

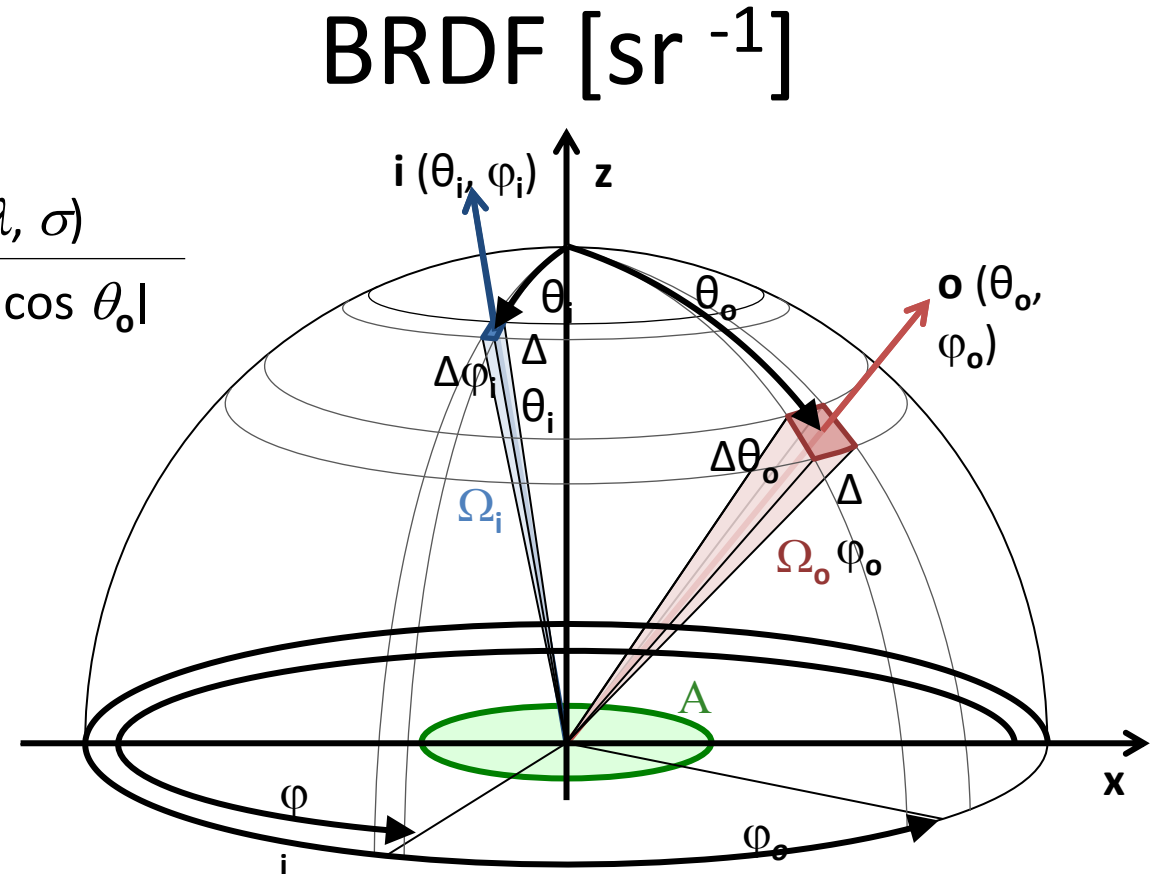
Multiscale and small size BRDF measurements WP1 – BRDF

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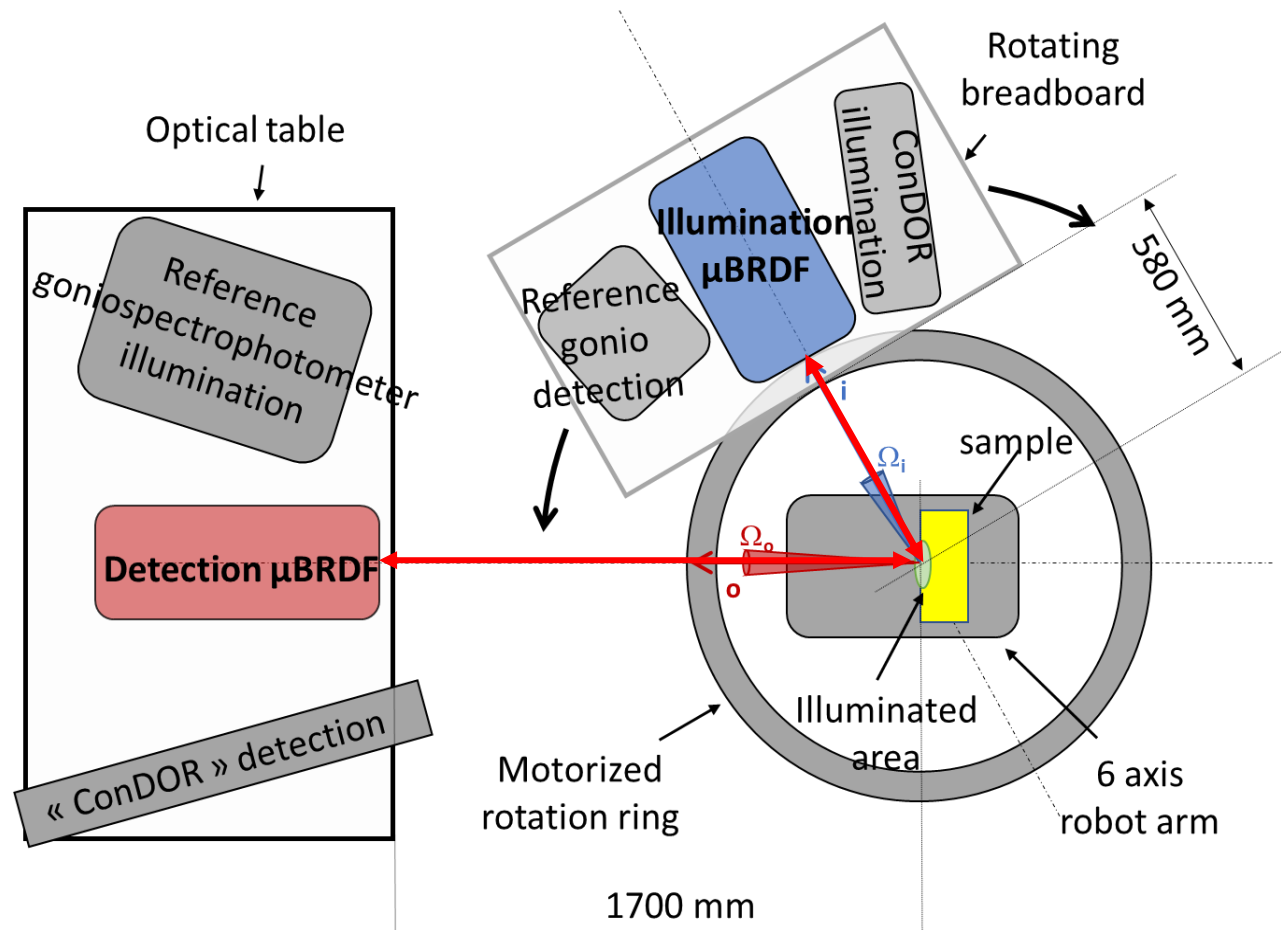
Objectives

