Fusion Power Associates 40th Annual Meeting and Symposium
Fusion Energy: Perspectives and Planning
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At Grand Hyatt Washington Hotel

Fusion Energy Research & Development in Japan: Perspectives and Planning toward DEMO

- ITER, JT-60SA and Other Broader Approach Activities -

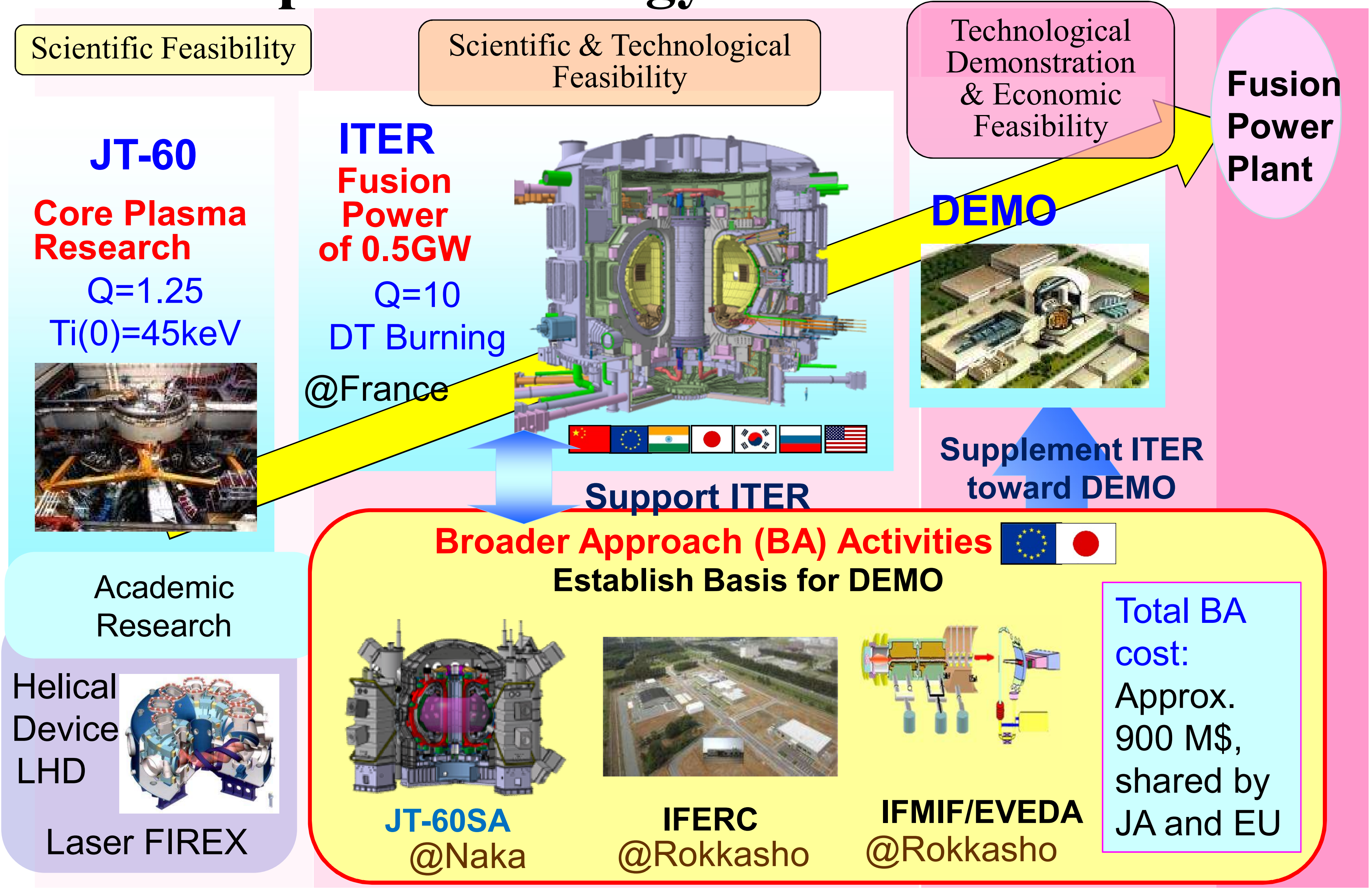
Presented by
Kenichi KURIHARA

QST
Naka Fusion Institute
National Institutes for Quantum and Radiological Science and Technology

Fusion Energy Research & Development in Japan: Perspectives and Planning toward DEMO

Contents

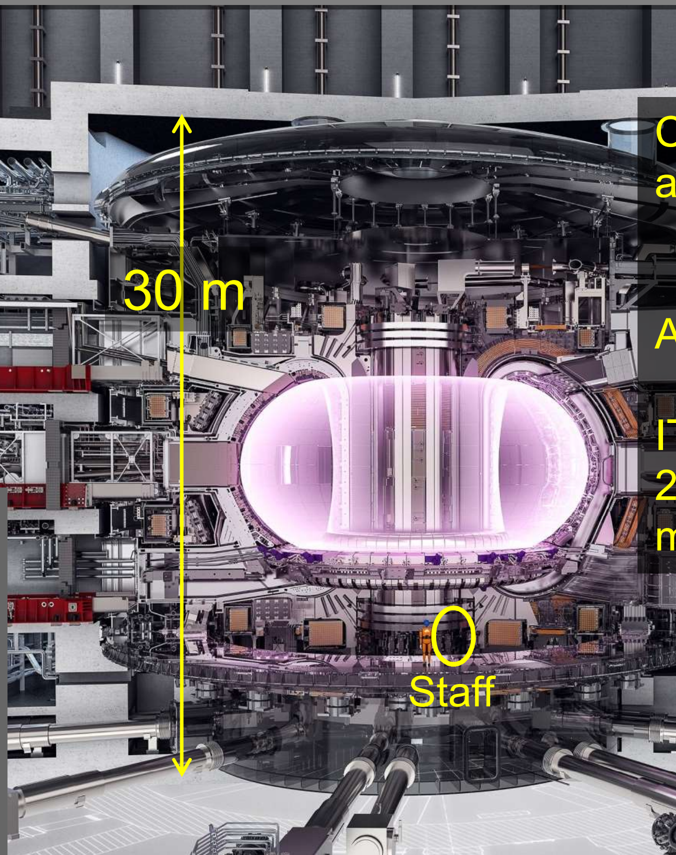
Japanese Strategy toward DEMO



ITER Project：7 Members Collaboration

65% Completed for FP

Demonstrate Long-pulse or Steady-state DT Burn
Fusion Output = 500 MW, Q = 10（Aux. Heating 50 MW）



China, EU, India, Japan, Korea, Russia, and USA (in Alphabetical Seq.)

At Saint-Paul-les-Durance, France

ITER Organization was established in 2007. Domestic Agencies are sharing manufacturing of the components.

Bigot DG

Tada DDG

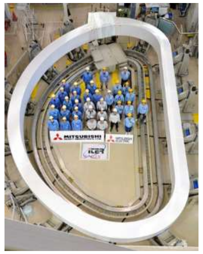
Lee DDG

2025: First Plasma
2035: DT Burn

Site View

ITER – Japanese In-kind Contribution

Manufacturing technology of ITER components is also indispensable for construction of DEMO.

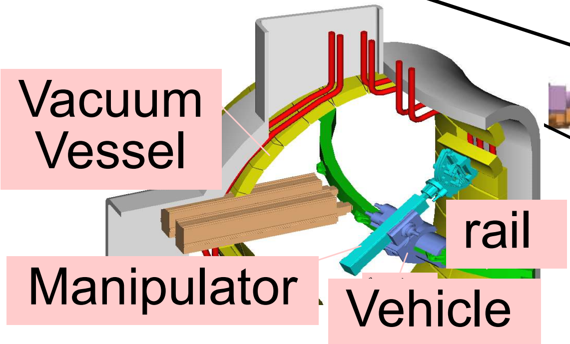


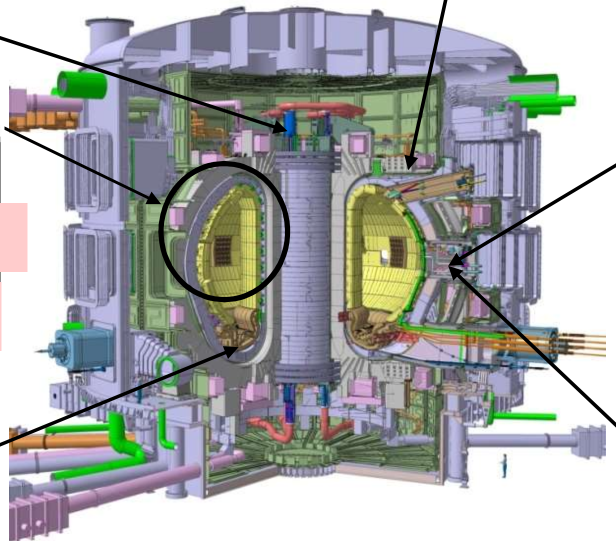
CS Coil

- All 49 conductors were completed, and delivered to U.S. Mar. 2018.

TF Coil

- 9 out of 19 TF Coils and all 19 Coil Structures are procured by JA.
- 6 Coil Structures were completed.
- First TF coil will be shipped in Feb. 2020.



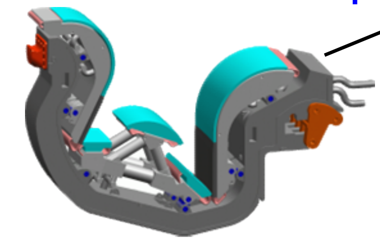


NBI system

1-MV PS were installed in the NBTF site at RFX in Italy.
- Commissioning is now going to the final stage.

Remote Handling

- Manufacturing design activities are in progress.



Divertor (Outer Target)

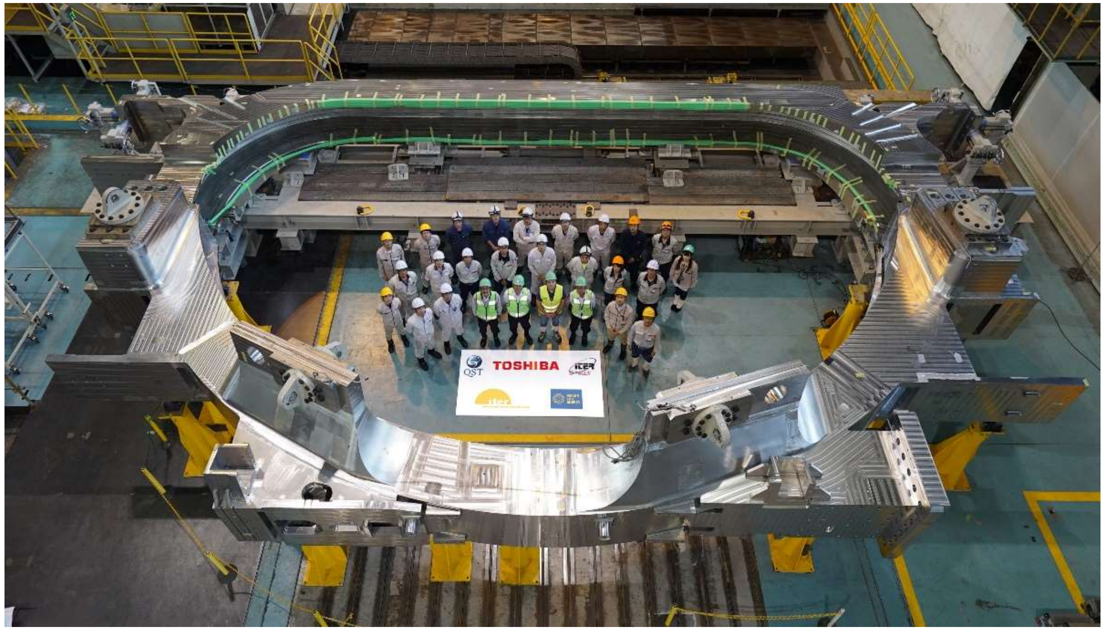
- Based on the major design change to full tungsten divertor, prototype manufacturing is starting.

