Max-Planck-Institut fur Plasmaphysik, EURATOM Assoziation

Edge simulations of an ASDEX Upgrade Ohmic shot.

D.P. Coster, A. Chankin, G.D. Conway, L. Horton, L. Kaveeva*, C. Konz, J. Neuhauser, M. Reich, T. Ribeiro†, V. Rozhansky*, J. Schirmer, B.D. Scott, M. Tsalas+, S. Voskoboynikov* and the ASDEX Upgrade Team
Max-Planck-Institut für Plasmaphysik, EURATOM Association, D-85748 Garching bei München, Germany
* St. Petersburg State Polytechnical University, St. Petersburg, Russia
† Centro de Fusão Nuclear – EURATOM/IST Association, Av. Rovisco Pais 1, 1049-001 Lisbon, Portugal
+ NCSR Demokritos, Greece

Introduction

Recent advances in diagnostics on AUG have caused us to re-look at Ohmic plasmas:

- Existing[1]:
  - YAG laser system: excellent mid-plane electron density and temperature profiles
  - Li beam diagnostic: excellent mid-plane electron density profile
- New:
  - the Li beam system[2]: edge ion temperature measurements
  - Doppler reflectometry[3, 4]: midplane radial electric field
- Re-activated
  - divertor reciprocating Langmuir probe [5]

Time, once again, to confront the modelling codes with experiment!

Choice of Ohmic shot was motivated by:

- the fact that the "standard" Ohmic shot ($I_p = 0.8MA$, $B_T = -2.1T$, $\bar{n}_e = 3.4 \times 10^{19} m^{-3}$) is repeated on every shot day means that we have data from a wide range of diagnostics;
- the absence of ELMs makes the interpretation of the Li-beam diagnostics much easier;
- the lower power means that the divertor reciprocating Langmuir probe can operate;
- the absence of ELMs makes the modelling easier;
- the lower power means that the drift terms in the edge simulation code are easier to operate; and
- turbulence simulations were possible.

In any sort of modelling scenario, trade-off between trying to match details or trying to match relatively robust results.

match details	match relatively robust results
radially varying profile for the anomalous transport coefficients	single radially constant transport coefficient is chosen
kinetic treatment of the neutrals	fluid treatment of the neutrals
impurities mandatory	impurities might be neglected

In this work, we have mainly adopted the 2nd approach for this investigation, using the SOLPS code ([6, 7] and references therein).

Results

Initial approach:

- the core boundary density and power fluxes were fixed as well as the pumping of neutrals
- anomalous radial transport coefficients were then varied to produce the best possible match to the upstream density and temperature measurements
  - without drift terms switched on

The experimental data used, and the match by the code, is presented in figure 1.