$$\rho(\theta_i, \varphi_i, \theta_o, \varphi_o, \lambda, \sigma) = \frac{\Phi_o(\theta_i, \varphi_i, \theta_o, \varphi_o, \lambda, \sigma)}{\Phi_i(\theta_i, \varphi_i, \lambda, \sigma) \cdot \Omega_o \cdot |\cos \theta_o|}$$

- Visible bandwidth, $380 \text{ nm} < \lambda < 780 \text{ nm}$
- In any direction of the hemisphere
- Angular resolution $\Delta\theta < 2^\circ$
- Spectral bandwidth $\Delta\lambda < 3 \text{ nm}$
- **Over a surface A with of diameter $\varnothing < 100\mu\text{m}$**

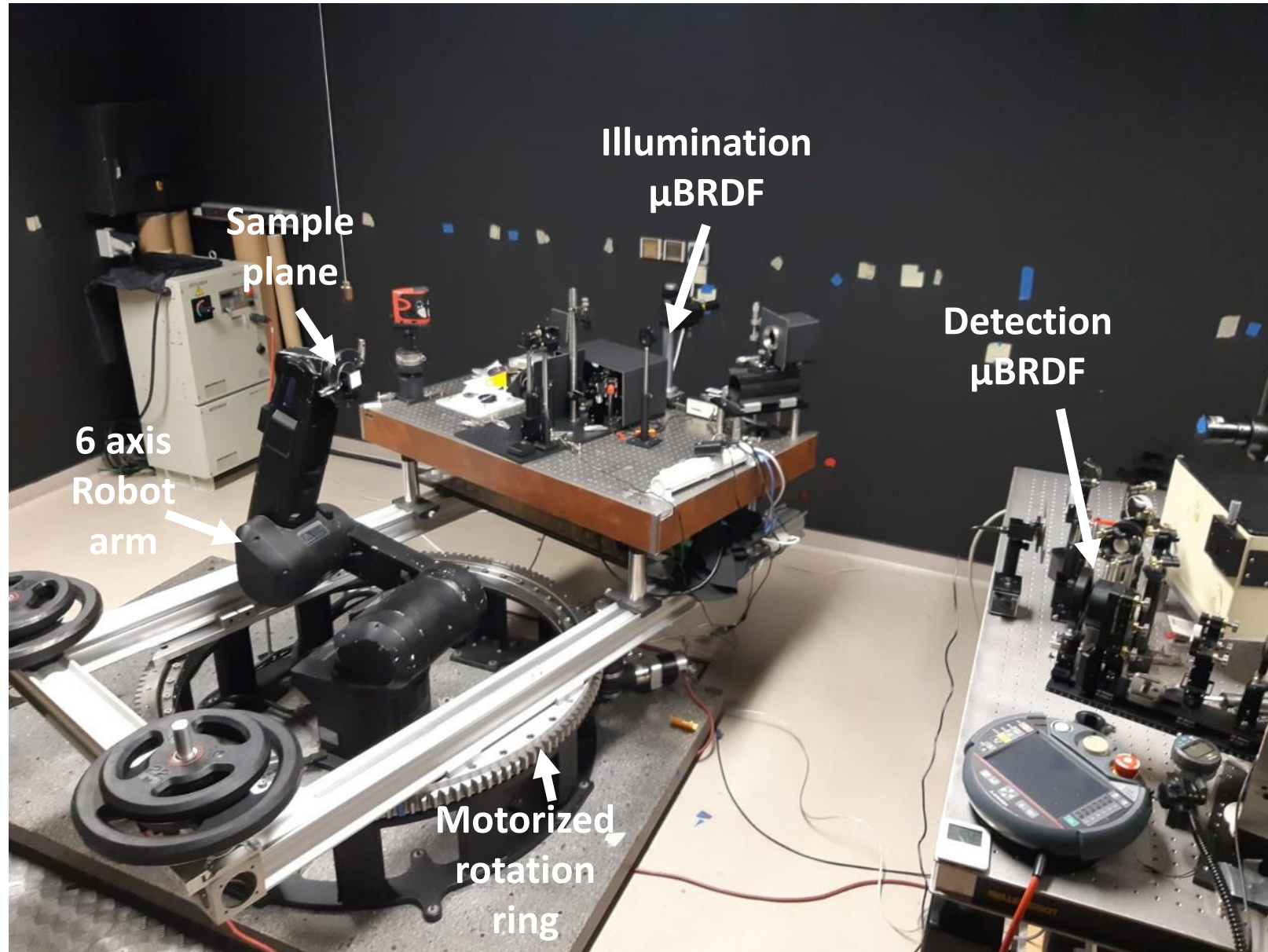


Design of the μ goniospectrophotometer

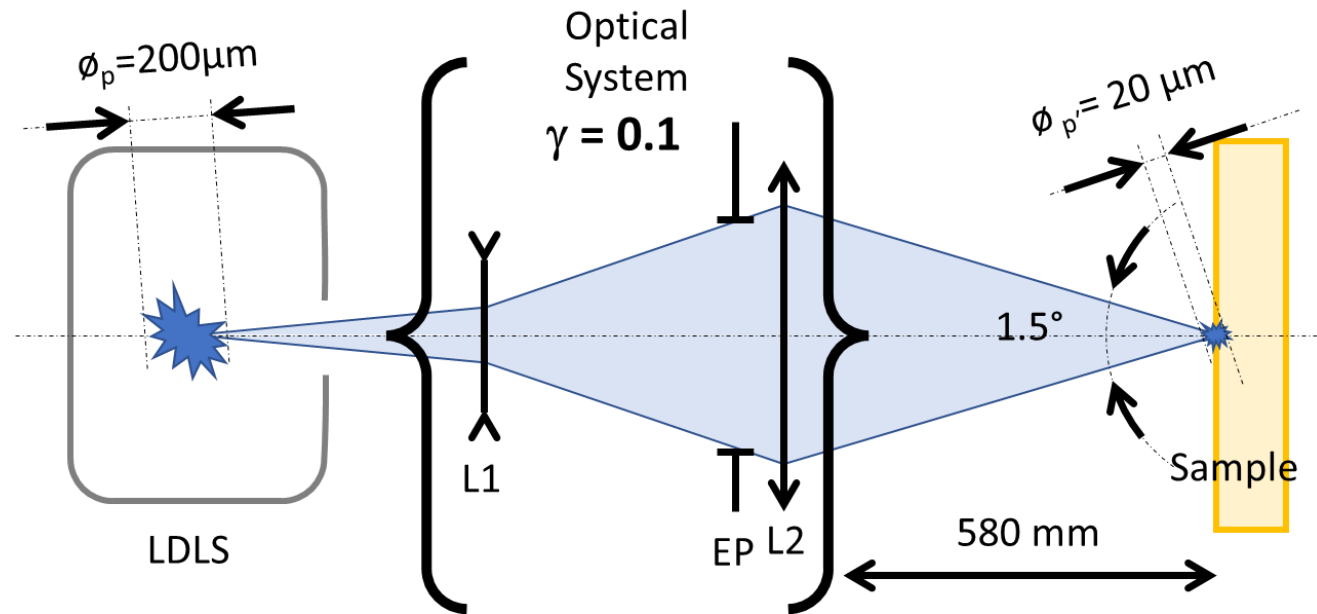


- A mobile illumination system embedded on a 1 m diameter ring
- A 6-axis robot as sample holder
- An immobile detection

