The JT-60SA Project

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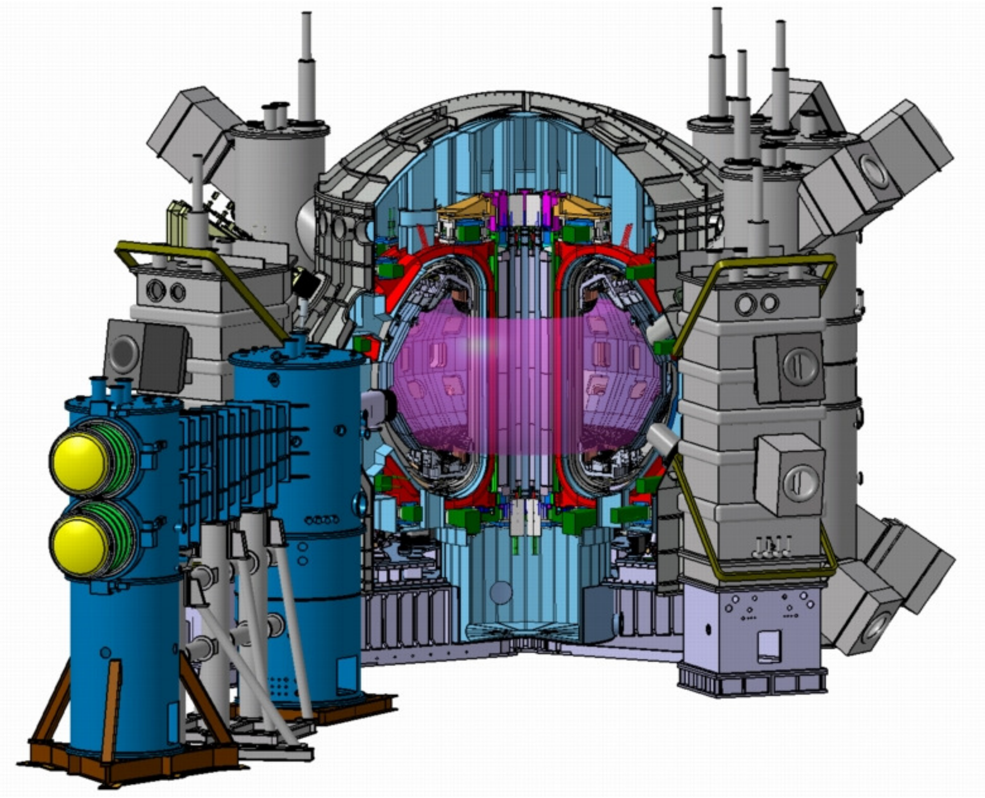
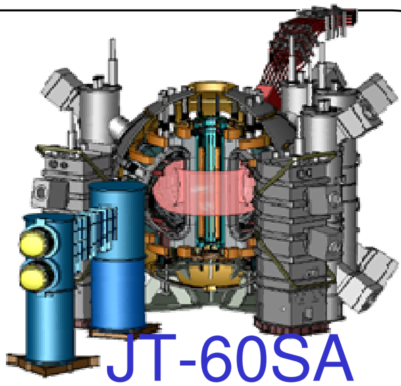
for the JT-60SA Integrated Project Team
EU: F4E-CEA-ENEA-CNR/RFX-KIT-CRPP-CIEMAT-SCKCEN
JA: JAEA



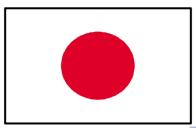
Presented by E. Gaio
on behalf of P. Barabaschi

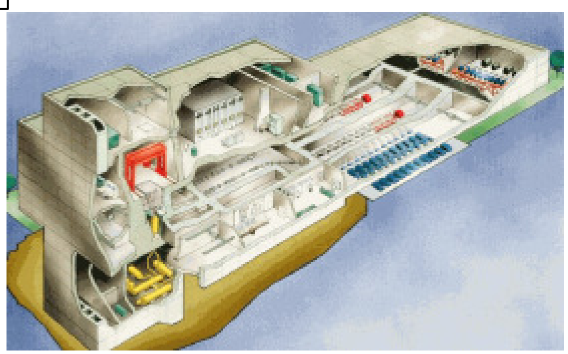
BA Agreement



JT-60SA

IFERC





IFMIF-EVEDA

Together with IFERC and IFMIF-EVEDA, JT-60SA is part of the « Broader Approach » agreement signed between Euratom and Japan

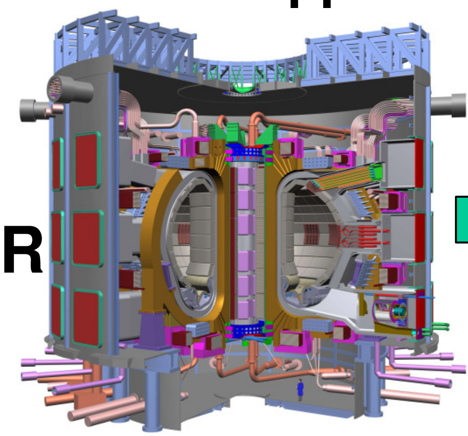
Entered into force in 2007

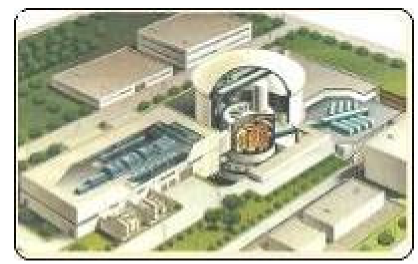
66% of PAs signed so far.

JT-60SA Objectives

- A combined project of **the ITER Satellite Tokamak Program of JA-EU** (Broader Approach) and **National Centralized Tokamak Program in Japan.**
- **The mission:** contribute to the early realization of fusion energy by its exploitation to support the exploitation of ITER and research towards DEMO.

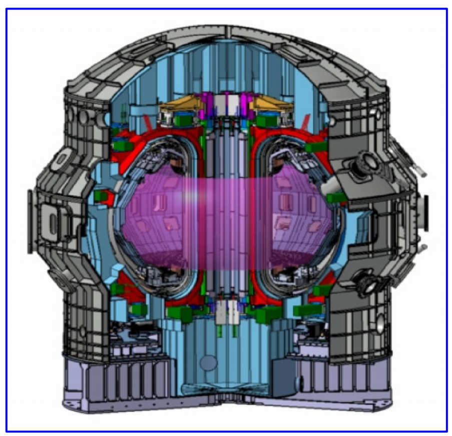
ITER





DEMO

Support ITER

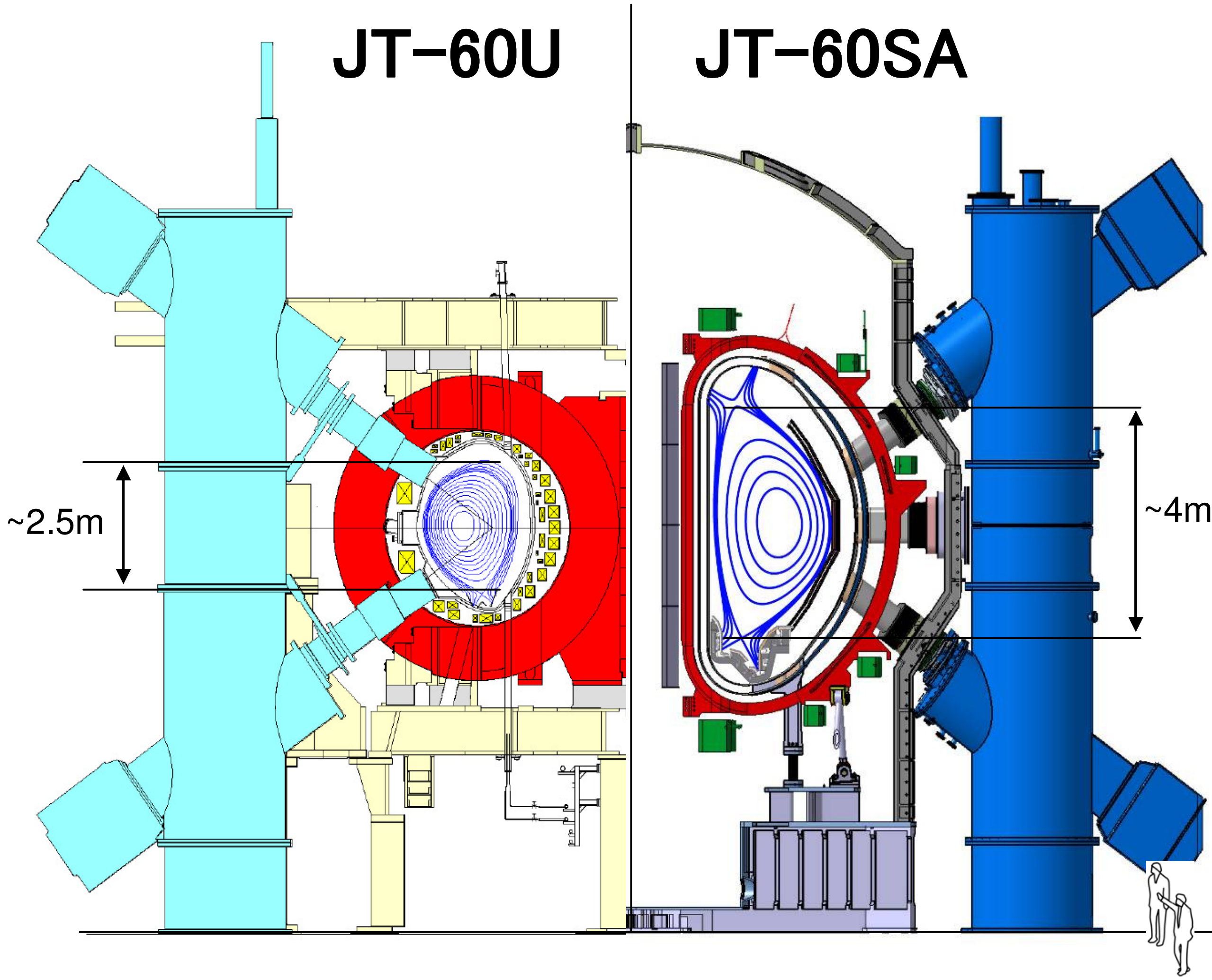


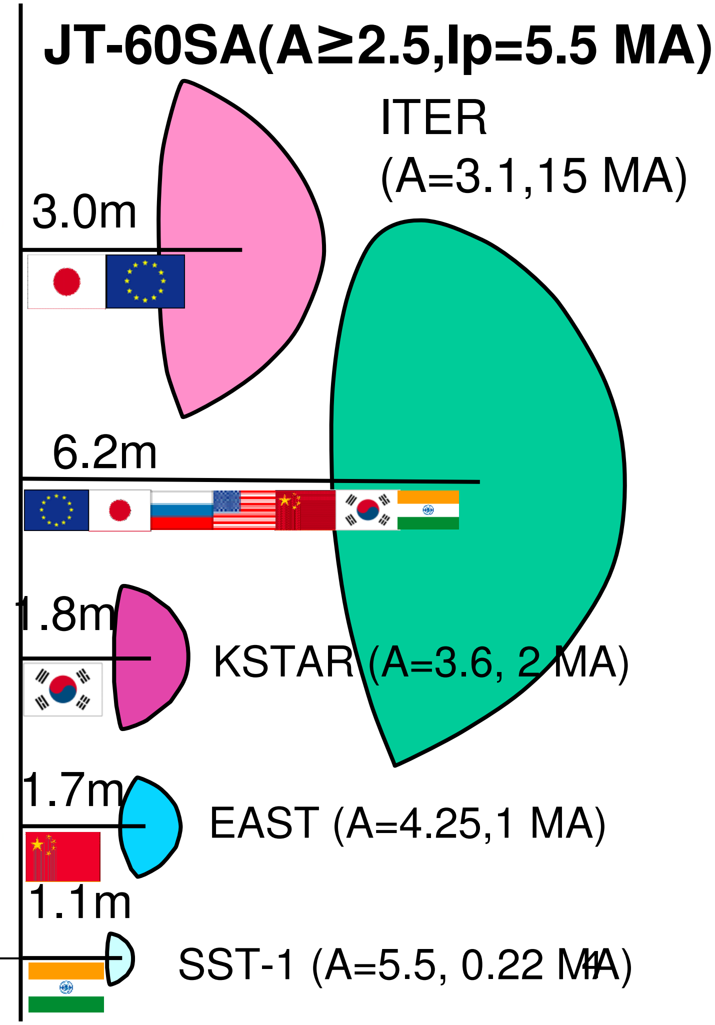
Complement ITER towards DEMO

JT-60SA

The New Load Assembly

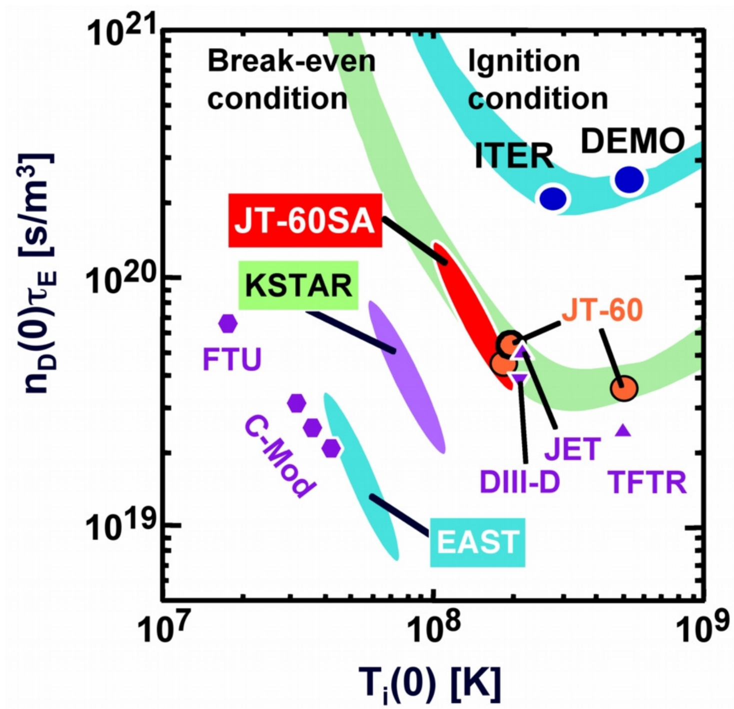
- **JT60-U: Copper Coils (1600 T), Ip=4MA, Vp=80m^3**
- **JT60-SA: SC Coils (400 T), Ip=5.5MA, Vp=135m^3**

