AXON®

THE HEART OF BROADCAST

HDR & WIDE COLOR GAMUT

How do we get there and remaining backwards compatible

Peter Schut, CTO | VP of R&D
peter.schut@axon.tv
www.axon.tv

IN THIS PRESENTATION

- Some Basics
- Stuff that puzzled me, maybe puzzles you
- Stuff that surprised me how easy it is to see wrong (and maybe help you)
- Standards, Norms, Facts, Opinions
- Curves and LUT's
- The Axon solutions

A personal note from the presenter

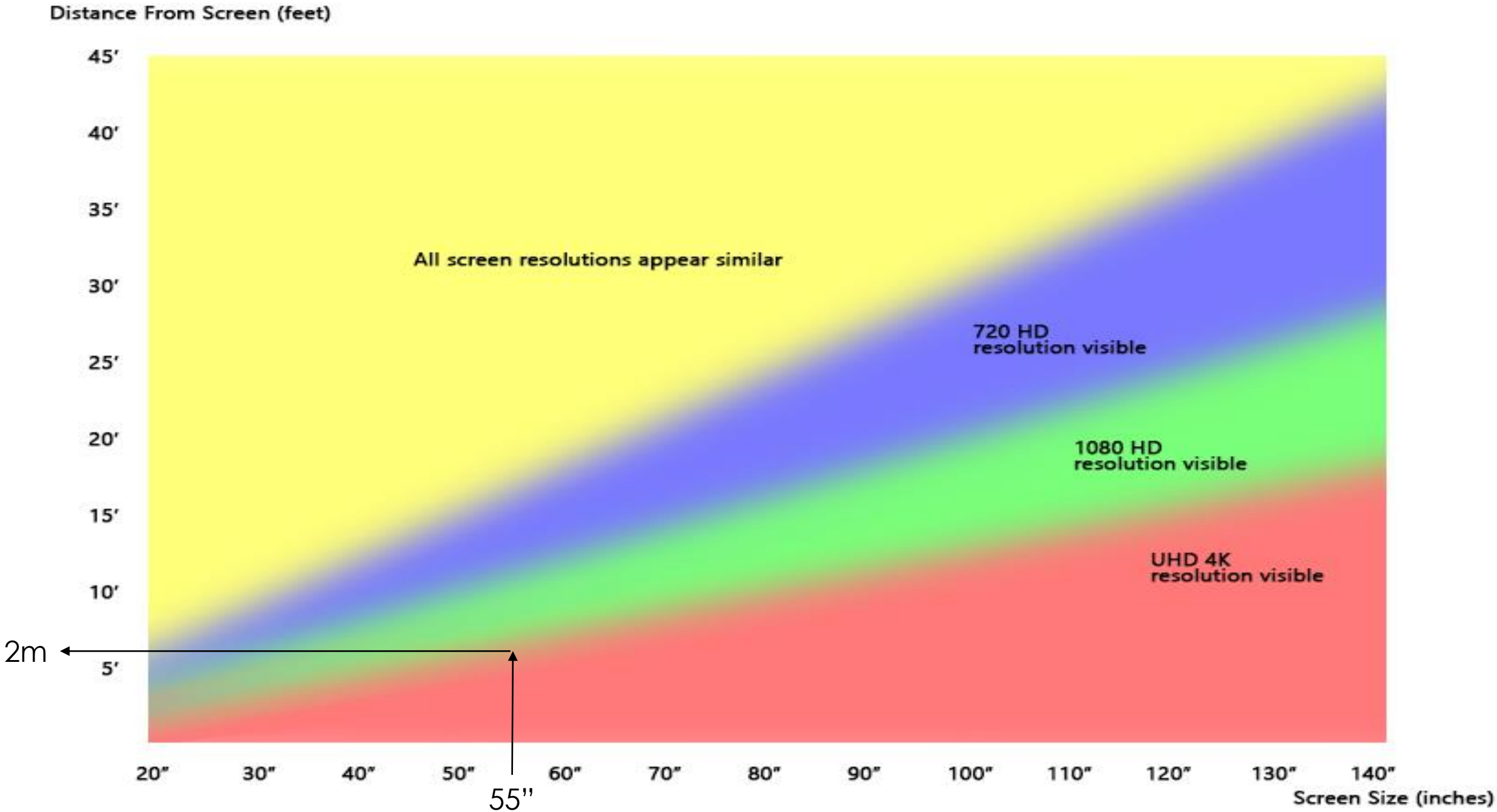
Television is moving to more pixels, more colors and higher dynamic range

And it is a jungle out there

We (the broadcast industry) need to provide an absolute WOW effect

(4k/709/SDR will not do that)

AXON
THE HEART OF BROADCAST


Distance From Screen (feet)
45'
40'
35'
30'
25'
20'
15'
10'
5'
All screen resolutions appear similar
720 HD
resolution visible
1080 HD
resolution visible
UHD 4K
resolution visible
2m
20"
30"
40"
50"
55"
60"
70"
80"
90"
100"
110"
120"
130"
140"
Screen Size (inches)

So we …….
(the broadcast industry)
need to do this right

AXON
THE HEART OF BROADCAST

Provide better pixels

(as just more is not enough)

We only have one chance and if we screw up, our audience will switch off

(and this is partly happening)

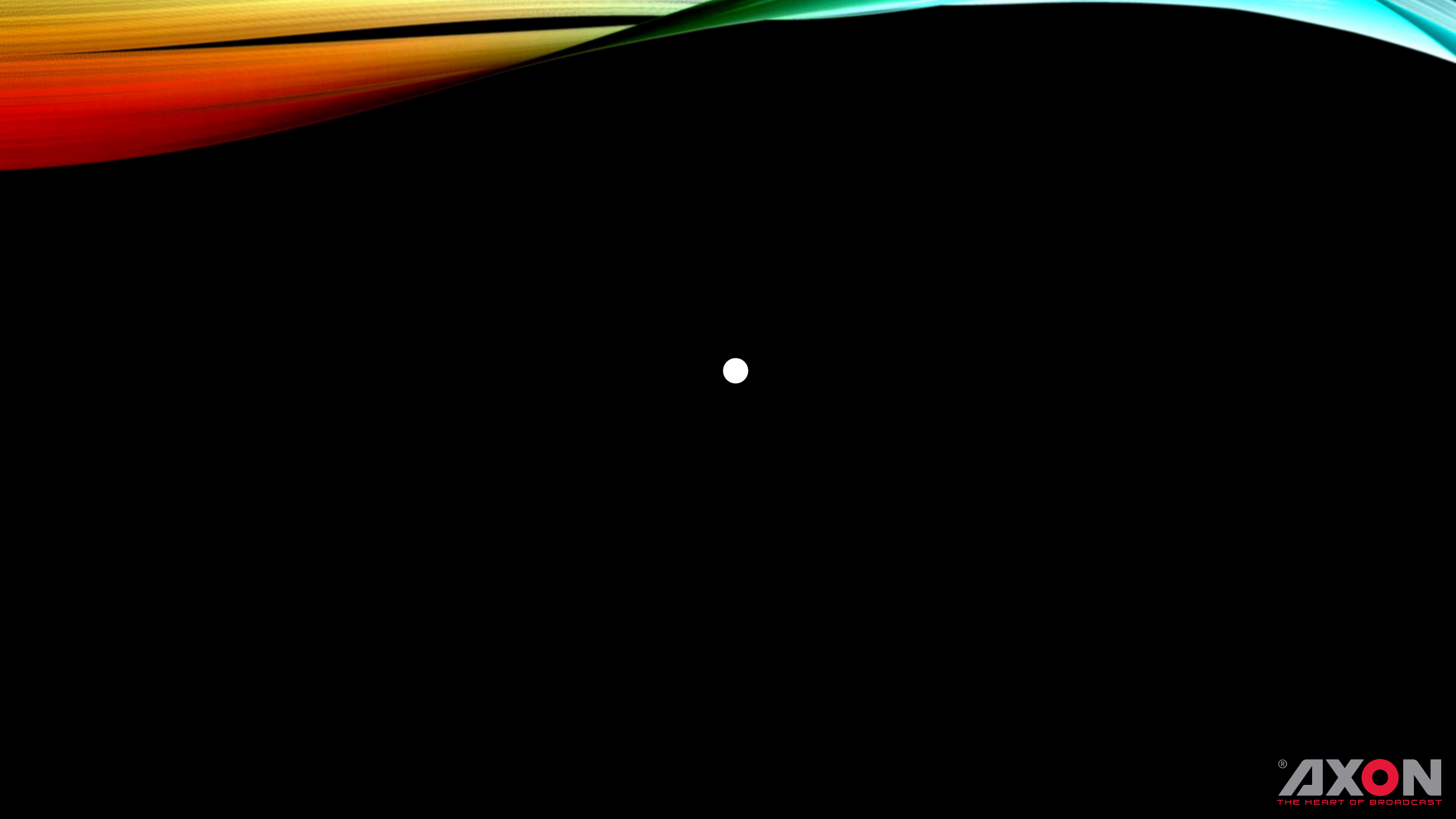
AXON
THE HEART OF BROADCAST

And please:
Do not accept any compromises

AXON
THE HEART OF BROADCAST

Let us provide pictures we can all be proud off

AXON
THE HEART OF BROADCAST


AXON
THE HEART OF BROADCAST

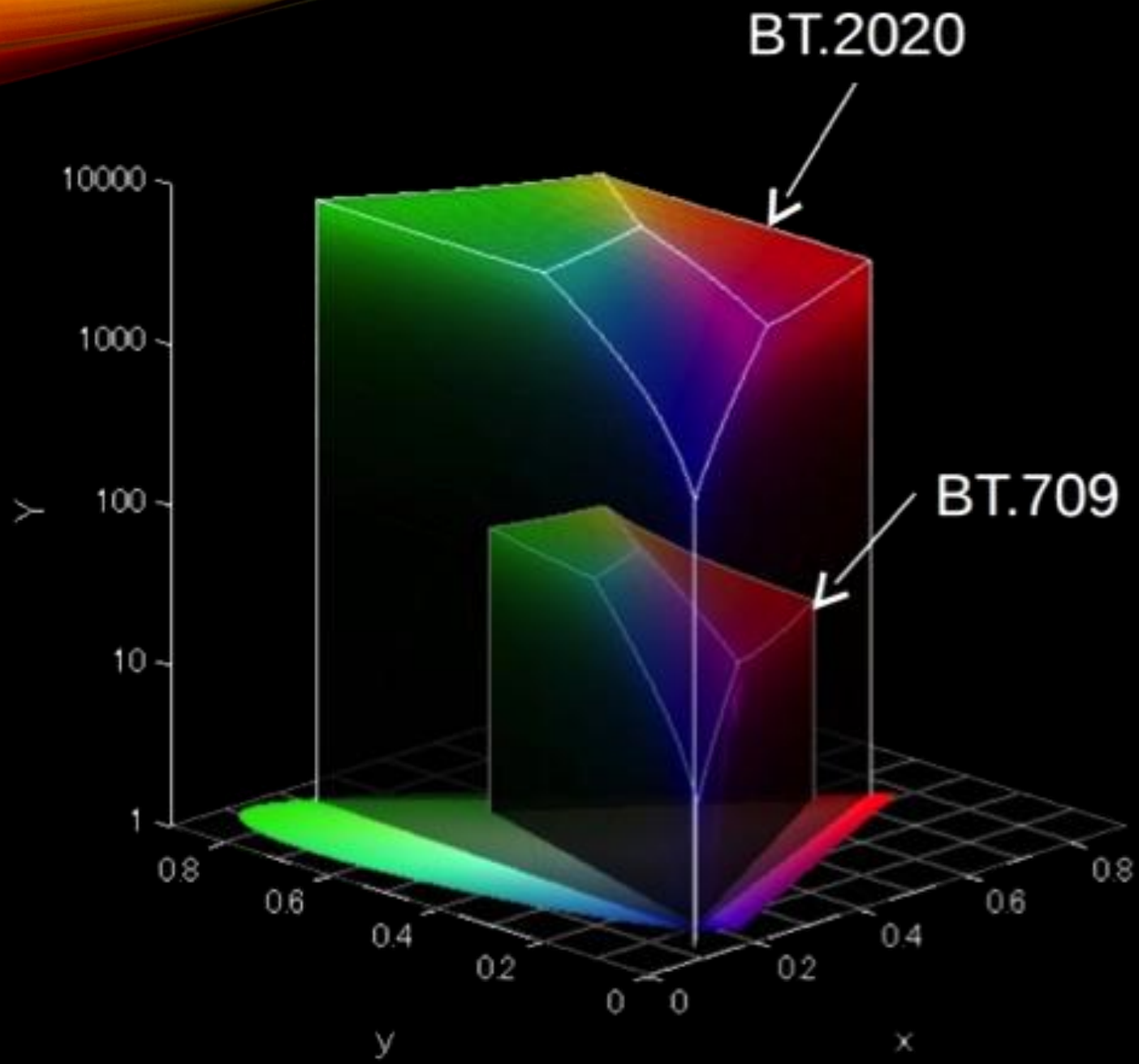
TERMINOLOGY

- ITU-R BT.601 — Good old color space in SD
- ITU-R BT.709 — Slightly more colors, but nothing really to get excited about
- ITU-R BT.2020 — A big increase in colors, close to the capability of the human eye
- PQ — Perceptual Quantization (a curve that is optimized for the human eye trough research from Dolby making best use of the bit depth at hand)
- HLG — Hybrid Log Gamma; HLG increases the dynamic range of the video compared to a conventional gamma curve by using a logarithmic curve for the upper half of the signal values
- ITU-R BT.2100-0 — Image parameter values for high dynamic range television for use in production and international program exchange

So what is this new challenge?

