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Apo Rodagon D1x 75mm with EL-16-40-TC

High quality and affordable setup for 1x magnification on large sensors

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Bernstrasse 388 | CH-8953 Dietikon | Switzerland
Phone +41 58 856 3040 | www.optotune.com | info@optotune.com

Summary

- Large z-range of 57mm achieved with +/-2 dpt
  - Optical leverage is ~14mm per diopter
- Magnification changes slightly with 0.5% per mm of WD change
- Slight vignetting at F4, no vignetting at F5.6 or higher
- No distortion measurable at 0 dpt and 1 dpt
- Nominal resolution of ~64lp/mm is maintained after adding EL-16-40 when optical axis is vertical
- In Horizontal optical axis a resolution of ~57lp/mm can be achieved by stopping the lens down to F11

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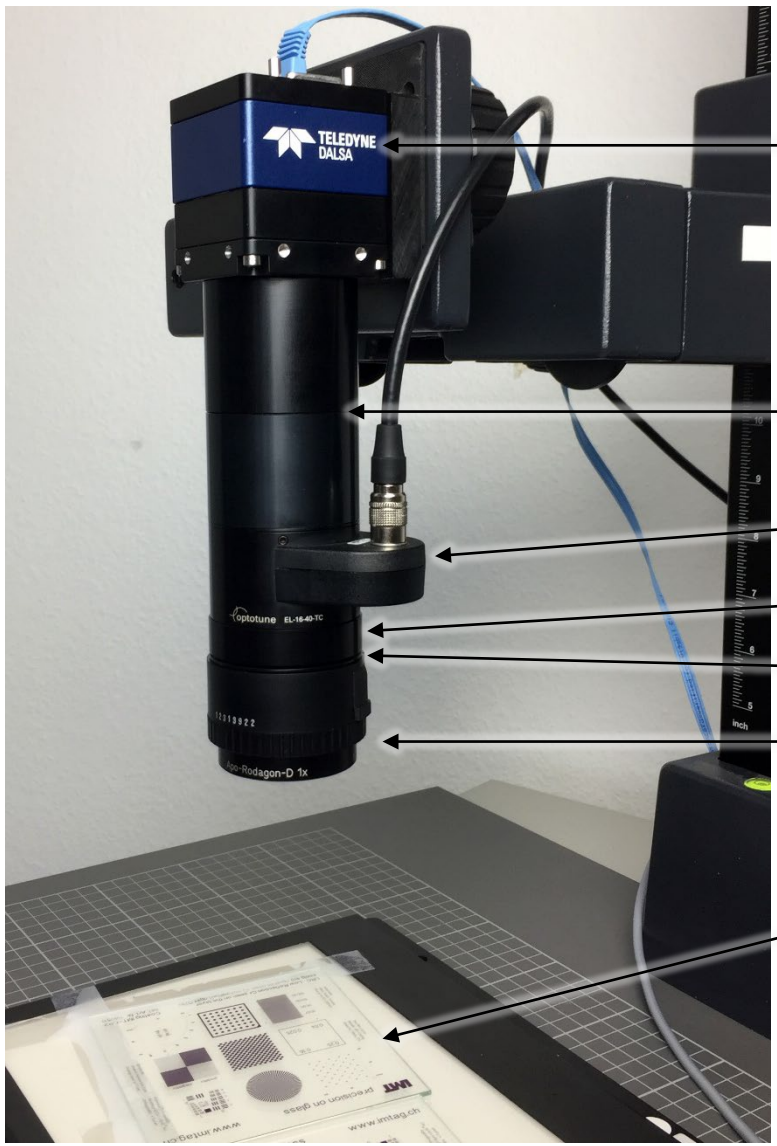
Test setup



M42-mount camera: Dalsa Genie TS-M4096,
4096 x 3072 @ 6um,
12mm flange to sensor distance

95mm of M42 spacers to cover a total back flange to sensor distance of about 136.7mm

Optotune lens: EL-16-40-TC-VIS-5D-M42

11m long M42 spacer (to clear the flange to rear edge)

M39 to M42 adapter P/N 2408-005-101-00

Apo Rodagon D1x 75mm lens by Linos
(formerly Rodenstock)

USAF test targets with white LED back light

Note: The whole setup can be rotated 90° to test vertical and horizontal optical axis

