Miniature 3D Profilometer for Accelerating structure Internal Shape Characterization

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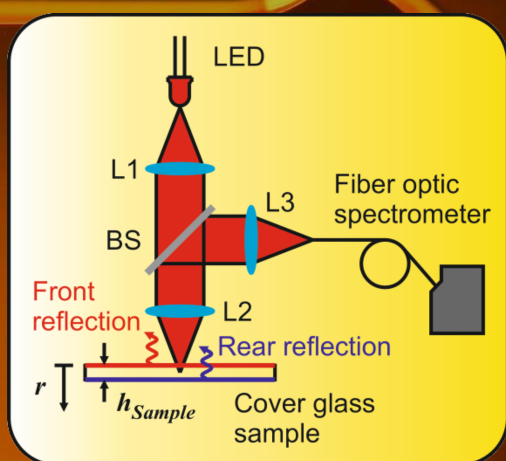
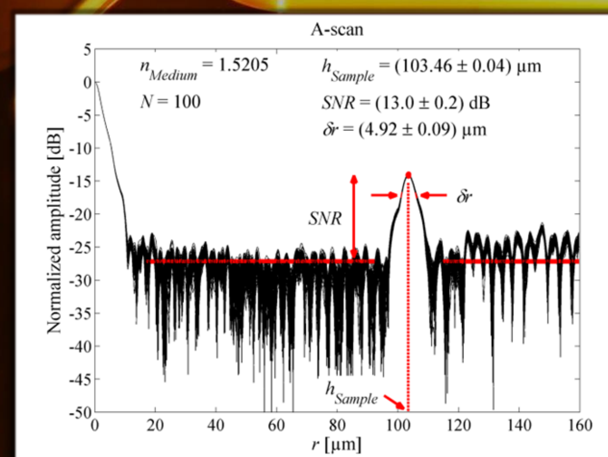
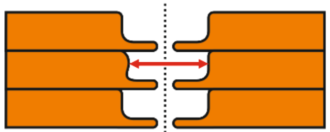
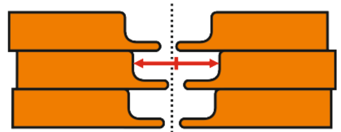
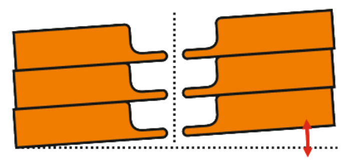
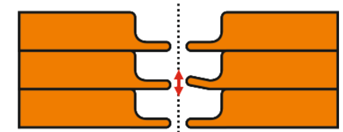
5 mm



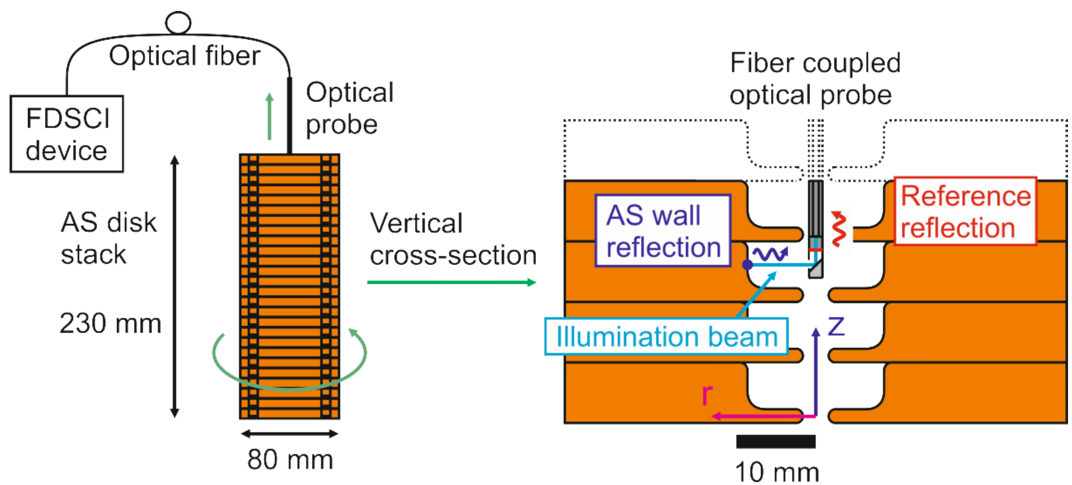


Introduction

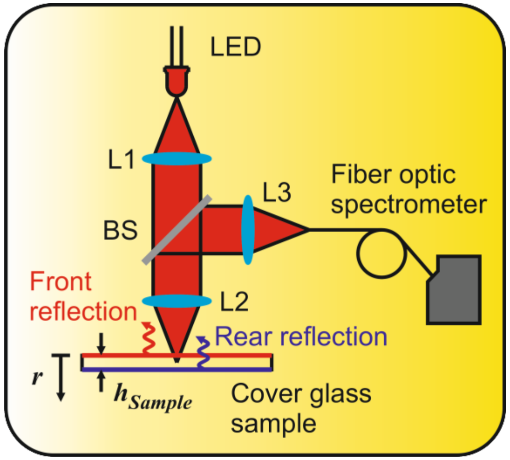
- Accelerating Structures (AS) comprising OFE Cu disks undergo permanent thermo-mechanical deformations during assembly [1,2,3] and RF operation [4,5].
- These deformations result in micron-level shape errors in AS.

