Current Status of ITER Components Manufacturing and JT-60SA Assembly

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National Institutes for Quantum and Radiological Science and Technology

Fusion Power Generation System

QST
Naka Fusion Institute

Plasma

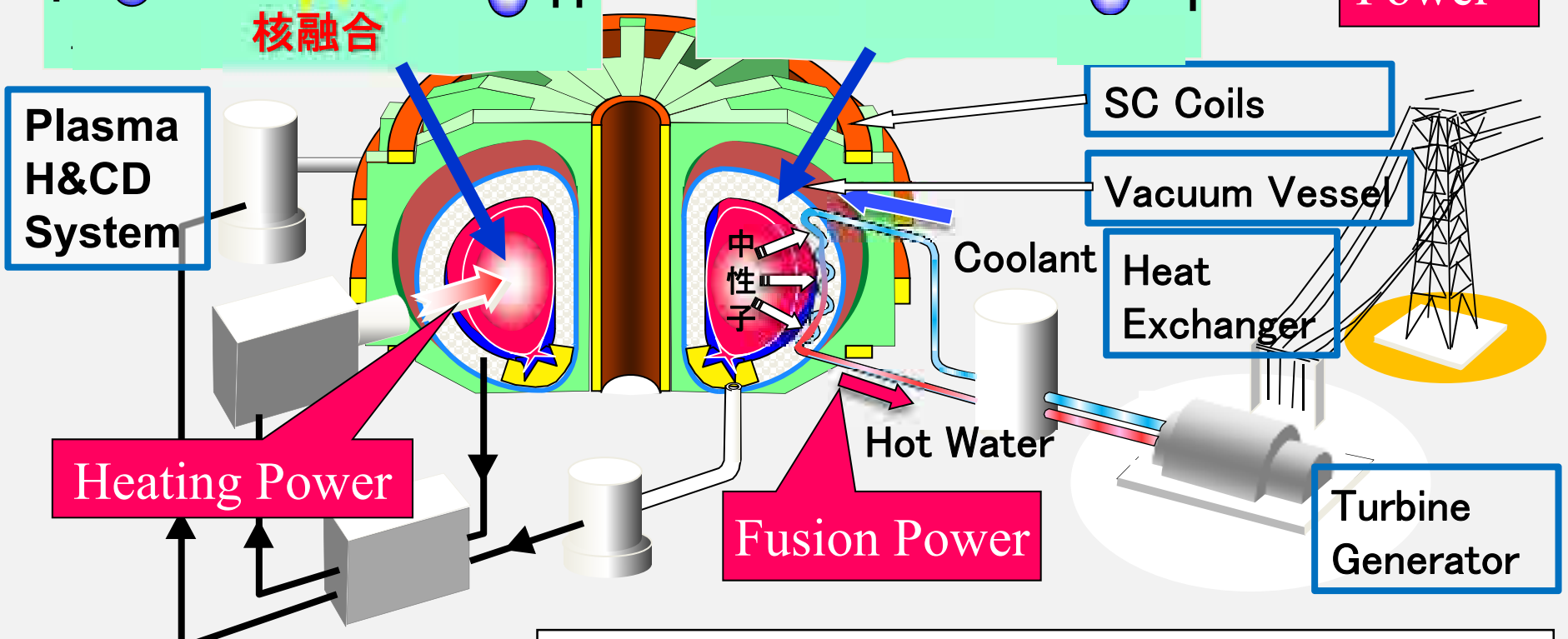
D + T → He + n

核融合

Blanket

n + Li → He + T

Electric Power



$$\text{Fusion Energy Gain } Q = \frac{\text{Fusion Output}}{\text{Heating Power}}$$

30~50 necessary for Demo

JT-60 Plasma Discharge

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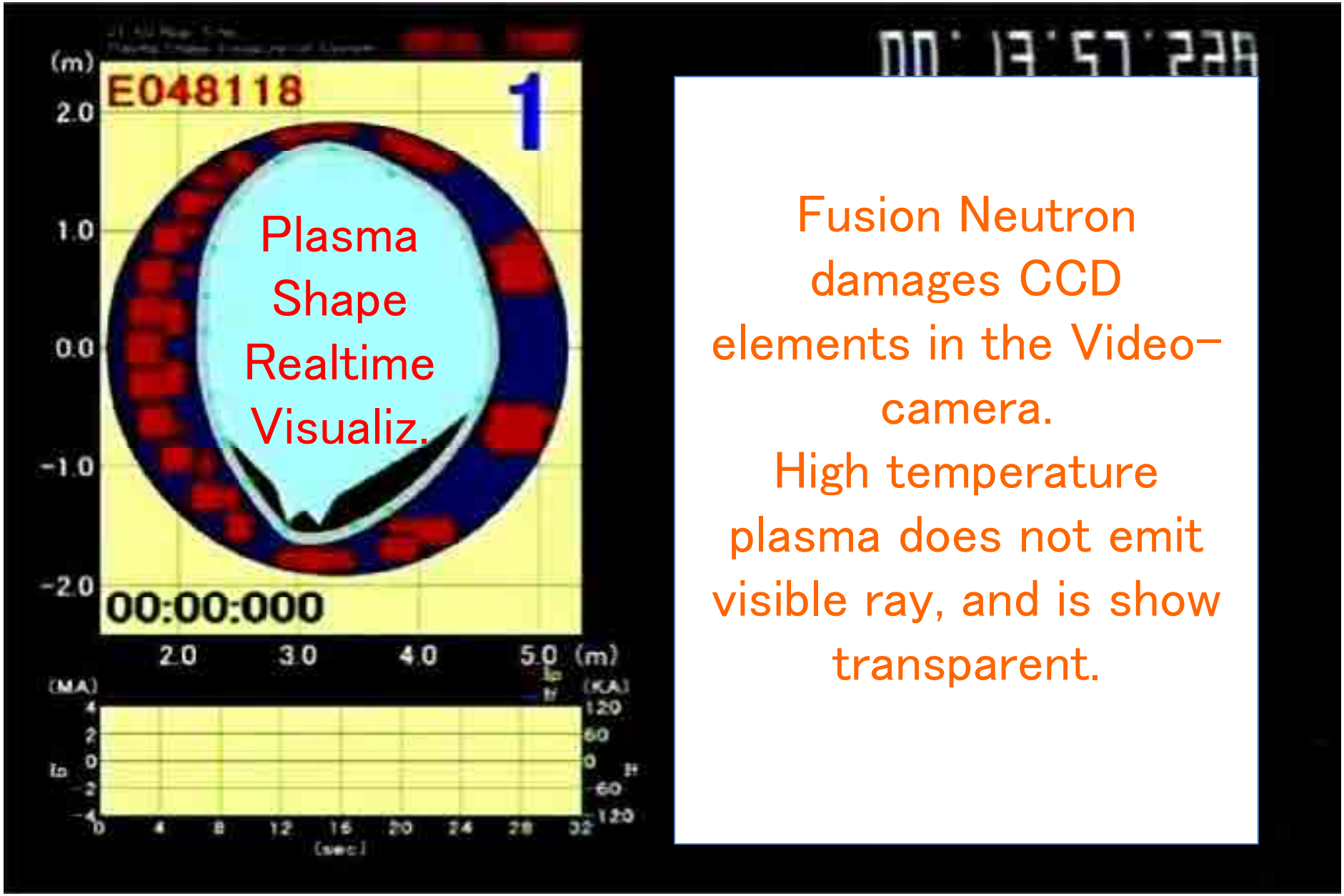


Fusion Neutron damages CCD elements in the Video-camera.

High temperature plasma does not emit visible ray, and is show transparent.

Towards Commercial Use of Fusion Energy

QST

Test Device | **Experimental Reactor** Present | **Demo** around middle of this century

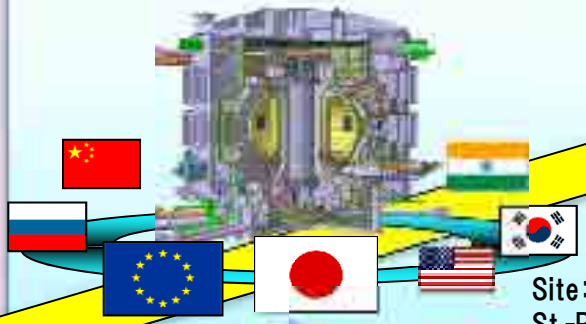
R&D for achieving and sustaining DT burning

JT-60
Achieve fusion temperature (1990s)

World Record of
- equivalent Q =1.25
- Ion temperature 520 M ° c

【Naka Fusion Institute】

ITER
Demonstrate sustained fusion output of 500MW



Site:
St.-Paul-les-Durance, France

Supporting ITER
JT-60SA

Fusion Demo
Demonstration of Power Generation, Prospect for Economy

Complementing ITER

making use of ITER

Prospect for Commercial Use

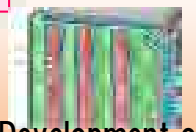
Carrying out them using JA-EU Joint Activities "Broader Approach (BA) Activities in Fusion Energy R&D"