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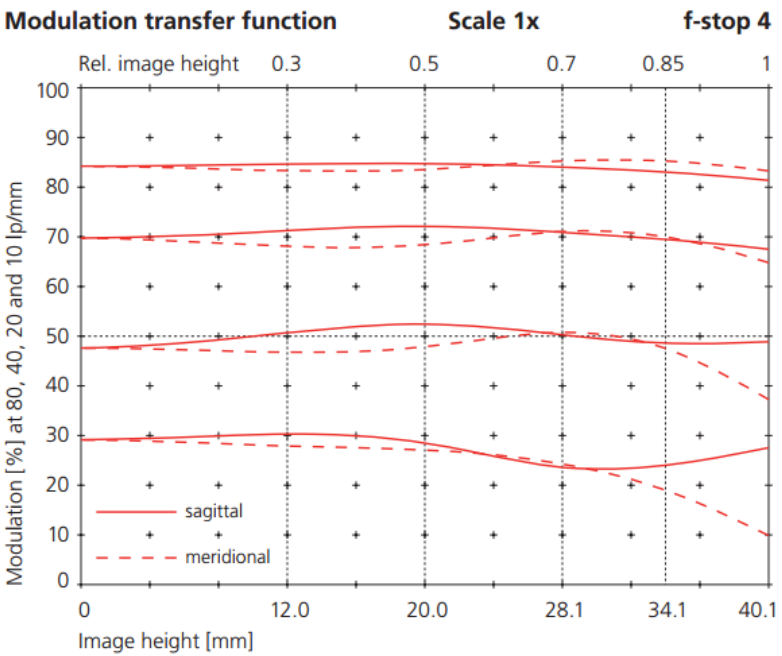
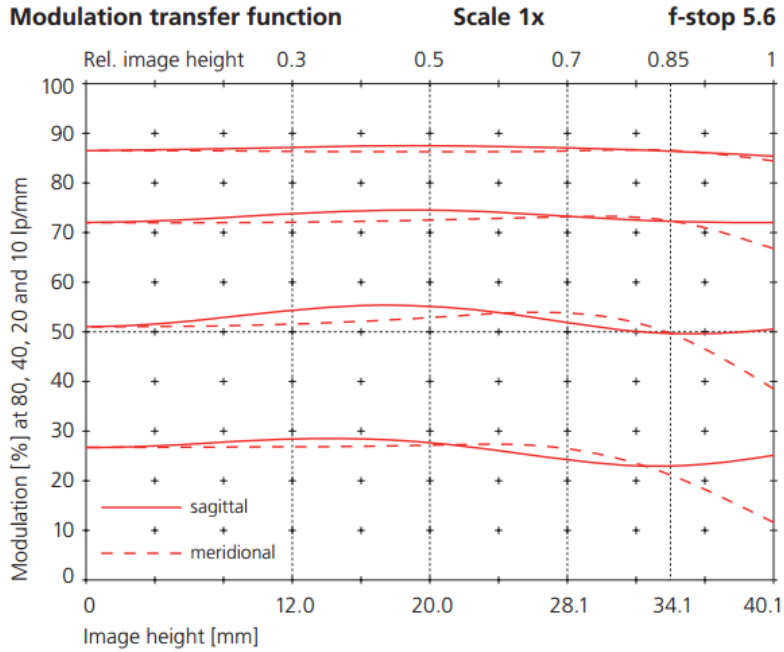
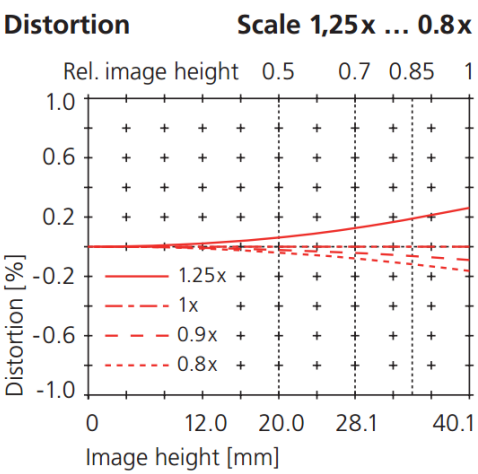
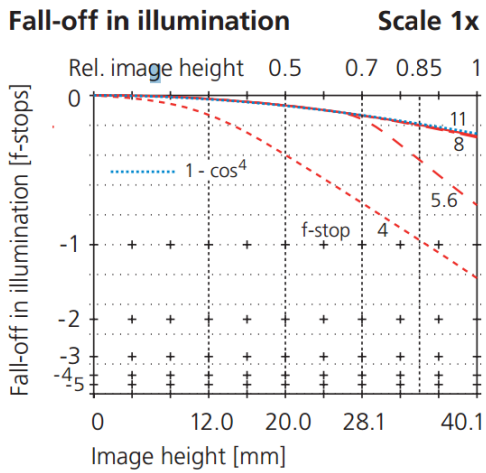
Apo-Rodagon-D 75mm specs from datasheet









Source: http://www.rodenstock-photo.com/Archiv/e_Rodenstock_Printing_CCD_43-62__8230.pdf

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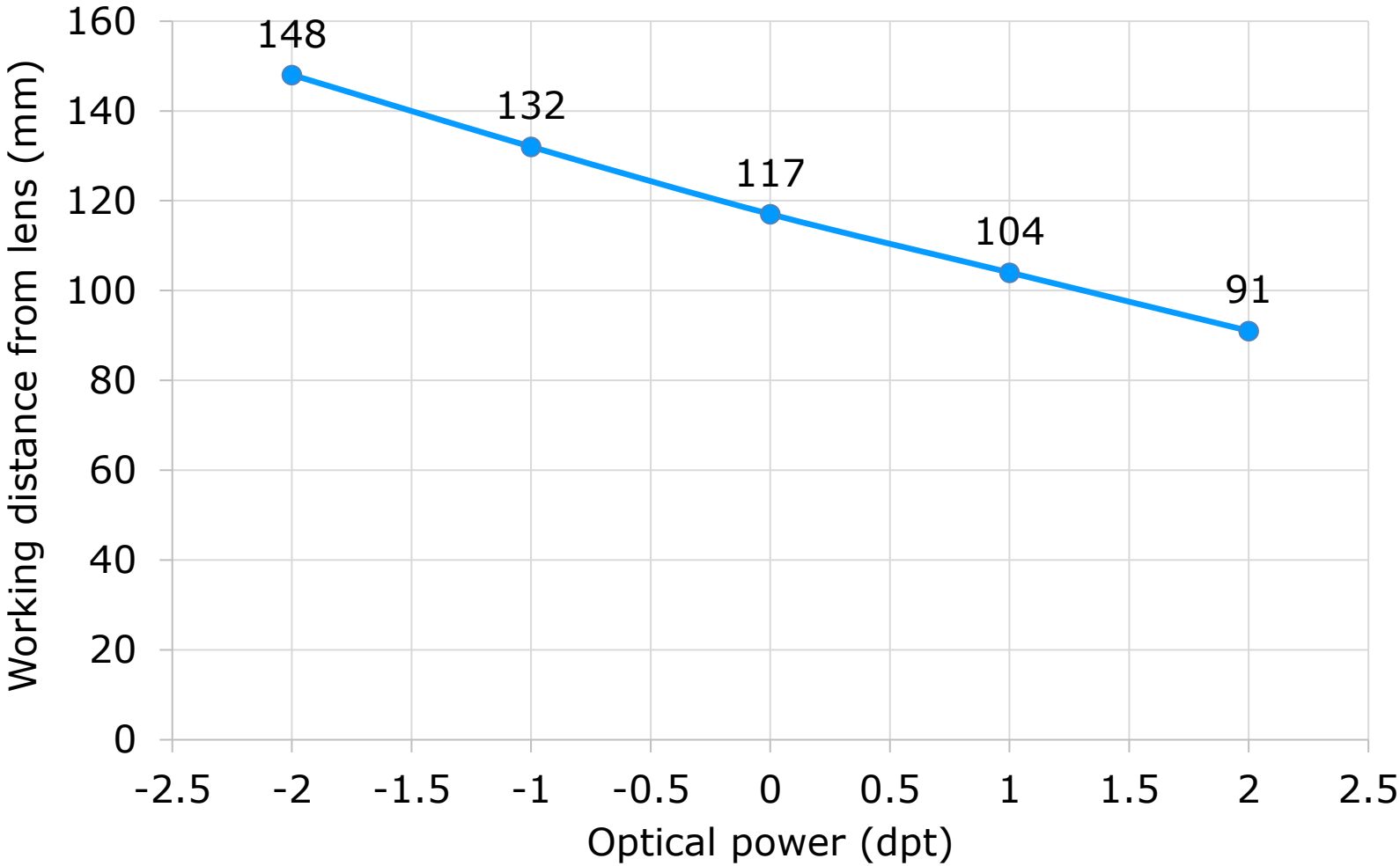
Working distance changes nearly linearly with optical power over a range of 57mm