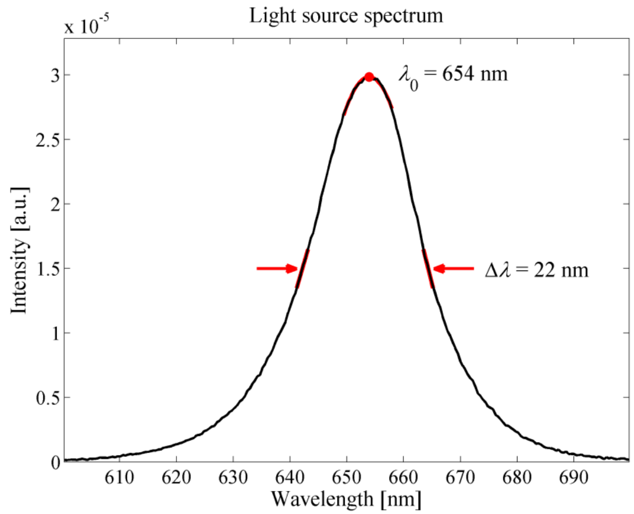
	Error in iris shape	Transversal offset	Tilt	Iris deformation
Shape error				
Tolerance	1 µm [1,6]	5 µm [4]	140 µrad [1,6]	

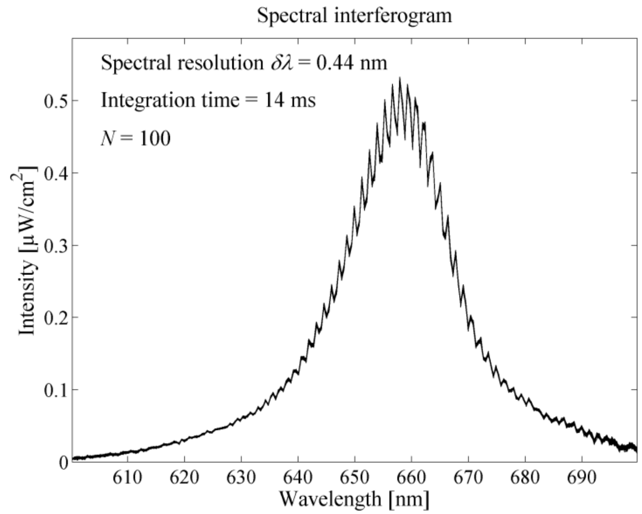
- > 10 mm axial depth range with sub-micron axial sensitivity is required.
- Fourier Domain Short Coherence Interferometry (FDSCI) -technique [7]



