EUROfusion

Work Package Tokamak Exploitation Progress Summary and Status for 2021

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Exploitation of EUROfusion Tokamaks in 2021

- Programme execution on 3 devices in 2021: ASDEX Upgrade, MAST-U, TCV with WEST (C6) postponed to 2022
- Proud of having managed 3 operating devices, with 2 simultaneously operating most of the time despite COVID-19 measures, lack of travel, remote meetings the 2021 campaign was successful
- For most scientific objectives complimentary effort between internal and WP TE program

Machine	2021											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
AUG												
	AUG programme 2021											
MAST-U												
					1st physics campaign							
TCV												
	w/o baffles			w/ baffles					w/ baffles		w/o baffles	
WEST												
	C5 camp.							C6 campaign				

WPTE WEST
Not before 03/2022

as of 17th June 2021

- JET to be integrated end of 2021 with a pre-defined programme (C40B)

List of Research Topics in Mission 1

Collaboration with WP rIO

Mission 1-1: Demonstrate and qualify MHD stable high performance operation with metallic plasma facing components for ITER and DEMO

RT1	IBL scenarios towards low detachment and low collisionality (14)
RT2	H-mode entry and pedestal dependence with impurities and isotopes (9)
RT3	RF-assisted breakdown and current ramp-up optimization (8)
RT4	Disruption avoidance development for ITER and DEMO (10)
RT5	Run-away electron generation and mitigation (11)
RT6	ELM mitigation and suppression in ITER/DEMO relevant condition (4)
RT7	Negative triangularity scenarios as an alternative for DEMO(4)
RT8	I-mode and QH-mode studies assessment in view of DEMO(7)
RT9	Extension of EDA and QCE performance towards DEMO (7)

Mission 1-2: Improve physics description (experiments, theory / simulation) of energetics particles including their non-linear interplay with thermal plasmas in order to control burning plasmas in ITER and DEMO.

RT10	Fast-ion physics with dominant ICRF heating (10)
RT11	Impact of MHD activity on fast ion losses and transport (14)

Mission 1-3: Develop integrated scenarios with controllers for long pulse, ultimately steady state, operation for ITER and DEMO.

RT12	Development of the steady state scenario (7)

List of Research Topics in Mission 2

Mission 2-1: Detachment control for ITER, DEMO baseline and HELIAS operation.

RT13	X-point radiation and control (8)
RT14	Physics of plasma detachment / impurity mix/ heat load patterns (16)
RT15	Extrapolation of SOL transport to ITER and DEMO (14)

Mission 2-2: Prepare efficient Plasma Facing Components (PFC) operation for ITER, DEMO and HELIAS.

