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Influence Of Temperature On The Dielectric Properties Of Unburnt Carbon In Ash From Stoker Furnace Bottom Ash

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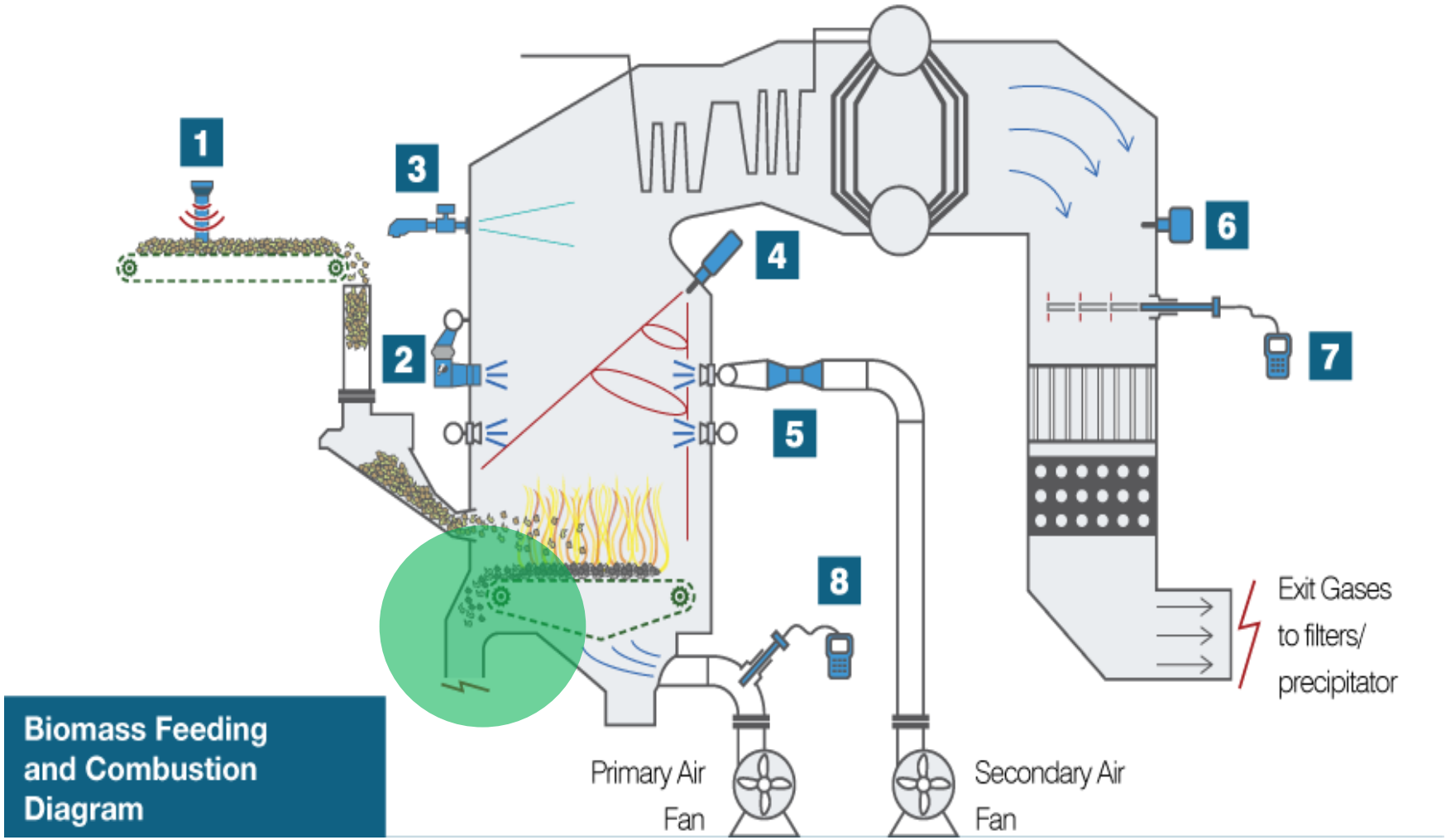
Sugar Mill Stoker Furnace



Stoker furnace with an over-grid feeding system

Source: ValveExport

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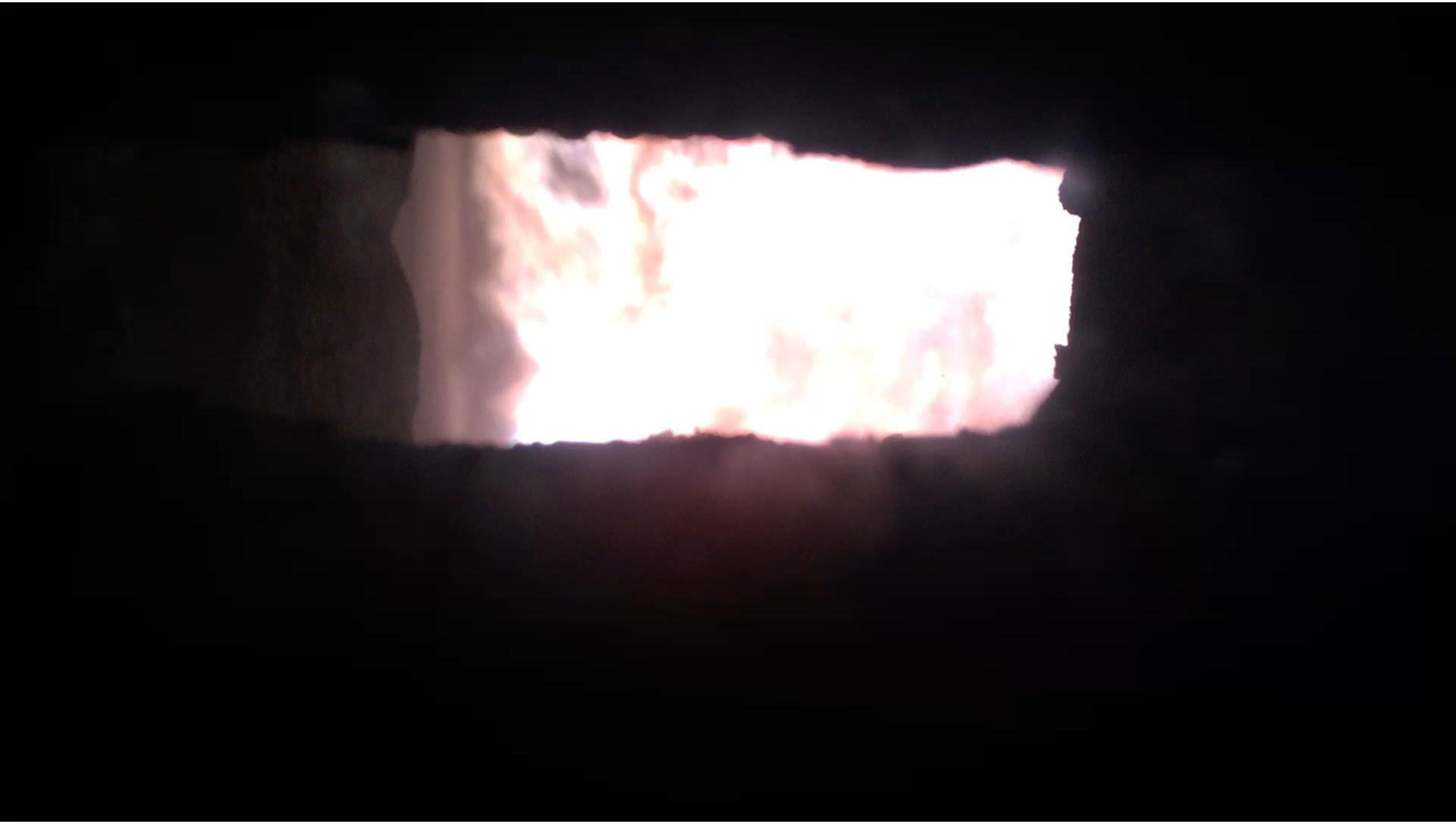
Inside the Furnace



