Using Low-Cost Plasma Displays As Reference Monitors

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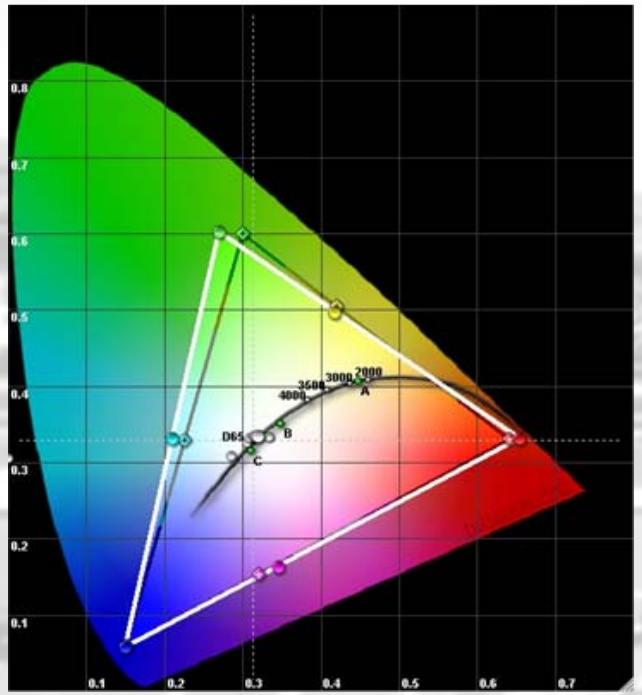
Time to Toss The CRT

- Advantages:
  - CRTs can scan multiple resolutions
  - Wide, linear grayscales are possible
  - Precise color shading is achieved
  - CRTs have no native pixel structure
- Drawbacks:
  - Brightness limited by tube size
  - Resolution (spot size) linked to brightness
  - Heavy, bulky displays for small screen sizes

