



# Exploitation of JT-60SA (WPSA)

## Project status and 2022 scientific goals

**Carlo Sozzi**

**G. Falchetto, J. Ayllon-Guerola, E. Belonohy (area coordinators)**

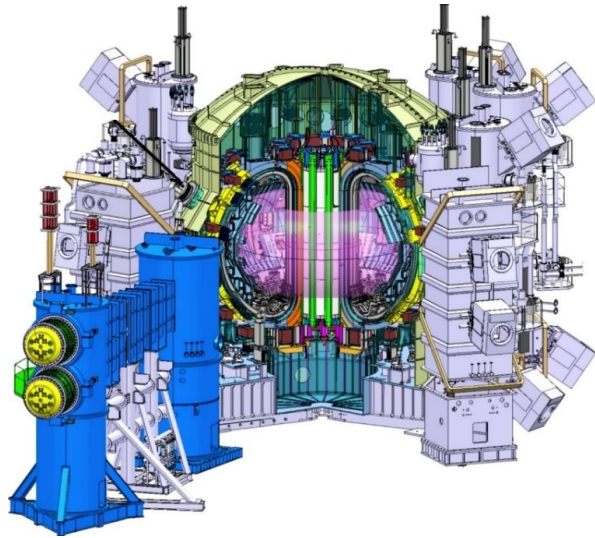
**A. Di Bastiano (PSO)**

**Thanks to E.Joffrin, G.Giruzzi, G. De Tommasi, J. Garcia**



This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 and 2019-2020 under grant agreement No 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission.

# WPSA: Exploitation of JT-60SA – project objectives



High current, large size,  
high triangularity shape  
=> **High confinement**

Long pulse=>**steady state**

High electron heating, High  
energy Negative NBI  
=>**energetic particles,  
ITER and DEMO relevant  
scenario, plasma  
controllability**

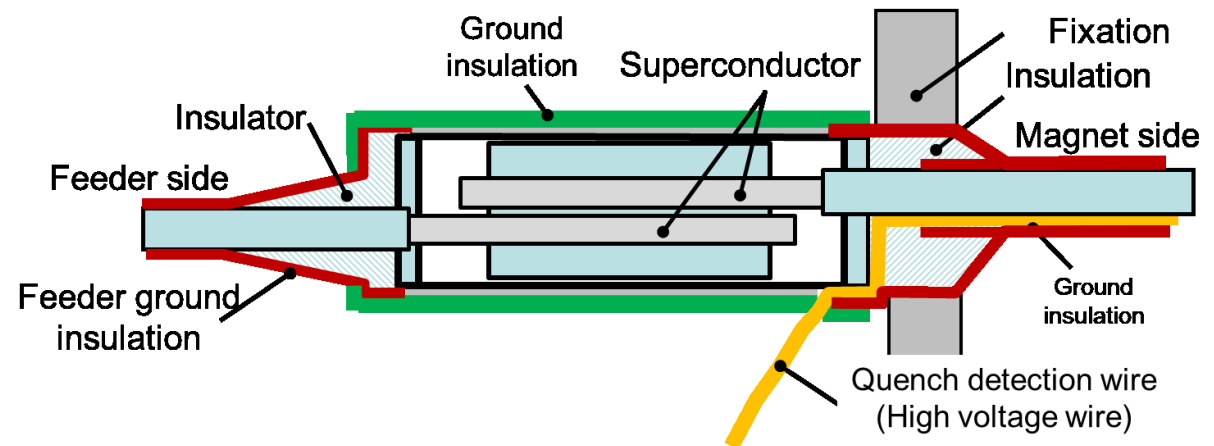
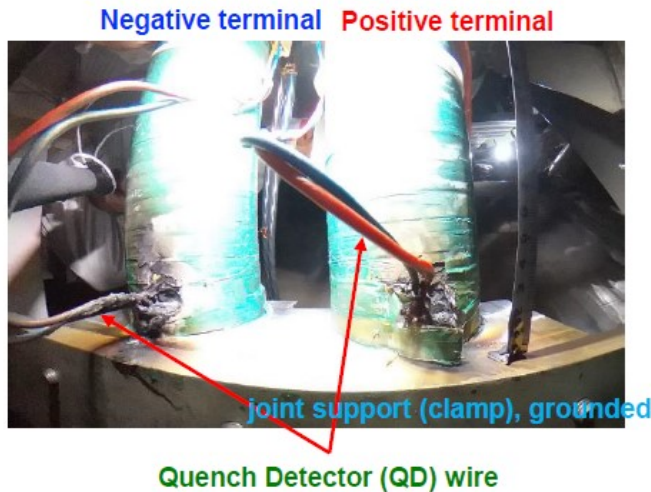
- support of the European exploitation of JT-60SA within the **Broader Approach**.
- The main objective is to support a **high-quality EU participation in the JT-60SA scientific exploitation, fully integrated in the EU fusion programme**.
- preparing to play an **active role in scientific exploitation and campaigns management**
- participation to the **machine integrated commissioning** and to **plasma operations**
- preparing a full and efficient **access to data and analysis** tools, on site and remotely;
- contributing to the **machine enhancements** plan with specific procurements
- **Maintaining/developing control room experience** in a large superconducting machine in view of EU participation in ITER operation
- Contribution to **specific items of the ITER Research Plan**
  - Start-up, Wall conditioning (w and w/o EC)
  - Disruption loads, mitigation, detection, triggering, avoidance...
  - H-mode, L-H transition, ELM control, plasma magnetic control, NBI shine-through
  - Topics in diagnostics R&D (high neutron flux resilience, very high plasma temperature, in-situ calibration...)

# JT-60SA status

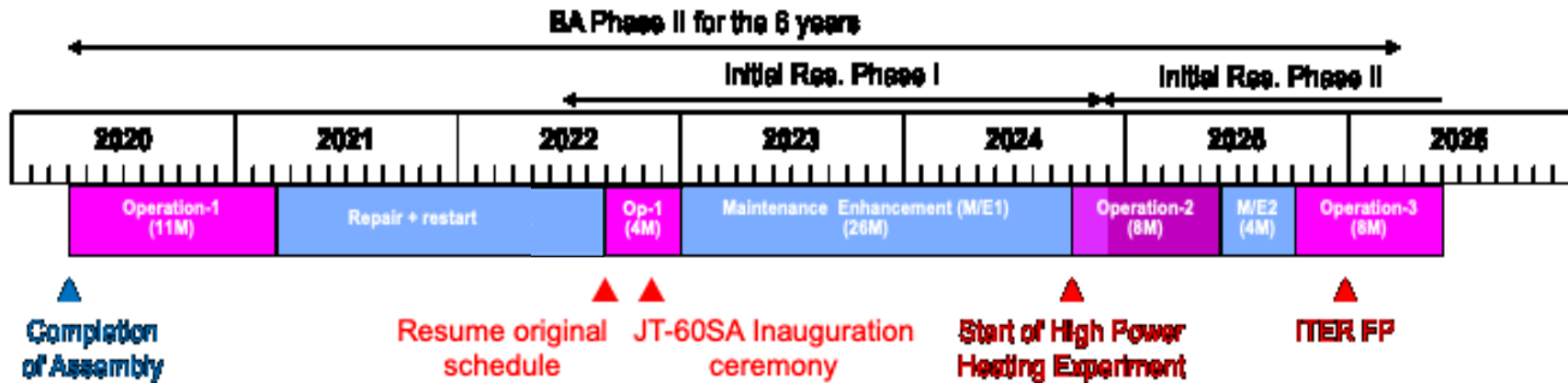


- **Incident**
- 02.03.2021 Toroidal field coils energized with a current of 25.7kA - full design magnetic field of 2.25 T
- 09.03.2021 Operations suspended during the Equilibrium Field Coil n.1 (EF1) energization test, while high voltage (5-7 kV) was applied. The coil current increased rapidly and then interrupted by the PS interlock.
- The cryostat pressure increased from  $10^{-3}$  Pa to 7kPa
- After warm-up of the coils and cryostat venting (30 days) the inspection was possible and melted spots with marks of discharge observed on the outer shell of the terminal joints of the EF1 coil
- **From inspection and analysis, the discharge was identified, root cause attributed to poor insulation at the exit of QD wires (inadequate tracking length, poor bonding to ground of EFTE wire insulation, insulation technique probably inadequate with signs of bubbles and partial debonding )**
- The pressure rise of cryostat was caused by the He leakage through the melted spots on the current feeders. No damage in the conductor and in the EF1 coil itself.

