"THEORY, SIMULATION, VERIFICATION AND VALIDATION"

TSVV TASK 6: IMPURITY SOURCES, TRANSPORT, AND SCREENING

THRUST 2: EDGE PHYSICS & PW MEETING 30.08.2021

Aims

- Establish an integrated modelling suite to predict the W impurity distribution in DEMO, including W source generation, W screening, W transport, W exhaust and its impact on the plasma performance.

- Develop 3D kinetic transport models for heavy impurities (including W) and seeding species like Ar, Kr, Xe in the SOL and pedestal regions of DEMO.

- Assess the effects of 3D perturbations and ELM suppression techniques on the W impurity distribution in ITER reference scenarios, along with their implications for DEMO.

Deliverables

- Validated suite of 3D codes and transport models to describe in an integrated way the W content and its distribution in metallic devices, in particular DEMO and ITER, with discrimination of main chamber and divertor sources, screening, transport, and exhaust along with its impact on the main plasma dynamics and performance.

- Assessment of the W influx, W screening, and W transport in ITER plasmas envisaged for pre-fusion and fusion power operation with semi-detached divertor and application of resonant magnetic perturbations for ELM suppression. Discussion of the impact on a potential loss of semi-detachment and ELM suppression on the W influx, W screening, and W transport in those ITER scenarios.

- Applications of the developed model. Assessment of the seeding impurity screening and transport in DEMO and ITER scenarios

Commitment of the TSVV Task team members during the period 2021-2023, and indication beyond 2023

The table below summarizes the commitment of team members **in terms of pm** for each year between 2021 and 2025, with values beyond 2023 being indicative. **Table received on IMS**

Team member	Beneficiary	2021	2022	2023	2024	2025
G Ciraolo	CEA	8	8	8	8	8
H Bufferand	CEA	6	6	6	6	6
E Gravier	CEA/UL	5	5	5	5	5
M Raghunathan	CEA/AMU	6	6	6	0	0
Y. Marandet	CEA/AMU	4	4	4	4	4
D. Harting	FZJ	8	6	6	6	6
Postdoc	FZJ	6	6	6	6	6
J. Romazanov	FZJ	0	4	6	6	6
H. Kumpulainen	VTT (Aalto Univ)	6	6	6	6	6
Postdoc/PhD	EPFL	0	0	0	6	6
M. Eder	OEAW (Graz TU)	6	6	6	0	0
ACH resources	ACH	1	1	1	6	6
TOTAL		59+1	59+1	59+1	54+6	54+6

- **TSVV 6 meetings**:

  - **Kick-Off Meeting the 12th of April**

  - **regular meetings** :

    - 29th of June (all participants)

    - 22nd of July morning: discussion on validation steps on JET (M Groth and Finnish group)

    - 22nd of July afternoon: discussion on ITER cases to be modelled (with D Harting, J Romazanov, H Frerichs, N Rivals)

    - **27th of August** (P. Tamain for SOLEDGE3X code with members from ACH in Lausanne)

- **Meetings SB/ACH/TSVV task leaders**

  - Kick-Off Meeting the 23rd of April

  - meetings for discussions on ACH resources

    - 2nd of June

    - 30th of June

Key Deliverable 1:

Validated suite of 3D codes and transport models to describe in an integrated way the W content and its distribution in metallic devices, in particular DEMO and ITER, with discrimination of main chamber and divertor sources, screening, transport, and exhaust along with its impact on the main plasma dynamics and performance.

- **Task 1** for key deliverable 1: **numerical development** and verification of **SOLEDGE3X, EMC3-EIRENE and ERO2.0** codes

- **Task 2** for key deliverable 1: **GyselaX and VENUS-LEVIS** code development for investigation for **W transport in the pedestal region**

- **Task 3** for key deliverable 1: **Validation of numerical tools on selected experiments on WEST, W7X and JET**

- **Task 1** for **key deliverable 1**: **numerical development** and verification of **SOLEDGE3X, EMC3-EIRENE and ERO2.0** codes

ID	Milestone-description	participants	Target date
M1.1	**Implementation of a 3D** wall (i.e. with objects toroidally localized) **in SOLEDGE3X-EIRENE**	H. Bufferand, M. Raghunathan	12/2021
M1.2	**Integrating Gorilla orbit tracing code into EIRENE**, first step: test of the efficiency of resulting combination in axisymmetric tokamak geometry	M. Eder, M. Raghunathan Y Marandet	12/2021
M1.3	Develop interface for importing **SOLEDGE3X** plasma backgrounds into **ERO2.0**	H. Bufferand, J. Romazanov, PhD student CEA (funded by other means)	06/2022

