Runaway electron suppression/amelioration by ECRH and RMP in KSTAR

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Runaway electron suppression by ECRH

ECRH at 110 GHz and 170 GHz is available at KSTAR

Runaway reduction effects with Electron Cyclotron Resonant Heating (ECRH) 110 GHz 2nd Harmonic: B_T = 1.96T

Observed reduction of the

runaway electron synchrotron radiation

hard x-ray (HXR) intensity

HXR photon energy

However, we did not see any significant effect from 170 GHz 2nd harmonic ECRH

IR and visible light TV cameras were used to observe the forward cone of synchrotron radiation from high energy runaway electrons in KSTAR.

Runaway electron suppression by RMP

In-vessel control coils (IVCC) were installed inside KSTAR

Runaway reduction effects with Resonant Magnet Perturbations (RMP) from the IVCC

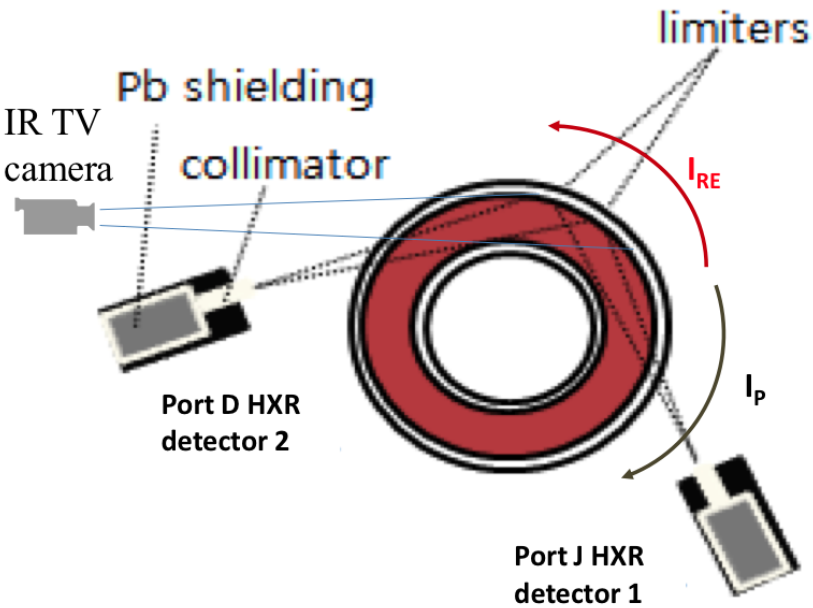
Observed changes to the

synchrotron images and

reduction of the HXR intensity

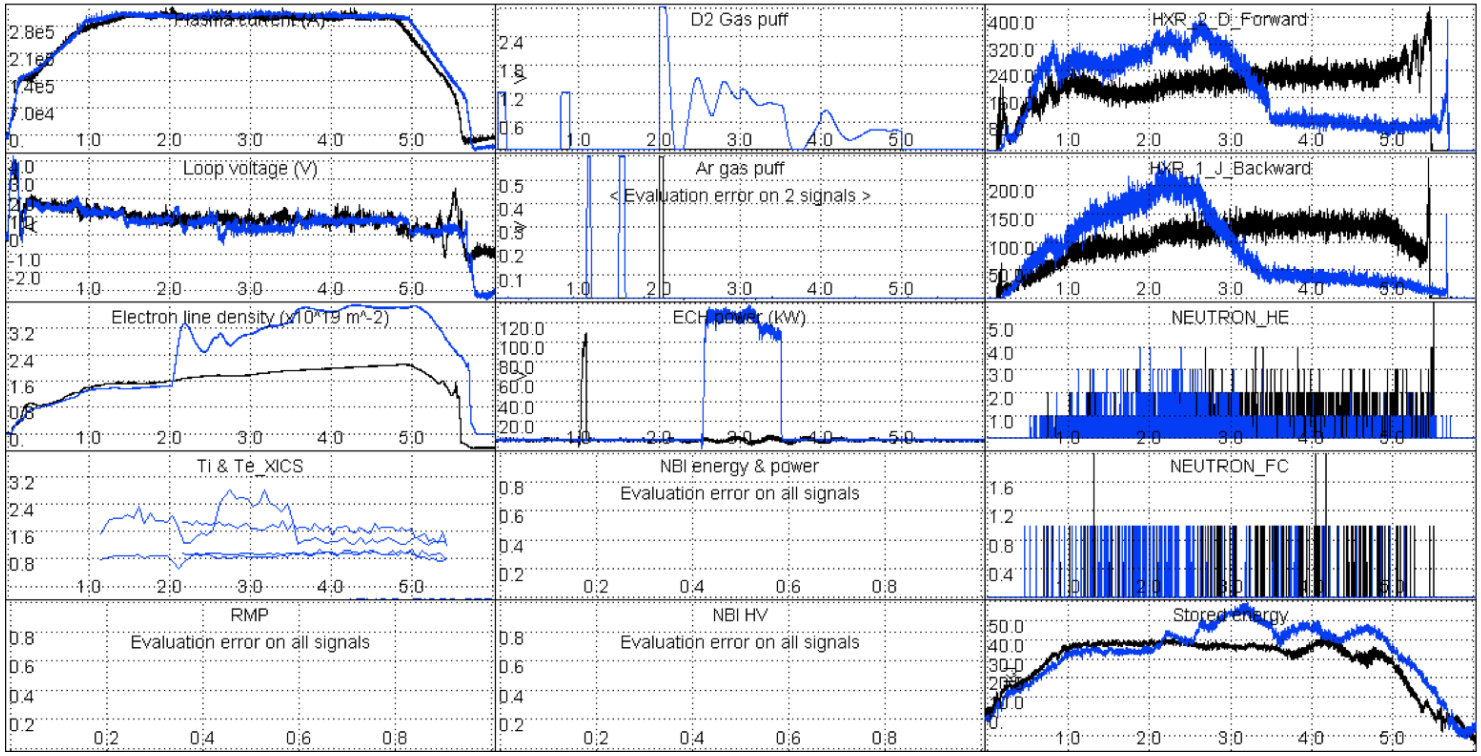
IR and visible light TV cameras were used to observe the forward cone of synchrotron radiation from high energy runaway electrons in KSTAR.

KSTAR experimental arrangement



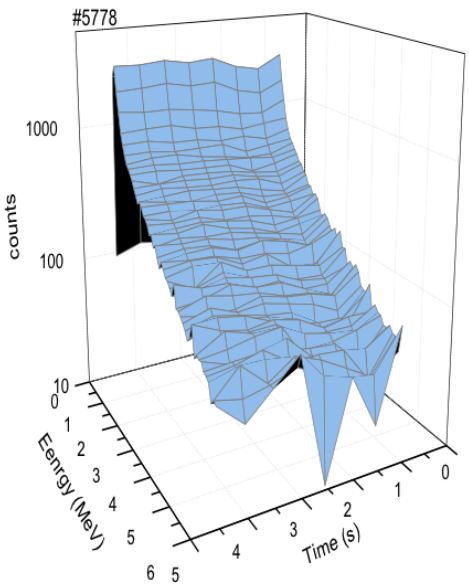
The HXR detectors are 3 x 3 NaI(Tl) crystals.

