



**FUSION  
FOR  
ENERGY**

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

# ITER satus and future business

**Benjamin Perier**

MIO, Fusion for Energy

**Big Science Industry Day**

**30<sup>th</sup> November 2018**

**The Institute of Nuclear Physics, Krakow**



- 1. Fusion for Energy (F4E)**
- 2. Europe contributions to ITER**
  - a) Site & Buildings**
  - b) Plant and Supporting Systems**
  - c) Tokamak Systems**
- 3. Business Opportunities**
- 4. Future Budget**

## 1. Fusion for Energy (F4E)

## 2. F4E Contributions to ITER

a) Site & Buildings

b) Plant and Supporting Systems

c) Tokamak Systems

## 3. Business Opportunities

## 4. Future Budget

# What is Fusion for Energy (F4E)?

- **F4E is the EU Agency for ITER & Broader Approach (incl. DONES) as well as long-term DEMO mission**

**ITER**



F4E is responsible for Europe's contribution to **ITER**, the world's largest scientific energy project

**BROADER APPROACH**



F4E is collaborating with Japan on a fusion projects known as the **Broader Approach**

**DEMO**



F4E will prepare a programme to develop **Demonstration Fusion Reactors**

- **F4E has ~500 staff & €7.7bn budget (2007-2020) with offices in Spain (HQ), France, Germany & Rokkasho**



## the COP24 2018 Edition E-Zine

Fusion For Energy is 1st of 3 articles on  
sustainable Energy  
(other 2 dealing with solar energy and wind  
energy.)

1. Fusion for Energy (F4E)
- 2. Europe contributions to ITER**
  - a) **Site & Buildings**
  - b) Plant and Supporting Systems
  - c) Tokamak Systems
3. Business Opportunities
4. Future Budget

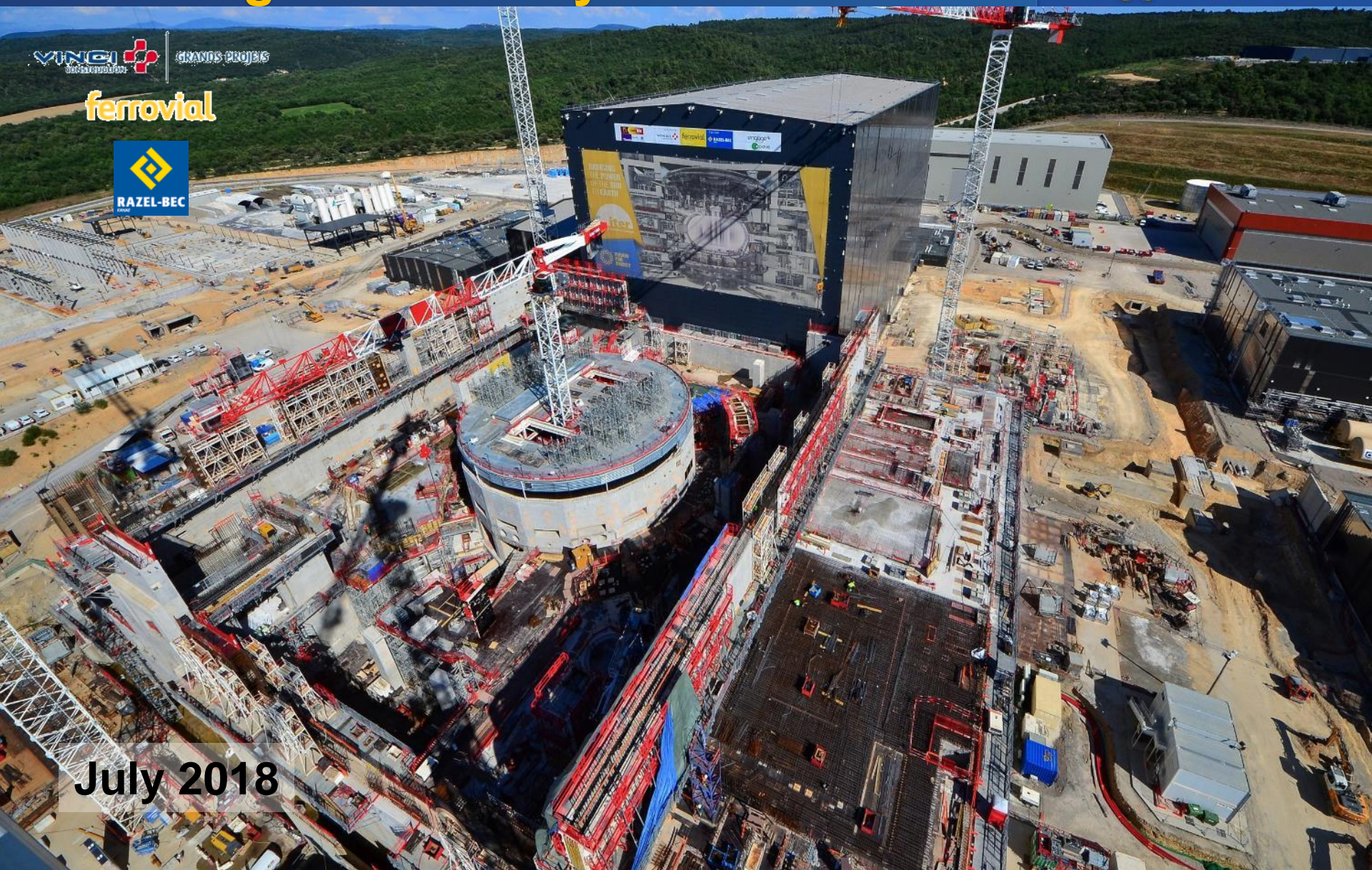


# ITER site is now a Construction buzzing with Activity in 2.5 Shifts...



VINCI  
GRANDS PROJETS

ferrovial



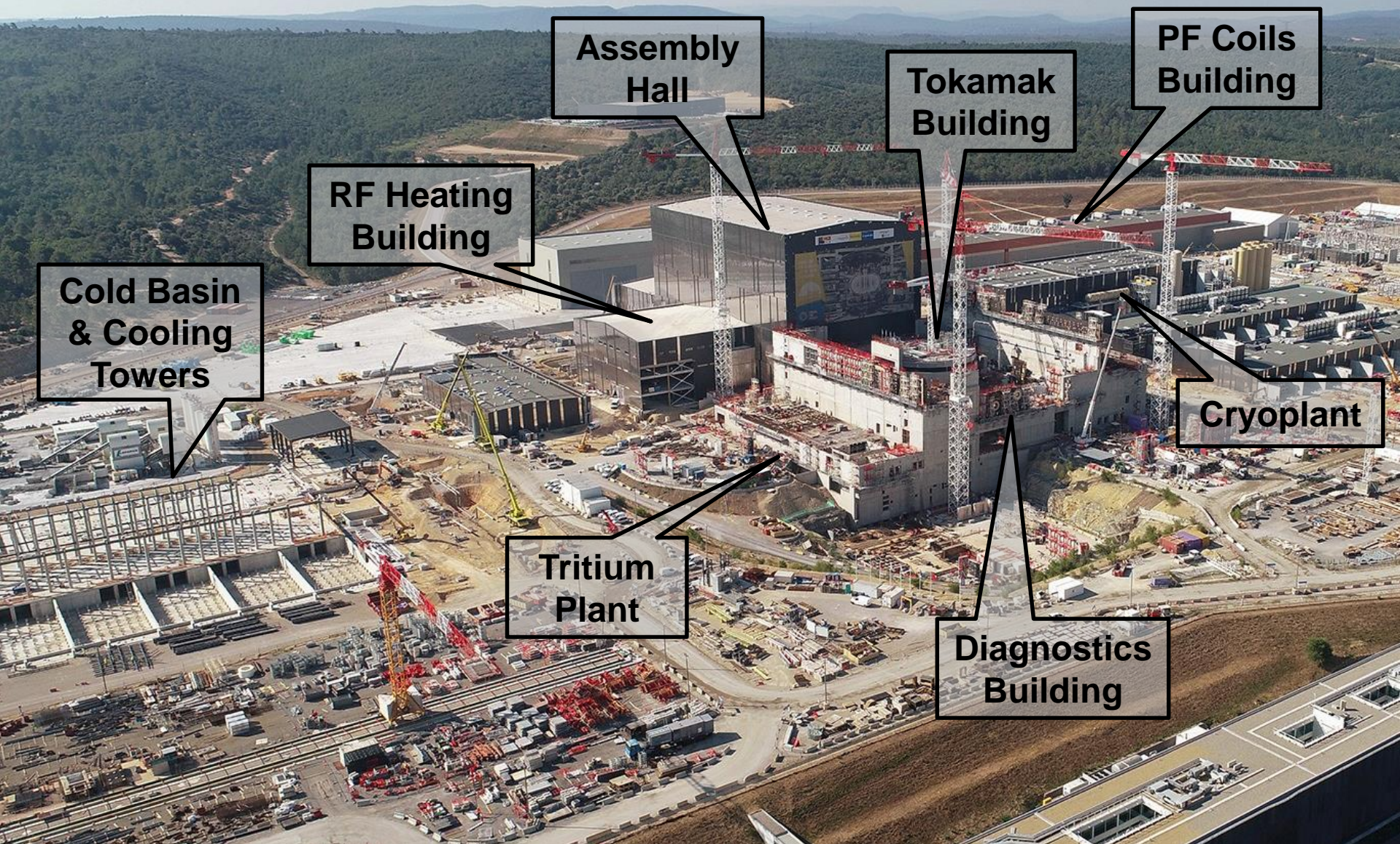
July 2018

B. Perier, Big Science Krakow, 30 November



## 2. F4E Contributions to ITER

### (a) Site and Buildings





# Drone's eye view of the ITER site (August 2018)





# Latest News - Tokamak “crown” completed one month early

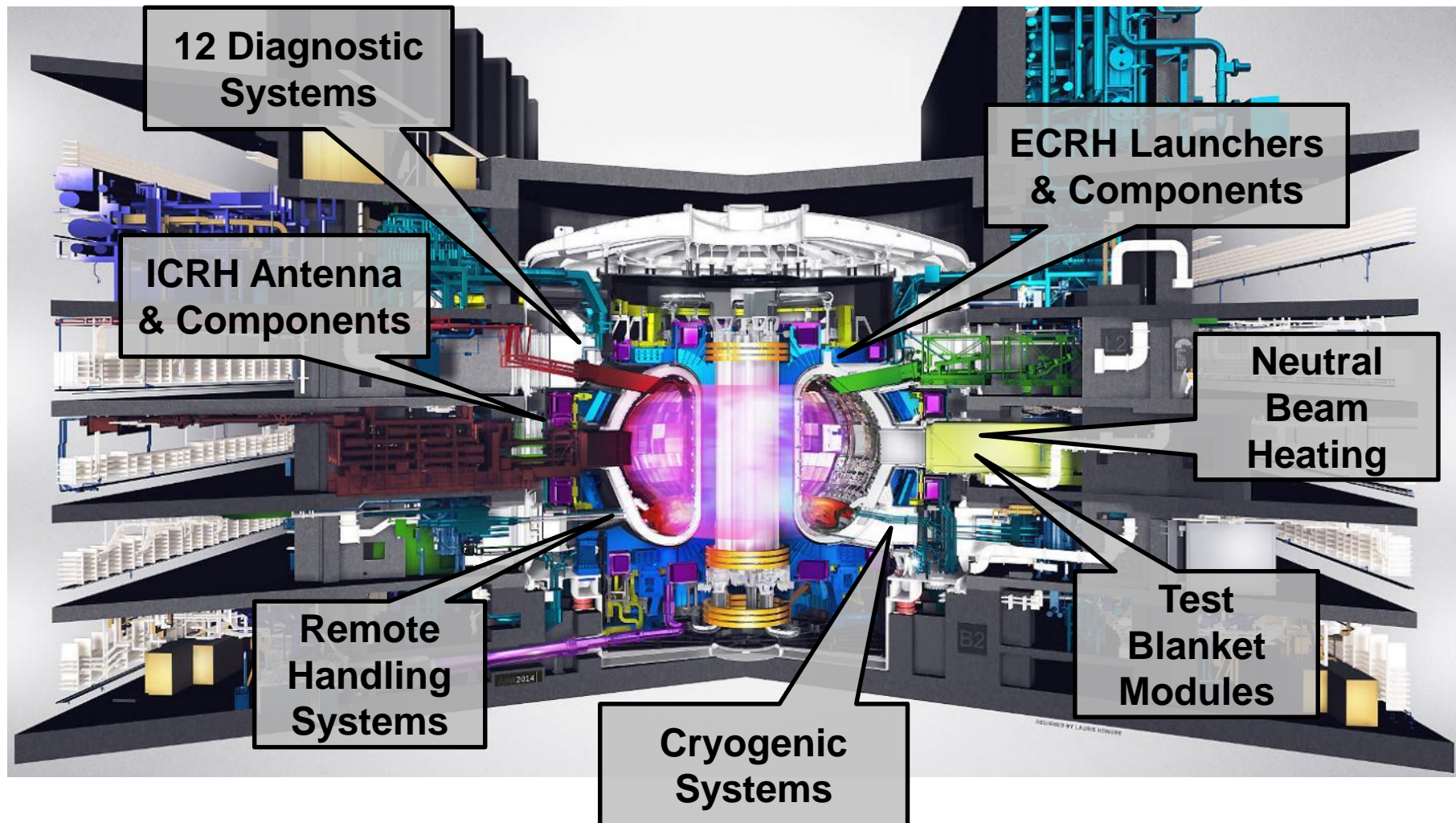




1. Fusion for Energy (F4E)
- 2. Europe Contributions to ITER**
  - a) Site & Buildings
  - b) Plant and Supporting Systems**
  - c) Tokamak Systems
3. Business Opportunities
4. Future Budget

