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# Annex 1: WLTE Research Topics for 2025 Experimental Campaign

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The present document describes the structure of Research Topics under WLTE in 2025. For each Research Topic, a **list of Scientific Objectives**, derived from the Consortium Workplan, is provided together with the WLTE devices where these objectives can be addressed.

In 2025, the same structure of 9 Research Topics as in the previous year will be maintained. This choice underlines the continuity of the WLTE program which is built to fulfil the two main missions: prepare ITER operation<sup>1</sup> and guide DEMO design<sup>2</sup> including the assessment of alternative divertor solutions. The work performed in previous year laid the foundation of the WLTE program and it is the intention to progress further on the objectives of each of the Research Topics which still reflect the main priorities of the research effort. We are aiming to continue the strong team effort to facilitate the technical and scientific realisation of these objectives.

The present Call for Proposals aims at collecting new experimental proposals to be carried out in the participating devices (ASDEX-Upgrade, TCV, MAST-U and WEST in 2025). Any analysis and modelling effort (including those for the past JET campaigns) will be reflected in the workplans addressing the individual scientific objectives and to be entered in the Call for Participation (to be launched later in October 2024). Therefore, the analysis and interpretative modelling of experimental data from previous campaigns will be an integral part of the activities inside each Research Topic.

Please note the following guidelines when preparing your proposals:

- Proposals are expected to be **well-structured**, built around a core team, taking advantages of the specific features of each device and considering the achievements from past Campaigns.
- Proposals should consider the **operational boundary conditions** and the diagnostic capabilities (Annex 2) and machine schedules (Annex 3).
- Proposals for **multi-machine experiments** making the best use of specific capabilities of WLTE devices are strongly encouraged.
- Proposals should also consider the new investigation needed in support of the proposed ITER rebaselining and the foreseen modification of PFC material. On this respect, proponents might consider the material presented by ITER representatives in the last EPS / PSI Conferences, as well as the indication provided by the different ITPA groups which assessed the possible implication of proposed change on the ITER expected scenarios. Background documents have been made available on the wiki-page for proper consultations.
- Proposals that will aim to make use of the 4 EU devices in this call (ASDEX-Upgrade, MAST-U, TCV and WEST) to address the preparation for the scientific exploitation of JT60-SA are also welcome.

Experimental proposals derived explicitly from TSVV activities aiming at undertaking benchmarking or validation exercises against experimental data are strongly encouraged.

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<sup>1</sup> [https://wiki.euro-fusion.org/images/1/1b/ITPA\\_CC\\_Workbook.xlsx](https://wiki.euro-fusion.org/images/1/1b/ITPA_CC_Workbook.xlsx)

<sup>2</sup> [https://wiki.euro-fusion.org/images/a/ad/Demo\\_priorities.pdf](https://wiki.euro-fusion.org/images/a/ad/Demo_priorities.pdf)

- TFLs encourage the proponents to discuss **with the current Research Topic Coordinators** in advance of the deadline to avoid duplication and to use the machine time available in the best possible way through combined and coherent proposals.

#### Research Topic RT01: Core-Edge-SOL integrated H-mode scenario compatible with exhaust constraints in support of ITER

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- Devices: AUG, TCV, MAST-U, WEST
- Scientific Objectives:
  - D1. Develop and understand stationary H-mode scenario at low collisionality and with dominant electron heating
  - D2. Provide physics-based cross-field transport coefficients to TSVVs (1, 3, 4 and 11) for turbulence modelling
  - D3. Determine the impact of different impurity mixes for partially detached divertors in high power operations in view of ITER radiative scenarios
  - D4. Assess pedestal performances in condition closer to future devices including large SOL opacity, low pedestal collisionality, peeling limited plasma
  - D5. Quantify impurity screening for high temperature pedestals

