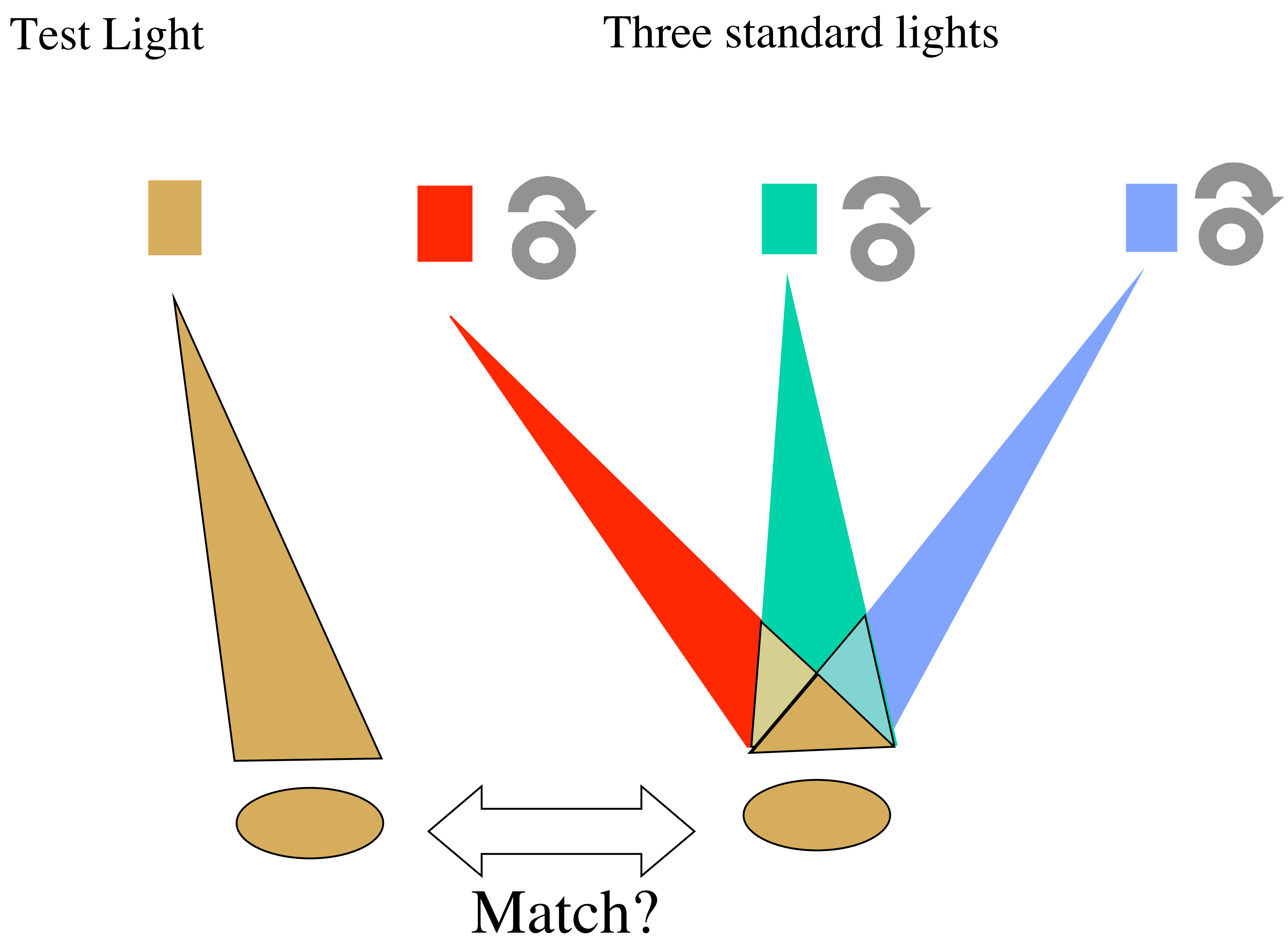
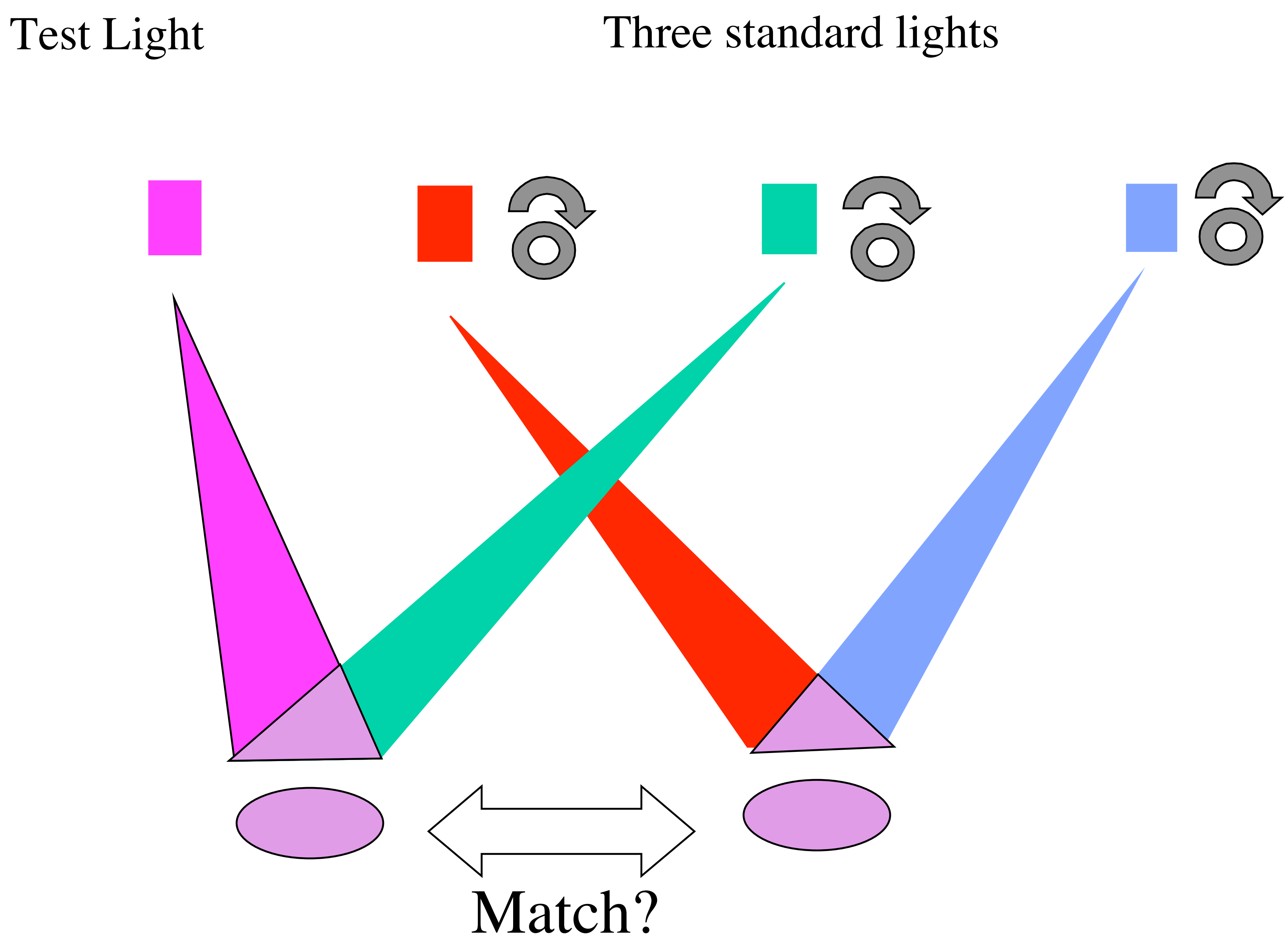
Colour Reproduction

