CALL FOR PARTICIPATION IN THE JT-60SA EXPERIMENT TEAM: IC-OP1 analyses and activity towards operations 2, 3.

Preface

JT-60SA is a large fully superconducting tokamak device with high plasma current, high auxiliary power and long pulse operation capability built in the framework of the Broader Approach (BA) activities. The JT-60SA tokamak was fully assembled in March 2020 and it produced the first plasma in October 2023 as part of the Integrated Commissioning (IC) and Operation-1(OP1).

The main scientific goals of JT-60SA can be found in the JT-60SA research plan, https://www.jt60sa.org/pdfs/JT-60SA_Res_Plan.pdf, which was developed in the period 2010-2020. The scientific exploitation of JT-60SA is ensured by the Experiment Team, formed by three experiment leaders, which will coordinate the experimental programme, and six Topical Groups that are responsible to coordinate different scientific topics as shown in Figure 1. Recently, the Experiment Team Leaders and Topical Group Leaders have coordinated an effort to identify the main scientific topics to be developed in the initial experimental campaigns of JT-60SA, Operation-2 (OP2) and Operation-3 (OP3) with carbon PFC. As shown in figure 2, OP2 is expected to start after the Maintenance and Enhancement phase 1 (ME1).

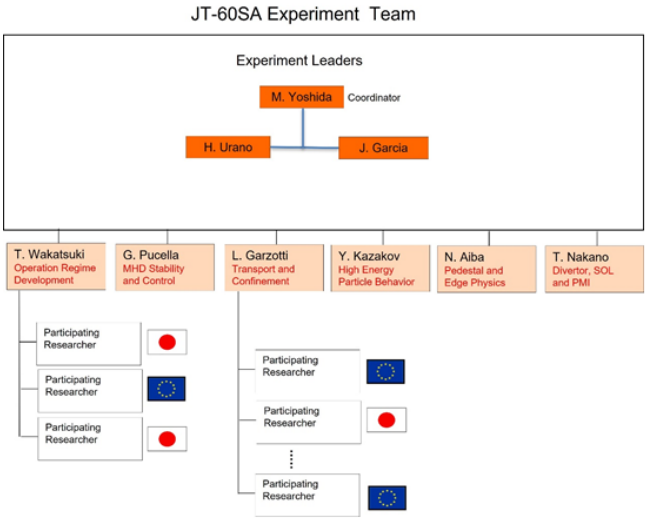

Figure 1. Strucutre of the JT-60SA experiment team. Three Experiment Leaders and six Topical Group Leaders manage the scientific exploitation of JT-60SA.

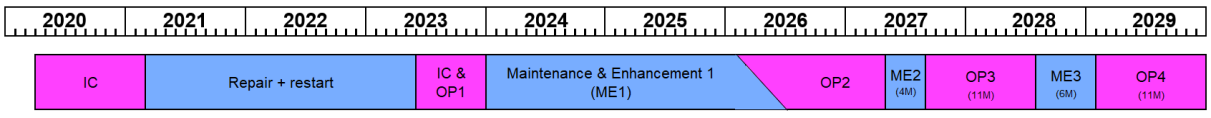

Figure 2. Timeline for JT-60SA

Eligibility of proponents and participants in projects

Towards a better assessment of the experimental programme to be developed in OP2 and OP3, the Experiment Leaders are inviting for the participation in the experiment team. This call is addressed to master students, Ph.D. students and researchers belonging to European and Japanese scientific institutions involved in EURATOM or the Japanese fusion research programme and agreed collaborators. Master students and Ph.D. students are considered for the participation in the experiment

team in the same terms than researchers as long as they participate together with their supervisors. The researchers in Japanese scientific institutions who collaborate in a framework with QST, e.g. “Tokamak Reactor Plasma Collaborative Research Programme” or Onsite laboratory of university can join. The researchers in European scientific institutions with a collaborative framework with EURATOM or with any other institution collaborating with EURATOM- such as EUROFusion- can apply. Proposals from other researchers to collaborate on specific tasks may be considered on an individual basis but such persons may not benefit from full membership of the Experiment Team. It is expected that the participants will work together to contribute to detailed analyses and modelling of IC-OP1 experimental data and/or to assess, by means of modelling or significant expert contributions, the main scientific topics proposed for OP2 and OP3. The JT-60SA Experiment Team membership should be renewed every Japanese fiscal year (starting 01 April) and their members reapply to each call for participation.

Proposal and selection

The analysis of IC-OP1 data is expected to focus on the experimental results obtained, which comprises the following topics:

- Wall status and conditioning with different techniques (ECWC, Baking, Glow discharge)
- Operation regime development (Breakdown, Plasma equilibrium and its control, current ramp-up, flat-top and ramp-down, ECRH characteristics)
- MHD, disruption and runaway electrons generation
- Plasma energy and particle confinement

In IC-OP1, a limited set of diagnostics were available (and limited data may be available from each diagnostic). Analyses and modelling of IC-OP1 plasmas should consider the experimental data availability. The list of available experimental data for IC-OP1 is shown in Annex 1.

