主辦機構
Organiser：

香港印刷業商會
THE HONG KONG PRINTERS ASSOCIATION

執行機構
Implementation Organisation：

APTEC 印刷科技研究中心
Advanced Printing Technology Centre

贊助
Sponsor：

CCIDAHK

中華人民共和國香港特別行政區政府
文化體育及旅遊局
Culture, Sports and Tourism Bureau
The Government of the Hong Kong Special Administrative Region of the People's Republic of China

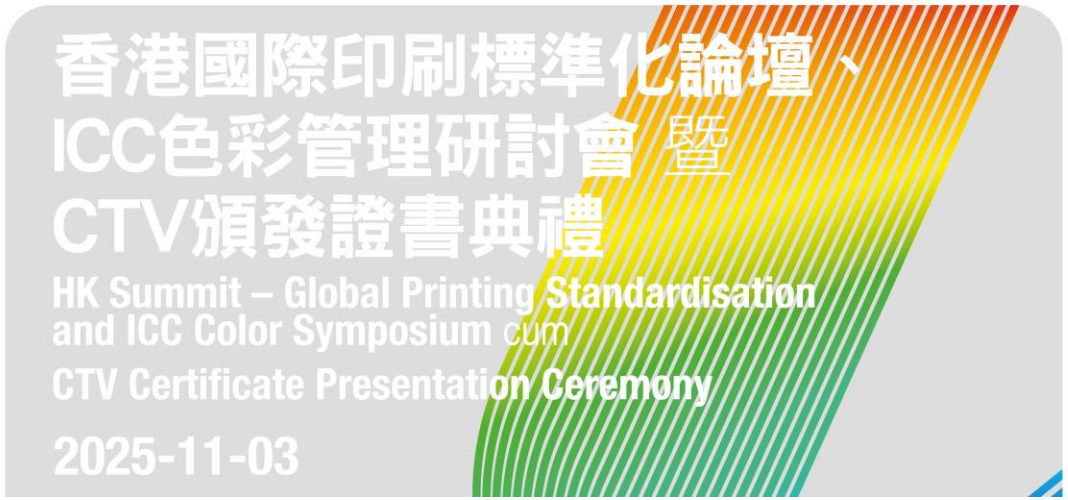
政府資助計劃
Government-funded programme

支持機構
Supporting Organisations：

ICC V4

AAAAA

IPP



CHARACTERIZING BACKLIT MEDIA: AN HDR (POTENTIAL?) PRINT APPLICATION

Mission:
Printing the Expected Backlit

Highlights

For later reading

UNDERSTANDING “BACKLIT” AND PROFILING PRINTING CONDITIONS FOR BACKLIT APPLICATIONS

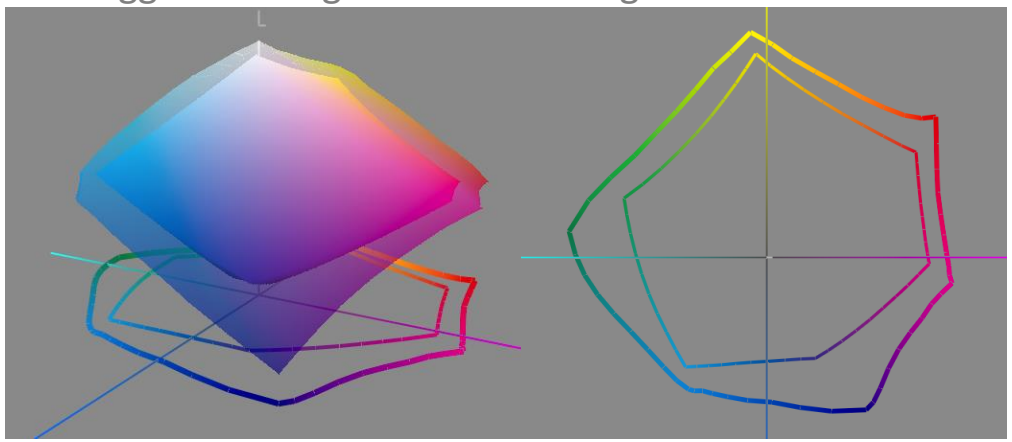
- **1. Concept of Backlit Print Applications**
  - Which printing systems, inks and substrates, “backlit” capable printing modes
- **2. “Backlit” metrology**
- **3. Light and lightbox construction influence**
- **4. Research topics:**
  - Concept for standardization (ISO 3664 and ISO 13655) by providing tools and guidelines for measuring, profiling and visual matching of transparent media
  - https://fogra.org/fileadmin/files/7_downloads/forschungsberichte/fogra-forschungsbericht-FB10060L.pdf
- **5. Printing the Expected objective: adaptability to expectations**
  - Fogra ProcessStandard Digital – PSD industrial procedure
  - Fogra PrintCheck for Large Format Printing application
- **6. HDR for “Backlit”?**