Motivates specifying color numerically (there are other reasons to do this also)

General (man in the street) observation--color reproduction *sort of* works.

Specifying Colour


Test Light
Three standard lights
Match?


Test Light
Three standard lights
Match?

Trichromacy

Experimental fact about people (with “normal” colour vision)---matching works (for reasonable lights), provided that we are sometimes allowed negative values.

Our “knob” positions correspond to (X,Y,Z) in the standard colorimetry system.

Technical detail: (X,Y,Z) are actually arranged to be **positive** by a linear transformation, but these “knob” positions **cannot** correspond to any **physical** light.

Specifying Colour

(50,150,75)

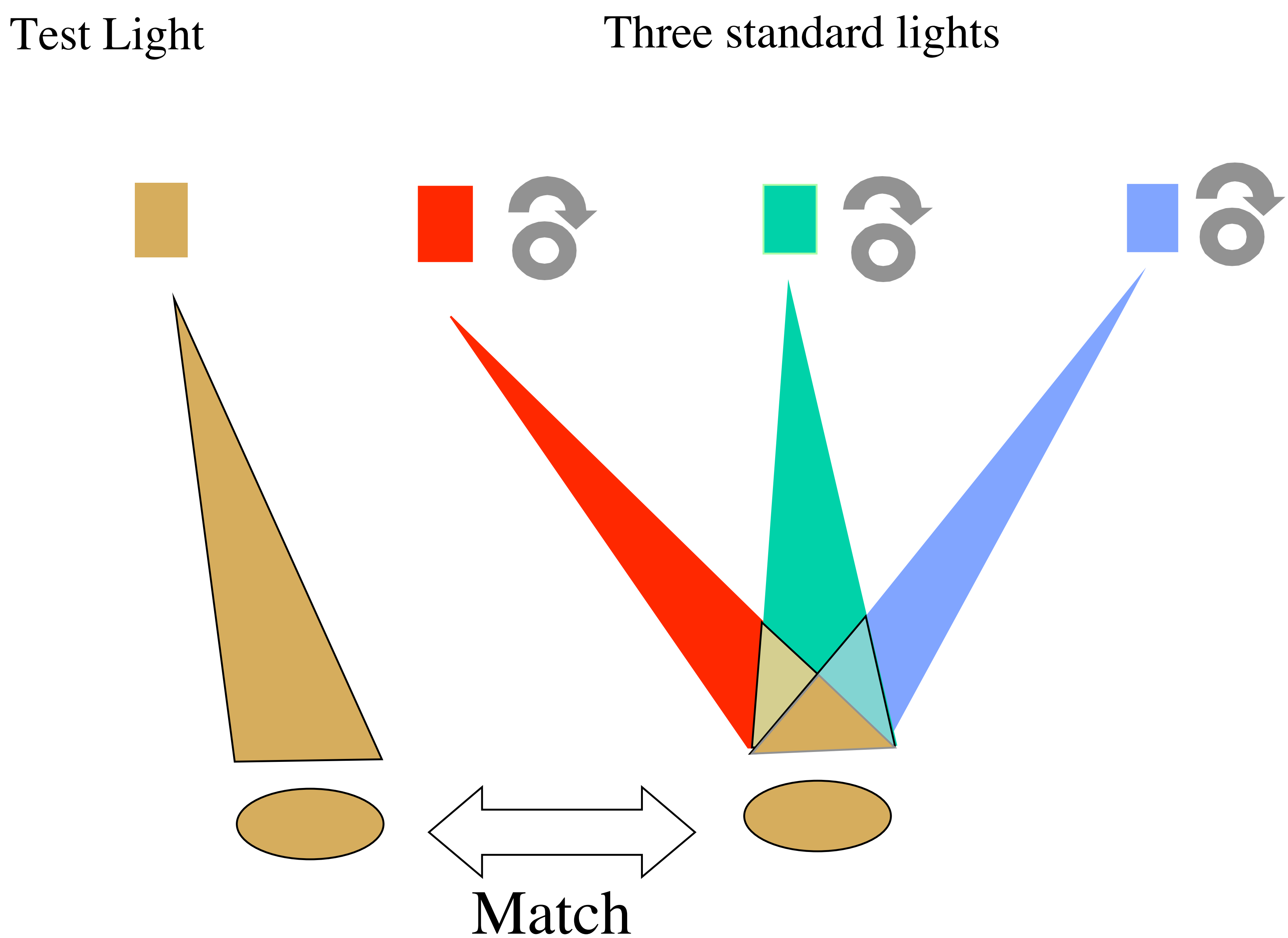
(50,150,75)