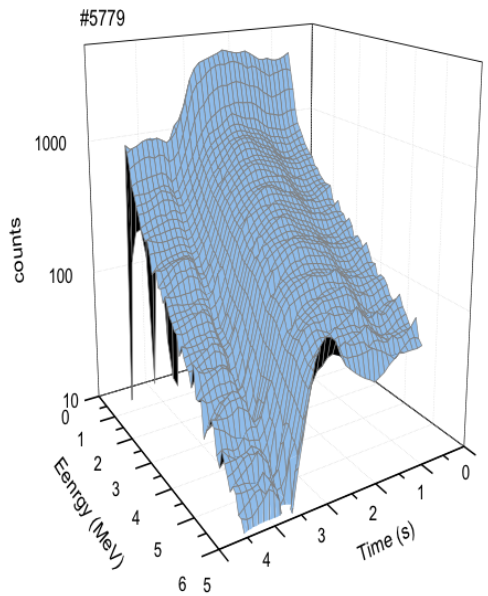
Reduction of HXR by ECRH



Shots 5778 and 5779. About 260 kW of 110 GHz ECRH radially injected caused the electron temperature to rise, the loop voltage to drop, and the RE x-ray signals to be depressed for both HXR detectors. The HXR signals continued to decrease after the end of the ECH pulse.

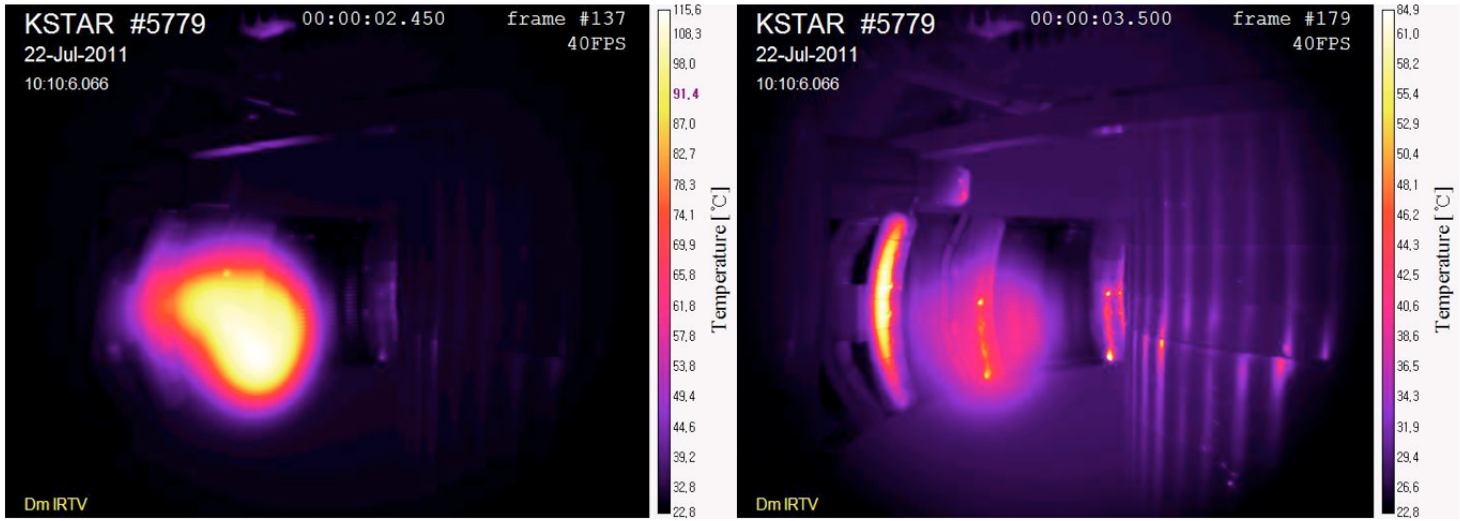
Reduction of HXR energy by ECRH





Shots 5778 (left) and 5579 (right) for the forward HXR detector, HXR-2, are shown in Fig 3 as a function of time. For shot 5778 the intensity and slope are relatively constant. For shot 5779 with ECRH, however, there is a decrease in photon energy (an increased slope) and a decrease in intensity starting at the time of the application of the 110 GHz ECRH. At the end of the ECRH pulse the energy and intensity remain low.

Reduction of synchrotron radiation by ECRH



IR camera images for shot 5779 at 2.45 s (left) just before and at 3.5 s (right) at the end of the ECRH pulse. Note the right image intensity has decreased considerably.

