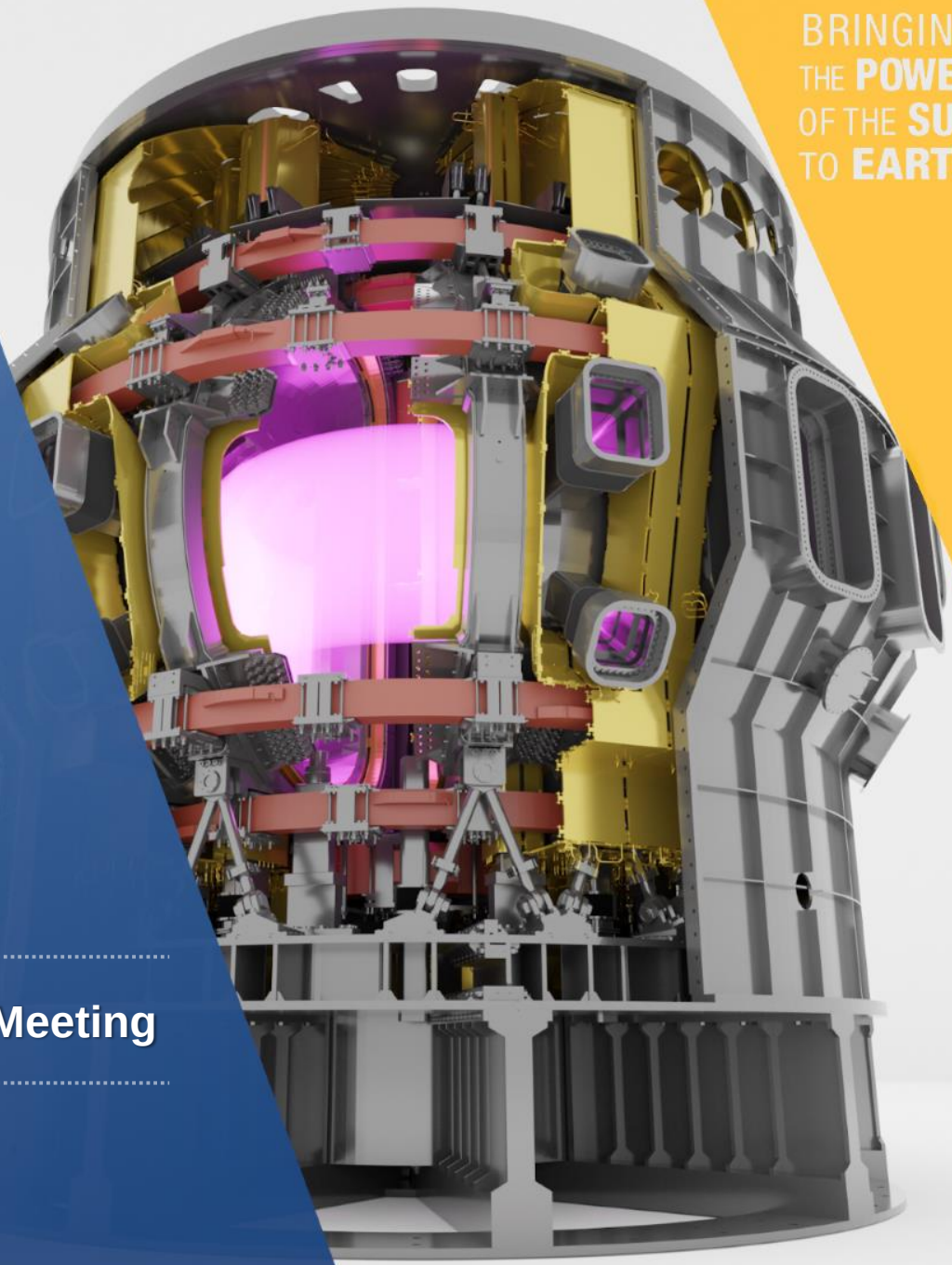
FUSION FOR ENERGY

BRINGING THE POWER OF THE SUN TO EARTH



JT-60SA – EU activities

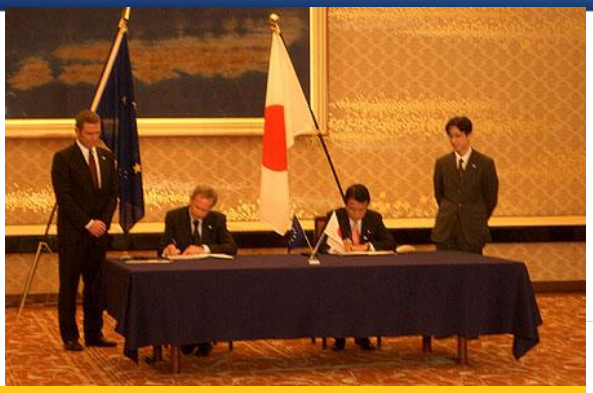
A Brief Overview

E. Di Pietro (F4E)

EUROfusion WPSA Planning Meeting

15 March 2021

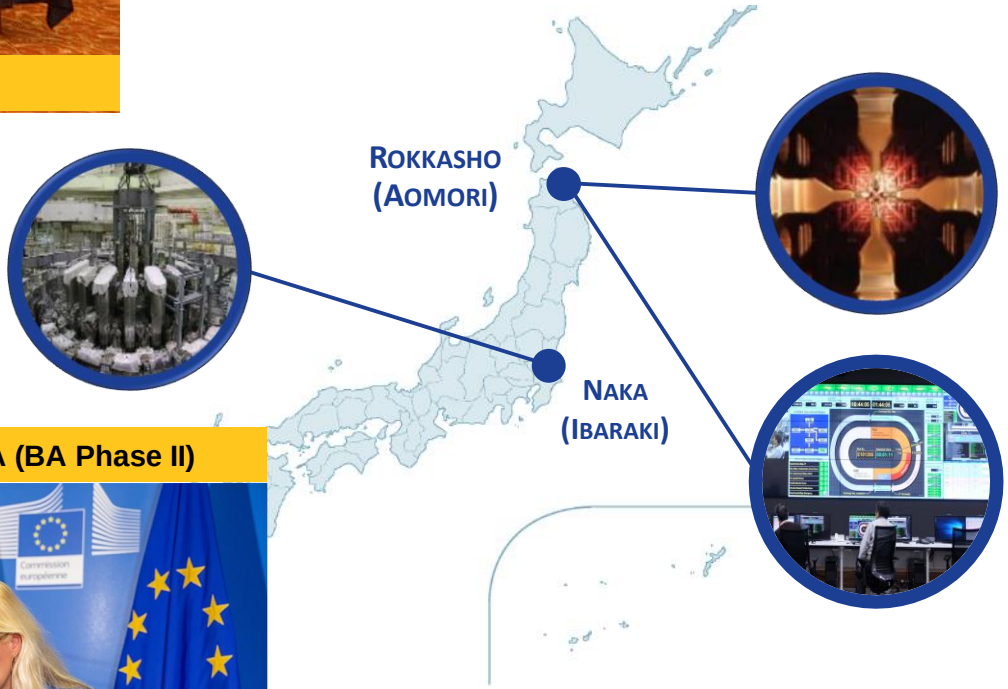
The Broader Approach Agreement



2007 Signing the BA Agreement

EU-Japan scientific cooperation is paving the way for ITER assembly and operation – signed in 2007