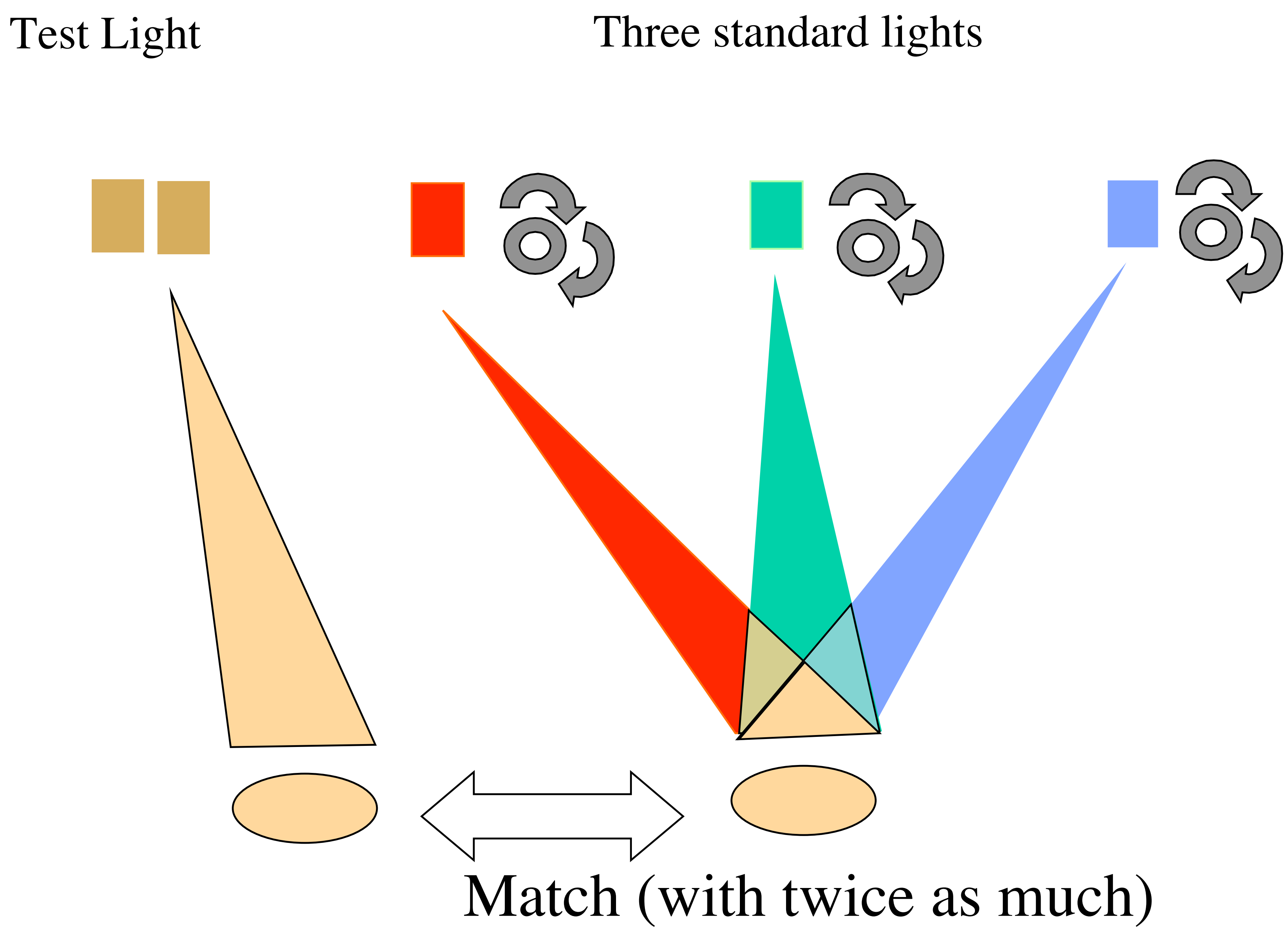
Specifying Colour

We don’t want to do a matching experiment every time we want to use a new color!

