A high-k mm-wave scattering diagnostic for measuring poloidal wavenumber electron scale turbulence on MAST-U

D. C. Speirs[1], A. D. R. Phelps[1], V. H. Hall-Chen[2,3], A. R. Field[3], R. G. L. Vann[4], K. Ronald[1]

[1] *Department of Physics, SUPA, University of Strathclyde, Glasgow, G4 0NG, Scotland, U.K.*

[2] *Rudolf Peierls Centre for Theoretical Physics, University of Oxford, Oxford OX1 3NP, U.K.*

[3] *CCFE, Culham Science Centre, Abingdon OX14 3DB, U.K.*

[4] *York Plasma Institute, Department of Physics, University of York, Heslington, York, YO10 5DD, U.K.*

Plasma turbulence plays a key, governing role on determining the spatial-temporal evolution of plasmas in astrophysical, geophysical and laboratory contexts. In particular, turbulence on disparate spatial and temporal scales limits the level of confinement achievable in magnetic confinement fusion experiments and therefore limits the viability of sustainable fusion power [1]. The TDoTP project (Turbulent Dynamics of Tokamak Plasmas) is a multi-institutional programme grant awarded by the EPSRC (EP/R034737/1). Its objective is to advance understanding of multi-scale turbulence at a fundamental level in tokamaks. As part of this effort, a mm-wave based scattering diagnostic has been designed for the MAST-U spherical tokamak, to measure poloidal oriented high-k (electron scale) turbulence in the core plasma. We present the results of Gaussian wave optics and beam-tracing calculations [2] that demonstrate the predicted spatial and wavenumber resolution of the diagnostic, as well as estimates for the sensitivity of measurement. Current specifications for the diagnostic include an operating frequency of 260GHz, a turbulence wavenumber measurement range of $k_\perp \rho_e$ = 0.1 -> 0.5 (where $k_\perp$ is the poloidal turbulence wavenumber and ρ_e the electron gyroradius) and a minimum spatial localisation of ~3cm along the primary beam path.

[1] Wilson H., Phil. Trans. R. Soc. A., "The impact of plasma physics on the timescale to a tokamak fusion power plant" 377, 20170435 (2019),

[2] V. H. Chen, F. Parra and J. Hillesheim, 62nd Annual Meeting of the APS Division of Plasma Physics, PP12.00011 (2020).