






WORKSHOP/TRAINING SESSION FOR STAKEHOLDERS AND END-USERS FROM INDUSTRY - 26TH NOVEMBER 2018

INVESTIGATION OF INDUSTRIALLY USED MEASUREMENT TECHNIQUES

JACQUES HAMEURY (LNE)

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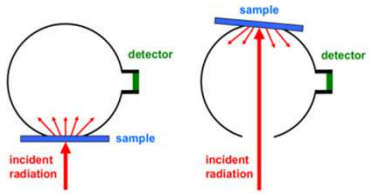
LABORATOIRE NATIONAL DE MÉTROLOGIE ET D'ESSAIS

Investigation of industrially used measurement techniques

Instruments used by end-users and tested in the project

- TIR100-2 emissometer manufactured by INGLAS GmbH & Co. KG (Bermatingen – Germany)
  - Technique of measurement recommended by standard « EN 16012 »
  - Instrument used in EU by several organizations involved in certification of thermal insulation materials and by producers of those materials.
  - End-users satisfied for control of stability and of uniformity of a production. → good fidelity.

- Infrared Integrating spheres associated to FTIR spectrometers
  - Technique of measurement recommended by standard « EN 16012 »
  - Instrument used in EU by several research institutes, by some organizations involved in certification of thermal insulation materials and by some producers of materials.

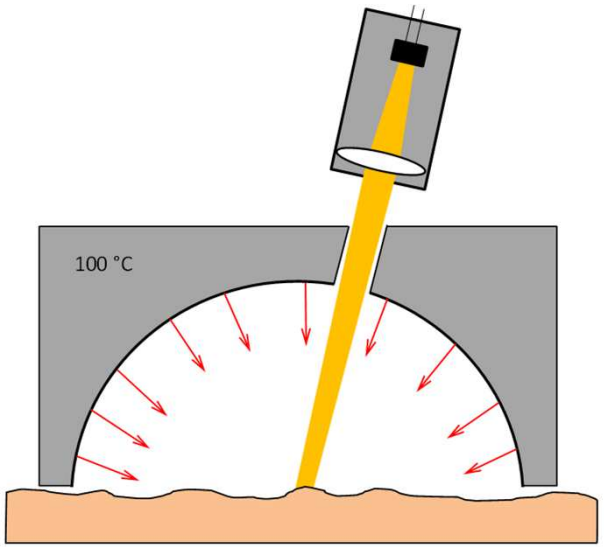


Investigation of industrially used measurement techniques

Features

- Parameter measured : total near-normal emissivity (opaque material)
- Sample at room temperature
- Hemispherical cavity : stabilized at 100 °C , high emissivity
- Infrared sensor : thermopile-sensor with Fresnel polymer lens
- Spectral range : 2.5 µm - 40 µm (data from INGLAS)
- Emissivity range : 0,02 to 0,98 ((data from INGLAS)
- Angle of measurement 12°
- Calibration : 1 low emissivity (polished aluminium) surface ($\varepsilon \approx 0.01$), 1 low emissivity black structured surface ($\varepsilon \approx 0.96$)

Principle of measurement



- Total hemispherical emissivity extrapolated from total near-normal emissivity by multiplication by factor

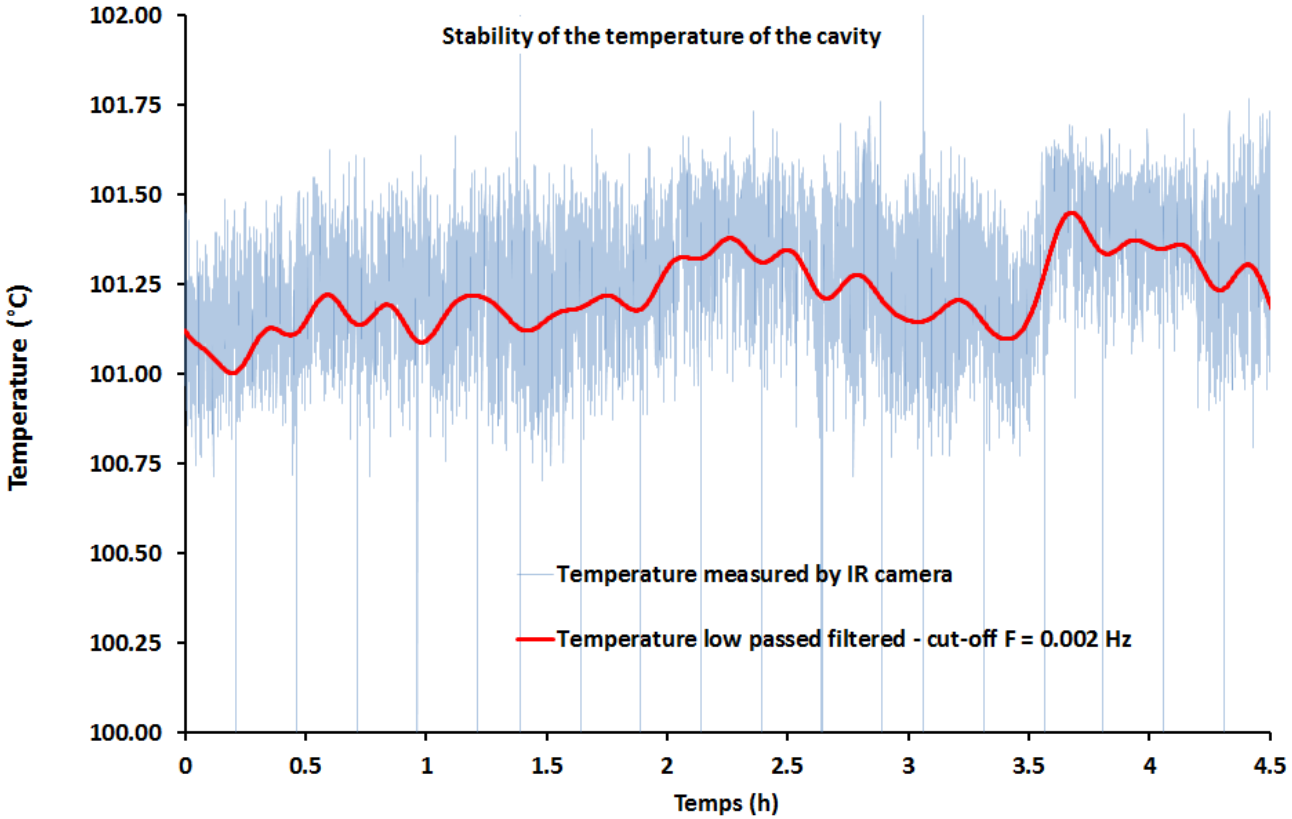
$$\varepsilon_{hemispherical} / \varepsilon_{normal} = f(\varepsilon_{normal})$$

