

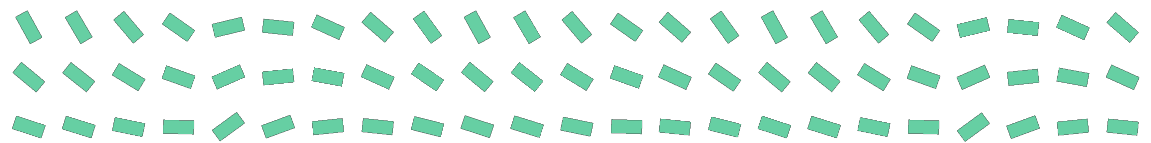
W3C WORKSHOP ON WCG AND HDR FOR THE WEB

Hybrid Log-Gamma HDR

Part 1 - Mixed Display and Viewing Environments

Andrew Cotton— Principal Technologist, BBC R&D
March 2021



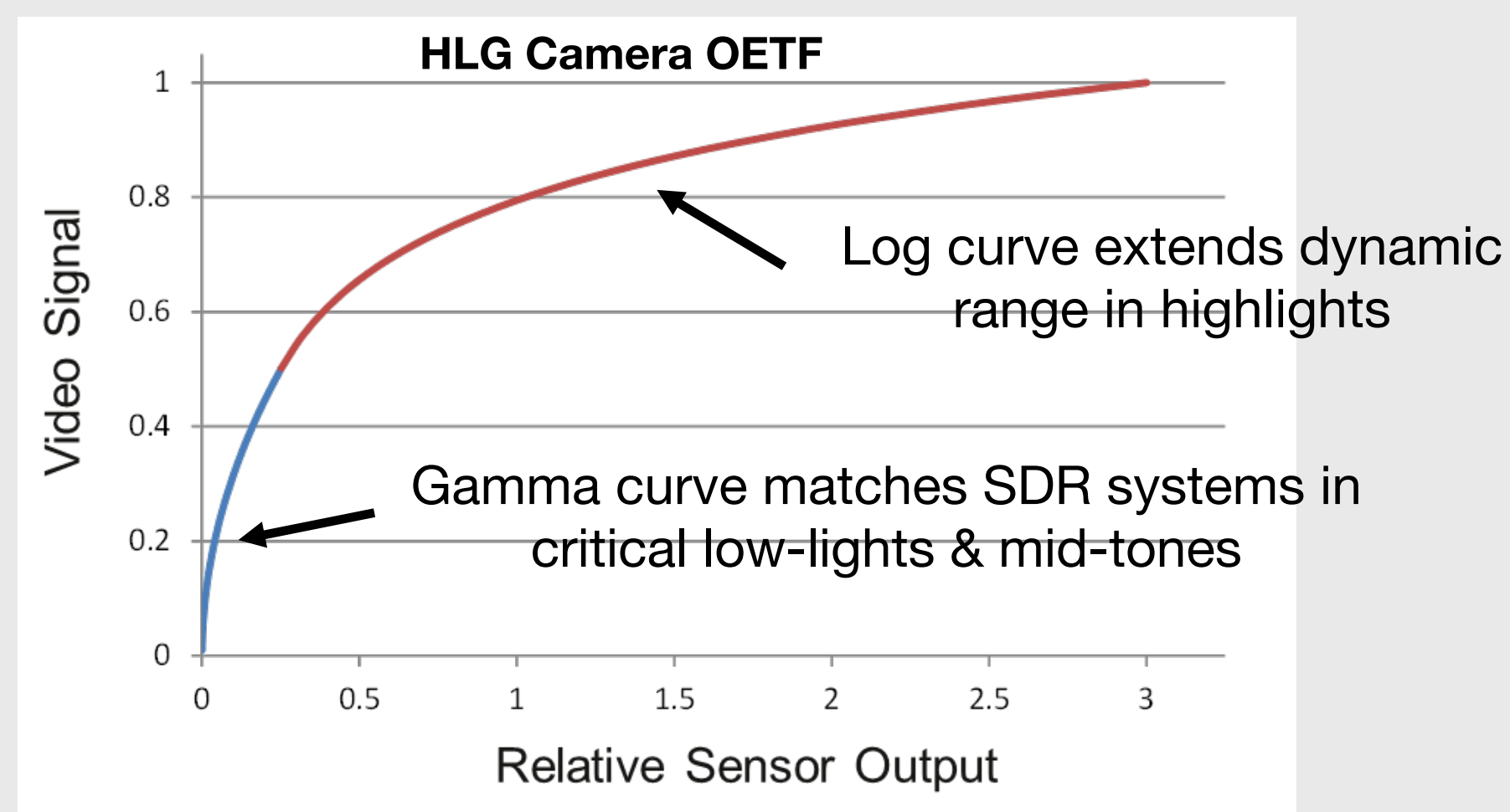


W3C WORKSHOP ON WCG AND HDR FOR THE WEB

Overview – Part 1

- Introduction to HLG
 - Designed for variety of displays
 - Domestic viewing environments
 - Summary
-
- Part 2, Format conversion and compositing

