EUROPEAN FUSION DEVELOPMENT AGREEMENT

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JET and ASDEX Upgrade Divertor Modeling

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** See the appendix of JET EFDA contributors (prepared by J. Paméla and E.R Solano),*
**See appendix of the paper by J.Pamela "Overview of recent JET results",*
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INTRODUCTION

Two issues are particularly important in extrapolating divertor conditions to future machines: perpendicular anomalous transport and the upstream separatrix density. In order to improve our understanding of these two issues, we attempted to use the same modelling tools and very similar experimental methodology on ASDEX Upgrade (AUG) and JET plasmas. It is important to use the same approach for both experiments, otherwise differences in the methods could cause an incorrect size scaling when the results are combined.

On AUG the use of upstream edge (pedestal and SOL) measurements of temperature and density have proved particularly effective in deriving edge transport coefficients by the use of an automatic fit procedure. This work describes the attempt to apply this technique to JET.

1. THE COMPUTER CODES USED: SOLPS4.0/B2-EIRENE, SOLPS5.0/B2-EIRENE AND B2.5-I

B2-Eirene [1, 2] is the coupling of a multi-fluid plasma code (B2) [3, 4] and a Monte-Carlo neutrals code (Eirene) [5], and has been used extensively to model AUG and for predictive runs for ITER. The original B2 has been enhanced to include drifts and currents [6, 7], and has been coupled to Eirene. B2.5-I [8, 9] allows for an automatic variation of fit parameters (e.g. D, χ) so as to produce a best fit between the experimental results and the code output.

In doing cross-machine comparisons, an important sanity check is to see that the code obeys the scalings that it should. With a simplified neutral transport model and the dropping of volume recombination and the density dependence of the atomic rates, the code should obey a scaling based on ρ_*, ν_* and T. This was tested by running a JET case, a half-size JET and a double-size JET. When the boundary conditions, plasma current, toroidal field and anomalous transport coefficients were set to satisfy the above scaling, the test to see whether the code obeyed the scaling was that the temperatures for the three cases should be identical. Figure 1 shows the results – indistinguishable differences.

2. DIAGNOSTICS

AUG has a vertical laser system (consisting of six lasers) that can be positioned so that it determines the electron temperature and density in the separatrix region [10], Fig. 2. Combined with a slow radial sweep, and the 20Hz laser repetition frequency, very good edge profiles can be obtained. A second density measurement is also routinely available from a lithium beam system. The JET laser system consists of a 1Hz LIDAR system [Beurskens, this conference]. For some JET shots, edge densities are also available from a lithium beam system.

An example of AUG edge electron temperature is shown with an example from JET in Fig 3. A straight line fit is made to the pedestal temperature and density (as indicated in the AUG electron temperature plot), and this data can then be compared to the simulations.

The gradients and nominal separatrix densities and temperatures for 6 very similar JET shots (each at 6 time points) were calculated, together with the same quantities calculated on the same basis for a wide variety of code runs (all with the same input power, but differing core boundary densities, pumping, transport coefficients). The JET experimental data showed a wide scatter in both the separatrix values and the gradients. The separatrix variation is probably caused by equilibrium mapping problems, but the automatict procedure allows for the separatrix position to be one of the fitted parameters – a feature that is particularly powerful when the same diagnostic measures both the density and the temperature. A larger problem is the scatter in the gradient – part of the explanation for this is that outlined in the paper of Beurskens [this conference]: that in a number of cases the edge LIDAR delivers only a lower bound for the gradient. In the forthcoming experimental campaign on JET, hardware upgrades and operational changes should decrease the scatter considerably.

3. LIMITATION

Given the above limitations with the JET upstream pedestal/SOL data [see also Kallenbach, this conference], it was decided, as a temporary measure, and with the *caveats* mentioned in the introduction, to match other JET diagnostics. Spectroscopic measurements of H-α, CII and CIII, as well as target Langmuir probe temperatures and densities have been compared to a series of B2-Eirene runs where transport coefficients, inner boundary densities and the amount of pumping, have all been varied, and some of the results are shown in Fig. 4. The results of the density and transport stands support the low upstream separatrix values predicted by OSM2/Eirene modelling.

4. DISCUSSION

The original hope to use the same tools and procedures on AUG and JET to better understand the SOL and divertor has been held up due to instrumental limitations of the JET edge/pedestal diagnostics. As an intermediate step, the more traditional approach used on JET of comparing with other diagnostics has been implemented, and reasonable agreement between diagnostic measurements and code results found. It is hoped that with hardware upgrades to the edge LIDAR at JET, and with additional optimisation of the plasma shape, the JET edge/pedestal data will improve, and that we will then be able to extend the regression analysis of derived edge transport coecients across both AUG and JET, and hence be in a better position to make predictions for future devices.

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REFERENCES

[1]. R.Schneider, D.Reiter, H. P. Zehrfeld, B.Braams, M.Baelmans, et al., J. Nucl. Mater. 196{198 (1992) 810.
[2]. D.Reiter, J.Nucl. Mater. 196-198 (1992) 80.
[3]. B.J.Braams, Computational Studies in Tokamak Equilibrium and Transport, PhD thesis, Rijksuniversiteit, Utrecht, Nederland., 1986.

[4]. B.J.Braams, Technical Report 68, Next European Torus, 1987.

[5]. D.Reiter et al., J.Nucl. Mater. 220{222 (1995) 987, PSI 94 Mito.

[6]. B.Braams et al., Contrib. Plasma Phys. 36 (1996) 276.

[7]. V.Rozhansky, S.Voskoboynikov, E.Kaveeva, D.Coster, and R.Schneider, Nuclear Fusion 41 (2001) 387.

[8]. D.Coster, J.Kim, G.Haas, B.Kurzan, H.Murmann, et al., Contrib. Plasma Phys. 40 (2000) 334.

[9]. J.-W.Kim, D.P.Coster, J.Neuhauser, R.Schneider, and ASDEX Upgrade Team, J.Nucl. Mater. 290{293 (2001) 644.

[10]. J.Neuhauser, D.P.Coster, V.Dose, J.W.Kim, B.Kurzan, et al., in Europhysics Conference Abstracts (CD-ROM), Proc. of the 26th EPS Conference on Controlled Fusion and Plasma Physics, Maastricht, 1999, edited by C.Bastian and C.Nieswand, volume 23J, pages 1521{1524, Geneva, 1999, EPS.

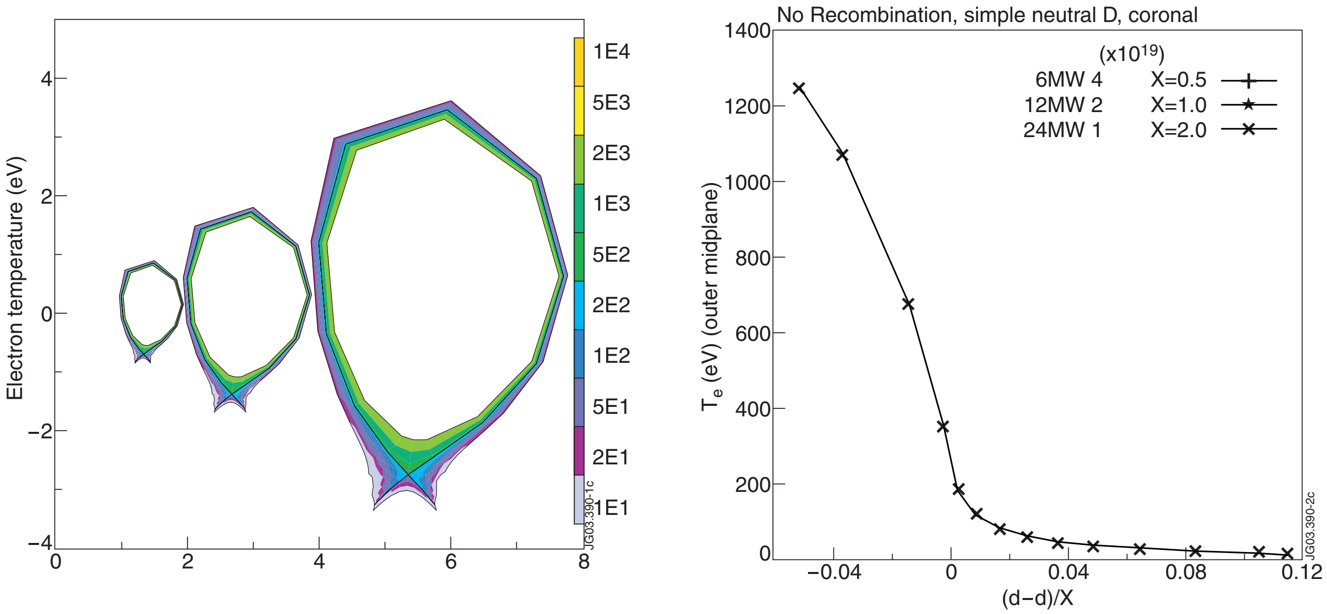

Figure 1: The intrinsic scaling of the code is tested by running three cases, with boundary conditions, anomalous transport, etc. The success of the test is given by the differences of the temperatures for the three cases – a test successfully passed.

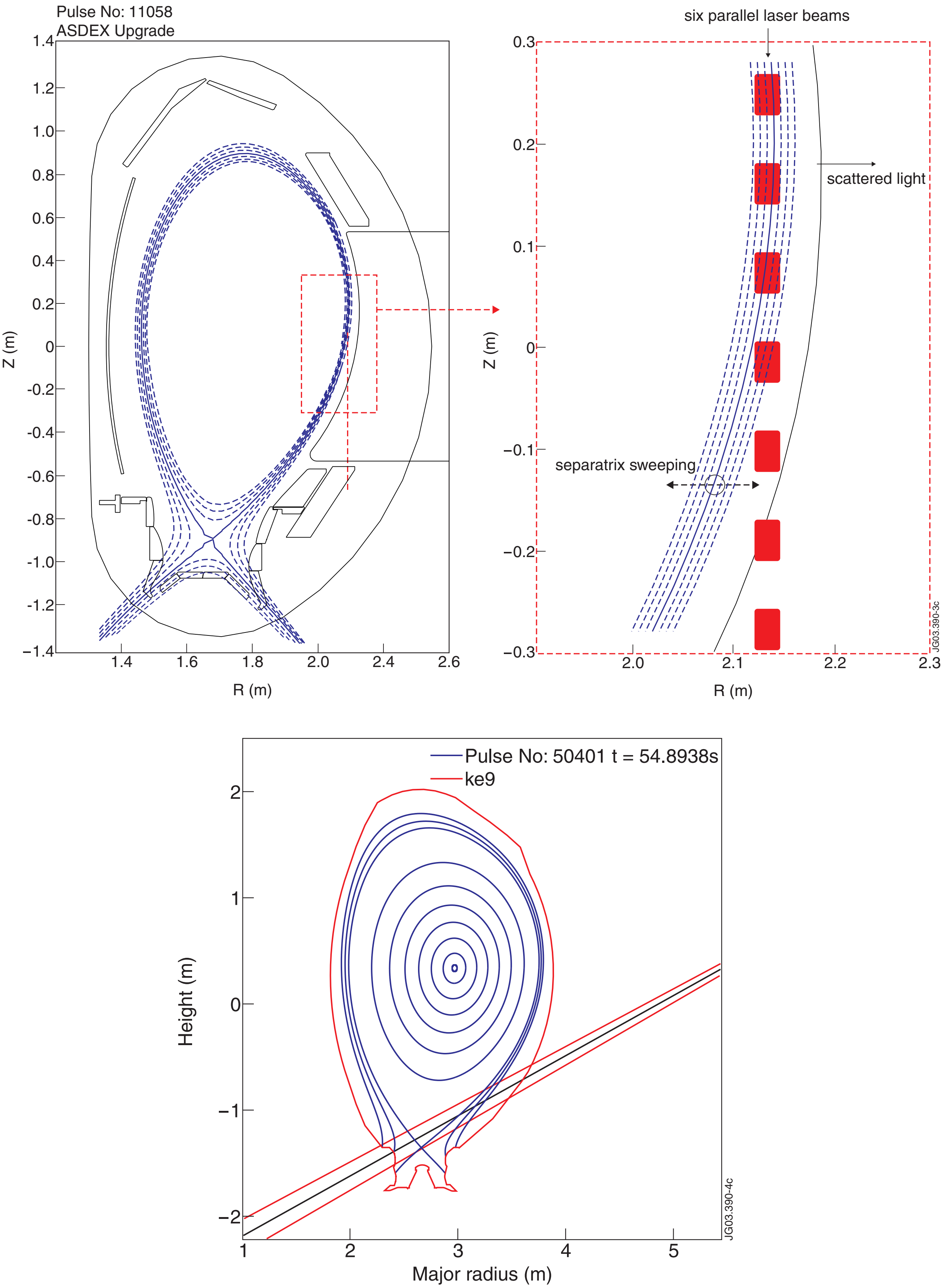

Figure 2: Edge laser systems on AUG and JET. The edge YAG system on AUG, with a zoom showing the viewing geometry, and the edge LIDAR system on JET.

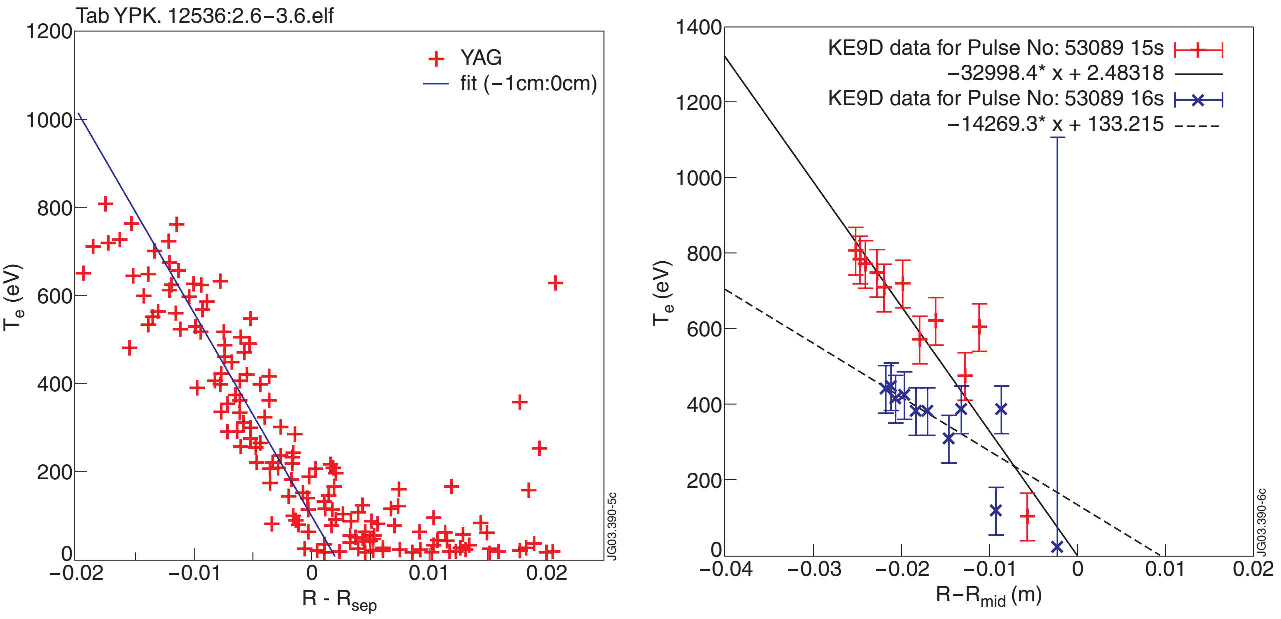

Figure 3: Te profiles for AUG and JET. The AUG data on the left result from a slow radial scan with multiple repetitions of the six YAG lasers. A straight linet has been made to the data starting at the nominal separatrix position to determine a nominal separatrix temperature and a temperature gradient. The JET data on the right come from two pulses of the edge LIDAR laser, and the same procedure used as for AUG to fit a straight line to each of the two measurement sets.

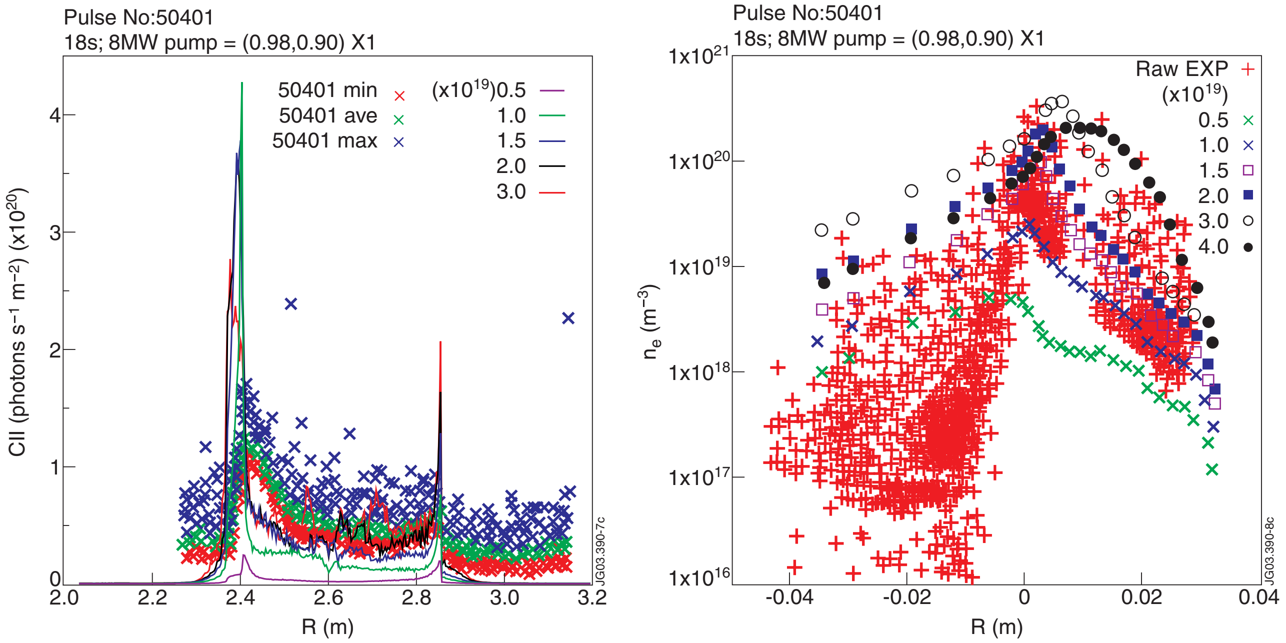

Figure 4: CII and target electron density comparisons. The CII light is observed from the top of the machine with the KL2 spectroscopic camera. The Langmuir measurements come from multiple probes and a Z-scan – and hence include ELMs (which are not included in these simulations).