EUROfusion

WPTE Inputs for TSVV1

Nicola Vianello on behalf of WP TE TFLs

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Thrust 1 - TSVVs Overview

TSVV1: Physics of the L-H Transition and Pedestals

- GBS
- GENE
- GYSELA
- HAGIS
- ORB5
- QuaLiKiz
- SOLEDGE3X
- TSVV4 Code

TSVV3: European boundary plasma modelling towards reactor relevant simulations

- BIT1/BIT3
- EBC
- FELTOR
- GBS
- GRILLIX
- SOLEDGE3X

TSVV4: Plasma Particle/Heat Exhaust: Gyrokinetic/Kinetic Edge Codes

- GENE-X
- GyselaX
- PICLS
- BIT1/BIT3
- VOICE

- The interaction between TSVVs and WP mediated by Thrusts where connected TSVVs are grouped:
- For Thrust 1 there are natural synergies with common physical issues faced by different TSVVs
    - Neutrals
    - Gyro-Kinetic, kinetic, gyrofluid and fluid limits and validity
    - Boundary conditions
    - …

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.

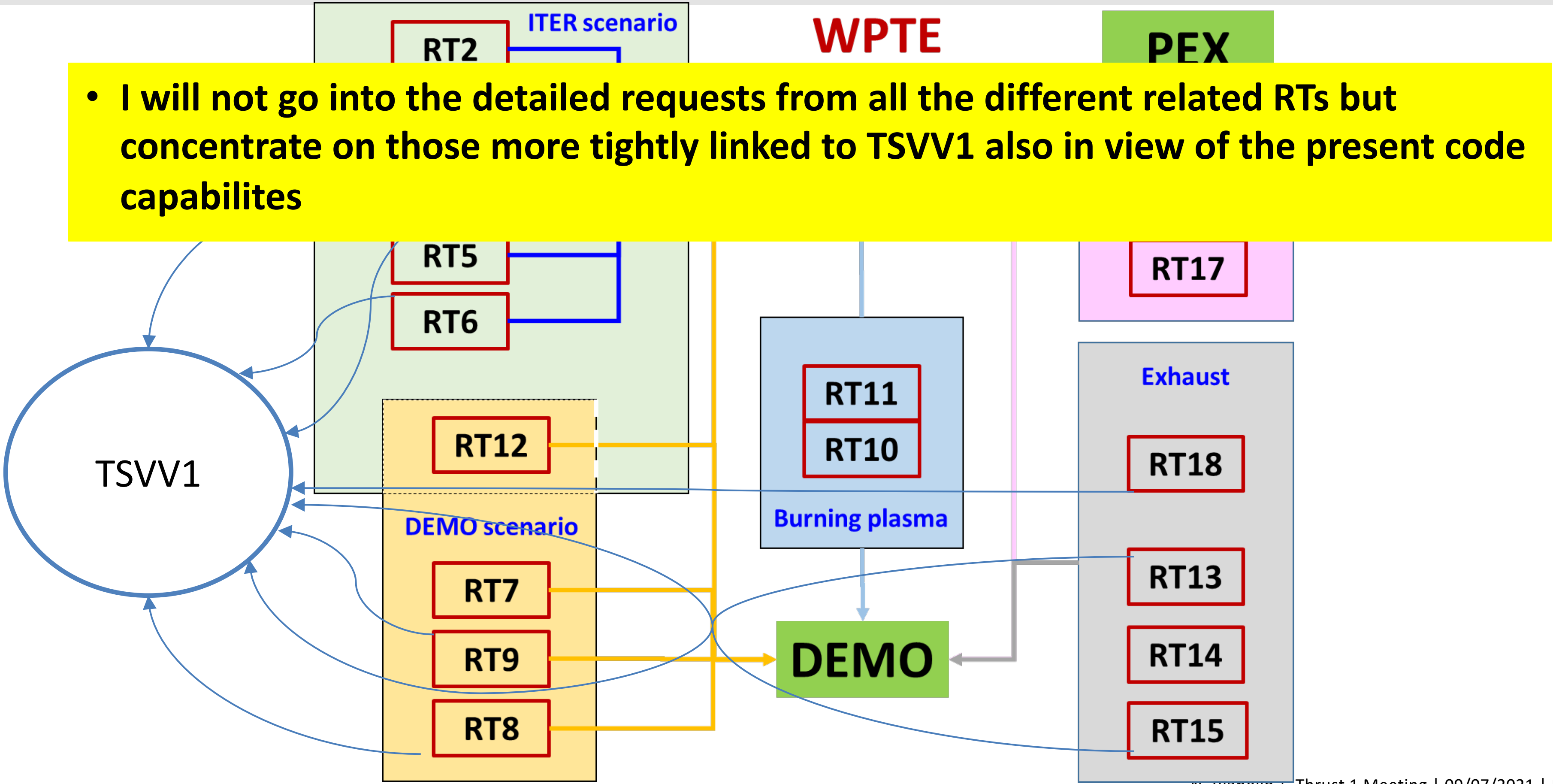
WPTE TFLs expect working meeting to take place between the SCs and PIs to define / identify:

- 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.