dp Arbeitskreis Digitaldruck
Digital Printing Working Group
Fogra

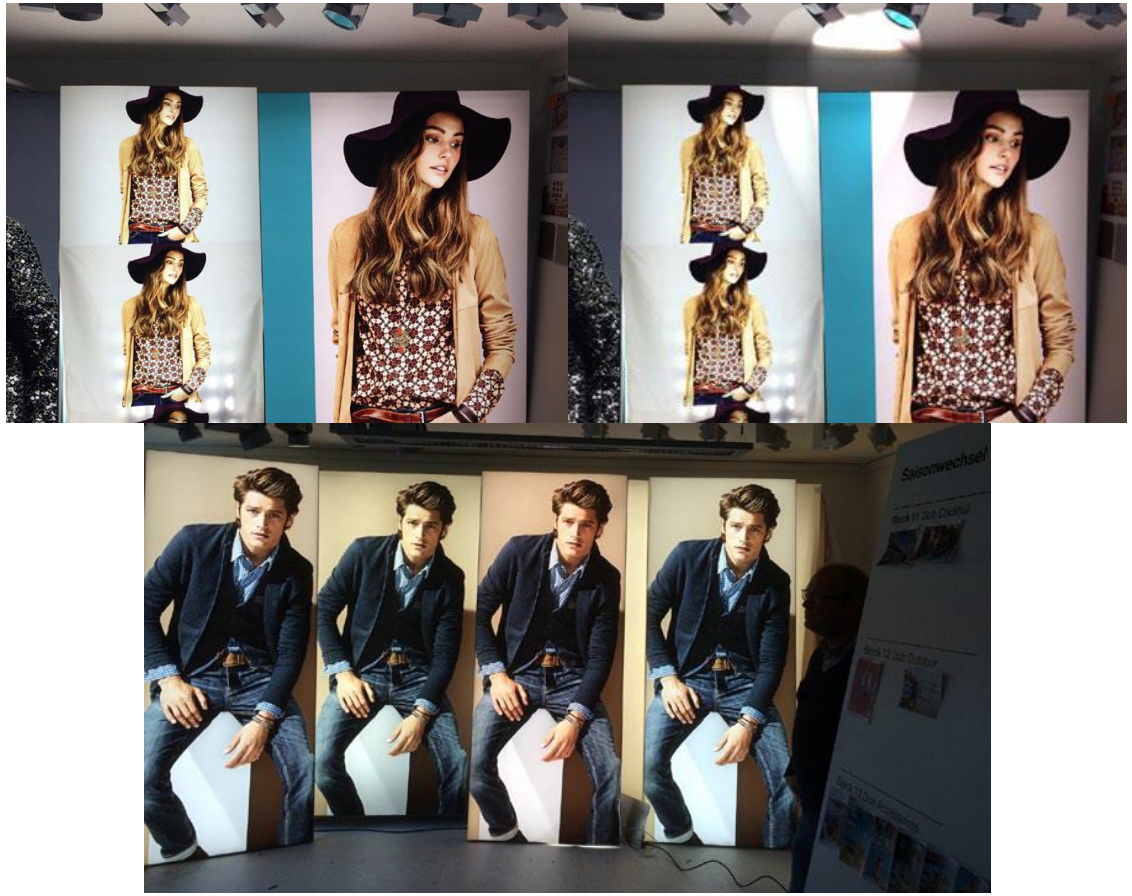
ProcessStandard Digital
fogra PSD

CONSIDERATIONS ABOUT BACKLIT PRINT APPLICATIONS

- **Chromatic adaptation influencers**
  - Transmissive light and ambient light SPD's
  - Different substrate properties (colour, fluorescence, gloss, light scattering and absorption of the combined reflection and transmission response)
- **Differences from typical reflective print applications**
  - Higher perceived dynamic range (contrast)
  - Bigger colour gamut with strong chromatic colours



ISO_coated_V2 (FOGRA39) vs.
Backlit Film printing condition



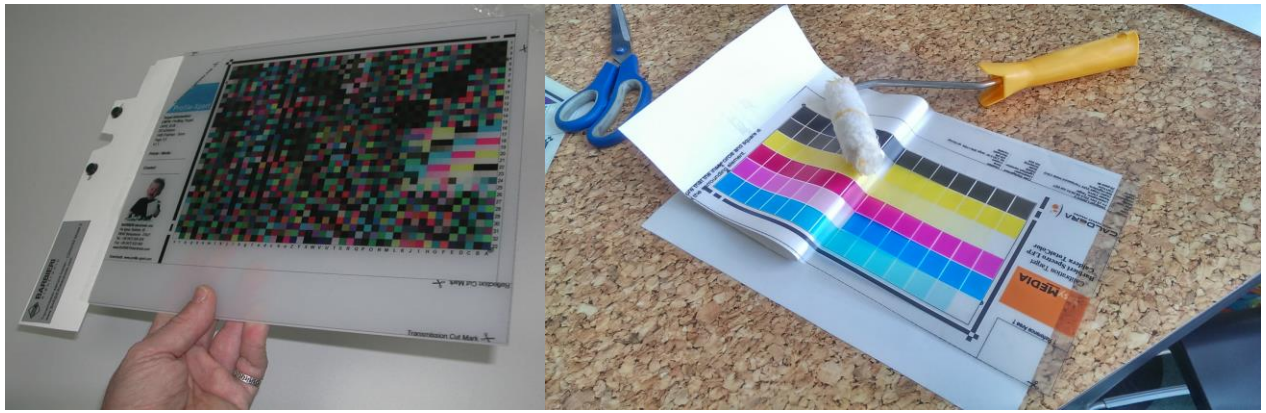
Source: Thomas Liesner - Vignold

MEASURING PROTOCOL – BASED ON ISO 13655:2017

- **Data**
  - Spectral measurements
  - d/0 transmission geometry, preferably M1 measurements, e.g. Barbieri Spectro LFP qb, optical density up to D3.0
  - Alternatively, emission measurements, e.g. X-Rite i1Pro 3 Plus/iO3, maximum supported luminance 5000 cd/m²
- **Specific consideration**
  - Measurements are taken media relative – device is calibrated on the substrate white resulting in a relative white point with the CIELAB value of 100/0/0
  - Large apertures, 6 or 8 mm for Barbieri SpectroLFP qb, 8 mm for X-Rite i1Pro 3 Plus/iO3

CONSIDERATIONS ABOUT SUBSTRATES

- **Thin flexible or rigid up to 1 mm**
- **Thick 1 – 3 mm, 3 – 5 mm increased measurement uncertainty due to:**
  - Stray light coming from outside
  - Substrate internal reflection
- **Depending on the substrate opacity, recommended thickness is less then 3 mm and is preferably less then 1 mm**
- **Translucent or transparent Self-adhesive substrates (e.g. SAV - Self-adhesive Vinyl) meant for transmissive application need to be removed from the liner and transferred to a thin transparent clear foil (100 µm – 500 µm)**

