DXOMARK AUTOMOTIVE/ROBOTICS EVALUATION REPORT

--Sample report--

Automotive raw camera – Premium report

corp.dxomark.com

P2020 Flare

Standard compliance

The Flare (also called stray light) measurement is fully compliant with IEEE P2020.

Metric details

$$\text{Flare Intensity} = 20 \cdot \log_{10}\left(\frac{E_{flare}}{E_{source}}\right)$$

With E_{source} the illuminance received from the light source on the surface of the lens and E_{flare} the equivalent illuminance received on the sensor

$$E_{flare} = \pi \cdot \frac{x}{\text{sensitivity} \cdot t}$$

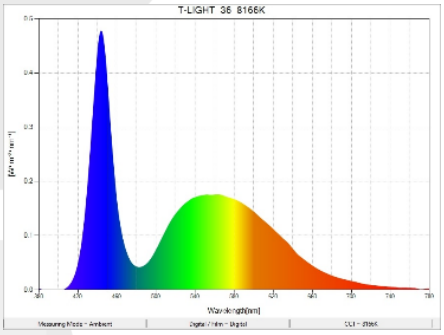
Where:

- t in s is the exposure time
- x in DN is the linearized gray level with dark level compensation
- sensitivity in DN/cd/m²/s is the measured flare sensitivity of the device.

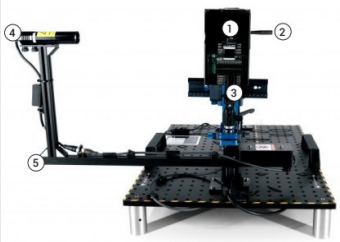
Reference article: *E. Souksava, E. Baudin, C. Greco, HP Nguyen, L. Chanas, F. Guichard, Improvement of the flare evaluation for cameras and imaging applications when using near-infrared lighting, in Electronic Imaging, 2023, pp 319-1 - 319-5.*

Measurement setup specifications

Spectrum of the LED light source:



Compass bench with flare light source:



1. Device under test
2. Indexed rotation stage to change from horizontal to vertical and diagonal axis,
3. 6 axes alignment stage equipped with 1/4 in. ISO 1222 compatible screw, designed to support any camera and demoboard,
4. Collimated light source with an apparent diameter of 0.95°
5. Motorized arm for rotating the light source between -160° and +160°

P2020 Noise

Standard compliance

The noise measurement is fully compliant with IEEE P2020.

Metric details

- **Temporal Noise** and **Fixed Pattern Noise (FPN)**, as well as **dark signal** are computed over 30 frames.
- **Total noise** is computed as the quadratic sum of Temporal Noise and FPN.
- **SNR** is computed as the ratio between mean signal and noise standard variation.
- **SNR1** in DN or in charge units is the mean signal where SNR is equal to 1.
- **Signal saturation** in DN or in charge units is the maximum signal level of the image sensor.
- **Effective full-well** in DN or in charge units is the mean signal value of the maximum of the temporal noise curve.
- **Dynamic range** is computed as the gray level ratio between effective full well and SNR1.
- **Simplified dynamic range** is computed as the gray level ratio between signal saturation and SNR1.
- **SG (system gain)** in DN/e- is the ratio between temporal noise power and mean signal in photonic noise regime. SG is used to convert metrics in DN to charge units.
- **DSNU** is the FPN in the dark.
- **Temporal-noise distribution** is the histogram of the pixel standard-deviation over dark frames.
- **Noise autocorrelation maps** are in addition to P2020 metrics. Reference article: *J. Buzzi, F. Guichard, Noise in imaging chains: correlations and predictions, IEEE International Conference on Image Processing 2005.*

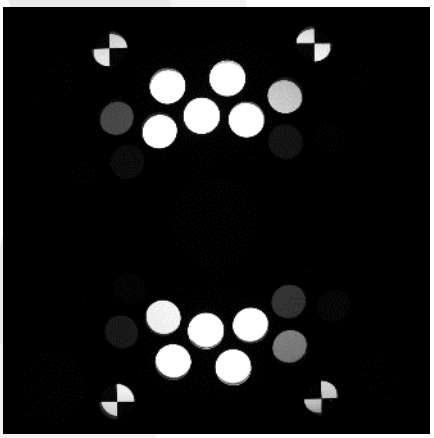
Measurement setup specifications

DXOMARK HDR noise target is a 120dB chart made of 30 neutral densities.

The chart is illuminated by a Nanlux Evoke 1200 or a Litepanels Gemini 1x1. Both are DC driven, dimmable, and have a stability over 95%.

Light level is measured using a Gossen MAVOLUX 5032B.

Temperature tests are done using a thermal chamber Binder.



P2020 Dynamic Range

Standard compliance

The Dynamic Range measurement is fully compliant with IEEE P2020.

Metric details

The dynamic range measurement is performed on pairs of patches (A, B), with a 2:1 contrast ratio between A and B in the scene

Adjusted CNR (Contrast to Noise Ratio):

$$\mathrm{CNR}(A,B) = \frac{s_A - s_B}{\sqrt{\sigma_A^2 + \sigma_B{}^2}} \cdot \frac{c+1}{c-1} \cdot \frac{1}{\sqrt{2}}$$

With:

- s_A, s_B the mean signal of A and B
- σ_A, σ_B the standard deviation of A and B
- c the contrast between A and B in the scene

TCG (Tonal Contrast Gain) is the transfer function between the scene contrast and the image contrast:

$$\mathrm{TCG}(A,B) = \frac{\log_2\left(L_{A,image}/L_{B,image}\right)}{\log_2\left(L_{A,scene}/L_{B,scene}\right)}$$

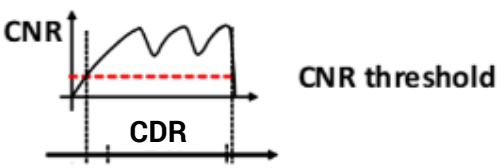
With:

- $L_{A,image}$, $L_{B,image}$ the mean signal of A and B in the image.
- $L_{A,scene}$, $L_{B,scene}$ the luminance of A and B in the scene.

CDR (Contrast Detection Ratio) is the dynamic range measured from CNR:

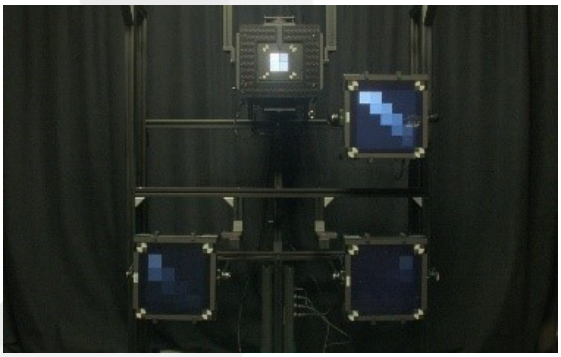
$$\mathrm{CDR}_{dB} = 20\log_{10}\left(\frac{L_{max}[\mathrm{CNR}>1]}{L_{min}[\mathrm{CNR}>1]}\right)$$

With $L_{max}[CNR>1]$, $L_{min}[CNR>1]$ the maximum and minimum luminance values that verify $CNR>1$.



Measurement setup specifications

The dynamic range setup is an assembly of 4 light panels and charts, delivering 25 patches that can reach 170dB dynamic.



SFR

Standard compliance

The SFR measurement is fully compliant with the standard ISO 12233.

Metric details

SFR is computed in a linearized image

Metrics are computed in 15 different field positions.

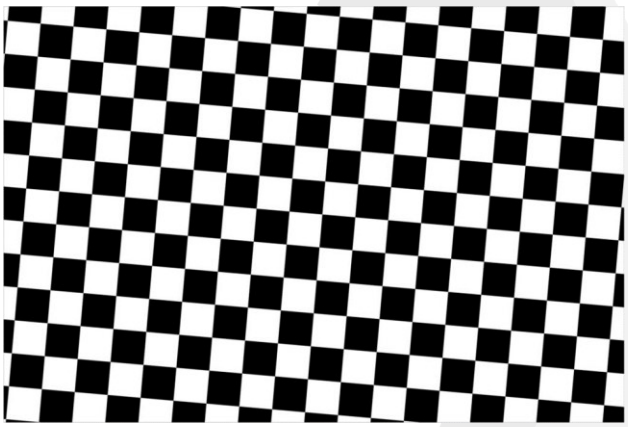
SFR measurement compensates the target printer MTF. The target MTF is measured compared to a true cutter target, and it is then taken into account during the camera MTF measurement

- **MTF** curve with frequency in cycles/pixels
- **MTF10** and **MTF50**: (raw images only) frequency (in cycles/pixel) corresponding to MTF=10% and 50%
- **MTF@Nyq/2** and **MTF@Nyq/16**: (raw images only) MTF value at frequency = 1/2 and 1/16 of Nyquist frequency

Measurement setup specifications

High contrast checkerboard chart

Through focus method is used to find the best focus.



SFR at Infinity

Standard compliance

The SFR measurement is fully compliant with the standard ISO 12233.

Metric details

A slanted edge is backlit with a collimated light source. This allows the SFR measurement to be performed on devices focused at infinity.

SFR is computed in a linearized image

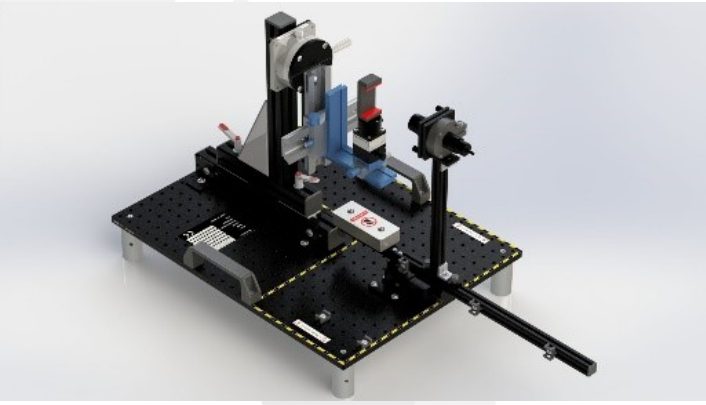
Metrics are computed in 15 different field positions.

SFR measurement compensates for the collimator reticle MTF during the camera MTF measurement. The collimator reticle MTF is measured compared to a true cutter target.

- **MTF profile:** MTF curve for each field position, with frequency in cycles/pixels
- **Acutance in the field:** acutance values for all tested positions

Measurement setup specifications
COMPASS bench with collimator:

- Focal length: 50 mm
- External diameter: 30 mm
- Reticle: Slanted edge 12 mm
- Aperture: f/2.8
- Motorized arm for rotating the slanted edge between -160° and +160°



P2020 Flicker Mitigation

Standard compliance

The flicker mitigation measurement is fully compliant with IEEE P2020.

Metric details

Flicker Modulation Index (FMI):

$$FMI = 100 \times \frac{s_{max} - s_{min}}{s_{max} + s_{min}}$$

With s_{max} and s_{min} the maximum and minimum values of the measured signal for the considered time-range of the video.

Flicker Detection Index (FDI):

$$FDI = P\left[\frac{s(t) - s_{off}}{s_{off}} \geq \text{th}\right]$$

Where:

- P[x] is the probability of x.
- $s(t)$ is the measured signal.
- s_{off} is the measured signal when the PMW signal is off.
- th is a minimum threshold above which the LED is considered visible.

Modulation Mitigation Probability (MMP):

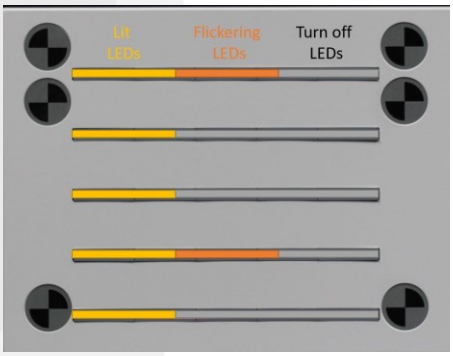
$$MMP = P\left[\overline{s_{ref}}(1-\delta) < s(t) < \overline{s_{ref}}(1+\delta)\right]$$

Where:

- P[x] is the probability of x.
- $s(t)$ is the measured signal.
- $\overline{s_{ref}}$ is the expected signal.
- δ is a parameter defining the lower and upper bounds of the signal interval in which the device is considered as able to successfully mitigate the LED flickering.

Measurement setup specifications

Flicker is generated by the DXOMARK LED Universal Timer. This device provides a light modulated by a square signal with frequency in range [50, 2000] Hz, adjustable duty cycle, phase and intensity.



P2020 Contrast Performance Indicators (CPI)

Standard compliance

The Contrast Performance Indicators measurement is fully compliant with the standard draft IEEE/P2020 under revision.

Metrics details

The CTA (Contrast Transfer Accuracy) quantifies the ability of a camera to record accurately the contrast in the scene:$CTA = P[C_{in}.\cdot (1 - \delta_{-}) \leq C_{meas} \leq C_{in}.\cdot (1 + \delta_{+})]$

Where:

- C_{in} and C_{meas} are respectively the input contrast in the scene and the measured contrast in the image.
- δ_{-} and δ_{+} are the parameters defining the lower and upper bounds of the confidence interval in which the device is considered as able to reproduce accurately the input contrast.

The CSNR (Contrast Signal-to-Noise Ratio) quantifies the ability of a camera to distinguish two objects:

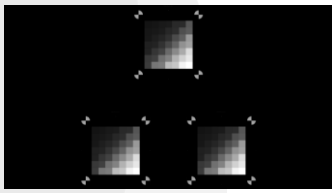
$$CSNR = \frac{\bar{C}}{\sigma_C}$$

Where:

- $\bar{C}$ is the mean of the contrast between two ROIs.
- σ_C is the standard deviation of the contrast between two ROIs.

Measurement setup specifications

The CPI chart is an assembly of 3 light panels, with a 7x7 patches matrix on each chart patches. The whole setup can reach at least 140dB dynamic.



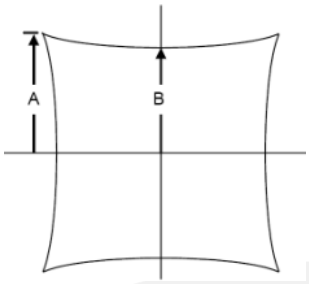
Distortion and lateral chromatic aberration

Standard compliance

The lens distortion measurement is fully compliant with ISO 17850, and the chromatic aberration measurement is fully compliant with ISO 19084.

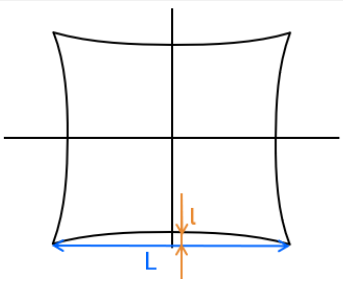
Metric details

TV distortion: $100 \cdot \frac{(A-B)}{B}$, with A and B defined on the following figure:

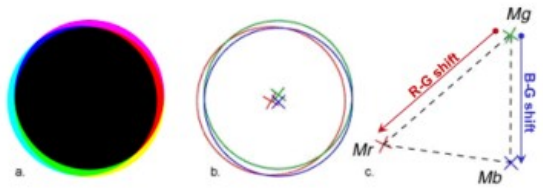


Distortion model reprojection error in pixels and ‰ of of image width, showing the precision of the distortion model.

Geometric distortion: $100 \cdot \frac{l}{L}$, with l and L defined on the following figure:



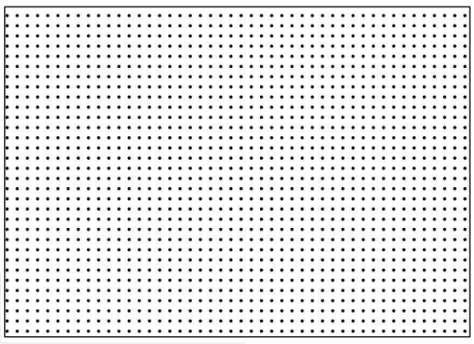
Chromatic aberrations: shift between R and G, and between B and G



Definition of chromatic aberration profiles

Measurement setup specifications

Glass-supported dot chart, offering a very flat surface: less than 1mm planarity difference between the center and the corners of the chart.



Vignetting and Color Lens Shading

Standard compliance

The Vignetting/Color Lens Shading measurement is fully compliant with the standard ISO 17957.

Metric details

Vignetting:
- **Vignetting Profile:** gray level value divided by the gray level value at the vignetting center, for each radial field position and each color channel.
- **Max attenuation:** $\max(1 - \text{VignettingProfile}) \times 100$
- **Max amplification:** $\max(\text{VignettingProfile} - 1) \times 100$

Color Vignetting:
- **Color Vignetting Profile:** each channel vignetting divided by green (average of G1 and G2 channels for raw images).
- **Max Attenuation:** $\max(1 - \text{ColorVignettingProfile}) \times 100$
- **Max Amplification:** $\max(\text{ColorVignettingProfile} - 1) \times 100$
- **Green Imbalance** (raw images only): maps of the relative difference between G1 and G2 channels.