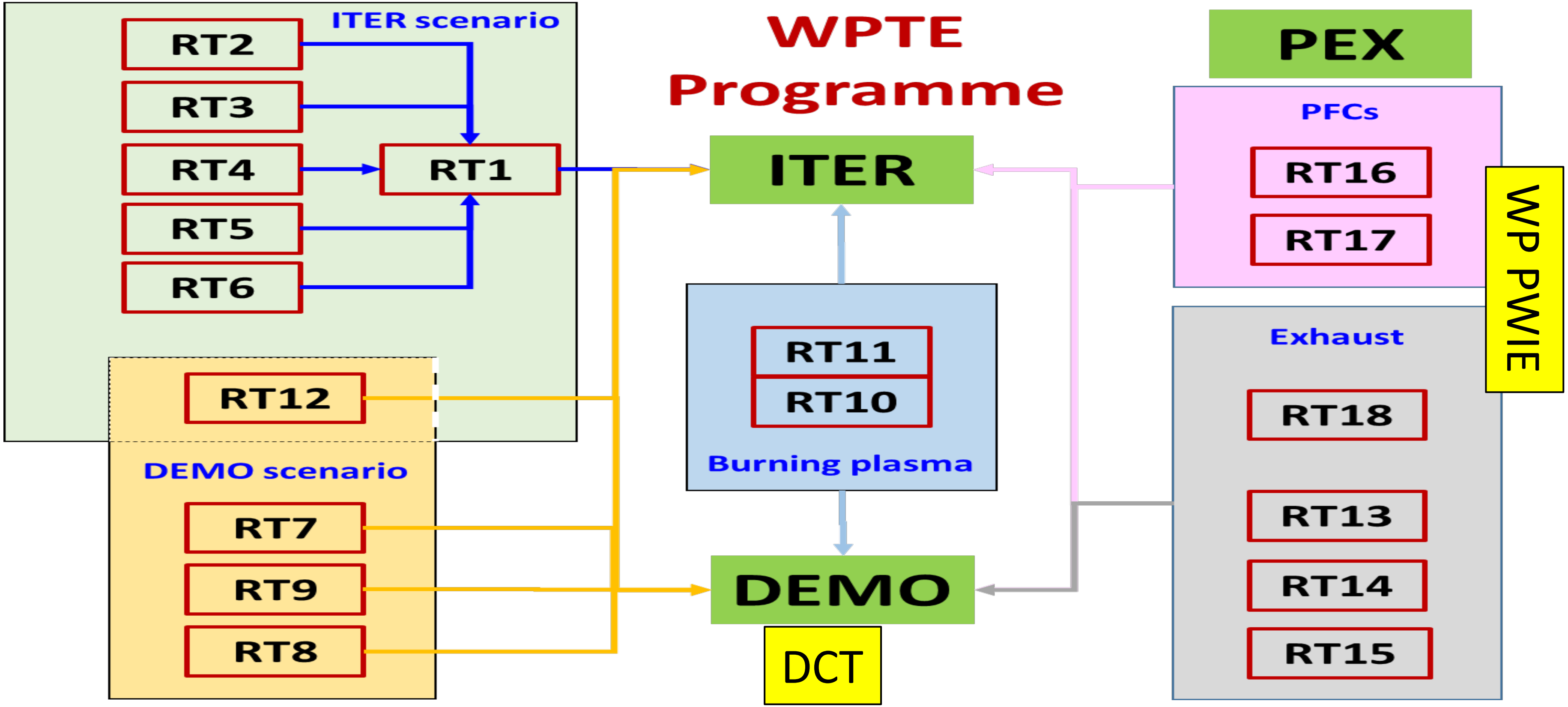
RT16	PFC damage evolution under tokamak conditions (7)
RT17	Material migration and fuel retention mechanisms in tokamaks (10)

Collaboration with WP WPIE

Mission 2-3: Investigate alternative innovative divertor geometries for DEMO.

RT18	Alternative divertor configurations (12)

Structure of WP TE



Pulse balance on devices as of 13th Sep 2021

Device	Total pulse budget	Contingency	Allocated Mission 1	Allocated Mission 2	Executed Mission 1	Executed Mission 2	percentage of total budget
AUG	387	67	219	101	260	116	97.2 %
MAST-U	360	61	165	134	72	101	48 %
TCV	806	161	339	306	138	170	38.2 %

- WEST C6 campaign moved to April/May 2022 (restart March 2022)
- AUG for Nov/Dec not yet allocated
- Mast-U foreseen to operate until end October – risk of not executing entire WP TE program

Research Topic Status Evaluation Criteria

Level	Criteria
Emerging	Little or no understanding yet on WP TE devices
Exploratory	Physical process is assessed on WP TE devices, transposing to ITER or DEMO is uncertain
Judgemental	Controlling physical processes has been assessed on WP TE devices, but extrapolation to ITER/DEMO requires scalable parameters and further investigation
Mature - needs underpinning	Good understanding of controlling physical processes on WP TE devices, but major uncertainty in view of transposing ITER/DEMO
Mature - needs support	A good understanding has been achieved on WP TE devices, further research exploring ITER or DEMO relevant parameters
Established	Understanding is well developed and can be applied to ITER or DEMO

- Further refinement of Ansatz may be needed; e.g. some distinction between ITER & DEMO
- WP TE deliverables given here = multi year programme
- N.B.: Ds marked as scientific objective for 2021 for which significant progress in 2021 targeted

RT01: IBL scenario towards detachment and low collisionality

		21	Status	Achievements
D1	Assess the core transport properties of IBL scenarios with dominant electron heating (low nu*, low rotation) and He seeding	X	Judgemental	❖ AUG: exploration of low nu* at q95=3 for different plasma currents with RMPs ❖ TCV: improve shape closer to ITER one: delta_top = delta_bottom = 0.5
D2	Improve the understanding of MHD stability and impurity accumulation during the transient phases of the H-mode.		Judgemental	❖ AUG: H-mode entry: EDA with strong fuelling and reduced power. ❖ AUG: H-mode exit: stable ramp-down w/o kappa change
D3	Optimize error field correction in MAST-U by using knowledge from other EU tokamaks (JET, AUG, COMPASS)	X	Mature - underpinning	❖ MAST-U: Compass scan at 0.4MA
D4	Extend the cross machine comparison of the dimensionless parameter dependence of momentum and particle transport		Exploratory	❖ Session planned on TCV with 2nd NBI
D5	Characterize the edge conditions with pellet fuelling and the detachment requirements for the IBL scenario		Exploratory	❖ TCV: N2 seeding in IBL. L-H transition at high density. fG~1 achieved

