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Optotune ELM-25-3.2-18-C

Test report

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Amir Saba, Application Engineer

Optotune Switzerland AG | Bernstrasse 388 | CH-8953 Dietikon | Switzerland
Phone +41 58 856 3121 | www.optotune.com | info@optotune.com

Summary

- **Working distance (WD) range of 200mm-Inf (Shorter WD possible)**
- **Performance close to the Nyquist rate of 2.74µm pixel size**
  Resolution >170 lp/mm for center of the image across the WD tuning range
  Resolution >140 lp/mm across the field and WD tunning range
- **FP-sensitivity: 200mm-Inf WD with only 3.6dpt range**
- **Very negligible field curvature and distortion**
  Distortion is <1%
- **Vignetting level of ~29%**
- **10% resolution degradation due to the gravity-coma for horizontal optical axis**
- **Very good polychromatic performance**
  Performance very similar between white and blue backlights

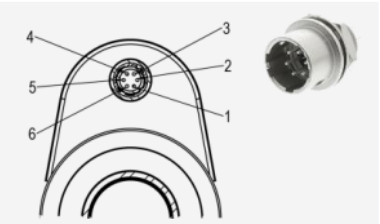
ELM-25-3.2-18-C Datasheet

Lens module specifications		EL-12-30-TC-VIS-16D	EL-7-20-TC-VIS-14D	
Effective focal length		24.5		mm
F/# (fixed)		3.2	3.7	
Maximum sensor format		1.1		inch
Maximum image circle (Φ)		18		mm
Lifecycles (10-90% sinusoidal)		>1'000'000'000		cycles
FOV for 1.1" sensor	Diagonal	40.0		°
	Horizontal	28.8		°
	Vertical	28.8		°
Back focal length (BFL)		13.53		mm (in air)
Optical distortion		<0.5		%
Pixel size (recommended)		2.74		µm
Wavelength range		420-900		nm
Relative illumination		>86	>89	%
Max chief ray angle		10.2	9.5	°
Working distance (WD) range[1]		200 to inf		mm
Optimal WD		1000		mm
WD at 0 dpt		inf		mm
Mount		C-mount		
Filter thread		M49x0.5		
Connector type		Hirose (6 pins)		
Total track length (TTL)		142.5		mm
Dimension (Φ x L)		60.2 x 129.0		mm
Weight		555		g
Operating temperature		-20 to +65		°C
Storage temperature		-40 to +85		°C

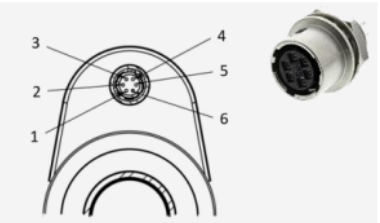
Focus tunable lens specifications	EL-12-30-TC-VIS-16D	EL-7-20-TC-VIS-14D	
Focal power range (@25°C)	-6 to +10	-6 to +8	dpt
Focal power range for module WD range	0.0 to +3.6		dpt
Temperature sensor and EEPROM	Yes		
Control current (typical)	-250 to +250		mA
Max. control current	-300 to +300		mA
Motor coil resistance @ 30°C	15	12	Ω
Absolute maximum voltage (coil)	6	6	V

Electrical layout

Hirose connector (HR10G-7R-6PB)	Function	Sensor pins
Pin 1	Control current +	-
Pin 2	Control current -	-
Pin 3	Ground	1-4
Pin 4	Vcc (3.0-3.7V)	8
Pin 5	I²C SCL	6
Pin 6	I²C SDA	5



Hirose connector (HR10G-7R-6SB)	Function	Value
Pin 1	GPIO Trigger	-
Pin 2	Analog In	0-10V
Pin 3	UART Tx / I²C SCL	TTL
Pin 4	UART Rx / I²C SDA	TTL
Pin 5	GND	-
Pin 6	Vcc	5-24V



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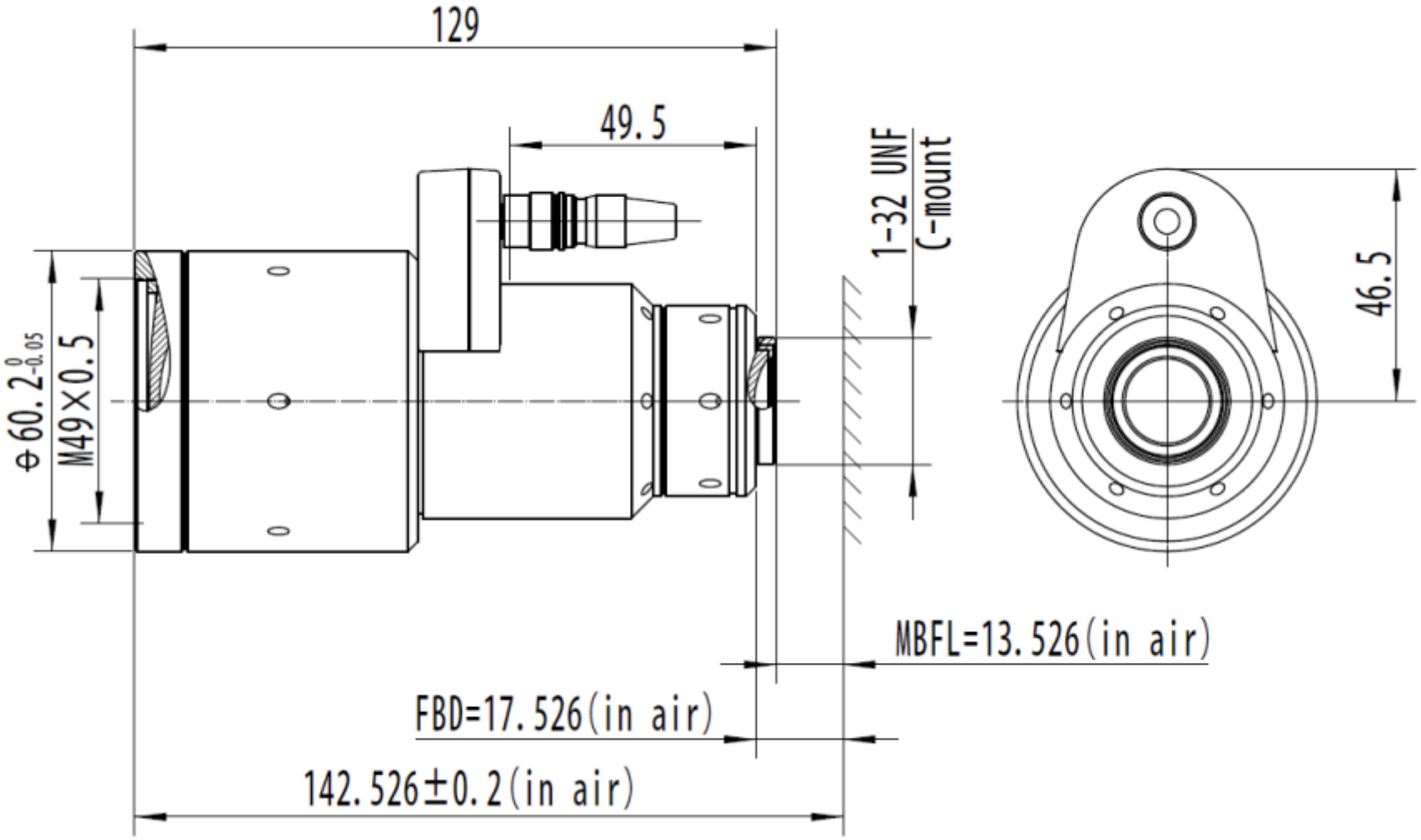
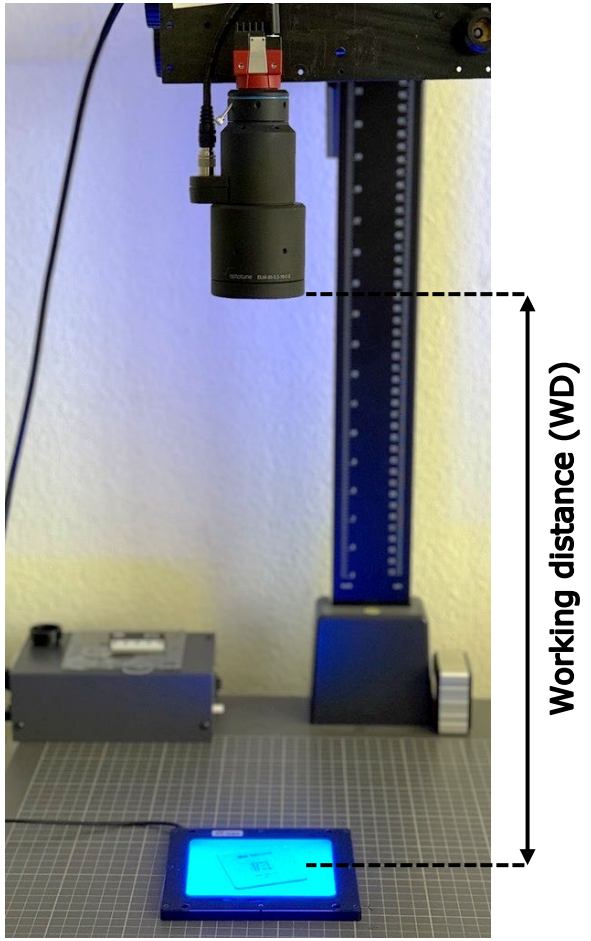
Mechanical drawing