HDR & Wide color gamut

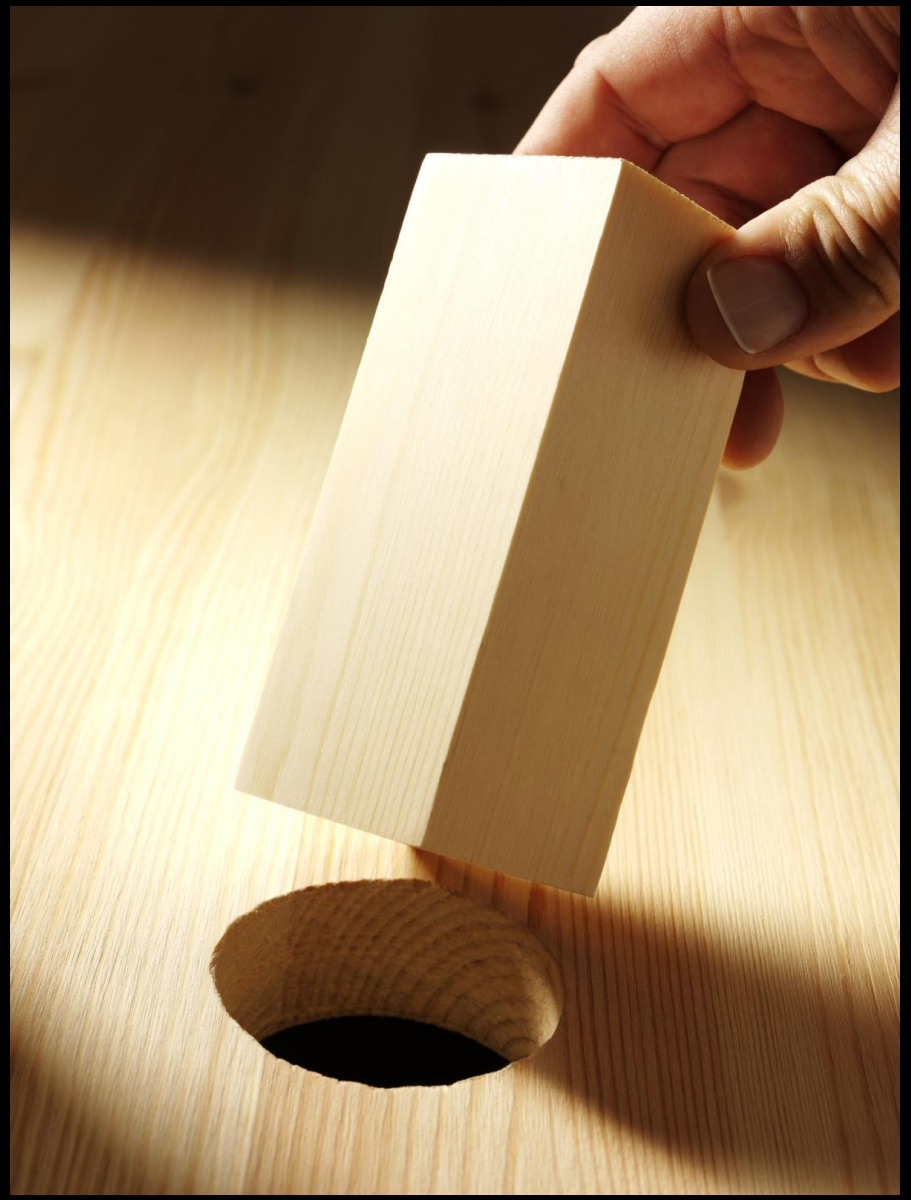
AXON
THE HEART OF BROADCAST



AXON
THE HEART OF BROADCAST

We are trying to put a square peg into a round hole

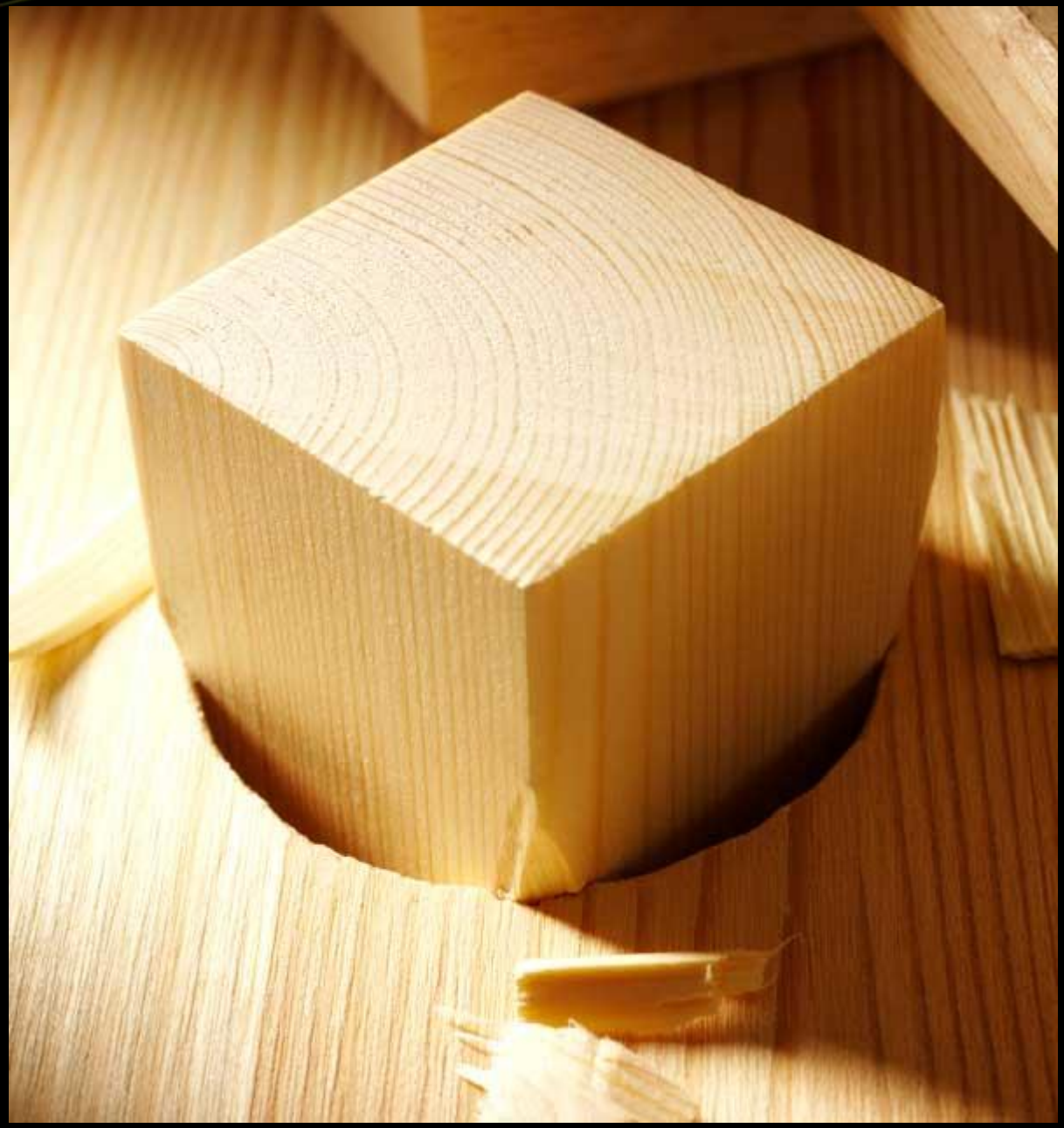
AXON
THE HEART OF BROADCAST



AXON
THE HEART OF BROADCAST

Sometimes brute force will work

(if you look how the consumer industry works)



AXON
THE HEART OF BROADCAST

It looks like 4:3 to 16:9 and back all over again

So we …….

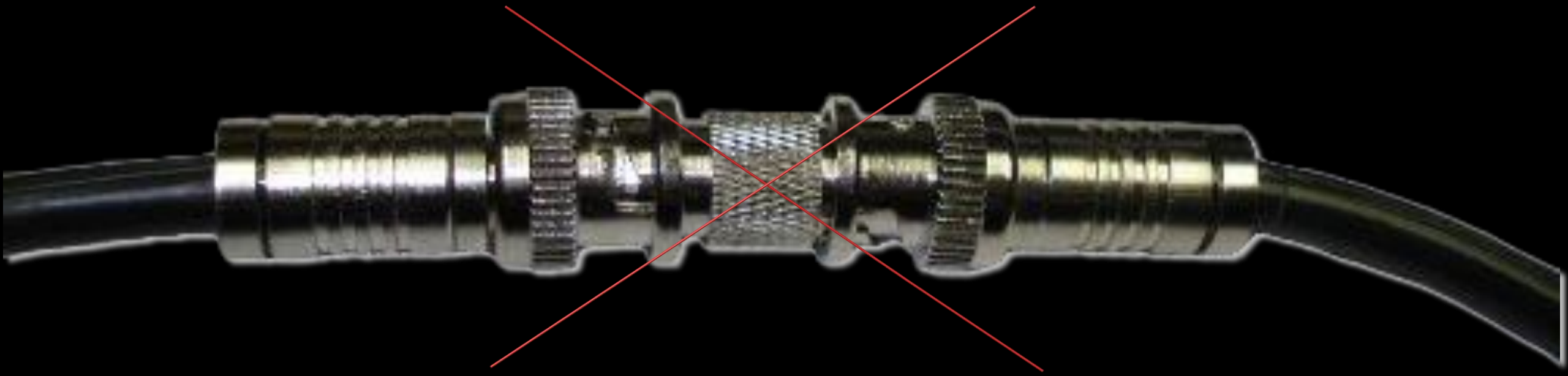
(the broadcast industry)

need to do this right

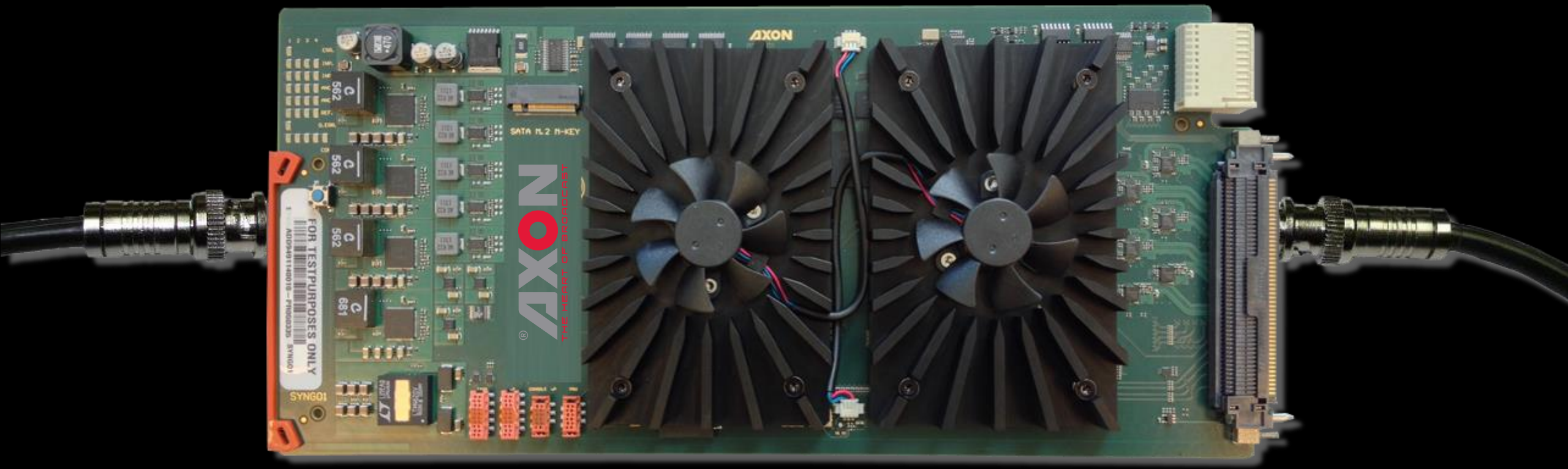
AXON®
THE HEART OF BROADCAST

AXON
THE HEART OF BROADCAST

In other words:



You need:


AXON
SATA M.2 M-KEY
FOR TESTPURPOSES ONLY
SYNGOI
AXON
THE HEART OF BRAINCREST

Before we start
Let’s get something straight

AXON
THE HEART OF BROADCAST

If we say HDR….
We mean HDR and WCG

The next picture is a hoax

Standard Dynamic Range

High Dynamic Range

AXON
THE HEART OF BROADCAST

Comparing SDR with HDR on the same screen is in most cases not possible

One is always wrong

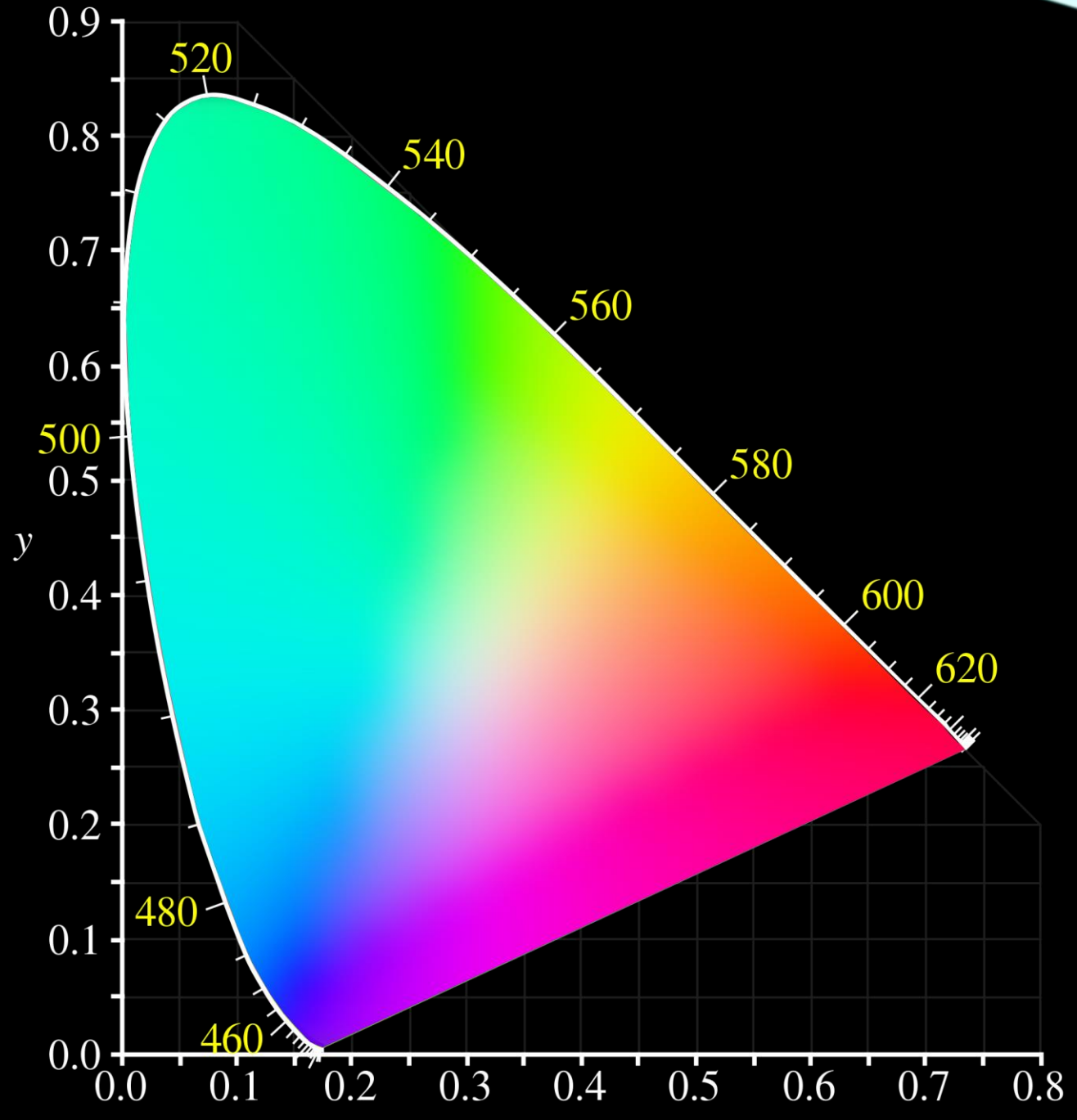
Some history

(for you to look back on later)

CIE is the International Commission on Illumination
(Commission internationale de l'éclairage).

