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First insights into runaway electron (RE) damage induced to the JET divertor

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High energetic runaway electrons (REs) triggered due to plasma disruptions in tokamak reactors pose significant challenges due to their potential damage of the plasma-facing components (PFCs). Previous studies on the Joint European Torus (JET) device have highlighted the RE interaction with PFCs during an induced disruption, mainly on the beryllium (Be) main chamber components [1]. Due to the significant risks REs posed to the integrity of the PFCs and the overall functionality of the reactor, studies on REs in JET were limited in number, and mainly focused on the main chamber components, while RE-induced damage to the divertor were left unexplored – until now.

During the final operational days of JET, in December 2023, dedicated experimental sessions were conducted to investigate the impact of REs also on the divertor PFCs, including their triggering mechanisms, a deeper understanding of the physics behind these events and improved observation of the resulting damage. Artificially triggered REs using argon (Ar) massive gas injection (MGI) were controlled and pushed towards the divertor interacting with the apron of Tile 1. For the first time, this study presents evidence of RE effects in the JET divertor, the RE-induced damage to the tungsten-coated carbon fibre composite (W–CFC) tiles. High-resolution photography, performed in 2024, following the end of JET operations, offered a unique and detailed visual representation of the destruction. The photographic survey revealed that the damage is not toroidally uniform: in some regions, parts of the W coating on the inner divertor tiles (Tile 1) was entirely removed, while in others, the tiles appeared intact. This observation aligns with prior findings of non-uniformity of the RE-induced damage to the JET main wall, highlighting the localized nature of RE interactions with the main chamber PFCs [2].

To further characterize the damage, LID-QMS (Laser-Induced Desorption-Quadrupole Mass Spectrometry) was performed on one of the damaged tiles, focusing on fuel retention in both damaged and undamaged areas. Results revealed notable differences in fuel retention between these regions. LIBS (Laser-Induced Breakdown Spectroscopy) was also performed in similar regions to investigate the material composition of the damaged areas and their surroundings, providing complementary insights into the erosion and fuel removal mechanisms.

[1] I. Jepu Nucl. Fusion 64 (2024) 106047 (15pp)
[2] C. Reux et al Nucl. Fusion 55 093013 (2015)
*See the author list of Maggi, C. F., & JET Contributors (2024) Overview of T and D-T results in JET with ITER-like Wall Nuclear Fusion, 64 (112012) https://doi.org/10.1088/1741-4326/AD3E16