6-7 December, 2017

# Japan's Perspective on Pathways and Technology Needs

QST
Kenji Tobita

# Overall picture of Fusion power development

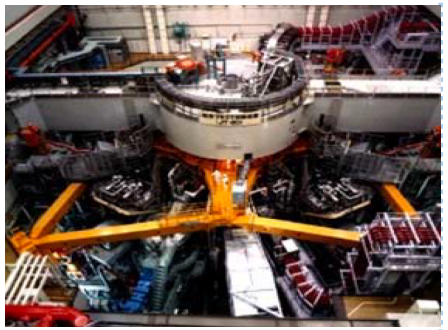
# Steps for fusion power realization

"Phased approach"

**2nd Phase**

Sci feasibility

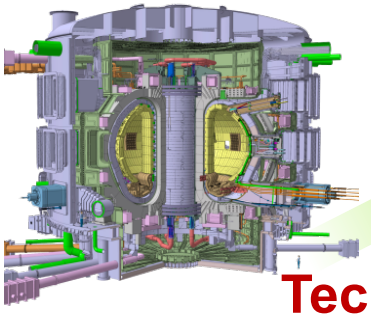
**JT-60**



**3rd Phase**

Tech feasibility

**ITER**



**4th Phase**

Tech. Demonstration
Econ. feasibility

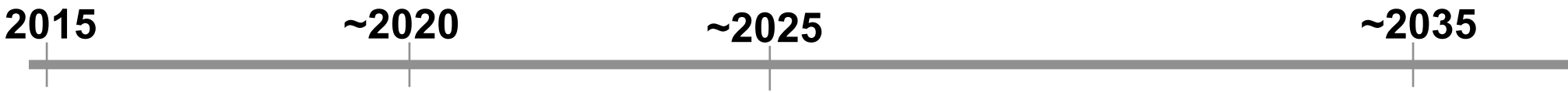
**DEMO**

**Technology bases for DEMO**

**BA & national programs**

**Commer-cialization**

# Timeline of DEMO development




**Conceptual Design Phase** | **Engineering Design Phase**

## Milestones

| | | ~2020 | ~2025 | ~2035 |
|---|---|---|---|---|
| ITER | | | First plasma | DT burn at Q ~ 10 |
| JT-60SA | | First plasma | → | SS op. at $\beta_N \geq 3.5$ |
| FNT | BB | | TBM #1 safety test compl. | |
| | RAFM | ~80dpa fiss. n-irrad start | → | DEMO design standard |
| | A-FNS | Concept design compl. | Construction start | init. irrad. of BB materials |

# Recent situation

- **“Action Plan (AP) toward DEMO” was formulated to implement DEMO-relevant R&Ds in a coordinated way, being under authorization by the Fusion Sci. and Tech. Commission of MEXT.**

- **AP defines the development timeline of 12 key technologies:**

1. DEMO design
2. SC magnet
3. Blanket
4. Divertor
5. H&CD
6. Theory/ simulation
7. Core physics
8. Fuels system
9. Material codes & standards
10. Safety
11. Availability/ maintenance
12. Diagnostics and control

- **AP considers priority of tasks taking account of budget, resource, etc.**

➔ Large scale R&Ds (magnet, remote maintenance) will start after the completion of DEMO conceptual design (2025).

➔ AP suggests to enhance DEMO design activity and to accelerate divertor study for a prospect for power exhaust in DEMO.