Optical leverage: ~14 mm per diopter

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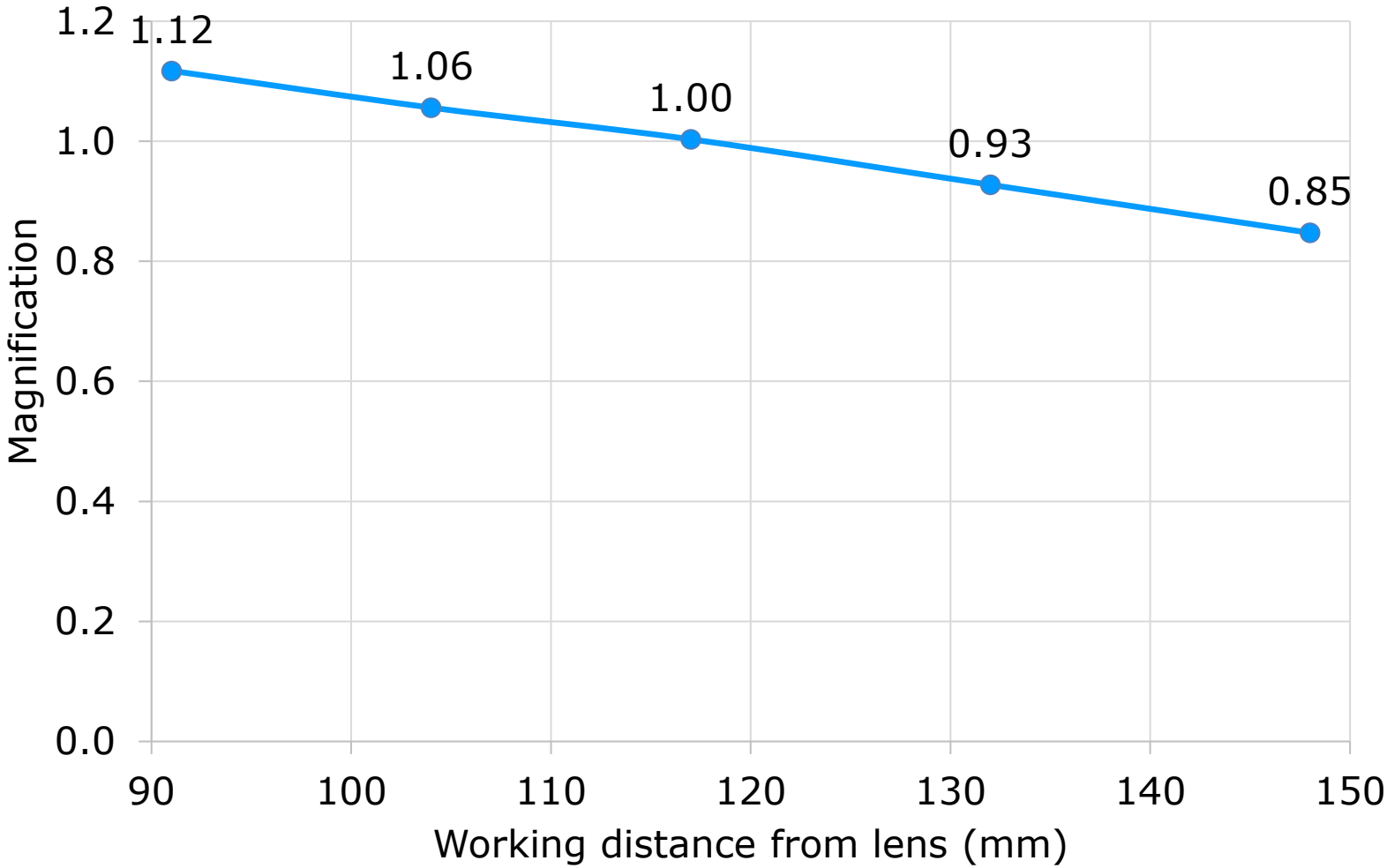
Magnification changes with 0.5% per mm of WD change



