Profile Reflectometer

n_e profiles and plasma position: multi-band swept-frequency measurement, physics-informed real-time reconstruction.

NEXT STEP FUSION

WHAT IT IS

A profile reflectometer sweeps a microwave beam in frequency; each frequency reflects at its cutoff, set by density and magnetic field, and its delay locates it: one sweep, one density profile. Non-perturbative, no in-vessel calibration targets, no large ports, no fragile optics. In dense, high-field next-gen MCF devices and future FPPs the beam is absorbed at the electron cyclotron resonance before the plasma core. We measure the gradient region and reconstruct the rest in real time.

WHAT YOU GET

- Multi-band, dual-polarization probing, bands chosen for your field and density: 18–75 GHz in the prototype, higher for FPPs
- Full-band sweep in ~20 µs in the prototype, with agile sources and IQ detection, robust at low signal-to-noise
- Resolution set by antenna and frequency, ~0.5 cm in the prototype; fast sweeps track ELM crashes and pellets
- Physics-informed reconstruction of the full profile in real time where density and field block the core
- Delivered as a standalone system or as part of our integrated Modular Diagnostics Platform solution

HOW IT WORKS

We derive the frequency plan, polarizations, and antennas from your field and density, and engineer systems for your port geometry, with our synthetic diagnostics and design tools (SynthDia, TRAVIS, others). All bands share one waveguide line and port: fewer penetrations in shielding and blanket. Physics-informed neural networks constrained by transport physics fill the core from the measured gradient, with uncertainties.

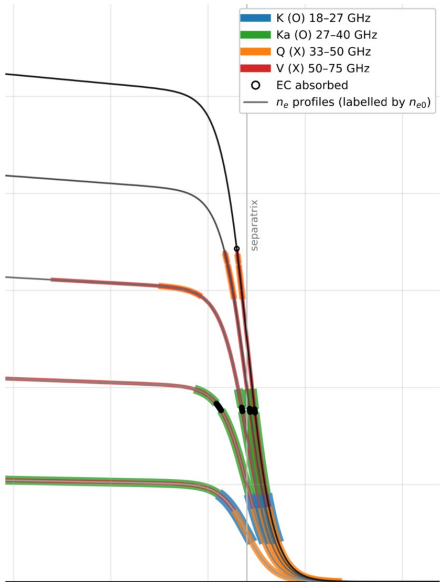


Fig. 1. Probed part of the n_e profile at the DIII-D edge, 1.9 T, for five central densities from 1 to 5 × 10^{19} m^{-3}: the colored segments are what the K, Ka (O-mode), Q, and V (X-mode) bands measure, the circles mark where the beam is absorbed at the electron cyclotron resonance. At low density the O-mode bands reach past the pedestal top; as density rises the X-mode bands take over and the probed region narrows toward the separatrix. The gradient region is covered; the core is reconstructed.

PROOF

Our team has reflectometry experience from JET, WEST, DIII-D, ASDEX Upgrade, and ITER. We are developing a prototype profile reflectometer and ECE radiometer, to be tested on TCV in early 2027 and on DIII-D in spring 2027, with Versatile Integrated Data Acquisition software and physics-informed neural networks for real-time n_e and T_e reconstruction. The prototype passed its DIII-D Physics Validation Review in 2026. Confinement-state classification with a profile reflectometer for FPPs is published in Nuclear Fusion with UC San Diego and UCLA.

Our mission is to accelerate fusion companies by bridging world-class science with deployable, industry-ready solutions.

Next Step Fusion is a specialized fusion supply chain company, founded in 2023, with its HQ in Luxembourg, a UK office, and a distributed team across Europe.

MADE IN LUXEMBOURG

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