Designing a Midplane Turbulence Probe for MAST-U.

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Motivation

Investigate how the Super-X and other alternative divertor configurations impact the dynamics of the scrape-off layer (SOL).

- Key phenomena born from turbulence vital in understanding SOL for longevity of reactors.
- Reciprocating Probe (RP) produces radial profiles of V_{float}, I_{sat}, and E_θ in the SOL.
- Existing diagnostics not designed for a variety of turbulent features.

Synthetic approach devised to target specific turbulent features such as:

- Filament transport.
- Plasma multi-point fluctuation statistics.
- Fluctuations over a range of length scales.

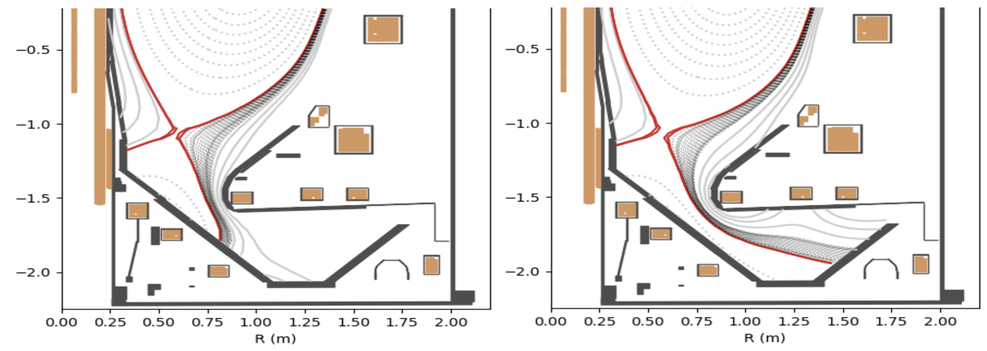

Figure 1: Conventional and Super-X Divertor (CD/SXD) Configurations for MAST-U.

1) Design

Included these features to allow a variety of turbulence measurements.

- Logarithmic-spaced array.
- 5-pin balanced triple probe array.
- Ball-pen probes.
- Linear array.
- Mach probes.
- internal noise pickup probe.
- internal 3-axis B-field sensor.

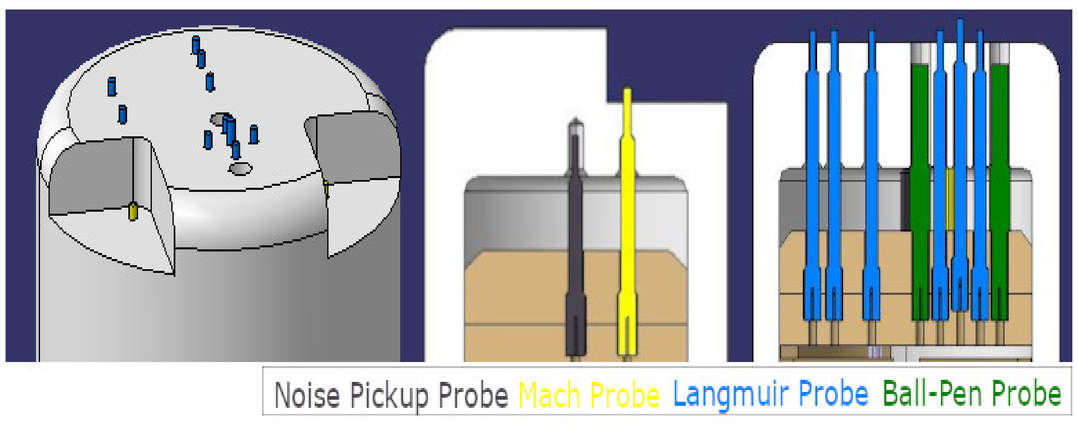

Figure 2: 3D CAD model of the Turbulence Probe.

2) Models

Used a variety of models to iterate the design through.

