§15. Fast RF Spectrometer system on LHD

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A prototype fast RF spectrometer system has been developed for the LHD to investigate the role of Alfven/whistler waves in magnetic reconnection [1] during MHD instability crashes such as ELMs and sawtooth crashes. This collaborative research is an extension of the previous work at the KSTAR tokamak [2], where RF emissions in the whistler wave frequency range were observed at every ELM crash, large sawtooth crashes, and during L→H transitions. Fig.1(a) shows a broadband antenna, a hybrid of dipole and monopole, installed on the 10-O port of the LHD. The spectra of the antenna signals are measured in μs time resolution by a 14-channel filter bank spectrometer in the range of 70 – 2800 MHz.

Fig. 2 shows an example of semi-periodic RF bursts during L to H transition, which is common to H-mode discharges in the LHD and similar to the KSTAR observations. Note that there exist no corresponding spikes in the H alpha signals neither in the Soft X-ray signals. In the KSTAR, such RF bursts were identified as small edge-localized crash events (using a 2-D imaging diagnostic), which suggests that the transition may involve a fast magnetic reconnection, i.e., reconfiguration of magnetic topology in the plasma edge region. Interestingly, as illustrated in the lower two time traces of Fig 2, the RF bursts were measured only at frequencies ~ 400 MHz, the cause of which is under investigation. Similar periodic RF bursts were often observed during the back transition but not always.

Fig. 3 shows an example of RF spikes (on top of the signal level modulation) corresponding to ELM crashes. Note that the modulation of both soft X-ray and lower-frequency RF (i.e., 410 MHz signal in Fig. 3) is due to the modulation of the perpendicular NBI (NBI#5), which may correspond to higher harmonics of ion cyclotron waves from the cyclotron instabilities caused by beam ions [3]. Interestingly, during the NBI injection, the ELM crashes caused negative spikes at those RF channels affected by NBI contrary to the usual positive spikes. This may indicate that the ELM crash depopulates fast beam ions reducing the RF level related to ion cyclotron emissions.

In summary, we have demonstrated the prototype RF spectrometer as a useful diagnostic tool for a broad range of physics studies such as MHD instabilities, confinement transitions, and beam-wave interactions. Future work may include development of addtional antenna sensitive for circular polarization, a more adequate choice for the detection of whistler waves.

[1] Bellan, Phys. Plasmas **5**, 3081 (1998)
[2] Leem, Yun, and Park, J. Instrum. **7**, C01042 (2012)
[3] Dendy et al., Nucl. Fusion **35**, 1733 (1995)

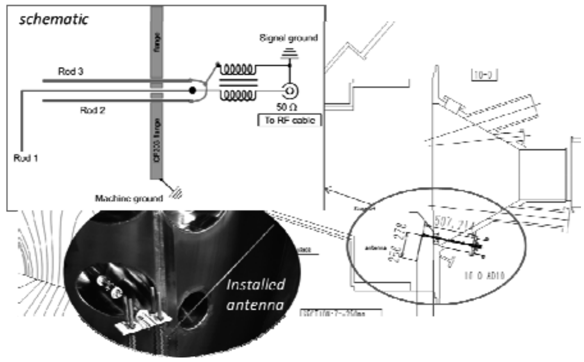

Fig. 1. Hybrid antenna installed inside the vessel at the 10-O port.

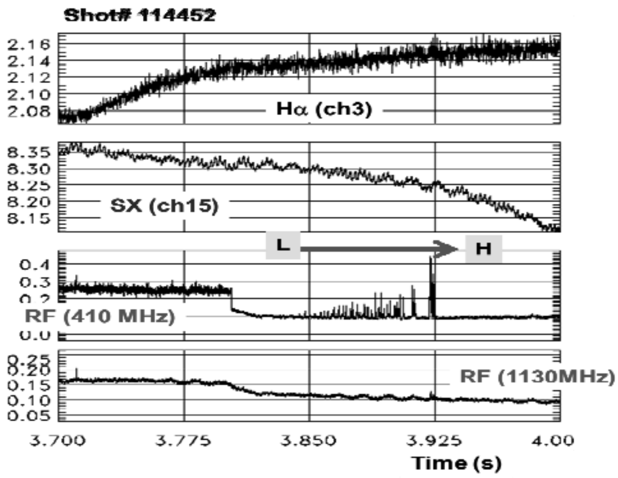

Fig. 2. Semi-periodic RF bursts during L→H transition

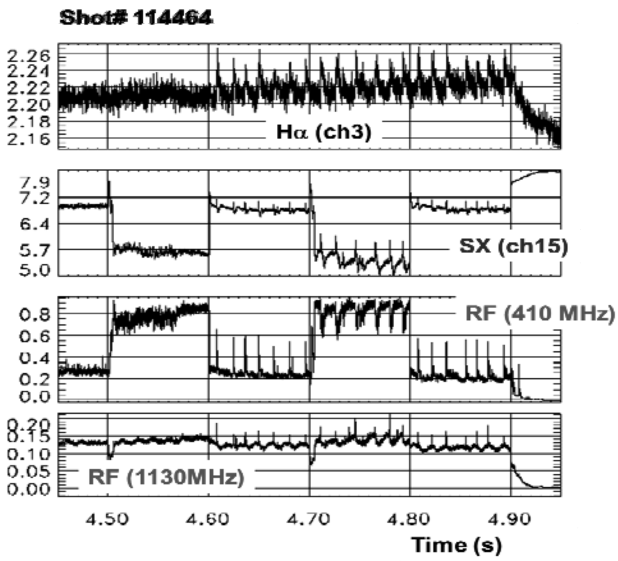

Fig. 3. RF spikes at ELM crashes. The modulations of the soft X-ray (SX) and the RF at 410 MHz are due to the NBI modulation. Note the negative RF spikes in the 410 MHz signals during the period of high level (i.e. NBI on).