The scientific topics proposed to be explored for OP2 and OP3, are described in Annex2. Modelling performed for OP2 and OP3 should consider the characteristics of subsystems in JT-60SA in this initial operational phase. A list of these subsystems and available tools is described in Annex 3.

In order to participate in this call, the proponents should describe their intended contribution by providing their scientific expertise, corresponding to one of the Topical Groups, and a short workplan or intended activity. The proponents should clearly indicate if they are intending to use experimental data from IC-OP1. In case modelling will be performed by the proponents for OP2 or OP3, a short description of the models and the input data to be used is necessary.

Scientific proposals outside the scope of IC-OP1, OP2 and OP3 (e.g. scientific analyses in the framework of future machine enhancements or operation, such as transition to W Plasma Facing Components) will be considered and potentially selected by the Experiment Team on an individual basis.

Proposals involving data integrated validation or generic data access (e.g. using IMAS for testing purposes) which require a validating process with experimental data will also be considered. Proponents should clearly indicate the experimental data required for such validation. In this case, their expertise should be labelled as “Data access and validation”.

Proposal should be sent by the research institutions from Europe and Japan to the JT-60SA experiment leaders from Europe and Japan respectively with the following format:

Last name	First name	Email	Affiliation	Topical group or "Integrated data validation and data access with IMAS"	Workplan or intended activity	Specify experimental or data access required if any

Proposals will be selected based on their alignment with the scientific topics described in this call and the quality of the participation proposed.

The status of activities and the team membership will be reviewed after one year and to this end a report will be requested to the TGL's.

Remark: Participation in the experimental campaigns will be defined in the future.

Presentation and publication of obtained results

Participation in topical group meetings and experiment team meetings is expected from the proponents. In such meetings, it is expected that the selected members of the experiment team will discuss their on-going work and potential contributions to journals and conferences. The JT-60SA pinboard must be used for JT-60SA related publications involving the experiment team as described in Annex 4.

Data Access

The accepted experiment team members will have to follow and sign the agreement on access to JT-60SA data and use of JT-60SA IT Facilities.

Contact

For any question related to this call, please contact the JT-60SA experiment leaders email list (JT60SA_Experiment_Leaders@qst.go.jp).

Annex1

List of available experimental data for OP1 plasmas analyses

CO_2 laser interferometer (tangential)
Visible TV cameras
Fast camera EDICAM
Divertor Langmuir probes and thermocouples
Soft X-ray detector intensity
Visible spectrometer (tangential)
Quadrupole Mass Spectrometer
Magnetic (flux loops, magnetic probes, Rogowski coils, diamagnetic loops, AT probes)

Annex2

The topics expected to be mostly studied in OP2 are the following ones.

Operation Regime Development

- Safe increase of toroidal current up to 5.5MA (here as high as we can safely) in L-mode
- Test of plasma control schemes: current, position, density, heating
- Break down and plasma formation studies in conditions of low loop voltage
- Initial integrated scenarios development towards ITER-relevant H-mode scenario. ($H_{98}(y,2)$~1, β_N~1.8), high beta ($H_{98}(y,2)$~1-1.2, β_N~3-3.5), and low collisionality

MHD Stability and Control

- Disruption studies at high current
- Runaway electrons generation and control studies
- Creation of disruption databases
- Error field measurement, characterization and impact on locked mode and NTM activity
- Study of anomalous vs neoclassical current diffusion.

Transport and Confinement

- Heat transport in electron heated dominated plasmas in L-mode
- Characterization of L-mode confinement
- Initial characterization of H-mode confinement

High Energy Particle Behavior

- Shine-through studies in H and D, especially with N-NBI
- Initial studies of fishbone and Alfvén modes destabilization by N-NBI
- Characterization of fast ions losses
- Neutron emission studies and reproducibility with codes

Pedestal and Edge Physics

- L-H power threshold characterization in H and D
- Pedestal and ELMs generation studies in different plasma conditions

Divertor, Scrape Off Layer and Plasma-Material Interaction

- SOL width scaling at high Ip
- Wall conditioning
- Characterization of heat flux to divertor in the ITER-relevant H-mode scenarios developed and neutral compression by the V-shaped corner.

The topics expected to be mostly studied in OP3 are the following ones.

Operation Regime Development

- Consolidate the access to ITER relevant H-mode and high beta scenarios towards integrated scenario demonstration
- Initial development of fully non-inductive steady-state scenarios with high values of the plasma pressure exceeding the no-wall ideal MHD stability limits in view of DEMO.

