IAEA FEC 2014

Contribution ID: **438** Type: **Oral**

Fast-Ion Response to Externally Applied 3D Magnetic Perturbations in ASDEX Upgrade H-Mode Plasmas

Tuesday 14 October 2014 08:30 (4 hours)

The fast-ion response to externally applied 3D Magnetic Perturbations (MPs) has been investigated on ASDEX Upgrade (AUG) in H-mode plasmas with a wide range of collisionalities / densities and MP spectra. MPs have little effect on kinetic profiles, including fast-ions, in high collisionality plasmas with mitigated ELMs while a strong plasma (including fast-ions) response is observed in H-mode regimes with low collisionality / density and low q95.
Multiple, absolutely calibrated, fast-ion loss detectors (FILDs) located at different toroidal and poloidal positions measure significant changes in escaping ion phase-space when MPs are applied. Fast-ion losses can be up to an order of magnitude larger with MPs than the nominal NBI prompt losses measured without MPs. The application of the 3D fields is followed by a rapid rise (within ms) of the associated fast-ion losses while the measured fast-ion losses exhibit a slow decay, ~100 ms, down to the nominal NBI prompt loss level, after the MP coils are switched off. The heat load associated to the MP induced fast-ion losses have been measured with infrared cameras imaging the divertor as well as FILD and the surrounding first wall. The measured heat load can be up to 6 times larger with MPs than without MPs. The impact the 3D fields have on the confined fast-ions have been monitored by means of Fast-Ion D-Alpha (FIDA) spectroscopy. FIDA measures an enhancement of the fast-ion content in plasma with a visible impact on the gradients of the fast-ion profiles when RMPs are applied and density pump-out is observed. A strong fast-ion response is typically accompanied by an apparent displacement of the outboard separatrix, 1-3 cm, as measured by Beam Emission Spectroscopy (BES) that modifies significantly the NBI deposition profile. The accurate fast-ion measurements presented here are used to test models of 3D fields using full orbit simulations. The perturbed equilibria are calculated in vacuum, using the 3D free boundary VMEC / NEMEC code as well as including the plasma response with the M3D-C1, MARS-F and JOREK codes.

Country or International Organisation

Spain

Paper Number

EX/P1-22

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Session Classification: Poster 1