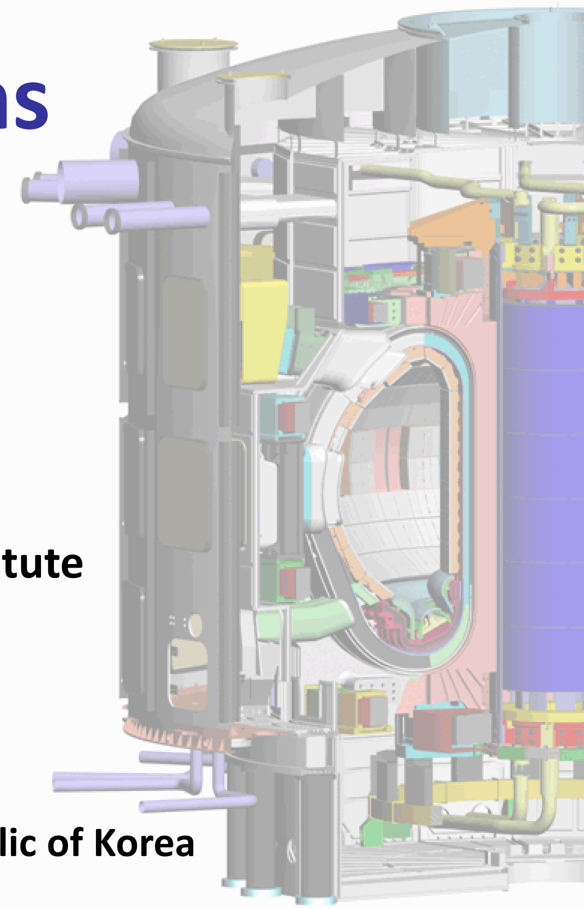
Korean Contributions to ITER



Hyeon Gon Lee

ITER Korea, National Fusion Research Institute

10th ITER International School

21 January ~ 25 January 2019, KAIST, Daejeon, Republic of Korea

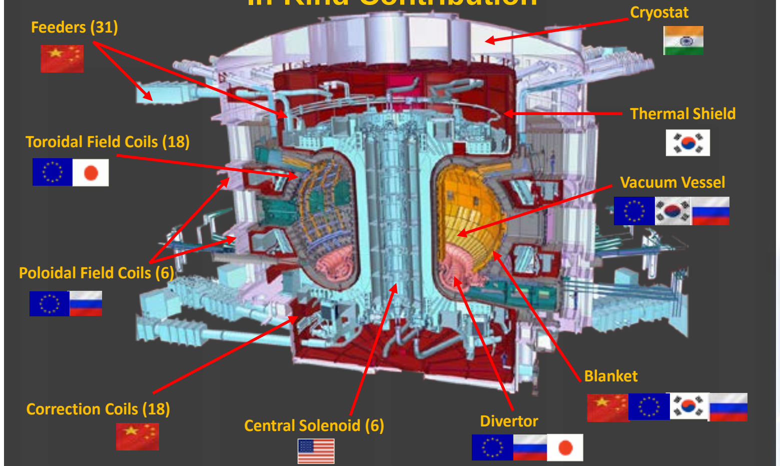
NFRI National Fusion Research Institute   iter KOREA   KOREA DOMESTIC AGENCY   iter

Contents

ITER Project

- **ITER is on the way to commercial fusion reactor and it will demonstrate the feasibility and integration of science and technologies, and safety features for a fusion reactor;**
- **The self-sustained D-T burning plasma in ITER will generate 500 MW which is 10 times more power than it receives;**
- **ITER enterprise will create a new collaborative culture and standard solving energy and environmental problems and contributing to the world peace;**
- **All of the intellectual properties obtained belongs equally to all seven Members.**

Who manufactures what?
In-Kind Contribution



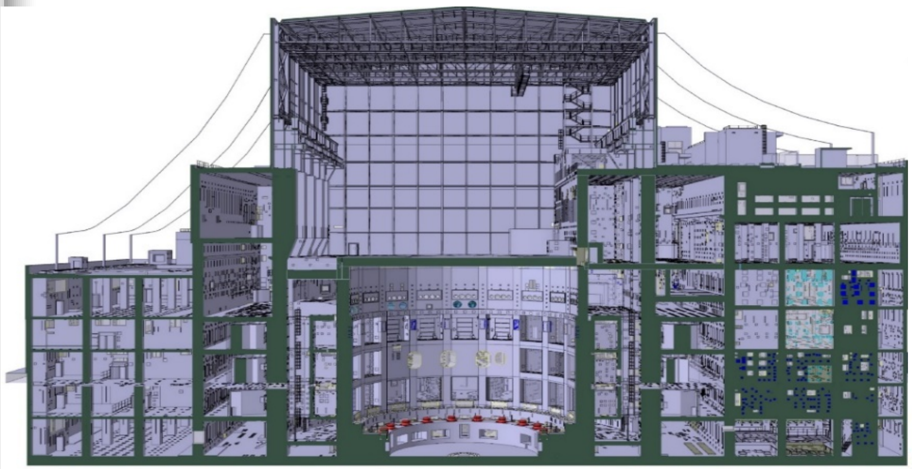
R=6.2 m, a=2.0 m, Ip=15 MA, Bt=5.3 T, m=23,000 tons, (H) 29.0 m x (D) 28.6 m

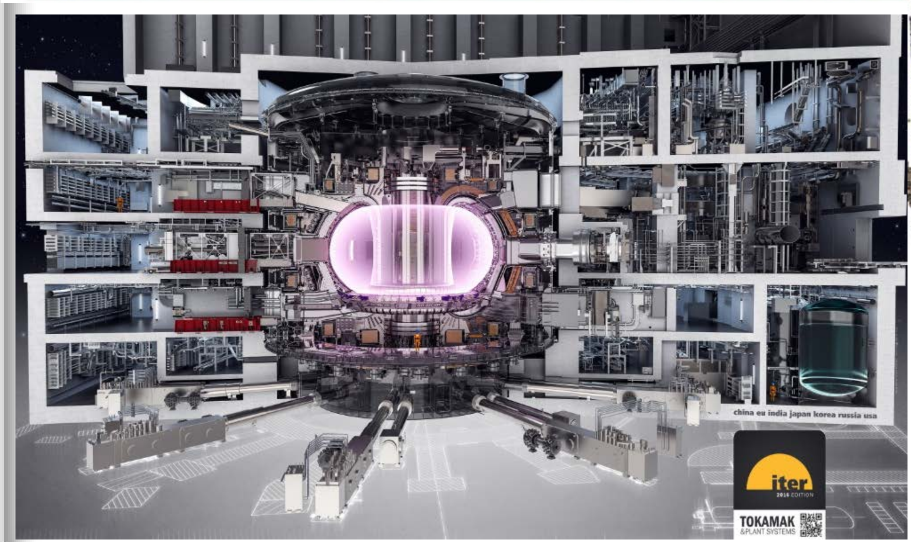
◆ **ITER Organization & Seven Domestic Agencies**

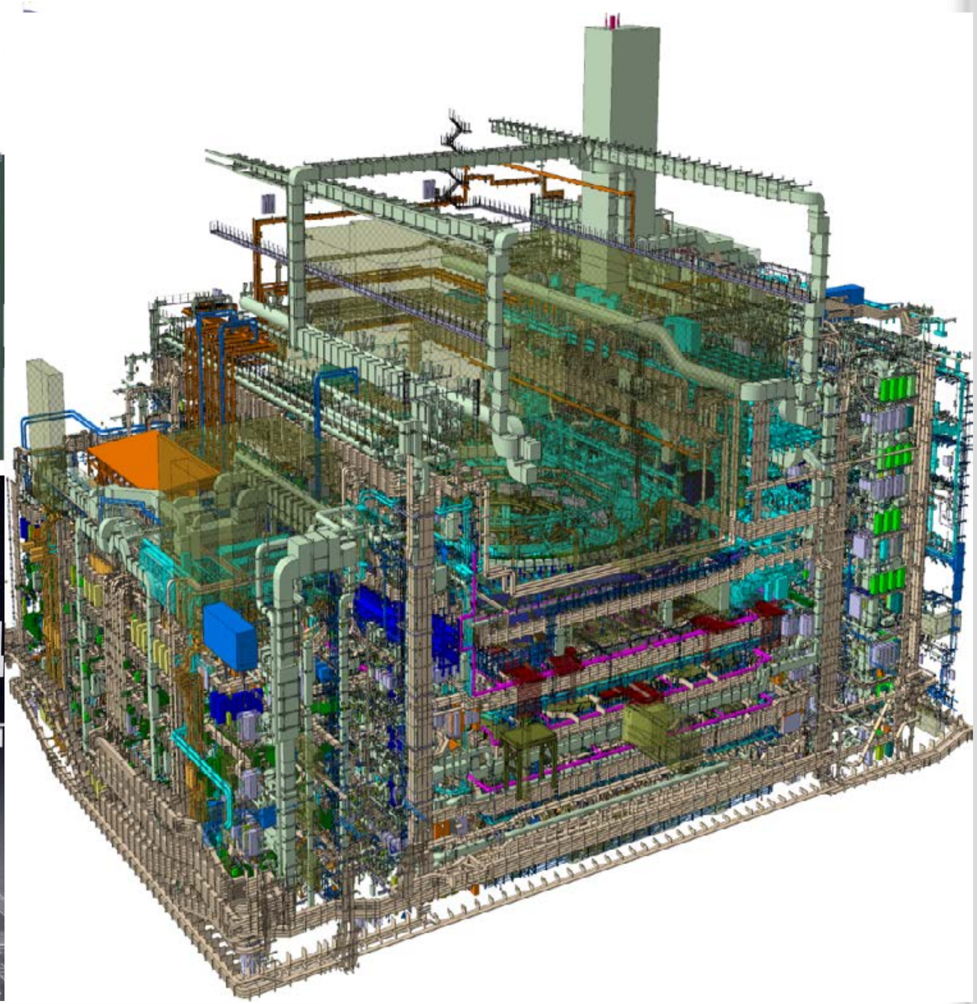
- The 7 ITER Members make in-cash and in-kind contributions to the ITER Project. They have established Domestic Agencies.

Technical Challenges of ITER Construction

◆ **Tokamak Complex Systems (First-of-a-kind Fusion Reactor Plant)**







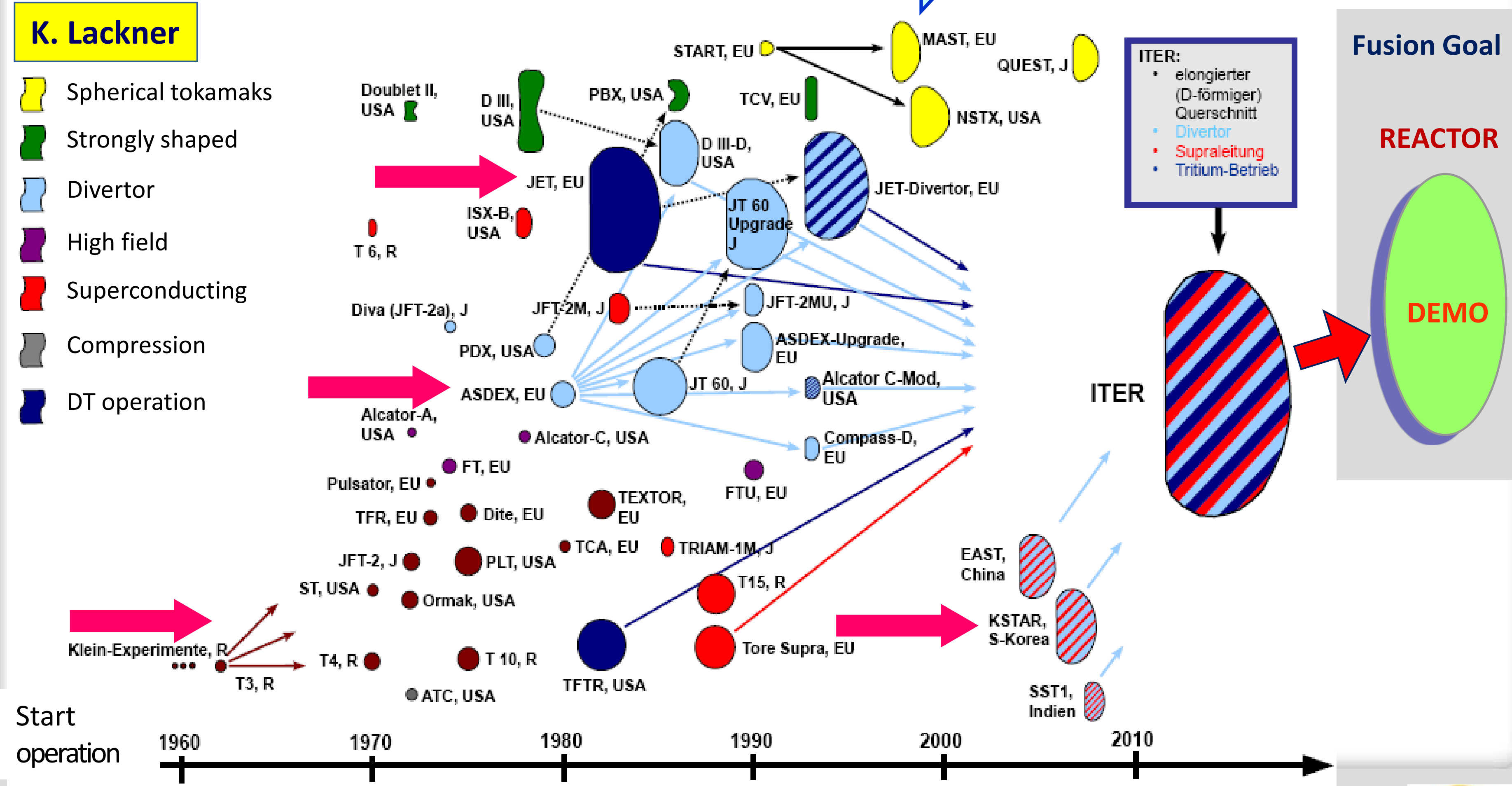
Fusion Research and ITER Project

◆ 20th Century: US-EU-RF-JA lead fusion studies;

As a result, the fusion research reached on the final demonstration to assess the scientific and technological feasibility of fusion energy realization.

ITER Project:

International research project in participation of world leading scientists & engineers



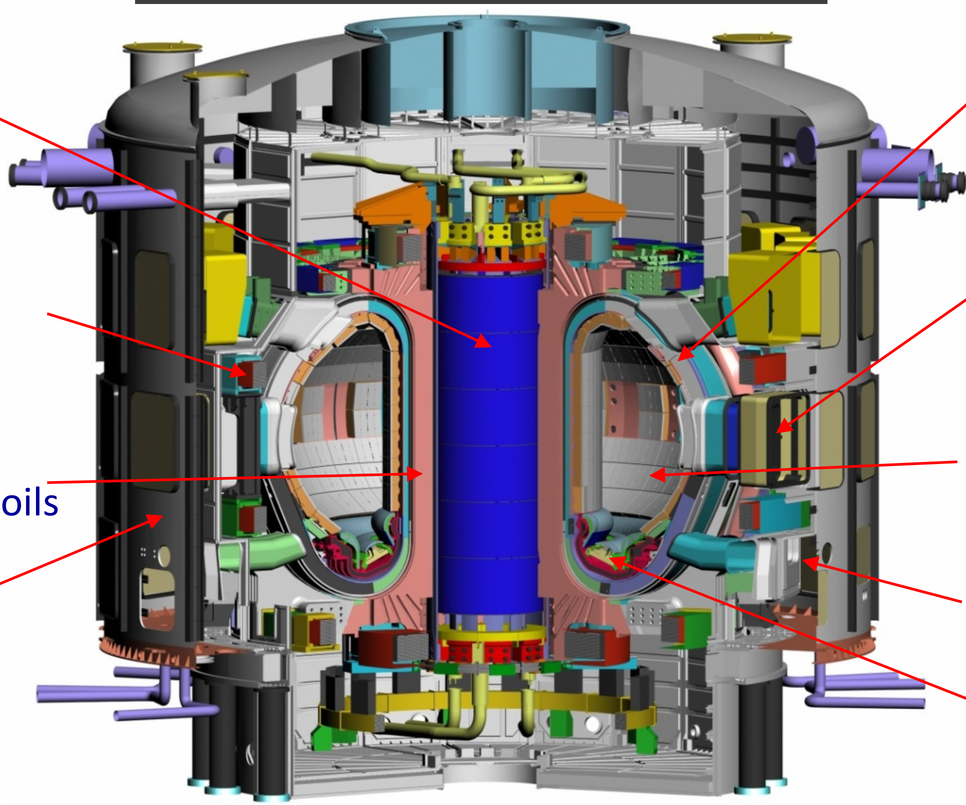
Brief History of ITER Project in Korea

- June 2003 — Join to the ITER Project
- November 2006 — Signed "ITER Joint Implementation Agreement (JIA)"
- April 2007 — "ITER JIA" Ratified by the KO National Assembly
- September 2007 — Established the "Korea Domestic Agency (KO-DA)" under the NFRI
- May 2008 — Signed the first PA for TF Conductors
- November 2014 — First delivery of the TF Conductors was successfully accomplished.
- June 2017 — Delivery of the SSAT-1 was accomplished (IC Milestone).

