FlowIP

UHD/HDR Broadcast

More Than Just Resolution

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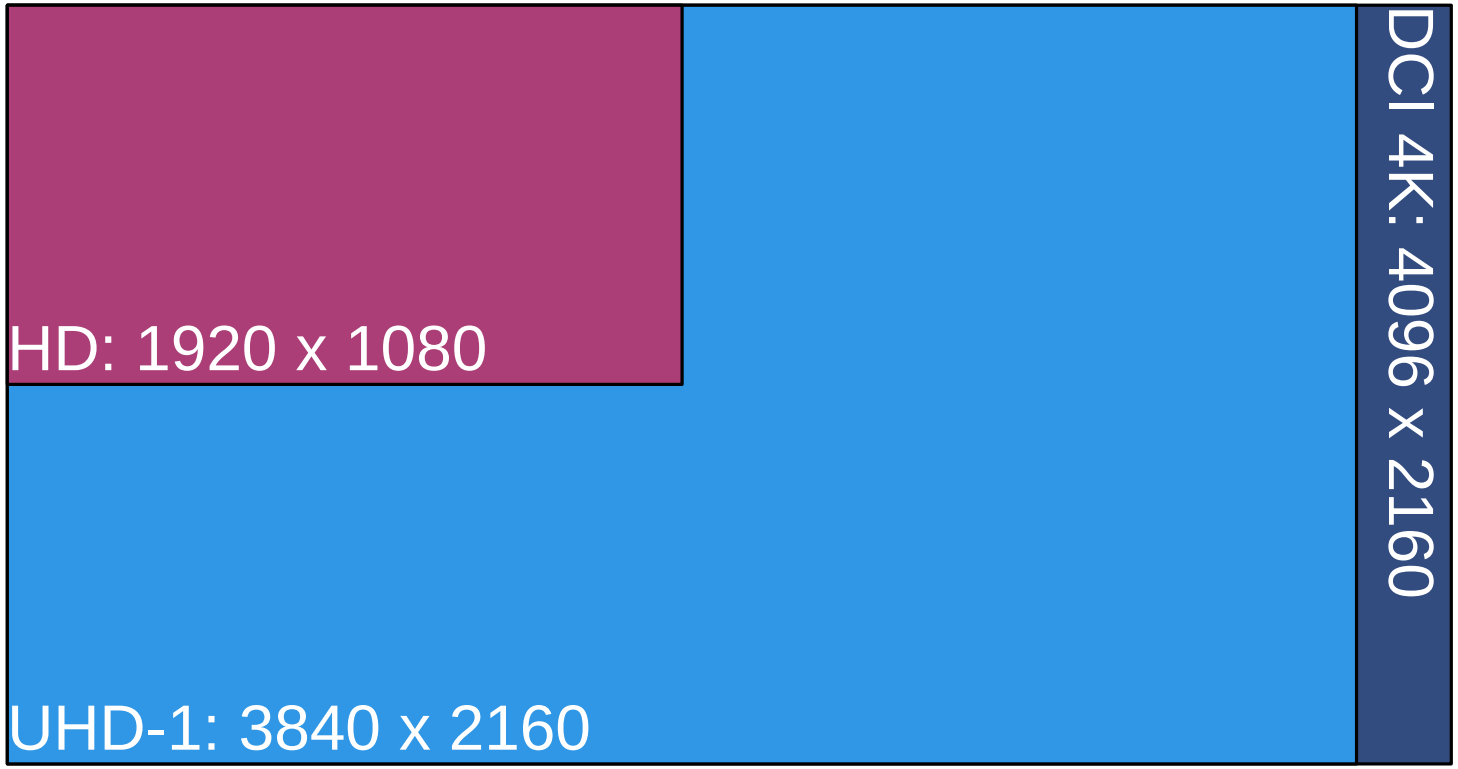
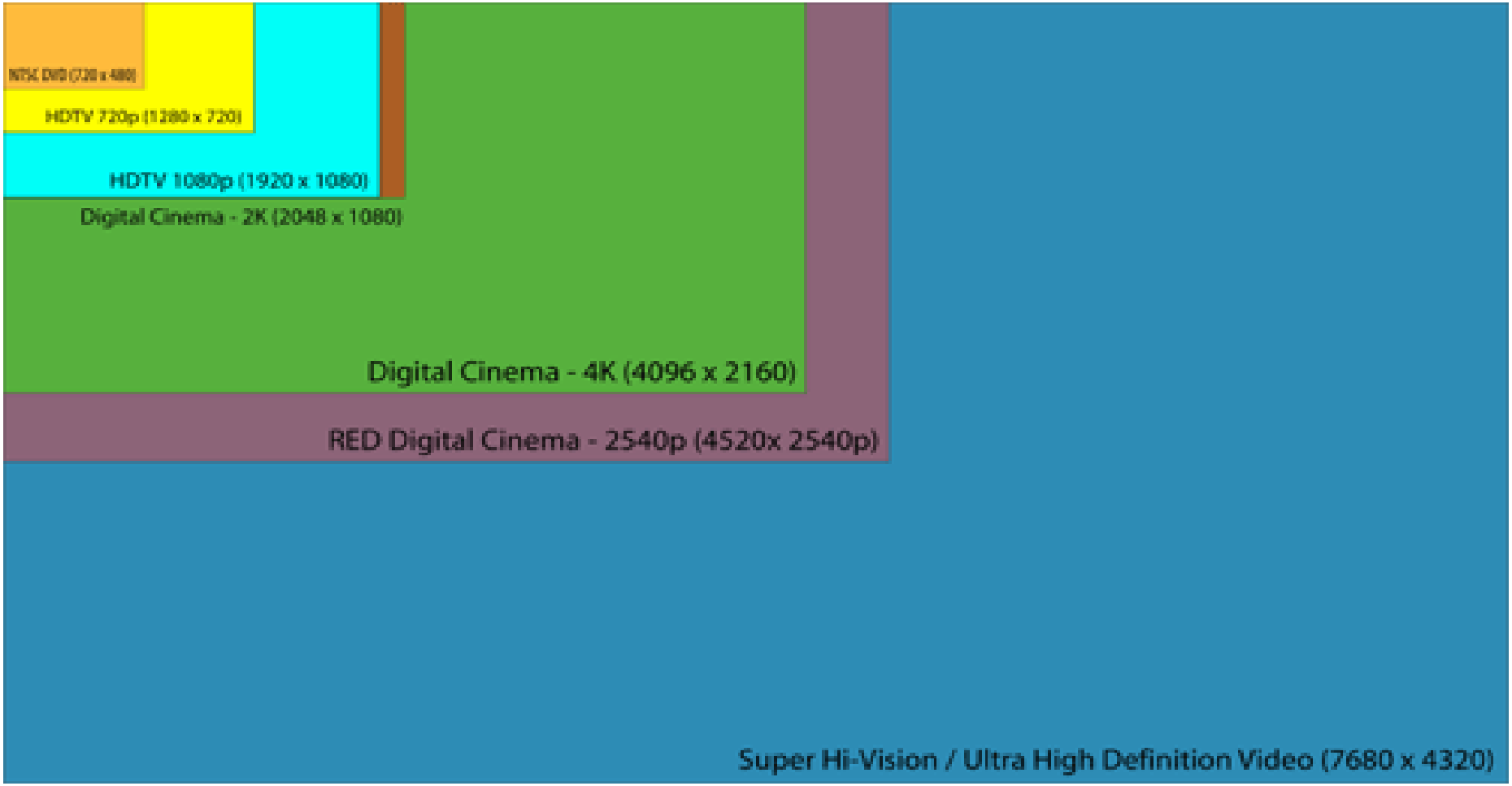
ROHDE&SCHWARZ

