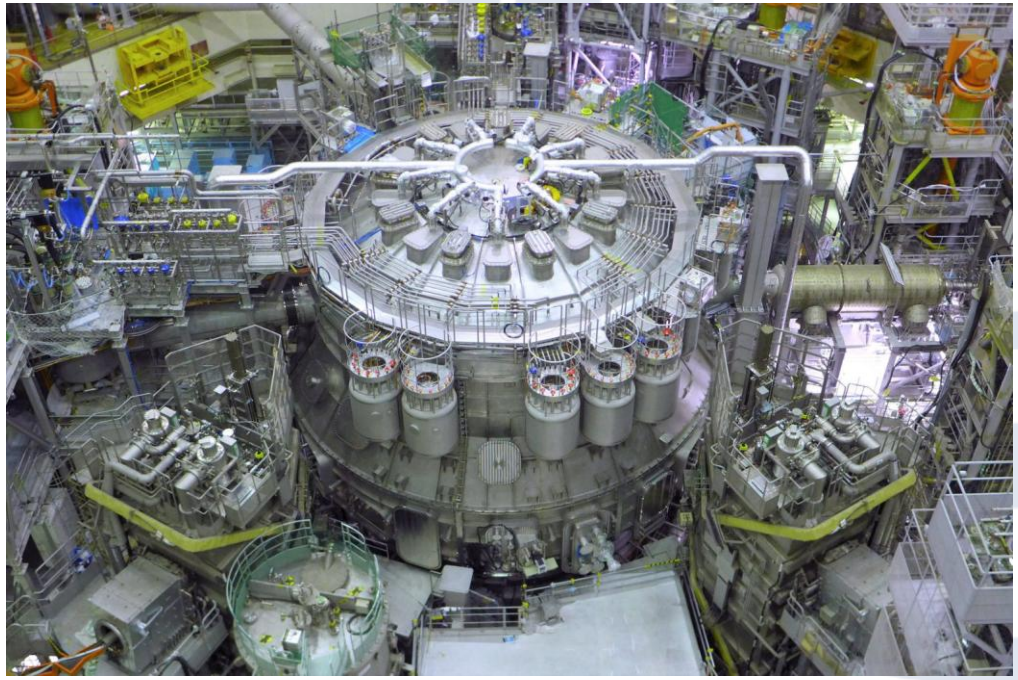
FSD Project Board 04 November 2026

Enhancement and Commissioning of JT-60SA (WPSA)
2026 Status summary

Carlo Sozzi

With contributions of Gloria Falchetto (Code Management, CEA), Matteo Iafrati (Operations, ENEA), Pilar Caño-Megias (Enhancements, CIEMAT) , Marcella Pellegrini (PSO), Joao Figueiredo (PMU)

ISTP-CNR (ENEA)



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WPSA scope

& hand over between SA, F4E and operations in JT-60SA

WPSA supports:

- proposals for enhancements (mainly diagnostics to achieve the scientific and operational objectives of JT-60SA), until scientific acceptance (JT-60SA Experiment Team priority) and until a degree of development (detailed conceptual design) such that a Procurement Agreement by the EU implementing agency (F4E) can be signed.
- Installation and commissioning of the developed systems until final acceptance (first data production for diagnostics)
- Development and test of operational oriented software tools (synthetic diagnostics, control room analysis, control tools). Does not support their exploitation (use for analysis or experiment design by a non-developer)

- NB: “Regular” operation of subsystems is at present outside the plans

Background

- JT-60SA tokamak through Machine Enhancements 1 for the most of year 2026, with start of the preparation for operations in plasma in the second half of the year
- Analysis cluster nakasvr26 accessible via IFERC network + access to OP1 data + progressive installation of analysis tools during 2026
- JT-60SA IPT Call for participation in ME1 (Maintenance and Enhancement 1) and OP2 (Integrated Commissioning and Machine Data Analysis) launched in June 2026

OP1: first plasma

Scope=>

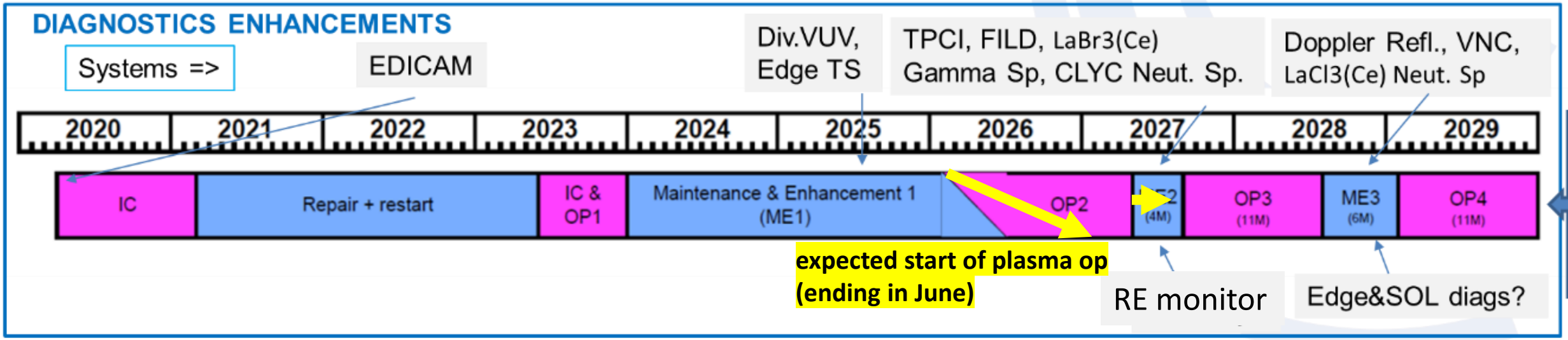
EC assisted breakdown at low $E_{//}$
Plasma control with SC coils
Disruption characterization

OP2: high Ip operation

Extension of the operation domain (high Ip, H mode, Beta, collisionality, …)
Disruptions and Runaway control, Error field
Heat transport L mode with dominant Electron heating
Shine through, Fast ion losses, LH transition, ELMs,
SOL scaling at high IP, Divertor characterization