## 2. F4E Contributions to ITER

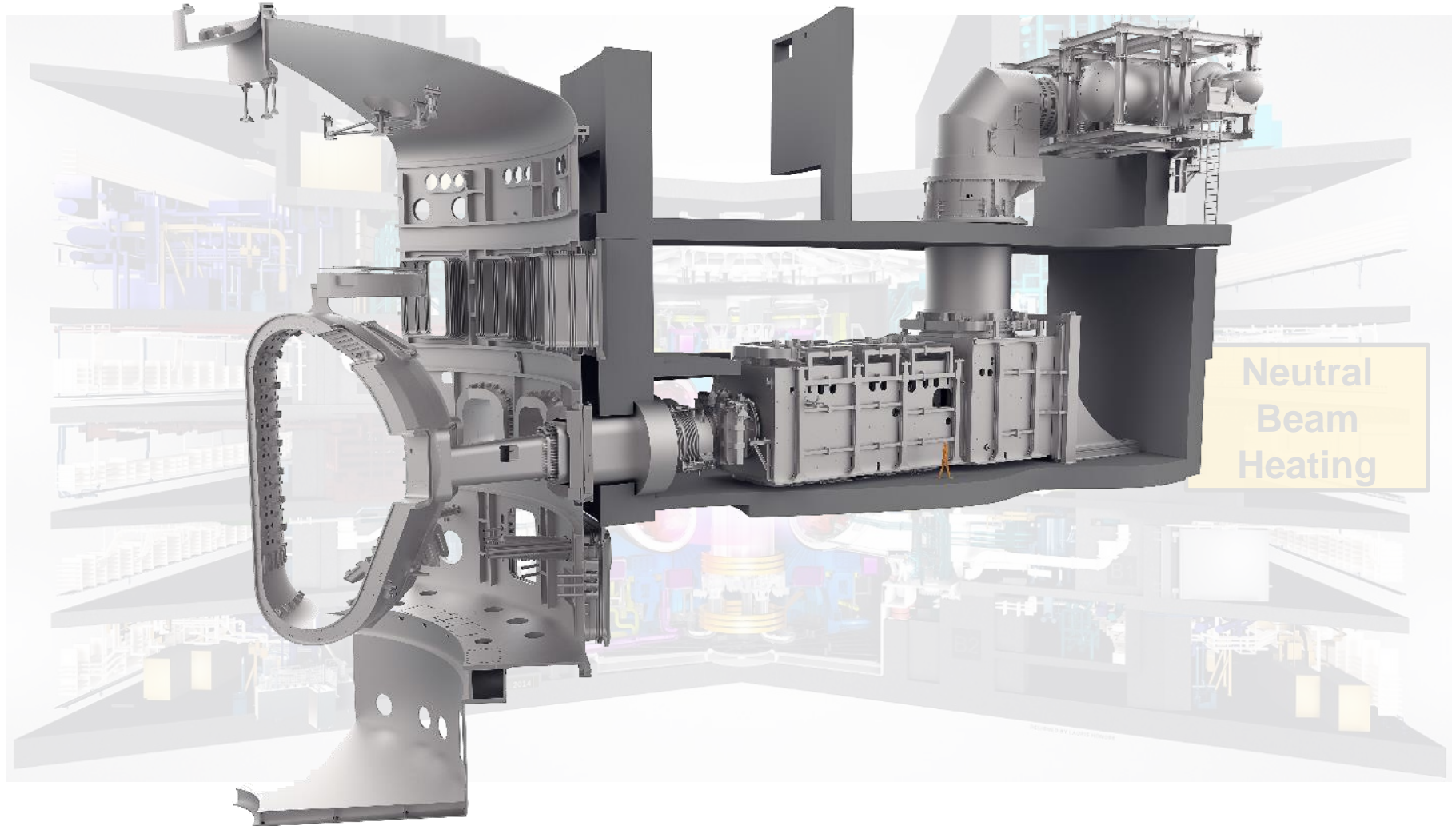
### (b) Plant & Supporting Systems





## 2. F4E Contributions to ITER

### (b) Plant & Supporting Systems



# Overview of the Neutral Beam Test Facility (NBTF) in Padua, Italy



Total area:	17,500 m <sup>2</sup>
Covered area:	7050 m <sup>2</sup>
Internal Surface:	9170 m <sup>2</sup>
Maximum height:	24.0 m



