WPSA-2024 objectives

FSD planning meeting

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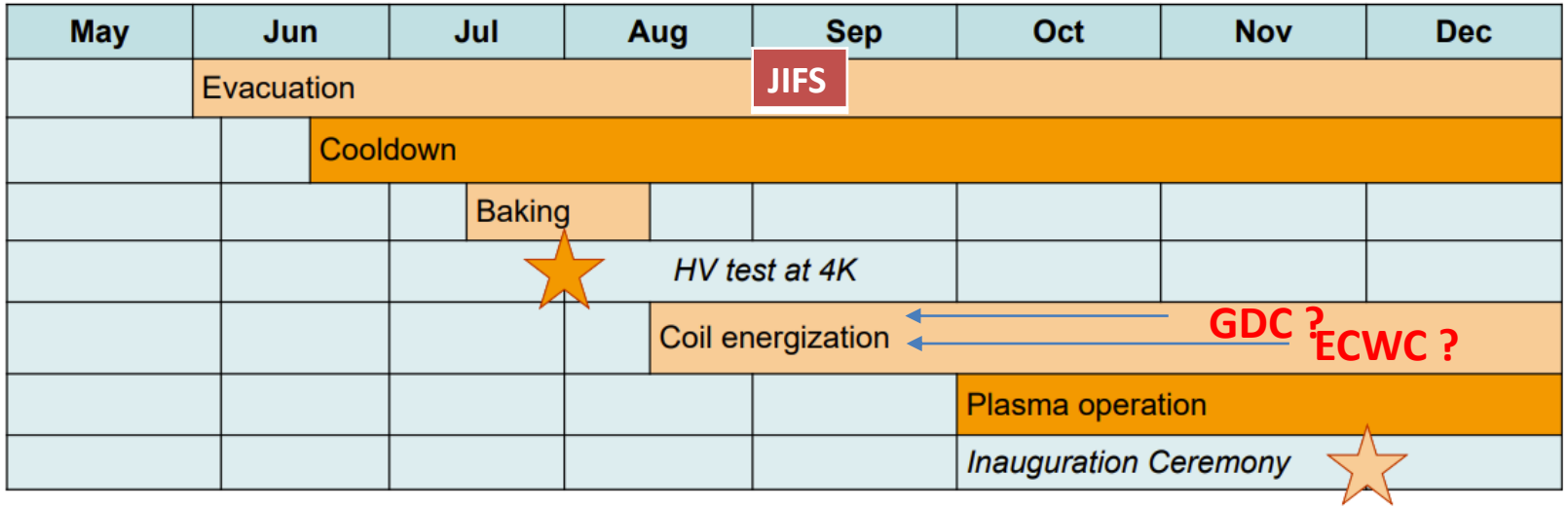
Present status of JT-60SA

- Extensive improvements were made after the EF1 coil incident, including in particular
  - Reinforcing the insulation of the magnet circuits within the cryostat
    - All terminal joints and mid joints
    - All current leads
    - All TF and EF QD wire extractions
    - All TF T-pipes and end caps
    - Specific weak points on CS tails, TF feeders and a TF tail
  - Implementing mid-point grounding to all PF coils, halving the voltage to ground experienced during operation
  - Installing filters to reduce the voltage ripple on the booster power supplies used on EF 1,2 5 & 6
  - Improving monitoring of the cryostat vacuum to prevent entering in Paschen conditions during operation

- TF coils have achieved High Voltage insulation performance under the Paschen condition up to 100 Pa.
- Full Paschen-proof condition not achieved

- Integrated commissioning restarted
  - Cryostat and vessel vacuum pumping from 30th May
  - Cooldown planned mid June

IC plan and objectives (in 2023)



- Initially, up to 3 kA and 2 kV across the PF coils at 2.25 T (full TF current), I_p~100 kA
- after that, perform DC tests on the PF at progressively higher voltage
- Objective: confirmation that the magnets and the rest of the plant operate as designed (i.e. at 20 kA) before the 2 year ME1 period

Further insulation reinforcements are foreseen during ME1

- Reinforce the pancake joints and helium inlets of the EF coils.
- Coat the outer surface of the central solenoid in situ with a layer of resin, aiming to seal any Paschen paths present. This would require the construction of a resin-proof enclosure around the CS within the narrow gap between the CS and the TF, which could then be filled with resin to coat the CS and then drained again.