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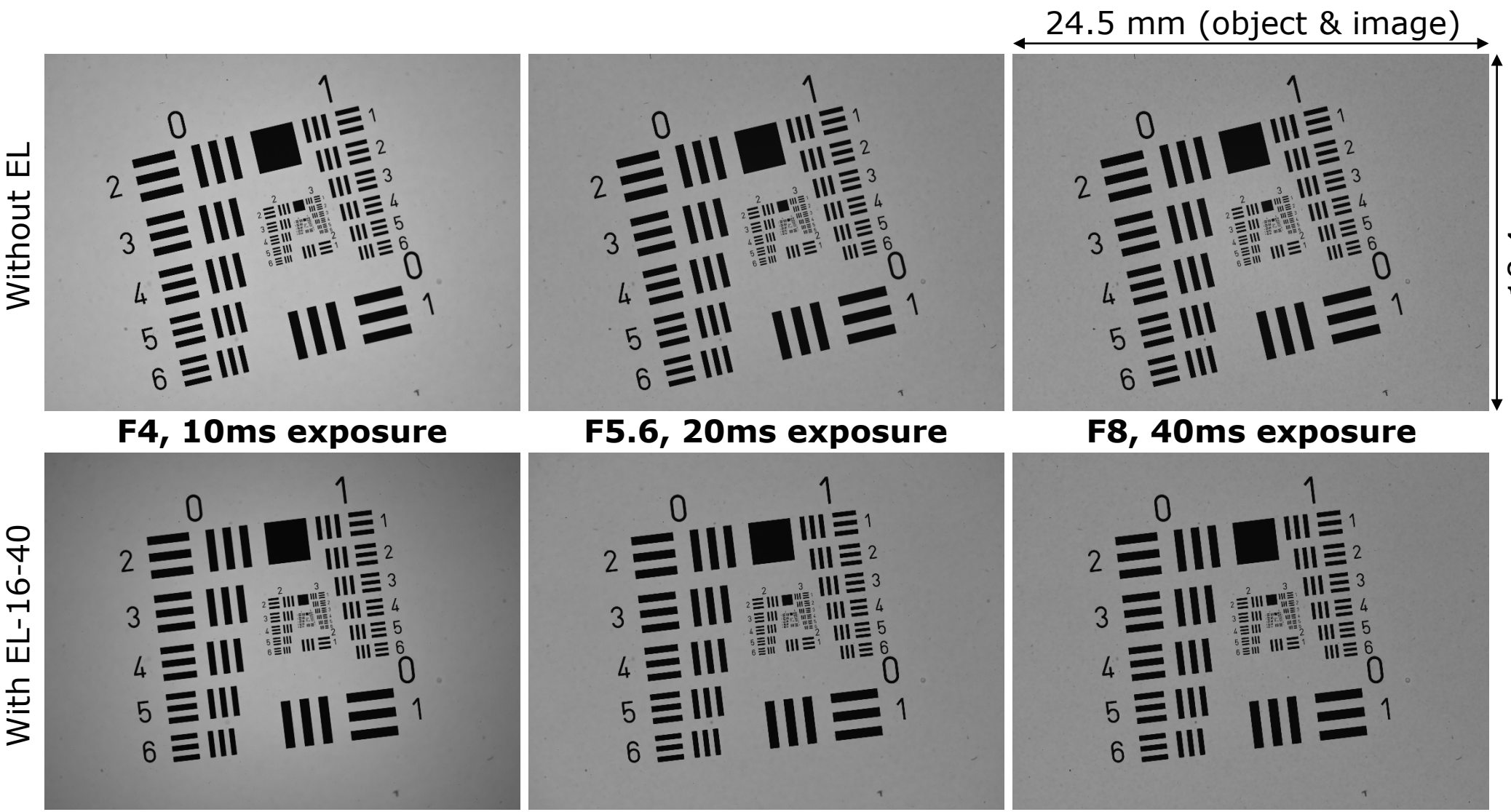
Additional vignetting only visible at full aperture



EL-16-40 @ 0 dpt → 117mm WD, 1.0X

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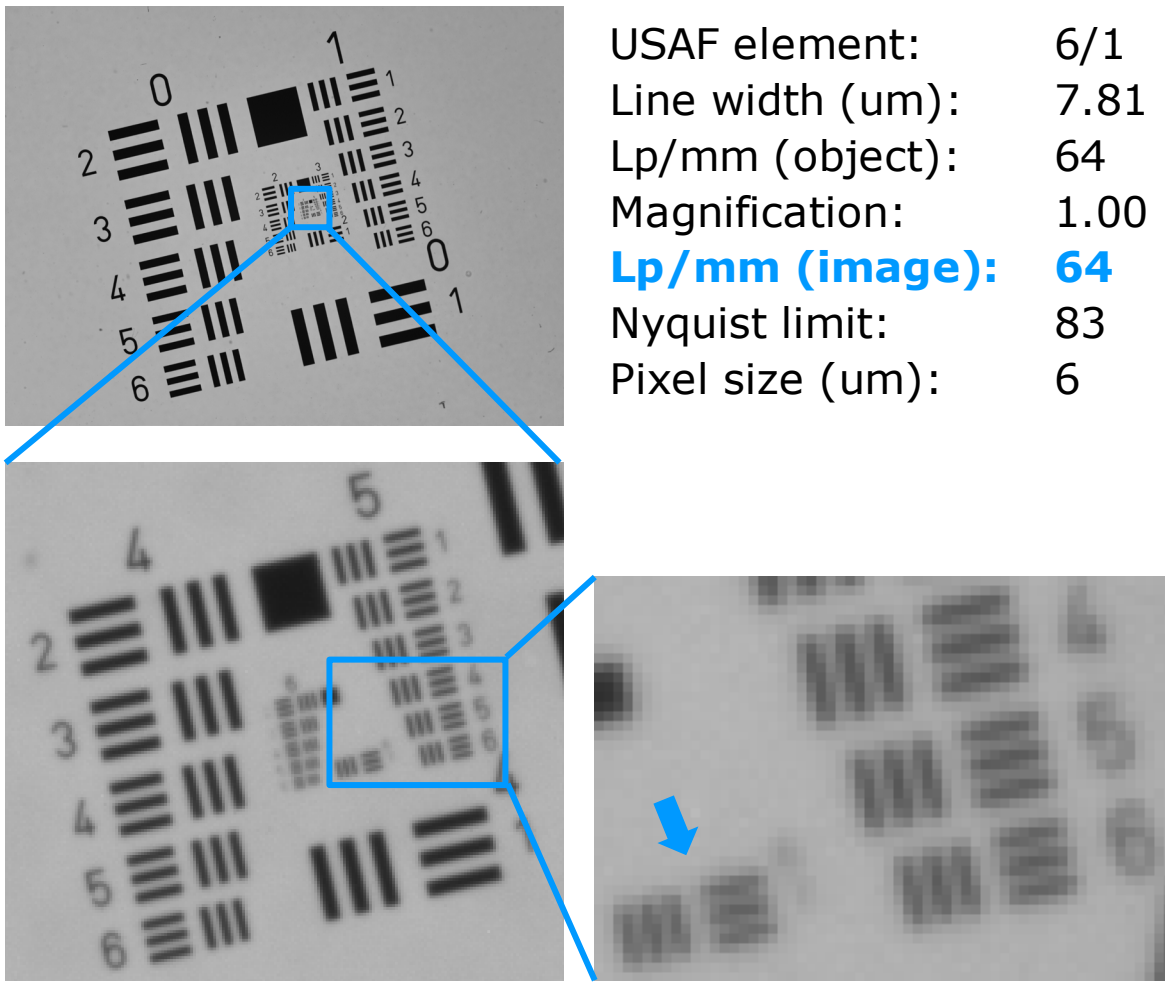
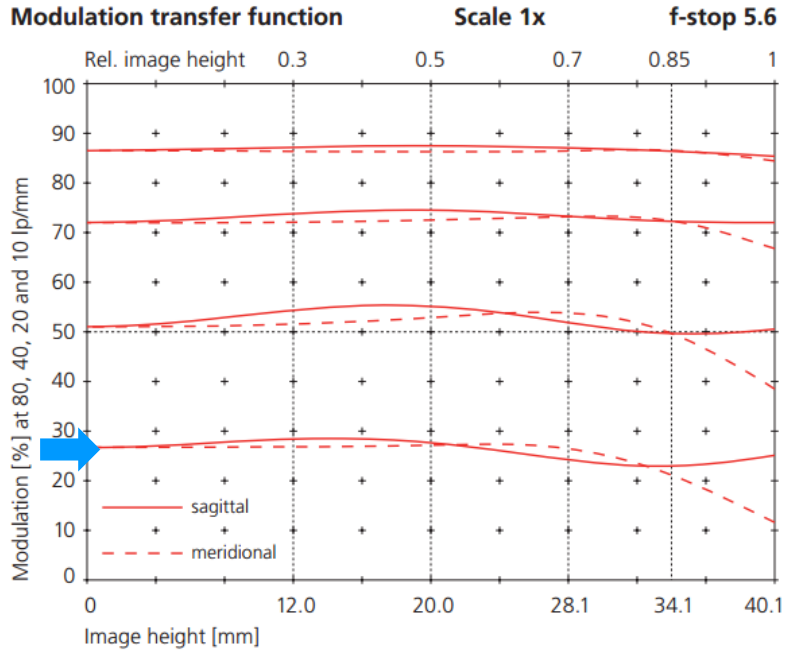
Measured resolution is in line with datasheet

