

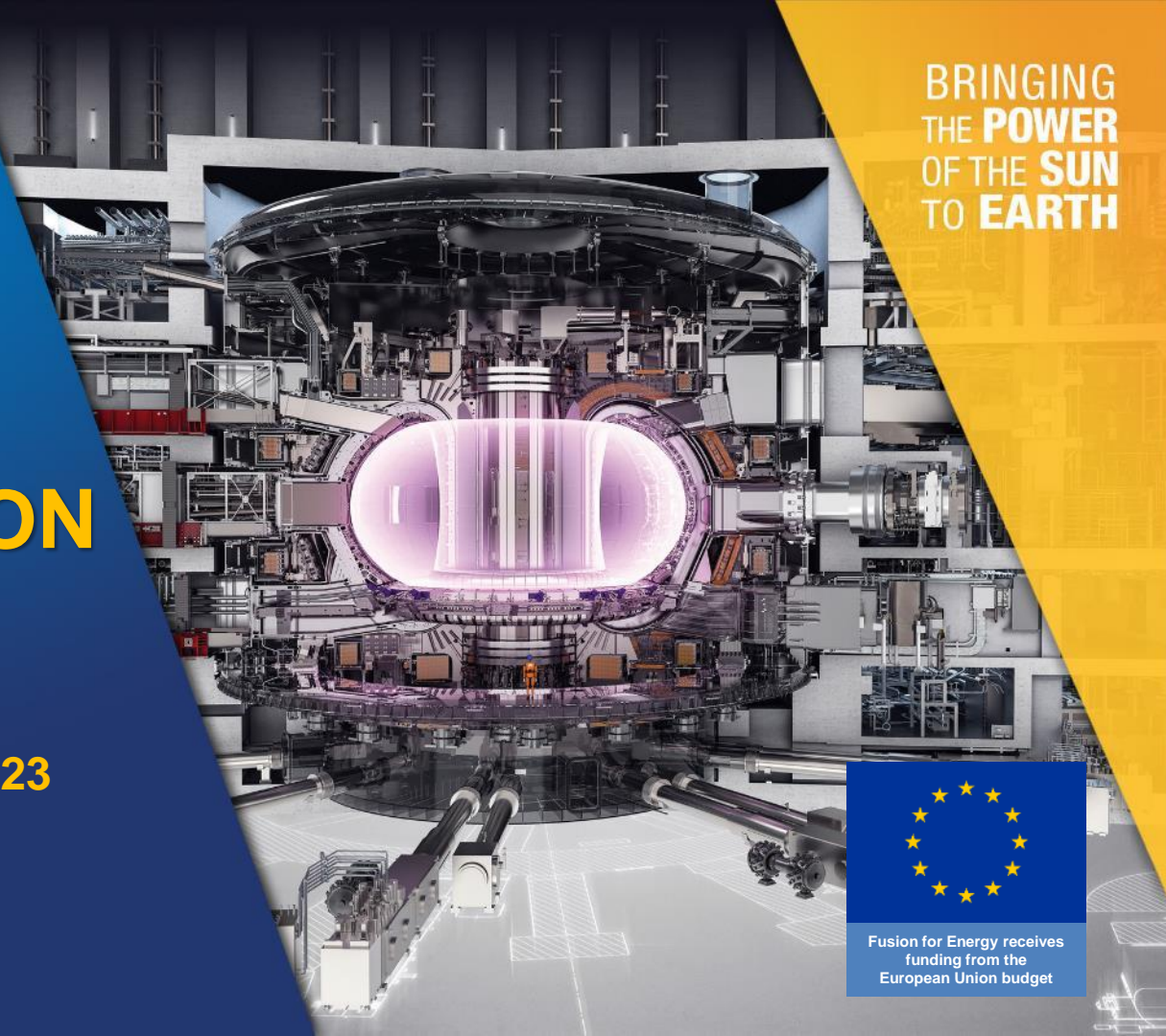


**FUSION
FOR
ENERGY**

4th Forum FUSION GERMANY

Thursday 7th December 2023
Laurent Schmieder

BRINGING
THE **POWER**
OF THE **SUN**
TO **EARTH**



Fusion for Energy receives
funding from the
European Union budget

F4E contribution to ITER Project Status

Business Opportunities

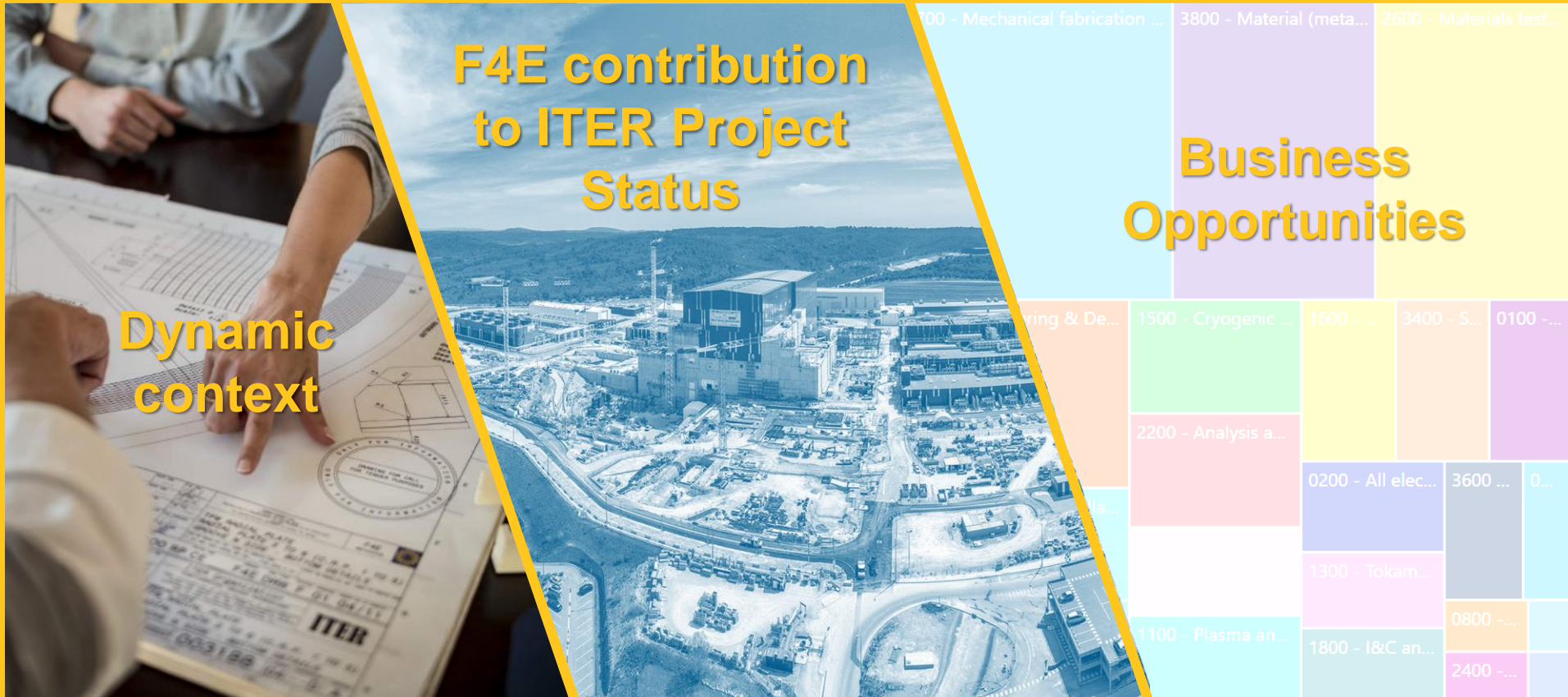
Dynamic
context



F4E contribution to ITER Project Status

Business Opportunities

Dynamic context



A dynamic context

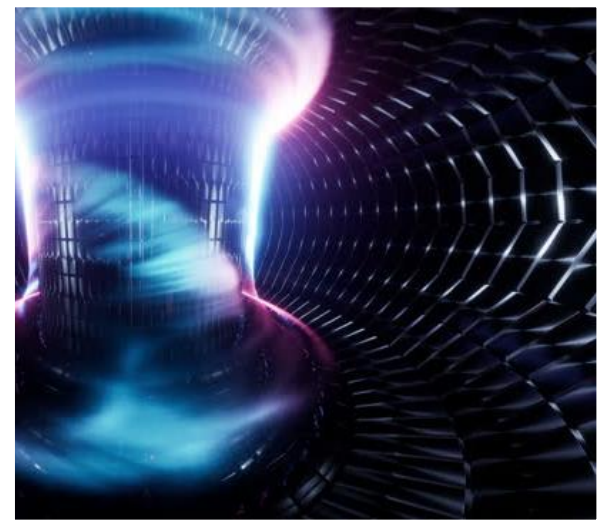


September

- **UK announced £650m (€760 m) for domestic fusion research** until 2027 after confirming that it would not join Euratom as an associated member

October

- IAEA announced the new **World Fusion Energy Group** will bring together scientists, engineers, policy makers, financiers & regulators with first meeting in 2024
- **IAEA hosted the first meeting focusing on the safety & regulation of fusion** with 100 persons from 23 countries including two F4E colleagues



Update on Recent News in Fusion (2/2)



November

- **UK and US governments signed a “bold” partnership to accelerate fusion energy development** through R&D collaboration & knowledge sharing
- **European Parliament adopted position on Net Zero Industry Act (NZIA) to include “fusion energy technologies”** among net zero technologies
- Southeastern China’s Jiangxi province announced plans to build a **fusion-fission power plant** for more than 20 billion yuan (€ 2.6 billion)

December

- US Climate Change Envoy John Kerry expected to reveal **US government’s vision on fusion energy** at 28th UN Climate Change Conference (COP 28)



Major Milestone Achieved on Broader Approach



JT-60SA Restart & First Plasma

Inauguration ceremony 1st December

Completion of the injector beam
characterization in continuous wave at
nominal conditional for phase B+



Achieved 24/10/23

Q423

As planned

Achieved

P15 co-view

2023-12-01 14:15:46.894 (1)

P15 ctr-view

2023-12-01 14:15:46.788 (1)

E101046 (CIF NTSC)

0.00 sec

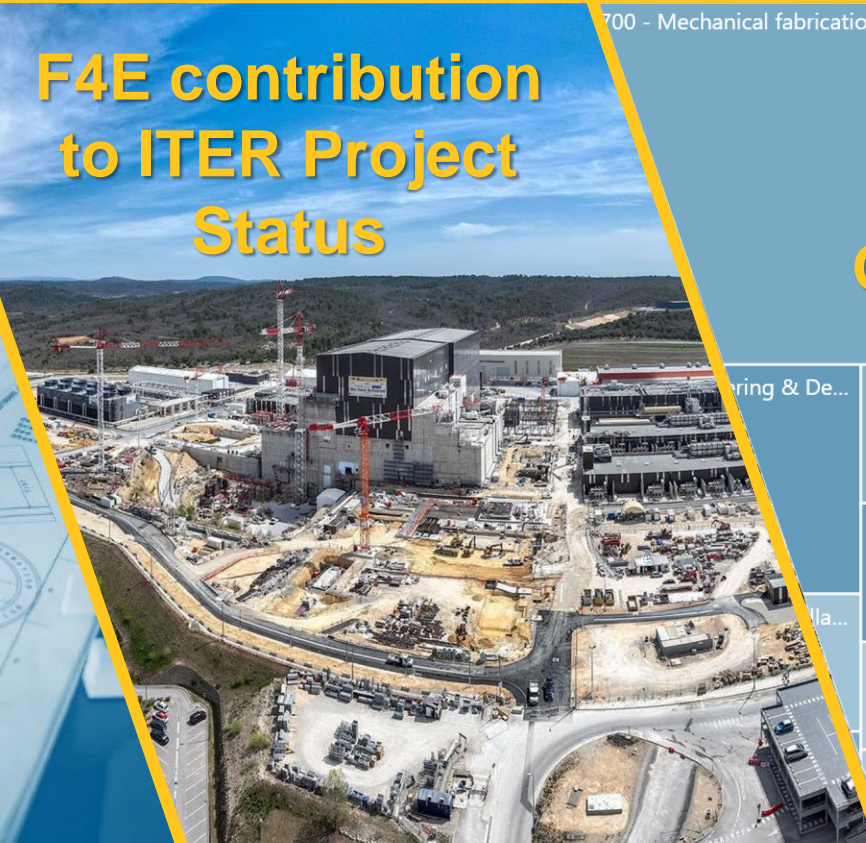
E101046 (CIF NTSC)

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F4E contribution to ITER Project Status

