

Real-Time Control of ELM and Sawtooth Frequencies: Similarities and Differences.

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* See the Appendix of F. Romanelli et al., Proceedings of the 25th IAEA Fusion Energy Conference 2014, Saint Petersburg, Russia

MOTIVATION

OPEN LOOP EXPERIMENTS

ELMs and Sawteeth appear in different parts of plasma and are associated with different physics, but as phenomena to be controlled, they show many similarities:





GAS INJECTION -> ELM FREQUENCY



ICRH -> SAWTOOTH PERIOD



- No new closed loop results 2013limited experimental time
- Main limitations:
- Very limited RF frequency range
- Very slow rate of change 100kl

14 due to	40 Hz request -> well controlled	Response to	Response to	0.8 Pellet size detected near $\frac{1}{4}$ $\frac{1}{4}$	84696
	20Hz request -> Saturates some of the	•Strikepoint movement	 Pellet Injection 	$ \bigcirc 0.4 \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \$	
e <1MHz Hz/s		 (and to a small step in the request) 	⇒ Controller reduces	0.0 = 0.0	



CONCLUSIONS : Closed Loop Control of ELM and Sawtooth periods have both been demonstrated on JET

Sawtooth control based on ICRH frequency variation:

- -> Very small ICRH frequency range available in real time (resonance range 10cm)
- -> Slow (10s to move 10cm)

(This will not pose a problem for ITER given long required sawtooth period - 30s)

- -> Difficult with present power to affect High power H-modes
- -> ECRH is likely to be more efficient.

ELM frequency Control using gas injection

- -> Developed taking advantage of experience from Sawtooth control
- -> Very effective in maintaining desired frequency
- -> Can be combined with Pellets etc. to allow minimum gas
- -> Can assure recovery from Tungsten Events

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