TC-26 L-H/H-L scaling in the presence of metallic walls

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| **TG priority:** Critical | **Start date:** 2015 | **Status:**  On-going | **Personnel exchange:**  Yes |
| **IO priority:** | **End date:** Not fixed | **Motivation:** Plasma Control | |

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| **Device /**  **Association** | **Contact**  **Person** | **2016 TG Request** | **Activity (from JEX/JA spreadsheet)** | | | |
| **2015** | **2016** | **2017** | **2018** |
| CCFE | D. C. McDonald | Desirable |  |  |  |  |
| ITER | A Loarte | Desirable |  |  |  |  |
| AUG | F. Ryter | Desirable | Committed |  |  |  |
| C-Mod | J. Hughes | Desirable | Committed |  |  |  |
| JET | C. Maggi, E. Delabie | Desirable | Committed |  |  |  |

**Purpose:** To use existing published experimental data, together with the existing ITPA global threshold database, to provide a physics basis for predicting the L-H and H-L transition of ITER with Be/W PFC.

**Achievements in 2015**

* Defined the subset of 29 parameters, from the 209 total, that needed to be collected for the study.
* Collected data from published metallic PFC studies of L-H on ASDEX Upgrade (129 shots), C-Mod (52 shots) and JET (47 shots). The dataset was validated and found to be well conditioned (to a similar extent to the full DB) with regards to the usual scaling parameters (density, magnetic field and size.)
* Combined metallic PFC data with existing ITPA threshold database and examine main trends
  + - As expected, the low density branch has the highest PL-H relative to the global scaling. The density for the PL-H minimum depends on both the PFC material and the configuration.
    - For the high density branch the AUG and JET PL-H is significantly below the global scaling. The C-Mod PL-H is broadly consistent with the global scaling, but the spread is broad and skew; reflecting complicated dependencies.

**Plans for 2016**

* Include 2013-2014 data from JET L-H studies with vertical target configuration – the most ITER-like – and AUG H/He data.
* Study effects highlighted in single machine studies, particularly the power threshold in the ion channel only, the role of radiated power, and the impact of metallic PFCs and configuration on the density of the minimum power threshold
* Make a specific study of the L-H threshold in He/H plasmas with metallic PFCs

**Background:** The existing scalings for predicting the L-H and H-L threshold on ITER [1] are based on an empirical fit to a database of discharges in machines with, primarily, plasma facing components (PFC) which are carbon based. However, ITER will operate with metallic PFCs: a W divertor and Be first wall components. Three tokamaks have performed extensive studies of H-mode access in the presence of metal PFCs: Alcator C-Mod [2], ASDEX Upgrade (AUG) [3,4] and JET [5]. Broadly, they find that the transition in machines with metallic PFC differs from that in machines with carbon PFC, but, whilst the power threshold is generally lower in the presence of metallic walls, the effect has not yet been quantified in a way that it can be extrapolated to ITER. A number of important effects have been found that influence the L-H threshold and need to be built into a common picture. Firstly, the existence of a minimum power threshold with respect to density has been well established in plasmas with C PFC and this phenomena is also observed with metallic PFC. The associated density of the minimum essentially defines two regimes, a low and high density branch, with different threshold dependencies and so predicting what this density will be on ITER with W/Be PFC is vital for making predictions. Secondly, standard global scalings of the L-H power threshold are based on the power flowing through the edge region of the confined plasma including the power flowing as radiation. It is not expected that the radiated power would play a role in the transition and several studies indicate that considering only the thermally transported power improves the ordering of the data. Thirdly, recent studies at ASDEX Upgrade have identified the power flowing in the ion channel as playing a key role in the L-H transition and showed that a single scaling for the ion power flux at the transition describes a series of ASDEX Upgrade L-H transitions in the low and high density branch without recourse to separate scalings. It remains to be shown if this can be extended into a multi-machine scaling and how such a scaling would take into account the material of the PFC.

Given the importance of the low activation phase of ITER operation, a predictive basis for the L-H transition in H, He or H-He plasmas with metallic PFC is a particular requirement and, perhaps more importantly, a predictive basis for how to extrapolate results from ITER H, He or H/He plasmas to predict the later active phase of operation in D, T and D-T plasmas.

This study aims to combine the results from existing H-mode access studies in the presence of metallic PFC [2-5] with the existing multi-machine database [1] to provide a physics basis for predicting the L-H and H-L threshold on ITER in both the low and high activation phase. The important effects of the minimum power threshold with respect to density, radiated power and the power flux in the ion channel will all be considered.

**References**

1. Martin Y. et al, J. Phys.: Conf. Ser. 123 (2008) 012033
2. Ma Y. et al. Nucl. Fusion 52 (2012) 023010
3. Ryter F. et al, Nucl. Fusion 53 (2013) 113003
4. Ryter F. et al, Plasma Phys. Control. Fusion 58 (2015) 014007
5. Maggi C. F. et al, Nucl. Fusion 54 (2014) 023007