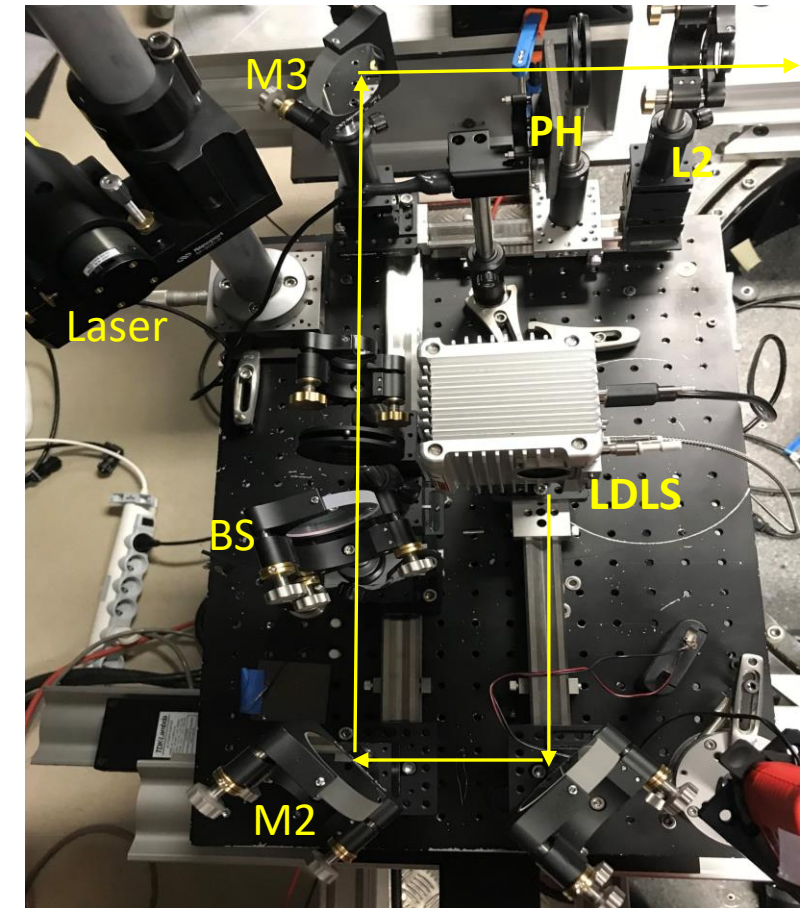
Image of the System



Illumination system

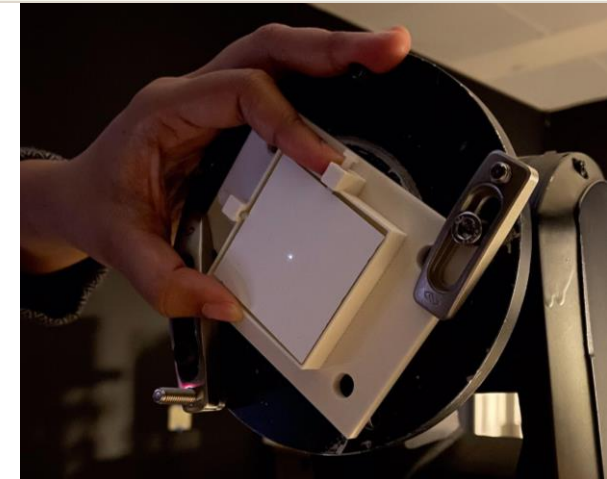
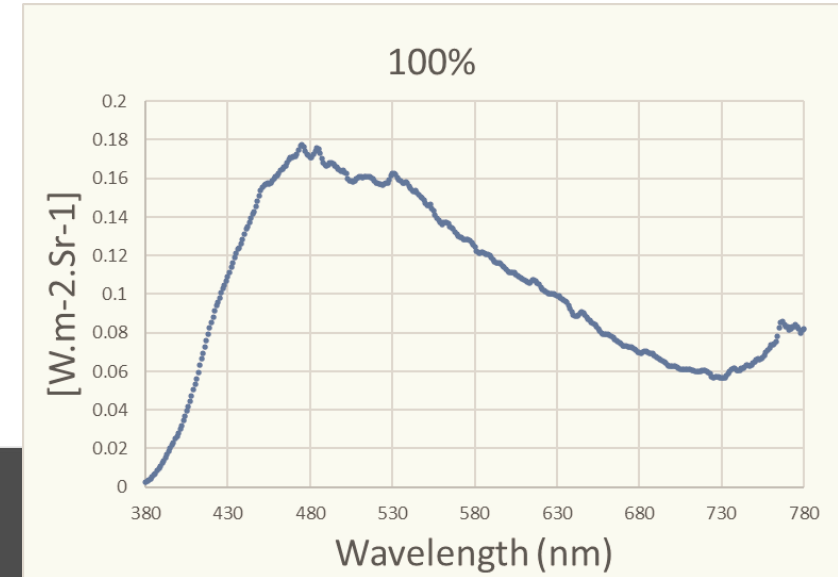
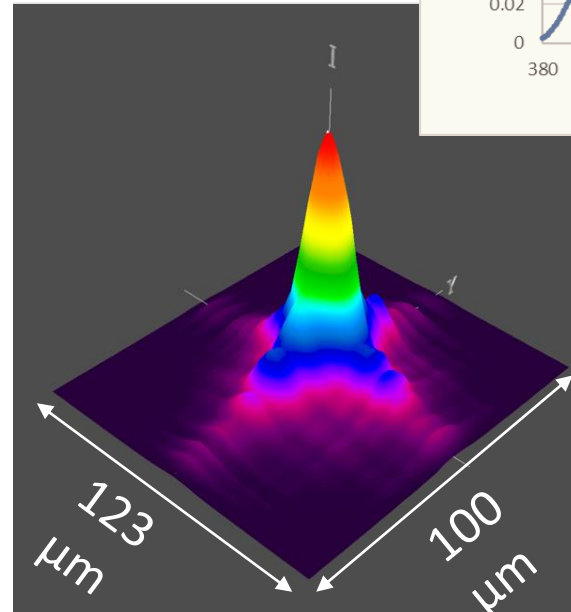


- Achieve an illumination area on the sample below $100 \mu\text{m}$
- Magnification of $1/10$
- The convergence angle is 1.5° to maximize the flux in the system while angular resolution is of 2° maximum.

