isf

Imaging Science

FOUNDATION, INC

# Do These Factories Calibrate?

Sharp Sakai City - $11 Billion

Panasonic Amagasaki $2.11 Billion

# Introductions…

Name -

Experience –

Personal Reference Quality Disc?

Have you ever calibrated an UHDTV?

# Quality in Taking Pictures?

Canon G10 had 14.7 MP – The next models G11 and G12 had 10 MP?

*Which created better quality pictures??*


# What is the Most Important Part of a Camera?

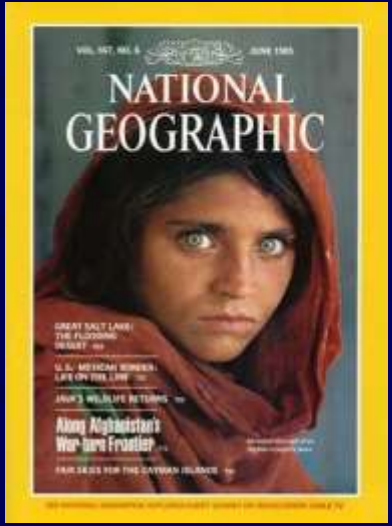
## *What Will You See on Your Screen With A Higher Quality Lens?*

Canon 50mm 1.4 - ***<u>$399</u>***


Leica 50mm 1.4 - ***<u>$3999</u>***

# Quality In Printing pictures

Which of these magazines deliver superior image quality?





Why?

# 21st Century HDTV Quality?

The Perception…..

The Reality……………

The Old HD Number everyone knew?…

The Marketing……….LED TV?

The Blacks?……………

# 1080p? – Did it make it to the HDTV?

1080p To Be?

Or

1080p Not To Be?

Vast majority of HDTVs – “Not To Be”

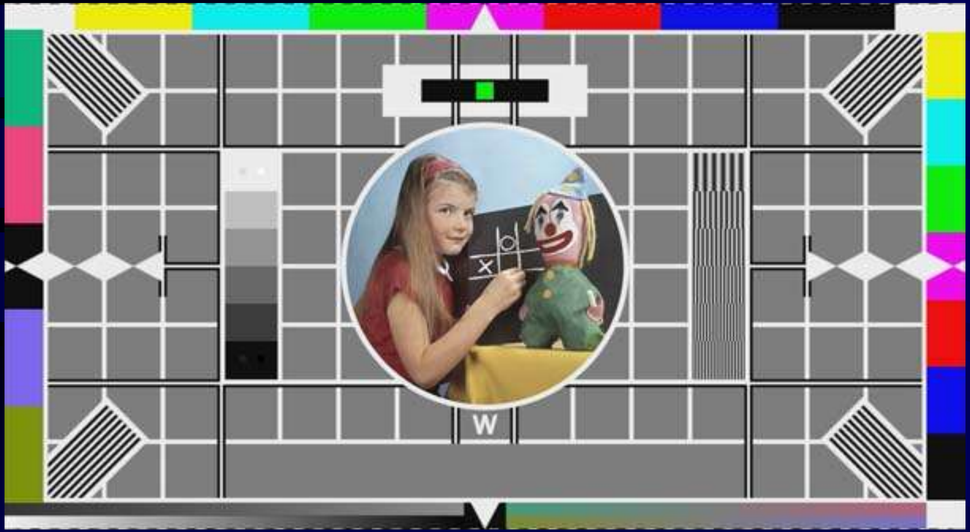
Overscan, aspect ratios and keystone

WHY IS THE FACTORY PRESET WRONG?

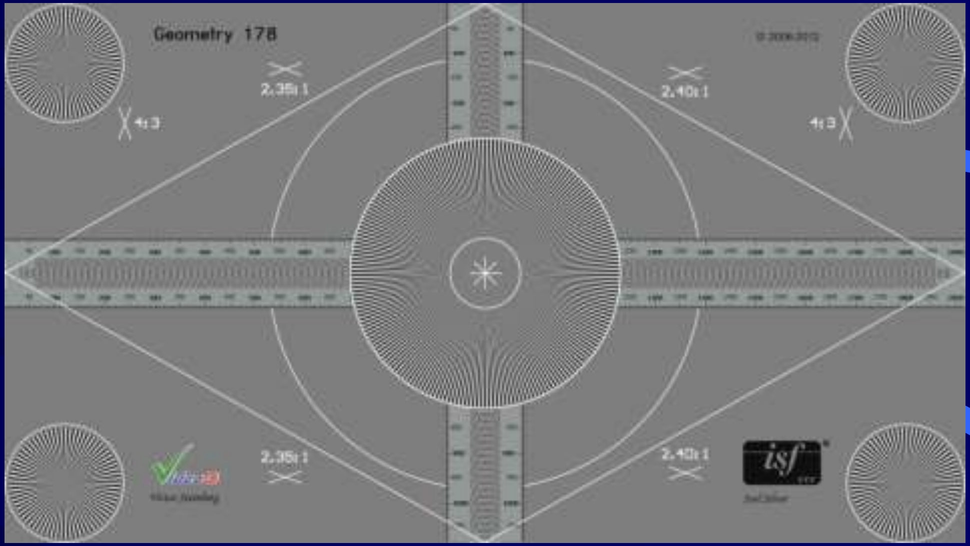
***What has changed in UHD 4K?***

# Overscan / Resolution Tools

**BBC Test Card**




**ISF 4K 2011**



# 1080p Bit Mapped Right Looks Better UHD Can Have Bit Mapping Errors Too

What else can we make look better?

What is “better”?

Where did “better” come from?

# STANDARDS

# Why must we all know about Standards?

# Who Here Owns an AVR?

- Who here has set audio levels on their AVR?
- Who used the built in set up process and mikes?
- Who used a superior equipment for their set up?
- What percent of buyers have their AVRs set up to MEET STANDARDS?
- What percent of clients have UHDTVs set up for them?

# What is the ISF?

We are a Standards Organization, We:

Represent Standards

Deploy Standards

Train Professionals to Understand Standards

Help develop UHDTVs that calibrate to Standards

Help Write Standards for CTA, InfoComm and CEDIA

# What are C.T.A. *R10 Standards*?

C.T.A = **C**onsumer **T**echnology **A**ssociation

www.cta.tech

Represents over 2000 major Electronics companies

Produces the yearly CES!

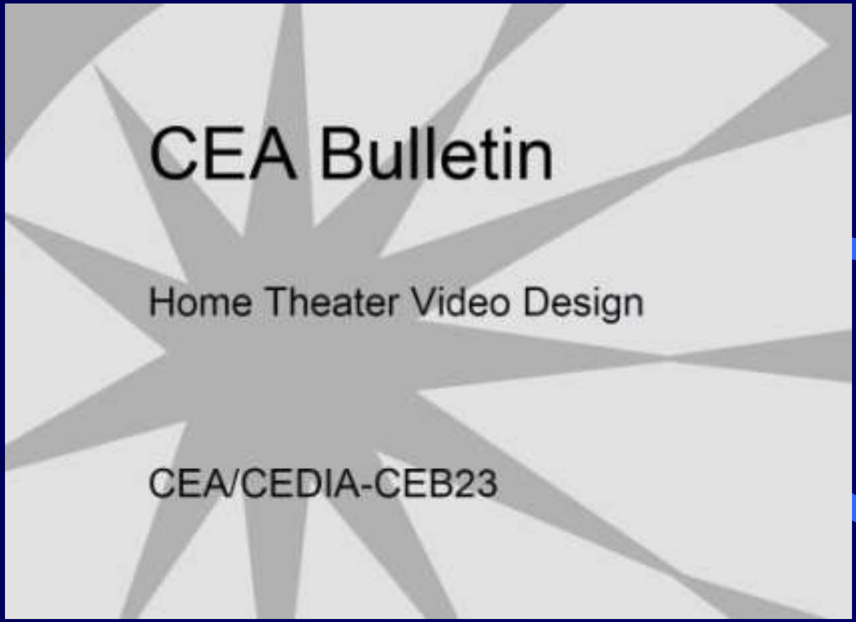
R10 is CTA's Standards and Technology group

ISF Chairs *Home Theater Video Design*

CEDIA Awards Require Compliance!

# CEDIA CTA CEB 23

This standard dictates a state of the art performance design that requires the best projectors and screens and room designs – it followed the two top tiers of the Digital Cinema specs!



# CEB 23 Uses Dual Methodology for Calculating Contrast

**"Intraframe"**

4 x 4 Checkerboard

150 : 1 (100:1 Tier One)

(This is very difficult)

**"Sequential"**

White and Then Black Test Patterns

2000 : 1 (1200:1 Tier One)

(This is not difficult with a quality projector)

# What is the SMPTE?

The Society of Motion Picture and Television Engineers (SMPTE) was founded in 1916

http://www.smpte.org/home

# What is the NTSC?

**National Television System Committee**

U.S. standardization body that adopted the broadcast standard in **1941**

In **1953** a second standard was issued, for **color** broadcasting compatibility with **black-and-white** receivers

**PAL** and **SECAM** were later TV systems that resolved some problems in NTSC

# What is the ATSC?

The Advanced Television Systems Committee (ATSC)

Formed in 1982 to develop Standards for DTV

1998 Recommendations are still being deployed now!

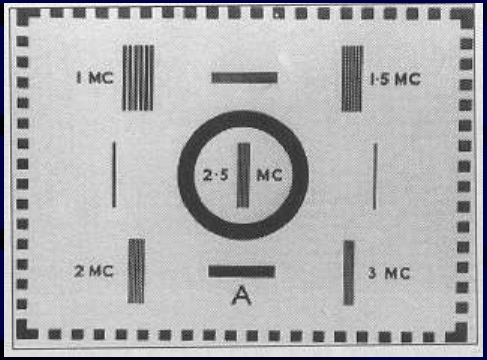
# What is the BBC?

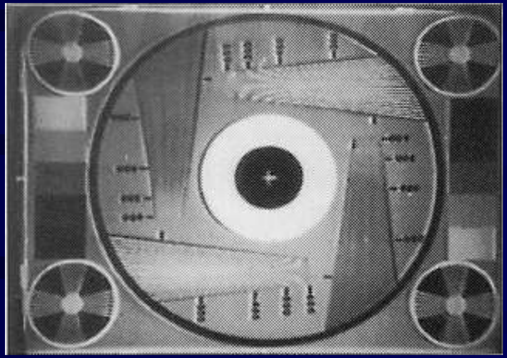
The **British Broadcasting Corporation**, abbreviation "**BBC**" is the world's largest broadcaster

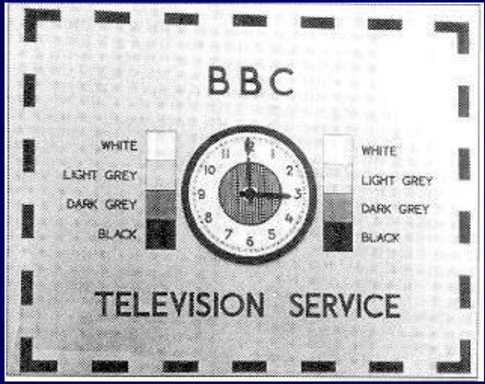
The BBC plays an active part in development of all open **standards** for UK broadcasting, Europe & world-wide where appropriate

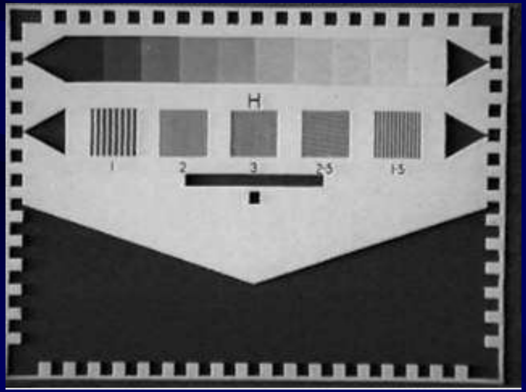
***<u>BBC and NHK - HLG HDR!</u>***

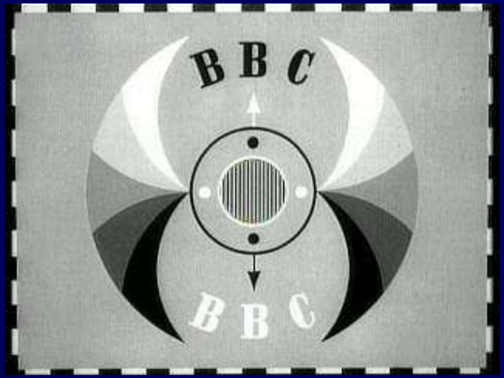
# Early BBC "Cards"





# What is the DCI?

Digital Cinema Initiatives, LLC (DCI) is a joint venture of Disney, Fox, Paramount, Sony Pictures Entertainment, Universal and Warner Bros. Studios.

DCI's primary purpose is to establish and document ***voluntary*** specifications for open architecture for digital cinema that ensures uniform, high level of technical performance, reliability and quality control.

www.dcimovies.com

# DCI Specs Categories For Contrast

## CEB23 includes Two Specs - “Theatrical” and “Nominal”

| Image Parameters | Nominal (Projected Image) | Tolerances (Review Rooms) | Tolerances (Theatrical) |
|---|---|---|---|
| Pixel Count | 2048x1080 or 4096x2160 | N/A | N/A |
| Luminance Uniformity, corners and sides | 85% of center | 80% to 90% of center | 70% to 90% of center |
| Calibrated White Luminance, center | 48 cd/m² (14 fL) | ±2.4 cd/m² (± 0.7 fL) | ±10.2 cd/m² (± 3.0 fL) |
| Calibrated White Chromaticity, center from code values [3794 3960 3890] | x=.3140, y=.3510 | ±.002 x, y | ±.006 x, y |
| Color Uniformity of White Field, corners | Matches center | ±.008 x, y Relative to center | ±.010 x, y Relative to center |
| Sequential Contrast | 2000:1 minimum | 1500:1 minimum | 1200:1 minimum |
| Intra-frame Contrast | 150:1 minimum | 100:1 mininum | 100:1 mininum |
| Grayscale Tracking | No visible color shading | No visible color shading | No visible color shading |
| Contouring | Continuous, smooth ramp, with no visible steps | (same) | (same) |
| Transfer Function | Gamma 2.6 | ± 2%[11] Per component | ± 5%[12] Per component |
| Color Gamut | Minimum Color Gamut enclosed by white point, black point[13] and Red: 0.680 x, 0.320 y, 10.1 Y Green: 0.265 x, 0.690 y, 34.6 Y Blue: 0.150 x, 0.060 y, 3.31 Y | (same) | (same) |
| Color Accuracy | Colorimetric Match | +/- 4 delta E[13] | +/- 4 delta E |


| | | | |
|---|---|---|---|
| Sequential Contrast | 2000:1 minimum | 1500:1 minimum | 1200:1 minimum |
| Intra-frame Contrast | 150:1 minimum | 100:1 mininum | 100:1 mininum |

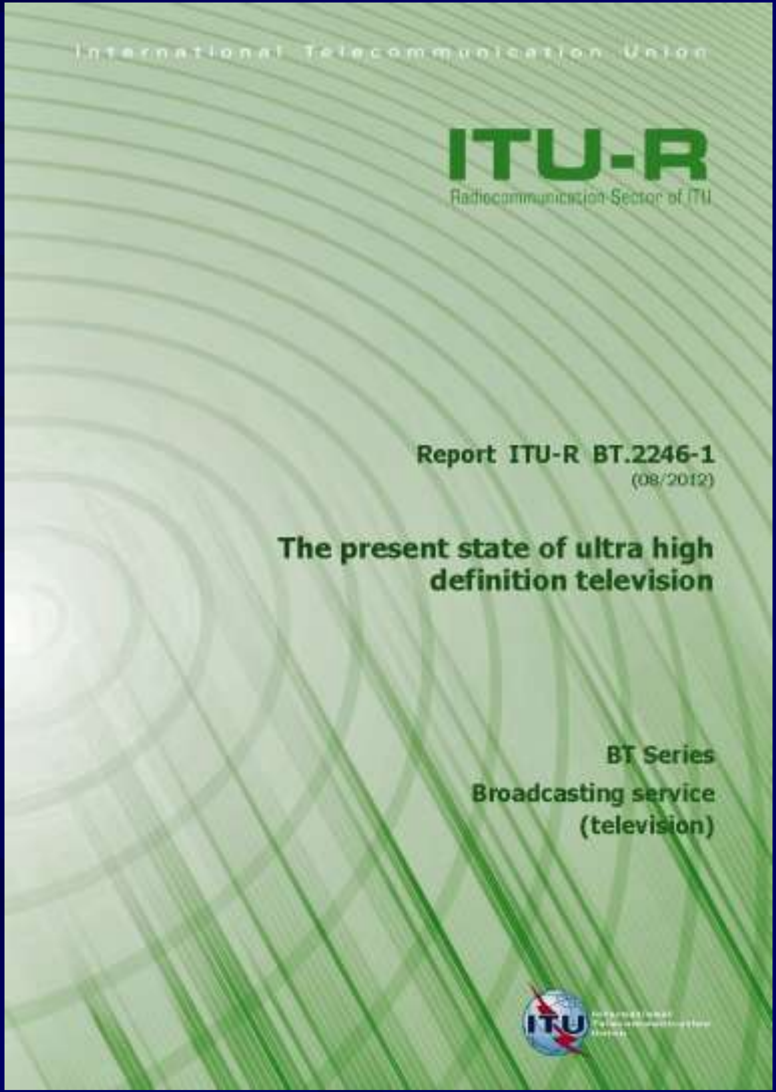
# What is the ITU?

International Telecommunication Union

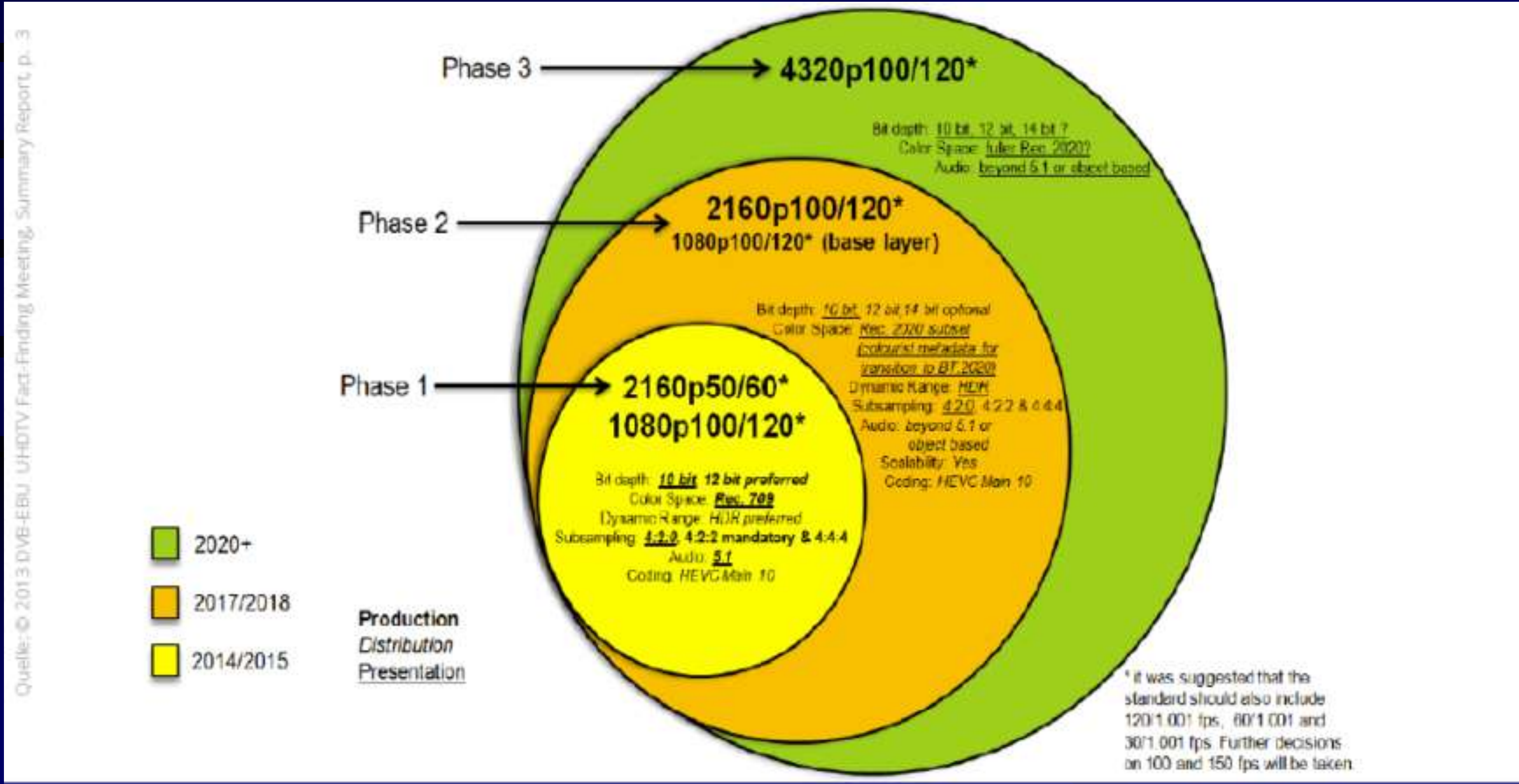
**ITU** is a United Nations **standards** agency for information and communication technology

TEST PATTERNS VERIFY ITU COMPLIANCE

# ITU-R UHD 2012

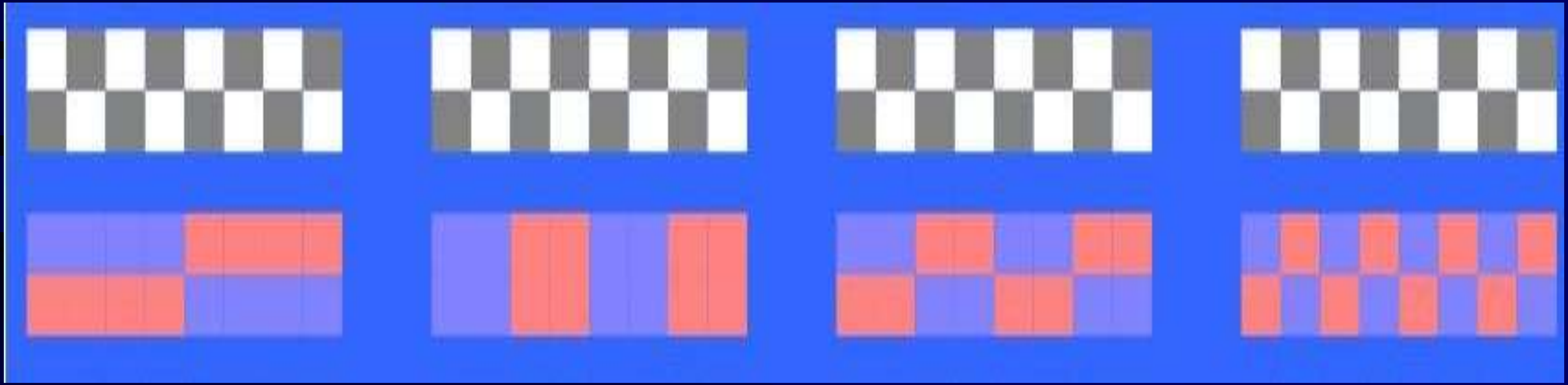


# 3 Phases of UHD: 2014 - 2017 - 2020+



# Color Compression – Sins of the Past
# Video Processing Creates What's Missing

4:1:1 | 4:2:0 | 4:2:2 | 4:4:4



# Next Generations Charted:

## The Roadmap to next-gen TV

Technology improvements will not come all at once with a big bang but gradually, making backward compatibility and graceful degradation essential for consumer confidence.

| | | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CE Connectivity | HDMI 1.4a CEA861-... | HDMI 2.0 CEA 861-E[1] | | HDMI 2.0a CEA 861.3[2] | | HDMI 2.0a CEA 861-G[3] | | | Display Port USB 3.0 or MHL | | |
| Resolution | 1920x1080p | 3840x2160p | | | | | | | 7680x4320p | | |
| Frame Rate | 30fps | | 60fps | | | 120fps HFR | | | | | |
| Color Depth | 8-bit | | 10-bit | | | 12-bit | | | | | |
| Dynamic Range | 100 nits SDR | | | >500 nits HDR | | | | | | | |
| Color Gamut | Rec.709 | | | Rec.2020 WCG | | | | | | | |
| Audio | Multi-Channel Audeo (5.1-7.1) | | | | | Object-based Audio | | | | | |
| | Pre-UHD | UHD-I Phase 1 | | UHD-I Phase 2 | | | | | UHD-II "8K" Super Hi-Vision | | |

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# ANSI INFOCOMM "I.S.C.R."

## ***I**mage **S**ystem **C**ontrast **R**atio*

This "SYSTEM" Standard defines five contrast ratios based on content viewing applications:

A. Informational Viewing

B. Basic Decision Making

C. Critical Decision Making

D. Full Motion Video

E. Video Editing for Corporate Comm.

| Viewing Environment Category | Minimum System Contrast Ratio | Viewer's Requirements | Environment – Example Characteristics | Examples |
|---|---|---|---|---|
| **Informational Viewing** | **7:1** | • Able to distinguish important images and text from background<br>• Passive engagement with content<br>• Projected image informative but not critical | • Little control of ambient light<br>• Ambient light may be high<br>• Task lighting may not be ideal<br>• Windows may have insufficient blinds or curtains<br>• May be reflective surfaces (e.g., furniture)<br>• Projector light output may be inadequate | Retail stores, family (TV) rooms |
| **Basic Decision Making** | **15:1** | • Actively engaged with content<br>• Images and text are legible to the extent that basic decisions can be made<br>• Decisions based on content itself, not resolution of detail | Improvements relative to the above category are often in evidence | • Information displays<br>• Presentations containing detail images (e.g., classrooms, boardrooms multi-purpose rooms, product illustrations) |
| **Critical Decision Making** | **50:1** | • Fully engaged with the finest detail to support critical image assessment<br>• Mission-critical image displays | • Controlled ambient light<br>• Focused task lighting<br>• No ambient light directly affecting screen, black-out window treatments | Engineering and architectural drawings, electrical schematics, legal evidence, failure analysis, photographic evaluation (e.g., courtrooms, medical galleries) |
| **Full Motion Video** | **80:1** | • High level of engagement with content<br>• Films below movie theater distribution standard | Precisely controlled ambient light | Controlled viewing environment (e.g., home theater, business screening room) |

# I.S.C.A.R Methodology

Measure all White Squares

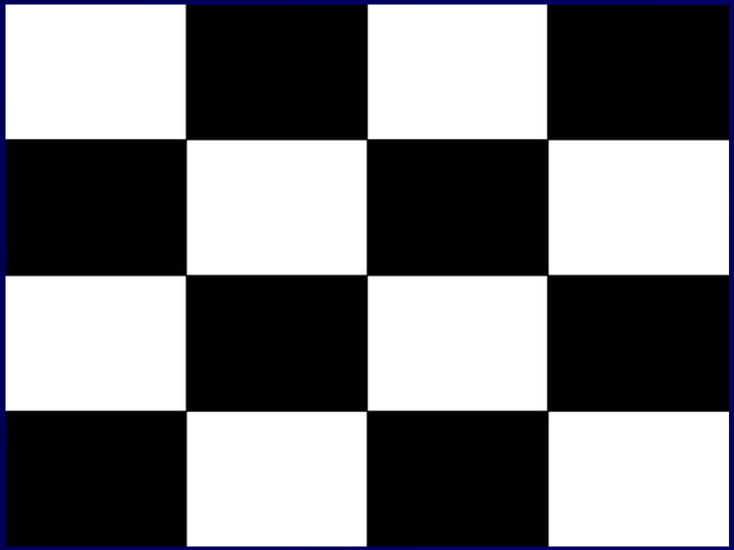
Average all measurements

Measure all Black Squares

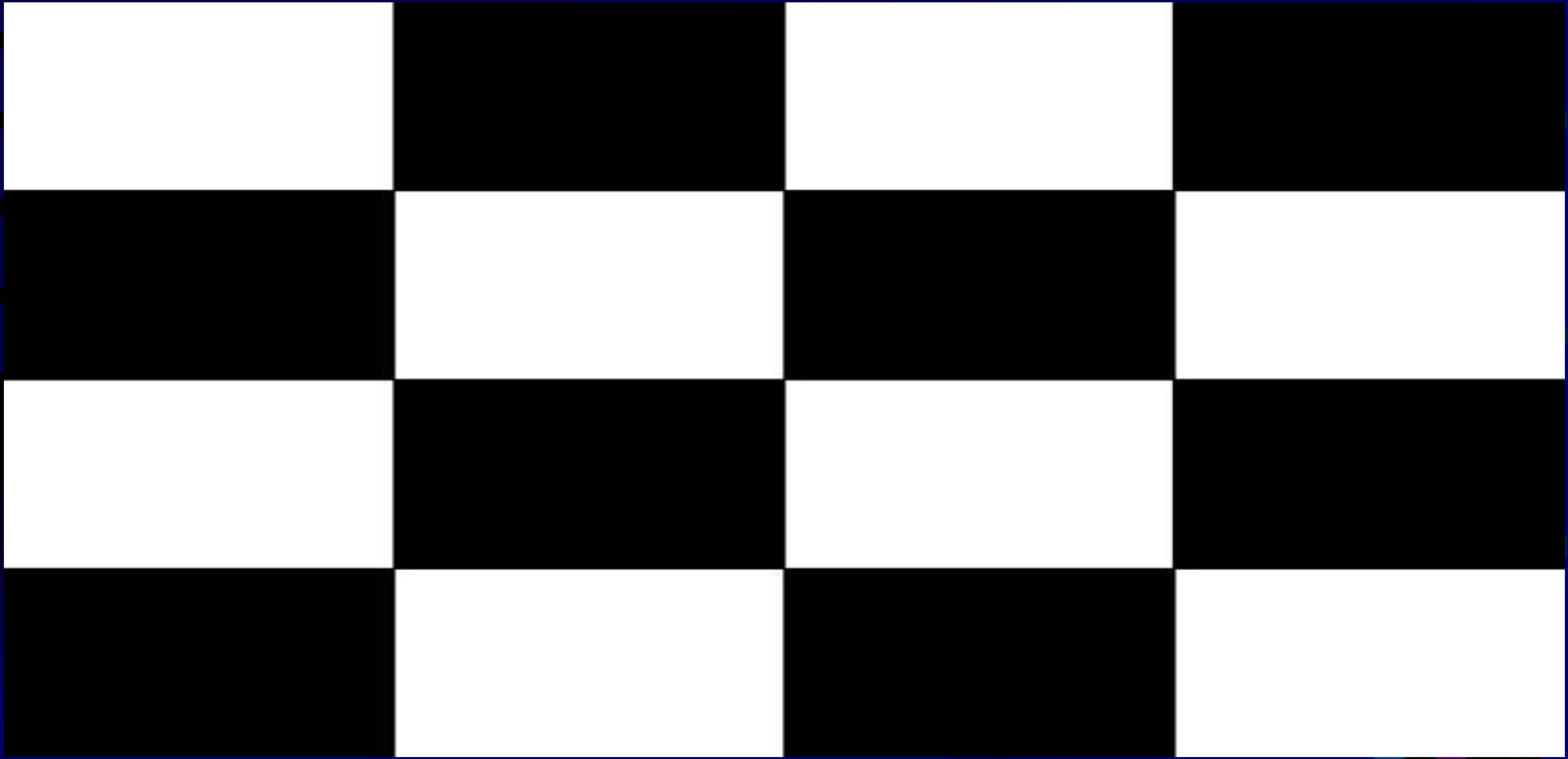
(Keeping white squares out of meter)

Average all measurements

Divide White data by Black



# What is the Contrast Ratio of This Room’s System?



# ISCR Applies To Every Installation

These are real world - easily achievable Standards - that enable you to define **<u>System</u>** performance and guarantee client satisfaction!


ANSI/INFOCOMM 3M-2011

ANSI/INFOCOMM 3M-2011

Projected Image System Contrast Ratio

InfoComm International Performance Standard

2011-06-30

infoComm INTERNATIONAL

There are Three Fundamental Approaches to Improving Contrast and Obtain I.S.C.R. Category Compliance With Contrast Ratio Specifications:

# 1 – Room Environment Design

Control Ambient Light

Darken wall color

Eliminate reflective surfaces

***This is the most logical and easiest thing to do – and almost always just impossible to do….***

# 2 – Use a More Powerful Light engine

- Projectors drive screens, more Lumens help deal with ambient light
- Projectors are not quite as bright as the sunlight coming in from windows
- More Lumens will help white levels – not black levels
- Fortunately, brighter projectors have come down in price

# 3 - Ambient Light Rejection Screens

- These screens minimize ambient light’s impact on CR
- Using gain surfaces can increase Contrast
- Fractional Gain substrates will improve Black levels
- Some products even deploy physical micro filters
- The challenge is always to preserve “Flat  Spectral Response” for color fidelity plus increase CR!

# Tools Of The I.S.C.R. Trade:
# Non-Contact Luminance Meters
# N.I.S.T. Refers to a “Frustum”

# INFOCOMM and CEDIA Have Done An Important Part of Your Work For You

Everyone is entitled to his own opinion, but not his own facts

Daniel Patrick Moynihan

# Using these Standards in the Field:

1 - Add Standards compliance to your proposals

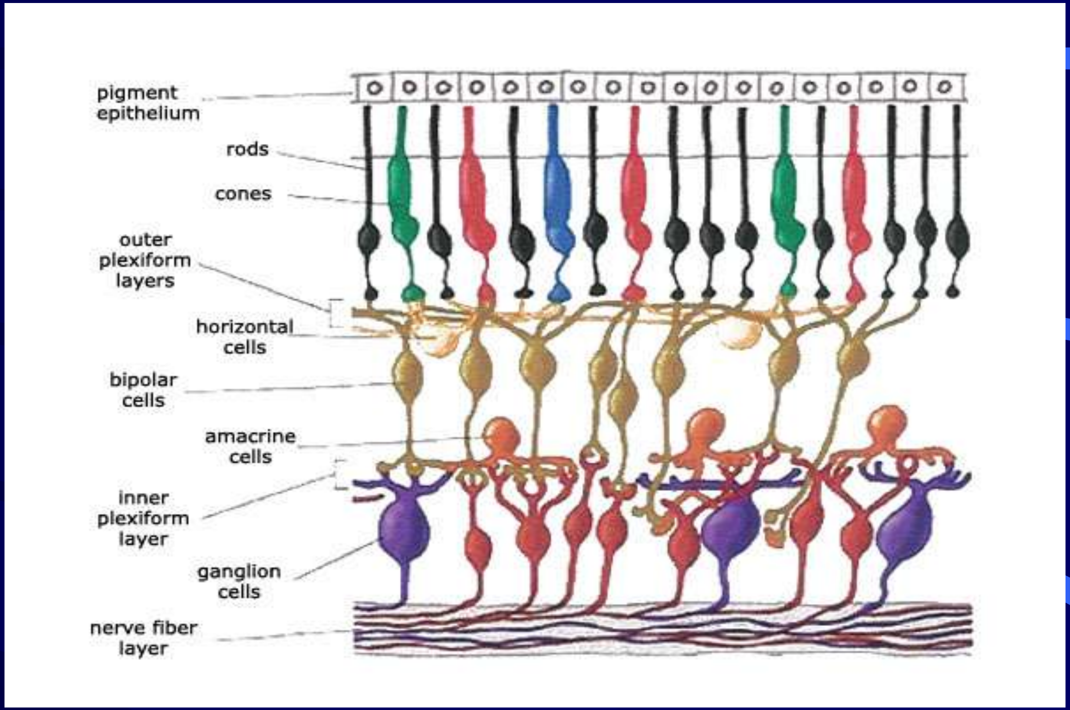
2 - Educate your clients about Industry Standards

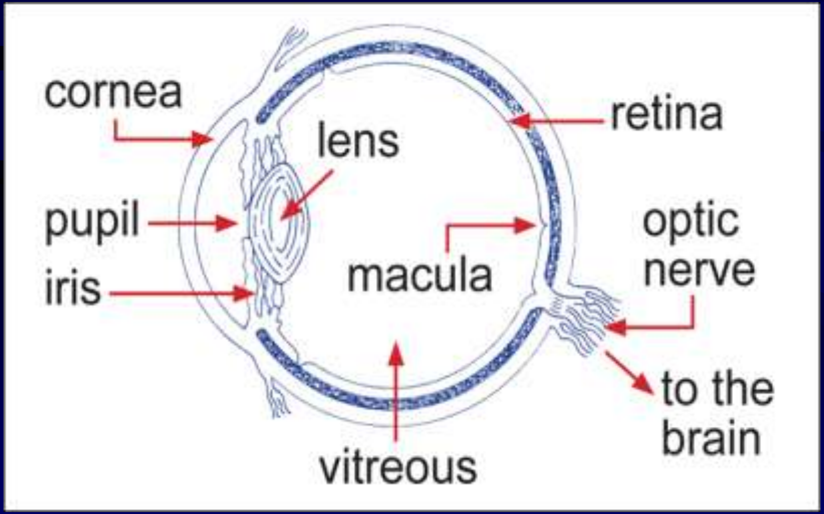
3 - Design your systems for compliance

4 - Deploy "Audit and Control" reports along with your invoices!

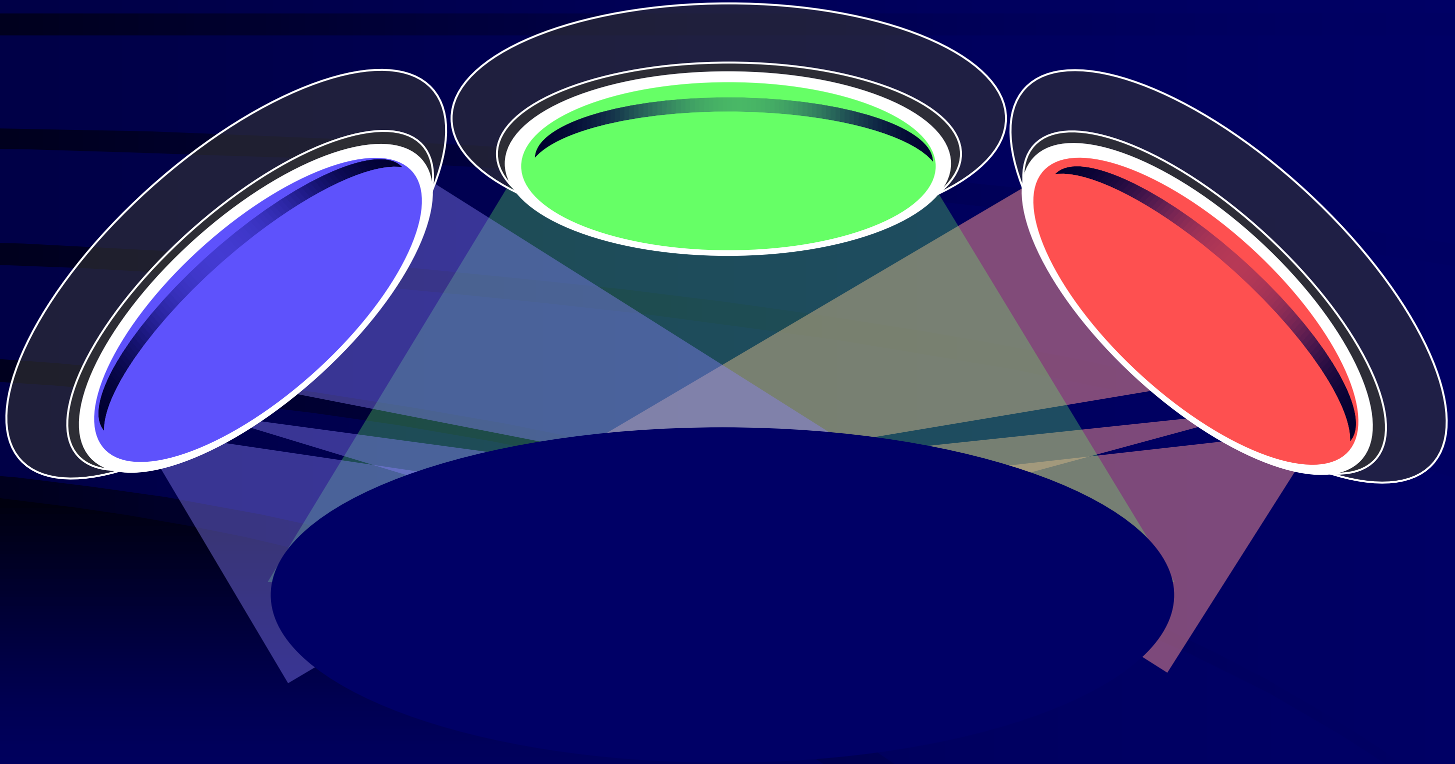
5 – Use these Standards to ***document*** that your installations are world class!

# What are Standards Based On?
# The Human Eye

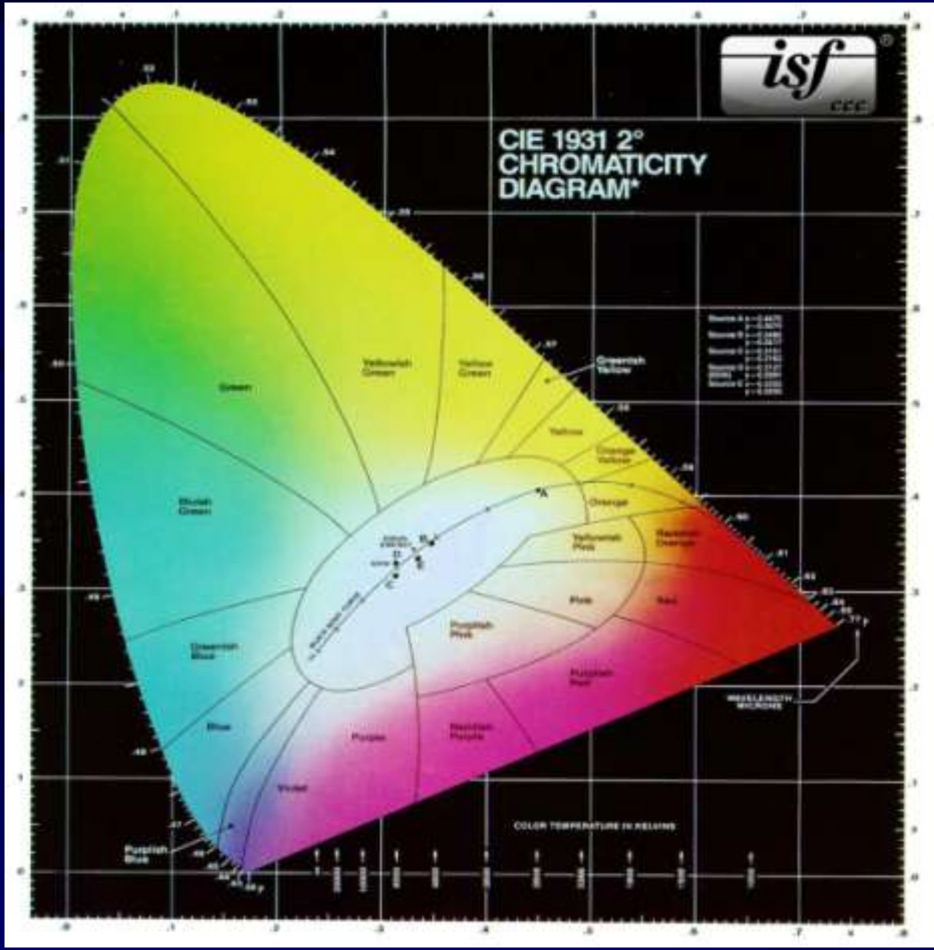


# Making White for TV Viewers With RGB



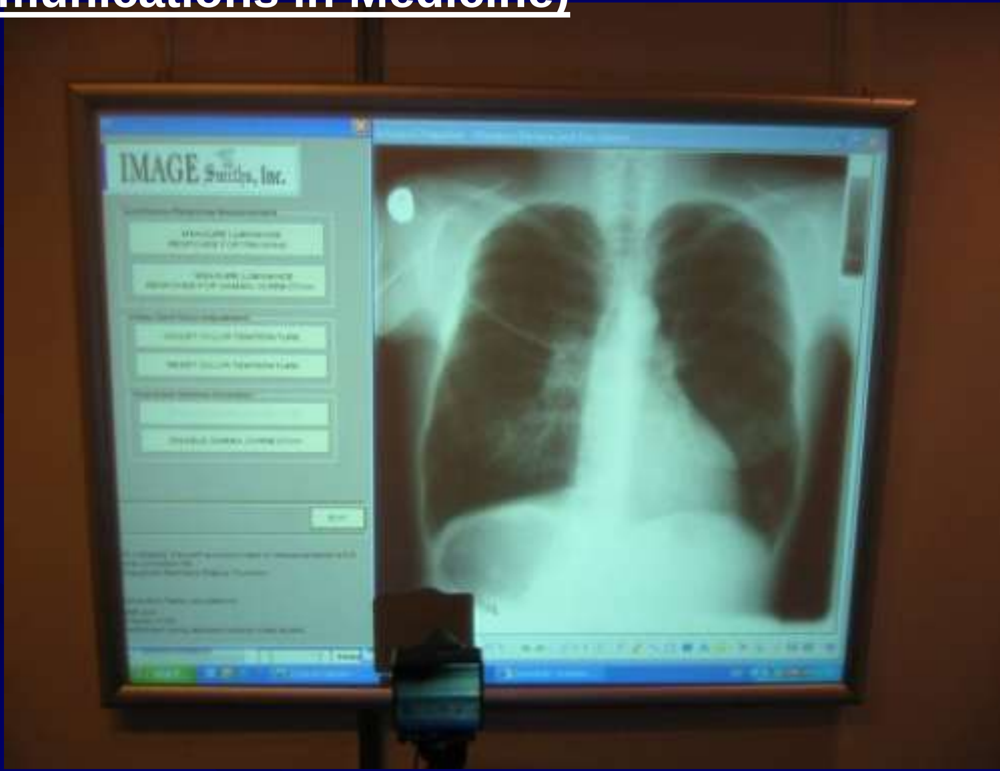
# What Data is Used For Color Standards?



