# Real-time classification of L-H transition & ELM in KSTAR

- From our previous study on automatic detection of the L-H transition to enhance density feedback control in KSTAR, we showed the possibility of real-time detection with SVM classifier trained through machine learning.
- To **overcome the previous results** and to apply **more suitable real-time algorithm** in KSTAR practically, we trained neural networks based on **long short-term memory** (LSTM).
- Using 65 shots in the **2017 KSTAR campaign**, we trained the LSTM network to learn L-H transition related patterns. According to a **test result**, the accuracy of the test set is **94.45%** (total 174,000 test samples in 58 shots)
- In the 2018 KSTAR campaign, **434 shots** of the total 542 H-mode shots are successfully **classified(80.07%)** using D_α and post processed $\overline{n_e}$. **448 shots** of the total 533 shots are also successfully **classified(84.05%)** using D_α and real-time $\overline{n_e}$.

- The LSTM classifier can classify the intermediate state such as dithering.
- The classifier has never been trained for the ELMs before the ELM phase

	SVM classifier	**LSTM classifier**
Data set	2017 campaign data (139 shots)	2017 campaign data (123 shots)
Number of labels	2 (L- and H- mode)	4 (L-mode, intermediate state, H-mode, and ELM)
Calculation time per a sample	About 8 ms	About 250 μs
Classification average accuracy for test set (same shots in 2017campaign)	74.47% (58 shots)	94.45% (58 shots)
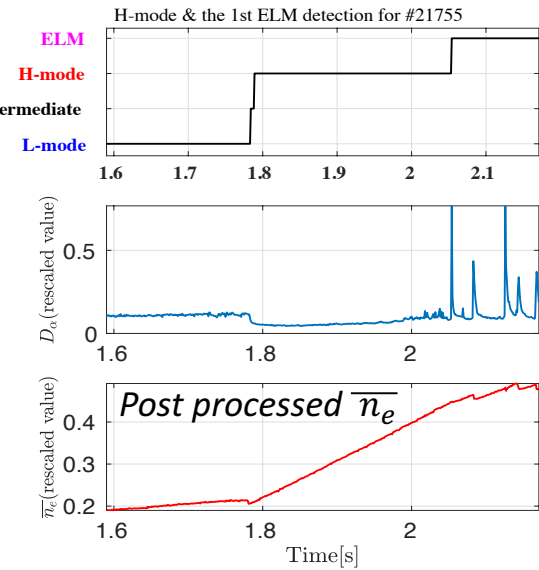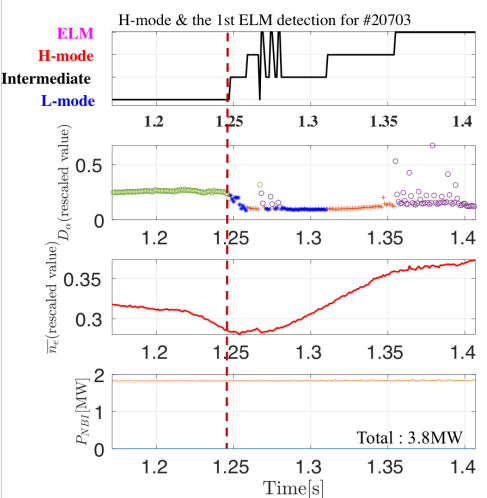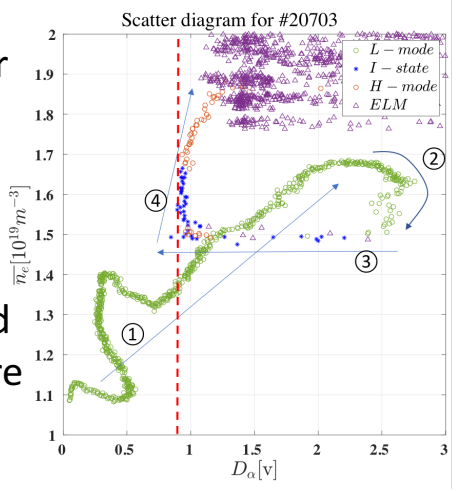
Example result for off-line version
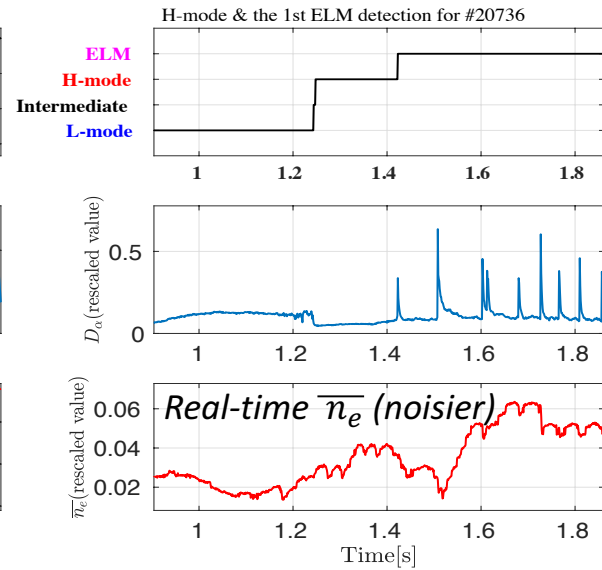
Example result for real-time version