Grassman's Contribution

Colour matching is linear


Test Light
Three standard lights
Match

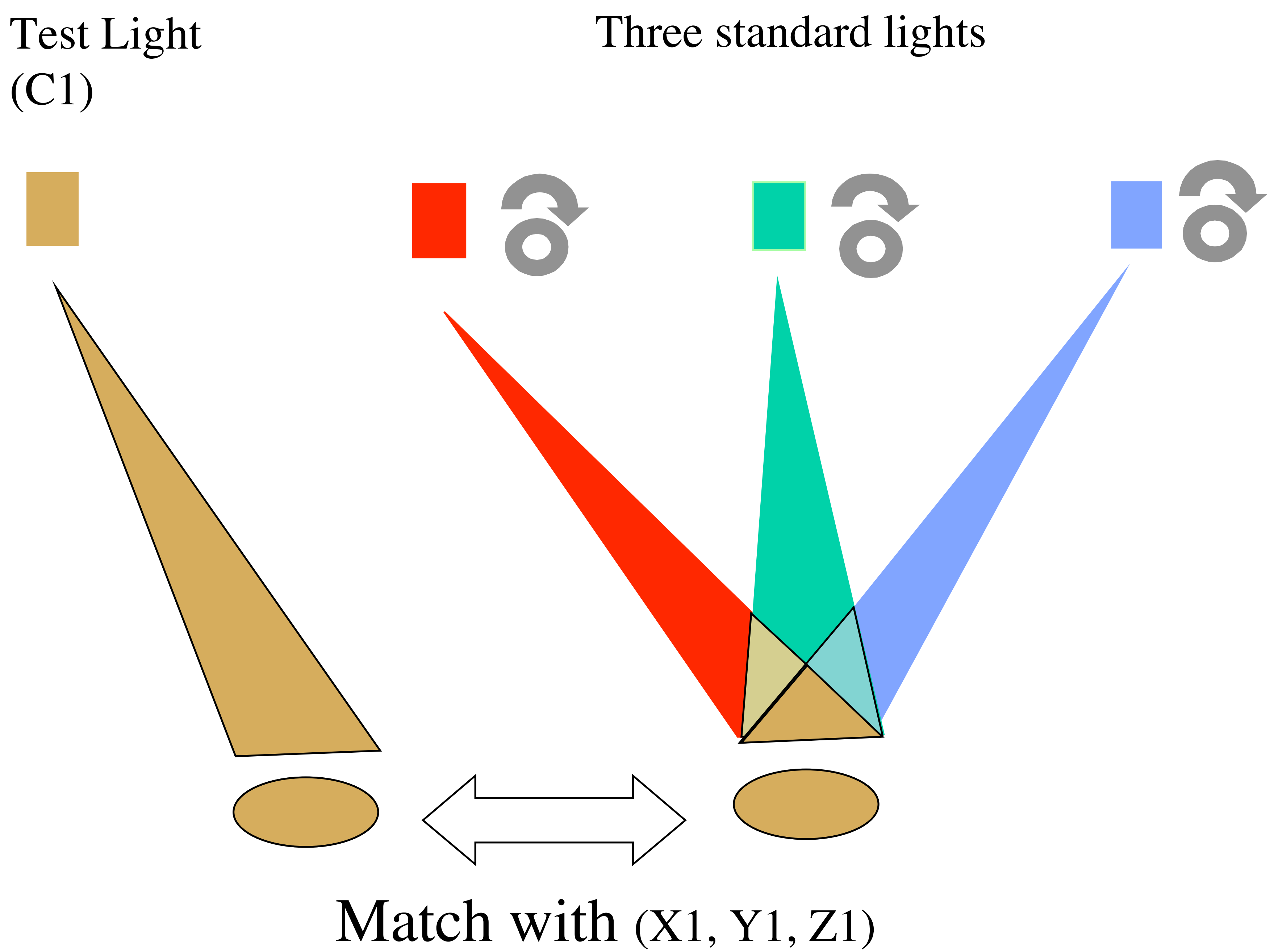

Test Light
Three standard lights
Match (with twice as much)

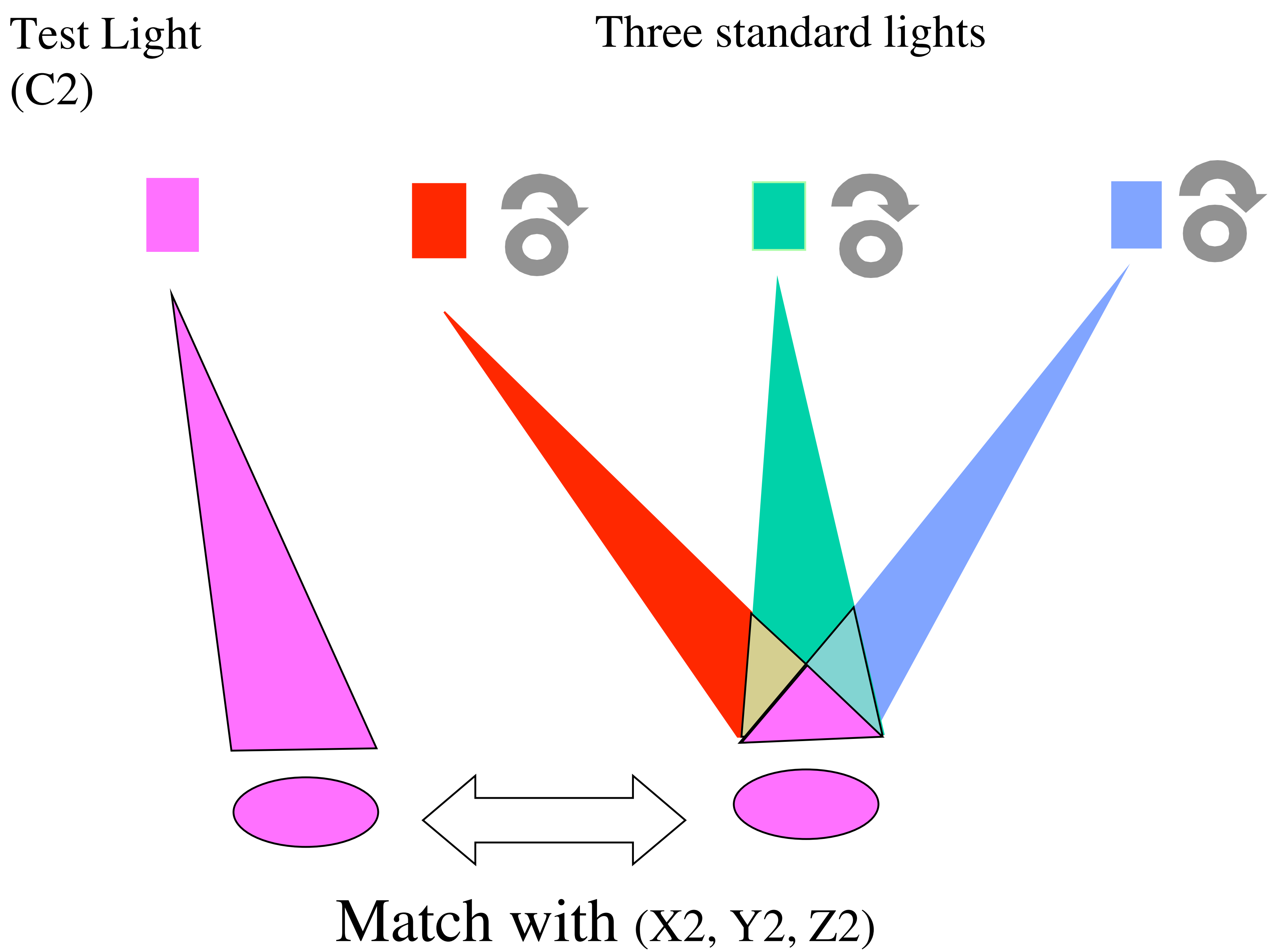
Matching is Linear (Part 1)