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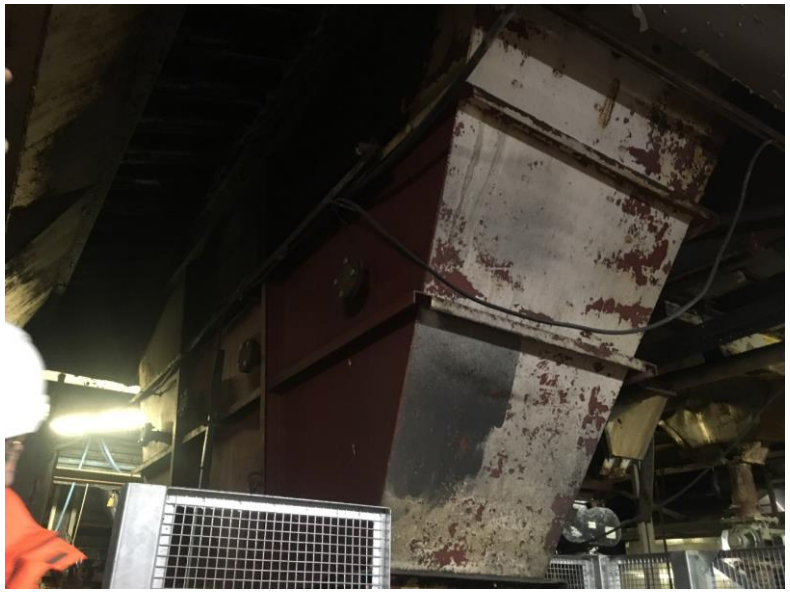
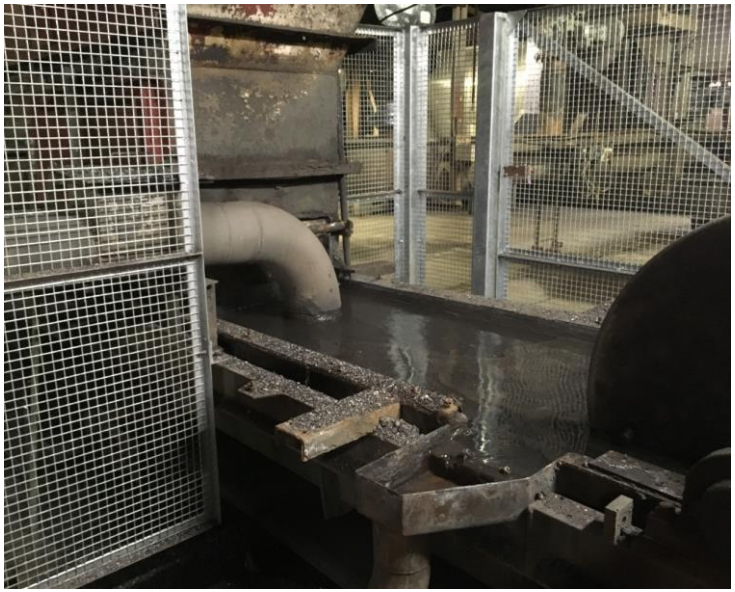
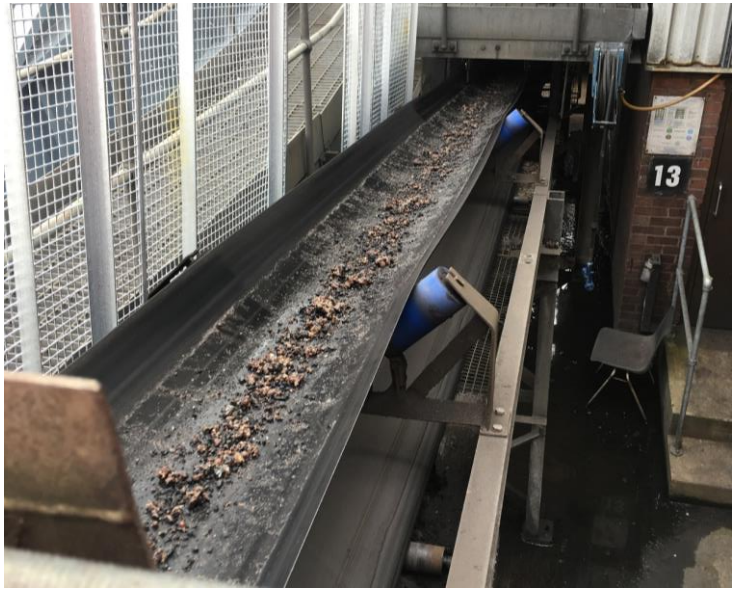
Stoker Furnace – Carbon in Ash Problem







Dielectric Sensoring of Carbon in Ash

Aim: Gain an understanding of how dielectrics carbon in ash vary with carbon content, mineral composition and temperature

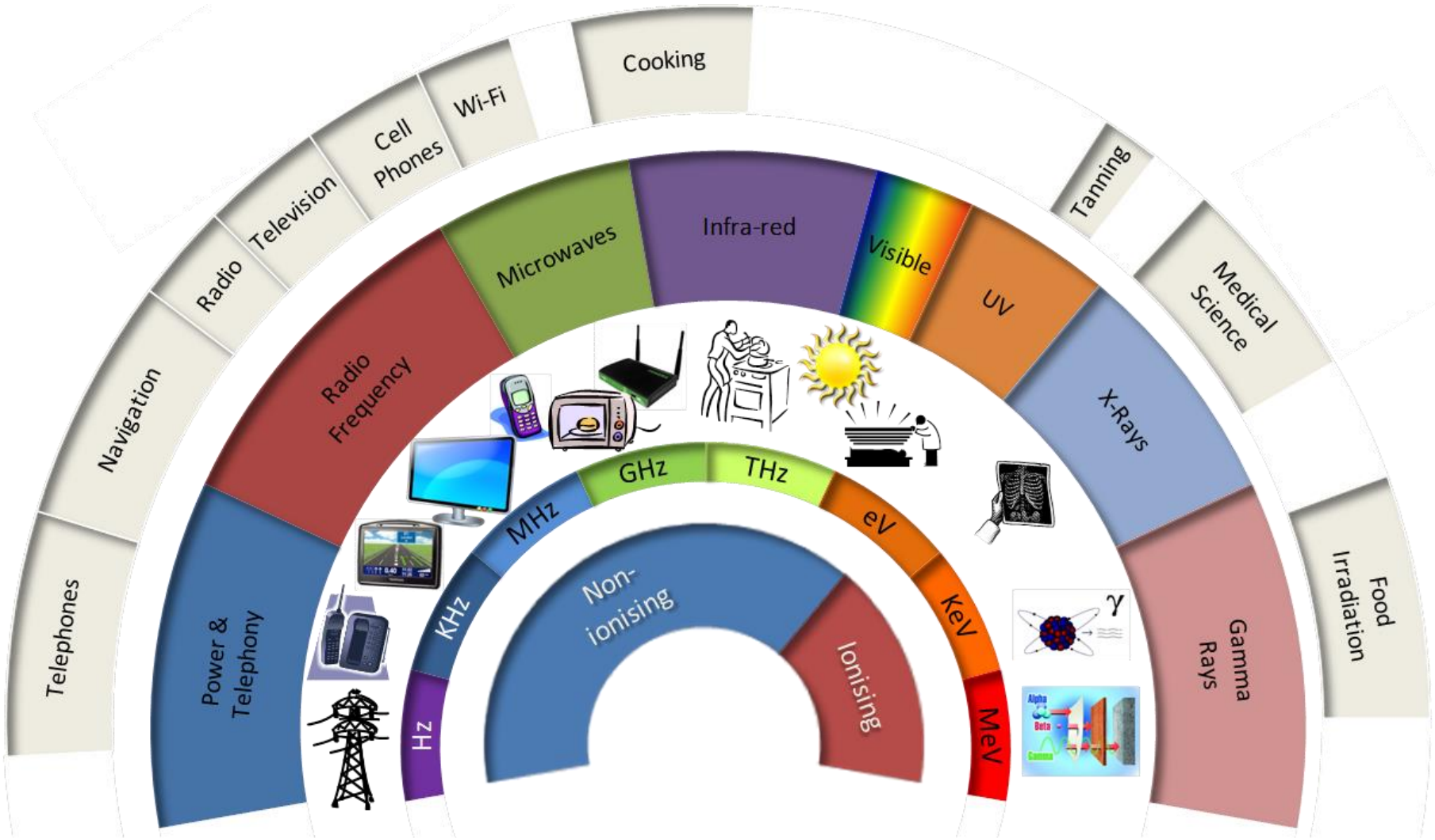
Objective: Develop methodology of measuring carbon in ash in real time using dielectric properties

