Introduction to Color Spaces

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Color Model

- A color model is simply a way to define color. A model describes how color will appear on the computer screen or on paper.

RGB (red, green, blue)

CMYK (Cyan, Magenta, Yellow, Black)

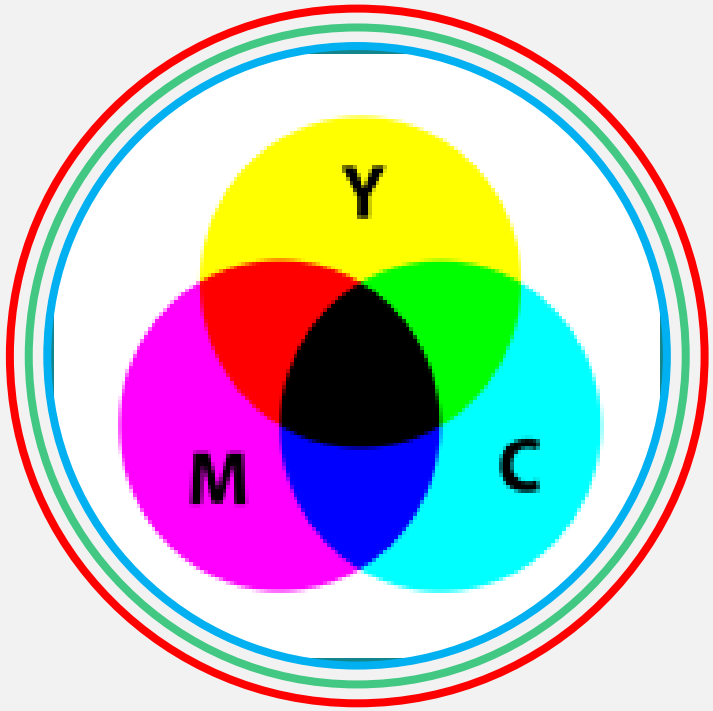
LAB Color

RGB Color Model

- Additive color mixing.
- Color based on percentage of red, green and blue saturation.
- Describes light needs to be emitted to produce a given color.
- Used with screen based designs.

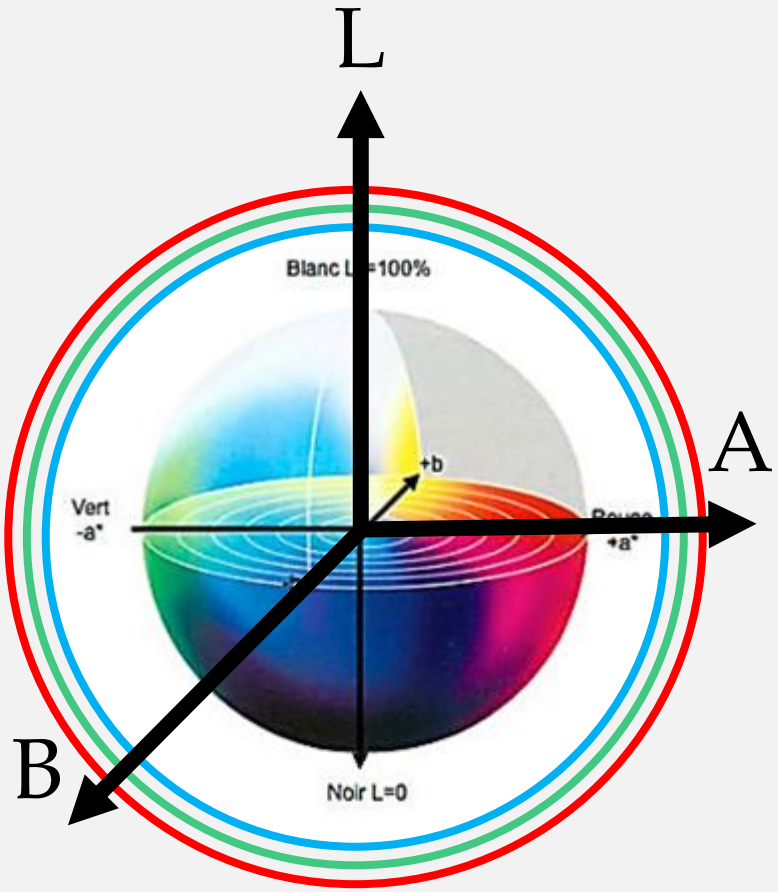
CMYK Color Model

- Subtractive color mixing.
- Colors based on their percentage of Cyan, Magenta, Yellow and Black
- Describes the inks need to be applied so the light reflected from the substrate and through the inks produces a given color.
- Used with print based designs.



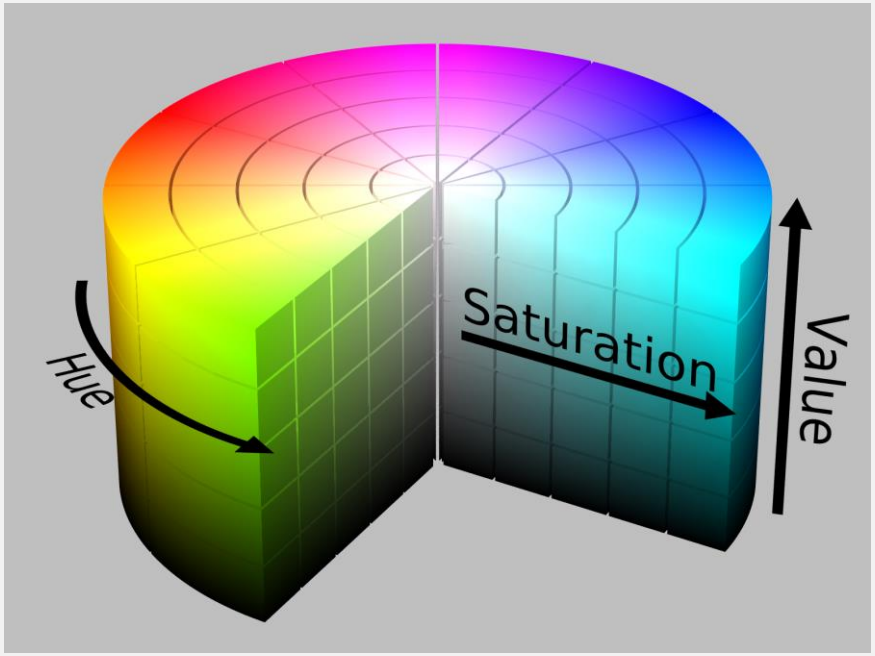
LAB Color Model

- Color Components
  - Lightness (L)
    - range = 0-100
  - ‘A’ color component
    - range = -128 to 127
  - ‘B’ color component
    - range = -128 to 127



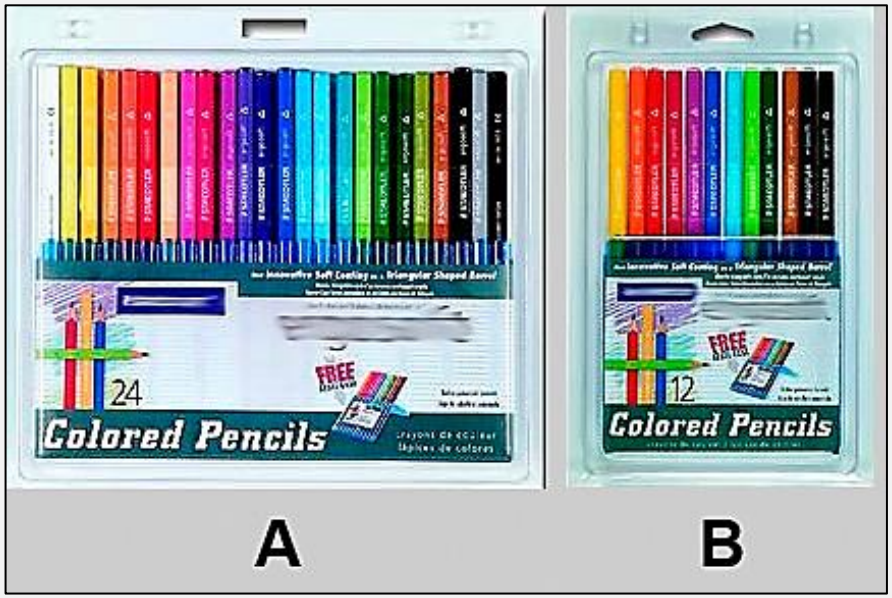
HSV Color Model

- Color Components
  - ‘H’, Hue
    - Angle 0-360
  - ‘S’ Saturation
    - range = 0-1 (0%- 100%)
  - ‘V’ value
    - range = 0-1 (0% -100%)



Color Gamut (Chromaticity Diagram)

- Range of colors in a color space
- Entire range of colors available on a particular device such as a monitor or printer



Color Spaces

- Method Chosen to represent brightness, luminance or intensity and colors.

