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sense and simplicity

Calibrating the Philips Slide Scanner

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Philips Digital Pathology
November 12, 2013

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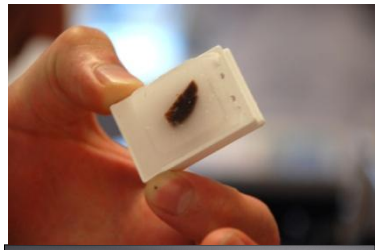
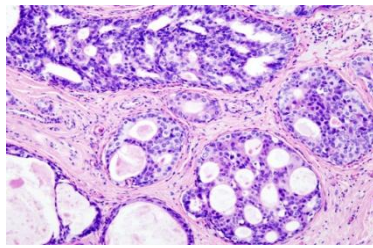
Contents

- Calibrating a Slide Scanner:
  - Scanner description: sources of variation
  - Color calibration method
  - How to make a color calibration slide
  - What affects color reproduction
  - Other calibrations: Resolution
- Lessons Learned





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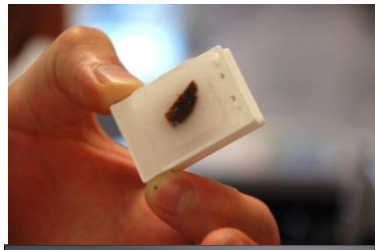

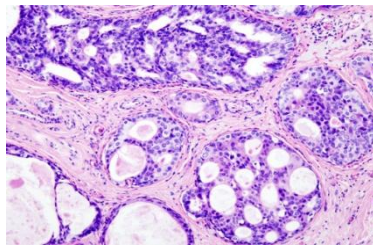

Our Product: The Philips Ultra Fast Scanner

- 30 sec scan time
- 50 sec total time
- 300 slide loader
- Random access
- 40x magnification
- Continuous autofocus
- Philips PACS compatible
- >400MB per second data transfer

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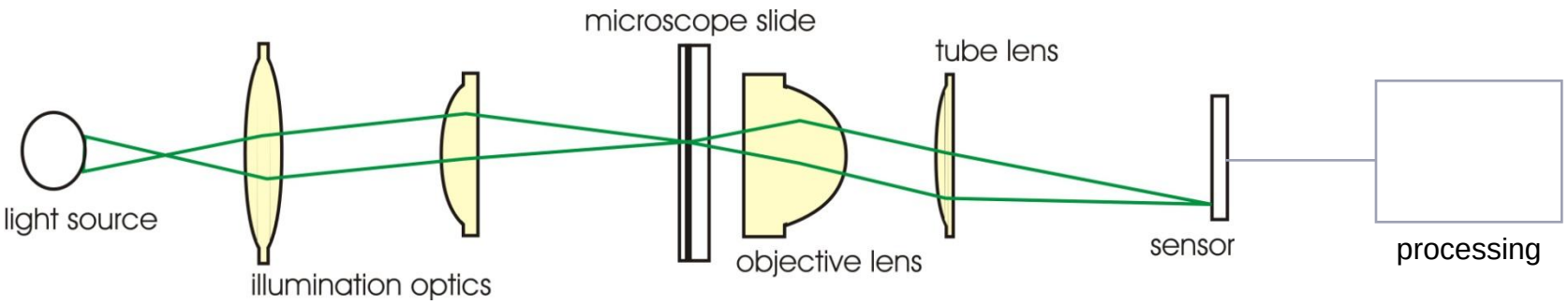
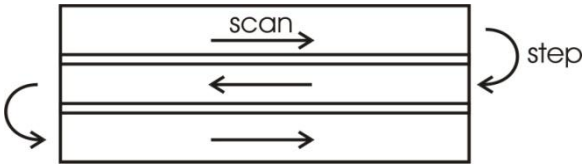
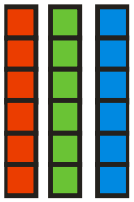
How to build a slide scanner







Illumination:
- White LED

Scanner:
- Constant velocity translation

Sensor:
- 3 separate TDI linescan camera's for R,G and B

Processing:
- compression
- storage

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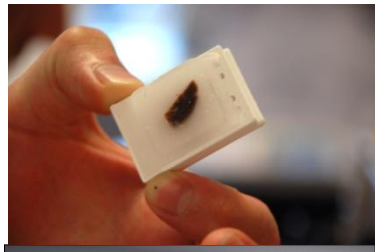