# Example of Action Plan – DEMO Design

Black: Kick off of Items
Red : Close of items

| DEMO Design | 2015 | 2020~ | 2025~ | 2035~ |
|---|---|---|---|---|
| | Conceptual design | | Engineering design | |
| | Establishment of phys.& eng. guideline | | Site asses. / Const. design<br>Decision of site ▲ | |
| | Definition of safety policy | Preparation for regulation of safety | Regulation and assess. for site safety | |
| | Database(DB) of physics, engineering & materials | | DB update w/JT-60SA & irrad. results | |
| **Concept & Construction plan** | (15)S: Phys.& eng. guideline →(19)<br>(15)S: Basic design of concept →(19)<br>(16)S/TF: Fuel cycle strategy ----------<br>(17)Q/N/U/S: Integrated simulator --------<br>(18)S/D: Cost evaluation ---------- | (20)S/D: Conceptual design →(26)<br>----------> (26)<br>----------> (26)<br>(23)S/Q/F: Rev. of target plasma →(26)<br>----------> | (27)D/S: Design of Demo core parts →(35)<br>----------> (31)<br>(29)G/TF: Decision of candidate site →(31)<br>(32)G: Site assessment →(35) | |
| **Equipment Design** | (15)S/Q: Basic design of SC →(19)<br>(19)S/Q: Demo TBM targets →(19)<br>(17)S/D: Equip. config. w/ BOP →(19) | (21)S/D: Conceptual Design of BOP →(26) | **(for site asses.)**<br>(27)D/S: Plant design, build.& Equip. →(31)<br>(27)A/S: Regulation & standard →(31)<br>**(after decision of standard & site candidates)**<br>(32)D/S: Design plant/build./equip →(35) | |
| **Safety Policy** | (16)S/D: Draft of safety policy →(19) | (20) S/D: Asses. of Safety aspect ----------<br>(20)S/D: Asses. of Safety aspect →(26)<br>(20)TF/S: Draft for safety regulation →(26) | ----------> (31)<br>(27)G/TF: Safety regulation →(35)<br>(32)G: Safety assessment →(35) | |
| **Database of Physics, Engineering & Materials** | (16)Q/U/F/S: Demo Phys. DB ----------<br>(16)Q/U/F/S: Eng. & Materials DB ---------- | ---------->(26)<br>---------->(26) | (27)Q/S: Update Eng.& materials DB →(31)<br>**w/ results of JT-60SA**<br>(32)Q/S: Update material DB →(35)<br>**w/ 14MeV heavy irradiation data** | |

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

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# Prospects of Ongoing Projects

# DEMO Design

## National activity

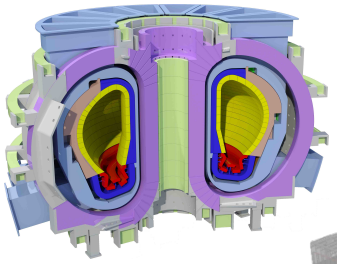
- "Special Design Team" organized for all-Japan activity
- More than 80 members incl. industry

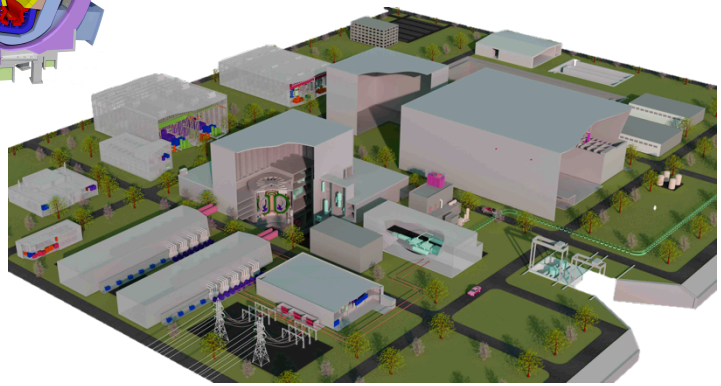
Design Team meeting (Rokkasho, July 2017)

## BA activity

Joint work on common design issues on DEMO

DEMO Task meeting (Garching, June 2017)





**Targets by 2025:**

- Conceptual design of DEMO plant
- Specs of components and facilities
- Safety design
- Waste management scenario
- Define R&D needs in the next phase

**Launch large-scale R&Ds in Eng. Design Phase**

# Breeding Blanket (BB) technology

## Views on BB technology

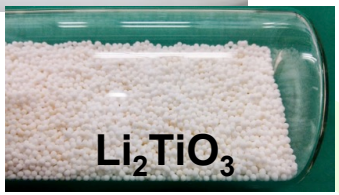
- **Challenging technology for DEMO**
  - ✓ Mass production *(a set of BB: 1,150 modules, 1,600 tons)*
  - ✓ Fabrication, inspection and joint technologies
  - ✓ Various material property database for design code and standard, and for lifetime evaluation of irradiated materials
- **Needs different level approaches for development**
  - ✓ System level – T recovery, heat extraction
  - ✓ Component level – blanket, maintenance
  - ✓ Element level – structural material, breeder, neutron multiplier

