Asian Linear Collider Workshop 2018 (ALCW2018)
May 28 – June 1, 2018 *Fukuoka, Japan*

Japanese Contribution to the ITER Project for the International Collaboration of Fusion Research

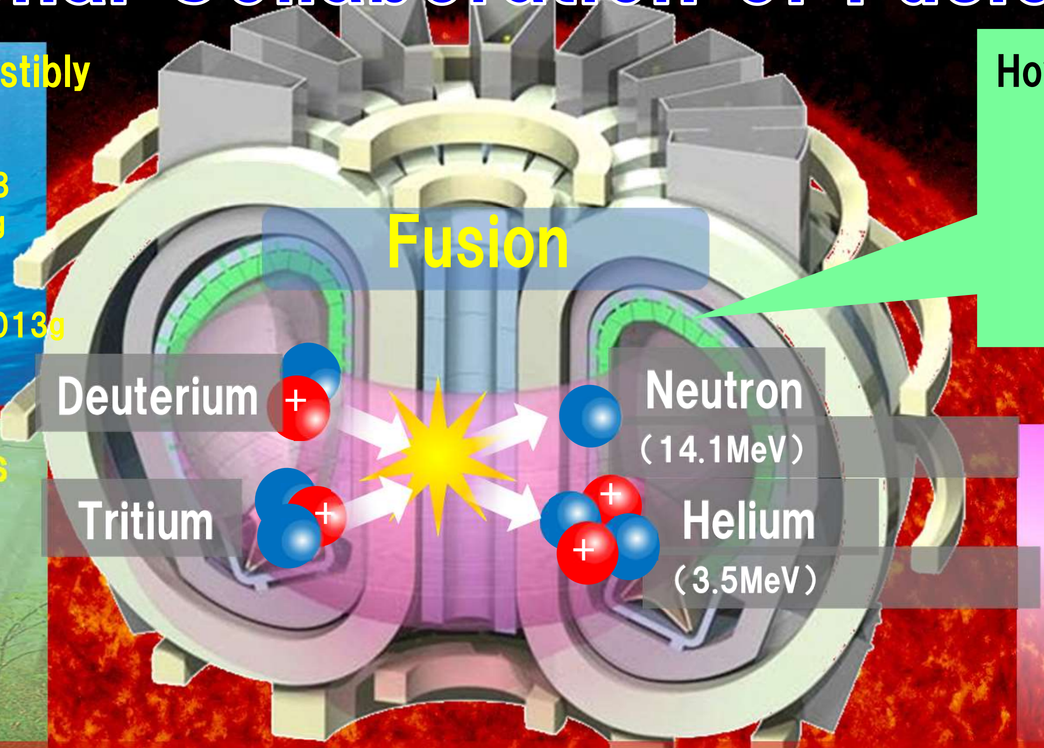
Deuterium and lithium are inexhaustibly included in the sea water.

Fusion can generate energy equivalent to 8 tons of oil with 0.4g of deuterium and 0.6g of tritium.

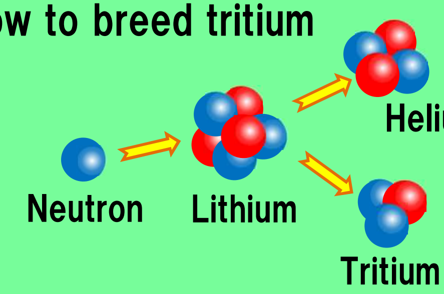
Deuterium of ~33g and lithium-6 of ~0.013g exist in 1m^3 of sea water.

No emission of greenhouse gases

No emission of high-level rad-waste



How to breed tritium



Fusion reaction can be easily stopped by closing the fuel supply valve.

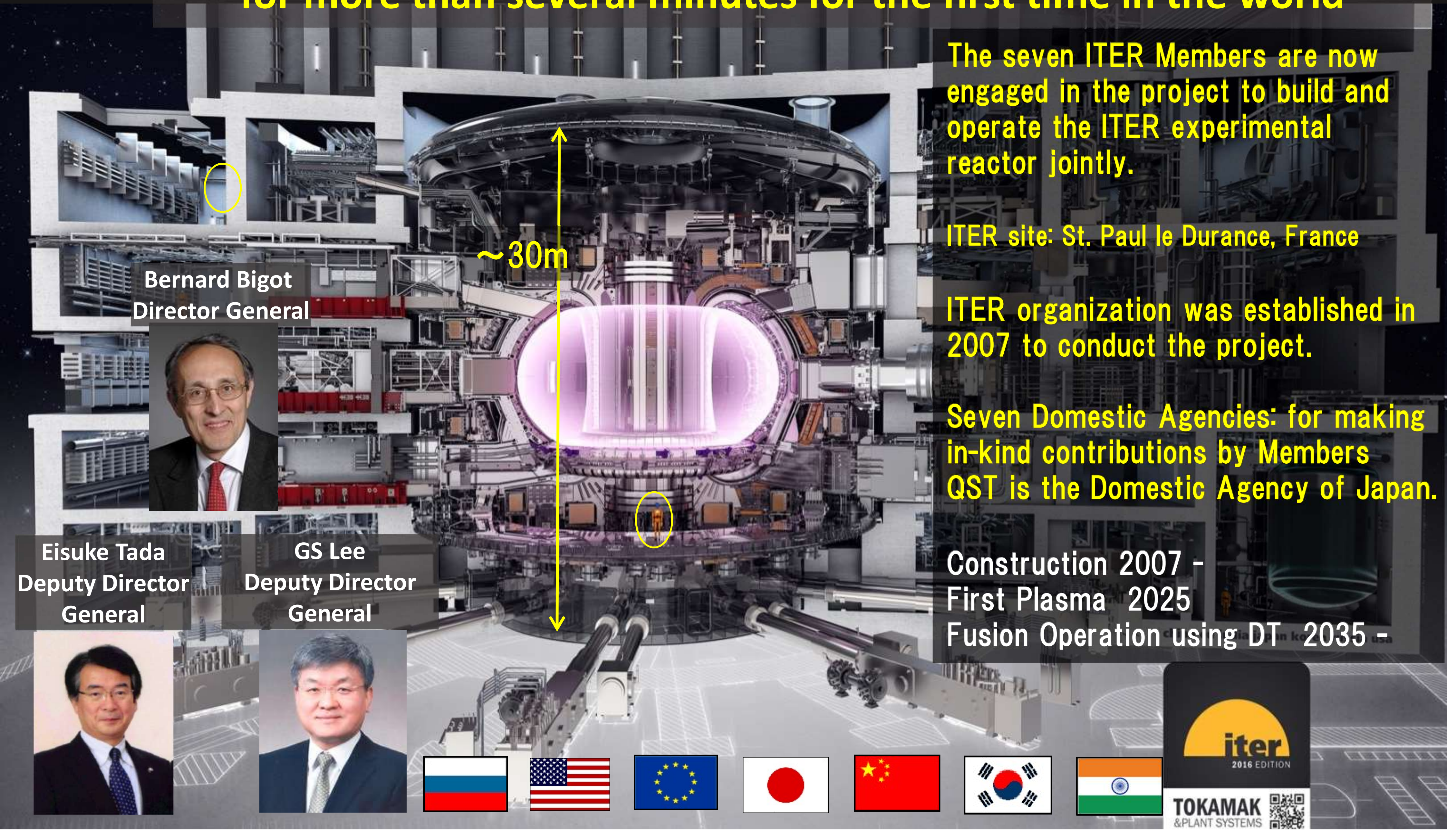
It is necessary to heat deuterium and tritium to a temperature exceeding 100million ℃ for fusion reaction.