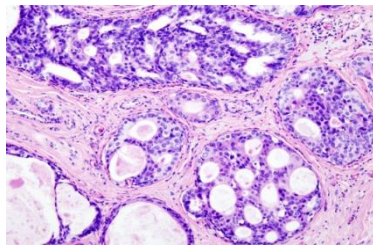

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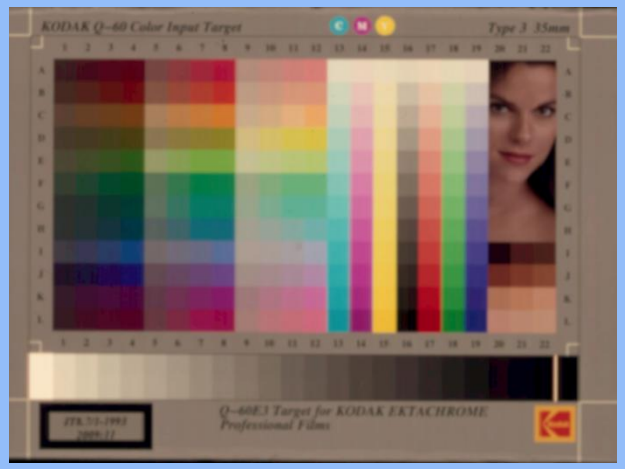
Color Calibration



Standarized Color Target

Scanner

Color Profiler

Residual Error (ΔE)

Correction Matrix

Reference

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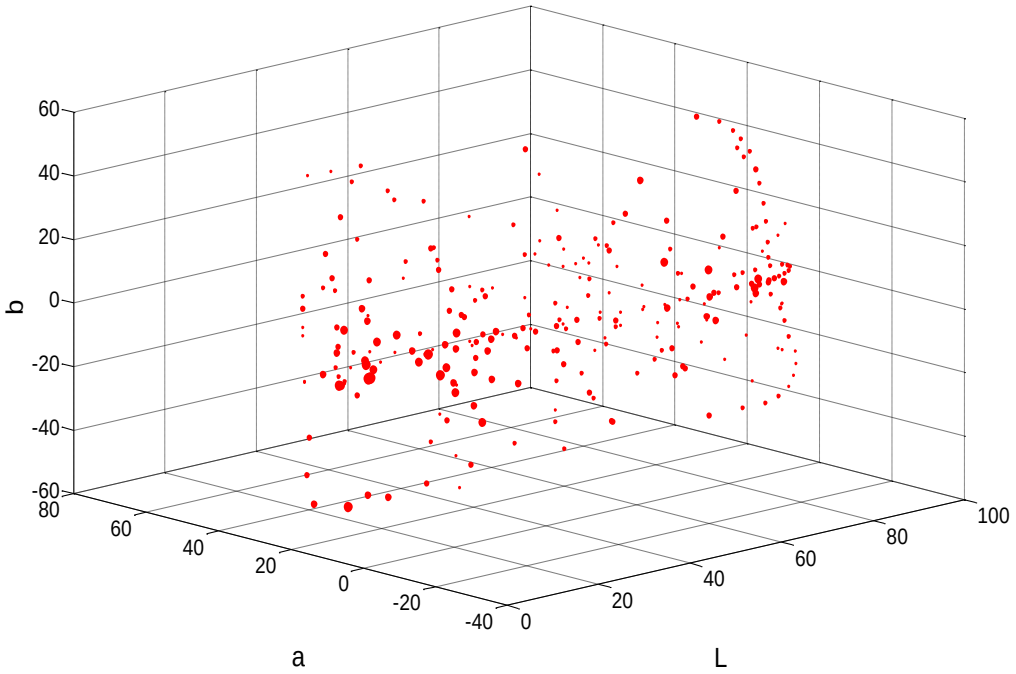
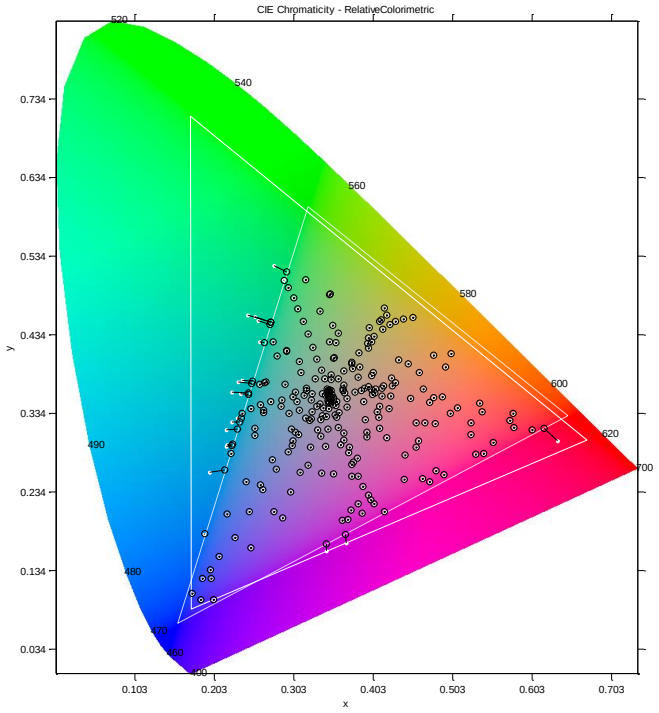
Color difference: ΔE CIE2000

