Validation of a new turbulence probe for MAST-U

W.G. Fuller [1,2], S. Allan [1], G. Decristoforo [3], B. Hnat [2], J. Omotani [1], P. Ryan [1], N.R. Walkden [1]

[1] *United Kingdom Atomic Energy Authority, Culham Centre for Fusion Energy, Oxon, UK*

[2] *Centre for Fusion, Space and Astrophysics, The University of Warwick, Coventry, UK*

[3] *Dept. of Physics and Technology, UiT The Arctic University of Norway, Tromsø, Norway*

MAST-U's 1st experimental campaign demonstrated a reduced heat flux to divertor surfaces by a factor of 10 [1] due to the super-X divertor. There is a need to characterise the relationship between alternate divertor geometries and the subsequent transport fluxes present in the Scrape-Off Layer (SOL). It is known that turbulence plays a key role in the SOL. In recent years new experimental techniques have been developed to better characterise the SOL, like fast sweeping Ball-Pen probes to obtain T_i measurements [2]. This work presents a new Langmuir probe array mounted on a reciprocating probe system specifically designed to measure properties of turbulence in SOL of MAST-U. The new probe design includes: Two Ball-Pen probes (BPP) in close proximity to regular probes allowing direct measurement of T_i, Φ_{plasma}, E_r, and $q_{\|}$; A 5-pin balanced triple probe array[4], allowing real-time measurements of both T_e and n_e and, when combined with poloidal electric field measurements from the BPP array, estimates of particle and heat transport fluxes; Logarithmically spaced probes to increase scale resolution for the detection of various turbulence modes and structures, and; An array consisting of three poloidally spaced probes with one probe radially offset to estimate poloidal and radial velocity distributions for plasma filaments. Prior to operation, this versatile probe design has been validated using a synthetic representation of the probe array in a variety of turbulence models, including a 2D Hasegawa-Wakatani drift wave model, a 2D stochastic filament model and the STORM2D interchange turbulence slab model in BOUT++. The simulation quantities taken at the probe positions were converted into relevant probe signals using probe equations from [2, 3, 4]. This paper will report on the results of this synthetic probe validation exercise, alongside plans for initial testing and exploitation in the upcoming MAST-U 2nd experimental campaign.

References

[1] J. R. Harrison, T. Farley, G. M. Fishpool, A. Kirk, B. Lipschultz, J. Lovell, F. Militello, D. Moulton, P. Ryan, R. Scannell, A. J. Thornton, K. Verhaegh, L. Xiang, Phys. Rev. Lett, [Preprint], (2022).

[2] J. Adamek, D. Cipciar, A. Devitre, J. Horacek, J. Cavalier, M. Komm, J. Krbec, M. Tich4, D. Trunec, P. Böhm, R. Panek and the COMPASS team, Nucl. Fusion, **61**, 036023, (2021).

[3] I. H. Hutchinson, Principles of plasma diagnostics, 2. ed. Cambridge: Cambridge University Press, (2002).

[4] H. Y. W. Tsui, R. D. Bengtson, G. X. Li, H. Lin, M. Meier, Ch. P. Ritz, and A. J. Wootton, Review of Scientific Instruments, **63**, 4608, (1992).