R&D for utilizing sustained DT burning

Demo Design

【Rokksha Fusion Instit.】

Blanket R&D



Development of Componets

R&D for Fusion Neutron Irradiation Facility

Progress of Domestic Procurement Activities on ITER Project

ITER: World Wide Joint Project of 7 Parties

QST
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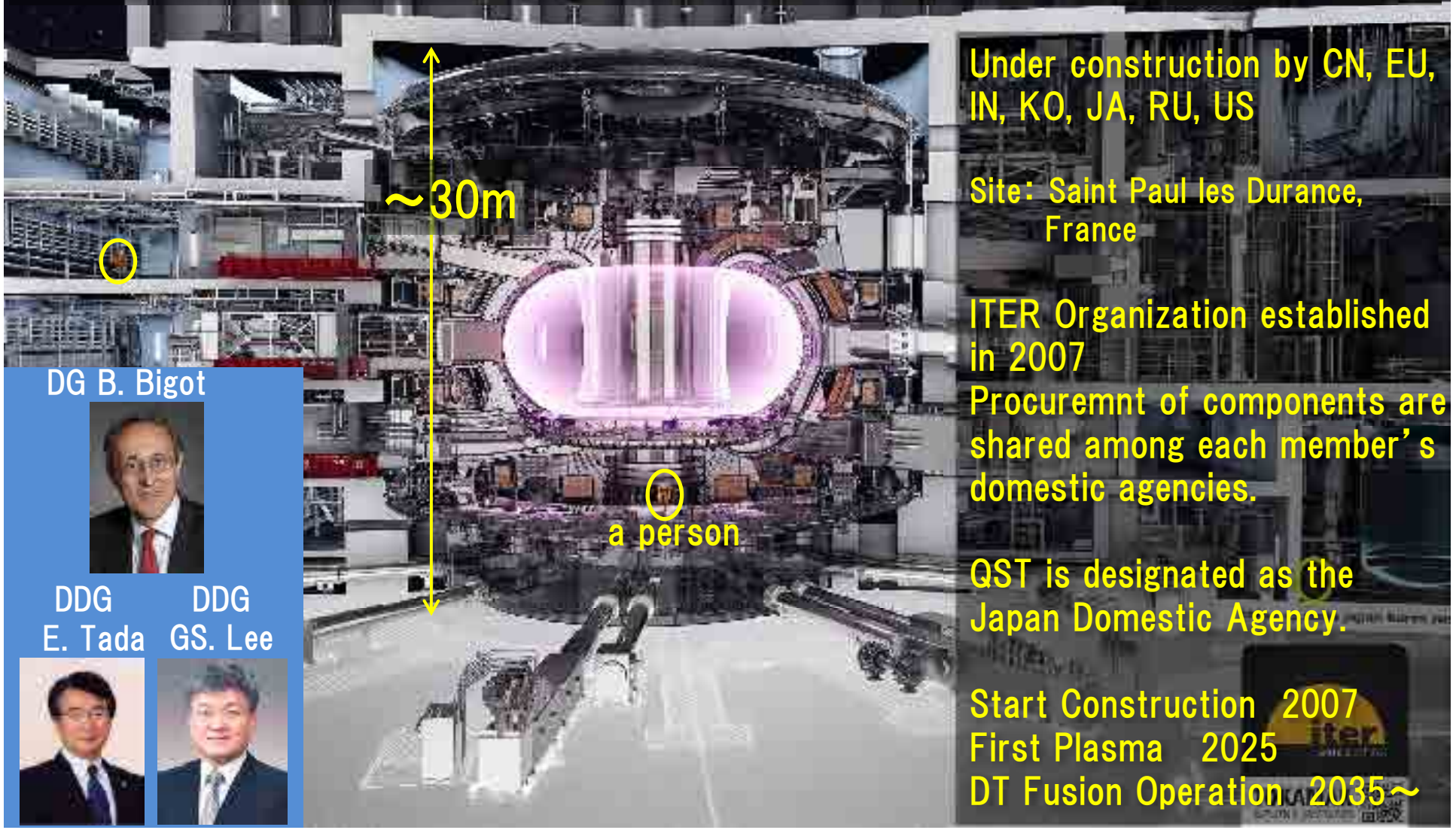
Demonstration of continuous fusion burning
Output: 500 MW, Fusion Energy Gain of 10 (external heating: 50 MW)



DG B. Bigot

DDG E. Tada

DDG GS. Lee

Under construction by CN, EU, IN, KO, JA, RU, US

Site: Saint Paul les Durance, France

ITER Organization established in 2007
Procuremnt of components are shared among each member's domestic agencies.

QST is designated as the Japan Domestic Agency.

Start Construction 2007
First Plasma 2025
DT Fusion Operation 2035~

State-of-the-art Main Body Components Shared by Japan

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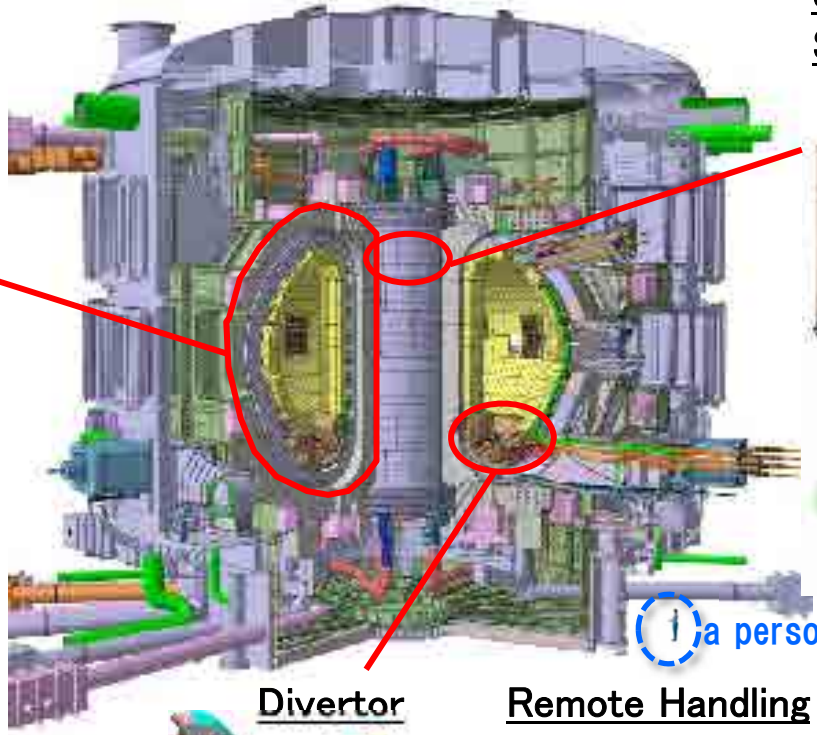
Superconducting Toroidal Field Coil

- 33 Conductors (about 33%)
- 19 Structures (All)
- 9 Windings / Integrations (about 50%)



Superconducting Central Solenoid Conductor

- 49 Conductors (All)

Diagnostics

- 6 Diagnostics Equipment (About 15%)

Radio Frequency Heating System

Neutral Beam Injector

- 8 Gyrotrons (about 33%)
- Equatorial Launcher (All)
- 3 1MeV Power Supply High Voltage Parts (All)
- 3 HV Bushings (All)
- 1 Accelerator (About 33%)

Divertor

Outer Target (All)

Remote Handling Equipment

Blanket Remote Handling Equipment (All)

Tritium Removal Plant

Tritium Removal System (50%)

Toroidal field (TF) coil

QST

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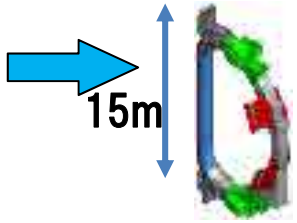
Conductor (33 unit length)

Winding Pack (WP) (for 9 TF coils)

Structure(19 sets)

Assembly (9 sets)



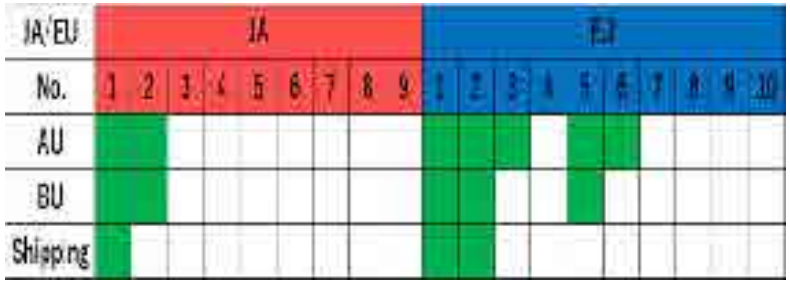
WP for 1st TF coil before cold test (Mitubishi)

Double pancake for 3rd TF coil (Toshiba)