RT02: H-mode entry and pedestal dependence with impurities and isotopes

		21	Status	Achievements
D1	Quantify heat and particle transport across the pedestal and the SOL in low nu	X	Exploratory	❖ AUG: Reached low nu* and ❖ TCV:n on-stationary low nu* plasmas on ❖ Good advancement in scenario development
D2	Isotope/mixed species dependence of the pedestal and SOL, including the LH transition		Exploratory	❖ Good shape scan in H and D at different fuelling levels
D3	Assess pedestal performance in ITER/DEMO relevant scenarios (dominant electron heating/low torque/seeded impurities/low nu*)		Judgemental	❖ Pretty large scan available between AUG and TCV on density, delta, power.
D4	Improve predictive capabilities of pedestal performance with coupled SOL/pedestal integrated modelling		Exploratory	❖ Not started but this is the key point
D5	Estimate the impact of radiative impurities on the H-mode access		Emerging	❖ Not started as low priority for 2021

RT03: RF-assisted breakdown and current ramp-up optimization

		21	Status	Achievements
D1	Develop reliable ECRH and/or ICRH methods for RF assisted breakdown and produce prediction for ITER to determine the required RF power.	X	Judgemental	❖ Burn through experiment in AUG and comparison with the BKD0 model ❖ Validation of the X3 ECRH scheme for ITER ❖ Close to achieve next highest status (bridge to ICRF experiments on JET)
D2	Optimize the ramp-up path (wrt impurity accumulation, MHD, flux saving) in metallic devices.		Exploratory	❖ Modelling on-going
D3	Produce an integrated simulation of the breakdown and ramp-up phase for the first ITER plasmas		Exploratory	❖ Modelling on-going with CREATE and RAPTOR together with WPrIO

RT04: Disruption avoidance development for ITER and DEMO

		21	Status	Achievements
D1	Advance control frameworks on WPTE devices for integrated disruption avoidance: state observers, actuator sharing, RT event detectors	X	Mature – needs underpinning	❖ Similar method developed on AUG and TCV
D2	Improve predictive understanding of specific disruption paths and their avoidance. Focus on H-mode density limit (HDL) disruptions and NTMs		Judgemental	❖ Avoidance scheme in development but not yet ready
D3	Implement and study automated methods for discharge recovery or soft-stop		Exploratory	

RT05: Run-way generation and mitigation

		21	Status	Achievements
D1	Determine the conditions including density increase by pellets for the damping physics mechanisms generating run-away electrons after the thermal quench	X	Judgemental	❖ Exploration of the hot-tail mechanism in AUG at high T_e ❖ D2/H2 flushing experiment.
D2	Determine the physics dependencies including heating, shape, and density for generating run-away electrons in the plasma start-up phase		Exploratory	❖ No new data produced yet
D3	Develop and exploit measurement tools including (e.g., energy spectrum, density) for characterizing run-away electron beams	X	Exploratory	❖ REIS and RF antenna in preparation for experiments this year in TCV. GEM and REIS also planned for WEST 2022
D4	Test run-away electron mitigation with alternative methods (e.g., fueling pellets, MHD EC waves)		Emerging	

RT06: ELM mitigation and suppression in ITER/DEMO relevant condition

		21	Status	Achievements
D1	Establish RMP ELM suppression on MAST-U and compare to AUG	X	Emerging	❖ First experiments initiated on MAST-U
D2	Document ELM suppression in view of ITER PFPO operations in H	X	Exploratory	❖ Found limit of 38% hydrogen concentration for ELM suppression
D3	Determine access window to RMP ELM suppression and its compatibility with low torque, dominant electron heating, and radiative divertor for ITER FPO and DEMO		Judgemental	❖ ELM suppression is most consistently obtained with sufficient NBI heating ❖ Maximum pedestal density during pellet injection can be maintained for ELM suppression
D4	Quantify the influence of 3D magnetic perturbations (2021) and transport of impurities (2022) on kinetic modelling of RMP ELM suppression for extrapolations towards ITER and DEMO.	X	Judgemental	❖ Kinetic modelling can provide explanations on ELM suppression and derived field penetration condition in line with experimental observations
D5	Determine effectiveness of ECRH / ECCD-driven ELM mitigation for DEMO		Emerging	❖ Late 2021 on TCV