Key events in 2023 that impact 2024 objectives

- HV holding test at 4K (end of July 2023) => the IC may be stopped or delayed

- Proof that the PF coil circuits can be safely operated at their maximum voltage and design current (20kA) (during IC) => IC may be suspended

- Qualification of the in situ coating technique of the central solenoid (performed in parallel with the IC) => in situ repair may be cancelled

Worst case: decision for CS extraction for more thorough reinforcement might be taken, depending on the output of the previous points (PF coil circuit performance)

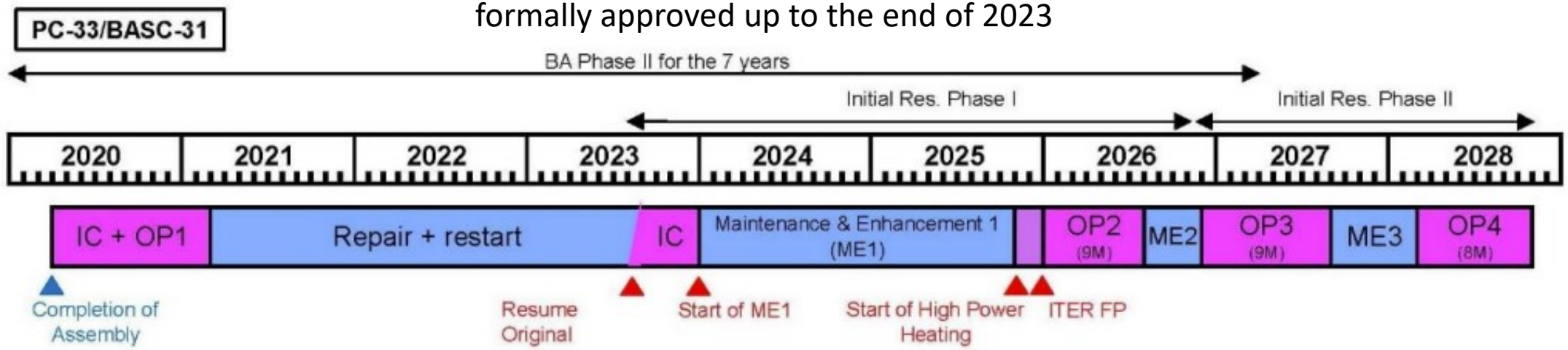
- CS removal would extend the duration of M/E1 by a further 2 years, pushing back Op2 to 2027
- (in situ repair would allow for start of OP2 in November 2025, provided that shift work can be performed in ME1)

- M/E1 is effectively the last realistic opportunity to remove the CS for repair, before the mounting of the upper stage with all of the plasma diagnostics and other equipments

2 scenarios:
- OP2 starting in November 2025 (reference in the following)
- OP2 starting in 2027 (unlike, but it may materialize at the end of 2023)

Mid term JT-60SA plan

Reference: https://users.jt60sa.org/?uid=2DGBXU Satellite Tokamak Project Plan – formally approved up to the end of 2023



Major milestones for the BA ST project

- Start of Maintenance & Enhancement-1: Jan 2024
- Start of High Power Heating Experiment: Nov 2025

Scientific objectives (much more details in JG's presentation)

- OP2 main objective:
  - Commissioning of the newly installed systems,
  - Stable operation at high current heated plasma, initially in H with transition to D
- OP3
  - develop ITER standard H mode
  - and exploration of High Beta scenario

Objectives for 2024: “FP8” enhancements

- A number of subsystems will be added in preparation of OP2
- Some of those are projects developed in EU (WPSA-F4E)

- Precise time plan of ME1 not yet available, but most of the systems are scheduled to be installed in ME1
- Delivery on site (several systems or part of them already there) in 2023 or early 2024
- Acceptance or post-delivery test when required
- Ready for the installation plan in 2024

EU-led Enhancements

- 2 MGI
- Divertor cryopumping system
- Pellet Launching System
- Thomson Scattering
- Divertor VUV
- (FILD originally in ME2, now being considered for ME1)

MGI in Naka

PLS system at risk:

as a consequence of the war in Ukraine, EU sanctions require the cancellation of the F4E contract with PELIN in Russia
Mitigation: interim solution providing small pacing pellets for several seconds in OP2 (scientific objective of ELM control)

QST site, Laser room II

Objectives for 2024: new enhancements

- For the scientific objectives of OP3 (ITER Risk Mitigation and Scenarios Development) a number of new diagnostics have been judged scientifically desirable (ET assessment) and set as priority I for the scientific objectives in in OP3 (2026-2027) and following.
- Some of those (not all) are systems proposed and developed (feasibility study) in WPSA

Desirable additional enhancements (not yet planned)	*Neutron emission profile monitor and neutron energy spectrometer* *Gamma-ray diagnostics* *Phase Contrast Imaging*	*Doppler Reflectometry System* *Fast CXRS* *Vertical ECE*