If SMPTE is the authority on all standards pertaining to video, then CIE is the authority on light. They were formed in 1913

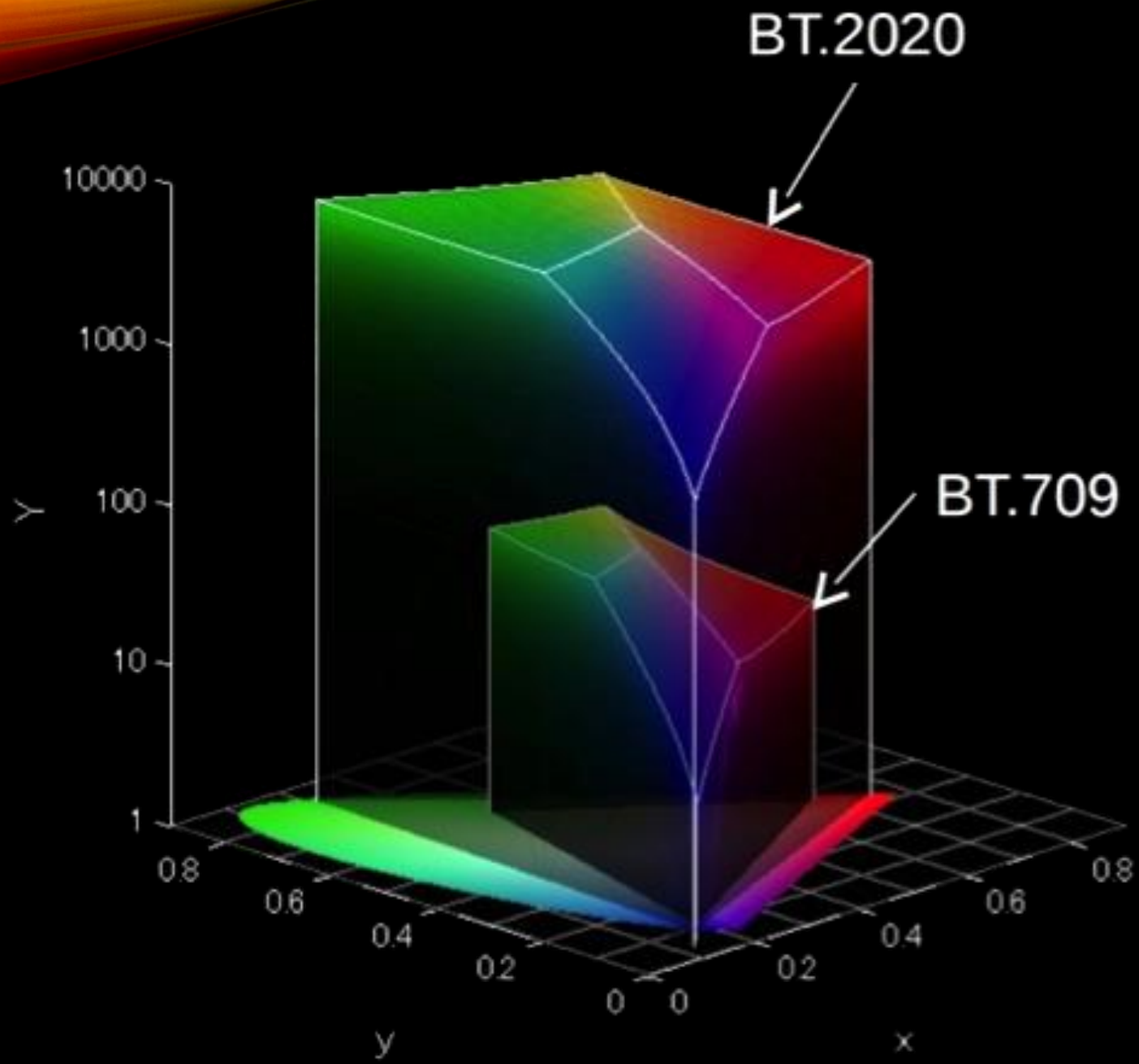
The CIE 1931 color space chromaticity diagram. The outer curved boundary is the spectral (or monochromatic) locus, with wavelengths shown in nanometers. Note that the colors your screen displays in this image are specified using sRGB, so the colors outside the sRGB gamut are not displayed properly. Depending on the color space and calibration of your display device, the sRGB colors may not be displayed properly either.



But there is another axis

(a very important one)

AXON
THE HEART OF BROADCAST



AXON
THE HEART OF BROADCAST

So the area we are working in is 3 dimensional

And the volume going from rec 709 – 100 nits to rec 2020 – 1000+ nits is expanding exponentially

In a linear environment we would need much more than 10 bits

So we need some sort of curve

(and use the bits more efficient)

(Gamma) Curves

Now things get messy

Colorspaces are well defined volumes

(and they are not compatible)

REC. 709 in CIE 1931

REC. 2020 in CIE 1931

Gama Curves make things even worse with respect to interoperability

AXON
THE HEART OF BROADCAST

Material recorded into one curve looks wrong on a display that expects a different curve