NASA/GSFC/Solar Dynamics Observatory

Masahiro Mori
National Institutes for Quantum and Radiological Science and Technology (QST)

ITER Project: An international project

to demonstrate Fusion output of 500MW maintained for more than several minutes for the first time in the world



Bernard Bigot
Director General

Eisuke Tada
Deputy Director General

GS Lee
Deputy Director General

The seven ITER Members are now engaged in the project to build and operate the ITER experimental reactor jointly.

ITER site: St. Paul le Durance, France

ITER organization was established in 2007 to conduct the project.

Seven Domestic Agencies: for making in-kind contributions by Members
QST is the Domestic Agency of Japan.

Construction 2007 -
First Plasma 2025
Fusion Operation using DT 2035 -

iter 2016 EDITION
TOKAMAK &PLANT SYSTEMS

Roadmap to Realize Fusion Energy

Experiment Phase

(Scientific Feasibility)

Achievement of High Temperature Plasma

JT-60

The highest fusion energy gain: 1.25
The highest ion temperature: 520M K

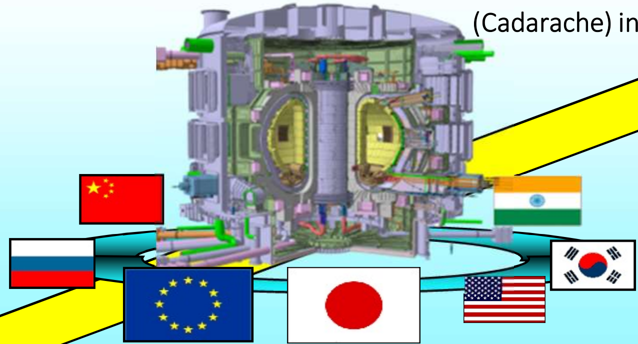
Experimental Reactor Phase

(Scientific and Technological Feasibility)

500 MW Fusion Power output
Long pulse fusion burning

ITER

The site is located at St Paul-Lez-Durance (Cadarache) in France



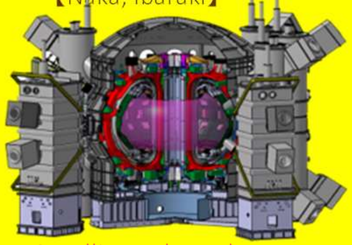
Support for ITER Project

Broader Approach (BA) Activities

Development of:

- Technical basis for PROTOTYPE reactors
- ITER operation scenarios, etc.

【Naka, Ibaraki】



Satellite Tokamak (JT-60SA)

International Fusion Energy Research Centre

DEMO Reactor Phase

(Technological Demonstration & Economic Feasibility)

Prototype

Demonstration of:

- **Power generation,**
- **Economic prospect**

Technologies for DEMO, complementing ITER

Commercial Reactor

Progress of ITER Project

1985 | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2025 | 2030

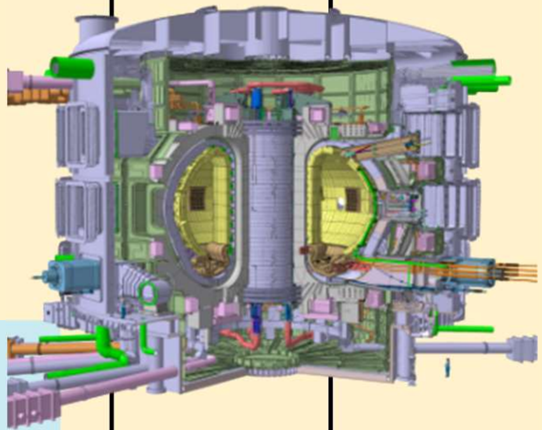
Japan
US
EU
Soviet Union/Russia

US withdrew

US, China joined

Korea joined

India joined



CDA Conceptual Design Activities

EDA Engineering Design Activities

Geneva Summit

The launch of an international effort on fusion: Reagan and Gorbachev at the Geneva Superpower Summit (1985).