TF structure for 1st JA portion

TF structure for 1st EU portion

WP fabrication status



TF structure fabrication status

Superconductor for CS Coil

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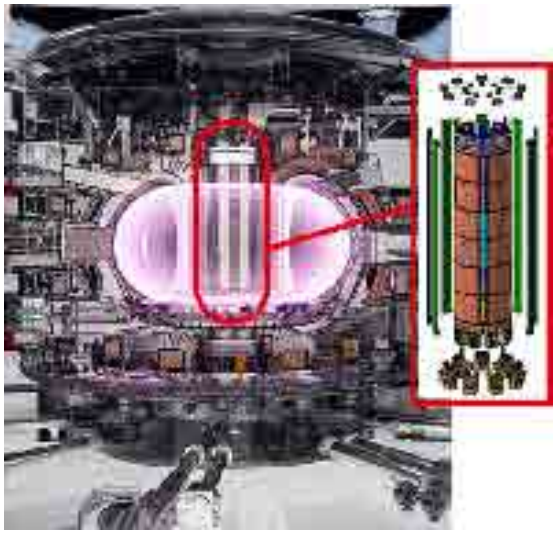
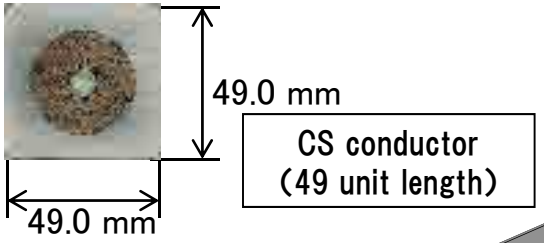


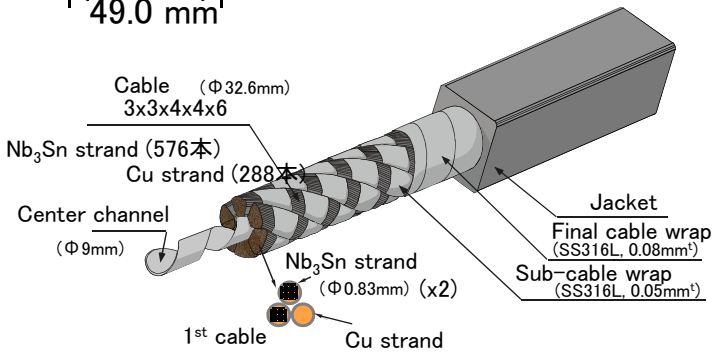
Oct. 2017: 49 CS conductors fabrication completed.

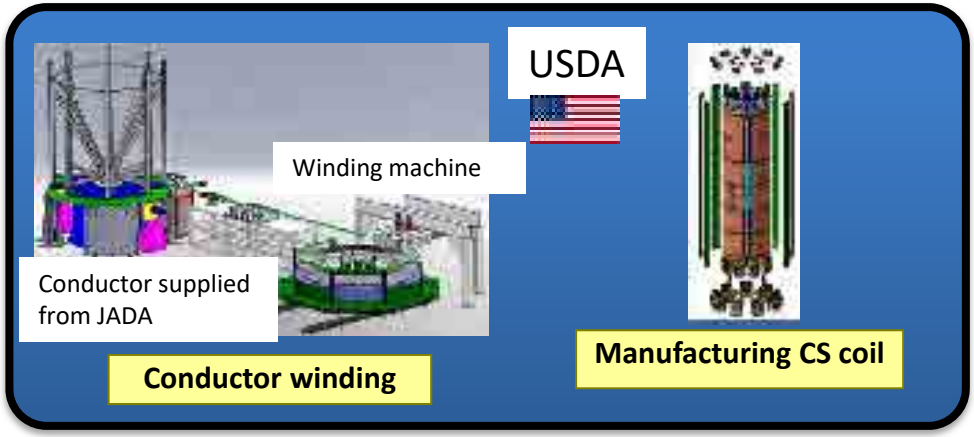
Mar. 2018: 49 CS conductors transportation to USDA completed.

Completion of the 49th CS conductor (at conductor fabrication factory)

49th CS conductor arrived at USDA







Neutral Beam Injector

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Development, manufacturing and testing of DC ultra high-voltage power supply to accelerate 1 MeV, 40 A hydrogen negative ion beam for neutral beam

NB test facility (NBTF) is under construction in advance of ITER

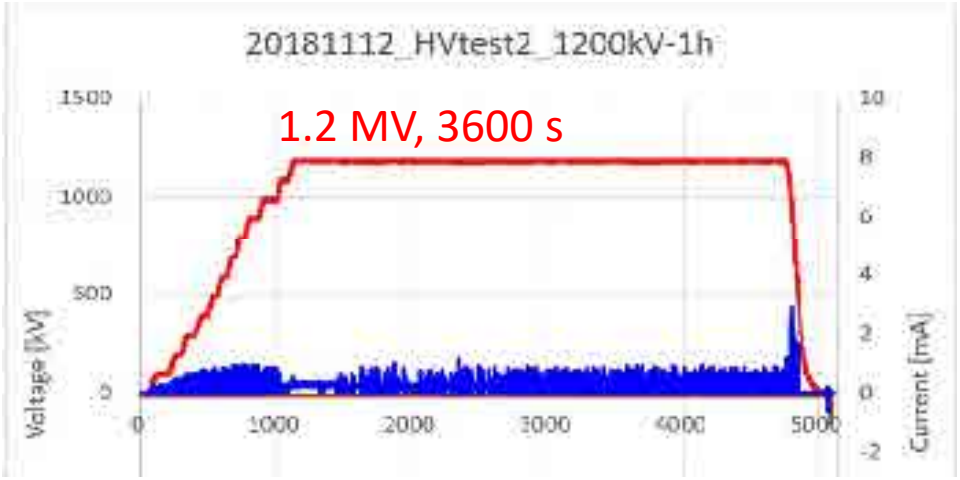
【Requirement on high-voltage power supply】

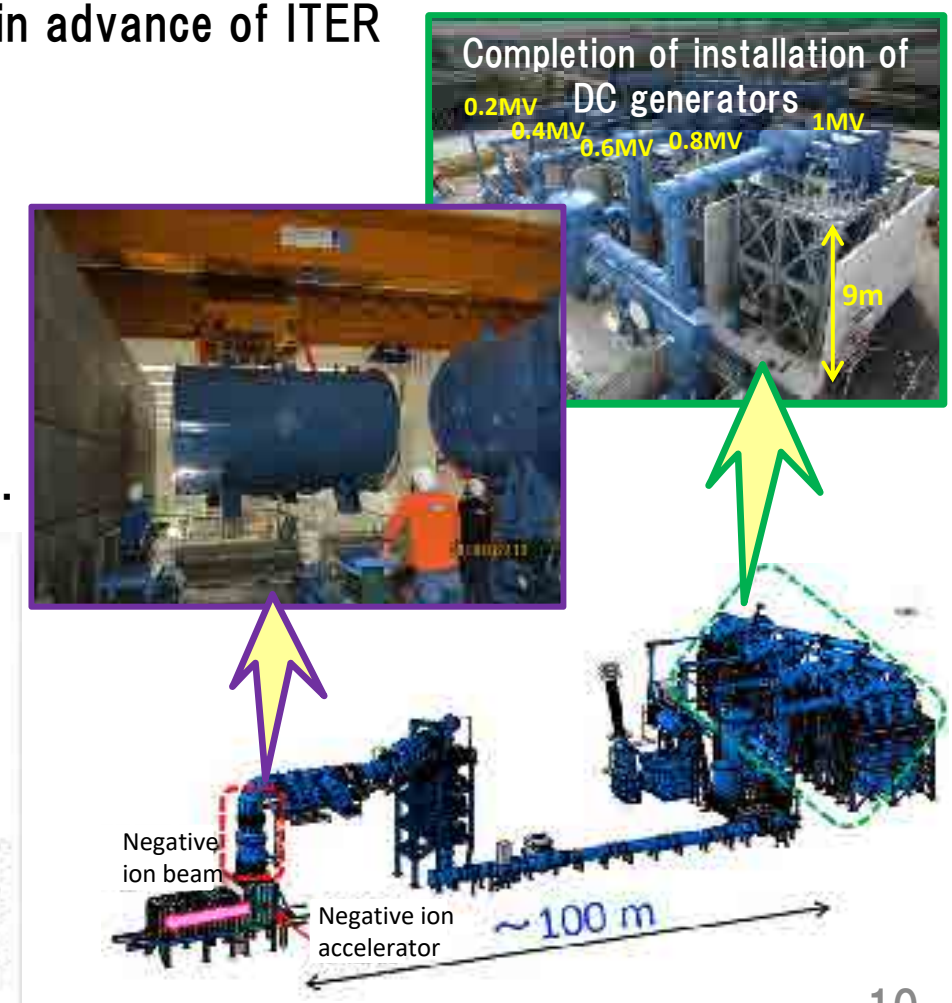
DC 1 MV, 60 A with pulse duration 3600 s.

Completion of

- manufacturing of all component
- installation except interface with EU (97%)
- voltage holding test of Japanese components at 1.2 MV in November

Next step is the joint test with EU component.