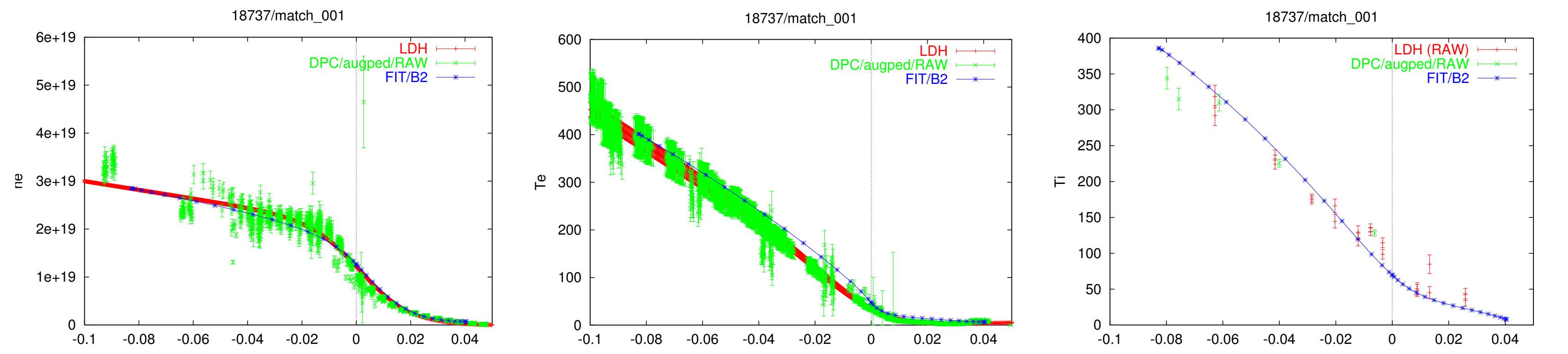

Figure 1: match of the code upstream electron density and electron and ion temperatures with those measured via the YAG Thomson and Lithium beam systems.

Inferred anomalous radial transport coefficients

- $D = 0.28\ m^2 s^{-1}$
- $\chi_i = 0.516\ m^2 s^{-1}$
- $\chi_e = 0.435\ m^2 s^{-1}$

A number of branches were then followed from this stage:

1. the core boundary condition was changed from a fixed density to a zero net particle flux, and an inward particle pinch term introduced (of $-0.75\ ms^{-1}$)
   - χ_i changed to $0.620\ m^2 s^{-1}$
   - χ_e to $0.522\ m^2 s^{-1}$)
2. the drift terms in the code were enabled;
3. a comparison with kinetic modelling, and with impurities, was performed

The comparison of the predicted radial electric field with that measured, is shown in figure 2. No additional free parameters were introduced to obtain this result — the transport coefficients and boundary conditions were those obtained when using the non-drift code to match the upstream densities and temperatures.