# SPIDER is operating – the most powerful negative ion source ever

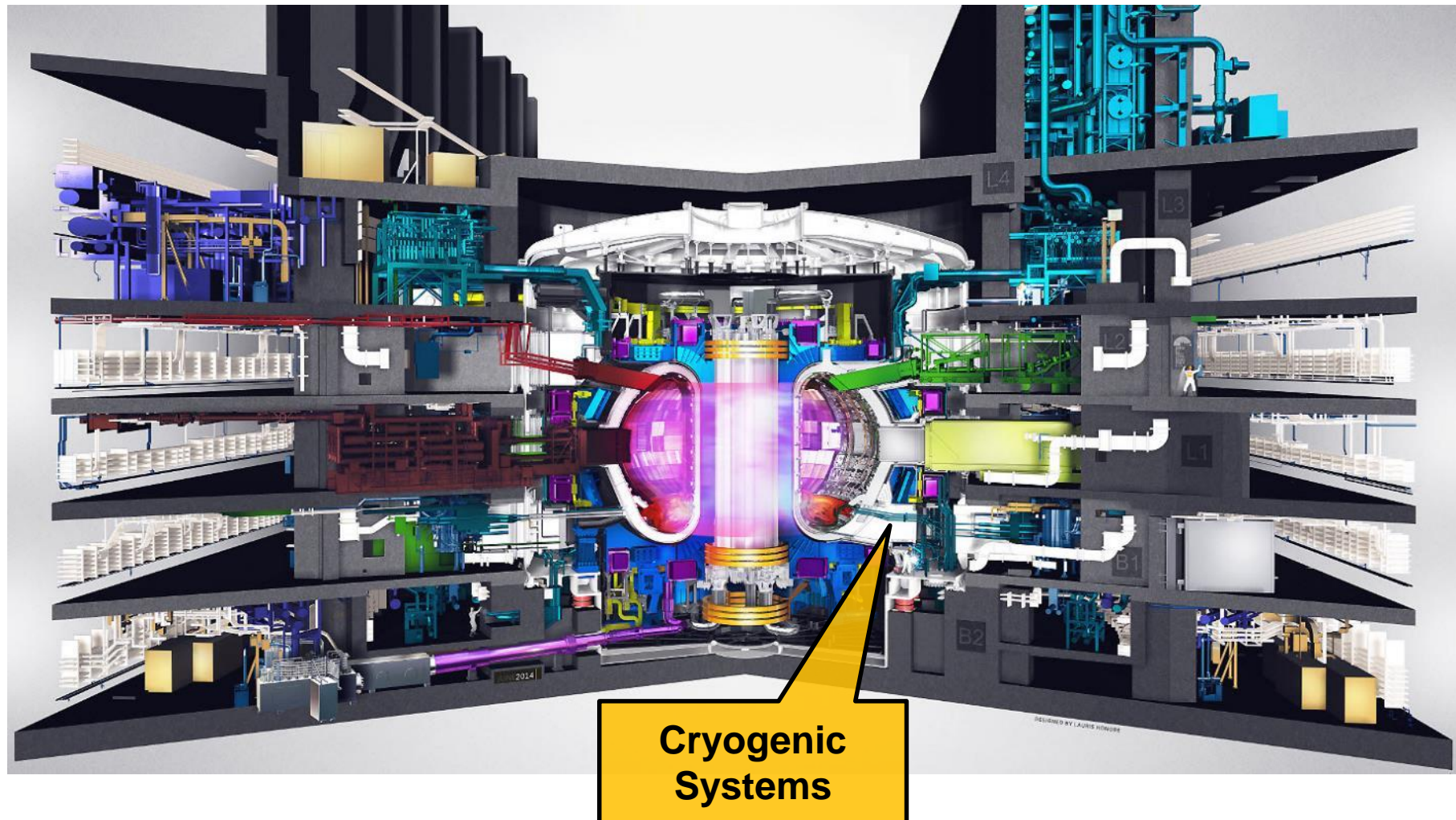


See I4.1, O2A.2, O2A.6, P4.023



## 2. F4E Contributions to ITER

### (b) Plant & Supporting Systems





# Visit to the Cryoplant



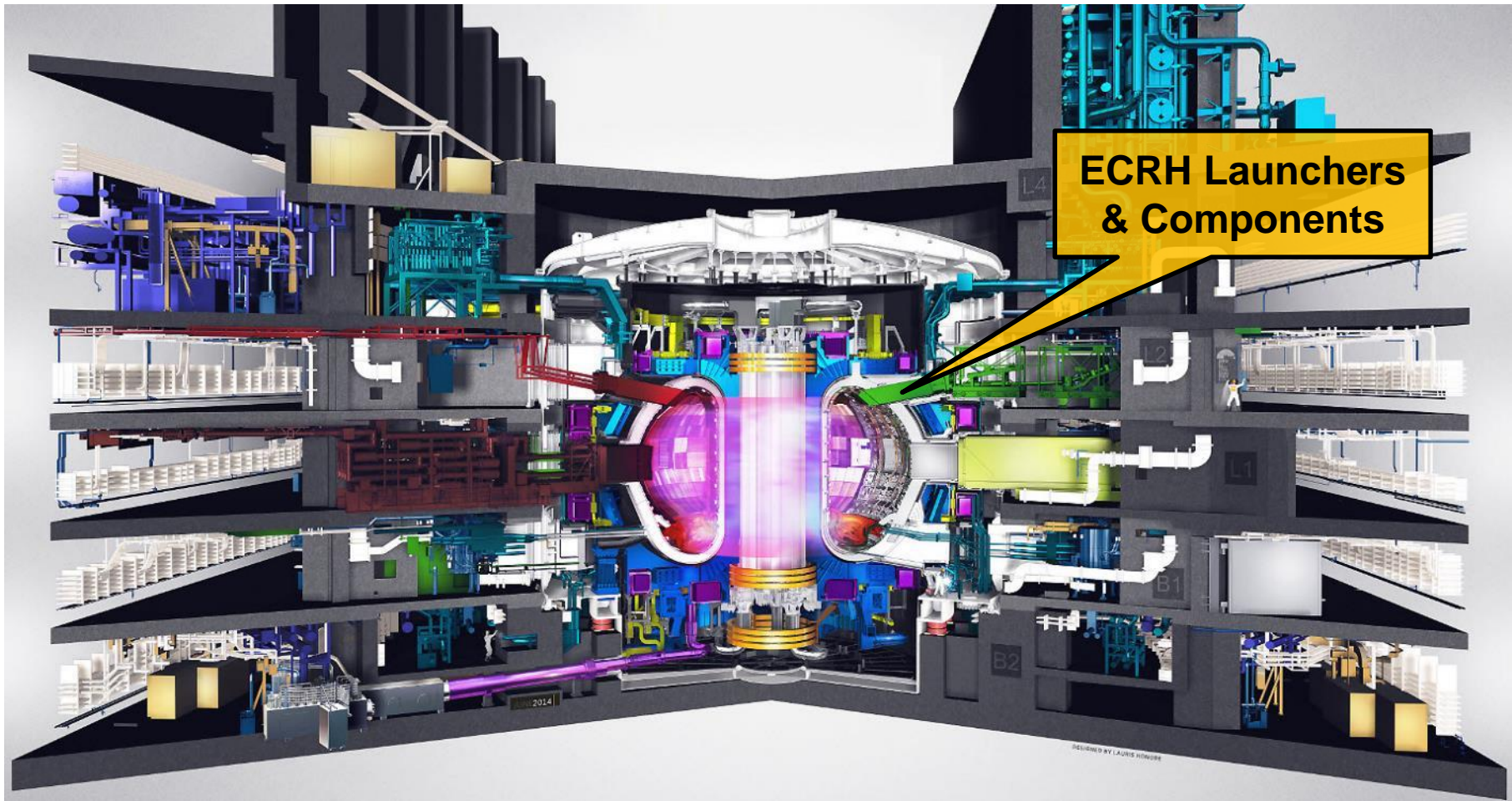


# Installing the Cryogenic Tanks



## 2. F4E Contributions to ITER

### (b) Plant & Supporting Systems

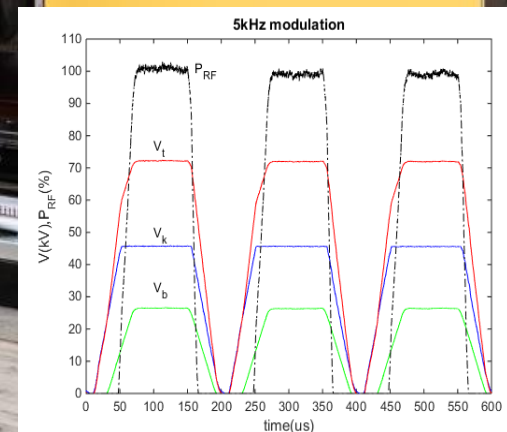




# F4E built the HV Power Supplies for the ECRH System

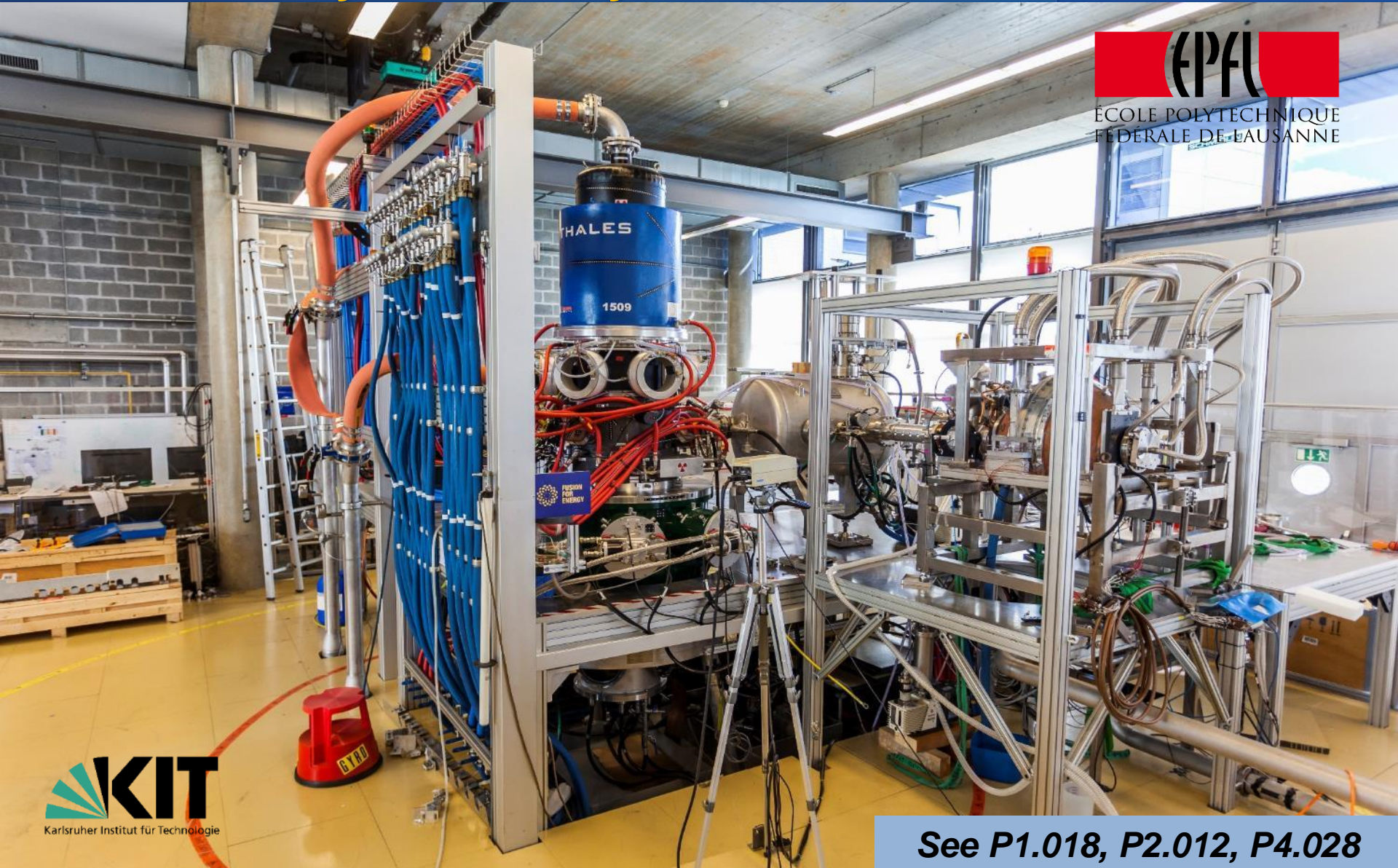


AMPECON





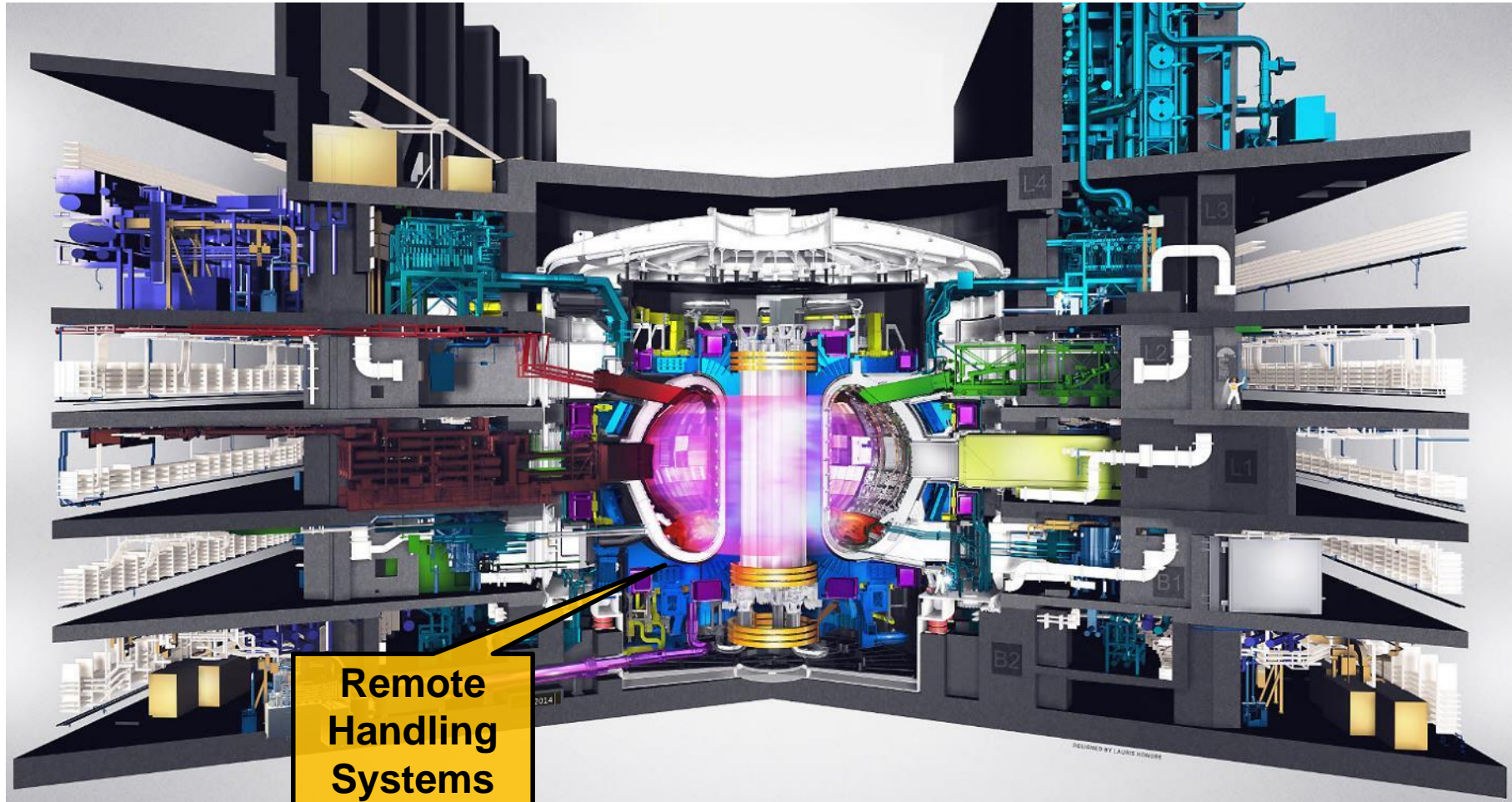
# We are testing the 1MW prototype Electron Cyclotron Gyrotrons





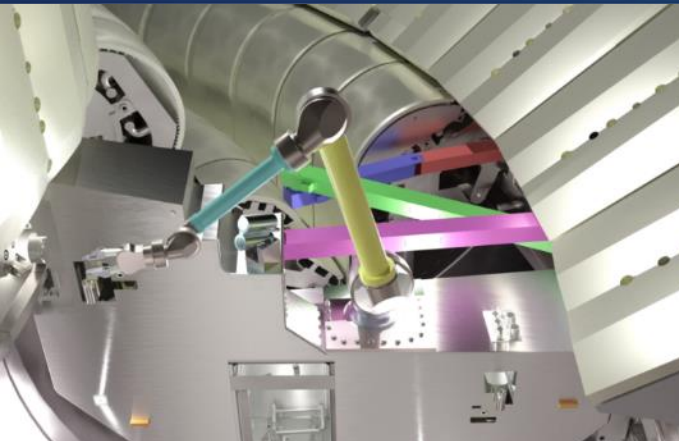
## 2. F4E Contributions to ITER

### (b) Plant & Supporting Systems

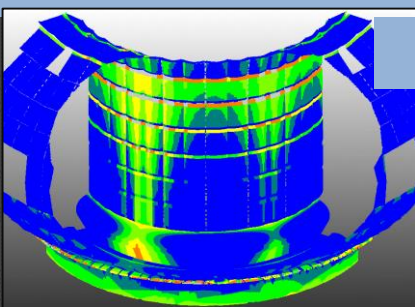




# Remote Handling – Intensive design & testing activities



**Preliminary design of the divertor  
cassette toroidal mover**



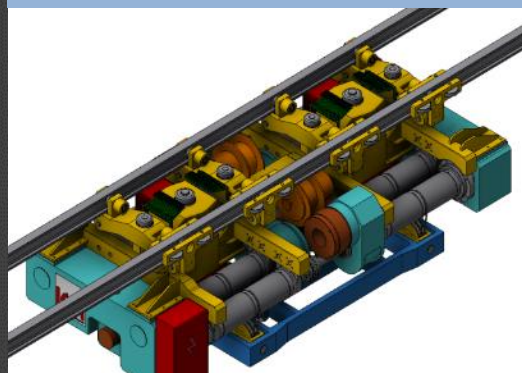
**See P4.156**

**In Vessel coverage simulation  
and analysis**

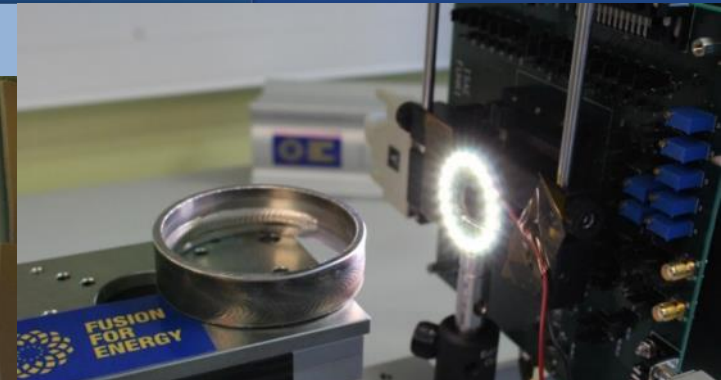
**See P1.147 & 148**



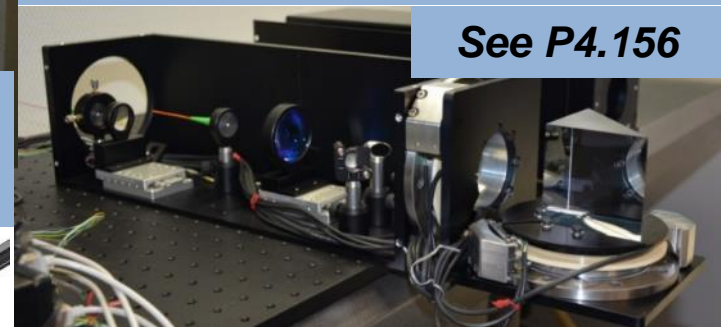
**Development & test of  
innovative water hydraulic  
digital valve**



