Observations of confined fast ions in MAST-U with the NCU

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Spherical tokamaks contribute to the design of future fusion reactors in several key areas such as divertor physics, neutral beam current drive and Fast Ion (FI) physics. MAST-U, which was design to address, among other objectives, these issues, has successfully concluded its first experimental campaign providing a wealth of new results. Thanks to its low magnetic field (< 1 T) and high energy (> 50 keV) of the NBI system, MAST-U is suitably poised to study the interaction of super-Alfvénic FIs with a wide range of MHD instabilities including global ones determined by the plasma equilibrium and scenarios such as sawteeth, NTMs and ELMs as well as broad categories of Alfvén instabilities such as TAEs, GAE and CAEs and of energetic particle modes such as fishbones. To further explore the role of the FI distribution function spatial gradient in driving these instabilities, MAST-U is equipped with two tangential NBI systems, one on the equatorial plane (on-axis) and one that is vertically shifted 65 cm above the equatorial plane (off-axis). In order to study the rich physics that was expected, and confirmed in the recent experimental campaign, several FI diagnostics were upgraded and new ones added. Among them, the prototype neutron camera [1] has been upgraded [2] to six sight-lines (all on the equatorial plane). The first observations of the confined FI behaviour in a wide range of plasma scenarios characterized by on-axis and/or off-axis heating and by sawteeth, fishbones and TAEs are presented here. Comparisons with fission chamber measurements are presented and the observed discrepancies discussed. Finally, clear evidence of different FI deposition profiles with off-axis NBI heating only compared to the on-axis only case are presented. In the former case, the neutron emissivity in the core is approximately hundred times smaller than in the latter and its radial profile is hollow, indicative of a regime characterized by high losses of fast ions. These initial results confirm the capabilities of the Neutron Camera Upgrade (NCU) and provide the opportunity, in combination with observations from other FI diagnostics and modeling, for a more constrained description of the FI dynamics in fusion reactor relevant scenarios.

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References

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