- The ITER Korea is performing all activities with respect to the Korean ITER project with full responsibilities as the Domestic Agency of the Republic of Korea.
- Its main role and activities are as follows;
  - Management of KO procurement activities
  - Delivery of the KO procurement packages with quality
  - Dispatch of KO experts to IO
  - Collaboration and coordination with IO & other DAs

ITER Design and Components

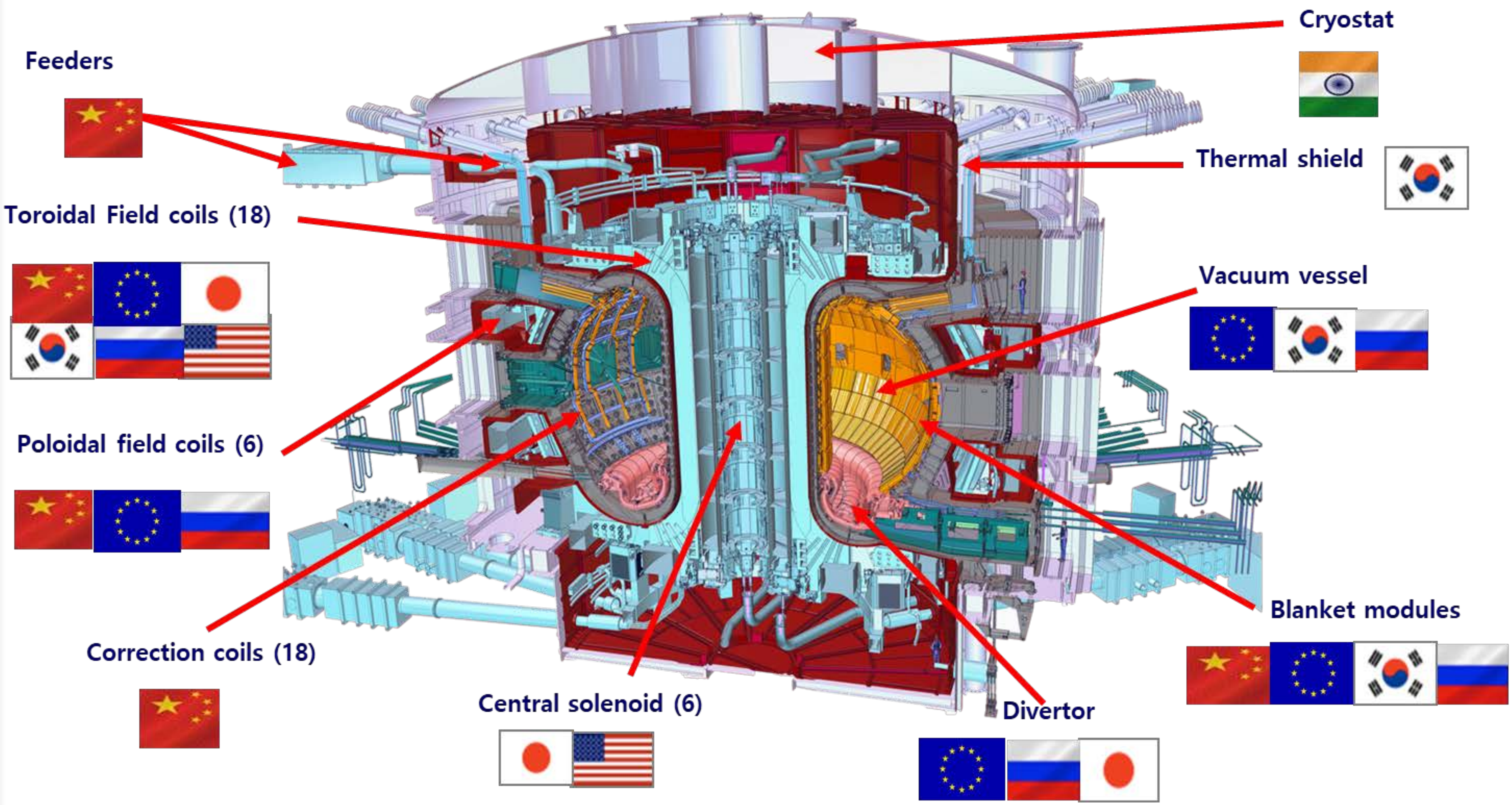
R=6.2 m, a=2.0 m, Ip=15 MA, Bt=5.3 T,
m=23,000 tons, (H) 29.0 m x (D) 28.6 m



- 1992~2001 CDA, EDA (R&D)
- 2001 FDR (Baseline 2001)
- 2007 ITER Baseline 2007

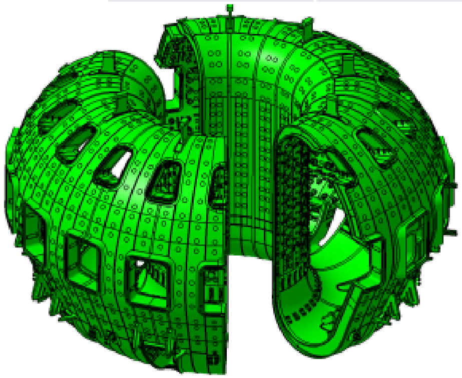
On **9 November 2012**, French Prime Minister signed the official decree that authorizes the ITER Organization to create the *Installation nucléaire de base* (**INB No.174**) ITER.

ITER Component Sharing

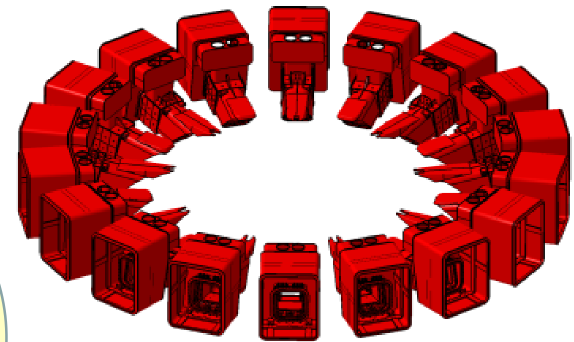


Vacuum Vessel Procurement Sharing

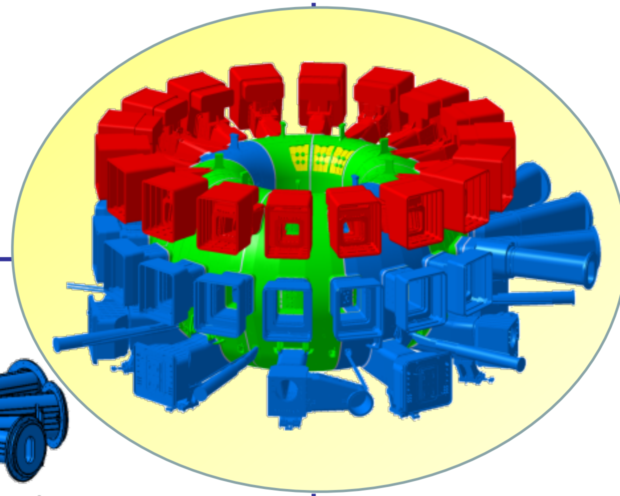
EU	Description
Items	7 Sectors of Main Vessel
Total Cost	92.06 kIUA (39%)

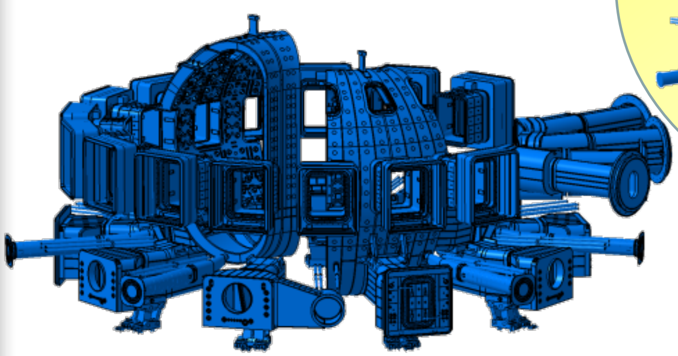


RF	Description
Items	18 Upper Ports
Total Cost	20.86 kIUA (9%)

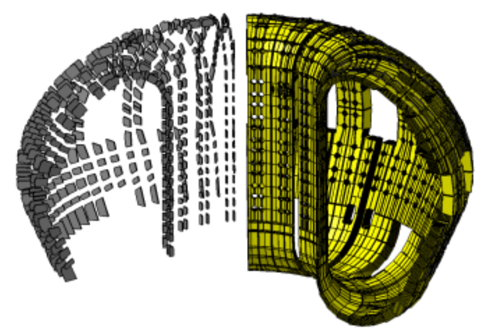


Total 234.28 kIUA
8% of total in-kind





KO	Description
Items	2 Sectors of Main Vessel 17 Eq. & 9 Lower Ports
Total Cost	84.06 kIUA (36%)



IN	Description
Items	In-Wall Shields/Ribs
Total Cost	37.30 kIUA (16%)

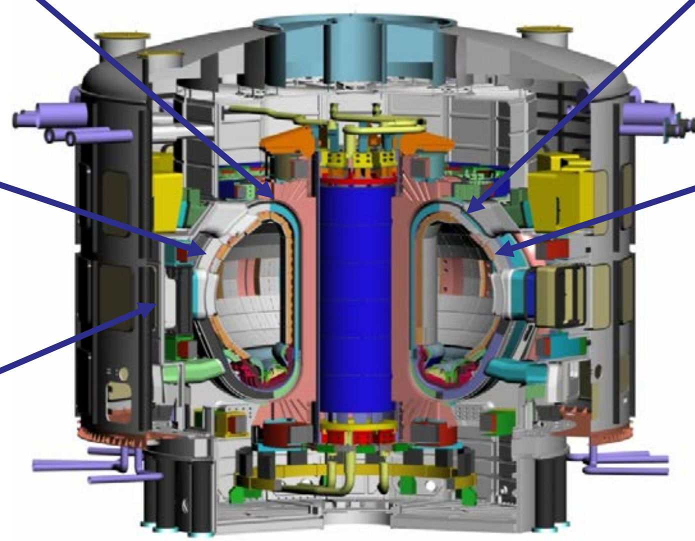
In-kind Contribution of Korea

1. TF Conductor (Completed)
Total Value (kIUA) : 215.01
KO Allocation : 20.2%
KO Contribution (kIUA) : 43.39

Test Blanket Module*
KO Contribution :
HCCR TBS (TBM System)
kIUA Value : N/A

4. Thermal Shield
Total Value (kIUA) : 26.88
KO Allocation : 100%
KO Contribution (kIUA) : 26.88

2. Vacuum Vessel Main Body
Total Value (kIUA) : 118.51
KO Allocation : 21.3%
KO Contribution (kIUA) : 25.20



5. Blanket Shield Block
Total Value (kIUA) : 56.34
KO Allocation : 49.8%
KO Contribution (kIUA): 28.07

3. Vacuum Vessel Port
Total Value (kIUA) : 76.98
KO Allocation : 72.9%
KO Contribution (kIUA) : 56.13

6. Assembly Tooling
Total Value (kIUA) : 18.45
KO Allocation : 100%
KO Contribution (kIUA): 18.45

7. Tritium SDS
Total Value (kIUA) : 12.51
KO Allocation : 94.2%
KO Contribution (kIUA) : 11.79

8. AC/DC Converters
Total Value (kIUA) : 122.61
KO Allocation : 37.1%
KO Contribution (kIUA): 45.58

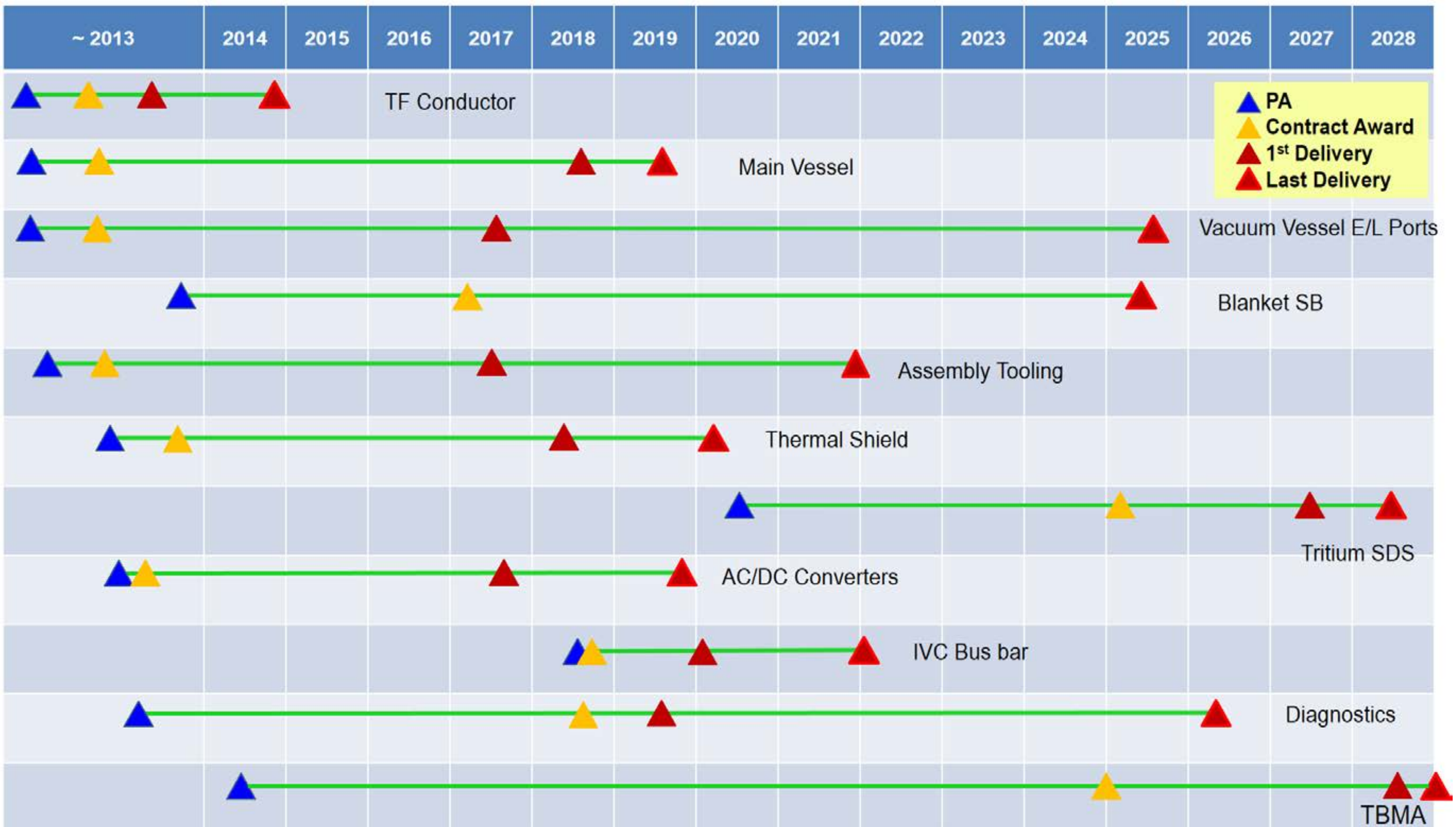
9. Diagnostics
Total Value (kIUA) : 205.66
KO Allocation : 2.0%
KO Contribution (kIUA) : 4.11

* TBMA (TBM Arrangement) was signed in 2014.

