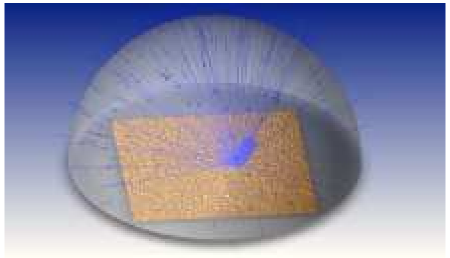
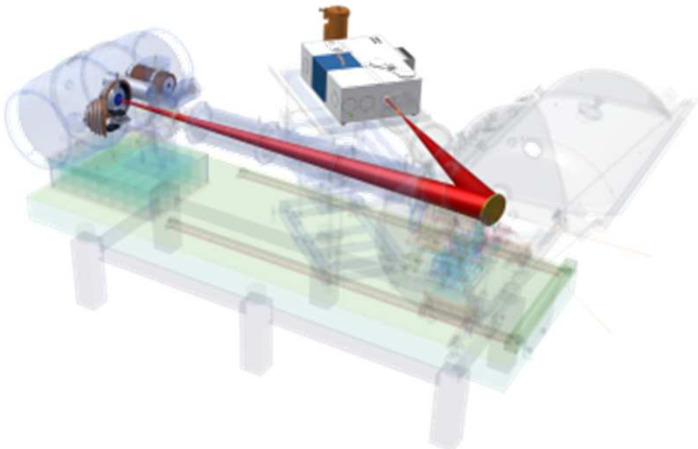
Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin
Nationales Metrologieinstitut

EMIRIM
Improved reference techniques

A. Adibekyan, E. Kononogova and C. Monte,

Working Group 7.32, Infrared Radiation Thermometry

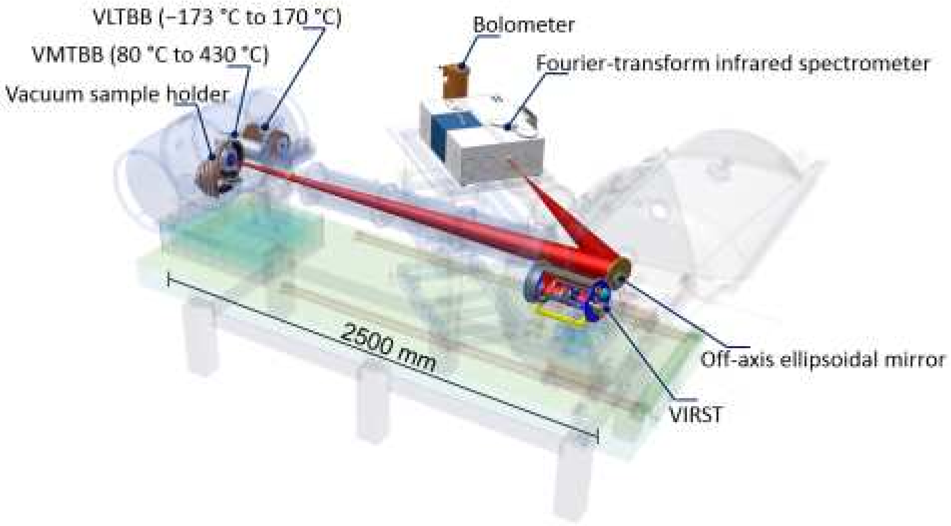




Measurement of emissivity in air and under vacuum

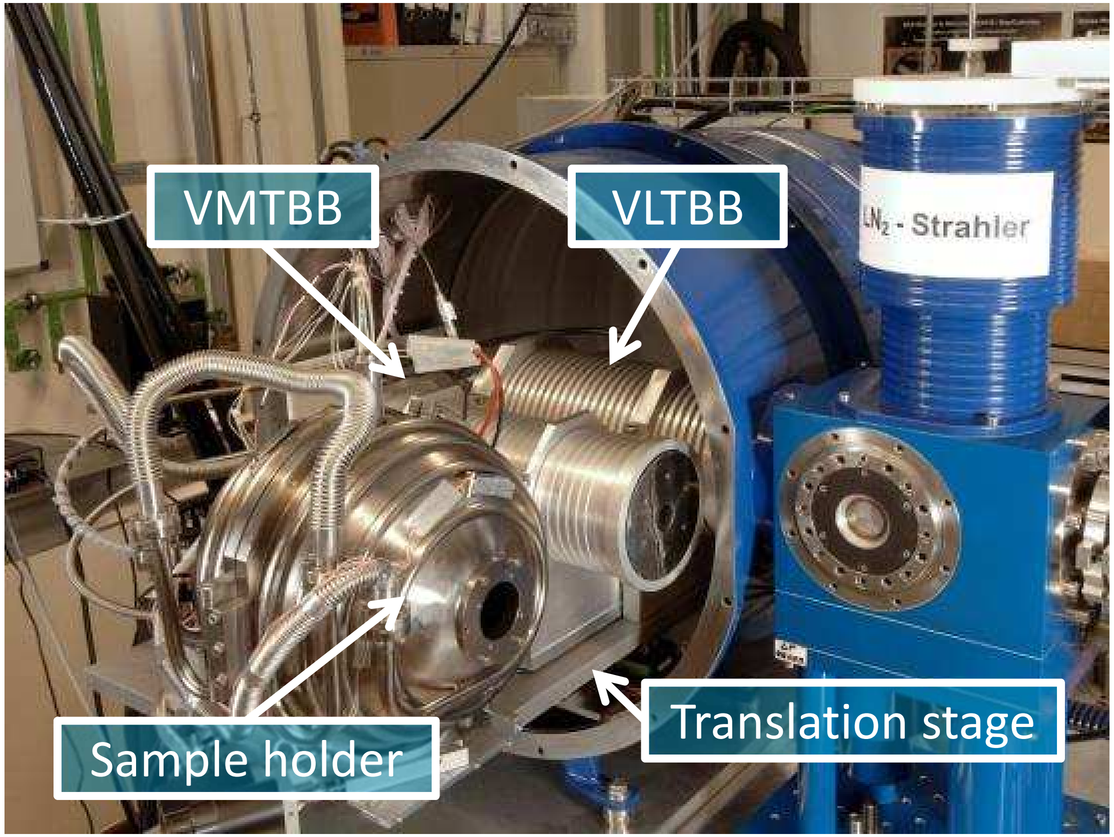
Setup in air: EMA

Setup under vacuum: RBCF



	Setup in air	Setup under vacuum
Temperature range:	20 °C to 500 °C	-40 °C to 1000 °C
Spectral range:	2.5 µm to 50 µm	1.2 µm to 200 µm
Angular range:	±80°	±80°

Measurement Scheme



Measurement Scheme :

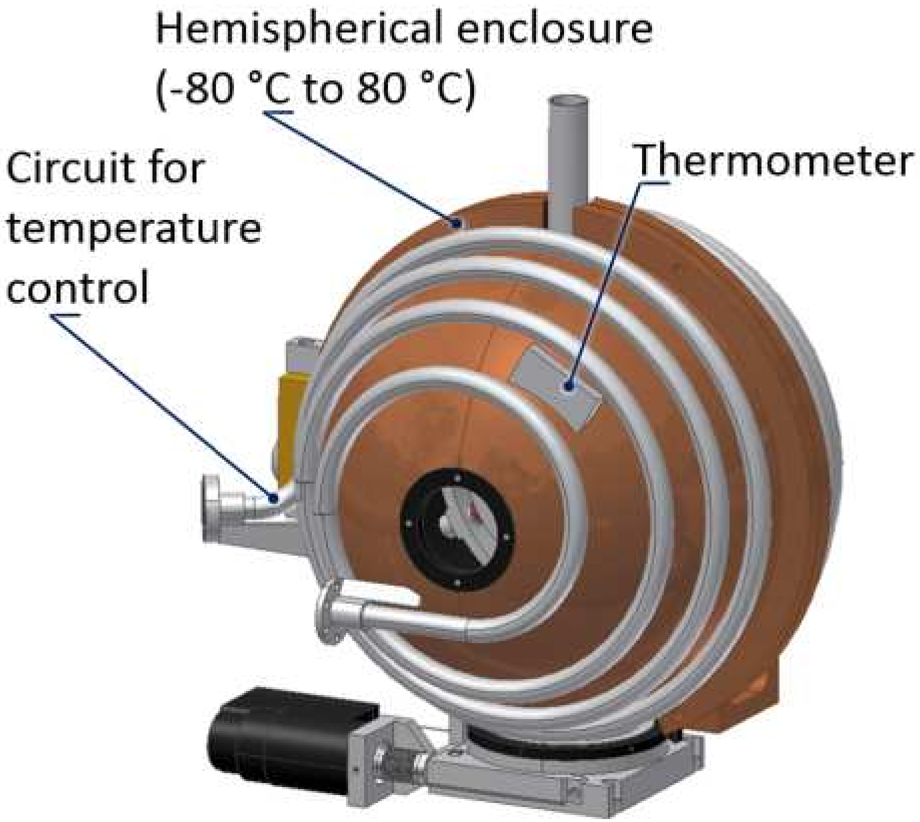
Comparison of the sample with two blackbodies at two different temperatures