Neutral Beam Injector

Naka Fusion Institute

Neutral Beam Injector

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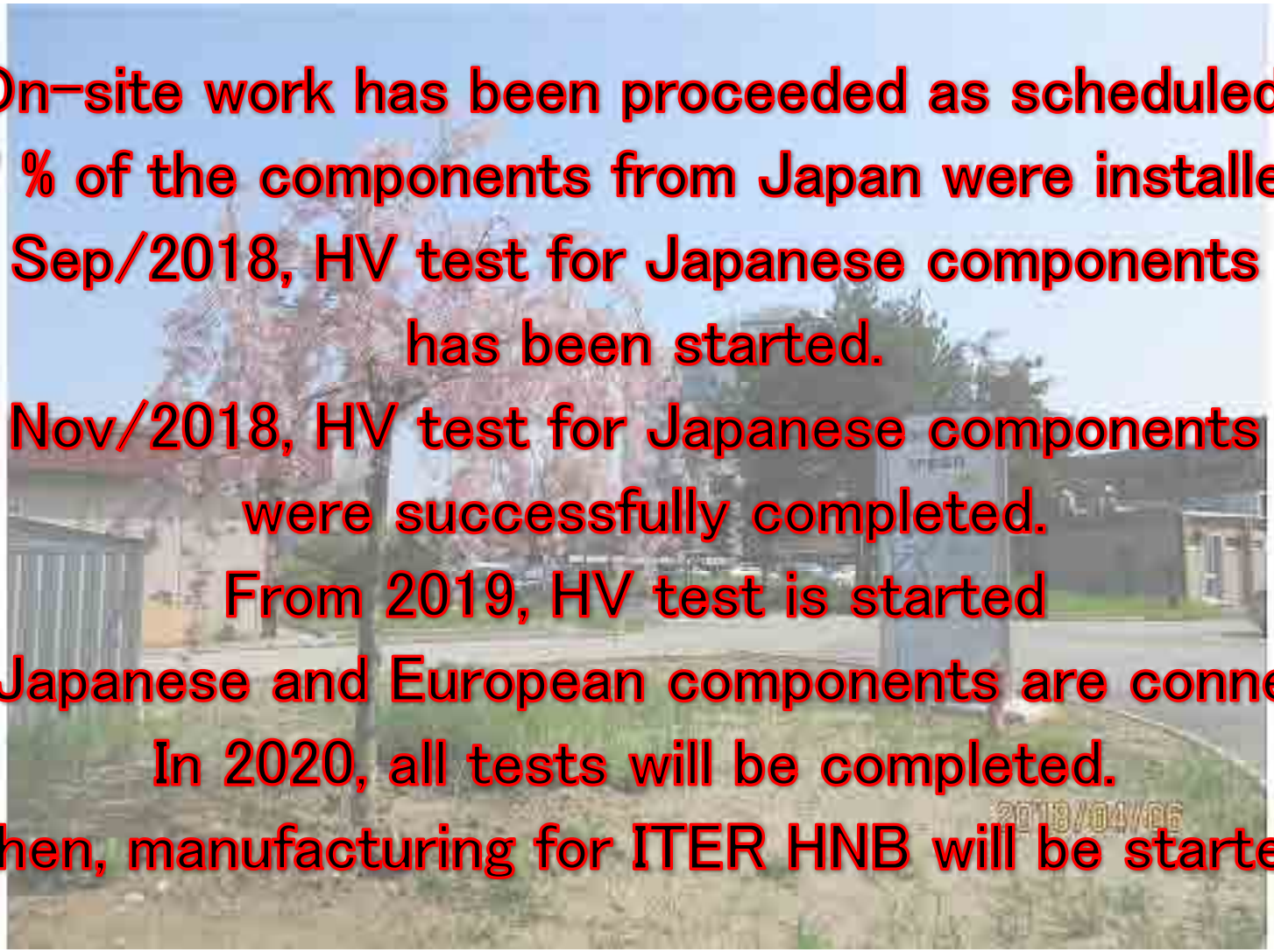

On-site work has been proceeded as scheduled.
97 % of the components from Japan were installed.
Sep/2018, HV test for Japanese components has been started.
Nov/2018, HV test for Japanese components were successfully completed.
From 2019, HV test is started after Japanese and European components are connected.
In 2020, all tests will be completed.
Then, manufacturing for ITER HNB will be started.

Progress in Production of Japan-shared ITER Components
Electron Cyclotron Heating System

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Completion of FAT for first JA-Gyrotron that generates ITER first plasma

High-power mm-wave oscillator
GYROTRON

JA procures 8 out of 24 sets.

[Requirements of factory acceptance test (FAT)]

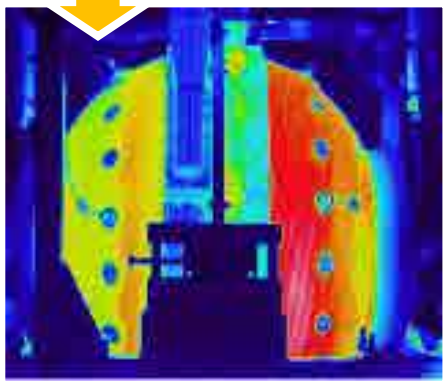
- Frequency/Power/Efficiency: 170GHz/ ≧ 1MW/ ≧ 50%
- Full-power modulation: 1～5kHz/ ≧ 60sec
- Duration time: ≧ 300sec
- Operation reliability: ≧ 95%

[Achievements/Progress]

- FAT of 1st gyrotron completed and the on-site test is foreseen.
- Operation test of 2nd gyrotron was started, and manufacturing of 3rd gyrotron is underway.

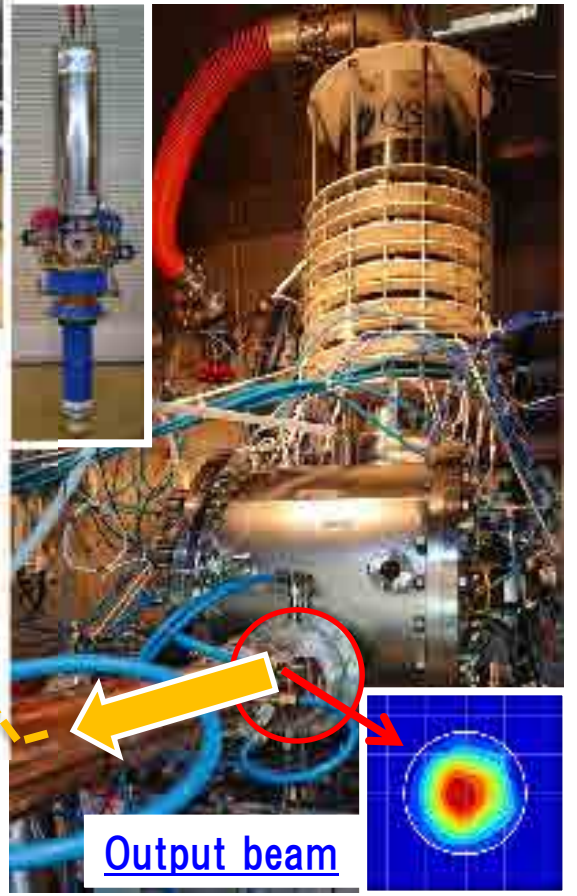
Test-stand for high-power and long-pulse operation

1MW power CW-injection



FAT completed

JA-GYROTRON system



Output beam

Procurement of ITER divertor outer vertical target - Manufacturing of full-scale prototype -

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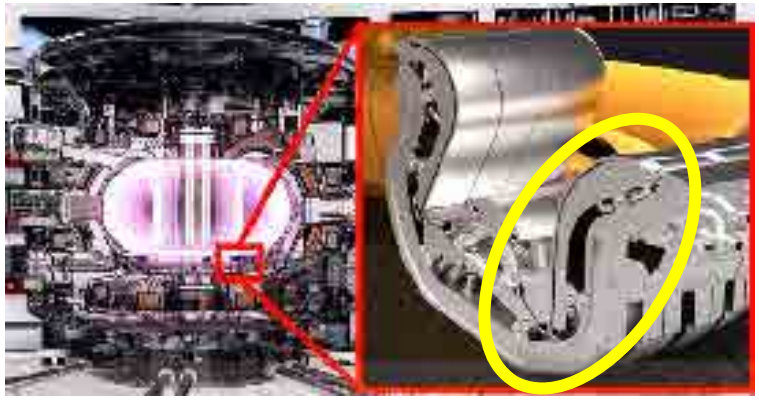
Plasma-facing material: Tungsten
Actively cooled by water
Heat flux: 20 MW/m^2



JADA and IO-CT have signed the amendment of the PA in November 2017. JADA has started material procurement for manufacturing of a full-scale prototype of the ITER divertor outer vertical target.

Manufacturing of tungsten monoblocks

About 3,600 tungsten monoblocks (including with or without support legs) are being manufactured.

Tungsten monoblock with a support leg

Manufacturing of stainless-steel forgings

XM-19 forging blocks and plates, which correspond to two outer vertical targets, are being manufactured.

XM-19 forging block

Detritiation System (DS)

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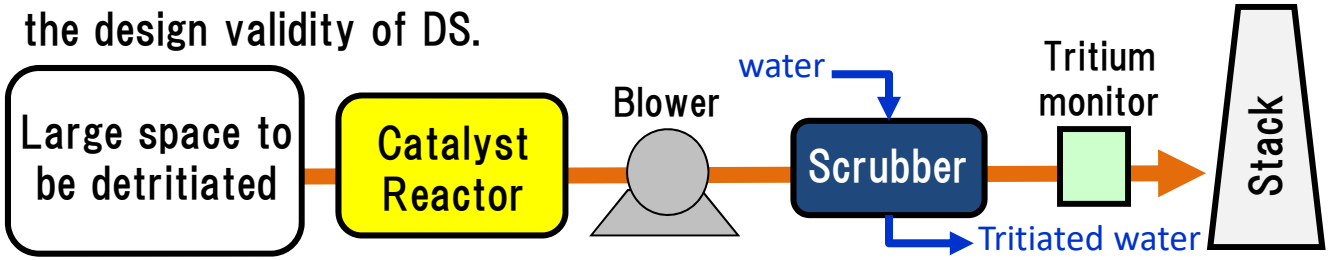
Detritiation System (DS) is a safety important component for ITER. According to the requirements of the French Nuclear Regulatory Authority, JADA is conducting the "DS qualification tests" to show the design validity of DS.