Total Value : 259.60 kIUA

Procurement Schedule of KODA

- **Procurement schedule according to the new ITER baseline schedule (2025 FP and 2035 DT)**

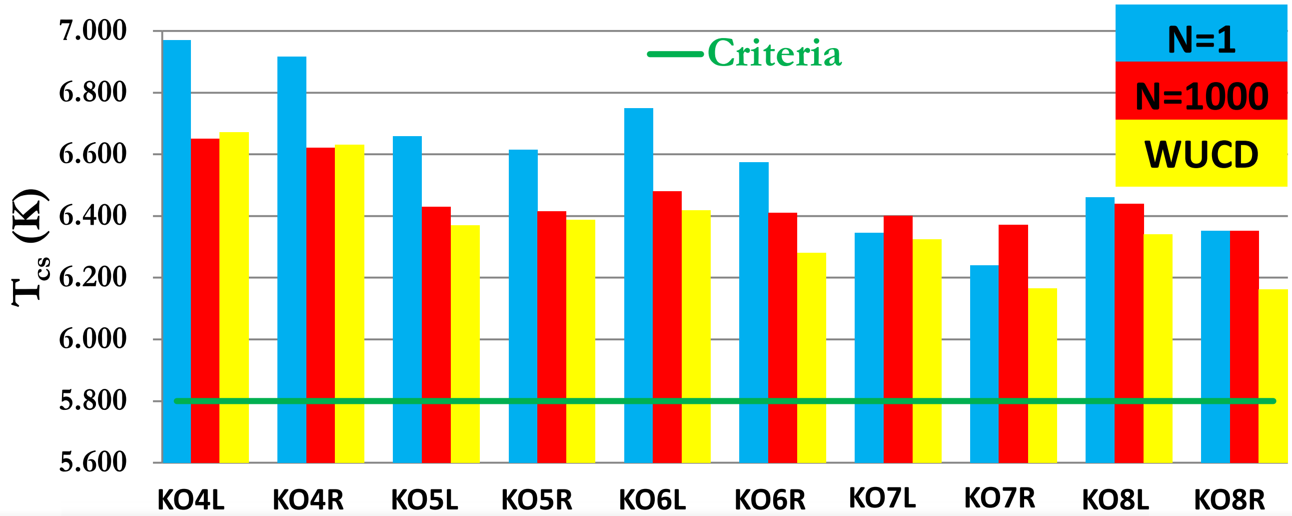


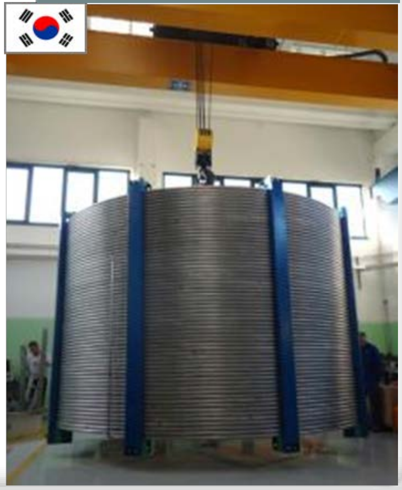
Contents

TF Conductors (completed work)

- **KO TF conductors (20.18 %)** consist of 19 rDPs (760 m) and 8 sDPs (415 m).
  - TF Conductor Performance Qualification Sample test had been passed on 5 November 2008.
  - Production of strands and cablings was completed in 2013 and in May 2014, respectively.
    - Strand Diameter: 0.82mm, Cable: 900 Nb_3Sn + 522 OFHC strands, CICC: 760m (19) + 415m (8)
  - **All 27 TF conductors** were delivered to JADA by the end of **November 2014**, on schedule.
    - This is the first procurement item successfully accomplished by KODA.
  - Key technology is an optimized design on **Twist Pitch Combination & Void Fraction**.

- **SULTAN Test**
  - K10 samples from 10 Conductor ULs were tested at Sultan after PA signature.
  - A lesson learned: sampling for quality control would be optimized (**10 %**, e.g.).

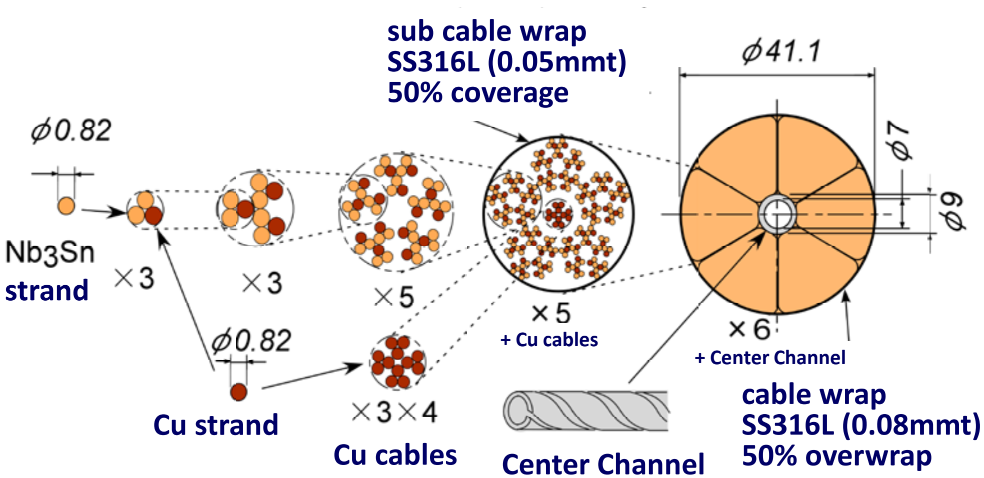


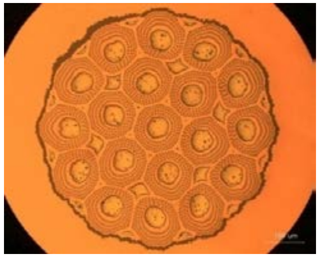


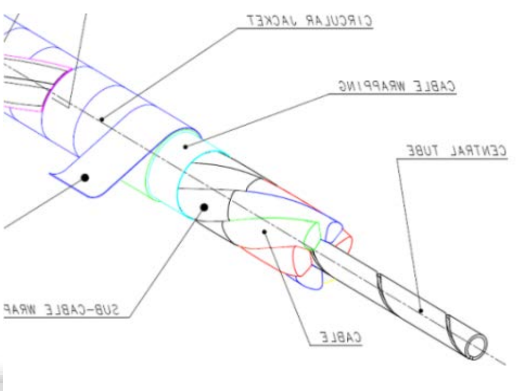
Manufacturing Process of TF Conductors

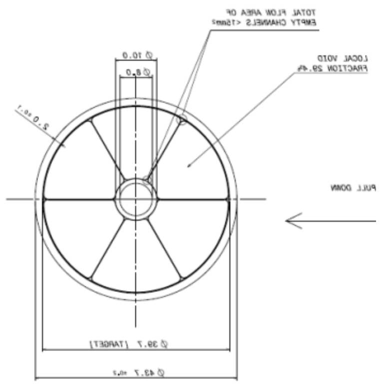
- **900 Nb3Sn and 522 copper Strands are assembled into a multistage, rope-type Cable which is inserted into a conduit of butt-welded stainless steel Jacket Sections and compacted (Cable In Conduit Conductor).**

  - Optimized **Twist Pitch Combination & Void Fraction** ([45/85/125/250/450] → [80/140/190/300/420] mm: 33 % → 30 %)



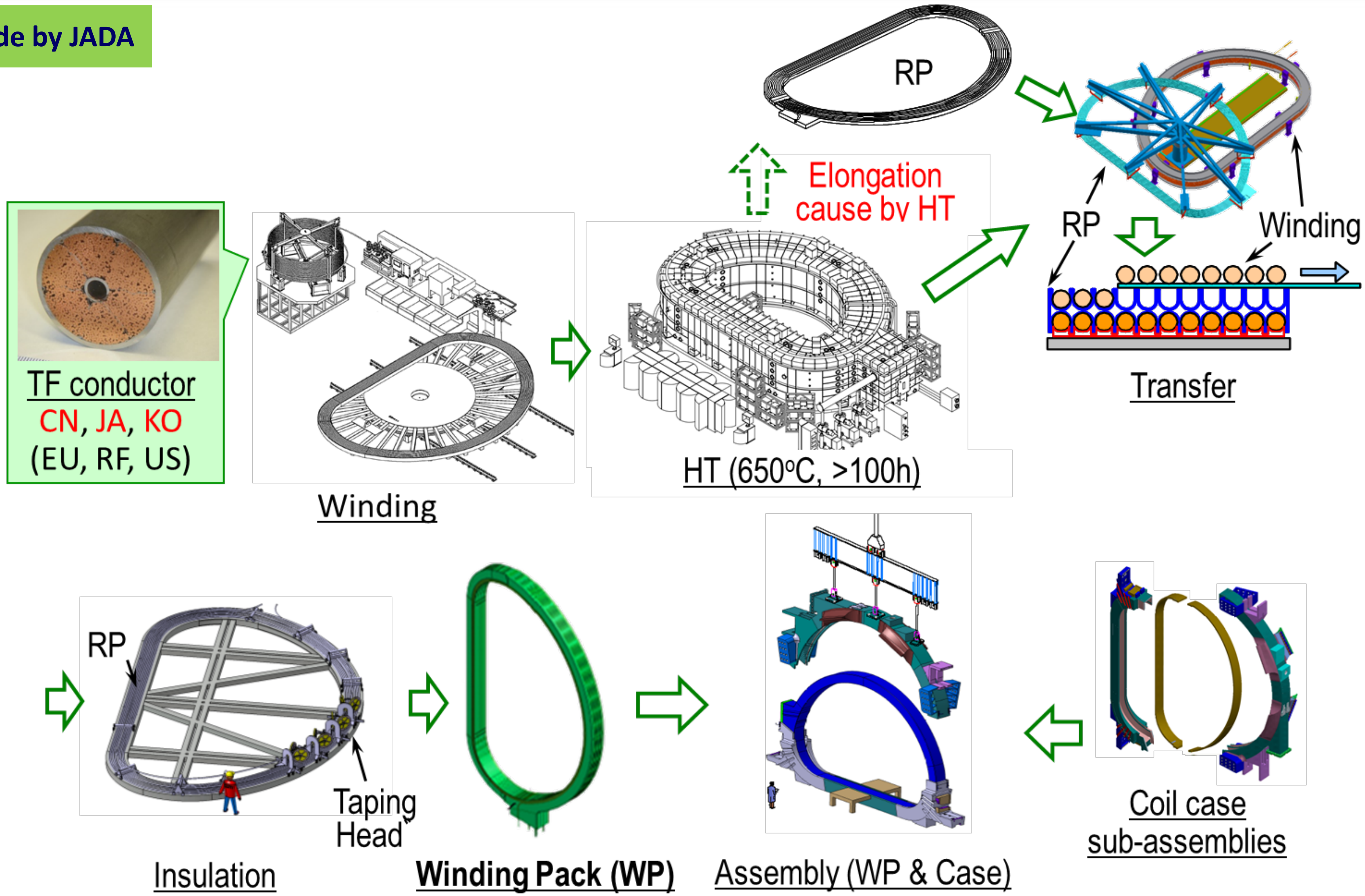






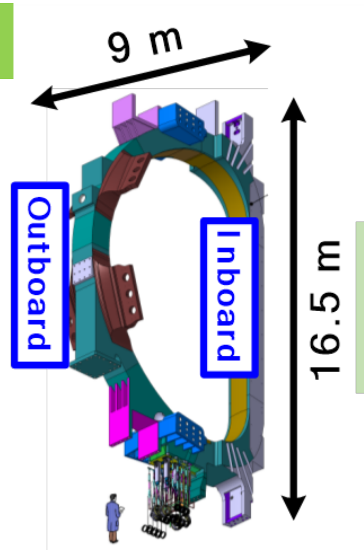
Manufacturing Process of TF Magnets

Slide by JADA

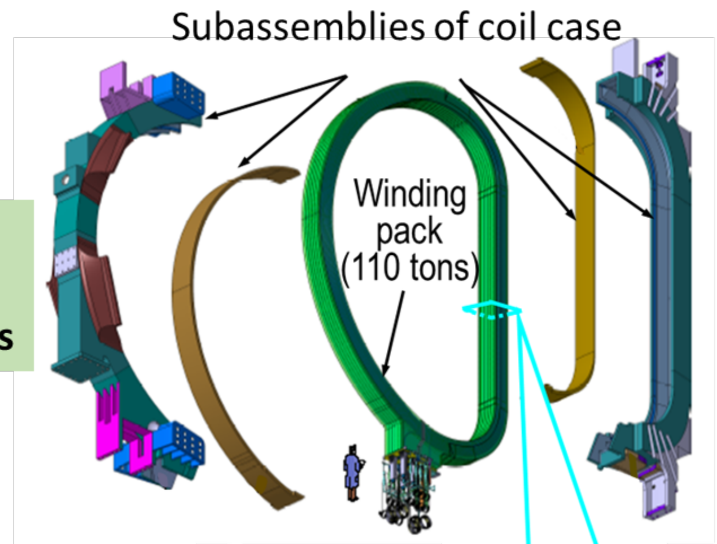


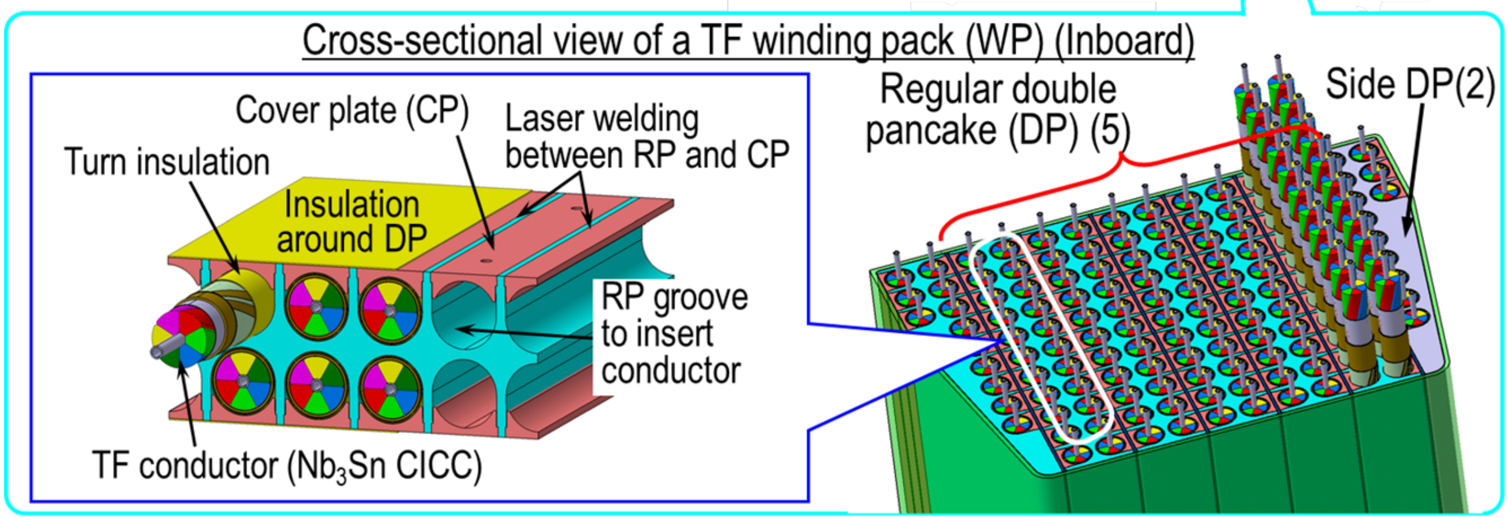
Structure of ITER TF Magnets

Slide by JADA



Field: 11.8 T
Current: 68 kA
Weight: ~300 tons





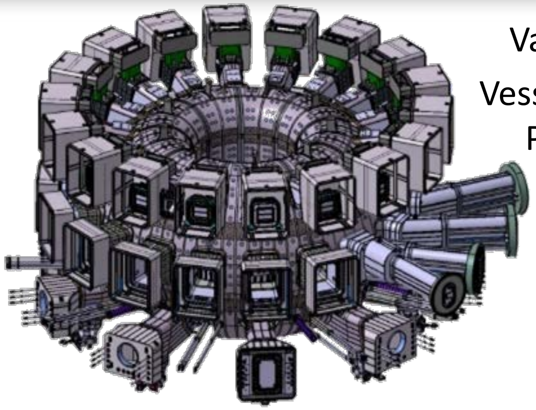
Vacuum Vessel Sectors

Functions

- Provide **high vacuum** for plasma operation
- **First safety barrier (PIC)** for radioactive materials
- **Support** all in-vessel and port components

