Thrust 1: Pedestal & SOL Turbulence

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On behalf of the WPTE TFLs
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Guidelines for the interaction of WPTE with Thrust 1 TSVVs

All WPTE research topics have a direct and relevant relation with at least one TSVV and most of the time with several of them (see WPTE wiki). Research topics have to execute a set of objectives that are often connected with code/model deliverables of TSVVs.

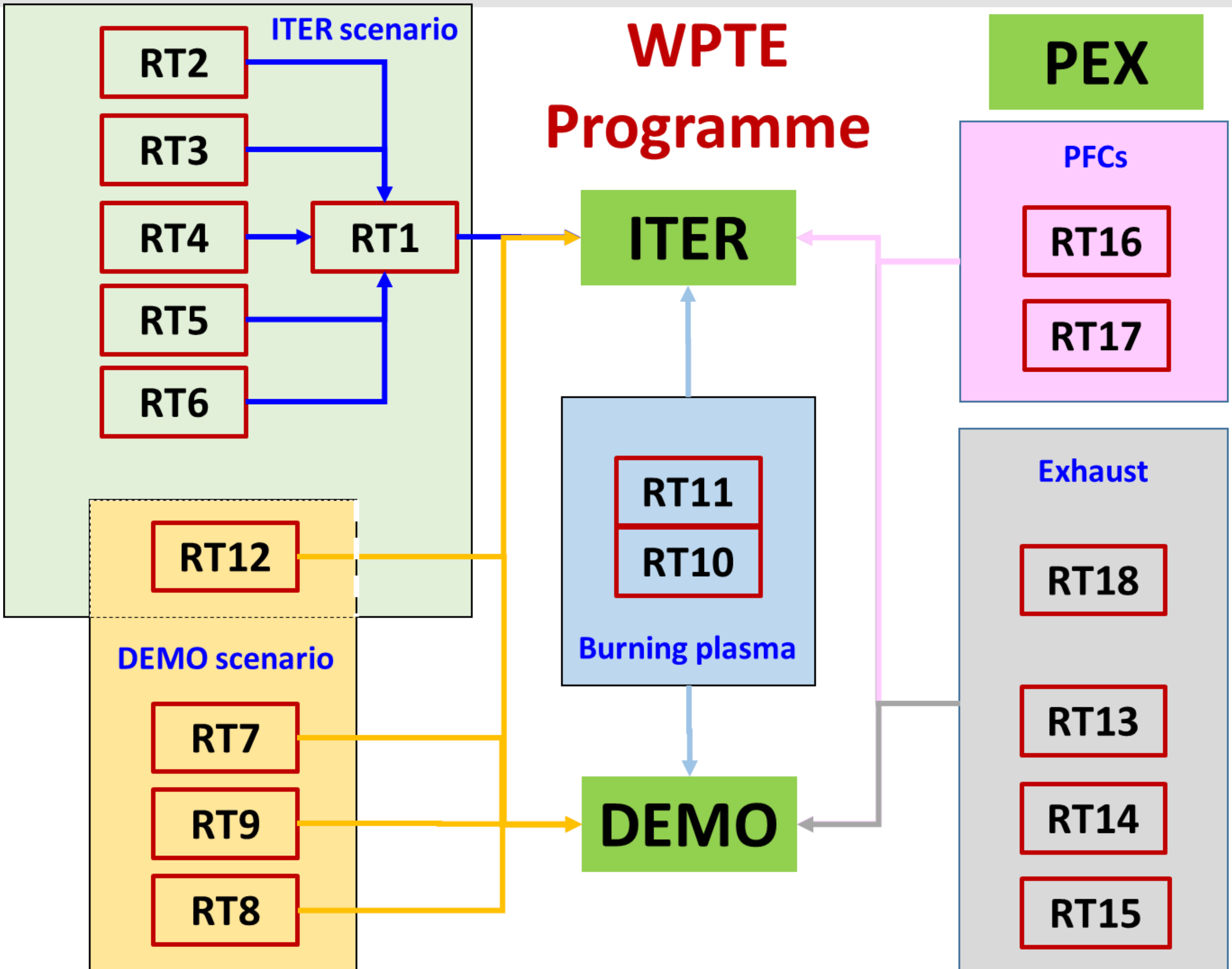
Scientific coordinators have been informed about the relations of their Research Topics with the relevant TSVVs. It is part of their duty to establish the relation with the relevant PI. TFLs will help in managing these relations but meeting should also take place at the working level.