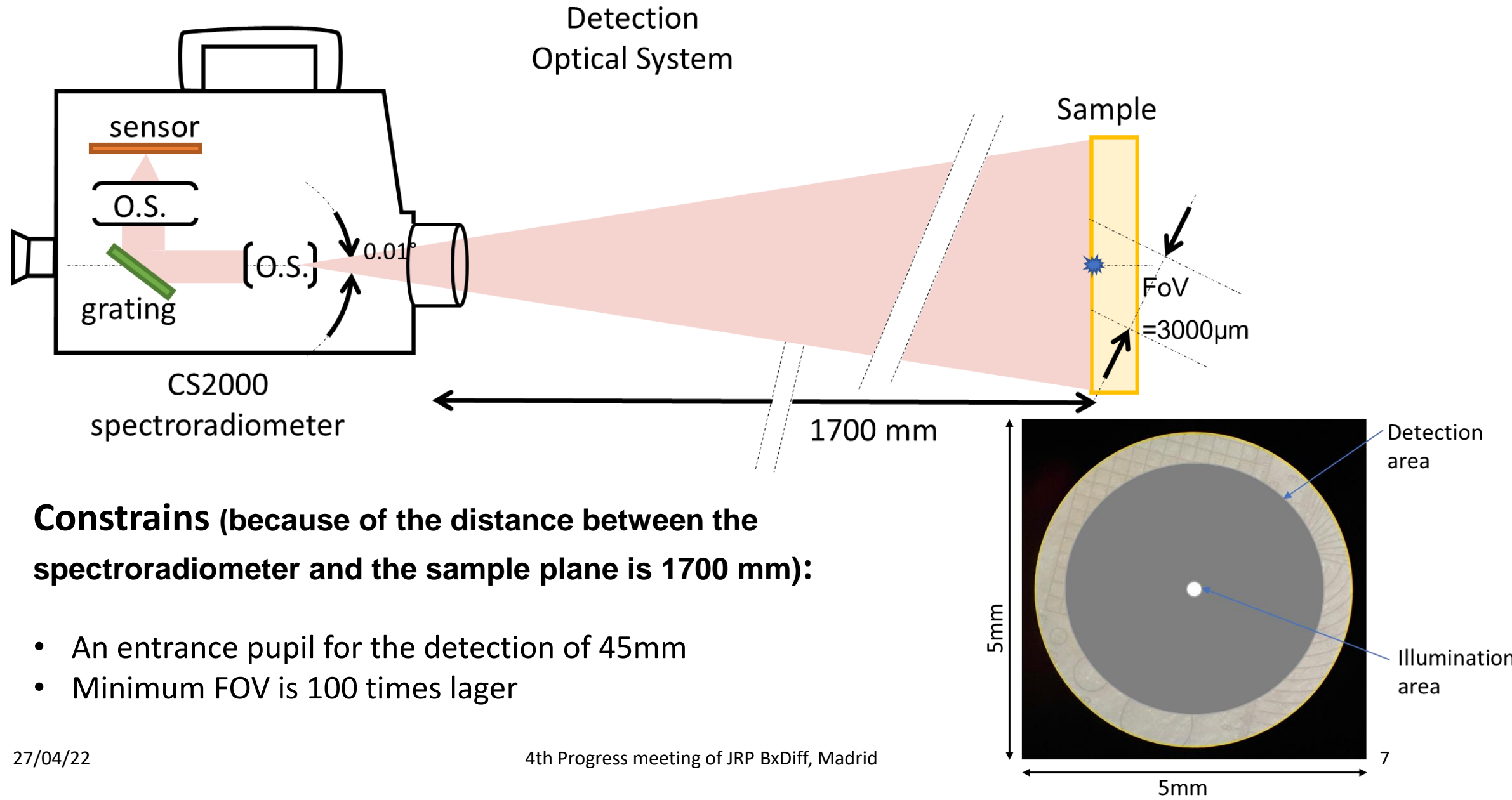


Characterisation of the beam

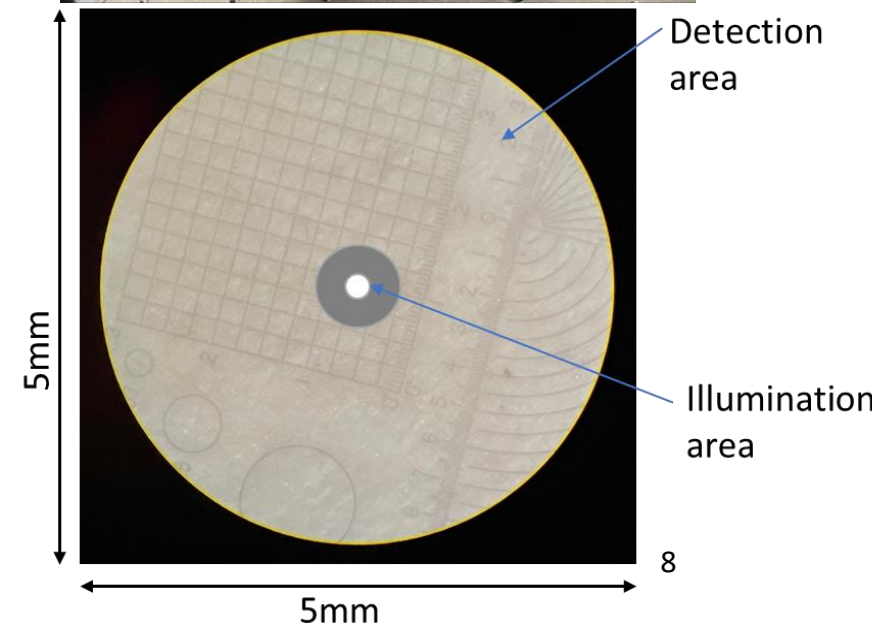
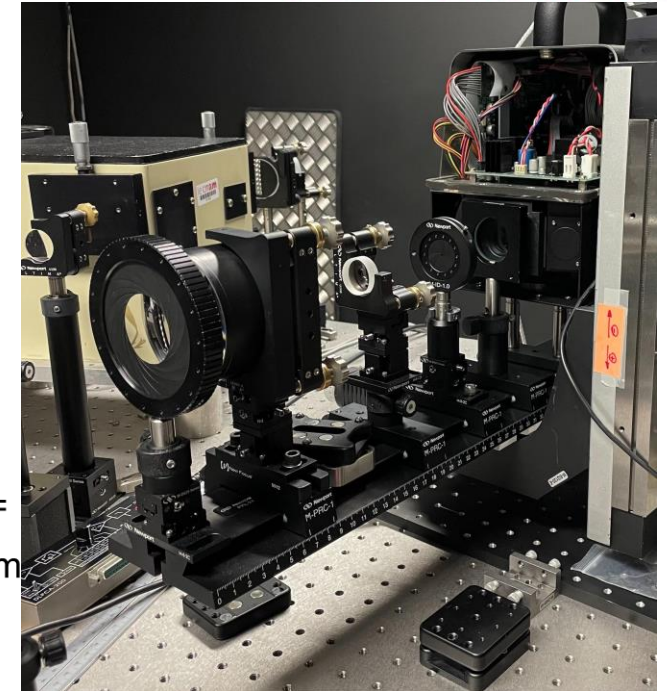
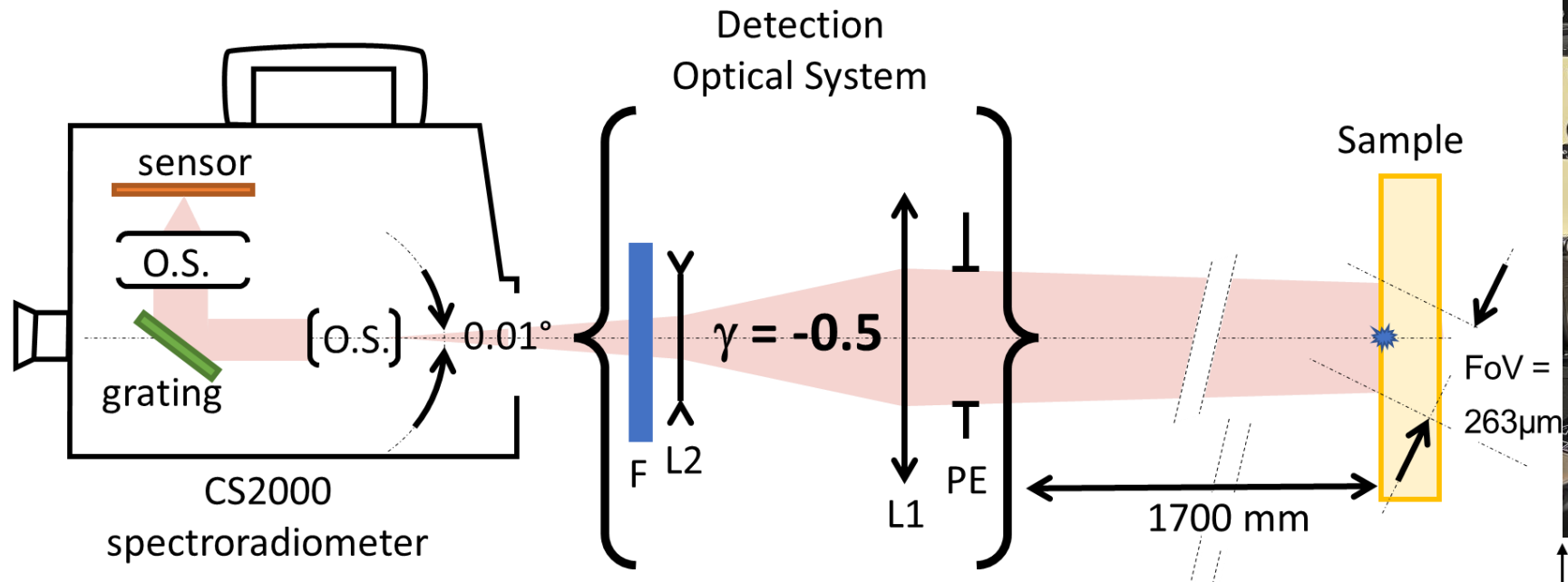
- An incoherent broadband beam
- Scanned by a slit beam-scanner from OPHIR NanoScan, which measures and analyses the spatial profiles of the beam power with a resolution of 10 nm.
- HWFM of the beam spot 27 x 29 μm .
- The beam power of that elliptical spot is 95%.