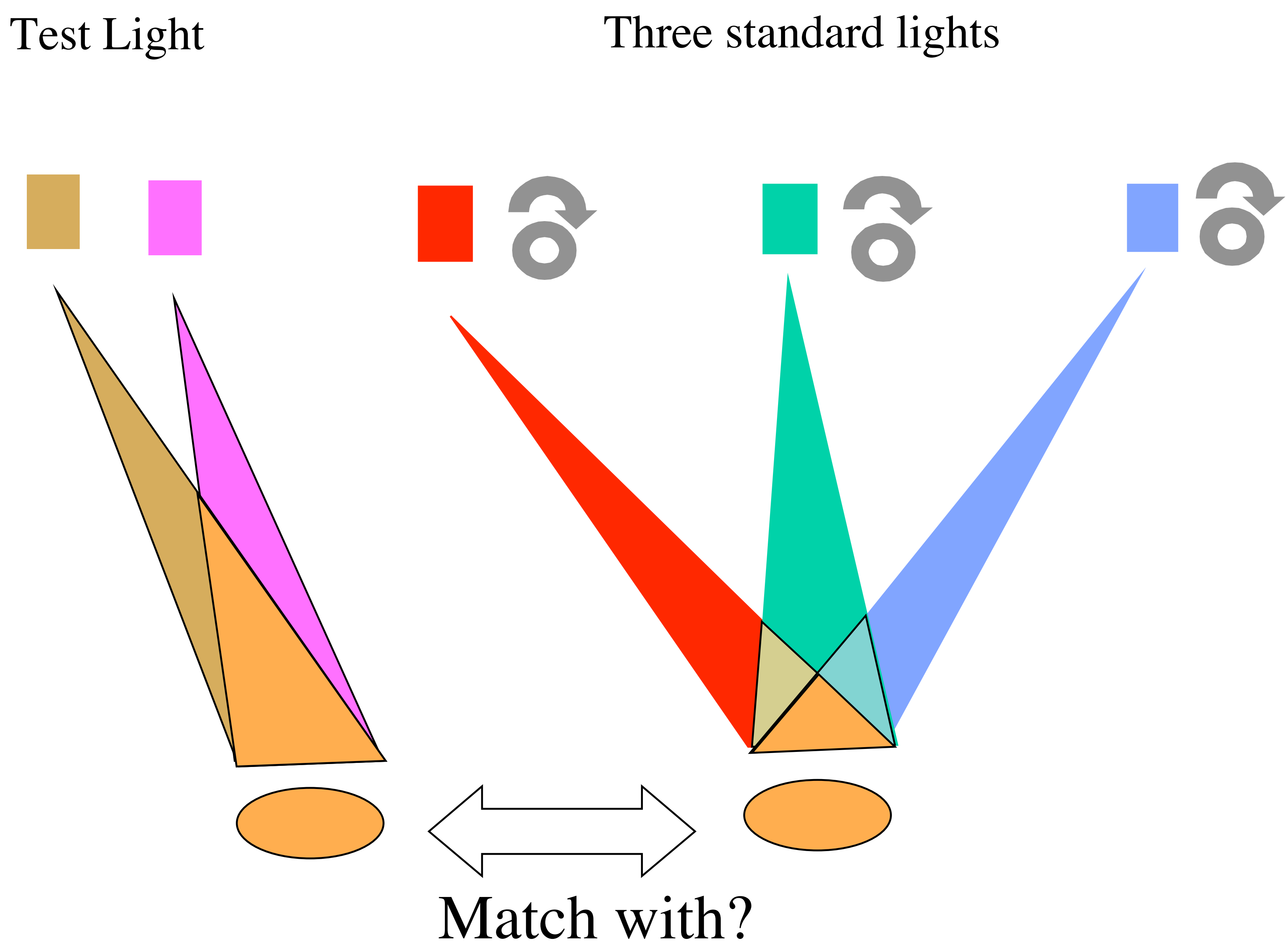
C1 is matched with (X1,Y1,Z1)