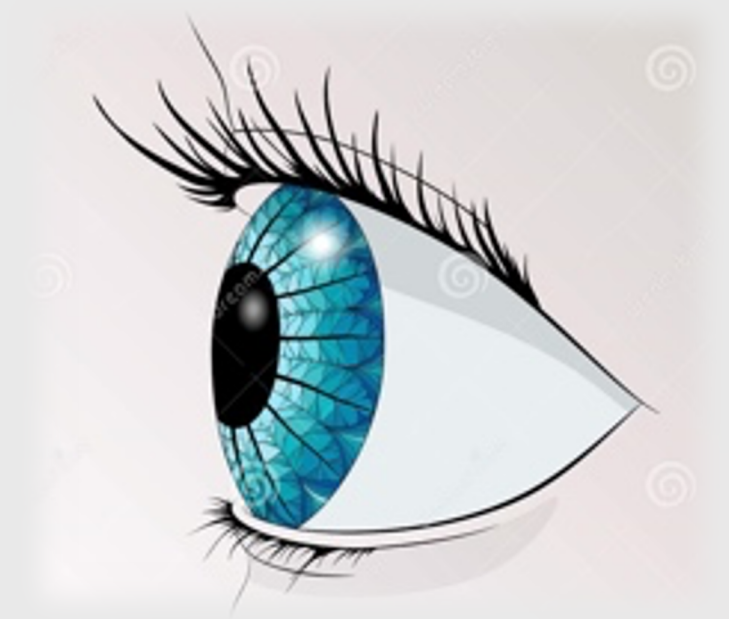
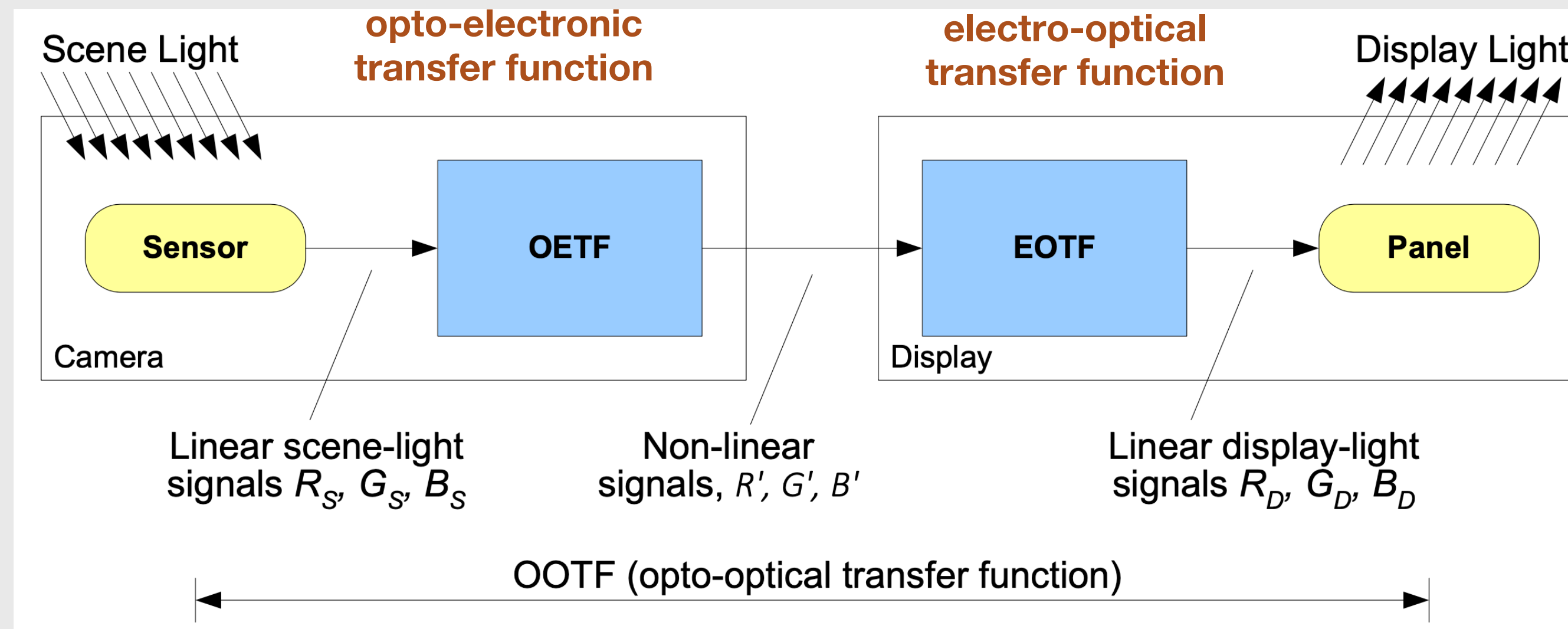
Hybrid Log-Gamma named after the camera OETF



- Converts linear ***scene-light*** from camera sensor into non-linear signal for 10-/12-bit digital interfaces
 - Matched to sensitivity of human visual system (HVS) to ensure minimal banding artefacts after quantisation
- HLG OETF (Opto-Electronic Transfer Function) combination of traditional “gamma” curve and logarithmic curve
- Delivers a compatible image on SDR WCG BT.2020 displays

“The most important aspect of any TV system is the OOTF”

Masayuki Sugawara, when Deputy Head NHK STRL



- End-to-end chain has **opto-optical transfer function (OOTF)**
 - OOTF ensures subjectively similar images on the display, to the scene in front of the camera
 - The OOTF must change to accommodate different brightness displays and environments
 - Both affect adaptation state of the eye, which changes perception of tones (and potentially colour)