KO Packages

- Procurement Sharing of VV
  - **2 sectors of Main Vessel (#6, #1)**
  - 2 additional VV sectors from IO (#7, #8)
- Major Dimension of MV
  - Outer Diameter : 13.8 m
  - Height : 6.6m
  - **Weight: 410 ton (assembled sector)**

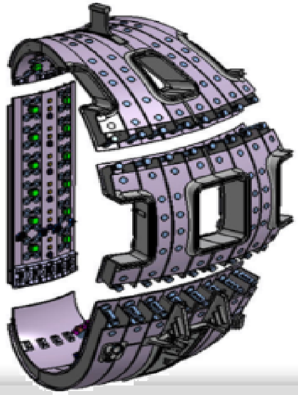


Vacuum Vessel (with Ports)

Major dimensions		Weight (ton)	
Outer diameter	19.4 m	Main vessel	1611
Height	11.4 m	Shielding	1733
Double wall thickness	0.34-0.75 m	Ports	1781
Interior surface	850 m^2	Supports	111
Interior volume	1600 m^3	Total	5236

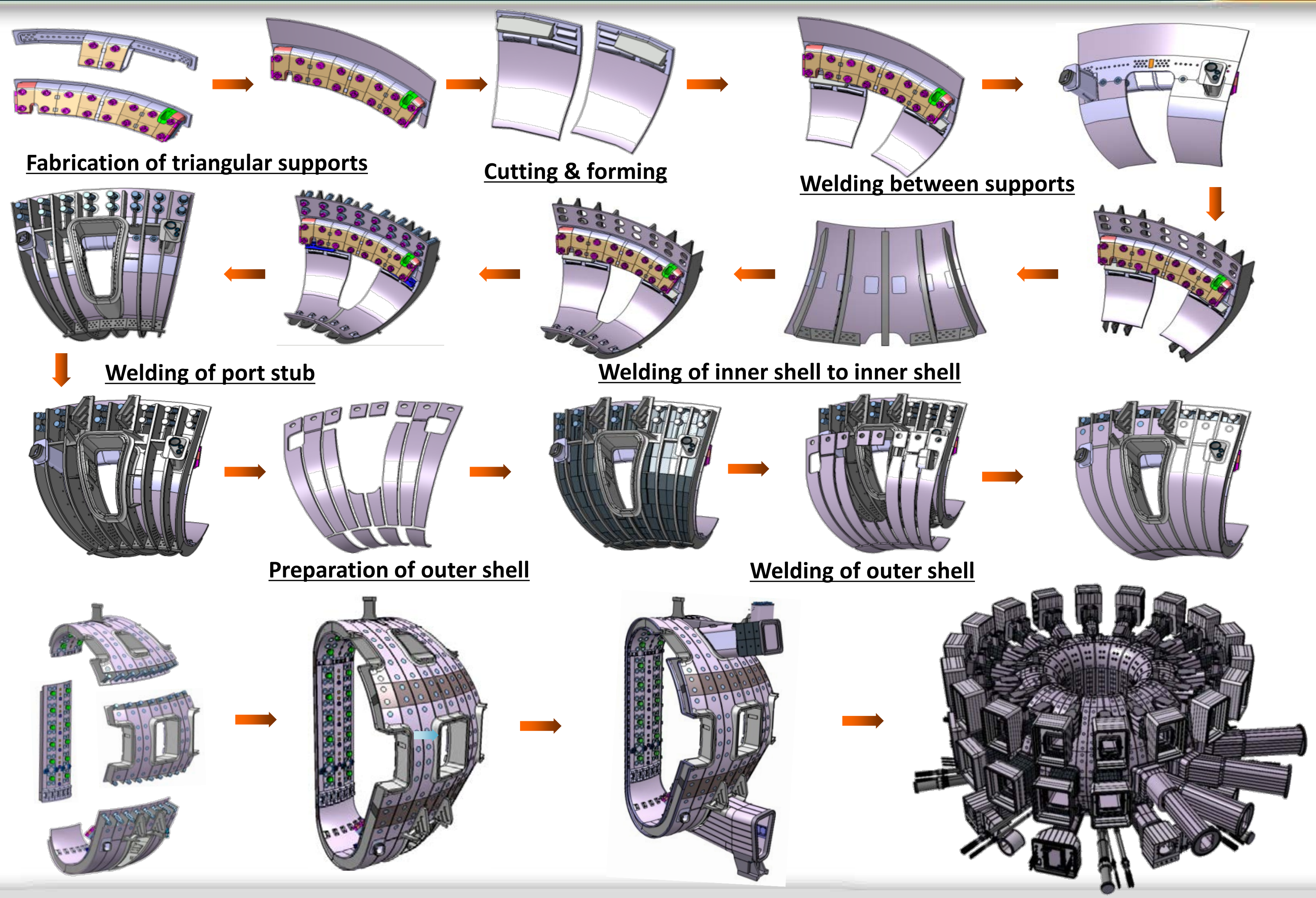
Technical Challenges

- The VV is very complex confinement structure with double walls, made of 60mm thickness 316L(N)-IG plate.
- Application of unexperienced stringent French nuclear regulations such as ESPN, PED, RCC-MR Code, EN std, etc.
  - **100% Volumetric Examination for Pressure Bearing parts**
  - **100% Visual Inspection on Backside Welding**
- Very tight manufacturing tolerances, even **a huge welded stainless steel structure** having **uncountable weld** seams and **deformations**



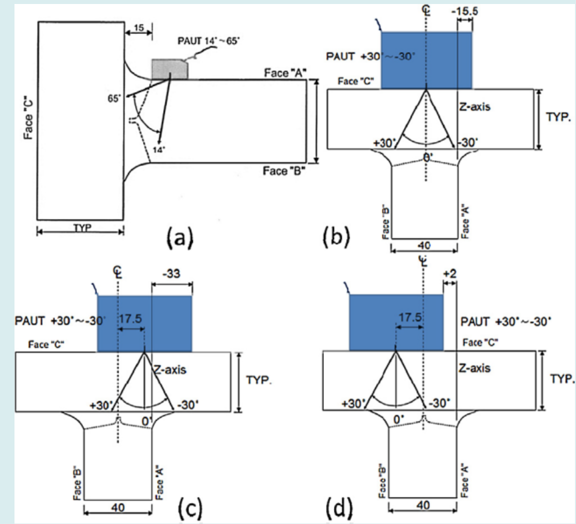
Main Vessel (40° Sector)

Manufacturing Process of Vacuum Vessel Main

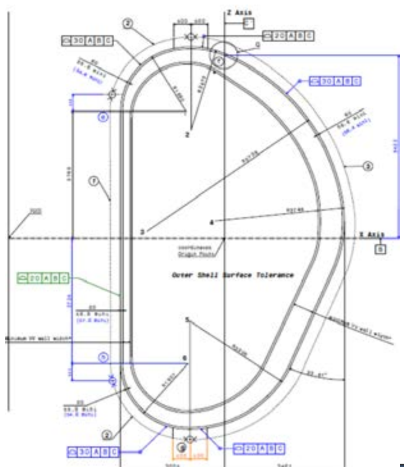


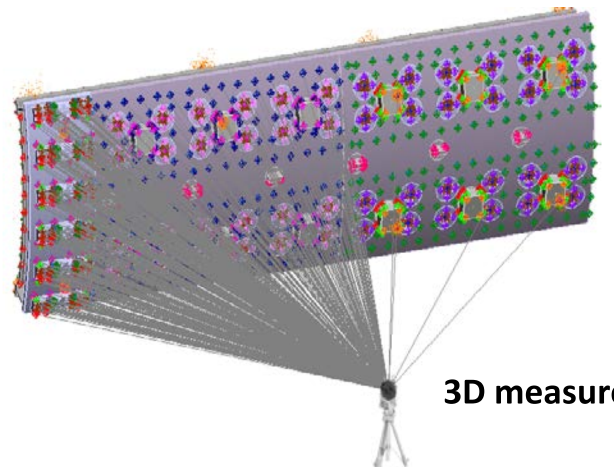
Manufacturing of Vacuum Vessel (Technology Development)

- **Welding and NDE of 100% Volume by (nuclear) ESPN**
  - 316L(N)-IG GTAW (165 mm), EB welding (60 mm)
  - 100% Volumetric NDT: RT (basic) and PAUT (by using Omni Scan MX)
    - UT qualifications: very difficult due to complicate shape & access



- **Tight tolerance:** Metrology and GD&T analysis process





3D measurement using laser tracker

3D Measurement
- Equipment: AT401 Laser tracker (1.5″/0.5″ SMR & Retro Probe)
- Analyzing S/W: SpatialAnalyzer

GD&T Analysis
- Best-fitting with instrument and points
- USMN for multi-bundle measuring
- Align to the datum

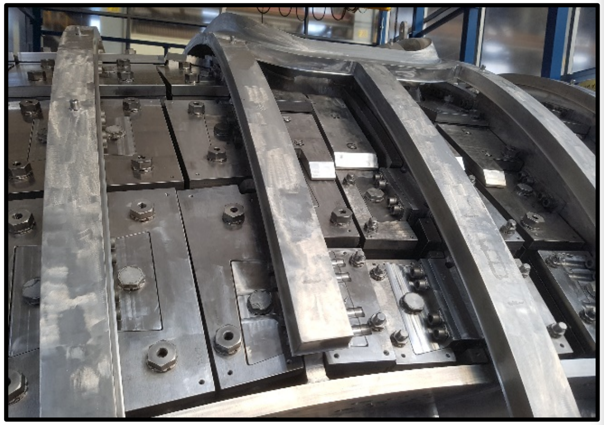
Application of GD&T
- Applying GD&T analysis, for fabrication optimization
- Given step is applied for every measuring process

Manufacturing Progress of Vacuum Vessel Main

- **Vacuum Vessel Main**
  - Manufacture of VV Sectors by HHI is ongoing in order to ensure First Plasma in December 2025, but with many technical challenges;
  - Manufacturing progress of the first Sector #6 is 85.6% (end of December 2018).
  - Sector 7 is 70.4%, Sector 8 is 50.5% and Sector 1 is 37.2% (end of December 2018).

Poloidal Segment #2 (PS2):
T-rib, Flexible Support Housing and
In-Wall Shielding Support Rib Assembly

Poloidal Segment #3 (PS3):
Outer Shell Welding Assembly



Poloidal Segment #4 (PS4):
IWS Block Assembly

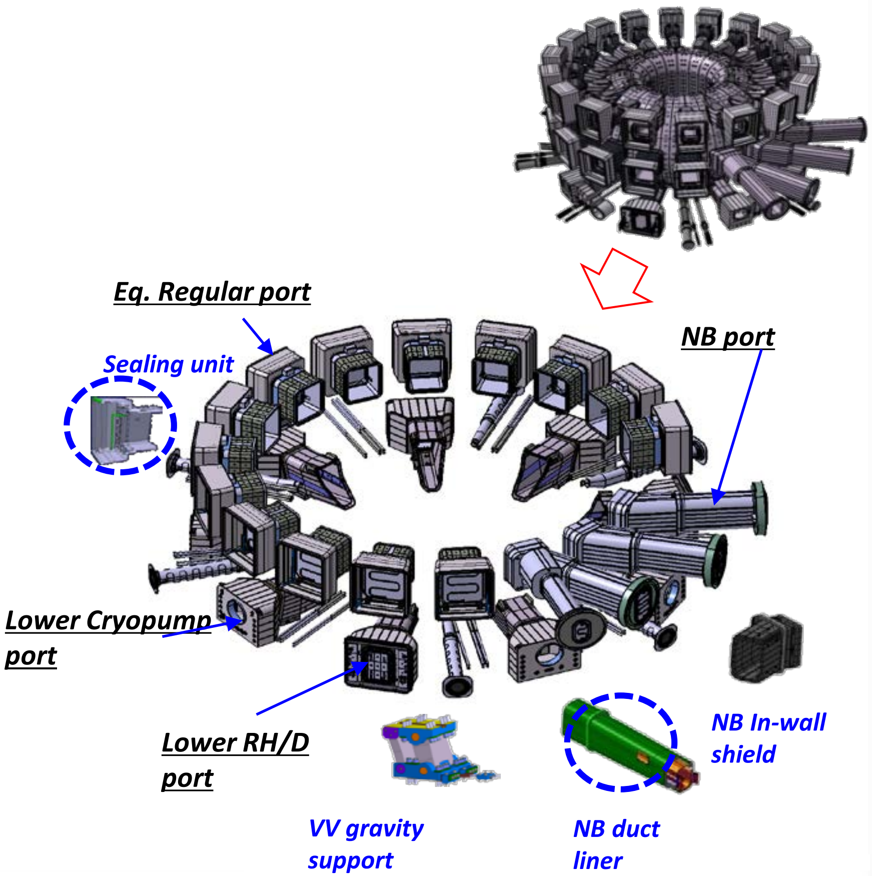
Vacuum Vessel Ports

Functions

- To **support the in-port components** (such as RF Antenna, test modules, etc.)
- To **provide access** for in-vessel components, maintenance equipment, diagnostics and plasma heating equipment

KO Packages

- **9 sets of Lower PSEs**
  9 sets of Lower PEs / Lower Penetrations
  14 sets of Eq. Regular ports
  1 sets of H/DNB Port
  2 sets of HNB Ports
- 3 sets of NB IWS
- **9 sets of VV Gravity Supports**
- 3 sets of NB Duct Liner
- Closure Plates & Sealing Flanges



Manufacturing Progress of VV Ports

- **VV Ports**
  - Factory Acceptance Test (FAT) of the first Lower Port Stub Extension (LPSE 10) was completed and manufacturing of remaining LPSEs is in progress on schedule;
  - All Lower Port Extensions (LPE) and Neutral Beam Port Stub Extensions (NB PSE) are being manufactured.