4k x 2k Ultra HDTV Format: UHD-1



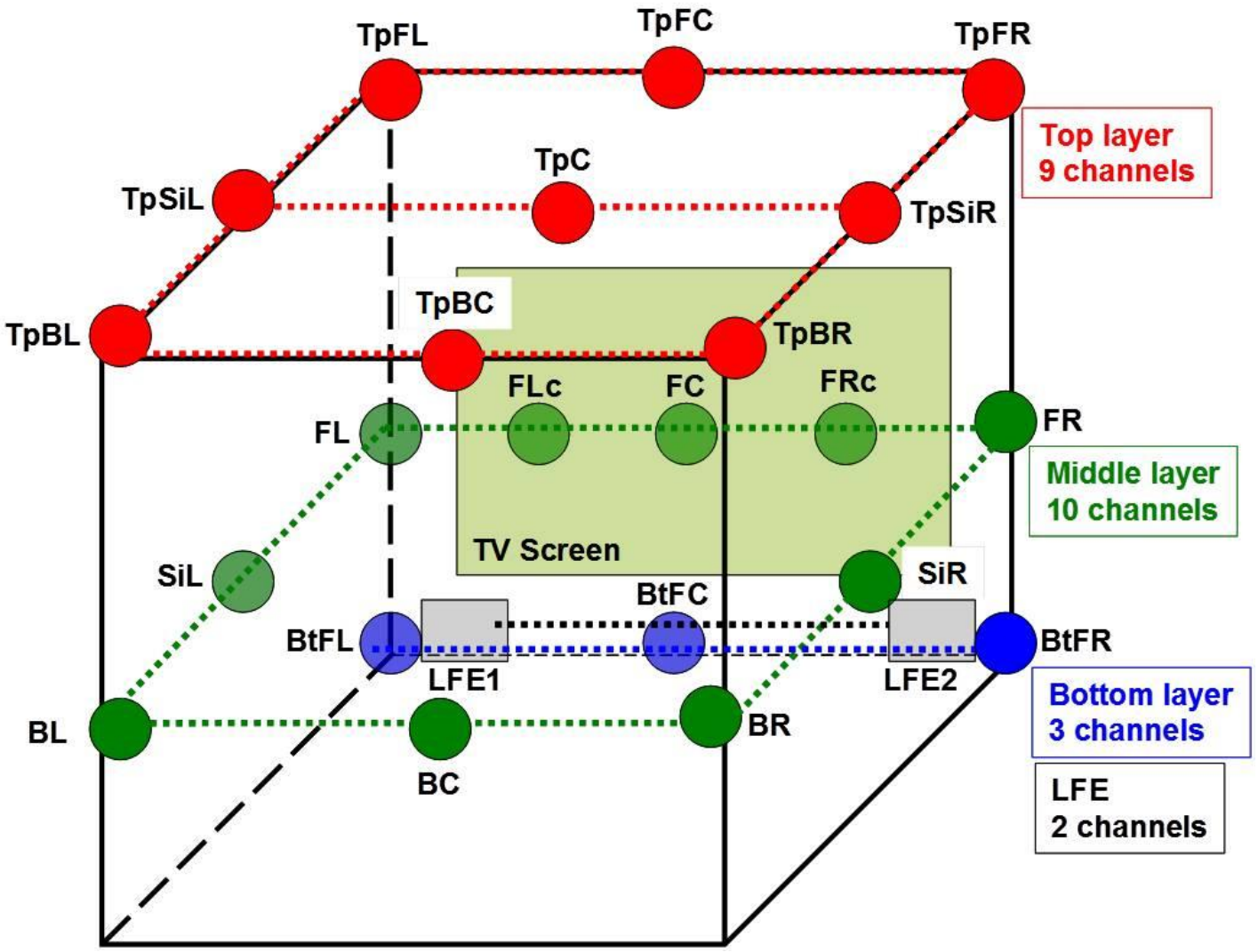
- **UHD-1: 3840 x 2160**
  - 4 x HD Resolution (8 Megapixels)
- **DCI 4K: 4096 x 2160**
  - Digital Cinema Initiative for equivalent resolution as 35mm Film

