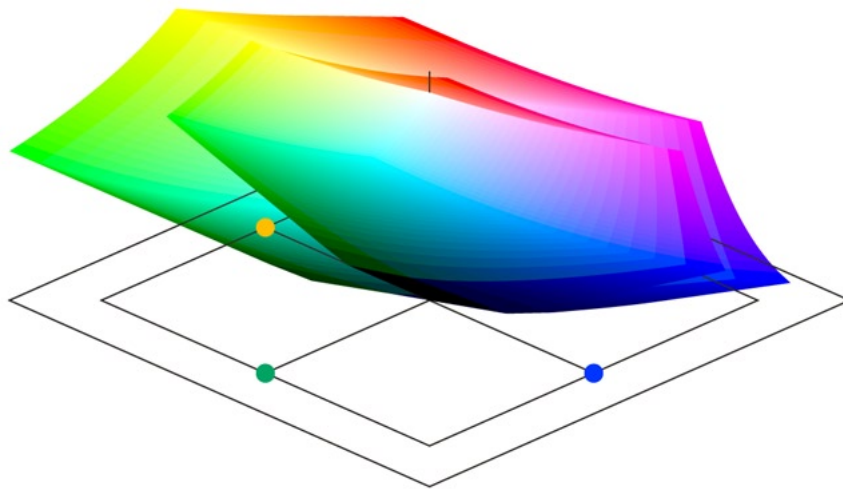


Gernot Hoffmann

Color Mathematics by PostScript

ColorCalc
SpectroCalc



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1. Introduction

ColorCalc [8] and *SpectroCalc* [9] are PostScript EPS programs. The source codes can be changed by any text editor.

The programs generate diagrams and text as vector graphics.

The page content can be shown by all programs with PostScript interpreter, e.g. PSAlter, PageMaker 7.0, InDesign, Photoshop or GhostScript (not tested).

PSAlter [4] is an editor and PostScript Level 2 interpreter - the best choice for editing *ColorCalc*.

Printing should be done by PageMaker or InDesign in order to retain vector quality.

Photoshop rasterizes the page. Good printing quality requires a resolution of 300ppi to 600ppi.

ColorCalc accepts inputs XYZ, xyY, Lab, RGB. Outputs are graphics and XYZ, xyz, Lab, RGB.

SpectroCalc calculates XYZ, xyY, Lab, RGB for a given reflectance factor spectrum and two illuminants. Graphics are shown as well.

The integration of spectra by *SpectroCalc* is based on 5nm steps for the wavelength. Two methods were investigated: Euler integration and Trapezoid integration.

Average results are better with the simple Euler integration. This is used finally. Older docs were updated.

Data by Avantes Spectrocam are already interpolated for steps 5nm.

Data by GretagMacbeth Eye-OnePro and X-Rite DTP-22 are delivered for steps 10nm and interpolated by the program.

Everything is based on the CIE (1931) Standard Observer for 2°.

Thanks to *Danny Rich* for helpful advice.

Major revision of *ColorCalc* and *SpectroCalc*:

December 02-05 / 2006:

New arrangement of tables and graphics.

Linear and nonlinear RGB values.

Matrices \mathbf{C}_{rx} and \mathbf{C}_{xr} or adapted matrices \mathbf{M}_{rx} and \mathbf{M}_{xr} .

2.1 ColorCalc / Input

2.1.1 Color space

```
%--Choose one standard set
/S 5 def
S 0 eq {} if % None, use settings above
S 1 eq {Prims709 WhiteD65 RefD65 Gam24 BradF RendA} if % sRGB AbsCol
S 2 eq {PrimsAd98 WhiteD65 RefD65 Gam22 BradF RendA} if % AdobeRGB(98) AbsCol
S 3 eq {PrimsOpti WhiteD65 RefD65 Gam22 BradF RendA} if % OptiRGB AbsCol
S 4 eq {PrimsProp WhiteD50 RefD50 Gam18 BradF RendA} if % ProPhoto AbsCol

S 5 eq {Prims709 WhiteD65 RefD50 Gam24 BradT RendR} if % sRGB RelCol
S 6 eq {PrimsAd98 WhiteD65 RefD50 Gam22 BradT RendR} if % AdobeRGB(98) RelCol
S 7 eq {PrimsOpti WhiteD65 RefD50 Gam22 BradT RendR} if % OptiRGB RelCol
S 8 eq {PrimsProp WhiteD50 RefD50 Gam18 BradT RendR} if % ProPhoto RelCol

S 9 eq {Prims709 WhiteD65 RefD50 Gam24 BradF RendA} if % sRGB AbsCol
S 10 eq {PrimsAd98 WhiteD65 RefD50 Gam22 BradF RendA} if % AdobeRGB(98) AbsCol
S 11 eq {PrimsOpti WhiteD65 RefD50 Gam22 BradF RendA} if % OptiRGB AbsCol
S 12 eq {PrimsProp WhiteD50 RefD50 Gam18 BradF RendA} if % ProPhoto AbsCol
```

A complete set contains:

Prims Primaries, e.g. Rec.709, AdobeRGB(1998)
White Media white point, e.g. D65
Ref Reference white point, e.g. D50
Gam Tone reproduction curve (TRC)
Gamma=1.0, 1.8, 2.2 or 2.4 which is used in a more complex TRC in sRGB
The *effective* Gamma for sRGB is 2.2
Brad Bradford chromatic adaptation transform (CAT), false or true
Rend Rendering Intent. With CAT: RelCol. Without CAT: AbsCol
Relevant if media white and reference white are different

The Bradford CAT is based on the cone response model as explained in [1], [3], [7].

The first group S=1...4 is useful for interpreting the physical parameters of a color space, e.g. for a monitor or for sRGB.

The second group S=5...8 converts everything to D50. This mode is used in all ICC profiles.

E.g. the primaries for a monitor or working space like sRGB will appear shifted (adapted primaries).

Not really useful, but a standard. For ProPhoto both sets in the list mean exactly the same.

New sets can be defined easily, using available modules like WideGamut, NTSC etc..

2.1.2 Input mode

```
%--Choose one input mode
/Mode 4 def
Mode 1 eq { XYZMode } if
Mode 2 eq { xyYMode } if
Mode 3 eq { LabMode } if
Mode 4 eq { RGBMode } if % gamma encoded
Mode 5 eq { RGBModeLinear } if % linear
```

2.1 ColorCalc / Input

2.1.3 Headline

```
%--Define headline  
/head (any text) def
```

2.1.4 Show CT-Curve in Lab-plane

```
%--Choose Show CT-Curve in Lab  
/CTLab 0 def  
% 0 No  
% 1 Yes
```

2.1.5 Colors

```
/XYZ [ 0.86783 0.89743 0.78069  
       0.84808 0.87618 0.80035 ] def
```

```
/xyY [ 0.2 0.2 0.8  
       0.3 0.3 0.8  
       0.4 0.4 0.8 ] def
```

```
/LAB [ 60 +25 +25  
       60 +50 +50  
       60 +75 +75  
       60 +100 +100 ] def
```

```
/RGB [ 255 255 255  
       255 0 0  
       0 255 0  
       0 0 255  
       0 255 255  
       255 0 255  
       255 255 0 ] def
```

Up to nine colors in each color space can be defined, each color by three numbers in a row. More colors are possible by extending the bounding box of the EPS doc.

For this example the program would calculate two colors for XYZ, three colors for xyY, four colors for Lab and seven colors for RGB, depending on the input mode.

2.2 ColorCalc / Output

2.2.1 Graphics

Please refer to the examples.

CIE chromaticity diagram xyY

Curve for the Planckian radiator, with color temperatures

White points D50, D65 and 9300K (D93)

Round color dots in xyY (colors in device RGB)

Small Lab plane a*b*

Square color dots in a*b* (colors in device RGB)

Tone reproduction curve

2.2.2 Header

| | |
|-----------|---|
| Head | Arbitrary header text, e.g. date |
| Med.White | Media white point (ICC: 'media'.The author's opinion: should be 'medium') |
| Ref.White | Reference white point |
| Primaries | Primaries |
| Trc | Tone reproduction curve |
| Input | Input data mode |

2.2.3 Numbers

| | |
|--------|---|
| XYZ | CIE XYZ as stimulus values |
| xyY | CIE xyY as stimulus values |
| L*a*b* | CIE Lab in reference space |
| RGB | Linear RGB values in media space, not clipped |
| RGB' | Gamma encoded values in media space, clipped for 0...255 |
| CCT | Correlated color temperature This calculation is based on tables, not very accurate but practically sufficient 'None' is indicated if the color is too far away from the curve for the Planckian radiator |
| RGB | In-gamut or out-of-gamut for RGB Out-of-gamut, if at least one value is less than -0.49 (rounded to 0) or greater than 255.49 (rounded to 255) |

2.3 ColorCalc / Calculation sequence

2.3.1 Nomenclature

| | |
|----------|--|
| s | Stimulus, general index for XYZ and xyY as inputs and outputs |
| m | Media white point for RGB systems, inputs and outputs |
| n | Reference white point for CIE Lab (XYZ_n are internal variables) |
| T | Tone Reproduction Curve, e.g. $y=x^{2.2}$ |
| T^{-1} | Inverse Tone Reproduction Curve, e.g. $y=x^{0.4545}$ |
| B | Bradford matrix, uses media and reference white points [7, 2.6] |
| B^{-1} | Inverse Bradford matrix |
| M_{rx} | Matrix for $R^T = M_{rx} X^T$ |
| M_{xr} | Matrix for $X^T = M_{xr} R^T$ |
| | These matrices contain the Bradford matrix, which can be an identity matrix: $M_{rx} = C_{rx} B^{-1}$, $M_{xr} = B C_{xr}$ Matrices C_{rx} and C_{xr} are calculated using the chromaticities and the white point of the media space, [7, 2.5]. |
| N | Matrix $\text{diag}(X_n, Y_n, Z_n)$ |
| N^{-1} | Matrix $\text{diag}(1/X_n, 1/Y_n, 1/Z_n)$ |
| L | Calculation of CIE Lab values, [7, 2.1] |
| L^{-1} | Inverse calculation [7, 2.2] |
| P | Projection of XYZ onto xy, [7, 2.3] |
| P^{-1} | Inverse projection |

2.3.2 Input mode XYZ

$$\begin{array}{l}
 XYZ_s \rightarrow [N^{-1}] \rightarrow XYZ_n \rightarrow [L] \rightarrow LAB_n \\
 \rightarrow [P] \rightarrow xyY_s \\
 \rightarrow [M_{rx}] \rightarrow RGB_m \rightarrow [T^{-1}] \rightarrow RGB'_m
 \end{array}$$

2.3.3 Input mode xyY

$$\begin{array}{l}
 xyY_s \rightarrow [P^{-1}] \rightarrow XYZ_s \rightarrow [N^{-1}] \rightarrow XYZ_n \rightarrow [L] \rightarrow LAB_n \\
 \rightarrow [M_{rx}] \rightarrow RGB_m \rightarrow [T^{-1}] \rightarrow RGB'_m
 \end{array}$$

2.3.4 Input mode Lab

$$\begin{array}{l}
 LAB_n \rightarrow [L^{-1}] \rightarrow XYZ_n \rightarrow [N] \rightarrow XYZ_s \rightarrow [M_{rx}] \rightarrow RGB_m \rightarrow [T^{-1}] \rightarrow RGB'_m \\
 \rightarrow [P] \rightarrow xyY_s
 \end{array}$$

2.3.5 Input mode RGB

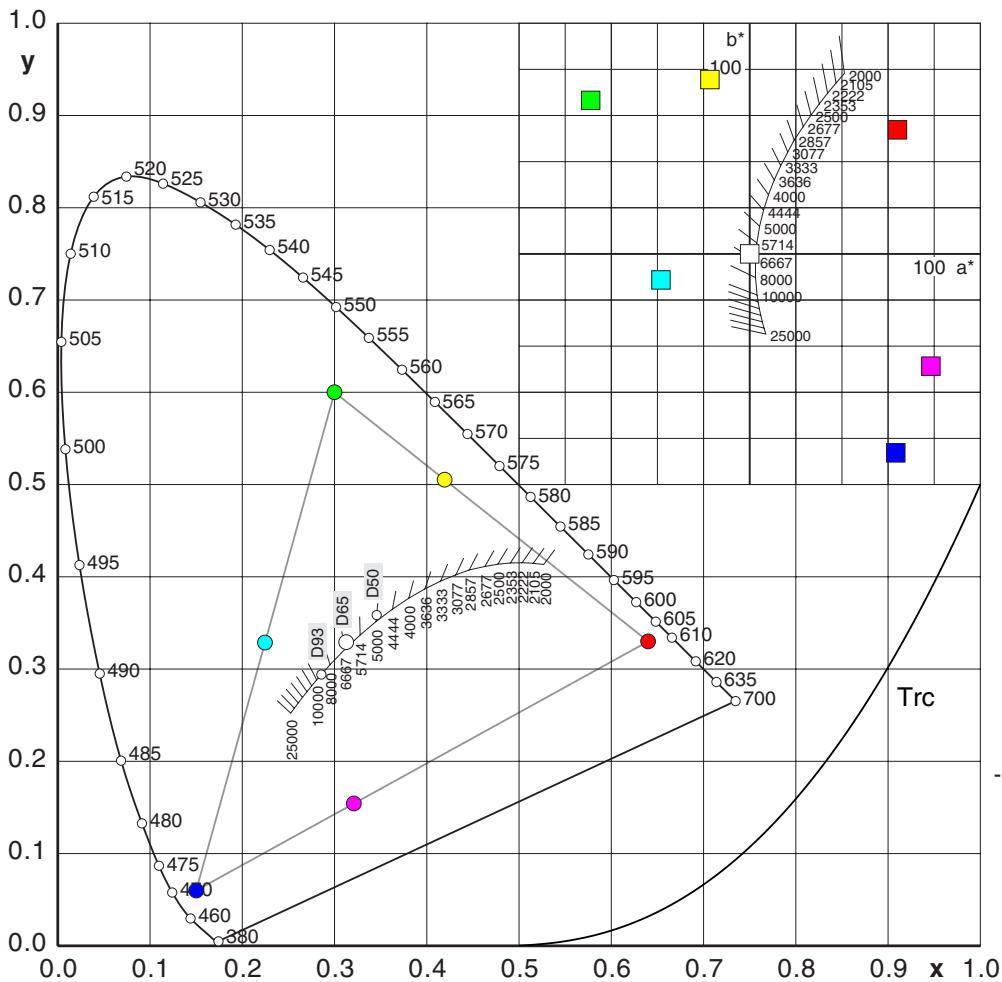
$$\begin{array}{l}
 RGB'_m \rightarrow [T] \rightarrow RGB_m \rightarrow [M_{xr}] \rightarrow XYZ_s \rightarrow [N^{-1}] \rightarrow XYZ_n \rightarrow [L] \rightarrow LAB_n \\
 \rightarrow [P] \rightarrow xyY_s
 \end{array}$$

2.3.6 Input mode RGBlinear

$$\begin{array}{l}
 RGB_m \rightarrow [M_{xr}] \rightarrow XYZ_s \rightarrow [N^{-1}] \rightarrow XYZ_n \rightarrow [L] \rightarrow LAB_n \\
 \rightarrow [P] \rightarrow xyY_s
 \end{array}$$

2.4.1 ColorCalc / Examples / sRGB without CAT

| ColorCalc G.Hoffmann Dec.04 / 2006 | Med.White: Ref.White: Input: | D65 D65 RGB' | Primaries: Trc: Bradford: | Rec.709 sRGB No | Intent: Set: | AbsCol 1 | |
|--|------------------------------------|--------------------|---------------------------------|-----------------------|-----------------|-------------|----------|
| X | 0.950456 | 0.412391 | 0.357584 | 0.180481 | 0.538065 | 0.592872 | 0.769975 |
| Y | 1.000000 | 0.212639 | 0.715169 | 0.072192 | 0.787361 | 0.284831 | 0.927808 |
| Z | 1.089058 | 0.019331 | 0.119195 | 0.950532 | 1.069727 | 0.969863 | 0.138526 |
| x | 0.312700 | 0.640000 | 0.300000 | 0.150000 | 0.224647 | 0.320893 | 0.419306 |
| y | 0.329000 | 0.330000 | 0.600000 | 0.060000 | 0.328731 | 0.154166 | 0.505257 |
| z | 0.358300 | 0.030000 | 0.100000 | 0.790000 | 0.446622 | 0.524941 | 0.075437 |
| L* | 100.0000 | 53.2371 | 87.7355 | 32.3009 | 91.1148 | 60.3227 | 97.1386 |
| a* | 0.0000 | 80.0901 | -86.1816 | 79.1953 | -48.0789 | 98.2374 | -21.5600 |
| b* | 0.0000 | 67.2033 | 83.1866 | -107.8555 | -14.1290 | -60.8289 | 94.4838 |
| R | 255.0000 | 255.0000 | 0.0000 | 0.0000 | 0.0000 | 255.0000 | 255.0000 |
| G | 255.0000 | 0.0000 | 255.0000 | 0.0000 | 255.0000 | 0.0000 | 255.0000 |
| B | 255.0000 | 0.0000 | 0.0000 | 255.0000 | 255.0000 | 255.0000 | 0.0000 |
| R' | 255.0000 | 255.0000 | 0.0000 | 0.0000 | 0.0000 | 255.0000 | 255.0000 |
| G' | 255.0000 | 0.0000 | 255.0000 | 0.0000 | 255.0000 | 0.0000 | 255.0000 |
| B' | 255.0000 | 0.0000 | 0.0000 | 255.0000 | 255.0000 | 255.0000 | 0.0000 |
| CCT | 6493 K | none | none | none | none | none | none |
| RGB | in-gam | in-gam | in-gam | in-gam | in-gam | in-gam | in-gam |