$$\Delta E_{00}^{12} = \Delta E_{00}(L_1^*, a_1^*, b_1^*; L_2^*, a_2^*, b_2^*)$$

$$= \sqrt{\left(\frac{\Delta L'}{k_L S_L}\right)^2 + \left(\frac{\Delta C'}{k_C S_C}\right)^2 + \left(\frac{\Delta H'}{k_H S_H}\right)^2 + R_T \left(\frac{\Delta C'}{k_C S_C}\right)\left(\frac{\Delta H'}{k_H S_H}\right)}$$





ΔE between a scanner colors and a reference colors represented by the size of a circle

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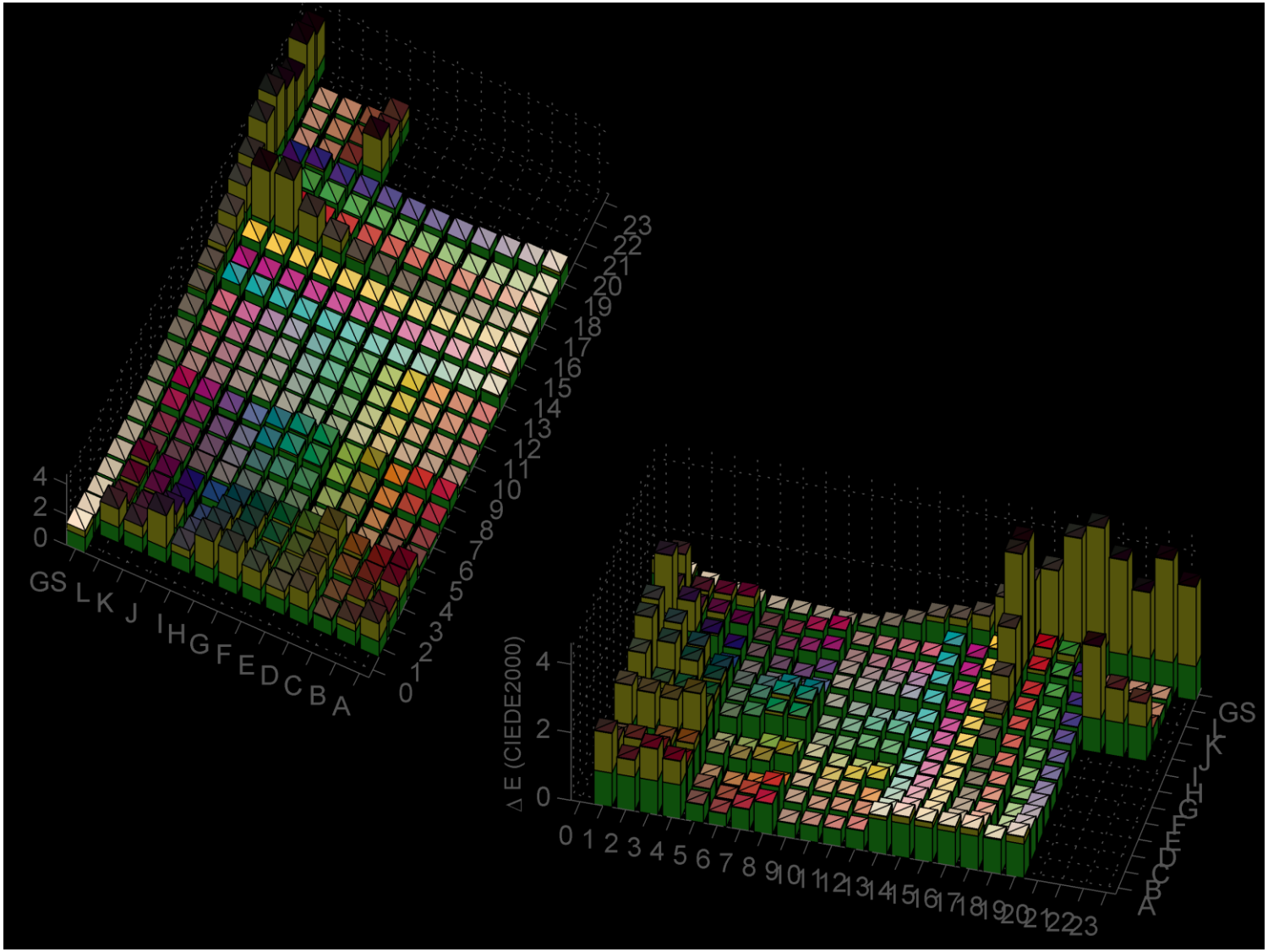
Color Calibration, same colors on all scanners