Design A: Setup





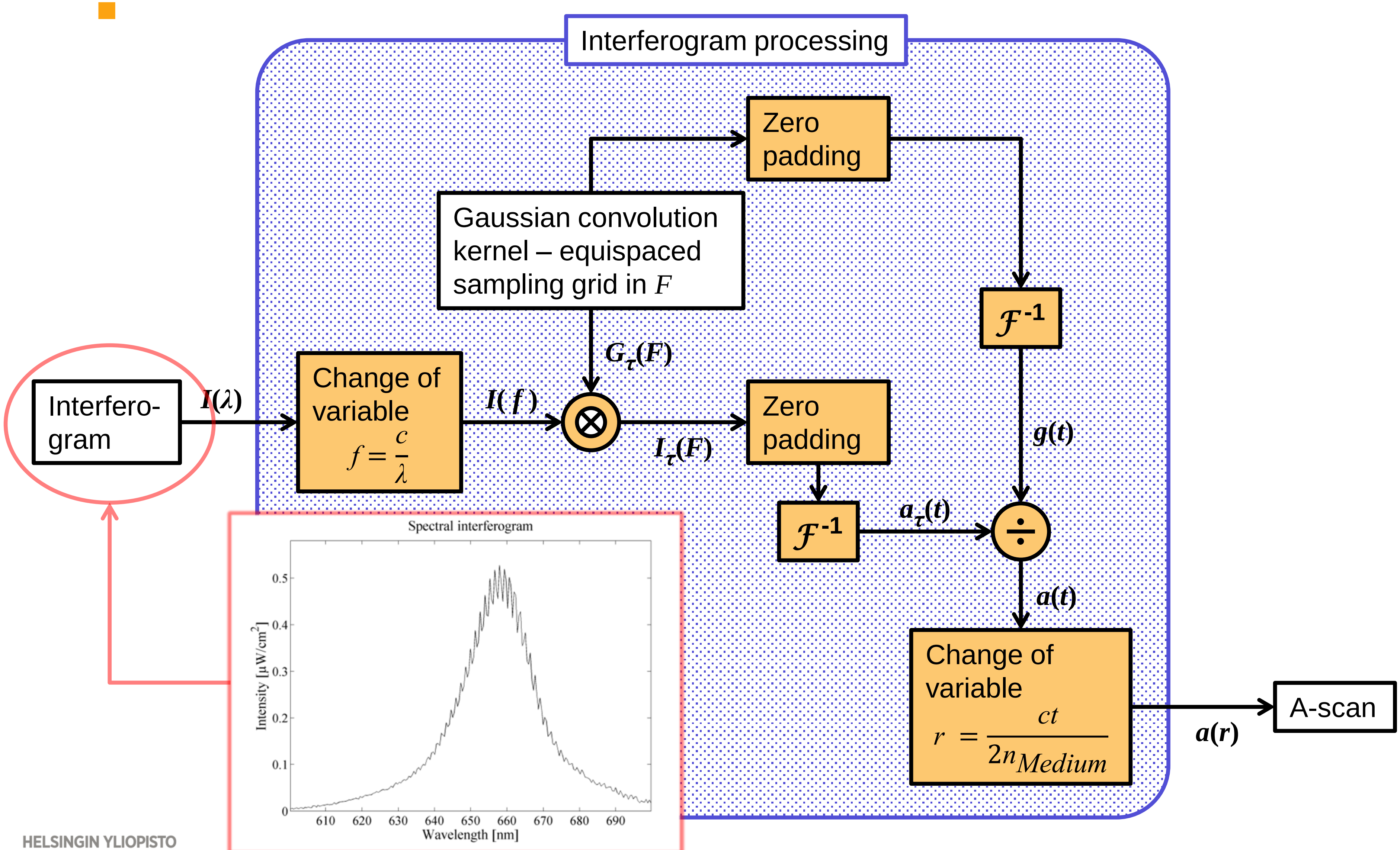


- LED light source (L-793SRC-E, Kingbright) emits light with $\Delta\lambda$ = 22 nm centered at λ_0 = 654 nm.
- Visible range fiber optic spectrometer (HR2000, Ocean Optics, Inc., spectral resolution $\delta\lambda$ = 0.44 nm) captures spectral interferogram constructed from front and rear reflections of the cover glass sample.
  - Modulation in the spectral interferogram reveals the sample thickness

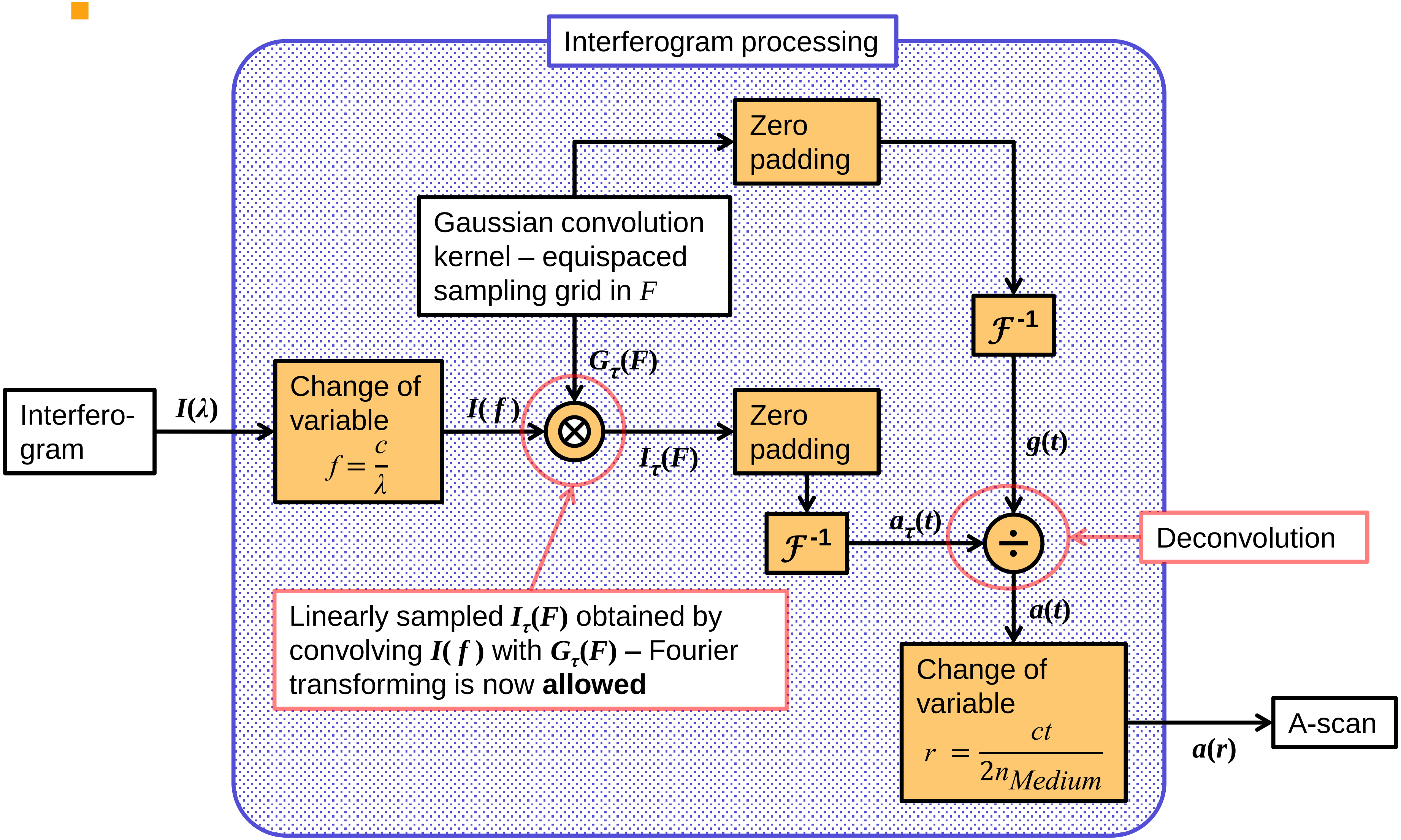
Axial depth range $$r_{max} = \frac{\lambda_0^2}{4n_{Medium}\delta\lambda}$$

