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Broadcast and Professional Cameras

Hitachi Kokusai Electric America

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…and now a word from our sponsor…

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Hitachi Limited

- Hitachi was founded in 1910
- Hitachi America started in 1959
- Over $90 Billion Annual Gross Revenue
- 335,000 employees World-wide

- Hitachi spends about $4 billion per year for R&D
- We receive the largest number of world patents per year.

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Hitachi Divisions

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Hitachi Kokusai America

FP-Z31 used Saticon camera pickup tubes patented by Hitachi Densi, 1978.

Technology and Engineering EMMY® award for development of the single-chip MOS camera in 1982.

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Hitachi Kokusai Divisions

- Broadcast and Professional: HD, 4K and 8K TV cameras
- IVS: Medical, Machine Vision & Surveillance cams
- Crucial Imaging: OEM custom imaging devices and software
- Comark: TV Transmitters, encoders

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SK-HD1800

BEST of SHOW at NAB SHOW 2019
TVTechnology
WINNER

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SK-UHD4000

World's first 4K camera with 2/3" imagers allowing a standard B4 lens mount.

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SK-UHD8060

5th Generation Super Hi-Vision System

Single 35mm imager.

7680×4320 pixels

4K OLED VF

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Hitachi Kokusai Comark

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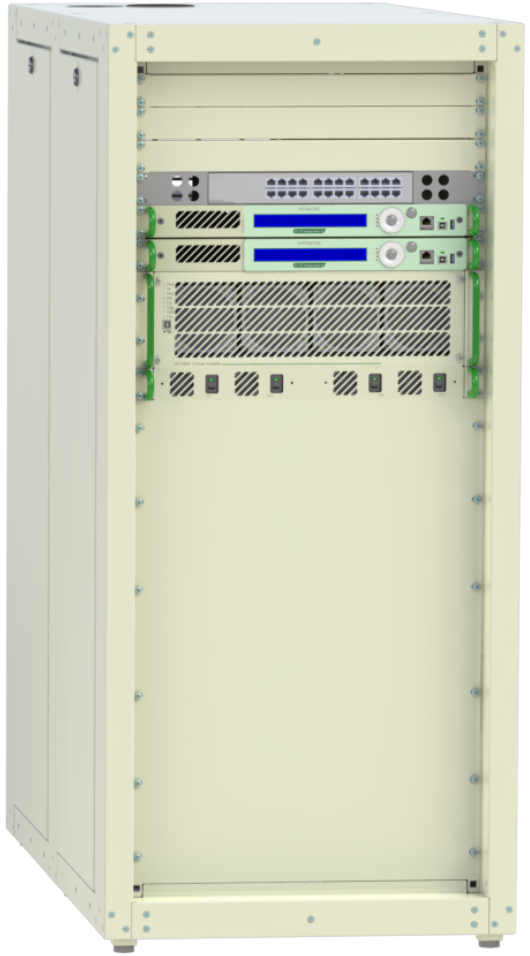
E-Compact
Less energy. More power.

EC710MP-BB

High-Efficiency,
Low Power
Solid State UHF
Transmitter



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New Camera Developments

Broadcast and Professional Cameras

Hitachi Kokusai Electric America, Ltd.

SMPTE

Atlanta Section

May, 2019

Once upon a time….

In a land not so far away…

- NTSC was ***the*** signal format
- …and all the signals were the same…
- …and if it was coax with a BNC connector…
- …everybody knew what the signal was…
- ***…and everyone was happy!***

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Now, it's a Hybrid world

Rolling Shutter and Global Shutter Imagers

Multiple HDR profiles and SDR

Resolution at 2K, 4K & 8K

SDI vs. ST 2110

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HDTV Television cameras at NAB

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- ✓ 2/3” Global Shutter
- ✓ 1080 progressive
- ✓ Motorized filters
- ✓ SDR & HDR adjust
- ✓ 4K 12G upconverter
- ✓ ST 2100 VoIP
- ✓ Triax & SMPTE Fiber
- ✓ V Control w/Dashboard

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Trends at NAB 2019

- 2/3” Global Shutter CMOS imagers
- High performance HDR displays. 8K displays are emerging.
- HDR is accepted, but how do we use it?
- 1080 60p is emerging de-facto standard for live events
- ST 2110 Media over IP Networks (VoIP)
- 4K cameras are mostly used in 1080p
- Cameras & lenses?

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Agenda

1. Rolling Shutter vs. Global Shutter
2. High Performance Pro and Consumer Displays
3. High Dynamic Range
4. 8K Super High Vision
5. ST 2110 media networks

A sip of water from a fire hose.

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Rolling Shutter & Global Shutter

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Charge Coupled Device

- The CCD imager can hold a charge and shift it to an adjacent cell.
- The individual cells also respond to light while retaining the ability to shift charges.

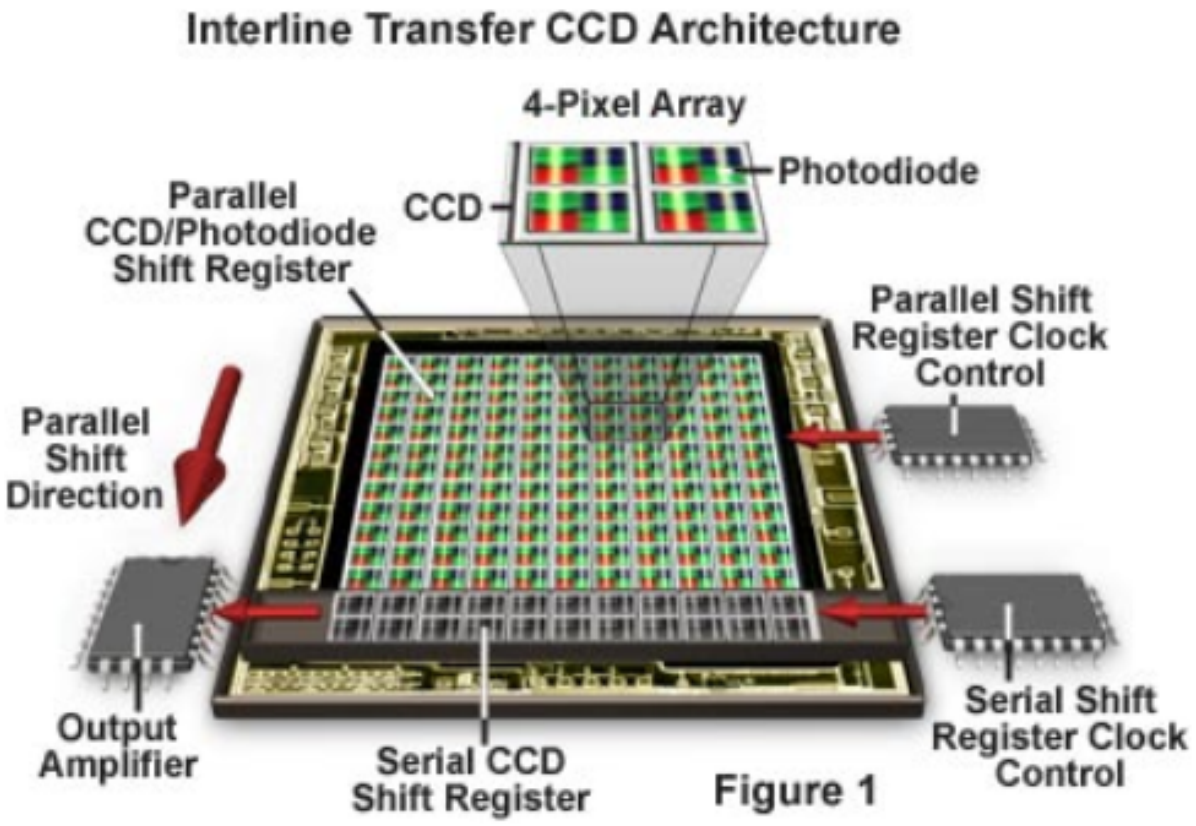

Figure 1

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Differences between CCD and CMOS

CCDs are analog and were (effectively) global shutter.

MOS & CMOS sensors are digital and have been rolling shutter.

Global Shutter vs Rolling Shutter

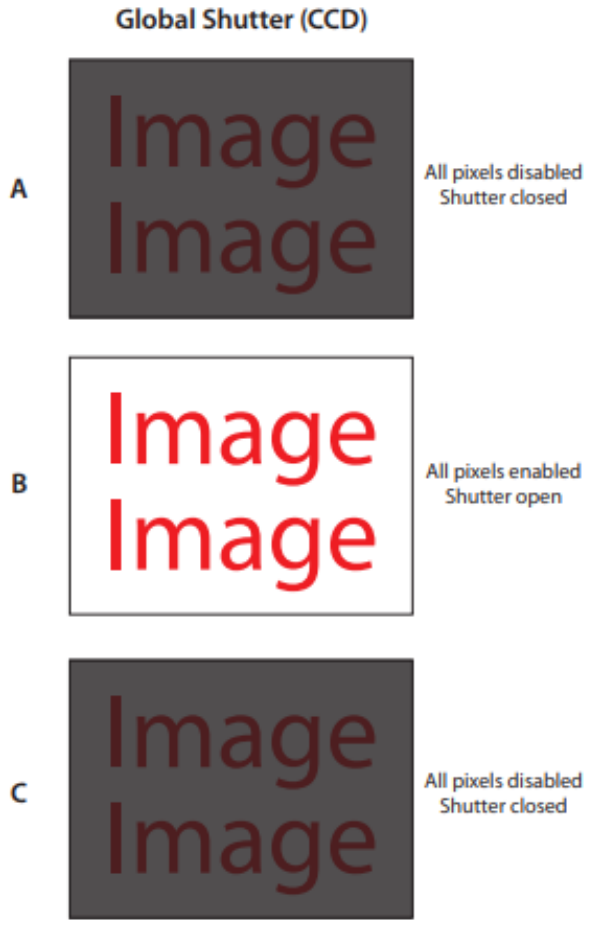

Figure 1 – Global shutter

Figure 2 – Rolling shutter

With Rolling Shutter, the image is scanned sequentially, from the top to bottom, line by line.

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Why do we have CMOS Rolling Shutter?

- Rolling shutter sensors provide good performance metrics **while keeping costs down.**

- Global-shutter sensor costs are dramatically higher.

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Why do we need Global Shutter?