**Need to pursue intense study on BB technology from now**

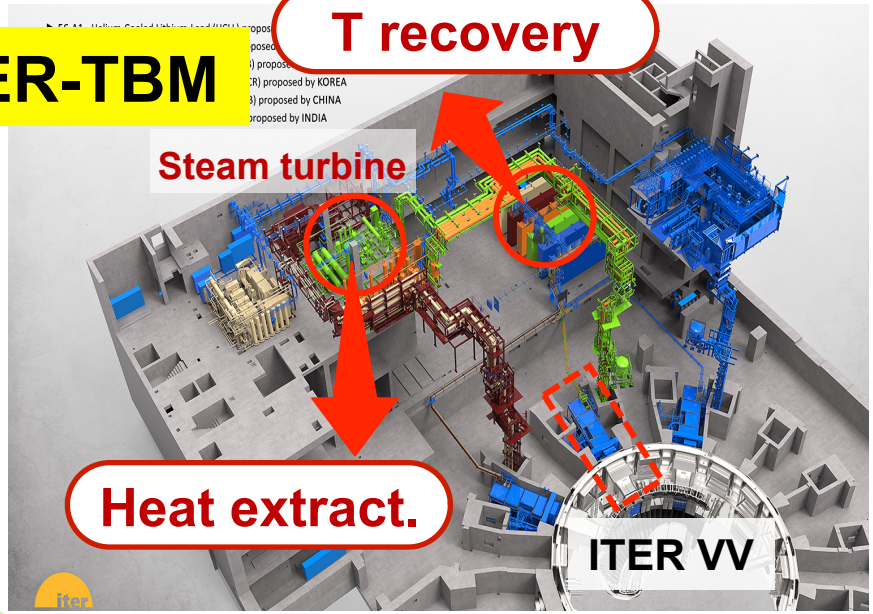
# Approaches to establish BB technology

## Functional materials

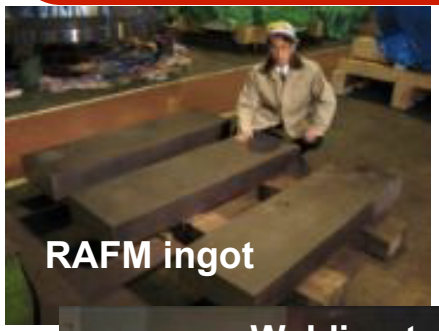
$B_{12}Ti$

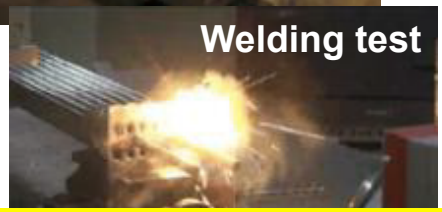



## ITER-TBM




## Mass production

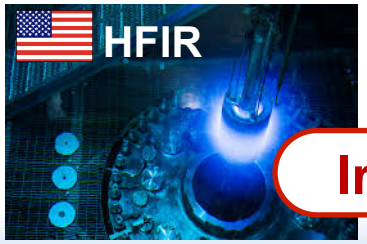


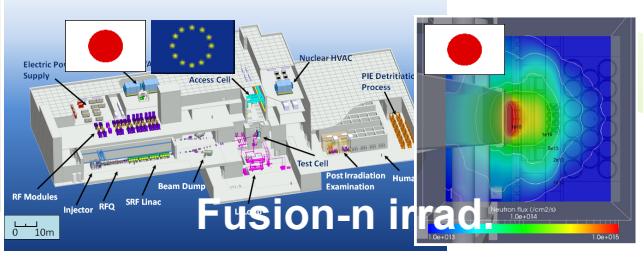

## Mater. properties

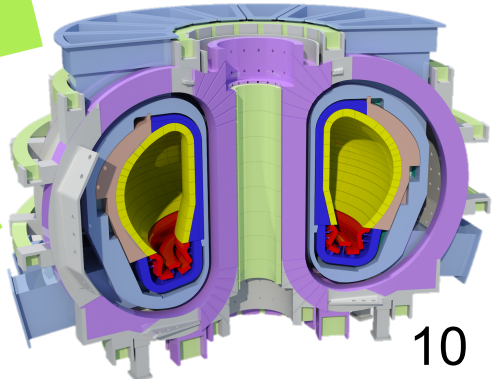
Small specimen testing technol.

Fission-n irrad.