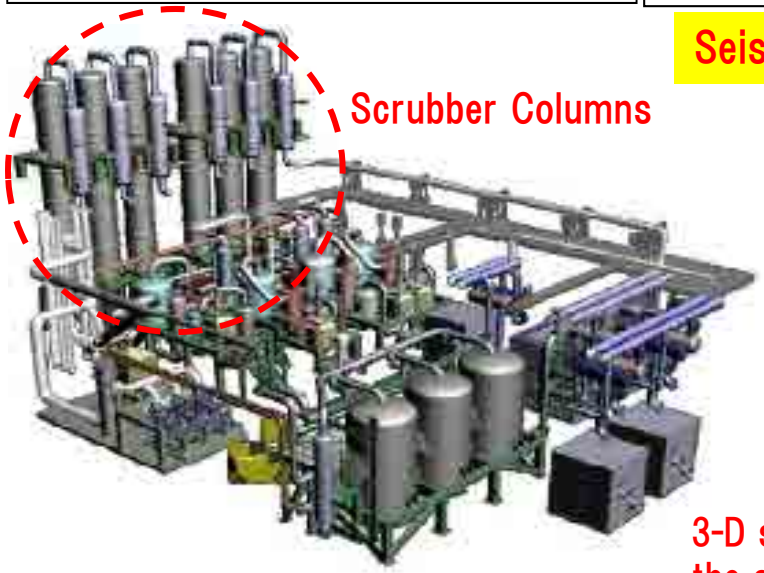


Specification of DS
Max. flow rate: 2,800m³/h
Tritium removal efficiency
Detritiation in an event of fire: 90%
Detritiation in other events: 99%
→Target detritiation efficiency is set to 99.9 % in design.

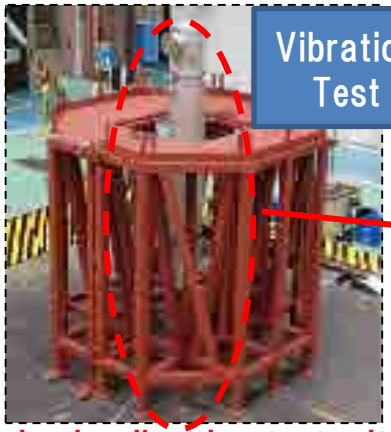
Catalyst reactor :
$2HT + O_2 \rightarrow 2HTO$
(tritium is oxidized to tritiated vapor.)

Scrubber : $H_2O(Liquid) + HTO(Vapor) \rightarrow H_2O(Vapor) + HTO(Liquid)$
(Tritium is collected in liquid.)

Seismic vibration test of the scrubber column was implemented.



A view of DS for ITER Tokamak Building



3-D seismic vibration test with the simulated floor response of the ITER site.

No reduction in detritiation efficiency occurred in the scrubber column after the seismic vibration

Progress in Manufacture of Japan-shared ITER Components
Blanket Remote Handling System

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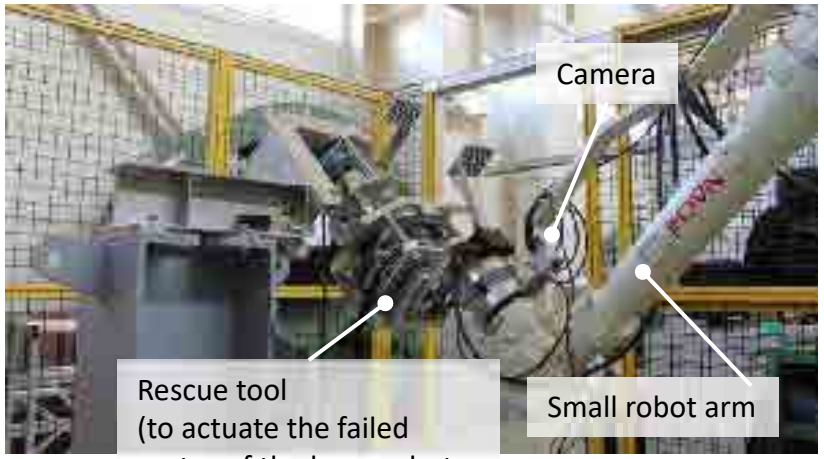
- A large robot arm to handle a Blanket module (max. 4 tons) with high accuracy is under development.
- Further studies for addition of new features:
  - Considering cost reduction for whole ITER project, function of fine manipulation was added to the Blanket Remote Handling System
  - Rescue function for the large robot arm was established using a small robot arm
- Blanket handling tests by the large robot arm are continued to improve precision (a movie in the next page)

New feature:
Fine manipulation

Feasibility was confirmed for the proposal of cost reduction by adding dual arm manipulator, which realize fine manipulation, to Blanket Remote Handling System

New feature:
Rescue function



Progress in Manufacture of Japan-shared ITER Components
Blanket Remote Handling System

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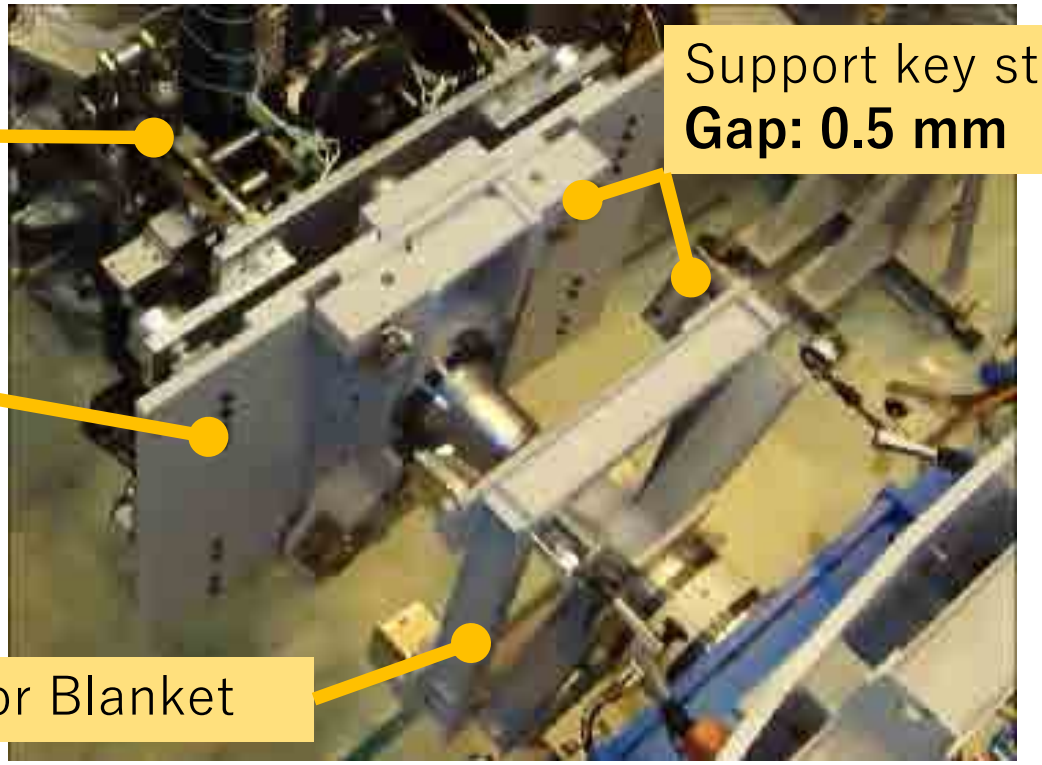
Blanket handling test

Challenge: insertion of large and heavy component with narrow gap



Progress in Manufacture of Japan-shared ITER Components
Blanket Remote Handling System

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ITER diagnostics procured by Japan making good progress

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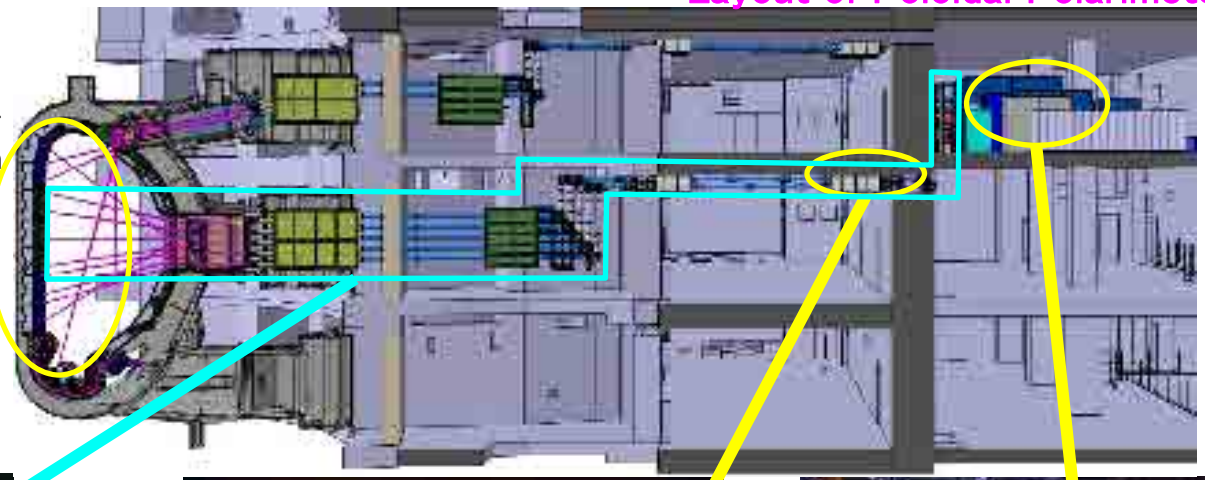
- Among five diagnostics procured by Japan, Poloidal Polarimeter and Edge Thomson Scattering systems are at the final design stage. Prototyping of major components to ensure that the final design is feasible has progressed.