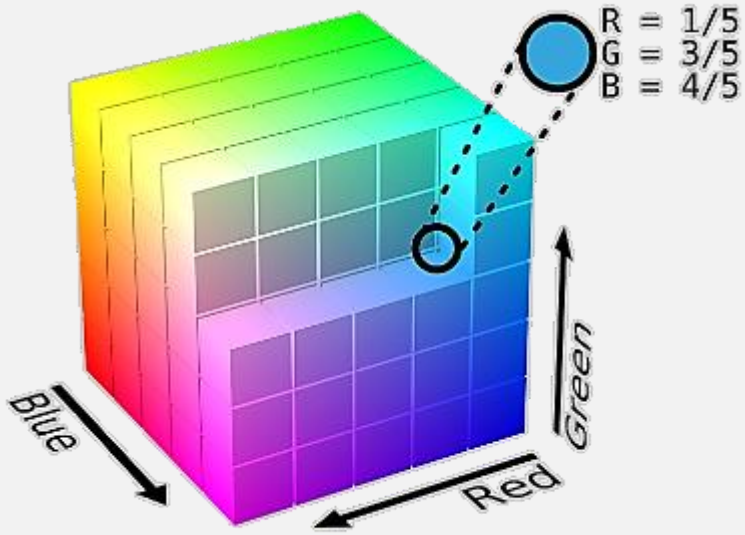
- A color space is a specific organization of colors.

Color Spaces

- Pro-photo RGB space
- Adobe RGB space
- sRGB (Standard RGB)
- YCbCr (Luma and chroma)
- HSI (Hue, Saturation & intensity)
- CMYK color space
- LAB color space

sRGB Color space

- Additive color mixing.
- Color based on percentage of red, green and blue saturation.
- Describes light needs to be emitted to produce a given color.
- Used with screen based designs.



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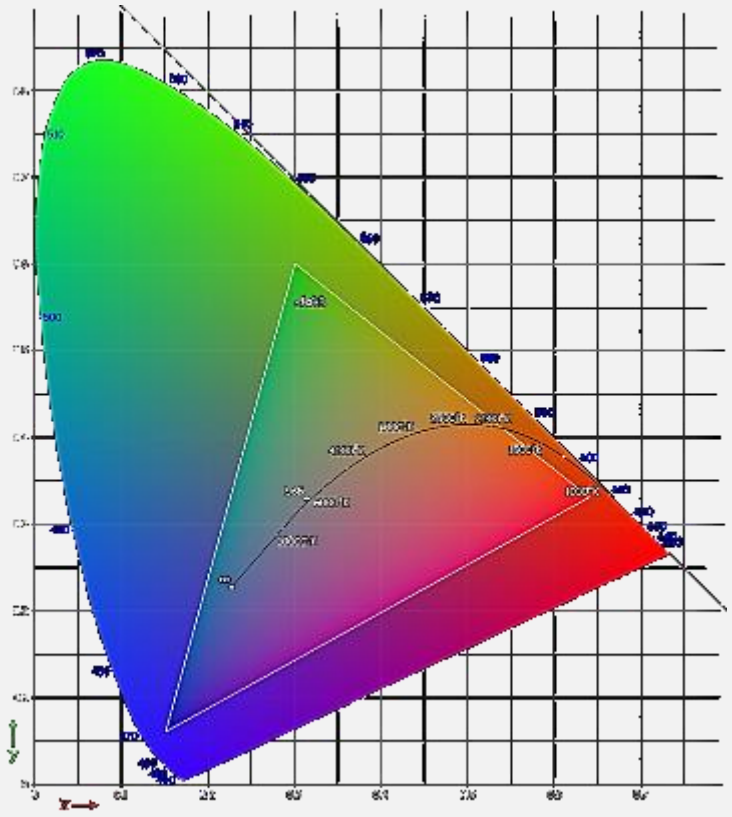
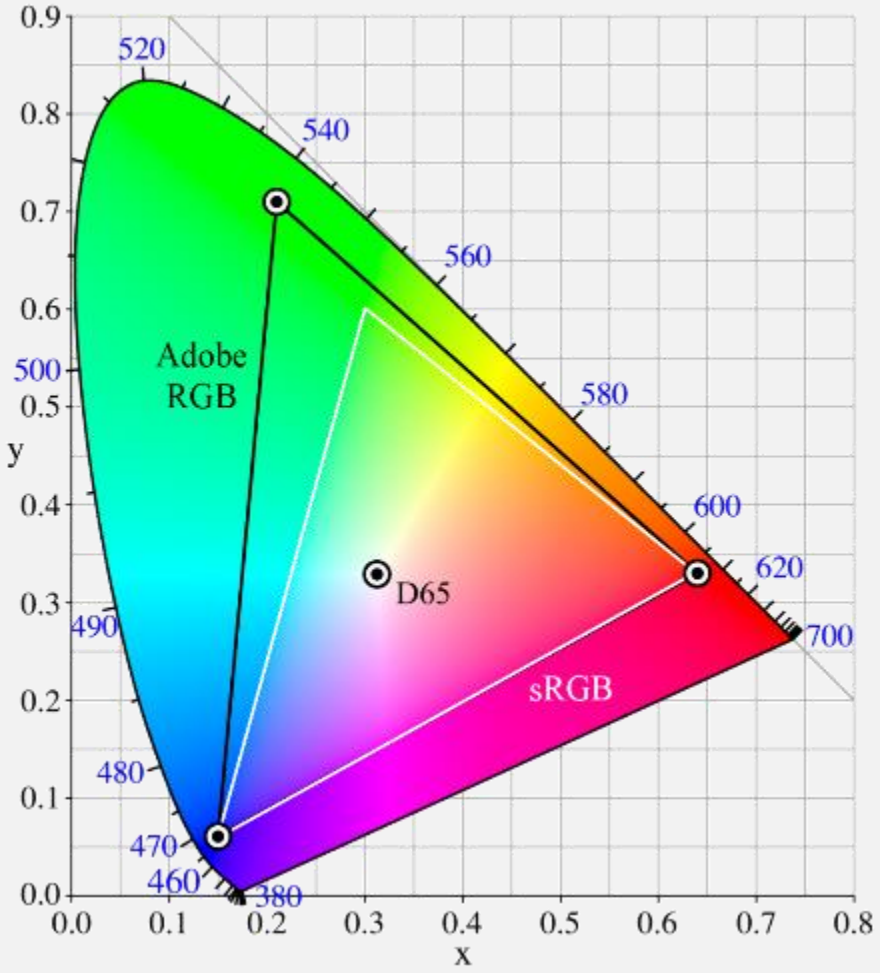
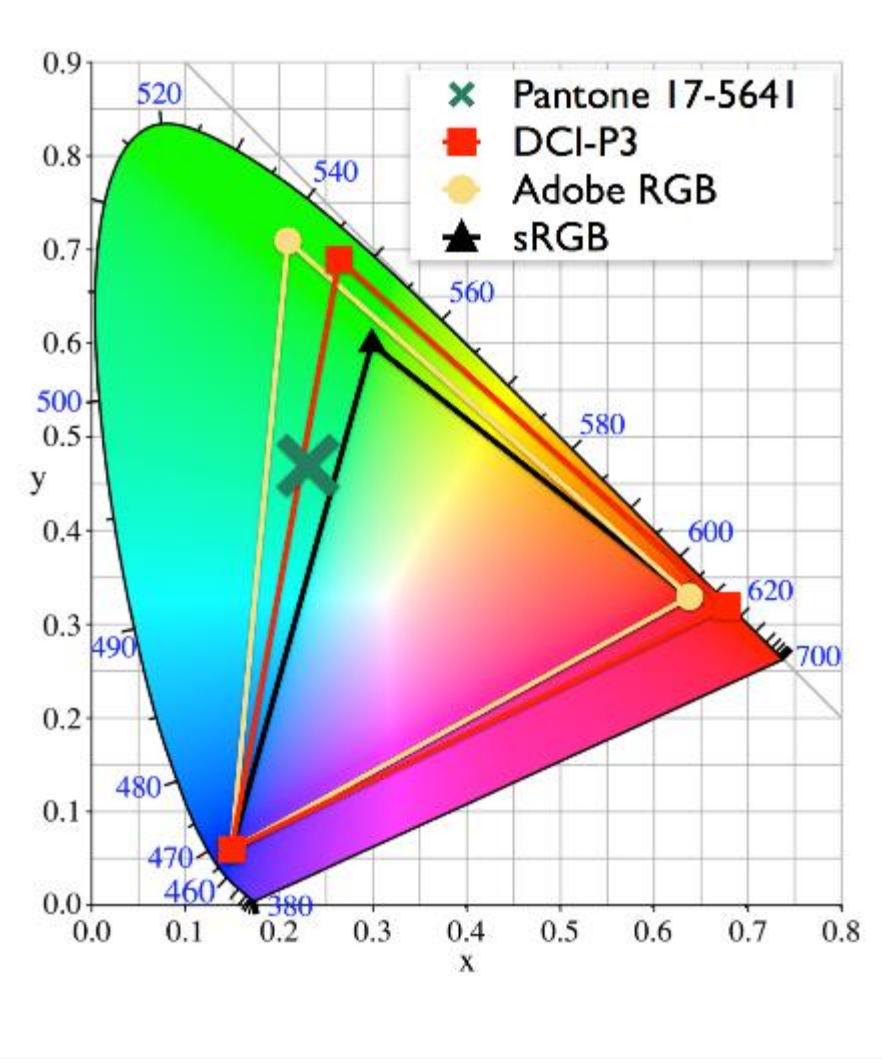