Informal intergovernmental talks

intergovernmental negotiation

Domestic procedures

Canada site proposal

Japan & EU site proposal

Agreed on EU site (St. Paul lez Durance)

ITER Organization established

CTA Co-ordinated Technical Activities

ITA ITER Transitional Arrangements

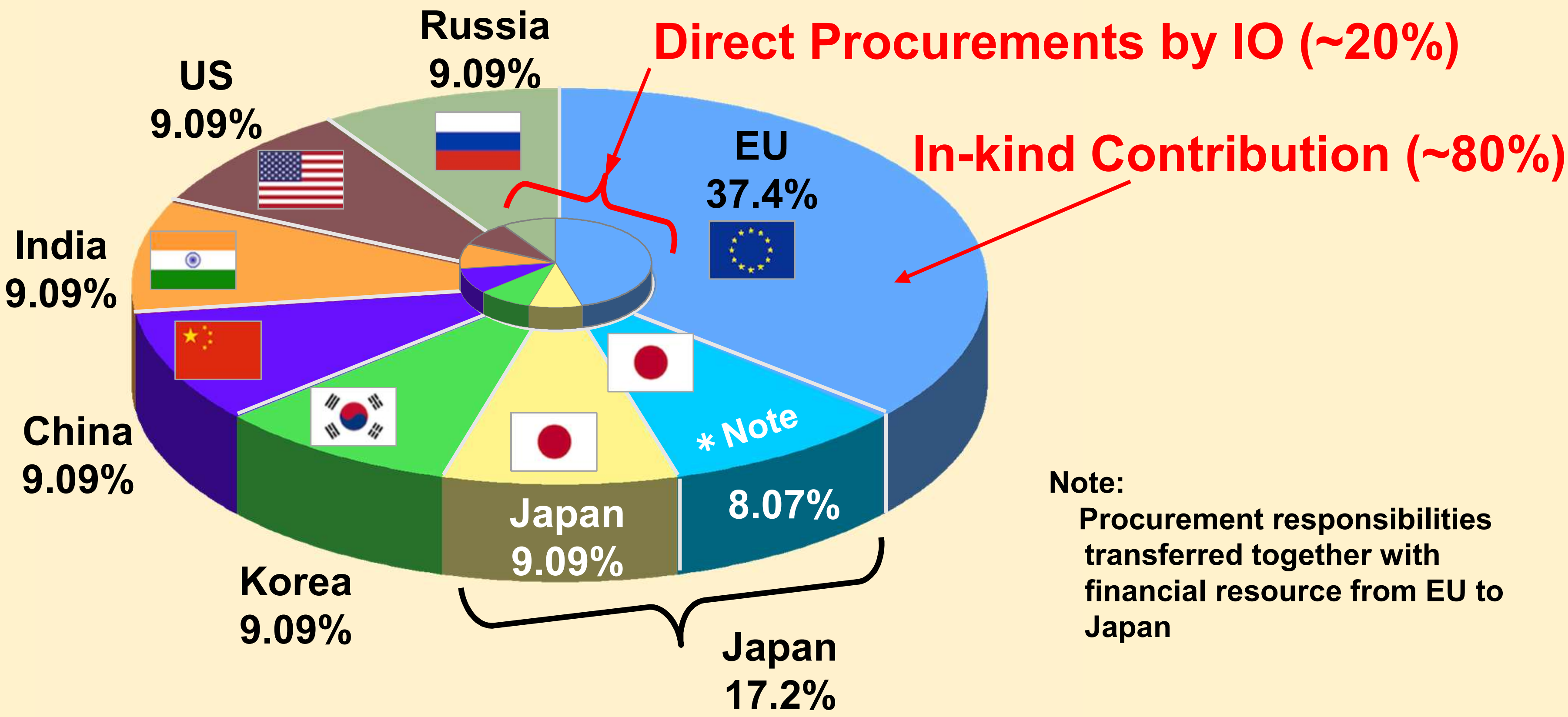
Construction

First Plasma

Operation

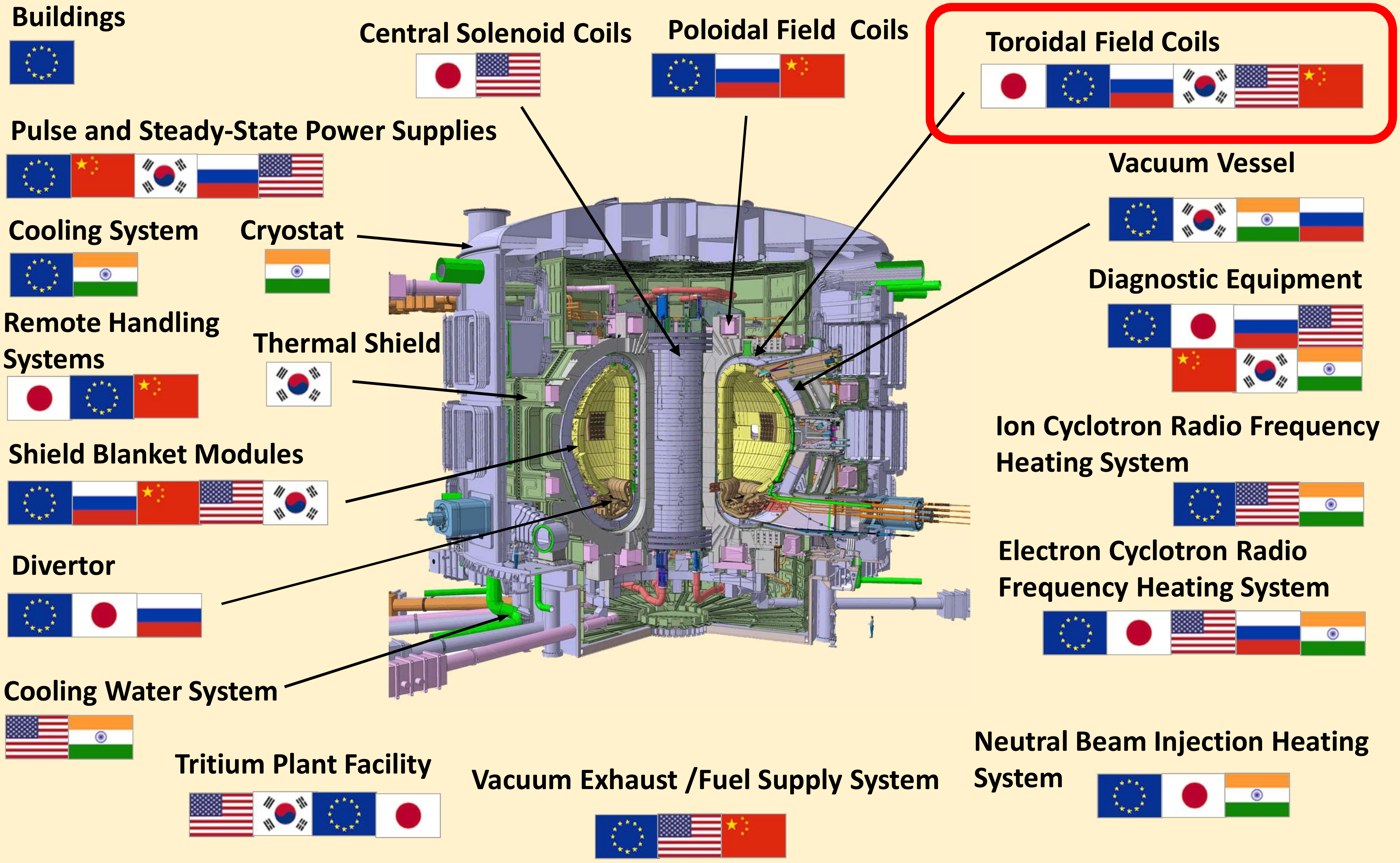
Procurements for ITER Construction

- **In-kind Contribution by seven members（~80%）**
  About 80% of procurements for ITER construction is covered by in-kind contribution by seven members. Each domestic agency (DA) of each member is responsible to the member's in-kind contribution.
- **Direct Procurements by ITER Organization (IO)（~20%）**
  The ITER Organization directly makes contracts for design integration and assembly/installation of the components at the construction site.



