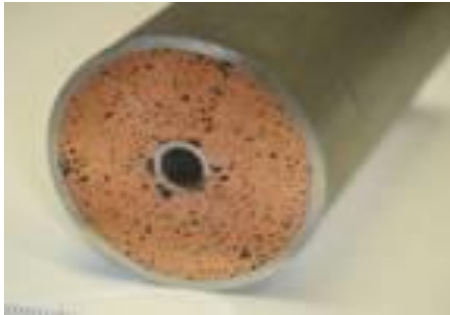
TF Winding Pack & Coil Case

Winding Pack: composition



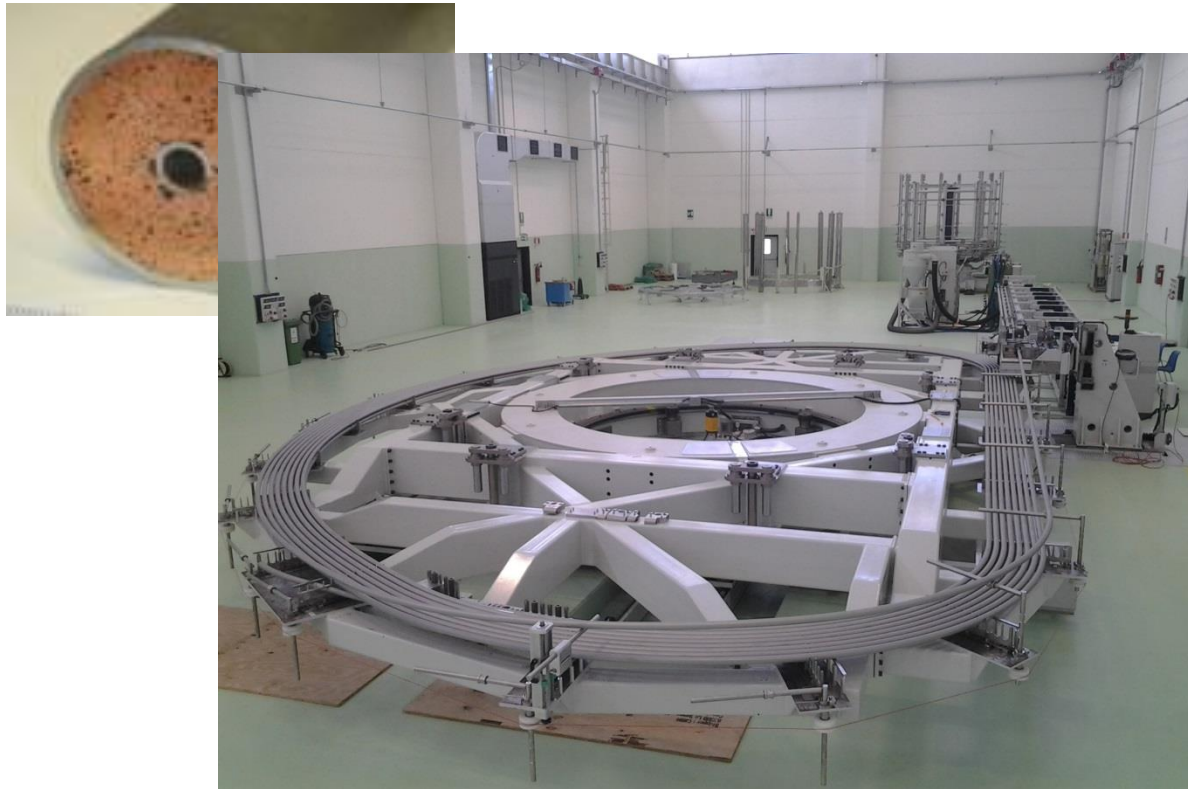
WP section

Winding the Double Pancake



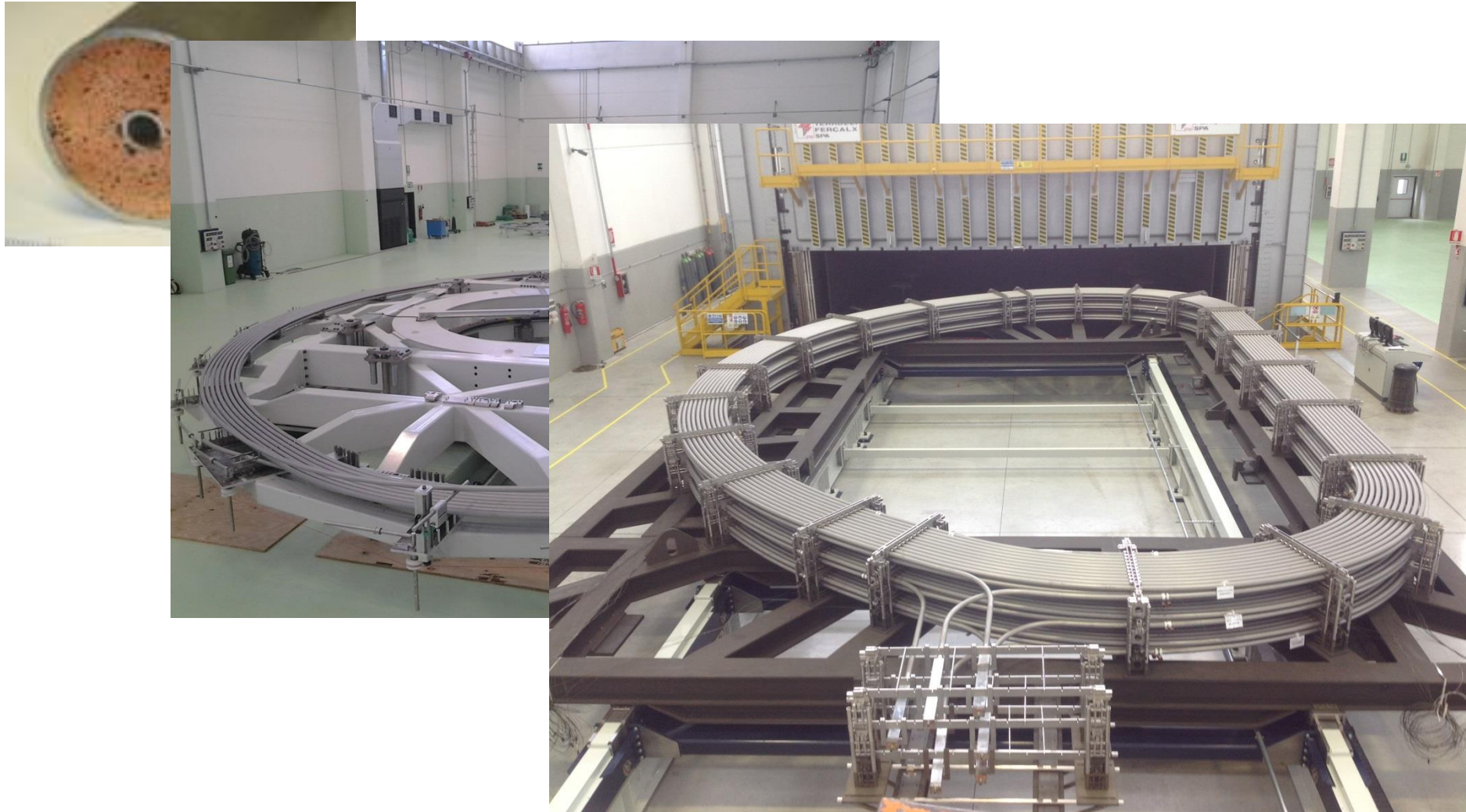
TF Nb₃Sn Conductor

Winding the Double Pancake

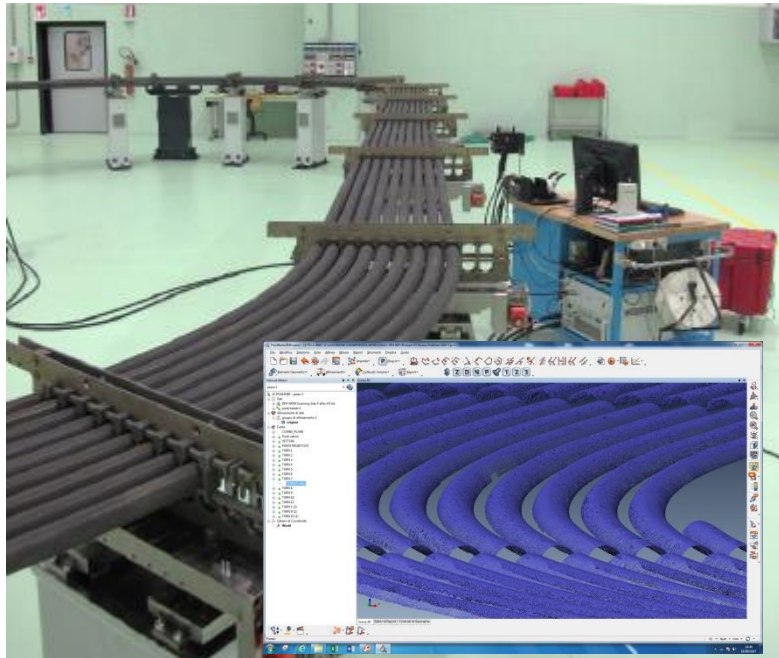


