

# ROUNDTABLE

## ITER Domestic Agencies' General fusion roadmap



**Min Wang**  
ITER China



**Marc Lachaise**  
Fusion for Energy



**Ujjwal Baruah to Narinder P Singh**  
ITER India



**Taro Matsumoto**  
ITER Japan



**Kijung Jung**  
ITER Korea



**Anatoly KRASILNIKOV**  
ITER Russia



**Kathryn McCarthy**  
ITER US



**Chairperson:**  
**DeLeah Lockridge**  
Head of the Engineering  
Services Department  
Deputy Director General  
ITER Organization



# Fusion Development in China

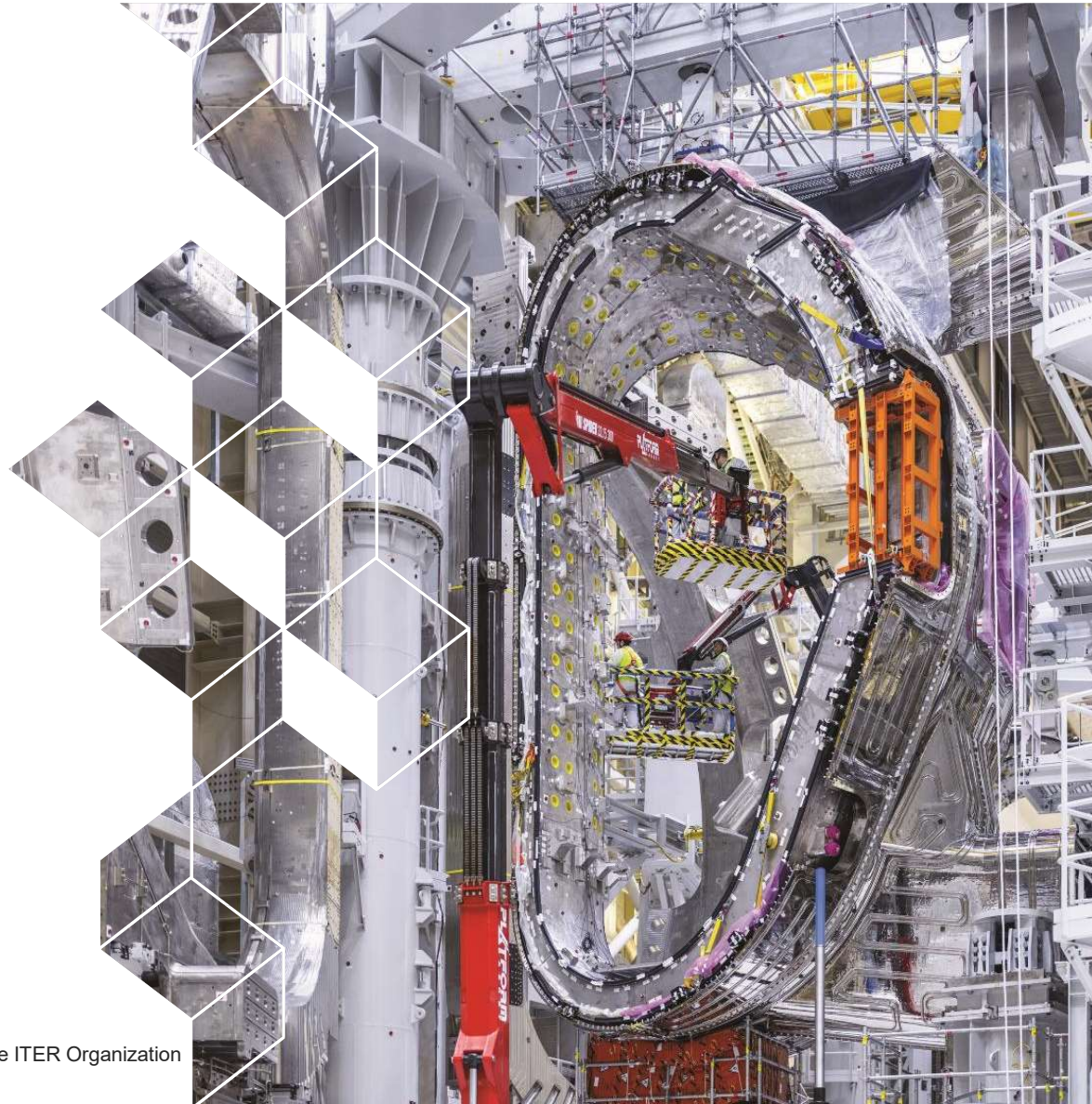


**WANG Min**

**DDG of ITER China**

**THURSDAY APRIL 24th**

Disclaimer: the views and opinions expressed herein do not necessarily reflect those of the ITER Organization



# Content

- 1. Overview of Fusion R&D in China**
- 2. Highlights of CN PAs**
- 3. Good Practice and Challenges**
- 4. Summary**

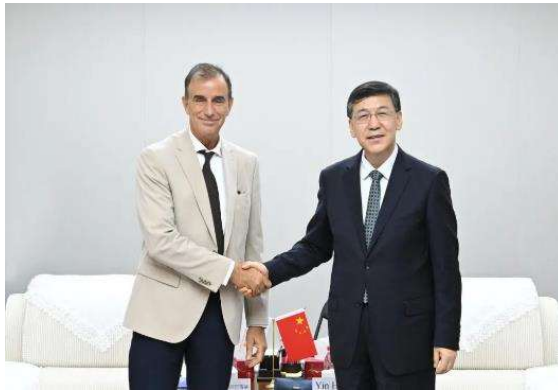





# **1. Overview of Fusion R&D in China**



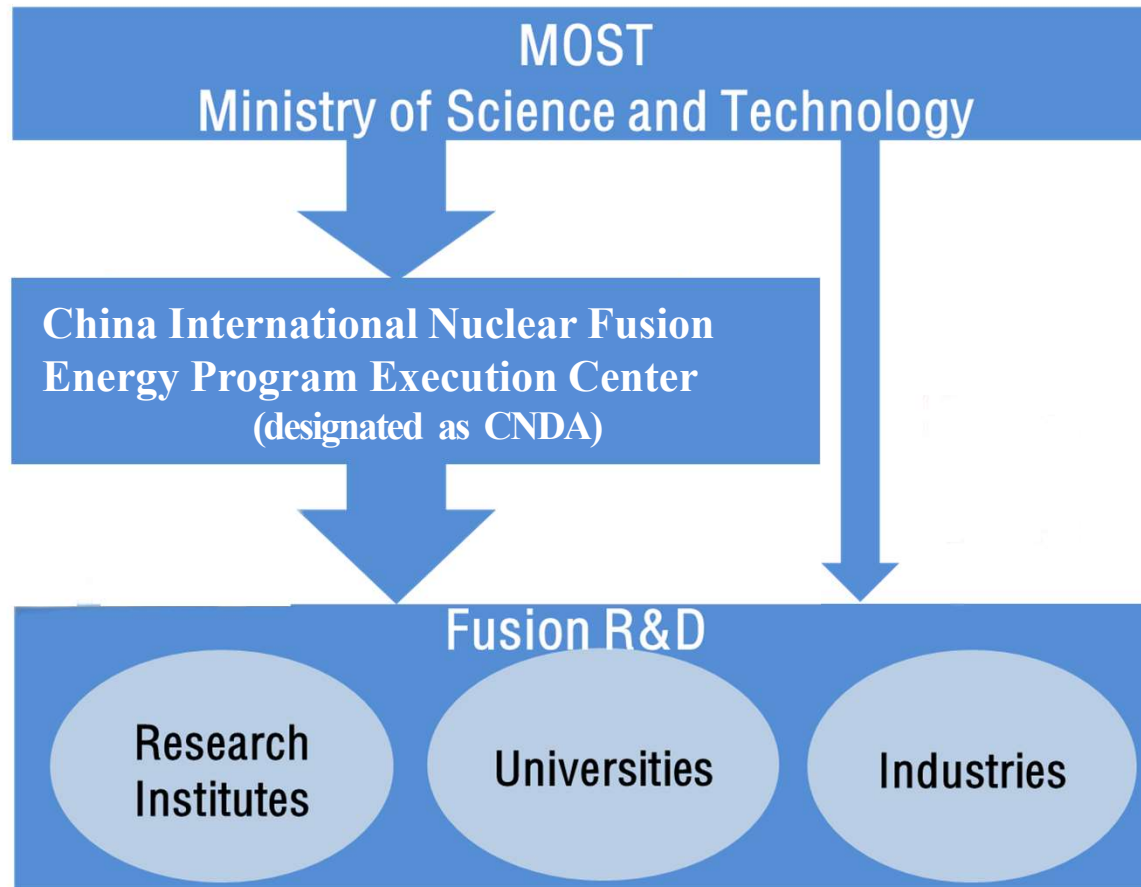
# Support from the Chinese Government



# Support from National Policies

- **Opinions on Fully Implementing the New Development Concept and Achieving Carbon Peak and Carbon Neutrality** issued by the Communist Party of China Central Committee and the State Council (Sep 22<sup>nd</sup>, 2021)
  - **The State Council's Action Plan for Carbon Peak before 2030** (Oct 24<sup>th</sup>, 2021)
- 
- To strengthen fundamental research and frontier technology layout, and promote low-carbon frontier technology research such as **controllable nuclear fusion**.

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# Our Mission

## China International Nuclear Fusion Energy Program Execution Center



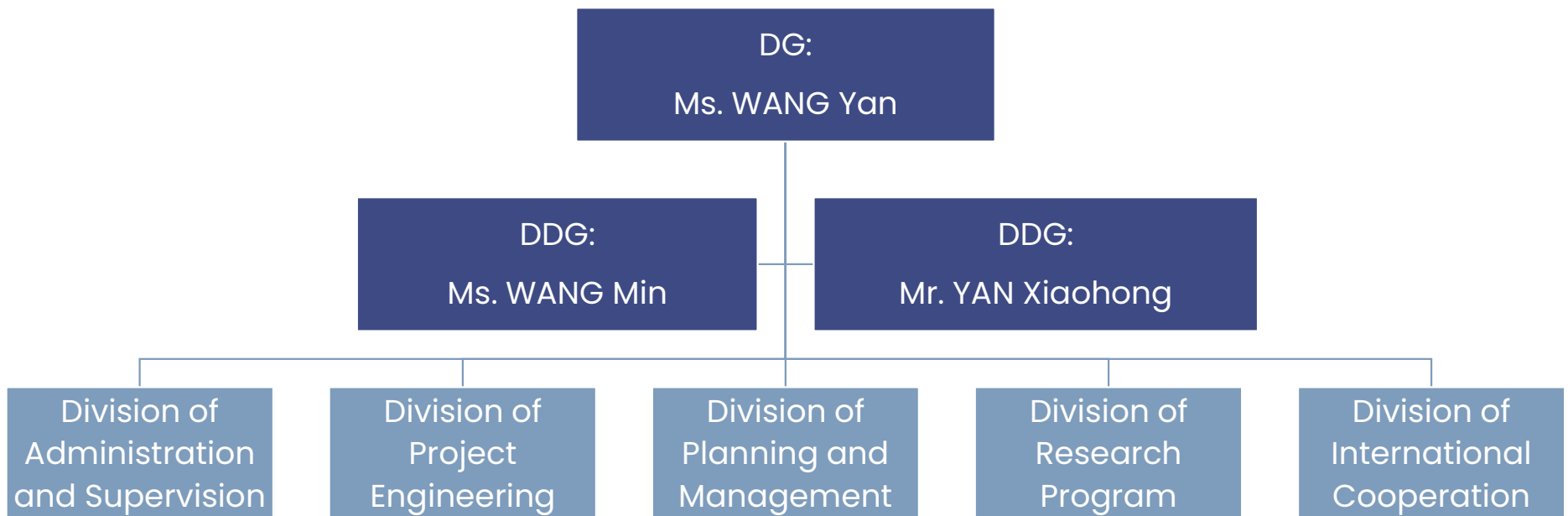
## Promotion of Fusion Energy Development



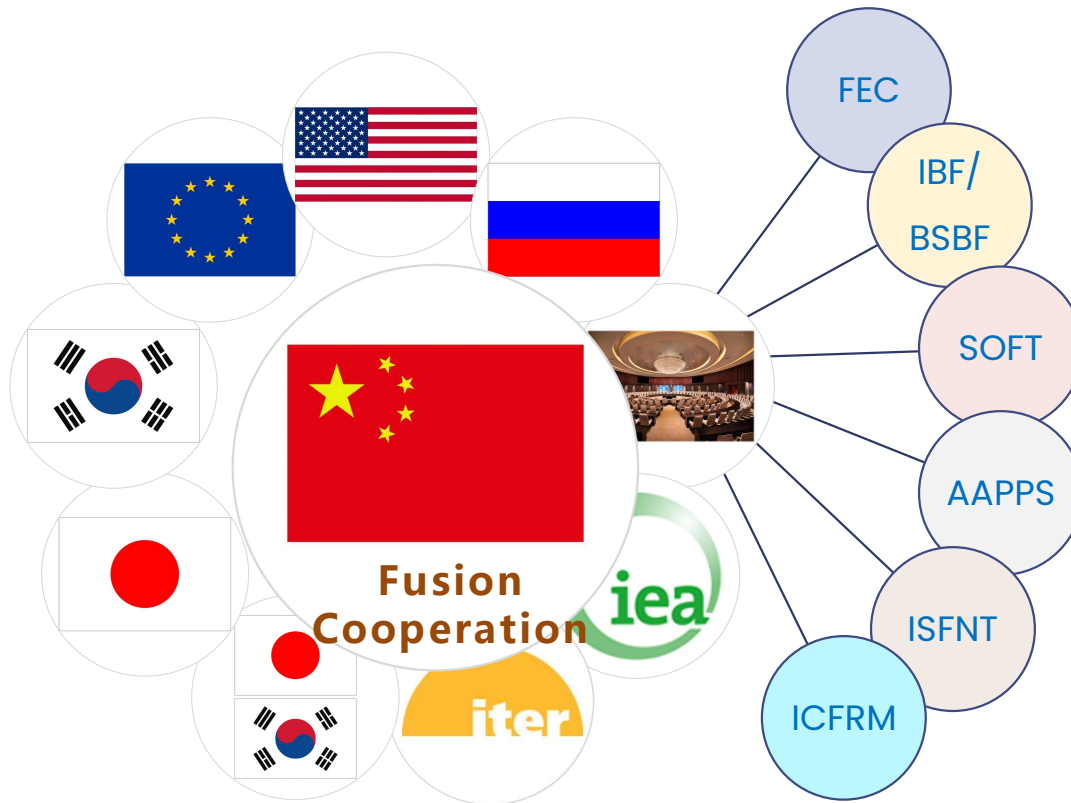
# Organization Structure

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## China International Nuclear Fusion Energy Program Execution Center



# Our International Cooperation



China has actively engaged in bilateral and multilateral cooperation in the field of fusion.



China has signed intergovernmental bilateral cooperation agreements on fusion with the United States (1986), Japan (2007), the European Union (2008), South Korea (2011), the ITER Organization (2012), and France (2017). Regular annual meetings are held to report the progress of bilateral cooperation.

## Provide Platform for Fusion Community



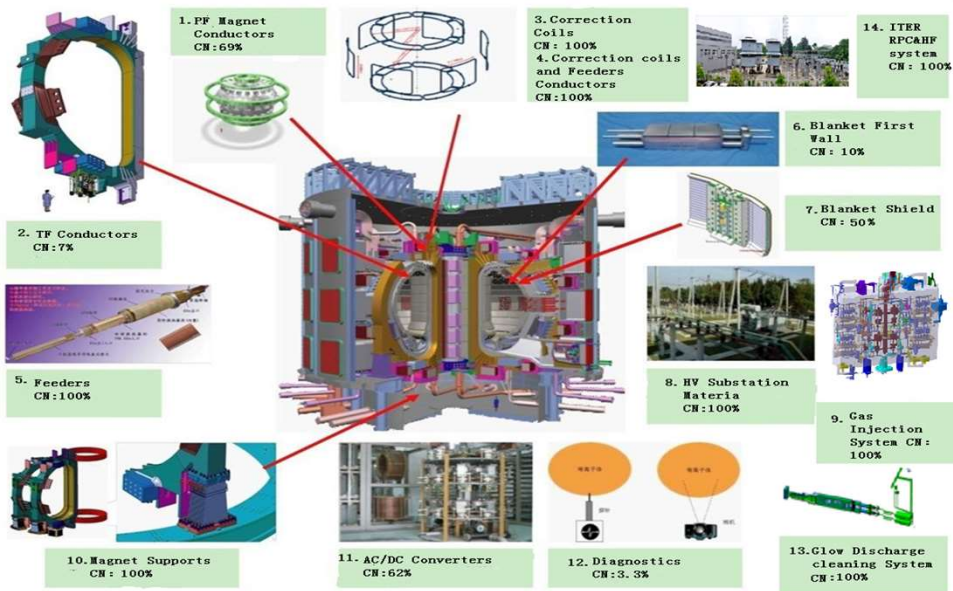
Since 2019, China Fusion Energy Conference (CFEC) was held every two years.



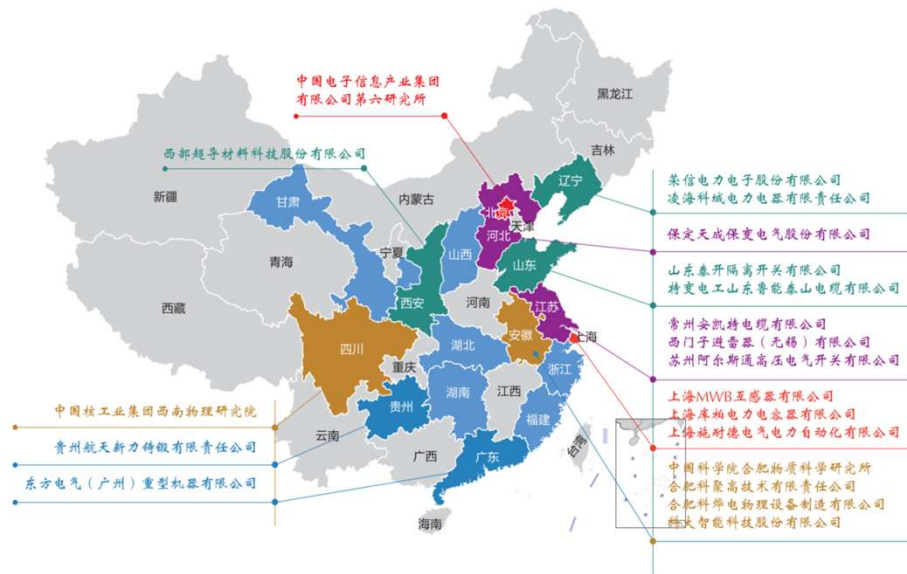


# 2. Highlights

## China's In-kind Contribution to ITER



- **Total 18 Procurement Arrangements (PA).**
- **all manufacturing and delivery tasks of 7 PAs have been completed.**
- **By December 2024, CNDA has received about 68.51% of the total credit.**

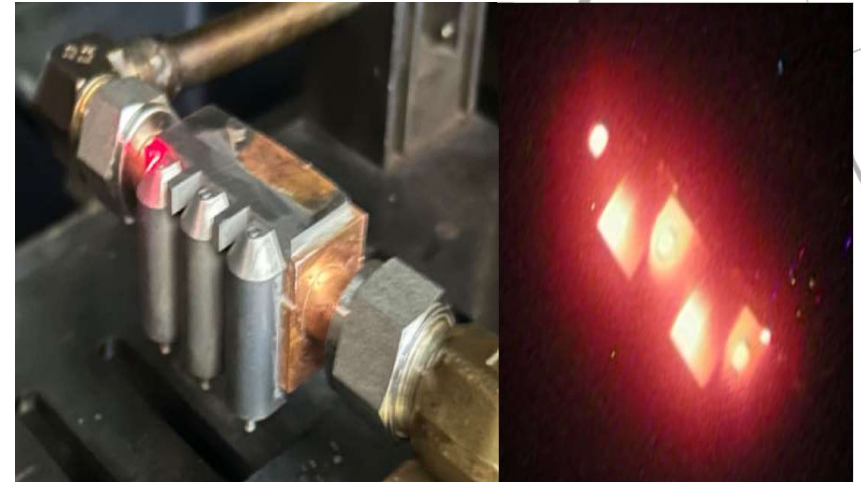


- More than 30 main suppliers join in ITER project
- Nearly 100 sub-suppliers participate in the PA tasks.