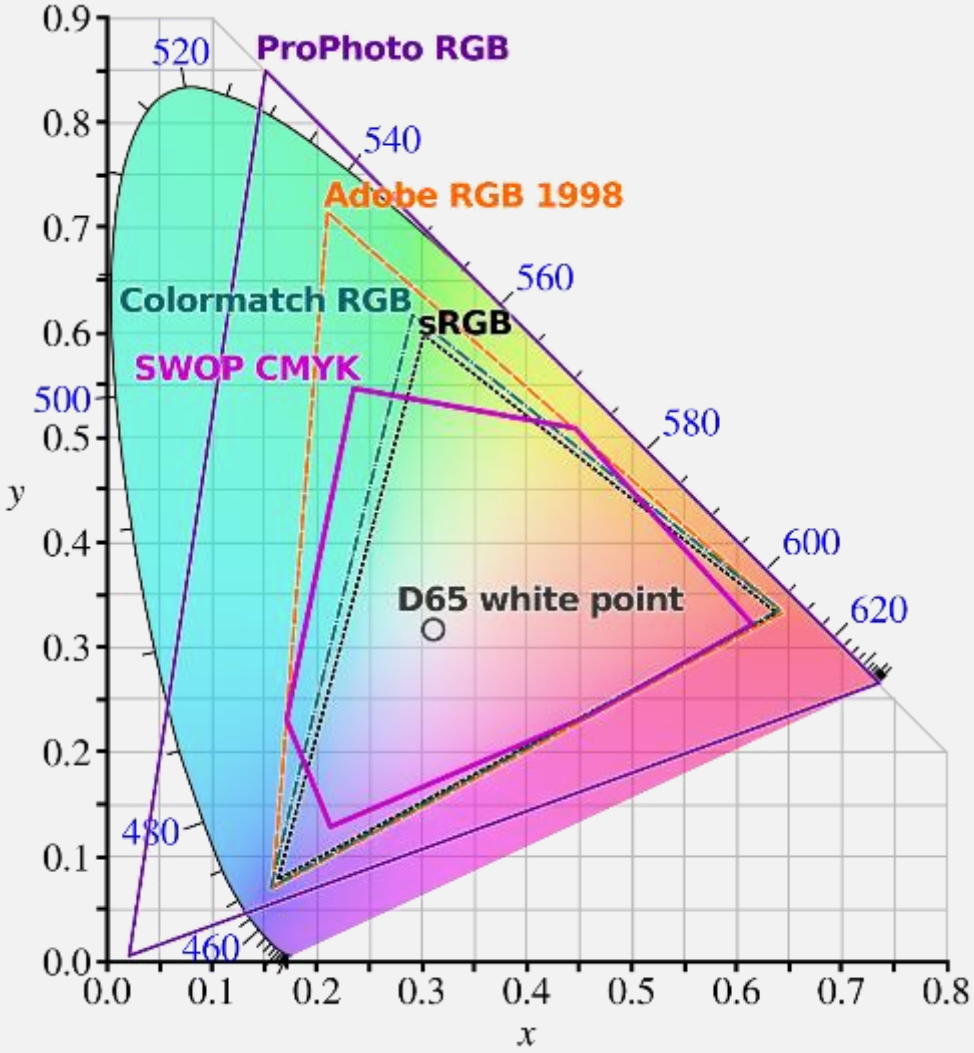
Color Gamut


0.9
0.8
0.7
0.6
500
0.5
y
0.4
0.3
490
0.2
480
0.1
470
460
0.0
380
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
x
520
540
560
580
600
620
700
Adobe
RGB
D65
sRGB

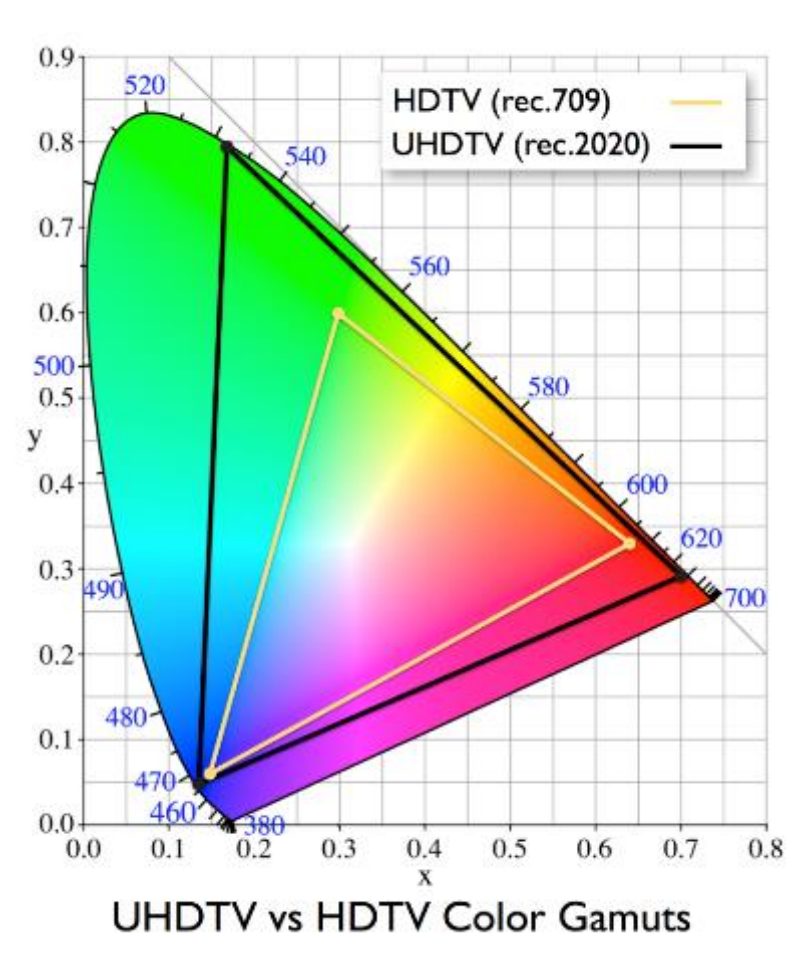
Color Gamut


Pantone 17-5641
DCI-P3
Adobe RGB
sRGB
520
540
560
580
600
620
700
500
490
480
470
460
380
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
y
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
x