- Drift-wave Hasegawa-Wakatani model
- Modified Stochastic Filament model [1–3]
- BOUT++ module STORM2D [4–8]

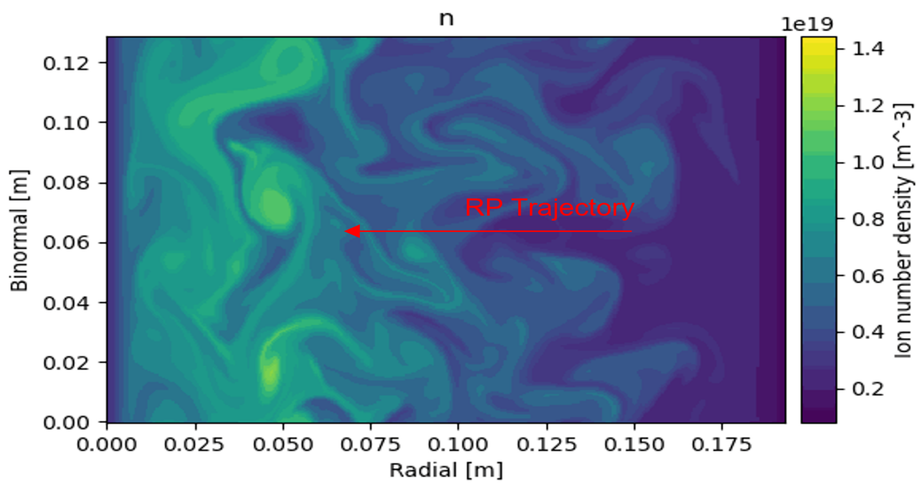

Figure 3: STORM2D radial-binormal slab.

We compare the models with recent experimental data using an existing probe. For ease in comparison we normalised the data using z-score normalisation. A common measurement that can be made in some models is the poloidal electric field.

$$E_{\theta_{1,2}} = k_{\theta_{1,2}}(V_{f_1} - V_{f_2}) \quad \text{Where;} \quad k_{\theta_{1,2}} = \frac{2\pi}{d_{\theta_{1,2}}}, \quad E'_\theta = \frac{E_\theta - \bar{E_\theta}}{\sigma_{E_\theta}}$$

3) Results

STORM2D simulation was setup with parameters of a typical MAST-U CD, shot 47124. A 750kA ohmic heated CD scenario with $n_e \approx 15 - 20 \times 10^{19} m^{-2}$.

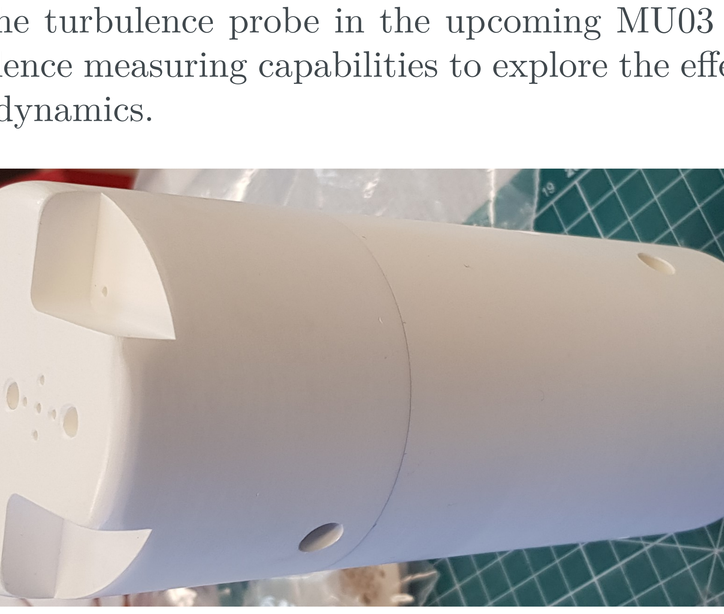

Figure 4: MAST-U RP data of E'_θ vs $r - r_{sep}$ for shot 47124, and the STORM2D simulation of a synthetic Mach probe. Note all the signals have been normalised.

4) Future Work

Commission the turbulence probe in the upcoming MU03 campaign, exploit its turbulence measuring capabilities to explore the effects of CD and SXD on SOL dynamics.

Figure 5: Test fit of components for the Turbulence Probe.

References and Acknowledgements

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