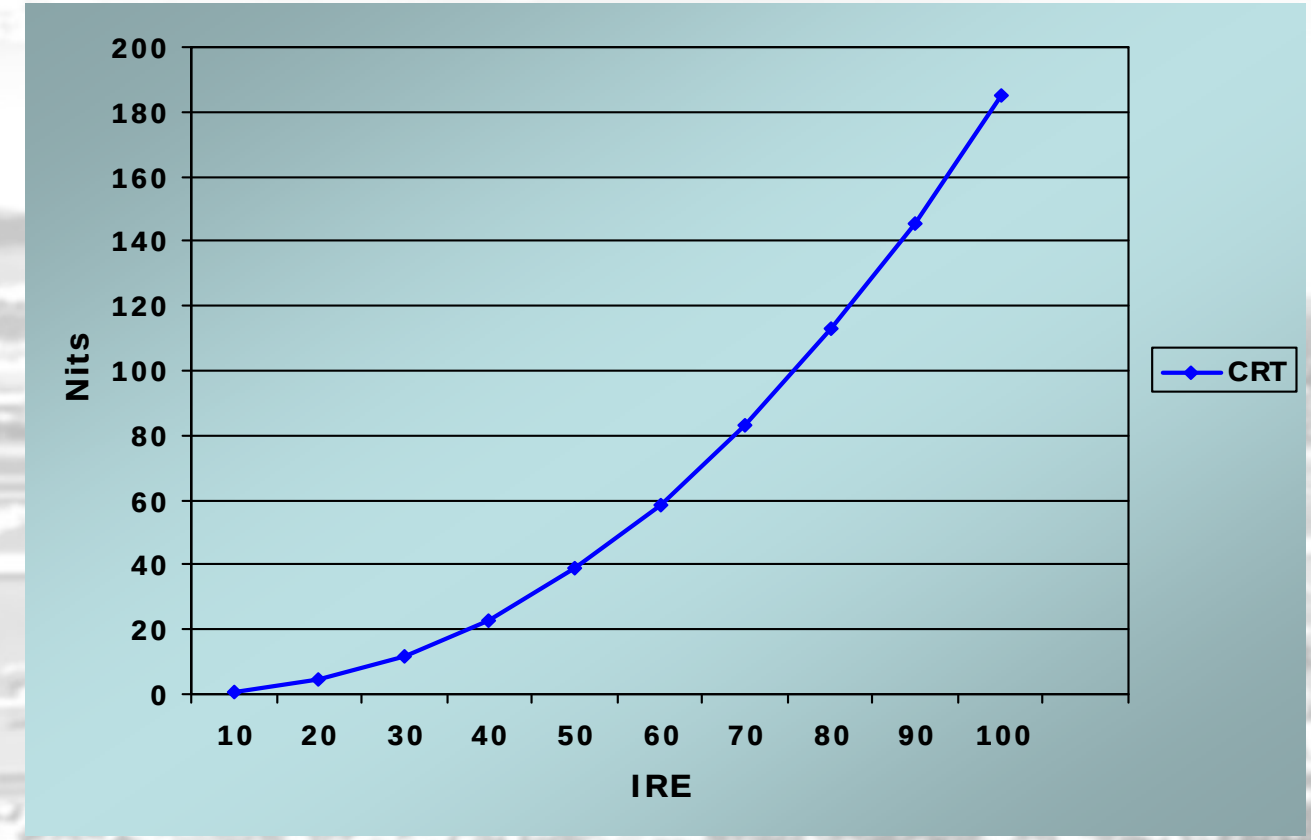
CRT Color Gamut



CRT compared to REC709

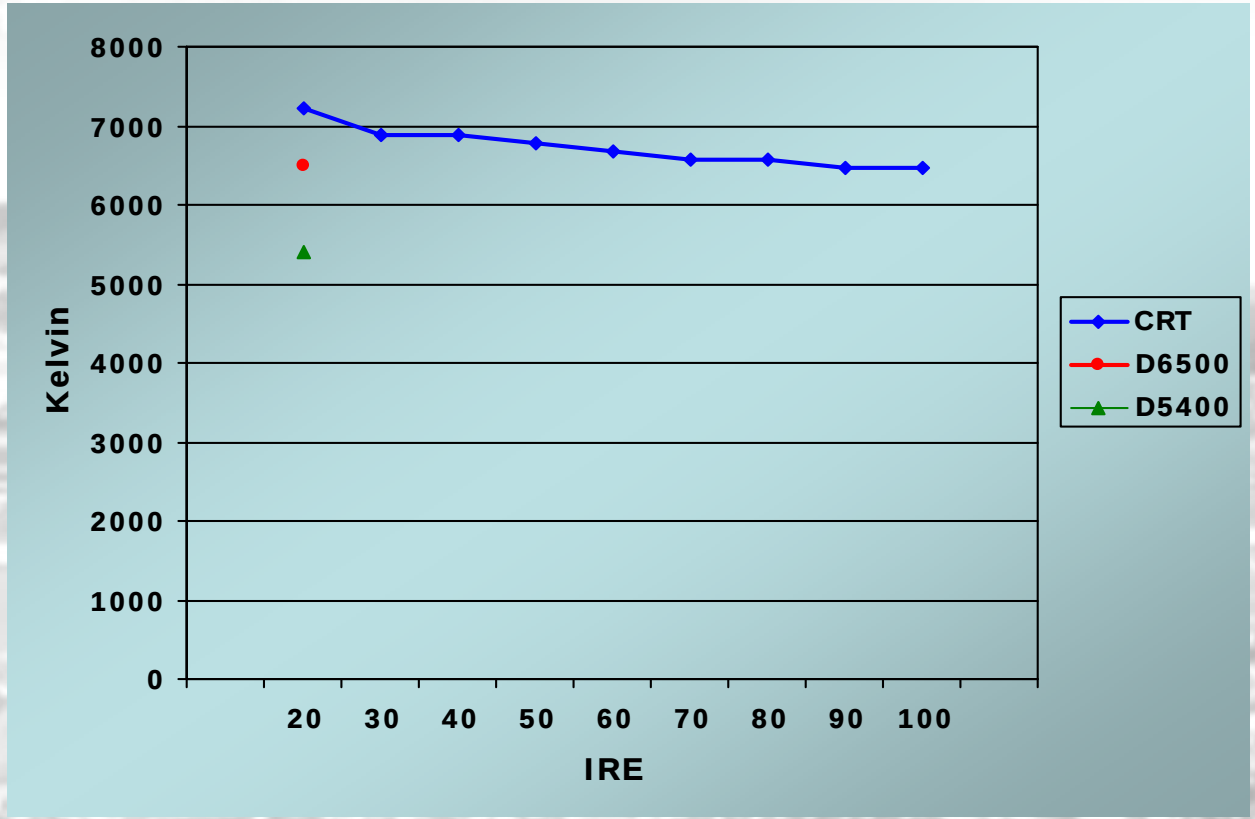
- SMPTE-C phosphor formulations
  - Blue close to ideal
  - Red close to ideal
  - Cyan, yellow close to ideal
  - Magenta shifted towards red
  - Green shifted towards cyan slightly, but with equivalent luminance value
- Close match to REC709 gamut, but not enough saturation for DCI

CRT Gamma Response



Plotted CRT Gamma Value – 2.3

CRT Grayscale Response



Plotted Grayscale Track for CRT

The Benchmarks

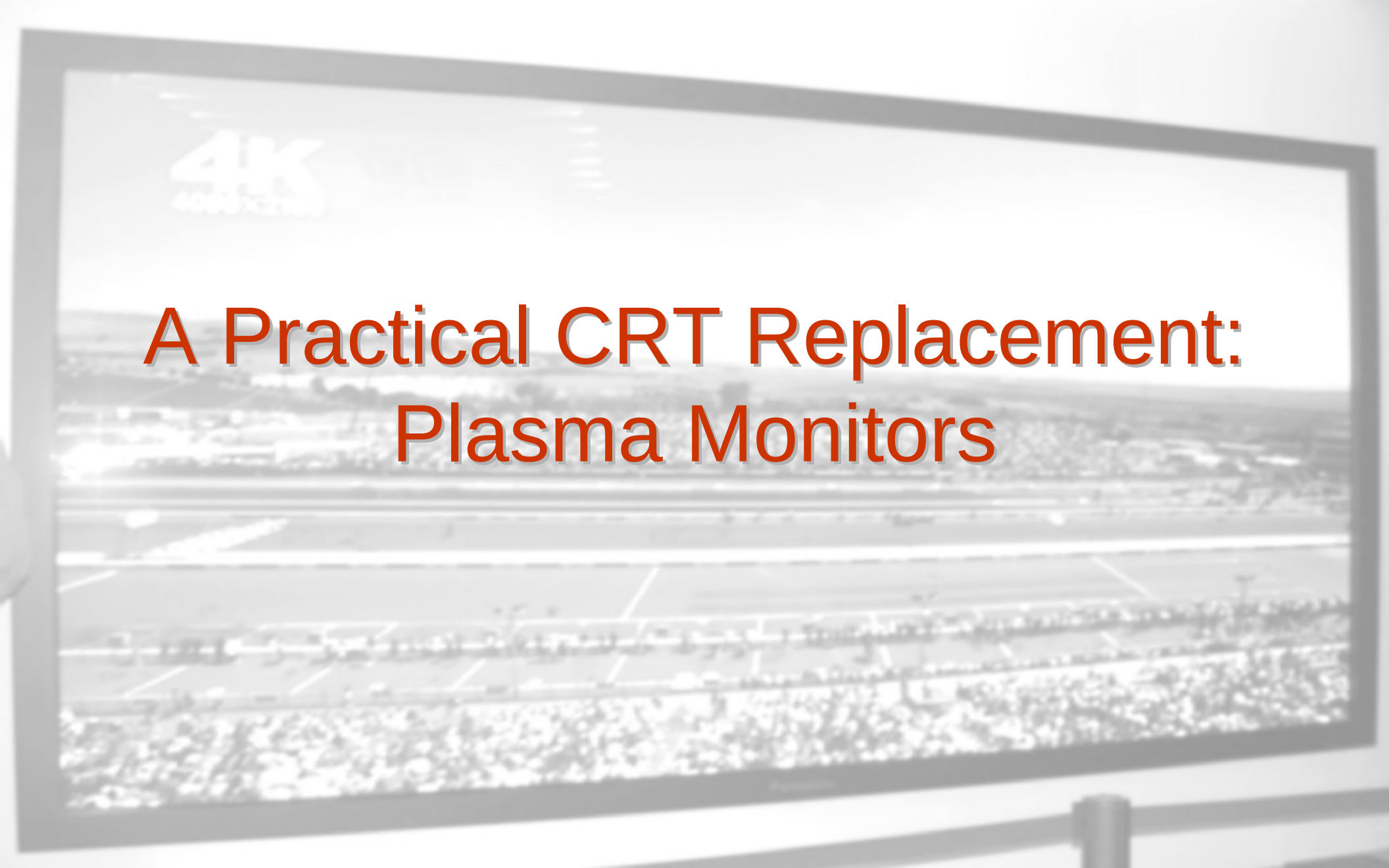
- A reference monitor must be able to:
  - Track a consistent color temperature
  - Produce a neutral color of gray
  - Display a wide, dynamic grayscale without clipping or crushing blacks and whites
  - Provide consistent performance over wide viewing angles
  - Calibrate precisely to standard reference color coordinates and spaces
  - Support a wide range of digital signal and display standards (SDI, HD-SDI, DVI, HDMI)