ECH system

- 8 out of 24 gyrotrons are procured by JA.
- 2 gyrotrons have passed the Factory Acceptance Tests defined by ITER Organization in 2019.

Progress on TF Coils and TF Coil Structures

The First TF Coil will be completed in a few months at MHI.



4 TF Coil Structures have been delivered to EU.

	JA TF coil								
	1	2	3	4	5	6	7	8	9
Double Pancake	M	M	T	M	T	M	T	T	M
Winding Pack	M	M	T	M	T	M	T	T	M
TF coil FAT	M	M	T	M	T	M	T	T	M

Green: completed, M: MHI, T: Toshiba

	JA portion									EU portion									
	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9	10
Inboard	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Outboard	H	H	T	H	T	H	T	T	H	H	H	H	H	T	T	T	T	T	T
Shipping																			

Green: completed, M: MHI, T: Toshiba, H: HHI

ITER – Essential and Crucial for DEMO –

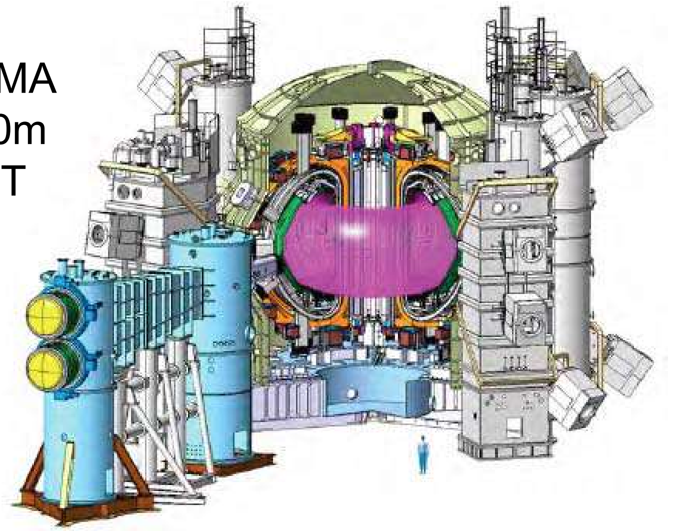
ITER provides the most essential manufacturing technology for DEMO construction, because….

- Manufacturing technology of the components such as **SC coils, heating & current drive systems (gyrotron, ion beam), divertor, remote handling, diagnostics, tritium handling,** etc., for ITER provides a basis for DEMO. (e.g. precise welding, high voltage technology, …..)
- ITER has similar power-plant-scale facilities to DEMO.
- Plant integration & project management experience could be valuable lesson learned for DEMO.
- ITER Test Blanket Modules directly contribute to ones for DEMO.
- Licensing procedures for ITER are surely a good example of the DEMO regulation for any country.
- DT burning plasma operation generates a physics basis for DEMO.

Success in ITER construction and operation is necessary for DEMO.

JT-60SA *(Super Advanced)* - Satellite Tokamak in BA Complementary to ITER Project -

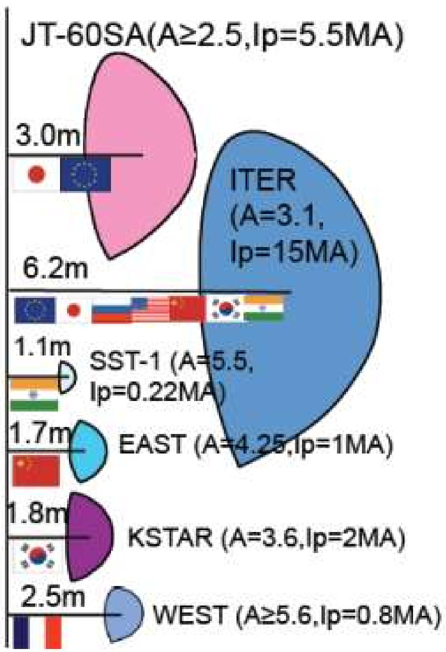
I_p=5.5MA
R_p=3.0m
B_t=2.3T



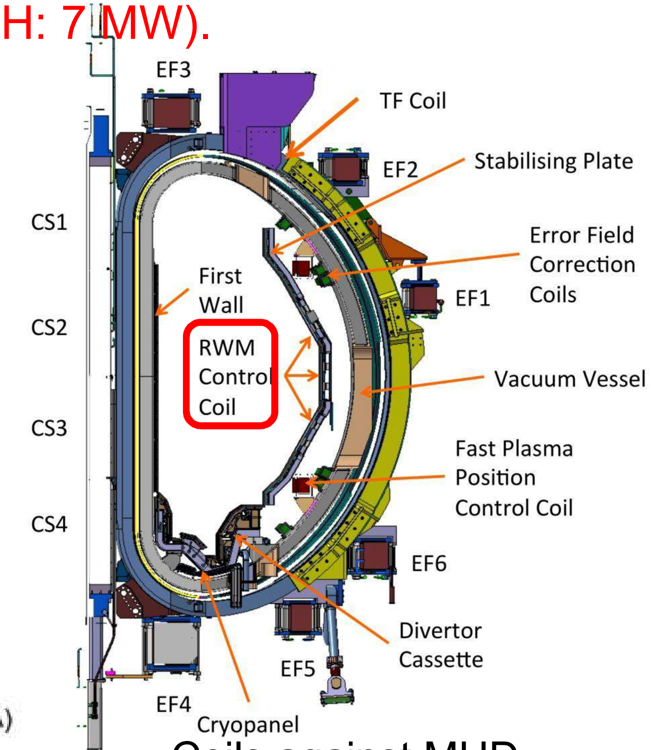
JT-60SA: a highly shaped ($S=q_{95}I_p/(aB_t)$~7, A~2.5) SC tokamak confining a deuterium plasma with I_p=5.5 MA for typically 100s longer than the timescales of the key plasma processes such as current diffusion with high heating power of 41MW (PNB: 24, NNB: 10, ECH: 7 MW).

Mission: contribute to early realization of fusion energy by addressing key physics and engineering issues for ITER and DEMO.

1. Support ITER using break-even-equivalent class high temperature D-plasmas
2. Supplement ITER toward DEMO with long sustainment (~100s) of high pressure steady-state plasmas necessary in DEMO
3. Train Next Generation Researchers playing leading roles in ITER & DEMO