RT07: Negative triangularity scenario as an alternative for DEMO

		21	Status	Achievements
D1	Advanced MHD equilibrium and stability analysis of TCV and AUG plasmas		Eploratory	❖ Activity started
D2	Develop similar scenarios in TCV and AUG to support iDTT design		Emerging	❖ Not touched
D3	Investigate power exhaust and detachment with simulations (2021) and in experiments in AUG and TCV (2022)	X	Emerging	❖ Modelling activity started on AUG; about to start on TCV
D4	Provide answers on the plasma core confinement properties (density limit, plasma current limit, …) to the EUROfusion Ad-hoc Group ("Proof of principle Phase")		Emerging	❖ Not touched

RT08: QH-mode and I-mode assessment in view of DEMO

		21	Status	Achievements
D1	Develop I-mode and QH-mode and determine existence space	X	Emerging	❖ AUG: looking for I-mode in fwd-Bt: promising results with improved confinement wrt L-mode ❖ TCV: 1 session done so far focusing on QH-mode: scenario development – no clear sign of QH/EHO phase
D2	Extend cross-machine scaling of PL-I threshold		Emerging	❖ Exploration of I-mode in fwd-Bt/Ip
D3	Compatibility of QH-mode and I-mode with DEMO constraints (including dominant electron heating, low torque, high ne_{sep}, dissipative divertor)		Emerging	❖ Not addressed; Rev-Bt/Ip campaign needed on AUG
D4	Access and sustainment of QH-mode with a metallic wall		Exploratory	❖ QH-mode phase extended up to 500 ms
D5	Quantify heat loads for I-mode and QH-mode and compare with existing scaling(s)		Exploratory	❖ Data collected (most likely), but missing competencies for analysis

RT09: Extension of EDA and QCE performance towards DEMO

		21	Status	Achievements
D1	Expand the cross-machine comparison for the QCE and the EDA regimes	X	Exploratory	❖ AUG: good progress ❖ TCV: QCE with comparison between baffles and non-baffles ❖ MAST-U: QCE re-established
D2	Extend the parameter range of both regimes towards low nu* and low q95	X	Judgemental	❖ AUG: low-q likely possible
D3	Assess the compatibility of both regimes with various radiative conditions (ITER/DEMO conditions)		Exploratory	❖ AUG: QCE partially detached, EDA compatible with Ar and N seeding. ❖ TCV: QCE executed within RT14
D4	Identify the key parameters for a scaling of the heat loads in both regimes		Emerging	❖ AUG: QCE data acquired
D5	Identify in experiments and with modelling the instabilities regulating the pedestal transport		Exploratory	❖ AUG: Some good data acquired.
D6	Characterise QCE and EDA regimes for hydrogen and helium plasmas		Exploratory	❖ AUG: Promising hydrogen discharges performed

RT10: Fast-ion physics with dominant ICRF heating

		21	Status	Achievements
D1	Determine fast-ion characteristics, plasma performance, and transport in ICRF-heated scenarios in multiple machines in preparation for ITER PFPO and FPO operations	X	Mature – needs underpinning	❖ 3-ion scenario on AUG (^3He or ^4He) with good plasma heating in ITER-relevant conditions demonstrated, comparison with and without ICRF and ECRF
D2	Provide essential diagnostics information for the characterization of confined and lost fast ions in plasmas relevant for ITER PFPO and FPO		Mature – needs underpinning	❖ Good data using CXRS and FILD on AUG, diagnostics working, ^3He and ^4He lines can be separated ❖ AE-induced FI losses can be mitigated by D-NBI heating spectrum ❖ NBI-driven AE modes during ICRF heating characterized and frequency decrease when density increases
D3	Quantify Ti heating and core turbulence stabilization by ICRF-generated fast ions in view of ITER and DEMO		Exploratory	❖ Demonstrated ICRF heating generates fast-ion populations, predicted Ti stiffening demonstrated & dependence on H/D
D4	Integrate the available heating, fast-ion and transport modelling tools for interpretation of experimental results in view of ITER and DEMO.		Emerging	❖ Later years

RT11: Impact of MHD perturbations on fast ion losses

		21	Status	Achievements
D1	Assessment of fast-ion transport and losses induced by MHD perturbations such as ELMs, NTMs, Sawtooth, Alfvén Eigenmodes and other relevant continuum fast-ion driven fluctuations	X	Exploratory	❖ ELM induced FI losses: q95 scan ❖ AE control with ECCD ❖ Fast ion slowing down at high ne: promising results from CTS diagnostic ❖ FI transport by NTM: data collected.
D2	Identification of control actuators to minimize AE-induced fast-ion losses in view of ITER and DEMO		Exploratory	❖ Not touched since not a priority for 2021
D3	Optimization of fast-ion confinement in tokamaks with RMPs		Exploratory	❖ AUG: FILD measurements with 3D fields ❖ AUG: ELM suppression sustained with rigid rotation