8k x 4k Ultra HDTV Format: 8K UHD-2

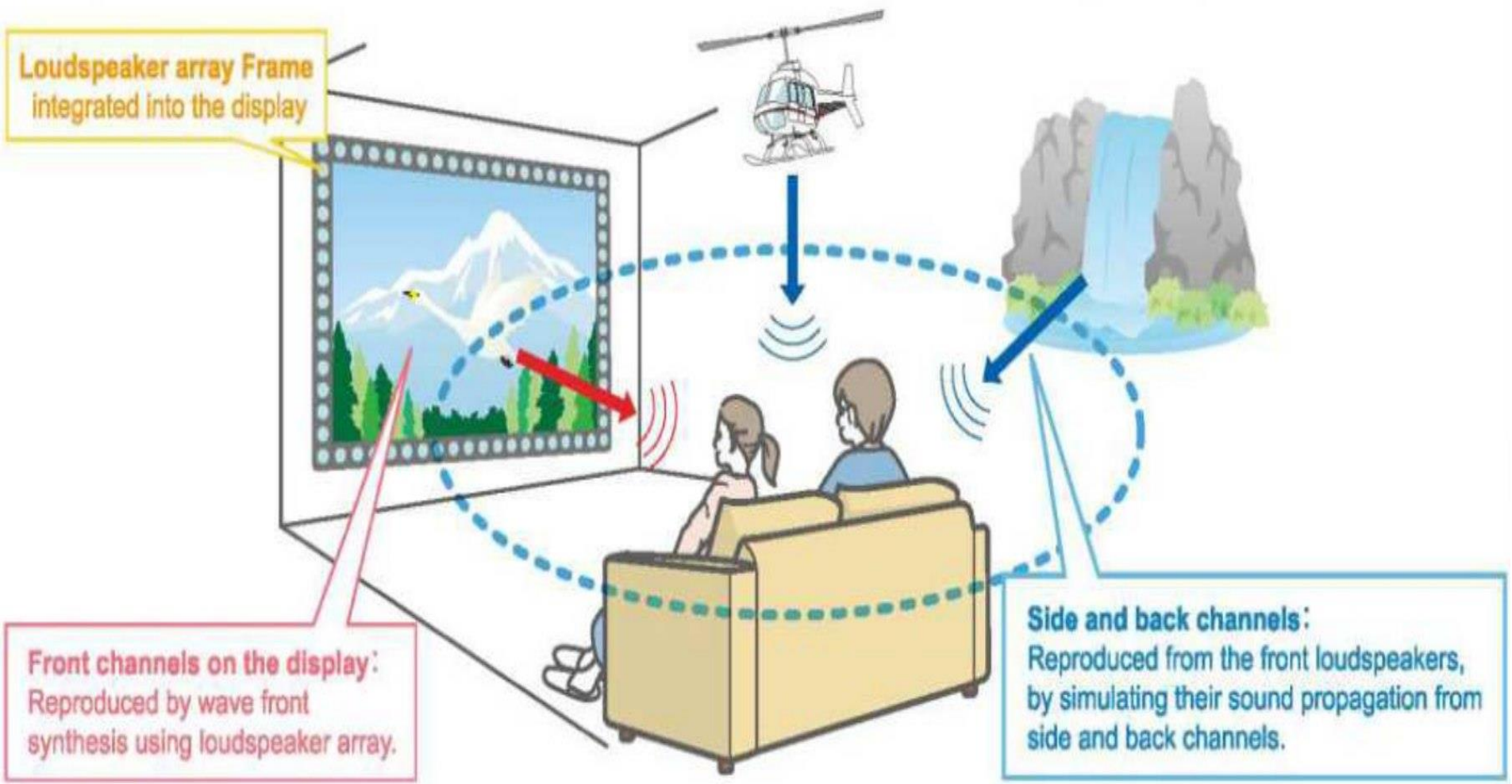


- **UHD-2: 7680 x 4320**

UHDTV: 22 Channel Audio

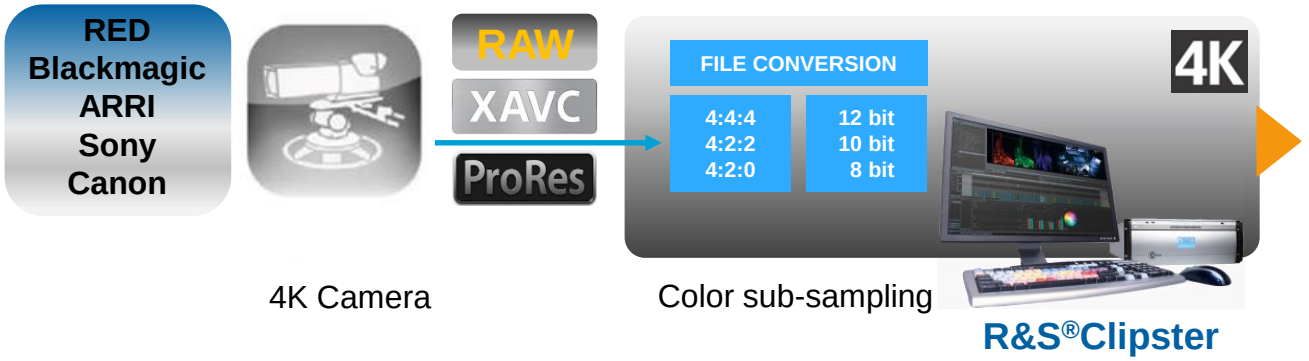


Speakers Integrated into TV Frame

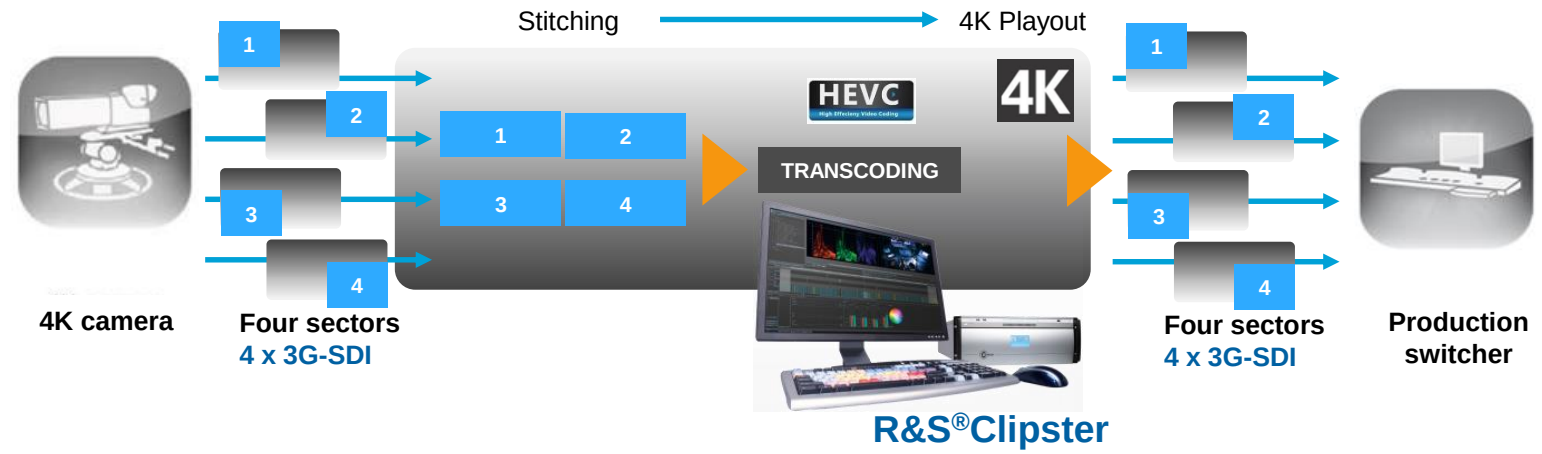


UHD/4K Ingest & Playout

4K Signal Ingest with different camera file formats



4K real-time ingest and transcoding



UHD/4K Real Time HEVC Encoding

Acc. to UHD-1 profile

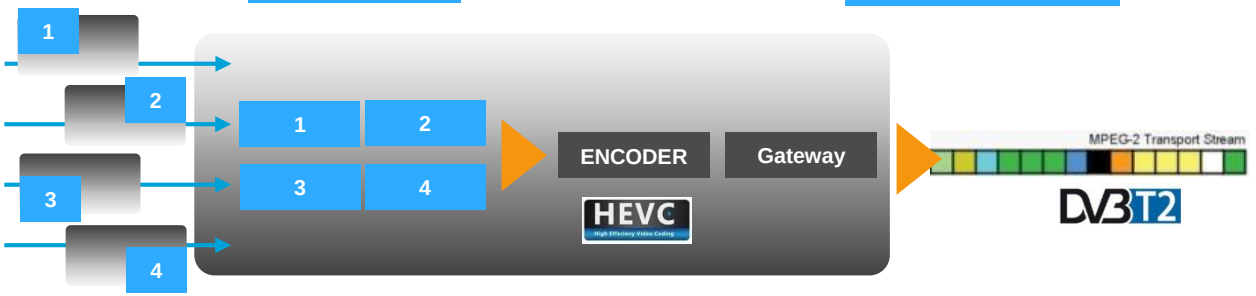
4K Real time HEVC encoding

R&S®Clipster

4K Camera

4K 60fps 4:2:2 10-bit 12Gbps

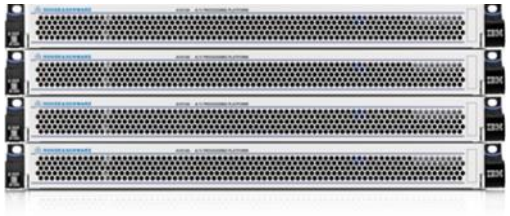
4K 60fps 4:2:0 8-bit 10bit 22-28Mbps



4 sectors
4 x 3G-SDI

Stitching | Encoding | Multiplexing

T2-MI
ASI or IP

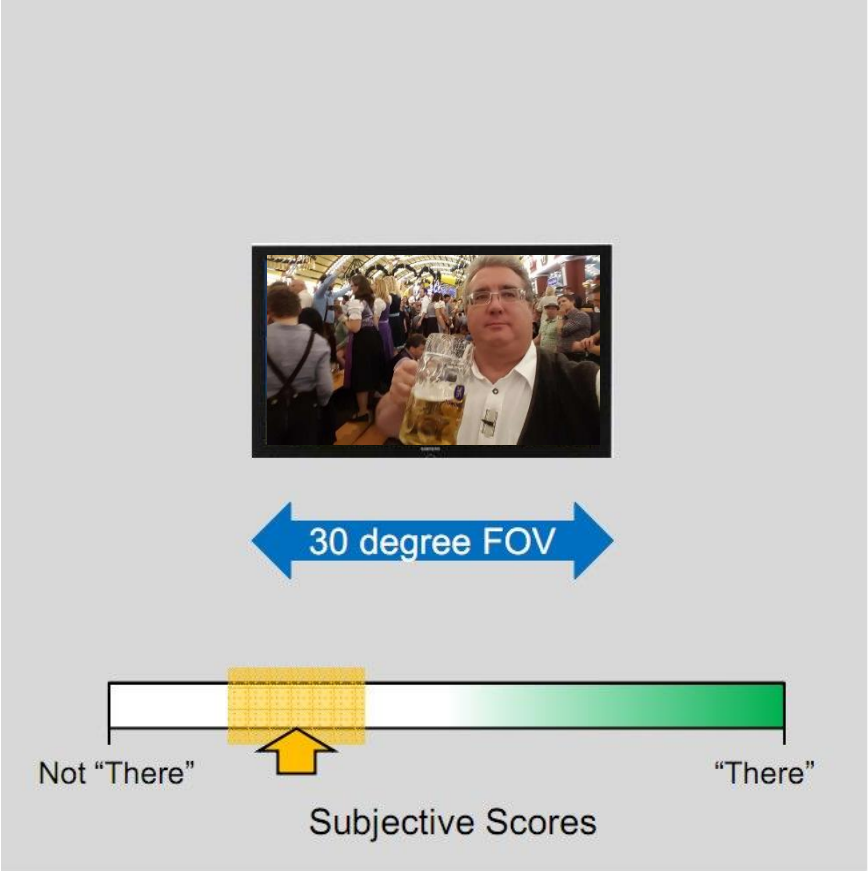


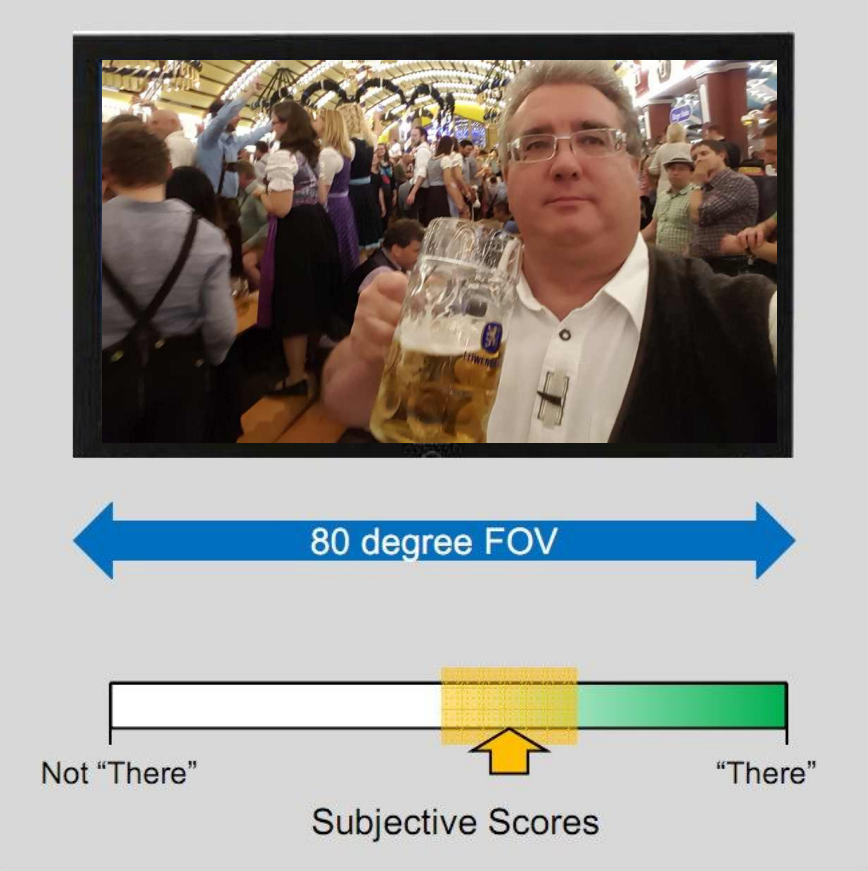
R&S®AVHE100

Beyond Resolution: The “WOW” Factor

- **Resolution not the only issue for better picture quality**
  - Need to create “Immersion” Experience!