LED Walls and lights are controlled by Pulse Width Modulation
Our Persistence of Vision allows this is to appear normal.

But it is visible by a camera with Rolling Shutter.

The relative frequency of the refresh rate, PWM vs. the camera shutter frequency can cause banding or other artifacts.

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Rolling Shutter artifacts – LED Banding

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Rolling Shutter artifacts – LED Banding

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Rolling Shutter artifacts – LED Lighting

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Direct View LED Video Wall - Moiré

Ways to control Moiré: Reduce sharpness:

- Diffusion filter in front of the lens - reduces camera resolution.
- Diffusion filter in front of the LED display - affects sharpness

- *Lower the gain of the camera and open the iris to reduce the depth of field, putting the LED screen slightly out of focus.*

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Rolling Shutter – Image Skew

Straight lines appear as curved with Rolling Shutter
Straight lines appear as a blur on a Global Shutter camera.

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Professional Displays & Consumer TVs

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High Rez LED Displays .9mm pixel pitch

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Professional Displays – Flanders Scientific

31” True 4K
Near 2020 WCG
3,000 nits HDR

2019 PRODUCT of the YEAR
NAB SHOW
Where Content Comes to Life

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Consumer TV Displays

- Price erosion causes fabs to increase panel size and pixel count.
  - They constantly need the “next big thing”.
- Consumer marketing purposely confuses buyers.
  - QLED vs OLED
  - Quantum dot is more about color, not contrast range.
- Consumer terminology purposely confuses buyers.
  - LED TVs are not LED, they are LCD with LED backlight
  - Big Screens and Micro LED Displays are really LED.

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Size Matters – Consumer TV Displays

- The market for 75-inch and bigger TVs is expected to grow by 43 percent in 2019.

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New 8K Consumer TV Displays

Sony 98” 8K TV. $70,000. …With floor stand
Samsung has a 98” 8K TV. No price.
Unilumin UTVII 165”LED TV. $158K (discontinued)

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Sony 8K Micro LED panels. 25’ diagonal.

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High Dynamic Range
HD and HLG

HDR Misconceptions

HDR is more about the display's capability

- ☒ **HDR video in not the same as still image HDR.**
- ☒ HDR is independent of resolution and color gamut.
- ☒ HDR is not more brightness, it's detail in the tonal RANGE.
- ☒ HDR is not a format war. They all accomplish similar things.
- ☒ HDR can be compatible with today's SDR displays.

SDR - HDR Comparison *(Simulated images)*

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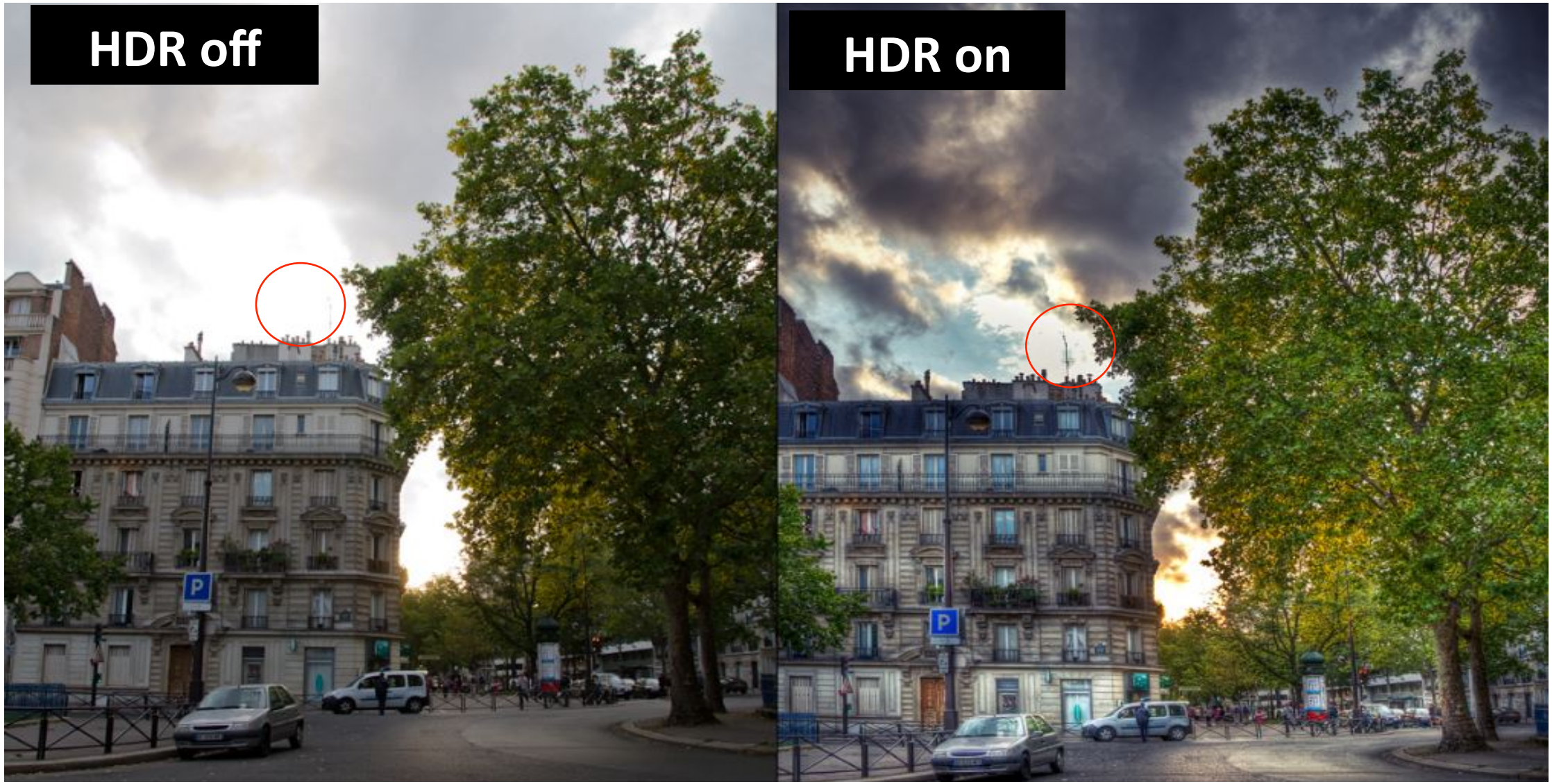

Why HDR is better than 4K alone

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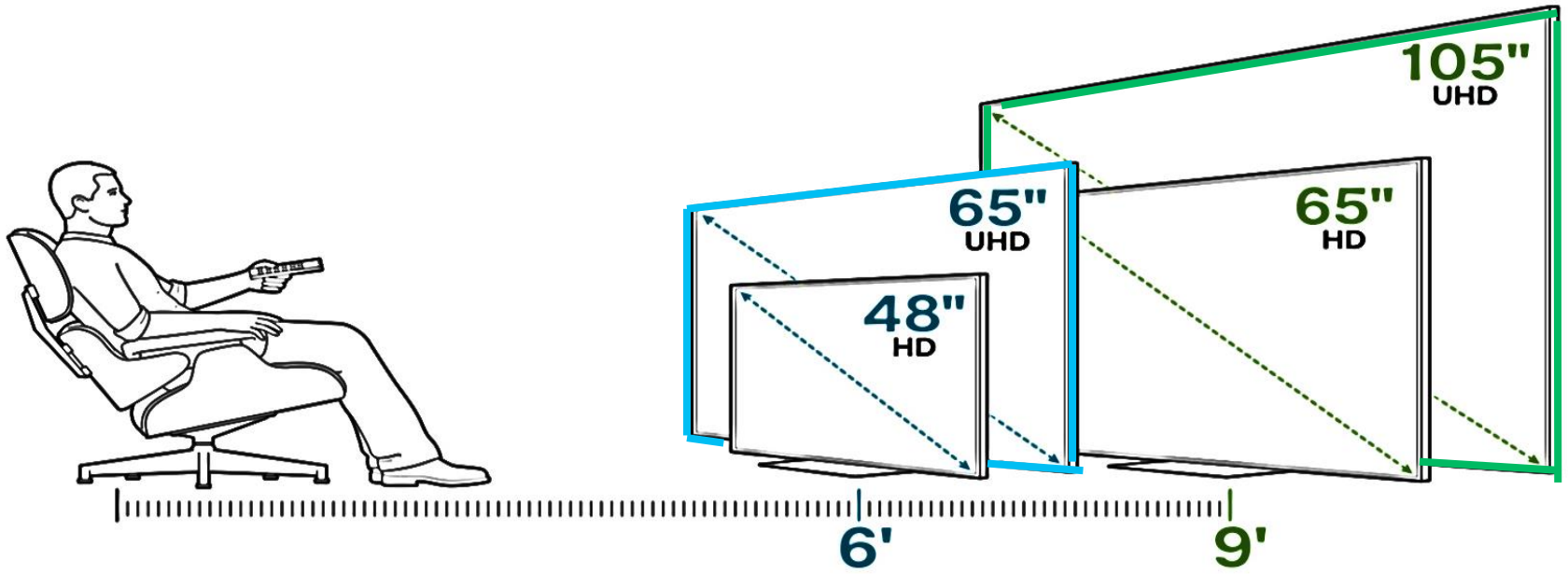
World-wide average TV viewing distance is about 9 feet.