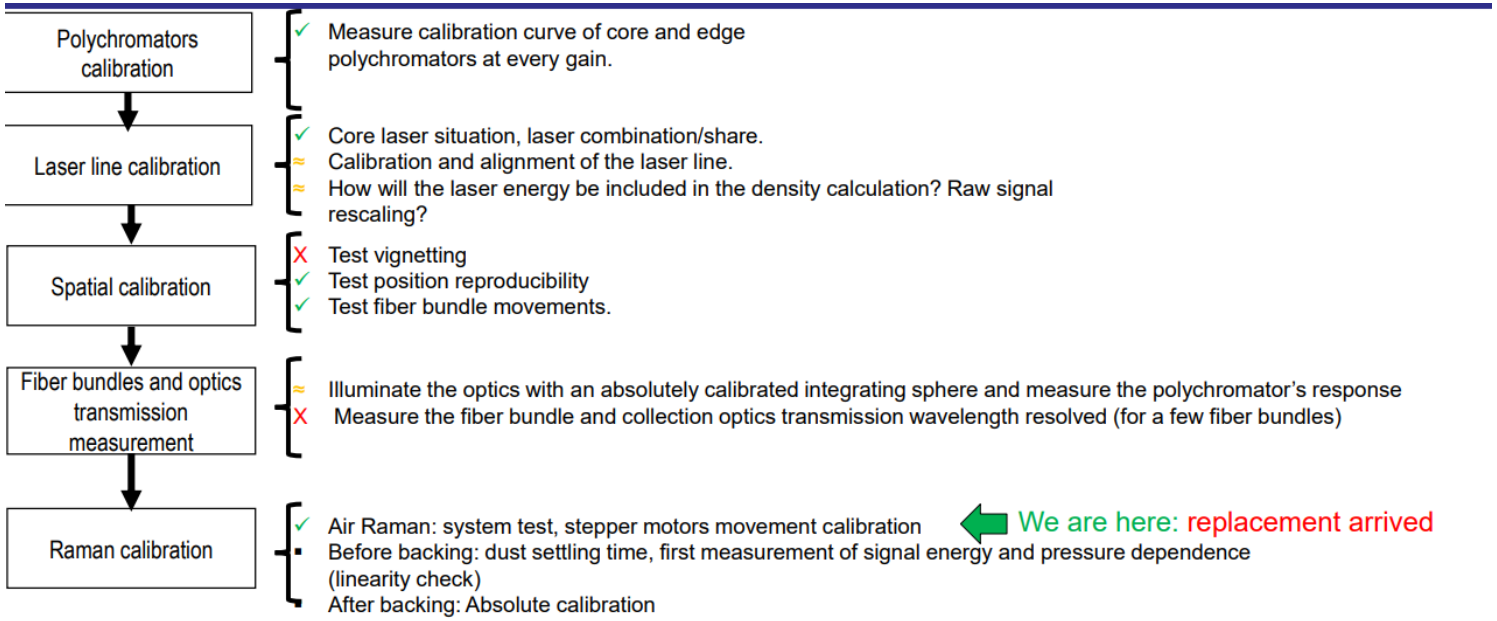
OP3: H mode development

ITER relevant H-mode and high beta scenarios
High Beta non-inductive steady-state scenarios
NTM, RWM, ST control
Heat transport L mode with dominant Electron heating
Fast ions and turbulence, Alpha particles in D-3He plasma
ELMs regimes, W screening, Seeding

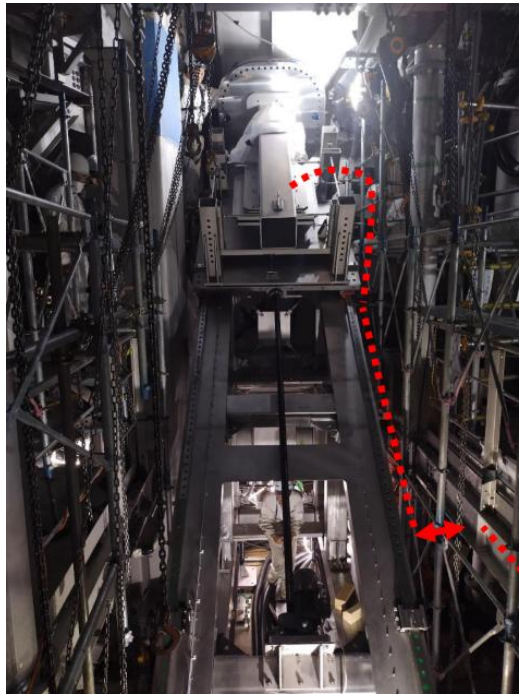


Objectives and status in 2026 - Operations

- Thomson Scattering System
  1. Installation of the in-vessel components and connection of the optical system (fibers and collection optics)
  2. Laser line tests and calibration
  3. Signal calibration (spatial, in vessel-relative, Raman, polychromators)
  4. Development of the analysis software (synthetic diagnostics)
  5. System commissioning and exploitation of the edge TS system
  6. Explore Real Time solutions



- Thomson Scattering System
  1. Ok
  2. Ok with caveat
  3. Ok with caveat (Raman planned mid November)
  4. Ok
  5. Delayed with plasma operations
  6. On going
- Dedicated SNE on site from August 2026



Objectives and status in 2026 - Operations

- Divertor VUV
  1. Installation of the system in JT-60SA (pre-assembled) and connection of auxiliaries (vacuum, fiber optics, power supplies etc)
  2. Alignment with divertor
  3. Development of the analysis software (synthetic diagnostics)
  4. Commissioning and evaluation/validation of the first spectra against noise
  5. Assistance to the Experiment Team for scientific exploitation in OP2

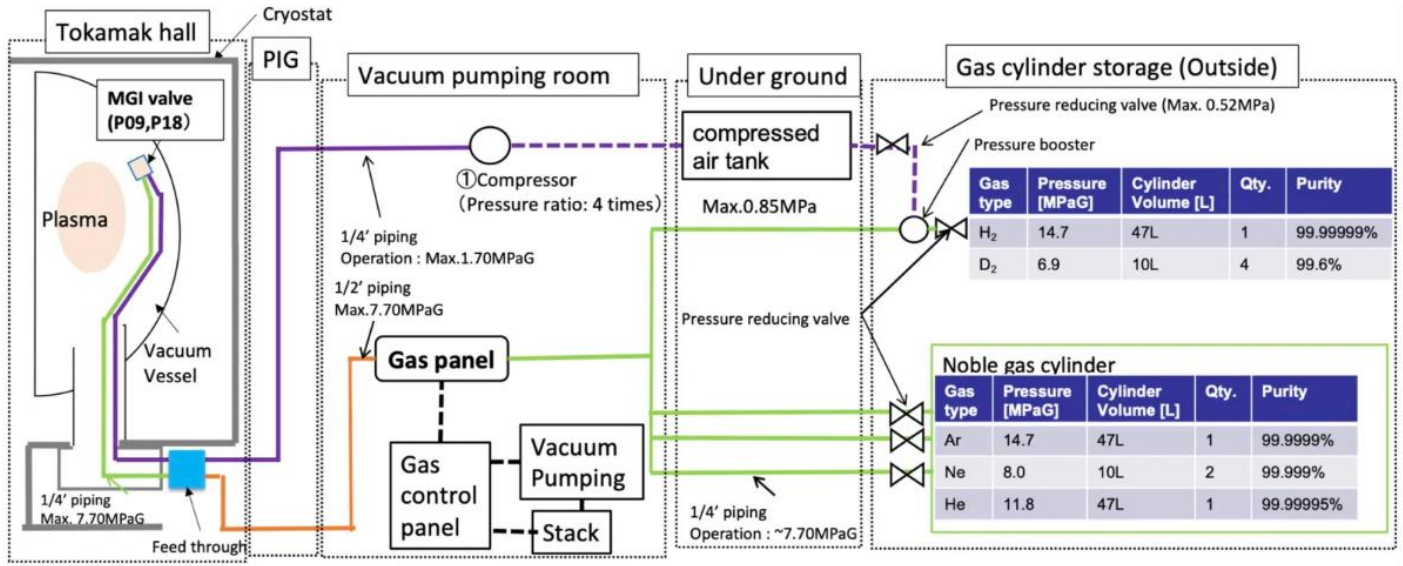
- Divertor VUV
  1. Installation mostly ok after recovering of the damage during transportation, but additional requests by QST not yet completed
     - additional fore-vacuum equipment
     - trigger system (mid November)
  2. Alignment Ok (Endoscope has broken during the transportation, but not essential)
  3. in progress
  4. Delayed with plasma operations
  5. Delayed with plasma operations
- Dedicated SNE on site from August 2026

