µBRDF measurements & traceability challenges

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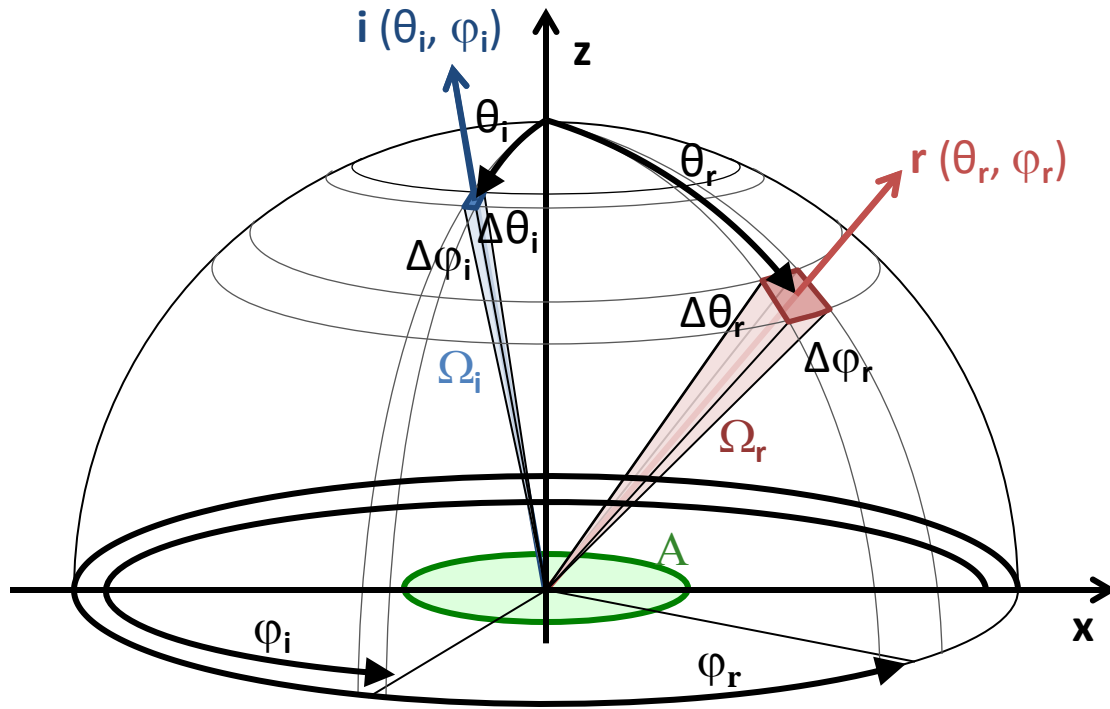
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Why measure Bidirectional Reflectance Distribution Function (BRDF, sr^{-1}) on very small areas ?

Scale of the measurement area ?