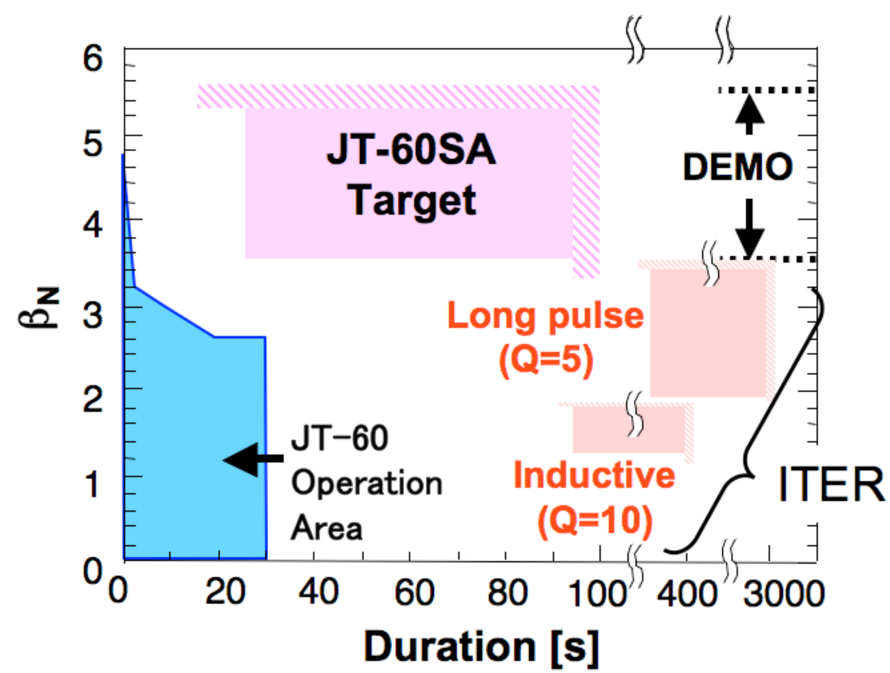




High Beta and Long Pulse

- JT-60SA is a fully superconducting tokamak capable of confining break-even equivalent class high-temperature deuterium plasmas (I_p^{max}=5.5 MA) lasting for a duration (typically 100s) longer than the timescales characterizing the key plasma processes, such as current diffusion and particle recycling.
- JT-60SA should pursue full non-inductive steady-state operations with high β_N (> no-wall ideal MHD stability limits).

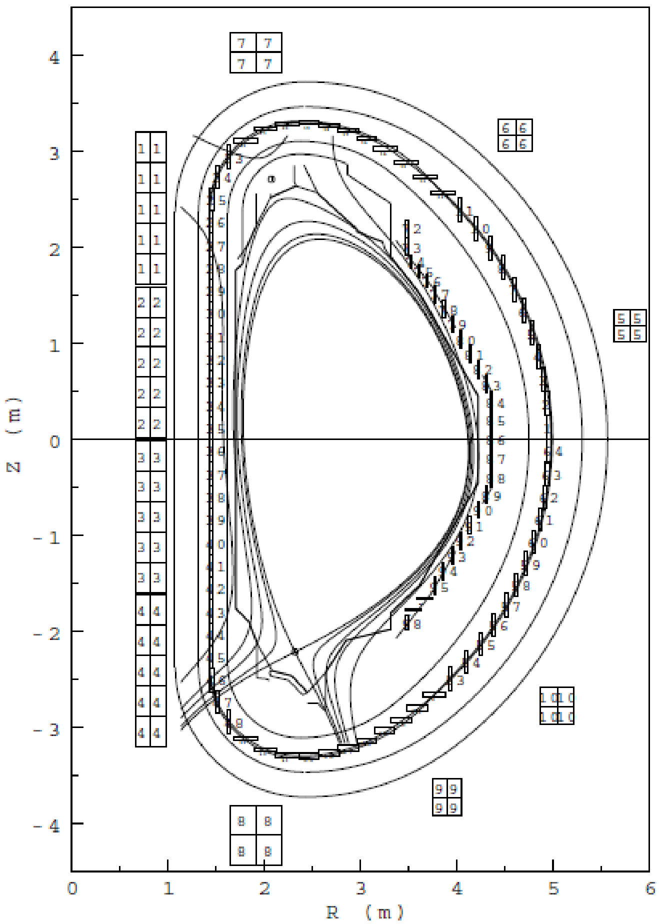




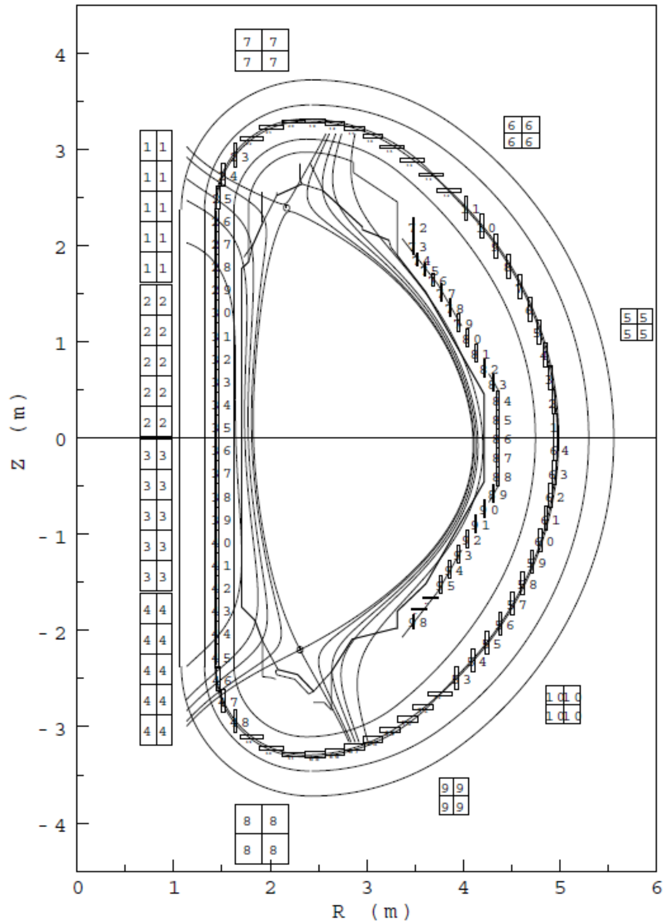
Plasma Shaping

JT-60SA
Advanced Superconducting Tokamak
BA-Satellite Tokamak Program

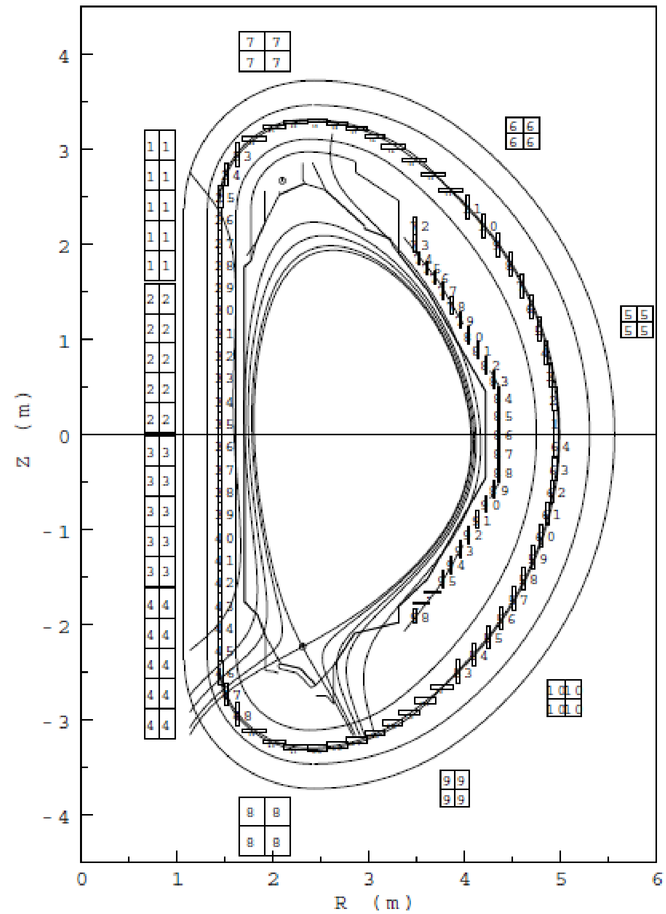
- JT-60SA will explore the plasma configuration optimization for ITER and DEMO with a wide range of the plasma shape including the shape of ITER, with the capability to produce both single and double null configurations.



Ip=5.5MA, Lower Single Null



Ip=5.5MA, Double Null



Ip=4.6 MA ITER like

Phased Research Plan

- **Exploitation within the BA period will aim at the initial research phase:**
  - HH operation for plasma full commissioning
  - DD operation for identification of the issues in preparation for full DD operation

- **Principles of "Joint Exploitation" later phases agreed between EU and JA**
- **Detailed "Research Plan" jointly prepared**

<table>
<tr><th></th><th>Phase</th><th>Expected Duration</th><th></th><th>Annual Neutron Limit</th><th>Remote Handling</th><th>Divertor</th><th>P-NB</th><th>N-NB</th><th>ECRF</th><th>Max Power</th><th>Power x Time</th></tr>
<tr><td rowspan="2">Initial Research Phase</td><td>phase I</td><td>1-2 y</td><td>H</td><td>-</td><td rowspan="3">R&D</td><td rowspan="2">LSN partial monoblock</td><td>10MW</td><td rowspan="5">10MW</td><td rowspan="2">1.5MW x100s + 1.5MW x5s</td><td>23MW</td><td rowspan="4">NB: 20MW x 100s
30MW x 60s
duty = 1/30

ECRF: 100s</td></tr>
<tr><td>phase II</td><td>2-3y</td><td>D</td><td>4E19</td><td rowspan="3">Perp. 13MW

