



Hochschule RheinMain
University of Applied Sciences
Wiesbaden Rüsselsheim Geisenheim

02/18/2011

Measurement of the Ghosting Performance of Stereo 3D systems for Digital Cinema and 3DTV

HPA Retreat 2011
Wolfgang Ruppel



Hochschule RheinMain
University of Applied Sciences
Wiesbaden Rüsselsheim Geisenheim

01 GHOSTING BASICS



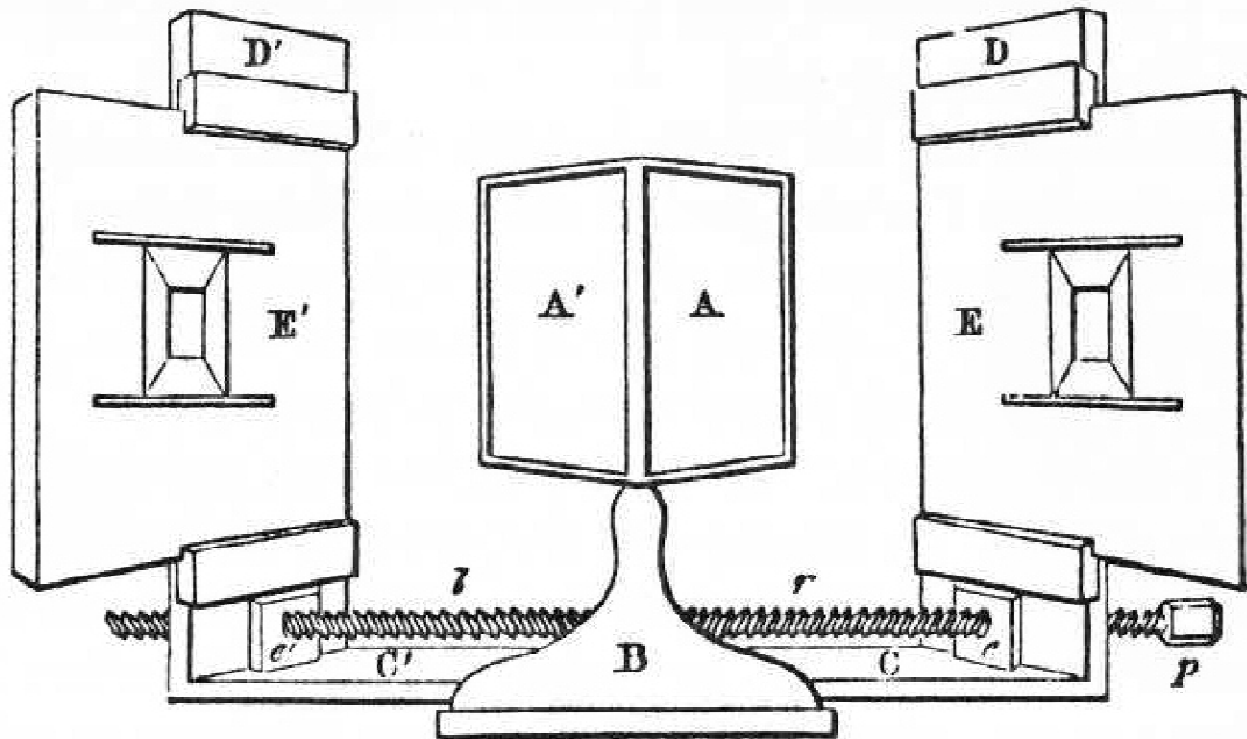
GHOSTING BASICS

- The term „Ghosting“ stands for the perception of leakage (or crosstalk) from the Left Eye to the Right Eye channel in stereoscopic presentation
- Ghosting occurs due to imperfect separation of the images being displayed for left and right eye.
- Ghosting is one of the reasons causing discomfort when watching Stereo 3D
- Ghosting impacts Stereoscopic perception
- Goal: Define metrics and quantify ghosting (this talk)
- Ongoing: Explain reasons and fight ghosting

A GHOSTING-FREE STEREOSCOPIC DISPLAY



Hochschule RheinMain
University of Applied Sciences
Wiesbaden Rüsselsheim Geisenheim

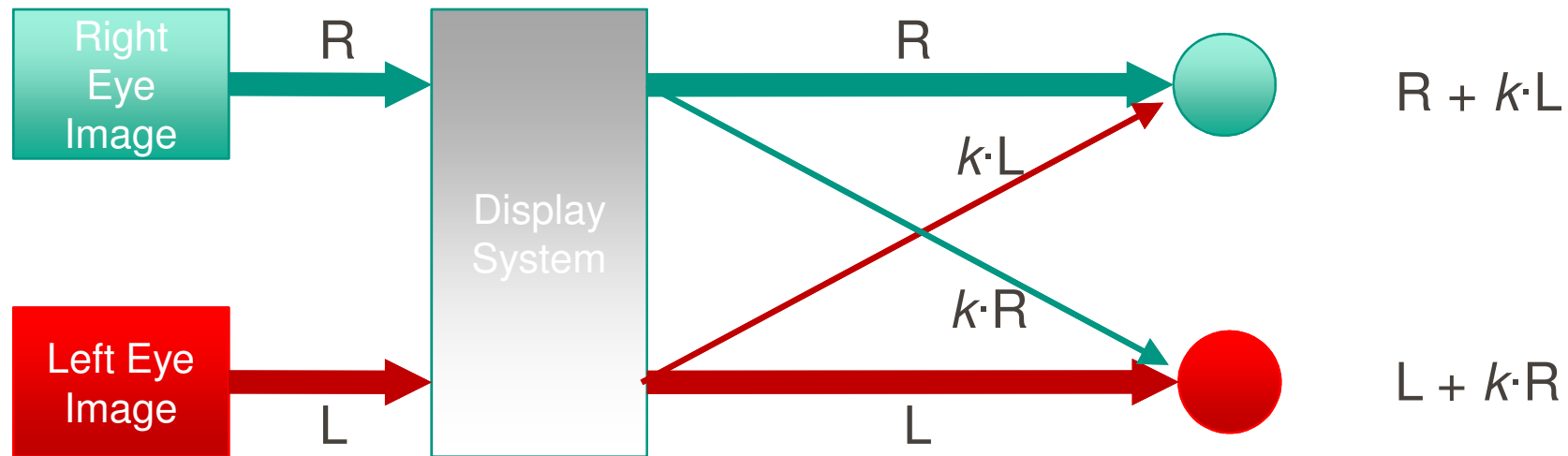


Source: Contributions to the Physiology of Vision.—Part the First. On some remarkable, and hitherto unobserved, Phenomena of Binocular Vision. By CHARLES WHEATSTONE, F.R.S., Professor of Experimental Philosophy in King's College, London. Received and Read June 21, 1838

GHOSTING BASICS



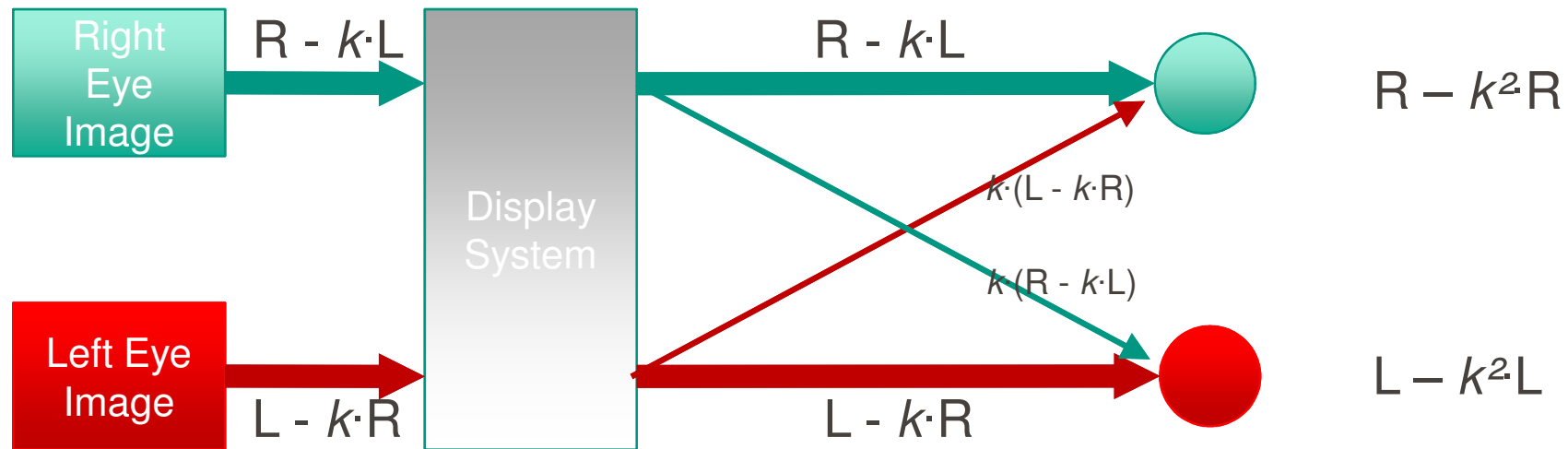
Hochschule **RheinMain**
University of Applied Sciences
Wiesbaden Rüsselsheim Geisenheim



GHOSTING BASICS „DE-GHOSTING“



Hochschule **RheinMain**
University of Applied Sciences
Wiesbaden Rüsselsheim Geisenheim





GHOSTING BASICS

So far, so good. Let's measure magic „ k “ and we are done.