Apo-Rodagon-D 75mm @F5.6

1X magnification, no tunable lens



USAF element:	6/1
Line width (um):	7.81
Lp/mm (object):	64
Magnification:	1.00
Lp/mm (image):	**64**
Nyquist limit:	83
Pixel size (um):	6



Resolution roughly matches the pixel limit of 6um

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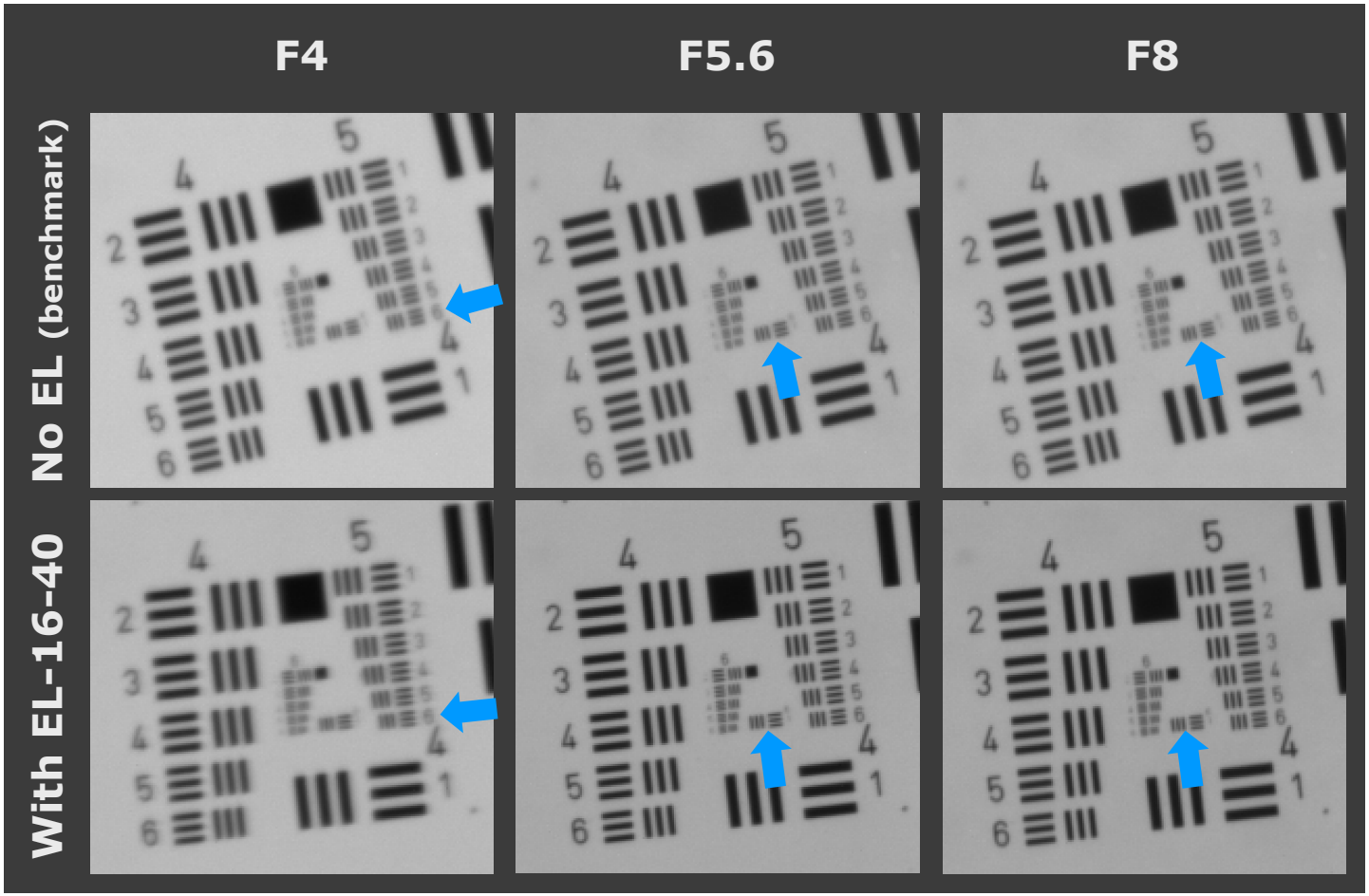
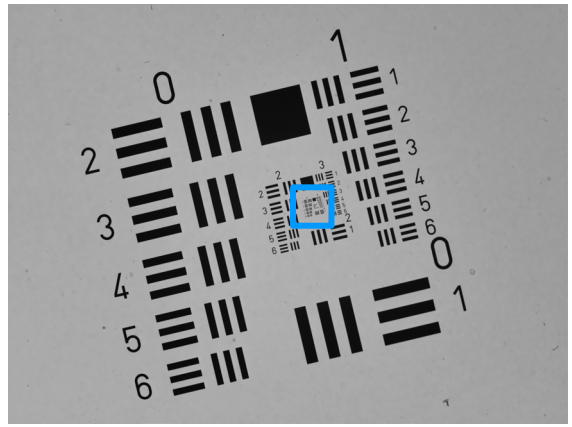
Resolution is maintained after adding EL-16-40