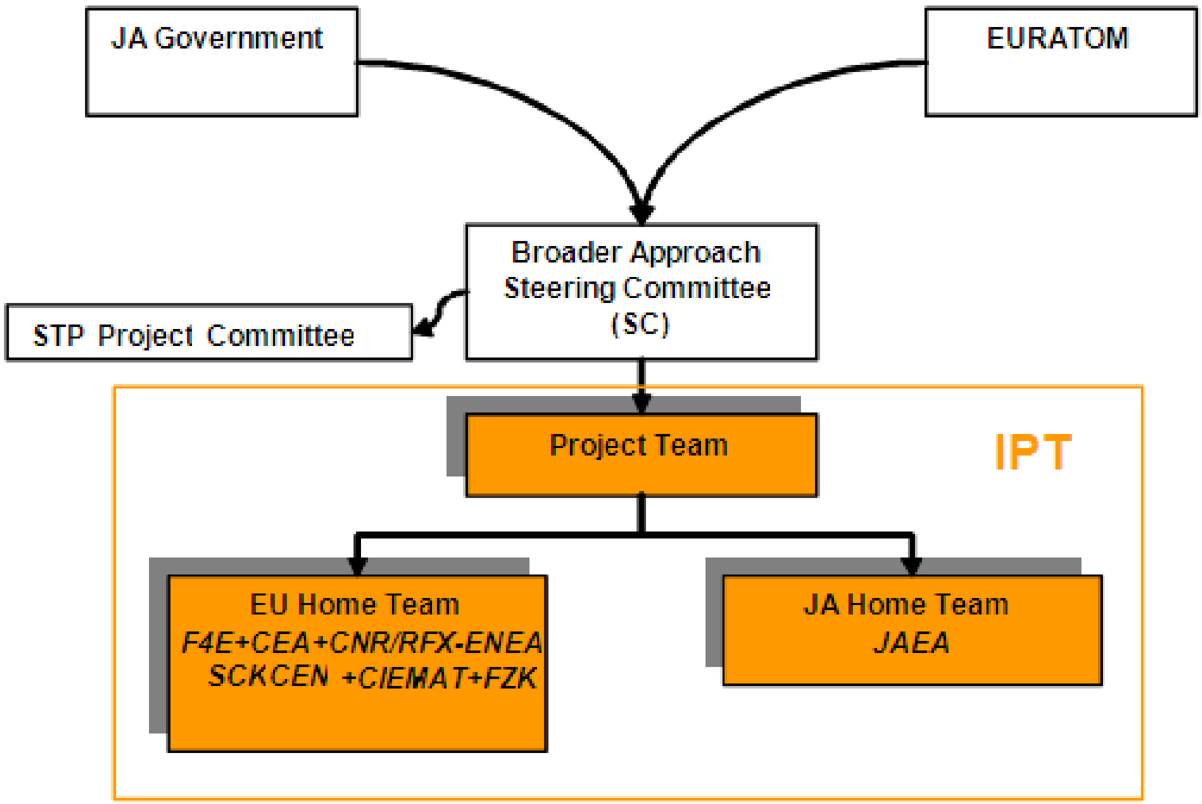
Tang. 7MW</td><td>33MW</td></tr>
<tr><td rowspan="2">Integrated Research Phase</td><td>phase I</td><td>2-3y</td><td>D</td><td>4E20</td><td rowspan="2">LSN full-monoblock</td><td rowspan="3">7MW</td><td rowspan="2">37MW</td></tr>
<tr><td>phase II</td><td>>2y</td><td>D</td><td>1E21</td><td rowspan="2">Use</td></tr>
<tr><td>Extended Research Phase</td><td></td><td>>5y</td><td>D</td><td>1.5E21</td><td>DN</td><td>24MW</td><td>41MW</td><td>41MW x 100s</td></tr>
</table>

Project Structure

JT-60SA
Advanced Superconducting Tokamak
BA-Satellite Tokamak Program

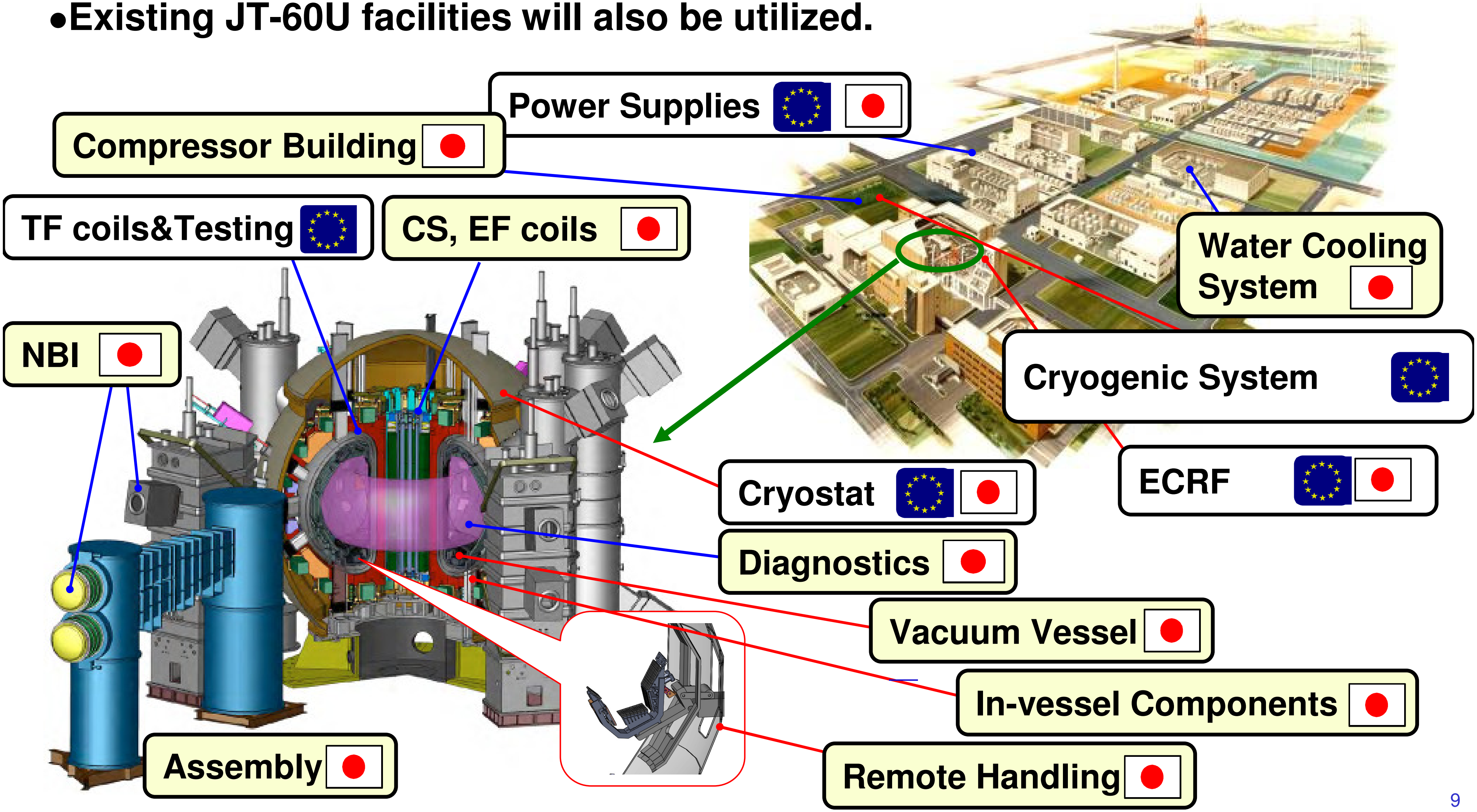
BA Agreement foresees

- **Very limited size Project Team with mainly coordination functions**
- **Procurement Arrangements signed between Implementing Agencies**
- **-> "collaboration" between EU and JA.**
- **Considering this arrangement, a *Common Management and Quality Program* was developed to define R&R and common processes**



Sharing

- Japan and EU implement in-kind contributions for components.
- Existing JT-60U facilities will also be utilized.

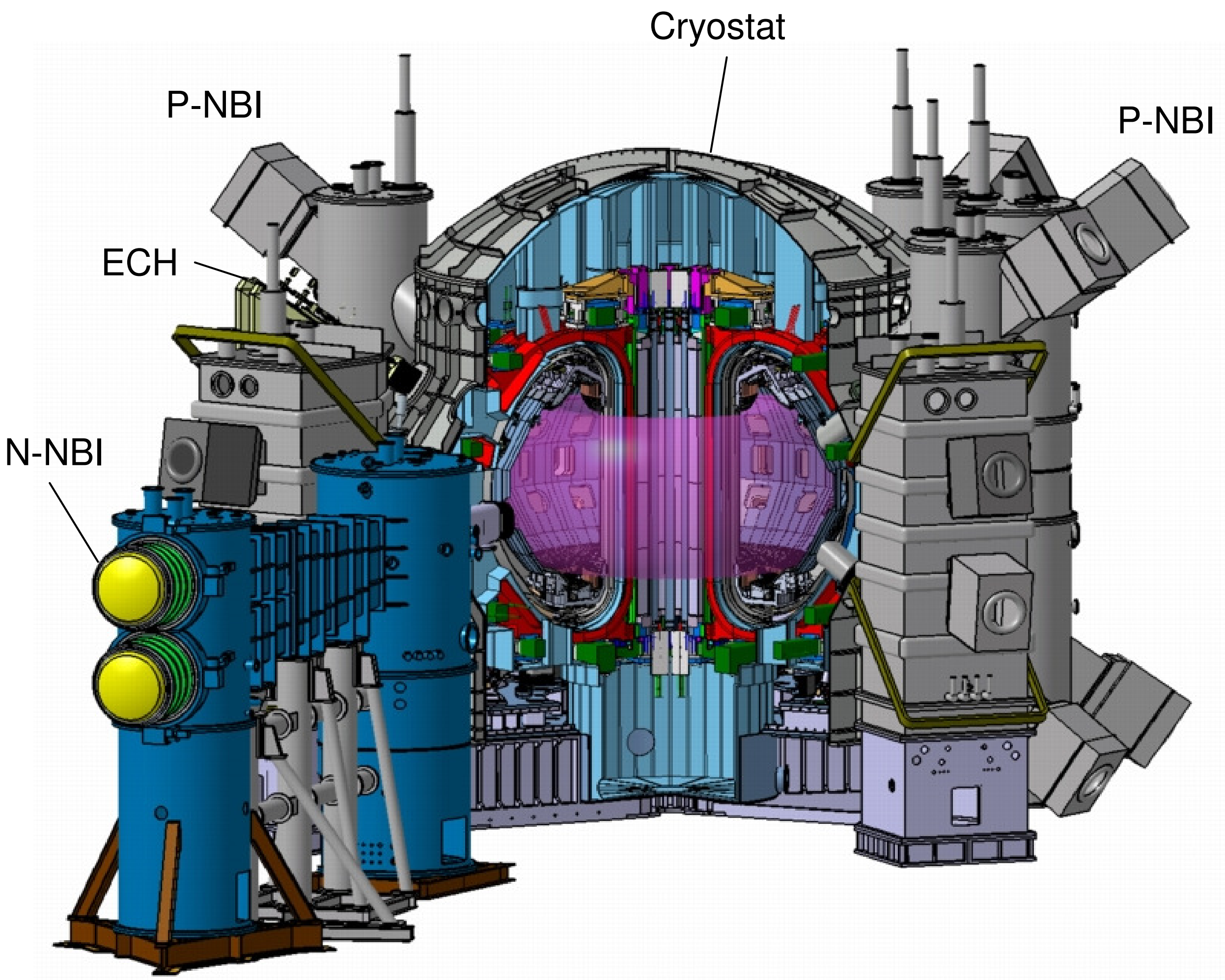


Machine Parameters

- **After successful completion of the re-baselining in late 2008, the JT-60SA project was launched with the new design with the following parameters.**

Basic machine parameters

Plasma Current	5.5 MA
Toroidal Field, B_t	2.25 T
Major Radius, R_p	2.96
Minor Radius, a	1.18
Elongation, κ_X	1.95
Triangularity, δ_X	0.53
Aspect Ratio, A	2.5
Shape Parameter, S	6.7
Safety Factor, q_{95}	~3
Flattop Duration	100 s
Heating & CD Power	41 MW
N-NBI	10 MW
P-NBI	24 MW
ECRF	7 MW
Divertor wall load	15 MW/m^2



