PEP-30 ELM control by pellet pacing in ITER-like plasma conditions and consequences for plasma confinement

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

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| --- | --- | --- | --- |
| **Device /****Association** | **Contact****Person** | **TGRequest** | **Activity (from JEX/JA spreadsheet)** |
| **2012** | **2013** | **2014** | **2015** | **2016** |
| DIII-D  | L. R. BaylorA. Bortolon | Desirable | Committed | Committed | Analysis | Committed |   |
| AUG | P. Lang | Desirable | Committed | Committed | Committed | Committed |   |
| ITER | A. Loarte | Desirable |   |   |   |   |   |
| MAST | M. Valovic | Desirable | Considering | Considering | Not doing |   |   |
| EAST | Z. Sun | Desirable |   |   |   |   |   |
| NSTX-U | R. Lunsford | Desirable |   |   |   | Committed |   |
| JET | P. Lang | Desirable | Committed | Committed | Committed | Committed |   |

**Results for 2015**

* In AUG, changing C → ILW reduced the pellet ELM pacing & mitigation potential. The use of N seeding has partially restored the pedestal recovery time after an ELM and improves the pellet ELM triggering. AUG-W has shown the pellets injected before the L-H transition can eliminate the ELM-free start of the H-mode and reduce the ELM size compared to non-paced cases. Studies of 70 Hz pellet pacing with N seeding have been attempted and find smaller ELMs but have not reached a steady-state scenario with the pellets leading to excessive density.
* JET ILW results have indicated a pellet size threshold and poloidal injection location dependence that has lead to the moving of the JET HFPI to the top of the machine for HFS vertical injection with a simplified injection guide tube system. The injector has completed the repositioning and is undergoing commissioning with experiments anticipated in 2016.
* In DIII-D An experiment with Li granule injection to pace ELMs was done in ITER like shape plasmas. It was found that ELMs are reliably triggered with sufficient Li granule size (0.7 microns spheres or greater). Similar electron content D2 pellets also triggered ELMs in the same discharges. The Li ELM pacing was able to strongly reduce impurity content and did not lead to significant confinement degradation. Li content in the core partially replaced the carbon impurity content, but Zeff was not significantly increased. Low rotation cases (using alternating co-counter NBI) were found to maintain large ELMs despite the triggering of many small ELM-like events between the large ELMs. Larger ELMs were found in this scenario with Li injection compared to non-paced periods in the discharge.
* Modeling with the 3D MHD code JOREK is being extended to JET and AUG simulations by S. Futatani. In both machines the pellet size is varied and injection location is being compared between HFS and LFS midplane injection. ITER simulations were presented that show a stronger ballooning mode growth for a given pellet size for the bottom HFS location for the assumed pellet perturbation geometry. LFS injection surprisingly shows the lowest growth rate of the three injection locations.

**Plans for 2016**

* JET has moved the HFPI to the top of the machine where it will have a single 90 degree bend in the injection line to inject on the vertical high field side. This should enable better pellet transmission than has been possible for the small ELM triggering pellets that can be injected at up to 50 Hz. Experiments are planned for the current run period.
* DIII-D will utilize new extrusion nozzles to improve the reliability of small pellets to optimize the injection of D2 pellet at up to 90 Hz. Experiments with low rotation are planned to compare with Li granule experiments. Further granule injection experiments are planned with additional materials.
* NSTX-U and EAST will join the experiments from 2016 using lithium granules and with D2 pellets on EAST.
* AUG-W plans to continue fueling optimization with HFS pellets combined with RMP ELM mitigation.

**Purpose:**

* The primary goal is further substantiation of pellet ELM pacing by demonstrating an enhancement of the natural ELM frequency (fELM) by > 90% with a corresponding reduction in ELM size.
* Determine if ITER relevant scenarios on existing devices yield good confinement/performance.

Due to its large size, JET is the most suitable device for this task, essentially as a low spontaneous ELM rate (few Hz) can be achieved reliably. This can be done while the relative fuelling impact of the pellet mass remains bearable. As fuelling constraints are expected to go down with increasing machine size they thus should be lowest at JET. JET and DIII-D are expected to validate the main ASDEX Upgrade results and extend their investigations over a wider range of plasma scenarios.

**Background:** ELM control by pellet ELM pacing as proposed for ITER has been demonstrated to some degree in various tokamaks. Experiments have shown that it is possible to reduce the ELM energy loss by high frequency pellet injection, and a demonstration at the ITER ELM size decrease range and for ITER-like plasma conditions remains has now been performed on DIII-D. The consequences for plasma performance and pellet ELM triggering requirements in these ITER-relevant conditions however remain uncertain and need further investigation on other devices.