Sharing Ratios of In-kind Contribution among ITER Members

Procurement allocation among seven Members



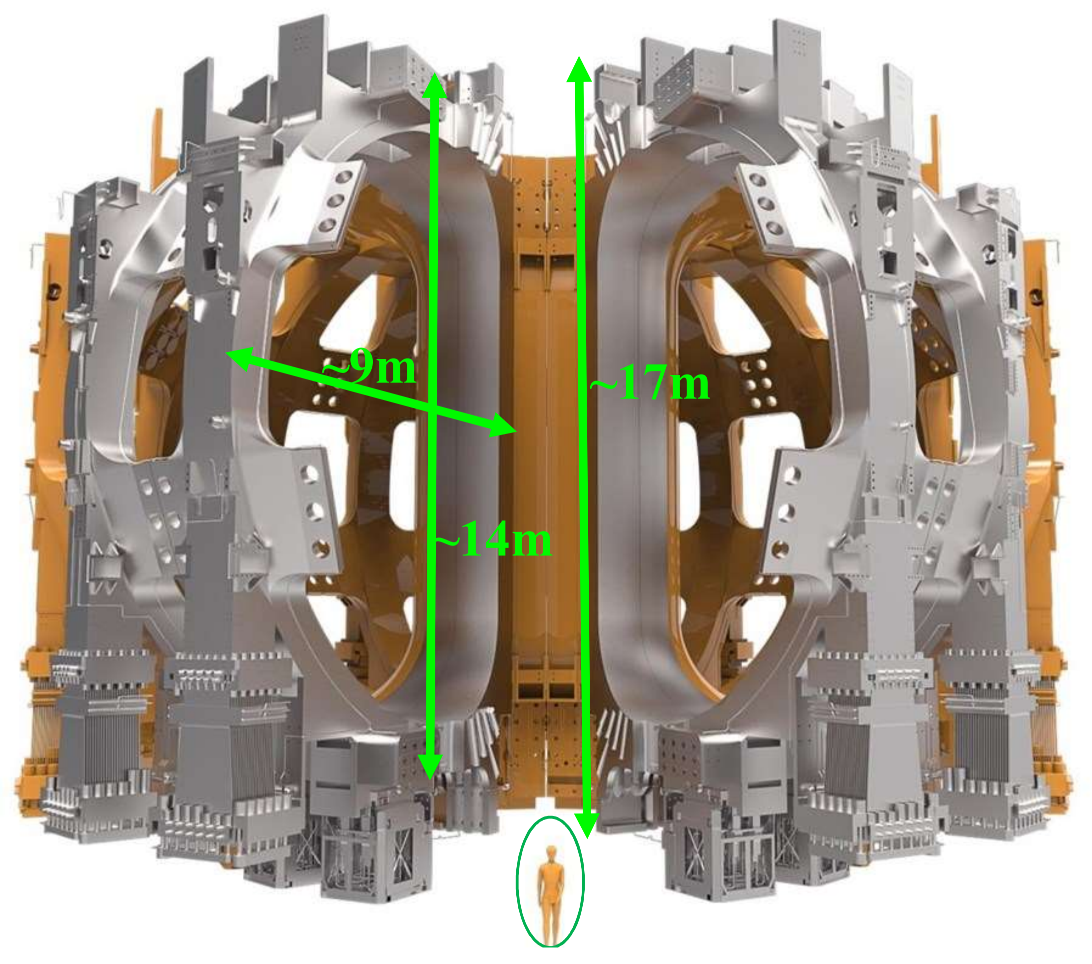
Superconducting Toroidal Field Coils

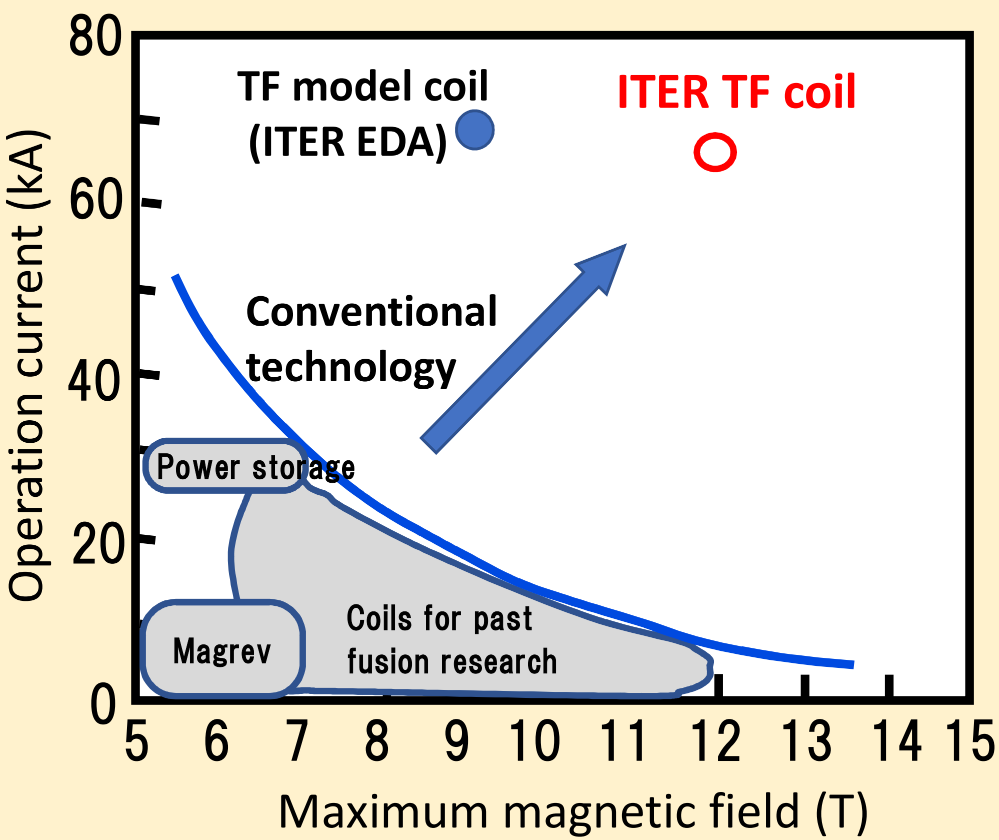
Total magnetic energy at all 18 coils: 41 GJ
Weight: 310 tons per coil
Superconducting material: $Nb_3 Sn$,
Supercritical helium cooling

Procurement: 19 coils including one spare