- Factor $\varepsilon_{hem.} / \varepsilon_{norm.}$ can be found in standard EN673 or other ref.

- **Potentially : sensitivity to angular distribution of reflected radiation**

Characterization of TIR100-2 reflectometer/emissometer

- **Stability and uniformity of the temperature of the cavity**
  Analysis with an IR camera



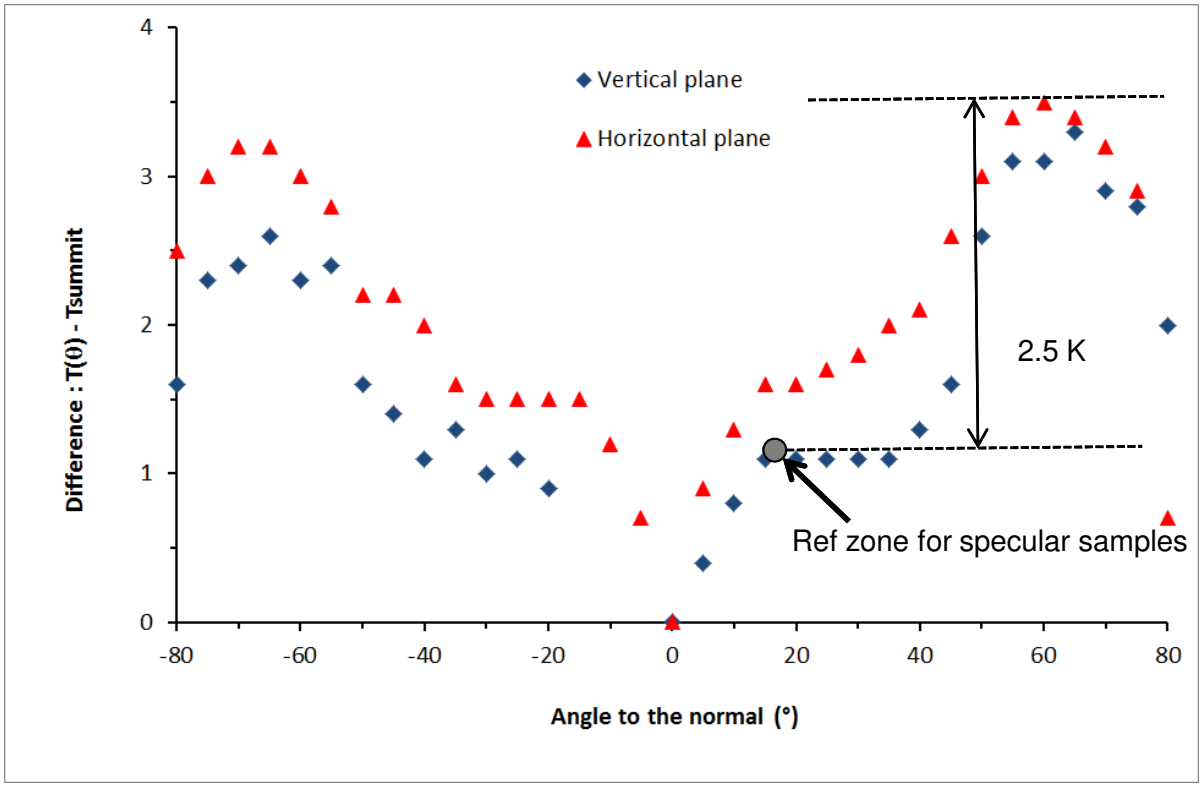
Short term stability : 0.25 K

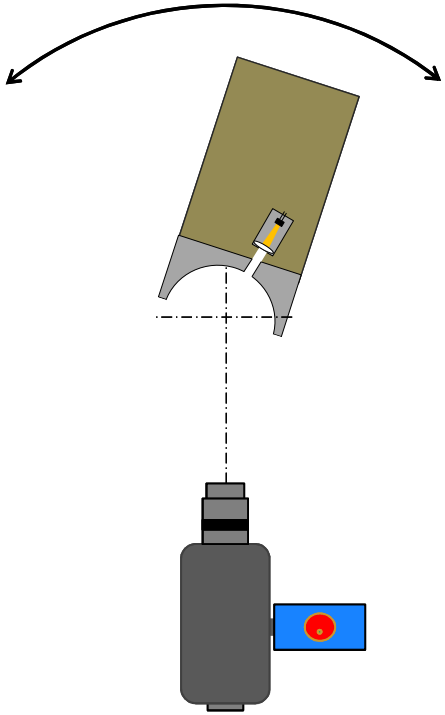
Long term stability : 0.5 K

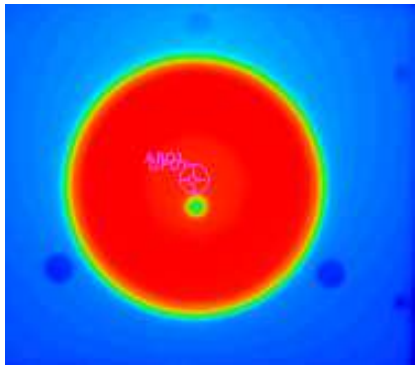
INGLAS recommends recalibration each 10 min.