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	

WPTE Programme in a nutshell



- **I will not go into the detailed requests from all the different related RTs but concentrate on those more tightly linked to TSVV1 also in view of the present code capabilites**

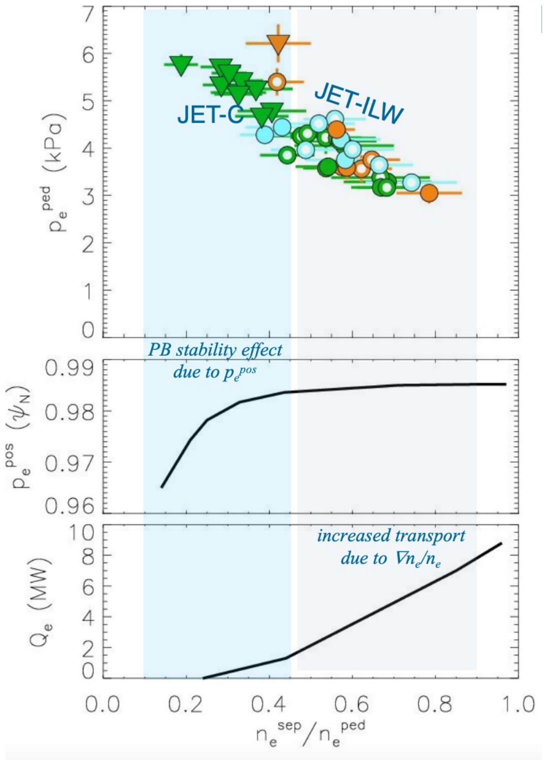
RT02: H-mode entry and pedestal dependence with impurities and isotopes

Scientific objectives
Quantify heat and particle transport across the pedestal and the SOL in low nu*
Isotope/mixed species dependence of the pedestal and SOL, including the LH transition
Assess pedestal performance in ITER/DEMO relevant scenarios (dominant electron heating/low torque/seeded impurities/low nu*)
Develop a modelling strategy with coupled SOL/pedestal predictive capability
Estimate the impact of radiative impurities on the H-mode access

SC: M. Dunne and L. Frassinetti

RT02 key questions

- **Questions for modelling extension:**
  - How are the SOL/divertor and upstream separatrix connected (sources, sinks, transport)
  - What is(are) the pedestal transport mechanism(s)?
  - Which are the key ingredient to be considered? q, dq/dr, Ip, Bt, Rotation, shaping (elevated triangularity f.e.)
  - For comparing e.g. R/LTe between machines, which R (and gradient basis of Te) is most applicable for the pedestal?
  - 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)
  - broad range of power, fuelling, and seeding scans at fixed field and current available for validation