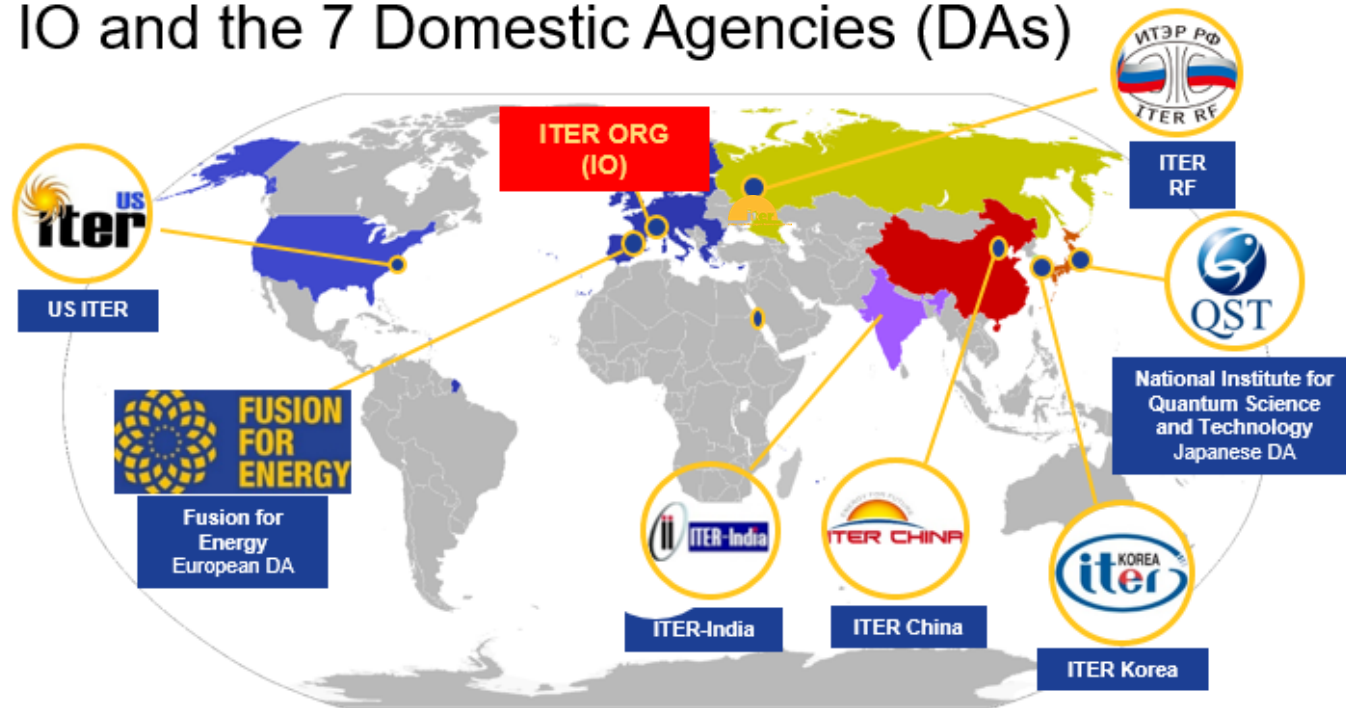
Business Opportunities

Dynamic context



700 - Mechanical fabrication ...	3800 - Material (meta...	2600 - Materials test...		
Engineering & De...	1500 - Cryogenic ...	1600 - ...	3400 - S...	0100 - ...
	2200 - Analysis a...			
lla...		0200 - All elec...	3600 ...	0...
	0900 - Remote H...	1300 - Tokam...		
	1100 - Plasma an...	1800 - I&C an...	0800 - ...	
			2400 - ...	

IO and the 7 Domestic Agencies (DAs)



ITER: Burning Plasma



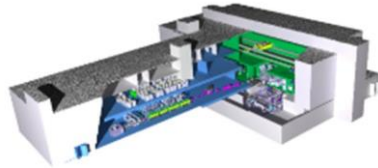
Responsible for Europe's
contribution to **ITER**

BROADER APPROACH



Working with Japan
on satellite fusion projects

DONES: Materials Testing



Contributing to design & construction
Demo Orientated Neutron Source

DEMO: Continuous Power



Preparing to build power-generating
Demonstration Fusion Reactor

ITER will create “burning” plasmas under conditions close to those in future power plants



