



HAL
open science

Impact of divertor configuration on tokamak performances: focus on WEST experiments supported by SOLEDGE2D modeling

G. Ciraolo, R Mao, N. Fedorczak, J. Gunn, H. Bufferand, J. Bucalossi, S. Baschetti, A. Gallo, Y. Marandet, E. Serre, et al.

► To cite this version:

G. Ciraolo, R Mao, N. Fedorczak, J. Gunn, H. Bufferand, et al.. Impact of divertor configuration on tokamak performances: focus on WEST experiments supported by SOLEDGE2D modeling. Third IAEA Technical Meeting on Divertor Concepts (DC 2019), Nov 2019, Vienne, Austria. cea-02555066

HAL Id: cea-02555066

<https://cea.hal.science/cea-02555066>

Submitted on 27 Apr 2020

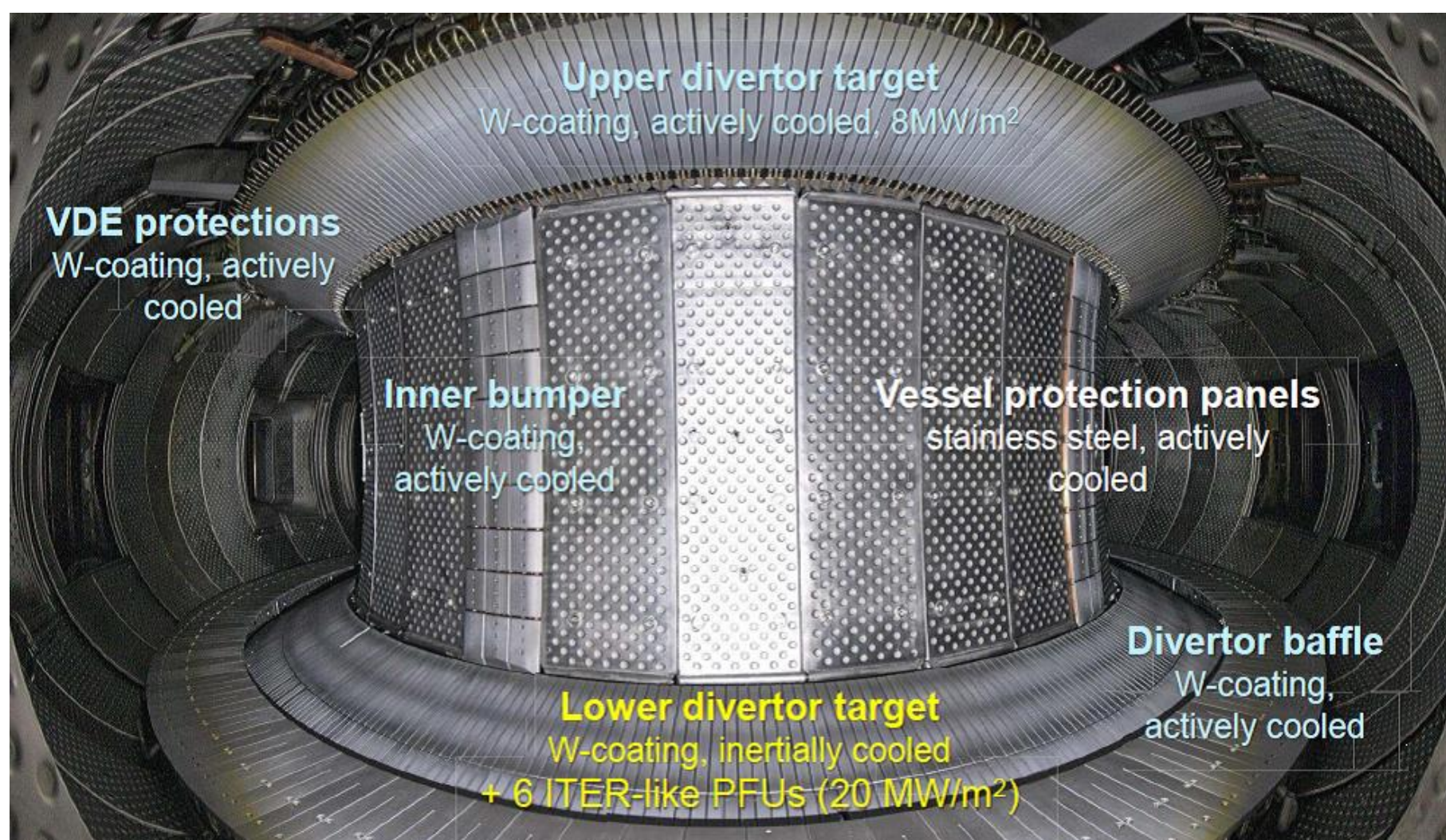
HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

G. Ciralo^{a*}, R. Mao^b, N. Fedorczak^a, J.P. Gunn^a, H. Bufferand^a, J. Bucalossi^a, S. Baschetti^a,
A. Gallo^c, Y. Marandet^c, E. Serre^b, P. Tamain^a, E. Tsitrone^a & the WEST team*^a CEA, IRFM, F-13108 Saint-Paul-Lez-Durance, France^b Aix Marseille Univ, CNRS, M2P2, Marseille, France^c Aix Marseille Univ, CNRS, PIIM, Marseille, France

* guido.ciraolo@cea.fr

WEST TOKAMAK



I_p ($q_{95} \sim 2.5$)	1 MA
B_T	3.7 T
R	2.5 m
a	0.5 m
A	5-6
κ	1.3-1.8
δ	0.5-0.6
V_p	15 m ³
n_{GW} (1MA)	1.5 $10^{20} m^{-3}$
P_{ICRH}	9 MW
P_{LHCD}	7 MW
$T_{flattop}$ (0.8 MA)	1000 s