- **Repair and recovery (update Sept. 2021)**
- **Extended HV dry test (15-20 kV DC) and wet test (1 kV)**
- Insulation of all joints (terminals and mid) has to be remade
- QD wires under the SS wrap has to be replaced with individually shielded wires (old QD cut and grounded)
- All insulation procedure and test procedures to be tested on mock-ups allowing also the qualification of personnel
- All terminals and mid-joints will be Paschen tested
- The machine will undergo a global Paschen test prior to energisation (feasibility of Paschen Test at cold conditions being evaluated)
- **HV test in January 2022**
- **Restart of commissioning in February 2022 (vacuum pumping)**
- **restart of plasma operation by September 2022 till end 2022.**



# Overall schedule (tentative)



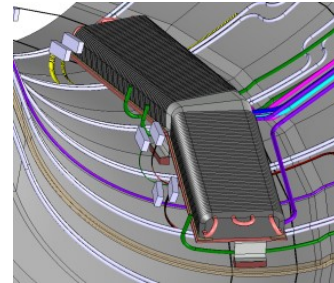
- After OP 1, shift 15 months wrt original plan
- Two months overlap of M/E1 and OP 2. Shorten M/E2 6→4 months.
- Integrated Project Team is examining the recovery of the delay by implementing the installation of enhanced components in parallel with repairs and improvement of voltage holding capability in the cryostat.
- For this reason, the planning of the activities outside the vessel, including the EU-led enhancement items is not delayed

# WP activities from FP8=>ending in 2022

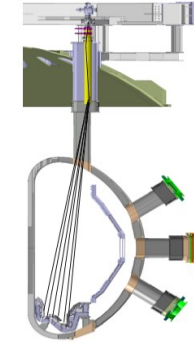
- Enhancements in implementation phase (with F4E):

- Divertor cryo-pumping system
- Pellet injector
- MGI (massive gas injection)- (HW)
- Edge Thomson Scattering (TS) – (HW)
- VUV spectrometry ) – (HW)
- FILD (fast ion loss detection) – (HW)
- EDICAM

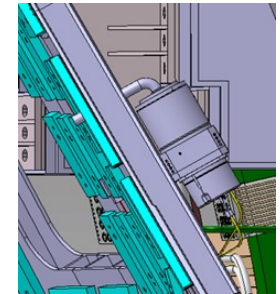
**Divertor Cryopumps**



**VUV Divertor Spectrometer**



**MGI**



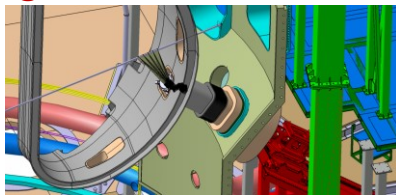
- Participation to the Integrated Commissioning with 7 operational topics

- Cryo & magnets,
- Scenario development,
- Wall conditioning,
- EDICAM,
- Magnetics & Disruptions,
- Equilibrium Control
- Breakdown

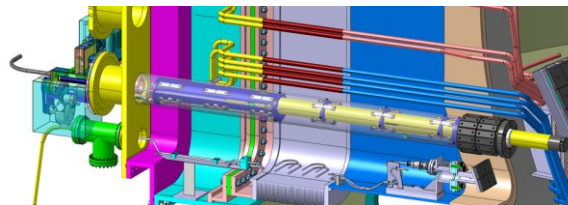


**Pellet Launching System**

**Edge Thomson Scattering**



**FILD**



**EDICAM wide-angle camera (in commissioning in Naka)**



# FP8 Enhancements status



## Pellet Launching System

- Fuelling and pacing pellet source a few months delay (not critical, expected to arrive at IPP by October)
- Centrifuge: it was approved to go for a worldwide CFT . In view of this, the specifications is being updated.
- IPP and F4E working on the preparation of the test bed (ready for extruders testing and commissioning).

## Divertor Cryopumps

- PA signed and ongoing
- 3D/2D largely ready design ready
- Manufacturing trials ongoing with issues on welding, material availability (due to COVID) and charcoal coating (may impact on delivery time, currently being addressed).

## MGI

- PA signed and ongoing
- Schedule not critical but now waiting formal approval of design and safety aspects from Ibaraki Prefecture

## FILD

- PA to be finalised and signed
- DRMs with QST produced several detailed questions being addressed

## VUV spectrometer

- PA to be finalised and signed.
- Spectrometer gratings issue (Zeiss emmitted quotation with very long delivery time – other provider being tried, conversations ongoing).
- Extra costs appeared on front mirrors after the firm steered to ZERODUR as bulk material after tests on other materials (partly reduced by increasing delivery time by 2/3 months, which is ok).
- DRM by beginning October: Configuration model available and analyses (thermal /electro mechanical under finalisation)

## Thomson scattering system

- PA signed and ongoing
- Mechanics: Still partially pending (port plug and trolley contracts issued) .
- Polychromators: progress in the procurement of the components (first acceptance tests by end October 2021).
- Optics: progress in the procurement of the components.
- Fibers : DEL4 arrived in Japan . Last shipment will be the 100 km extra length that should provide margins for the bundling process (ready for shipment, documentation verification in progress)

NO particularly critical points impacting the machine schedule

Possibly critical points related to administration/project management FP8-funded projects must end by 2022

Actions being taken to avoid issues related with this

# Integrated commissioning (IC) in FP8



Coordinator: EU Coordination Team (E. Joffrin, G. de Tommasi, E. Belonohy)

wiki: [EU IC team wiki](#)

IC topic	2021 activity
<b>Cryo and Magnets</b>	1 EU expert in Naka. Direct participation to the coil energization test analysis of the cooldown, AC losses, magnet data, polarities, etc.
<b>ECWC and wall conditioning</b>	Strong collaboration on wall conditioning strategy, ECWC preparation (with modelling), EC plasmas and commissioning of the GDC system (sharing EU operational experience, daily QST-EU meetings and direct input during GDC commissioning)
<b>Scenario Development</b>	1 EU expert in Naka. Sharing of European operational experience in preparation of first plasma operation.
<b>EDICAM</b>	EDICAM system installed and commissioned. Ready for first plasma. Camera had minor fault during EC plasmas and yet to generate data. Camera tomography tool optimised, calibrated for JT-60SA and ready for EDICAM data and first plasma.
<b>MHD &amp; disruption</b>	Magnetic calibration (model) and disruption database
<b>Breakdown and ECH</b>	Exchanges on breakdown scenario and production of breakdown simulation in various conditions
<b>Equilibrium control</b>	Exchanges on first plasma plan and use of MECS initiated

- JT-60SA Visitors' handbook developed, visa application management with F4E
- First group of EU experts obtained access to IC data. Remote data access discussion ongoing.
- Scientific organization: founding document (CQMS), pinboard conceptual requirements developed

# Activity (FP9) organized in 3+1 areas ~ 40 tasks



Project Leader  
Carlo Sozzi

Experiment Team  
Leader from EU  
Jeronimo Garcia

JIFS  
Gerardo Giruzzi

Enhancements  
Juan Ayllon-Guerola

Code Management  
Gloria Falchetto

Operations  
Eva Belonohy

Organization of  
the JT-60SA  
International  
Fusion School

Coordination of  
Enhancements project

Coordination of code  
management

Coordination of  
the operations  
area

Experiment Team  
leader activities

Phase Contrast Imaging  
system design and  
procurement

MHD stability analysis  
of initial research  
phase scenarios

Review  
commissioning  
and operational  
processes of  
EDICAM.