Matrix Crx

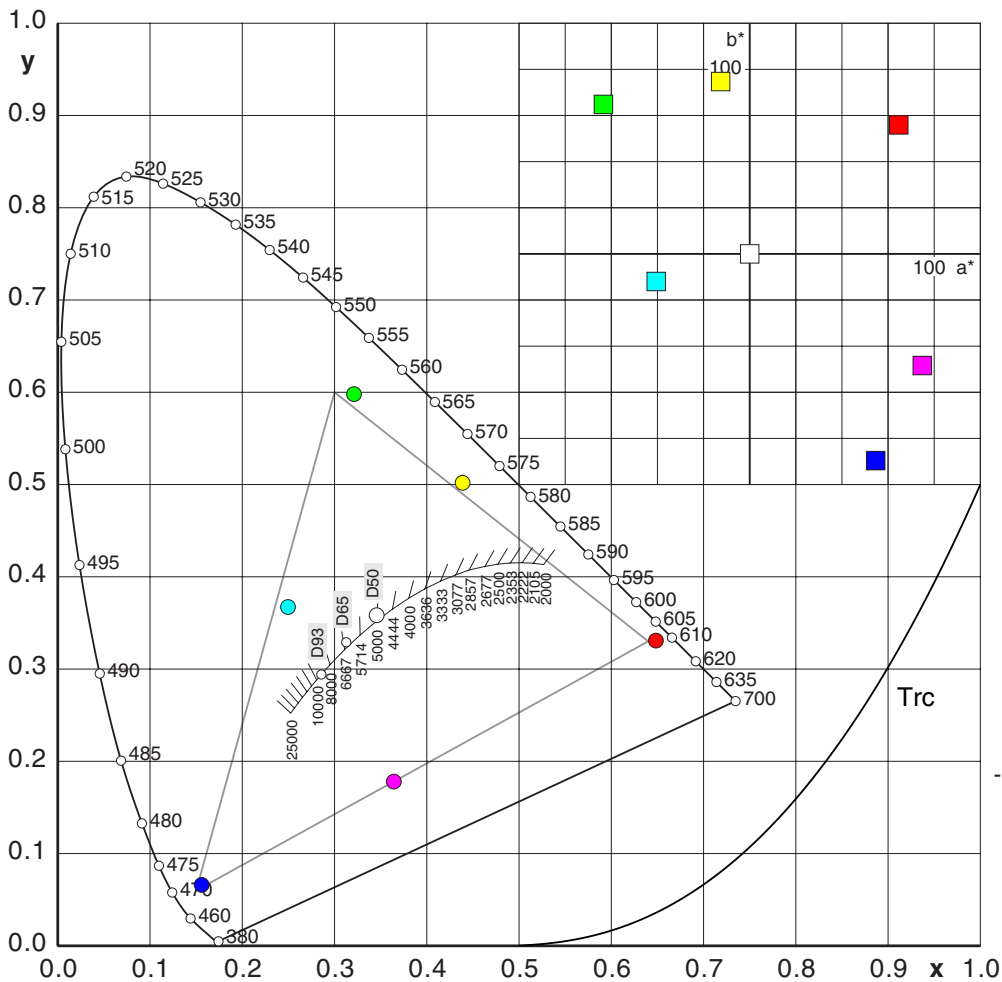
```
3.240970 -1.537383 -0.498611
-0.969243 1.875967 0.041555
0.055630 -0.203977 1.056971
```

Matrix Cxr

```
0.412391 0.357584 0.180481
0.212639 0.715169 0.072192
0.019331 0.119195 0.950532
```

2.4.2 ColorCalc / Examples / sRGB with CAT

| ColorCalc | Med.White: | D65 | Primaries: | Rec.709 | Intent: | RelCol | |
|---------------|------------|----------|------------|-----------|----------|----------|----------|
| G.Hoffmann | Ref.White: | D50 | Trc: | sRGB | Set: | 5 | |
| Dec.04 / 2006 | Input: | RGB' | Bradford: | Yes | | | |
| X | 0.964295 | 0.436066 | 0.385151 | 0.143078 | 0.528230 | 0.579144 | 0.821217 |
| Y | 1.000000 | 0.222493 | 0.716887 | 0.060620 | 0.777507 | 0.283113 | 0.939380 |
| Z | 0.825105 | 0.013924 | 0.097081 | 0.714099 | 0.811181 | 0.728023 | 0.111005 |
| x | 0.345700 | 0.648441 | 0.321195 | 0.155893 | 0.249528 | 0.364177 | 0.438778 |
| y | 0.358500 | 0.330853 | 0.597844 | 0.066049 | 0.367283 | 0.178027 | 0.501912 |
| z | 0.295800 | 0.020705 | 0.080960 | 0.778058 | 0.383190 | 0.457796 | 0.059310 |
| L* | 100.0000 | 54.2905 | 87.8185 | 29.5683 | 90.6660 | 60.1689 | 97.6070 |
| a* | -0.0000 | 80.8049 | -79.2711 | 68.2874 | -50.6565 | 93.5396 | -15.7499 |
| b* | 0.0000 | 69.8910 | 80.9946 | -112.0297 | -14.9617 | -60.5008 | 93.3936 |
| R | 255.0000 | 255.0000 | 0.0000 | 0.0000 | 0.0000 | 255.0000 | 255.0000 |
| G | 255.0000 | 0.0000 | 255.0000 | 0.0000 | 255.0000 | 0.0000 | 255.0000 |
| B | 255.0000 | 0.0000 | 0.0000 | 255.0000 | 255.0000 | 255.0000 | 0.0000 |
| R' | 255.0000 | 255.0000 | 0.0000 | 0.0000 | 0.0000 | 255.0000 | 255.0000 |
| G' | 255.0000 | 0.0000 | 255.0000 | 0.0000 | 255.0000 | 0.0000 | 255.0000 |
| B' | 255.0000 | 0.0000 | 0.0000 | 255.0000 | 255.0000 | 255.0000 | 0.0000 |
| CCT | 5001 K | none | none | none | none | none | none |
| RGB | in-gam | in-gam | in-gam | in-gam | in-gam | in-gam | in-gam |



Matrix Mrx

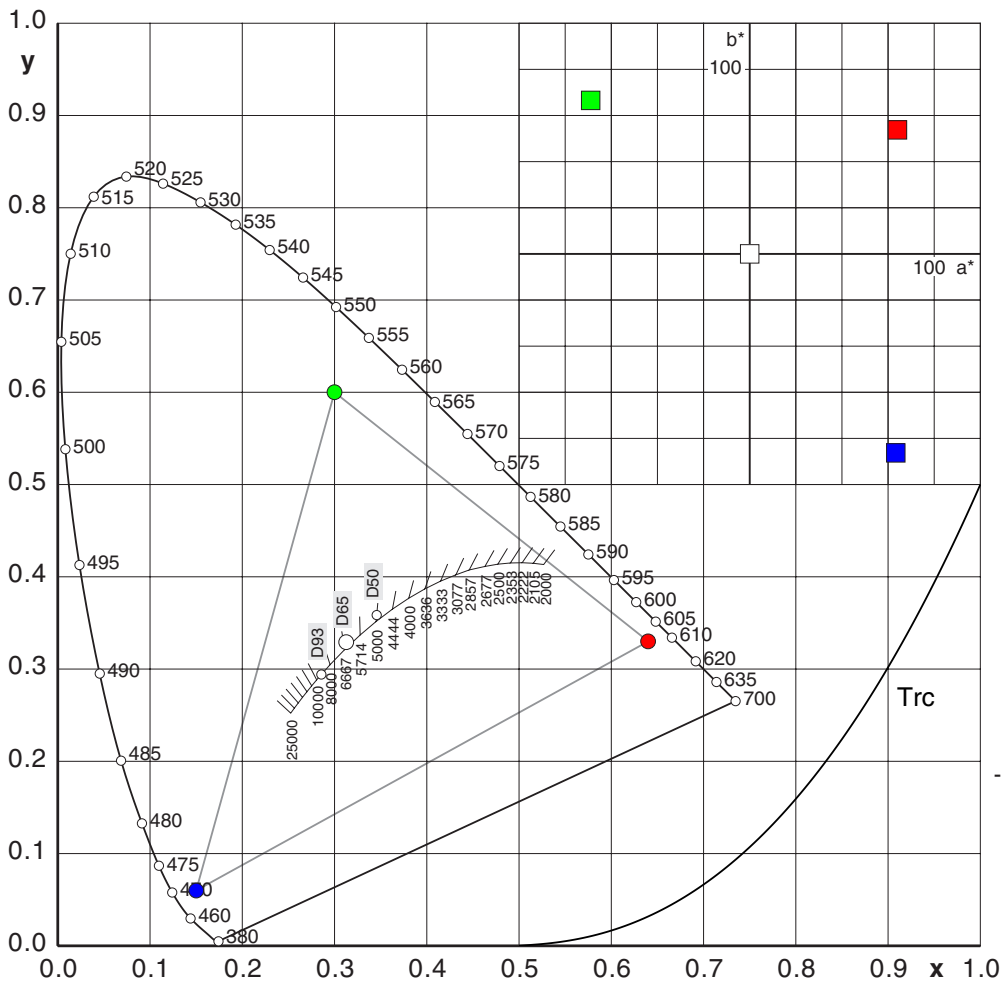
| | | |
|-----------|-----------|-----------|
| 3.134137 | -1.617386 | -0.490662 |
| -0.978796 | 1.916254 | 0.033443 |
| 0.071955 | -0.228977 | 1.405386 |

Matrix Mxr

| | | |
|----------|----------|----------|
| 0.436066 | 0.385151 | 0.143078 |
| 0.222493 | 0.716887 | 0.060620 |
| 0.013924 | 0.097081 | 0.714099 |

2.4.3 ColorCalc / Examples / sRGB without CAT, XYZ-Input

| ColorCalc G.Hoffmann Dec.04 / 2006 | Med.White: Ref.White: Input: | D65 D65 XYZ | Primaries: Trc: Bradford: | Rec.709 sRGB No | Intent: Set: | AbsCol 1 |
|--|------------------------------------|-------------------|---------------------------------|-----------------------|-----------------|-------------|
| X | 0.950456 | 0.412391 | 0.357584 | 0.180481 | | |
| Y | 1.000000 | 0.212639 | 0.715169 | 0.072192 | | |
| Z | 1.089058 | 0.019331 | 0.119195 | 0.950532 | | |
| x | 0.312700 | 0.640000 | 0.300000 | 0.150000 | | |
| y | 0.329000 | 0.330000 | 0.600000 | 0.060000 | | |
| z | 0.358300 | 0.030000 | 0.100000 | 0.790000 | | |
| L* | 100.0000 | 53.2371 | 87.7355 | 32.3008 | | |
| a* | 0.0000 | 80.0902 | -86.1818 | 79.1957 | | |
| b* | -0.0000 | 67.2031 | 83.1866 | -107.8556 | | |
| R | 255.0000 | 255.0001 | -0.0004 | 0.0003 | | |
| G | 254.9999 | -0.0001 | 255.0002 | -0.0002 | | |
| B | 255.0001 | 0.0001 | 0.0000 | 254.9999 | | |
| R' | 255.0000 | 255.0000 | 0.0000 | 0.0041 | | |
| G' | 254.9999 | 0.0000 | 255.0000 | 0.0000 | | |
| B' | 255.0000 | 0.0007 | 0.0006 | 254.9999 | | |
| CCT | 6493 K | none | none | none | | |
| RGB | in-gam | in-gam | in-gam | in-gam | | |



Matrix Crx

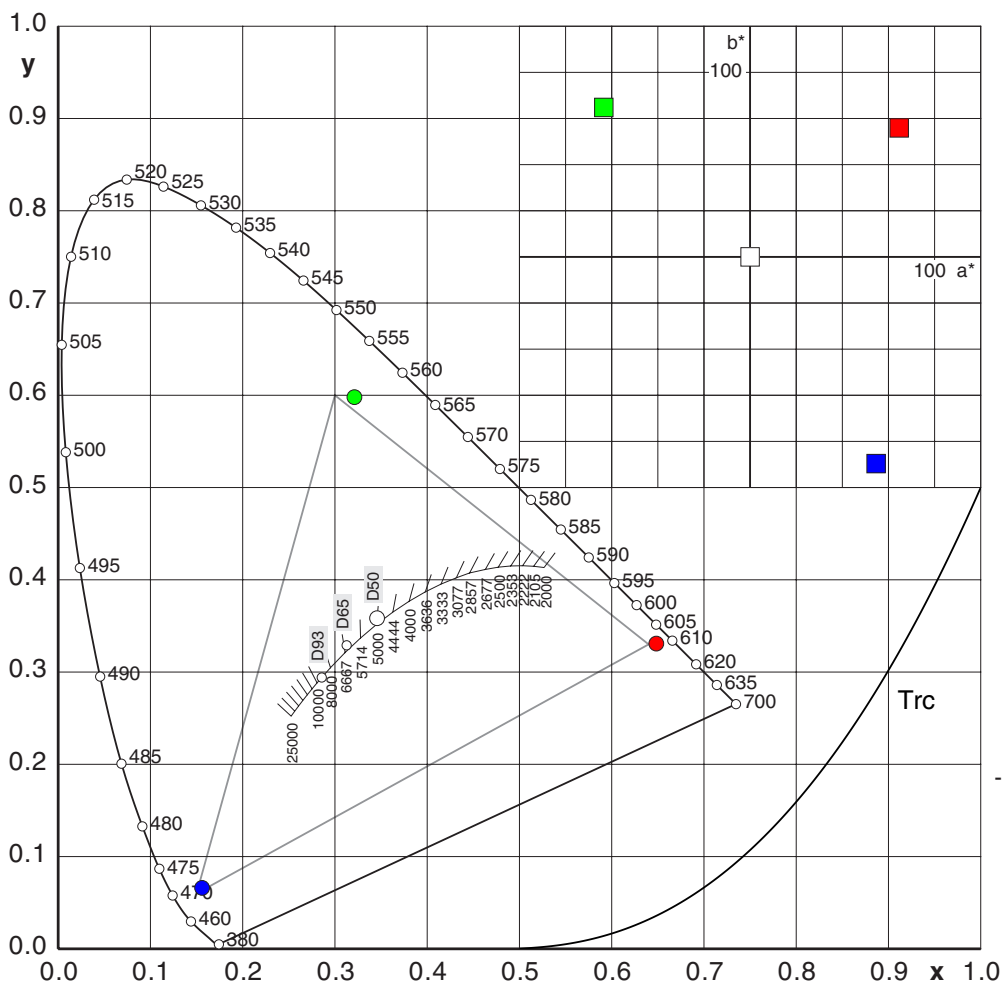
| | | |
|-----------|-----------|-----------|
| 3.240970 | -1.537383 | -0.498611 |
| -0.969243 | 1.875967 | 0.041555 |
| 0.055630 | -0.203977 | 1.056971 |

Matrix Cxr

| | | |
|----------|----------|----------|
| 0.412391 | 0.357584 | 0.180481 |
| 0.212639 | 0.715169 | 0.072192 |
| 0.019331 | 0.119195 | 0.950532 |

2.3.4 ColorCalc / Examples / sRGB with CAT, XYZ-Input

| ColorCalc | Med.White: | D65 | Primaries: | Rec.709 | Intent: | RelCol |
|---------------|------------|----------|------------|-----------|---------|--------|
| G.Hoffmann | Ref.White: | D50 | Trc: | sRGB | Set: | 5 |
| Dec.04 / 2006 | Input: | XYZ | Bradford: | Yes | | |
| X | 0.964295 | 0.436066 | 0.385151 | 0.143078 | | |
| Y | 1.000000 | 0.222493 | 0.716887 | 0.060620 | | |
| Z | 0.825105 | 0.013924 | 0.097081 | 0.714099 | | |
| x | 0.345700 | 0.648442 | 0.321195 | 0.155893 | | |
| y | 0.358500 | 0.330853 | 0.597845 | 0.066049 | | |
| z | 0.295800 | 0.020705 | 0.080960 | 0.778058 | | |
| L* | 100.0000 | 54.2905 | 87.8185 | 29.5683 | | |
| a* | -0.0001 | 80.8051 | -79.2712 | 68.2869 | | |
| b* | -0.0000 | 69.8908 | 80.9947 | -112.0296 | | |
| R | 254.9996 | 255.0003 | -0.0003 | -0.0004 | | |
| G | 255.0001 | -0.0002 | 255.0001 | 0.0002 | | |
| B | 255.0001 | 0.0000 | -0.0001 | 254.9998 | | |
| R' | 254.9998 | 255.0000 | 0.0000 | 0.0000 | | |
| G' | 255.0000 | 0.0000 | 255.0000 | 0.0025 | | |
| B' | 255.0000 | 0.0006 | 0.0000 | 254.9999 | | |
| CCT | 5001 K | none | none | none | | |
| RGB | in-gam | in-gam | in-gam | in-gam | | |



Matrix Mrx

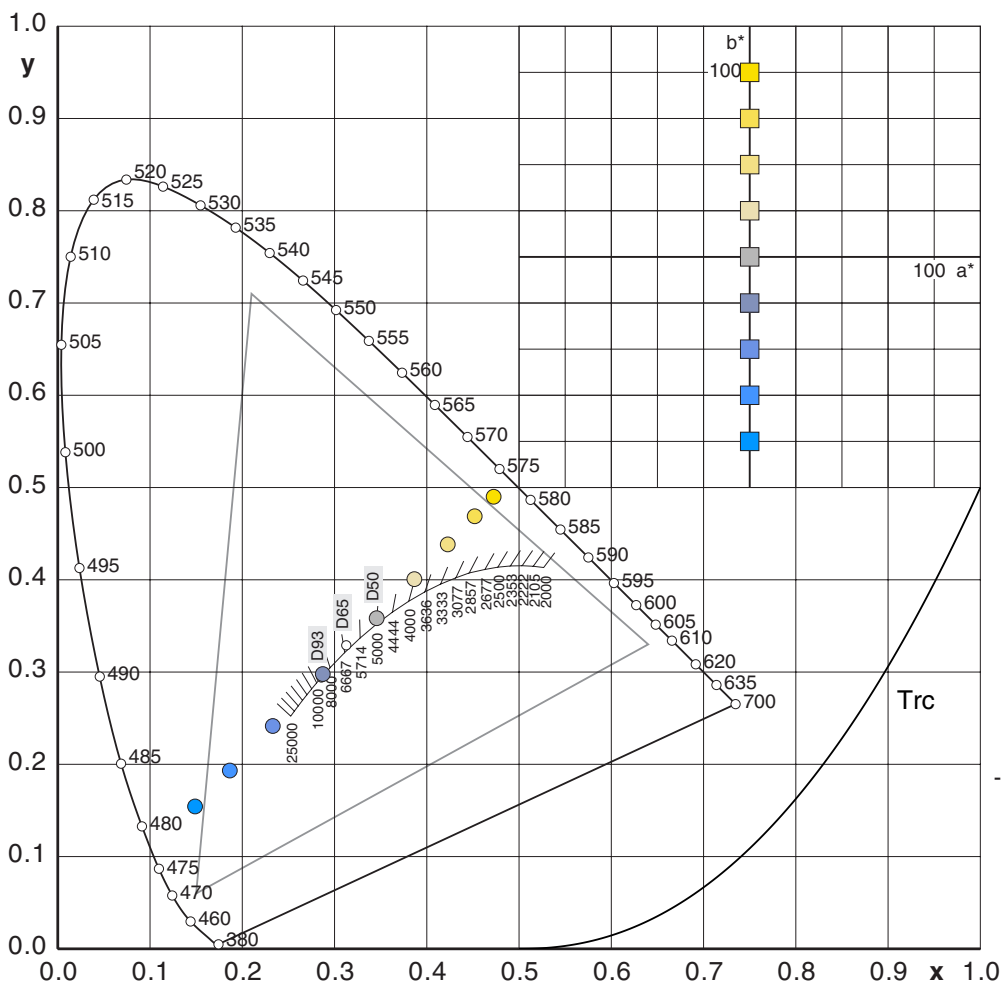
| | | |
|-----------|-----------|-----------|
| 3.134137 | -1.617386 | -0.490662 |
| -0.978796 | 1.916254 | 0.033443 |
| 0.071955 | -0.228977 | 1.405386 |

Matrix Mxr

| | | |
|----------|----------|----------|
| 0.436066 | 0.385151 | 0.143078 |
| 0.222493 | 0.716887 | 0.060620 |
| 0.013924 | 0.097081 | 0.714099 |