JT-60SA
Tokamak about half the size of ITER

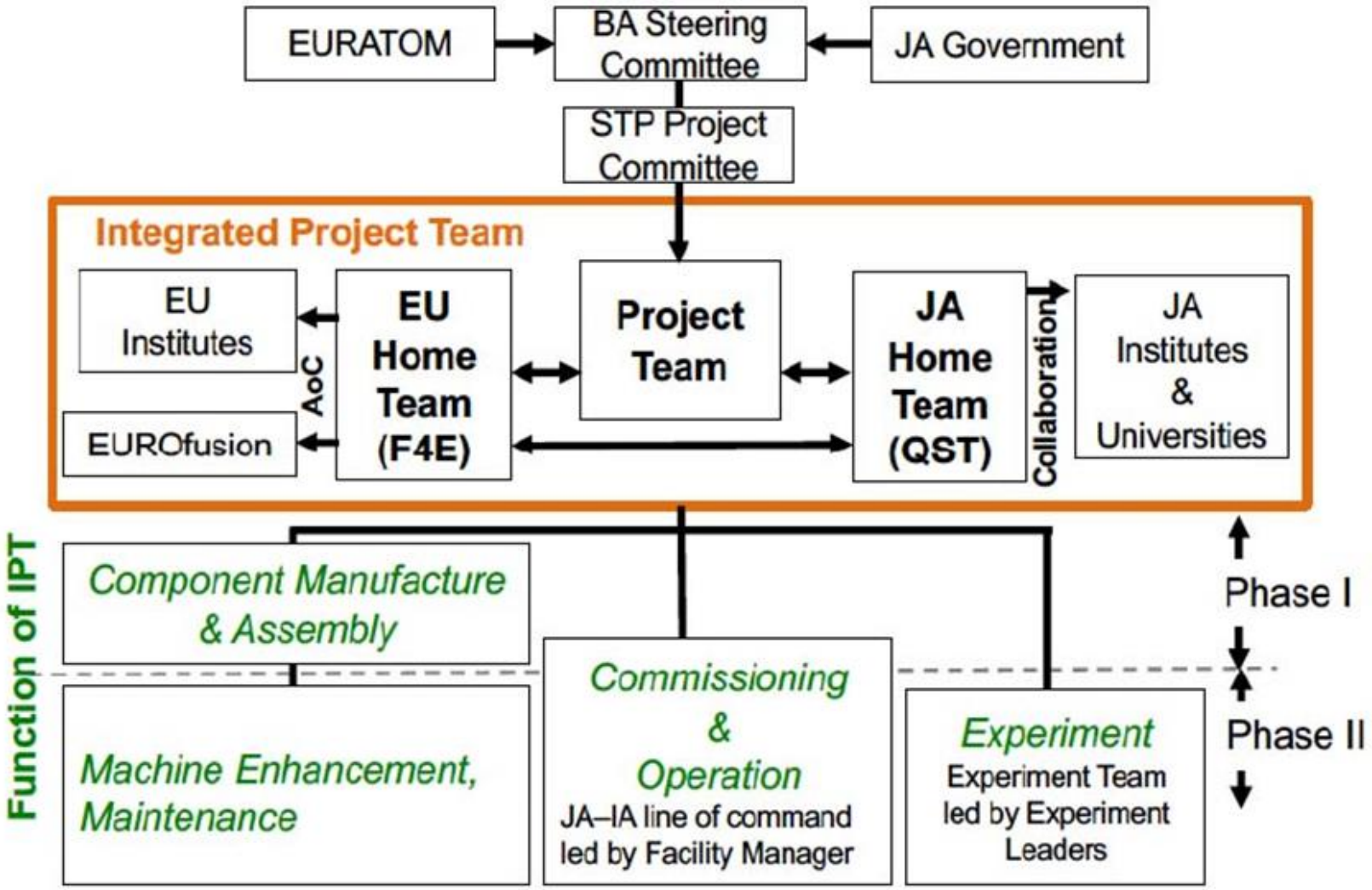


IFMIF-EVEDA
Prototype materials testing facility & accelerator

IFERC
Plasma remote exp. and simulation center

2020 Extending the scope of BA (BA Phase II)

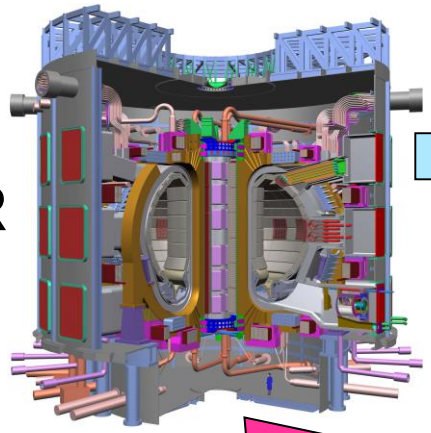
JT-60SA Organisation

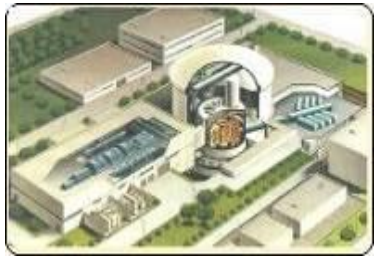


JT-60SA (Super Advanced)

- Contribute to the early realization of fusion energy by its exploitation to support the exploitation of ITER and research towards DEMO.