Experiment:

- Tested 3 industrial ashes and several minerals with varying carbon contents different cavities to ascertain dielectric properties at different carbon contents

- Tested 3 industrial ashes at high temperatures to see how dielectric properties vary with temperature

The Electromagnetic Spectrum



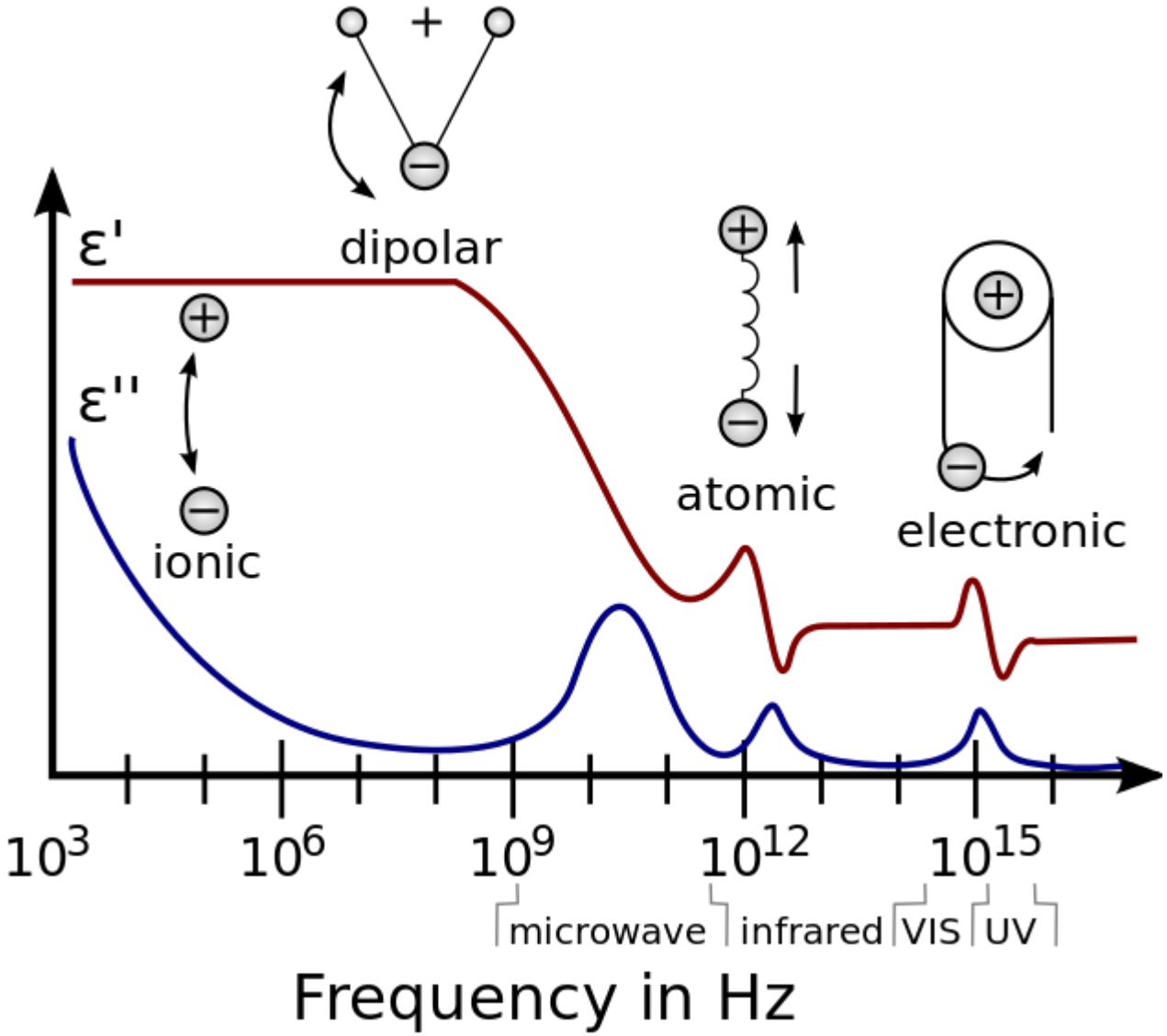
Dielectric Properties

- All materials interact with materials under the influence of a electromagnetic field.
- The electrical interaction of materials is described by its permittivity
- The absolute complex permittivity (ε) of a material is :

$$\varepsilon = \varepsilon' - j\varepsilon''$$

- Where ε’ is the dielectric constant and ε’’ is the dielectric loss factor.
- ε’ describes a materials ability to absorb electrical energy, while ε’’ is a materials ability to reject this energy as heat