OOTF usually a “gamma law” - preserves subjective appearance of the scene

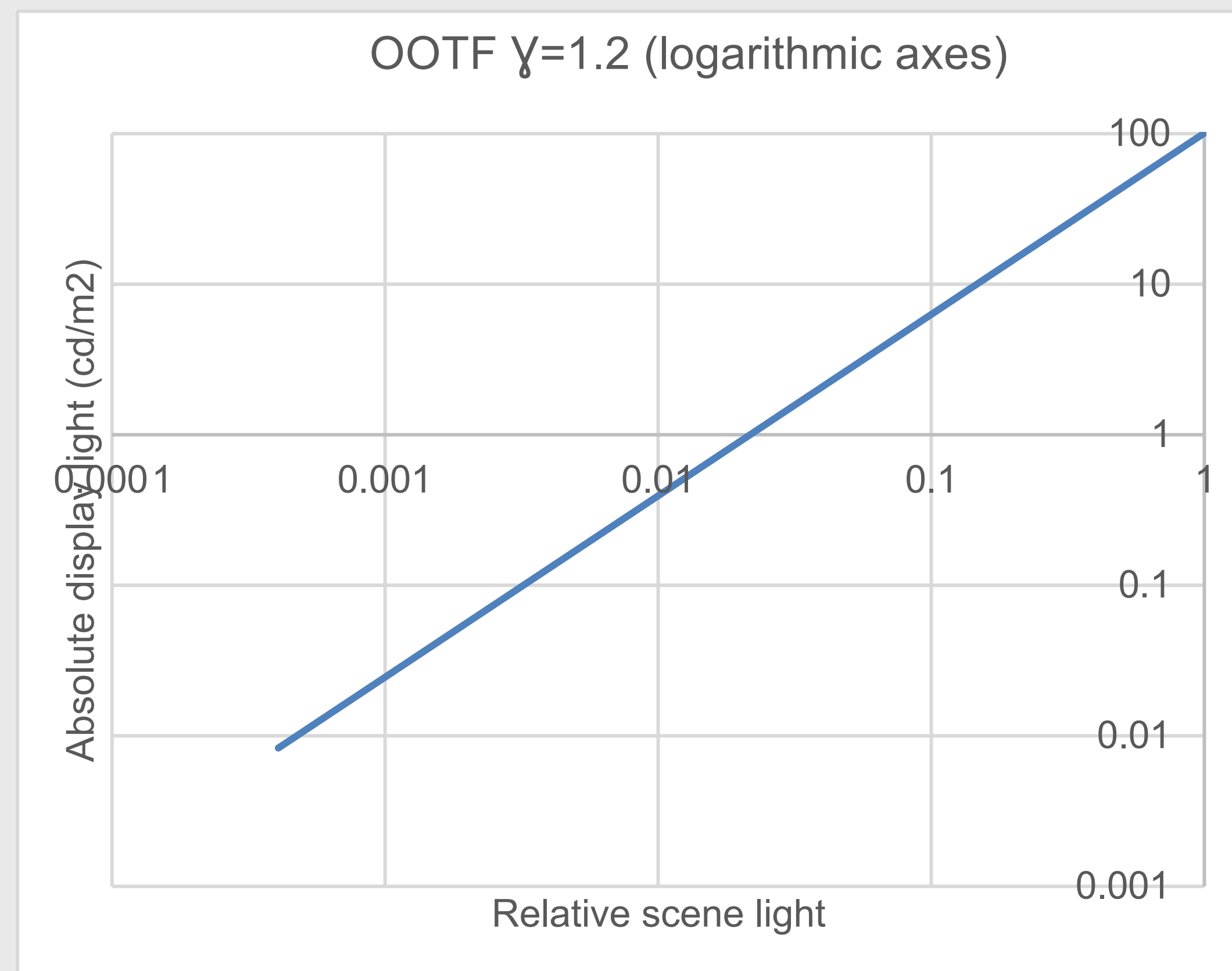
- For a gamma law OOTF,

$$\text{displayed light} \propto \text{scene light}^\gamma$$

- Eye's sensitivity to light intensity is approximately logarithmic
- So as seen by the eye,

$$\text{Log}(\text{displayed light}) \propto \gamma \text{Log}(\text{scene light})$$

