# Risposta Italiana a WPTE call 2022/23

11/07/2022

M. Baruzzo, N. Vianello

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# WP Organization: Changes undertaken for 2022/2023 programme in D

## 2021 → 1st half 2022

| | Research Topics | |
|---|---|---|
| RT1 | ITER Baseline scenarios towards low collisinality and detachment | ITER Scenario |
| RT2 | H-mode entry and pedestal dependence with impurities and isotopes | ITER Scenario |
| RT3 | RF-assisted breakdown and current ramp-up optimization | ITER Scenario |
| RT4 | Disruption avoidance and control for ITER and DEMO | ITER Scenario |
| RT5 | Run-away electron generation and mitigation | ITER Scenario |
| RT6 | ELM mitigation and suppression in ITER/DEMO relevant condition | ITER Scenario |
| RT7 | Negative triangularity scenarios as an alternative for DEMO | DEMO Scenario |
| RT8 | QH-mode and I-mode assessment in view of DEMO | DEMO Scenario |
| RT9 | Extension of EDA and QCE performance towards DEMO | DEMO Scenario |
| RT12 | Development of the steady state scenario | DEMO Scenario |
| RT10 | Fast-ion physics with dominant ICRF heating | Burning plasma |
| RT11 | Impact of MHD activity on fast ion losses and transport | Burning plasma |
| RT13 | X-point radiation and control | Exhaust (PEX) |
| RT14 | Physics of plasma detachment / impurity mix/ heat load patterns | Exhaust (PEX) |
| RT15 | Extrapolation of SOL transport to ITER and DEMO | Exhaust (PEX) |
| RT18 | Alternative divertor configurations | Exhaust (PEX) |
| RT16 | PFC damage evolution under tokamak conditions | PFC (PEX) |
| RT17 | Material migration and fuel retention mechanisms in tokamaks | PFC (PEX) |

## 2nd half 2022 & 2023

| | Research Topics |
|---|---|
| RT1 | Core-Edge-SOL integrated H-mode scenario compatible with exhaust constraints in support of ITER |
| RT3 | Strategies for disruption and run-away mitigation in support of the ITER DMS |
| RT4 | Physics-based machine generic systems for an integrated control of plasma discharge |
| RT8 | Physics and operational basis for high beta long pulse scenarios |
| RT2 | Physics understanding of alternatives to Type-I ELM regime |
| RT9 | Physics understanding of energetics particles confinement and their interplay with thermal plasma |
| RT5 | Physics of divertor detachment and its control for ITER, DEMO and HELIAS operation |
| RT7 | Physics understanding of alternative divertor configurations as risk mitigation for DEMO |
| RT6 | Preparation of efficient Plasma Facing Components (PFC) operation for ITER, DEMO and HELIAS |

# Scientific progress poses challenge of physics and control integration of Programme

**ITER**

**RT01: Core-Edge-SOL integrated H-mode**

**DEMO**

**RT02: Alternative to type-I ELM regimes**

**Physics & Control integration**

**RT03: Disruption & RE mitigation strategies**

**RT04: Machine generic integrated control**

**RT05: Physics of divertor detachment**

**RT08: Physics of high β long pulse scenario**

**RT09: Physics of energetic particles**

**RT06: preparation of efficient PFC operation**

**RT07: Alternative divertor configuration**

**PEX**

| Mission 1 | Mission 2 |
|---|---|

# The RTs, Research Topic Coordinators, TFLs and other relations foreseen until end 2023

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| RT22-01 | L. Frassinetti | C. Giroud | S. Wiesen | D. King | **AK**/NV/MW | IOS/PEP/DSOL | JET,TCV, MAST-U, WEST | |
| RT22-02 | M. Faitsch | M. Dunne | O. Sauter | E. Viezzer | **BL**/*AK/MW* | PEP | JET, TCV, MAST-U, WEST | DCT |
| RT22-03 | O. Ficker | U. Sheikh | C. Reux | S. Jachmich (M. Lehnen) | **AH**/MB/EJ | MDC | JET, TCV, WEST | |
| RT22-04 | F. Felici | B. Sieglin | L. Piron | | **MB**/BL/EJ | IOS | JET, TCV, MAST-U, WEST | PrIO |
| RT22-05 | H. Reimerdes | M. Bernert | D. Brida | N. Fedorczak | **NV**/ET/MW | DSOL | JET, TCV, MAST-U, WEST | |
| RT22-06 | Y. Corre | A. Winddowson | K. Krieger | | **ET**/AH/EJ | DSOL | JET, WEST | PWIE |
| RT22-07 | C. Theiler | K. Verhaegh | | | **NV**/AH/MW | | TCV, MAST-U | PWIE |
| RT22-08 | A. Burckhart | C. Piron | R. Dumont | | **DK**/MB/EJ | IOS | JET, TCV, MAST-U, WEST | DCT |
| RT22-09 | J. Galdon | M. Vallar | Y. Kazakov | | **DK**/AK/MW | FP | JET, TCV, MAST-U, WEST | |