Measurement setup specifications

Litepanels Gemini LED panel or Integrating sphere RO-LIS-3CR80

Chip total size	165x40x35 mm
Pixel size	2 µm
Max resolution	3840 x 2160
Full frame rate	36 fps
Lens FOV (H)	105°
Sensor format	1/1.7"
Shutter control	Rolling shutter

Testing Conditions

Mode sensor	Default
Frame Grabber	vRGB-E2s
SW version	13.12
Output	RAW

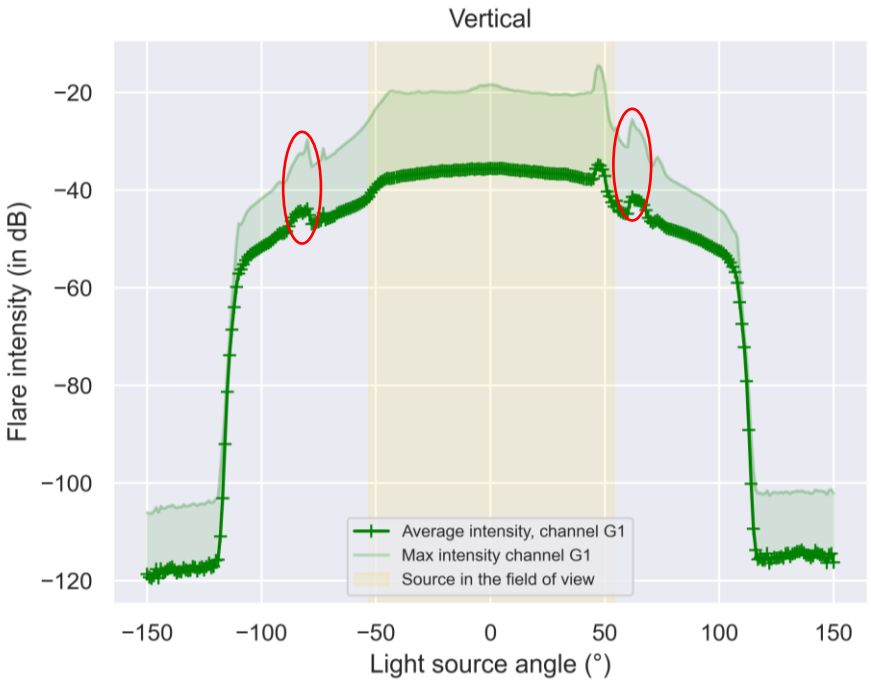
Framerate	30 fps
Image resolution	3840 x 2160
Exposure time (ms)	16
Gain	8

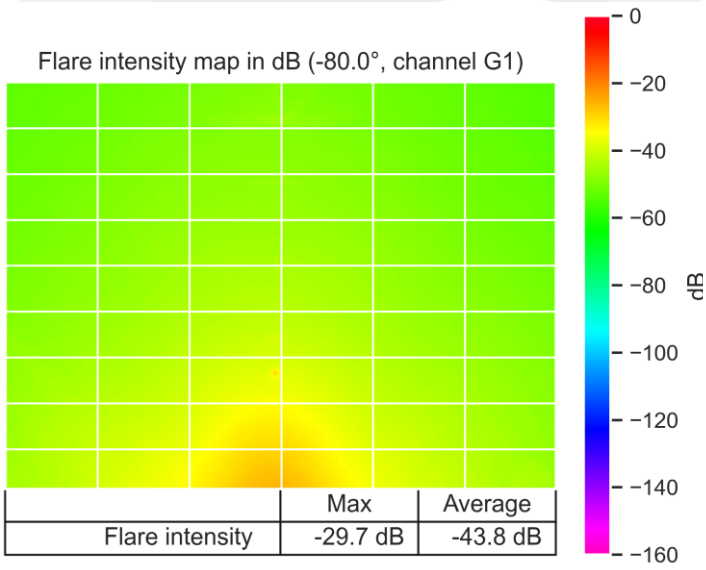
Overall Performance

DR (SNR1 40°C)	120 dB
Saturation (D65)	1200 cd/m²
Dark (40°C)	26e-
Full Well Capacity	847860e-
Dark flatness	3.1

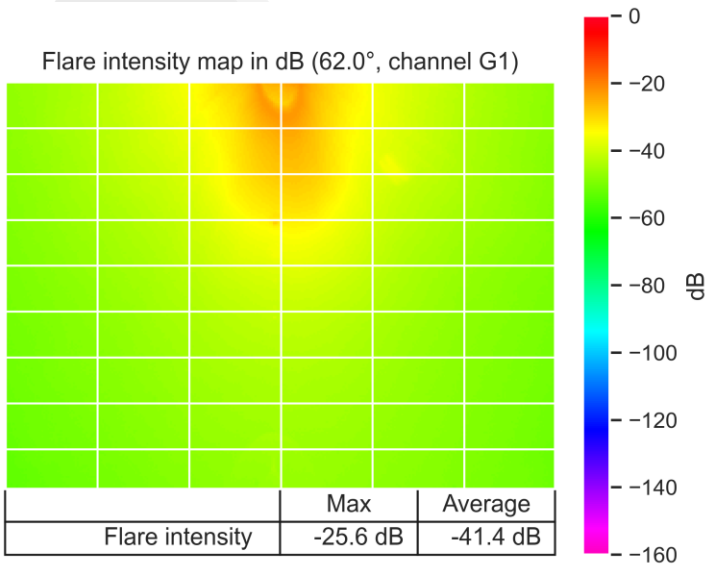
DR P2020	108 dB
Noise Autocorrelation	True RAW
Max vignetting attenuation	26%
TV distortion	-47%
Chromatic aberrations	< 1 pixel

- **Measurement conditions**
  - 3 axis: Horizontal, vertical, diagonal
  - Flare light source from -150° to 150°, with 1° step
- **Results**
  - Flare when the light source is at the center of the image: -30dB average flare intensity, and -10dB maximum flare intensity
  - More flare when the light source is close to the sides of the FOV, for vertical axis: up to -15dB maximum flare intensity

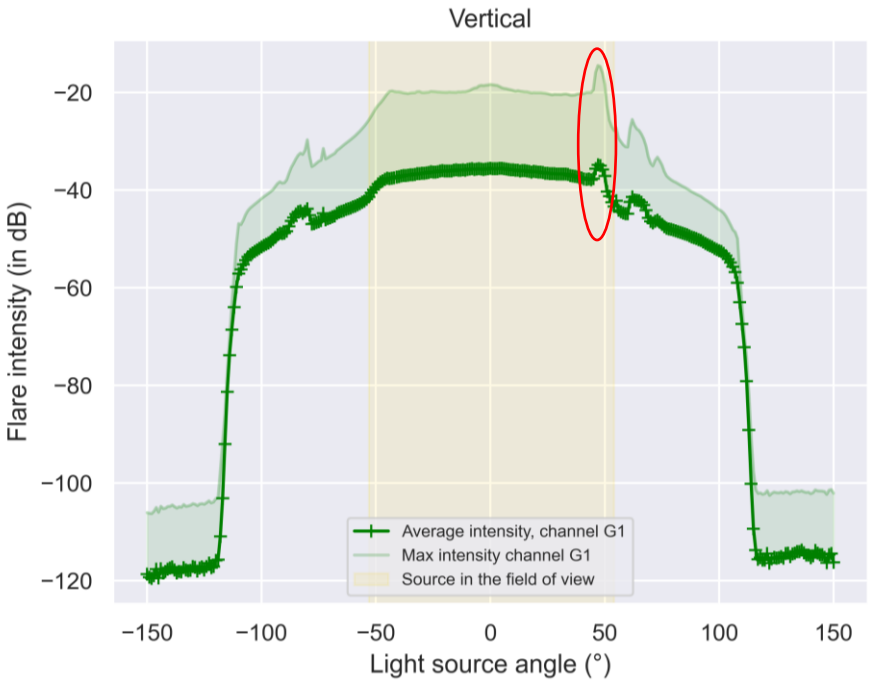


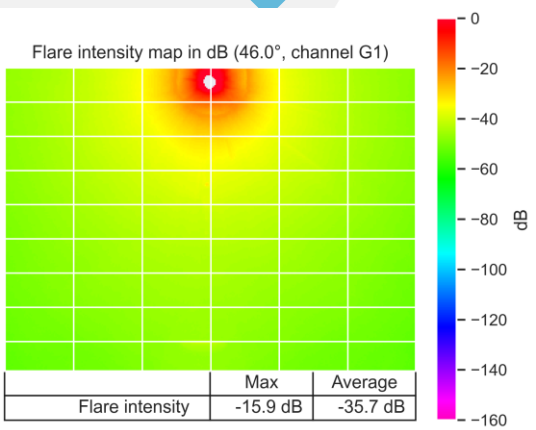


	Max	Average
Flare intensity	-29.7 dB	-43.8 dB

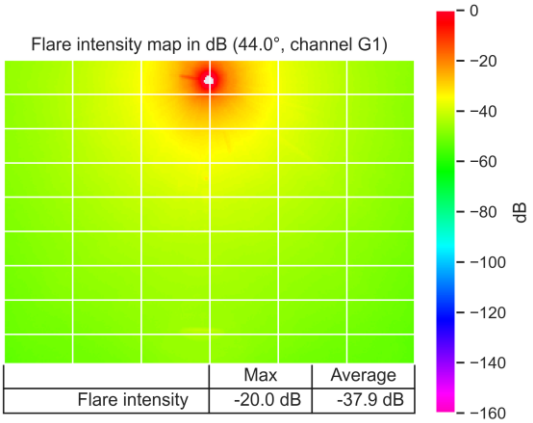


	Max	Average
Flare intensity	-25.6 dB	-41.4 dB

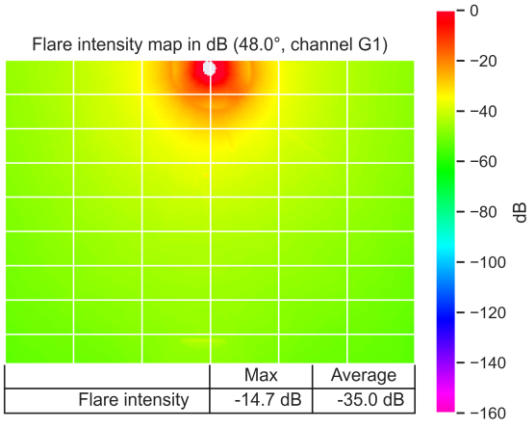




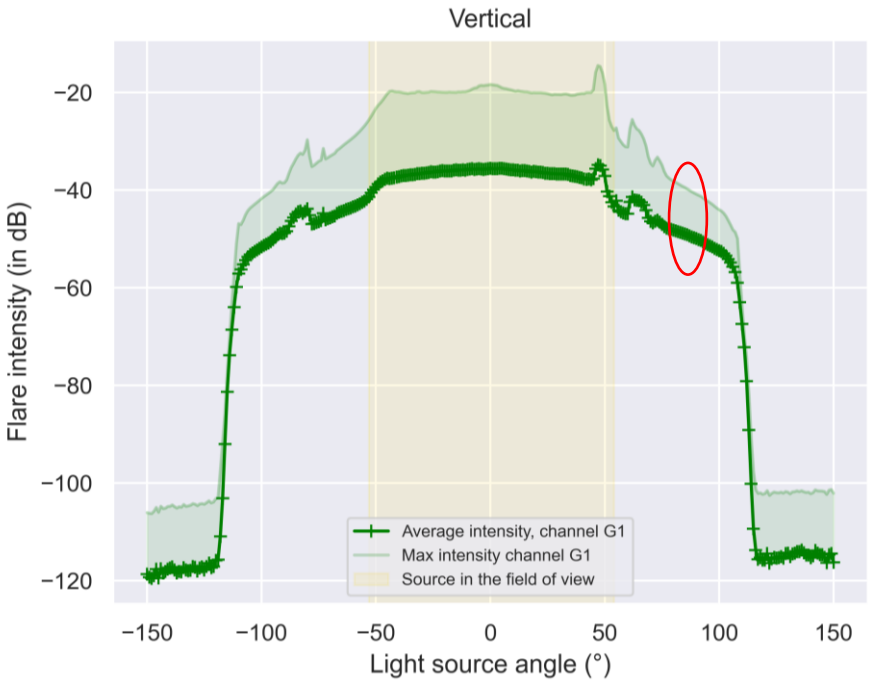
	Max	Average
Flare intensity	-15.9 dB	-35.7 dB

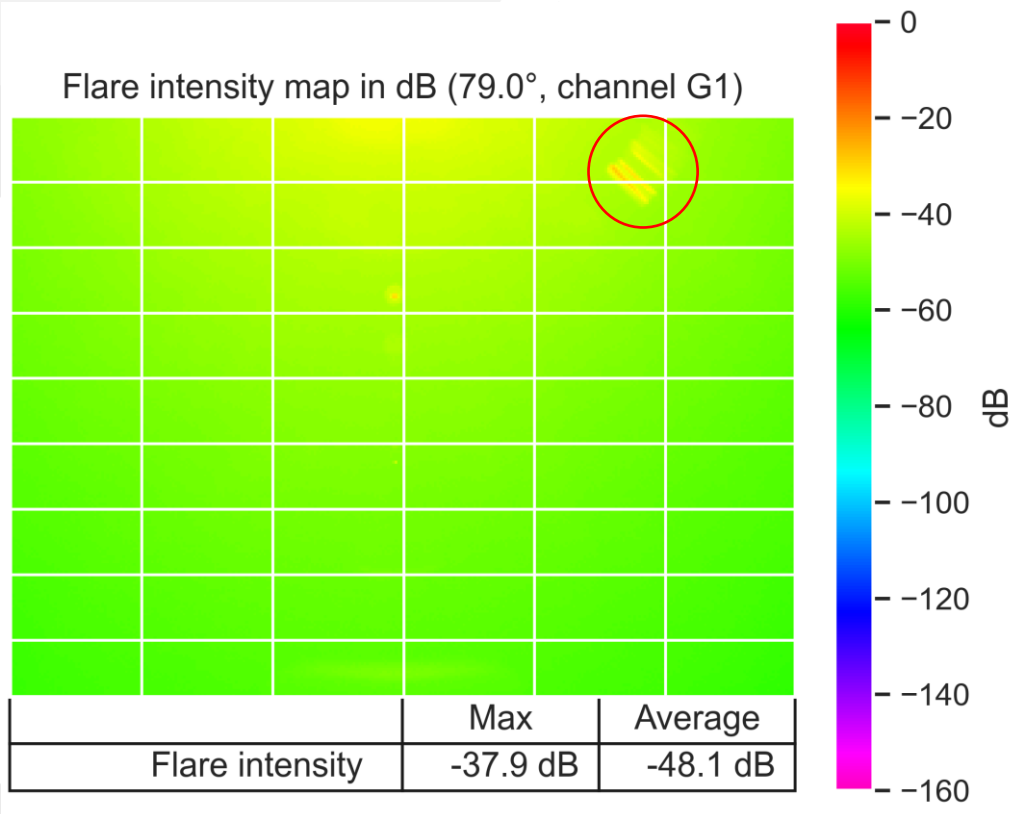


	Max	Average
Flare intensity	-20.0 dB	-37.9 dB

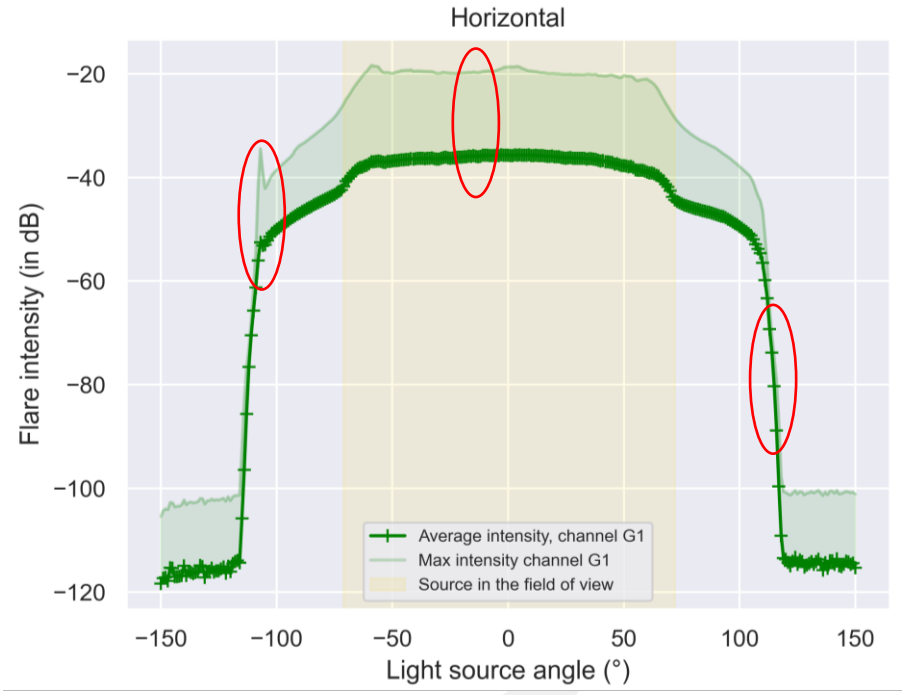


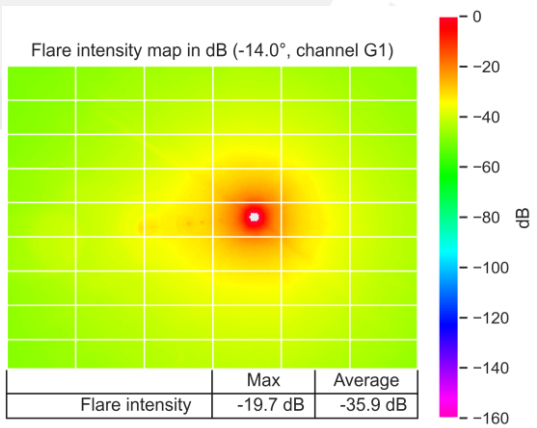
	Max	Average
Flare intensity	-14.7 dB	-35.0 dB