Test Setup

Camera:	Alvium 1800 C-2040 1.1" 4512 x 4512 px Pixel size = 2.74 µm Nyquist rate = 182 lp/mm C-mount
Lens:	ELM-25-3.2-18-C
Tunable lens:	EL-12-30-TC-VIS-16D SN: CGAM1792
Orientation:	Vertical Optical Axis
Driver:	ECC-1C SN:CXAB1413, FW: 2.0.741648
Target:	USAF chrome target, positive
Light:	White backlight (LED1-FLS-110x110W) Blue backlight



Field of view with 1.1” sensor

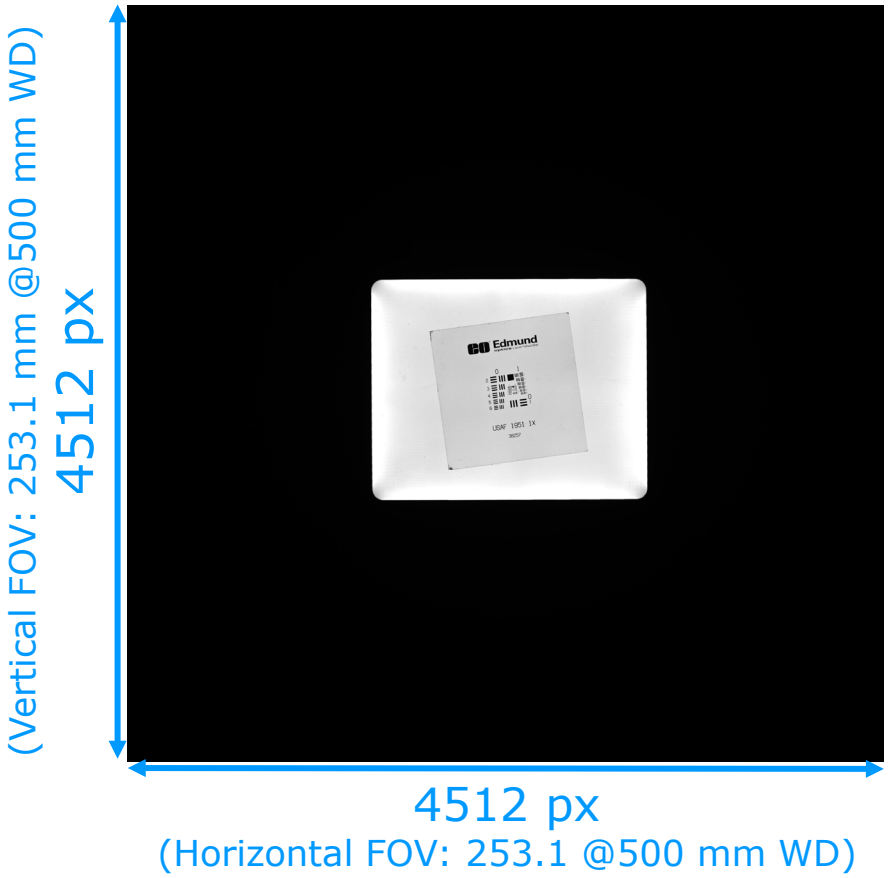
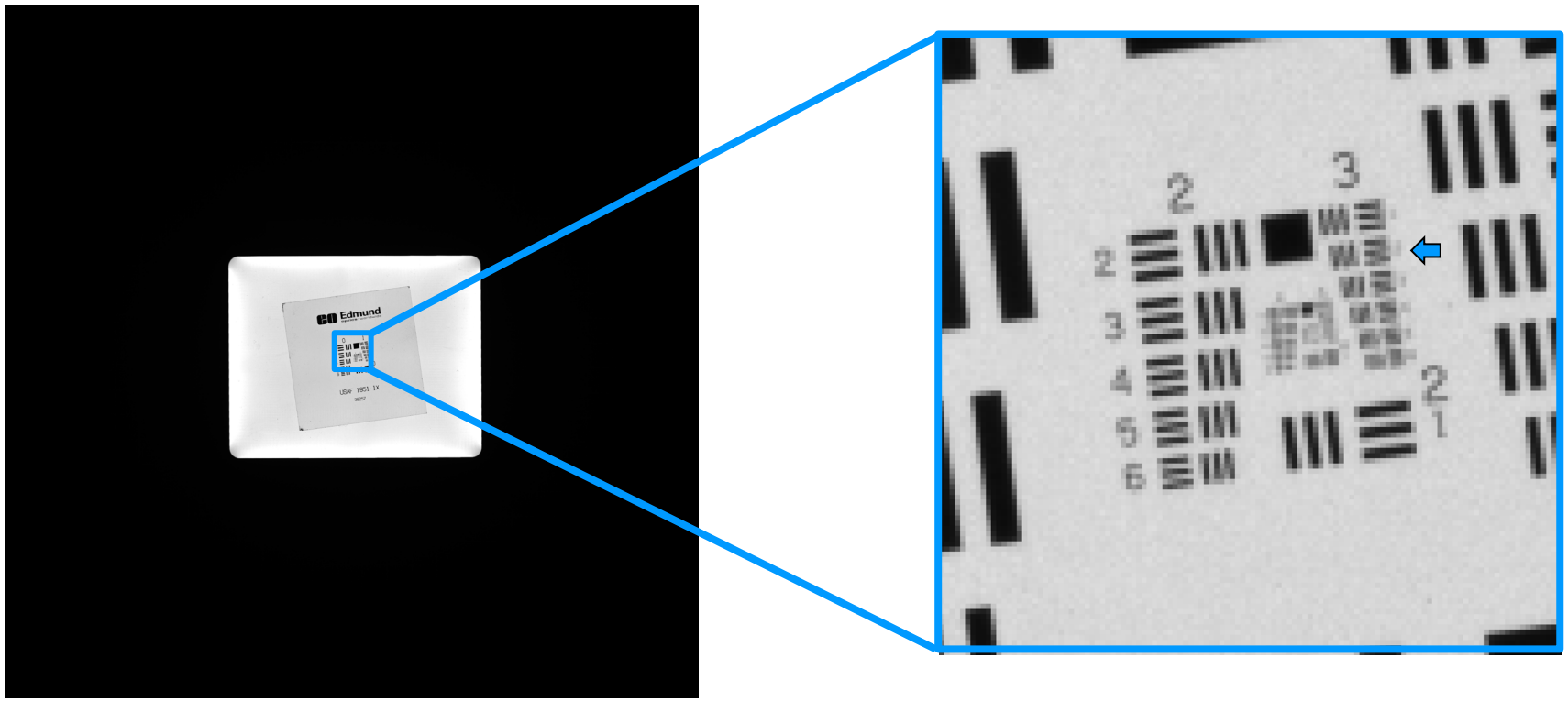