3D inspection before Factory Acceptance Test of LPSE

Factory Acceptance Test (Pressure Test) of LPSE 10

Phased Array UT (NDE) inspection on Shield Plate weldment of NB PSE

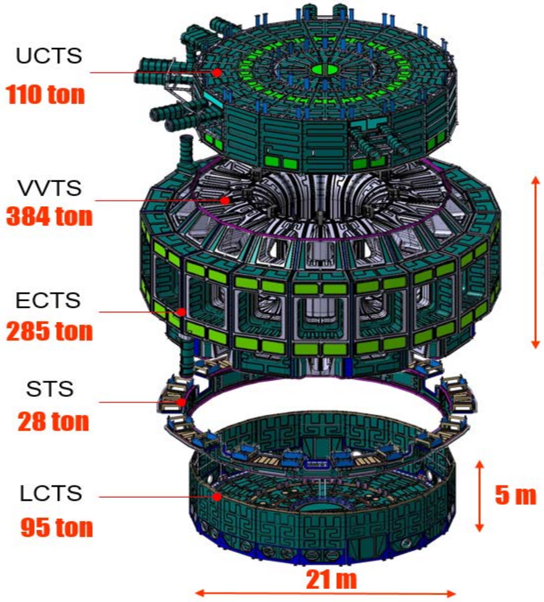
Thermal Shields

Functions

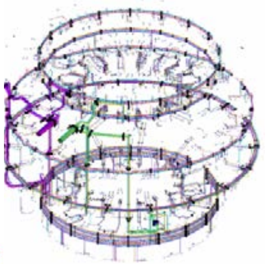
- Thermal shield (TS) **minimizes radiation heat loads** from warm components (vacuum vessel and cryostat) in order **to protect superconducting magnet**.
- **Emissivity < 0.05 (Ag coating 5 μm with surface Ra<0.24 μm)**
- 80K structure of 304LN, cooled by pressurized He gas (1.8 MPa)

KO Packages of 100% Thermal Shield

- Upper **Cryostat** Thermal Shield (UCTS)
- Lower **Cryostat** Thermal Shield (LCTS)
- Equatorial **Cryostat** TS (ECTS)
- **Vacuum Vessel** Thermal Shield (VVTS)
- **Support** Thermal Shield (STS)
- TS Manifold (TSM)
- TS Instrumentation (TSI)



TS Main Components


TS Manifold

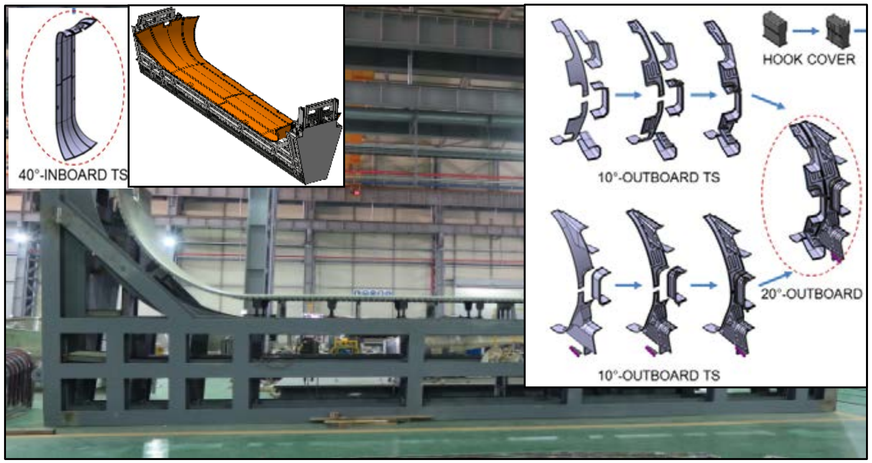
TS Instrumentation

Status of TS Manufacturing

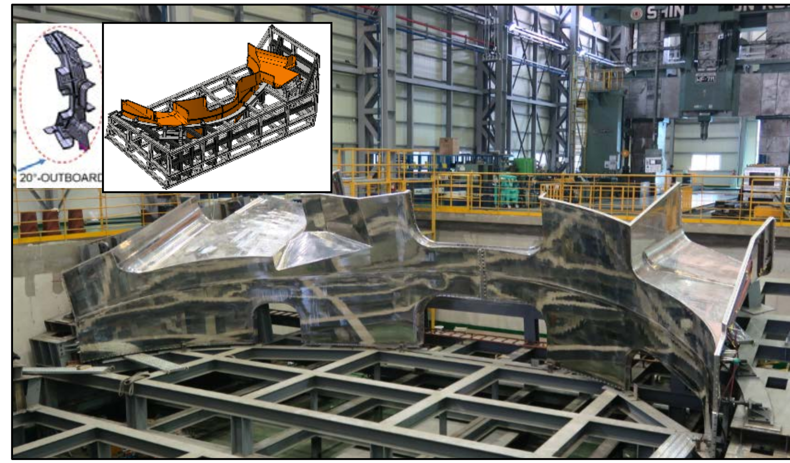
- Preassembly of VV Thermal Shield (VVTS) Sector #6 (23 pieces) was completed;
- FAT (Factory Acceptance Test) of LCTS cylinder was completed;
- **Silver coating of LCTS cylinder was completed**;
- **Progress of Thermal Shield manufacturing is about 73% (end of December 2018).**

Manufacturing of Thermal Shields (Technology Development)

- **Tight Tolerance**
  - Manufacturing with assembly of 23 pieces to meet rigorous tolerance
    * Plate size of VVTS: 12,000mm (height), 20mm (thickness) → tolerance: 2mm

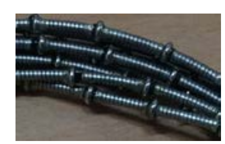


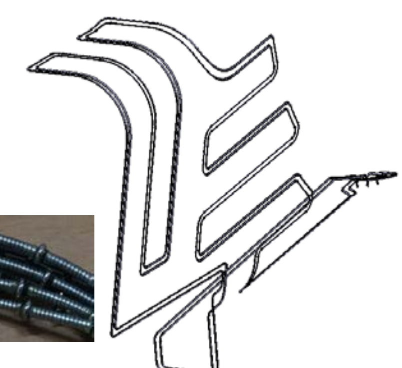
VVTS Inboard Pre-assembly



VVTS 20-deg. Outboard Pre-assembly

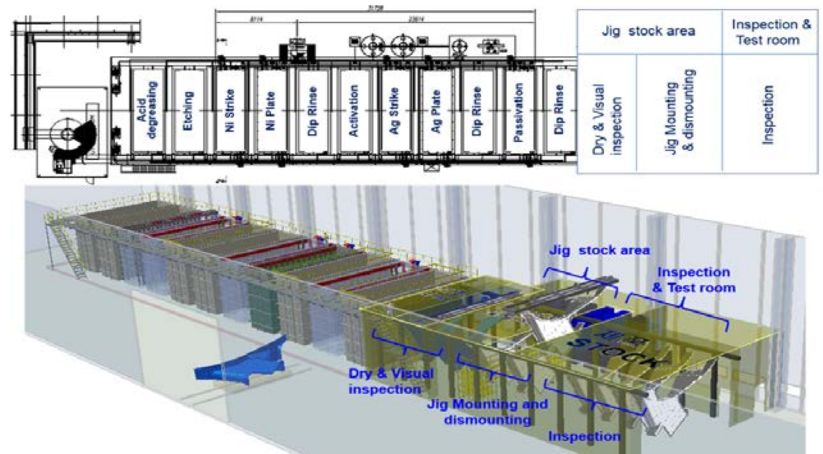
- **Endoscope Inspection**
  - Requirement: 100% visual inspection inside surface of cooling pipe after welding on the panel to detect possible burn-through or depression, etc. (Pipe ID: 9.24mm, thickness: 2.24mm, total length: 35m bended)
  - Issue: Impossible to insert a conventional endoscope into 35m pipe
  - Solution: Development of novel endoscope (low friction ring spacer, compressed air pushing concept)

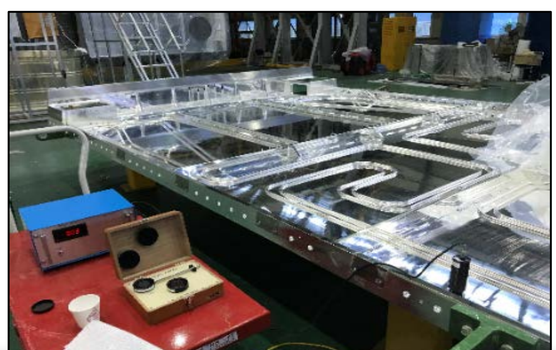




Thermal Shields: Silver Coating Technology

- **Silver Coating against big-size stainless structure for low emissivity**
  - **The thermal shield shall be electroplated by silver of 5 um to maintain its emissivity below 0.05.**
  - **The process and facilities for the ITER TS is challenging due to its huge size and complex shape.**
  - **Silver coating process lines consist of 11 baths, having the inner size of 9 m(L) x 3 m(W) x 6 m(H), which can accommodate the largest part of the ITER thermal shield.**

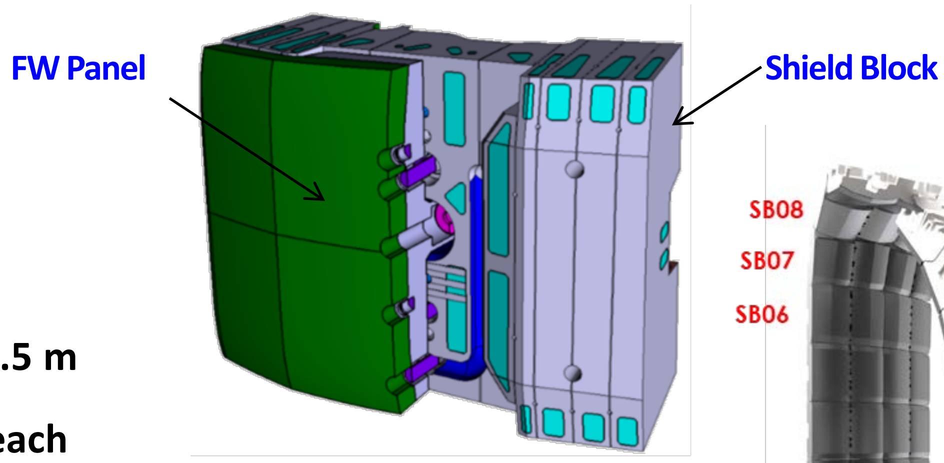




Blanket Shield Blocks

Functions

- **Absorb radiation and particle heat fluxes** from the plasma and the Neutral Beam
- Contribute in **neutronic shielding** to the vacuum vessel and external vacuum components



Material

- Stainless Steel **316L(N)-IG**
- Size: (about) **1.5 × 1.0 × 0.5 m**
- Weight: (about) **2.6 ton/each**
- Number: 440 modules (Total)
- KO Allocation: **220 modules** (CN : 220)

KO Shield Block

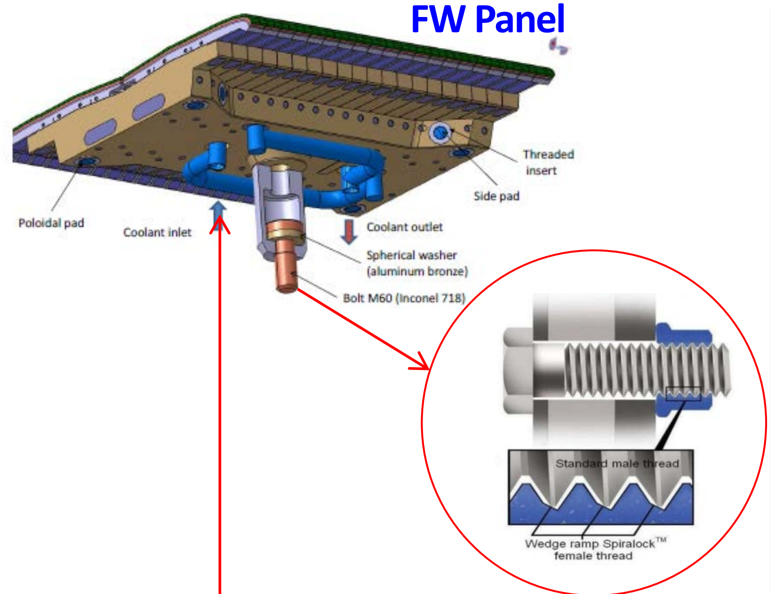
Blanket Shield Blocks: Key Technology

- **Hot Helium Leak Test**
  - Protocol: number of heating cycles; use of N2-gas; need of pressurization cycles;
  - Measurements: hydrogen outgassing difficulty to attain the sensitivity at high temperature;

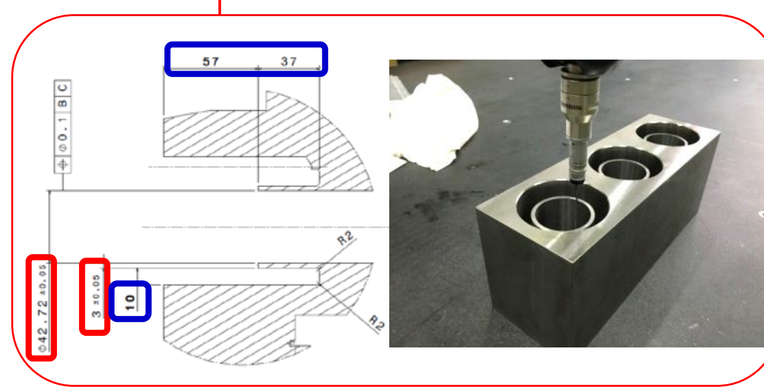
- **Low Friction Coating (MoS2) on the Female thread of FW central Bolt insert**
  - Technical Specification of Low-Friction/Anti-seize coating (friction coefficient: 0.05~0.1) is very challenging in the following requirements of 2,500 sliding cycles;
    - Roughness: all the surfaces to be coated shall be a recorded roughness measurement.
    - Surface finishing: the bolt and nut threads shall be a final surface roughness ≤ Ra 0.4 µm.
    - Coating uniformity: the coating thickness should be 2±0.5 µm.

- **Tight Tolerances of Inlet/Outlet**
  - Requirements (3 ± 0.05 mm) of the dimensional tolerances on Inlet/Outlet was checked by KODA R&D through development of a special tool set.

