Katz und Maus –
Kameratests im Wandel der Zeit

Uwe Artmann

Image Engineering GmbH & Co KG

- **Kameras werden besser – Messverfahren müssen mithalten**

- Neue Technologien erfordern neue Messverfahren

- Was der Kunde nicht weiß… Den Finger in die Wunde legen

Objektive Tests

1997


TEST

14 Einsteigerkameras im Vergleich

Auflösung, Farben, Bildrauschen – der erste Digitalkameratest, der auf exakten Meßdaten basiert. Wir vergleichen vierzehn Digitalkameras in zwei Klassen mit 300 000 und 800 000 Bildpunkten.

Das erste Meßverfahren für Digitalkameras

Die Testtabelle

Image Engineering Diemtar Wüller
Erster Digitalkameratest für ColorFoto

Objektive Tests

1998

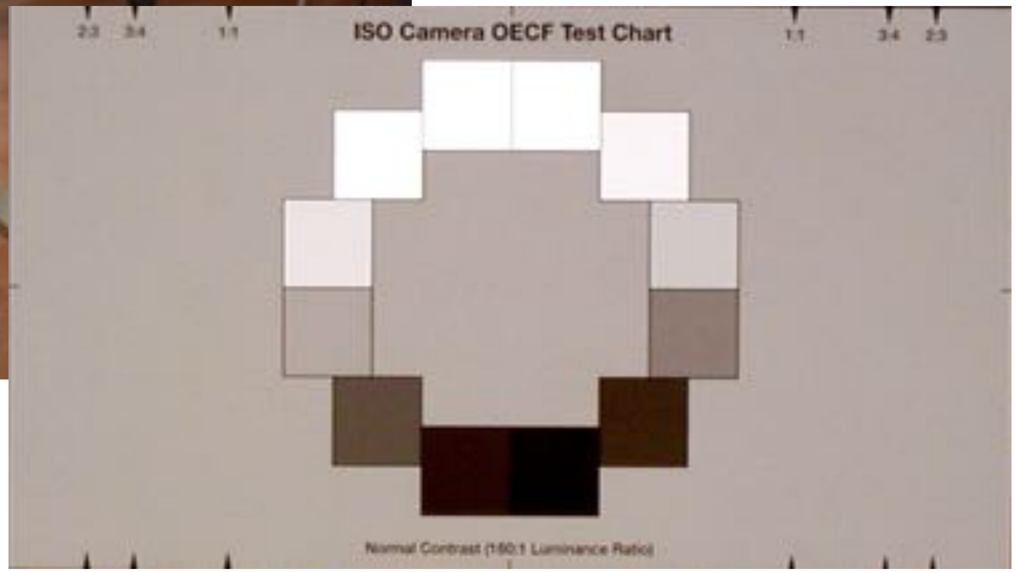


Image Engineering Diemtar Wüller
Erster Digitalkameratest für ColorFoto

Objektive Tests

2004

“Image Engineering Diemtar Wüller”
Komplett digitaler Objektivtest

The image part with relationship ID rId2 was not found in the file.

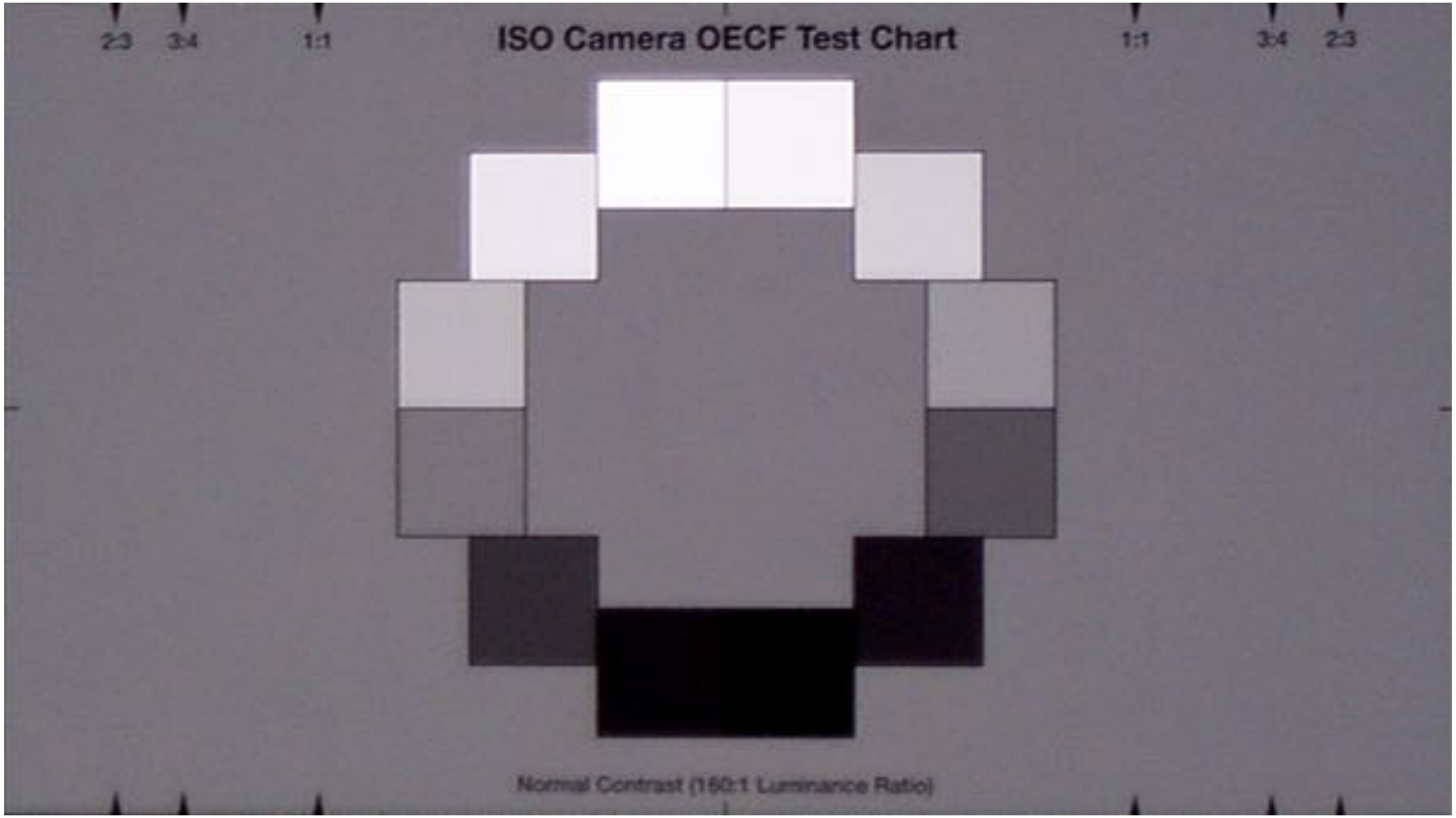
Objektive Tests

2015

Vollautomatisierter Teststand im Kundenauftrag

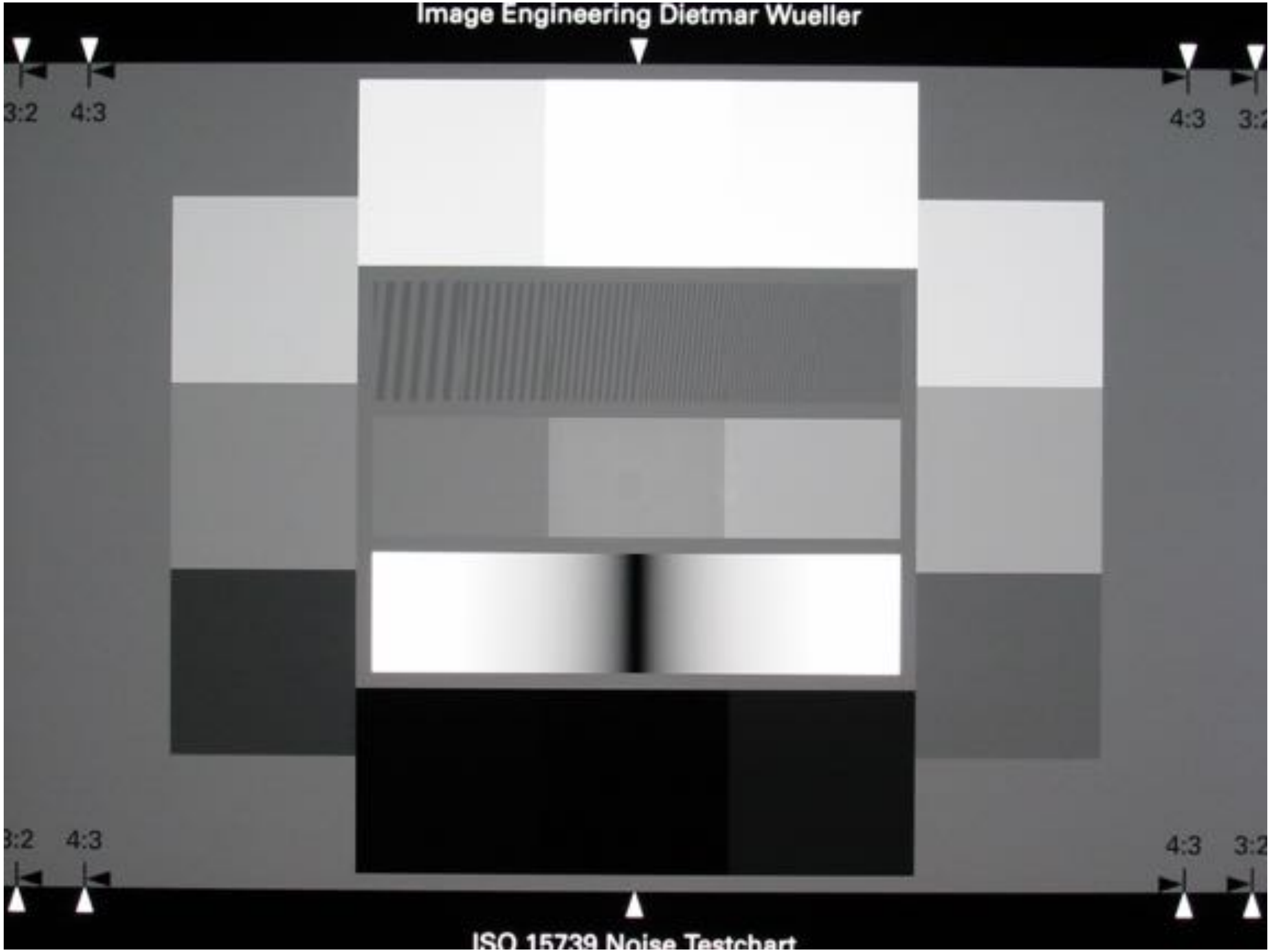
www.image-engineering.de

Weiterentwicklung



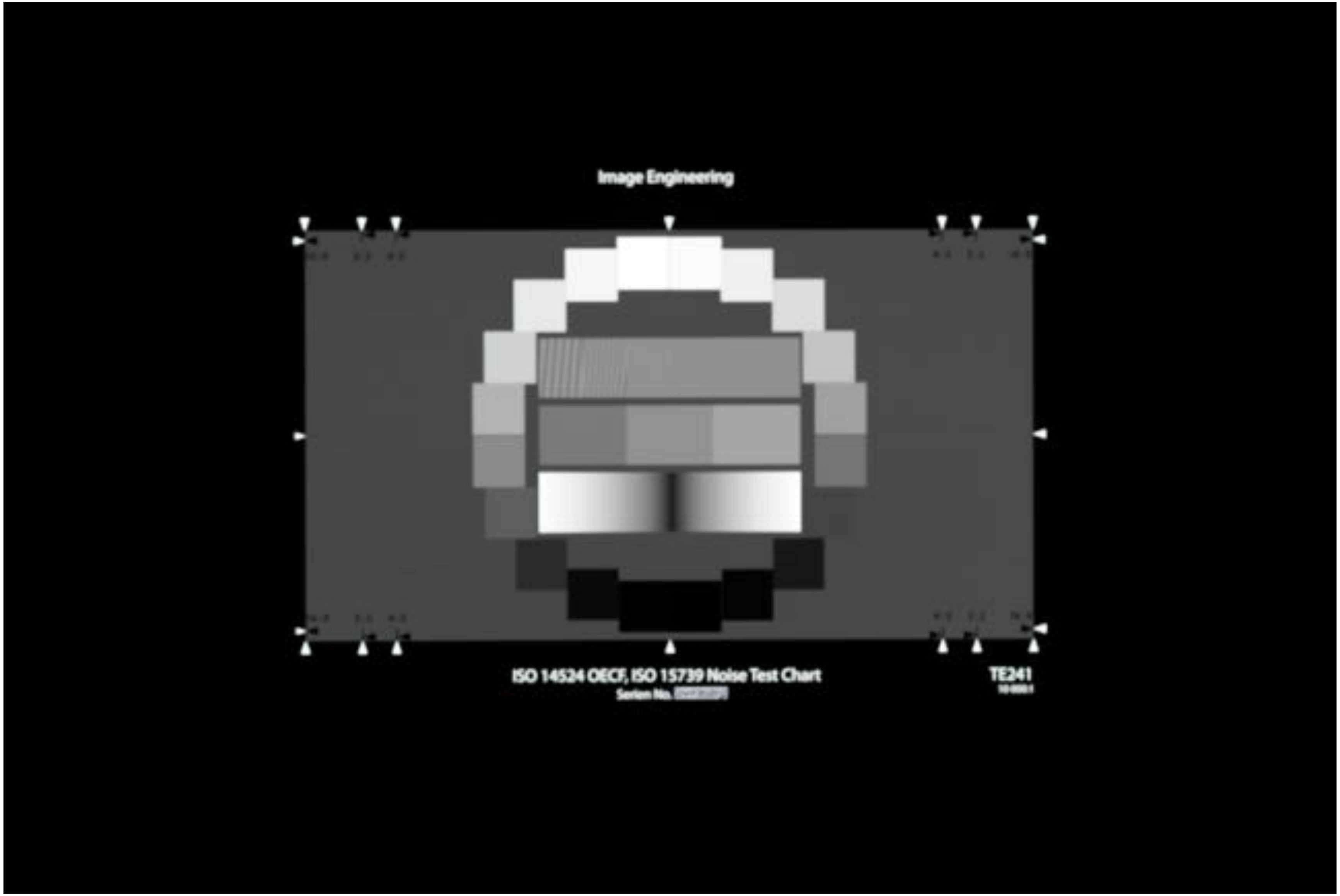
Kontrast 160:1 – ab 1997

Weiterentwicklung



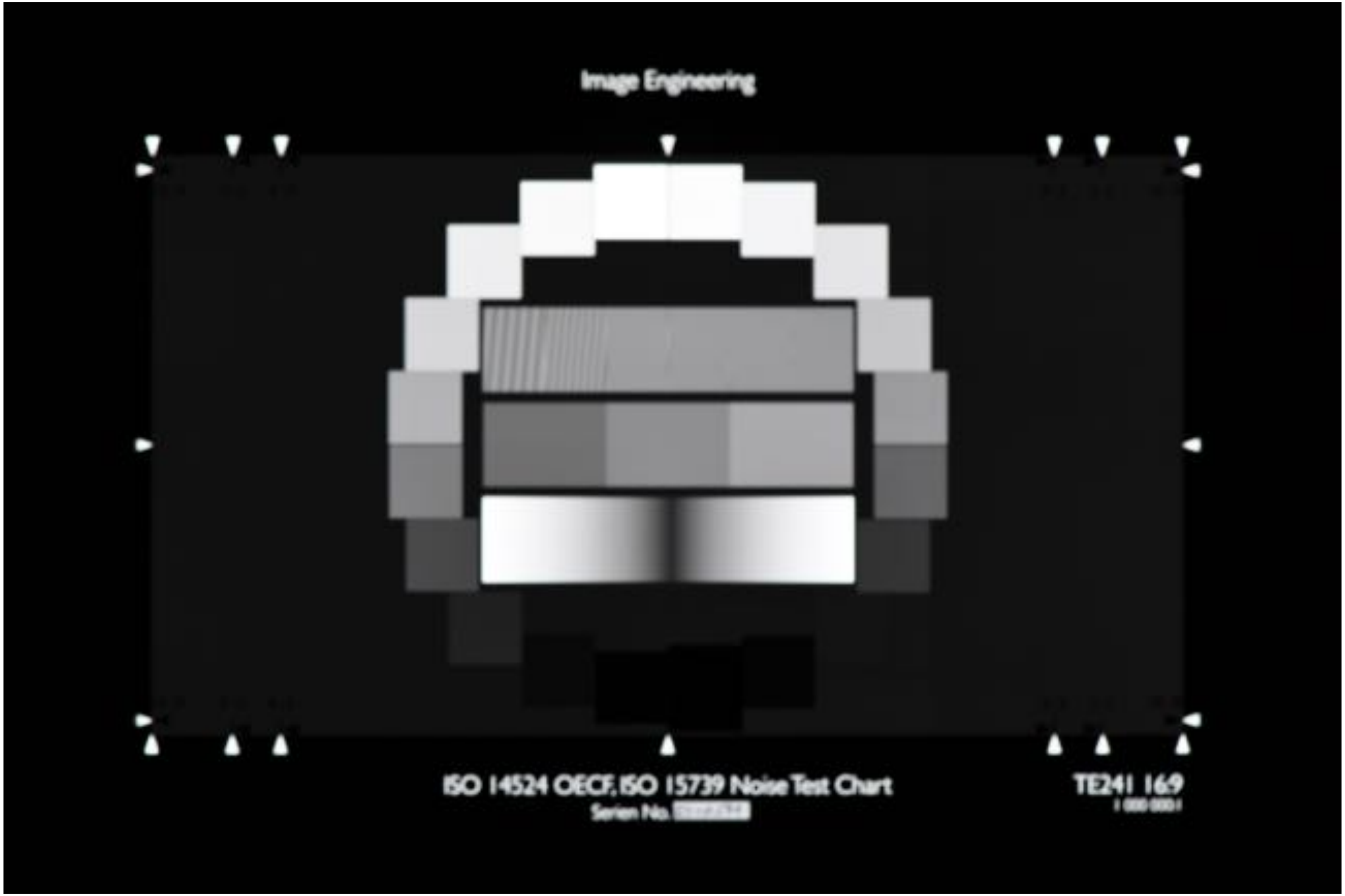
Kontrast 1000:1 – ab 2000

Weiterentwicklung



Kontrast 10.000:1 – ab 2003

Weiterentwicklung



Kontrast 1.000.000:1 – ab 2015

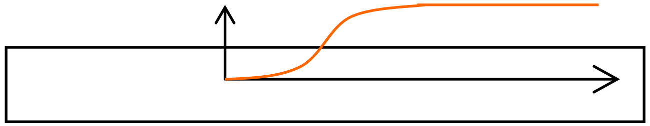
Dynamic Range

Rendering

12-bit input

Schatten-Tonwertkurve

8-bit R,G,B

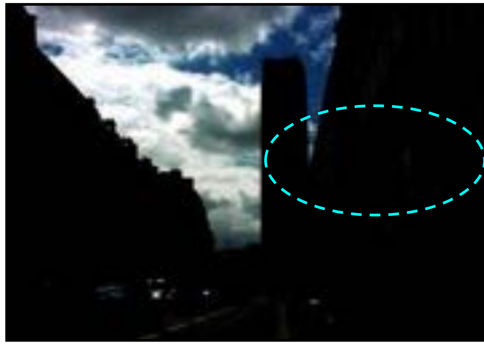


12-bit R,G,B

8-bit output

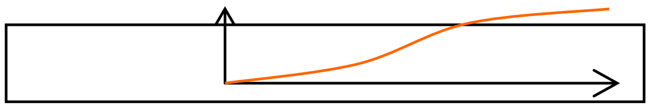
Lichter verloren

Lichter-Tonwertkurve



Schatten verloren

Individuelle Tonwertkurve



Details in Lichter und Schatten

HDR

HDR

Objektive Tests

2004

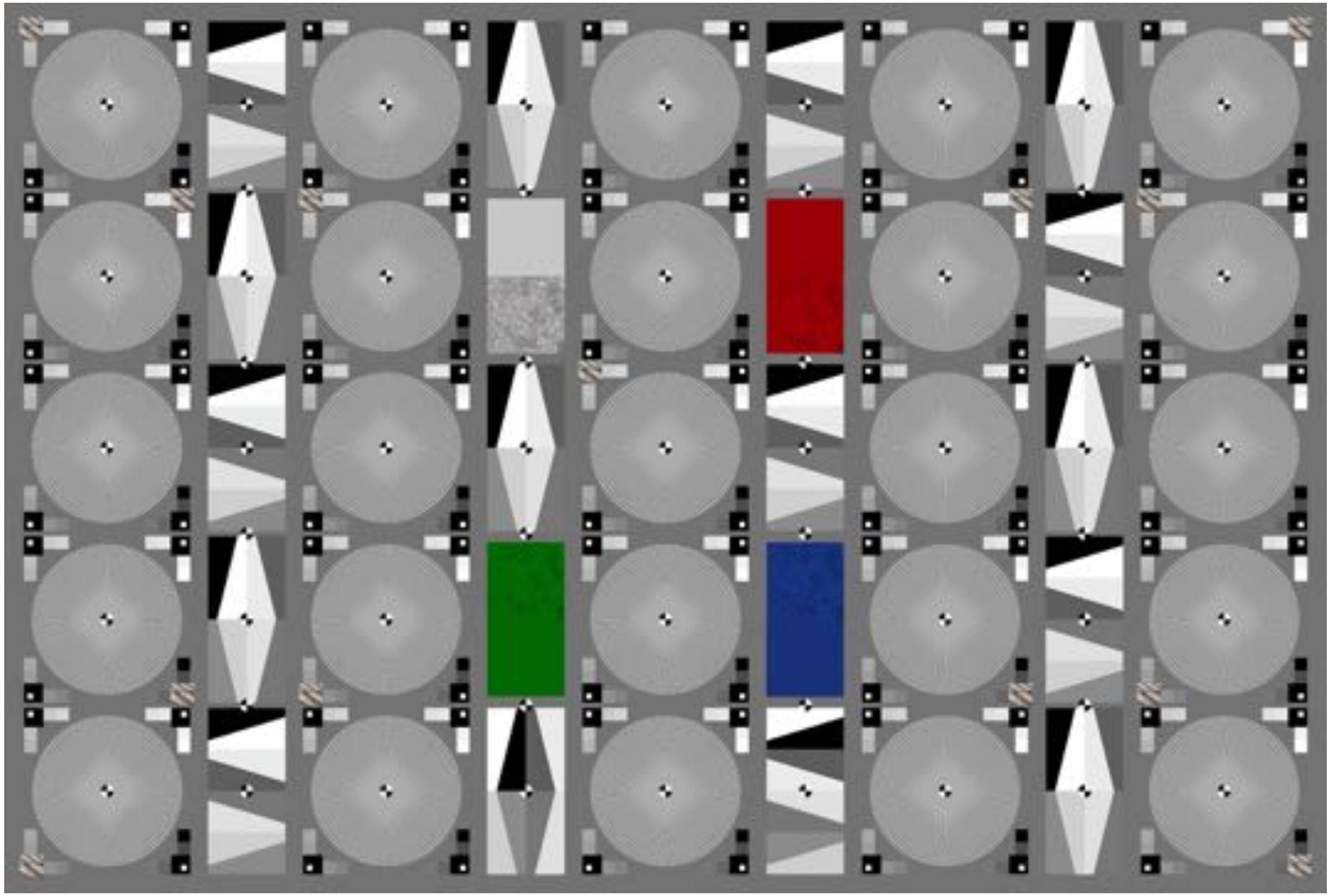
"Image Engineering Diemtar Wüller"
Komplett digitaler Objektivtest

Auflösungsmessung mit harmonischen Siemenssternen.