#### Research Topic RT02: Physics understanding of alternatives to Type-I ELM regime

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- Devices: AUG, TCV, MAST-U, WEST
- Scientific Objectives:
  - D1. Quantify turbulent and MHD driven transport in the vicinity of the separatrix and implications for predictions for ITER and DEMO
  - D2. Quantify first wall load in no-ELM scenarios and provide model for SOL transport extrapolation
  - D3. Extend the parameters space of no-ELM scenarios to pedestal top collisionalities relevant for ITER and DEMO
  - D4. Determine the key physics mechanisms regulating edge transport in order to access no-ELM regimes
  - D5. Determine access window and physics understanding for RMP ELM suppression and its compatibility with ITER FPO scenarios
  - D6. Quantify the overall performance of negative triangularity plasmas in view of DEMO

#### Research Topic RT03: Strategies for disruption and run-away electron mitigation

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- Devices: AUG, TCV, WEST
- Scientific Objectives:
  - D1. Optimize disruption and run-away electron mitigations by single and multiple shattered pellet injection (SPI) at high plasma current and energy content in an all-metal environment to validate the ITER disruption mitigation strategy
  - D2. Quantify the required neon quantity for SPI into dilution cooled plasmas for sufficient thermal and current quench mitigation in ITER and the synchronisation requirements for dual deuterium/neon SPI in ITER
  - D3. Characterize/optimize the RE impact mitigation schemes and their interactions with the RE companion plasma with different hydrogen/deuterium injection techniques
  - D4. Determine the physics mechanisms generating run-away electrons in the current quench and in the plasma start-up phase
  - D5. Interpretative modelling of disruption mitigation dynamics (TSVV-8, TSVV-9) for the current devices and prediction for ITER
  - D6. Quantify the radiation asymmetry during disruption mitigation with SPI
  - D7. Validate the modelling of image currents in conducting structures during disruption with halo current measurements

#### Research Topic RT04: Physics-based machine generic systems for an integrated control of plasma discharge

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- Devices: AUG, TCV, MAST-U, WEST
- Scientific Objectives:
  - D1. Develop MIMO (Multi-Input Multi-Output) state-observers for e.g., radiative detachment control on different devices
  - D2. Develop machine independent strategies for the H-mode entry and exit and off-normal events supported by modelling
  - D3. Develop and test disruption avoidance schemes and apply them on several different devices
  - D4. Develop robust strategies to optimize error field corrections supported by modelling
  - D5. Optimize plasma start-up and current ramp-up schemes supported by modelling in ITER like scenarios

#### Research Topic RT05: Physics of divertor detachment and its control for ITER, DEMO and HELIAS operation

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- Devices: AUG, MAST-U, TCV, WEST
- Scientific Objectives:
  - D1. Characterize detachment access and core plasma performance in scenarios using different fuelling schemes, different impurity mixtures
  - D2. Development of reduced physics model which can be included in radiative detachment control schemes or extrapolations to DEMO/ITER
  - D3. Quantify edge-SOL particle and heat transport, including the interaction with neutrals, above and below the X-point under detached conditions
  - ~~D4.~~ Assess the compatibility and stability of X-point radiator regimes with confinement
  - D5. Quantify the degree of ELM heat load mitigation achievable by impurity seeding, investigating the dependences on relevant machine parameters
  - D6. Assess the evolution of detachment under slow transients (L-H transitions, sawtooth, loss of impurity seeding)

#### Research Topic RT06: Preparation of efficient Plasma Facing Components (PFC) operation for ITER, DEMO and HELIAS

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- Devices: AUG, WEST
- Scientific Objectives:
  - D1. Quantify local power load distributions on castellated and shaped PFCs for ITER and DEMO, including melting events using experimental data and predictive modelling
  - D2. Assess the impact of sustained high power / high particle fluence plasma exposure on the thermo-mechanical properties of metallic PFCs as well as on plasma operation
  - D3. Quantify material erosion sources from metallic walls under ITER relevant plasma conditions (including high power and impurity seeding plasmas) and determine material migration pathways, in particular to assess the net erosion rates.
  - D4. Quantify fuel retention in devices with metallic walls, with a focus on long pulse operation (using recent fuel retention diagnostic upgrades such as laser-based diagnostics where available) and including impact of boronisations
  - D5. Determine fuel-removal in metallic devices in conditions relevant for ITER (including the impact of boronisation) and extrapolate to DEMO