  - Field of View and at limits of visual acuity
- **Higher Frame Rates (HFR)**
  - Reduction of Temporal (Flicker/Judder) Effects Needed
- **Wider Colour Gamut (WCG)**
  - More bits/pixel reduces contouring and banding effects
  - Greater Colour Space Needed
- **High Dynamic Range (HDR)**
  - Enhanced Detail in Light and Dar Regions
  - Faster shutter times

Immersive Experience





- **ITU-R Report BT.2246: “UHDTV ..provides.. wide field of view”**

Limits of Visual Acuity

SDTV

20º FOV

Snellen Acuity

Readable

HDTV

32º FOV

Simple Acuity

Pixel Fusion

4K UHDTV

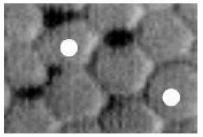
62º FOV

Simple Acuity

Pixel Fusion

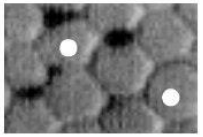
"Being There"

Enabling



Photoreceptor sampling

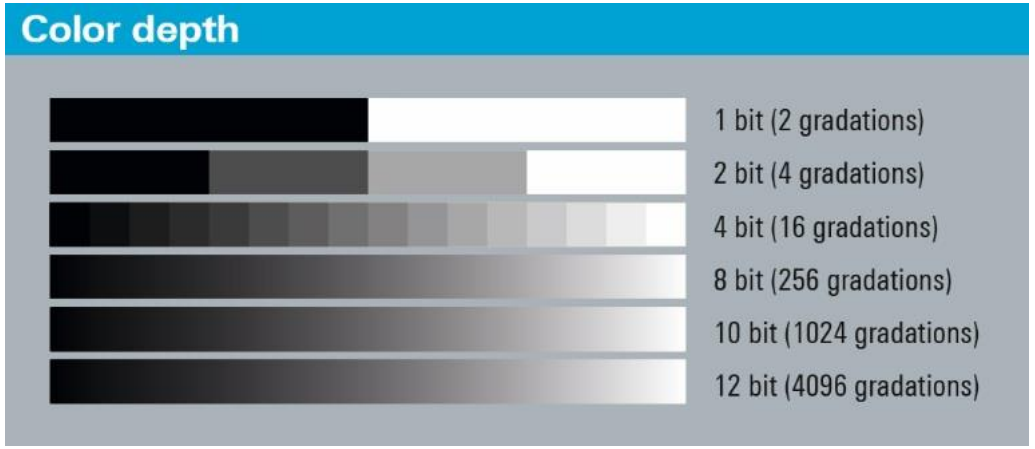
Minimal Change



Photoreceptor sampling

- **4K on large TVs can appear similar to HD on smaller TVs**
  - Minimal "WOW!" Factor