Doppler Reflectometry  
system design and  
procurement

Non-linear MHD  
modelling

Preparation for  
participation in  
machine and  
plasma operations

Neutron and Gamma  
diagnostics design and  
procurement

Ramp-up modelling of  
initial phase scenario

Plasma magnetic  
control. Interface  
CREATE-EGENE  
with JT-60SA  
Experiment  
Database

EC Stray Detection system  
design and procuremen

Turbulence modelling  
of high-beta scenario

Plasma magnetic  
control. Learning  
of QST tools.

Beam Spectroscopy system  
(BES) design and  
procurement

Edge transport codes  
modelling of C  
scenarios

Installation and  
update of the  
camera  
tomography code.

Ultra-Fast Reflectometry  
Upgrade  
IR imaging system design  
and procurement

Edge transport codes  
benchmark  
High-energy ions  
stability study

Remote access architecture  
design and procurement

G. De  
Tommasi

Disruption modelling  
RE modelling  
ECWC tools validation

Optimization and  
simulation of  
breakdown scenarios  
Integrated data  
analysis tools

Disruption  
mitigation/avoidance  
trigger  
Camera tomography  
EDICAM visualization  
tools

Discharge simulator  
development

E.  
Joffrin

SA.EN aims to promote scoping and feasibility studies up to the level of conceptual design for new enhancement projects.

SA.CM aims to provide validated selected simulation tools for application to JT-60SA in support to the preparation of the experimental campaigns, the data analysis and interpretation of the experiments.

SA.OP supports the (integrated) commissioning activities and execution of the experimental campaigns providing expertise in plant and plasma operations, vacuum conditioning, real-time control, diagnostics, heating and fuelling systems.

SA.JIFS. aims to develop links between Japanese and EU students and young researchers, completing their training by lectures and practical examples and applications.



# Work package milestones 2021



Sequential M ID	Related WBS ID	Title	Due Date (mm/yyyy)	Related GA D/M no.
SA.SE.CM.M1	SA-SE.CM.OP.01-T001	First simulation of a JT-60SA discharge with the coupled METIS-CREATE codes with controllers.	12/2021	
SA.SE.CM.M2	SA-SE.CM.SD.01-T001	Implementation of visible imaging analysis tool (camera tomography)	12/2021	
SA.EN.M1	SA-EN.AC.01-T001	Complete the detailed design and secure the procurement to meet the deadline for delivery of the BA phase 2 Enhancements projects	12/2021	SA.D.06
SA.EN1	SA-EN.REC.01-T001	Start of the EU-REC activity (*)	06/2021	SA.D.05/SA.M.02



❖ Activity in synergy with F4E, QST. (ENEA,CEA, IPP as EUROfusion contributors)

# ENH – Enhancement Projects



ENH Area Coordinator: J. Ayllon-Guerola

Wiki: [https://wiki.euro-fusion.org/wiki/WPSA: Enhancements](https://wiki.euro-fusion.org/wiki/WPSA:Enhancements) (in work)

- KOMs launched: - Tasks and deliverables defined – Direct QST contacts to be established
- Synergies with other areas (Modelling, Operations) being identified

SA-EN	2021 TASKS	STATUS
FE.01 PCI system	Phase Contrast Imaging system design and procurement (EPFL)	Ongoing Proposal being prepared for consideration by experimental/scientific teams and QST/F4E
FE.02 DR system	Doppler Reflectometry system design and procurement (CIEMAT)	Ongoing Proposal being prepared for consideration by experimental/scientific teams and QST/F4E
FE.03 N&G diagnostics	Neutron and Gamma diagnostics design and procurement (ENEA, ENEA-UNIMB, VR, IPPLM, UKEA)	Ongoing Pending QST contact Feasibility study launched
FE.04 EC Stray detection system	EC Stray Detection system design and procurement (ENEA)	Ongoing IO contact established Feasibility study launched
FE.05 BES system	Beam Spectroscopy system (BES) design and procurement (EK)	Ongoing Proposal upgrade
FE.06 UF Reflectometry upgrade	Ultra-Fast Reflectometry Upgrade (CEA)	Ongoing Pending QST contact Feasibility study launched
FE.07 IR Imaging system	IR imaging system design and procurement (CEA)	Ongoing Pending QST contact Feasibility study launched



## Remote data and computer access (G. De Tommasi)

- Regular QST-F4E meetings with EUROfusion representative to discuss the remote data and computer access needs for the integrated commissioning and future campaigns focusing on:
  - Data access from Europe (raw and processed data)
  - Outside the pulse data (GDC, ECWC)

## Project Management

- Call for pre-selection of the EU candidates **Topical Group Leaders**
  - **Scenarios, Transport, Energetic particles, MHD, PWI and SOL, Pedestal**
  - Draft profile and duties sketched (ETLs)
  - Required commitment, Objectives (especially in the initial phase) being drafted
  - Aiming to issue a call in October and to complete the selection in 2021.

# CM - Plasma operation oriented tools and synthetic diagnostics development



CM Area Coordinator: G. Falchetto    Wiki : [https://wiki.euro-fusion.org/wiki/WPSA:\\_Code\\_Management\\_and\\_Simulation](https://wiki.euro-fusion.org/wiki/WPSA:_Code_Management_and_Simulation)

- Operation related tools developments / validation covering also 2022.
- New activities presented to F4E
- Direct QST contacts for each task to be established

SA-SE.CM	2021 TASKS	STATUS
OP.01 Discharge simulator	Deployment of the discharge simulator coupling METIS-CREATE codes with controllers for simulating a JT-60SA discharge (CEA (IRFM/Univ Nice), ENEA CREATE)	Ongoing <b>Gateway repository created – maintenance ?</b>
OP.02 ECWC tools	Validate ECWC simulation tools on the <b>first data from IC</b> (ERM-KMS)	<b>Postponed to 2022 manpower to be replaced</b>
OP.03 Breakdown simulators	Optimization and simulation of breakdown scenarios for JT-60SA with strongly coupled simulation using BKDO+GRAY for kinetics + EC power absorption and CREATE-BD for magnetics (ENEA (CREATE, ISTP Milano))	Ongoing
OP.04 Integrated Data Analysis	Adaptation of the Integrated Data Analysis and Validation (IDAV) tool to JT-60SA diagnostics, for physics exploitation. (MPG-IPP Garching)	Task Kicked off– pending QST contact
OP.05 Disruption mitigation /avoidance trigger	Proposal for building disruption mitigation/avoidance trigger starting from scratch (CIEMAT, ENEA Tor Vergata, IAP, NCSR(NTUA))	<b>Kick off meeting on 15/09</b>
SD.01 Visible imaging analysis tools	Release of the EDICAM Data Visualization Software (EDVIS, FLAP) adapted to JT-60SA (EK)	Ongoing
	Release of the validated camera tomography tool for JT-60SA, calibrated to EDICAM (IPP.CR)	Done

Synergy with IC and OP

# CM - Modelling for JT-60SA Initial Research Phase



CM Area Coordinator: G. Falchetto Wiki : <https://wiki.euro-fusion.org/wiki/WPSA: Code Management and Simulation>

- Coordinated effort on modelling of JT-60SA initial phase scenarios – most tasks foresee two years work