RT12: Development of the steady state scenario

		21	Status	Achievements
D1	Develop an intrinsically steady state solution at high betaN (>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.	X	Emerging	
D2	Quantify the impact of Ti/Te and rotation on the core performance with dominant electron heating.	X	Emerging	❖ Possible revision of scientific objective in view of RT01 & RT02
D3	Identify, define and test the required control schemes for robust operation		Emerging	
D4	Compatibility of long pulse (> several resistive time) with the boundary interface with high-performance core.		Emerging	
D5	Characterize the ExB, magnetic shear, turbulence conditions in the achieved solution		Emerging	

RT12: Development of the steady state scenario

		21	Status	Ac
D1	Develop an intrinsically steady state solution at high betaN (>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.	X	Emerging	
D2	Quantify the impact of Ti/Te and rotation o… the core performance with domina… electron heating.			…entific objective in view of
D3	Identify, d… sch…			
D4	…terface		Emerging	
D5	Ch… …e ExB, magnetic shear, turb…nce conditions in the achieved solution		Emerging	

It is expected that RT12 can make faster progress towards judgemental once experiments take off on all relevant devices, as it is expected that for D1-D3 sufficient physics knowledge exists – but has not been applied under conditions required for RT12

RT13: X-point radiation and control

		21	Status	Achievements
D1	Determine existence diagram and improve understanding for X-point radiation on all WP TE devices in comparable scenarios in H-mode		Judgemental	❖ First exploration on MAST-U ❖ XPR characterized ❖ LSN well established on AUG ❖ Interpretative modelling ongoing ❖ Wide range of data
D2	Identify the stability of X-point radiator using available analytical models and numerical methods in conjunction with experimental data	X	Exploratory	❖ Modelling ongoing for establishing numerical XPR regimes as basis for sensitivity studies ❖ Requires validation of combination/integration of codes: e.g. SOLPS-ITER, SOLEDGE-EIRENE type of codes & Pedestal/Core codes (EUROPED, ETS, ASTRA, JETTO/JINTRAC)
D3	Demonstrate reliable (multi-sensor) detachment control schemes in multiple devices		Exploratory	❖ Partially applied on AUG, MANTIS on TCV, MAST-U needs to reach D1 first
D4	Demonstrate exhaust-compatible ramp-up/-down into detachment (including L-H transition) for at least one device		Emerging	❖ No activities inside TE yet

RT14: Physics of plasma detachment / impurity mix/ heat load patterns

		21	Status	Achievements
D1	Characterize detachment access and core plasma performance in scenarios using different gas valve locations, enrichment and compression, impurity mixtures, and field direction		Mature – needs underpinning	Impurity seeding scan performed in AUG (Ar/N2) and TCV
D2	Explore the effect of divertor pressure on detachment and plasma core performance through changes in pumping speed and divertor closure	X	Judgemental	Impact of divertor closure investigated in TCV (old vs new baffles) and MAST-U (first experiments)
D3	Assess whether the parameter dependences related to detachment scale the same between (reduced) SOL models and experiment and determine the impact of divertor geometries (e.g. baffled vs. non-baffled and compact vs. conventional) on these trends		Judgemental	AUG and TCV simulations started
D4	Quantify the degree of ELM buffering achievable by impurity seeding, investigating the dependences on relevant machine parameters (e.g. Ip and divertor geometry) and the different measurements that may scale with the energy deposited by the ELM (e.g. floating potential or H-alpha)		Exploratory	ELM buffering assessed in AUG and TCV seeding experiments.
D5	Measure divertor heat loads and assess power/energy balance in attached & detached divertor operation	X	Emerging	Not adressed yet