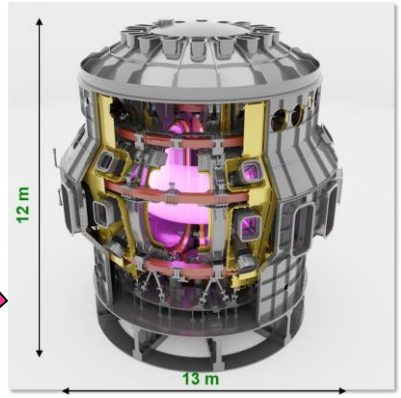
ITER





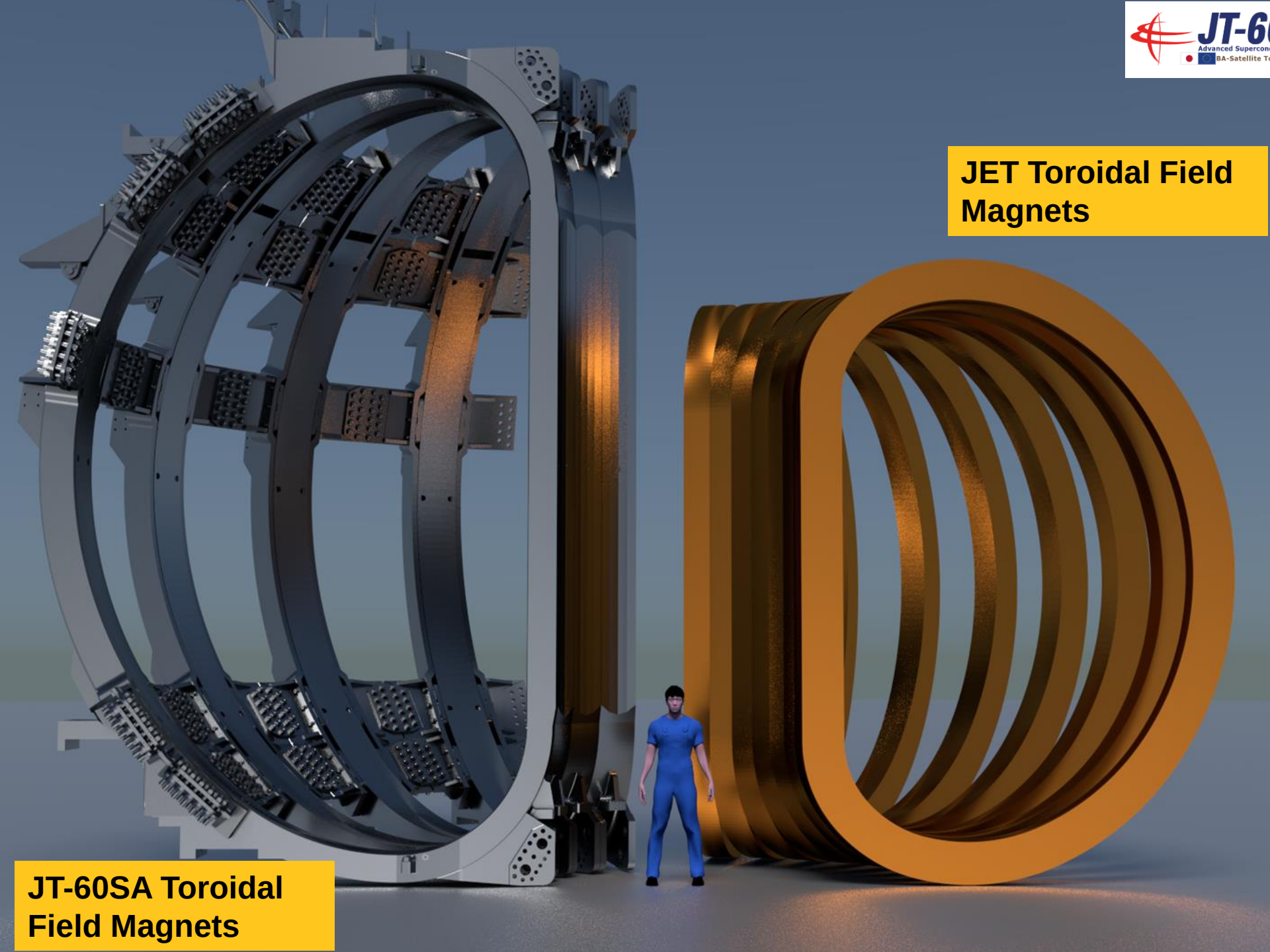
DEMO

JT-60SA



Support ITER

Complement ITER towards DEMO


JET Toroidal Field Magnets
JT-60SA Toroidal Field Magnets

JT-60SA Assembly timeline

Cryostat Base

Lower Poloidal Field Coils

Vacuum Vessel

VV thermal shield

TF Coils

Upper Poloidal Field Coils and Central Solenoid

Cryostat

March 2020 – Assembly Completed

TF Coil Cold Test Facility

Cryostat

Current Lead

TF Coils

power supplies

QPC

MG

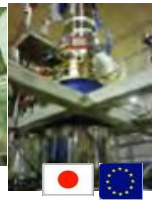
SCMP

SNU

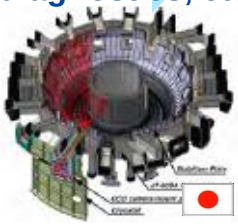
cryoplant

NBI

ECRF



diagnostics, etc

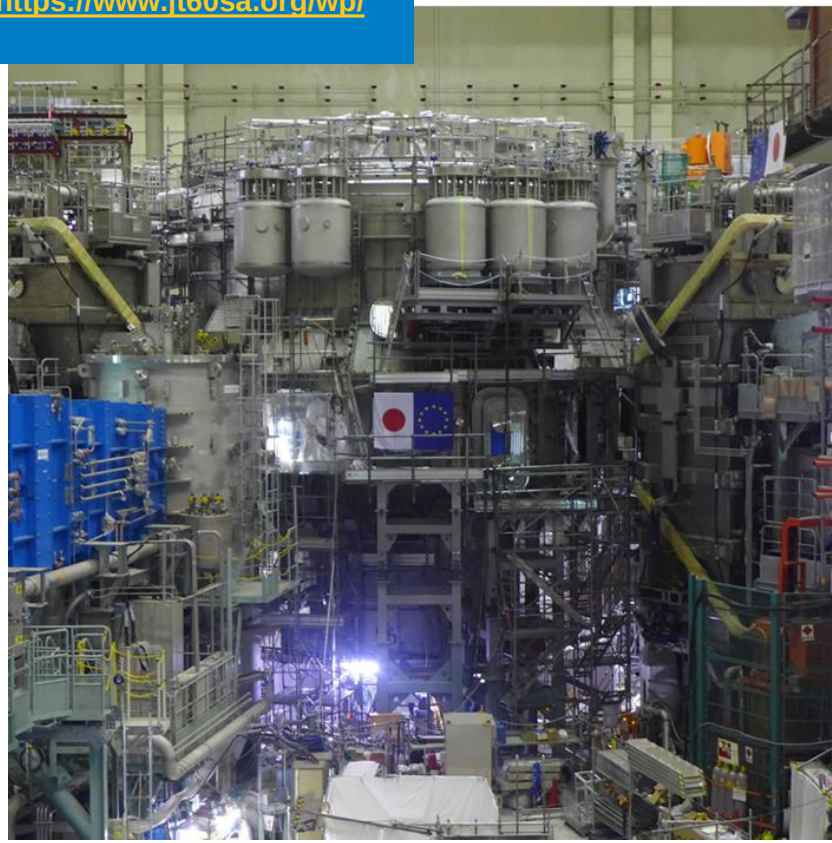


March 2013 – March 2020

JT-60SA Status

For more info please visit
https://www.jt60sa.org/wp/

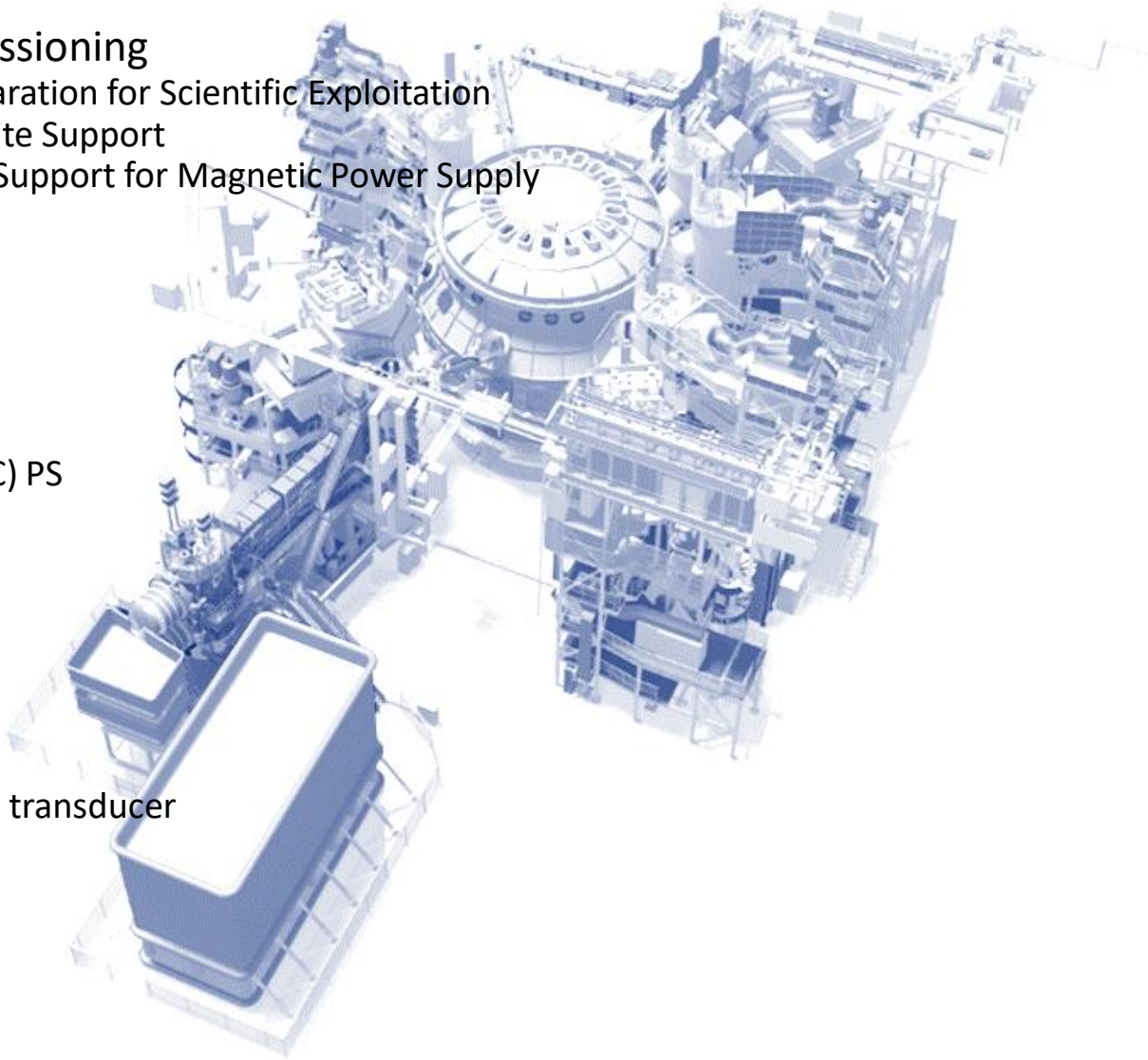
- JT-60SA assembly completed with installation of Cryostat Top Lid in March 2020
- Final hydraulic/electrical/instrumentation connections completed in Sept 2020
- In vessel Components: first wall completed, upper divertor installed, basic diagnostics installed
- Control System: Integrated linkage tests completed
- Vacuum Pumping System: baking 150C/ operation vacuum reached in VV and cryostat
- Cryoplant: cool down started on 10 October 2020
- Magnets superconductive 26 November 2020