- That’s too far away to see the full resolution of 4K.
  - 4K/UHD maximum viewing distance is about **6 feet for 65” TV**
  - At average distance of 9’ the optimum size is **4K/UHD TV is 105”**



Bandwidth For Picture Improvement

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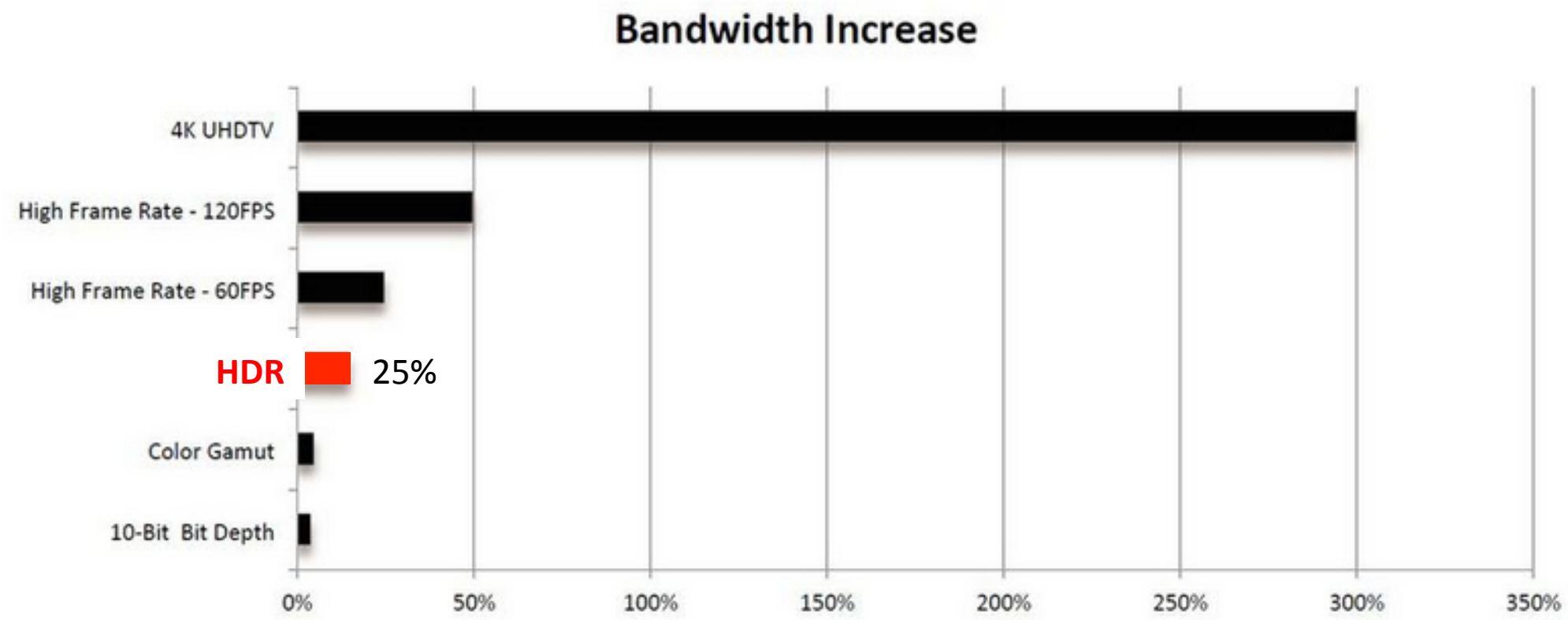

History of Dynamic Range

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The CRT characteristics are standardized as BT.1886

This limits the display's peak white to 100 nits.

BT.709 was established in 1934.

Modern displays are capable of higher luminance, contrast ratio and wider color gamut than is employed in today's program production.

Display Luminance

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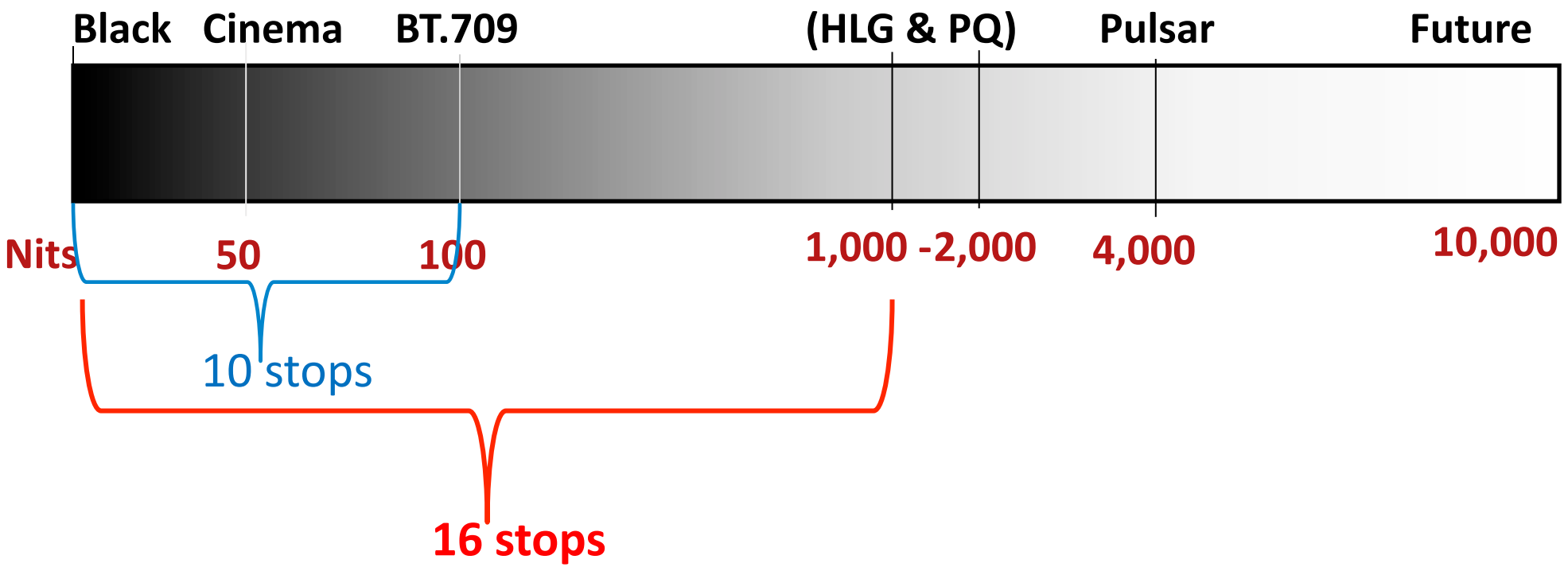
Luminance: 1 candela per square meter = 1 nit



HDR Quantization

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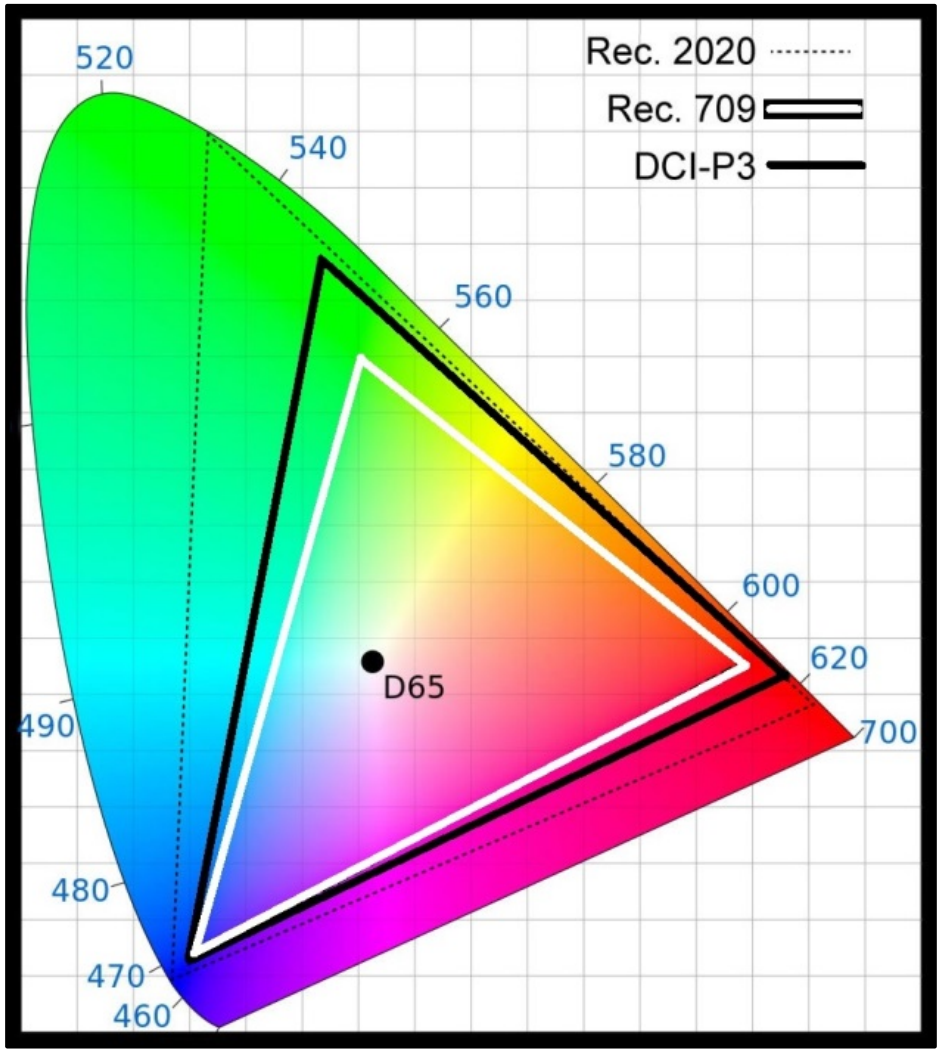
A minimum of 10 bit quantization is required for HDR.
It offers a wider range of tones and colors needed for HDR & WCG.

Wide Color Gamut



In 1931, CIE established the 2D Chromaticity Diagram.

CIE was first to describe the perception of colors in a quantifiable manner.

Rec.601 & Rec.709 are similar.

No current monitor or TV can display the full BT.2020 color gamut. (DCI-P3)

Visual Difference between HDRs (simulated)

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SDR
BT.709

Static HDR-WCG
PQ (HLG)

Dynamic HDR-WCG
DolbyVision

HDR / SDR Compatibility

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HDR adoption requires how legacy SDR sets will display HDR.