Reference: https://users.jt60sa.org/?uid=2DGBXU Satellite Tokamak Project Plan

- In a meeting held this week with JT-60SA Project Leader (Shirai) and Manager (Davis), ETL (Yoshida), WPSA PL (Sozzi), F4E(Phillips), QST (Ide) it has been decided that EU will proceed in developing the Implementation Plan for
  - Neutron Energy Spectrometer
  - Gamma-ray diagnostics
  - Phase Contrast Imaging
  - Doppler Reflectometry System
- QST will manage the plan for Fast CXRS and vertical ECE, will provide the support for integration in JT-60SA and contacts for the review of the design and implementation steps
  - NB: EC stray detection system (has lower scientific priority but is technically relevant for the mitigation of the risk of operation of ITER which is providing the prototype sensors), then an implementation plan will be proposed
- Elements of the implementation Plan (in 2023)
  - Rough cost,
  - time plan,
  - implementing team,
  - Existing or exploitable collaborations with Japanese teams where suitable
- F4E will provide support for the procurement (HW cost with a contract with the identified provider)
- EUF-WPSA will support HR cost

Objectives for 2024: start of new enhancements

TPCI
- Completion of detailed diagnostic design, including the optical, mechanical, electronic, and control components
- Detailed hardware listing and budgeting with actionable quotations
- Launching of all procurements (with the goal of receiving all components by the end of 2024)
- Search for a junior personnel to be integrated in the team

GAMMA
- Finalize definition of system location, size, list and specification of components. Begin purchase of components and, if available within the year, laboratory test of most critical items (project duration: 2024-2025)
- Evaluation of needs for neutronics shielding after specification of final system location and shielding already available at installation location.

DR
- Integration of Japanese/European parts of the proposal into coherent one.
- Develop a conceptual design which adapts to the final diagnostic position and solves a number of minor open issues left in the feasibility study.

NEUTRON SPECTROSCOPY
- Identification of the development team (in 2023)
- Review of the conceptual design coherent with the scientific scope, space constraints and port allocation.

EC stray
- Characterization of the prototype ADAPTED to JT-60SA case: provide and replace the coated bolometer with a specific one compatible with JT-60SA EC frequencies
- minimal system layout (including requirements for signal boards, I/O units, PCF, cubicles, ...)

WPSA Code Management and simulation Area - 2023 Objectives

1. Progress towards the release of validated simulation tools for JT-60SA scientific exploitation
2. Support to the JT-60SA Topical Groups leaders for IC analysis and modelling activities

Area Coord.: G Falchetto

- **Contribute to the successful exploitation of the scientific outcomes from the Integrated Commissioning**
  - **Improve the modelling tools as needed as a consequence of the application to JT-60SA IC**
    - Thermohydraulics calculations for the cryo-magnet system with improved modelling
    - ECWC code
    - Breakdown model
    - Disruption modelling codes
    - Disruption mitigation trigger
- **Optimize and release to EU users the simulation tools for operation and scientific exploitation**
  - **Equilibrium control**
  - **Discharge simulator**: performance optimization, identification of test cases, **training** to ET
  - **MHD stability workflow: training to ET**
  - **Energetic particle workflow – training to ET?**
  - **Integrated Data Analysis**
- **Complete the development of synthetic diagnostics (TPCI, FILD) in support to the EU procured/proposed diagnostics and NEW ENH**

Operation oriented tools
Cryo & magnets
ECWC tools
Disruption modelling tools
Discharge simulator
Breakdown simulator
Disruption mitigation trigger
Integrated data analysis tools
Synthetic diagnostics development
Synthetic diagnostics for PCI
FILD synthetic diagnostics

WPSA Code Management and simulation Area - 2024 Objectives

Area Coord.: G Falchetto

- **Simulation and Modelling area converging into Experiment Team / Topical Groups implementing the scientific directions from ET / eventual redirections to align to ITER new baseline plan**

CM area coordinator to coordinate specifically

1. **Cross-topics simulation tools development and validation**
2. **ensure consistent modelling across topical groups**

- **Extend modelling of revised initial research phase and nominal scenarios**
  - **Core-edge integration**
  - **RMP**
  - **Error fields**
  - **Non-linear MHD**
  - **Edge modelling with W wall**
  - **…**

Modelling of Initial Research Phase and nominal scenarios
Scenario development and analysis
MHD and control
Edge and divertor modeling
Fast Particles modelling
Runaway modelling

Objectives for 2024: operations and remote participation

- WPSA area coordinator for operation being identified with a call (2023)

- Preparing and support in execution of the commissioning of the EU-led Enhancements
- Favour the bidirectional exchange of operational experience towards/from the European machines
- In collaboration with the WPSA PL, F4E and the Integrated Project Team of JT-60SA, develop a plan for the Eurofusion contribution and participation to the machine operation, including the necessary steps of training and licensing

- Implement and test IMAS wrapper
- Consolidate and test tools for remote participation

Objectives for 2024: JIFS

- Evaluate output of the first edition (2023)
- Review the members of the organizing team (GG stepping down ?) (2023)