Tore Supra

25 m³

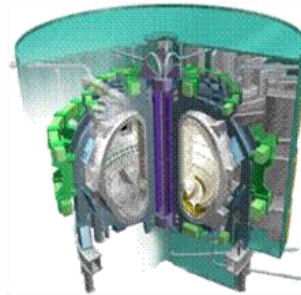
~ 0 MW_{th}



JET

80 m³

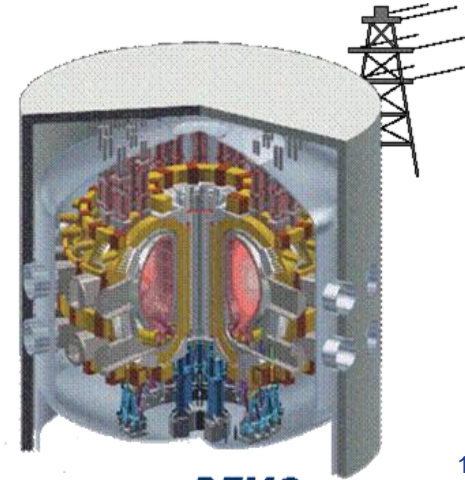
~16 MW_{th}



ITER

800 m³

~ 500 MW_{th}



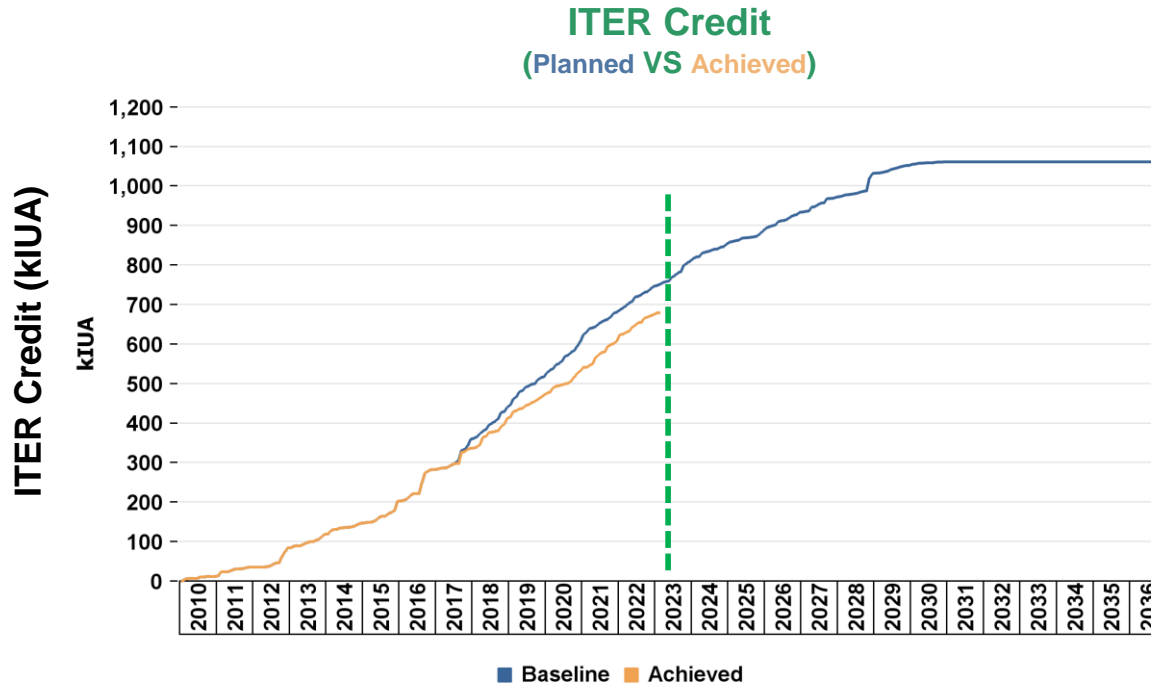
DEMO

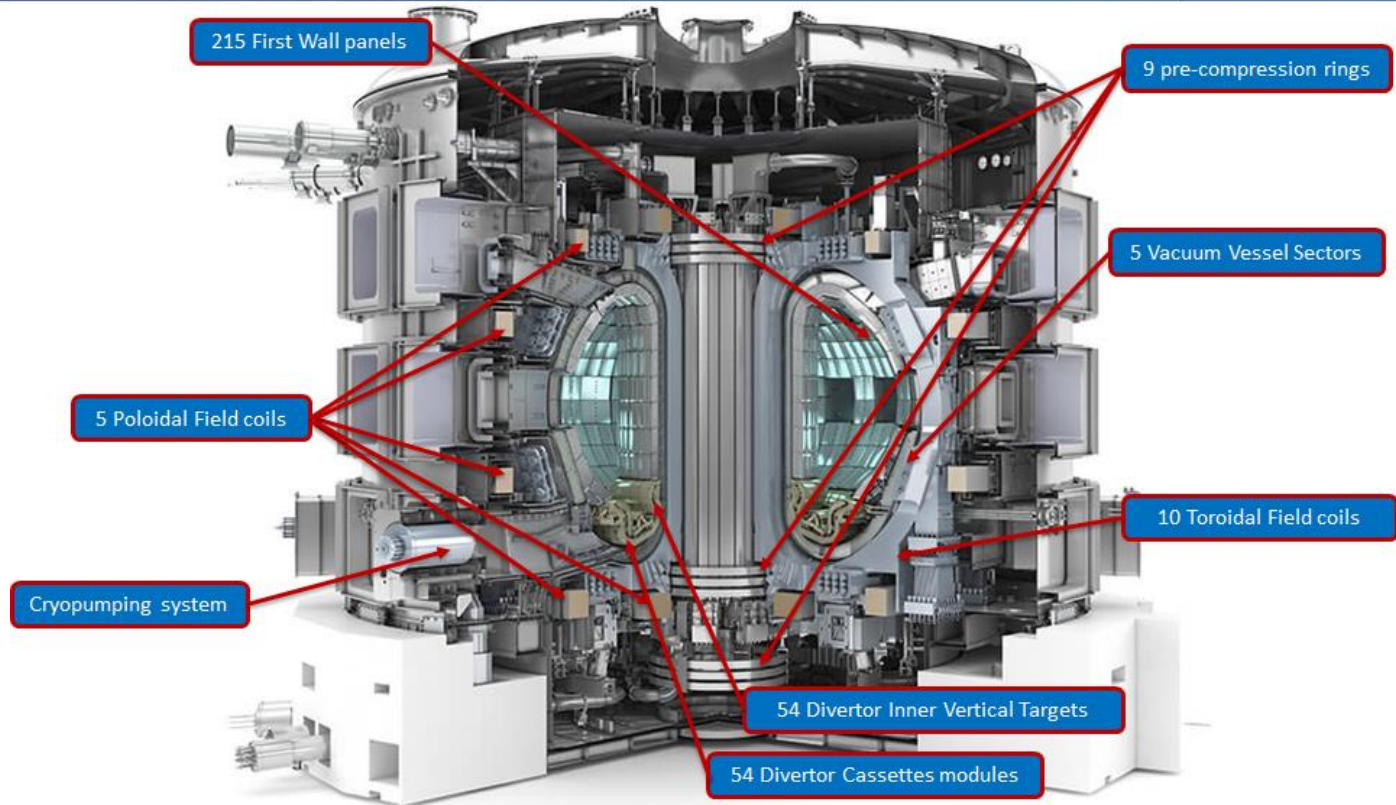
~ 1000 - 3500 m³

~ 2000 - 4000 MW_{th}

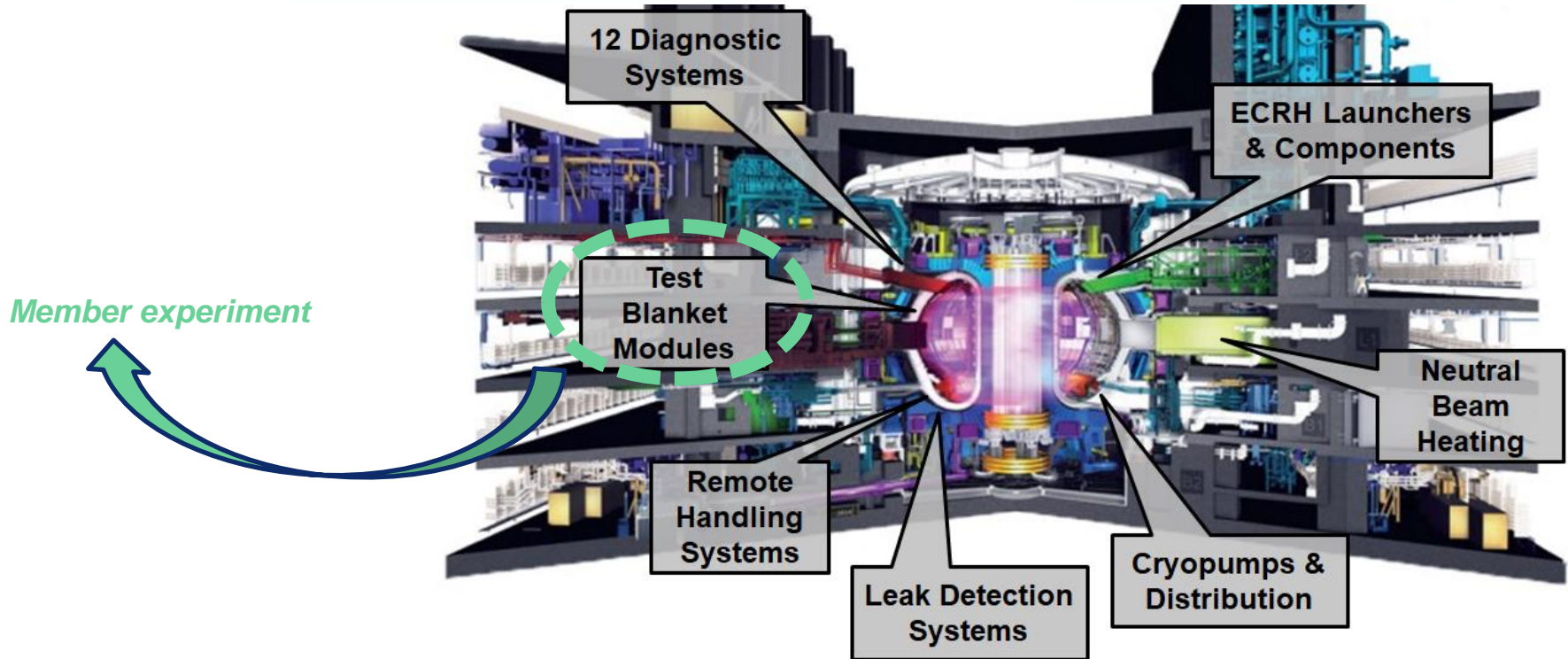
11

F4E has delivered >65% of its in-kind contributions for ITER

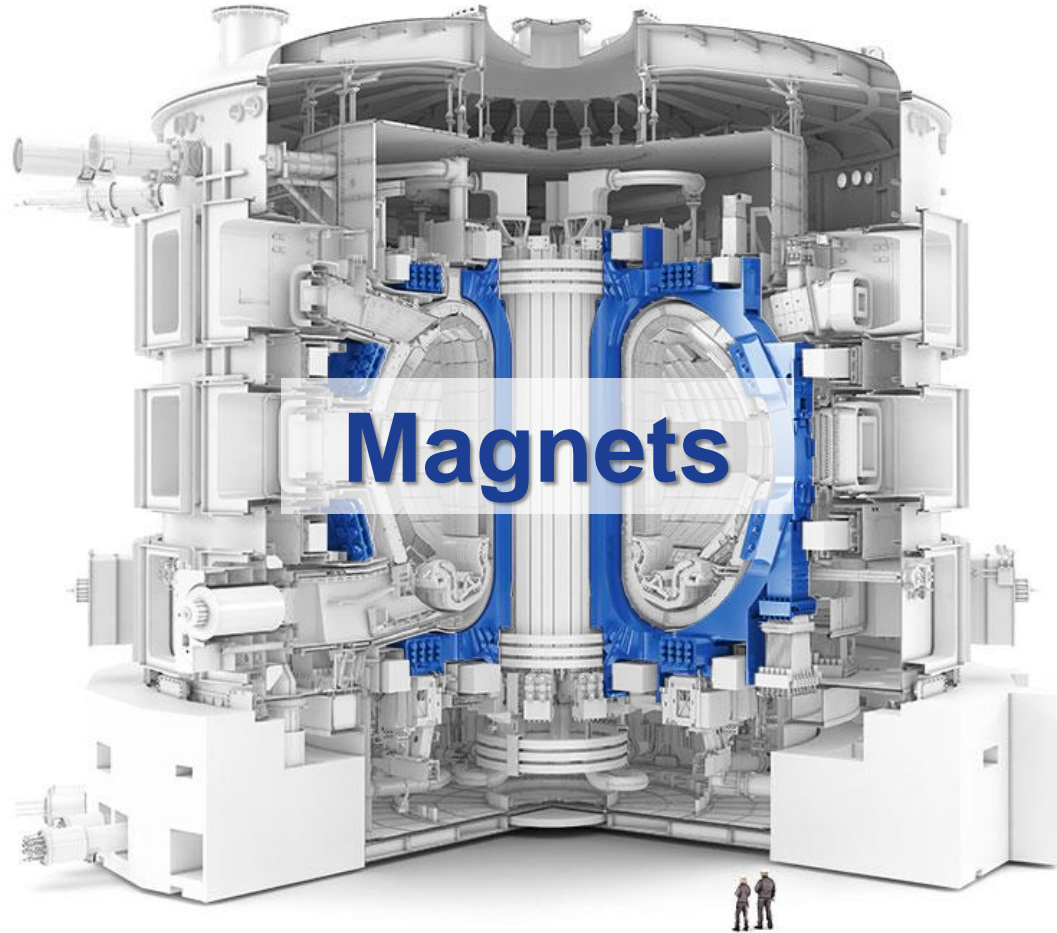




Also Power supplies, cooling water systems, detritiation systems...



Also Cryoplant, Electrical SSEN and PPEN, Building services, Gyrotrons, PS for Gyrotrons and for HNB, Rems...



Magnets

TF coils production (almost) accomplished

TFC#01 (TF09)	completed and delivered	100%
TFC#02 (TF11)	completed and delivered	100%
TFC#03 (TF05)	completed and delivered	100%
TFC#04 (TF03)	completed and delivered	100%
TFC#05 (TF06)	completed and delivered	100%
TFC#06 (TF04)	completed and delivered	100%
TFC#07 (TF17)	completed and delivered	100%
TFC#08 (TF14)	completed and delivered	100%
TFC#09 (TF01)	completed and delivered	100%
TFC#10 (TF18)	completed and to be delivered in Dec-23 (*)	95%

(*)

last TF18 will be shipped with a small electrical NC
NC will be repaired on site by the supplier in Jan/Feb 2024

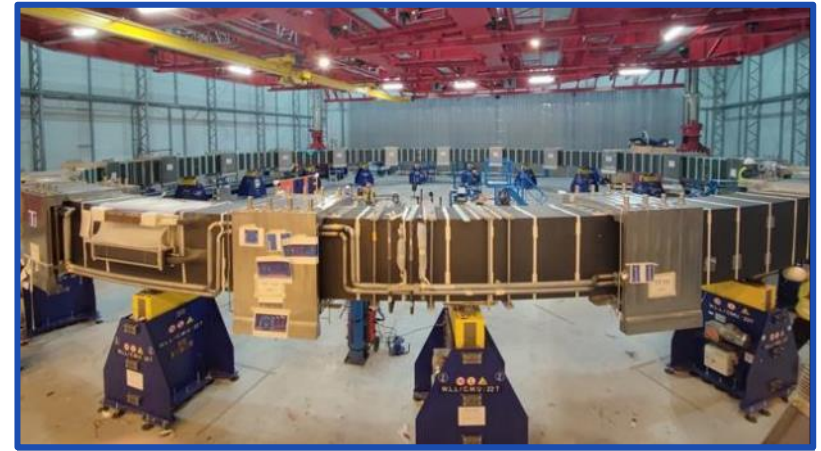


PF coils (almost) accomplished

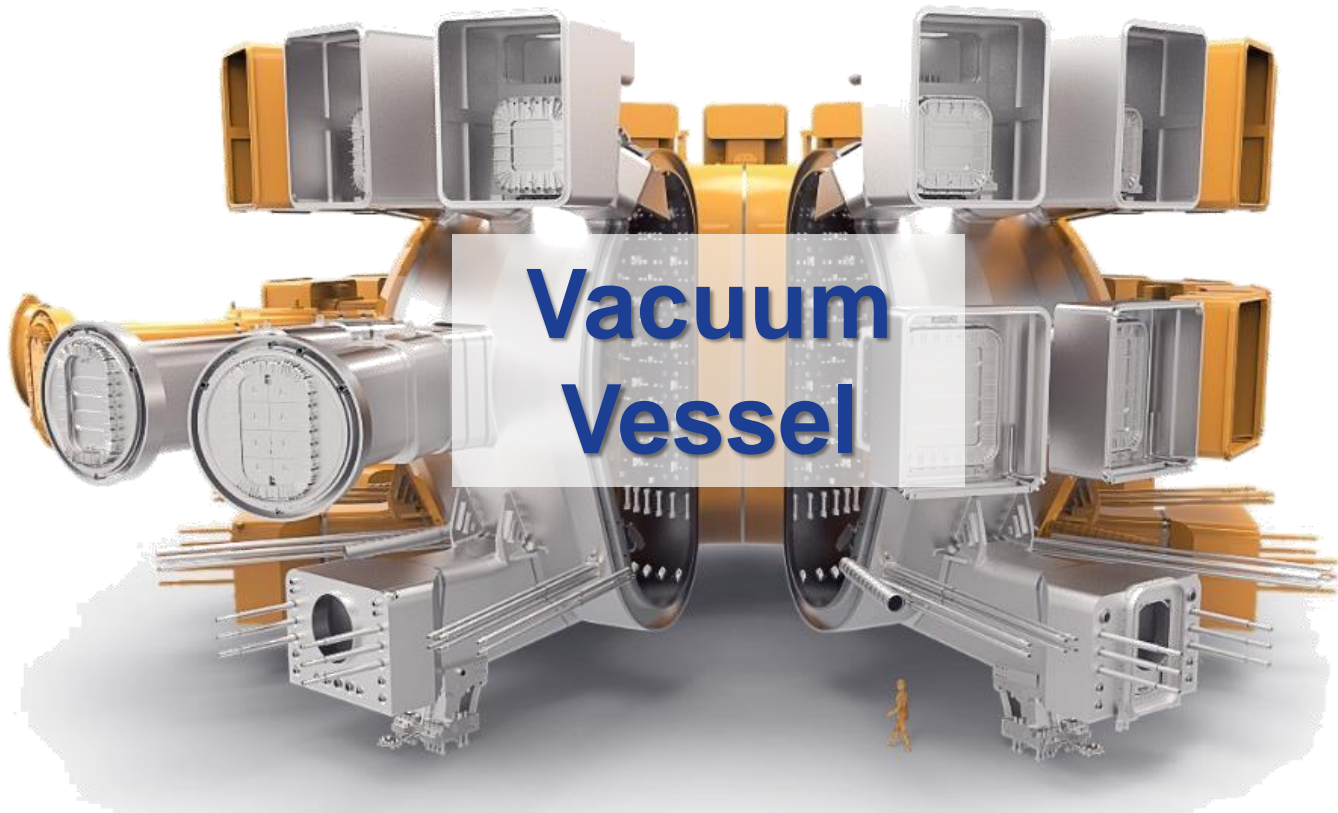
PF6 Coil	completed and delivered	100%
PF5 Coil	completed and delivered	100%
PF2 Coil	completed and delivered	100%
PF4 Coil	completed and delivered	100%
PF3 Coil	assembly before cold test ongoing	85%



PF4 Delivered (August 2023)

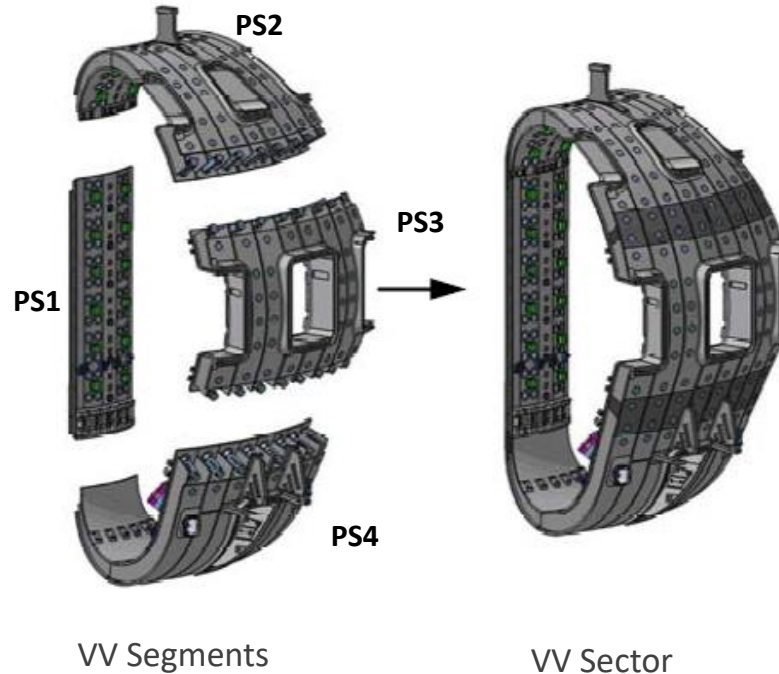


PF3 Assembly ongoing



Vacuum Vessel

Each Vacuum Vessel Sector consists of 4 Poloidal Segments (PS)



Overview of Vacuum Vessel Status

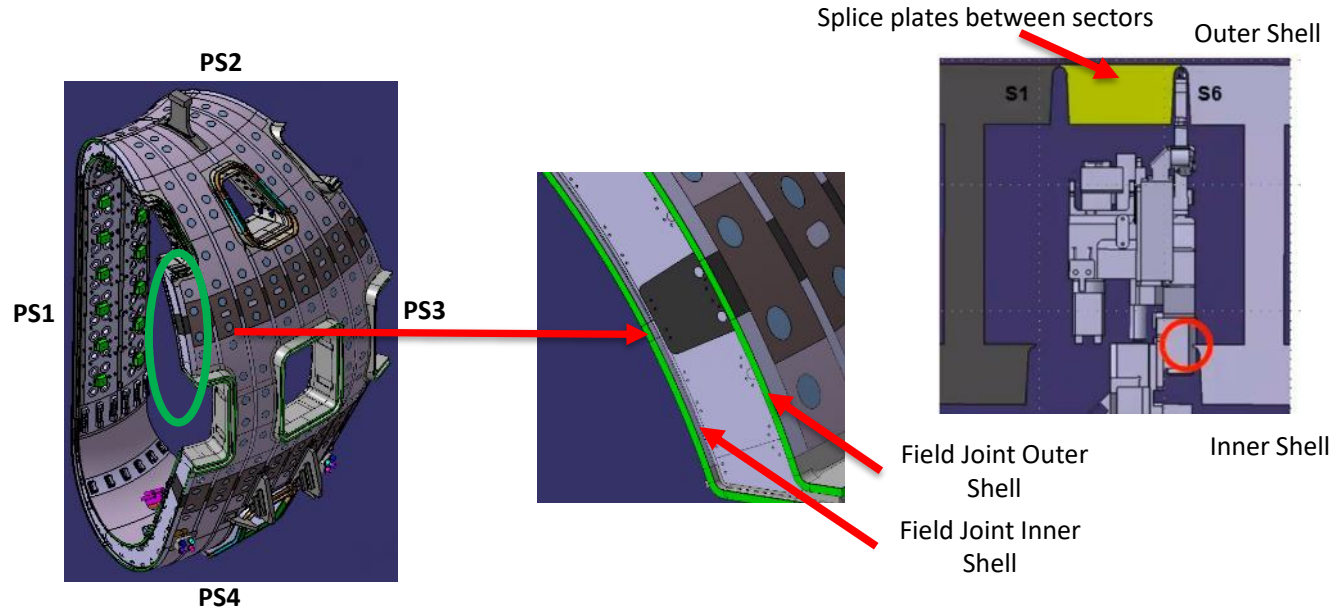
MANUFACTURING PHASE	SECTOR 5				SECTOR 4				SECTOR 9				SECTOR 3				SECTOR 2			
SEGMENT LEVEL	PS1	PS2	PS3	PS4	PS1	PS2	PS3	PS4	PS1	PS2	PS3	PS4	PS1	PS2	PS3	PS4	PS1	PS2	PS3	PS4
Flexible housing welding	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
T-ribs welding	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
Inner shell welding	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
IWS installation	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
Outer shell welding	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
Final machining	V	V	V	V	V	V	V	V	V	V	V	V	V	/	V	/	/	/	/	/
Outer shell weld repairs	V	/	/	V	/	/	/	/	V	/	/	/	V	V	/	/	V	V	/	/