D7. Assess efficiency and lifetime of conditioning methods in metallic devices, with a focus on boronisation<sup>3</sup>

#### Research Topic RT07: Physics understanding of alternative divertor configurations as risk mitigation for DEMO

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- Devices: AUG, TCV, MAST-U, WEST
- Scientific Objectives:
  - D1. Determine detachment onset, radiated power fractions, and core compatibility in H-mode for different alternative divertor configurations (ADCs) and characterization of ELM activity in view of pedestal, heat flux and control in ADCs
  - D2. Characterize possible benefits of snowflake and other ADCs with multiple X-point configurations for X-point radiation stability and dissipated power in H-mode
  - D3. Quantify the degree of heat load mitigation during transients (including ELMs) achievable by impurity seeding and investigate the dependences on relevant machine parameters
  - D4. Evaluate reduced SOL models against ADCs

#### Research Topic RT08: Physics and operational basis for high beta long pulse scenarios

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- Devices: AUG, TCV, MAST-U, WEST
- Scientific Objectives:
  - D1. Consolidate understanding of flux pumping mechanism and extrapolate to ITER/DEMO/JT-60SA
  - D2. Quantify compatibility of high  $\beta_N$  long-pulse with mitigated ELMs and/or with exhaust in metallic devices in view of subsequently testing the scenario in JT-60SA W-wall and extrapolating to ITER and DEMO
  - D3. Characterize the fast and thermal ion transport together with the ExB, magnetic shear, turbulence conditions in steady-state scenarios at high-q
  - D4. Develop projection schemes of long pulse at high  $\beta_N$  as a potential reactor scenario
  - D5. Develop an intrinsically steady-state solutions at high  $\beta_N$  ( $>3$ ) in terms of q/pressure profile with mild MHD activity ( $q_{\min} \geq 1$ ), and compare it to the expected JT-60SA and DEMO scenarios particularly in terms of extending operational space toward high Gw fractions
  - D6. Develop steady-state scenarios in metallic devices at high  $\beta_N$  in conditions of MHD characteristics close or above the no-wall ideal limit and assess feasibility on JT-60SA in view of DEMO.

#### Research Topic RT09: Physics understanding of energetics particles confinement and their interplay with thermal plasma

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- Devices: AUG, TCV, MAST-U, WEST
- Scientific Objectives:
  - D1. Provide high quality diagnostic information and qualify diagnostic analysis techniques for the characterization of confined and lost fast ions with fast ion characteristics relevant for ITER and JT-60SA
  - D2. Quantify ion and electron heating and core-turbulence stabilisation by fast ions (FI) in view of the JT-60SA, ITER and DEMO including tailored FI energy profiles and radial locations relevant to JT-60SA.

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<sup>3</sup> Note that the previous Scientific Objectives D6, dealing with gross vs net erosion is no longer in use and it is embedded into D3. For sake of consistency the new Scientific Objectives on conditioning has been numbered D7

- D3. Quantify the impact of fast ions and fast ion MHD driven instabilities on transport in various scenarios including those relevant to JT-60SA in view of ITER and DEMO.
- D4. Integrate the available heating, fast-ion and transport modelling tools for interpretation of experimental results in view of ITER and DEMO
- D5. Quantify fast-ion losses and associated heat load from edge perturbations (ELMs and RMPs)
- D6. Quantify neutral beam current drive and make predictions for ITER
- D7. Identification of AE control actuators and preliminary assessment for ITER, using JT-60SA relevant scenarios where appropriate for eventual experimental testing