**On-going design of  
monorail crane for NB cell**



**In Vessel coverage simulation  
and analysis**



**See P4.156**

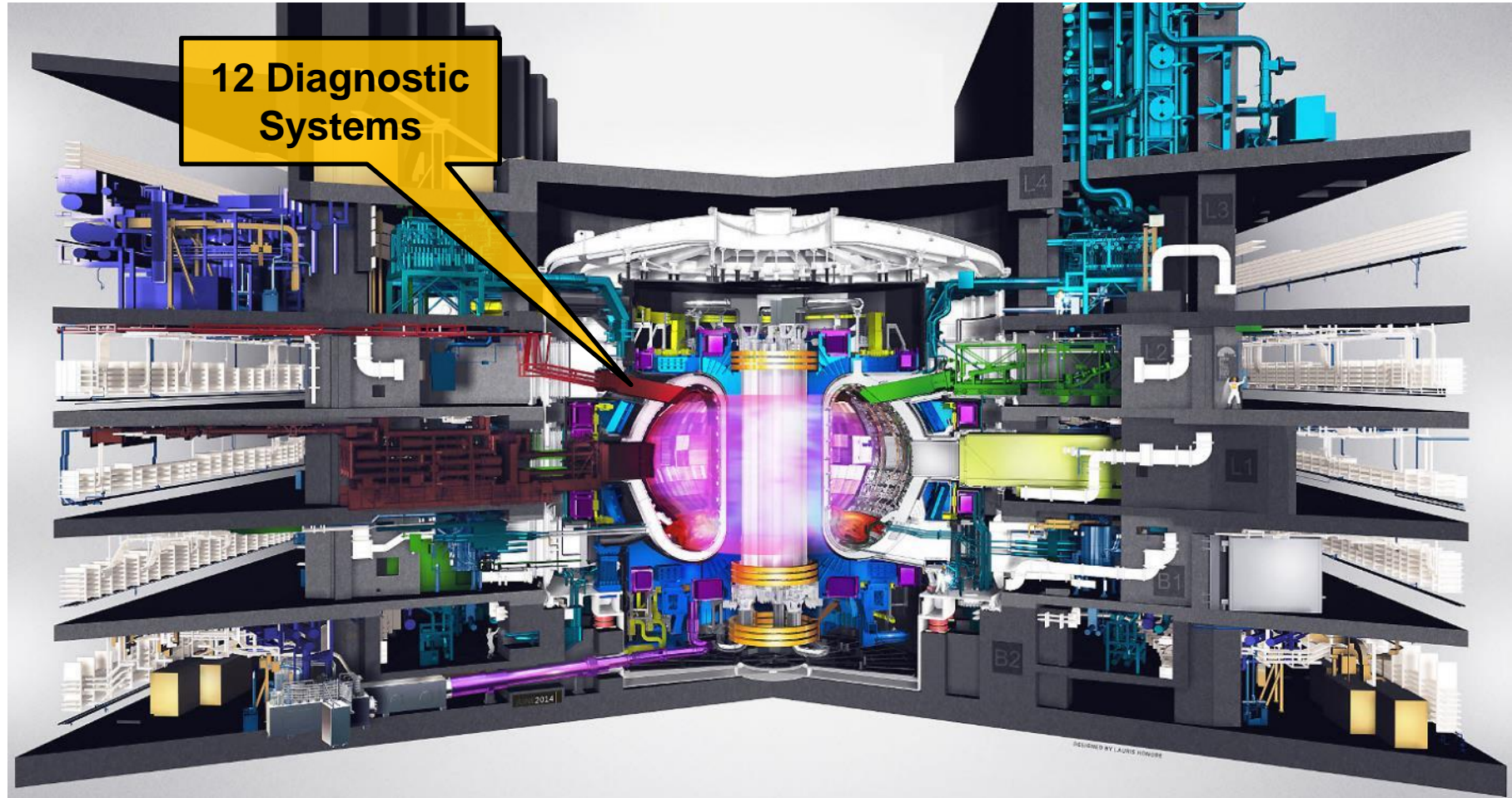


**Development & test of innovative  
water hydraulic digital valve**



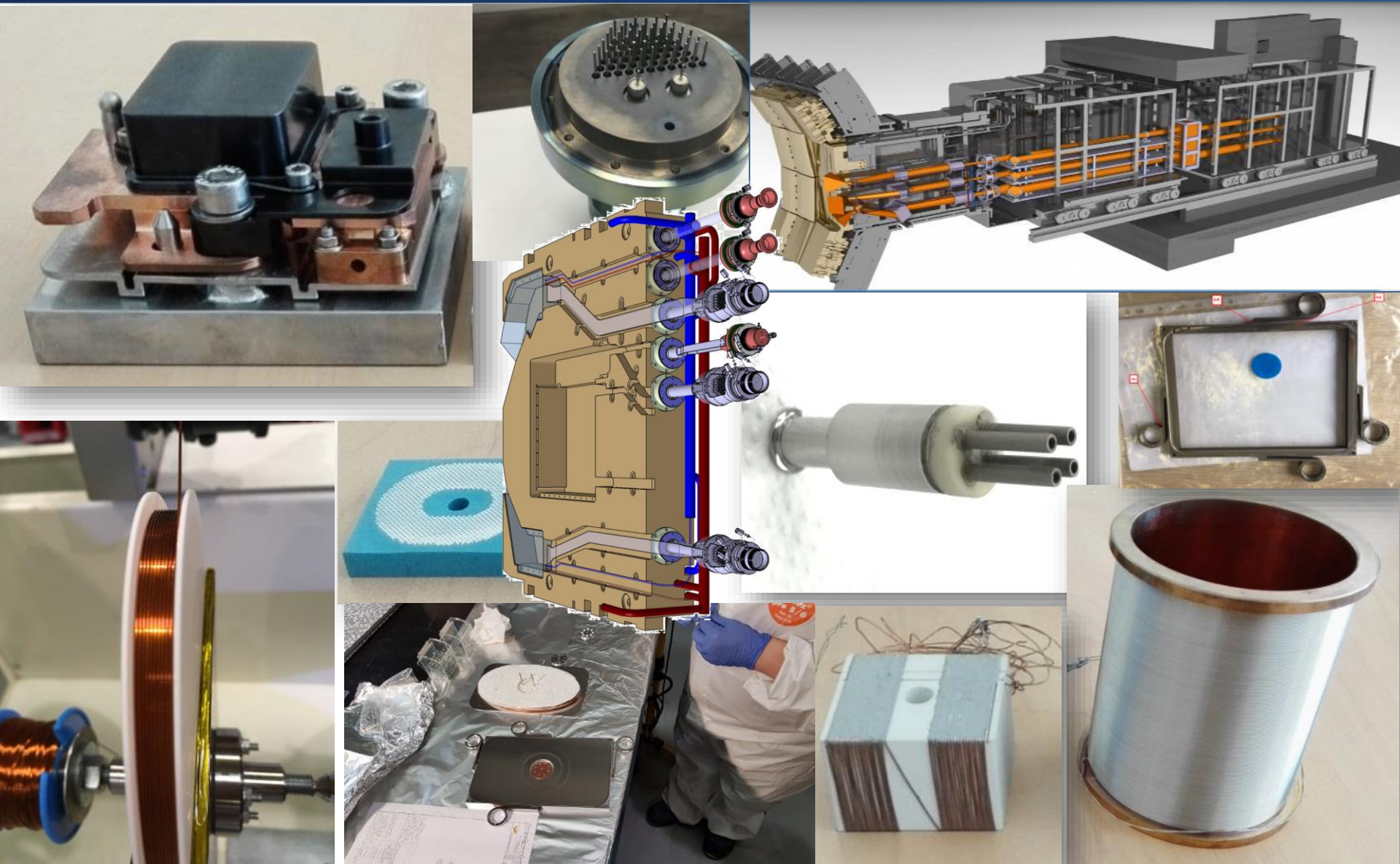
## 2. F4E Contributions to ITER

### (b) Plant & Supporting Systems





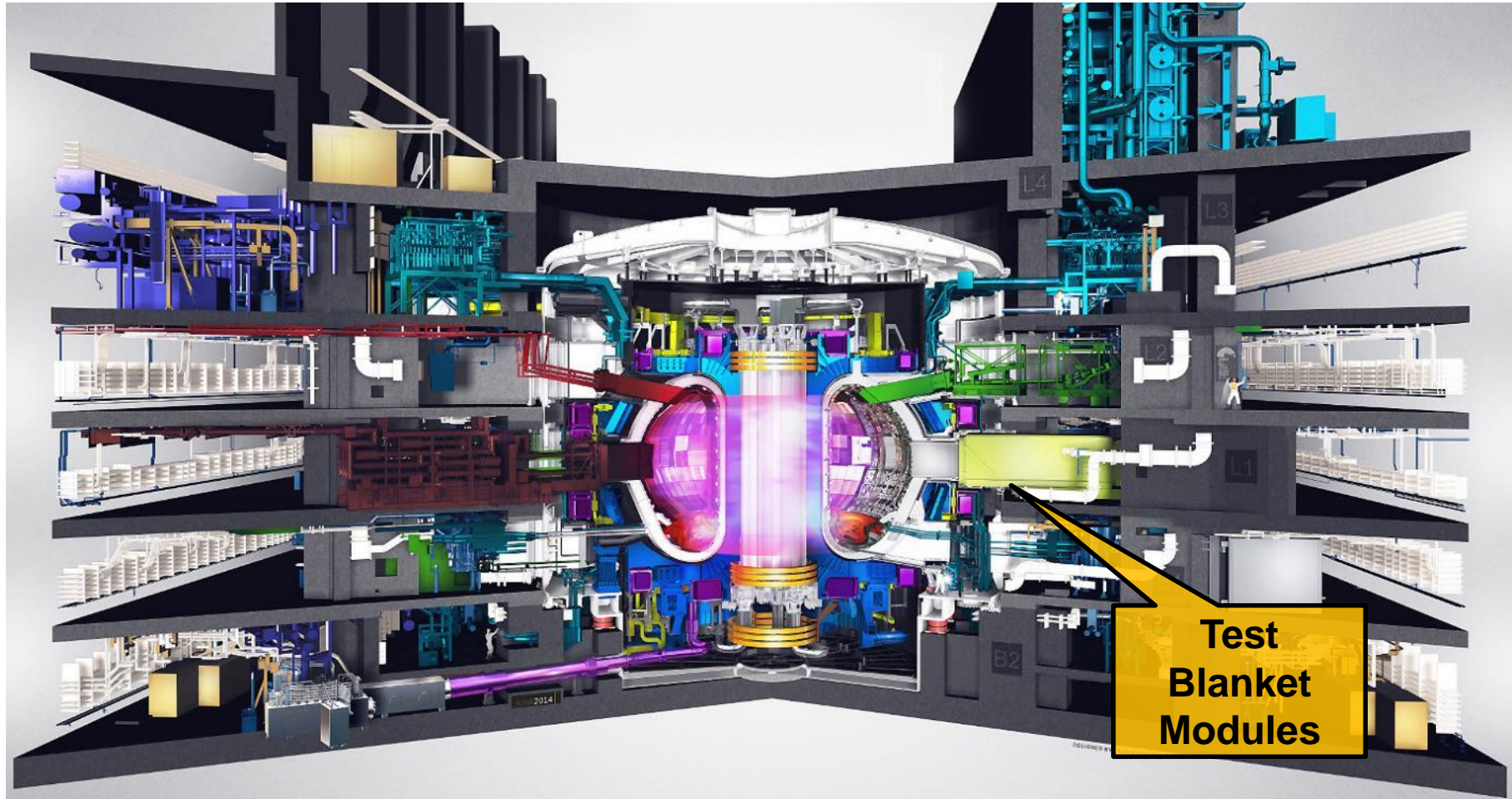
# Diagnostics – Design & prototyping continues with European laboratories





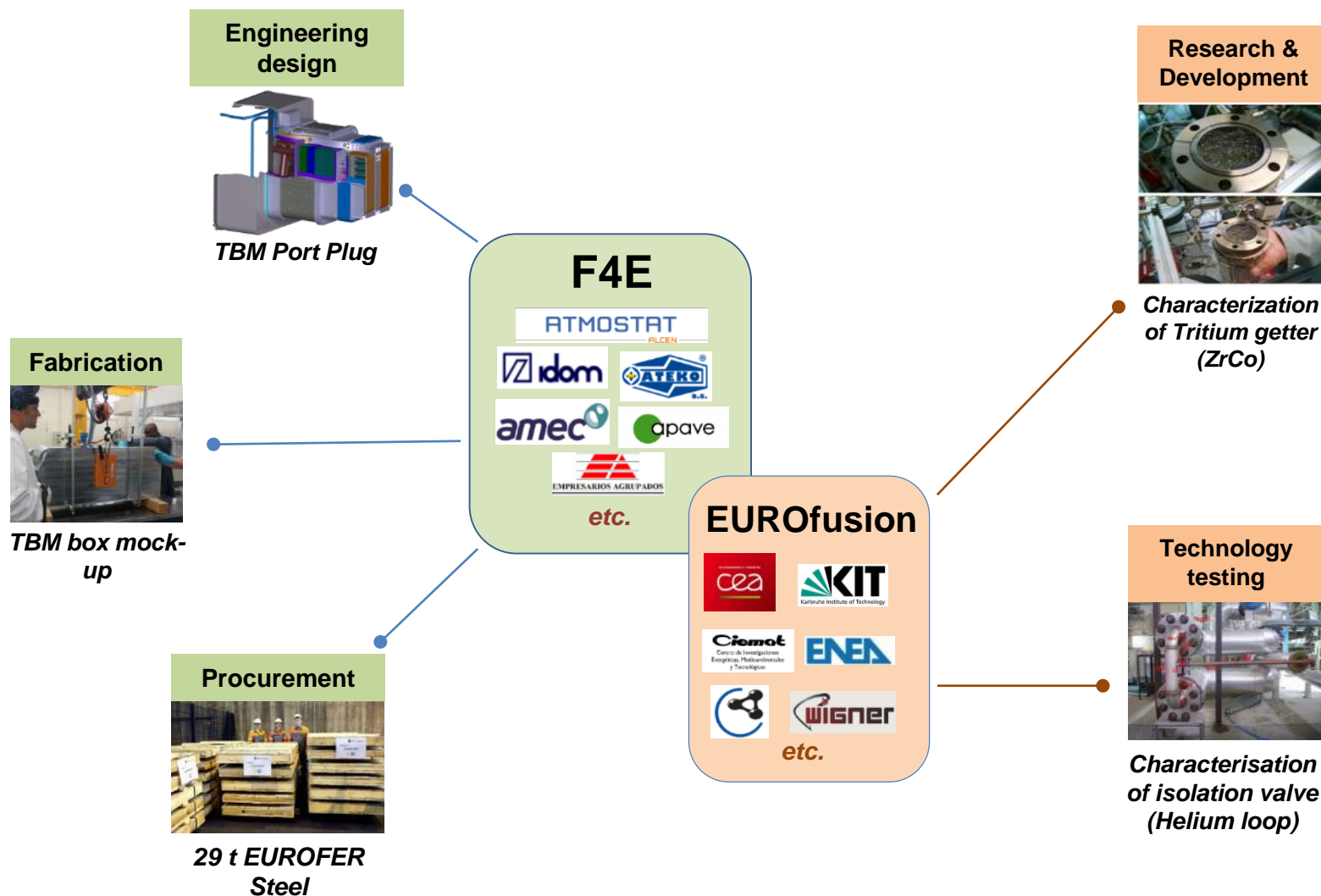