- 2,1m hohes Chart
- max. 20 Megapixel

Objektive Tests

2006

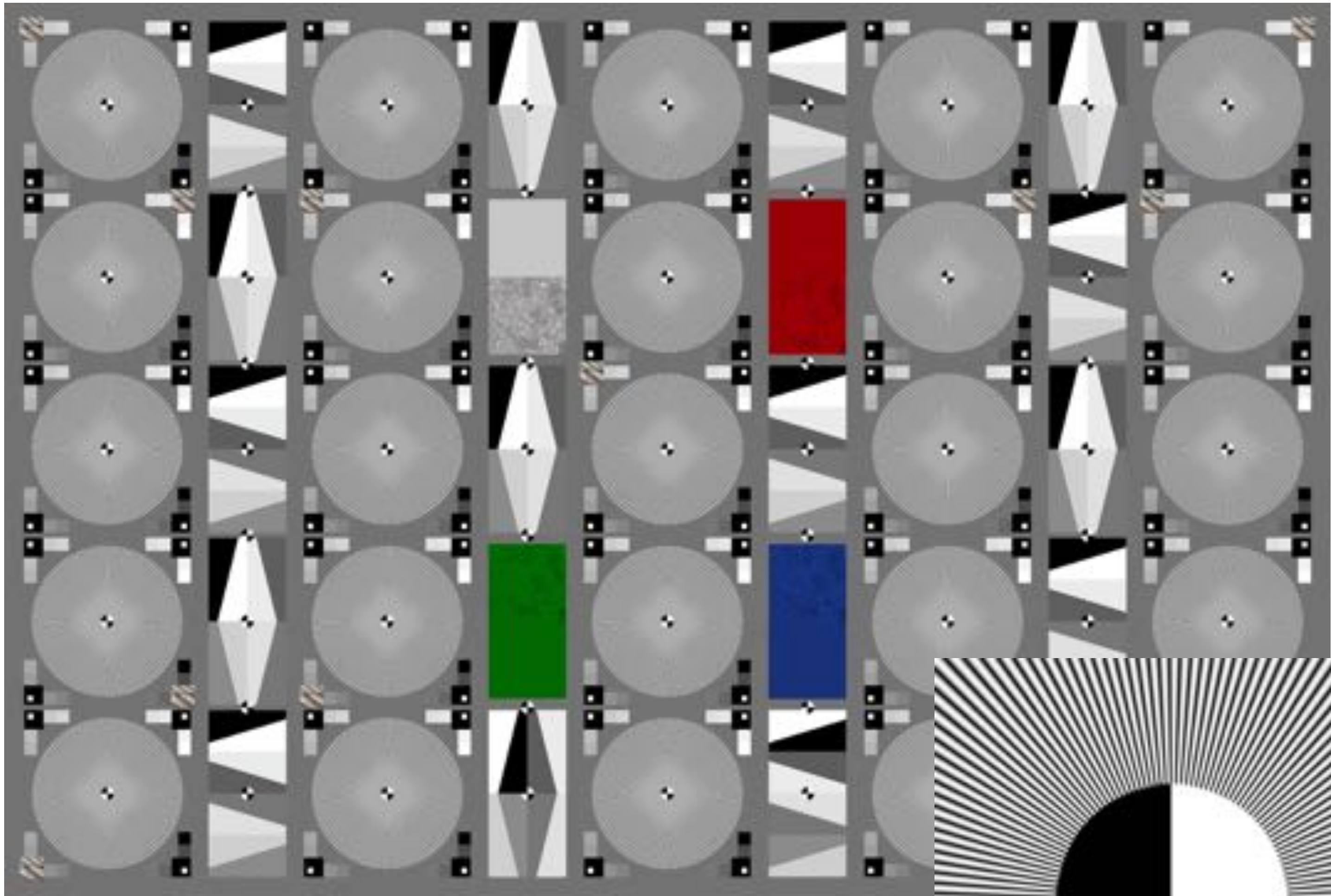


Auflösungsmessung mit harmonischen Siemenssternen.

- 0,8m hohes Chart
- max. 30 Megapixel

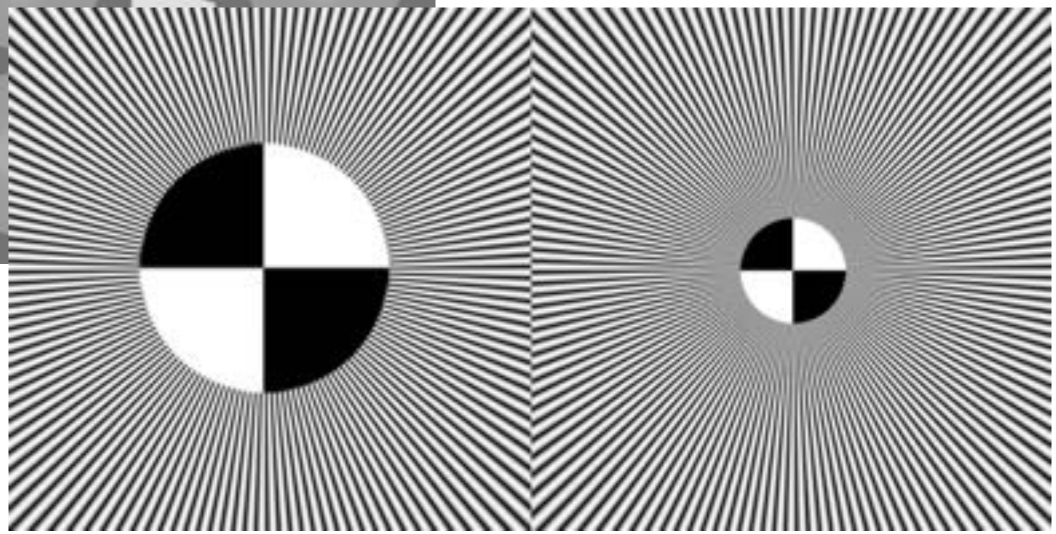
Objektive Tests

2013



Auflösungsmessung mit harmonischen Siemenssternen.

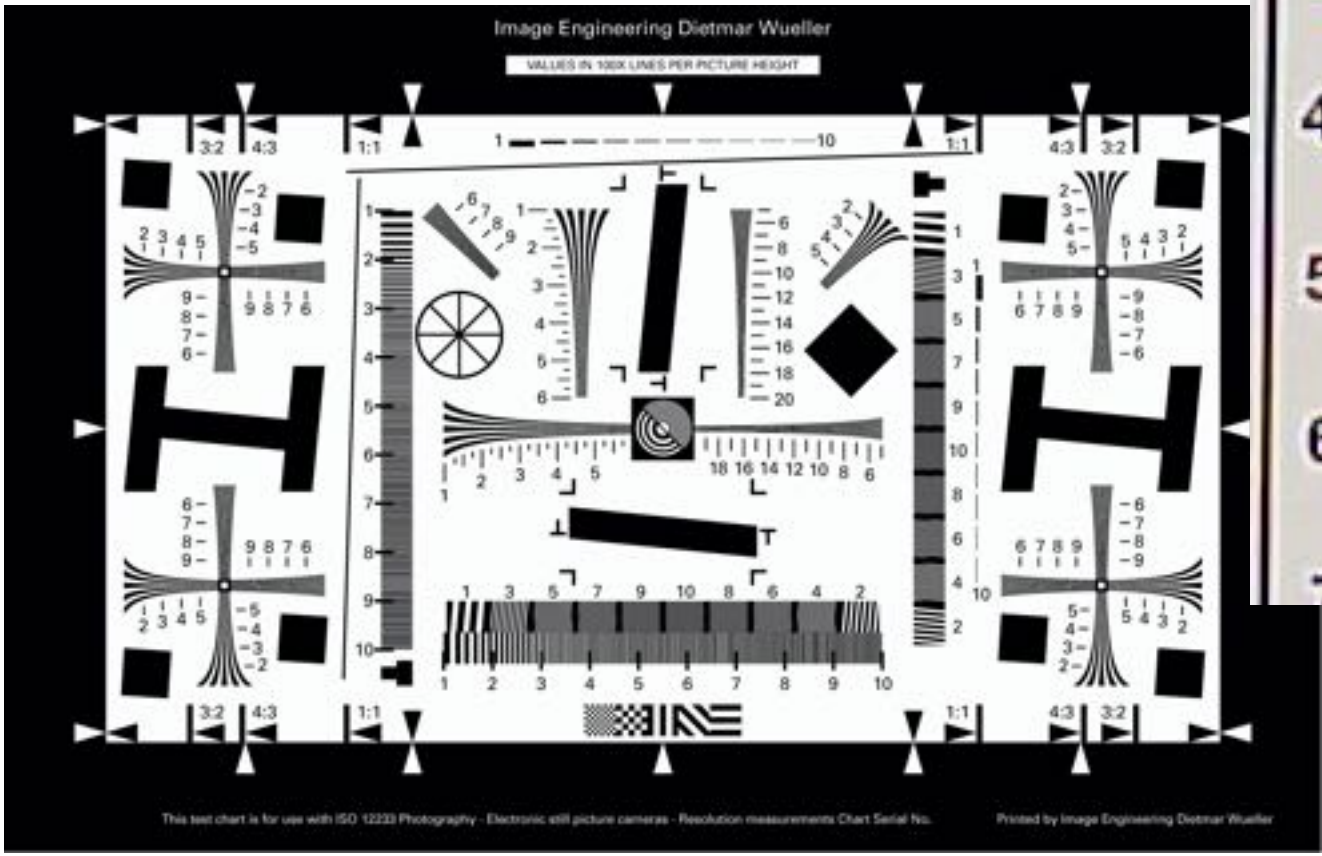
- 0,8m hohes Chart
- max. 180 Megapixel



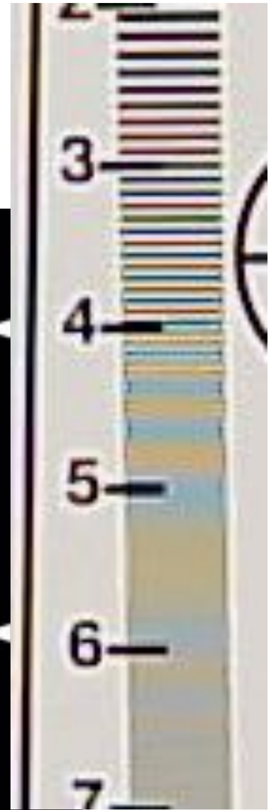
12mm → 5mm

- Kameras werden besser – Messverfahren müssen mithalten
- **Neue Technologien erfordern neue Messverfahren**
- Was der Kunde nicht weiß… Den Finger in die Wunde legen

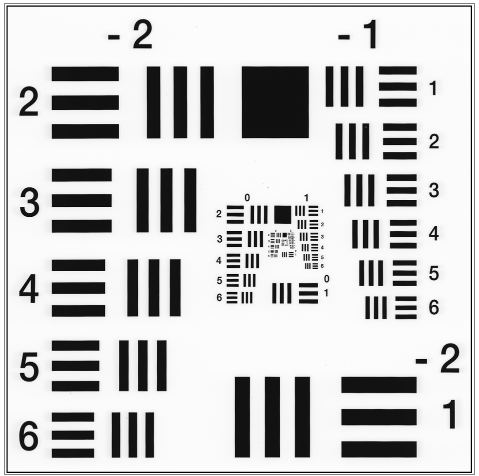
ISO12233 – 2000 // Visuelle Auswertung oder Kante



ISO12233-2000

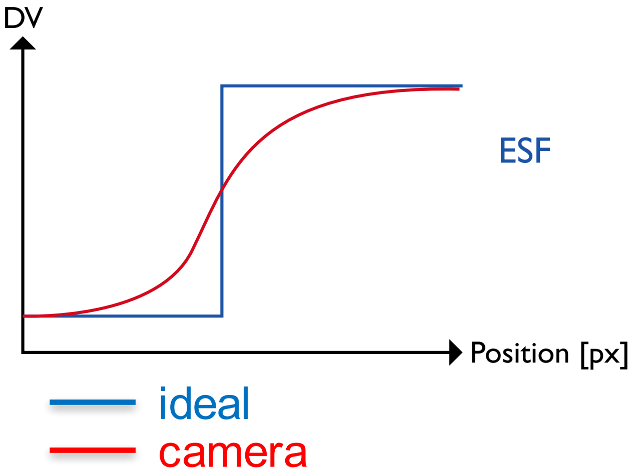


USAF Chart

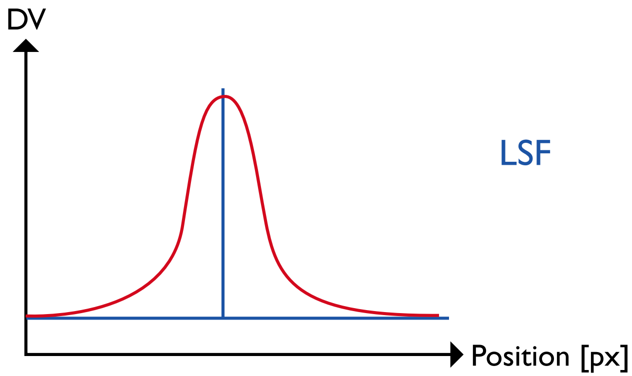


Resolution – Slanted edge

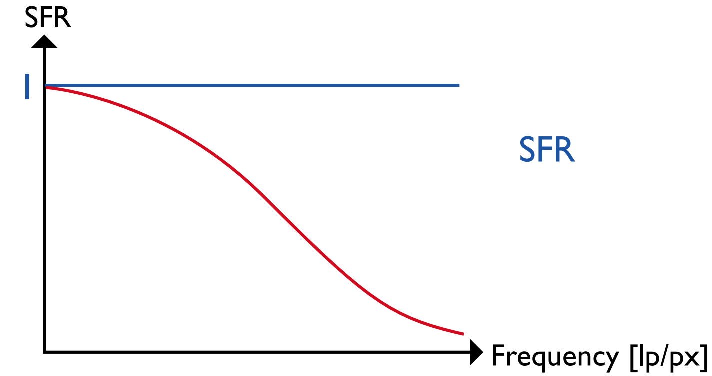
Edge Spread Function
f(x)

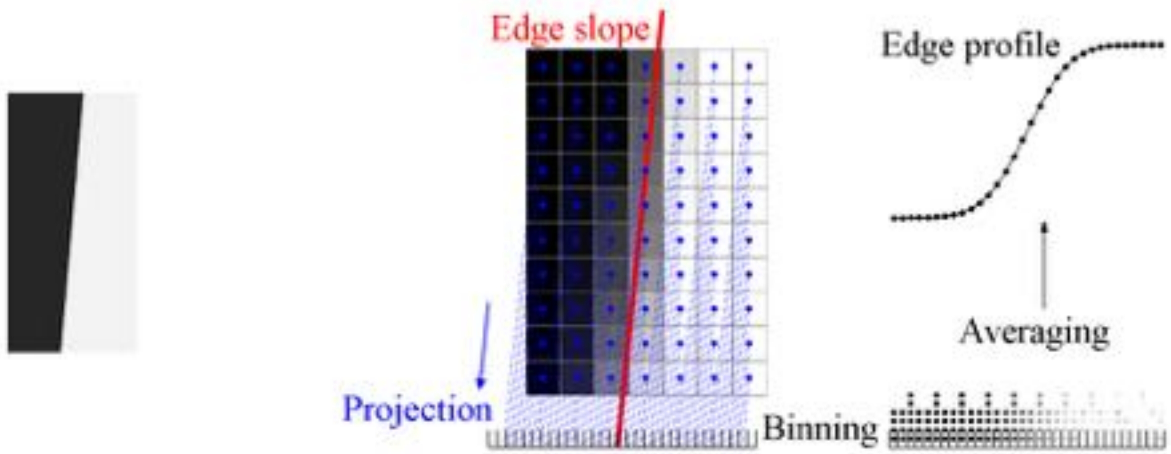


Line Spread Function
f'(x)



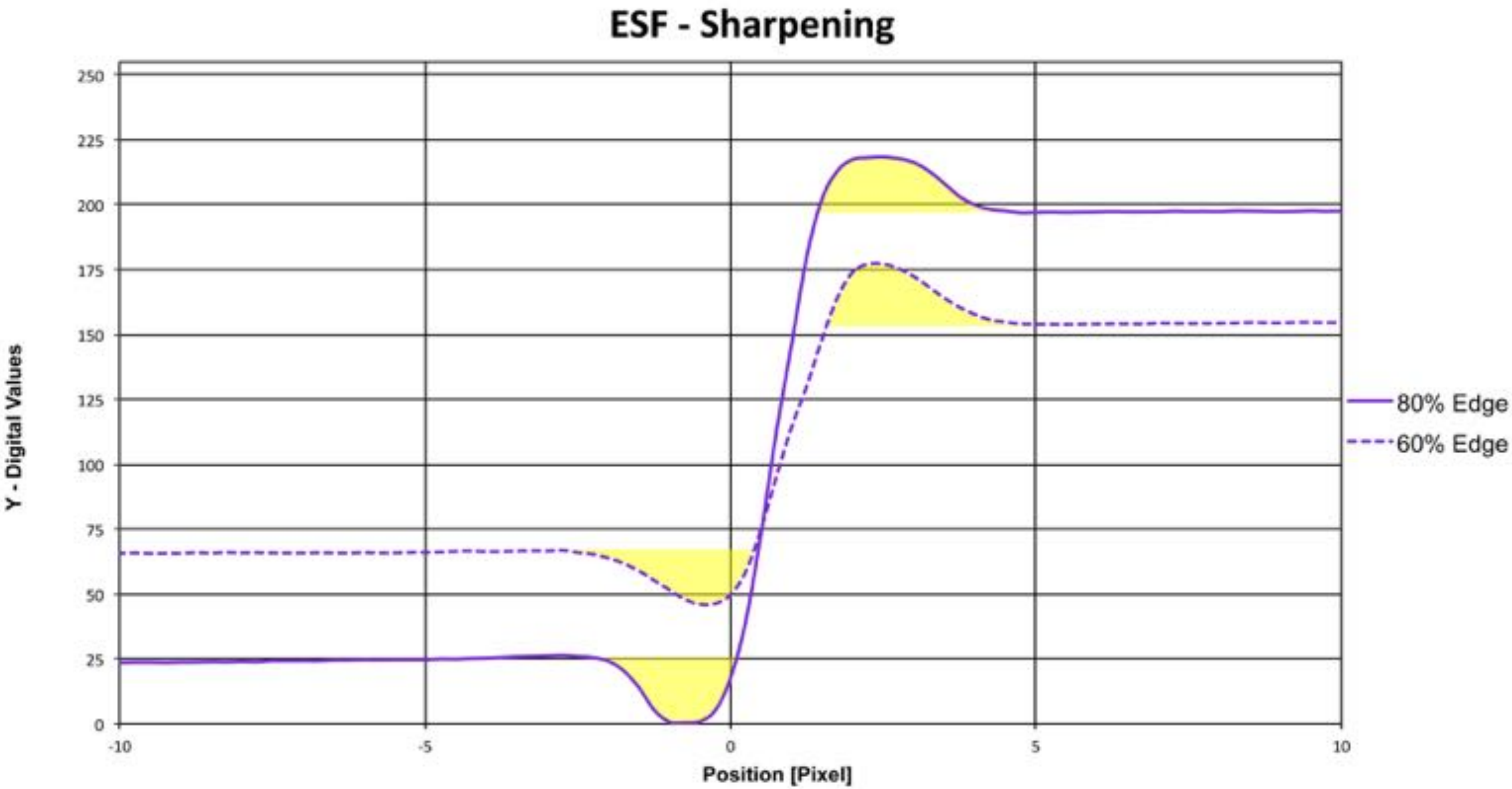
SFR
Fourier(f'(x))



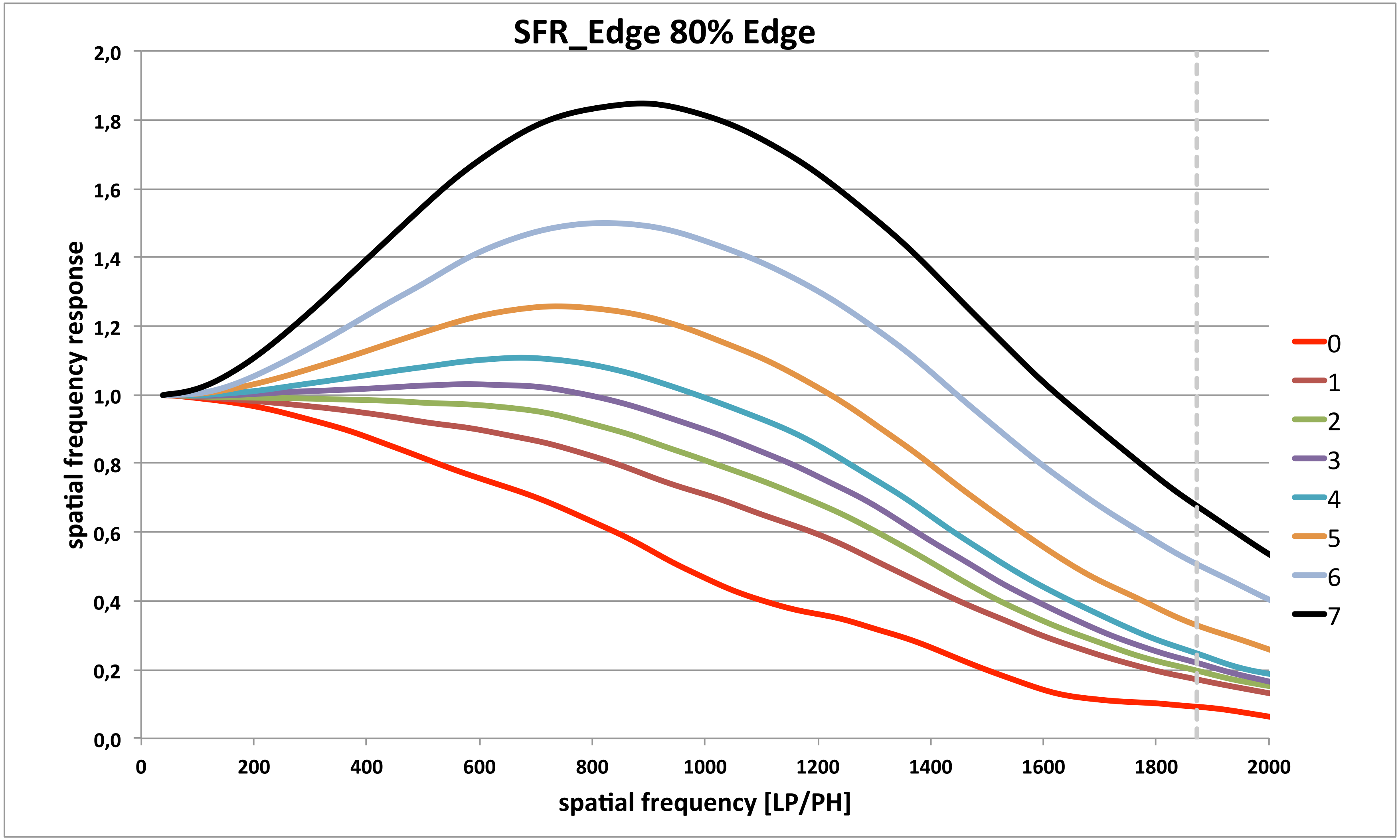


(a) (b)

Sharpening

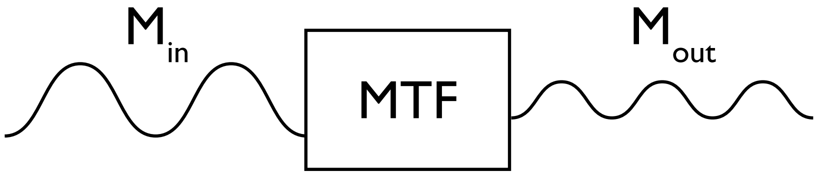


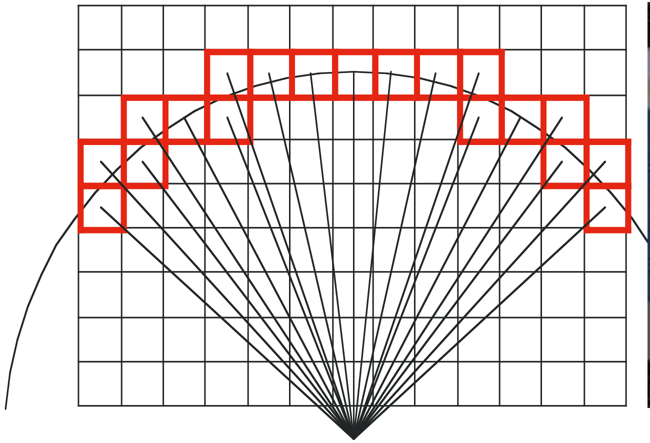
ESF - Sharpening
250
225
200
175
150
125
100
75
50
25
0
Y - Digital Values
-10
-5
0
5
10
Position [Pixel]
80% Edge
60% Edge

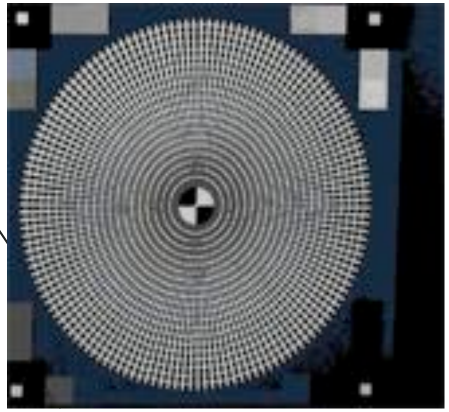


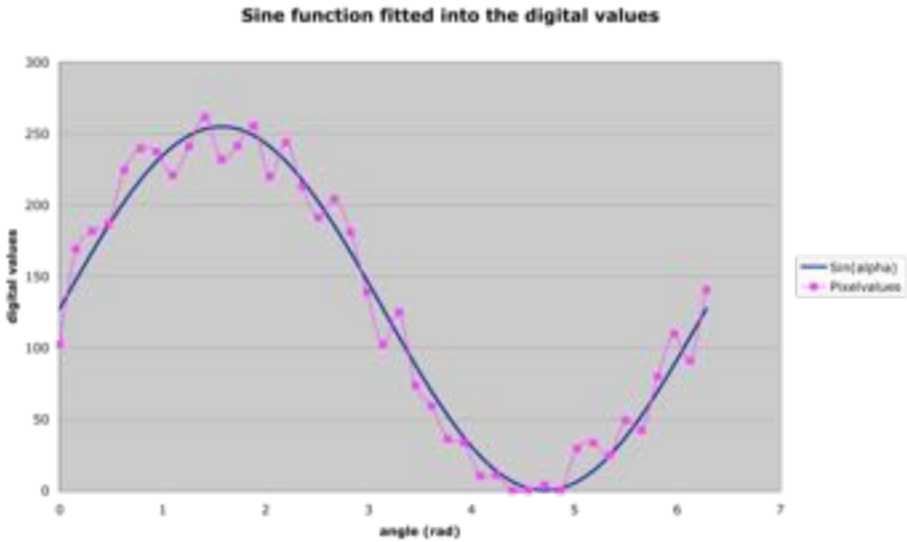
Die Analyse der schrägen Kante ist stark durch Bildoptimierung wie z.B. Schärfung beinflusst.

