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Simulation and experiment of EC steering of LH deposition on EAST

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The use of electron cyclotron (EC) power to localize the deposition of lower hybrid (LH) waves has been predicted in simulation and confirmed in experiment on EAST. In a typical EAST discharge, LH power is in the multi-pass absorption regime, which results in a broad deposition profile that is difficult to control. On the other hand, EC power can be aimed accurately at a particular radius, but in most cases has lower current drive efficiency than the LH. While synergistic effects between EC and LH have been previously observed on EAST[1] and other machines[2,3], this work demonstrates the possibility of using the EC to create a local population of fast electrons in the phase space, which the LH will preferentially damp on, in effect concentrating the LH power damping at the EC resonance layer. This result has been predicted in time-slice simulations using the ray-tracing code GENRAY[4] and the 3D Fokker-Planck solver CQL3D[5], and is confirmed in experiment for the first time.

A number of different tests were performed in the experiment. First, changing the deposition location of 2.2 MW of EC from a radius of rho = 0 to 0.25 across discharges reduced the internal inductance from $l_i = 1.31$ to 0.94, indicating a broader current profile. As the EC were set for co-Ip current drive (CD), a portion of this change is the direct result of moving the ECCD location radially outward. However, a simultaneous broadening can be observed in the hard x-ray (HXR) profile, which measures bremsstrahlung radiation from the fast electron population created by the LH waves. A second test was setup with about 0.6-0.8 MW of EC power moving radially outward during one discharge. A comparable decrease in l_i (from 1.16 to 0.93) and broadening of HXR profile were also observed in these discharges. Interestingly, while an inward movement of EC does produce the expected trend of increasing l_i, the magnitude of change is much smaller (from 0.933 to 0.976). Work is underway to explain the source of this asymmetry.

Finally, a test of shifting the toroidal injection angle of a subset of ECCD from co-I_p to counter-I_p to heating only, under the same EC and LH power levels, showed that the synergistic effect between EC and LH is dependent on the fast electron population created by co-I_p ECCD, not just on the locally increased T_e. The combination of the steerable ECCD and the highly efficient LHCD provides a new tool for broadening and tailoring steady-state current profiles, which may open new avenues in scenario development for advanced tokamak concepts that requires efficient off-axis current drive.

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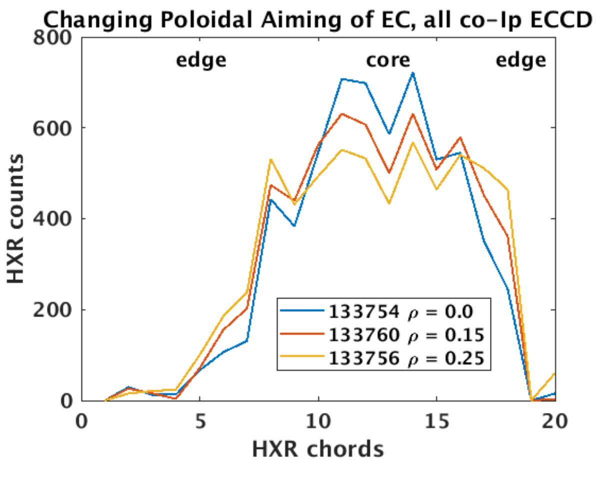

Figure 1: Moving the EC deposition location radially outward broadens the LH absorption, as shown by HXR profiles.

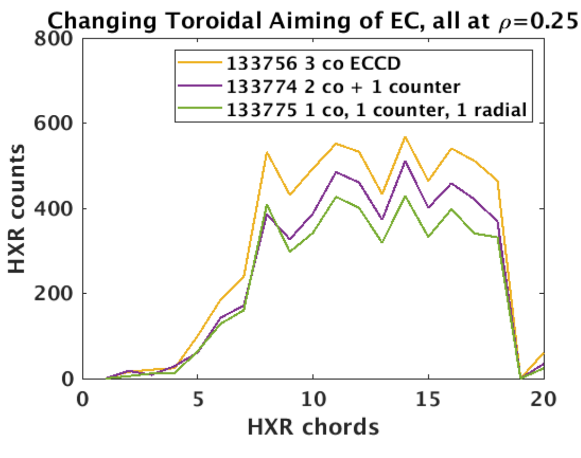

Figure 2: Reducing the number of co-Ip ECCD beams also reduced the LH absorption, as shown by HXR profiles.