Fabric ⇔ ~1 cm

Thread ⇔ ~1 mm
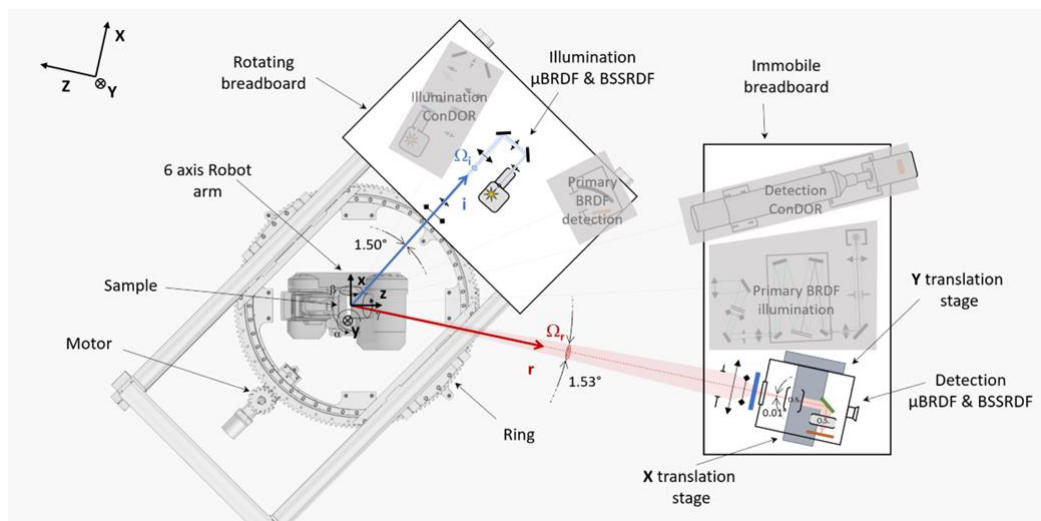
Fiber ⇔ ~1 µm

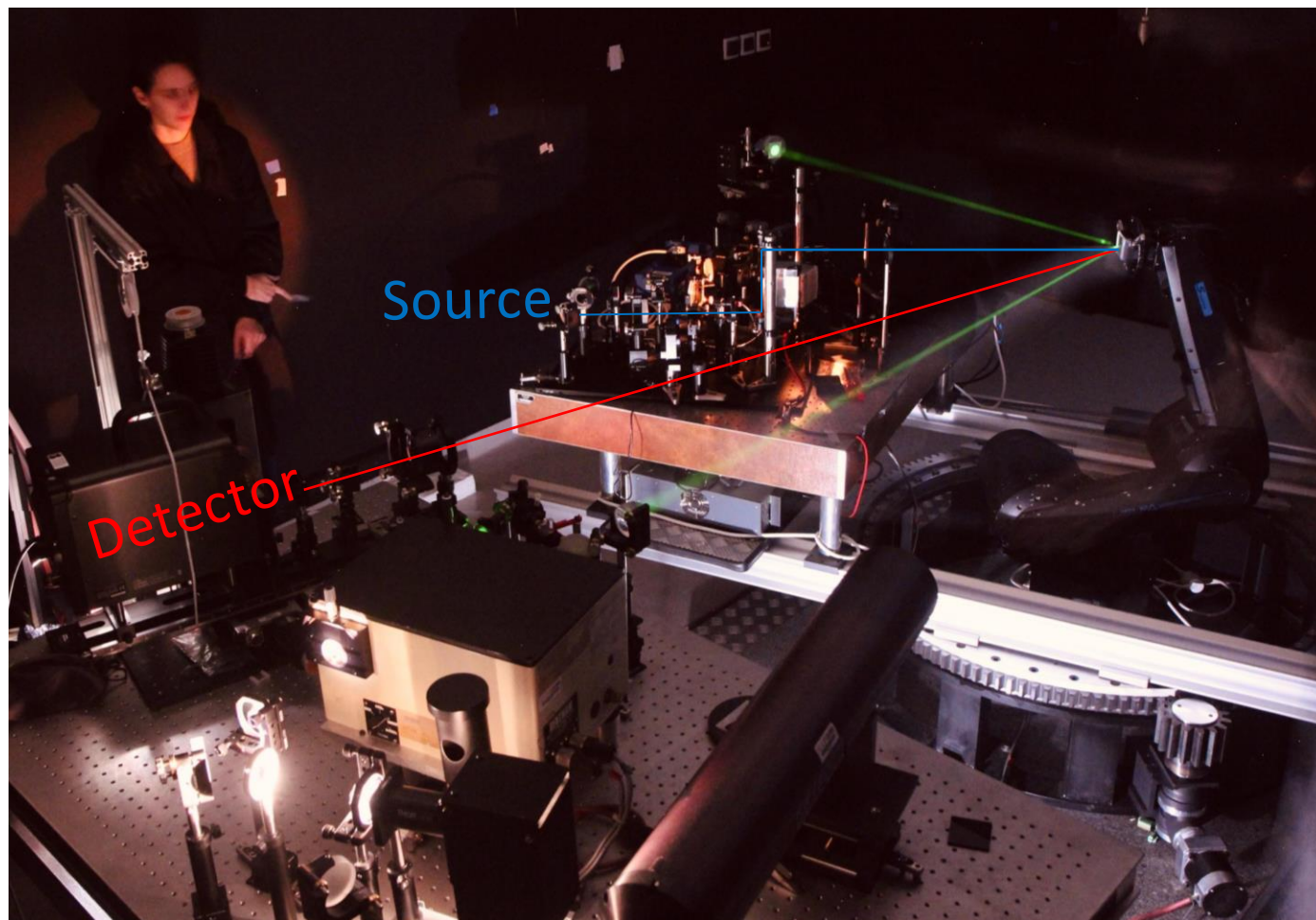BRDF [sr $^{-1}$] = $Radiance\_\mathbf{r}/Irradiance\_\mathbf{i}$
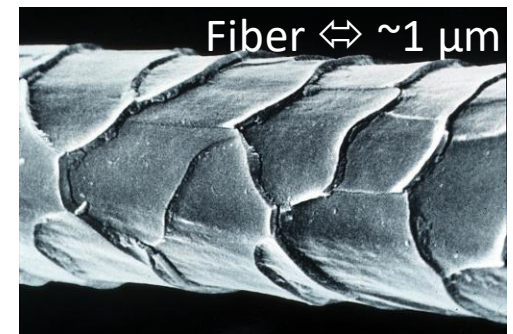
Presentation outline