# PA Highlights in 2024



**In June, 2024, the 1st set of Side Correction Coil (SCC1) cold test at 80K was successfully finished.**



**In June, 2024, Divertor Langmuir Probe (DLP) prototype successfully passed the 20MW/m<sup>2</sup> heat load thermal cycle test for the first time.**

# PA Highlights in 2024



In July, 2024, the ITER Poloidal Field coil converter power supply system entered into low-voltage commissioning.



In Nov, 2024, the ITER Reactive Power Compensation system passed the HV commissioning and SAT.

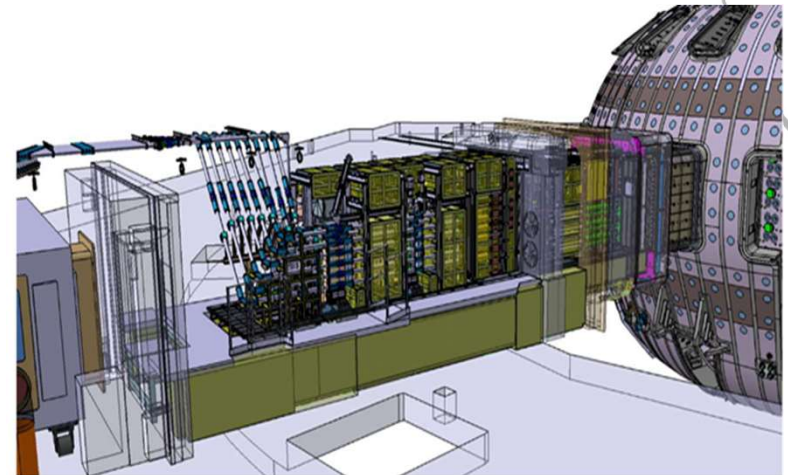
**With excellent team and rich experience, design, manufacture, delivery and installation of ITER stage 1 MCPS and RPC has been successfully completed by good communication and cooperation.**



# PA Highlights in 2024

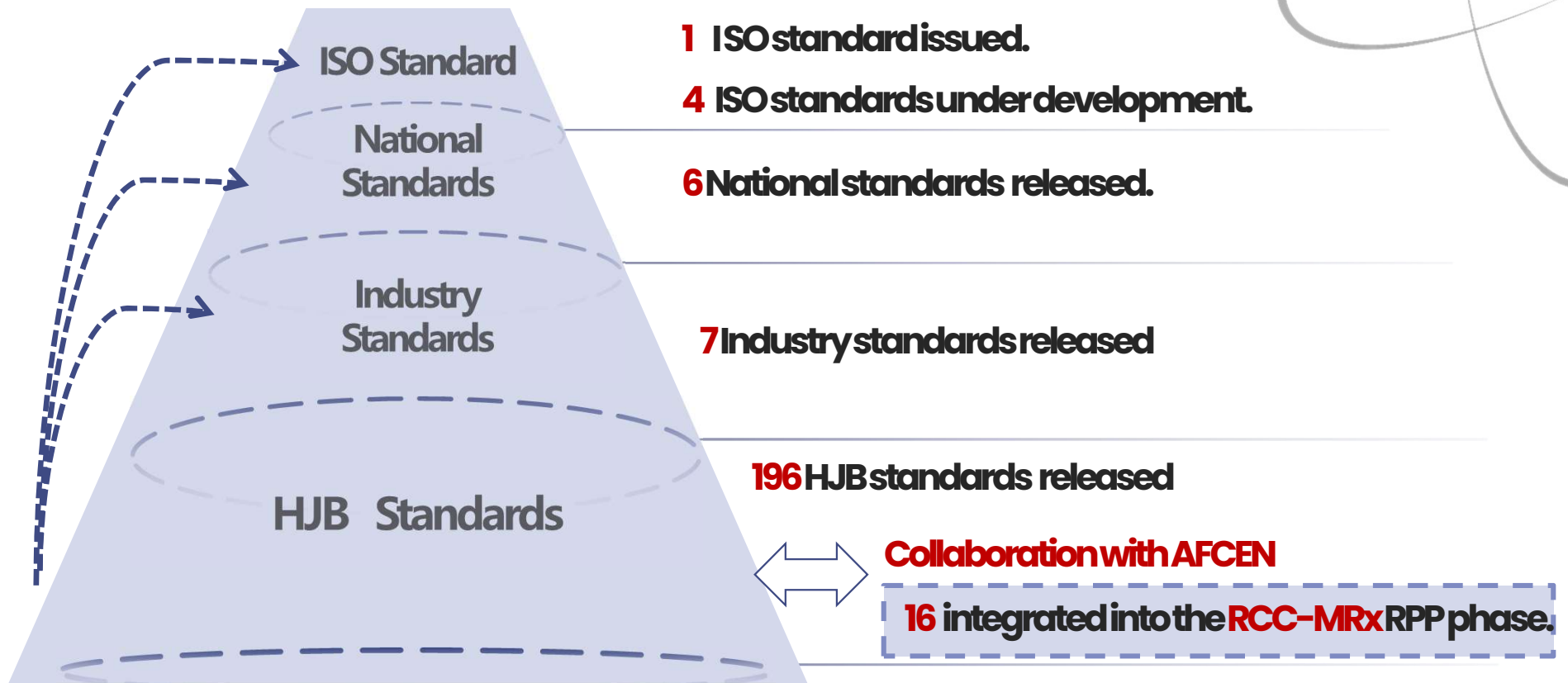


**In Nov. 2024, the first batch of large-scale in-vessel components of ITER tokamak - 48 shielding modules were delivered to ITER from China.**



**In Nov. 2024, contract for equatorial 12 Port Integration was successfully signed.**

# PA Highlights in 2024





# **3** ■ **Good Practices & Challenges**

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## ■ A good opportunity to enhance the International cooperation

(some examples)

- Sino-French-Italian Cooperation on Fusion Energy: Shared Values, Shared Vision and Shared Action.

Through more than 5 years of project practice at ITER since 2019, the Chinese Consortium (CNPE, CNI23, SWIP and ASIPP) work closely with French Framatome and Italian SIMIC, integrate as One Team and win-win based on each other's strengths.



**Sector Module 7 moved to the pit**



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**(continue)**

- **In May 2024, French company named Photonis as a subcontractor for CN PA NFM, working with SWIP (PA main contractor) to manufacture ITER Neutron Flux Monitor fission chamber and cable prototypes.**
- **Explore in-depth collaboration with ISO and AFCEN.**

**In 2024, 16 HJB standards have integrated into the RCC-MRx RPP stage.**

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## ■ A good platform to enhance communication and information exchanges

E.g. Annual meetings for ITER Magnet Conductors are held to share experiences and lessons learned so as to effectively promote the development of superconductors technology in the related parties.

## ■ Boost further recognition in relevant fields through taking some tasks of ITER Project

E.g.

WST

HTXL

Jiuli

CNPE

RXHK

.....

ASIPP

SWIP

# Neutron Flux Monitor (NFM)

## PA Scope

- 18 Fission chamber (FC) detectors, including 9 FCs, 4 dummy FCs and 5 spares, moderators, cables and connectors,
- electrical and gas feedthrough (PIC),
- electronics and I&C system

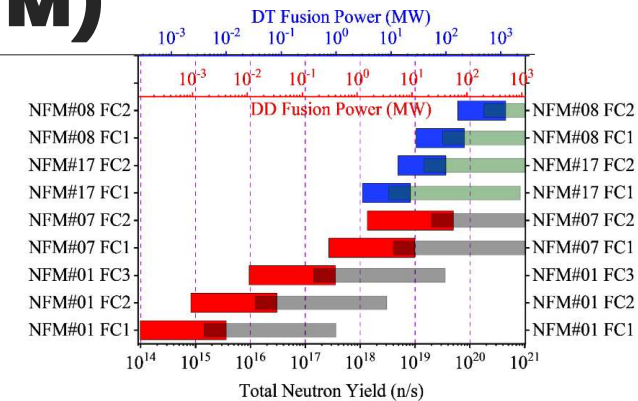
NFMs are located at 4 locations in ITER Equatorial Ports #1, #7, #8 & #17 to cover the whole toroidal view.

## Current status

- The support structure of NFM#07: completion of delivery and assembly
- Remaining components: in final design phase

## Challenges & Opportunities

- Limited space for integration. E.g. NFM#01 FC cable connector integration with the electrical feedthrough in Equatorial port #1
- High Radiation requirement. E.g. the Radiation Shielding of electronic components
- Tight schedule

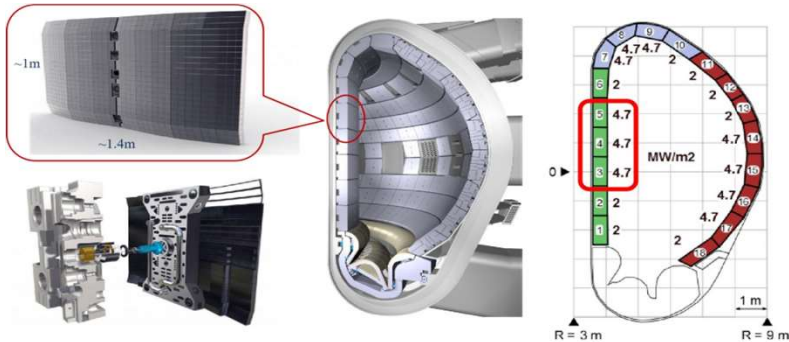


## NFM measurement range



## Installation of support structure of NFM#07

# First Wall



## PA scope

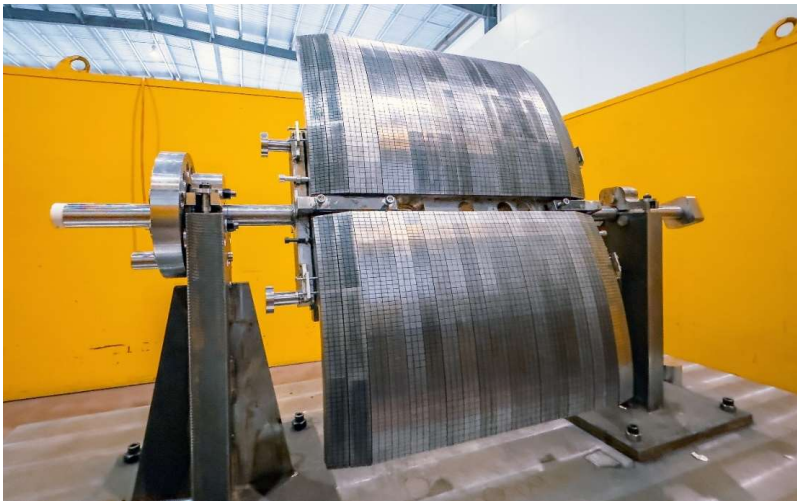
- 54 enhanced heat flux (EHF) first wall (FW) products on Row 3, 4&5 in ITER Blanket system;
- 6 spares FW products;
- 9 kinds of standard parts with total quantity of ~9000.

## Current status

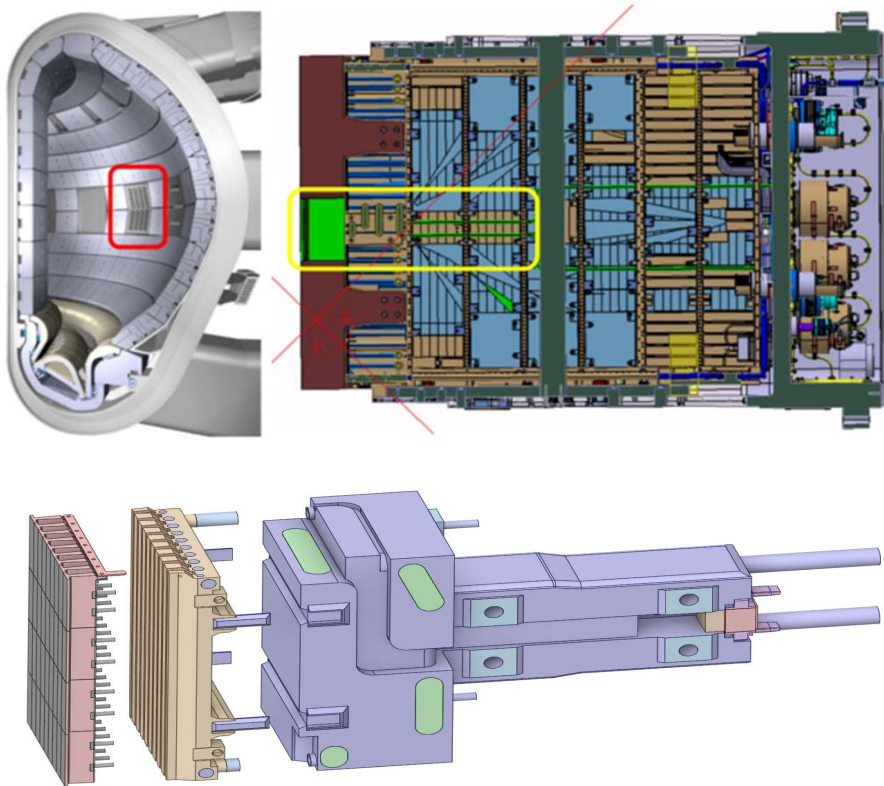
- Completed the process qualification work with a beryllium-armoured FW prototype
- R&D work of tungsten-armoured FW mock-ups and a prototype;
- Series procurement of tungsten FW products.

## Challenges & Opportunities

- Very strict tolerance control is required on outline of armour surface;
- Welds are many (393) and the deformation is hard to control;
- Series manufacture schedule is tight.



# GDC



**GDC Permanent Electrode**

## PA scope

7 sets of glow discharge cleaning (GDC) system, including:

- I&C units;
- Power supply units;
- Electrodes.

## Current status

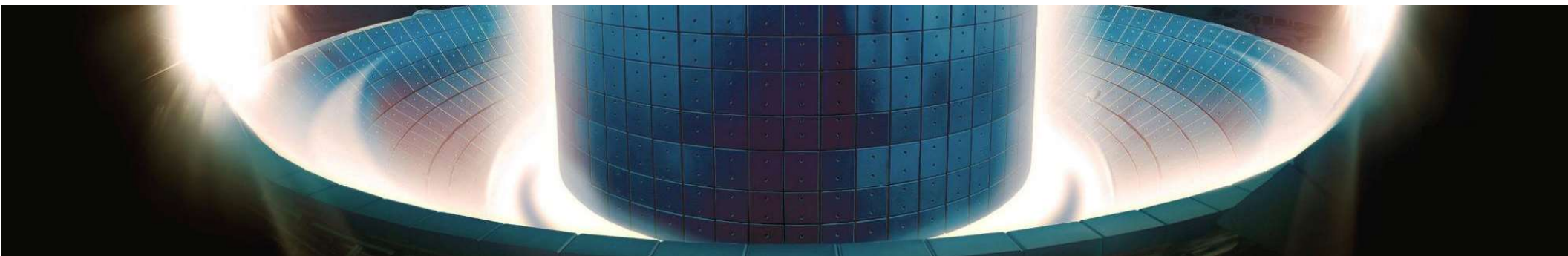
- the final design of the I&C and power supply units to be completed in this August;
- manufacturing a dummy electrode for a trial fit with diagnostics in Eq12 port to be completed in this June.

## Challenges and opportunities

- Design optimization and verification, mainly on the feasibility and reliability of the ceramic insulation layer.
- GDC system will provide boronization function in ITER machine, which is the first time to deposit a homogenous boron-based coating on such a large tokomak.