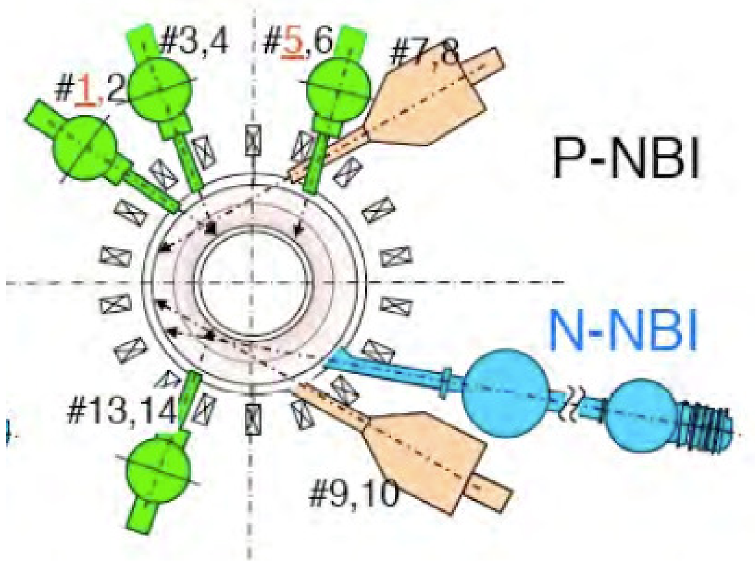
Heating and CD Systems

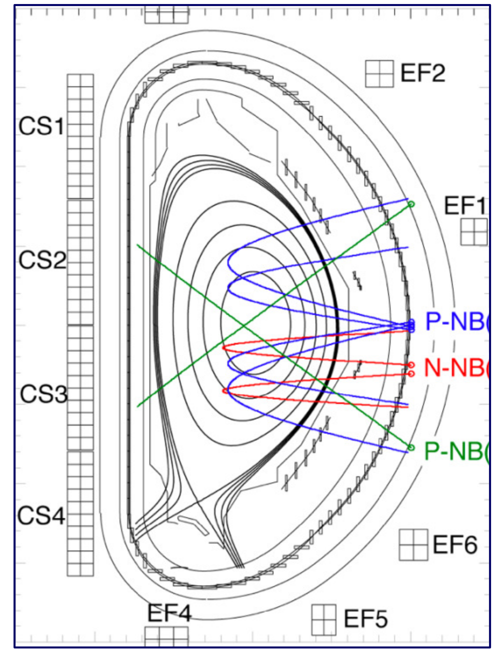
Variety of heating/current-drive/ momentum-input combinations

NB: 34MWx100s

Positive-ion-source NB
85keV
12units x 2MW=24MW
COx2u, 4MW
CTRx2u, 4MW
Perpx8u, 16MW

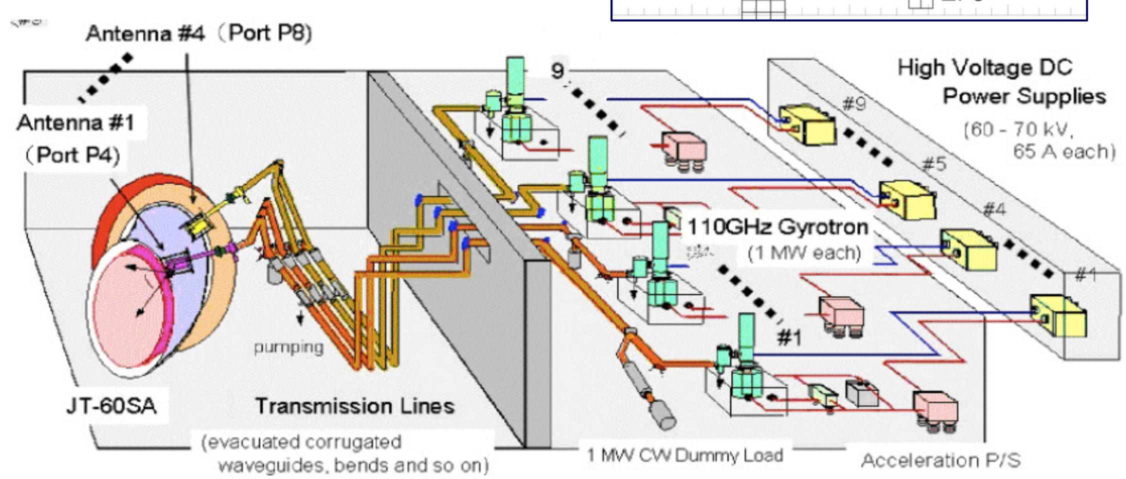
Negative-ion-source NB
500keV, 10MW
Off-axis for NBCD



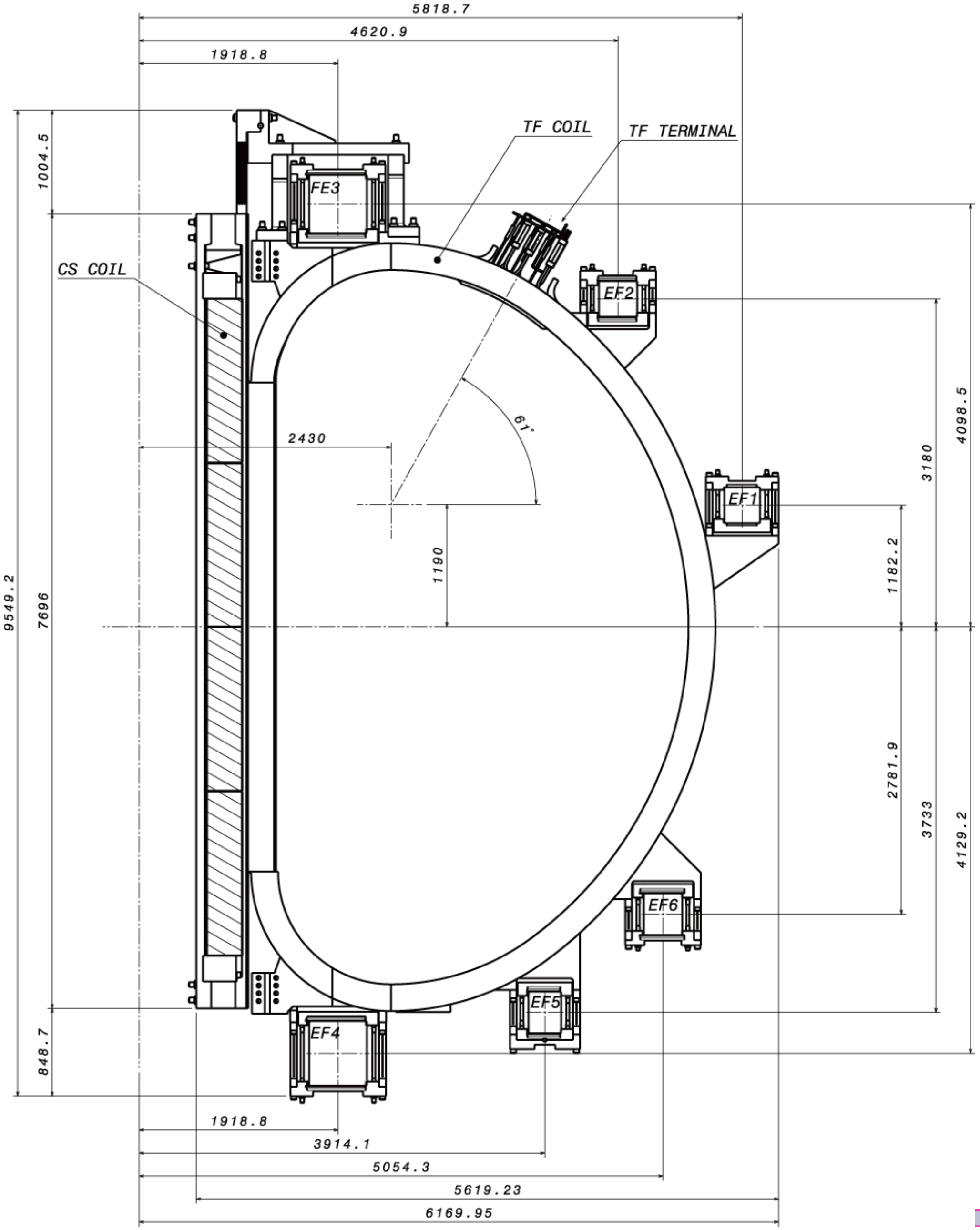


ECRF: 110GHz, 7MW x 100s

9 Gyrotrons,
4 Launchers with movable mirror



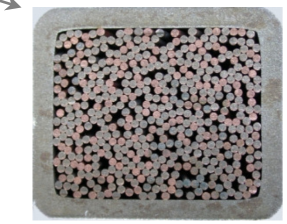
Magnet



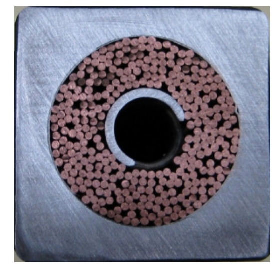
- All SC Magnet
  - Nb3Sn for CS
  - NbTi for TF, EF
- 18 TF Coils
- 6 EF Coils
- 4 CS independent modules

Conductors

Coil	TF	CS
Type of strands	N_bT_i	Nb_3S_n
Operating current (kA)	25.7	20
Nominal peak field (T)	5.65	~9
Operating temperature (K)	<5K	<5.1K
Number of SC strands/Cu strands	324 / 162	216 / 108
Local void fraction (%)	32	34
Cable dimensions (mm)	18.0 x 22.0	Φ21.0
Central hole (id x od) (mm)	-	7 x 9
Conductor ext. dimensions (mm)	22.0 x 26.0	27.9 x 27.9

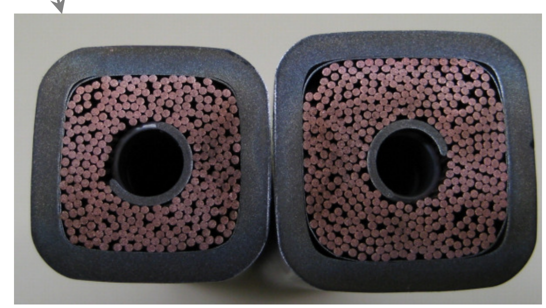


TFC conductor



CS conductor

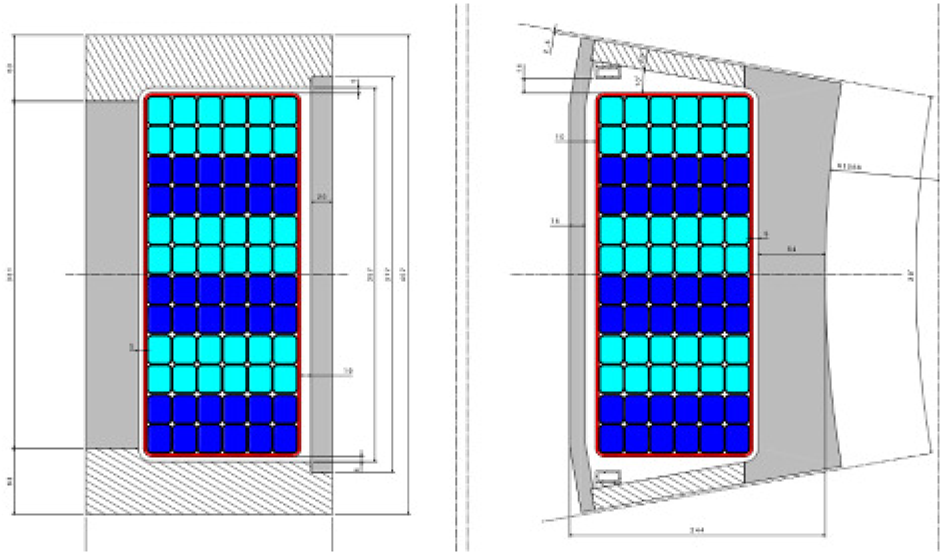
Conductor type	EF-H	EF-L
No. of coils	EF3, 4	EF1, 2, 5, 6
Type of strand	N_bT_i	←
Operating current (kA)	20.0	←
Nominal peak field (T)	6.2	4.8
Operating temperature (K)	5.0	4.8
Number of SC/Cu strands	450 / 0	216 / 108
Local void fraction (%)	34	34
Cable dimensions (mm)	21.8	19.1
Central hole (id x od) (mm)	7 x 9	←
Conductor ex. dimensions (mm)	27.7	25.0