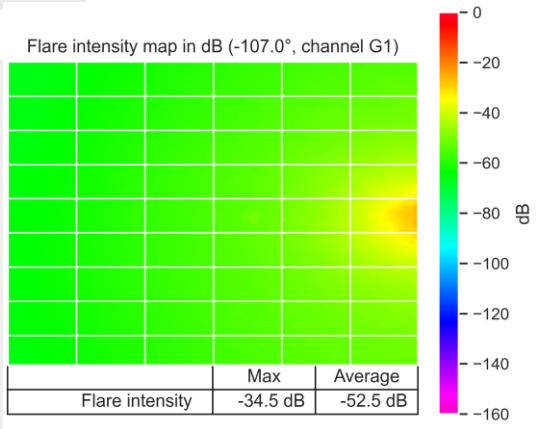


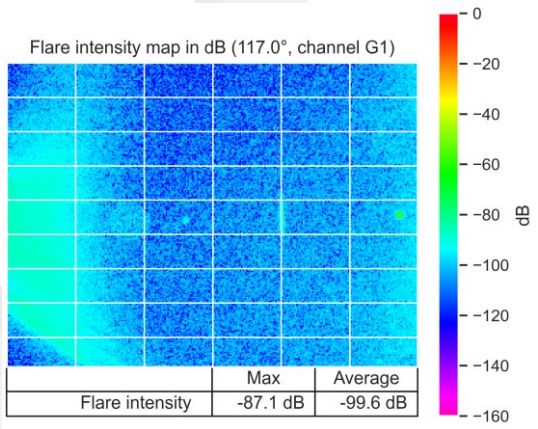


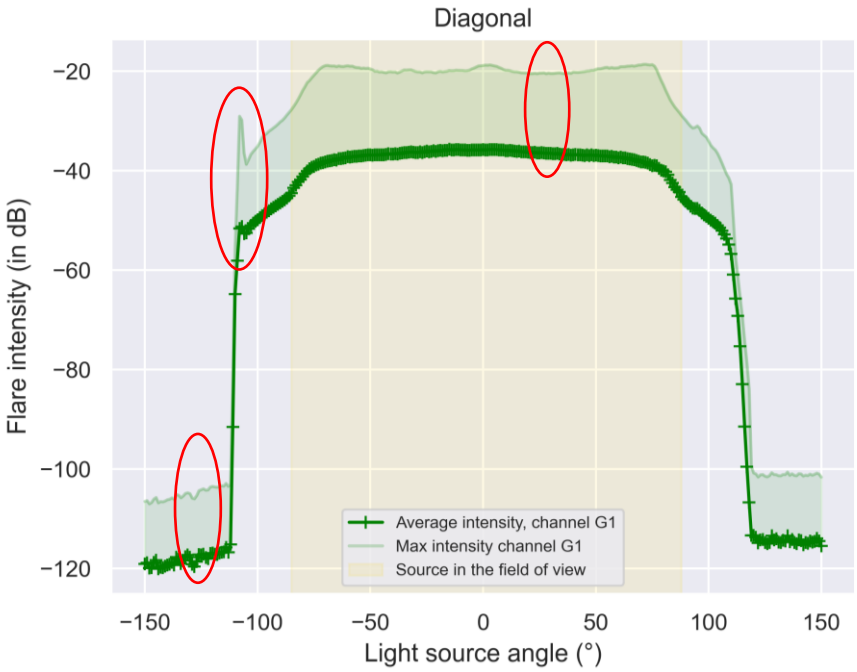
	Max	Average
Flare intensity	-37.9 dB	-48.1 dB

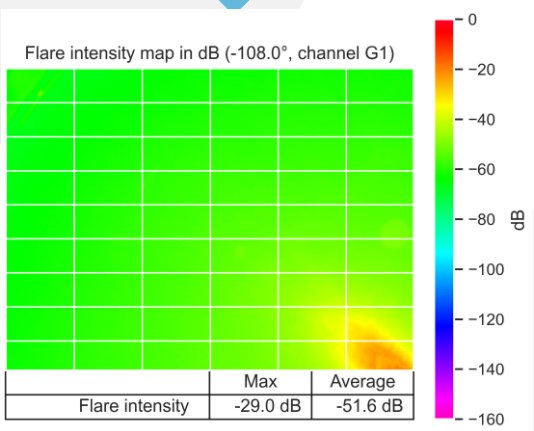

Horizontal
Flare intensity (in dB)
−20
−40
−60
−80
−100
−120
−150
−100
−50
0
50
100
150
Light source angle (°)
Average intensity, channel G1
Max intensity channel G1
Source in the field of view

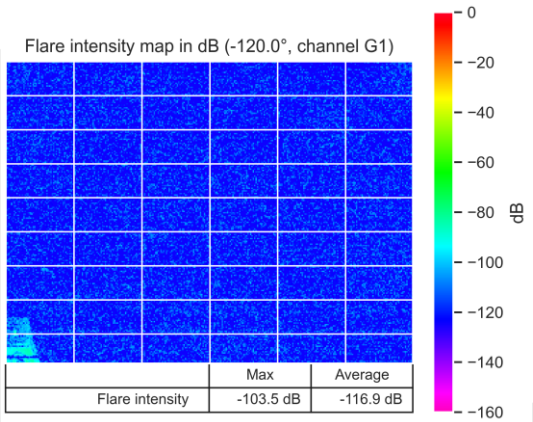

Flare intensity map in dB (-14.0°, channel G1)
0
−20
−40
−60
−80
−100
−120
−140
−160
dB
Max
Average
Flare intensity
-19.7 dB
-35.9 dB

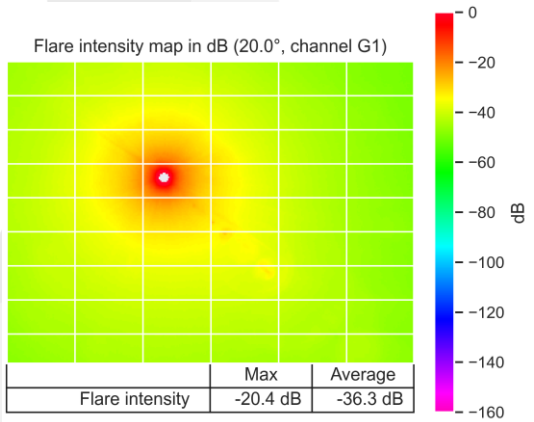

Flare intensity map in dB (-107.0°, channel G1)
0
−20
−40
−60
−80
−100
−120
−140
−160
dB
Max
Average
Flare intensity
-34.5 dB
-52.5 dB


Flare intensity map in dB (117.0°, channel G1)
0
−20
−40
−60
−80
−100
−120
−140
−160
dB
Max
Average
Flare intensity
-87.1 dB
-99.6 dB


Diagonal
Flare intensity (in dB)
−20
−40
−60
−80
−100
−120
−150
−100
−50
0
50
100
150
Light source angle (°)
Average intensity, channel G1
Max intensity channel G1
Source in the field of view

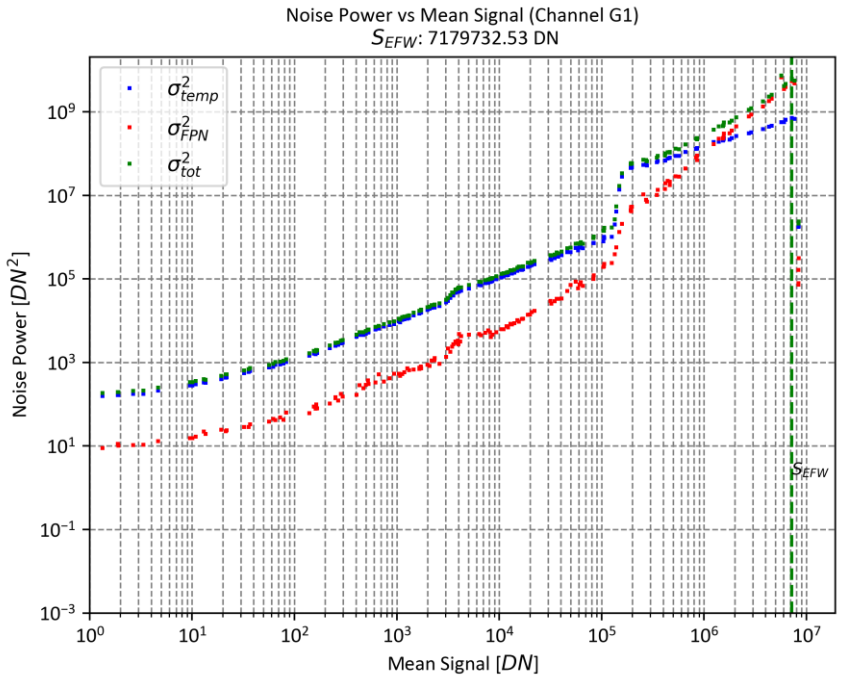

Flare intensity map in dB (-108.0°, channel G1)
0
−20
−40
−60
−80
−100
−120
−140
−160
dB
Max
Average
Flare intensity
-29.0 dB
-51.6 dB

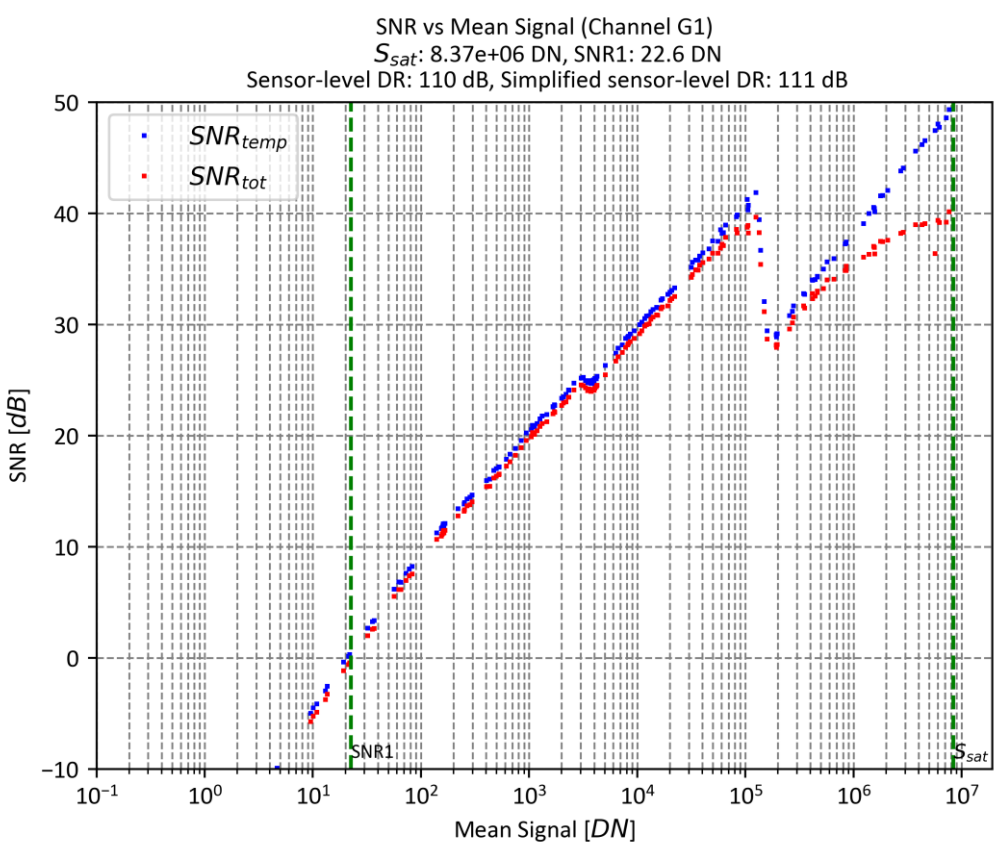

Flare intensity map in dB (-120.0°, channel G1)
0
−20
−40
−60
−80
−100
−120
−140
−160
dB
Max
Average
Flare intensity
-103.5 dB
-116.9 dB

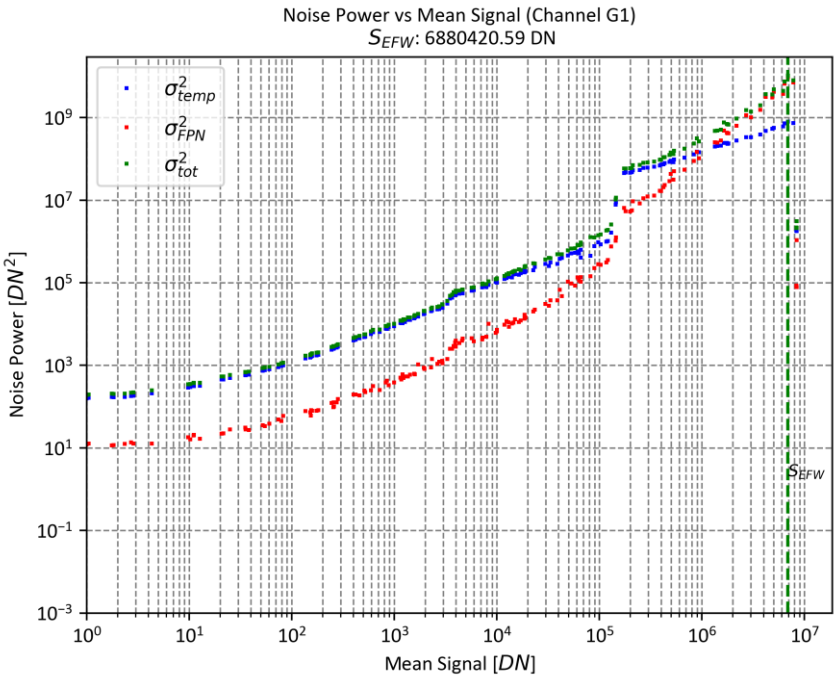

Flare intensity map in dB (20.0°, channel G1)
0
−20
−40
−60
−80
−100
−120
−140
−160
dB
Max
Average
Flare intensity
-20.4 dB
-36.3 dB

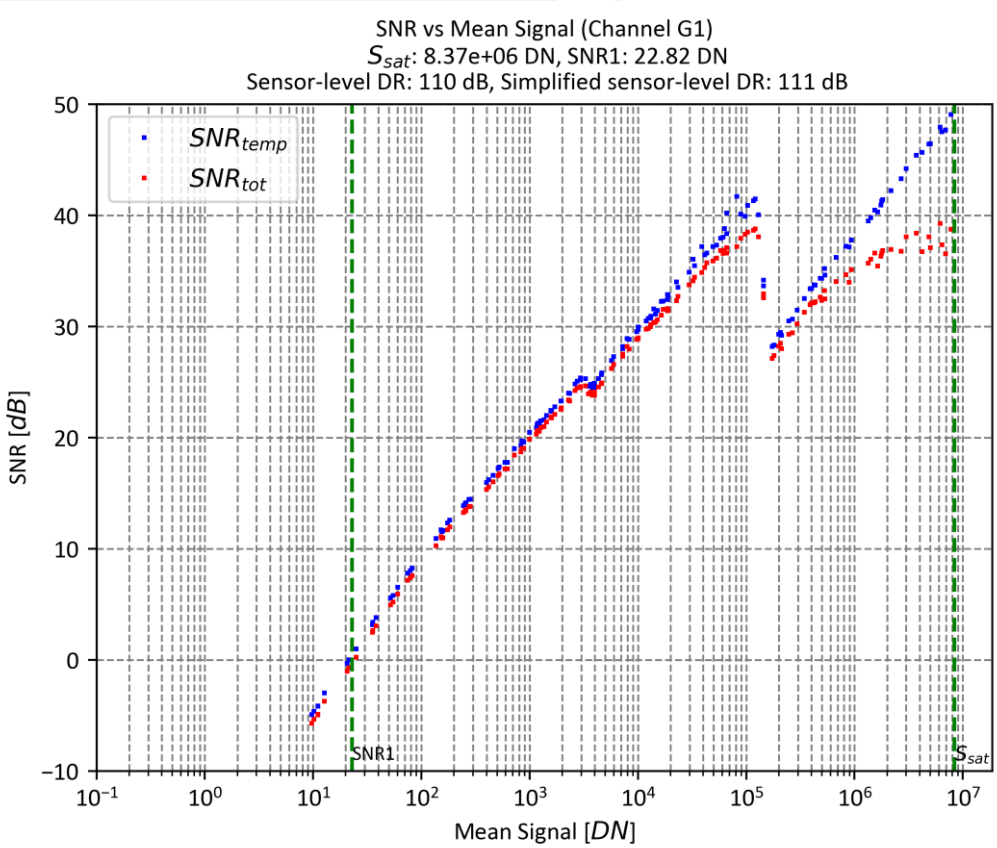
- **Measurement conditions**
  - 6 exposures from 100 to 70 000 cd/m2
  - 30 images per exposure
  - Illuminant D65
  - 5 temperatures from 20°C to 115°C (sensor temperature)