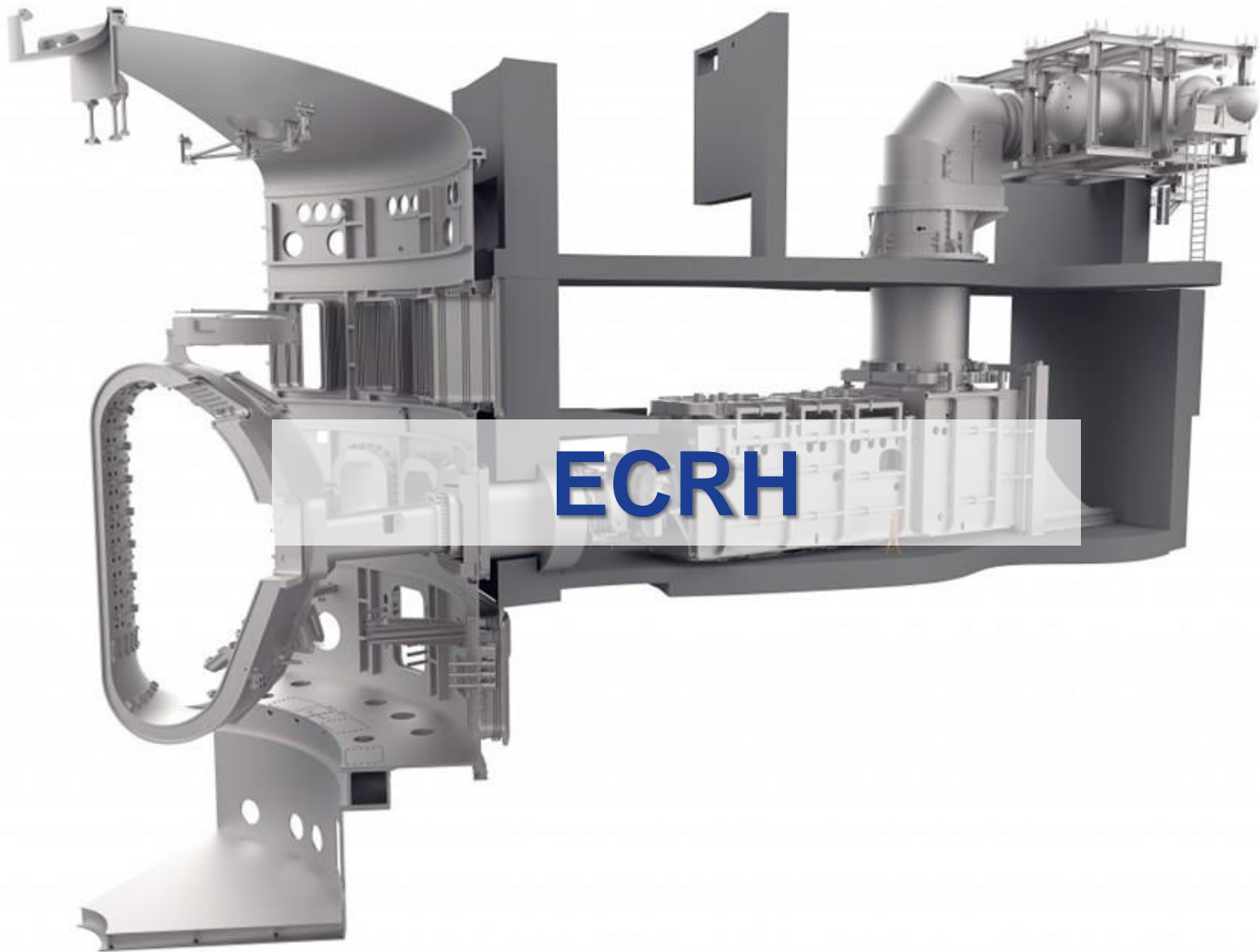
SECTOR LEVEL	S5	S4	S9	S3	S2
D-shape assembly	V	V			
Inner shell welding	V	V			
Splice T-rib welding	V	V			
IWS installation	V	/			
Outer shell welding	V	/			
Outer shell weld repairs	/				
Acceptance tests					

 = Changes since previous TAP meeting

- Final welding completed **for all 20 Segments**
- Final machining completed for **13** of 20 Segments
- **Seven** segments are fully repaired, **12** Segments under repair
- Two Sectors are in final assembly stage, with inner shell welding completed.
- Outer shell welding on Sector 5 **completed** and Sector 4 ongoing

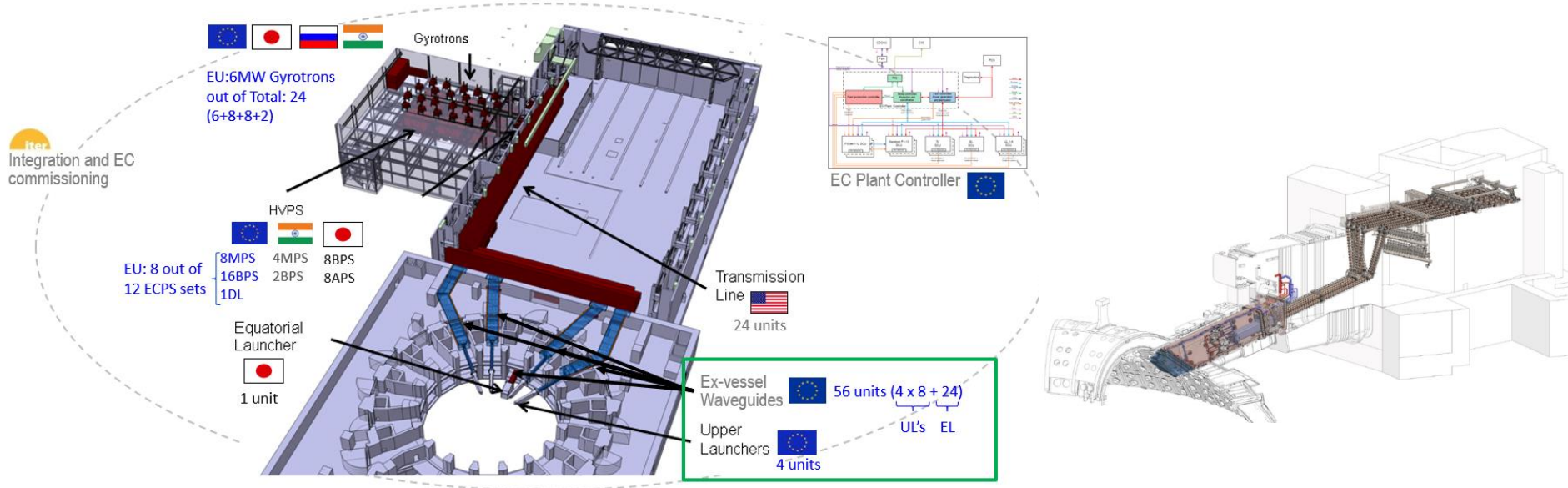
Legend	
V	Completed
/	Ongoing





ECRH

Electron Cyclotron Radiofrequency Heating ECRH system – current baseline sharing

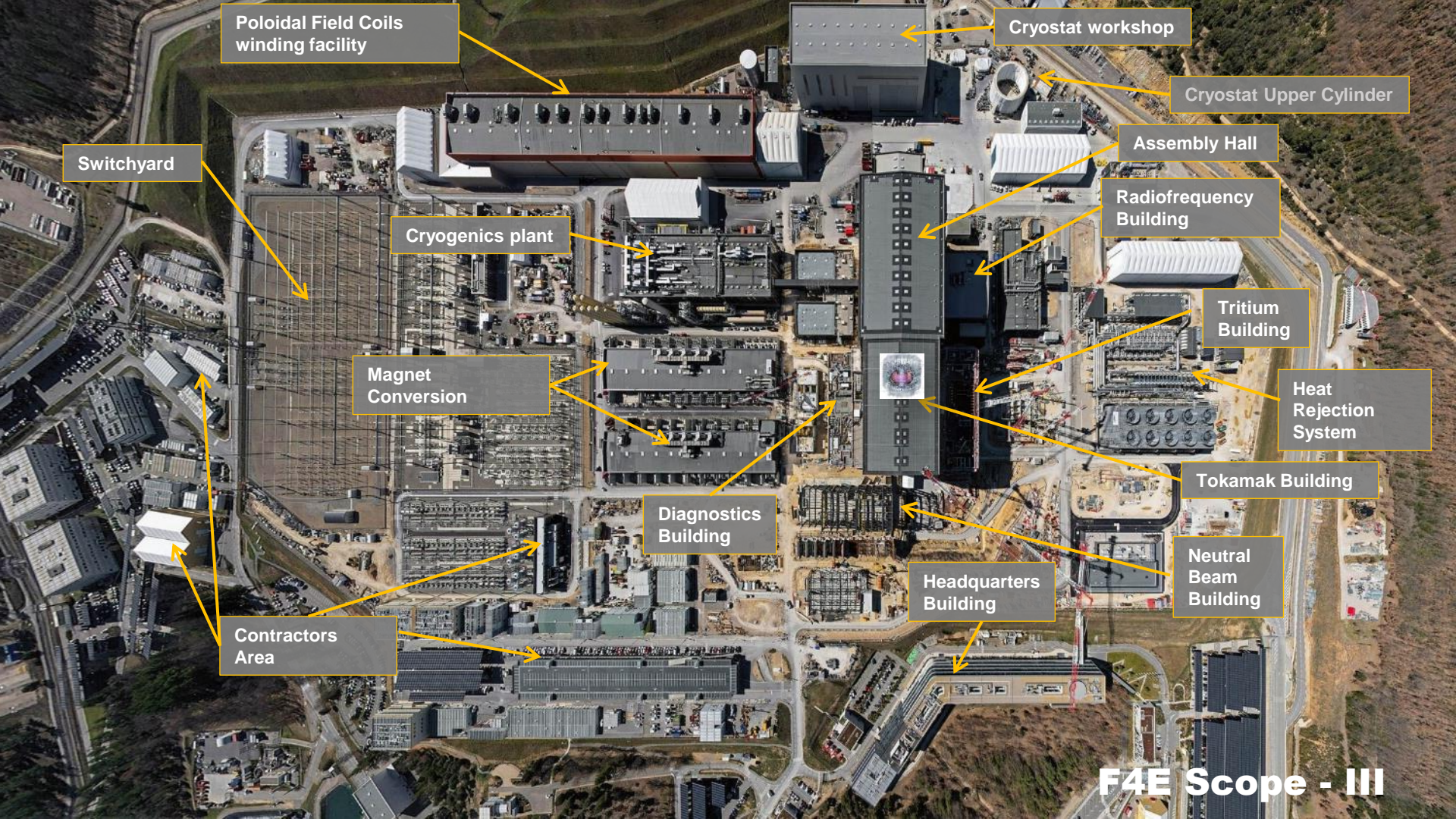


Scope: Design and procurement of 4 upper launchers (UL), and 5 sets of ex-vessel waveguide systems (EW)

Status: Final design ongoing (FDR planned for Q4 2024 – Q1 2025)

Status of Buildings Programme





Poloidal Field Coils winding facility

Cryostat workshop

Cryostat Upper Cylinder

Switchyard

Cryogenics plant

Assembly Hall

Radiofrequency Building

Magnet Conversion

Tritium Building

Heat Rejection System

Diagnostics Building

Tokamak Building

Contractors Area

Headquarters Building

Neutral Beam Building

F4E Scope - III



F4E completed construction works
Buildings handed over to IO

Site infrastructure across platform delivered

* Civil works already taken over by IO and Building services equipment delivery is ongoing