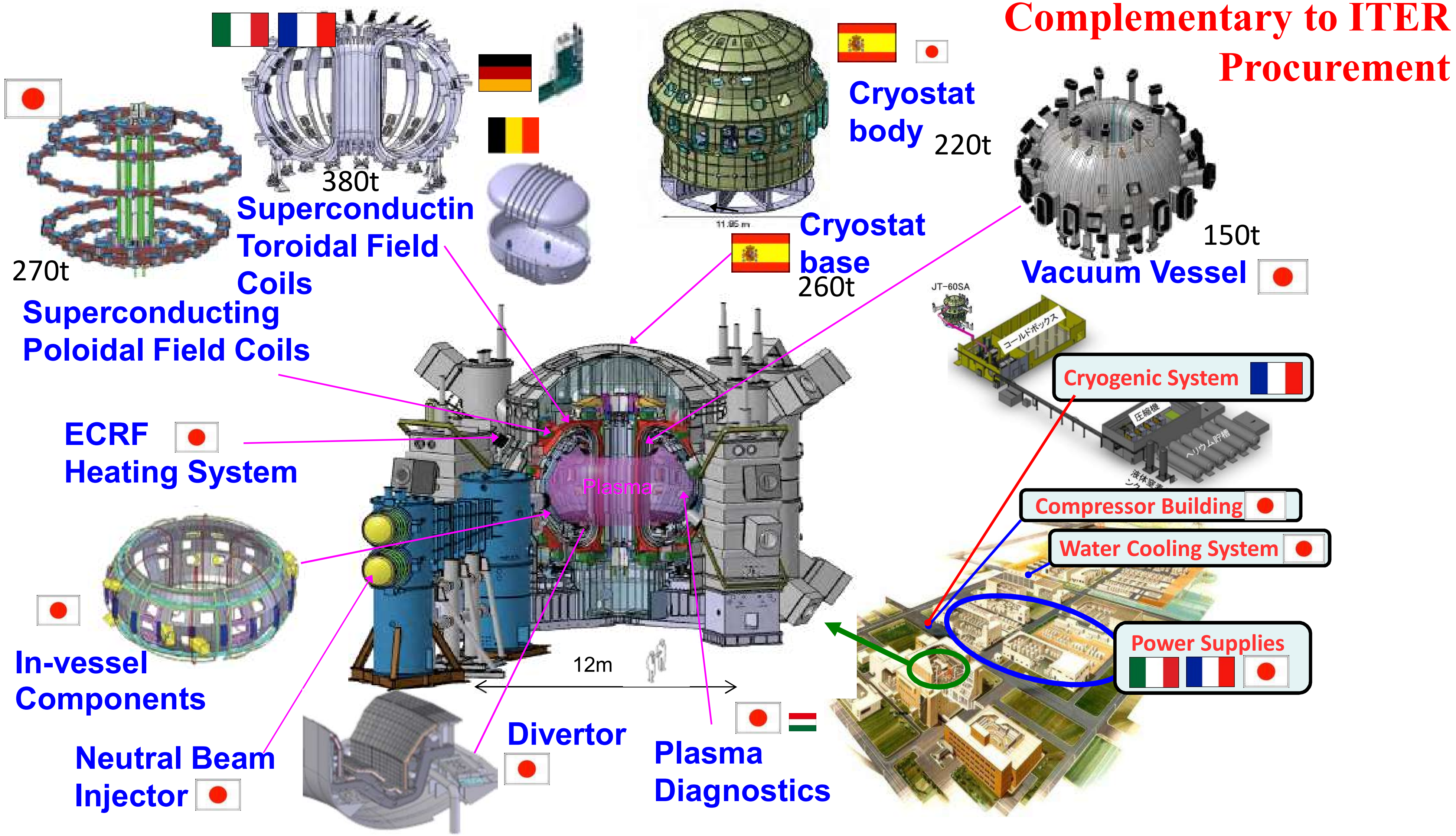
SC Tokamaks



Coils against MHD Instabilities

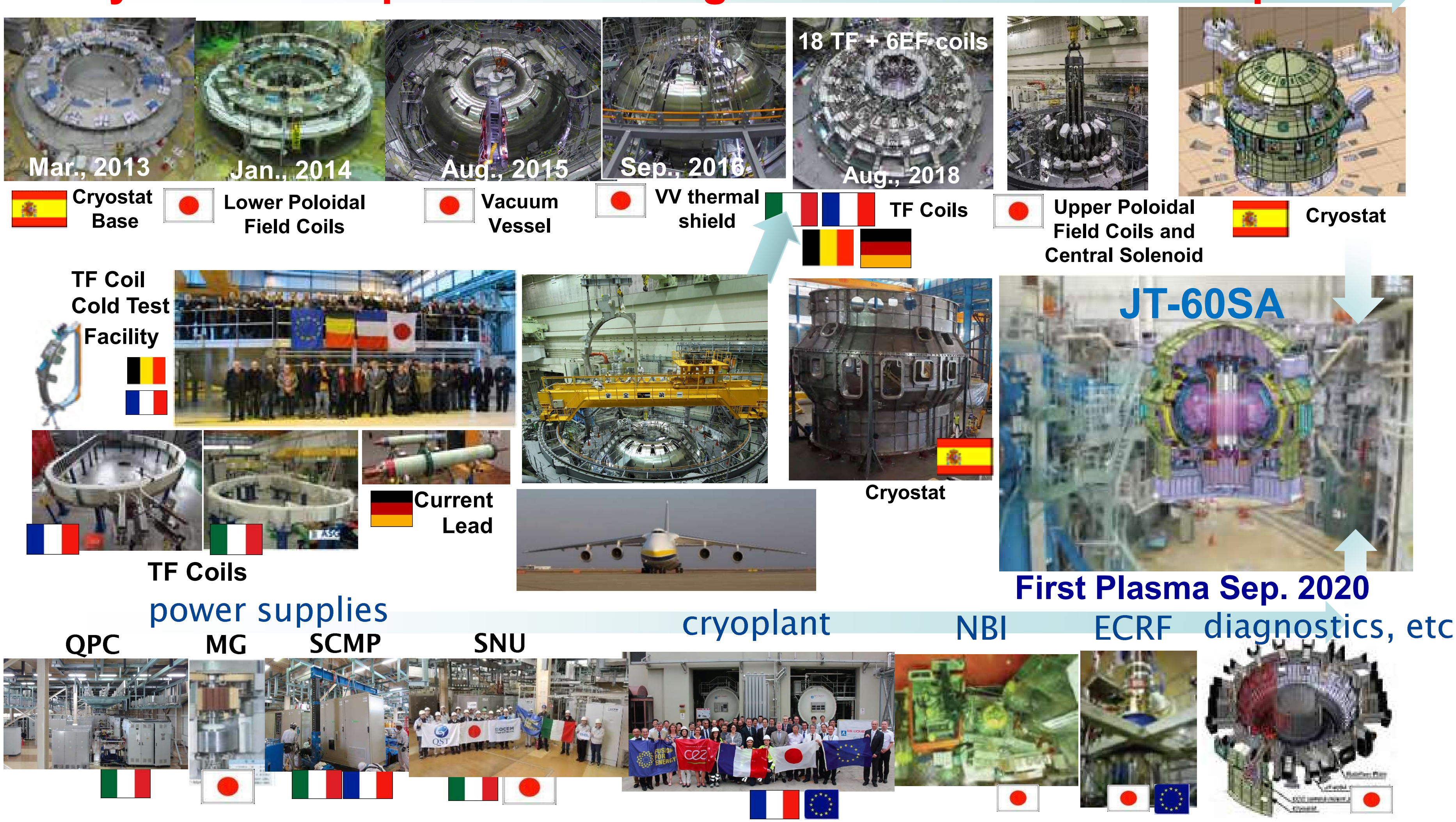
EU & JA Procurement Sharing of JT-60SA Components

Complementary to ITER Procurement



JT-60SA Assembly is going well on schedule.

Assembly will be completed in coming March & First Plasma September 2020



Achieved Small Tolerance of Manufacture and Assembly

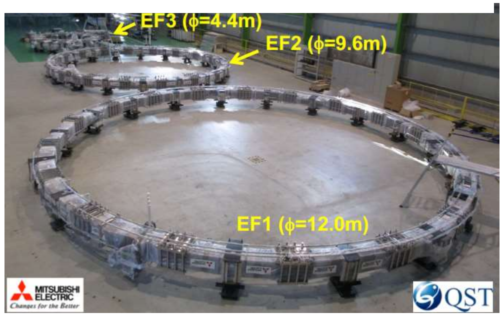
Allowable magnetic field error : ～10^{-4}

=> Manufacture & assembly accuracy is ~ mm

⇨ Achieved.

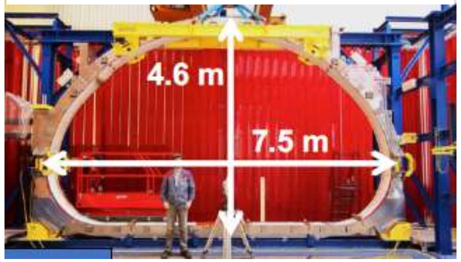
CB, surface flatness 0.6mm

EF, Deviation from exact Circle 0.2-1.3mm



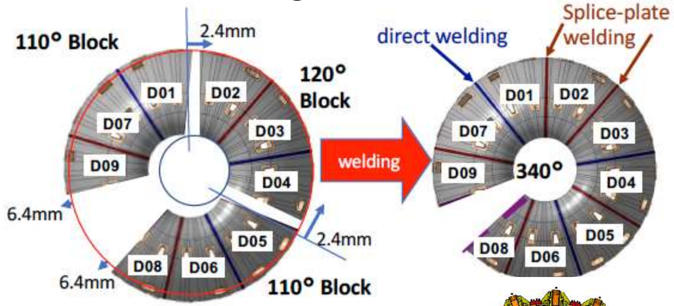
CS, Deviation from exact Circle 0.3-0.4mm

TF, Deviation of Current center 2 mm

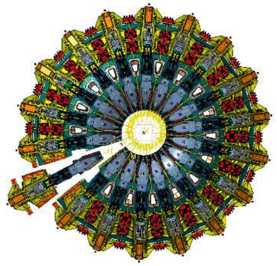


VV ±2 - 5 mm

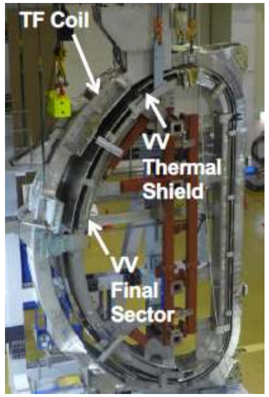
VV welding : ±4 - 8 mm



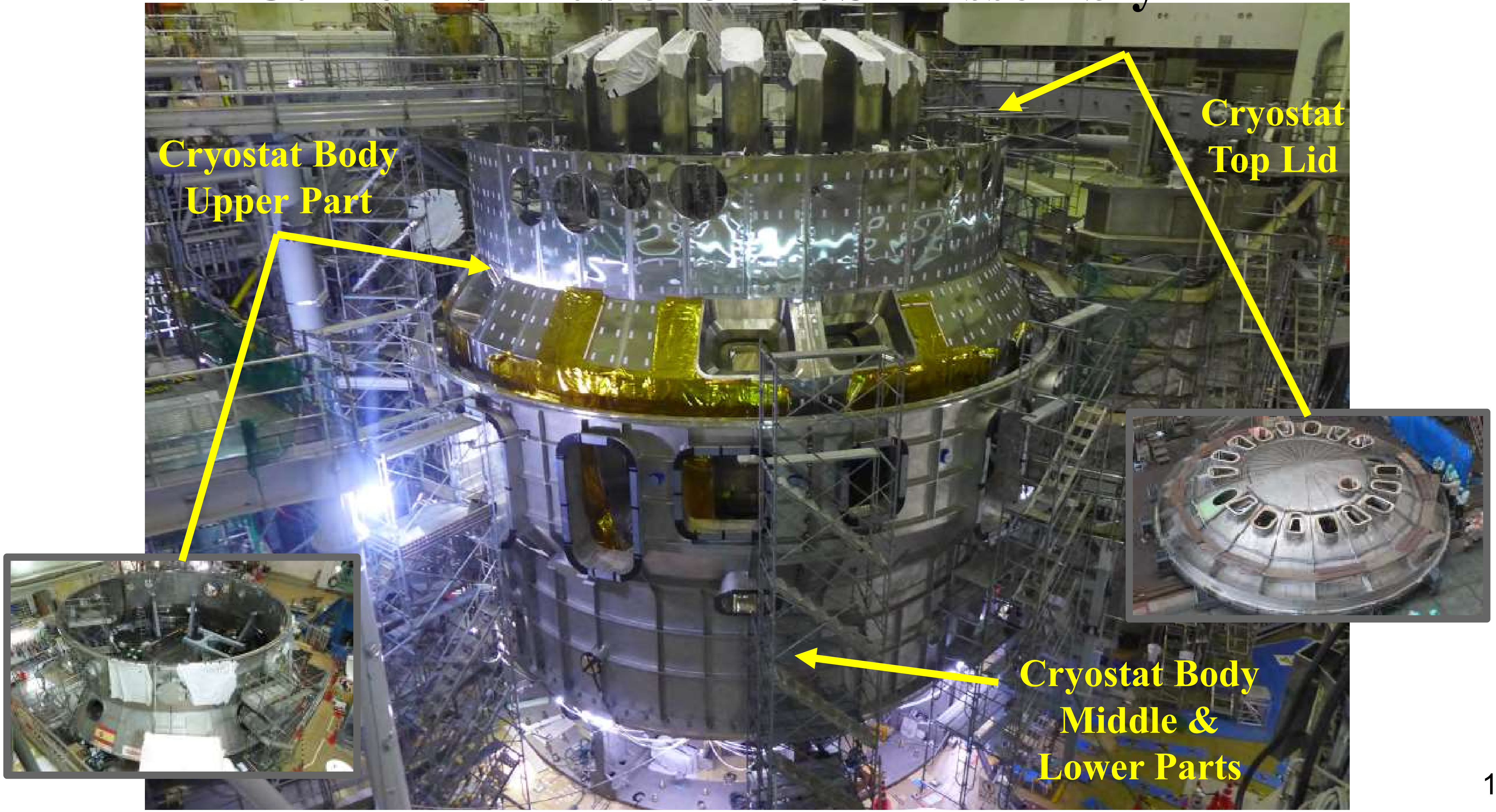
TF assembly : ±1 mm



Laser tracker



Current Status of JT-60SA Assembly



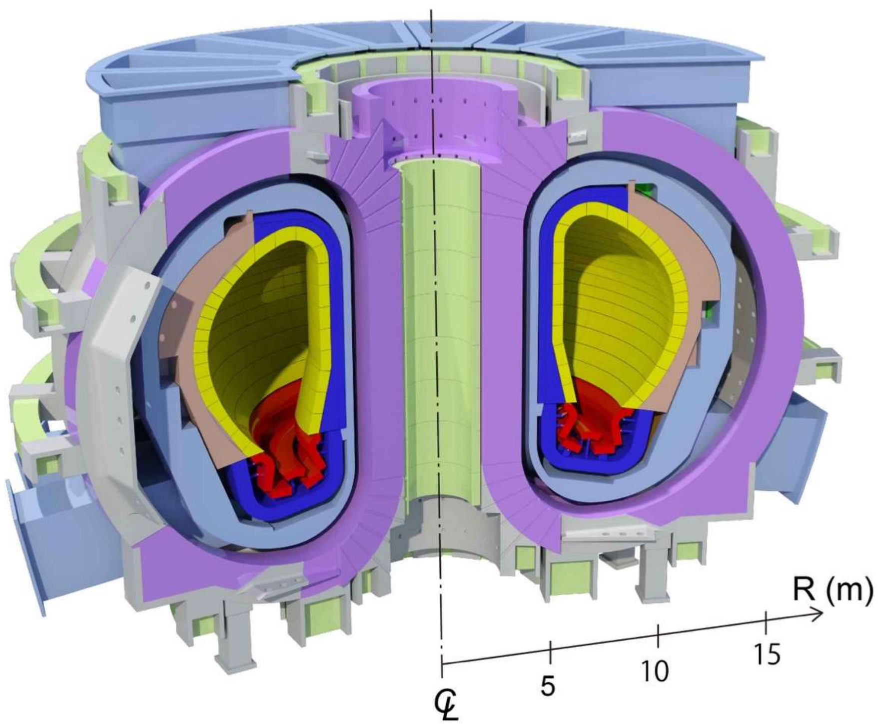
JA DEMO (2018)

Major Parameters

R_p = 8.5 m ← Sufficient Volt-sec supply for operational flexibility

P_{fus} ~ 1.5 GW ← Divertor heat removal, W mono-block < 10 MW/m^2

Breeding Blanket (BB) : Water-cooled Solid Breeder (WCSB)



R_p	**8.5**	**m**
A	**3.5**	
k_{95}	**1.65**	
q_{95}	**4.1**	
I_p	**12.3**	**MA**
B_T (Nb_3Sn)	**5.94**	**T**
P_{fus}	**1.46**	**GW**
n_e	**0.66**	**10^{20} m^{-3}**
HH_{98y2}	**1.31**	
β_N	**3.4**	
Neutron WL	**1.0**	**MW/m^2**