Color Gamut

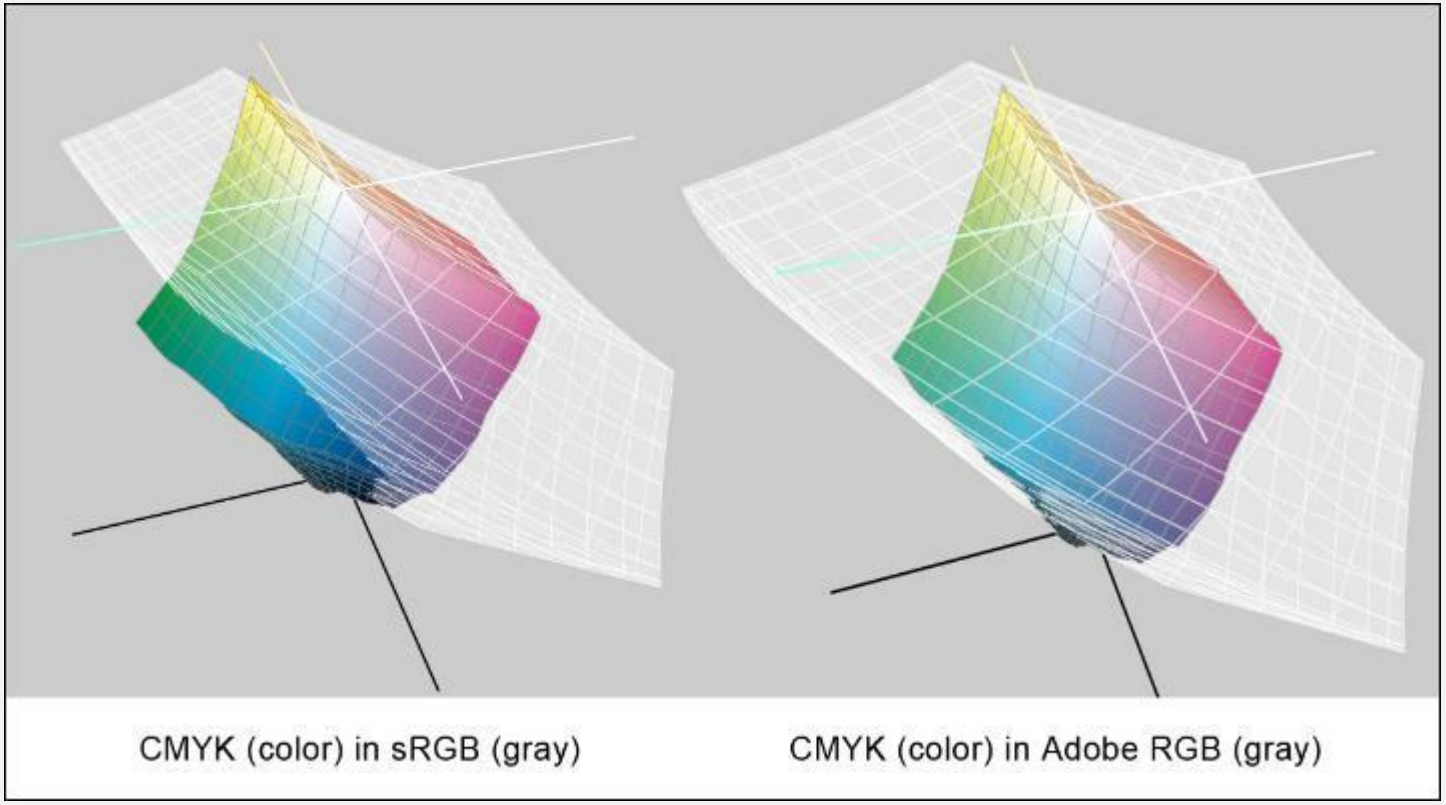

ProPhoto RGB
Adobe RGB 1998
Colormatch RGB
sRGB
SWOP CMYK
D65 white point
520
540
560
580
600
620
500
480
460
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
y
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
x