Advantage:

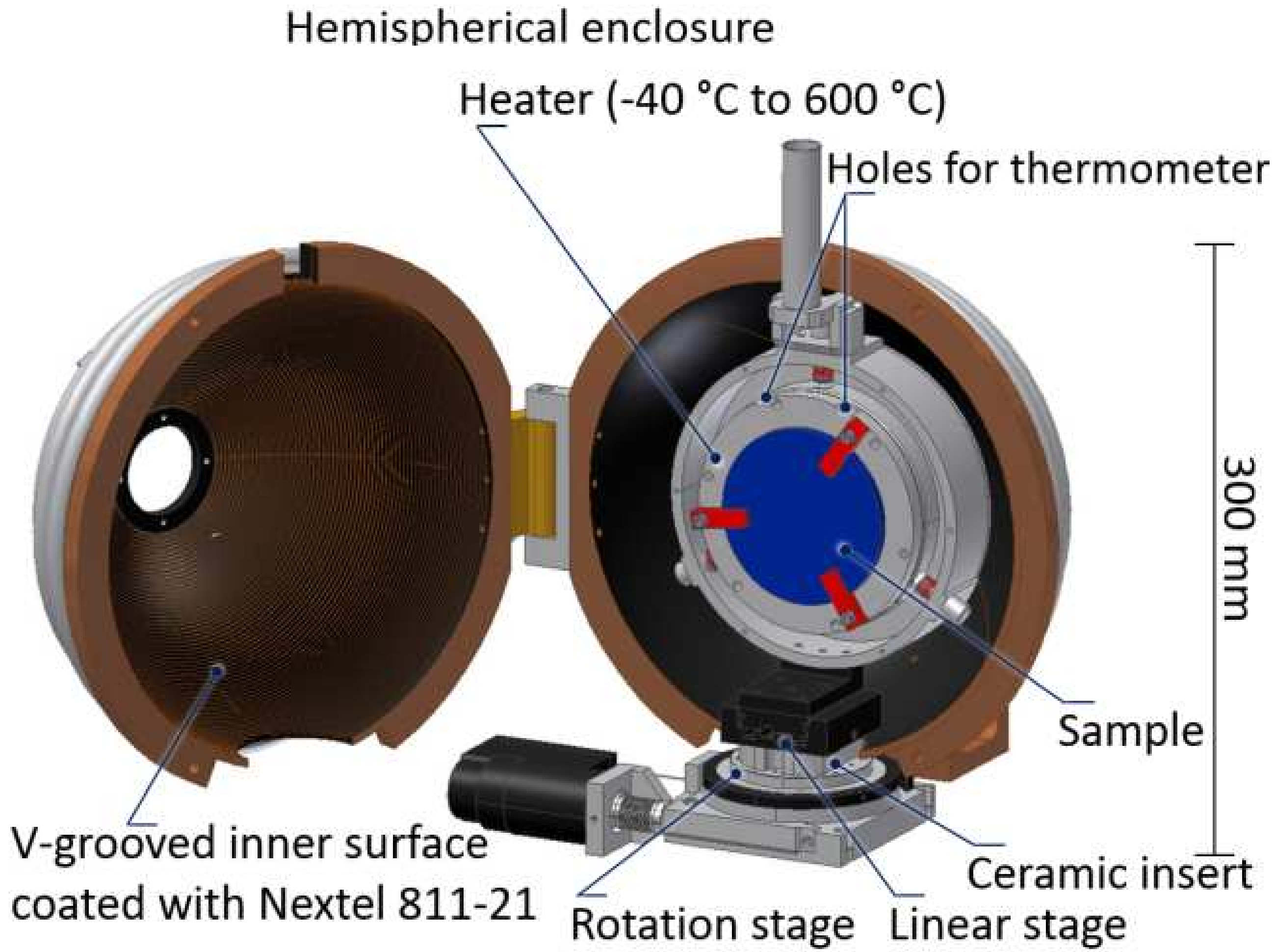
the thermal background, of the "warm" spectrometer components and the spectral responsivity of the detection system cancel out

$$Q = \frac{\tilde{L}_{\text{Sample}}(T_{\text{Sample}}) - \tilde{L}_{\text{LN}_2\text{BB}}(T_{\text{LN}_2\text{BB}})}{\tilde{L}_{\text{VLTBB or VMTBB}}(T_{\text{VLTBB or VMTBB}}) - \tilde{L}_{\text{LN}_2\text{BB}}(T_{\text{LN}_2\text{BB}})}$$