Wound conductor, according to geometry which anticipates change in length

Winding the Double Pancake



Conductors ready for HT cycle at 650°C



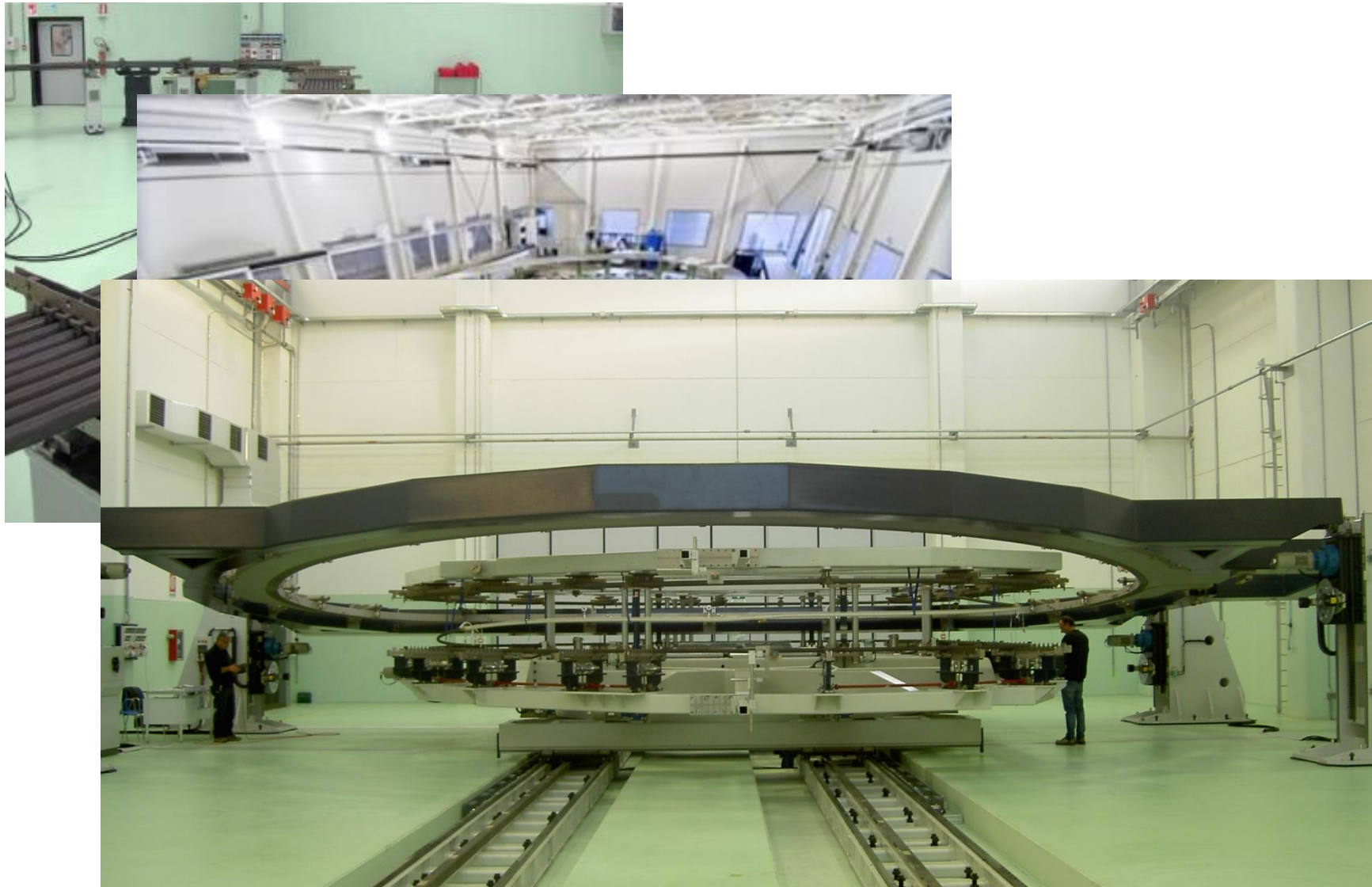
3D-scan of the conductor after HT

Conductor transfer

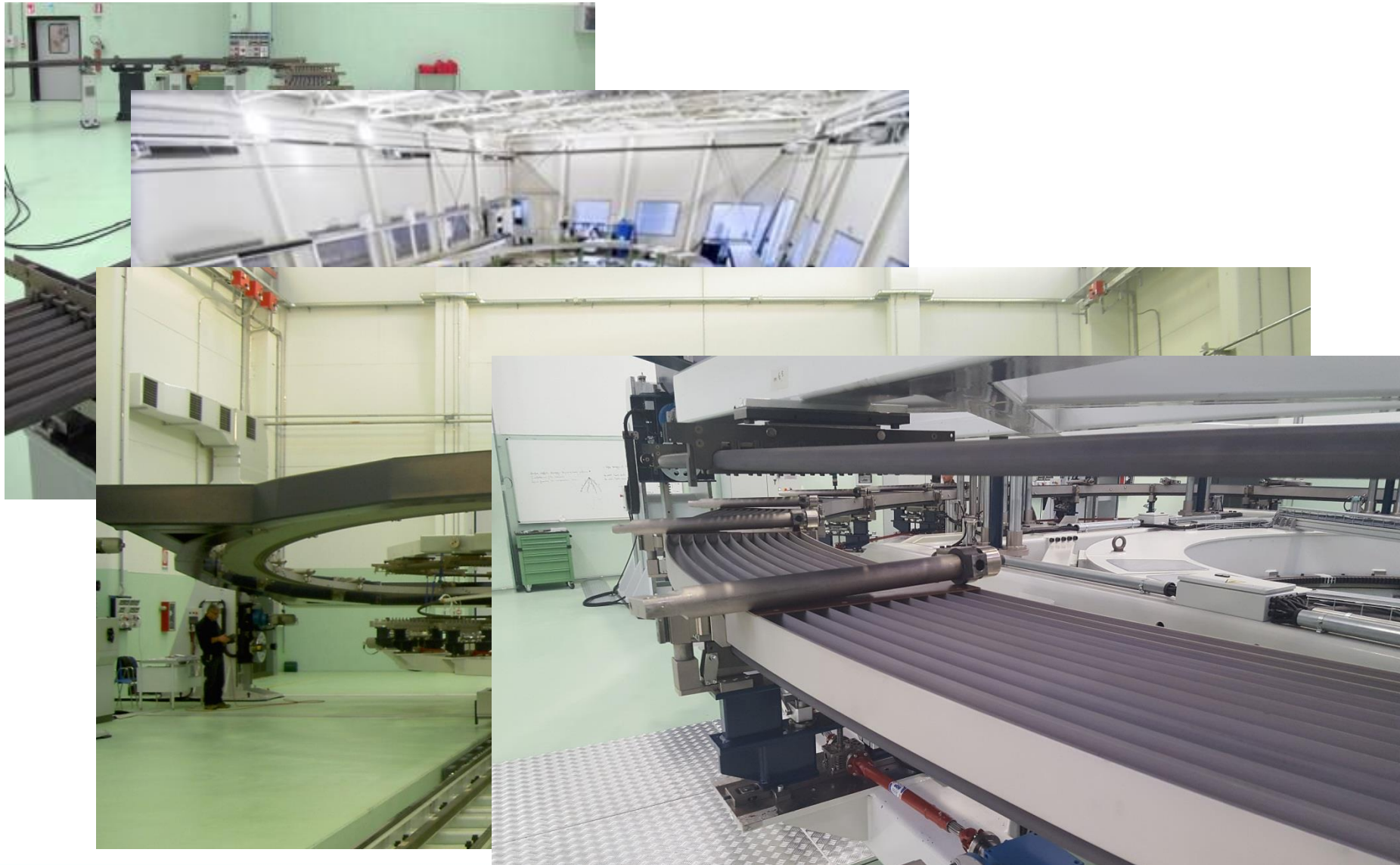