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Line width (um):	7.81
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Lp/mm (image):	**64**
Nyquist limit:	83
Pixel size (um):	6

- Resolution is slightly lower at fully open aperture (F4), both with and without EL

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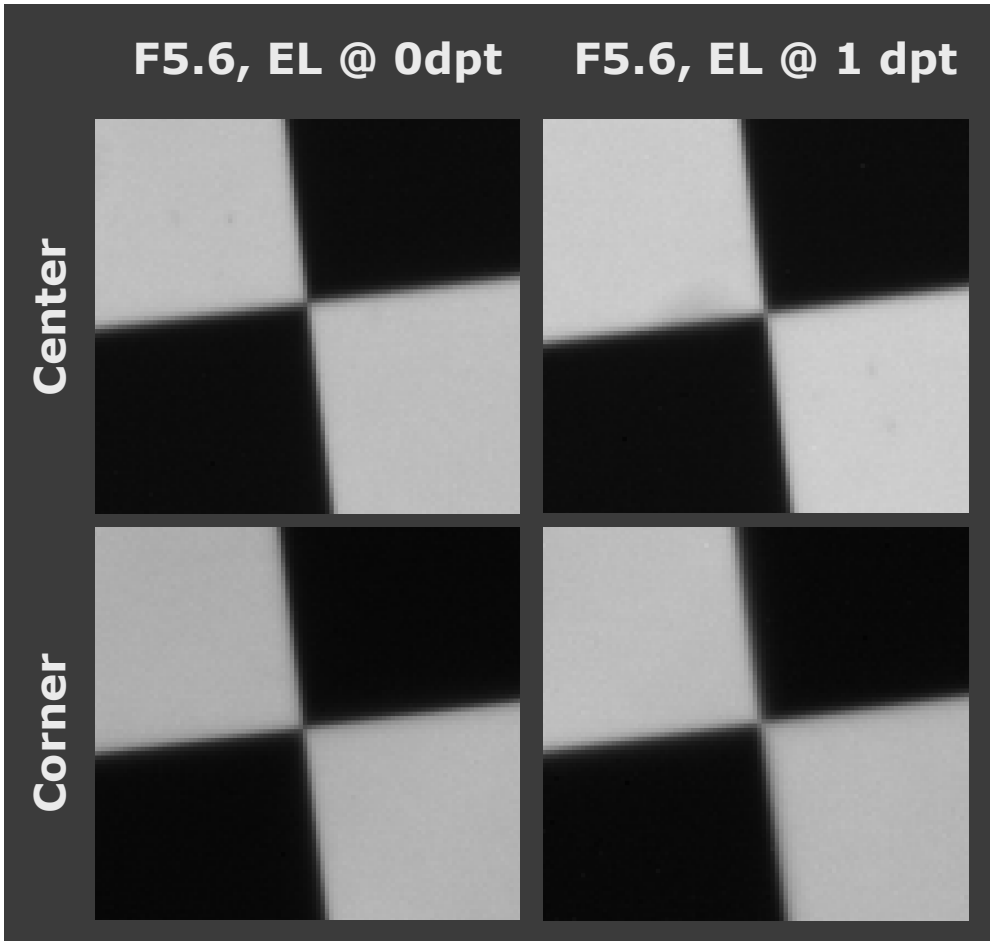
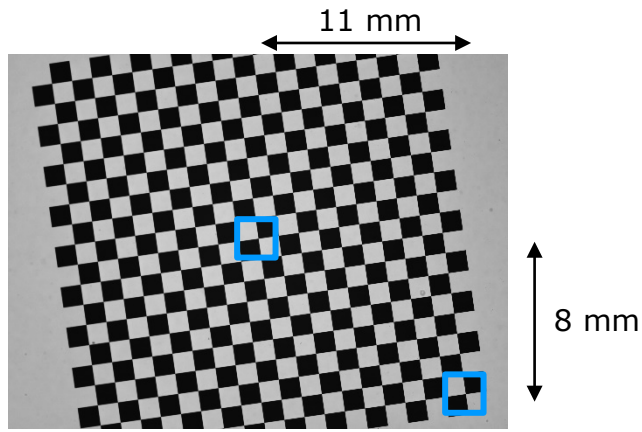
Resolution is maintained across the whole field





