‘Rail’ Probe Design

- Traditionally, Langmuir probes embedded in the divertor are designed to have large field line collection area (≥ 0.1°) to minimize the effects of sheath expansion [1,2,3].
- Under the high-flux divertor conditions in ITER and future reactors will have actively cooled high-field magnetostatic probes regularly matrixed into the divertor heat sinks at the engineering limits of heat extraction. These probes will not be a reliable diagnostic.

- Under high-flux, flush mounted electrodes appear to be the only viable option for fixed divertor probes and have been extensively studied [1,3,4,5].
- However, the main barrier to their implementation is sheath expansion and angle dependence. These probes have been made in model test with little to moderate success [3-4].

‘Rail’ probes were installed for the first time in the Alcator C-Mod divertor.

Questions to be answered

- Was sheath expansion mitigated down to incident field angles ≤ 0.5°?
- How do the models compare to the standard proud probe geometry?
- How do these results fit with our current understanding of divertor physics?
- How do the ‘rail’ probes perform in the ‘death-ray’ regime?
- Does a method exist for the reliable interpretation and/or implementation of flush mounted probes?

Sheath expansion mitigated down to incident field angles ≤ 0.5°.

Scan of diverter target regime reveal differences in probe response

- A series of experiments were conducted where the plasma density was varied from 0.8 × 10^{20} m−3 to 5.4 × 10^{20} m−3 which translated to a scan of divertor collisionality.
- Figures shows the trends in the measured electron probe current signals (Vs) due to an atomic error in the magnetic wall resistance correction which was close to but not always at 90° injection.
- The probe target angle affects ‘rail’ probe response. The proud probe measurements are characteristic of the scrape-off layer physics while the ‘rail’ probe appear to be less unstable but still an effect as demonstrated in Figure 4.

‘Rail’ probe divertor geometrical effect of sheath expansion on the Langmuir probe projected area (ΔA ≈ 0.5 × 0.64 mm2).

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‘Rail’ probe geometrical effect of sheath expansion on the Langmuir probe projected area (ΔA ≈ 0.5 × 0.64 mm2) (Figure 3).

Simple exponential analysis yields discrepancy between ‘rail’ and proud probes.

- The proud probe measurements are bunched in all regimes except during the divertor collisionality [3,4,5].
- The proud probe measurements are characteristic of the scrape-off layer physics while the ‘rail’ probe appear to be less unstable but still an effect as demonstrated in Figure 4.

Open questions

- Can current ‘death-ray’ models replicate the differences associated with probe geometry?
- Were the differences that are being observed in the ‘death-ray’ regime explained by the probe field line traversal of divertor detachment near the strike point [2,10,11].
- Can current ‘death-ray’ models replicate the differences associated with probe geometry?

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