SA.CM.M	2021 TASKS	STATUS
Scenario development and analysis	T1. Ramp-up modelling of initial phase scenario with operationally oriented integrated transport codes (CCFE, CEA, IPPLM, VR)	Ongoing
	T2. Non-linear gyrokinetic modelling of a representative high-b JT-60SA plasma scenario, in support to the proposed <b>PCI diagnostics</b> . (EPFL)	Ongoing
Edge and divertor modeling of the initial phase and nominal C scenarios	T1. Investigate conditions for divertor detachment with edge/SOL transport modelling codes including impurity seeding impact (CEA, IPPLM, MPG IPP-Garching)	Task kicked off
	T2. Benchmark of EU/JA edge transport codes on C scenario (ENEA UnivTuscia)	Ongoing
Fast Particles modelling	Investigate the stability of high-energy ions for the initial phase scenarios (MPG IPP-Garching, IST)	Ongoing <b>NBI modelling support needed</b>
MHD stability analysis of initial research phase scenarios	T1. MHD stability analysis of scenario 4 and 5, including pressure driven mode stability and kinetic modelling of RWM. (ENEA RFX, IST)	Ongoing
Non-linear MHD modelling	T2. Non-linear MHD modelling of pellet triggered ELMs with JOEUK for a realistic scenario (CIEMAT)	Ongoing
Disruption and runaway modelling	Validation of disruption modelling tools (CarMa0NL-CARIDDI) <b>on first JT-60SA mechanical data</b> . (ENEA CREATE).	<b>Deliverable to be modified</b>
	Modelling of the interaction of RE with PFC (IPP.CR)	Task kicked off

Synergy with ENH



OP Area Coordinator: E. Belonohy    Wiki: [https://wiki.euro-fusion.org/wiki/WPSA:\\_Plasma\\_and\\_Subsystem\\_Operations](https://wiki.euro-fusion.org/wiki/WPSA:_Plasma_and_Subsystem_Operations)

SA-OP	2021 TASKS	STATUS
<b>PO.01</b> Plasma Operations	Preparation for participation in machine and plasma operations.	Task on track to be completed in 2021. EU(-QST) introduction workshop planned in November 2021.
<b>RT.01</b> CREATE Tools	1. Interface CREATE-EGENE with JT-60SA Experiment Database (using the Web API). 2. Training with QST tools for design (MECS)	Task on track to be completed in 2021. MECS training agreed for 1 EU expert during Naka-site visit in November 2021. This EU expert to train other EU experts in December 2021.
<b>DO.01</b> EDICAM	Review commissioning and operational processes, experience and their impact in view of 2023-25 campaigns including discussion on how to deal with the weekly vacuum window testing.	Task on track to be completed in 2021. Ongoing work with close relation to IC. The need for vacuum window testing resolved.
<b>DO.02</b> Camera Tomography	Installation of the camera tomography tool to support ECWC modelling and breakdown studies on the Naka-server and test with test data.	Task completed. Camera tomography calibrated and installed on the Naka-server. Ready to be used in IC 2022.

## FP9 Operations activities in 2021 have strong connection to IC 2021 activities

- Funding: FP9
- Coordinated by: E. Belonohy
- Funding: FP8/FP9
- Coordinated by: EU Coordination Team (E. Joffrin, G. de Tommasi, E. Belonohy)



Coordinator: G. Giruzzi

JIFS working group with EUROfusion and F4E representatives, QST experts and Japanese professors to establish the foundations of a JT-60SA fusion school.

- 1st plenary meeting of the JIFS Advisory Board (JAB) with Japanese and European professors, QST, F4E and EUROfusion representative was held on 9/7/2021. Detailed proposal of the 1st edition programme presented.
- Strong support by the European Commission and the Japanese Foreign Ministry (MEXT). Request to extend JIFS initiative to a comprehensive support network for student and early-career researchers and engineers.
- First JIFS school is planned in Autumn 2022.



## Code Management & Modelling

- Fast particle modelling task in link to TSVV10 + ENR
- Edge/divertor modelling in link with TSVV3-6
- PCI synthetic diagnostics in gyrokinetic codes – TSVV1
- TSVV13 Turbulence simulations



**TSVV-01:** *Physics of the L-H Transition and Pedestals*

**TSVV-02:** *Physics Properties of Strongly Shaped Configurations*



**TSVV-03:** *European boundary plasma modelling towards reactor relevant simulations*



**TSVV-04:** *Plasma Particle/Heat Exhaust: Gyrokinetic/Kinetic Edge Codes*



**TSVV-05:** *Neutral Gas Dynamics in the Edge*



**TSVV-06:** *Impurity Sources, Transport, and Screening*

**TSVV-07:** *Plasma-Wall Interaction in DEMO*

**TSVV-08:** *Integrated Modelling of MHD Transients*

**TSVV-09:** *Dynamics of Runaway Electrons in Tokamak Disruptions*



**TSVV-10:** *Physics of Burning Plasmas*

**TSVV-11:** *Validated Frameworks for the Reliable Prediction of Plasma Performance and Operational Limits in Tokamaks*

**TSVV-12:** *Stellarator Optimization*



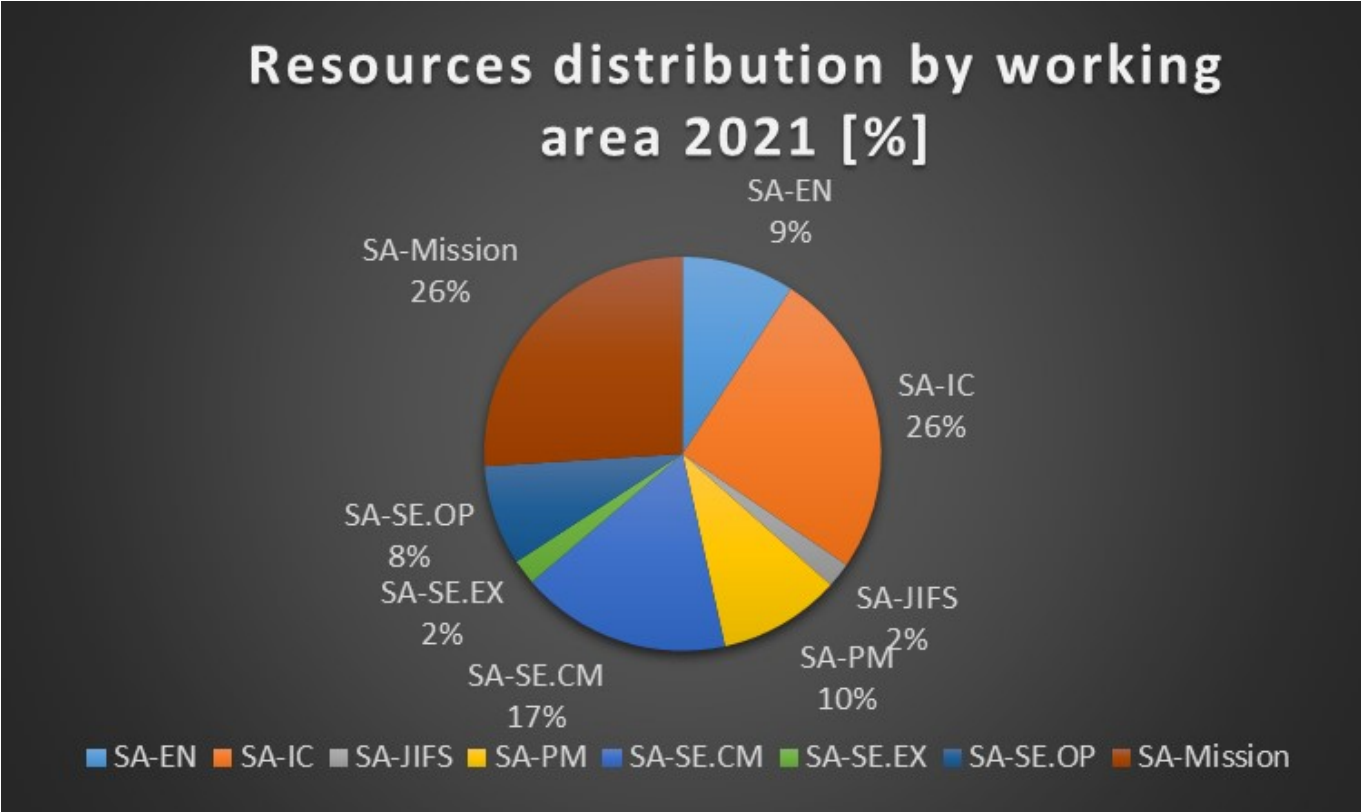
**TSVV-13:** *Stellarator Turbulence Simulation*