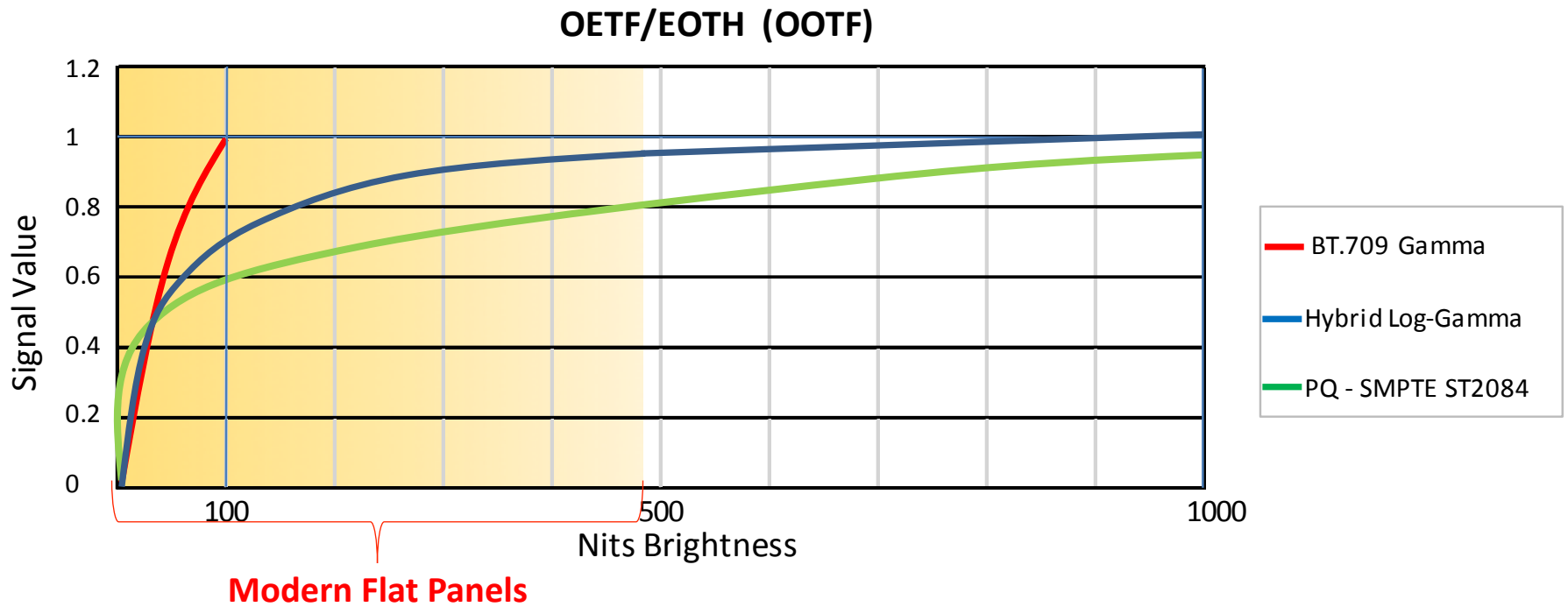
HLG – no metadata. A more compatible “hybrid” curve for traditional TVs.

PQ curve is less compatible usually post produced. **Static (or no metadata).**

Dolby Vision is the least compatible. **Dynamic metadata and 12 bits.**

It is unlikely that a single HDR will be best for all situations.

HDR OOTF Transfer Curves



Hybrid Log-Gamma is more similar to the BT.709 gamma curve up to 65%

The HLG curve follows BT.709 and is more compatible with SDR TV

Modern displays are capable of higher luminance, contrast ratio and wider color gamut than is allowed in production.

HLG & SDR Compatibility

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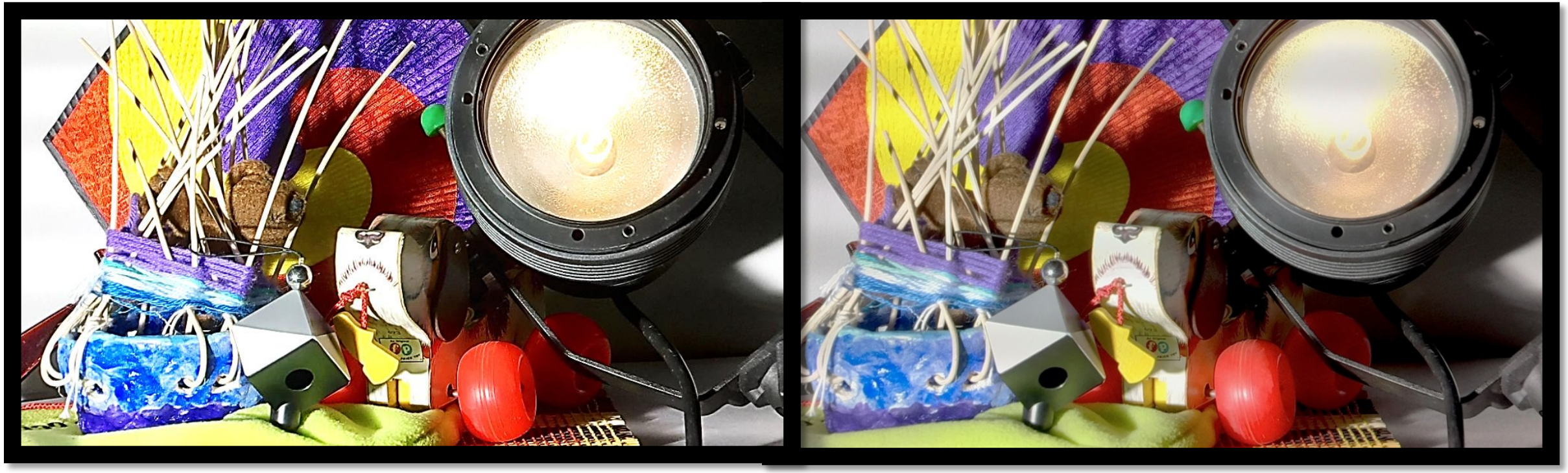

4K HDR monitor (HLG)

HD SDR monitor (HLG)

HLG “Hybrid” Log-Gamma Curve is more compatible with SDR displays.

PQ Curve on SDR Display

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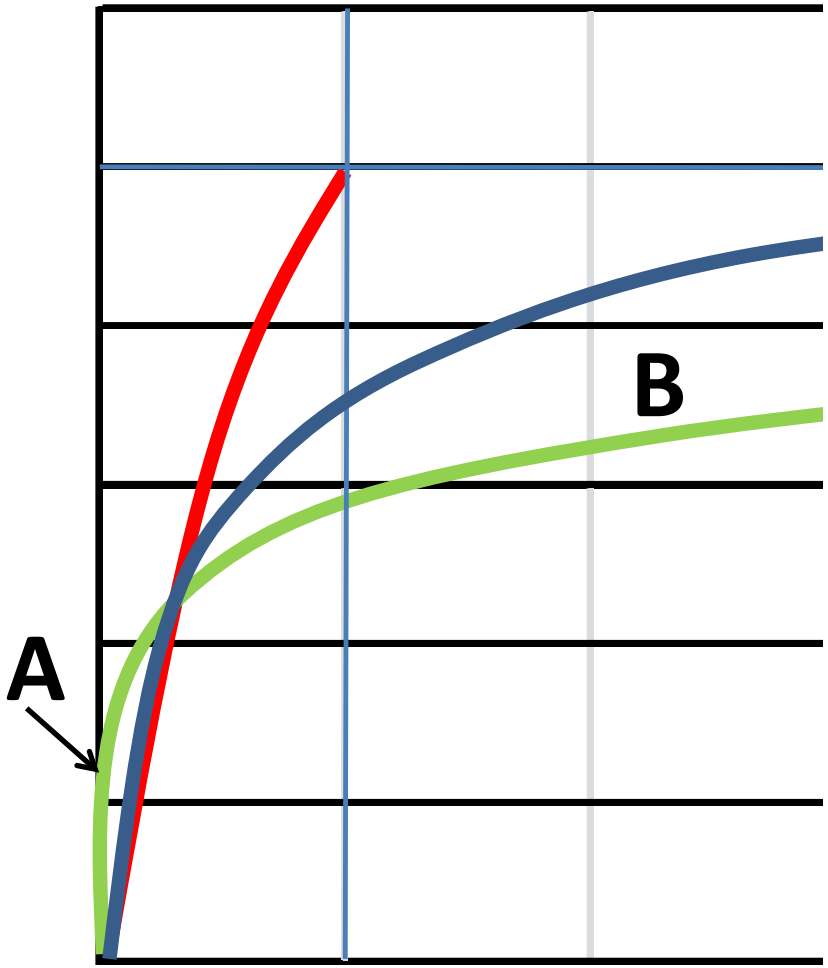

BT-709 Curve

HLG Curve

PQ Curve

Using PQ on a SDR display would make the picture brighter at A and darker at B, creating a low contrast image.

PQ & SDR Compatibility

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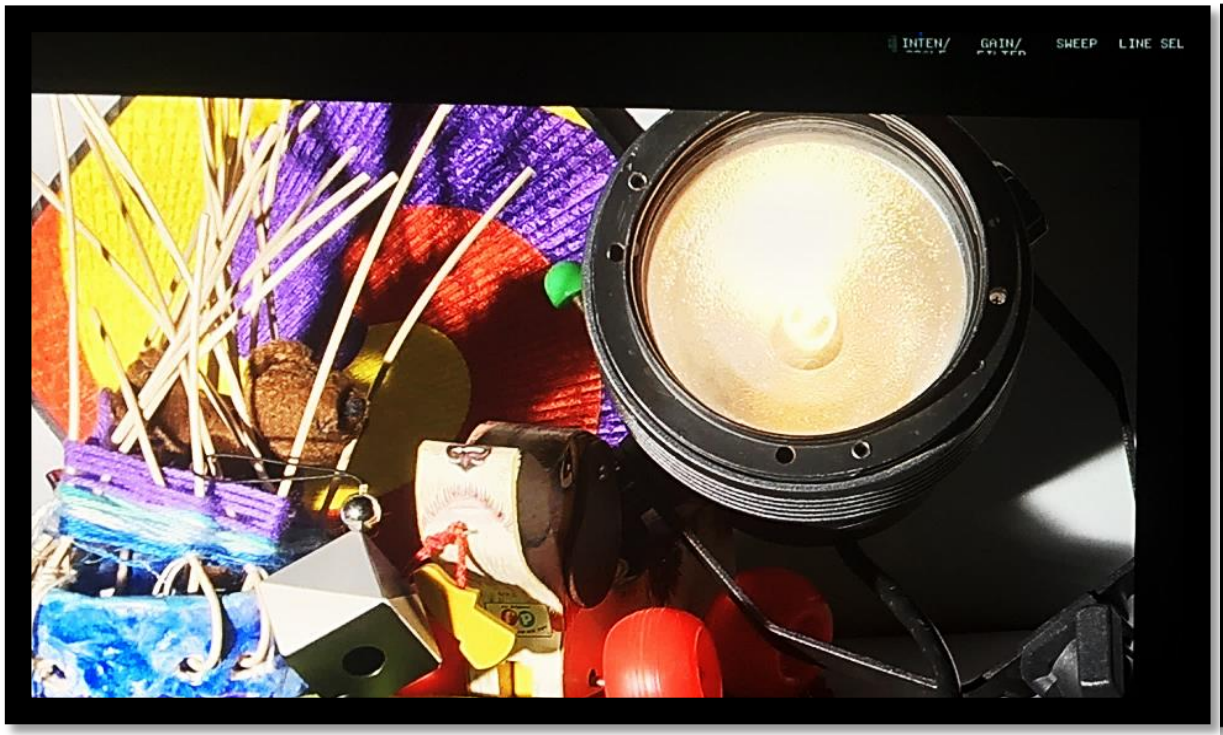