Characterization of TIR100-2 emissometer

- **Uniformity of the cavity temperature**

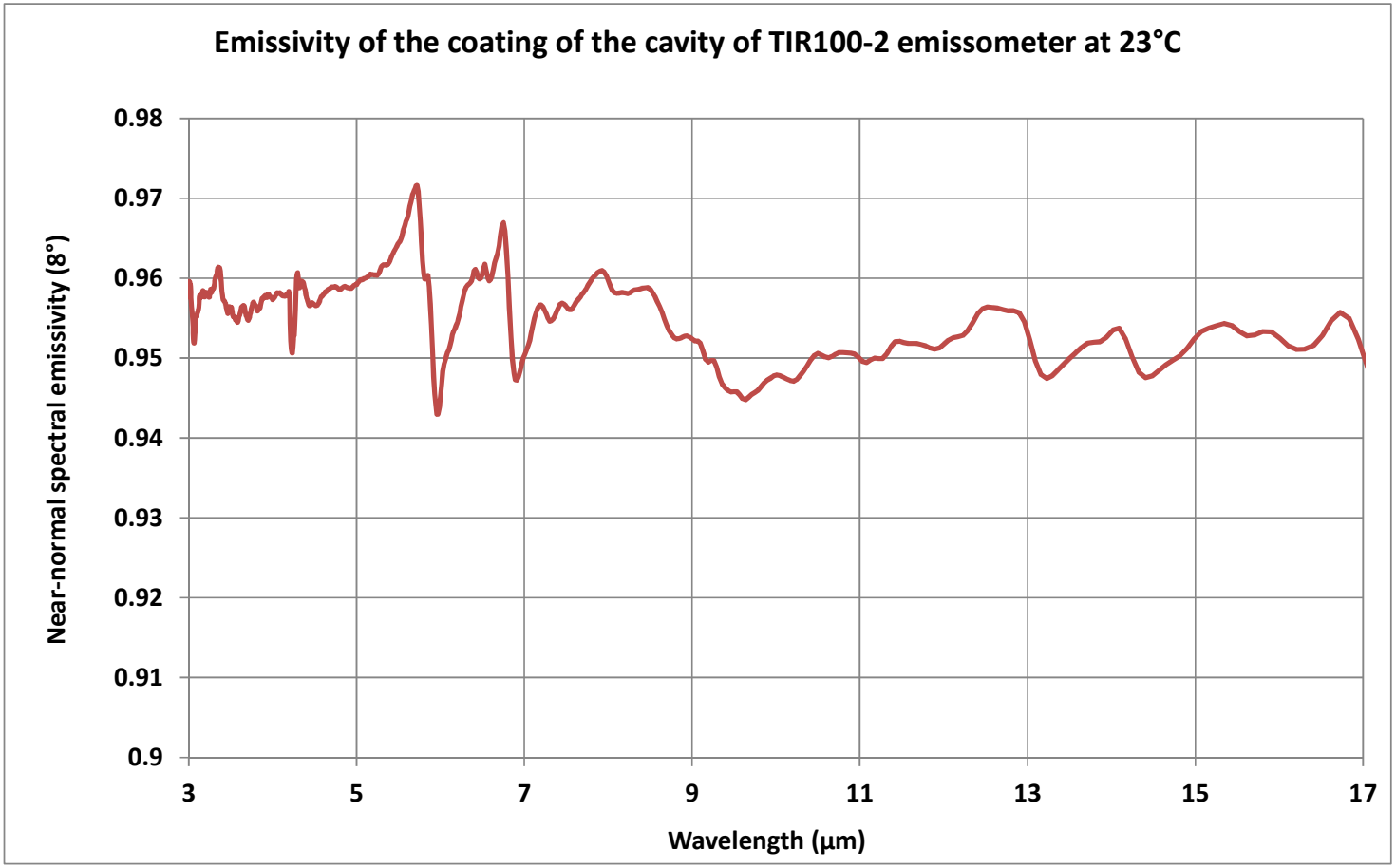






Characterization of TIR100-2 emissometer

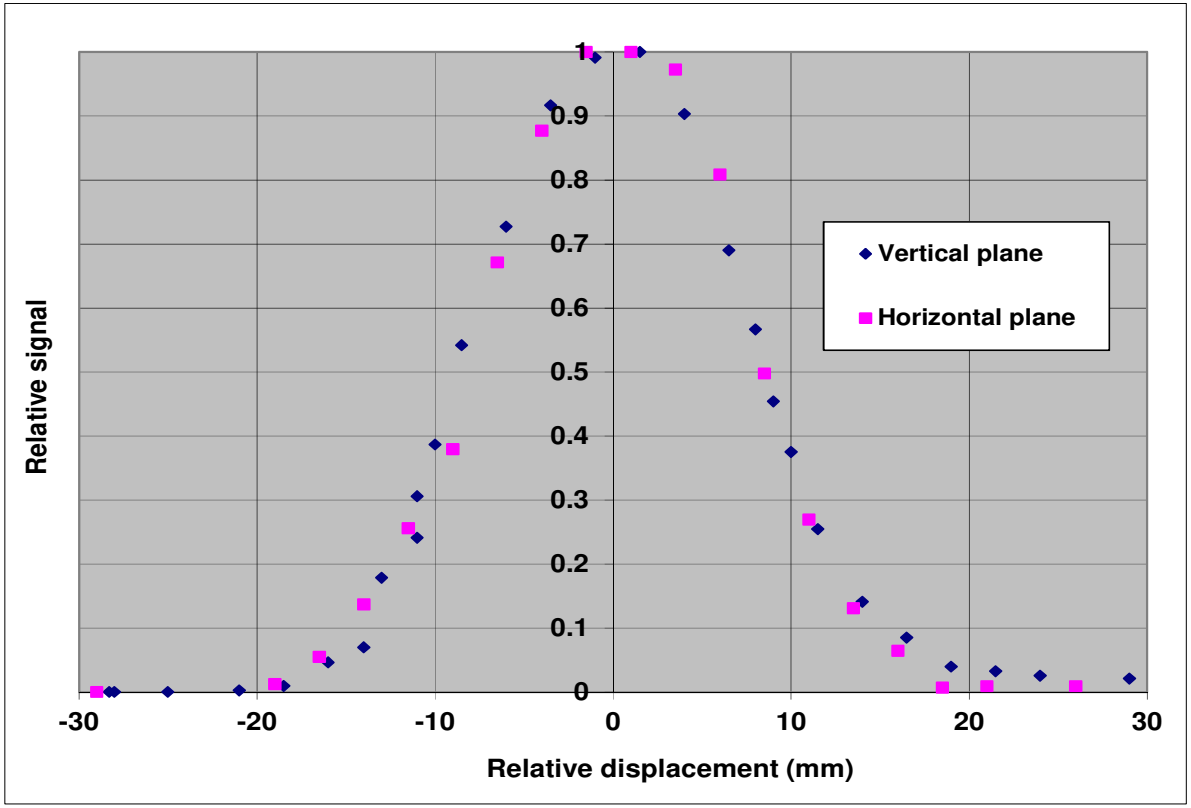
- Emissivity of the cavity coating



Total hemispherical emissivity = 0.91 ±0.03

Characterization of TIR100-2 emissometer

- Spot size measured by LNE : analysed by displacement of a reflective strip (width 16 mm) stuck on a high emissivity block



Spot diameter at the base = 22 mm

Spot size measured by PTB :
17 mm at 90% of intensity

Measurement by using different apertures or scanning the field with a ∅ 6 mm aperture.

Characterization of TIR100-2 emissometer

- Linearity of response :

  Still to be analysed in detail with samples with different levels of reflectance (2019).

- Spectral sensitivity :