- Integration of advanced real time control techniques , e.g. q-profile and pressure profile in transient phase, beta or ELMs control, in scenario development

MHD Stability and Control

- Neoclassical tearing modes destabilization with ECH/ECCD and NBI
  Resistive wall mode studies
- Sawtooth activity and modification by ECH
- Tearing modes during ramp-up, flat-top and ramp-down phases
- Disruption study and avoidance at high stored energy,
- Expansion of disruption databases

Transport and Confinement

- Heat transport in electron heated dominated plasmas in H-mode
- Characterization of H-mode confinement in type-I ELMs plasmas
- Testing of core and pedestal W screening with TESPEL/partial W tile/Xenon gas

High Energy Particle Behavior

- Characterization of fast ions losses at high N-NBI power
- Interplay between fast ions and turbulence. Transport reduction by fast ions
- Compatibility of RMP with fast ion confinement
- Initial studies of alpha particle behavior in D-^{3}He plasmas

Pedestal and Edge Physics

- Characterization of the access to type-I ELMs
- Characterization of the access to plasmas with no/small ELMs with RMP or pacing pellets and comparison with type-I ELMs
- Characterize potential pedestal W screening.

Divertor, Scrape Off Layer and Plasma-Material Interaction

- He pumping
- Initial seeding studies and impact on the heat flux to divertor
- Characterize potential SOL W screening.
- Compatibility of neutral gas penetration at high pedestal operation

Annex3

Available subsystems in operations 2 and 3

- Carbon PFC
- Lower pumped divertor with intershot cooling
  Allowable heat flux onto the divertor plate <10MW/m^2 x ~5s, 15MW/m^2 x ~3s
- 18 RWM coils
- Massive gas injection
- TESPEL
- Neutral beams
    - In the Initial Research phase, the NBI system consists of eight positive-ion-based NBI (P-NBI) units and one negative-ion-based NBI (N-NBI) unit. The P-NBI consists of two co-current tangential beam units, two ctr-current tangential beam units and, four perpendicular beam units.

	P-NBI	**N-NBI**
Power per unit	1.6-1.7 MW	10 MW
Number of units	8	1
Operational period	14 s continuous at full power	14 s continuous at full power
Duty cycle	1/30	1/30
Perpendicular injection	4	
Co-tangential injection	2	1
Counter-tangential injection	2	
Ion source	2/unit, 85 keV, 28 A (D+ current)	2/unit, 500 keV, 22A (D- current)

- ECRH
    - In the Initial Research phase, two gyrotrons operating at 110 GHz for up to 5 s and other two multifrequency gyrotrons able to operate at 110 GHz/138 GHz for up to 100 sec will be installed.

Frequency	110 GHz	82/110/138 GHz
Max. Power into Plasma	~ 1.5 MW	~ 1.5 MW
Max. Pulse Duration	5 s	100 s (110/138 GHz) 1 s (82 GHz)
Number of gyrotrons and transmission lines	2	2
Number of Steerable Launchers	1	1

Port allocation	P08 (upper oblique)	P11 (upper oblique)
Max. Power at gyrotron window	1 MW	1 MW
Launcher outlet power	~ 0.73 MW/beam	~ 0.8 MW/beam
Modulator frequency	< 5 kHz (RF only)	≤ 5 kHz

- Diagnostics
  - Diagnostics systems shown below will be available in the operations 2 and 3. Those diagnostics will be used to evaluate plasma performance, to understand characteristics of plasma behaviours, and to conduct plasma control.
  - Specifications of each diagnostics are shown in https://www.jt60sa.org/wp/qst-additional-diagnostics/

    Diagnostics in Op-2 and Op-3: Visible TV camera, Infrared TV camera, EDICAM, Neutron monitor, Neutron profile monitor, Thomson scattering (T_e, n_e), ECE (T_e), CXRS (T_i, V_ϕ, V_θ, n_c), MSE (j_r), XICS (T_e, T_i, V_ϕ), Visible spectrometer (Z_{eff}), VUV spectrometers, Dα/Hα intensity, TESPEL, Bolometer, CO_2 interferometer/polarimeter, Soft X-ray, Divertor probes and thermocouples, Neutral pressure, Magnetic sensors, FIDA,

Additional equipment for Op3

- Pellet launching system

Available tools

- Analysis tools
  - A basic experimental data analysis software (eDAS) for the JT-60SA implemented in the Analysis Server, which provides the users with smooth and interactive data analysis environment for the wave form, equilibrium and spatial profile, including the functions of data retrieval from various DBs.
  - Data access libraries for various DBs are available particularly for users who step further into advanced analysis so that they could develop their own tools.
  - https://qstgojp.sharepoint.com/teams/JT-60SAResearchManagementSite/SitePages/Data-Analysis.aspx(JT-60SA Research Management Site account required)

Annex4

Terms of references of Experiment Team members

- Proposals
  - As mentioned, the proponents should describe their intended contribution by providing their scientific expertise, corresponding to one of the Topical Groups, and a short workplan or intended activity. In case modelling will be performed by the proponents, a description of the models and the input data to be used is necessary.
- Annual report

An annual report summarizing the activity of the members of the Experiment Team for each TG will be prepared by the TGLs

- Publication
    - All Publications & Presentations using JT-60SA experiment data need endorsement of the corresponding TGL and EL and the clearance of PL/PMs in accordance with CQMS-07070. The publications and contributions to scientific conferences must be uploaded to the JT-60SA pinboard.