Image size (2.74 µm pixel size):

- Width = 12.4 mm
- Height = 12.4 mm
- Diagonal = 17.5 mm

Image evaluation

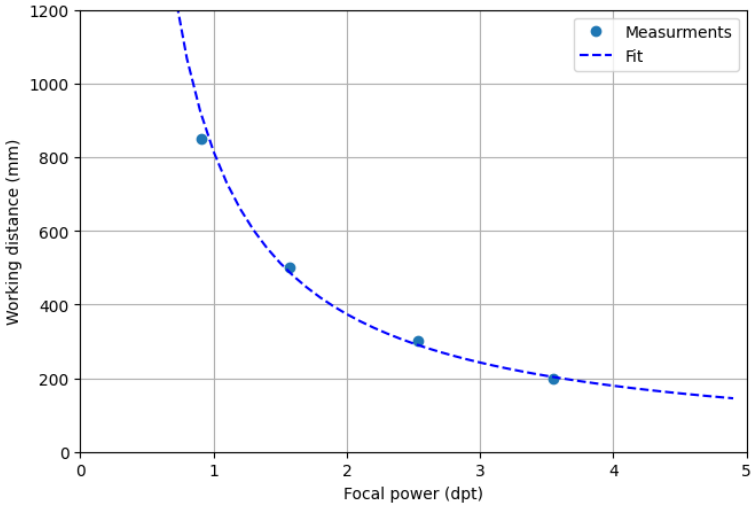
- All the images are taken at Gain 0, and without gamma correction
- The intensity of illumination is controlled to adjust the histogram of the images
- After acquisition, images are zoomed in to show the resolution-limited element



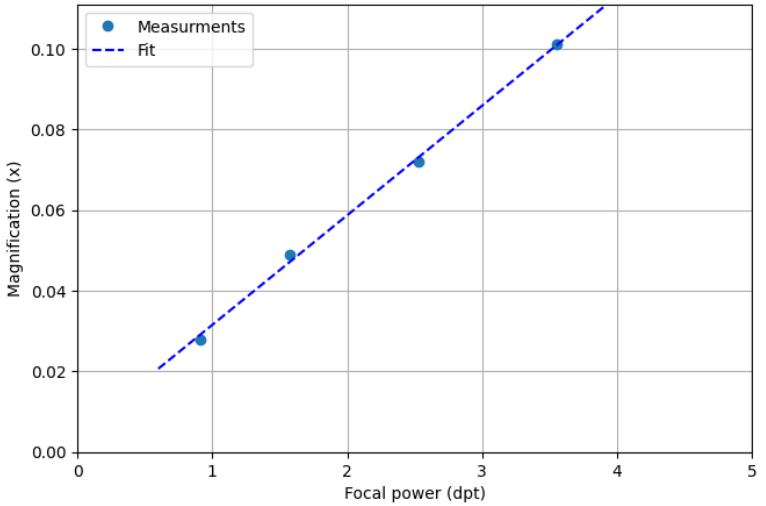
Working distance, Magnification

- Magnification and working distance of this ELM is very well aligned with an ento-centric lens

Working distance



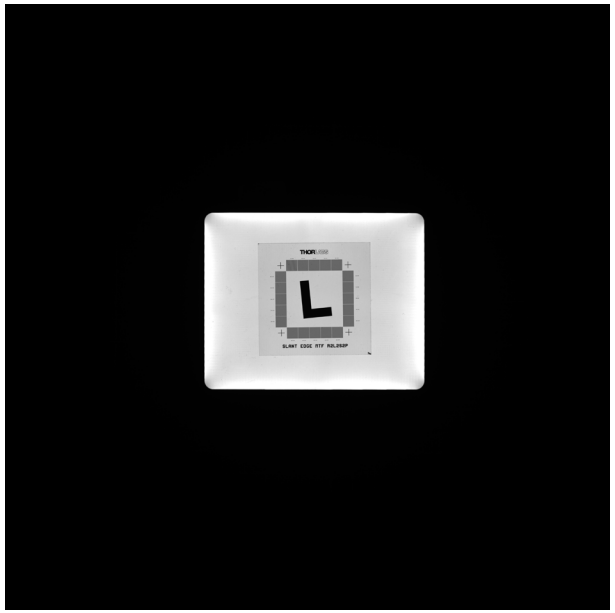
Magnification



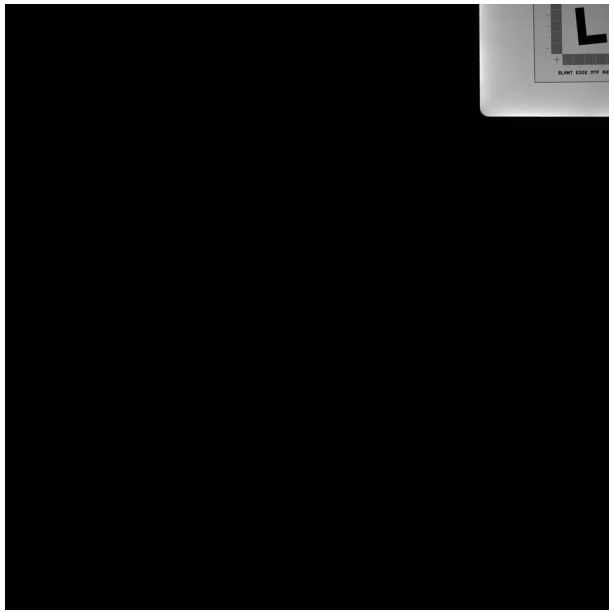
* Measured with blue LED backlight
* Magnification measured at the center of the image