FW Panel

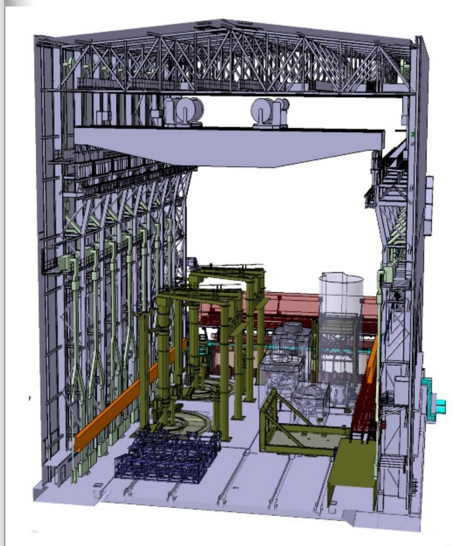


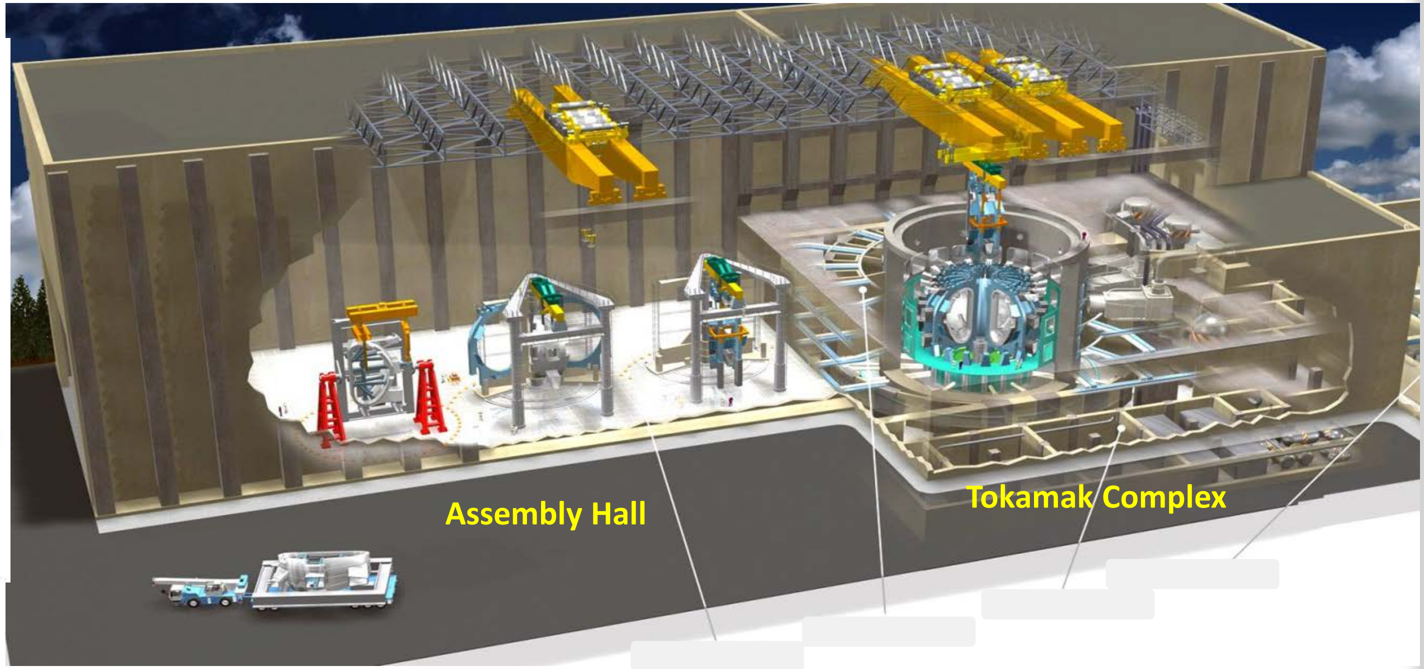
Low friction coating

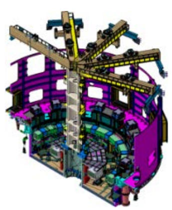


Hydraulic connector

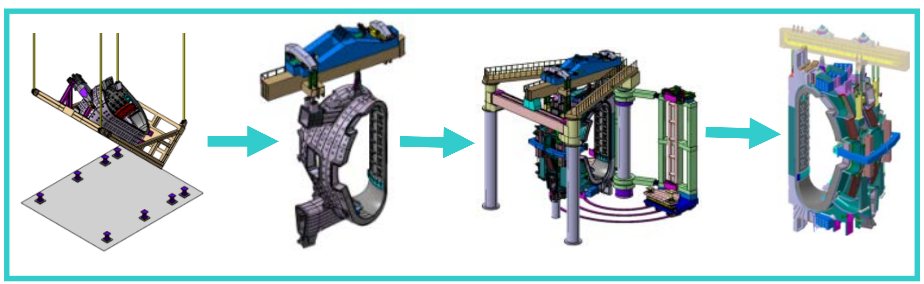
ITER Assembly Process



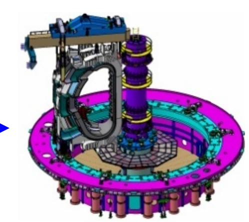




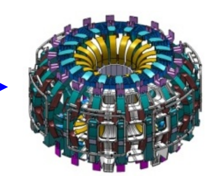
Lower Cryostat Activities Tools



Sector Sub-Assembly Tools



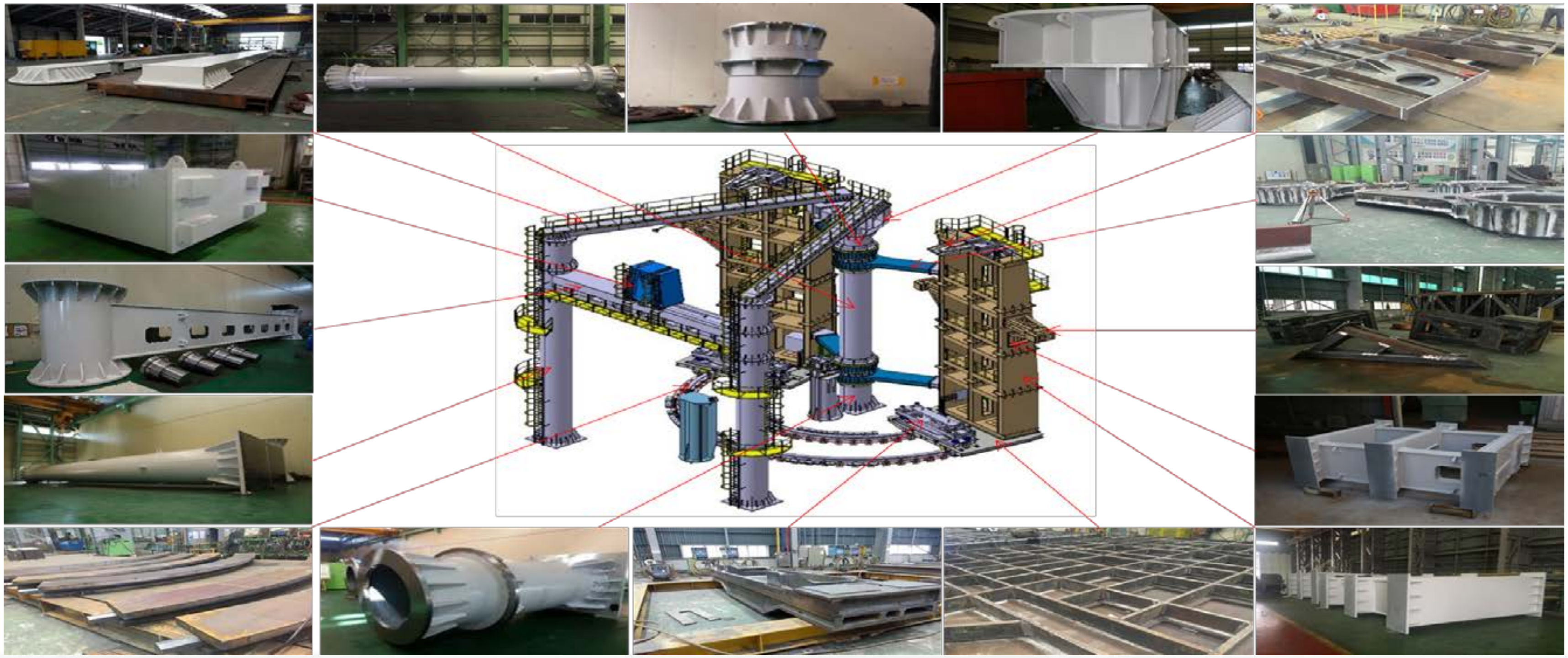
Sector Assembly Tools



In & Ex-Vessel Activities Tools

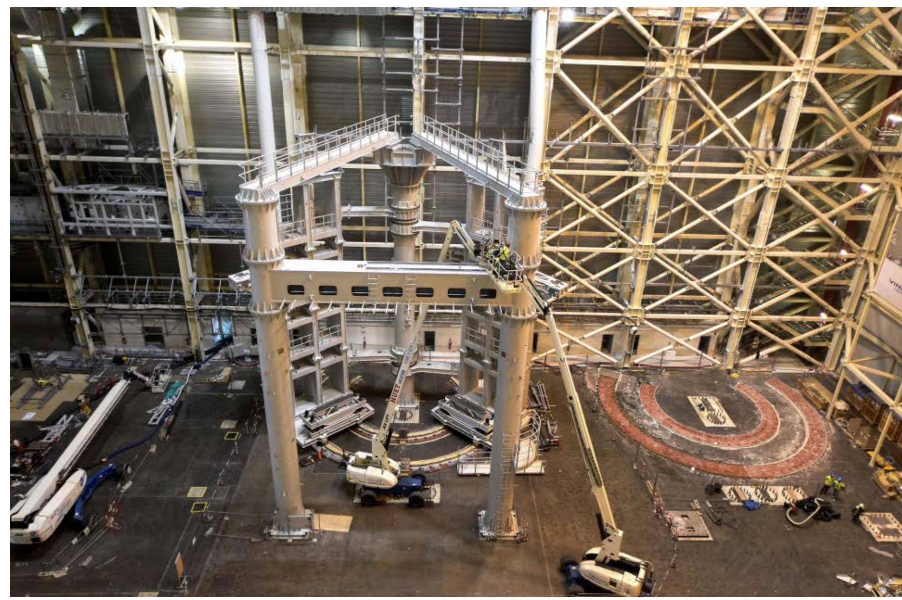
Assembly Tooling (1/2)

- **KO Packages of Assembly Tools** (100% of major tools)
  - **Sector Sub-assembly Tools, Sector Assembly Tools, Ex-Vessel Assembly Tools**
- **Sector Sub-assembly Tool**
  - Handling heavy components up to **1,200 t**
  - **6 DoF** (radial, toroidal, vertical translation & rotation) alignment: **(+/- 1 mm precise control)**
  - **16.7 m (L) × 16.5 m (W) × 22.6 m(H)** and **820 t**



Assembly Tooling (2/2)

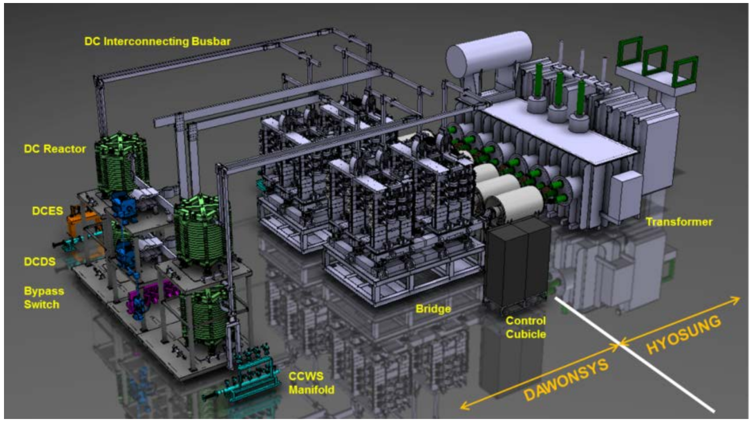
- **SSAT-1 FAT at the KO Factory and SAT at the ITER Site (+/- 1 mm precise control)**
  - **The first Sector Sub-Assembly Tool (SSAT) #1 was delivered to IO in June 2017.**
  - Assembly/Installation activities of the SSAT-1 in the ITER Assembly Building have reached 90 % progress and now it is almost ready to the Site Acceptance Test by IO.
  - **The second SSAT #2 is under transportation to IO since July 2018.**



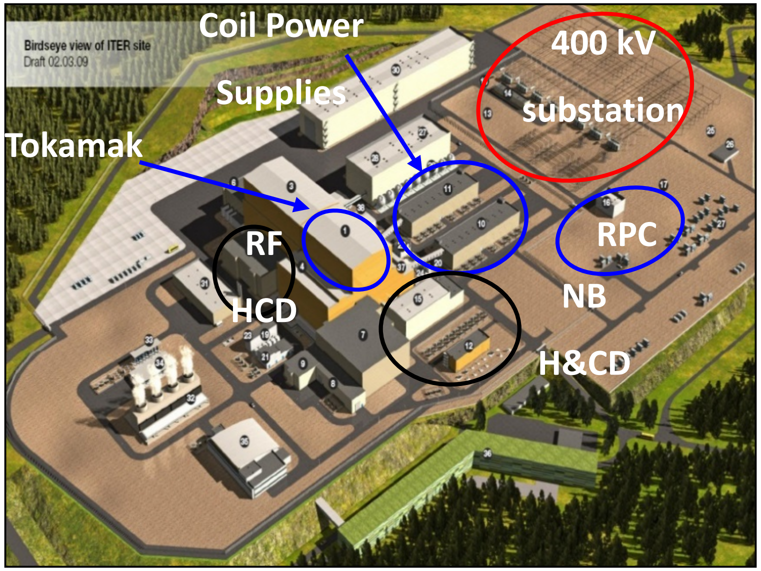
Site Installation of SSAT -1

AC/DC Converters (1/3)

- **Functions**
  - **Provide required current** for TF, CS, PF, CC coils
  - Cooperate protection of power supplies and coils
  - Integrate the coil power supply I&C by MCS
- **Manufacturing status**
  - First CCU/L, CCS, VS1, CS converters are completed.
  - First TF converters are under manufacturing.
  - Master Controllers (CC, TF, PFCS) are completed.
- **Factory Acceptance Test**
  - **Assembly of AC/DC converter for FAT with same configuration as ITER installation**
  - FAT of first CCU/L, CCS, VS1 converters is completed.
  - FAT of all CCU/L, CCS, VS1, CS transformers is completed.
  - **First CCS, VS1 transformers were placed at ITER site in January 2018.**
- **Key Technology**
  - **Converter topology optimization design** (site adaptation)
  - fabrication feasibility of **high-power thyristor rectifier unit**
  - Short circuit test (facility)
  - Seismic structure analysis



< Configuration of AC/DC Converter >

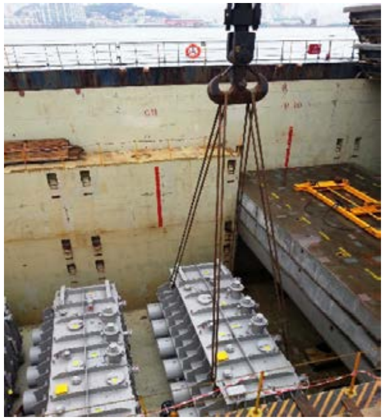


< Configuration of ITER Coil Power Supply System >

AC/DC Converters (2/3)

- **17 units of transformers (6 CCU/L, 3 CCS, 2 VS1, 6 CS): delivered to ITER site**
- **CS transformer weight (89 tons) is close to maximum capacity of FOS crane (90 tons).**

  - Considering +/- 5% crane tolerance, heavy lift ship having own 2 cranes (450 tons) is used.



AC/DC Converters (3/3)

- **Installation Progress of Transformers**
  - Contract with local company (FATSUR): April 2018
  - Start of site work: May 2018 (Teamwork of IO/CMA - KODA/Supplier - Local Company)
  - Installation work has been completed for VS1 (2), CCU/L (4), CCS (3), CS (3) transformers in October 2018.