Conventional Detection System



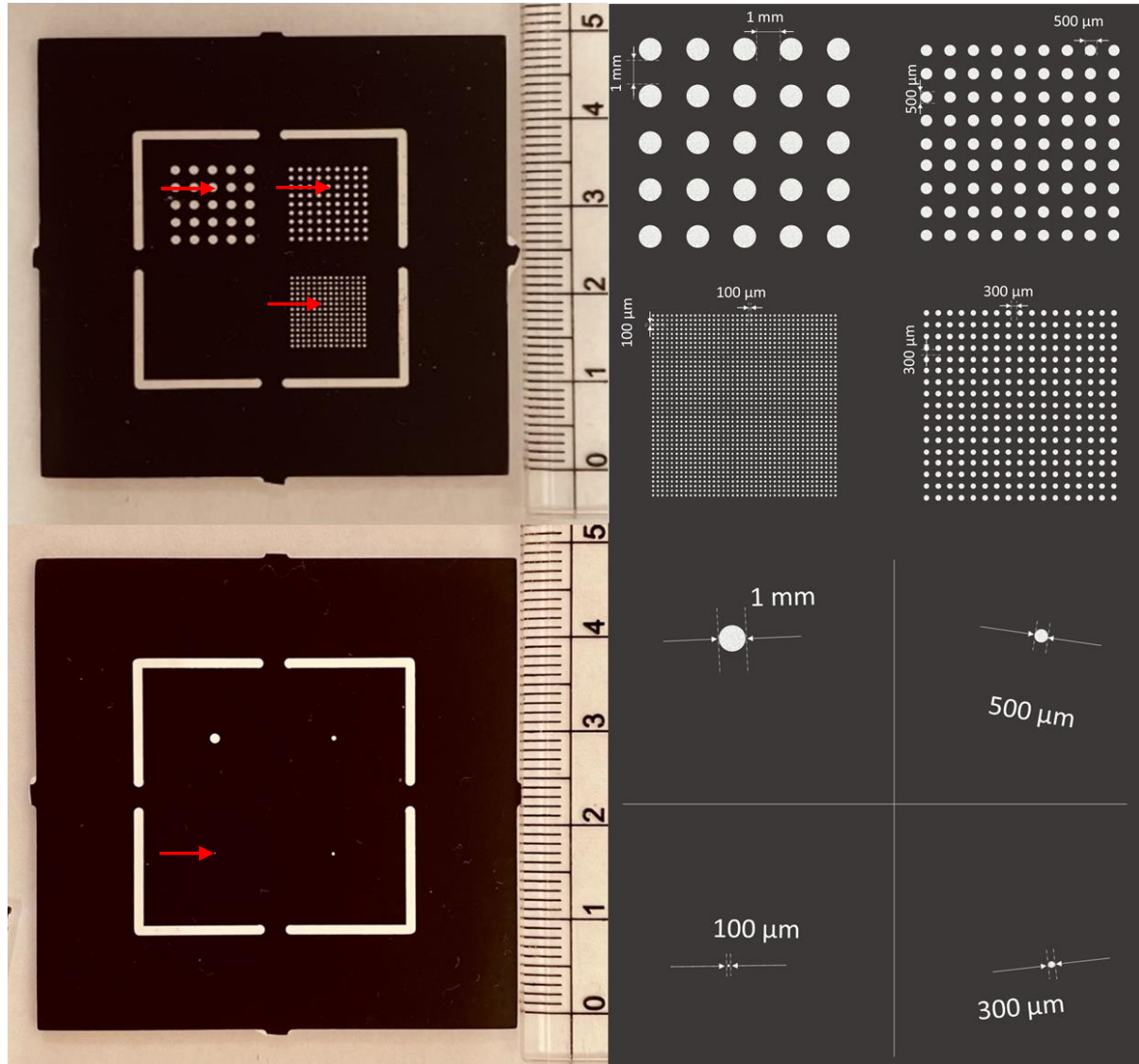
Customised Detection System



Solutions

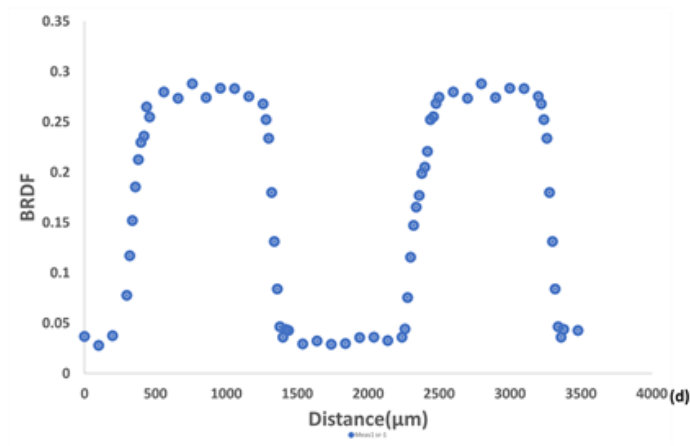
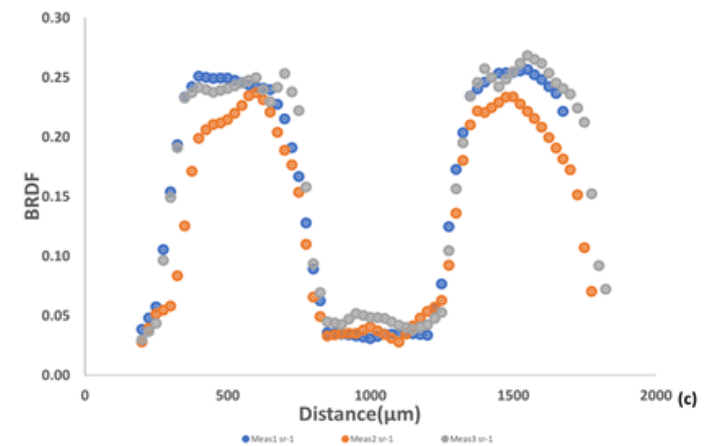
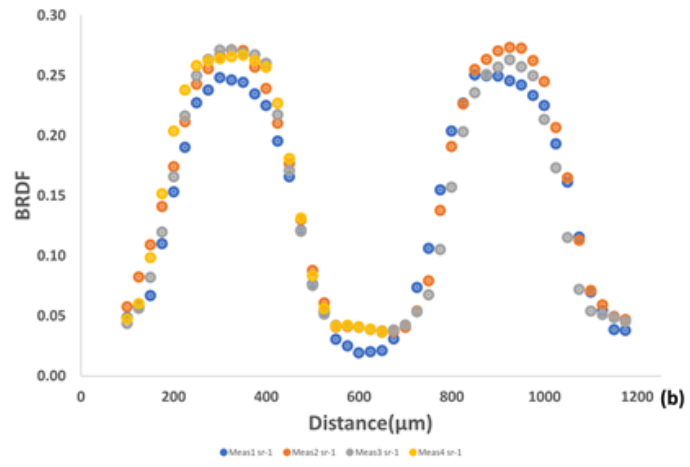
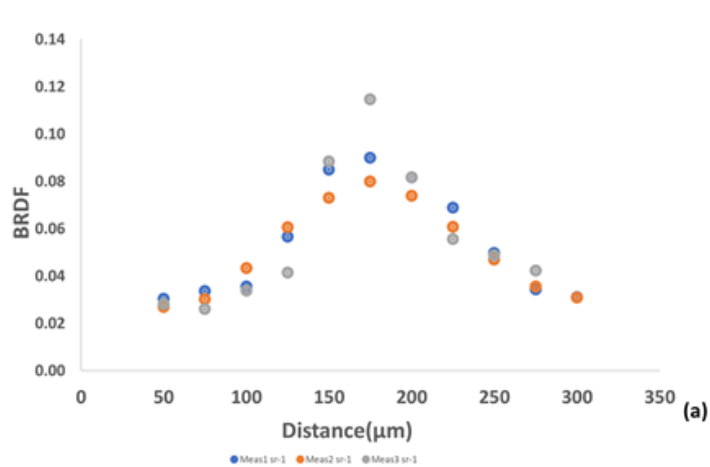
- FOV is only 10 times larger
- Enough flux acquisition for measurement

Sample



- First validation attempt with spectralon didn't work. We got translucent effect on spectralon so we can't validate this system by comparing with classical gonio data.
