Status of JT-60SA Project and its Research Planning

A. Sakasai, Y. Kamada, P. Barabaschi, H. Shirai
M. Hanada, E. Di Pietro and the JT-60SA Team

The 5th IAEA DEMO Programme Workshop (DPW-5)
7-10 May 2018
Laon Convention Hotel (Daejeon, Republic of Korea)
Assembly of the JT-60SA will be competed in Mar. 2020. First plasma is expected in Sep. 2020.
JT-60SA (JT-60 Super Advanced) Project

JT-60SA Project is implemented under the Broader Approach (BA) Agreement between EU and Japan as well as the Japanese national fusion programme.

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

Major Objectives:
(1) Supportive Researches for ITER
   JT-60SA starts operation earlier than ITER.
   → optimization of ITER operation scenarios
(2) Complementary Researches for DEMO
   study of long sustainment of high $\beta_N$ plasmas
(3) Training of Scientists and Technicians

JT-60SA
(superconducting Tokamak)
(Naka, Japan)
## JT-60SA Machine Parameters

### Major Machine Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plasma Current, $I_p$</td>
<td>5.5 MA</td>
</tr>
<tr>
<td>Toroidal Field, $B_t$</td>
<td>2.25 T</td>
</tr>
<tr>
<td>Major Radius, $R_p$</td>
<td>2.96 m</td>
</tr>
<tr>
<td>Minor Radius, $a$</td>
<td>1.18 m</td>
</tr>
<tr>
<td>Plasma Volume</td>
<td>133 m³</td>
</tr>
<tr>
<td>Elongation, $\kappa_X$</td>
<td>1.95</td>
</tr>
<tr>
<td>Triangularity, $\delta_X$</td>
<td>0.53</td>
</tr>
<tr>
<td>Aspect Ratio, $A$</td>
<td>2.5</td>
</tr>
<tr>
<td>Shape Parameter, $S$</td>
<td>6.7</td>
</tr>
<tr>
<td>Safety Factor, $q_{95}$</td>
<td>$\sim 3$</td>
</tr>
<tr>
<td>Flattop Duration</td>
<td>100 s</td>
</tr>
<tr>
<td>Heating and CD Power</td>
<td>41 MW</td>
</tr>
<tr>
<td>N-NBI</td>
<td>10 MW</td>
</tr>
<tr>
<td>P-NBI</td>
<td>24 MW</td>
</tr>
<tr>
<td>ECRF</td>
<td>7 MW</td>
</tr>
<tr>
<td>Allowable Divertor Heat Load</td>
<td>15 MW/m²</td>
</tr>
</tbody>
</table>

Operational scenarios intrinsic to the superconducting Tokamaks under high $\beta_N$ condition will be investigated.
Highly Shaped Large Superconducting Tokamak

JT-60SA:
- Large superconducting tokamak ~ half size of ITER
- High plasma current (max. \( I_p = 5.5 \text{ MA} \))
- Long pulse (typically 100s)
- Highly shaped (\( S = q_{95} I_p / (a B_T) \approx 7, A \approx 2.5 \))
- High heating power 41 MW with variety and flexibility for future (shape, divertor etc.)

Superconducting tokamaks in the World

- JT-60SA (\( A \geq 2.5, I_p = 5.5 \text{ MA} \))
- ITER (\( A = 3.1, I_p = 15 \text{ MA} \))
- SST-1 (\( A = 5.5, I_p = 0.22 \text{ MA} \))
- EAST (\( A = 4.25, I_p = 1 \text{ MA} \))
- KSTAR (\( A = 3.6, I_p = 2 \text{ MA} \))
- WEST (\( A \geq 5.6, I_p = 0.8 \text{ MA} \))

Lawson Diagram

Allowable Error Field ~ \( 10^{-4} \):
Size of Device ~ 10m
=> Manufacture & assembly Error ~ a few mm
Existing JT-60U facilities (e.g. transformer substation, motor generators, etc.) are also reused to reduce overall project cost.
All members of the JT-60SA Integrated Project Team share the same clear target of Construction.