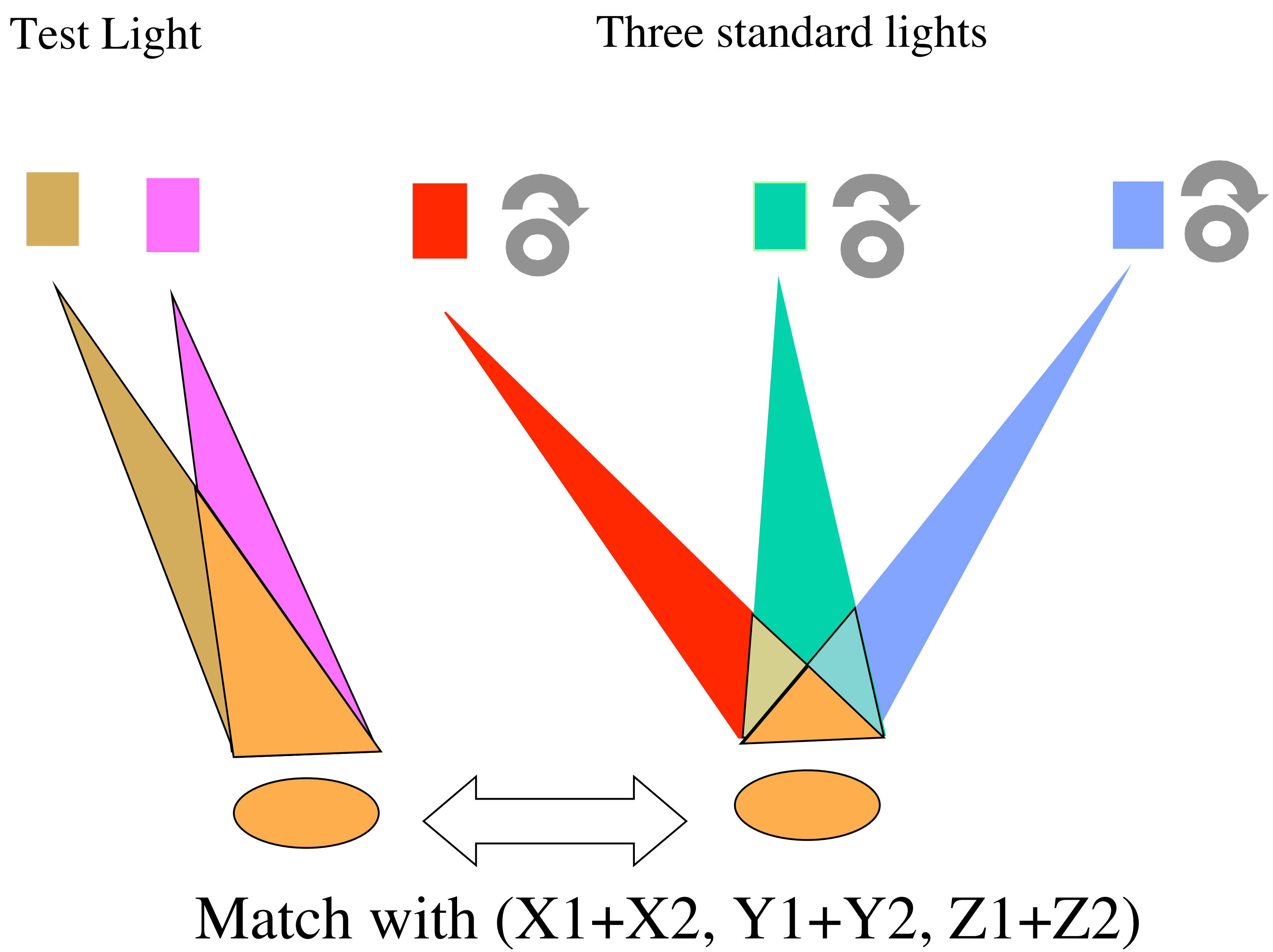
C = a*C1

C is matched with a * (X1, Y1, Z1)


Test Light
(C1)
Three standard lights
Match with (X1, Y1, Z1)


Test Light
(C2)
Three standard lights
Match with (X2, Y2, Z2)


Test Light
Three standard lights
Match with?


Test Light
Three standard lights
Match with (X1+X2, Y1+Y2, Z1+Z2)

Matching is Linear (formal)

C = a*C1 + b*C2

C1 is matched with (X1,Y1,Z1)
C2 is matched with (X2,Y2,Z2)

C is matched by
a*(X1,Y1,Z1) + b*(X2,Y2,Z2)

Specifying Color

On my monitor it’s
(R,G,B) = (75,150,100)

Specifying Colour

But what is (R,G,B)?

Specifying Colour

R matches (X_r, Y_r, Z_r)

G matches (X_g, Y_g, Z_g)

B matches (X_b, Y_b, Z_b)

Specifying Colour

Then by
(R,G,B)=(75,150,100)
you mean (X,Y,Z),
where …..

$$X = 75^* X_r + 150^* X_g + 100^* X_b$$

$$Y = 75^* Y_r + 150^* Y_g + 100^* Y_b$$

$$Z = 75^* Z_r + 150^* Z_g + 100^* Z_b$$

(No need to match--just compute!)

Specifying Colour

… , now that we have
specified the colour,
I can print it!

$$\begin{vmatrix} X \\ Y \\ Z \end{vmatrix} = \begin{vmatrix} X_r & X_g & X_b \\ Y_r & Y_g & Y_b \\ Z_r & Z_g & Z_b \end{vmatrix} \begin{vmatrix} 75 \\ 100 \\ 150 \end{vmatrix}$$

$$\begin{vmatrix} X \\ Y \\ Z \end{vmatrix} = \begin{vmatrix} X_r & X_g & X_b \\ Y_r & Y_g & Y_b \\ Z_r & Z_g & Z_b \end{vmatrix} \begin{vmatrix} R \\ G \\ B \end{vmatrix}$$

$$\begin{vmatrix} X \\ Y \\ Z \end{vmatrix} = M \begin{vmatrix} R \\ G \\ B \end{vmatrix}$$

Colour Reproduction
(Monitors & Projectors)

$$\begin{vmatrix} X \\ Y \\ Z \end{vmatrix}_{apple}$$

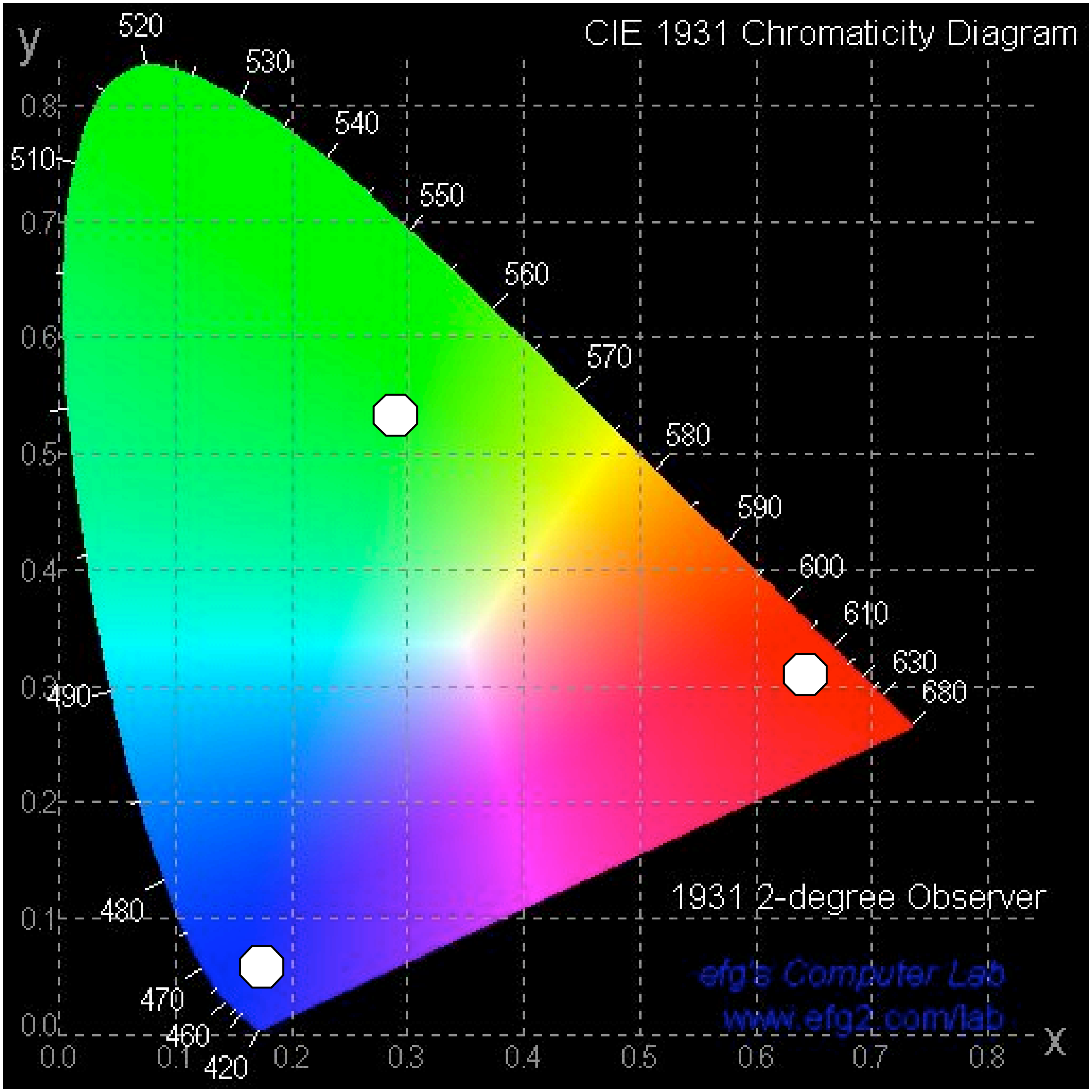
Find (R,G,B)