Grayscale Reproduction

- This is the hardest thing for any display to handle
  - And digital imaging systems have it tougher (PWM)
  - Shadow detail is always difficult to render, limited by lowest black levels and sampling
- Expansive grayscales are problematic
  - Consumer TV business drives the professional market
  - TV industry is obsessed with contrast ratios, so…
  - White detail crush is very common on LCD and PDPs
  - S-curve gammas are also common

Grayscale Reproduction

- Dynamic Range
  - Out of the box, LCD and plasma displays run too hot and cannot achieve consistent gamma
  - High-end clipping is not unusual (white crush, S-curve gamma)
  - Black levels inconsistent (AGC, auto contrast)
  - Most units “tamed” in range of 100 – 150 nits (29 – 44 ft-L)
- Color Temperature
  - Consistent tracking a challenge for LCDs with CCFLs
  - LED backlights improve performance
  - Plasma displays track stable color temperatures

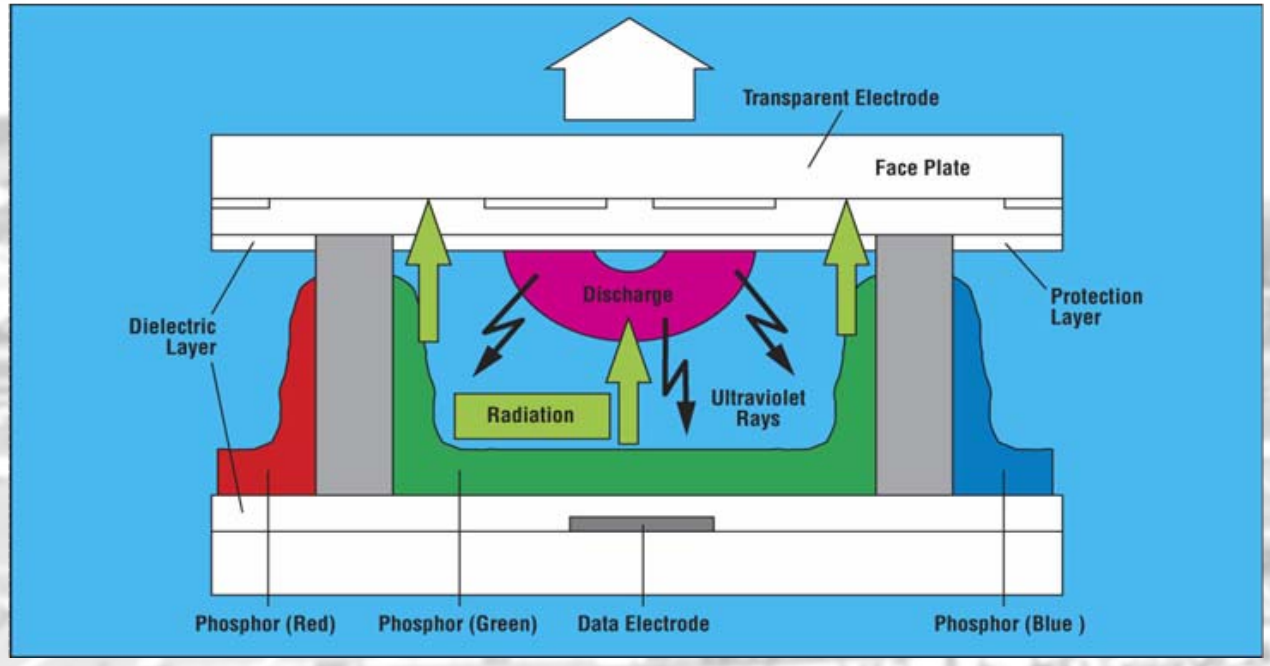


A Practical CRT Replacement: Plasma Monitors

Plasma Imaging Process

- Illumination is based on high voltage discharge
  - Pixels are primed with initial voltage
  - Lower voltage pulses address specific pixels
  - Higher voltage then sustains all “on” pixels
- This process happens very quickly (>600 Hz)
- The cycle is “on-off” and there are no incremental steps of operation for different luminance levels
- Pulse-width modulation technique used

Plasma Imaging Process



Plasma uses emissive color imaging, just like a CRT

And Now, To The Lab…

The Experiment

- **Question:** Is a $2,000 42-inch industrial plasma display good enough to be used as a reference monitor?
- **Why?** Many end users are looking to replace CRTs, and aren't enthusiastic about using LCD monitors
  - Current pro LCD solutions are perceived as costly
  - Complaints about LCD image quality:
    - Black levels are too high
    - Color gamuts are limited or inaccurate
    - Off-axis shifts in grayscale and color are a problem