RT15: Extrapolation of SOL transport to ITER and DEMO

		21	Status	Achievements
D1	Determine changes of the upstream profiles (including electric field and density, eg density shoulder) under different SOL and divertor conditions	X	Judgemental	❖ TCV: H-mode investigation on main chamber neutral dependence for shoulder formation, E_r only in L-mode → extension to H-mode required ❖ AUG: Geometry scan for shoulder formation ❖ AUG: E_r investigation w.r.t. target conditions and collisionality in L-Mode
D2	Disentangle the role of ion/electron channel transport in the near and far SOL	X	Judgemental	❖ Good database on AUG and TCV.
D3	Quantify particle and heat load in the near and far SOL under different confinement regime (including no-ELM regimes) and divertor recycling state.		Emerging	❖ None reported; RFA in L-mode → more effort required ❖ Data base existing, missing data analysis and modelling
D4	Document associated turbulence properties near the X-point and in divertor region		Emerging	❖ None reported – unclear if required data acuired
D5	Determine filament dynamics dependence on separatrix and divertor condition (ne,sep, collisionality, shearing, αt, recycling state) and how it impacts the near and far SOL transport		Exploratory	❖ None reported but we know work in progress both on AUG and TCV at least in H-mode.

RT16: PFC ageing under tokamak conditions

		21	Status	Achievements
D1	Quantify using experimental data and predictive modelling local power load distributions at castellated and shaped PFCs for ITER and DEMO	X	Mature – underpinning	❖ AUG : data from previous experiments on gap penetration conclusive, corresponding paper = work in progress ❖ WEST : data analysis from previous campaigns ongoing, complex interpretation of IR data evidenced (emissivity, reflections, cavity effects in gaps); good basis for 2022 experiments ❖ Modelling effort just started
D2	Determine the role of plasma parameters and thermionic emission in melt dynamics on metallic plasma-facing components in view of ITER operation	X	Mature - support	❖ AUG : data from previous melting experiments + Ir vs Nb experiment conclusive, modelling ongoing ❖ WEST : update of the MEMOS code for actively cooled PFC performed, modelling of previous WEST sustained melting experiments ongoing
D3	Assessment of thermo-mechanical degradation of ITER like actively cooled W PFCs (including pre-damaged PFC) in tokamak conditions by sustained high power / high particle fluence plasma exposure		Emerging	❖ Preparation of pre damaged PFU (pronounced crack network) performed, pre damaged PFU installed, ready for exposure in WEST for C6 campaign ❖ Plans to produce a more severe pre-damage (self castellation) for C7

RT17: Material migration and fuel retention mechanisms in tokamaks

		21	Status	Achievements
D1	Determine mutual strength of divertor and main chamber W sources during L and H-mode operations with varying ELM sizes in multiple machines	X	Mature – needs underpinning	❖ Comparison made at the divertor region between L- and H-mode plasmas: gross erosion higher during inter-ELM conditions by a factor of 10-100 while net erosion only amplified by a factor of 2-3 ❖ AUG and WEST indicate comparable net erosion rates in divertor
D2	Quantify material migration pathways in the SOL and in the confined plasma in L and H-mode plasmas in multiple machines		Judgemental	❖ Modelling confirms strong role of electron temperature in erosion ❖ Increasing surface roughness strongly suppresses net erosion, surface features should be characterized by inclination angle distribution, not by average mean roughness
D3	Document fuel retention and ammonia formation in long-pulse conditions	X	Emerging	❖ Preliminary experiments on ammonia formation in WEST analyzed (paper)
D4	Determine fuel-removal and conditioning efficiencies in metallic devices in conditions relevant for ITER PFPO and extrapolate to DEMO		Exploratory	❖ First ECWC experiments carried out in AUG

RT18: Alternative Divertor Configuration

		21	Status	Achievements
D1	Characterize possible benefits of the snowflake configuration for X-point radiation stability and dissipated power	X	Exploratory	MAST-U: none planned TCV: Mostly L-mode, H-mode lack of time; Benefits of baffled SF+: Effect of poloidal flux expansion and L_{II} near X-point on potential of X-point radiator in H-mode started, issue vertical stability
D2	Quantify the effect of total flux expansion on detachment onset, radiative stability and SOL dissipative capability, comparing MAST-U and TCV through both experiment and modelling	X	Judgemental	MAST-U: Scenario with Super-X plasma generated 700 kA, L mode, δRsep ~ 0 mm, constant density, detachment at lower density in SX, investigation hampered by locked modes TCV: L- and H-mode (few attempts, lack of time) Interpret with existing and new modelling just started
D3	Determination of detachment onset, radiated power fractions, and core compatibility in H-mode for the most promising ADCs and characterization of ELM activity in view of pedestal, heat flux and control in ADCs		Exploratory	MAST-U: SX no H-mode or seeding yet TCV: SF- over SN, benefits of radiation blob between X-points on core compatibility, ELMy H-mode, ELM free H-mode on going