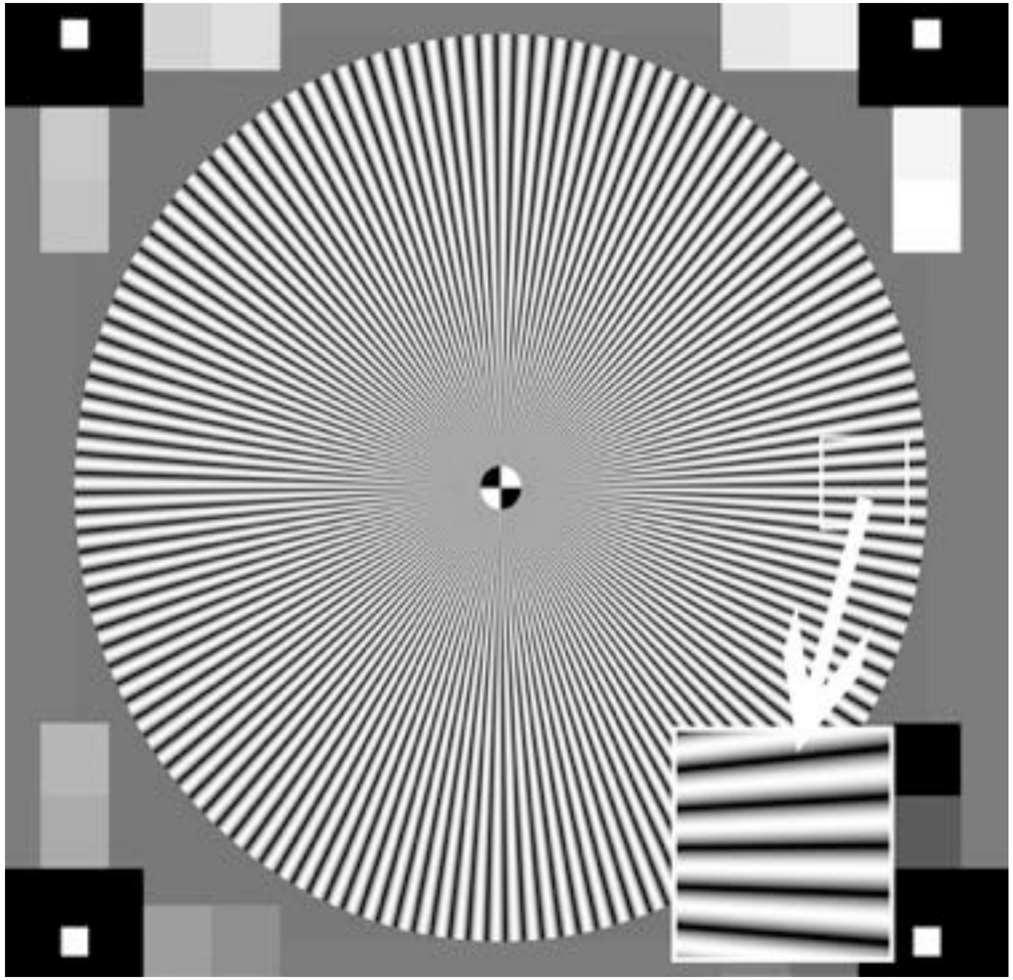
Auflösungsmessung





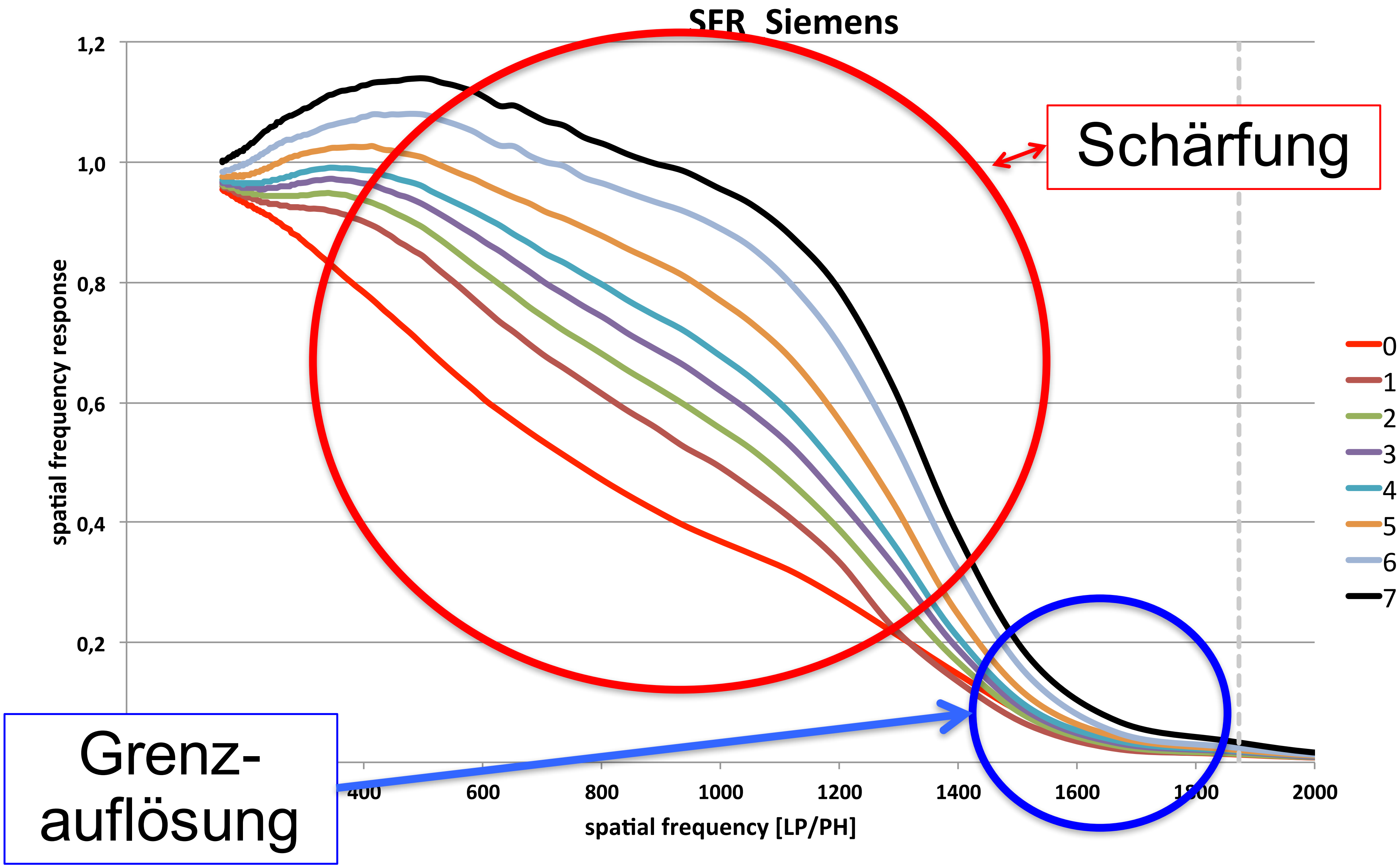




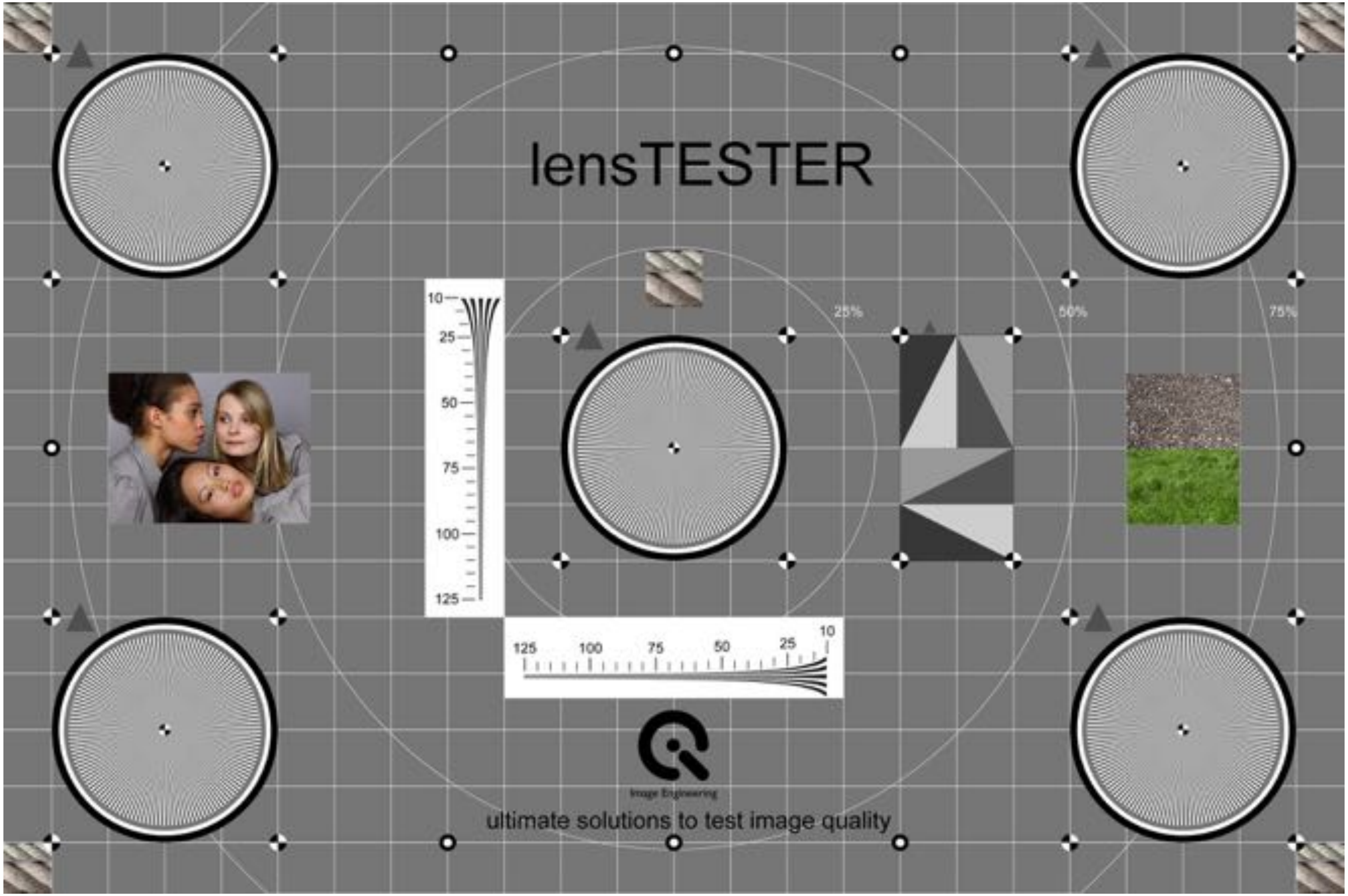


ISO12233-2014
Entwickelt durch Image Engineering 2003

Auflösung

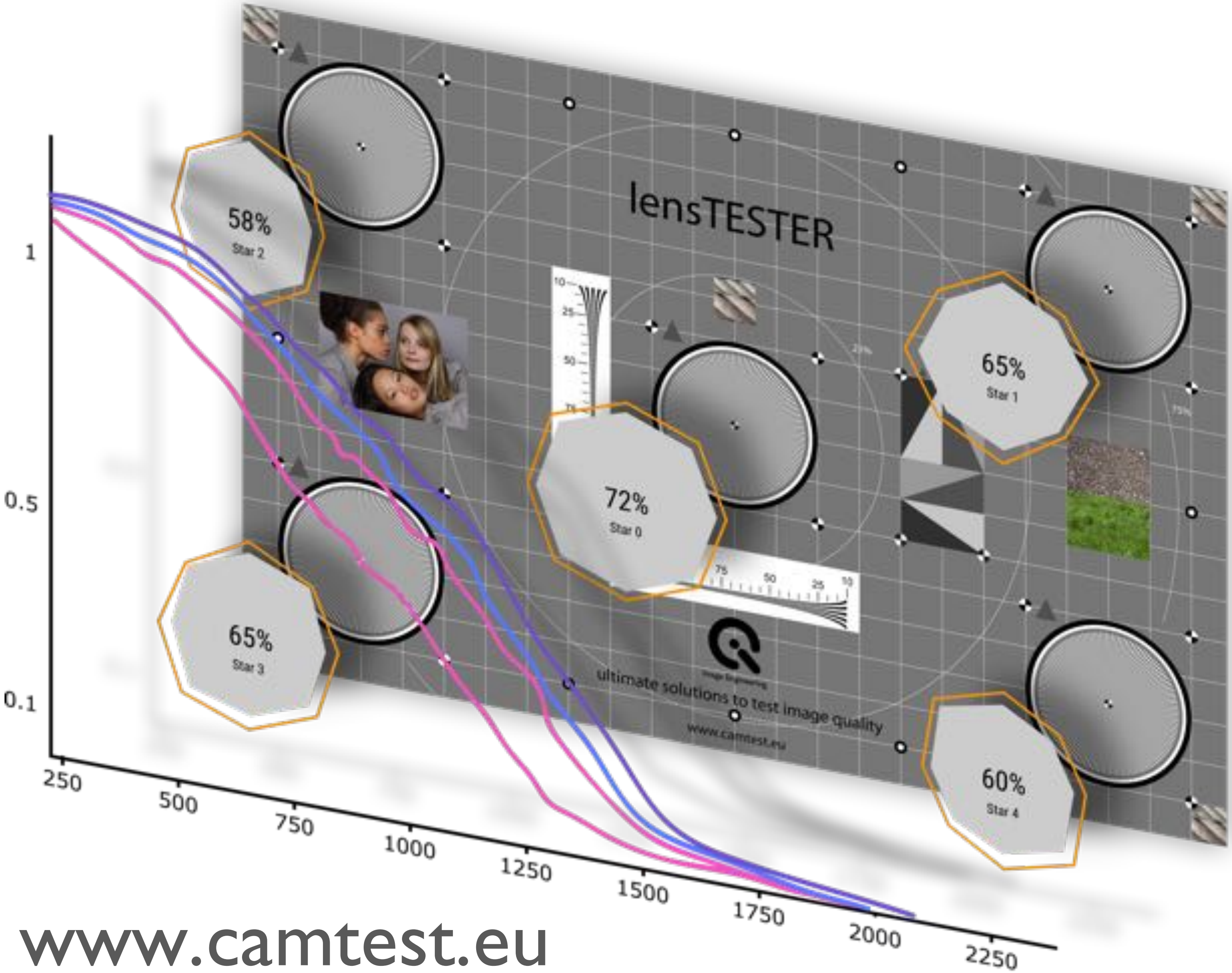

SFR Siemens
1,2
1,0
0,8
0,6
0,4
0,2
spatial frequency response
400
600
800
1000
1200
1400
1600
1800
2000
spatial frequency [LP/PH]
0
1
2
3
4
5
6
7
Schärfung
Grenz-
auflösung

lensTESTER



lensTESTER
25%
50%
75%
10
25
50
75
100
125
125
100
75
50
25
10
Image Engineering
ultimate solutions to test image quality

lensTESTER



www.camtest.eu

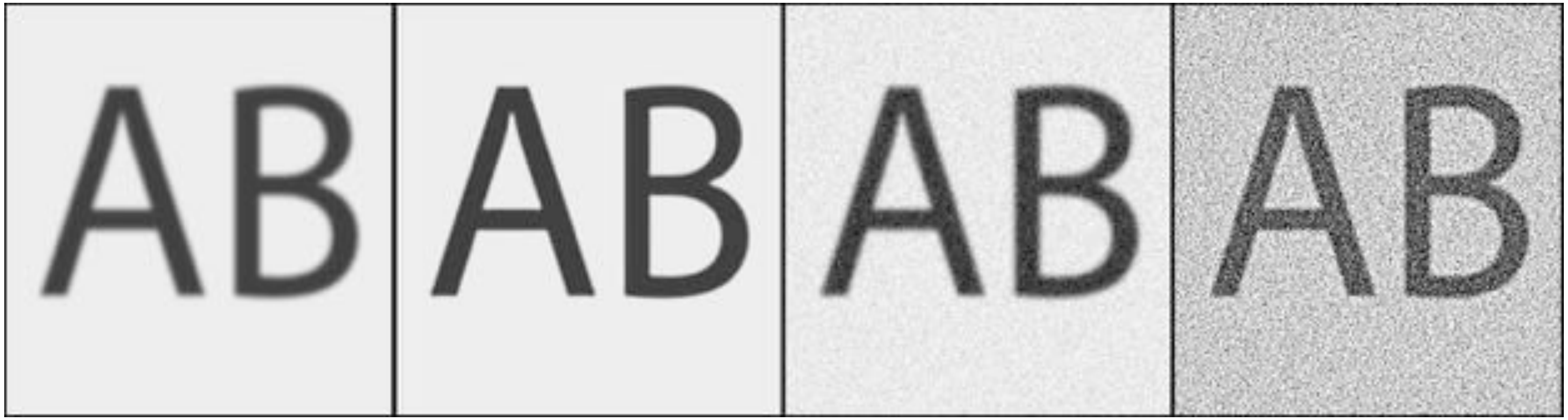
www.image-engineering.de

lensTESTER

www.camtest.eu

Texture loss

Sharpness vs. Noise vs. Texture loss

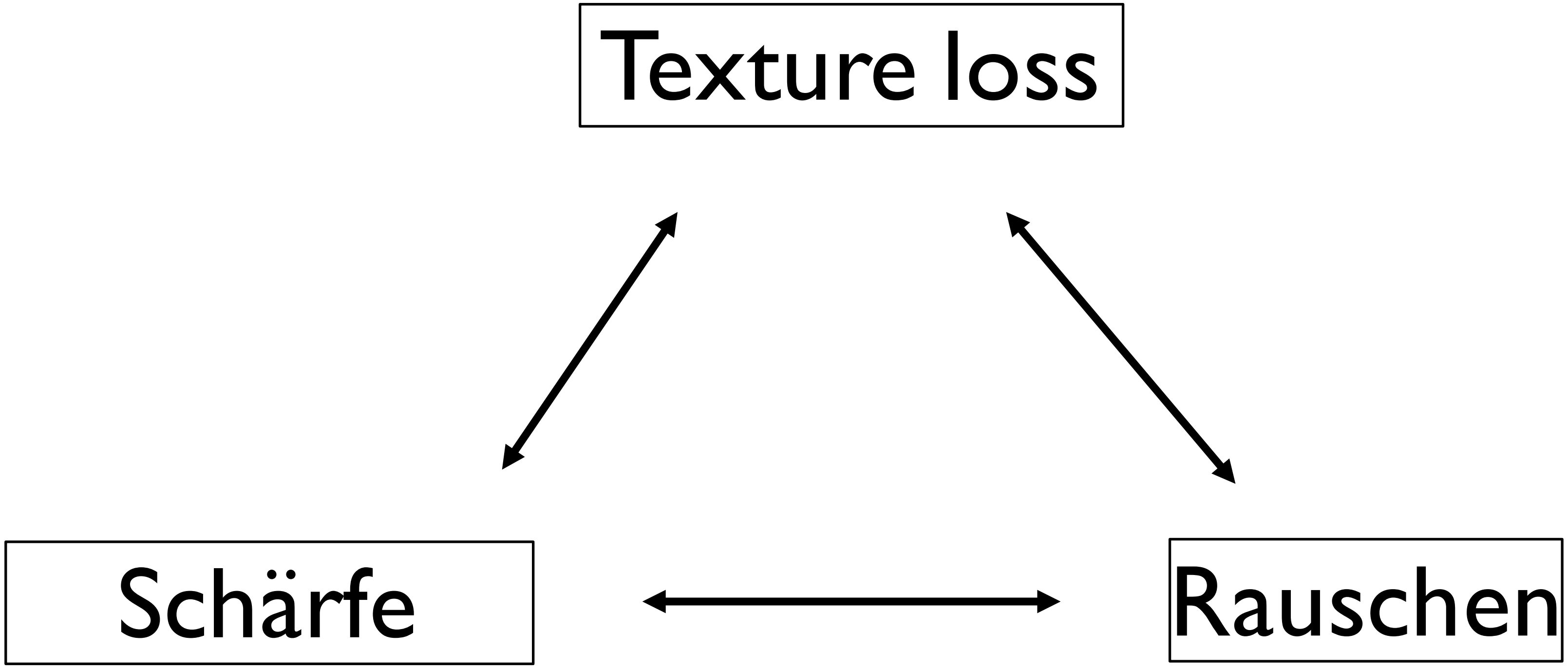


Kein Rauschen | Kein Rauschen + Schärfung | Wenig Rauschen | Wenig Rauschen + Schärfung