## 2. F4E Contributions to ITER

### (b) Plant & Supporting Systems





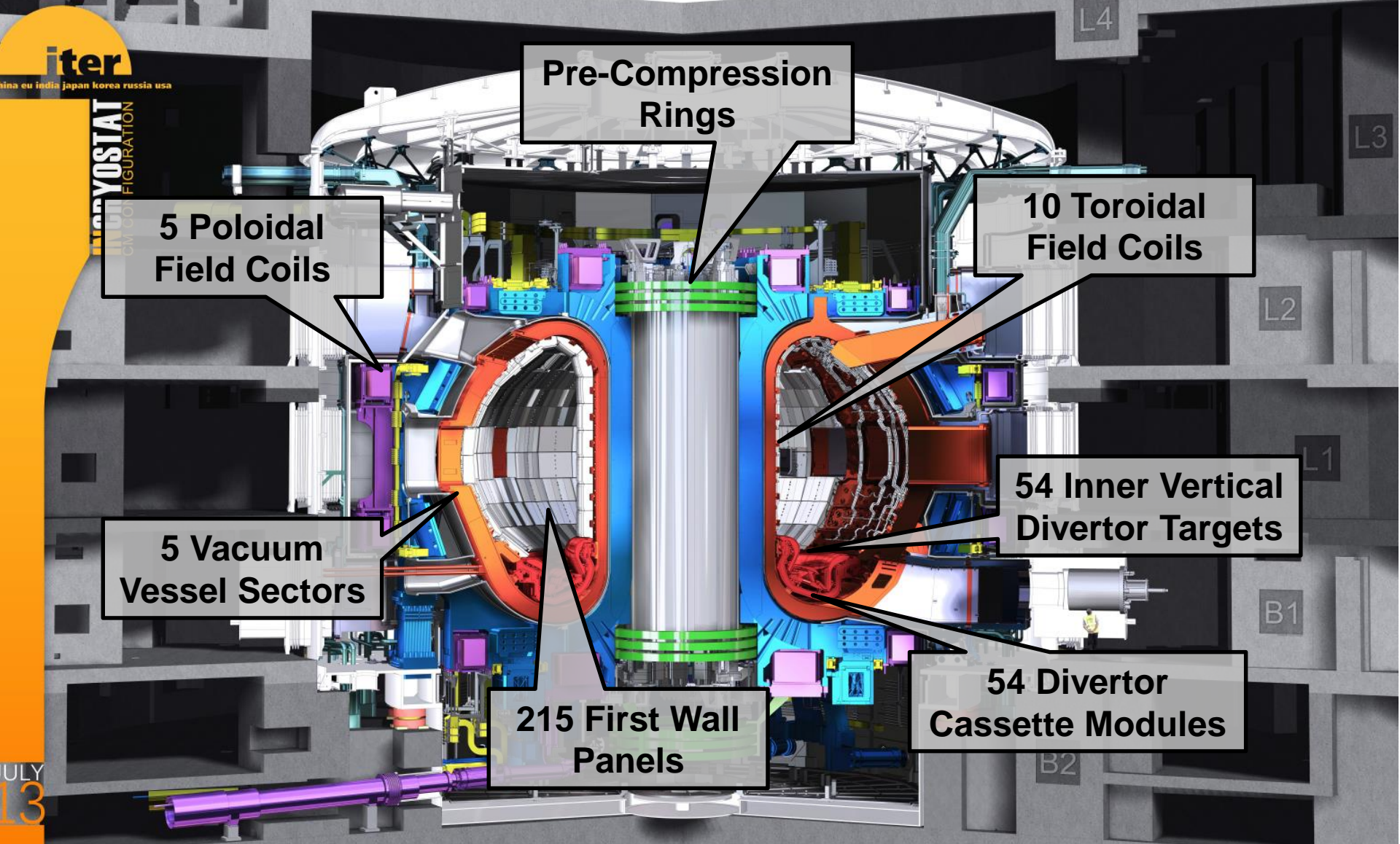
# F4E and EUROfusion are creating a new organisation for the EU TBM Programme



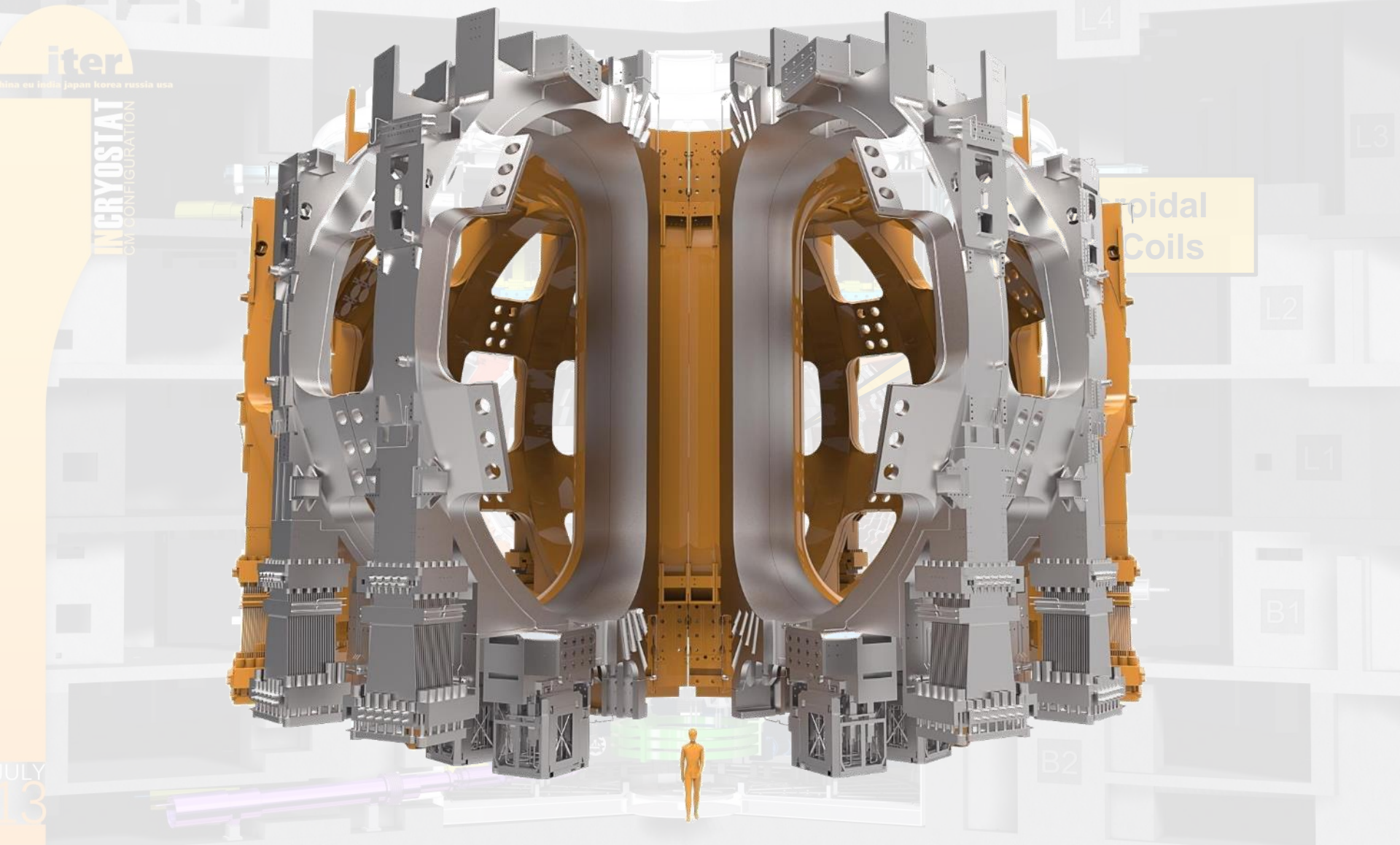
1. Fusion for Energy (F4E)
- 2. Europe contributions to ITER**
  - a) Site & Buildings
  - b) Plant and Supporting Systems
  - c) Tokamak Systems**
3. Business Opportunities
4. Future Budget