< Bldg. 33, VS1 Transformer >

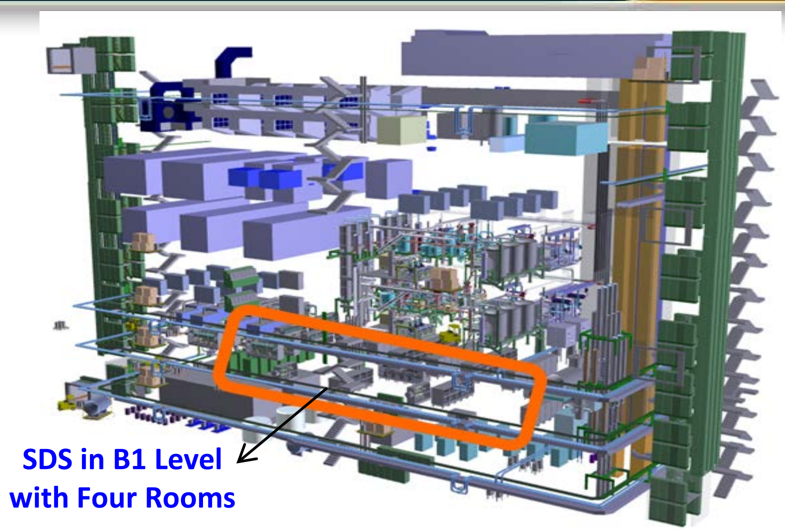
< Bldg. 33, CCS Transformer >

< Bldg. 32, CS Transformer >

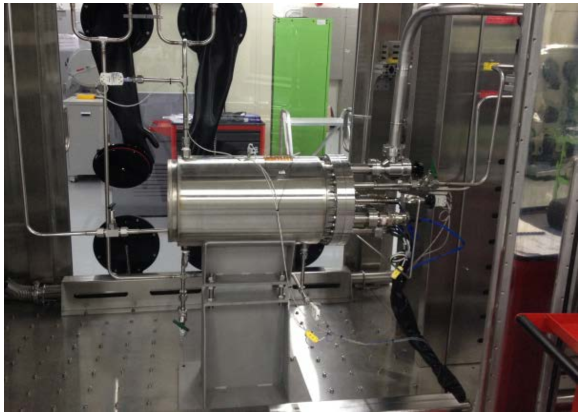
- **Preparation for Installation of Converters: Restrictions to Installation Plan**
  - Floor: strength for heavy components and roughness for air pad
  - Beam structure: Crane/Hoist applicability
  - Non-routine lifting, CoG unbalance

Tritium Storage & Delivery System (1/3)

- **Key Technologies to be developed by KO-DA**
  - Process design, fabrication and delivery (2 kg T inventory)
  - Tritium storage bed design & fabrication (70 g T)
  - Tritium inventory accountability
- **On-going R&D Works (PD R&D Phase)**
  - SDS getter (DU) bed 1:1 mock-up test (with 2 kg DU)
  - SDS unit process feasibility verification test
  - Tritium inventory calorimetry, He-3 recovery
  - SDS modeling, Fuel cycle modeling
- **Schedule**
  - CD (May 2014), PD (Oct. 2020), PA(Jun. 2021), FD (2023), Delivery (2027~28)



ITER Tritium Plant

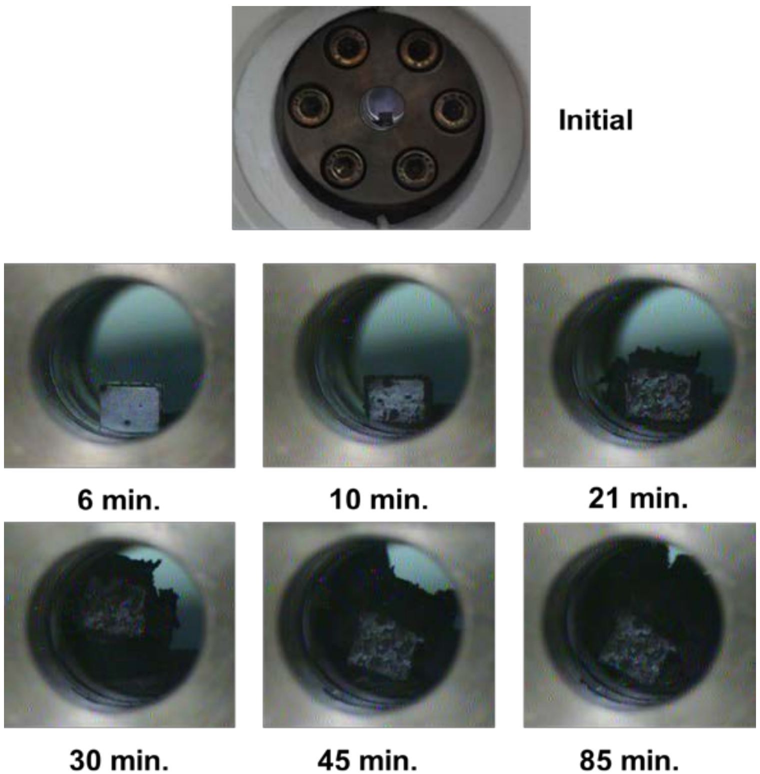


DU Bed (1:1 Mock-up)

DU SDS Process Verification Experiment

Tritium Storage & Delivery System (2/3)

- **Uranium Hydride Reaction via Visual Cell Reactor**
  - Micro-sizing after 3 cycles of hydride (room temp.) /dehydride (450°C)
    - → Need 0.5 um sintered metal filter for safety
    - → Requirements: 4,000 hydride/dehydride cycles

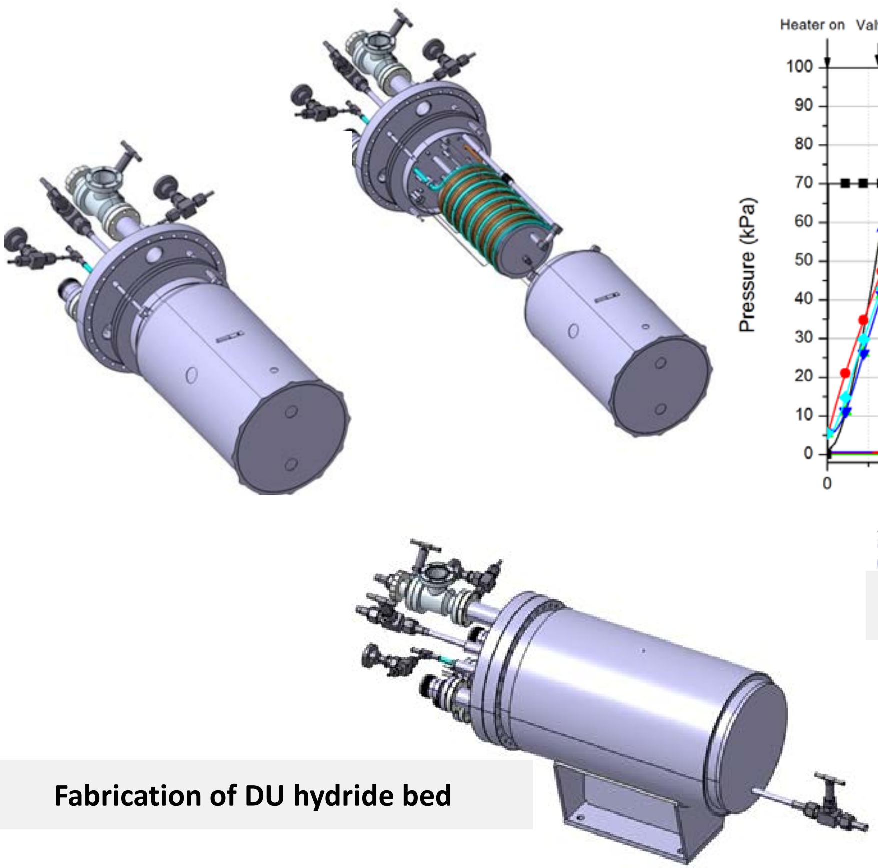


Gradual surface change and volume expansion of DU by 1st hydriding going on.

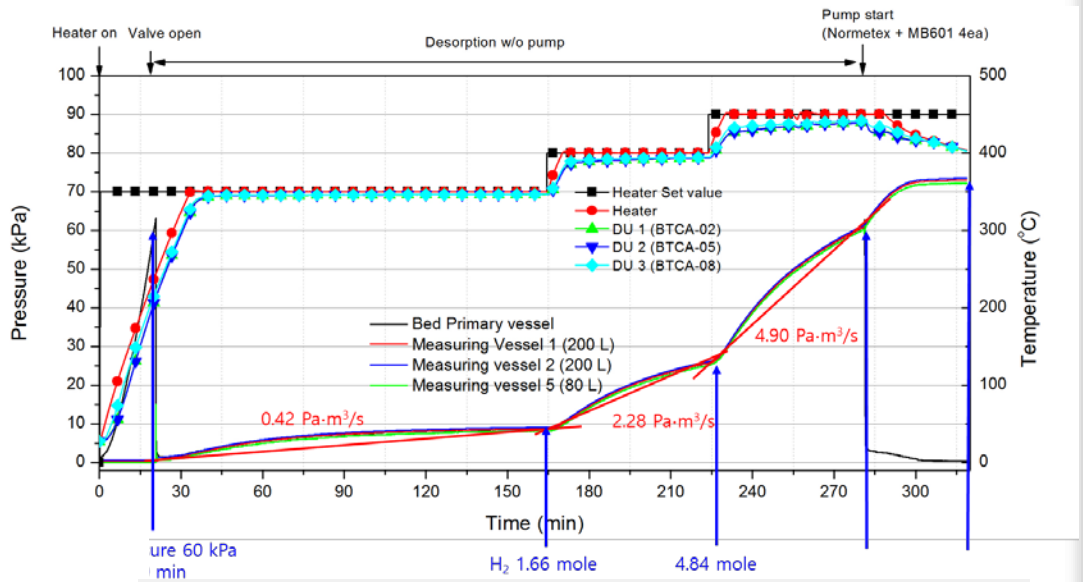
DU powder after number of hydriding/ dehydriding cycles.

Tritium Storage & Delivery System (3/3)

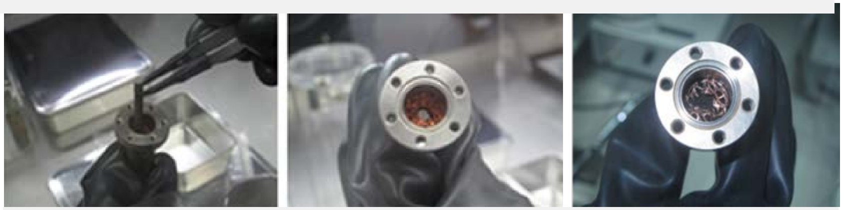
- **Metal (DU) Hydride Bed:** 4,000 hydride/dehydride thermal cycles
  - Hydriding & dehydriding reactions with thermal cycles: after cycles, DU is pulverized and spread into the space of Cu form so that the Cu form is squeezed by rapid volume expansion of DU.
  - Cu foam installation to enhance heat transfer inside a DU bed



Fabrication of DU hydride bed



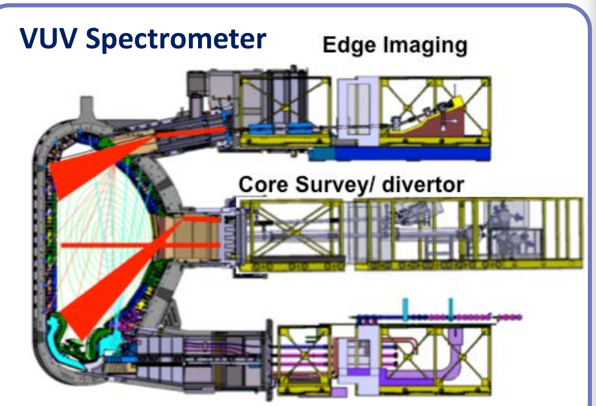
Dehydriding reaction of the DU bed

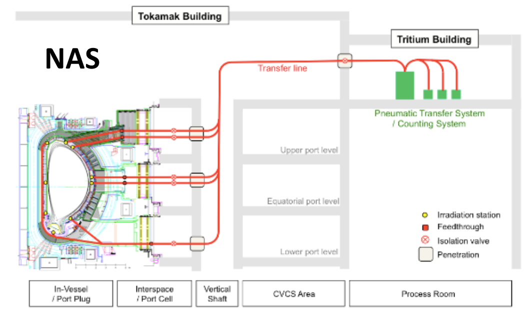


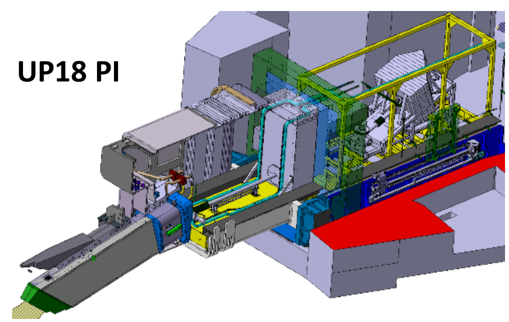
Cu form deformation with hydride/dehydride reactions

Diagnostics (1/3)

- **Functions:** Diagnostic systems shall measure the plasma and the plasma facing surfaces for
  (1) basic machine control, (2) machine protection,
  (3) advanced plasma control, (4) physics study.
- KO procures 5 systems among > 100 ITER diagnostic systems.
- KO Procurement package
  - Three VUV Spectrometers for impurity measurement
    - Core (C/N/O), edge (Be), divertor (W)
  - Neutron Activation System (NAS)
    - first wall fluence and total neutron flux
  - Upper Port #18 Port Integration (UP18 PI)
    - diagnostic integration and infrastructure in UP#18







Diagnostics (2/3)

◆ KO-DA diagnostics are at the preliminary and final design phase for now.

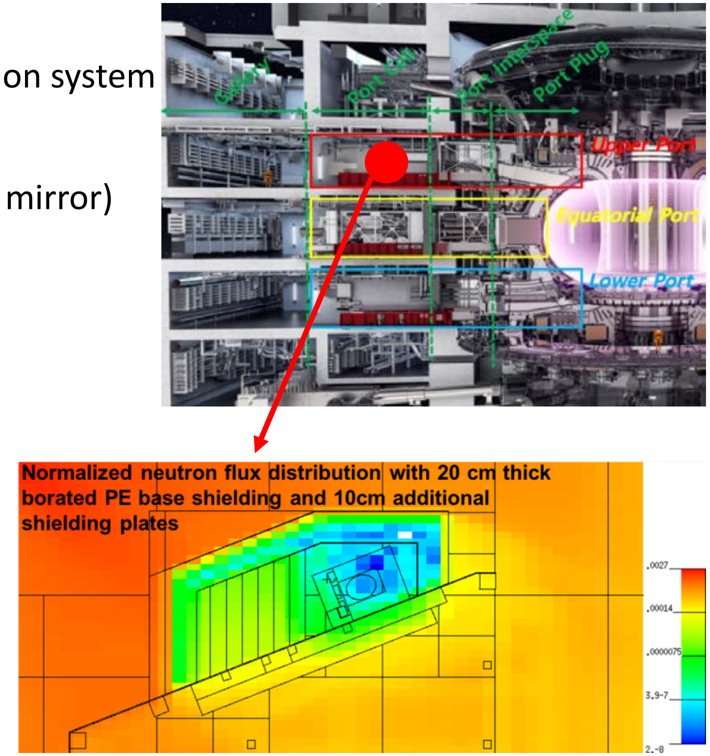
2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Design (2018–2022)										
	Manufacturing and Delivery (2019–2026)									
		Installation and Commissioning (2020–2028)								

◆ VUV Spectrometer

- **Mirror protection**: (1) shutter and feedthrough (2) deposition mitigation system
- **Neutron and gamma shielding** for CCD camera
- **Fabrication of VUV sample mirror:** 0.5-1 nm roughness (Au coated SS mirror)

Shutter test at KSTAR

VUV sample mirror



Neutron shielding for CCD camera

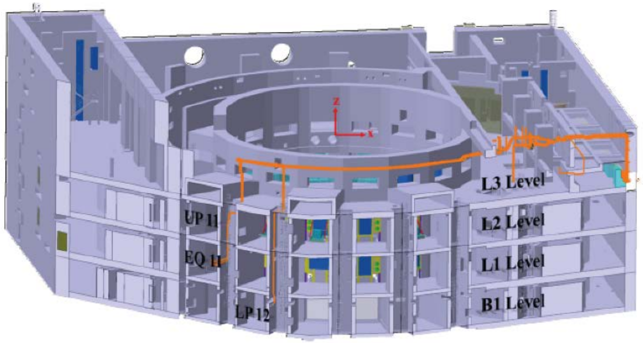
Diagnostics (3/3)

◆ Neutron activation system (100~200 m)

- Capsule: pneumatic transfer (~10 m/s) of activation sample, made of CFC
- Activation sample: **In, Si, Cu, etc.**
- **Capsule position monitoring system**
- **High thermal load** on the irradiation stations
- Many interfaces with other PBS systems