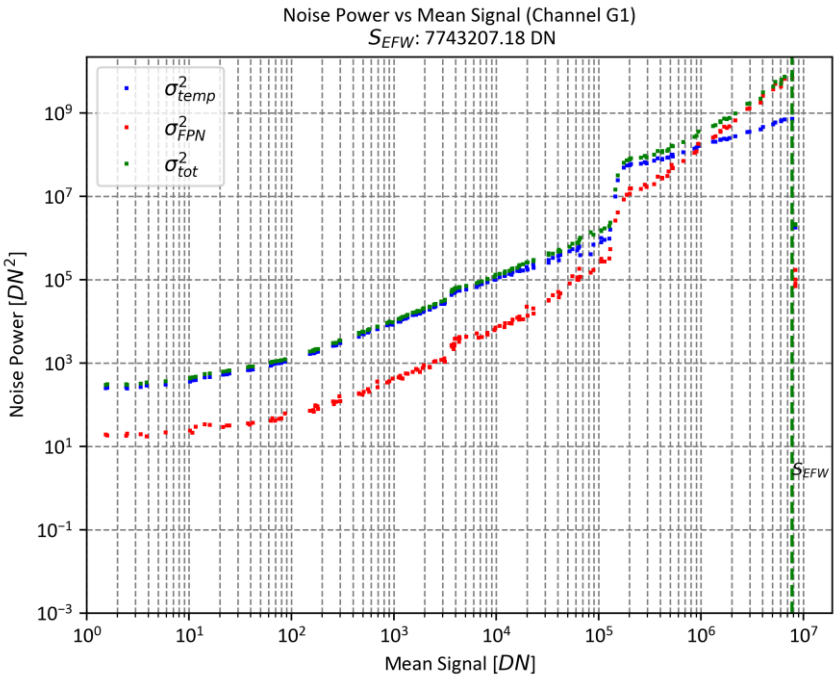
- **Results:**
  - Sensor level dynamic range: 110dB for sensor temperature 40°C
  - With the current lens, the sensor saturates for objects with luminance equal or higher than 17 000 cd/m²
  - The sensor has 3 exposures. The system gain of the first two exposures is the same
  - Autocorrelation graphs show that the raw files are not processed
  - No significant row and column noise
  - SNR is 15dB lower at 115°C sensor temperature, compared with 40°C
  - The dark signal has strong non-uniformity at 115°C

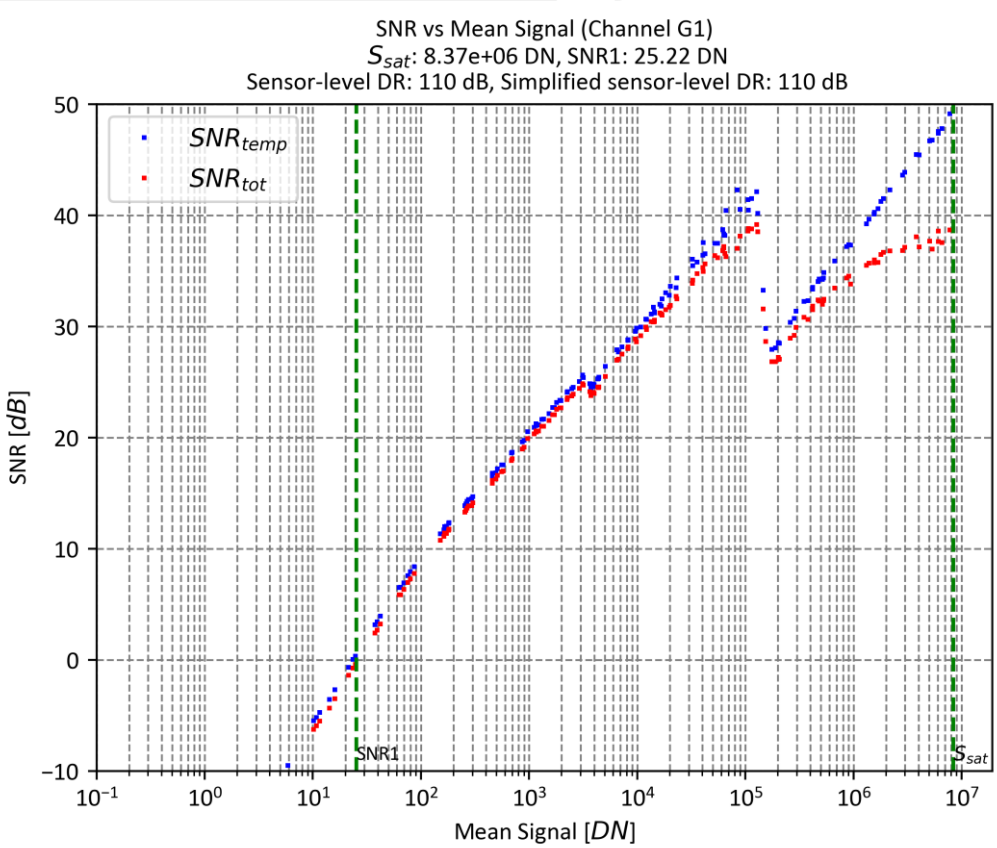

Noise Power vs Mean Signal (Channel G1)
S_{EFW}: 7179732.53 DN
σ^2_{temp}
σ^2_{FPN}
σ^2_{tot}
Noise Power [DN^2]
Mean Signal [DN]
S_{EFW}

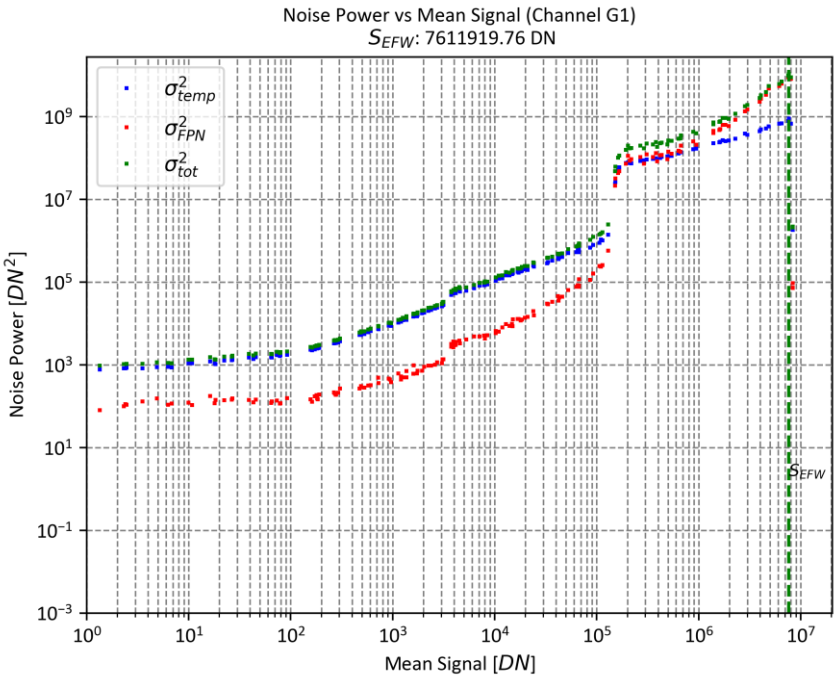

SNR vs Mean Signal (Channel G1)
S_{sat}: 8.37e+06 DN, SNR1: 22.6 DN
Sensor-level DR: 110 dB, Simplified sensor-level DR: 111 dB
SNR_{temp}
SNR_{tot}
SNR [dB]
Mean Signal [DN]
SNR1
S_{sat}

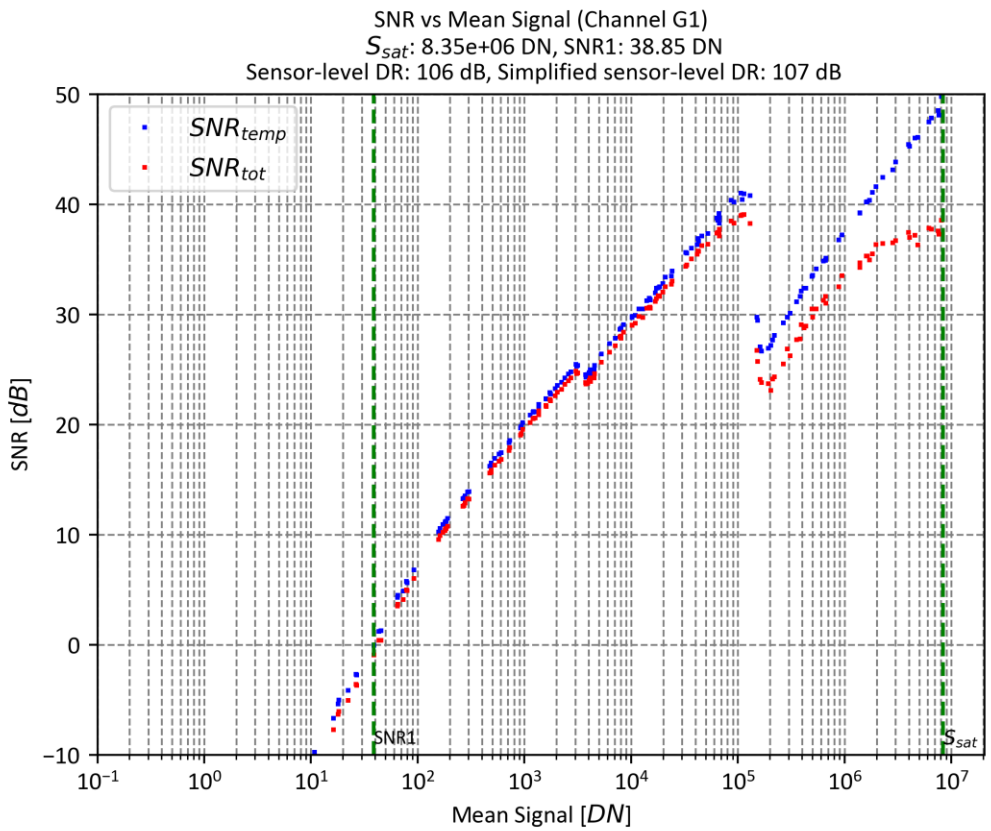

Noise Power vs Mean Signal (Channel G1)
S_{EFW}: 6880420.59 DN
σ^2_{temp}
σ^2_{FPN}
σ^2_{tot}
Noise Power [DN^2]
Mean Signal [DN]
S_{EFW}

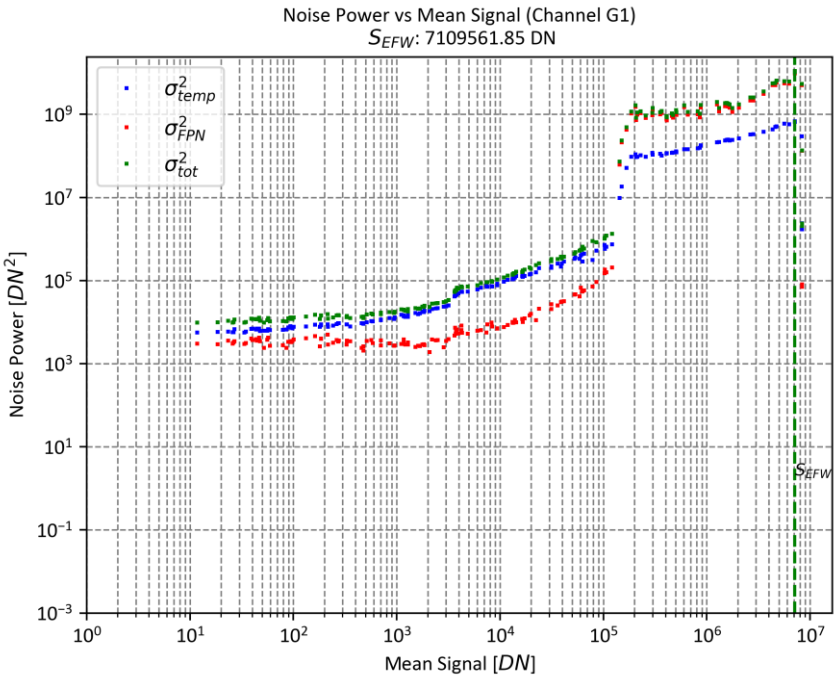

SNR vs Mean Signal (Channel G1)
S_{sat}: 8.37e+06 DN, SNR1: 22.82 DN
Sensor-level DR: 110 dB, Simplified sensor-level DR: 111 dB
SNR_{temp}
SNR_{tot}
SNR [dB]
Mean Signal [DN]
SNR1
S_{sat}

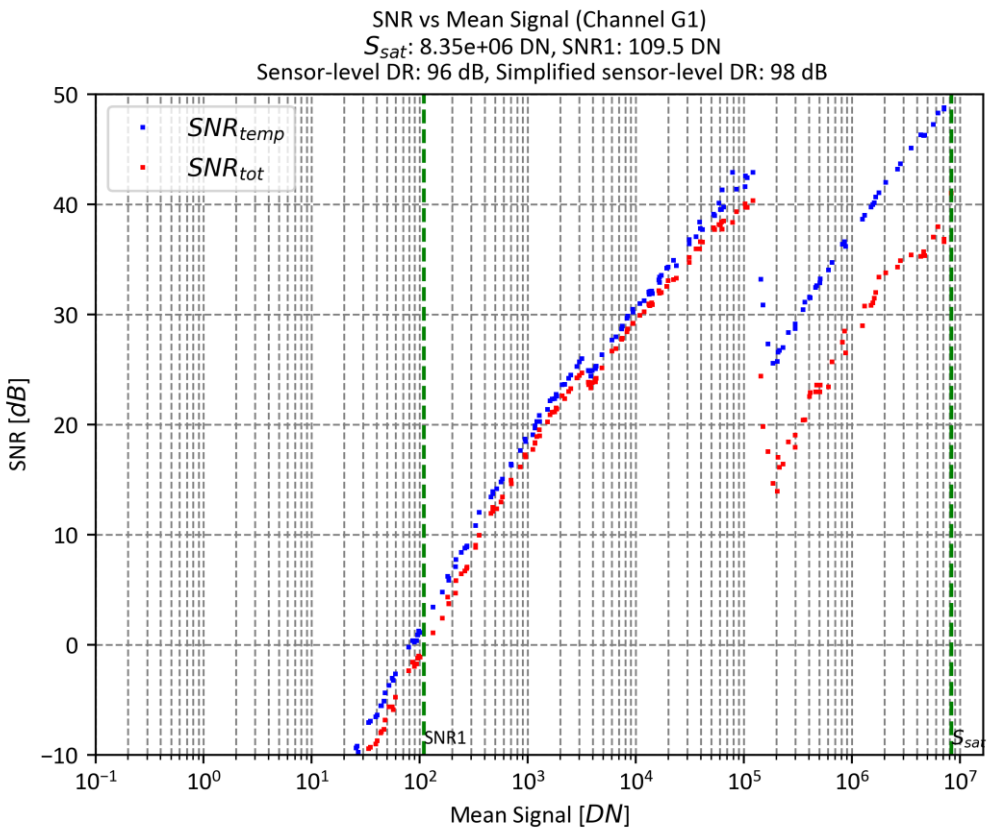

Noise Power vs Mean Signal (Channel G1)
S_{EFW}: 7743207.18 DN
σ^2_{temp}
σ^2_{FPN}
σ^2_{tot}
Noise Power [DN^2]
Mean Signal [DN]
S_{EFW}


SNR vs Mean Signal (Channel G1)
S_{sat}: 8.37e+06 DN, SNR1: 25.22 DN
Sensor-level DR: 110 dB, Simplified sensor-level DR: 110 dB
SNR_{temp}
SNR_{tot}
SNR [dB]
Mean Signal [DN]
SNR1
S_{sat}


Noise Power vs Mean Signal (Channel G1)
S_{EFW}: 7611919.76 DN
σ^2_{temp}
σ^2_{FPN}
σ^2_{tot}
Noise Power [DN^2]
Mean Signal [DN]
S_{EFW}

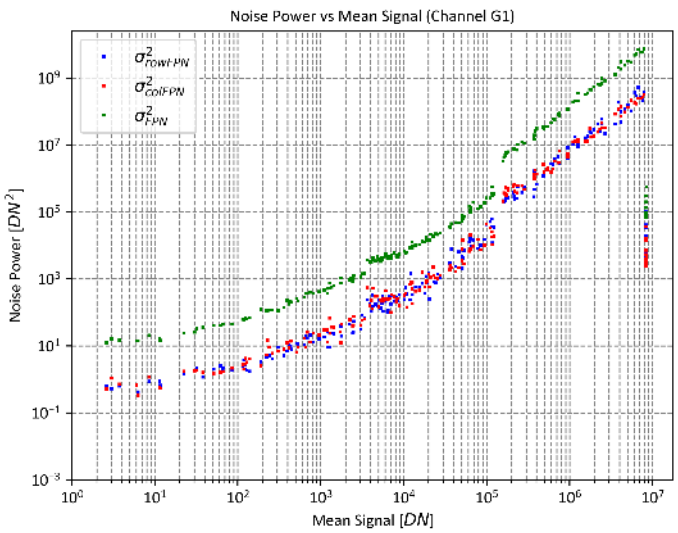

SNR vs Mean Signal (Channel G1)
S_{sat}: 8.35e+06 DN, SNR1: 38.85 DN
Sensor-level DR: 106 dB, Simplified sensor-level DR: 107 dB
SNR_{temp}
SNR_{tot}
SNR [dB]
Mean Signal [DN]
SNR1
S_{sat}

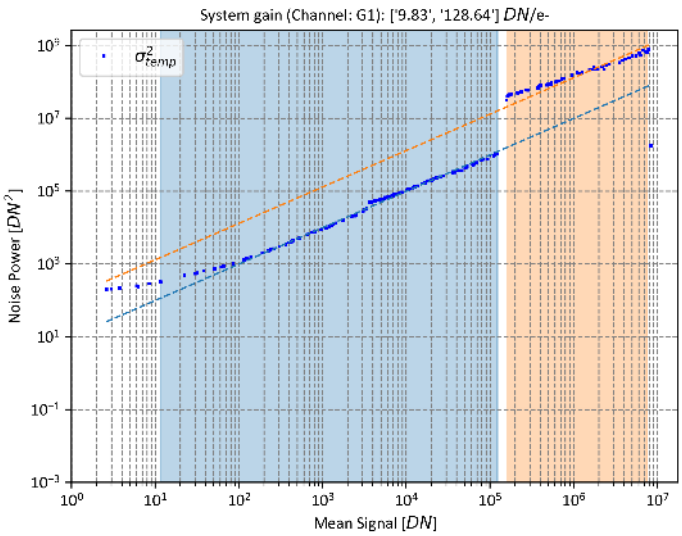

Noise Power vs Mean Signal (Channel G1)
S_{EFW}: 7109561.85 DN
σ^2_{temp}
σ^2_{FPN}
σ^2_{tot}
Noise Power [DN^2]
Mean Signal [DN]
S_{EFW}

