

## ELM Suppression by Real-Time Boron Powder Injection

A. Diallo, R. Hager, Z. Sun, R. Maingi, A. Bortolon, C.S. Chang, A. Nagy, K. Tritz, J.S. Hu, Y.M. Duan, L. Zhang, W. Xu, G.Z. Zuo, Y. Ye, J.P. Qian, X.Z. Gong

<sup>1</sup> Princeton Plasma Physics Laboratory, Princeton, <sup>2</sup> John Hopkins University, Baltimore, <sup>3</sup> Institute of Plasma Physics, Chinese Academy of Sciences, China  
e-mail (speaker): adiallo@pppl.gov

Experiments provide the first observation of edge-localized-modes (ELMs) suppression without confinement degradation when boron powder is injected in the upper X-point of the EAST tokamak [1] (as shown in figure 1). While boron powder injection was previously aimed at conditioning walls, experiments reveal that interactions of the ablated boron with background plasmas have beneficial effects for confinement as well as impurity accumulations. In addition to these effects, ELM suppression was shown to occur when the ablated boron reaches a certain threshold in the discharge. Similarly, when boron injection is halted during the discharge, ELMs return promptly suggesting that the effects of boron on the wall can be ruled out. Furthermore, boron injection and subsequent ELM suppression are associated with the onset of an edge harmonics mode (see figure 2). The observed mode has multiple harmonics and was shown to produce particle transport. The ablated boron produces a local density perturbation akin of a density accumulation that in turn leads to GAM-like modes[2]. We hypothesize that boron injection can in principle trigger a GAM-like mode in the edge and enhance X-point orbit loss. Preliminary calculations show using two-fluid and XGC gyrokinetic that secondary GAM frequencies are consistent with the frequency observed

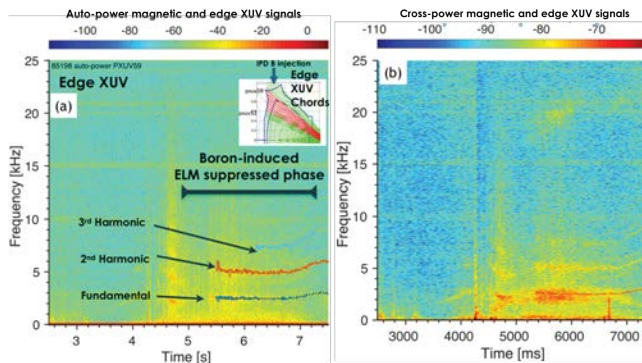


Figure 2: **Edge coherent modes.** (a) spectrogram of XUV chord. (b) cross-spectrogram of magnetic probe and XUV

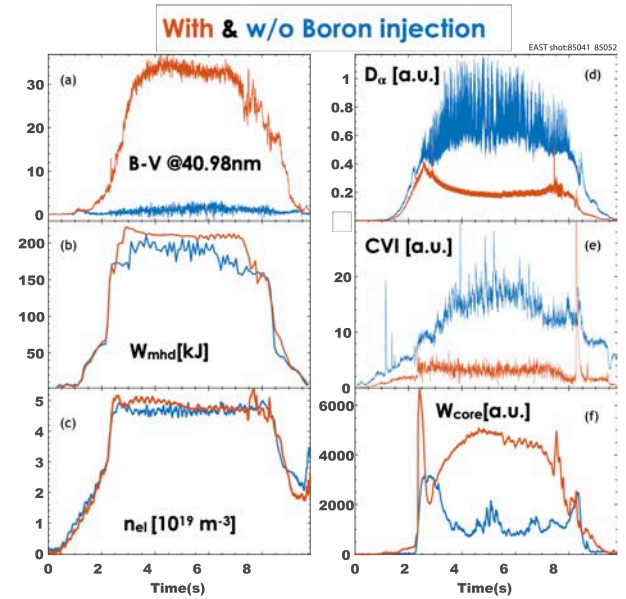


Figure 1: **Time history of the boron-induced ELM suppression (red) and the reference ELMy discharge (black).** (a) A proxy for the boron injection indicated by the B-V line emission. (b) The total stored energy showing a slight increase during boron-induced ELM suppression. (c) The line-averaged density essentially showing stationary density evolution. (d) The upper D<sub>α</sub> trace showing the ELMs in the reference case and the absence of ELMs when the IPD is injected. (e) Time history of carbon impurity, clearly indicating a drop. (f) No W accumulations observed during boron injection with slight drop in W after 5 s.

in the experiments. Results presented could open new research opportunities in providing an actuator for triggering edge mode capable of making the pedestal marginally “leaky” in order to suppress ELMs without confinement degradation.

- [1] Sun Z., *et al.*, Nuclear Fusion 61 (2021).
- [2] Diallo et al. IAEA-FEC ICN 1167 2021

This work was supported by the U.S. Department of Energy under contract number DE-AC02-09CH1146, and in part by the National Key Research and Development Program of China (2017YFA0402500, 2017YFE0301100), and National Nature Science Foundation of China (11625524, 11775261, 11905148, and 11905138).