## Allocated machine resources to the various RTs for the period 2022/23

# Machine allocation (following priority discussion)

| RT | JET (sessions) | | TCV (pulses) | | MAST-U (pulses) | | WEST (pulses) | |
|---|---|---|---|---|---|---|---|---|
| year | 2022 | 2023 | 2022 | 2023 | 2022 | 2023 | 2022 | 2023 |
| RT22-01 | 20 | 15 | 50 | 110 | 34 | 30 | 15 | 0 |
| RT22-02 | 10 | 15 | 50 | 100 | 40 | 35 | 15 | 0 |
| RT22-03 | 30 | 15 | 60 | 70 | 0 | 0 | 0 | 30 |
| RT22-04 | 5 | 9 | 50 | 100 | 30 | 25 | 15 | 15 |
| RT22-05 | 7 | 6 | 70 | 70 | 40 | 45 | 0 | 30 |
| RT22-06 | 4 | 8 | 0 | 0 | 0 | 0 | 30 | 105 |
| RT22-07 | 0 | 0 | 70 | 100 | 50 | 50 | 15 | 0 |
| RT22-08 | 4 | 4 | 50 | 50 | 35 | 50 | 15 | 15 |
| RT22-09 | 4 | 4 | 40 | 80 | 20 | 25 | 0 | 0 |
| Contingency | 40 | | 270 | | 131 | | 70 | |

Split among 2022-23 subject to change according to machine time availability

N. Vianello| 2022-23 Pulse allocation| Remote |15/06/2022| Page 7

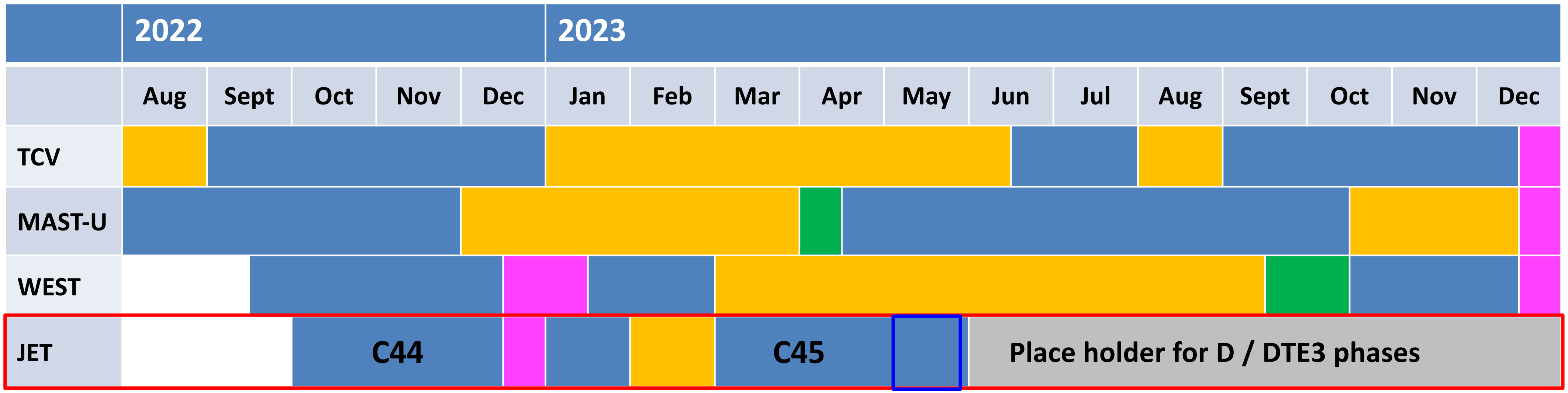
**NEW:**

❖ From 2022/23 campaign introduction of regular 3 TFLs + RTCs + other people as TSVV Pis / ITPA members / PLs (or sub project leaders)

❖ Call for participation for 2022/2023 (JET until end May 2023) has been launched and closes on 22nd of July 2022

