WPSA | 2025 Progress Meeting

SA-EN.IM.09-T002
EC Stray Detection system design and procurement

Saul Garavaglia, Alex Bruschi, Francesco Fanale, Hans Oosterbeek, Jonas Zimmermann

This work has been carried out within the framework of the EUROfusion Consortium, funded by the European Union via the Euratom Research and Training Programme (Grant Agreement No 101052200 — EUROfusion). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the European Commission can be held responsible for them.

Task 2025

- Development of the prototype
- Tests on prototype and system performances qualification
- Development of data acquisition system requirements
- Implementation plan, including assembly and installation issues
- Investigation on fast sensors

Introduction

Purpose: Integrate an EC stray radiation sensor in JT-60SA, adapting the ITER design.

Key component: ceramic coating layer optimized for the JT-60SA EC frequencies (82,110, 138 GHz).

Function: Frequency-independent monitoring of microwave stray radiation via surface power density levels [W/m^2].

Measurement Principle: Incident surface power density derived from bolometer temperature increase.

2024: Characterized ceramic coatings; studied two materials to determine complex dielectric constants using low-power measurements.

2025 Progress: Studied and selected optimal coating thicknesses for JT-60SA frequencies based on 2024 data.

2024 measurements

Incidence Angle Study: Low-power measurements using VNA taken at 25°–65°, for both TE and TM polarizations.

Frequency Ranges: W-band (63–112 GHz) and G-band (136–220 GHz) covered.

Data Analysis: Model fitting for real and imaginary parts of dielectric constant.

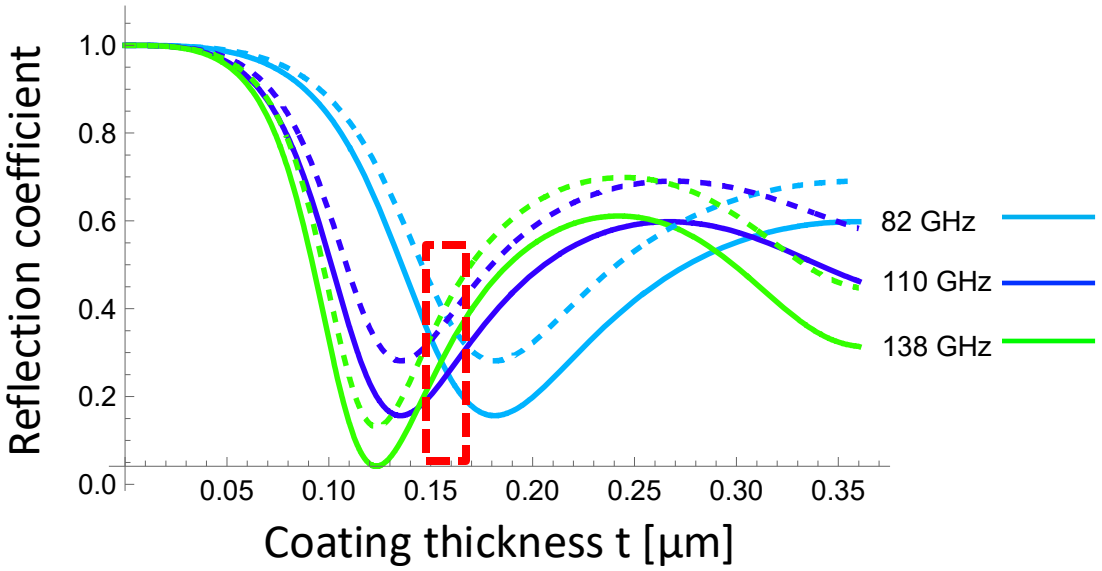
Materials: Al_2O_3-TiO_2 Cr_2O_3

Coating Thickness: Samples ranged from 30 µm to 250 µm.