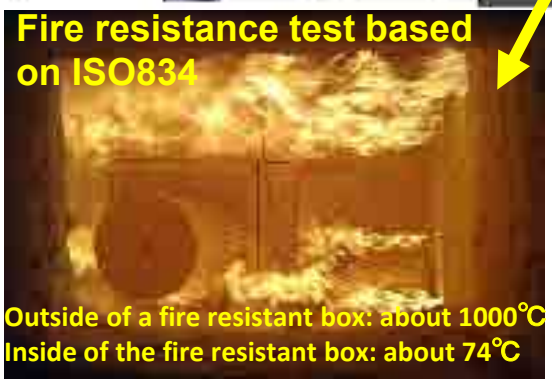
Layout of Poloidal Polarimeter

Retroreflector in the vacuum vessel

Confirmed that a retroreflector can be manufactured by grinding tungsten material, which is robust



Laser transmission line with the actual length. Currently evaluating the automatic alignment system and the influence of light attenuation



Performed fire resistance test on an airtight shutter in a fire-resistant box and confirmed the soundness

FIR laser prototype was manufactured and adjustment of the laser oscillation is ongoing (target value: output 600 mW with a wavelength of 119 mm)

Progress of Satellite Tokamak JT-60SA Project in Broader Approach Activities

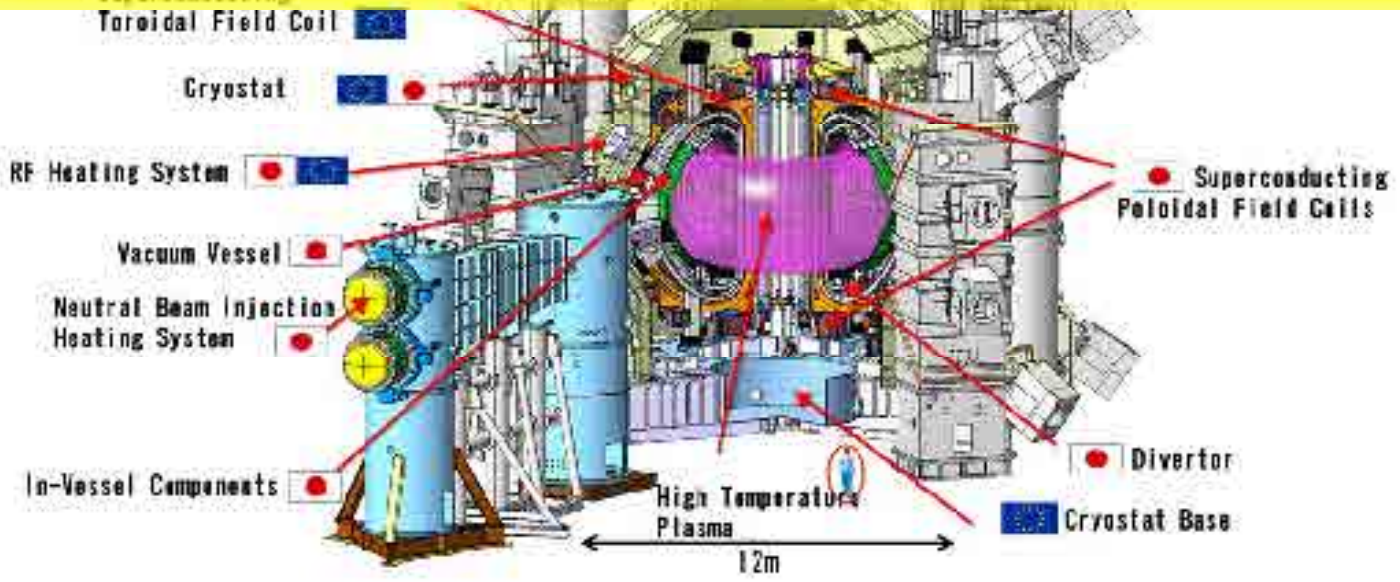
JT-60SA *(Super Advanced)* Project

Naka Fusion Institute

JT-60 with copper coils is upgraded to a new device JT-60SA (Super Advanced) equipped with superconducting coils. Objectives of the project are

- to conduct leading research to support ITER in achieving its technical objectives and to reflect the results on how to optimize experimental operations of ITER,
- To try to develop more advanced operations than ITER and reflect them in the Fusion Demo design,
- to cultivate experts who can lead experimental research and next-generation R&D.

Under construction
aiming at starting operation in 2020 !



Non-use of tritium makes flexible studies possible.

Japan-EU Joint Project

QST is the Implementing Agency of Japan.

JT-60SA Project:Progress on Tokamak Assembly

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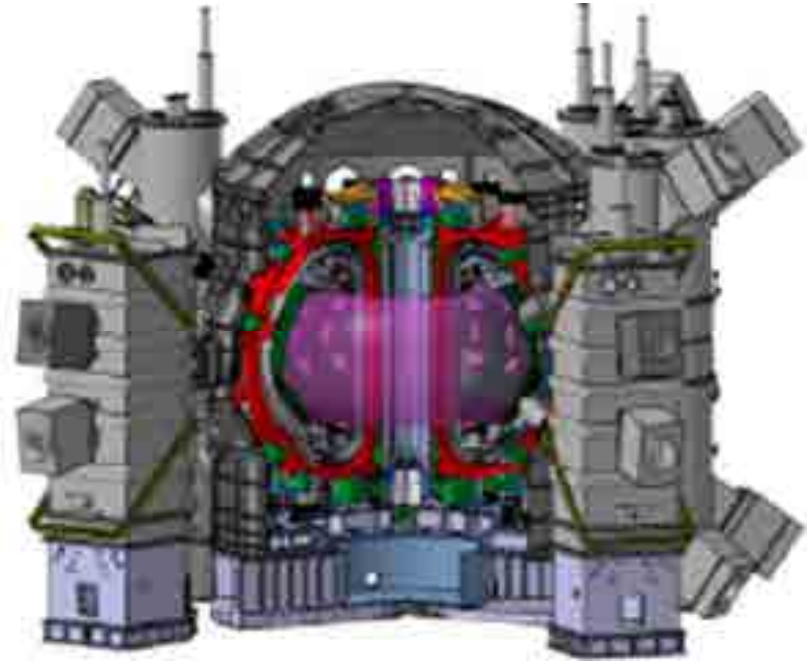
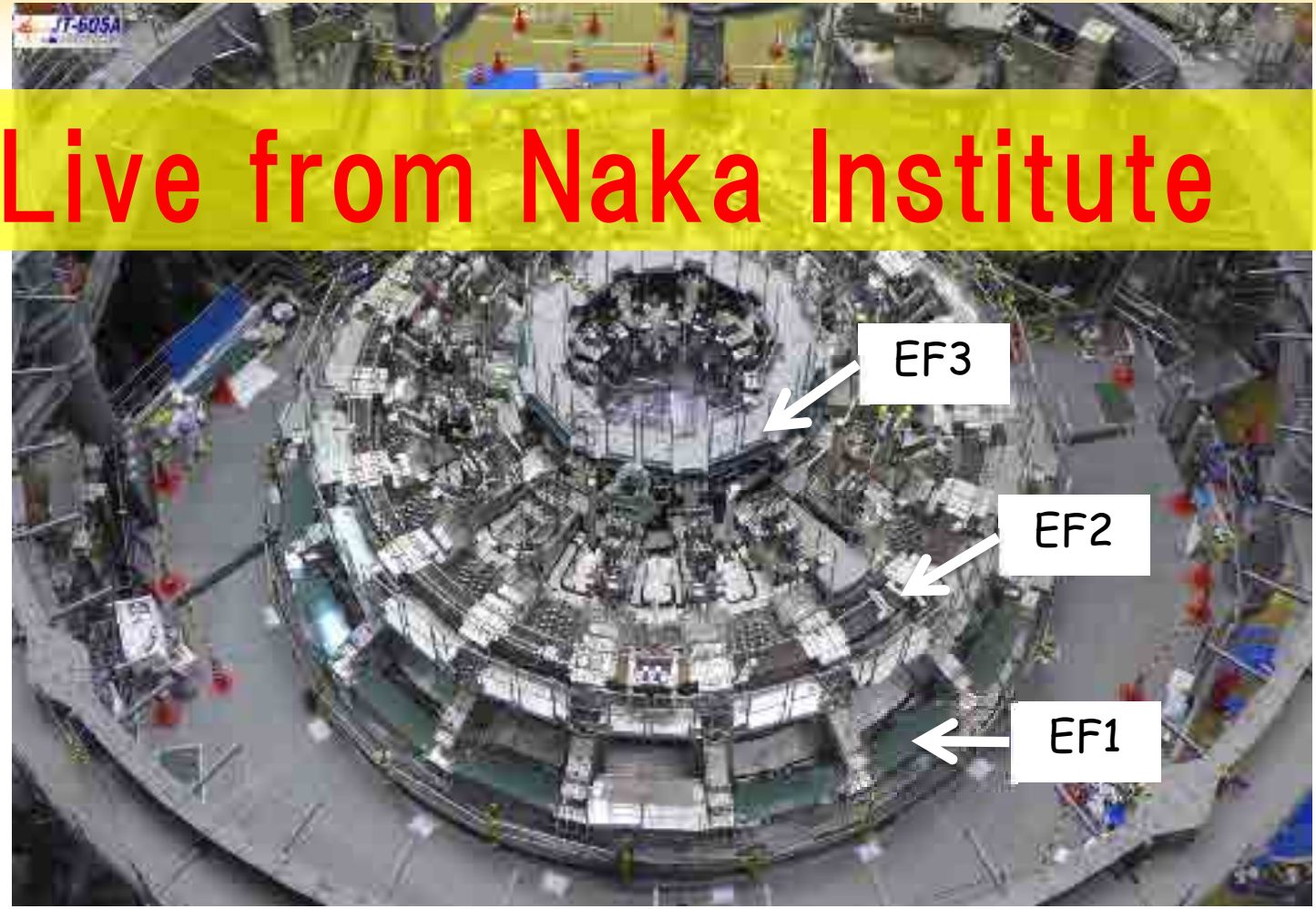