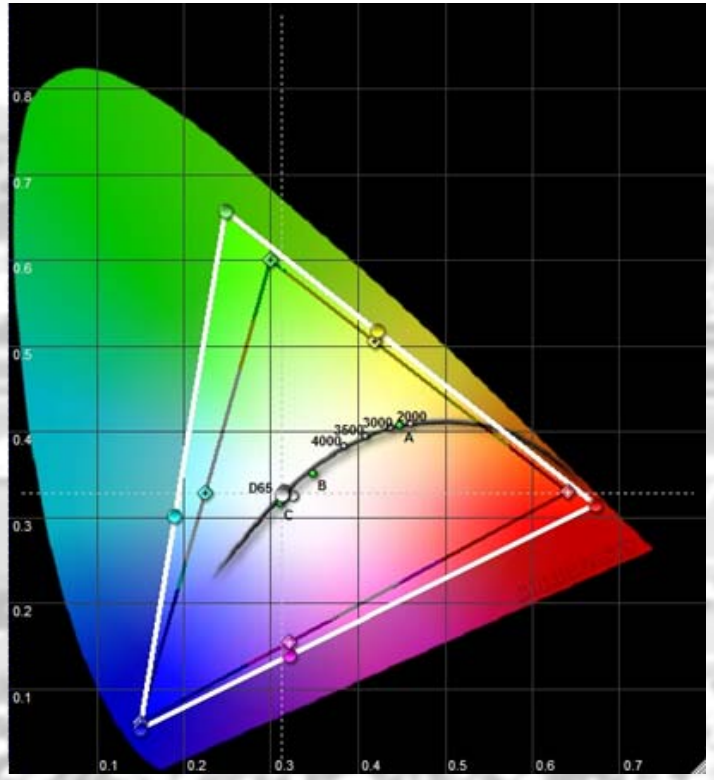
Methodology

- Take a stock Panasonic TH-42PF11UK and calibrate for best dynamic range (the widest, uncompressed and consistent grayscale without clipping or crush)
  - Calibration done with basic ($2,500) hardware and software
  - Measure gamma response, black levels, color gamut, color accuracy, contrast, and brightness
  - Equip with HDMI and HD-SDI input cards for demos
  - Gather feedback from “critical eyes”

The Results?

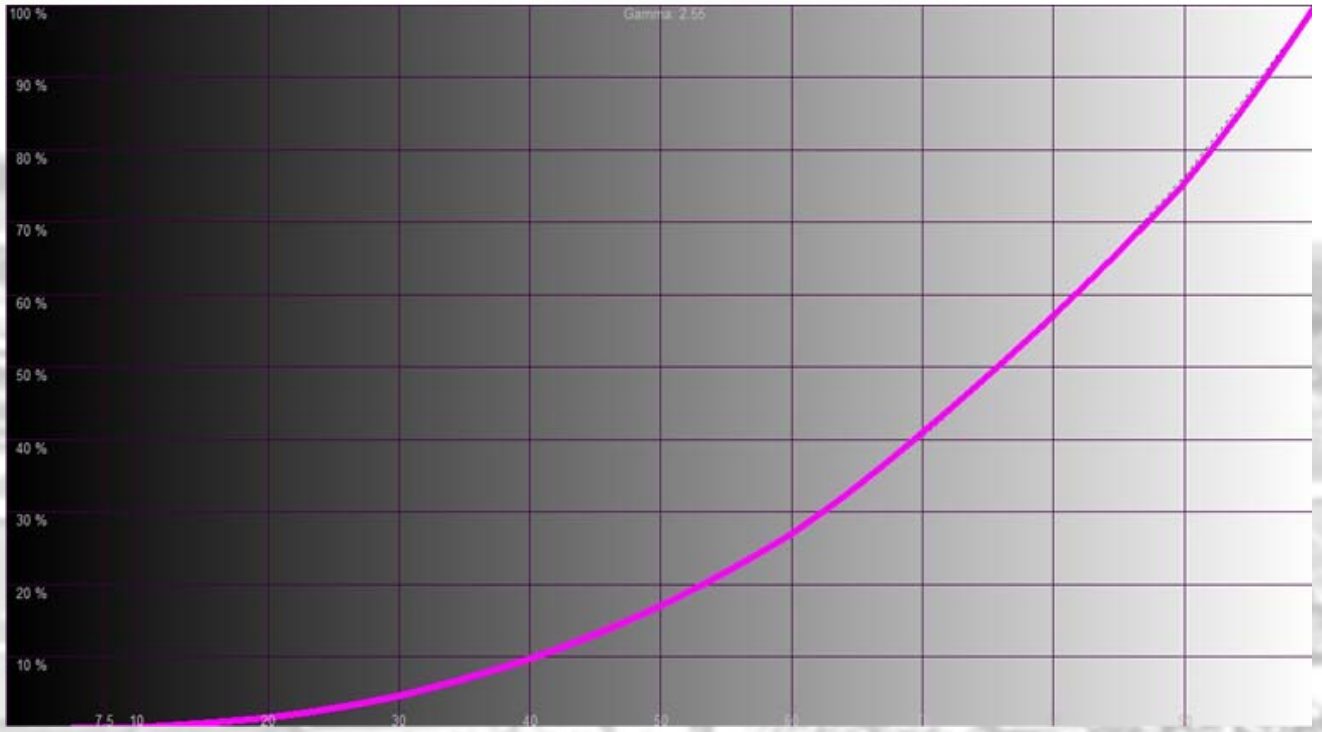
- Very good dynamic range performance
- Stable gamma, with some ‘speed bumps’
- Consistent (not perfect) RGB tracking
  - Room for improvement using detailed software control
- Resulting color gamut supports many video standards
  - Again, room for improvement
- Excellent black level and contrast performance
- It worked much better than I expected!