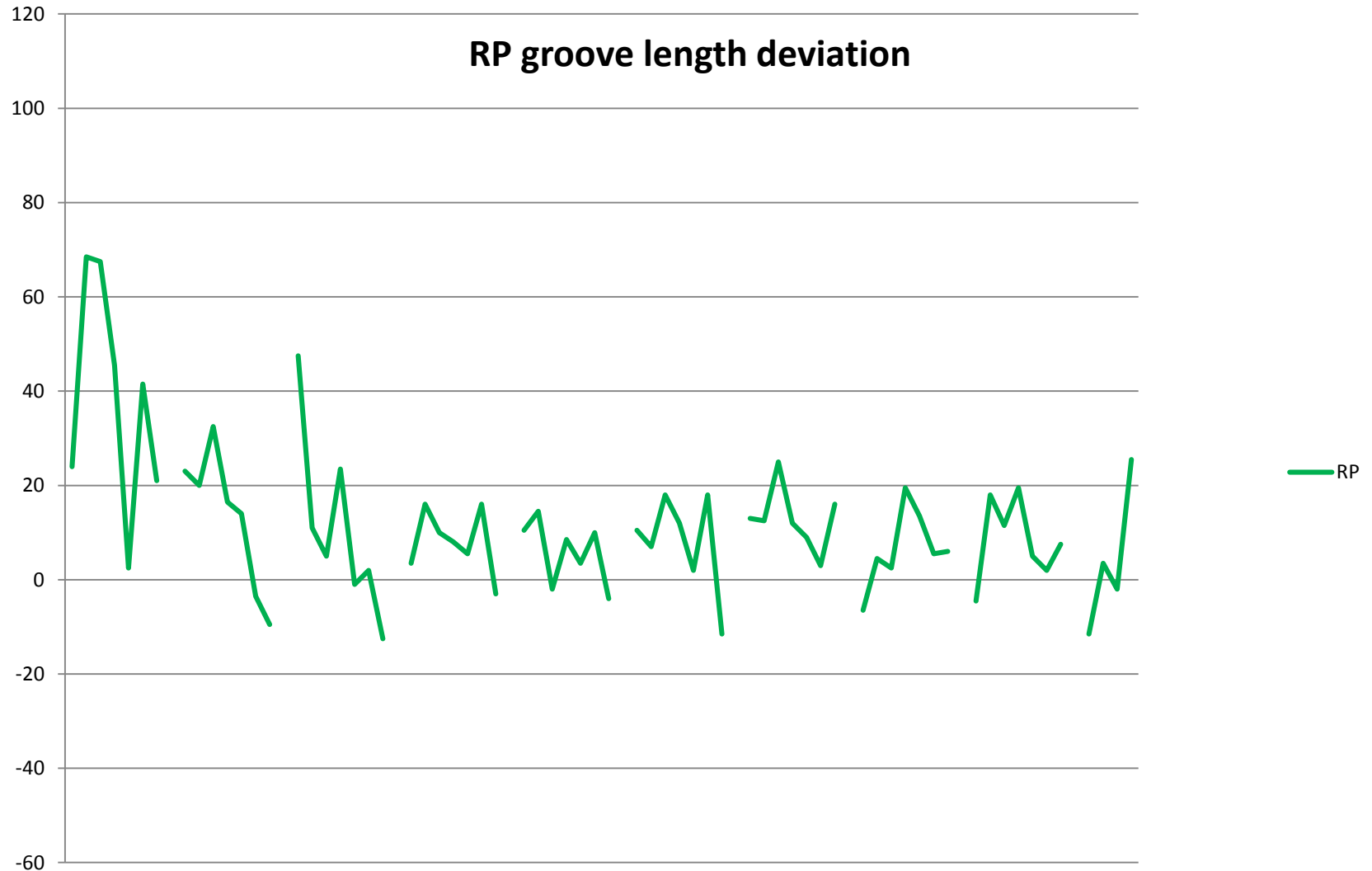
Radial Plate

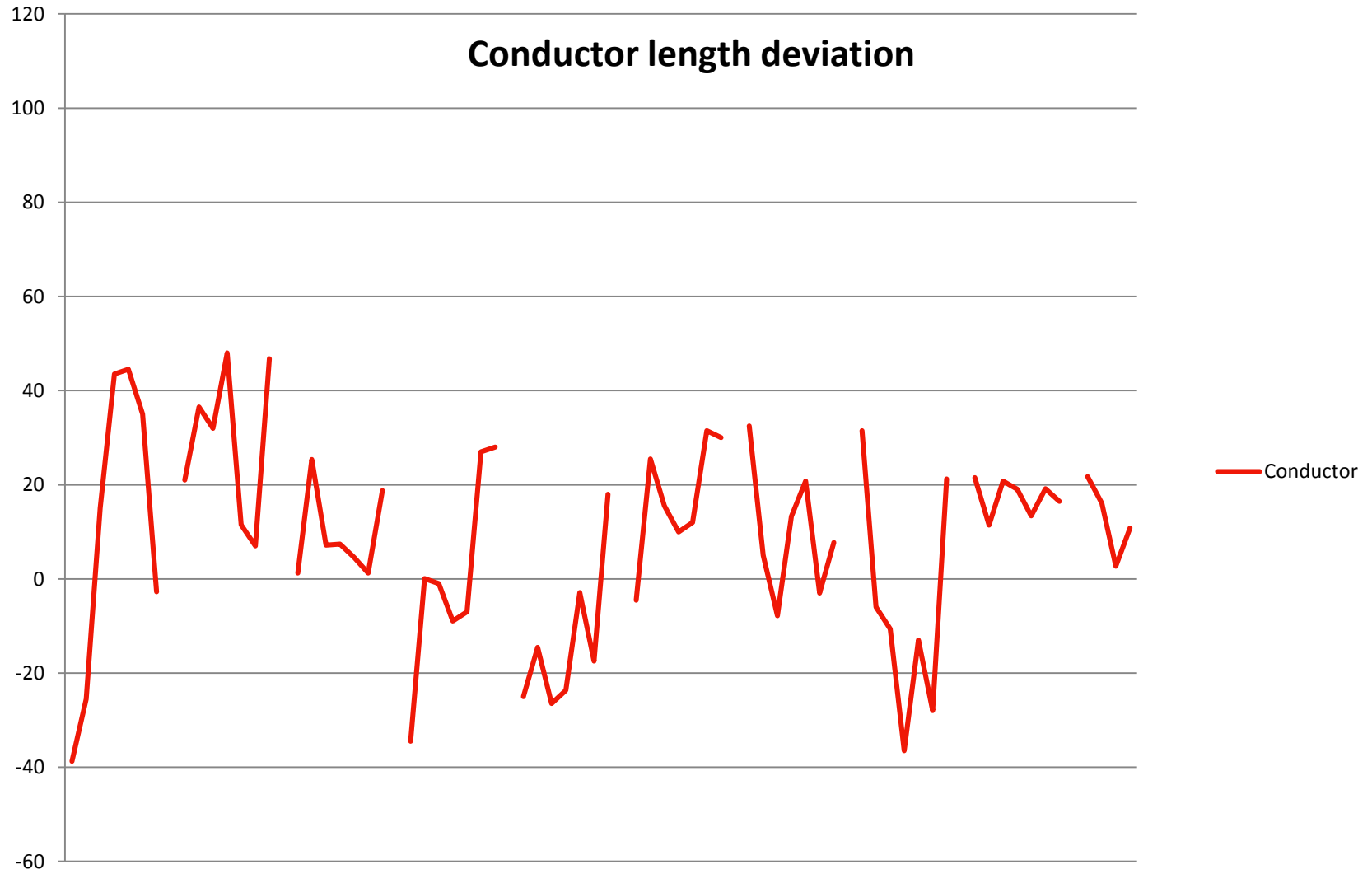
Conductor transfer

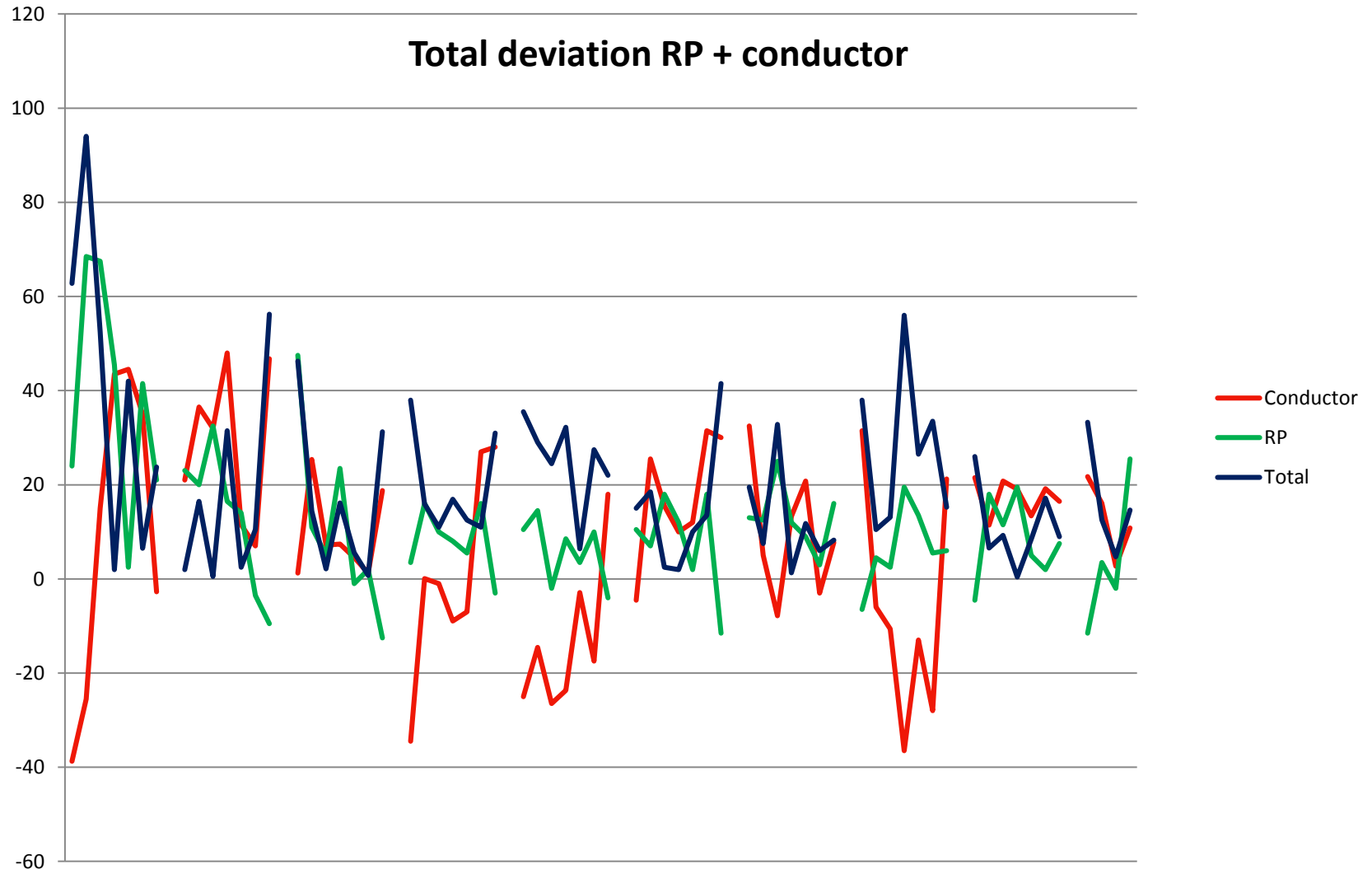


Conductor transfer











Successful fitting

Remaining DP operations



Conductor insulation wrapping