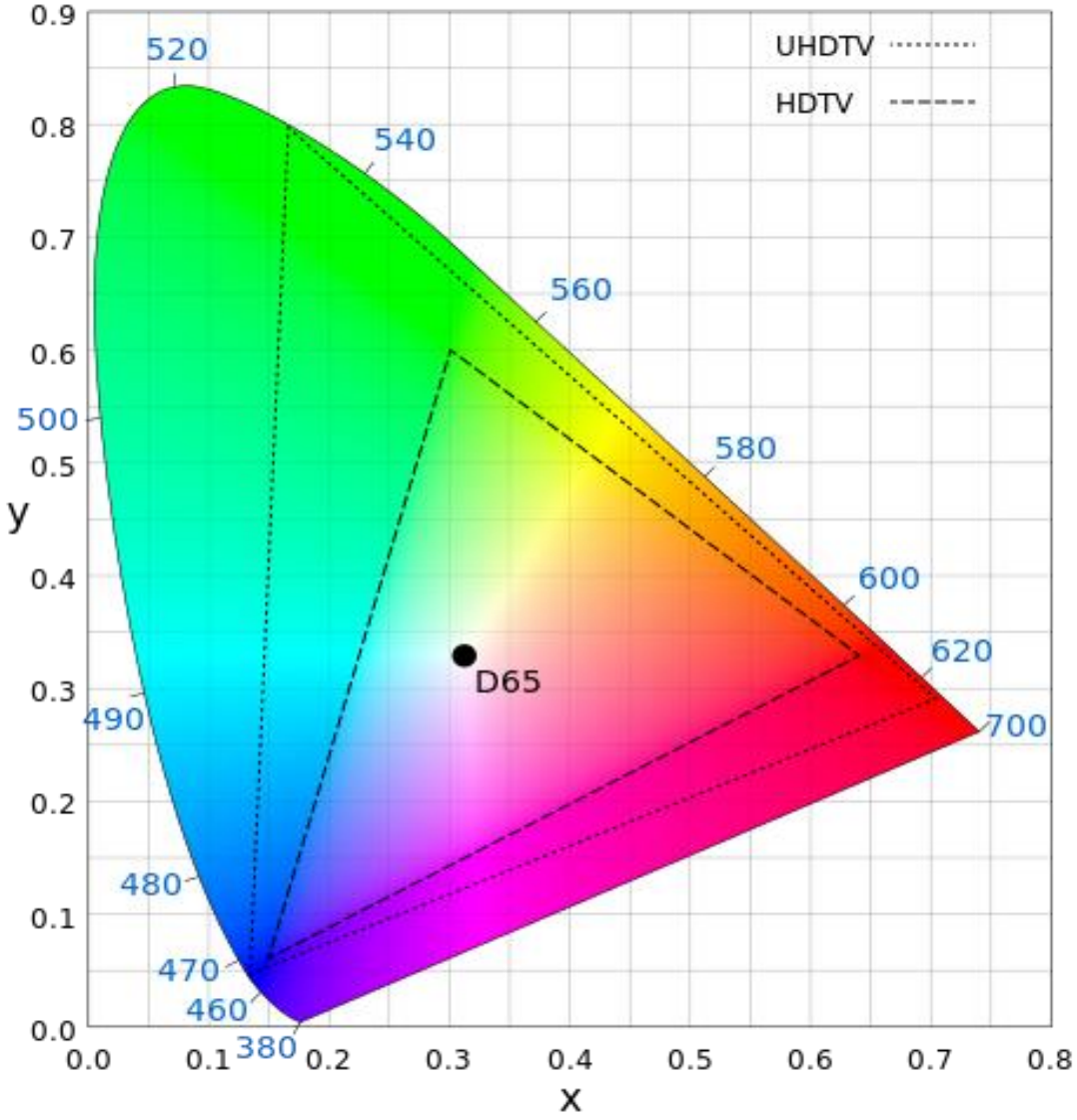
Increased Colour Depth



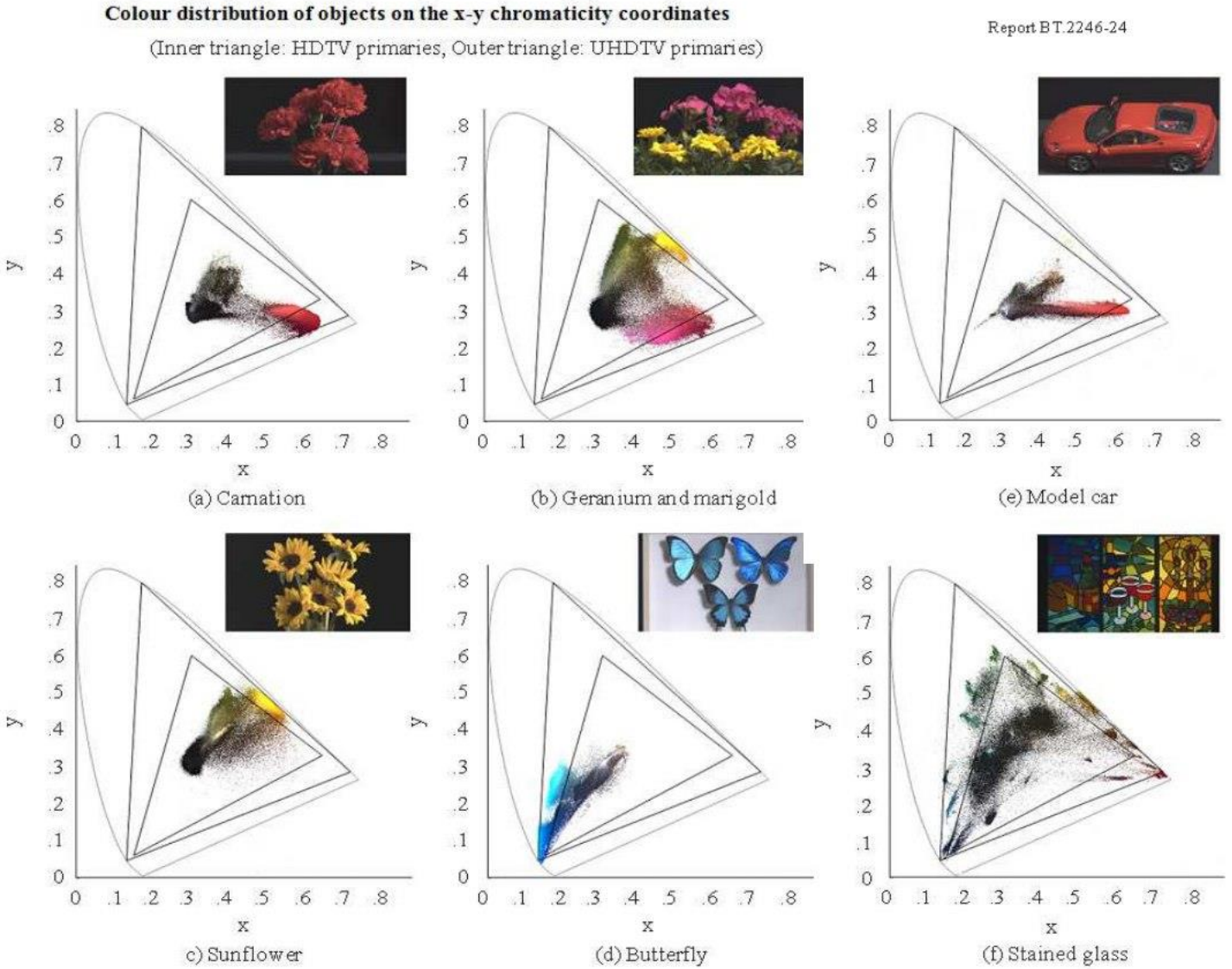
- **More bits to reduce contouring/banding**
- **Rec2020: 12 Bits/pixel**

Extended Color Space with UltraHDTV

- **~40% larger range**
  - UHDTV: Rec 2020
  - HDTV: Rec 709
- **8 or 10bit colour space**
- **Most 2015 TVs still Rec709**
  - New panels to support Rec2020



Colour Gamut Examples



Higher Frame Rates (HFR) with UHD TV

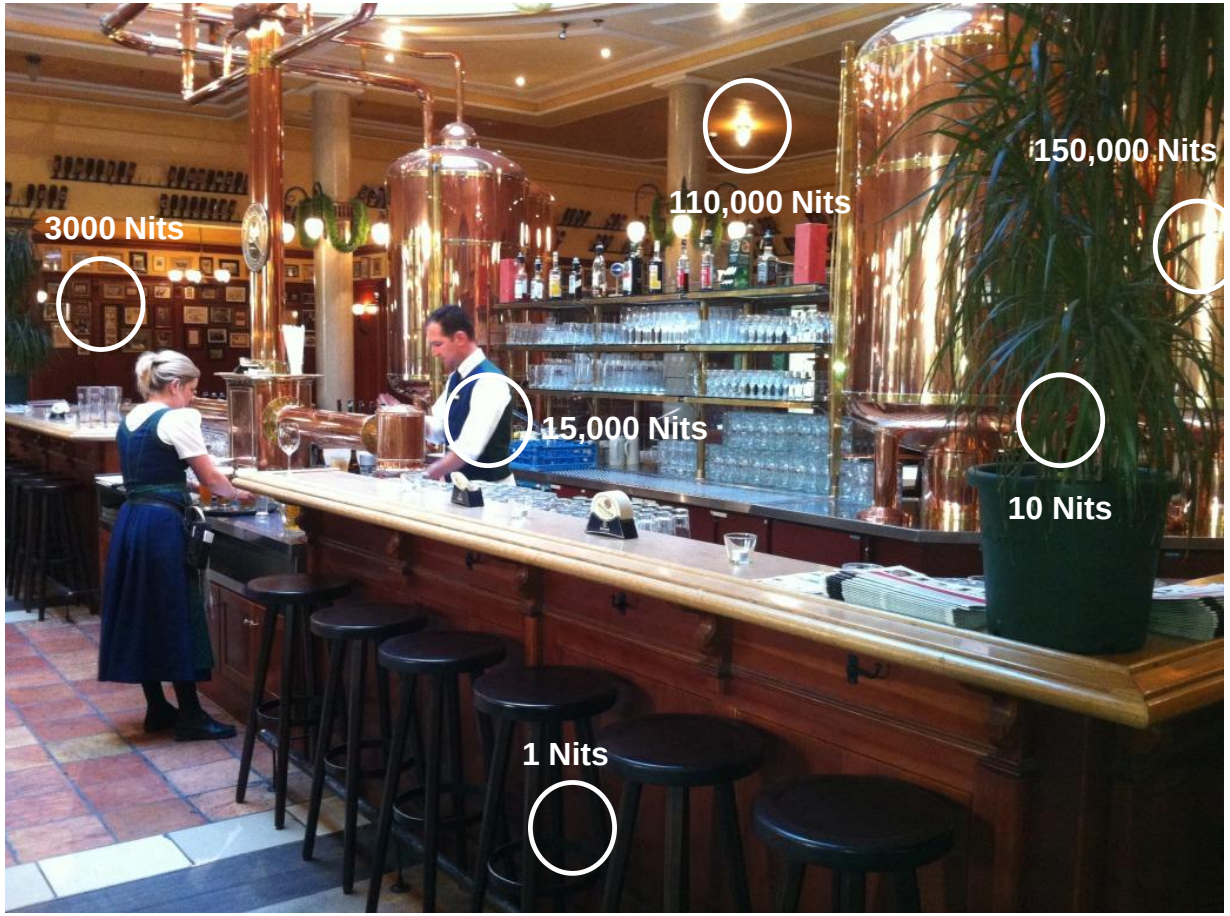
- **UHD will support frame rates up to 300fps**
  - 100fps in Europe and 120 in USA most likely (?)
- **HFR Reduces judder on scrolling text/titles**
- **HFR Reduces motion blur**