Slanted-Edge MTF

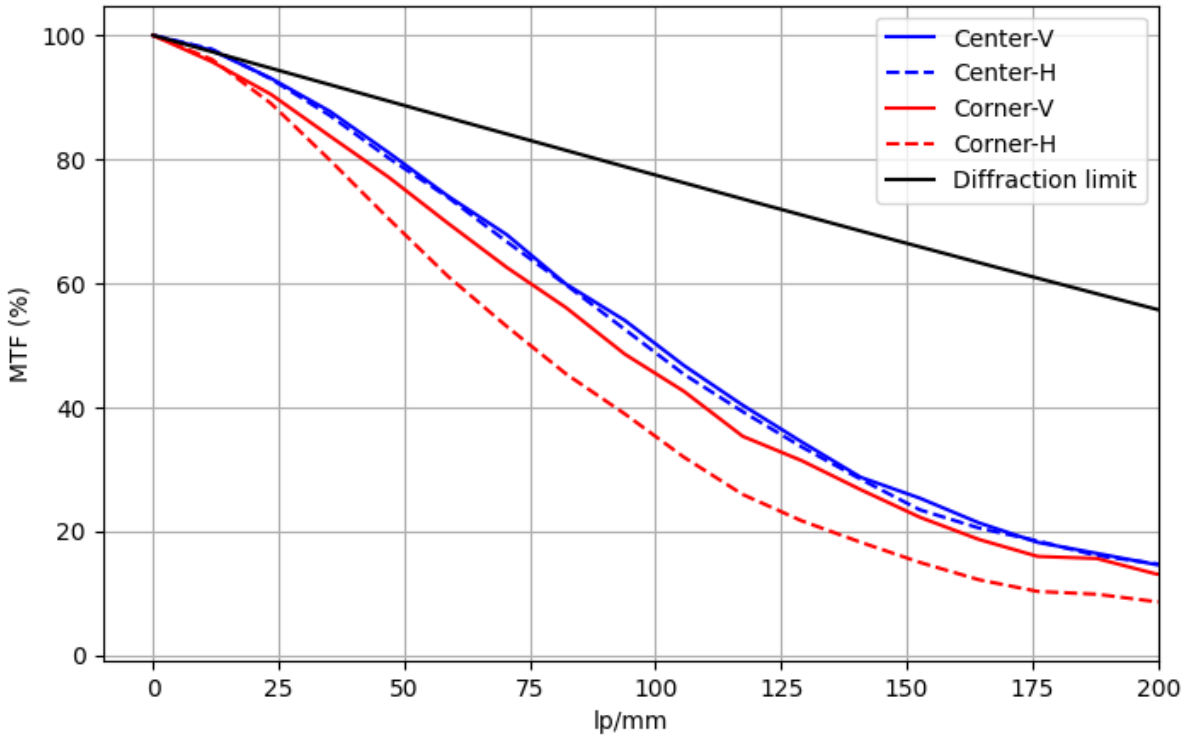
Center



Corner

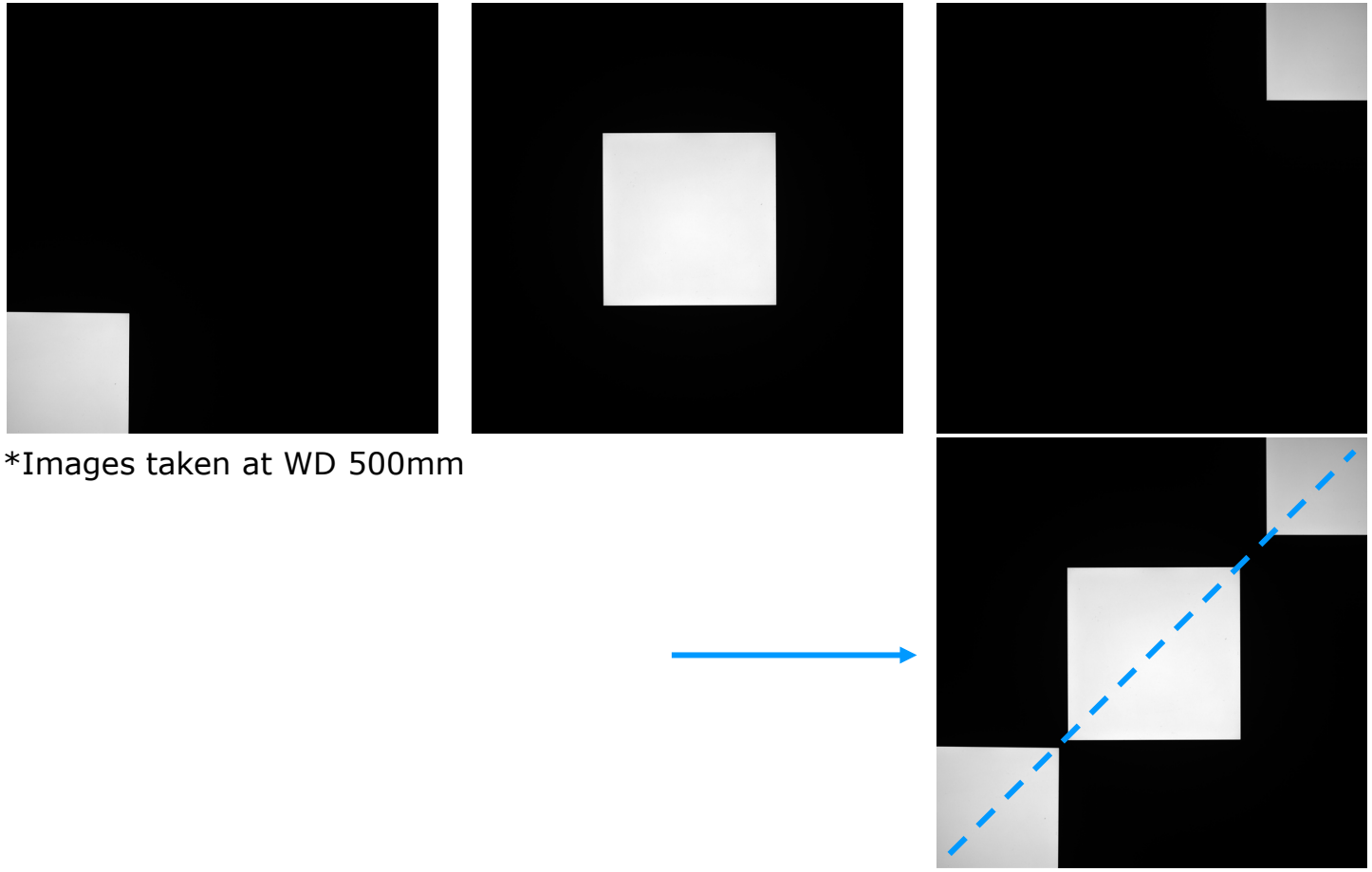


*Images taken with the blue LED at WD 500mm

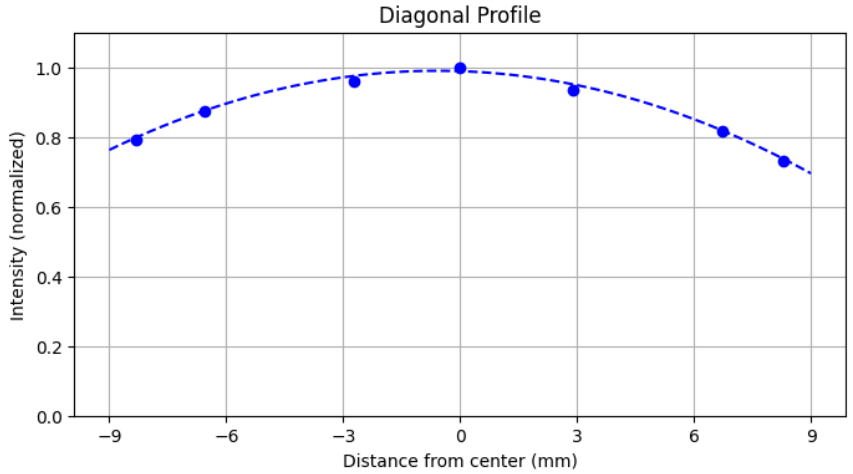


Relative illumination

- Due to the wide-angle FOV, we did image stitching for multiple measurements with a uniform LED
- Vignetting of this ELM is 0.49EV (29%) for 1.1” sensor
- There is a negligible dependence to the focal power/WD for the vignetting