# Calibration Standards for X-RAYs?

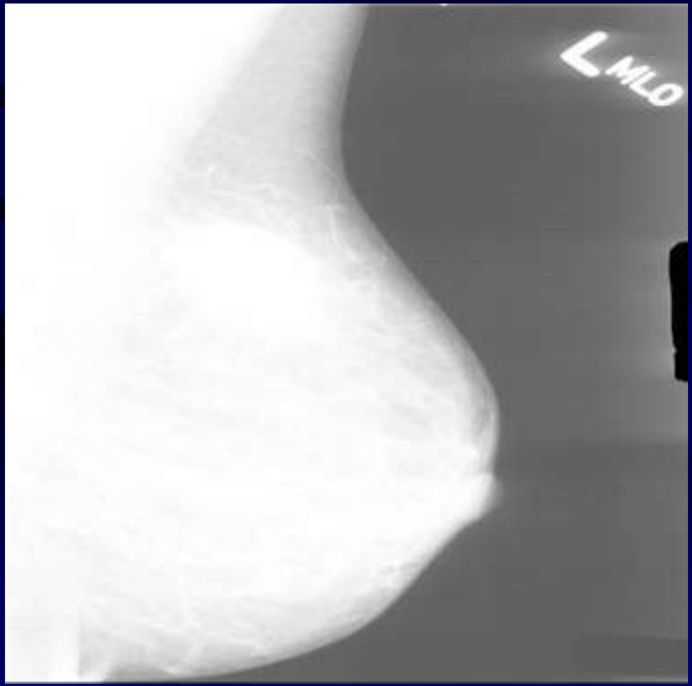
**NON calibrated** | ***DICOM* 14 calibrated**

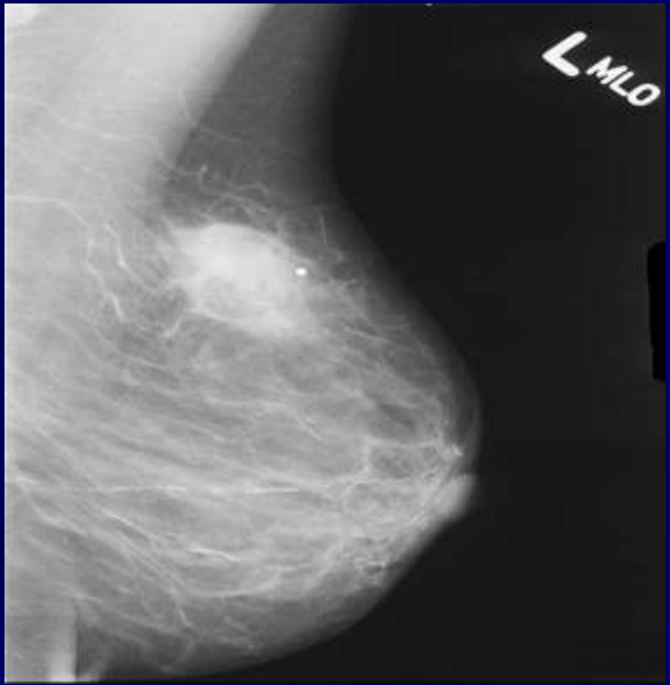
**(Digital Imaging and Communications in Medicine)**



# Radiology Monitor Contrast Issues?

## Same Scan – contrast too high versus correct…



# ISF Calibrators:

***Must Thank Those Volunteers Who Developed TV Standards***

They enable us to deliver thousands of superior experiences every day at workplaces and homes

# The Market Niche For ISF

International Instant Adopters

Cutting Edge Installations & Service

Automation and integration?

Calibration = Customer care

**“Booties” and ISF Calibrators?**

# Why Has The ISF Market Grown?

1 – Calibrated old CRTs had to be dim – RIP CRTs!

2 – Calibrated Flat Panels can be bright enough for any room

3 – Gamma adjustments are now really common (more later)

4 – HD and UHD make calibration's improvements obvious

5 – UHDTV system set up is way too hard for consumers

6 – ISF UHDTV menu designs in over 90,000,000 TVs

7 - CTA says customers DEMAND both price & service

# Recommended Questions for Clients…..

**What type of content is displayed?**

Movies

TV shows

Sports

Gaming

Photography

Internet or streaming video or PowerPoint

Live Performances, Houses of Worship

# Recommended Questions for Clients…..

<u>Tell us about the room for the display</u>

1 - Is there a display there now?

2 - Lighting & light control

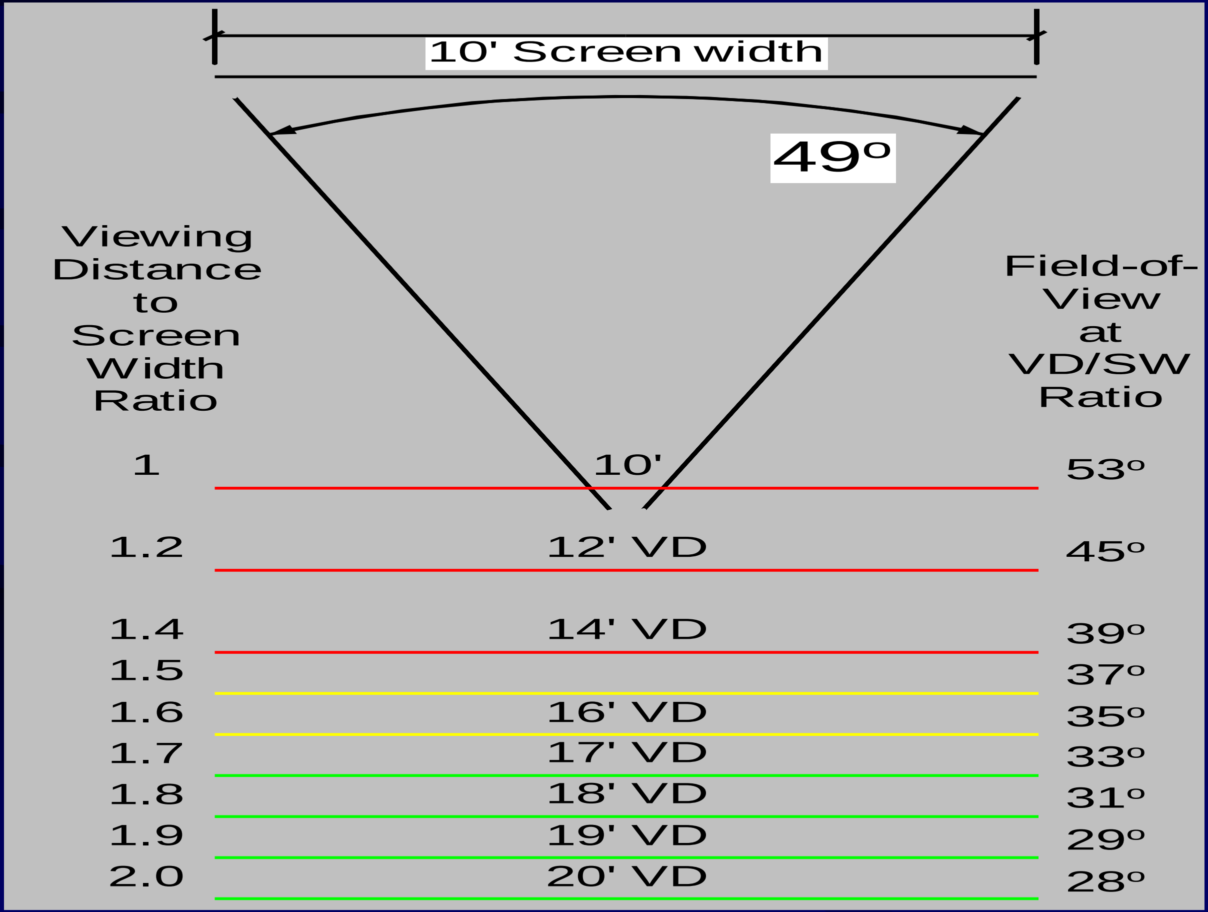
3 - Viewing angles and distances

# Critical Recommended question!!

What would you describe as your favorite place to sit in a movie theater?

Do you typically like to sit up close, midway, or further back?

# HD Viewing Angles and Visible Artifacts



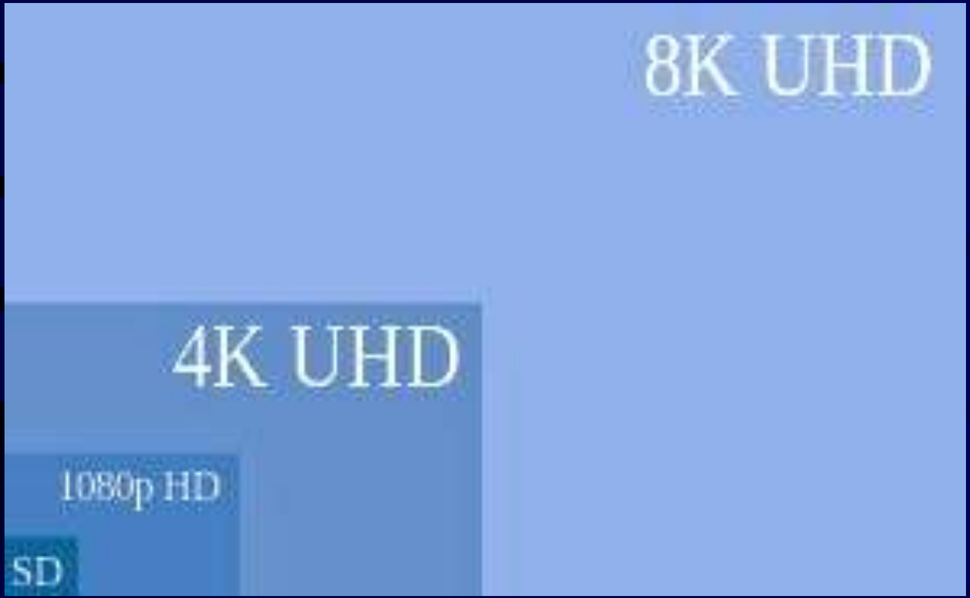
# 2K 4K 8K Viewing Angles and Distances

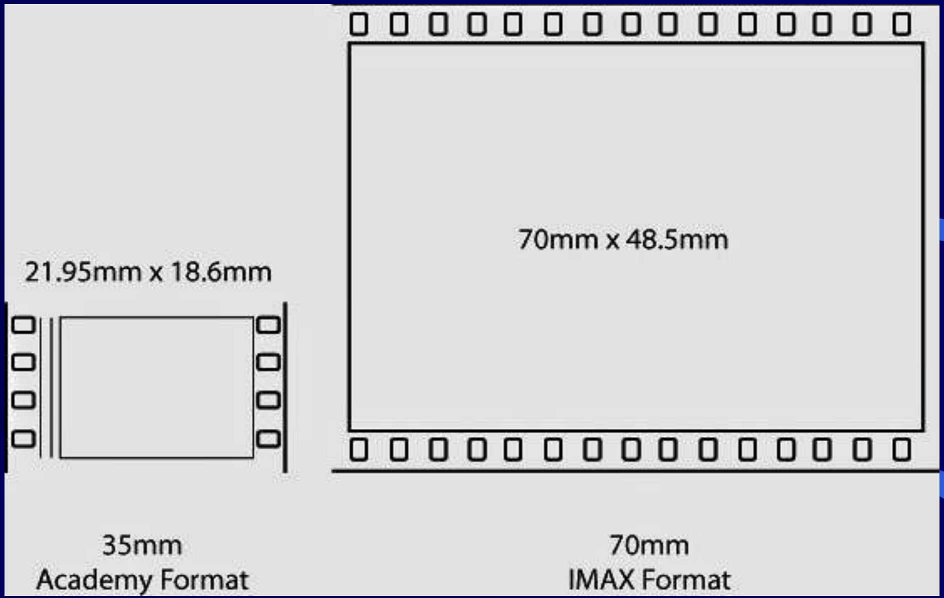
**Optimal horizontal viewing angle and optimal viewing distance in image heights (H) for various digital image systems**

| Image system | Reference | Aspect ratio | Pixel aspect ratio | Optimal horiz. viewing angle | Optimal viewing distance |
|---|---|---|---|---|---|
| 720 × 483 | Rec. ITU-R BT.601 | 4:3 | 0.88 | 11° | 7 H |
| 640 × 480 | VGA | 4:3 | 1 | 11° | 7 H |
| 720 × 576 | Rec. ITU-R BT.601 | 4:3 | 1.07 | 13° | 6 H |
| 1 024 × 768 | XGA | 4:3 | 1 | 17° | 4.4 H |
| 1 280 × 720 | Rec. ITU-R BT.1543 | 16:9 | 1 | 21° | 4.8 H |
| 1 400 × 1 050 | SXGA+ | 4:3 | 1 | 23° | 3.1 H |
| 1 920 × 1 080 | Rec. ITU-R BT.709 | 16:9 | 1 | 32° | 3.1 H |
| 3 840 × 2 160 | Rec. ITU-R BT.1769 | 16:9 | 1 | 58° | 1.5 H |
| 7 680 × 4 320 | Rec. ITU-R BT.1769 | 16:9 | 1 | 96° | 0.75 H |

# Advanced Resolution, Analog and Digital

Credit - ITU State of Ultra High Definition Television, **ITU-R BT.2246-1, (08/2012)**



# Where Did Calibration Come From?

Like in most successful endeavors….

The key to the future is understanding the past…..

Selecting and calibrating the best TVs started 80 years ago…..

# TV is Based on Communication Theory

Electronic imaging dictate TV signals and sets speak the same “language”

***International*** TV systems were ***Regional*** since the ***1930’s*** – originally based on radio tower’s transmission range.

1998 DVD was “Heard Around the World”, not just fifty miles – DVD Digital TV instantly went ***Global*** !


MSNBC
InfoCenter
Search
Help
NewsTools
Write Us
Clearer pictures
The high-definition television revolution
The Net's top pirated movies
Internet banned in Afghanistan
YEAR
MAGNIFY
MSNBC

# MSNBC Headlines...

1923 - **28** line TV from John Logie Baird's spinning disc to…….

1935 - **343** line RCA system………

1936 - **375** In Germany…..USA's RMA 441i/30

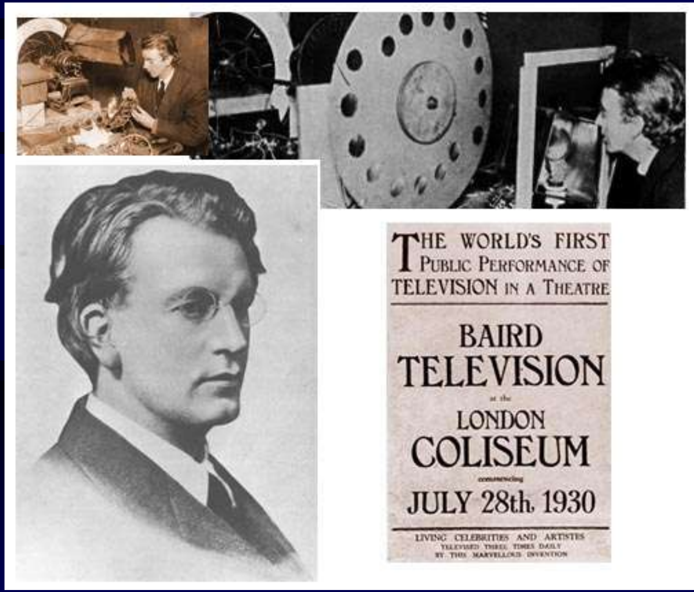
1939 - **525** USA's NTSC B&W system……….

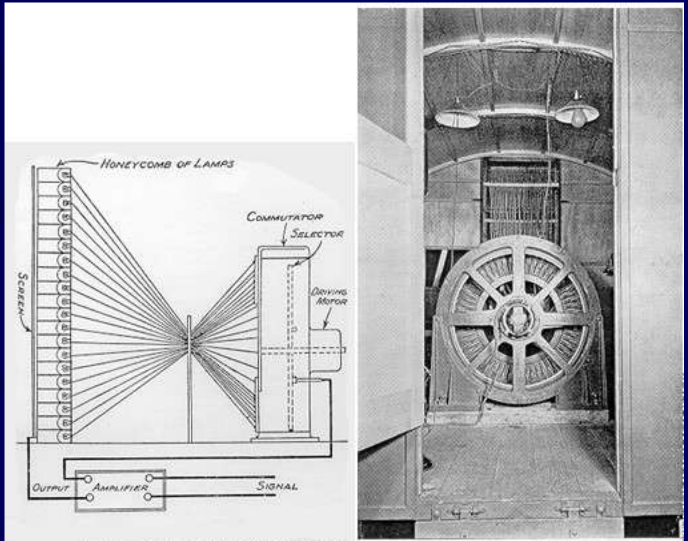
1941 - **625** Multiple International PAL systems

***1998 – 1080 USA's ATSC HDTV***

***2010's – Ultra High Definition TV 4K and 8K***

# John Logie Baird's 750 rpm Spinning Disc TV - With 2100 lamps!




ILLUSTRATING SIMPLY HOW THE COMMUTATOR AND SELECTOR MECHANISM ARE ELECTRICALLY CONNECTED TO THE HONEYCOMB OF LAMPS

THE LARGE COMMUTATOR AND BACK OF THE LAMP SCREEN AS HOUSED IN THE TRAILER VAN WHEN SHOWN IN VARIOUS BRITISH AND CONTINENTAL THEATRES

# 1930's HDTVs – 1800 Lbs!

Eidophor "oil film" Projectors – Philo's TV!



# What did the Entire Planet Agree Was "Great Picture Quality" For almost a Century?

Only one imaging system was recognized as high quality in the 20$^{th}$ Century:

It was delivered on every continent

In every city and town

And played everywhere on Earth….

***35mm Film***

# So….Film “WAS” our real competition - in the last century

So….Just ***how*** good was 35mm film?

ISF’s #1 Empirical image analysis tool?

**THE DEAD PIXEL TEST?**

What will you see if you analyze film?

# How Many Pixels Equaled Film Quality?

In Digital moving images can and do slide across pixels, causing "***Artifacts***" which reduce resolution – Just like Multiburst with overscan on

So – what level of Digital resolution is like 35mm Film?

# 35mm Film's Resolution? - SMPTE 3/2004

6 Theaters tested with "Release Prints"

"Original Negative/Interpositive/Internegative/Release"

Experts evaluated at **1.5 picture heights**

Theaters were Orlando, LA, NY, Montreal, Paris, Milan – 1.85 prints

Conclusion - 35mm Film's resolution was basically:

***A Mere 1 Mega-Pixel!***

# So - If Film Was ONLY “1” Megapixel?

## Why Did Projected Film Look Great to Our Eyes – <u>HDR!</u>

ISF Imaging Hierarchy of Quality Parameters

| | | |
|---|---|---|
| #1 - <u>**Dynamic Range**</u> | = | Dark to Bright |
| #2 - <u>**Color Saturation**</u> | = | Colorful |
| #3 - <u>**Colorimetry**</u> | = | Life-like Color |
| #4 - <u>**Resolution**</u> | = | Detailed |

# Welcome to H.D.R. in the UHDTV Era!
# High Dynamic Range + WCG

Perfectly follows ISF's hierarchy of imaging

Will expand dynamic range and color saturation!

CES HDR demos were some of the best images and some of the WORST!

HDR developers represent some of the world's top imaging technical companies:

***Dolby Vision***

***Technicolor***

***Philips***

***Samsung HDR 10+***

***BBC and NHK - HLG***

# HDR Adds Color and Dynamic Range!

# HDR Evolves….

**DolbyVision:**

Vizio was the 1st TV Licensee

LG signed on at CES 2016

Philips and TCL in May 2016

Sony Pictures, Universal and MGM will make Dolby Vision movies, more to follow

Christie / Dolby launch Dolby Vision theaters Worldwide

Dolby's PQ EOTF = SMPTE

Philips and Technicolor join together for HDR TV

BBC and NHK HLG

Samsung' HDR 10+

Upconverting old content

Encoding SDR and HDR in a single stream with a "System on Chip"

SMPTE ST-2084 is HDR 10 E.O.T.F. from Dolby's "Perceptual Quantizer"

# BBC and NHK HDR Evolve……

BBC / NHK Hybrid Log Gamma (HLG)

Designed for real time broadcast – live video coverage

One transmission can include both SDR and HDR simultaneously

Limited "color mapping" capability

(more on this topic  shortly)

# HDR's Production Evolves….

SMPTE ST 2084 - High Dynamic Range ElectroOptical Transfer Function of Mastering Reference Displays

SMPTE ST 2085 - Color Differencing for High Luminance and Wide Color Gamut Images

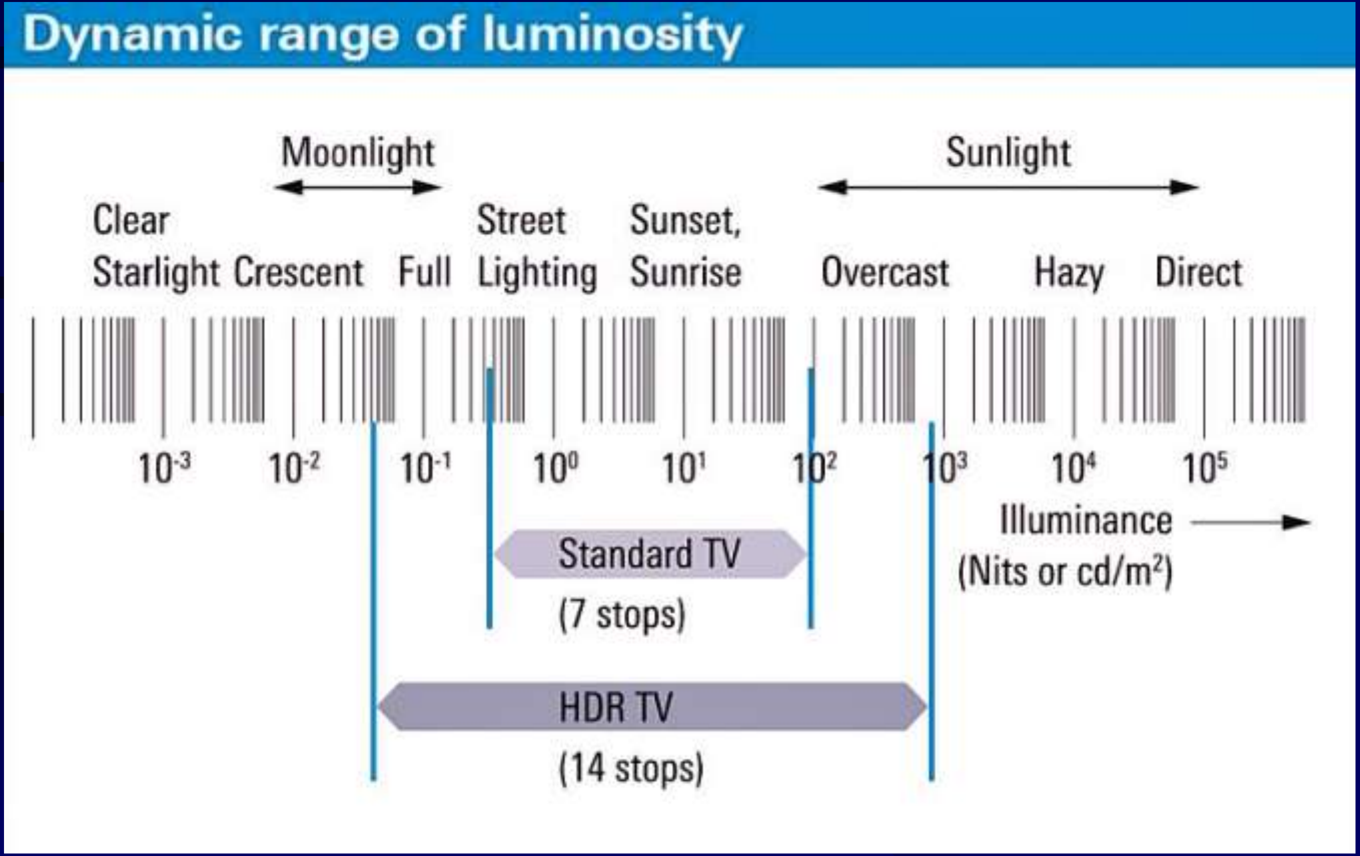
SMPTE ST 2086 - Mastering Display Color Volume Metadata Supporting High Luminance and Wide Color Gamut Images

SMPTE ST 2094 - Content-Dependent Metadata for Color Volume Transformation of High Luminance and Wide Color Gamut Images

# What Is An F-Stop

- Dynamic range is the ratio of maximum light intensity to minimum light intensity
- In digital cameras, the most common unit for measuring dynamic range is an F-stop, which describes light by a power of 2 – or a doubling of Dynamic Range

# HDR's Improvement over SDR



# How Do F-Stops Relate to SDR / HDR?

Standard Dynamic Range (SDR) is < 10 f-stops

High Dynamic Range (HDR) is > 16 f-stops

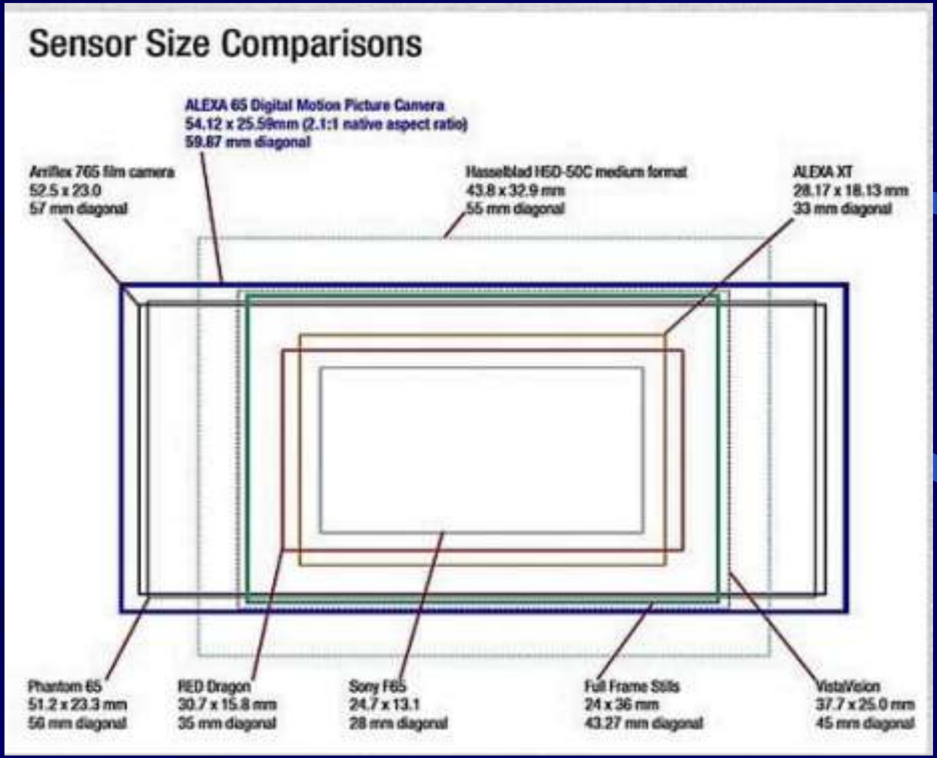
*What will we see on screen?*

10 f-stops = 1,024: 1 contrast ratio

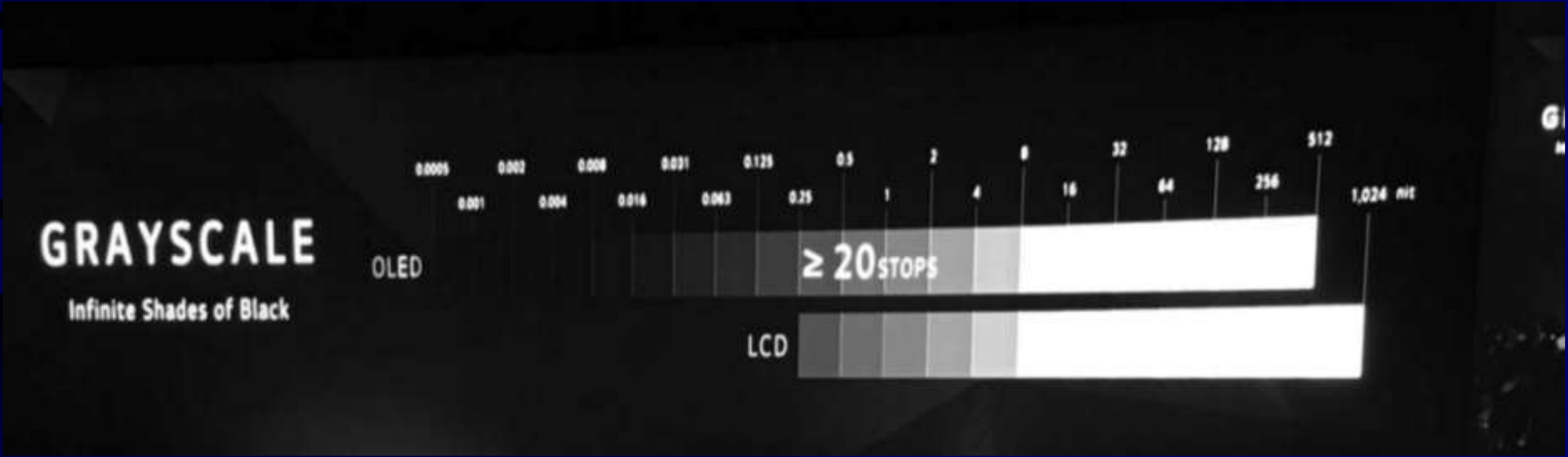
16 f-stops = 65,536: 1 contrast ratio

*From Day to Night Humans See 42 Stops!*

# Where Does HDR Originate?
# Arri's Alexa 65 with 16 Stops!

# HDR With 20 Stops at Home?
# LG's 2106 Signature Series OLED



# HDR Viewing Experience

- In the past content was adapted for distribution to fixed consumer TV products for HD and SD
- In HDR the consumer system will synch to wider color space, HDR, and eventually higher frame rates
- This will require significant EEDID/Metadata exchanges to enable the advances that now include “WCG” - and eventually will include “HFR”

# Dynamic HDR – It That Redundant?

## CTA - 861 - G/HDMI

This is CTA's developing Standard to support Dynamic HDR - requires large amounts of metadata for scene by scene color volume data – an ***"eInfoFrame"***

CTA is aiming at compliance tests to avoid distortion

"Dynamic HDR" is based on the upcoming SMPTE ST 2094 suite for scene by scene, read "live" data

# HDMI 2.0a Enables HDR and Much More

Multiple EOTF (Gamma) for Multiple HDRs:

*NO HDR STANDARD Chosen or Defined – Thankfully!*

4K at 50/60 Hz and Dual Viewing

Up to 18 Gb/s

32 Audio Channels and Multi-Stream audio

Dual Viewing, CEC Extensions (we hope)

**HDMI 2.1 WILL BE 48 Gb/s**

# HDMI 2.0a Cannot Do Everything We Want to do Even in 2017

4K 60 4:4:4 (no HDR) = **17.82Gbps**

4K 30 4:4:4 10 bit - HDR (no 60fps) = **11.14Gbps**

4K 60 4:2:2 10 bit - HDR (no 4:4:4) = **17.82Gbps**

4K 60 4:4:4 10 bit - HDR = ***22.28Gbps***

# Real World 18GB Blu-ray

# Disc Player OSD for 18 GB

# “Premium” Ultra HD Alliance

## Performance specs from the “UHD Alliance”:

1 - Content mastering criteria for all distribution – not just UHD Blu-ray

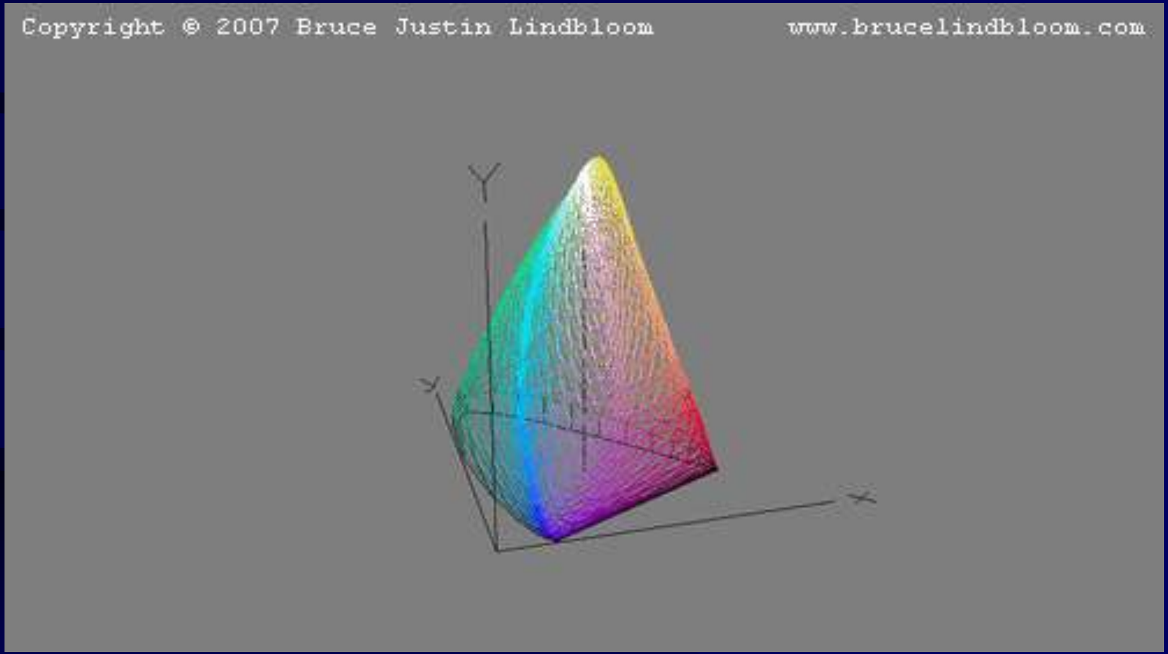
2 - Color Gamut – at least 90% of P3 (DCI)

3 - Capable of accepting ITU 2020 signal input (not displaying it is accepted)

4 - Two HDR ranges – one for OLED and one for LCD

5 - SMPTE’s 2084 HDR10 EOTF capable

# What is a TV’s Color Volume? The CIE in 3D



# Calibrating HDR - *Mapping Color Volume?*

## Dolby Vision's "Golden Reference":

- Dolby Vision HDR tools are already in CalMAN
  - Test signals coming from the PC? Can that be a compromise
- Murideo Test Signals are in development
  - Updates to 6G units will be made available
- SMPTE 2084 HDR10 tools are not universal quite yet…….
- Test discs and more to follow - UHD Blu-ray!

# Dolby Vision Calibration

Confidential at the moment – we can show these slides but not share them – yet…..

# Homework Project 1:
# Describing the 4 Quality Parameters

If you can do that you can:

Describe the benefits of investing in a superior HDTV

Describe the benefits of calibration to a client

# Why is SDR/HDR Calibration Important?

Matching a display to a source

Matching a system to a room

Getting the whole picture

Getting the right picture

Getting nothing but the picture

Matching to a “Golden HDR” reference?

Accurately displaying a subjective image….

# Why match UHDTVs to sources?

Will UHD HDR Disc Players have reference output?

What will a 10% differential source in hardware parts translate to in the field?

Can your display's manufacturer anticipate these differences in sources?

Will you be mixing HD + SD + PC + Gaming + Photo?

Will all sources be the same signal?

# Why match UHDTVs to room environments?
# What Will We Do With HDR?

Variables in ambient light make black level settings in manufacturing a W.A.G.

Fighting ambient light during the day and minimizing viewer fatigue at night requires different calibrations

# ISFccc "Day" and "Night" Modes

# ITU Digital Video

## From 1982!

193 Countries Agree on setting Black and White

Create in Bollywood, play back in Hollywood!

*“0 to 255, with 220 quantization levels with the black level corresponding to level 16 and the peak white level corresponding to level 235. The signal level may occasionally excurse beyond level 235”*

# "Getting the Whole picture"

# ANALOG

## Analog "IRE" levels

**I**nstitute of **R**adio **E**ngineers, founded 1912 in NYC

Merged with American Institute of Electrical Engineers to form the IEEE in 1963

100 IRE = White

0 IRE = Black

*(7.5 IRE = Black in 1963 when color was added)*

0 IRE = Black, Since DVD in 1998 in the US

*(0 to -40 IRE = Footroom and Synch)*

# "Getting the Whole picture"

# <u>DIGITAL</u>

8 Bit Digital Video is 0 to 255

**ITU / HDMI Specs**

**"0" and "255"** are T.R.S. (Timing Reference Signals – AKA Synch)

**<u>1</u> to <u>254</u>** is the LEGAL range for the **<u>entire</u>** signal

**<u>16</u>** = Is the Black level as per ITU-R BT601 & 709!

<u>235</u> = Is the White level as per ITU-R BT601 & 709

***<u>236 to 254 = "above white", 1 to 15 = "below black"</u>***

# Calibrating 16 -235, 4 Simple Steps!

ITU and HDMI specs call for above white and below black so we……

1 - Use test patterns with above White elements!

2 - Use test patterns with below Black elements!

**3 - Preserve above White, Visible to 234?**

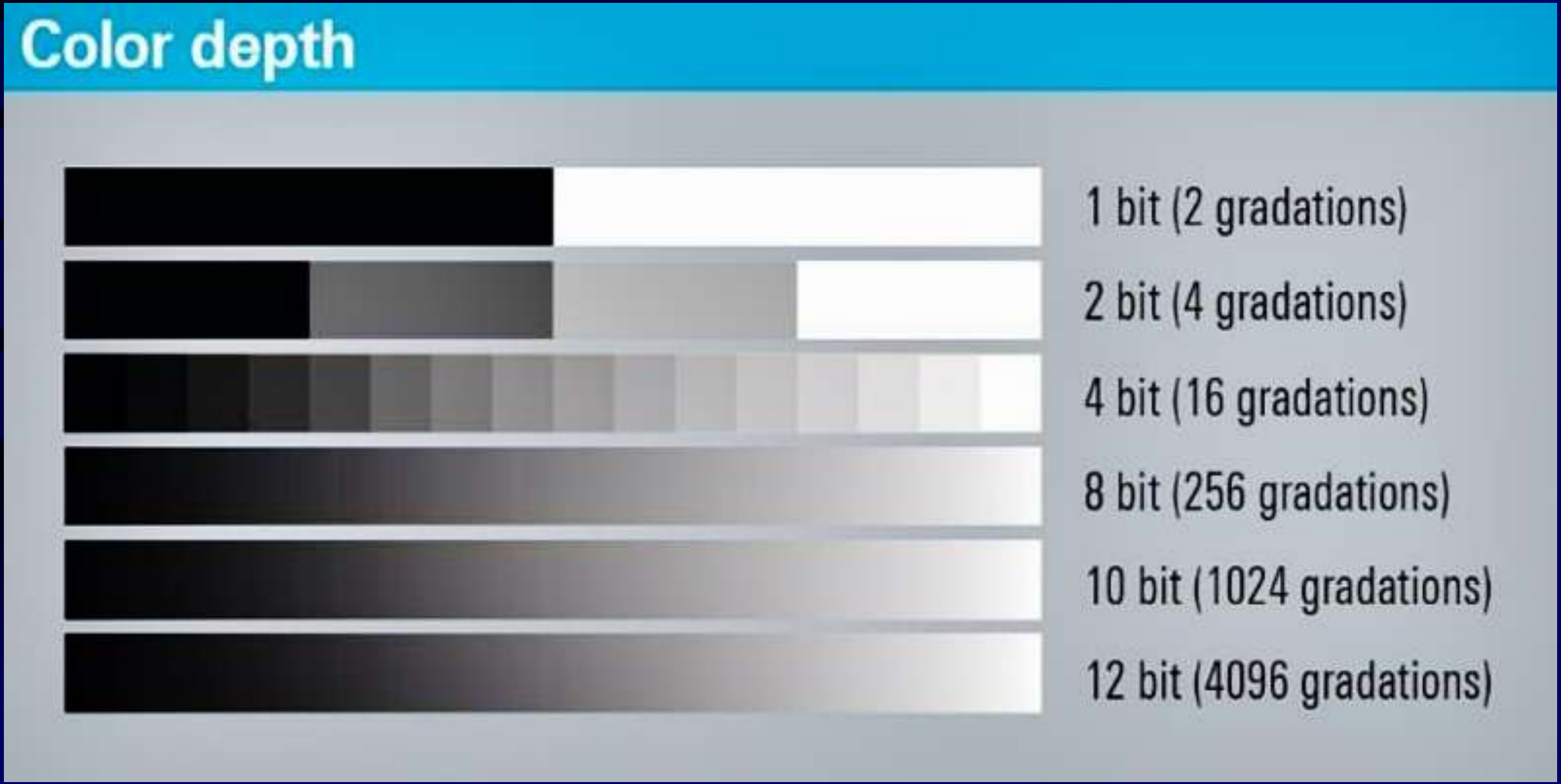
**4 – Verify below Black, then Set Black at 16**

# What About UHD's 10 Bit and 12 Bit?

"10-bits per sample Rec. 2020 uses video levels where the black level is defined as code ***64*** and the nominal peak is defined as code ***940***. Codes 0-3 and 1,020-1,023 are used for the timing reference. Codes 4 through 63 provide video data below the black level while codes 941 through 1,019 provide video data above the nominal peak"

"12-bits per sample Rec. 2020 uses video levels where the black level is defined as code ***256*** and the nominal peak is defined as code ***3760***. Codes 0-15 and 4,080-4,095 are used for the timing reference. Codes 16 through 255 provide video data below the black level while codes 3,761 through 4,079 provide video data above the nominal peak"

# What is improved With 10 Bit?



# ISF / Microsoft Calibration Wizard

We do  not believe Test Patterns and Humans can Coexist….Color Bars were on Broadcast TV for 50 years……

ISF / Microsoft Windows 7 and 8 free user friendly basic tools!