2.3.5 ColorCalc / Examples / AdobeRGB(98) with CAT, Lab-Input

| ColorCalc G.Hoffmann Dec.04 / 2006 | Med.White: Ref.White: Input: | D65 D50 Lab | Primaries: Trc: Bradford: | AdobeRGB 2.2 Yes | Intent: Set: | RelCol 6 | | | |
|--|------------------------------------|-------------------|---------------------------------|------------------------|-----------------|-------------|----------|----------|----------|
| X | 0.271192 | 0.271192 | 0.271192 | 0.271192 | 0.465544 | 0.735790 | 0.735790 | 0.735790 | 0.735790 |
| Y | 0.281233 | 0.281233 | 0.281233 | 0.281233 | 0.482781 | 0.763033 | 0.763033 | 0.763033 | 0.763033 |
| Z | 1.271889 | 0.902067 | 0.611932 | 0.391815 | 0.398345 | 0.404947 | 0.241328 | 0.129055 | 0.058460 |
| x | 0.148654 | 0.186451 | 0.232911 | 0.287207 | 0.345700 | 0.386491 | 0.422831 | 0.451993 | 0.472483 |
| y | 0.154158 | 0.193355 | 0.241535 | 0.297841 | 0.358500 | 0.400801 | 0.438487 | 0.468729 | 0.489977 |
| z | 0.697187 | 0.620194 | 0.525553 | 0.414952 | 0.295800 | 0.212708 | 0.138682 | 0.079278 | 0.037540 |
| L* | 60.0000 | 60.0000 | 60.0000 | 60.0000 | 75.0000 | 90.0000 | 90.0000 | 90.0000 | 90.0000 |
| a* | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| b* | -100.0000 | -75.0000 | -50.0000 | -25.0000 | 0.0000 | 25.0000 | 50.0000 | 75.0000 | 100.0000 |
| R | -18.7999 | 13.3918 | 38.6469 | 57.8073 | 123.1092 | 214.1273 | 228.3698 | 238.1427 | 244.2877 |
| G | 80.5822 | 77.4284 | 74.9541 | 73.0770 | 123.1092 | 192.6579 | 191.2625 | 190.3051 | 189.7030 |
| B | 429.3924 | 302.1833 | 202.3847 | 126.6703 | 123.1092 | 117.3050 | 61.0243 | 22.4056 | -1.8772 |
| R' | 0.0000 | 66.8124 | 108.1619 | 129.8852 | 183.1430 | 235.5346 | 242.5307 | 247.1945 | 250.0738 |
| G' | 151.0535 | 148.3369 | 146.1632 | 144.4878 | 183.1430 | 224.4904 | 223.7498 | 223.2400 | 222.9187 |
| B' | 255.0000 | 255.0000 | 229.5730 | 185.5323 | 183.1430 | 179.1665 | 133.1222 | 84.4222 | 0.0000 |
| CCT | none | none | none | 8864 K | 5001 K | 4011 K | 3500 K | none | none |
| RGB | out-gam | out-gam | in-gam | in-gam | in-gam | in-gam | in-gam | in-gam | out-gam |



Matrix Mrx

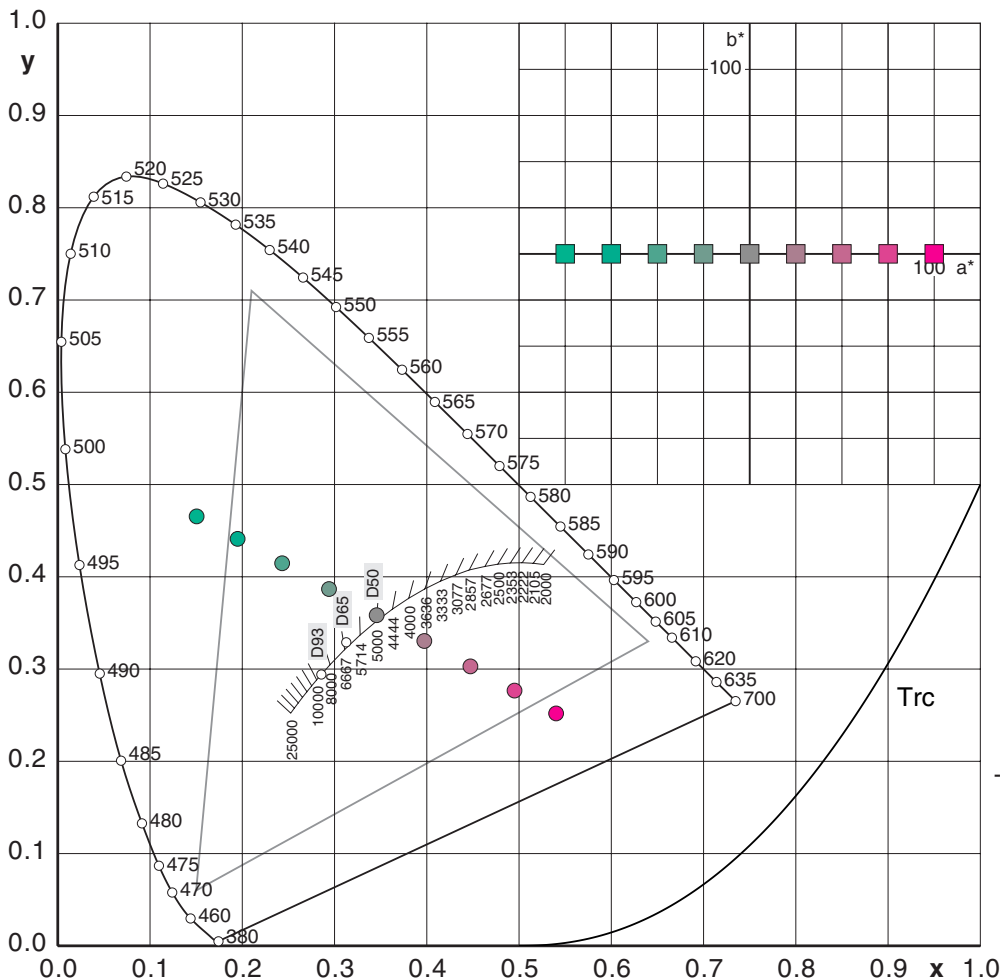
| | | |
|-----------|-----------|-----------|
| 1.962467 | -0.610742 | -0.341358 |
| -0.978796 | 1.916255 | 0.033443 |
| 0.028705 | -0.140675 | 1.348914 |

Matrix Mxr

| | | |
|----------|----------|----------|
| 0.609775 | 0.205300 | 0.149221 |
| 0.311125 | 0.625653 | 0.063222 |
| 0.019471 | 0.060879 | 0.744755 |

2.3.6 ColorCalc / Examples / AdobeRGB(98) with CAT, Lab-Input

| ColorCalc | Med.White: | D65 | Primaries: | AdobeRGB | Intent: | RelCol | | | |
|---------------|------------|----------|------------|----------|----------|----------|----------|----------|----------|
| G.Hoffmann | Ref.White: | D50 | Trc: | 2.2 | Set: | 6 | | | |
| Dec.04 / 2006 | Input: | Lab | Bradford: | Yes | | | | | |
| X | 0.090936 | 0.124317 | 0.165004 | 0.213721 | 0.271192 | 0.338140 | 0.415287 | 0.503358 | 0.603075 |
| Y | 0.281233 | 0.281233 | 0.281233 | 0.281233 | 0.281233 | 0.281233 | 0.281233 | 0.281233 | 0.281233 |
| Z | 0.232047 | 0.232047 | 0.232047 | 0.232047 | 0.232047 | 0.232047 | 0.232047 | 0.232047 | 0.232047 |
| x | 0.150503 | 0.194977 | 0.243266 | 0.293976 | 0.345700 | 0.397148 | 0.447234 | 0.495120 | 0.540218 |
| y | 0.465451 | 0.441083 | 0.414625 | 0.386840 | 0.358500 | 0.330311 | 0.302868 | 0.276631 | 0.251921 |
| z | 0.384046 | 0.363940 | 0.342109 | 0.319184 | 0.295800 | 0.272541 | 0.249898 | 0.228249 | 0.207861 |
| L* | 60.0000 | 60.0000 | 60.0000 | 60.0000 | 60.0000 | 60.0000 | 60.0000 | 60.0000 | 60.0000 |
| a* | -100.0000 | -75.0000 | -50.0000 | -25.0000 | 0.0000 | 25.0000 | 50.0000 | 75.0000 | 100.0000 |
| b* | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| R | -18.4907 | -1.7863 | 18.5748 | 42.9544 | 71.7145 | 105.2171 | 143.8240 | 187.8971 | 237.7984 |
| G | 116.7050 | 108.3736 | 98.2184 | 86.0588 | 71.7145 | 55.0048 | 35.7494 | 13.7675 | -11.1211 |
| B | 70.3951 | 70.6394 | 70.9373 | 71.2938 | 71.7145 | 72.2045 | 72.7692 | 73.4139 | 74.1438 |
| R' | 0.0000 | 0.0000 | 77.5250 | 113.4840 | 143.2571 | 170.5251 | 196.5580 | 221.9516 | 247.0320 |
| G' | 178.7493 | 172.8318 | 165.2724 | 155.6363 | 143.2570 | 126.9842 | 104.3973 | 67.6582 | 0.0000 |
| B' | 142.0530 | 142.2769 | 142.5492 | 142.8745 | 143.2570 | 143.7012 | 144.2109 | 144.7902 | 145.4428 |
| CCT | none | none | none | none | 5001 K | 3098 K | none | none | none |
| RGB | out-gam | out-gam | in-gam | in-gam | in-gam | in-gam | in-gam | in-gam | out-gam |



Matrix Mrx

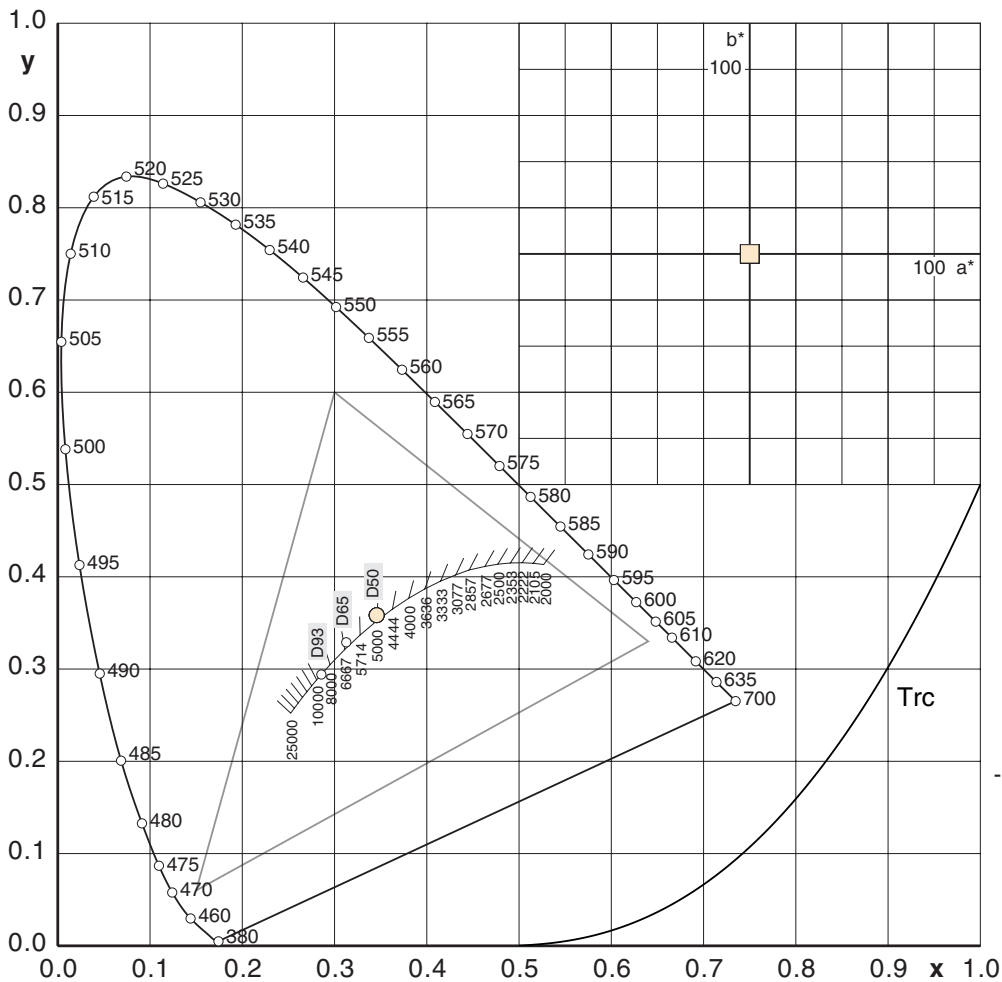
| | | |
|-----------|-----------|-----------|
| 1.962467 | -0.610742 | -0.341358 |
| -0.978796 | 1.916255 | 0.033443 |
| 0.028705 | -0.140675 | 1.348914 |

Matrix Mxr

| | | |
|----------|----------|----------|
| 0.609775 | 0.205300 | 0.149221 |
| 0.311125 | 0.625653 | 0.063222 |
| 0.019471 | 0.060879 | 0.744755 |

2.3.7 ColorCalc / Examples / sRGB AbsCol, Lab-Input light gray

| ColorCalc G.Hoffmann Dec.04 / 2006 | Med.White: Ref.White: Input: | D65 D50 Lab | Primaries: Trc: Bradford: | Rec.709 sRGB No | Intent: Set: | AbsCol 9 | | |
|--|------------------------------------|-------------------|---------------------------------|-----------------------|-----------------|-------------|----------|----------|
| X | 0.964296 | 0.939571 | 0.915273 | 0.891398 | 0.867941 | 0.844900 | 0.822270 | 0.800047 |
| Y | 1.000000 | 0.974360 | 0.949162 | 0.924403 | 0.900078 | 0.876183 | 0.852715 | 0.829670 |
| Z | 0.825104 | 0.803949 | 0.783158 | 0.762729 | 0.742658 | 0.722943 | 0.703579 | 0.684565 |
| x | 0.345700 | 0.345700 | 0.345700 | 0.345700 | 0.345700 | 0.345700 | 0.345700 | 0.345700 |
| y | 0.358500 | 0.358500 | 0.358500 | 0.358500 | 0.358500 | 0.358500 | 0.358500 | 0.358500 |
| z | 0.295800 | 0.295800 | 0.295800 | 0.295800 | 0.295800 | 0.295800 | 0.295800 | 0.295800 |
| L* | 100.0000 | 99.0000 | 98.0000 | 97.0000 | 96.0000 | 95.0000 | 94.0000 | 93.0000 |
| a* | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| b* | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| R | 299.9984 | 292.3065 | 284.7472 | 277.3193 | 270.0219 | 262.8536 | 255.8132 | 248.8997 |
| G | 248.7824 | 242.4037 | 236.1349 | 229.9752 | 223.9235 | 217.9790 | 212.1406 | 206.4074 |
| B | 184.0536 | 179.3345 | 174.6968 | 170.1397 | 165.6626 | 161.2647 | 156.9453 | 152.7038 |
| R' | 255.0000 | 255.0000 | 255.0000 | 255.0000 | 255.0000 | 255.0000 | 255.0000 | 252.2994 |
| G' | 252.2471 | 249.3809 | 246.5209 | 243.6672 | 240.8198 | 237.9787 | 235.1440 | 232.3158 |
| B' | 220.8271 | 218.2991 | 215.7765 | 213.2595 | 210.7481 | 208.2423 | 205.7421 | 203.2476 |
| CCT | 5001 K | 5001 K | 5001 K | 5001 K | 5001 K | 5001 K | 5001 K | 5001 K |
| RGB | out-gam | out-gam | out-gam | out-gam | out-gam | out-gam | out-gam | in-gam |



Matrix Crx

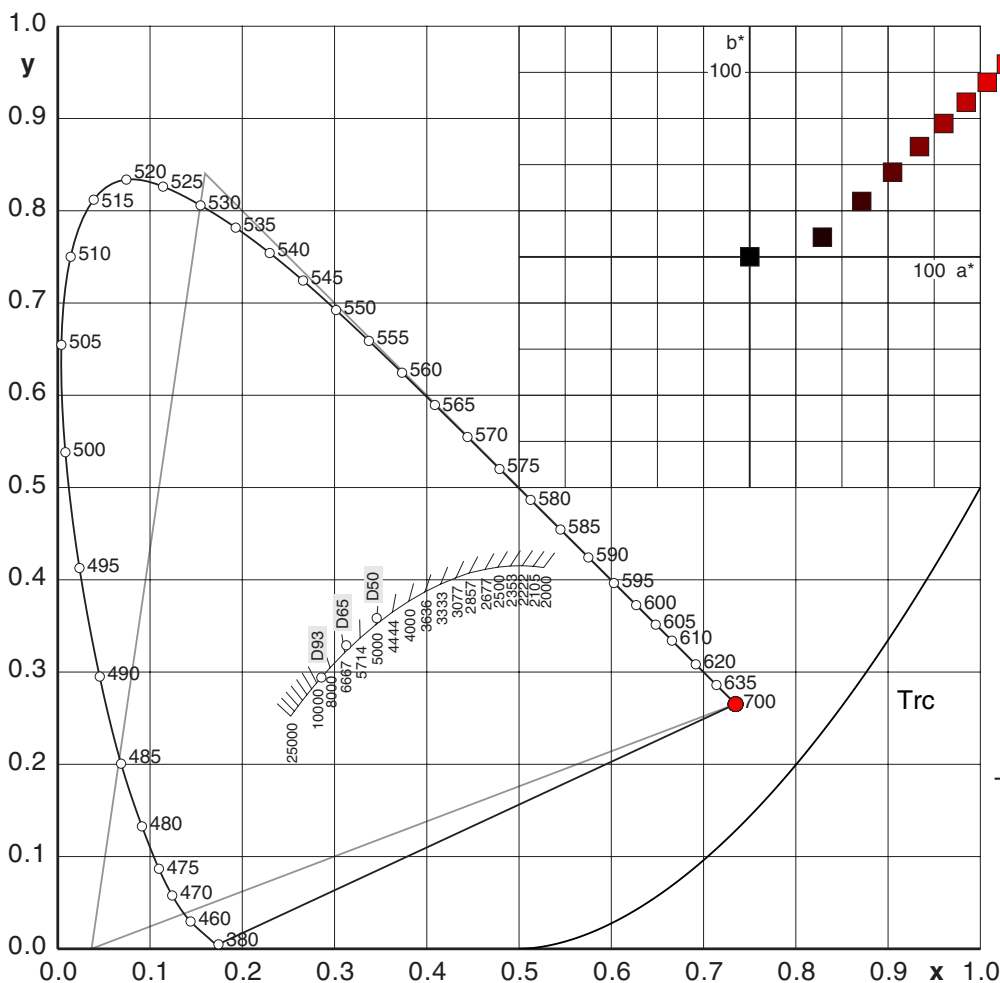
| | | |
|-----------|-----------|-----------|
| 3.240970 | -1.537383 | -0.498611 |
| -0.969243 | 1.875967 | 0.041555 |
| 0.055630 | -0.203977 | 1.056971 |

Matrix Cxr

| | | |
|----------|----------|----------|
| 0.412391 | 0.357584 | 0.180481 |
| 0.212639 | 0.715169 | 0.072192 |
| 0.019331 | 0.119195 | 0.950532 |