Tuning

Sharpness ⟷ Noise

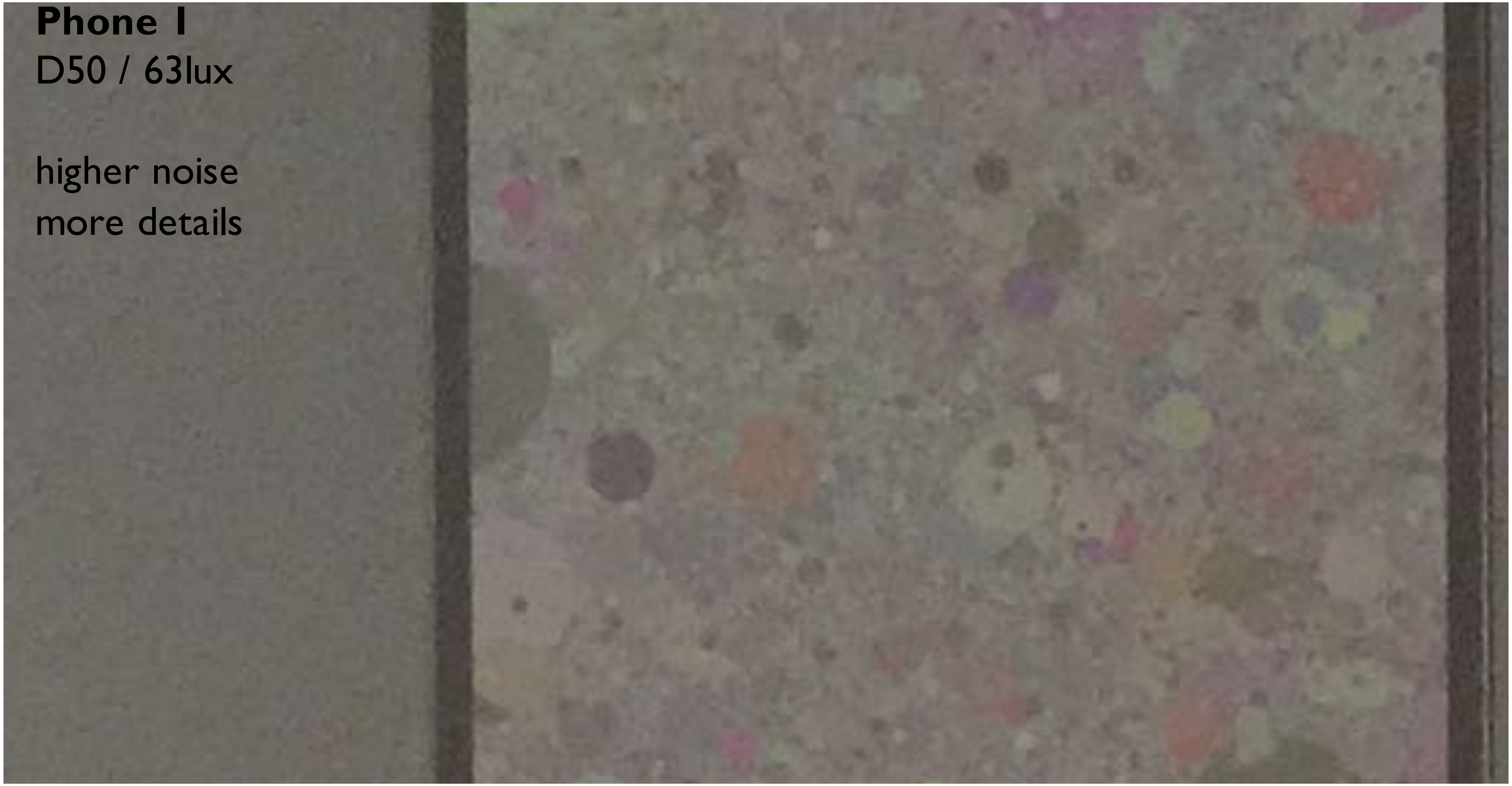
Tuning



Texture loss

Texture loss

Texture loss

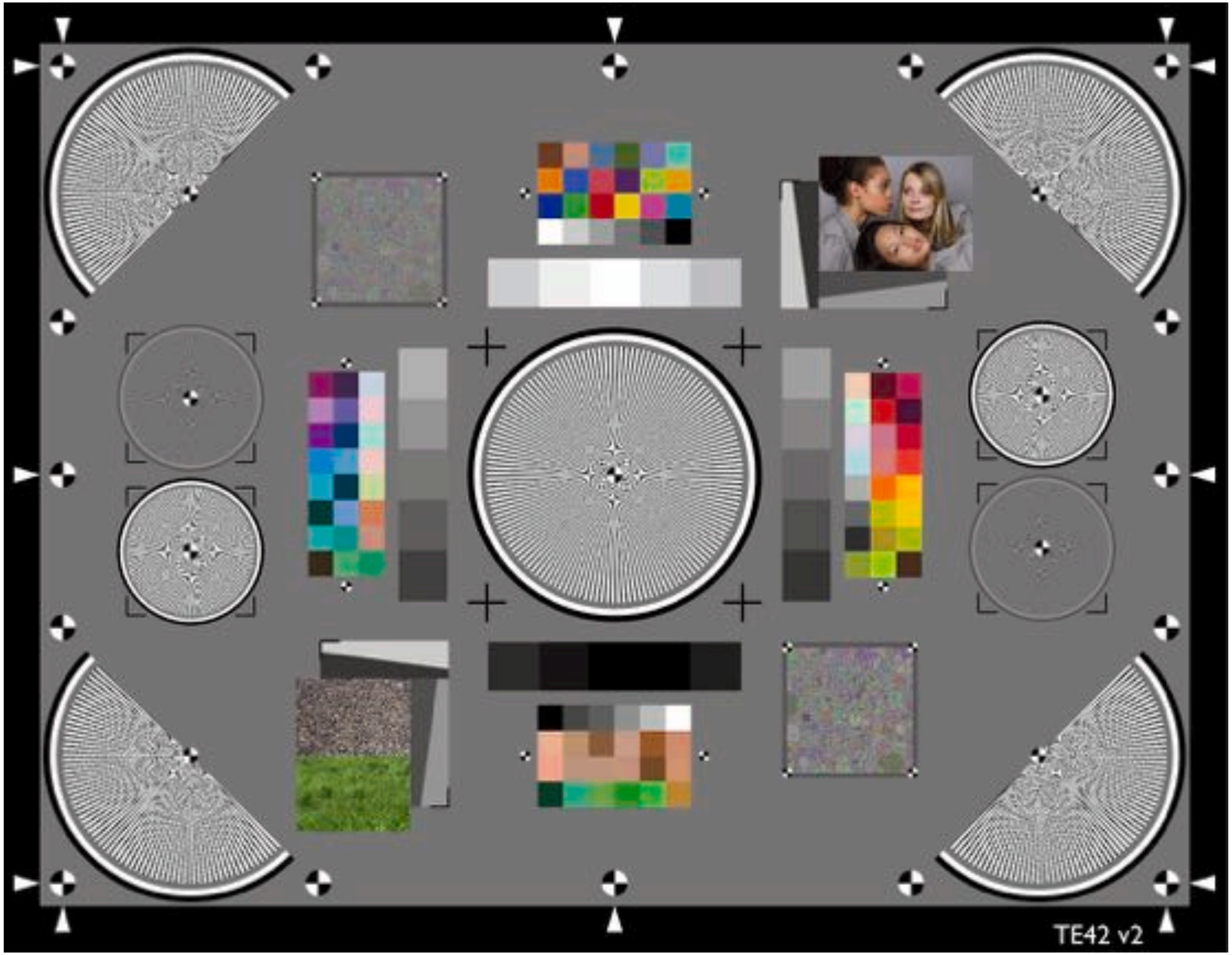


Texture loss

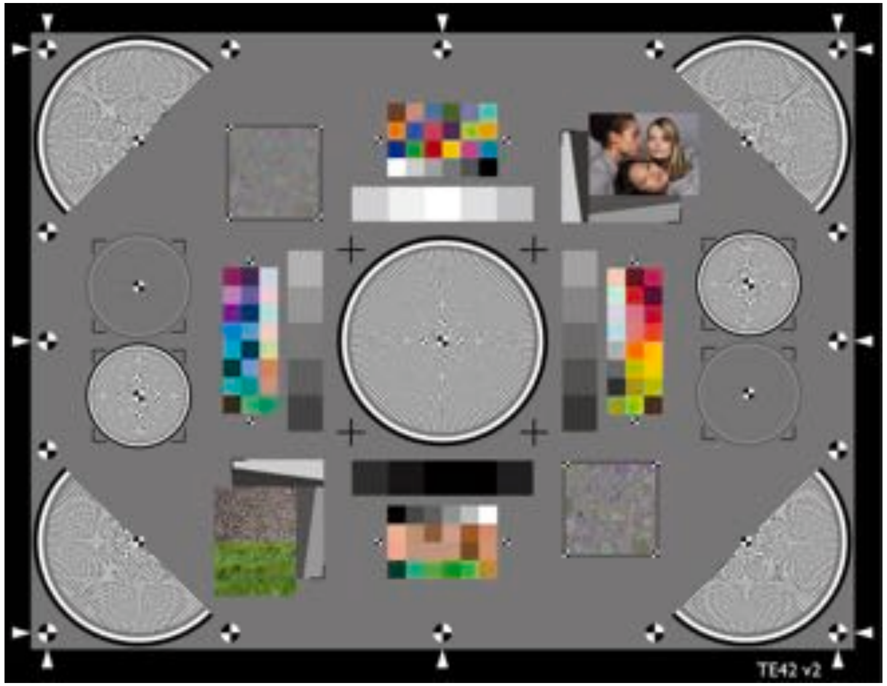
- Eine Kamera stellt ein komplexes System dar. Es ist wichtig nicht nur einzelne Teile zu beurteilen.

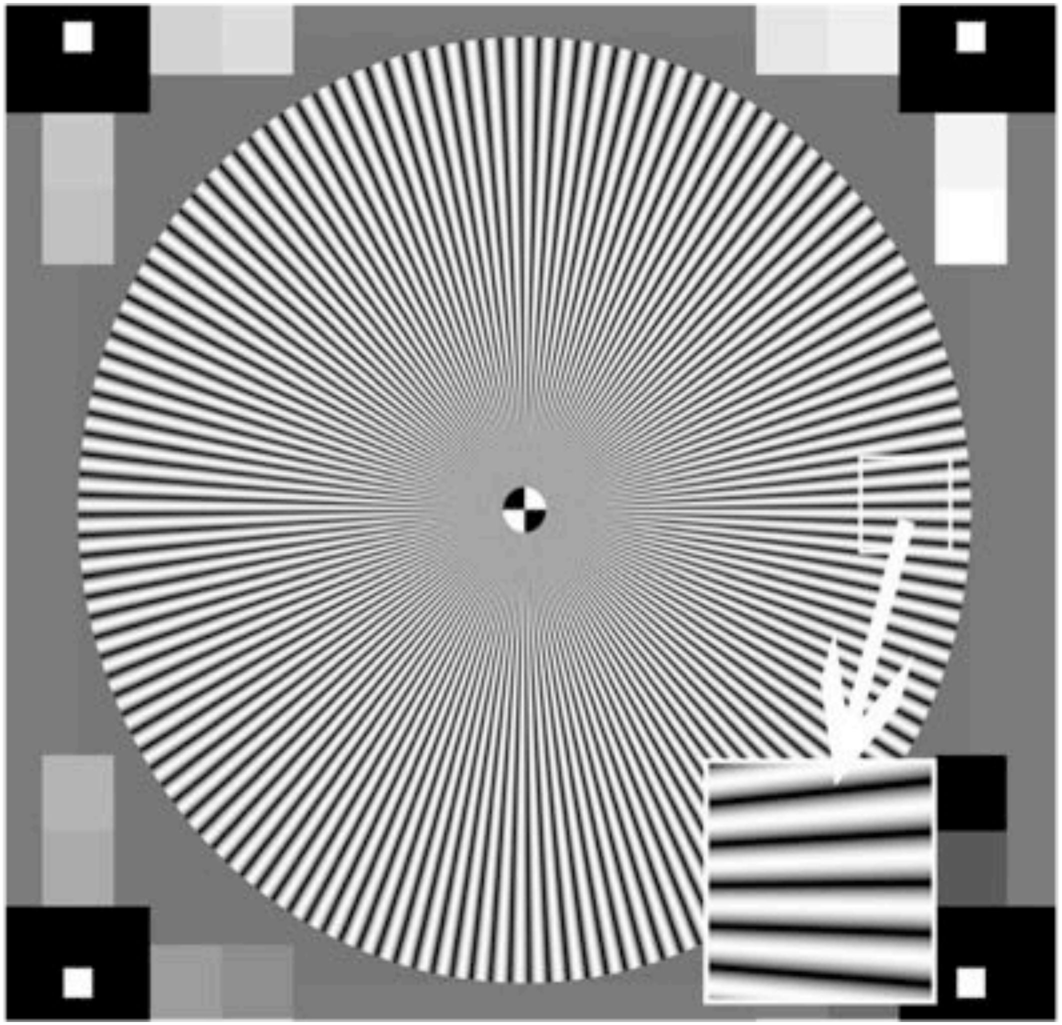
Kürzester Bremsweg !

Spatial Frequency Response



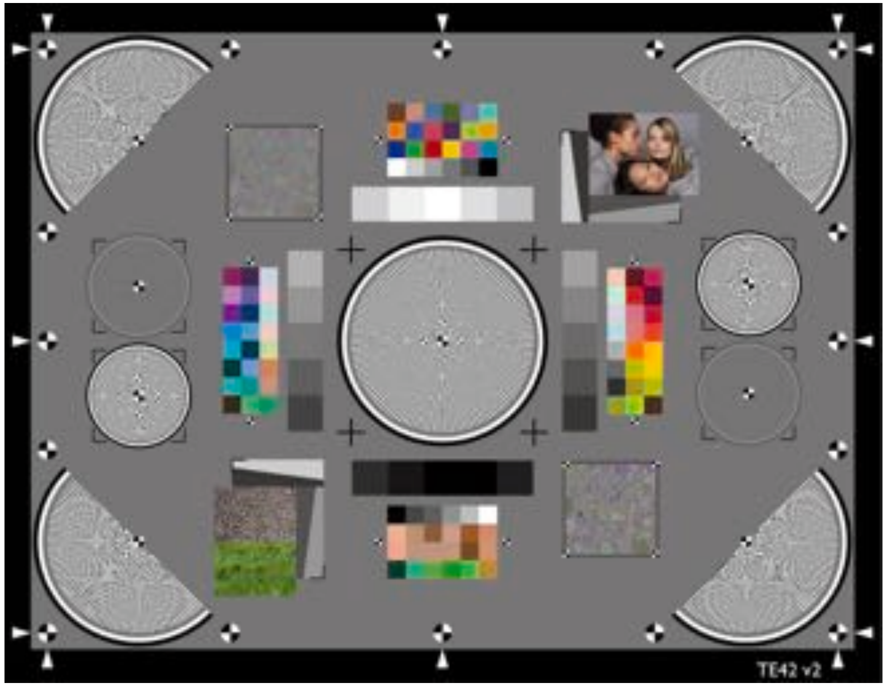
Spatial Frequency Response





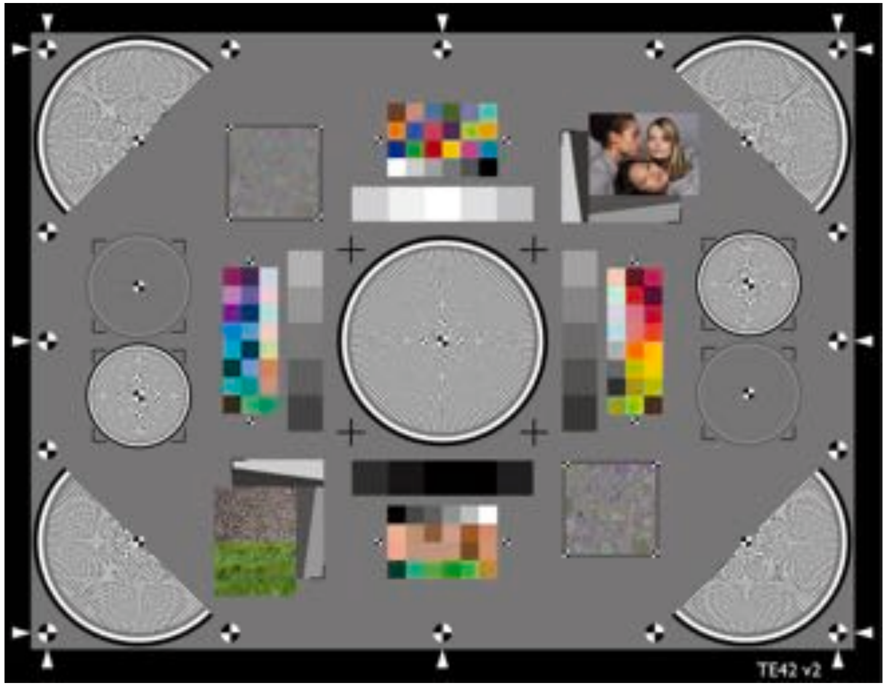
SFR-Siemens based on a sinusoidal Siemens star. It is part of the standard ISO12233:2014 "Photography - Electronic still picture imaging - Resolution measurements"

Spatial Frequency Response

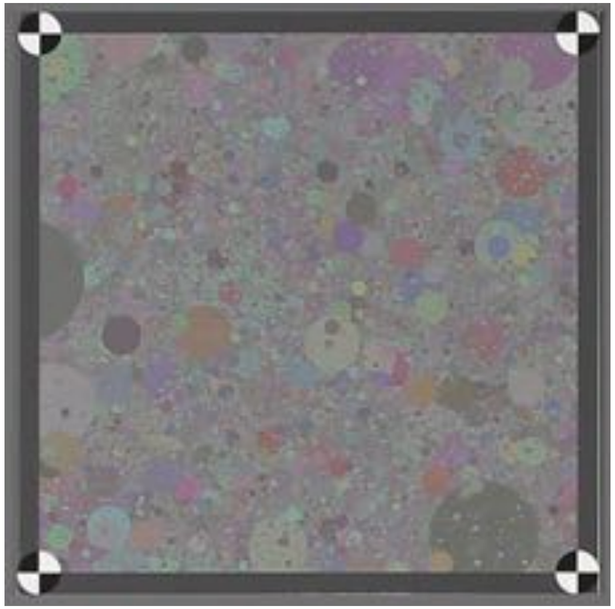


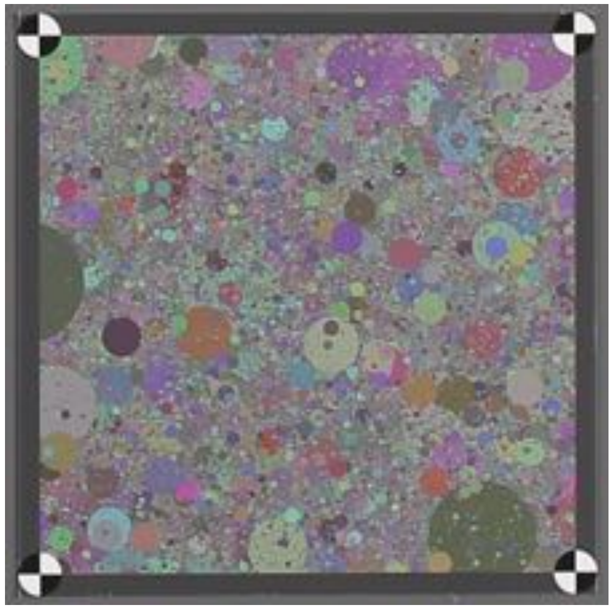
SFR-Edge measured on a 60% edge and a 80% edge. It is part of the standard ISO12233:2014 "Photography - Electronic still picture imaging - Resolution measurements"

Spatial Frequency Response

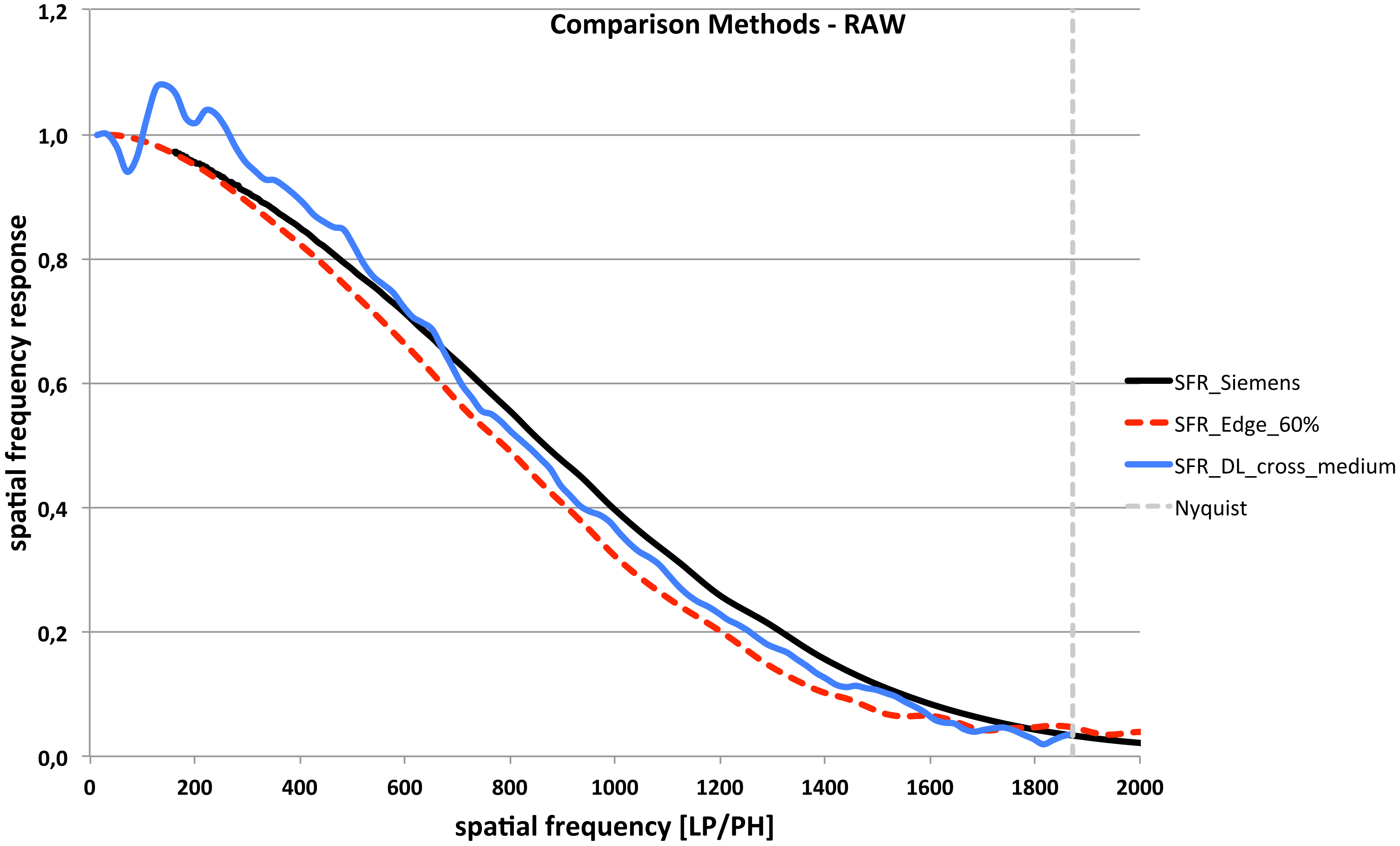


Dead Leaves pattern in two contrast ratios. “low” and “medium”



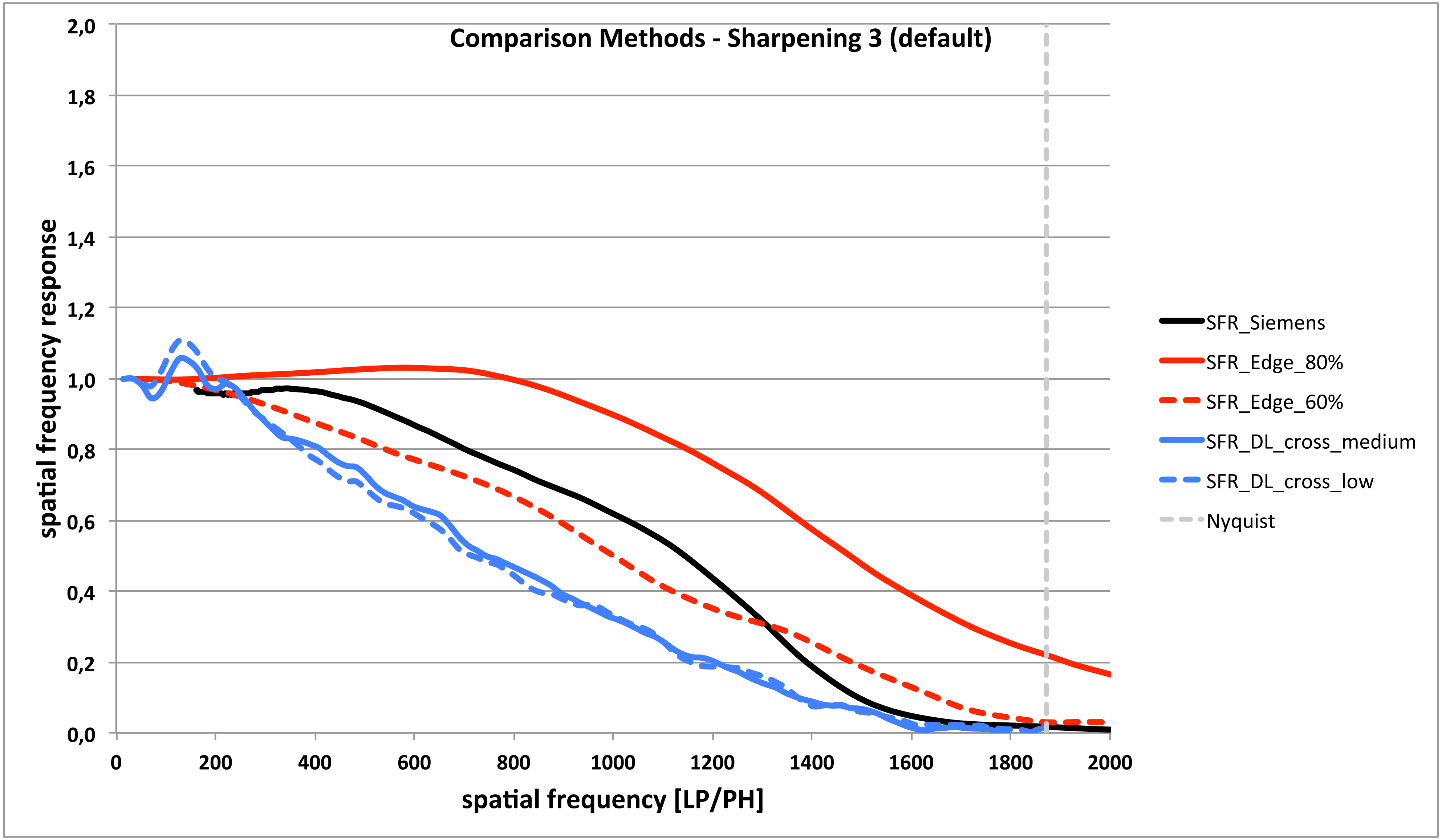


SFR - RAW

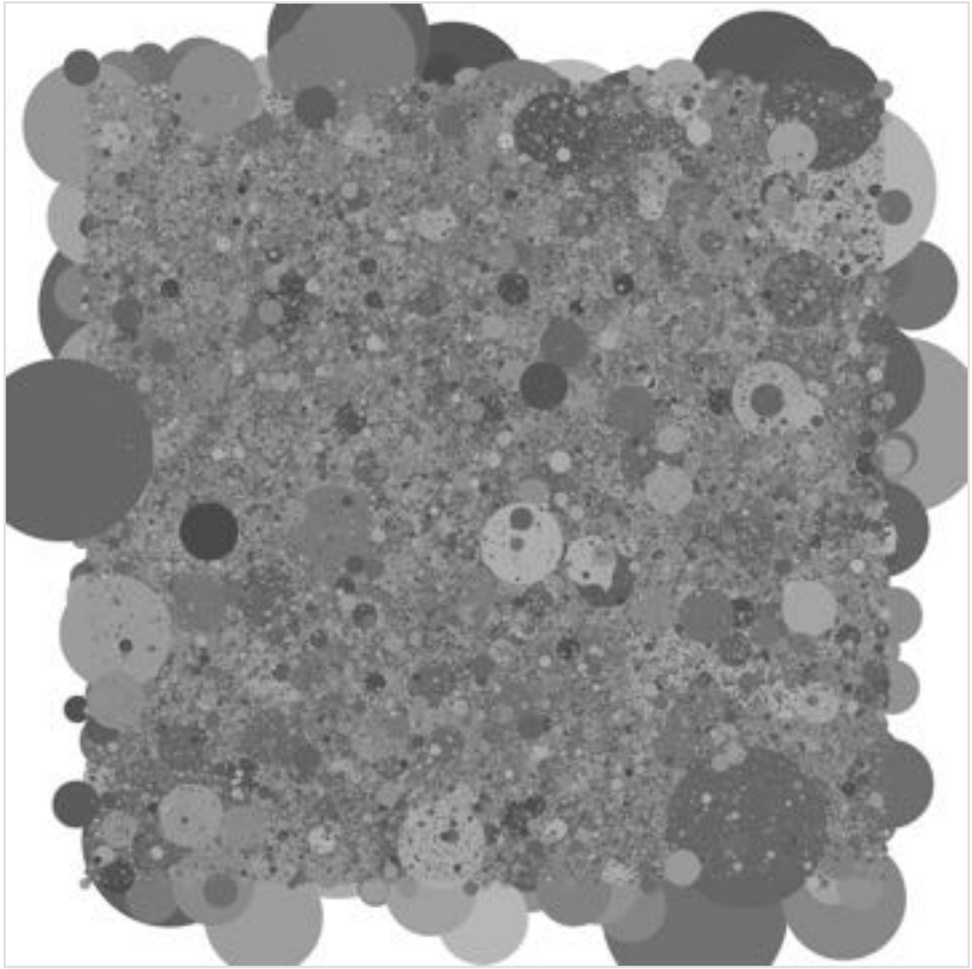


Comparison Methods - RAW
1,2
1,0
0,8
0,6
0,4
0,2
0,0
spatial frequency response
0
200
400
600
800
1000
1200
1400
1600
1800
2000
spatial frequency [LP/PH]
SFR_Siemens
SFR_Edge_60%
SFR_DL_cross_medium
Nyquist