- Repair actions successfully completed: collection mirrors, CCD channel 2 CCD, gate valve position switch
- Pending:
  - test of the newly installed trigger system: planned after mid November
  - complete the integration and test the fore-vacuum system (QST action)
  - shutter control: insufficient air pressure (upgrade ongoing)
  - CCD data transfer: back-up connection being set
  - Broken gate valve – mitigation actions being defined waiting for the replacement (ME2)
  - Repair of the alignment endoscope (ME2) – not essential



Objectives and status in 2026 Operations

- Commissioning and first operation with plasma of the MGI system

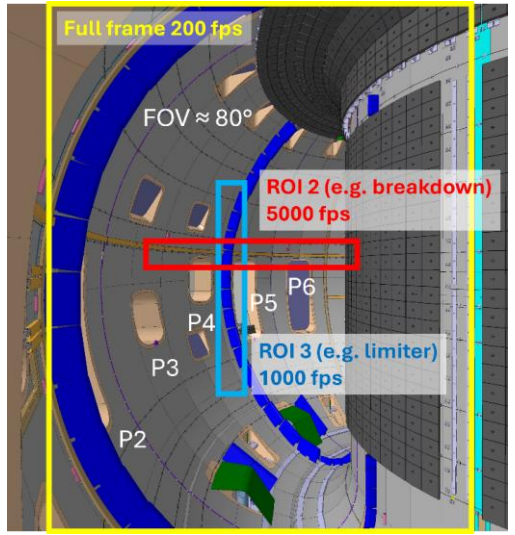


Gas type	Pressure [MPaG]	Cylinder Volume [L]	Qty.	Purity
H_2	14.7	47L	1	99.99999%
D_2	6.9	10L	4	99.6%

Gas type	Pressure [MPaG]	Cylinder Volume [L]	Qty.	Purity
Ar	14.7	47L	1	99.9999%
Ne	8.0	10L	2	99.999%
He	11.8	47L	1	99.99995%

- Support for the operation of EDICAM and assistance to data interpretation in particular in assisting the development of high current scenarios

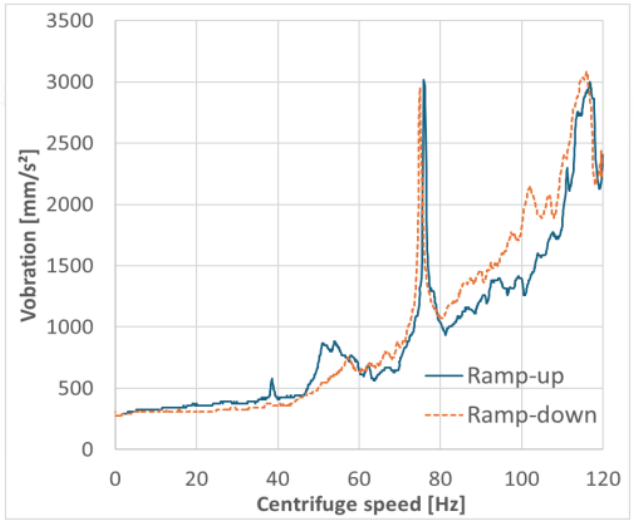
- 2 MGIs installed and ready for commissioning (with limitations in performance)
  - To trigger approximately at <=0.1 s when the pressure is <=24 bar (MGI#2) and <=0.5 s when the pressure is <=15 bar (MGI#1) –
  - More trigger speed tests are necessary and can potentially be done during MGI commissioning before OP-2 starts.
  - IPP Garching expert supporting commissioning



- EDICAM DAQ major upgrade.
- Data visualization software and access to raw data available for all users in OP2.
- =>EDICAM ready for operations
- Dedicated SNE on site from January 2027

Objectives and status in 2026 - Enhancements

- Support to the development of the Pellet Launching System (procurement and integration of the launcher, sources development and procurement)

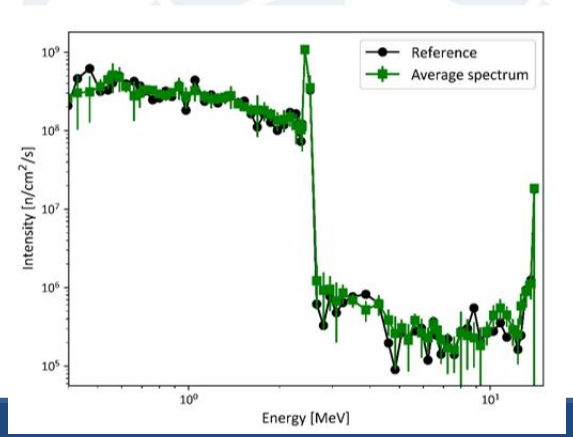




PLS
- launcher delivered to IPP Garching
- Pellet speed range: 100-500 m/s
- selection for sources development (F4E contract) ongoing
- Mockup of Master PLC supervising all PLS sub-systems developed and sent to QST

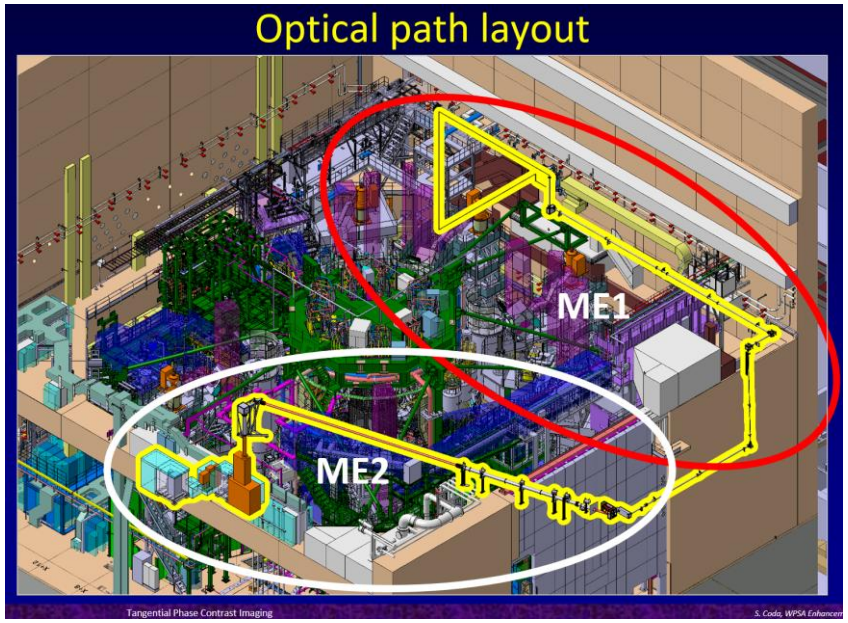
Neutronics
- Simplification of PLS for JT60-SA CAD to input MCNP neutronics model
- Number of solids reduced 7633 =>1783
- Calculations for the collimators ongoing
- Neutron Spectrum Reconstruction
  - tools optimized for application in JT-60SA (irradiation sequence + definition of spectral regions)