Measured Color Gamut



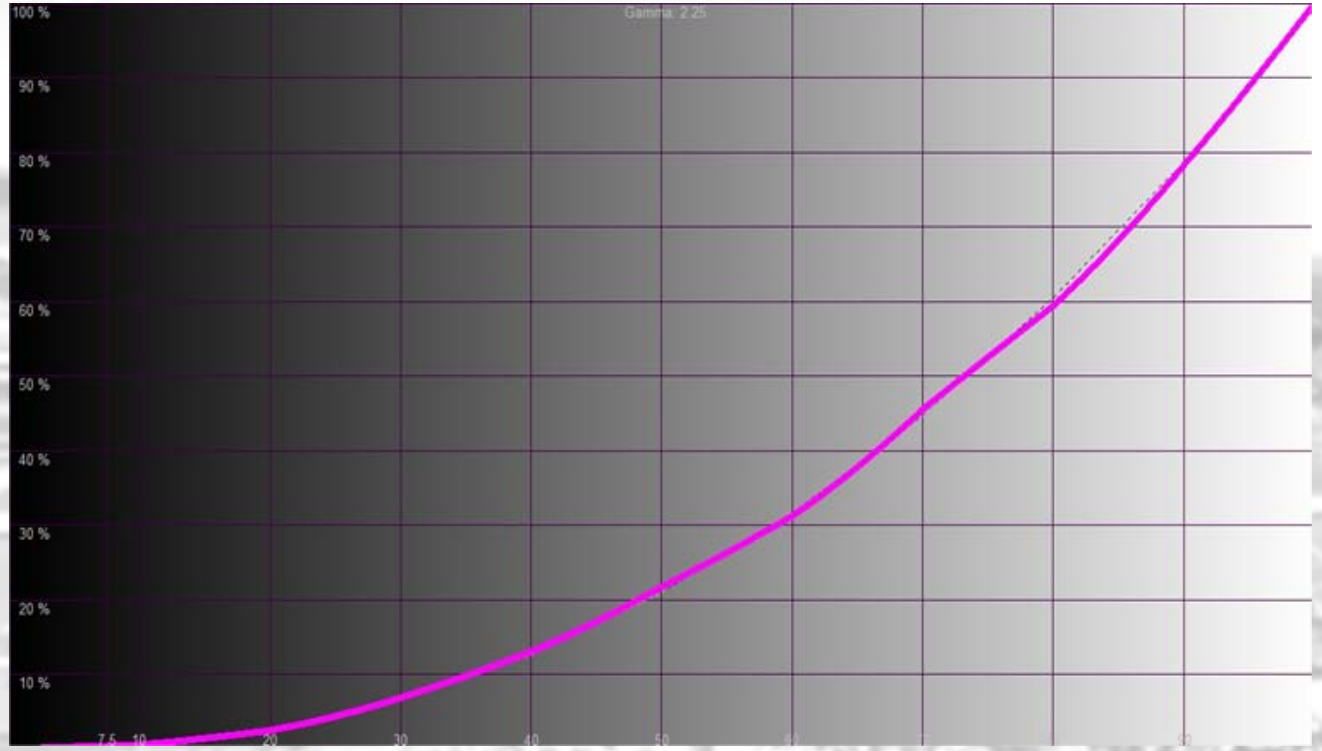
- Color gamut plotted using HD-SDI input card
  - Space is large enough to cover all of HDTV gamut (BT.709)
  - Also large enough to cover good portion of digital cinema P3 minimum gamut
  - Needs ‘snap-to’ correction

Gamma Response #1



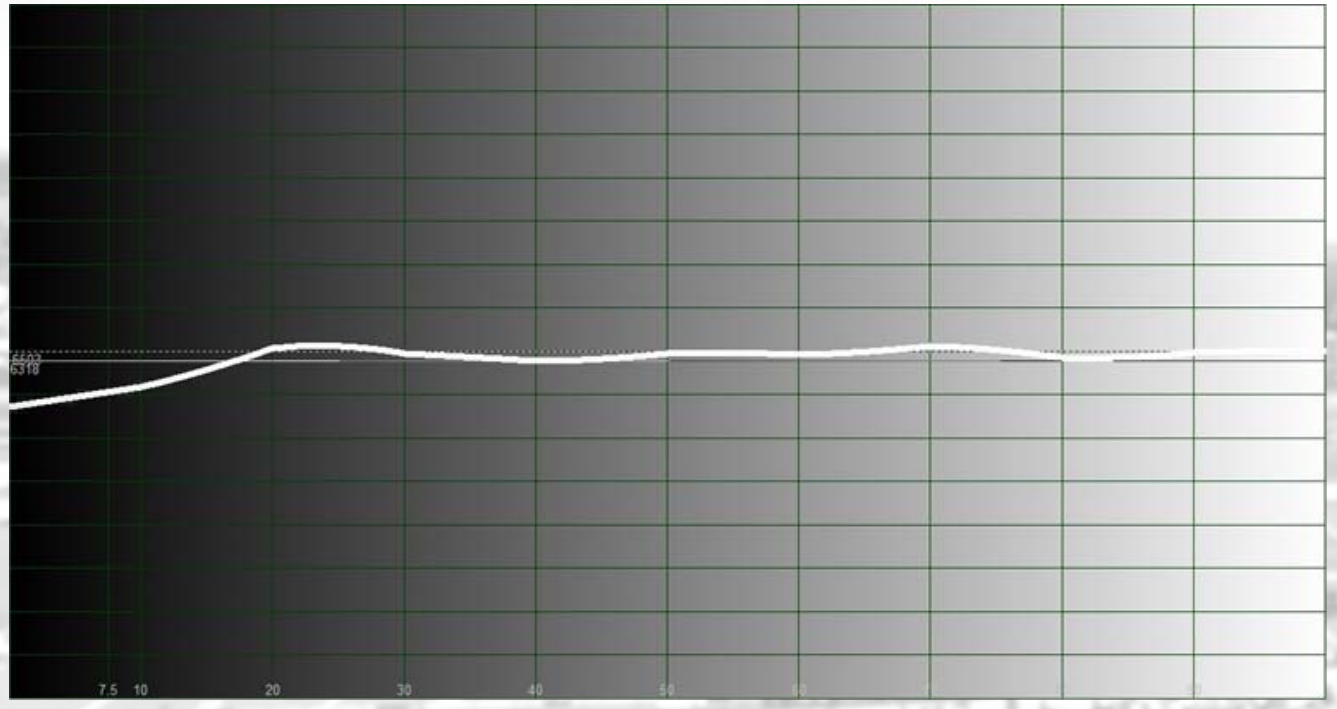
Actual gamma response = 2.55 (peak white @ 120 nits) in Film mode