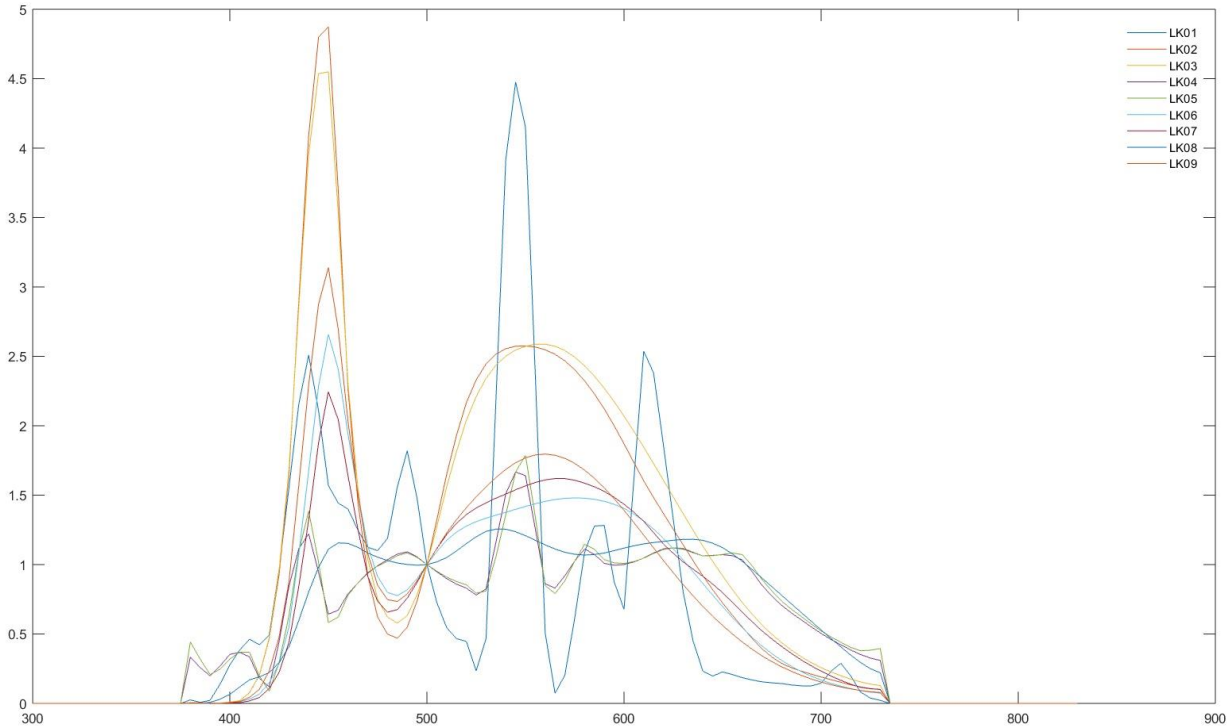


Transmission Sample Holder

Frame Transmission Sample Holder

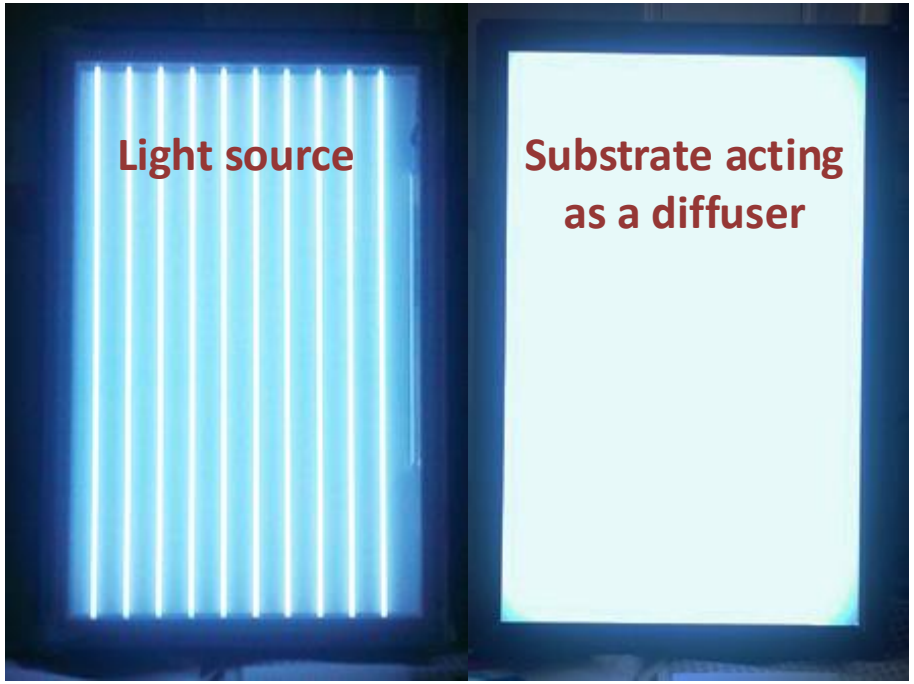
LIGHT SPD FOR VARIOUS LIGHTBOXES

- **Different types and with different SPD provide the backlight using various lighting technologies**
  - Fluorescent tubes (LK1 and LK5)
  - Edge lit (side) LED (LK3, LK7 w/ diffuser, LK8 w/ diffuser and LK9)
  - Backlit LED (LK2, LK4 and LK6)



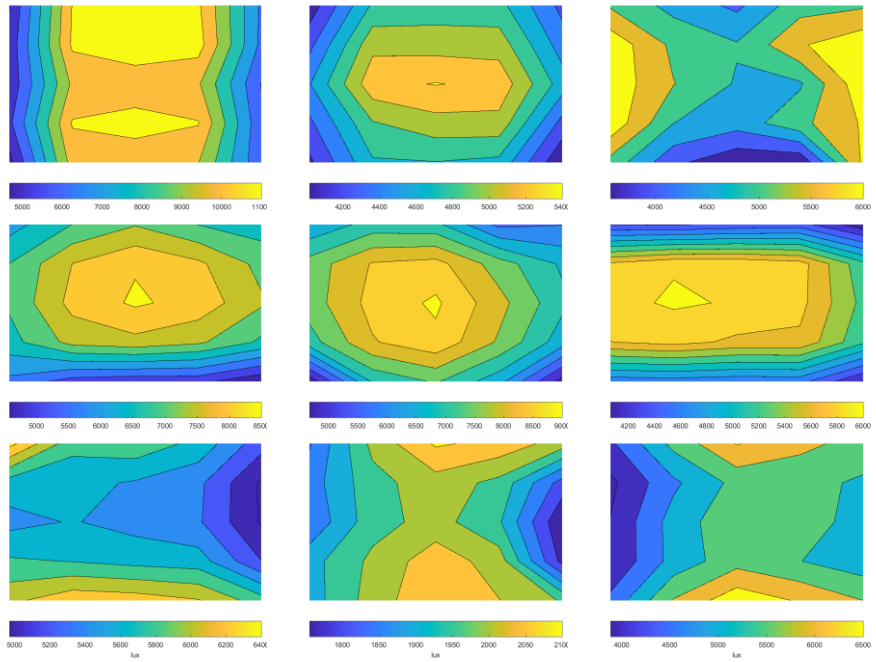
CHROMATIC ADAPTATION TO THE LIGHT BOX

- Relative substrate measurement count toward "Measure as we see"
- Light in the box count toward what we see