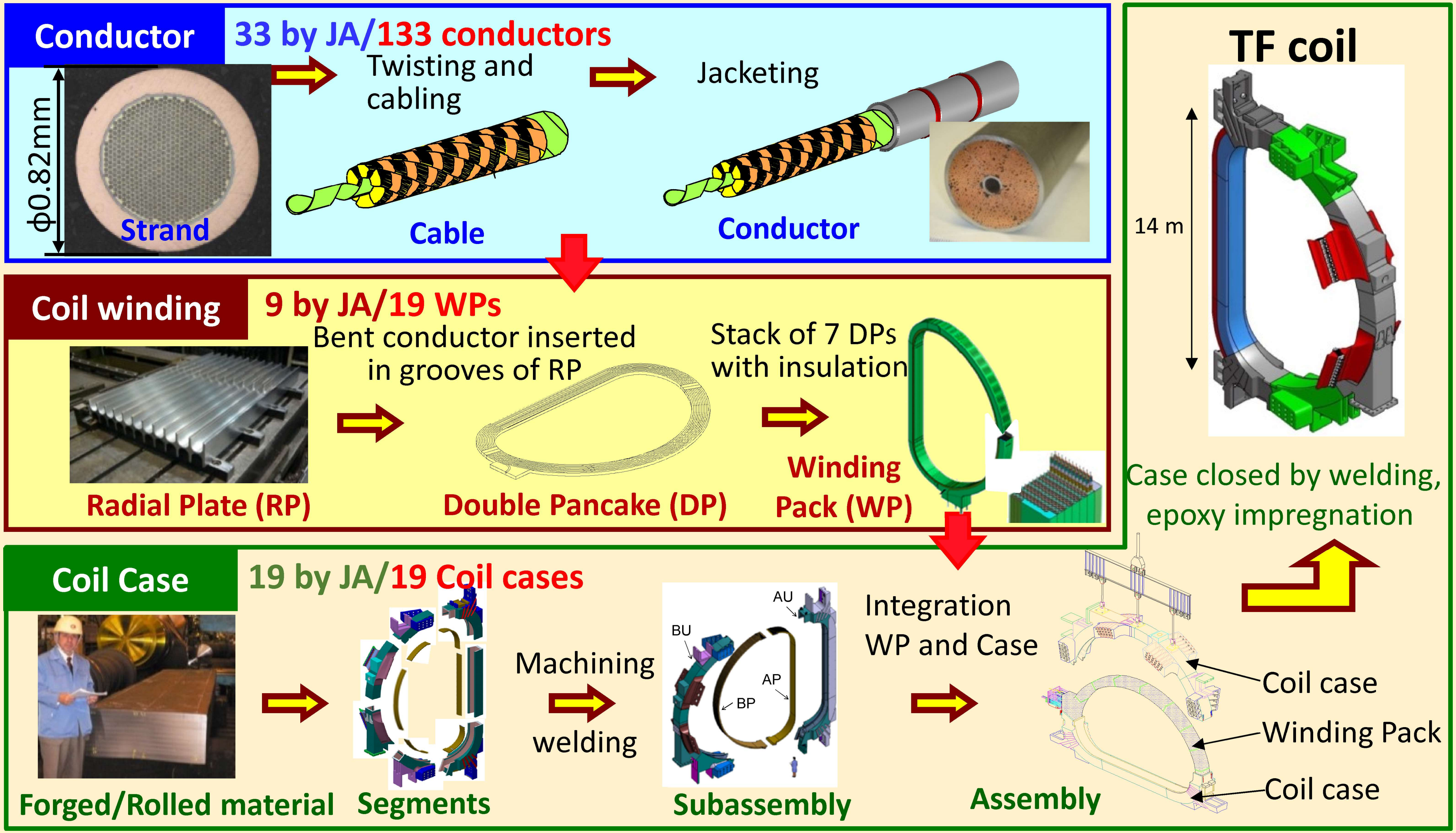
Challenging technical features

- Extremely large (9 x 17 m) ··· the world's largest superconducting coils
- High current (65 kA) in high magnetic field (maximum 11.8 Tesla)
- High precision ← Interfaces, magnetic field accuracy, low distortion
- High strength at cryogenic temperature (~ 4 ° K) withstanding strong electromagnetic force → special stainless steel for coil case etc.