SFR - Sharpening



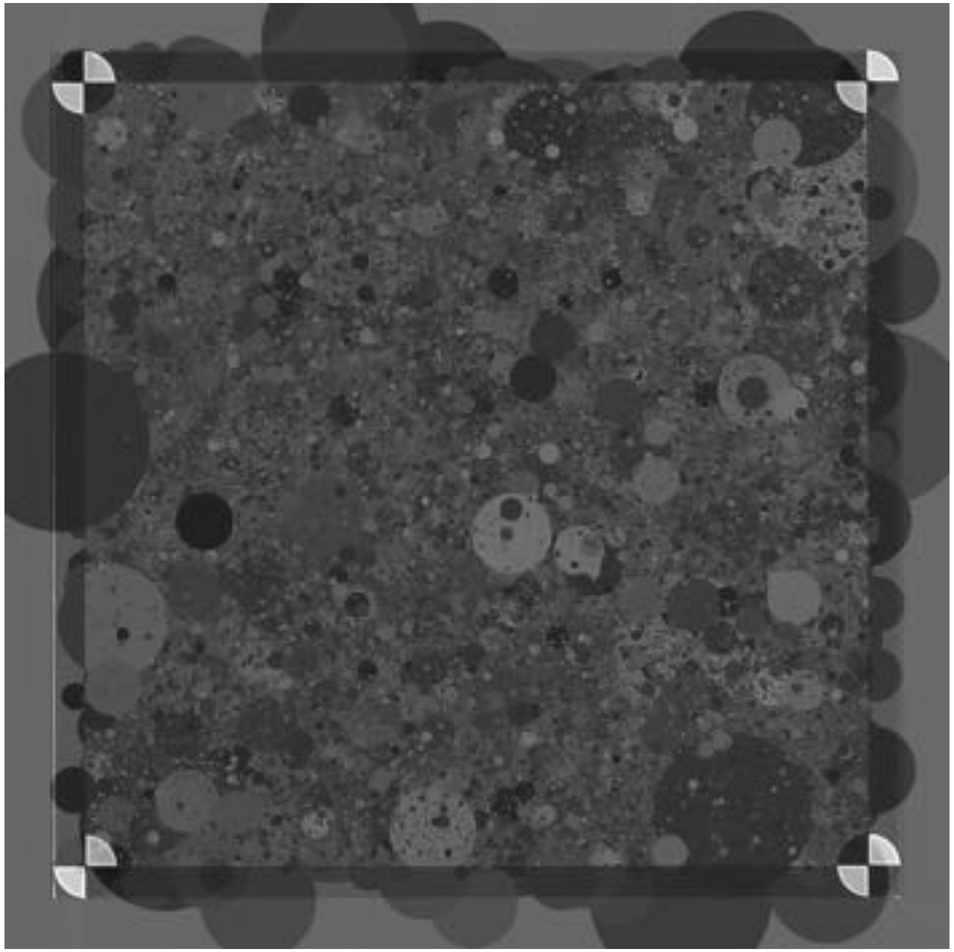
Spatial Matching

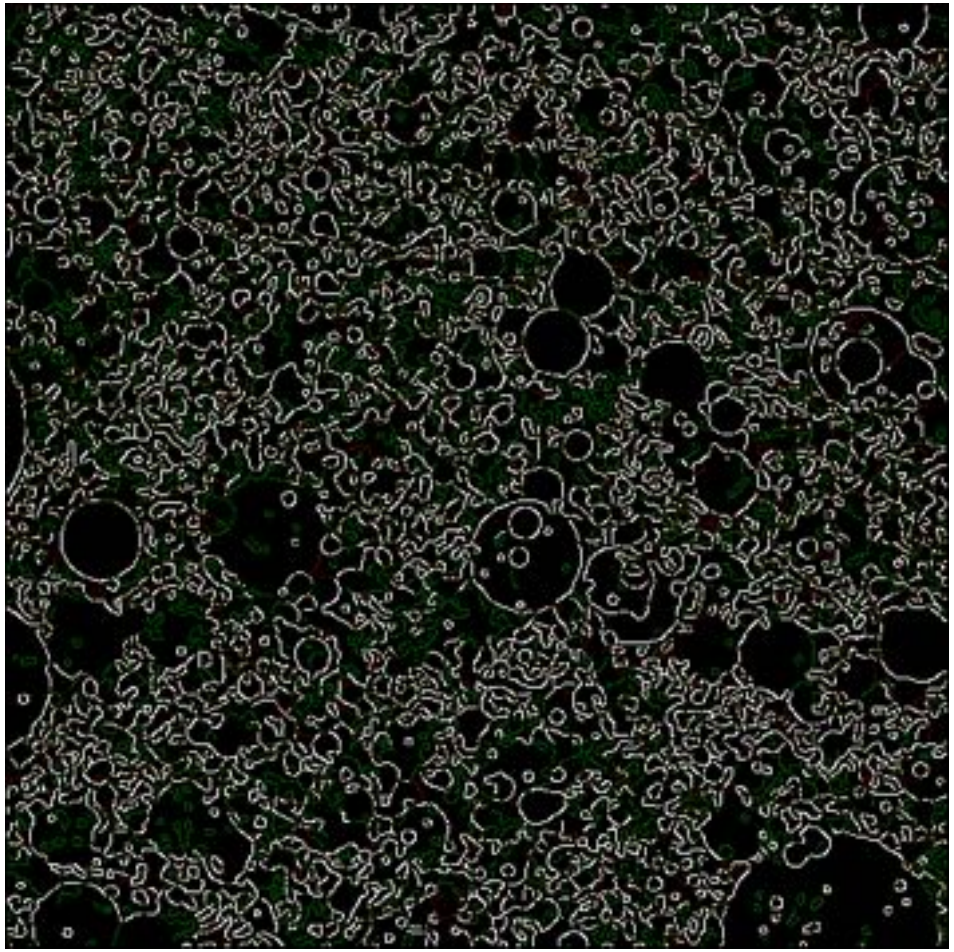


Let the pattern cover only a small part of the image to reduce the influence of distortion.

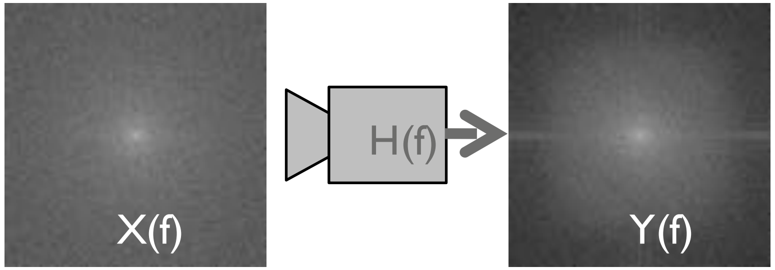
Create projection matrix from position of marker and apply to reference data.

Spatial Matching





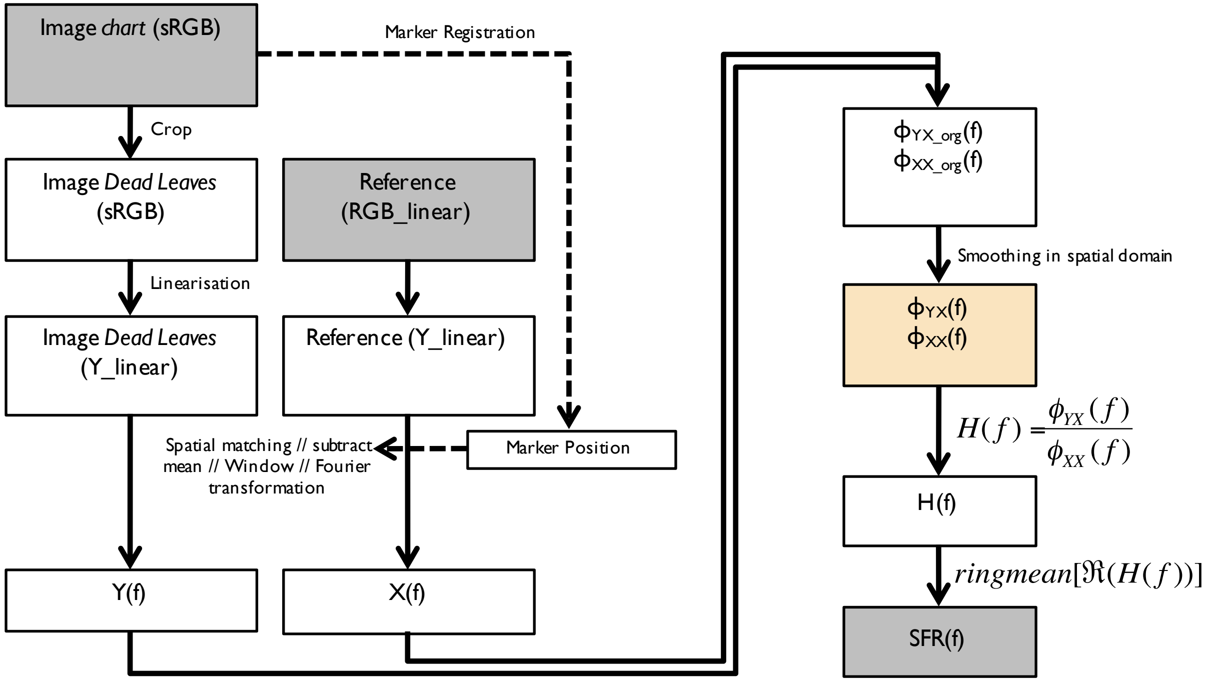
Dead Leaves _ cross



full transfer function available!

$$H(f) = \frac{\phi_{YX}(f)}{\phi_{XX}(f)}$$

$\varphi_{XX}(f)$: power spectrum of the input
$\varphi_{YX}(f)$: cross power spectrum of input and output



Based on the work of Image Engineering

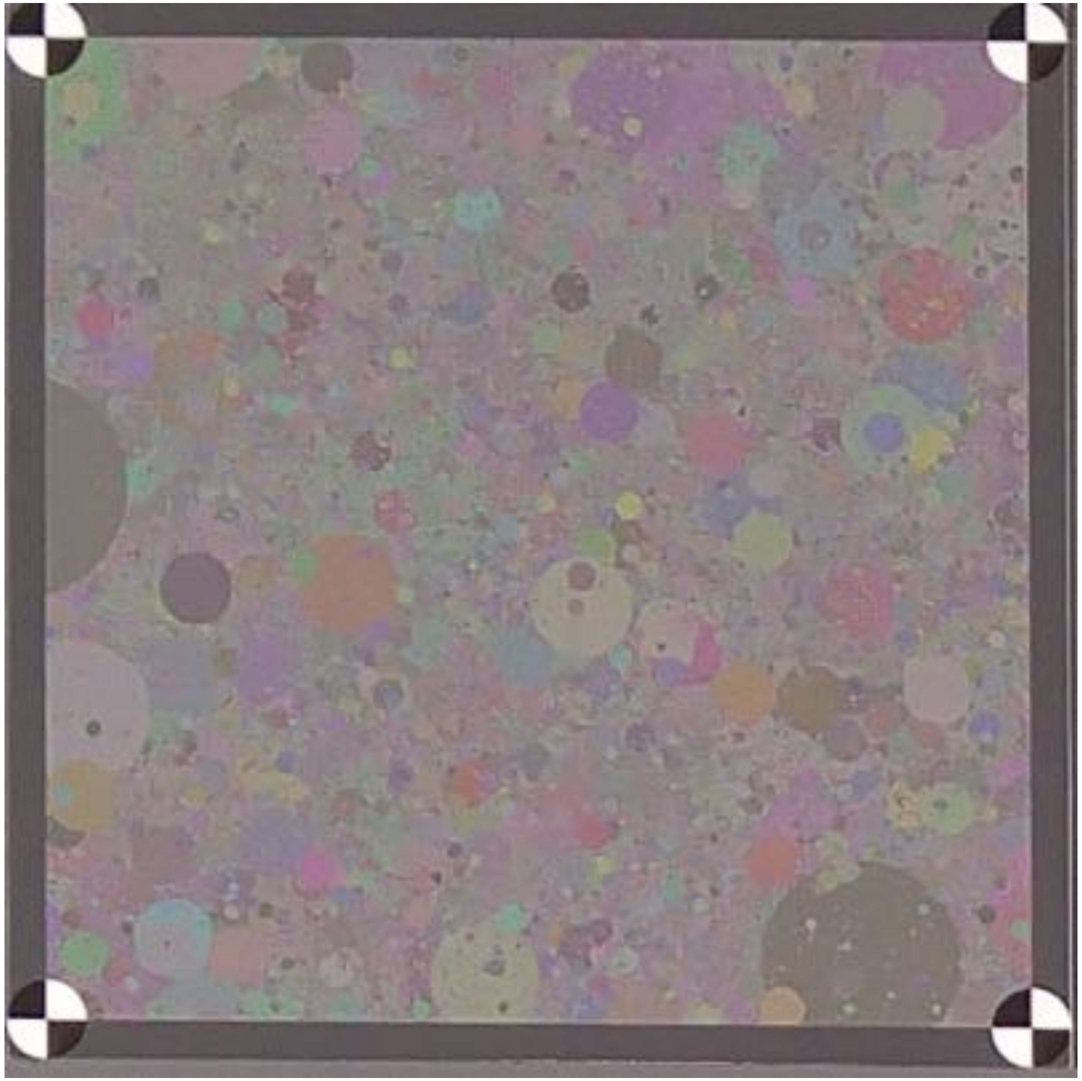
"Description of texture loss using the dead leaves target: current issues and a new intrinsic approach", Kirk, Herzer, Artmann, Kunz, Proc. SPIE 9023, Digital Photography X, 90230C (7 March 2014); doi: 10.1117/12.2039689

The only Dead Leaves approach that really describes the texture loss!

The latest approach (DeadLeaves_cross)

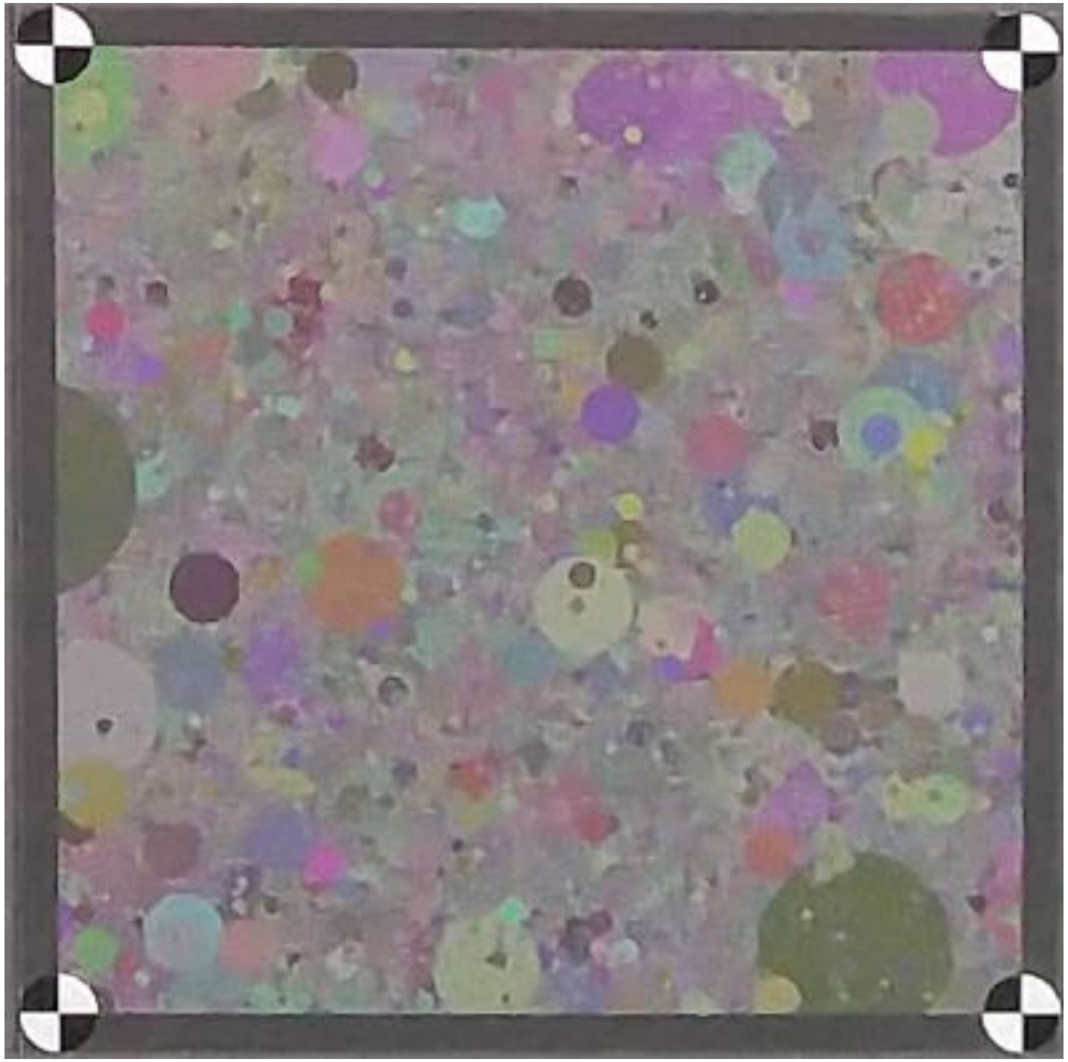
“-4EV” – low contrast

“bright” – low contrast

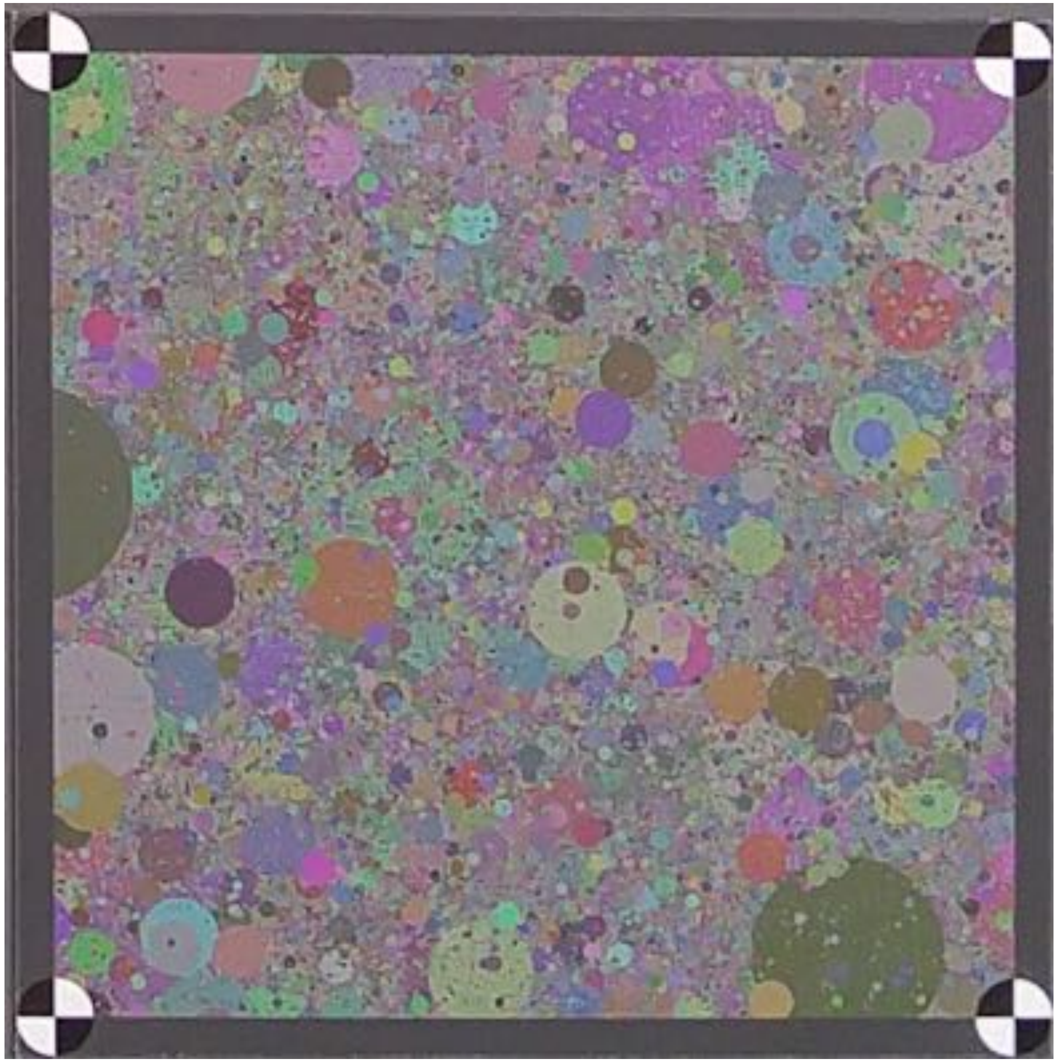


The latest approach (DeadLeaves_cross)