- A major upgrade for investigating Tungsten environment

- Taking full benefit from Tore Supra assets Long pulse physics and operation

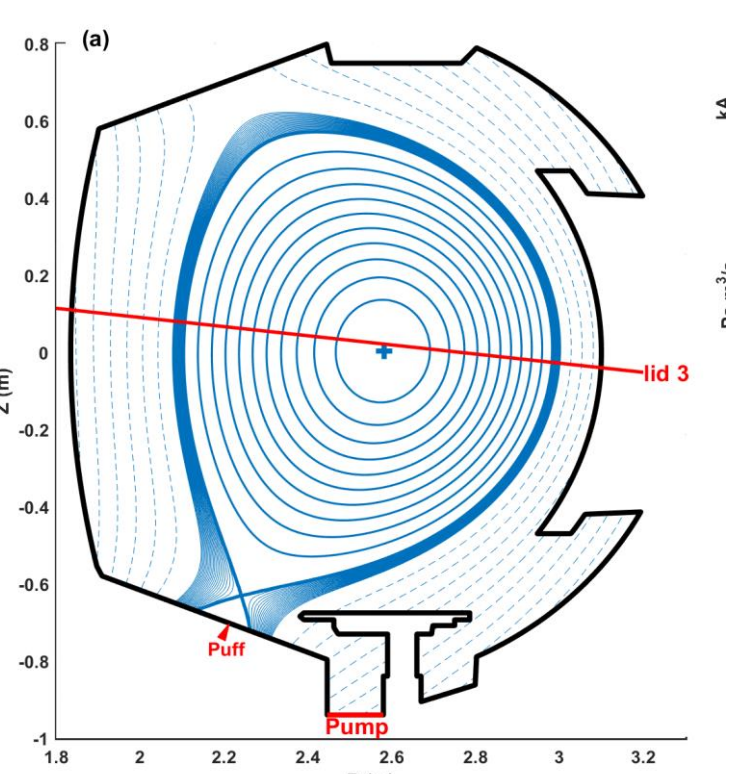
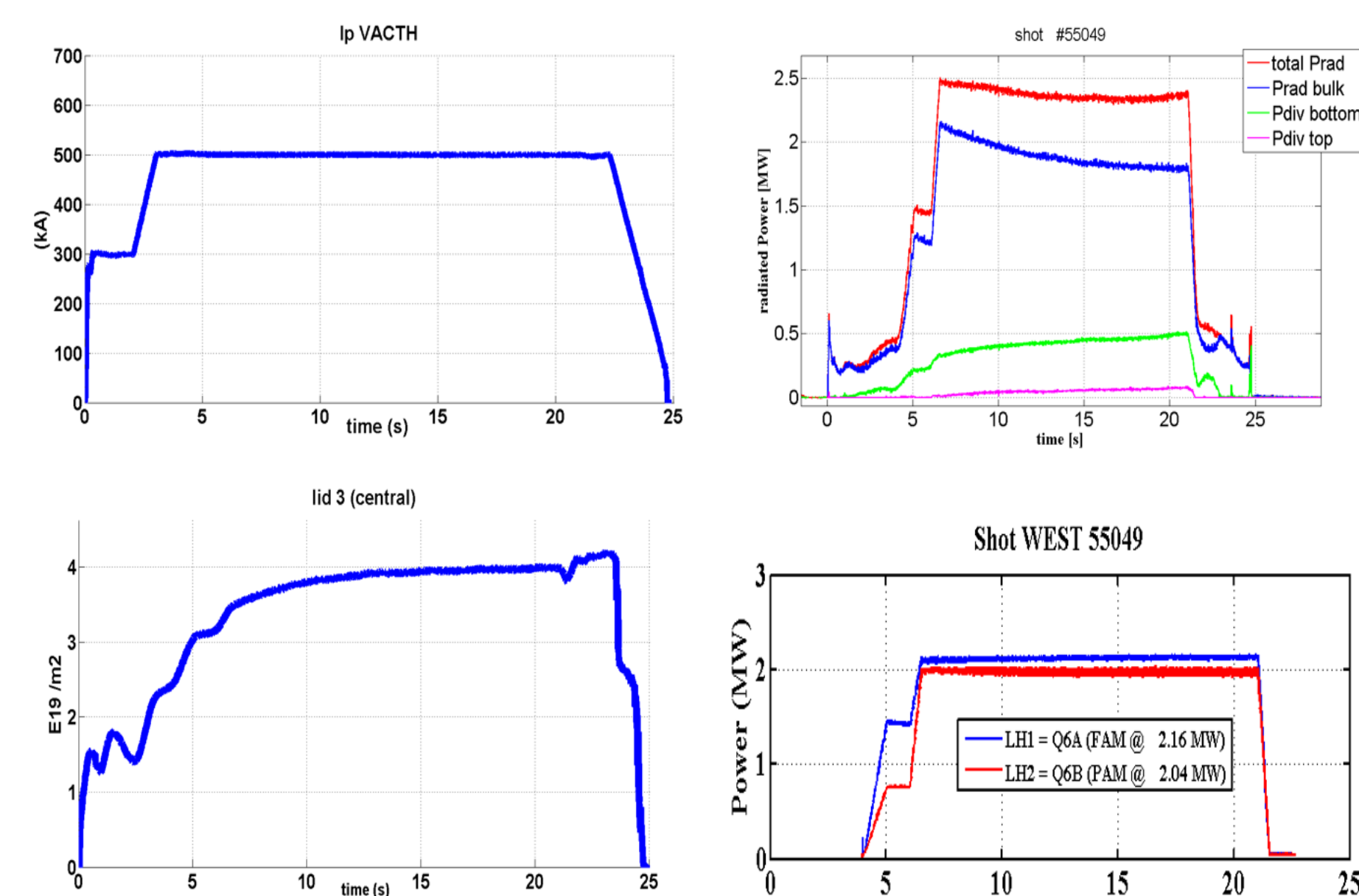
Assessment of power handling capabilities/ lifetime of ITER-like tungsten divertor components under high heat flux in tokamak environment