Lightbox without Substrate

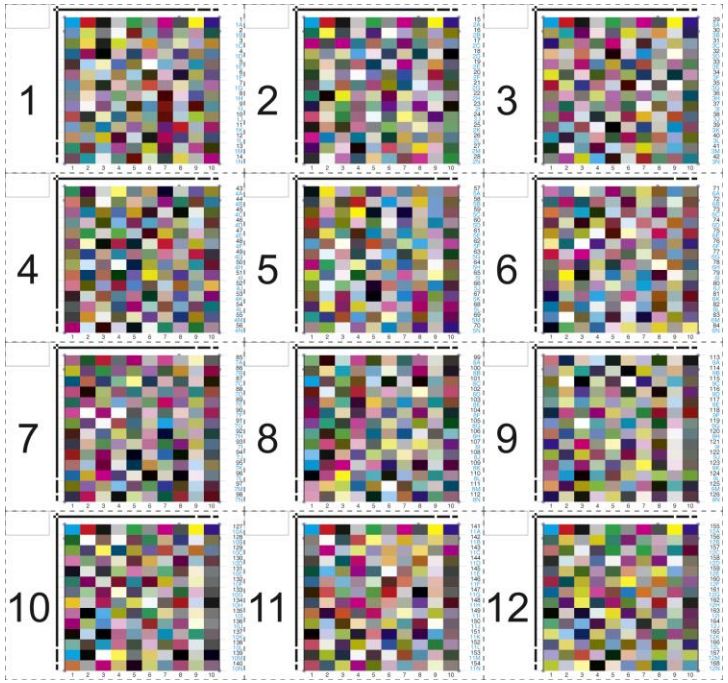
Lightbox with Substrate



LK1..LK9 luminance variation relative to each lightbox min and max lux determination

COLOUR MANAGEMENT METHOD

- **The combination of CMYK driving values with the spectral stimuli hitting the human eye is based on the additive model with the two sets being multiplied together wavelength by wavelength resulting the combined colour spectrum of the characterization data set**



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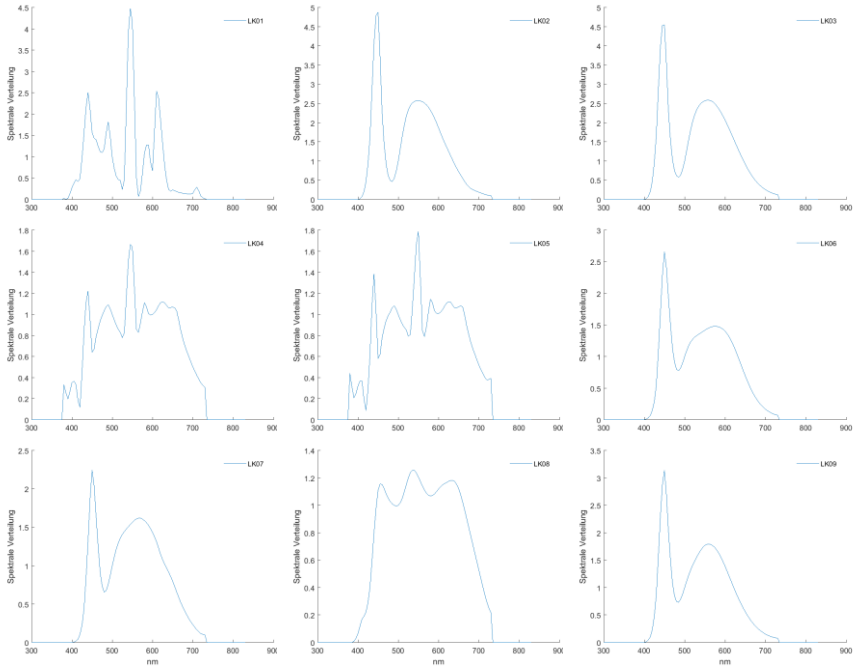
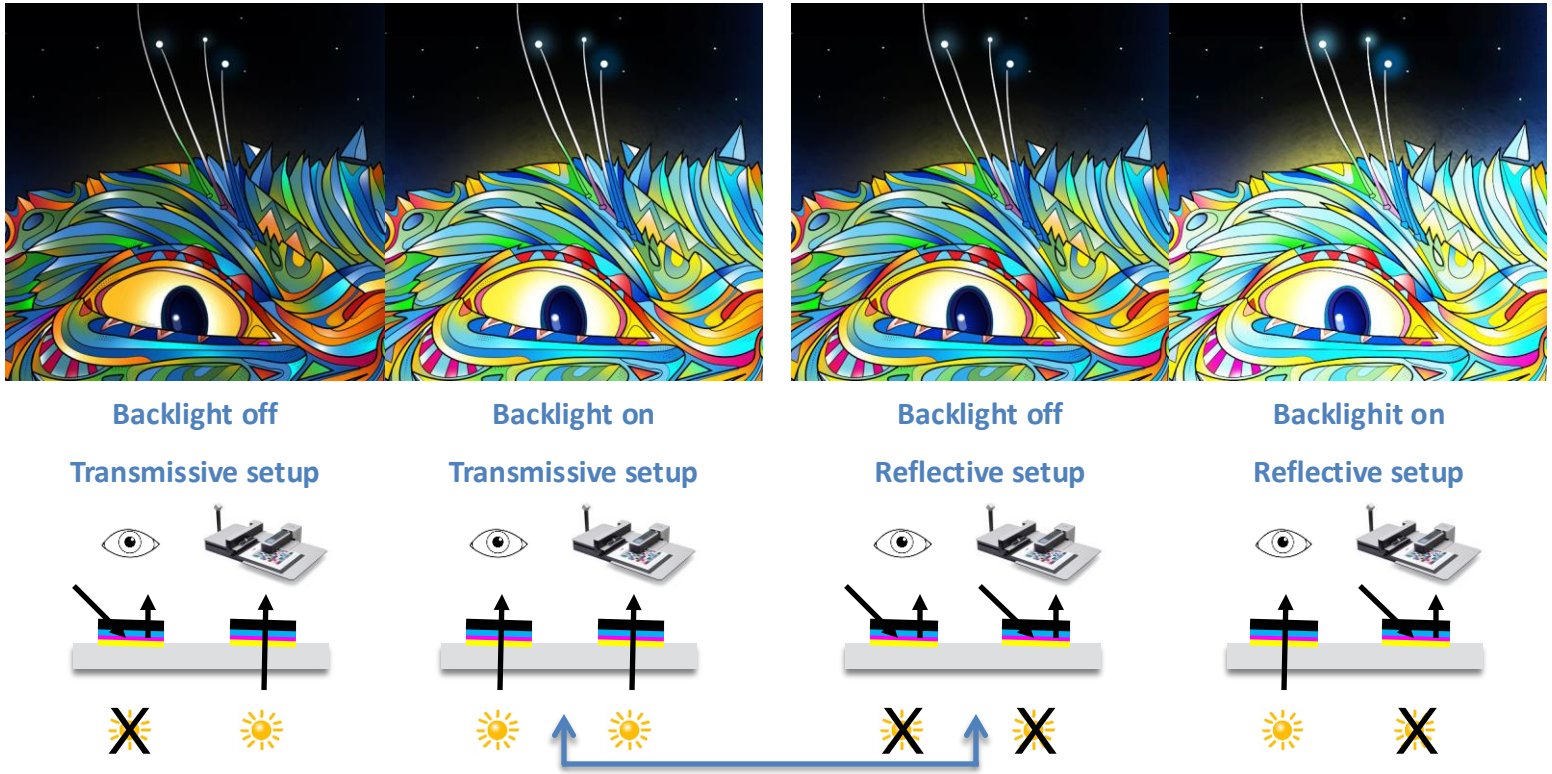