=> Arguably 2K@48fps is better than 4k@24fps

Shutter Speeds: 60fps

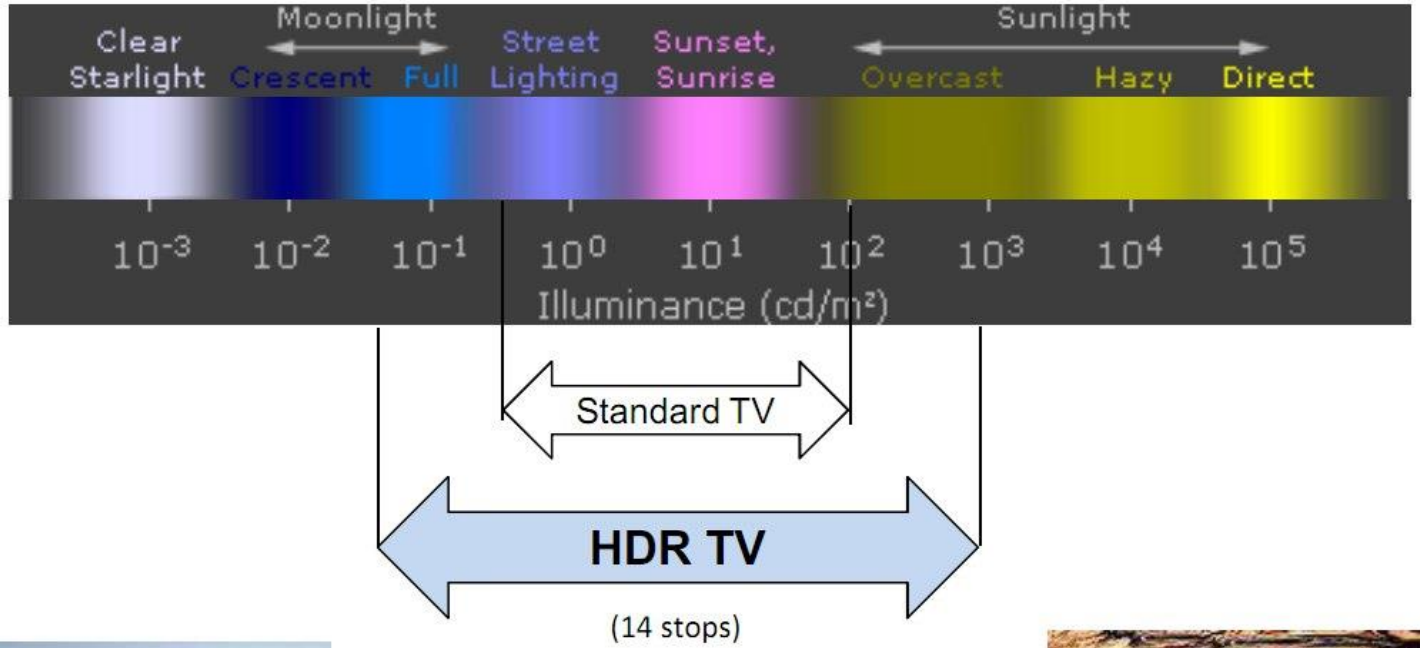
- **Faster Shutter speeds freezes motion better**
- **Slower shutter speeds better for low light applications**
  - Limitations for live sports and outside broadcast filming

Real World Brightness



- Extreme light and dark part of everyday experience
- Measured in candela/m2 (“nits”)