2.3.8 ColorCalc / Examples / ProPhotoRGB / Red

| ColorCalc G.Hoffmann Dec.04 / 2006 | Med.White: Ref.White: Input: | D50 D50 RGB' | Primaries: Trc: Bradford: | ProPhoto 1.8 No | Intent: Set: | AbsCol 4 | | | |
|--|------------------------------------|--------------------|---------------------------------|-----------------------|-----------------|----------------|----------------|----------------|----------------|
| X | 0.000037 | 0.019027 | 0.066256 | 0.137464 | 0.230717 | 0.344761 | 0.478678 | 0.631754 | 0.797763 |
| Y | 0.000013 | 0.006871 | 0.023925 | 0.049639 | 0.083313 | 0.124494 | 0.172852 | 0.228129 | 0.288075 |
| Z | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| x | 0.734698 | 0.734698 | 0.734698 | 0.734698 | 0.734698 | 0.734698 | 0.734698 | 0.734698 | 0.734698 |
| y | 0.265302 | 0.265302 | 0.265302 | 0.265302 | 0.265302 | 0.265302 | 0.265302 | 0.265302 | 0.265302 |
| z | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| L* | 0.0121 | 6.2063 | 17.4254 | 26.6316 | 34.6635 | 41.9217 | 48.6175 | 54.8791 | 60.6114 |
| a* | 0.0978 | 39.3942 | 60.7147 | 77.4370 | 92.0263 | 105.2102 | 117.3726 | 128.7463 | 139.1586 |
| b* | 0.0209 | 10.7005 | 30.0439 | 45.9166 | 59.7646 | 72.2787 | 83.8232 | 94.6191 | 104.5023 |
| R | 0.0119 | 6.0819 | 21.1783 | 43.9396 | 73.7473 | 110.2006 | 153.0066 | 201.9363 | 255.0000 |
| G | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| B | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| R' | 1.0000 | 32.0000 | 64.0000 | 96.0000 | 128.0000 | 160.0000 | 192.0000 | 224.0000 | 255.0000 |
| G' | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| B' | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| CCT RGB | none in-gam | none in-gam | none in-gam | none in-gam | none in-gam | none in-gam | none in-gam | none in-gam | none in-gam |



Matrix Crx

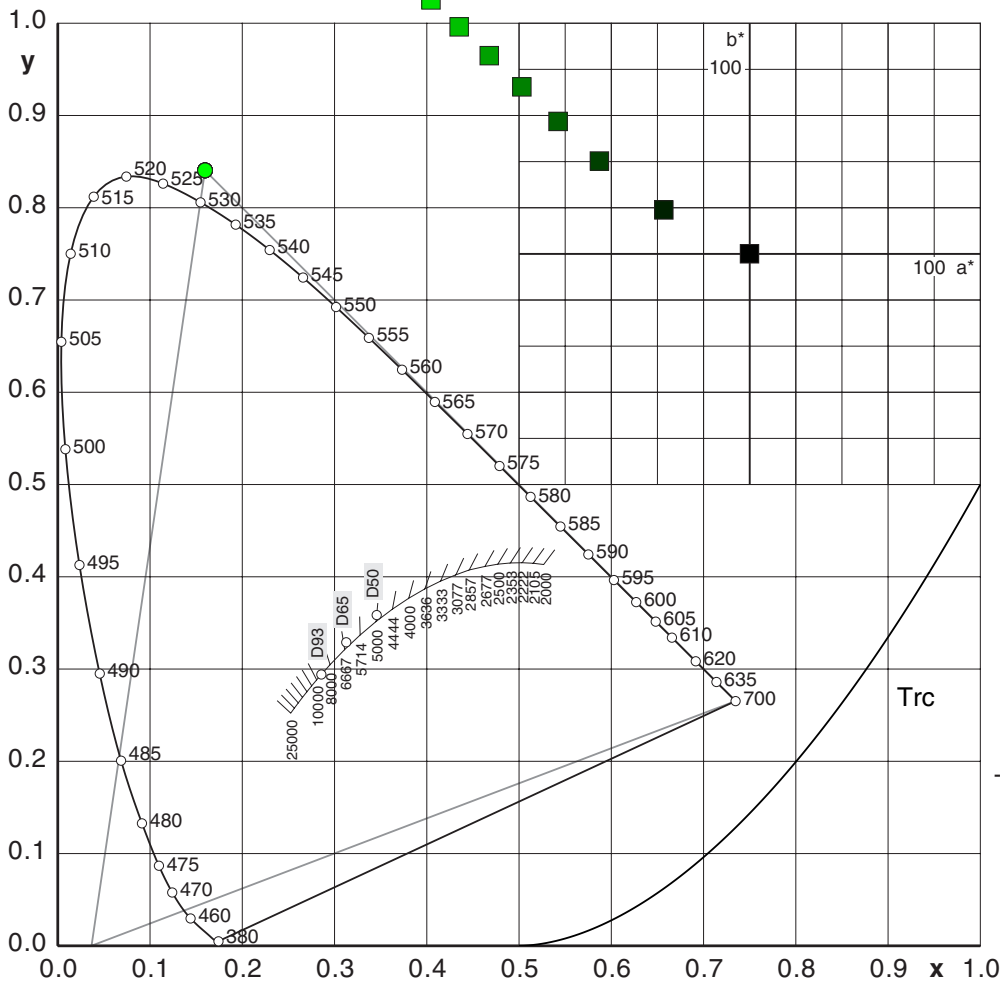
| | | |
|-----------|-----------|-----------|
| 1.345795 | -0.255577 | -0.051105 |
| -0.544636 | 1.508254 | 0.020526 |
| 0.000000 | 0.000000 | 1.211967 |

Matrix Cxr

| | | |
|----------|----------|----------|
| 0.797763 | 0.135183 | 0.031350 |
| 0.288075 | 0.711833 | 0.000092 |
| 0.000000 | 0.000000 | 0.825105 |

2.3.9 ColorCalc / Examples / ProPhotoRGB / Green

| ColorCalc G.Hoffmann Dec.04 / 2006 | Med.White: Ref.White: Input: | D50 D50 RGB' | Primaries: Trc: Bradford: | ProPhoto 1.8 No | Intent: Set: | AbsCol 4 | | | |
|--|------------------------------------|--------------------|---------------------------------|-----------------------|-----------------|-------------|-----------|-----------|-----------|
| X | 0.000006 | 0.003224 | 0.011227 | 0.023294 | 0.039096 | 0.058421 | 0.081113 | 0.107052 | 0.135183 |
| Y | 0.000033 | 0.016978 | 0.059119 | 0.122658 | 0.205866 | 0.307625 | 0.427118 | 0.563706 | 0.711833 |
| Z | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| x | 0.159599 | 0.159599 | 0.159599 | 0.159599 | 0.159599 | 0.159599 | 0.159599 | 0.159599 | 0.159599 |
| y | 0.840401 | 0.840401 | 0.840401 | 0.840401 | 0.840401 | 0.840401 | 0.840401 | 0.840401 | 0.840401 |
| z | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| L* | 0.0300 | 13.8138 | 29.1892 | 41.6354 | 52.4940 | 62.3067 | 71.3590 | 79.8243 | 87.5740 |
| a* | -0.1037 | -46.5239 | -81.4564 | -103.8915 | -123.4648 | -141.1526 | -157.4700 | -172.7292 | -186.6986 |
| b* | 0.0516 | 23.8168 | 50.3262 | 71.7852 | 90.5069 | 107.4253 | 123.0327 | 137.6280 | 150.9897 |
| R | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| G | 0.0119 | 6.0819 | 21.1783 | 43.9396 | 73.7473 | 110.2006 | 153.0066 | 201.9363 | 255.0000 |
| B | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| R' | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| G' | 1.0000 | 32.0000 | 64.0000 | 96.0000 | 128.0000 | 160.0000 | 192.0000 | 224.0000 | 255.0000 |
| B' | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| CCT | none | none | none | none | none | none | none | none | none |
| RGB | in-gam | in-gam | n-gam | in-gam | in-gam | in-gam | in-gam | in-gam | in-gam |



Matrix Crx

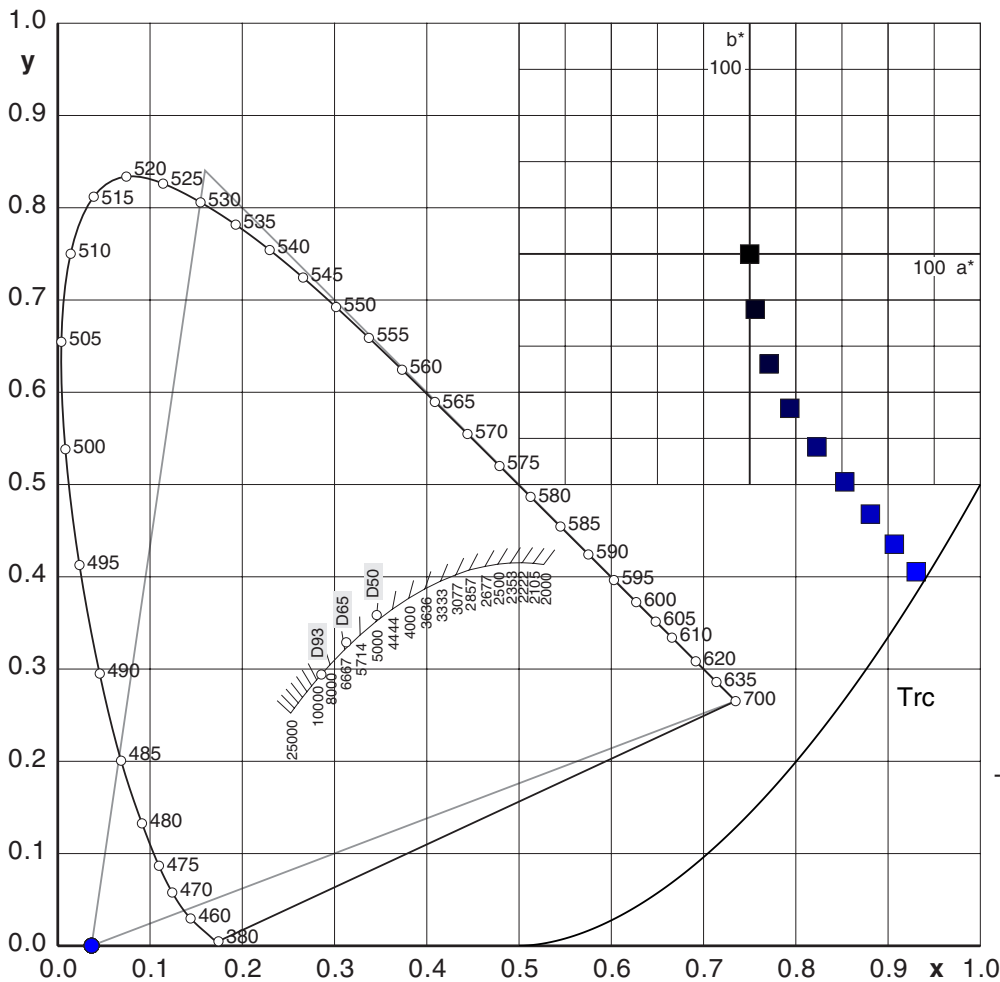
| | | |
|-----------|-----------|-----------|
| 1.345795 | -0.255577 | -0.051105 |
| -0.544636 | 1.508254 | 0.020526 |
| 0.000000 | 0.000000 | 1.211967 |

Matrix Cxr

| | | |
|----------|----------|----------|
| 0.797763 | 0.135183 | 0.031350 |
| 0.288075 | 0.711833 | 0.000092 |
| 0.000000 | 0.000000 | 0.825105 |

2.3.8 ColorCalc / Examples / ProPhotoRGB / Blue

| ColorCalc G.Hoffmann Dec.04 / 2006 | Med.White: Ref.White: Input: | D50 D50 RGB' | Primaries: Trc: Bradford: | ProPhoto 1.8 No | Intent: Set: | AbsCol 4 | | | |
|--|------------------------------------|--------------------|---------------------------------|-----------------------|-----------------|----------------|----------------|----------------|----------------|
| X | 0.000001 | 0.000748 | 0.002604 | 0.005402 | 0.009066 | 0.013548 | 0.018811 | 0.024826 | 0.031350 |
| Y | 0.000000 | 0.000002 | 0.000008 | 0.000016 | 0.000027 | 0.000040 | 0.000055 | 0.000073 | 0.000092 |
| Z | 0.000038 | 0.019679 | 0.068527 | 0.142176 | 0.238624 | 0.356577 | 0.495084 | 0.653406 | 0.825105 |
| x | 0.036600 | 0.036600 | 0.036600 | 0.036600 | 0.036600 | 0.036600 | 0.036600 | 0.036600 | 0.036600 |
| y | 0.000107 | 0.000107 | 0.000107 | 0.000107 | 0.000107 | 0.000107 | 0.000107 | 0.000107 | 0.000107 |
| z | 0.963293 | 0.963293 | 0.963293 | 0.963293 | 0.963293 | 0.963293 | 0.963293 | 0.963293 | 0.963293 |
| L* | 0.0000 | 0.0020 | 0.0069 | 0.0143 | 0.0239 | 0.0358 | 0.0497 | 0.0656 | 0.0828 |
| a* | 0.0059 | 3.0105 | 10.4830 | 21.7496 | 36.4620 | 51.5296 | 65.4169 | 78.3912 | 90.2572 |
| b* | -0.0725 | -29.9803 | -59.6617 | -83.6824 | -104.6335 | -123.5612 | -141.0171 | -157.3361 | -172.2711 |
| R | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| G | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| B | 0.0119 | 6.0819 | 21.1783 | 43.9396 | 73.7473 | 110.2006 | 153.0066 | 201.9363 | 255.0000 |
| R' | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| G' | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| B' | 1.0000 | 32.0000 | 64.0000 | 96.0000 | 128.0000 | 160.0000 | 192.0000 | 224.0000 | 255.0000 |
| CCT RGB | none in-gam | none in-gam | none in-gam | none in-gam | none in-gam | none in-gam | none in-gam | none in-gam | none in-gam |



Matrix Crx

| | | |
|-----------|-----------|-----------|
| 1.345795 | -0.255577 | -0.051105 |
| -0.544636 | 1.508254 | 0.020526 |
| 0.000000 | 0.000000 | 1.211967 |

Matrix Cxr

| | | |
|----------|----------|----------|
| 0.797763 | 0.135183 | 0.031350 |
| 0.288075 | 0.711833 | 0.000092 |
| 0.000000 | 0.000000 | 0.825105 |

3.1 SpectroCalc / Input

3.1.1 Color space (same as in chapter 2.1)

```
%--Choose one standard set
/S 5 def
S 0 eq {} if % None, use settings above
S 1 eq {Prims709 WhiteD65 RefD65 Gam24 BradF RendA} if % sRGB AbsCol
S 2 eq {PrimsAd98 WhiteD65 RefD65 Gam22 BradF RendA} if % AdobeRGB(98) AbsCol
S 3 eq {PrimsOpti WhiteD65 RefD65 Gam22 BradF RendA} if % OptiRGB AbsCol
S 4 eq {PrimsProp WhiteD50 RefD50 Gam18 BradF RendA} if % ProPhoto AbsCol

S 5 eq {Prims709 WhiteD65 RefD50 Gam24 BradT RendR} if % sRGB RelCol
S 6 eq {PrimsAd98 WhiteD65 RefD50 Gam22 BradT RendR} if % AdobeRGB(98) RelCol
S 7 eq {PrimsOpti WhiteD65 RefD50 Gam22 BradT RendR} if % OptiRGB RelCol
S 8 eq {PrimsProp WhiteD50 RefD50 Gam18 BradT RendR} if % ProPhoto RelCol

S 9 eq {Prims709 WhiteD65 RefD50 Gam24 BradF RendA} if % sRGB AbsCol
S 10 eq {PrimsAd98 WhiteD65 RefD50 Gam22 BradF RendA} if % AdobeRGB(98) AbsCol
S 11 eq {PrimsOpti WhiteD65 RefD50 Gam22 BradF RendA} if % OptiRGB AbsCol
S 12 eq {PrimsProp WhiteD50 RefD50 Gam18 BradF RendA} if % ProPhoto AbsCol
```

3.1.2 Headline

```
%--Define headline
/head (any text) def
```

E.g. the date

3.1.3 Illuminants

```
%--Choose two illuminants
/Ilu1 4 def
/Ilu2 108 def
% 0 Equal Energy
% 1 A
% 2 B
% 3 C
% 4 D50
% 5 D55
% 6 D65
% 7 D75
% 101 F1
% 102 F2
% 103 F3
% 104 F4
% 105 F5
% 106 F6
% 107 F7
% 108 F8
% 109 F9
% 110 F10
% 111 F11
```

3.1 SpectroCalc / Input

3.1.4 Zoom factor

```
%--Choose zoom factor for fluorescent spectrum graphic  
/Fscale 4 def
```

3.1.5 Show CT-Curve in Lab-plane

```
%--Choose Show CT-Curve in Lab  
/CTLab 0 def  
% 0 No  
% 1 Yes
```

3.1 SpectroCalc / Input

3.1.6 Spectrum mode

```
%--Choose spectrum mode
/SMode 0 def
% 0 Perfect Reflector
% 1 Spectrum Function
% 2 Spectrum Table
% 3 Spectrum Spectrocam
% 4 Spectrum Eye-One Pro
% 5 Spectrum DTP-22
```

Spectrum mode Perfect Reflector (perfect diffuser) uses the constant reflectance factor 1.0. This is useful for measuring the parameters of the illuminants themselves.

Spectrum mode Function builds a reflectance spectrum by the sum of three Gaussian bell curves. This is useful for metamerism tests.

Spectrum mode Table uses a few values and fills the table by linear interpolation.

Spectrum mode Spectrocam uses spectral data by Avantes Spectrocam.

Spectrum mode Eye-One Pro uses spectral data by GretagMacbeth Eye-One Pro

Spectrum mode DTP-22 uses spectral data by X-Rite DTP-22

3.1.6.1 Spectrum Function

```
%--Define spectrum function by three Gaussian bells
/lam1 420 def % center in nm
/lam2 520 def
/lam3 620 def
/sig1 20 def % standard deviation in nm
/sig2 20 def
/sig3 20 def
/amp1 0.9 def % peak amplitude 0..1
/amp2 0.3 def
/amp3 0.9 def
```

Each of the Gaussian bell curves has three parameters: the center wavelength λ_{mi} , the standard deviation σ_i and the peak amplitude amp_i . Amplitudes can have any sign and size. The graph is clipped for the rectangle (380,0) to (780,2).

3.1.6.2 Spectrum Table

```
%--Define spectrum by table, steps 5nm
%--Minimal entries: at 380nm,at any between,at 780nm
/CwT [380 0.2
      560 0.8
      780 0.2 ] def
%--Actual table
/CwT [380 0.2
      420 0.9
      520 0.7
      620 0.9
      780 0.2 ] def
```

The table has at least three pairs of entries. The wavelengths are integer in steps of 5nm. Missing values are generated by linear interpolation.

