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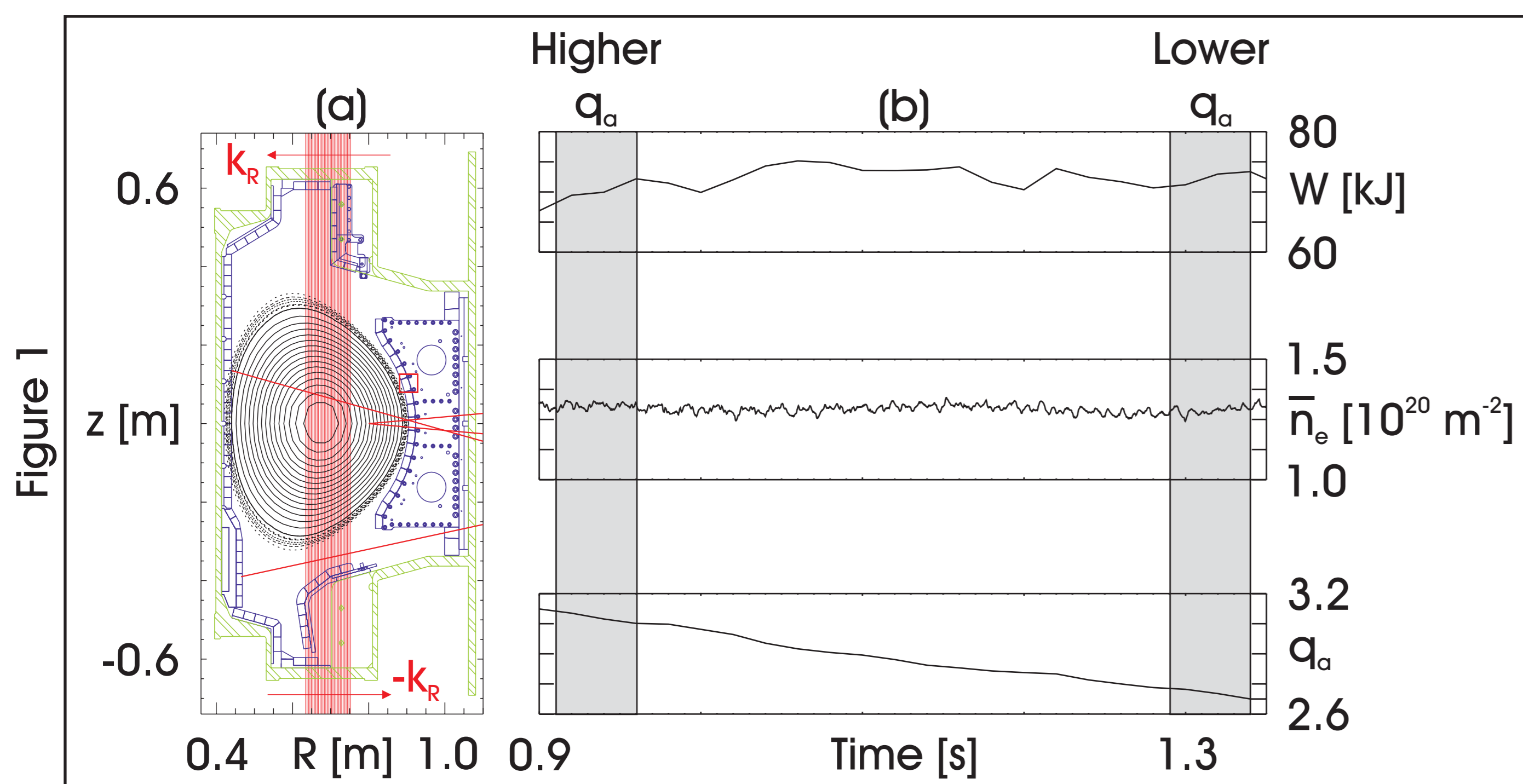
## 1. Introduction

At certain values of the edge rotational transform,  $\tau_e = 1/q_e$ , the confinement time of plasmas in the Wendelstein 7-AS (W7-AS) stellarator was found to be very sensitive to small modifications of  $\tau_e$ . These transitions provided a means to perform systematic investigations of differences in turbulence during 'good' ( $q_e = 2.91$ ) and 'bad' ( $q_e = 2.76$ ) confinement phases [1].

The macroscopic changes of confinement in W7-AS were attributed to the presence of internal transport barriers (ITBs) close to low-order rational  $\tau$ -surfaces in the plasma and the fact that W7-AS had small magnetic shear [2]. Related empirical and theoretical models on thermal electron transport around low-order rational surfaces can be found in e.g. Refs. [3].