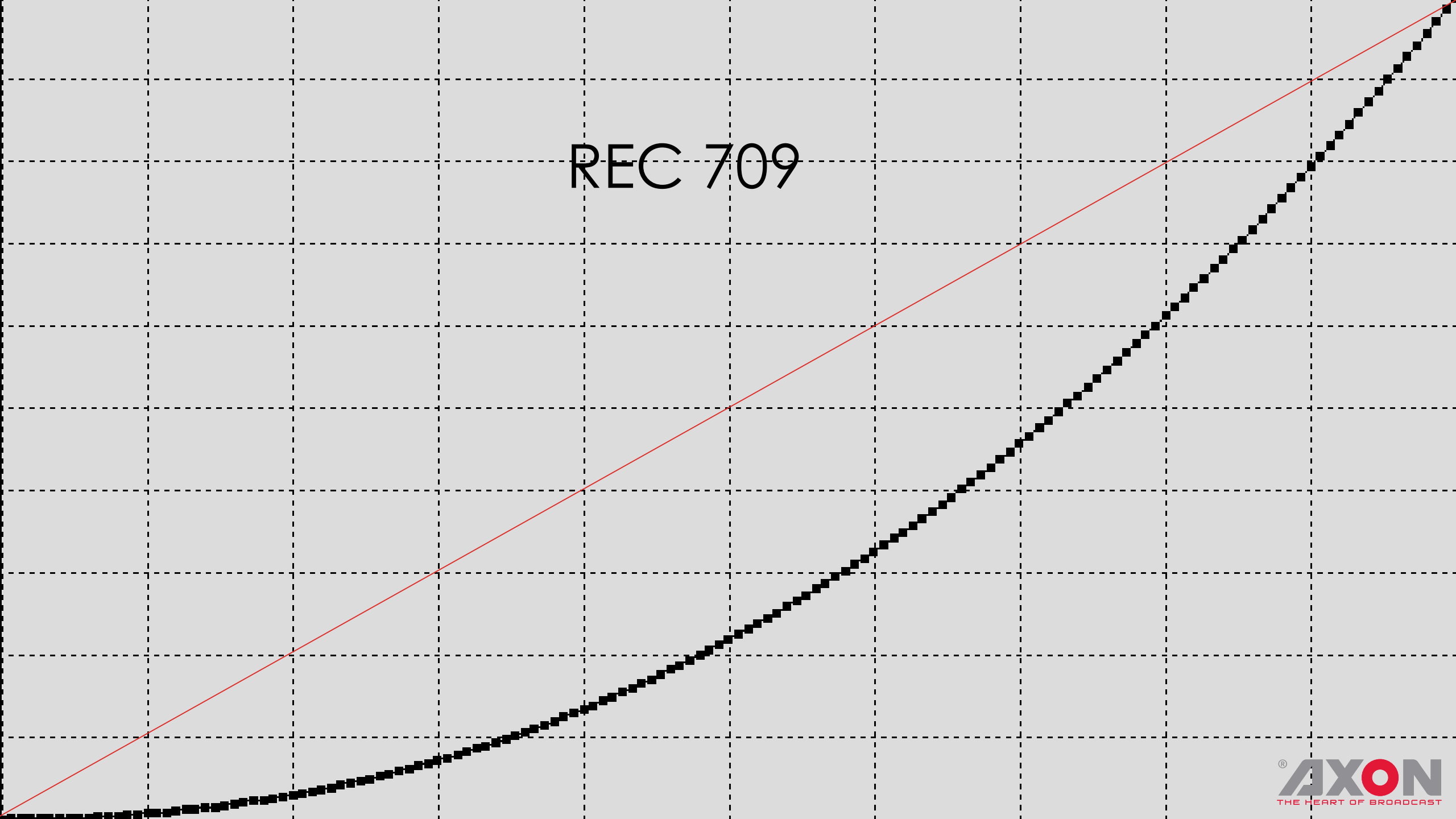
AXON
THE HEART OF BROADCAST

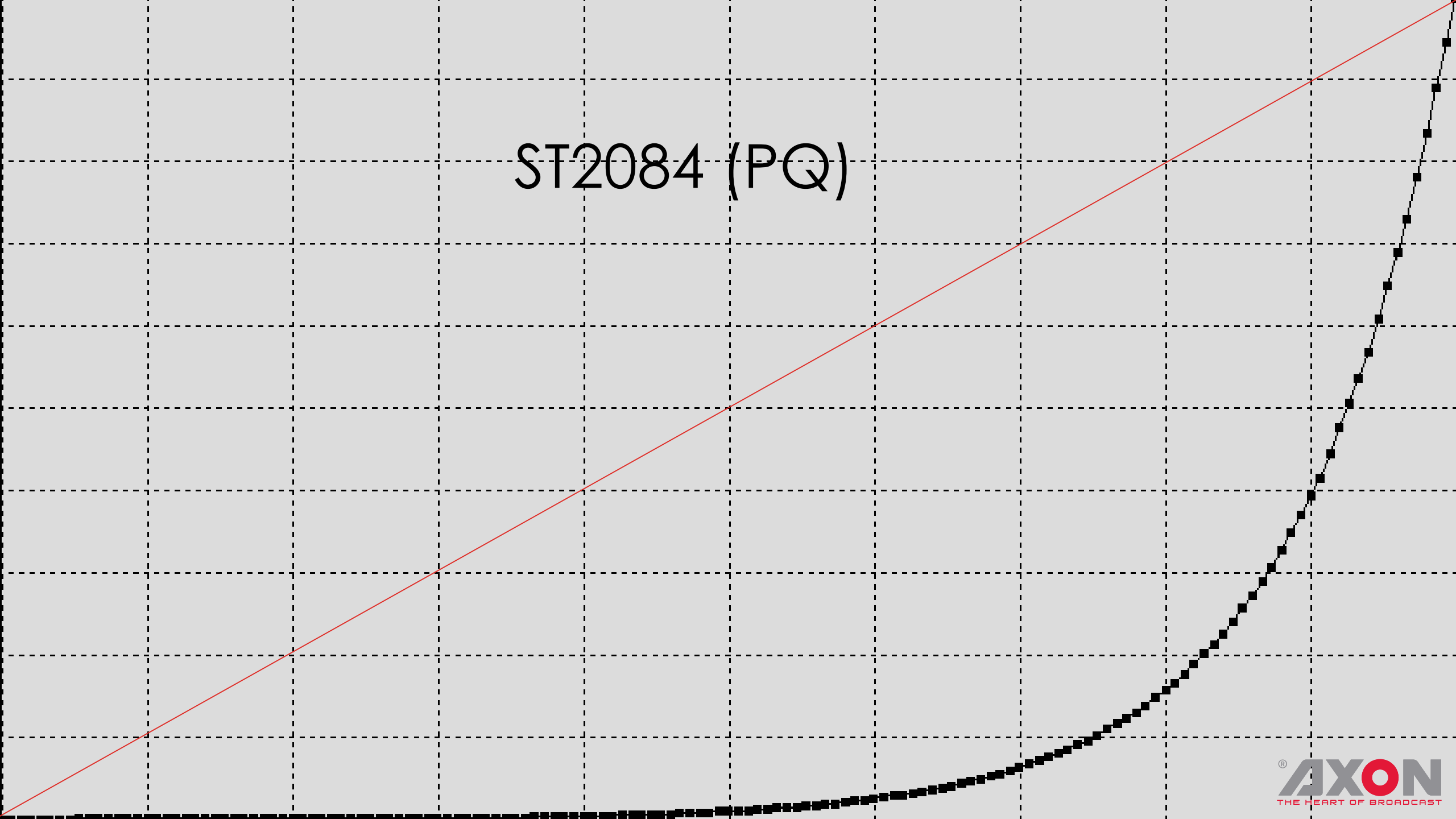
THE MOST IMPORTANT CURVES

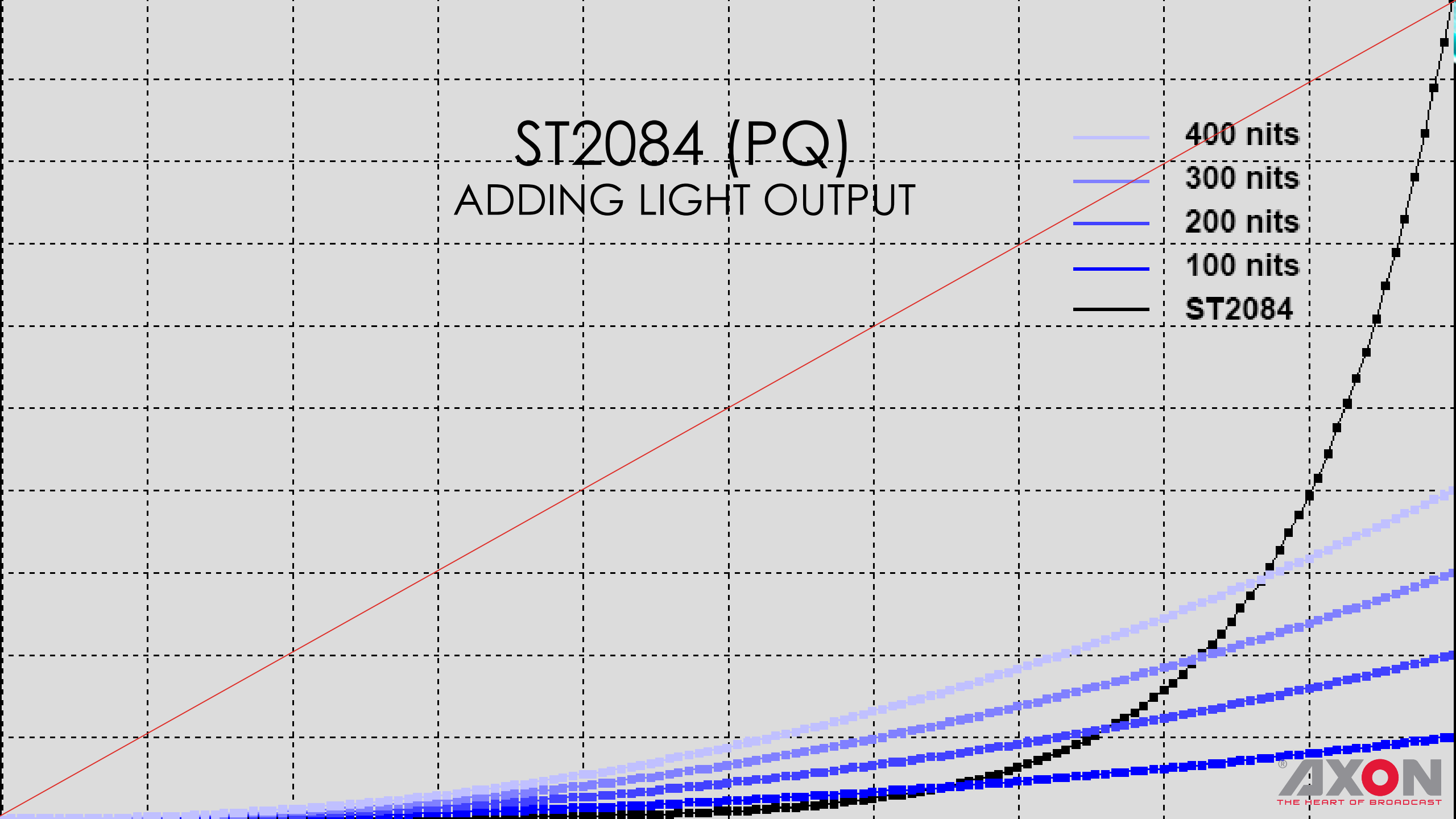
- PQ (perceptual quantization by Dolby but free to use) now covered as part of ST2084
- HLG (Hybrid Log Gamma, a backwards compatible curve as long as the color space is 709)
- Slog3 (Sony, a production standard not seen in TV's)

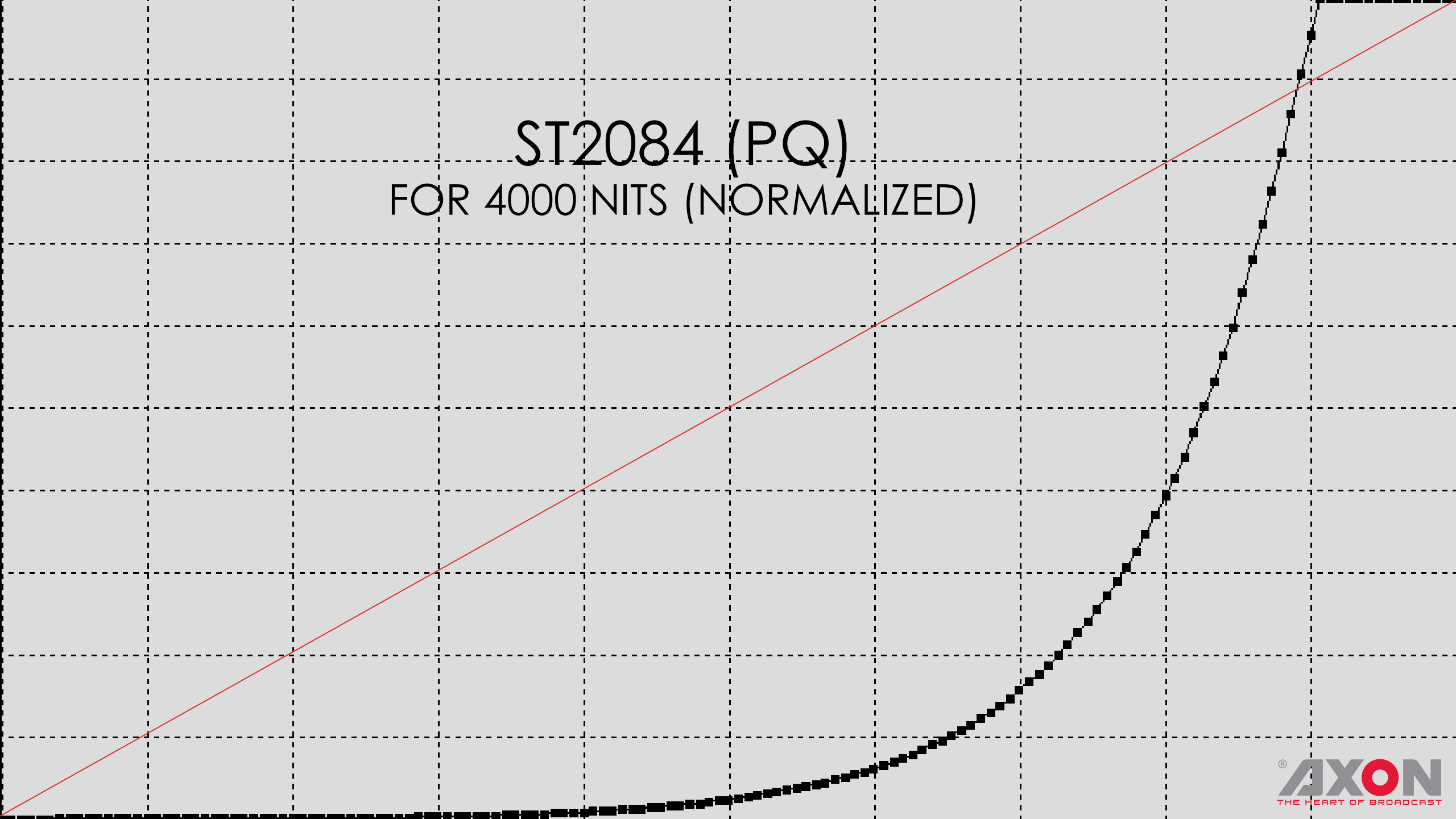
ST2084 (PQ)