**Project Coordination Meeting (PCM):** 197 times (every 2-3 weeks)

**Technical Coordination Meeting (TCM):** 29 times (~3 times/year)

**Research Coordination Meeting (RCM):** 6 times (since 2011, every year)

**Integrated Project Team**

- **EU Implementing Agency (F4E)**
  - EU Project Manager
  - Manufacturing
  - Integration Activities
  - Project Team + HTs
  - 112

- **JA Implementing Agency (QST)**
  - JA Project Manager
  - Manufacturing
  - Tokamak Assembly
  - 138

**Total:** 256 persons

TCM-15 (Padua, Sep. 2012)  
TCM-17 (Grenoble, May. 2013)  
TCM-21 (Saclay, Nov. 2014)

F4E JT-60SA Team, coordinating the whole EU PAs and interfaces towards tokamak assembly, commissioning & operation.
JT-60SA Project is at the peak of Full Assembly phase. Tokamak, Cryoplant, Power Supply, Heating & Diagnostics => commissioning

- **Cryostat Base**
- **Lower Poloidal Field Coils**
- **Vacuum Vessel**
- **VV thermal shield**
- **TF Coils**
- **Upper Poloidal Field Coils and Central Solenoid**

**Completion of Tokamak Assembly: Mar. 2020**

- **First Plasma: Sep. 2020**
18 TF coils plus 2 spare coils are manufactured, and then tested before delivery. Key technologies for high-accuracy manufacturing are developed.

(1) winding pack (WP) fabrication
Development of winding machine for the dimension control with high accuracy

(2) impregnation of WP
(3) WP and coil case incorporation
(4) final machining of coil case
Manufacturing accuracy and test result

Manufacturing accuracy for winding:
Achieved deviation of the current center
< 2 mm of design value
Cross section of WP
144 ±1.5 mm (T) x 342 ±1 mm (W)
Design tolerance: ± 3 mm & ± 5 mm

Manufacturing accuracy for Packing:
Position of WP in the case
Tolerance: -0.14 mm in X, +0.15 to 0.36 mm in Y.

Cold test after manufacturing:
Required performance is validated.
- Nominal 25.7kA at 4.5-7 K
- $T_{cs} \sim 7.47$ K (> design 7.32K),
- Joint resistances in nano-Ohm range).

All 18 TF coils have been already manufactured and tested in Europe. The last 18th coil was delivered to Japan in Mar. 2018.
Manufacture of Outer Intercoil Structures (OIS) and Pre-assembly was completed at CEA Saclay.

All 18 coils were pre-assembled with OIS. The Last 18th OIS were delivered to Naka together with TFC in Mar. 2018.
Equilibrium Field (NiTi) Coils completed

EF4, 5 & 6 placed on the Cryostat Base

High accuracy manufacture → **New winding machine**
- Feedback control of the bending force.
- Direct curing after winding without changing vessel.
- Joints between the WPs are uniformly allocated.

**Circularity of current center.**

<table>
<thead>
<tr>
<th></th>
<th>Diameter</th>
<th>Circularity</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>EF1</td>
<td>12.0 m</td>
<td>0.3 mm</td>
<td>≤8 mm</td>
</tr>
<tr>
<td>EF2</td>
<td>9.6 m</td>
<td>0.4 mm</td>
<td>≤7 mm</td>
</tr>
<tr>
<td>EF3</td>
<td>4.4 m</td>
<td>0.2 mm</td>
<td>≤6 mm</td>
</tr>
<tr>
<td>EF4</td>
<td>4.4 m</td>
<td>0.6 mm</td>
<td>≤6 mm</td>
</tr>
<tr>
<td>EF5</td>
<td>8.1 m</td>
<td>0.6 mm</td>
<td>≤7 mm</td>
</tr>
<tr>
<td>EF6</td>
<td>10.5 m</td>
<td>1.3 mm</td>
<td>≤8 mm</td>
</tr>
</tbody>
</table>
Central Solenoid (Nb3Sn) modules completed

- CS1 (completed in Sep. 2016)
- CS2 (completed in Feb. 2017)
- CS3 (completed in Mar. 2018)
- CS4 (completed in Mar. 2017)

Achieved circularity of current center 0.3mm for design of 4.0 mm.

