DSOL-34 **Far-SOL fluxes and link to detachment**

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| **TG priority:** Moderate | **Start date:** 2014 | **Status:**  On-going | **Personnel exchange:**  Yes |
| **IO priority:**   | **End date:** Not fixed | **Motivation:** Physics Basis |

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| **Device /****Association** | **Contact****Person** | **2016 TGRequest** | **Activity (from JEX/JA spreadsheet)** |
| **2015** | **2016** | **2017** | **2018** | **2019** |
| AUG | D. Carralero | Desirable | Analysis |   |   |   |   |
| JET | M. Groth,B. Lipschultz | Desirable | Analysis |   |   |   |   |
| COMPASS | M. Komm | Desirable | Committed |   |   |   |   |
| C-Mod | B. LaBombard | Desirable | Not doing |   |   |   |   |
| DIII-D | A. McLean | Desirable | Data mining |   |   |   |   |
| TCV | N. Vianello | Desirable | Committed |   |   |   |   |
| KSTAR | J.-G. Bak | Desirable | Analysis |   |   |   |   |
| ITER | R. A. Pitts | Desirable |   |   |   |   |   |
| NSTX-U | M. Jaworski | Desirable | Not doing |   |   |   |   |

**Purpose**

The width of the Scrape-off Layer (SOL) will be of paramount importance for ITER, as it will determine erosion levels and heat loads onto many critical plasma facing components. Recent L-mode experiments carried out in the ITER stepladder (including COMPASS, ASDEX Upgrade and JET tokamaks) have proven the link between divertor detachment and the onset of SOL density profile flattening (development of a shoulder) [1]. These studies indicate that the increased collisionality caused by the conditions in the divertor region at the onset of detachment leads to a change in the regime of filamentary propagation, greatly enhancing particle and heat transport. Extrapolation of these results suggests that the shoulder might be present in ITER baseline scenario, thus probably exceeding present predictions for main wall loads [2]. Further work carried out in ASDEX Upgrade (AUG) has also demonstrated the formation of a density shoulder in ITER-relevant inter-ELM H-modes, which did not show such a clear link to divertor detachment [3]. These results have been refined by a series of dedicated L-mode experiments carried out in AUG, which have demonstrated that density decay length and filament size are not directly influenced by the density with respect to the Greenwald limit, but scale with divertor collisionality [4]. The same scaling is obtained when the detachment is induced by Nitrogen seeding. These results provide a framework with the potential to explain the formation of the shoulder in ITER relevant H-mode plasmas and pave the way for a general scaling of the SOL width, capable of improving current predictions for ITER operation. The results will also be extremely valuable input to new studies which are planned for ITER using the upgraded SOLPS code package, SOLPS-ITER, which is being launched by the IO in Spring next year. This new code package will incorporate full grids to the wall and a physics study (W. Dekeyser) will be performed in 2015-16 to test this new capability, with the aim of being able to reproduce some aspects of the experimentally observed SOL density behaviour (a more accurate comparison likely requires a 3D code – see below).

**Situation by November 2015**

* AUG: Analysis of L-mode shoulder formation experiments carried under MST program have proved a clear connection between divertor collisionality, change of far-SOL filament regime and shoulder formation. It has been proven that this result is in good agreement with current analytical models of filament propagation. This lot of work was presented in June in the ITPA meeting (Princeton) and in the EPS Conference (Lisbon). Also, it has led to the publication of a Physical Review Letters paper [1]. Besides, a series of experiments were carried out in July in AUG under MST program, in which a low power H-mode scenario was establish where detachment in the divertor could be induced by impurities while observing the whole process with a pin probe. With this data it should be possible to assess the validity of L-mode findings in H-mode. Analysis is ongoing. More experiments in this line will be carried out in February 2016.
* JET: Data mining was carried out in order to contribute JET data to the aforementioned publication on the L-mode shoulder formation [1]. Besides, a series of experiments will be carried out in December and January (M15) in order to follow up the general scaling of transport studies already began by B. Lipschultz [2]. In these experiments, it will be attempted to observe the evolution of SOL profiles with LiB, and the impact of divertor collisionality on midplane will be investigated. Additionally, the role of neutrals near the midplane will also be looked at as well as the amount of ionisation inside the separatrix.
* COMPASS: Shoulder formation had never been verified in COMPASS at the beginning of this project. The reason for this is probably the low Greenwald fraction (in the range of fGW = 0.2-0.3) achieved in this machine, caused partly by its small size and moderate typical densities. In order to overcome this, a dedicated scenario development campaign was performed in summer 2015, aiming to achieve higher densities. Unfortunately, due to the unavailability of the NBI system, only ohmic heating could be used. As a result, discharges disrupted at fGW=0.4 -most probably due to the onset of MARFEs-, which is still insufficient to achieve shoulder formation. Since NBI is again operational, a new campaign is foreseen at January 2016, in which the additional heating should prevent the disruptions until higher fGW are reached.
* DIII-D: Data mining has been carried out in order to compare DIII-D and AUG shoulder formation. A number of discharges of interest, including some with detailed divertor Thomson scattering measurements have been identified. Analysis is ongoing. Preliminary results indicate that the role of collisionality would be similar to that already found in AUG, although the SOL would be hotter in DIII-D (ie., less collisional), and would thus have a shoulder formation at higher densities. Possible reasons for this would be the open divertor or the Carbon wall found in DIII-D.
* KSTAR: A first series of experiments were carried out in September in KSTAR, in which a first characterization of turbulence was carried out, including a radial scan of the ion saturation and particle fluxes in the midplane. Unfortunately, not all required diagnostics were available (most notably, no measurements could be obtained at the divertor), and experimental results are still incomplete. New experiments are planned for 2016, in which these problems will be solved.
* TCV: A first group of experiments was programed for early October, in which the connection length would be increased without affecting the plasma shape by modifying the poloidal field gradient near the target. Unfortunately, these experiments had to be postponed due to operational problems. Next experiments will be carried out in December, during TCV He campaign.

**References:** [1] D. Carralero et al., PRL (2015), [2] B. Lipschultz et al., PPCF (2005).