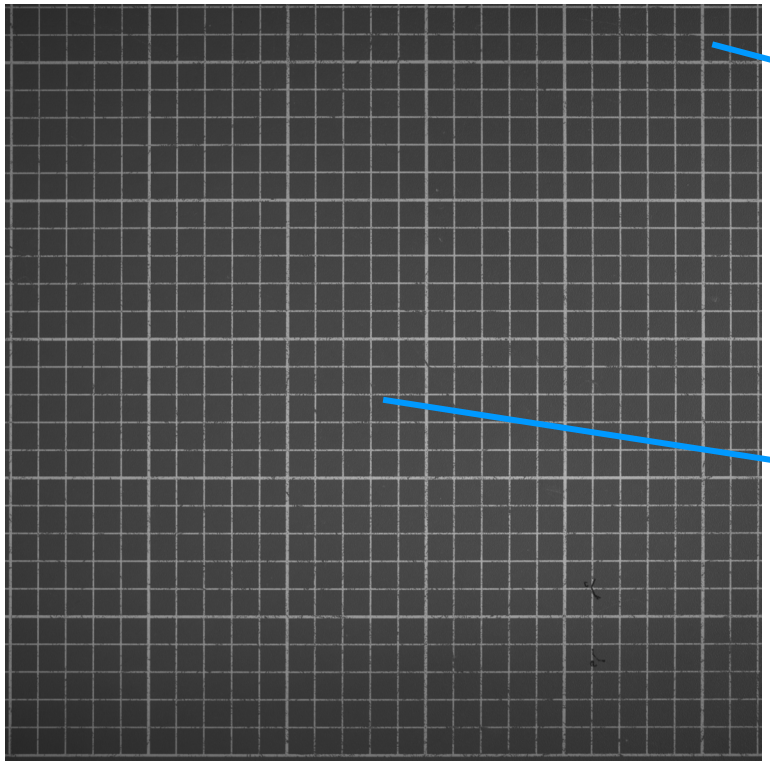
*Images taken at WD 500mm



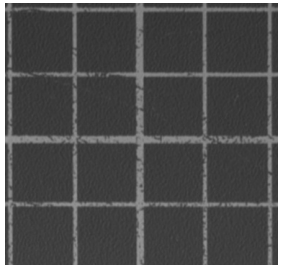
Distortion and field curvature

- We see some distortion but no field curvature
- Geometrical distortion value: **<1%**

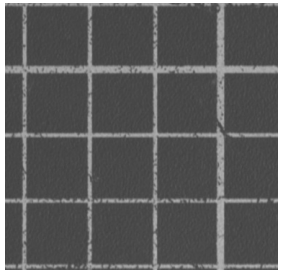
Image taken at WD 500mm



Corner



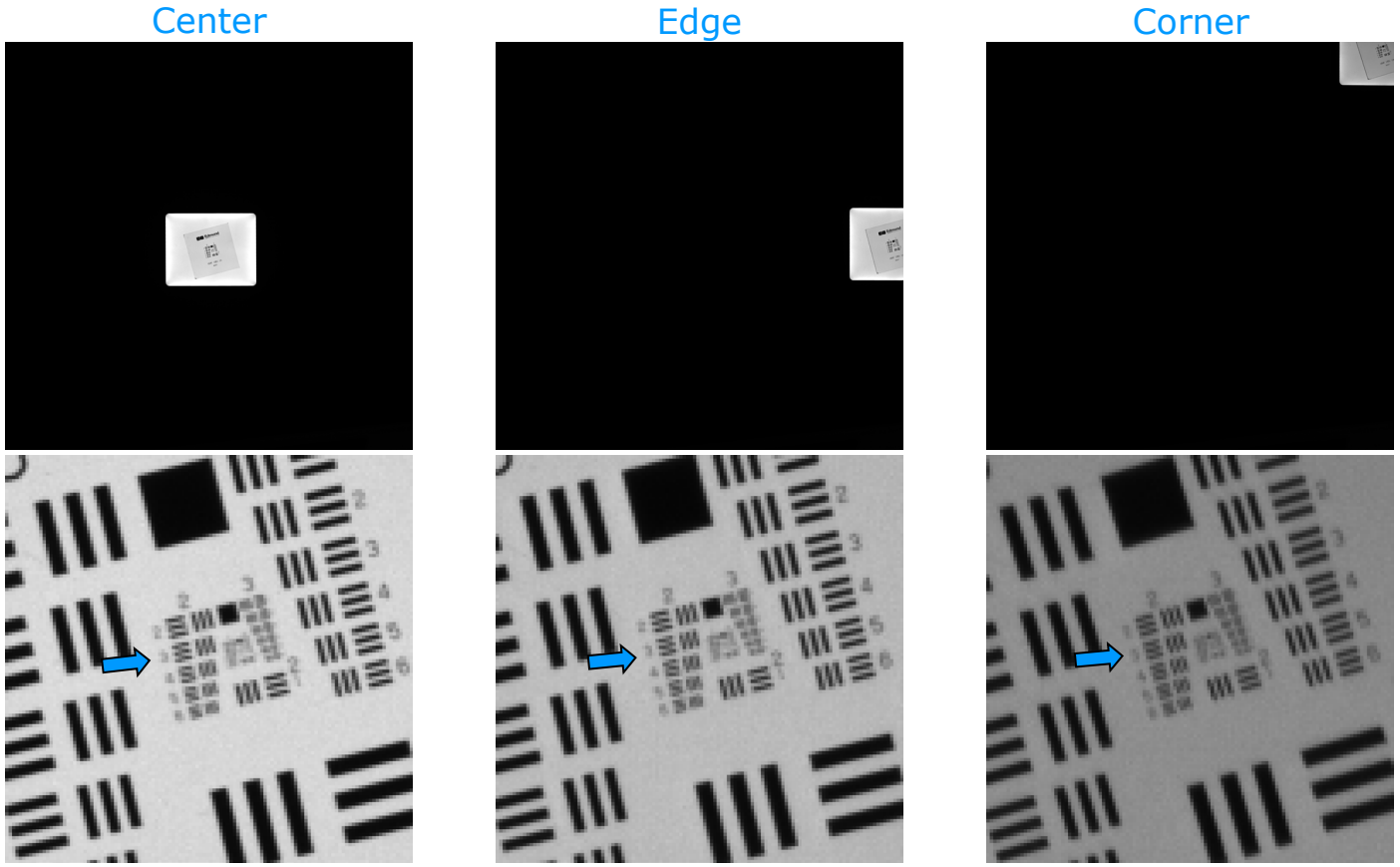
Center



WD 850 mm: +0.91dpt, Blue light
Performance is close to Nyquist limit

Camera
Sensor size = 4512 x 4512 px
Pixel size = 2.74 um
Nyquist limit = 182 lp/mm