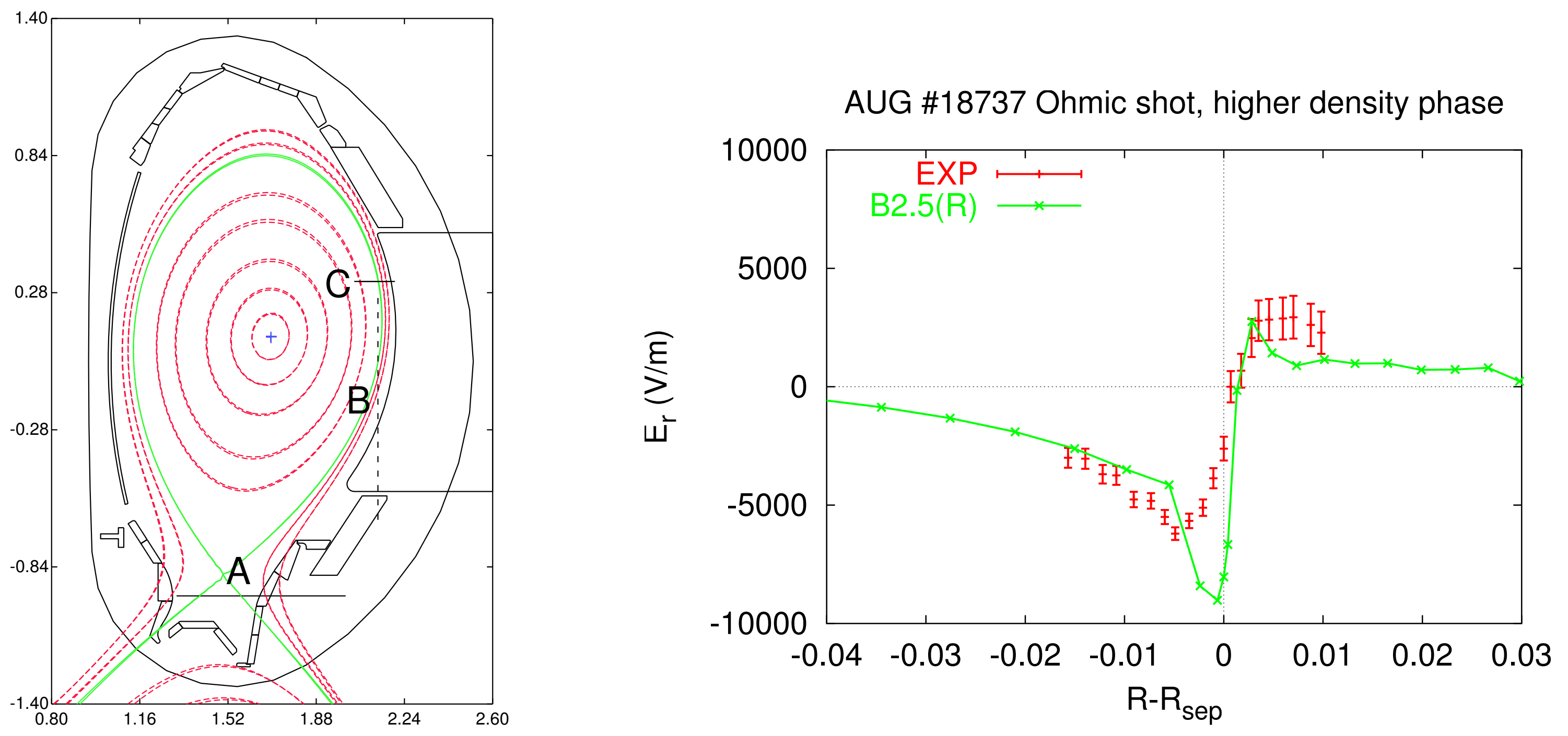

Figure 2: Left: cross section of ASDEX Upgrade showing the magnetic equilibrium at the modelled time, as well as the position of the reciprocating divertor Langmuir probe (A), the positions of the vertical Thomson electron temperature and density measurements (B), and the position of the Lithium beam electron density and ion temperature measurements (C). Right: comparison of the midplane radial electric field from the code with that measured by Doppler reflectometry.

The comparison of the simulation with the divertor reciprocating Langmuir probe is shown in figure 3. Again, no additional fitting of parameters has been performed.

- It can clearly be seen that the run with drifts provide a better match to the experiment than the run without drifts
- Impurities are also likely to play a stronger role in the divertor than upstream, and have been neglected for these runs