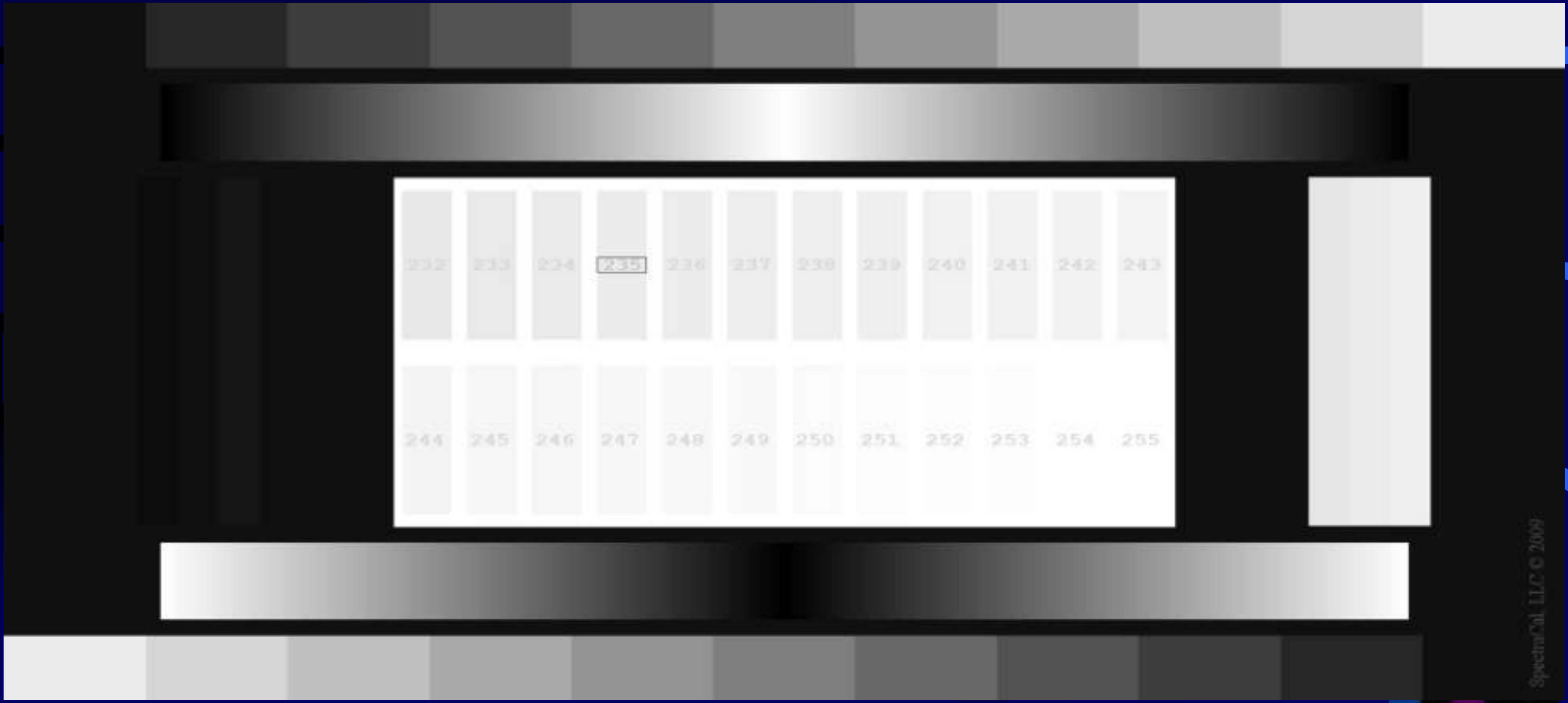
– Over 150,000,000 PCs have it – and virtually nobody knows it is there

# The Microsoft / ISF Consumer Tools
# Simple to Use Basic Set Up – White Level

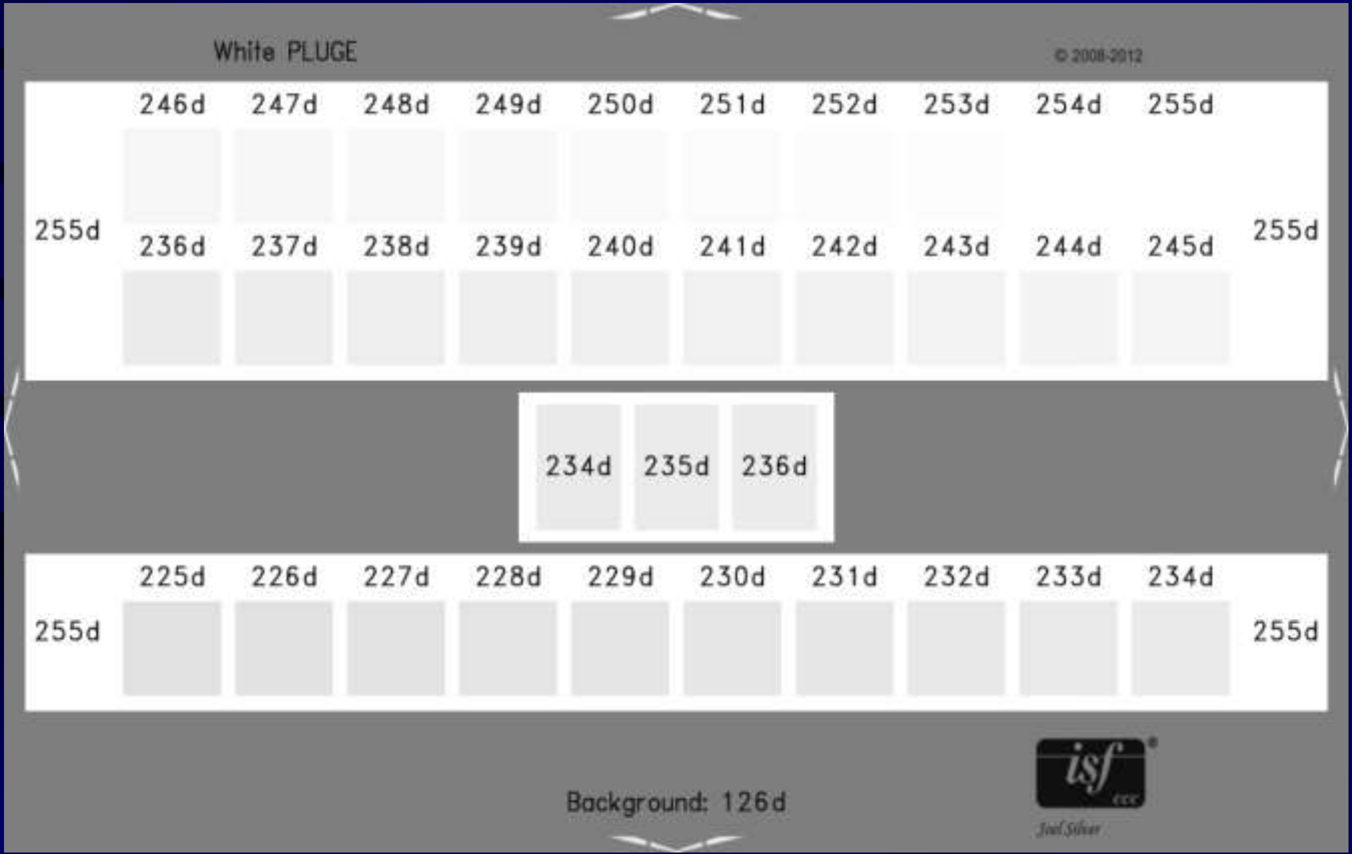
The Calibration Wizard is already in over 111,000,000 PCs! Is it in Yours??

# ISF Cal Wizard Black Level Tool

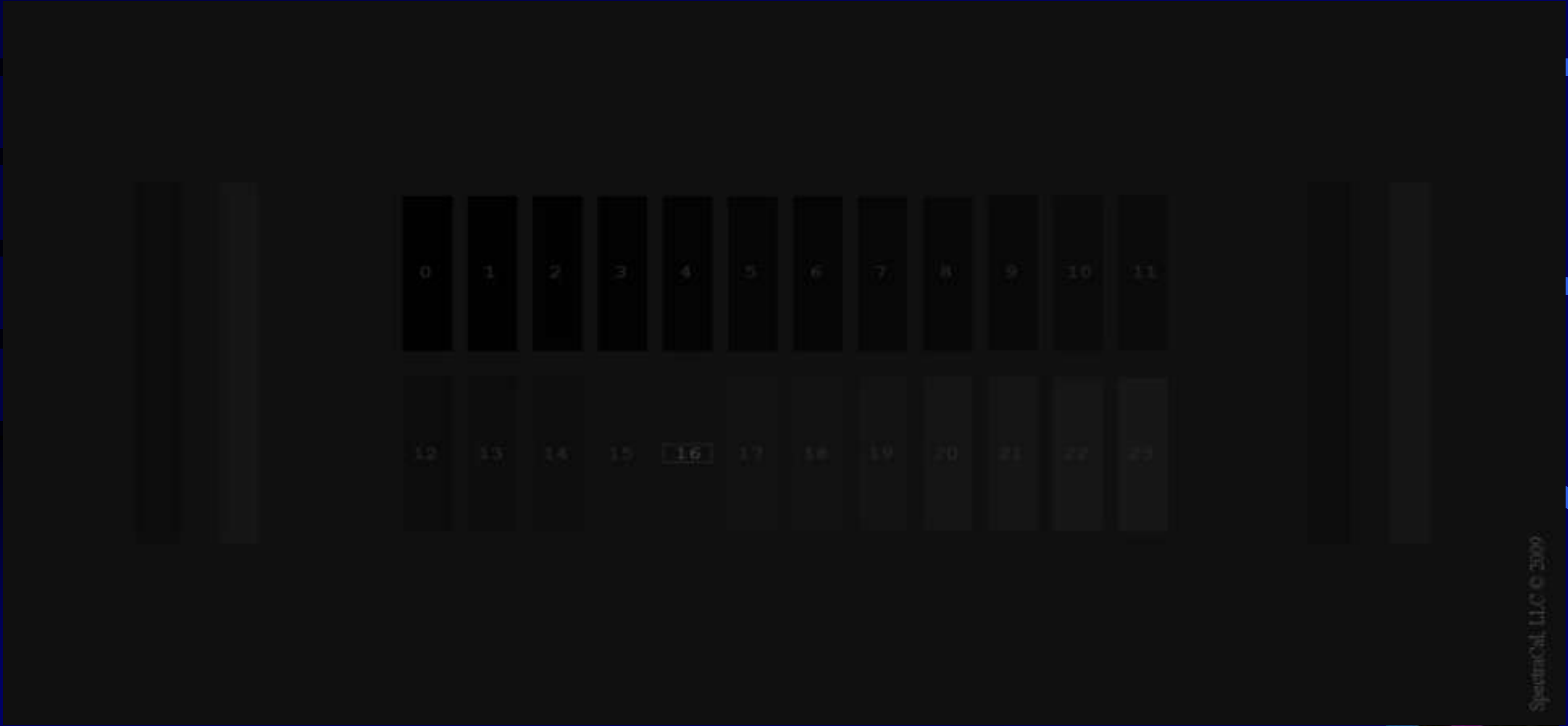
# Pattern With Above White Details



# “Free” ISF UHD 4K Patterns



# Pattern With Below Black Details



# White "CLIPPING"
# Use "White" PLUGE Patterns

**<u>Digital Devices "*Clip*</u>"**

Clipped TVs Are ***Missing*** Parts Of The Picture;
Look at a Ten Step pattern..

Clipped Images <u>Do</u> Appear Brighter

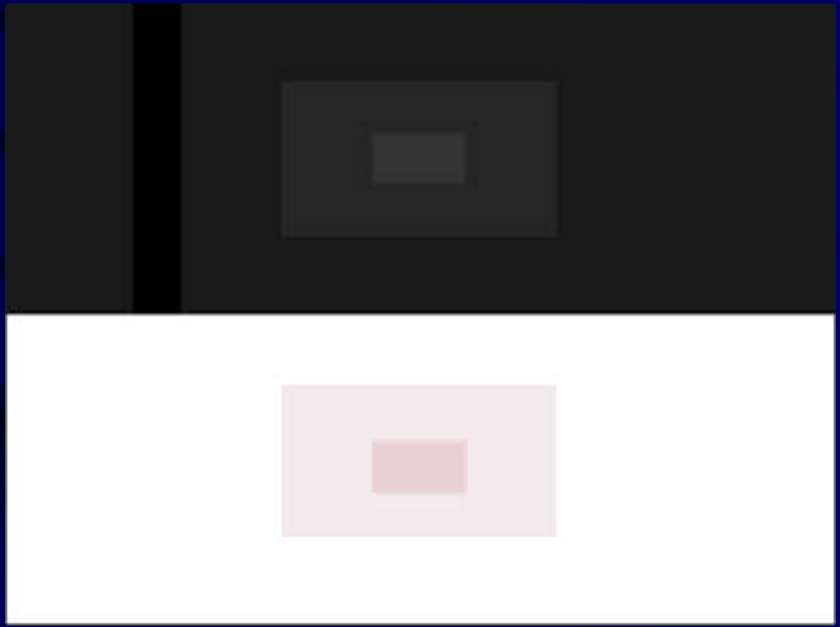
# Ten Step Pattern B & W Errors

# Near White Color Shifting

Use a full field gray scale or a High APL Pluge

Look for **interaction** between moving the control and the color of Light Gray or Near White changing

# “Near White” Color Shifting



# Test Black and White Levels Now Summary for Setting 16 to 235

- **Black Level:**

Verify under 16 is visible by raising brightness, then……..

Lower brightness to lock in Black at 16

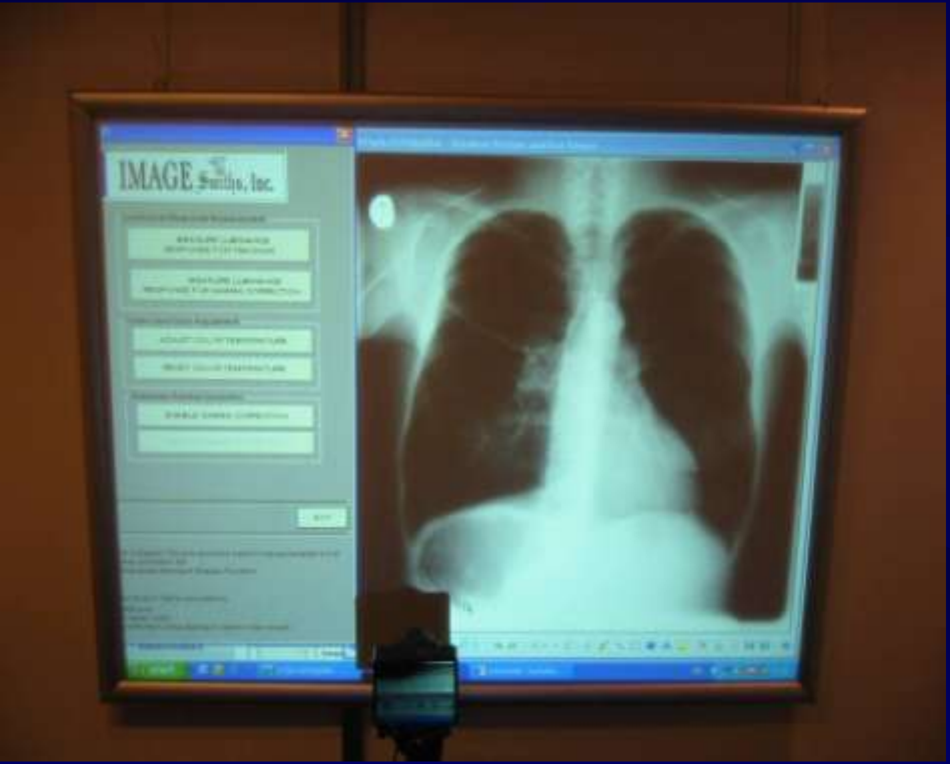
- **White level:**

Ideally, test pattern elements visibly to 254

***Real world, get the most elements visible without losing light output!!***

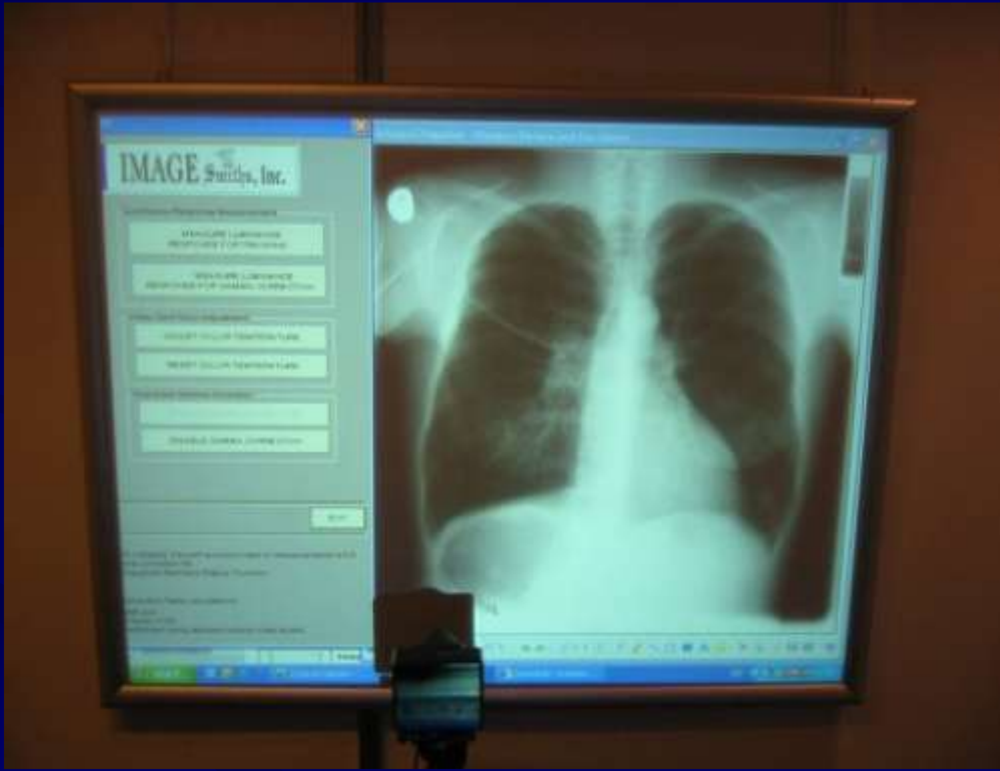
# Video 101 Test - How Would You Fix the Left Image?

**NON calibrated**



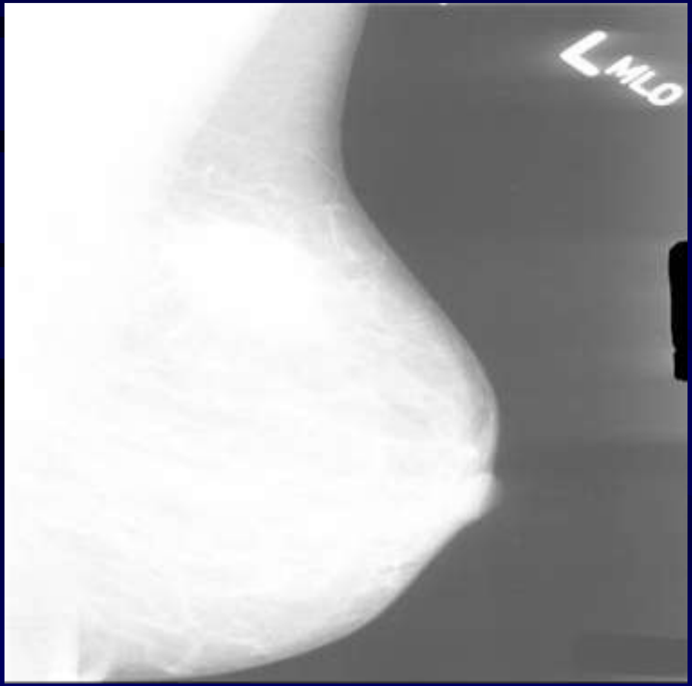
***DICOM* 14 calibrated**

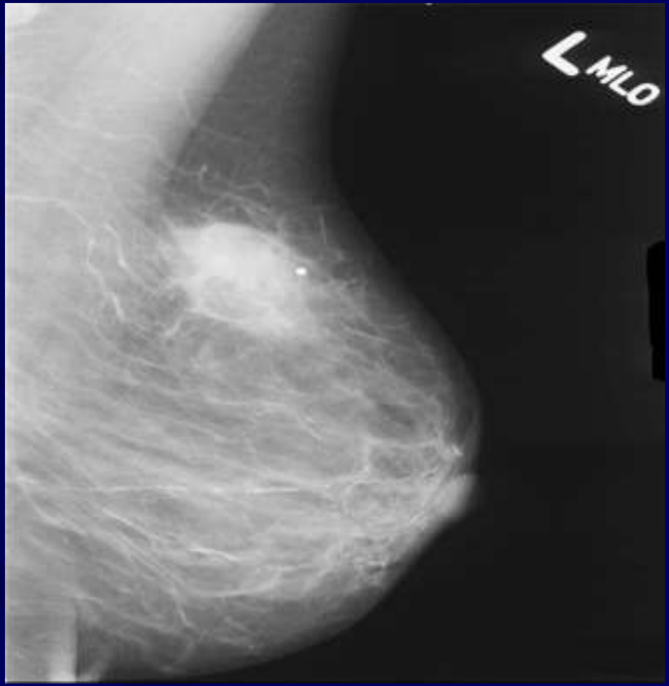
**(Digital Imaging and Communications in Medicine)**



# Video 101 Test - How do you fix this Left Image?

*Same Scan – Right one is a correct DICOM 14 image...*



# LCD/OLED Backlight – Set With 100 IRE Field **BEFORE and AFTER** Setting B&W

40 to 50 FtL will work well for most Night Modes!

60 to 150 FtL may be needed for Day Modes

Room conditions will dictate the right settings

These Controls are light output VOLUME controls!

***If you are not sure – GO BRIGHTER!***

# LCD Flat Panel Backlight, or Projector Lamp and Iris Settings – Use Full White Field
# OLED Requires 18% Windows (Like CRTs and PDPs)

**These settings Adjusting Light Output**

- Meters should be used!!!!
- However, setting these levels in 2 modes to be close enough to be at least bright enough for Day viewing, and not too bright to be uncomfortable for Night viewing is relatively easy
- ISF recommends Day and Night light levels in "Foot Lamberts" and "Nits"

**Pattern for setting these controls**

# LCD LED “Local Area Dimming” – Off for Calibration? - On for viewing

- Blacks are of course rendered Black in blocks that are off
- The number of LED does not = number of zones.
- Example: VF55 LED backlight local-dimming turn LEDs on and off to improve black level – These are numbers for an older LED: The backlight consists of 960 LEDs, positioned in 80 **control blocks”**
- **Example:** Sharp Elite 2011 had over 300 control blocks!
- Artifacts occurred when bright elements on dark backgrounds move from block to block – nicknamed **“Tinker Bell Effect”**

# Projector "Iris" Features

- Many projectors offer Iris options
  - Auto iris will impact calibrations
    - **You must test with all options both on and off**
- Obtaining good light output and contrast ratio are both objectives
- Mechanical Iris functions may be too slow – LED functions are faster and may be preferred

# Disc Player "Set Up"

Many disc players are not ITU Compliant

Some Critical options in **<u>Disc Player Set Up</u>**:

*Video Level controls, modes, output formats*

Some units are wrong when up-converting

Some just need the Contrast or Brightness set!

Some units will never be correct!

# Video Test Generator Versus Test Disk

**1 - A Disc player itself doesn’t provide a calibrated output**

**2 - You must Match the player’s output to a reference!**

Test generator should be used to calibrate TV input; a reference disk is then used to check/adjust disc player’s internal controls, IF THAT IS POSSIBLE!

- Players might not have controls
- Player’s controls might not have fine enough adjustments

# Measurement Tools
# Test Pattern Generators – Reference Sources

- Need reference test pattern source to play into TV.
  - Reference test pattern generator

- Need reference content to play through source device.
  - Reference test disk and/or reference program material

# An HDMI Only 2K Video Generator

AV Foundry VideoForge 3D HDMI Video Generator

- HDMI video test signals to 230 MHz pixel clock 12-bit output, with resolution, frame rate, and test pattern selection. Supplied test patterns, plus user-loaded patterns from SD card. <u>PC control ONLY</u>

# Compact 4K Generator

HDMI Powered

Remote Control or PC Patterns Access

ISF B&W PLUGES

# Video Generators 2K and 4K

## Including EEDID and HDCP Diagnostic Testing Tools

### Quantum Data 780a Handheld Test Instrument for HDMI

- Portable audio/video generator and HDMI troubleshooting tool for testing and adjusting analog or digital input, HDMI input and output tests troubleshoot system interoperability issues.

# Murideo SIX G - 4K, 18Gb, HDR

- ISF Patterns
- HDMI 2.0a
- HDR Test
- HDCP 2.2 Test
- EEDID Reader
- Dolby Vision HDR
- In Field Updates

# *“E-EDID”* “Plug and *Pray*” Solutions
# HDMI Problems That You Can Not Fix!

TV and a source component talking to each other...

***E**nhanced **E**xtended **D**isplay **I**dentification **D**ata* for resolution, timing, color transfer functions and more

***VESA*** Standard www.vesa.org

If TV is not compliant - connections will not work!

HDCP is two-way com, like EDID!

ImagingScience

# HDCP = D.R.M.

## Now it is far more robust with *HDMI 2.0 with HDCP 2.2*

In July 2005, IBM Corp., Intel Corp., Microsoft Corp., Matsushita Electric Industrial Co., Ltd., Sony Corp., Toshiba, Walt Disney Company and Warner Bros. Studio formed:

AACS
advanced access content system

***Upgrading Players is REQUIRED!***

***Is this done for clients?***

# HDCP –What is it?  How does it work?

## *Typical Environment*

**Source Authenticates Downstream Devices**

**Key Exchange**

**Encryption**

**Re-Check (every 2 seconds)**

**High-bandwidth Digital Content Protection (HDCP)**

**HDCP is a content protection technology developed by Intel for HDMI**

**All HD cable and satellite set-top boxes require HDCP for HDMI**

# HD-SDI Generators

## High Definition Serial Digital Interface

Evolution of SD-SDI (Serial Digital Interface)

Single Coax connection

720p / 1080i over single link /1080p over dual-link

Broadcast, Commercial & Medical applications

Converters are available for DVI / HDMI

**Does NOT pass HDCP – now…..**

Can carry 16 channels PCM Audio

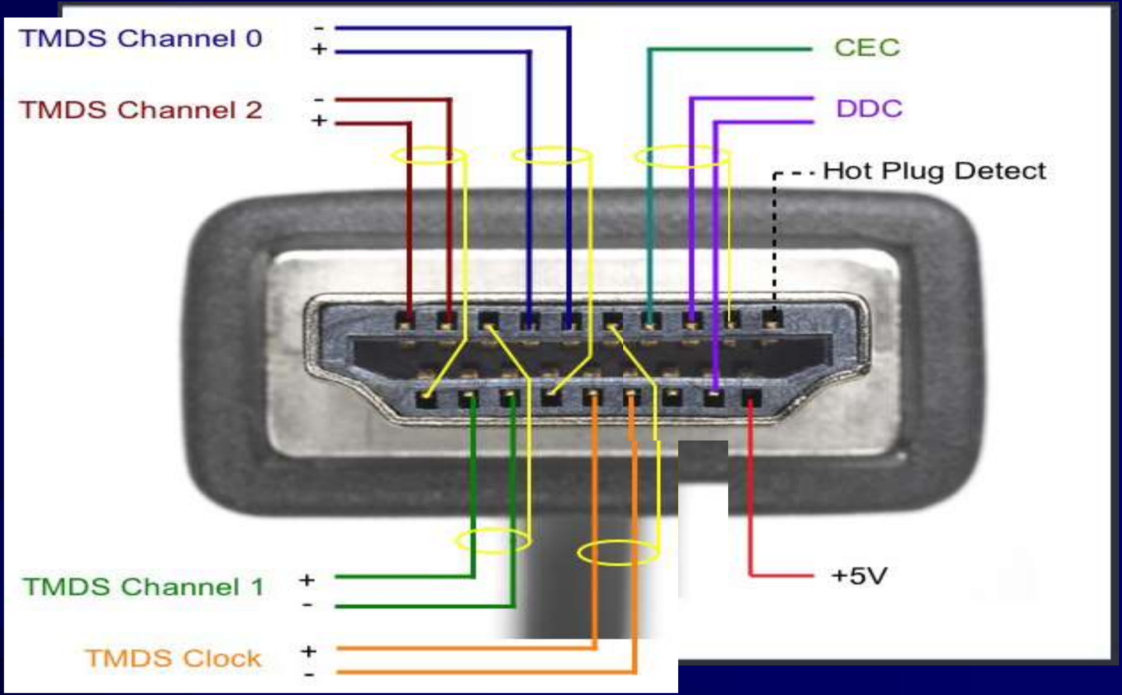
# HDMI "Under the Hood"
## *Plug Technology*

19-pin plug supports:

- 3 TMDS channels*

(*Transition Minimized Differential Signaling transmitting high-speed serial data used by the DVI and HDMI video interfaces.)

- Clock
- DDC channel
- CEC channel
- +5V power
- Hot plug detect




- TMDS Data must arrive in precise alignment
  —Requires each cable to be exactly same within 1/20,000 of inch!
- All pins are critical- do not cut any lines

# Questionable Video Signal Paths

Built In Switchers In AVRs?

Consider Them SUSPECT until tested!

Stand Alone High Quality Matrix Switchers

ISFccc AVRs! Denon/Marantz

HDMI to Cat and Fiber, HDBaseT, Wireless

ISF Research….conclusion….be careful!

# HDMI / Mini-HDMI

## High Definition Multimedia Interface – www.hdmi.org

- Single connection can carry Ultra High Definition video, multi-channel audio, format & command data and 100Mbps Ethernet
- Integrated remote control – *named CEC for Consumer Electronic Control*
- Automatic format adjustment – RGB or Component
- Fully compatible with DVI video
- HDTVs and UHDTVs and Computer Monitors
- Set Top Boxes
- DVD and Blu-ray and UHD Blu-ray disc players
- PCs and Gaming Systems
- Cameras and camcorders
- PDAs and Phones and more to come!

# HDMI Cable Categories

www.hdmi.org

HDMI®
HIGH SPEED

HDMI®
HIGH SPEED
with ETHERNET

HDMI®
STANDARD
with ETHERNET

HDMI®
STANDARD

HDMI®
STANDARD
AUTOMOTIVE

# HDMI Premium - 2016

## Premium HDMI Cable Certification Program

HDMI PREMIUM
Certified Cable
SAMPLE
BCDFG123456
www.HDMI.org

- HDMI cables certified under this program can branded and promoted as:
  - Premium High Speed HDMI Cables
  - Premium High Speed HDMI Cables with Ethernet
- The products will carry a special anti-counterfeit authentication label to differentiate them from other HDMI cables
- Once certified, authentication labels will be placed on product packaging

HDMI

## Premium HDMI Cable Certification Program—Availability

- The Premium HDMI Cable Certification Program will be available to HDMI Adopters by the end of September, 2015

Participation Agreement completed

Candidate Cables undergo ATC testing

HDMI Licensing, LLC confirms/registers results

Labels ordered for Premium HDMI Cable SKUs

Premium HDMI Cables available for sale

Adopters who wish to participate in the program will sign an Participation Agreement and submit Candidate Cables for testing

Once Candidate Cables have been certified to Premium HDMI Cable standards, Adopters will be able to order labels for packaging

Premium HDMI Cables may be publicly available as early as Q1, 2016

HDMI

ImagingScience Foundation, Inc.

# HDMI 2.0

| 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|
| ⇧ HDMI 2.0 | | ⇧ HDMI 2.1 | | ⇧ HDMI 3.0 | | ⇧ HDMI 3.1 | | ⇧ HDMI 4.0 | |

- **4k TV era**
- 4kx2k/60, 24 bpp
- 120 fps (3D)
- Multi-stream (bi)
- 1 Gbps data
- Compression min
- Legacy cable/conn*
- New cable/conn
- Power
- Pix bw ~20-40 Gbps
- New control
- Backward compatible

- **8k TV era**
- 8kx4k/60, 30 bpp
- 120 fps (Multi-view)
- Multi-stream (bi)
- 4-20 Gbps data
- Data tunnel (PCI)
- Compression >4k era
- New cable
- Pix bw ~80-160 Gbps
- Advanced power
- Discard some legacy

- **Beyond 8k**
- 16kx8k/60, 36 bpp
- 120 fps (Multi-view)
- Multi-stream
- Bi-directional
- 40-80 Gbps data
- Compression >8k era
- Pix bw >>160 Gbps
- New cable

* may have limited capability

# HDMI 300 MHz or 600 MHz Chipsets?

| Video Format | 300MHz | 600MHz |
|---|---|---|
| UHD/24-30 8-bit 4:2:0 | ✓ | ✓ |
| UHD/24-30 8-bit 4:4:4 | ✓ | ✓ |
| UHD/24-30 10-bit 4:2:0 HDR* | ✓ | ✓ |
| UHD/24-30 10-bit 4:4:4 HDR* | - | ✓ |
| UHD/50-60 8-bit 4:2:0 | ✓# | ✓ |
| UHD/50-60 8-bit 4:4:4 | - | ✓ |
| UHD/50-60 10-bit 4:2:0 HDR* | - | ✓ |
| UHD/50-60 12-bit 4:2:2 HDR* | - | ✓ |
| UHD/50-60 10-bit 4:4:4 HDR* | - | - |

# What Format Needs What Bandwidth?

| Format^ | Active Res | Color | HDMI ver | HDCP ver* | Data Rate | Char. Rate | Chipset Speed ♦ | TMDS Clock | Bandwidth |
|---|---|---|---|---|---|---|---|---|---|
| 1080p/24 | 1920x1080 | 8b 4:2:0 | 1.4b | 1.x | 2.23Gbps | 74.25Mcsc | 225MHz | 74.25MHz | 371.25MHz |
| 1080p/60 | 1920x1080 | 8b 4:2:0 | 1.4b | 1.x | 4.45Gbps | 148.5Mcsc | 225MHz | 148.5MHz | 742.5MHz |
| 1080p/60 | 1920x1080 | 8b 4:4:4 | 1.4b | 1.x | 4.45Gbps | 148.5Mcsc | 225MHz | 148.5MHz | 742.5MHz |
| UHD/24 | 3840x2160 | 8b 4:2:0 | 1.4b | 2.2 | 8.91Gbps | 297Mcsc | 300MHz | 297MHz | 1.485GHz |
| 4K/24 | 4096x2160 | 8b 4:4:4/RGB | 1.4b | 2.2 | 8.91Gbps | 297Mcsc | 300MHz | 297MHz | 1.485GHz |
| UHD/24 | 3840x2160 | 8b 4:4:4/RGB | 1.4b | 2.2 | 8.91Gbps | 297Mcsc | 300MHz | 297MHz | 1.485GHz |
| UHD/24 | 3840x2160 | 10b 4:2:2 HDR | 2.0b | 2.2 | 8.91Gbps | 297Mcsc | 300MHz | 297MHz | 1.485GHz |
| UHD/24 | 3840x2160 | 10b 4:4:4/RGB HDR | 2.0b | 2.2 | 11.14Gbps | 371.25Mcsc | 600MHz | 92.82MHz* | 1.856GHz |
| UHD/60 | 3840x2160 | 8b 4:2:0 ◆ | 2.0 | 2.2 | 8.91Gbps | 297Mcsc | 300MHz | 297MHz | 1.485GHz |
| UHD/60 | 3840x2160 | 10b 4:2:0◆ HDR | 2.0b | 2.2 | 11.14Gbps | 371.25Mcsc | 600MHz | 92.82MHz* | 1.856GHz |
| UHD/60 | 3840x2160 | 12b 4:2:0◆ | 2.0 | 2.2 | 13.37Gbps | 445.5Mcsc | 600MHz | 111.38MHz* | 2.23GHz |
| UHD/60 | 3840x2160 | 10/12b 4:2:2 | 2.0 | 2.2 | 17.82Gbps | 594Mcsc | 600MHz | 148.5MHz* | 2.97GHz |
| UHD/60 | 3840x2160 | 8b 4:4:4/RGB | 2.0 | 2.2 | 17.82Gbps | 594Mcsc | 600MHz | 148.5MHz* | 2.97GHz |
| UHD/60 | 3840x2160 | 10b 4:4:4 HDR | - | - | 22.28Gbps | 742.5Mcsc | NOT SUPPORTED | | |

# Real World 17.819 Gbps Test


# HDMI 2.2 Terms for HDCP Mapping

RSA – a Cryptosystem with Public and Private Keys

Authentication and Key Exchange (AKE)

128 bit Random, Secret Cryptographic Keys (Master)

Locality Check - Round Trip Time = 20 ms (RTT)

Session Key Exchange (SKE)

HDCP Cipher – Module operating in a Counter (CTR)

*(*72 pages on HDMI 2.2 are in our USB drive for you)*

# HDMI Errors…..
# The Very Shortest Summary….

No Image at all - Why?

Wrong image color or poor image – Why?

Blinking image – Why?

Never guess – save time and use test equipment!

# Test Pattern Tour

1 - Visual Test Patterns

2 - Metering Test Patterns

3 - Processing Test Patterns - on Blu-ray

# Trust Your Eyes or Your Meter?

***Color versus Black and White – Eyes versus Meters***

<u>**Metering White Fields** </u>- Measure the center of the screen, sides and the corners – compare readings!

***Are smooth ramps smooth on 8 Bit systems?***

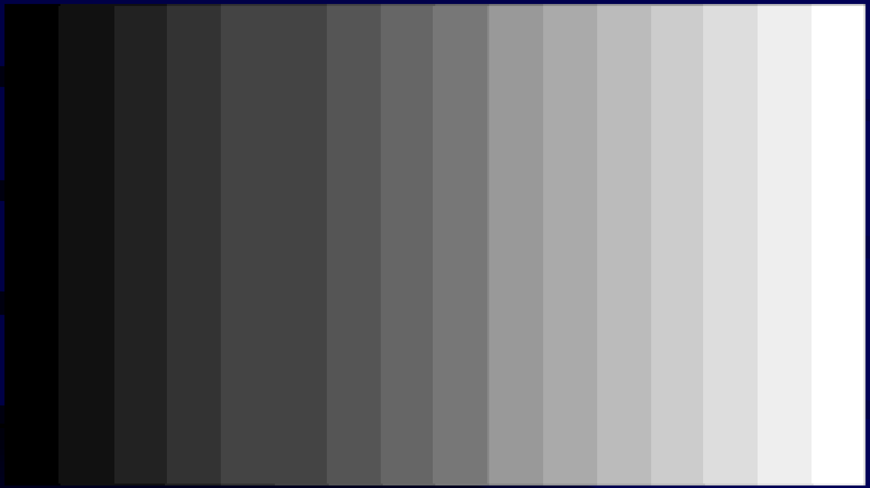
SMPTE Color Bar pattern problems on CE HDTVS?

Introduction to instrumentation #101

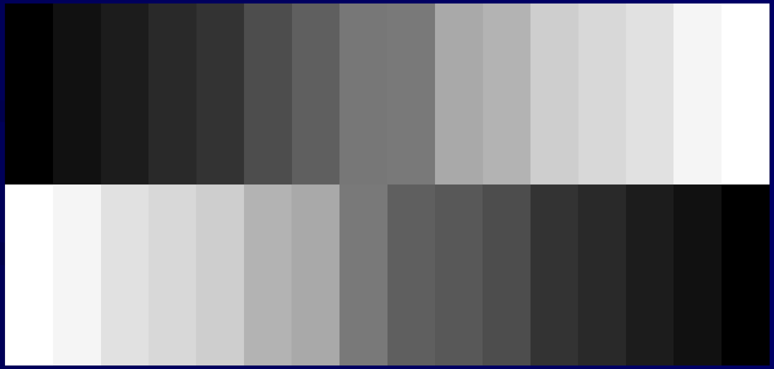
***Computing contrast ratios 101 – pre or post calibration?***

***Intra Frame vs. Sequential Contrast ratios?***

## Staircase



## Split Gray

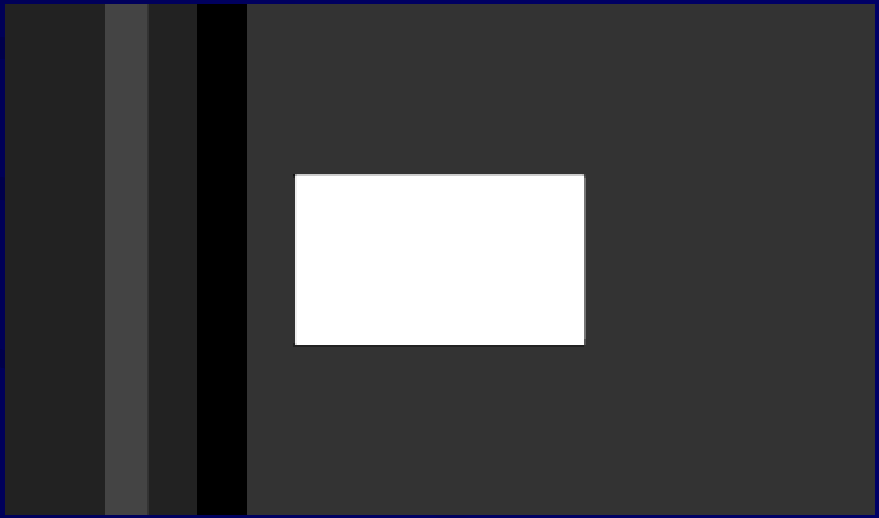


**Check video amplifier linearity and gray scale tracking. Sixteen steps. Good reference signal for signal tracing.** ***Always look carefully at 90IRE to 100IRE transitions – and carefully watch for color shifts at every level***

# Use a “Full Field” or A “Window”

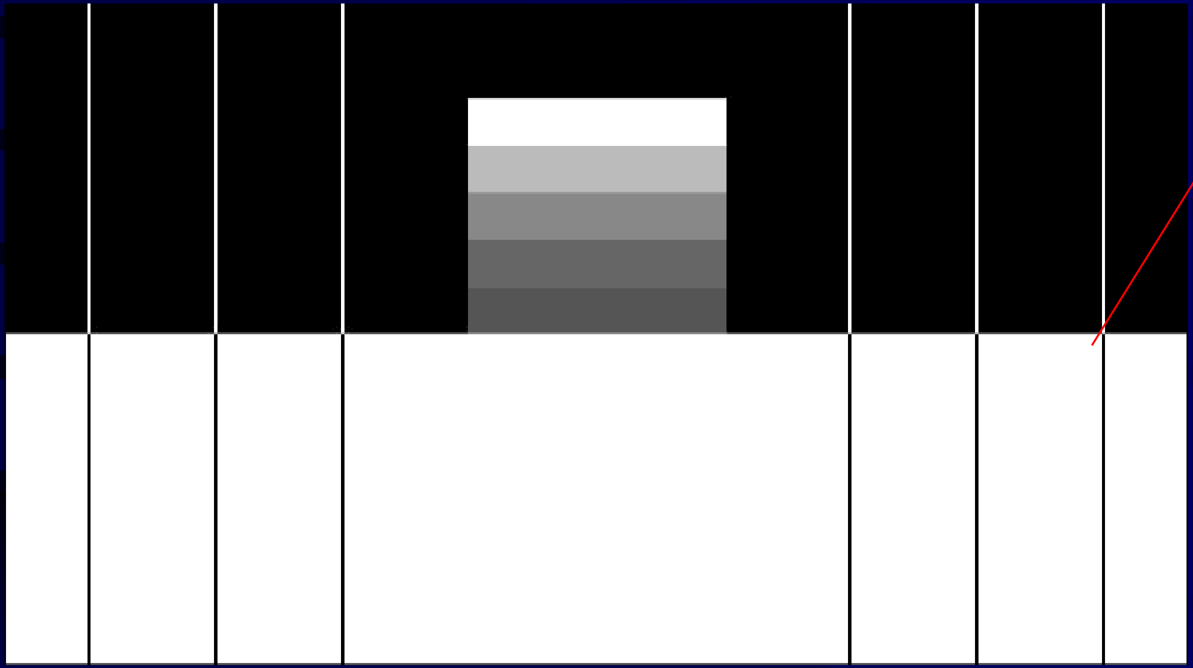
**For Local Area LCD, Projectors**

**For OLED, Plasma, CRT**



# Needle Pulse – Obsolete?

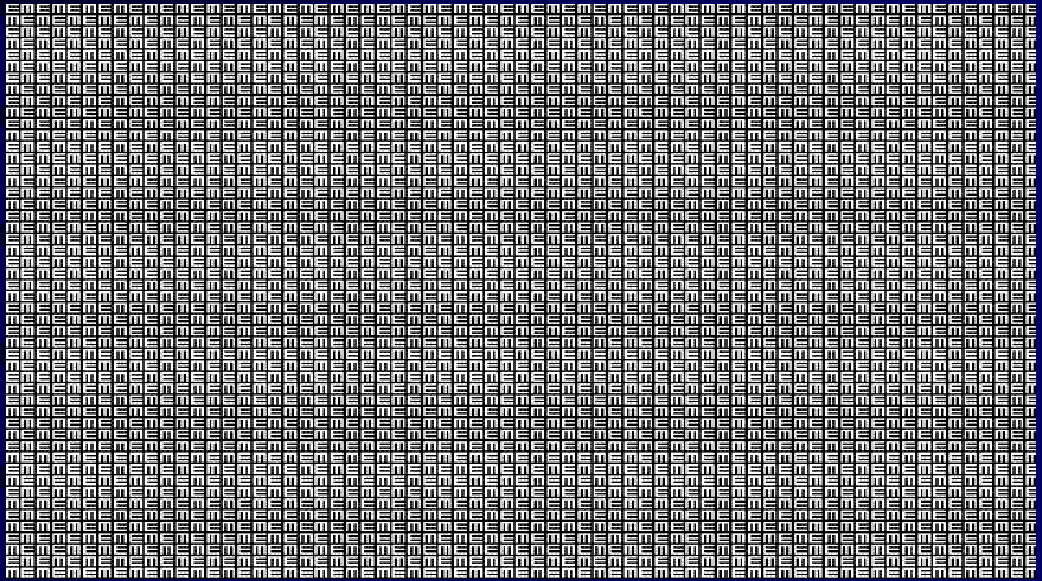
White Lines (Top) are equal width to black lines (Bottom)



Grayscale Bars

Top Bar is 100% white

# External Focus Pattern versus Internal?



**"E"s and "M"s alternating across screen.**

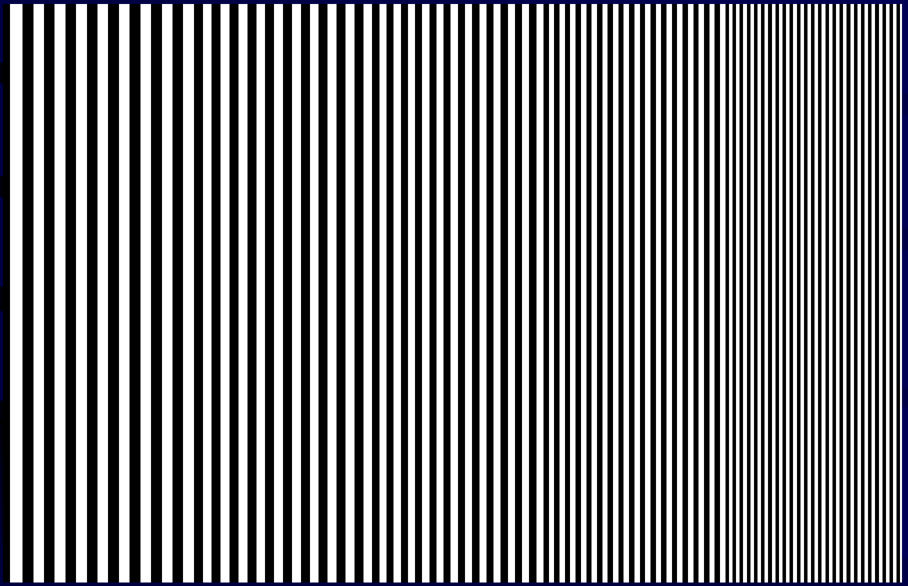
**Letter size varies with resolution**

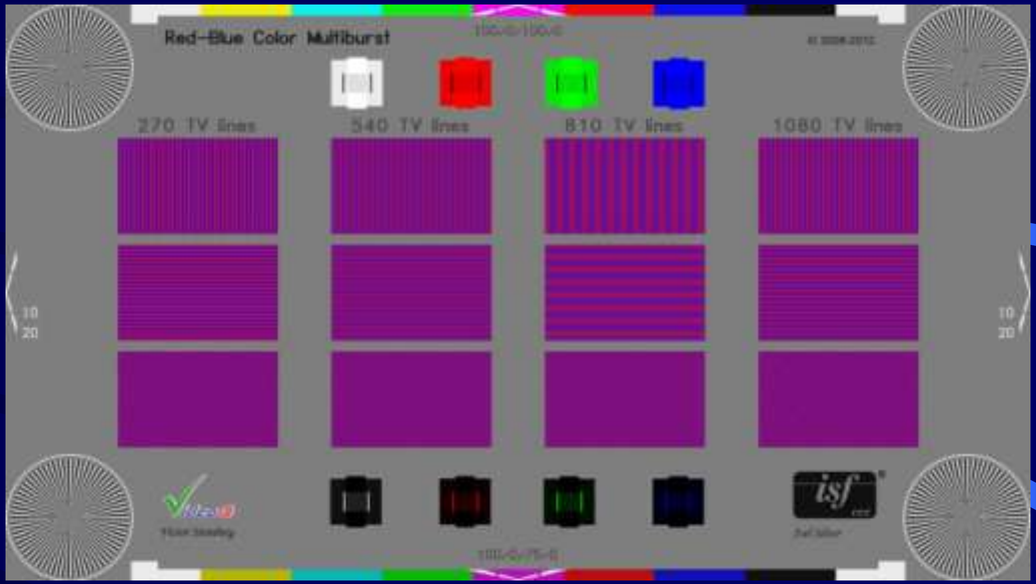
**Traditionally referred to as a "me-me" pattern.**

**Check for proper operation at both screen center and edges – look for "Chromatic Aberrations"**

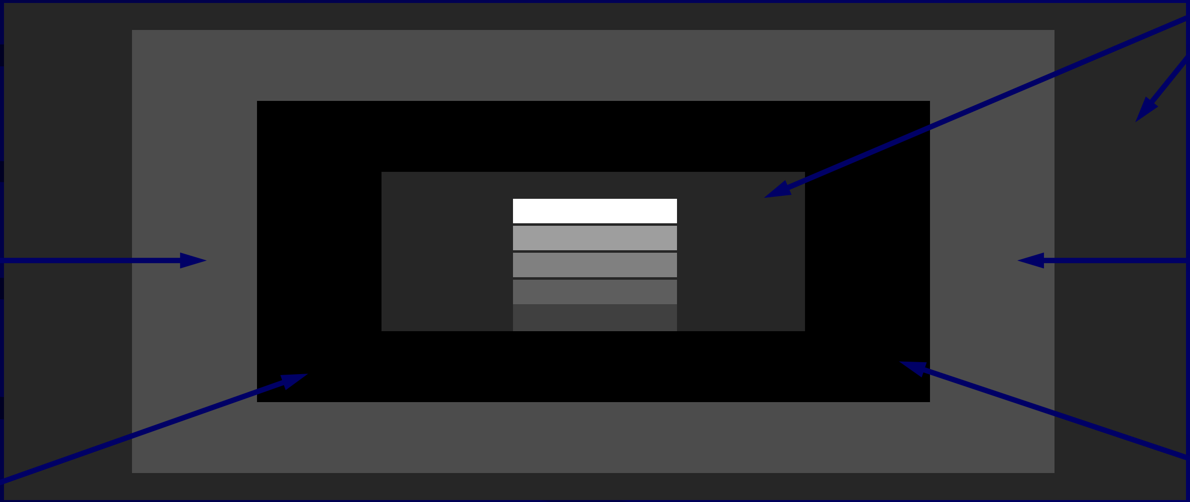
# Luma and Chroma Multiburst

**Should we set Disc players to RGB or Component? Perhaps 4:2:2 or 4:4:4?**



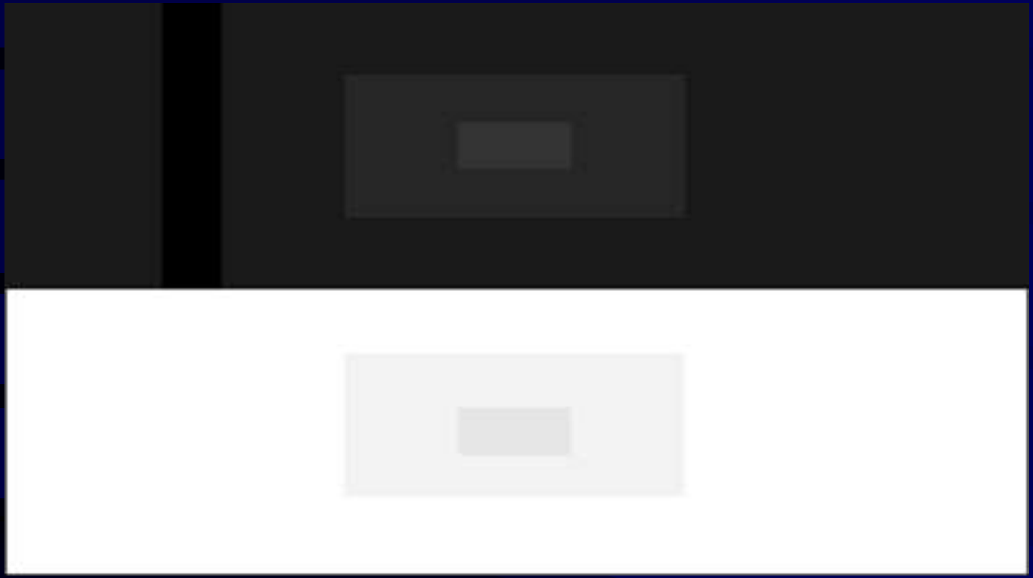


# Obsolete Black Pluge




Check for proper black level setup. Includes alternating black/blacker-than-black and black/just-above-black sections in newest models.