Gamma Response #2



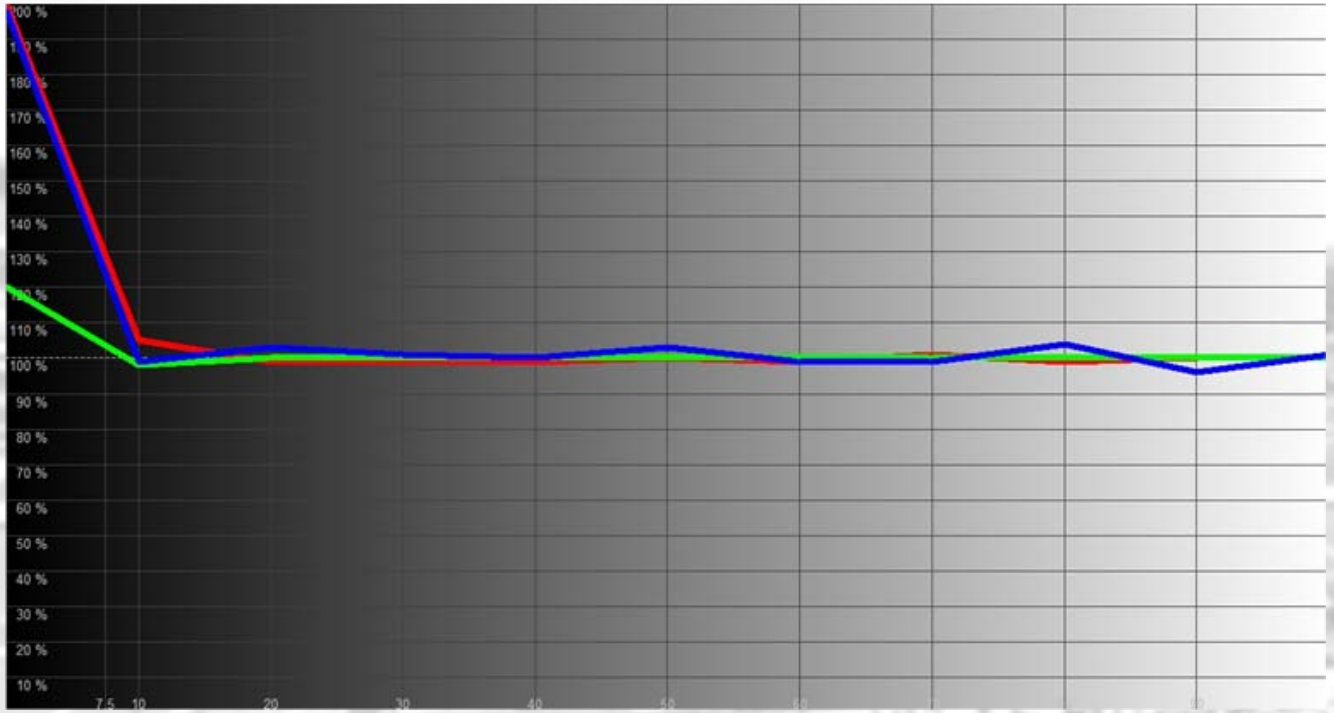
Actual gamma response = 2.25 (peak white @ 120 nits) in Video mode

Grayscale Tracking



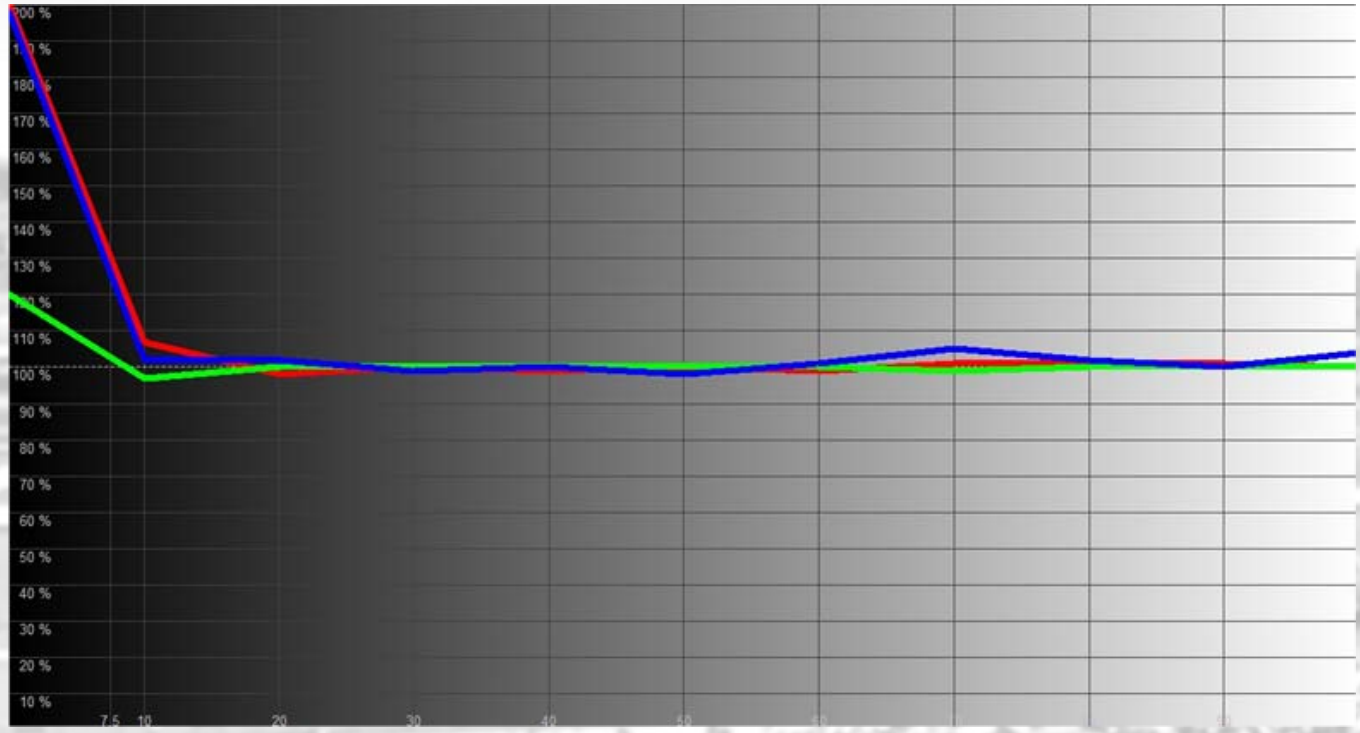
Target reading – 6500K (Maximum shift seen was 145K from 20-100 IRE)