Sample holder for emissivity measurements



Sample holder for emissivity measurements

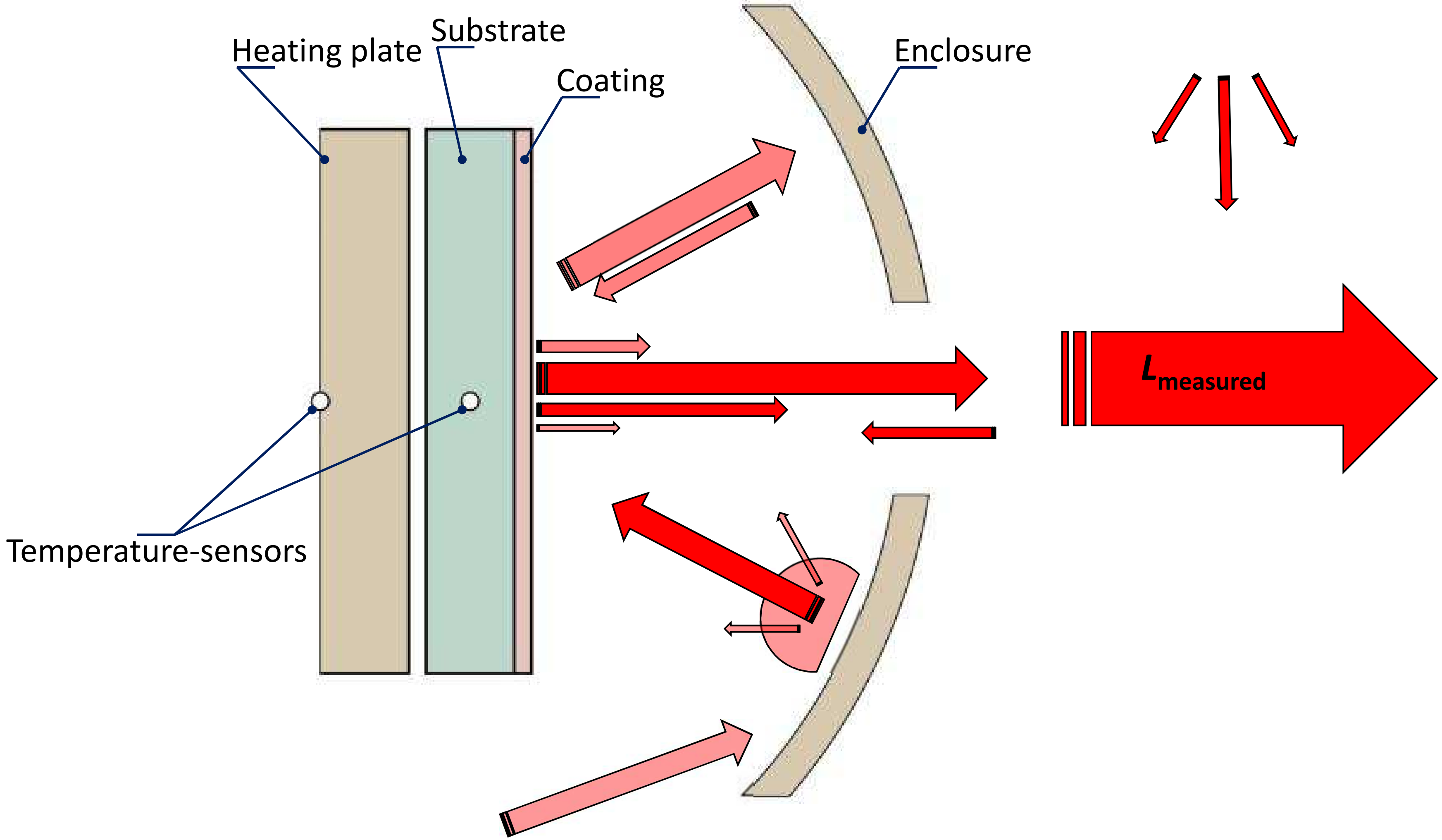


The value of the directional spectral emissivity of the enclosure is important for:

– Calculation of the radiation incident on the sample from the hemispherical enclosure

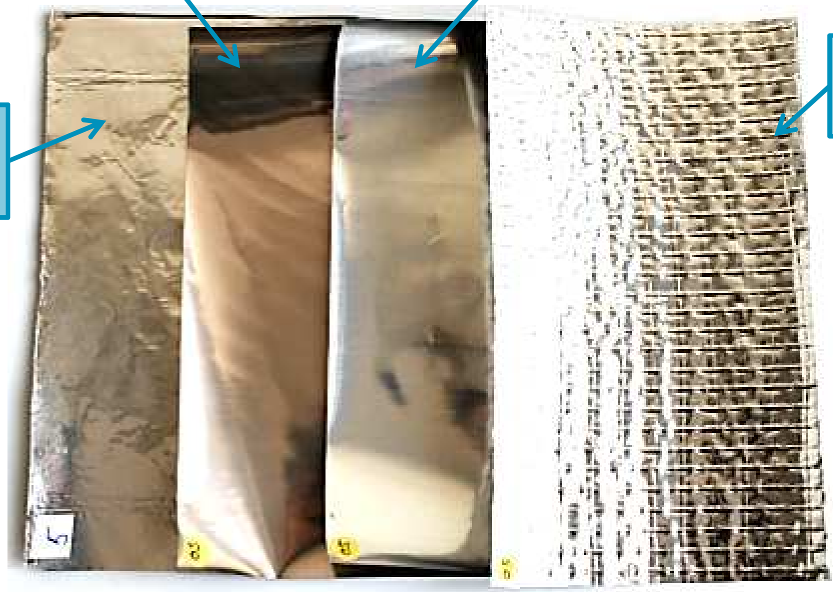
– Reduction of multiple reflections between sample and enclosure

Considering multiple reflections for Low-ε-Samples



$$\overline{L}_{Sample} = s(\varepsilon\, L_{Sample} + \varepsilon_{Encl.}\, L_{Encl.}\, \rho_{Sample} \sum\sum\ldots + L_{Background} + \varepsilon_{S.hem} L_{S.}\, \rho_{Encl.}\, \rho_{S.} \sum\sum\ldots - L_{Detector})$$

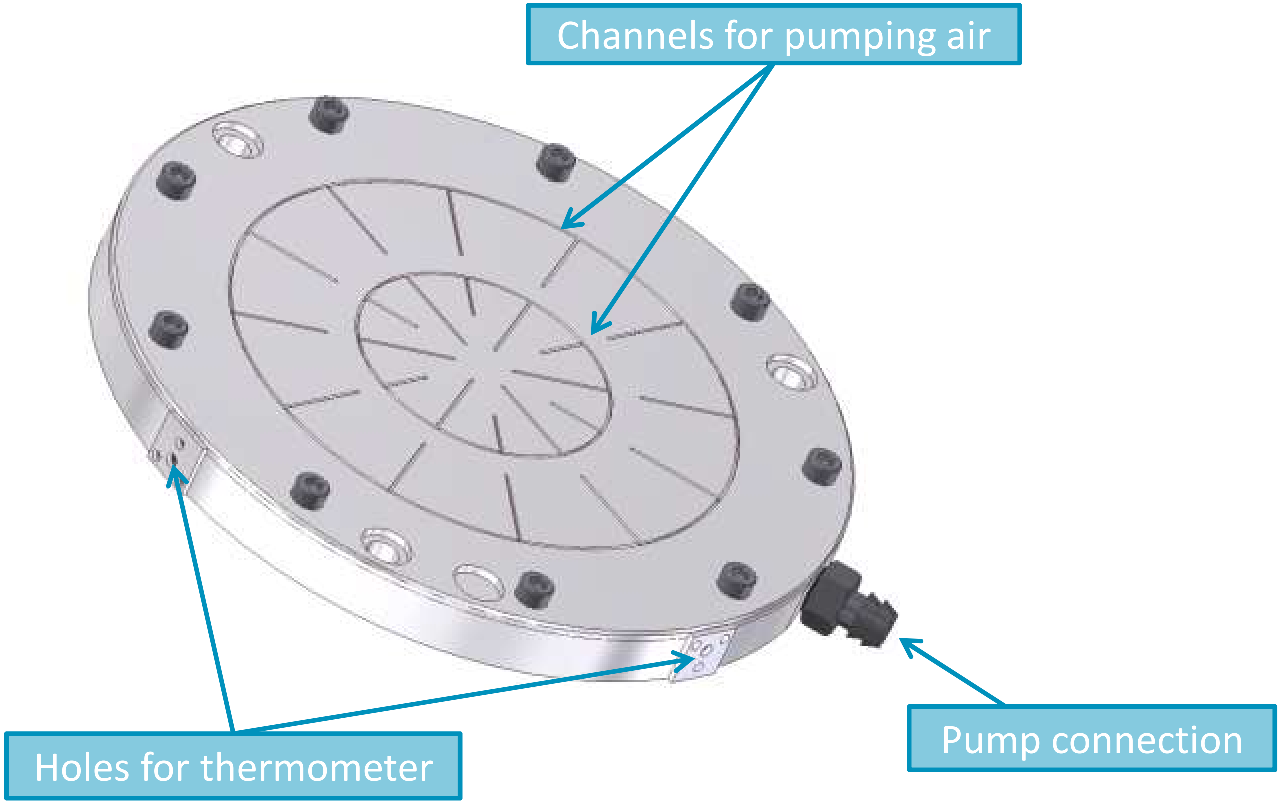
Four different types of foils



Foil	Thickness (µm)	Thermal conductivity (W/(m·K))
Bare aluminium foil	30	
PE foil colorless lacquered	80	0.44
PE foil „copper" lacquered	80	0.40
Mesh reinforced foil (aluminium color)	85 (average)	