Ongoing construction works

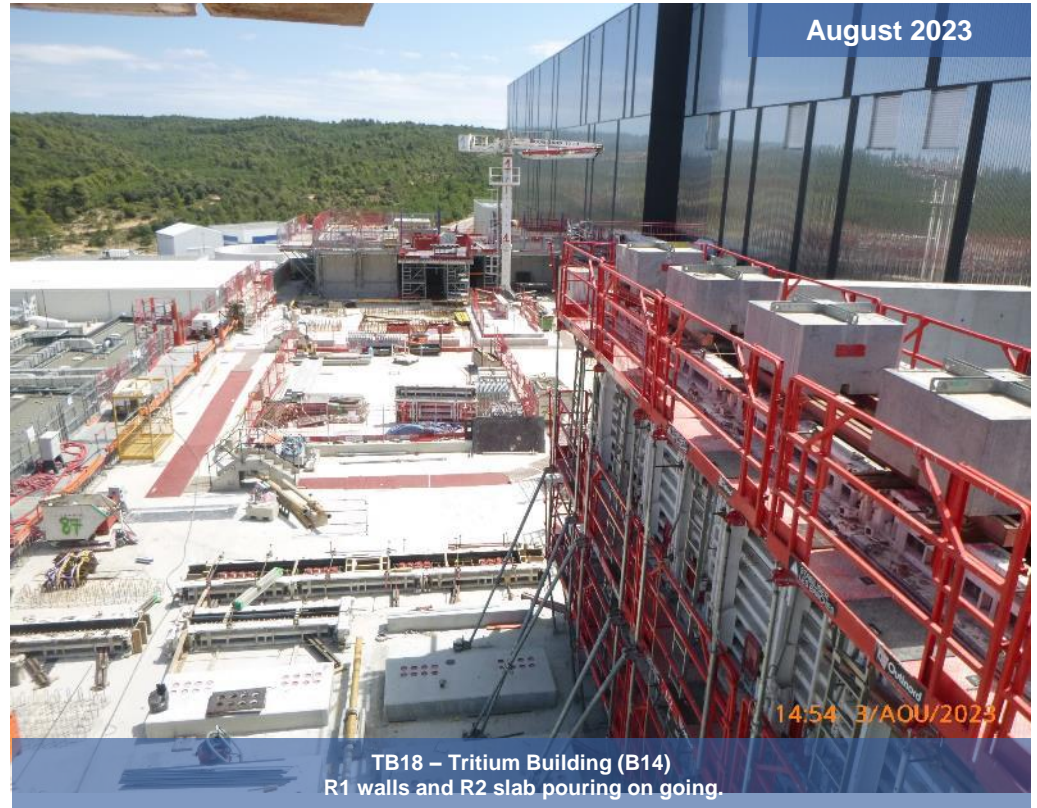
Tokamak Complex (Nuclear buildings)
B11 – Tokamak Building
B14 – Tritium Building
B74 – Diagnostic Building

B34 – NB Power Supply Building
B37 – NB High Voltage Power Supply Building
B44, B45, B46, B47 – Emergency Power Supply and Distribution Buildings
B71-N – Control Building North
B75 – FD & Switching Network Resistor Building
B62 – Hot Water Boilers Building

Test and Commissioning

B15 – RF Heating Building
B51, B52 – Cryoplant Buildings

Tritium Building (B14) Civil Works Construction Progressing As Per Plan



Cryobridge installation: RFE conditions were met on 5 May 2023 allowing the start of works by IO

March 2023



August 2023



Busbar bridge installation: The M1 and M2 bridges steel structures were erected during summer

March 2023



August 2023



Control Building (71), Fast Discharge Resistor Building (75), Neutral Beam Power Supplies Building (37) Works Progressing

March 2023



August 2023



Emergency Power Supply & Distribution Buildings (44-45,46-47) Works Progressing

March 2023

TB13 – Emergency Power Supply Train A (B44) & Medium Voltage Distribution LC/1A (B46) –
B44 Level 1 reinforcement and pouring ongoing.
B46 Level1 Central Shaft pouring and steel structure L1+2 completed. L2 slab precast installation ongoing



TB13 –Emergency Power Supply Train B (B45) –L1 completed.
Level 2 slab poured. L2 reinforcement ongoing

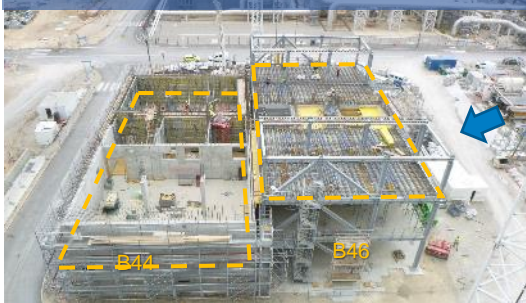


TB13 – Medium Voltage Distribution LC/2B (B47) – reinforced concrete in L1 completed, L2 ongoing.
Main Steel structure L1 and L2 completed



August 2023

TB13 – Emergency Power Supply Train A (B44) & Medium Voltage Distribution LC/1A (B46) –
B44 Level L1 slab poured. L2 walls pouring ongoing
B46 Primary steel structure works completed



TB13 –Emergency Power Supply Train B (B45) –Level 3 walls
North part poured. L1 painting completed



TB13 – Medium Voltage Distribution LC/2B (B47) – Primary steel structure works completed. Precast elements L3 roof, L4 slab secondary precast elements completed. Reinforced concrete L3 roof L4 slab ongoing



F4E contribution to ITER Project Status

Business Opportunities

Dynamic
context



GEOGRAPHICAL DISTRIBUTION OF ENTITIES

Where are the main German entities located?

Cryotherm GmbH & Co KG:
Cryogenics



Rolf Kind GmbH:
Steel.



Research Instruments GmbH:
Divertor vertical inner target



ATLAS COPCO ENERGAS, :
Compressor stations for cryogenic materials



Wilhelm Schulz GmbH, Krefeld:
Pipes and fittings for tokamak cooling water system



Forschungszentrum Jülich:
R&D on laser-induced desorption of beryllium co-deposits



Karlsruhe Institute for Technology:
Design of electron cyclotron upper Launcher
Material characterization at cryogenic temperatures



Saarschmiede GmbH, Völklingen:
EUROFER-97 plates for test blanket modules



Diamond Material, Freiburg:
Diamond disks for electron cyclotron heating system



Exyte (M+W Group):
Civil engineering, nuclear buildings



Bruker:
Superconductivity and superconductor magnets



Dockweiler AG, Neustadt-Glewe:
Prototype of blanket cooling manifold



Witzenmann GmbH, Pforzheim:
Contributes to tokamak cooling water system



NKM Noell Special Cranes, Veitshöchheim
(together with REEL S.A.S., France):
Overhead cranes to assemble tokamak
Himmelwerk GmbH, Tübingen:
Four radio frequency generators



Max-Planck-Institute for Plasma Physics, Garching:
Final design of plasma control systems for First Plasma operations
Experiment for the development of the neutral beam heating systems (ELISE)



Sommer Fassadensysteme-Stahlbau-Sicherheitstechnik GmbH:
Heavy Nuclear Doors that surround the tokamak on three levels and each of them closes an access cell



Acentrix GmbH, München:
Customization of 3D engineering and design software



Siemens AG, München:
High voltage power supply units for neutral beam injector



Kraftanlagen Heidelberg GmbH
Engineering, nuclear buildings

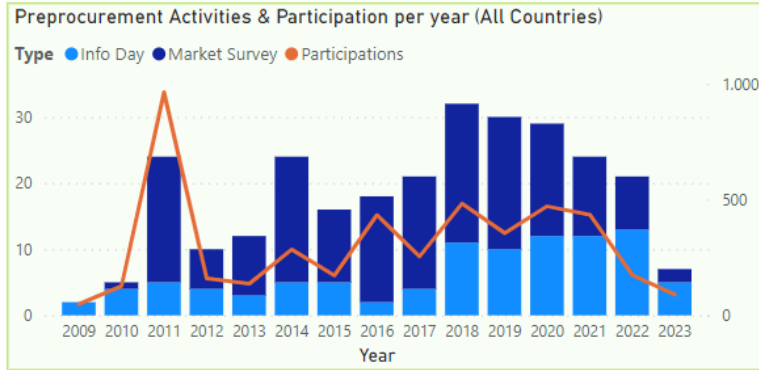




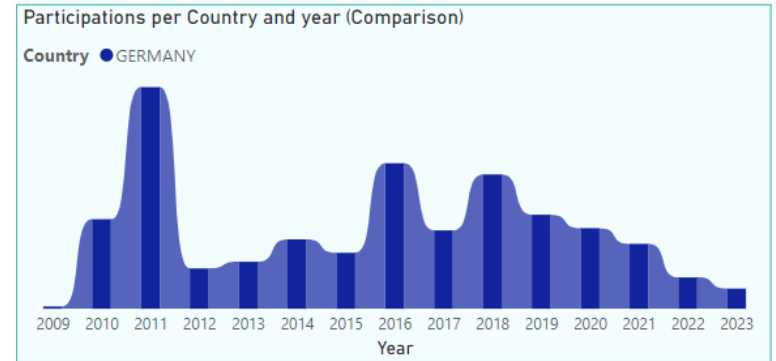
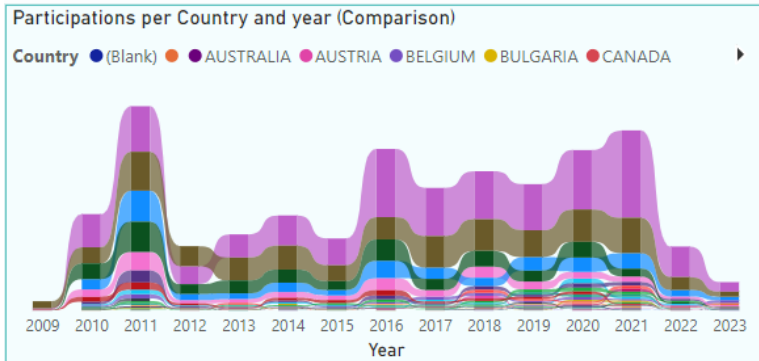
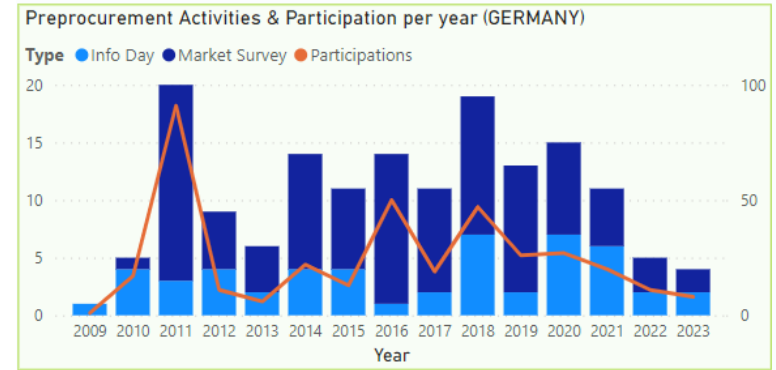
PRE-PROCUREMENT ACTIVITIES

How many pre-procurement activities does Germany participate in?

All Countries



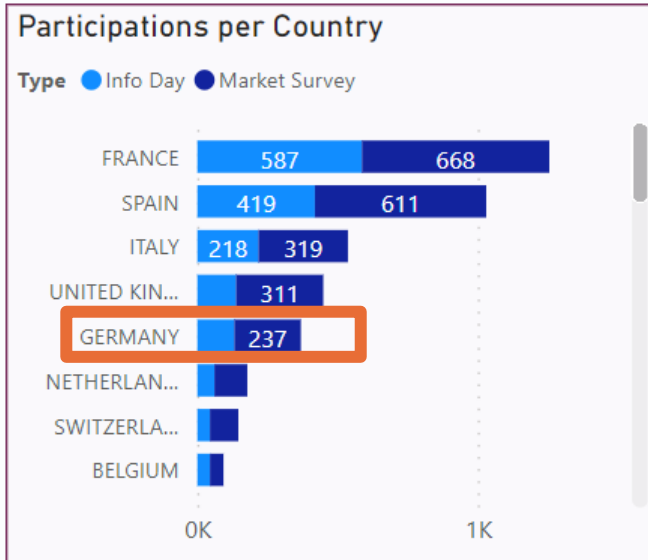
Germany



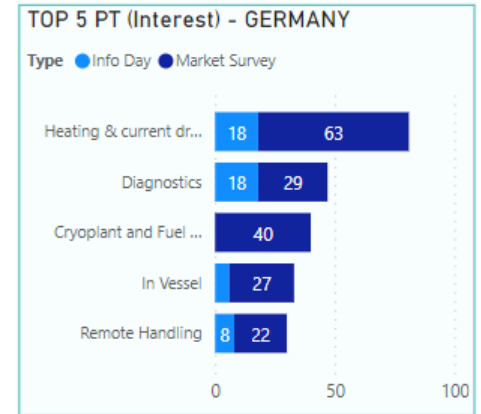
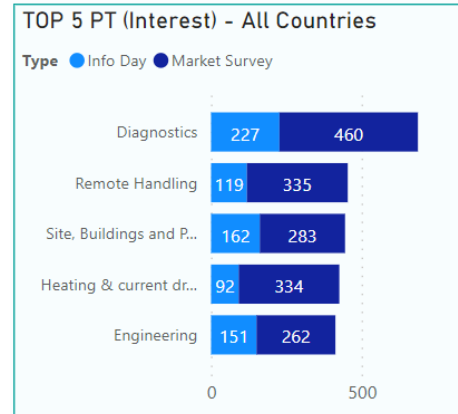
How many pre-procurement activities does Germany participate in? Which programs is Germany interested in?