# Obsolete White Pluge - HiLo Trk (HIGH/LOW TRACK)



**Black "reference" section**

**Outer box: 1% above black.**
**Inner box: 2% above black.**

**White "adjustment" section**

**Outer box: 99% of peak white.**
**Inner box: 98% of peak white.**

## WHAT IS MISSING? - Above White!
## QD 780 updates are coming!

# Both Disc and PC Based Patterns

- The patterns themselves may be OK, but the source hardware output may not be at all!
- Verify them with reference generators before you trust them
- PC patterns have even failed at basic white luminance levels for I.S.C.R. testing

# PC “Set Up”

- 16 to 235 “Enhanced”?
- 0 to 255 “Normal”
- LUT?  -  1D or 3D?
- Aspect ratio or Scaling?
- RGB or Component?
- EEDID Compliance?
- Inverse Telecine?

# Game Console “Set Up”

Super White?

RGB or Component?

4:2:0 or 4:2:2 or 4:4:4?

Aspect Ratio?

Output Format?

# Redundant Controls…..

Processors & PCs & Displays & DVD players & Game Consoles & AVR have controls

Four, Six - or more - places to check for problems!

Calibrate everything! Check everything!

***WHAT DO YOU ADJUST FIRST?***

***YOU ABSOLUTELY NEED THESE!***

# What do we need to calibrate?

1 - Select best user Mode and Display options for Color Temp and Gamut

2 - Disable Auto Features (for now)

3 - Luminance - Lamp Setting / Iris / Backlight / Cell light / Panel Brightness

4 - Brightness and Contrast, Technically Black level and White level

5 – Gamma / EOTF* Preset

6 - Color &Tint

7 - Bit Mapping Accuracy / Overscan / Geometry

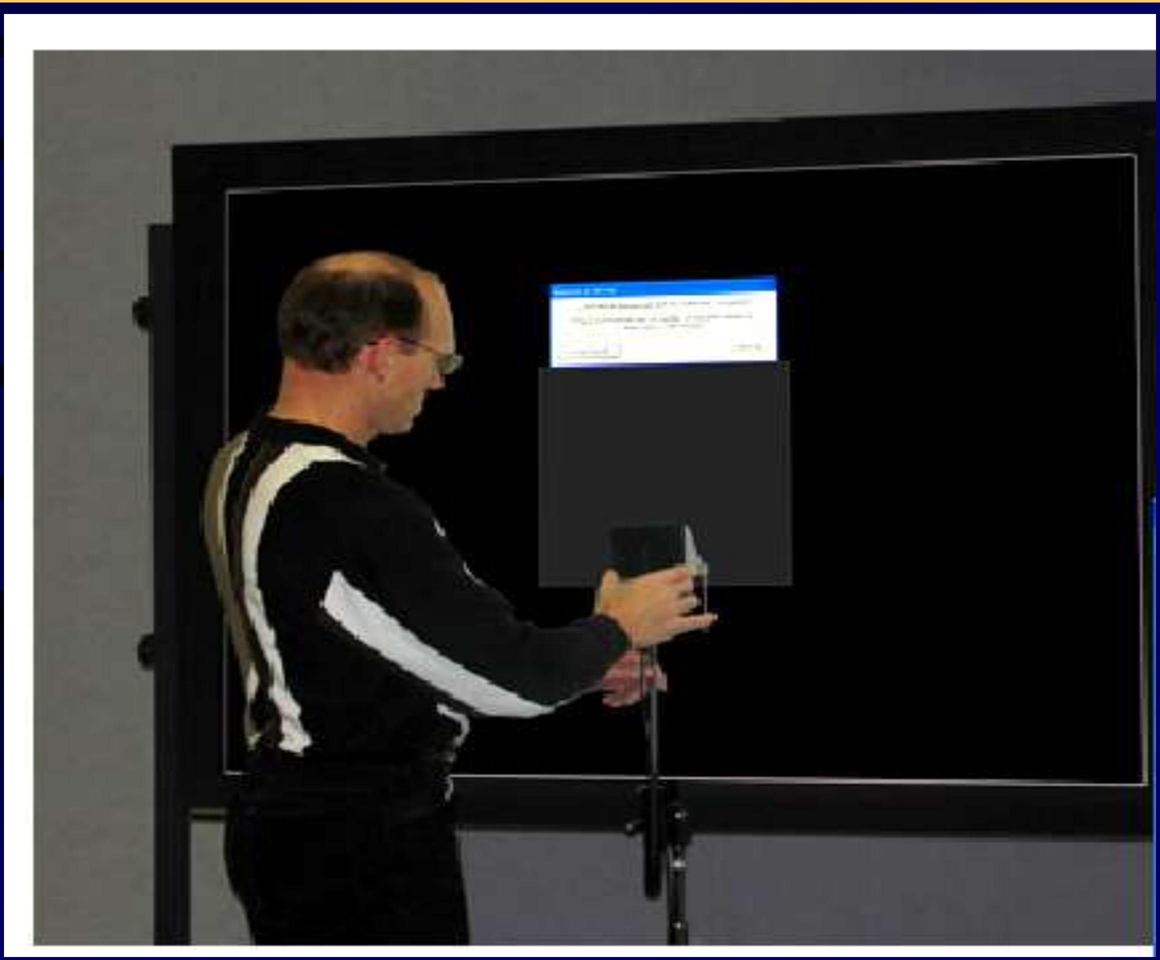
8 - Gray scale 2 Point

9 - Grayscale and Gamma Multipoint / 10 Point / 20 point

10 - Color Management Systems, 3D CMS, Gamut RGBCMY

11 - Video Processing and 1080p HDMI Optimization

# Using the equipment for Front Projector Calibration



Always wear an appropriate shirt when using precision equipment

The room is now a major limitation!

# What is Calibration?

Calibration is the matching a device to a standard

In Home Theater, Calibration is balancing science, knowledge and experience with the major compromises made when building today's hardware.

Calibration should not be confused with hacking

Calibration is now multiple small improvements whose sum is far greater than the parts

Professional video without calibration is not Professional

# Video Calibration Benefits

**Running Post calibration A/B Demo material defines your skills**

**Reproduction following the Standard used in content creation!**

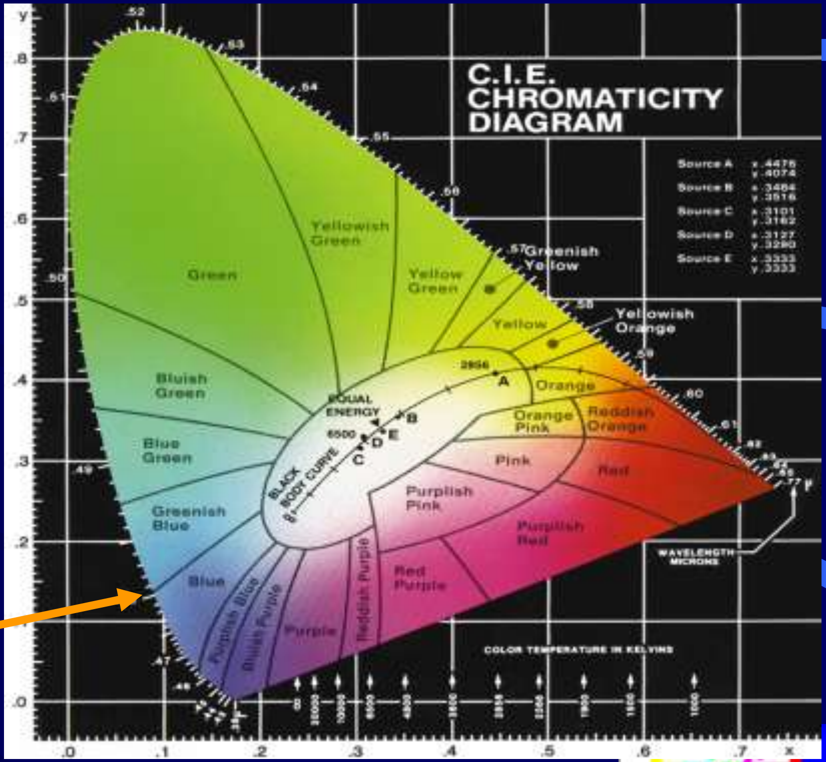
- ✓ **Full details in the darkest and brightest parts of all scenes. (Avoids "Crushing" and "Clipping)**
- ✓ **Match the viewing environment.**
- ✓ **Produce full range *accurate* colors, including flesh tones, grass, sky, and sports jerseys *WITHOUT EXAGARATING COLORS***
- ✓ **Minimize picture artifacts (distortions).**
- ✓ **Produce a "film look" superior to commercial theaters.**

# CIE Chromaticity Diagram – Color Science from 1931

**You Cannot Manage What You Cannot Measure! Color Space CIE 1931 Model – Commission Internationale de l'Eclairage**

Graphically depicts relationship between hue and saturation

Shows pure spectral colors around the curved border

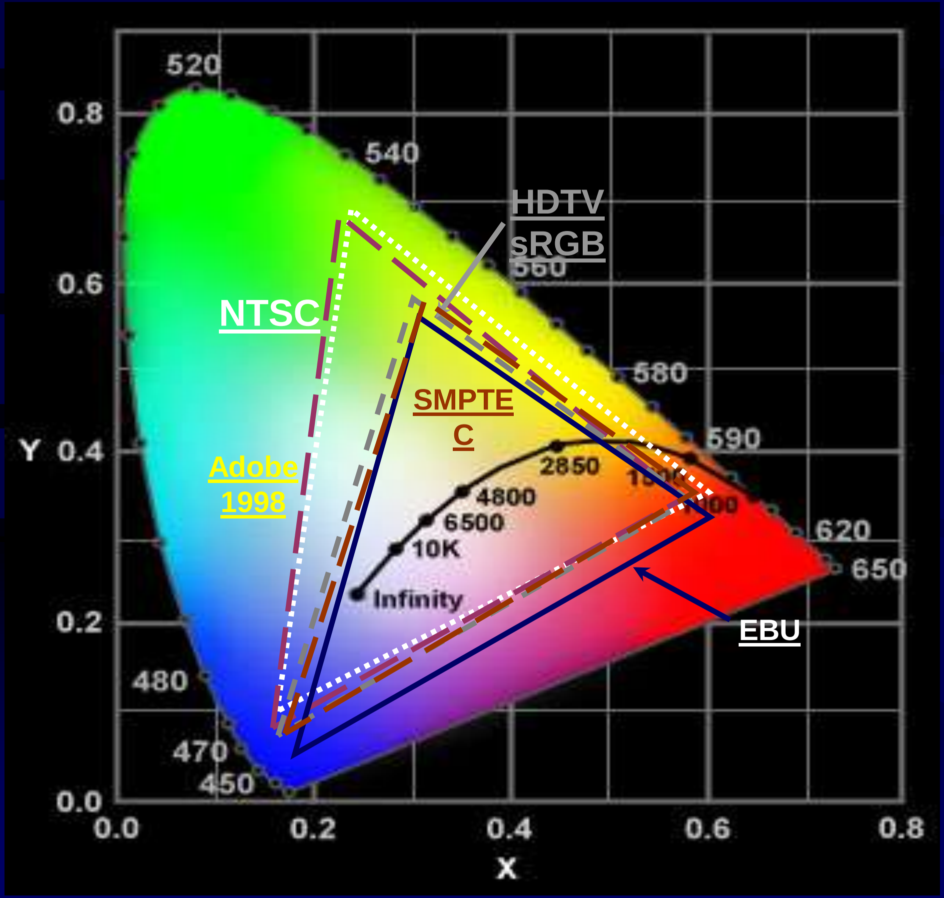



**3D Space View**

**"COLOR SPACE"**

Hues form the circumference, Color Saturation is middle to edge, Brightness equates to the 3D "Z" axis

# Different Color Space Triangles




**HDTV (709)**

| x | y |
|---|---|
| 0.640 | 0.330 |
| 0.300 | 0.600 |
| 0.150 | 0.060 |

**sRGB**

| x | y |
|---|---|
| 0.640 | 0.330 |
| 0.300 | 0.600 |
| 0.150 | 0.060 |

**NTSC**

| x | y |
|---|---|
| 0.670 | 0.330 |
| 0.210 | 0.710 |
| 0.140 | 0.080 |

**SMPTE C**

| x | y |
|---|---|
| 0.630 | 0.340 |
| 0.310 | 0.595 |
| 0.155 | 0.070 |

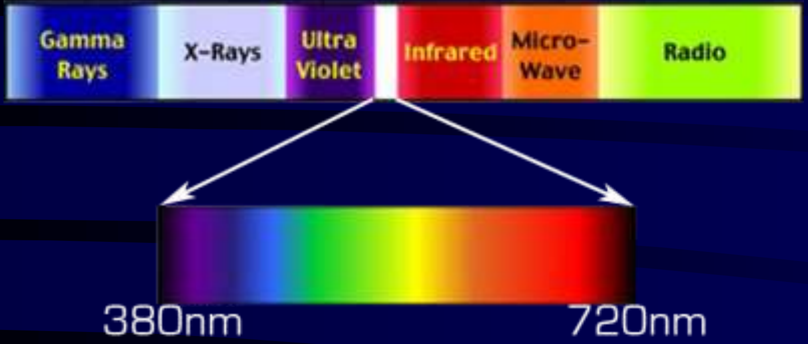
**Adobe 1998**

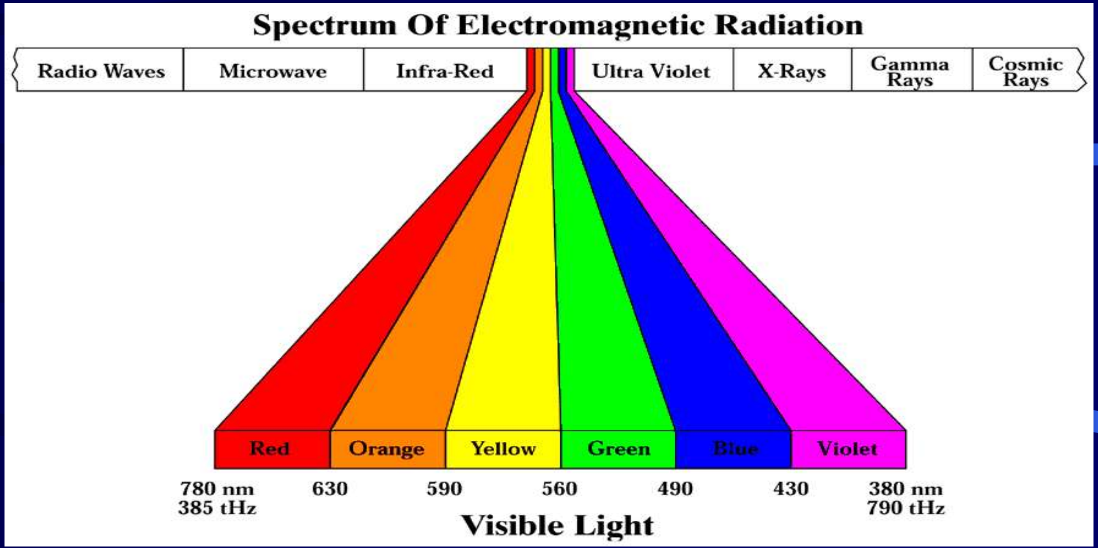
| x | y |
|---|---|
| 0.640 | 0.340 |
| 0.210 | 0.710 |
| 0.150 | 0.060 |

**EBU (601)**

| x | y |
|---|---|
| 0.640 | 0.330 |
| 0.290 | 0.600 |
| 0.150 | 0.060 |

# Another Way Of Looking at the Visible Spectrum



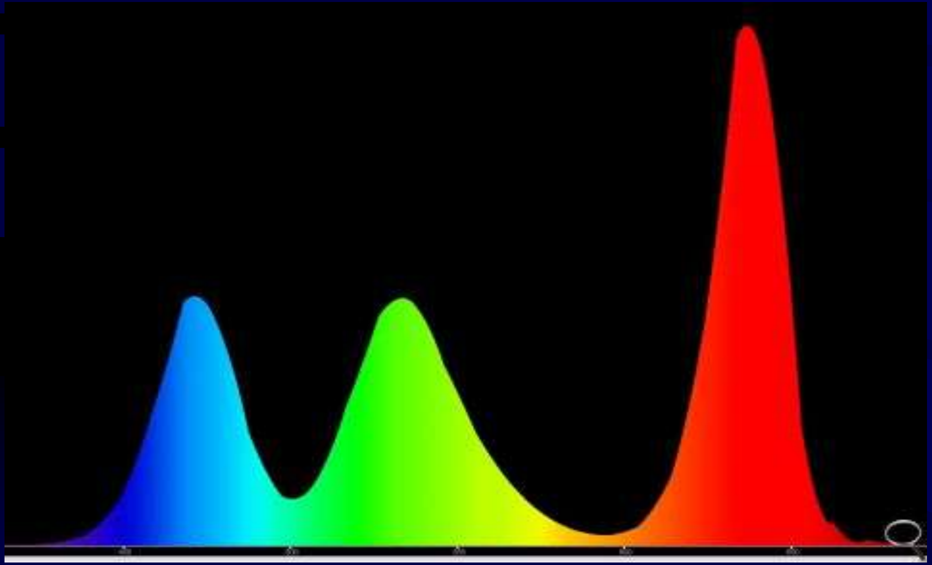

Light is electromagnetic energy within a narrow range of frequencies.

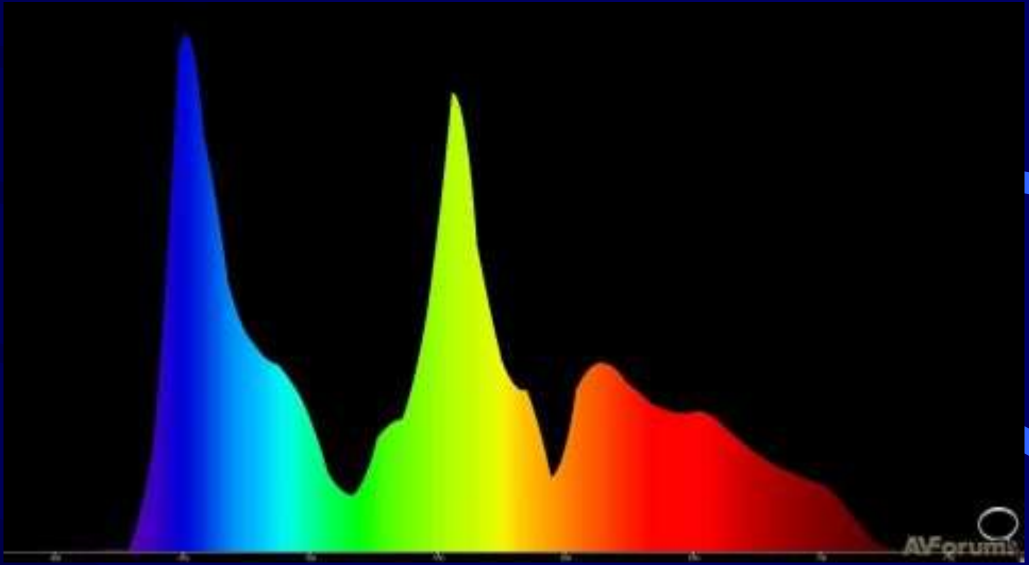
Each different wavelength of light energy (if seen alone) is perceived by the human eye/brain as a different, fully saturated, color.

# LED and UHP Projector Spectrum

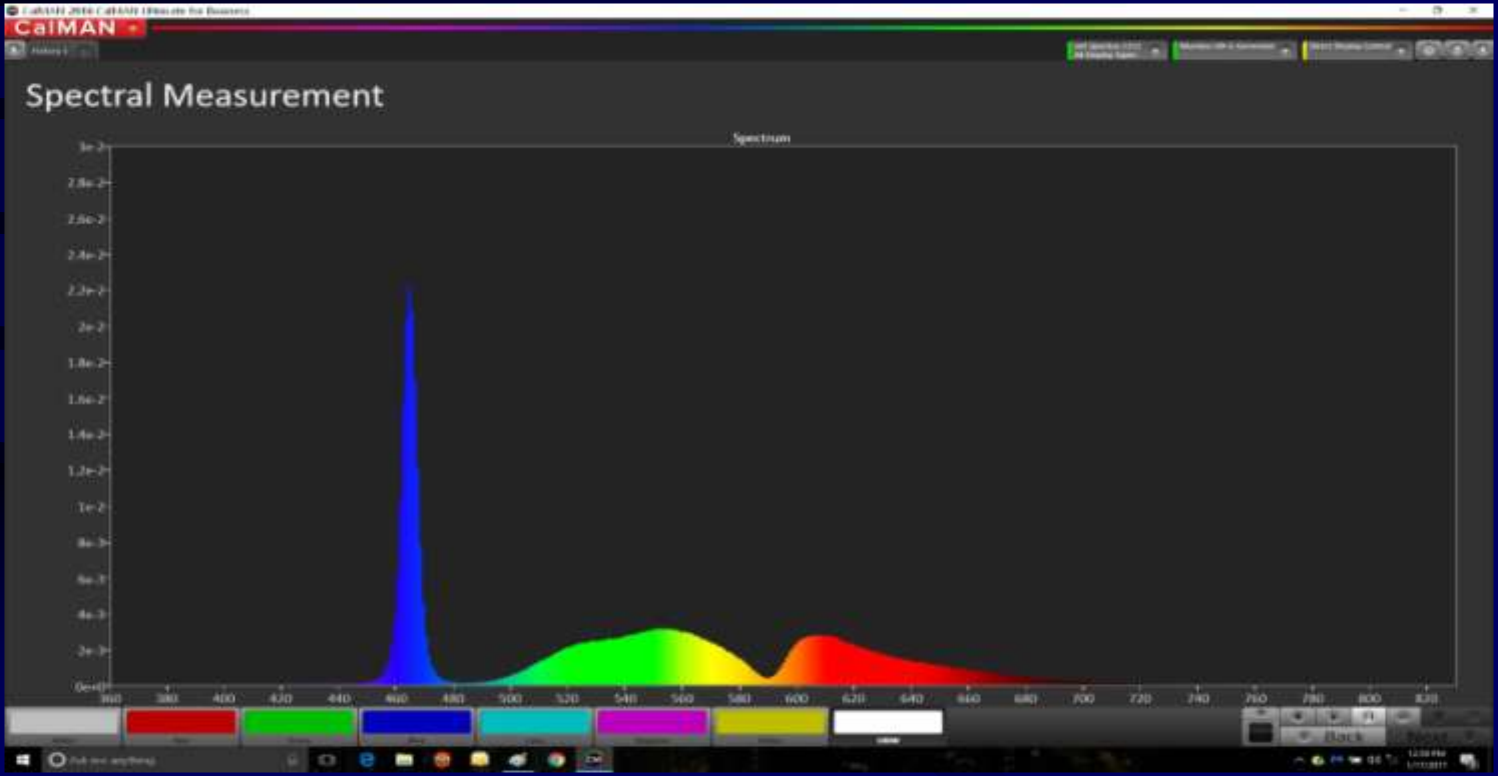
Look at the difference in the RED – What does that mean?

**You See Them The Same – Your Meter Does Not!**



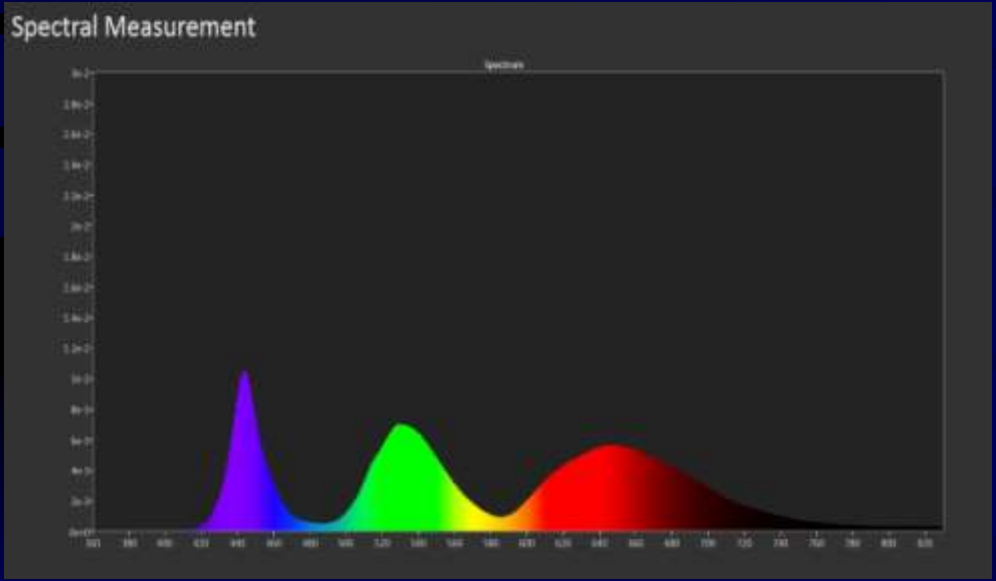


# Laser Phosphor Projector SPD

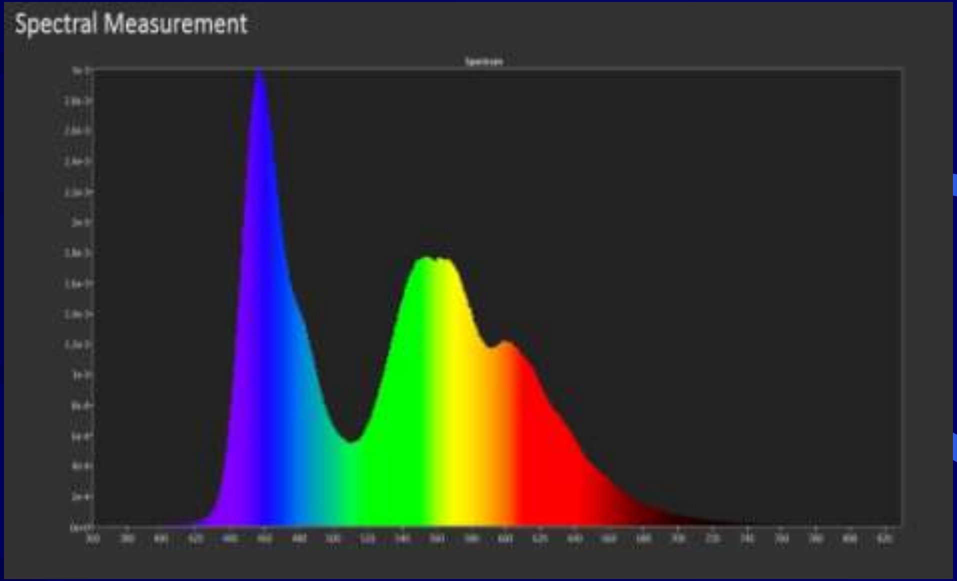


# Spectrum Differences LED / OLED

**White LED Backlit LCD**

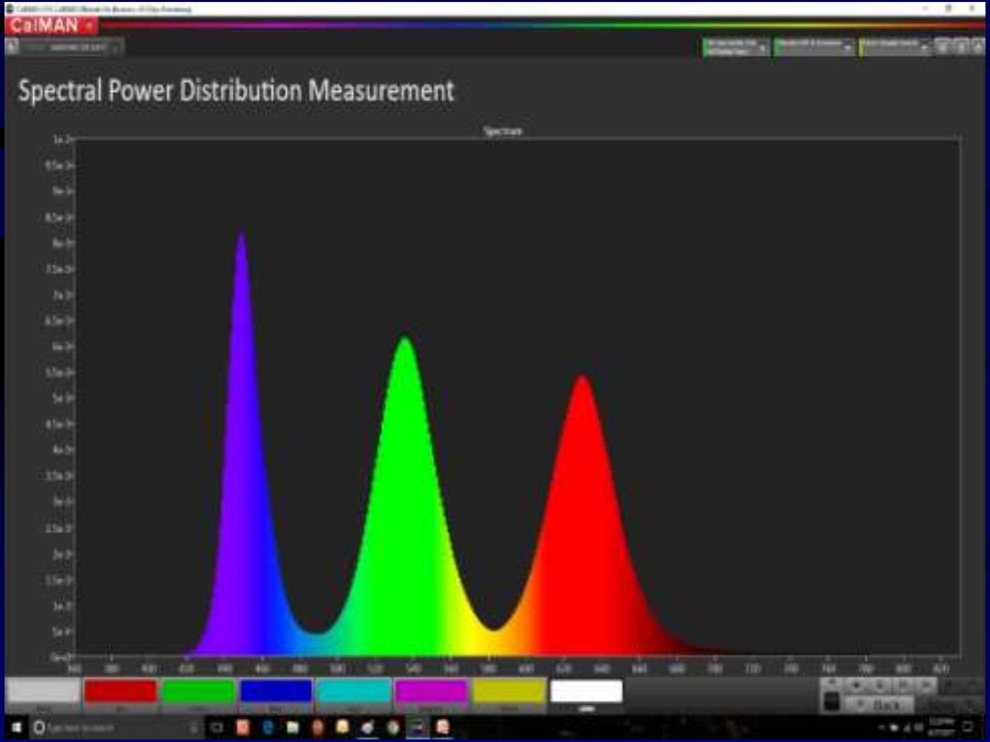



**LG OLED 2015**

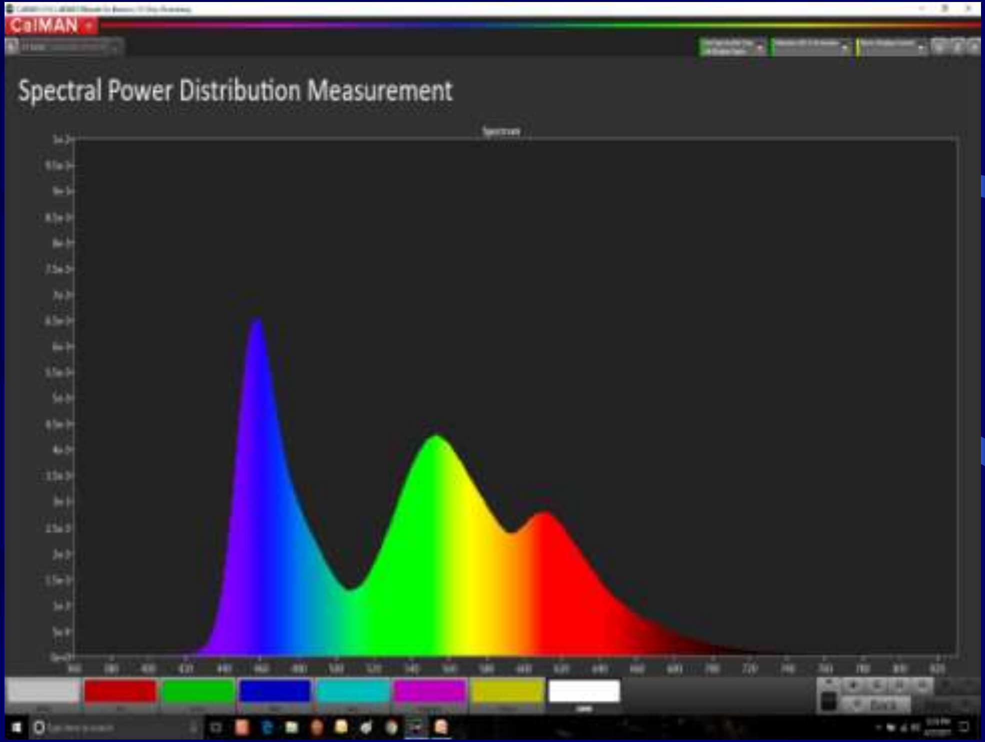


# Spectrum Differences LED / OLED

**Samsung QLED 2017**



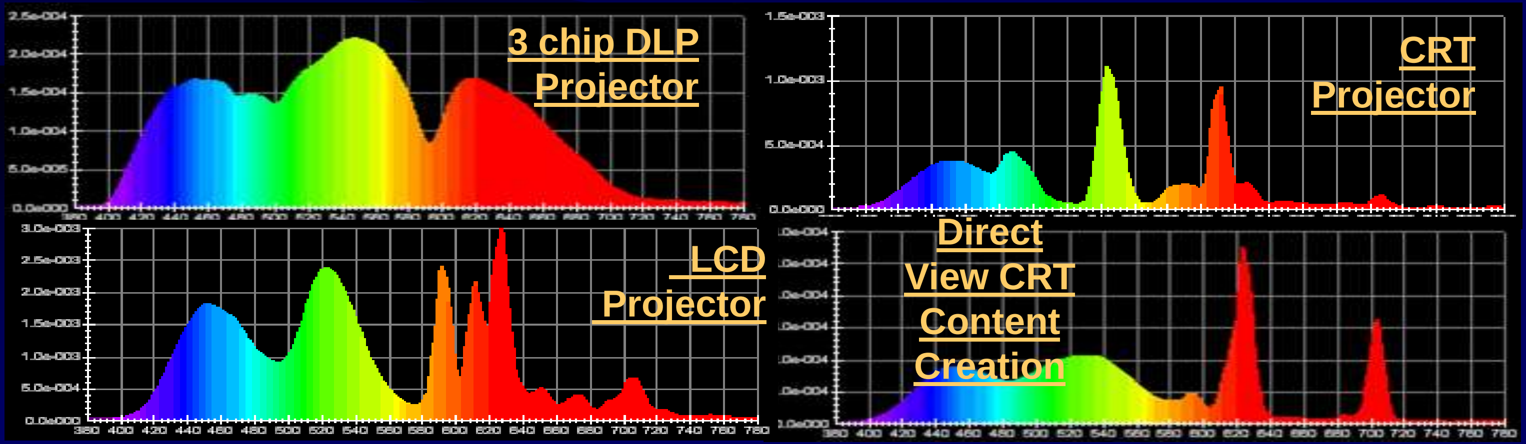

**LG OLED 2017**



# CalMAN's Biggest Weakness – Wetware! - You! You Must Tell Your Meter What TV It Is Reading!

Colorimeters measure TV's Spectrums – setting CalMAN for the right type of TV makes your meters more accurate

<u>YOU MUST DO THIS IN ISF CalMAN SET UP EVERY TIME!</u>



# Matching LCDs to OLEDs?

Same x,y, Y calibration done with $30K meter looks different to the human eye!
Spectral Power Distribution is the issue
Offsets from Manufacturers have helped – but are not perfect
For signage or studio use identical displays are ideal

## W. Edwards Deming, 1900-1993

## *ISF's Inspiration for the ISF CalMAN Workflow!*

**The ISF CalMAN workflow is a <u>step by step</u> compilation of many top calibrator's methodologies – and is a living breathing process that will continue to develop!**

THE W. EDWARDS DEMING INSTITUTE®

W. Edwards Deming

# ISF CalMAN Display Calibration Software – Quick Tour!

## C.A.C = Computer Assisted Calibration

**The Goals:**

**1 - A step by step process that will insure more consistent ISF Calibration services worldwide . Since calibration adjustments are interactive, the process must be repeated until no additional adjustments are required throughout one entire step by step workflow!**

**2 - A framework that makes learning ISF Calibrations easier**

**3 - A process that speeds the work of experienced calibrators**

**4 – Software that will make Calibration Hardware more accurate**

**5 - Producing customer reports that can establish histories and generate referrals**

**6 – An updateable process that will adapt to upcoming HDTV technologies**

**7 – An automated network that earns your client's respect – Now Tour ISF Workflow!**

# CalMAN PC Set up Check

- Is ISF CalMAN open on every PC?
- Get ready to follow along on your PC…
- We will run a quick tour of all the 1st steps, and then cover complex steps in detail…..
- Hands On - Tour some of the Steps - Stop at "Gamma" So We Can Talk About EOTF…..

# Goodbye Gamma – Hello EOTF and OETF

Or……

## *How to confuse as many people as possible for as many decades as possible!*

# Gamma, EOTF and OETF

What is Gamma?

Why is it now called EOTF and OETF?

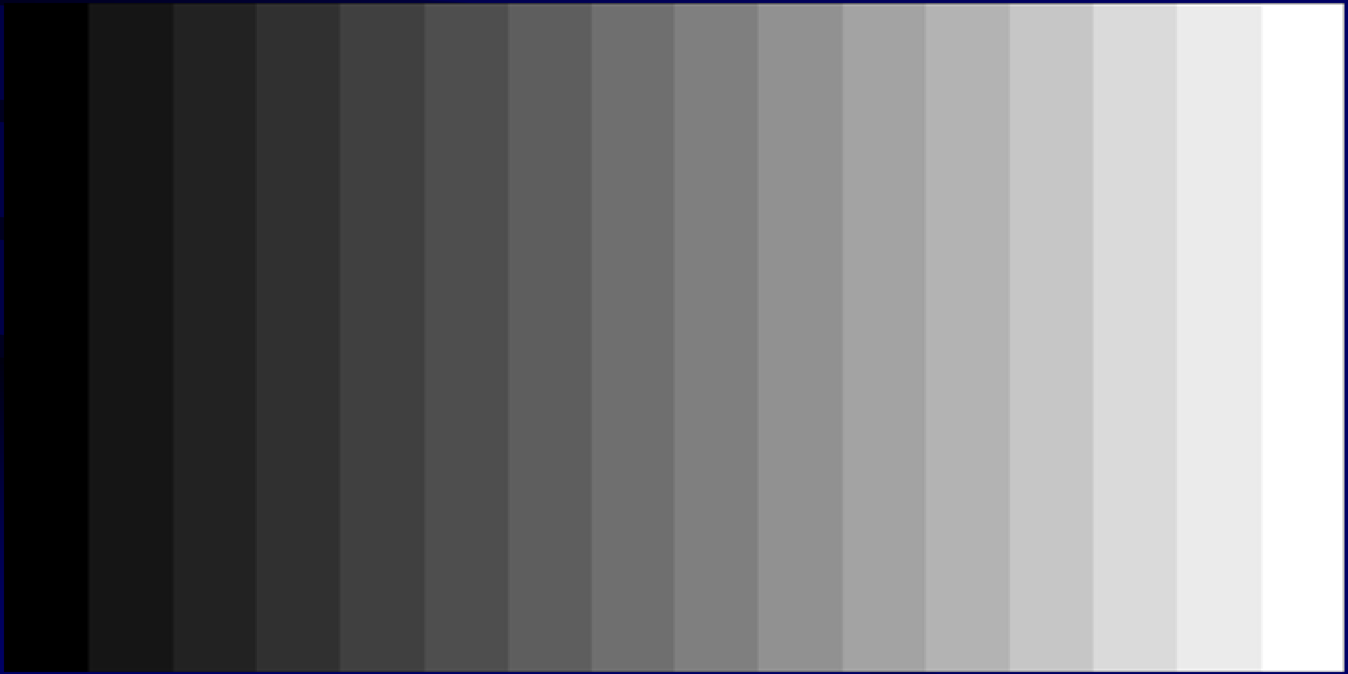
How can you explain it to a client in 30 seconds?

Why are we stuck with it?

How do you determine how to set it best for every installation?

# *Going From Fixed Black to Fixed White,*

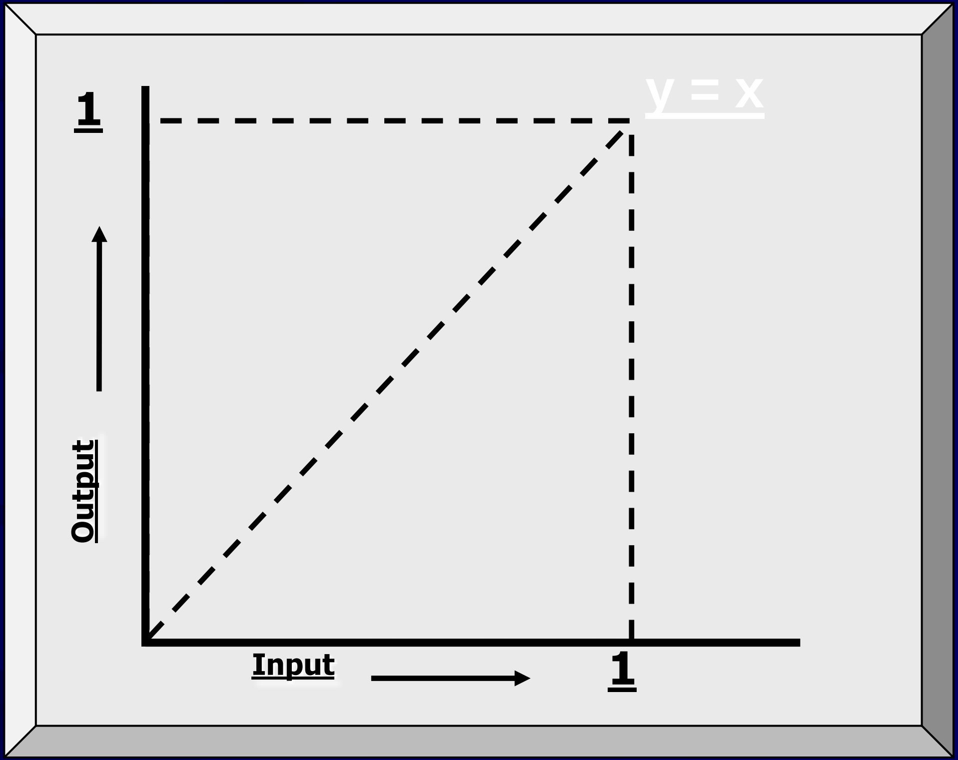
## How Much Brighter Should Each Step Below Be Than the One Before it?