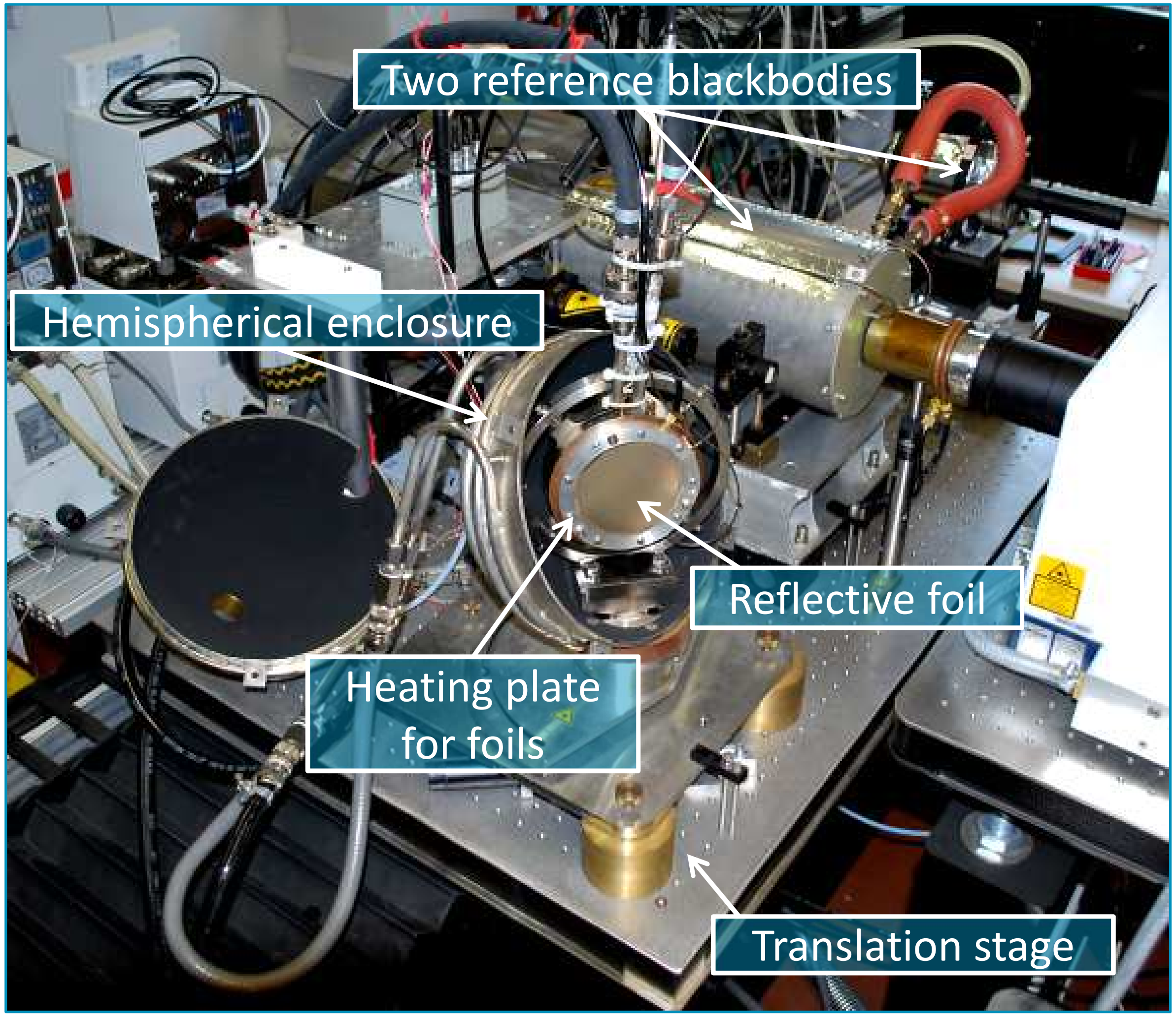
Emissivity measurements of foils

- Objective:
  - Maintaining a good thermal contact even with thermally expanding samples
  - Fitting in existing emissivity sample holder