WP TE Grant deliverables for 2021

			Status
TE.D.01 (M 01)	Successful establishment of Type I ELMy H-mode scenario with dominant electron heating for the first safe operation of ITER.	12/2021	Partial; experiments planned in TCV in 2021
TE.D.02 (M 05)	The effect of total flux expansion and snowflake configurations in environments with intrinsic impurities on power dissipation quantified.	12/2021	Experiments nearly completed – only L-mode but not H-mode; modeling ongoing

WP TE Milestones 2021

Sequential M ID	Related WBS ID	Title	Due Date	Status of achievement
M01	RT01 / RT02	Mission 1.1: Achieve and complete TE.D1.01	12/2021	Partial; experiments planned in TCV in 2021
M02	RT12	Mission 1.3: Proposals for achievement of steady state high β controlled scenario assessed.	12/2021	Progress on TCV and AUG power in MAST- U lacking, delay in completion on TCV (power)
M03	RT13/RT14/RT 15/RT18	Mission 2.1: Quantify the effect of divertor pressure on detachment and plasma core performance through changes in divertor closure.	12/2021	expected to be completed; interpretative modelling on going
M05	RT18/RT13/RT 14	Mission 2.3: Achieve and complete TE.D1.02	12/2021	Experiments nearly completed – only L-mode but not H-mode; modeling ongoing

Progress on Thrusts and TSVVs 1/2

TSVV / Research topic No	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
TSVV 01 Physics of the L-H Transition and Pedestals																		
TSVV 03 Plasma Particle/Heat Exhaust: Fluid/Gyrofluid Edge Codes																		
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 Transient MHD Events																		
TSVV 09 Dynamics of Runaway Electrons in Tokamak Disruptions																		
TSVV 10 Physics of Burning Plasmas																		
TSVV 02 Physics Properties of Strongly Shaped Configurations																		
TSVV 11 Validated Frameworks for the Reliable Prediction of Plasma Performance and Operational Limits in Tokamaks																		
TSVV 14 Multi-Fidelity Systems Code for DEMO																		

Progress on Thrusts and TSVVs 2/2

Member of the E-TASC Scientific Board: Marco Wischmeier (Emmanuel Joffrin)

Thrust / TFL	
Thrust 1 (1/3/4) – WPTE as facilitator	Nicola Vianello (Marco Wischmeier)
Thrust 2 (5/6/7) – WPTE member	Antti Hakkola (Emmanuelle Tsitrone)
Thrust 3 (8/9/10) – WPTE member	Emmanuel Joffrin (Antti Hakola)
Thrust 5 (2/11/14) – WPTE member	Benoit Labit (Emmanuel Joffrin)

- All but Thrust 5 started
- Thrust as a space for facilitating TSVVs interactions as well as interactions with WPTE Research Topics
- Interaction with SCs to identify mid and long term needs ongoing
- Timely validation of code components wished ➔ Interaction with PIs and SCs for mutual awareness & opportunity for mutual participation to progress meetings
- Attempt to identify and foster synergies between TSVVs for code development and code validation/benchmark against WP TE experimental data
- All activities started, no palpable result yet as all in process of lift-off

Interaction with WP PWIE (RT16/17/18)

From TE to PWIE

- Carry out experiments to expose marker samples/plasma-facing components to pre-selected plasma discharges/during experimental campaigns
- Production of a variety of background plasmas to take into account specific features of individual experiments on the basis of well-defined base cases prepared under PWIE
- Comparison of PFC evolution (high heat-flux and fluence exposures, erosion experiments) in HHF/linear devices/tokamaks: data from tokamaks
- Additional resources for interpretation of experimental results in areas where resources are scarce (e.g., experimental piggy-back dust studies on AUG)
- ADC: TE executes experiments on TCV and MAST-U for physics basis including interpretative modelling

From PWIE to TE

- Post mortem data on erosion/deposition/surface modification profiles on exposed marker samples/plasma-facing components to be benchmarked against plasma conditions during the actual experiments/campaigns (IR, LP, spectroscopy etc. data)
- Background plasmas for well-defined base cases to be further used for “theme variations” under TE
- Reproduction of the obtained erosion/deposition/melting/surface modification patterns using numerical modelling for planning new experiments
- Comparison of PFC evolution (high heat-flux and fluence exposures, erosion experiments) in HHF/linear devices/tokamaks: data from HHF and linear devices
- ADC: PWIE to use this information for ADC DEMO and DTT (through WP DES) modelling and feedback open questions for TE to investigate on devices