WPTE TFLs expect working meeting to take place between the SCs and PIs to define / identify:

- Specific model/code requests that the Research Topics have towards the TSVVs.
- People involved in this work on both sides at the working level + gaps if any
- The validation actions required for the models/codes developed such as database, data mining, targeted experiments & their analyses, etc.

Please update wiki-page/INDICO page meetings with relevant presentation and made them available to Thrust members

WPTE Programme in a nutshell



Overview of RTs, SCs and related TFLs

	TFLs	Title	SC	SC	SC
RT1	EJ/BL	IBL scenarios towards low collisionality and detachment	O. Sauter,	T. Puetterich	L. Piron
RT2	NV/BL	H-mode entry and pedestal dependence with impurities and isotopes	M. Dunne,	L. Frassinetti	
RT3	EJ/BL	RF-assisted breakdown and current ramp-up optimization	D. Ricci,	T Wauters	
RT4	EJ/MW	Disruption avoidance and control for ITER and DEMO	F. Felici,	M. Maraschek	O. Kudlacek
RT5	EJ/AH	Run-away electron generation and mitigation	U. Sheikh,	C. Reux,	O. Ficker
RT6	NV/AH	ELM mitigation and suppression in ITER/DEMO relevant condition	W. Suttrop	D. Ryan	
RT7	NV/BL	Negative triangularity scenarios as an alternative for DEMO	T. Bolzonella		
RT8	NV/BL	QH-mode and I-mode assessment in view of DEMO	E. Viezzer	A.Merle	
RT9	MW/BL	Extension of EDA and QCE performance towards DEMO	M. Faitsch	L. Gil	
RT10	ET/AH	Fast-ion physics with dominant ICRF heating	Y. Kazakov	R.Bilato	
RT11	NV/BL	Impact of MHD activity on fast ion losses and transport	M. Vallar	M. Garcia-Munoz	
RT12	EJ/NV	Development of the steady state scenario	S. Coda,	C. Piron	
RT13	MW/AH	X-point radiation and control	M. Bernert,	S. Wiesen	
RT14	MW/ET	Physics of plasma detachment / impurity mix/ heat load patterns	O. Février,	S. Henderson	A. Jarvinen
RT15	NV/ET	Extrapolation of SOL transport to ITER and DEMO	D. Brida,	G. Harrer	
RT16	ET/AH	PFC damage evolution under tokamak conditions	Y. Corre,	K. Krieger	
RT17	ET/AH	Material migration and fuel retention mechanisms in tokamaks	T. Loarer,	J. Likonen	
RT18	MW/EJ	Alternative divertor configurations	A. Thornton	C. Theiler	

Linking WP TE RTs with TSVVs and Thrusts

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																		

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

- **Modelling deliverable:** Improve predictive capabilities of pedestal performance with coupled SOL/pedestal integrated modelling
- **Applicable TSVVs**: 1,3,4 (Pedestal + LH, boundary plasmas, GK heat exhaust)
- **Capabilities within RT02:**
  - IPED/EUROped modelling using “standard” EPED pedestal width/gradient scaling
  - IMEP modelling using “ETG” scaling (average pedestal gradient length ~2cm)
  - Some SOLPS modelling for TCV
  - HESEL for L2H isotope scan
- **Experiments in RT02:**
  - Collisionality scan at various triangularities
  - Detailed power scan in H & D at two plasma currents
  - Older experiments: broad range of power, fuelling, and seeding scans at fixed field and current, some field variations also included

M. Dunne and L. Frassinetti

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

- **Questions for modelling extension:**
  - How are the SOL/divertor and upstream separatrix connected (sources, sinks, transport) → TSVV1, TSVV3, TSVV4
  - Can the SOL/divertor physics be included in a (generalised) minimal model, or is feedback required between the two? → TSVV3, TSVV4
  - What is(are) the pedestal transport mechanism(s)? → TSVV1
  - Can a reduced/quasi-linear model reproduce relevant heat and particle flux levels? ("Even" electron-scale turbulence could be of use)
  - Is rotation important for pedestal transport? → TSVV1
  - Is q, Ip, or Bt more important for transport? → TSVV1
  - How applicable are current models in the high magnetic shear pedestal (aside from the common gradient length issues)? → TSVV1
  - For comparing e.g. R/LTe between machines, which R (and gradient basis of Te) is most applicable for the pedestal? → TSVV1
  - When is too much transport likely to lead to an HL back-transition? (useful to know for scaling of gradients & pedestal width in predictive models) → TSVV1,TSVV3, TSVV4
  - Integrated question: does high triangularity change the particle source or transport (or both)? (density often rises significantly at elevated triangularity) → TSVV1