Remaining DP operations



Wrapping heads

Remaining DP operations



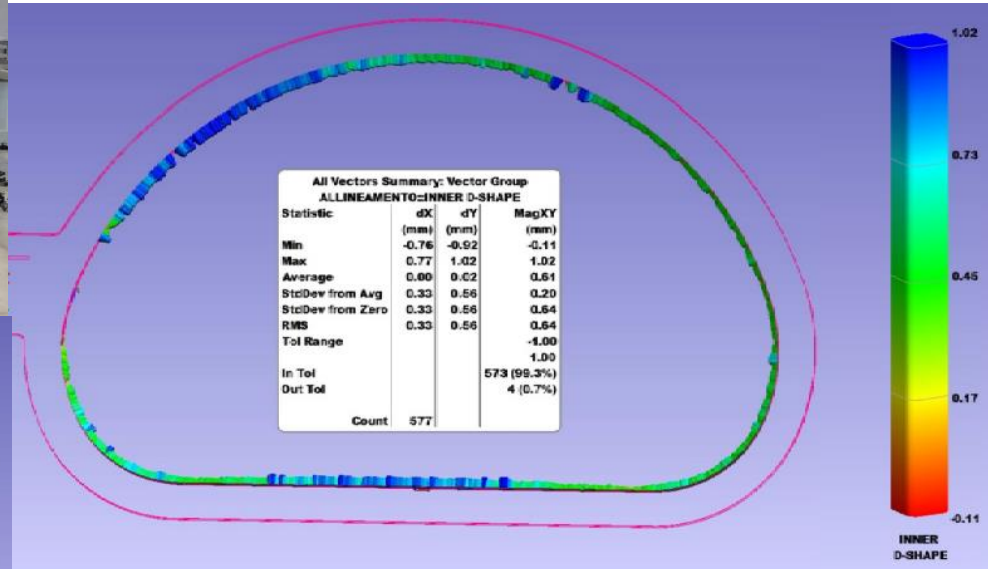
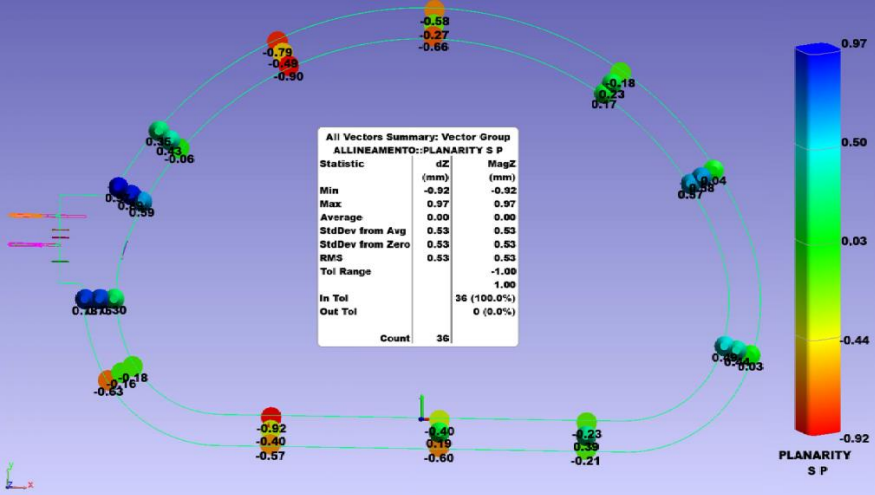
CP laser welding

Remaining DP operations



DP ground insulation and impregnation

Completed Double Pancake dimensional control