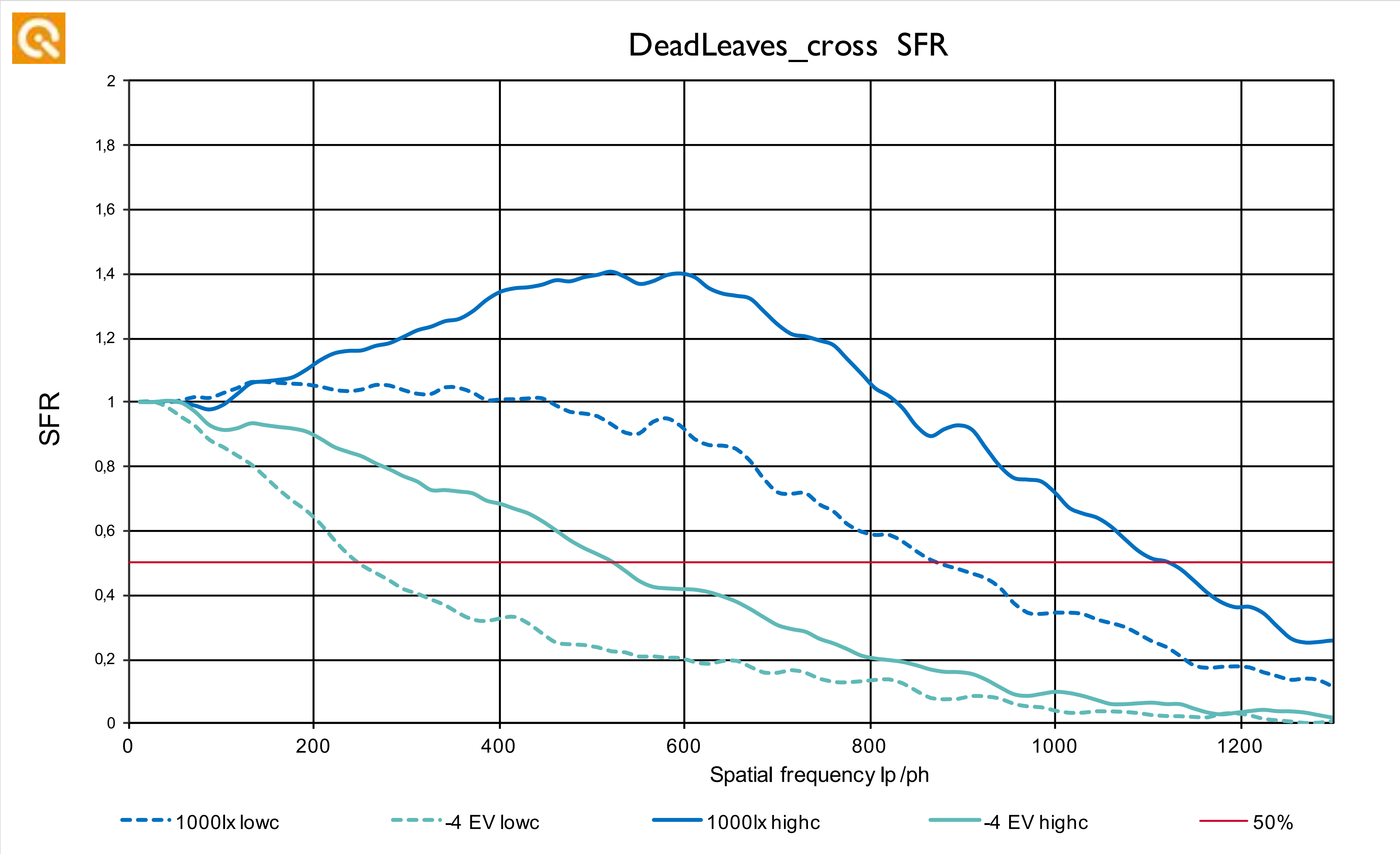
"-4EV" – high contrast



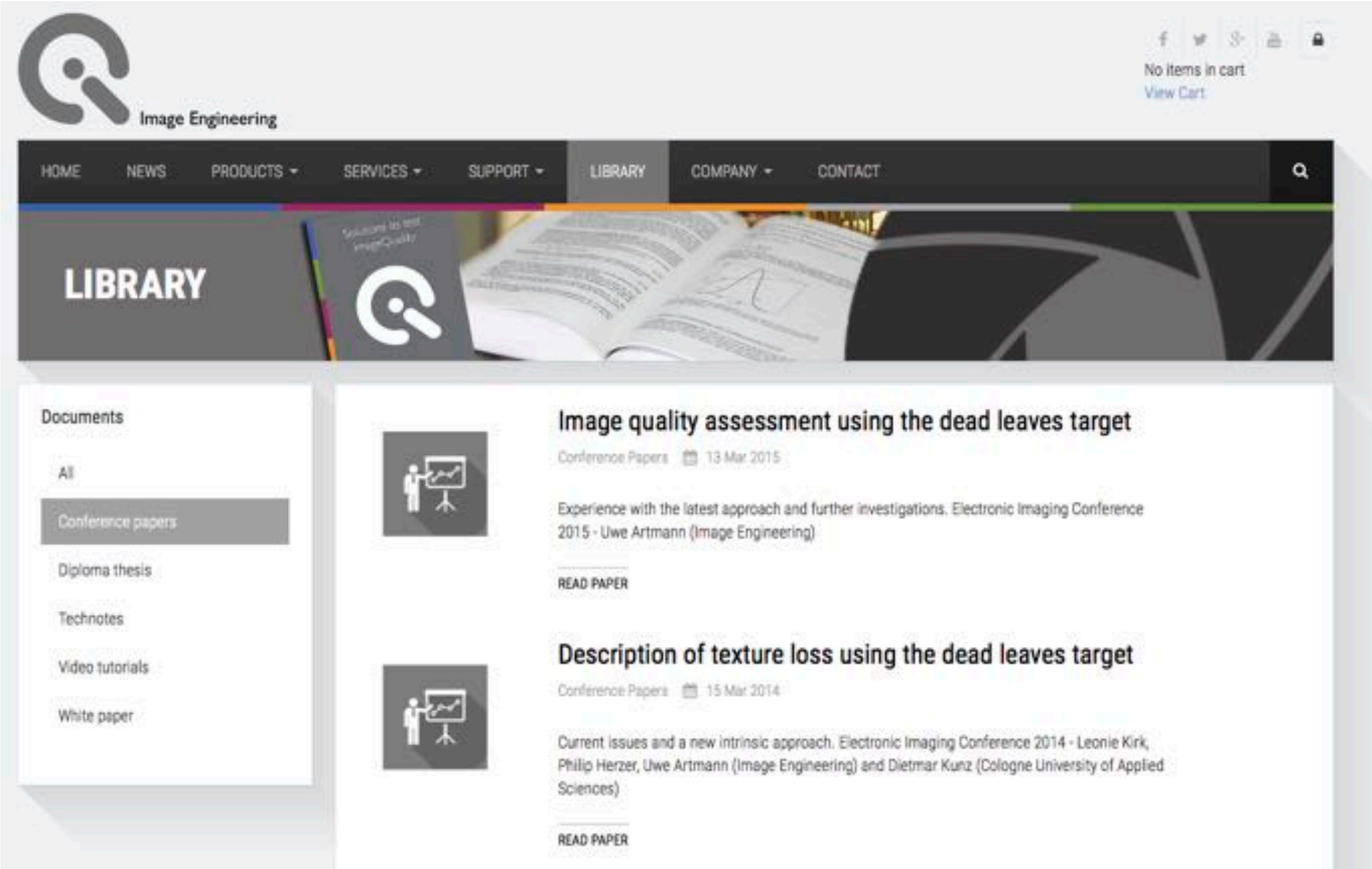
"bright" – high contrast



The latest approach (DeadLeaves_cross)

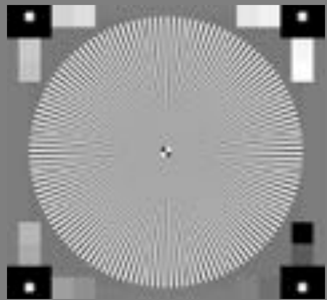


Download



http://www.image-engineering.de/library/conference-papers

Comparison

	Sinusoidal Siemens star 	Slanted edge 	Dead Leaves 
Advantages	• Reliable measurement of limiting resolution • Robust • Visual interpretation	• Fast • Easy way to measure sharpening	• Random pattern triggers “Texture loss” • More “natural” than other structures
Utilization	Assessment of optical performance of devices	Assessment of signal processing of a device	Assessment of texture loss of a device

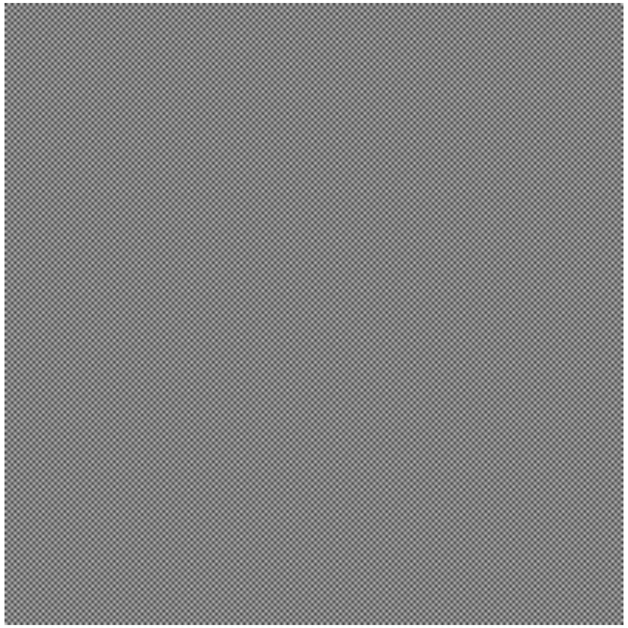
Visual Noise

Aus der allgmeinen Messtechnik übernommen, wurde das Rauschen lange als „Signal-Rauschabstand“ (SNR) angegeben. Das Problem: Dies korreliert nicht mit der Rauschwahrnehmung

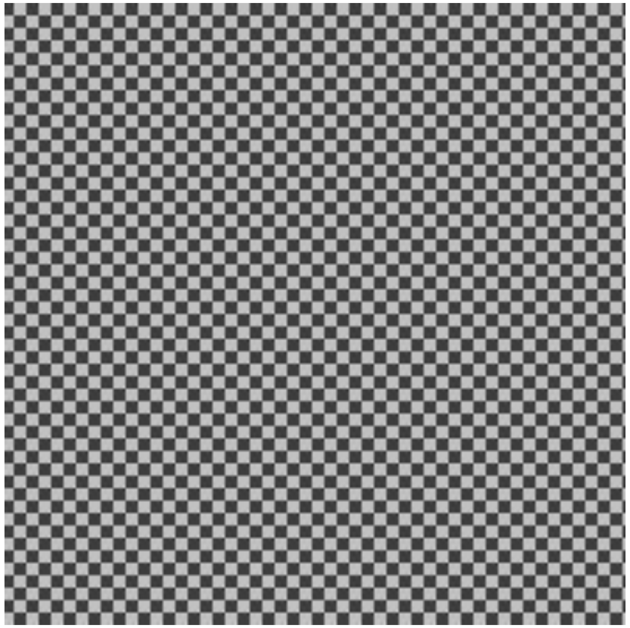
Unterschiedliche Rauschwahrnehmung – gleicher SNR

Visual Noise

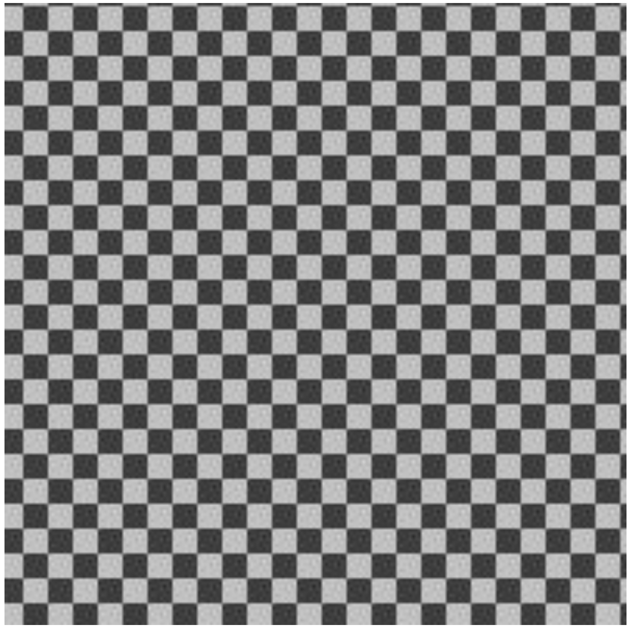
Aus der allgmeinen Messtechnik übernommen, wurde das Rauschen lange als „Signal-Rauschabstand“ (SNR) angegeben. Das Problem: Dies korreliert nicht mit der Rauschwahrnehmung



$\mu = 128$
$\sigma = 64$

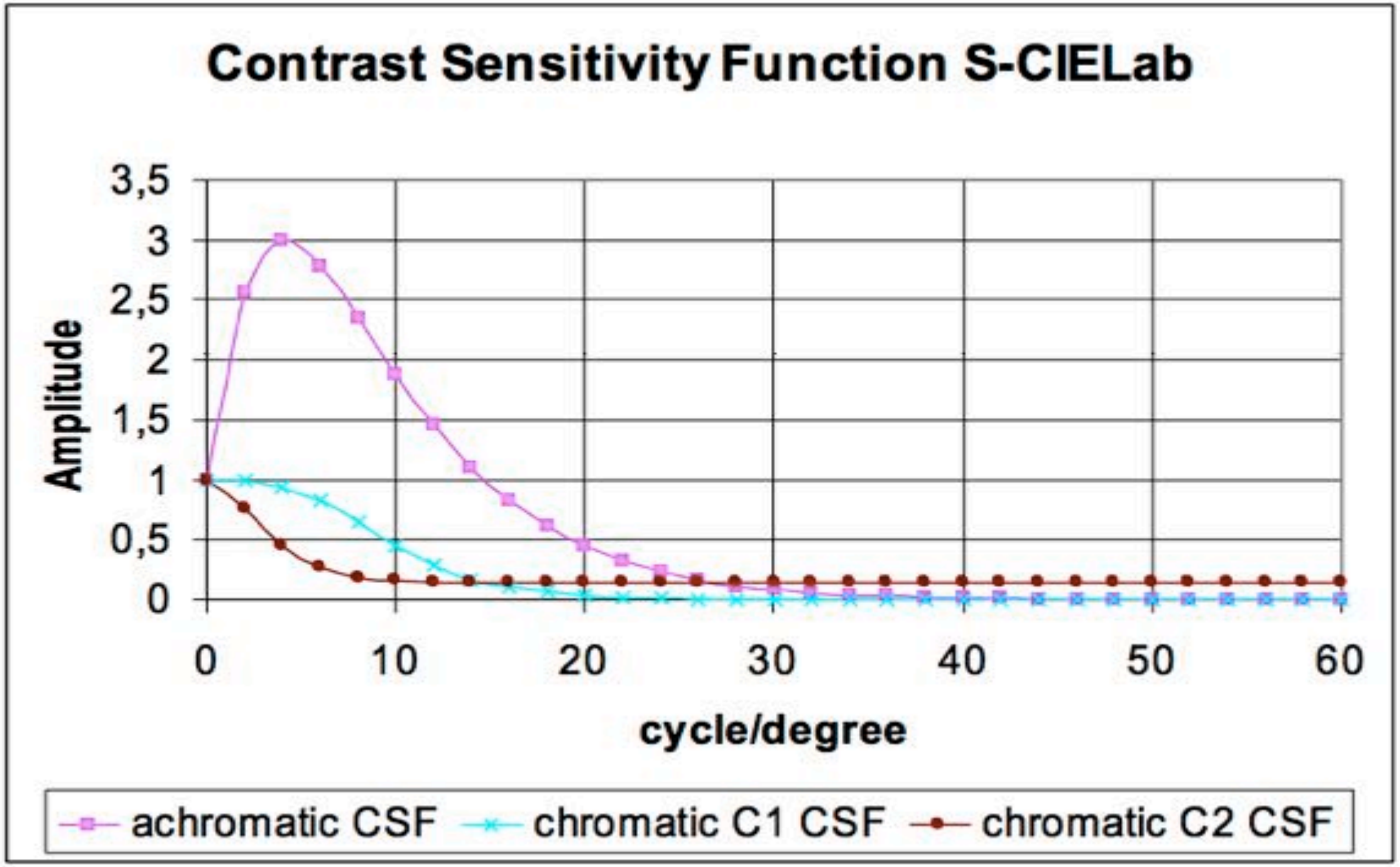


$\mu = 128$
$\sigma = 64$



$\mu = 128$
$\sigma = 64$

Unterschiedliche Rauschwahrnehmung – gleicher SNR

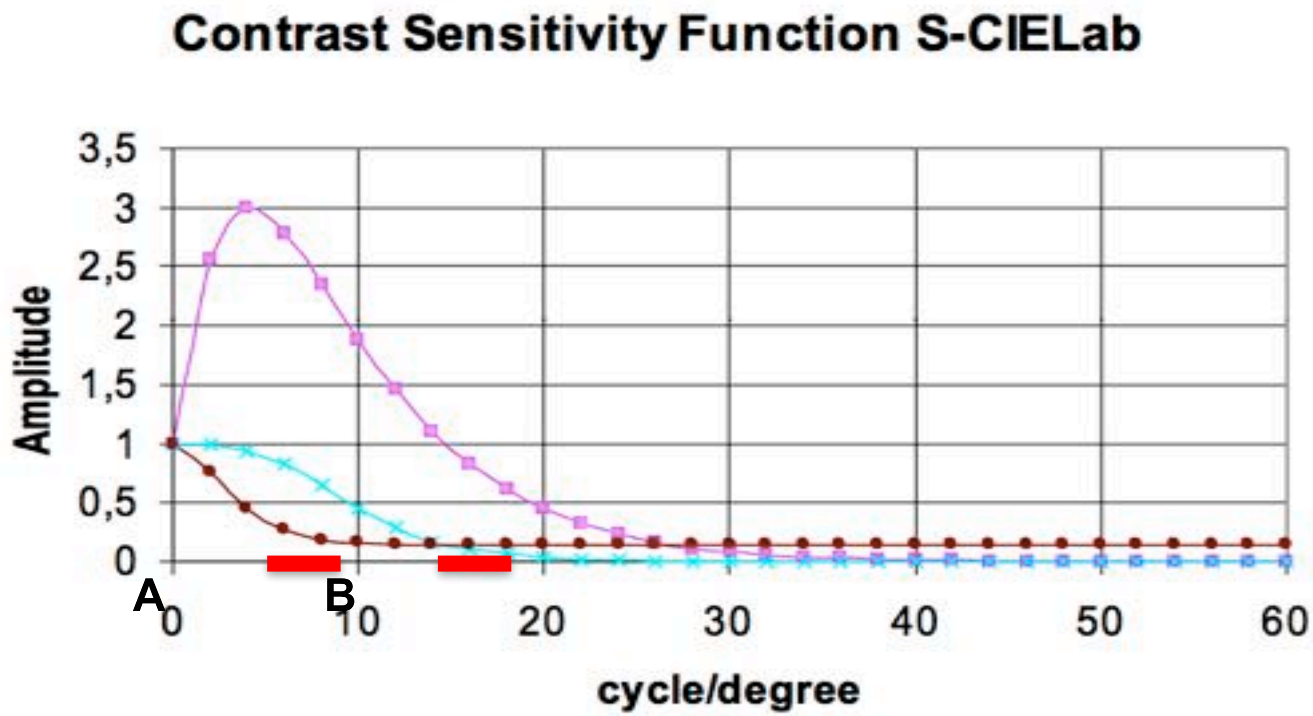


A C_1C_2 – opponent space – a color space based on analysis of color receptors of human eye and of processing the resulting color signals

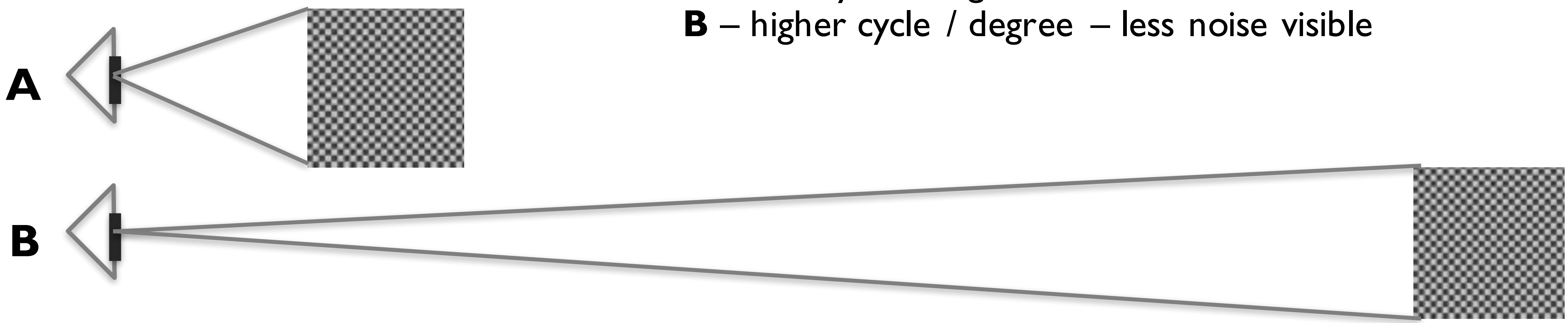
A	– achromatic information	– only intensity, no color
$C_{1\&2}$	– color information	– only color, no intensity

Visual Noise

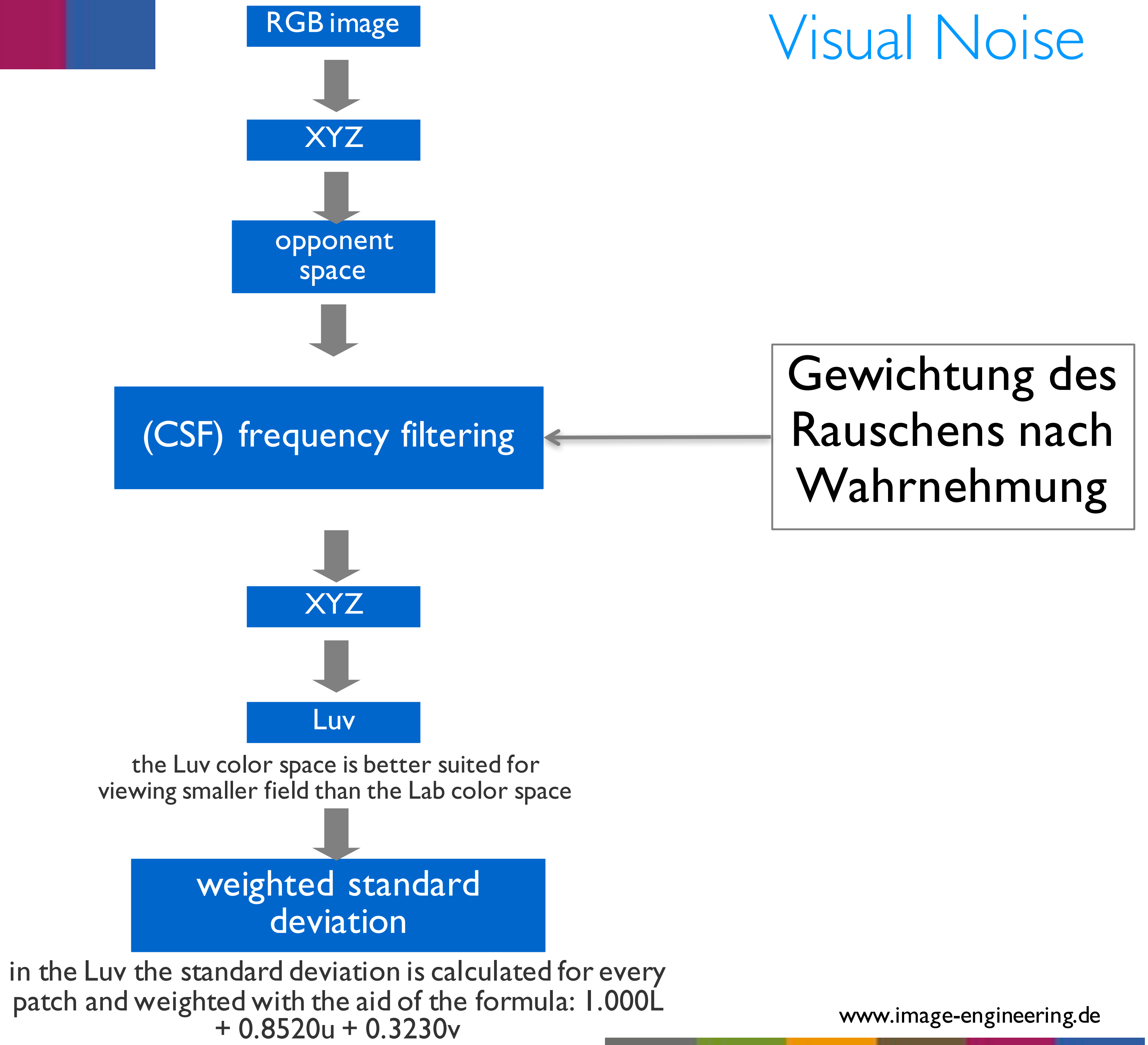
Die Rausch-wahrnehmung hängt von der Betrachtungs-bedingung ab !