BUT....

- k is not a constant
- k depends on viewing position, brightness, color, saturation, ambient light level...
- What are the „R“ and „L“ signals, or –more precisely- what signals do we look at when we measure ghosting?
- Candidates:
 - Linear light values
 - „Gamma“-pre-distorted values
 - Code values (pretty much the same as above)
 - Lightness L^*



Hochschule RheinMain
University of Applied Sciences
Wiesbaden Rüsselsheim Geisenheim

02

GHOSTING METRICS AND MEASUREMENT



GHOSTING METRICS AND MEASUREMENT

- We have decided to use code values as metrics
- Fairly good approximation to lightness
- Easy to handle in test patterns

- Example:

- Input signal to DC playback:

Left eye: $CV_{Y'} = 3960$ (DC Peak white), Right Eye $CV_{Y'} = 0$

- Measurement of White Level: Left eye 10 cd/m^2 ,
Measurement of White Ghosting: Right Eye 1 cd/m^2 (should be „0“)

- Corresponding Input CV of Ghosting level: $4,8 \text{ cd/m}^2 = 1633$

- → White Ghosting Level $1633 / 3960 = 44\%$ (and not 10%..)

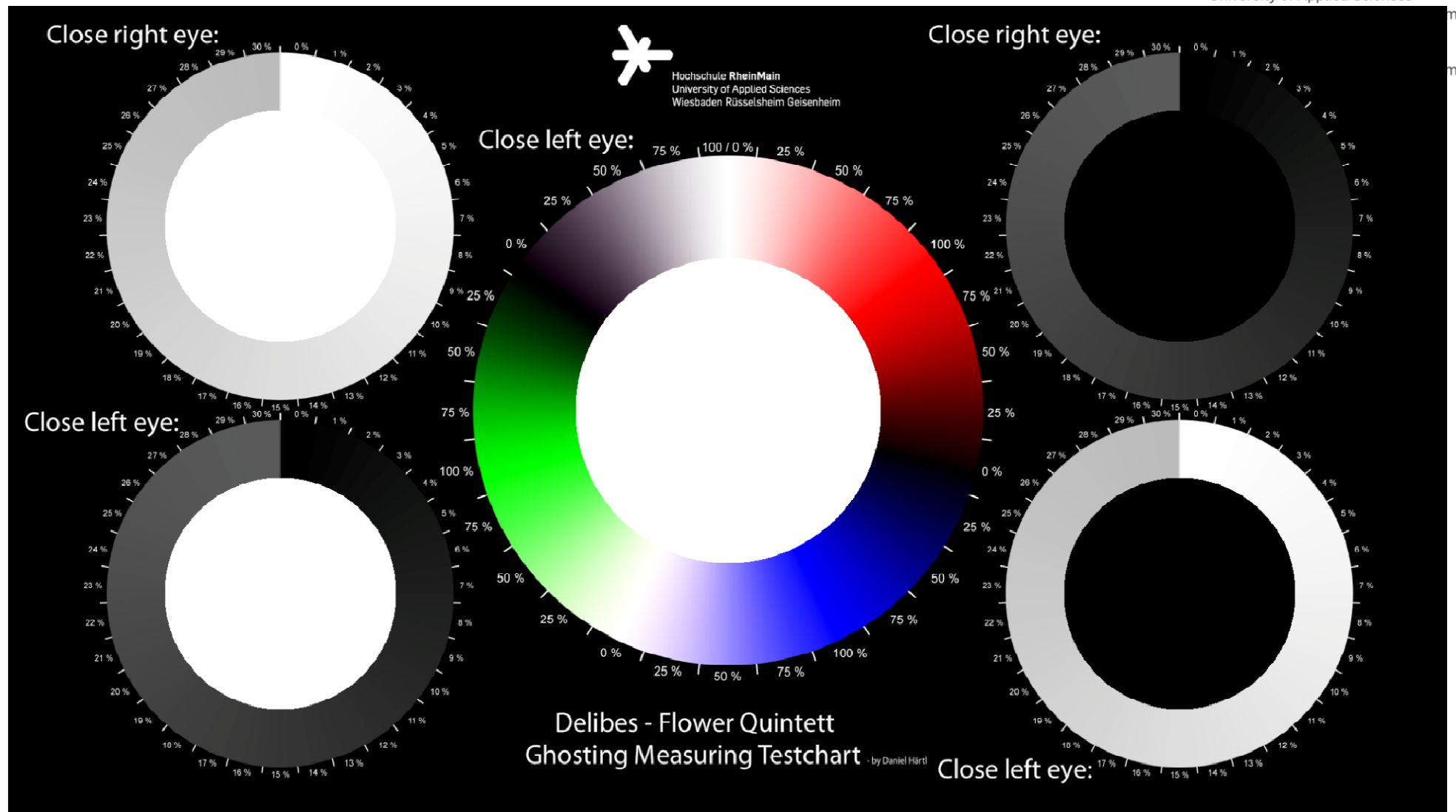
- Our test charts use percentage of the full code value range as scale