## 2. F4E Contributions to ITER (c) Tokamak Systems



## 2. F4E Contributions to ITER Tokamak Systems: TF Coils





# Successful completion of manufacturing process for TF Coil Winding Packs

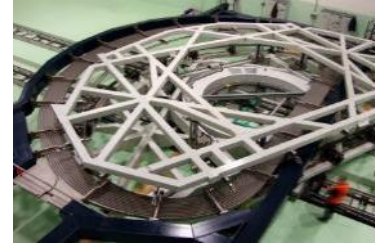
**1. DOUBLE PANCAKE  
WINDING**



**2. CONDUCTOR HEAT  
TREATMENT**



**3. INSERTING DOUBLE  
PANCAKE INTO PLATE**



**4. TURN INSULATION**



**5. COVER WELDING**



**6. DOUBLE PANCAKE  
GROUND INSULATION**



**7. DOUBLE PANCAKE  
IMPREGNATION**



**8. DOUBLE PANCAKE  
STACKING**



**9. WINDING PACK  
GROUND INSULATION**



**10. WINDING PACK  
IMPREGNATION**



**11. WINDING PACK TEST**

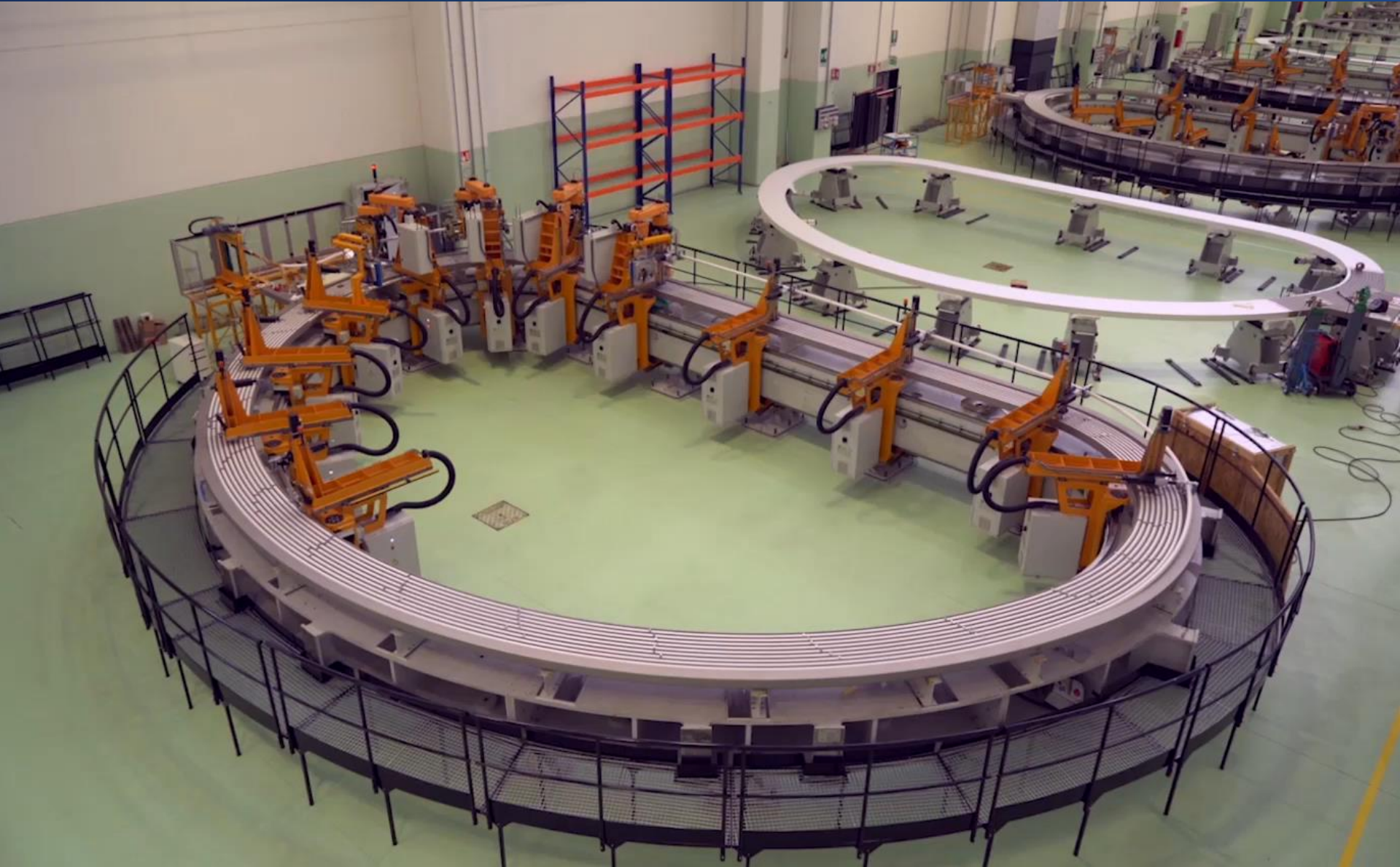


**12. WINDING PACK  
READY FOR SHIPPING**





# Visit to the Toroidal Field Coils factory in Italy



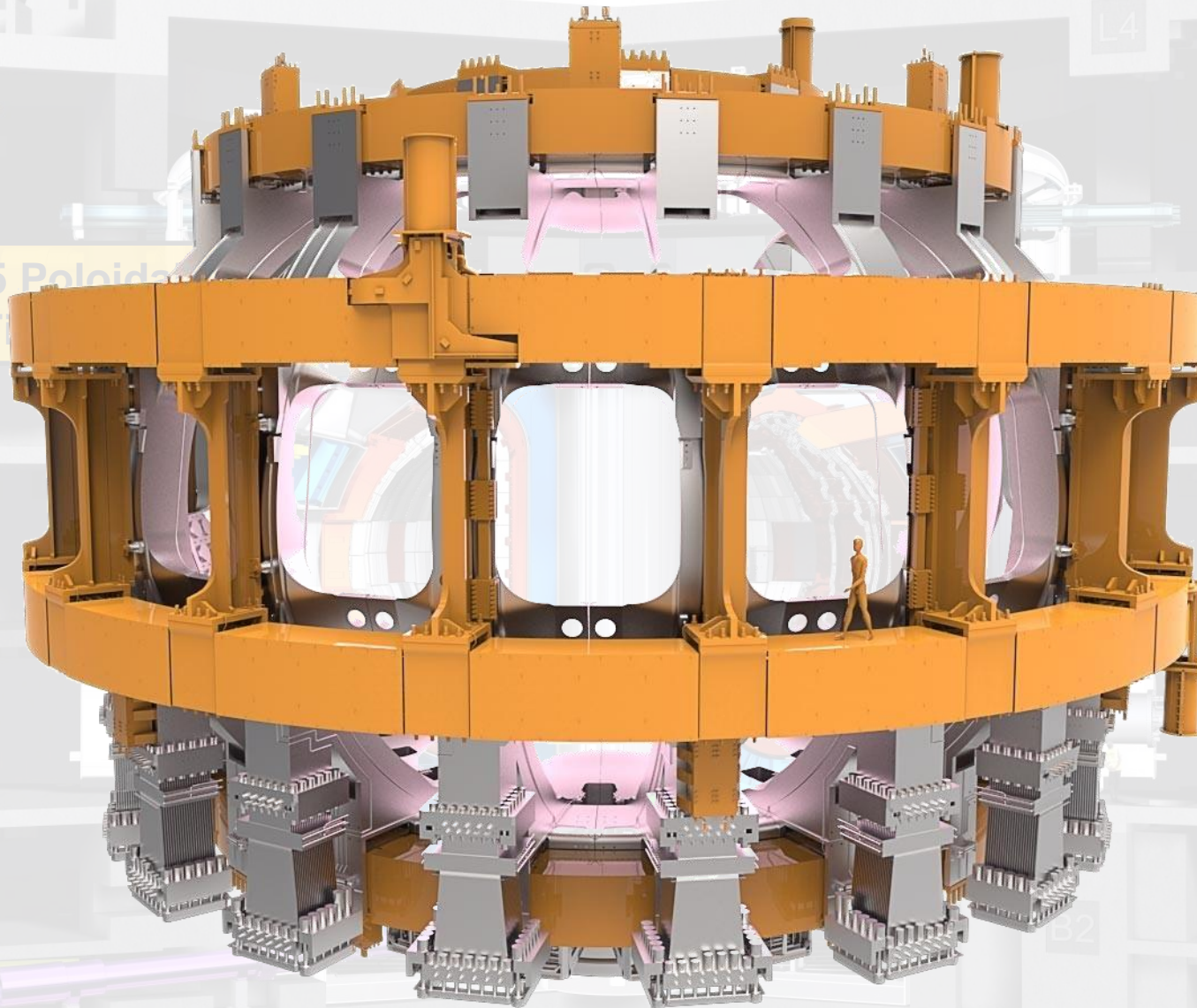


# SIMIC / Italy cold testing the TF Coils @78K before inserting in the cases





## 2. F4E Contributions to ITER Tokamak Systems: PF Coils



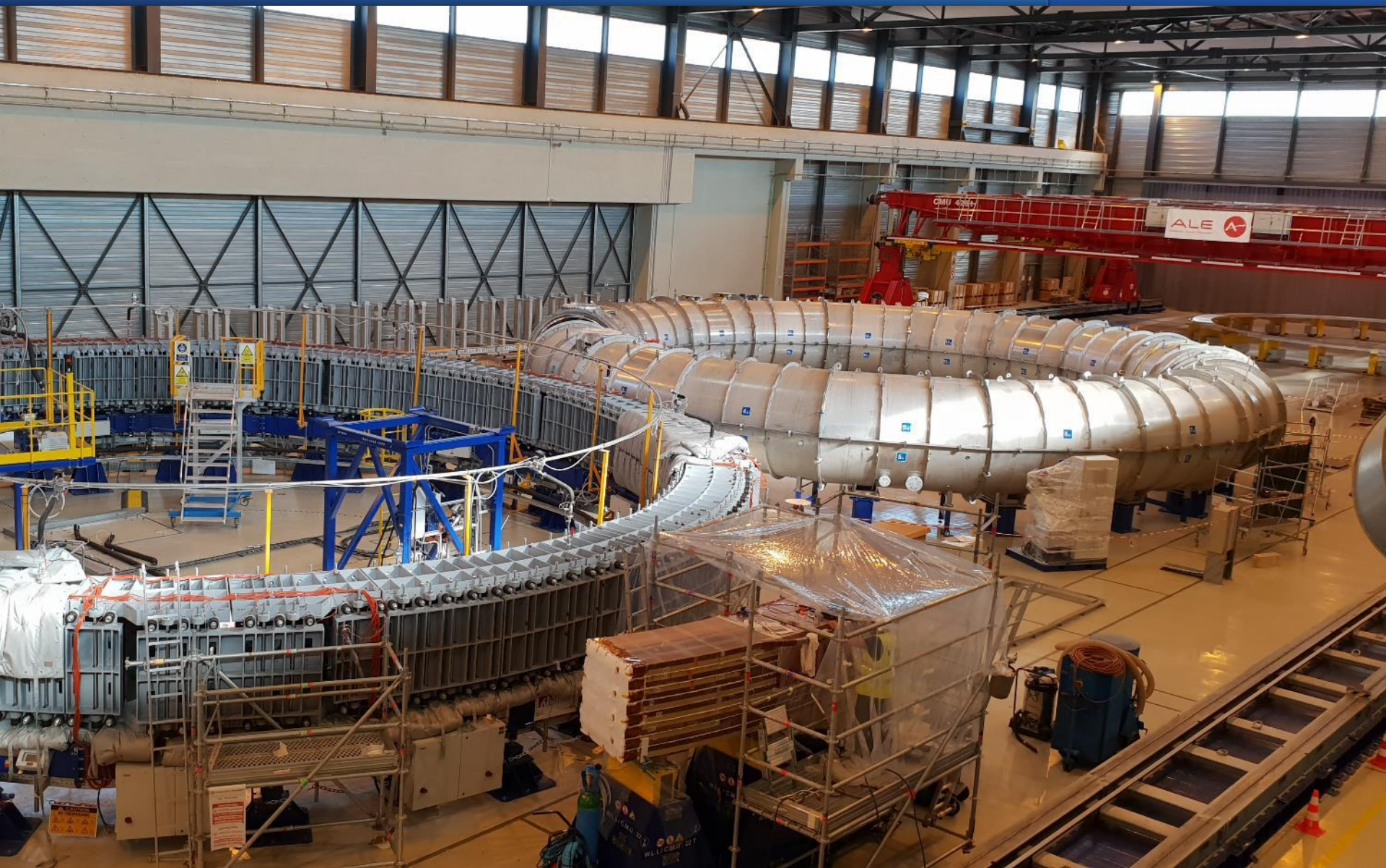


# Visit to the Poloidal Field Coil Factory on the ITER Site!





# Recent update from the PF Coil Assembly – Cryostat assembled





# ASIPP in China completed winding of last PF6 Double Pancake for F4E

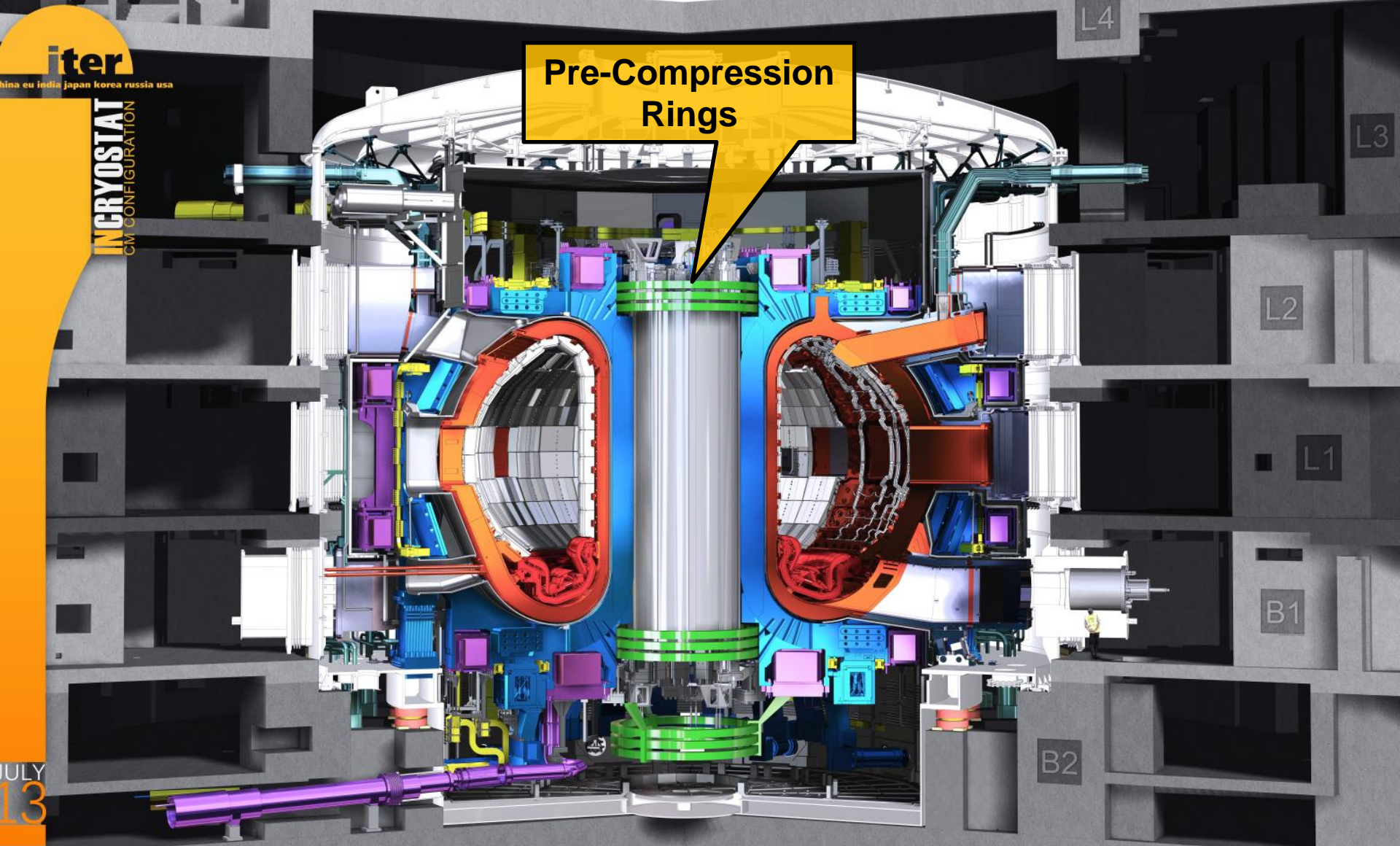


FUSION  
FOR  
ENERGY





## 2. F4E Contributions to ITER (c) Tokamak Systems





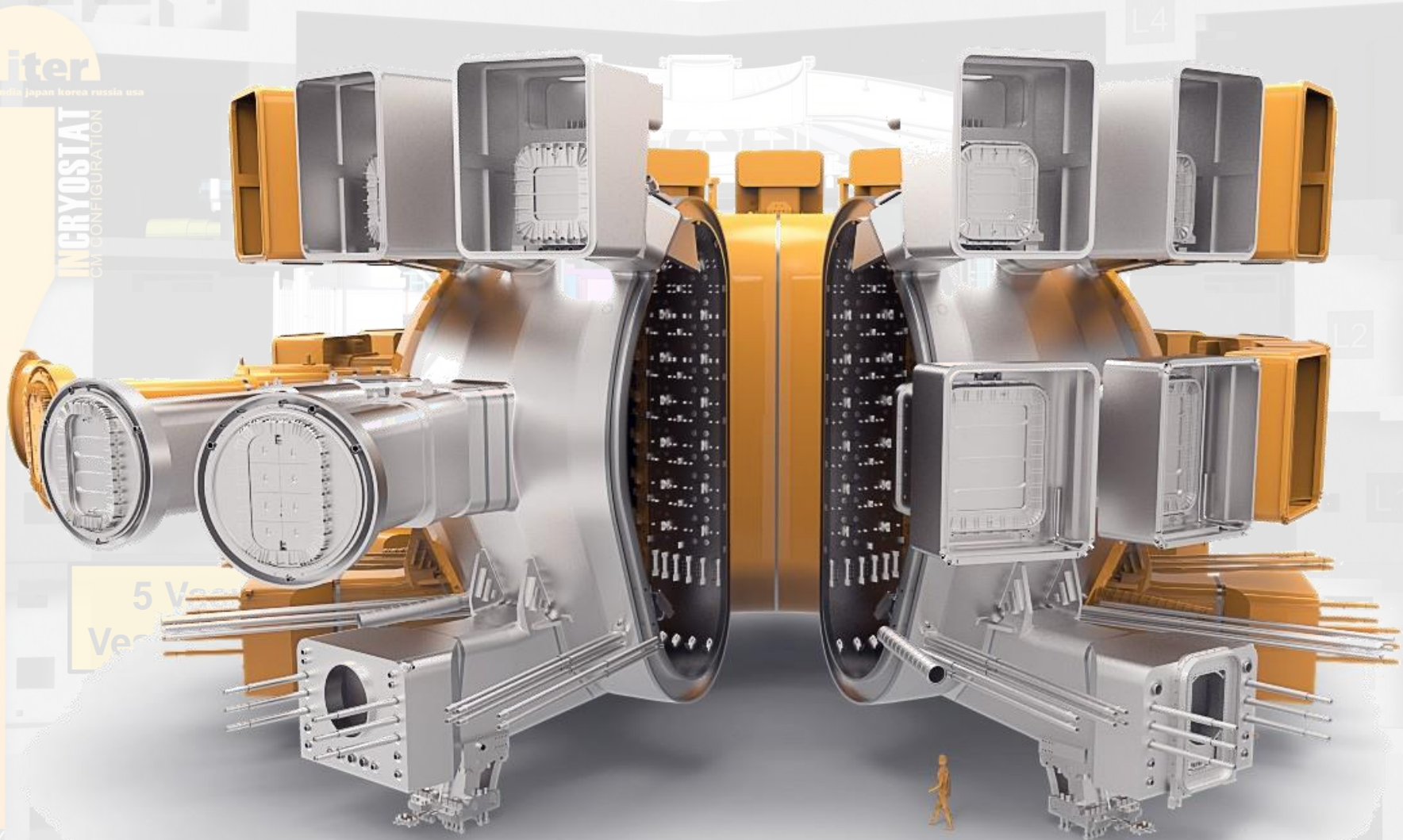
# Facility ready to test Pre-Compression Rings to 36,000 tonnes





## 2. F4E Contributions to ITER

### (c) Tokamak Systems: Vacuum Vessel

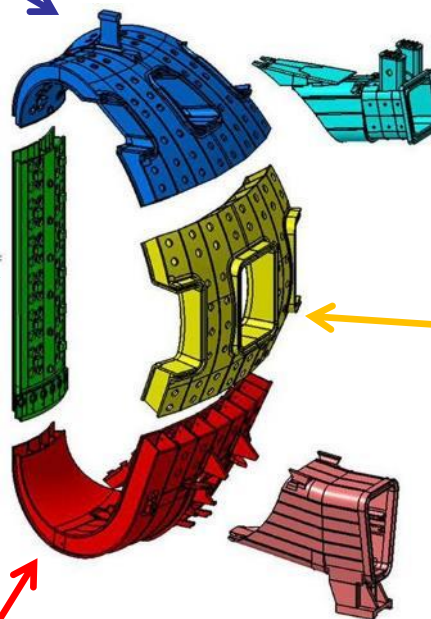
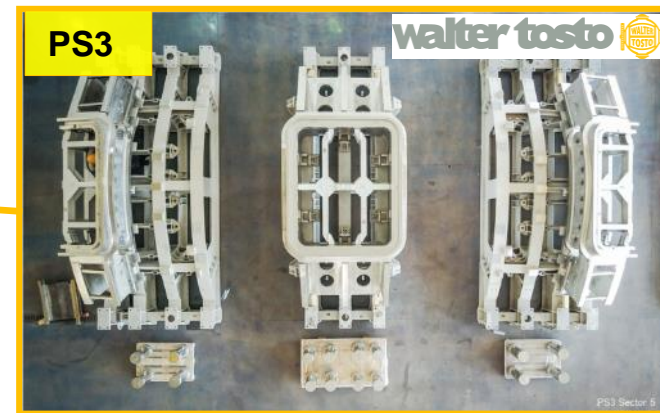
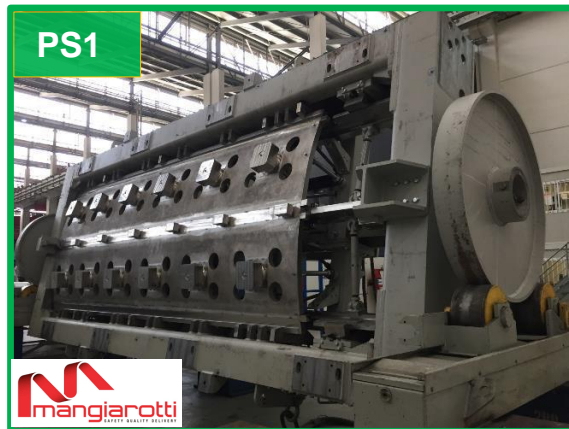