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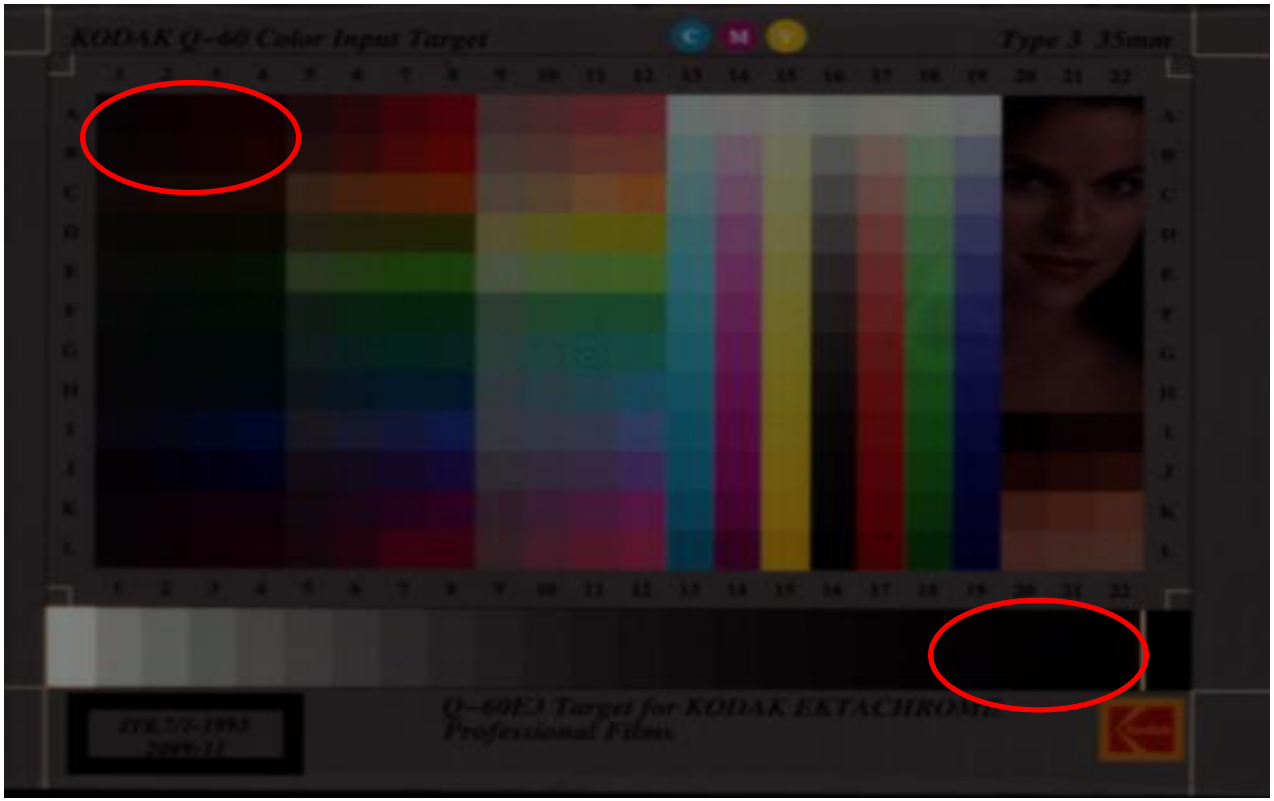
First problem, dark patches

ΔEs are consistently high in the darker color regions.