# Video Signal Input Plotted to TV Light Output

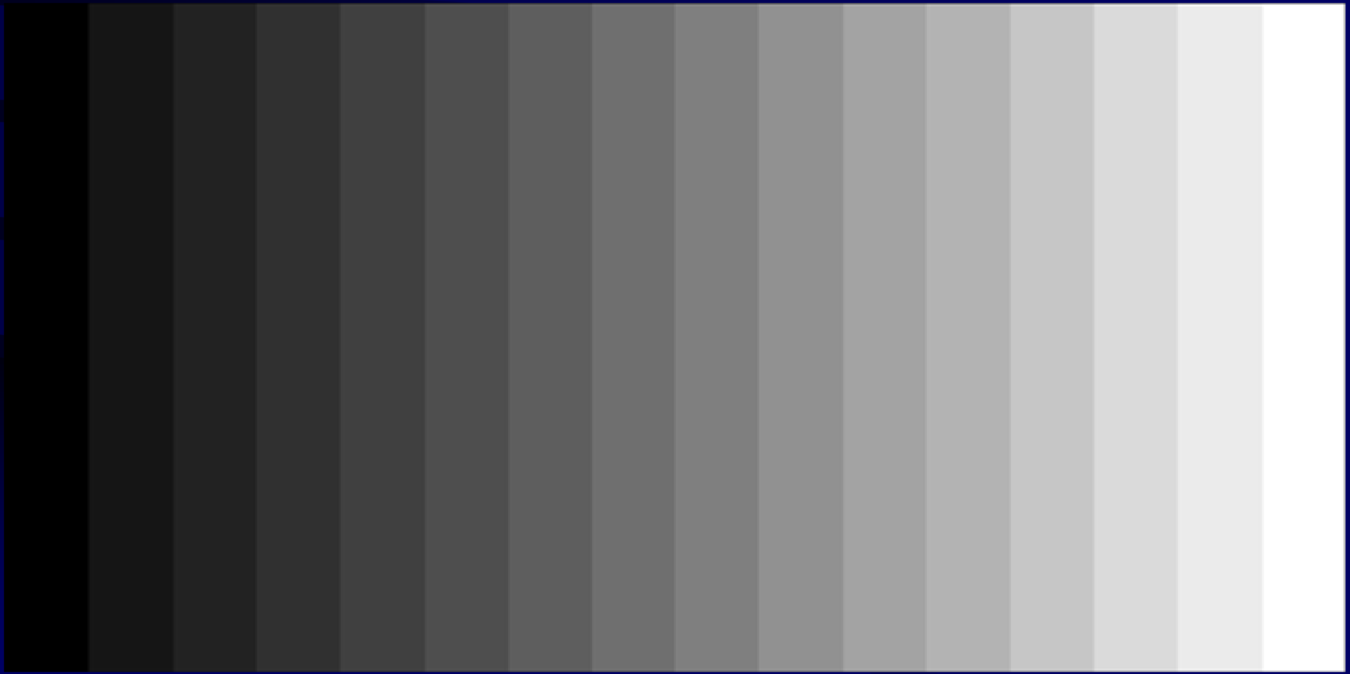
A Linear Display Input / Output plot:

No “Gamma” or “EOTF”



## ***Humans are hopelessly non linear, and totally analog***

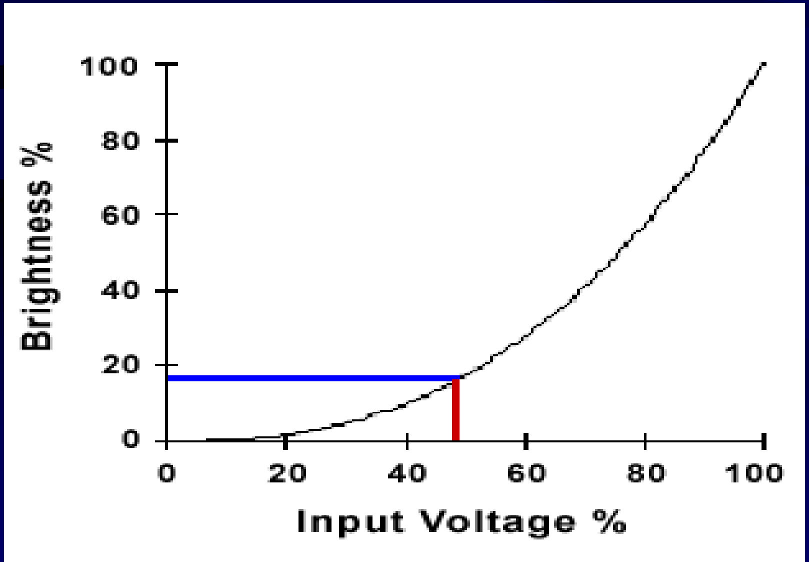
If the steps get brighter in equal amounts, people do not see the steps as becoming brighter equally



# CRTs to the Rescue – CRTs Have "Human Like" Non-Linear Response

Relation of Input signal to Light output

- Input is video signal
- Output is the Brightness of the display



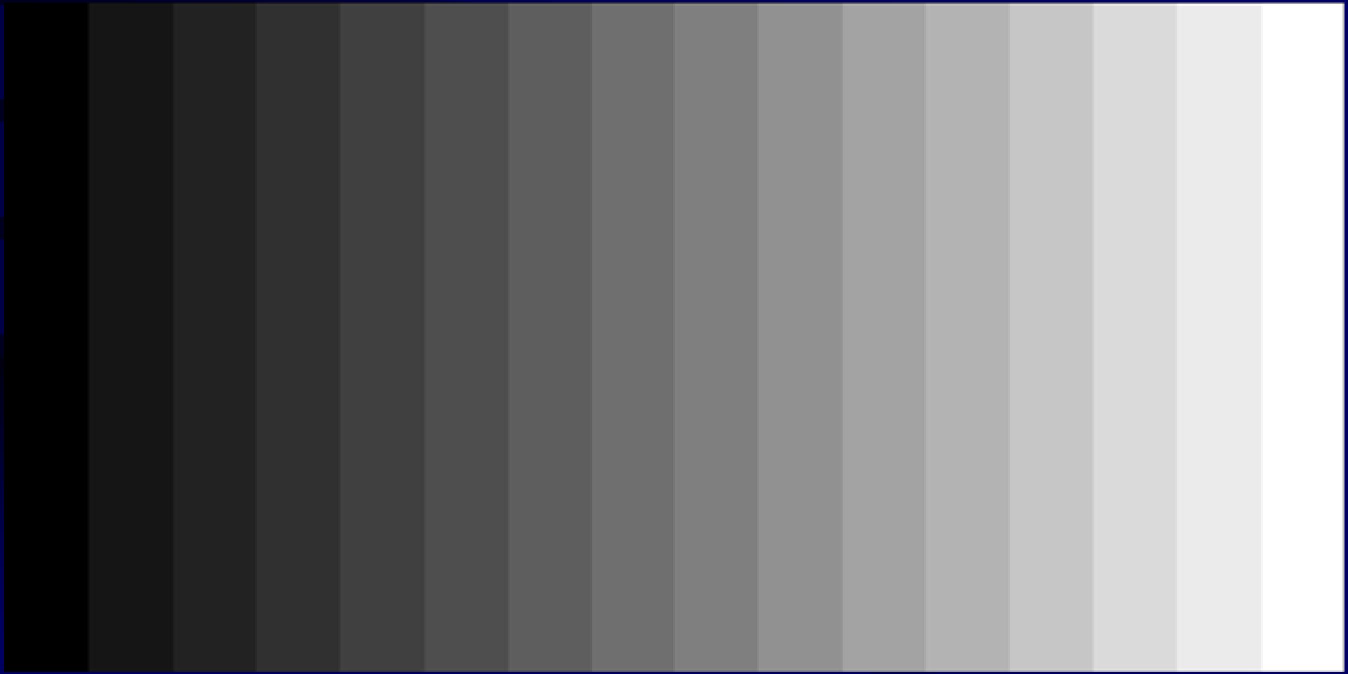

***This graph shows the nonlinear relationship between input signal voltage and light output for a CRT display.***

1 - With Signals from an Analog Tube Camera -

2 - Displayed On an Analog CRT TV -

3 - These Steps Looked Right to Us Analog Creatures!

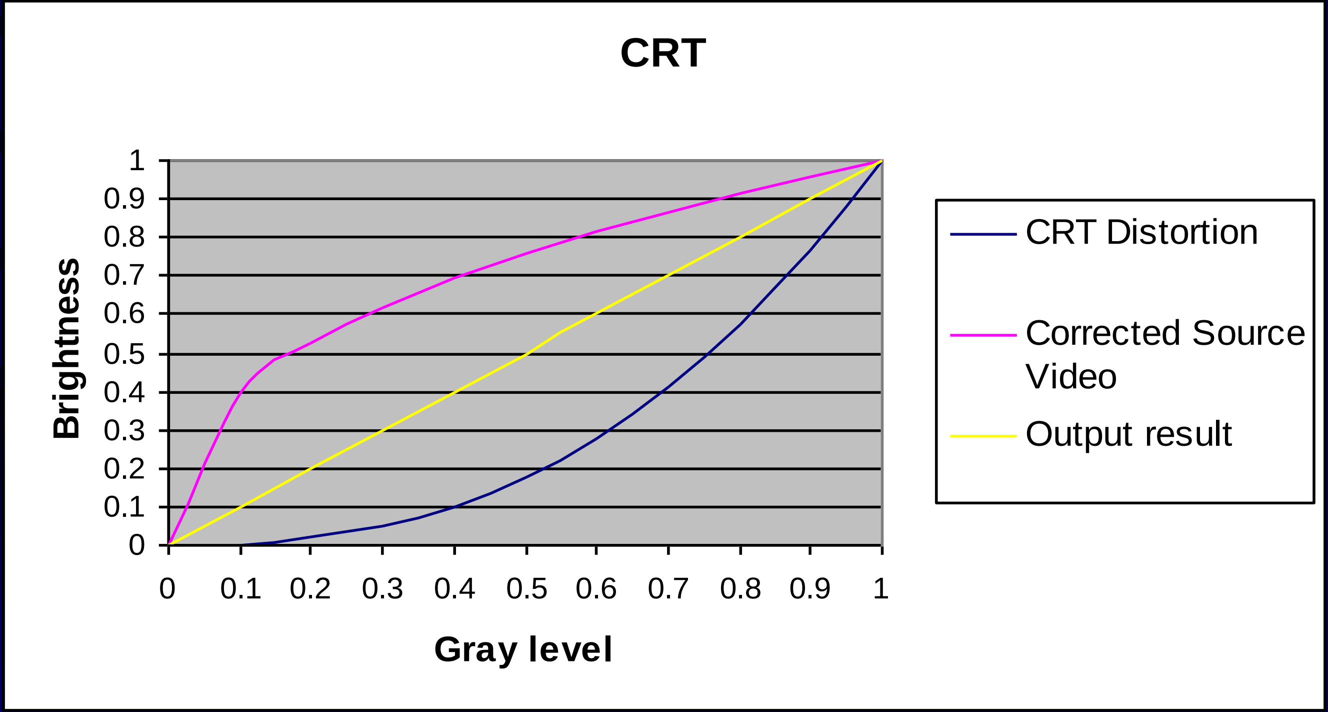
Welcome to CRT's Non-Linear  Response, or Gamma!!



# Intro to Gamma – *The 1930's CRT Legacy*

## How Digital TVs ***should*** respond to sources

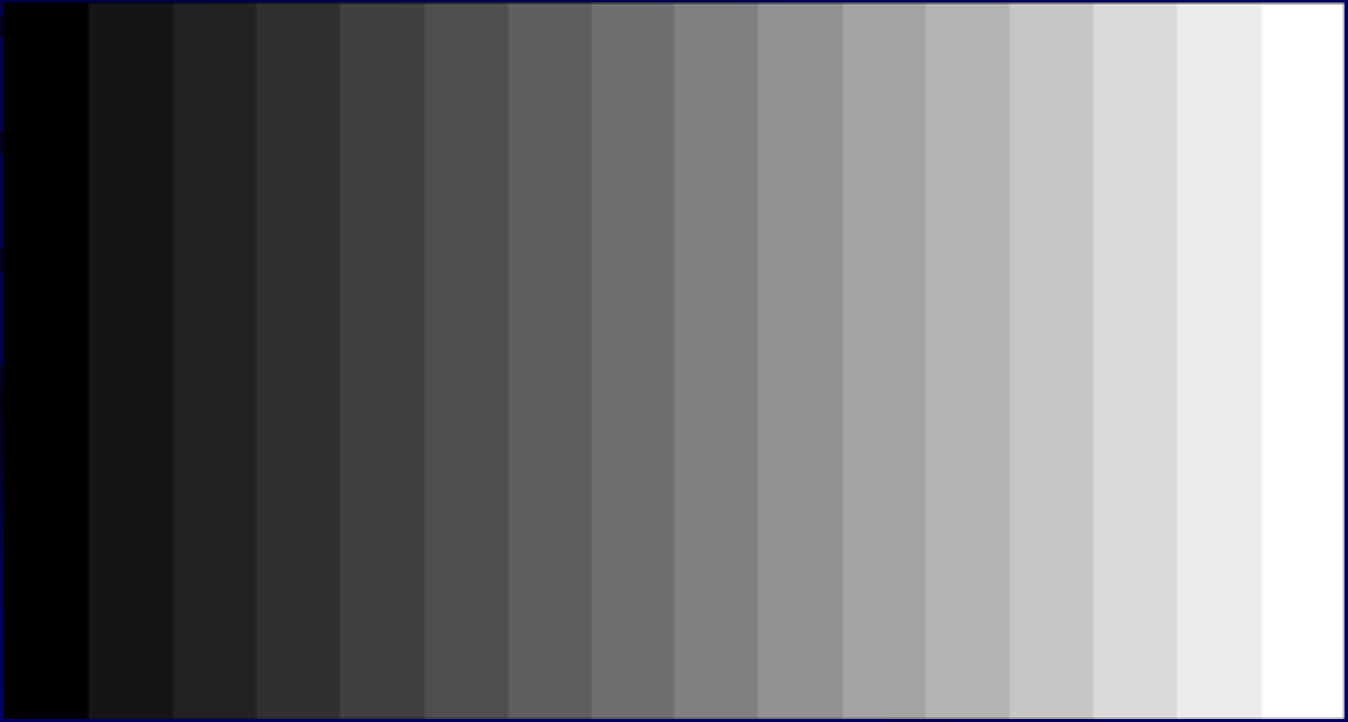
**Pink Line = OETF** ***Blue Line = EOTF***



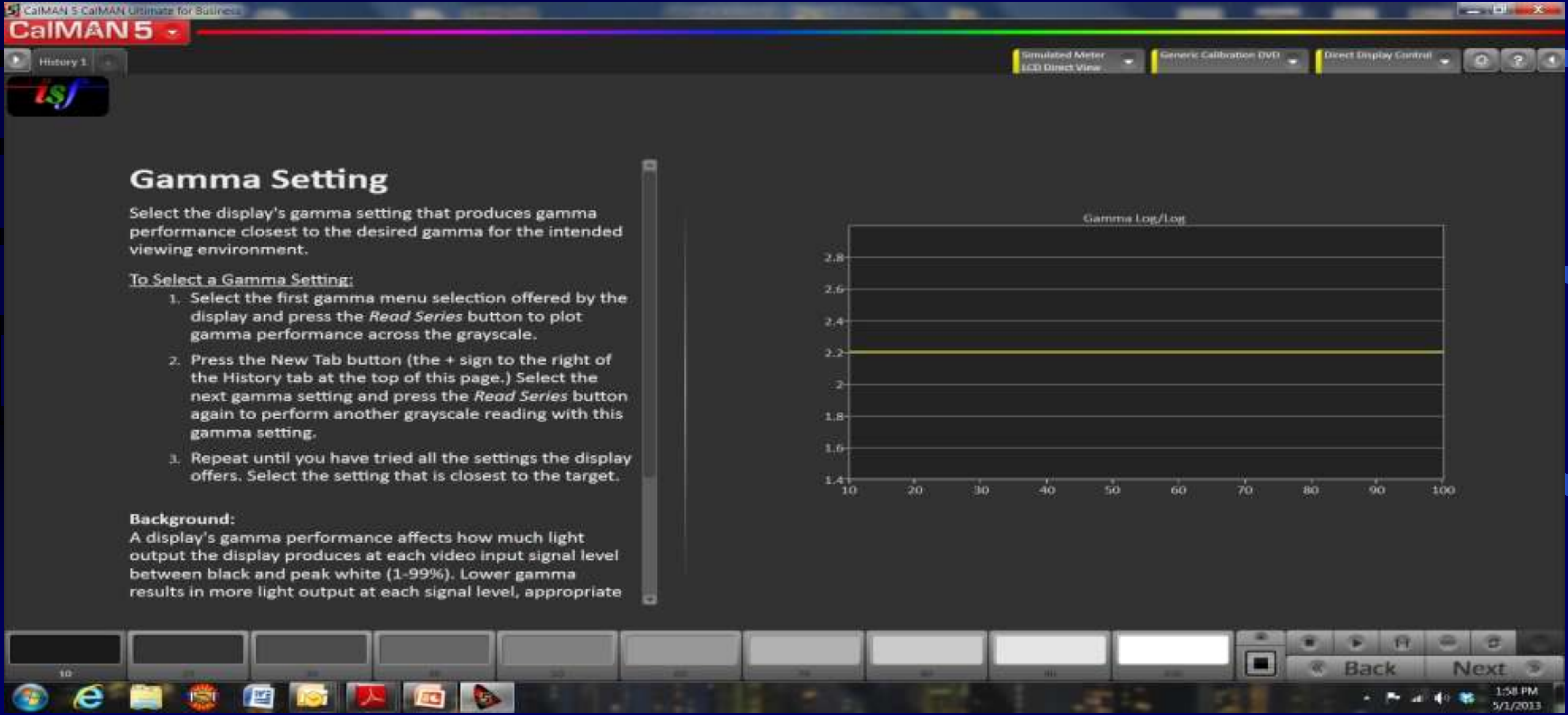
# How does Gamma Change This Picture?

How Does Changing Gamma Settings Change How You See This Pattern?

Where In The Pattern Do You Immediately See Changes?



# Gamma, EOTF – Measuring it…



# Matching Digital Displays to CRTs

- Professional CRT specs for Gamma were 2.2
- Setting reference DLPs to 2.2 did not match CRTs
- All Broadcast CRTs did not actually measure 2.2
- ISF research showed Pro CRTs to be Higher

# Geneva 2008 EBU Tech Spec


EBU – TECH 3320

EBU·UER

User requirements for Video Monitors
in Television Production

Source: P/Display

Version 1.1

Geneva
May 2008

***Gamma characteristics***

1) The luminance gamma characteristic (electro-optical transfer function) of the screen should be equivalent to those of a reference CRT with the rendering intent (dim-surround) expected of a TV system. It is *believed* that a nominal value of 2.35 is *appropriate.*

# Geneva 2010 EBU Tech Spec


EBU – TECH 3320

EBU·UER

User requirements for Video Monitors in Television Production

Source: ECV-Display

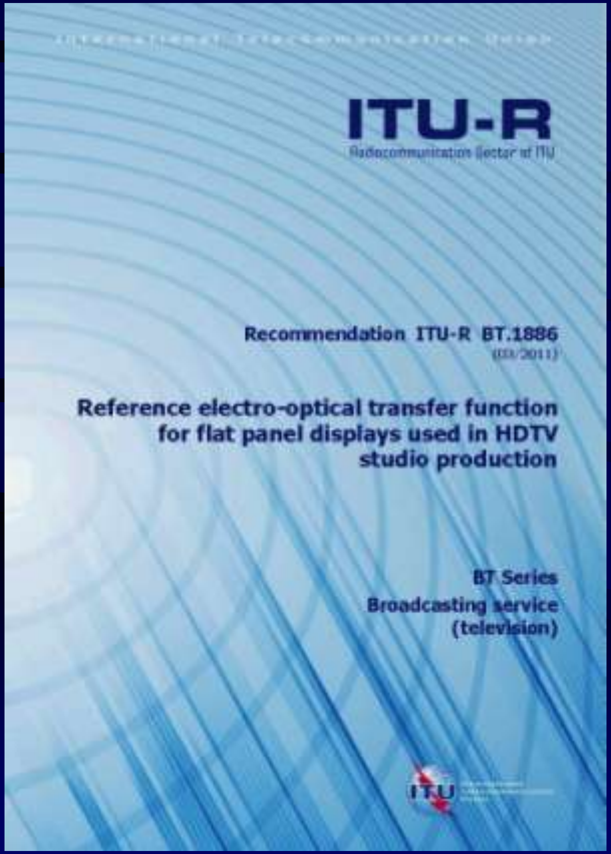
Version 2.0

Geneva
October 2010

***Gamma characteristics***

1) The luminance gamma characteristic (electro-optical transfer function) of the screen should be equivalent to those of a reference CRT with the rendering intent (dim-surround) expected of a TV system. It is *recommended* that a nominal value of 2.35 be used

# ITU 2011 – Finally a spec!



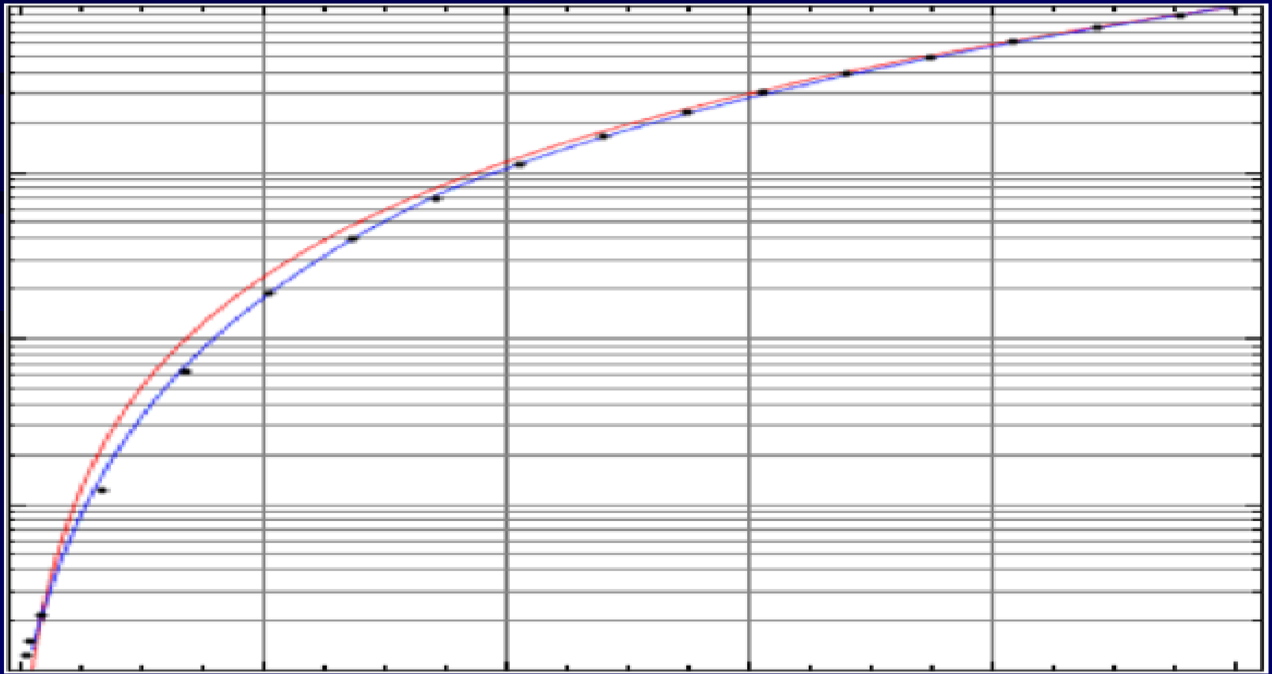

- It is a Studio Production Function for <u>Studio Lighting Conditions</u>
- It is designed for digital displays – not CRTs
- It is close to 2.4, but it is a different curve
- Blacks are measured!

# *Finally! – After 80 Years! – A Gamma (EOTF) Spec*

# Recommendation ITU-R BT.1886

# 03/2011

## Reference electro-optical transfer function for flat panel displays used in HDTV studio production *(In Red below)*



# Bright Room or Dark Room Settings

Home theaters are easy – BT.1886 with excellent light control

Rooms with ambient light require careful evaluation

- +Backlight and OLED Light raise the VOLUME of light
- +Lamp output settings for projection provide options
- +Expanded Color Gamut to compensate for loss of color

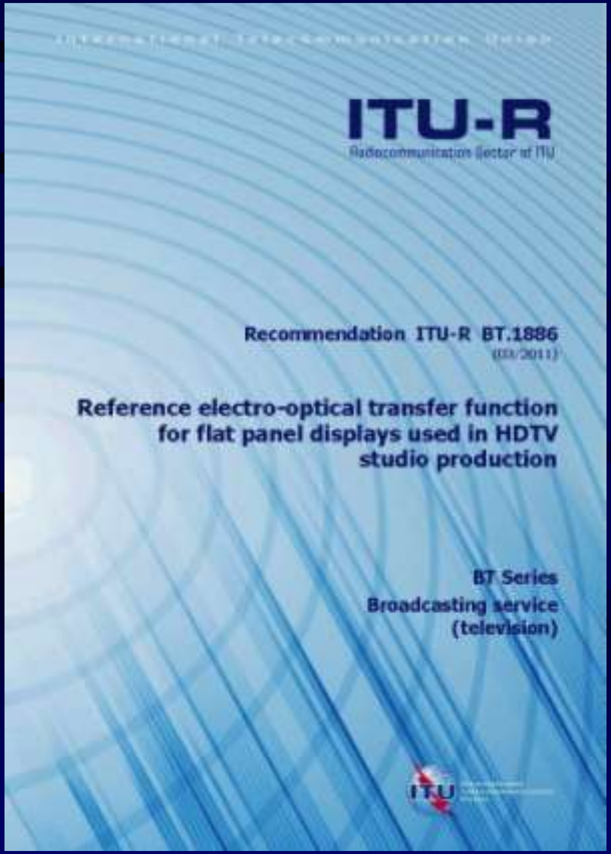
Gamma settings simply should be set lower in brighter rooms

| | |
|---|---|
| Very bright | perhaps 1.8 to 2.0 |
| Medium bright | perhaps 2.2 to 2.35 |
| Studio like lighting | BT.1886! |

# Day / Night Modes and Gamma

- Home theaters are easy – approx 2.4 with light control
- Rooms with ambient light require careful evaluation
  - Backlight settings for LCDs and OLED light settings raise the VOLUME of light
  - Lamp output settings for projection provide options
- Gamma settings need to be lower in brighter rooms
- LED LCDs will perform best in extreme room lighting

# Where is BT.1886 Applicable?




It is a Studio Production Function for Studio Lighting Conditions

For CE use – Home Theater Lighting

“ISF Night” Calibration…

# Gamma Summary?

Defining Gamma:

- New term from the ITU – EOTF
- “Non-standard” is not Content Creation Gamma
- DCI Gamma is 2.6 as is DICOMM
- Day / Night Gamma
- “S” shaped Gamma

HDR’s EOTFs can be helpful in high ambient light

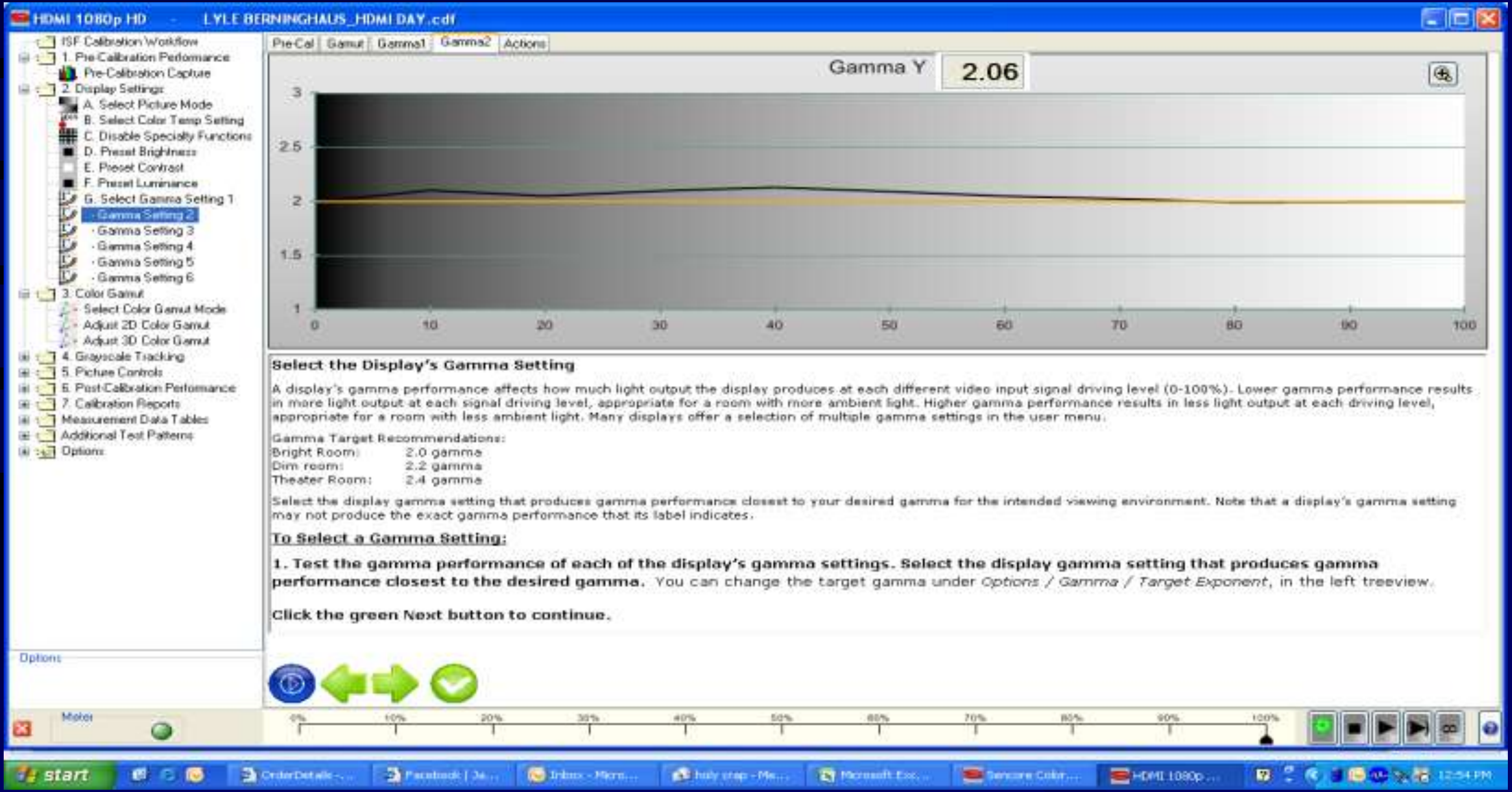
# EOTF Tech Tip

Running digital signals through multiple components should not change EOTF

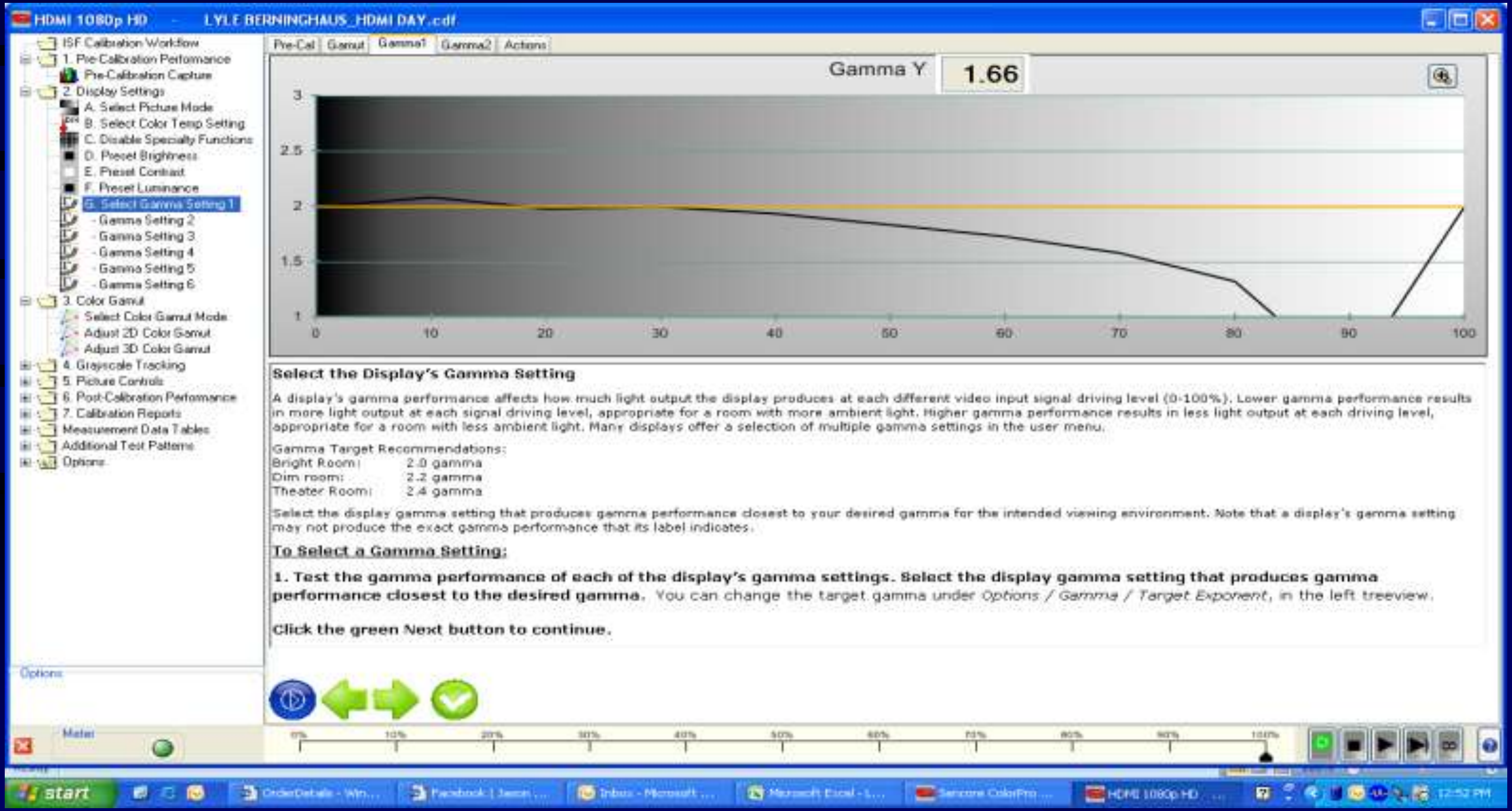
Guess what…

Running digital signals through some components can be hazardous to picture quality – see next two slides!

# Gamma Post Calibration No AVR



# Same TV's Gamma Through AVR



# Different Tools for OLEDs and LEDs!

## What Test Patterns to Use for Calibrations?

For Local Area Dimming LED and IMLEDs:

Full Screen Pattern

(Credit Panasonic Engineering, Japan)

For OLED, Plasma and CRT:

18% Window Pattern (ANSI)

(Credit LG Picture Quality Lab 2016!)

# Why are there Gamma Options?

1 – Accuracy and Image Fidelity

*Match Gamma to content creation in a studio like light environment*

2 – Compensation for Bright Environments

*Reasonable compromises for rooms that are not like studio light environments*

# EOTF Explained:

1 – The 30 second answer?

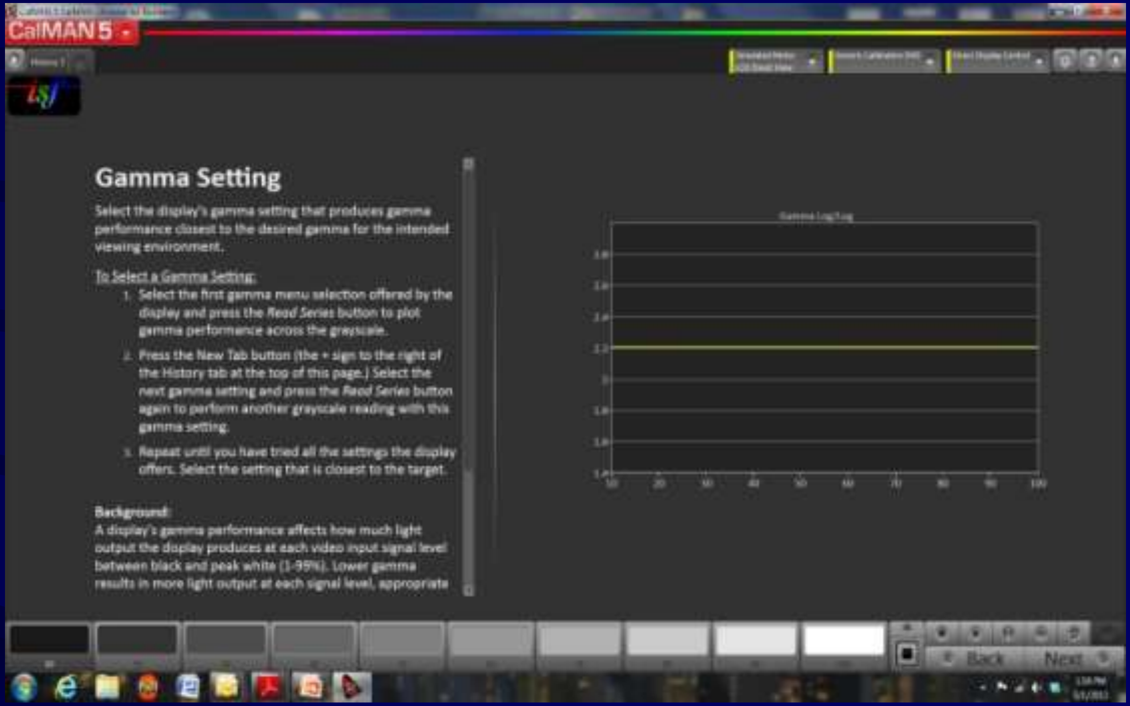
Multiple TV gamma options enable knowledgeable integrators to optimize a TVs performance to multiple room lighting conditions

2 - Gamut, light output settings, black level settings, different factory presets, dynamic contrast modes, and local area dimming are other settings to help you deal with sometimes harsh multiple lighting conditions!

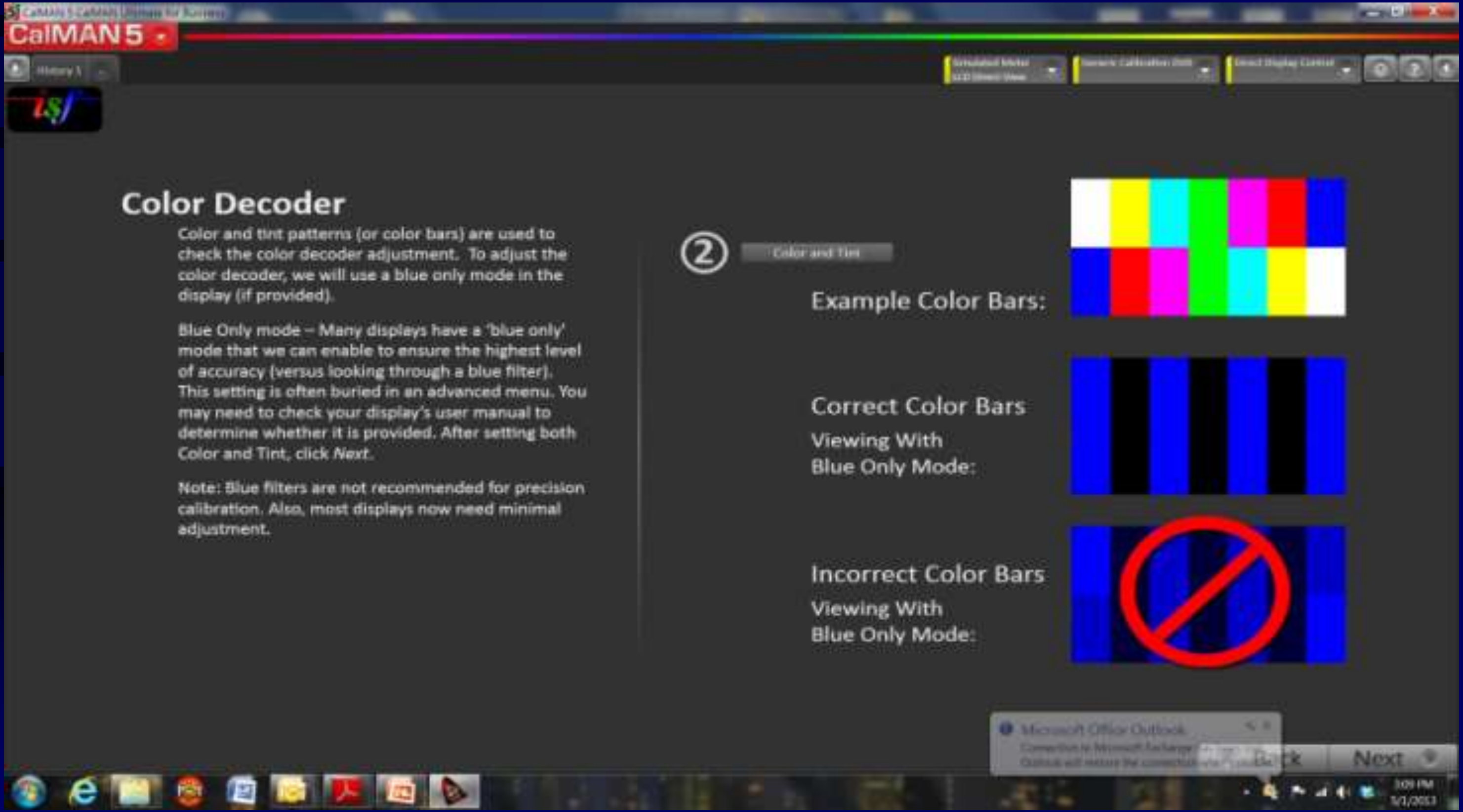
# Measure All Gamma Options

Go To ISF CalMAN!
- *Run Gamma Tests on all HDTVs and components at all options*

Check to see if a numerical value is correct, *or what Gamma options really measure*



# Next – Color Encoding and Decoding



# Why Do We Encode and Then Decode When Content Creation Starts as RGB?

*(Cameras are RGB and CGI are RGB)*

RGB is simply and easy – but bandwidth intensive

Encoding to PAL, NTSC, SECAM, or H.264 saves bandwidth

# Bringing Pictures to your HDTV

1 - Cameras capture RGB

2 - We **<u>ENCODE</u>** to save bandwidth to transmit

3 - HDTVs **<u>DECODE</u>** back to RGB

| | | | | |
|---|---|---|---|---|
| RGB | to | NTSC | to | RGB |
| RGB | to | PAL (Phase Alternating Line ) | to | RGB |
| RGB | to | SECAM (Sequentiel Coleur Avec Memoire) | | RGB |
| RGB | to | MPEG | to | RGB |
| RGB | to | VC1, AVC | to | RGB |

# 1952- Introducing Color in NTSC Creating an Analog *Bio/Mechanical* Color System

How Many Colors Does the Human Eye See?

Rods & Cones – **Which is HD?** Key Point!!

100 million rod cells, 5 million cone cells

Color perception is poor for resolution

# All Color Compression is Based On:

THIS IS ALL ABOUT HUMAN FACTORS!

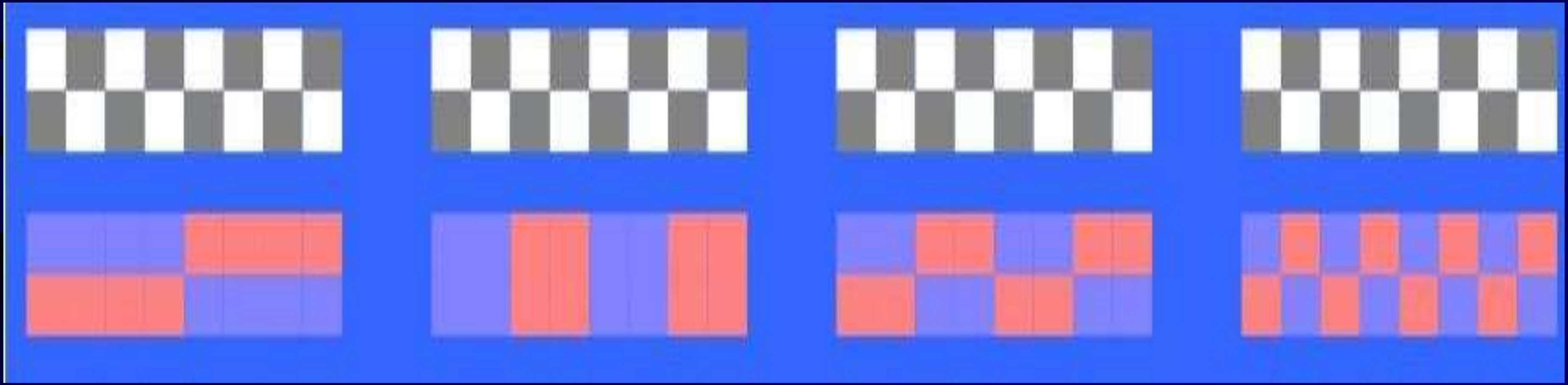
- Preserve B&W detail for our RODS
- Get away with color compression with our CONES

**That is why content is delivered in Component!!**

ISF considers this just Brilliant…………..