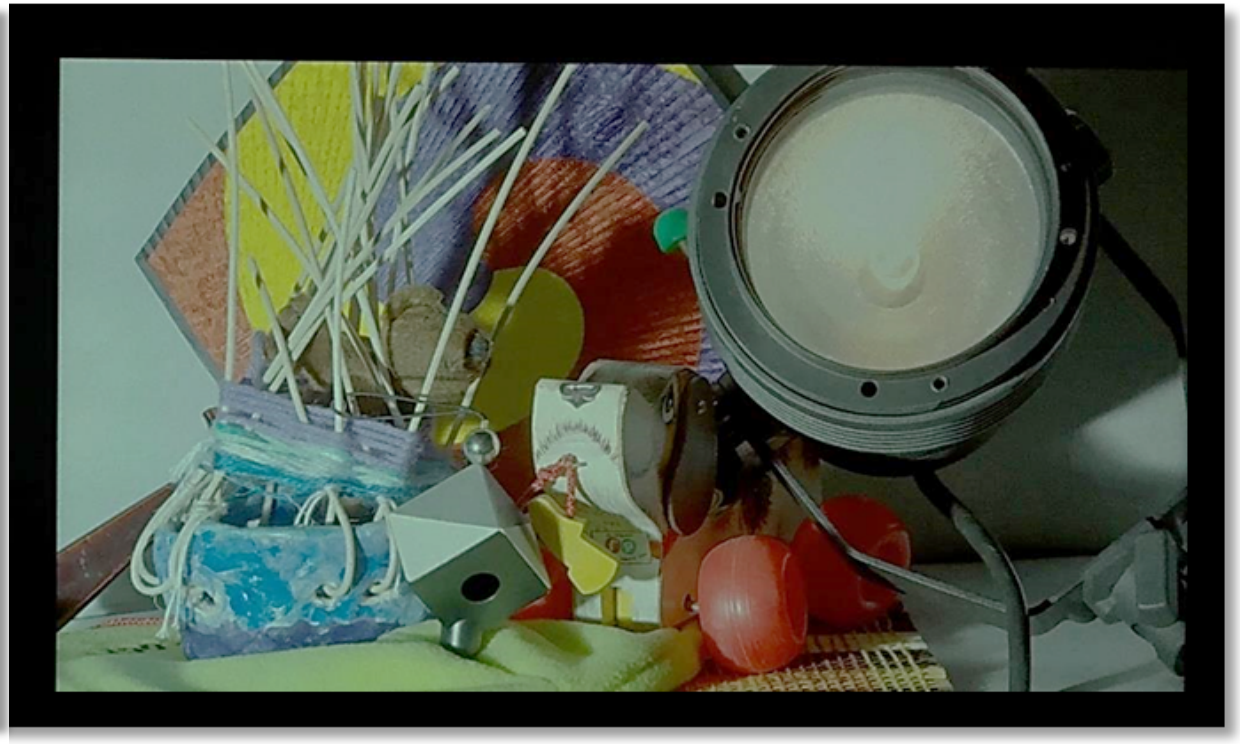

4K HDR monitor (PQ)

HD SDR monitor (PQ)

The PQ curve will appear grey, muddy & washed out a SDR display.

Consumer support of HDR Profiles (2018)

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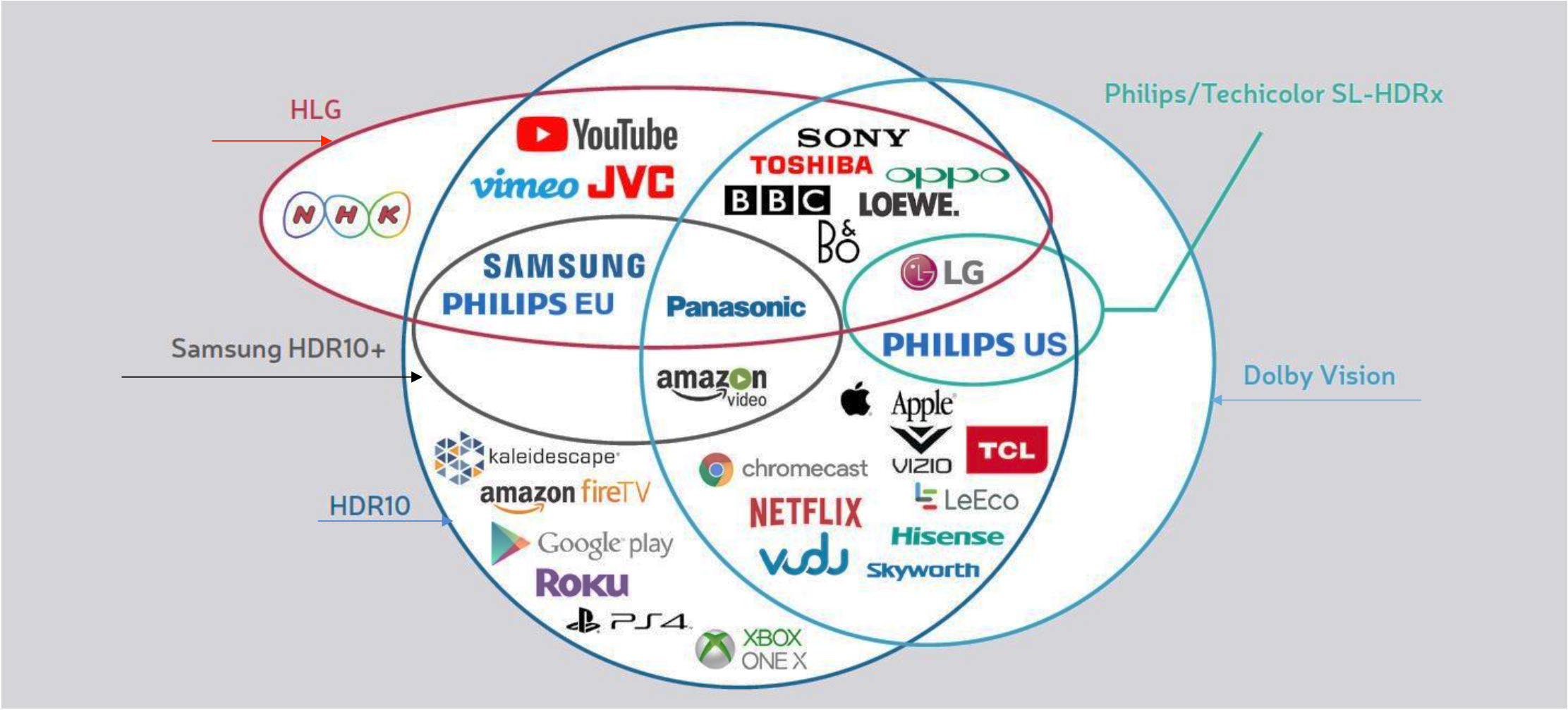

HDR Workflow Considerations

Mixing various SDR sources in HDR Workflow?

HDR conversion to accurate SDR

Simultaneous HDR and SDR CCU output?

Live Workflow – Compatible HDR/SDR Shading?

Delivery of SDR and HDR?

Multiple format signal feeds?

Broadcast Delivery of Simultaneous HDR and SDR?

Mixed Sources in HDR Production

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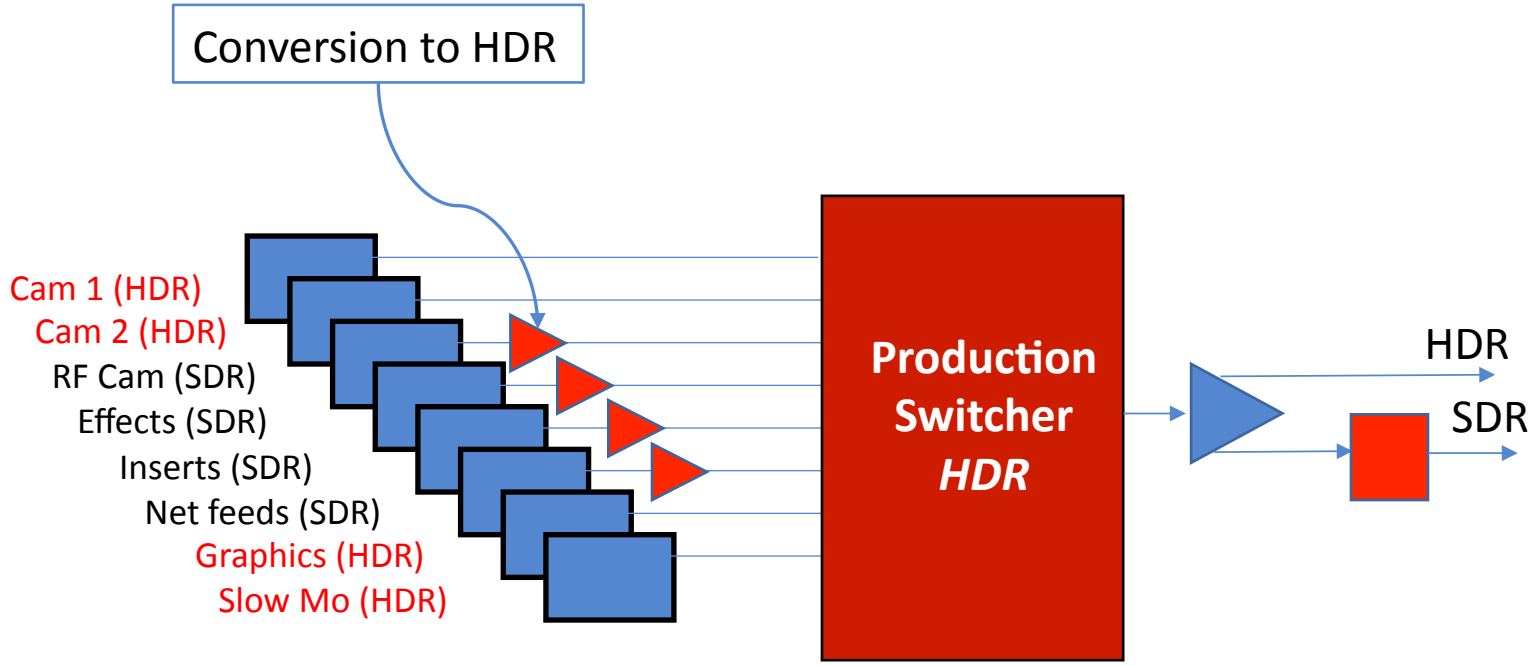
Live production must handle many different sources and intermix HDR & SDR material.