Grayscale Tracking



RGB histogram plotted with Gamma 2.2 and Warm CT setting

Grayscale Tracking



RGB histogram plotted with Gamma 2.5 and Warm CT setting

Brightness & Contrast

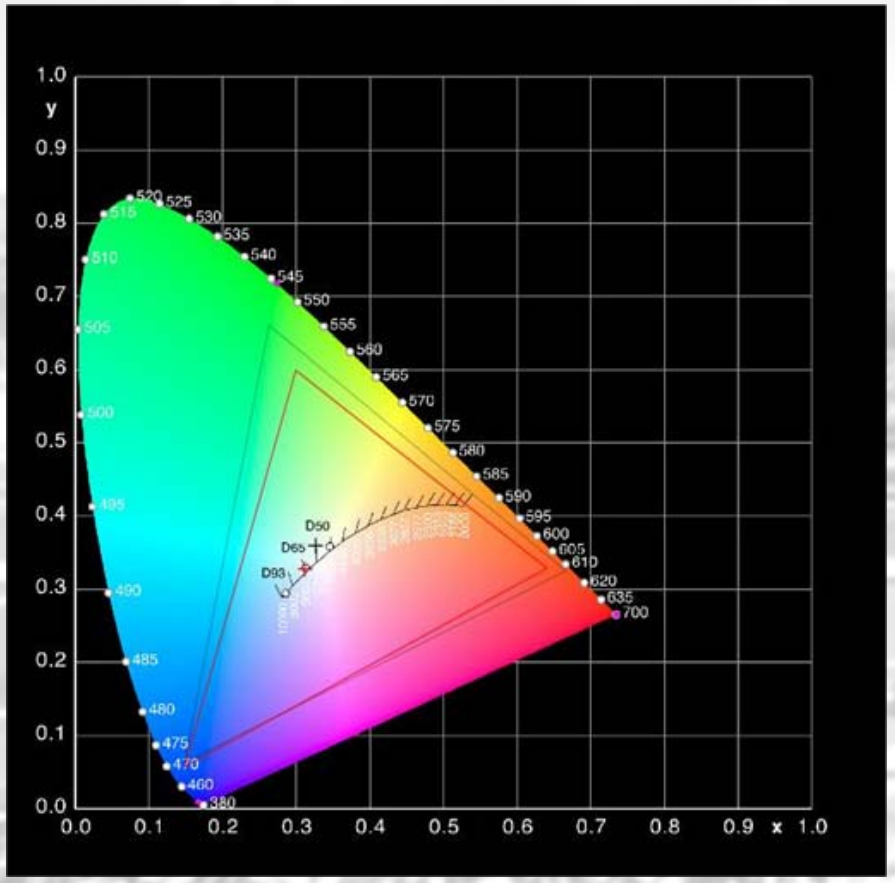
- Brightness measurements:
  - 100-120 nits (29–35 foot-Lamberts)
- Contrast measurements:
  - 829:1 ANSI, 1189:1 peak (checkerboard)
  - Sequential – 11370:1 (Gamma 2.2), 18750:1 (2.5)
- Black level measurements:
  - .124 nits average, .09 nits lowest reading