## Irradiation



## Structural materials

# Fusion neutron source

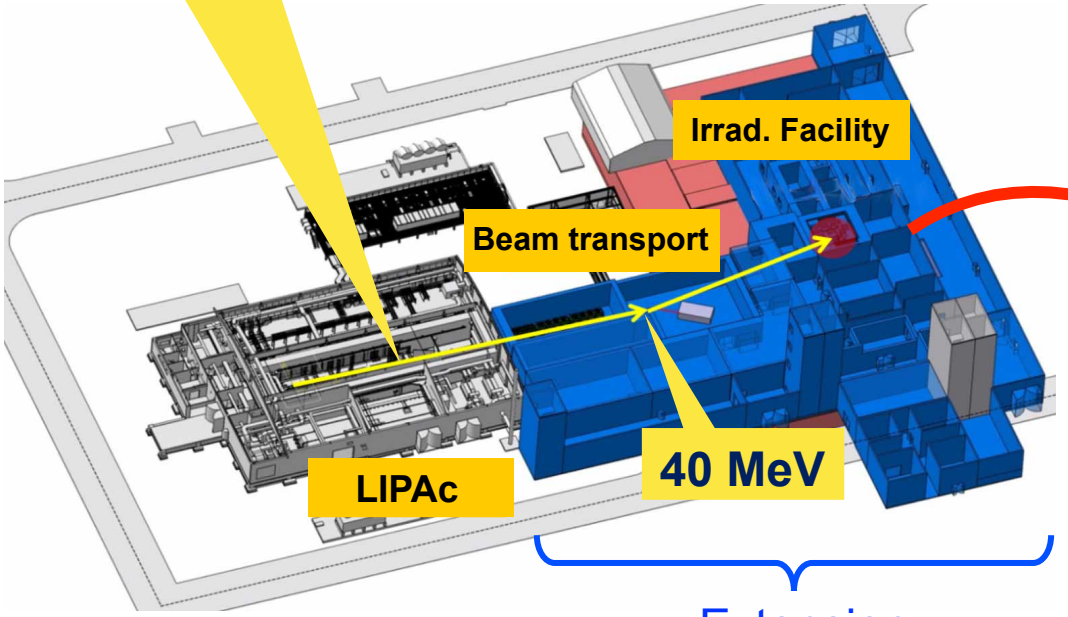
Conceptual design of A-FNS started on the premise of the 9 MeV acceleration in LIPAc of IFMIF/EVEDA.

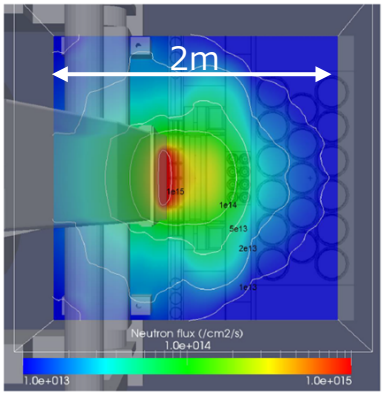

**Specs of A-FNS**

**40 MeV, 5 MW (CW)**

**$7 \times 10^{16}$ n/s, 10 dpa/fpy**

**Completion: ~2030**

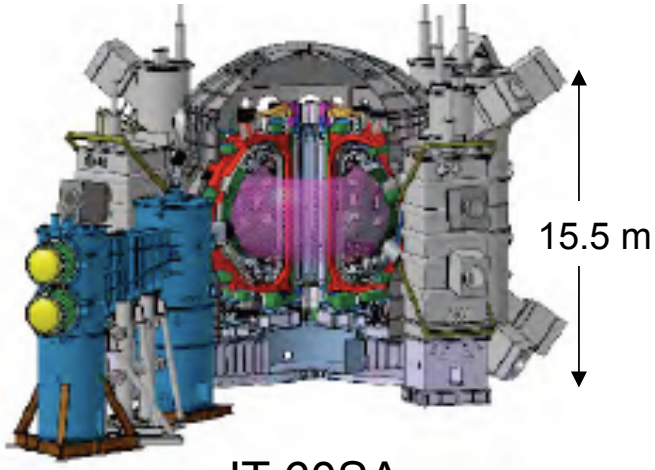



Neutron intensity distr.

# JT-60SA

JT-60SA is being constructed under the BA activities as well as a national project.



JT-60SA

**Mission toward DEMO:**

Develop steady state operation at $\beta_N > 3.5$

← DEMO requires ”steady and stable operation”

**Status:**

Construction in progress, as planned

12 TF coils out of 18 installed

**Schedule:**

- Completion of construction: March 2020
- First plasma: Fall in 2020
- Heating experiments start in BA Phase II (2020-2025)

# Summary

- “Action Plan toward DEMO” that defines the timeline of 12 key technologies, is under authorization by the Fusion Sci. and Tech. Commission of MEXT.
- AP contributes to implementing DEMO-relevant R&Ds in a coordinated way under the cooperation of QST, NIFS, universities and manufacturing companies.
- In addition to ongoing projects (ITER and BA), Japan plans to enhance DEMO design activity, BB-related R&Ds, A-FNS conceptual design.
- Large-scale R&Ds such as magnet and remote maintenance will start after the completion of DEMO conceptual design in 2025 and the definition of targets of the R&Ds.