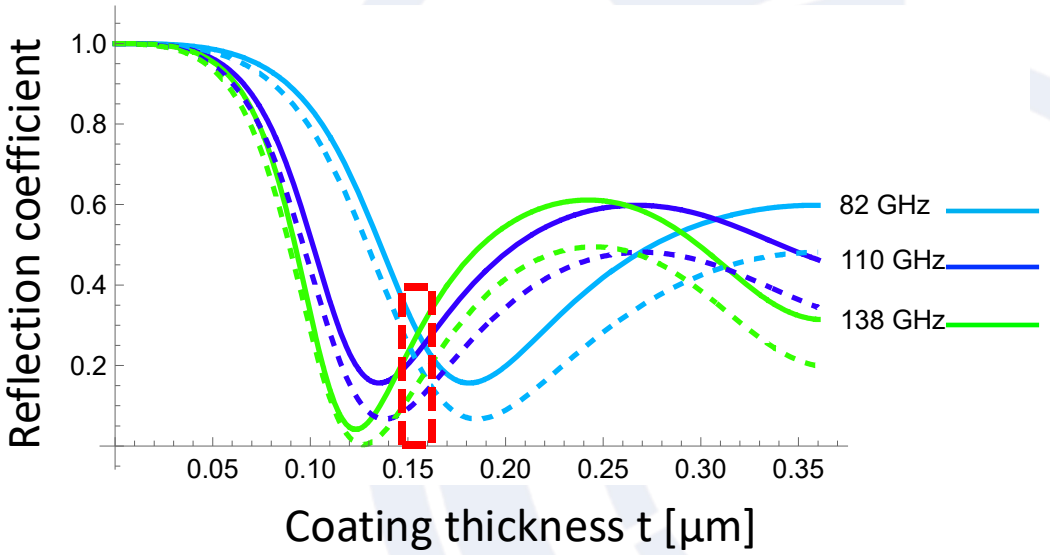
For both materials and frequency ranges: best-fit values for the dielectric constant were identified.

2025 activities - coating thickness study: Al_2O_3-TiO_2

Polarization perpendicular to the incidence plane.



Polarization parallel to the incidence plane.

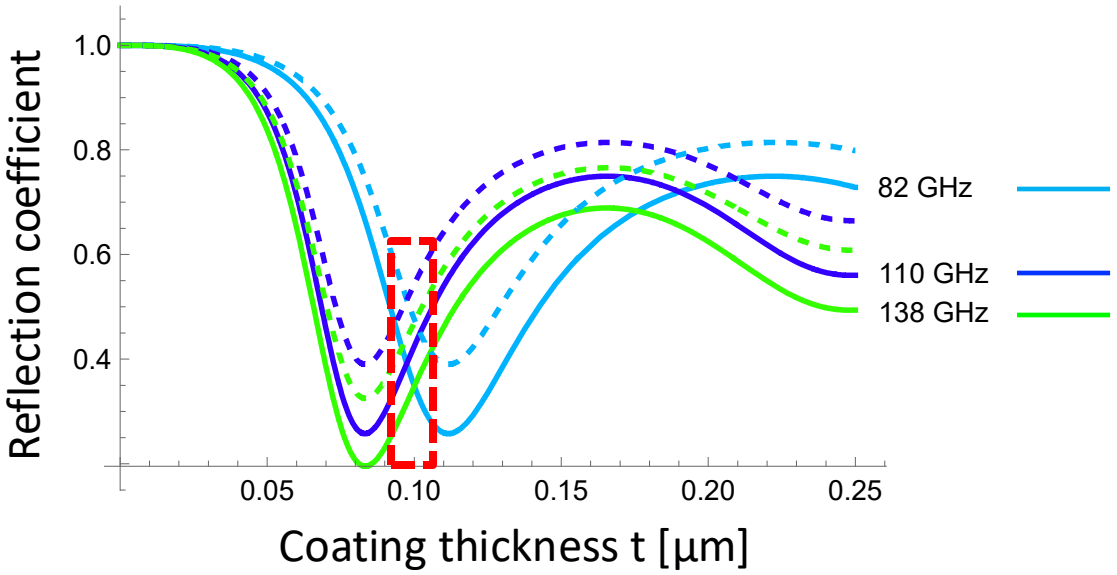


The two curves for each frequency correspond to perpendicular (solid line) and 45° (dashed line) incidence