K. Tobita, et al, Overview of the DEMO conceptual design activity in Japan, FED 136 (2018) 1024-1031

Basic Plant Design Target of JA DEMO

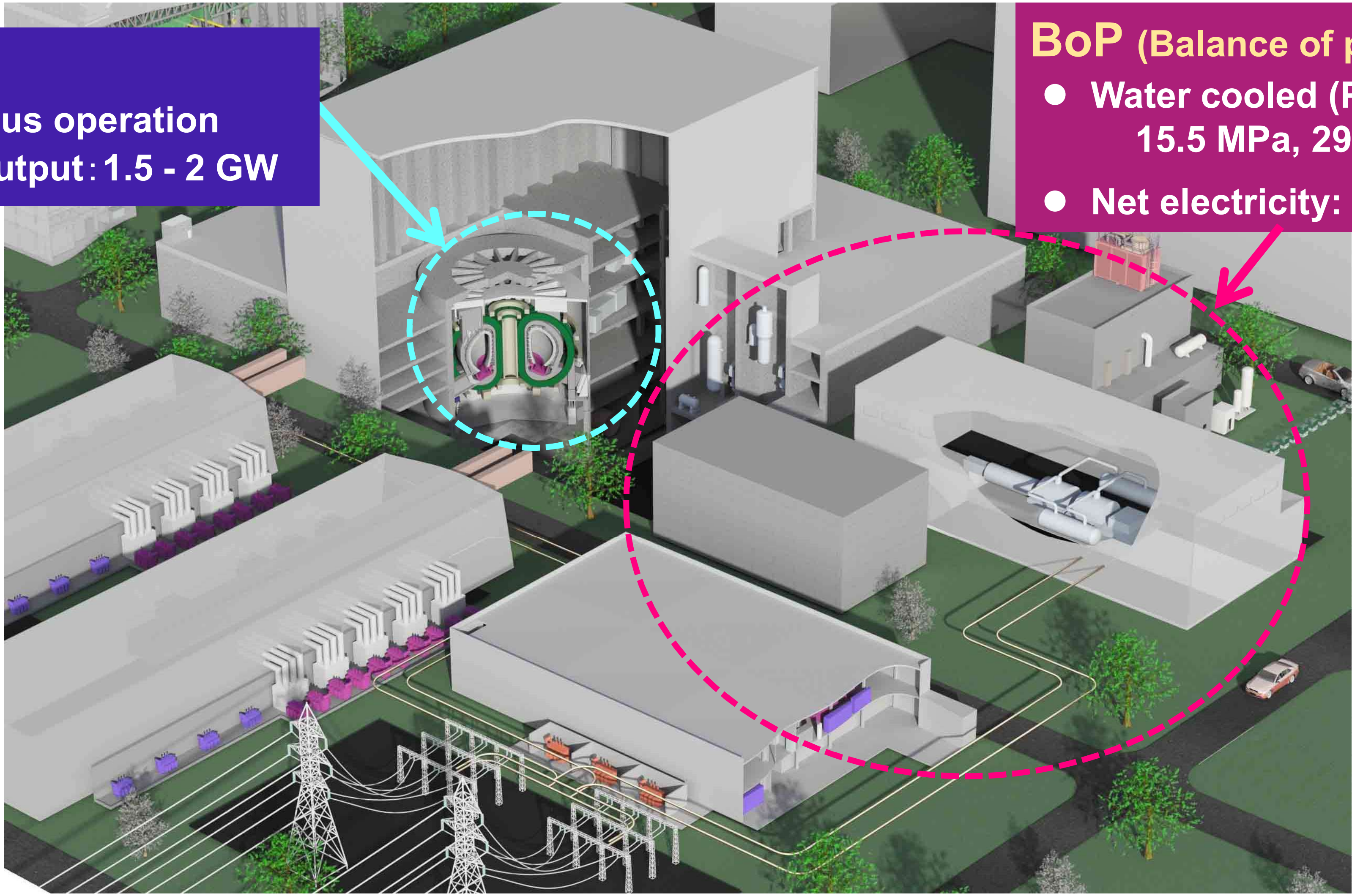
feasible on the premise of the success of ITER

Reactor

- Continuous operation
- Fusion output : 1.5 - 2 GW

BoP (Balance of plant)

- Water cooled (PWR cond.)
  15.5 MPa, 290-325ºC
- Net electricity: 0.2-0.3 GWe



Fusion DEMO

Other Broader Approach (BA) Activities

Broader Approach (BA) Activities (2007-2020: Phase I)

(a)Satellite Tokamak JT-60SA Program: high-β_N SC Tokamak

(b) Engineering Validation and Engineering Design Activities for the International Fusion Materials Irradiation Facility (IFMIF/EVEDA):

- Develop prototype accelerator for IFMIF

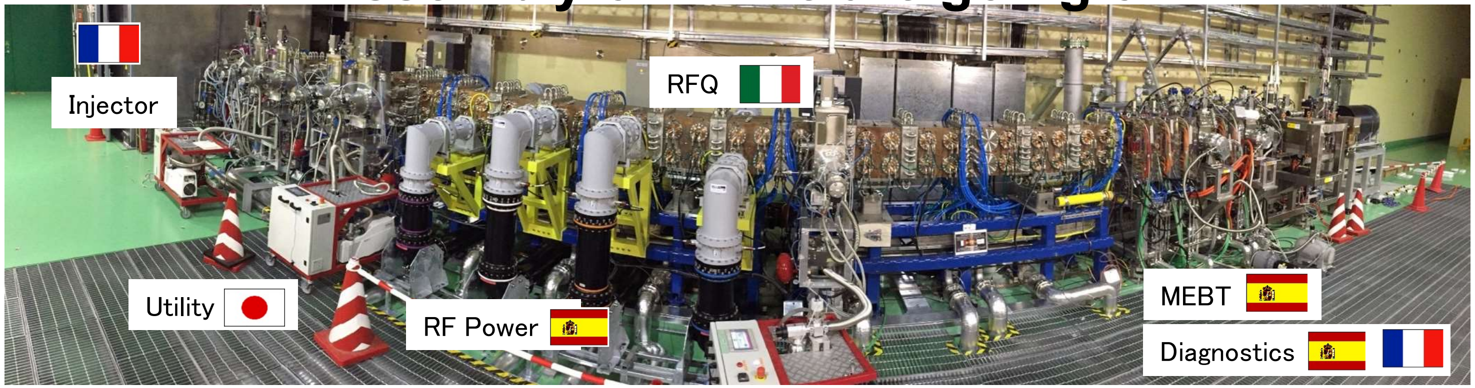
(c) International Fusion Energy Research Center (IFERC):

- DEMO Design
- DEMO R&D

BA Phase II (2020 - 2025)

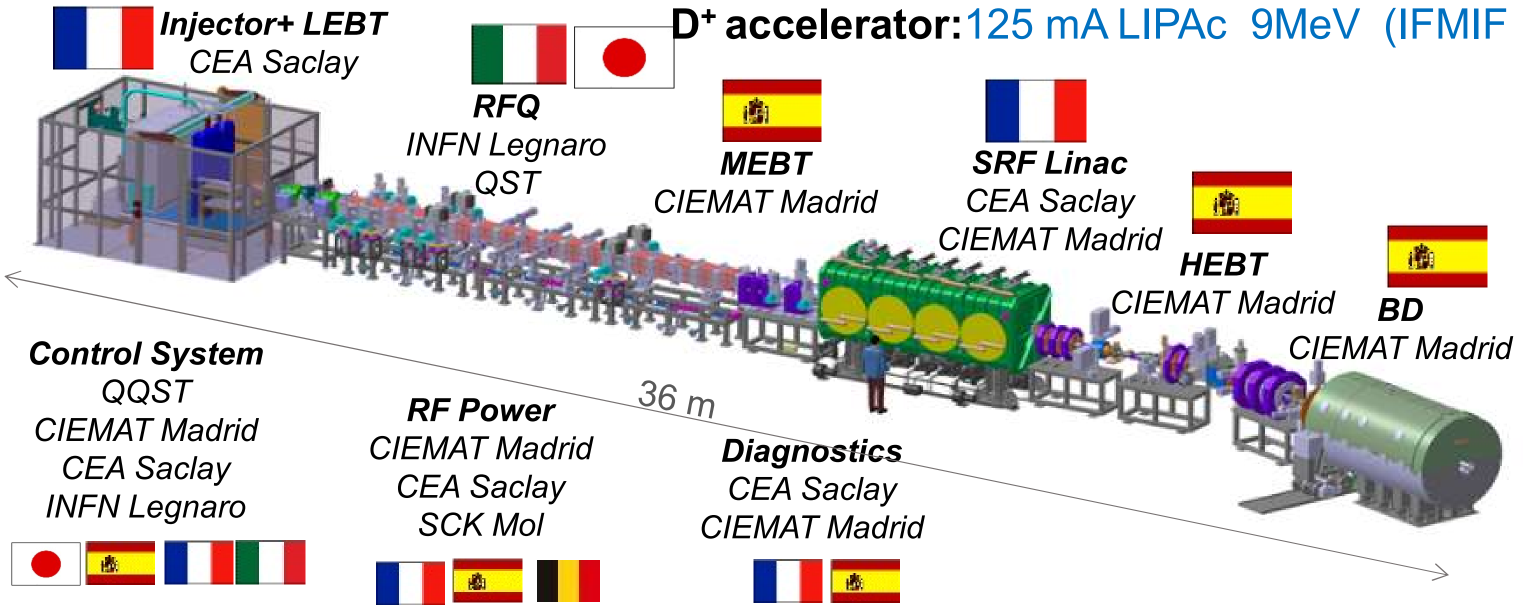
(b) BA IFMIF/EVEDA Project

Assembly of LIPAc are going on.



125 mA
@9 MeV
achieved
in June, 2019

D^+ accelerator: 125 mA LIPAc 9MeV (IFMIF 40MeV)



Linear IFMIF Prototype Accelerator - **LIPAc**

RFQ: Radio Frequency Quadrupole

MEBT/HEBT: Medium/High Energy Beam Transport Lines

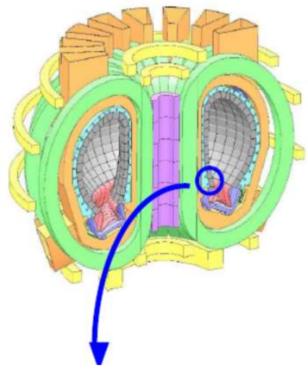
SRF Linac: SC RF Linac

(c) BA International Fusion Energy Research Center (IFERC)

DEMO R&D

Five R&D subjects for DEMO Blanket from 2007 to 2017.

R&D activities are going on.



DEMO

Breeding Blanket

4. Tritium Breeder

Li_2TiO_3
1 mm diameter

$^6Li + n \rightarrow T + He$

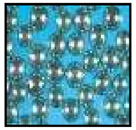
1. RAFM (Reduced Activated Ferric Martensite)

Structural material for DEMO Blanket

2. SiC/SiC

Advanced functional materials

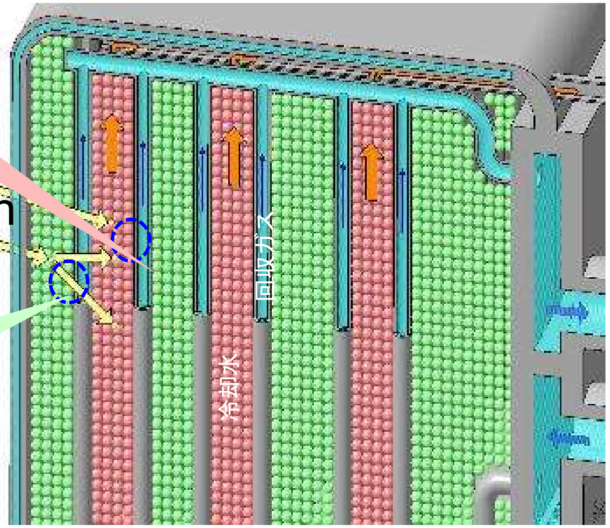
5. Neutron Multiplier



$Be_{12}Ti$
1mm diameter

$Be + n \rightarrow 2He + 2n$

Neutron



Recovery of tritium

3. Tritium Technology

Coolant outlet
325ºC

Coolant Inlet
290ºC

Discussion of BA Phase II

- BA Activities were launched under the BA Agreement between Japan and EU in 2007, and will finish in March 2020. The activities are (1) JT-60SA, (2) IFMIF/EVEDA, and (3) IFERC.
- BA Activities have been very well managed by both JA and EU, and now come to a mutual-trust-based collaboration.