Color Gamut

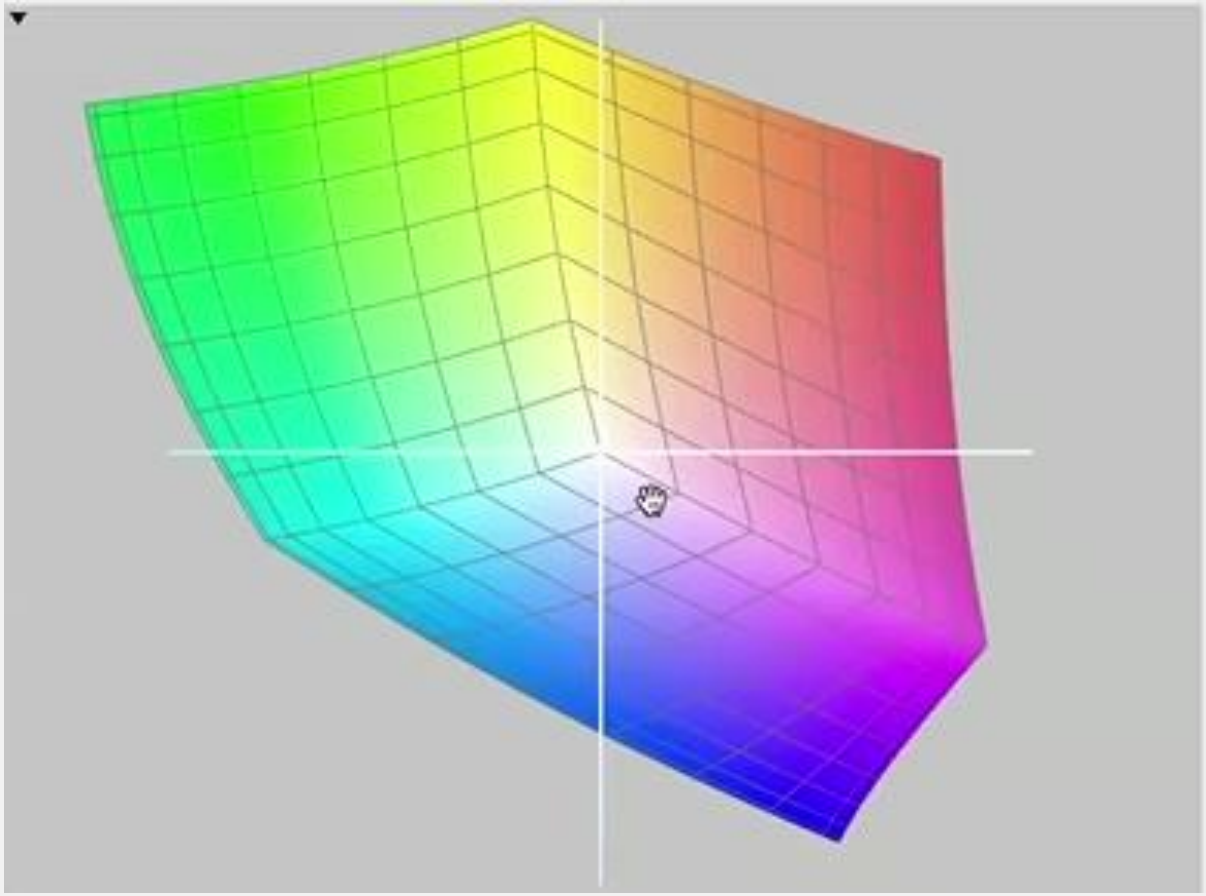


UHDTV vs HDTV Color Gamuts

Color Gamut

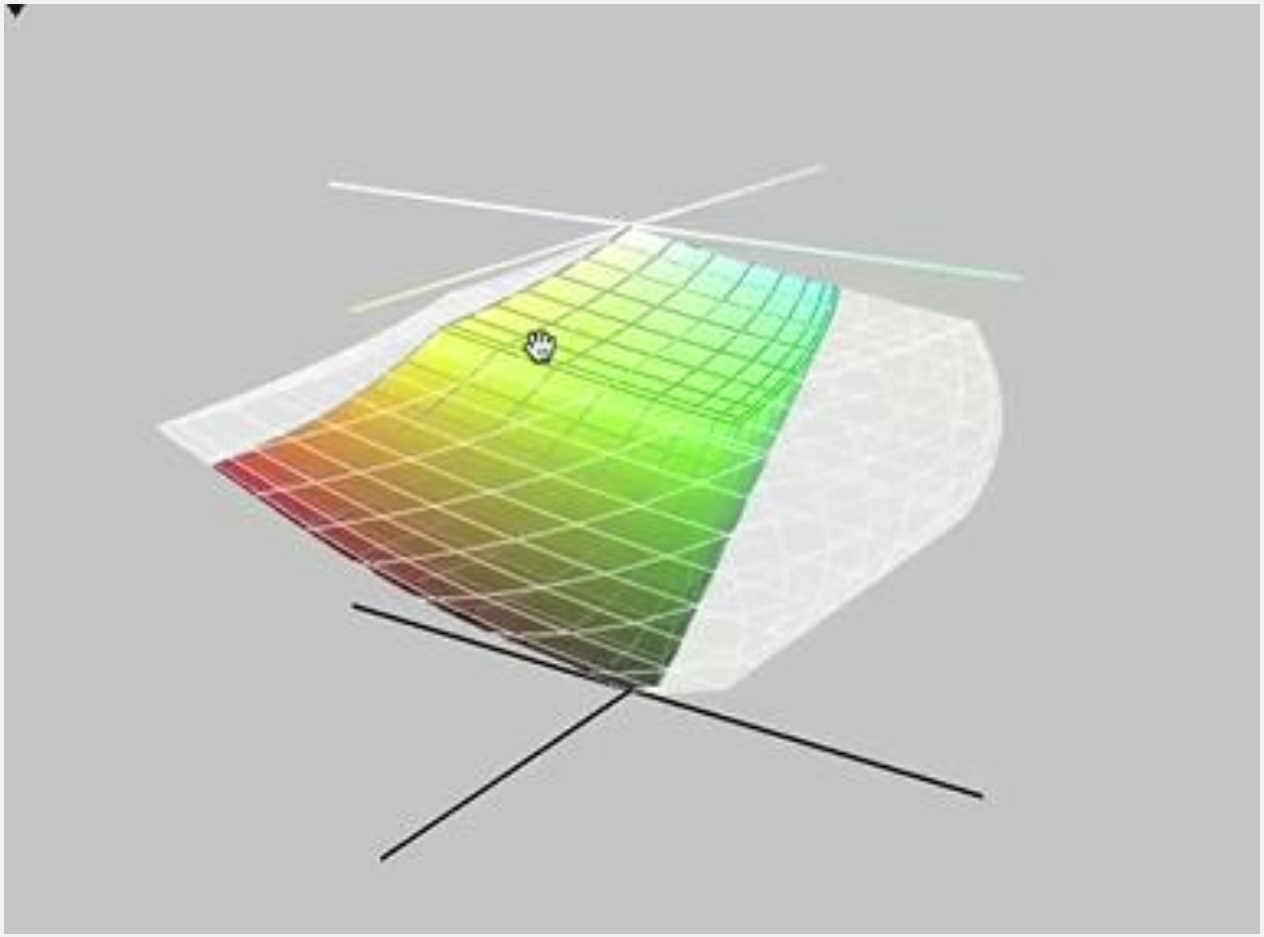


Color Gamut



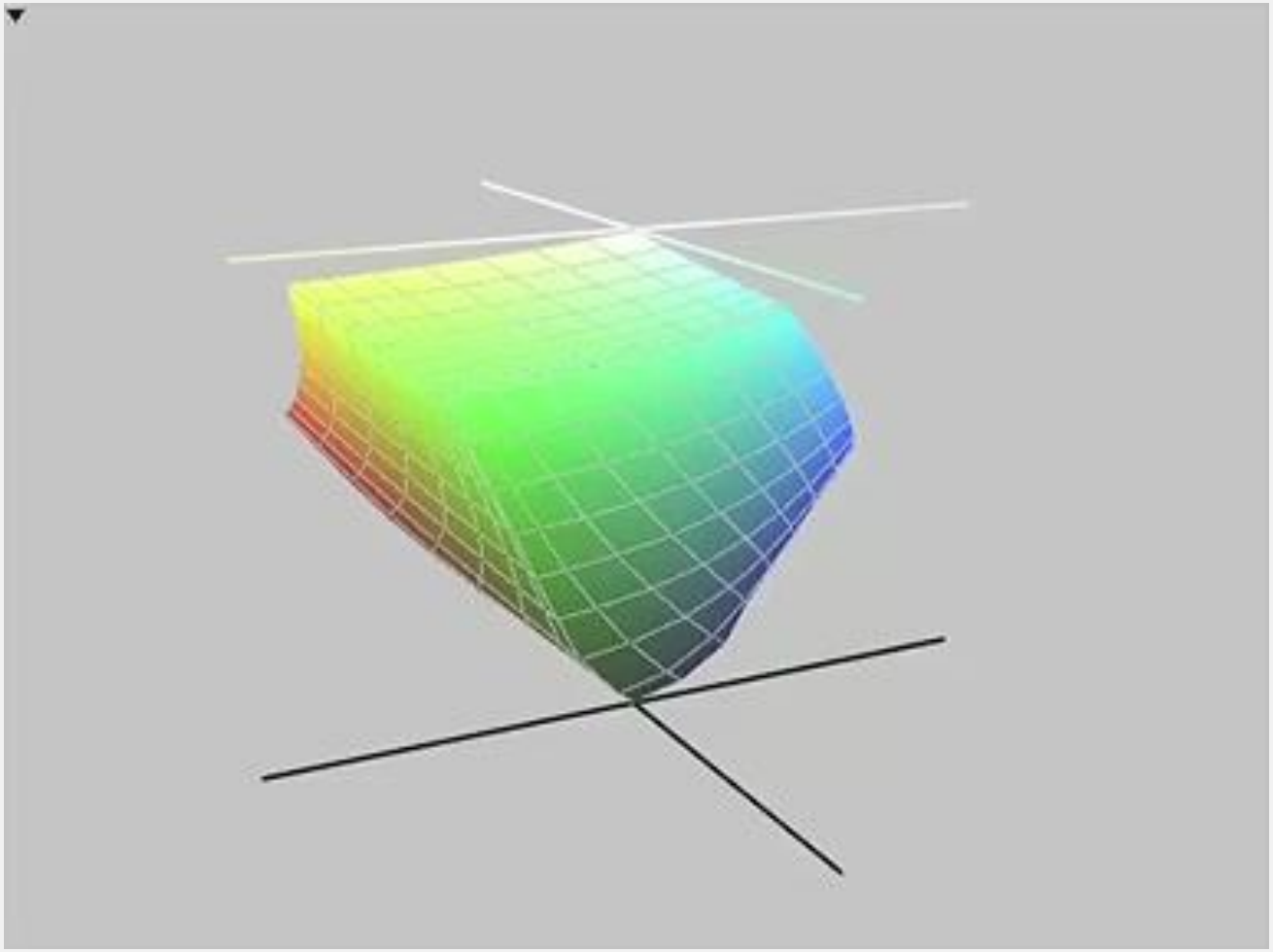
sRGB (color) gamut

Color Gamut Comparison



sRGB (color) vs Adobe RGB (wiregird) comparison

Color Gamut Comparison



sRGB (grid) vs CMYK(color) comparison

Color Gamut Output Comparison

YC_BC_R Color space

- HVS (Human Visual System) is less sensitive to color than luminance.

