ECE Radiometer

Absolute T_e profiles: system-on-chip measurement, physics-informed real-time reconstruction.

NEXT STEP FUSION

WHAT IT IS

Electron cyclotron emission (ECE) radiometry is the key electron temperature diagnostic. Electrons gyrate in the magnetic field and emit at cyclotron harmonics; the field's distribution sets where each frequency is measured. It delivers absolute profiles: non-perturbative, no in-vessel calibration targets, reliable under field and neutrons. In dense, high-field next-gen MCF devices and future FPPs part of the profile is lost beyond the density cutoff and where harmonics overlap. We measure what is accessible and reconstruct the rest in real time.

WHAT YOU GET

- Absolute T_e profiles at a time resolution set by your task (100 µs in the prototype), standalone calibration
- On-chip backend: over 30 dB gain, 0.1 nW detectable power, 3.4 mm receiver chip, 120 channels per rack
- Chip family from 50 to 220 GHz for devices up to 6 T; radiation-hard GaN versions tested
- Physics-informed reconstruction of the full profile in real time where high field and density block ECE
- Delivered as a standalone system or as part of our integrated Modular Diagnostics Platform solution

HOW IT WORKS

We derive the frequency plan, channels, and antennas from your field and density, and engineer systems for your port geometry, with our synthetic diagnostics and design tools (SynthDia, TRAVIS, others). Where high fields and densities leave part of the profile unmeasurable, we are developing physics-informed neural networks to reconstruct it in real time.

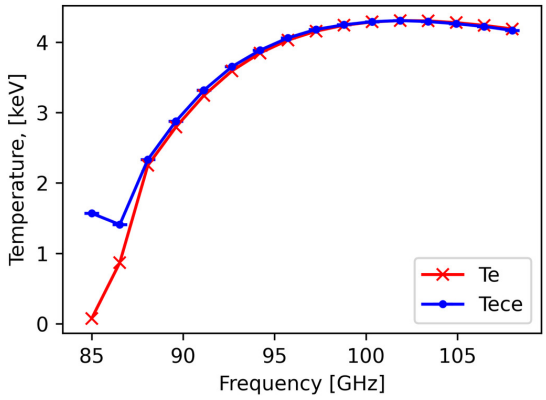


Fig. 1. Synthetic ECE validation for a DIII-D reference discharge (TRAVIS ray tracing): the simulated radiometer measurement (blue) reproduces the model electron temperature profile (red) over the 85–108 GHz band, 16 channels covering ρ = -0.15 to 0.88 at 2.0 T. The prototype measures full profiles on TCV; on DIII-D it measures partial profiles and tests physics-informed reconstruction of the rest.

PROOF

The on-chip backend by UC Davis runs the ECE imaging system on DIII-D, maintenance-free for seven years. We are developing a prototype ECE radiometer and profile reflectometer in one port-plug unit, to be tested on TCV in early 2027 and on DIII-D in spring 2027, including Versatile Integrated Data Acquisition software and physics-informed neural networks for real-time T_e and n_e profile reconstruction. The prototype passed its DIII-D Physics Validation Review in 2026, and the concept was presented at the International Reflectometry Workshop and the International Conference on Frontiers in Diagnostic Technologies.

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

Next Step Fusion S.à r.l. · 33 Rue du Puits Romain, L-8070 Bertrange, Luxembourg
info@nextfusion.org · nextfusion.org