➢ Setup for measuring µBRDF

➢ How can the setup be validated ?

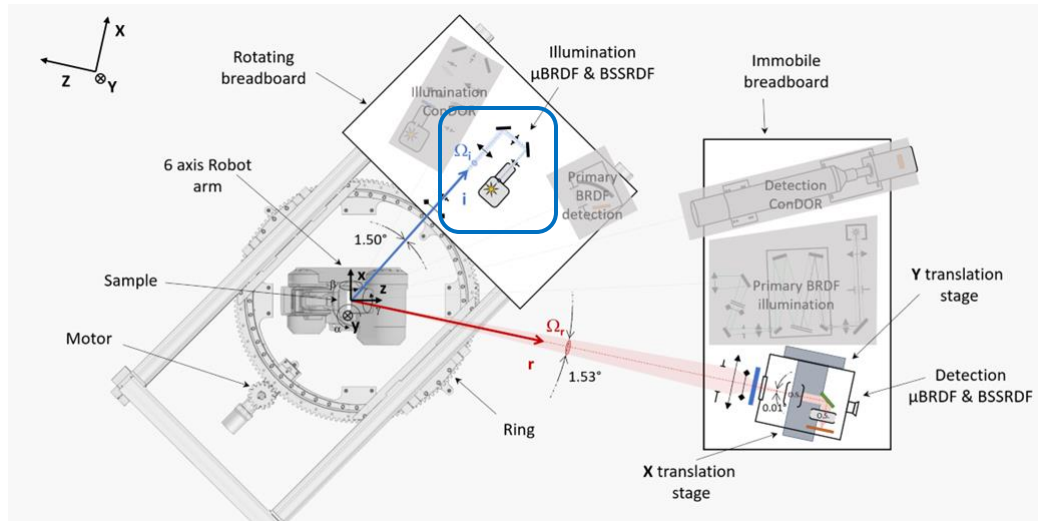➢ What solutions are there for establishing traceability ?