**High accuracy manufacture → New winding machine**
- Bending force to be automatically adjusted for different eccentricity of conductor.
- Vibrating turn table to suppress residual stress.

CS stacking started in Mar. 2018. The stacked CS will be delivered to Naka in Dec. 2018.
Manufacture and test of all 26 HTS-CLs have been completed by KIT.

- TF01~TF06 (25.7 kA)
- PF01~PF20 (20 kA)

Remaining 10 HTS-CLs were delivered to Naka in Nov. 2017.
Magnet Shared Components

5 Coil Terminal Boxes (CTB)
- CT01 for TFC was completed in Feb. 2017.
- CT04, CT05 for lower EF coils and lower CS modules was completed in Dec. 2017.
- CT02, CT03 under manufacturing

11 Valve Boxes (VB) for helium feeding
- 6 VBs were completed in Mar. 2017.
- 5 VBs were completed in Sep. 2017.
SUS316L with low cobalt content (<0.05%wt) for low radio-activation

Double wall structure is adopted
- ensure high rigidity at operational load (EMF and VDE) and high one-turn resistance.
- Nitrogen gas of 200°C is circulated for baking
- Boric-acid water in the double wall circulates to reduce nuclear heating (<0.3 mW/cc) on inboard side of TFC.

Issue: control welding deformation and keep tolerance of ±10 mm
To solve, three welding types were chosen for the VV structure
1) Twin MAG welding (small deformation, precise rib angle)
2) Plasma arc welding for butt joints and narrow grooves (8 mm width)
3) MAG welding (continuous-plug welding to close outer wall)
   - Welding robot (improve work efficiency and welding quality)

Inner/outer wall: 18 mm
Rib: 22 mm

6.6 m
9.95 m

9.95 m

Inner wall (RT)
Twin MAG welding (RT)

Plasma arc welding (RT)

18 mm

18 mm

Plasma arc welding

MAG plug welding

(UT, PT)

(UT, PT)

TIG

Twin MAG welding (fillet-weld rib to Inner wall)

Plasma arc welding (butt joint of inner/outer walls)

TIG (1st layer for pug welding)
MAG (continuous-plug welding)
Fabrication of VV 40-degree Sector completed

Manufacturing accuracy:
- ±2 mm at inboard (IB) for ±10 mm
- ±5 mm at outboard (OB) for ±20 mm

Final 20° VV sector was completed in Apr. 2014.
Cryostat vessel body was completed by EU.

Body was delivered to Naka in Feb. 2018. Top-lid will be delivered in Mar. 2019.
Power Supply System for Magnets

Most of magnet power supply systems are newly manufactured for SC coils.

- Quench Protection Circuit (QPC): extract stored energy of coils in quench events. Manufactured and installed by EU (Consorzio RFX).

QPC: to avoid burn-out of coils in quench events

Installation & commissioning have been carried out by EU colleagues on Naka site (Collaborative work)

Commissioning was completed in June 2015
Superconducting Magnet PS (SCMPS)
by CEA (EF2-5 and TF)

Superconducting Magnet PS (SCMPS)
by ENEA (CS1-4, EF1&6, FPPCC)
- Acceptance tests → May 2018.

CS Switching Network Units (SNU), ENEA

DC current Feeder for PF coils (20 kA)
Torus Build.
Rectifier Build.

Manufacture and Installation of PS is well in progress.
- 36-hours continuous operation, thermal load test by baking and plasma operation was performed.
- Ownership transferred to QST in Dec. 2016.
- A ceremony was held on 12 Jan. 2017 in Naka.
Improvement of Assembly Accuracy by Metrology

To realize the high accuracy of on-site assembly.