Film based targets are darker than tissue slides!

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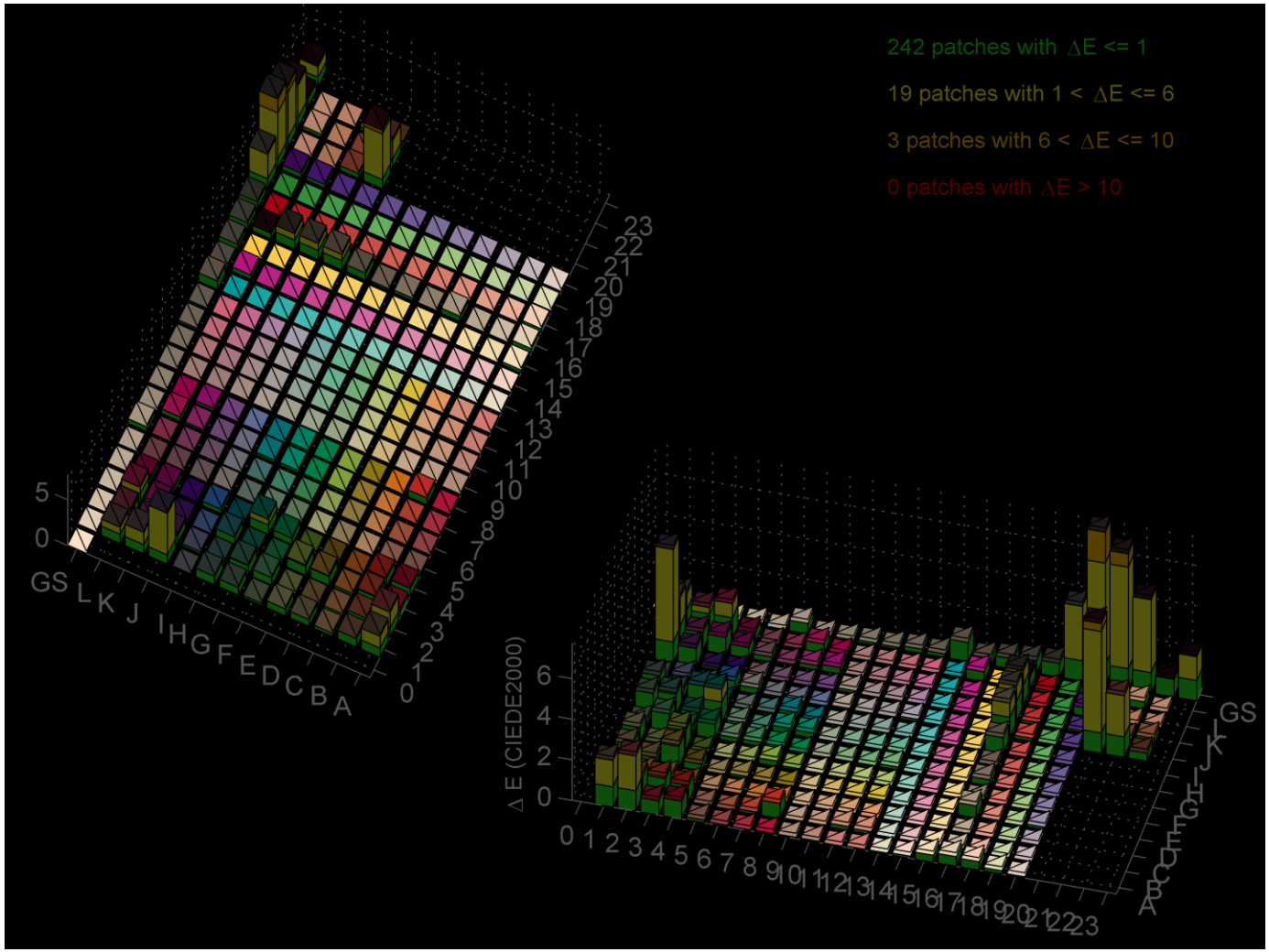
Correction Method