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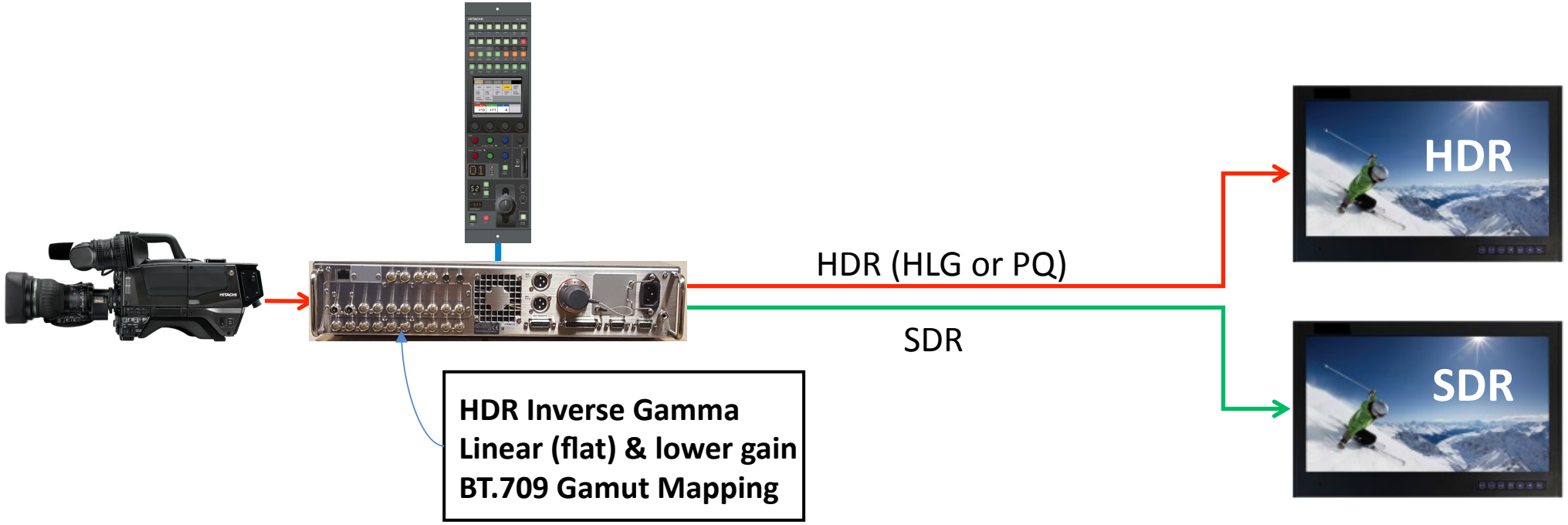
HDR/SDR Conversion

Required conversions for Broadcast HDR to SDR formats

- ✓ Dynamic Range: BT.2100 → BT.709/BT.1886 (display)
- ✓ Color Space: BT.2020 → BT.709
- ✓ Bit Depth: 10 bit → 8 bit (Broadcast)
- ✓ Spatial Resolution: 2160 (4K) → 1080/720 (HD)
- ✓ Temporal Resolution: 60 Hz Progressive → Interlace
- ✓ Video coding: HEVC → MPEG-2 (Broadcast)

Camera HDR & SDR Outputs

Hitachi 4K and 2K Cameras have two simultaneous outputs.
Each CCU output is individually adjustable from Remote



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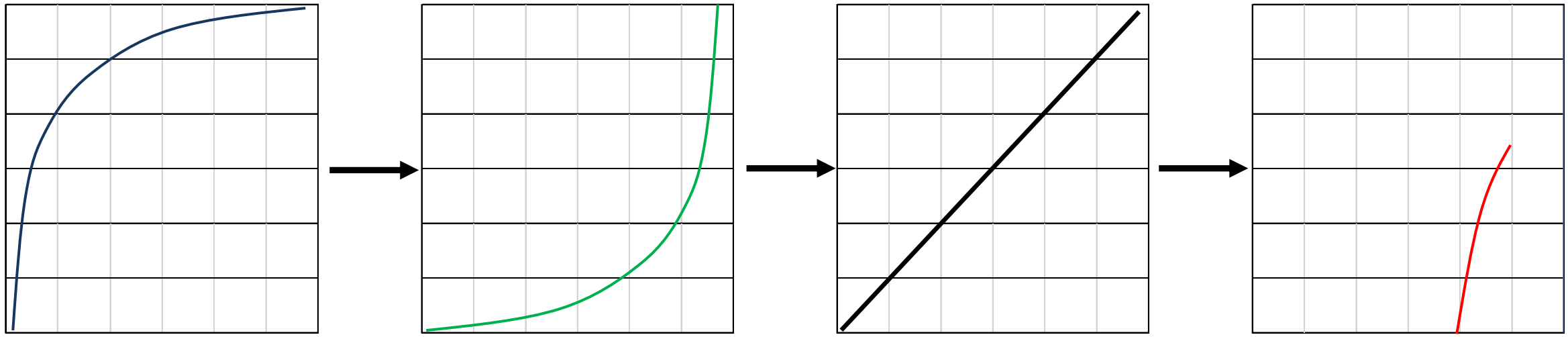
Inverse Gamma – Gamma Conversion



The camera exposure is adjusted for the HDR output.

The SDR signal is derived by using an inverse gamma curve.

Gain is lowered about -9 dB, followed by a conventional BT.709 OETF.

HDR and SDR shading…

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Camera video shaders should adjust the picture for the SDR image

If SDR is correct, HDR will be OK.
The SDR lies within HDR.

However, shading only for HDR may clip the SDR picture.

Simplified Live Delivery of SDR/HDR

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CU-UHD4000

Inverse Gamma/Gamut Mapping

Mobile Production Truck

SDR

SDR Feed

HDR

Master Control distribution

3D LUT

SDR Feed

HDR Feed

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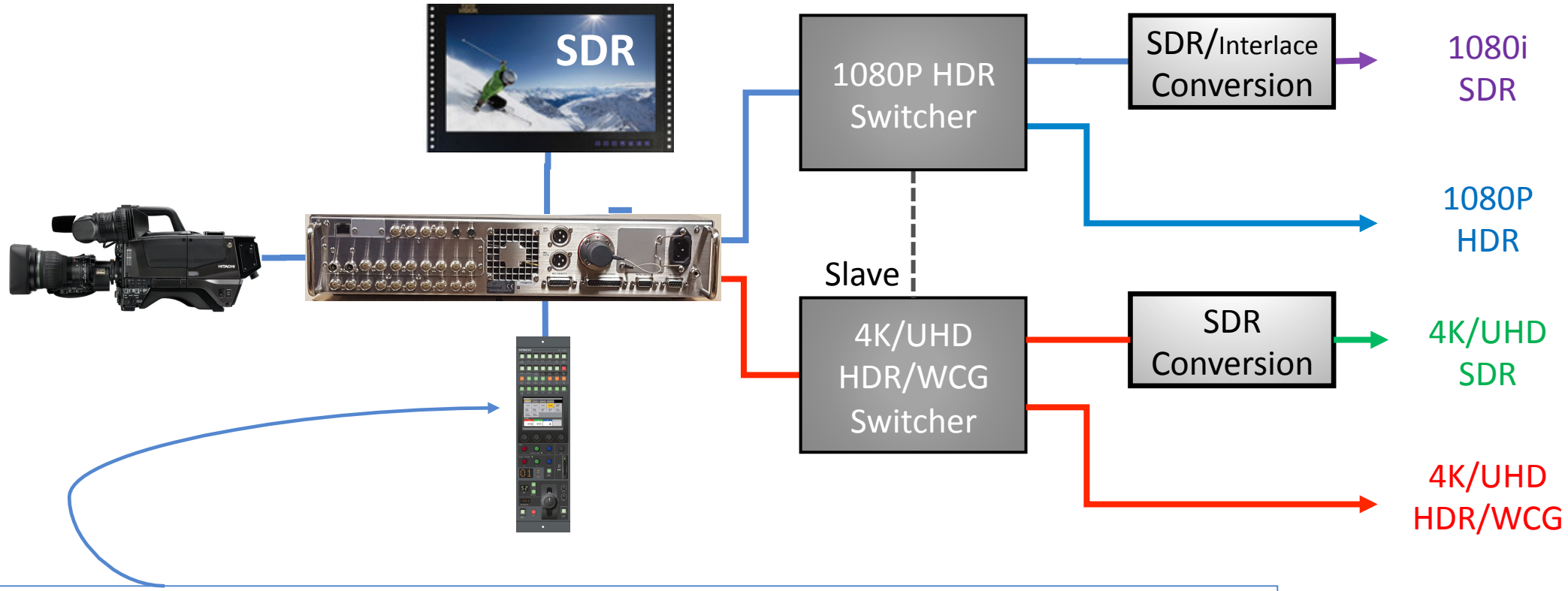
Multiple Feed Signals

The 4K HDR signal has to be converted to HD SDR for wide distribution.



Camera shaders manage cameras primarily using SDR monitoring from the CCUs.
The HDR signals will track the offset iris adjustments made for SDR

Broadcast SDR/HDR Delivery

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Stations will be able to deliver simulcast HDR/SDR with ATSC 3.0

ATSC 3.0 A/341 Standard – SL-HDR1

Technicolor's Single Layer (HDR1)

Encodes a SDR signal with HDR metadata for transmission

Provides SDR & Reconstruction of HDR signal at the TV receiver.