$$CV_{Y'} = INT \left[4095 * \left(\frac{L * Y}{52.37} \right)^{1/2.6} \right]$$

DELIBES Test Chart



Hochschule RheinMain
University of Applied Sciences

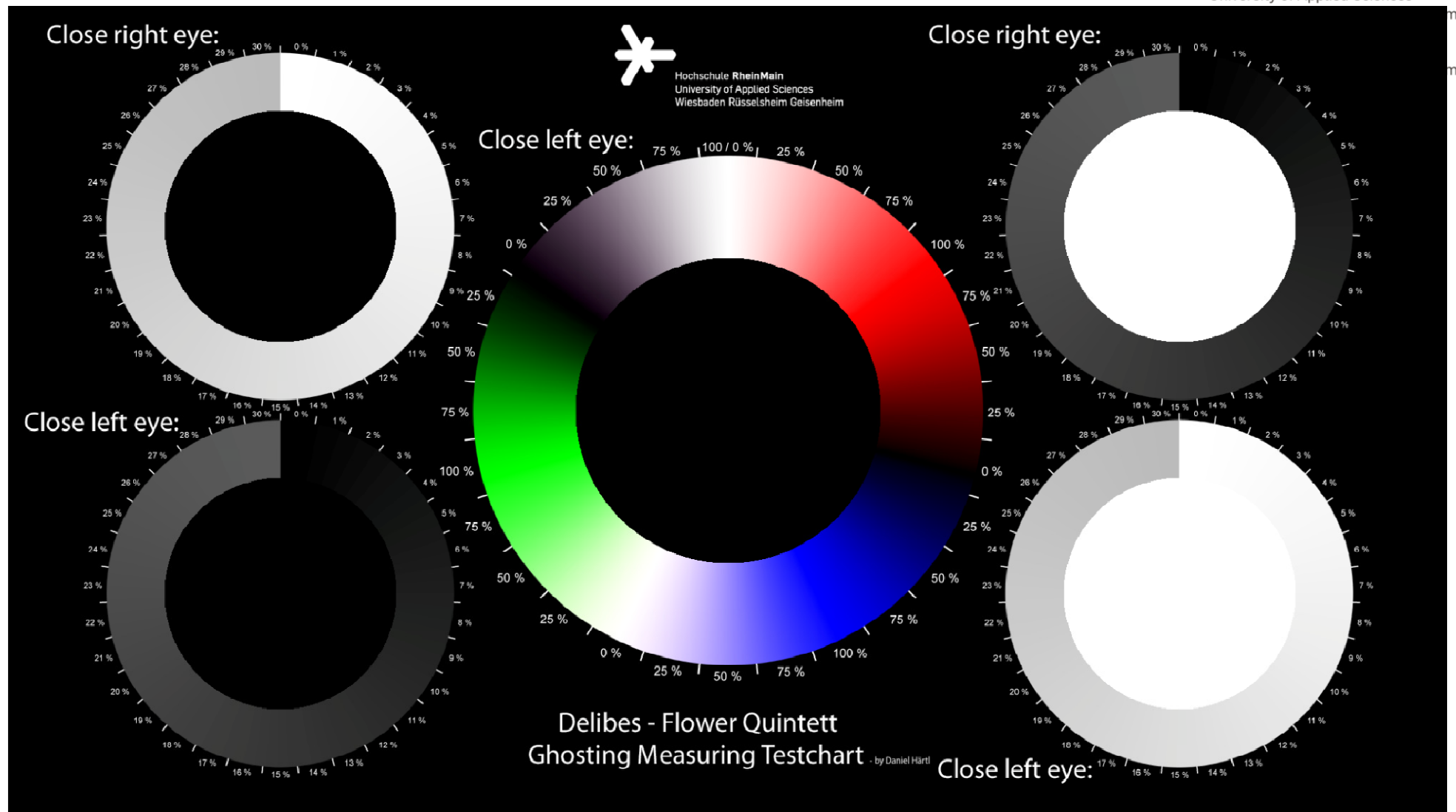


LEFT EYE © Daniel Härtl 2010, all rights reserved

DELIBES Test Chart



Hochschule RheinMain
University of Applied Sciences



RIGHT EYE © Daniel Härtl 2010, all rights reserved

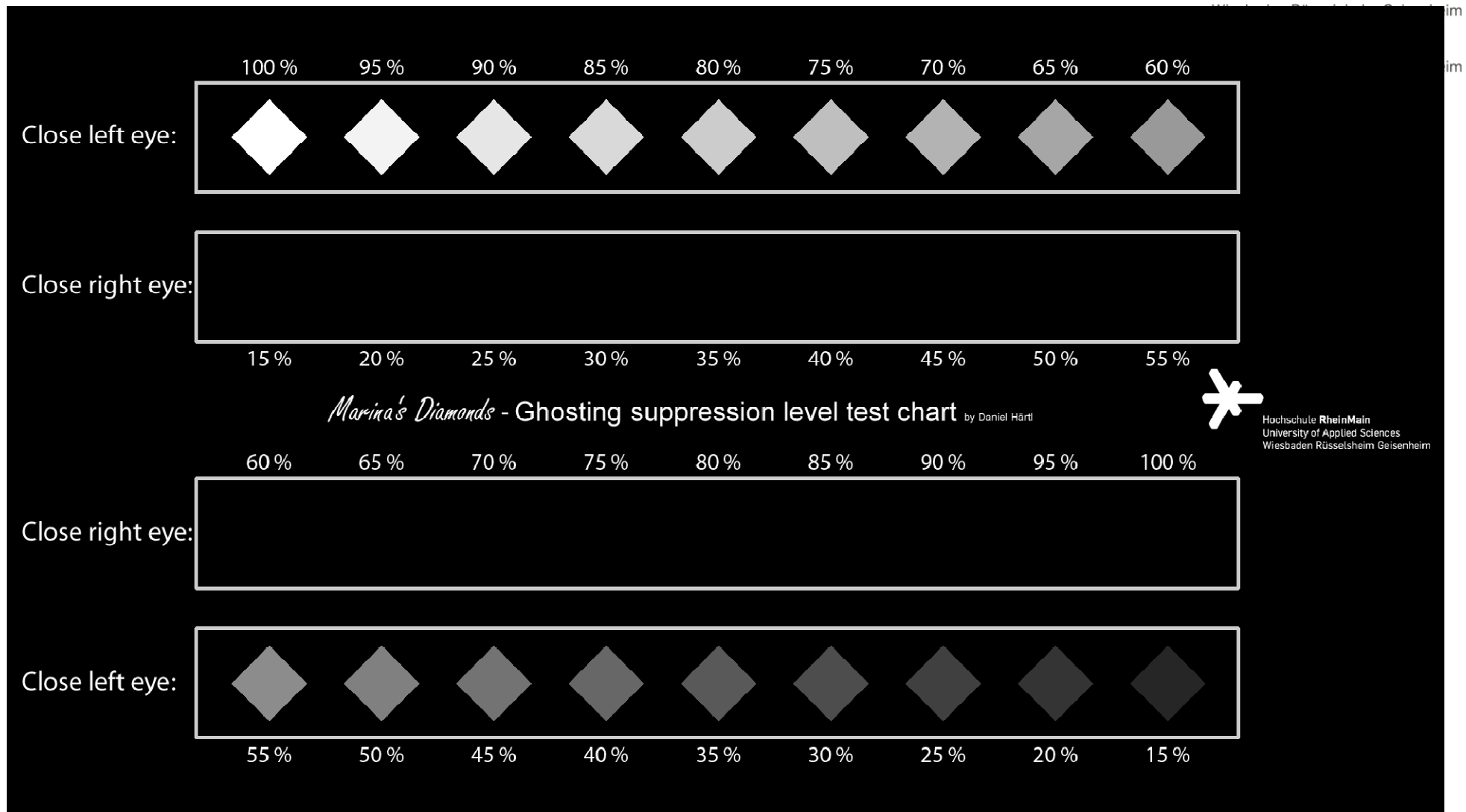


GHOSTING SUPPRESSION LEVEL

- Intention: Single-value metrics for Ghosting effects
- The minimum signal level (again in % of code values) in one channel down to which Ghosting in the other channel is visible.
- CVs below the suppression level do not cause visible ghosting
- CVs above the suppression level do cause ghosting
- The higher the suppression level is, the less ghosting will be visible