- Expect 160 µm axial depth range r_{max} [7,8]
- Cover glass samples with 3 different thicknesses (microscope #00, #0, and #1, $n_{Medium}(\lambda_0)$ = 1.5205)

Design A: Spectral interferogram processing [9]



Design A: Spectral interferogram processing [9]



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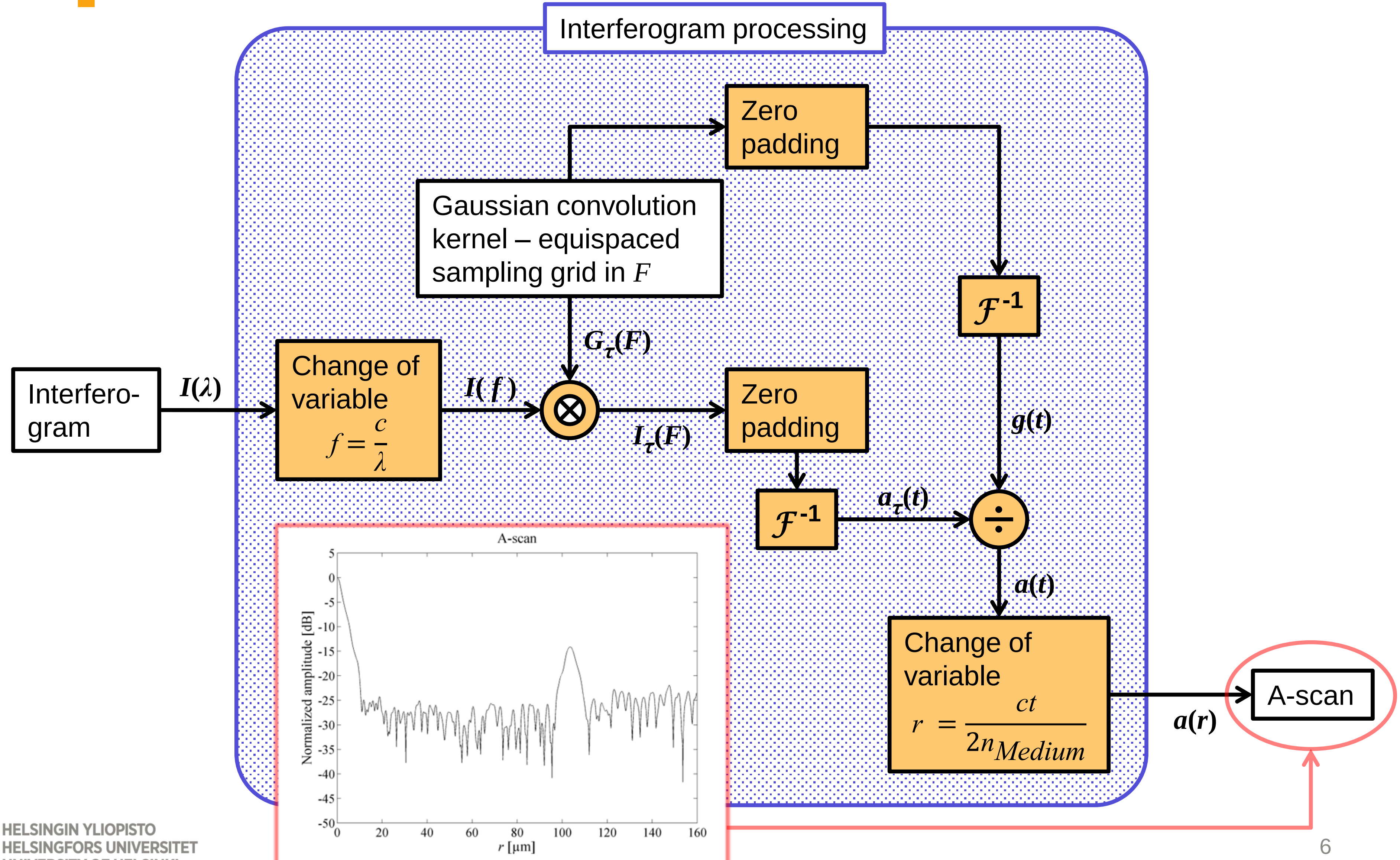
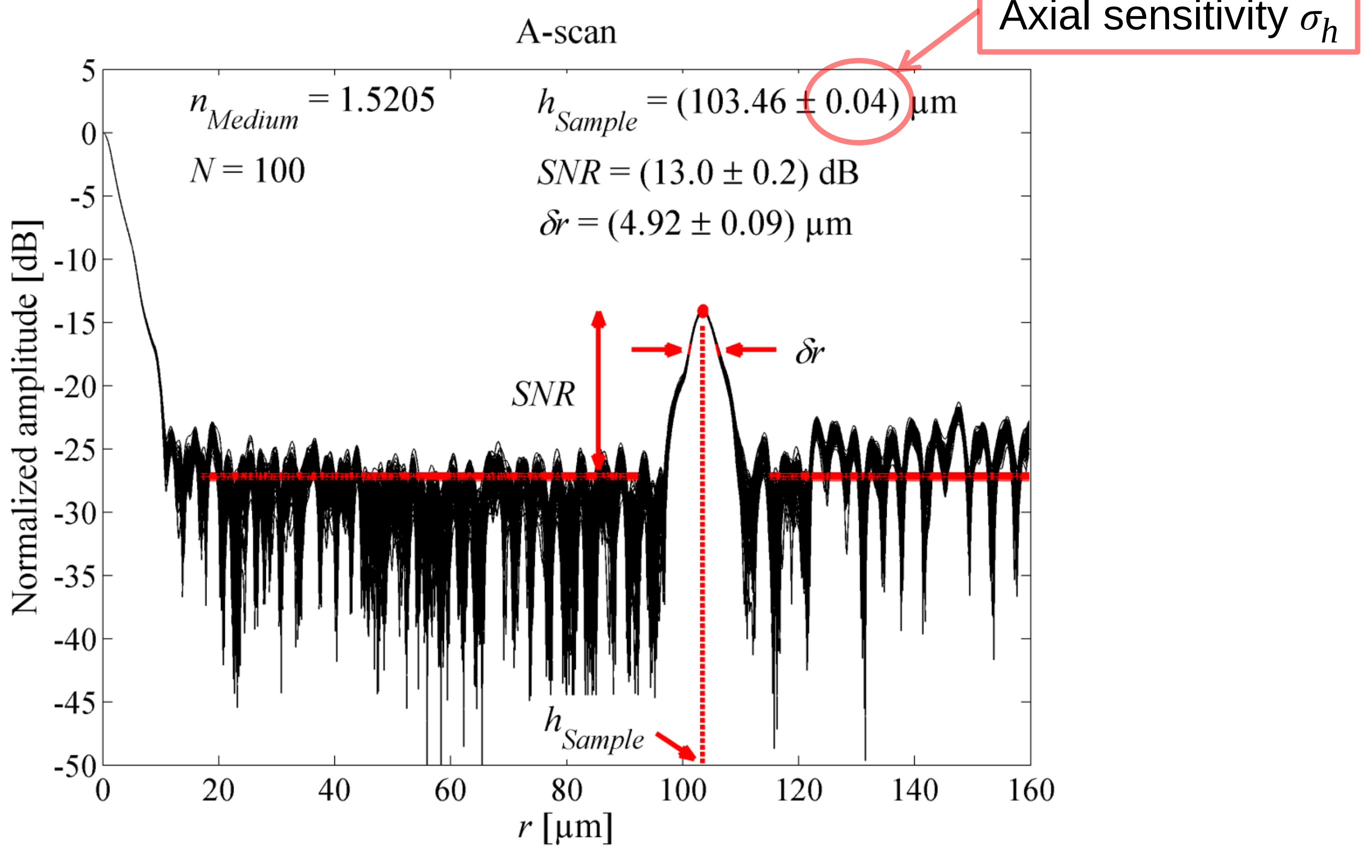