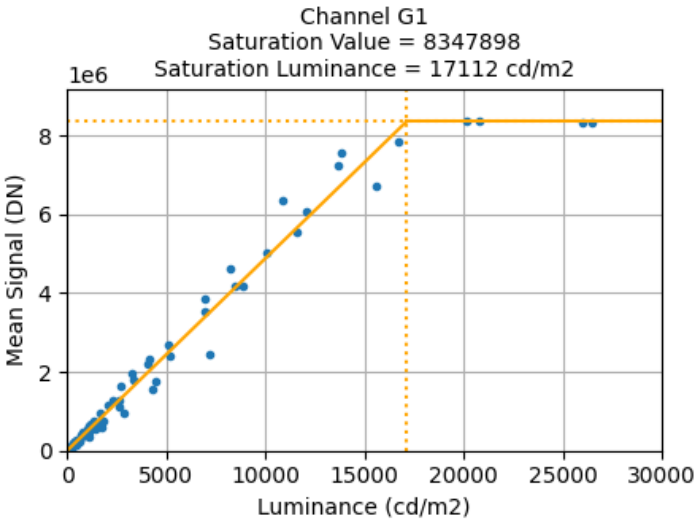

SNR vs Mean Signal (Channel G1)
S_{sat}: 8.35e+06 DN, SNR1: 109.5 DN
Sensor-level DR: 96 dB, Simplified sensor-level DR: 98 dB
SNR_{temp}
SNR_{tot}
SNR [dB]
Mean Signal [DN]
SNR1
S_{sat}

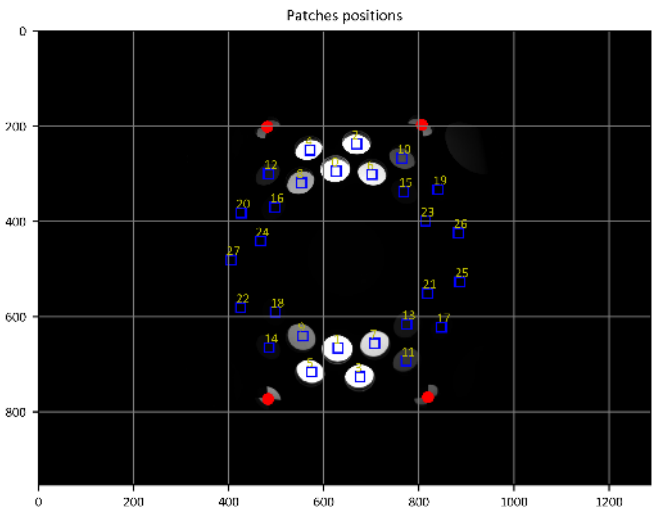
KPIs/Thermal Chamber Temperature (°C)	-8	20	40	60	80
Sensor junction temperature (°C)	23	40	66	87	115
Lower System Gain [DN/e-]	9.94	9.96	9.89	10.28	9.47
KPIs in digital number					
Dark signal [DN]	239.1	239.1	239.9	240.2	180.8
SNR1 [DN]	22.6	22.8	25.2	38.8	109.5
Signal saturation [kDN]	8375	8366	8366	8347	8347
Effective full-well [kDN]	7180	6880	7743	7612	7110
KPIs in charge units					
SNR1 [e-]	2.27	2.29	2.55	3.78	11.56
Signal saturation [ke-]	843	840	846	812	881
Effective full-well [ke-]	723	691	783	741	751
KPIs in dB					
Sensor-level dynamic range [dB]	110.0	109.6	109.8	105.8	96.2
Simplified sensor-level dynamic range [dB]	111.4	111.3	110.4	106.6	97.6

Row and Column fixed pattern noise

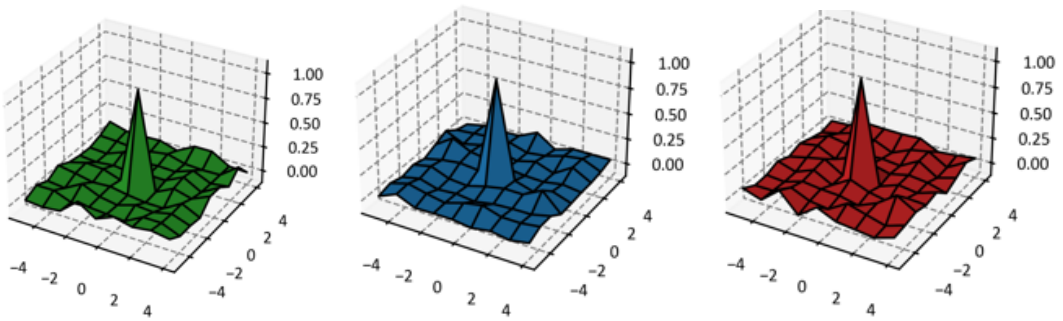




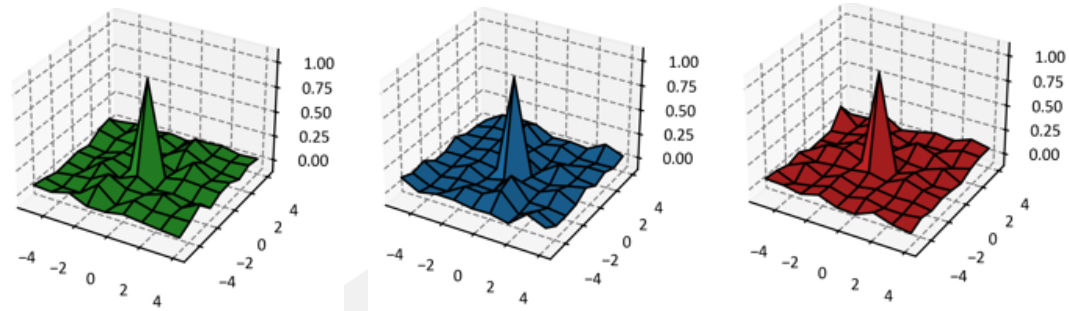




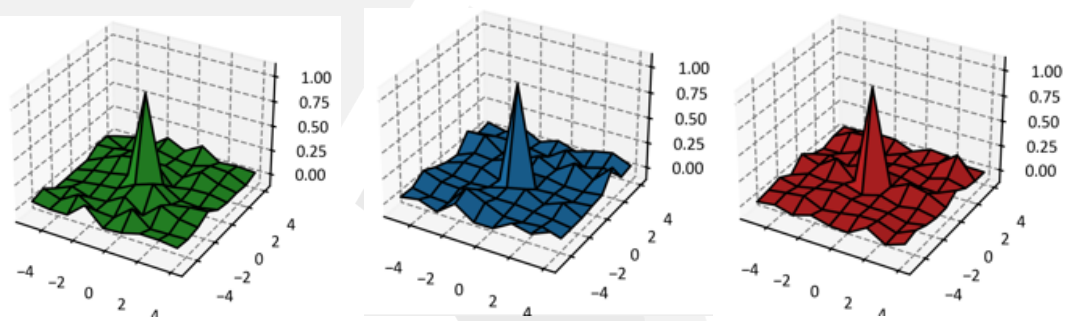
L = 15 cd/m²
GL = 5600



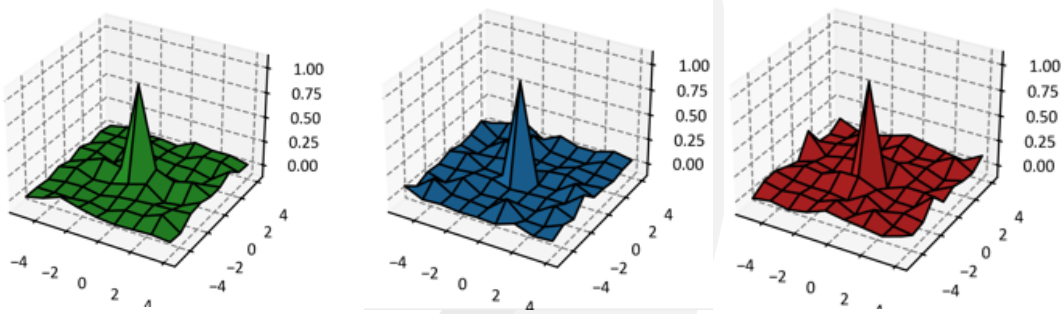
L = 150 cd/m²
GL = 69000



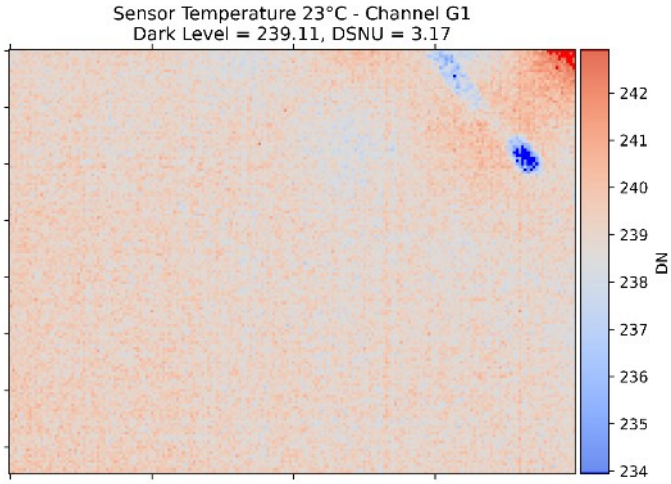
L = 1.5 kcd/m²
GL = 725000

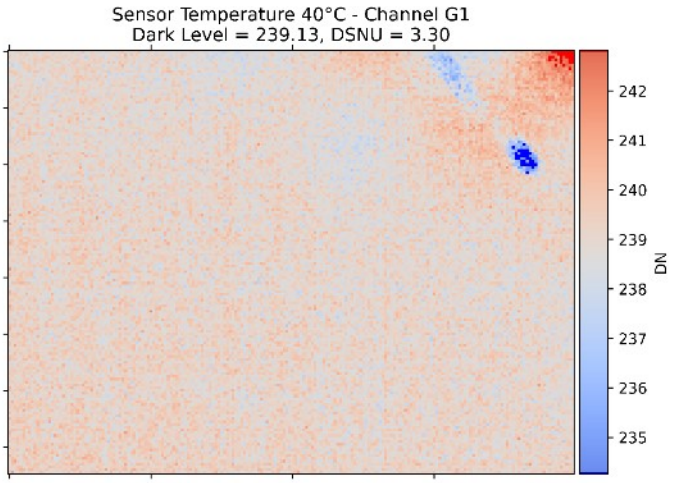


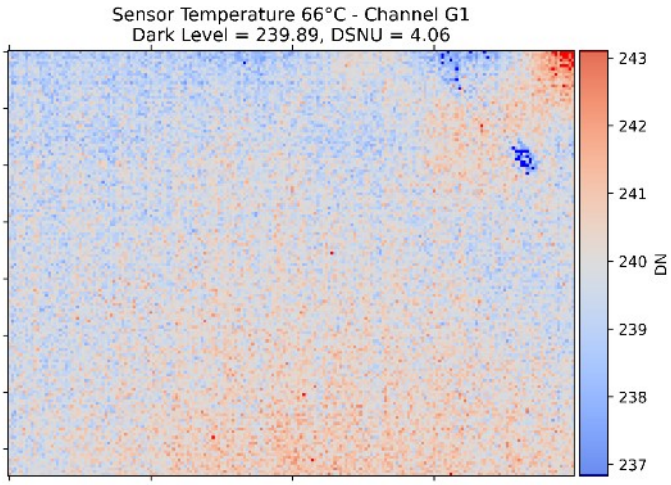
L = 15 kcd/m²
GL = 6710000

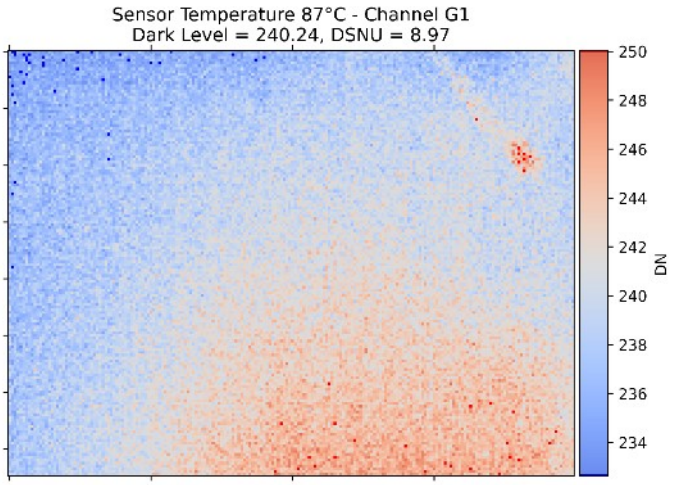


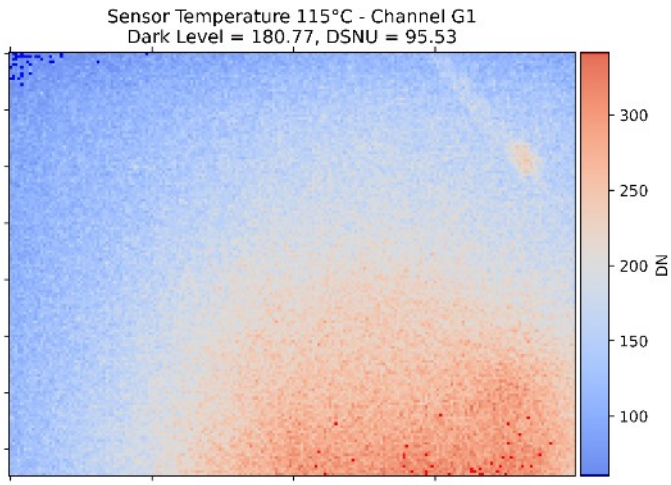
The autocorrelation is a measure of resemblance of a signal and a version shifted of itself. High value means a high correlation.





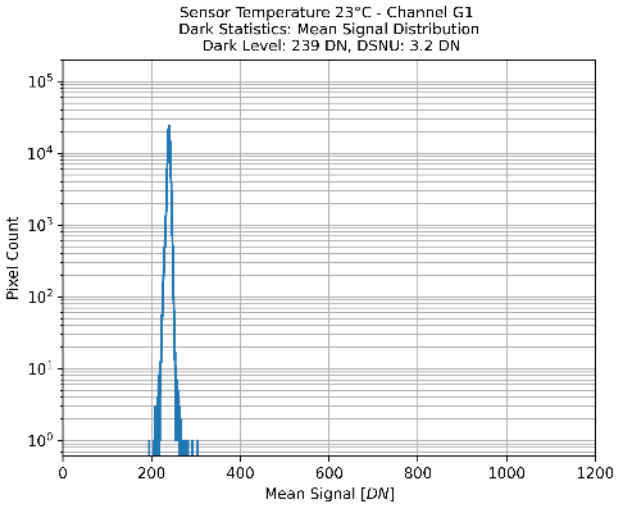


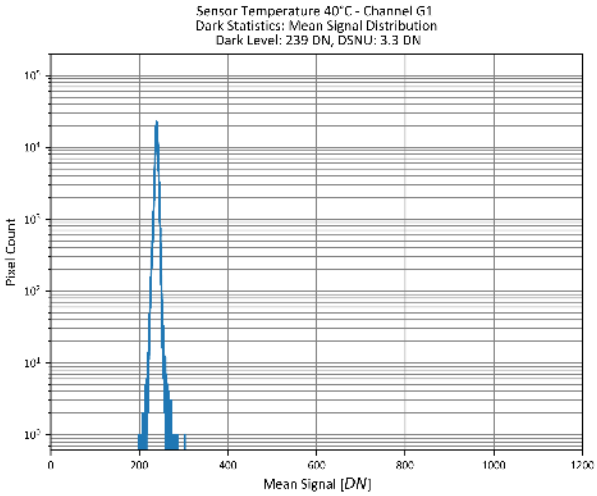


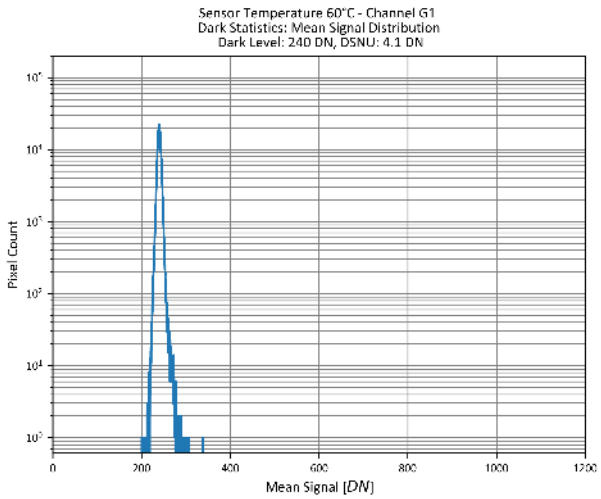


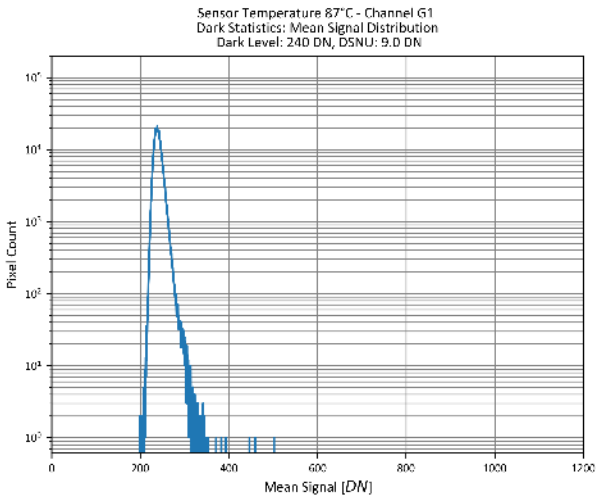
Notice that map scales are different for each temperature.
2 phenomena can be noted:

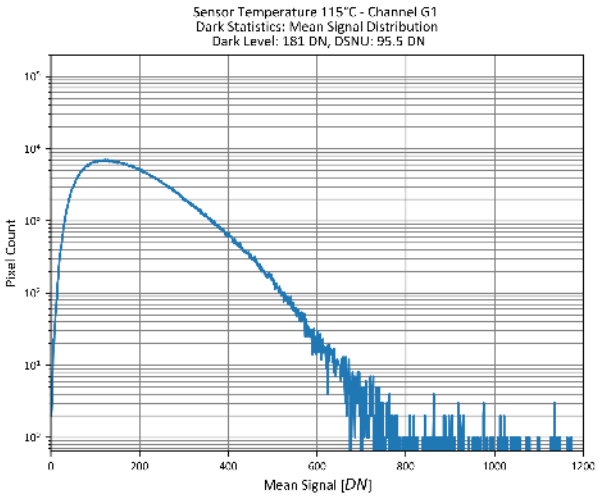
- A strange shape of lower dark signal on top left corner.
- An increasing non-uniformity of the dark when the temperature raises.