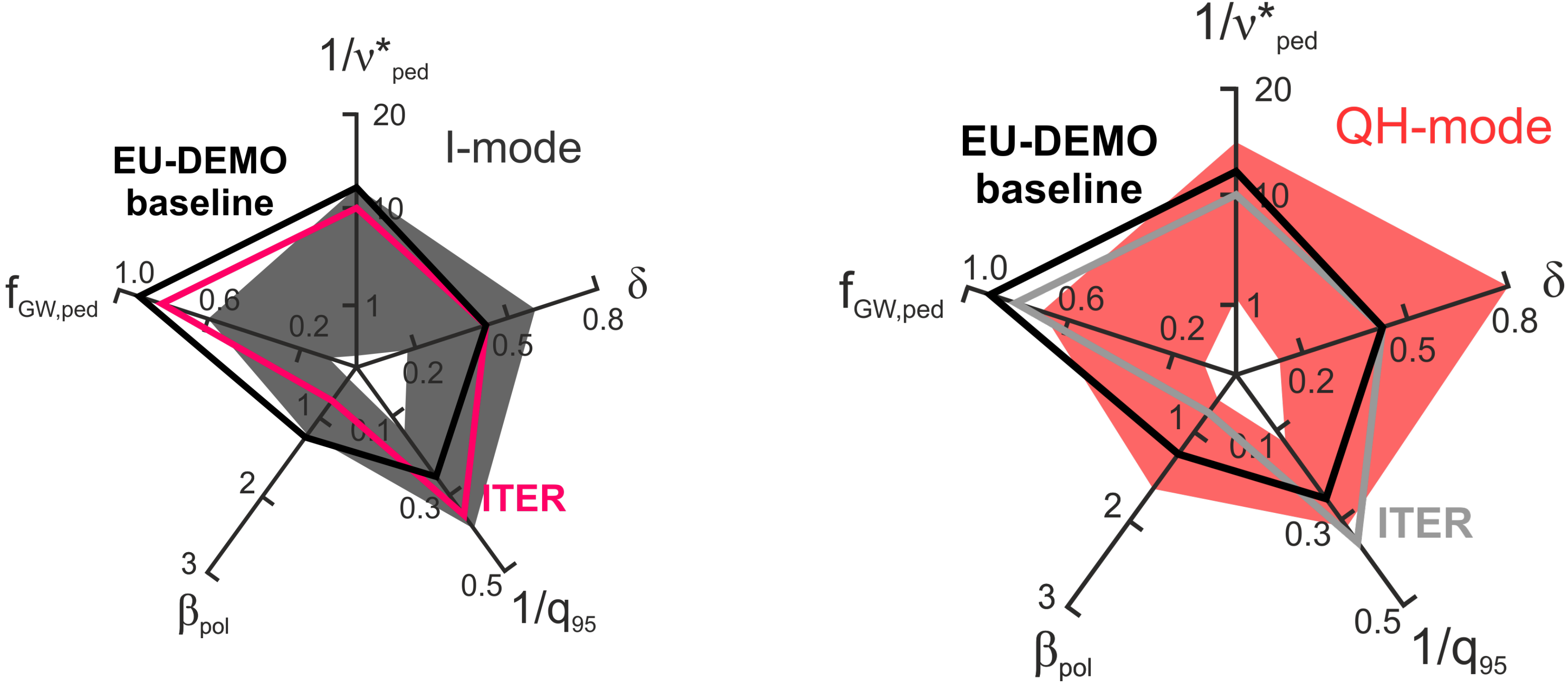


RT08: QH-mode and I-mode assessment in view of DEMO

Scientific objectives
D1. Develop I-mode and QH-mode and determine existence space.
D2. Extend cross-machine scaling of P_L-I threshold.
D3. Compatibility of QH-mode and I-mode with DEMO constraints (including dominant electron heating, low torque, high n_e,sep, dissipative divertor).
D4. Access and sustainment of QH-mode with a metallic wall.
D5. Quantify heat loads for I-mode and QH-mode and compare with existing scalings.

SC: E. Viezzer, A. Merle

Compatibility with confinement requirements in view of DEMO



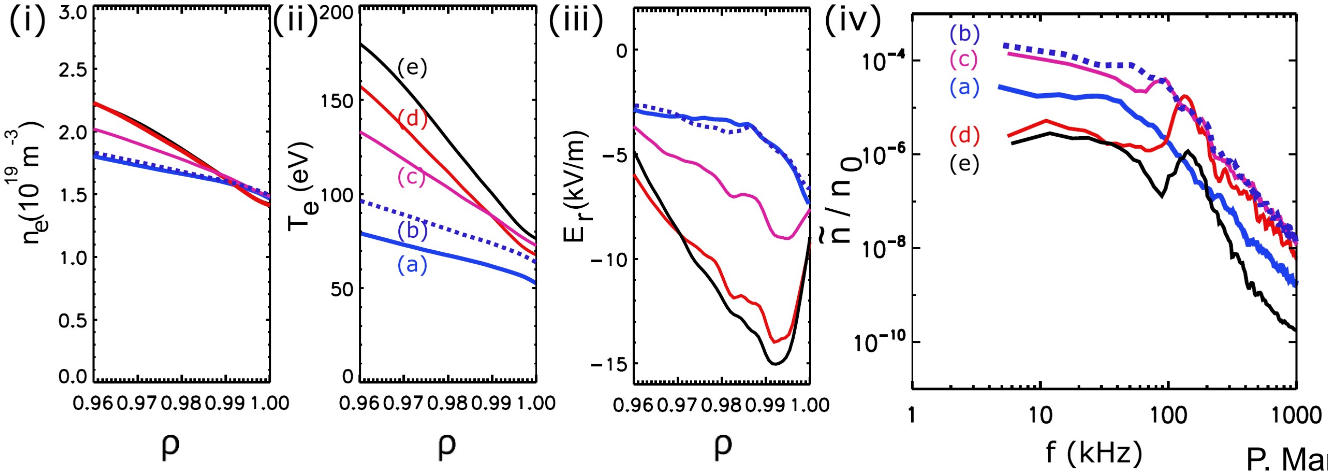
High f_{GW} and low ν^* cannot be reached simultaneously in nowadays machines