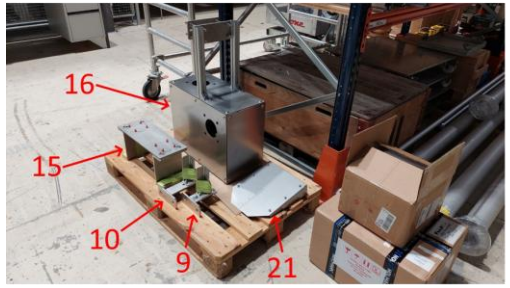
- Support to neutronics calculation
  - for subsystems shielding
  - and for the development of the collimator of the Gamma Rays Spectrometer and of the Compact Neutron Spectrometer
- Neutron Spectrum Reconstruction from Radiation Foil Sensors for evaluating the radiation levels and the validation of the MCNP model



Objectives in 2026 / Enhancements – OP3 diagnostics

- Partial ex-vessel installation of the TPCI diagnostics







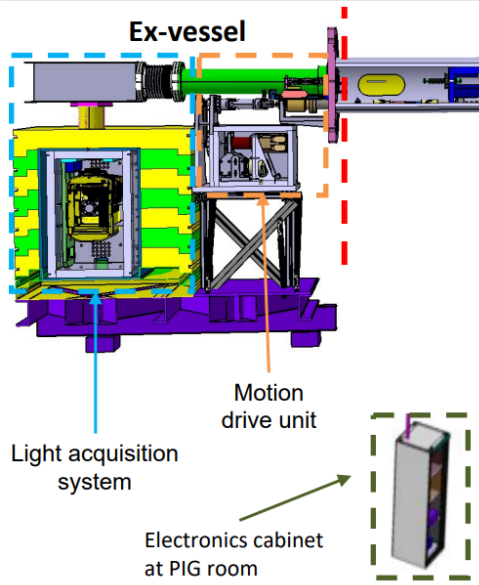
TPCI:

- Optics and optical supports from the laser room to a point before the beam expander (v.v.) ready for installation install (November)

FILD

- In-vessel components: ready for manufacturing;
- details of ex-vessel components being finalized (motion drive, light collection, supporting structure)
- Procurements contracts being issued

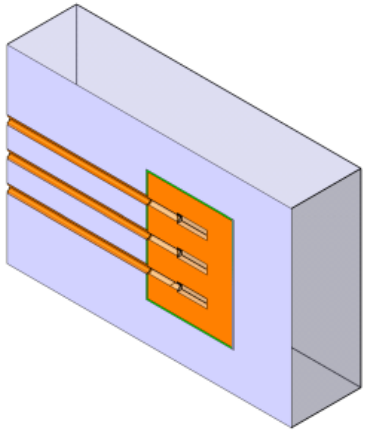
- Laboratory integration of the FILD diagnostics



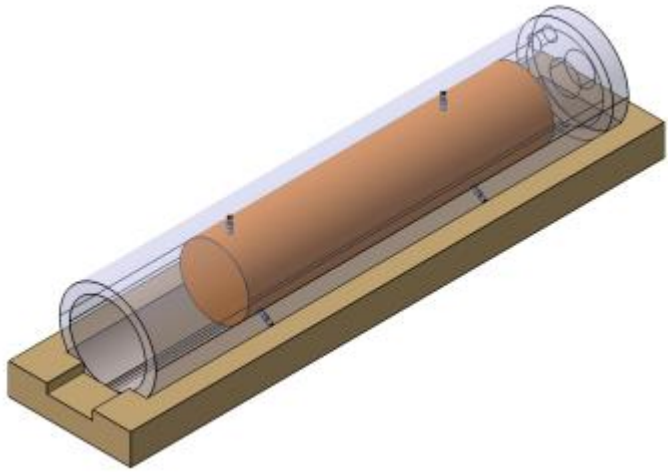
- **In-vessel components:** ready for manufacturing
- **Ex-vessel motion drive unit:** components selected, mechanical assessment of support structure pending
- **Ex-vessel light acquisition system:** neutronics assessment finalised, selection of ex-vessel lenses pending
- **Ex-vessel supporting structure** to common stage beams: re-designed to avoid clash, reinforced and insulated. Anchoring to common stage beams confirmed. New design approved by QST
- **Electronics cabinet**: location at PIG room and cabling routing confirmed, reduced from 2 to 1 cabinets after iterations with QST
- **Grounding/connection schemes** revisited and discussed with QST, including detailed utilities required
- **PID chapter ready**

Objectives in 2026 / Enhancements – OP3 diagnostics

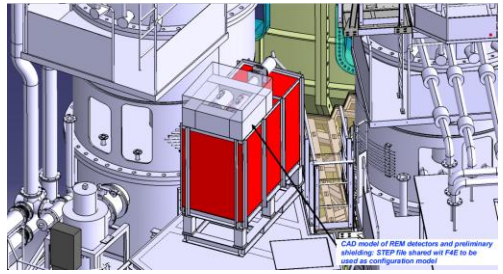
- Procurement and lab test of the Gamma Ray Spectrometer

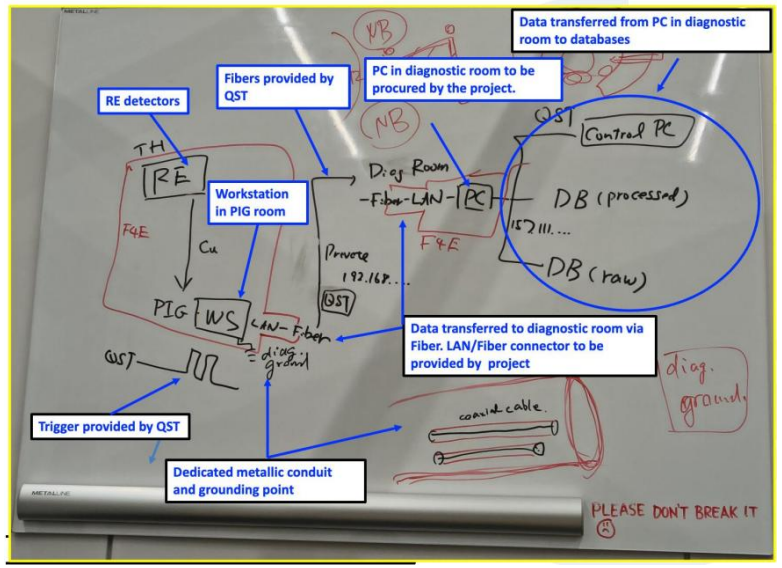


View of the GRS collimator.