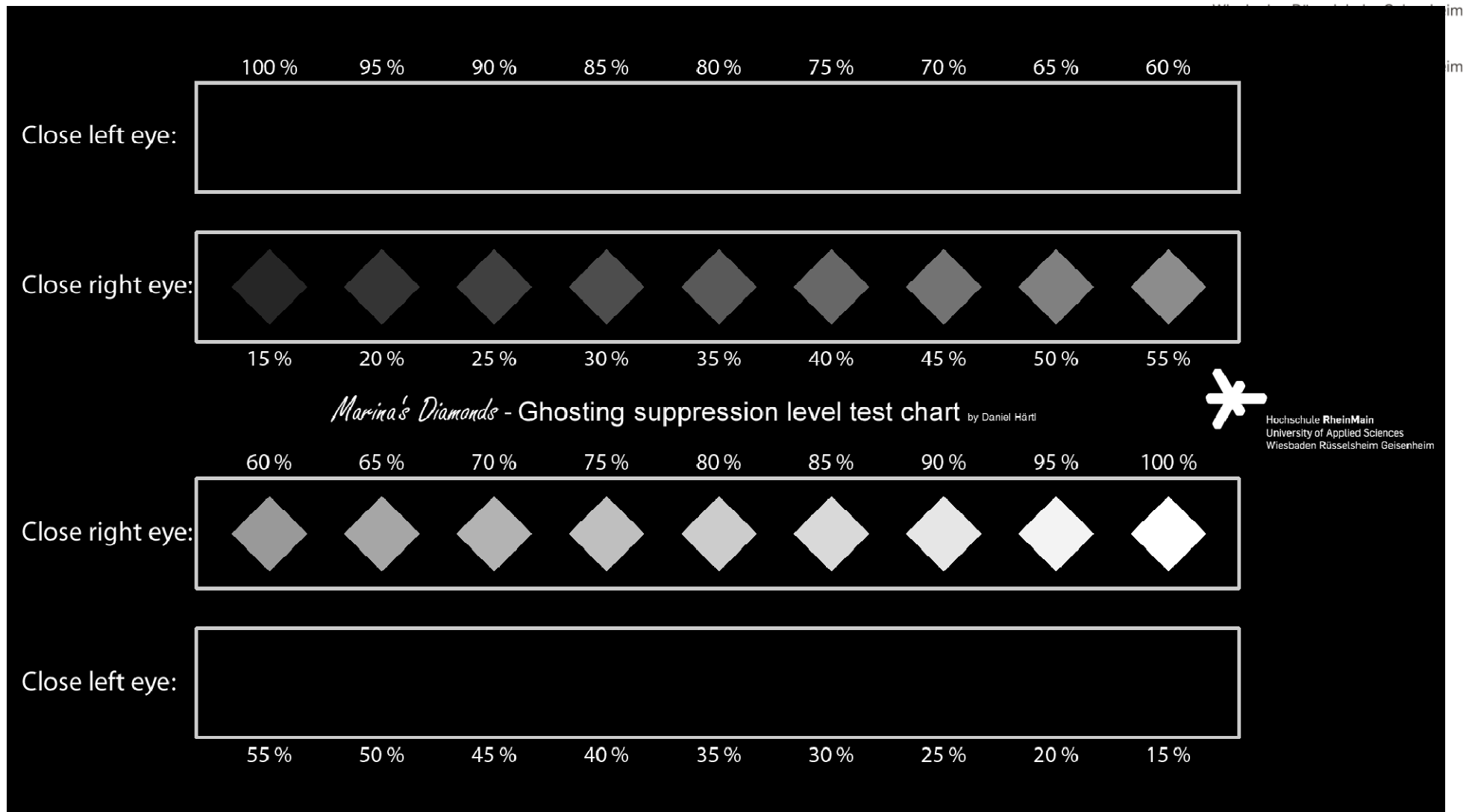


Marina's Diamonds Test Chart





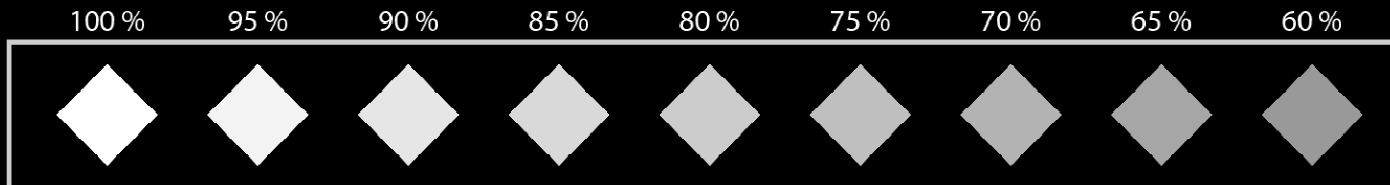
Marina's Diamonds Test Chart





Marina's Diamonds Test Chart

Close left eye:



Marina's Diamonds - Ghosting suppression level test chart by Daniel Härtl

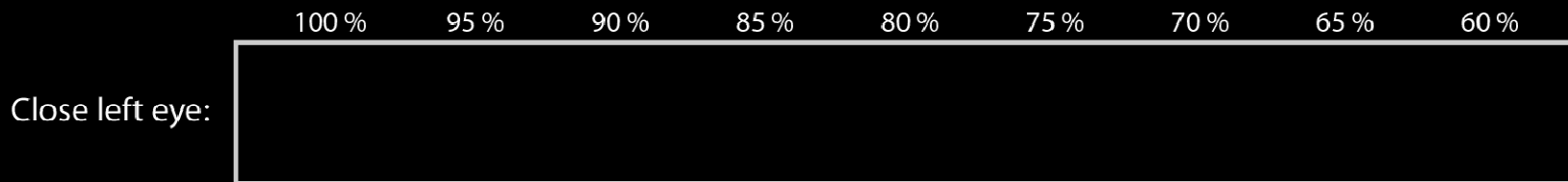


Close left eye:

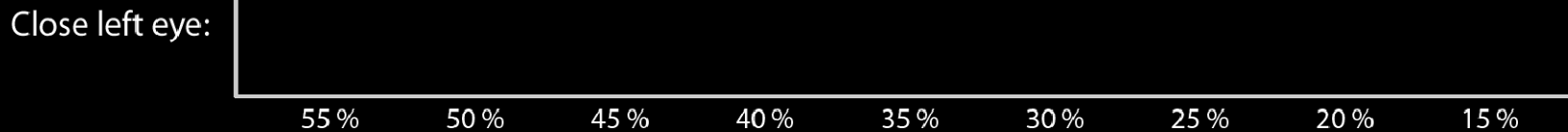




Marina's Diamonds Test Chart

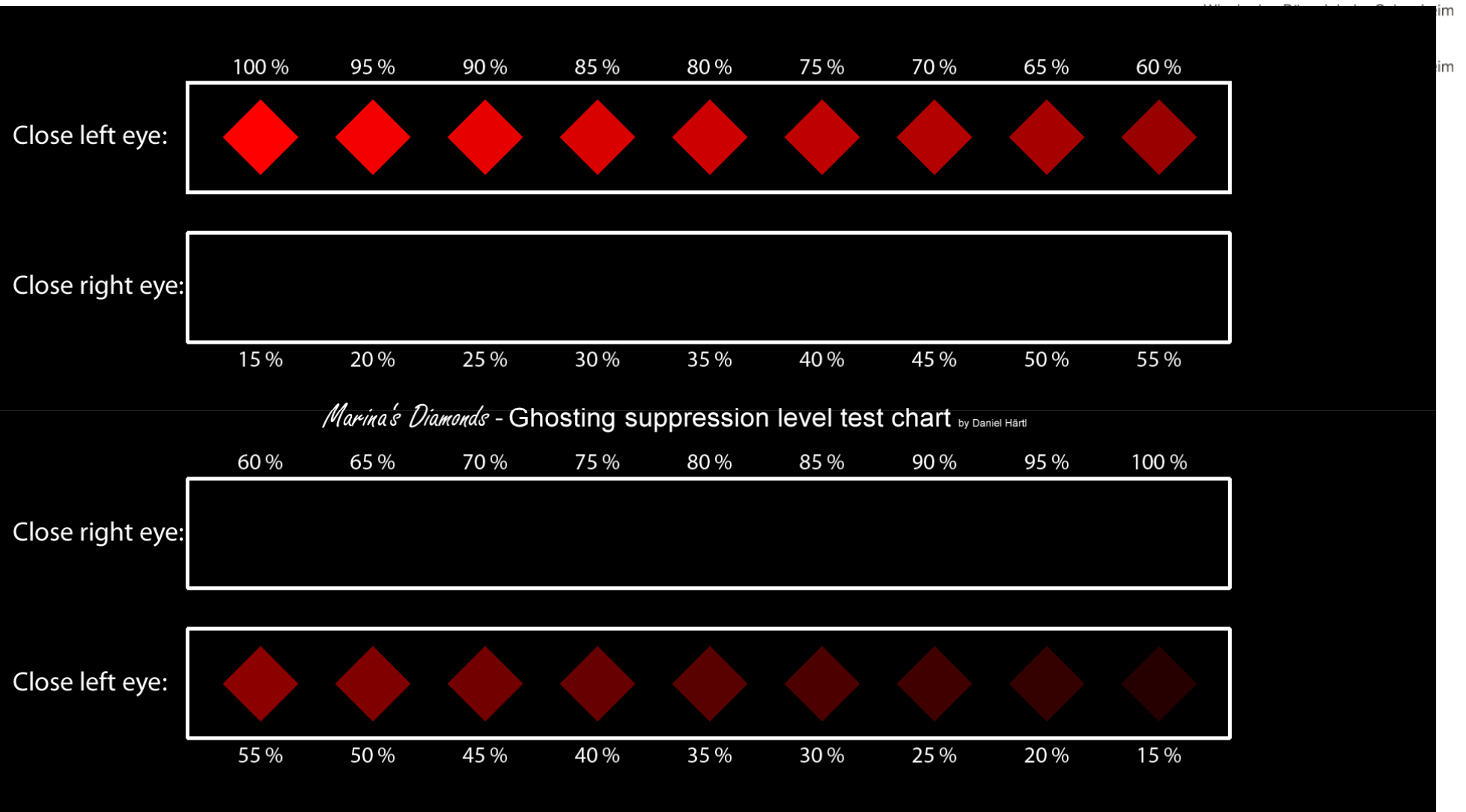


Marina's Diamonds - Ghosting suppression level test chart by Daniel Härtl





Marina's Diamonds Test Chart





Hochschule RheinMain
University of Applied Sciences
Wiesbaden Rüsselsheim Geisenheim