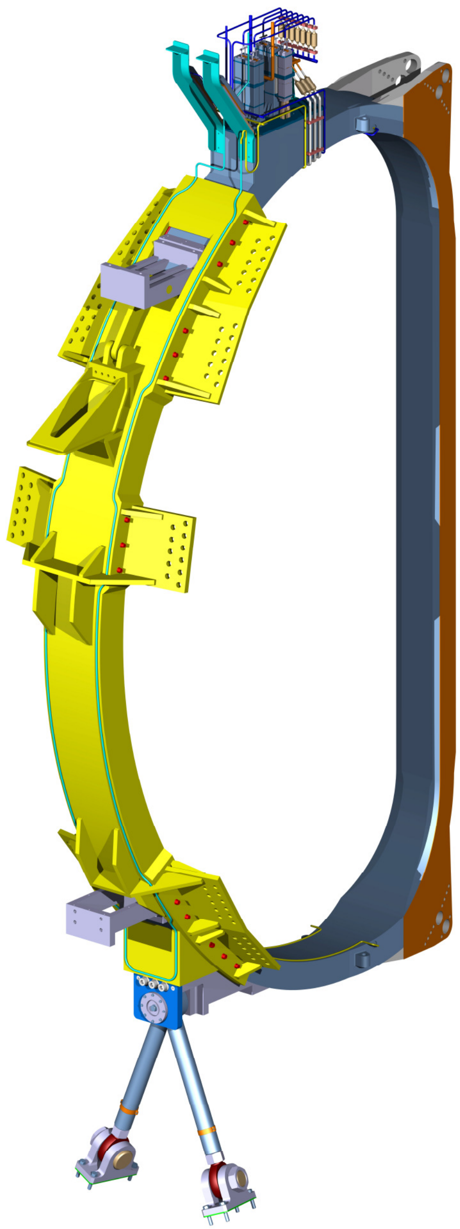


EF-L&H conductor

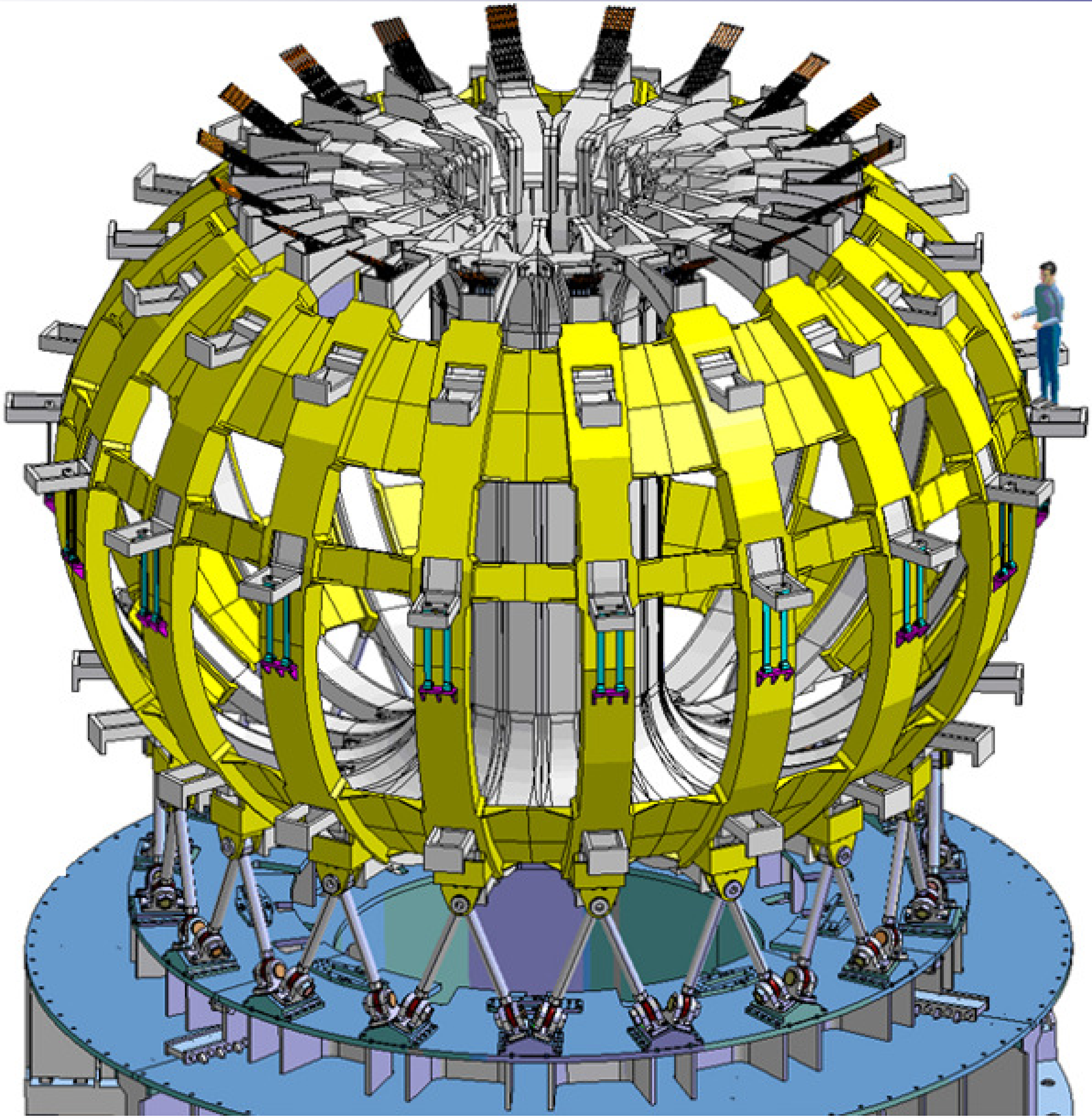
TF Magnet features

- Cable in Conduit Conductor , 72 turns, 25.7kA each
- 6 double pancakes, 6 turns/pancake. Helium inlets in high field side – joints in external low field side
- Windings enclosed in Steel Casings
- Steel casings supported to ground vertically and toroidally - connected in inboard curved regions by “Inner Intercoil Structure”
- Steel casings guided toroidally by “Outer Intercoil Structure” to support out of plane loads.



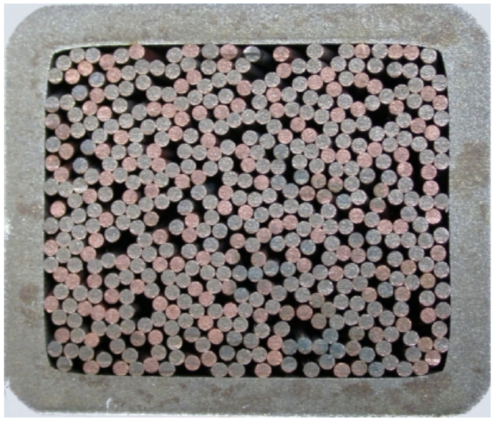


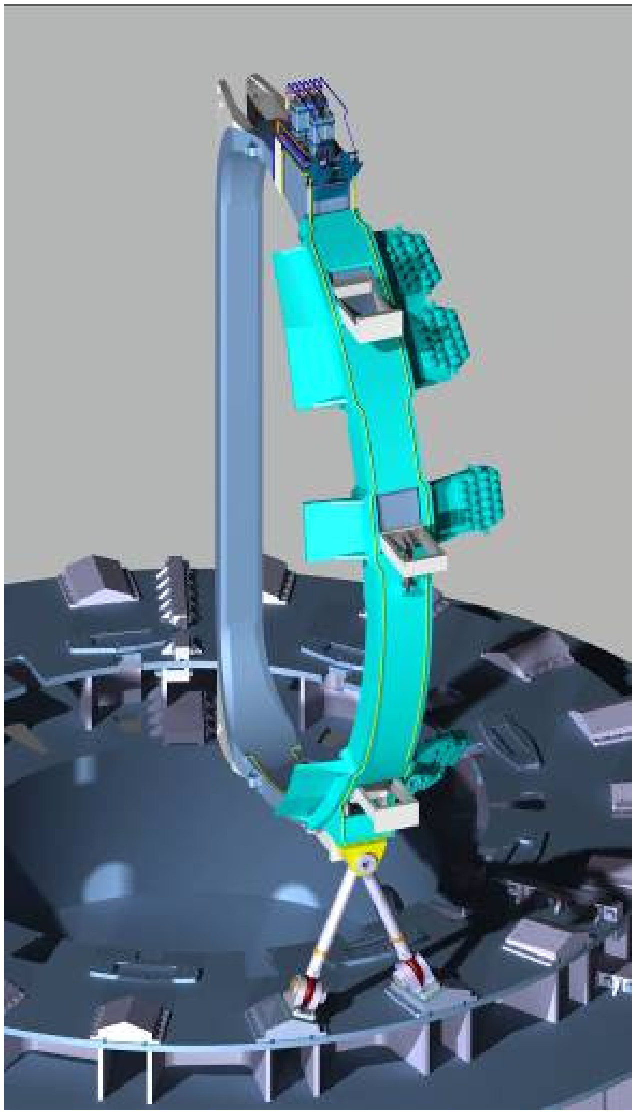
View of Magnet - assembly



TFC Procurement

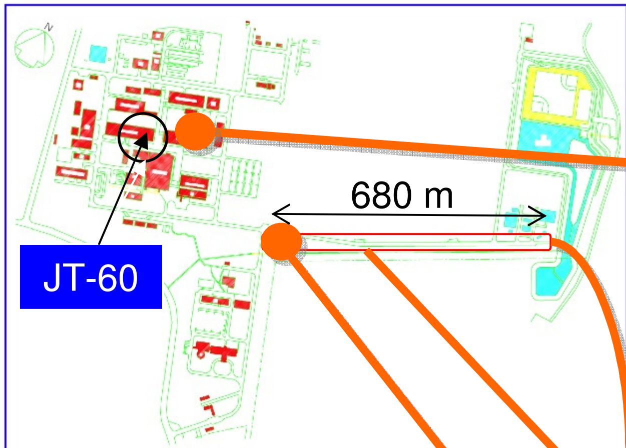
- Conductor being fabricated
  - Strand: Furukawa
  - Cabling/Jacketing: ICAS
- Winding: contracts to be signed soon
- Casings: call for tender by summer





PF Coils – on site manufacturing

- Two buildings were constructed in Naka Site in 2009.

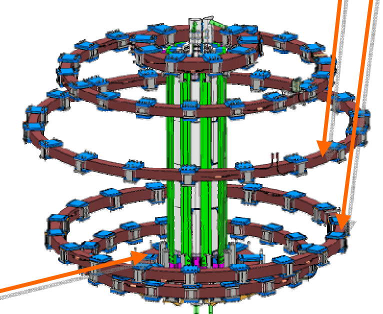


Two large PF coils (EF-1&6 coils) of 12m in diameter will be manufactured in this building because they are too big to be transported by using public road.

(2) **PF coil** manufacturing building constructed in March 2009

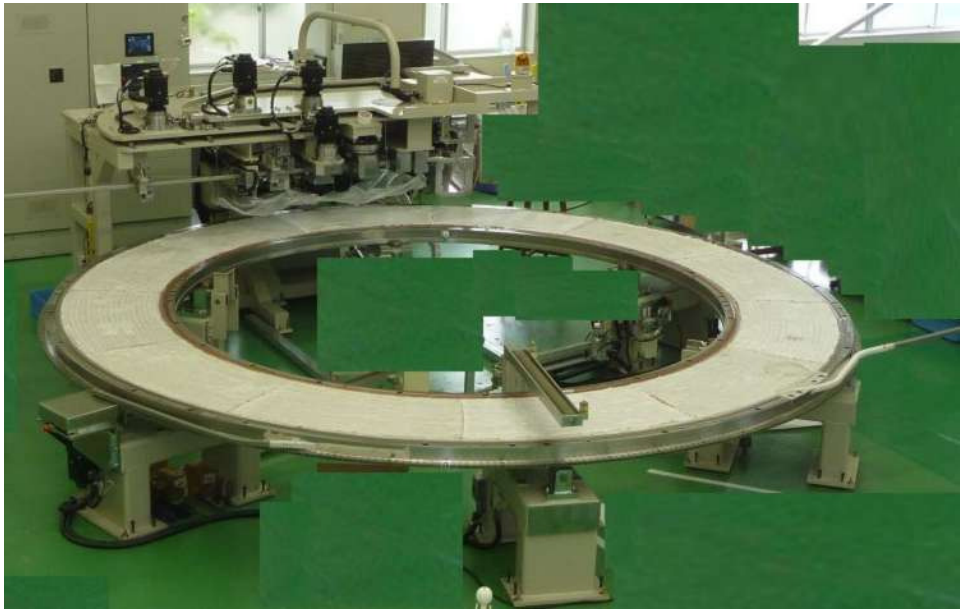
(1) **PF conductor** manufacturing building constructed in March 2009

The first superconducting conductor of 450m for the EF-4 coil has been completed in March 2010.