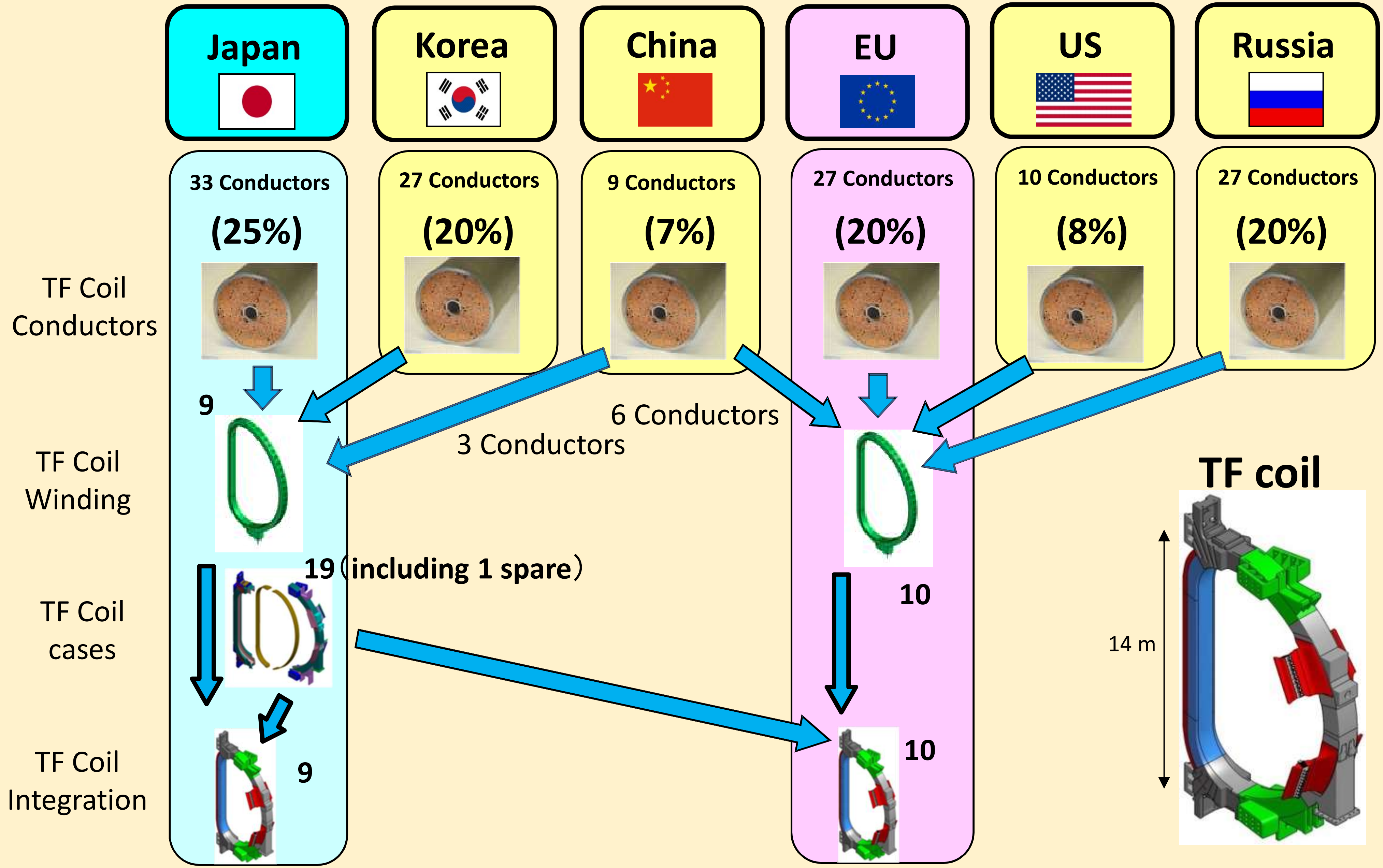




Process for making Toroidal Field (TF) Coil



International Procurement Allocation of the TF Coils



Completion of TF Conductors Procurement by Japan

QST

Manufacturing strands

(1 to 20km per strand)

Strand cross section (ϕ0.82mm)

Strands wound on bobbins

Total produced:
23,000 km
(appx 100 tons)

Manufacturing cables

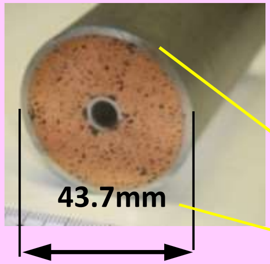
Stranded conductor wound on a bobbin

Total produced:
760 m x24
415m x9

Manufacturing of conductors

- 760 m (7.3 ton) x 24, 100% complete
- 415m (4.0 ton) x 9, 100% complete

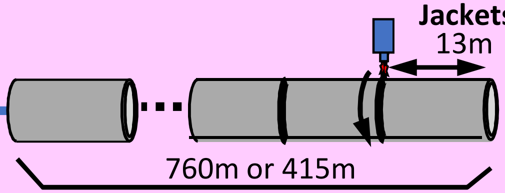
Conductor manufacturing facility



A finished conductor

Jackets (13m)