Luminance (Y)	Chrominance (C_B, C_R)

YC_BC_R Color space

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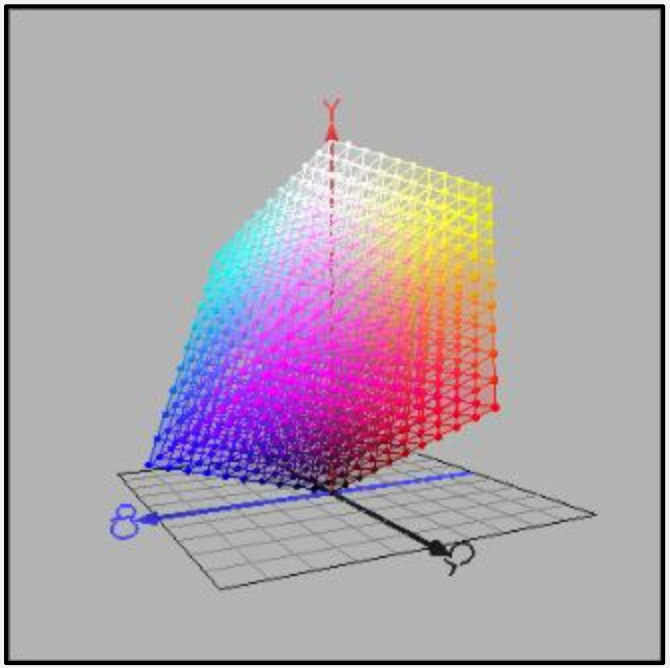
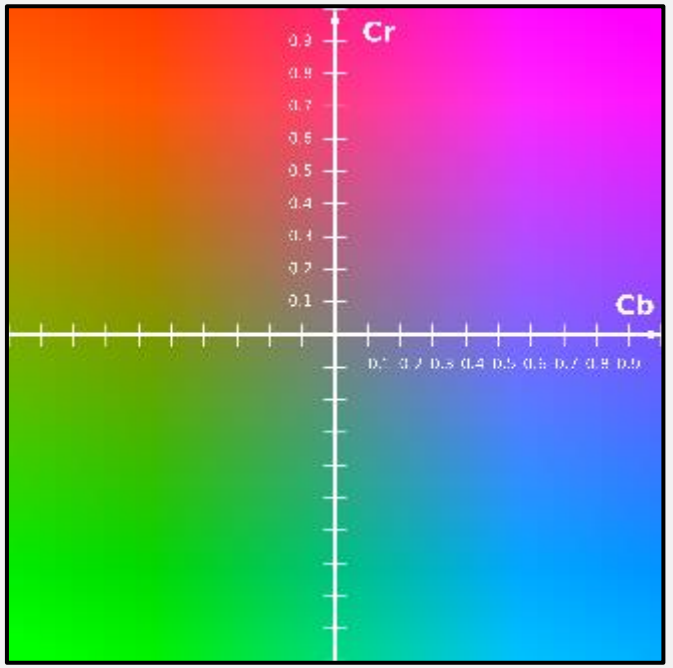
Luminance (Y)	Chrominance (C_B, C_R)

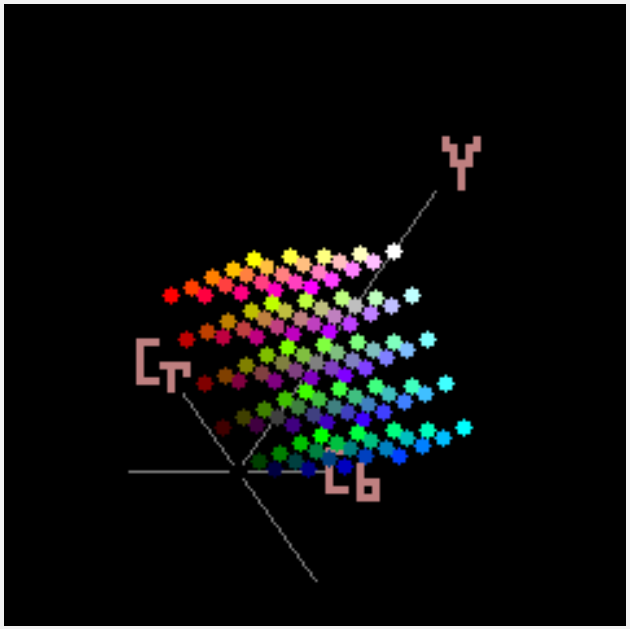




YC_BC_R Color Space

- HVS (Human Visual System) is less sensitive to color than luminance.

Luminance (Y)	Chrominance (C_B, C_R)



YC_BC_R Color Space

$$\begin{bmatrix} Y \\ C_b \\ C_r \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.147 & -0.289 & 0.436 \\ 0.615 & -0.515 & -0.100 \end{bmatrix} . \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1.000 & 0.000 & 1.140 \\ 1.000 & -0.395 & -0.581 \\ 1.000 & 2.032 & -0.000 \end{bmatrix} . \begin{bmatrix} Y \\ U \\ V \end{bmatrix}$$