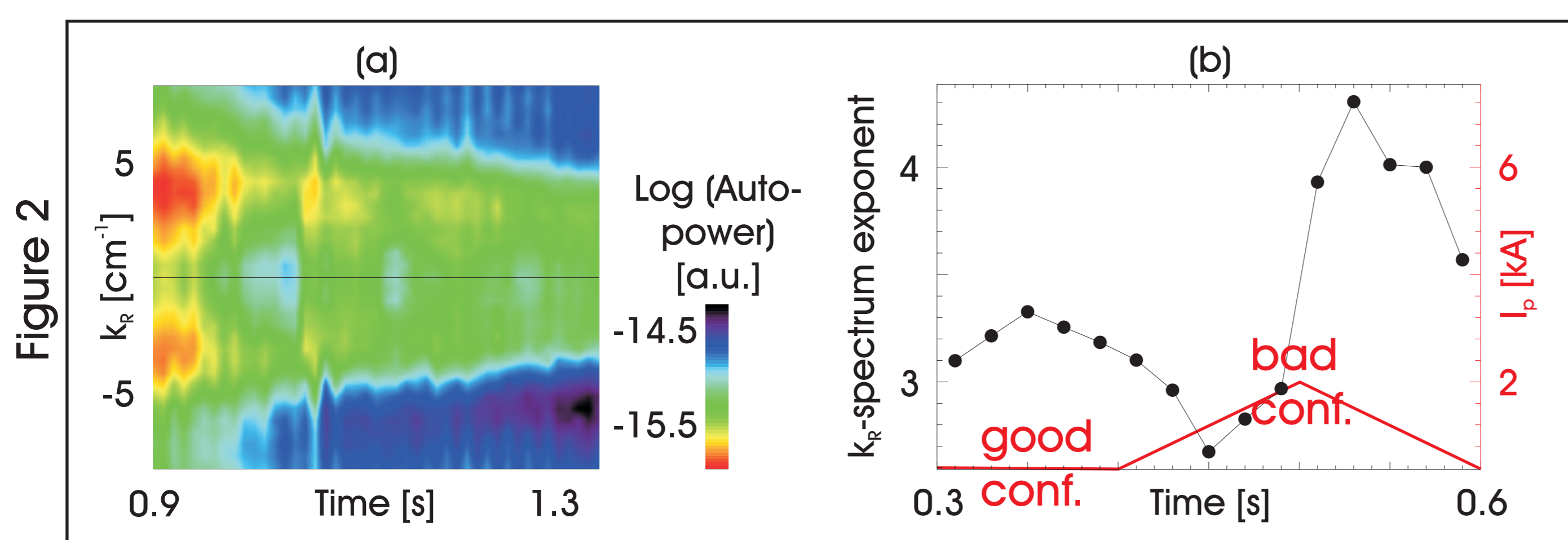
## 2. C-Mod current ramp discharges

To study the effect of the presence or absence of low-order rational surfaces in C-Mod, we designed discharges where the current was ramped slowly up to lower  $q_e$  in a controlled fashion, see Fig. 1. If an ITB is associated with the  $q = 3$  surface, this barrier would be removed from the plasma resulting in a (local) worsening of confinement. Since global confinement in C-Mod is seen not to be affected by the current ramp, we name the time intervals shown in Fig. 1 (b) 'higher  $q_e$ ' (HQA) and 'lower  $q_e$ ' (LQA).



## 3. W7-AS and C-Mod wavenumber spectra

Line integrated fluctuations in the electron density of C-Mod plasmas parallel to the major radius were measured using the recently upgraded phase-contrast imaging (PCI) diagnostic [4]. In Fig. 2 (a) we show wavenumber spectra vs time for fluctuations in the [250 kHz, 2 MHz] range. It is observed that the fluctuation amplitude increases as  $q_e$  is lowered, and that the characteristic wavenumber decreases.



## 3. W7-AS and C-Mod wavenumber spectra (cont'd)

Density fluctuations in W7-AS at wavenumbers ranging from 14 to 62  $\text{cm}^{-1}$  were measured using small-angle scattering. Fitting wavenumber spectra assuming a power-law dependence showed that the slope of these spectra increased during bad confinement, see Fig. 2 (b). In other words, the relative weight of smaller wavenumbers increases for degraded confinement. Further, the amplitude of turbulence at small wavenumbers ( $k_r = 15 \text{ cm}^{-1}$ ) rose.