Difficult to analyse over a wide spectral range.

May be : measurement of variations of the spectral transmittance of the lens.

Investigation of industrially used measurement techniques

Features

- Parameter measured : total near-normal emissivity (opaque material)
- Sample at room temperature
- Spectral range : 3 µm – 17; 20 or 40 µm
- Angle of incidence : usually 8°
- Calibration : 1 low emissivity diffusing ref. sample or mirror
  + check of 0% level.

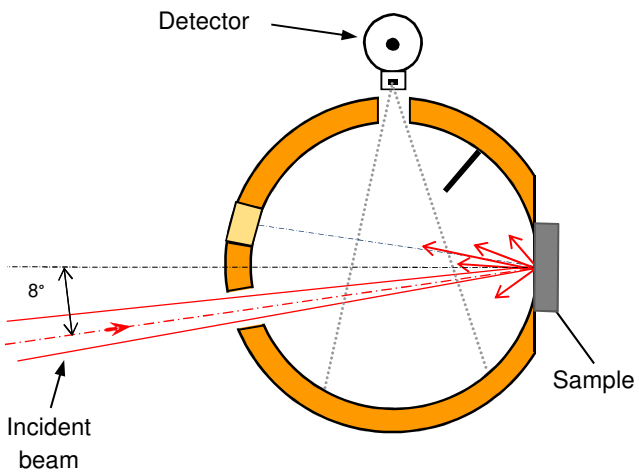
❖ Total hemispherical emissivity extrapolated from total near-normal emissivity by multiplication by factor

$$\varepsilon_{hemispherical} / \varepsilon_{near-normal} = f(\varepsilon_{near-normal})$$

❖ Factor $\varepsilon_{hem.} / \varepsilon_{near-norm.}$ can be found in standard EN673 or various ref.