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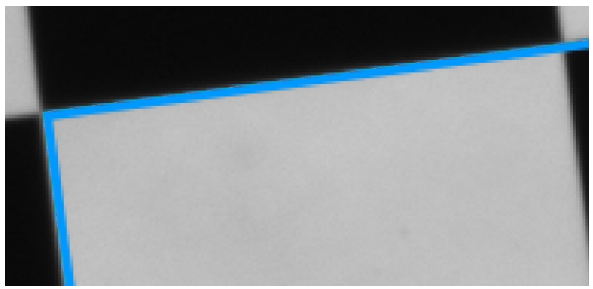
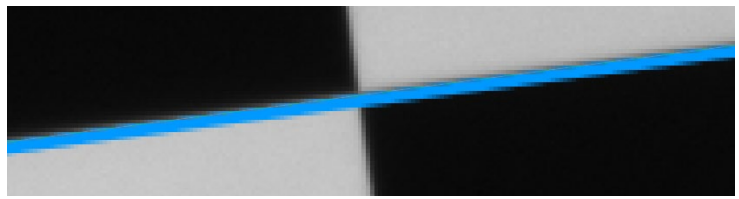
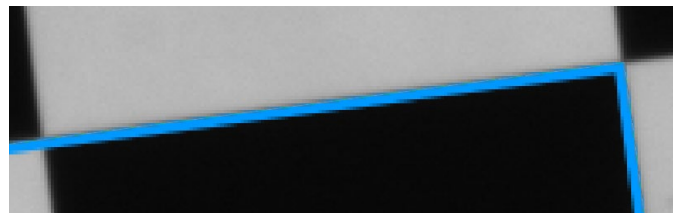
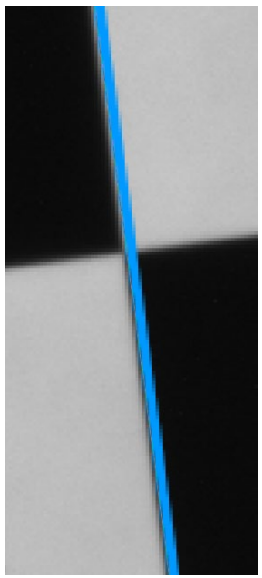
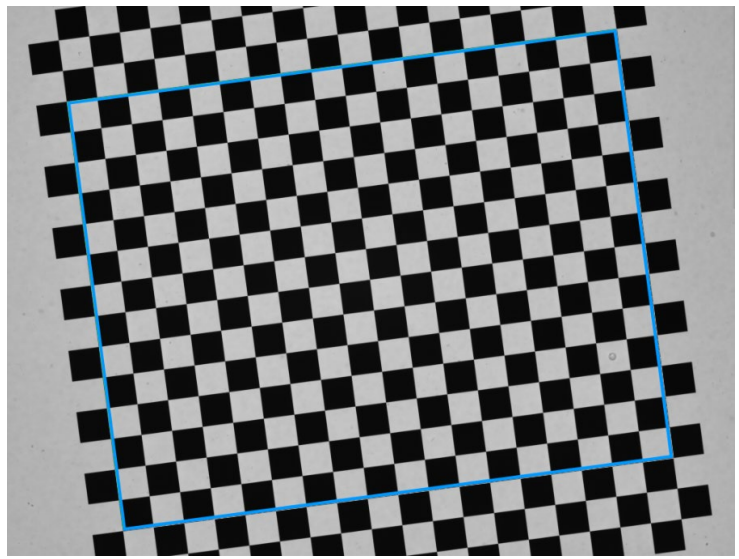
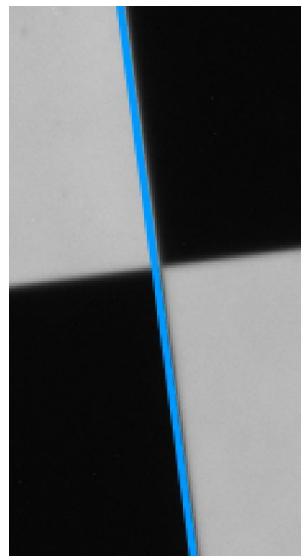
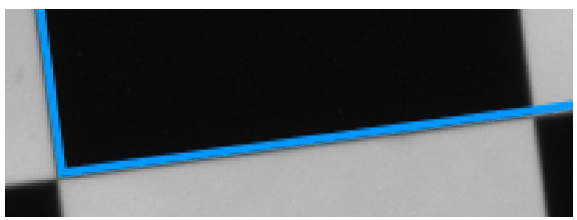
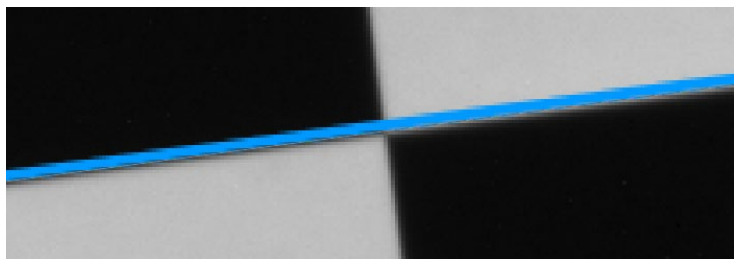
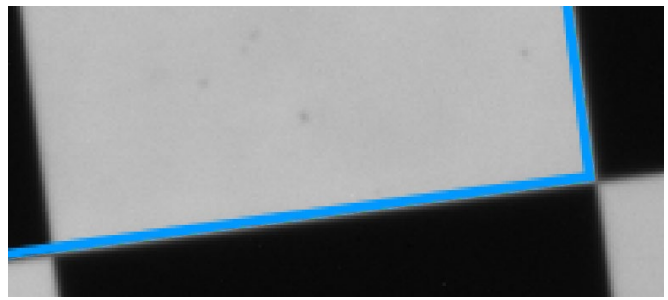
No measurable distortion, even when EL-16-40 at 1 dpt

