Project Board Pre Meeting

Activities in 2026-2027 towards the future and FP10

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Project Board Pre Meeting and FP 10 Brainstorming

- Thursday: 2027 Perspectives and Priorities and additional desired budget by WPs including attempt of prioritization
- **Friday: FP10 outline of scientific priorities and activities in 26/27 towards FP10**

Aim: Discuss and outline ideas of physics and physics – engineering boundaries and their priorities in view of FP10 and identify if and which impact this could/should have on activities in 26/27 that are either part of the AWP, but might not be sufficiently visible or are lacking in the AWP and could need corrections if budget became available in 26/27.

Towards FP10

- Discussions on revising the EU Roadmap for fusion-based energy are still **in progress**, and no definitive strategic direction has been issued. A communication by the EC is expected in the first half of 2026.

- Established funding for Go4Fusion with aim to accelerate nuclear fusion development by building a new European Public-Private Partnership (PPP), a co-programmed collaboration between public and private entities.

  - Creation of a new industry led association Fusion Now

- The boundary conditions for the “EUROfusion” activities towards FP10 are not clear; it likely remains an indirect co-funded activit will it remain a training and education research grant? Will appl for this grant remain unique to “EUROfusion”? Will it remain a c funded European partnership or become or fall under a EURATC joint undertaking (similar to F4E or under F4E?)

*link to the EC article of 15 April 2025 *In focus: Europe’s road to fusion energy*

Assumption for discussion

- *Business as usual, i.e. a co-funded European partnership – aka EUROfusion*
- The main scientific priorities for physics and physics-engineering research are independent of the funding scheme
- The funding scheme and amount will determine how and which of these priorities could be pursued inside a future organization
- The ideas brought forward for/towards FP10 are “brainstorming” in nature with an attempt to try to rethink (content / structure / connections / structural problems and their possible solutions)
- Some kind of working group would be installed by the GA to prepare FP10 and physics might be (even maybe on short notice) asked for input at some point → *collect your thoughts as WP leaders*
- Build on the strength of the present EUROfusion programme: its coherent goal-oriented programme, facilitating joint access to the exploitation of devices and infrastructure that attempts to provide added value
- Try to overcome the risk of (at least perceived) fragmentation of European programme in e.g. F4E, PPP, national programmes and private initiatives: in all cases “EUROfusion” could continue playing a determining role for facilitating a coherent research and training activity

FP10: 2028 - 2034

- ITER: will start operation in 2035 and increasing activities in preparing operations as well as commissioning of subsystems will become important
- MST: AUG/WEST/TCV/MAST-U will be in operation
- COMPASS-U: likely in operation towards end of FP10
- SPARC
- BEST from ~2028 with Q>1 from ~2030
- JT-60SA with C wall and transition to W/metal wall
- DTT

WEST expected availability and planned upgrades

Availability:

- **2028**: 3 months plasma campaign (ITER-like tungsten first wall upgrade)
- **2029-2034**: 6 months plasma campaigns per year (~2x3months)

Planned upgrades:

- **First Wall → *full tungsten ITER-like, 15MW-1000s heat exhaust capability***
- **TBM port plug → *cold test of mock-ups***

- **H&CD → *15MW-1000s***
  - *ECRH (1 launcher) 3MW-1000s, LHCD (2 launchers) 6MW-1000s, ICRH (2 TWA launchers) 6MW-1000s*
- **Fuelling & pumping → *improved divertor pumping, pellet injector and new tracks***
- **Diagnostics → *FILD, Neutrals diag., divertor LIBS, edge XICS***
- **Wall conditioning → *new boronization system + associated diagnostics, ICWC and ECWC capability***

- **High Duty Operation → 100h+ plasma/year**

ASDEX Upgrade Schedule 2027 and beyond

Current Planning until 2034 sees year 2027 as blue print

Upgrades of up to three versions of baffles in upper divertor foreseen in 2028, 2029 and 2030, but upgrades will prolong the vent only by weeks rather than months.

DTT outlook FP10

- the present schedule foresees the DTT first plasma middle 2032.

- The activity during the initial phase is under discussion.

MAST-U outlook FP10

We have a reasonably detailed plan until 2029, with the following physics campaigns:

- February 2028 - September 2028: MU06 campaign
- May 2029 - December 2029: MU07 campaign

After 2029, the plan for MAST-U is more uncertain, depending on the outcome of funding decisions from the UK government to operate the device and whether any further improvements to the machine are made. Assuming MAST-U is funded to continue operating with no major refurbishments or upgrades to the machine, we would aim to run physics campaigns for 6 months each year, with this very approximate timing:

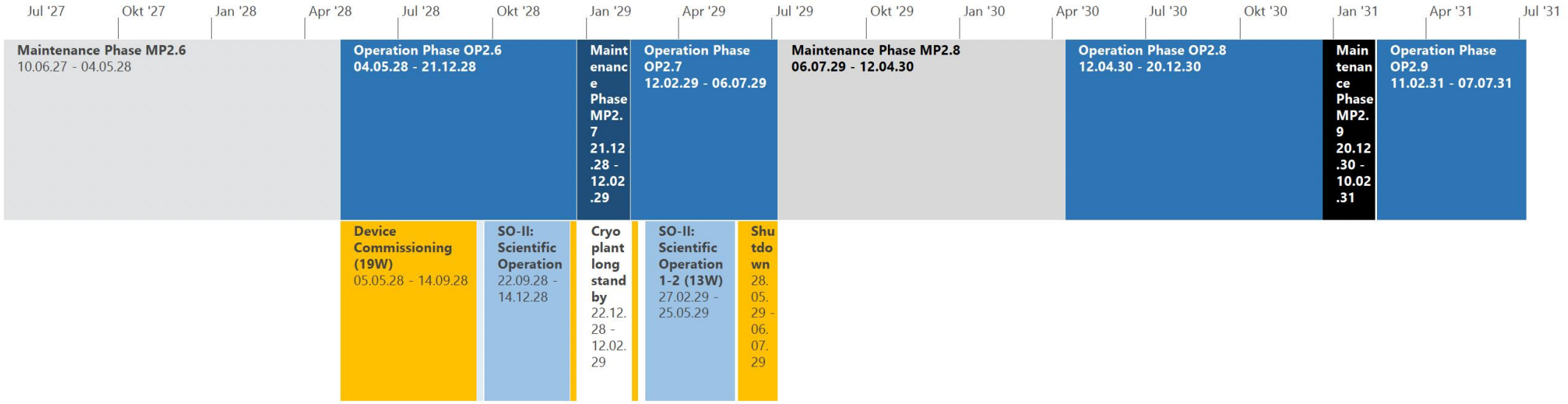
- June 2030 - December 2030: MU08 campaign
- June 2031 - December 2031: MU09 campaign
- June 2032 - December 2032: MU10 campaign
- June 2033 - December 2033: MU11 campaign

However, it is highly likely that significant refurbishments to MAST-U will be required to replace critical components in this period, so please treat these dates from 2030 onwards as very uncertain.

TCV outlook 2026-2034

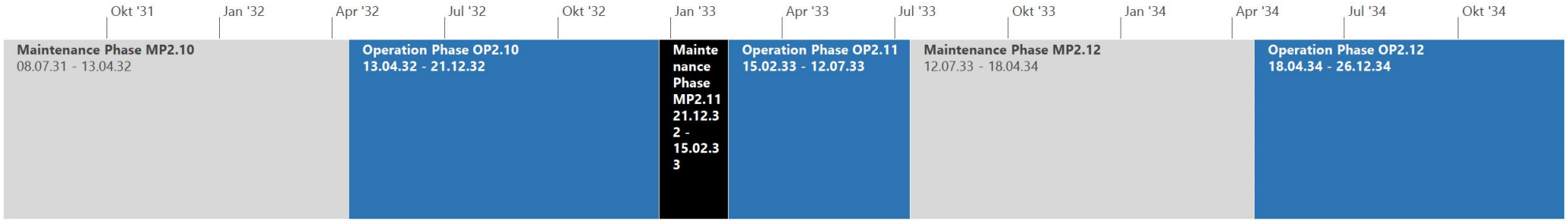
- 2026-2027 upgrades:
  - Tightly-Baffled Long-Legged Divertor (TBLLD)
  - 2 additional 1-MW dual-frequency (X2+X3) gyrotrons
  - Runaway Electron Mitigation Coil (REMC)
  - Adjustable toroidal field ripple for runaway electron mitigation
- 2028-2029 upgrades:
  - Follow-up of TBLLD, to be decided (possibilities: upgraded version of TBLLD, passive stabilizer plates to optimize negative triangularity, array of divertor pumps)
- It is broadly expected that TCV will remain in operation at the current yearly rate through 2034

Operation planning 2028 - 2031



- current schedule of operation planning foresees a regular sequence over the upcoming years without major interruptions
- scheme follows running „double campaigns“ to allow a rather long plasma operation with onlys one commissioning period

Operation planning 2031 - 2034



- exactly the same scheme will be followed in subsequent operation campaigns, with commissioning being part of the operation phase

Main system upgrades

- **key improvements focus on the extension of plasma heating power via ECRH and NBI**
  - NBI extension planned from currently 4 to 6 sources, increasing the plasma heating power from ~8MW to ~12MW
  - ECRH extension involves three different schemes
    - fill remaining gyrotron and beam line slots to in total 12 heating gyrotrons
    - continue installation of newly developed 1.5MW gyrotron (delivery of 3 gyrotrons planned in years 2027, 2028, 2029)
    - development and delivery of prototype 2MW gyrotron in year 202
- **installation of additional main 20kV transformer**
  - to provide sufficient power to support heating power extension
  - increase of power from currently ~50MW to ~85MW in year 2027

Main planned diagnostics upgrades

- **improvement of divertor heat flux observation underway**
  - new IR endoscope system viewing the entire divertor and baffle structures
- **multi-channel interferometry**
  - installation of multi-beamline interferometry system for the reconstruction of density profiles and density peaking
- **heavy ion beam probe**
  - direct measurement of radial electric field
  - measurement of turbulent density transport ranging from plasma core to edge
- **likely additional diagnostics systems for investigations of plasma edge and SOL behavior**