3.1 SpectroCalc / Input

3.1.6.3 Spectrum Spectrocam

%-Spectrocam: complete data, re-arranged for 10 number columns

/CwC

```
[
Nr   X       Y       Z       L       a       b       C       hue   Y       M
     C       Vis     x       y       u       v
     Illuminant/Observer
     Density status
     380     385     390     395     400     405     410     415     420     425
     430     435     440     445     450     455     460     465     470     475
     480     485     490     495     500     505     510     515     520     525
     530     535     540     545     550     555     560     565     570     575
     580     585     590     595     600     605     610     615     620     625
     630     635     640     645     650     655     660     665     670     675
     680     685     690     695     700     705     710     715     720     725
     730     735     740     745     750
A1   68.04  69.67  2.93  86.84  1.87  111.58 111.59 89.04 1.7626 0.2110
     0.0814          0.1593 0.48  0.50  0.24  0.56  D50 2  E
     2.18   2.03   1.94   1.77   1.61   1.61   1.60   1.70   1.68   1.73
     1.65   1.64   1.67   1.66   1.77   1.80   1.81   1.81   1.75   1.72
     1.65   1.58   1.98   3.81   8.30  16.45  28.08  41.59  54.44  64.22
     70.56  74.26  76.20  77.41  78.37  79.14  79.91  80.61  81.09  81.52
     81.79  82.24  82.32  82.52  82.67  82.79  82.89  83.03  83.11  83.30
     83.47  83.56  83.83  83.93  84.05  84.32  84.34  84.34  84.35  84.22
     84.31  84.41  84.60  84.87  85.12  85.46  85.58  85.82  86.02  86.05
     86.36  86.68  86.55  86.67  86.69
] def
```

Use the complete file, re-arrange for 10 number columns and write data in brackets as above. The numbers after 'E' are the reflectance factors. Only these are extracted.

Modification February 23, 2006.

3.1.6.4 Spectrum Eye-One Pro

%--Eye-One Pro: use only spectral data from file *.lcp by ColorPicker

%--From 380nm to 730nm, step 10nm. Re-arrange for 4 columns. Delete kommas.

/CwE

```
[ 0.0170541442930698 0.0158690381795168 0.0147084509953856 0.0141440043225884
 0.0137486308813095 0.0138662662357092 0.0139446845278144 0.0143155101686716
 0.0146184880286455 0.0150265172123909 0.0169226862490177 0.0271776393055916
 0.0787448436021805 0.2387251853942870 0.4879423379898070 0.6712245345115660
 0.7550856471061710 0.7915746569633480 0.8096777796745300 0.8240625262260440
 0.8303878307342530 0.8356326222419740 0.8380561470985410 0.8414235711097720
 0.8443459868431090 0.8456398844718930 0.8489986658096310 0.8527597784996030
 0.8562397956848140 0.8583341836929320 0.8615325093269350 0.8655382990837100
 0.8712845444679260 0.8773978352546690 0.8816110491752620 0.8868564963340760
] def
```

Not valid for files by i1share. Use ColorPicker and *.lcp file.

Not very convenient because the komma after each number has to be removed.

Feature since February 24, 2006

3.1 SpectroCalc / Input

3.1.6.5 Spectrum DTP-22

Define standard settings in ColorShop Preferences. E.g. output XYZ, Lab and spectrum. Choose format 'Tab-delimited text option' and save as *.txt.

The file will look like this, already somewhat ordered for better readability here:

```
Color Name CIE Lab                CIE XYZ
Spectral Data(nm)
390  400  410  420  430  440  450  460  470  480
490  500  510  520  530  540  550  560  570  580
590  600  610  620  630  640  650  660  670  680
690  700
Unnamed  87.59  2.56 112.33  69.86  71.22  3.00
0.0208 0.0200 0.0192 0.0184 0.0175 0.0169 0.0167 0.0170 0.0144 0.0200
0.0289 0.0958 0.304  0.5351 0.6795 0.7720 0.8134 0.8258 0.8371 0.8434
0.8460 0.8471 0.8499 0.8536 0.8584 0.8629 0.8655 0.8665 0.8647
0.8633 0.8659 0.8713
```

Now delete all data, here by comments (%), with the exception of spectral data.

Write relevant data in brackets as below.

```
%--DTP-22: use only spectral data from file *.txt
%--From 390nm to 700nm, step 10. Re-arrange for 10 columns
% Color Name CIE Lab                CIE XYZ
% Spectral Data(nm)
%   390 400 410 420 430 440 450 460 470 480
%   490 500 510 520 530 540 550 560 570 580
%   590 600 610 620 630 640 650 660 670 680
%   690 700
% Unnamed 87.59 2.56 112.33  69.86  71.22  3.00
/CwD
[
    0.0208 0.0200 0.0192 0.0184 0.0175 0.0169 0.0167 0.0170 0.0144 0.0200
    0.0289 0.0958 0.3040 0.5351 0.6795 0.7720 0.8134 0.8258 0.8371 0.8434
    0.8460 0.8471 0.8499 0.8536 0.8584 0.8629 0.8655 0.8665 0.8647 0.8633
    0.8659 0.8713
] def
```

The values in CwD are the reflectance factors.

The complete file cannot be read by PostScript because its structure is not fixed. There may be any other data besides the spectral data, depending on the Preference settings.

3.2 SpectroCalc / Output

3.2.1 Graphics

Please refer to the examples.

Spectrum for two illuminants and the reflectance spectrum

CIE chromaticity diagram xyY

Curve for the Planckian radiator, with color temperatures

White points D50, D65 and 9300K (D93)

Round color dots in xyY (colors in device RGB)

Small Lab plane a*b*

Square color dots in a*b* (colors in device RGB)

Two color patches

3.2.2 Header

| | |
|-----------|---|
| Head | Arbitrary header text, e.g. the date |
| I1,I2 | Two illuminants |
| Med.White | Media white point |
| Ref.White | Reference white point |
| Primaries | Primaries |
| Trc | Tone reproduction curve |
| Mode | Spectrum generator mode With parameters for Spectrum Function and Spectrum Table |

3.2.3 Numbers

| | |
|--------|---|
| XYZ | CIE XYZ as stimulus values |
| xyY | CIE xyY as stimulus values |
| L*a*b* | CIE Lab in reference space |
| RGB | Linear RGB values in media space, not clipped |
| RGB' | Gamma encoded values in media space, clipped for 0...255 |
| CCT | Correlated color temperature This calculation is based on tables, not very accurate but practically sufficient 'None' is indicated if the color is too far away from the curve for the Planckian radiator |
| RGB | In-gamut or out-of-gamut for RGB Out-of-gamut, if at least one value is less than -0.49 (rounded to 0) or greater than 255.49 (rounded to 255) |

3.3 SpectroCalc / Calculation sequence

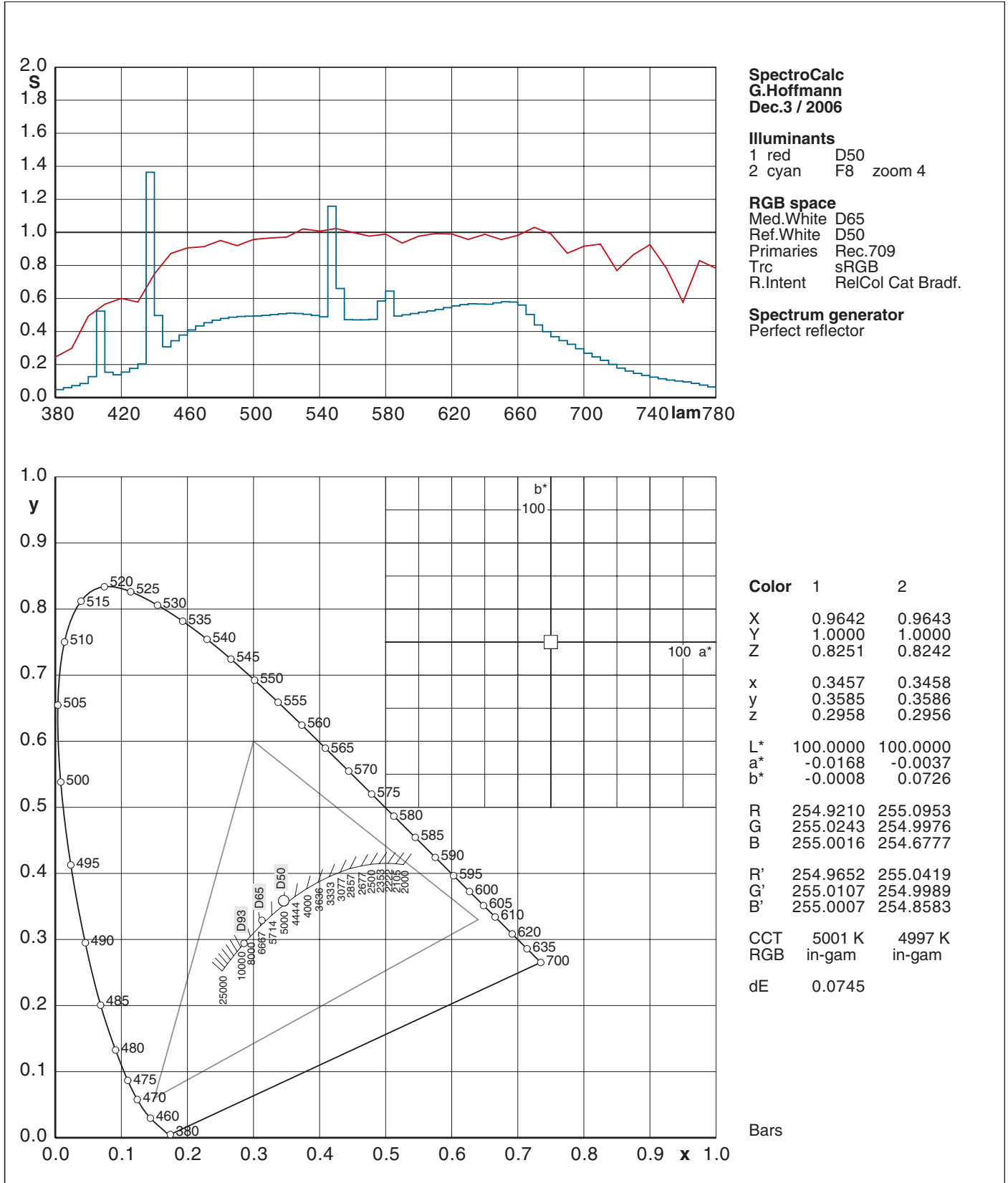
SpectroCalc works similarly to ColorCalc, entry point XYZ Input 2.3.2.

Spectra for Illuminants are normalized for Y=100.

XYZ values are calculated by multiplying and summing spectral values of illuminant, reflectance factor and color matching functions (Euler or rectangle integration for stepsize 5nm).

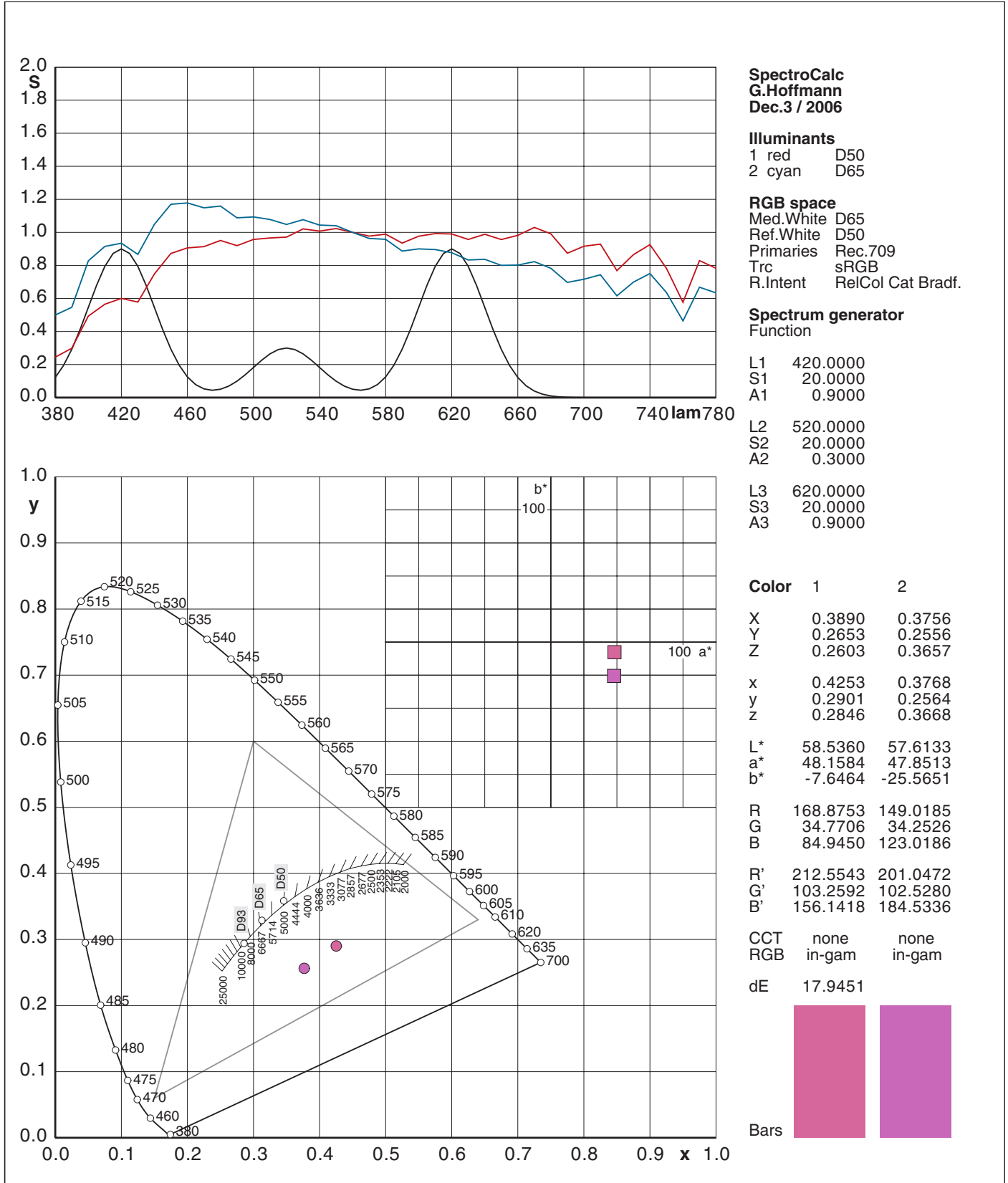
3.3.1 SpectroCalc / Examples / sRGB with CAT / Illumin. D50+F8

The fluorescent tube Type F8 has approximately the correlated color temperature 5000K. Spectrum mode: Perfect Reflector.



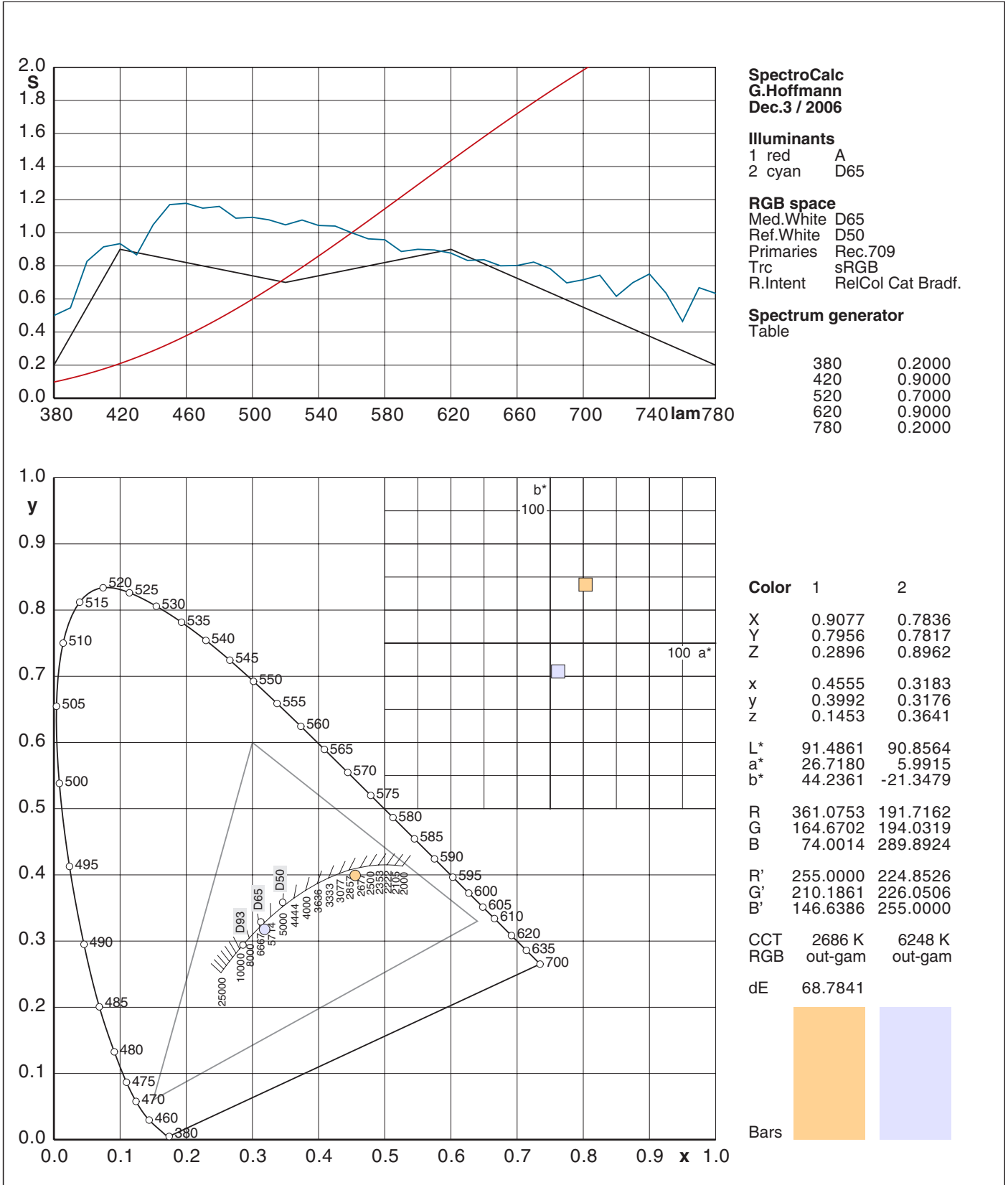
3.3.2 SpectroCalc / Examples / sRGB with CAT / Illumin. D50+D65

A magenta spectrum is rather sensible to illuminant changes.
Spectrum mode: Function.



