DSOL-35 In-out divertor ELM energy density asymmetries

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| **TG priority:** High | **Start date:** 2014 | **Status:**  On-going | **Personnel exchange:**  Yes |
| **IO priority:**   | **End date:** 2016 | **Motivation:** Engineering Design Support |

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| **Device /****Association** | **Contact** **Persons** | **2016 TGRequest** | **Activity (from JEX/JA spreadsheet)** |
| **2015** | **2016** | **2017** |
| ITER | R. A. Pitts | Essential |  |   |   |
| AUG | T. Eich, B. Sieglin | Essential | Committed |   |   |
| JET | T. Eich,A. Thornton | Essential | Committed |   |   |
| KSTAR | S.-H. Hong | Essential | Considering |   |   |
| DIII-D | M. Makowski | Desirable | Analysis |   |   |
| TCV | H. Reimerdes | Essential | Committed |   |   |
| MAST | A. Thornton | Shutdown | Considering |   |   |

**Purpose**

The ITER W divertor design (notably the analysis of transient heat loads on shaped monoblock surfaces) is being based on the expectation that there will be asymmetries in the ELM energy deposited on the divertor targets. This follows previous observations on JET, AUG and DIII-D of a typical (average) 2:1 asymmetry favouring the inner divertor for the total (Type I) ELM energy. However, what really matters for the transient response on leading edges (in the case of no shaping), or chamfered surfaces (in the case of shaping) is the peak ELM energy density. The tacit assumption that higher ELM total energy also means higher ELM peak energy density has not been systematically investigated. What has been more carefully studied is the dependence of the peak ELM energy density on the outer divertor target (where most tokamaks have the best IR coverage), for a range of ELM sizes across AUG and JET. The result is an important and interesting scaling (T.Eich et al, APS-56) which appears to demonstrate that the main parameters controlling the outer target ELM energy density are the pedestal top pressure and machine size (major radius). At present, there is very little knowledge of the situation at the inner divertor, nor is there much data for pure He plasma, which is the baseline target species for non-active phase operation on ITER. This coordinated task proposal aims to improve the database for this new scaling, by including more devices, including a smaller machine (to confirm the size scaling) and to attempt to provide much more data on the in-out divertor ELM energy density asymmetry.

**Brief Summary of results from 2015**

* JET: no dedicated experiments in 2015.
* AUG: experiments already performed in the domestic programme and the 2015-16 MST1 programme (AUG15-2.3-1, two sessions). Good data obtained already for both inner and outer targets in SNL. Peak ELM energy densities at both targets in line with the proposed pedestal pressure scaling developed for the outer target (based on JET and AUG data). Note: these new data obtained with 2D IR camera systems operating at 2.5 kHz with 1.1 mm spatial resolution on the target and self-adjusting integration times. Peak parallel ELM energy densities are similar on both inner and outer targets, but preliminary results do show that more total energy deposited on the inboard side, consistent with previous findings on DIII-D, JET and AUG.
* KSTAR: Type I ELM loading experiments performed in dedicated session of KSTAR 2015 Campaign (10/09/2015) but unfortunately only a single fast IR camera available viewing the outer target (inner target IR unavailable due to technical fault). So no ELM in-out asymmetries can be derived. Some data will be available for the outer target but analysis is still underway.
* TCV: device shutdown through most of 2015. Experiments planned in the MST1 programme (TCV15-2.3-1, 4 sessions in March-April 2016) with Type I ELMs in FWD and REV-B.
* DIII-D: Data from experiments in 2015 and previously show, surprisingly, that the in-out asymmetry seen elsewhere in the TOTAL ELM energy is reversed on DIII-D – there is more ELM energy to the outer target than the inner. There are indications (but more analysis required) that the peak ELM energy density also favours the outboard target. However, some shots have been analysed for which both strike points are located on the outer shelf of the lower divertor. In this case, the ELM total energy asymmetry favours the inboard, as previously found on DIII-D and other tokamaks. An additional dependence on lower triangularity has also been found, with the in-out asymmetry increasingly favouring the inner divertor as lower increases. The observation of configuration dependence on the magnitude (and even direction) of the asymmetry implies that new experiments should be performed on DIII-D and elsewhere to investigate this more carefully.
* MAST: device was not in the original list of participating machines (shutdown), but some new analysis performed in 2015 on older ELM data for the outer target also follow the pedestal pressure scaling. Analysis also waited for the inner target ELM heat fluxes.

**Plans for 2016**

* JET: three dedicated sessions planned (M15-28) on 22/01/2016 and 11/03/2016.
* AUG: further sessions allocated (AUG15-2.3-1) in early 2016.
* KSTAR: experiments will be proposed in the 2016 campaigns to obtain the first ELM data at both strike points simultaneously.
* DIII-D: further experiments to be proposed for 2016 but not guaranteed due to high pressure on experimental time in the boundary plasma area. New data can to some extent be obtained parasitically.
* TCV: experiments planned (TCV15-2.3-1, 4 sessions in March-April 2016) with Type I ELMs in FWD and REV-B.
* MAST: machine unavailable for experiments in 2016 🡪 further analysis of existing data prior to MAST Upgrade to be performed.