Jackets joint by butt welding
and inspections

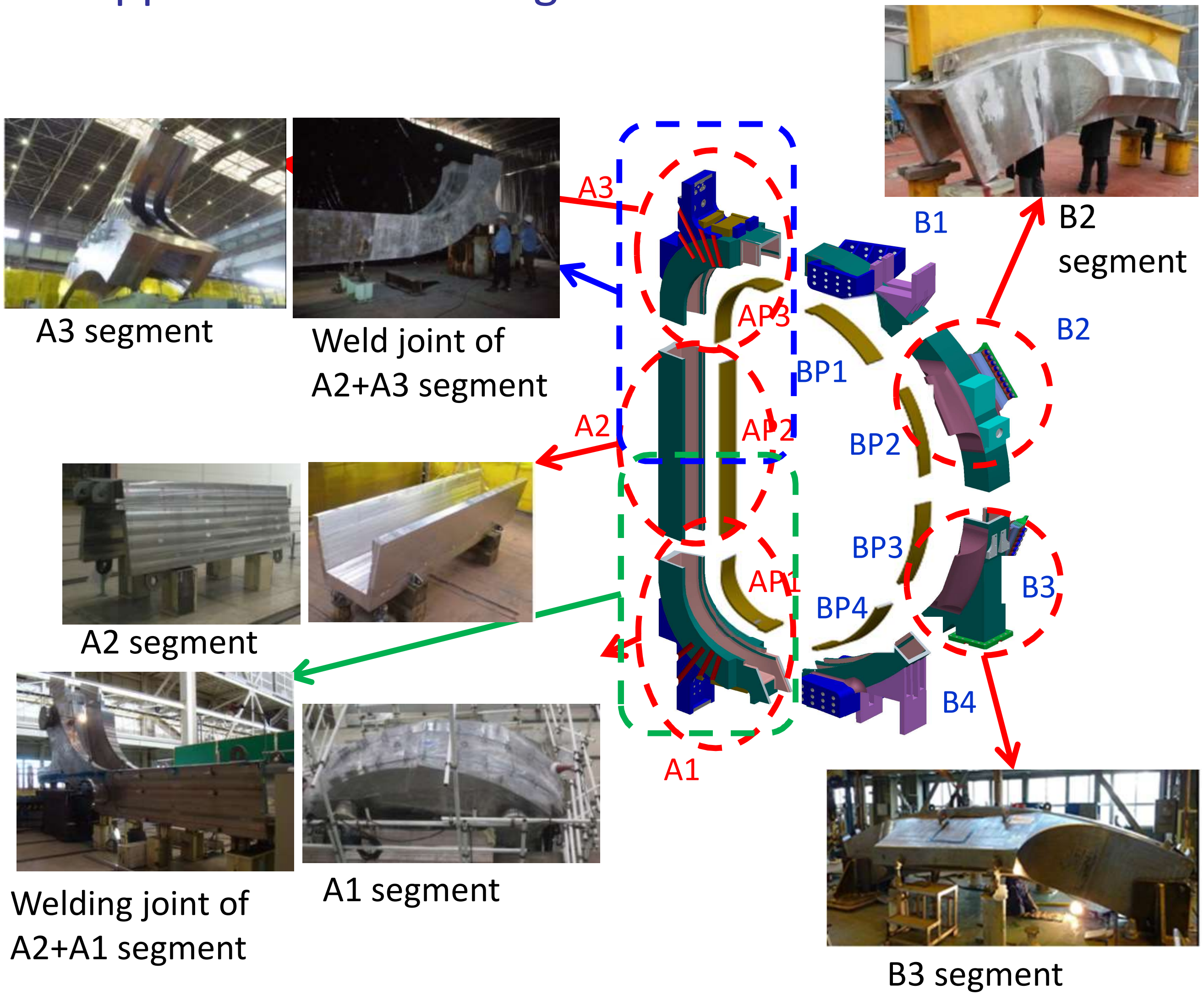


Lead-in of stranded conductor (<4 ton)
Compression molding
bending

Fabrication completed in 7 years, as scheduled (Dec. 2014 press release)

TF Coil Cases – tight tolerance

- Full-size prototypes have been manufactured for optimization of manufacturing technologies, such as suppression of welding deformation.



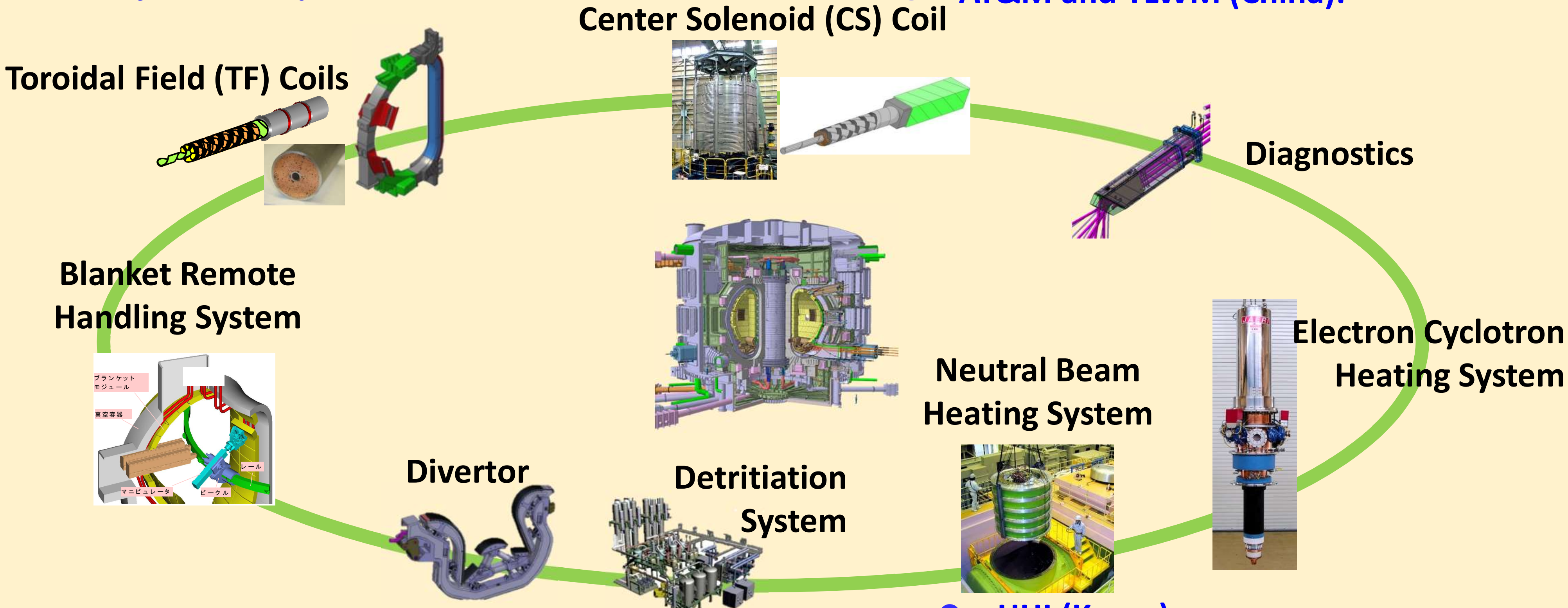
First TF coil case was completed by MHI and HHI in Jan. 2018.