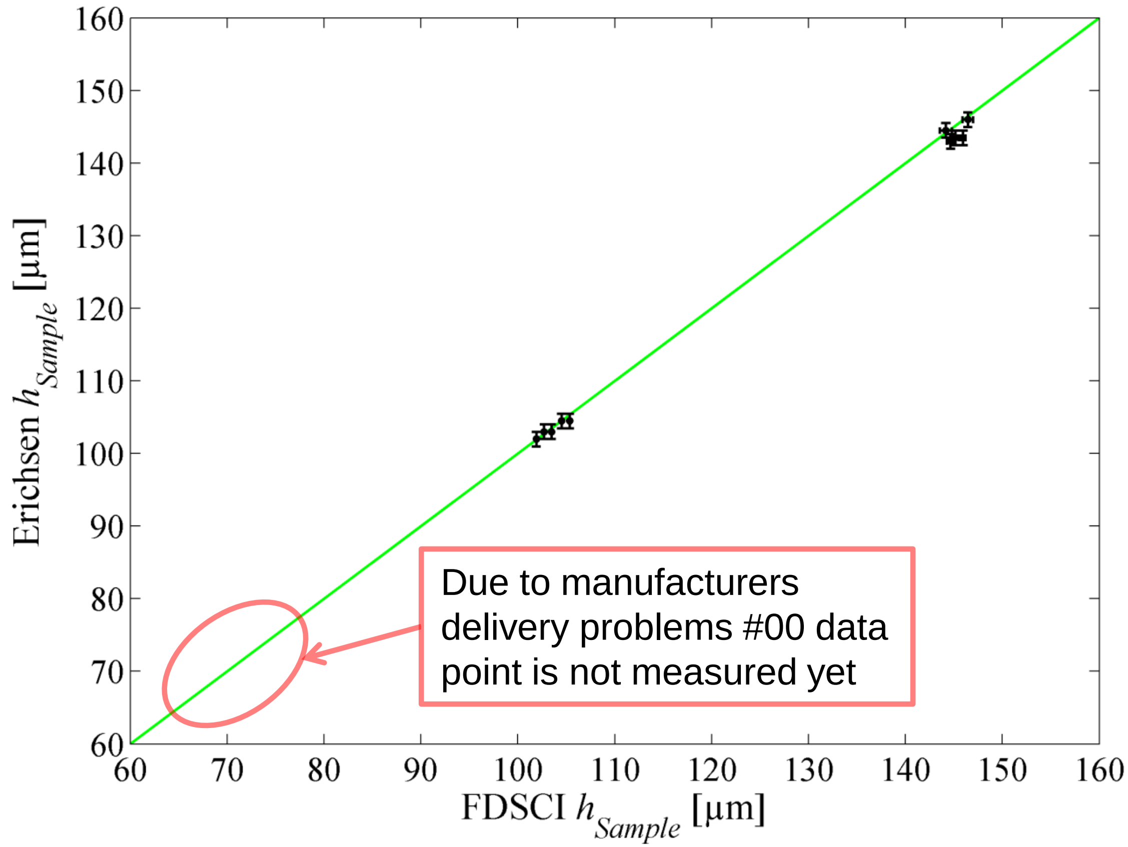
Design A: A-scan analysis

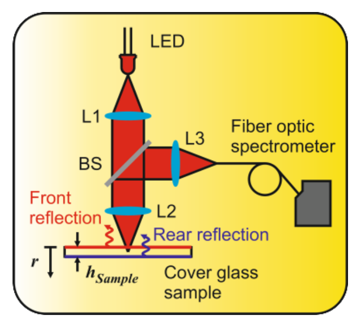


- Glass sample thickness h_{Sample}
- Axial sensitivity σ_h
- Signal to noise ratio SNR
- -3 dB spreading δr of the point spread function (PSF)