# Digital Component Color Compression for Our Eyes! HDTV Video Processing Creates What’s Missing

4:1:1 4:2:0 4:2:2 4:4:4



# How do RGB & Component connections differ?

RGB has one cable for each signal plus sync(s)

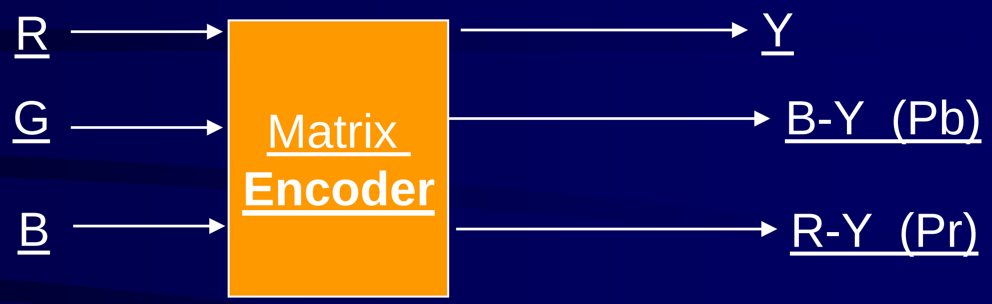
Component has 1 cable for B & W info (Y) & 2 cables for color info (R – Y) & (B – Y)

Is Component "lossless" compared to RGB?

***<u>It is a compressed derivative of RGB!</u>***

# How RGB Becomes Component

## The 3 x 3 Matrix



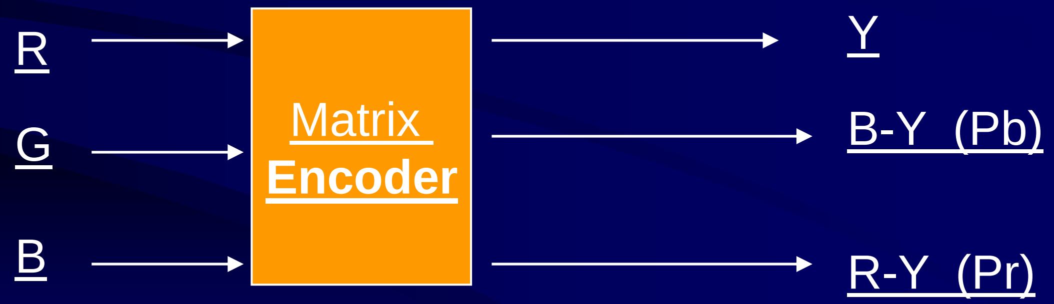

$$Y = R + G + B$$

Y = Black and White, or Luminance

1 - RGB is Encoded to Component

2 - Consumer Video is Delivered Component!

3 - Processing and Decoding Component to RGB is ***required*** for displaying a picture….



# SD or HD – Uses Different **3 x 3 Matrix?**

R → **Matrix Encoder** → Y

G → **Matrix Encoder** → B-Y (Pb)

B → **Matrix Encoder** → R-Y (Pr)

1953 SD "Y" AKA (SMPTE 170M) or (ITU 601)

Y = G + B + R

1998 HD "Y" AKA (SMPTE 296M) or (ITU 709)

Y = **G** + B + R ***Same or Different?***

# SD "Y" is Different From HD!

S.D.

$$Y = \underline{0.2990}\ R + \underline{0.5870}\ G + \underline{0.1140}\ B$$

H.D.

$$Y = \underline{0.2126}\ R + \underline{0.7152}\ G + \underline{0.0722}\ B$$

# The NTSC Decoder Adjustments

**Sharpness**, aka Detail, Aperture

It is "Edge Enhancement"

**Color**, aka Saturation, Chroma

The **Amount**, of color in the picture

**Tint**, aka Hue, Phase (PAL TV ELIMINATED THIS!)

The **Type** of color in the picture

# Edge Enhancement Artifacts-
# AKA - The *Sharpness* Control

The best way to start calibration demos.

Adjust to max rez and min artifact….judgment call?

HD and SD can and will be different!

# USING SMPTE COLOR BARs

Color Bars are designed for "Blue ONLY" modes

Color filters are NOT  Blue Only Modes!!!!

PLEASE TEST FILTERS & BLUE ONLY MODES

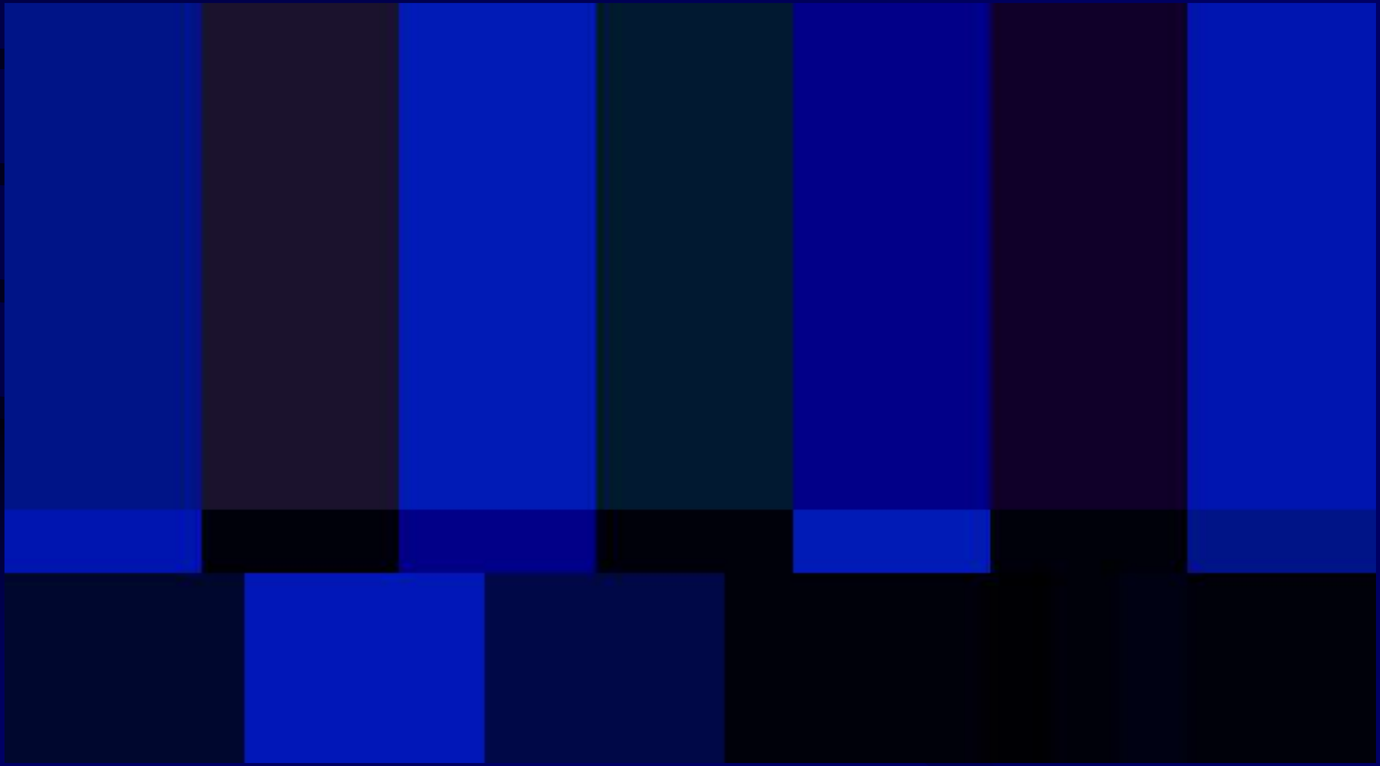
ELV RGB FILTERS

Many HDTVs now have Blue Only modes!

Seek those HDTVs out!

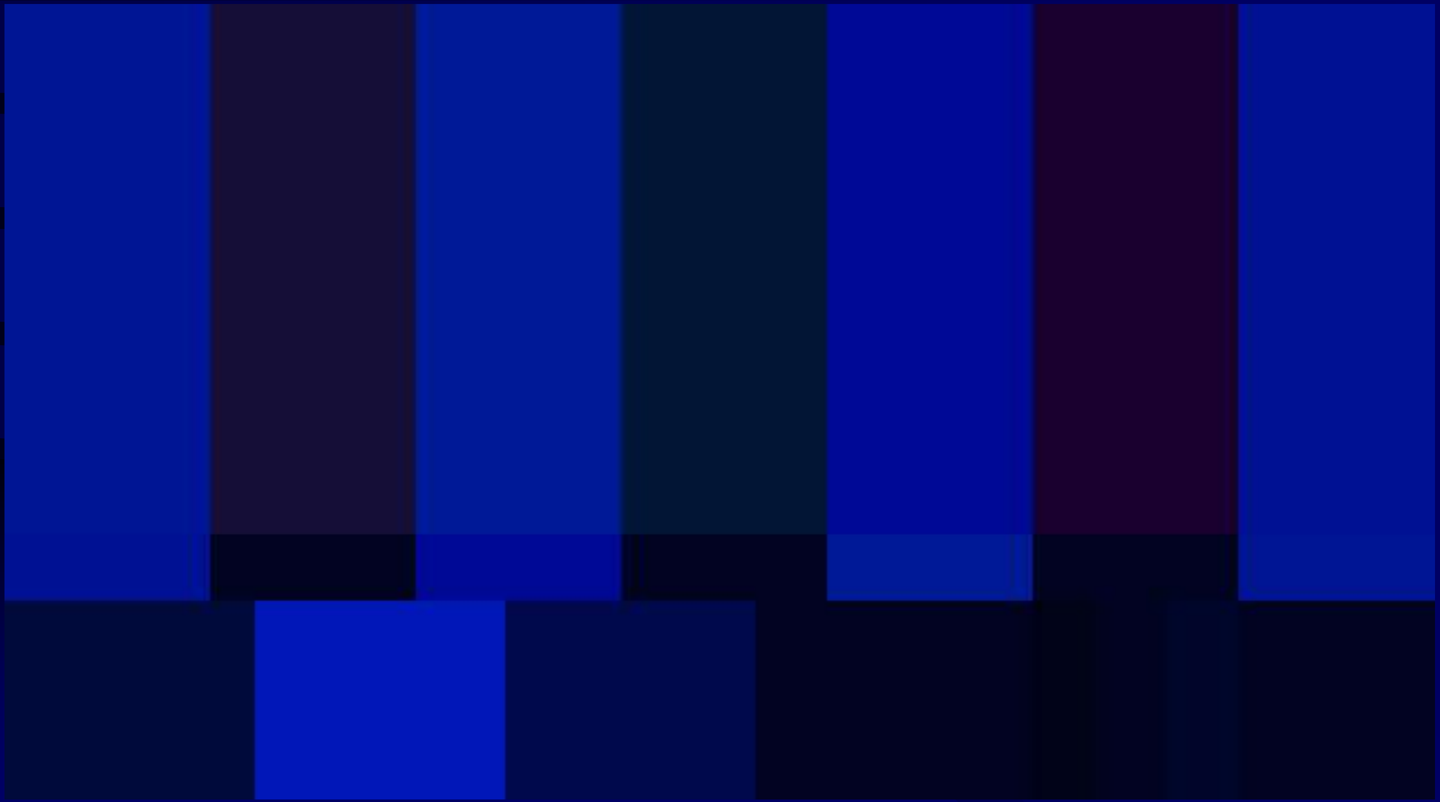
# Blue Only Incorrect Color & Tint Settings

Look at outer Blue bars for Color – Inner Blue bars for Tint

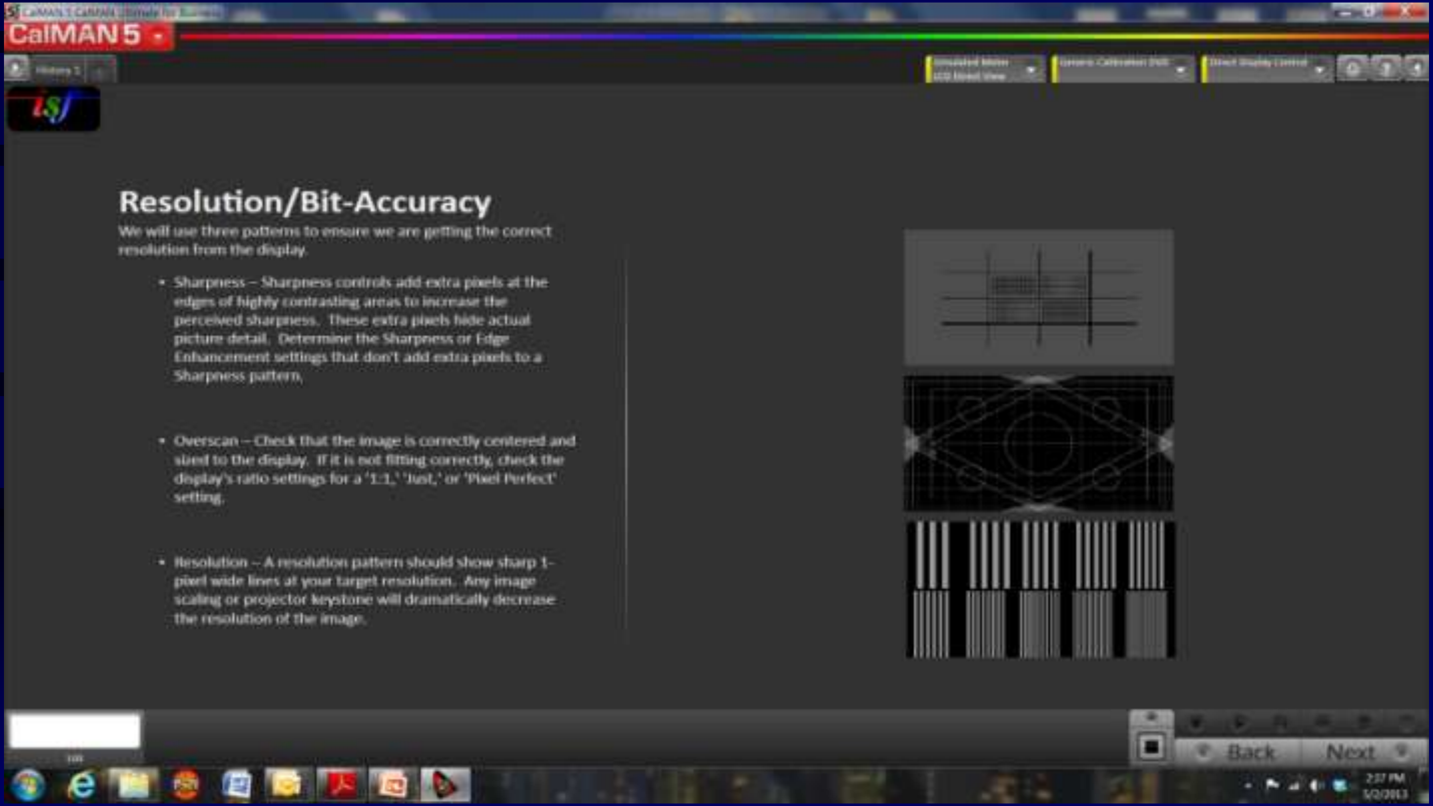


# “Reasonably” Correct Color & Tint

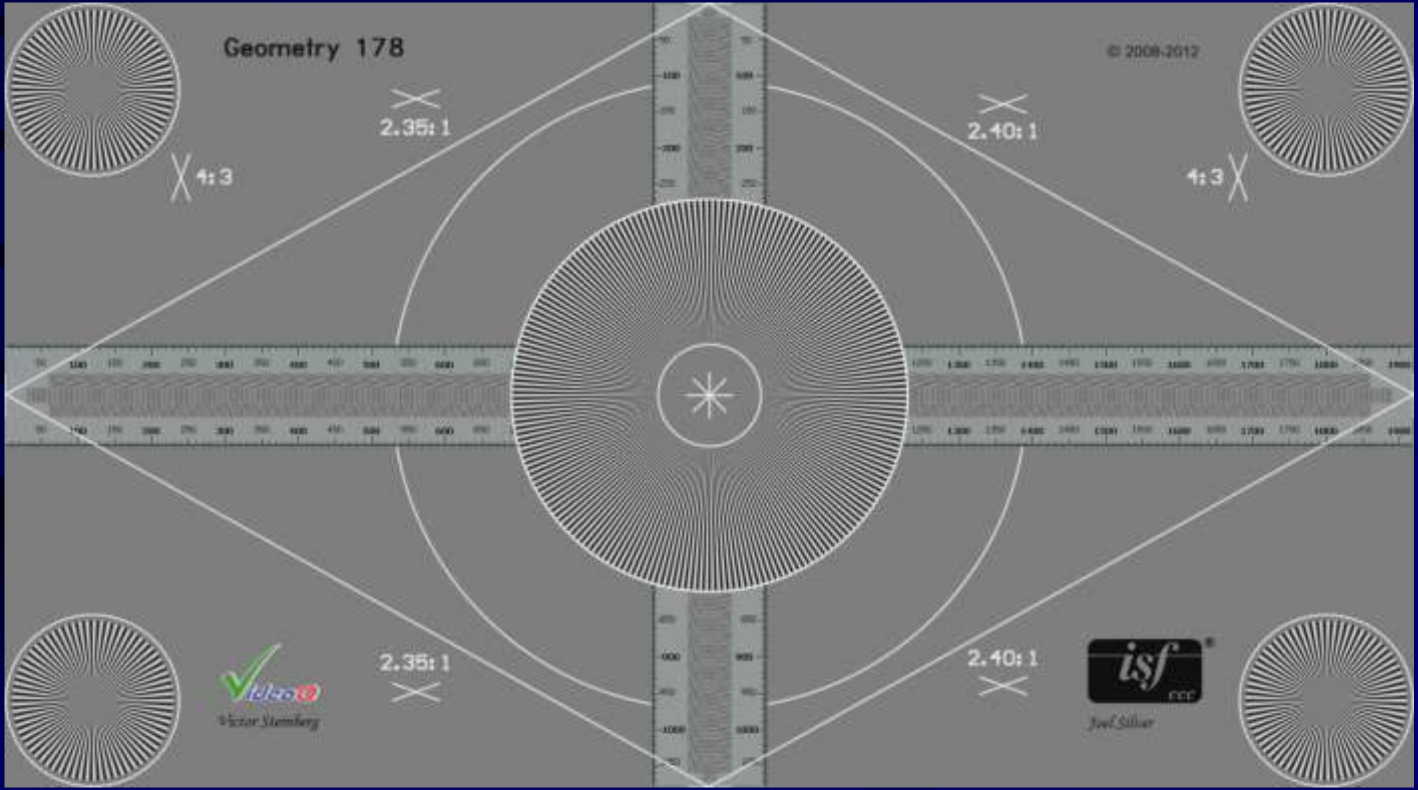
## Why “Reasonably” Correct and Not Perfectly Correct?



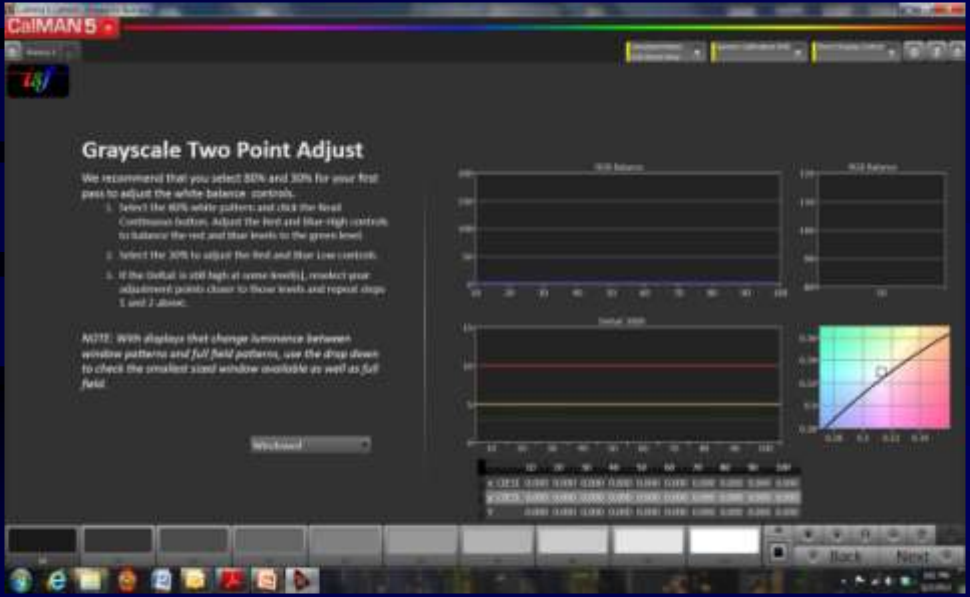
# Next - Resolution/Bit-Accuracy

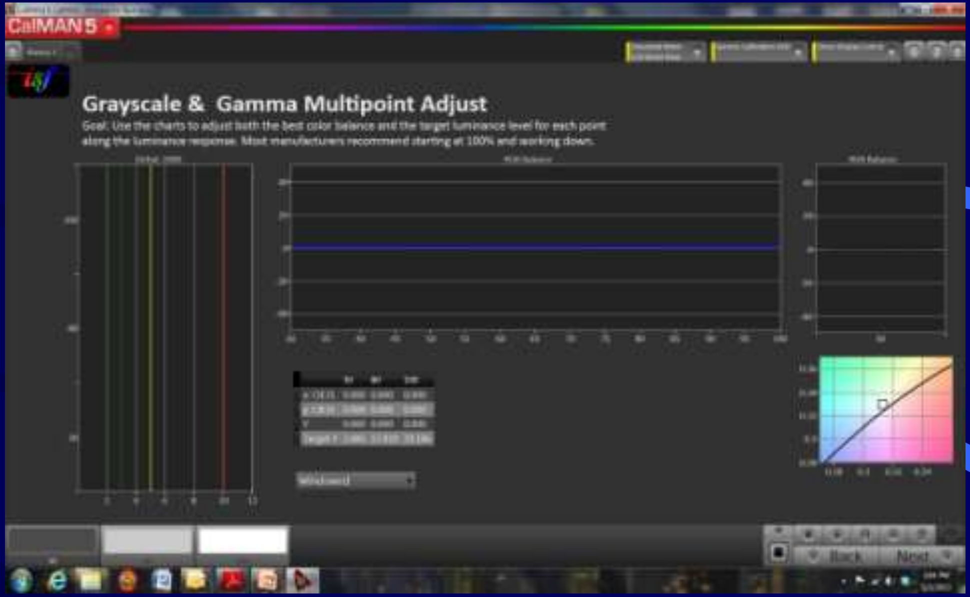


# Overscan and Geometry Adjustment



# Next – Grayscale Setting Tools: 2 Point IRE / Multipoint IRE + Gamma

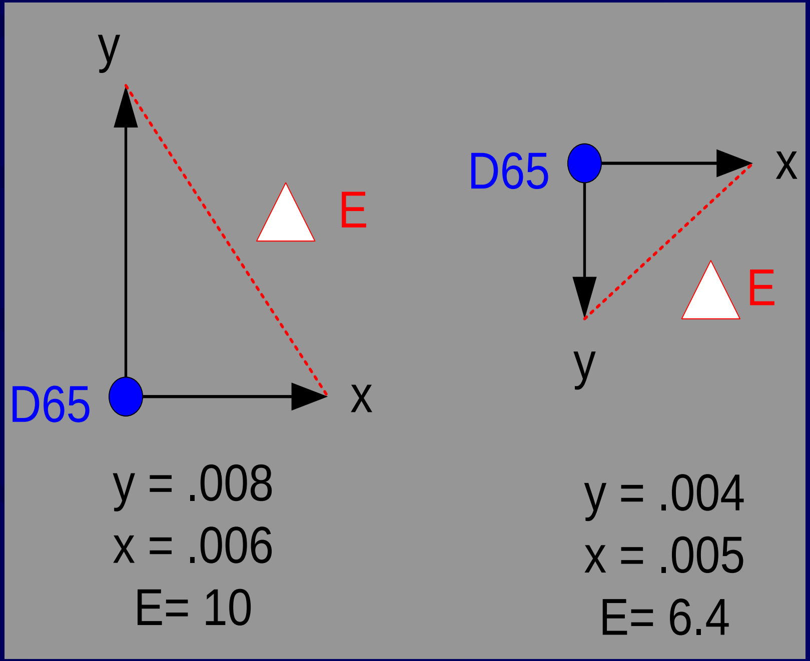


# Delta E Graphs are “Approximations”

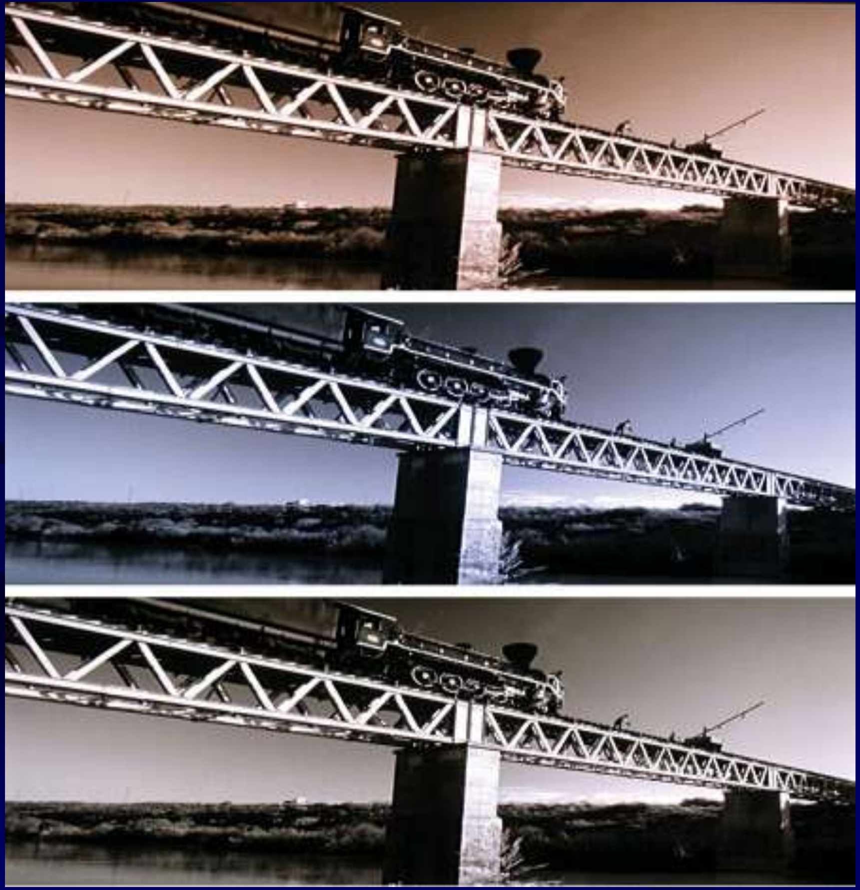
The Greek letter Delta (the symbol Δ) is used to indicate a difference and E stands for the German word Empfindung, meaning "sensation." So, "Delta E" literally means "difference in sensation."

Delta E values below 6 are tolerable, below 4 are not perceptible to eye, below 3 considered OK



# How Gray Scale Impacts Content

Credit Tom Norton, Home Theater Magazine



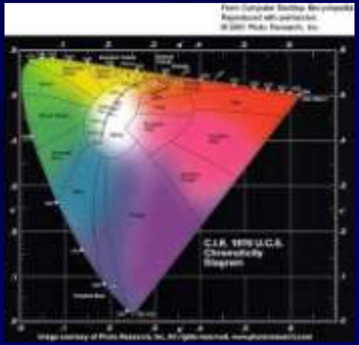
# What is “The Color Of Grey”

Commission Internationale de l’Eclairage

x & y coordinates are ***precision measurements***

D65 - A Point In Theoretical Space

L*a*b* Color Space in 1976 – a 1931 CIE Variant



# Color Temperature vs Brightness

“Perceived” Brightness

Blue Automotive Headlights

Human Factors, Sales and 16,000 Kelvin

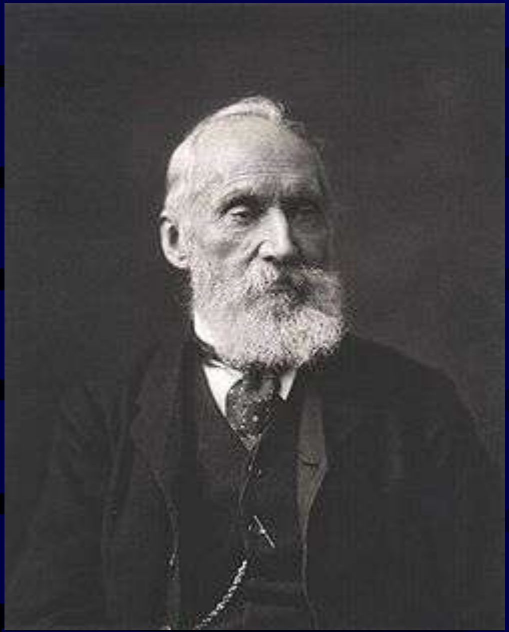
Calibrating For Marketing Departments

Calibrating for retail showrooms is a necessary evil

# A History of Expressing Colors Numerically

Color Management Requires Measurement!

The Physics we use for measurements are merely High School level concepts…..



# Color Temperature & Kelvin

William Thomson, 1st Baron Kelvin (1824-1907), the Belfast born Physicist that the Kelvin Scale Is Named For

International Standard For Thermodynamics

Zero kelvin = -273.15 Degrees Celsius

Scientifically a Kelvin Is Not Considered a Degree

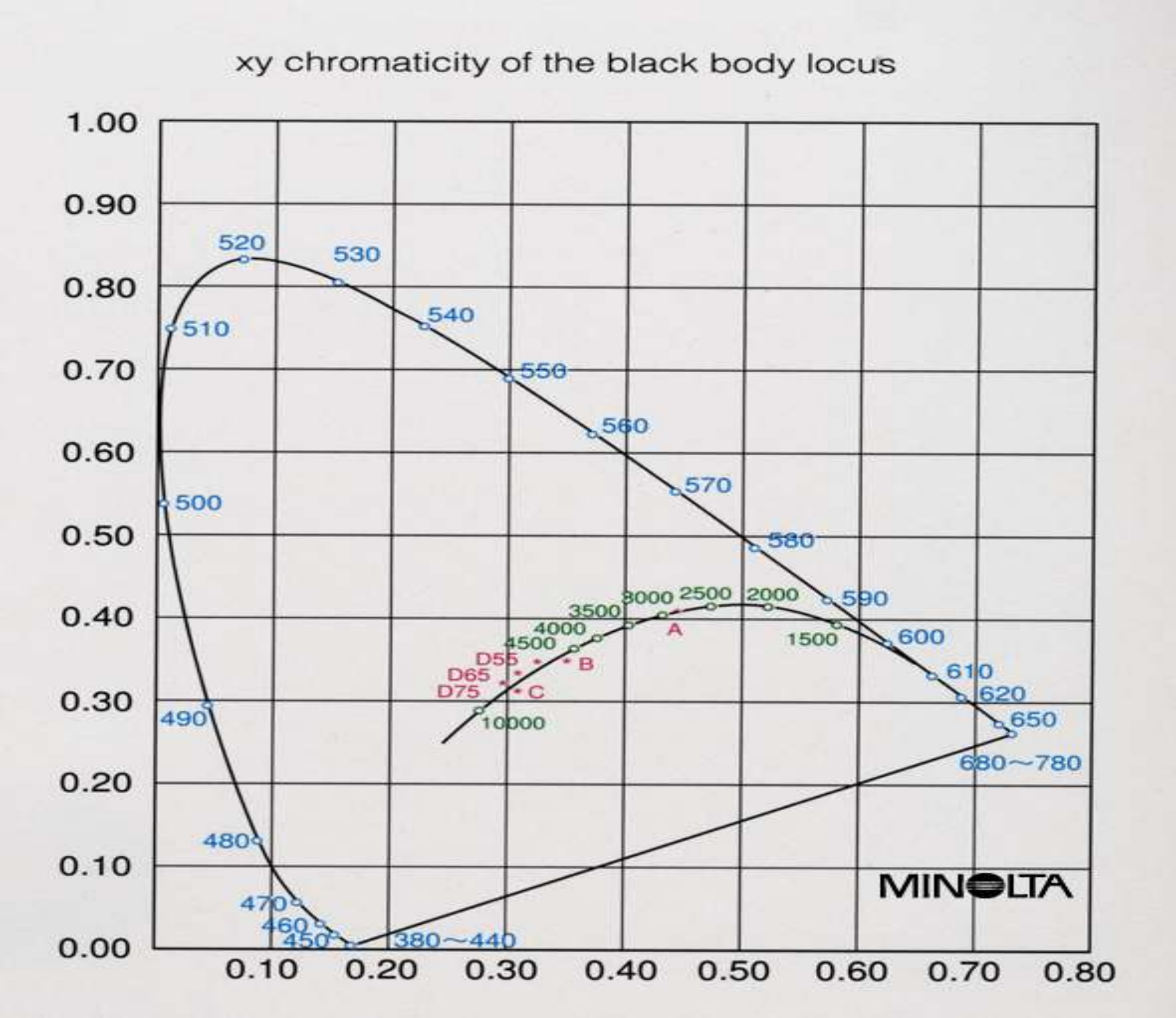
Always say “Kelvin”, never “Degrees Kelvin”

# The Planckian Locus

Thank you Max Planck, the German physicist, for "Plank's Black Body Curve" – What is it?

High School physics – **<u>"Things"</u>** get red hot, then white hot and then blue hot –

What **<u>"Things?"</u>** are we talking about? An "Ideal Black Body"

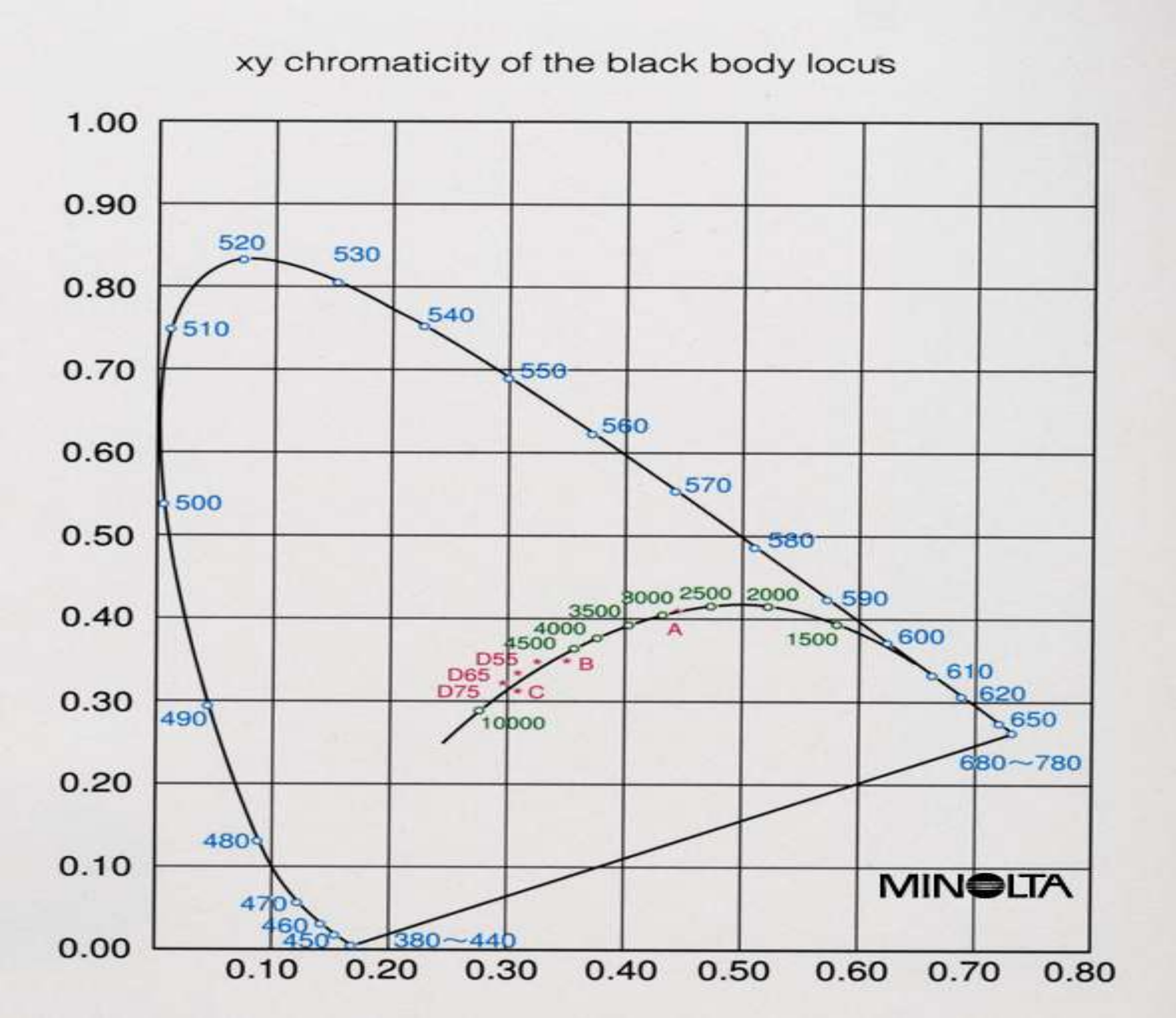


xy chromaticity of the black body locus
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
520
530
540
550
560
570
580
590
600
610
620
650
680~780
510
500
490
480
470
460
450
380~440
3000
2500
2000
3500
4000
4500
1500
10000
D55
D65
D75
A
B
C
MINOLTA


isf
Imaging Science

# A 24 Year Set Up To Make ISF Calibrators Look Smarter!

- Color Temperature Is ***MISINFORMATION***
- ***1994 ISF Editorial Decisions – Write about Kelvin***
- ***<u>D65</u> vs 6500 "Degrees" vs CCT***
- ***<u>D65</u>*** = ***<u>x .313</u>*** and ***<u>y .329</u>***
- ***Correlated Color Temperatures*** refer to ***Multiple*** colors near the black body curve & along ***<u>ISOTEMPERATURE LINES</u>***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0.50
0.60
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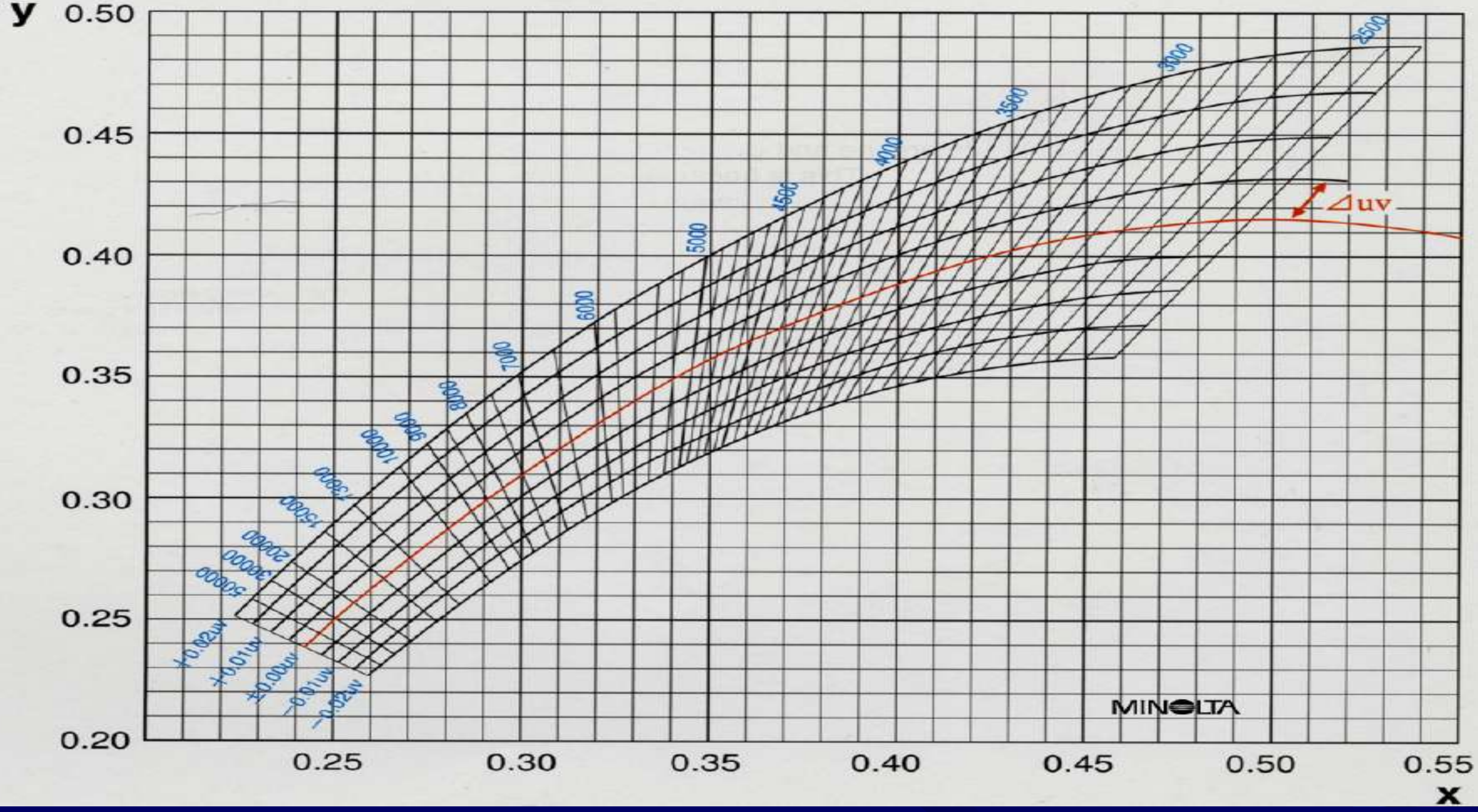
520
530
540
510
550
560
500
570
580
590
600
610
620
650
680~780
490
480
470
460
450
380~440
3000
2500
2000
3500
4000
4500
1500
10000
A
B
C
D55
D65
D75
MINOLTA

xy chromaticity chart indicating the black body locus, the isotemperature lines and equal Δuv lines.



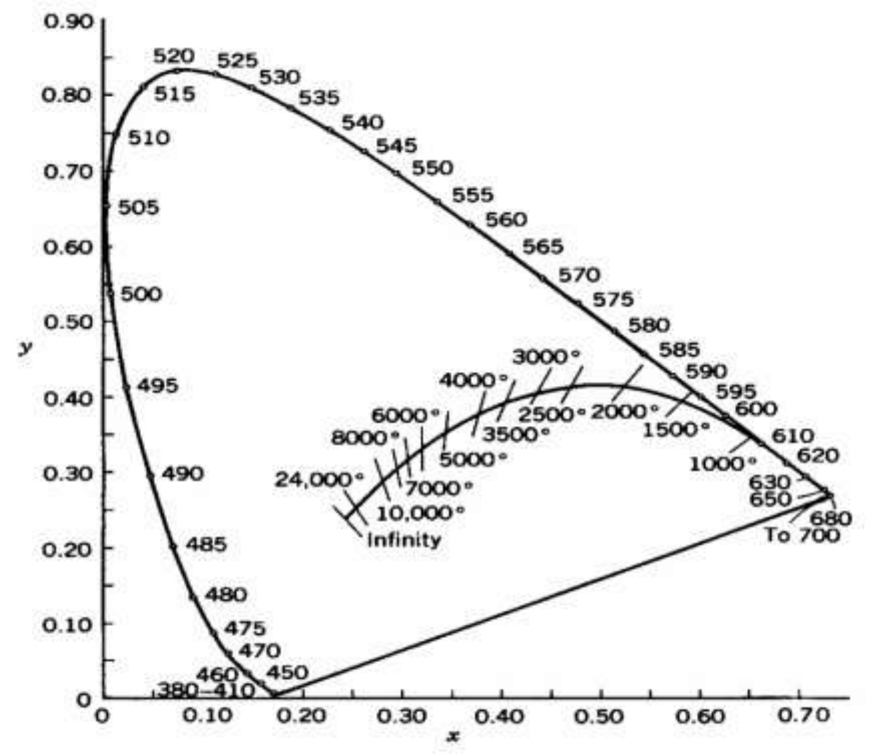
# Summary:

## Correlated Color Temperature

Correlated color temperature was developed to specify near-white colors

Correlated color temperature of can mean any color along the <u>ISOTEMPERATURE</u> line.

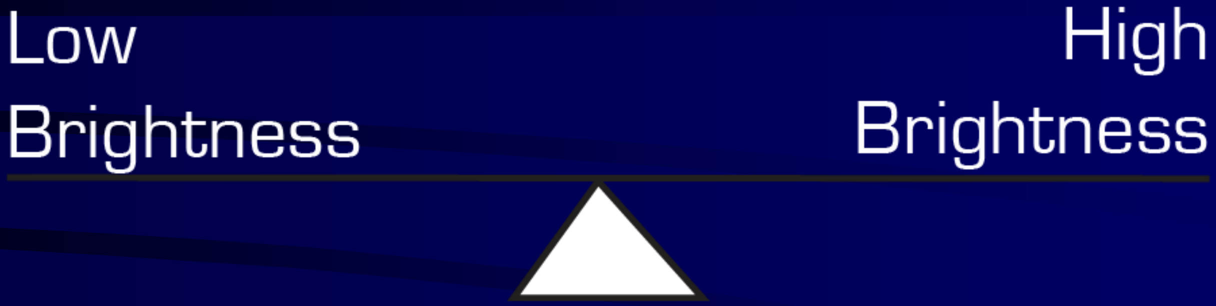
Since color temperature is an unspecified x,y point, it cannot be relied upon to reach a desired point (D65).



