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Experiments and Modelling on FTU Tokamak for EC Assisted Plasma Start-up Studies in ITER-like Configuration

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The intrinsic limited toroidal electric field (0.3 V/m for ITER) in devices with superconducting poloidal coils (ITER, JT-60SA, DEMO) requires an additional heating, like Electron Cyclotron (EC) waves, to initiate plasma current and to sustain it during the burn-through phase. The circular full metallic FTU tokamak, equipped with an ECRH system (140 GHz, 0.5 s, up to 1.6 MW), has contributed in the past to a wide documented study on the possible configuration and perspective of EC assisted plasma breakdown, performing experiments focused on low electric field start-up with perpendicular injection of EC power. Afterwards a new experimental and modelling activity, addressing the study of assisted plasma start-up in a configuration close to ITER one (magnetic field, wave oblique injection and polarization) realized on FTU, has been initiated and presented. These new experiments have been supported by a 0-D code, BKD0, developed to model the FTU plasma start-up and linked to a beam tracing code to computing, in a consistent way, EC absorption. The FTU results demonstrate the role of polarization conversion with oblique injection at the inner wall reflection, confirmed by a faster plasma current ramp up (from 3.5 to 8.6 MA/s), when the waves reflects on the inner vessel surface. This effect is related to the higher temperature reached as a result of the better power absorption of extraordinary polarized waves generated at reflection, guaranteeing a wider operational window in term of filling pressure and toroidal electric field. Dedicated experiments showed also the capability of EC power to sustain plasma start-up even in presence of strong vertical magnetic field (10mT), with a null outside the vacuum vessel. These results assume more and more importance considering that the first plasma in ITER will be likely obtained at half field (2.5 T), where the influence of stray field is doubled. The 0-D BKD0 code, developed and applied to FTU data to reproduce the ITER relevant configurations at half and full toroidal magnetic field, has been used to determine operational window of sustained breakdown as a function of toroidal electric field and filling pressure. Experimental results are in agreement with the BKD0 simulations, supporting the use of the code to predict start-up also in future tokamaks, like ITER and JT60SA.

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Author: Dr GRANUCCI, GUSTAVO (ISTITUTO DI FISICA DEL PLASMA - CNR)

Co-authors: SOZZI, Carlo (ISTITUTO DI FISICA DEL PLASMA - CNR); FARINA, Daniela (ISTITUTO DI FISICA DEL PLASMA - CNR); RICCI, Daria (ISTITUTO DI FISICA DEL PLASMA - CNR); ARTASERSE, Giovanni (ENEA-UTF); CALABRÒ, Giuseppe (ENEA UTF); RAMOGIDA, Giuseppe (ENEA UTF); FIGINI, Lorenzo (ISTITUTO DI

FISICA DEL PLASMA - CNR); CAVINATO, Mario (Fusion for Energy); TUDISCO, Onofrio (ENEA UTF); GARAVAGLIA, Saul (ISTITUTO DI FISICA DEL PLASMA - CNR); BIN, William (ISTITUTO DI FISICA DEL PLASMA - CNR); MORO, alessandro (ISTITUTO DI FISICA DEL PLASMA - CNR)

Presenter: Dr GRANUCCI, GUSTAVO (ISTITUTO DI FISICA DEL PLASMA - CNR)

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