

Color for Computer Animated Features

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Animated Feature Pipeline

- **story**
- **art**
- **layout**
- **anim**
- **shading**
- **lighting**
- **mastering**
- **exhibition**



Color Critical

- story
- art
- layout
- anim
- shading
- lighting
- mastering
- exhibition



Color Critical - Review Spaces

- **Monitors**
 - CRT
 - Calibratable LCD
- **Projection**
 - Texas Instruments DLP projectors



Color Critical - Review Spaces

- **Monitors**
 - Desktop
- **Projection**
 - Review Room
 - Screening Room
 - Grading Suite



Reference Target

- Response Curve
- Color Primaries
- White Point
- Brightness
- Contrast Ratio



Calibration

- **Colorimetric**
- **Same as each other, same as a target**
- **Colorimeter (3 or 4 sensor puck)**
- **Spectroradiometer (spectral data)**
- **Response Curve**
- **Color Primaries**
- **White Point**
- **Brightness**
- **Contrast Ratio**



Response Curve

- For a given signal value, how much light does the viewer see?
 - Gamma
 - sRGB
- Response Curve
 - Color Primaries
 - White Point
 - Brightness
 - Contrast Ratio



Color Primaries

- **Red Green Blue**
- **CIE xy coordinates**
- **Chromaticities**
 - Rec709
 - P22 phosphor emulation
 - P3
 - ACES
- **Response Curve**
- **Color Primaries**
- **White Point**
- **Brightness**
- **Contrast Ratio**



White Point

- D65
 - D55
 - DCI Calibration White
 - CCT 6500K is NOT D65
 - There is no D6500K
- Response Curve
 - Color Primaries
 - White Point
 - Brightness
 - Contrast Ratio

Brightness

- Foot-lamberts (fL)
- candela per square meter (cd/m²)
- 1 nit == 1 cd/m²
- fL == $(100/(12*2.54))^2 / \pi = 3.426$ nits
- 14 fL $\approx$ 48 nits
- 35 fL $\approx$ 120 nits
- Response Curve
- Color Primaries
- White Point
- Brightness
- Contrast Ratio



Contrast Ratio

- Relative brightness measure of whitest white to blackest black
- Simultaneous contrast
- Sequential contrast
- Response Curve
- Color Primaries
- White Point
- Brightness
- Contrast Ratio

Art Direction

- Reference photos
- Color palettes
- Look development

Shading

- **Reference textures**
- **Texture painting**
- **RenderMan Shading Language**

Lighting

- Linear processing
- Artistic intent
- Non-linear look modification



Mastering

- In-house Color Grading
- Projection Color Spaces for HD, Dcin, Film
 - Rec709
 - P3D65
 - P3FilmWhite



Mastering - Film

- Film has different gamut than digital projection
- Preview gamut change during grading

Mastering - DCIN

- Color grading in P3D65 color space
- Digital Cinema Distribution Master - DCDM
- X'Y'Z' encoded 12bits per channel



Mastering - HD

- Color grading in Rec709 color space
- HD Master is RGB 10bit



Exhibition - Digital Cinema

- Digital Cinema Package (DCP)
- JPEG2000 (J2K)
- Compressed to 250 mb/s
- Texas Instruments DLP projector



Exhibition - HD

- RGB 10bit >> YCbCr >> 4:2:2 >> 8bit
- MPEG4 AVC compression
- Blu-ray Disc
- 28-30 mb/s average bit rate, 34 peak