# White Balance Adjustments

- White Balance (Hi/Lo) Adjustments
  - Preset Brightness and Contrast controls, to be in correct operating range.
  - Adjust Gain/Drive controls at high brightness (70-80%) for desired color of white.
  - Adjust Offset/Cutoff controls at low brightness (20-30%) for desired color of white.
  - Repeat adjustments to minimize interaction.

# Achieve Proper White Balance




Imagine white balance as a ying and yang.
When you adjust one side you will affect the other

# Moving WB Controls Changes?

Moving Red Controls:

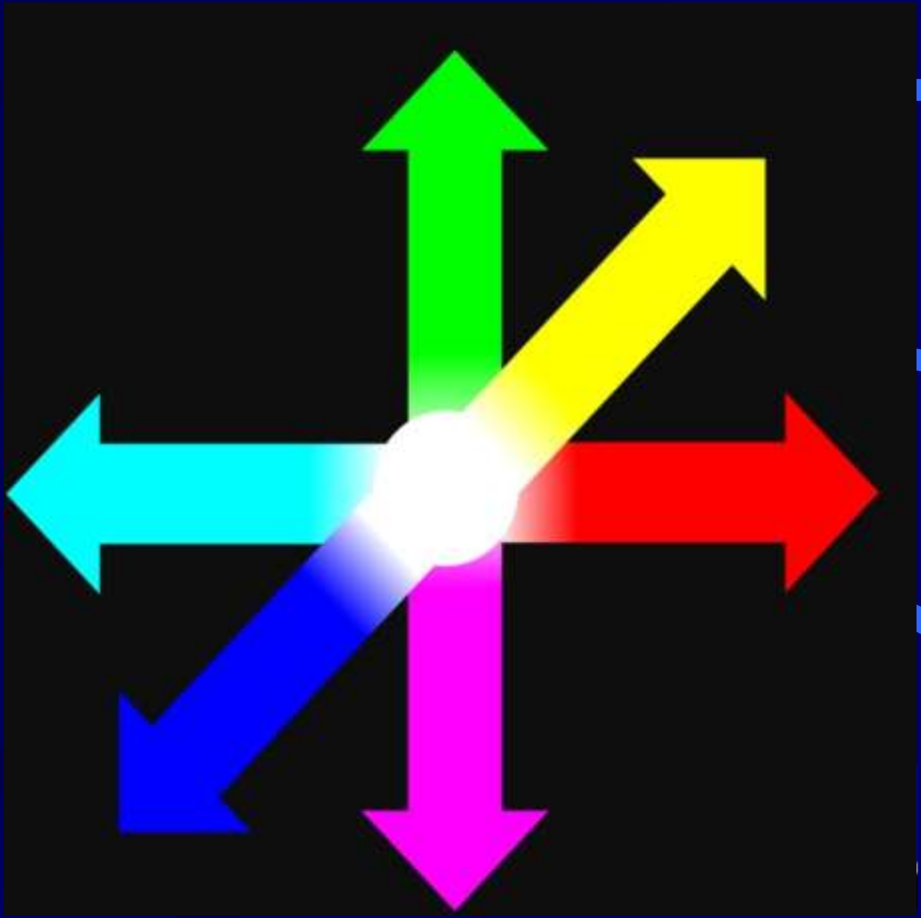
Red to Cyan – East/West

Moving Blue Controls:

Blue to Yellow – SW/NE

Moving Green Controls:

TRY TO NEVER MOVE IT!



# Ideal Gray Scale Tracking

- Calibrate One  level near Top & One level near the Bottom EVERY level then measures perfectly

- No Top & Bottom Interactivity

- Happens often with displays at $80,000 and up

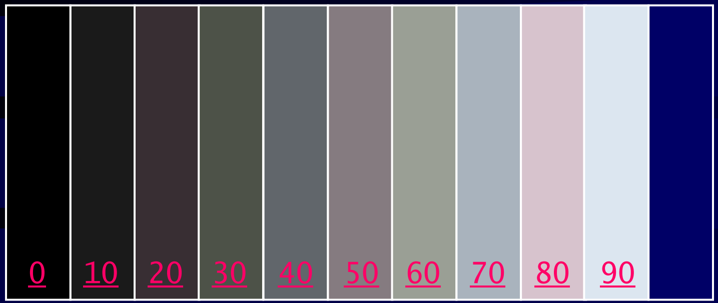
# Real World HDTV Tracking

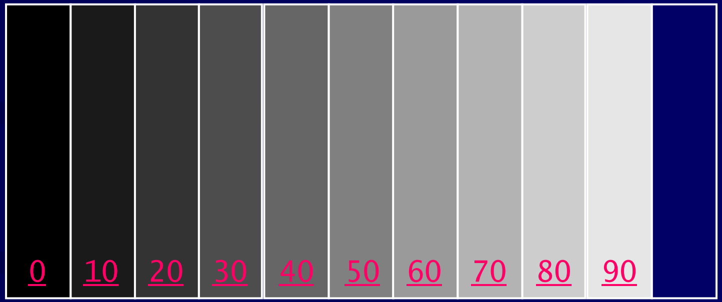
Extreme Interactivity Of Controls

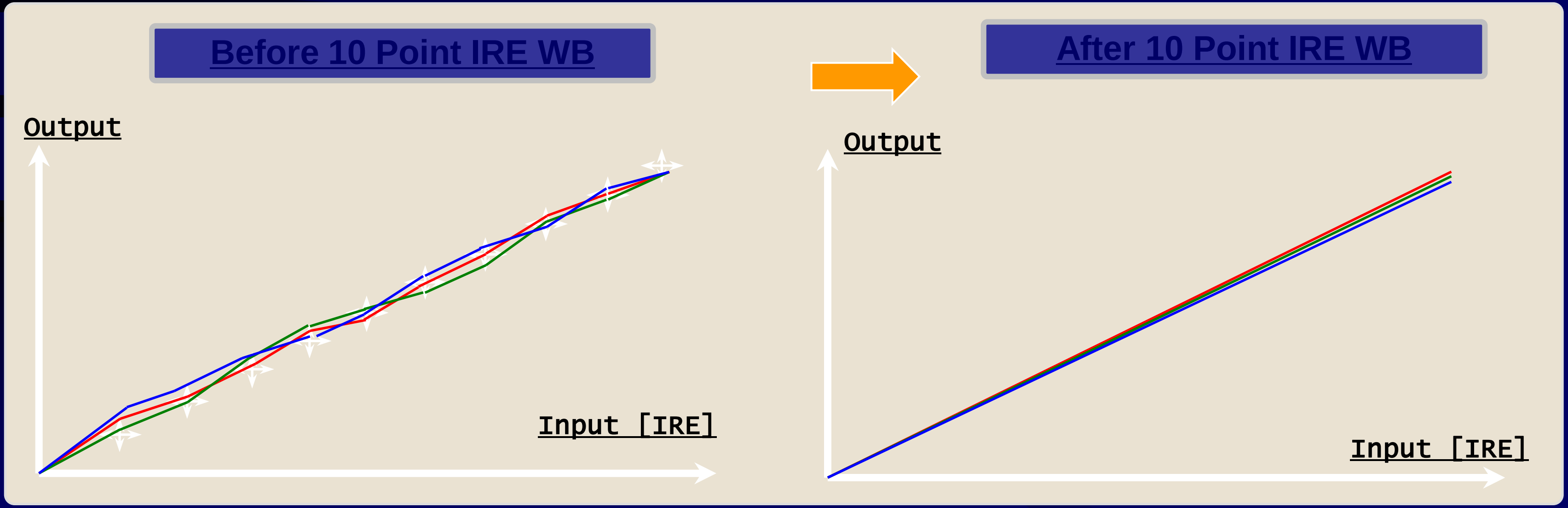
Repetitive Steps To Balance Top & Bottom

Some Errors in the Middle of The Gray Scale

# Intro to 10 Point RGB Gamma-precision color balance



# Multipoint Point Grayscale / Gamma

Adjusting BOTH Grayscale and Luminance

Starting at 100 IRE is the most common practice

*Recheck Gamma scan after multipoint adjustments

Results from consumer HDTVs can be SUPERB!

# 10 Point Grayscale With Internal Patterns

## * Example LG Flat Patterns

Check LG HDTV internal 10 step patterns

Then check with External Test pattern with 10 steps

Then run the calibration with External (Generator)

Are there differences?

# IF Grayscale / Gamma Is Not Perfect:
# YOUR JUDGEMENT IS CRITICAL!

- There Will be Errors in Gray Scale Tracking
- How severe an error is acceptable
  - Plus or Minus .004 is the conventional solution
  - **ISF specifies zero plus error on Green (y)**

# Hazards Of "Antique" Digital Service Modes

Getting Access To Them

Tripping The Wrong Codes

***Document Factory Presets - Work With A SAFETY NET!***

TAKE A DIGITAL 16x9 PICTURE!!

**MODERN HDTV DESIGNS HAVE CONTROLS READILY ACCESSABLE – NO SERVICE MODES!**

# Next - Tools Of The Trade
# Color Analyzers – TriStimulus Devices



# What are we paying for when investing in metrics? The instrumentation's Calibration!

# Spectroradiometers

Examples:

- Konica Minolta CS-2000
- Konica Minolta CS-200
- Photo Research PR-655
- JETI Specbos
- X-Rite i1 Pro2





# Part 3 – Budget Spectroradiometers

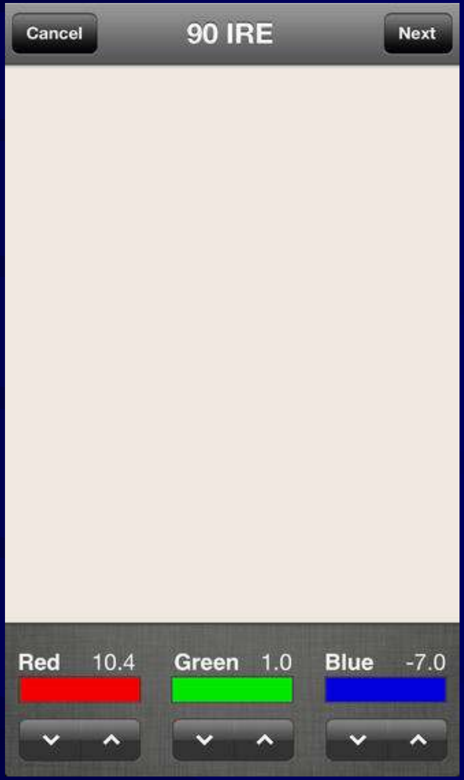
- Inexpensive units can be used as accessories for Tristimulus meters to check and improve accuracy for Projection systems, LED and other displays
- They do have limitations as stand alone devices

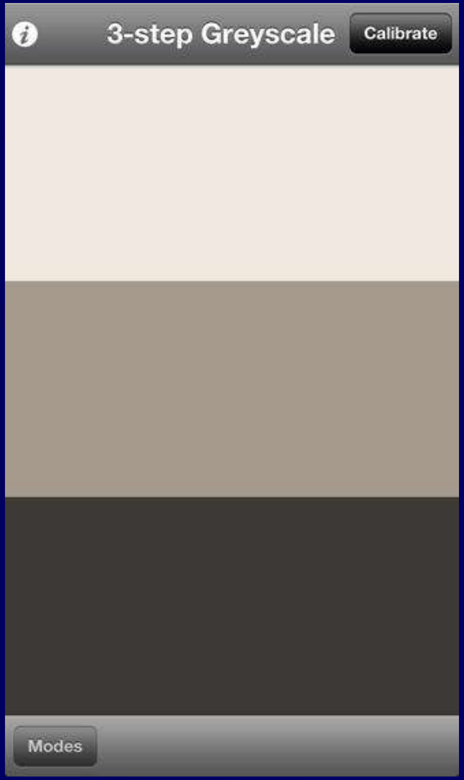
# Comparisons of Measuring Techniques

**Credit Steffen Goerlich at JETI Technische Instrumente GmbH**

| | Tristimulus | Spectral |
|---|---|---|
| Advantages | • Fast measurement (larger sensors, more energy per sensor)<br>• Straightforward number of influences to measuring uncertainty<br>• More economic (in general) | • No matching errors or matching errors of CMFs<br>• Spectral data available - extended calculation possibilities, e.g. of Color Rendering Index or spectral weighted data |
| Disadvantages | • Matching errors plus additional matching errors of CMFs<br>• Therefore matrix correction to individual spectrum is necessary (profiling)<br>• Limited number of data sets for CMFs | • Not as fast (spectrometer: small aperture input, many tiny sensors)<br>• More influences to measuring uncertainty<br>• More expensive (in general) |

# PART 4 - COMPARATIVE

# Go Calibrate Grayscales!

1 - Use 2 point Grayscale 1st

2 - Then if needed and if possible use Multipoint Grayscale

3 - Than if needed and if possible use Multipoint Gamma

# Two Piece Projection Calibration

The Impact Of Screens

- Projectors & Screen vs Amplifiers & Speakers

Non-Contact meters are recommended

# More Variables For Calibrating a Projector

- Sizing, Lens Shift and Focus Must All Be Optimized 1st
- All available "Auto-IRIS" Settings must be CAREFULLY researched. ***May need to be defeated for Calibration!!***
- Fixed Iris settings are used for light output and black levels
- Again - Grayscale requires non contact meters.

# Analyzers & Front Projection

Contact & Non/Contact Meters

Use the right tool for the right job

Tripod Mount Sensors & Read Away

*THE SCREEN IS PART OF THE SYSTEM!!*

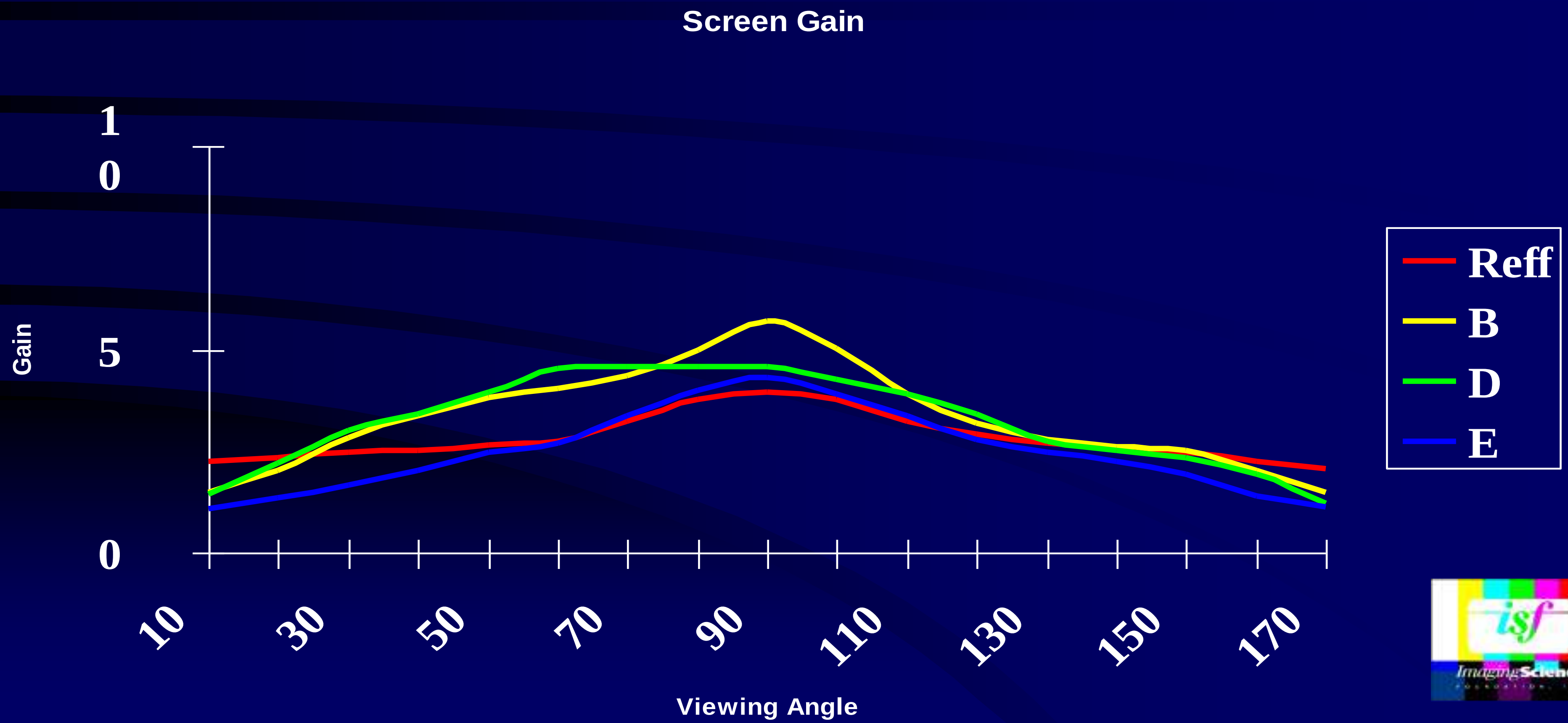
# D65 Light Coming Out Of A Projector?

Might Not Accomplish Anything!

ISF Certified Flat Spectral Response Screens

Color Shift In Mirrors & Screens

# ISF Reference Screens…



# Angular Reflective Screens

## "Gain Screens"

Reflective Screens – The Law of Reflection

The Angle of Incidence Equals The Angle of Reflection – so where do you put the unit?

"High or Low, Near or Far"

The "Billiard Table" Analogy

# "Matte" Screen Technologies

"Matte" or light scattering "Lambertian Emitters" (more on this later)

The light bounces off such screens in a uniform manner that is independent of the incident angle – The billiard analogy…..

When do we use these screens?

# Rear Projection Screen Technologies

Rear projection

Lenticular and Fresnel combinations

Interaction with pixel structure

Diffusion screens

Loss of resolution with screen thickness….

Bring lots of Lumens…..

Contrast Enhancing Dark Screens

# Ambient Light Rejection Screens

All are based on rejecting light from select angles

Most Start With Fractional Gain Grey Substrates

Some use Gain – others use Filters

The challenge is to preserve ‘Flat  Spectral Response”

# “Acoustic” Screen Technologies

Acoustically *“Transparent”* Perforated/Woven screens?

Screens that let sound through will cost you…..

Currency….always

Resolution? From what distance?

Light….sometimes more than other times

Sound….sometimes more than other times

Audiophile or Videophile or <u>**Design**</u> priorities???

All front speakers behind the screen?

# Screen Gain Pro & Cons

- Efficiency Of a Mirror is less than 100%
- Gain As Measured Against A Reference "Lambertian" surfaces, *Magnesium Carbonate* Gain = Multiple of Light off the reference
- Legacy Technology? Gain on Light Valves?
  - CRT & Light valves benefit for opposite reasons

# Negative, or ***Fractional*** Gain Screens?

- Tools for challenging applications & technologies.
- Developed for applications with projection technologies with less than perfect blacks
- Valid for rooms that challenge projection systems

# Screen Surface Selection Logistics

## Client Interview and On-Site Screen Size Evaluation

| | |
|---|---|
| Viewing angles | Client's input! |
| Seating preferences | Client's input! |
| Room environment | Client's input! |
| Content applications | Client's input! |
| Light output numbers | CEA ISF "**r10wg3**" spec! |

# Screen Surface Selection Logistics

*Lamp Light Falloff* – a known issue normally ignored!

LED/Laser Phosphor projector features will change this!

Room's ambient light issues must all be dealt with

**Test** projector's "real" light output post calibration?

*Screen calculator tools can fail using factory specs!*

# Screen Surface Selection Logistics

***ISCR and CTA Contrast Ratio Performance Specs!***

**CTA ISF R10 specs** – meet and/or exceed commercial theaters…

**(Both Sequential and Intra-frame must be determined )**

*From this perspective Contrast Enhancing Screens are tools to:*

Match or Exceed ISF CEA/CEDIA and ISCR specs

Resolve room issues

Compensate for projector black level issues

Continue dialogue with clients to balance budgets and realities

***Metering Black level limits is now a major issue!***

# Screen Surface Selection Logistics

***<u>Screens for Ideal System Designs</u>***

Lambertian Emitters – a concept finally comes of age in CE

Required for deployment:

Ideal Room Environment + Ideal Projector + Ideal Calibration

***Unity Gain Reference Screens – Only for the Very Best Rooms!***

# Physical Projector Set Up Guidelines

- Placement and Stability - (CRITICAL FOR ALL PROJECTOR TECHNOLOGIES!)
- 3 Way Measurements + Throw Distance
  - Manufacturers Guidelines for:
    - Distance from screen
    - Projector height - determines angle
    - There is no real flexibility without focus compromises or ***digital "Keystone" losses***

# “Aziz LIGHT!”

DCI specifies 14Ft.L for correct Digital Cinema – that is your **minimum** target FOR THE LIFE OF LAMP

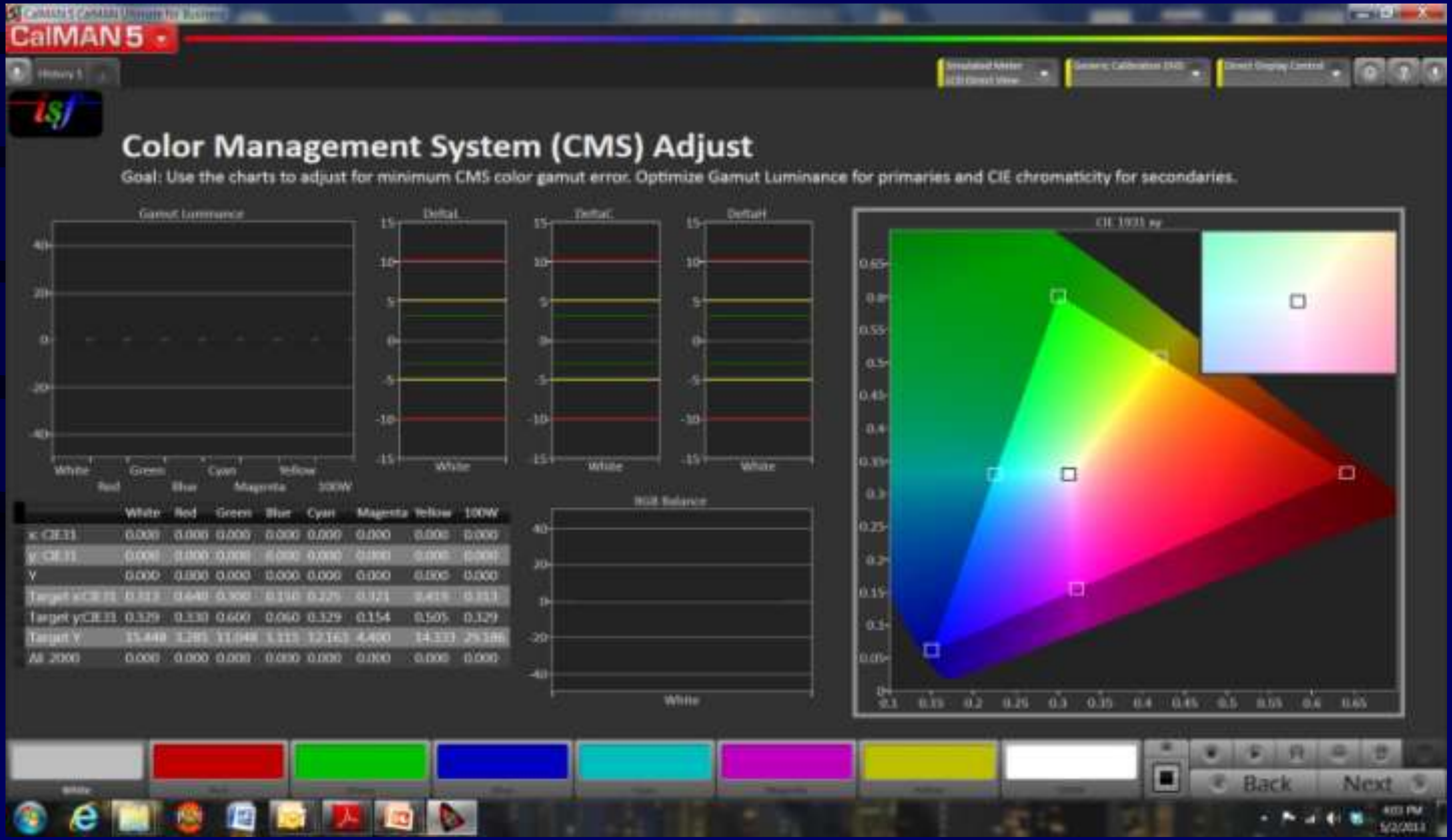
High End projectors have lamp light stabilization

You will need double 14Ft.L when new if your lamp light output degrades over time!

# Periodic Maintenance & C.S.I.

- The key to ***C***ustomer all ***S***atisfaction ***I***ndexes
- Referrals - Will the original client possibly  see the new client's projector?
- Document light output for reference performance when new
  - JS changes client's lamps when output goes down 30%
  - Keep a history – think Mr. Demming!
  - Documentation enables recurring revenue and CSI

# Next – Color Management Systems

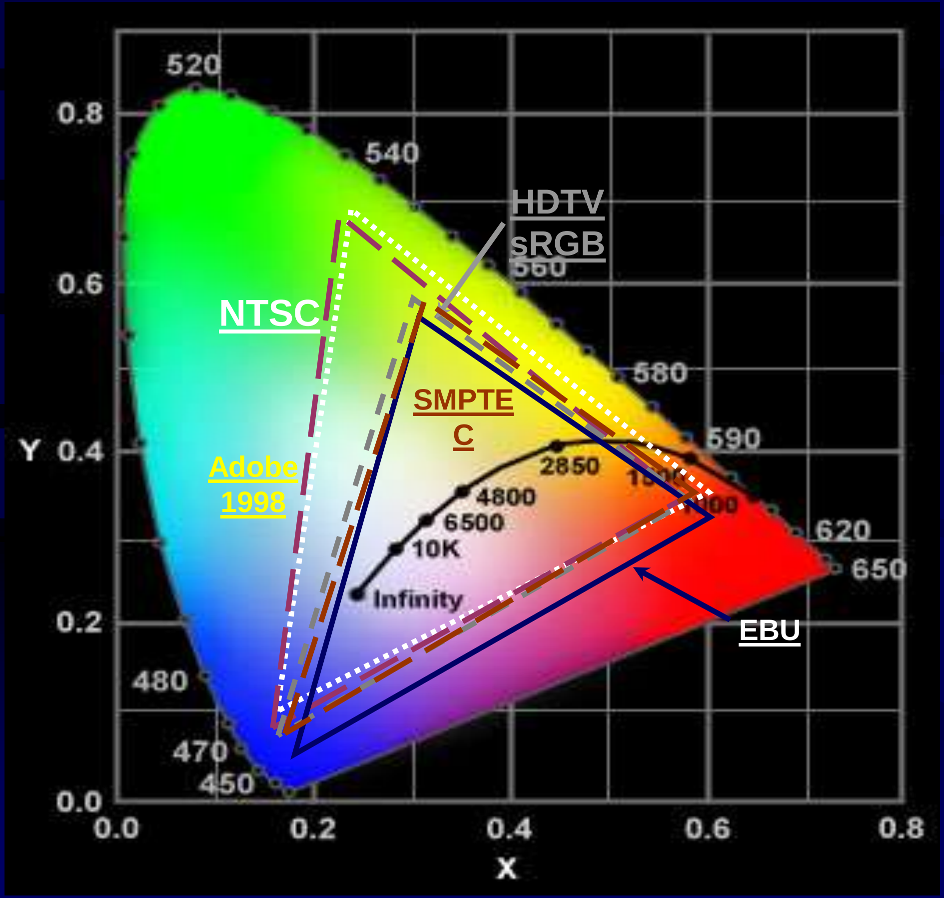


# Color Gamut


Crayola
Beginnings
24M+
16 WASHABLE
TRIANGULAR
CRAYONS


CRAYOLA CRAYONS
CRAYOLA
CRAYONS
64
DIFFERENT
BRILLIANT
COLORS
New
BUILT-IN
SHARPENER

# Different Color Space Triangles




**HDTV (709)**

| x | y |
|---|---|
| 0.640 | 0.330 |
| 0.300 | 0.600 |
| 0.150 | 0.060 |

**sRGB**

| x | y |
|---|---|
| 0.640 | 0.330 |
| 0.300 | 0.600 |
| 0.150 | 0.060 |

**NTSC**

| x | y |
|---|---|
| 0.670 | 0.330 |
| 0.210 | 0.710 |
| 0.140 | 0.080 |

**SMPTE C**

| x | y |
|---|---|
| 0.630 | 0.340 |
| 0.310 | 0.595 |
| 0.155 | 0.070 |

**Adobe 1998**

| x | y |
|---|---|
| 0.640 | 0.340 |
| 0.210 | 0.710 |
| 0.150 | 0.060 |

**EBU (601)**

| x | y |
|---|---|
| 0.640 | 0.330 |
| 0.290 | 0.600 |
| 0.150 | 0.060 |

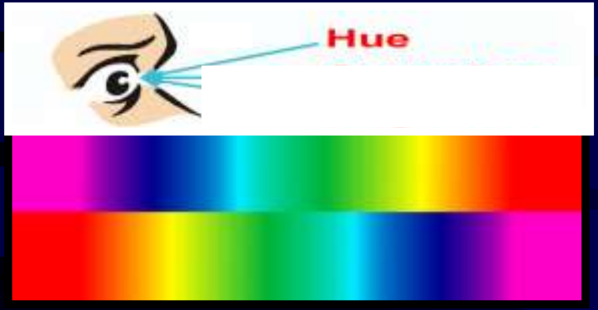
# Do Not Forget the Secondary Colors!

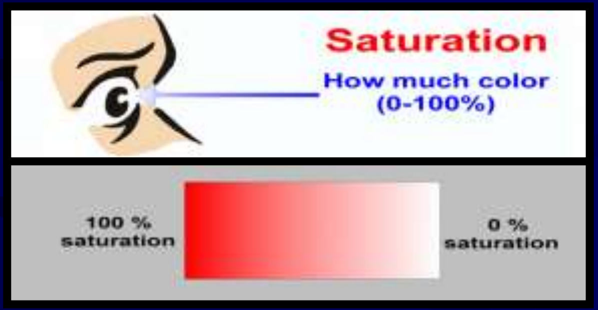
| NTSC SMPTE C | | ATSC HDTV | |
|---|---|---|---|
| Yellow | x .421 y 0.507 | Yellow | x .419 y .505 |
| Cyan | x .231 y .326 | Cyan | x .225 y.329 |
| Magenta | x .314 y .161 | Magenta | x .321 y .154 |

# Light Measurement Overview

Three characteristics define the way the human eye/brain sees light.

1. Hue 2. Saturation 3. Brightness





**Hue**: Dominant wavelength, color or tint of the color.

**Saturation**: Degree of purity from light of other wavelengths (zero saturation = white; equal energy of all wavelengths)

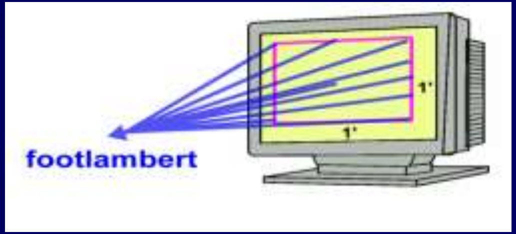
**Brightness**: Perceived light energy level

# Light Measurement Units:

**(Two light measurements used to relate light to human sight)**

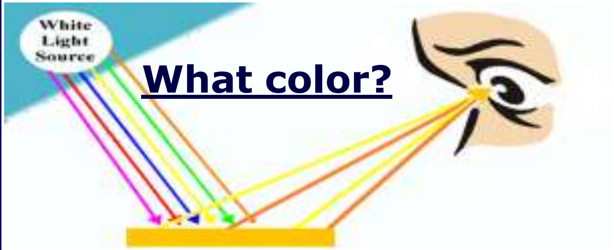

## Luminance (brightness):

**Foot-lambert**: U.S. unit of luminance (radiated light), 1 lumen per square foot




**Candela ($cd/m^2$)**: Standard International unit of luminance (radiated light), 1 candela per square meter – also called NITS

***1 Footlambert = 3.42625 Candelas P.M.SQ. (Nits)***

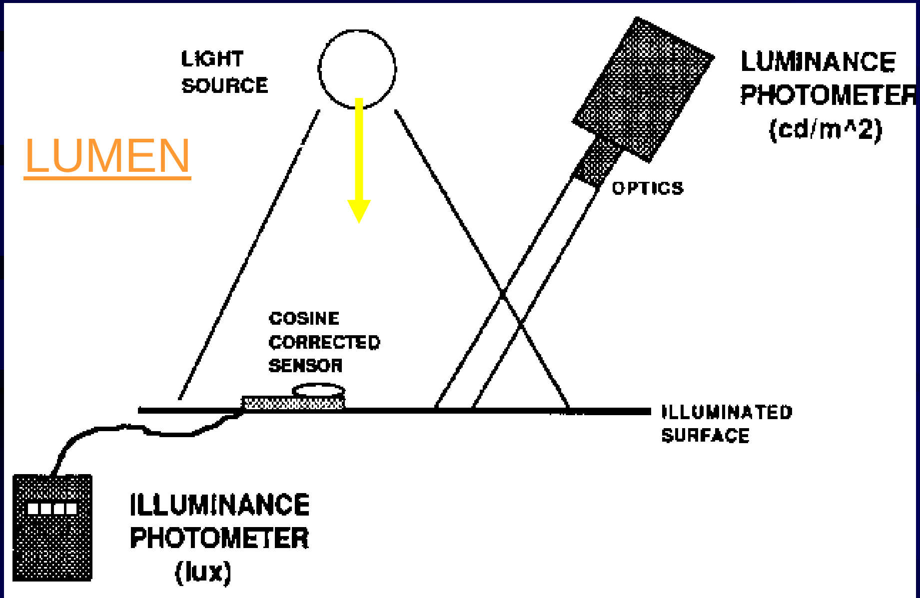



## Color (hue and saturation):

**CIE chromaticity coordinates (x, y)**: From 1931/1976 CIE Chromaticity Diagram

# Understanding Units of light

The human eye does not see illuminance; it sees luminance.  You can feel illuminance and see luminance




**Luminance** is Foot Lamberts
Measurement Of Light coming off of a surface

**Illuminance** is the measure of light falling on a surface per unit area

# Different CMS Objectives for

## **Primary** versus **Secondary** colors

**LUMINANCE** ("Y") IS THE CRITICAL OBJECTIVE TO GET RIGHT FOR RGB **PRIMARY** COLORS

**HUE** ("x,y") IS THE CRITICAL OBJECTIVE TO GET RIGHT FOR CMY **SECONDARY** COLORS

**If you see "Absolute Luminance" RGB errors you should not deploy a CMS feature at all!

# CMS Calibration Features

## Obsolete 2D CMS had 12 Controls

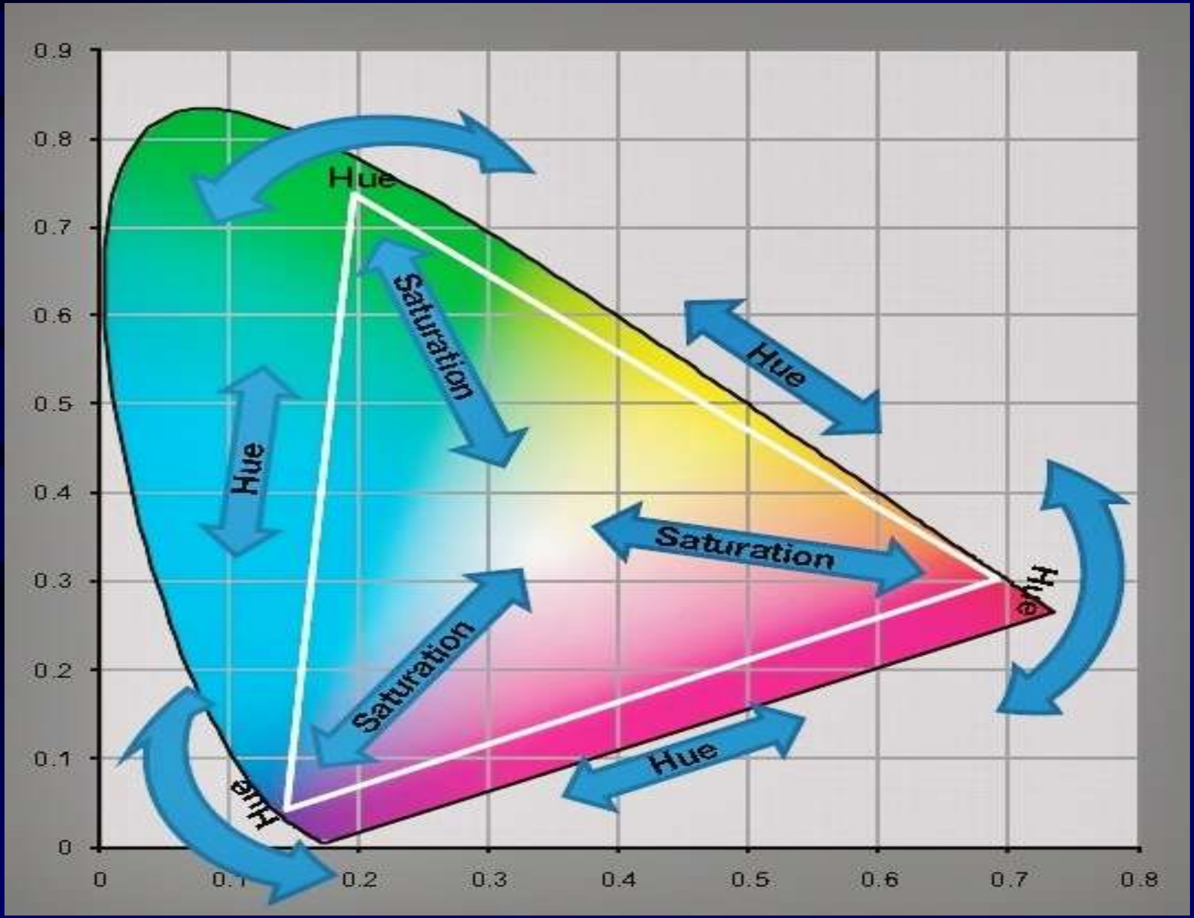
- Hopefully, we can calibrate a color in color space along a line heading to the target color point from the white point
- Some controls adjust both saturation and tint together – CAUTION!

## Current 3D CMS have 18 Controls

- These controls often have confusing names
- x,y and Y are the ideal functions and nomenclature
- Some work well – others cause easily visible errors!

Colorimeter GUIs help us learn how controls work and interact!