- Installation, commissioning and support to operation of the Runaway Electron Monitor



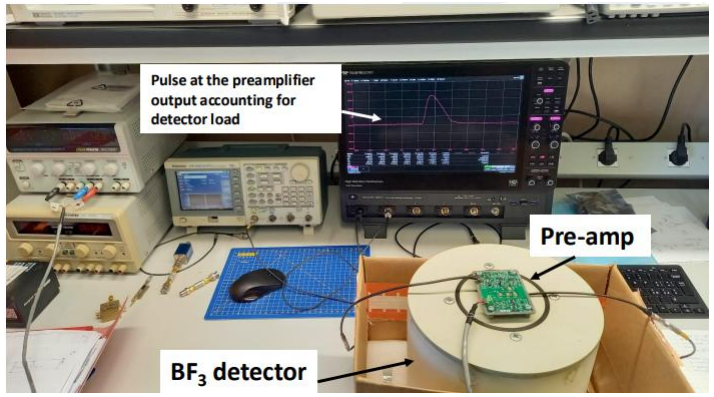


GRS

- Detector design completed
- The detector is a 1.5 in × 1.5 in LaBr3 scintillator
- coupled to a photomultiplier tube (PMT).
- The envelope is approximately cylindrical, with maximum diameter about 44 mm and 180 mm long.
- Procurement started
- Collimator structure under design
- Low-activation α-particle scenarios defined

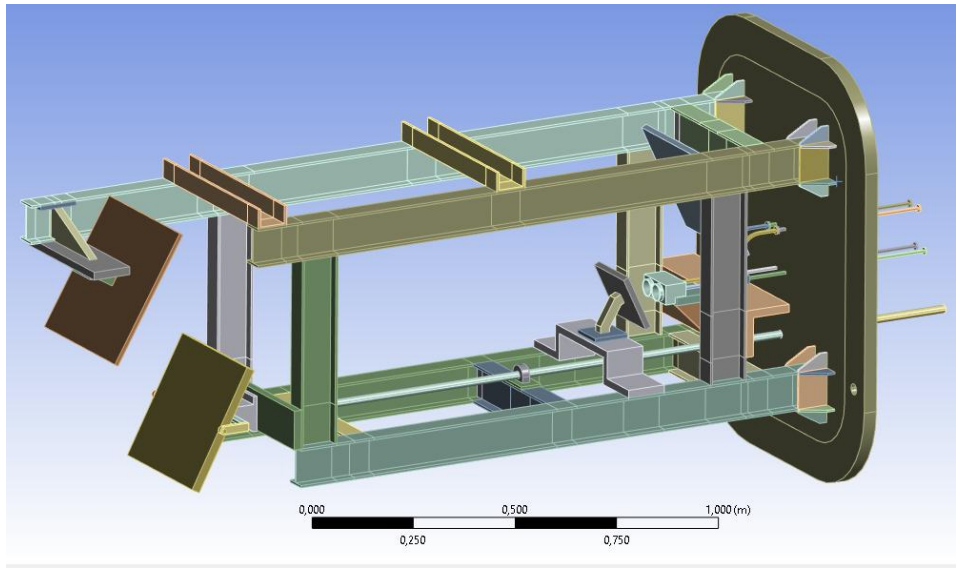
REM (moved to ME2)

- Physical interfaces assessed, detector performances assessed
- Front-end electronics developed



Objectives and status in 2026 – preparatory studies for diagnostics

- Design of the Compact Neutron Spectrometer
- Support the design of the Vertical Neutron Camera (profile monitor)
- Support the design of the Doppler Reflectometry



- Selection of Edge and SOL diagnostics feasibility studies for advancement to detailed conceptual design

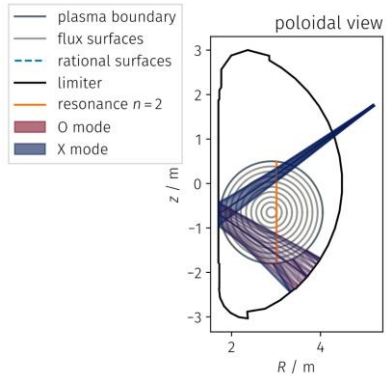
- CNS
  - Diagnostics components defined
  - Expected fluxes at the detector under confirmation
  - Return of experience from MAST-U and EAST
- VNC design
  - Count rate evaluation under the geometrical constraints
  - In lab detector test
- DR diagnostics
  - Engineering analysis (thermal, EM, seismic) of the in-vessel support structure
  - Validation and optimization of the in-vessel optical design
  - Selection of a possible path for the ex-vessel waveguides, including space requirements

- Selection pending in 2026 (no funding),
- ongoing coordination with ET regarding scientific priorities and preparations for the transition to a tungsten wall and divertor
- EUROfusion meeting held on April 2026 https://indico.euro-fusion.org/event/3995/

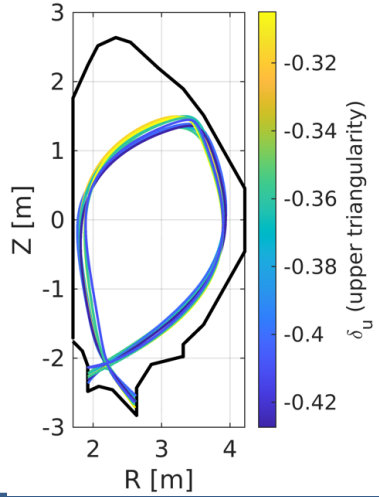
Objectives and status in 2026 - Software tools

- Training for users of the developed Pulse Design Simulator and other tools: EC waves tools, ATEP (Advanced Transport for Energetic Particles) workflow, MHD stability chain (sensitivity of the MHD unstable spectra to variations on the q-profile)

- PDS training introduction and demonstration in July Training week in Naka => EU training week in Cadarache, 18-22 January
- Demonstration of Data visualization tools in October ET workshop
- Demonstration of EC waves tool planned in November A&M week
- Equilibrium reconstruction & Magnetic control
  - LIUQE integrated in the MECS workflow



EPFL Simulation tools



Achieved a NT flat-top plasma considered doable in terms of **required active currents** and **vertical stabilizability**

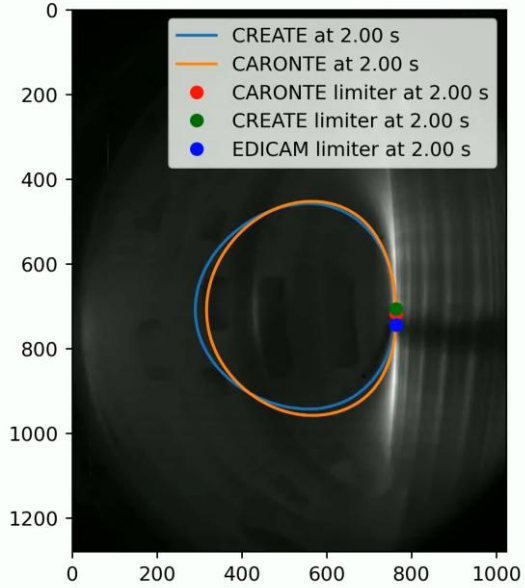
$(Ip = 1MA,\ \delta_u = -0.4,\ k = 1.6)$

Assumptions
- profiles from RAPTOR for NT scenario
- power supply model
- conservative flux consumption (from OP1 data)
- strike-point limits and current limits from OP2

NL simulation run with FGE, currently being **benchmarked against MECS** (S. Kojima)

- After LIUQE, the whole **MEQ** suite is being adapted to JT-60SA
  - **FBT** for scenario design
  - **FGS** for static GS equilibria
  - **FGE** for nonlinear evolutive simulations
  - **FGEL** for linearization/growth rate estimation

- The suite has been used to study **NT scenarios feasibility**
  - FBT: current and voltage feedforwards generation
  - FGE: closed-loop simulation with “basic” magnetic controllers
  - FGEL: growth rate validation and Best Achievable Performar analysis
    - D. Frattolillo, SOFT26 poster