# 4. Summary



- The Chinese government attaches great importance to fusion energy and ITER Project.
- A series of breakthroughs have been achieved in the Fusion area.
- We would like to further enhance our collaborations and public-private partnerships.
  - As a Chinese saying goes, “Dreams and wishes may be far, but they can be fulfilled with dedicated pursuit and joint efforts.”
  - **We welcome cooperation with everyone here to jointly realize our common dream!**



# THANKS

TO BE PART OF THE WORLDWIDE **FUSION** NETWORK





# **FUSION FOR ENERGY (F4E) EU-DA FOR ITER**

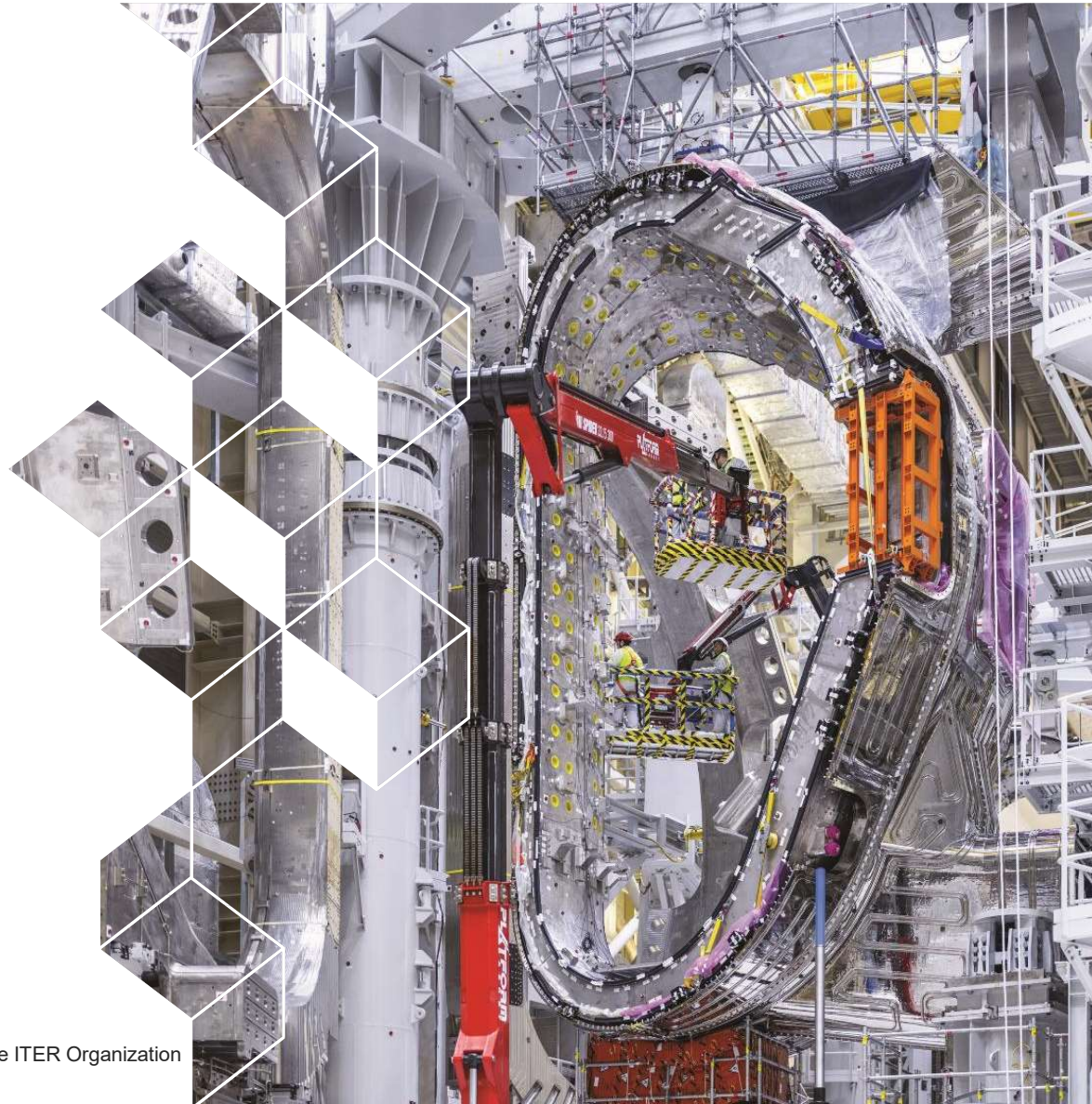


**FUSION  
FOR  
ENERGY**

**Marc Lachaise  
Director**

**Thursday 24th April 2025**

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# Agenda

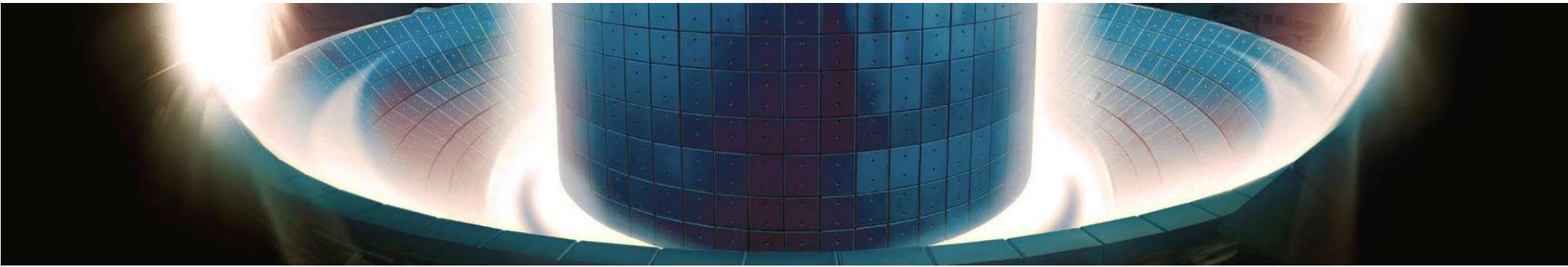
- 1. F4E Vision & Mission**
- 2. Achievements**
- 3. Fusion Supply Chain**
- 4. Business opportunities & challenges**







# **1. Mission and Vision**



- **Mission:**
- **F4E is the European Union's Joint Undertaking for ITER and the development of fusion energy**
  - Headquarters in Barcelona. Offices in Cadarache (ITER site) & Garching (Munich).
  - Staff: ~465 highly competent team of engineers and project managers
  - Budget: €5.6 billion 2021-2027
  - F4E Director: Marc Lachaise
- **It provides the European contribution to ITER as its European “Domestic Agency”, and is involved in other fusion projects**
- **We are multicultural organisation, capitalising on diversity of talent and minds, sensitive to well being and sustainability**

# F4E Vision



**F4E Strategic  
Vision:** Looking  
to the future



We develop  
talent and  
knowledge for  
the future fusion  
power plants in  
Europe

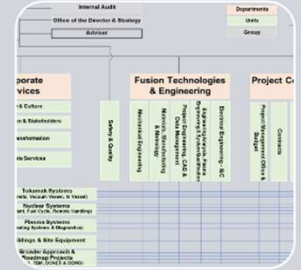
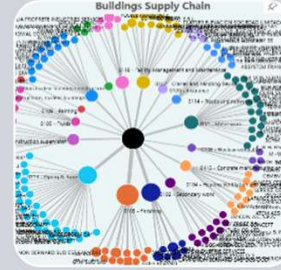
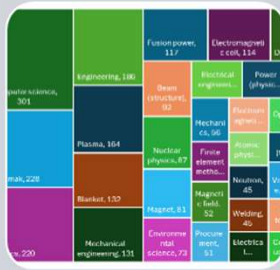


We focus on the  
construction and  
operation of ITER  
and other fusion  
projects



We help create  
a competitive  
European Fusion  
Industry

# F4E – An Innovation Hub for Design, Engineering & Project Management



**Project  
Delivery  
Capacity**

**Broad Range  
of Fusion &  
Project  
Management  
Competences**

**Dedicated,  
Competent &  
Diverse  
Workforce  
(~465 staff)**

**EU Centre of  
Excellence for  
First of a Kind  
Procurement  
(>€7 billion  
since 2008)**

**Extensive  
Knowledge of  
the EU Fusion  
Supply Chain**

**Organisation  
Restructured  
for the Future**



# **2.** Achievements



# Main technical achievements since IBF/19

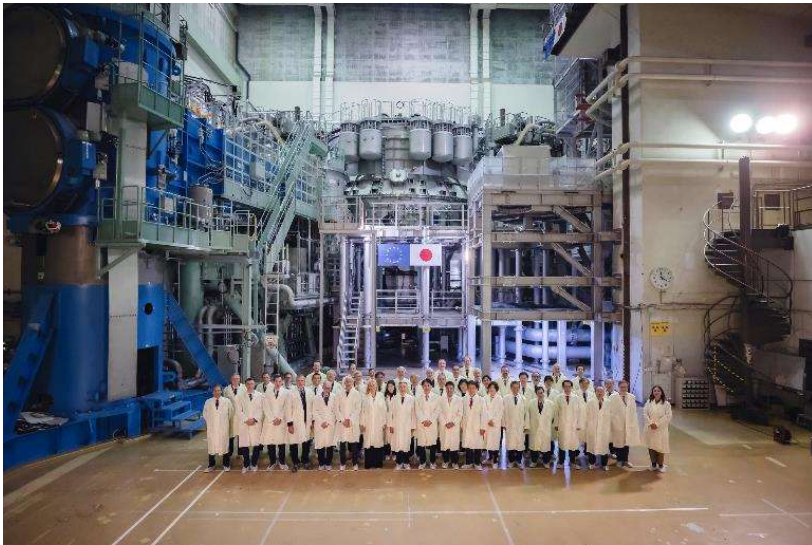


**2023 – Engineering works for the Tokamak Complex completed**



**2023 – Europe's final TF coil delivered on-site**

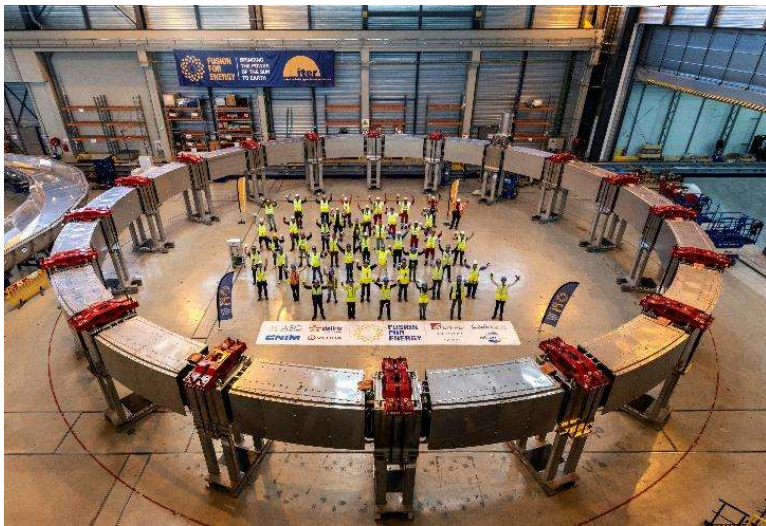
# Main technical achievements since IBF/19



**2023 – First operations at JT-60SA,  
the world's largest tokamak**



# Main technical achievements since IBF/19



**2024 – Final and largest  
Poloidal Field coil completed**



**2024 – First European Vacuum  
Vessel sector ready for ITER**

# Main technical achievements since IBF/19



**2024 – MITICA beam line components delivered**



**2024 – Auxiliary buildings handed over: Radio Frequency Building, Cryoplant**



# Main technical achievements since IBF/19



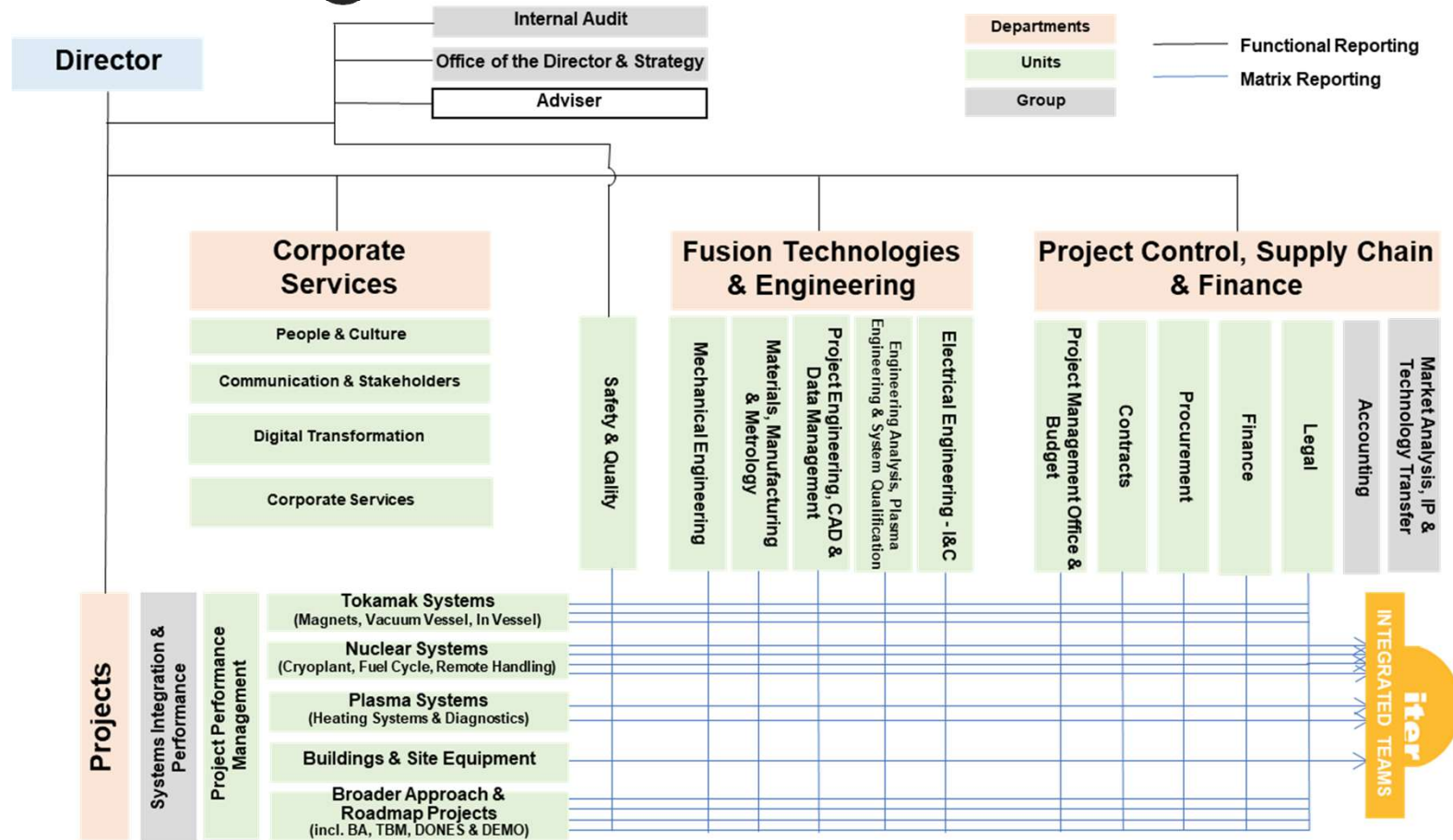
**2025 – Second European Vacuum Vessel sector completed**



**2025 – Europe delivers all eight torus and cryostat cryopumps**



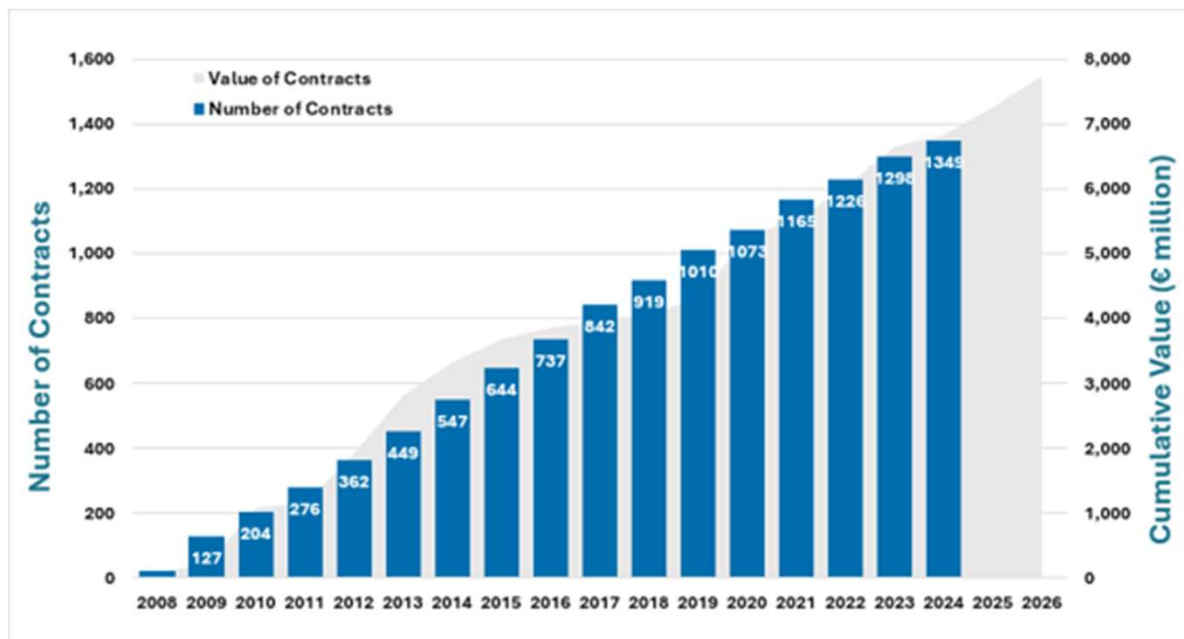
# Our New Organisation





# 3 ■ Fusion Supply Chain

# More than €7 billion awarded to Europe's supply chain



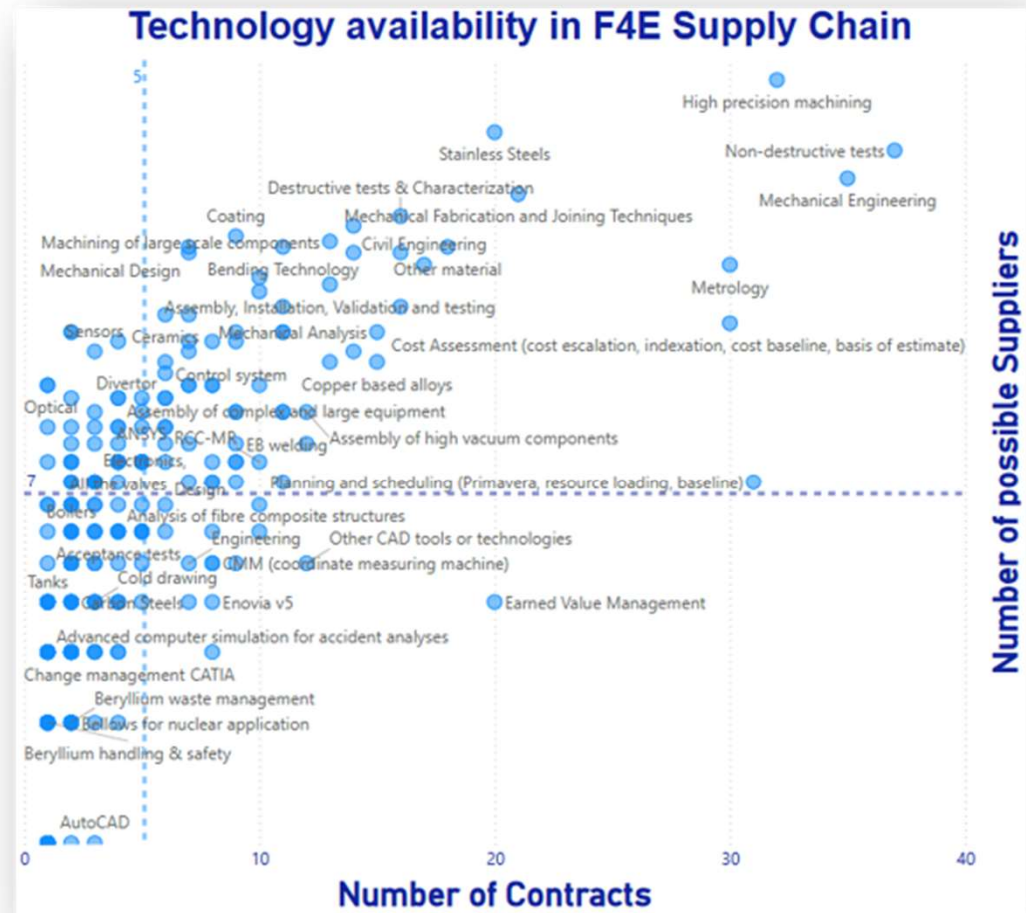
- >1200 contracts
- >700 industries
- >2100 subcontractors
- >75 Research organizations

# Building a unique knowledge base



# Improving Europe's resilience

**Pro-active identification of critical technologies to improve industrial readiness**





# Empowering & Supporting companies

## F4E Industry Portal Partnership tool

- Facilitating Partnerships
- Offering visibility to SMEs

**Fusion for Energy**  
Industry and Fusion Laboratories Portal

HOME

Opportunities

- F4E Calls +2
- Fusion Partnerships +1**
- Market Surveys +1
- Information Days +1
- Other Opportunities +4
- ITER Org. Calls +5

**Technology Partnerships**  
Need a Partner? - Connect with potential industrial partners

**Registration Form**  
Receive information for upcoming opportunities

**Industry Portal at a Glance**  
The Industry and Fusion Laboratories Portal is your point of entry for F4E and ITER business opportunities, as well as other initiatives around Fusion.