Dielectric Properties at Different Frequencies



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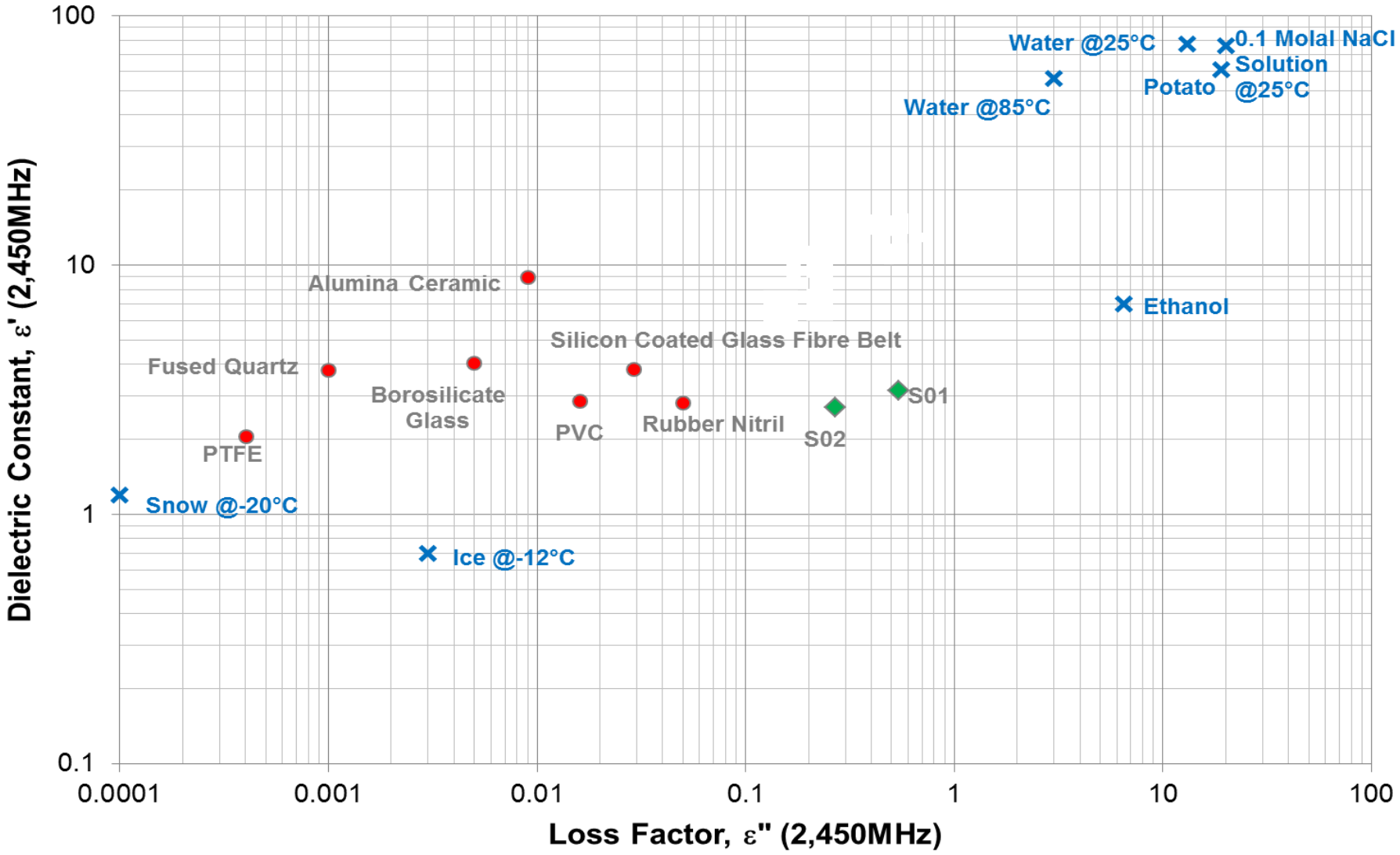
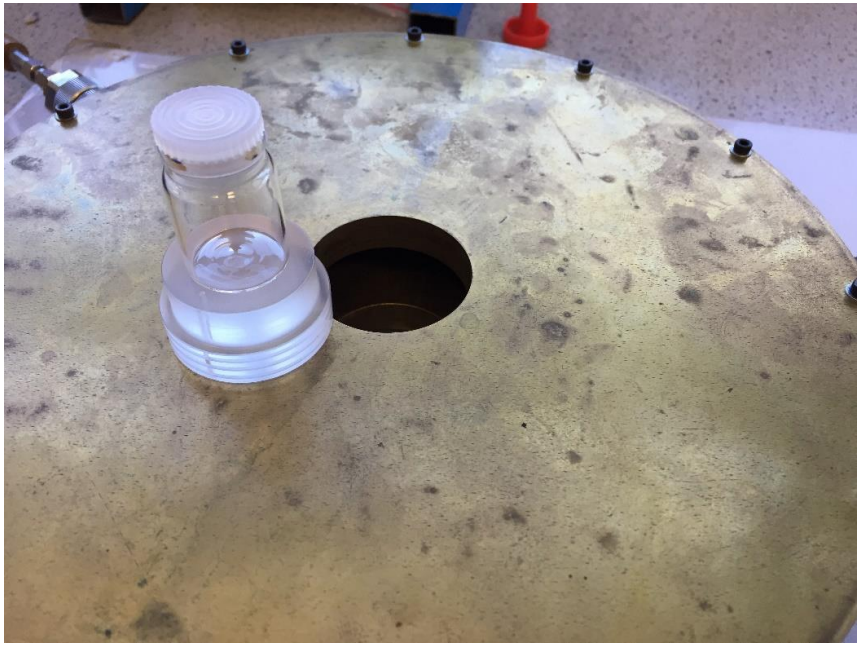
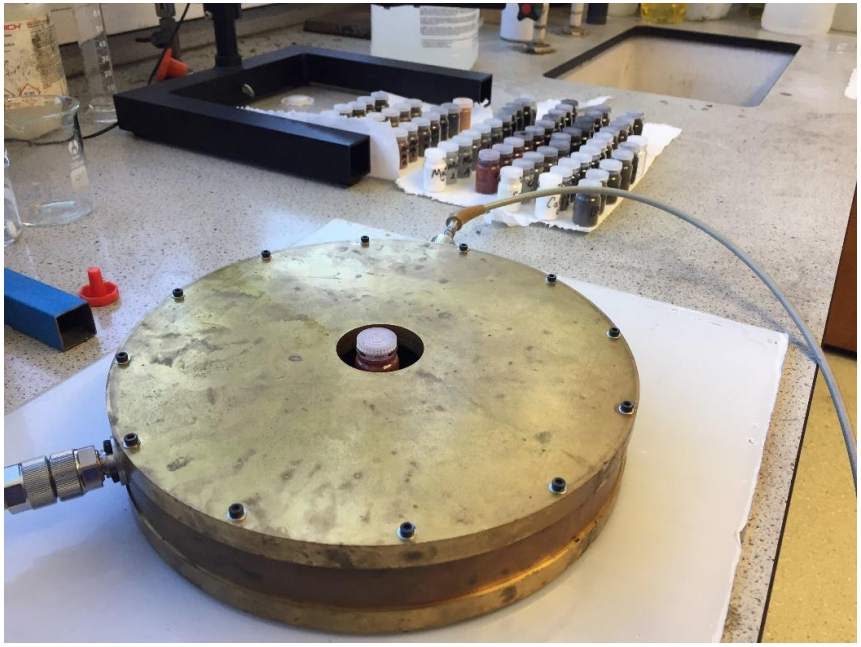
Dielectric Properties of Common Materials at 2.45 GHz