Master integrated plasma scenario over relevant plasma-wall equilibrium time scale in a metallic environment

ANALYSIS OF WEST SHOT #55049 WITH SINGLE NULL DIVERTOR CONFIGURATION

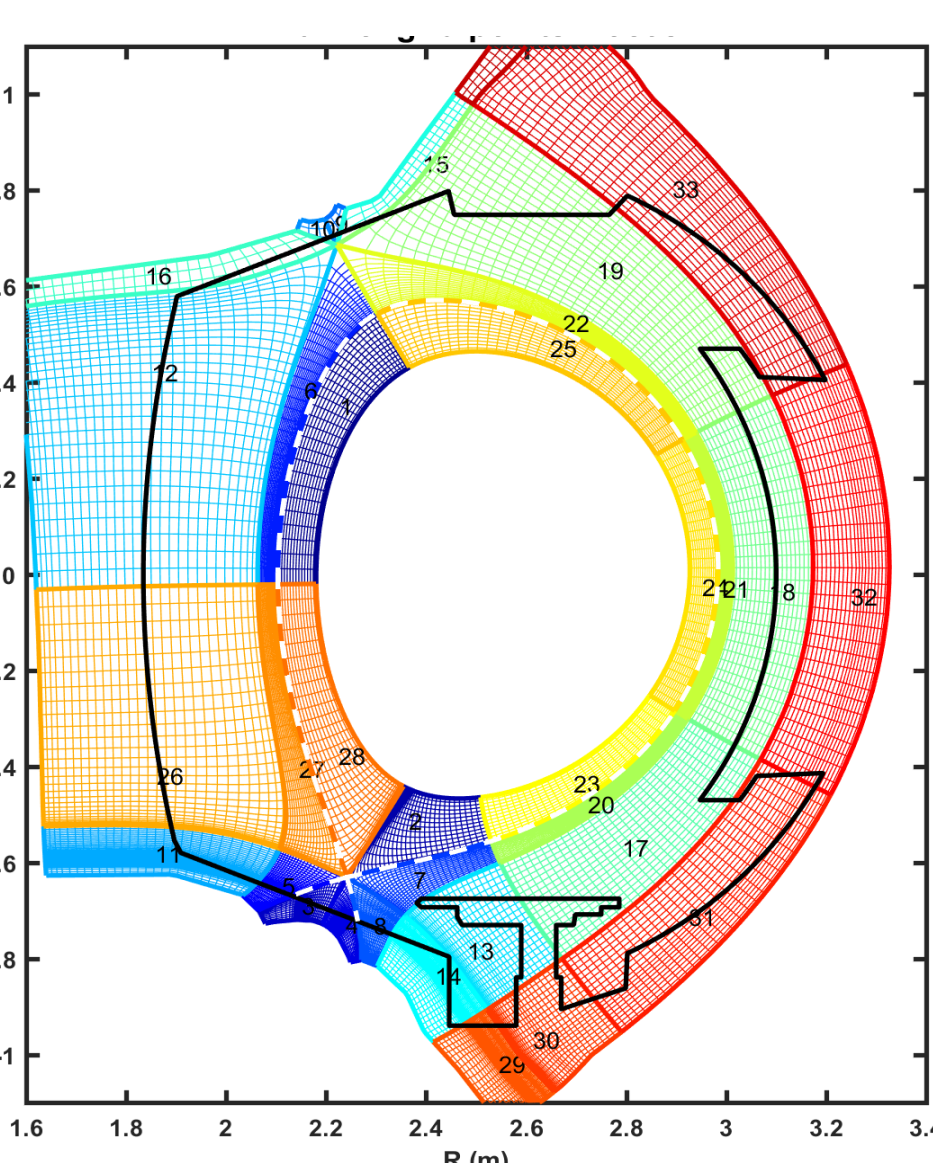
Parameter	Value
I_p	500kA
B_T	3.7T
R	2.5m
a	0.44m
κ	1.36
δ	0.46
P_{LHCD}	4MW
$T_{flattop}$	20s

We focus on a recent long discharge in WEST, the shot #55049 of C4 campaign obtained in September 2019. We report below the main time traces of the experiment. The LH injected power was about 4MW for more than 10s, the total radiated power around 2.5MW, central line integrated density of about $4 \times 10^{19} m^{-2}$ and plasma current of 500 kA with a height of the X point of about 80 mm from the wall.



SOLEDGE2D-EIRENE NUMERICAL MODELLING

SoEdge2D meshgrid for WEST shot #55049 (SN configuration)