- **JA-EU recommends the following activities should be expected in the extended period of 5 years as BA phase II just after the current BA phase I.**
  (1) To develop operation scenarios for the ITER and DEMO reactor by using JT-60SA.
  (2) To achieve the long-duration operation of Prototype Accelerator LIPAc (IFMIF/EVEDA).
  (3) To design a DEMO reactor, to execute necessary R&D, and to operate the computer simulation center (IFERC).
- **JA and EU are preparing to jointly declare to extend the BA activities.**

BA Phase II Objectives for JT-60SA

i) Start operation of the largest superconducting (SC) tokamak JT-60SA, and complete the integrated commissioning including the first plasma in 2020.

ii) Evaluate the engineering achievements in constructing this large SC tokamak device for ITER, and

iii) Execute the experiments for the “Initial Research Phase” defined in **the JT-60SA Research Plan v.4.0**: ITER scenario development, ITER risk mitigation, and preparation of steady-state high β_N scenario for DEMO.

Machine enhancements

a) Manufacture & installation to allow high power heating Deuterium Exp. with i) In-vessel components, ii) Heating (P-NB 8unit, N-NB 2 unit), and iii) Fundamental Plasma Diagnostics, pellet, MGI, etc.

b) Manufacture/Preparation: CFC monoblock & Divertor cassettes, Advanced Diagnostics, Components for collaboration with ITER.

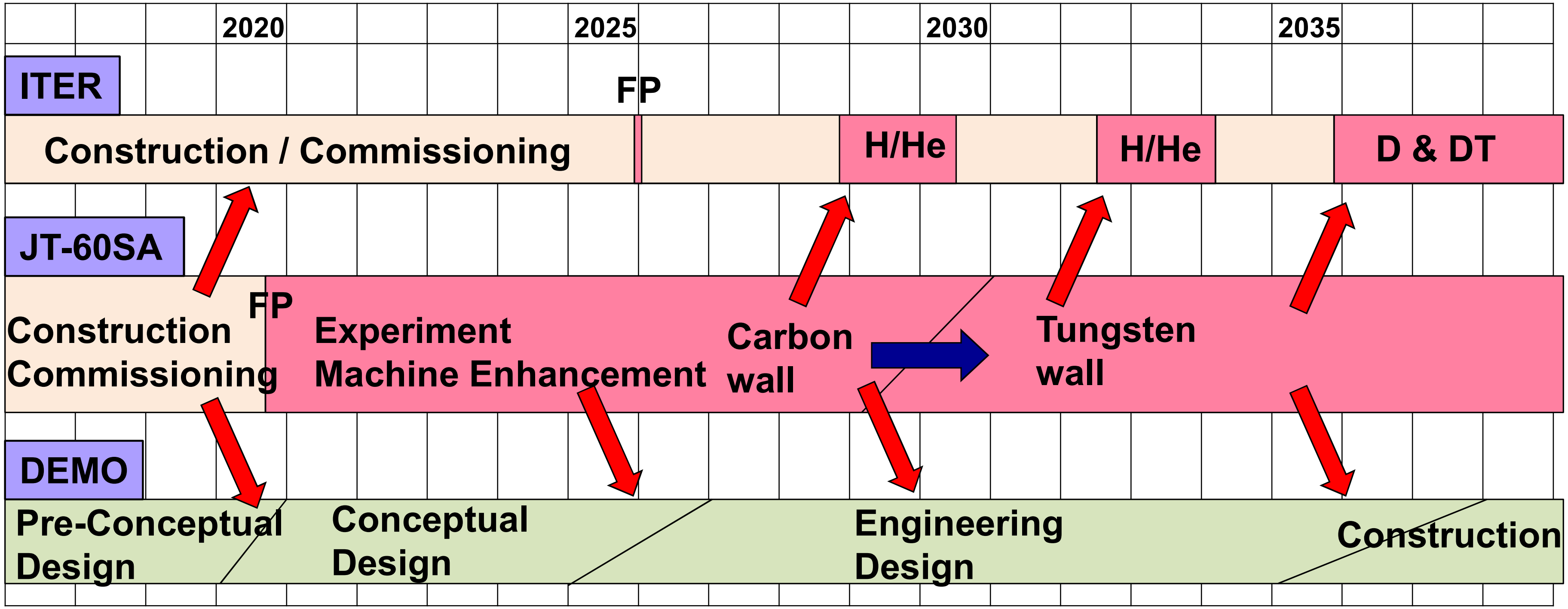
JT-60SA Research Plan
http://www.jt60sa.org/b/index_nav_3.htm?n3/operation.htm

Assumed JT-60SA Contributions to ITER and DEMO

Manufacture & Assembly
Experiments/ Analyses/ Modeling => ITER, and DEMO

ITER & JT-60SA Collaboration Arrangement: Signed on Nov. 20, 2019

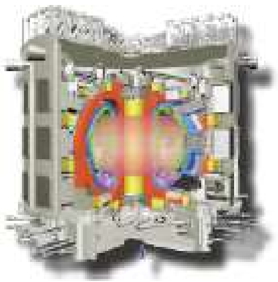
On-site Laboratory of JA & EU Univ. will be open at Naka site for Students



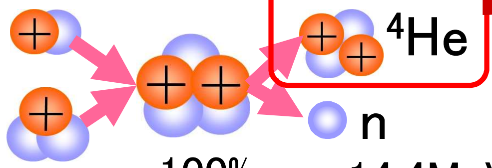
Target Plasma Comparison: ITER, JT-60SA & DEMO

∗1: Fuel, ∗2: Self Heating Ratio, ∗3: Plasma Pressure β_N

ITER DT*1 70%*2

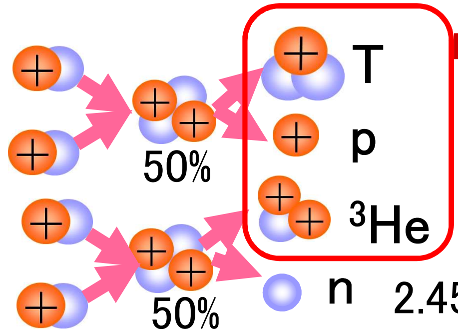


$Q_{DT}=10$

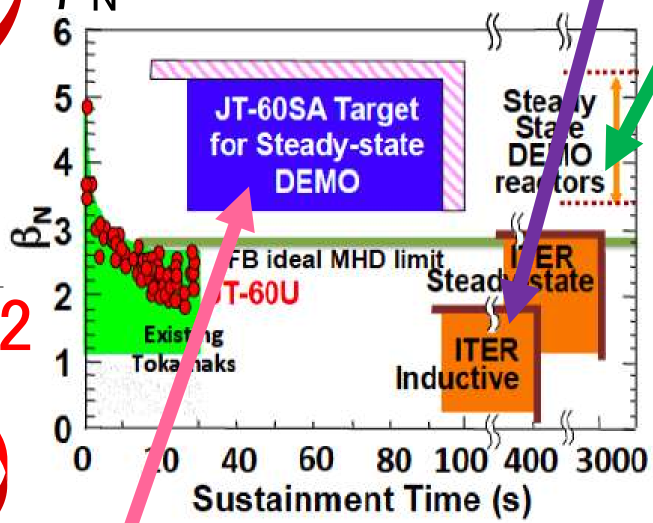


JT-60SA DD*1 <<10%*2

$Q_{DT}^{eq}=1$ ($Q_{DD}=0.01$)

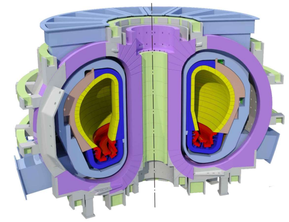


lower β_N*3



high β_N*3

JA-DEMO



DT*1

90%*2

high β_N*3

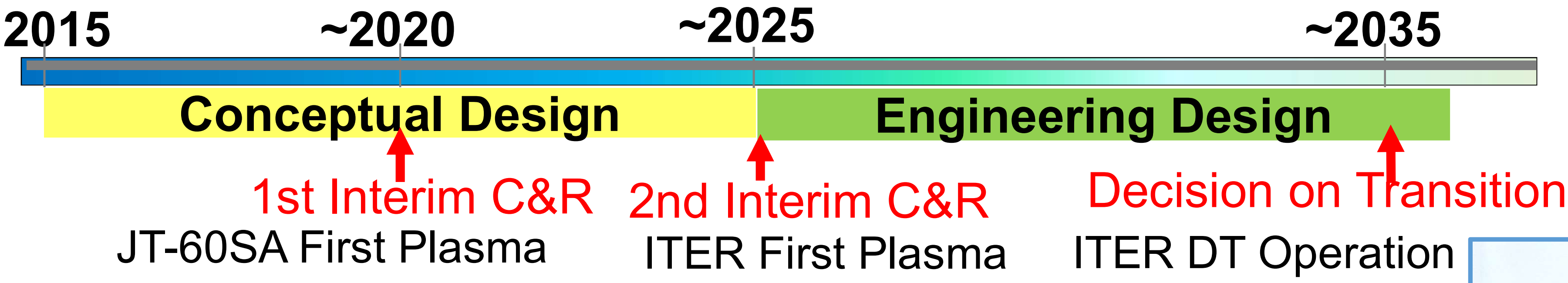
$Q_{DT}=20$

New Strategy toward DEMO (1/2)

Japan's Strategy to Promote R&D for a Fusion DEMO Reactor

http://www.mext.go.jp/b_menu/shingi/gijyutu/gijyutu2/074/attach/1400127.htm

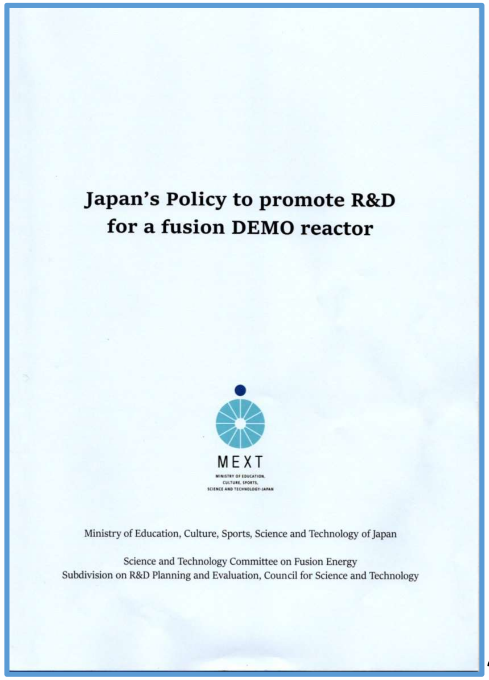
Check & Review's and Transition to DEMO through 2020s-2030s



C&R Items

(1) Validate burn control in the self-heating area by ITER.
(2) Establish an operational technique for stationary high-β plasma for operation of the DEMO reactor.
(3) Establish integrated technologies by ITER.
(4) Develop materials for the DEMO reactor.
(5) Develop reactor engineering for DEMO.
(6) Design the DEMO reactor.
(7) Establish public acceptance.