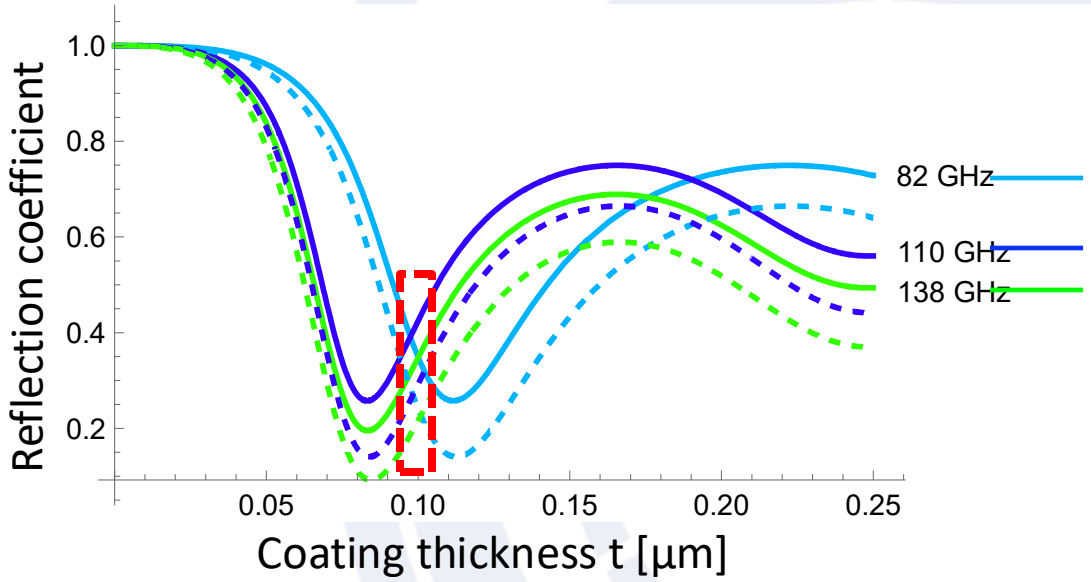
- Good absorption at all frequencies for both incident polarizations at t~ 155 µm
- Absorption coefficient from 60% to 90% is foreseen at all frequencies
- Single frequency max absorption for 82 GHz (t~180 µm) and 110-138 GHz (t~130 µm)

2025 activities - coating thickness study: Cr_2O_3

Polarization perpendicular to the incidence plane.



Polarization parallel to the incidence plane.



The two curves for each frequency correspond to perpendicular (solid line) and 45° (dashed line) incidence

- Good absorption at all frequencies for both incident polarizations at t~ 100 µm
- Absorption coefficient from 45% to 80% is foreseen at all frequencies
- Single frequency max absorption for 82 GHz (t~110 µm) and 110-138 GHz (t~80-85 µm)

2025 activities - coating thickness study: summary

Best Material > Al_2O_3–TiO_2 coating (155 µm) offers 60–90% absorption for radiation up to 45° incidence, any polarization.

Less Effective > Cr_2O_3 lower absorption.

Limitations Not Yet Considered:
-Exact material composition and spray method (TiO_2/Al_2O_3 ratio must be controlled for reproducibility).

-Thermal stability: Al_2O_3–TiO_2 may degrade at very high temperatures.

Joint development

- Established a joint development line for a stray radiation sensors among WPSA-F4E-DTT
- Application to JT-60SA (110-138 GHz), ITER & DTT (170GHz)
- Development and testing of prototypes suitable for the different machines.
- Define materials/thicknesses.
- Optimize electronics to reduce response time.
- Characterization tests on **Mistral** (>2026) and **Falcon** (TBD)

Workplane

- Types of sensors to be developed (both for JT-60SA and DTT):
  - 1 coated copper bolometer
  - 1 uncoated copper bolometer
  - 1 sniffer

Bolometer:

- Production: body + coated surface.
- Define materials/thicknesses.
- Optimize electronics to reduce response time.
- Characterization tests on **Mistral** (>2026) and **Falcon** (TBD).

Sniffer:

- W7-X model with Schroeder (or equivalent) diffuser.