Participations



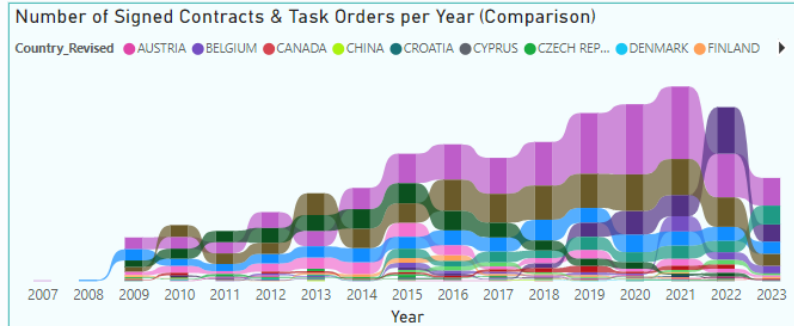
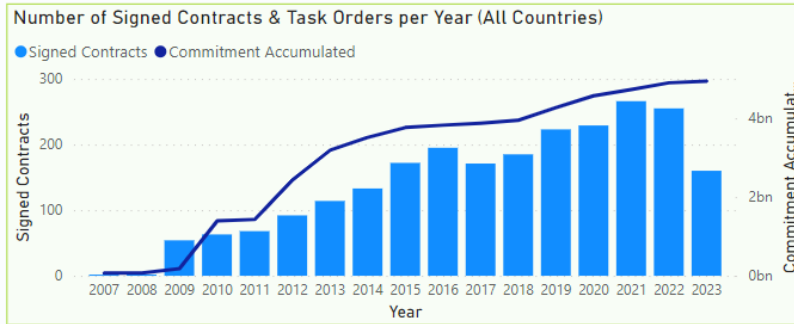
Programs



SIGNED CONTRACTS

How many contracts have been signed in Germany? How much money has been committed to Germany?

All Countries



Germany*

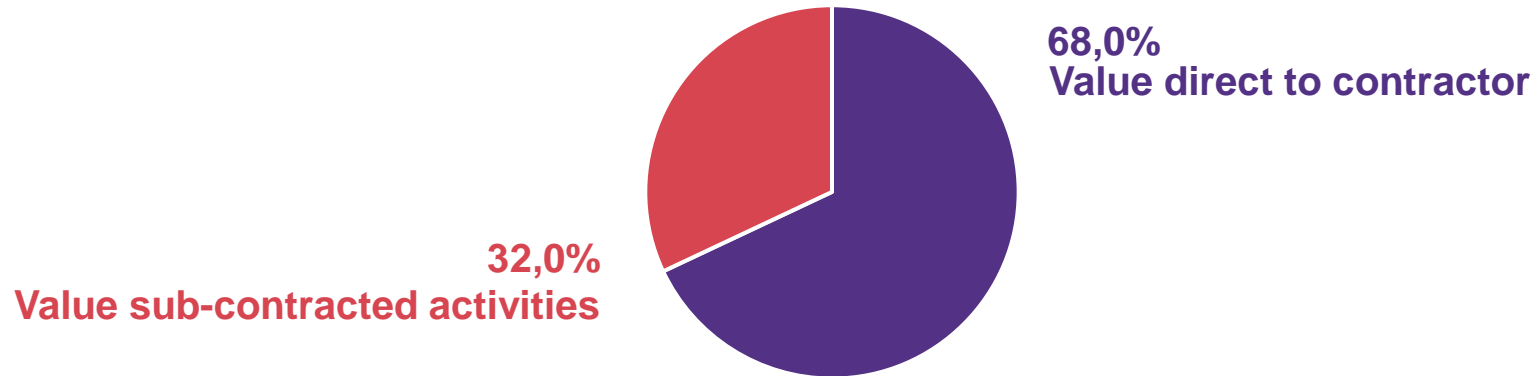


* It does not include subcontracted activities



VALUE OF CONTRACTS

**Germany total value:
567.199.439 €**



How much has been paid to German entities?

Total value: 567.199.439 €

Already paid

283.944.850 €

Remain to be paid

283.254.589 €

Direct to contractor value: 385.711.780 €

Already paid

174.835.801 €

Remain to be paid

210.875.979 €

Subcontracted activities value: 181.487.659 €

Already paid

109.109.049 €

Remain to be paid

72.378.610 €



IDENTIFIED TECHNOLOGIES

Which technologies are the focus of German entities?

Technologies in Germany

Technologies in contracts

1102 - Optical
1103 - Imaging
1813 - Fusion Diagnostic System
2219 - Neutronics analysis
3606 - Sensors
0104 - Heating Ventilation and Air Conditioning
0105 - Fluids
0106 - Nuclear ventilation
0107 - Cranes and handling device
0113 - Piping & Tube
0201 - All HV MV technologies
0202 - Power supplies
0205 - High Voltage

Technologies in pre-procurement

1102 - Optical
1103 - Imaging
1104 - Spectroscopic
1813 - Fusion Diagnostic System
3605 - Manufacture
3606 - Sensors
0101 - Other complex civil constructions, nuclear buildings
0104 - Heating Ventilation and Air Conditioning
0105 - Fluids
0106 - Nuclear ventilation
0107 - Cranes and handling device
0110 - Commissioning
0111 - Metal work

Legend



Strategic technologies

List of strategic technologies

1102 - Optical
1103 - Imaging
1104 - Spectroscopic
1105 - Microwave
1106 - Neutrons and gamma rays
1813 - Fusion Diagnostic System
2219 - Neutronics analysis
3605 - Manufacture
3606 - Sensors

Companies from the country

DIAMOND MATERIALS GMBH & CO. KG
KARLSRUHER INSTITUT FUR TECHNOLOGIE
PRO-BEAM BETEILIGUNGS AG & CO. KG
RI RESEARCH INSTRUMENTS GMBH*

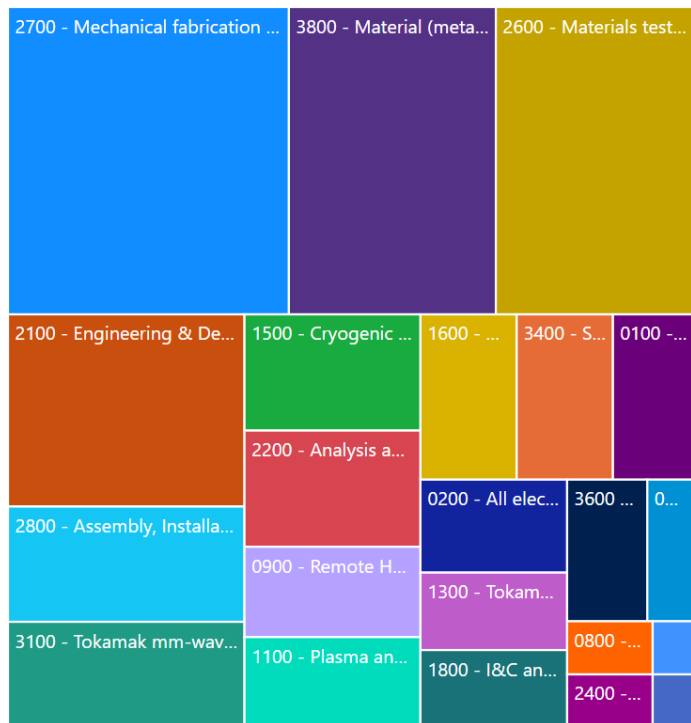
Legend



Strategic companies

In which areas does Germany get more contracts?

Germany



Category Tech (Code - Name)

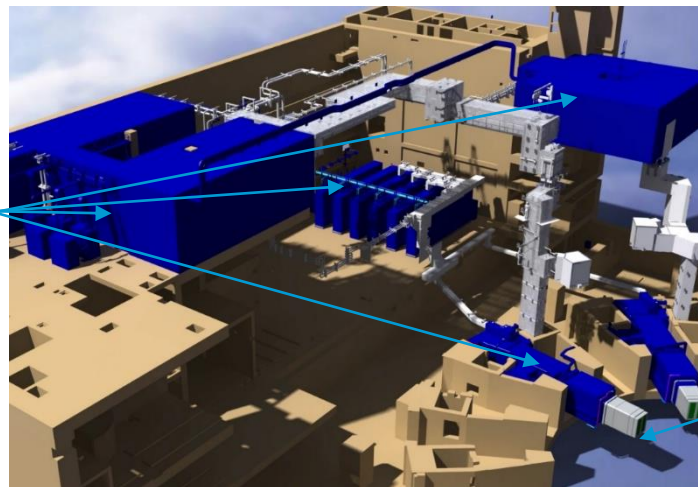
Category Tech (Code - Name)	Count of Contract
2700 - Mechanical fabrication and Joining techniques	38
3800 - Material (metallic, non-metallic) and Gases	28
2600 - Materials testing (destructive, non-destructive)	27
2100 - Engineering & Design	20
2800 - Assembly, Installation, Validation and testing	12
3100 - Tokamak mm-waves launchers	11
1500 - Cryogenic technology	9
2200 - Analysis and modelling	9
0900 - Remote Handling systems for nuclear environment	7
1100 - Plasma and First Wall diagnostics	7
1600 - Vacuum & Leak Detection Technologies	7
3400 - Superconductivity and Superconductor Magnets	7
0100 - Complex civil constructions, nuclear buildings	6
0200 - All electrical components	6
1300 - Tokamak Heating & current drive systems	5
1800 - I&C and CODAC	5
3600 - Measurement Systems	5
0700 - Transportation of nuclear and conventional large components	3
0800 - Large components for conventional and nuclear	2
2400 - Safety, Licensing and Protection of nuclear installations and devices	2

(...)

Test Blanket Module (TBM) Systems in ITER

Test and validate during ITER operation tritium breeding blanket concepts relevant to future fusion reactors

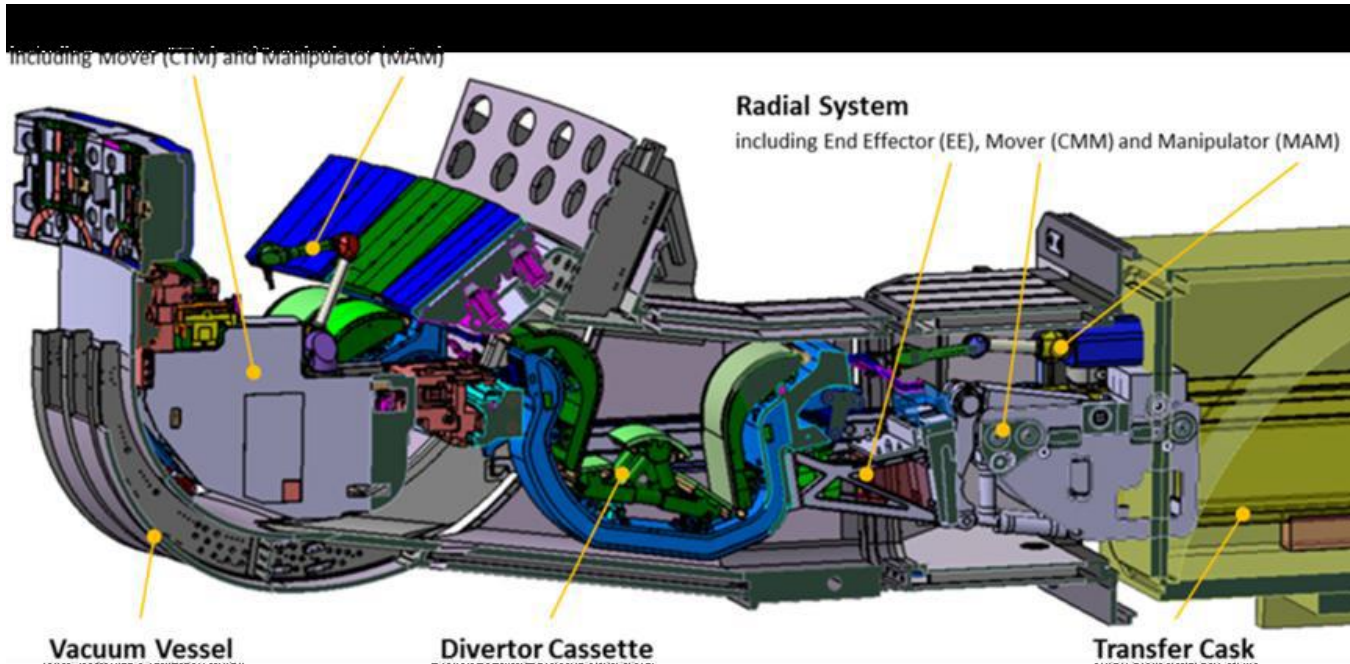
Ancillary systems connected to the TBMs



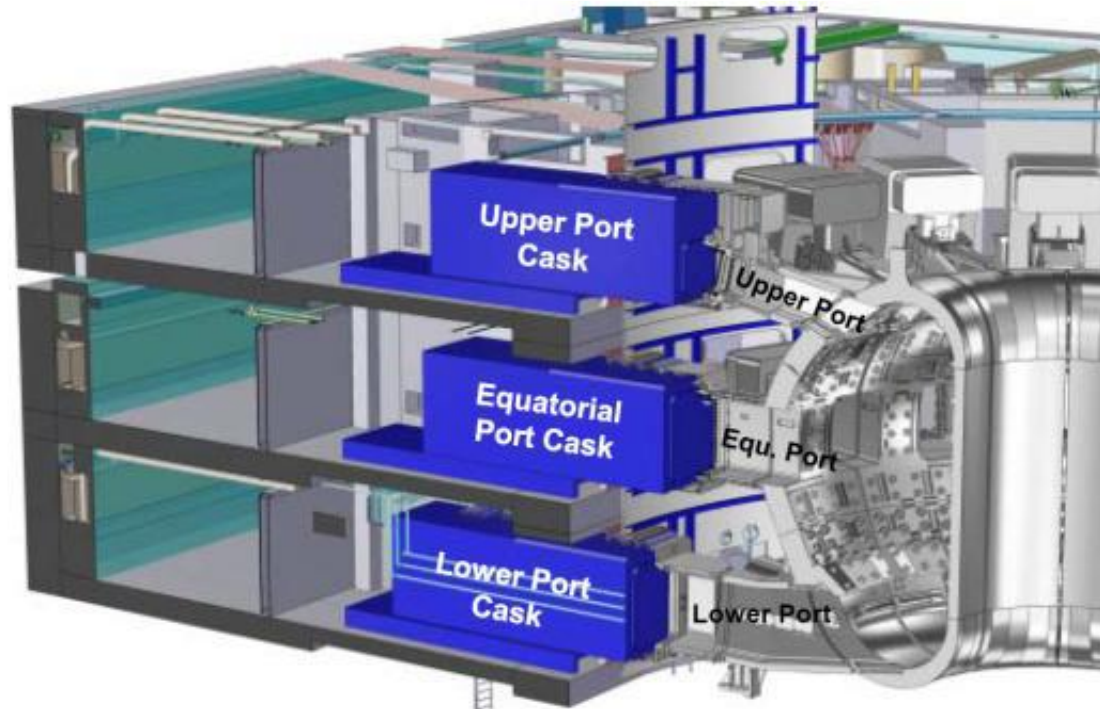
4 TBMs installed in equatorial plan of ITER
TBMs are mock-ups of future TBB modules