- Power Supplies: ‘ Combination Tests’ and safety checks completed 10 Jan 2021
- Coil energisation from 13 Jan 2021
- **02.03.2021 – JT-60SA successfully reaches its full design toroidal field**



09.03.2021 – Incident

- Three days ago we had an **incident involving the poloidal field coil EF1 and the cryogenic system** which has resulted in a significant interruption to the Integrated Commissioning.
- During **planned tests at 5kV on EF1**, **the current supplied unexpectedly increased, very suddenly,** and was eventually interrupted, at 5 kA by the PS safety interlock.
- Almost immediately, **the cryostat pressure (helium, from spectrometer measurements) increased rapidly** and reached 7000 Pa, resulting in a large **increase of the heat conducted to the cold masses**. The pressure in the cooling circuit, rapidly, reached values at which the **safety devices (rupture disks), located on the cryolines outside the cryostat, opened** and released the gaseous helium to the atmosphere in the Tokamak Hall.
- The **structures inside the cryostat are now rapidly warming up**. The latest measurement indicates that the **TF coils are at about 200 K.** Unfortunately , due to a planned power disconnection on Saturday 13 , Sunday 14 and Monday 15, no power was available, neither for measurement nor for any operation of the cryoplant or power supplies. QST put in place battery operated measurements which provided info on coils temperatures and cryostat vacuum. Energy was resumed on Monday 15th at evening .
- **At present, the root cause of a series of incident is being examined.**
- While a **leak on the helium lines inside the cryostat vacuum is certain**, the nature and size of **any damage to EF1 or other components is still unknown**. Identification the he loop where the leak is located has been performed. Actual analyses of the nature and location of the damage requires access to the cryostat.
- Therefore, as soon as power is again available on Monday 15th , **the cold mass will be warmed up to ambient temperature and the cryostat will be vented to atmospheric pressure**.
- At the moment **we don't have elements** to provide reasonable **information on the damage and estimate on the possibilities and time required for repair**.
- Naturally, we will naturally need to find out the **root cause**, also to make sure it does not happen again and to transfer this experience to our ITER colleagues.
- For sure this is a setback we would have happily avoided, but we are also aware that such events happen during commissioning. **We will fix it and move on**.