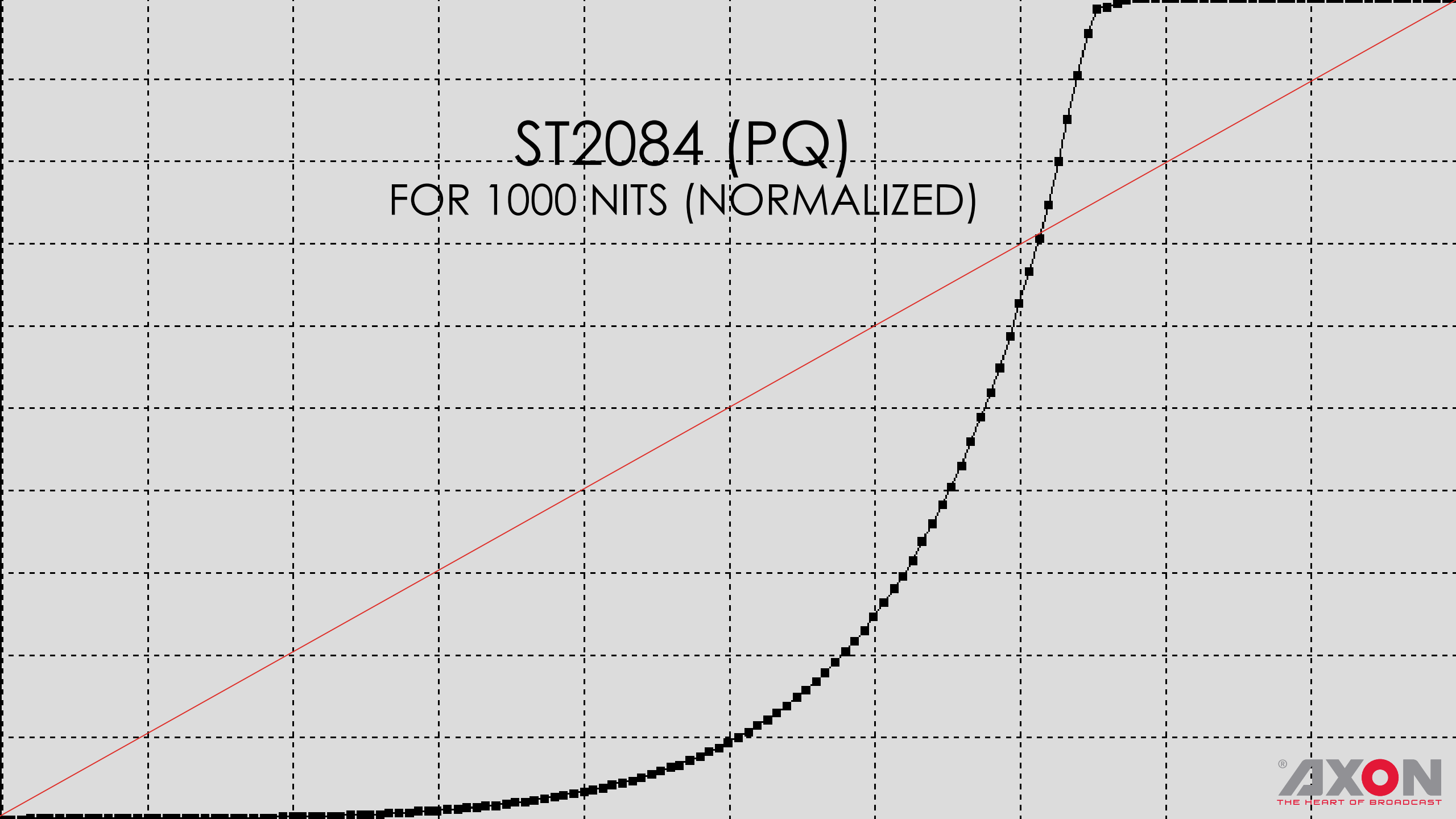
AXON
THE HEART OF BROADCAST

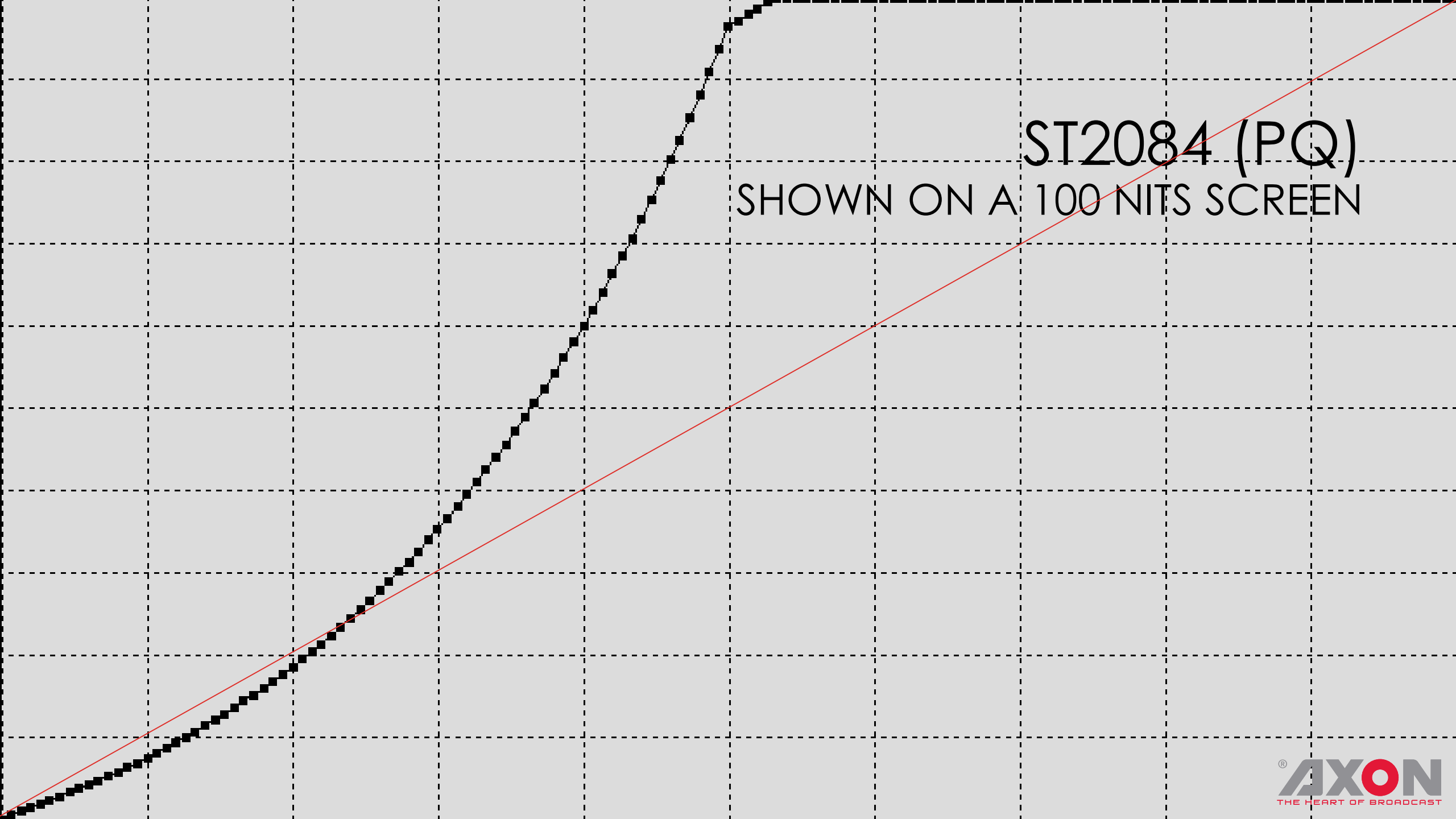

REC 709

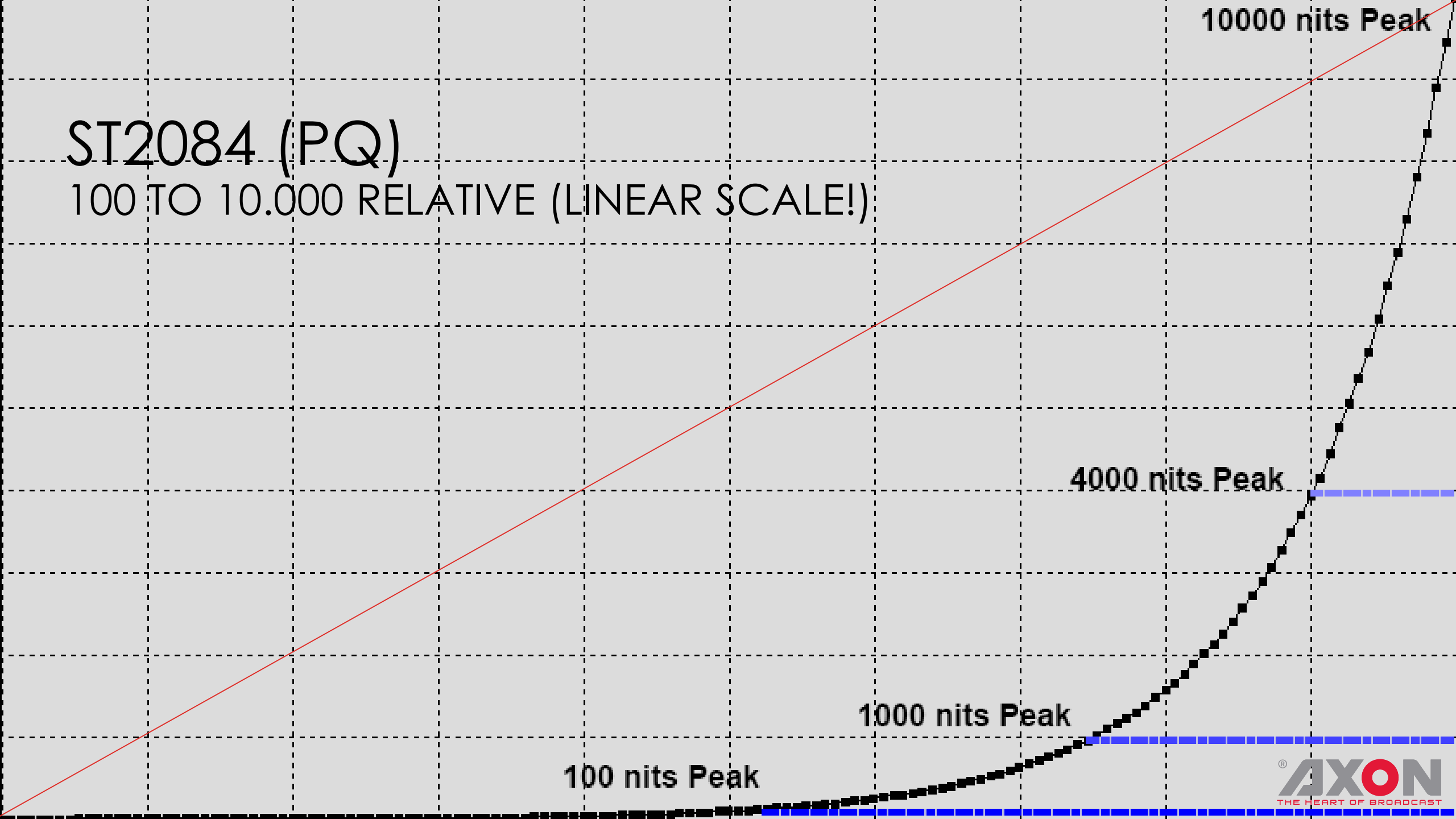

ST2084 (PQ)


ST2084 (PQ)
ADDING LIGHT OUTPUT
400 nits
300 nits
200 nits
100 nits
ST2084
AXON
THE HEART OF BROADCAST


ST2084 (PQ)
FOR 4000 NITS (NORMALIZED)

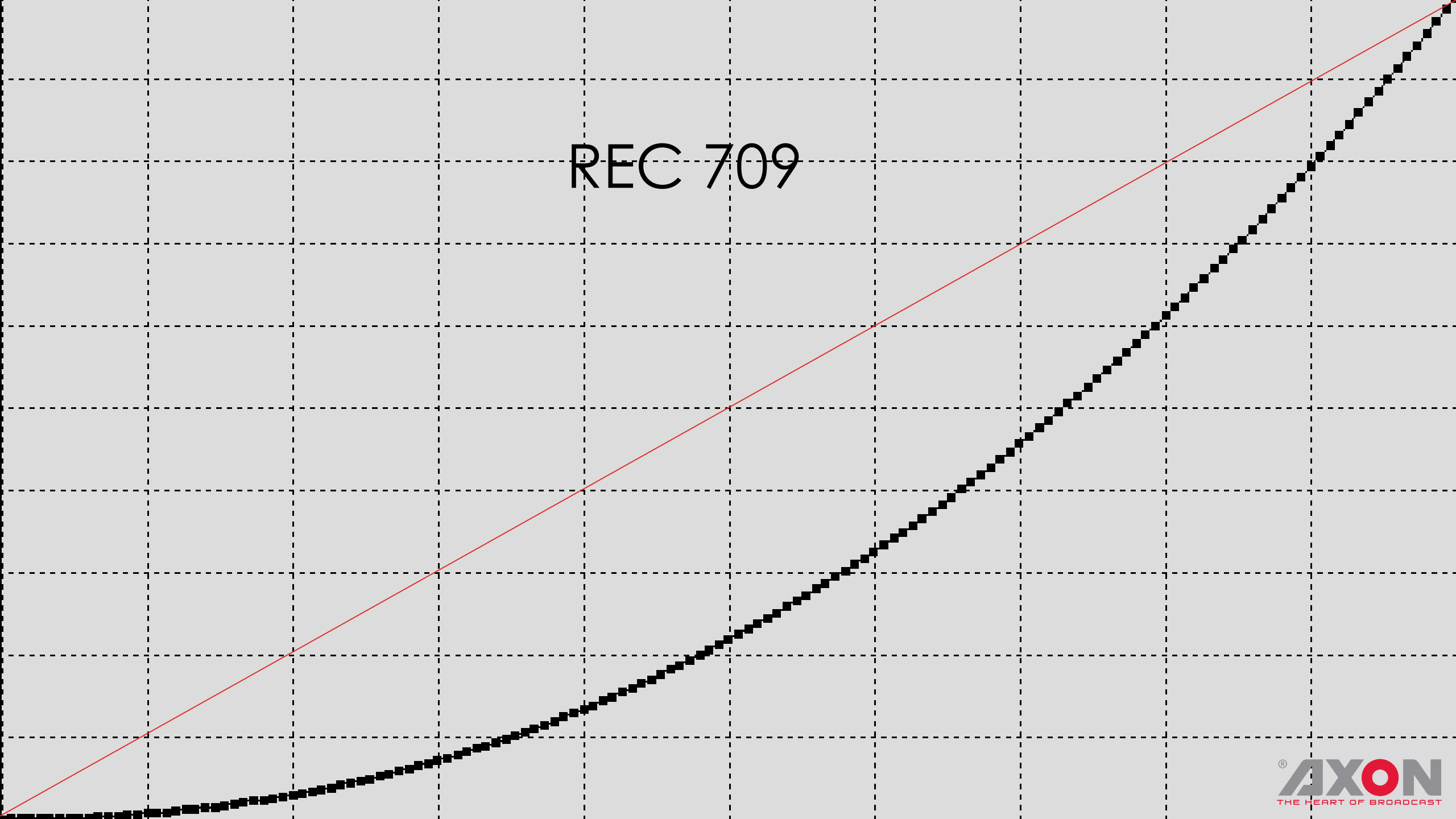

ST2084 (PQ)
FOR 1000 NITS (NORMALIZED)

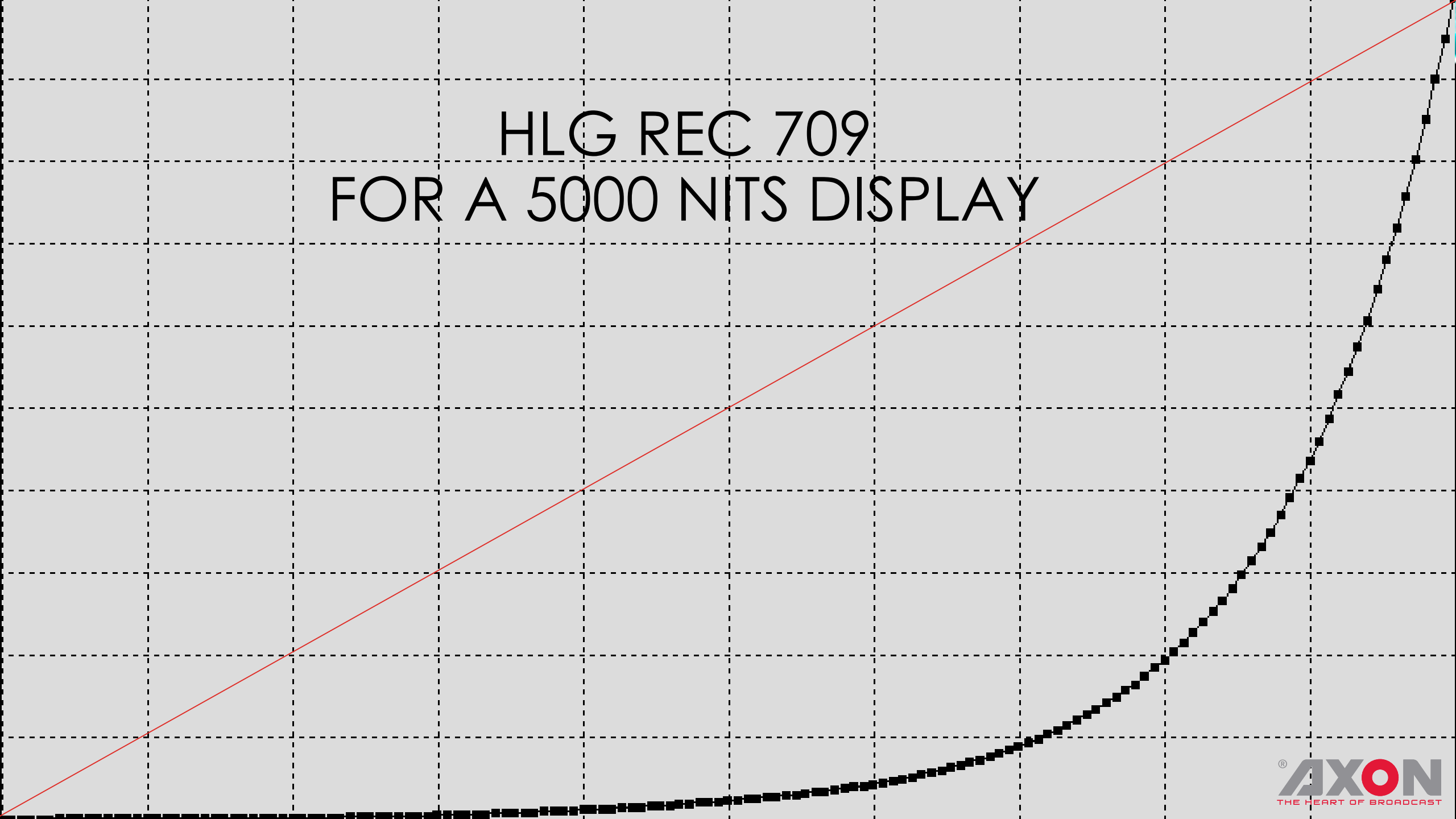

ST2084 (PQ)
SHOWN ON A 100 NITS SCREEN

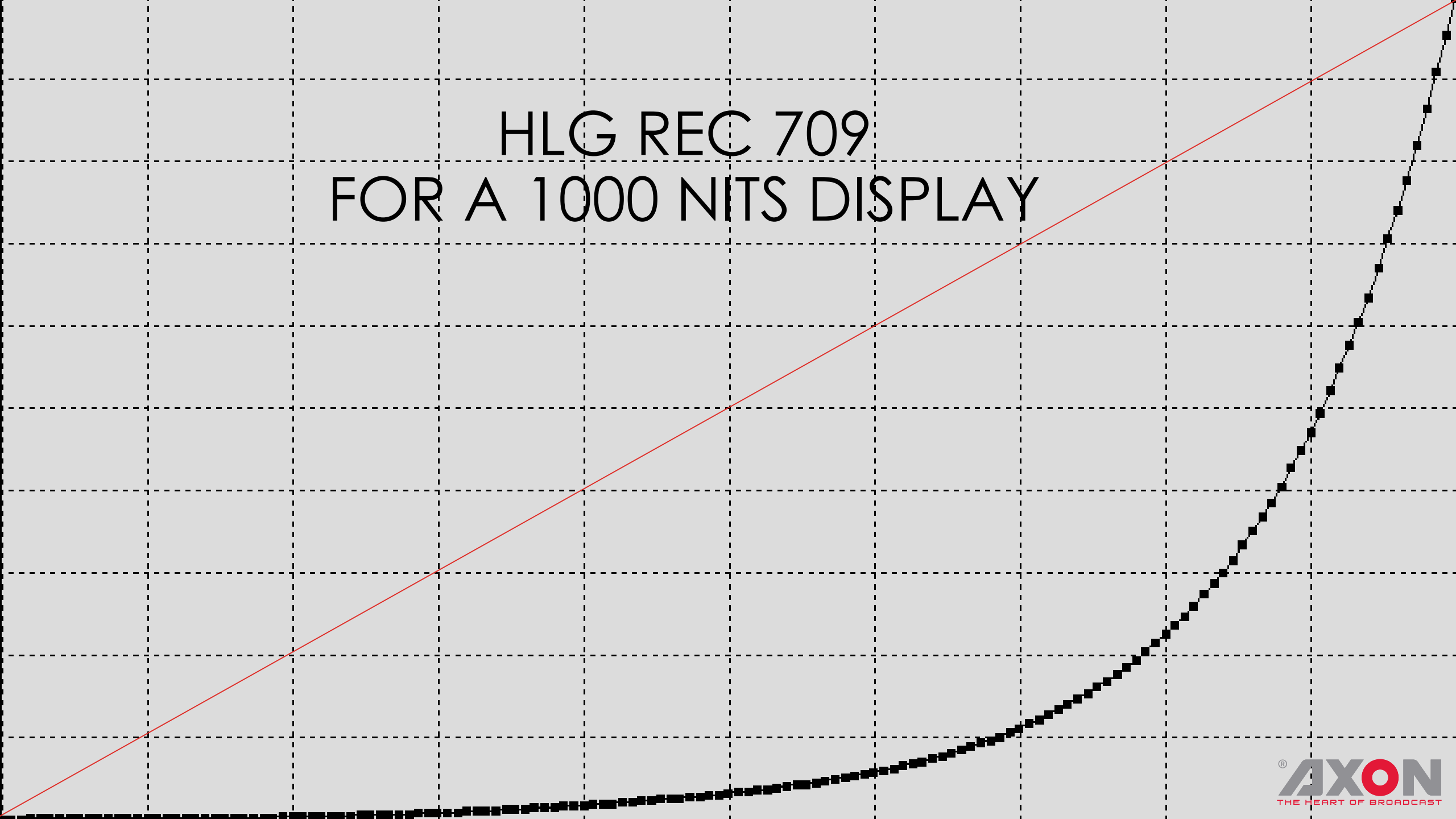

ST2084 (PQ)
100 TO 10.000 RELATIVE (LINEAR SCALE!)
10000 nits Peak
4000 nits Peak
1000 nits Peak
100 nits Peak
AXON
THE HEART OF BROADCAST

