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Progress on MAST

G Cunningham, R Akers, L Appel, K Axon, C Bunting, R Buttery, P Carolan, N Conway, G Counsell, J Dowling, M Dunstan, T Edlington, AR Field, S Fielding, M Gryaznevich, T Hender, D Howell, M Hole, P Jones, A Kirk, P Knight, I Lehane, B Lloyd, G Maddison, S Manhood, R Martin, T Martin, G McArdle, E McCarron, M McGrath, R McStay, H Meyer, AW Morris, A Odblom, A Patel, K Patton, T Pinfold, M Price, J Rainnie, C Ribeiro, C Roach, V Shevchenko, S Shibaev, M Smith, K Stammers, R Stephen, A Sykes, A Tabasso, N Thomas-Davies, M Tournianski, M Valovic, M Walsh, C Warrick
EURATOM Fusion Association, Culham Science Centre, Abingdon, Oxon OX14 3DB, U.K.

Introduction

Since the last ST workshop, MAST has had a major vacuum break for modifications to the centre column graphite armour, and the second neutral beam injector has been commissioned. To date, use of both injectors gives up to 2MW at about 36keV in hydrogen. A number of other systems such as a reciprocating probe, a pellet injector [1] and a scanning reflectometer are also close to being operational. Results from the first 36 run days in the second campaign are presented.

H mode

In view of the success in obtaining H mode discharges in the first campaign, a focus of the second campaign has been to design a reliable 1MA H-mode discharge with regular ELMs. Although this objective is not yet completely realised, it is very close; figure 1 shows the D_α signal for a series of H mode discharges, figure 2 shows other salient data, and figure 3 shows TS profiles at various times. Although these shots are all similar, they are by no means identical, so the H mode is reasonably robust. We are now beginning to study the access criteria quantitatively, but it is already clear that conventional threshold power scaling laws such as $P = 0.65 .\overline{n_e}^{0.93} .B_T^{0.86} .R^{2.15}$ [2] do not extrapolate well to these aspect ratios; this one would predict a threshold less than 100kW. On the other hand the 'canonical profile transport model' [3, 4] does appear to fit the observed power requirements fairly well [5]. It is not yet possible to make a clear statement on power threshold: in some cases the ELMs can be seen to evolve from small and high frequency to larger and lower frequency when the NBI power is raised, but in other cases ELMs are obtained with no auxiliary heating at all. On the other hand some qualitative statements can be made. For example, wall conditioning is critical, and periodic boronisation is used to maintain this. Fuelling the plasma with gas from the high field side appears to give easier access to H mode than from the low field side, and this can be achieved either by loading the centre column graphite with deuterium in a preceding discharge, or by using a high field side gas feed. This behaviour has previously been reported on Compass D [6]. Edge currents appear to inhibit H mode access, as the transition is often observed to follow a programmed decrease in the applied loop voltage. Such an observation would tend to support the 'peeling mode' hypothesis [7].

A first estimate of the energy confinement time in shot 4171 gives an energy confinement time of 45 to 50ms, which is about equal to the value given by ITER PBY98(y,2) scaling. This is a conservative estimate as it assumes all the NBI power is absorbed, and omits fast ions from the stored energy. Also, the discharge is by no means optimised for confinement, in particular the sawteeth, which start at about 180ms, seem to cause significant degradation, and we will develop discharges with $q_0 > 1$ to avoid this. It is notable that shot 4171 is at a density that is 0.7 of the Greenwald density limit.

Other topics

Halo currents. Measurements of the halo currents driven in the vessel structure during a plasma termination have been extended to somewhat higher currents, (figure 4) with similar results, that the total halo current is generally less than 15% of the plasma current, and the toroidal peaking factor is around 1.2 or less.

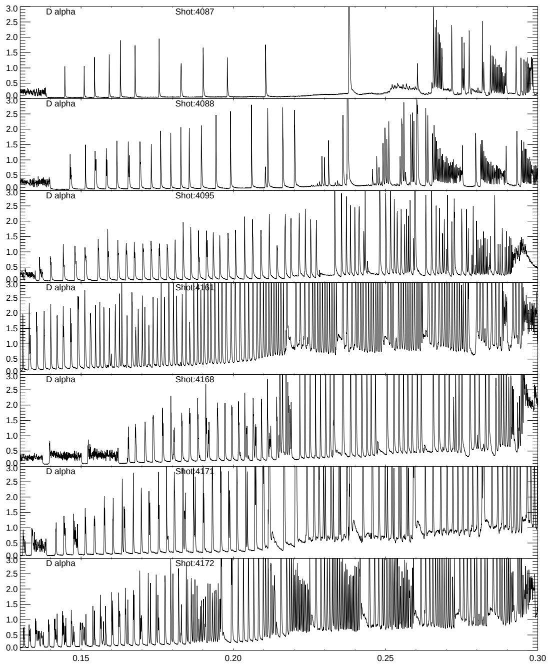
Density limit. With the advent of higher beam power it has been possible to extend the range of high- density (Greenwald factor greater than 1) discharges to higher currents, figure 5.

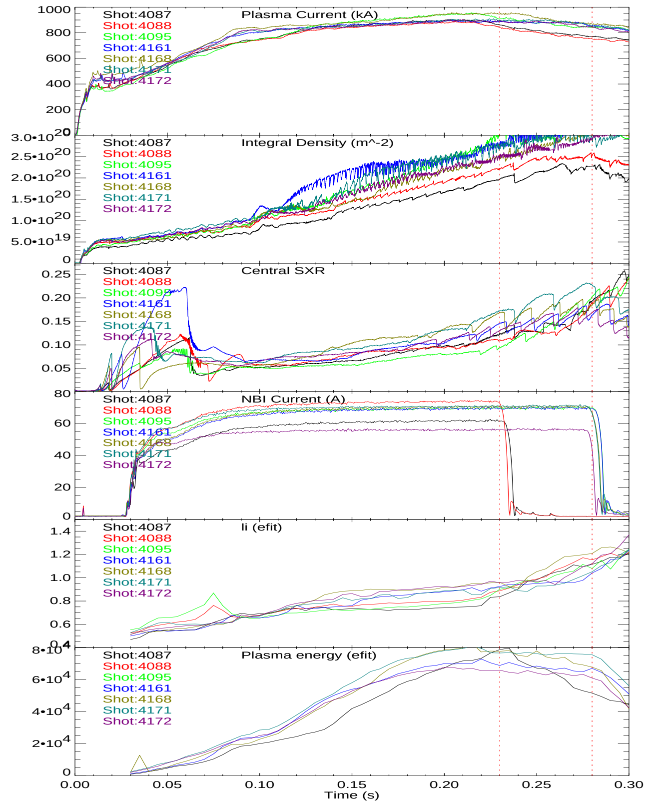
Divertor power loadings. It was reported previously that some 85% of the power efflux goes to the outer divertor leg in MAST. However, it now appears that in ELM-free H mode, this is not the case, and the inboard/outboard power ratio changes to be approximately equal to the ratio of the surface areas of the last closed flux surfaces. On the other hand, during ELM-y H mode, the balance moves back to be more like the L mode case.

MHD activity. A broad spectrum of MHD activity is observed in MAST. M. Gryaznevich [8] presents an overview of the high frequency activity, but a few words about internal reconnection events (IREs) are appropriate. IREs do not, in general, terminate the plasma, and particularly in the early stage when the plasma is limited on the centre tube, they are quite benign. Later on, when the plasma is DND, and vertically unstable, an IRE is quite likely to overwhelm the vertical position control system, resulting in a vertical disruption. IRE's are generally associated with the edge q (q_{95}, say) passing through an integral value, so that a steady state plasma will not suffer IRE's. However, such a transition does not necessarily trigger an IRE, and for reasons that are not yet clear, strong gas puffing tends to permit such transitions without an IRE. IRE's are observed to create a high-energy tail in the ion energy spectrum, figure 6, a phenomenon that is well known in other reconnecting magnetised plasmas such as the ionosphere.

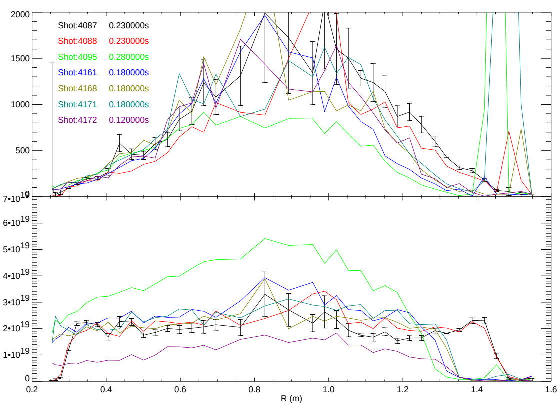
Conclusion

Considerable progress has been made in developing a stable H mode discharge in MAST, and this is now being exploited for physics studies. Manipulation of the plasma current ramp rate, NBI timing, and gas injection is allowing a modicum of control over the q profile, which is important for production of reliable plasmas. The coming months will see up-rating of the NBI and improved control systems, which will facilitate the main objectives of the next campaign, studies of beam-plasma interaction and current drive.





Figures 1 (above left) Dalpha signals, 2 (above right) other signals, and 3 (below) TS profiles during recent H mode discharges.



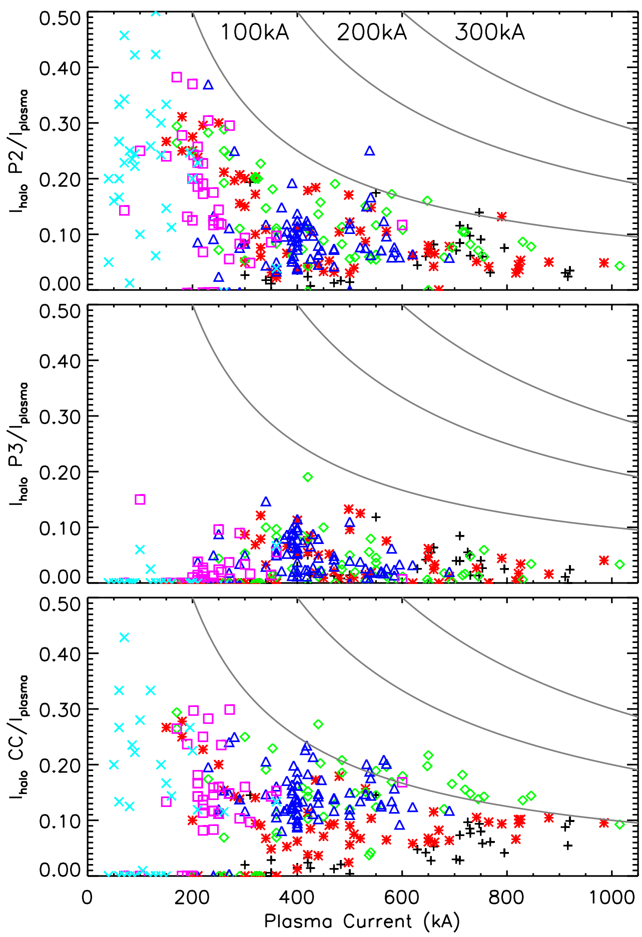


Figure 4 (right). The total halo current to selected coil cases during plasma termination, expressed as a fraction of the toroidal plasma current.

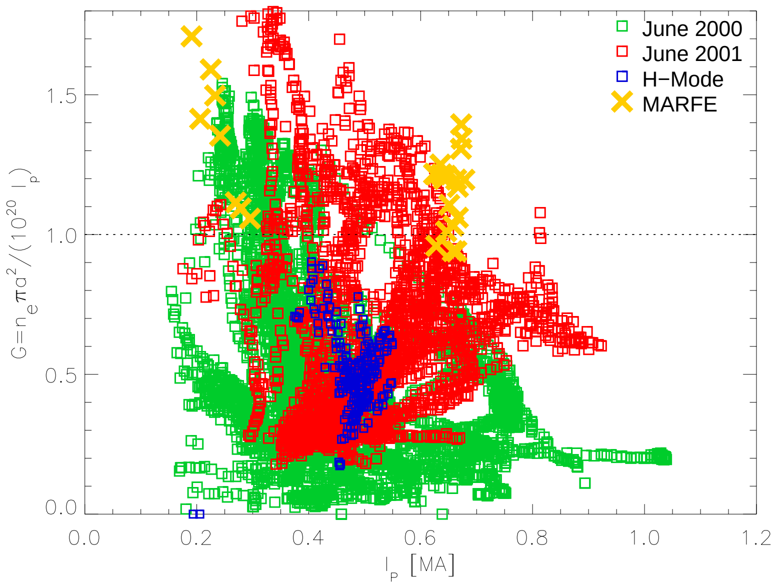


Figure 5 (left). Evolution of a selection of high-density discharges, expressed as a fraction of the Greenwald limit density. Since this graph was compiled the database of H mode discharges has been extended to 1MA

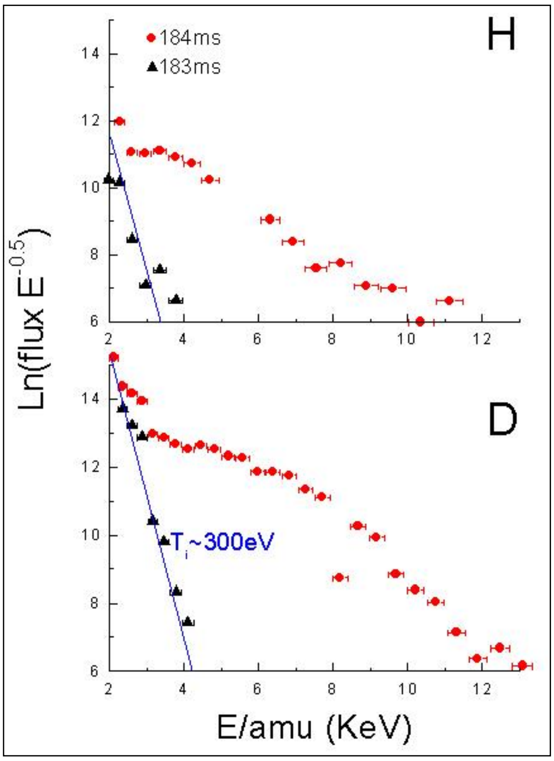


Figure 6 (left). NPA measurements of the ion energy spectrum, made just before and after an internal reconnection event. This was an ohmic plasma with deuterium puffing; the hydrogen has been recycled from the walls.

References

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Acknowledgements

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