## 4. C-Mod correlation analysis

Differences between the HQA and LQA phases are also observed when we cross correlate power detected in a core PCI channel (17) integrated over the [250 kHz, 2 MHz] interval with electron cyclotron emission (ECE) measurements, see Fig. 3. The shot analysed is sawtoothing throughout the discharge, and has a central temperature of 2 keV.

In Fig. 4 we use power detected in a core PCI channel (17) integrated over the [250 kHz, 2 MHz] range as a reference, and correlate this signal with corresponding measurements from 31 PCI channels. Note that all chords pass through the  $q < 1$  region, so they detect a mixture of fluctuations inside and outside the sawtooth inversion radius.

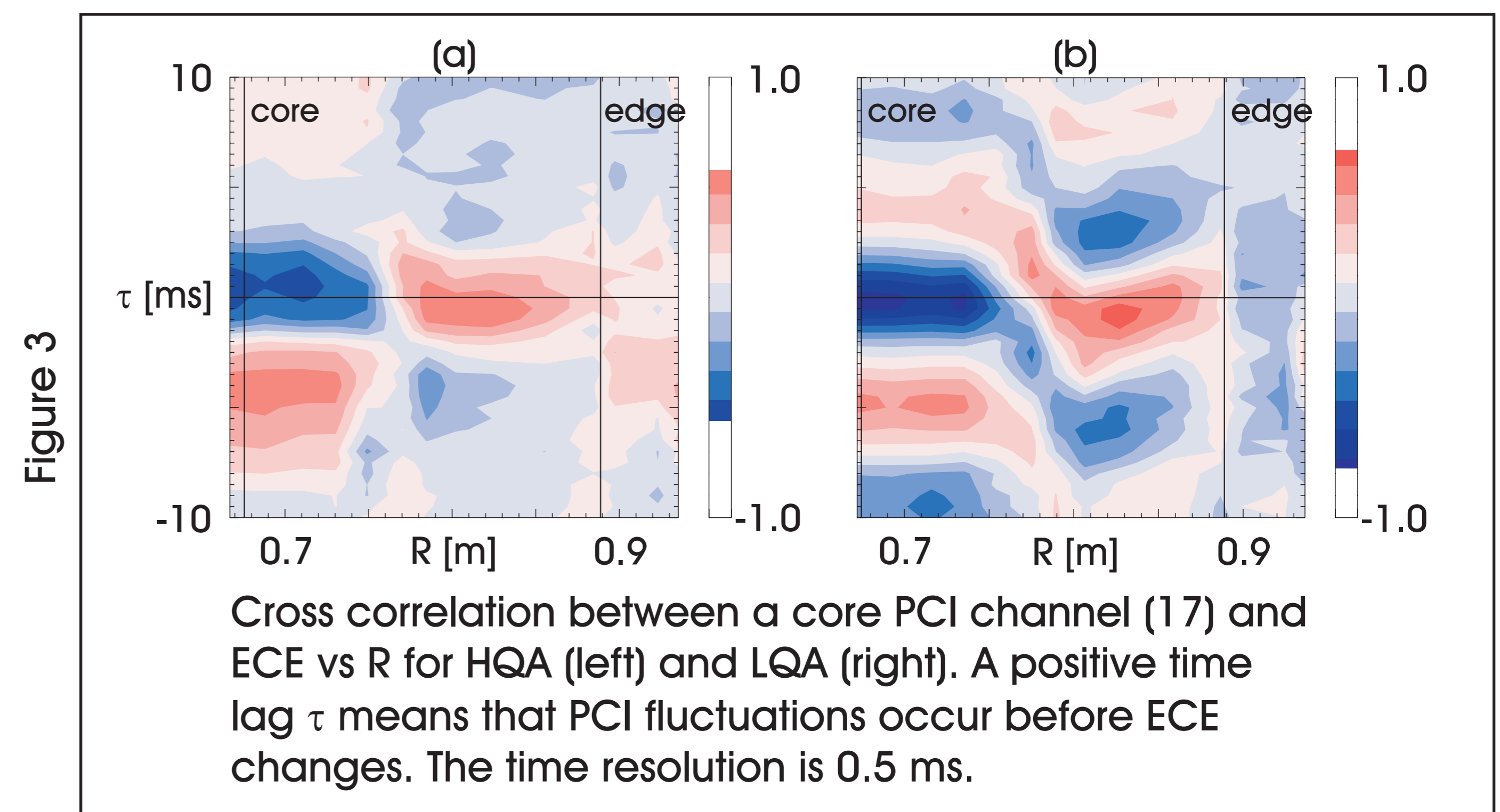


Figure 3 Cross correlation between a core PCI channel (17) and ECE vs R for HQA (left) and LQA (right). A positive time lag  $\tau$  means that PCI fluctuations occur before ECE changes. The time resolution is 0.5 ms.