Light
Blue background illumination



	Center	Edge	Corner
USAF element:	2/3	2/3	2/3
Line width (um):	99.21	99.21	99.21
Lp/mm (object):	5	5	5
Magnification:	0.028	0.028	0.028
Lp/mm (image):	**183**	**183**	**183**

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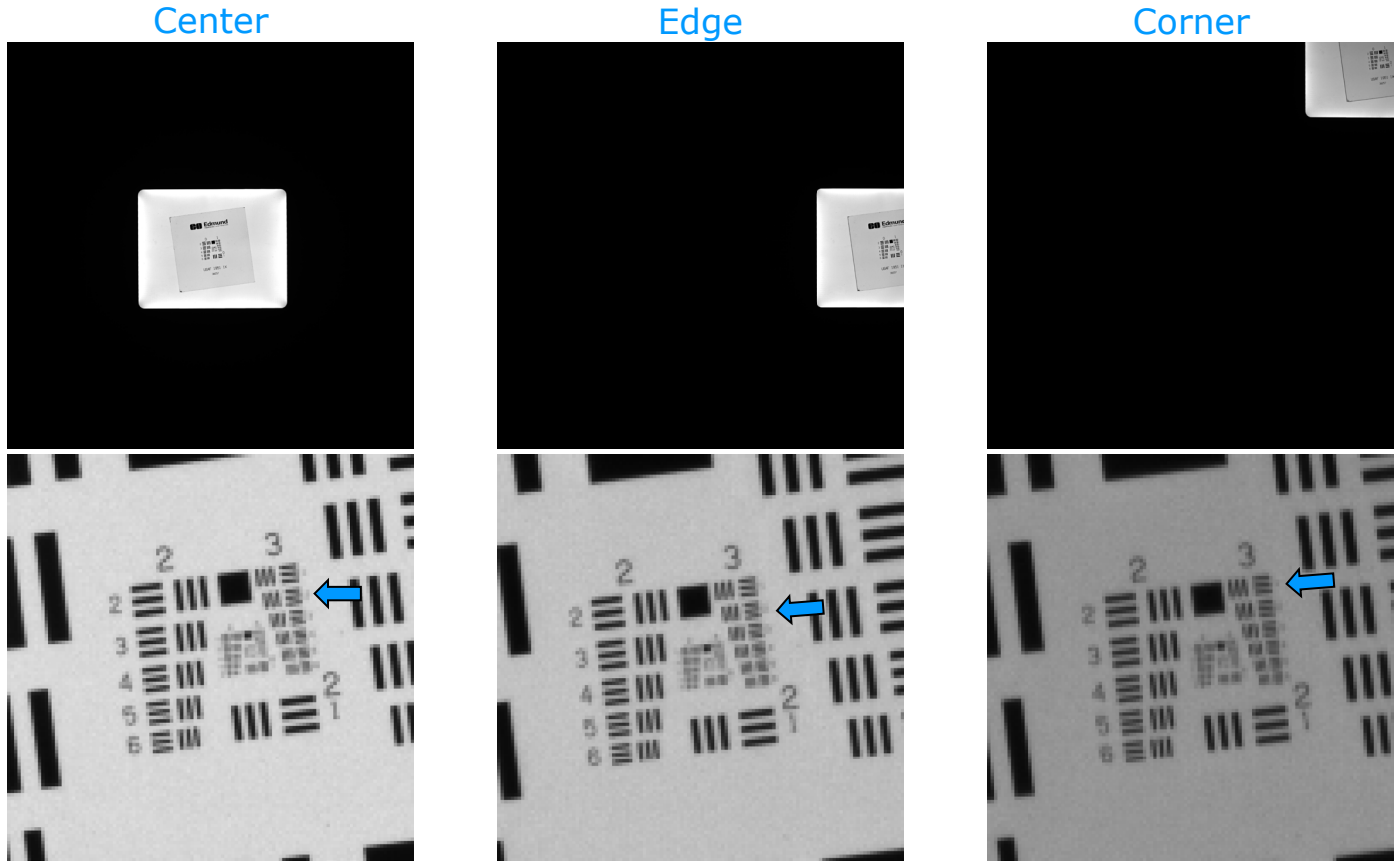
WD 500 mm: +1.57dpt, Blue light
Performance is close to Nyquist limit

Camera
Sensor size = 4512 x 4512 px
Pixel size = 2.74 um
Nyquist limit = 182 lp/mm

Light
Blue background illumination



	Center	Edge	Corner
USAF element:	3/2	3/2	3/1
Line width (um):	55.68	55.68	62.5
Lp/mm (object):	9	9	8
Magnification:	0.049	0.049	0.049
Lp/mm (image):	**183**	**183**	**163**

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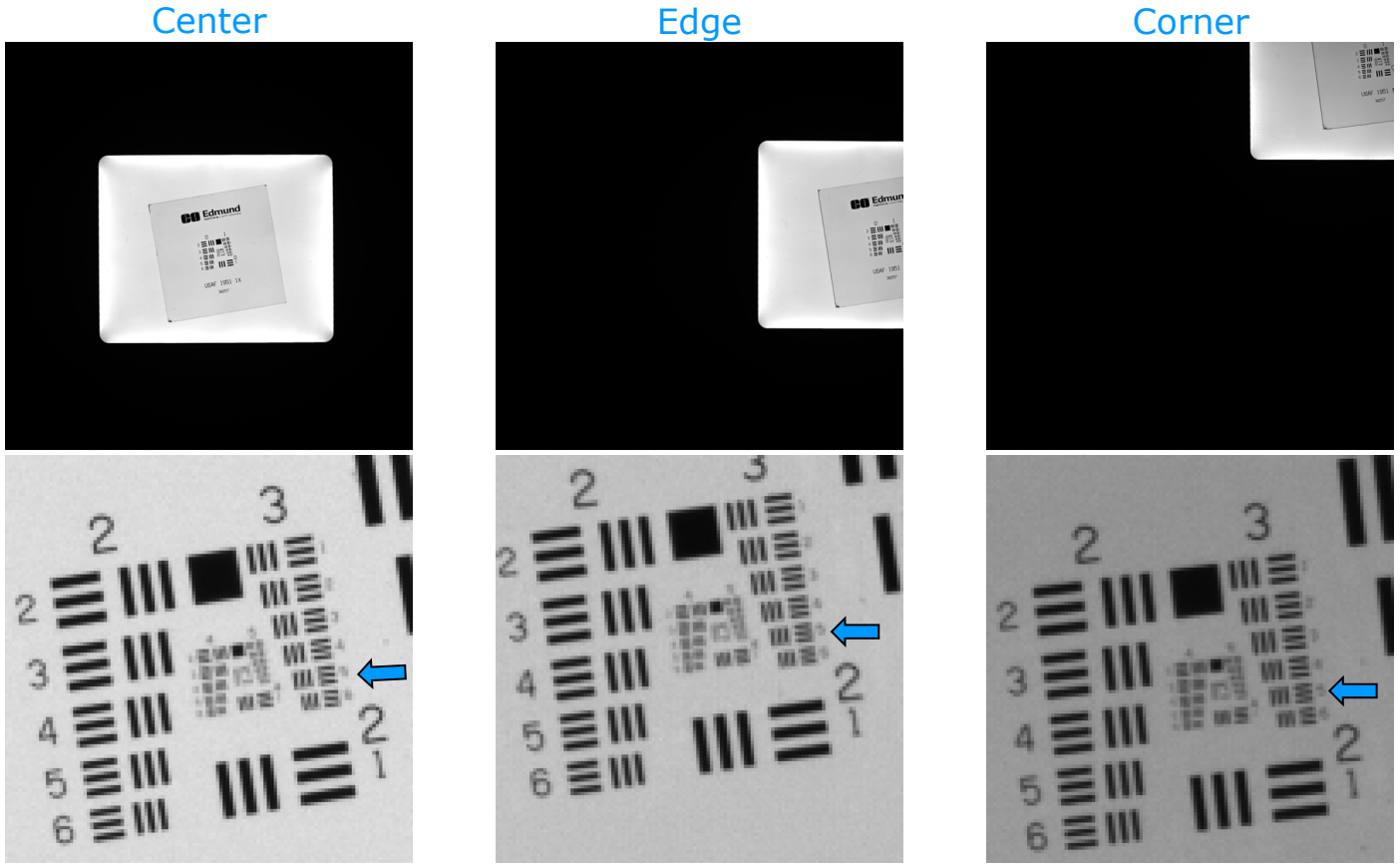
WD 300 mm: +2.53dpt, Blue light
Performance is close to Nyquist limit