- Thus, appearance of scene in front of camera is maintained on TV display



OOTF Gamma critical for HDR as display capabilities so diverse



Gamma too low



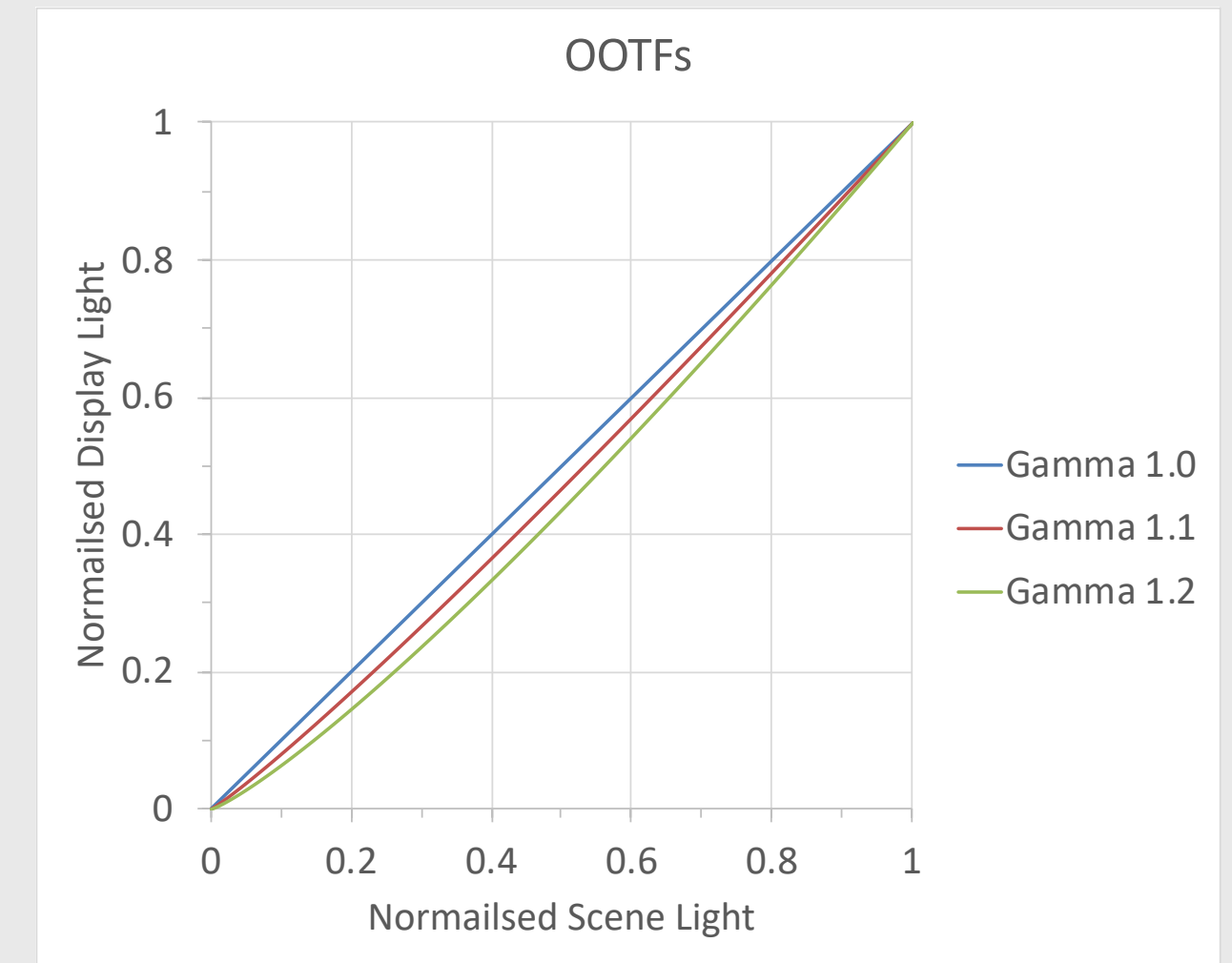
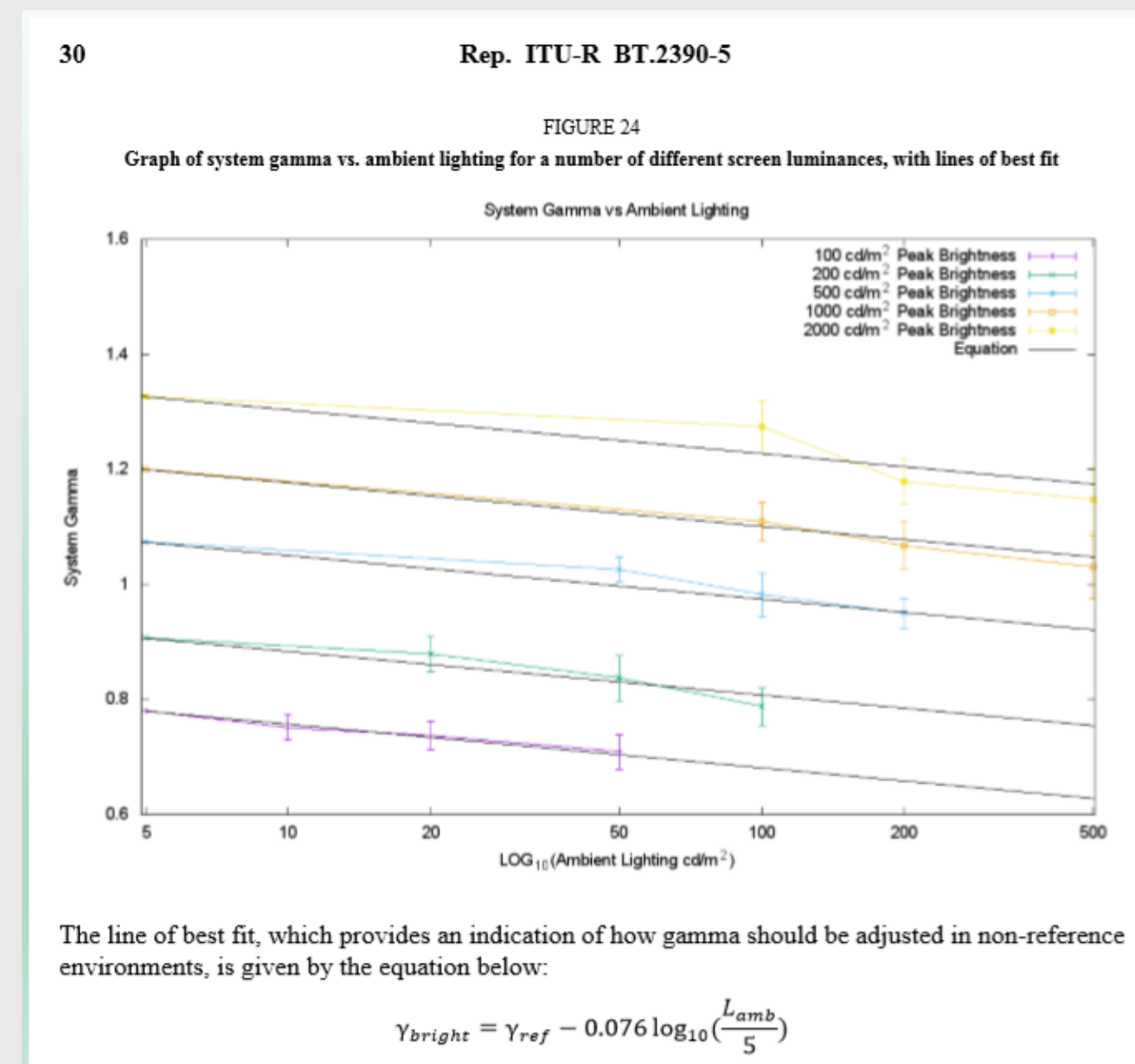
Gamma correct



