# PEP-28 Physics of H-mode access with different X-point heights

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| **TG priority:** High | **Start date:**   | **Status:**  Closing | **Personnel exchange:**   |
| **IO priority:**   | **End date:**   | **Motivation:**   |

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| **Device** | **Contact** | **Activity** |
| **2012** | **2013** | **2014** | **2015** | **2016** |
| MAST  | H. Meyer | Considering | Considering | Analysis | Not doing |   |
| AUG | E. Wolfrum | Considering | Committed | Committed | Analysis |   |
| DIII-D | P. Gohil | Considering | Considering | Analysis | Completed |   |
| C-Mod | J. Hughes | Committed | Analysis | Analysis | Commited |   |
| JET | C. Maggi | Committed | Committed | Committed | Analysis |   |
| NSTX | D. Battaglia | Analysis | Not doing | Not doing | Completed |   |
| TCV | Y. Martin | Committed | Committed | Analysis | Completed |   |

 **Purpose in Brief:** Determine the physics mechanism that leads to different access conditions for H-mode with at different distance of the X-point and the target plates.

**Results for 2015**

New experiments have been performed on CMOD and COMPASS. On CMOD, the experiments of 2012 have been revisited in 2014 and 2015 with better diagnostic coverage. The previous results on the lower Pth at high density in the so called slot configuration compared to the vertical target (VT) configuration have been confirmed [1]. Measurements with reciprocating probes in the Ohmic and L-mode phases of the discharge show that the kinetic profiles are similar, but the peaking of the plasma potential (estimated from the floating potential and Te) are less peaked towards the separatrix in the slot configuration. This would lead to a lower ExB shear in the slot configuration, but further analysis of the full profiles is needed.

The first experiments on COMPASS show also a reduction of Pth with decreasing X-point height on Ohmic discharges at constant current. Boronisation further reduces the L-H power threshold and dIp/dt seems to have little influence on the L-H transition. Ballpen probe measurements show a more positive Er in the SOL in configurations with a lower X-point.

For AUG the analysis of the reflectometer data has been on-going. Each L-H transition is found to be preceded by a limit cycle oscillation phase also known as I-phase on AUG. No difference in power to access either transition L-mode to I-phase (L-I) and I-phase to H-mode (I-H), is found. At high density the lowest power for both transition is found in the configuration with the highest X-point and both strike points on the vertical targets, which is the opposite to all other devices. The threshold power increases with decreasing distance between the X-point and the horizontal target plate, again opposite to the behaviour in other tokamaks. For the L-I transition the density profiles show no consistent behaviour, but for the I-H transition the steepest gradient in ne is found for the high X-point position due to the length of the I-phase. This would lead to a more negative neocl. Er. Here also the fluctuation level at low frequency is reduced. The mid X-point configuration shows a high field side high density front and an enhanced density in the SOL.

JET analysis in 2015 has concentrated on SOL profiles for the vertical target configuration VT (higher Pth) and the horizontal target configuration HT (lower Pth) [2]. Between these configurations the gradients of Te at the outer strike point changes in a way that would lead to a lower Er ≈ -3 ∇Tetarget in the SOL and therefore a lower Er gradient in the outer shear layer. These measurements are supported by EDGE2D/EIRENE modelling. Furthermore, in HT an oscillation of the divertor is observed at powers close to the L-H power threshold when the inner divertor detaches and the outer divertor becomes hotter. The state with the inner divertor leg detached shows a stronger gradient of Te at the target, which may favour the L-H transition. In the VT configuration first measurements of Er with Doppler Backscattering have been achieved on JET. The data show signs of stationary zonal flows behaving differently towards the L-H transition below and above the density at minimum Pth. This could point to a different turbulent state in these to branches of Pth as function of density. Analysis of these discharges is on-going and a dedicated Doppler Backscattering system has been implemented on JET prompted by these results.

[1] J. Hughes et.al. 57th APS DPP (2015), Savanah, US

[2] E. Delabie et.al. 42nd EPS (2015) , Lisbon, Portugal

**Plans for 2016**

It is planned to close the PEP-28, due to the limited scope. It is clear from the analysis of the data collected that to make sense of the different findings the focus needs to be more towards the impact of the SOL conditions induced by changes in the divertor conditions. To this extend it is suggested to open a new joint experiment that widens the scope of PEP-28 to a study of the divertor conditions at the onset of H-mode with different divertor configurations in order to better predict the behavior of the ITER divertor with respect to H-mode access. To this extent further experiments are planned on JET studying the corner configuration. Also a joint experiment proposal will be developed for the AUG 2017 campaign to collect missing data on SOL and target profiles, edge Er (not available in 2016) and turbulence characteristics.

**Background:** The divertor and SOL conditions have a strong impact on the access conditions to H-mode. This is manifested by significant changes in PL-H measured on multiple devices when changing the distance between the X-point and the outer strike point or the lower triangularity at the acticve X-point [1-6]. On JET [2], DIII-D [4], MAST [3] and TCV PL-H has been measured to change by about or more than a factor of 2 with changes of the X-point height of about 6cm-15cm. In general lower X-point height gives lower PL-H. In contrast to this on C-Mod [6] a strong change in PL-H at higher density has been observed when the outer leg length is increased, showing the same dependence as observed on TCV in Ohmic H-modes with the unfavourable ion B-drift direction [8]. However, the change on C-Mod also incorporates a small change in δx, which on JET [5] and NSTX [7] also changes of PL-H. Here, however, on JET an increase of PL-H with lower δx is seen whilst on NSTX a decrease is observed. Also the density where the minimum PL-H is measured, nemin, is influenced by the divertor configuration. This changes not only with the first wall material as seen on JET [5], but also if both strike points are operated on the vertical target on JET [9]. Here, an increase of PL-H by a factor of two is observed and nemin shifts to lower density. In contrast to this, similar experiments conducted on AUG showed a reduction of PL-H at high density with both strike points on vertical targets. Furthermore, correlated to low PL-H on JET seems to be connected to a change of state in the divertor or SOL [10] [11].

There is currently neither a theoretical nor an experimental understanding of this effect. In particular it is difficult to distinguish the changes occurring in the scrape-off-layer (SOL) due to the change of the connection length between the outer mid-plane and the target plates, and the changes in neutral influx due to the changed distance between the X-point and the main recycling zones. Hence it is hard to gain insight into the relevant physics from data on one device only, and the comparison between different devices is needed to progress the physics understanding, because of the different divertor configurations and SOL conditions. Another important question with respect to ITER whether the access to HH98 =1 the good confinement regime changes with X-point height. Few experimental data with respect to this question are currently published.

*References:*

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4. P. Gohil et. al., Nucl. Fusion 49 (2009) 115004
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6. Y. Ma et.al., 24th IAEA Fusion Energy Conference, 8-13 Oct. 2012, San Diego, USA.
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8. R. Pitts et. al., 26th EPS Conference on Contr. Fusion and Plasma Phys. , ECA 23J (1999) 1085
9. H. Meyer et.al 41st EPS Conf. on Plasma Physics (2014) P1.103, Berlin, Germany
10. E. Delabie et.al. 25th IAEA FEC (2014) EX/P5-24, St. Petersburg, Russia
11. E. Delabie et.al. 42nd EPS (2015) , Lisbon, Portugal

**Description:** Measure key edge and SOL parameters such as Te, ne, Ti, Er, v|| and v as well as turbulence characteristics were possible in L-mode close to the L/H transition with the variation of the poloidal distance LX/a between the X-point and the outer strike point. There is not yet a unified picture with respect to connection length across the devices.