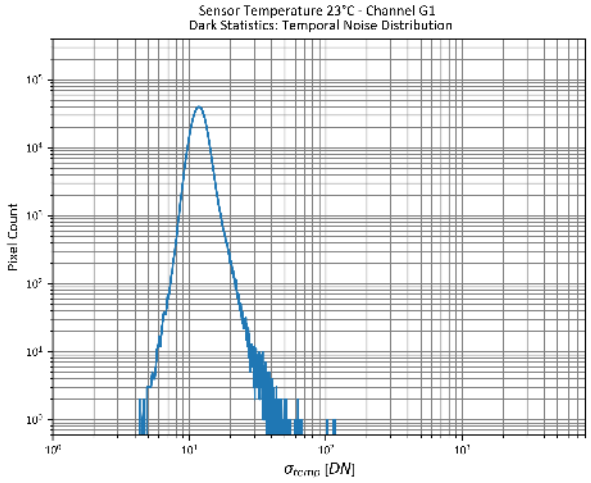


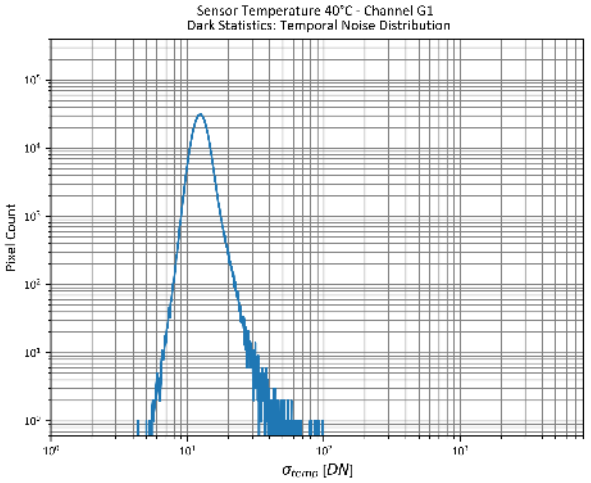


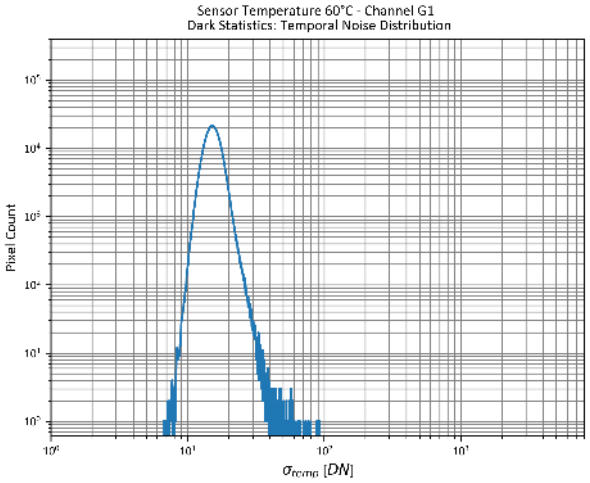


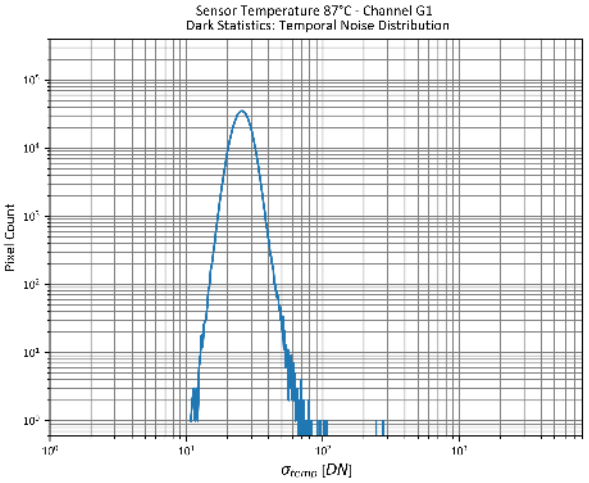


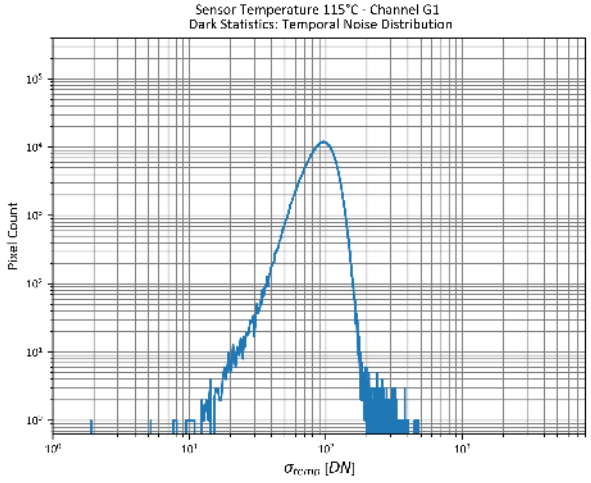
The graphs are at the same scale for each temperature.





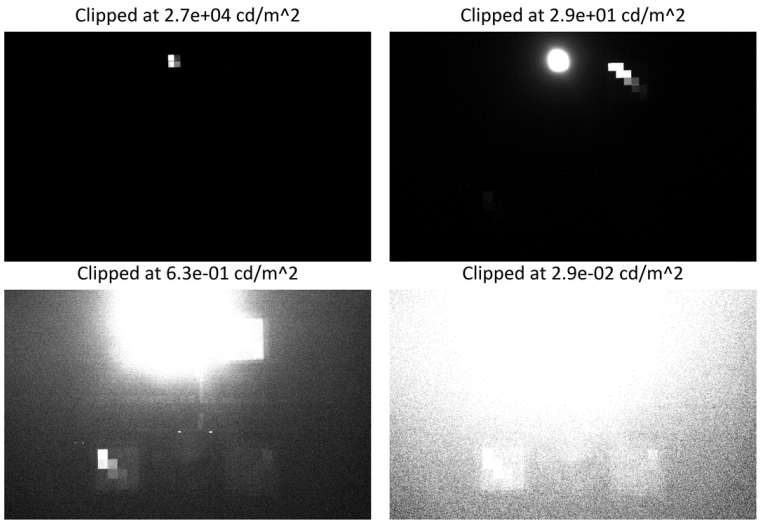




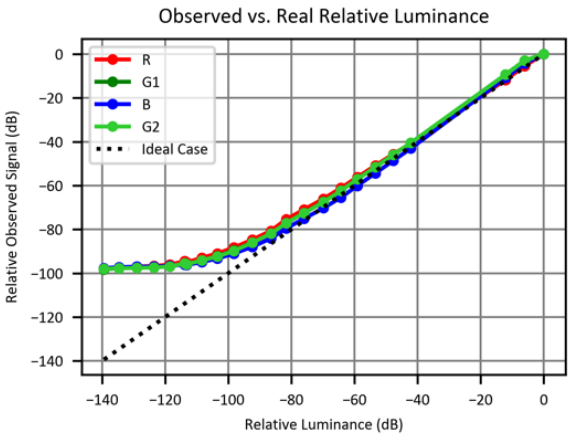


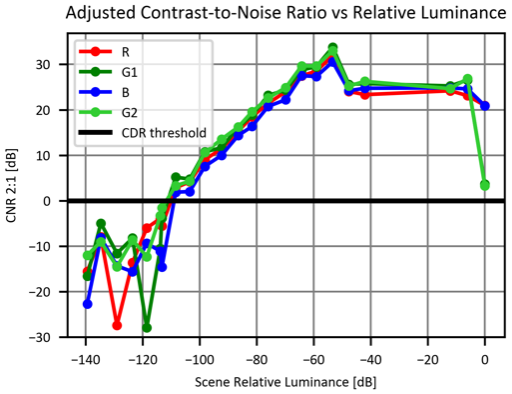
The graphs are at the same scale for each temperature.

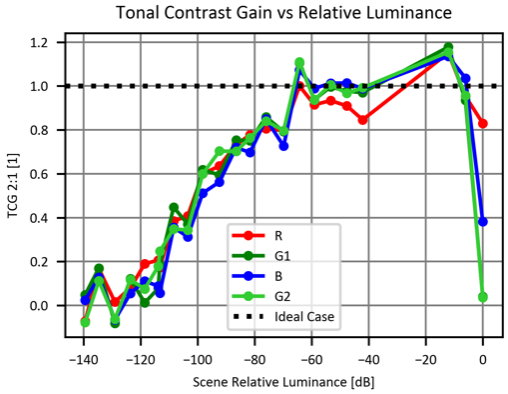
Image preview with different amplification factors



140dB setup with maximum scene luminance 27000 cd/m²



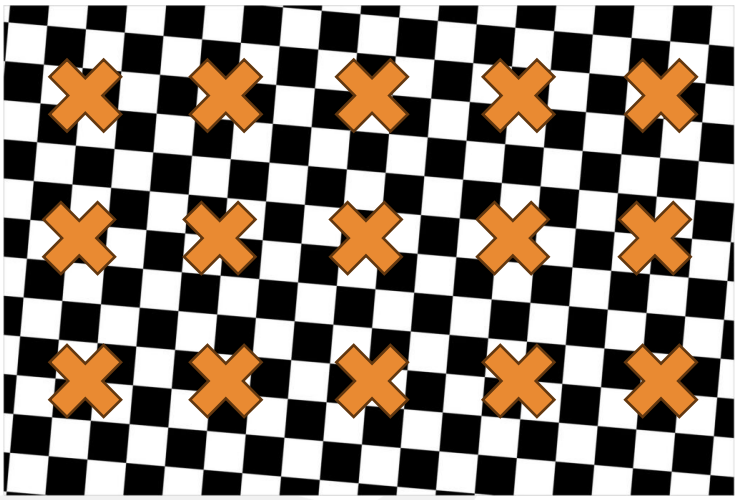




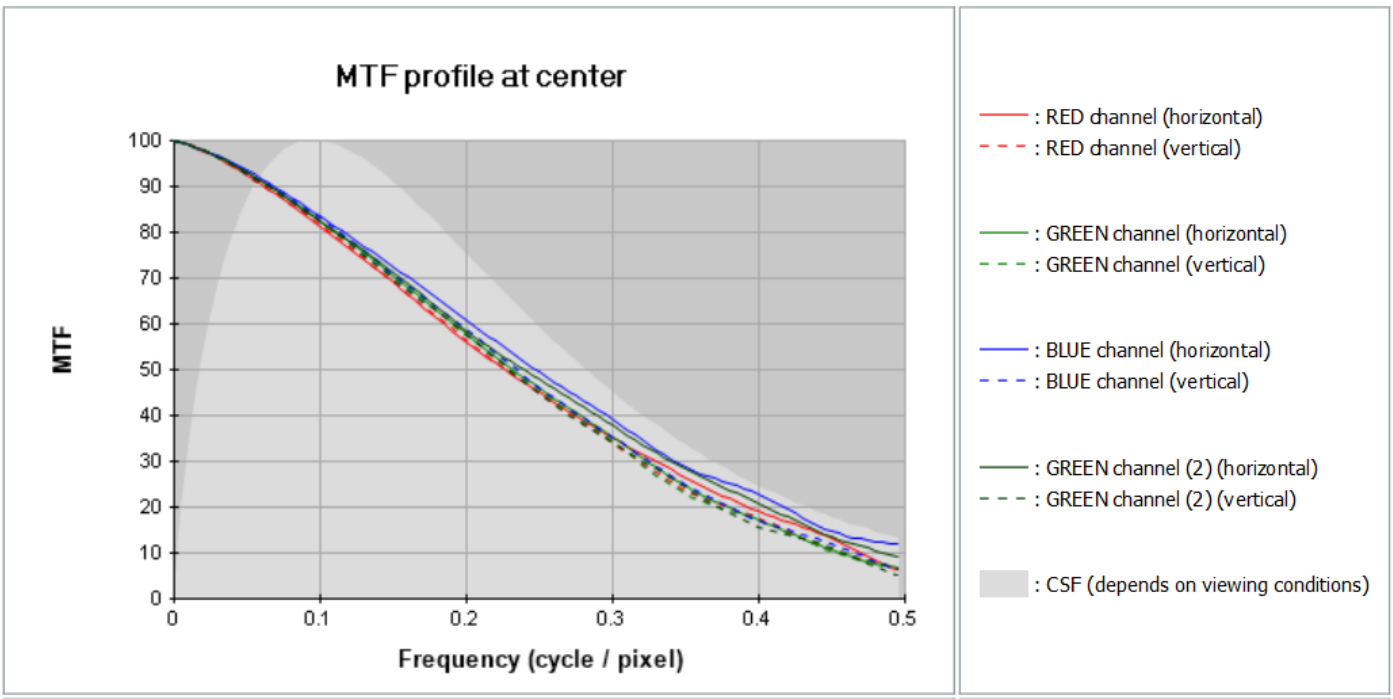
	R	G1	B	G2
CDR (dB)	110 dB	111 dB	109 dB	112 dB

The P2020 dynamic range (CDR) value is only 10dB lower than the sensor level dynamic range, which means that the lens is well fitted to the sensor.