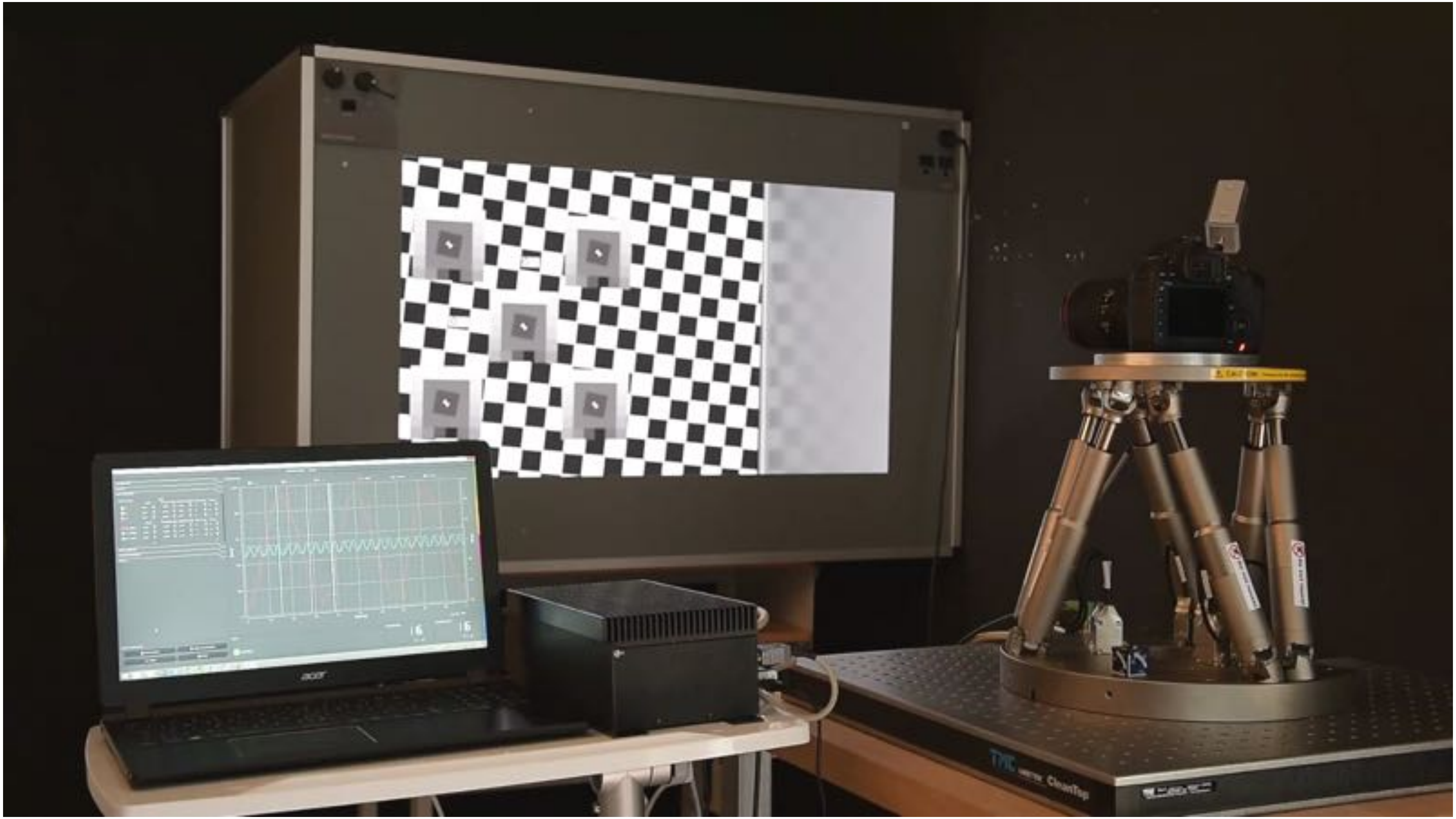
A – low cycle / degree – more noise visible
B – higher cycle / degree – less noise visible



Visual Noise

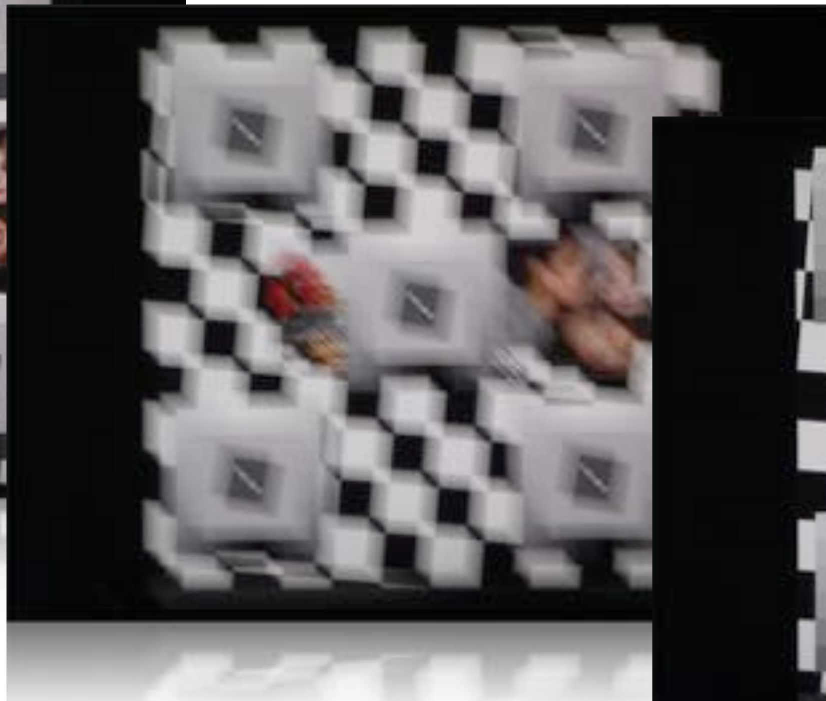


Optische Bildstabilisierung



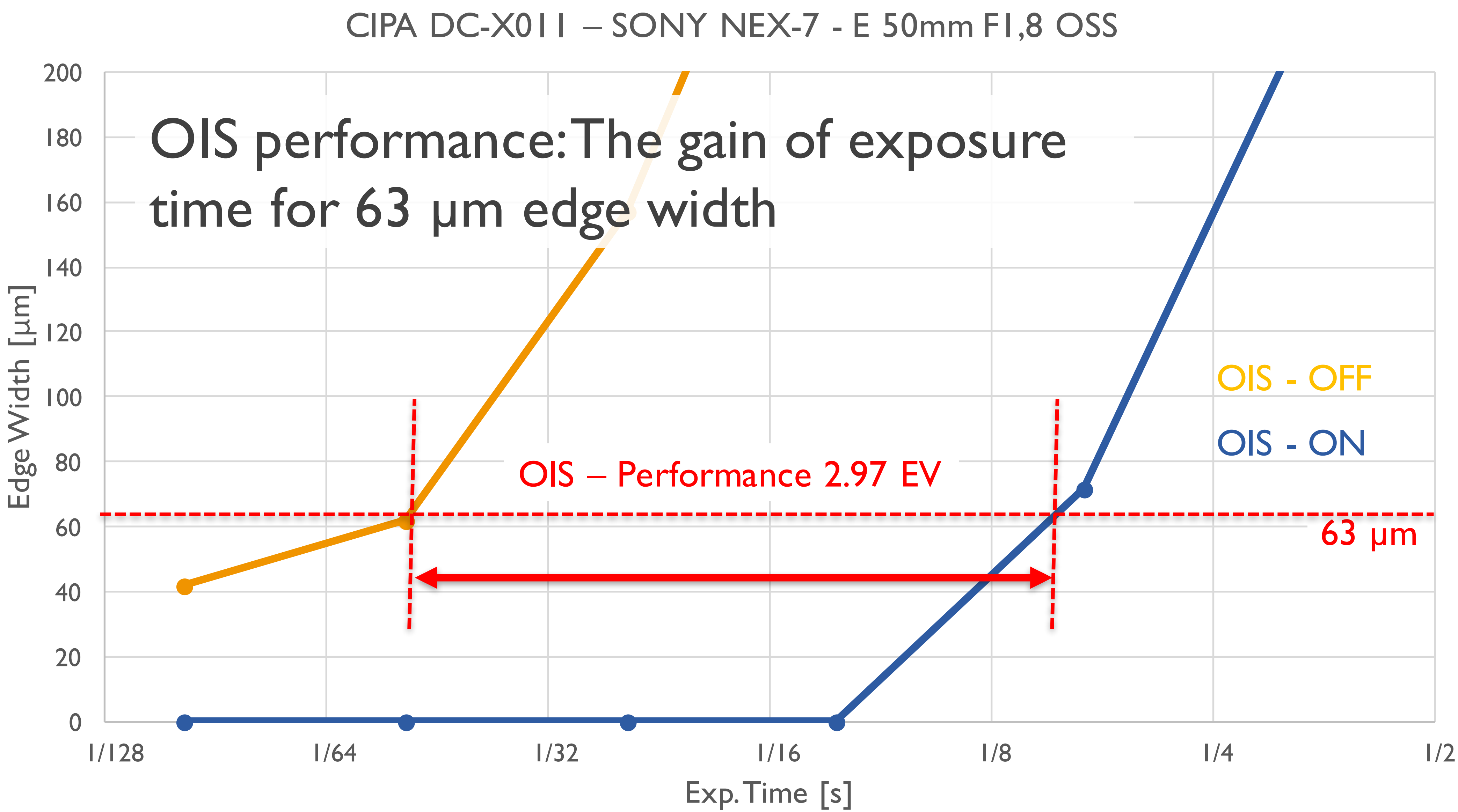
Optische Bildstabilisierung

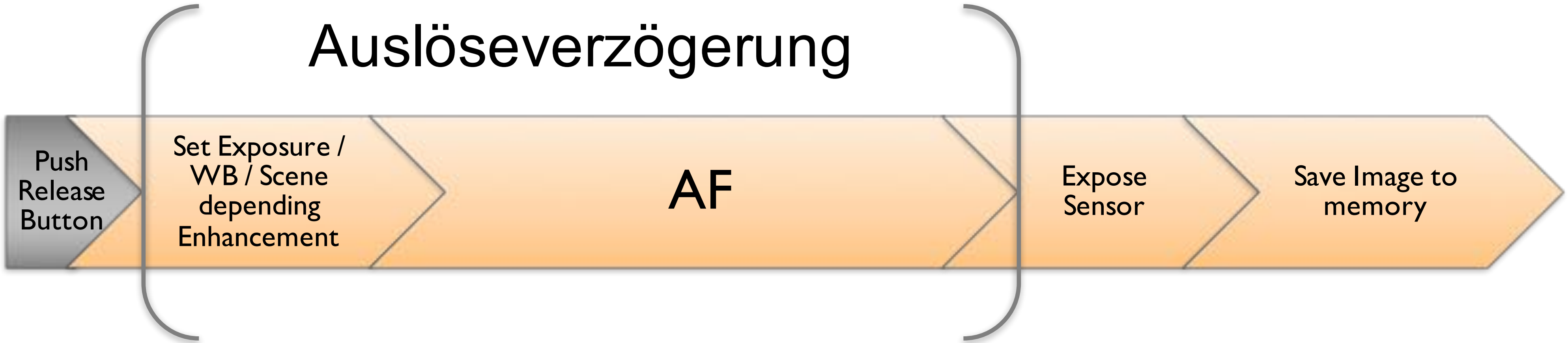
STEVE OFF
image stabilization OFF



STEVE ON
image stabilization OFF

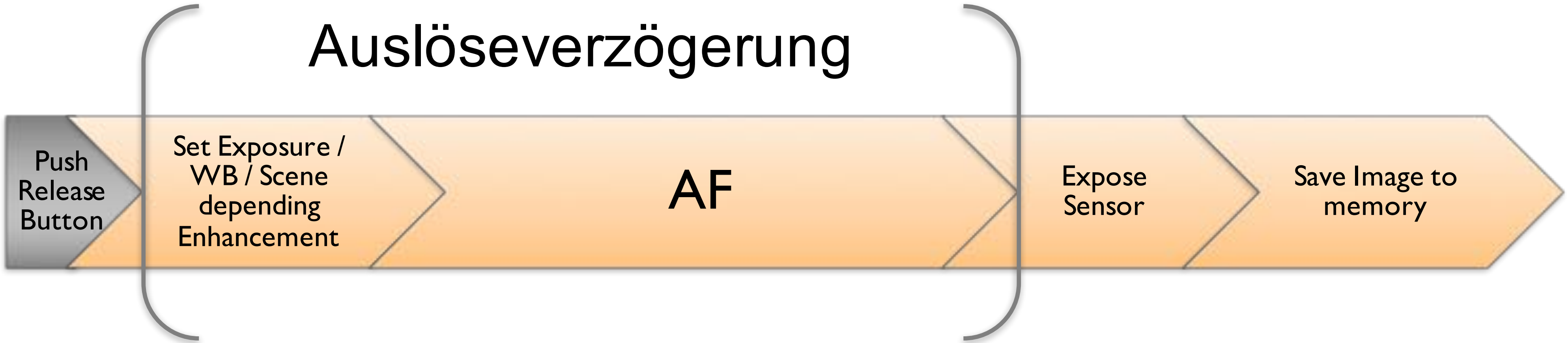
STEVE ON
image stabilization ON


CIPA DC-X011 – SONY NEX-7 - E 50mm F1,8 OSS
OIS performance: The gain of exposure time for 63 µm edge width
Edge Width [µm]
200
180
160
140
120
100
80
60
40
20
0
1/128
1/64
1/32
1/16
1/8
1/4
1/2
Exp. Time [s]
OIS - OFF
OIS - ON
OIS – Performance 2.97 EV
63 µm



Definition: Die Zeit die zwischen dem Druck auf den Auslöser und dem beginn der Belichtung.

Auslöseverzögerung



Definition: Die Zeit die zwischen dem Druck auf den Auslöser und dem beginn der Belichtung.

Time Measurement - Method

ISO15781 - Zeitenmessung

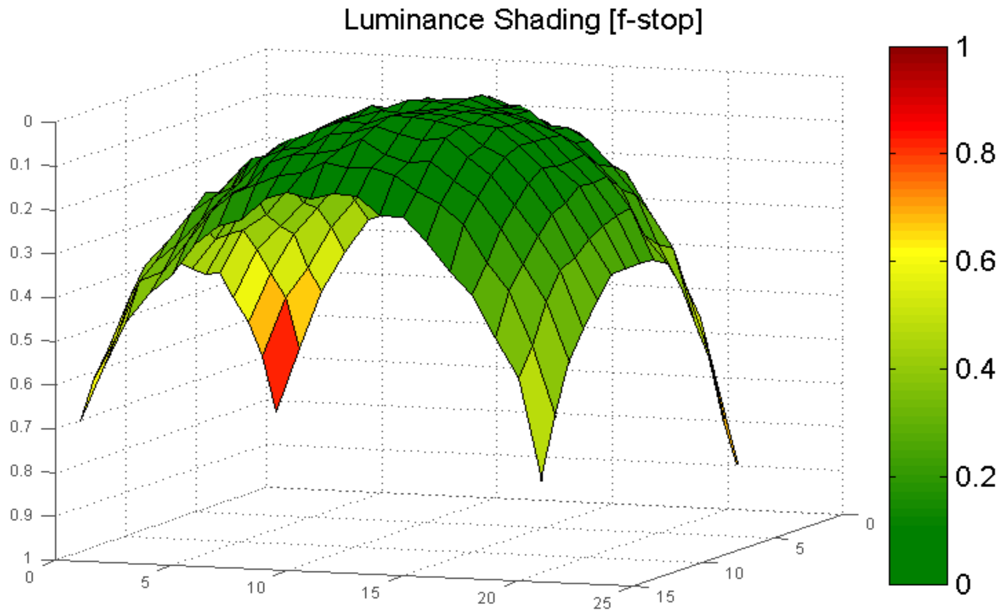
Vignettierung

Vignettierung

Vignettierung führt zu einem Randlichtabfall – die Bildecken sind dunkler als die Bidmitte.

Ein Problem so alt wie die Fotografie.

Vignettierung



Yi_CAL3.jpg

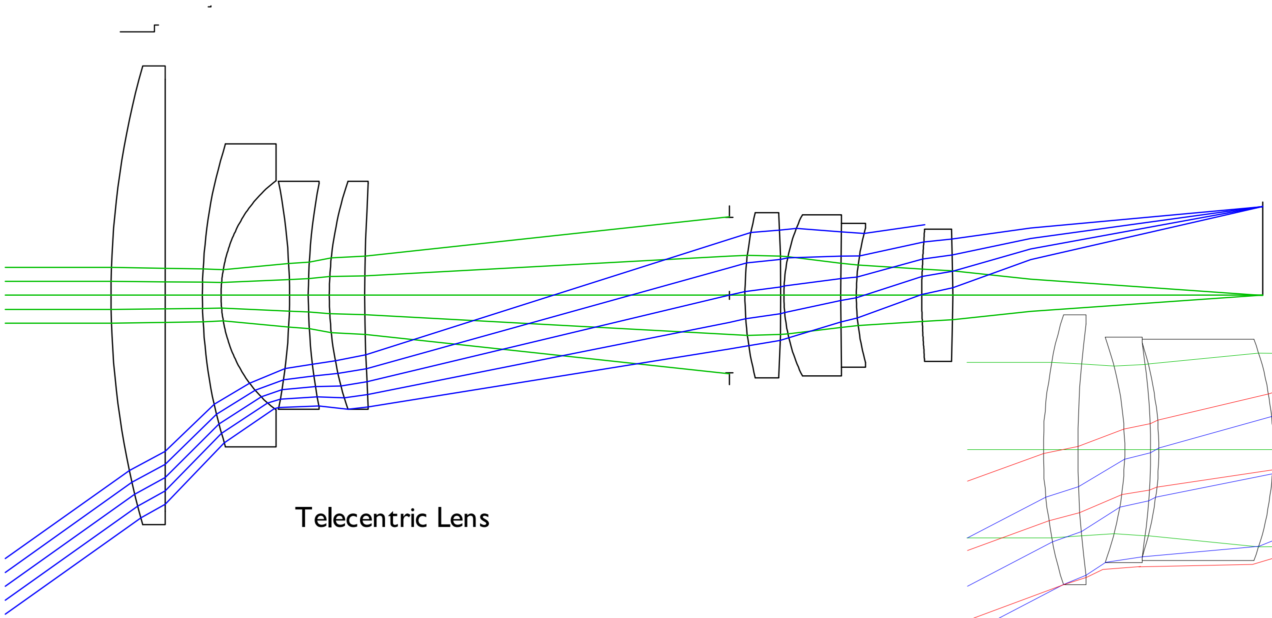
Make	XIAOYI
Model	YDXJ1
Width	4608
Height	3456
Time	480
F-Stop	2.8
ISO	171
f[mm]	2.7
EV	0.000
Serial:	
Lens:	
Firmware:	Ver.1.0.000
Illumination [lux]:	
Object Distance [m]	
Laboratory:	
Operator:	

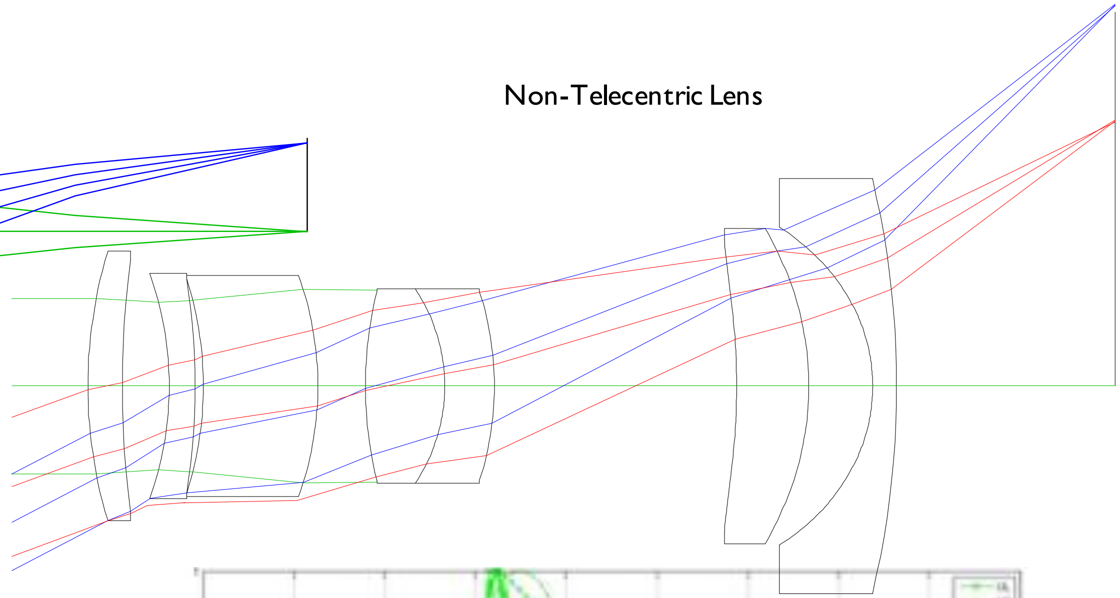
Luminance	
Shading[f-stop]	0.9
Shading[%]	24.7
dL	13.6
percentilesY[DV]	-22.2/-1.2/-0.3/0.1
percentilesY[f-stop]	-0.54/-0.03/-0.01/0.00
Color	
dEab	9.8
dC	8.8
dG-R[DV]	27.4
dG-B[DV]	9.1
R/G&B/G	1.04/0.83
Noise	
dSNR[dB]	9.1
dVNSet1	2.0
dVNSet2	1.7
dVNSet3	1.8

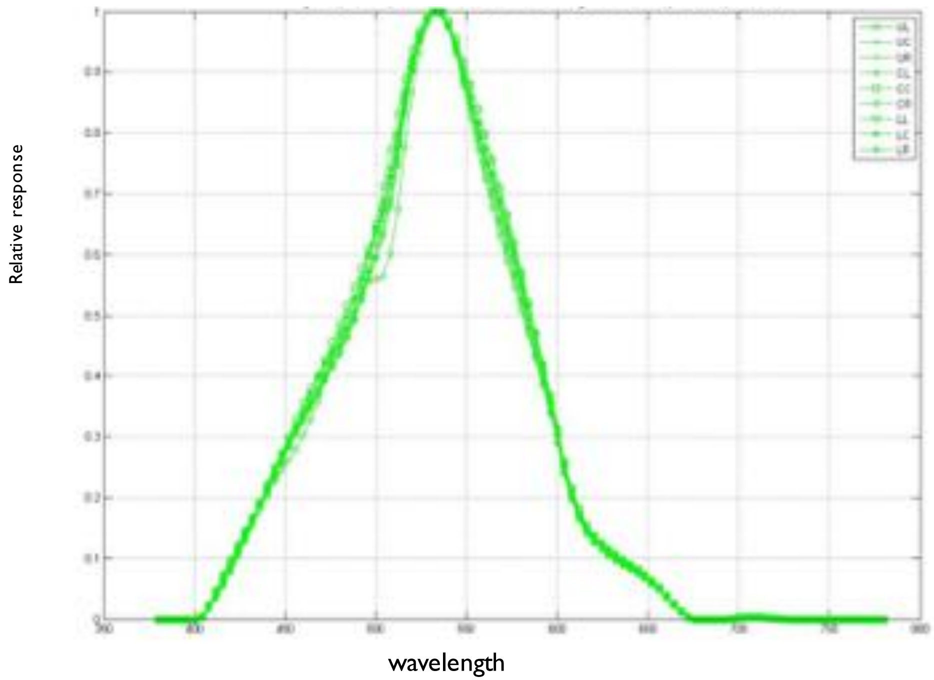
iQ-ANALYZER

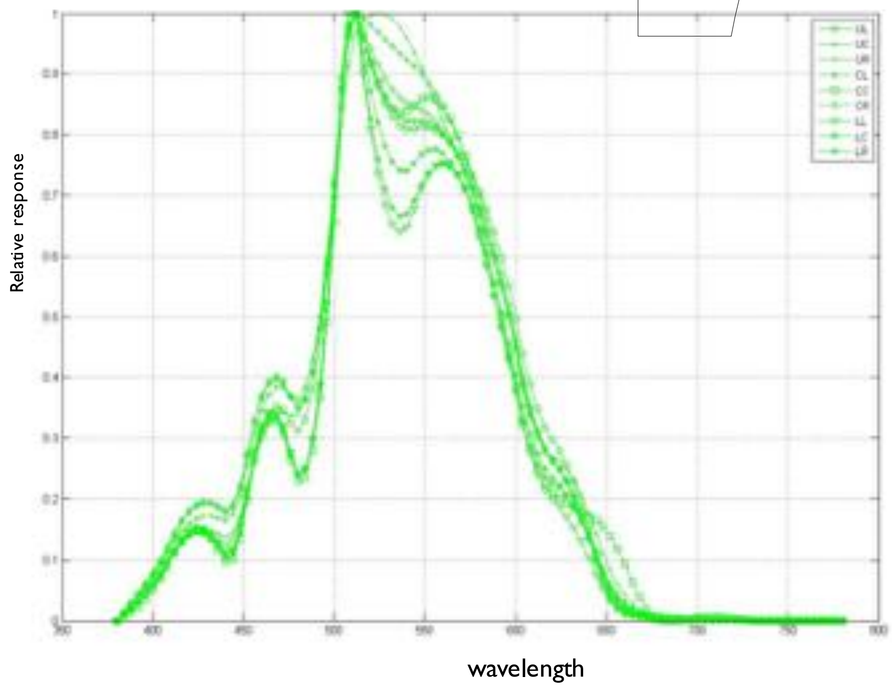
Color Shading

Color Shading

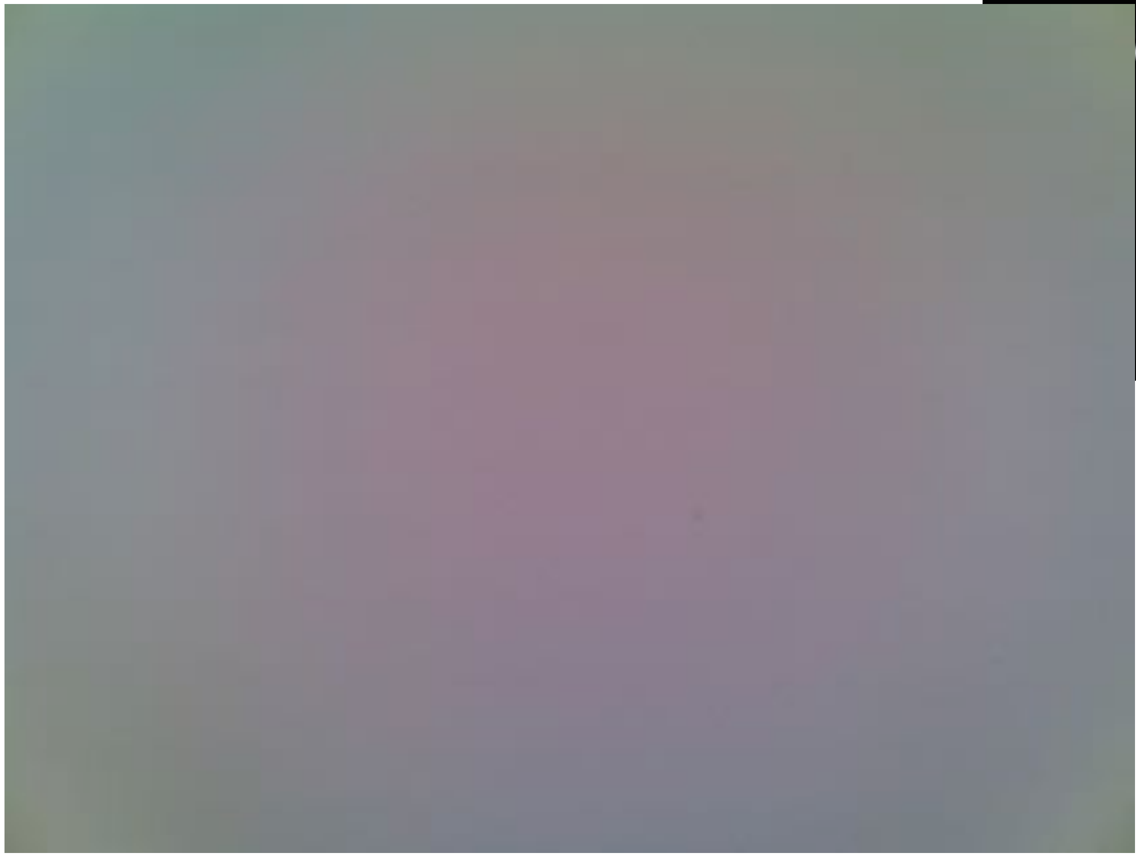








Color Shading



Color-Shading wird auf einer homogenen und spektral gleichmäßgen Fläche gemessen.