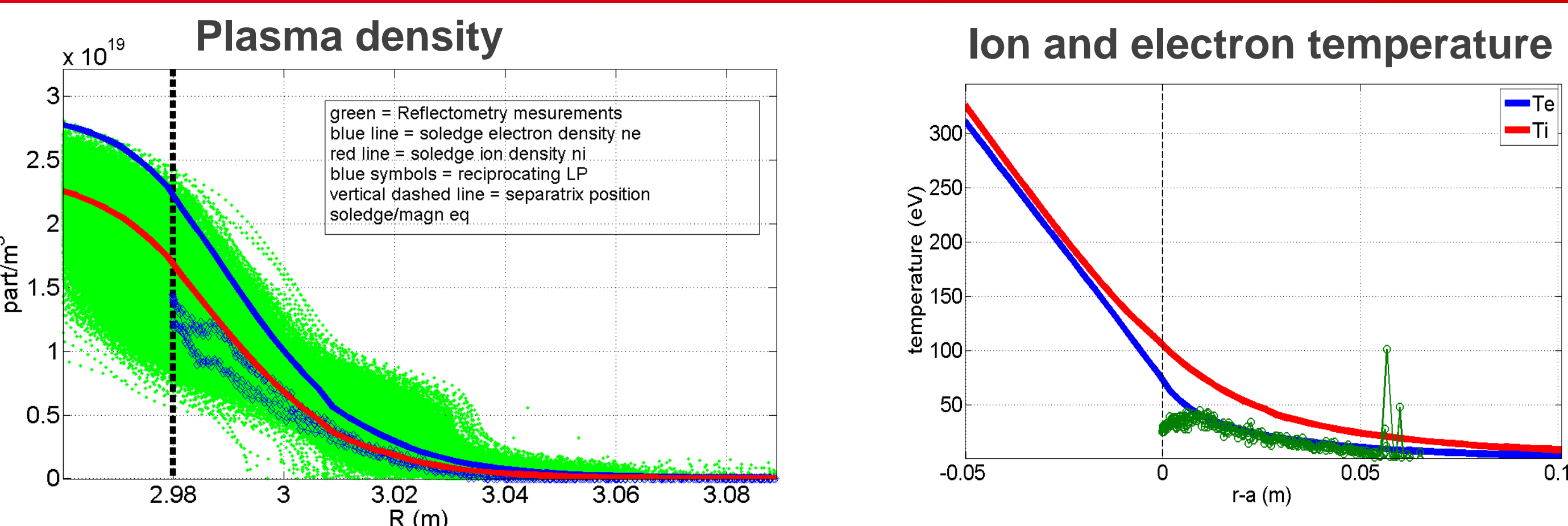
- Multi-species plasma solver coupled to EIRENE for neutrals
- Solves equations for densities, parallel velocities, temperatures and electric potential
- Multi-species Zhdanov closure (no impurity trace and light impurity assumption) provides linear relation between temperature gradients, velocities and heat fluxes and friction forces (see poster by H Bufferand)
- Realistic wall geometry and flexible magnetic configuration (SN, DN, SF+, SF-...)
- Plasma up to the main chamber wall
- Advanced numerical scheme (shock capturing, immersed boundary condition...)

H Bufferand *et al*, Nucl. Fusion **55** (2015) 053025

Simulation setup, results and comparison with experiment

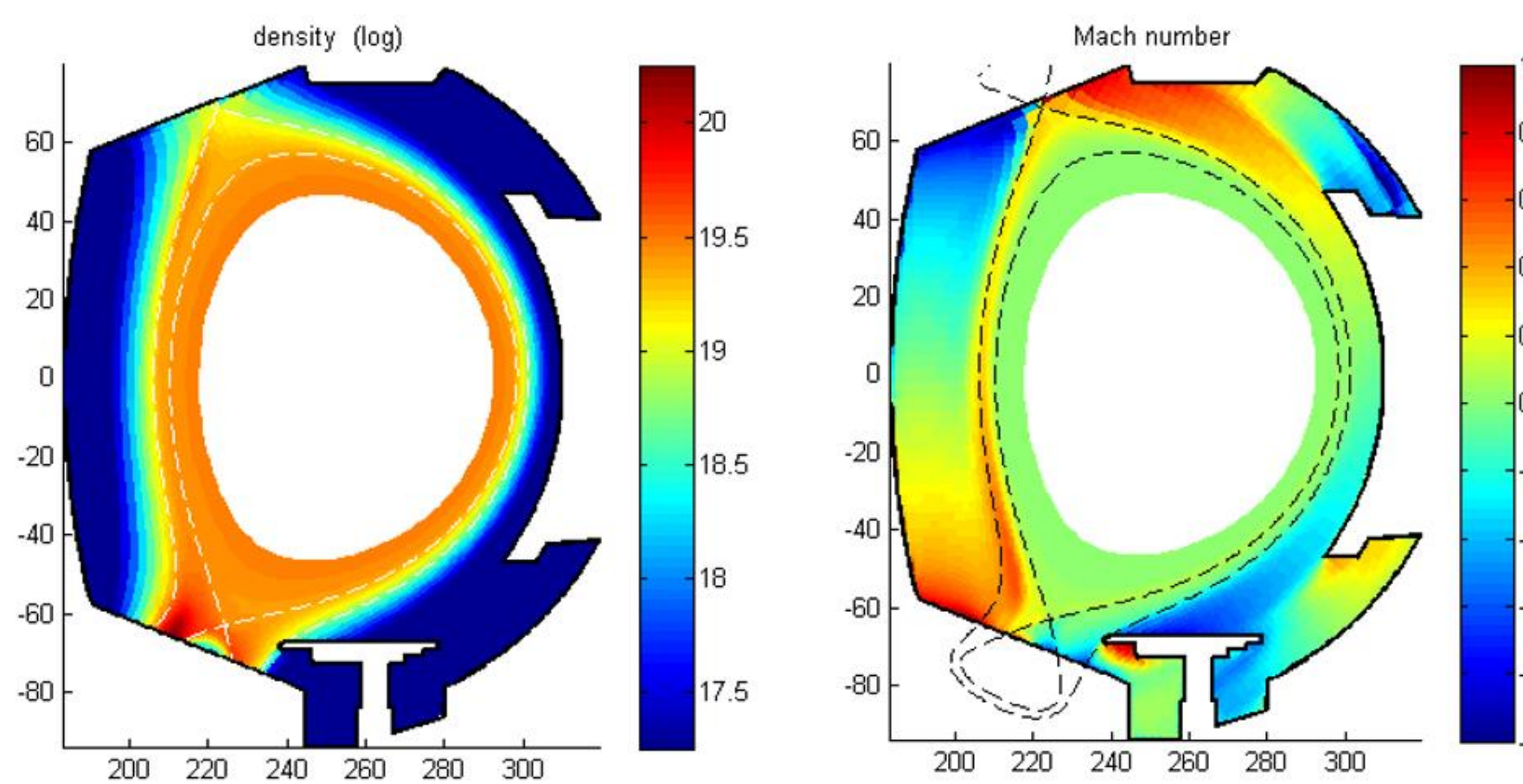
P_{in}	N_{sep} (feedback on gaspuff)	composition	R_n	Neutrals	Radial transport coefficients	wall
1.5 MW	$2 \cdot 10^{19} m^{-3}$	D + O (3%)	99 %	EIRENE	$D = v = 0.3 m^2 s^{-1}$ $\chi_e = \chi_i = 1 m^2 s^{-1}$	W