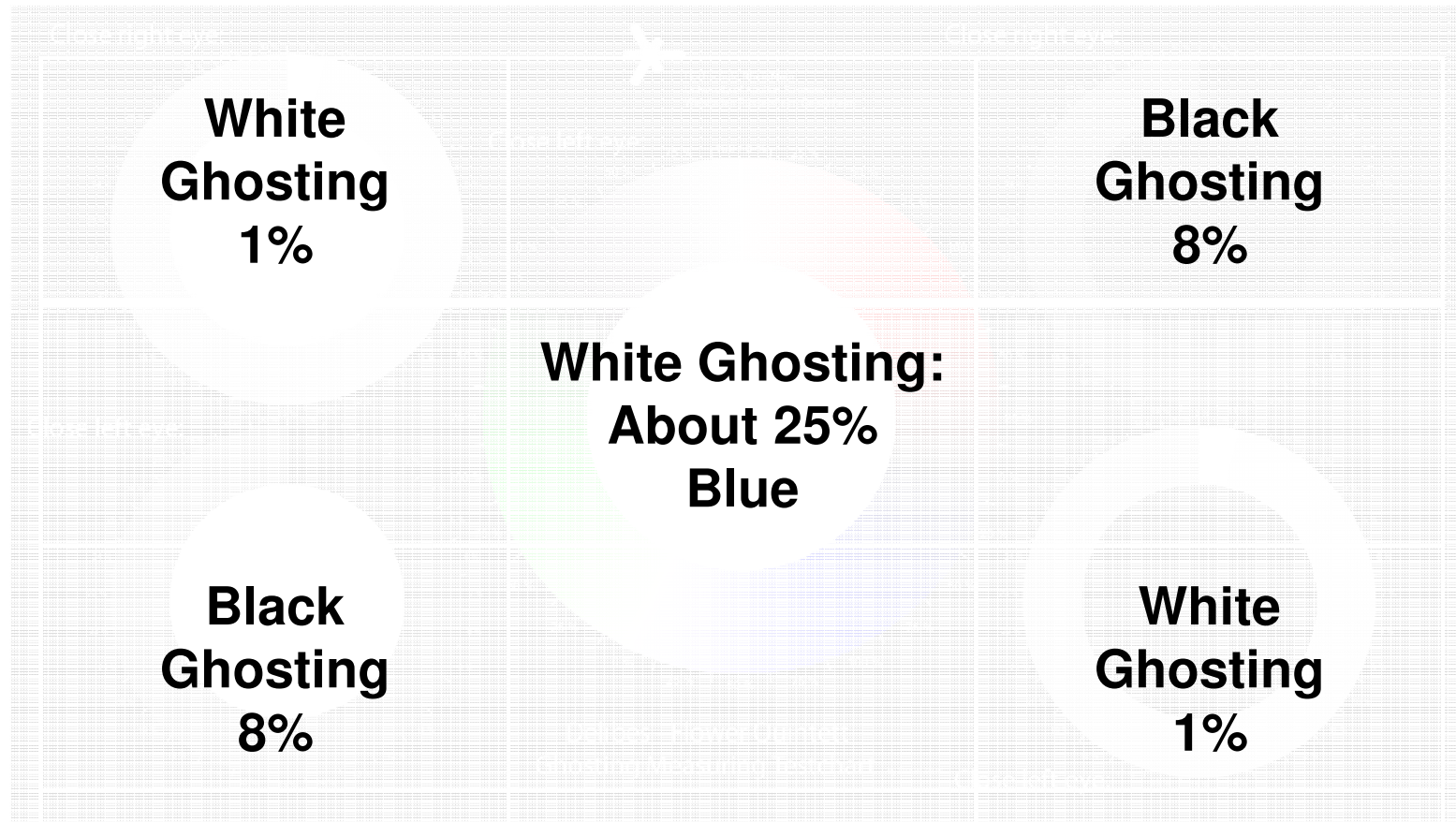
03

MEASUREMENT RESULTS

XPAND D-CINEMA SYSTEM



Hochschule **RheinMain**
University of Applied Sciences
Wiesbaden Rüsselsheim Geisenheim



DOLBY D-CINEMA SYSTEM (LEFT EYE)



Hochschule **RheinMain**
University of Applied Sciences
Wiesbaden Rüsselsheim Geisenheim



DOLBY D-CINEMA SYSTEM (RIGHT EYE)



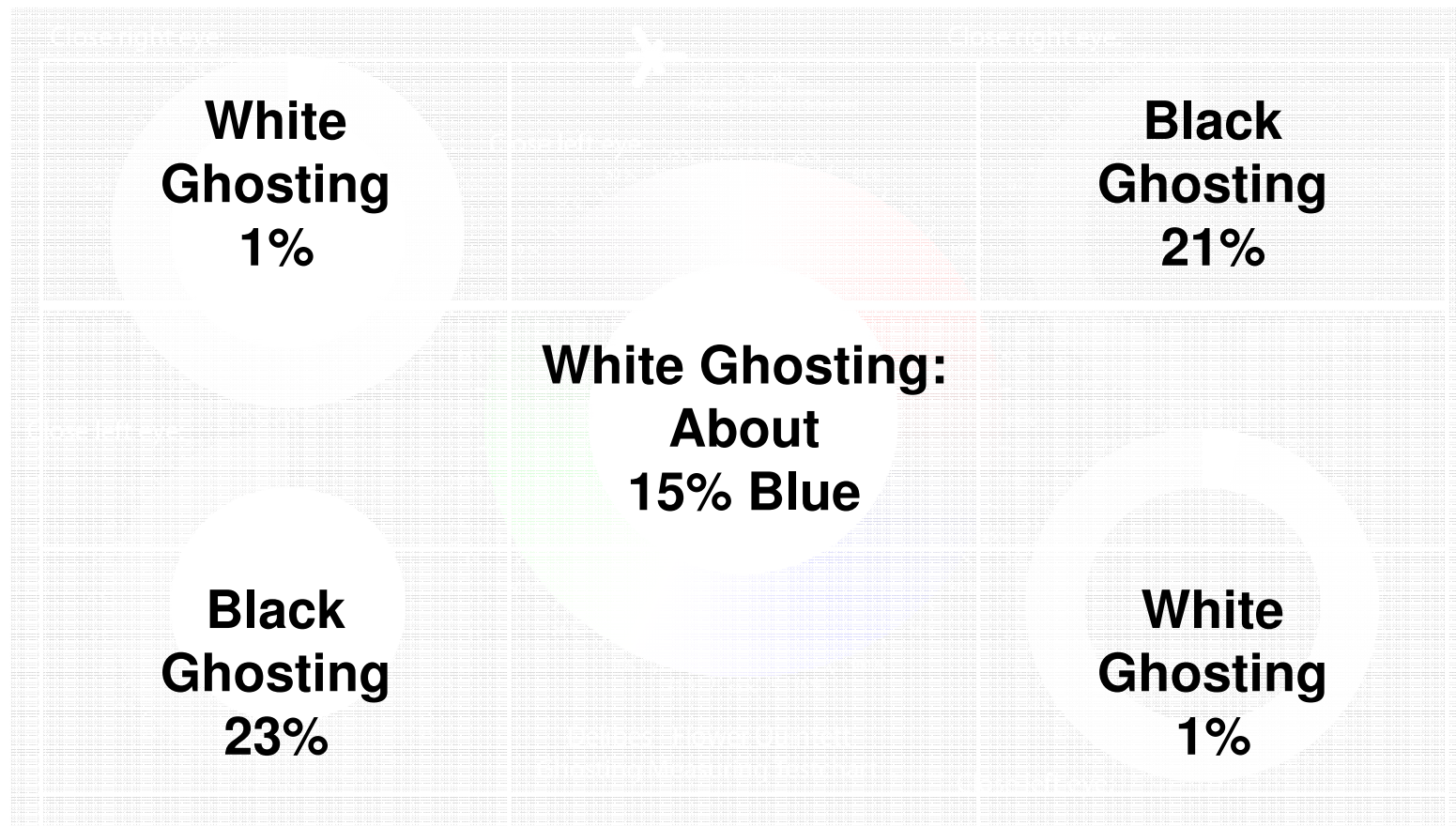
Hochschule **RheinMain**
University of Applied Sciences
Wiesbaden Rüsselsheim Geisenheim