EL-16-40 @ 1 dpt → 104mm WD, 1.06X

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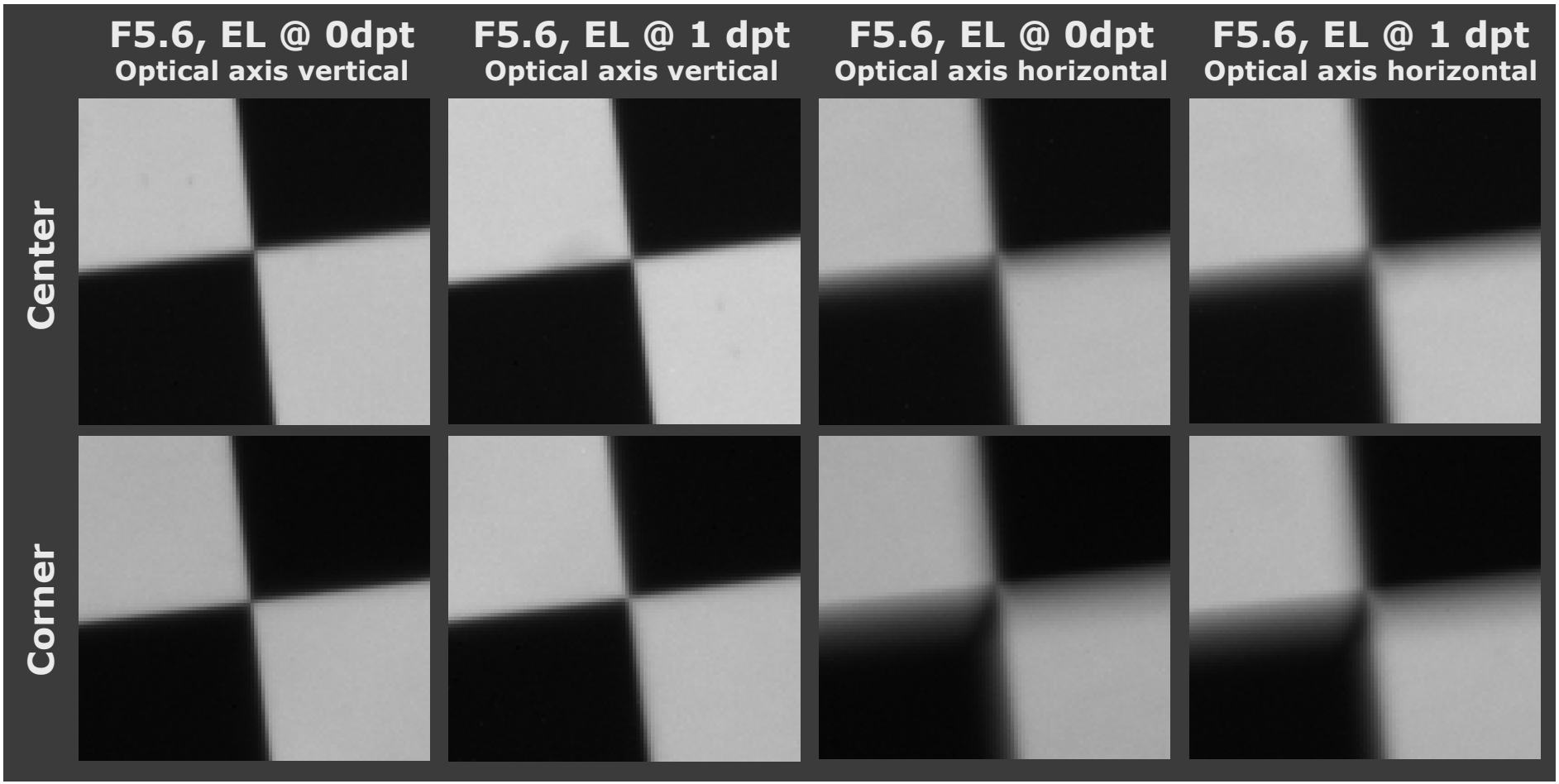
Resolution drops in horizontal axis due to gravity induced coma on tunable lens



Note: As the available z-range is very large, a stiffer membrane can be used to significantly improve performance in horizontal optical axis.

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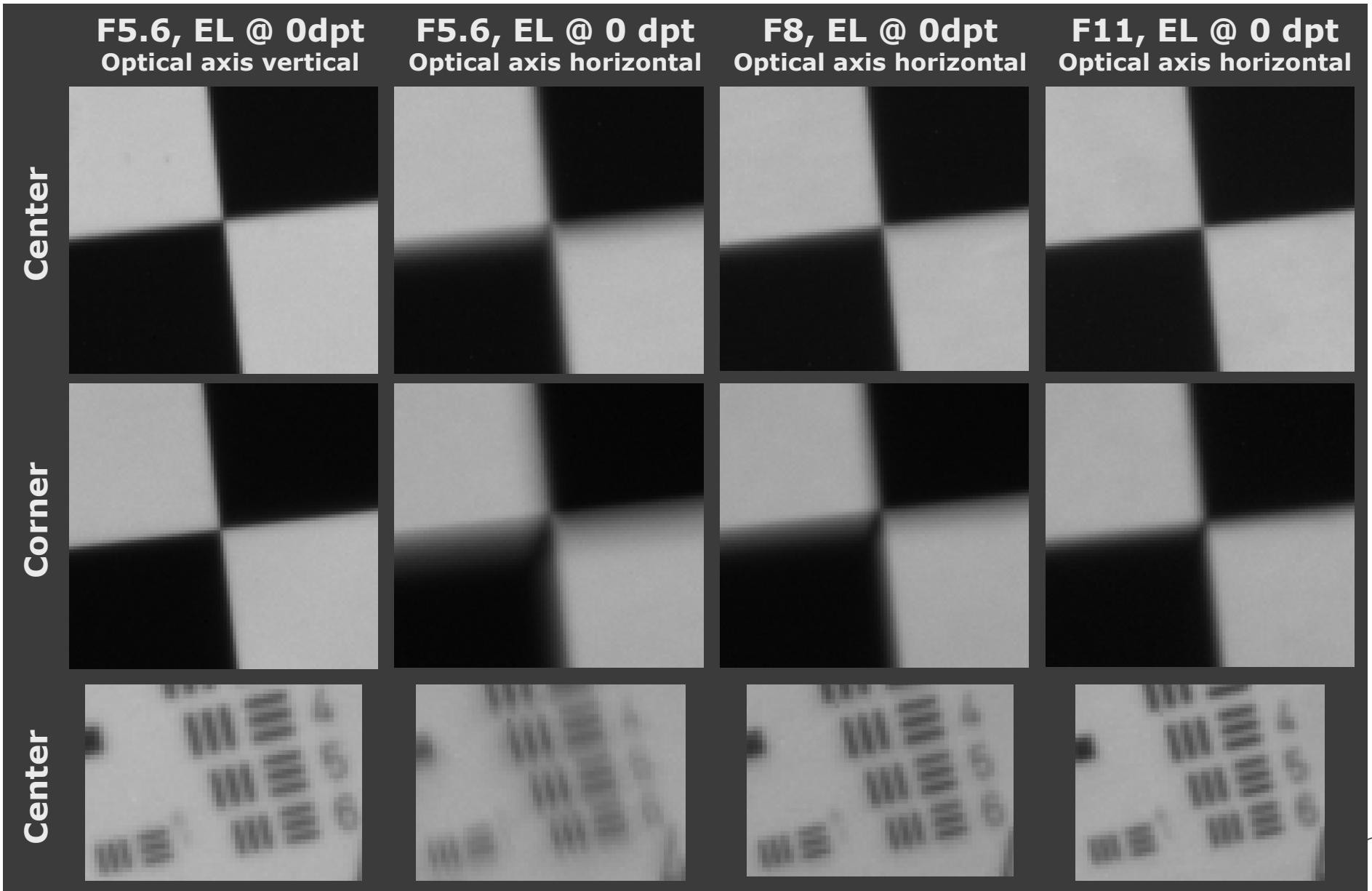
Stopping down to F11 improves image quality in horizontal optical axis back to ~57lp/mm



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