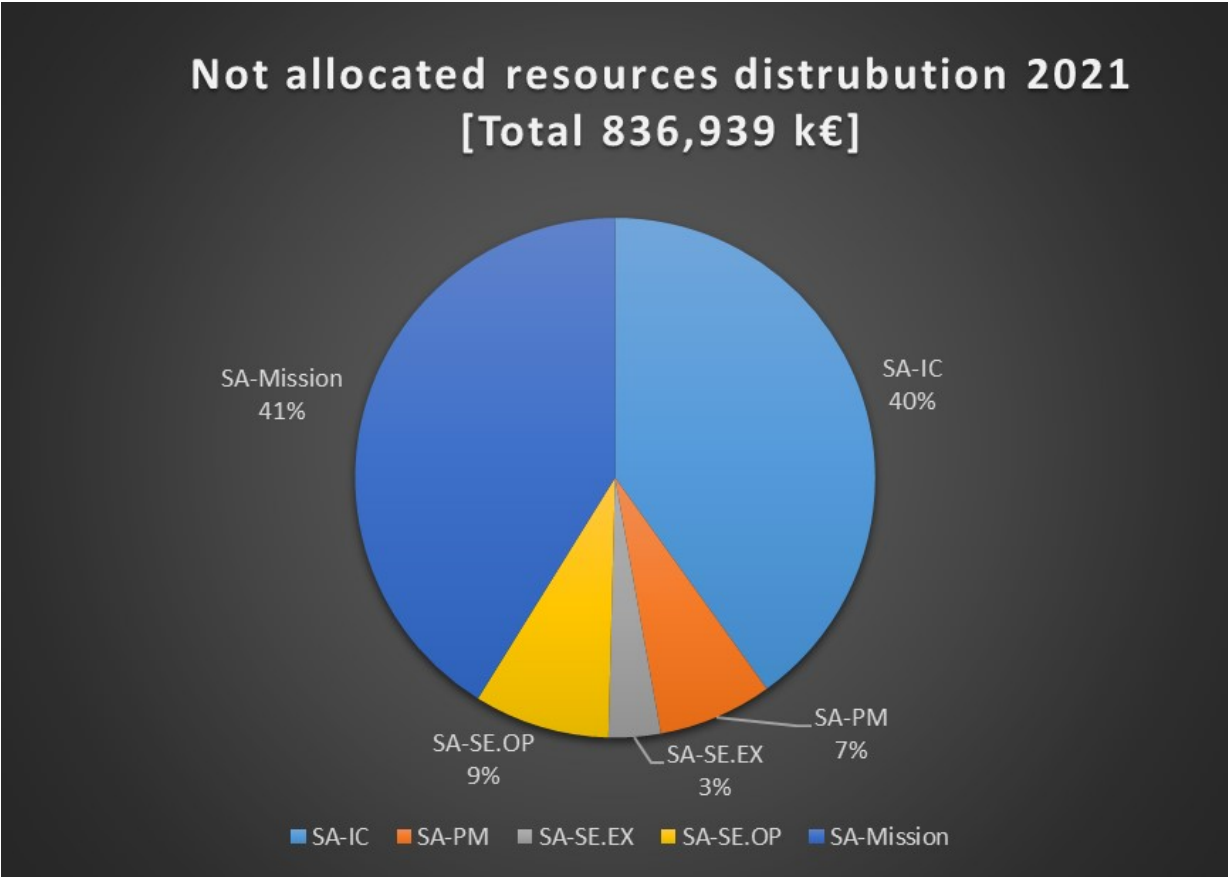
**TSVV-14:** *Multi-Fidelity Systems Code for DEMO*





**2021 Total Cons. Contr. k€ 1323,941786**







- Issues & impact
  - Incident => lack of data from IC => tasks to be postponed
  - RU unable to participate in 2021 => lack of expertise in NBI modelling / ASCOT
  - Manpower loss = > lack of expertise in ECWC
  - Strong limitation in travelling (Covid 19)
- Risks
  - Delay in procurements
  - Further delay in machine recovery



## Code management:

- breakdown simulator activity in synergy with **WPPrIO** (Preparation for ITER Operations) and **WPTE** (Tokamak Exploitation) – coordination meetings occurred
- "Edge/divertor modelling" & "interaction of RE with PFC" synergetic to **WPDIV**: prepare operation scenarios compatible with C Divertor, ACD-C Divertor and in future with W divertor: coordinating meetings occurred

## Operations:

- **WPPrIO** (Preparation for ITER Operations) work package
  - The EUROfusion Operations Networks subnetworks (seminars, workshops, trainings) will be offered to QST staff to join -> NBI seminar series in 2021



- Direct collaborations (EUROfusion members – INTL partner)
  - ITER for IMAS workflow developments within modelling tasks
  - ITER for EC stray sensors development and test
  - NIFS (National Institute for Fusion Science) for TPCI diagnostics
  - Kyoto University for IDAV
  - NIFS for Doppler Reflectometry
- Collaboration through the JT-60SA project as partner together with F4E, QST
  - ITER-F4E-QST trilateral agreement: Meetings on three topics with EUROfusion representative (IC, Assembly, Scientific Exploitation)
  - US for diagnostics (XICS, FIDA)
  - Broader Approach (IFERC, REC)

# Status of the 2021 GA milestones/deliverables



GA Milestone no.	Title	Due Date (mm/yyyy)
SA.M.01	Participation in the Integrated Commissioning before plasma operations	June 2021 ✓

- Active and extended participation until coil incident (March 2021)
- Participation focused to the recovery activities and to the preparation of next year phase in the following period
- Report at the end of the 2021

GA Deliverable no.	Title	Due Date (mm/yyyy)
SA.D.01	Appointment of Experiment Leader from EU (after call issued end 2020)	Apr. 2021 ✓
SA.D.03	Report and plan on organisation of the JT-60SA scientific exploitation	Dec. 2021

- SA.D.03 to be prepared with the main contribution of the ETL from EU.



# **PART II**

## **– 2022 programme goals & strategy**

**Carlo Sozzi**  
**G. Falchetto, J. Ayllon-**  
**Guerola, E. Belonohy (area coordinators)**  
**A. Di Bastiano (PSO)**

**Thanks to E.Joffrin, G.Giruzzi, G. De Tommasi, J. Garcia**



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1. Development and investigation of **high-performance scenarios compatible with future W-PFCs**.