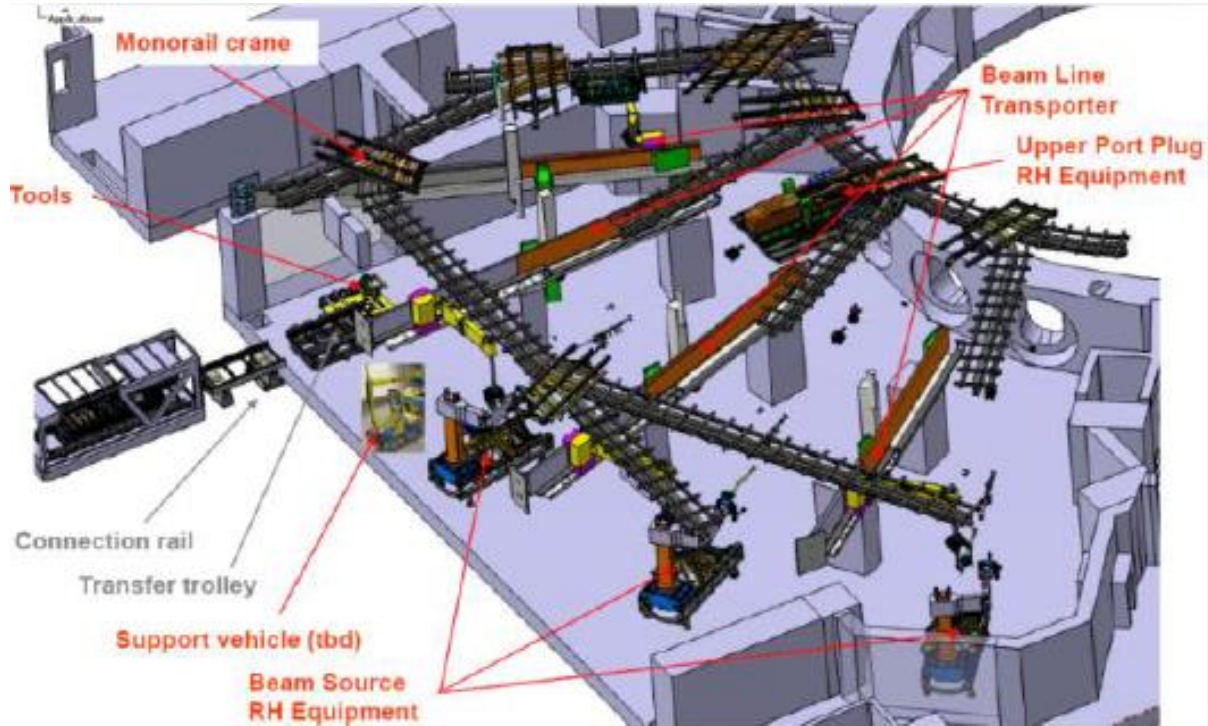
Divertor Remote Handling System (DRHS)



Cask and Plug Remote Handling System (CPRHS)



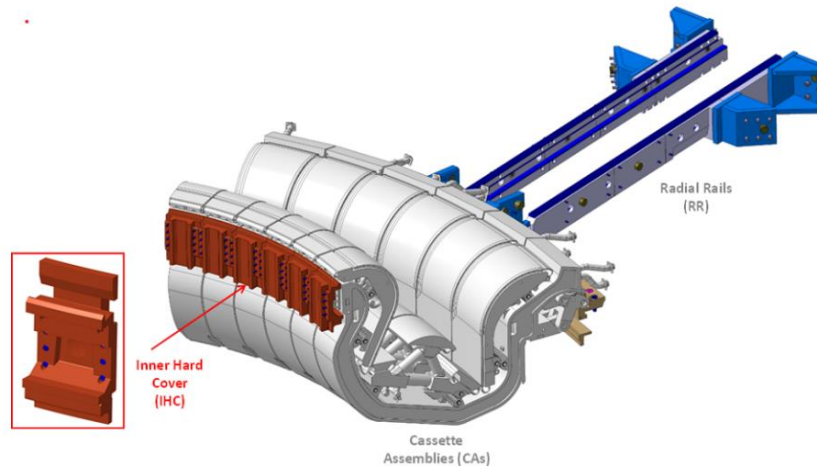
Neutral Beam Remote Handling System (NBHS)



- **Divertor rails.**

=> Market Survey in Q3 2023.

=> Contract Signature Q3 2025



•Neutral Beam Cryopumps

- 500 cryopanel, >650 thermal shield panels
 - Tight tolerances
- ⇒Target Call For Tender 2025 (contract signature 2026)



Mitica cryopump prototype

• Isotope Separation System

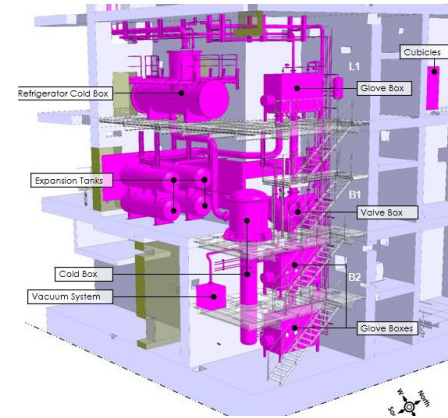
- Cryogenic distillation of >650 thermal shield panels
- Tight tolerances

=> Market Survey 2025

• REMS (Radiological and Environmental Monitoring System)

- Gamma and Neutron sensors; Gas monitors; Tritium detectors; Tritium and Beryllium Samplers; Radiological Synthesis Unit; Hand/Foot monitors, Alarm Units etc.

=> Target CFT Q3 2026



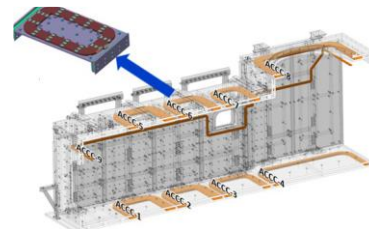
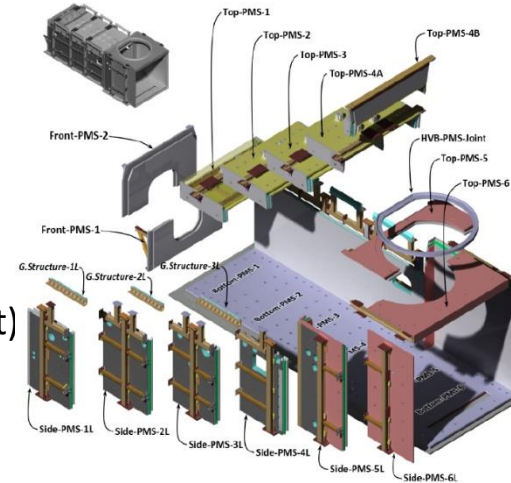
• Passive Magnetic Shielding (PMS)

Steel Plate Material S235 (EN 10025-2) 2 x 400 tons

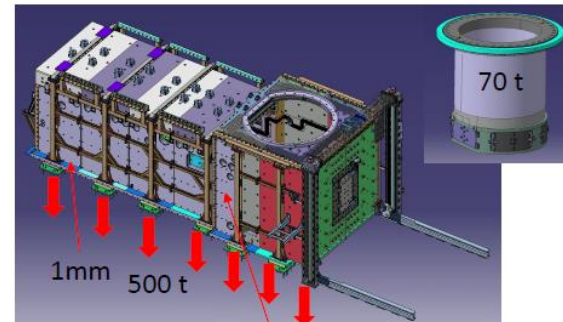
Active Compensation Correction Coils Total 16 units.

Skills: High precision machining and assembly (1mm gaps/0.1 mm tolerances) of heavy components (500t) nuclear classified (RCC-MR) + coil design and manufacturing.

=> Target CFT: Q1 2024.



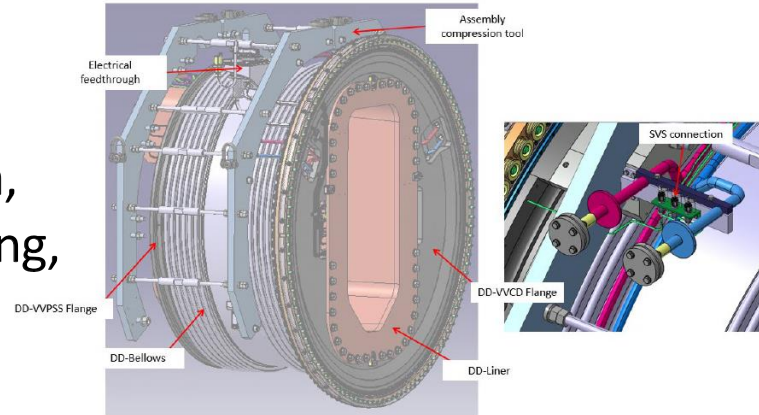
Active
Compensation
Correction Coils
(ACCC)



•Drift Duct.

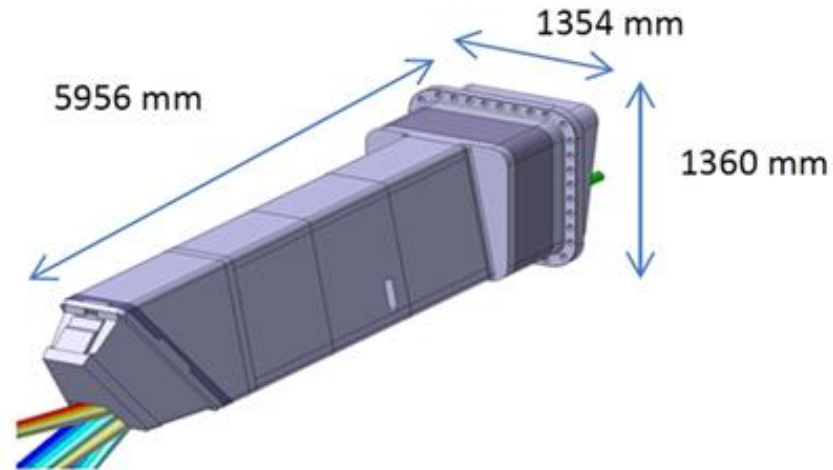
Skills: Nuclear component manufacturing, High Vacuum, Stainless Steel welding, Brazing, NDTs, EBW of CuCrZr.

- Market Survey closed.
=> Target CFT: Q4 2024.



L1.4 m x W3.2 x H3 m -Weight ~ 5.7 t

- 6 Diag PORTS Manufacturing and Assembly.
- Market Survey ongoing
- Target CFT: end Q1 2024.