REALD D-CINEMA SYSTEM



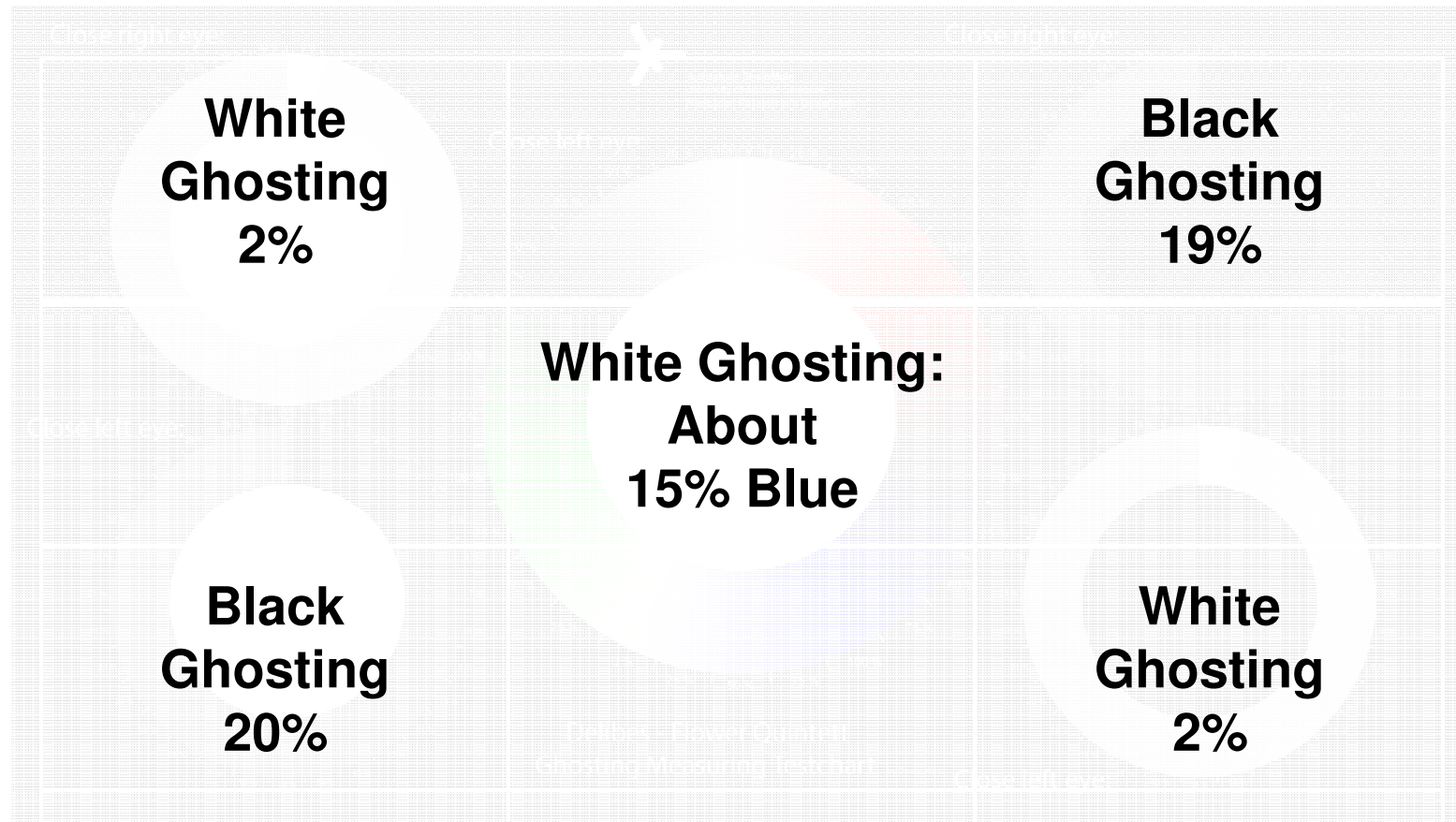
Hochschule **RheinMain**
University of Applied Sciences
Wiesbaden Rüsselsheim Geisenheim



MASTERIMAGE D-CINEMA SYSTEM



Hochschule **RheinMain**
University of Applied Sciences
Wiesbaden Rüsselsheim Geisenheim



COMPARATIVE TABLE ON THE GHOSTING PERFORMANCE



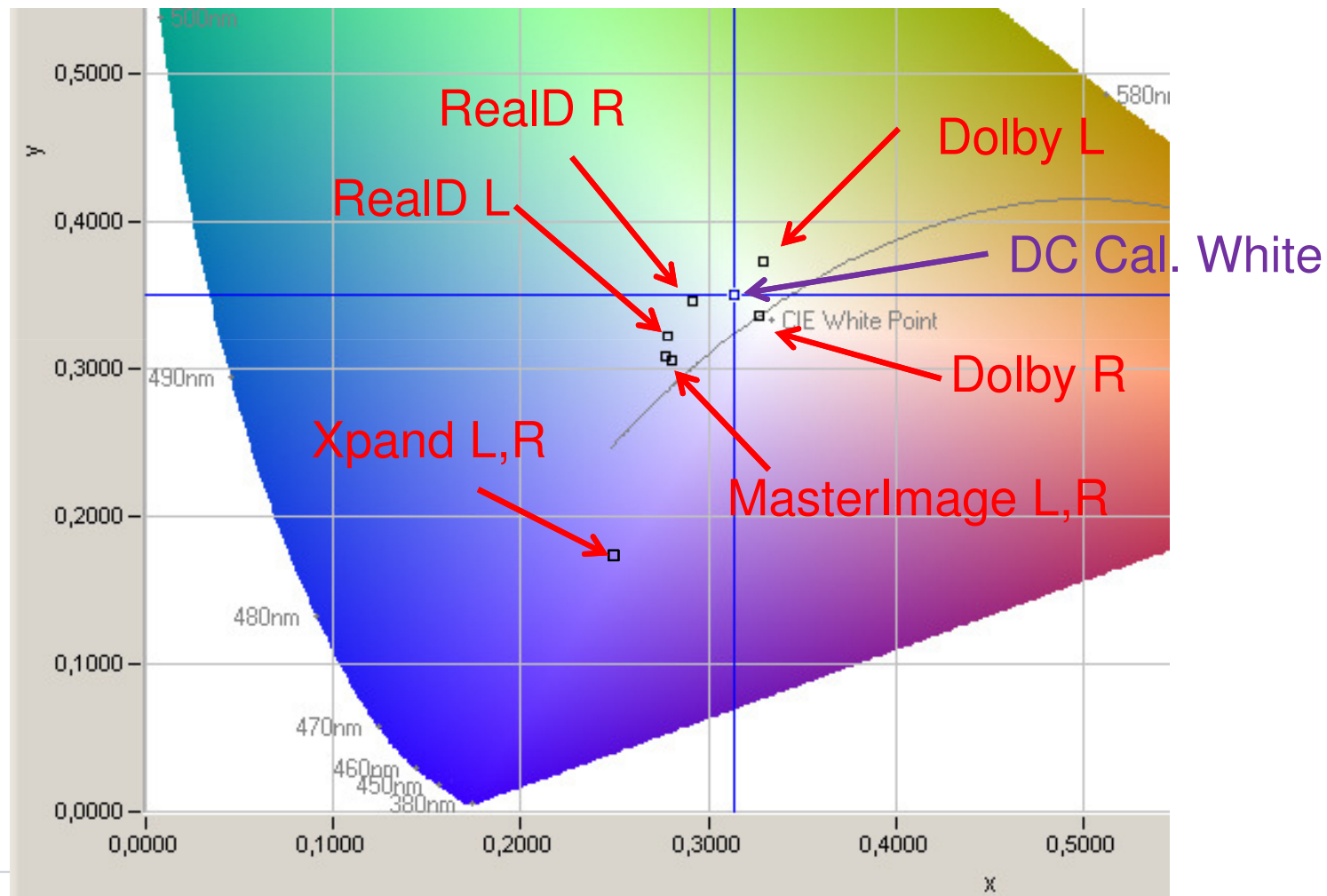
Hochschule **RheinMain**
University of Applied Sciences
Wiesbaden Rüsselsheim Geisenheim