Brochure "Japan's Strategy to Promote R&D for a Fusion DEMO Reactor"



New Strategy toward DEMO (2/2)

New Strategy toward DEMO indicates the following points to solve technological issues:

- Development plan should contain construction cost, operation scenario, etc., with technical consistency.
- **Technological issues are classified into 15 elements (12 issues (Slide 9) and 3) below** as "**Action Plan.**"
  1. DEMO design, 2. SC Magnets, 3. Blanket, 4. Divertor, 5. Heating and CD, 6. Theory and Numerical Simulation, 7. Core Plasma Physics, 8. Fuel Systems, 9. Material Development and Code/Standards/Criteria, 10. Safety, 11. Availability and Maintainability, 12. Diagnostics and Control Systems, 13. Social Relation, 14. Helical, and 15. Laser
- Action Plan provides Work Breakdown that leads to solutions for 15 R&D issues along with the R&D timeline of 3 periods of now-2020, 2020-2025 and 2025-2035. (Please see the supplements.)
- Framework covering industry, academia and government should be reorganized.
- Human resources for long-term R&D should be cultivated.

An Integrated Preparation Scheme to Build DEMO

Technological issues should be solved by executing "Action Plans."

1. DEMO design, 2. SC Magnets, 3. Blanket, 4. Divertor, 5. Heating and CD, 6. Theory and Numerical Simulation, 7. Core Plasma Physics, 8. Fuel Systems, 9. Material Development and Code/Standards/ Criteria,10. Safety, 11. Availability and Maintainability, 12. Diagnostics and Control Systems, 13. Social Relation (Public Acceptance),

ITER and JT-60SA component manufacture, and DEMO R&Ds → Industries, QST, etc. have acquired crucial techniques and know-hows through experience of manufacturing.

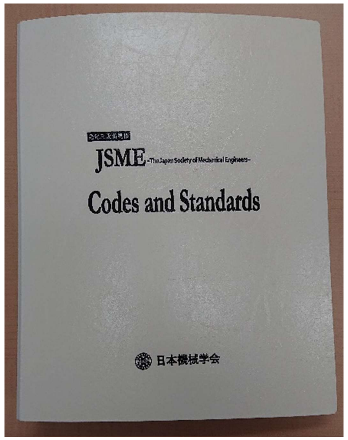
Manufacturing R&Ds, and Materials development using a Neutron Source, etc. → **Codes and Standards** with/in Academic Societies, Associations, QST, etc.

Plasma Experiments in JT-60SA, ITER, other Int'l tokamaks, and alternatives → QST, ITER Organization, Int'l Collaborators, Universities, Industries, etc. develop a control method of a steady-state high β_N plasma with DT burning (at ITER).

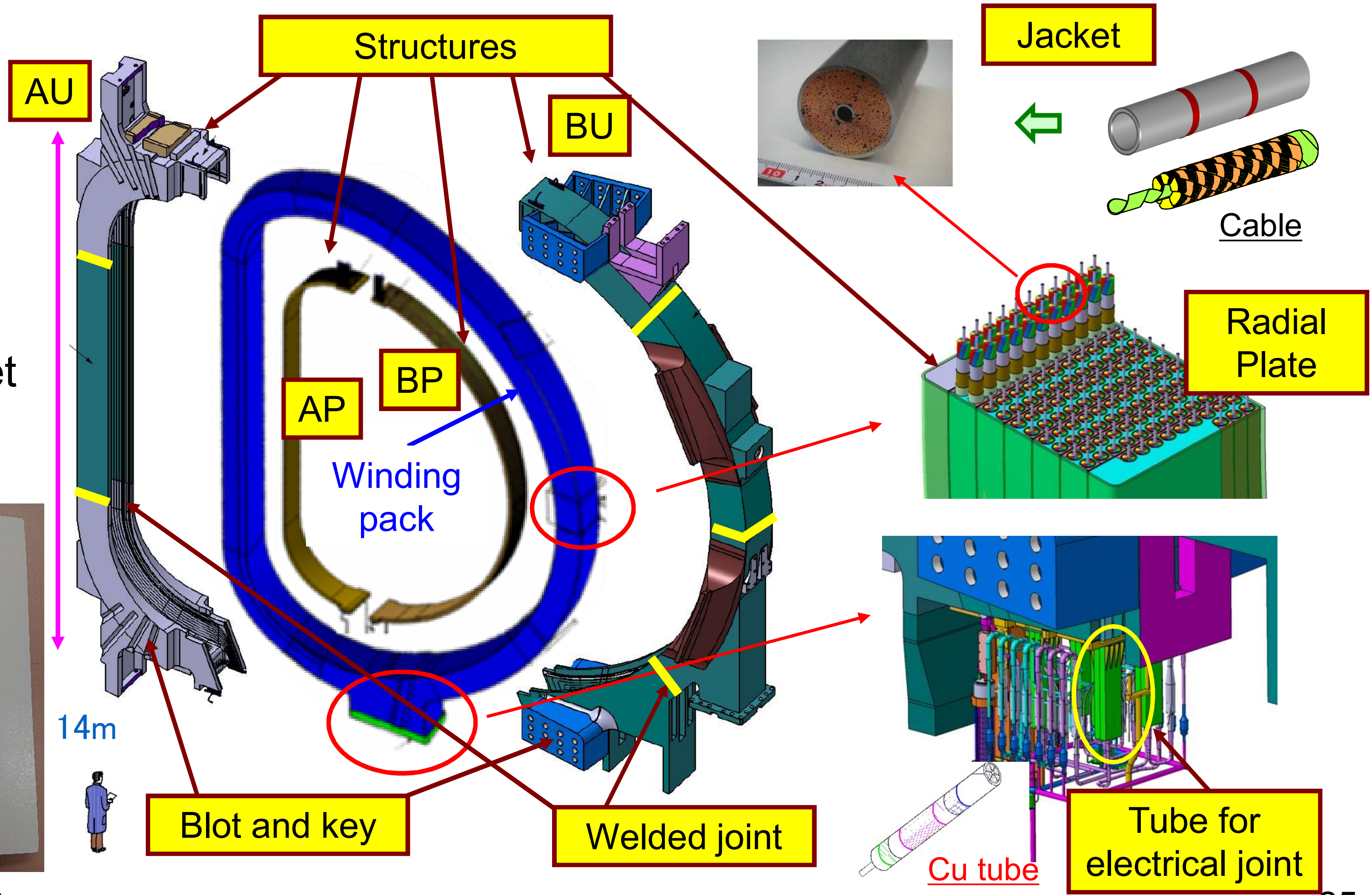
Government-level Approval and Commitment are necessary for DEMO with Regulation & Licensing Scheme (Domestic Laws and Rules).

An Example of Code Development for Fusion Facility

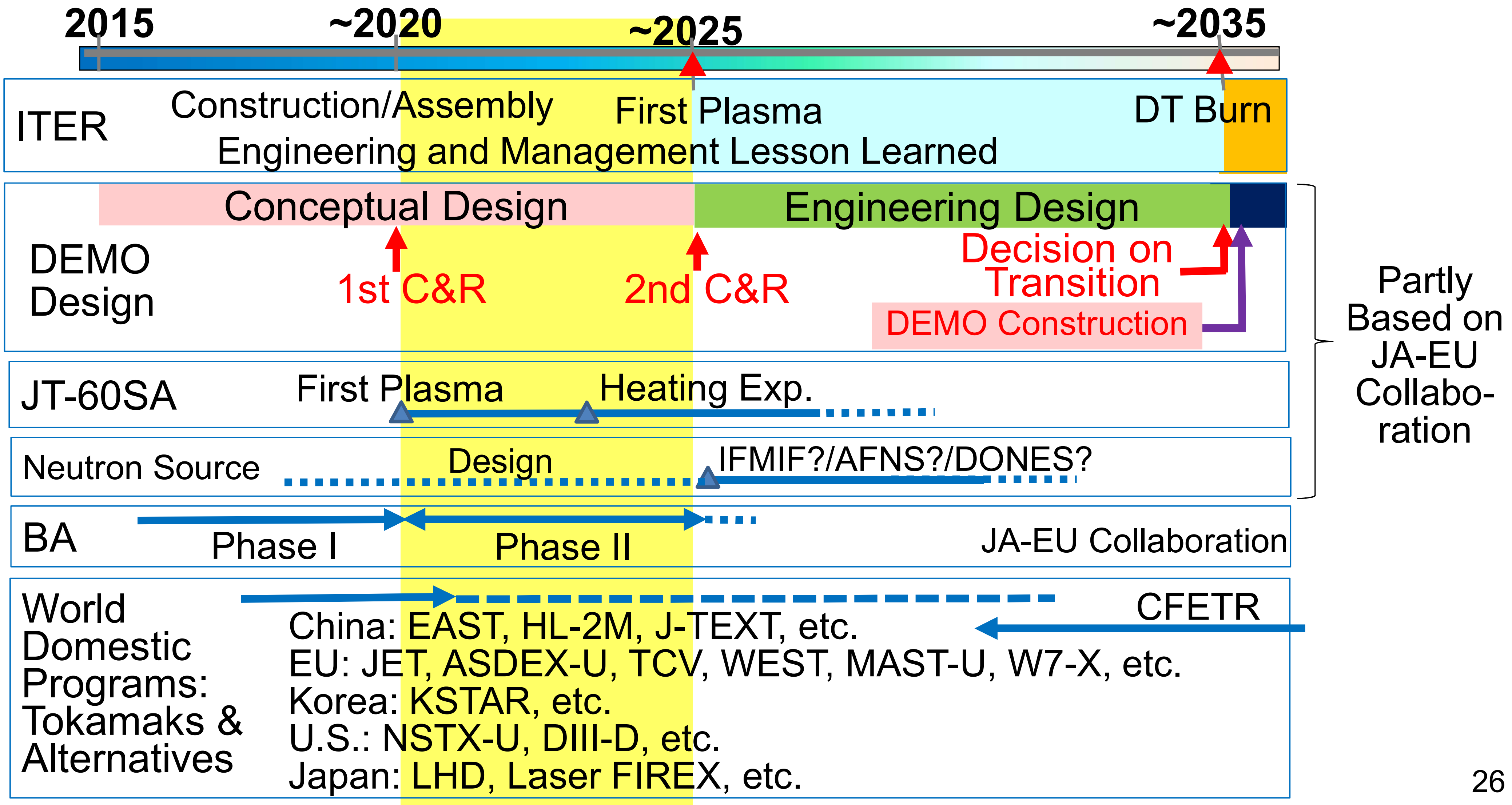
- The Japan Society of Mechanical Engineers (JSME) has been developing construction code for fusion facility.
- The JSME issued the “Codes for Fusion Facilities - Rules on Superconducting Magnet Structure - (JSME S KA1-2017) in October 2008,
- Undated in Dec. 2013 and Dec. 2017.



Cover page



Overall Schedule toward DEMO Construction



Summary
Fusion Energy: Perspectives and Planning

(1) ITER: Procurement is basically going well by overcoming engineering difficulties.

(2) Broader Approach (BA) Activities (2007-2020: Phase I)

- (a) In **JT-60SA** project (high-β_N SC Tokamak), construction/assembly is going well on schedule.
- (b) In **IFMIF/EVEDA** project, assembly of prototype accelerator for International Fusion Materials Irradiation Facility (LIPAc) is being collaboratively conducted.
- (c) In **IFERC**, DEMO Design and R&D are going well. New CSC started its operation.

BA Phase II (2020 - 2025): Under discussion by JA-EU.

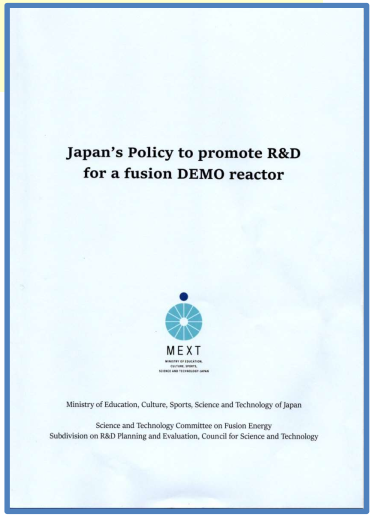
In order to solve all the issues for DEMO completely,

(3) New Strategy toward DEMO was formulated:

C&R Items for 2020 and 2025, and Transition criteria for 2035 were decided.