EU - Phase II Main Contributions



Operation/Maintenance/Commissioning

- On-site support for IC and Preparation for Scientific Exploitation
- Cryogenic Spare Parts and On-Site Support
- Spare Parts and for the On-site Support for Magnetic Power Supply
- EU cash contribution

Machine Enhancements

- Pellet Launching System
- Massive Gas Injection (MGI)
- Actively Cooled Divertor
- Divertor Cryopumps
- Error Field Correction Coil (EFCC) PS
- Additional LN2 Storage
- ECRF Transmission Line (TL)
- PS for ECRF System
- Thomson Scattering
- VUV Divertor Spectrometer
- Fast Ion Loss Detector (FILD)
- JT-60SA Simulator
- TF coil strain and displacements transducer
- EDICAM (ownership transfer)

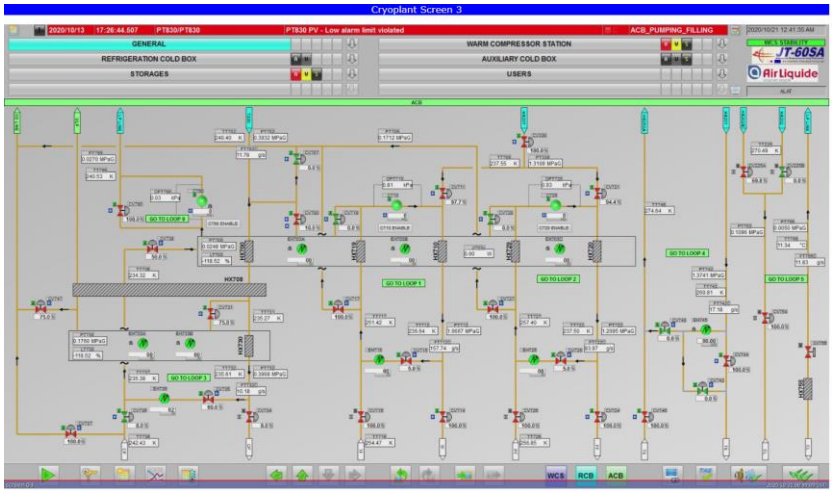
Residual Phase I activities

- RWM PS
- ECRH PS

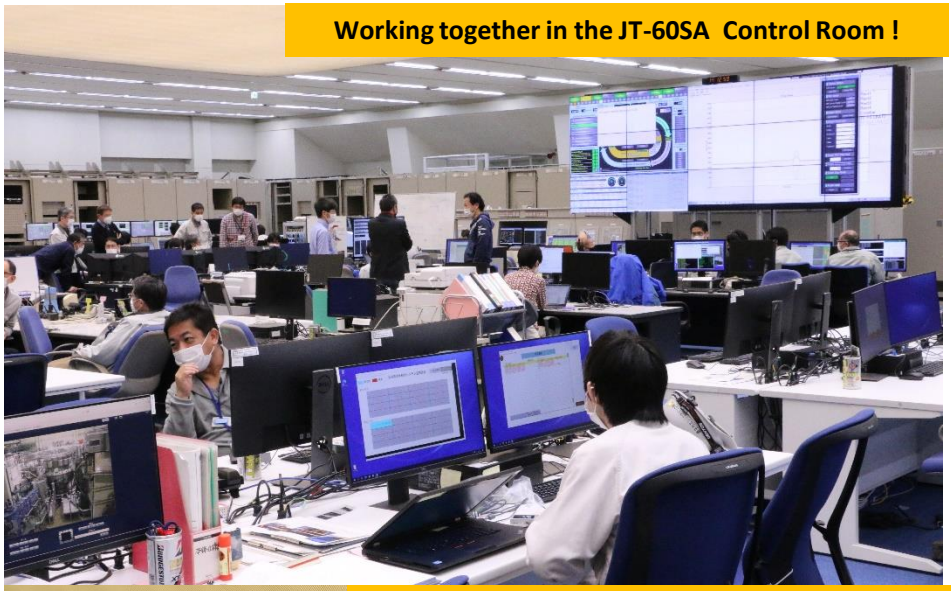
On-site support for IC and Preparation for Scientific Exploitation

F4E and EUROFusion Experts → support to the Integrated Commissioning

- PS `operation (QPC, Pyrobreakers, firmware etc..)
- Magnet and Cryoplant operation (cool-down, quench simulation, cryo-disconnection, fast discharges etc.)
- Plasma working group



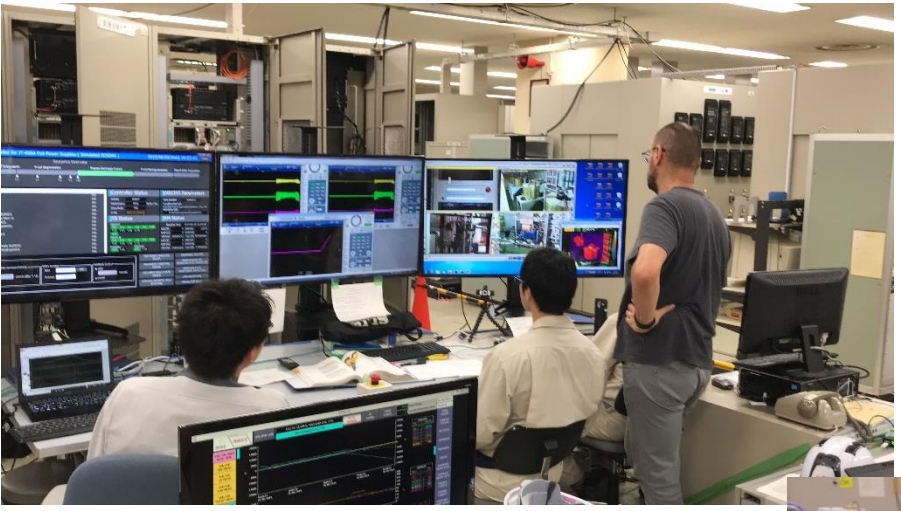
Working together in the JT-60SA Control Room !



Eventually we managed to be present on site!

Working together for IC and Preparation for Scientific Exploitation

FUSION FOR ENERGY



QST-EU Collaboration

EUROfusion support for the JT-60SA integrated commissioning and first plasma operation with 44 EU experts (14 long-term visit, 15 short-term visit, 15 support without visit). Due to travel restrictions, only 2 EU experts travelled to Japan.