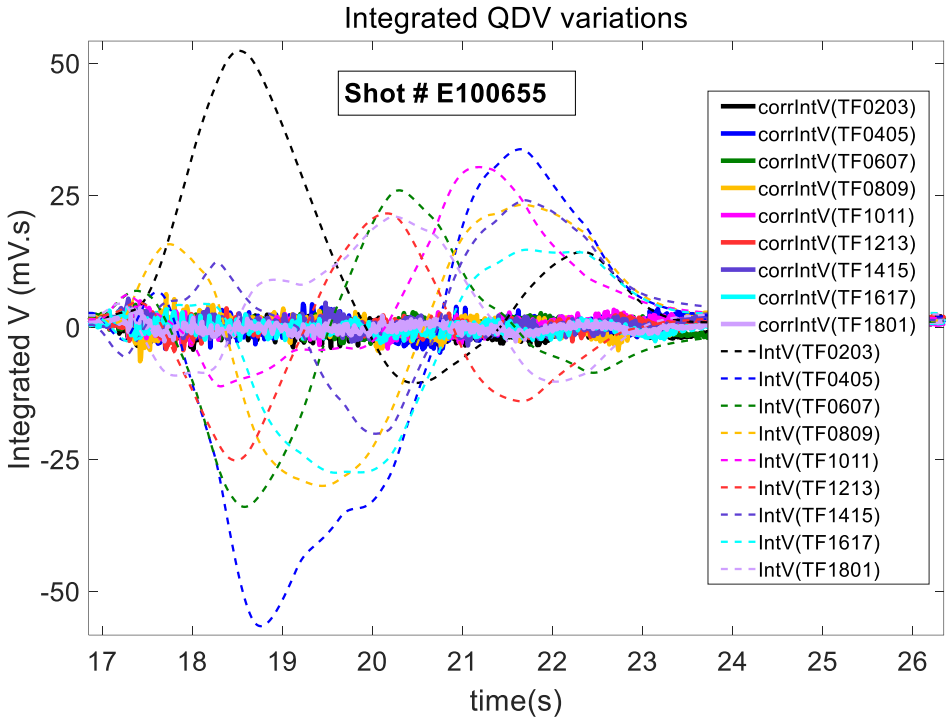
Objectives and status in 2026 – Cryomagnet system

- Update of the magnet THEA (thermohydraulic models settings and code consolidation) in preparation of OP 2.
- Validation and consolidation of the TFQDV signal processing for signal retrieval, correction and transmission to TF interlock system.
- Simcryogenics modeling of loop 2 (energy assessment)

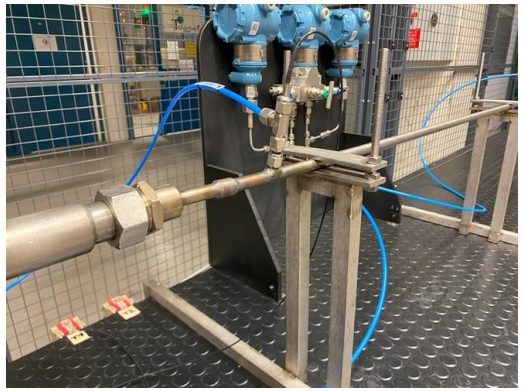
- Test of CICC samples at the Othello facility at CEA.
  - Hydraulic characterization of conductor sample with gaseous nitrogen flow.
  - Pressure drop measurement to evaluate the friction factor.

➢ Results consistent with the 2011 CEA test campaign

➢ Comparison with experimental data from the tokamak operation is on-going;



Integrated TFQDV curves before and after correction



GD status

- SA.D.05 *Delivery and final tests of EU-REC Completed* (due: 30/06/2024; **expected delivery date: 30/09/2026**) - proposed delay to 30 November (after op. rehearsal during ETW05)
  - Comment: **Activity performed in conjunction with QST and F4E and in pace with the schedule of the machine preparation for next operational phase**

- SA.D.06 *Installation of the EU systems before the OP2 campaign* (due: 31/12/2024; **expected delivery date: 31/07/2026**) – proposed delay to 31 December (after machine pump-down)
  - Comment: **The installation plan is strongly dependent on the schedule of the shutdown for the Machine Enhancement 1 (now ongoing)**

- SA.D.10 *Delivery of EU procurements (TBD) for the campaign 2026 Completed*. (due: 31/12/2025; **expected delivery date: 31/07/2026**) – COMPLETED

- 02_WPSA GA-Milestone *Commissioning of the Edge Thomson Scattering diagnostics in JT-60SA completed - Records of commissioning available.* **(due: 31.12.2026 - l**ikely delay according to start of plasma operation)

Tasks modification (from mission budget to PMs)

DATE	BENEFICIARY	RESEARCHER	PM	MISSION FOUNDS	PM COST	CC	TOTAL RESOURCES	JUSTIFICATION	ADDITIONAL INFOS
18/05/2026	EPFL	FRATTOLILLO	0.5	4.958	5.667	3.5415	7.0835	PDS support & training	PMB 2026 reduced by 4.958k to 350.337k
04/09/2026	MPG	NAMURA	0.5	3.566	4.075	2.5465	5.468	TESPEL prepation	PMB 2026 reduced by 3.566k to 346.771k
26/10/2026	ENEA	BELPANE	7	35.423	40.483	25.302	50.604	Div VUV TRO+SNE 2026	PMB 2026 reduced by 80.762k to 266.009k
	ENEA	D'ISA	6	30.363	34.700	21.688	43.375	Edge TS TRO + SNE	
	ENEA	PLATANIA	1	5.060	5.783	3.615	7.229	DR support for optical design	
	EPFL	FRATTOLILLO	1	9.916	11.333	7.083	14.167	PDS support & training	

NIFS TESPEL fabrication lab (a similar setup is currently being prepared at the QST Naka)