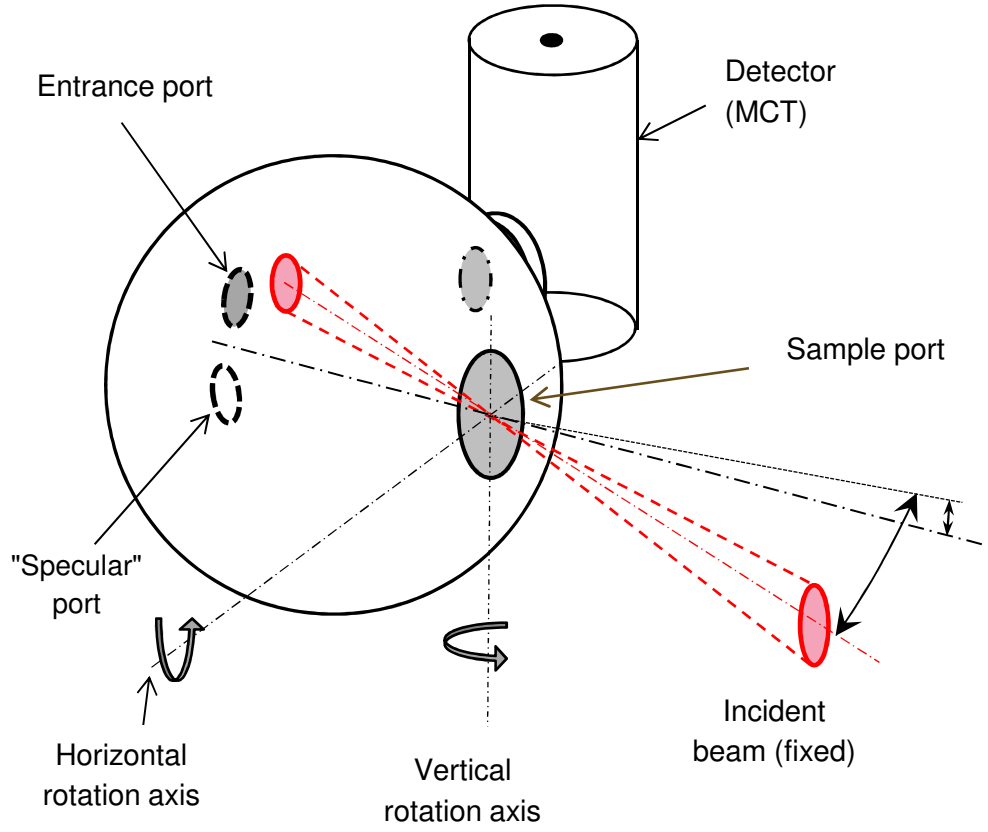
■ **Potentially : sensitivity to angular distribution of reflected radiation**

Principle of measurement



Characterization of Integrating spheres

- **Sensitivity to angular distribution of reflection : Analysis of the angular sensitivity of a integrating sphere.**



Infrared Integrating sphere : diffusing gold coating

Internal diameter : 75 mm

Sample port : ∅ 15 mm

Entrance and « specular » ports : ∅ 10 mm

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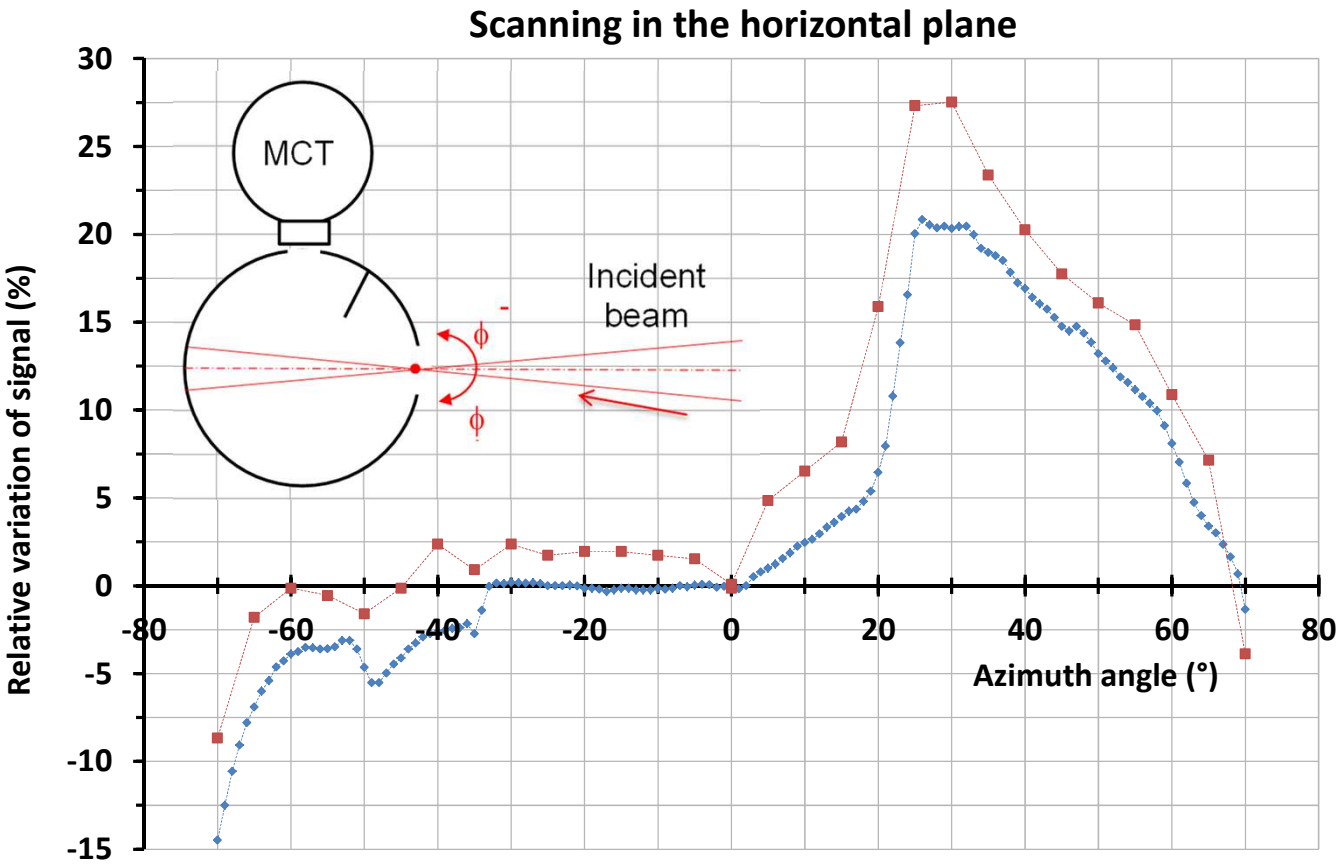