YC_BC_R Color Space

$$Y = k_r R + K_g G + K_b B$$

$$C_r = R - Y$$

$$C_b = B - Y$$

$$C_g = G - Y$$

YC_BC_R Color Space

$$Y = 0.299R + 0.587G + 0.114B$$

$$C_b = 0.564(B - Y)$$

$$C_r = 0.713(R - Y)$$

YC_BC_R Color Space

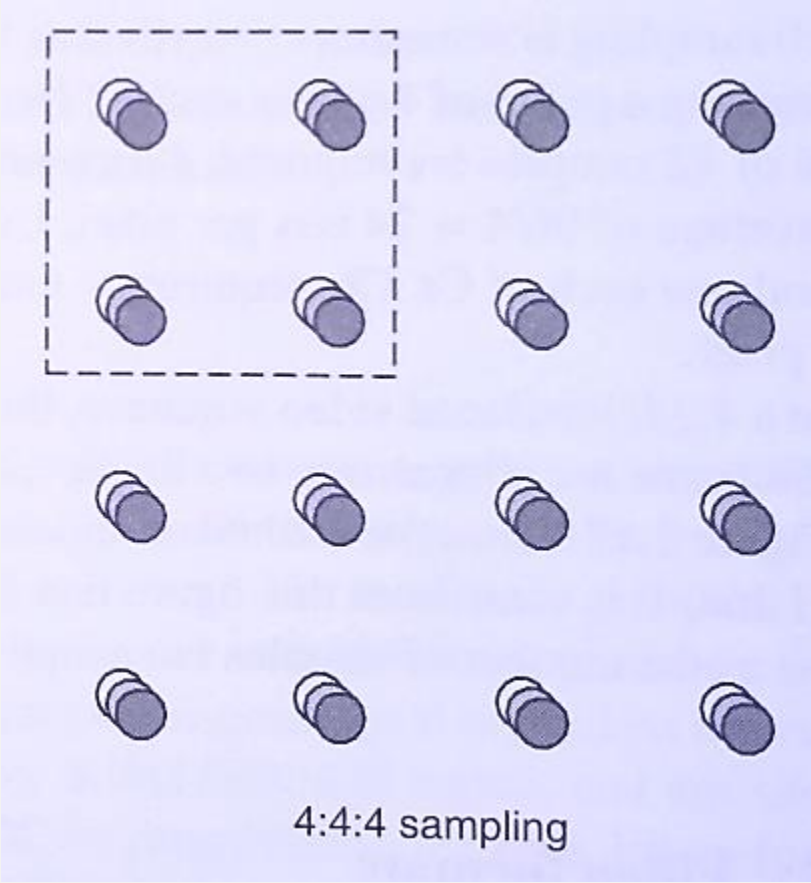
$$R = Y + 1.402C_r$$

$$G = Y - 0.344Cb - 0.714C_R$$

$$B = Y + 1.77Cb$$

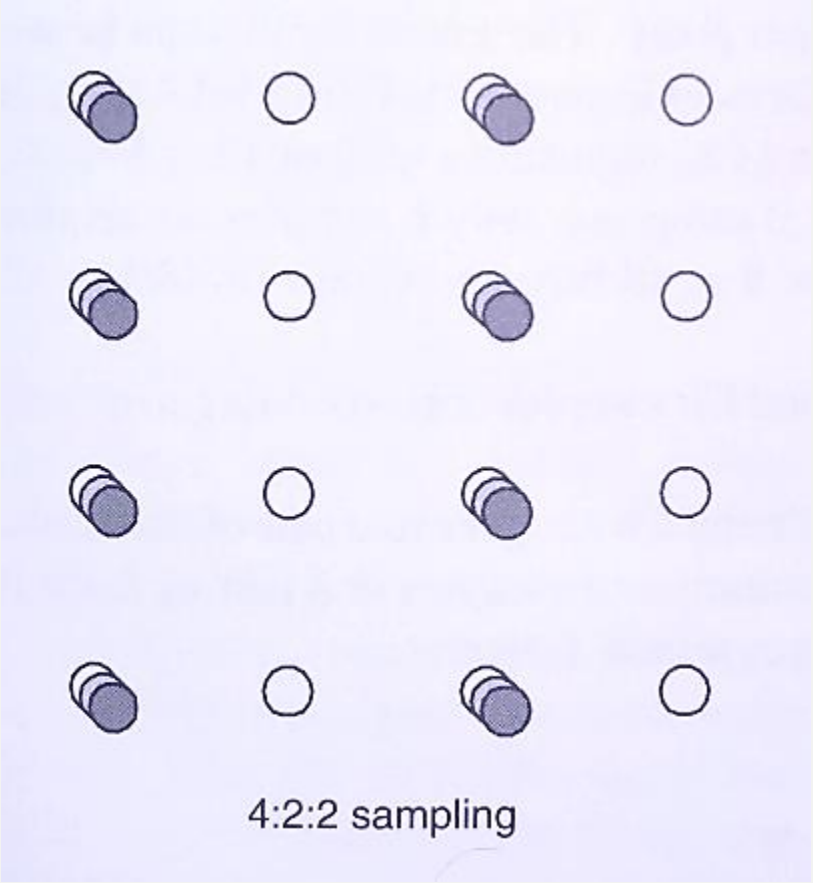
YCBCR (4:4:4) Sampling

- For every Y sample there is one C_b and C_r samples



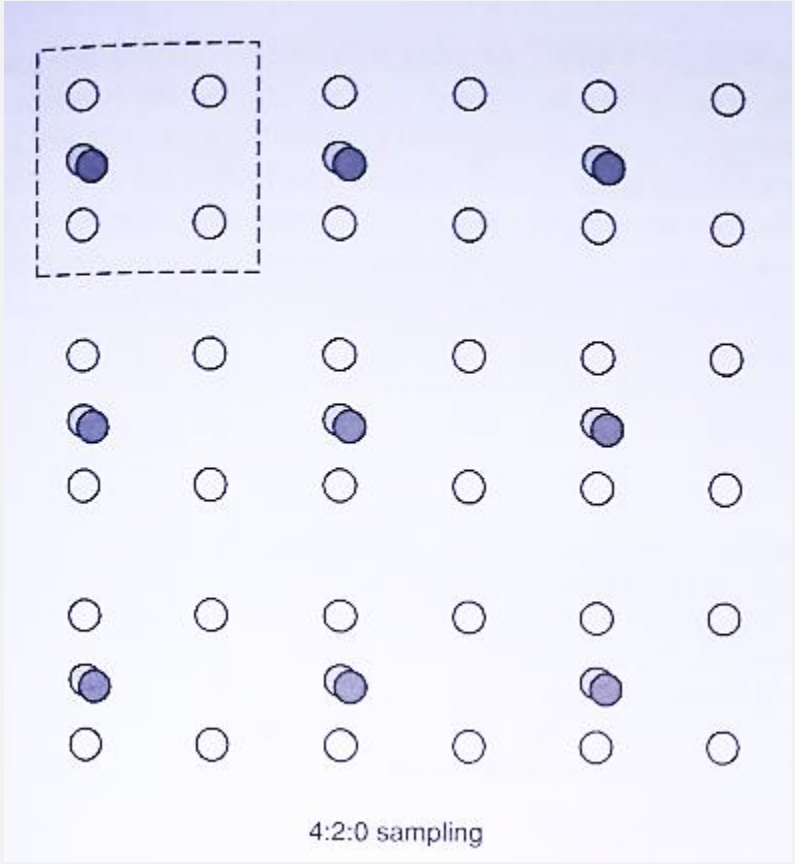
YCBCR (4:2:2) Sampling

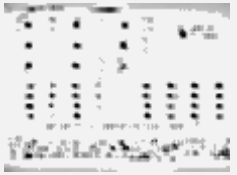
- For every 4 Y samples there are 2 C_b and 2 C_r samples



YCBCR (4:2:0) Sampling

- For every 4 Y samples there are 1 C_b and 1 C_r samples





YC_BC_R Color Space

$Image\ resolution: 720 \times 576\ pixels$

$Y\ (luma) resolution =$

YC_BC_R Color Space

$$Image\ resolution: 720 \times 576\ pixels$$

$$\boxed{Y\ (luma) resolution = 720 \times 576\ (each\ pixel\ 8 - bit)}$$

YC_BC_R Color Space

$$Image\ resolution: 720 \times 576\ pixels$$

$$\boxed{Y\ (luma) resolution = 720 \times 576\ (each\ pixel\ 8 - bit)}$$

$$4:4:4\ Cb, Cr\ resolution = 720 \times 576\ (each\ pixel\ 8 - bit)$$

$$Total = 720 \times 576 \times 8 \times 3 = 9953280\ bits$$

YC_BC_R Color Space

$$Image\ resolution: 720 \times 576\ pixels$$

$$\boxed{Y\ (luma) resolution = 720 \times 576\ (each\ pixel\ 8 - bit)}$$

$$4:4:4\ Cb, Cr\ resolution = 720 \times 576\ (each\ pixel\ 8 - bit)$$

$$Total = 720 \times 576 \times 8 \times 3 = 9953280\ bits$$

$$4:2:0\ Cb, Cr\ resolution = 360 \times 288\ (each\ pixel\ 8 - bit)$$

$$Total = (720 \times 576 \times 8 \times 1) + (360 \times 288 \times 8 \times 2)$$
$$= 4976640\ bits$$

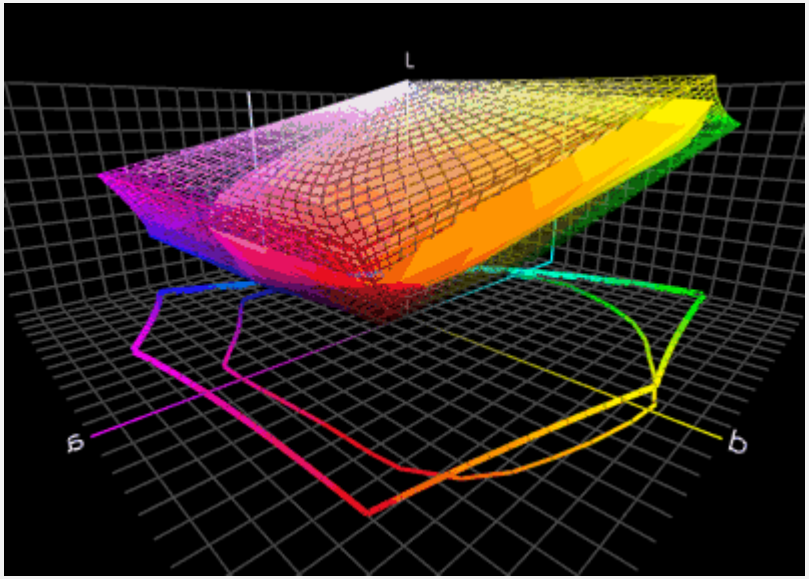
Color Profile

There are two kinds of color profiles:

- Image profiles: An image profile tells the hardware and software what color space the image is in.
- Device profiles: Device profiles use this information to reproduce the colors.