PF Conductors

JT-60SA
Advanced Superconducting Tokamak
BA-Satellite Tokamak Program



- **Jacketing the superconducting cables and winding them around drums 3 m in diameter underway at the Superconducting Conductor Jacketing Building at the Naka Fusion Institute**
- **CS conductor also being fabricated**
- **First double pancakes of EF coils completed**

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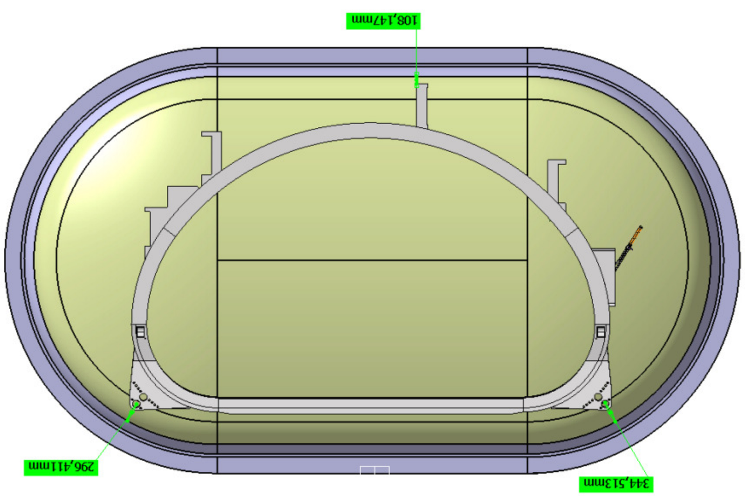
TFC Cold Tests

- **All TFC will be cold (4.5K) tested at full current before shipping to Japan**
- **Test Facility will be in CEA-Saclay. Facility under preparation.**
- **PA prepared with test facility specifications and cold testing specifications**
  - **HV Tests, Leak Tests**
  - **Flow, Pressure Drop**
  - **Dimensional Stability during and after cooldown**
  - **Resistance, Joints**
  - **Tmargin, Quench tests (2 coils)**
- **Cryostat to be delivered in Saclay soon**

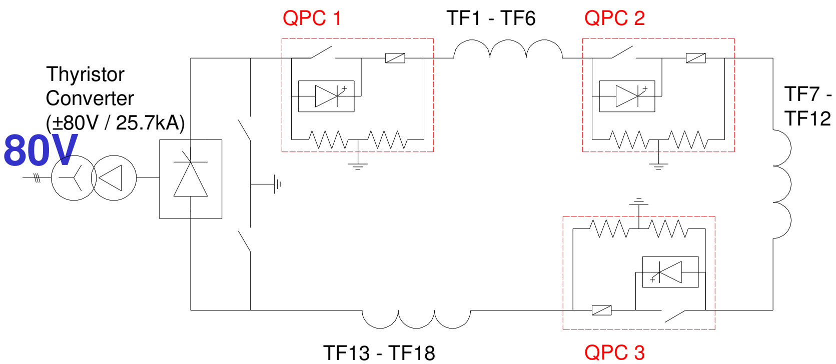


Power Supplies

A full new set of Power Supplies compatible with long pulse operation is being procured

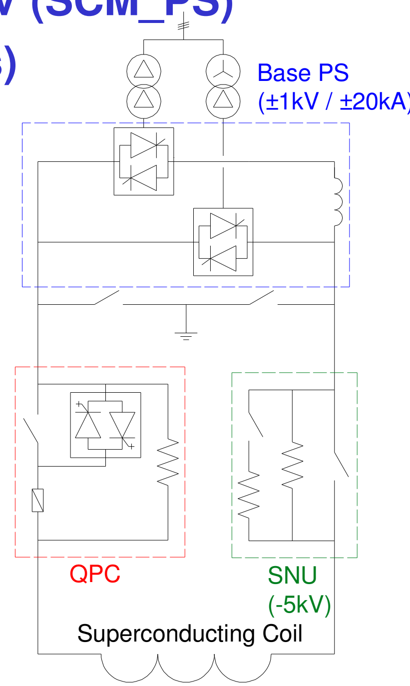
Toroidal Field circuit

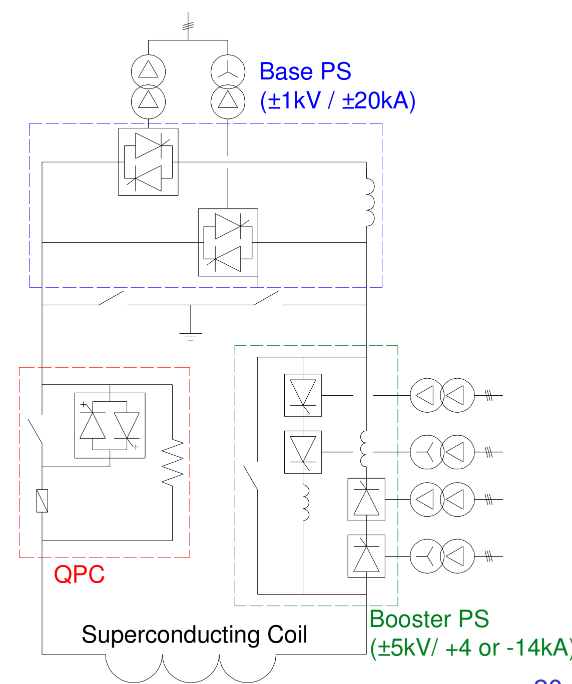
- 18 SC coils grouped in 3 units of 6 coils
- One 6 pulse unidirectional thyristor converter, 25.7kA, 80V
- 3 Quench Protection Circuit (QPC) (1.5KV to ground)



10 Poloidal Field circuits FC, each coil with:

- 1 bidirectional 12 pulse converter 20kA, ~1KV (SCM_PS)
- Switching Network Unit or Booster (old units)
- 1 QPC for fast discharge





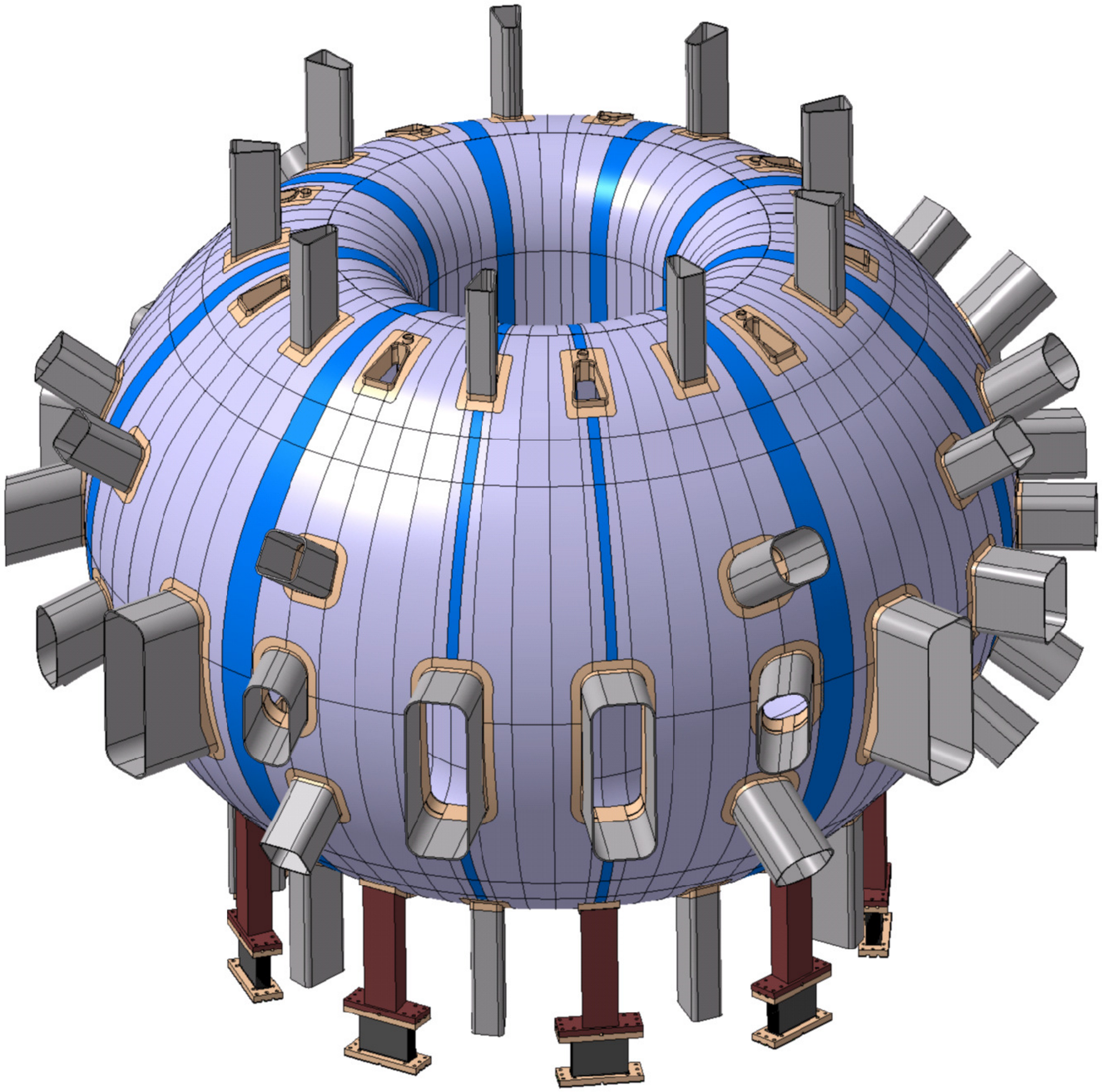
SCM-PS, SNU:
both PA signed, call for tender on-going