The measurement is performed for different positions in the field of view of the device:

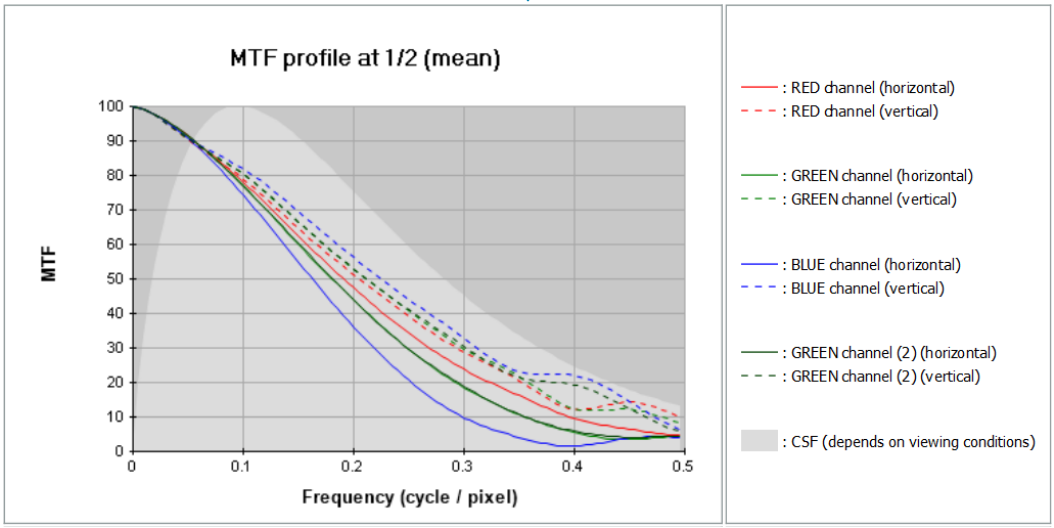


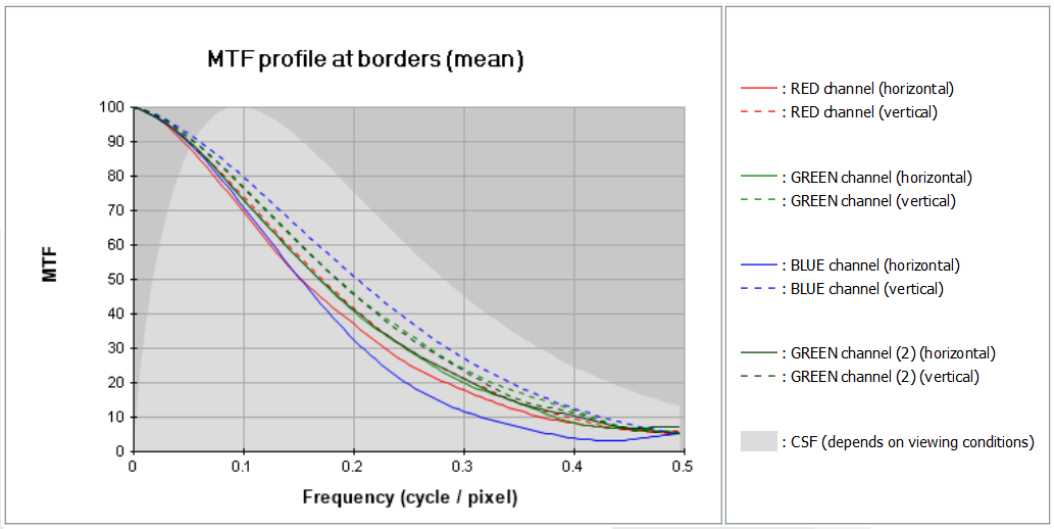
- **Measurement conditions:**
  - Illumination: D65 1000lux
  - Through focus to find the position with best sharpness in the center:
    - DUT to chart distance: 2m
  - Viewing condition for acutance computation:
    - Distance: 600mm
    - Pixel pitch: 0.254mm

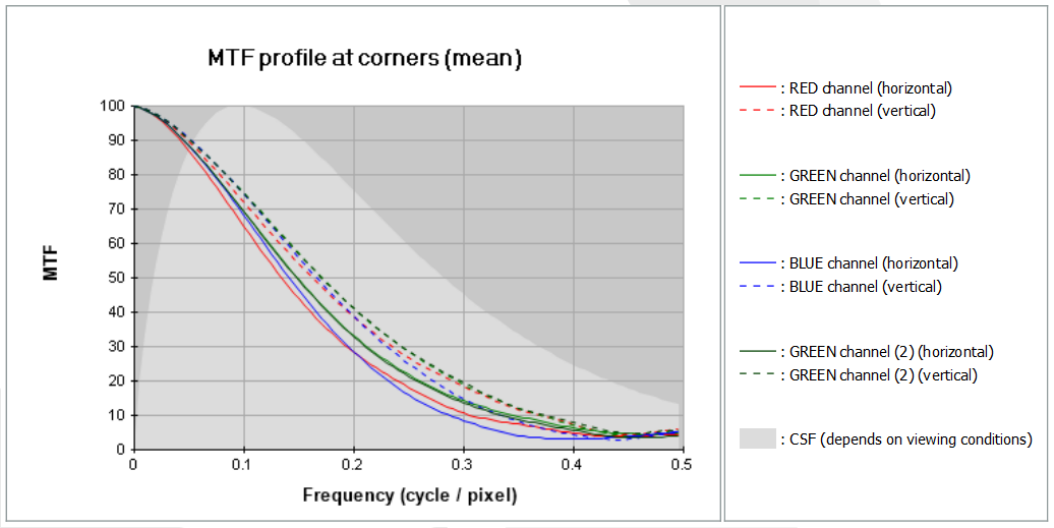


	Center				All corners (mean)			
	R	G1	B	G2	R	G1	B	G2
Acutance	0.58	0.58	0.6	0.59	0.43	0.46	0.44	0.46
MTF10% (cy/pix)	0.47	0.46	0.49	0.47	0.34	0.36	0.31	0.36
MTF50% (cy/pix)	0.23	0.23	0.24	0.23	0.15	0.16	0.16	0.16
MTF@Nyq/2	45%	46%	48%	46%	22%	25%	20%	25%
MTF@Nyq/16	95%	96%	96%	96%	93%	94%	94%	94%

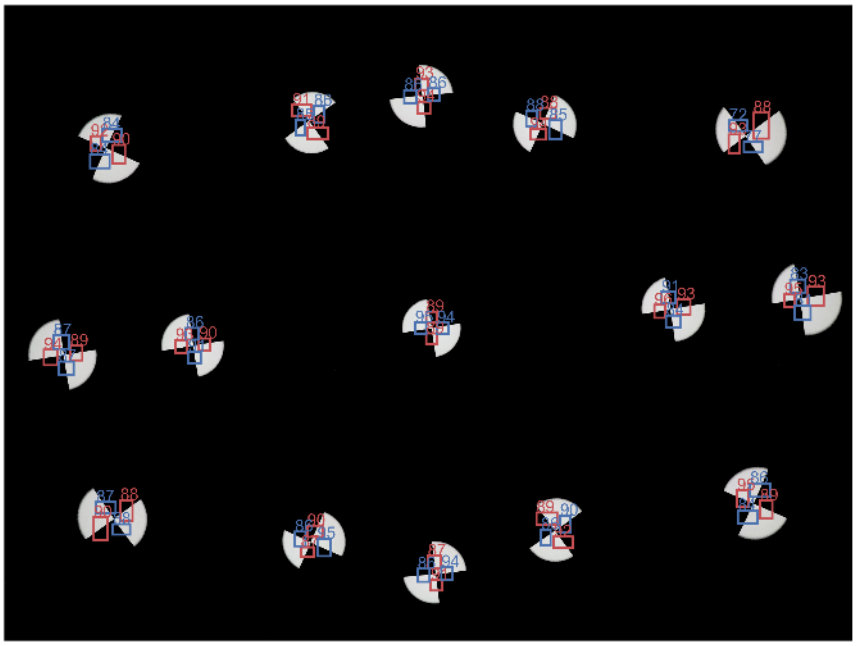
Conversion factor between cycles/pixels and cycles/degrees	
Pixel/Degree	41.89


MTF profile at 1/2 (mean)
MTF
Frequency (cycle / pixel)
: RED channel (horizontal)
: RED channel (vertical)
: GREEN channel (horizontal)
: GREEN channel (vertical)
: BLUE channel (horizontal)
: BLUE channel (vertical)
: GREEN channel (2) (horizontal)
: GREEN channel (2) (vertical)
: CSF (depends on viewing conditions)

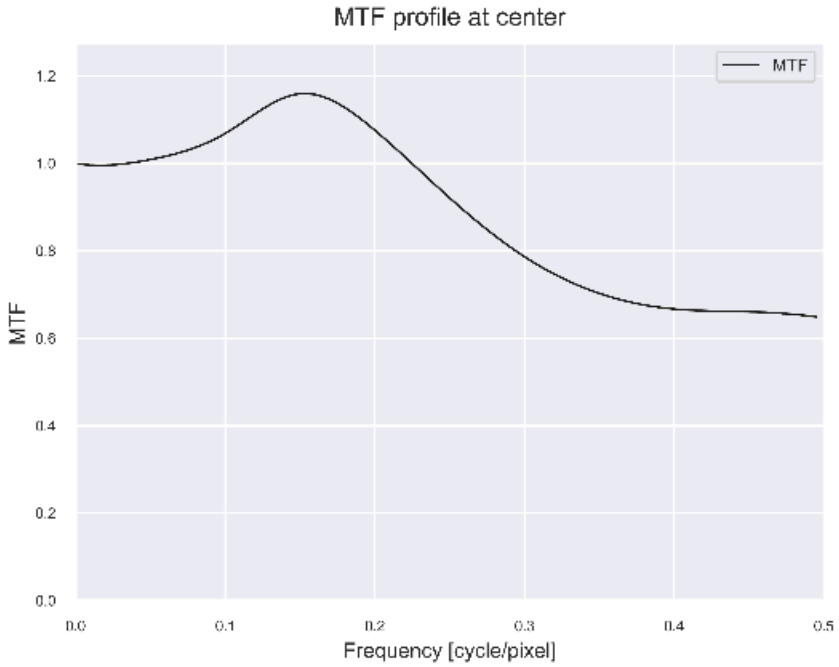

MTF profile at borders (mean)
MTF
Frequency (cycle / pixel)
: RED channel (horizontal)
: RED channel (vertical)
: GREEN channel (horizontal)
: GREEN channel (vertical)
: BLUE channel (horizontal)
: BLUE channel (vertical)
: GREEN channel (2) (horizontal)
: GREEN channel (2) (vertical)
: CSF (depends on viewing conditions)

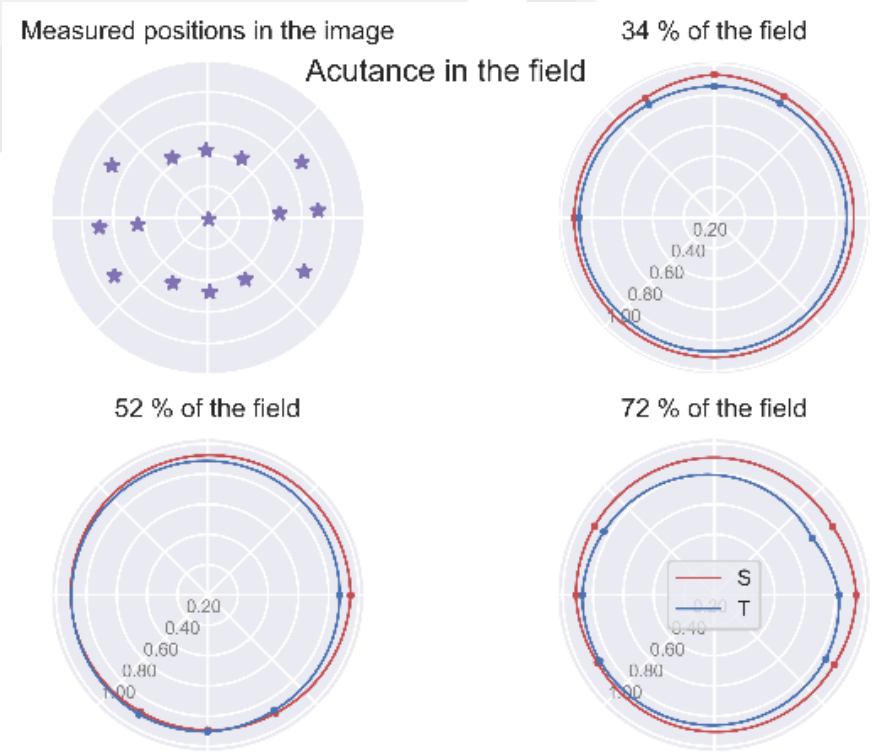

MTF profile at corners (mean)
MTF
Frequency (cycle / pixel)
: RED channel (horizontal)
: RED channel (vertical)
: GREEN channel (horizontal)
: GREEN channel (vertical)
: BLUE channel (horizontal)
: BLUE channel (vertical)
: GREEN channel (2) (horizontal)
: GREEN channel (2) (vertical)
: CSF (depends on viewing conditions)

The measurement is performed for different positions in the field of view of the device:



- **Measurement conditions:**
  - Slanted edge at infinity
  - Viewing condition for acutance computation:
    - Distance: 600mm
    - Pixel pitch: 0.254mm

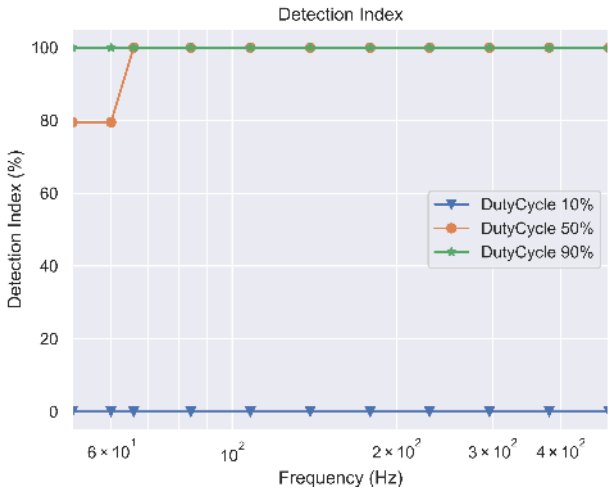

MTF profile at center
MTF
1.2
1.0
0.8
0.6
0.4
0.2
0.0
MTF
0.0
0.1
0.2
0.3
0.4
0.5
Frequency [cycle/pixel]

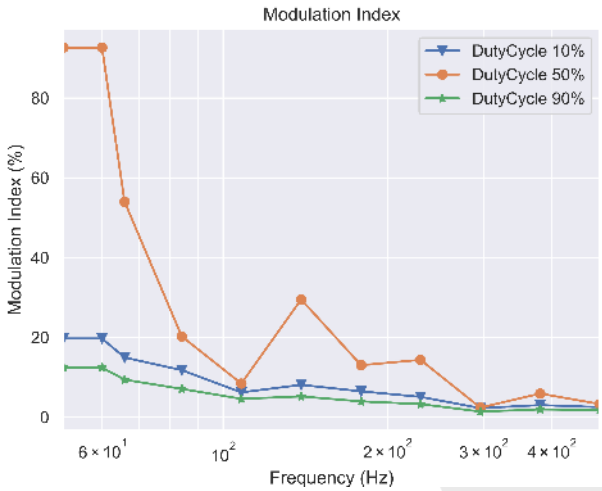

Measured positions in the image
Acutance in the field
34 % of the field
0.20
0.40
0.60
0.80
1.00
52 % of the field
0.20
0.40
0.60
0.80
1.00
72 % of the field
S
T
0.60
0.80
1.00

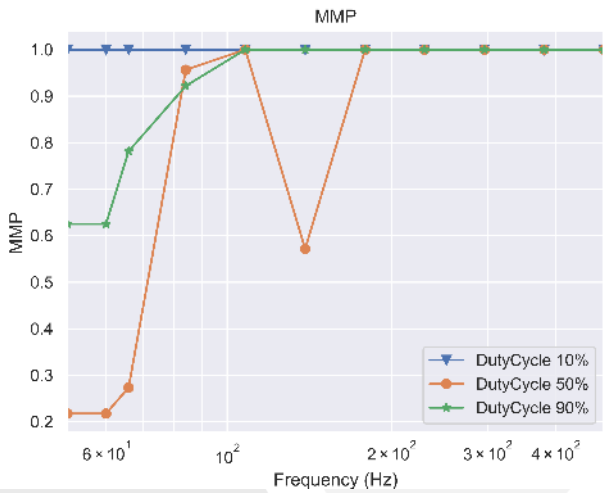
- **Measurement conditions:**
  - 10 LED PWM frequencies in Hz: 50, 51, 60, 66, 84, 108, 139, 179, 230, 296, 381, 490
  - 3 LED PWM duty cycles: 10%, 50%, 90%
  - 3 test conditions:
    - Background at 10000 lux, LED light intensity at 3000 cd/m²
    - Background at 180 lux, LED light intensity at 90 cd/m²
    - Background at 0.5 lux, LED light intensity at 6 cd/m²

- **Results:**
  - The exposure time is 10ms:
    - Significant flickering for frequencies below 100Hz (1 / exposure time)
    - Limited flickering for high frequencies
  - No other visible LED flicker mitigation effect
  - The response to flickering is the same for the 3 tested lighting conditions

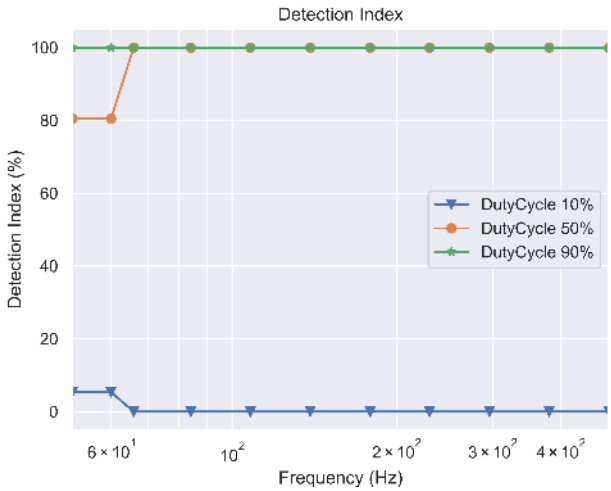
Background at 10000 lux, LED light at 3000 cd/m²

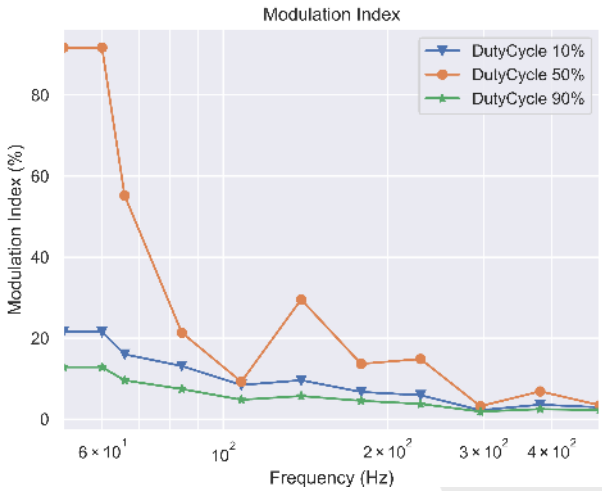


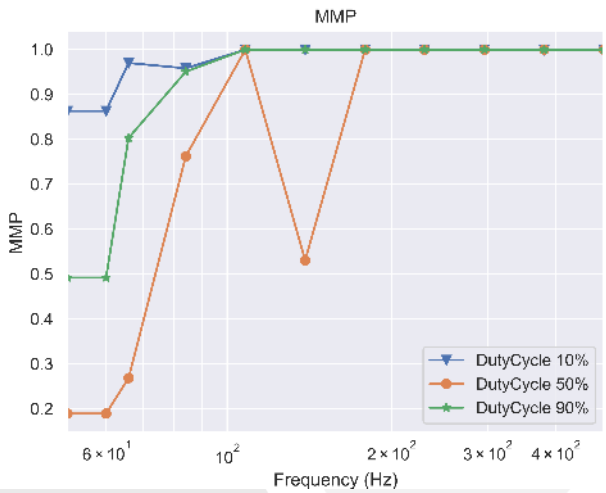




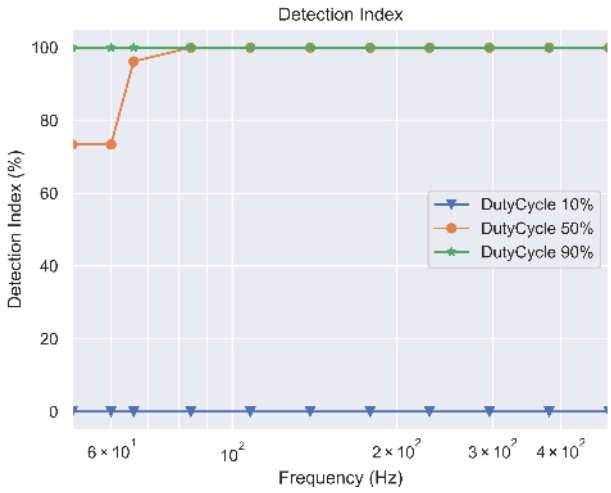
Background at 180 lux, LED light at 90 cd/m²