Movie of JT-60SA Assembly History

JT-60SA Project：Progress on Tokamak Assembly

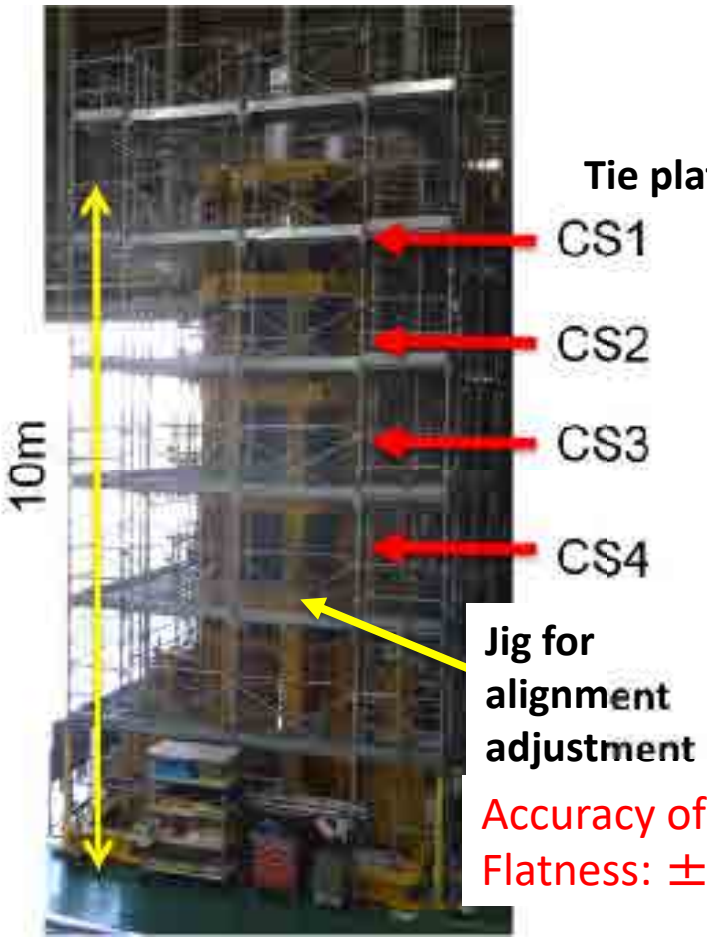


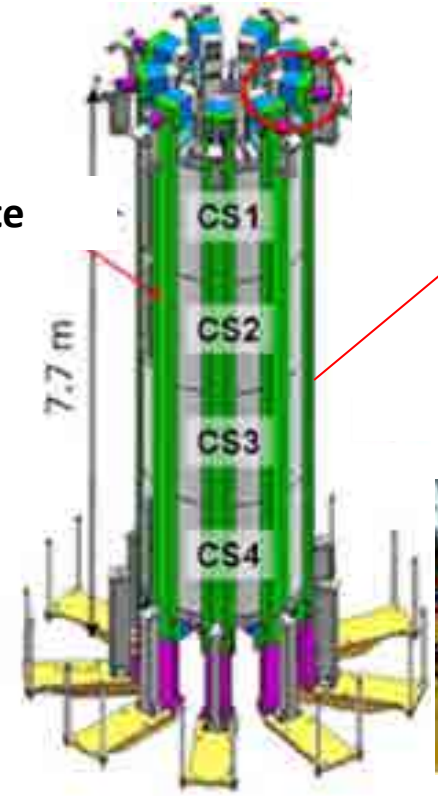
Live from Naka Institute

Towards start of operation in 2020, the construction is going on schedule.

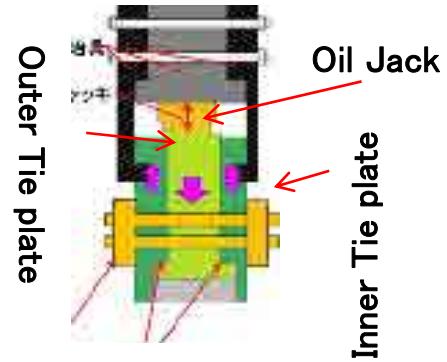
Central solenoid CS
Manufacturing is going well.

Manufacturing is facing the final stage where four modules are stacked and compressed one another by a force of 4.2 MN to suppress the separation of modules by thermal stress and/or electro magnetic force.





Cross section of CS top

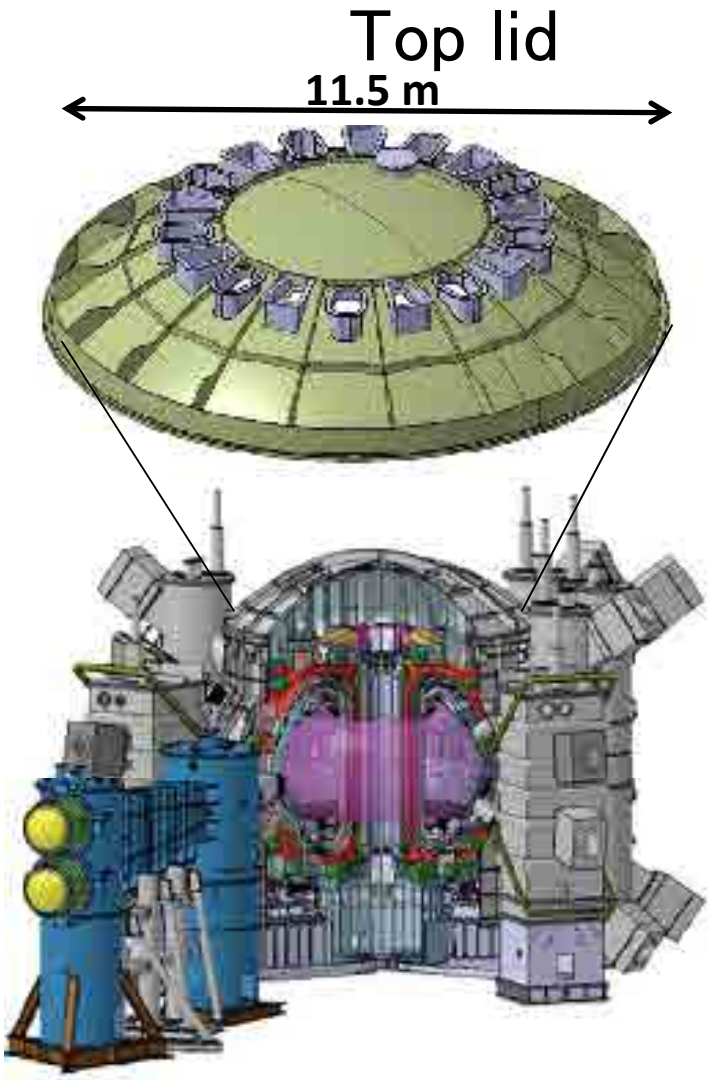


Accuracy of position at current center :±0.8mm (design:±1.0 mm)
Flatness: ±0.7mm (設計値 ±1.0 mm)

CS will be delivered in FY 2018.

Cryostat Top Lid

Manufacturing is going well.