**Latest Published News**

Show 10 entries

Reference / News title	Categories
ARTIFICIAL INTELLIGENCE Technology Mapping Workshop - 8 April (online) - 26/27 May (Barcelona)	Other Opportunities
DIAGNOSTICS - Market Survey on Test Rig Facilities for calibration of ITER Pressure Gauges - DEADLINE 17 April 2025 EOB	Market Surveys
ITER BUSINESS FORUM April 23-25, Marseille - Join IBF/25 and connect with key fusion industry players!	Other Opportunities
TBM: Market Survey on TBM Ancillary systems #3 - Lead Lithium loop (LLP) - DEADLINE 21 March 2025 EOB	Market Surveys
BUILDINGS: Procurement Strategy Update (2)	Updates on F4E Calls
PARTNERSHIP Opportunities - Tungsten Carbide, Vacuum chambers, I&C Electrical works, AI/Machine Learning in fusion	Fusion Partnerships
NEW PARTNERSHIP Opportunity 1 - FFinn offers to support for Tender Success	Fusion Partnerships

## EU Fusion Technology Marketplace

- Supporting Business Development of our Suppliers

EUROfusion FUSION FOR ENERGY

WHO WE ARE | OUR TECHNOLOGY PORTFOLIO | SUCCESS STORIES | NEWS

Unleash your business potential with fusion technologies

**European Fusion Technology Marketplace**

Our aim is to promote the technologies developed by Fusion for Energy (F4E) and the European Fusion Laboratories (EUROfusion) by making them widely available and commercially viable to industry.

OUR TECHNOLOGY PORTFOLIO

EUROfusion FUSION FOR ENERGY

## Diapositive 46

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- A(0**      [ @Perier Benjamin (F4E)] do you think it makes sense to insert something along the lines- your portal F4E to business opportunities? Just suggesting this as an additional bullet point  
Apollonatos Aris (F4E); 2025-04-08T15:18:12.619
- P(0 0**    if I was to do the prez I would insert it, but probably the Director will go quickly on this one and focus on the targeted features (and we will have other opportunities during IBF to remind on this) so I would not bother  
Perier Benjamin (F4E); 2025-04-08T15:29:34.406

# Empowering & Supporting companies



**Identifying gaps and priorities  
in fusion technologies**



**Dialogue with private  
fusion initiatives**

# Empowering & Supporting companies



**EU Blueprint  
for Fusion  
2024**



**Big Science  
Business  
Forum 2024**



**F4E SME  
Day 2024**



**F4E Legal  
Roundtable  
2024**



# **4. Business opportunities**



# Some upcoming opportunities

## ■ CRYO & FUEL CYCLE

- Isotope Separation System (1st phase Engineering Support)
- Leak Detection System
- REMS (Radiological and Environmental Monitoring System)

## ■ DIAGNOSTICS

- Ports Manufacturing & Assembly

## ■ HEATING & CURRENT DRIVE

- Passive Magnetic Shielding & Active Correction Coils

## ■ IN-VESSEL

- High Heat Flux testing

## ■ TEST BLANKET MODULES

- Final Design and Supply of 3 major Ancillary Systems

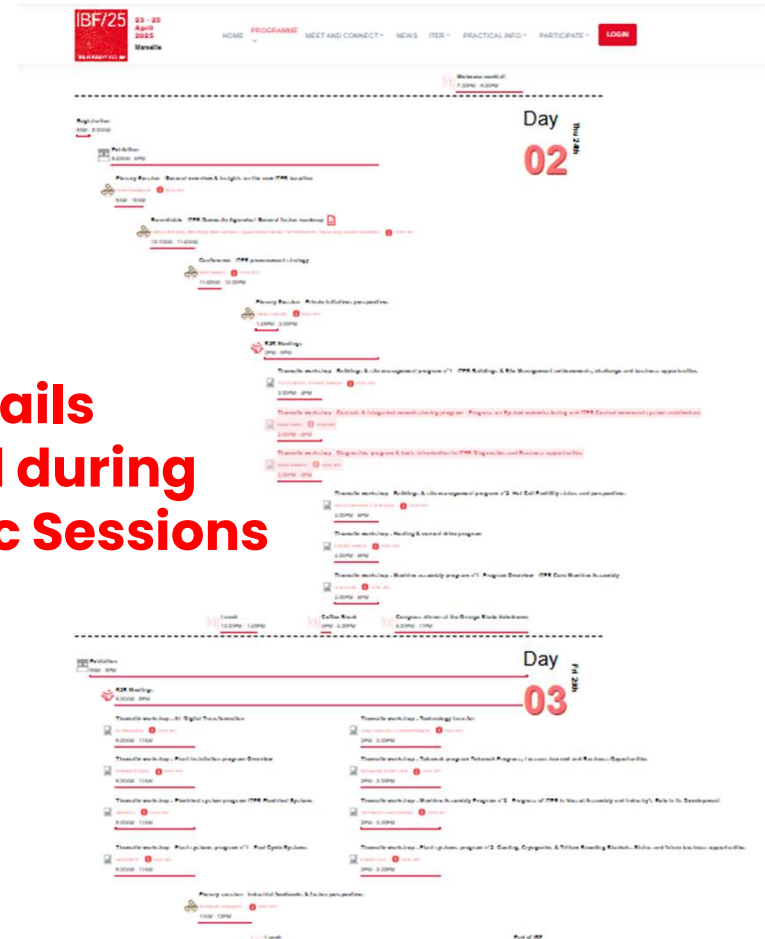
## ■ TECHNICAL SUPPORT

- I&C Integration Services

## ■ TECHNOLOGY DEVELOPMENT PROGRAM

- TDP25 Calls for Proposals (TBD)

**More details  
provided during  
Thematic Sessions**



# Looking ahead

- Maintain momentum for delivery of key ITER components (F4E priority)
- Aim highest level of Health & Safety and Nuclear Safety
- Reinforce integration with the IO to keep improving efficiency
- Consolidate our Supply Chain and implement our Industrial Policy
- Continue to leverage F4E's experience for benefit of start-ups
- Advance Technology Development Programme incl. Mapping Workshops



# THANKS

TO BE PART OF THE WORLDWIDE **FUSION** NETWORK





## DA Roundtable Indian Domestic Agency

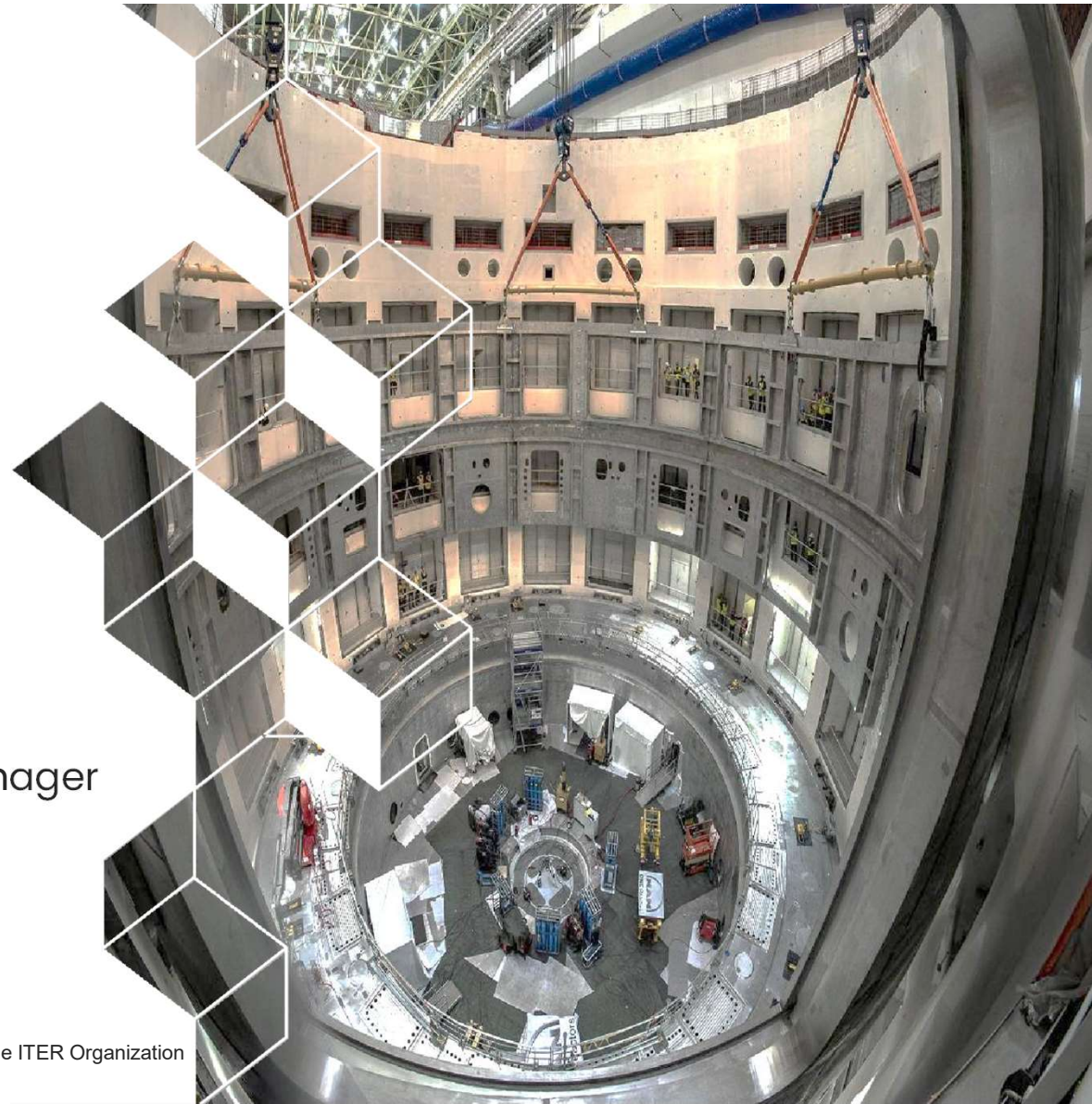


**ITER-India**

Narinderpal SINGH

ITER-INDIA, Senior Project Manager

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## IBF25 ITER-India:

- An overview of DA activities

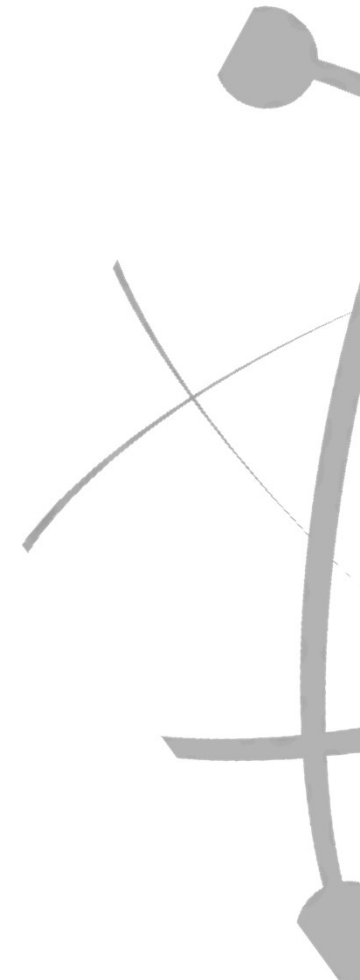
- Past successes/achievements

- Major upcoming procurements & opportunities



# Indian In-Kind Contributions

- 1. Cryostat & TCPH**
- 2. In-wall Shielding**
- 3. Cooling Water System**
- 4. Cryogenic System (Cryo line and Cryo distribution)**
- 5. Ion-Cyclotron RF Heating System**
- 6. Electron Cyclotron RF Heating System**
- 7. Diagnostic Neutral Beam System**
- 8. Power Supplies**
- 9. Four important ITER Diagnostics systems & 1 Port**



# Cryostat & TCPH

## CRYOSTAT

- Gigantic outer vacuum shell 30m D x 30H, weighing ~ 4Kilo Tonnes, SS 304/304L and thickness varies from 25 to 200 mm
- Manufactured at Larsen and Toubro, Hazira, Gujarat,
- Key technologies developed in the areas of heavy & precision engineering, welding, assembly & installation



- Section assembly: 2016-2022,
- Number of segments fabricated : 54
- Length of weld joints for in-workshop assembly (four sections): ~ 1,015 m
- Length of weld lines (passages): 50 km. Welding wire: 1,500 km (17 tonnes) Length of weld joints for in-pit assembly: ~ 390 m

## Torus Cryopump Housings TCPH

- Located on the Cryostat cylinder with main functions to accommodate and support the Torus Cryo-Pump, connect it to the Vacuum Vessel & is part of Nuclear confinement boundary. Each package weighs ~20 tons, dimensions 4.3 m L X 3.2 m W X 3.75 m H It is shell in shell structure with interconnecting ribs.
- ITER-India has successfully supplied six TCPH to ITER. SAT Completed.
- Manufactured at M/s Vacuum Techniques Pvt Ltd.
- Key technologies developed in the areas of heavy and precision engineering, complicated welding, assembly & installation



Receipt Inspection at site workshop (2025)



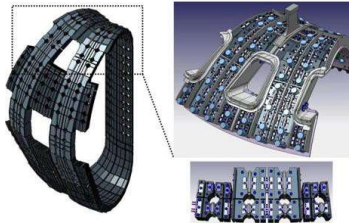
Tested at Site for the global Helium Leak requirement of 10e-7 mbar l/s (2025)

# IWS & CWS

## IWS- IN-WALL SHIELDING

- IWS specialized neutron shielding blocks to shield the neutrons
- Completed the procurement of about 9,000 in-wall shielding blocks and accompanying support ribs, brackets and fasteners are manufactured from special grade steel.
- These blocks delivered to Europe, Korea & ITER Site.

- Manufactured at Avasarala Technologies Ltd., Bengaluru & L&T Hazira.
- Key technologies demonstrated in the area of precision engineering.



- The design, manufacturing, and assembly were challenging because of the variety of design configurations and the tight tolerance requirements.

## CWS- COMPONENT COOLING WATER SYSTEM / CHILLED WATER SYSTEM / HRS

- A unique cooling water system designed to handle peak loads of 1150 MW. It has interfaces with most Tokamak sub-systems.
- Major items include types of Chillers (4MW), Heat Exchangers (upto 70MW), Cooling towers (~520MW), Water polishing units, Pressurizers, Pump sets, Piping, Valves and strainers / filters, Instrumentation, Electrical items and insulation. Equipment / components are being sourced through Larsen & Toubro, Chennai with several other Indian industries (Kirloskar, Paharpur, Ratnamani, GIPL etc).
- Demonstration of challenging operating parameters and interface handling with various Tokamak clients.



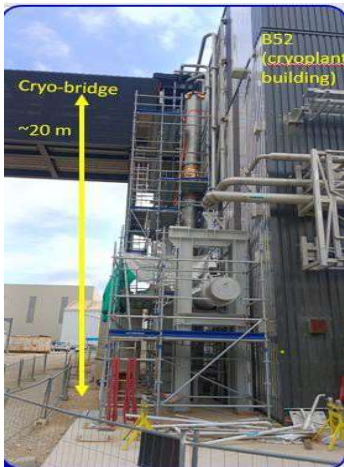
CWS:- CT operation since 2024



# Cryogenic System

## CRYOLINE

- A unique cooling system for the ITER magnets Cryoline being built for the first time with large mass flow rates) [up-scaling of technology & availability of test facility]; vacuum jacketed cryolines (diameter up to 1 meter, length ~5 km) and warmlines (size up to 0.6 meter, length ~ 5 km)



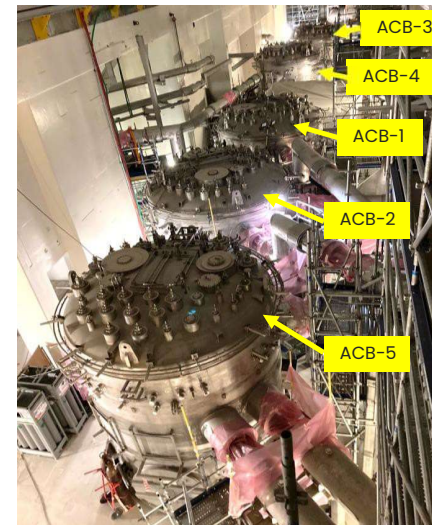
Installation of Seismic decoupling spool



All deliveries of Cryolines and Warmlines have been completed (2022), installation and acceptance testing in cryoplant building completed. The global progress of Y+W lines is around 90.9%.

## CRYODISTRIBUTIONSYSTEM

- Cryo-Distribution (CD) system distributes liquid Helium at 4K at required flow rate to the superconducting magnets and cryopumps via five ACBs (Auxiliary Cold Boxes, Cold circulator), one CTCB, and one Thermal-shield Cold Valve Box



All ACBs have been successfully positioned at ITER site (2025).



FAT of TCVB (2025)

Components developed with industries like INOX India Ltd., Air Liquide France, Linde Kryotechnik Switzerland, IHI Corp. Japan.