QPC Units: Contract awarded Dec 2010
Detailed design phase just completed

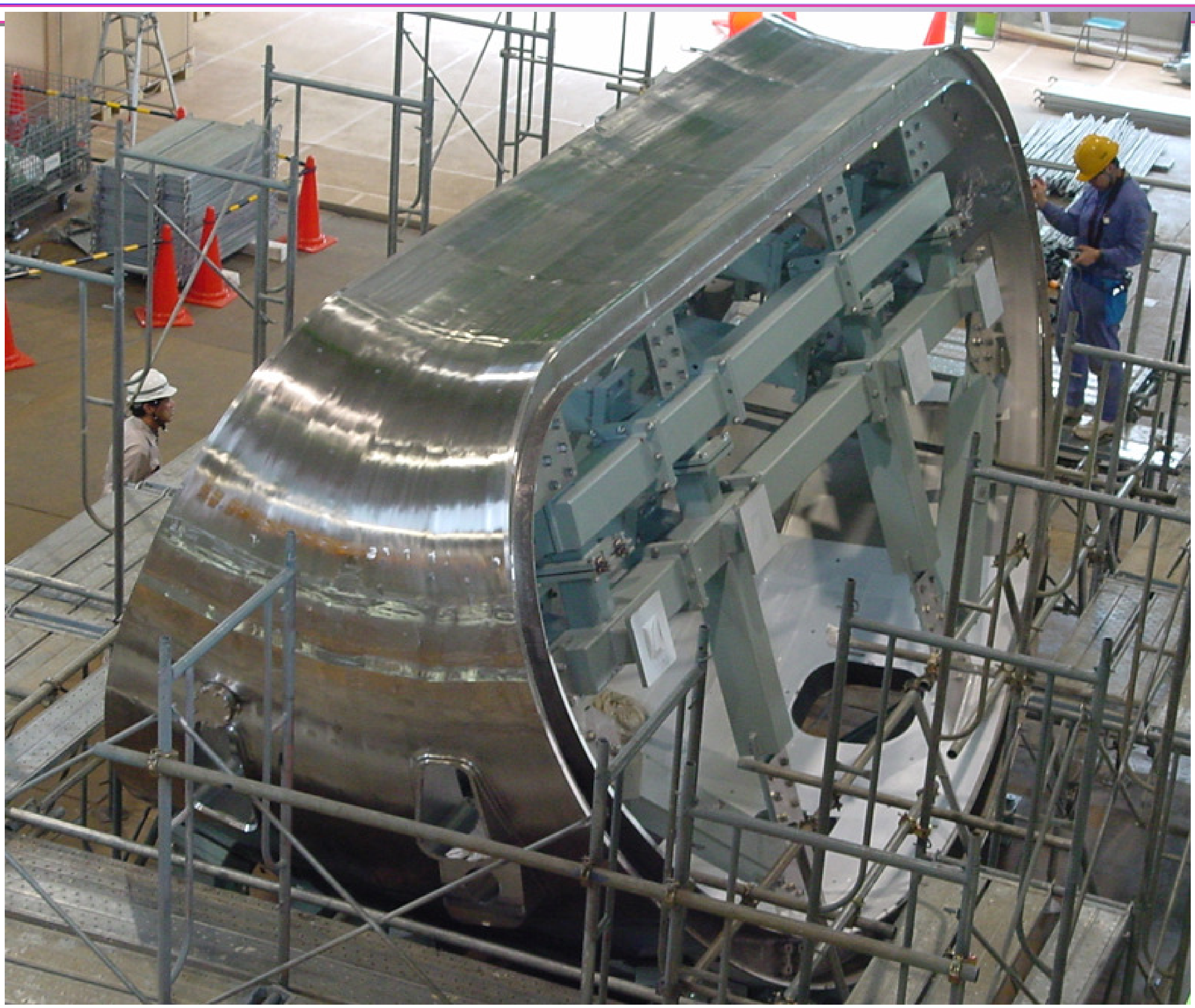
oral presentation SO4D-2 on Thursday

Vacuum Vessel

- Double Walled
- 18mm+18mm
- Boronised Water interspace (~160mm)
- 200C Baking

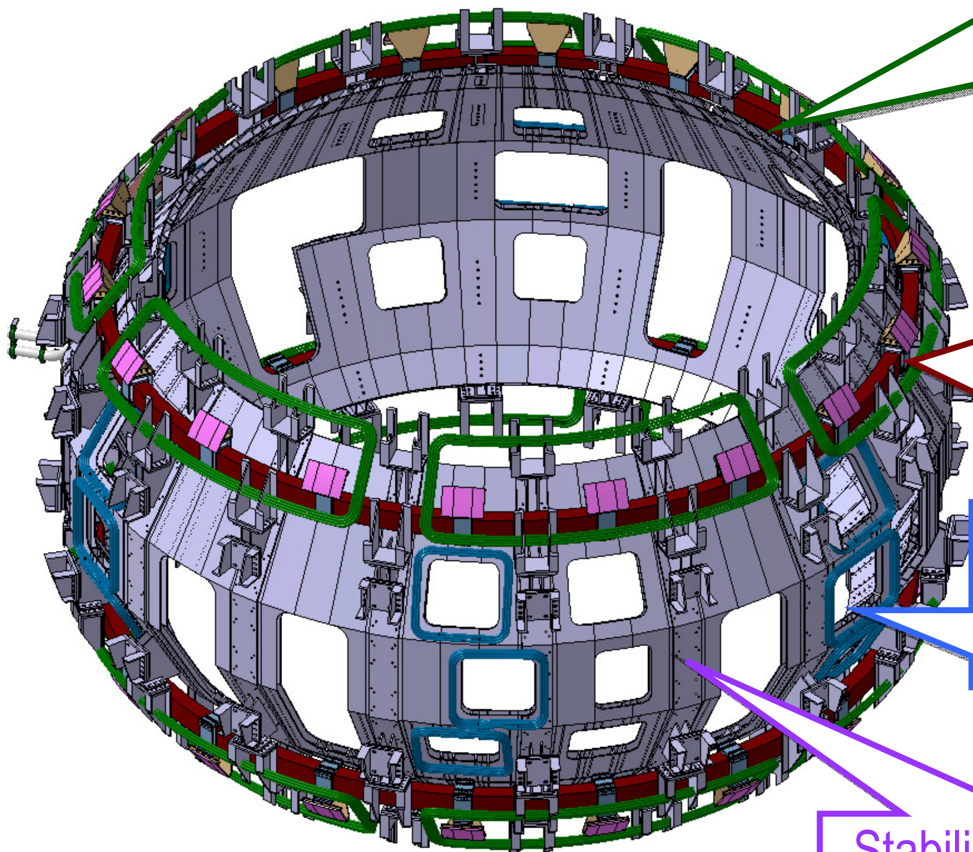


Vacuum Vessel (2)



- First Sector completed in Naka
- Tolerances well within requirement

MHD Control in-vessel components



Error Field Correction Coil (EFCC)
- toroidal 6 x poloidal 2 coils (TBD)
- 30kAT (TBD)
- frequency ~100Hz (TBD)
- RMP for ELM control

Fast Position Control Coil (FPCC)
- upper and lower coils
- 120kATurn
- time response <10ms
- VDE

RWM control Coil (RWMC)
- toroidal 6 x poloidal 3 coils (TBD)
- 20kAT (TBD)

Stabilizing Plate
- SUS316L
- Double Shell
- VDE & RWM

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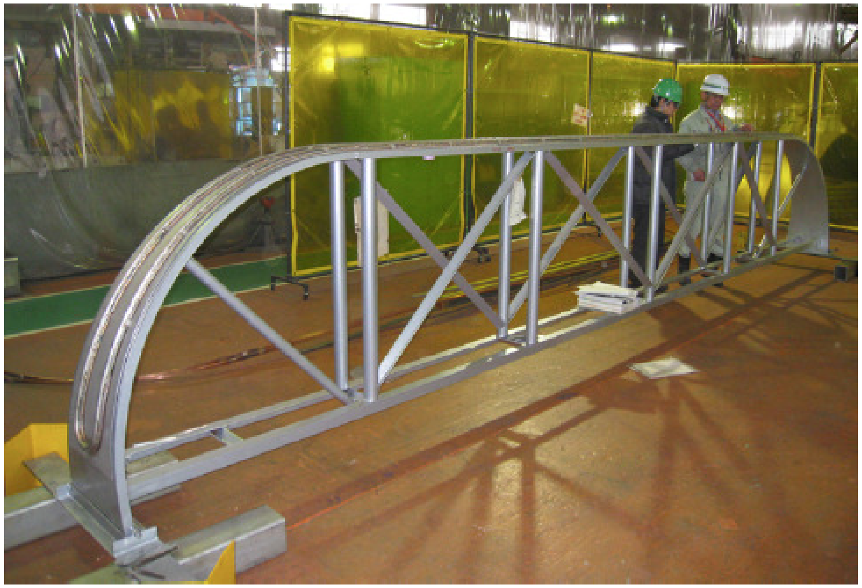
Thermal Shields