Action Plan for DEMO and Roadmap including Domestic Programs are now being carried into action (2018-).

(4) An Integrated Preparation Scheme to Build DEMO


Japan's Policy to promote R&D for a fusion DEMO reactor

MEXT

Ministry of Education, Culture, Sports, Science and Technology of Japan

Science and Technology Committee on Fusion Energy
Subdivision on R&D Planning and Evaluation, Council for Science and Technology

We will further promote the Fusion R&D activities toward DEMO.

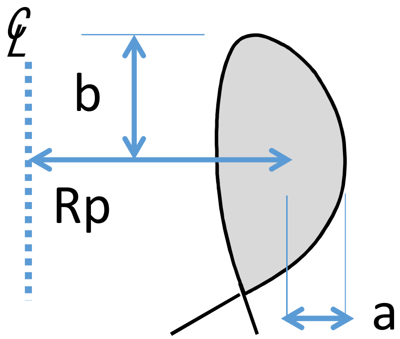
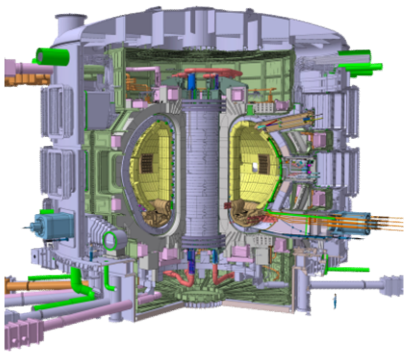
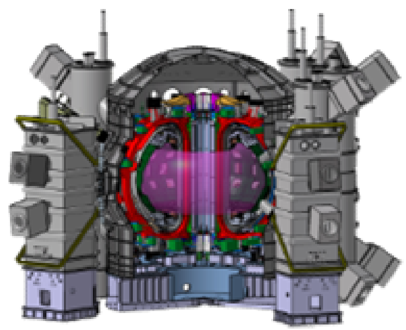
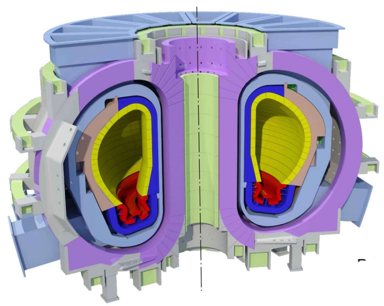
Thank you for your attention!

Acknowledgments

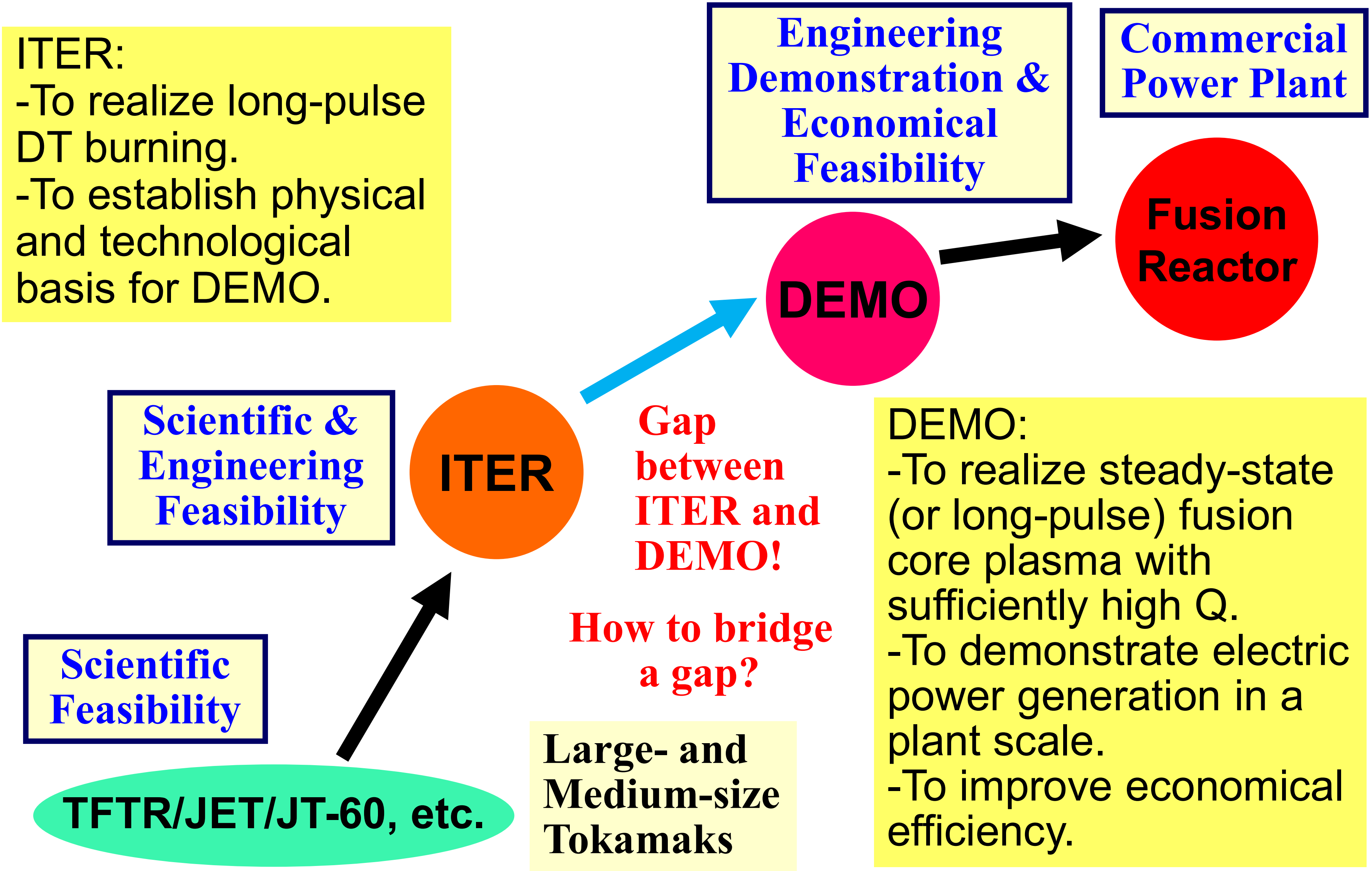
Ministry of Education, Culture, Sports, Science and Technology of Japan.

Supplements

Target Plasma Performance: ITER, JT-60SA & DEMO

Device	ITER	JT-60SA	JA-DEMO
Plasma Current Ip	15.0 MA	5.5 MA	12.3 MA
Toroidal Field B_T	5.3 T	2.25 T	5.94 T
Plasma Pressure β_N	1.8-3.0	2.8-4.3	3.4
Fusion Output	0.5 GW (Q_{DT}=10)	D (Q_{DT}^{eq}=1)	1.46 GW (Q_{DT}=17)
Major Radius Rp	6.2 m	3.0 m	8.5 m
Minor Radius a	2.0 m	1.1 m	2.4 m
κ (= b/a)	1.7	1.87	1.65
			

Major Devices toward a Fusion Reactor



Phased R&D Programs toward Fusion Energy in Japan

In the Past

In 1968-1974, the 1st Program

Mission: Improve Confinement Performance

= Construction of Small/Medium Size Tokamaks

In 1975-1991, the 2nd Program

Mission: Achieve the Breakeven Plasma

= Construction of JT-60 (1985-2008)

In 1992- now, the 3rd Program (effective)

Mission: Achieve the high-Q Steady-state DT Burn

= Construction of Experimental Reactor (=ITER)

In the Future

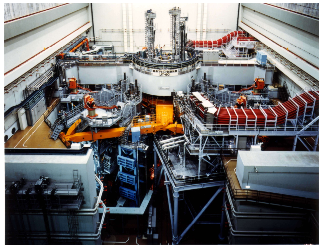
If the scientific, technological, and social conditions are satisfied, …

In 2030s, the 4th Program will start.