# RF System

## ION CYCLOTRON RF HEATING

- An external heating system for the ITER Plasma, Heating power of about 20 MW, 8 sources; about 2.5-3MW/source made using amplifier chains, Power Supplies Frequency range: 35-65 MHz



1.5 MW Diacode based system



3MW MMTL

- ITER-India has completed R&D phase (Phase 1) in 2019 & Demonstrated in a single chain - 1.5 MW / 2000s / 35- 65 MHz at VSWR 2.0 with any phase angle of reflection. Diacode and Tetrode.
- Additional Indigenous Developments- Completed testing of, 12-inch 3 MW Mismatch Transmission line [MMTL] system for mismatch testing of 3MW RF source, 3MW Combiner, Tx line components

## ELECTRON CYCLOTRON RF HEATING

- An external heating system for the ITER Plasma High power Gyrotron (1 MW, 170 GHz) tubes and Auxiliary systems



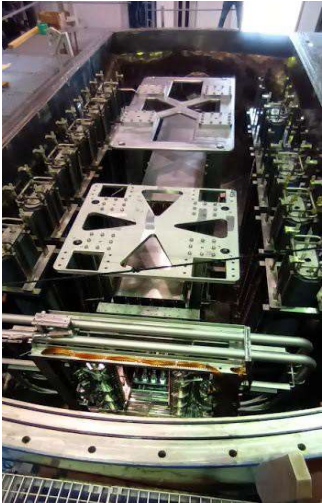
- Successfully demonstrated ITER relevant parameters of 1MW RF Power at 170 GHz for 1000s at ITER-India Gyrotron Test Facility in 2024
- Further up-gradations and system improvements are ongoing to enhance the overall system performance and reliability

# Diagnostic Neutral Beam

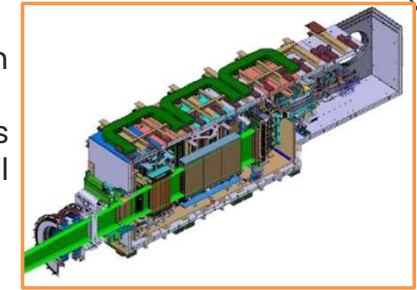
## DIAGNOSTIC NEUTRAL BEAM INJECTOR

- Required for measurement of Helium ash in ITER through Charge exchange and Beam emission spectroscopy. Involves Intense physics R&D.
- Development of components in collaboration with various domestic and international industries like Vacuum Techniques, Hind High Vacuum, BHEL (Bengaluru), NFTDC (Hyderabad), Veeral Electronics (Gandhinagar), PVA Tepla (Germany), Siemens, National Instruments etc.

### DNB BL components



### 2nd calorimeter in INTF lab



### DNB Beam Source



Assembled 3 grid accelerator

- Successfully completed the Integrated Testing of DNB-Beam Line Components, at Indian Test Facility (INTF).

- Promoting the development / application of Electron-beam welding, High Precision Manufacturing, Material Development, meter size ceramics for insulation.



# Power Supplies

**Power Supply (PS)** systems of ITER, where loads are radio frequency (RF) generators or neutral beam (DNB) injectors. In particular, the DC High Voltage PS systems will be connected to:

- **the anodes and driver stages of the IC tetrodes:** ICHVPS 27/18kV (Dual Output), 3MW –Final Design Review of ICRF power supply is completed
- **the cathodes, anodes and bodies of the EC gyrotrons:** EC MHVPS 55kV, 5.5MW– Final Design Review of ECRF power supply is completed
- **the acceleration grids and auxiliaries of DNB injectors:** DNBPS including AGPS 100kV, 7.2MW, ISEPS 5MW, GRPS 4MW
- Several Indian Industries are manufacturing power supply components for ITER through Electronics Corporation of India Ltd. (ECIL)



The commissioned 6 MW MHVPS for MW gyrotron cathode circuit at ITER India.



25kV, 100mA Body power supply developed for Gyrotron using a new control topology



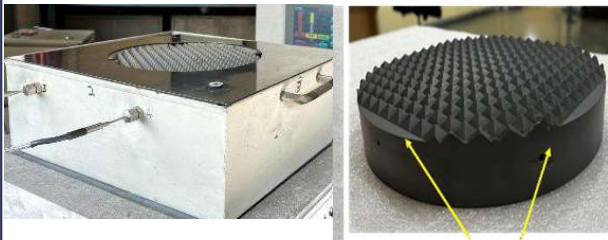
Accelerator power supplies 7.2MW, 100kV HVPS operational at SPIDER facility, RFX, ITALY  
100kV Power supply at SPIDER is operational since 2018

# Diagnostics

Major Deliverables: 4 Diagnostic systems & 1 Port

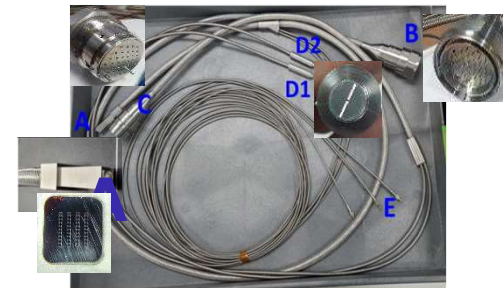
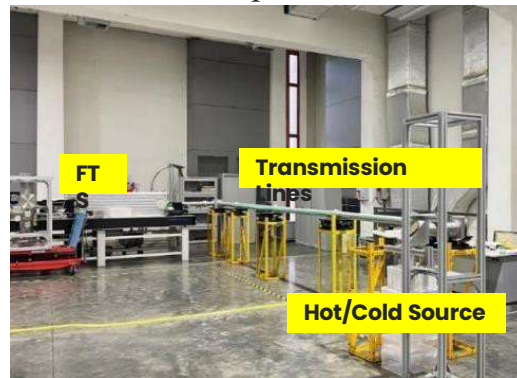
- **XRCS (Edge):** Prototype development of a large area hybrid pixel detector set up has been completed and tested for its performance.
- **XRCS (Survey):** Front-end sight-tube delivered.
- **ECE:** PDR of ECE Ex-vessel TL& Receivers completed
- **CXRS:** Manufacturing ongoing of Prototype Misalignment Compensator (MAC), Experiments with different shielding materials have been conducted in order to shield the motors from magnetic Field, Shielding has been achieved up to ~75% at high magnetic field ~ 200mT .
- **Upper Port- 09 (UP#09) :** Complex integration with Interspace Support Structure (ISS) & Port Cell Support Structure (PCSS) etc., and customization for XRCS(edge) (Boron Carbide shielding)

**ECE-** Testing of ECE Prototype Hot Calibration Source developed & transmission line attenuation measurements.



In house Hot Calibration source

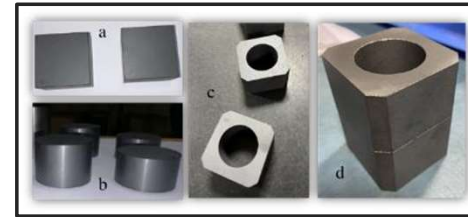
FTS, Transmission line and source test set up



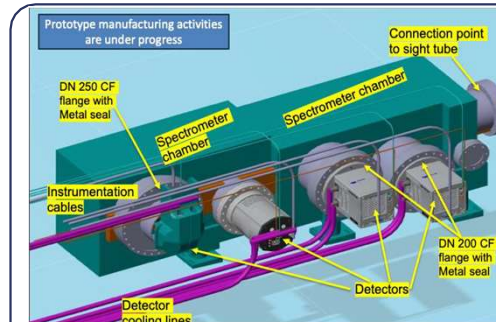
40 channel Prototype fiber bundle



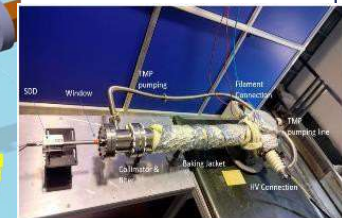
Magnetic field compatible motor ( 0.3T)



In house ITER qualified B4C blocks



In house X-ray source



**XRCS Spectrometry:** To detect and measure impurities in plasma, in the energy range 124 eV to 12.4 keV (0.1 – 10 nm wavelength range)

# Forthcoming Procurements

**ICRH:** Phase2- Driver and Final stage High Power RF Amplifiers for 2 sets of ICRF source including auxiliaries , 3 MW Combiner (Hybrid coupler with load), RF Switch & Splitter, Solid state power amplifier , Low power RF component (Phase shifter, Attenuator, RF measuring components & detection module), Set of auxiliary power supplies, Set of RF measurement units, Inter-connecting Transmission line components (Tx-line), directional coupler, Local Control Unit (LCU) etc.

**ECRH:** 1MW Gyrotron - 2 sets including auxiliaries, Ion pumps, MOU including alignment (Manual) system and arc detector for gyrotron window and any other indicator, Data Acquisition & Control with all Interlock and protection system for operation of Gyrotron

**CWS:** Design & Procurement of CCWS-2F (100 MW) and CHWS-H4 (5.6 MW)

## **Power Supply :**

EC MHVPS Rating EC MHVPS 55kV, 5.5MW

IC HVPS Rating ICHVPS 27/18kV (Dual Output), 3MW

Radio frequency power supply 1MHz 200kW

## **Diagnostic**

ECE :- Polarization splitter unit, Waveguides, Transmission Lines and supports, FTS, Radiometer, Stray radiation Protection System, Hot Source

XRCS Survey:- X-Ray calibration sources, CCD & HPC Detectors, vacuum Pumping stations, Fast controller, Crystals

**DNB:** Large diameter metallic seal vacuum valves,

**Other Opportunities:** Site Support & Installation



# Engagement with Indian Industries





# THANKS

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## Recent Progress of JADA Activities

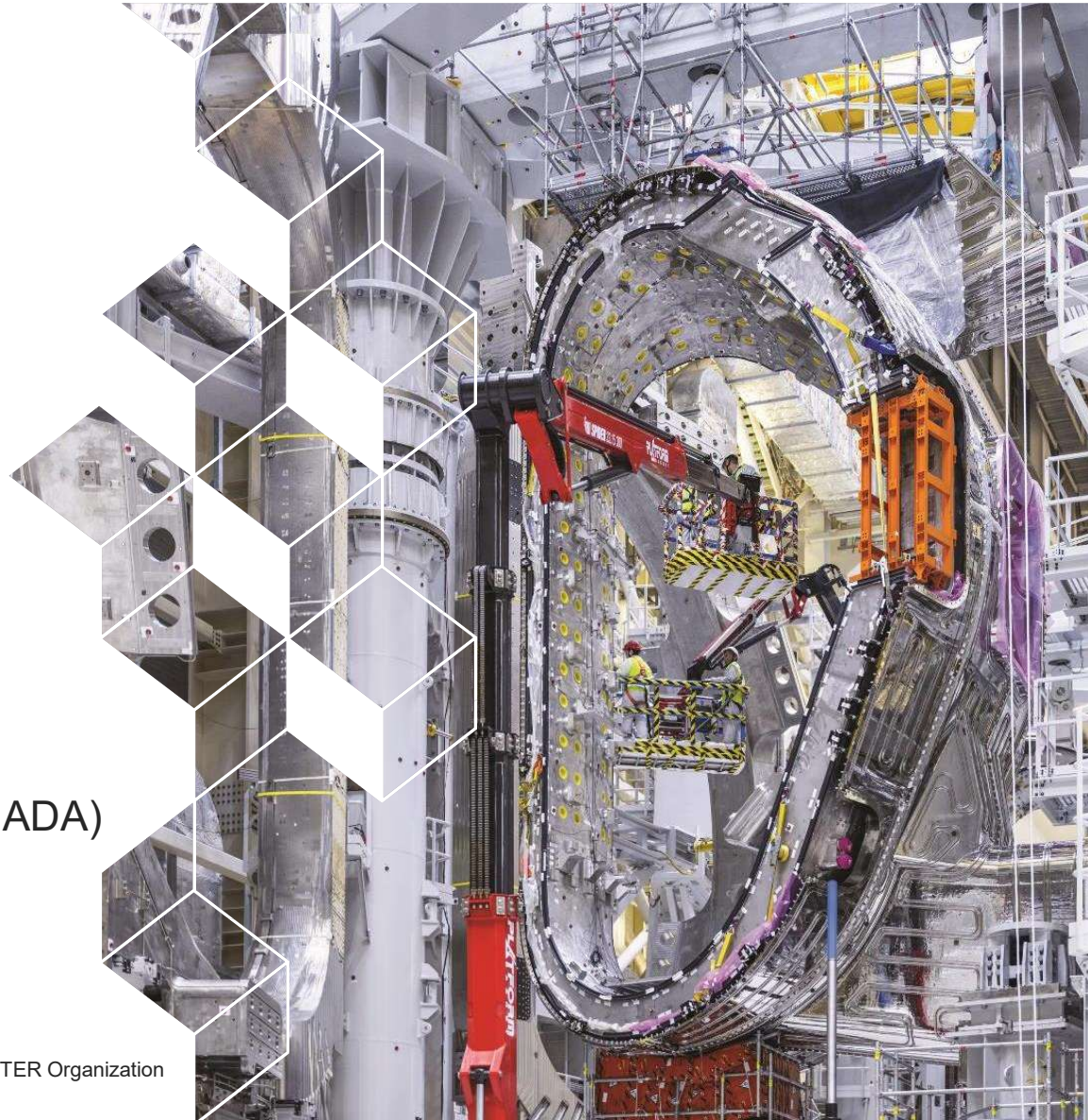


Taro MATSUMOTO

Head of Japan Domestic Agency (JADA)

**THURSDAY APRIL 24<sup>th</sup>**

Disclaimer: the views and opinions expressed herein do not necessarily reflect those of the ITER Organization





# Contents

## 1. Overview of JADA Procurements

## 2. Major Activities

Toroidal Field Coils

Gyrotrons

Full Tungsten Divertor Outer Vertical Target

Blanket Remote Handling System

Plasma Diagnostics System

## 3. Summary

Overall Procurement Schedule

Overall Procurement Progress

JADA-contracted Industries in IBF/25

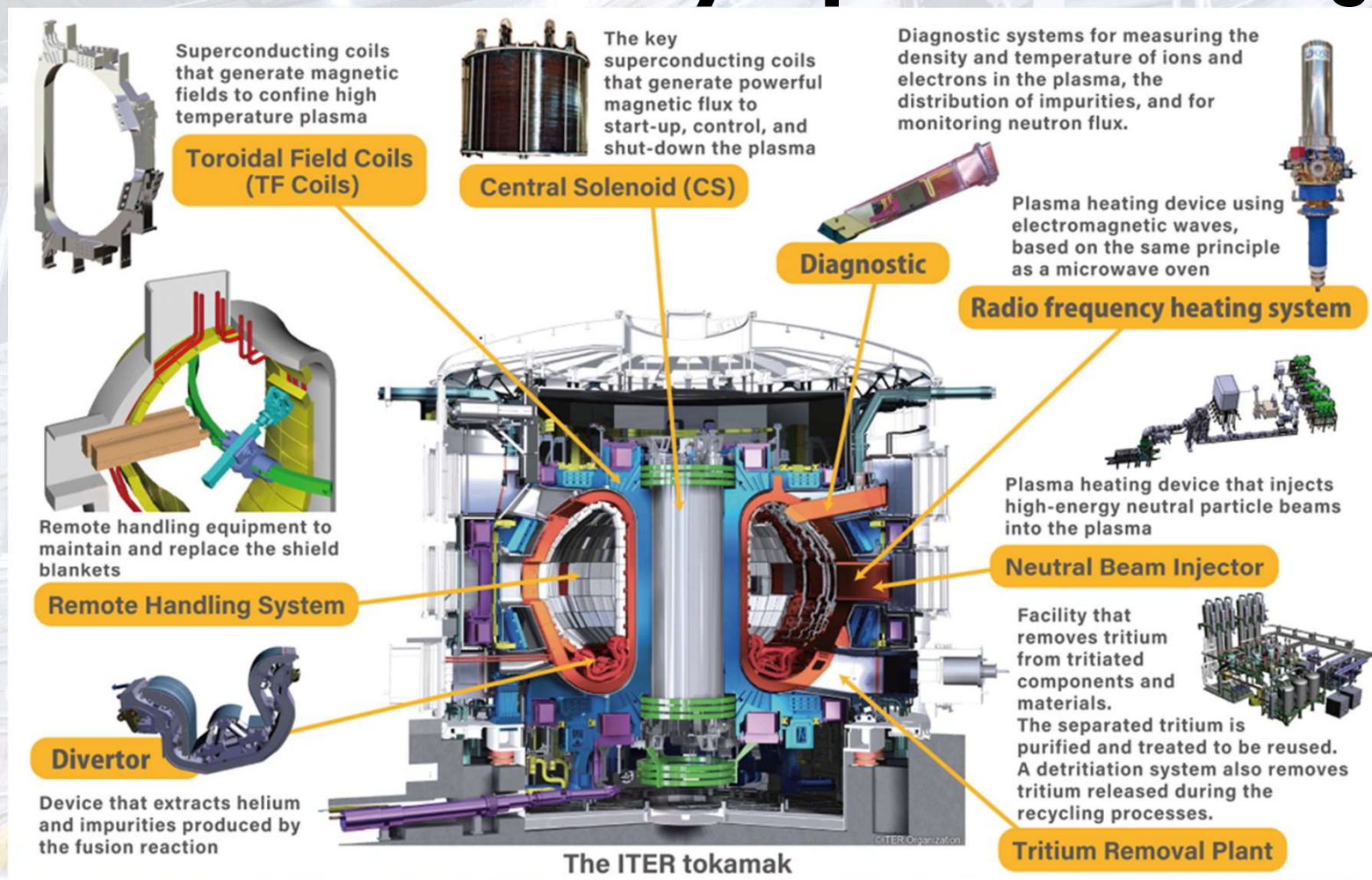




# **1. Overview of JADA Procurement**



# In-kind Procurements by Japan Domestic Agency





# 2. Major Achievements

over the past year



# TF coils: Successfully Completed



All the 9 Japanese TF coils were successfully manufactured and delivered to the IO site by the end of 2023. The ceremony to mark TF coil completion was held on 1 July 2024 at the IO site.



# Gyrotrons: Successfully Delivered

Factory acceptance tests for final 2 sets of gyrotrons were completed.



**B15 L2**

8 sets of APS/BPS were successfully installed in B15 L2.

Assembly and installation of gyrotron support-structures is ongoing in B15 L3.

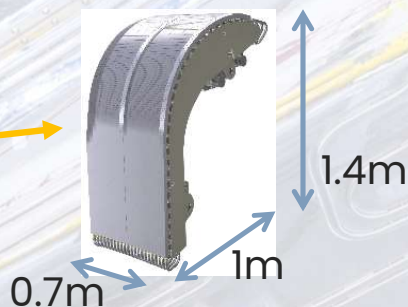
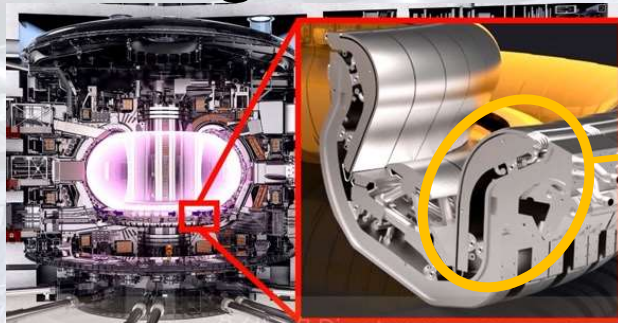


**B15 L3**

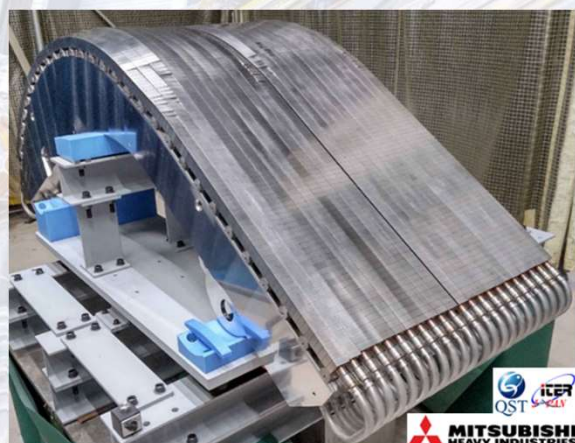
All the 8 Japanese Gyrotrons were successfully manufactured and delivered to the ITER site by 2024. Now the assembly and installation activities are ongoing at the ITER site.