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8K Super High Vision 7,680 x 4,320

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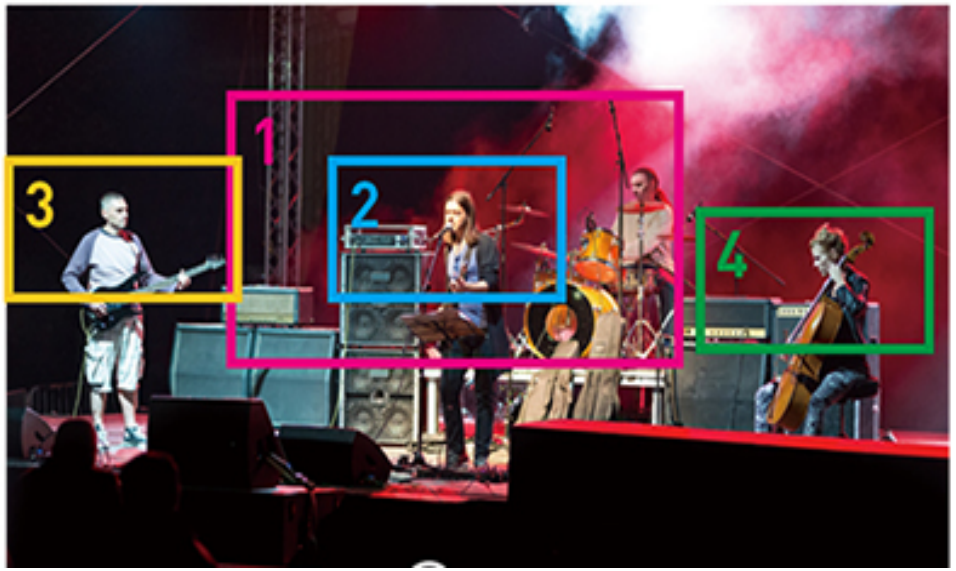
Panasonic 8K camera with ROI cutout …and movement tracking.



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Hitachi 8K = 7,680 x 4,320 High Speed

- One frame is 32-megapixel
- RGB, 10 bit, 59.94 = 60 Gb data rate
- 240 Gbps. Uses a new type of multi-strand fiber cable

True 8K box lens. 7.5:1 zoom. $500,000

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Shown under glass

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Managed, High Bit-Rate, Real-Time, Professional Media Networks SMPTE ST 2110

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Serial Digital Interface

SMPTE Standardized SDI in 1989
12G standardized in 2015

BNC connector was patented in **1951**

SDI Drawback: send or receive a single signal

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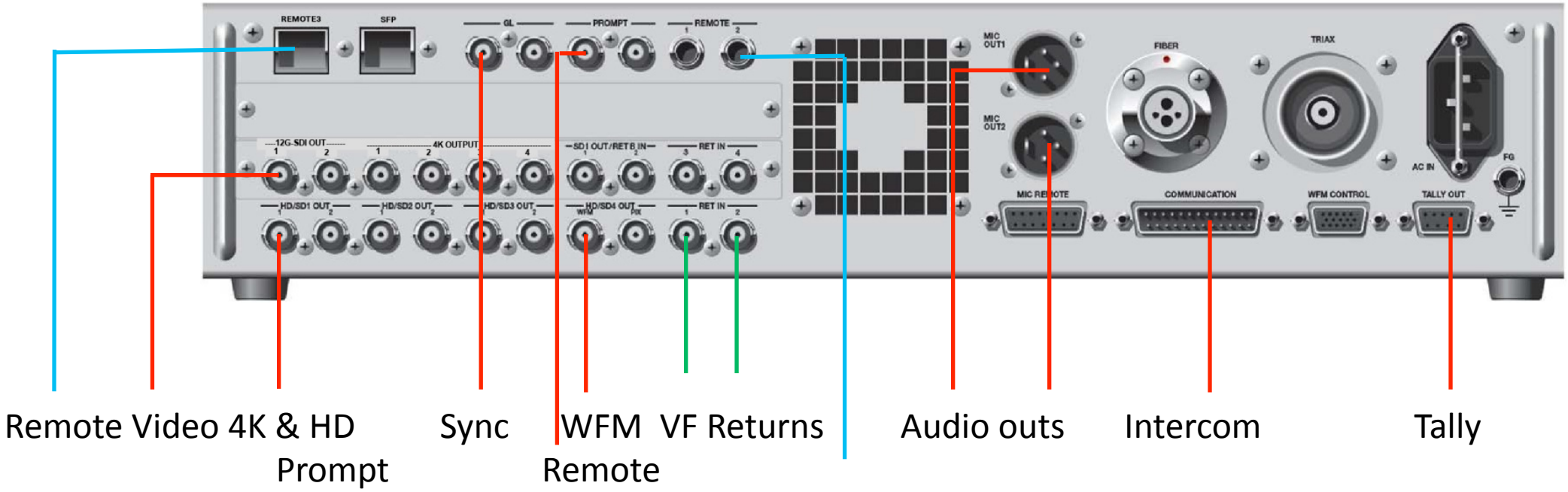
CU-HD1300 CCU - Today



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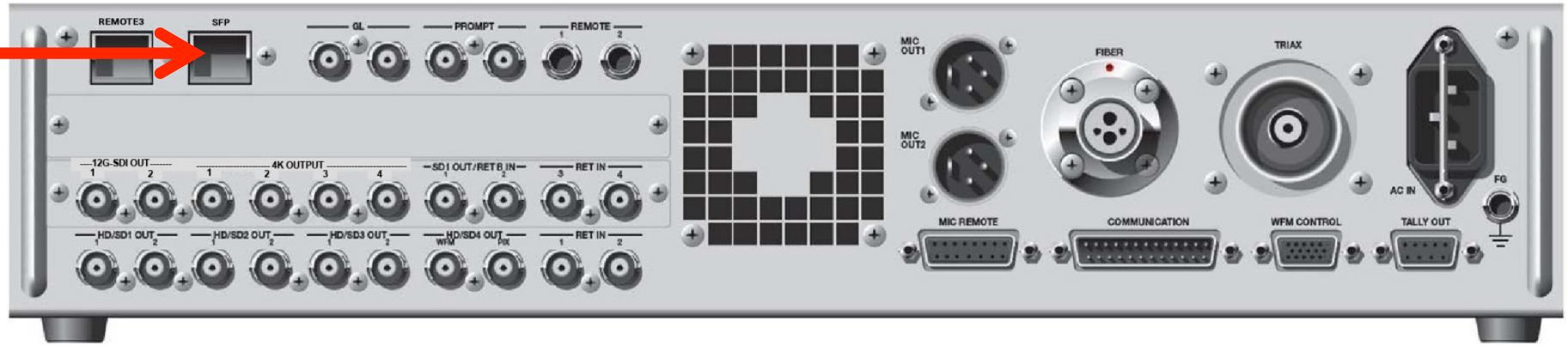
CU-HD1300 CCU - Someday



Video 4K & HD, Sync, PIX/WFM, Prompter, VF Returns, Remote, Audio out, Intercom, Tally

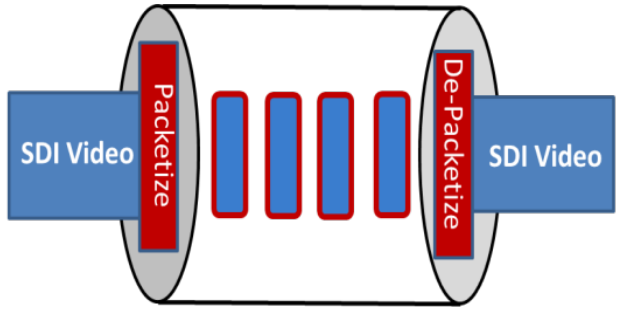
ST 2110

The Beginning… ST 2022

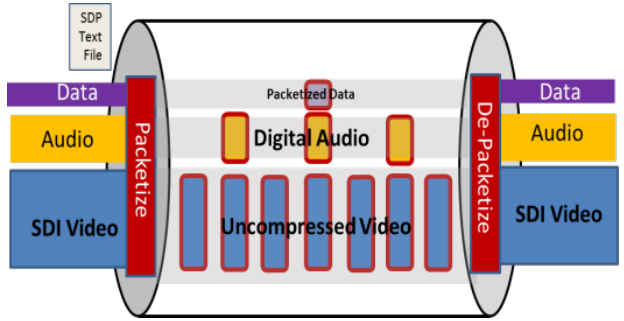
Video is steady signals using full bandwidth. Not available previously

2022 Packetizes SDI data into 1 stream
Easy conversion from SDI
Typically MPEG-2 compressed
Requires SDI to be reconstructed/de-embedded