First-principles modelling

- Nonlinear resistive MHD modeling of QH-mode conditions (all Deliverables)
  MHD modelling of QH-mode conditions with JOREK/MEGA started on old QH-mode case (AUG with C wall), but requires substantial numerical effort. Ideally, perform simulations for old QH-mode case and new transient QH-mode case.

- Gyro-fluid simulation of I-mode conditions (all Deliverables) → TSVV1

- Both can give precious insight for scenario development on machines where the regimes have not been achieved and can also help identifying key features for extrapolation to future reactors.

E. Viezzer and A. Merle

RT09: Extension of EDA and QCE performance towards DEMO

- Model quasi-coherent mode (QCM) and small-ELMs/filaments with realistic geometry (including X-point) and determine associated transport
  - Non-linear resistive MHD
  - (Gyro)Fluid → TSVV1/TSVV4
  - Gyrokinetic → TSVV1
- Model divertor detachment:
  - Steady-state TSVV3
  - Time-dependent with small-ELMs/filaments → TSVV3/TSVV4

L. Gil and M. Faitsch

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

- **Overarching:** Identify where transport and turbulence codes fail to reproduce detachment and power exhaust features and why? *e.g. TCV SOLPS-ITER simulations show discrepancies wrt to experiments* -> Inform TSSVs when discrepancies are identified and characterized
- To what extent do 2D multi-fluid codes recover experimentally observed scaling laws for e.g. threshold impurity concentration for detachment or sub-divertor neutral pressure for detachment, how does additional physics (drifts) influence these scaling laws? -> Identify discrepancies between the experimental / numerical scaling → TSVV3, TSVV4
- To what extent do 2D multi-fluid codes capture the experimentally observed retention of radiative impurities in the divertor and the depence of this retention on SOL conditions? → TSVV3
- How do these vary with variation in divertor closure and to what extent these variations are captured by the numerical simulations. → TSVV3
- What is the relative importance of cross-field transport due to turbulence and steady-state drifts and how does this vary with SOL conditions? How justified is a diffusive-convective ansatz for turbulent cross-field transport and how does the relative scale/magnitude of the turbulent fluctuations scale with SOL conditions. → TSVV3, TSVV4
- How significant is the role of kinetic features, such as non-maxwellian electrons, in various SOL conditions? → TSVV4, TSVV3

Aaro Järvinen, Olivier Février, Stuart Henderson

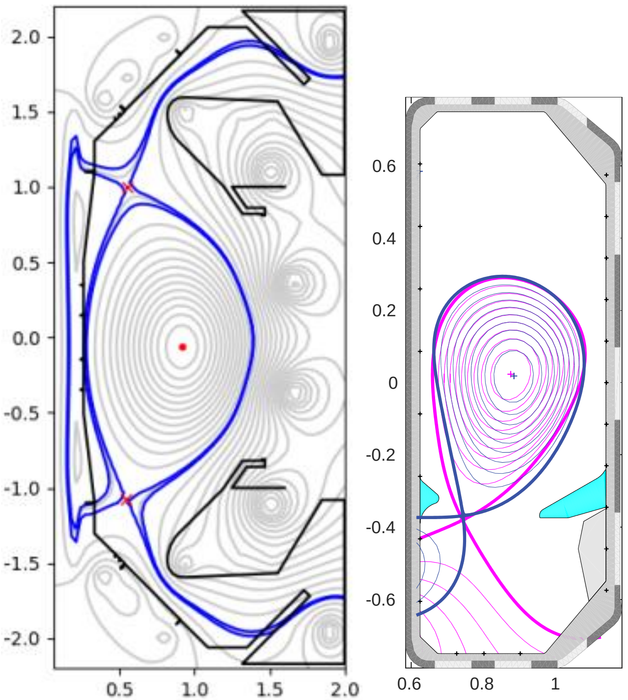
RT15:Extrapolation of SOL transport to ITER and DEMO