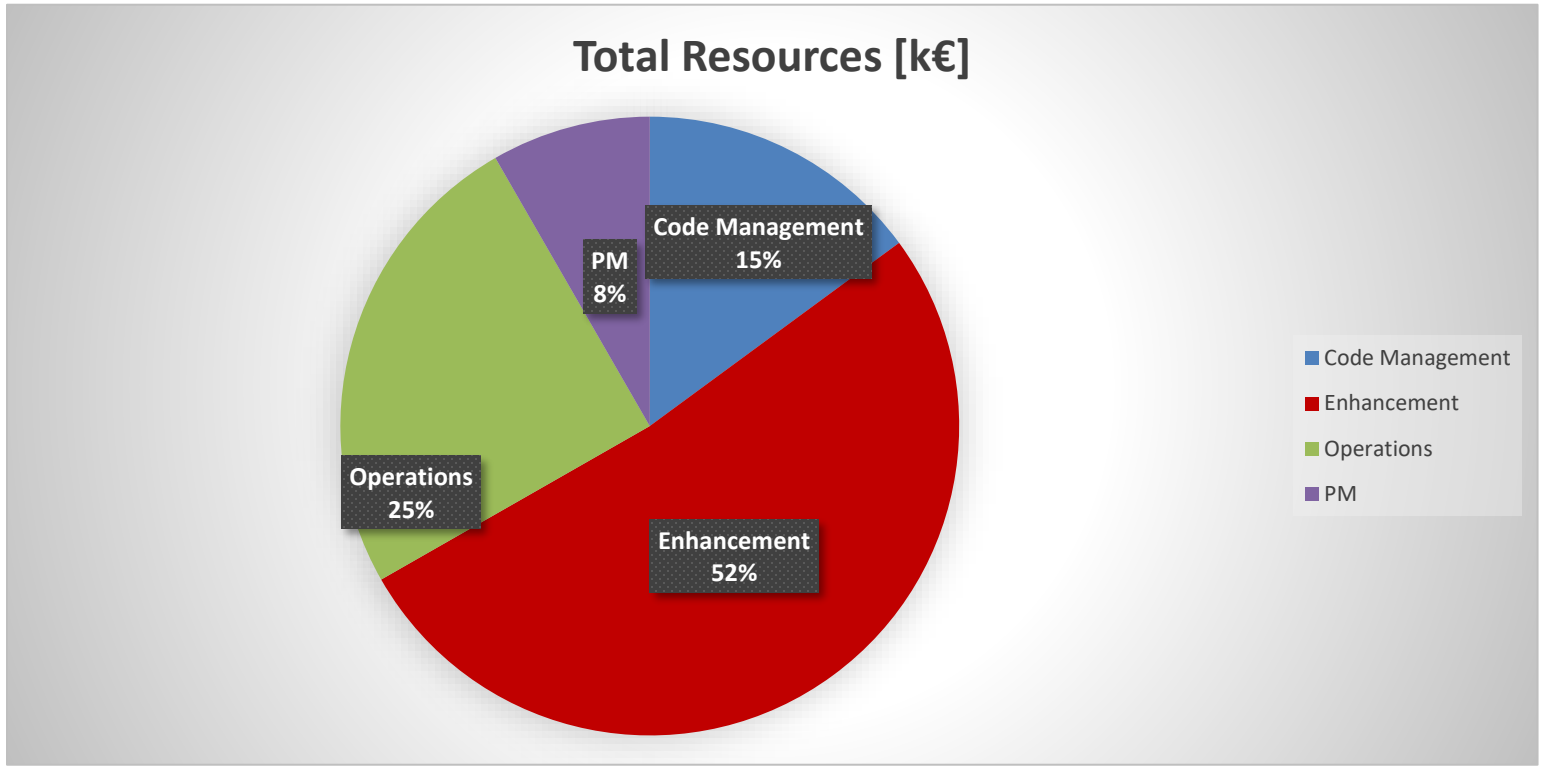




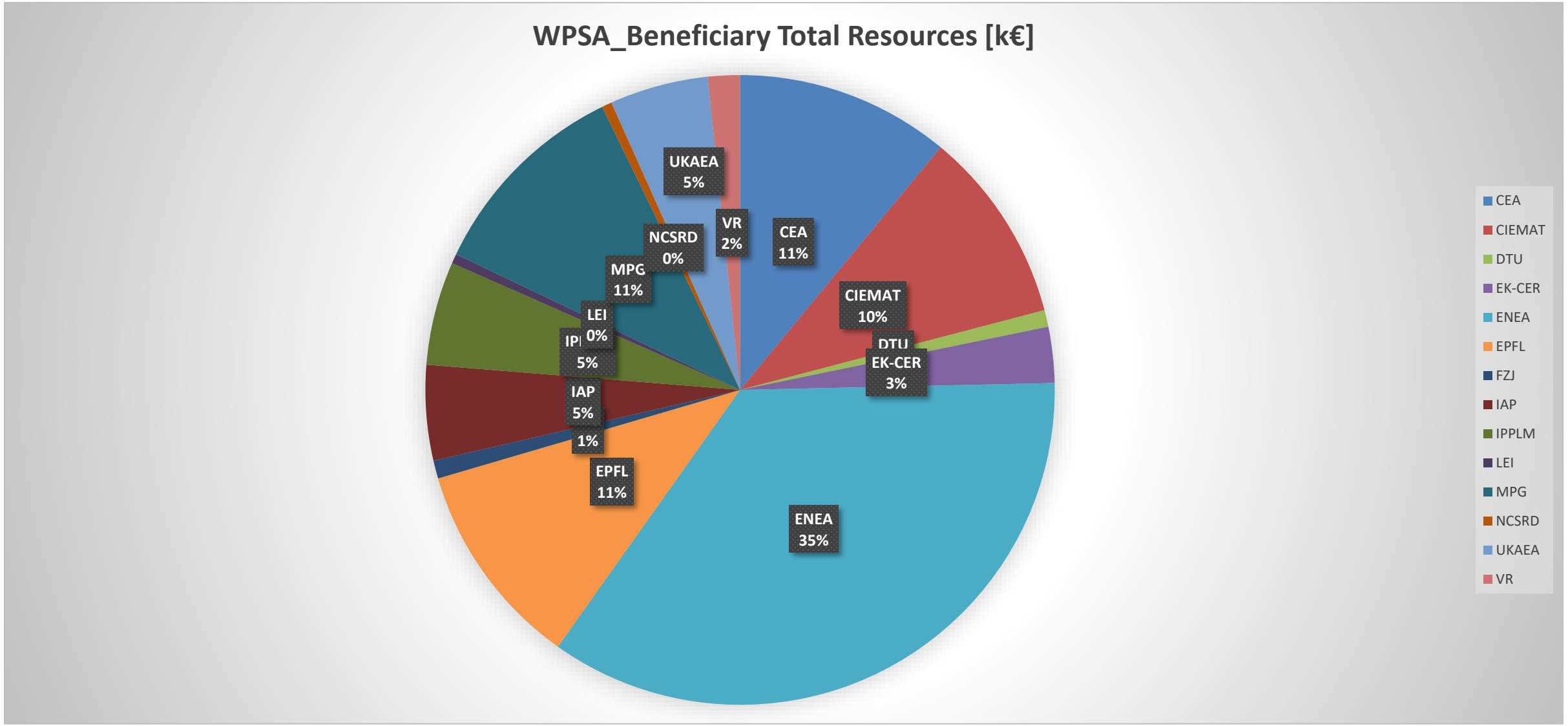
EUROfusion

WPSA_Budget by Area

Area	Total Commission Contr. [k€]	Total Cons. Contr. [k€]	Total Resources [k€]	Total Indirect Costs [k€]	Total PM
Code Management	77,017	70,016	140,031	28,006	16
Enhancement	237,528	201,560	486,557	97,311	61,35
Operations	128,835	116,497	234,245	46,849	30,5
PM	42,94125	54,6525	78,075	15,615	10,8



