The pellet ELM pace making project at AUG, DIII-D and JET: status and first results

P. T. Lang[1], L. R. Baylor[2], J. Hobirk[1], A. Loarte[3], A. Alonso[4], B. Alper[5], T.Eich[1], K. Gál[6], A. Geraud[7], G. Kocsis[6], R. Koslowski[8], Y. Liang[8], T. Loarer[7], P.J. Lomas[5], M. Maraschek[1], H.W. Müller[1], G. Saibene[3], R. Wenninger[1], ASDEX Upgrade Team and JET-EFDA contributors*

JET-EFDA, Culham Science Centre, OX14 3DB, Abingdon, OXON, UK
1MPI für Plasmaphysik, EURATOM Association., Boltzmannstr. 2, 85748 Garching, Germany
2Oak Ridge National Laboratory, Box 2008, Oak Ridge, TN 37831, USA
3FUSION FOR ENERGY, Joint Undertaking, 08019 Barcelona, Spain
4Laboratorio Nacional de Fusion, Euratom-CIEMAT, 28040 Madrid, Spain
5Euratom/UKAEA Fusion Association, Culham Science Centre, Abingdon, OX14 3DB, UK
6KFKI RMKI, EURATOM Association, P.O.Box 49, H-1525 Budapest-114, Hungary
7CEA Cadarache, Association Euratom/CEA, 13108, St Paul-Lez-Durance, France
8 Institut für Energieforschung - Plasmaphysik, Association EURATOM-FZJ, D-52425 Jülich, Germany
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The erosion of plasma-facing materials by Edge Localized Modes (ELMs) has been recognized as a possible threat to the viability of ITER. Several approaches to solve this problem are currently under investigation, aiming at either to avoid the occurrence of ELMs at all or to enhancing their frequency in order to achieve sufficient mitigation. One possible technique of the latter category is pellet pacing with the ELM frequency controlled by the pellet injection rate. A proof of principle demonstration for this approach was obtained in ASDEX Upgrade and recently confirmed at JET, however with respect to a potential application at ITER several questions remain still open. In particular, experiments have to provide information to establish by how much pellet pacing can enhance the spontaneous ELM frequency. Up to now only a factor of two could be achieved (for technical reasons), but ITER requires at least a ten fold increase. Experiments and modeling have to clarify if a proportional reduction of the maximum ELM induced power flux can still be achieved under such circumstances and if pellet pacing can be integrated in ITER relevant scenarios. At the same time the confinement reduction observed during pellet pacing sequences needs to be minimized. The confinement reduction is attributed mainly to convective energy losses introduced by the pellet related particle fuelling, and it is expected that smaller pellets can still trigger ELMs but cause less impact on the confinement. The key question here is the pellet penetration depth and amplitude of the local pellet perturbation required to trigger an ELM.

Suitable pellet injection systems are currently under development at ASDEX Upgrade, DIII-D and JET to perform the relevant experiments. The ASDEX Upgrade blower gun uses small pellets (particle inventory $m_P = 6 \times 10^{19}$ D) in the speed range 100 – 200 m/s for straight or tangential injection from the torus outboard side at repetition rates up to 100 Hz. Pellets of the same size but with velocities in the range of 10 m/s only, propelled by gravitational acceleration entering from the top of the torus are delivered by the DIII-D pellet dropper. The most sophisticated system is under commissioning at JET, allowing for launch from different poloidal locations with variable mass and speed, covering both fueling and pacing requirements. However, with the pacing part yet unavailable, experiments had to be conducted using the fuelling part. Launching at up to 10 Hz repetition rate and at speeds up to ~200 m/s was performed from the LFS and the vertical HFS track in JET. ELM pacing was demonstrated at the maximum available pellet rate of 10 Hz from the LFS. The dynamics of triggered, in comparison to, spontaneous ELMs was studied in a variety of different scenarios e.g. in plasmas with mixed type-I and type-III ELMs or during experiments operating with a perturbed magnetic configuration in the plasma edge due to enhanced toroidal field ripple or imposed n = 1,2 error fields.