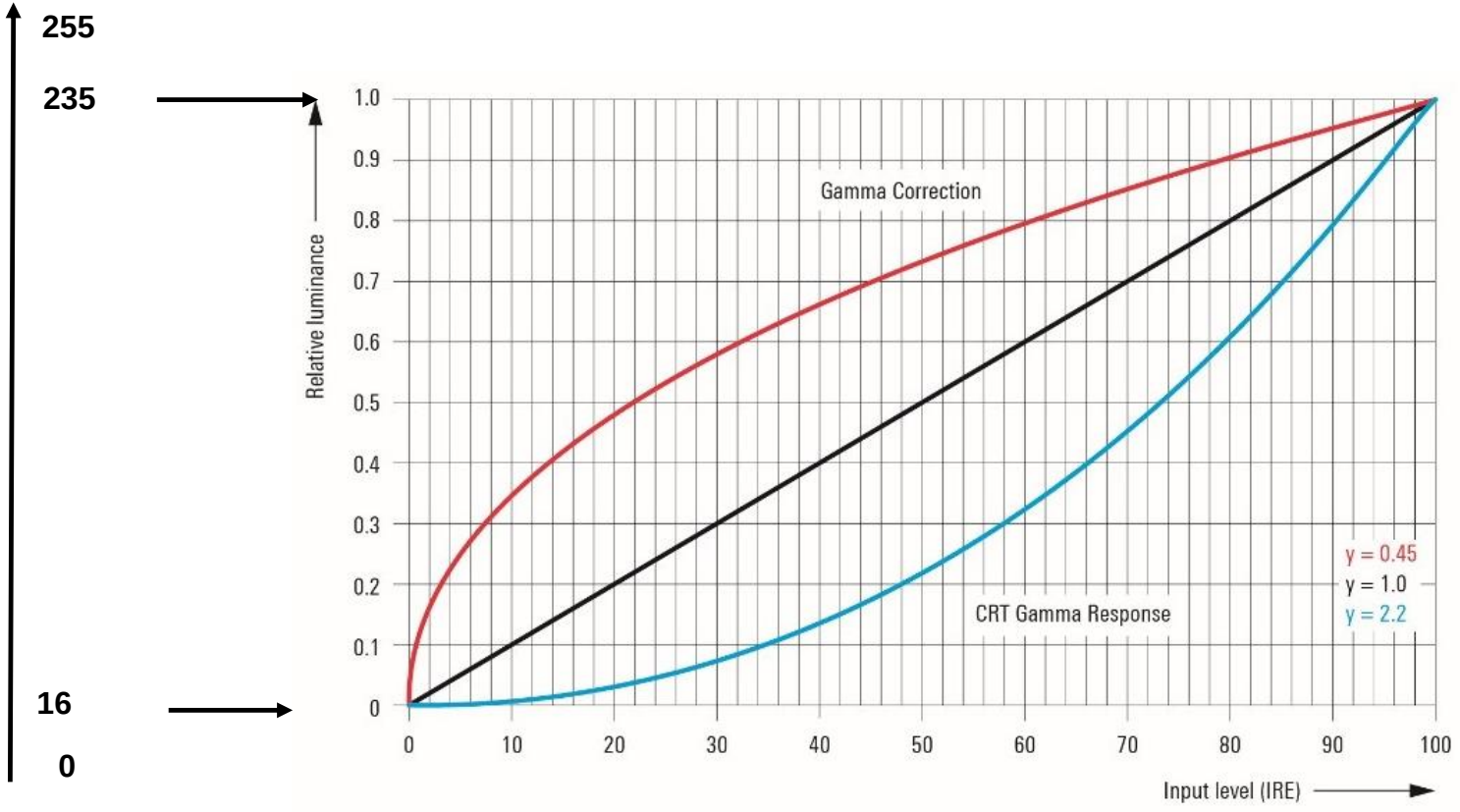
Brightness Ranges



Uneven lighting

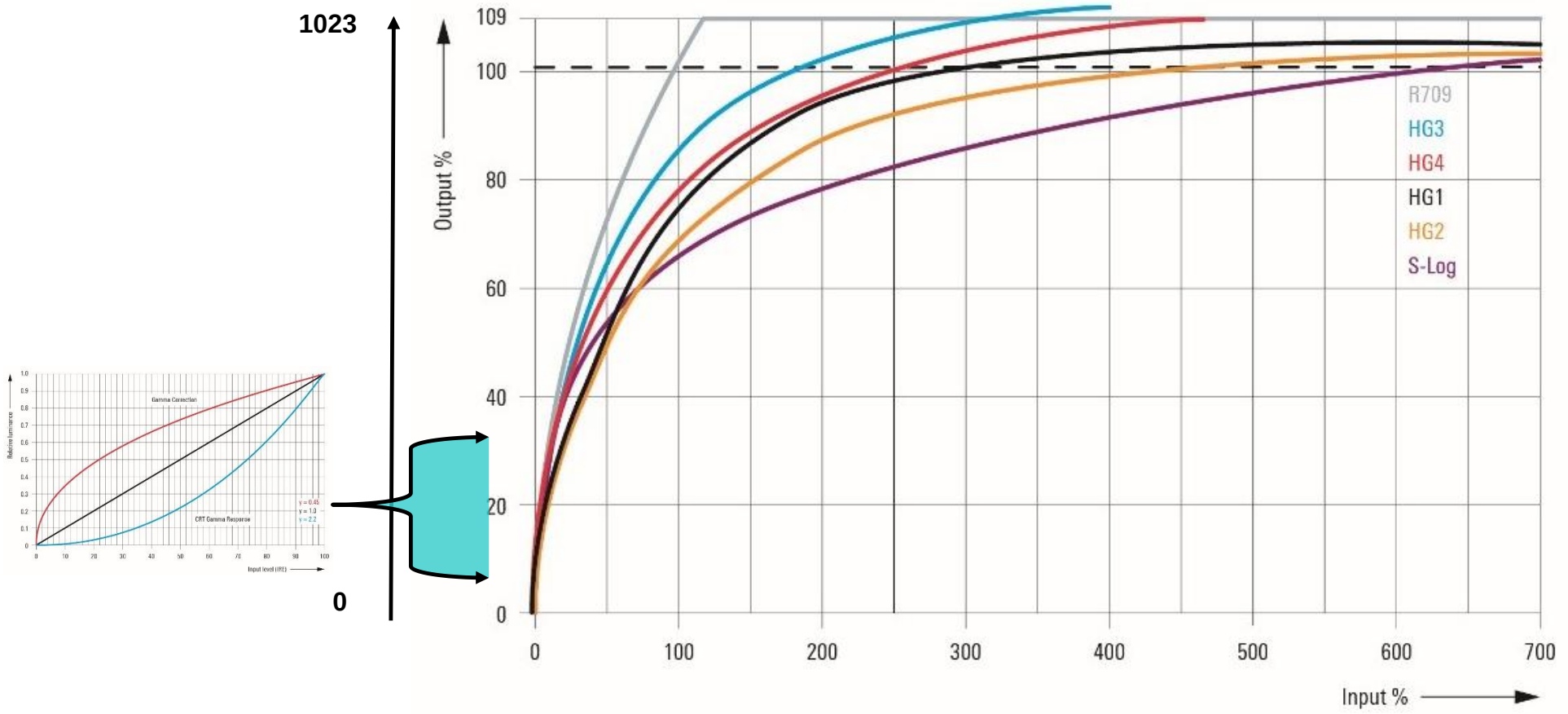
Strong reflections

SDR: 8 Bits for 100 Nits



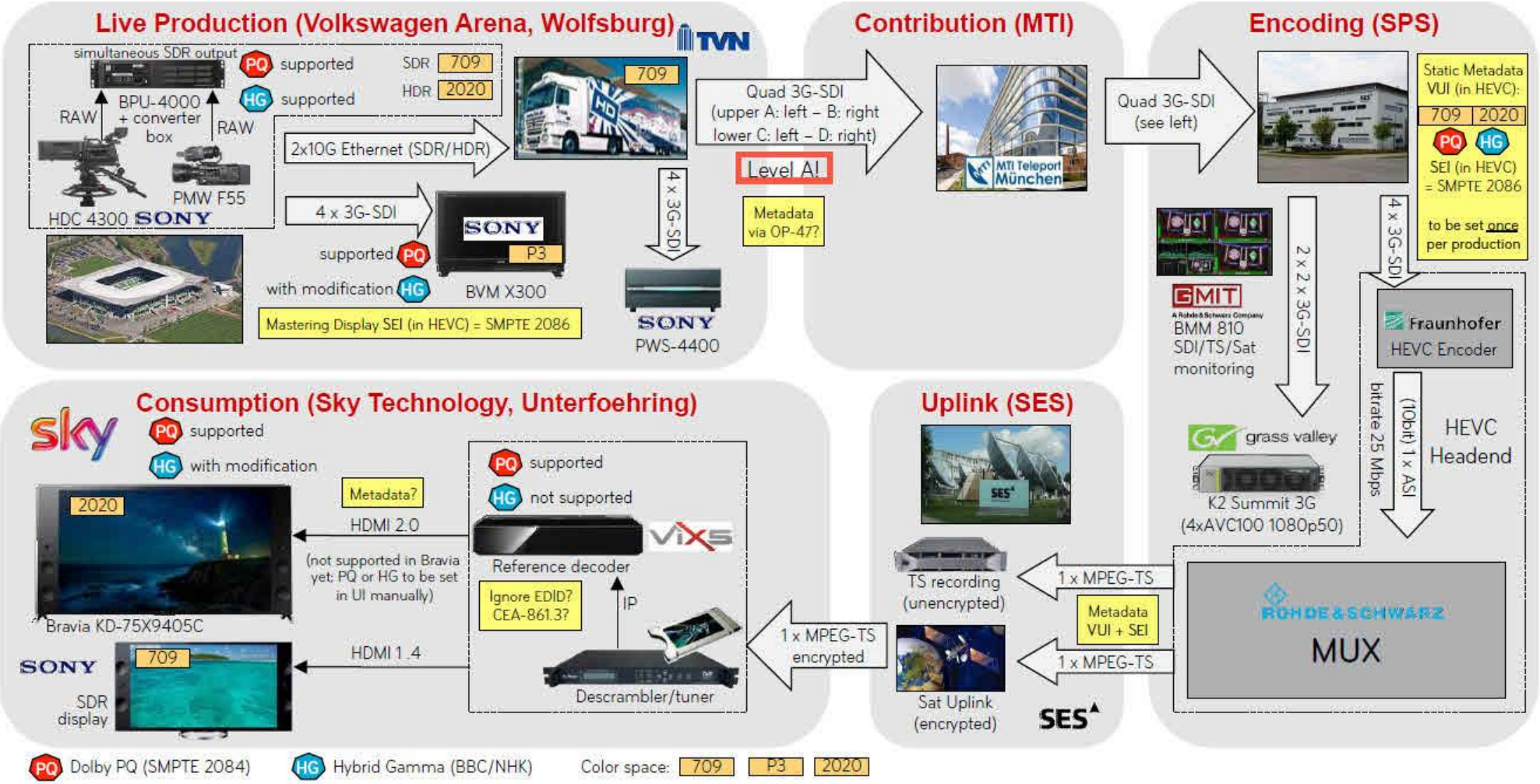
- **Standard CRT TVs max brightness around 100 Nits**
  - Mapped to 8 bits in CCIR601
- **Non-linear Response of Camera/CRT requires Gamma correction**