Camera
Sensor size = 4512 x 4512 px
Pixel size = 2.74 um
Nyquist limit = 182 lp/mm

Light
Blue background illumination

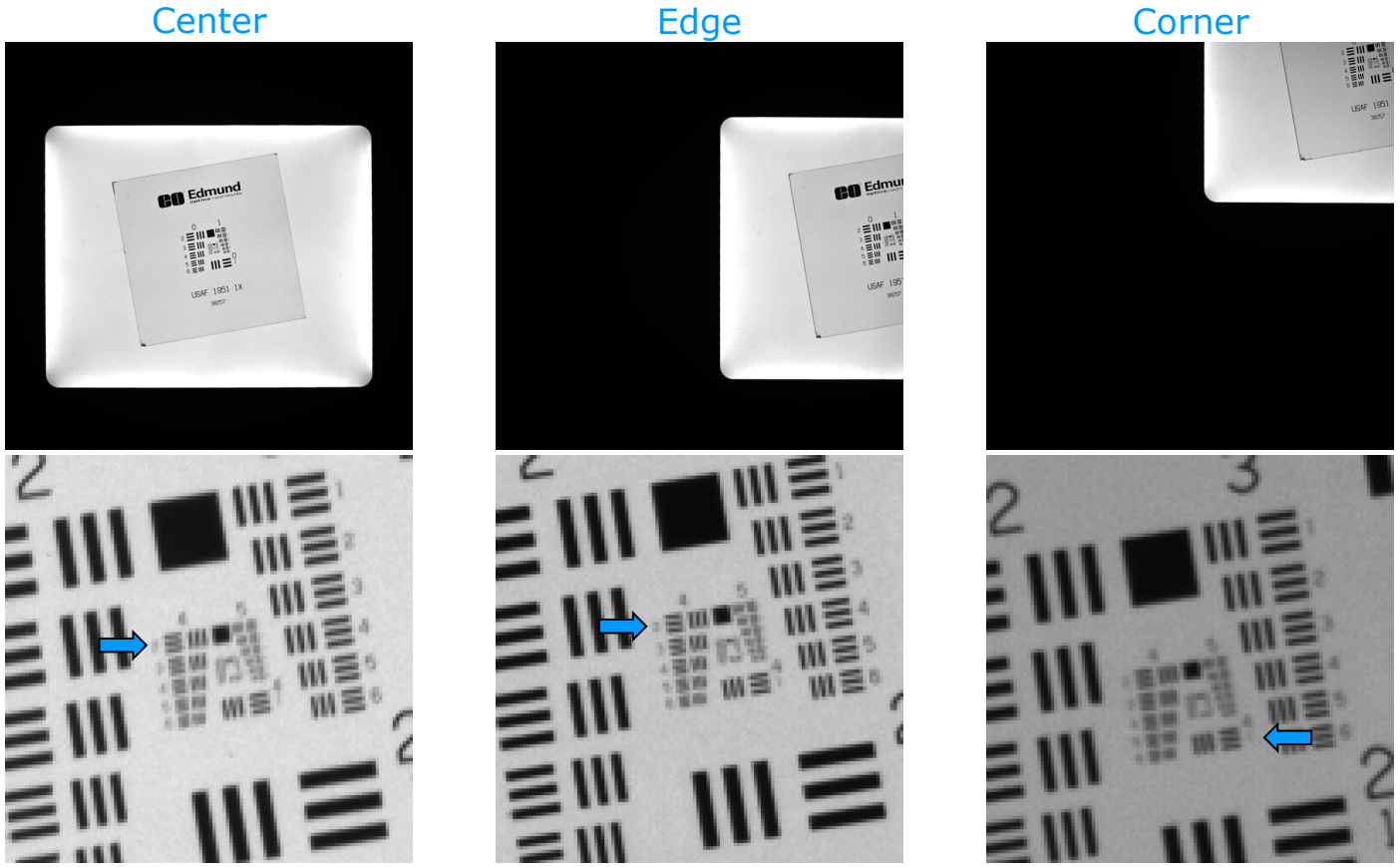


	Center	Edge	Corner
USAF element:	3/5	3/5	3/5
Line width (um):	39.37	39.37	39.37
Lp/mm (object):	13	13	13
Magnification:	0.072	0.072	0.072
Lp/mm (image):	**177**	**177**	**177**

WD 200 mm: +3.55dpt, Blue light
Performance is close to Nyquist limit

Camera
Sensor size = 4512 x 4512 px
Pixel size = 2.74 um
Nyquist limit = 182 lp/mm

Light
Blue background illumination



	Center	Edge	Corner
USAF element:	4/2	4/2	4/1
Line width (um):	27.84	27.84	31.25
Lp/mm (object):	18	18	16
Magnification:	0.101	0.101	0.101
Lp/mm (image):	**179**	**179**	**159**