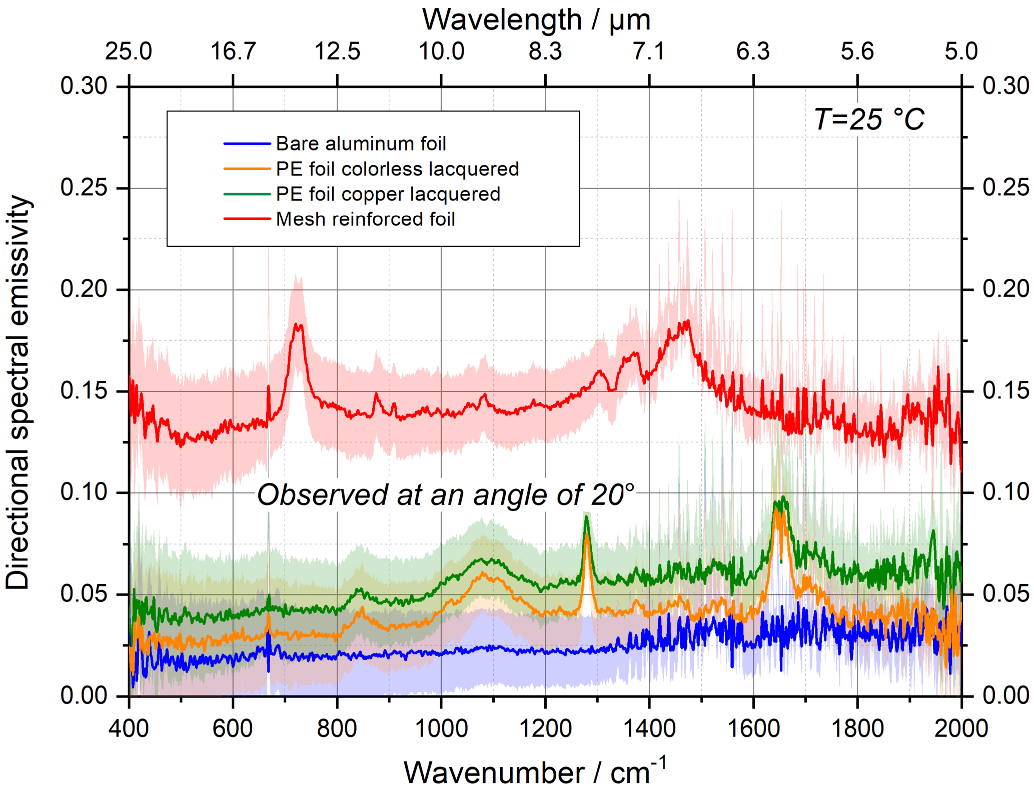


Dedicated heating plate for foils: vacuum mounting of flexible objects

Emissivity measurements of foils



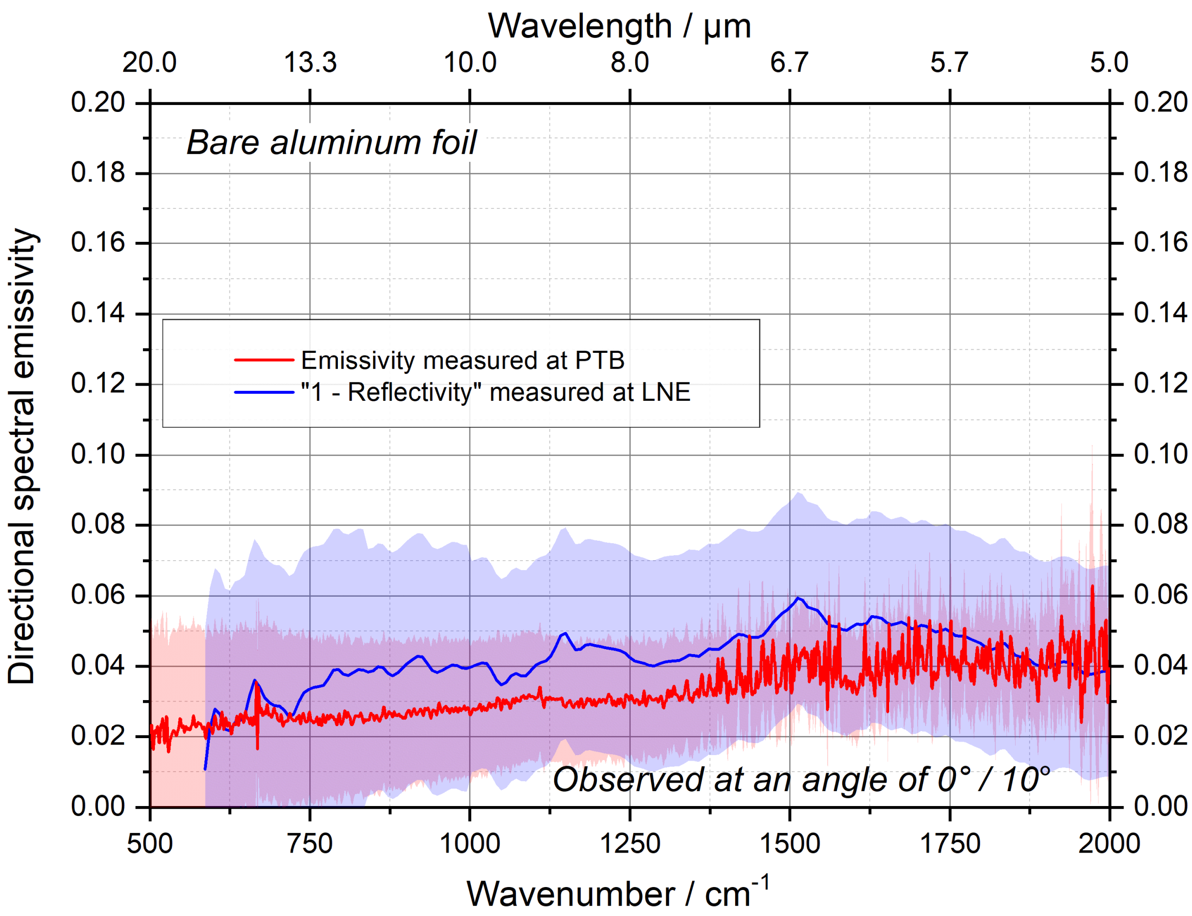
Emissivity measurements of foils



Angle	Bare aluminium ε (25 °C)	u(ε) (k=1)	PE Foil Colorless ε (25 °C)	u(ε) (k=1)	PE foil "copper" ε (25 °C)	u(ε) (k=1)	Mesh reinforced ε (25 °C)	u(ε) (k=1)
20°	0.023	0.022	0.038	0.023	0.052	0.022	0.145	0.021
30°	0.017	0.022	0.040	0.023	0.051	0.023	0.145	0.021
40°	0.018	0.022	0.040	0.022	0.053	0.022	0.162	0.022
50°	0.043	0.022	0.071	0.022	0.088	0.022	0.167	0.021
60°	0.041	0.021	0.108	0.022	0.094	0.021	0.186	0.021
70°	0.053	0.022	0.046	0.024	0.126	0.021	0.213	0.020
ε_{hem}	0.039	0.019	0.070	0.022	0.085	0.022	0.179	0.020

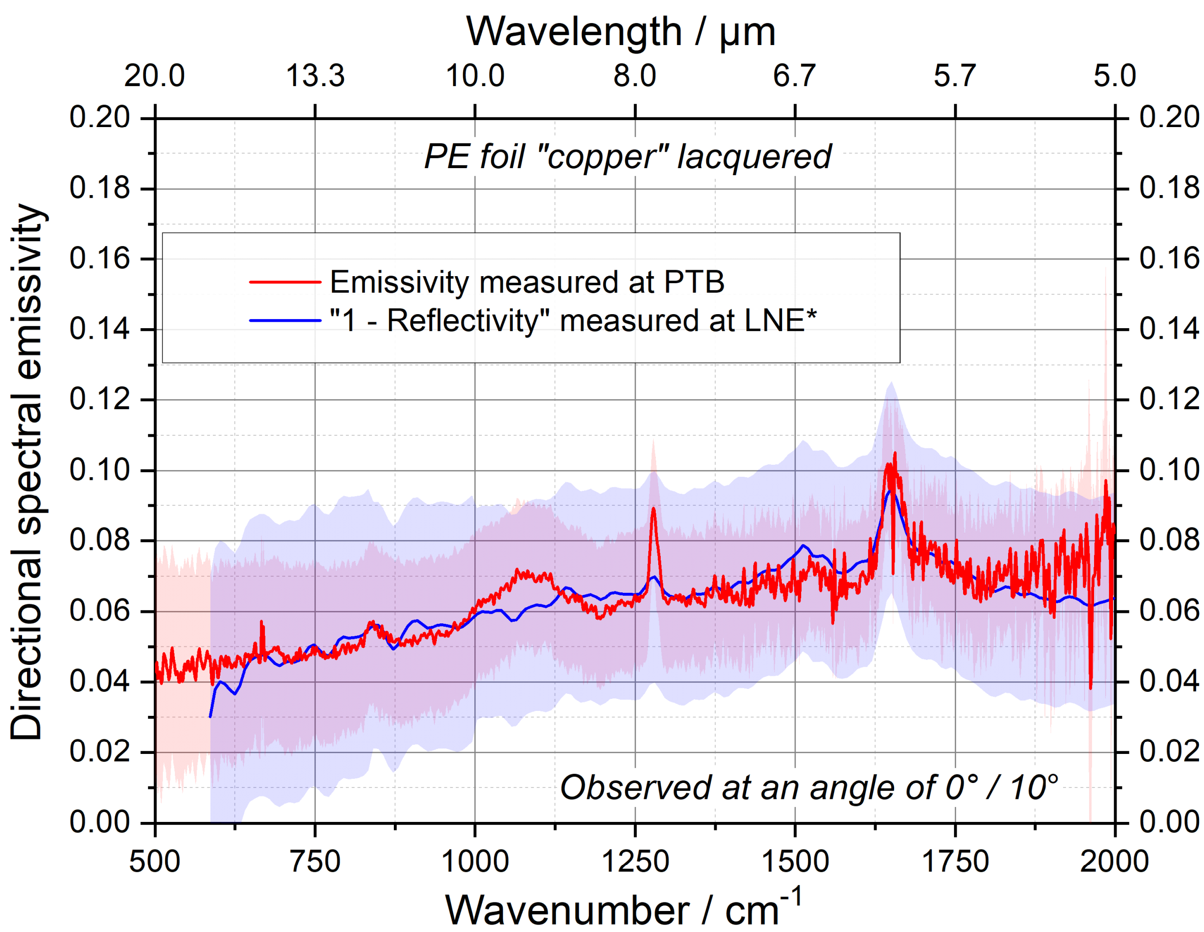
- *PTB has determined the emissivities of the foils*