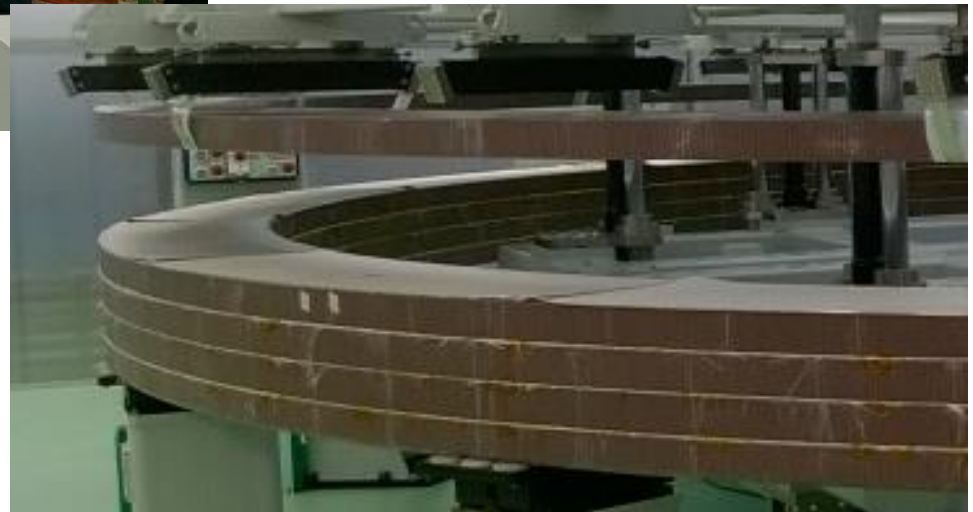


	Flatness			Inner D-shape deviation Spread/Distortion		
	Av.	Max.	σ	Av.	Max.	σ
Radial Plate	0.80	1.36	0.21	0.57	1.61	0.25
After CP tack welding	1.10	1.66	0.24	0.51	0.92	0.19
After CP laser welding	1.63	2.00	0.22	0.11	0.64	0.27
Completed DP	1.40	1.89	0.26	1.64	1.96	0.23