	Xpand	Dolby 3D	RealD XL	Master Image	Panasonic	Nvidia
Luminance max. White ($\frac{cd}{m^2}$)	293,3	161,1	67,8	225,4	37,3	273,4
Luminance White w/ glasses ($\frac{cd}{m^2}$)	26,0	16,8	18,7	26,1	4,12	13,9
Efficiency	9%	10%	28%	12%	11%	5%
White-Ghosting-Level	8 %	13,5 %	22 %	19,5%	9 %	5 %
Black-Ghosting-Level	1 %	1,5 %	1 %	2%	1 %	17 %
Color Shift of Black-Ghosting	Green	Slightly green	Slightly green		Desaturated	Slightly blue
Color Shift of White-Ghosting	Blue	Slightly yellow	Slightly blue	Slightly blue	Green	Slightly blue

COLOR SHIFT OF BLACK DUE TO WHITE GHOSTING



Hochschule **RheinMain**
University of Applied Sciences
Wiesbaden Rüsselsheim Geisenheim



The diagram illustrates the CIE 1931 color space, showing the relationship between color gamuts and white points. The x-axis is labeled 'x' and the y-axis is labeled 'y'. The diagram includes labels for 'Dolby L', 'Dolby R', 'RealD L,R', 'Xpand L,R', 'MasterImage L,R', and 'DC Cal. White'. A 'CIE White Point' is marked with a dot. Wavelengths from 380nm to 580nm are indicated along the top and left edges.

VERIFICATION OF TEST CHART RESULTS BY SPECTRORADIOMETER MEASUREMENTS



Hochschule RheinMain
University of Applied Sciences
Wiesbaden Rüsselsheim Geisenheim

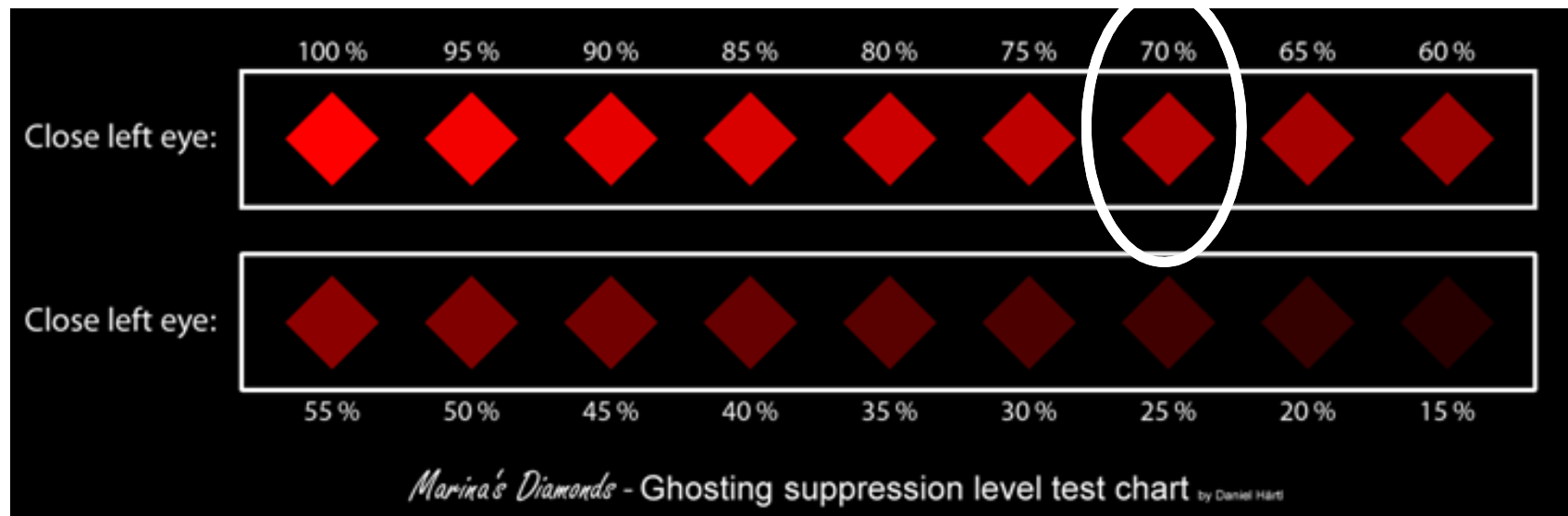
White Ghosting (From white into black)		Xpand	Dolby 3D	RealD	MasterImage	Panasonic	Samsung/Nvidia
Lum. White 3D w/ glasses	cd/m ²	26	16,9	18,8	26,1	4,12	13,9
Lum. Black 3D w/ glasses	cd/m ²	0,154	0,037	0,029	0,067	0,057	0,025
Lum. White Ghosting w/glasses	cd/m ²	0,182	0,26	0,42	0,845	0,233	0,049
CV Y' white	CV	3960	3960	3960	3960	255	255
CV Y' White Ghosting (theoretical)	CV	286	750	893	1025	61	14
White Gosting calculated	%	7,22%	18,94%	22,55%	25,88%	23,92%	5,49%
White Ghosting estimated from Charts	%	8%	13,50%	22%	20%	9%	5%
Black Ghosting (From black into white)							
Lum. Black Ghosting w/glasses	cd/m ²	25,8	15,9	18,35	24,45		
CV Y' Black Ghosting (theoretical)	CV	3948	3868	3923	3862		
Black Gosting calculated	%	0,30%	2,32%	0,93%	2,47%		
Black Ghosting estimated from Charts	%	1%	1,50%	1%	2%		

GHOSTING SUPPRESSION LEVEL XPAND D-CINEMA SYSTEM



Hochschule **RheinMain**
University of Applied Sciences
Wiesbaden Rüsselsheim Geisenheim

Farbe	Left Channel	Right Channel	Average
White	40 %	35 %	35 %
Red	60 %	80 %	70 %
Green	40 %	45 %	40 %
Blue	40 %	40 %	40 %

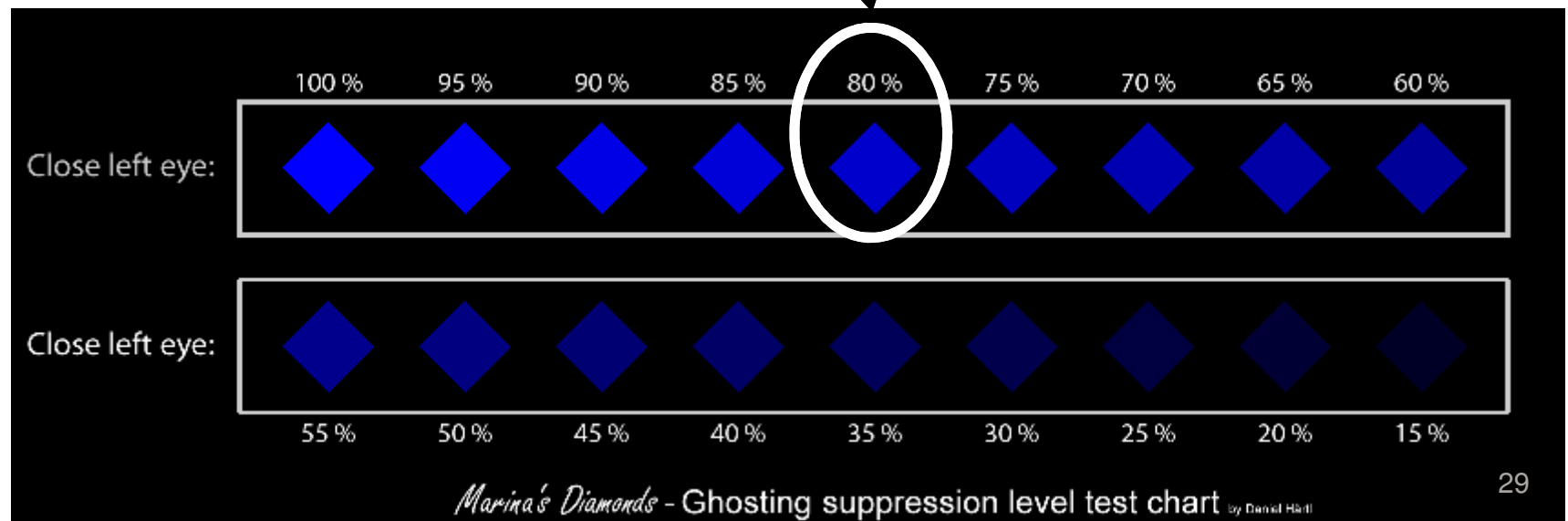


GHOSTING SUPPRESSION LEVEL DOLBY 3D D-CINEMA SYSTEM



Hochschule **RheinMain**
University of Applied Sciences
Wiesbaden Rüsselsheim Geisenheim