Metrology for the positioning with high accuracy

- Laser tracker are used for high-accuracy positioning in torus hall.
- Many reference points (~80) are sets to recognize the position of laser tracker.
- Spatial resolution of measurement is less than 0.5 mm.

Design of special jigs for positioning and position control during assembly by metrology and CAD are key points.
Assembly of cryostat base

Parts of CB

Double Ring (three pieces)

Cylindrical shell (one piece)

Lower Structure (three pieces)

Tolerance of ~ 1 mm by machining parts after welding

Assembly by laser metrology and precise tuning of the position by shim

Position: -0.7 mm in X and 1.1 mm in Y, allowable tolerance
Flatness: ±0.6 mm, allowable tolerance

Mar. 2013
Assembly of 340-degree Vacuum Vessel was completed.

- VV Assembly was taken account of welding shrinkage (4mm/line, total 52mm/13 lines) in toroidal direction.

- Sector connection by direct welding and splice-plate welding.
- Edge face correction and splice plate for designed position adjustment.

High dimensional accuracy was achieved by careful welding work.

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inboard</td>
<td>(\leq \pm 10) mm</td>
</tr>
<tr>
<td>Outboard</td>
<td>(\leq \pm 10) mm</td>
</tr>
</tbody>
</table>
Assembly of Vacuum Vessel Thermal Shield

- Assembly of 340-degree VVTS was completed in Nov. 2016.

VVTS: Double wall structure of thin SS304 plates (3mm), which includes pipes of 80K helium gas.
Assembly of TF coils reached the final stage.

- TF coils are placed around VV through 20° opening by rotary crane.
- Set coils at proper position by “Adjustment jig” and “Guide ring”.
- Finalize the position by tuning with shim and jack at three different positions.

TF coils were assembled within the high accuracy of ±1mm < tolerance of 3mm. This also allows a high-accuracy assembly of EF coils and CS coils because their coils are supported on TF coils.
OIS + Splice plates are fixed by 22 bolts (M42) x 5 position/coil, total 1980 bolts, which are customized after dimensional measurement of shear panels respectively.

IIS are fixed by (15 bolts (M36, M38) + 2 key) x 2 position/coil after shim adjustment.
Assembly of Final Sector of VV/VVTS and 18th TFC

Procedure of final sector
1. VV and VVTS is set in place and connect with neighbors by jigs. In this step, TFC is shifted outward by 3 cm.
2. TFC assembly: Centering, IIS bolt tightening, measurement of OIS are carried out.
3. VVTS assembly: The final sector is connected with couplers. Radiation cover sheet is attached.
4. VV connection by welding: In parallel, shear panels are connected with splice plates.

Installation of the last 18th TFC with VV and VVTS was completed in Apr. 2018. The connection of VV final sector by welding will be started in May 2018.
Manufacturing/Assembly of Super Conducting Coils with high accuracy are to reduce the error magnetic field of JT-60SA to closer the allowable error field limit. The locked mode database on large super conducting Tokamak will be constructed and improved for ITER and DEMO. (ex. study the error field effect of Dummy TBM as a benchmark test.)

From the point view of welding shrinkage and deformation control, assembly technology for a set of 3 components (TFC, VV, VVTS) with high accuracy will contribute to ITER assembly and DEMO design.

To clarify the validation of the JT-60SA design and to quantify the operational window of each component, Plant Simulator of JT-60SA is also useful for ITER operation and DEMO design. (preparing many displacement sensors, strain gauges for components.)
Divertor cassettes are compatible with RH maintenance.

Divertor Cassettes: All 36 cassettes was completed in March 2013.