- **First simulations with a 3D wall with SOLEDGE3X (using fluid neutrals)**
- **Recruited a postdoc (K Galazka,** arrived end of July) **for coupling SOLEGDE3X and EIRENE** with a 3D wall

- Meetings in June/July between Y Marandet and M Eder and colleagues for preparing the first test of the integration of Gorilla into EIRENE

- Regular discussions and common articles between CEA/AMU and FZJ on the coupling between ERO20 and SOLEDGE3X, **already done in 2D**

- **Task 1** for **key deliverable 1**: **numerical development** and verification of **SOLEDGE3X, EMC3-EIRENE and ERO2.0** codes

ID	Milestone-description	participants	Target date
M1.1 2	Include stabilization scheme [Frereichs2019] in **EMC3-EIRENE for dissipative divertor conditions**	D. Harting, Postdoc FZJ	**12/2021**
M1.1 3	**Implementation of EIRENE Kinetic Ion Trace module in EMC3 for low Z impurities**	D. Harting, Postdoc FZJ	12/2021

- **Meeting with D. Harting (FZJ) and H Frerichs (Univ of Wisconsin Madison) in July, ongoing discussions for having a common** EMC3-EIRENE version

Extended operation range of EMC3-EIRENE is verified by comparison to SOLPS-ITER (for PFPO-I)

- Continuous reduction of peak heat flux during gas puff scan
- A clear **roll-over** of peak particle flux is found by both codes in reasonably good agreement
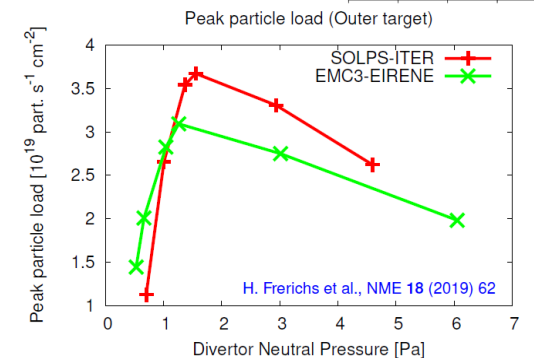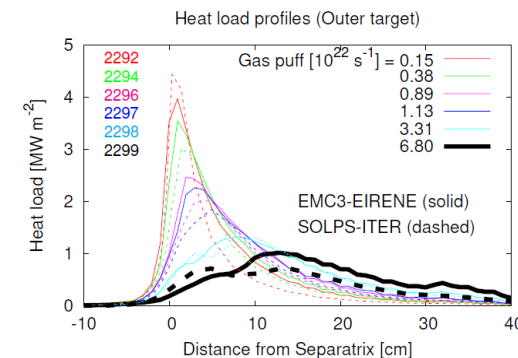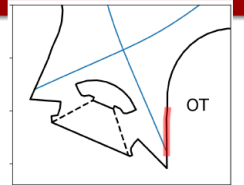

(H Frerichs courtesy)

Task 2 for key deliverable 1: GyselaX and VENUS-LEVIS code development for investigation for W transport in the pedestal region

ID	Milestone-description	participants	Target date
M1.19	Implementation of a source term in the vorticity equation of GyselaX code (following what had been done previously, see A. Strugarek et al., PRL (2013)]:	E. Gravier, PhD student CEA/UL (funded by other means)	12/2021
M1.20	Generation of transport barriers by sheared poloidal flows, triggered by a vorticity source (poloidal momentum), with GyselaX code.	E. Gravier, PhD student CEA/UL (funded by other means)	12/2022

E Gravier
(Univ Nancy)