OUTBOARD MIDPLANE PROFILES

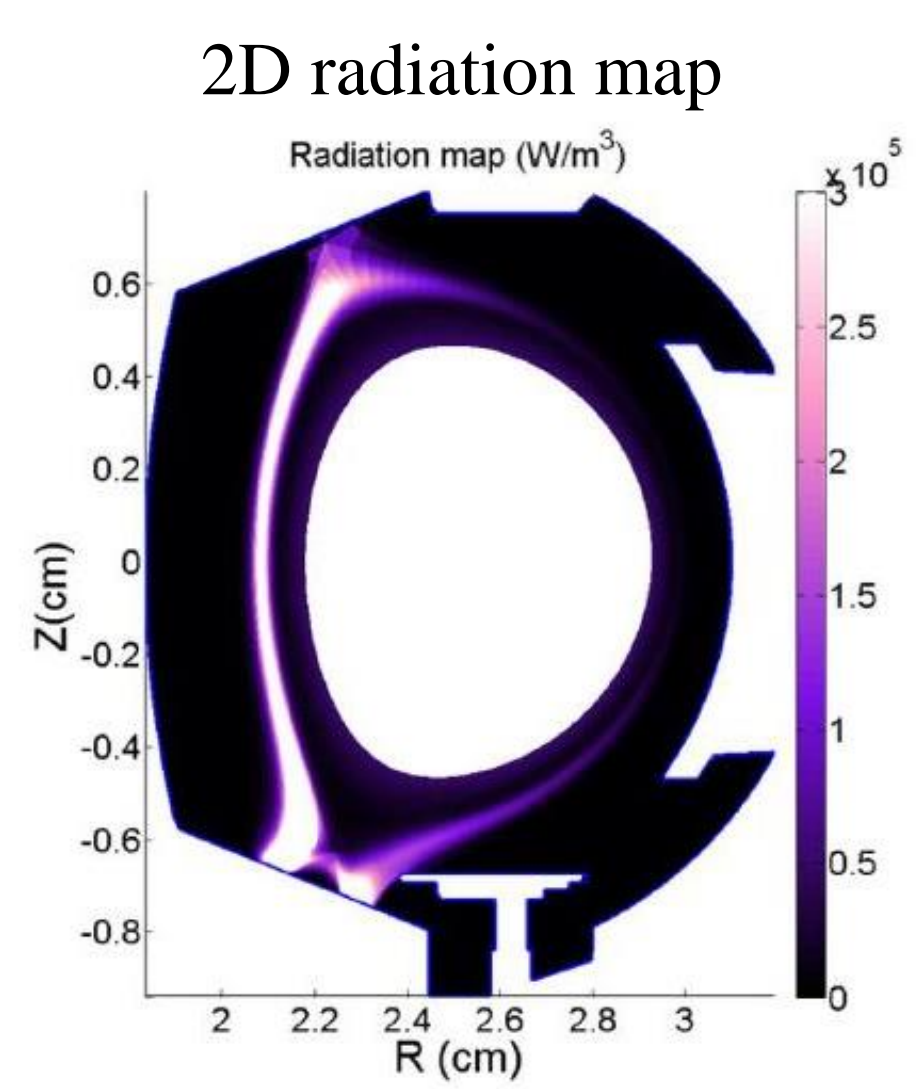