Farbe	Left Channel	Right Channel	Average
White	60 %	55 %	55 %
Red	60 %	55 %	55 %
Green	65 %	55 %	60 %
Blue	75 %	85 %	80 %

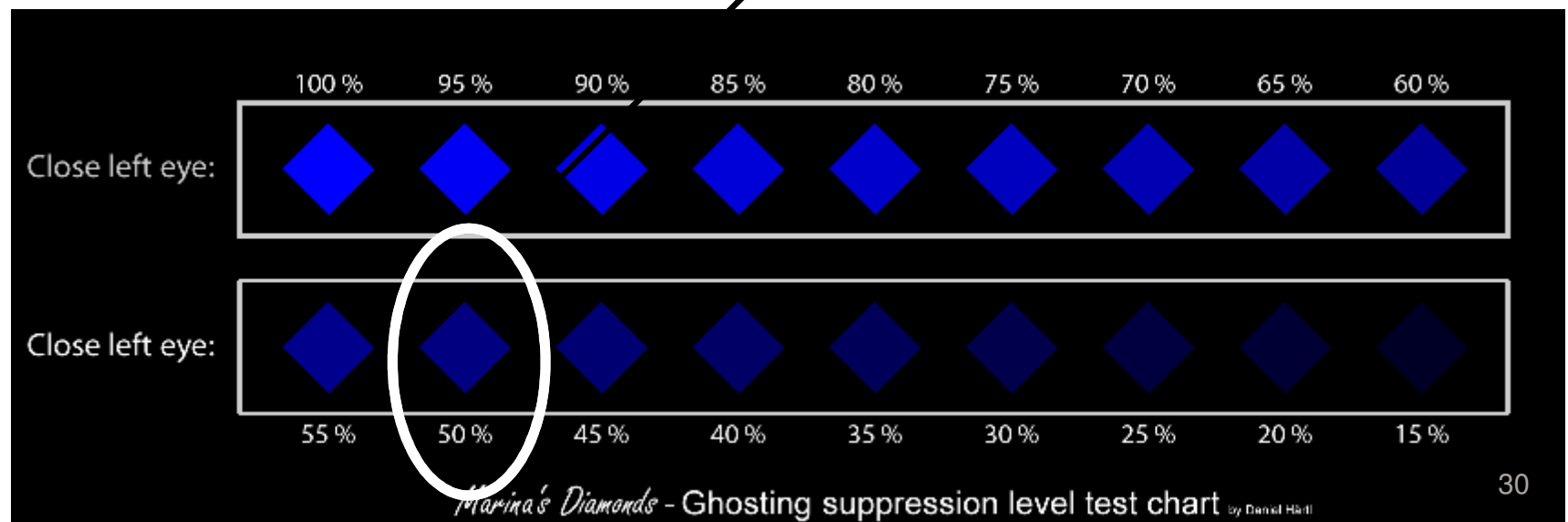


GHOSTING SUPPRESSION LEVEL REALD D-CINEMA SYSTEM



Hochschule **RheinMain**
University of Applied Sciences
Wiesbaden Rüsselsheim Geisenheim

	Left Channel	Right Channel	Average
White	25 %	20 %	20 %
Red	45 %	35 %	40 %
Green	35 %	30 %	30 %
Blue	50 %	50 %	50 %

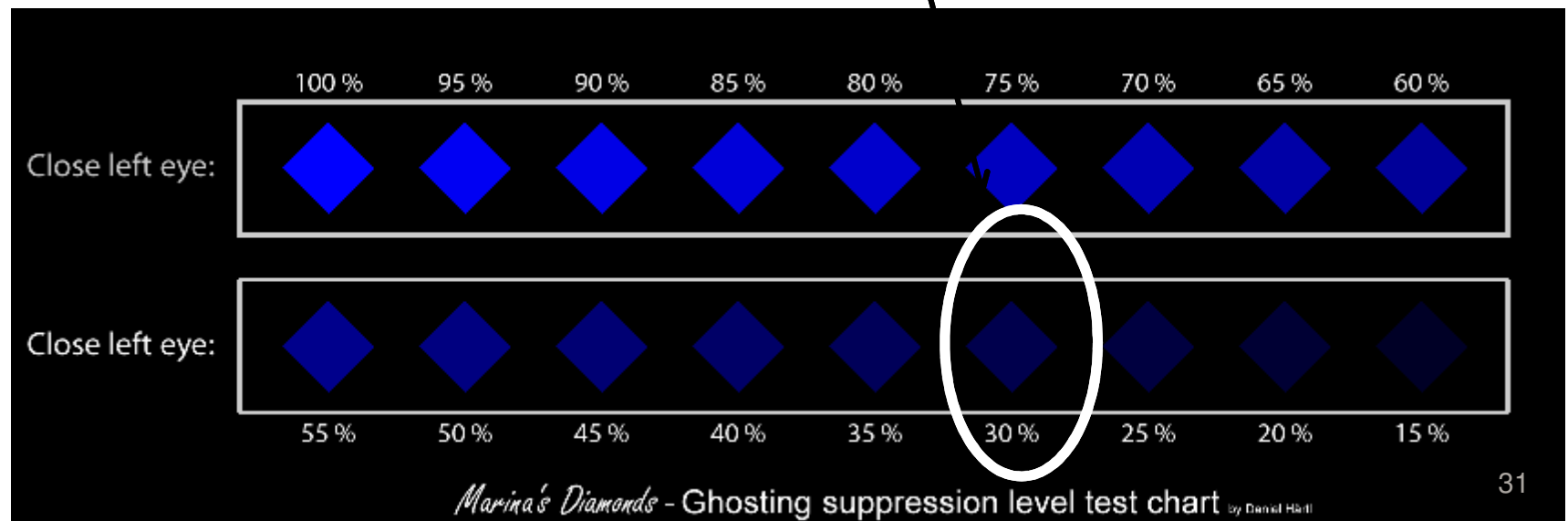


GHOSTING SUPPRESSION LEVEL MASTERIMAGE D-CINEMA SYSTEM



Hochschule **RheinMain**
University of Applied Sciences
Wiesbaden Rüsselsheim Geisenheim

	Left Channel	Right Channel	Average
White	15 %	15 %	15 %
Red	25 %	30 %	25 %
Green	25 %	20 %	20 %
Blue	30 %	35 %	30 %





Hochschule RheinMain
University of Applied Sciences
Wiesbaden Rüsselsheim Geisenheim

04 CONCLUSIONS

CONCLUSIONS



Hochschule **RheinMain**
University of Applied Sciences
Wiesbaden Rüsselsheim Geisenheim

- Two metrics for ghosting have been defined
- Test charts for evaluating the Ghosting performance have been developed
- The Ghosting of selected D-Cinema 3D Systems and two 3DTVs has been evaluated with these test charts
- The Ghosting values gathered from the charts have been verified by spectroradiometer measurements and a good correlation between the two has been found
- The suppression level provides a metric to quantify Ghosting at lower brightness
- A good Ghosting performance at Peak White does not necessarily translate into a high suppression level (and vice versa)

THANK YOU FOR YOUR ATTENTION



Hochschule **RheinMain**
University of Applied Sciences
Wiesbaden Rüsselsheim Geisenheim

Prof. Dr. Wolfgang Ruppel

B. Eng. Daniel Härtl

RheinMain University of Applied Sciences

Wiesbaden, Germany

Study Programs

„Media Technology“ (B.Eng.)

„Media & Communications Technology“ (M.Eng.)

wolfgang.ruppel@hs-rm.de

**This work has been funded by the German Federal Ministry of Education
and Research (Project No. 17N4209)**

SPONSORED BY THE



**Federal Ministry
of Education
and Research**