*The hybrid scenario, proposed by Europe since 2011 as Scenario 4-2, is the most promising scenario of this type. It requires optimisation of H&CD schemes, density profiles, pedestal and ELMs, MHD properties, divertor protection and long-pulse control schemes. Particular focus on mitigation/elimination of ELMs*

2. Avoidance and mitigation of **disruptions and runaways**

*Essential for the preparation of the W-PFC phase and for the JT-60SA key mission of ITER risk mitigation*

3. **Fast ion physics**

*Core item of the JT-60SA (as well as of ITER) programme, owing to the distinctive features of the fast ion distribution driven by the NBI system. Development and experimental validation of models combining stability and transport with fast ions*

4. Development and validation of **high-level real-time control** strategies

*Key research subject for ITER and DEMO, combining core and edge, MHD and PFC state control. It involves all the communities of fusion specialists, from mathematical control theory to engineering*

From EU strategy document: <https://idm.euro-fusion.org/?uid=2NPW2R&version=v1.1>

- Implementation in the JT-60SA programme of such topics will be discussed and set by the ETLs



# 2022 programme goals & strategy (AWP 2022)



## Overall objectives

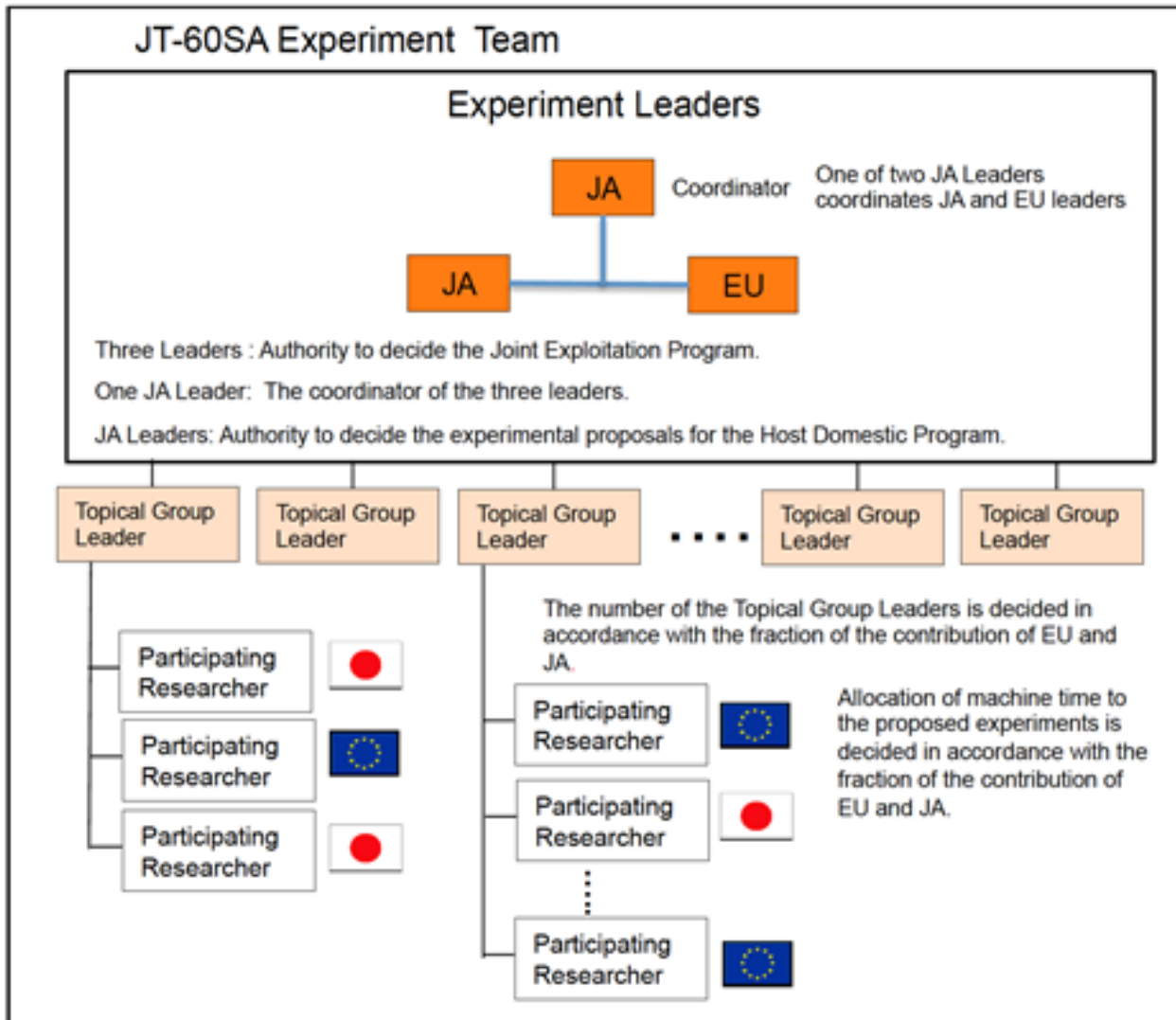
- Participation to the IC, particularly to the plasma phase \*
- Complete the delivery of the EU led systems under implementation \*\*
- Progress towards the release of validated simulation tools for scientific exploitation
- Contribute to the start-up of the Experiment Team \*\*
  - in 2022 there will be 2 parallel structures, IC team and Experiment Leaders / TGL
  - some level of coordination is being discussed in view of designing how the experiment team will work when the IC phase will finish.
- Prepare proposals for future Enhancements (>2025)

\* Possible milestone for 2022 (depending on external conditions)

\*\* Possible milestone for 2022

Sequential M ID	Related WBS ID	Title	Due Date (mm/yyyy)	Related GA D/M no.
SA.SE.OP.M1	SA-SE.OP.DO.01-T001	Commissioning of the EDICAM camera system on plasma	09/2022	
SA.JIFS	SA-JIFS.O.01-T001	Organize the first edition of the JT-60SA International Fusion School	12/2022	

# Experiment Team



- There will be one integrated JT-60SA Experiment Team
- Part of the activities in Operation and Modelling areas will evolve in accordance with the needs of the experimental campaign preparation, execution and exploitation after the ET setting
- The ET also will assess the Enhancement objectives
- WPSA contributors (but not only them) are expected to be part of the ET



## SA-CM Code management and modelling area

Coordinator G. Falchetto

- **Validate operation oriented tools** on data from IC
  - ECWC code
  - Disruption modelling
- **Optimize and provide to EU users simulation tools for operation/scientific exploitation**
  - Discharge simulator
    - strong coupling and performance improvements
    - call for test users (operators/scientists) and provide training
  - Breakdown simulator: optimization and simulation of breakdown scenarios for JT-60SA using a nonlinear optimization technique
  - MHD stability workflow operational for routine use
  - Fast ion workflow => requires support from NBI modelling experts
- **Finalize/extend the modelling of initial phase scenarios**
  - Assessment of ramp up in Scenario 2 with operationally oriented integrated transport codes including first principles transport models and MHD stability analysis
  - Report on sensitivity study on conditions for divertor detachment for the initial phase and nominal C scenarios with edge/SOL transport modelling codes, including impurity seeding impact.
  - Extend to RE and disruption modelling: available manpower?
- **To be started:** coupling non-linear runaway electron solver to breakdown and burn-through simulations



## SA-OP Operations area:

Coordinator: E. Belonohy

- Support the **integrated commissioning in 2022** in

- Plasma Operations and Commissioning incl. vacuum conditioning and plasma breakdown
- Magnetics commissioning, MHD, disruption database
- Control and equilibrium reconstruction
- Cryo and magnets
- EDICAM operation
- Camera tomography

### SA-CM will support integrated commissioning with ECWC & breakdown modelling

-> Share European operational experience and support QST from Europe and on the Naka-site in establishing commissioning strategies, day-to-day analysis support and recording/reviewing of the IC experience

- Start **new activities in support of the experimental campaigns in 2024-25**

- Commissioning of enhancements provided by Europe (Thomson Scattering, VUV spectrometer, Divertor Cryo)
- Control room support preparation (real-time experts for scientific networks)
- Plant system commissioning (consider collaboration on the NBI plant system commissioning)

## SA-Enhancement Projects area:

Coordinator: J. Ayllon-Guerola

- Tangential Phase Contrast Imaging system: being considered for implementation (JT-60SA ETLs, Project Managers)
- Doppler Reflectometry system: ready for final design by end of 2022 - to be submitted for consideration
- New diagnostics (Neutron & Gamma, Beam Emission Spectroscopy, EC Stray, IR imaging, Ultra Fast reflectometry):
  - Final feasibility study by end of 2022
- Linked to Milestone 2023: Include new enhancement programmes in BA
- Scheme of support to be defined



## **SA-JIFS JT-60SA International Fusion School**

**Coordinator: G. Giruzzi**

- Launch of the 1st JIFS school with support from the European Commission and the Japanese Government in early 2022
- Finalisation of the JIFS programme and selection of the lecturers, supervisors of practical activities
- Call for participation in the 1st JIFS school for European and Japanese participants
- The 1st JIFS school is planned in-person in Autumn 2022 following the JT-60SA first plasma.