Emissivity measurements of foils



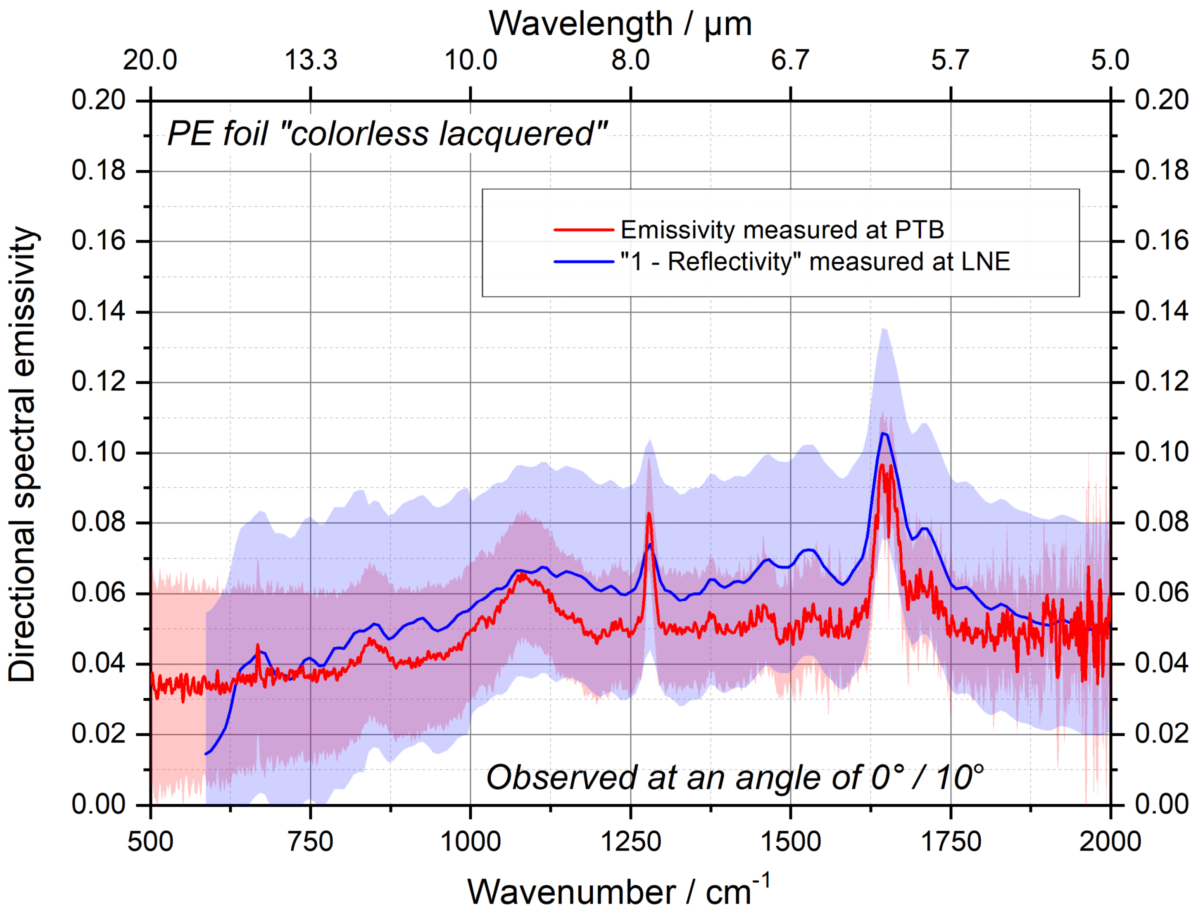
- *Very good agreement within the range of uncertainties*

Emissivity measurements of foils



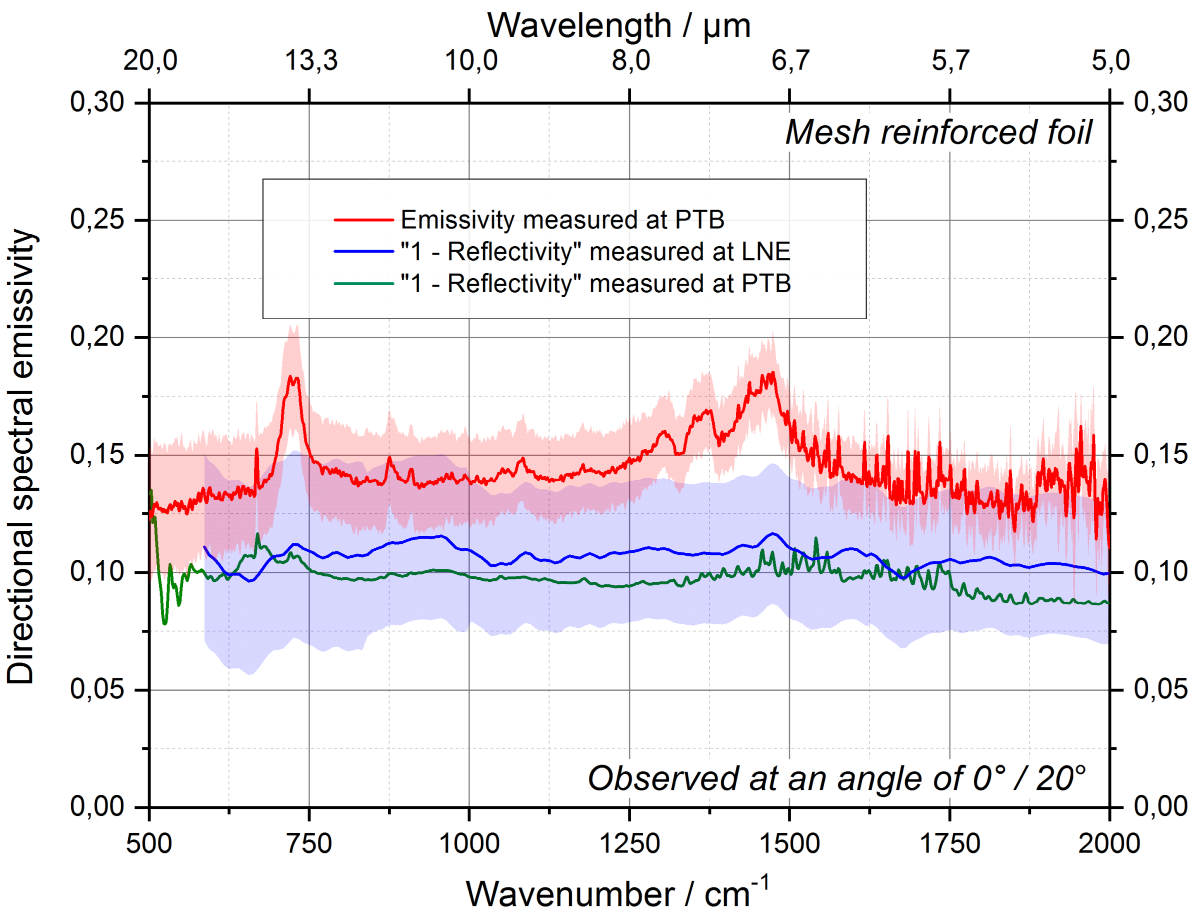
- *Very good agreement within the range of uncertainties*

Emissivity measurements of foils



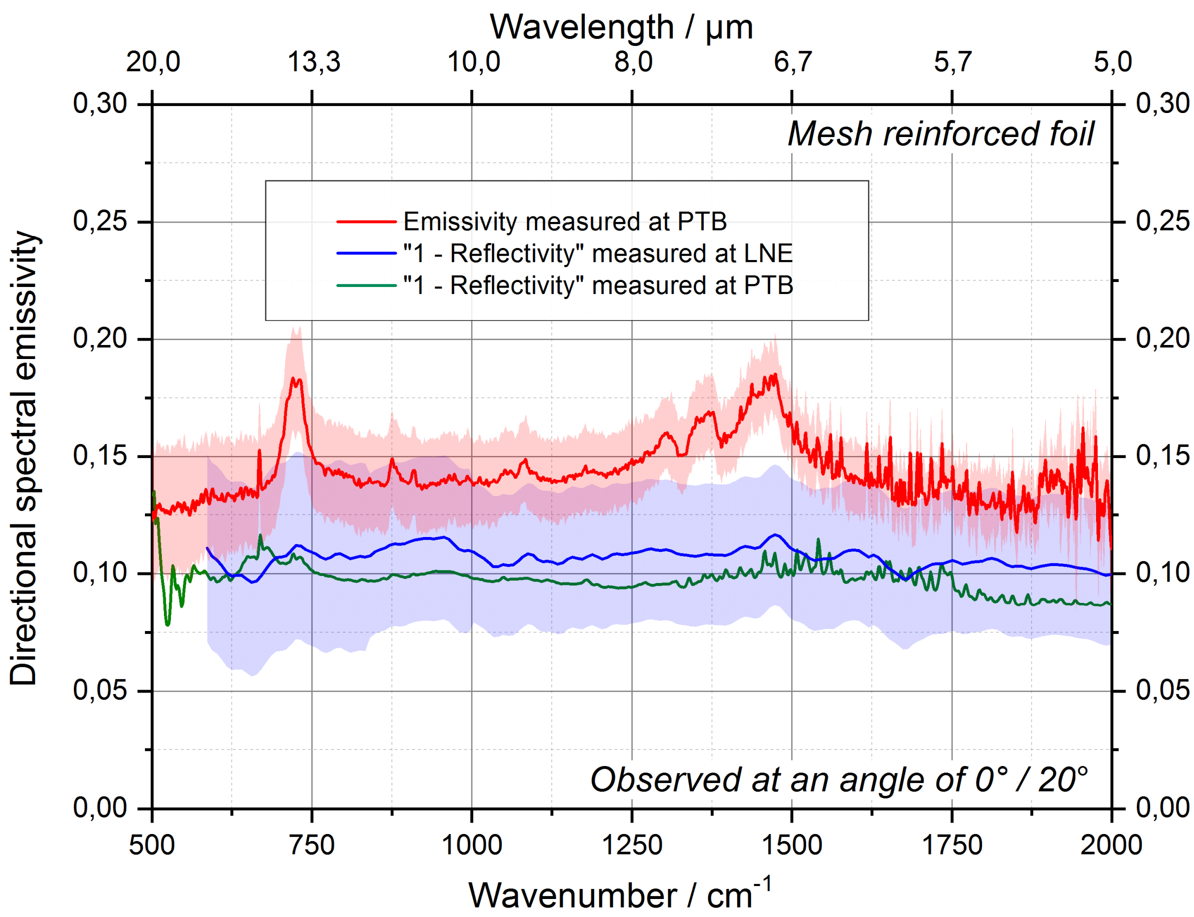
- *Very good agreement within the range of uncertainties*