Collaboration topics:

EDICAM (first EU diagnostic)

Cryogenics and Superconducting Magnets

Plasma Operation

Plasma Breakdown

Scientific Exploitation

Wall conditioning

MHD and disruptions

Equilibrium control

Remote participation

Collaboration moved online:

Regular topic meetings with QST and EU colleagues

Joint QST-EU Plasma Team Meeting every 1-2 weeks with all topics

Weekly Integrated Commissioning Status meeting with QST, F4E, EU and ITER

Daily F4E meetings

Dedicated meetings on the future disruption programme (Shattered Pellet Injection - SPI, Runaways Electrons, Massive Gas Injection - MGI)

Strong motivation to join QST staff in Naka once the travel restrictions are lifted.

Collaboration on Wall Conditioning

Collaboration started on the Electron Cyclotron Wall Conditioning (ECWC) technique that was further extended to include other techniques such as Glow Discharge Cleaning (GDC), baking and Electron Cyclotron (EC) plasmas.

Preparation:

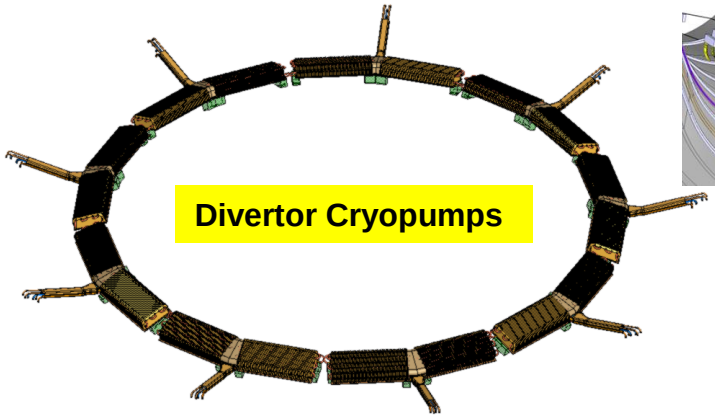
Regular topic meetings to share EU experience on ECWC and GDC from W7-X, MAST-U, Tore Supra/WEST and JET and share QST experience on JT-60U and KSTAR.

QST strategy on wall conditioning with feedback from Japanese University professors and EU colleagues.

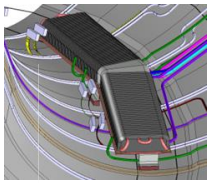
During wall conditioning experiments:

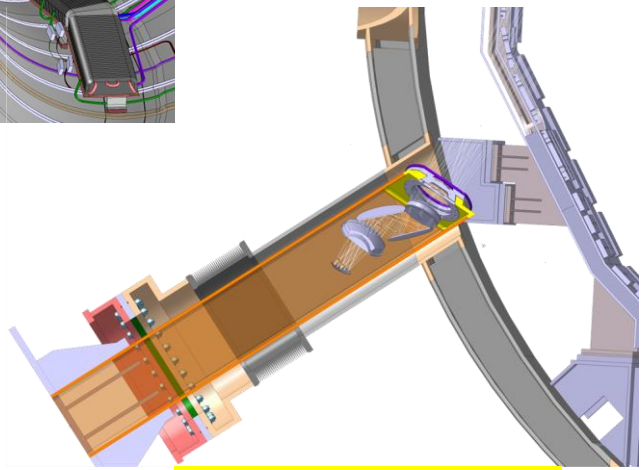
- **Daily QST-EU meeting (10-20 minutes) on wall conditioning from 1-9 March 2021 with direct input into next steps in the control room.**
- **Use of Japanese night as extra analysis time by EU to support QST colleagues.**