# View at the timeline

- For 2022-23, WPTE has developed a unified Scientific Programme (GPM last week) spanning over all 4 devices
- For JET, the second half of 2023 was kept open, awaiting for the decision on DTE3 and the DT & TT analysis results. The contingency kept in May will be impacted by the recent delays of C42. A DTE3 phase requires a cleanup phase in October/November 2023 (time blocked for compatible experiments)
- The programme has been built on an assumption of 200 sessions in deuterium until end of May 2023
- JET delayed start from early June to 07/07/2022; He campaign cut from 80 to 70 sessions
- **Even though AUG is not operating during this call, WPTE activity on AUG data can be carried out if propaedeutic to RT scientific goals (in the response to the call please indicate a different tokamak and explain the work in the work plan)**



# Use of Work Awareness table in WP TE wiki may ease definition of status as well as progress of SSRL

## STRATEGY [ edit | edit source ]

[Collapse]

- *Please describe here the overall strategy to achieve each of the scientific objectives as they appear above, by defining specific deliverables for the Research Topic.*
- *Include information both on the experimental strategy as well as for the analysis and modelling plan.*
- *The strategy should cover details for the experiments in each of the devices individually, when appropriate, but also the interrelati... ...n between them.* ***It is important to identify leaders for each of the task in order to properly distribute the workload amon... ...ho need to report on what***

| No | Task | Deliverable | Report by (month) | Device (Pulse planned/achiev... or ... | Estimat... | ...ment / ...on (date) |
|---|---|---|---|---|---|---|
| T1 | | | | | | |
| T2 | | | | | | |

| |
|---|
| EXPERIME... |
| • ... |
| ANALYSIS A... ...LAN |
| • ... |

Nomination of task leaders by RTCs (may execute experiments, coordinate modelling, lead sub projects like cross contact with other RT, diagnostic needs, identifying scarces resources, maintaining sections of wiki, reporting at meetings, or with e.g. control related issues of experiment)

(also sometimes referred to as “work awareness table”)

# JET CR expertise

- Control room roles for JET: Please note that your participation in the JET campaign can include time as Session Leader (SL), Diagnostic Coordinator (DC), **MHD expert and TRANSP Expert .**
- When replying to the Call in IMS, select the campaign/experiment RT22-CR JET Control Room Roles (IMS tag "RT10"), then the Competence "Other" and finally indicate Session Leader or Diagnostic Coordinator as workplan.
- The other roles in the control room, such as Viewing System Operator (VSO) or Plasma Duty Officer (PDO) are not supported by WP TE.

# RT22-01: Core-Edge-SOL integrated H-mode scenario compatible with exhaust constraints in support of ITER

| # | |
|---|---|
| D1 | Develop stationary high power H-mode scenario at low core and pedestal collisionalities compatible with detached divertor |
| 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 with large SOL opacity |
| D5 | Determine pedestal stability and transport characteristics at large plasma current (>3MA) |
| D6 | Quantify impurity screening for high temperature pedestals |
| D7 | Assess the compatibility and stability with X-point radiator regimes with confinement |

Integrated H-mode scenario in ITER-like divertor condition is one of the main missions of DTT

# RT22-02: Physics understanding of alternatives to Type-I ELM regime

| # | |
|---|---|
| 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 large $P_{sep}$/R and/or pedestal top collisionallities 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 |

Low ELMs/no EMLs scenario at large Psep/R are also key physics items of DTT, and 3D coils system adds further tools to address it

# RT22-03: Strategies for disruption and run-away mitigation

| # | |
|---|---|
| D1 | Optimize disruption 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 flushing effect with different deuterium injections 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) 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 |

Disruption mitigation studies are also among the capabilities of DTT, where a SPI-based DMS in collaboration with ITER is planned.

# RT22-04: Physics-based machine generic systems for an integrated control of plasma discharge

| # | |
|---|---|
| D1 | Develop and implement state-observers for physical plasma quantities on different devices in particular for radiative detachment control |
| 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 |

Development of PCS (plasma control system) and focus of algorithms and capabilities needed is an important point for DTT

# RT22-05: Physics of divertor detachment and its control for ITER, DEMO and HELIAS operation

| # | |
|---|---|
| D1 | Characterize detachment access and core plasma performance in scenarios using different fuelling schemes, different impurity mixtures |
| D2 | Develop Control schemes for radiative detachment, transferable to DEMO/ITER |
| D3 | Quantify edge-SOL particle and heat transport in detached conditions |
| D4 | Characterize the interaction between plasma transport, neutrals (i.e. molecules) and the impact of baffling |
| 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) |