Emissivity measurements of foils



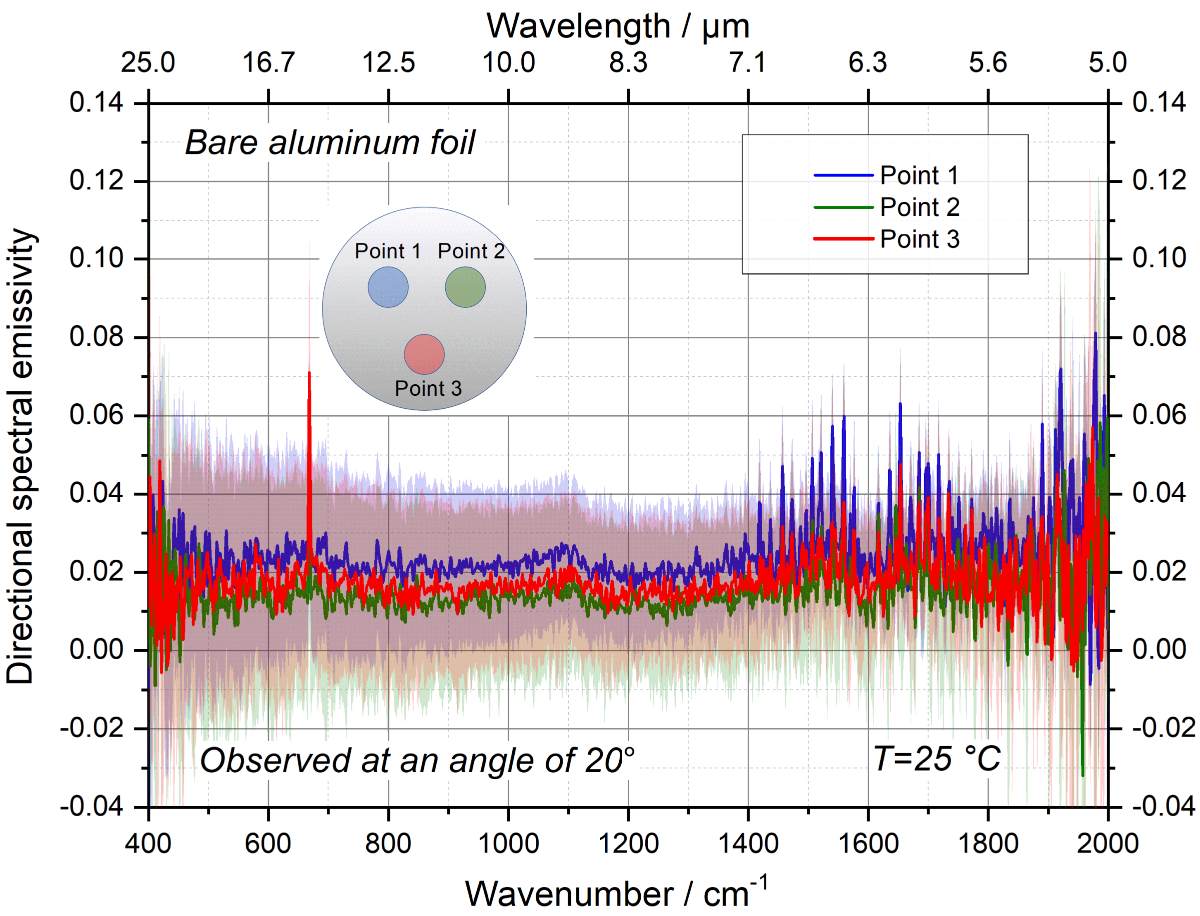
- *Very good agreement within the range of uncertainties*
- *Two spectral features in emissivity measurement of mesh foil*

Emissivity measurements of foils



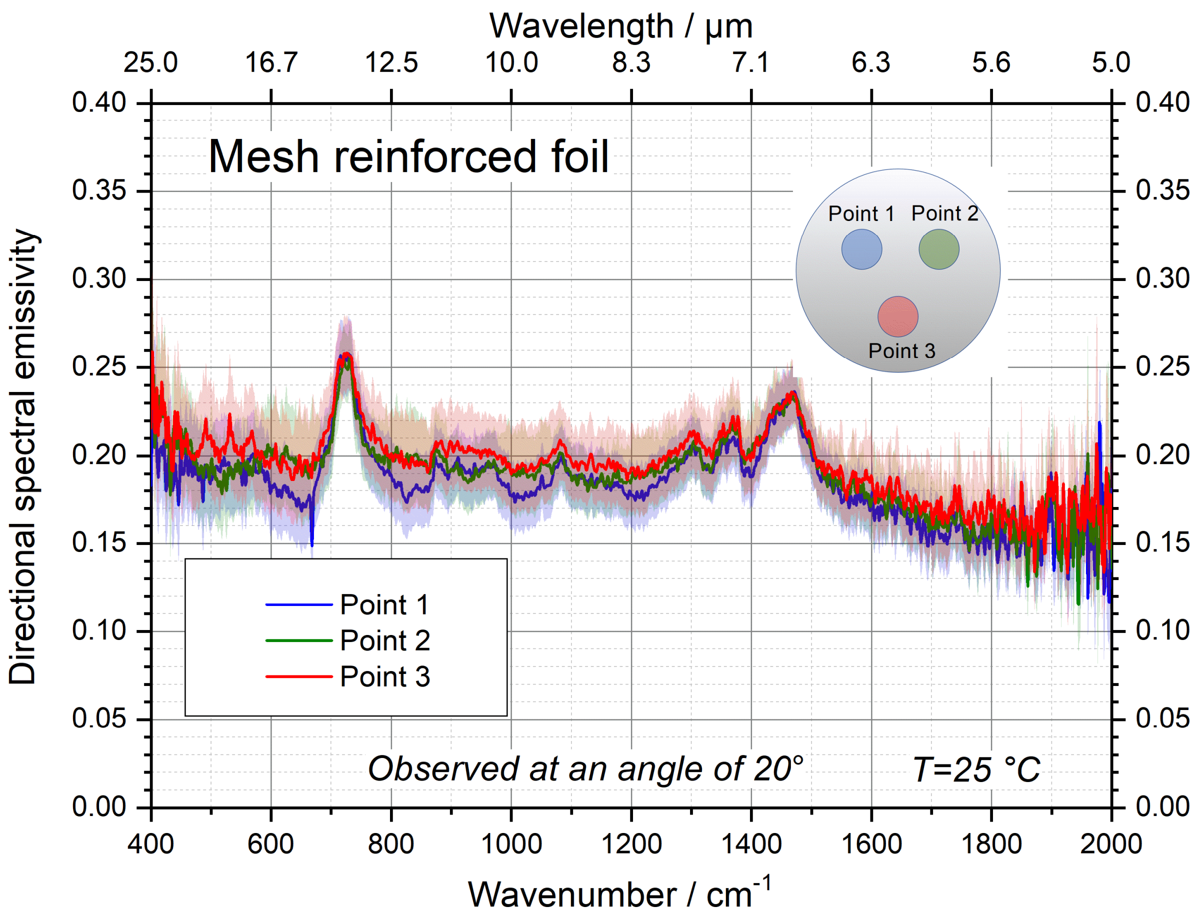
- *Very good agreement within the range of uncertainties*
- *Two spectral features in emissivity measurement of mesh foil*