Double Pancake stacking

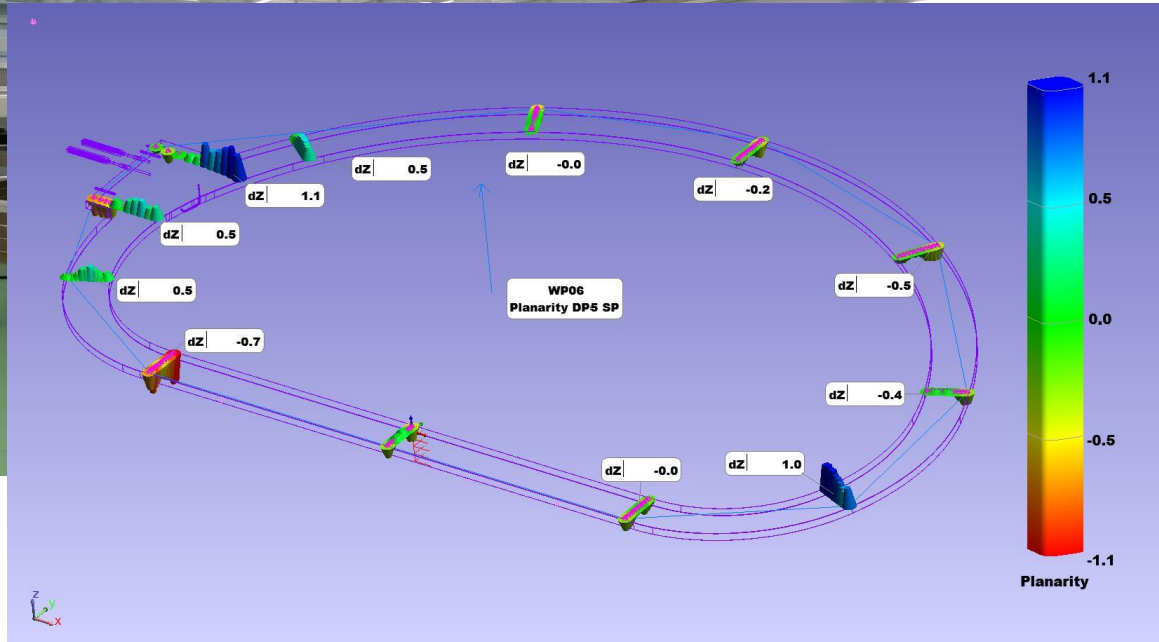


DP alignment and stacking

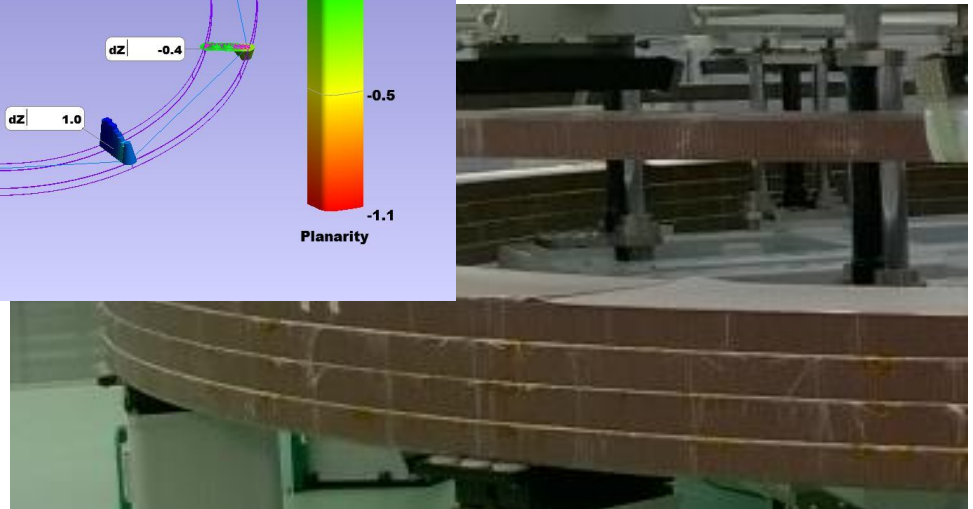


Interleave material

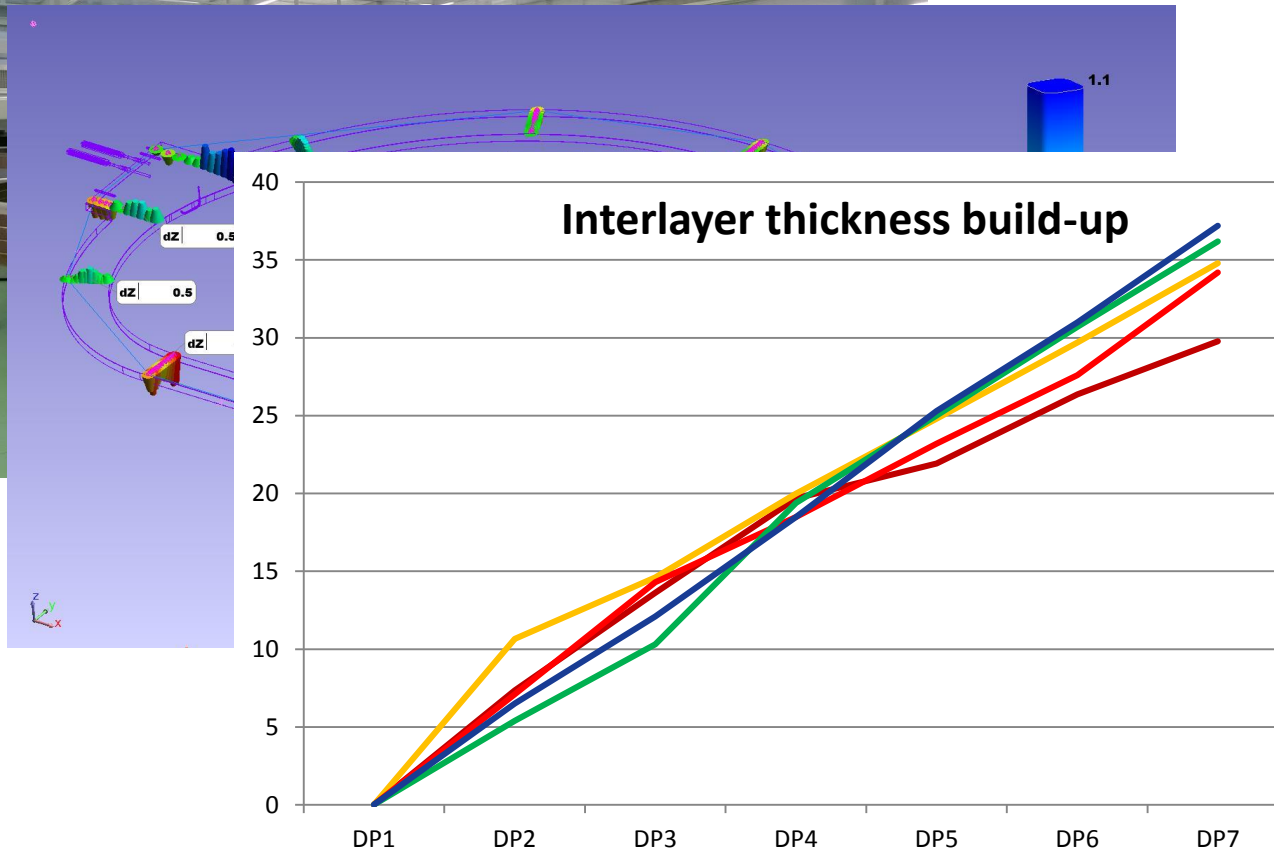
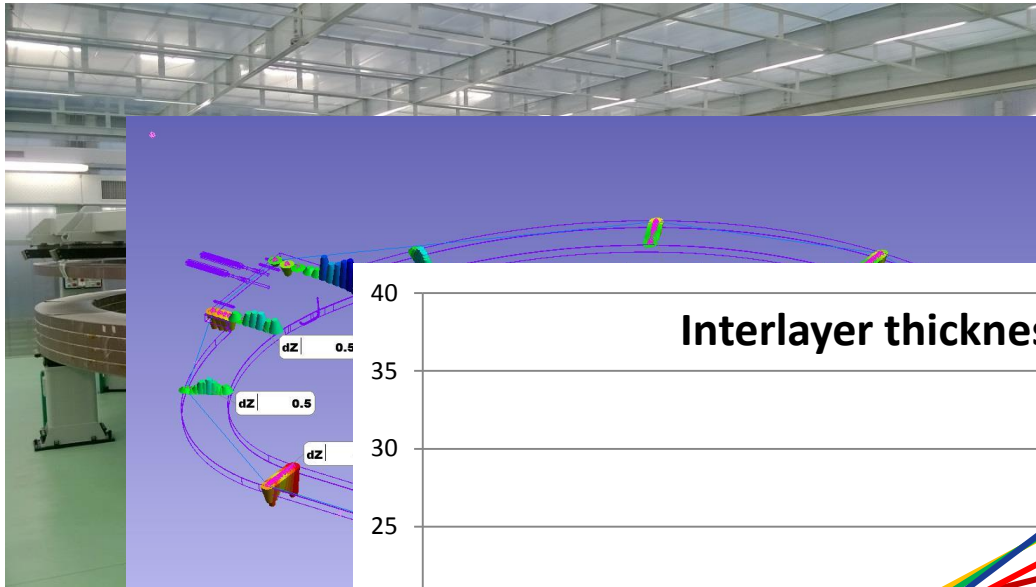
Double Pancake stacking