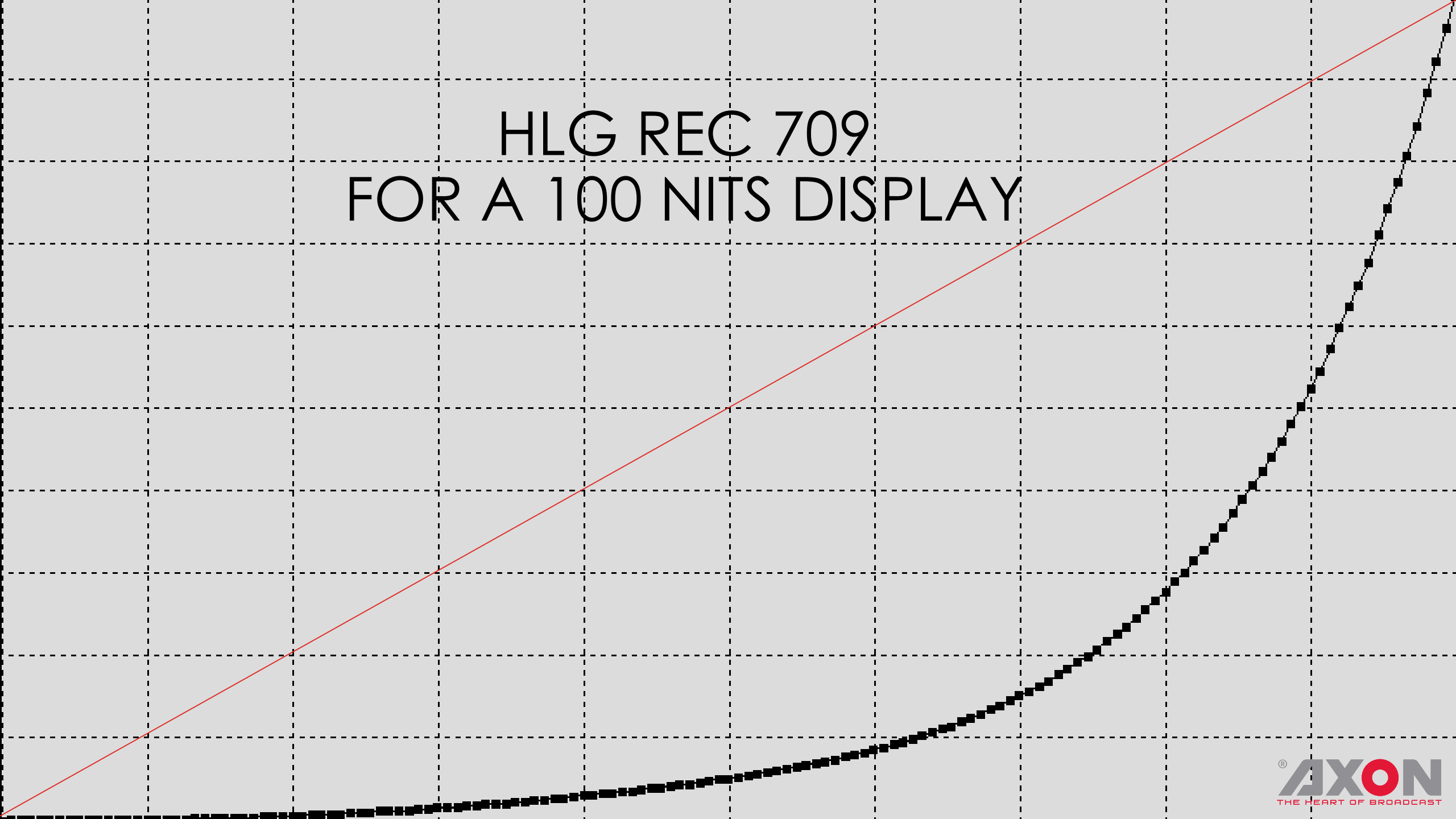
HLG

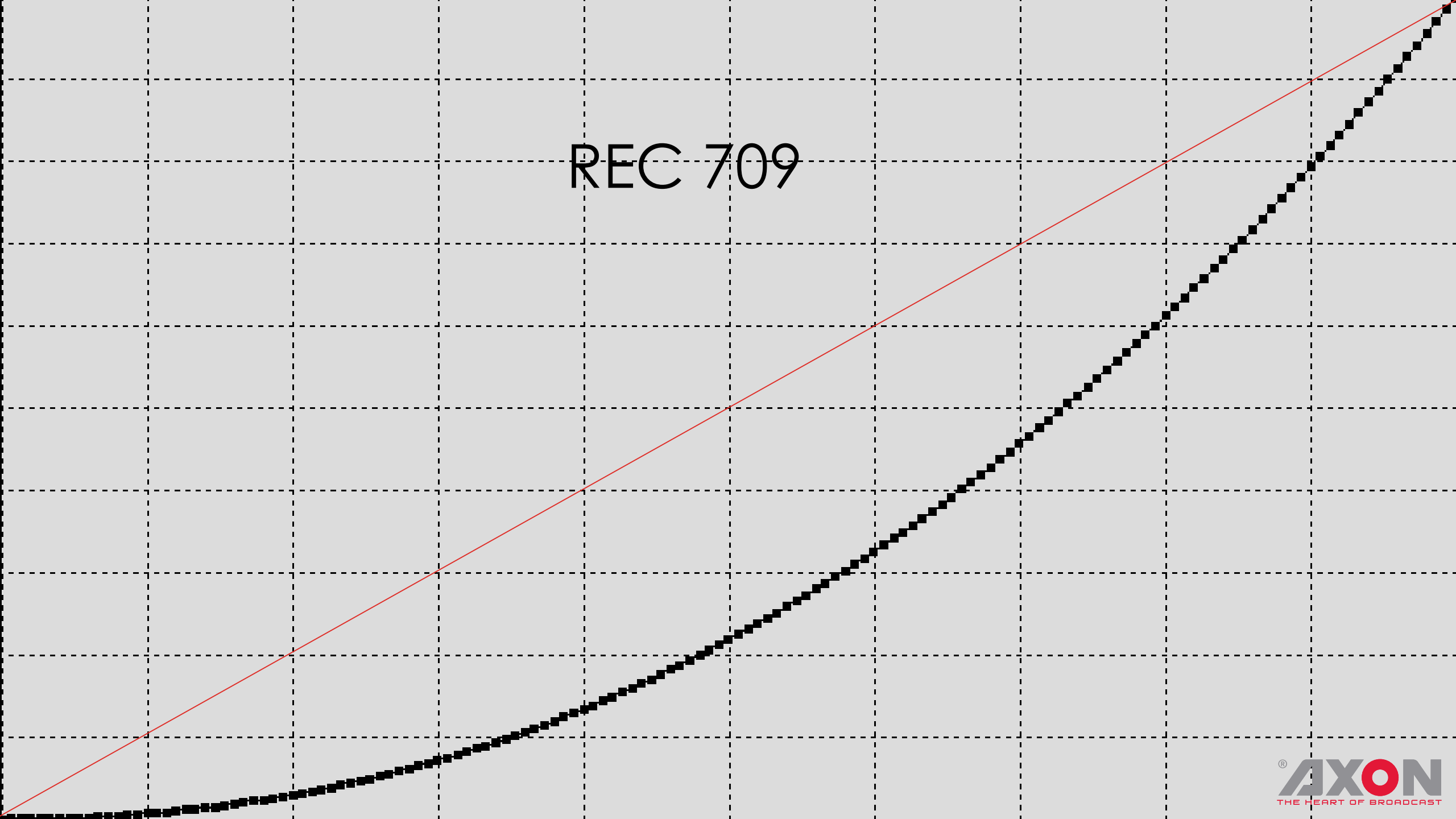
AXON
THE HEART OF BROADCAST


REC 709


HLG REC 709
FOR A 5000 NITS DISPLAY
AXON
THE HEART OF BROADCAST


HLG REC 709
FOR A 1000 NITS DISPLAY


HLG REC 709
FOR A 100 NITS DISPLAY
AXON
THE HEART OF BROADCAST


REC 709

SOME FACTS (AND STATEMENTS) 1

- The digital television image formats for HDTV and UHDTV have been specified by the ITU-R in Recommendations ITU-R BT.709 and ITU-R BT.2020
- These television image formats have been limited in dynamic range due to their reliance on legacy cathode ray tubes (CRT)
- In fact early flat panel screens weren't to good in providing a high dynamic range so improving on DR wasn't possible with these panels when HD started

SOME FACTS (AND STATEMENTS) 2

- But modern displays are capable of reproducing images at a higher luminance, greater contrast ratio and wider color gamut
- Viewers (and our industry) expect future TV's to provide improved color and dynamic range compared with the current HDTV and UHDTV
- High dynamic range television (HDR-TV) has been shown to increase viewer enjoyment of television pictures
  - More than higher resolution does

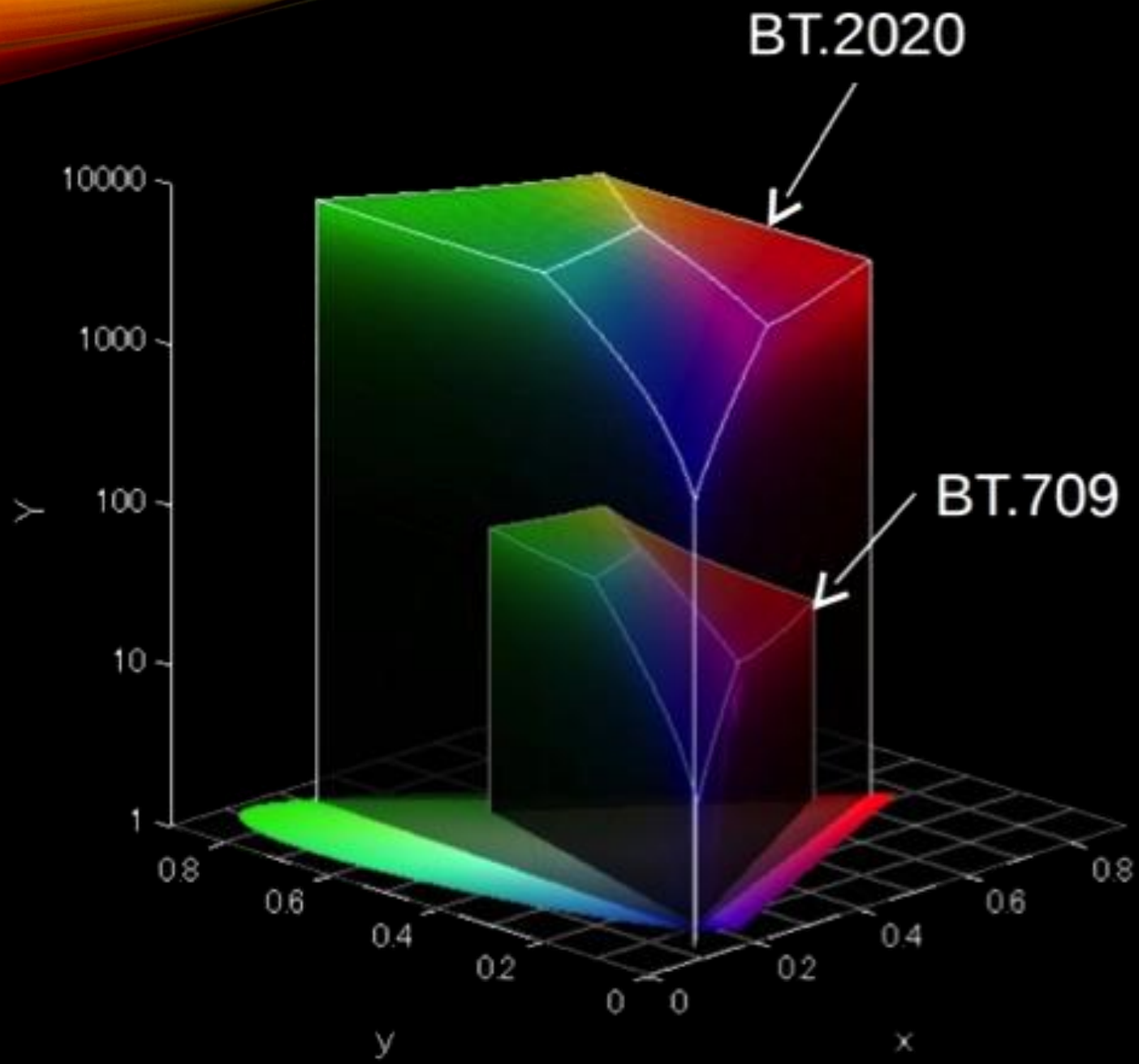
SOME FACTS (AND STATEMENTS) 3

- HDR-TV provides a massive improvement in viewer experience by means of substantially higher brightness and detail in highlights and diffuse reflecting objects, while providing greater detail in dark areas
- The combination of extended dynamic range and extended color gamut give HDR-TV a substantially larger color volume
- HDR-TV image formats should ideally have compatibility with existing workflows and infrastructures
- Due to rapid developments in HDR technology we are facing a moving target (the CE industry)

This is not going to be easy!