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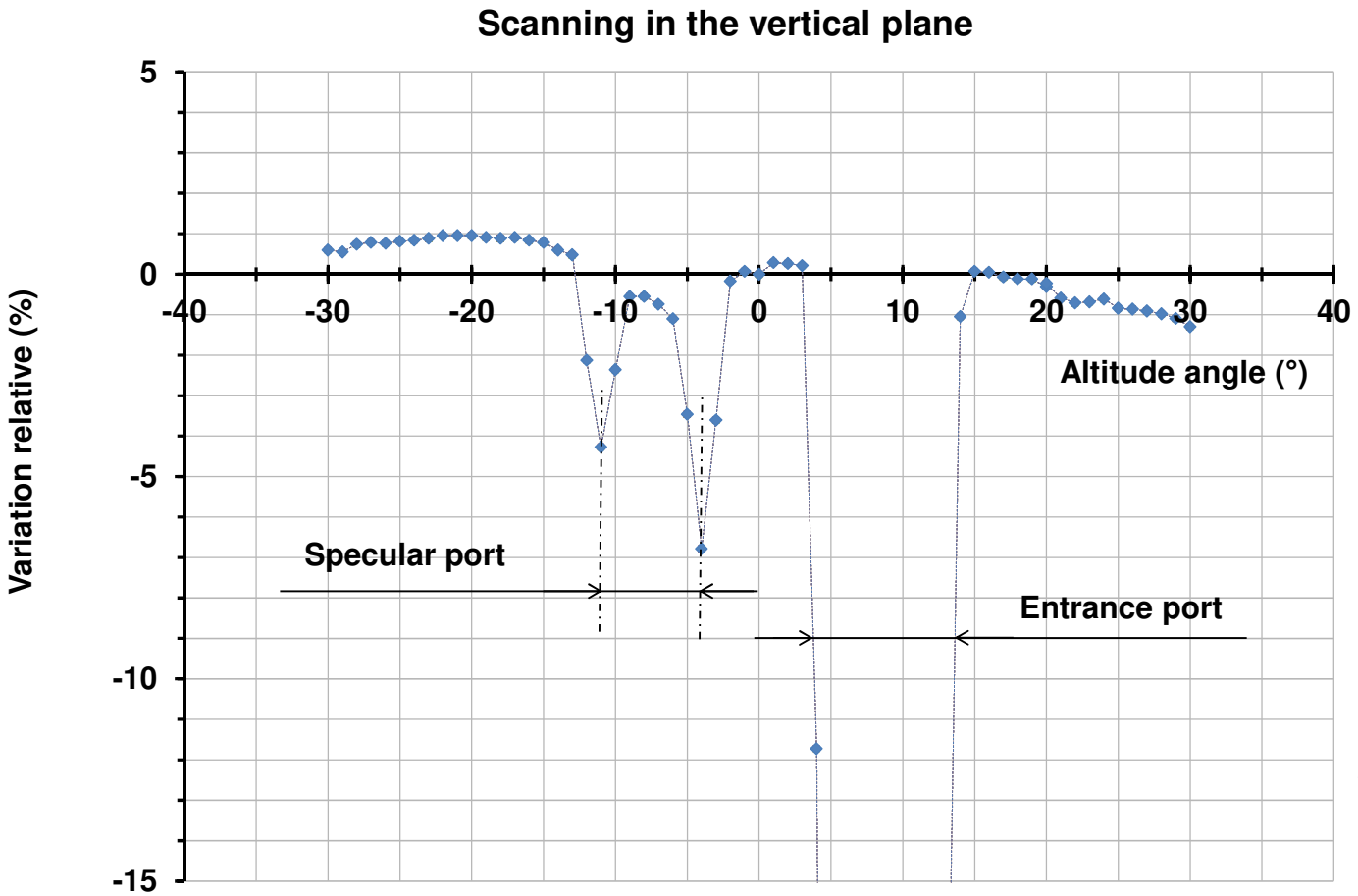
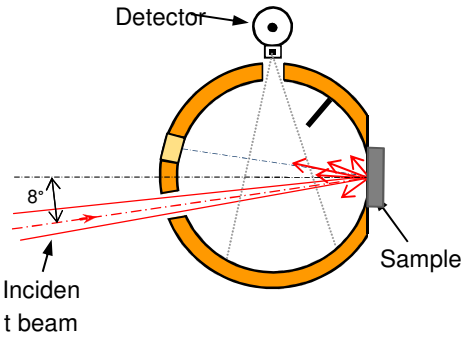
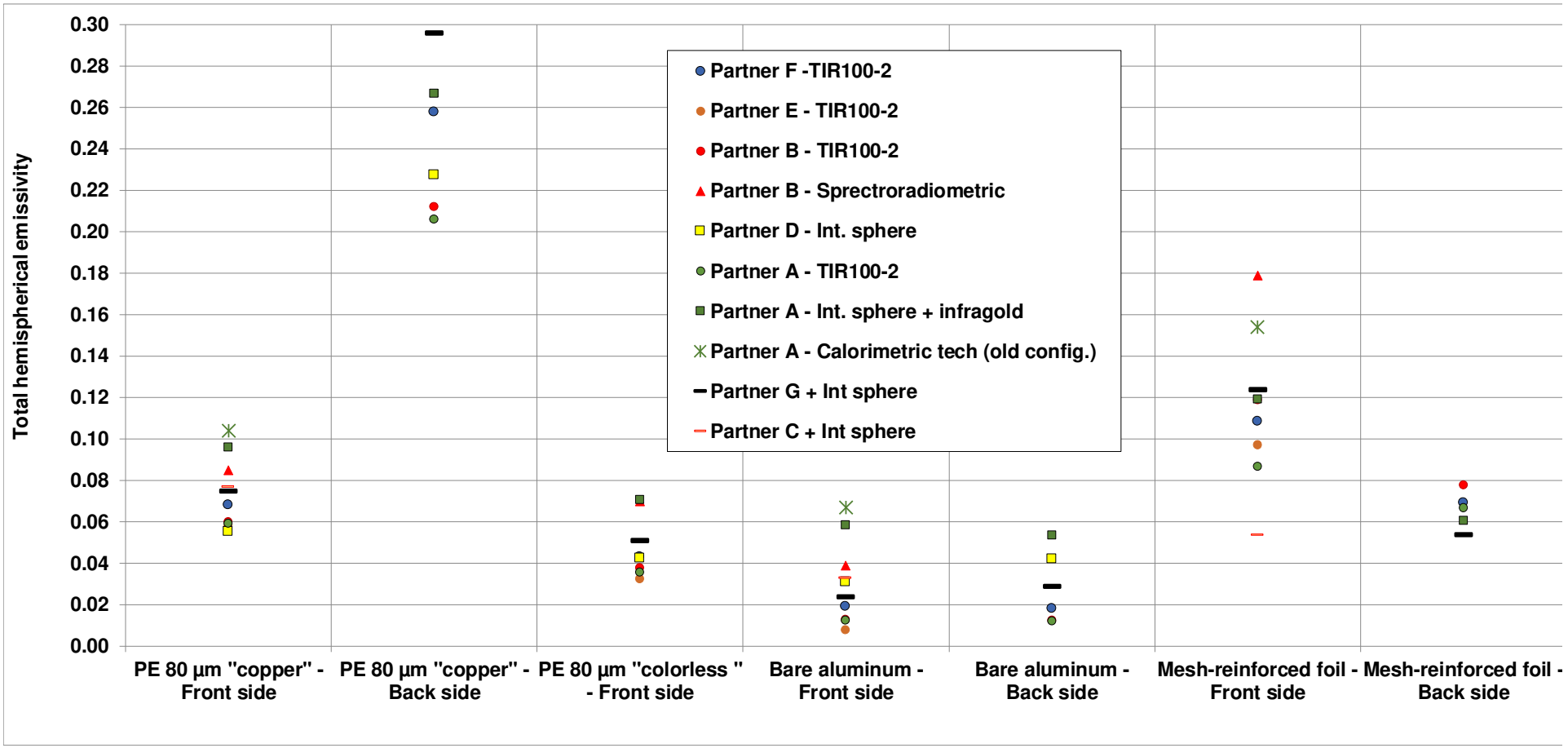