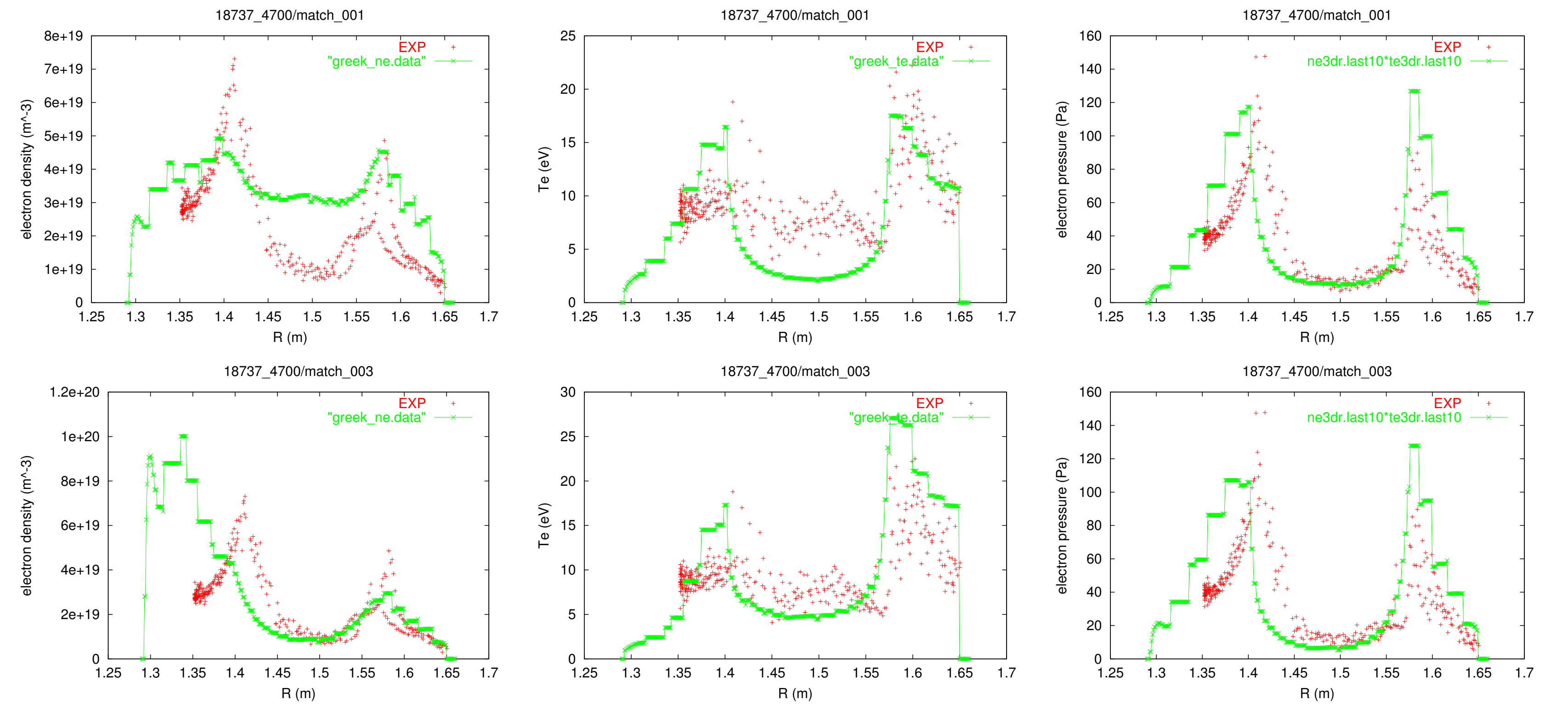

Figure 3: Comparison of the code output with data from the divertor reciprocating Langmuir probe. From left to right: electron density, temperature and pressure. Top: without drifts, Bottom: with drifts.

The runs with drifts also give a better match for the target profiles, figure 4. As a reminder, no additional fitting of transport parameters from those derived by fitting the mid-plane profiles has been performed, and these are runs without impurities and with the fluid neutral model.

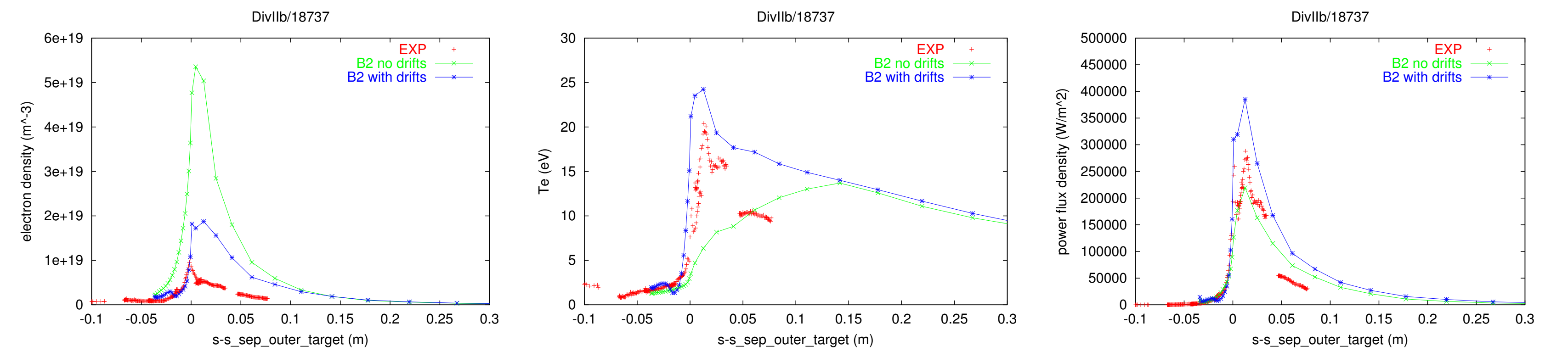

Figure 4: Comparison of the code output with data from the target Langmuir probes. From left to right: electron density, temperature and power (for the experiment, based on a sheath transmission factor of 8).