- Background: glossy black plexiglass (PMMA) of 1 mm thickness
- Dots: white resin which consists of polyurethane resin and titanium dioxide powder
- polished with grit 180 sandpaper
- Scanned illumination beam over the dots.

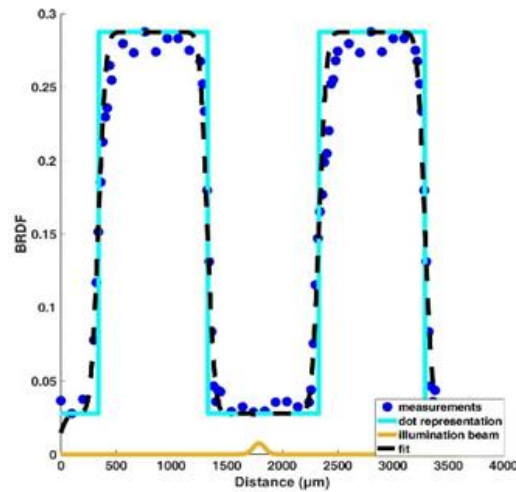
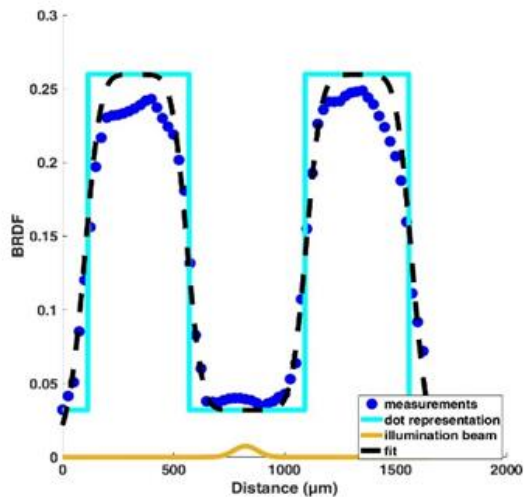
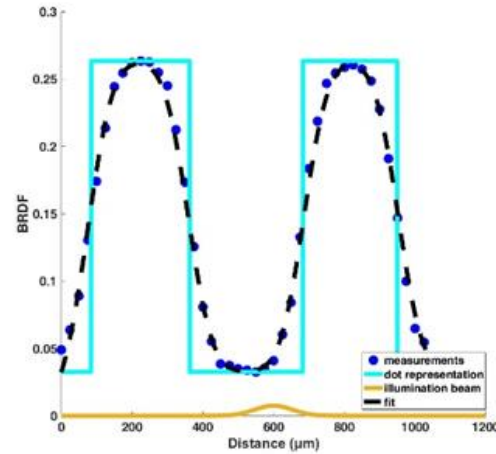
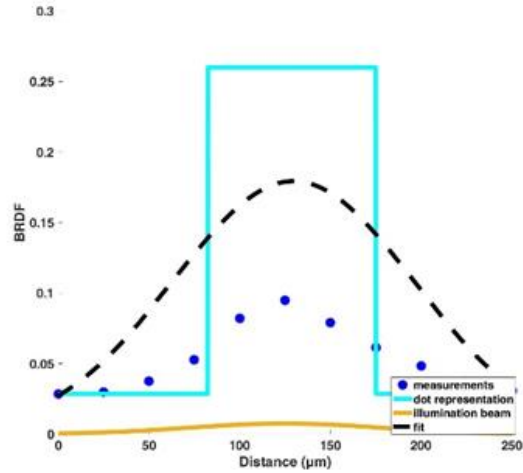
μ BRDF measurements