Characterization of Integrating spheres

- **Comparison of techniques of measurement of partners (using their own measurement procedures and standards).**



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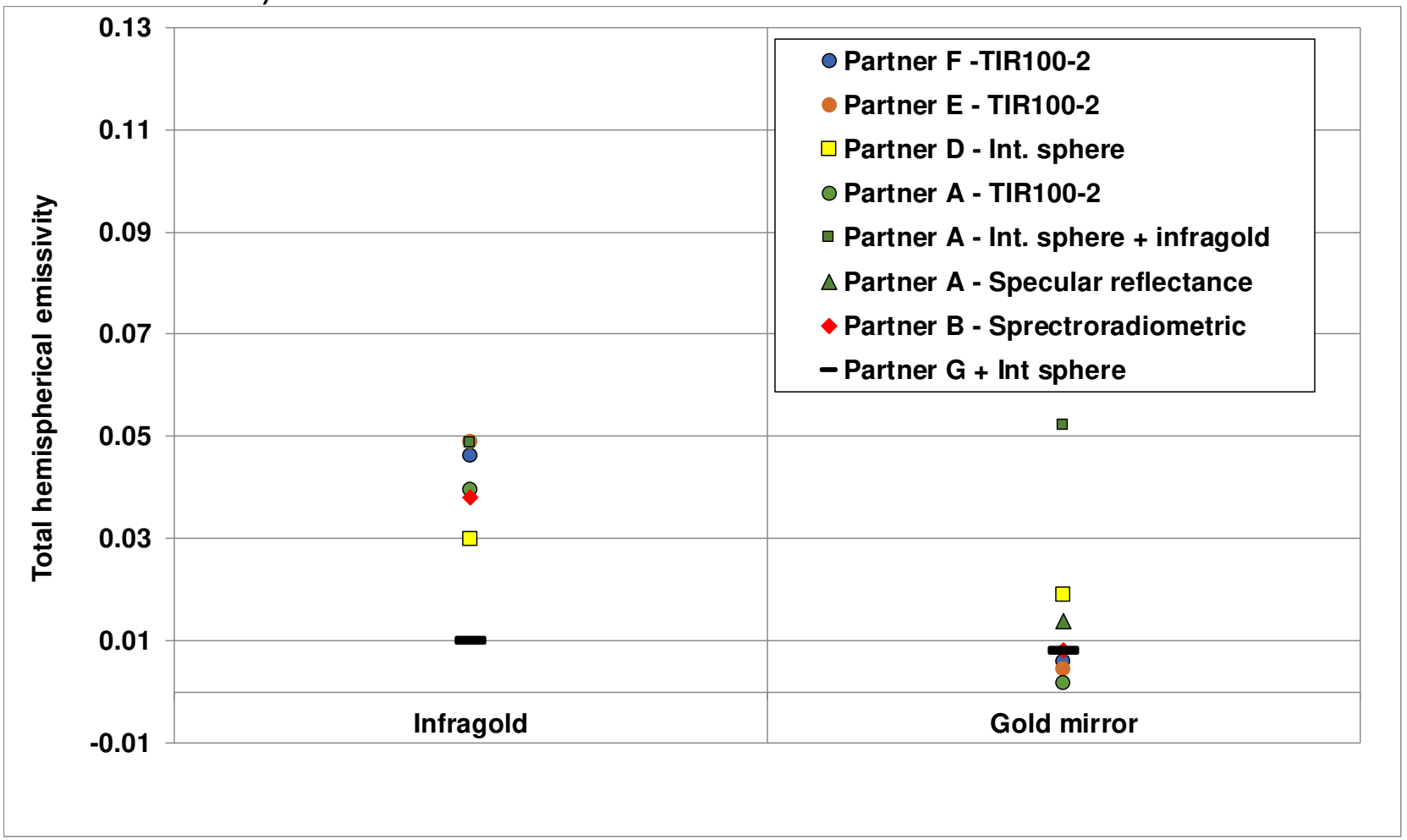