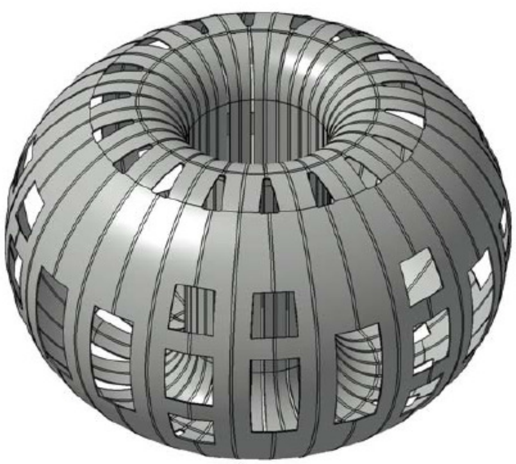


Detailed design nearly completed

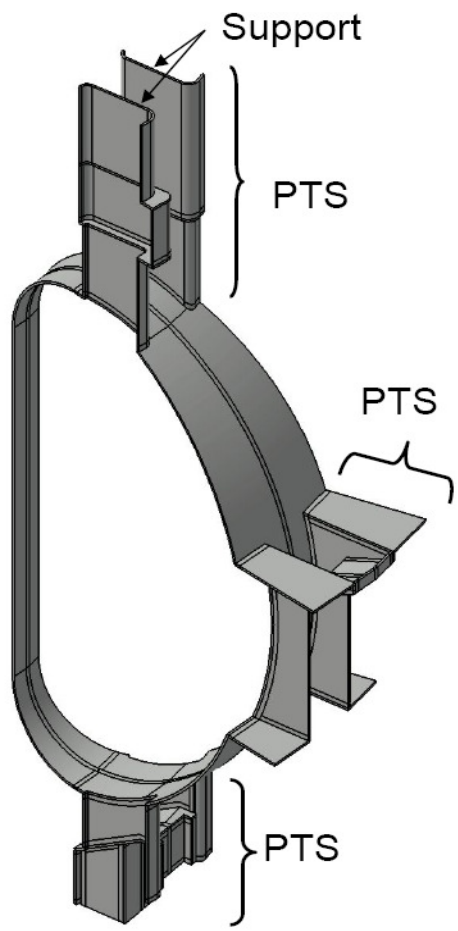
Assembly studies underway

Fabrication Trials underway

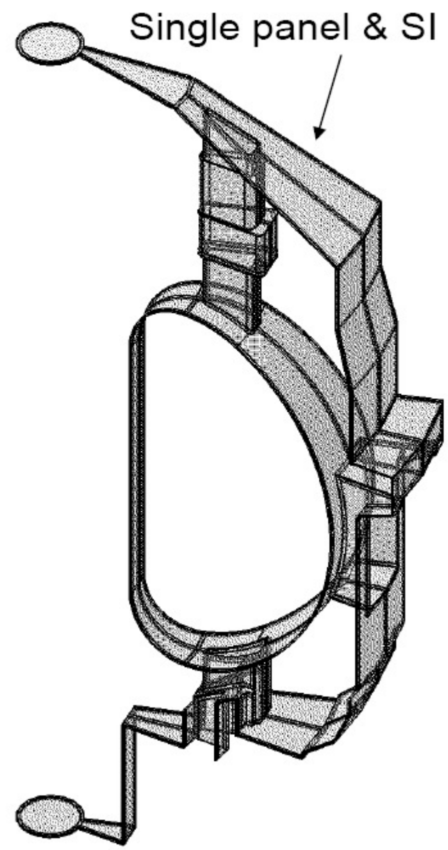
Double walled panel



VVTS



VVTS and PTS

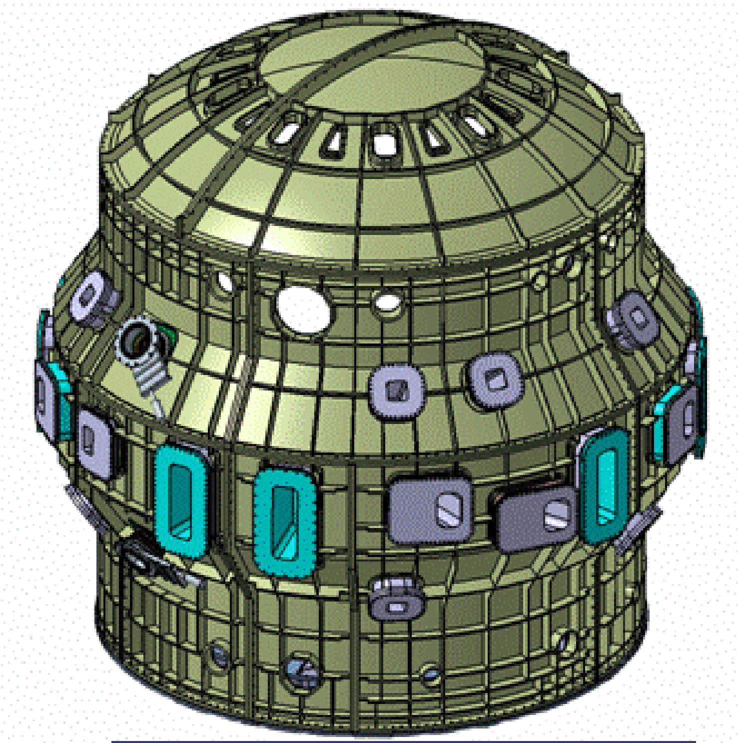


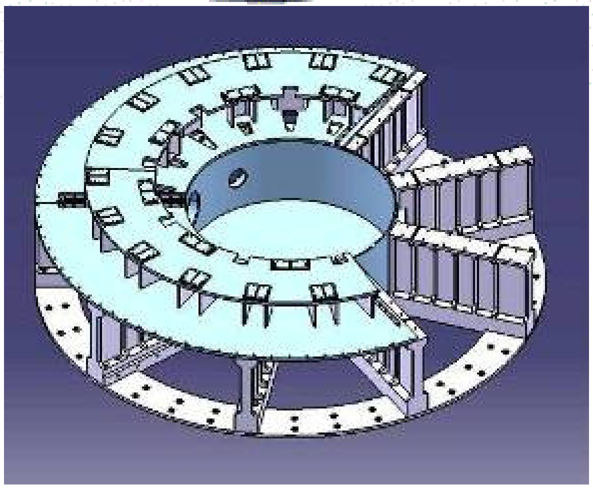
VVTS, PCS and CTS

Cryostat

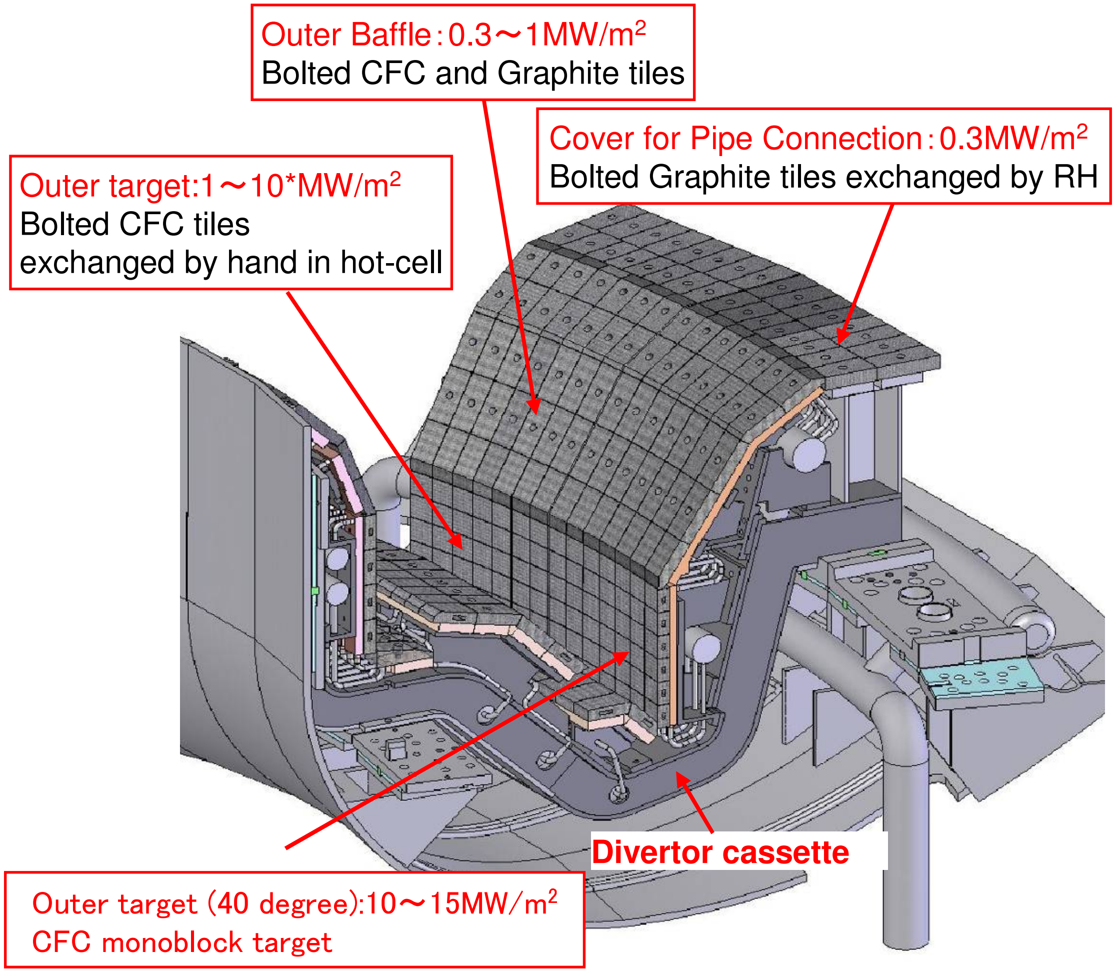
- Faceted
- Single wall

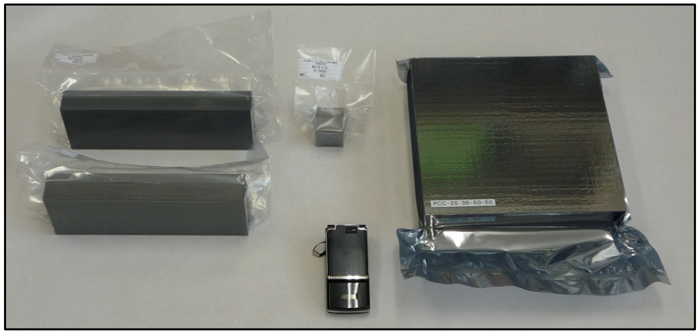
- Two parts (~650 Tonnes):
  - Main machine support
  - Cylindrical and lid
- Fabrication of Base started.
- Specifications for cylindrical body completed
- First component to be installed in torus hall. Delivery in Naka planned for Mid 2012





Divertor Cassette





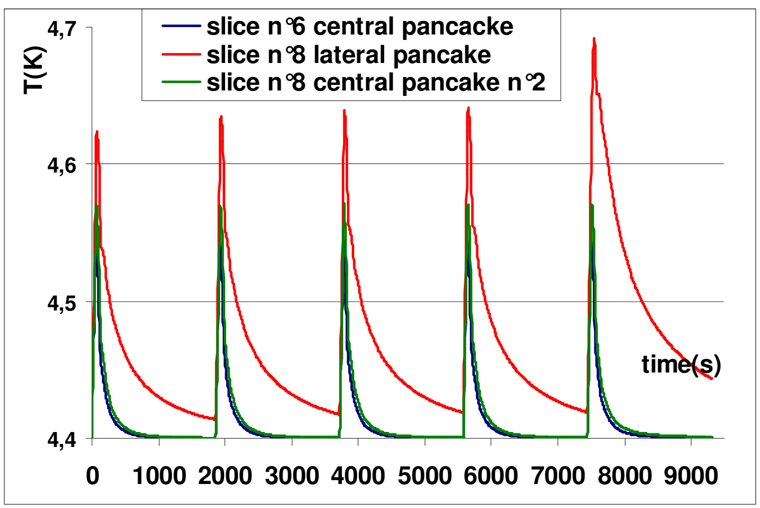
- CFC (type I and II) materials at the first stage were delivered at Naka in March 2009.

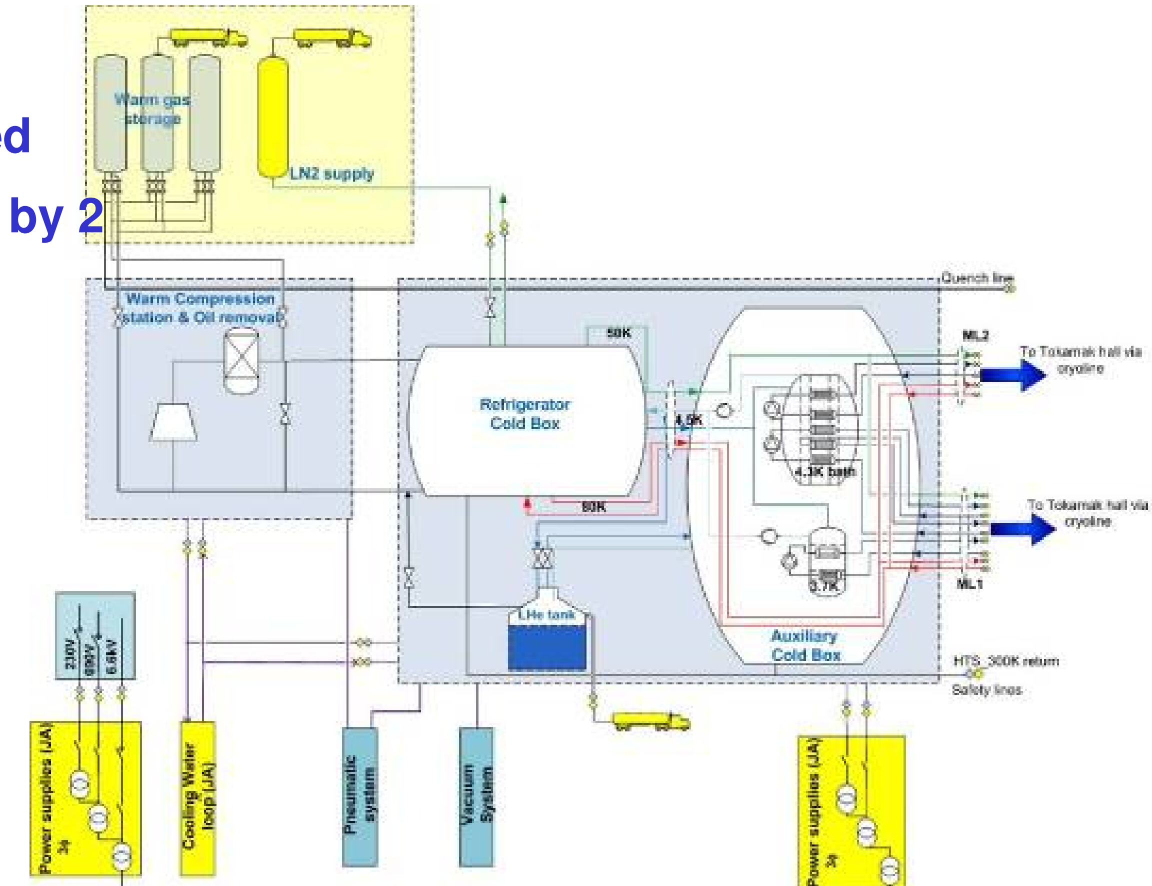
- Development of the divertor target is in progress to examine brazing for the divertor target.

- Fully water cooled PFC, in which CFC monoblock targets are partially installed.
- Carbon tiles are bolted on cooled heat sinks.
- RH compliant divertor cassette is adopted for future maintenance.

Cryoplant

- Strong effort in magnet design devoted to minimization of peaked loads by increasing as much as possible time constants.
- Full TH model of TF magnet developed
- detailed industrial studies completed by 2 companies
- Technical Specifications completed
- Call for tender started





JT-60 Disassembly underway

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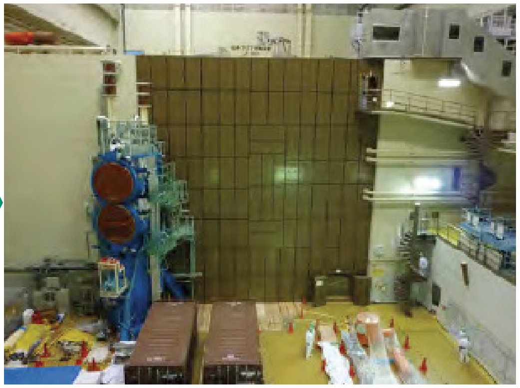
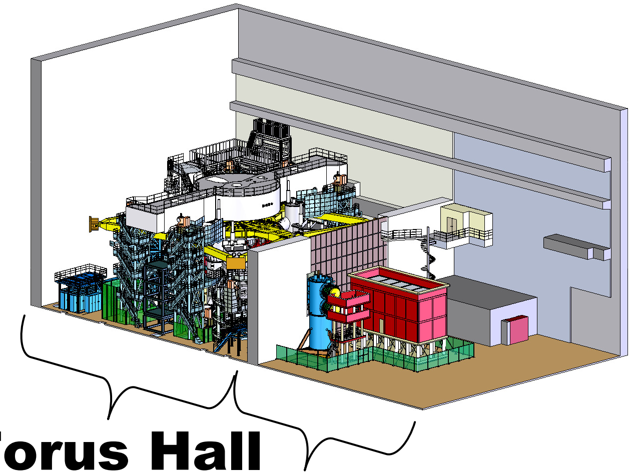
High Voltage Deck of N-NBI



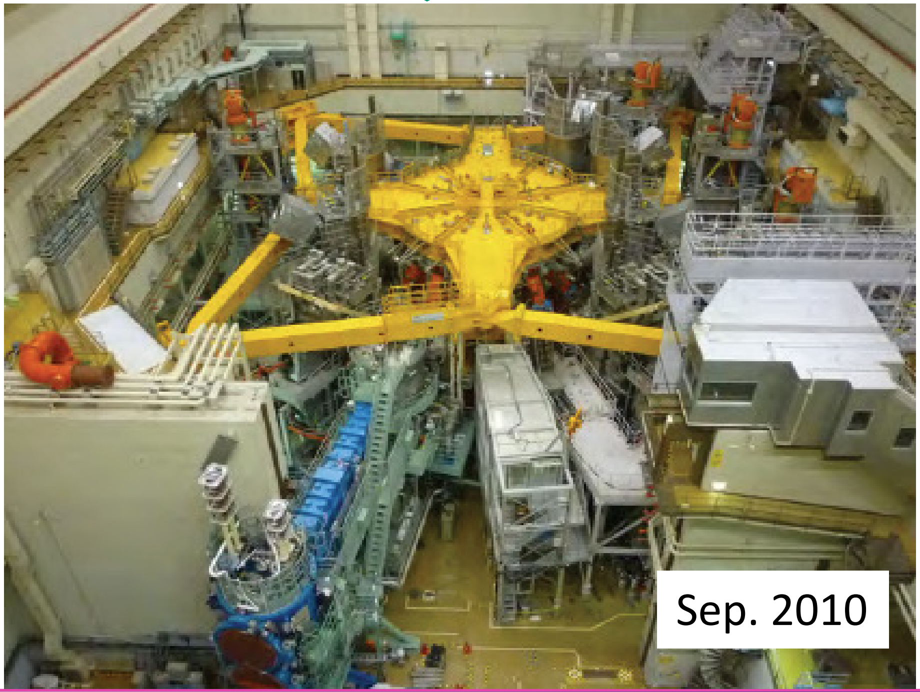
Neutron Shielding Wall

Mar. 2010



Torus Hall

Assembly Hall



Sep. 2010

Conclusions

- JT-60SA has undergone a major rebaselining in 2008 in order to reduce costs while maintaining its objectives
- After successful completion of this re-baselining, the project has made a large progress in designing, manufacturing, planning and site preparation
- The procurement implementation for the components has progressed with relevant contracts following the PAs for the supply of PF coils, vacuum vessel and divertor by Japan and power supply, cryostat, current leads and TF magnet by EU. The majority of the PAs are either signed or in final preparation
- Manufacturing activities are now well underway
- Finally, as a consequence of the great Earthquake in Japan no major damage at JT60-U facilities as well as the involved factories were observed. Work is progressing well.

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Thanks for the attention!

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