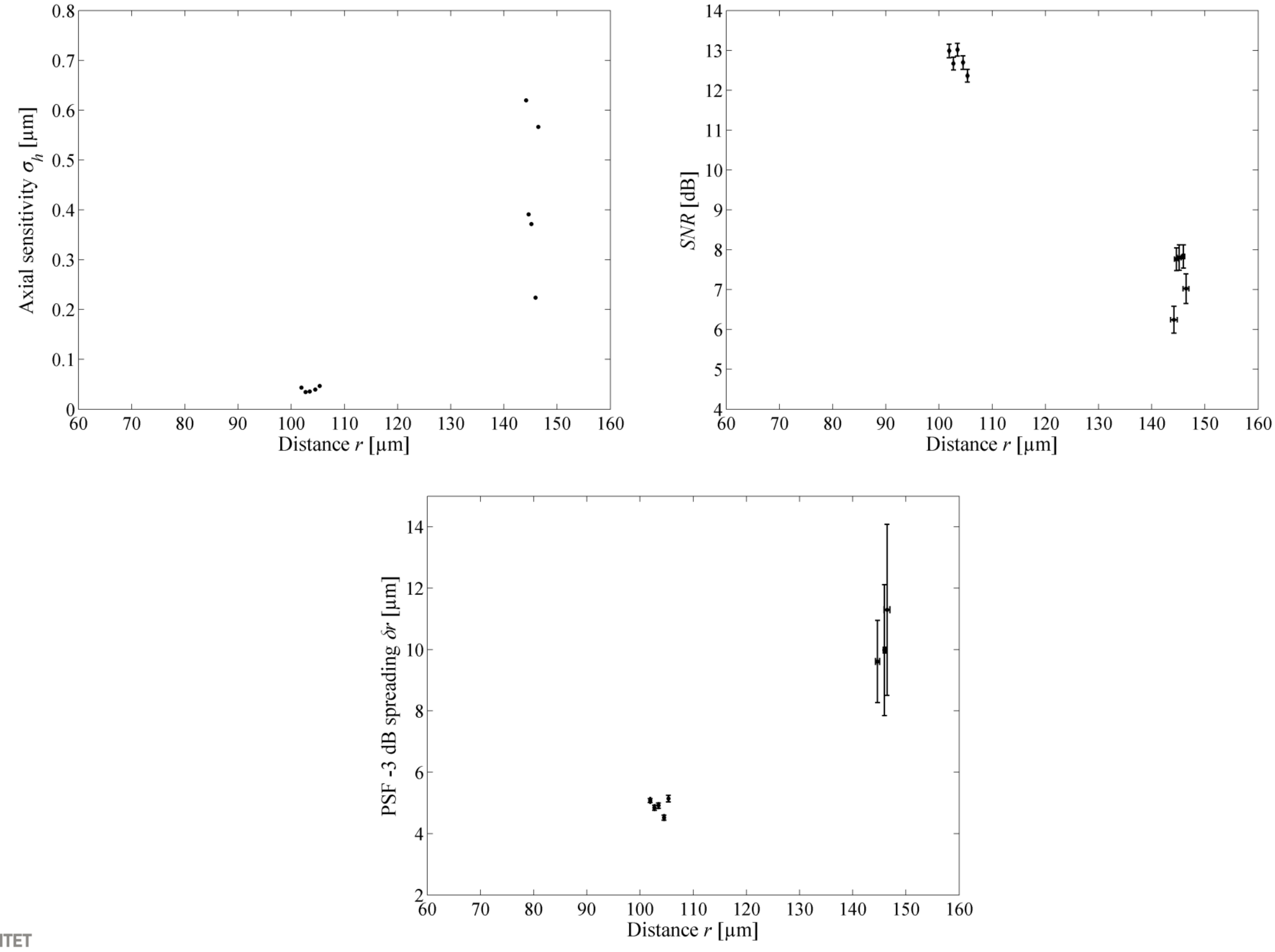
Design A: Setup verification

- Erichsen modell 497
- 1 µm resolution

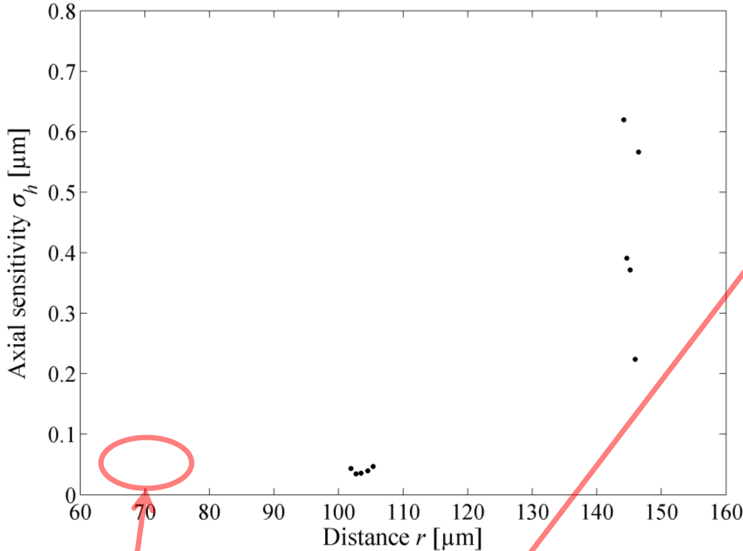


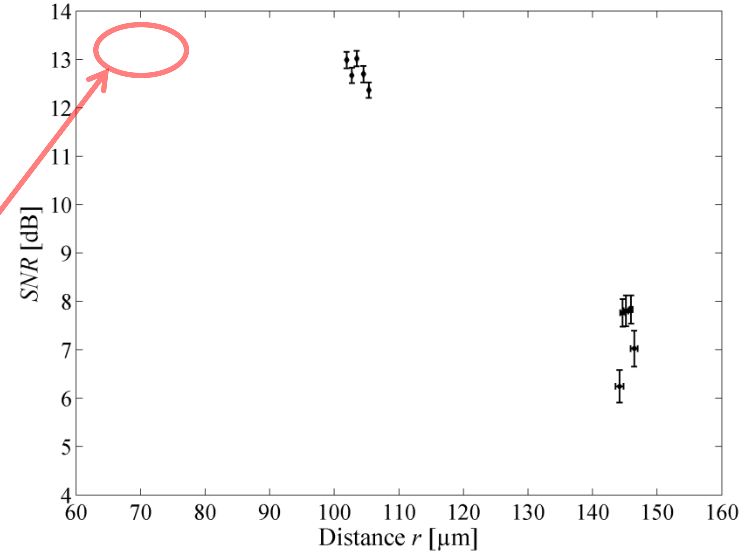


Design A: Setup performance

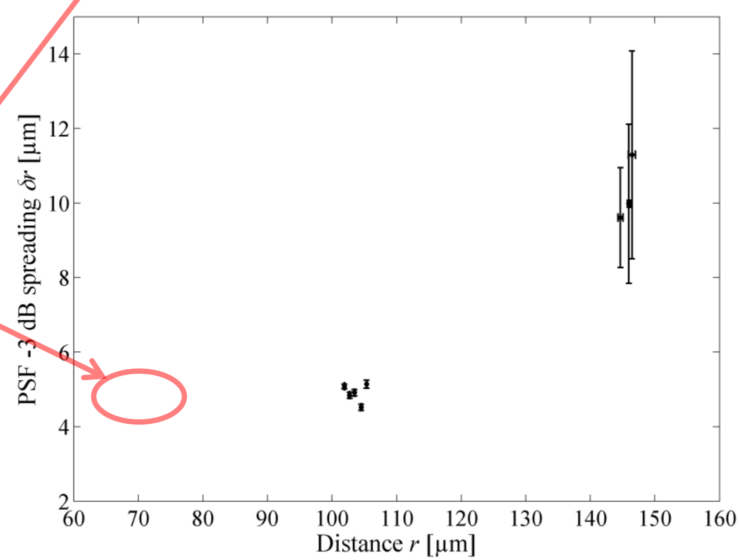


Design A: Setup performance

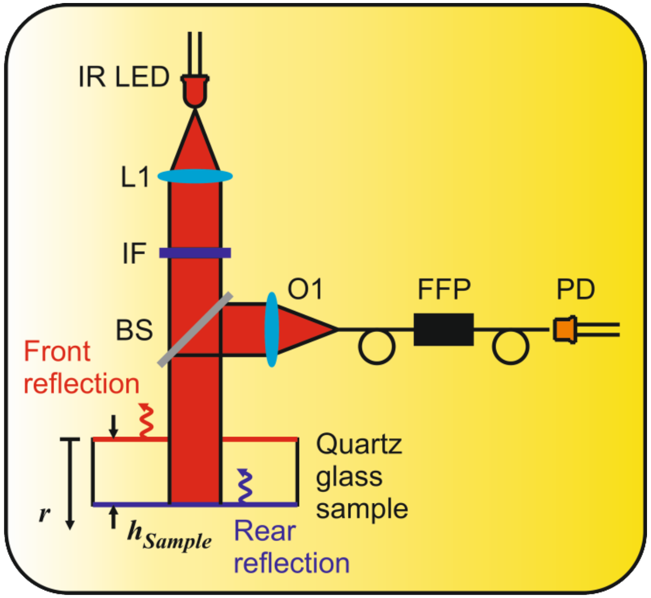




Expected appearance of #00 data points

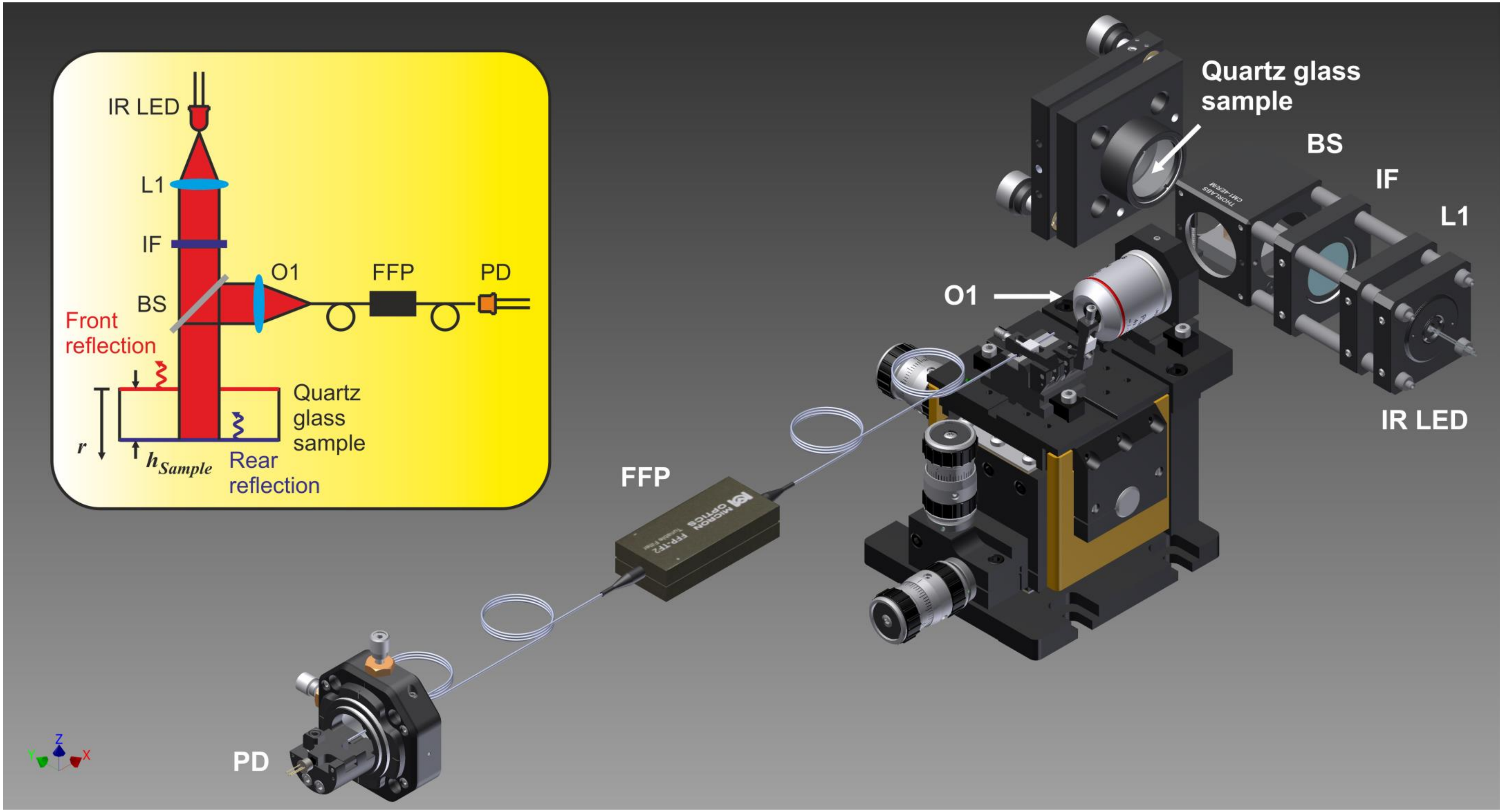


Next step: Design B



- Goal to reach the axial depth range across 10 mm
- NIR LED (LED1550-35K42, Roithner Lasertechnik) + interferense filter (IF) (NIR01-1550/3-25, Semrock) $\Rightarrow \Delta\lambda$ = 8.8 nm centered at λ_0 = 1550 nm
- Tunable fiber Fabry-Perot (FFP) filter (FFP-TF2, Micron Optics) combined with photodetector (PD) (PT511-2, Roithner Lasertechnik) captures the spectral interferogram [10].
  - 23.2 nm free spectral range (FSR) at λ_0 = 1550 nm, $\delta\lambda$ = 0.025 nm
- Expect 16.6 mm axial depth range r_{max} [7,8].
- 1 – 10 mm quartz glass samples ($n_{Medium}(\lambda_0)$ = 1.4440) [11]

Next step: Design B



Conclusions

- First setup towards Miniature 3D Profilometer -device works fine.
- Proof of concept for sub-micron sensitivity metrology has been achieved.
- Work to reach the required axial depth range of 10 mm is currently ongoing.
- Integration of the fiber optic probe and AS scanning system are the following steps.

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Thank You