Shot 5778 without ECRH

Shot 5779 with ECRH

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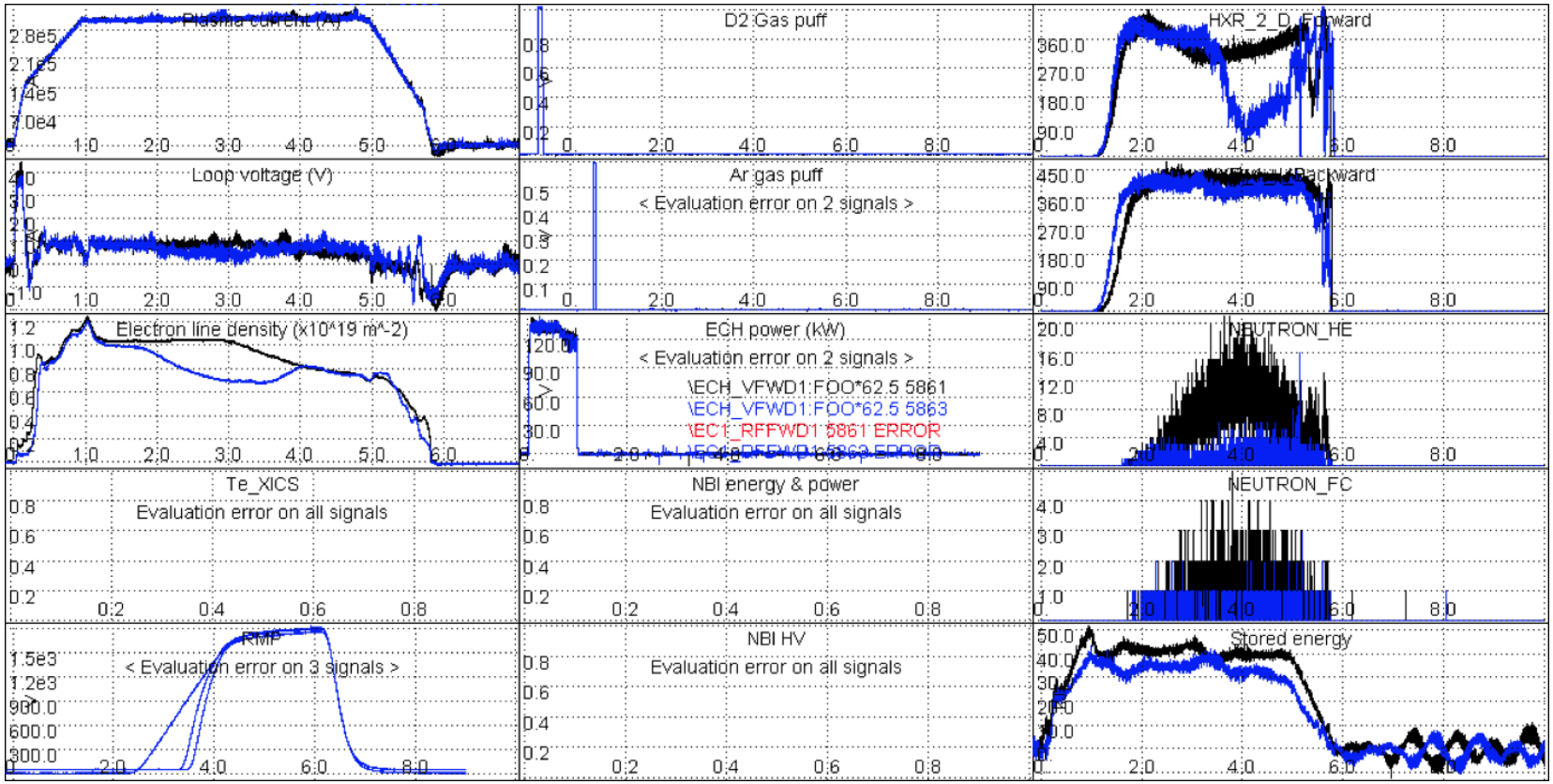
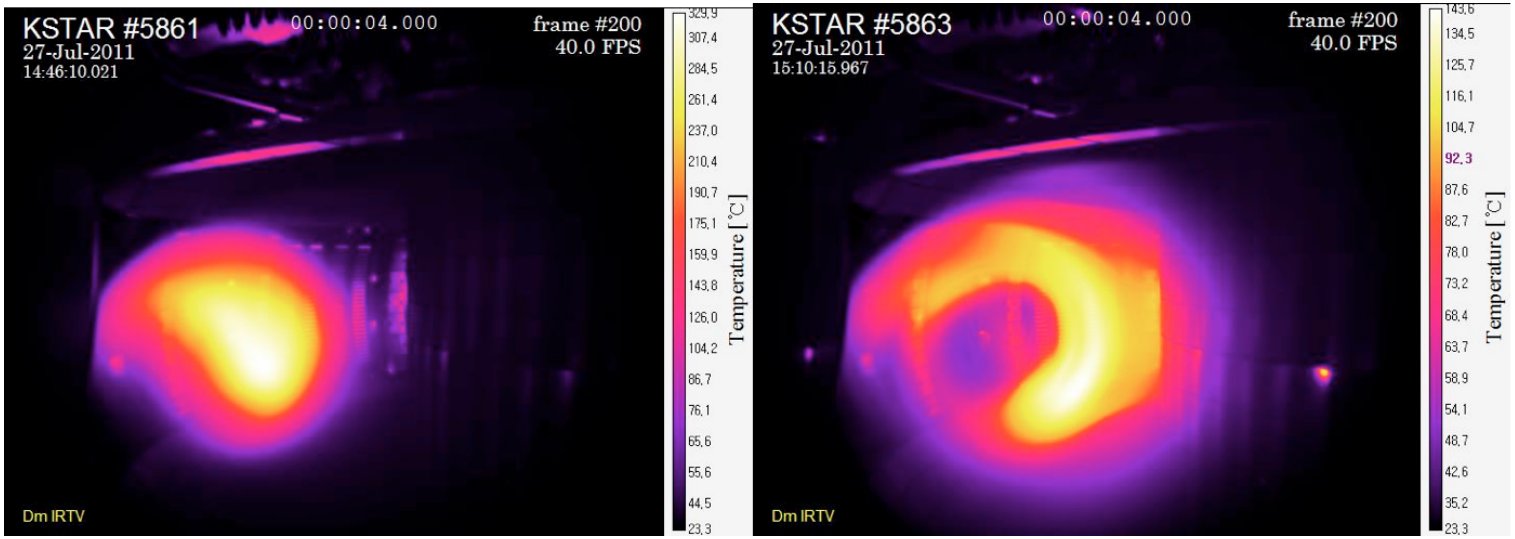
Changes in HXR by RMP with n=1