3x3 Matrix

3D LUT

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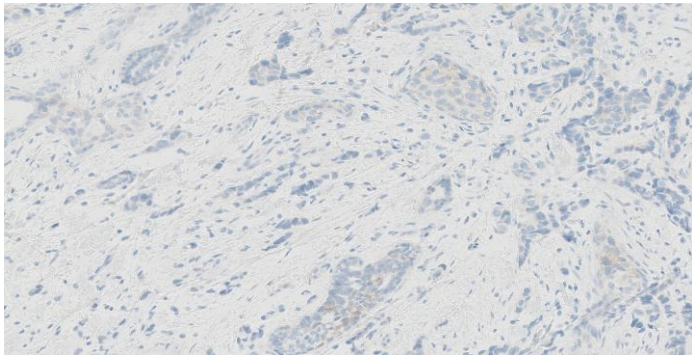
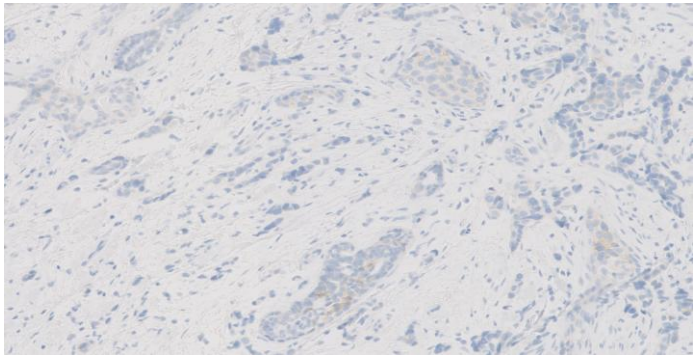
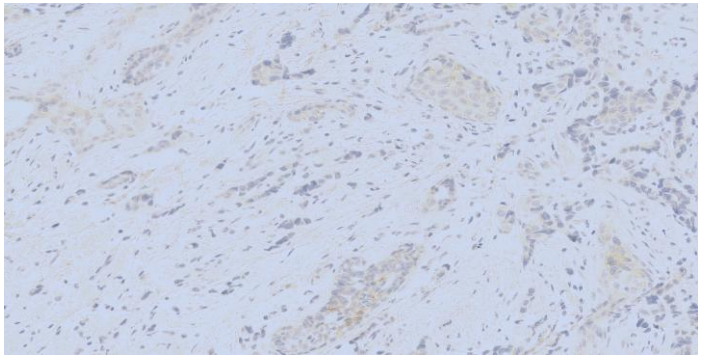
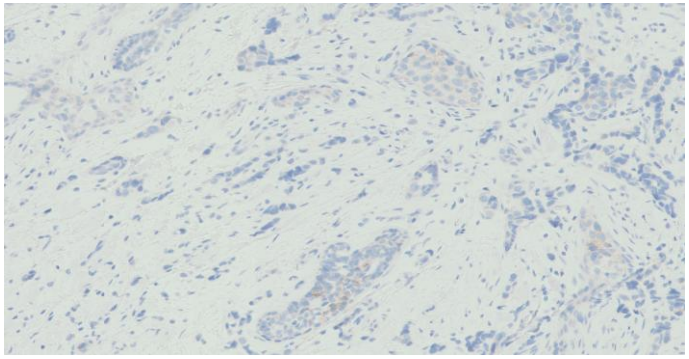
Results on Tissue