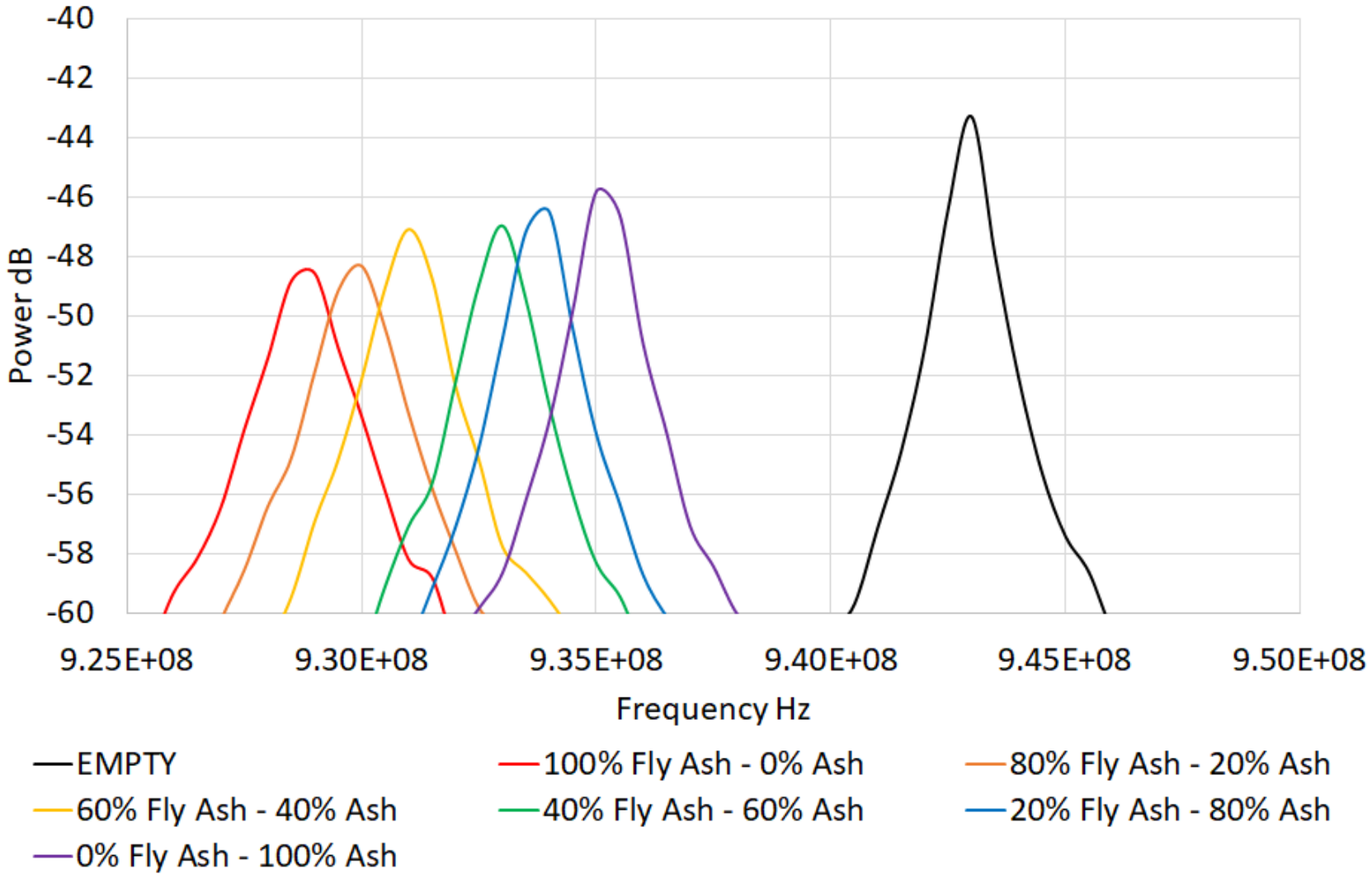
Cavity 1 – Proof of Concept

- Copper cavity connected to network analyser
- 5 different frequencies between 937 MHz and 5.6 GHz tested
- 3 industrial ashes and 4 minerals tested with varying carbon contents (by weight)
- Carbon contents: Fly Ash 1 - 2.2%, Fly Ash 2 – 10%, Fly Ash 3 – 6.6%





Cavity 1 – 937 MHz – Fly Ash 1



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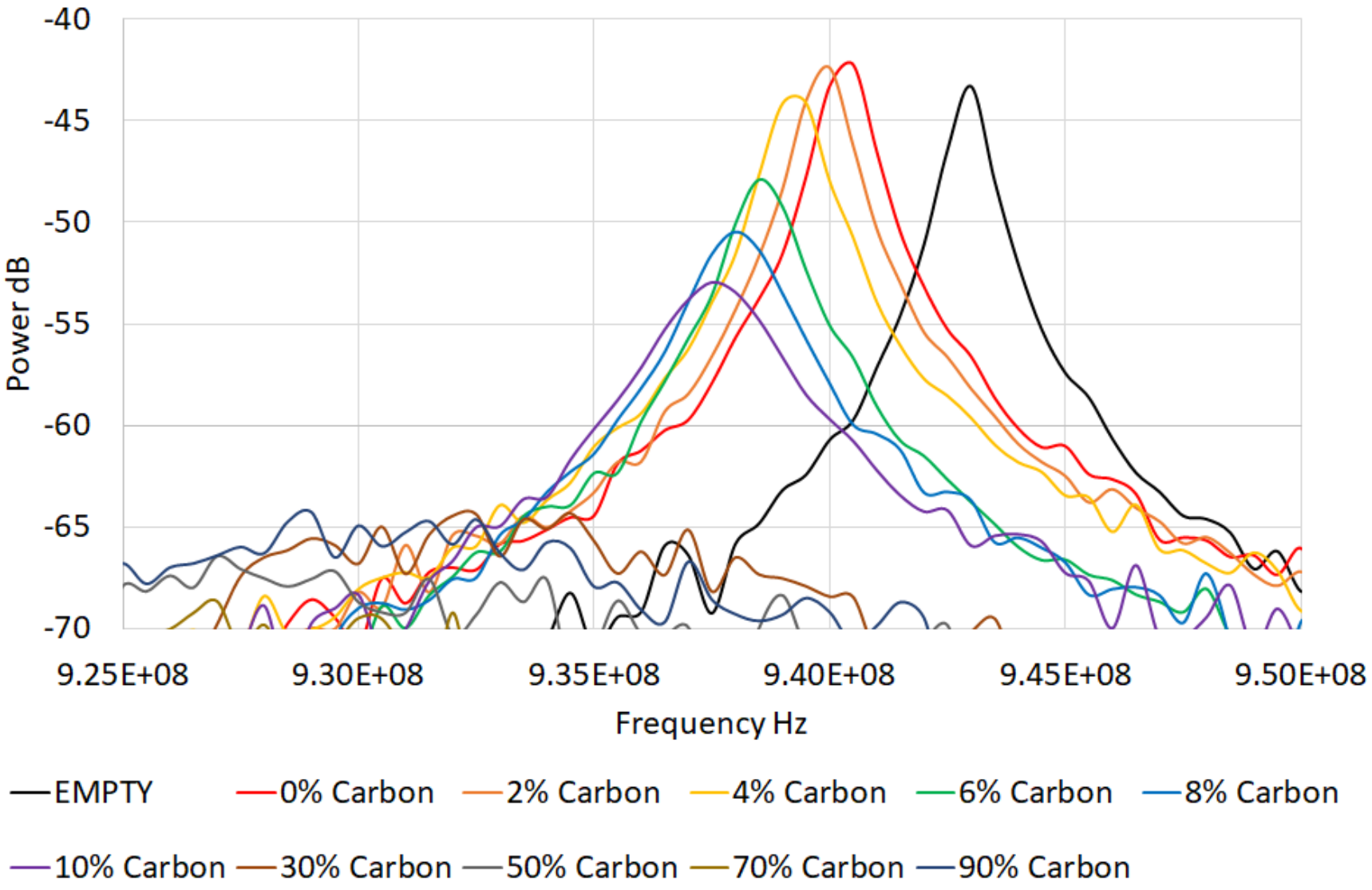
Cavity 1 – 937 MHz – Minerals – Calcium Carbonate