VISUAL: BACKLIGHT OFF/LIGHT ON VS. BACKLIGHT ON/LIGHT OFF

DAY – NIGHT PRINTING APPLICATIONS (BACKLIGHT OFF/ON)

⇨ **The challenge:**

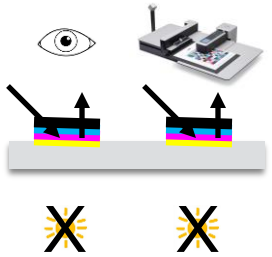


Backlight on/off – One setup to fulfill “Measure as we see”?

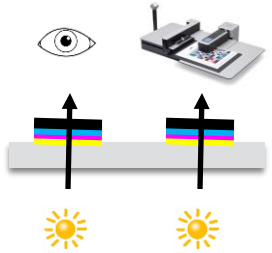
COLORANT RESPONSE IN TRANSMISSION

⇨ **Comparison and analysis of three setups related to the same printing combination**

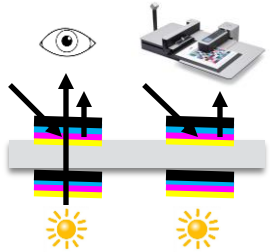
A – Reflective mode Frontside as reflective setup



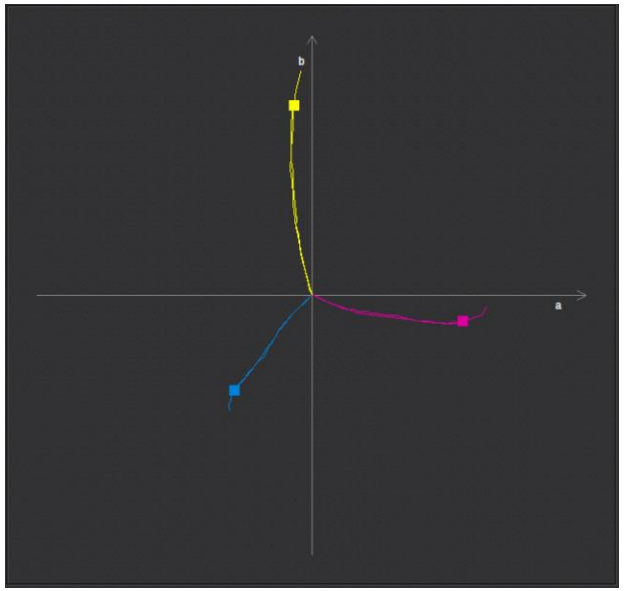
B – Backlit mode Frontside as transmissive setup

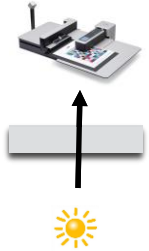


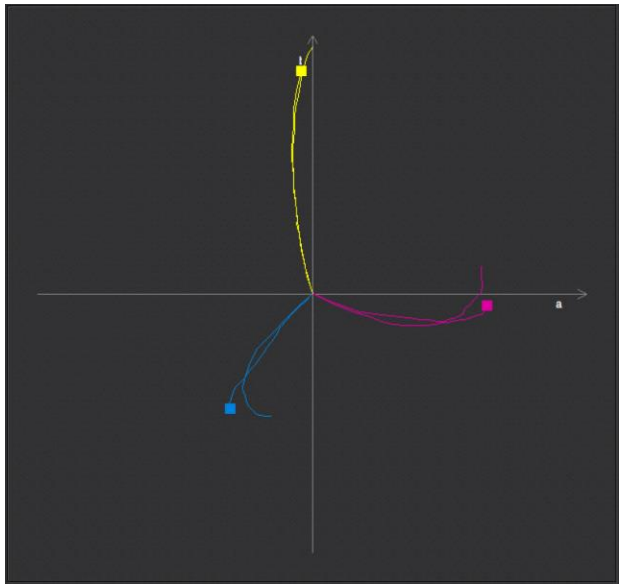
C – Dual sided Frontside/Backside or 3-Layer sandwich as reflective setup, identical Front & Back (A)



TX A vs. B



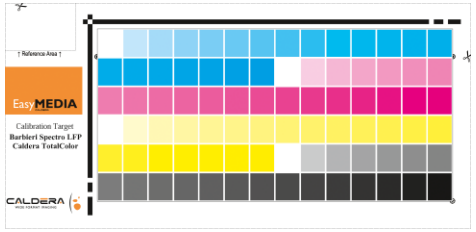




TX B vs. C

COLOUR MANAGEMENT METHOD

⇨ **Calculate the Backside to add to Frontside (A) to match Backlit (B) mode for Dual side setup:**



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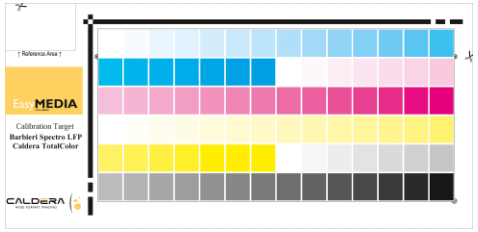