ITG instabilities + vorticity source
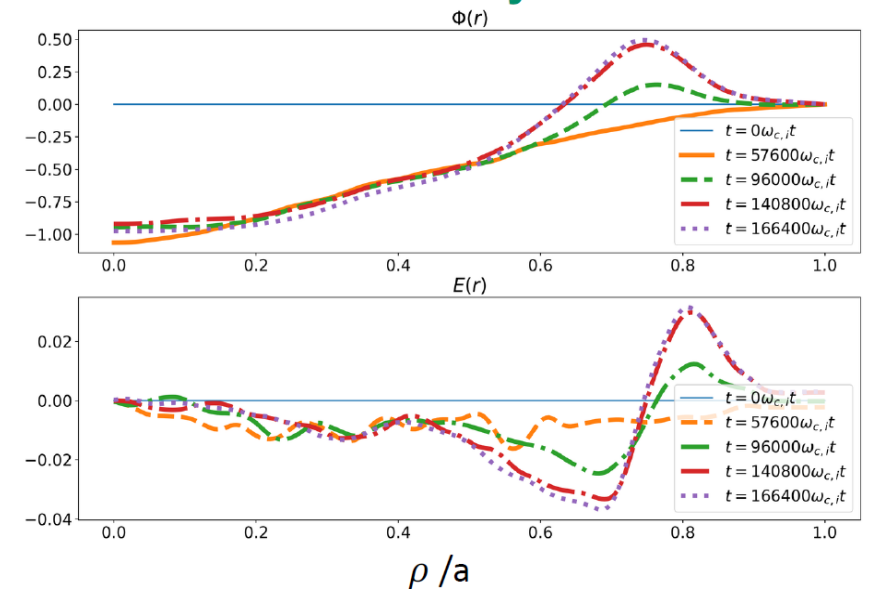
**Vorticity source implemented in Gysela and first simulations ongoing**

Key Deliverable 2:

Assessment of the W influx, W screening, and W transport in ITER plasmas envisaged for pre-fusion and fusion power operation with semi-detached divertor and application of resonant magnetic perturbations for ELM suppression. Discussion of the impact on a potential loss of semi-detachment and ELM suppression on the W influx, W screening, and W transport in those ITER scenarios.

ID	Milestone-description	participants	Target date
M2.1	Review and document ITER scenarios to be modelled	All (site activity managers are responsible for local coordination)	06/2021
M2.2	**2D Plasma background in semi-detached conditions** (no RMP) (both with EMC3-EIRENE and SOLEDGE3X)	D. Harting, H. Bufferand, G. Ciraolo	12/2021

Example from SOLEDGE ITER simulations in 2D

Illustration of case 2297
(mid-upper part of the gas puff scan)
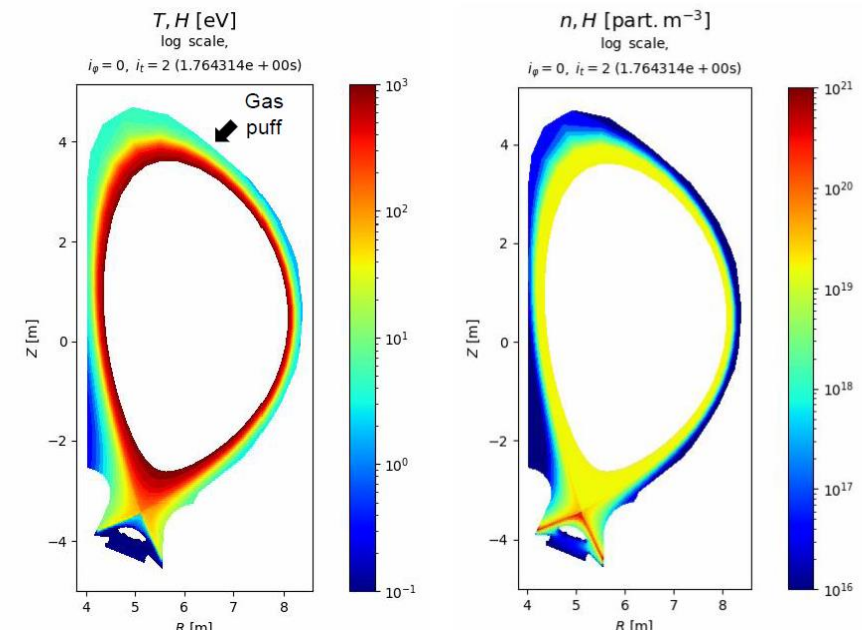
Key Deliverable 2: from the July meeting a first proposal for the ITER cases to be modelled

Scope of Work for ITER simulations cases

Throughput scans from PFPO-1, low-power, pure H plasmas

Common parameters:

Species mix:	Pure H
Heating power:	20 MW
Confinement:	L-mode (constant & homogeneous $D_\perp = 0.3\ \mathrm{m^2 s^{-1}}$, $\chi = 1.0\ \mathrm{m^2 s^{-1}}, v_\perp = 0.2\ \mathrm{m^2 s^{-1}}$)
Equilibrium:	2008 baseline, q_{95}=3, 7.5MA/2.65T
Wall:	2008 baseline, full Beryllium

Throughput scan values:

Case number	Puff rate [part.s^{-1}]	IMAS ITER DB case number
2292	1,46E+21	*n.a.*
2294	3,81E+21	*n.a.*
2296	8,85E+21	*3027*
2297	1,13E+22	*3028*
2298	3,31E+22	*3029*