PEP-38 Access conditions for ELM mitigation and ELM suppression by magnetic perturbations at low pedestal collisionalities

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| **TG priority:** High | **Start date:** 2015 | **Status:**  On-going | **Personnel exchange:**   |
| **IO priority:**  | **End date:**   | **Motivation:**   |

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| **Device** | **Contact** | **2016 TGRequest** | **Activity (from JEX/JA spreadsheet)** |
| **2015** | **2016** | **2017** | **2018** | **2019** |
| AUG  | W. Suttrop | Desirable | Committed |   |   |   |   |
| DIII-D | R. Nazikian | Desirable | Committed |   |   |   |   |
| EAST | Y. Sun | Desirable | Committed |   |   |   |   |
| KSTAR | Y. M. Jeon | Desirable |   |   |   |   |   |
| MAST-U | A. Kirk | Desirable |   |   |   |   |   |

**Background and Previous Results:** ELM mitigation or suppression by magnetic perturbations (MP) at low pedestal collisionality has been observed in a range of tokamaks. Experiments in MAST, AUG, DIII-D, and KSTAR have shown a critical influence of the poloidal mode spectrum on the plasma response. The occurrence of ELM suppression, or if ELMs are not suppressed the degree of ELM loss reduction, depend on the degree of alignment of the MP with the plasma magnetic field and/or modes driven by the plasma pressure. Access to ELM mitigation or suppression appears to be possible at either very high or very low pedestal collisionality; however so far there is no evidence that actually collisionality itself is the critical parameter. Given that now a similar low density H-mode regime with comparable phenomenology is encountered in several experiments, there is scope for an inter-machine effort to define better the access criteria for ELM mitigation or ELM suppression and ultimately develop better predictive capability.

 **Outline of Proposed Experiments, Purpose and Goals:** This experiment is intended to mainly target those questions that can benefit from a closer comparison of experiments in the various participating machines and from performing joint experiments that can be directly compared. For the benefit of producing results in a reasonable time frame, it is proposed to focus (in the frame of this proposal) primarily on the following topics:

1. Explore the effect of different coil geometries on the plasma response including density pumpout, ELM mitigation, ELM suppression and locked mode avoidance.
2. Document the response of the plasma including ELM mitigation, pumpout and suppression at low electron collisionality and other related plasma parameters.
3. Is there a threshold of MP amplitude density pumpout, ELM mitigation and/or suppression and in which way does this depend on toroidal mode number n and pedestal parameters?

These topics are addressed first by inspection of already existing data and second by performing controlled parameter variations in new joint experiments. The following tasks are envisaged:

1. Define common criteria to quantify the effect of MPs on ELMs, plasma rotation, plasma density, and confinement,
2. Perform pedestal collisionality scans, possibly independent of density, to test if access windows shift with shifting magnetic field pitch,
3. Compare the effects of varying poloidal structure of the MP, e.g. by varying the toroidal phase difference between poloidally separated rows of coils to vary field-aligment,
4. Provide experimental data suitable for modeling the ideal and resistive plasma response with codes such as MARS-F/K/Q, M3D-C1, and possible others.
5. Perform variations of plasma-beta (ideal response) and pedestal plasma rotation (field shielding, resistive response).

Activities in 2015

Experiments in MAST, ASDEX Upgrade (AUG) and DIII-D with varying poloidal spectrum indicate that maximised plasma response (density pump-out, ELM mitigation and/or ELM suppression) requires alignment of the external perturbation with a low-n peeling amplified mode, driven by the edge pressure gradient in the barrier region.

A data base of AUG shots at low collisionality shows that effective ELM mitigation is achieved for pedestal collisionalities nu\*<0.4. The ELM loss is a function of pedestal density (smaller losses at low density), regardless of whether magnetic perturbations are applied or not. Thus ELM mitigation appears as a result of the density pump-out that is produced by the magnetic perturbation. However, it is possible to switch off the perturbation on a time scale faster than the density recovery, leading to ELM-free H-mode. This indicates the magnetic perturbation is necessary to produce (destabilise) mitigated ELMs. ASDEX Upgrade data for selected cases of the 2014 campaign is available as “modeling kit” and so far, this has been used in VMEC/NEMEC, NEO-2, JOREK, MARS-F, and M3D-C1 calculations. Data of the ongoing 2015 campaign is in preparation.

**Plans for 2016**

A similarity experiment between AUG and DIII-D has been prepared and is planned to be executed on 3-Dec-2015 in DIII-D. The purpose of this experiment is to port complete ELM suppression to ASDEX Upgrade (where ELM suppression has not been observed to date despite fierce attempts) and thereby identify the critical parameters. Starting with a known case of ELM suppression with n=3 perturbations produced by the I-coils, the plasma shape will be ramped towards an AUG-similar shape. During this ramp, the access window in q95, torque input and alignment of the magnetic perturbation will be monitored and if necessary, control parameters be adjusted. Baseline plasmas at medium high triangularity have been produced in ASDEX Upgrade and the final matching pulses will be performed after the DIII-D experiment.

KSTAR has extensively investigated the effect of poloidal spectrum, varied by means of three rows of perturbation coils, on ELM mitigation and ELM suppression.

EAST has commissioned a new set of in-vessel saddle coils and has started experimenting with this new extension. Contributions to this experiment are expected for 2016.

MAST is currently out of operation for a major upgrade and will continue to contribute after restart (planned for 2017). Meanwhile, old MAST data is available for comparison and further modelling.