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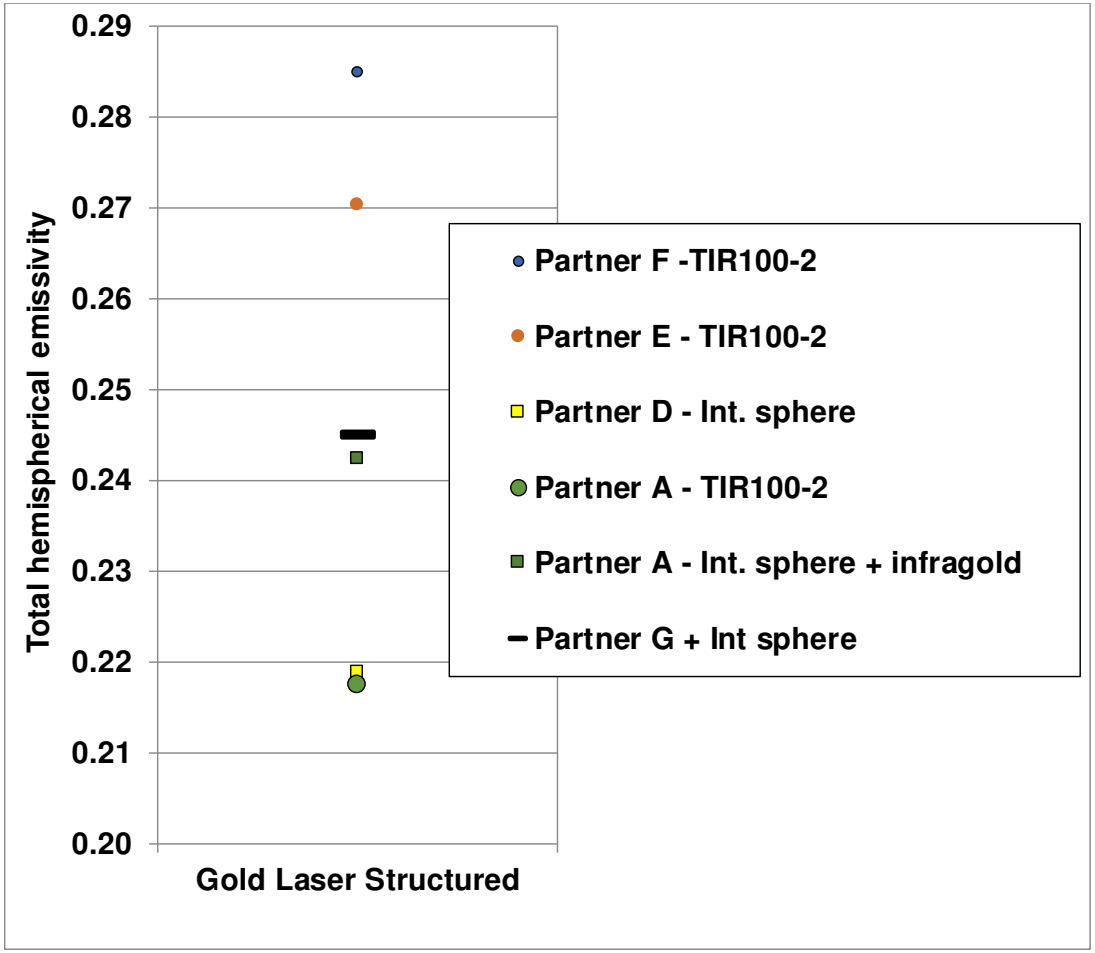

Conclusion from first investigations of industrially used measurement techniques :

Integrating sphere :

- **It would be better to not have a specular port for almost-specular materials (cavity around the « specular port » plug).**
- **Integrating spheres can show relative variations of the angular sensitivity of a few to many percents around the specular direction.**

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TIR100-2 :

- **Tendency to give ”low values” of total hemispherical emissivity → still to be explained.**
- **Good fidelity and reproducibility.**
- **Quite large area of measurement (not uniform in sensitivity).**

Comparison results obtained recently → still to be exploited in detail to explain variations of results.

Questions ?