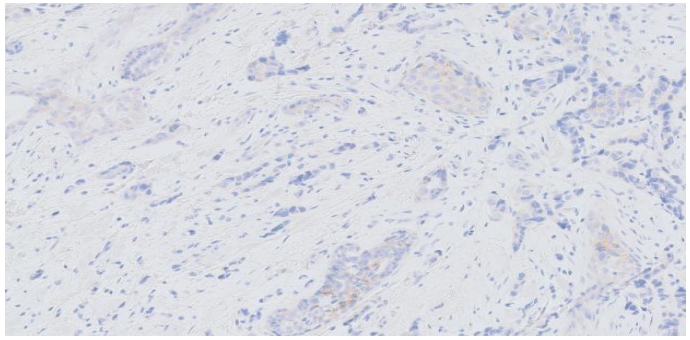


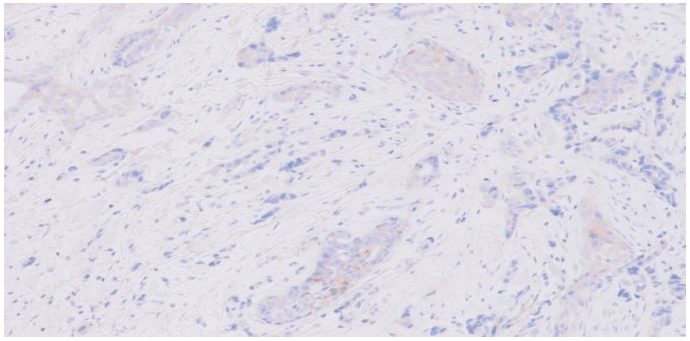
3x3 Matrix





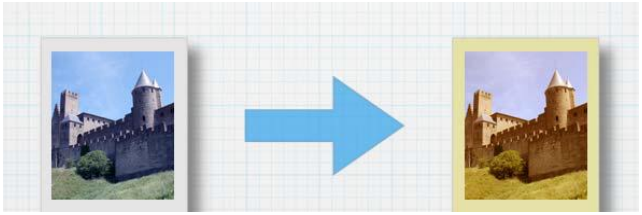
Shaper+ Matrix



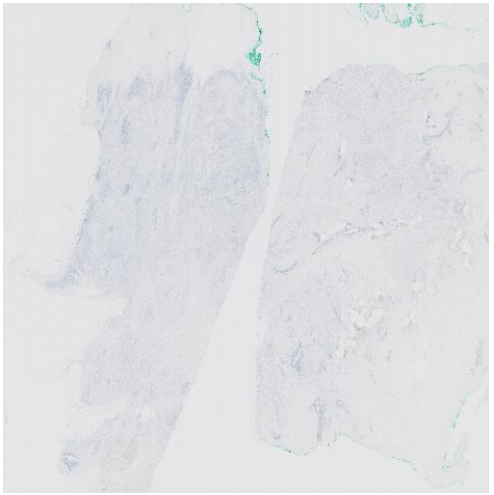


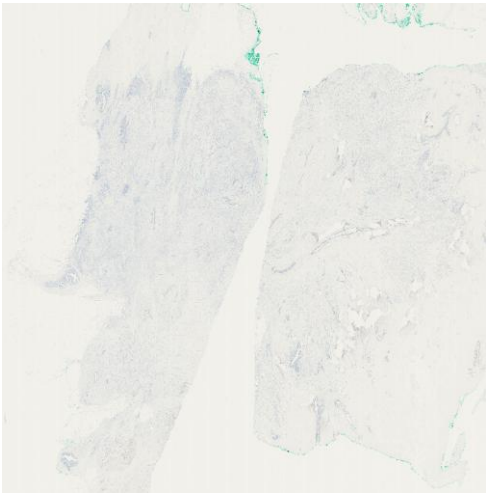
3D LUT

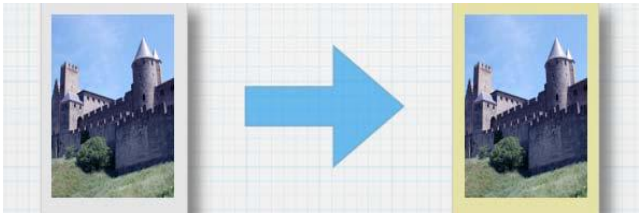
Absolute versus Relative Rendering Intent