CNAM's goniospectrophotometer for measuring µBRDF

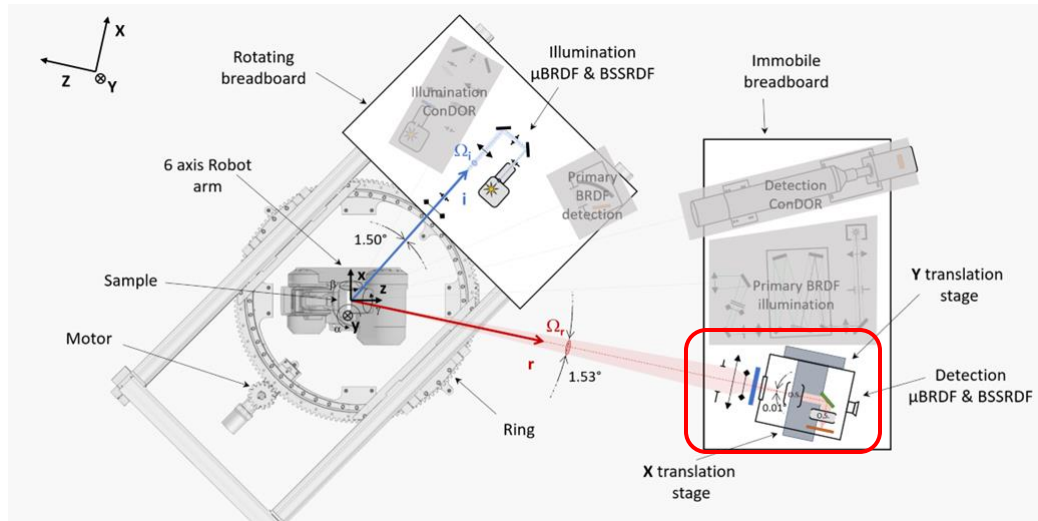CNAM goniospectrophotometer, top view, µBRDF line

CNAM's goniospectrophotometer for measuring µBRDF
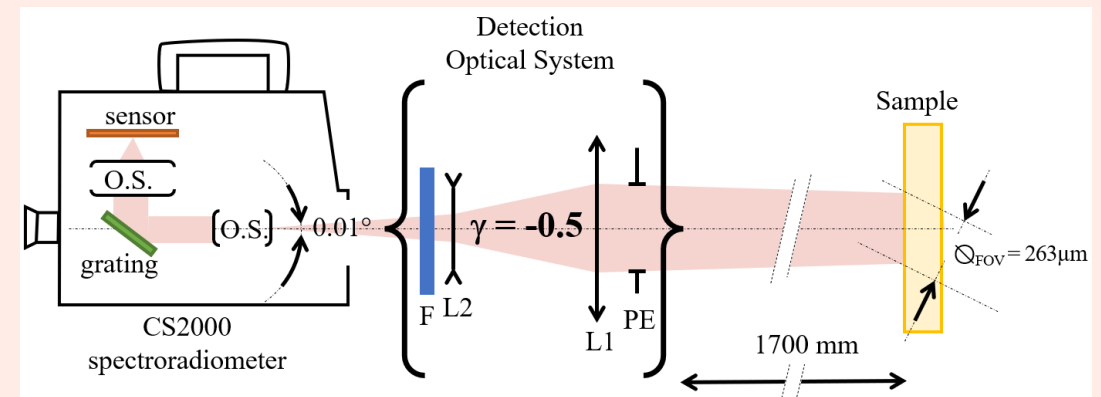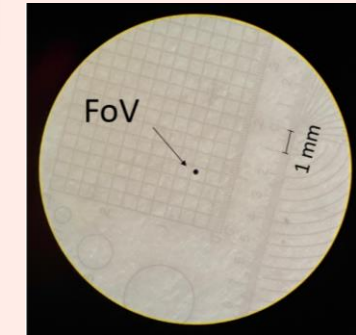

CNAM goniospectrophotometer, top view, µBRDF line
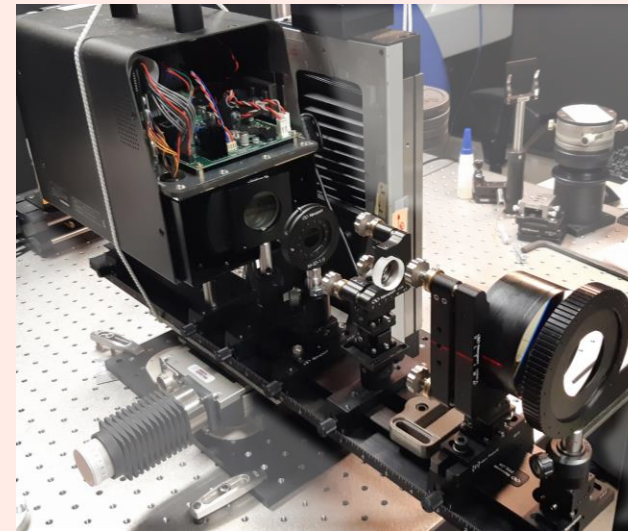
SOURCE UNIT