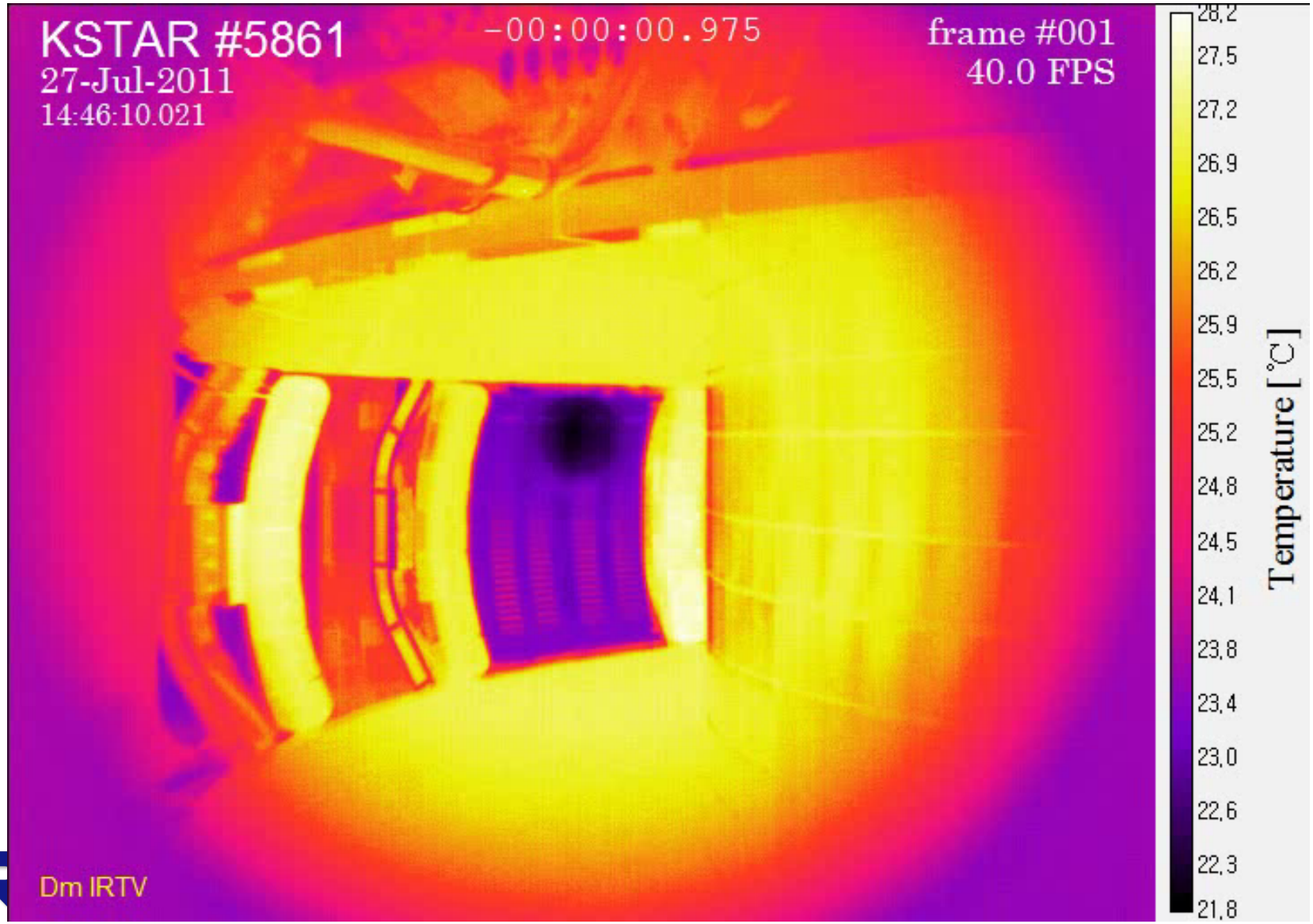
Shots 5861 and 5863. The n=1 RMP was applied to a RE discharge. The HXR-2 signal (forward) HXR detector showed a drop which appeared to be the result of RE suppression by the RMP but the signal returned during the RMP current flat top. The top, middle, and bottom RMP coil currents are shown on the lower left.