Comparisons of the simulations performed using the fluid neutral model with those done using the kinetic model show reasonable agreement, particularly if the neutral kinetic flux limiter was set to 1.0, figure 5, as recommended in [8]. The agreement at the target is also good.

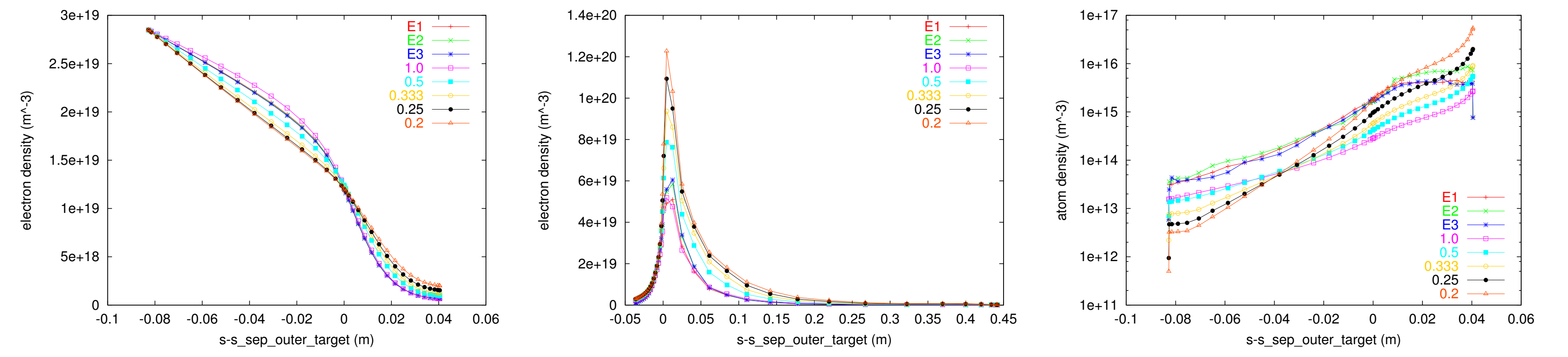

Figure 5: Comparison of the code results done with kinetic and fluid neutrals. From left to right: upstream electron density, outer target electron density and upstream neutral density (atoms only for the kinetic results). E1, E2, E3: runs with kinetic neutrals with differing amounts of pumping; 1.0, 0.5, 0.333, 0.25, 0.2: the neutral flux limiter used in the fluid neutral treatment (1.0 was used in the results previously presented).

Gyro-fluid turbulence runs[9] were also performed (but for an earlier phase of this discharge with a somewhat lower density) using the measured temperatures and densities, and their gradients. The inferred transport coefficients were

- $\chi_i = 0.15\ m^2 s^{-1}$
- $\chi_e = 0.49\ m^2 s^{-1}$

but with about $1/6$ of the power in the ion channel (the above edge transport modelling had assumed the power equally divided between ions and electrons), and a total power about $2/3$ of that in the experiment.

The 1d NEOART neoclassical transport module was implemented in the B2 code [10], and the neo-classical ion transport level on closed field lines was found to be about

- $\chi_{i,\mathrm{neo}} = 0.1\ m^2 s^{-1}$

(based on the pure D plasma), below that inferred from the plasma transport simulations but not too far from that from the turbulence code.

Acknowledgments

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