Upper Port Plug general dimensions



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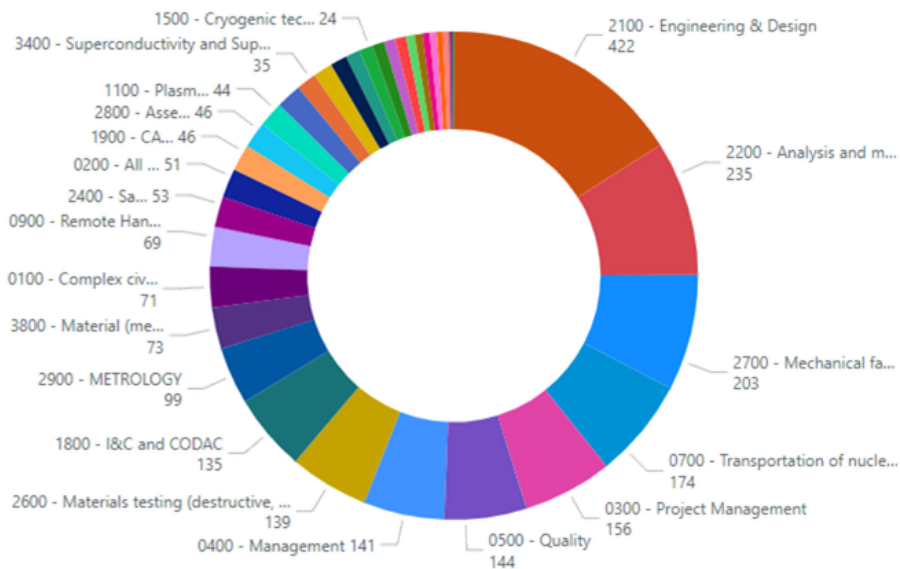
www.linkedin.com/company/fusion-for-energy



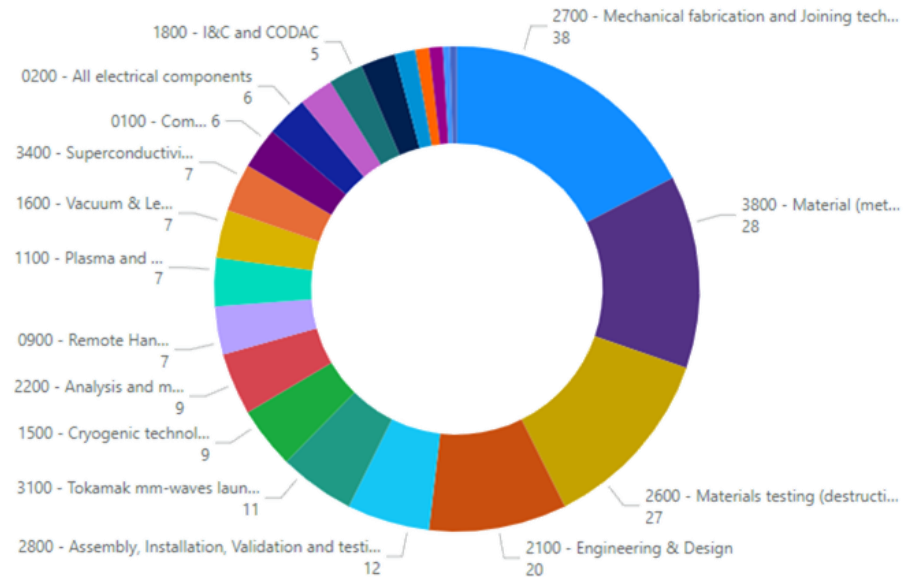
www.flickr.com/photos/fusionforenergy

In which areas does Germany get more contracts?

All countries

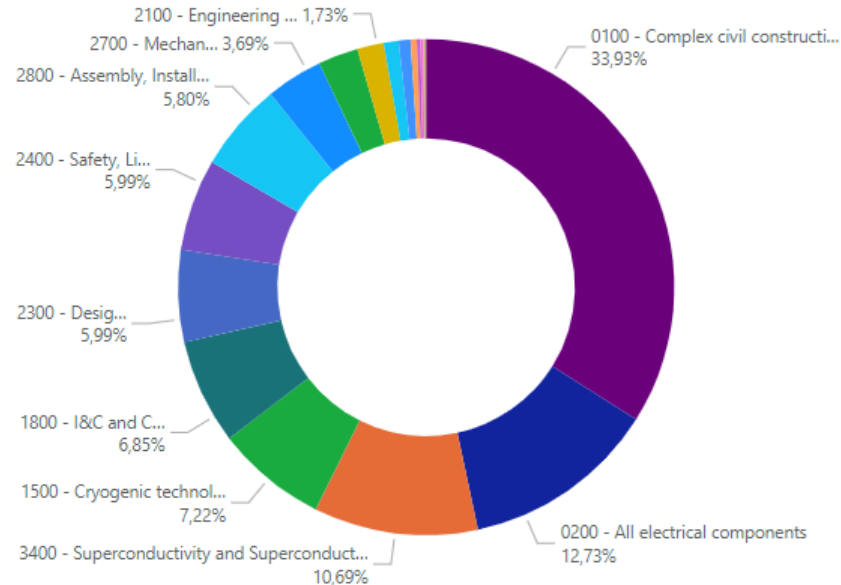


Germany



In which areas has Germany received a larger income? (subcontracting not included)

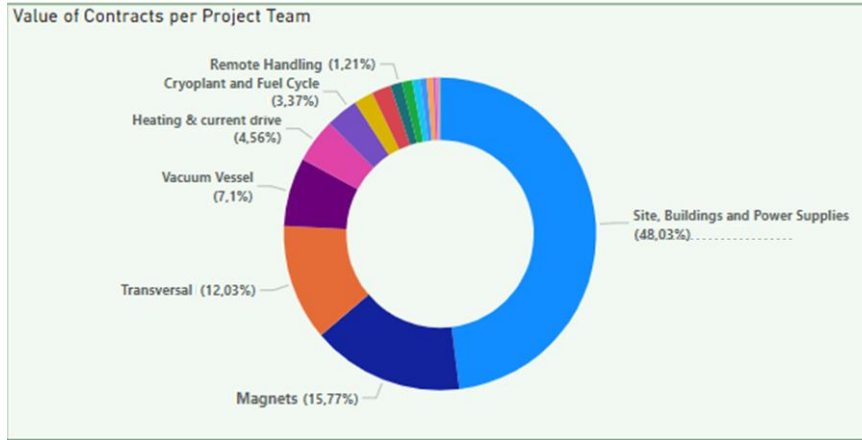
Germany



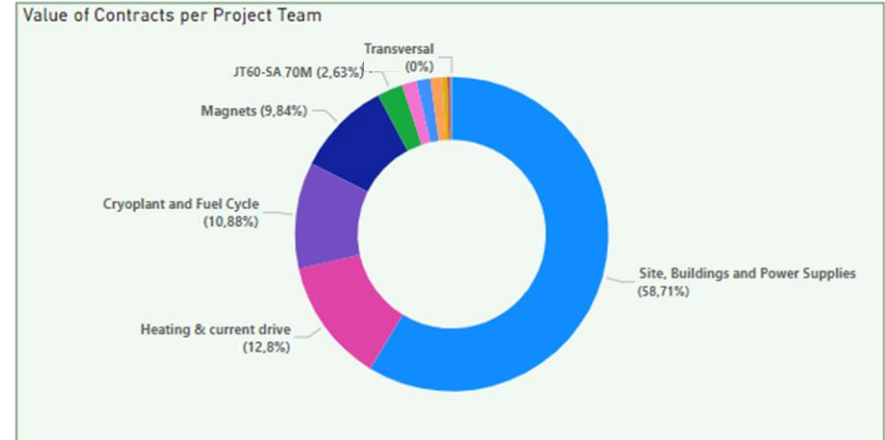
RELATED PROGRAMS

In which programs has been Germany working on?

All countries



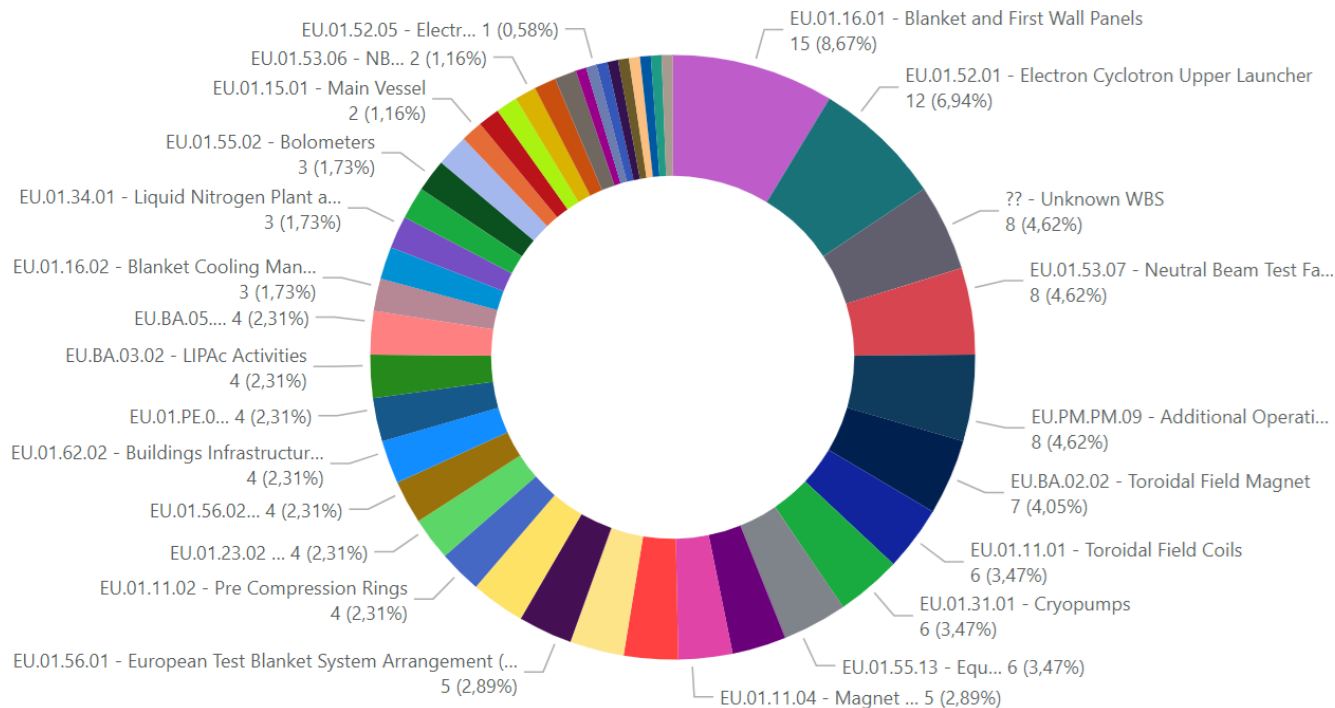
Germany



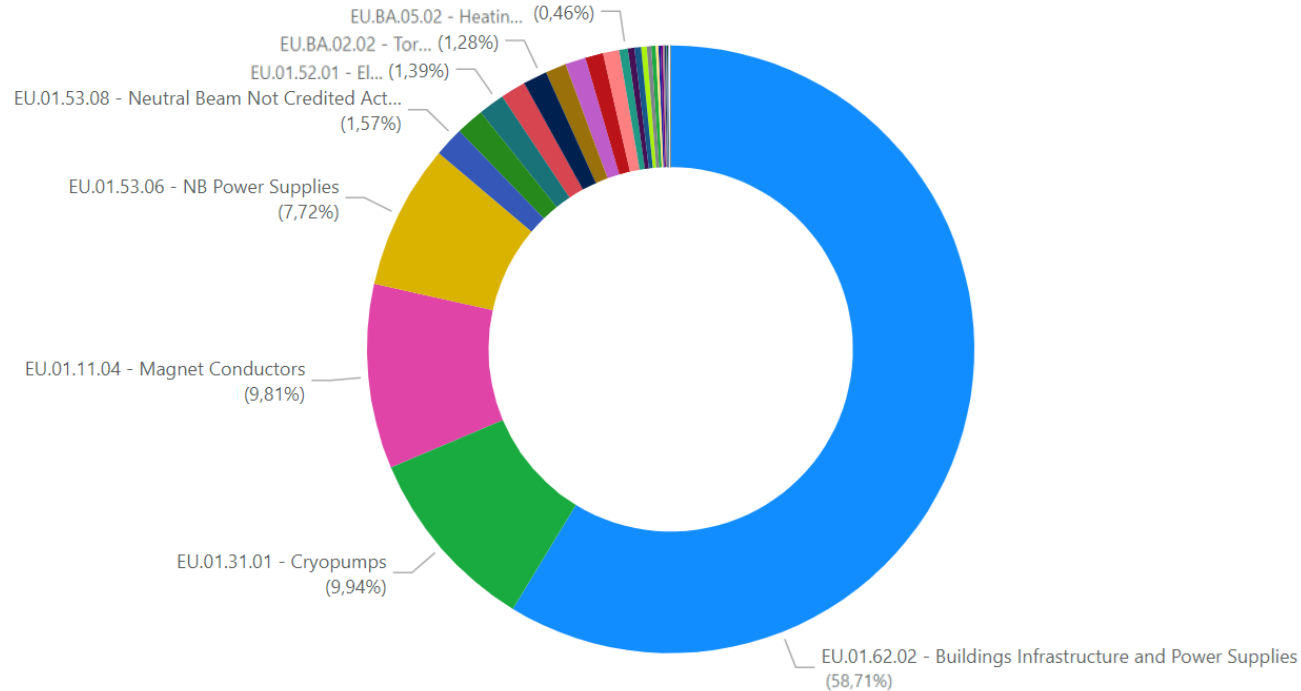


MAIN COMPONENTS

Main components Germany (WBS L3)



Main components Germany (WBS L3)



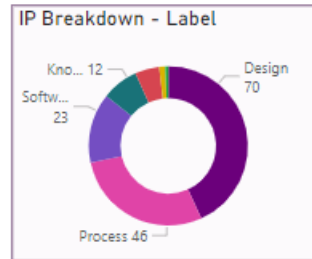
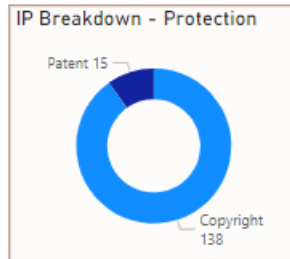
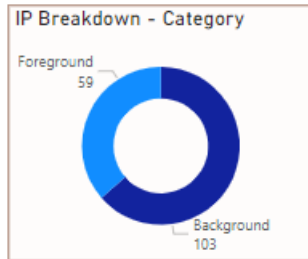
IP ASSETS

IP Assets

161
IP Assets

59
Foreground IP Assets

26
Contracts with FG IP Assets



TOP 15 Technology Category in IP Assets