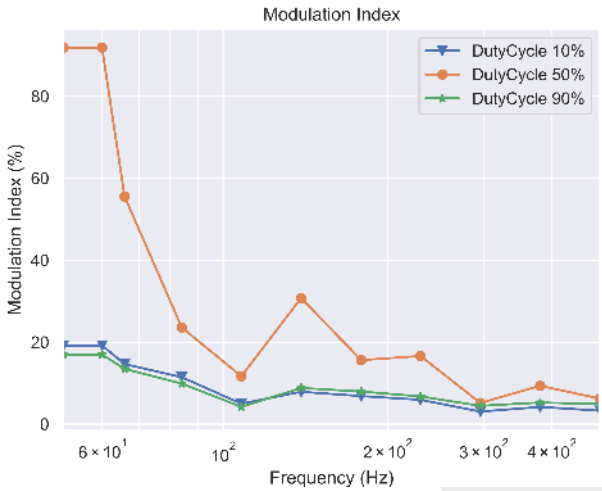


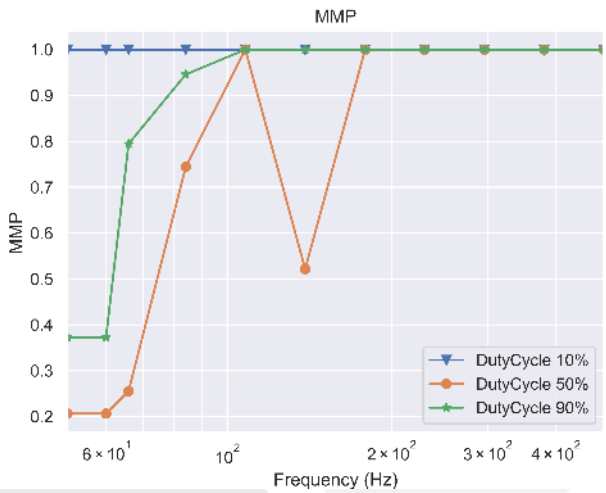


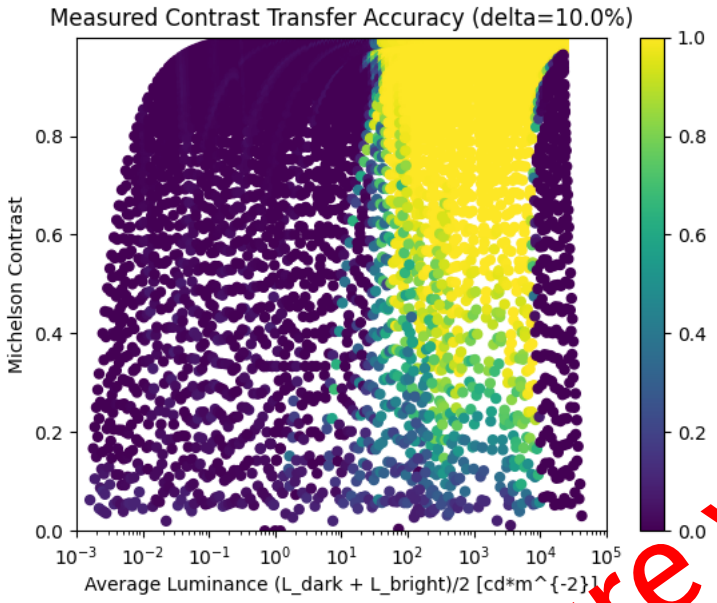


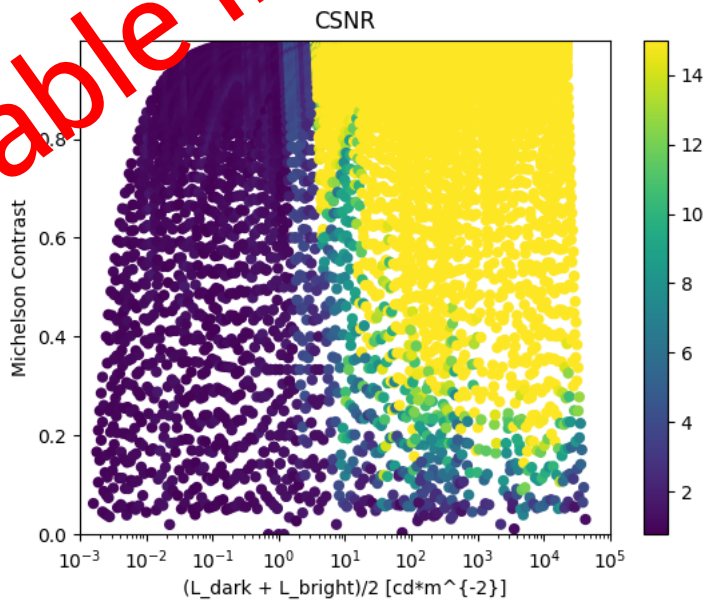
Background at 0.5 lux, LED light at 6 cd/m²

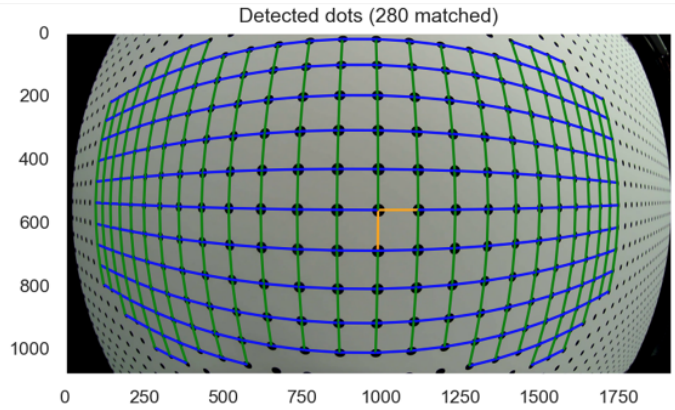


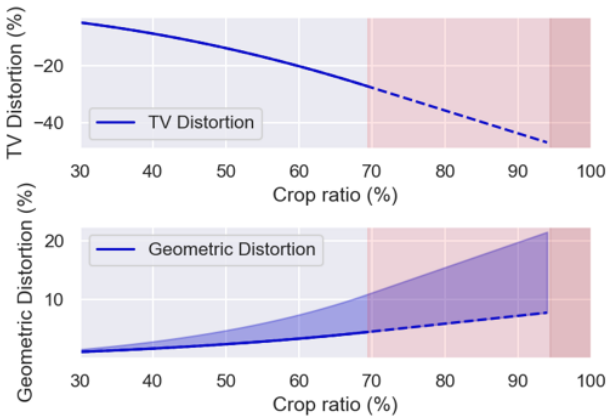


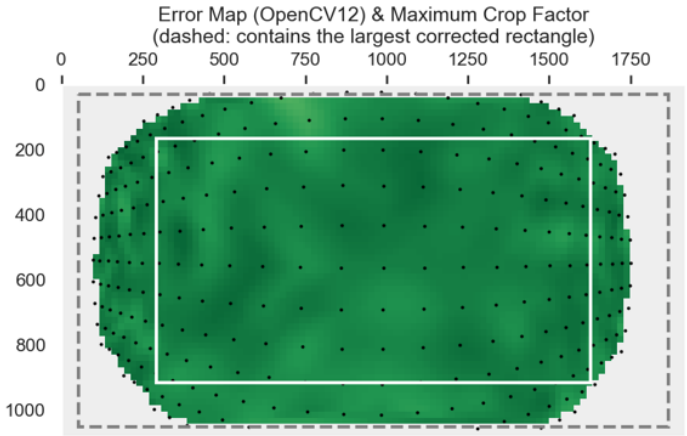


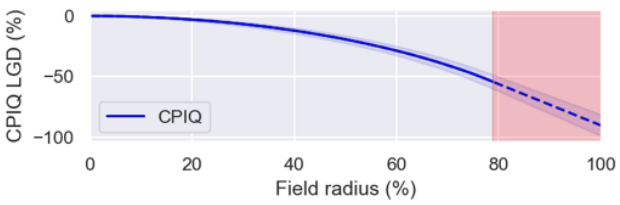


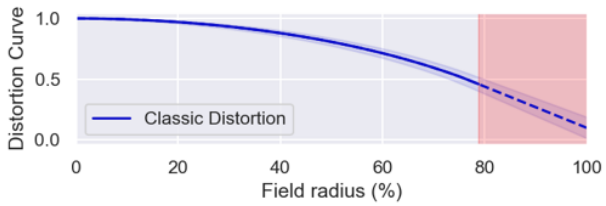


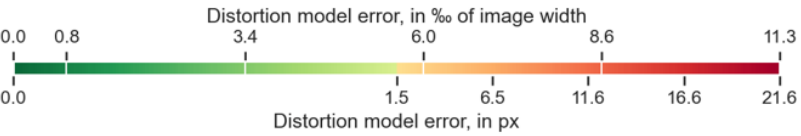






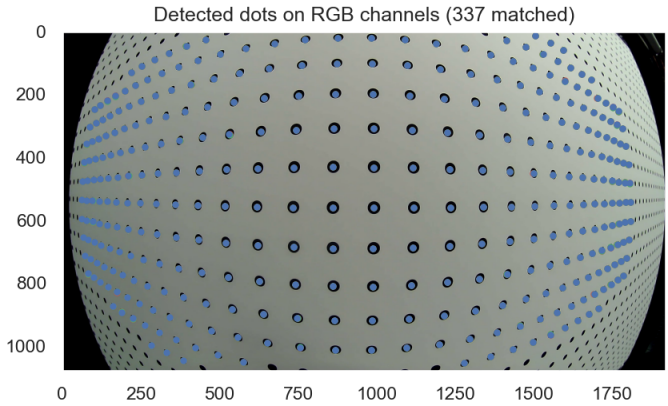


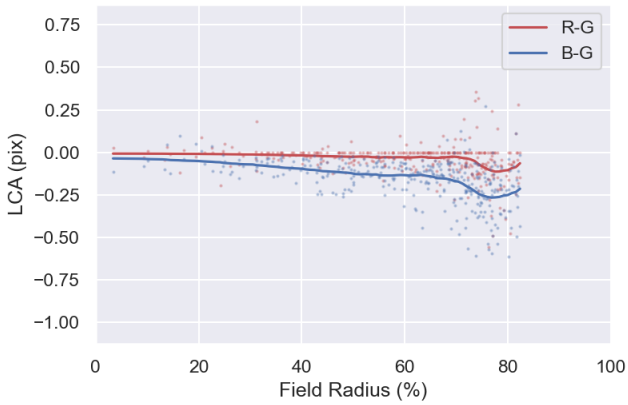


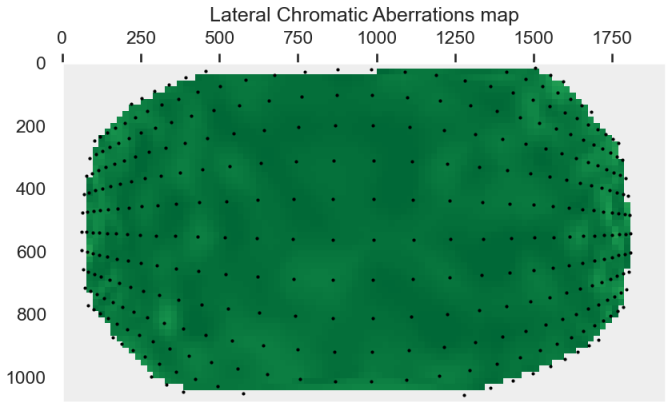


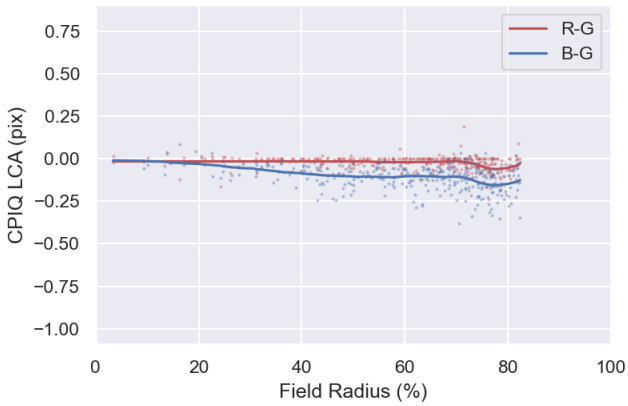
	Results	Results (non extrapolated)
TV Distortion	-46.83%	-27.27%
Geometric Distortion (avg)	+7.81%	+4.55%
Geometric Distortion (Max)	+21.48%	+11.00%

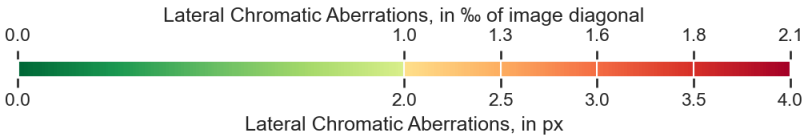
Good fitting of the distortion model (small reprojection error)





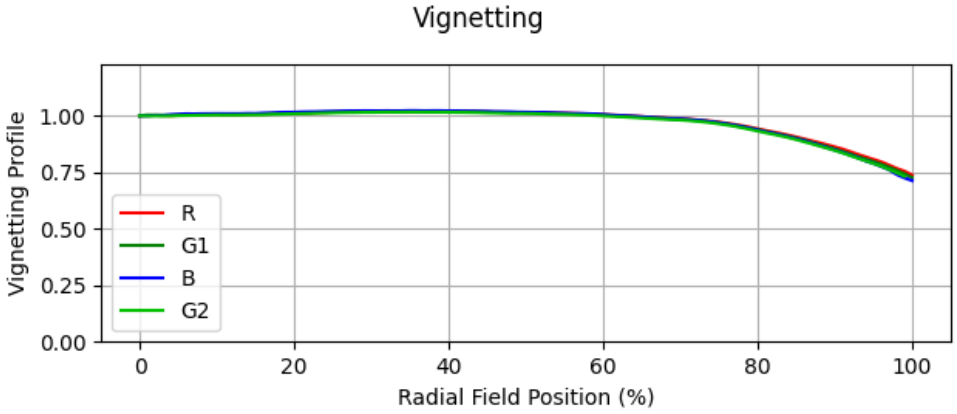




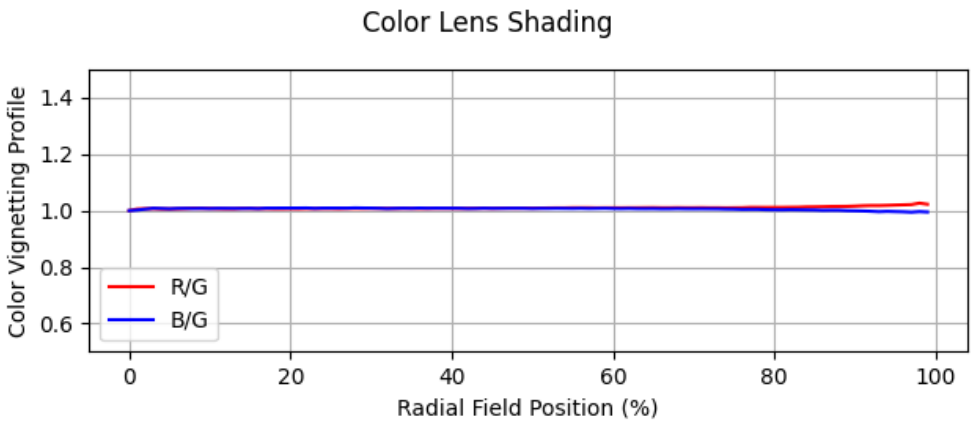


CPIQ Max LCA (Pixels)	-0.15 px
CPIQ Max LCA (Percent)	-0.01 %
CPIQ Max LCA (JND)	0.00

Chromatic Aberrations are negligible (less than 1 pixel in the full measurement area)



	R	G1	B	G2
Max Attenuation	24.5 %	25.6 %	27.5 %	26.8 %
Max Amplification	2.0 %	2.0 %	2.3 %	1.6 %



	R	B
Max Attenuation	0.8 %	2.3 %
Max Amplification	3.5 %	2.4 %

Green Imbalance	1.2 %

Vignetting Measurement done with illuminant D50
Results: Good vignetting and color lens shading performance

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