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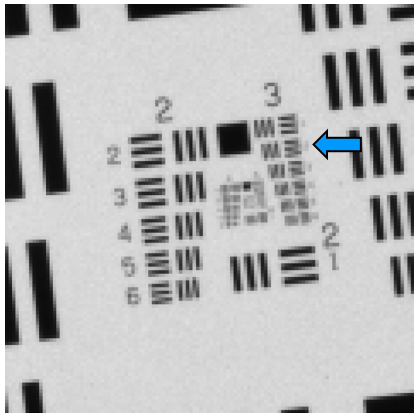
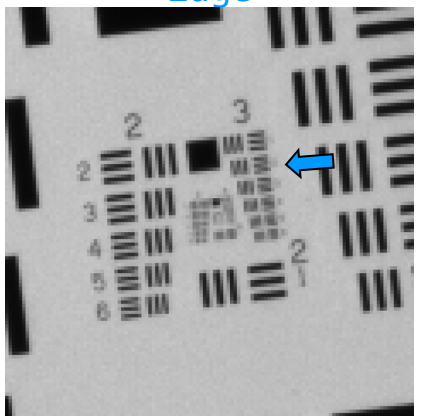
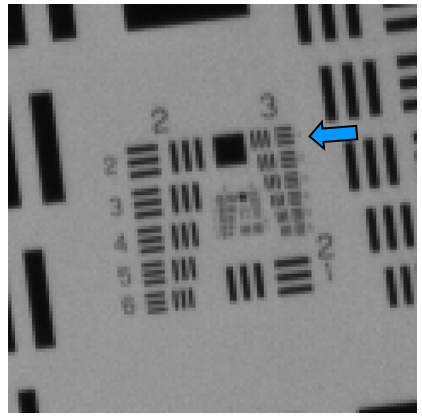
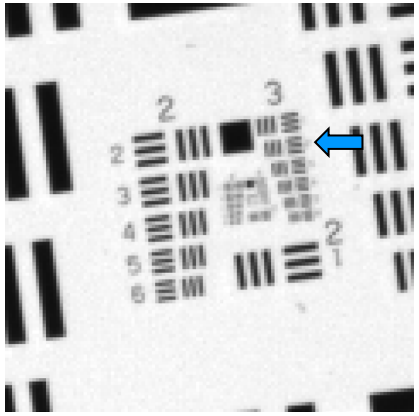
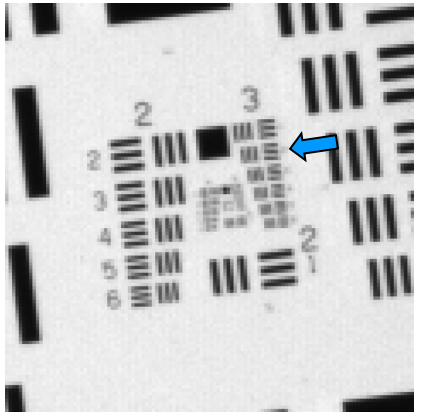
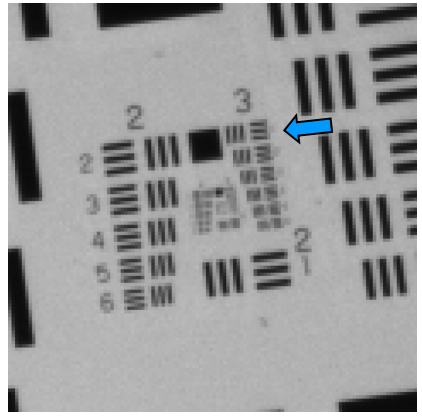
Polychromatic performance: White LED vs. Blue LED
WD 500mm, +1.57dpt

Camera
Sensor size = 4512 x 4512 px
Pixel size = 2.74 um
Nyquist limit = 182 lp/mm

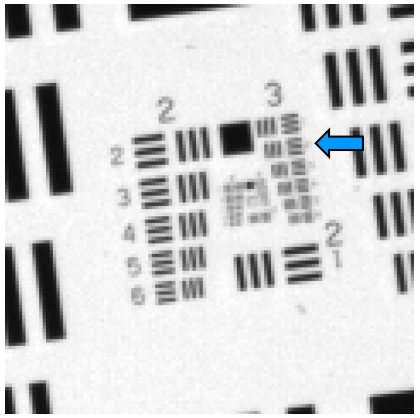
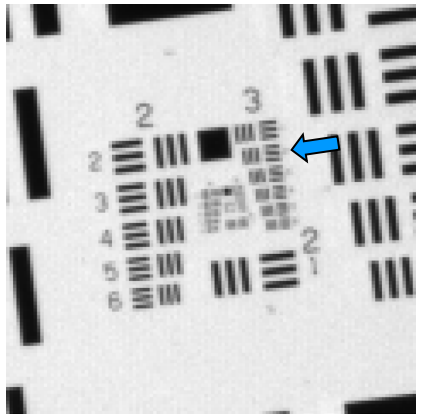
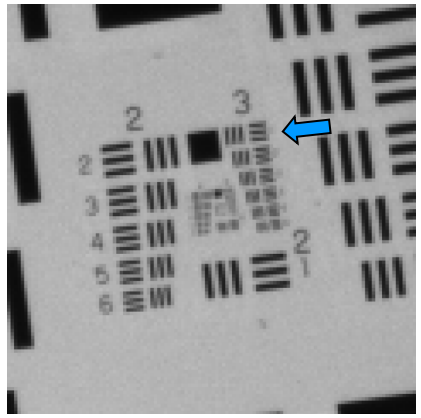
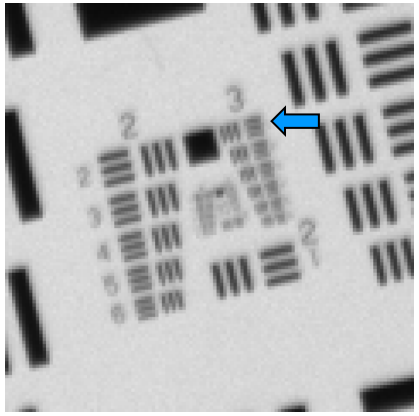
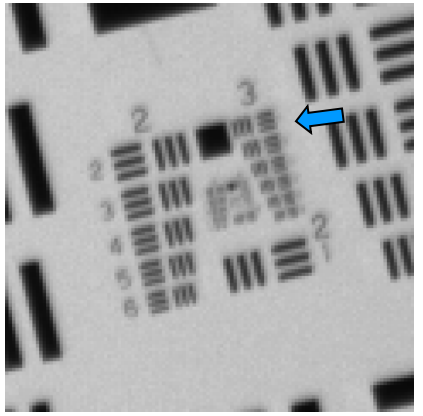
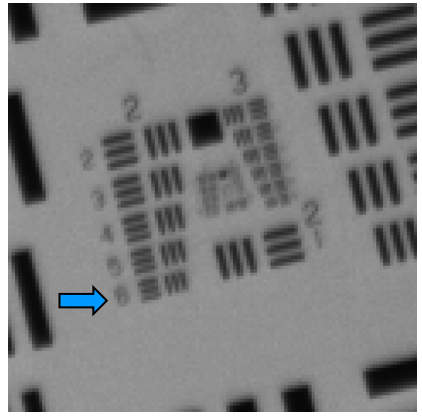
	Center	Edge	Corner
Blue			
	183 LP/mm	183 LP/mm	163 LP/mm
White			
	183 LP/mm	183 LP/mm	163 LP/mm

Vertical vs. Horizontal optical axis
WD 500mm, +1.57/1.42dpt, White LED

Camera
Sensor size = 4512 x 4512 px
Pixel size = 2.74 um
Nyquist limit = 182 lp/mm

Light
White background illumination

EL-12-30 Gravity coma: 0.18λ

	Center	Edge	Corner
Vertical OA	 183 LP/mm	 183 LP/mm	 163 LP/mm
Horizontal OA	 163 LP/mm	 163 LP/mm	 146 LP/mm