- Modelling of Er in the SOL both from 2D/3D codes → TSVV3, TSVV4, TSVV1
- Ti/Te ratio at the separatrix → TSVV3, TSVV4, TSVV1
- Shoulder formation → TSVV3, TSVV4, TSVV1
- Validation of 2D/3D codes and applicability to 3 different devices AUG/MAST-U/TCV → TSVV3, TSVV4, TSVV1

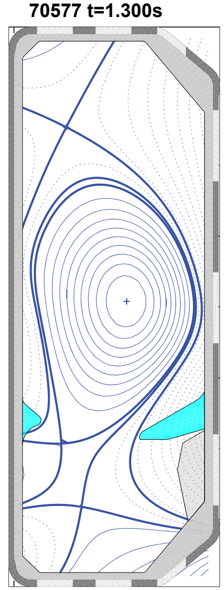
D. Brida and G. Harrer

RT18: Alternative divertor configurations

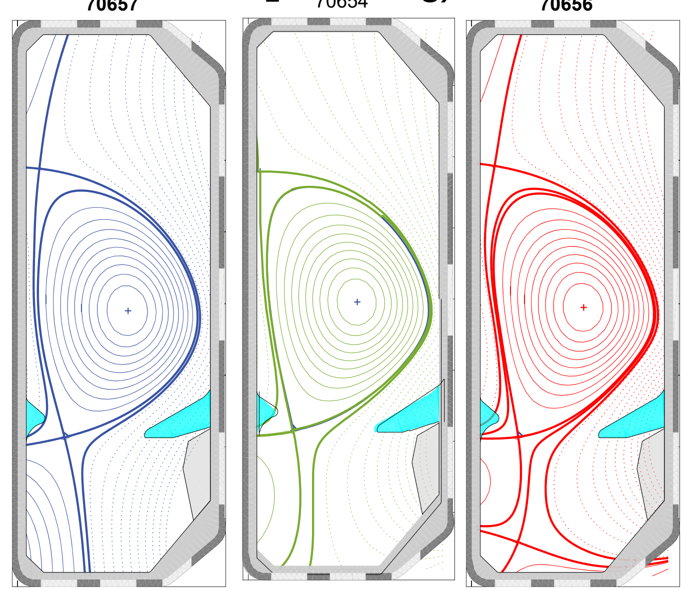
Super-X geometries, L- and H-mode



Snowflake (L- and H- mode, N_2 seeding)



Small and large poloidal flux expansion and X-point target (Type-I and small ELM regimes, N_2 seeding)



A Thornton & C Theiler

RT18: Alternative divertor configurations

Interpretative modeling with edge transport codes (mostly planned within RT18, but manpower limited)

- Understand effect of large outer target major radius on detachment access and stability and possible effects limiting expected benefits
- Same for other geometrical features (poloidal flux expansion, additional X-points)
- Better understand physics of X-point radiator and its dependence on geometry (e.g. in SN vs Snowflake)
- Better isolate effect of magnetic vs wall geometry on power exhaust (which is particularly hard to do in the experiment)

Turbulence modelling → TSVV3, TSVV4

- Model and extrapolate effect of various divertor geometric features (varying flux expansion, additional X-points) on turbulent transport and in particular on l_q
- Determine relative importance of cross-field transport due to turbulence and steady-state drifts
- Understand role of turbulence on impurity transport and divertor compression

Model validation → TSVV1,TSVV3,TSVV4

- To what extent can transport and turbulence codes reproduce existing experiments?

Extrapolations towards a reactor (planned mostly in collaboration with PWI&E)

- How does modelling of alternative divertor geometries, (once) validated on MAST-U and TCV, extrapolate to higher power conditions? Are effects enhanced? Reduced? What will be the role of plasma self-baffling vs role of physical baffling structures etc.

The validation process: where interactions occur

Theory, Simulation, **Validation** and Verification

From RTs: open physical problems, unresolved experimental observations, detailed experimental dataset

From TSVVs: Needs for validation. Ad-Hoc experimental proposals for validation

- Started the path along the first of the two arrows …