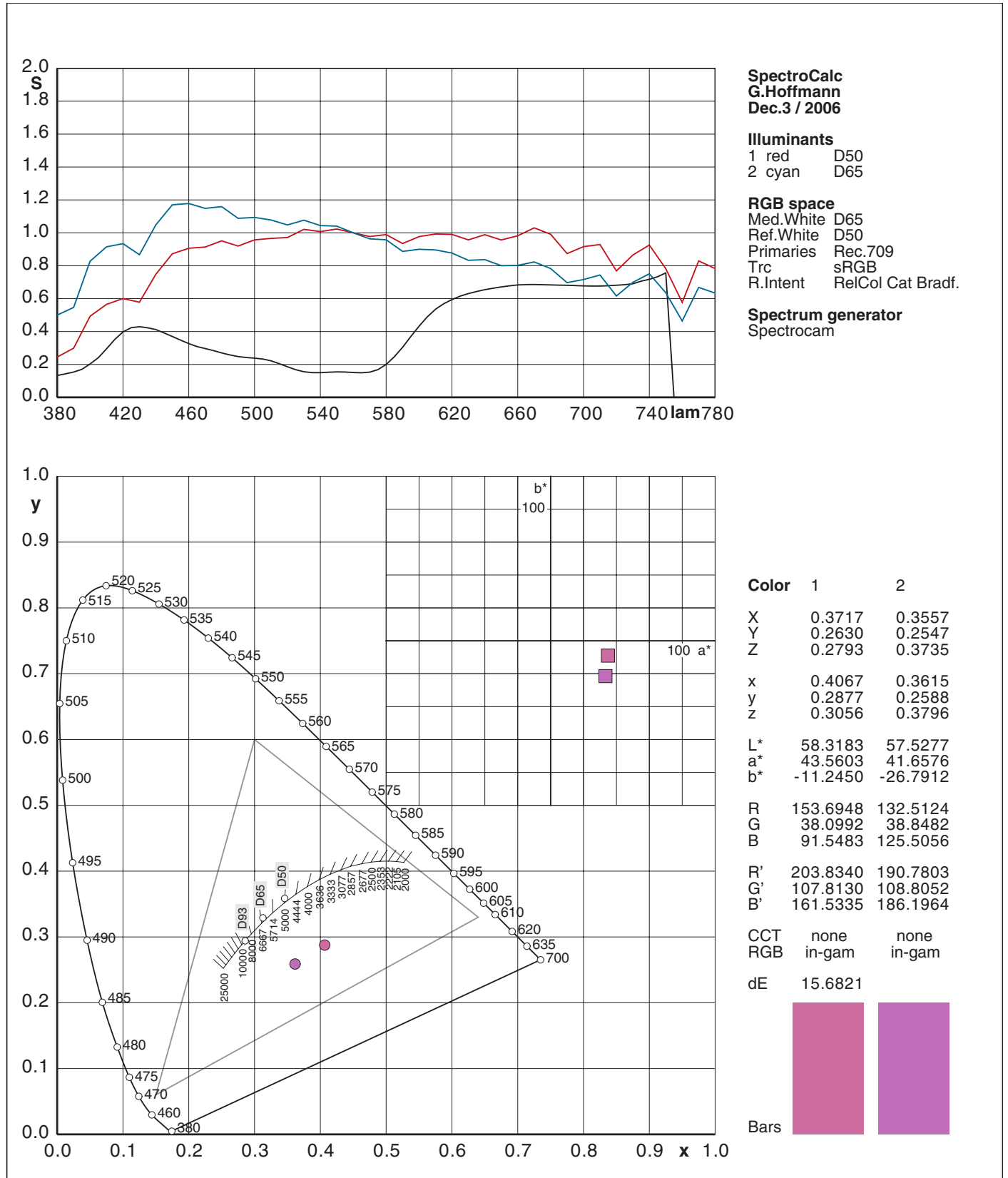
3.3.3 SpectroCalc / Examples / sRGB with CAT / Illumin. A+ D65

This non-realistic spectrum is rather sensible to illuminant changes, here for illuminants A and D65. Spectrum mode: Table.



3.3.4 SpectroCalc / Examples / sRGB with CAT / Illumin. D50+ D65

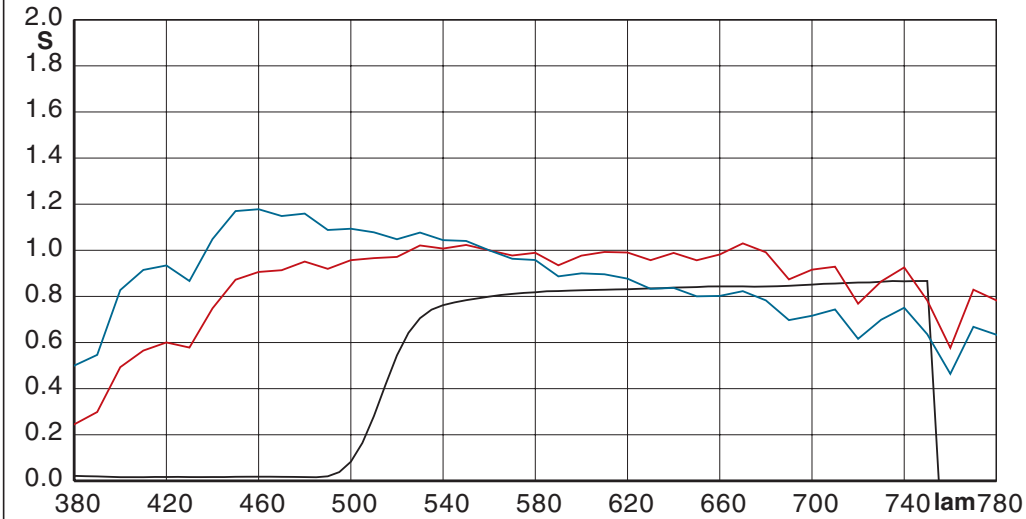
This spectrum was measured by Spectrocam: the first patch of example 3.3.2, printed by a toner printer. Spectrum mode: Spectrocam.



3.3.5 SpectroCalc / Examples / Main test for Spectrocam data

Pantone Yellow 012C (old swatch book). Spectrum mode: Spectrocam. Lab values.

| | | | | |
|---|-------|------|--------|---------------------------------|
| Photoshop 7.0 | 87.00 | 2.00 | 114.00 | integer, uses table |
| ProfileMaker ColorPicker 4.1 | 86.59 | 2.59 | 114.22 | uses table |
| ProfileMaker ColorPicker 5.0 | 87.47 | 4.03 | 113.78 | uses table |
| Measured by Pantone Color Cue | 86.87 | 1.83 | 114.33 | uses table after identification |
| Measured by Spectrocam | 86.84 | 1.87 | 111.58 | |
| Spectrocam data, calculation by SpectroCalc | 86.84 | 1.86 | 111.57 | |

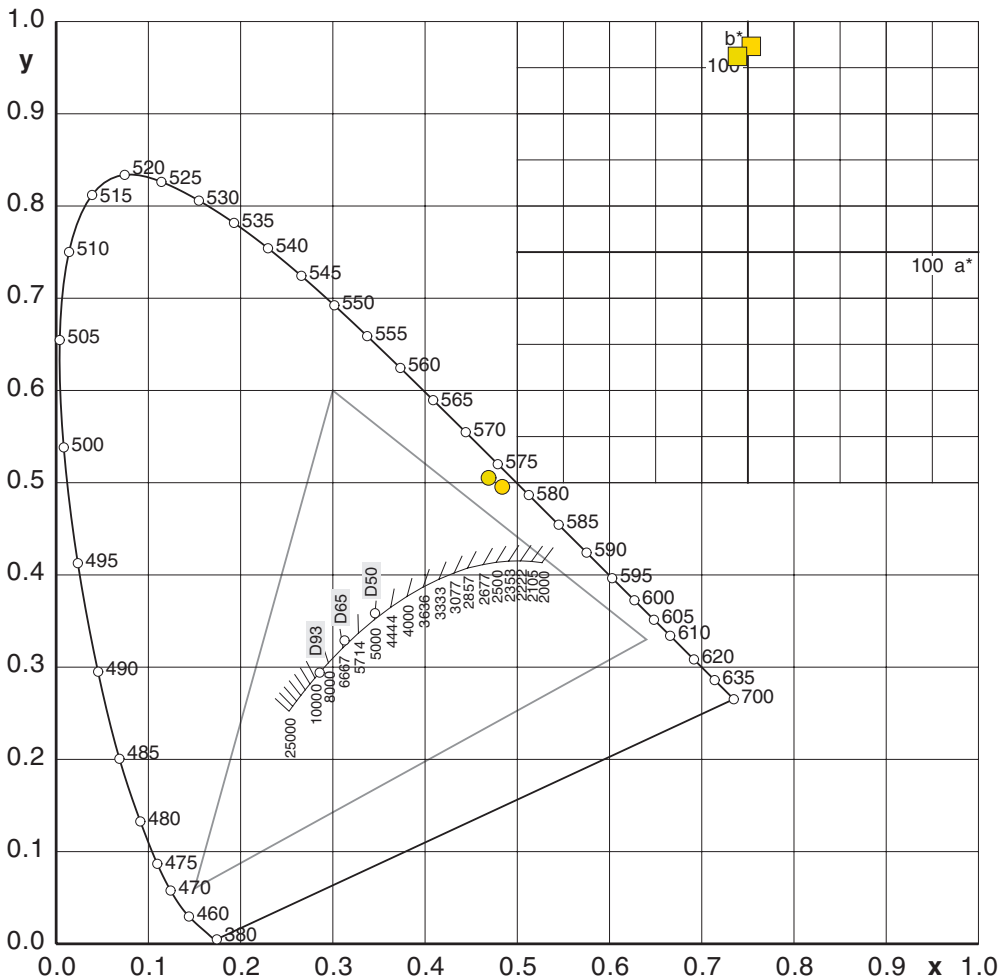


SpectroCalc
G.Hoffmann
Dec.3 / 2006

Illuminants
 1 red D50
 2 cyan D65

RGB space
 Med.White D65
 Ref.White D50
 Primaries Rec.709
 Trc sRGB
 R.Intent RelCol Cat Bradf.

Spectrum generator
 Spectrocam



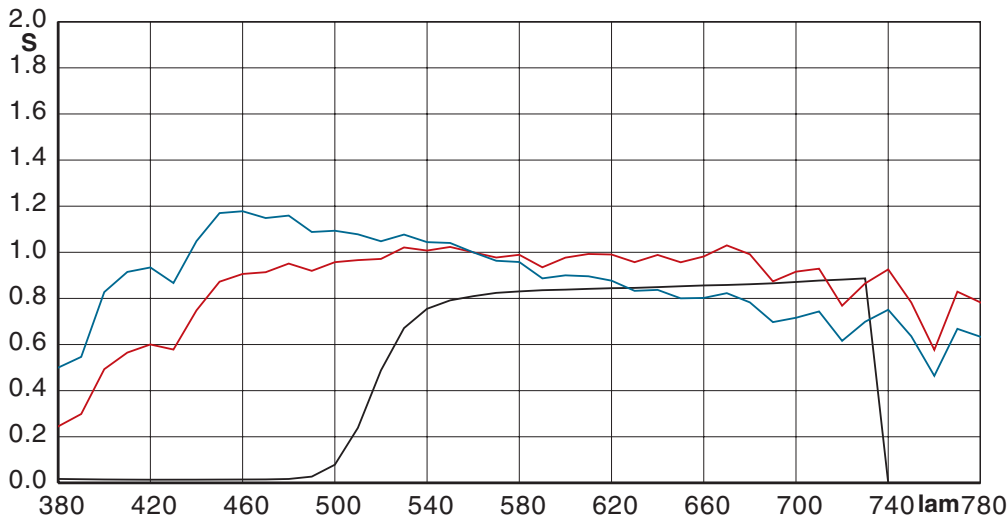
| Color | 1 | 2 |
|-------|----------|----------|
| X | 0.6803 | 0.6304 |
| Y | 0.6967 | 0.6795 |
| Z | 0.0293 | 0.0349 |
| x | 0.4838 | 0.4687 |
| y | 0.4954 | 0.5053 |
| z | 0.0208 | 0.0260 |
| L* | 86.8364 | 85.9829 |
| a* | 1.8593 | -5.6413 |
| b* | 111.5710 | 106.1335 |
| R | 252.7147 | 219.1578 |
| G | 170.8950 | 175.0124 |
| B | -17.7001 | -15.5957 |
| R' | 253.9928 | 238.5457 |
| G' | 213.6794 | 215.9494 |
| B' | 0.0000 | 0.0000 |
| CCT | none | none |
| RGB | out-gam | out-gam |
| dE | 9.3034 | |



3.3.6 SpectroCalc / Examples / Main test for Eye-One Pro data

Pantone Yellow 012C (old swatch book). Spectrum mode: Eye-One Pro.Lab values.

| | | | | |
|--|-------|------|--------|---------------------------------|
| Photoshop 7.0 | 87.00 | 2.00 | 114.00 | integer, uses table |
| ProfileMaker ColorPicker 4.1 | 86.59 | 2.59 | 114.22 | uses table |
| ProfileMaker ColorPicker 5.0 | 87.47 | 4.03 | 113.78 | uses table |
| Measured by Pantone Color Cue | 86.87 | 1.83 | 114.33 | uses table after identification |
| Measured by GMB Eye-One Pro | 86.73 | 3.98 | 113.63 | |
| Eye-One Pro data, calculation by SpectroCalc | 86.70 | 4.07 | 113.29 | |

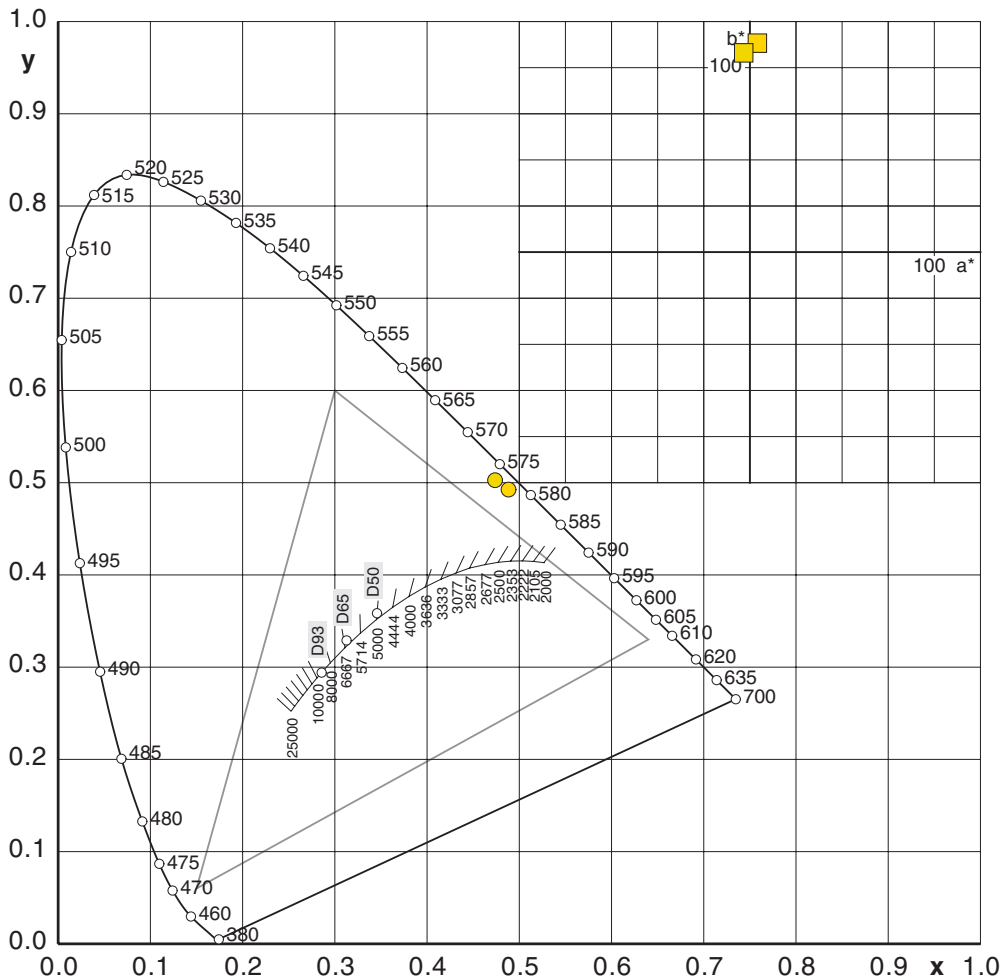


SpectroCalc
G.Hoffmann
Dec.3 / 2006

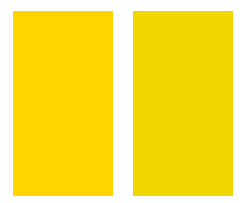
Illuminants
 1 red D50
 2 cyan D65

RGB space
 Med.White D65
 Ref.White D50
 Primaries Rec.709
 Trc sRGB
 R.Intent RelCol Cat Bradf.

Spectrum generator
 Eye-One Pro



| Color | 1 | 2 |
|-------|----------|----------|
| X | 0.6878 | 0.6368 |
| Y | 0.6939 | 0.6757 |
| Z | 0.0267 | 0.0317 |
| x | 0.4883 | 0.4738 |
| y | 0.4927 | 0.5027 |
| z | 0.0190 | 0.0236 |
| L* | 86.6984 | 85.7908 |
| a* | 4.0656 | -3.3349 |
| b* | 113.2946 | 108.0290 |
| R | 260.1156 | 226.3112 |
| G | 167.6535 | 171.4985 |
| B | -18.3125 | -16.4148 |
| R' | 255.0000 | 241.9485 |
| G' | 211.8698 | 214.0141 |
| B' | 0.0000 | 0.0000 |
| CCT | none | none |
| RGB | out-gam | out-gam |
| dE | 9.1278 | |

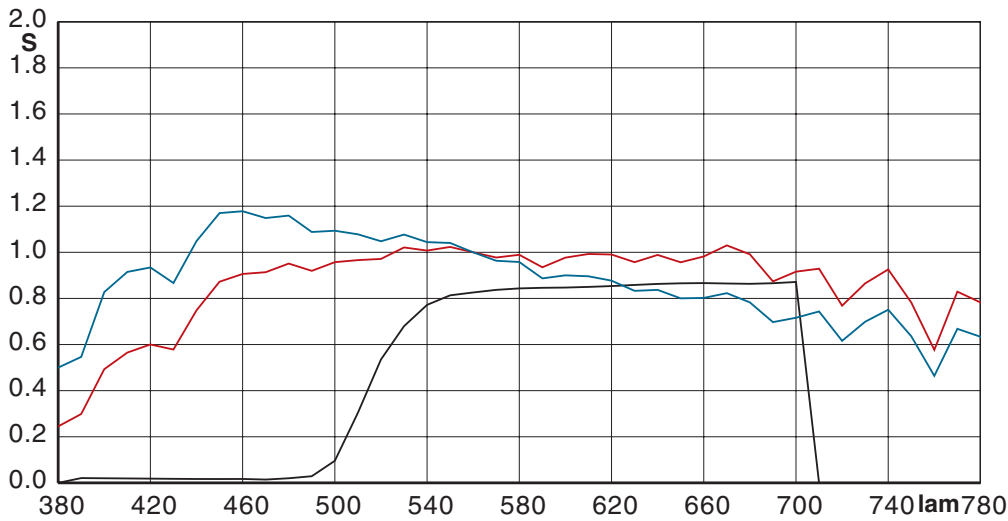


Bars

3.3.7 SpectroCalc / Examples / Main test for DTP-22 data

Pantone Yellow 012C (newer swatch book). Spectrum mode: DTP-22. Lab values.