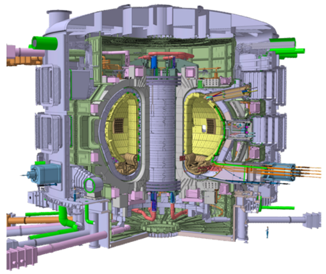
➔ Construction of DEMO

JFT-2

JT-60

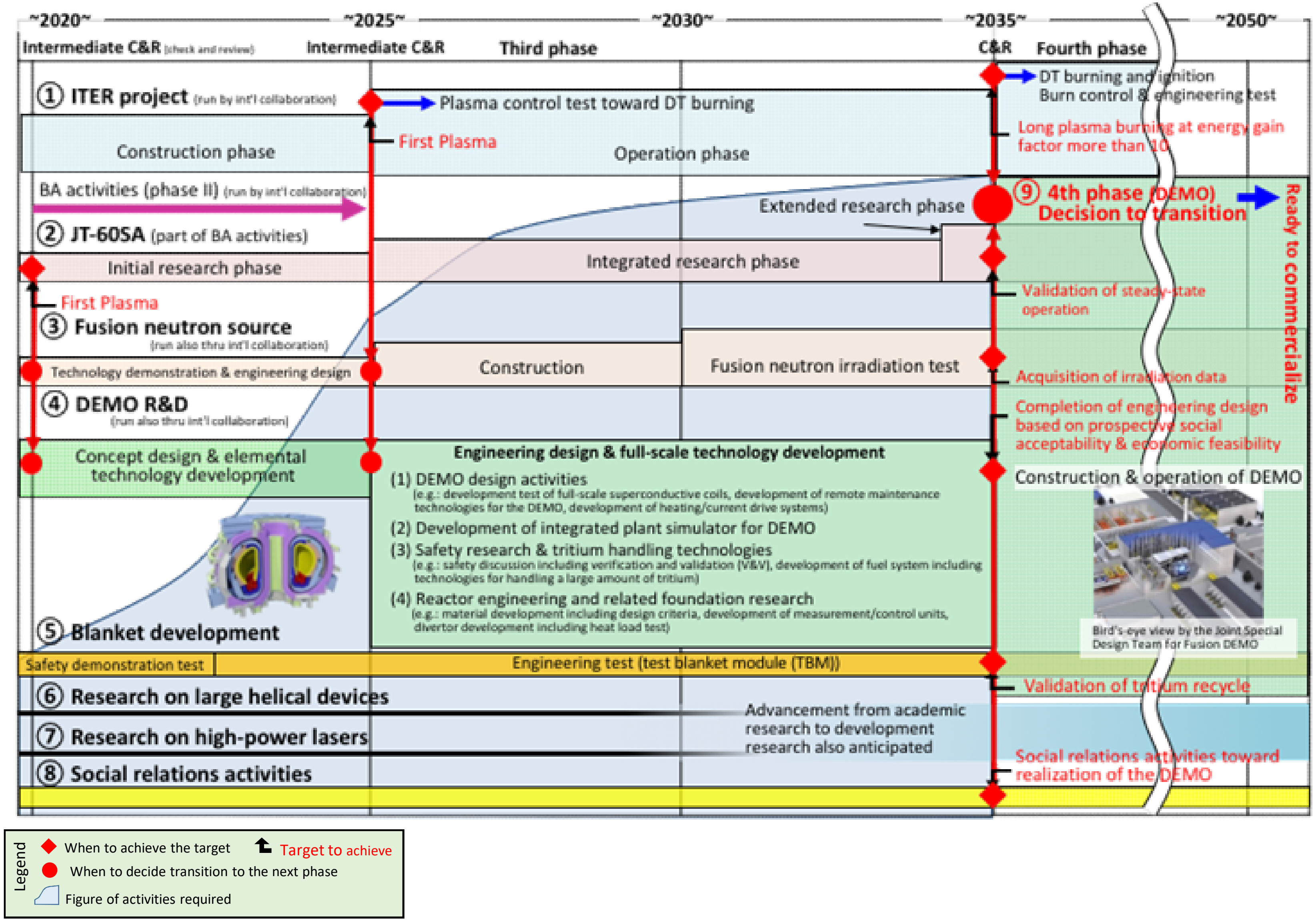


ITER

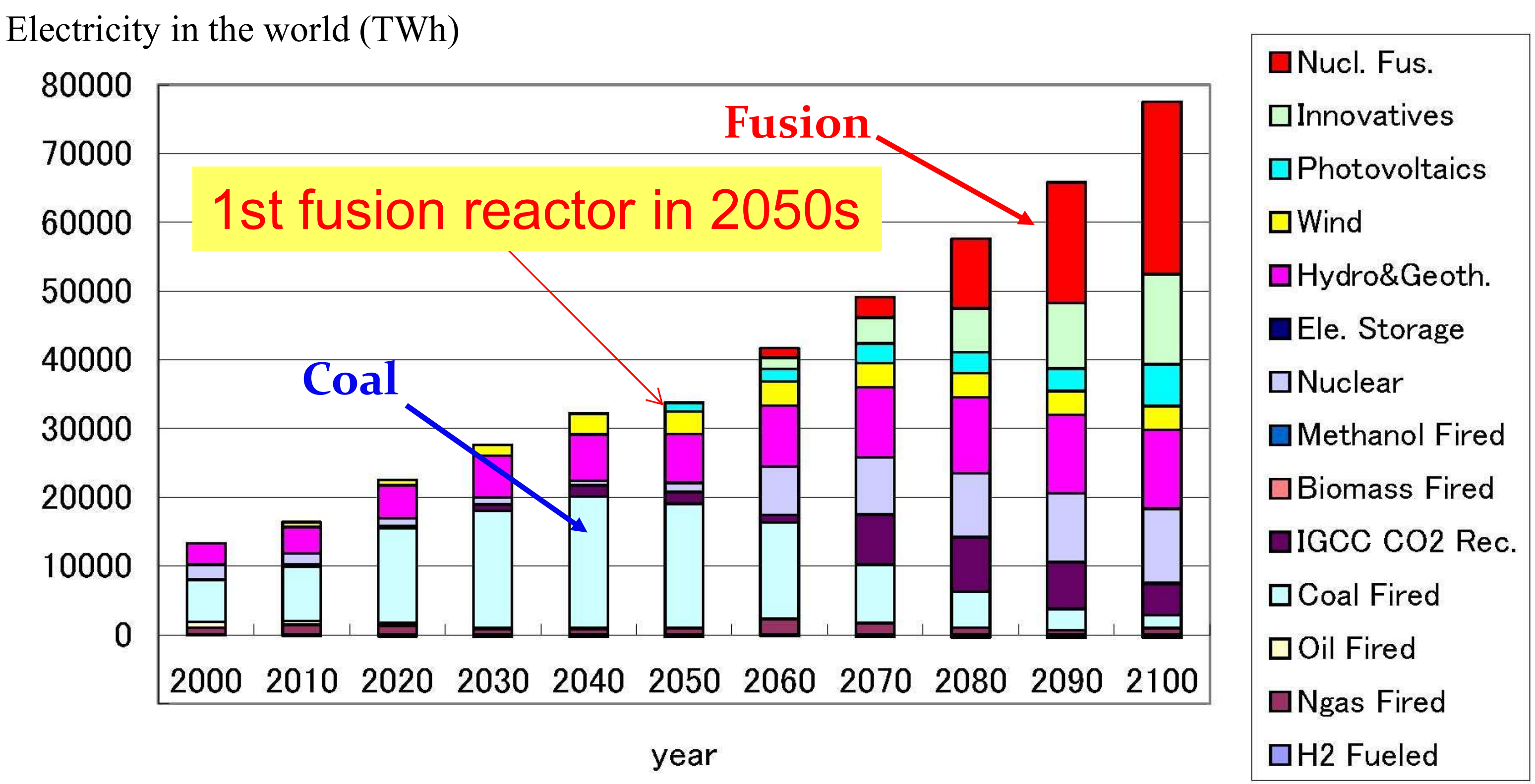


DEMO

Japanese Roadmap toward DEMO



Introduction of Fusion Energy into the World Energy Market



@ In the case of 550 ppmv CO_2 concentration constraint.
@ Future energy demand is assumed to be the case of IS92a.
@ In nuclear fusion the cost of electricity (COE) in the introduction year (i.e., 2050) is assumed to be 65 mill/kWh,

TOKIMATSU, K., et al., Studies of breakeven prices and electricity supply potentials of nuclear fusion by a long-term world energy and environment model, Nuclear Fusion 42 (2002), 1289.

Check & Review Items, Works, and Criteria (1/4)

Items	1st C&R (~ 2020)	2nd C&R (~ 2025)	Criteria for transition to DEMO (2030s)
(1) Validate burn control in the self-heating area by ITER	- Create a technical target achievement plan for ITER.	- Conduct collaborative research based on the ITER technical target achievement plan.	- Maintain fusion power of Q=10 or higher (for over several hundred seconds) and validates burn control in ITER.
(2) Establish an operational technique for stationary high-beta plasma for operation of the DEMO reactor	- Proceed with ITER collaborative research and preparatory studies on stationary high-beta plasma and start JT-60SA research.	- Achieve a high-beta plasma by non-inductive current drive in JT-60SA. - Have integrated simulations including the divertor verified by JT-60SA and other projects. - Create a plan for JT-60SA divertor research compatible with the DEMO reactor's plasma-facing walls.	- Gain prospects for non-inductive steady operation by achieving non-inductive current drive in ITER, and integrated simulations based on ITER knowledge of burn control. - Validates the stationary operation of a high-beta (βN = 3.5 or higher) collisionless plasma in JT-60SA compatible with the DEMO plasma-facing walls.

Check & Review Items, Works, and Criteria (2/4)

Items	1st C&R (~ 2020)	2nd C&R (~ 2025)	Criteria for transition to DEMO (2030s)
(3) Establish integrated technologies by ITER	- Establish manufacturing technologies for SC coils and other key components and build an integrated technological foundation through the construction of JT-60SA.	- Launch ITER operation. - Acquire integrated technologies to manufacture, install and adjust the ITER apparatus.	- Establish integrated technologies through ITER operation and maintenance and confirm the safety technology.
(4) Develop Materials for the DEMO reactor	- Obtain reactor irradiation data of low activation ferrite steel (LAFS) up to 80 dpa and finalize the materials for testing under a neutron irradiation environment similar to nuclear fusion. - Complete the concept design of the nuclear fusion neutron source.	- Complete the validation of heavy irradiation data by fission reactor irradiation of LAFS up to 80 dpa. - Evaluate the initial irradiation behavior of blanket and diverter materials by reactor irradiation and validate the principles of Li-securing technology. - Start the construction of a fusion neutron source and create a plan for collecting material irradiation data.	- Draw up the structural design criteria. - Establish Li-securing techniques on a pilot-plant scale. - Collect initial irradiation data on low activation ferrite steel and blanket and divertor functional materials with a nuclear fusion neutron source.

Check & Review Items, Works, and Criteria (3/4)

Items	1st C&R (~ 2020)	2nd C&R (~ 2025)	Criteria for transition to DEMO (2030s)
(5) Develop reactor engineering for DEMO	- Formulate divertor development strategies. - Create technical development plans for reactor engineering requiring early preparation, including SC coil technology. - Collect the necessary data for blanket design from the cold testing facilities.	- Collect the necessary data relevant to the divertor, including the properties of the plasma-facing materials in JT-60SA, LHD, etc. - Create development plans for the SC coil, divertor, remote maintenance, heating/current drive, fuel system, measurement/control, etc. for the engineering technology of a medium- or plant-sized reactor, and complete the concept designs of these items for the development test facilities. - Establish basic technology for the power generation blanket, build the first ITER-TBM, and complete the safety verification tests on the actual device.	- Establish reactor engineering technologies that support DEMO reactor design, including such items as the SC coil, divertor, remote maintenance, heating/current drive, fuel system and measurement/ control, based on the outcomes of the development test facilities and the performance results from ITER, JT-60SA, etc. - Evaluate tritium recovery in ITER and validate the evaluation technique for tritium behavior using the fusion neutron source.

Check & Review Items, Works, and Criteria (4/4)

Items	1st C&R (~ 2020)	2nd C&R (~ 2025)	Criteria for transition to DEMO (2030s)
(6) Design the DEMO reactor	- Formulate the overall objectives for the DEMO reactor. - Draw up a basic concept design of the DEMO reactor. - Submit requests regarding reactor core and reactor engineering developments.	- Complete the DEMO reactor's concept design that ensures high safety standards and economic feasibility by incorporating reactor core and reactor engineering developments. - Identify issues in developing reactor core and reactor engineering to establish a technological foundation for engineering design and create a development plan.	- Acquire social acceptability, confirm economic feasibility at the stage of practical use, and complete the DEMO reactor engineering design by coordinating reactor core and reactor engineering developments. - Draw up policies on safety laws and regulations.
(7) Establish Public Acceptance	- Establish a headquarters for promoting social awareness. - Draw up an awareness activity promotion plan.	- Promote social awareness initiatives and conduct social relations activities.	- Proceed with social relations activities toward the construction and operation of the DEMO reactor.

An Example of Action Plan – DEMO Design (1/2)

Black: Kick off of Items
Red : Close of items

	2015	2020~	2025~ (to 2035~)
DEMO Design	Conceptual design (2015–2025) Establish phys.& eng. guideline Definition of safety policy Database(DB) of physics, engineering & materials (2015–2025)	Prepare for licensing	Engineering design Site asses. / Const. design Decision of site assess. for site safety DB update w/JT-60SA & irrad. results
Concept & Construct. Plan	(15)S: Phys.& eng. Guideline (19) (15)S: Basic design of concept (19) (16)S/TF: Fuel cycle strategy ------ (17)Q/N/U/S: Integrated simulator (18)S/D: Cost evaluation ------------	(20)S/D: Conceptual design(26) -------------------------------> (26) -------------------------------> (26) (23)S/Q/F: Rev. of target plasma (26) --------------------------------------->	(27)D/S: Design of Demo core parts (35) -------------------------------> (31) (29)G/TF: Candidate site (31) (32)G: Site assessment (35)
Equipment Design	(15)S/Q: Basic design of SC (19) (19)S/Q: Demo TBM targets (19) (17)S/D: Equip. config. w/ BOP (19)	(21)S/D: Conceptual Design of BOP (26)	**(for site asses.)** (27)D/S: Plant design,(31) (27)A/S: Reg & stand (31) **(after site candidates)** (32)D/S: Design plant (35)

Responsibility: S - Special Design Team, Q – QST, N – NIFS, U – universities, D – manufacturing companies, G – Japan. Gov.

An Example of Action Plan – DEMO Design (2/2)

Black: Kick off of Items

Red : Close of items

	2015	2020~	2025~ … 2035~
DEMO Design	Conceptual design Establish phys.& eng. guideline Definition of safety policy Database(DB) of physics, engineering & materials	(Conceptual design, cont.) Prepare for licensing (Database(DB) of physics, engineering & materials, cont.)	Engineering design Site asses. / Const. design Decision of site assess. for site safety DB update w/JT-60SA & irrad. results
Safety Policy	(16)S/D: Draft safety policy (19)	(20) S/D: Asses. of Safety aspect -------------- (20)S/D: Asses. of Safety aspect (26) (20)TF/S: Draft for safety regulation (26)	--------------------------------> (31) (27)G/TF: Safety regulation (35) (32)G: Safety assess (35)
Database of Physics, Enginrg & Materials	(16)Q/U/F/S: Demo Phys. DB ------- (16)Q/U/F/S: Eng. & Materials DB-	-------------------------------->(26) -------------------------------->(26)	(27)Q/S: Update Eng.& materials DB (31) **w/ results of JT-60SA** (32)Q/S: Update material DB (35) **w/ 14MeV heavy irrad data**

Responsibility: S - Special Design Team, Q – QST, N – NIFS, U – universities, D – manufacturing companies, G – Japan. Gov.