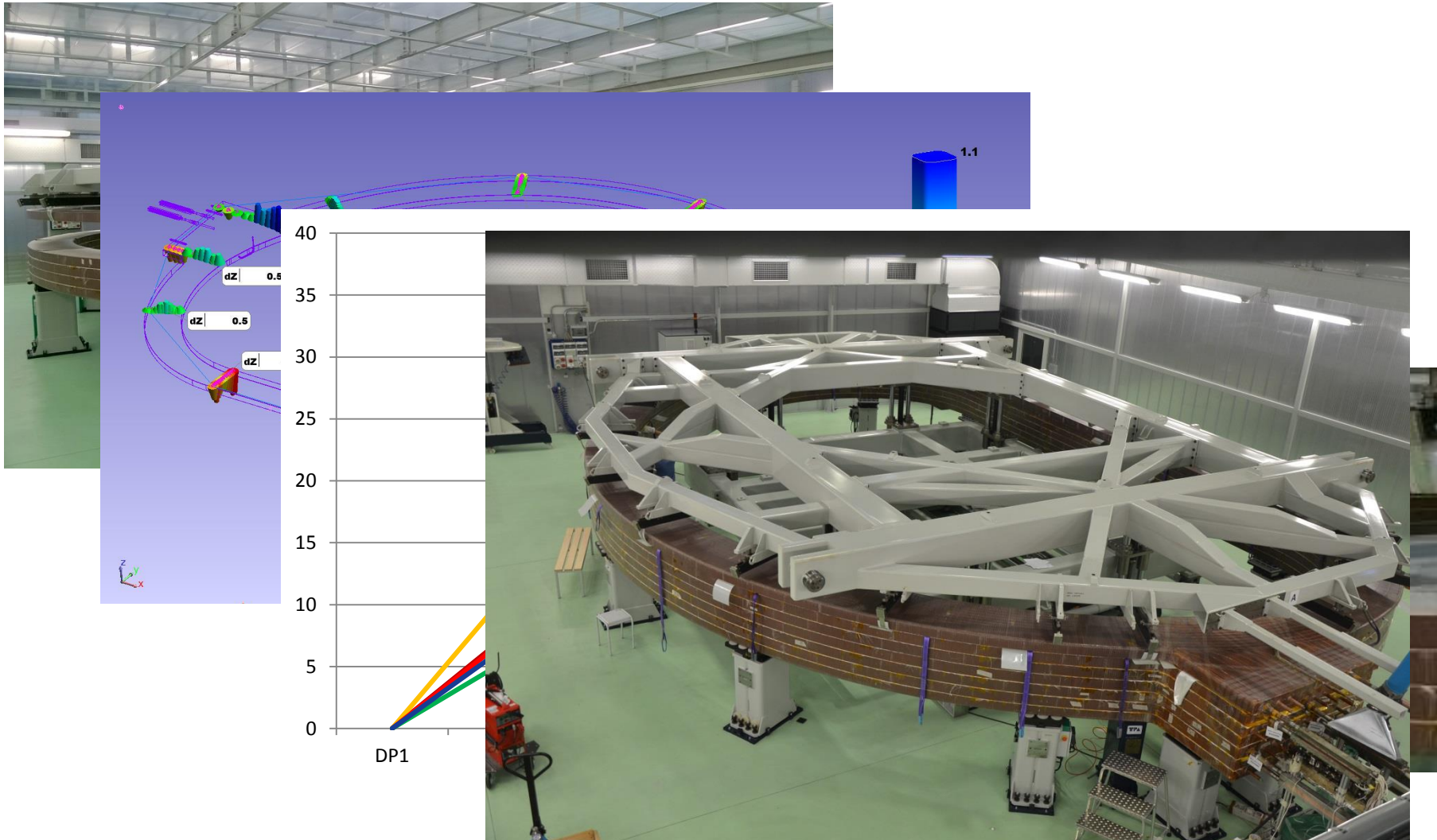
Flatness & height measurement



Double Pancake stacking

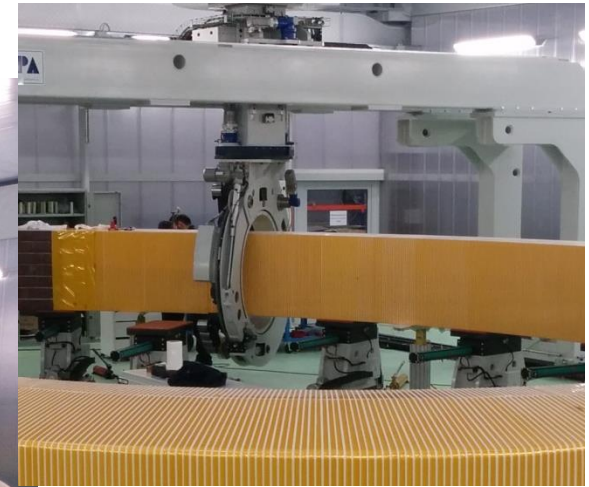


Double Pancake stacking



Stacking completed

Winding Pack ground insulation



Insulation wrapping and WP pre-compaction

Winding Pack compaction and impregnation

	TFWP-EU01	TFWP-EU02	TFWP-EU03
H after Stacking (HS)	812.4	817.4	816.8
Total interlayer thickness (IT)	29.8	34.8	34.2
H after Ground Insulation (HGI)	821.0	824.1	822.9
Ground insulation thickness (GI)	6.5	7.2	7.2
DH after ground insulation (HGI-HS)	8.6	6.7	6.1
Interlayer pre-compaction ($IPC=2*GI-DH$)	4.4	7.7	8.3
Vertical mould compaction (VMC)	3.4	3.7	5.6
Total compaction ($TC=IPC+VMC$)	7.8	11.4	13.9
Partial compaction ground insulation ($PCGI=5\%*2*GI$)	0.7	0.7	0.7
Partial compaction interlayer material ($PCI=TC-PCGI$)	7.1	10.7	13.2
Compaction ratio interlayer material (PCI/IT)	24%	31%	39%