# Vacuum Vessel production involves several industrial methods (welding, forming, NDE)



# Vacuum Vessel sub-assemblies of sector 5 completed (>50% overall)

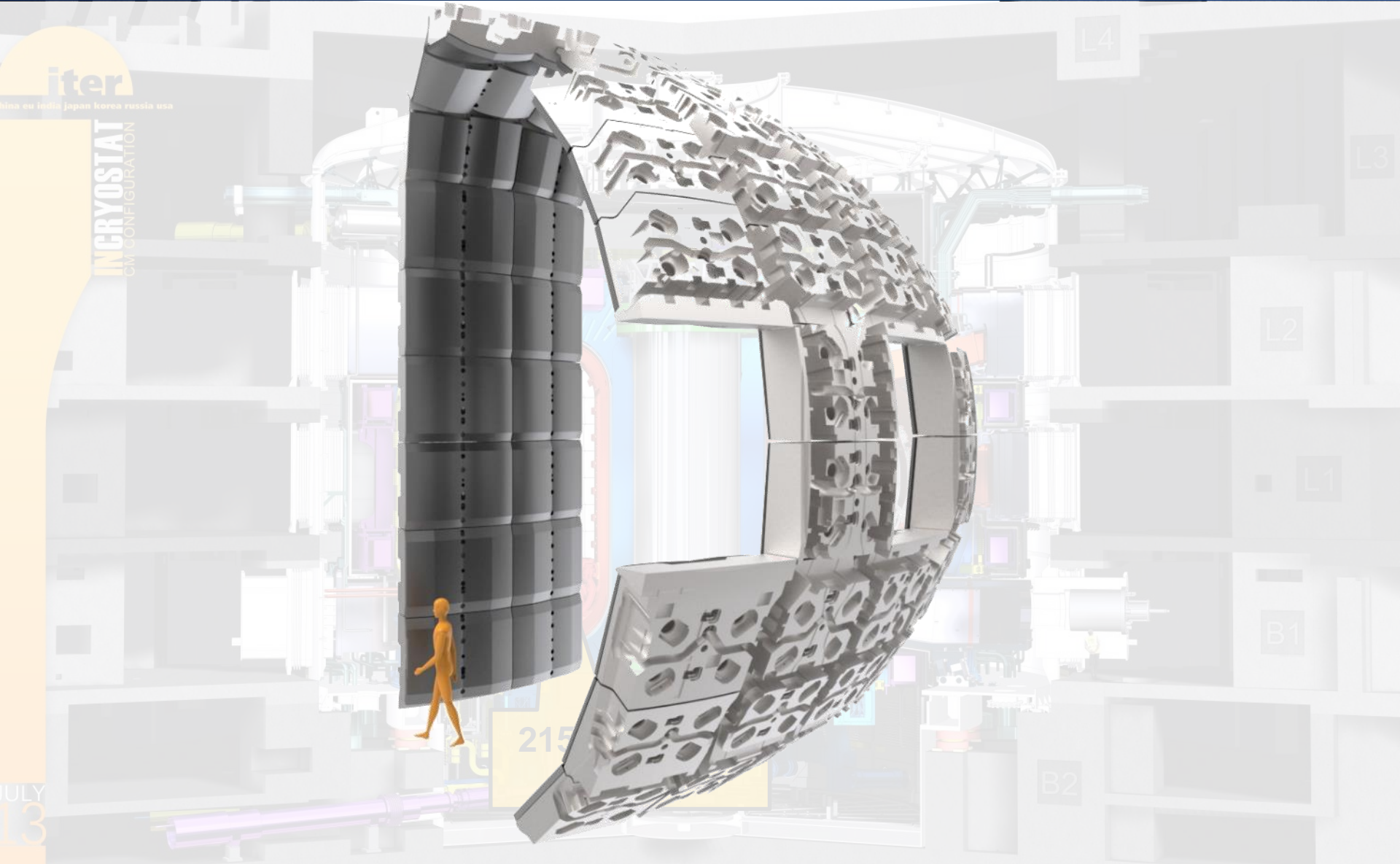


See P2.145



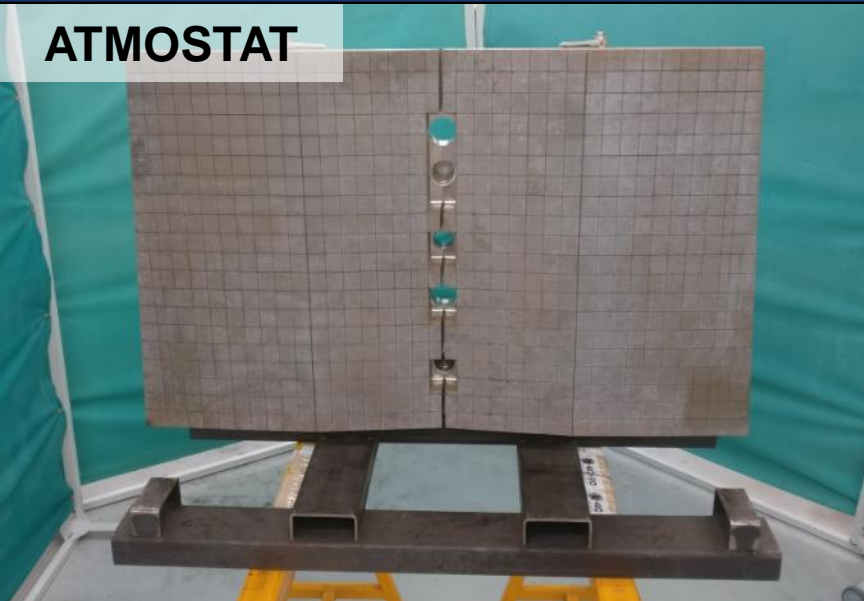
## 2. F4E Contributions to ITER

### (c) Tokamak Systems: First Wall

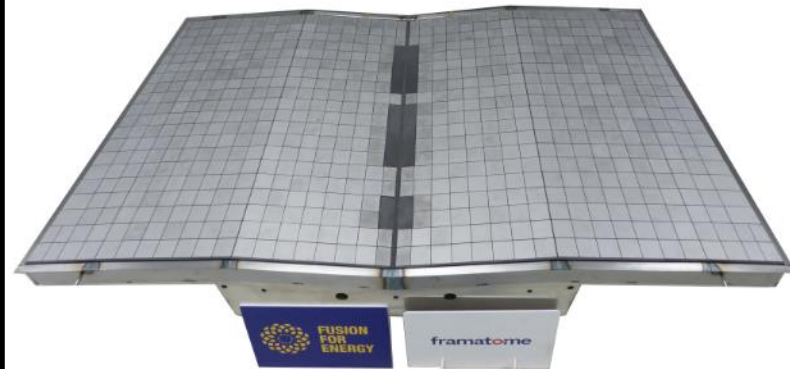


# F4E's industrial partners completing three full-size First Wall prototype modules

**ATMOSTAT**



**FRAMATOME**



**IBERDROLA-LEADING-WOOD**

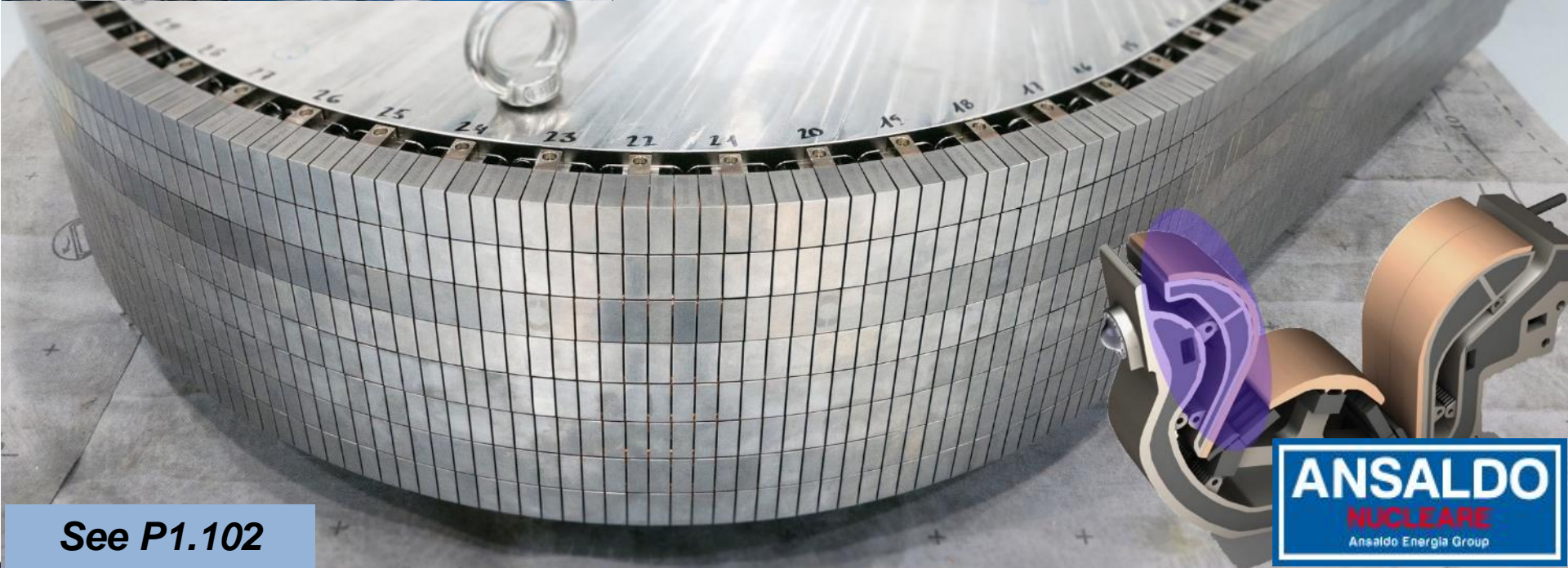
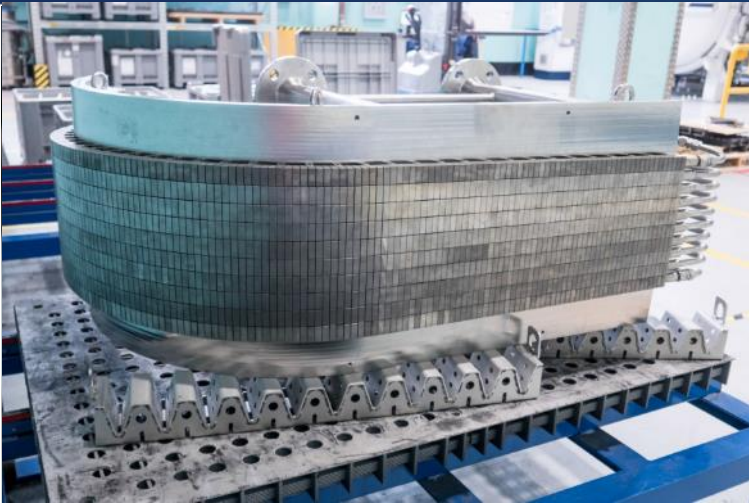




# F4E Contributions to ITER Tokamak Systems: Divertor



# First full-scale Inner Vertical Target Prototype ready for testing



See P1.102



# Full-scale Divertor Cassette Prototypes completed

walter tosto 

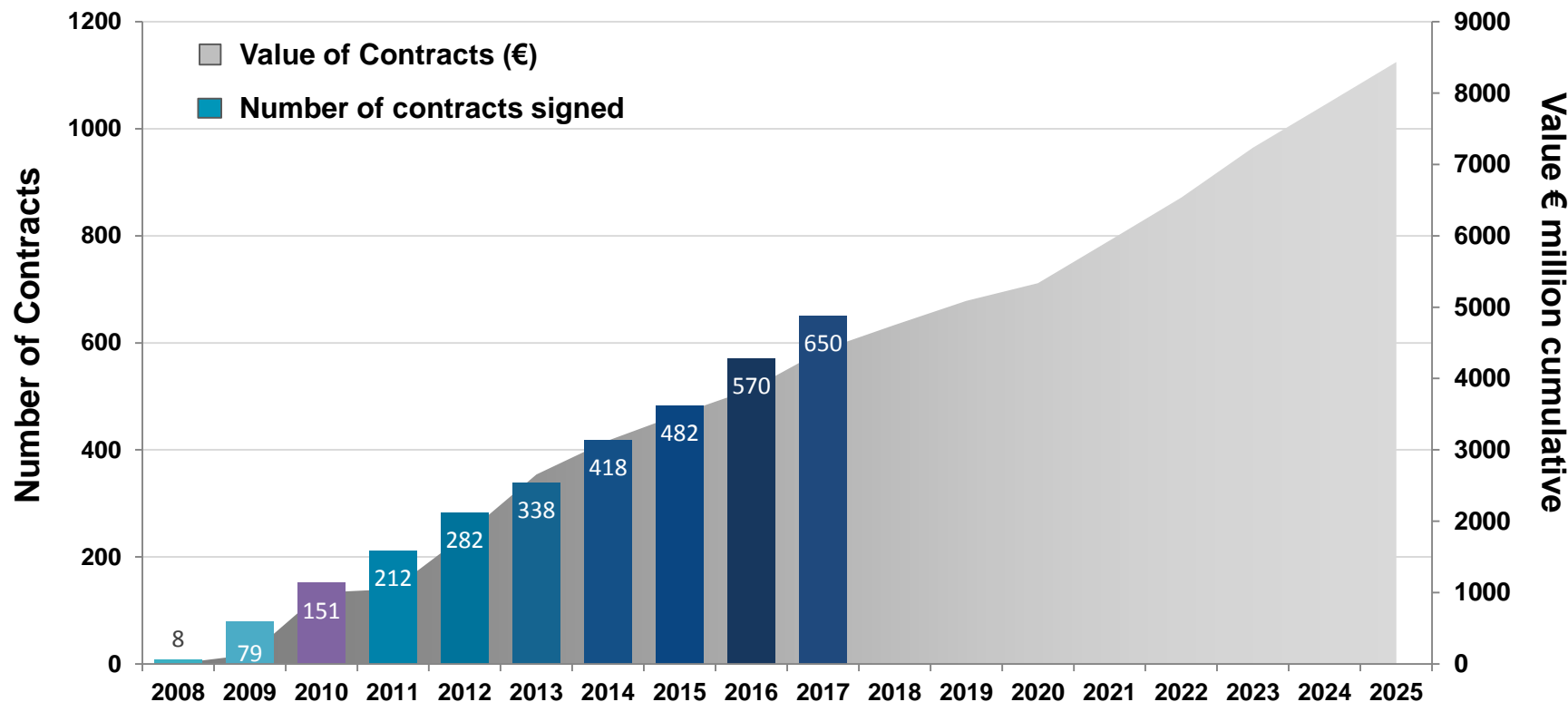


1. Fusion for Energy (F4E)
2. F4E Contributions to ITER
  - a) Site & Buildings
  - b) Plant and Supporting Systems
  - c) Tokamak Systems
- 3. Business Opportunities**
4. Future Budget



# F4E is approx. half way through its ITER mission in budgetary terms

So far >€4.5 billion through >950 signed contracts

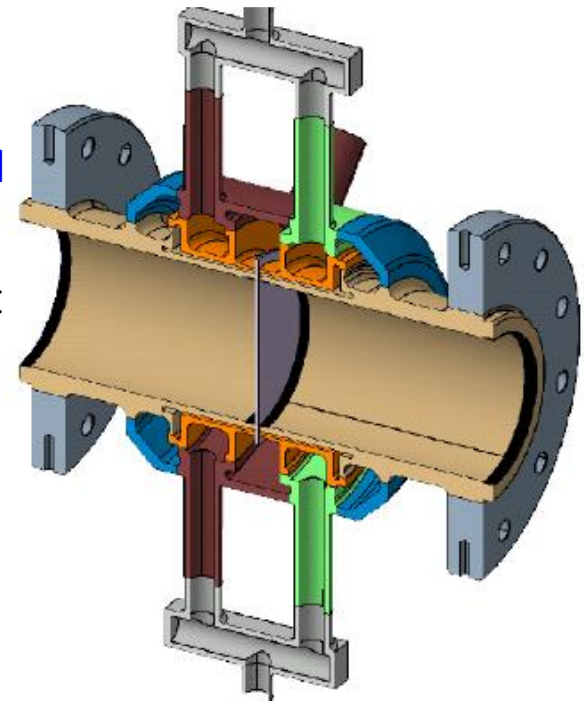


Working with ~450 contractors & >1000 sub-contractors in 24 countries

- OPE-0885: Electron Cyclotron Heating (ECH) window mechanical part (Q1 2019).

In parallel of Negotiated procedure OPE-0729 for ECH diamond window with Diamond Material (Q1 2019).

The torus window unit acts as vacuum and tritium confinement barrier, while allowing transmission of mm-wave beams up to 1.5 MW (incident design power in window location is 1.25 MW). Part of the first ITER confinement: it has stringent requirements in the ITER safety, quality, seismic, vacuum and tritium classifications. As a consequence, special requirements for the procurement preparation and prototyping & testing apply.



Section view of the Diamond Window Unit CATIA design

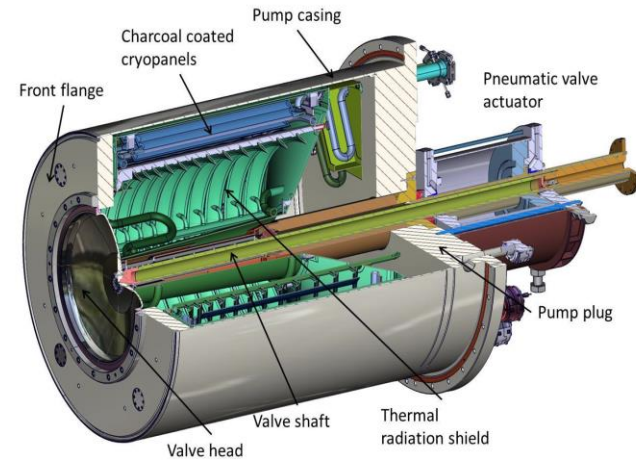
**Scope of Supply:** Manufacturing, assembly, and Testing of 3 units, upon BtP drawings provided by F4E (produced by KIT).

**Skills:** High Precision mechanic, assembly, and testing,



## ITER CRYOPUMPS (CFT: Q4 2018):

The Torus Cryostat Cryopumps measure about 3.4 m long and 1.8 m in diameter. The overall weight of each pump is about 7.8T. They are composed of two cryogenic circuits made up mainly of hydroformed panels of austenitic stainless steel: a circuit of charcoal coated cryopanel which fulfil the pumping function, cooled with Helium at 4.3 K and 0.4 MPa. A thermal radiation shield to minimize heat loads on the cryopanel circuit, cooled with Helium at 80 K and 1.8 MPa. The circuits are enclosed in a cylindrical pump casing that can be isolated by means of an integral valve.



***1cut-out view TER  
Cryopump***

**Scope of Supply:** 8 units

**Skills:** precision machining, assembly, special coating, hydroforming.

## Primary Leak Detection and Localisation System (CFT: Q2 2019):

### Business Opportunity: Engineering & Procurement contract

- Preliminary (PDR) and Final Design review (FDR)
- Manufacturing Design + Manufacturing Readiness Review (MRR)
- Procurement of raw material and Qualification of components under load cases.
- Manufacturing + Assembly of all subsystems
- Factory Acceptance Tests + Packing and shipping to ITER site (Cadarache, France).