MHI: Mitsubishi Heavy Industries (Japan)
HHI: Hyundai Heavy Industries (Korea)

Suppliers participating in procurements by Japan

- Furukawa Electric Co., Ltd.
- Hitachi, Ltd
- Hitachi Metals, Ltd.
- Japan Super Conductor Technology, Inc.
- J-Power Systems Corporation

- Mitsubishi Heavy Industries
- NIPPON STEEL & SUMIKIN Engineering
- TOSHIBA Corporation
- Toshiba Electron Tubes & Devices Co., LTD.
- AT&M and TLWM (China):



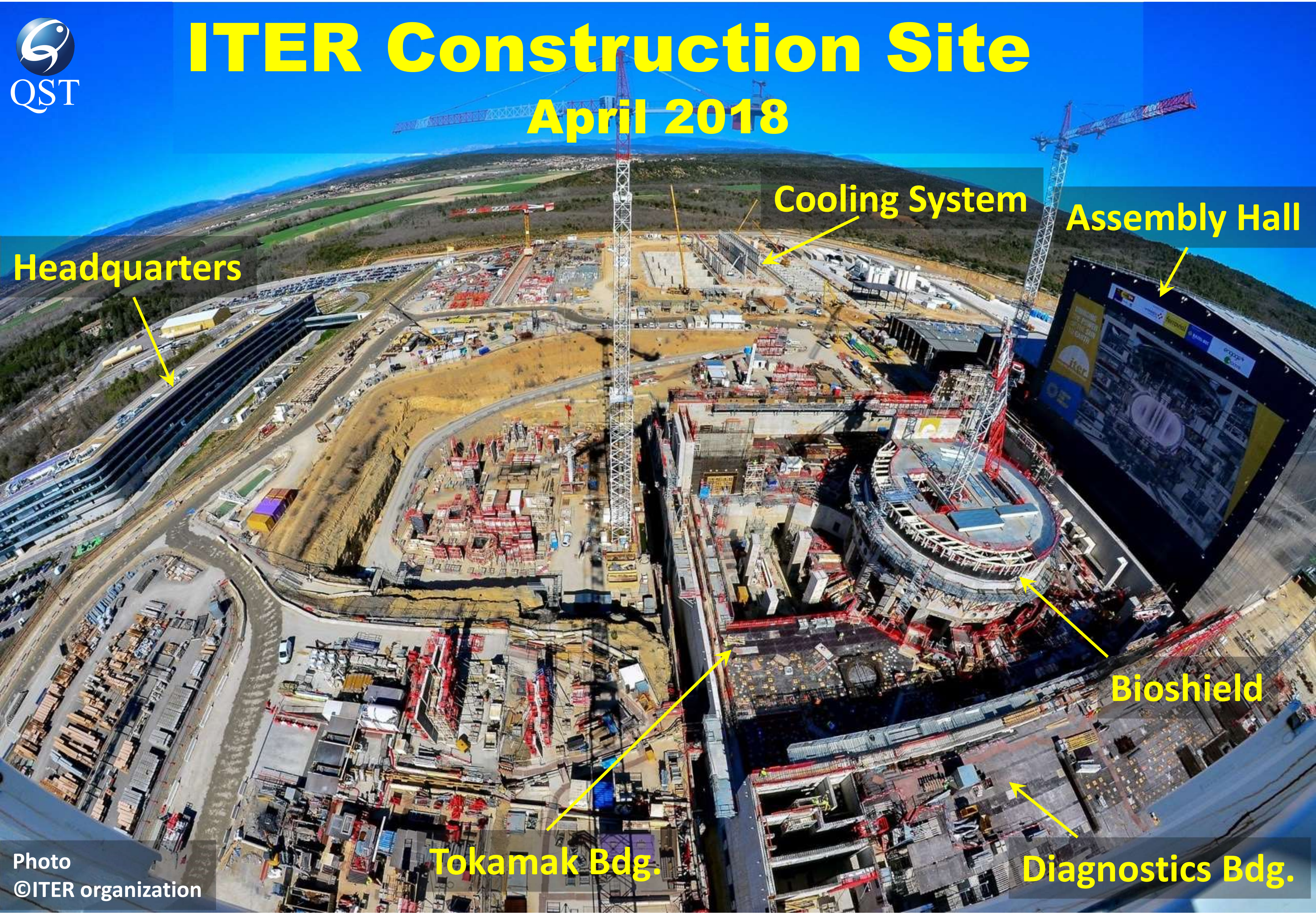
- Kawasaki Heavy Industries, Ltd
- KYOCERA Corporation
- Metal Technology Co. Ltd.
- Mitsubishi Electric Corporation

- HHI (Korea)
- KIND (Germany)
- Industeel (France)
- FAV (Italy)
- Kiswire Advanced Technology (Korea)

ITER Construction Site

March 2007


QST
ITER Construction Site
April 2018
Cryostat Workshop
Coils Winding facility
Assembly Hall
Cryoplant
Service Bdg.
400 kV Switchyard
400 m
Cooling System
Magnet power conversion Bdgs.
Tokamak Bdg.
Diagnostics Bdg.
Headquarters
1 km
Photo
©ITER organization


QST
ITER Construction Site
April 2018
Cooling System
Assembly Hall
Headquarters
Bioshield
Tokamak Bdg.
Diagnostics Bdg.
Photo
©ITER organization

Summary

ITER Organization and seven Domestic Agencies are jointly making their utmost effort in the ITER construction towards its First Plasma operation in 2025.

The ITER construction can be completed only by integrating various leading edge technologies. Contributions by manufacturing companies with their advanced manufacturing capabilities are indispensable.

ITER Project is an international joint challenge contributing to not only the realization of controlled fusion energy but also the world peace through developing international mutual understandings.