Courtesy E. Viezzer

Status of interpretative model: I-Mode

- Gyrofluid simulations reproduce main features of I-mode → Dynamics parallel to the magnetic field can induce difference in transport channels

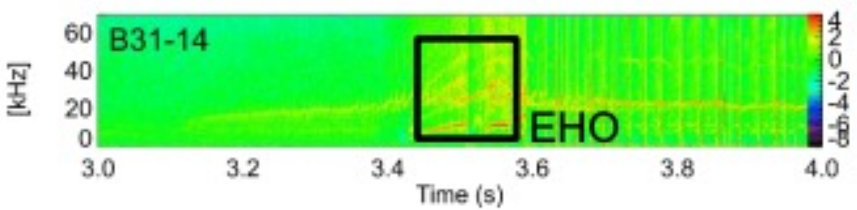
- ITG weak at the plasma edge (higher separatrix T_i and flatter T_i gradient compared to T_e) → DW turbulence dominant → decoupling of n and T fluctuations through parallel heat conduction

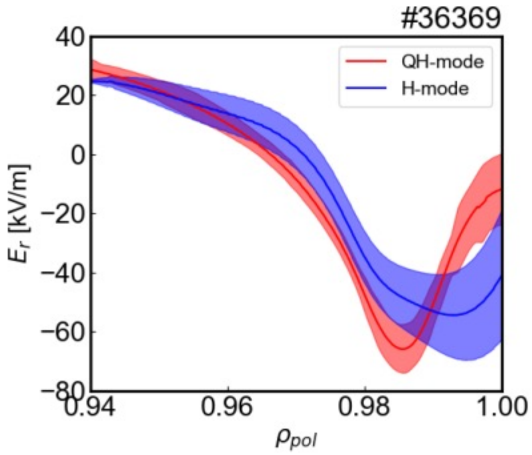


P. Manz *et al*, NF **60** 096011 (2020)

Status of the interpretative model: QH-mode

- Nonlinear MHD modelling (JOREK, NIMROD) show EHO is saturated kink-peeling mode driven by edge current
- Rotation can be important, but first JOREK sims obtained EHO without $v_{E\times B}$
- Many different models: exfernal mode theory (Brunetti et al), current ribbon (Solano et al), etc.
- Nature of EHO not completely clear – affects both particle and energy transport? Or just one?
- Role of $\omega_{E\times B}$ shearing rate? Phase-slip model by Guo-Diamond provides qualitative picture [Z. B. Guo, P. H Diamond, PRL **114** 145002 (2015)]
- Role of Zeff (why so difficult in metallic devices)?





RT09:Extension of EDA and QCE performance towards DEMO

Scientific objectives
D1. Expand the cross-machine comparison for the QCE and the EDA regimes.
D2. Extend the parameter range of both regimes toards low nu* and low q95.
D3. Asses the compatibility of both regimes with various radiative conditions (ITER/DEMO conditions).
D4. Identify the key parameters for a scaling of the heat loads in both regimes
D5. Identify in experiments and with modelling the instabilities regulating the pedestal transport
D6. Charactherise QCE and EDA regimes for hydrogen and helium plasmas

SC: M. Faitch and L. Gil

RT09: status of interpretative model

<u>QCE:</u>

- Main hypothesis: high-n ballooning modes close to the separatrix provide enhanced transport, preventing large ELMs
- HELENA calculations: ideal infinite-n ballooning modes unstable close to separatrix

<u>EDA:</u>

- Main hypothesis: quasi-coherent mode (QCM) provides enhanced transport, prevent ELMs
- GENE simulations reproduce core transport reasonably well, but pedestal is challenging (speculative)
- GEMR: QCM is a kinetic ballooning mode, code does not include important physics
- MISHKA calculations provide contradictory results regarding pedestal stability, but we have plausible explanations for this, *the main problem: lack of manpower*

<u>Open questions:</u>

- Overarching question: How is the pedestal structure determined and ELMs avoided?
- Likely requires answers to: What is the nature, driven transport, and role of the observed instabilities in each regime?
- In additional question regarding core plasma: is the Te/Ti ratio well understood? How does it extrapolate to large-scale devices?

Conclusion and remarks

- Several RTs have expressed interest in the code capabilities embedded within TSVV1
- We strongly encourage to extend the validation exercise to scenarios experimentally explored within WPTE
- We highlighted the most critical issues:
  - Transport setting pedestal width beyond ideal MHD (EPED) limit
  - Instabilities on the pedestal region (QCM) setting and regulating transport for EDA H-mode
  - Instability sitting at the bottom of the pedestal setting and regulating the transport in QCE regime
  - EHO nature and existence on ITER/DEMO relevant scenarios (low torque, Electron dominant heating, metallic wall -- > Z_{eff} effect)