ICC's Color Profile

ICC profile is a standard (pre-defined) set of data that characterizes a color input or output device



A 3D view of two ICC profiles

Color Profile

Cameras	RGB
Display	RGB
Printers	CMYK

Color Profile

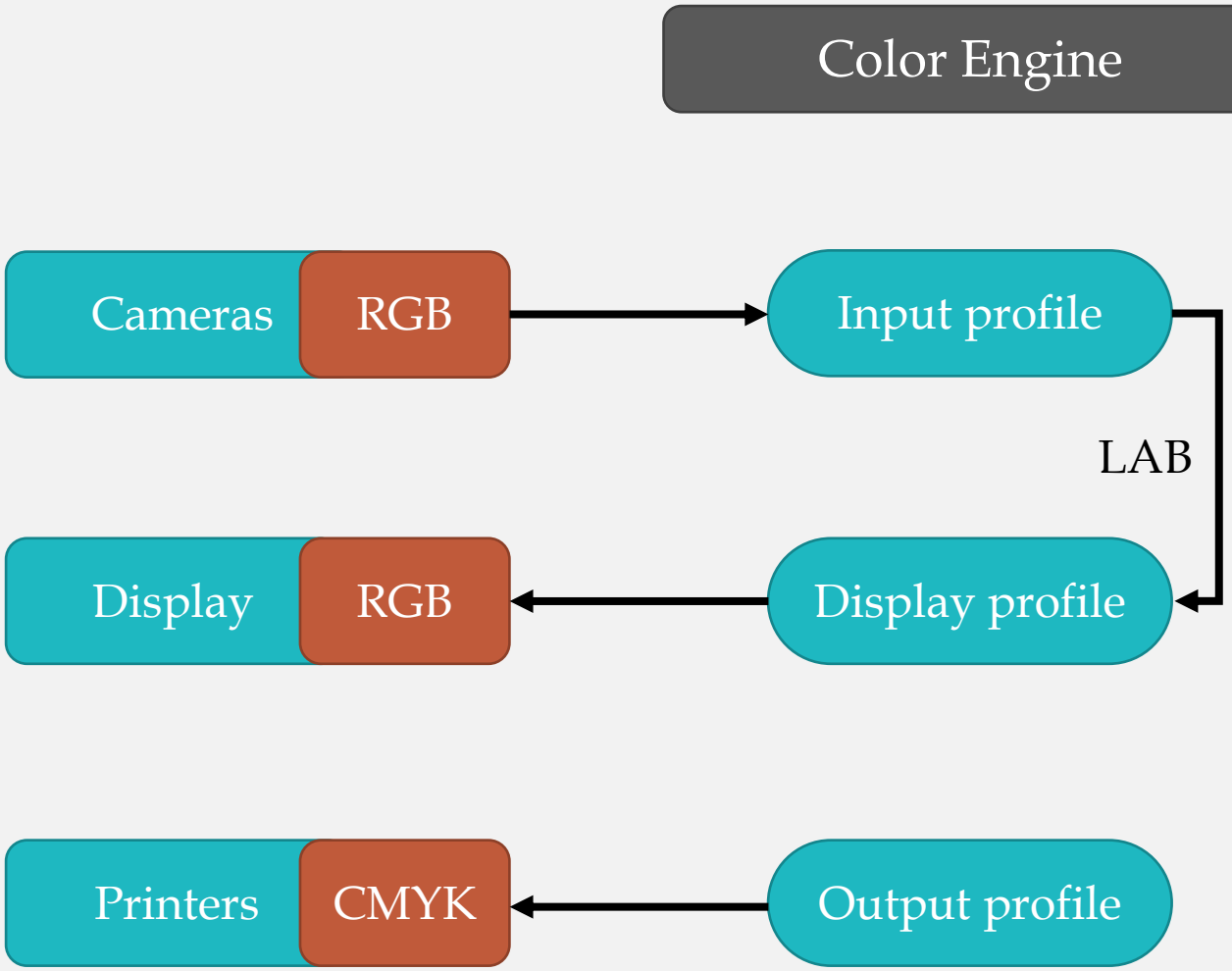
Color Engine

Cameras RGB → Input profile

Display RGB ← Display profile

Printers CMYK ← Output profile

Color Profile



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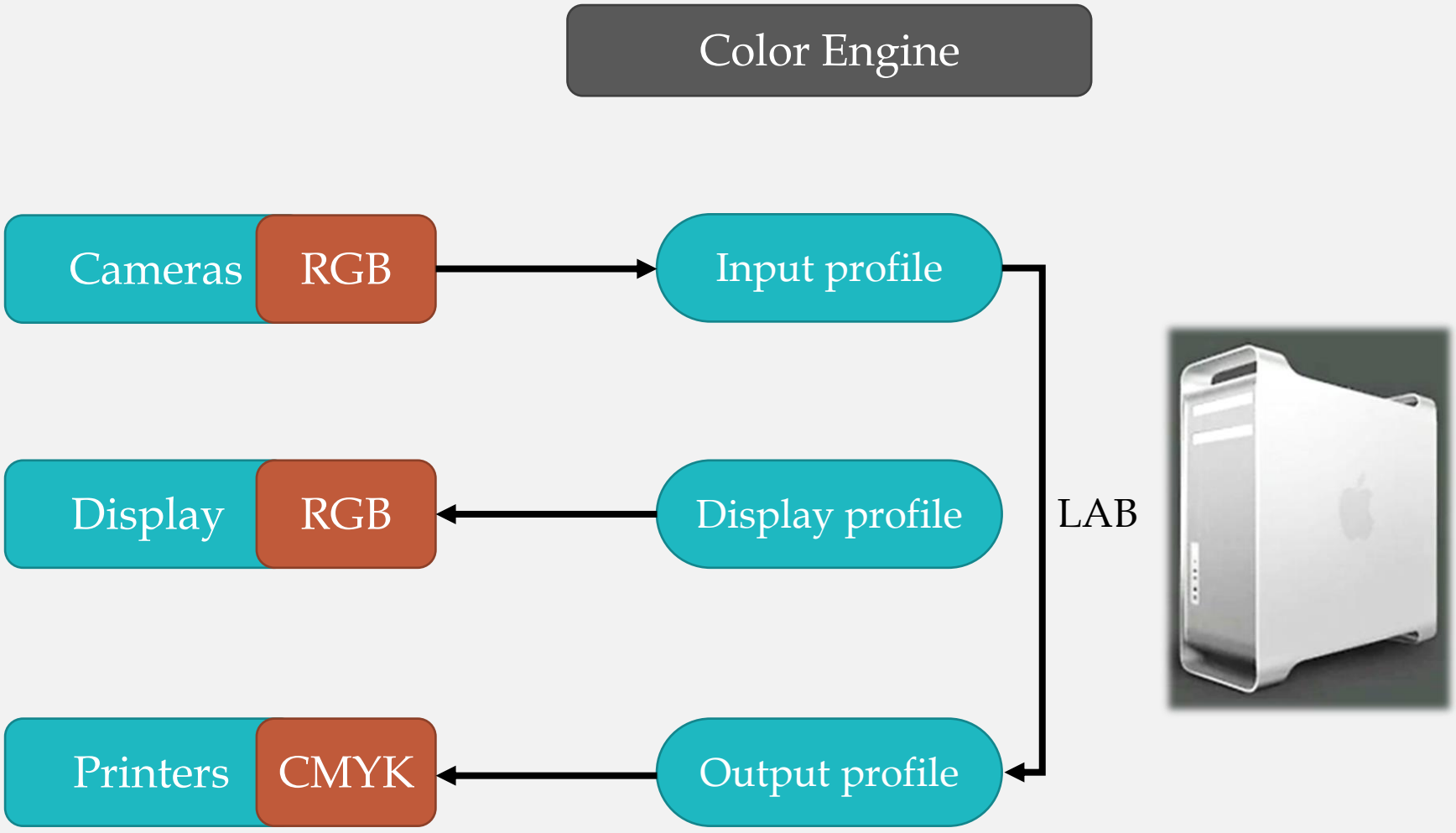

Questions ?

Thank you