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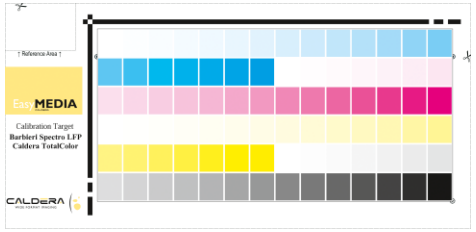
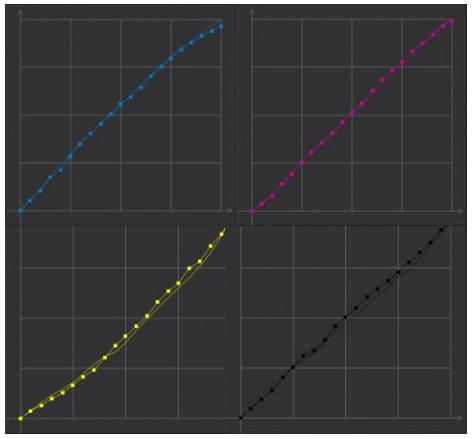
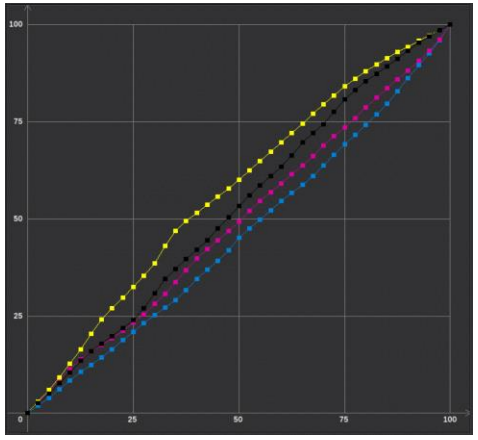


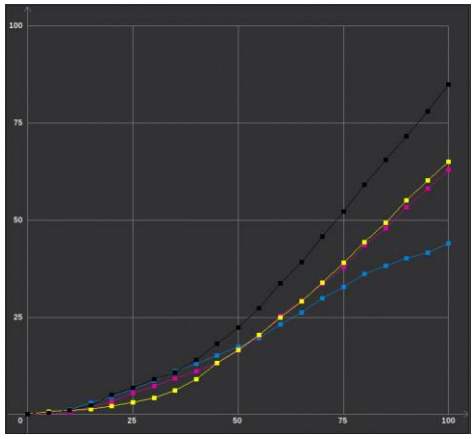
Case B (Frontside Backlit mode) transmittance aim

Case A (Frontside) used for reflectance, but also contribute towards transmittance