HDR: 10Bits/1400Nits for Rec2020 Panels



- **HDR: Many OETF (Opto-Electrical Transfer Functions) Gamma Curves**
  - Non-linear response of camera, panel and eye to brightness
  - Additional (SEI) data transmitted to identify exact EOTF in use

Live UHD/HDR Trials
Supercup August 2015



Different HDR EOTFs Tested

Test case	Start time	camera set to	converter box set to	VUI	SEI	Bravia set to	Remarks
PQ 2020 NBC	20:15	BT.2020	PQ	PQ, 2020	DCI-P3	PQ HG	PQ during remaining daylight incl. pre-show and opening ceremony
HG 2020 NBC	20:47	BT.2020	HG	HG, 2020	n/a	HG PQ	intended for HDR displays with HG EOTF
HG 709 BC	21:02	BT.709	HG	HG, 709	HG	HG PQ	intended for SDR (8 bit) & HDR displays
halftime	21:18						
PQ 709 NBC	21:35	BT.709	PQ	PQ, 709	DCI-P3	PQ HG	
HG 709 NBC	21:50	BT.709	HG	HG, 709	n/a	HG PQ	
HG 2020 BC	22:05	BT.2020	HG	HG, 2020	HG	HG PQ	
end of match	22:20						
PQ 2020 NBC	penalty	BT.2020	PQ	PQ, 2020	DCI-P3	PQ HG	PQ during floodlight entire penalty shoot-out
HG 2020 BC	cup	BT.2020	HG	HG, 2020	HG	HG PQ	additional test case entire cup award ceremony

HDR/HEVC Encoding and Distribution

- HEVC Video Encoding Parameter:
  - Resolution: 3840x2160
  - Framerate: 50 fps
  - Bitdepth: 10 bit
  - Color Subsampling: 4:2:0
  - Bitrate: 25 Mbit/s
  - Coding Structure: Hierarchical B-Pictures (GOP8), Random Access every 48 frames
  - Conformance: Main 10 Profile, Level 5.1, Main Tier

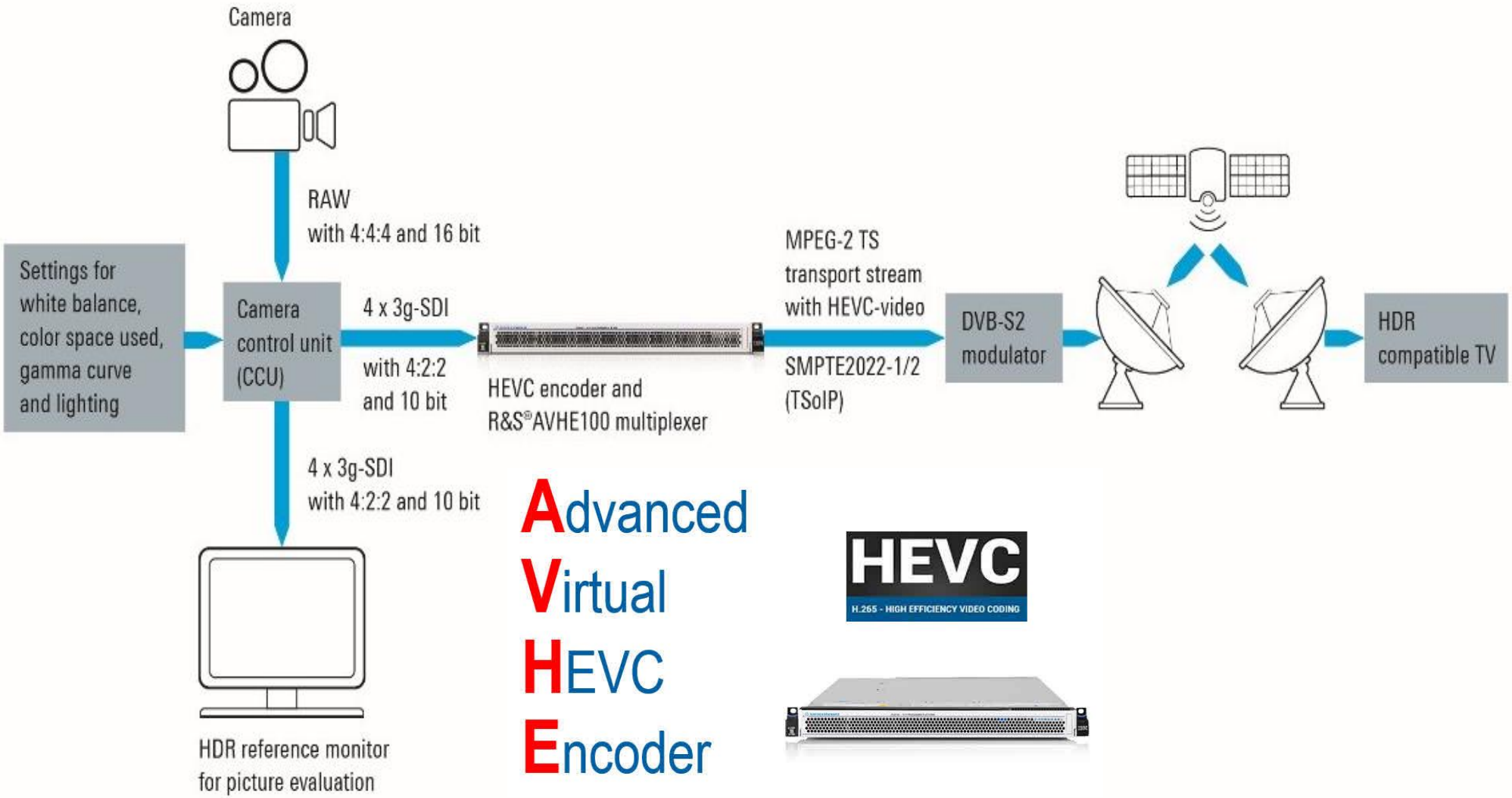
- HE-AAC Audio Encoding Parameter:
  - Sampling Rate: 48.000 KHz
  - Channels: 2 (Stereo)
  - Bits per Sample: 16
  - Bitrate: 64 kbit/s
  - Packaging: LOAS/LATM
- TS multiplexing:
  - 42 Mbit/s CBR

- DVB-S2
- Modulation: 8PSK, PILOT ON, LDPC 2/3
- Freq: 10.862 MHz (TP 1.059)
- Sym Rate: 22 Ms/s
- LNB Voltage: 14 V
- Tone: Off
- Polarization: Horizontal

- Network ID: 1
- Orginal Network ID: 1
- TSID: 0x0423 (1059)
- Video PID: 0x00FF (255)
- Video Codec: HEVC, stream type 0x24
- Audio PID: 0x0100 (256)
- Audio Codec: HE-AAC, stream type 0x0F
- PCR PID: 0x00FF (255)

- Service ID: 13501 to 13599
- service type 0x1F
- PMT PID: 0x0062 (98)

UHD/HDR Transmission Chain



FlowIP

HEVC
H.265 - HIGH EFFICIENCY VIDEO CODING

Advanced Virtual HEVC Encoding

The R&S AVHE100

Encoding and Multiplexing Solution

For

UHD/HDR Broadcasting

The AVHE100 UHD/HDR Headend System
Encoding, Multiplexing and More…

- **Software-based Virtual Headend Solution**
  - **Real-time HEVC/H.265** encoding of **UHD, HDR**, HD and SD video/audio
  - DVB SI generation and (de)scrambling
  - DVB-T/T and DVB-S/S2
  - Integrated T2-Gateway with Multi-PLP support
  - Full redundancy and seamless switchover
  - Software virtualisation simplifies future upgrades

Summary

- **UHDTV Undergoing Very Rapid Deployment Worldwide**
- **Much Faster Consumer Adoption of UHDTV than for HDTV**
- **High Dynamic Range Key to "WOW" Factor**
  - HD (and even SD!) Look Better with HDR
- **HDR Broadcast Now Possible with the AVHE100 from R&S**

UHD/HDR: More Than Just Resolution

Thank You

Any Questions?