$$\begin{vmatrix} X \\ Y \\ Z \end{vmatrix}_{apple} = M \begin{vmatrix} R \\ G \\ B \end{vmatrix}_{apple}$$

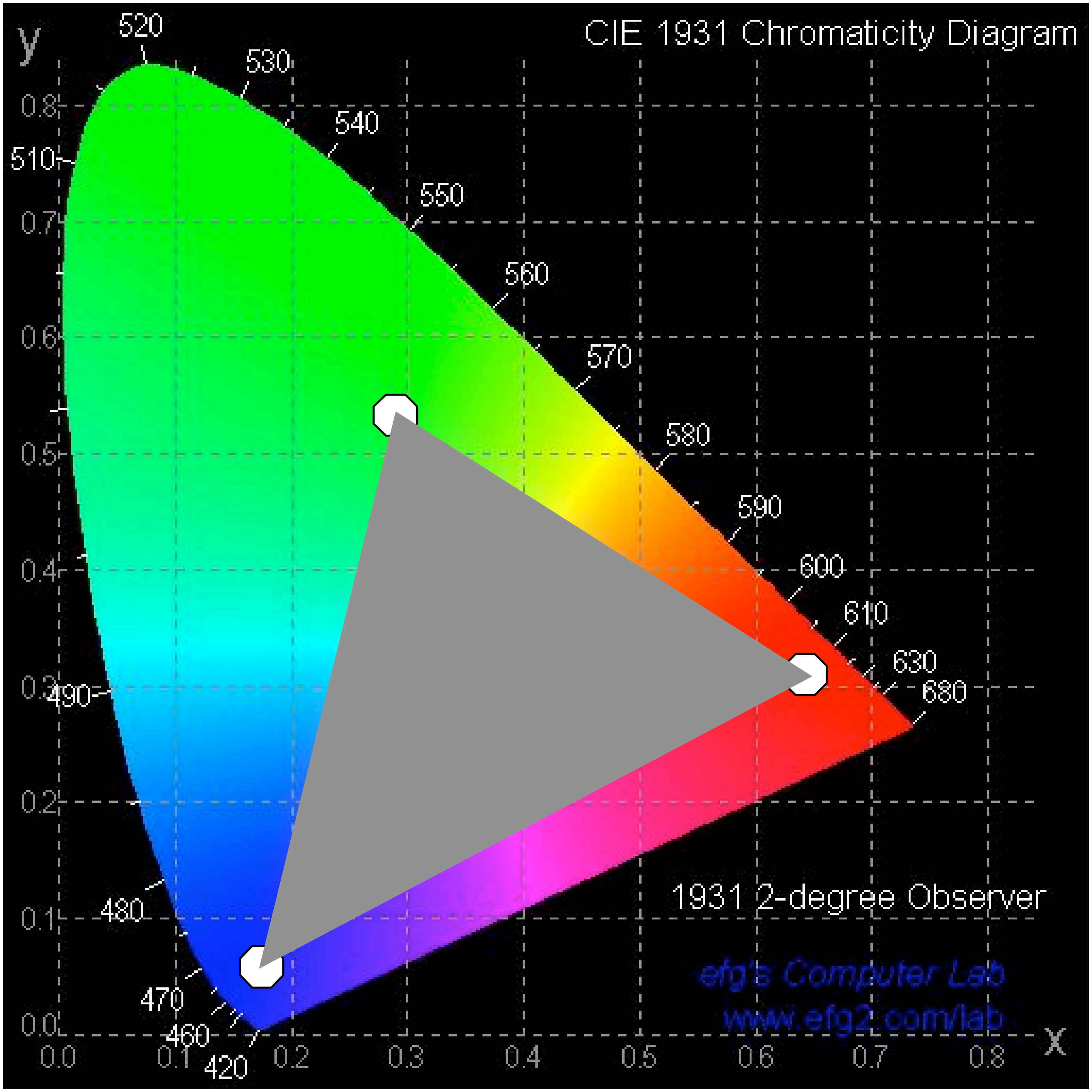
$$\begin{vmatrix} R \\ G \\ B \end{vmatrix}_{apple} = M^{-1} \begin{vmatrix} X \\ Y \\ Z \end{vmatrix}_{apple}$$

$$\begin{vmatrix} R \\ G \\ B \end{vmatrix}_{apple} = M^{-1} \begin{vmatrix} X \\ Y \\ Z \end{vmatrix}_{apple}$$

Possible problems?