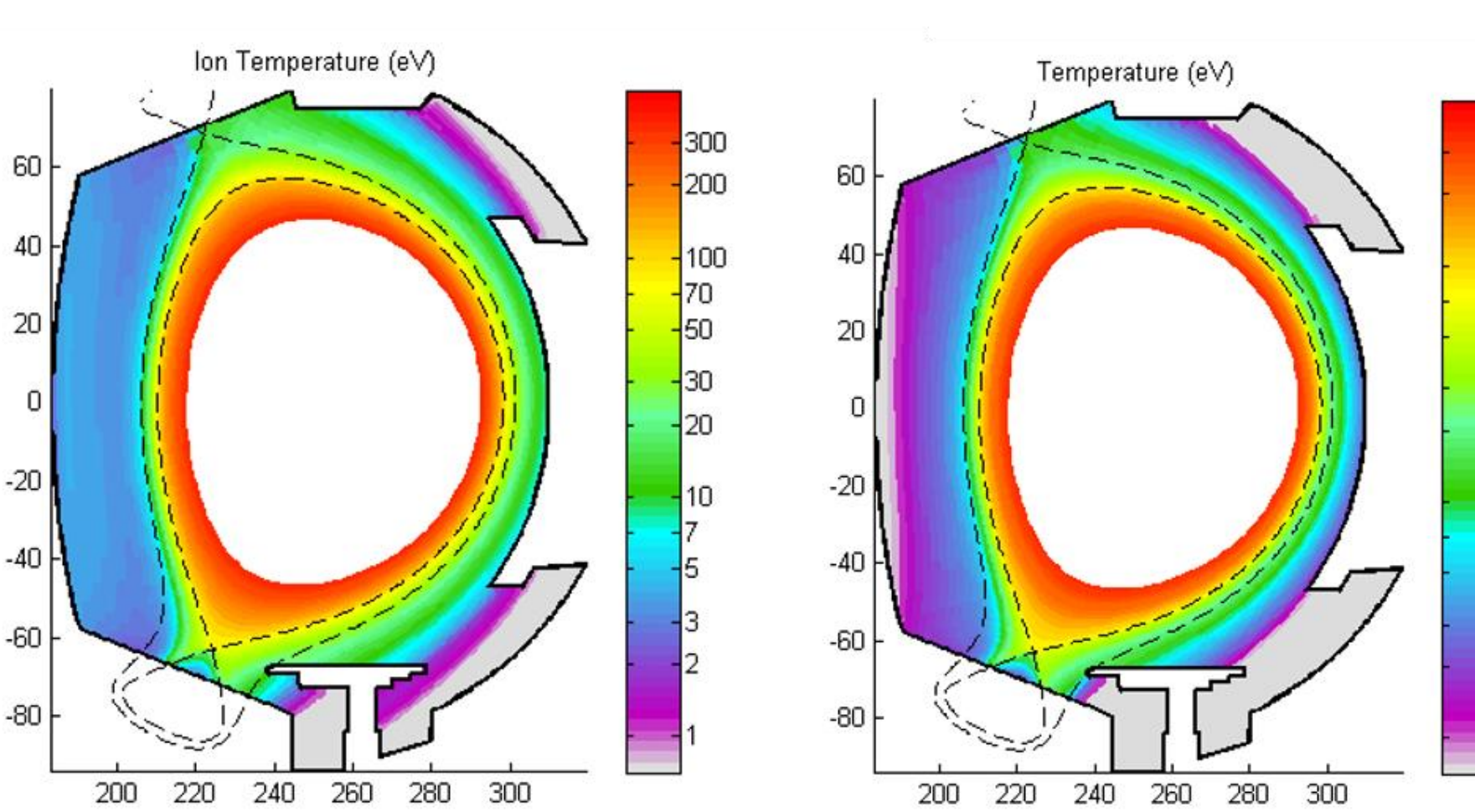
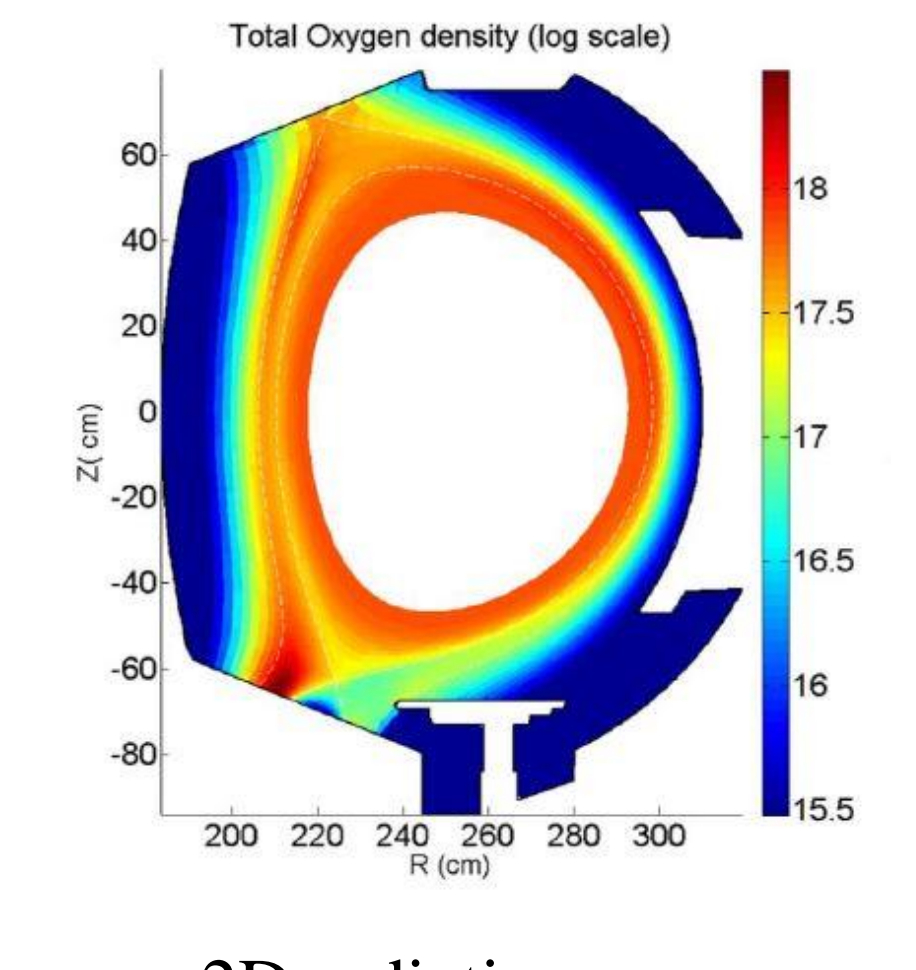