ST 2022



ST 2110



ST 2110 supported by Hitachi CU-HD1300

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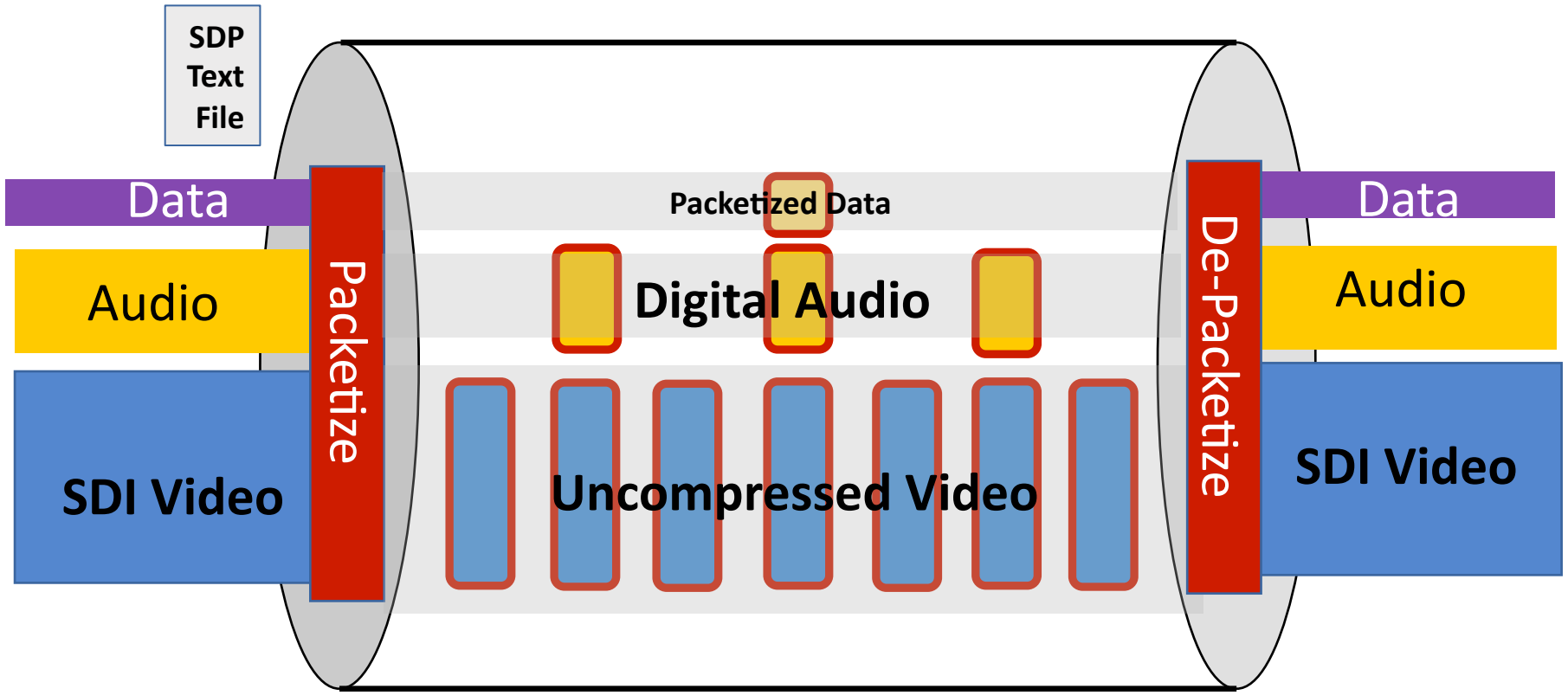
ST 2110 IP Packets



ST 2110 Media is packetized separately for transport across a standard IP network.

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ST 2110 Benefits

- ✓ **Separate Audio, Video & Metadata Flows. Bandwidth efficiency**
- ✓ Uses COTS equipment *(Possible future cost reduction)*
- ✓ Un-Compressed (currently)
- ✓ Accurate Synchronization (PTP)
- ✓ Uses Existing & Industry Standards
- ✓ Flexibility, Availability, Scalability, Infrastructure reduction

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ST 2110 Suite of Standards

SMPTE ST 2110 – 10 (System – Time Stamps, RTP, PTP, SDP)

SMPTE ST 2110 – 20 (Uncompressed Video)

SMPTE ST 2110 – 21 (Traffic shaping (packet pacing, bursts, gaps)

SMPTE ST 2110 – 30 (Uncompressed Audio – AES67)

SMPTE ST 2110 – 31 (Compressed Audio – AES3)

SMPTE ST 2110 – 40 (Ancillary Data)

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Delivery Terminology

Media over IP is a very large amount of continuous data:

Multicast SMPTE ST 2110 uses “one to many” connections

RTP (Real-time Transport Protocol)

UDP (User Datagram Protocol)

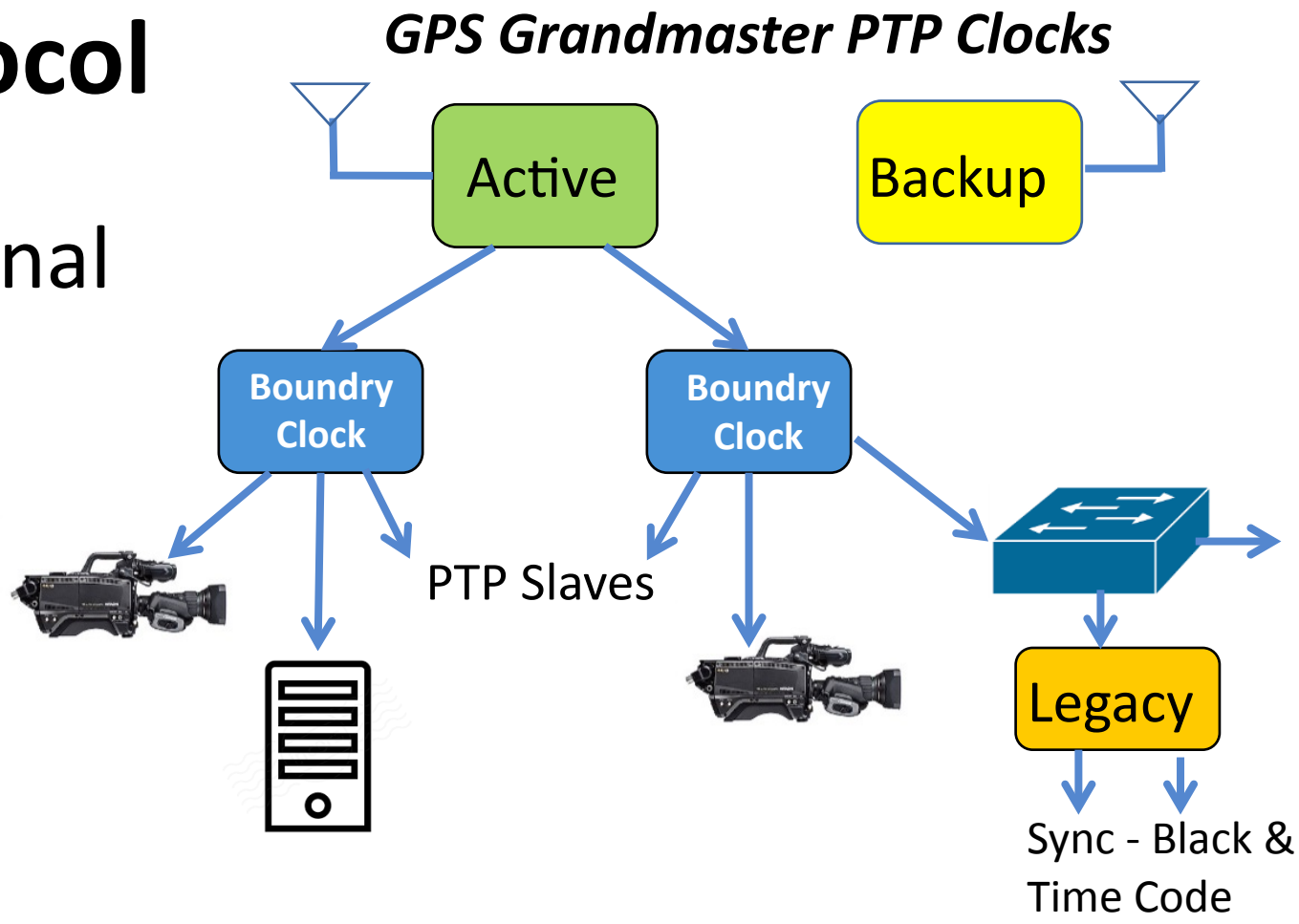
TCP (Transport Control Protocol) / IP (Internet Protocol)

SMPTE ST 2059 / IEEE 1588

Precision Time Protocol

No need for separate signal paths for sync

PTP will allow devices to be precision slaved to a common master clock



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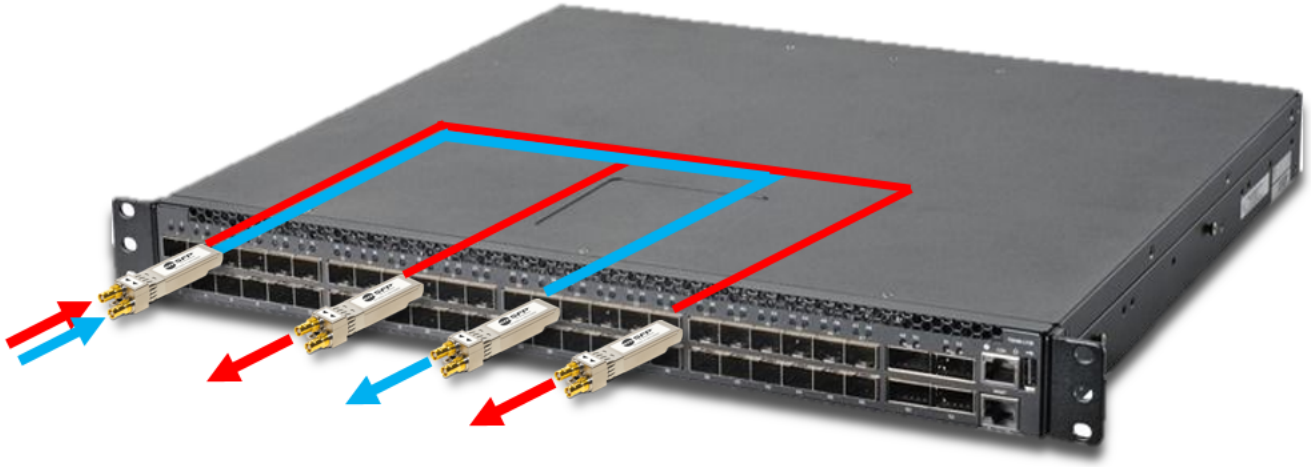
Hybrid SDI/IP System



Small Form Factor Pluggable (SFP)

Converts SDI inputs and/or outputs to ST 2110

Plugs into Switch SFP ports. 1Gb, 10Gb and 25Gb

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Professional Groups

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Standards Groups

SMPTE ST 2110
SMPTE ST 2022
AES67

IETF RFC 4566 (SDP)

IETF RFC 791 (IPv4), RFC 2460/8200 (IPv6)

IETF RFC 793 (TCP), RFC 768 (UDP), RFC 3550 (RTP), RFC 2236/3376 (IGMP Multicasting)

IEEE 802.3 (Ethernet), 802.11 (WiFi), IEEE 1588 (PTP)

Cat 5 ANSI/TIA, ISO/IEC 11801 (Copper/Fiber)

ITU-T G.651.1 (Fiber), IEEE 802.11 (WiFi)

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SMPTE ST 2110 clearly defines those devices on the network that can send and receive packets.

However, it does not currently specify control or application layers of the network.

Significant work is still needed to achieve useful interoperability and automation in professional networked media environments.

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Questions?

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