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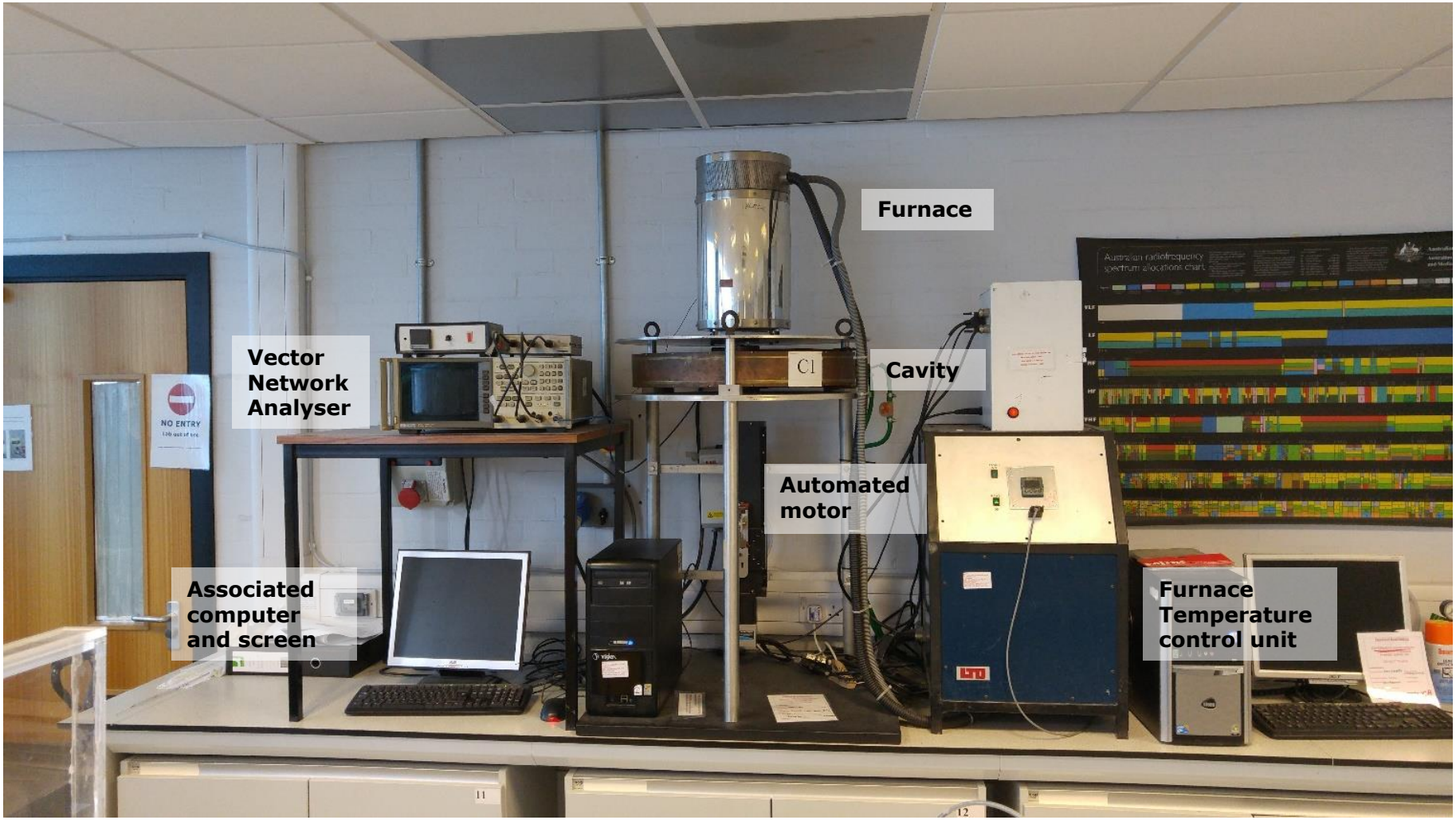
Cavity 2 – Cavity Perturbation Technique



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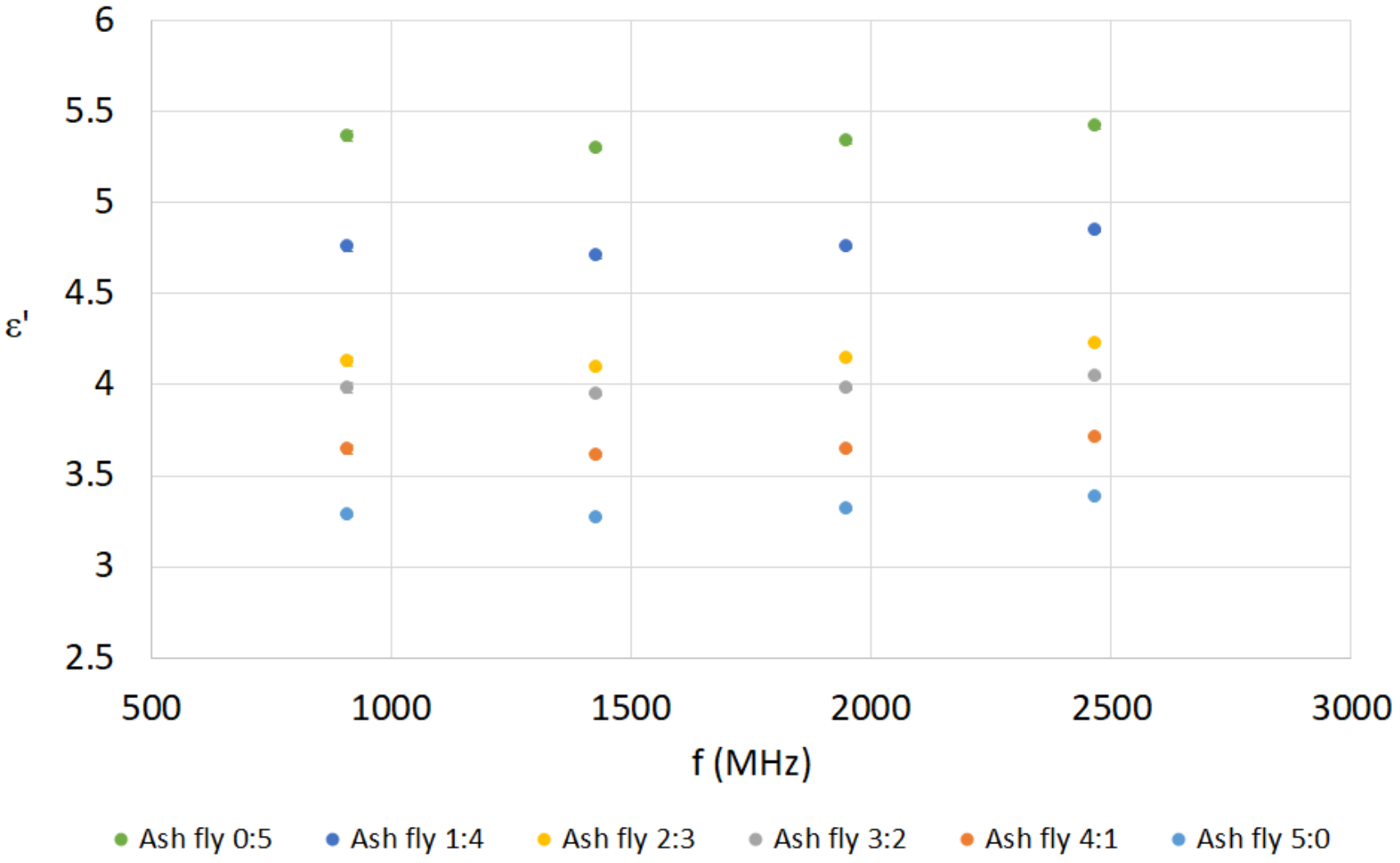
Dielectric Constant of Fly Ash 1 with Varying Carbon Content