SOLEDGE2D SIMULATION FOR WEST SHOT #55049 :

2D poloidal maps for main species D

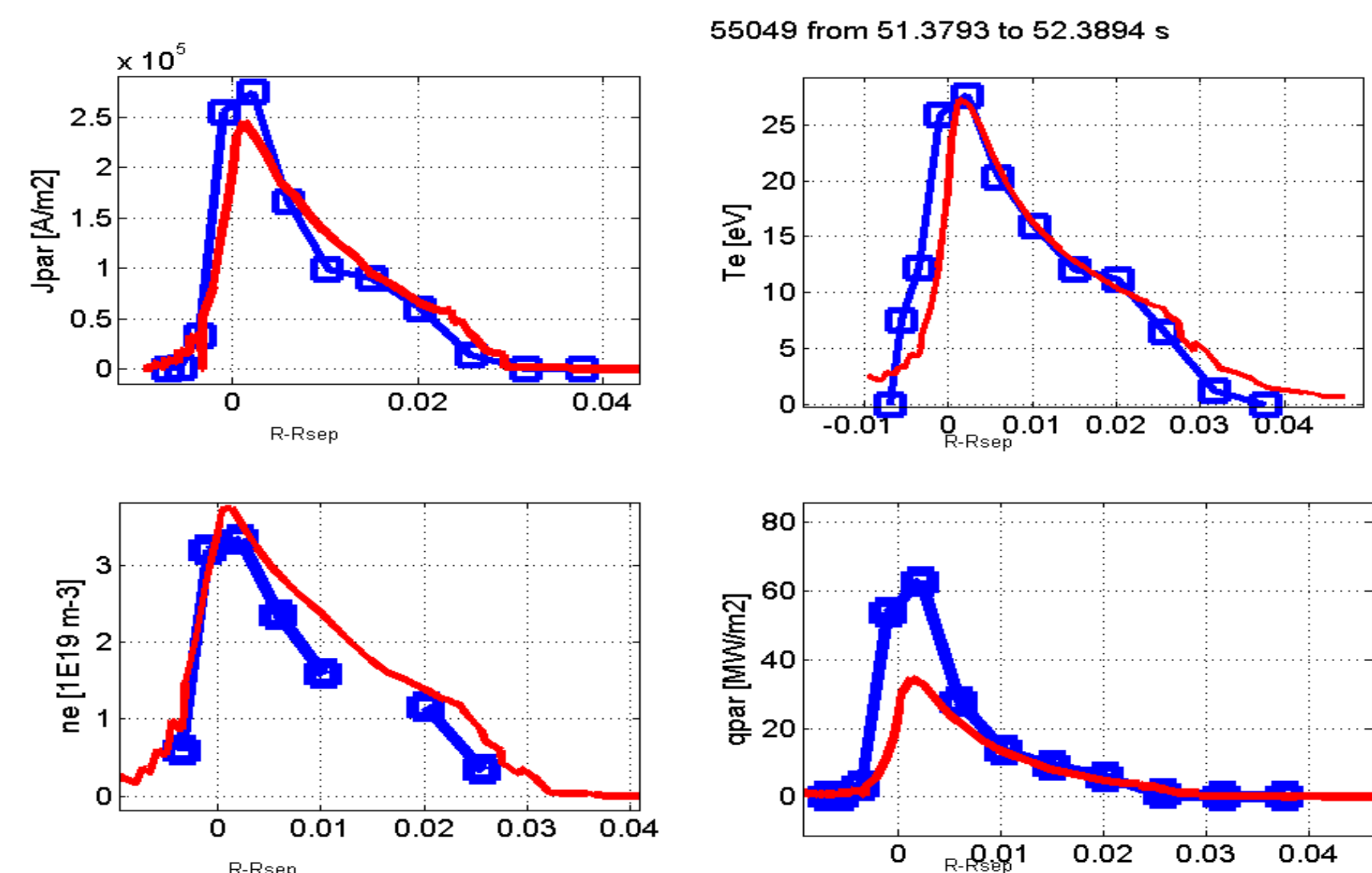


2D poloidal map for oxygen density



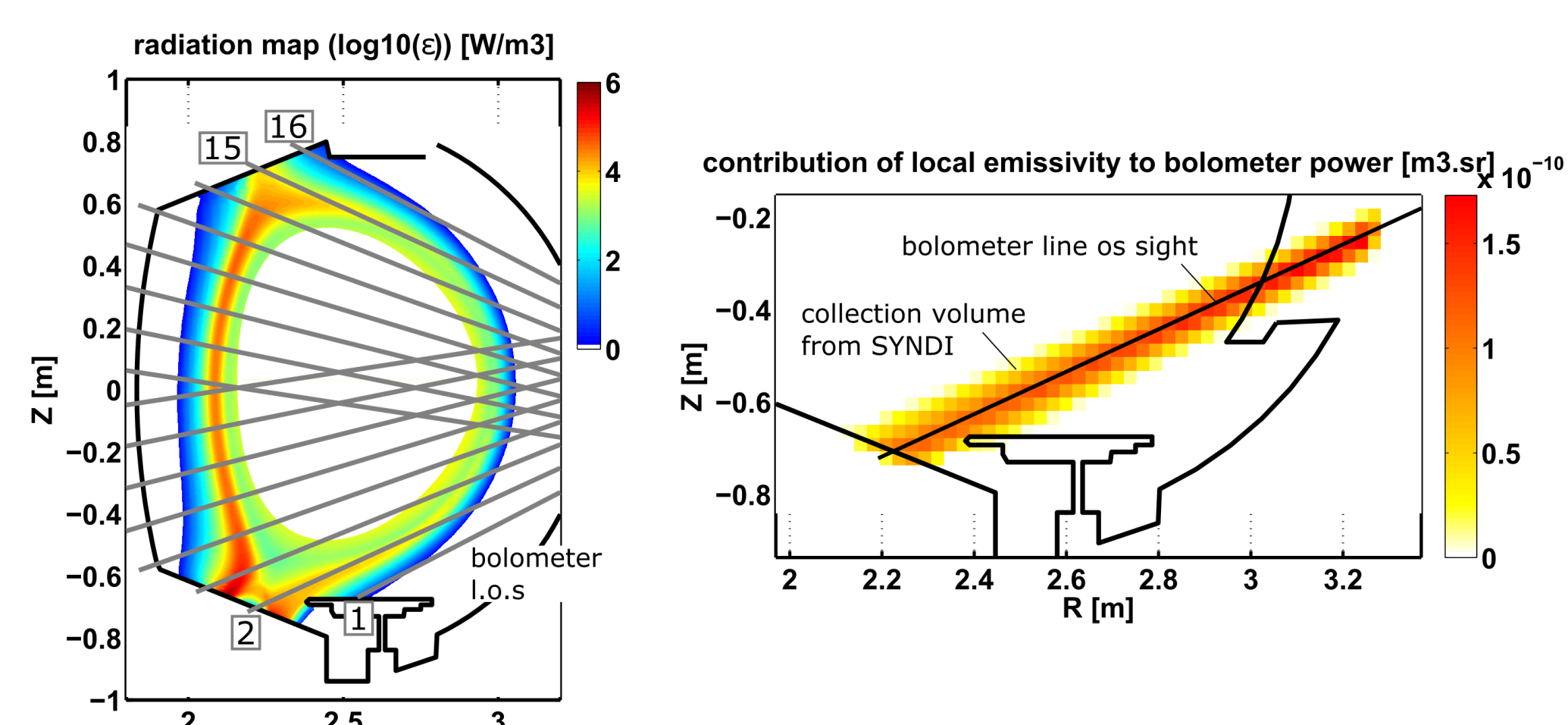
780 kW total radiated power in the simulation domain