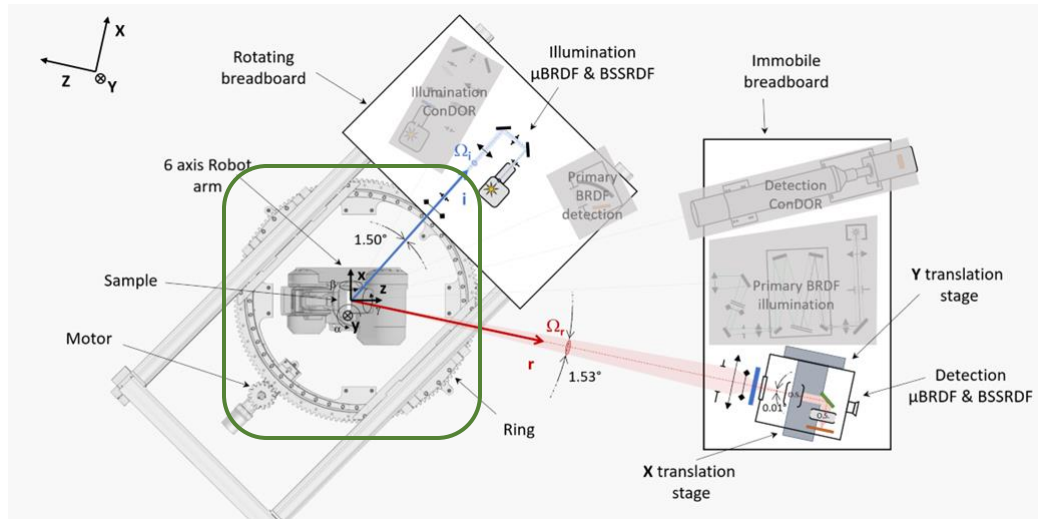# CNAM's goniospectrophotometer for measuring µBRDF

CNAM goniospectrophotometer, top view, µBRDF line

DETECTION UNIT

CNAM's goniospectrophotometer for measuring µBRDF

CNAM goniospectrophotometer, top view, µBRDF line

MECHANICAL ELEMENTS

- 6-axis robot arm

- Rotation ring

➢ Low tolerances on the setup alignment and sample alignment for µBRDF measurements

➢ Absolute measurements

Validation of the µBRDF setup ?

Sintered PTFE diffuser

Geometry	BRDF (primary gonio)	µBRDF
In plane, 0°:10°	0.33 sr⁻¹	

Sintered PTFE is translucent at the submillimeter scale (edge loss effect)
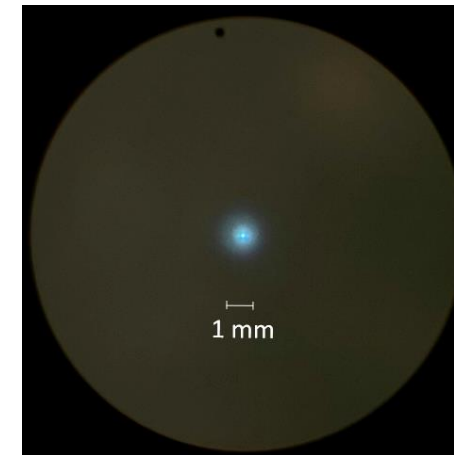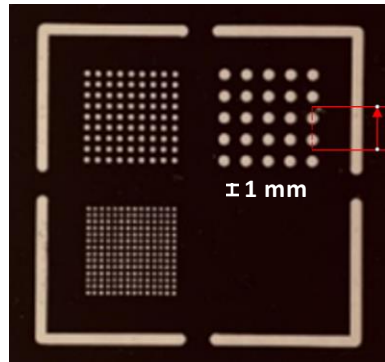
➔ BSSRDF measurement required