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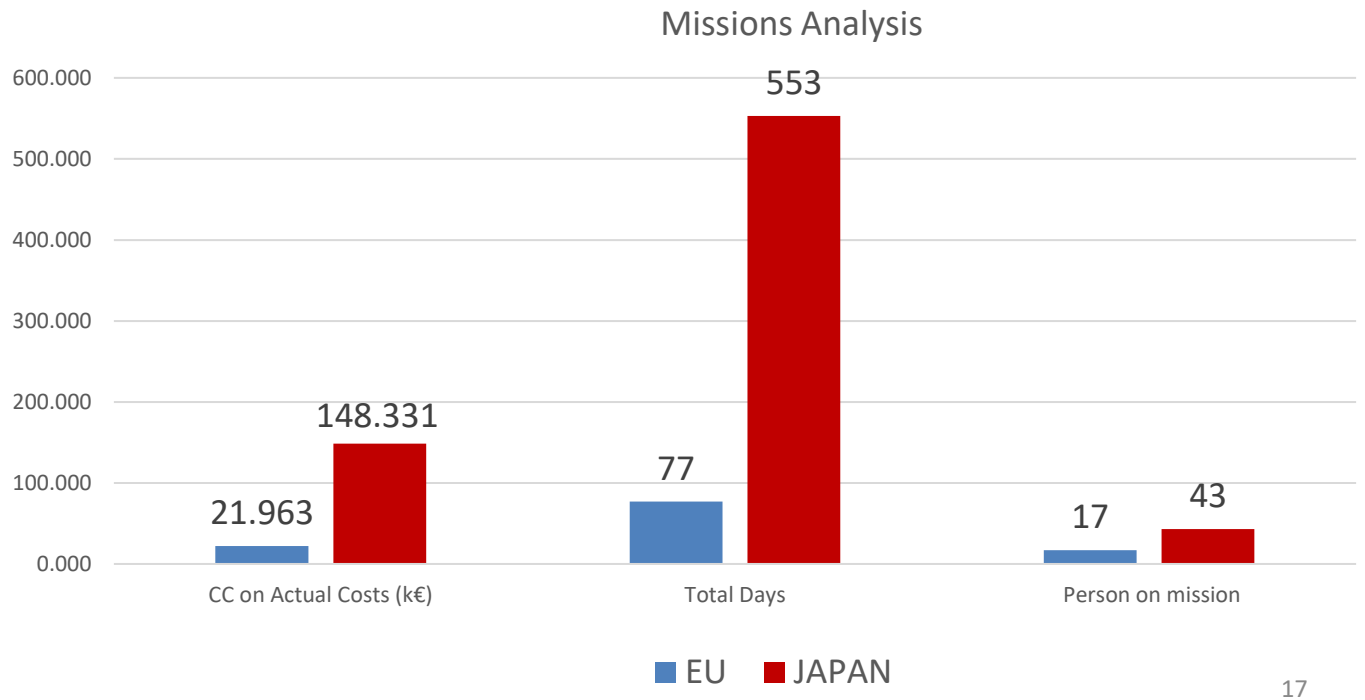

WPSA_Beneficiary Total Resources [k€]
UKAEA 5%
VR 2%
CEA 11%
NCSRD 0%
MPG 11%
CIEMAT 10%
LEI 0%
IPP 5%
DTU
EK-CER 3%
IAP 5%
1%
EPFL 11%
ENEA 35%
CEA
CIEMAT
DTU
EK-CER
ENEA
EPFL
FZJ
IAP
IPPLM
LEI
MPG
NCSRD
UKAEA
VR

EUROfusion

WPSA_Mission Budget_October 2026

Mission budget update October 2026	
Available mission budget 2026 CC	346,771
Approved missions	170,293
Available budget for the activities	176,478

Destination	CC on Actual Costs (k€)	Total Days	Person on mission
EU	21,963	77	17
JAPAN	148,331	553	43
Total	**170,293**	**630**	**60**



Visits in preparation

#	First Name	Last Name	Email	beneficiary	need IPT membership	need AF	Topic	TCM 16-20 November 2026	Analysis and Modelling Week 24-27 November 2026	additional weeks 2026	additional weeks IC (Jan-Feb 2027)	IMS approved (27.11.2026)
1	Lina	Velarde	lvelarde@us.es	CIEMAT (US)	1		FILD diagnostic	1				1
2	Adriano	Mele	adriano.mele@epfl.ch	EPFL			Magn. Control	1				1
3	Lukasz	Swiderski	Lukasz.Swiderski@ncbj.gov.pl	IPPLM (NCBJ)	1		Vertical Neutron Camera	1				1
4	Krystian	Grodzicki	Krystian.Grodzicki@ncbj.gov.pl	IPPLM (NCBJ)	1		Vertical Neutron Camera	1				1
5	Lidia	Pavan	lidia.pavan@igi.cnr.it	ENEA (RFX)	1	1	Div VUV	1		1		1
6	Philippe	Moreau	Philippe.Jacques.MOREAU@cea.fr	CEA			Tools for plasma operation					
7	Matteo	Iafrati	matteo.iafrati@enea.it	ENEA			Tools for plasma operation					
8	Pilar	Cano-Megias	pcano1@us.es	CIEMAT (US)	1		WPSA ENH coordinator	1				1
9	Carlo	Sozzi	carlo.sozzi@istp.cnr.it	ENEA (CNR)			WPSA PL	1	1			1
10	Gianmaria	De Tommasi	detommas@unina.it	ENEA (UNINA)			Magnetic control		1			1
11	Federico	Fiorenza	federico.fiorenza@unina.it	ENEA (UNINA)			Magnetic control		1			1
12	Attila	Buzas	buzas.attila@ek.hun-ren.hu	EK-CER	1		EDICAM		1			1
13	Eric	Gauthier	Eric.GAUTHIER@cea.fr	CEA			Diagnostics operation		1			1
14	Lorenzo	Figini	lorenzo.figini@istp.cnr.it	ENEA-CNR		1	ECH/ECE tools				2	
15	Michele	Guerini Rocco	m.guerinirocco2@campus.unimib.it	ENEA-CNR		1	ECH/ECE tools				2	
16	Paul	Heinrich	paul.heinrich@ipp.mpg.de	MPG	1	1	MGI expert		1	1		1
17	Laura	Laguardia	laura.laguardia@istp.cnr.it	ENEA-CNR			Gas Analysis expert		1			1
18	Massimo	Nocente	massimo.nocente@mib.infn.it	ENEA (UNIMIB)	1		GRS diagnostic	1				1
19	Federico	Scioscioli	federico.scioscioli@istp.cnr.it	ENEA (CNR)	1		GRS diagnostic	1				1
20	Frederic	Michel	Frederic.MICHEL2@cea.fr	CEA	1	1	Cryo magnet system				2	
21	Daniele	Marocco	daniele.marocco@enea.it	ENEA	1		REM diagnostic	1				1
22	Quentin	Le Coz	Quentin.LECOZ@cea.fr	CEA	1	1	Cryo magnet system				2	
23	Leonardo	Pigatto	leonardo.pigatto@igi.cnr.it	ENEA (RFX)		1	In vessel coil control			1		1
24	Andrea	Corbioli	andrea.corbioli@igi.cnr.it	ENEA (RFX)		1	In vessel coil control			1		1
25	Ruggero	Milazzo	ruggero.milazzo@igi.cnr.it	ENEA (RFX)	1	1	Edge TS			2		
26	Naoki	Tamura	naoki.tamura@ipp.mpg.de	MPG	1	1	TESPEL			2		
27	Kristel	Crombé	Kristel.Crombe@ugent.be	LPP-ERM/KMS (UGent)			**EC Wall cleaning (tbc)**			2		
28	Johan	Buermans	JOHAN.BUERMANS@mil.be	LPP-ERM/KMS			**EC Wall cleaning (tbc)**			2		
29	Gianluca	De Marzi	gianluca.demarzi@enea.it	ENEA	1	1	Cryo magnet system (tbc)				2	
30	Chiarasole	Fiammozzi Zignani	chiarasole.zignani@enea.it	ENEA	1	1	Cryo magnet system (tbc)				2	
								10	7	12	12	18

- Participation to TCM-46
- Handover of analysis tools to ET
- Activities related to ME1, IC and start of machine operation
- Some mission need to be moved in 2027 due to the machine timeline
- 2026=>2027 some mission funding (~50k)