EFDA Task Force
EUROPEAN FUSION DEVELOPMENT AGREEMENT
INTEGRATED TOKAMAK MODELLING

The European Transport Solver (ETS): an integrated approach for transport simulations in the plasma core

The new transport simulator developed by the EU Integrated Tokamak Modelling Task-Force (ITM-TF, https://www.efda-itm.eu/ is a modular package for transport simulations and scenario modelling which couples precompiled physics modules into a workflow, using the user friendly interface of KEPLER workflow manager (http://kepler-project.org).

The main solver for 1-D transport equations is declined over several numerical schemes, which a user can choose to optimize the code performance for a particular physics problem (i.e. stiff transport model)

The ETS workflow presently incorporates a large number of sophisticated physics modules for the equilibrium, pellets, impurities, neutrals, sawteeth and NTM, as well as a variety of modules for the auxiliary heating and particle sources, neoclassical and turbulence transport. Integrated modules can be executed on the same node as KEPLER or can be submitted by the workflow as a batch job to the ITM computing cluster or to an external HPC.

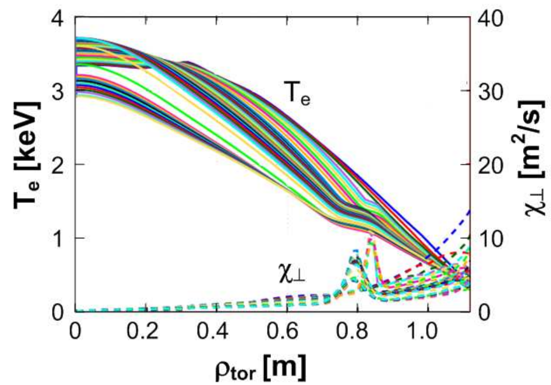
The ETS has been subject to an extensive V&V for a variety of JET discharges and ITER conditions against leading tokamak plasma core transport codes. Satisfactory agreement was obtained for temperatures and q-profile simulated by ETS, ASTRA and CRONOS as well as for the computed thermal diffusivities.

Physics applications

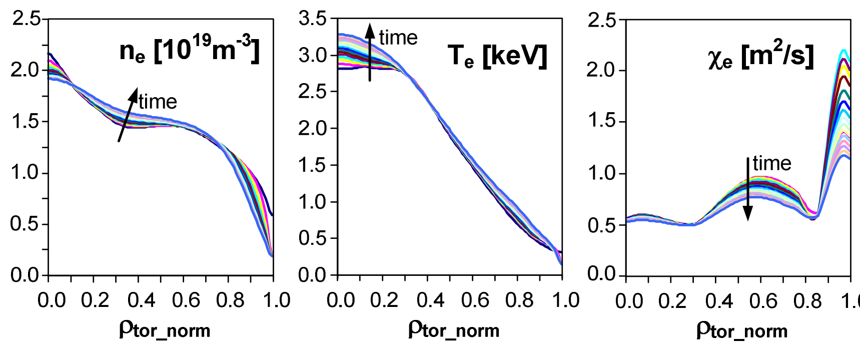
- ✓ **Impurity simulations performed for JET conditions allow to infer that the increased radiation during the ICRH phase as compared to the NBI phase can be explained by an increased W source.**
- ✓ **Simulations including NTM module show a modification of temperature profile as a consequence of increased radial transport due to 2/1 magnetic island growing over resistive time scale.**

Capabilities of ETS simulator

- ✓ **Proof of principle of turbulence-transport coupling by coupled simulations of GEM fluid turbulence code and ETS**
- ✓ **Demonstration of coupling of ETS with a free-boundary equilibrium code (CEDRES++) , tested on forced VDEs for ITER plasma conditions.**



Modification of the heat transport coefficient due to 2/1 magnetic island and its effect on the temperature profile



Relaxation of plasma profiles due to turbulence transport coefficients from GEM turbulence code, run remotely on HPC-FF on 256 cores while the main ETS workflow, which is serial, is run on the ITM computing cluster

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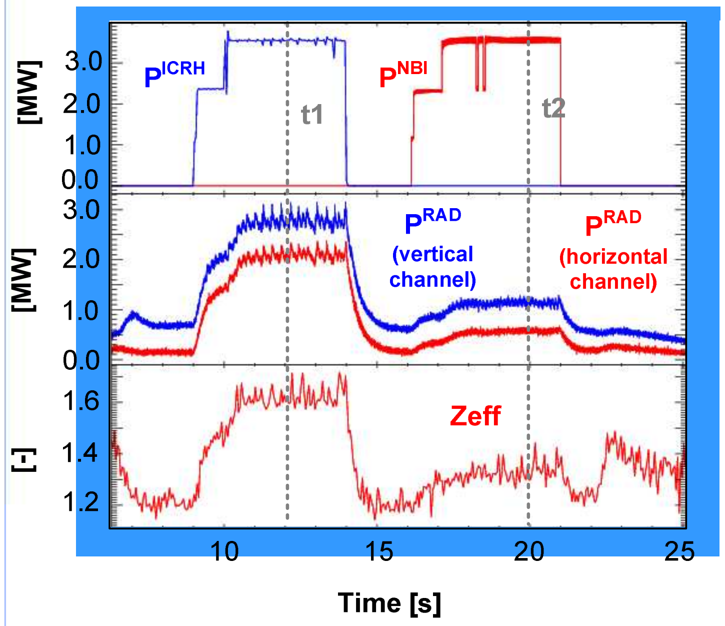
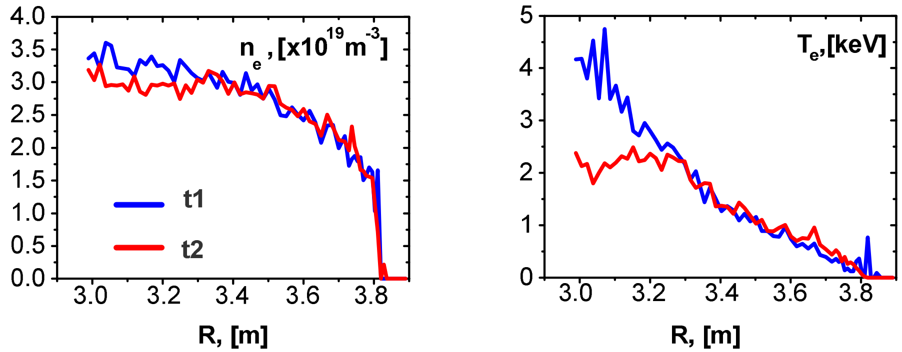
Modelling of JET discharge #81856 [for details about experiment see M.-L. Maypral, EX/4-3]