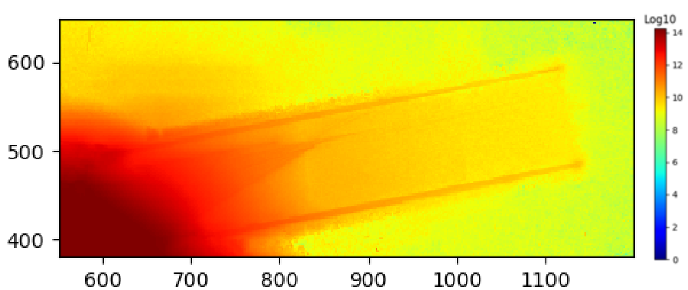
Capsule design

Capsule transfer line design

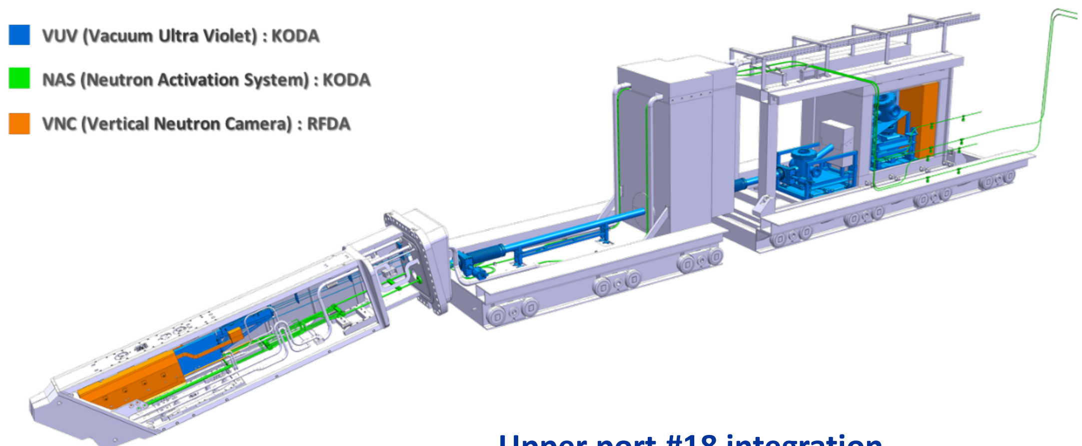


◆ Upper port #18 port integration

- Integration of 3 diagnostics: VUV, NAS, and UVNC
- Neutron shielding: **shutdown dose rate**
- Development of **pipe feedthrough**



Neutron flux calculation

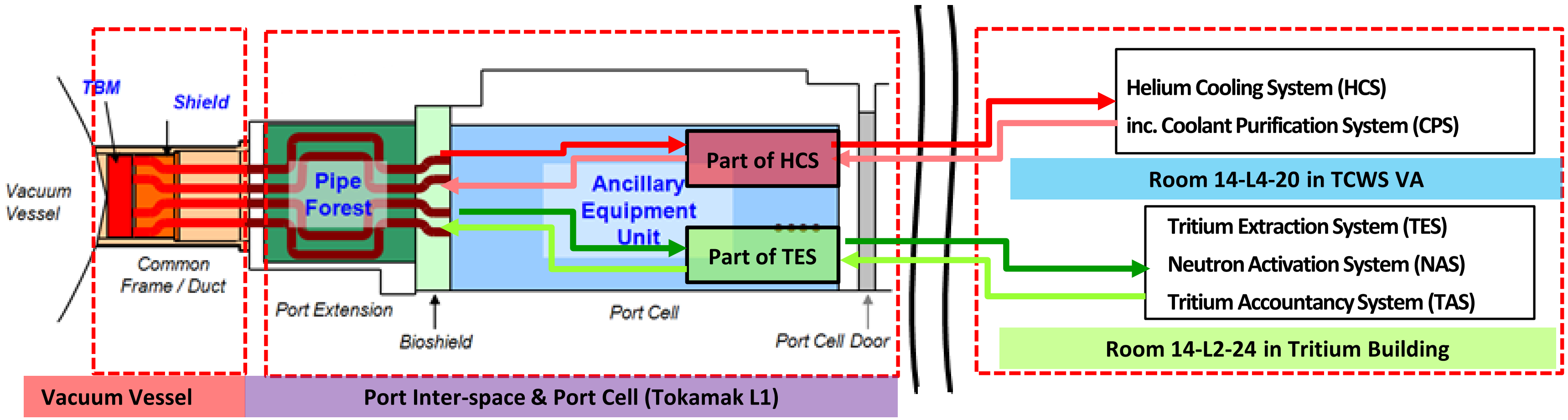


Upper port #18 integration

HCCR (Helium Cooled Ceramic Reflector) TBM (1/2)

Functions

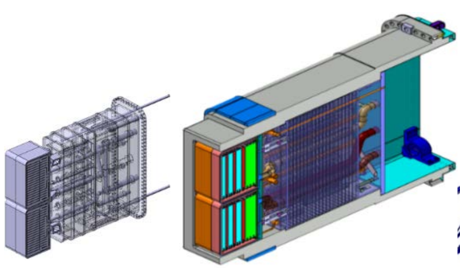
- To demonstrate **tritium breeding capability**
- To **extract high-grade heat** for electricity generation



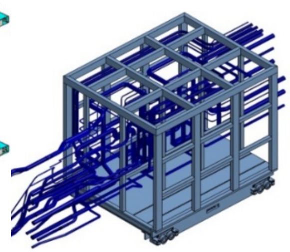
TBM-set
(TBM body/TBM shield)

TBM Systems in Port Cell
(Pipe Forest/ bio-shield / AEU)

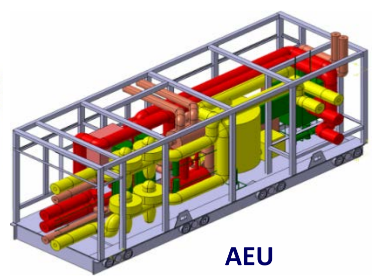
TBM Ancillary Systems
(HCS, CPS, TES, NAS, TAS)



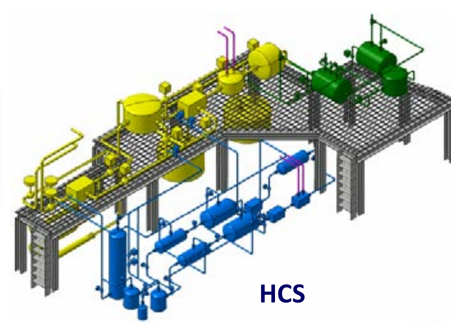
TBM-set with frame



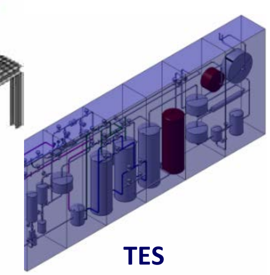
Pipe Forest



AEU



HCS

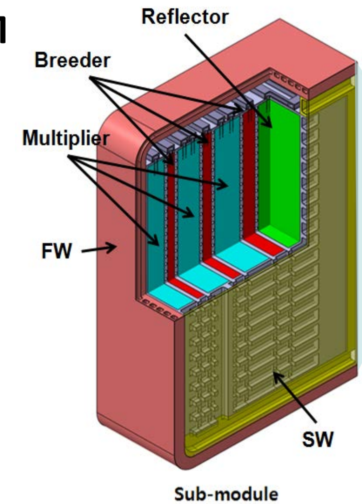


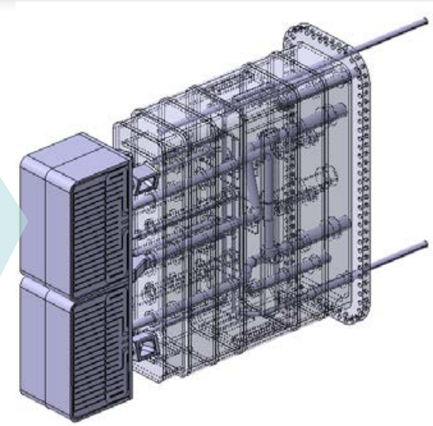
TES

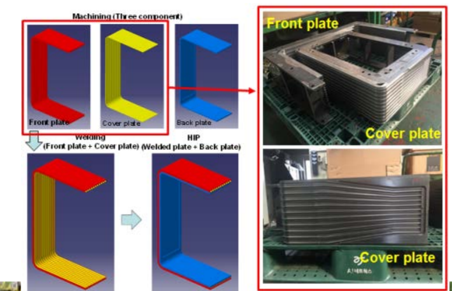
Test Blanket Module (2/2)

- **KO Helium Cooled Ceramic Reflector (HCCR) TBM**
  (DEMO-relevant breeding breeder concept)

Parameter	Values
FW heat flux	0.3 MW/m^2
Neutron wall load	0.78 MW/m^2
Thermal Power	**0.98 MW**
Structural material	**KO-RAFM (ARAA) (< 550°C), 0.01% Zr** **Improved creep and impact resistances**
Breeder	**Li_2TiO_3 (< 920°C), ~80 kg** **70% enrichment Li-6**
Multiplier	**Be (< 650°C), ~100 kg**
Reflector	**Graphite (<1200°C)** **Reduce the Be Multiplier up to 50%**
Size	**1670(P) x 462(T) x 605(R) (mm)**
Coolant	8 MPa He, 1.14 kg/s (Nominal) 300°C inlet / 500°C outlet
Purge gas	He with 0.1 % H_2
TBM-shield	316L(N)-IG Block/Cooling Channels ITER FW/BLK-PHTS (40°C, 4 MPa)





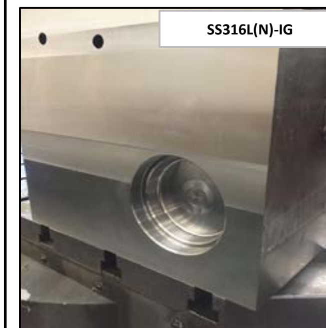
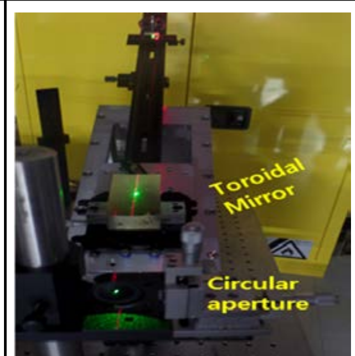


ARAA (Advanced Reduced Activation Alloy) Product

Contents

Overall Physical Progress of KODA Procurement Activities

❖ Overall Physical Progress of KODA Procurement Activities (including design) is recorded as about **64.2% in October 2018.**

TF Conductors	Vacuum Vessel Sector	Vacuum Vessel Ports	Thermal Shield	Blanket Shield Blocks
				
100.0%	85.5%	41.3%	65.5%	24.5%
Assembly Tools	**Tritium SDS**	**AC/DC Converters**	**Diagnostics**	
				Average about 64.2 % (as of October 2018) (Activity Progress as per Item × Weight of its kIUA)
89.0%	13.3%	76.1%	30.7%	

ITER Roles for K-DEMO Technology

- **Fusion Plant EPC Technology (in the Construction Phase)**

⇒ **Key Construction Technology for K-DEMO**

- Engineering design and manufacturing (Codes & Standards) of components/systems (VV, SCM) and buildings for Tokamak reactor construction
- Remote handling, maintenance, repair under the radioactive environment
- Systems of CODAC, Heating and Current Drives, and Diagnostics

⇒ **License Technology for Safety of K-DEMO**

- Licensing and Environmental Safety, etc. → Safety Analysis & Preliminary Safety Report (RPrS)

⇒ **Project Lifecycle Management Technology for K-DEMO Project**

- Managements of Quality, Performance, Risk, Interface, Baselines, Engineering Dossiers, etc.

- **Physics and Operation Technology (in the Operation Phase)**

⇒ **Burning Plasma Physics Understanding**

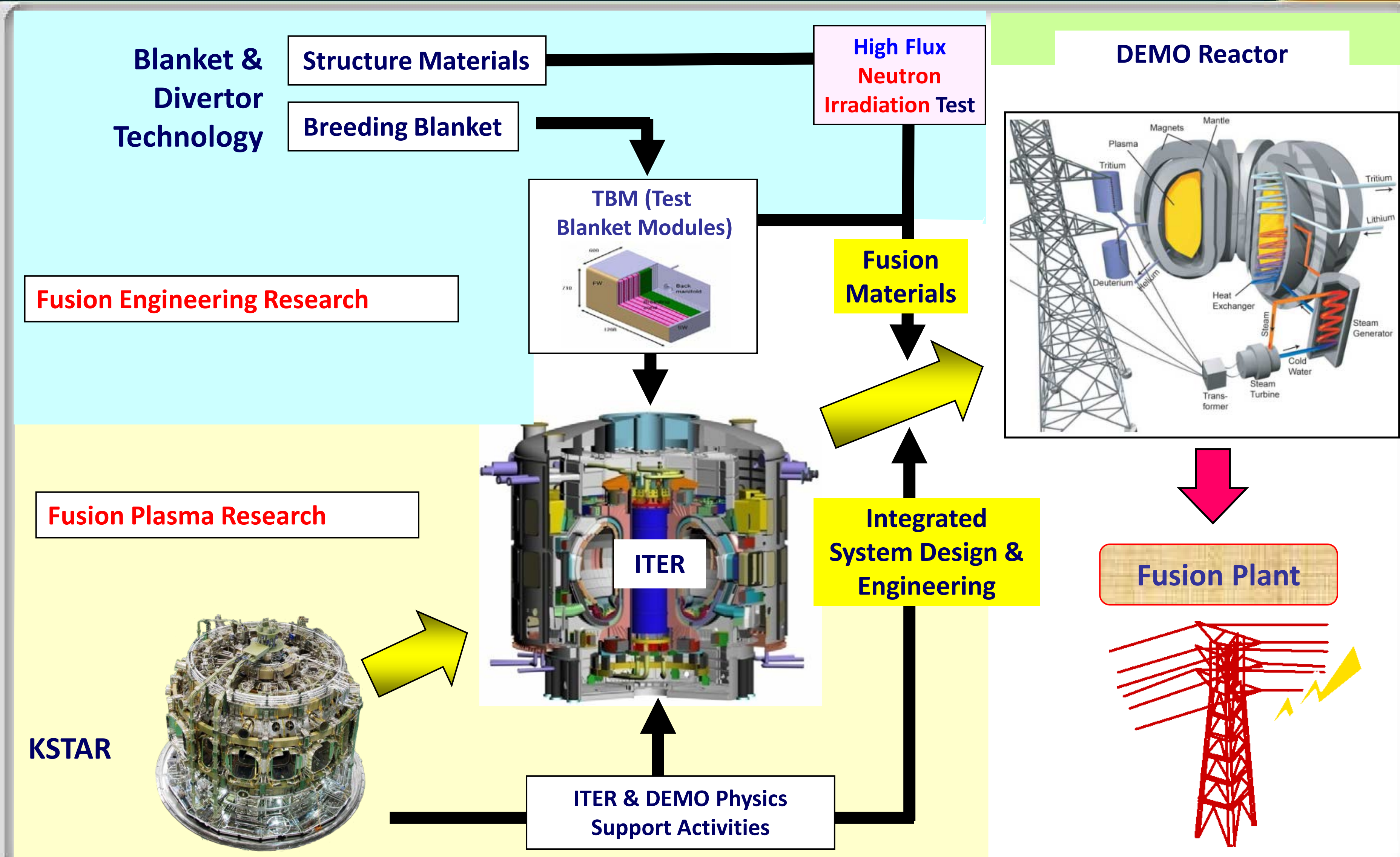
- Burning plasma operation, integrated operation scenarios, integrated plasma control
- Alpha particle: Plasma stability, MHD, ELM & disruption mitigation, transport & confinement,
- Divertor and plasma-wall Interactions

- **Fusion Reactor Engineering ⇒ Test Blanket Modules**
  - Breeding blankets (tritium extraction), etc.
  - Tritium fuel cycle (exhaust processing, detritiation, isotope separation, etc.)
  - Blanket/Divertor (W) materials under the heavy heat and nuclear loads

Summary

- The ITER project is a first-of-a-kind fusion reactor enterprise that has the technical challenges inherent. So, it is important for world-wide fusion communities to make their common efforts towards the success of ITER.
- International Enterprise is a challenge on how to control and manage the quality of in-kind components/systems.
- KO-DA is working collaboratively with the IO and other DAs to meet the FP in 2025.
- KO-DA procurement activities are actively progressing for design and manufacturing.
- ITER Korea is very keen to accumulate the core fusion technology of ITER tokamak systems, including non-KO procurement items.
- Systematic approach with coordinated strategy for fusion programs in Korea is very important to integrate not only all of the key technologies but also human resources and infra-structures to develop a DEMO fusion reactor.
- The success of ITER would give a big momentum to the KO fusion community to undertake a fast track to build the commercial fusion power plant in the future.

Korean Fusion Energy Development Roadmap



National Fusion Research Institute

Thank you for your attention.