JT-60SA / QST

- Should there be organizational changes for sustaining the human resources required to support the JT-60SA scientific exploitation as well as the subsystems provided to JT-60SA/QST?
- How to keep the competence and at the same time reinforce the operativity and the scientific output of the many subsystems in delivery to QST? The present status is that whatever subsystem has passed the acceptation phase (commissioning) is QST property and EU teams that developed it are treated as a normal user.
- How to ensure that the SRL tracking in TE incorporates the activities in the JT-60SA related RT? How could the integration of the European contribution proceed in view of the present boundary conditions with a one team approach, the TG structure,…?

BEST

- BEST research plan published at end of November 2025

- Aim for EUROfusion: identify and evaluate the potential of BEST as a DT device (credibility of performance claims) --> where is BEST considered essential and beneficial (also in view of JT-60SA)?
- Interest in BEST has been triggered, but not all RU will have an appetite to engage
- Is engaging in BEST a fruitful cooperation that should be promoted?
- Should there be an attempt to have a joint and co-coordinated approach? BEST will (and is) likely approaching individuals and individual RUs for specific tasks of their need. Should it be a JT-60SA like engagement or more like a PPPL engagement in W7-X or more a standard INCO activity level?
- Topic of data access not finalized but possibly an agreement on EC level (willingness on BEST side to provide access)
- Presently activity to identify diagnostics for which there could be an interest to have these on BEST from Europe (S. Zoletnik to report to GA in April)
- Keep in touch funds available in INCO (1ppy to be used in 2026 extending some of the activities initiated in the BEST research plan, e.g long pulse)
- How long will the engagement last? (Likely high interest across all of FP10 to achieve high current and DT as fast as possible following the present BEST timeline)
- Balance of engagement in JT-60SA and BEST – or is it for EF just about providing opportunities?

DTT & COMPASS - U

- EUROfusion asked to be engaged in further developing / revising / reviewing the DTT research plan → on the agenda of PSD/FSD since autumn 2024 but waiting finalization of discussion of pilot plant as the choice could have an impact on what possible role DTT could play
- Continued delay and low initial heating power limiting factors in present engagement
- An evaluation of the DTT research plan will eventually be required as there is a high appetite for the device to be exploited mostly as European facility

International collaborations

- EU-US agreement on small/no ELMs – in the pipeline since 2019 as an idea; since 2023 as a workplan… (most activities I believe are covered by ITPA activities anyways…)
- EU-KO (issue with signatories and desire for Korean participation to European devices)
- EU-In / EU-Ca: will physics be involved…?
- A lot of these collaborations are born from a desire to extend the international collaboration from the EC side and are considered as part of strategic partnerships for the EC

Participation to ITER with start of operation in 2035 beyond FP10

- increasing activities in preparing operations as well as commissioning of subsystems will become important
- There appears to exist a layout for the evolution of operator training that is started in 2026
- The involvement of EUROfusion scientists in the exploitation of ITER remains unclear (to me) – there exists a whitepaper from 2020/2021 “EUROfusion role in ITER operation and scientific exploitation” (X. Litaudon) – and the issue has been discussed several times with limited outcome (e.g. EFPW 2023)

Need of a central physics unit at PMU / extension combination with PSD in DCT?

- At the General E-TASC meeting the idea was brought up if there would be for certain (which?) activities the desire to have similar to WPDES and the DCT a centralized physics unit that could support with supplying modelling resources to activities that appear to have difficulties being executed but are seen by the community as indispensable modelling activities – these would need to be identified and argued for why and or/that this does not progress in the normal scheme with 55% funding rate

Collaboration with private companies ?

- Personal opinion: EUROfusion likely not able to directly interact with a private company, but could be involved in facilitating research undertaken by several RU with a private company if that would accelerate achieving the agreed consortium workplan goals
- Main question is what is the scope and how?
- Is the interest more limited to the access of devices e.g. smaller EF RUs might be likely excluded from accessing a device like SPARC as CFS (naturally) selects it partners that are of value to the success of the project – different to the possible device being built as research platform?
- Which are devices or projects that would be of interest and engagement could provide added value and why or how?

Development of codes and role of physics for digital twins

- The present scheme has provided great progress in code development
- Deployment and dissemination of codes remains an issue
- The organization of work for extrapolations to ITER is not always clear across work packages (who does or should do it – see discussion on Thursday)
- Personal hope: 26/27 will help to smoothen the communication between TSVVs/WPs and enhance the application/deployment of those codes that are ready for deployment at a specific scale (TCV/AUG/JET/JT-60SA) & desire for an increase engagement in JT-60SA as soon as experimental data will become available in 2027 and beyond
- Several issues regarding data access and common data for code validation discussed in General E-TASC meeting
- Digital twins: while many definitions exist – one may think of EF providing tools that can help accelerating designs and design reviews possibly as primary objective (?)