EF/F4E Collaboration for Phase II

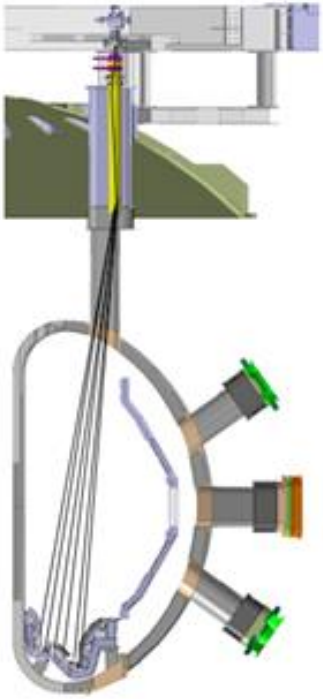


Divertor Cryopumps



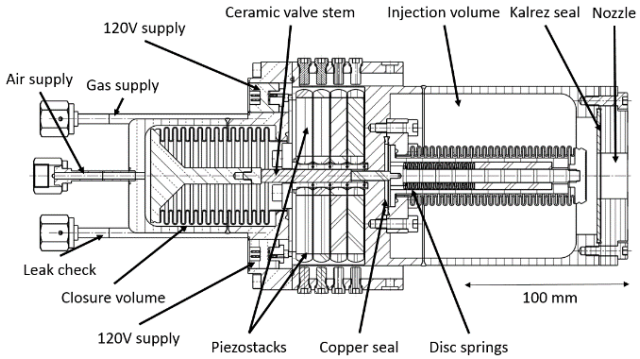


Thomson Scattering

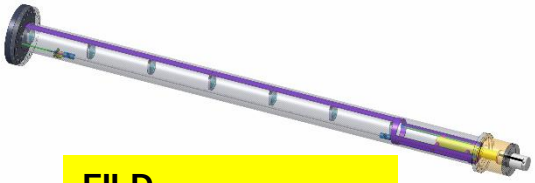


VUV Spectrometer

Pellet LS

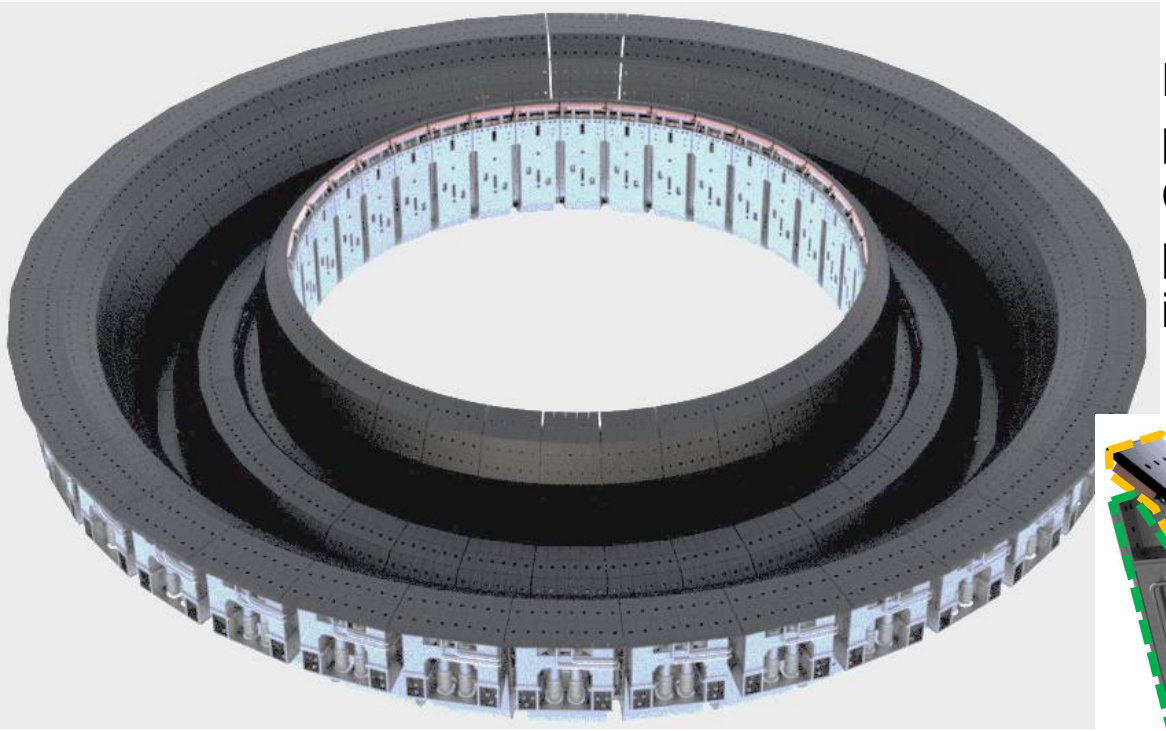


MGI valves

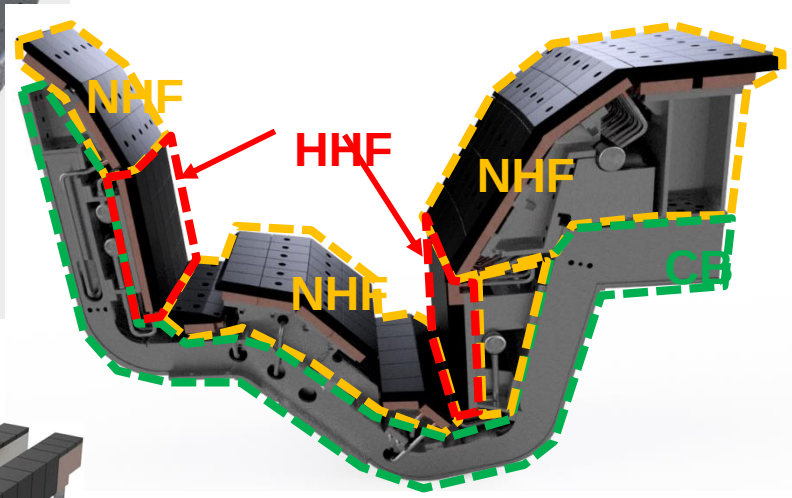


FILD

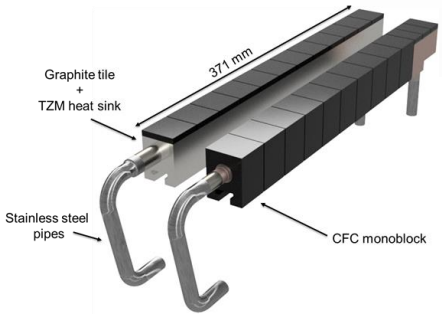
Actively Cooled Divertor (ACD)



EU HT is preparing for the procurement of the Actively Cooled Divertor for high heating power and long pulse for installation after 2025.



- Procurement ready to start
- Procurement Strategy developed
- EUROFusion support starting (design, testing, NDE..)
- Target : delivery to site mid 2025



Conclusion

- JT-60SA as an example of collaboration between EU and Japan and, even more, among F4E, EU laboratories and EUROFusion
- Important and appreciated contributions from EF and F4E, in spite of COVID 19 difficulties
- 9th March incident produce immediate delays and consequences can not be quantified at the moment
- Integrating Commissioning will be completed in spite of present difficulties
- First Scientific Exploitation foreseeably delayed
- But Machine Enhancement activities are progressing well (with a fundamental contribution of EUROFusion and the EU laboratories

FUSION FOR ENERGY

EUROfusion

Thank you

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