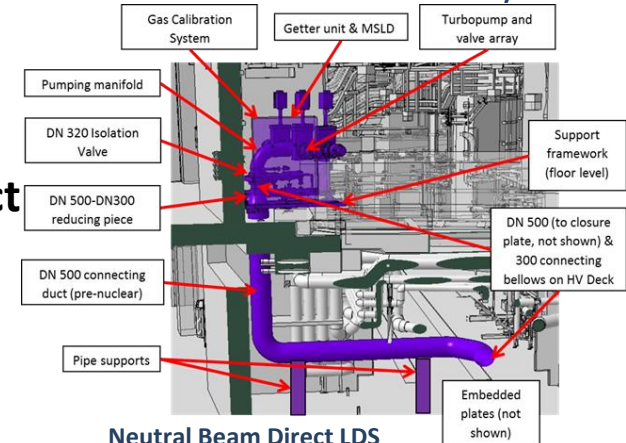
### Scope of the Primary and Cryostat LDS:

- 1 Torus Direct LDS
- 4 remote LDS (SVS, Torus, NB, Cryostat)
- 1 Cryostat direct LDS
- 1 Gas Analysis system
- 1 Leak Calibration system
- 3 Control cubicle (hardware)

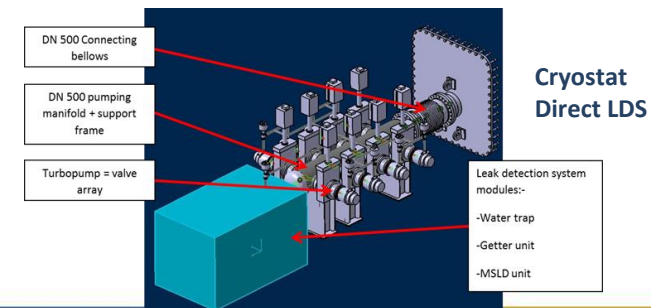
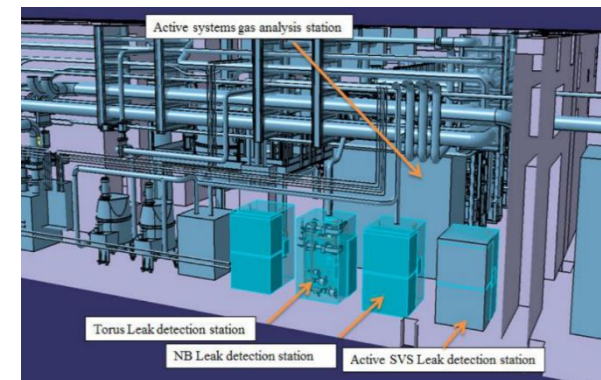
**Skills:** High Vacuum Engineering, assembly, SIC components etc.

[See documents on F4E Industry Portal.](#)

Torus VV Direct LDS + Leak Calibration system



Neutral Beam Direct LDS





## In-Vessel Cables (CFT: Q4 2018):

- Transmit signals generated by the diagnostic sensors within the ITER Vacuum Vessel
- Irradiation hard – cabling cannot be replaced and must outlive the machine (minimum 20 years)
- Ultra High Vacuum compatibility
- Low cross-talk
- Thermally and mechanically fixed to the ITER vacuum vessel

## Scope of Supply:

- Supply of ~2000 terminated cables for installation inside the ITER VV:
- Mostly twin or quad twisted Mineral Insulated Cabling, 4 mm diameter, around 10 m long, with Ultra High Vacuum terminations at each side



*Prototype Cable Termination*



*Coiled cable*

## Core Plasma Thomson Scattering System (CFT: Q1-Q2 2019)

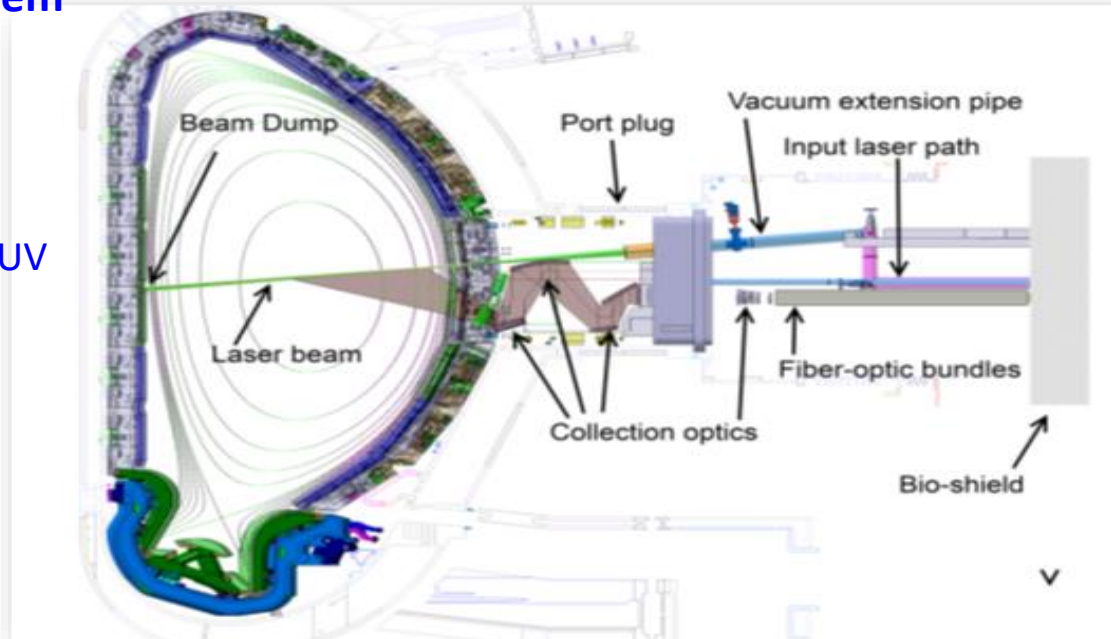
- Measures plasma density and temperature
- Collects scattered laser light in near UV to near IR

### Main Components:

- Injection/collection optics
- High heat flux beam dump
- Mirrors, lenses, optical fibres, supports, shutter
- Spectrometers
- I&C/Electronics/S'ware

### Scope of Supply:

- Preliminary Design of the CPTS → framework baseline
- Final Design of the CPTS → under task orders
- Includes prototyping of key components and technologies
- Excludes lasers and electronics (separate contracts)
- Market Survey to be published in Q4 2018



Optical design  
Engineering analyses  
Lifetime and reliability studies  
Measurement performance

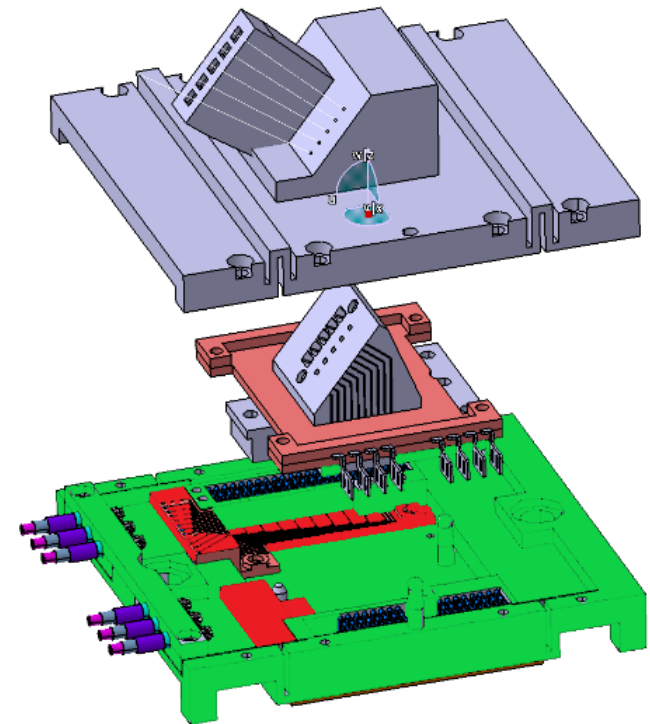


## Mounting Platforms for Bolometers (CFT Q2-Q3 2019):

- Bolometer diagnostic measures total-radiated power
- 22 cameras require near-identical mounting platforms to be attached to the ITER vacuum vessel (VV) and electrically connected, which will be installed early

Platform for VV-mounted bolometer cameras:

- Metal structure with flexing elements and good thermal conduction (green)
- Ceramic structures (red) providing electrical connection by tracks and connectors
- Temporary cover (not shown)



## Scope of Supply:

- **Design** based on a functional requirements. a concept provided and defined interface with the top part of the camera
- **Manufacturing** of **22 platforms**
- Will involve engineering analysis in line with applicable codes & standards
- May involve prototyping of key components and technologies

## Seismic Analysis & design of buildings and mechanical components of the ITER facility (Q1-Q2-2019)

### Scope of Supply:

- 1 lot.
- Framework Contract (Continuation of activities of OMF-0503 contract- Seismic and dynamic load)
- 4 years duration

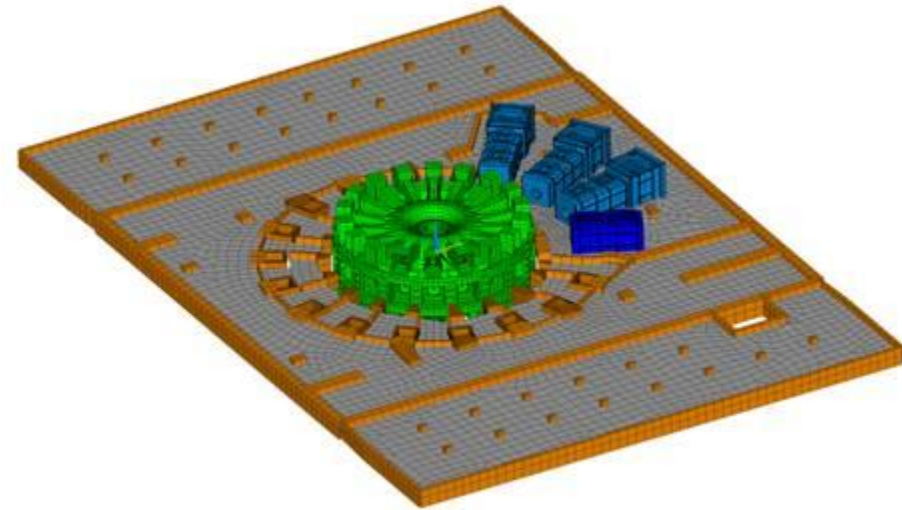


Figure 1: Example of FE model used for seismic analysis, Tokamak machine and Neutral beam injectors inside the Tokamak building.



## CODAC: Supply of I&C integration services to F4E

- These services will range from the implementation of the interface between industrial supplied systems and ITER CODAC, to the development of the complete control systems of a plant.
- Framework service contract by means of Task Orders. The support services shall be performed partially within the Supplier facilities (development of components) and partially at F4E designated locations (integration and test of components).
- Duration of 4 years.
- Ceiling of about 8M euros
- Similar scope to previous OFC-0811 CFT.

## OMF-0563: Provision of Material Characterization at Cryogenic temperatures

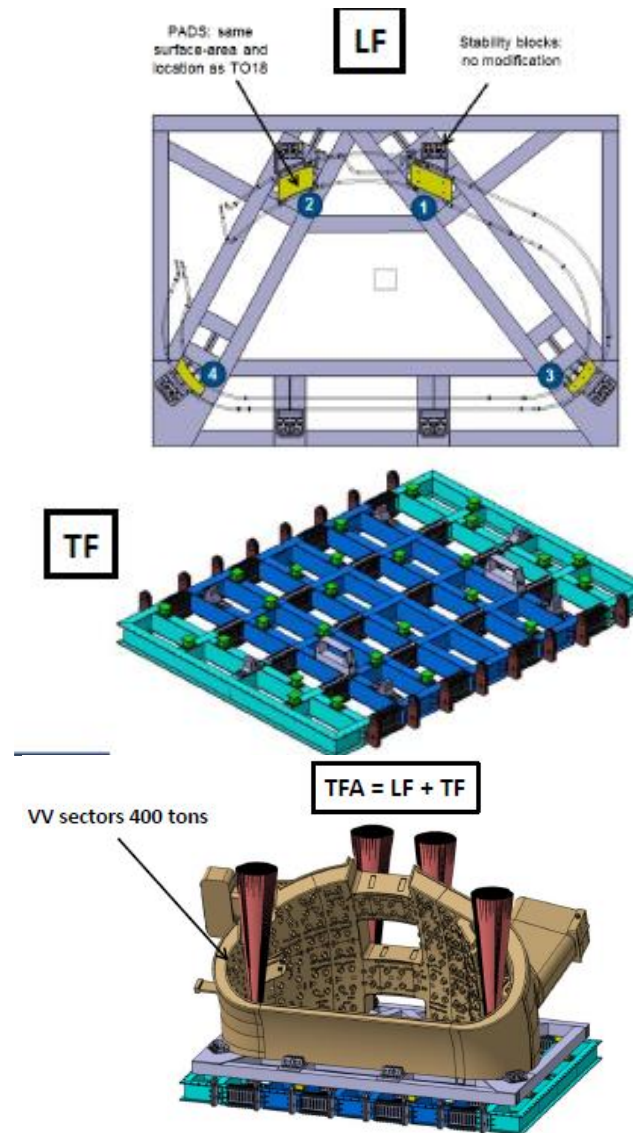
- The work consists of measurements of mechanical- and physical properties of structural-, electrical insulators- and other fusion relevant materials at the mentioned temperature range. Additionally optical and electron microscope inspections are required.
- CFT planned for Dec 2018-January 2019
- Framework contract
- Duration of 4 years.
- Ceiling > 250k euros.



## Vacuum Vessel Transportation Frame Assembly (TFA) (Q1 2019)

It consists in:

- **Lifting Frame (LF)** mainly for lifting and handling operations at Hyundai Heavy Industries, Consortium AMW and/or ITER Organization.
- **Transportation Frame (TF)** to rigidify the whole TFA during Vacuum Vessel (VV) sectors ocean & road transportation.
- **Scope of Supply:** 5 main structures of beam 650 mm height and additional sub-components. See F4E Industry portal presentation
- Target date launch CFT: February 2019



## Warning

- The information provided for these Calls For Tender is for general information only and can be subject to changes of any nature.
- Only the Tender Documentation attached to a Call For Tender during its publication is valid.



1. Fusion for Energy (F4E)
2. F4E Contributions to ITER
  - a) Site & Buildings
  - b) Plant and Supporting Systems
  - c) Tokamak Systems
3. Business Opportunities
- 4. Future Budget**

# Europe continues to strongly support ITER



- **In April the Council of the EU:**
  - **Underlined the fundamental importance of ITER in the European fusion roadmap**
  - **Mandated the Commission to approve the new ITER baseline on behalf of Euratom**
- **In May European Commission has proposed a budget of €6.07 billion for 2021-2027**
- **Negotiations on next EU budget starting.**





# Where to meet all ITER project stakeholders?



ITER BUSINESS FORUM  
26 to 28 March 2019  
Antibes Juan-les-Pins / France

IBF/19  
ITER BUSINESS FORUM

	ITER	CONFERENCE	OPTIONAL PROGRAMME	EXHIBITION & SPONSORSHIP	PRACTICAL INFORMATION	REGISTRATION	LOGIN
--	------	------------	--------------------	--------------------------	-----------------------	--------------	-------

[Iterbusinessforum.com](http://Iterbusinessforum.com)



# Thank You!



Fusion for Energy has received  
funding from the European Union  
budget