Ongoing discussion to extend the JIFS activities to a comprehensive support programme for students and early-career researchers and engineers.

# 1<sup>st</sup> JIFS edition programme proposal



Time	Monday	Tuesday	Wednesday	Thursday	Friday
<b>Session</b>	plenary	plenary	plenary	plenary	plenary
8.30 - 10.00	Welcome & Logistics	4 Heating Systems	A 7 Power Exhaust systems	F 10 Tokamak System Optimisation	A 14 From JT-60SA to ITER, DEMO & fusion reactors
10.00-10.30	Break	Break	Break	Break	Break
10.30-12.00	1 Introduction - tokamak overview	A 5 Plasma physics 1	B 8 Diagnostics - general	C 11 Realising & Assembling a Tokamak	A 15 Questions & Discussions
12.00-13.00	Lunch	Lunch	Lunch	Lunch	Lunch
13.00-14.30	2 Vacuum Systems and Cryogenics	A Visit - Torus Hall	A Visit - Auxiliary Systems	A 12 Operating and Maintaining a Tokamak	E Operation 1
14.30-15.00	Break	Break	Break	Break	Break
15.00-16.30	3 Magnets and Thermal Shields	A 6 Plasma physics 2	B 9 Loading Conditions, Safety, Standards	A 13 Discharge scenarios	D Operation 2
Travel					
18.00-20.00	Reception		Social dinner		Career evening

Time	Monday	Tuesday	Wednesday	Thursday	Friday
<b>Session</b>	plenary	plenary	5 groups	5 groups	5 groups/plenary
8.30 - 10.00	Diagnostics 1	C Plasma Wall Interaction 2	F Optional topic advanced lecture 1	Optional topic Practicals 3	Presentations by students: preparation
10.00-10.30	Break	Break	Break	Break	Break
10.30-12.00	Diagnostics 2	C Scenarios 1	D Optional topic advanced lecture 2	Optional topic Practicals 4	Presentations by students
12.00-13.00	Lunch	Lunch	Lunch	Lunch	Lunch
13.00-14.30	Visit - Diagnostics	C Visit - control room	E Optional topic Practicals 1	Optional topic Practicals 5	Presentations by students
14.30-15.00	Break	Break	Break	Break	Break
15.00-16.30	Plasma Wall Interaction 1	F Scenarios 2	D Optional topic Practicals 2	Optional topic Practicals 6	Closing
Travel					
18.00-20.00	Report on weekend joint activities		Culture evening		Farewell Dinner


# TSVV links




- All WPSA modelling will benefit from developments under TSVVs
  - high fidelity plasma simulator from TSVV11 for scenario modelling
  - advanced codes from Thrust 3 (MHD an RE) and Thrust 2 (Edge Physics & PWI) as ready ! Probably beyond 2022
    - predictive transport model for RE generation
    - MHD - CARIDDI/JOEK for eddy currents, halo currents evaluation
    - JOEK simulations of disruptions/mitigation
    - reduced models from TSVV10
    - prepare operation scenarios compatible with C Divertor, ACD-C Divertor and in future with W divertor
- JT-60SA excellent opportunity for validation of TSVV codes
  - include validation plan in Thrust 3


**TSVV-01:** *Physics of the L-H Transition and Pedestals*


**TSVV-02:** *Physics Properties of Strongly Shaped Configurations*


 **TSVV-03:** *European boundary plasma modelling towards reactor relevant simulations*


**TSVV-04:** *Plasma Particle/Heat Exhaust: Gyrokinetic/Kinetic Edge Codes*


 **TSVV-05:** *Neutral Gas Dynamics in the Edge*


 **TSVV-06:** *Impurity Sources, Transport, and Screening*

 **TSVV-07:** *Plasma-Wall Interaction in DEMO*

 **TSVV-08:** *Integrated Modelling of MHD Transients*

 **TSVV-09:** *Dynamics of Runaway Electrons in Tokamak Disruptions*

 **TSVV-10:** *Physics of Burning Plasmas*

 **TSVV-11:** *Validated Frameworks for the Reliable Prediction of Plasma Performance and Operational Limits in Tokamaks*

**TSVV-12:** *Stellarator Optimization*

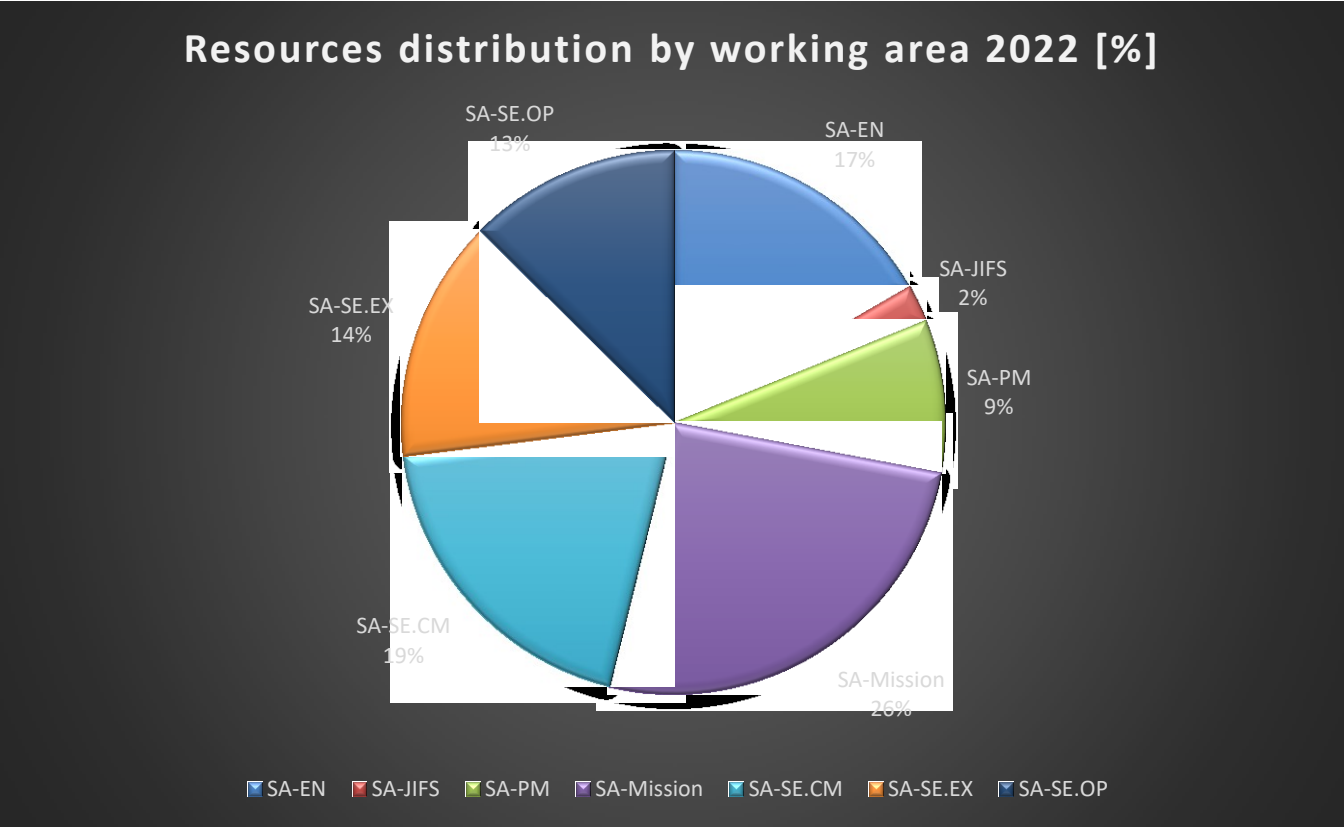
**TSVV-13:** *Stellarator Turbulence Simulation*