Angular configuration : $0^\circ/15^\circ$

Dot size	measurement points	Measurement time (by point)	Total time
100 μm	20	8 mins	160 min
300 μm	46	7 mins	322 min
500 μm	64	7 mins	448 min
1000 μm	88	7 mins	616 min

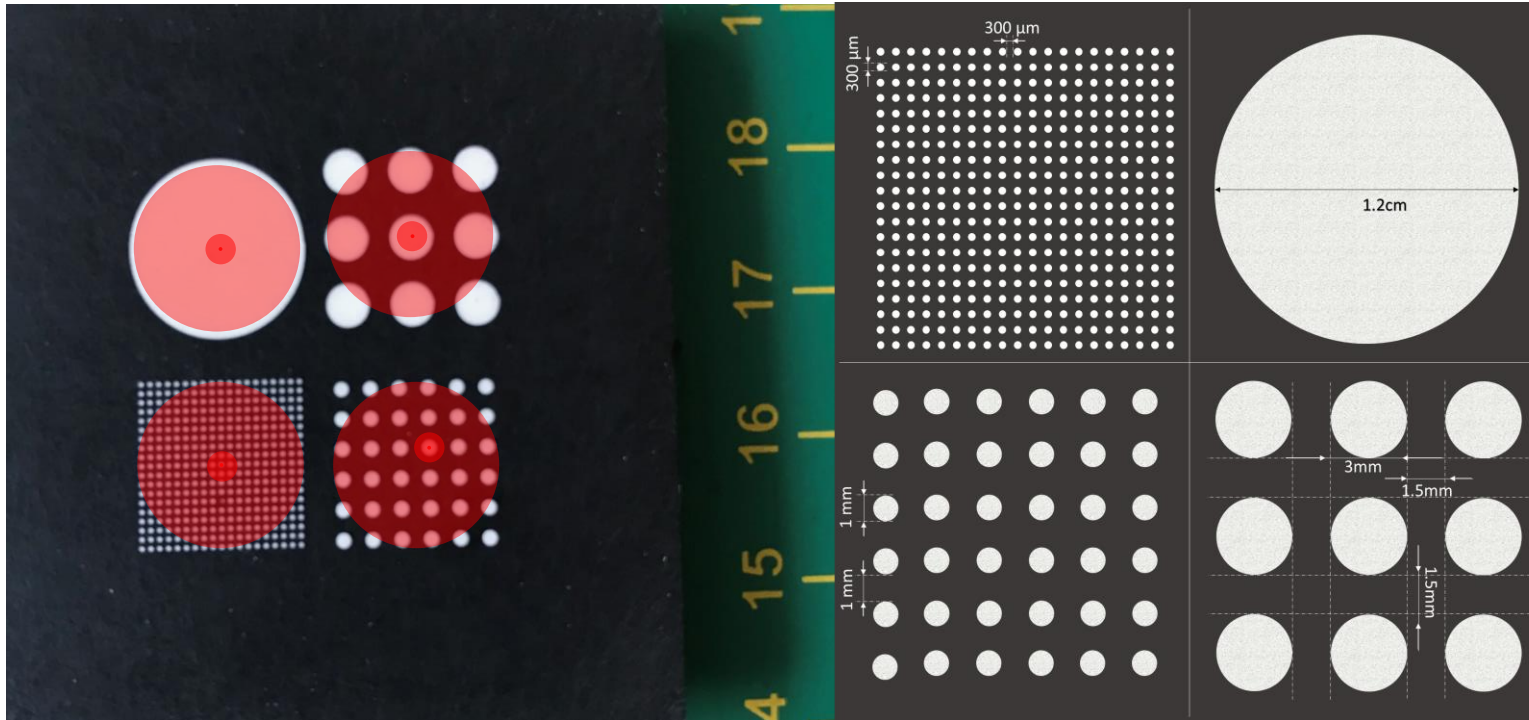
Model based validation



Sample (dots)	Translation (z_0)	Tilt (g_0)	Reflectance of background (r_b)	Reflectance of dots (r_w)	SD of beam (s)
100 μm	0 μm	0 rad	0.03	0.1	47 μm
300 μm	51 μm	0.02 rad	0.03	0.26	54.4 μm
500 μm	107.4 μm	-0.01 rad	0.03	0.25	50.5 μm
1000 μm	-131 μm	0.1 rad	0.03	0.28	57 μm

Sample	Correlation coefficient
100 μm dots	0.95
300 μm dots	0.99
500 μm dots	0.99
1000 μm dots	0.98

Future Work



Multiscale measurements:

- Dot sizes: 300 μ m, 1mm, 3mm and 1.2 cm
- Beam size: 1cm, 2mm and 53 μ m
- Gonio: Spectral line and μ BRDF
- Angular configuration: 0°/20°, 0°/30°

Thank you

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