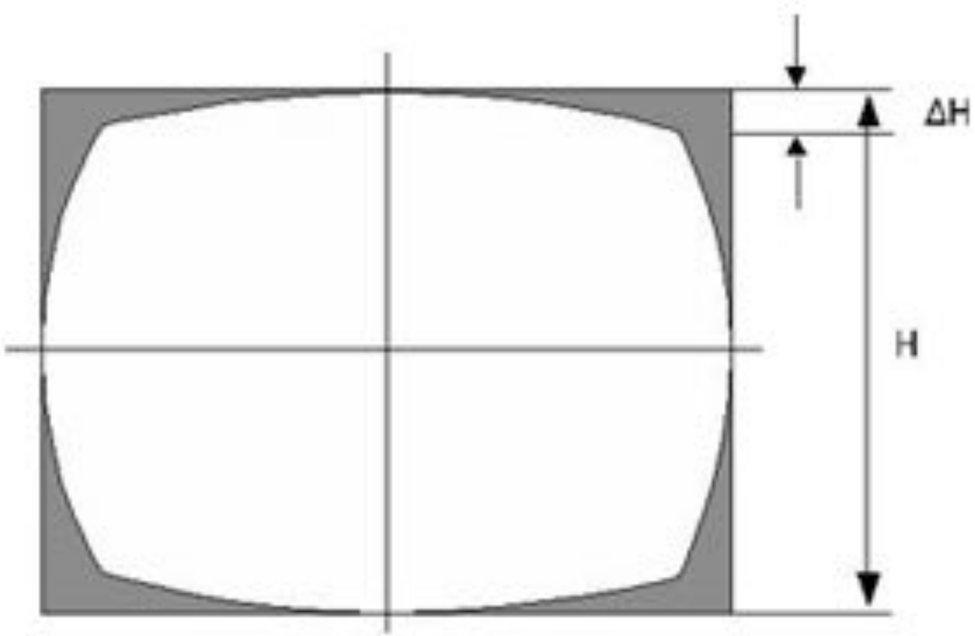
Die Angabe erfolgt üblicherweise in ΔE_{ab}

Bei klassischen Objektiven gibt es zwei Arten von Verzeichnung

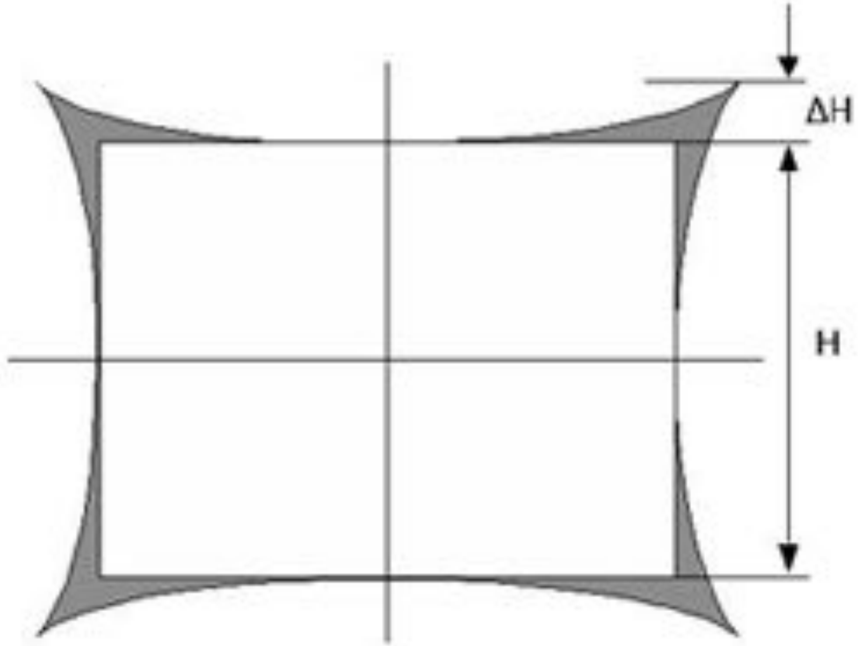
Kissen-Verzeichnung

Tonnen-Verzeichnung

$$D_{TV}[\%] = \frac{\Delta H}{H} \cdot 100$$



picture height distortion
with barrel shape (negative)



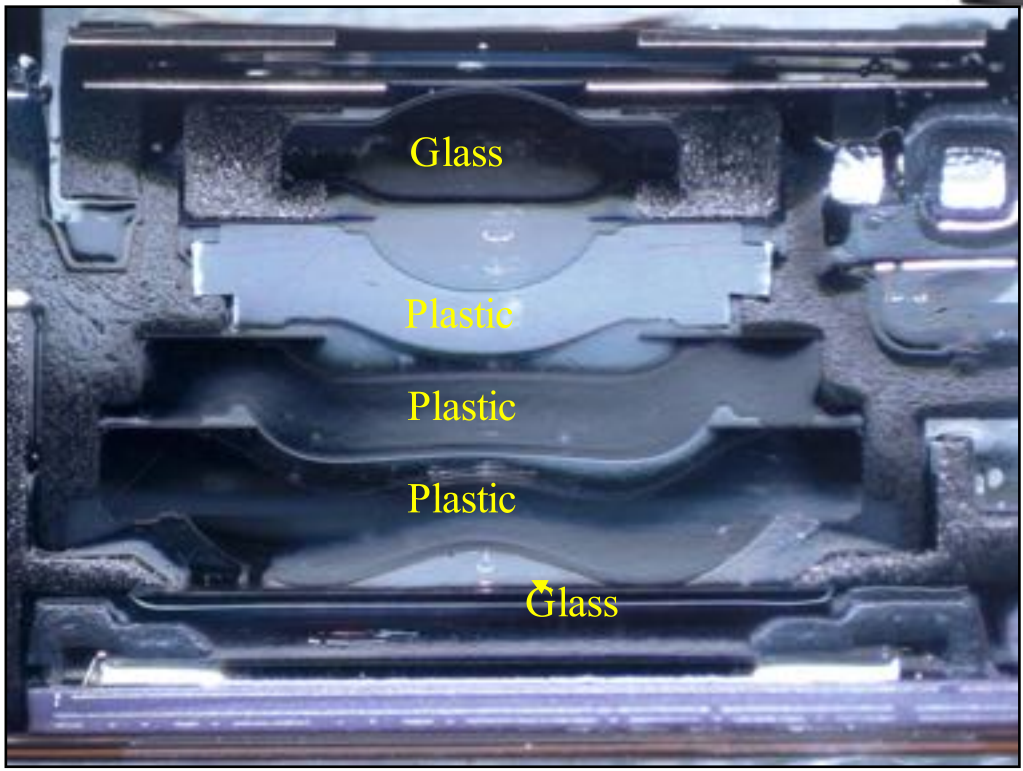
picture height distortion
with pincushion shape (positive)

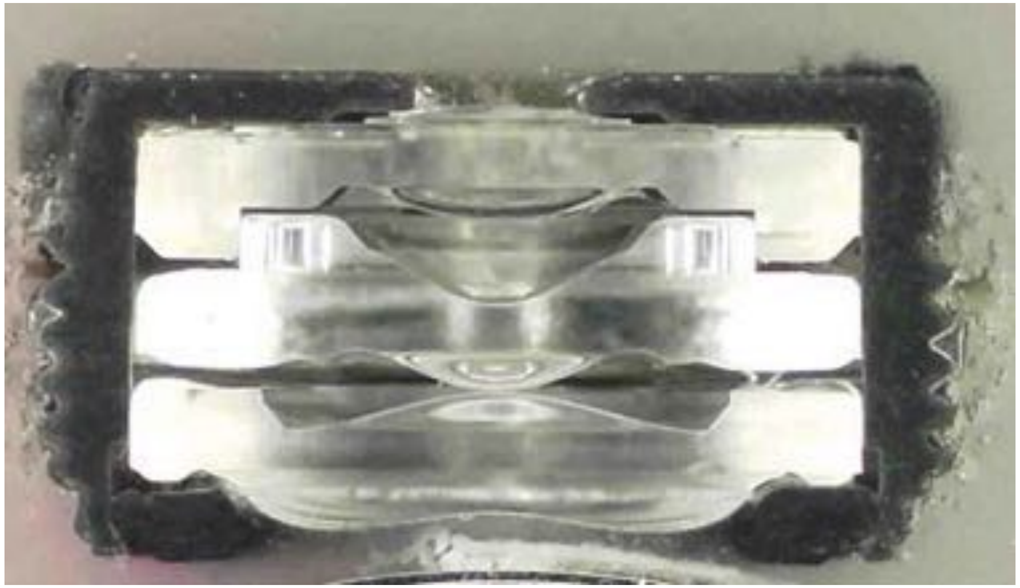
maximum picture height

minimum picture height

Verzeichnung

Leica Summilux 35mm f1.4

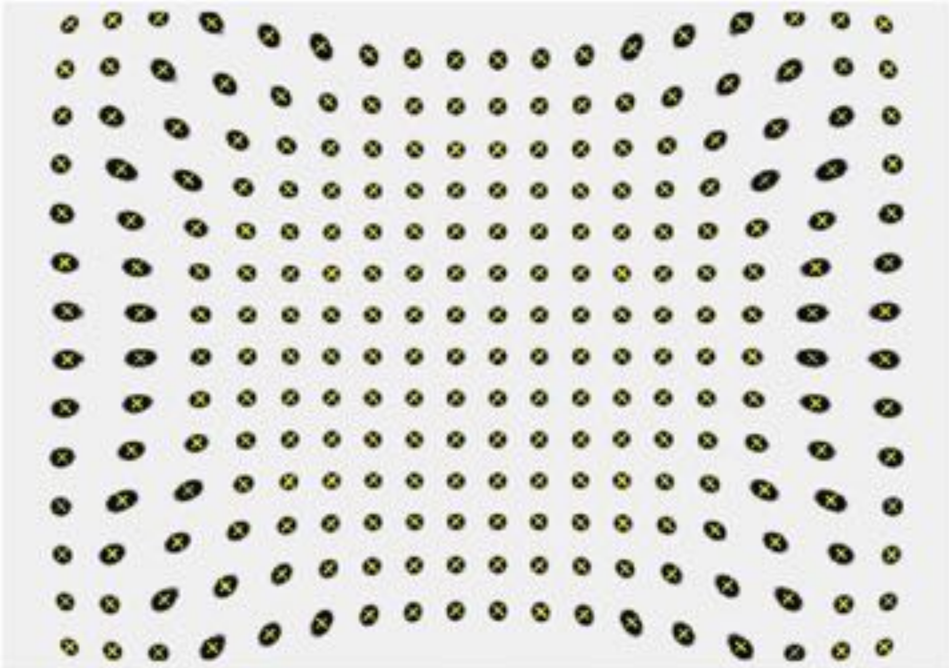




Mobiltelefon

Moderne Optiken in Mobiltelefone kennen Zwischenformen

Mischform – “Wave Distortion” oder “Moustache Distortion”



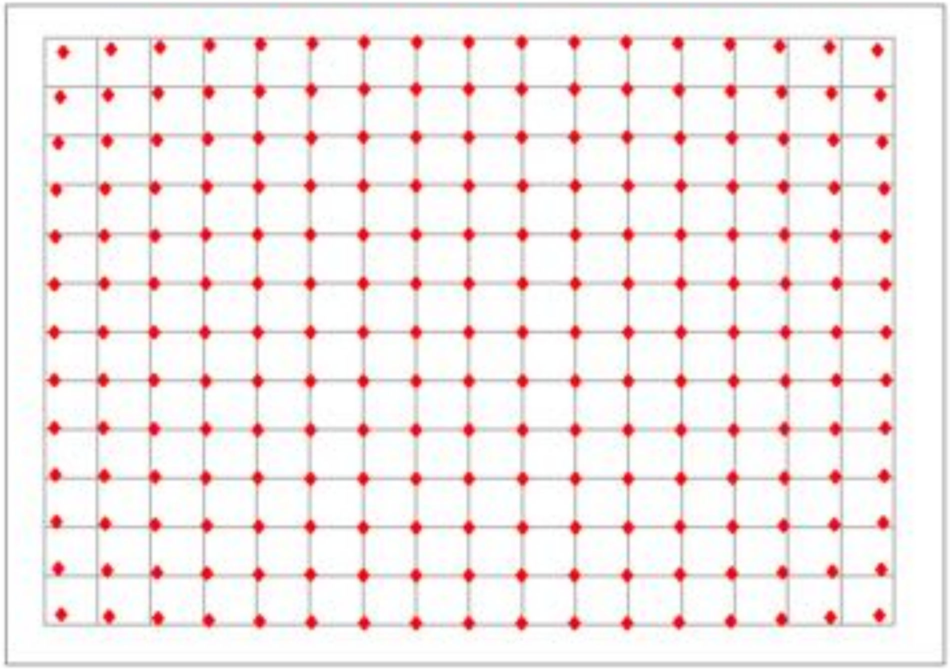
example for wave distortion

Local Geometric Distortion

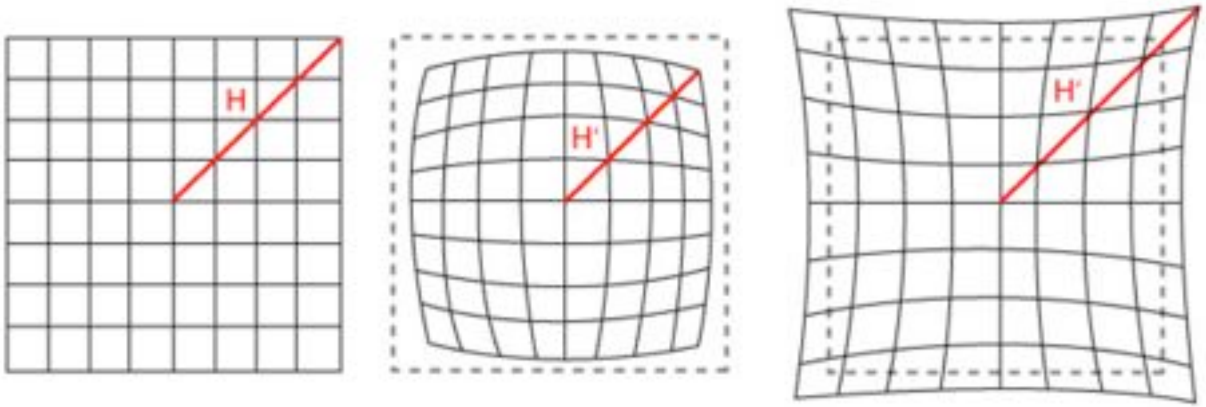
1. Detection von Kreuzen im Bild /Subpixel

2. Berechnung des idealen Gitter

3. Berechnung der Differnz von idealer Position zu realer Position für alle Kreuze



$$D[\%] = \frac{(H' - H)}{H} \cdot 100$$



Local Geometric Distortion

1. Detektion von Kreuzen im Bild /Subpixel

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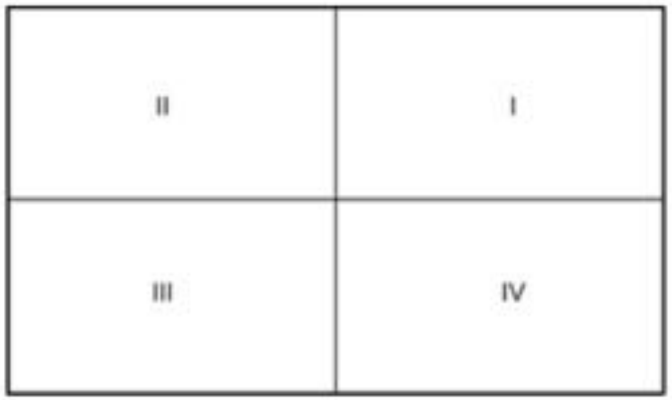
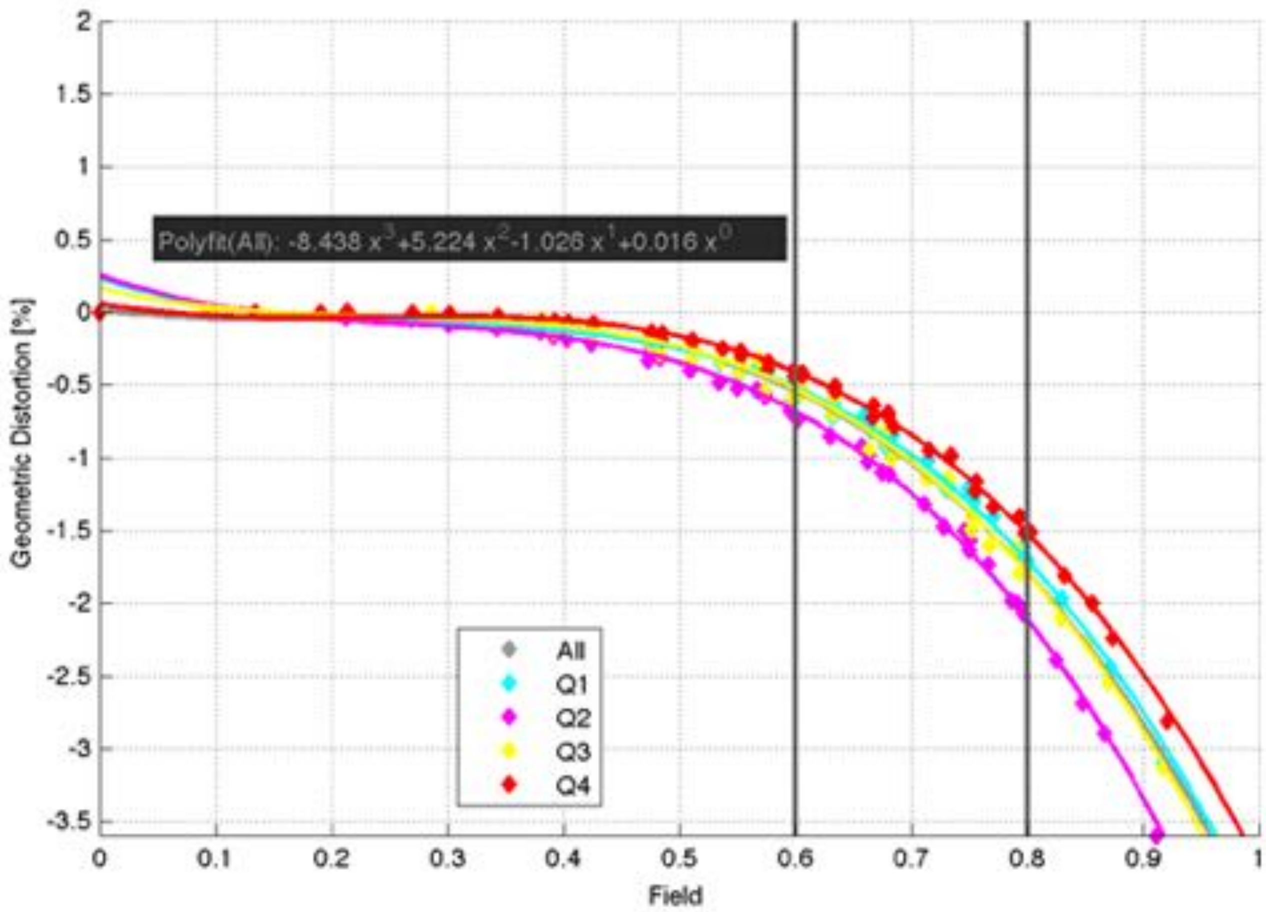
3. Berechnung der Differnz von idealer Position zu realer Position für alle Kreuze



• the four quadrants (Q1, Q2, Q3, Q4)



Was ist ein guter Weißabgleich ?

Was ist ein guter Weißabgleich ?

Paralaxe / Anschlussproblem bei Multi-Kamerasystemen

360° Kameras

Farbübergänge bei Multi-Kamerasystemen

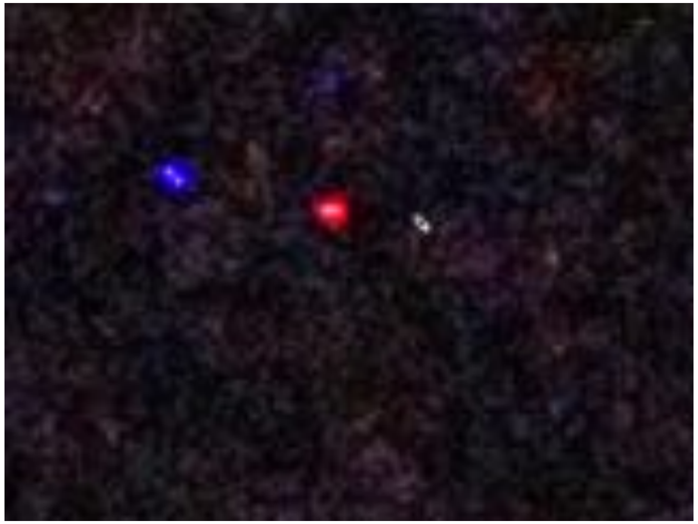
- Kameras werden besser – Messverfahren müssen mithalten

- Neue Technologien erfordern neue Messverfahren

- **Was der Kunde nicht weiß… Den Finger in die Wunde legen**

JPEG

Detailvergrößerung Schwarzbild



Langzeit ohne NR

Langzeit mit NR

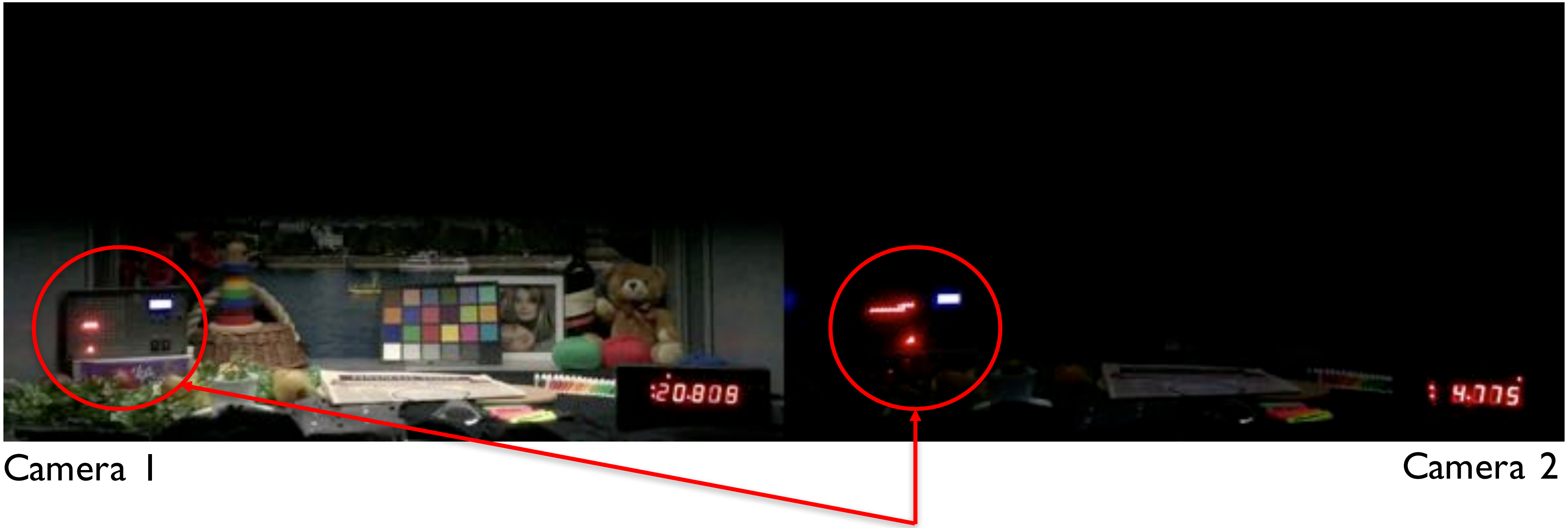
Langzeit mit NR (abgebrochen)



RAW

Video Framerate

lightSTUDIO – Testszene mit anpassbaren Lichtbedingungen



Camera 1

Camera 2

Es werden immer 30 Bilder/s in die Datei geschrieben…