# Full Tungsten Divertor Outer Vertical Target (OVT)



Procurement responsibility is for 54 OVTs and 4 spares, totalling 58 OVTs.



**Completion of OVT prototype**



**Start of Series production of ITER divertor OVT**

ITER divertor OVT prototype was manufactured and qualified.  
Series production of OVT is on-going.



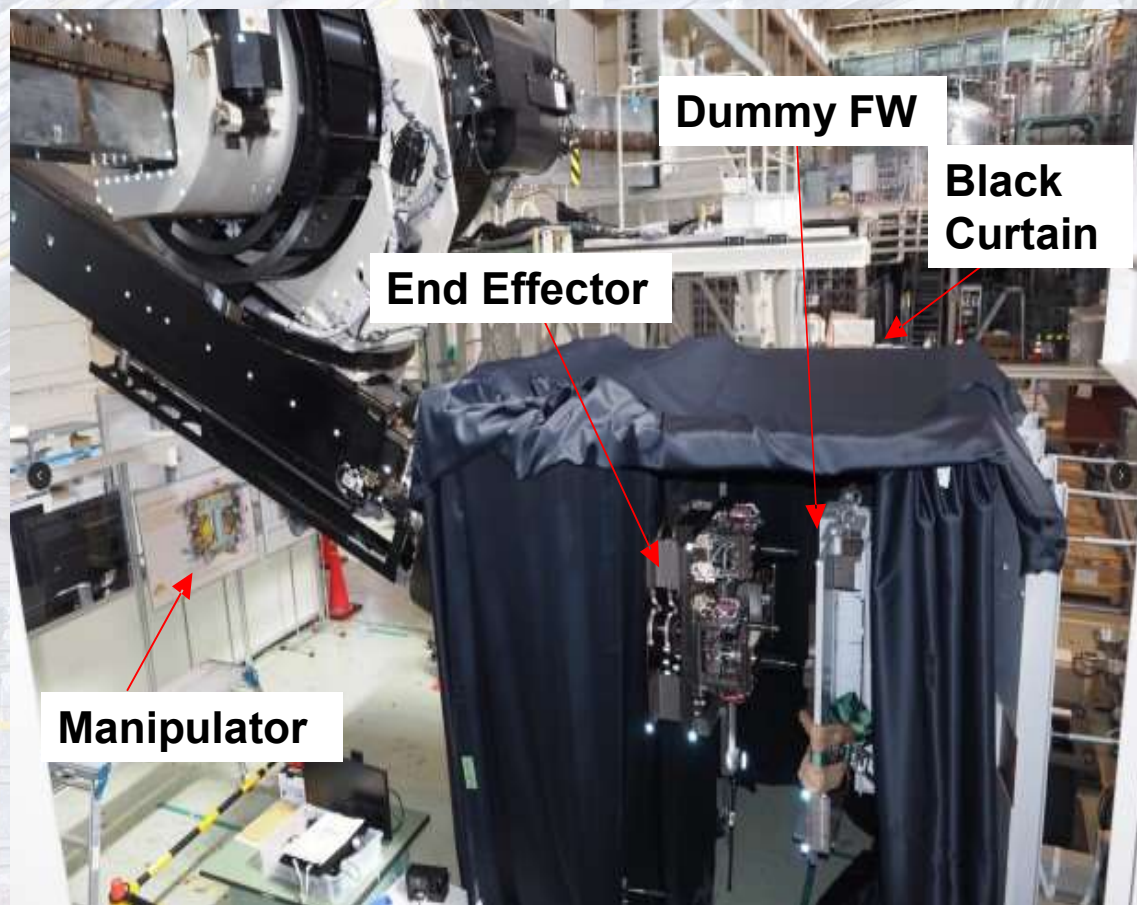


# Blanket Remote Handling System (BRHS)

## First wall handling with “Robot Vision”

First Wall handling tests are on-going using the full-scale prototype of the Vehicle Manipulator.

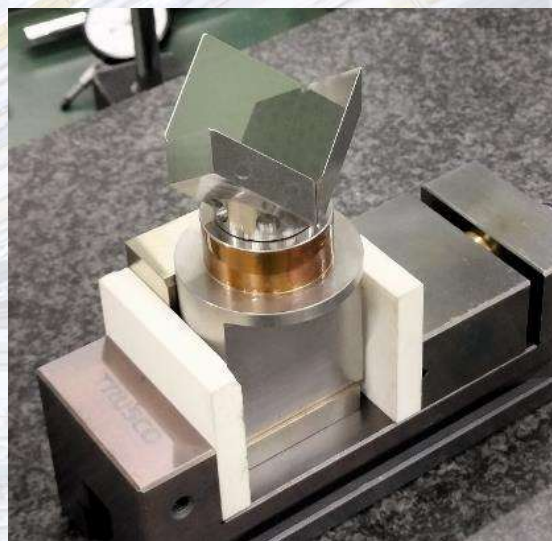
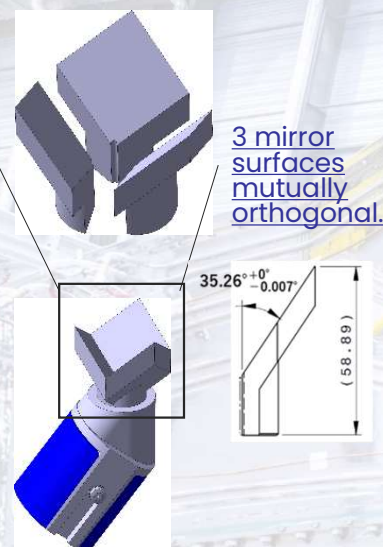
JADA confirmed feasibility of “Robot Vision” technology, which uses pattern recognition of known target image to obtain relative distance between the manipulator and the First Wall, simulating the lighting in the Vacuum Vessel in the black curtain.



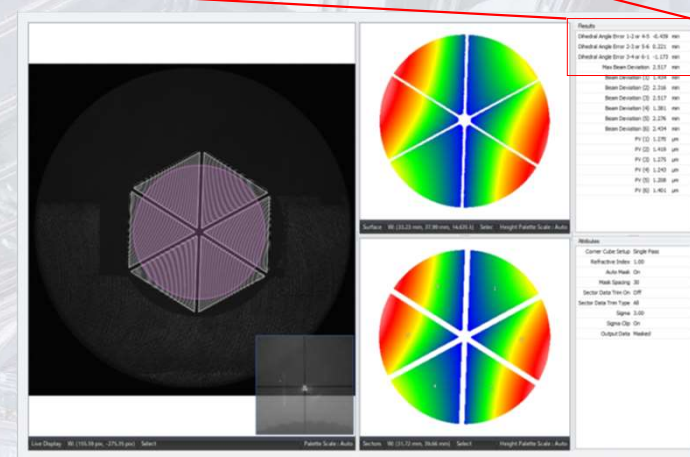


# Plasma Diagnostics System - 1

## Mock-up Manufacturing of retroreflectors on the first wall for Poloidal Polarimeter



Results		
Dihedral Angle Error 1-2 or 4-5	-0.439 min	= -0.0073°
Dihedral Angle Error 2-3 or 5-6	0.221 min	= 0.0037°
Dihedral Angle Error 3-4 or 6-1	-1.173 min	= -0.0196°



Retroreflector made of tungsten Mockup of the retroreflector

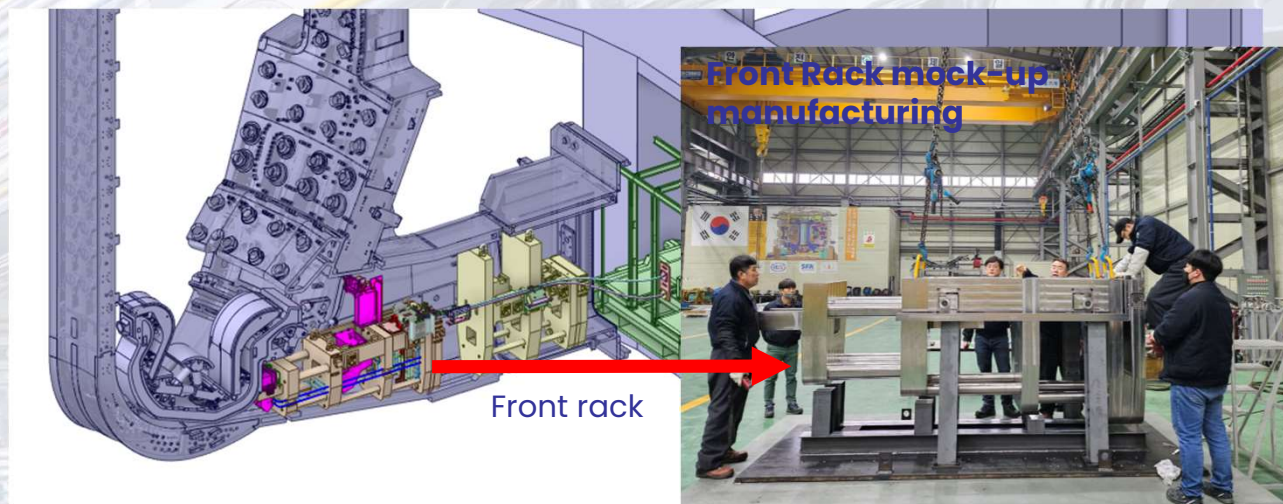
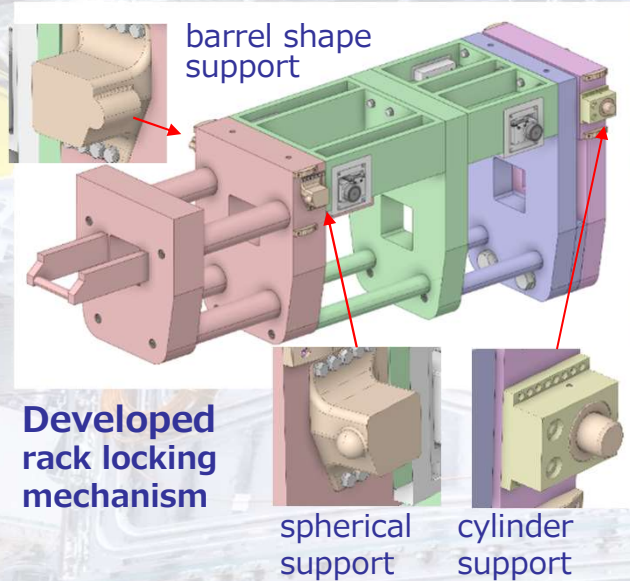
Mirror angle measured by the interferometer

- Factory Qualification Test to demonstrate the manufacturing process of the retroreflector was successfully completed and manufacturing has started.
- The mock-up manufacturing confirmed that the mirror angle deviated from a right angle by -0.0196 to +0.0037 degrees, which satisfied the requirement (-0.090 to +0.049 degrees).



# Plasma Diagnostics System - 2

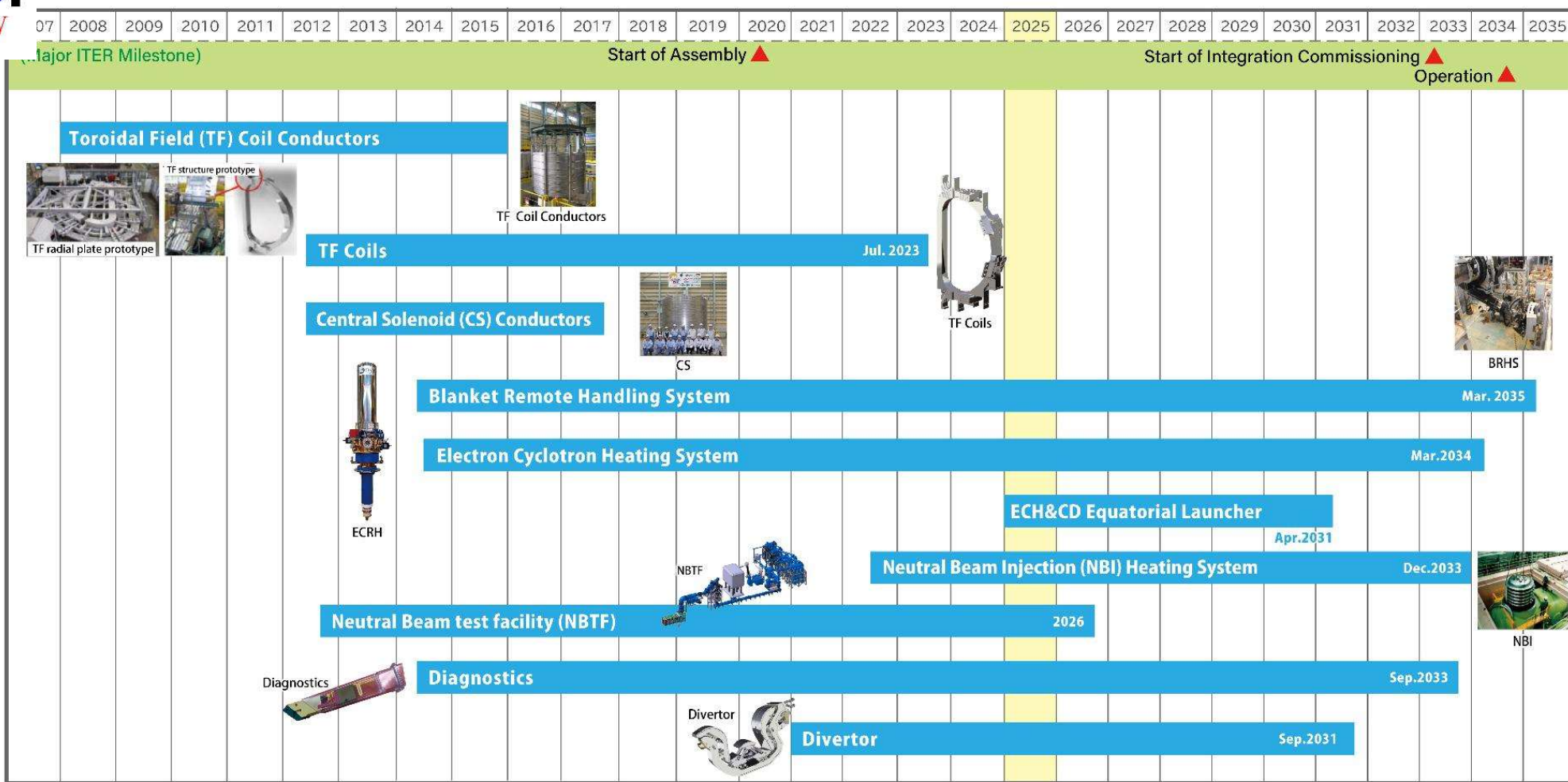
## Mock-up manufacturing of lower port diagnostic rack - Demonstration of the rack locking mechanism -



- JADA and KODA cooperated in the manufacturing of the diagnostic rack mock-up.
- The rack locking mechanism was established based on a Japanese concept.
- The placement repeatability was within 0.5 mm for each front rack installation, satisfying the requirement.
- This mechanism was adopted as the common design for all lower ports.

# 3. Summary

# Overall Procurement Schedule





# Overall Procurement Progress

Components	Final Design	Manufacturing
TF Conductor	Completed	Completed
TF Coil	Completed	Completed
TF Coil Structure	Completed	Completed
CS Conductor	Completed	Completed
NBTF Power Supply	Completed	Completed
NBTF HV Bushing	Completed	Completed
NB Accelerator	80%	
NB Power Supply	89%	1%
NB HV Bushing	73%	
Remote Handling	70%	
ECH Gyrotron	Completed	Completed
ECH Launcher	95%	
Diagnostics System	55%	22%
Tritium Detritiation	55%	
Divertor	Completed	7%

## **JADA-contracted Industries in IBF/25**

**Industries involved in JADA procurements join to IBF/25.**

<b>A.L.M.T. Corp.</b>	<b>(Tungsten Monoblocks for Divertors)</b>
<b>Yamato Gokin Co., Ltd.</b>	<b>(Copper Chromium Alloy for Piping of Divertors)</b>
<b>Tokyo Electronics Co., Ltd</b>	<b>(Auxiliary Power Supply for Gyrotrons)</b>
<b>Sugino Machine</b>	<b>(Blanket Initial Assembly Tools)</b>
<b>Sojitu Machinery Cooperation</b>	<b>(Blanket Initial Assembly Tools)</b>
<b>Arisawa Mfg. Co., Ltd.</b>	<b>(Insulating Material for TF Coils)</b>
<b>Kyocera</b>	<b>(HV Bushing for Neutral Beam Injectors)</b>

**They are waiting for B2B meetings here.**



# THANKS

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# Status Report by Korea Domestic Agency

Kijung JUNG  
Head of KODA

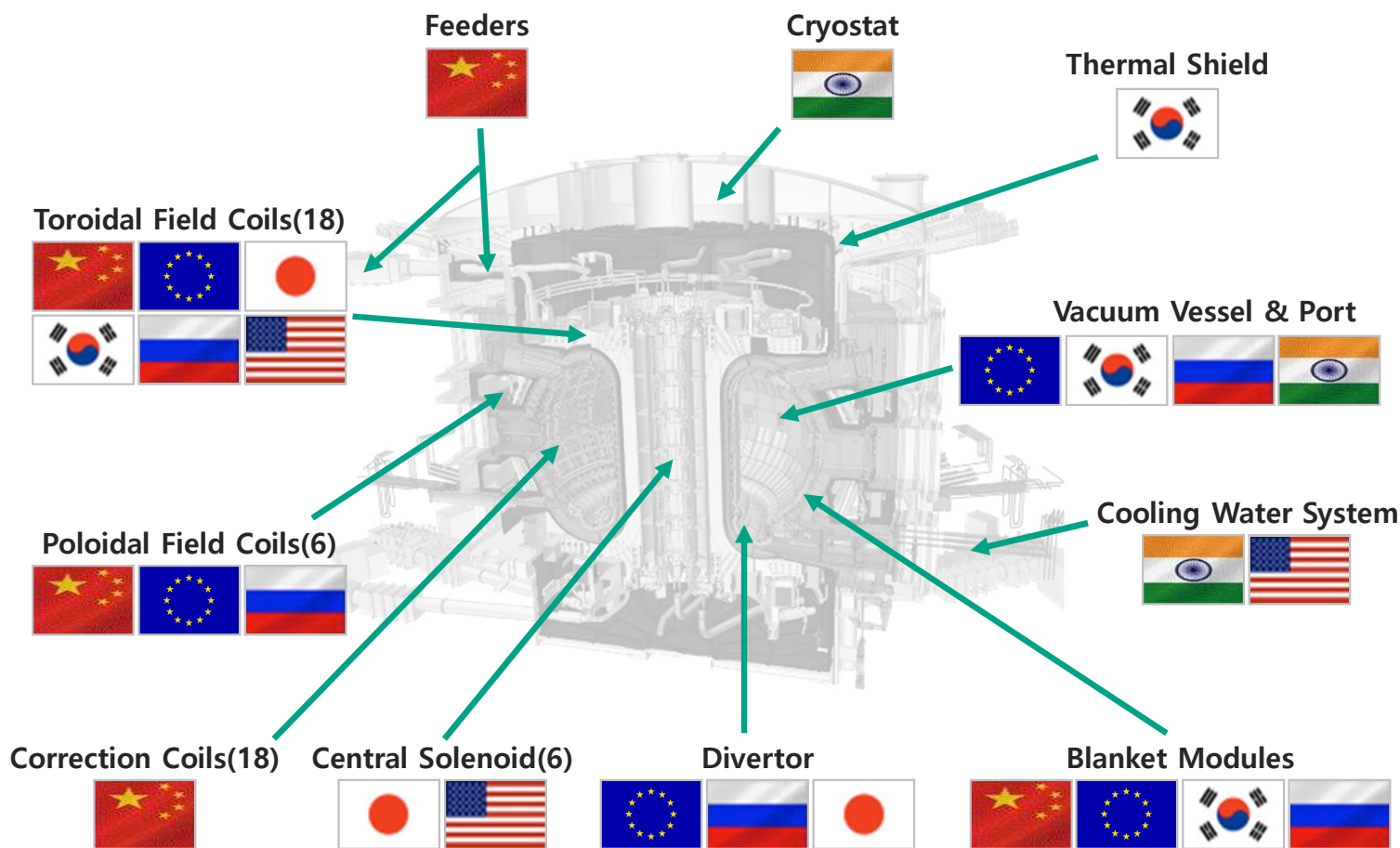
**THURSDAY APRIL 24<sup>th</sup>**

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# Korea's ITER procurement (Total: 9 PP)



## ITER Procurement:

Most contributions will be delivered in the form of completed components, systems or buildings, with little monetary contribution for labor and operational cost.