Further Fine-Tuning of
Grayscale Performance

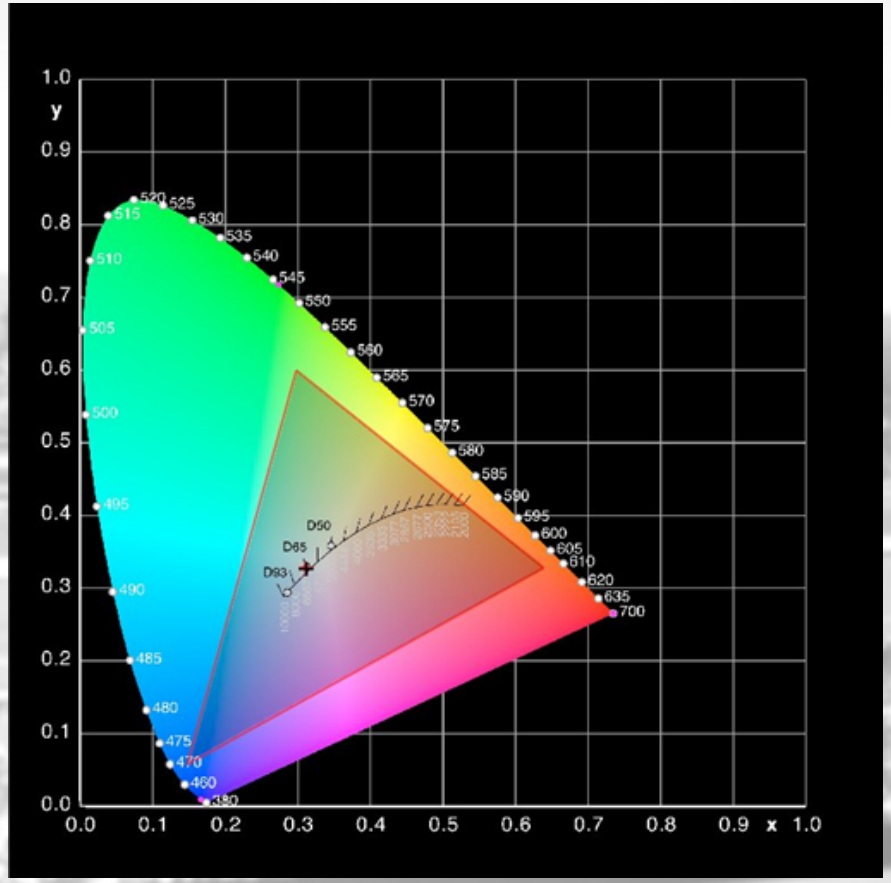
For Added Precision

- **Cine-tal Davio platform**
- Characterizes the display using thousands of color shades
- Generates cineSpace profile for monitor-specific correction of each display
- Provides flexible routing through multiple high-precision 3D LUTs for more accurate response
- Supports multiple color spaces, including RGB and XYZ

Color Gamut Correction



TH42PF11UK color gamut after basic calibration



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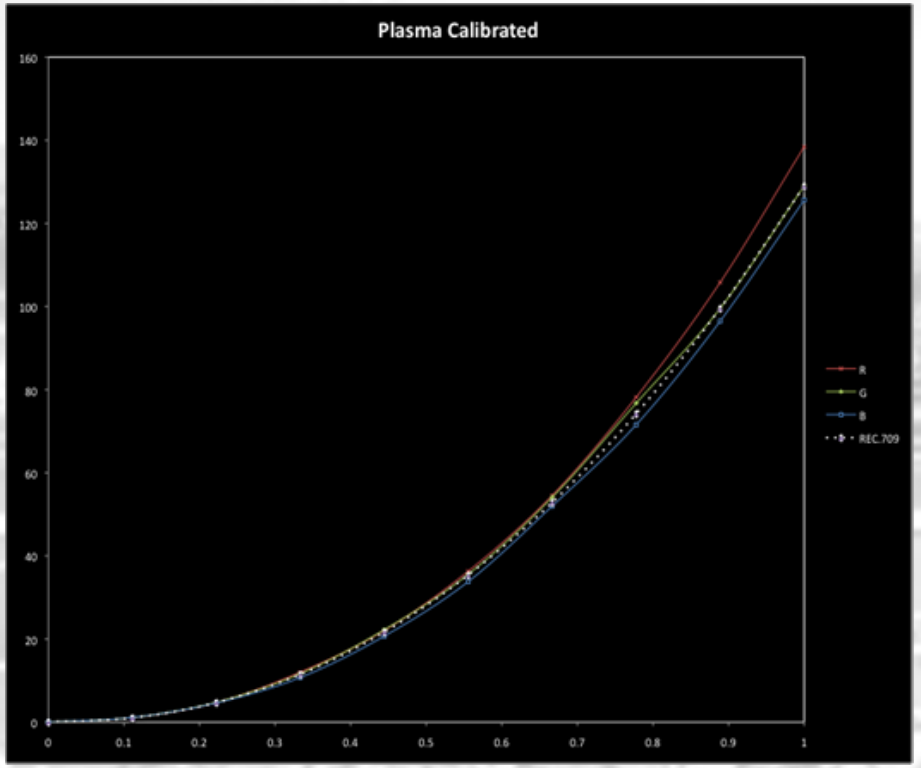
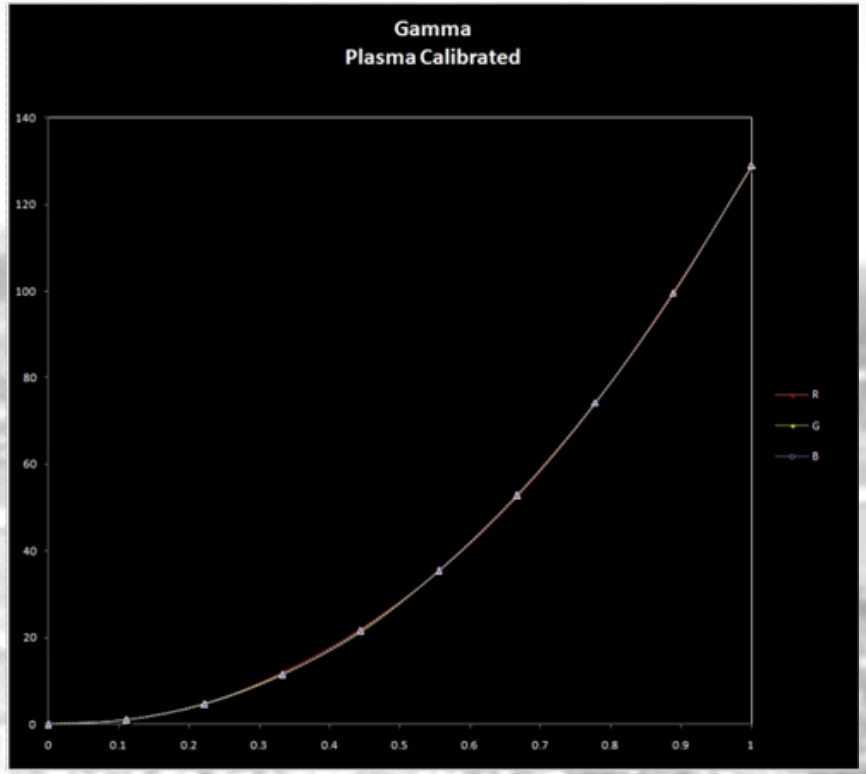
Color Gamut Correction



TH42PF11UK RGB gamma after basic calibration



TH42PF11UK RGB gamma after Davio correction

Conclusions

- Off-the-shelf Gen 11/12 Panasonic plasma displays are suitable for use as BT.709 evaluation monitors
  - But, they must be calibrated for best dynamic range
  - Gamma and black levels are reference quality
  - Color gamut is wider than CCFL-equipped LCDs
- Brightness sufficient for post and grading facilities
- Color accuracy using Davio software tweaks is comparable to reference-grade CRTs
- Best of all – a very cost-effective solution!


Thank you!