Gamma too high

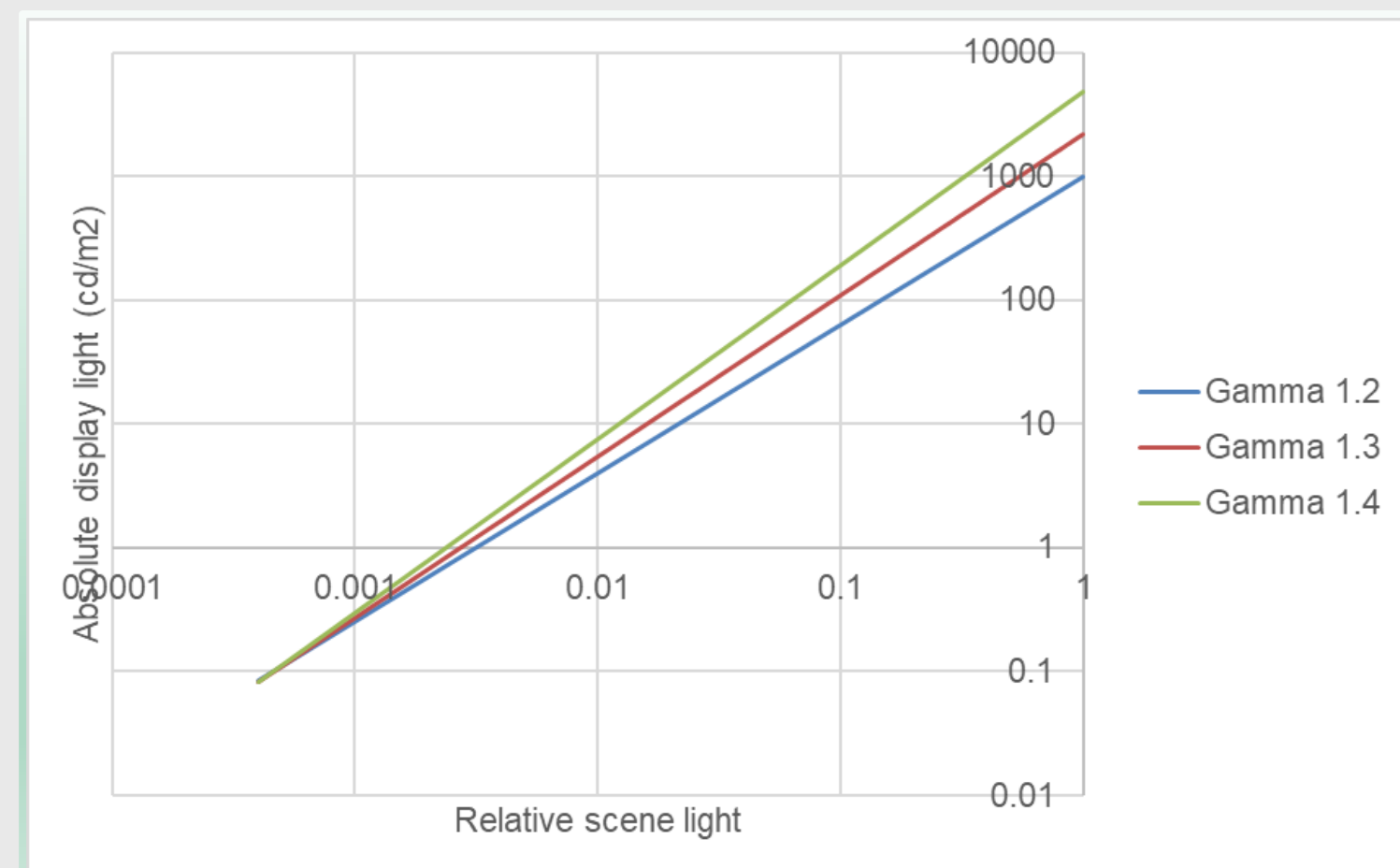
Brighter viewing environments require a lower OOTF gamma

- A lower display gamma lifts detail out of the shadows
 - More visible with brighter ambient light
- **Formula for HLG “gamma” change with viewing environment derived through BBC subjective testing**
 - Specified in ITU-R Report BT.2390
 - Now implemented in some consumer TVs