- Review the organization if and where necessary
- Identify the training programme for 2024 edition

Overall WP objectives

- Manage (in EU) Call for IC analysis in 2024 – relevant to ITER - topics to be confirmed depending on the results of the IC-2023
- Role in the call for proposal for experiments in JT-60SA to be clarified.
- Call for INTEREST in participation to the ET to be launched soon (2023 - waiting discussion with F4E/QST) – not necessarily implying assignment of dedicated resources in this phase
- Gradual evolution of the WPSA structure – integration and progressive shifting of the roles between WPSA and ET
  - CM area focusing in the development and validation of tools, while application for scientific analysis coordinated by the Topical Groups structure
  - A better framework for Eurofusion participation *might be* the assignment of a PA for
    - Support in scientific exploitation
    - Support in operation
    - Support in enhancement development
  - At present, even if rather significant elements of the JT-60SA programme come from the EuF “influence”, the official role of EuF is not clear at all
  - Also, need to equalize the opportunity for participation on site. At present, national rules heavily affect the possibilities of on site participation, and this will impact the participation to the experimental campaign in future.

Grant Deliverables

GA Deliverable No.	GA Deliverable Title	Due Date [mm/yyyy]
SA.D.01	Appointment of Experiment Leader from EU (after call issued end 2020)	Apr. 2021
SA.D.02	Report on the first phase of the Integrated Commissioning (before plasma operations). Results and return of experience, mainly for DTT	Dec. 2021
SA.D.03	Report on the initial organisation of the JT-60SA scientific exploitation	Dec. 2021
SA.D.04	Documented plan of EU enhancement programme for BA Phase II– 2025-2029	Dec. 2022
SA.D.05	Delivery and final tests of EU-REC completed	Jun. 2024
SA.D.06	Installation of the EU systems before the OP2 campaign.	Dec. 2024
SA.D.07	Report on participation to the OP.2 campaign. Results and return of experience	Dec 2025
SA.D.08	Final Report on the Integrated Commissioning (including plasma operations)	Dec. 2023
SA.D.10	Delivery of EU procurements (TBD) for the OP3 campaign completed.	Dec. 2025*

Milestones

GA Milestone No.	GA Milestone Title	Due Date [mm/yyyy]
SA.M.01	Participation in the Integrated Commissioning before plasma operations	June 2021
SA.M.02	Start of the EU-REC project	Apr. 2022
SA.M.03	Decision on plan and resources of EU enhancements for BA Phase II – 2025-2029	June 2023
SA.M.04	Call to start EU enhancement programme for 2025-2029	Sept.2023
SA.M.05	Start of the new EU enhancement projects (TBD)	Nov. 2023
SA.M.06	Participation to the development of scenario at high plasma current in H-mode**	Dec. 2025*

Back-up slides and details for discussion

Table 2: Operation phases and status of key components

Research phase	Focus of exploitation	Operation Campaign	Expected operation schedule	[1]	Annual neutron limit	RH	Divertor	Installed NB power	ECRF	Max. usable aux. power[2]
-	Integrated pre-plasma Commissioning	Op-1	2020-2021 (6M) 2023 (6M) First plasma 2023	H	- (N_2 in VV interspace[3])	R&D	Open upper inertially cooled carbon[4]	0	1.5 MW (2 Gyro.)	1.5MW
Initial research phase I	**Initial stable and reliable operation** • H operation for commissioning towards D operation. • Stable operation at high current heated plasma	Op-2	2025-2026 (9M)				Inertially cooled lower pumped carbon[5] (limits high power heating duration)	PNB 8 units, plus NNB Total 16MW (with H) 23.5 MW (with D)	3 MW (4 gyro)	19MW 26.5MW
Initial research phase II	**ITER and DEMO regime access** (high power and high Ip with short pulses) • Access to the ITER standard scenario • High beta access • ITER risk mitigation (ELM, disruption)	Op-3	2026-2027 (9M)	D	3.2e19 (N_2 in VV interspace)					
		Op-4	2028 (8M)					PNB 12 units, plus NNB Total 30 MW		33 MW
Integrated research phase I	**High beta long pulse** **Burning plasma relevant** • ITER standard and hybrid stationary (~2-3tR) • High beta steady-state (~2-3tR), DEMO contribution	TBD	TBD		4e20 (water in VV interspace)		Actively cooled lower pumped carbon[6]			37MW
Integrated research phase II	**High beta and metal wall compatibility** • Radiative divertor with impurity seeding • Impurity pumpout from core	TBD	TBD		1e21 (water in VV interspace)	Use	Actively cooled lower pumped tungsten		7MW (9 gyro.)	
Extended research phase		TBD	TBD		1.5e21 (boronated water in VV interspace)		Actively cooled tungsten advanced structure (Upper div. TBC)	34MW[7]		41MW