Photo taken through the spectroradiometer eyepiece. Spectralon illuminated by the µbeam.
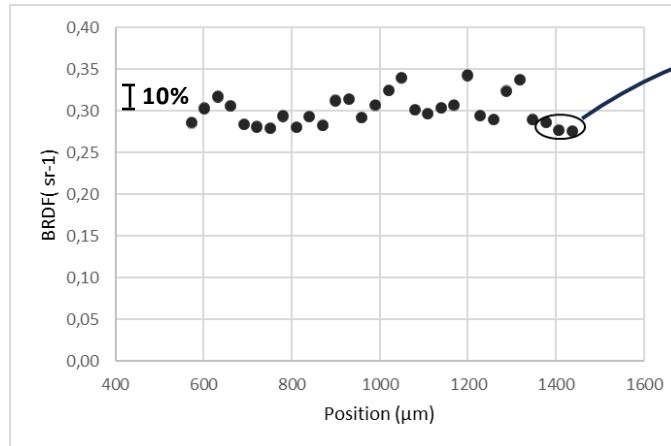
[Gevaux, Applied Optics 2023]

Validation of the µBRDF setup ?

White resin sample

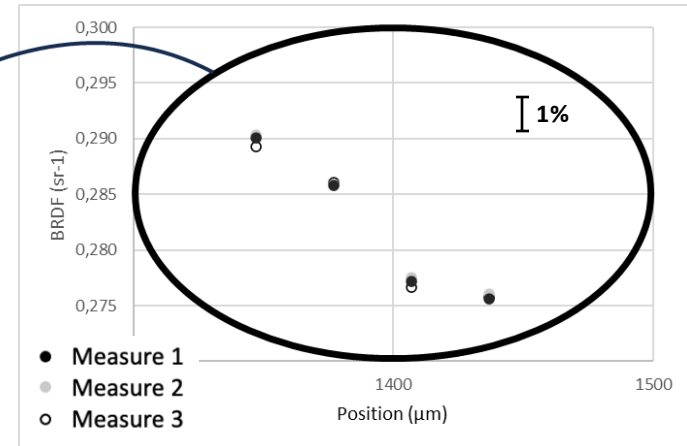µBRDF measurements along a line (in plane, 0°:14°)

I 1 mm

Polyurethan resin + TiO2
= white diffusing sample
as opaque as possible

Mean value: 0.30 sr⁻¹

Repeatability

➔ Issues with surface roughness
- spatial non-uniformity
- high uncertainty for reproducibility

µBRDF measurements traceability ?

First solution: Find a 'perfect' reference sample ?

➢ Not translucent : metallic or silicon reflector ?

➢ Surface with constraints on the roughness:
Roughness << Beam size
**&**
avoid coherence effects

DG10-120-P01
120 Grit

Metallic diffuse reflector

10

µBRDF measurements traceability ?

Second solution: Use a camera-based goniospectrophotometer ?

➢ Possibility of averaging µBRDF measurements on a large area

➢ Overfilled configuration rather than underfilled configuration (Are they equivalent?)

➢ Complex calibration for camera-based systems, especially for absolute measurements (issues with dynamic range and stray light)
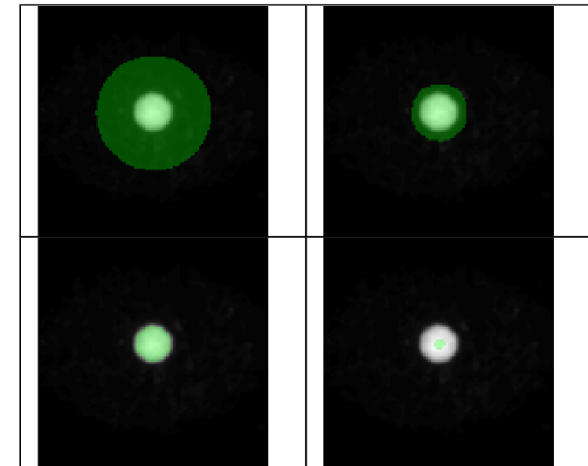
Example of camera-based BRDF measurement, with the option of measuring an area of different size (green selection) by averaging the results for each pixel. [Courtesy of N. Basic, METAS]

Thank you !

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