AXON
THE HEART OF BROADCAST

Looking at the color volume



AXON
THE HEART OF BROADCAST

(Source: Dolby; modified by P.Schut)

THE HUMAN DYNAMIC RANGE COLOR & CONTRAST

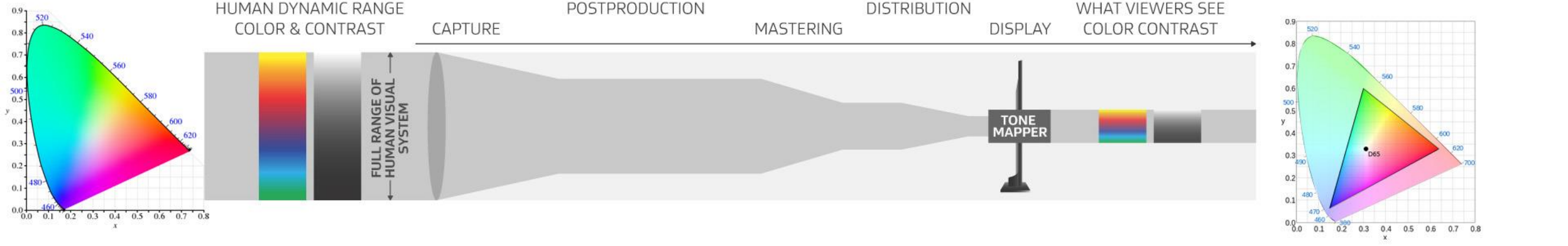
(Source: Dolby; modified by P.Schut)

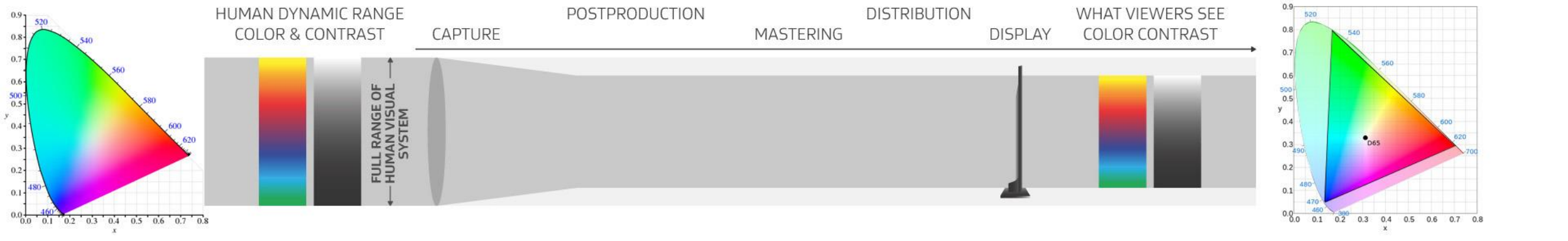
THE FAIRLY SMALL 709-100 NITS COLOR & CONTRAST

(Source: Dolby; modified by P.Schut)

NOW GOING TO REC2020 AND HDR (>1000 NITS)

(Source: Dolby; modified by P.Schut)





Going from SDR to HDR and back

AXON
THE HEART OF BROADCAST

We are in a learning curve here and many experiments will need to guide us in what works and what doesn't

AXON
THE HEART OF BROADCAST

Going from one color space to another color space and different dynamic range can be done with a LUT

A LUT or Look-Up-Table is a list of parameters with an input and an output

1 => 3

2 => 5

3 => 8

4 => 13

132 => 99

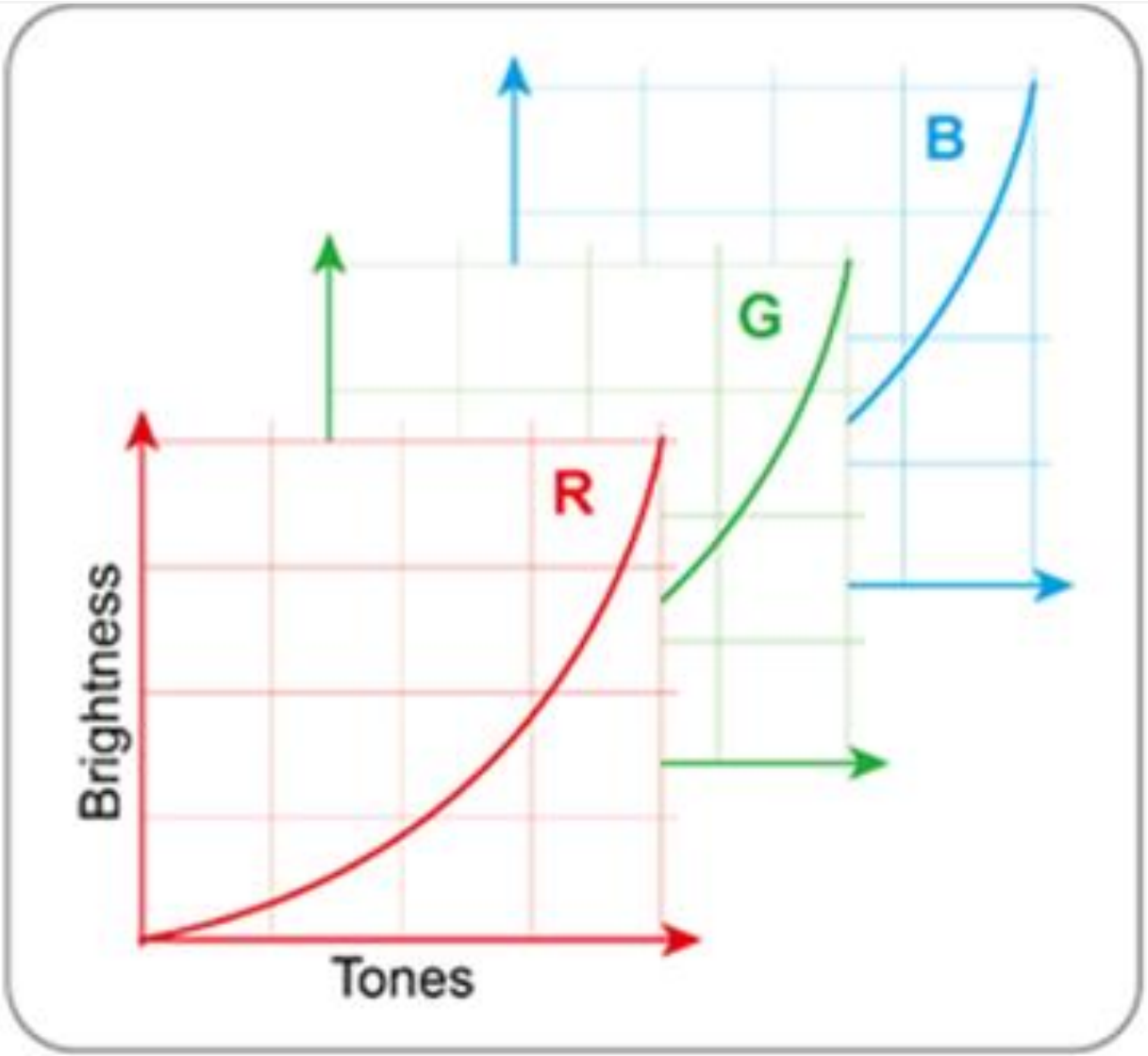
One value of R (red) becomes another value of R
The same applies for G and B.
Making an RGB LUT