ITER-like shape => good test stand for ITER

'Replaceable Divertor Cassettes' is the Key ‘Flexibility’ of JT-60SA for future trials with new Divertor Structure / Material for DEMO.
41MW×100s high power heating with variety

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

NB: 34MW×100s
Positive-ion-source NB (85keV), 12units × 2MW=24MW,
CO:2u, CTR:2u, Perp:8u
Negative-ion-source NB,
500keV, 10MW, Off-axis

ECRF: 7MW×100s
110GHz+138GHz,
9 Gyrotrons,
4 Launchers
with movable mirror
>5kHz modulation
Progress of ECRF system

Launched test was successfully completed
Full length (~7 m) mock-up of the mirror steering structure was installed in a inclined vacuum chamber (35.5 deg.).

Rotation for
Toroidal steering &
Linear motion for
Poloidal steering

Following to the “cyclic test for rotation motion” (10,000 cycles) in 2016, “linear motion test” (100,000 cycles) was successfully completed in Feb. 2017.

Enhanced Performance of multi-freq. Gyrotron

1. ‘JT-60SA Target’ was confirmed in 2014:
   1MW x 100s at both 110 & 138GHz.
2. Oscillation at 82GHz (1MW x 1s) was confirmed in 2015 for plasma start-up assist & wall cleaning at fundamental EC resonance.
3. At higher power, 1.5MW x 5s, 1.8MW/1.2s, 1.9MW x 1s (110GHz), 1.3MW x 1.3s (138 GHz) were achieved.
   
RF supported by nonmagnetic, oil-free LM guides with MoS2 composite solid lubricant.
Adjustment of two CO₂ lasers for interferometer/polarimeter has finished successfully. Both branches for probe beam and reference beam are well aligned after propagating through 220 m transmission line.

Prototype of visible camera system has been manufactured. Moving, fixing and collecting of camera for ~3m to/from head of port-plug has been demonstrated successfully.

Proposal of construction of EDICAM for JT-60SA by EURO Fusion has been approved. Design of optical system is on-going at Wigner RCP in Hungary in collaboration with QST.
MHD stability control / Disruption mitigation

- Stabilizing Wall
- Fast Plasma Position Control coil
- Error Field Correction (EFC) coil = RMP coil (18 coils 30 & 45 kAT, ~9 G~4x10^-4 B_T)
- RWM Control coil: 18 coils + ECCD (NTM), rotation control
- MGI for disruption mitigation
- Pellet injection for ELM pacing
- Pellet injection for disruption mitigation
EFCC: Manufacture completed

EFCCs were manufactured by "Tesla Engineering Ltd." in UK and delivered to Naka in April 2017.

- Upper: 6 coils (30 kAT, 860 A, 35 turns)
- Middle: 6 coils (45 kAT, 1300 A, 35 turns)
- Lower: 6 coils (30 kAT, 860 A, 35 turns)
JT-60SA is a flexible ‘Test Stand’ for ITER

ITER like non-dimensional parameters, small-torque input, electron heating, etc.

H-mode operations (H, He, D) towards Q=10, @ Ip ~ 5.5 MA
  L-H transition, Pedestal Structure
  H-mode confinement (incl. compatibility with radiative divertor, RMP, etc.)
  Local Ripple & TBM Test
  Burning plasma control simulation using various heating systems

MHD stability at small ~ zero rotation

Improved H-mode (Hybrid) Operation with ITER-like shape @ Ip ~ 4 MA

ELM mitigation (RMP, pellet pacing, …) & small / no ELM regime at low $\nu^*$

Disruption avoidance & mitigation R&D at high current (tests of MGI, SPI etc.)

Divertor Heat Load reduction with ITER-like-shaped divertor & Steasy-State

Effects of Error Field / noise

Integrated Operation scenario optimization with superconducting PF coils.

High Energy particle physics at ITER-relevant conditions using 500 keV N-NB

Operation Experience of the large superconducting tokamak
JT-60SA Research Regime for DEMO

Goal of JT-60SA: ‘Simultaneous & steady-state sustainment of the key performances required for DEMO’ (= highly self regulating)

JT-60SA should decide the practically acceptable DEMO parameters, and develop & demonstrate a practical set of DEMO plasma controls. We treat ‘the DEMO regime’ as a spectrum.