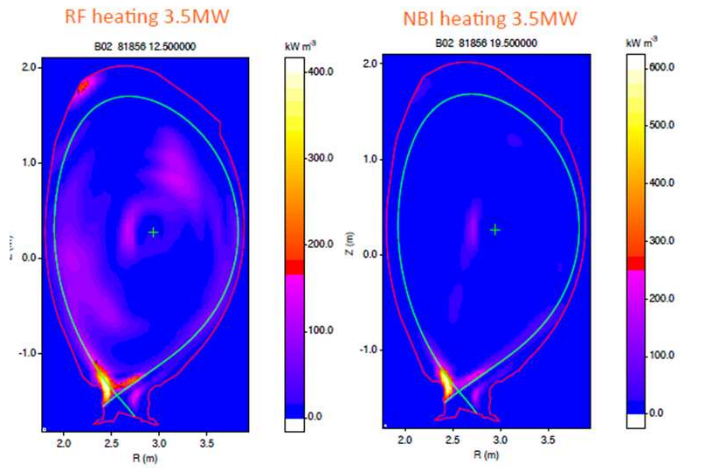


The ETS was applied for the impurity simulations of JET shot #81856 (ITER like wall) with two phases of 3.5 MW of auxiliary heating delivered by ICRH and NBI respectively. The ICRH results in a substantial increase of both effective charge, Zeff, and radiative power, P^{RAD}, compared to the NBI phase.

The plasma contamination during the ICRH phase can be caused either by an increased source of impurities or by changes in their transport.

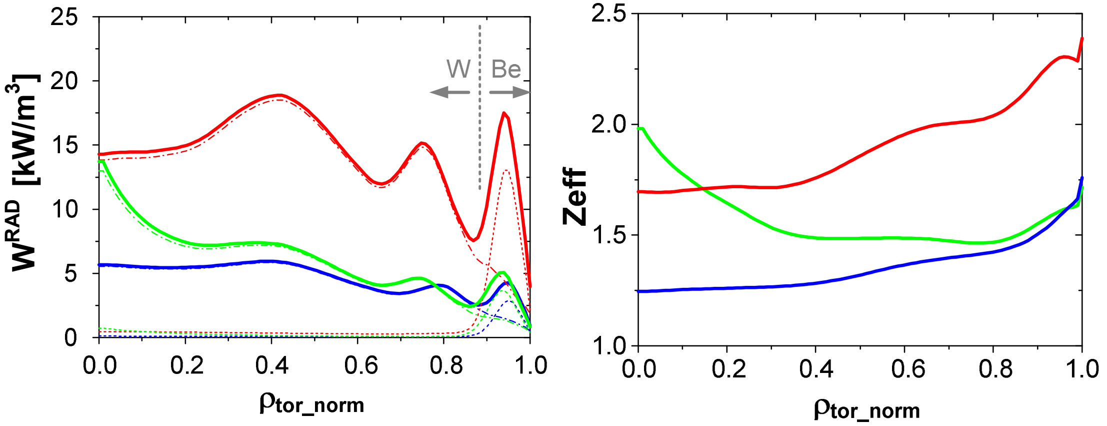


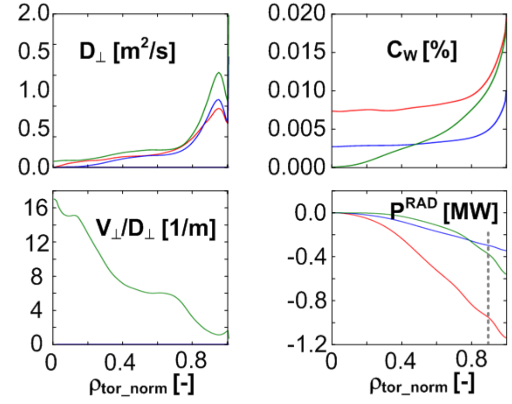
• No essential difference between density and temperature profiles during NBI and ICRH phases



• No radiation peaking in the core, the increase is quite uniform

- *time: 20s (ICRH), n_W = 8.0E14, n_Be = 3.0E17, D_imp = BgB, V_imp = 0 m/s*
- *time: 12s (NBI), n_W = 8.0E15, n_Be = 3.0E17, D_imp = BgB, V_imp = -0.5 m/s*
- *time: 12s (NBI), n_W = 2.35E15, n_Be = 9.1E17, D_imp = BgB, V_imp = 0 m/s*





These simulations indicate that an increased impurity source is a possible reason for the W accumulation during the ICRH phase of #81856, although the effect of the radially shaped convective velocity can not be excluded.