BOTTOM DIVERTOR OUTER STRIKE POINT PROFILES

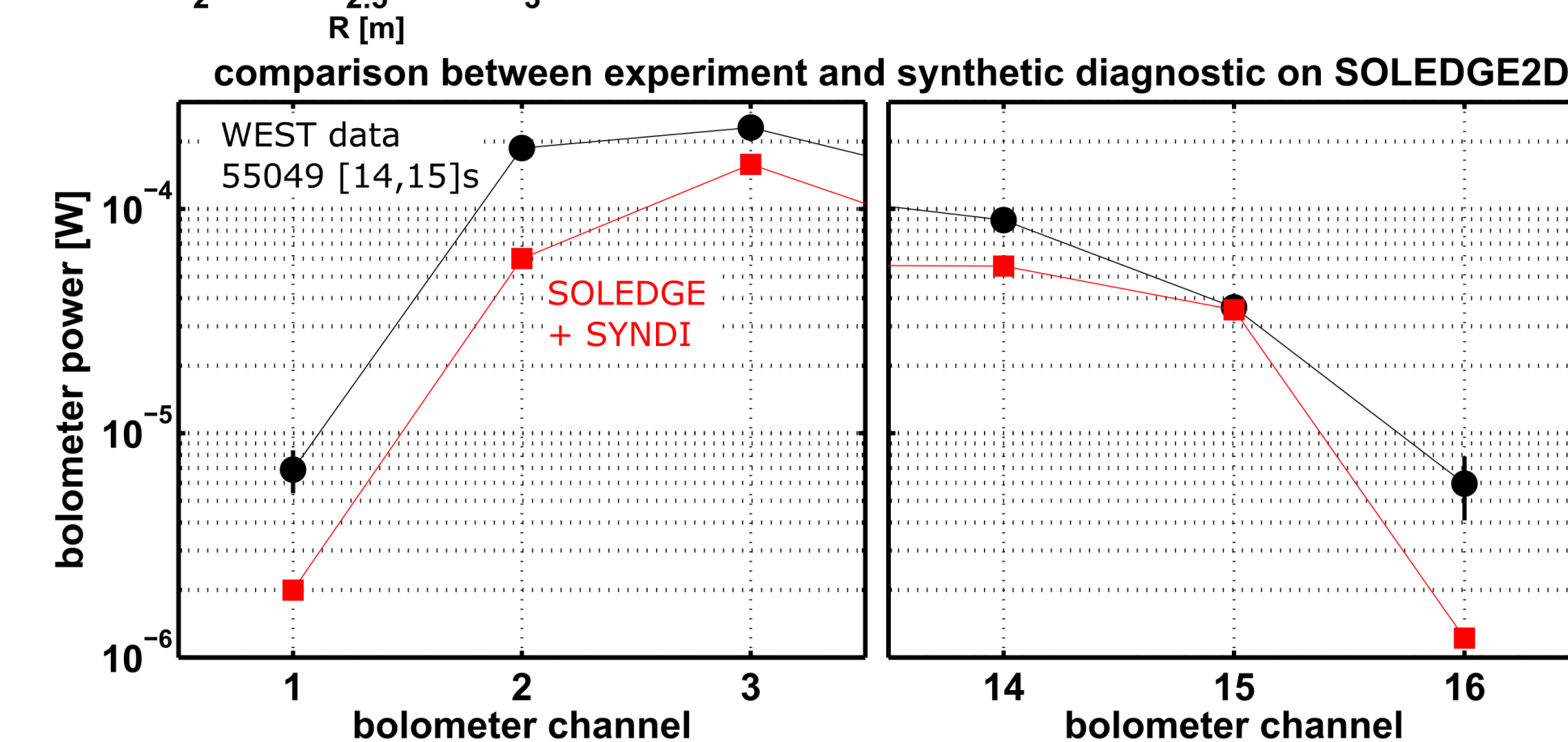


Parallel ion saturation current, electron temperature, electron density and parallel heat flux on outer divertor target computed with Soledge2D-Eirene (red lines) and measured by Langmuir probes (blue symbols and line).

BOLOMETRY MEASUREMENTS AND SYNTHETIC DIAGNOSTICS



We consider the bolometer channels intercepting the edge and SOL plasma in WEST, that are channels from one to three and from 14th to 16th as shown on top left panel.



On the bottom panels we compare the estimation from experimental data (black symbols) with the ones obtained from the application of SYNDI to radiated map from SOLEDGE simulation.

One can notice that the simulation reproduces quite well the qualitative behavior and even a good quantitative comparison is obtained on the upper divertor channels.

Acknowledgements

This work was granted access to the HPC resources of CINES, under the allocation 2018-A0040510482 made by GENCI and to the HPC resources of Aix-Marseille University financed by the project Equip@Meso (ANR-10-EQPX-29-01). This work was supported by the EoCoE-II project, grant agreement 824158, funded within the EU's H2020 program. This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 and 2019-2020 under grant agreement No 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission.