Pedestal Structure Evolution and Scaling with Plasma Current on MAST

A. Diallo[1], R. Scannell[2], S. Saarelma[2], A. Kirk,[2] J.C. Hillesheim[2] and the MAST team.

[1] *Princeton Plasma Physics Laboratory, Princeton, NJ, USA*

[2] *CCFE Culham Science Centre, Abingdon, Oxon, OX14 3DB, UK.*

Core plasma performance on future fusion devices has been shown to strongly correlate with the edge pedestal height [1]. For improving the predictive capabilities of present day numerical models such as EPED [2], research effort has focused on investigating the pedestal structure evolution (therefore contrasting it from the static prediction) during its buildup and its scaling with global plasma parameters such as the plasma current. Here, we report recent work on the Mega Ampere Spherical Tokamak (MAST) tokamak to characterize the pedestal evolution in lower-single-null (LSN) discharges for varying plasma currents. Using the lasers in burst mode to obtain Thomson scattered data with high temporal resolution, we captured the density and temperature pedestals recovery after an edge localized mode (ELM) crash.

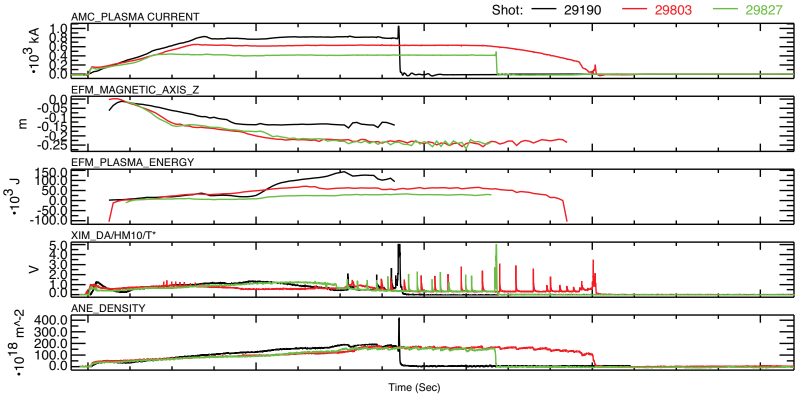

Figure 1: Example of ELMy LSN discharges for the three plasma current.

Experiments are performed MAST of major radius, R ∼ 0.75 m and a minor radius, a ∼ 0.5 m. The data presented in this proceeding have been extracted from dedicated ELMy H-mode discharges when the plasma is close to a LSN configuration with the ion ∇B drift direction towards the lower targets. The discharges are heated with one and two beams with BT = 0.58 T and 0.4T. Figure 1 displays the matched ELMy discharges for three plasma currents used in the analysis presented below.

The analysis focusses on the edge pedestal in LSN configuration as measured using the Thomson scattering system (described in [3]). More specifically, the region of interests are the inboard (high-field side) and outboard (low-field side) regions as indicated in figure 2 in the top panel.

In top two panels, each radial profile represent a time slice indicated on the bottom panel. The lasers were fired in burst mode top enable the capture of the pedestal density and temperature evolution after an ELM crash for various plasma current.

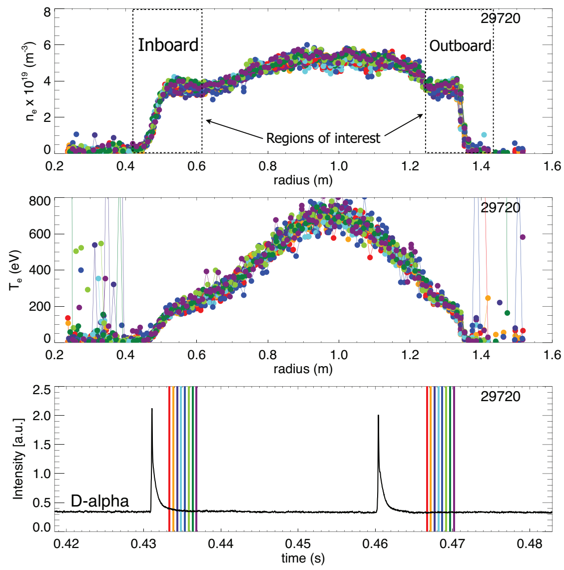

Figure 2: Example of temperature and density profiles during the pedestal recovery for Ip=400 kA. Note the region of interests as inboard(HFS) and outboard(LFS) are regions where the analysis will be focussed.

We also examined the pressure gradient evolution for various plasma current as shown in figure 3. This figure indicates that the pressure gradient saturates early on the ELM cycle. In addition, the saturated pressure gradient inboard and outboard clearly increase with Ip. Figure 4 displays the density and pressure evolution and their

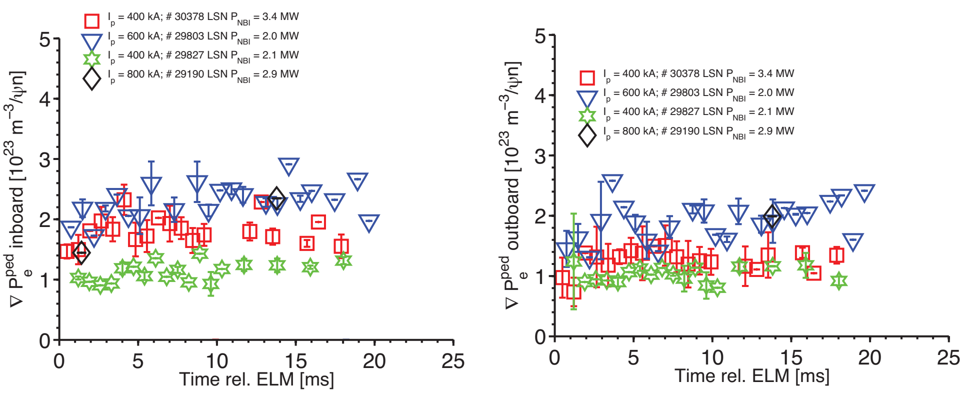

Figure 3: (color online) Pressure gradient evolution.

scalings with plasma current. In this figure, (a) and (b) indicate the density pedestal height evolution in both the inboard(high-field side) and outboard(low-field side) regions. It can be observed that the density pedestal recovery takes $\sim$ 5 ms and is independent of plasma current, which suggests that the recovery is not correlated with confinement. After an ELM crash, particles are deposited on the divertor tiles independently of the plasma current. These particles are recycled and provide the increased source of particles all thing being constant, consistent with recycling being a dominant fueling source during the pedestal initial recovery. While the density pedestal recovery is plasma current inde-

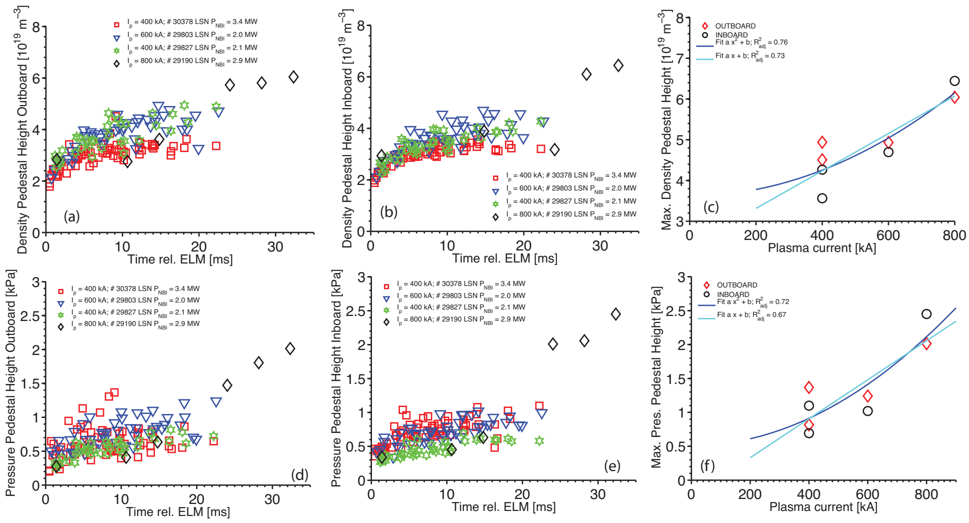

Figure 4: (color online) Pedestal evolutions after an ELM crash and their scaling with Ip.

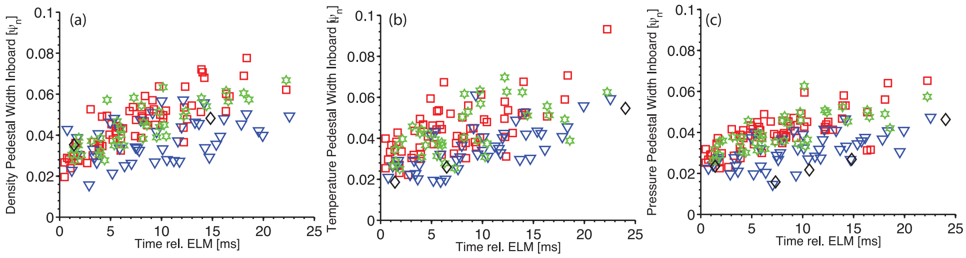

Figure 5: Pedestal width evolution for various Ip. Note that the legends are the same as those from the previous figure.

pendent, the maximum density pedestal achieved toward the end of an ELM cycle is found to scale with plasma current (Figure 4 (c)). Note that, unlike the density pedestal scaling, the temperature pedestal did not exhibit any trend (not shown here) after an ELM crash. Overall, the electron pressure pedestal height in the latter part of an ELM cycle scales with Ip^2 as observed on NSTX[4] and EDA-H modes in C-Mod [5]. Such scaling appears to be consistent with ballooning limited pedestals.

We also examined the pressure gradient evolution for various plasma current as shown in figure 3. This figure indicates that the pressure gradient saturates early on the ELM cycle. In addition, the saturated pressure gradient inboard and outboard clearly increase with Ip.

Figure 5 shows both the width evolution and scaling with Ip. Note that to reduce the scatters on the width measurements, we only consider the inboard Thomson measurement width evolutions as the outboard measurements exhibit uncertainties possibly due to ELM filaments and fluctuations. After an ELM crash, the inboard width increases and does not appear to saturate during the ELM cycle. In addition, the pressure width is observed to decrease with Ip. This suggests that narrow widths occur for higher con-

finement. Figure 6 shows the pedestal pressure widths scaling with β^{pol}_{ped}. The pressure width scaling with $\sqrt{\beta^{pol}_{ped}}$ has been shown to be a proxy for KBM instabilities [6]. On MAST, as reported in ref. [7], it was shown that the pedestal temperature and pressure widths scale separately with $\sqrt{\beta^{pol}_{ped}}$. During the dedicated experiments carried out last campaign, we analyzed the pedestal width scaling separating the inboard and outboard measurements. As shown in figure 6, the inboard and outboard pressure and temperature widths scale with,$(\beta^{pol}_{ped})^{\gamma}$, where $\gamma \geq 0.5$. From figure 6(a), the pedestal temperature width normalized to the minor radius at the *outboard* scales with $(\beta^{pol}_{ped})^{0.8}$, while the *inboard* widths (see figure 6(b)) show a scaling with $(\beta^{pol}_{ped})^{0.6-0.7}$. These scalings are also observed when the pedestal pressure widths are used (as shown in figure 6(c) and (d)). These inboard pedestal width scaling are slightly higher than the previous scalings reported in ref [7]. The outboard width scaling, on the other hand, is similar to NSTX scalings.
In summary, pedestal evolution and scaling with Ip have been performed in LSN discharges in MAST. Experiments clearly show the density pedestal height recovery after an ELM crash while the temperature pedestal remains unaffected. The maximum achievable pedestal pressure occurs prior to the ELM onset. This pedestal pressure height is found to scale with Ip^2 and the pedestal width increases with Ip. Work is in progress to investigate correlations between the pedestal evolution and edge fluctuations.

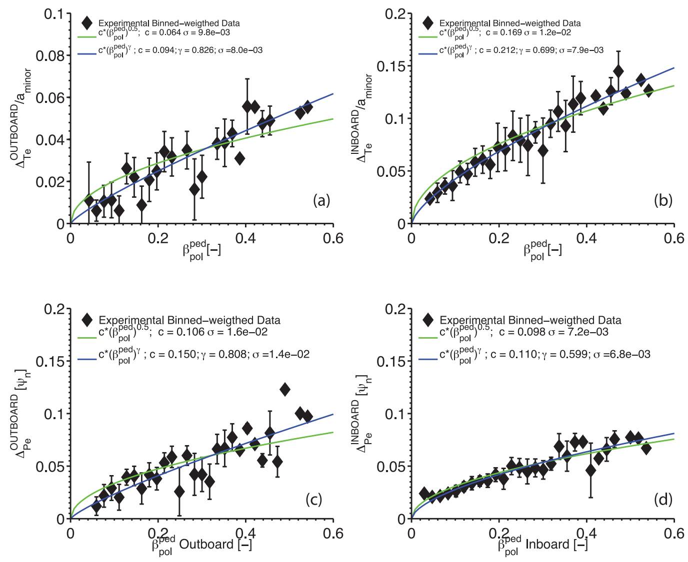

Figure 6: Pedestal temperature and pressure widths-β scalings (see text for details).

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