Detachment studies are also in the main mission of DTT

# RT22-06: **Preparation of efficient Plasma Facing Components (PFC) operation for ITER, DEMO and HELIAS**

| # | |
|---|---|
| D1 | Quantify local power load distributions on castellated and shaped PFCs for ITER and DEMO, including melting situations using experimental data and predictive modelling |
| D2 | Assess the impact of sustained high power / high particle fluence plasma exposure of metallic PFCs |
| 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 |
| 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) |
| D5 | Determine fuel-removal and conditioning efficiencies in metallic devices in conditions relevant for ITER PFPO and extrapolate to DEMO |
| D6 | Quantify the balance between gross and net erosion of W under different operational conditions |

Plasma-Wall interaction also within the main missions of DTT

# RT22-07: Physics understanding of alternative divertor configurations as risk mitigation for DEMO

| # | |
|---|---|
| D1 | Determine detachment onset, radiated power fractions, and core compatibility in H-mode for the alternative divertor configurations (ADCs) and characterize ELM activity in view of pedestal, heat flux and control in ADCs |
| D2 | Characterize possible benefits of the snowflake configuration for X-point radiation stability and dissipated power in H-mode |
| D3 | Quantify the degree of ELM heat load mitigation achievable by impurity seeding, investigating the dependences on relevant machine parameters |
| D4 | Evaluate reduced SOL models against ADCs |

Alternative Divertor studies also within the main missions of DTT

# RT22-08: **Physics and operational basis for high beta long pulse scenarios**

| # | |
|---|---|
| D1 | Develop scenarios to assess the flux pumping mechanism efficiency |
| D2 | Quantify the compatibility of high b long pulse with mitigated ELMs and/or with exhaust in metallic wall devices |
| 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 as a potential reactor scenario |
| D5 | Develop an intrinsically steady state solution at high $\beta_N$ (>3) in terms of q/pressure profile and stability. Compare it with other existing solutions in view of its application to JT-60SA and DEMO |

- Long pulse non inductive scenarios are feasible and within capabilities of DTT current drive system, including integration with DEMO relevant pedestal and edge

- **High Beta steady state scenarios are a key physics element of JT60SA programme**