JT-60SA regime for Steady-state DEMO - R&D

We treat 'the DEMO regime' as a spectrum.
JT-60SA demonstrates particle controls under saturated wall condition by utilizing variety of the fuelling and pumping systems. Divertor pumping with cryopumps allows pumping speed of $0 - 100 \text{m}^3/\text{s}$ by 8 steps.

Compatibility of the radiative divertor with impurity seeding and sufficiently high fuel purity in the core plasma should be demonstrated.

Starting with Carbon to keep a wide operation regime => then changing to Tungsten
# JT-60SA Research Phases (under update)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Initial Research Phase</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>phase I</td>
<td>2020–2021 (5M)</td>
<td>H</td>
<td>–</td>
<td>Upper Carbon</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1.5MWx5s 2Gyrotrons</td>
<td>1.5MW</td>
</tr>
<tr>
<td></td>
<td>2023 (2M)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>phase II</td>
<td>2023 (6M)</td>
<td>D</td>
<td>3.2E19</td>
<td>Lower Carbon Div. Pumping</td>
<td>3MW 4units</td>
<td>3MW 4units</td>
<td></td>
<td>6.5MW 4units</td>
<td>1.5MWx100s 2Gyrotrons + 1.5MWx5s 2Gyrotrons</td>
<td>19MW</td>
</tr>
<tr>
<td></td>
<td>2024–2025 (8M)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Integrated Research Phase</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>phase I</td>
<td>2026– 2028</td>
<td>D</td>
<td>4E20</td>
<td>Lower monoblock– Carbon Div. Pumping</td>
<td>13MW 8units</td>
<td>7MW 4units</td>
<td>10MW 2units</td>
<td>20MW x 100s 30MW x 60s duty = 1/30</td>
<td>37MW</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Extended Research Phase</strong></td>
<td>&gt;5y</td>
<td>D</td>
<td>1.5E21</td>
<td>SN/DN monoblock– Tungsten–Coated Carbon Advanced Structure</td>
<td>16MW 8units</td>
<td>8MW 4units</td>
<td></td>
<td></td>
<td>34MW x 100s</td>
<td>41MW</td>
</tr>
</tbody>
</table>

*Upper Divertor (open divertor, inertia cooling) is always ready*
JT-60SA Contributions to ITER and DEMO

Manufacture & Assembly Experiments => ITER, DEMO

<table>
<thead>
<tr>
<th>Year</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
<th>2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITER</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construction / Commissioning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H/He</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H/He</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D &amp; DT</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

JT-60SA: FP Experiment, Machine Enhancement, Carbon wall, Tungsten wall

Pre-Conceptual Design, Conceptual Design, Engineering Design, Construction

JT-60SA after Mar. 2020: ‘BA Phase II’ under discussion by EU&JA
Summary

• Towards the first plasma in Sep. 2020, the construction of JT-60SA is steadily progressing by the EU and JA Integrated Project Team.

• Manufacturing and assembly of the tokamak components with high accuracy have been developed through JT-60SA construction to realize accuracy of $\sim 10^{-4}$.

• JT-60SA is producing experience of manufacture and assembly of a large superconducting tokamak for ITER and DEMO.

• JT-60SA has variety of plasma control capabilities (heating system, in-vessel coils) in order to cover ITER/DEMO parameter region and optimize their operation scenarios.
JT-60SA Research Unit is also 1 Team

JT-60SA Research Plan Ver. 3.3 was documented in Mar. 2016 by 378 co-authors
JA 160 (16 institutes)
EU 213 (14 countries, 30 institutes)
Project Team 5

Utilizing the ITER- and DEMO-relevant plasma regimes, JT-60SA contributes to all the main issues of ITER and DEMO.

Research Plan Organizers:
Maiko Yoshida (QST)
Gerardo Giruzzi (EUROfusion)