Maintain skin colors is the goal

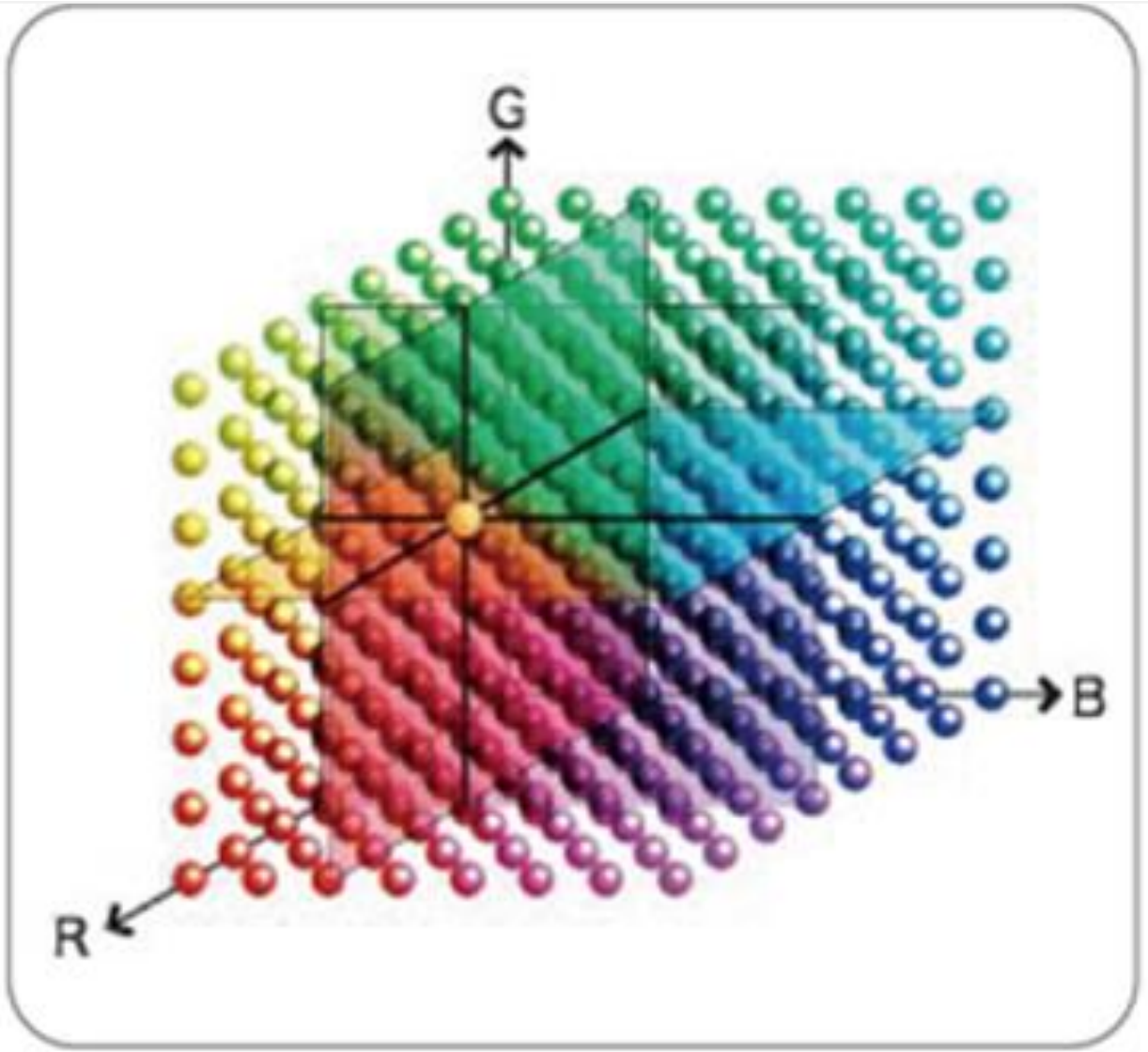


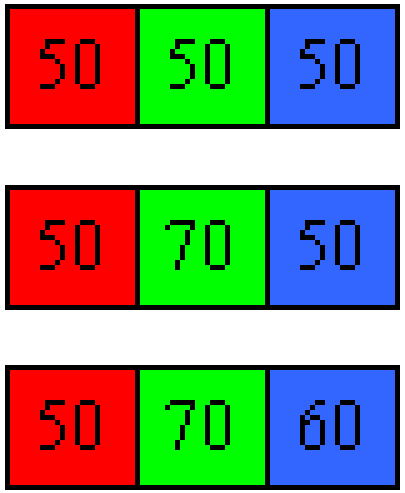

There are 1D and 3D LUT's

1D LUT

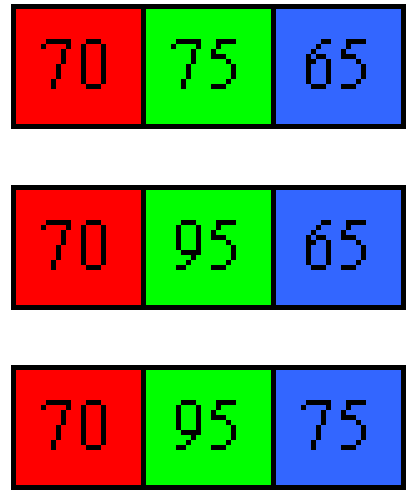


3D LUT

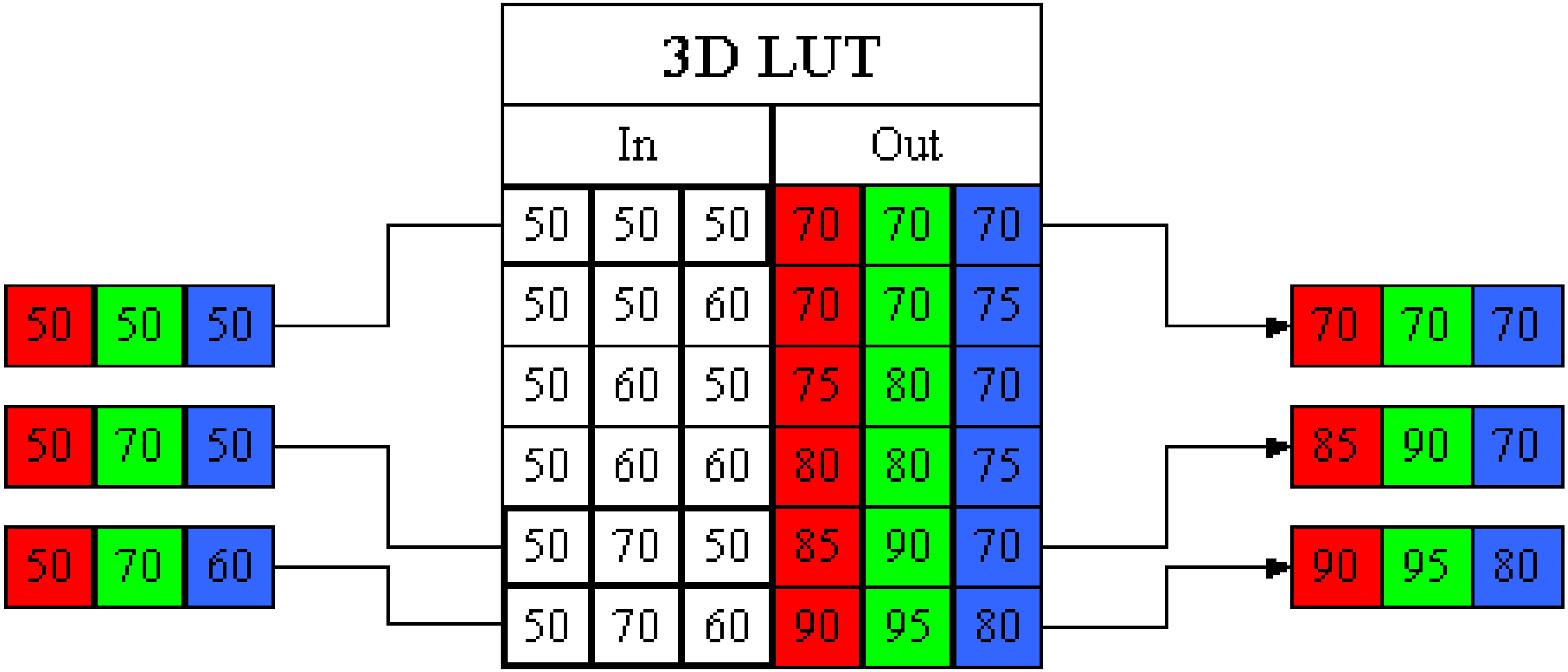




LUT			
In	Out		
50	70	75	65
60	80	85	75
70	90	95	85
80	100	105	95
90	110	115	105



The 1D LUT


3D LUT
In
Out
50 50 50 70 70 70
50 50 60 70 70 75
50 60 50 75 80 70
50 60 60 80 80 75
50 70 50 85 90 70
50 70 60 90 95 80
50 50 50
50 70 50
50 70 60
70 70 70
85 90 70
90 95 80

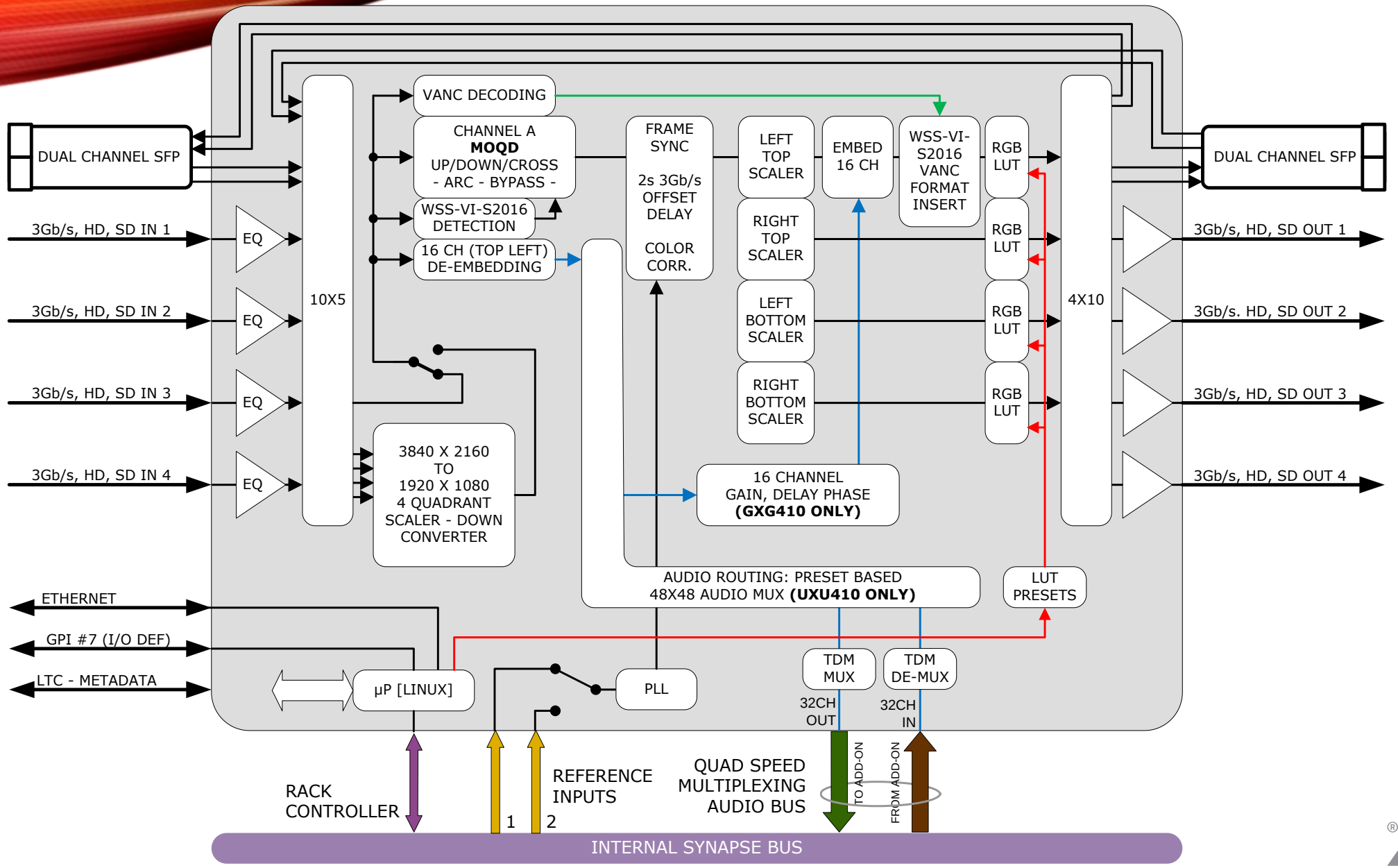
The 3D LUT

THE SOLUTION:

AXON
THE HEART OF BROADCAST

UXU400 – UXU410

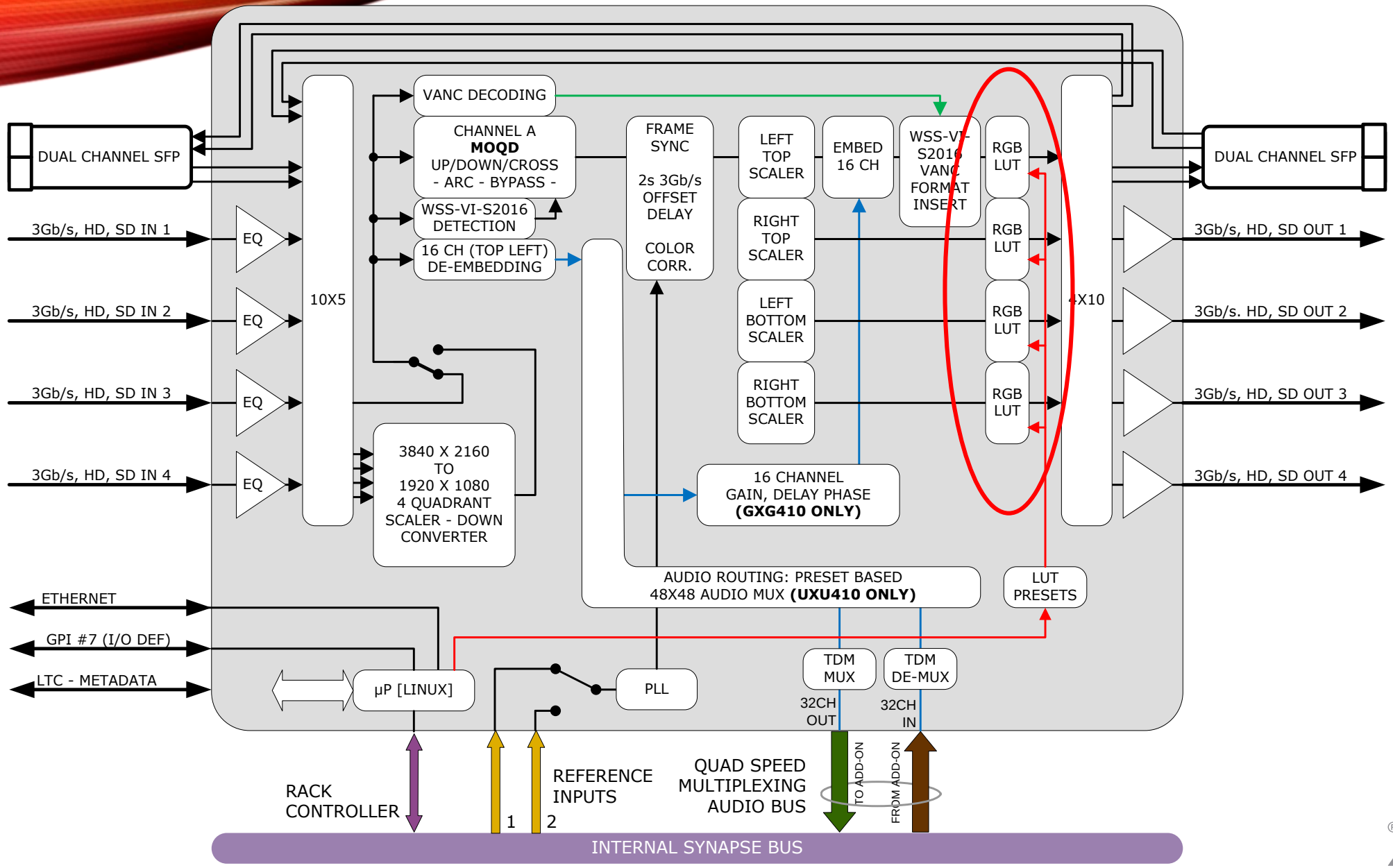
[QUAD SPEED AUIO BUS]



AXON
THE HEART OF BROADCAST

UXU400 – UXU410

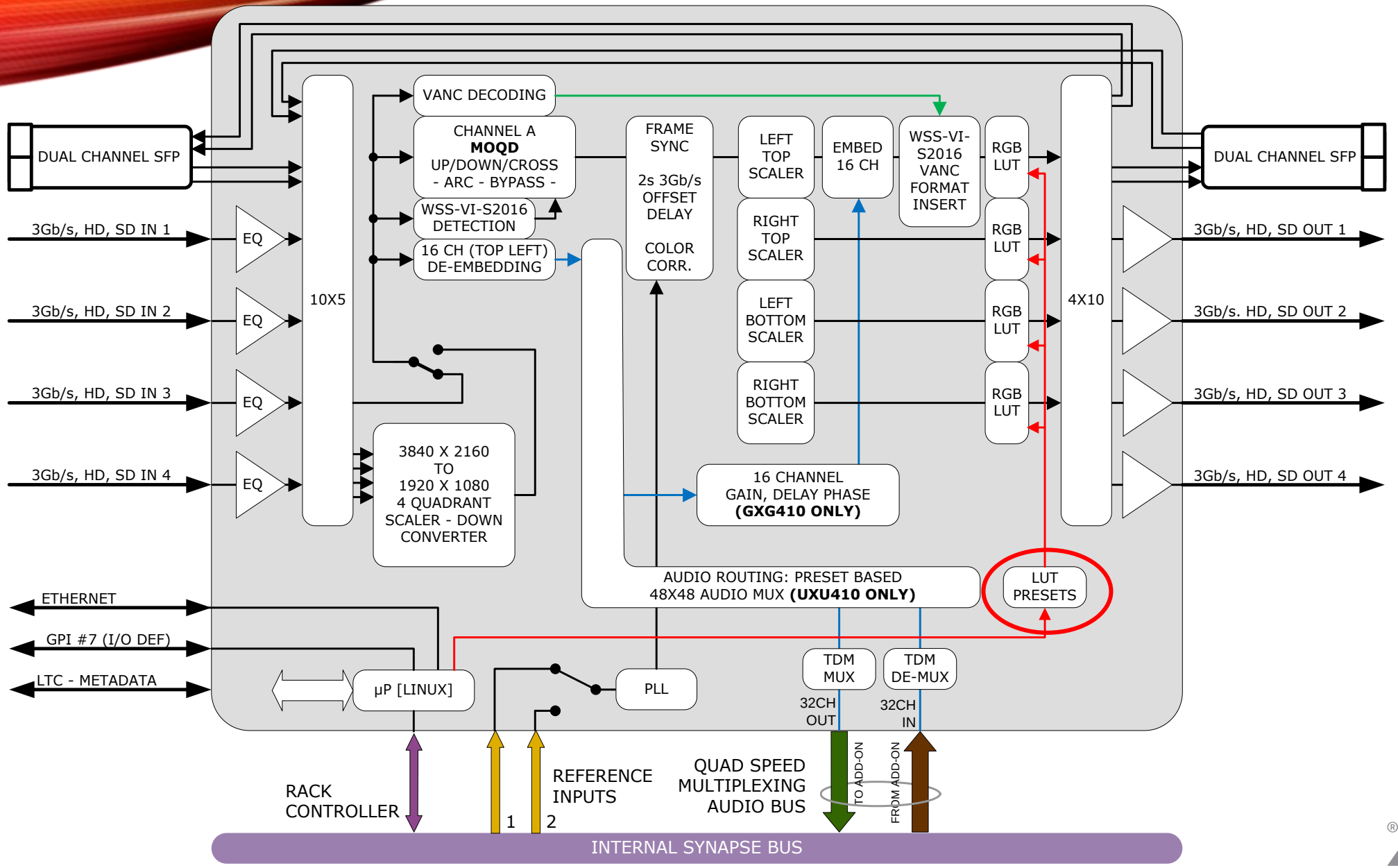
[QUAD SPEED AUIO BUS]



AXON
THE HEART OF BROADCAST

UXU400 – UXU410

[QUAD SPEED AUIO BUS]



AXON
THE HEART OF BROADCAST

QUESTIONS?

AXON
THE HEART OF BROADCAST

THANK YOU

Peter Schut, CTO | VP of R&D
peter.schut@axon.tv
www.axon.tv

AXON
THE HEART OF BROADCAST