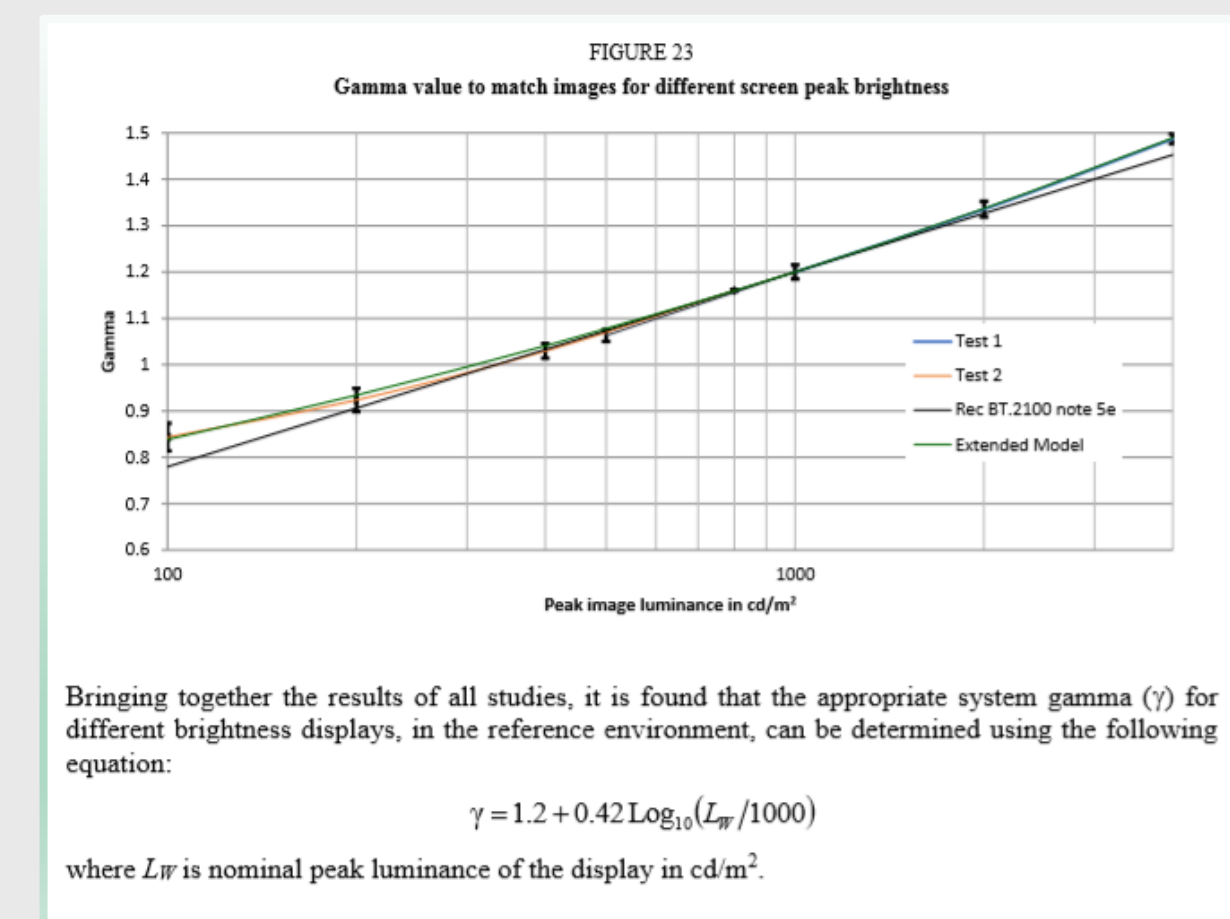


Brighter displays require a higher OOTF gamma

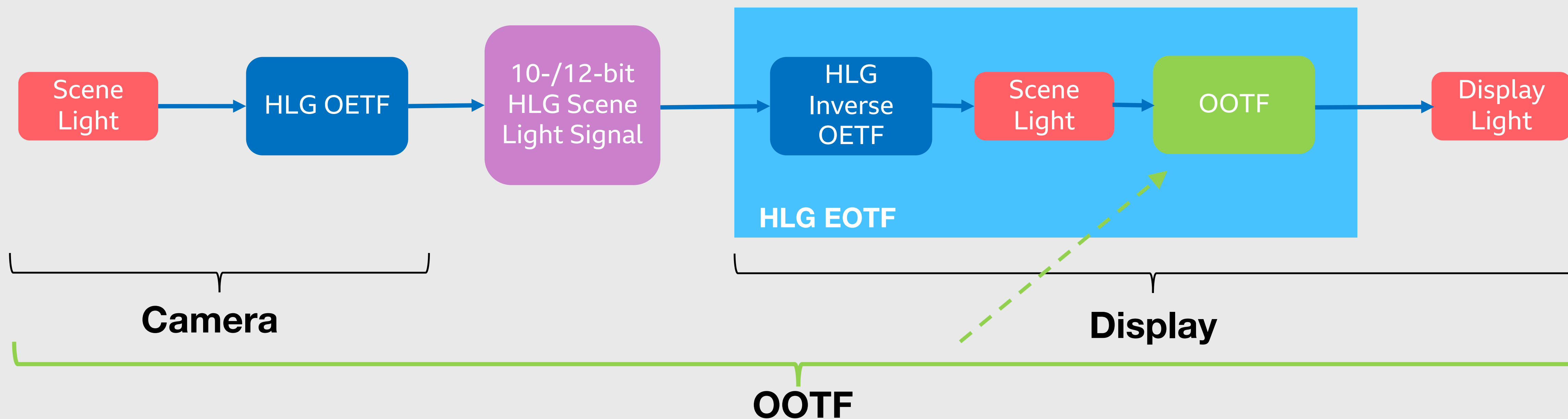
- Should have been no real surprise due to logarithmic sensitivity of HVS
- **Formula for HLG gamma with different luminance displays derived through BBC & NHK subjective testing**
 - *specified in ITU-R Recommendation BT.2100, Note 5f & Footnote 2*
- *Entire signal displayed regardless of display peak luminance*



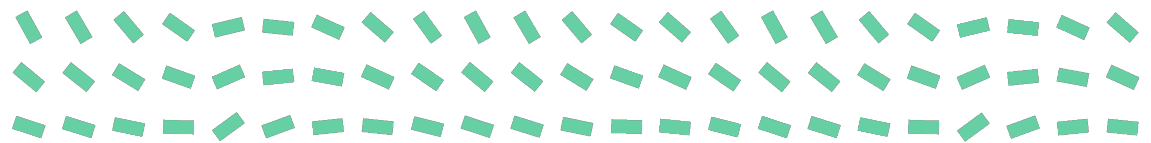
DVB-EBU HDR Workshop
IRT, Munich, Germany, 17 June 2014



For “scene-referred” systems like HLG, OOTF is part of the display so can vary



- For display-referred systems such as PQ, the OOTF is part of the camera/grading so burnt-in to signal and cannot vary (see BT.2100 Annex 1)



Same HLG signal, different gamma for each environment and display



		Surround Luminance(cd/m2)						
		Dark		Dim			Daytime	
		0.05	1	2	5	10	100	500
Display Nominal Peak Luminance	108	1.01	0.91	0.89	0.86	0.83	0.76	0.70
	400	1.20	1.10	1.07	1.04	1.02	0.94	0.89
	600	1.26	1.16	1.14	1.11	1.09	1.01	0.96
	1000	1.35	1.25	1.23	1.20	1.18	1.10	1.05
	2000	1.49	1.39	1.36	1.33	1.31	1.23	1.18
	4000	1.63	1.53	1.51	1.48	1.46	1.38	1.33

- Use more accurate BT.2100 “Footnote 2” gamma formula, especially for dimmer displays (e.g. <=400 cd/m²)
- Viewing environment survey results:

<https://www.bbc.co.uk/rd/blog/2020-12-results-from-the-ambient-lighting-survey>

W3C WORKSHOP ON WCG AND HDR FOR THE WEB

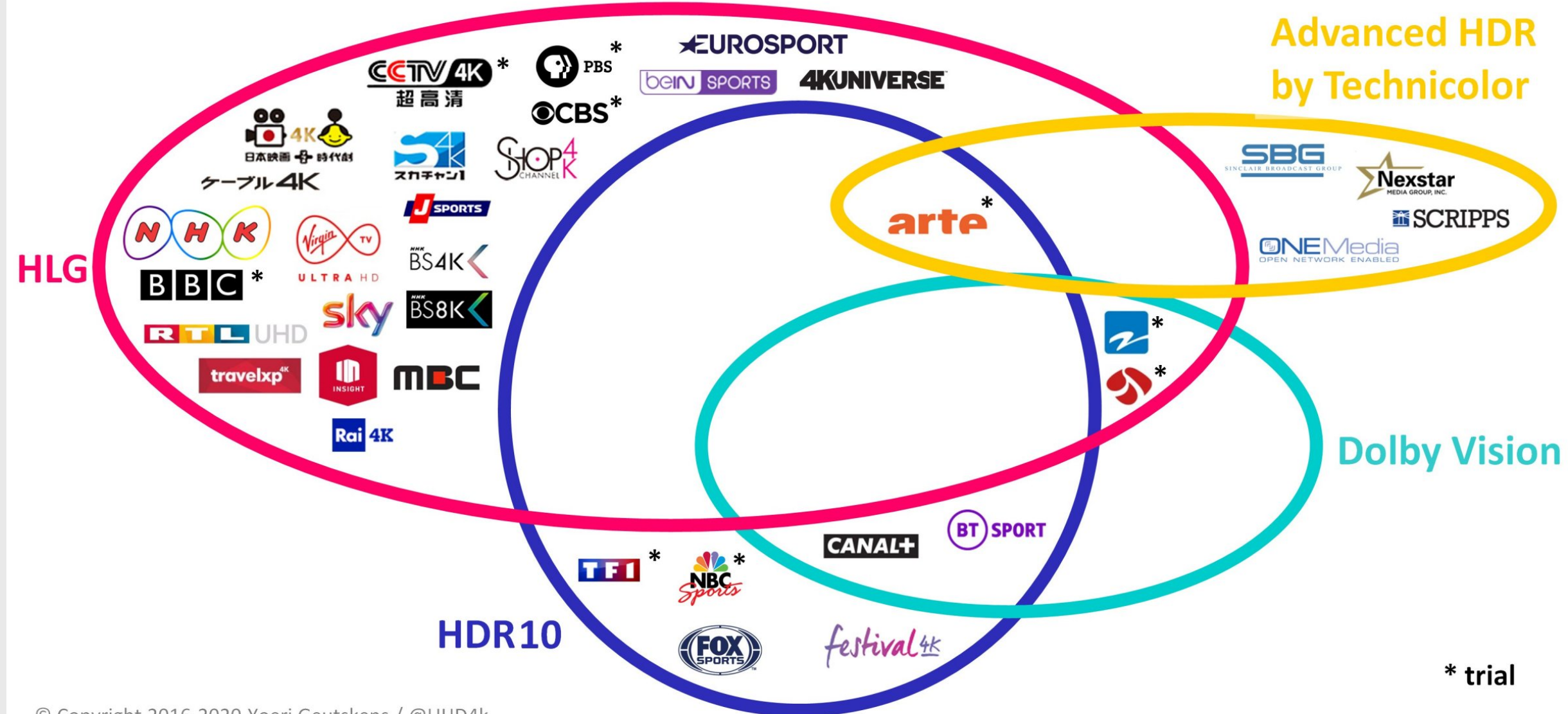
HLG in other applications



HLG is the HDR format of choice for TV broadcasters



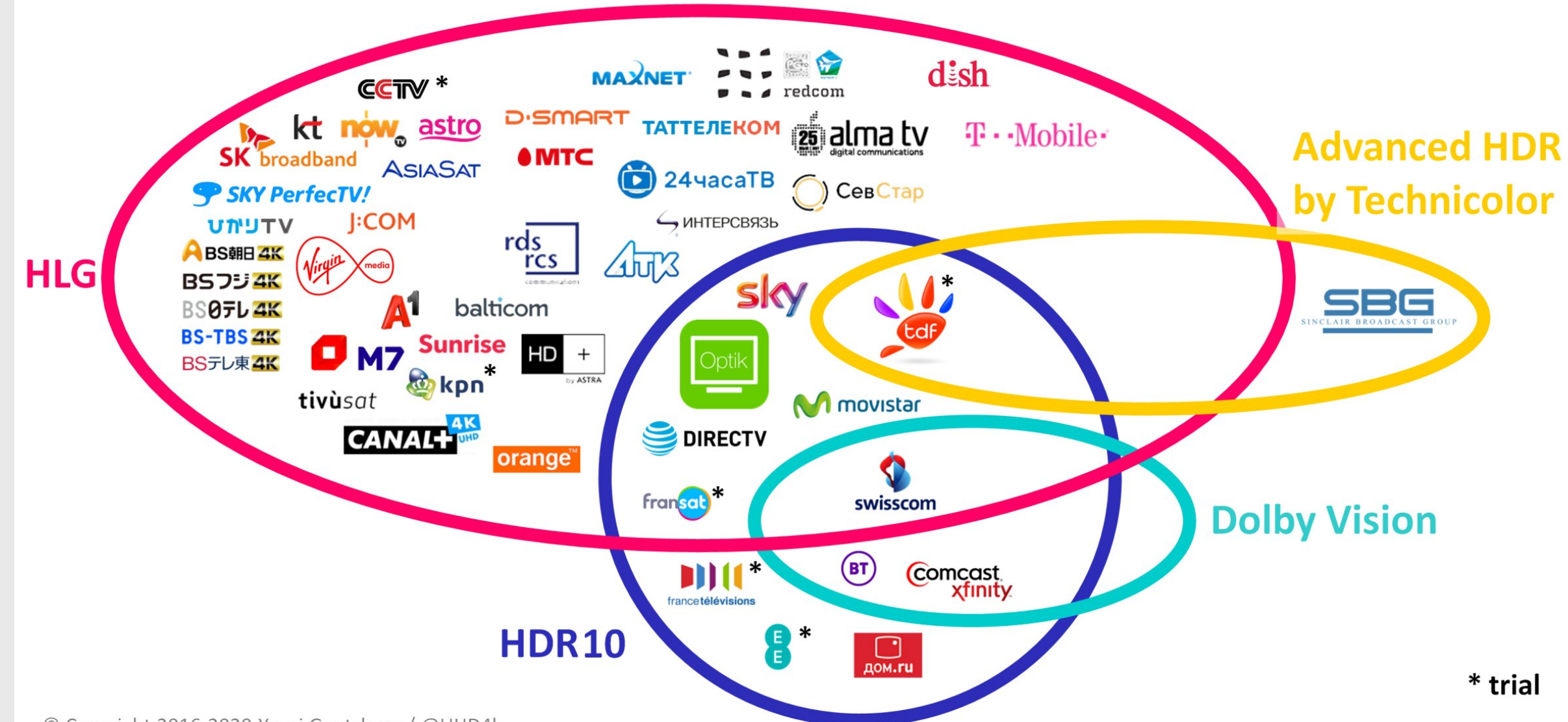
HDR Ecosystem Tracker fall 2020



© Copyright 2016-2020 Yoeri Geutskens / @UHD4k

Operators (DTT, DTH, Cable, IPTV)