| | | | | |
|---|-------|------|--------|---------------------------------|
| Photoshop 7.0 | 87.00 | 2.00 | 114.00 | integer, uses table |
| ProfileMaker ColorPicker 4.1 | 86.59 | 2.59 | 114.22 | uses table |
| ProfileMaker ColorPicker 5.0 | 87.47 | 4.03 | 113.78 | uses table |
| Measured by Pantone Color Cue | 86.87 | 1.83 | 114.33 | uses table after identification |
| Measured by X-Rite DTP-22 | 87.59 | 2.56 | 112.33 | |
| DTP-22 data, calculation by SpectroCalc | 87.54 | 2.52 | 111.96 | |

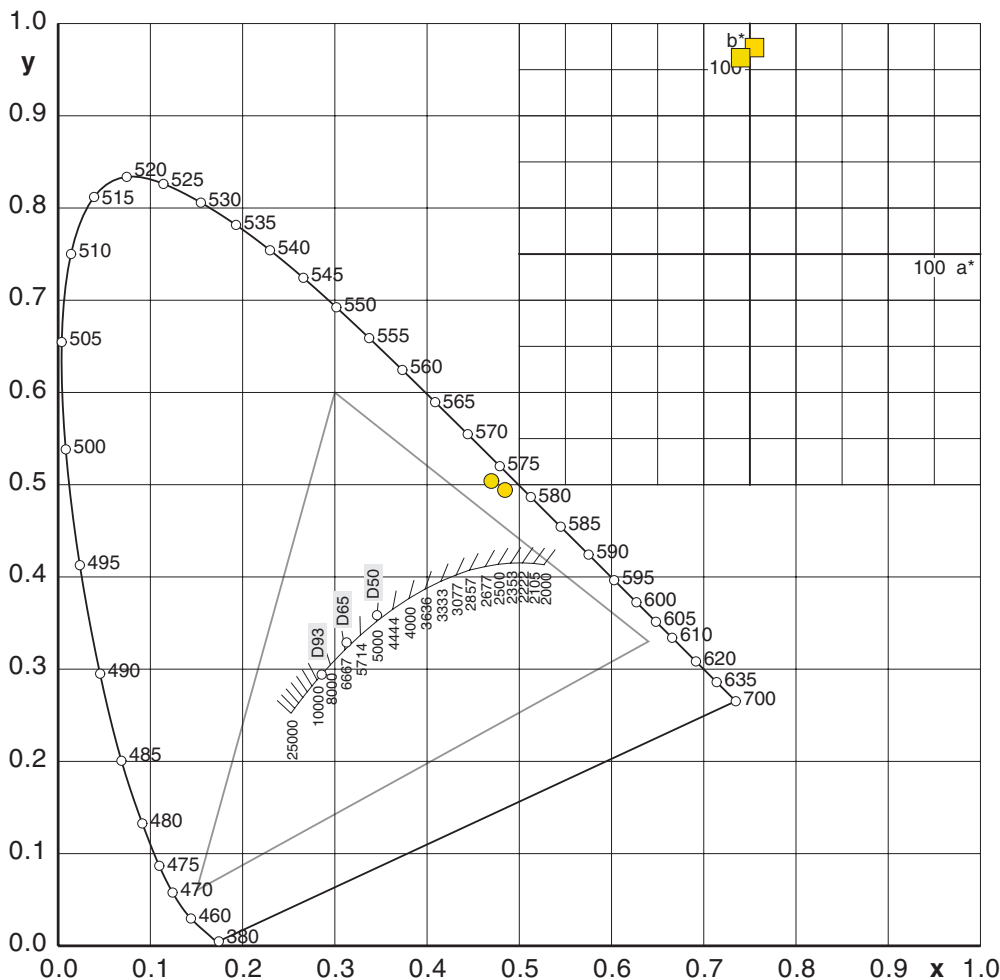


SpectroCalc
G.Hoffmann
Dec.3 / 2006

Illuminants
1 red D50
2 cyan D65

RGB space
Med.White D65
Ref.White D50
Primaries Rec.709
Trc sRGB
R.Intent RelCol Cat Bradf.

Spectrum generator
DTP-22



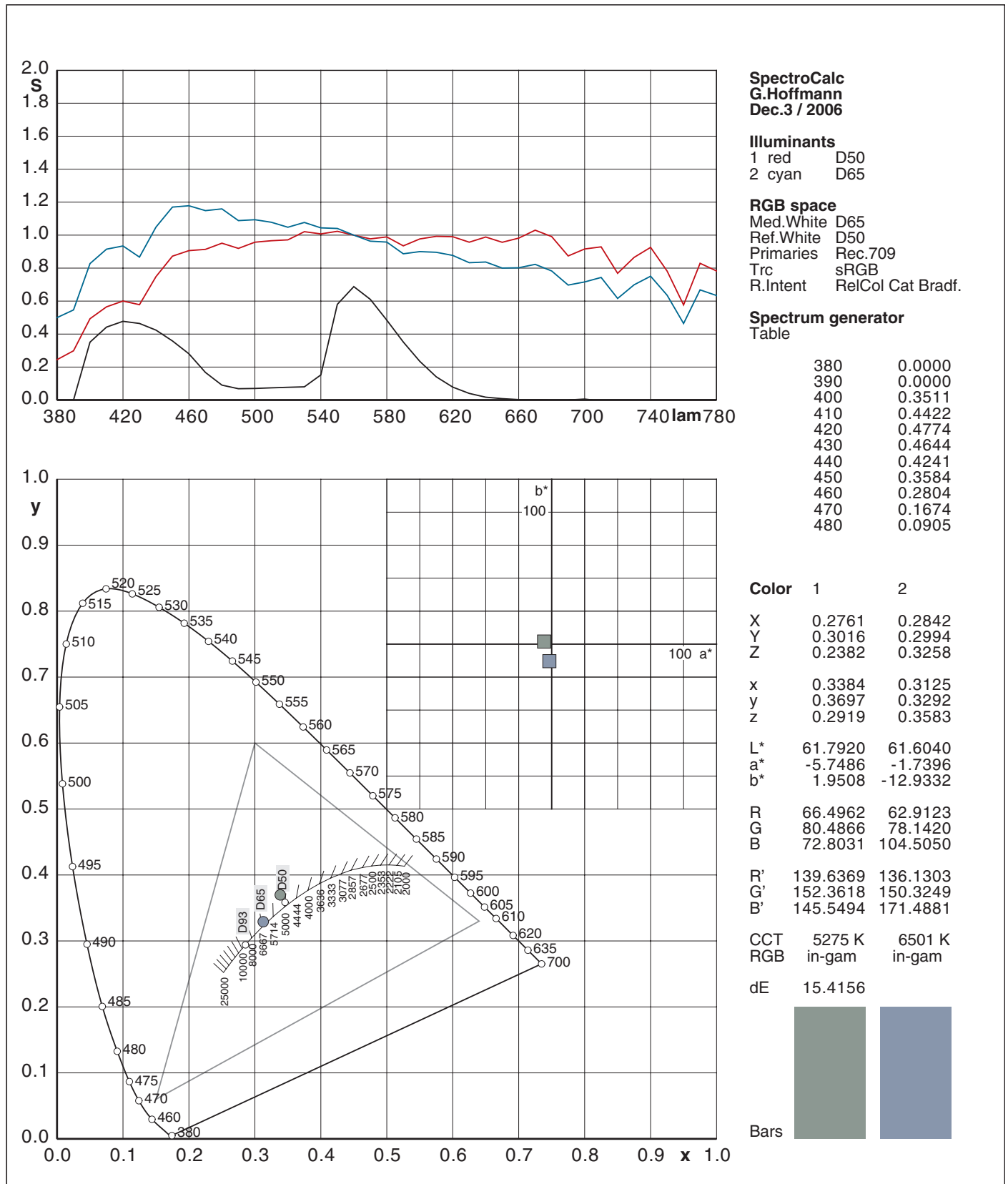
| Color | 1 | 2 |
|-------|----------|----------|
| X | 0.6975 | 0.6462 |
| Y | 0.7112 | 0.6934 |
| Z | 0.0304 | 0.0362 |
| x | 0.4847 | 0.4697 |
| y | 0.4942 | 0.5040 |
| z | 0.0211 | 0.0263 |
| L* | 87.5422 | 86.6717 |
| a* | 2.5181 | -5.0035 |
| b* | 111.9634 | 106.4691 |
| R | 260.2947 | 225.9450 |
| G | 173.6918 | 177.8411 |
| B | -17.8295 | -15.6497 |
| R' | 255.0000 | 241.7759 |
| G' | 215.2248 | 217.4910 |
| B' | 0.0000 | 0.0000 |
| CCT | none | none |
| RGB | out-gam | out-gam |
| dE | 9.3552 | |



Bars

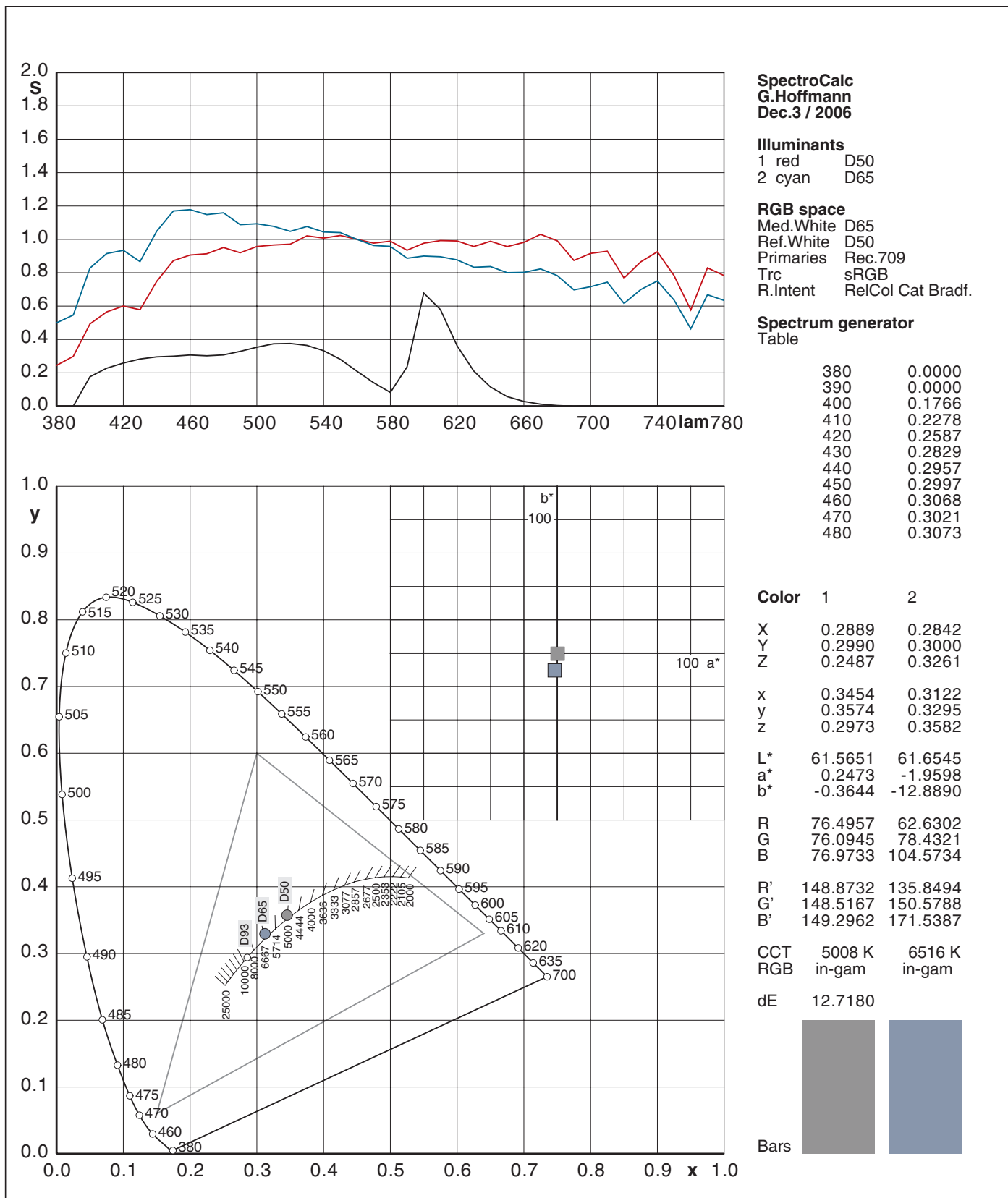
3.3.8 SpectroCalc / Examples / Metameric Grays / Gray 1

This page and the next belong together. The spectra show two hypothetical grays which are metamers under D65. The example was taken from [5], Table IV (3.8.2), p. 784, the first two table columns. The color coordinates are almost the same for D65 (column 2 in the diagrams on this page and the next). They are clearly different under D50 (column 1 on both pages).



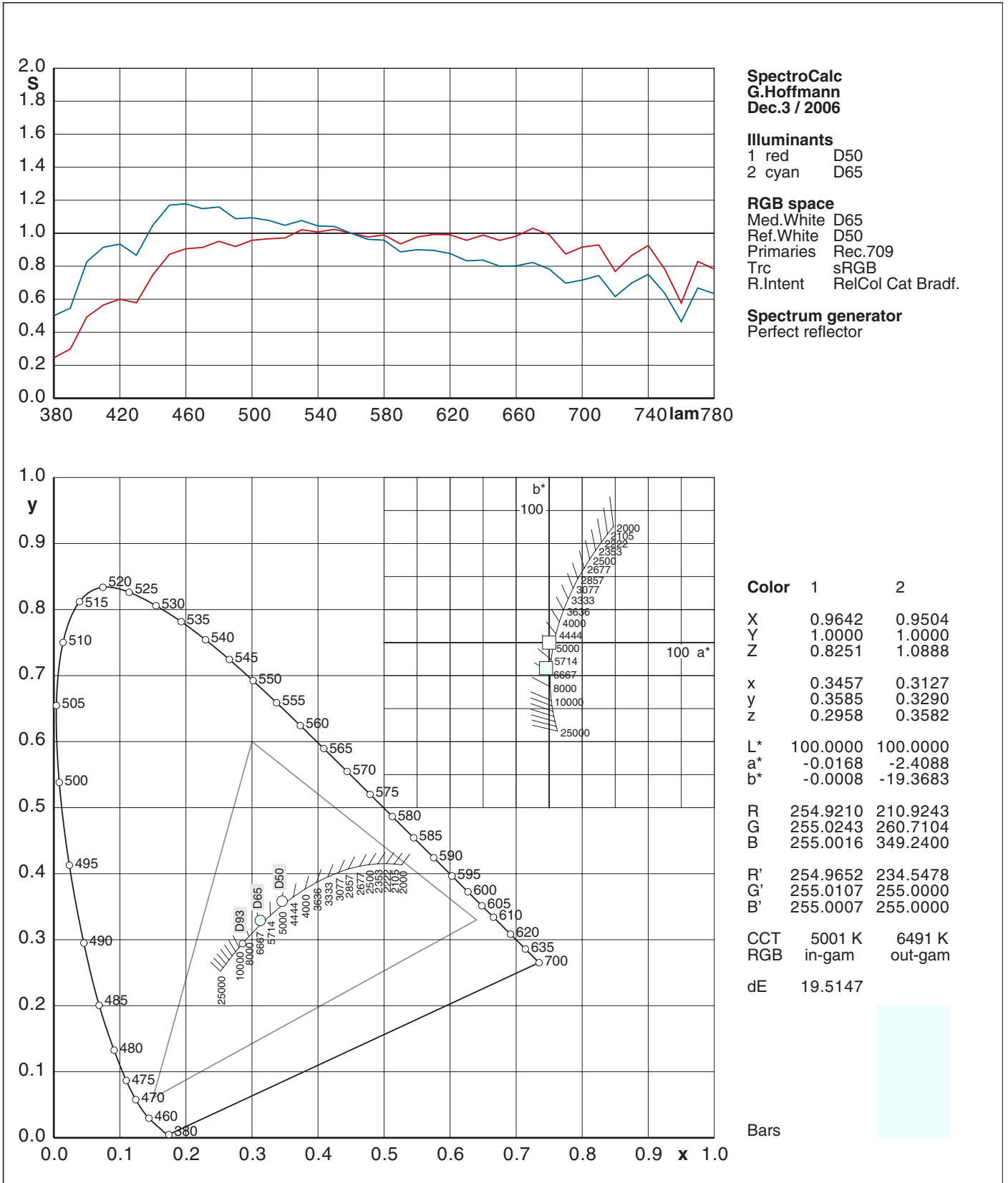
3.3.9 SpectroCalc / Examples / Metameric Grays / Gray 2

Please refer to the previous page.



3.3.10 SpectroCalc / Examples / Show CT-Curve in Lab-plane

The curve for the Planckian radiator can be shown in the Lab-plane a^*b^* .
 Spectrum Mode: Perfect Reflector for the comparison of D50 and D65.



4.1 SpectroCalc-Moni / Input

4.1.0 Introduction

SpectroCalc-Moni is used only for this configuration:

Measure monitor spectra by Eye-One Pro and ProfileMaker Measure

4.1.1 Create Reference file

Logo TestChart for Color Monitors

```
BEGIN_DATA_FORMAT
```

```
Sample_ID RGB_R RGB_G RGB_B
```

```
END_DATA_FORMAT
```

```
BEGIN_DATA
```

```
A1 255 0 0
```

```
A2 0 255 0
```

```
A3 0 0 255
```

```
A4 255 255 255
```

```
A5 0 255 255
```

```
A6 255 0 255
```

```
A7 255 255 0
```

```
A8 0 0 0
```

```
END_DATA
```

4.1.2 Measure Reference file colors

Save as e.g. SpeCalc-Moni-test1.txt

4.1.3 Insert test result in SpectroCalc-Moni

Download the program specalc-moni [11] and rename txt by eps.

Insert SpeCalc-Moni-test1.txt and convert by % each line into a comment.

```
% Original Eye-One Pro file (without %)
% LGOROWLENGTH 2
% CREATED "9/26/2007" # Time: 14:28
% INSTRUMENTATION "Eye-One Pro"
% MEASUREMENT_SOURCE "Illumination=Emission Filter=No"
% ILLUMINATION_NAME "Emission"
% OBSERVER_ANGLE "2"
% KEYWORD "SampleID"
% KEYWORD "SAMPLE_NAME"
% NUMBER_OF_FIELDS 41
% BEGIN_DATA_FORMAT
% SampleID SAMPLE_NAME RGB_R RGB_G RGB_B nm380 nm390 ...
% END_DATA_FORMAT
% NUMBER_OF_SETS 8
% BEGIN_DATA
% 1 A1 255.00 0.00 0.00 -0.0001 -0.0003 -0.0005 -0.0005 ...
% 2 A2 0.00 255.00 0.00 -0.0003 0.0002 -0.0001 -0.0010 ...
% 3 B1 0.00 0.00 255.00 0.0006 0.0007 0.0054 0.0322 ...
% 4 B2 255.00 255.00 255.00 0.0011 0.0012 0.0063 0.0371 ...
% 5 C1 0.00 255.00 255.00 0.0013 0.0017 0.0059 0.0345 ...
% 6 C2 255.00 0.00 255.00 0.0005 0.0012 0.0062 0.0343 ...
% 7 D1 255.00 255.00 0.00 0.0005 0.0003 0.0008 0.0020 ...
% 8 D2 0.00 0.00 0.00 -0.0012 -0.0005 -0.0002 -0.0001 ...
% END_DATA
```

4.1 SpectroCalc-Moni / Input

4.1.3 Edit test result in SpectroCalc-Moni

Pack the relevant part into an array.