Contribution: EU 45.46%, Others 9.09%

All ITER members share the resulting intellectual property.

**+ Assembly Tools**  
**AC/DC Converters**  
**Diagnostics**  
**SDS**



## Manufacturing and delivery status of In-Kind Components – Progress (9 Procurement Packages)

TF Conductors	Vacuum Vessel Sector	Vacuum Vessel Ports	Thermal Shield	Blanket Shield Blocks
				
100.0%	100.0% (KO 2) + EU 2ea	86.83%	100.0%	74.38%
Assembly Tools	Tritium SDS	AC/DC Converters	Diagnostics	Average about <b>90.53%</b> (as of Feb 2025)  *Activity Progress as per Item × Weight of its <u>klUA</u>
				
100.0%	44.94%	97.72%	69.85%	



# Supply chain: Emphasizing the importance of maintaining a sustainable supply chain for the fusion

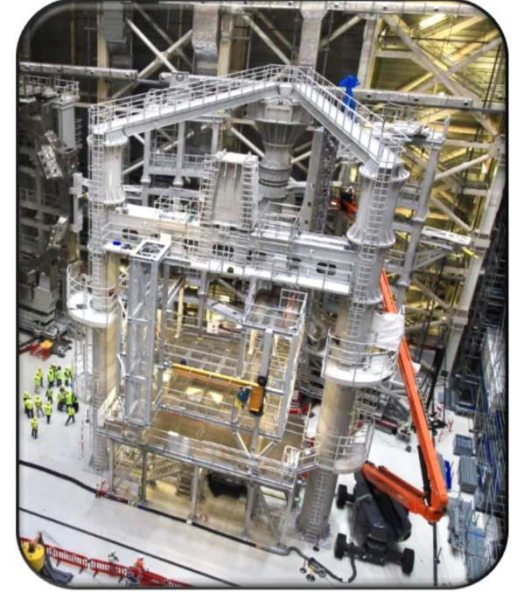
- Korean industries have played a key role in the manufacturing of major components such as:  
TF Conductor, Vacuum vessel, Thermal shields, Assembly tools, AC/DC converters.



Last VV sector delivery ceremony (Nov. 2024)



TF conductor, AC/DC convertor, thermal shield

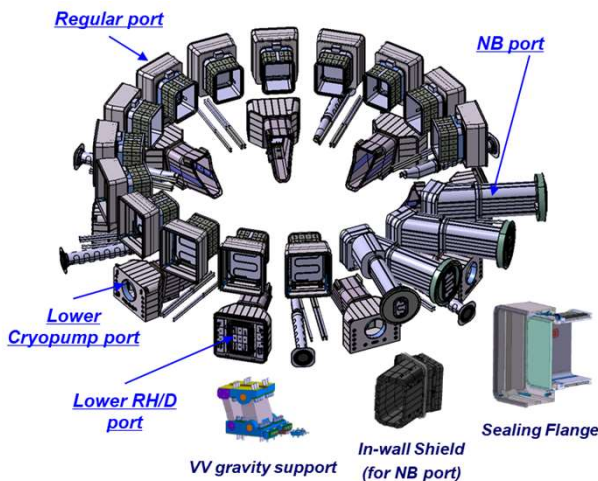


Assembly tools

# On-going Procurements: VV Ports, Shield Blocks

## Vacuum Vessel Ports and Gravity Support:

- Providing ultra-high vacuum environment and supporting structures to VV system as well as part of first confinement barrier
- To be procured **all the Equatorial and Lower ports and VV gravity supports** from KODA
- Completed the manufacturing/test and delivery of **all VVGs and 27/51 units of port structure** up to now



NB Port IWS assembly



Functional test of VVGs

## Shield Blocks:

- Providing nuclear shielding for the vacuum vessel and coil systems as well as support for the first wall panels
- To be procured **220 Shield Blocks** from KODA (50% of the ITER shield blocks)
- Completed the manufacturing and testing of **130 shield blocks** up to now



Machining



Welding



Completion of the manufacturing and testing



# On-going Procurements: AC/DC Converters, Diagnostics

## AC/DC Converters:

- Korea is responsible for supplying AC/DC Converters for TF, CS, VS1 and CC superconducting magnets
- **18 sets of AC/DC converters** were installed and Legal Inspections are on-going
- Low voltage commissioning started from master controllers and SAT will be completed in 2028
- **KO Master Control System** will integrate central I&C, CN circuit controllers, KO circuit controllers, CN converter, and KO converters.



Completion of installation of the last TF transformer

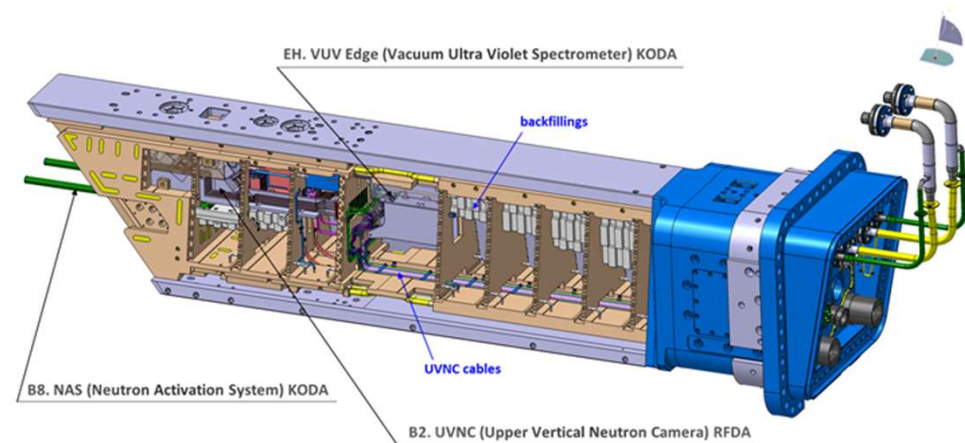


Legal inspection for starting low voltage commissioning



## Diagnostics:

- Korea is responsible for **3 VUV spectrometers**, **Neutron activation system**, and **Upper port #18** diagnostics integration
- Final design of all systems and manufacturing of some components is on-going
- **Technical challenge:** Complex interfaces, design standardization, PIC/vacuum qualification, port integration, radiation effect, etc.

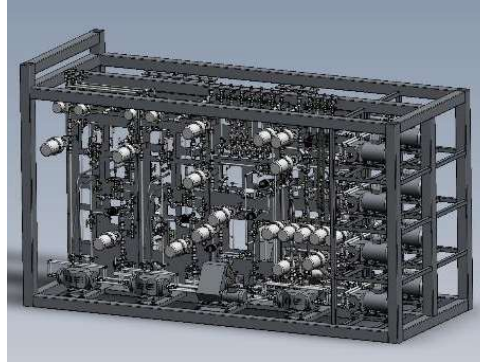


Final design of diagnostic upper port #18

# Upcoming Procurements: SDS, TBM

## Storage and Delivery System (SDS):

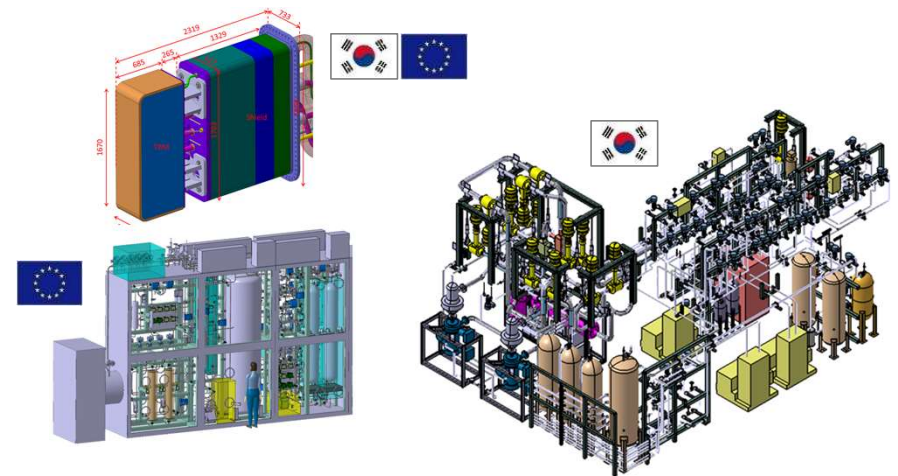
- KODA supported IO for CD & PD phase.
- Engineering study, validation of unit process, development and experimental validation of Tritium storage Uranium hydride bed have been conducted by KO-DA.
- **Procurement Arrangement(PA)** covering Final Design, Fabrication and Delivery signed in **Mar. 2025**.
- **Technical challenge:** Complicated interfaces, operational modes and SIC signals, Tritium compatible components, etc..



[SDS unit process validation experimental apparatus with uranium hydride bed (left), SDS pump glovebox 3D layout (right)]

## Test Blanket Module (TBM):

- Since the signature of “**Partnership Arrangement**” (‘23.3), ITER KOREA and Fusion for Energy have been developing the HCCP(Helium Cooled Ceramic Pebble) Test Blanket System
- **Preliminary design** activities are on-going until 2026
- **Technical challenge:** Joint development, (1<sup>st</sup>) breeding blanket test under fusion environment, R&Ds for new materials & key components, complex geometry & innovative manufacturing technology, plant technologies of wide spectrum to cover the system, complex interfaces, equipment & instrumentation qualifications, PIC



[HCCP TBM-set(upper), Tritium Extraction System/Tritium Accountancy System(left), Helium Cooling System/Coolant Purification System(right)]



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# RUSSIAN KEY CONTRIBUTION TO ITER

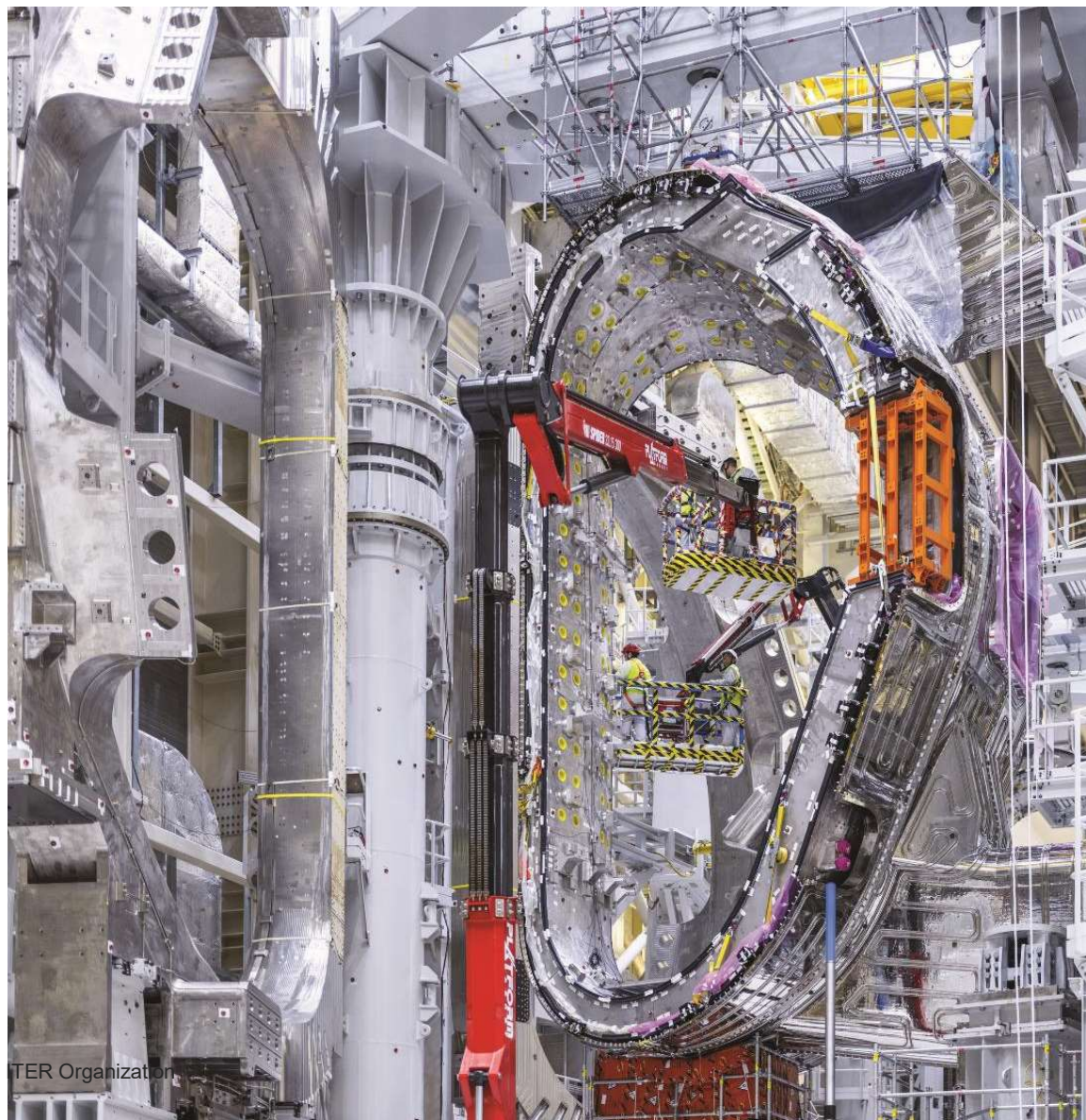


Anatoly Krasilnikov

RF-DA, Director

**THURSDAY APRIL 24<sup>th</sup>**

Disclaimer: the views and opinions expressed herein do not necessarily reflect those of the ITER Organization



# Contents

- 1. PF1 Superconducting Coil**
- 2. EC Gyrotrons**
- 3. Blanket Module Connectors**
- 4. In-Vessel components**
- 5. Switching Network**
- 6. High Heat Flux Tests**
- 7. Diagnostic systems**
- 8. Port Plug Test Facilities**
- 9. Conclusion**





# PF1 Superconducting Coil (Efremov Institute, JSC SNSZ)



9 m in diameter and 160 t in weight, PF1 Magnet is the largest superconducting system ever developed in Russia. The Magnet consists of eight double pancakes with Ni-Ti superconductor inside. Fabrication of the PF1 Coil required implementation of most advanced technology at each stage.



# PF 1 Superconducting Coil

On February 10<sup>th</sup> 2023, the superconducting magnetic coil was successfully delivered to the ITER construction site



# EC Gyrotrons (IAP RAS, Gycom)

Parameter	Value
Beam energy	80 - 90 keV
Beam current	40 - 50 A
Magnetic field	6.9 T
Operational mode	TE <sub>25,10</sub>
Frequency	170±0.5 GHz
Pulse duration	400 (3600) sec
The form of radiation	Gaussian distribution
Window, CVD diamond	80mm (106mm)
Efficiency in TEM mode	50 %
Weight	270 kg
Size	0.5 x 0.5 x 2.7 m <sup>3</sup>

Russian industries have manufactured 8 (out of 24) Gyrotron sets for ITER. Gyrotrons are critically necessary for the successful operation of the future machine. In November 2024, Russian specialists began installing the first Gyrotron sets on the ITER construction site.





# Blanket Module Connectors (Dollezhal Institute)

A total of 1053 units of Russian electrical connectors are currently being manufactured for the purpose of connecting the panels of the First Wall to the Blanket modules. Bimetallic (stainless steel/bronze) pedestals are welded to the Vacuum Vessel of the machine, providing a secure mounting point for electrical connectors



# In-Vessel components (Efremov Institute)

179 First Wall panels (40% of total need, up to  $5 \text{ MW/m}^2$ ) and all 54 Dome Divertors are fabricated in Russia. These are the most energy-loaded structural elements of the machine. A full-scale prototype of the highly loaded panel of the ITER tokamak First Wall has been fabricated and tested.



# Switching Network (Efremov institute)

32 deliveries of Russian electrical equipment have already been shipped to the ITER construction site. Almost 5.5 km of Russian-made busbars will supply electricity to the ITER magnetic system. The process of installing domestic busbars and other equipment at the reactor site is in full swing.



# High Heat Flux Tests (Efremov Institute)



Russia is conducting a series of high heat tests of plasma-facing components under conditions close to the machine operation. The Russian facility is conducting testing not only of domestic but also of foreign plasma-facing components, including those from Japan and Europe.