Homogeneity of foils



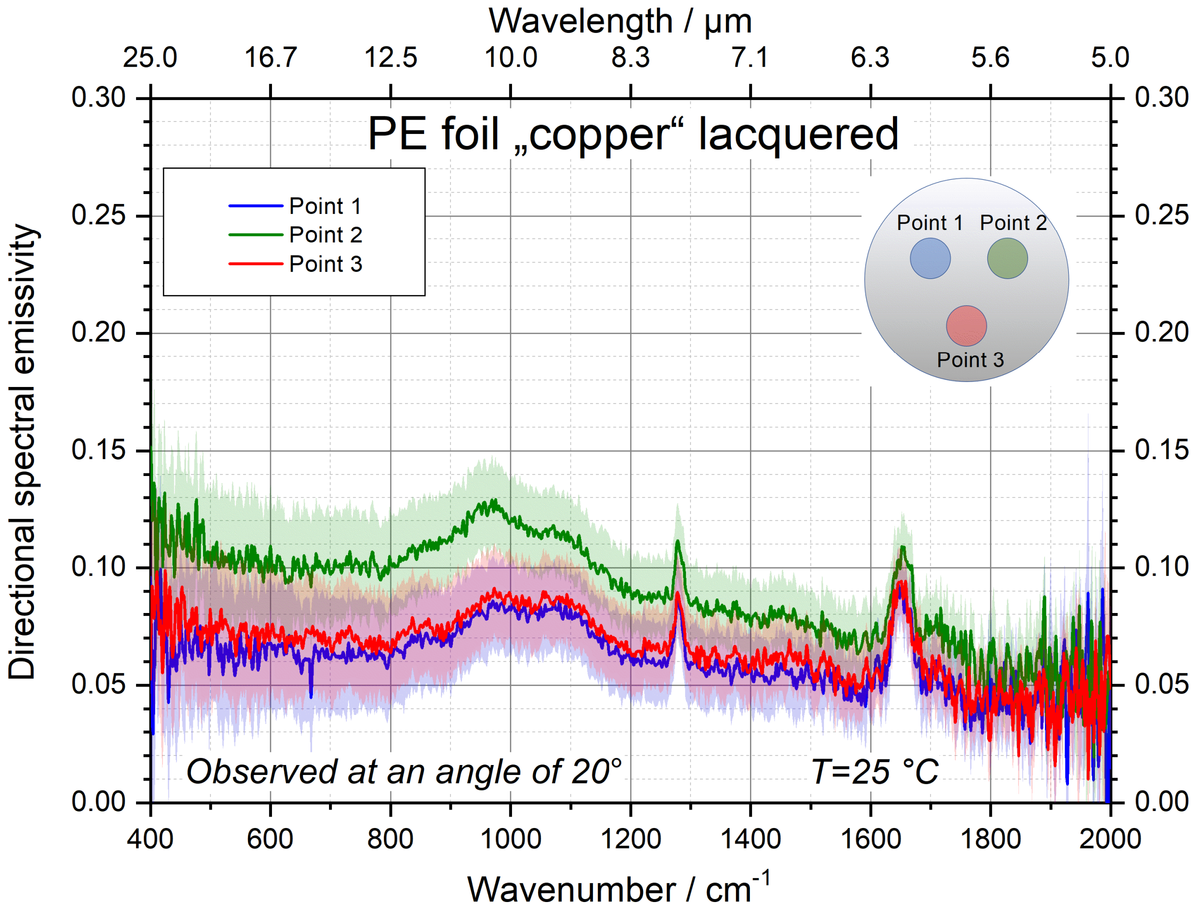
- *Good agreement of three measurement points within the range of uncertainty*

Homogeneity of foils



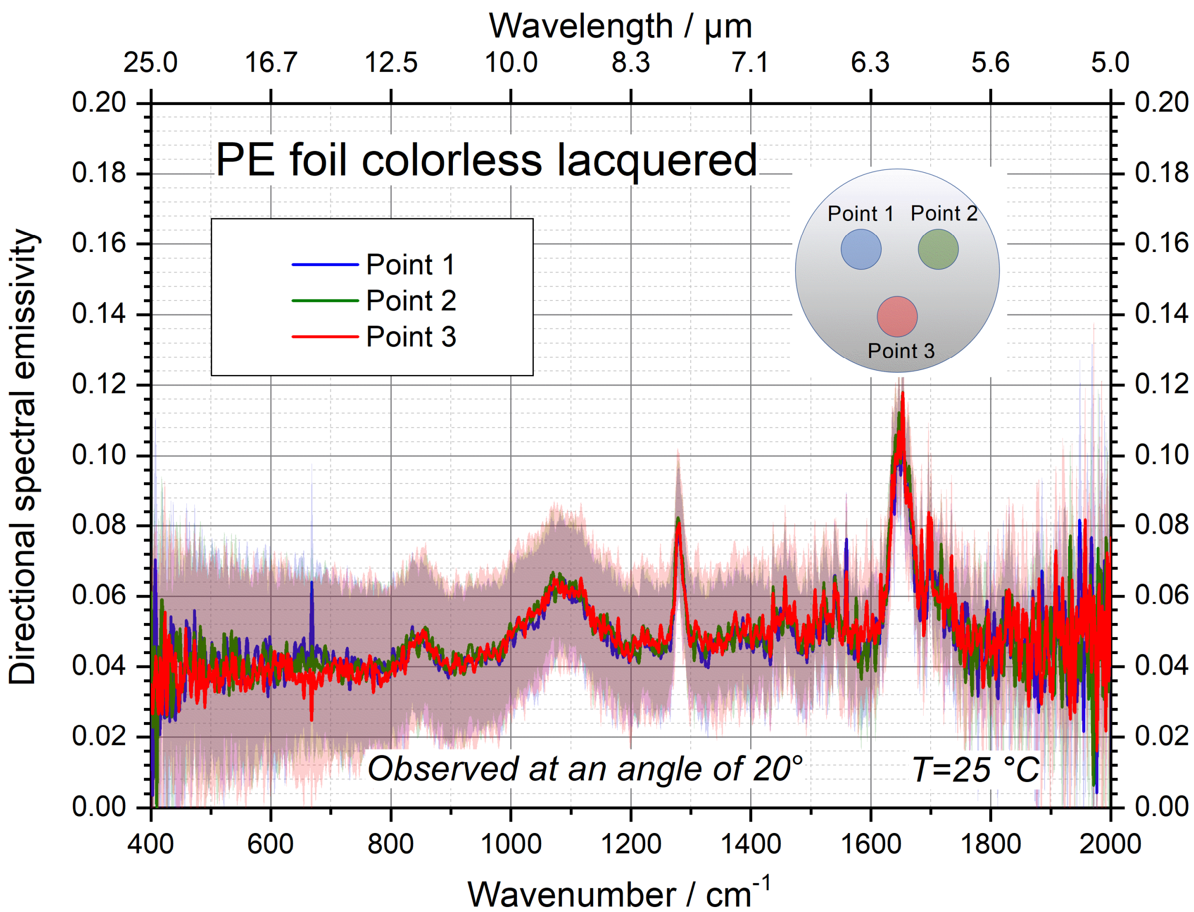
- *Good agreement of three measurement points within the range of uncertainty*

Homogeneity of foils



- *Good agreement of three measurement points within the range of uncertainty*

Homogeneity of foils



- *Good agreement of three measurement points within the range of uncertainty*