Avalable from efg2.com



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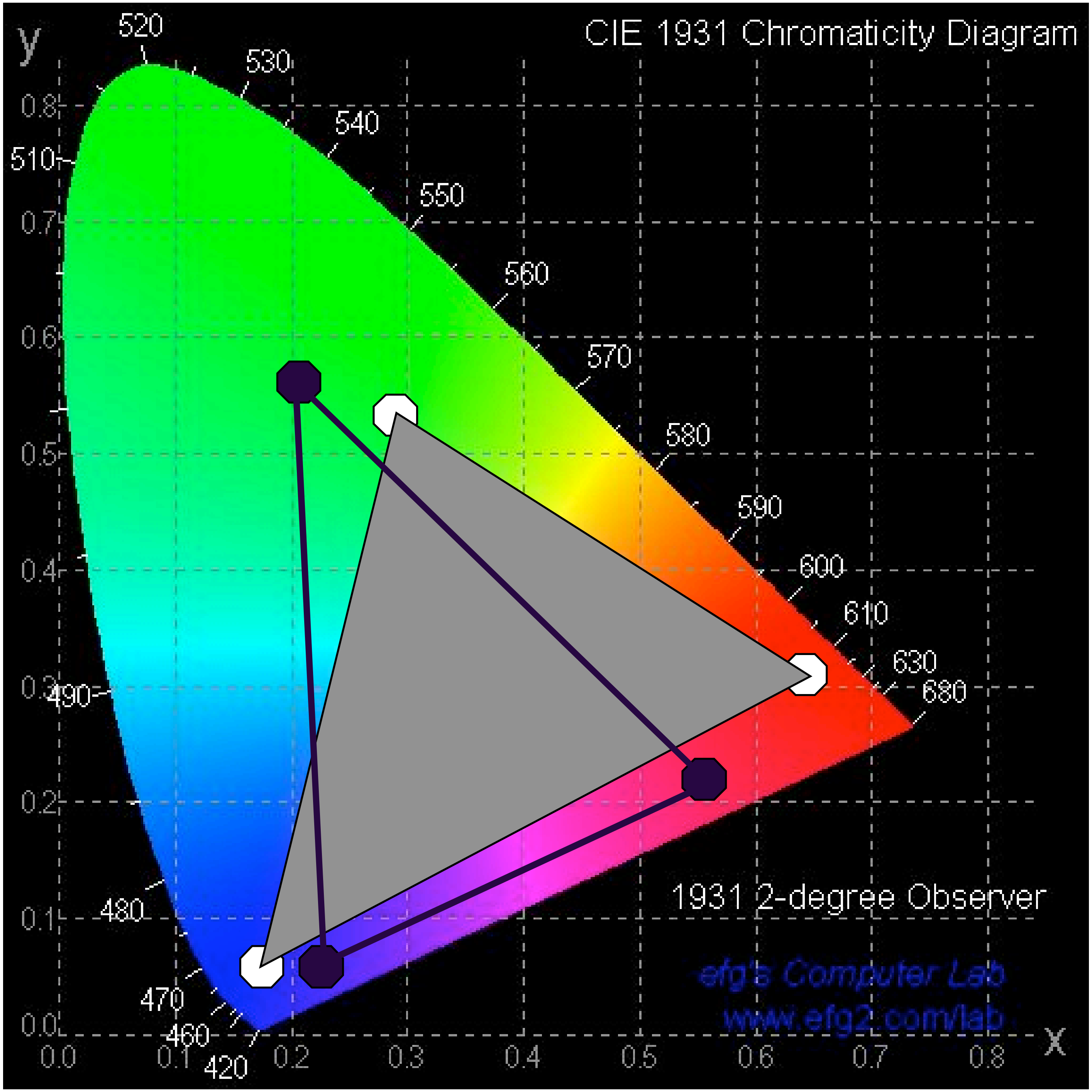
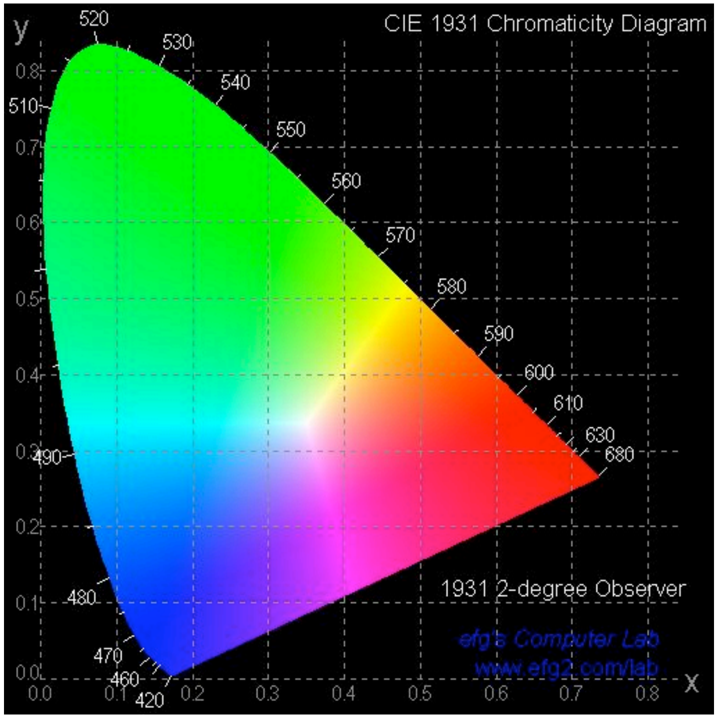


Avalable from efg2.com

Qualitative features of CIE x, y

- Linearity implies that colors obtainable by mixing lights with colors A, B lie on line segment with endpoints at A and B
- Monochromatic colours (spectral colors) run along the "Spectral Locus"
- Dominant wavelength = Spectral color that can be mixed with white to match



Qualitative features of CIE x, y

- Purity = (distance from C to spectral locus)/(distance from white to spectral locus)
- Wavelength and purity can be used to specify color.
- Complementary colors=colors that can be mixed to get white