# Diagnostic systems

## Neutron

### Divertor Neutron Flux Monitor

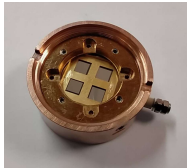


Fission cameras  
U-235 и U-238

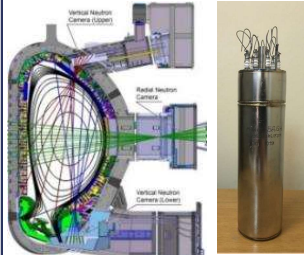
### Diamond Neutron and Fast Atom Spectrometer



ER<1%



### Vertical Neutron Camera for tomography



Detection block  
АД + U-238

### Thomson Scattering & LIF in Divertor



Full scale prototype  
of in-vessel optics

Spectroscopy equipment:

Polichromator 5-200 eV.

Polichromator 0.3-200 eV

• Laser systems:

Nd:YAG 1.0645μm (2 J, 3 ns, 50Hz)

Nd:YLF laser 1.047 μm (2 J, 10 ns, 5Hz)

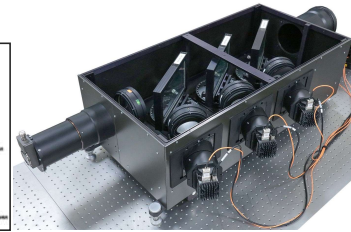
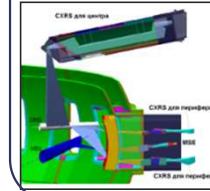
Nd:YAG laser 0.946μm (0.1J, 10ns, 100Hz)

Laser 2J / 100Hz

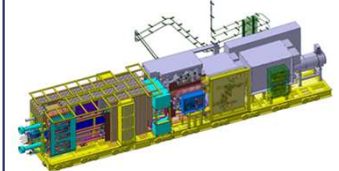


## Optical

### CXRS



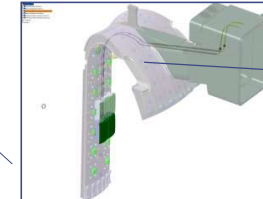
### H-Alpha Spectroscopy



First mirror  
Plasma  
cleaning

3-D integration of H-Alpha  
Spectroscopy in Port Plug No. 11

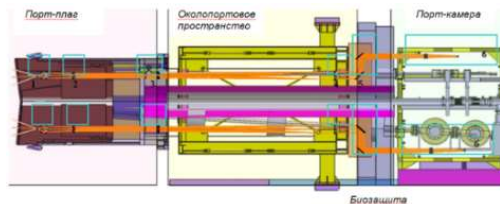
### Reflectometry & Refractometry



From 12 to 140 GHz

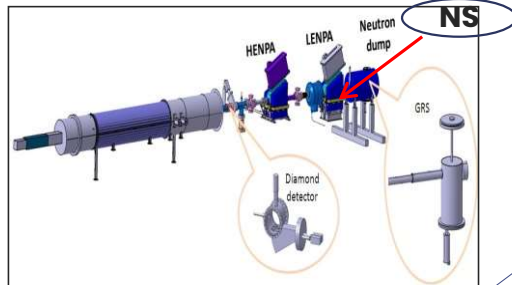
## Plasma diagnostics

### Port Plugs



Upper Ports No. 02, 08, 14  
Lower Port No. 08  
Equatorial Port No. 11

## Charge Exchange Analysers(NPA)



NS

GRS

Diamond detector

Neutron dump

LENPA

HENPA

GRS

Diamond detector

Neutron dump

LENPA

HENPA

GRS

Diamond detector

Neutron dump

LENPA

HENPA

GRS

Diamond detector

Neutron dump

LENPA

HENPA

GRS

Diamond detector

Neutron dump

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Diamond detector

Neutron dump

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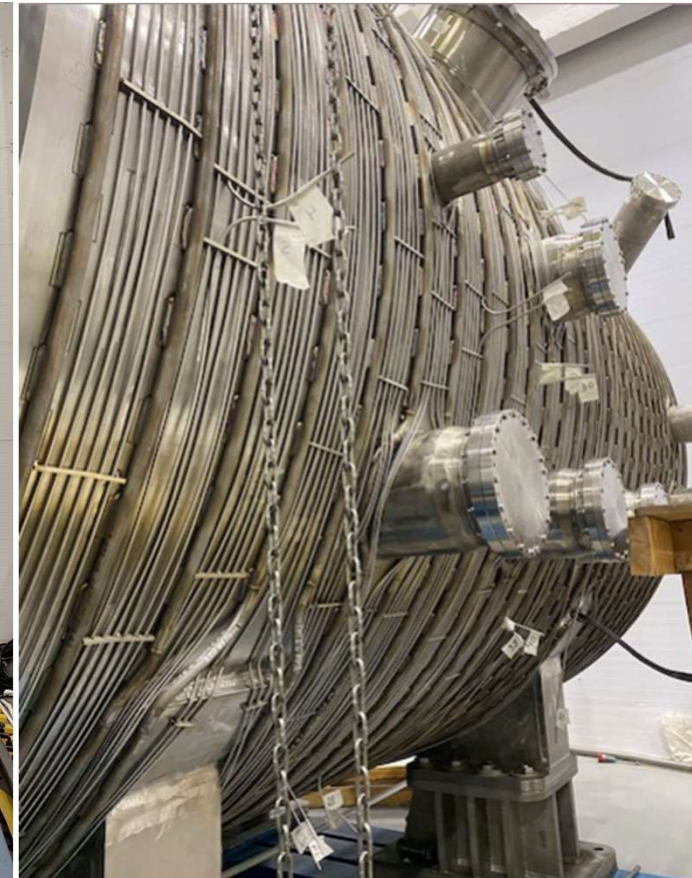
Diamond detector

Neutron dump

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# Port Plug Test Facilities (JSC GKMP)



Four test facilities are being designed for vacuum, strength, thermal, and functional testing of the port plug components of the ITER vacuum vessel.

In August 2024, the first common frame of the stand No.3 was shipped to the ITER Organization in France.

PPTF #4 components are under FAT now

## Conclusion

- Russian industries are fully in line with the schedule and quality requirements of the components manufacture and delivery to the ITER construction site.
- In terms of the New Baseline and recent technical solutions, one of Russia's key tasks is study on materials for the ITER First Wall, including B<sub>4</sub>C panel cover.
- Worldwide cooperation in terms of the ITER Project joint implementation, as well as national fusion programs, is essential for best accomplishments in fusion research.





# THANKS

TO BE PART OF THE WORLDWIDE **FUSION** NETWORK





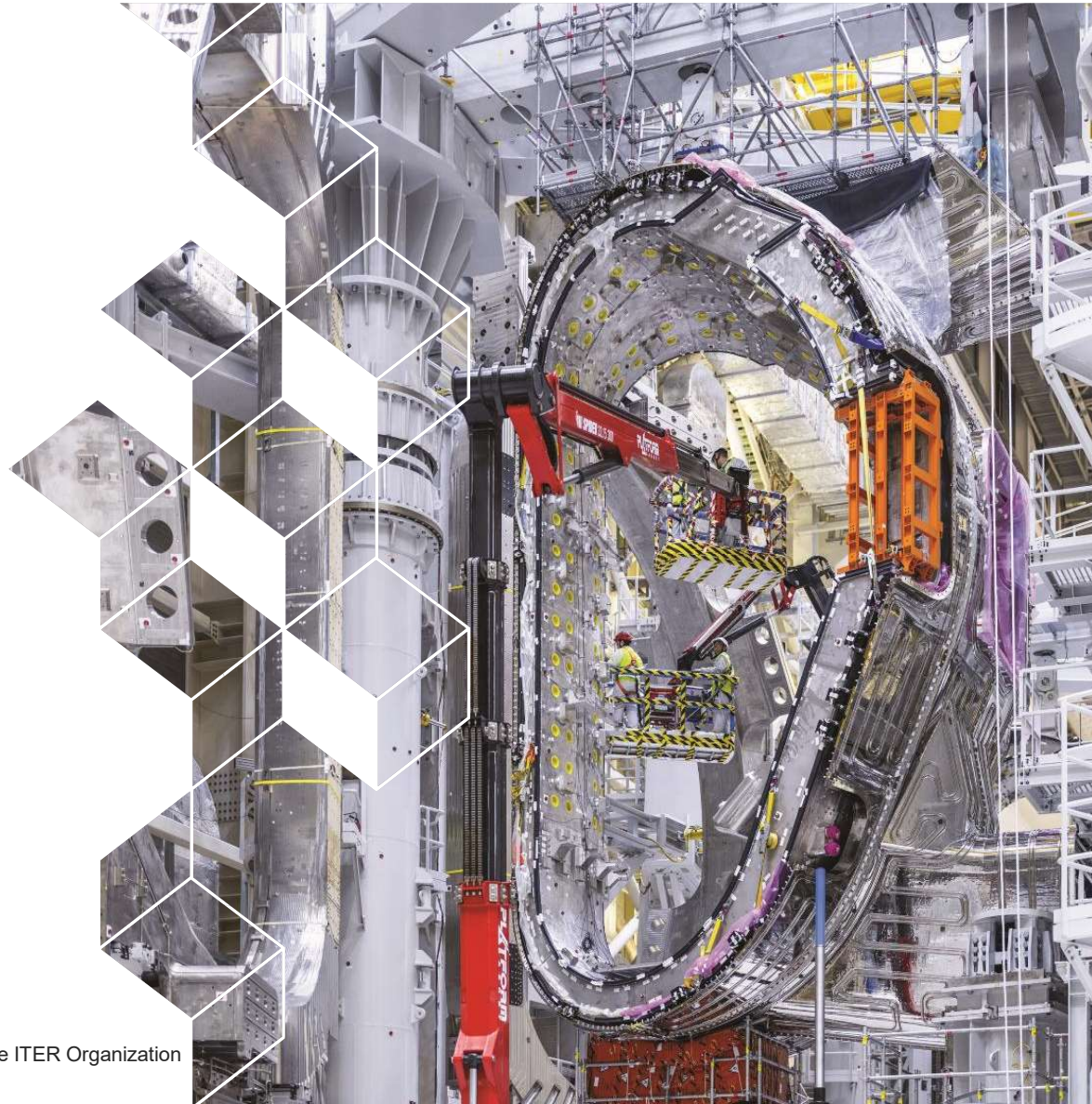
## US ITER Highlights



Kathy McCarthy  
Project Director

**THURSDAY APRIL 24<sup>th</sup>**

Disclaimer: the views and opinions expressed herein do not necessarily reflect those of the ITER Organization

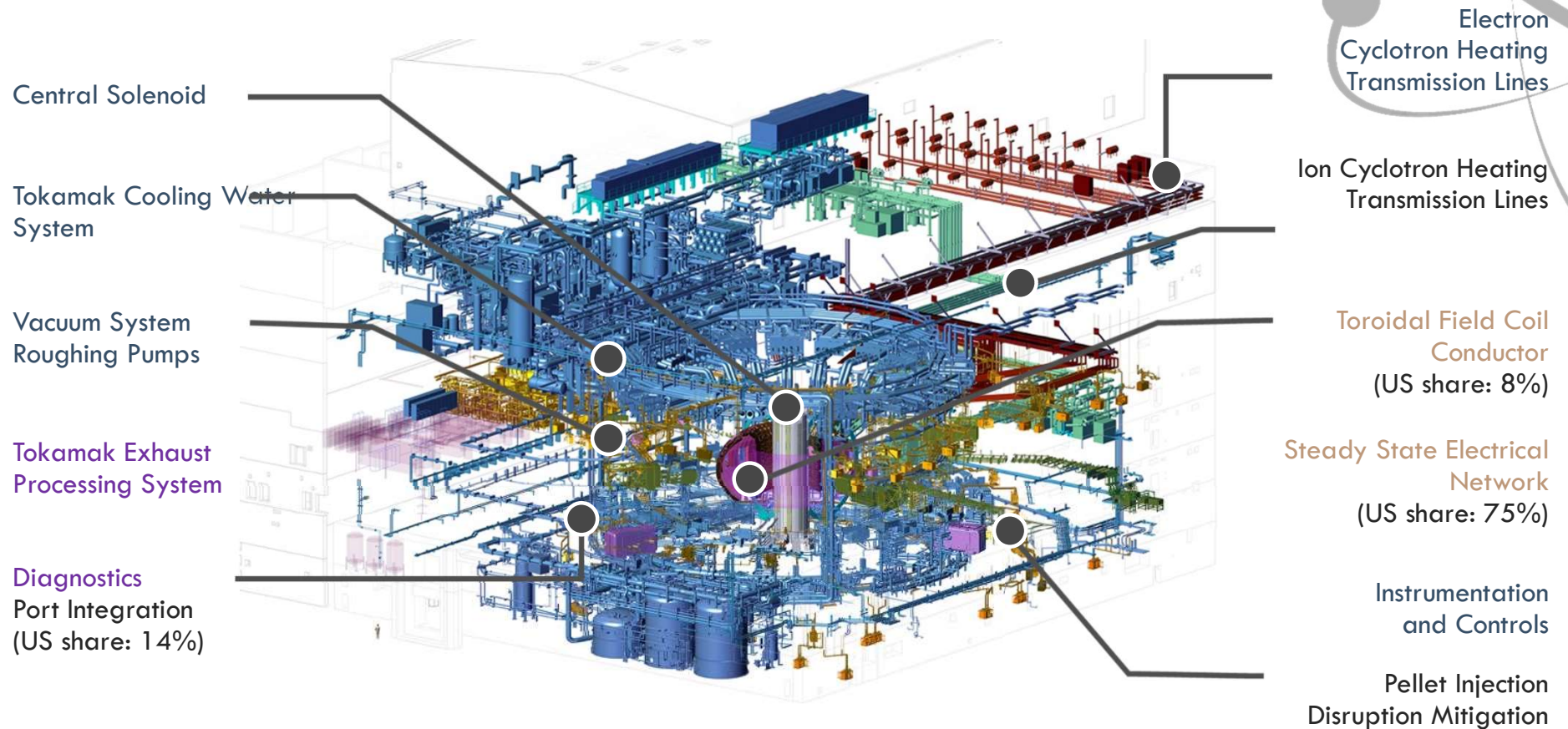




# 1. US ITER Scope



# Some hardware is complete, most is in fabrication

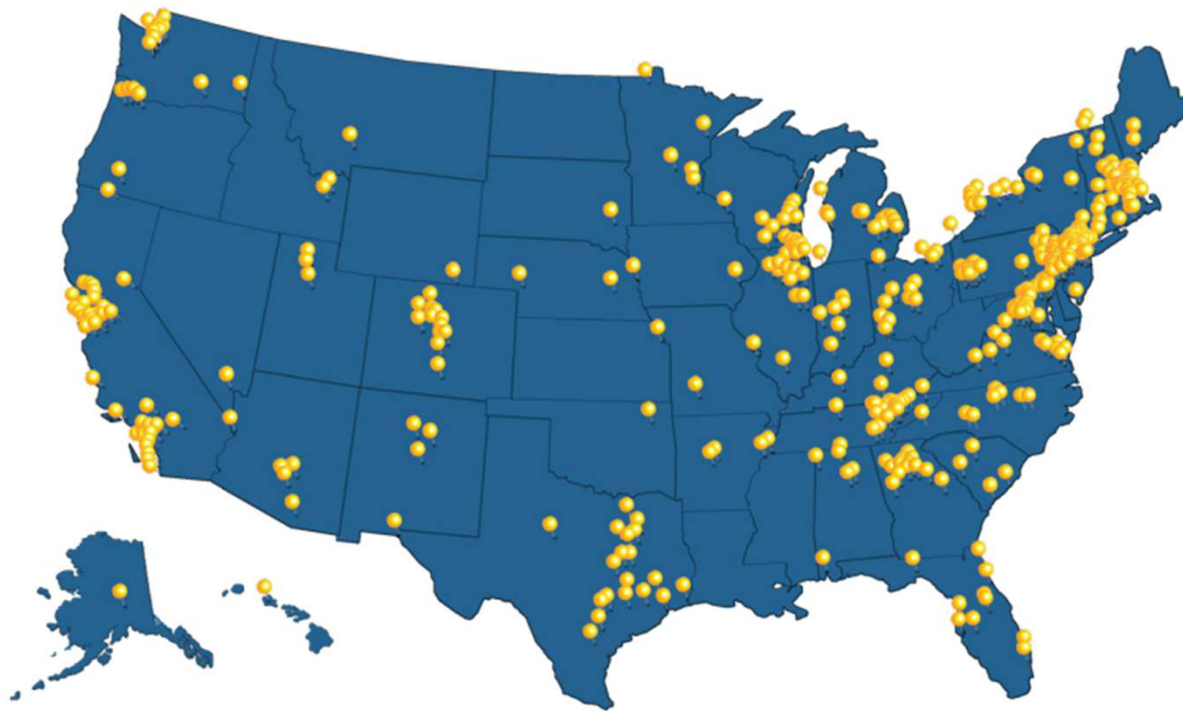


Key: **Finished** • **Hardware in fabrication** • **Prototypes in fabrication** • **In design**

# Industry, universities and national laboratories from across the United States are contributing to ITER

**>\$1.4 billion  
awarded since  
project inception**

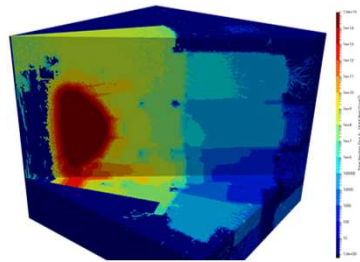
as of December 2024





# US continues design, fabrication and deliveries

## >200 deliveries completed since 2017







# **2. Recent accomplishments**

# Central solenoid magnet scope is approaching completion



Four modules are now on site; two more will be delivered in 2025. Central solenoid tooling deliveries were completed in 2021.



Structural support component deliveries were completed in February 2025



# **3 ■ Upcoming procurements and opportunities**



# US ITER tendering and acquisition process

- We work in accordance with US law and policy, the US Department of Energy Prime Contract, and the appropriate procurement arrangement with the ITER Organization
- Acquisitions are conducted as competitive, best value procurements, with evaluations based on technical and price factors
- Foreign Suppliers are encouraged to participate in US ITER procurements, and should note that the Buy American Act does not apply to equipment being delivered to the ITER site

For more information: [usiter.ornl.gov/procurements/](https://usiter.ornl.gov/procurements/)

# Planned procurements through CY2026 span multiple hardware systems

## Electron Cyclotron Transmission Lines [plasma heating]

Supports and Installation Hardware / Water Cooling / Polarizers

## Vacuum Auxiliary and Roughing Pumps Systems [cryostat vacuum]

Bellows / Gaskets / Spools / Leak Tests / Instrumentation and Controls Electronics

## Tokamak Exhaust Processing System [tritium recycling]

Pumps / Valves / Tooling / Molecular Sieve Bed and Elements

## Pellet Injection System [plasma fueling]

Flight Tubes / Bellows



# Future procurements will focus on diagnostic systems

US diagnostics are now largely in design



Using microwaves, photos and atoms, diagnostics will measure plasma profiles of:

- Electron density
- Electron temperature
- Ion temperature
- Impurity density
- Plasma rotation
- Fluctuations
- Plasma current density







# THANKS

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