Needed (Backside) in transmittance



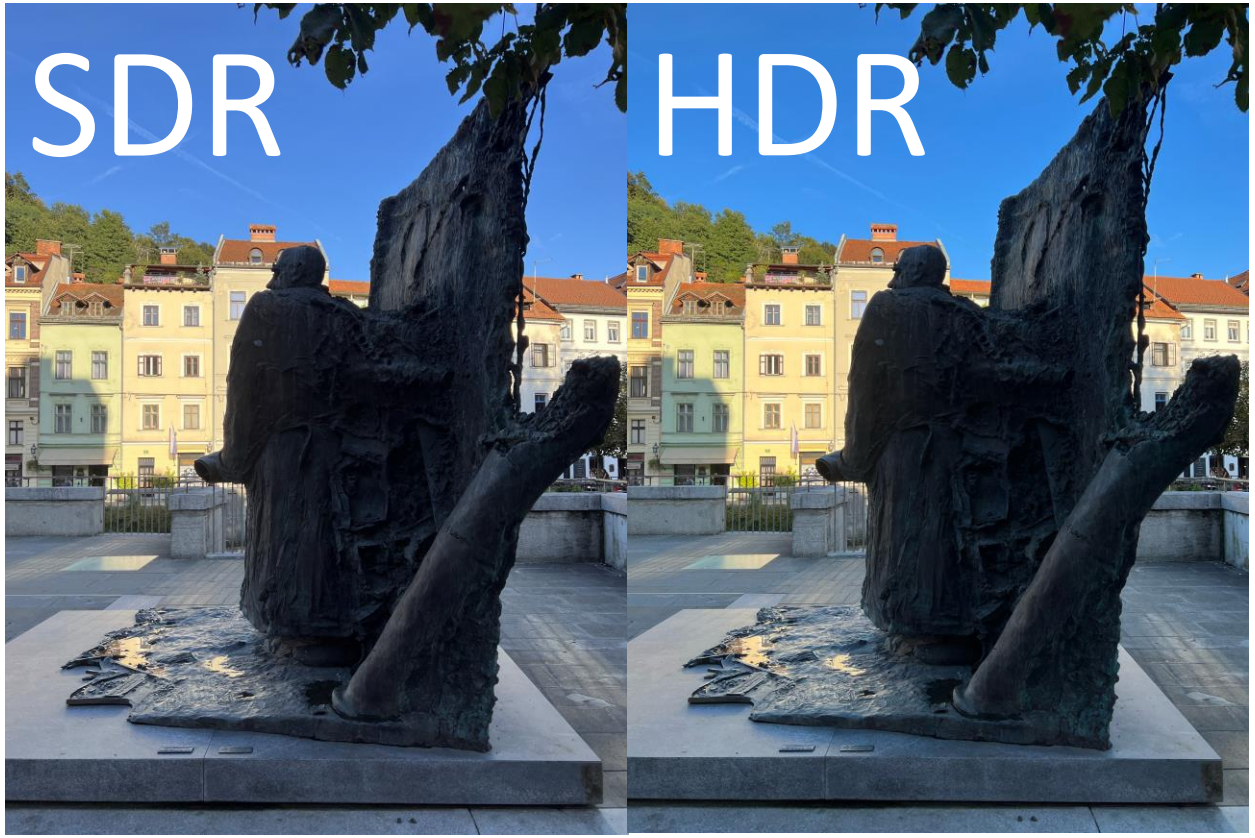




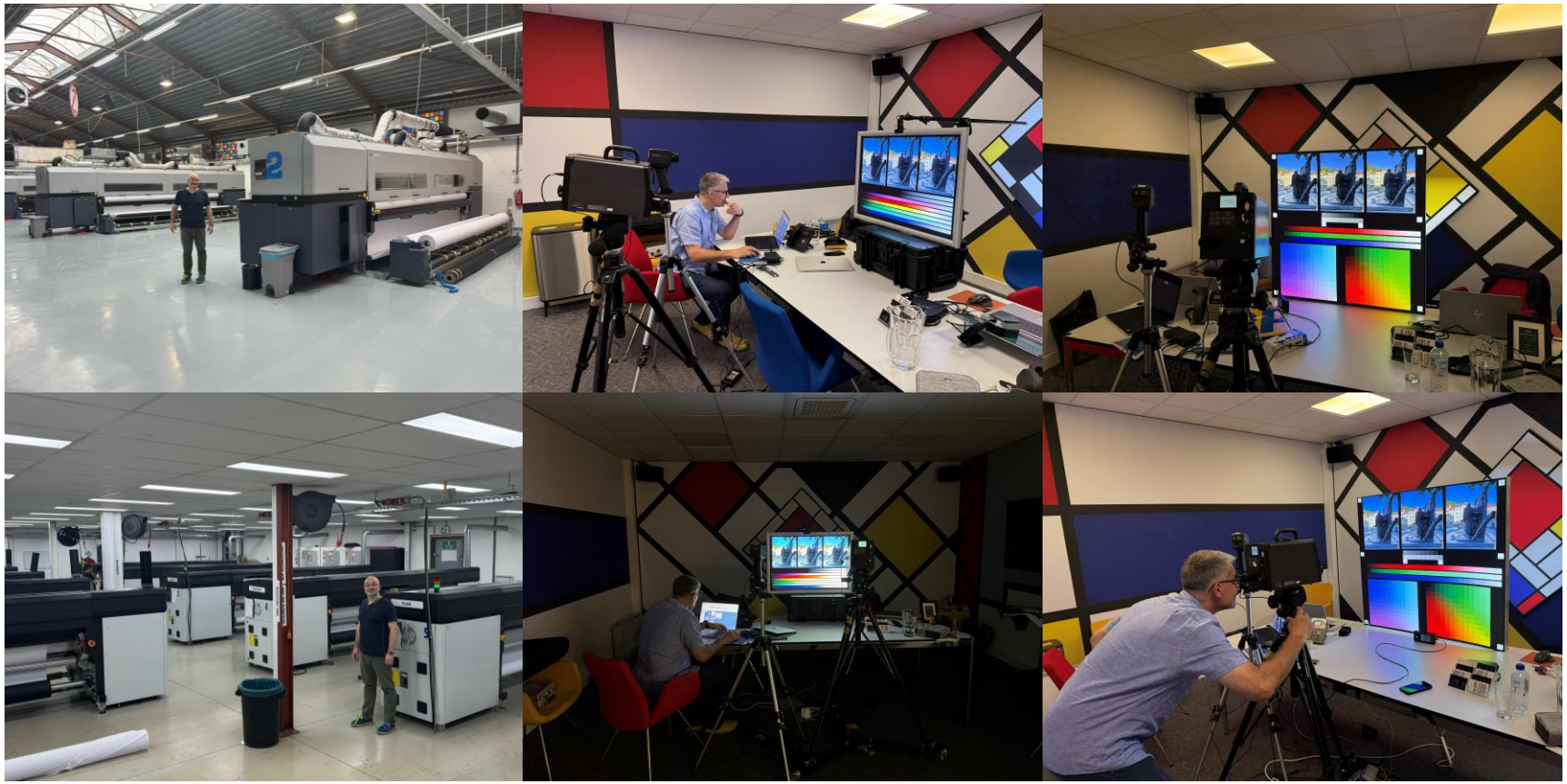
⇨ **Comparison of media-relative transmittance characterization data sets between single side Backlit with Dual Side/Sandwich – Avg. 1,5 ΔE^*_{00} /95% 2,4 ΔE^*_{00} /Max. 5,4 ΔE^*_{00}**

IS BACKLIT PRINTING A POTENTIAL HDR APPLICATION?

- **HDR is …**
  - … all about contrast,
  - … requires specific capable hardware for input (camera) and display (monitor)
  - … additional software features are necessary to handle the HDR content,
  - … it is possible to replicate the effect for backlit printing applications?
- **Some background**
  - Discussions inside DPWG
  - A bit of research together with Prof. Florian Süßl from Berliner Hochschule für Technik (BHT)
  - 3 days on-site at Van Straaten in The Netherlands
  - 2 backlit printing combination and 2 light boxes



BACKLIT PRINTING: PROCESS AND EVALUATION



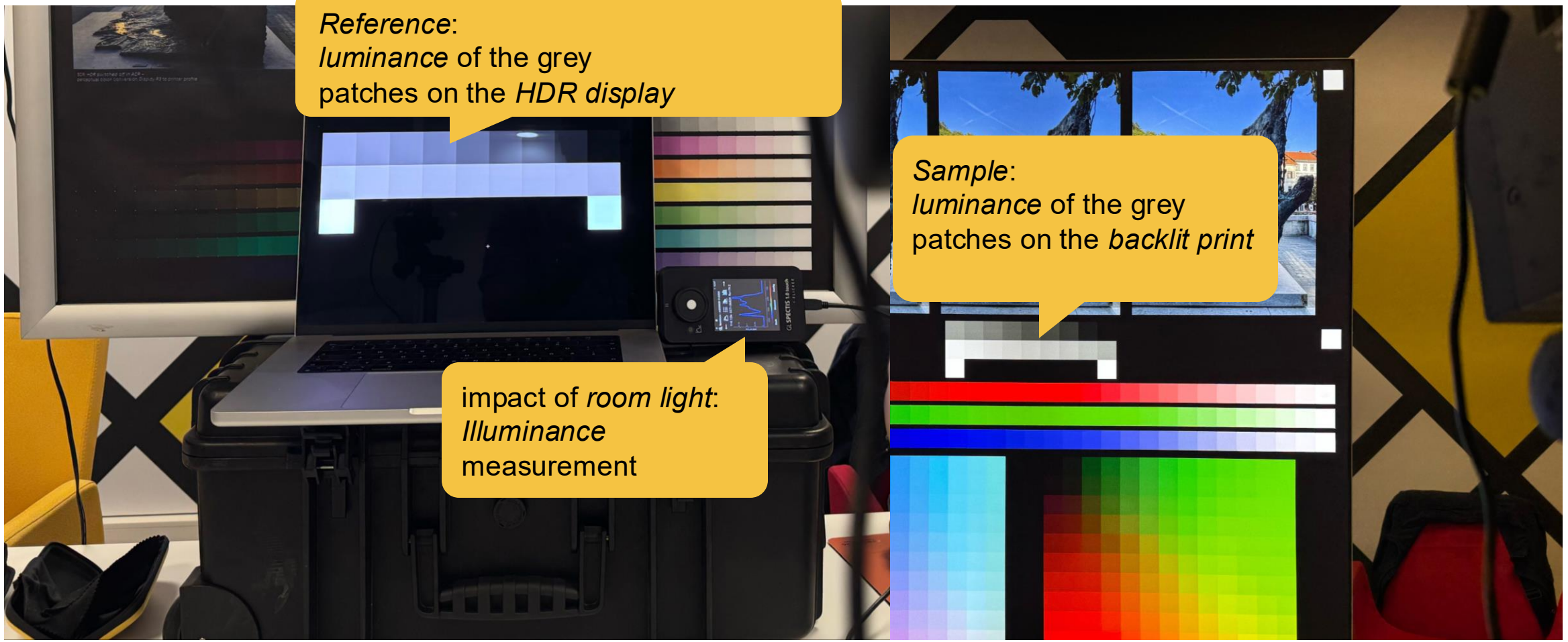
PARAMETERS AND TOOLS TO EVALUATE THE DYNAMIC RANGE

