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First Demonstration of Laser Induced Breakdown Spectroscopy using Remote Handling for In-vessel Analysis of Tritiated and Activated JET Components

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The feasibility of laser-induced breakdown spectroscopy (LIBS) for measuring fuel retention was demonstrated for the first time in a tokamak operating with tritium using a remotely controlled in situ application in JET. In JET and future fusion reactors such as ITER and DEMO, thick co-deposited layers will be formed at the inner wall during extended plasma operations. Experiments in present-day fusion devices indicate that these layers consist of eroded plasma facing materials, various impurities and plasma fuel species like deuterium and tritium. Accumulation of radioactive tritium in the reactor vacuum vessel is a particularly critical safety issue requiring active monitoring. LIBS is one of the few techniques available for monitoring the tritium content and the composition of co-deposited layers during maintenance breaks [1]. This paper will provide an overview of the LIBS experiment that was performed post DTE3 campaign, and D and H cleanup at JET in October 2024.
Prior to the LIBS experiment at JET, preliminary test measurements were performed at VTT using the LIBS tool developed at ENEA and optimized by FZJ. The tool consisted of the LIBS enclosure equipped with a sub-nanosecond Nd:YAG laser and focusing optics, which was connected via a 20 m optical fibre to an Echelle type spectrometer with wide spectral range (260-760 nm. Samples, including from JET limiters and divertor, were characterised for calibration-free LIBS and for calibration of the ablation rate. The final setup of the JET LIBS tool consisted of a high resolution Littrow spectrometer for separation of the hydrogen isotopic lines, an Echelle spectrometer and photomultipliers. The LIBS enclosure was mounted onto the MASCOT robot which was remotely operated from a dedicated control room by the UKAEA remote handling team. During the LIBS experiment at JET ˜840 locations on the main wall and the divertor were analysed successfully. The high spatial accuracy of the MASCOT manipulator was also demonstrated by analysing single castellations on the limiter tiles. Validation of results will take place with future ex-situ LIBS measurements and post-mortem analysis on JET tiles.

[1] H.J. Van Der Meiden et al, Monitoring of tritium and impurities in the first wall of fusion devices using a LIBS based diagnostic, Nucl. Fusion. 61 (2021) 125001.