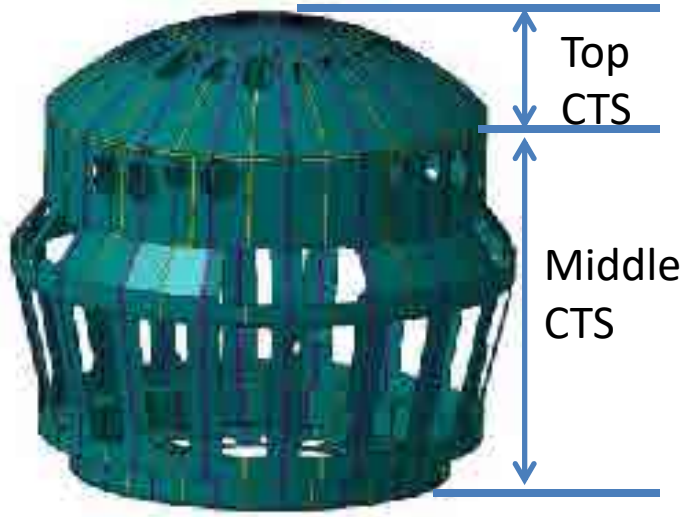
Two of the half modules are being manufactured in factory and will be integrated on-site.

The top lid will be delivered in first quarter of FY 2019.

Cryostat Thermal Shield (CTS)

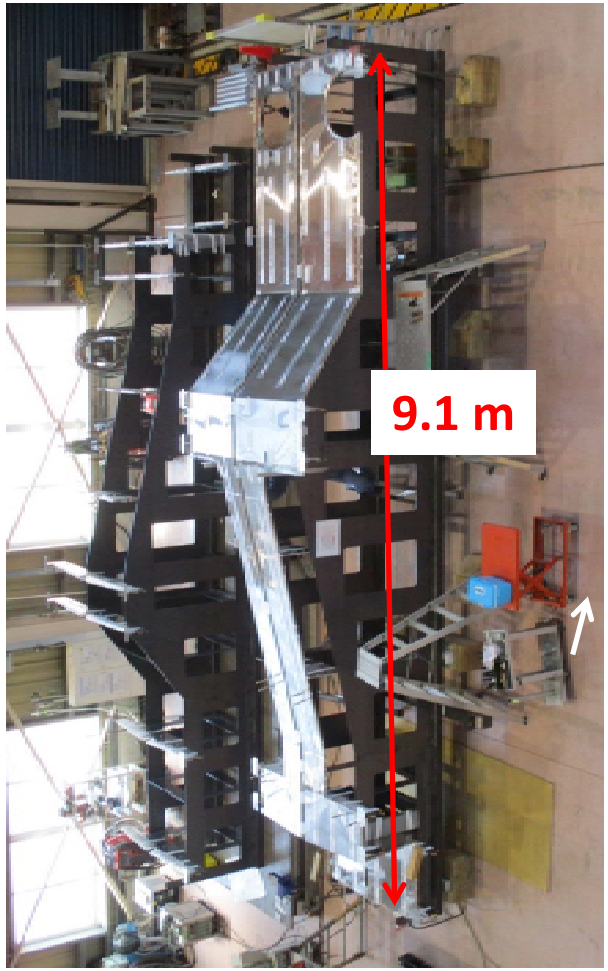
Manufacturing will be completed in FY 2018

CTS is installed on the inner wall of cryostat to suppress thermal radiation.



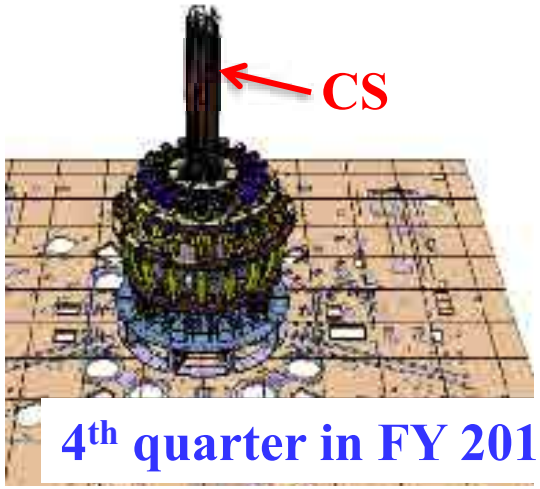
Top CTS 20° 10/18 completed

Middle CTS 20° 13/18 completed.

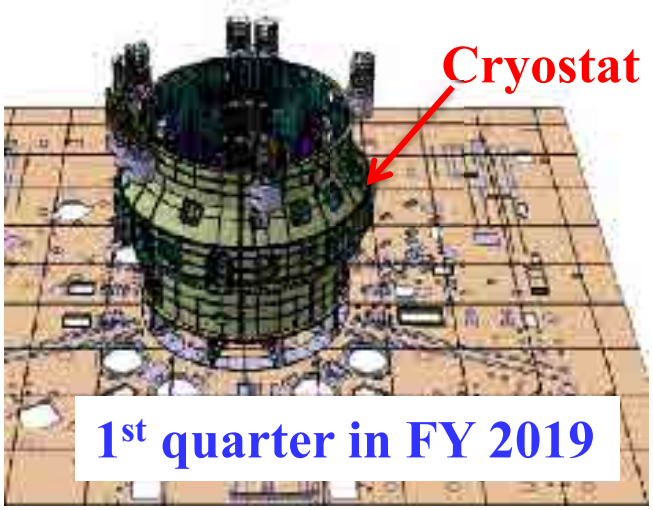


Future Plan

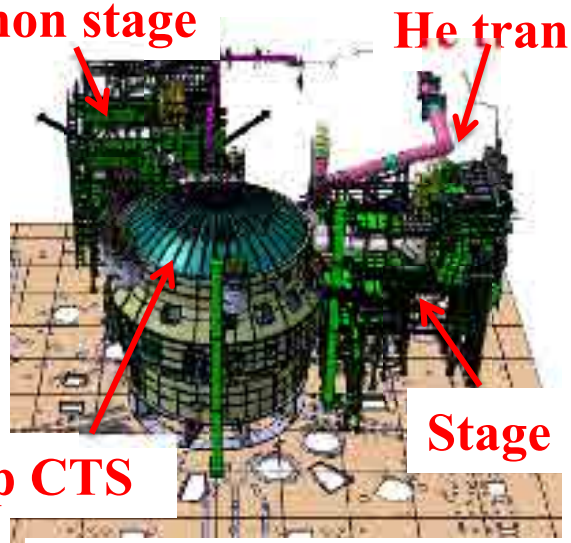
JT-60SA Assembly will be completed in the 4th quarter of FY 2019.



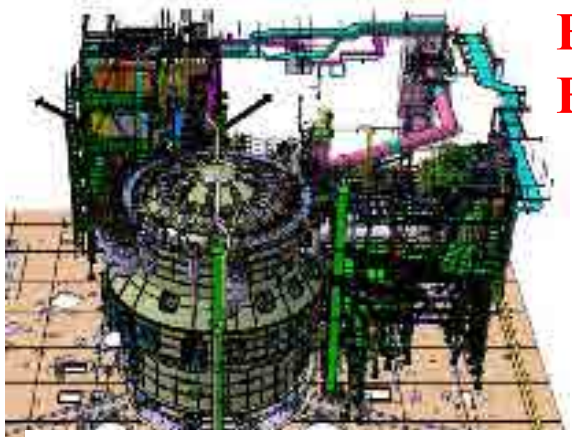
4th quarter in FY 2018



1st quarter in FY 2019

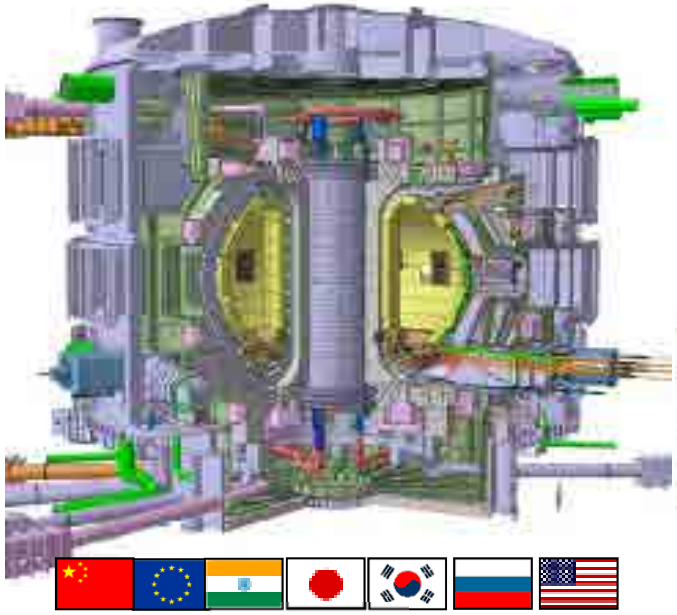


3rd quarter in FY 2019

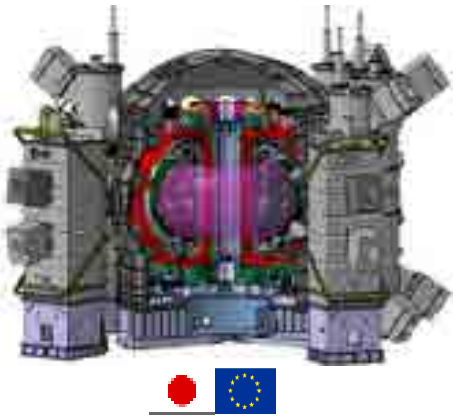


4th quarter in FY 2019
Completion (March, 2020)

Thank you for your attention!



ITER



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