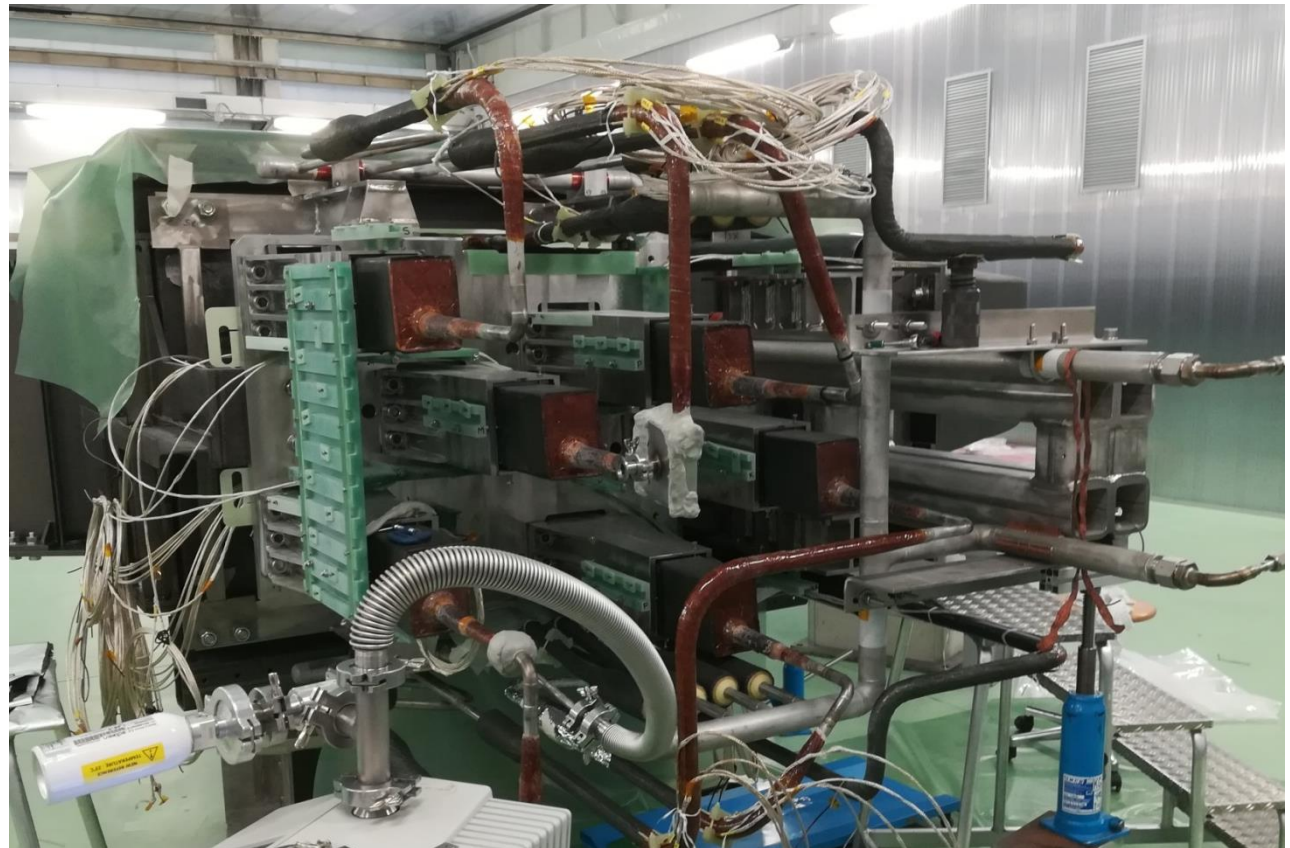
WP impregnation mould



WP impregnation completed

Winding Pack final assembly

- Termination support structure
- He-circuit
- Instrumentation wiring



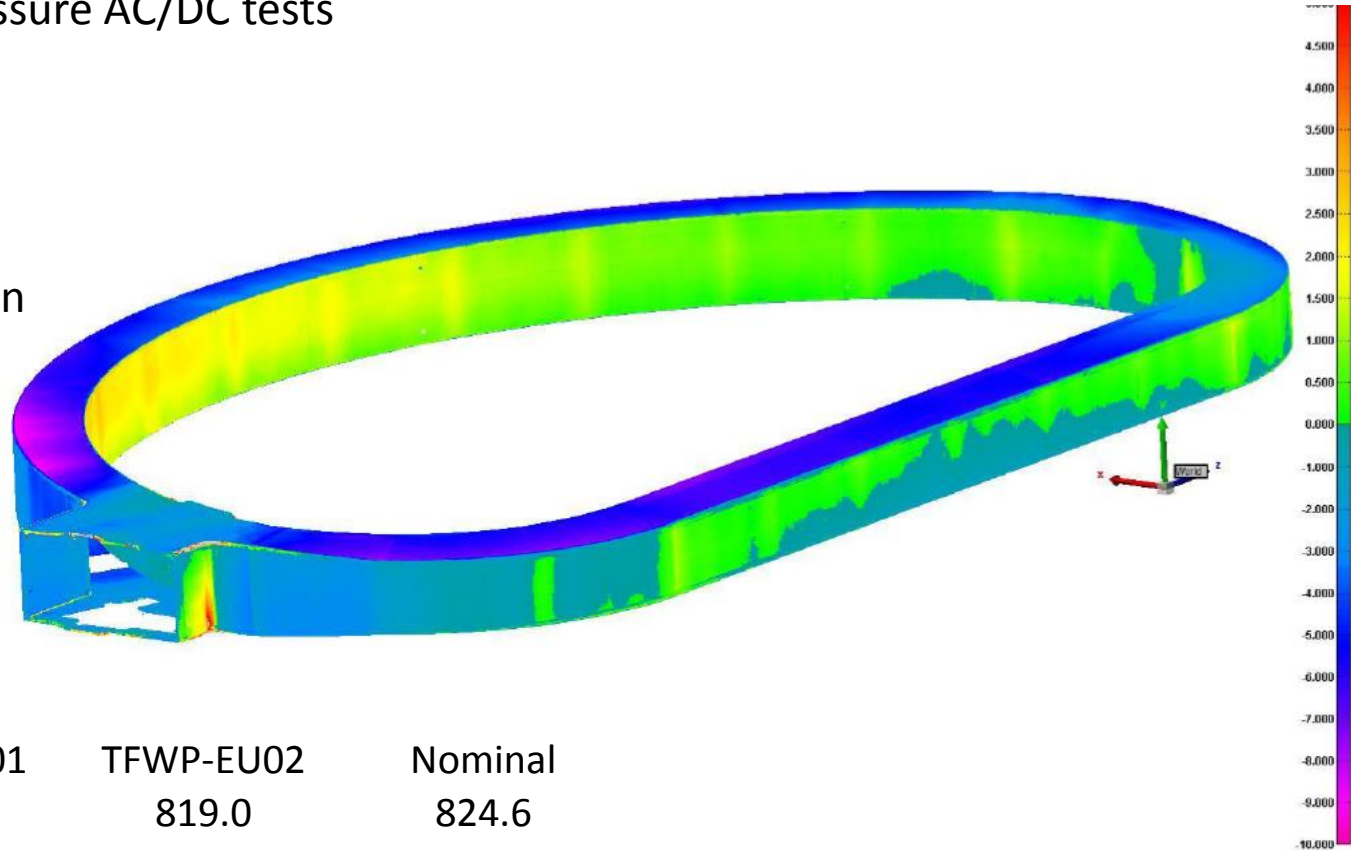
- Magnetic measurements



- Magnetic measurements
- Electrical tests:
 - Atmospheric pressure AC/DC tests
 - Paschen tests

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- Electrical tests:
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 - Paschen tests
- He-circuit:
 - Leak test
 - Flow test

- Magnetic measurements
- Electrical tests:
 - Atmospheric pressure AC/DC tests
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 - Leak test
 - Flow test
- Dimensional inspection



	TFWP-EU01	TFWP-EU02	Nominal
WP height	816.8	819.0	824.6
WP length	13801.39	13799.4	13800.5
WP width	8681.2	8680.2	8680.9



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Thank you for your attention