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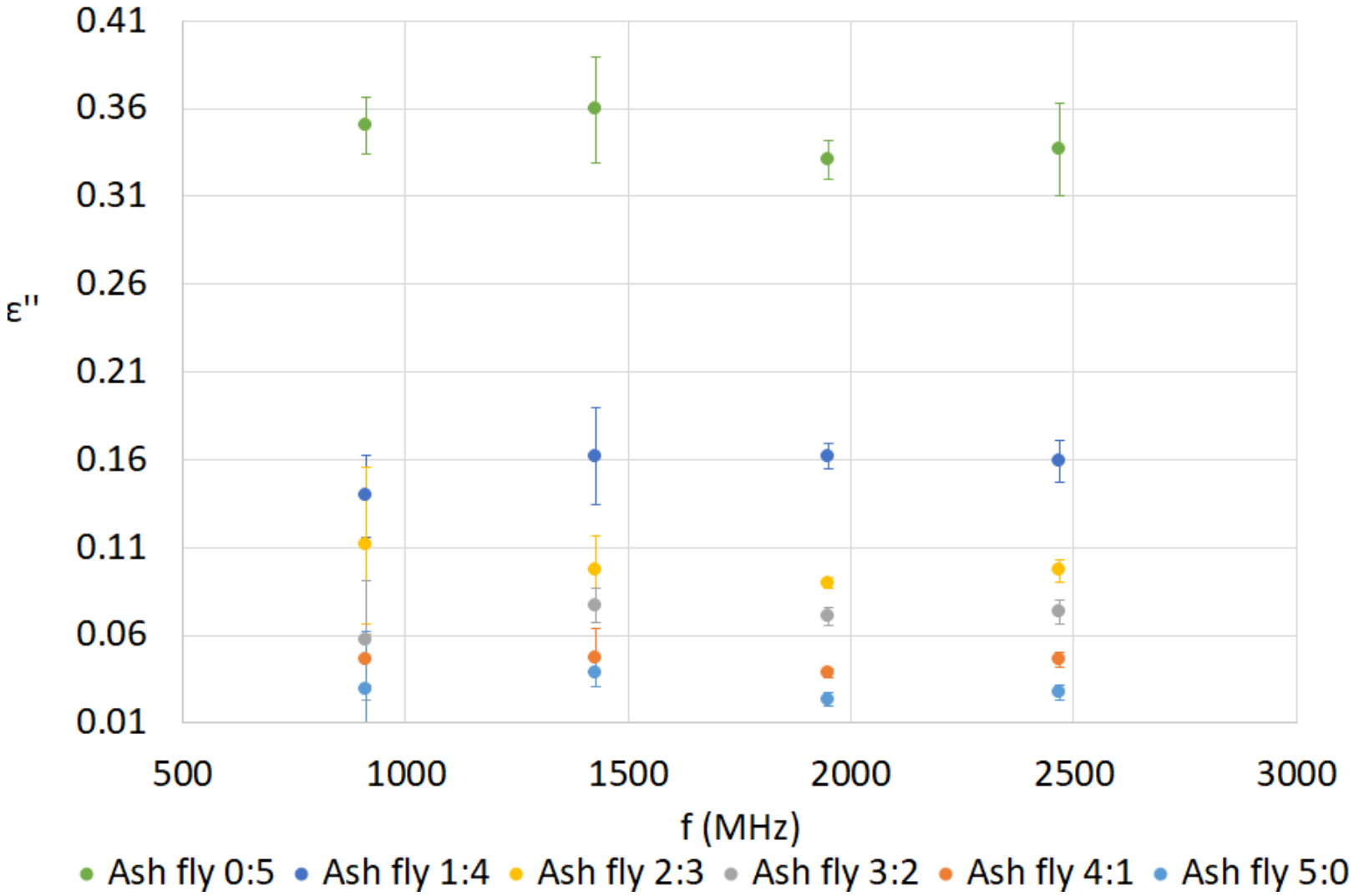
Dielectric Loss of Fly Ash 1 with Varying Carbon Content



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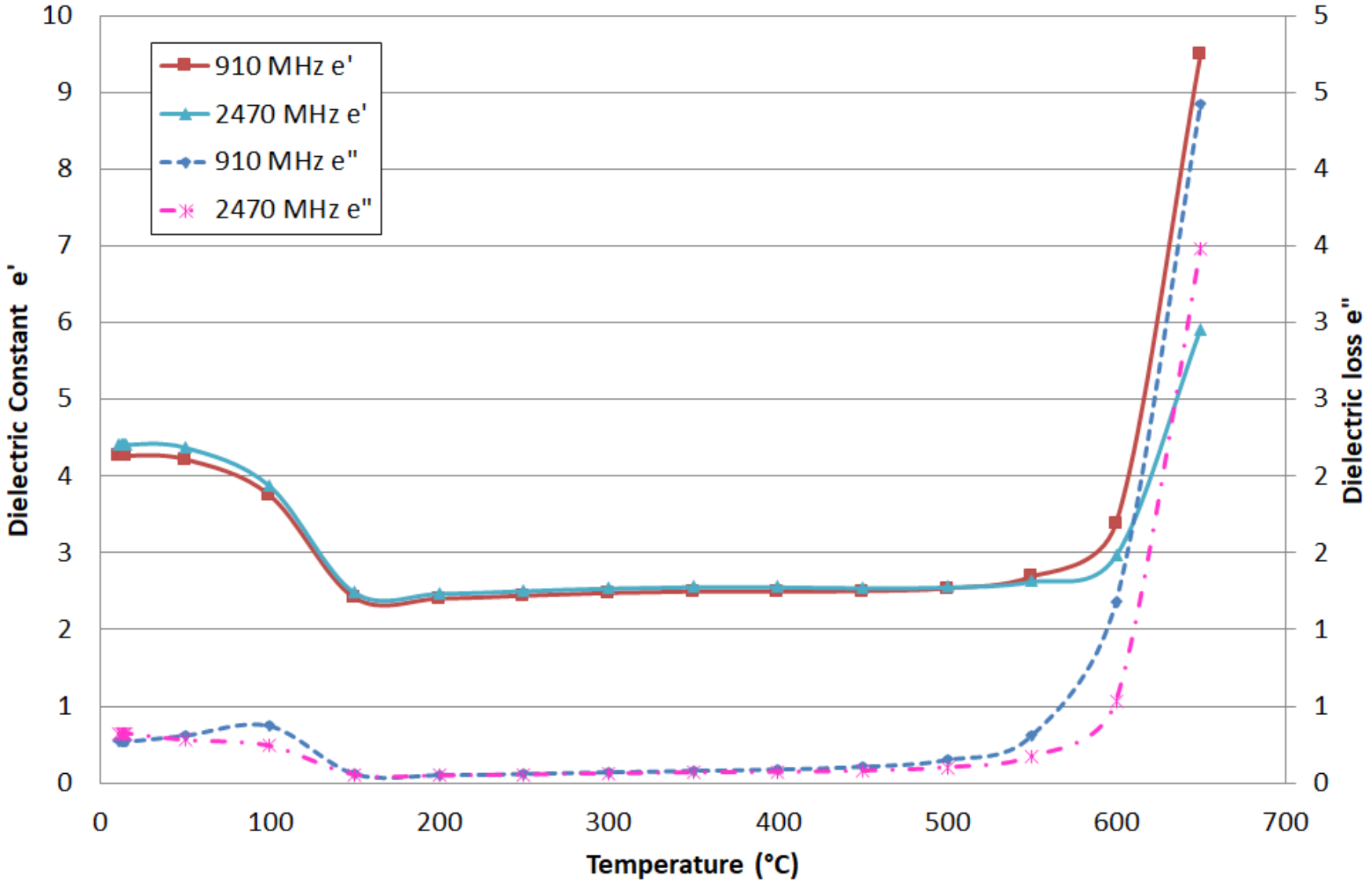
High Temperature Dielectric Properties of Coal