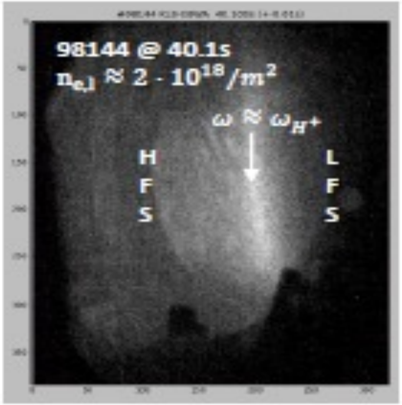
No formalized interaction with WP SA yet

- No meeting held with WPSA yet (Delay of JT-60SA).
- Known overlap:
  - First plasma: RT03 (breakdown + ramp-up) + RT04 (control of disruptions), RT17 (conditioning)
  - First campaigns: RT12 (advanced scenario) + RT10 & RT11 (fast particles) + RT02 (pedestal) + RT05 (run-aways) are topics of interaction between the WPs, RT17 (conditioning)
- more overlap expected in 2022 in view of integrated comissioning

Interaction with WP PrIO

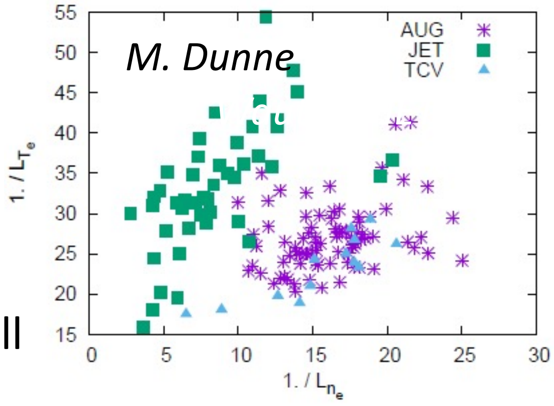
Plasma start-up

- ❑ Through WPrIO, TE (RT03) interacting with IO on IC and EC assisted breakdown, start-up together with TSVV11 and WPSA.
- ❑ Experiments and modelling activities regularly discussed in meetings organized by WPrIO.



EUROfusion database

- ❑ TE participates to the database activity as data provider in link with the exprimental programme and the R.O.
- ❑ Pedestal, disruption and confinement databases logistics (IMAS, platform, etc …) is managed by WPrIO.



ITPA

- ❑ TE is strongly involved in ITPA groups & participates to coordination of ITPA actions organized by WPrIO and members will report in TF meetings.

Interaction with DCT through FSD-FTD

Regular meetings between FSD & DCT identified following items:

- Transient phases: set of 11 specific tasks on key physics or technical questions for strengthening the scenario development on DEMO; couple of TSVVs may play a role (TSVV7, TSVV11), tools mostly existing, experiments can be motivated in WP TE
- Exhaust and Re-attachment: List of open points identified (operational, basic physics, reduced model, off-baseline), list of activities for participation, topics for master/PhD students identified
- Small/no ELMs: key role of JET for certain aspects identified, categorization criteria identified and need to be applied

- No down selection at this stage desired by DCT
- Analysis how to proceed on prioritization of research areas underway
- Issue of resource prioritization and allocation for these activities – i.e. agreed to do, but none explicitly started as a result yet
- Comments: expecting tasks defined inside WPTE to contribute to DCT (ongoing how this is done, priorities for 2022 defined – schedule?)

Key Gaps and Deficiencies

- Human resources for numerical interpretative modelling (e.g. Jorek, SOLPS-ITER,…) – competition with TSVVs
- Available resource for allocation to interpretative modelling
- At similar experimental and modelling support estimated budget for missions likely insufficient if COVID-19 restrictions lifted for traveling

Back Up slides

Risk Identification

Risk description	*Mitigation action*
Non availability of any WP TE devices	*Reprioritization of device usage*
Delay in the PEX Upgrades on the various devices	*Reprioritize PEX experiments and develop international collaboration*
SPI experiments not conclusive in mitigating the disruption loads on tokamaks.	*Find alternative mitigation solution to be developed on tokamaks*
Transferability of no/reduced ELM scenario to ITER and DEMO not feasible.	*Increase focus on JT-60SA and the importance of stellarator research*
Monitoring of the retention in metallic devices not sufficiently quantifiable	*Develop alternative monitoring methods*
JET DT campaign not or partially achieved in 2021	*Review JET extension objectives for DTE3*
Delay on real time diagnostics deployment for radiation control	*Put more resources on real time control*
Fast ion losses found too high in high beta scenarios for viable fusion performance	*Expand the studies to JT-60SA*