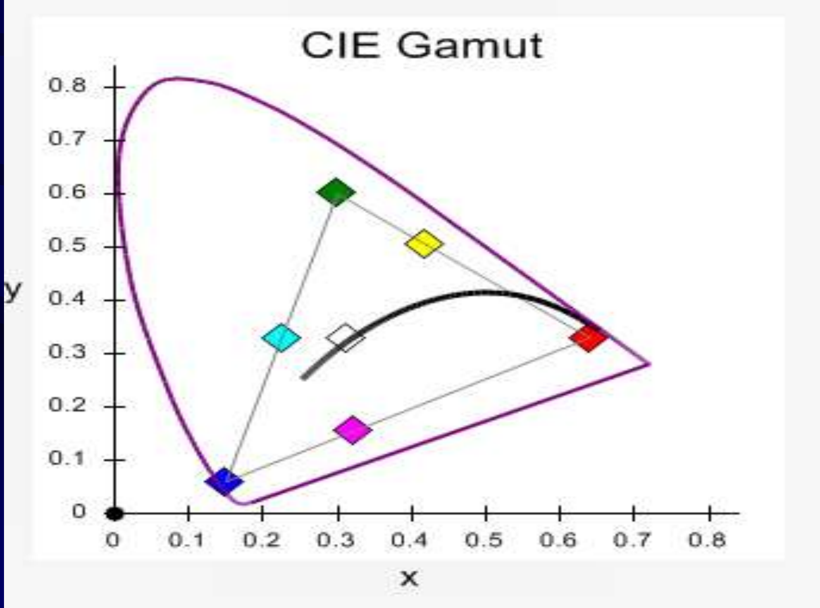
# One Brand's 3D CMS x,y Functions:



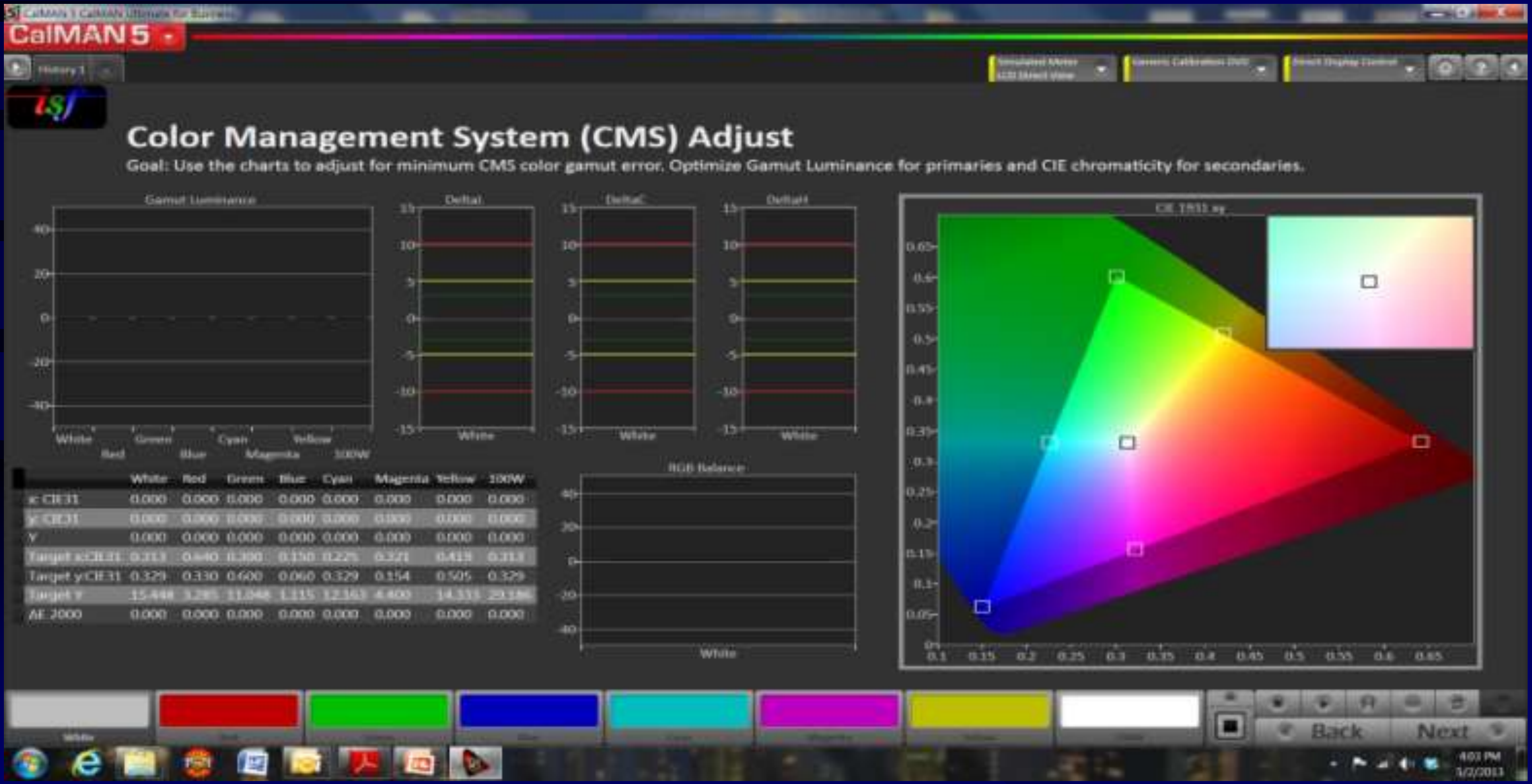
# Basic Chart to Follow How, or If Controls Work:

| | | |
|---|---|---|
| Color Squares | = | Targets |
| Black Dots | = | Will Show CalMAN During Readings |

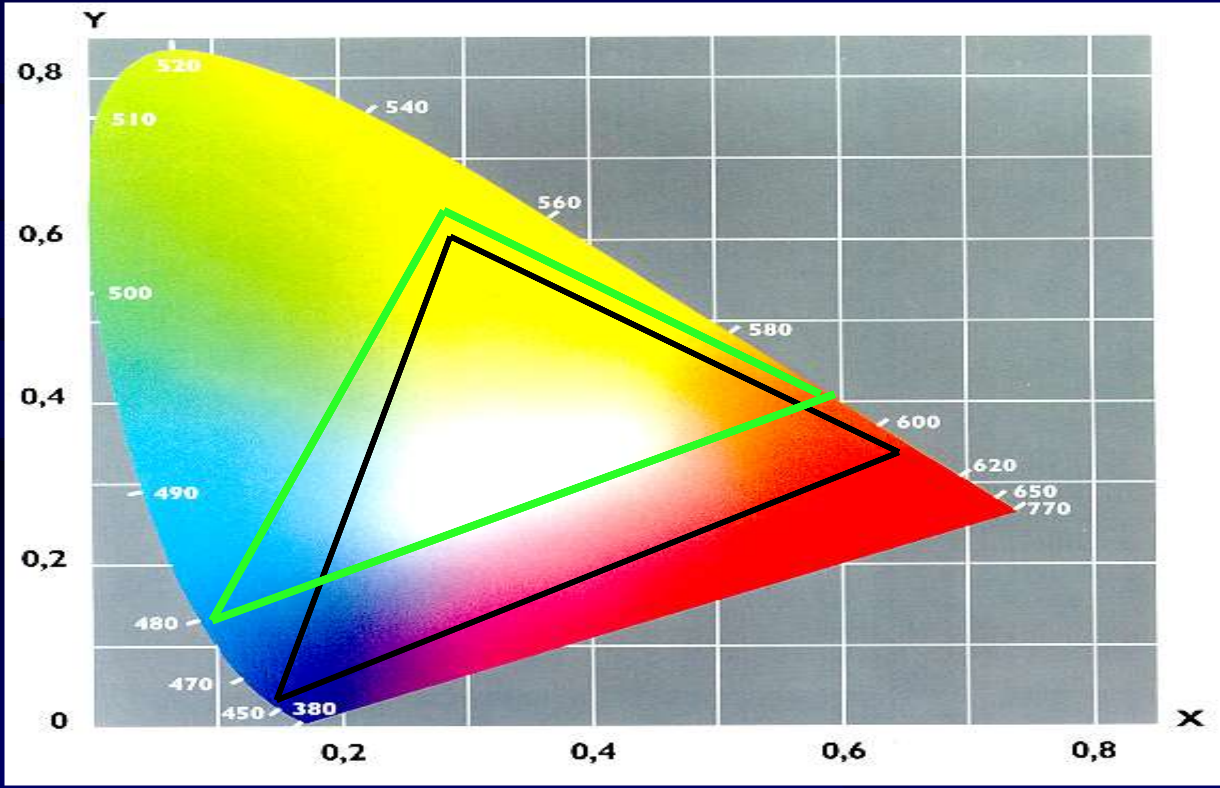
*Move controls – observe changes –* ***ELV the CMS!***



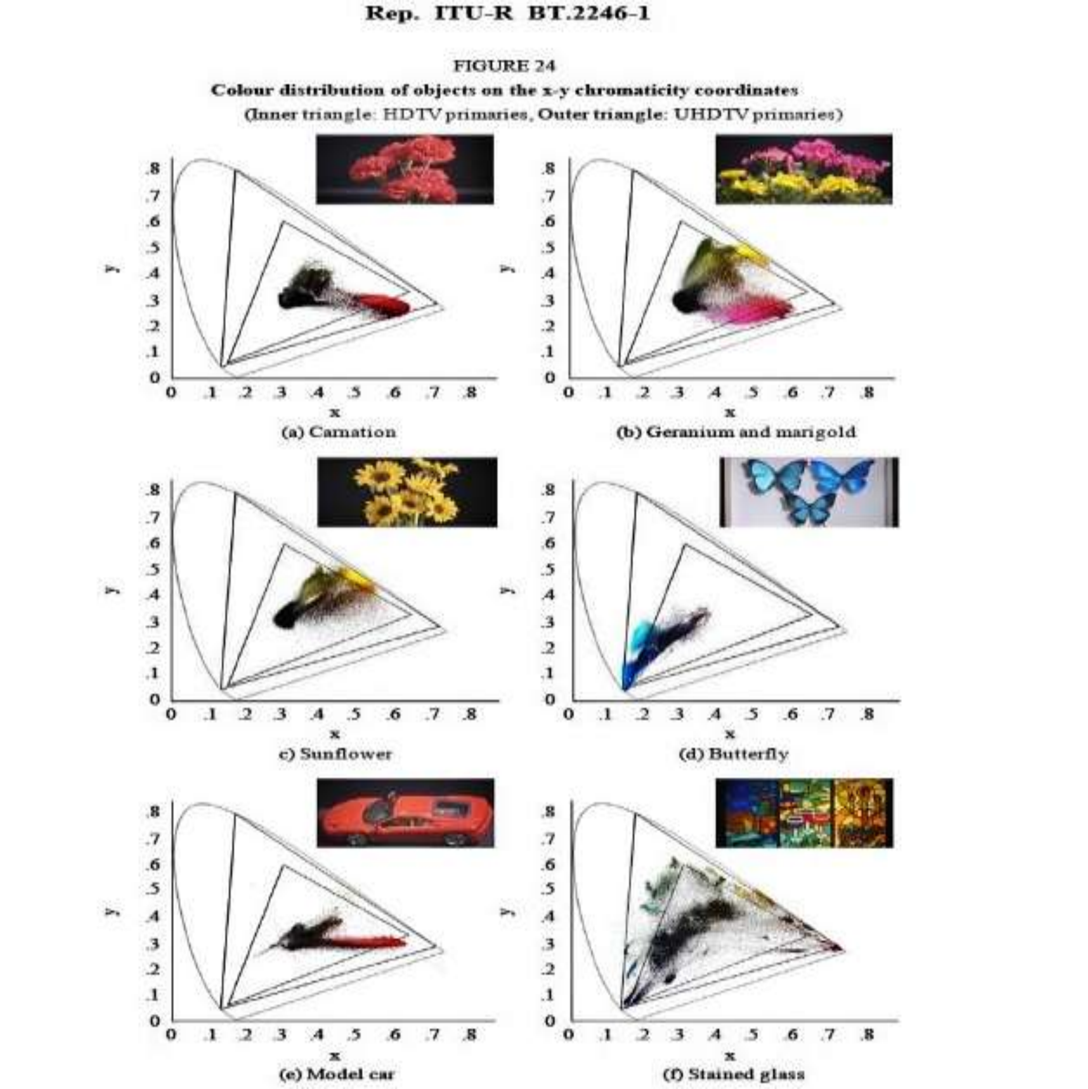
# Define x, y,Y, Target x, Target y, Target Y



# If Primaries CANNOT Match CIE Targets….Native Colors May Be Wrong

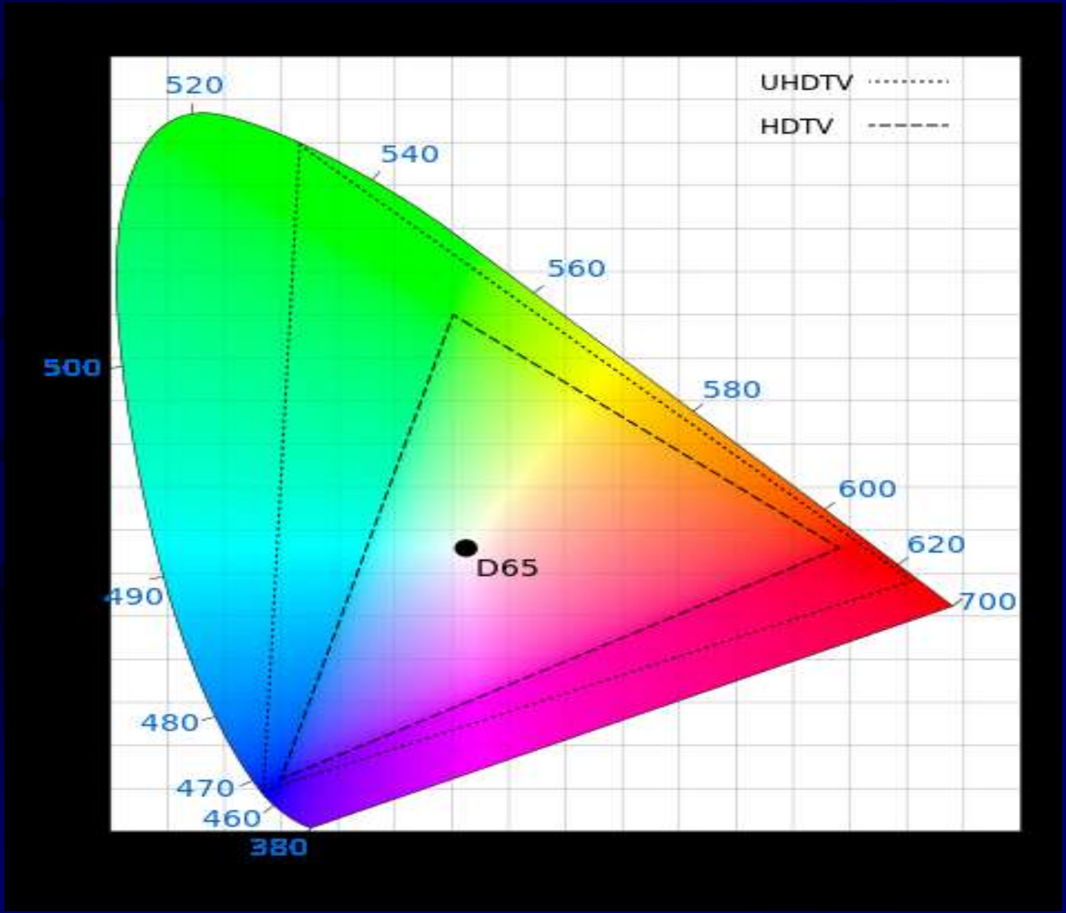


# ITU Ultra HD Gamuts Go Way Beyond What We Have Seen in HDTV!

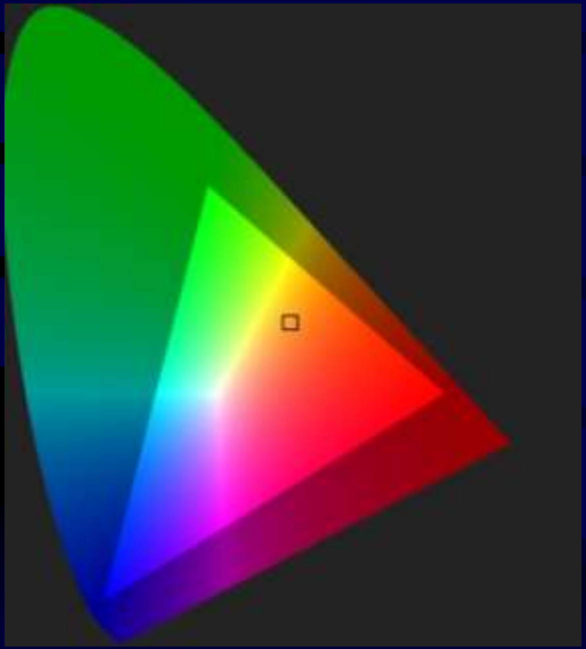


# 2020 / REC 709 and "Pointer's Gamut"

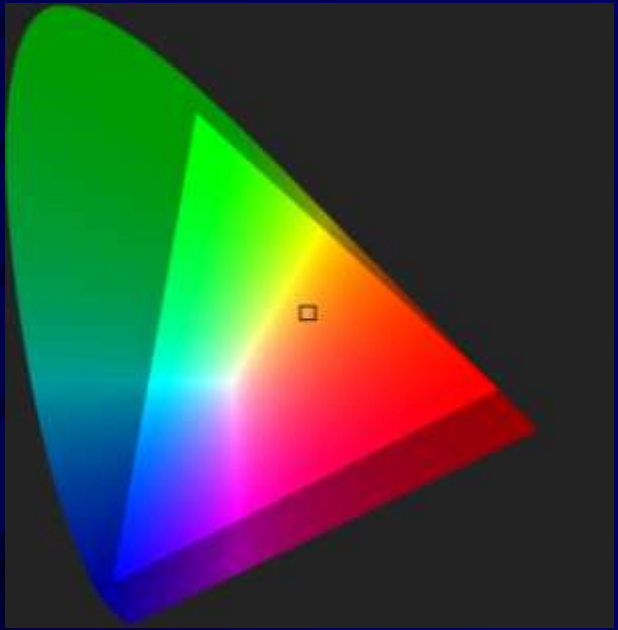
(Approximation of visible colors reflected of of surfaces)



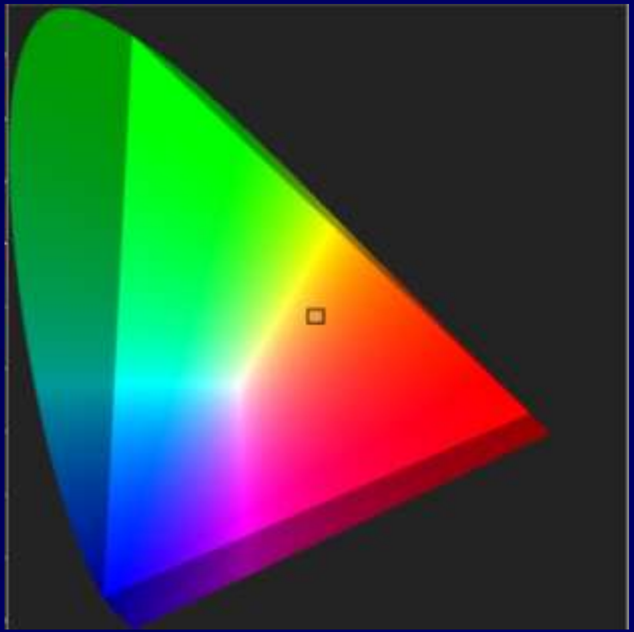
HDTV



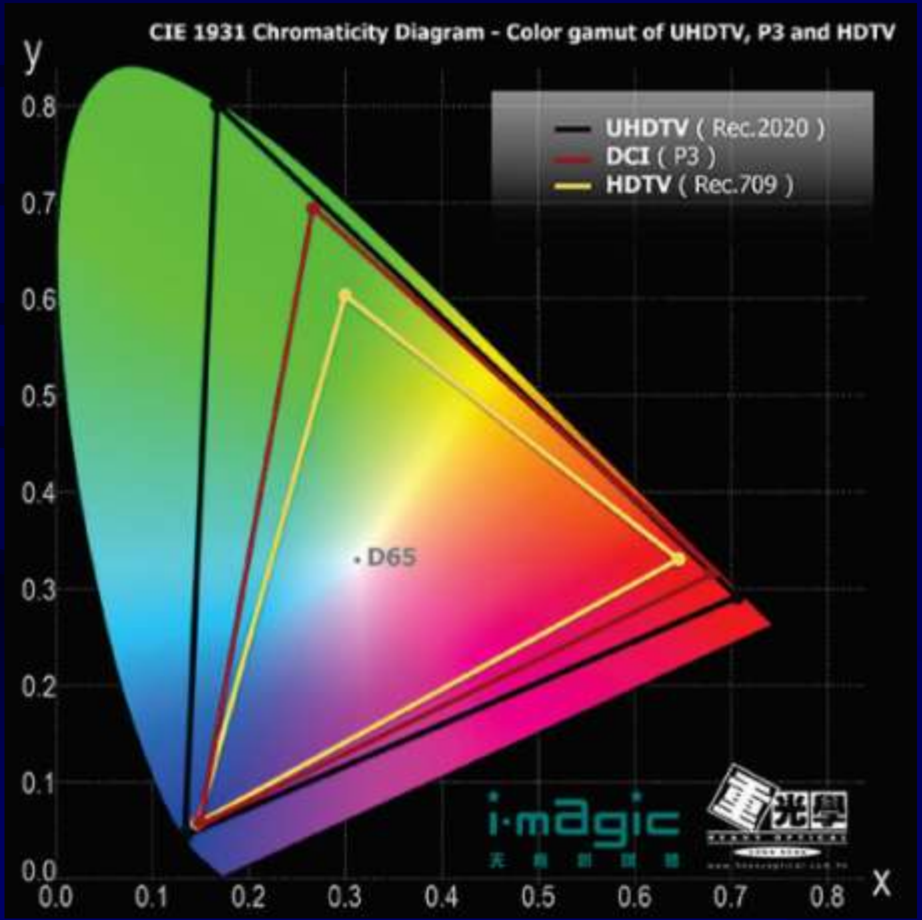
P3



2020



# HDTV DCI and 2020 Gamuts



# Go Calibrate TV's CMS

- Run through RGBCMY adjustments
- Check all levels on all CalMAN charts
- If Luminance levels are not correct - Check for decoding errors!
- Did CMS solve problems or create them?

# Calibrate Through Video Processors & *AVRs*

**Evaluate** and Calibrate basic HDTV settings 1st

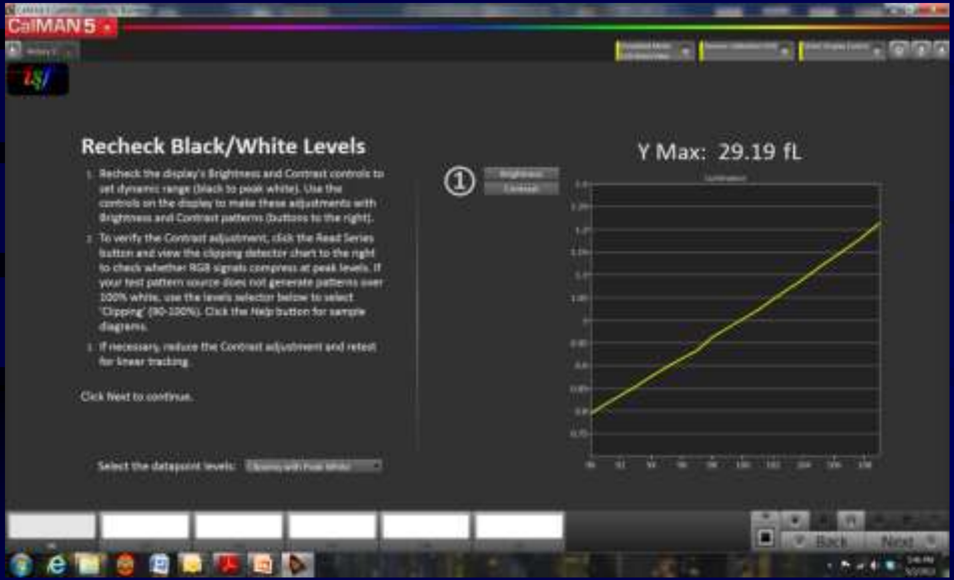
Then **Check** the **<u>One</u>** **<u>Output</u>** Calibration

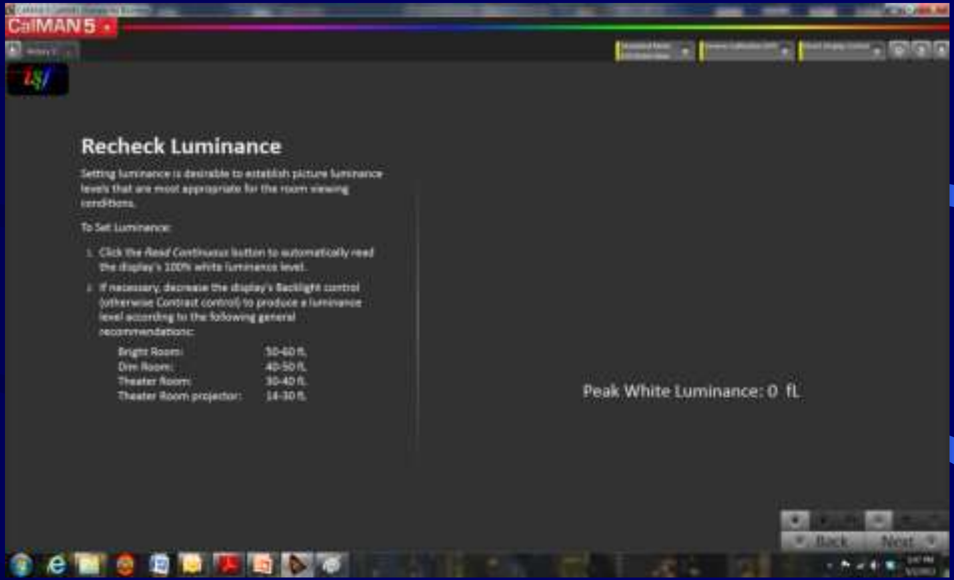
- Gamma Factor
- Color Gamut
- Color Decoder
- Re-check Color Gamut
- Grayscale/Gamma

Then **Check** All **<u>Multiple</u>** **<u>Input</u>** Calibrations

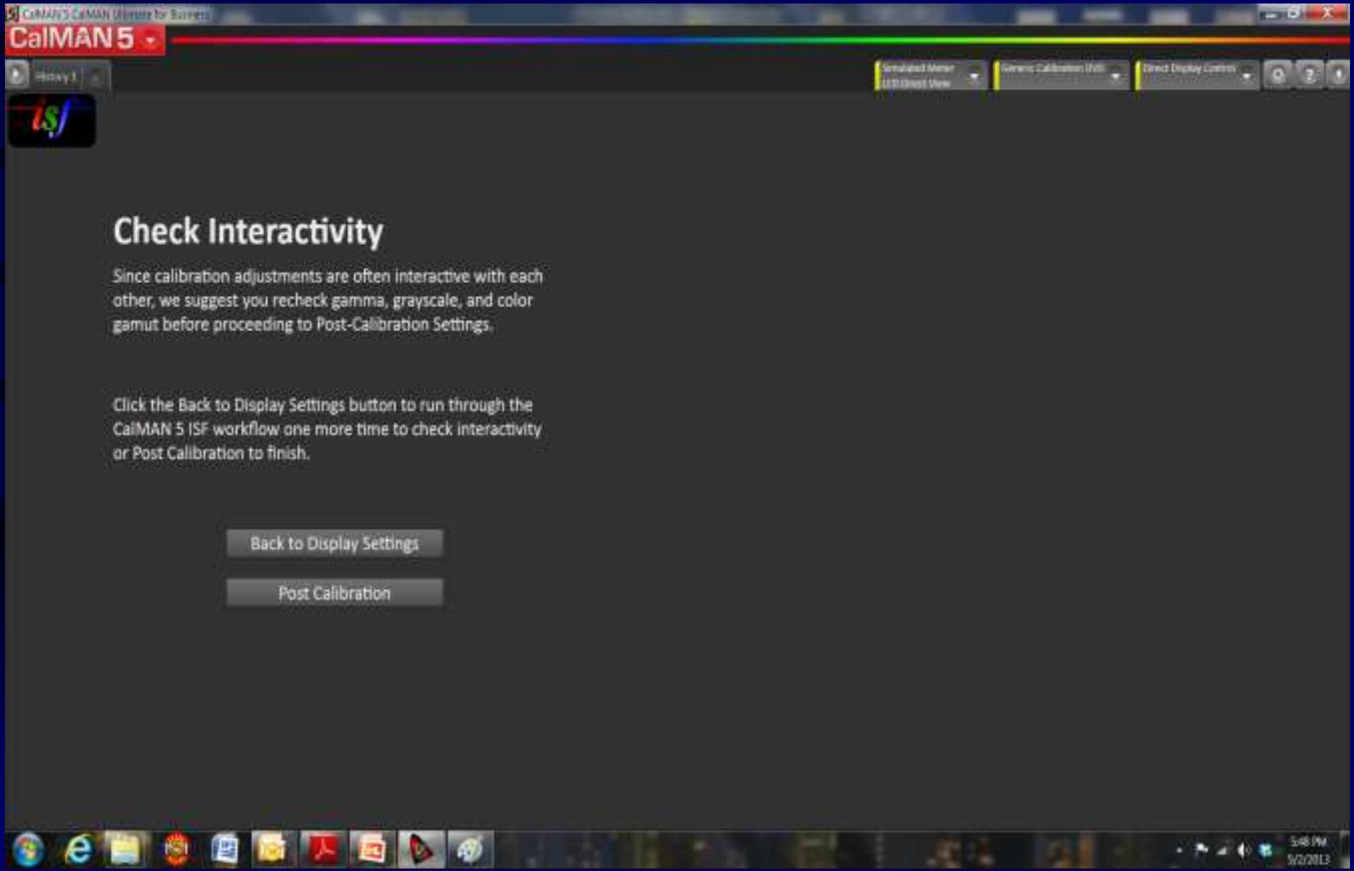
- Source device output resolution
- Source device picture controls
- Processor Input Picture controls

# Next ISF CalMAN Steps:

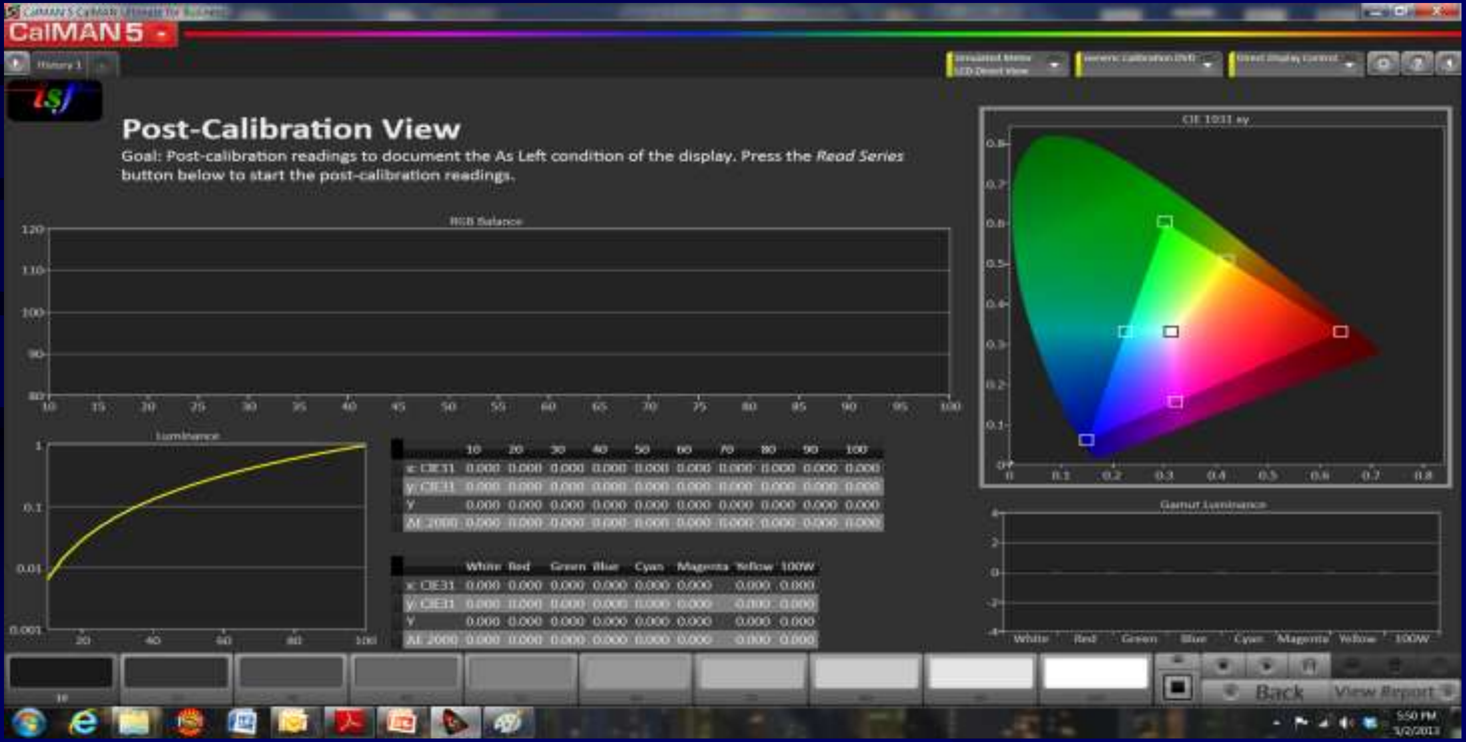


# Recheck Everything at Least Once!



# Post Calibration Scan and Reports



# Now That the Display Is Calibrated, We Can Evaluate Video Processing

The BEST Video Processor is built inside the?

- HDTV
- Disc player
- Set top box ( probably NOT )
- Audio Video Receiver
- Stand alone processors/switcher
- Home Theater PC Video Card

WHICH ONE SHOULD YOU USE?

# Overview of Steps in Video Processing

1 Confirm HDMI EEDID and HDCP functionality

2 Upconvert to <u>RGB</u> <u>**4:4:4**</u> from 4:2:0, 4:1:1, or 4:2:2

3 Deinterlace if content format is interlaced

4 Scale software to match display hardware

5 Change aspect ratio if desired

6 Optimize motion and minimize noise

7 Match color reproduction to content creation

# Configuring HD Set Top boxes "Native"

Is there a "Native Resolution" output option?

*What will that enable?*

*Are there other names for "Native"*

What problems might occur with that option?

What will produce superior pictures?

The only "perfect" processing is……….

* NO processing*

Always Test….never guess!

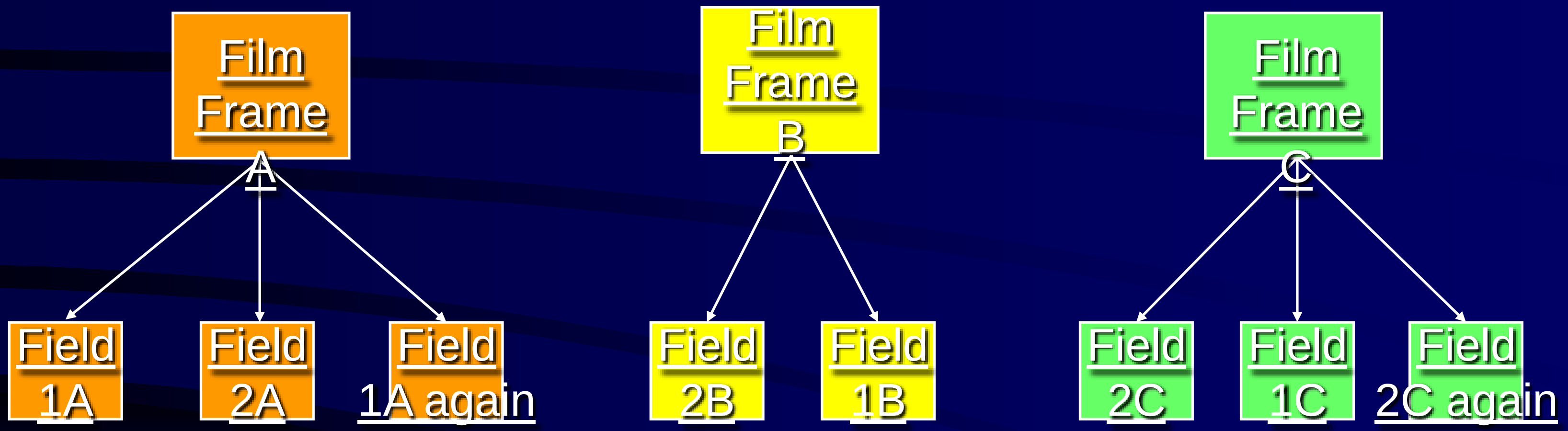
# Overview 2 / 3 Pulldown

Also known as reverse Telecine or Film or movie Mode, as well as other names

# Film To Video Transfer Problem #1

- If we transfer film to video by creating one even field and one odd field from every film frame what would film look like on television?
- What do we do in PAL in 50Hz markets?
- What do we do in NTSC – 2/3 Pulldown

# The 60Hz 2/3 Pulldown Solution….



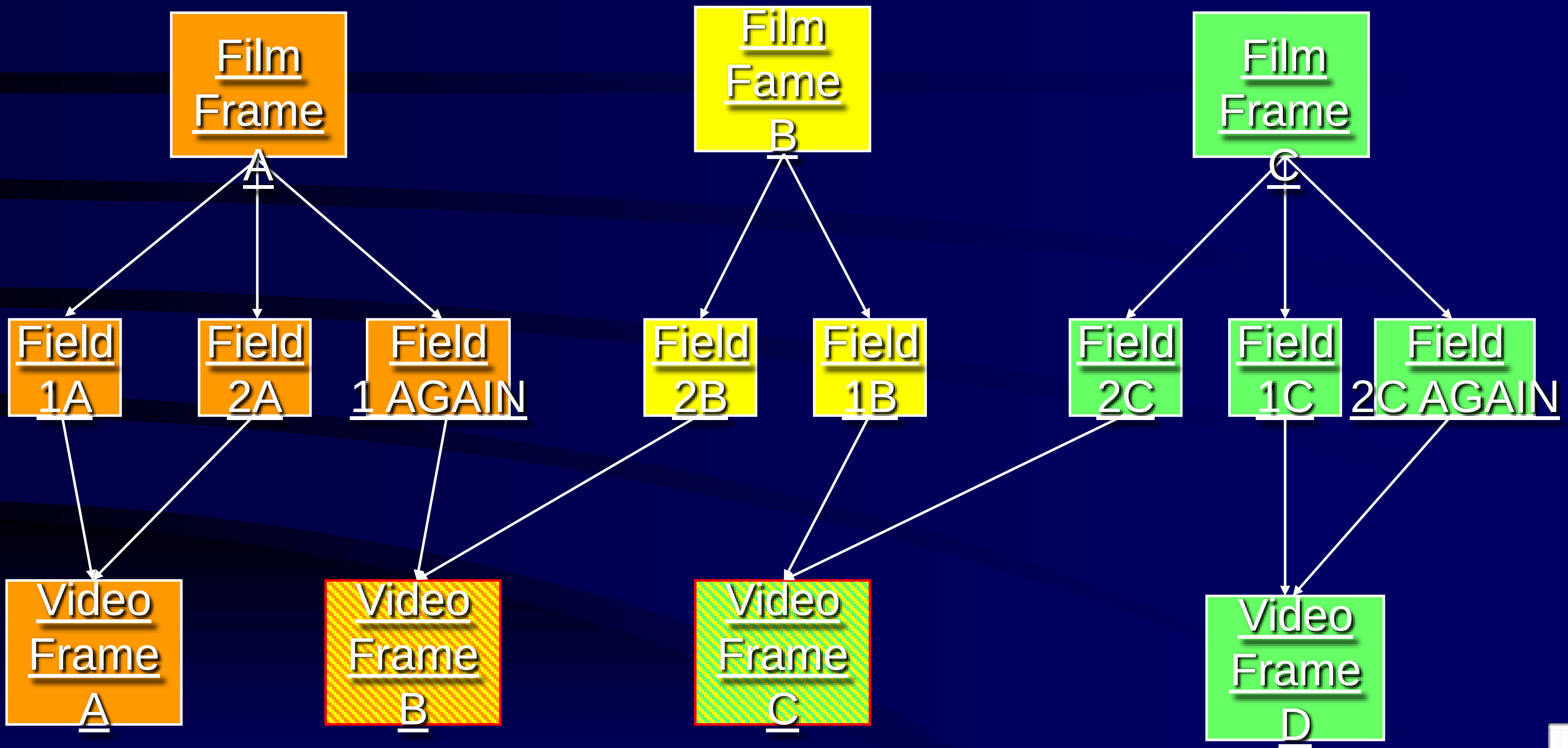

- Film is 24 frames per second
- Interlaced Video is 30 frames per second, remember there are 2 fields per frame & 60 images per second!

# Past 2/3 Pulldown Problems

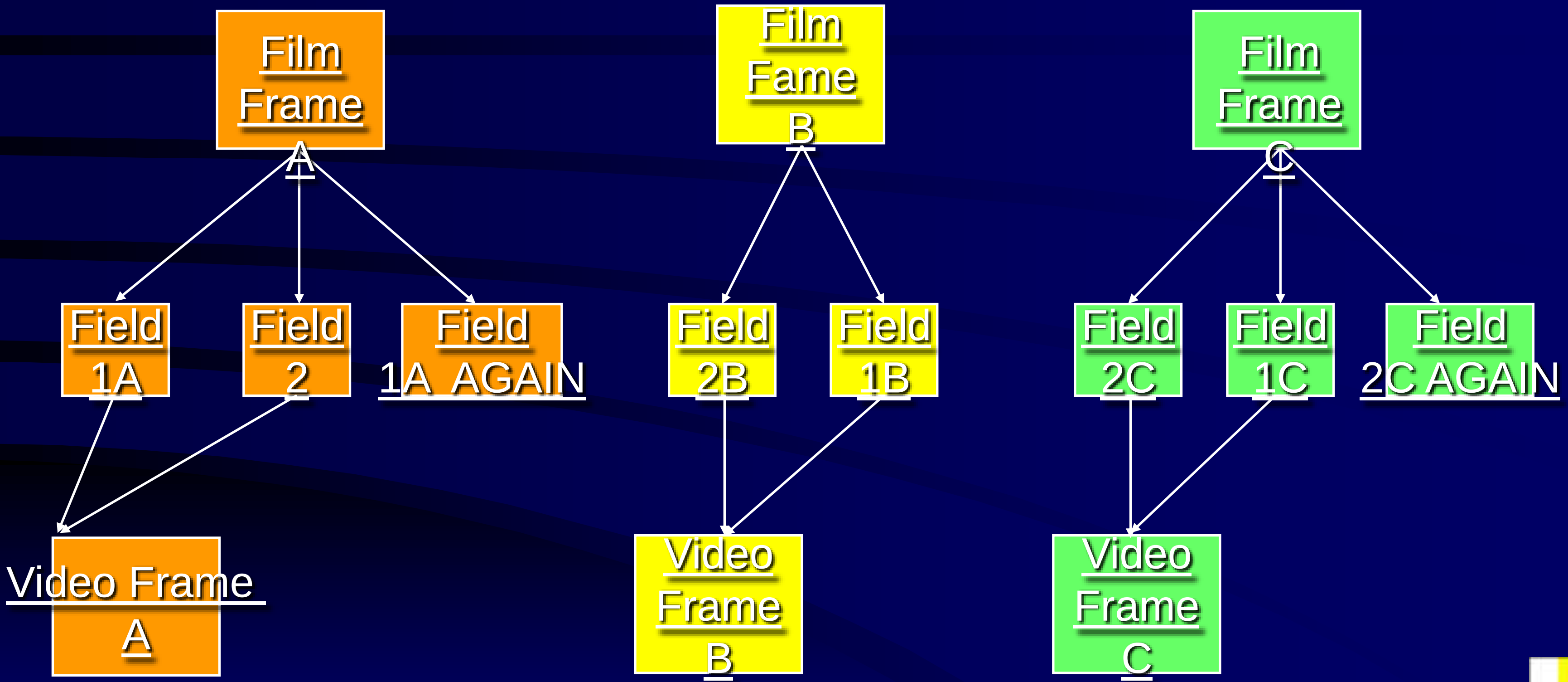
There were only minor “judder” 3/2 Pulldown problems until deinterlacing devices created visible artifacts from film content

*72/96/120/240/480 Hz IMAGING….*

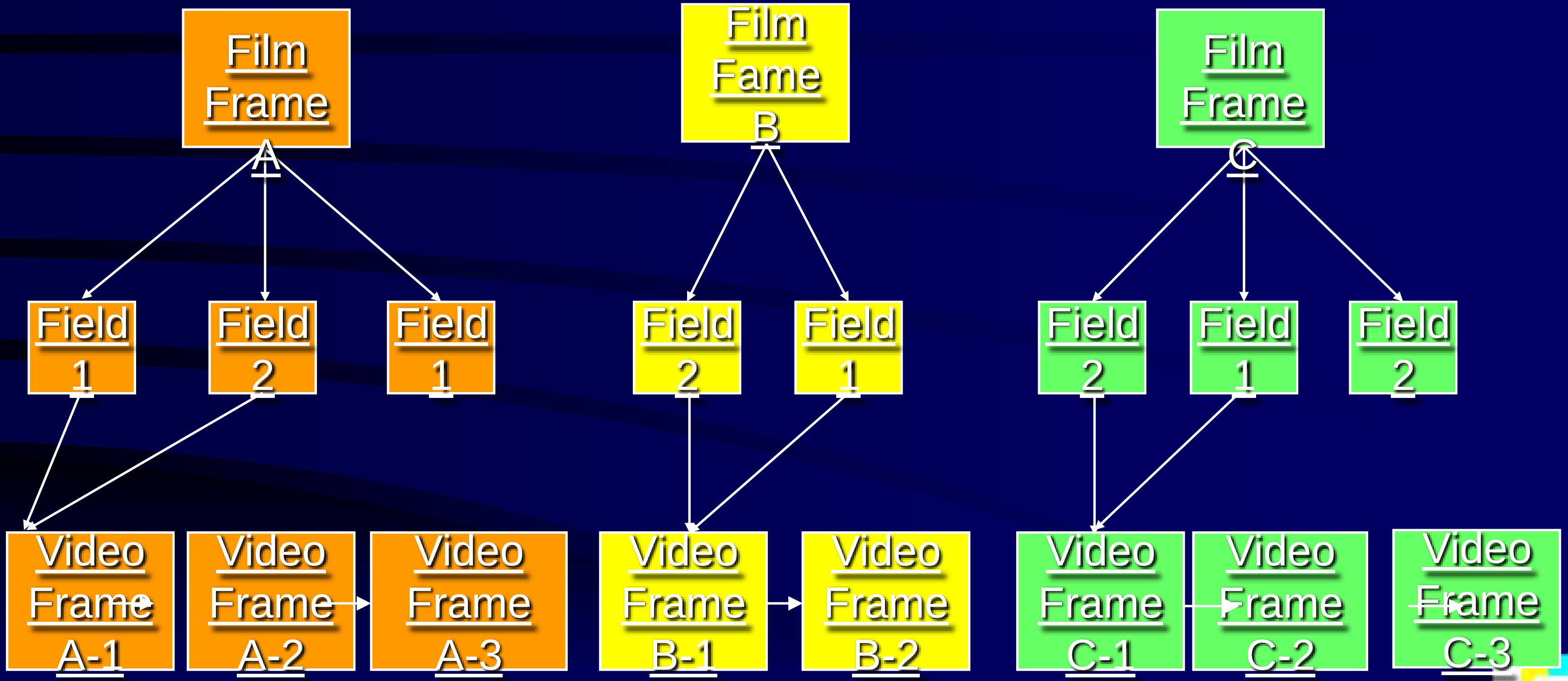
# 2/3 Pulldown De-interlaced Errors



# Using 2/3 Pulldown…..



# 2/3 Pulldown Preservation



# Why **Must** you understand 2/3 Pulldown Film Mode Video Processing?

1 – Many HDTV presets do not have their film modes turned on

2 – Calibrators must know how to **TURN ON** 2/3 Pulldown modes for their end users for superior looking, artifact free Film content!

# Motion Tests on SD and HD Test Discs

AVIA Pro for Legacy SD Upconversion
HQV DVD
Spears & Munsil
Qdeo by Marvell
WOW by Disney
1080i Guitar String Close Up – Shallow Angles

# Test Everything via Different Signal Paths

HDMI Direct to HDTV

HDMI through multiple components

Cat5 and Fiber and HDBaseT

***Should all digital paths test the same?***

***Never Guess – ALWAYS TEST!***

# We Fail at 3D AGAIN! - 3D Technologies…

Glasses Mounted Micro Display, one picture for each eye

Spectral Separation (ancient and old fashioned two color)

The three major current Technologies:

1 - Polarization Separation

2 - Time-Sequential with IR synchronized shuttered glasses

3 - Dolby and Panavision Wavelength based Discrete Separation

AutoStereoscopic – Major failures again

3D has failed to find a market repeatedly for 100 years

Perhaps VR or AR will succeed?

# Specialized 3D Camera – Circa 2010

# Calibrating 3D Cameras?

Credit MIT Technology Review and ESPN

# Viewing Angles and 3D

Camera angles are critical

Home viewing angles are also critical

- Expect end user issues

Perceived distortion from to incorrect viewing position:

New geek terms, Percival's Zone of Comfort, Retinal Disparity

"**V**ergence-**A**ccommodation" issues cause user fatigue & discomfort

Early 3D efforts at low refresh rates actually caused nausea

"The Hobbit" by Peter Jackson is 1st 3D shot at 48Hz!

# 1.4a 3D Variants Bit Map Nomenclature

Credit Quantum Data

| | |
|---|---|
| **FP** | = Frame Packing |
| **LAlt** | = Line Alternative |
| **SbSF** | = Side-by-Side (Full) |
| **TB** | = Top-and-Bottom |
| **HHOO** | = Side-by-Side (Half), Horizontal sub-sampling, odd/left, odd/right |
| **HHOE** | = Side-by-Side (Half), Horizontal sub-sampling, odd/left, even/right |
| **HHEO** | = Side-by-Side (Half), Horizontal sub-sampling, even/left, odd/right |
| **HHEE** | = Side-by-Side (Half), Horizontal sub-sampling, even/left, even/right |
| **HQOO** | = Side-by-Side (Half), Quincunx matrix, odd/left, odd/right |
| **HQOE** | = Side-by-Side (Half), Quincunx matrix, odd/left, even/right |
| **HQEO** | = Side-by-Side (Half), Quincunx matrix, even/left, odd/right |
| **HQEE** | = Side-by-Side (Half), Quincunx matrix, even/left, even/right |

# 3D Method of Calibration

**Active shutter and Polarized passive glasses impact imaging**

When watching a 3D movie we are effectively looking through sunglasses. The glasses cut a substantial amount of light and usually color shift

- Active 3D glasses rely on liquid-crystal shutter elements
- These vary in transmission efficiency and color transparency
- Passive glasses also impact image light and color

# 3D Black and White Level Setup

When setting the display's contrast and brightness for proper dynamic range make sure you are wearing the 3D glasses - and that active ones are on

# 3D Metering Set Up

Carefully position meters to read through 3D glasses

Emulate user's exact H&V viewing position

# ISF Certification Test

- Your tests will just be reminders of what we covered – make sure we have your EMAIL address
- They will be short ones, but there WILL be some essay questions.
- Completed tests must be emailed to ISF and then an oral review will follow – that is basically an hour of private 1 on 1 tutoring on us!
- Your free tutoring is only free for 30 days……

# Future “Resistant” Calibration Gear?

“Future Proof” is never possible

ISF Equipment Recommendations:

- Tristimulus meters with upgrade paths
- Spectral meters for profiling Tristimulus meters
- Displays change faster now so your gear must keep up
- We strive to keep you up to date!

# Continuing in the Field

**Practicing** will help you to master the new model features delivered each year – we expect innovations constantly!

We hope that you enjoy your work as much as we do – and we wish for you many productive years with many happy clients!

# Fini