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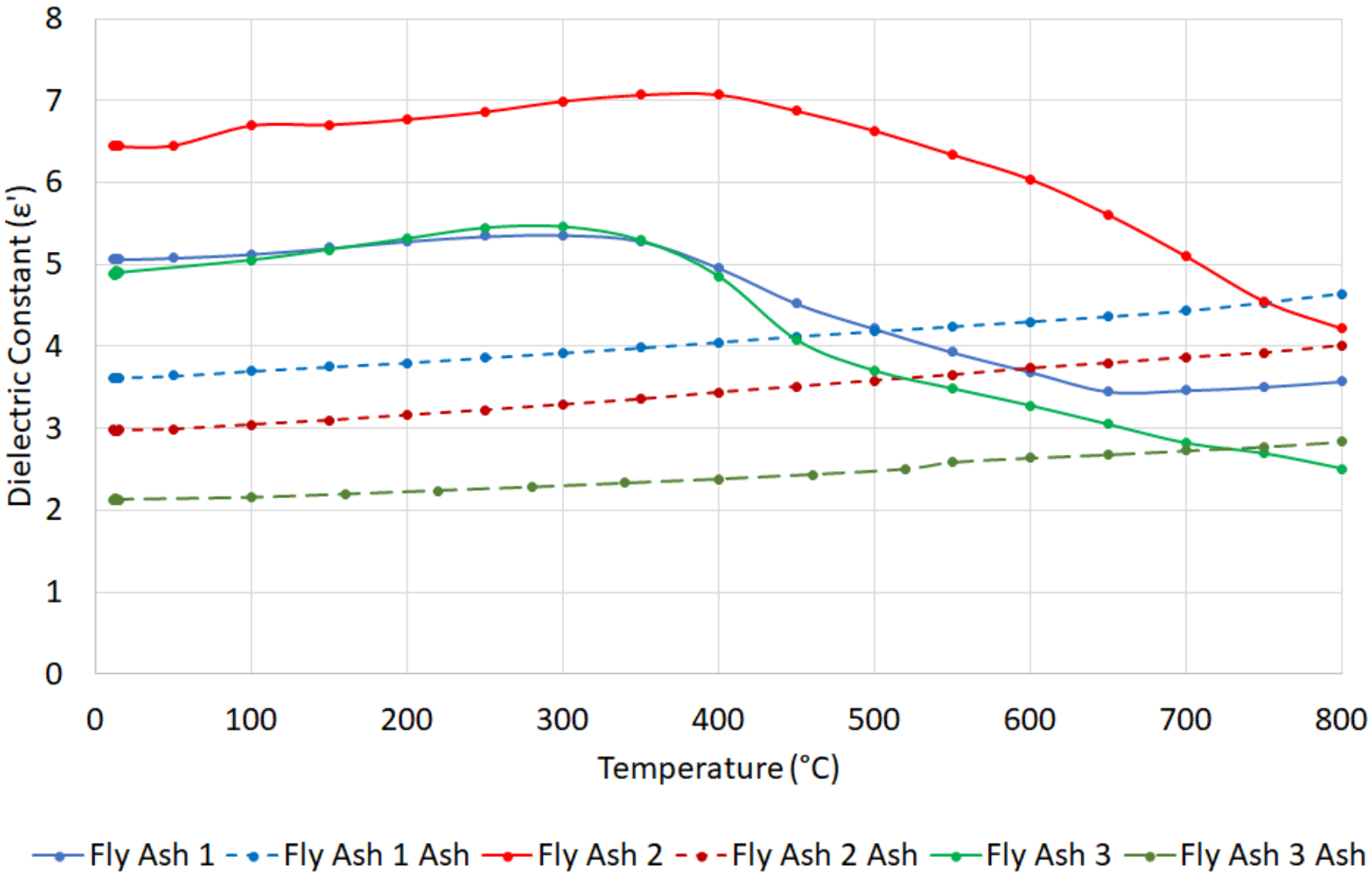
High Temperature Dielectric Constant of Ash at 2470 MHz



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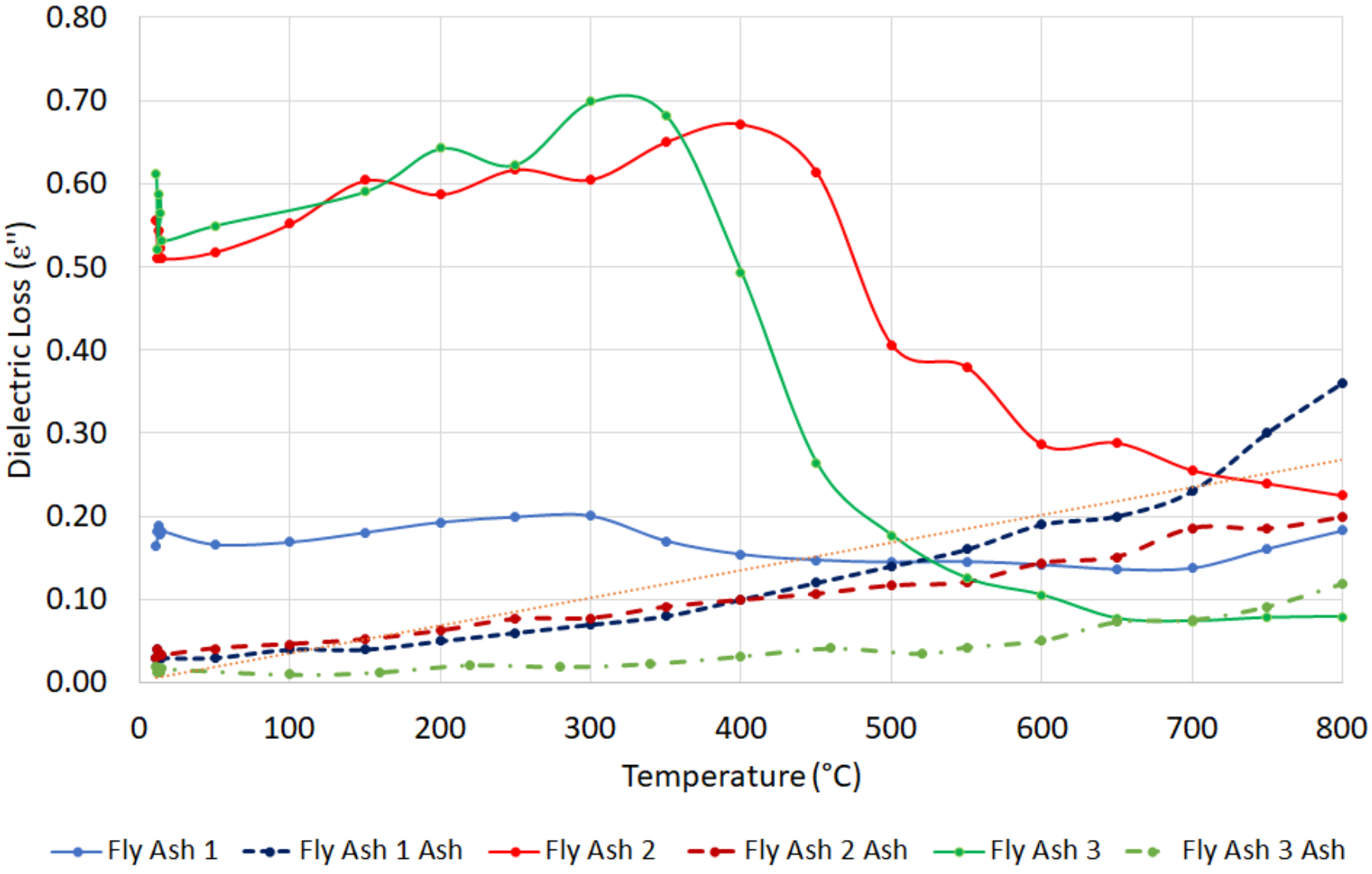
High Temperature Dielectric Loss of Ash at 2470 MHz



Summary

- Proof of concept tests show that the dielectric properties of ash varies with carbon content
- Signal depends on carbon content and mineral composition of the ash
- Dielectric properties of coal and unburnt carbon in ash are very different
- Up to 400 degrees, dielectric constant of industrial ashes is stable, and then drops with increasing temperature
- Knowledge of dielectric properties can be used to develop continuous inline monitoring system for carbon in ash contents

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Thank you for listening

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