Change in synchrotron images from RMP



Single frames from the IR TV camera at 4.0 s (left) for shot 5861 without RMP and (right) for shot 5863 with RMP. There is a clear difference in the shape and intensity.

Shot 5861 without RMP



Shot 5863 with RMP

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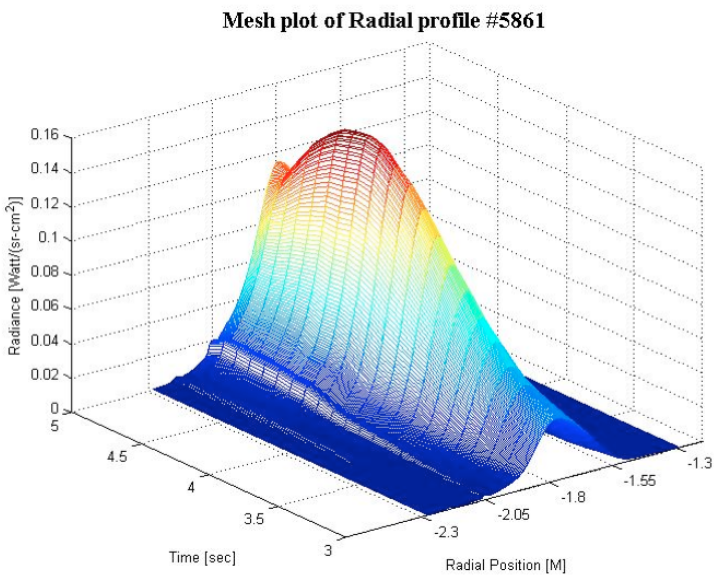
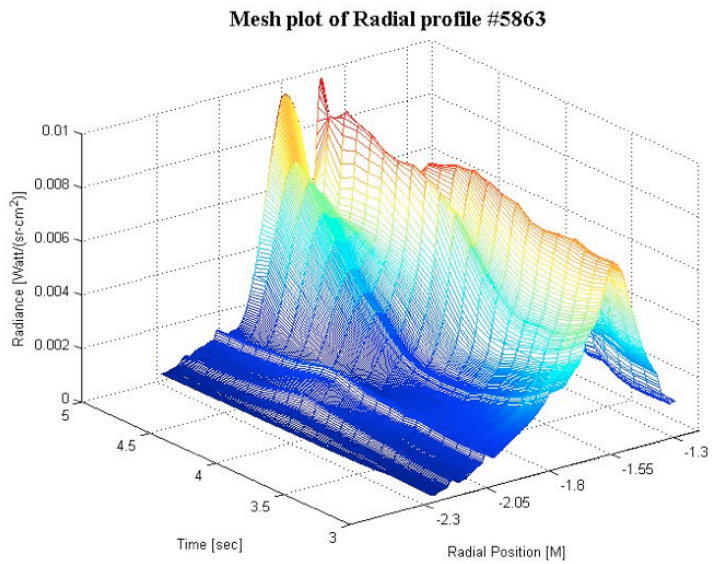
Changes in IR synchrotron intensity from RMP





Radiance plots from the IR camera for (left) shot 5861 without RMP and (right) shot 5863 with RMP from 3.0 s to 5.0 s. The peak radiance for shot 5861 is ~ 15 times higher than 5863. The radiance is measured along the horizontal midplane.

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Summary and Conclusions

ECRH

Experiments on the KSTAR tokamak with 110 GHz radiation at the 2nd harmonic showed the reduction of energy and intensity of the HXR signal during application of ECRH heating.

Synchrotron radiation from the runaway electrons was considerably decreased by the ECRH. However, a similar experiment with higher power 2nd harmonic 170 GHz radiation at $B_T = 3.04$ T did not show any significant effect on the intensity.

RMP

The results of the n=1 RMP experiment are not clear. The n=1 RMP field initially reduced the HXR signal but it reappeared inside the RMP pulse. The RMP also changed the synchrotron radiation pattern and lowered the synchrotron radiance by more than an order of magnitude. We were not able to test n=2 RMP.

Comments on the 2012 KSTAR Conference

Muju Resort

2012.2.22-2012.2.24

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Program and files of many presentations are found at:

http://kstar.nfri.re.kr/kstarweb/conference/index.jsp

Some Highlights

Confinement and ELM Characteristics of KSTAR Plasmas: J-W. Ahn (ORNL)

Efforts to suppress and ameliorate ELMs: SW Yoon, Y. M. Jeon, W. Xiao (NFRI)

The ITER PWI challenge: R. Pitts (IO) given remotely

Overview of LHD experiments: B. Peterson, NFRI

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Thank you for your attention!