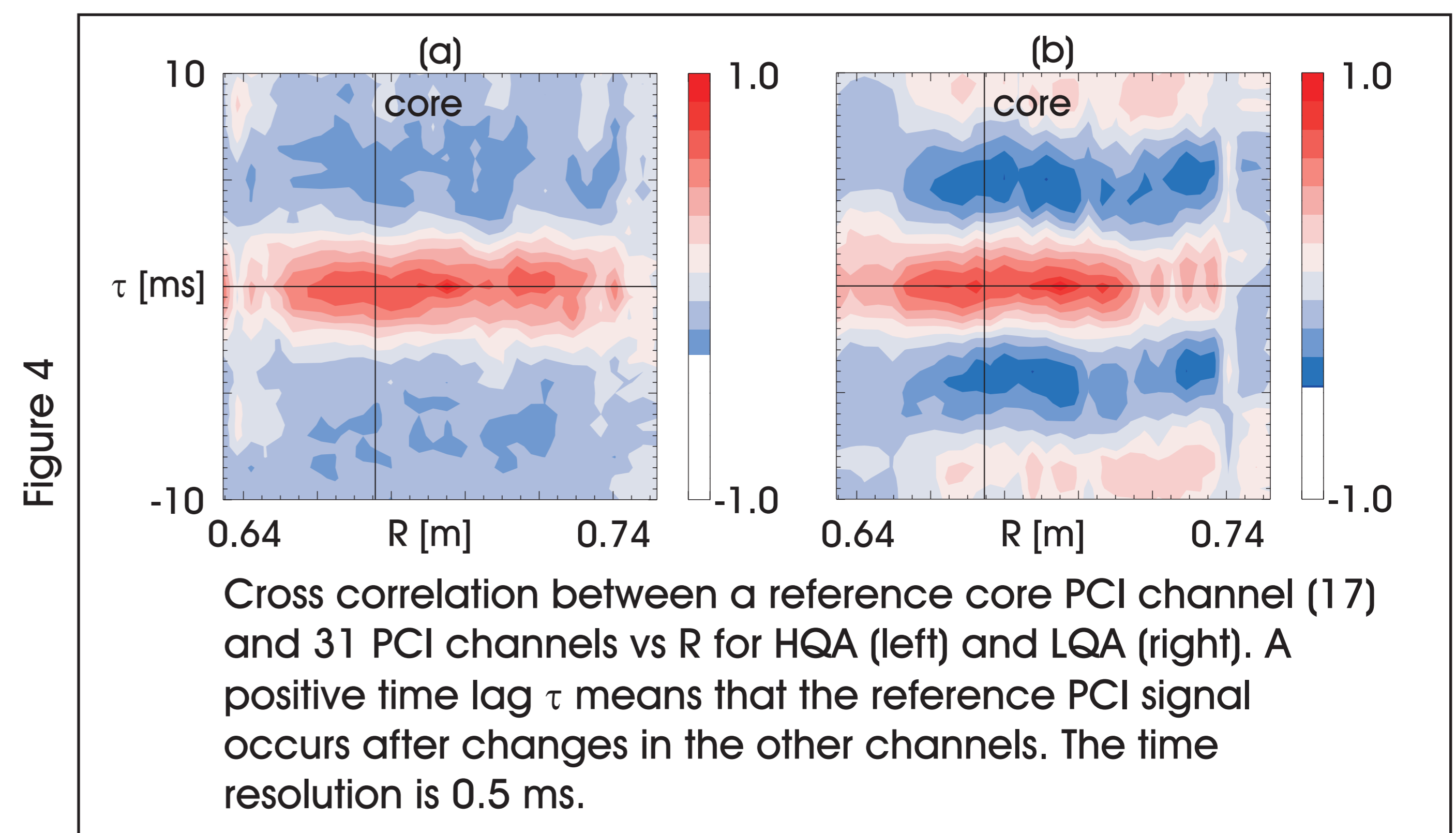


Figure 4 Cross correlation between a reference core PCI channel (17) and 31 PCI channels vs R for HQA (left) and LQA (right). A positive time lag  $\tau$  means that the reference PCI signal occurs after changes in the other channels. The time resolution is 0.5 ms.

**Conclusion** There is a global change in confinement at low shear (W7-AS) and a local change in heat transport and turbulence at high shear (C-Mod) as a function of  $q_e$ .

## References

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