# RT22-09: Physics understanding of energetics particles confinement and their interplay with thermal plasma

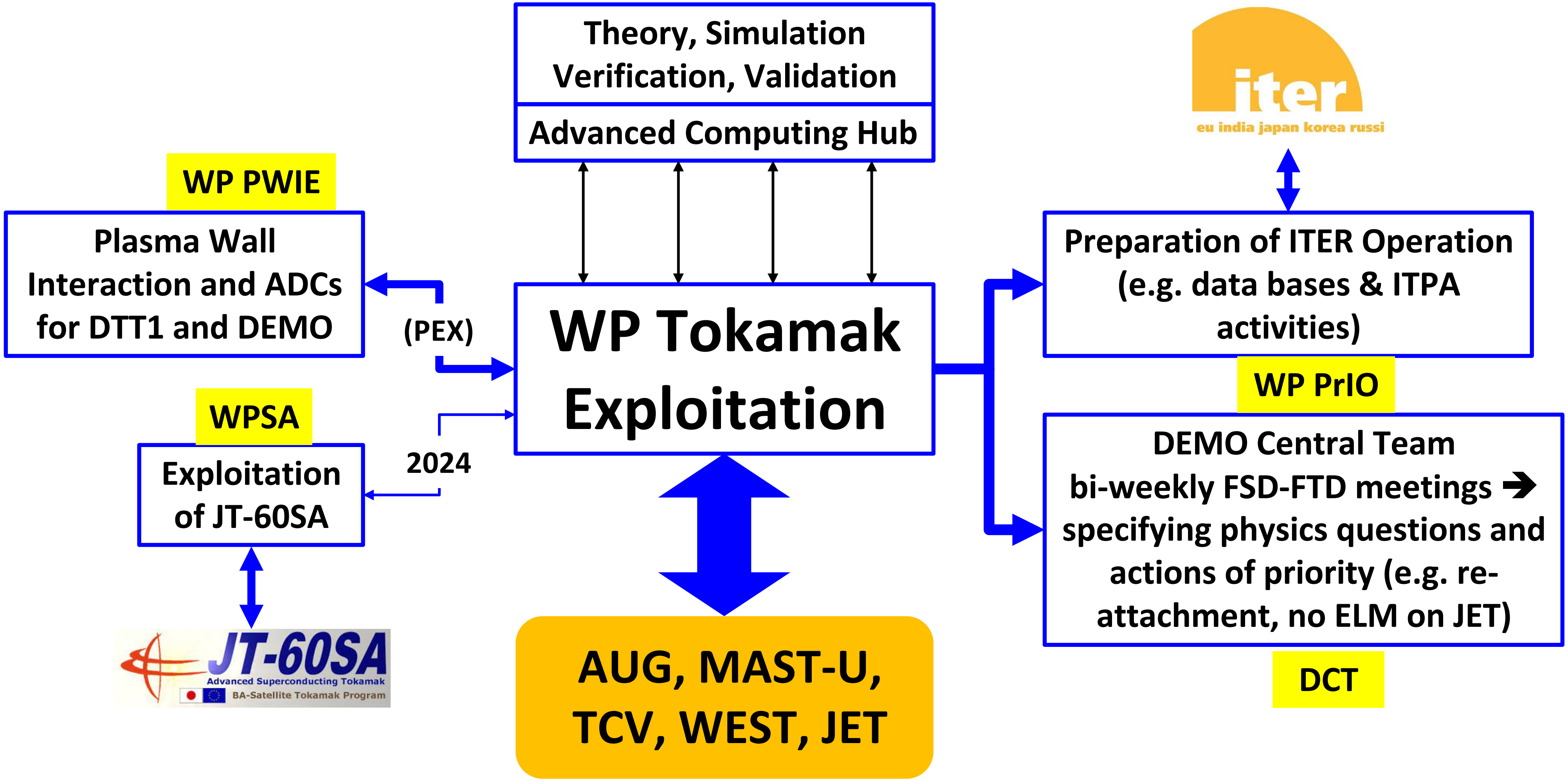
| # | |
|---|---|
| D1 | Provide high quality diagnostic information for the characterization of confined and lost fast ions in plasmas relevant for ITER and JT60-SA |
| D2 | Quantify ion heating and core turbulence stabilization by ICRF-generated fast ions in view of ITER and DEMO |
| D3 | Quantify the impact of fast ions and fast ion MHD driven instabilities on core transport |
| 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 | Identify AE control actuators and preliminary assess for ITER |

In DTT, ICRF (and NBI) super-Alfvenic ions will be present.

# Backup Slides

- Backup Slides

# WP TE in FSD with overarching priorities: ITER & DEMO & PEX



# WP TE Grant Deliverables (2022 & 2023 as one campaign)

| | | |
|---|---|---|
| TE.D.03 | High fluence operation on actively cooled divertor at WEST assessed, and documented. | Dec. 2022 |
| TE.D.04 | Achievement of ELM control during the transient phases ($I_p$ ramp-up and down, entering and exiting H-mode etc.) integrating ITER operational constraints. | Dec. 2022 |
| TE.D.05 | The role of turbulent and MHD driven transport in the vicinity of the separatrix for the stability of the pedestal quantified and the implications for predictions for ITER and DEMO reported. | Dec. 2022 |
| TE.D.06 | Achievement of state-observer based control of radiative detachment using multiple diagnostics. | Dec. 2023 |
| TE.D.07 | The disruption and run-away electron mitigation efficiency by single and multiple shattered pellet injectors on different sized devices to validate the ITER Strategy assessed and documented. | Dec. 2023 |
| TE.D.08 | Balance between gross and net erosion of W under different operational conditions in full-metallic toroidal devices | Dec. 2023 |
| TE.D.09 | Establishment and comparison of N and Ne-seeded partially-detached divertor in high-power operations in view of ITER radiative scenario. | Dec. 2023 |
| TE.D.10 | The role of electron and ion heat channels and plasma rotation on the access to H-mode for hydrogen, helium and mixed plasmas in view of the ITER non-active phase quantified. | Dec. 2023 |
| TE.D.11 | Incorporation of turbulence in multi-fluid calculations using physics-based diffusion coefficients (with TSVV4). | Dec. 2023 |

❖ GDs of 2021 considered completed as of 06/22

Prior to call for proposals:

- ❖ Definition of Research Topics
- ❖ Definition of Scientific Objectives cross-checked against WP TE GD and MS
- ❖ Emphasizing integrative aspects (e.g. exhaust and control related objectives combined with ITER and DEMO scenarios)

Most of the WP TE programme until end 2023 has been defined and discussed at recent WP TE programme meeting on $30^{th}/31^{st}$ of May 2022