Several cases can be distinguished by Cw=1, 2, ..., including specific text.

```
Cw 1 eq
{
/head14 (Example by Gernot Hoffmann) def
/head15 (Eizo CG19 / September 26 / 2007) def
/head16 () def
/CwE1
[
255.00  0.00  0.00  -0.0001  -0.0003  -0.0005  -0.0005  0.0034  ...
0.00    255.00 0.00  -0.0003  0.0002  -0.0001  -0.0010  0.0012  ...
0.00    0.00  255.00 0.0006  0.0007  0.0054  0.0322  0.2027  ...
255.00  255.00 255.00 0.0011  0.0012  0.0063  0.0371  0.2327  ...
0.00    255.00 255.00 0.0013  0.0017  0.0059  0.0345  0.2197  ...
255.00  0.00  255.00 0.0005  0.0012  0.0062  0.0343  0.2171  ...
255.00  255.00 0.00  0.0005  0.0003  0.0008  0.0020  0.0066  ...
0.00    0.00  0.00  -0.0012  -0.0005  -0.0002  -0.0001  0.0005  ...
] def
} if
```

4.1.4 Other inputs

Nothing else should be changed.

4.2 SpectroCalc-Moni / Output

4.2.1 Outputs

As shown by the examples.

Spectra for R G B W.

Calculations for R G B W C M Y K.

RGB values are given in Device RGB 0 or 255.

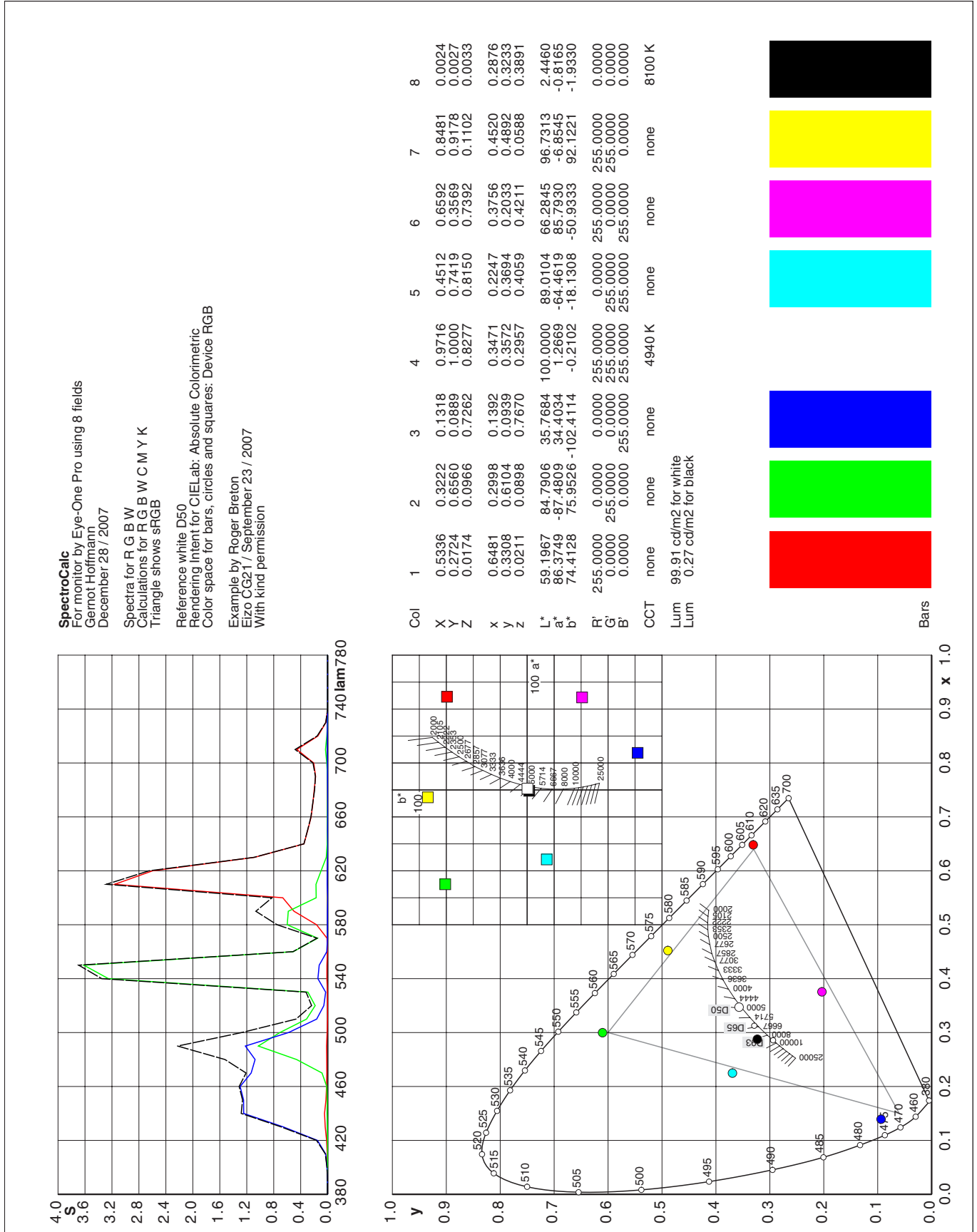
Indicated RGB colors are shown in Device RGB 0 or 255.

XYZ to CIELab calculations by Absolute Colorimetric.

4.3 SpectroCalc-Moni / Examples

4.3.1 Eizo CG21

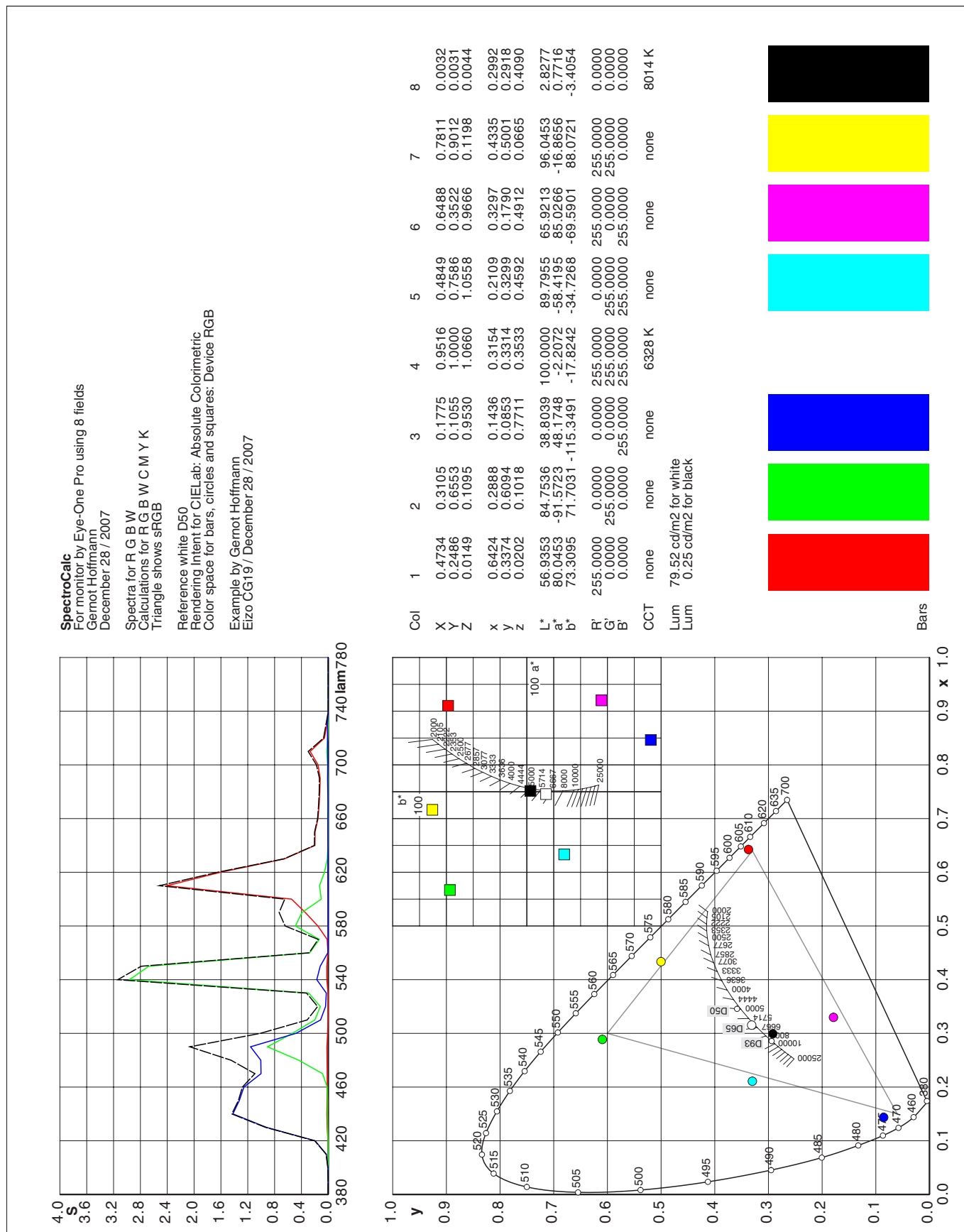
Eizo CG21 by Roger Breton. Calibrated for D50 white point.



4.3 SpectroCalc-Moni / Examples

4.3.2 Eizo CG19

Eizo CG19 by Gernot Hoffmann. Calibrated for D65 white point.



5. References

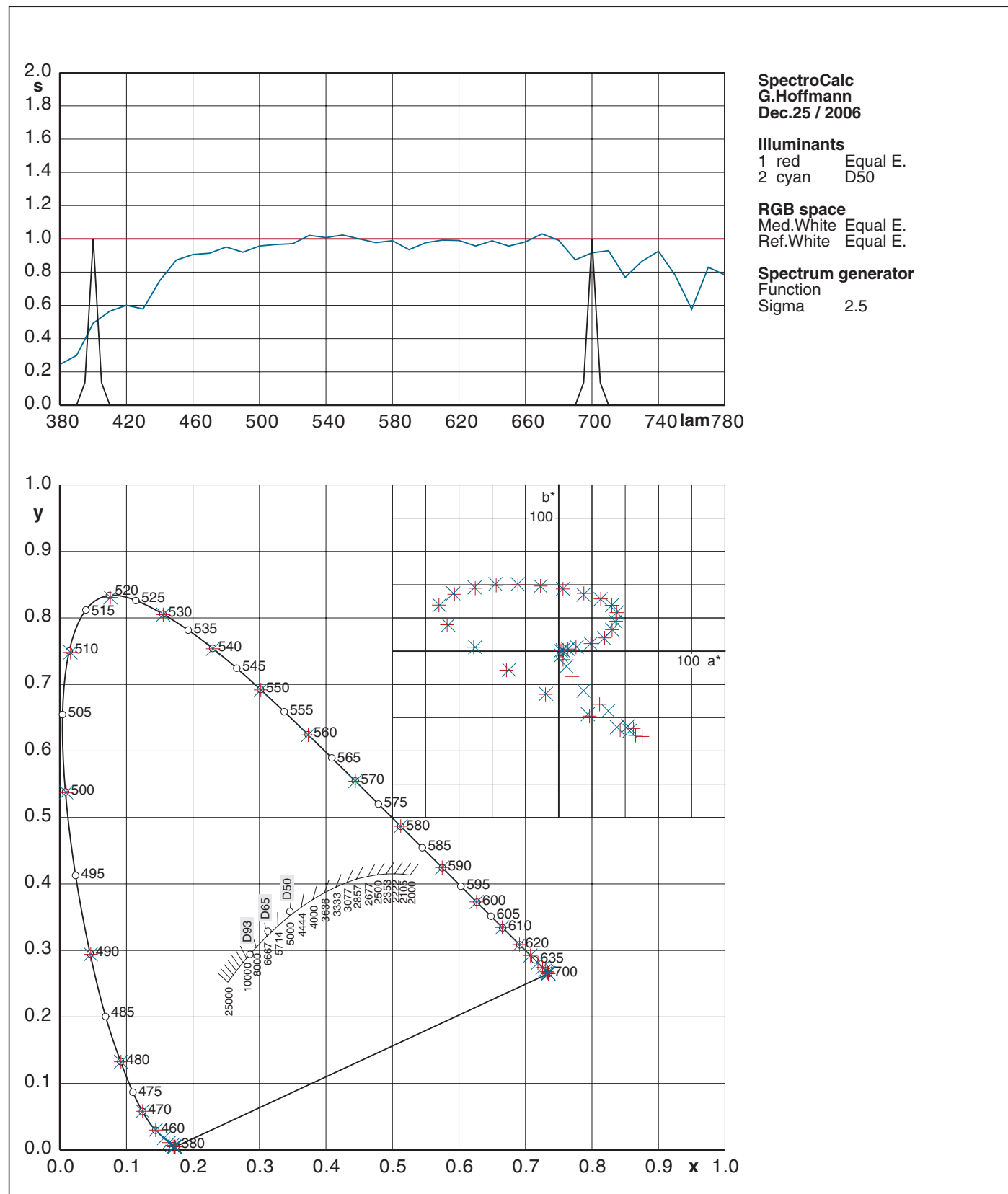
- [1] R.W.G.Hunt
Measuring Colour
Fountain Press, England, 1998
- [2] International Color Consortium
<http://www.color.org>
- [3] Specification ICC.1:21001-12
File Format for Color Profiles (Version 4.0.0)
<http://www.color.org/newiccspec.pdf>
- [4] PSAlter
<http://www.quite.com>
- [5] G.Wyszecki + W.S.Stiles
Color Science
John Wiley & Sons, New York .., 1982/2000
- [6] G.Hoffmann
CIE (1931) Color Space
<http://docs-hoffmann.de/ciexyz29082000.pdf>
- [7] G.Hoffmann
CIELab Color Space
<http://docs-hoffmann.de/cielab03022003.pdf>
- [8] G.Hoffmann
ColorCalc PostScript Code
<http://docs-hoffmann.de/colcalc03022006.txt>
Rename as *.eps
- [9] G.Hoffmann
SpectroCalc PostScript Code
<http://docs-hoffmann.de/specalc03022006.txt>
Rename as *.eps
- [10] G.Hoffmann
Color Management by ICC profiles
<http://docs-hoffmann.de/cmsicc08102003.pdf>
February 06 / 2013:
Conversion from PageMaker to
InDesign
- [11] G.Hoffmann
SpectroCalc-Moni PostScript Code for Monitors
<http://docs-hoffmann.de/specalc-moni.txt>
Rename as *.eps
May have caused minor layout
bugs (tabs)

This doc:
<http://docs-hoffmann.de/colcalc03022006.pdf>

Gernot Hoffmann
February 03 / 2006 – October 27 / 2013
Website
Load browser / Click here

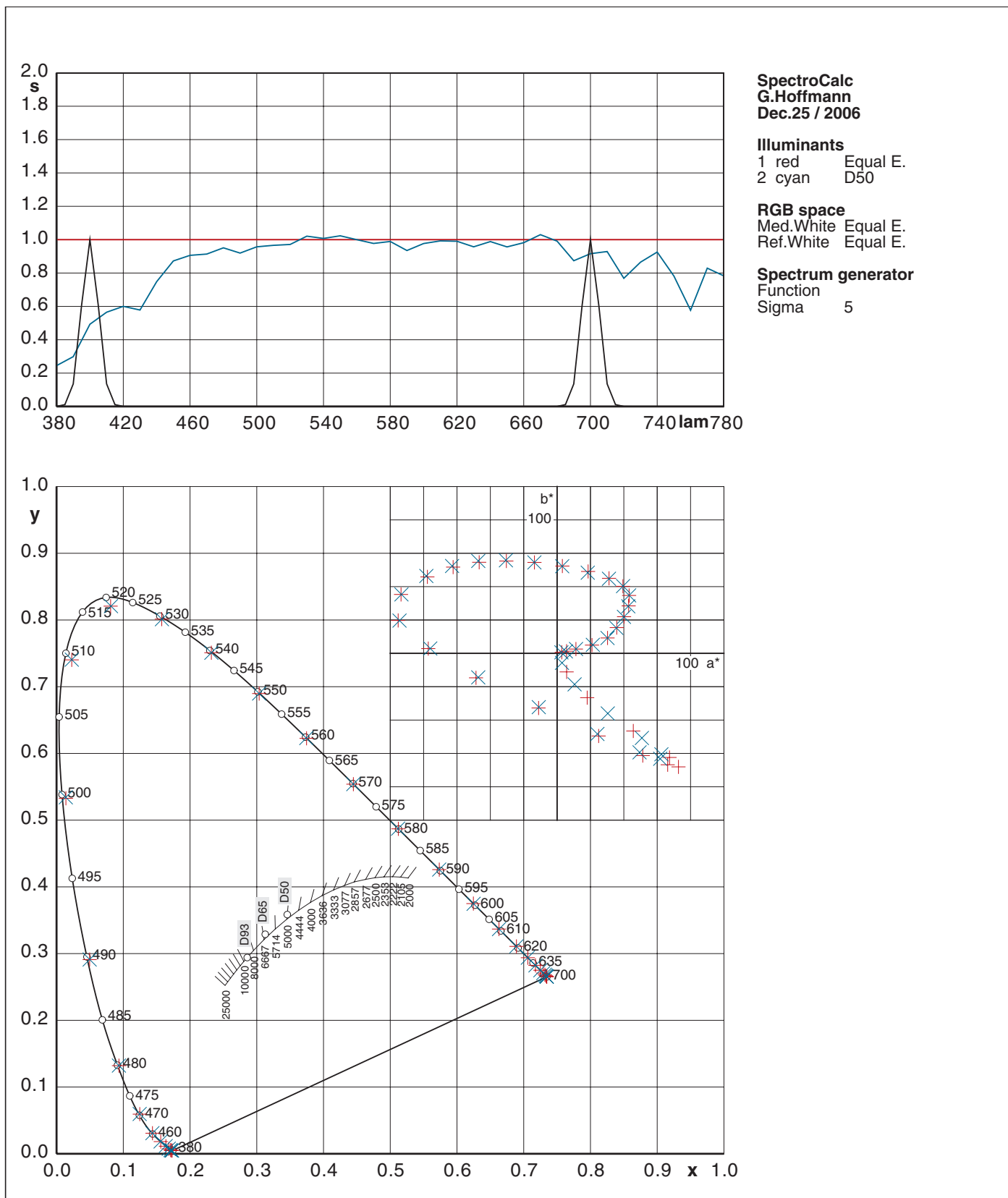
6.1 Appendix 1.1 Narrow Band Spectrum / 2.5nm

Narrow band reflectance factor spectrum.
 Values were taken from a Gaussian bell.
 Standard deviation 2.5nm.
 400nm to 700nm step 10nm.



6.2 Appendix 1.2 Narrow Band Spectrum / 5nm

Narrow band reflectance factor spectrum.
 Values were taken from a Gaussian bell.
 Standard deviation 5nm.
 400nm to 700nm step 10nm.



6.3 Appendix 1.3 Narrow Band Spectrum / 10nm

Narrow band reflectance factor spectrum.
 Values were taken from a Gaussian bell.
 Standard deviation 10nm.
 400nm to 700nm step 10nm.