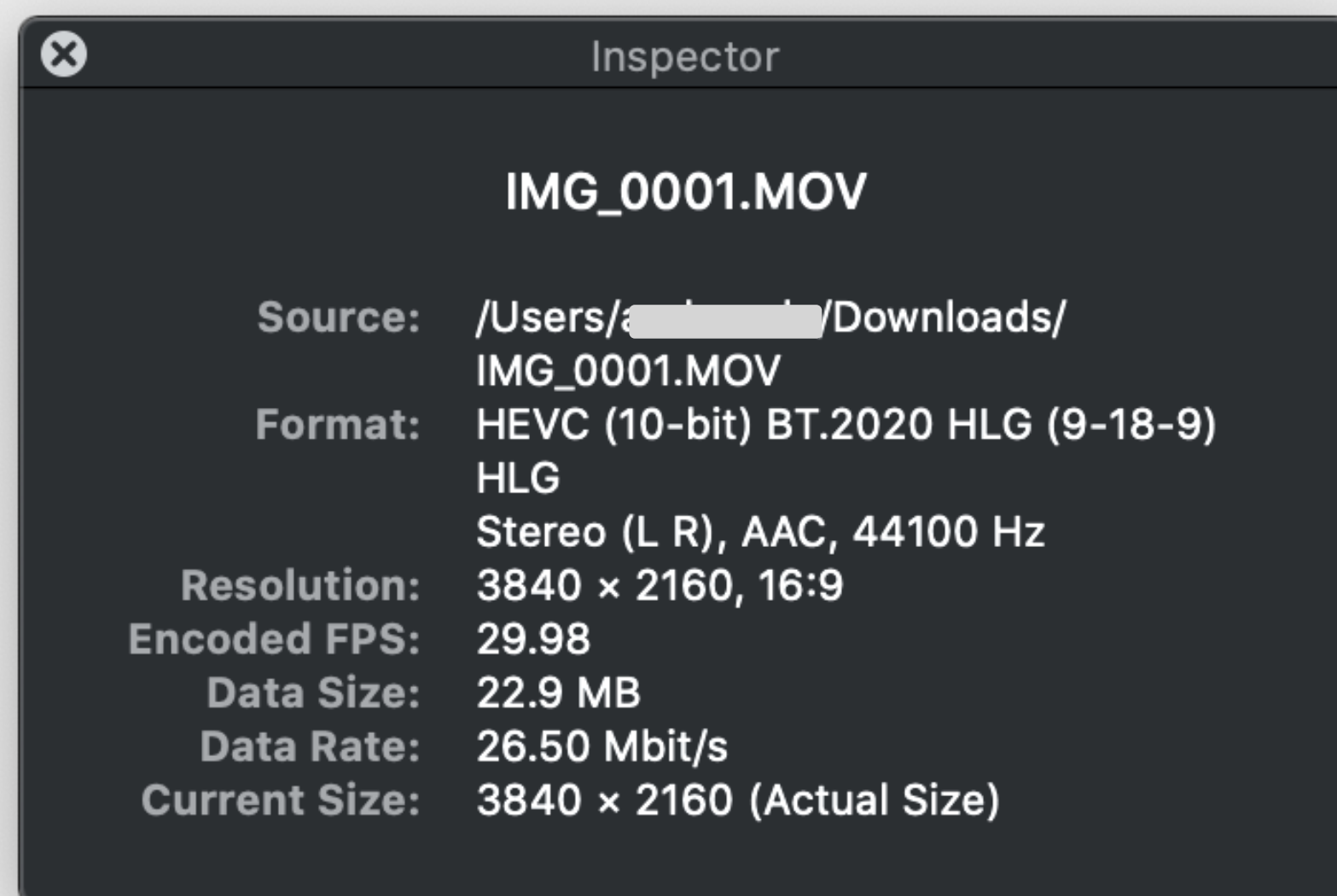
HDR Ecosystem Tracker fall 2020

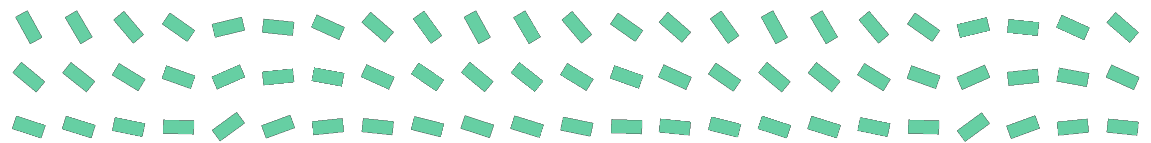


© Copyright 2016-2020 Yoeri Geutskens / @UHD4k

Apple iPhone records HDR video in HLG

- HDR Dolby Vision recording
 - *Built on HLG*





W3C WORKSHOP ON WCG AND HDR FOR THE WEB

Summary – Part 1

- HLG designed from the outset to address a wide range of displays and viewing environments
- OOTF gamma for different peak luminance displays in ITU-R BT.2100 (Footnote 2)
- OOTF gamma for different surround luminance in ITU-R BT.2390
- HLG the predominant HDR format amongst TV broadcasters

Andrew Cotton

andrew.cotton@bbc.co.uk

www.bbc.co.uk/rd/projects/high-dynamic-range