- **Luminance Lv [cd/m2 or nits] – "how bright an object appears to the eye"**
  - $DynamicRange = \frac{Lv_{max}[cd/m^2]}{Lv_{min}[cd/m^2]}$
- **How to measure luminance – "measure what you see"?**
  - Luminance Meter (Konica Minolta LS-160)

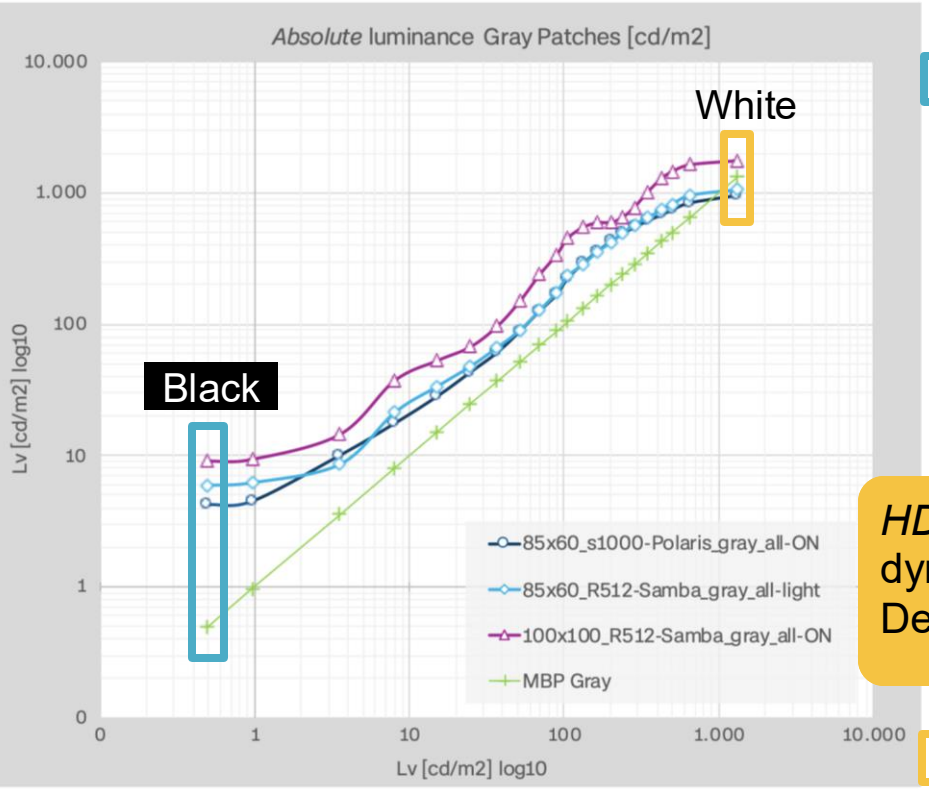
  - Spectroradiometer (Konica Minolta CS-2000)

  - … not to forget illuminance (GL Optic Spectis 1.0)

LUMINANCE AND ILLUMINANCE – HDR-DISPLAY (REFERENCE) VS. BACKLIT PRINT (SAMPLE)



LUMINANCE OF BACKLIT PRINT VS. HDR DISPLAY (REF.)



Patch	HDR 32float[1]	RGB 8bit	MBP Grav	85x60 s1000-Polaris grav all-ON	85x60 R512-Samba grav all-light	100x100 R512-Samba grav
Black	0	0	0,49	4,22	5,92	9,05
	0,004	13	0,96	4,49	6,21	9,35
	0,010	26	3,54	10,03	8,56	14,45
	0,019	38	7,99	17,53	21,19	37,06
	0,033	51	15,12	28,26	33,62	52,78
	0,051	64	24,83	43,2	47,82	67,26
	0,074	77	36,92	60,93	66,35	96,33
	0,100	89	51,72	88,39	90,06	149,42
	0,133	102	69,52	126,29	127,7	239,02
	0,171	115	89,38	168,18	174,86	337,07
	0,216	128	105,72	224,83	233,55	453,27
	0,262	140	133,45	291,09	286,23	548,36
				358,6		592,83
				425,		597,07
				489,		655,08
				548,		777,65
				612,		016,52
				680,		1285,4
ref. Wht.	1,012	230	99,84	741,32	814,72	1452,46
	1.361	242	650.3	839.77	958.29	1638.37
White	2,642	255	1325,83	957,6	1058,76	1763,78
		Dynamic range:	2706 : 1	227 : 1	179 : 1	195 : 1
		D vis:	3,4	2,4	2,3	2,3
		Illuminance:	186,95 lx (»VS all on«)	186,95 lx (»VS all on«)	186,95 lx (»VS all on«)	186,95 lx (»VS all on

[1] *HDR 32float*: Linear Rec. 2020

HDR patches (*headroom*)

HDR display (reference):
dynamic range: *2700 : 1*
Density range (Dvis): *3.4*

Backlit print (sample):
dynamic range: *227 : 1*
Density range (Dvis): *2.4*

HDR BACKLIT PRINT – FINDINGS

- ✅ **White point**
  - Luminance of light box and substrate matches the HDR display peak luminance
- ❌ **Black point**
  - The typically achieved black point D2.4 is not yet dark enough
  - At least D3.0 is required, but both tested printing combinations were at the highest achievable values
- ❌ **Tone mapping and tone reproduction**
  - Deviating contrast/ gradation
  - Missing headroom and shadow details

HDR BACKLIT PRINT – NEXT STEPS

- **Improve Black point for an increase dynamic range of at least 1000:1**
  - Backlit only application: find higher >D3.0 density able K ink that can be used for the project printing combinations
  - For dual side and sandwich, alternative ways to increase the overall optical density
- **Measurements**
  - ❗ Evaluate consistency and stability in the D3.0 range
- **Tone mapping and tone reproduction**
  - Better match with the tone reproduction of HDR on display
  - ❗ Adopt and use the methods already defined for still images (gain map, adaptive gain curve, ICC cicpTag)
- **Integrate the presented color management methods**
  - Lightbox SPD
  - Daylight illumination (Frontside/1st layer) as SDR
  - Backlit illumination (contribution from Backside/2nd layer) as HDR

THANK YOU FOR YOUR ATTENTION

Q & A

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