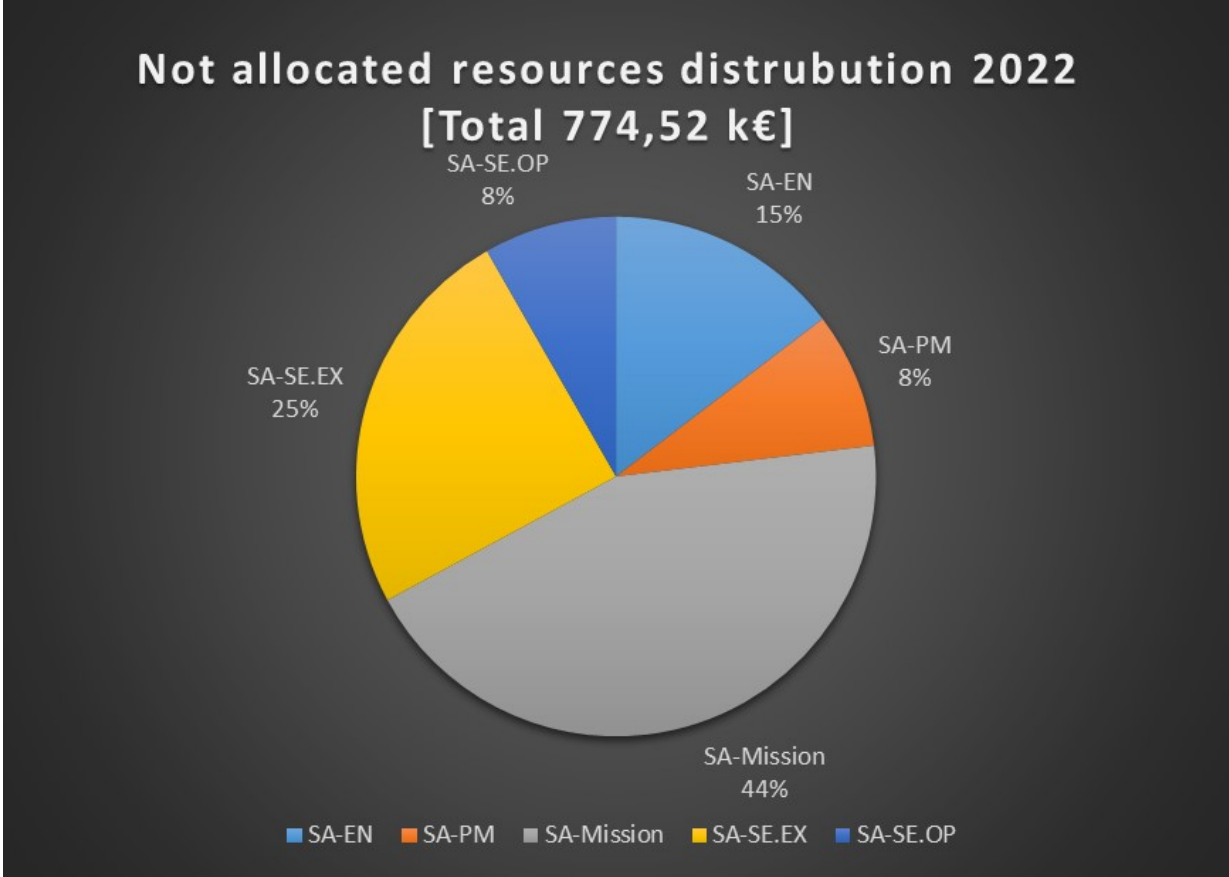
**TSVV-14:** *Multi-Fidelity Systems Code for DEMO*





**2022 Total Cons. Contr. k€ 1318,665**







- Lack of available manpower in some priority topics (disruptions, runaway modelling, NBI modelling for fast-ion studies)
- Availability of IC experts in 2022 – checked in September-October
  - Some experts moved to ITER (ECWC, Cryo) – hope to maintain connection/involvement through the ITER-F4E-QST trilateral agreement
- Ability to travel to Naka in 2022 (with or without visa)
  - Strong border limitations in Japan due to COVID19
  - Visa-free travel unlikely in early 2022, long process to obtain visa (>6 months)
- Access to IC data cumbersome and limited to a small group of European scientists
- Potential delay in IC plasma phase
- Potential delay in FP8 Enhancement delivery impacting other scientific objectives



- **Code management:**
- breakdown simulator activity in synergy with **WPPrIO** (Preparation for ITER Operations) and **WPTE** (Tokamak Exploitation)
- Development of synthetic diagnostics (**WPPrIO, WPTE, TSVVs...**)
- "Edge/divertor modelling" & "interaction of RE with PFC" synergetic to **WPDIV**: prepare operation scenarios compatible with C Divertor, ACD-C Divertor and in future with W divertor
- **Operations:**
- **WPPrIO** (Preparation for ITER Operations) work package
  - The EUROfusion Operations Networks subnetworks (seminars, workshops, trainings) will be offered to QST staff to join -> NBI seminar series in 2021
  - Disruption database could be connected to the EUROfusion database
- **Scientific exploitation**
- **WPTE** link for the development of the scientific programme



- See 2021
- Development of ITER-like EC stray sensors (with ITER)
- ITER collaboration involving EEGs (of course if topic/candidates selected)
  - EEG21-15 EU enhancement project for JT-60SA: Thomson Scattering Diagnostics
  - EEG21-20 Development of software tools for ECH exploitation (JT60-SA and ITER)

# 2022 GA milestones/deliverables



GA Milestone no.	Title	Due Date (mm/yyyy)
SA.M.02	Start of the EU-REC project	Apr. 2022

The activity is ongoing, however a reformulation of the milestone may be required due to the changed scope and objective of the work

GA Deliverable no.	Title	Due Date (mm/yyyy)
SA.D.02	Final report on Integrated Commissioning. Results and return of experience, mainly for DTT	Dec. 2022*
SA.D.04	Documented plan of EU enhancement programme for BA Phase II– 2025-2029	Dec. 2022

(\*)Milestones/deliverables dependent on external conditions to which the workpackage is constrained, see Risk Table



- All the activities launched and in progress: revision point at the end of 2021
- High impact on the program due to consequences of Covid-19 and of the coil incident during the IC
- 2022 challenging year with
  - next IC phase
  - Enhancements procurements
  - Setting of the Experiment Team
- The agreed objective is to support 40% of the scientific activity. Resources may be marginal for the scope when things will go to full speed
- Extremely important to reach a level of effective coordination in the side of modelling and simulation
- Another critical aspect is the support for enhancements of high scientific impact using the most suitable scheme. This is a key for effective participation and team integration