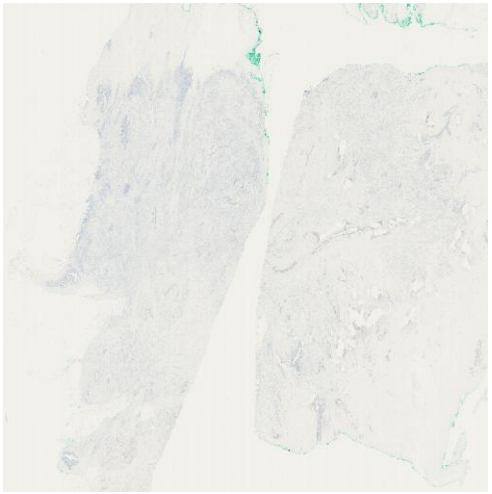
relative

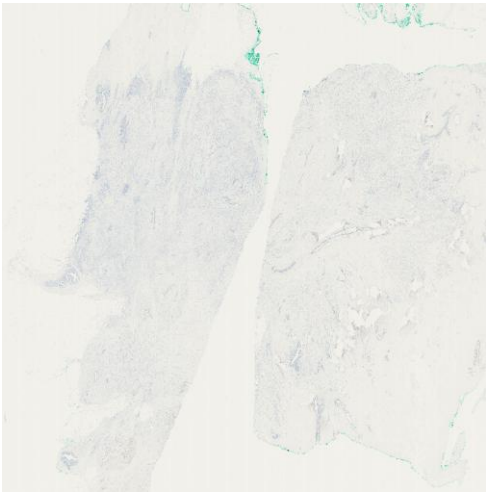






absolute





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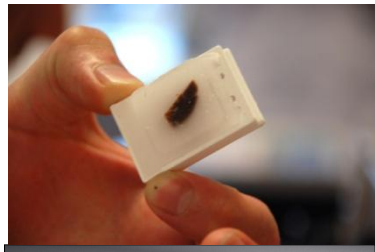


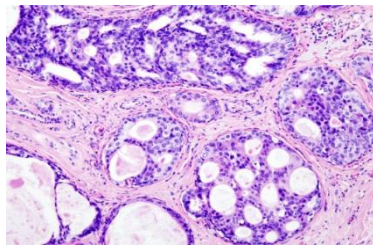

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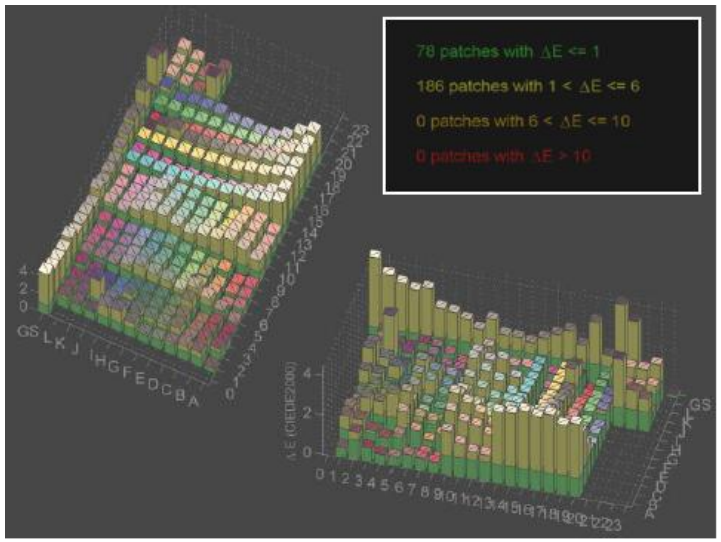
How similar are calibration targets?



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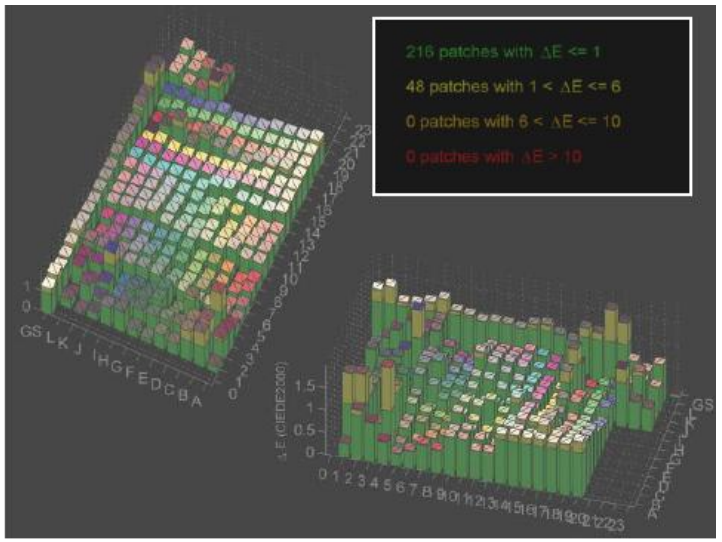
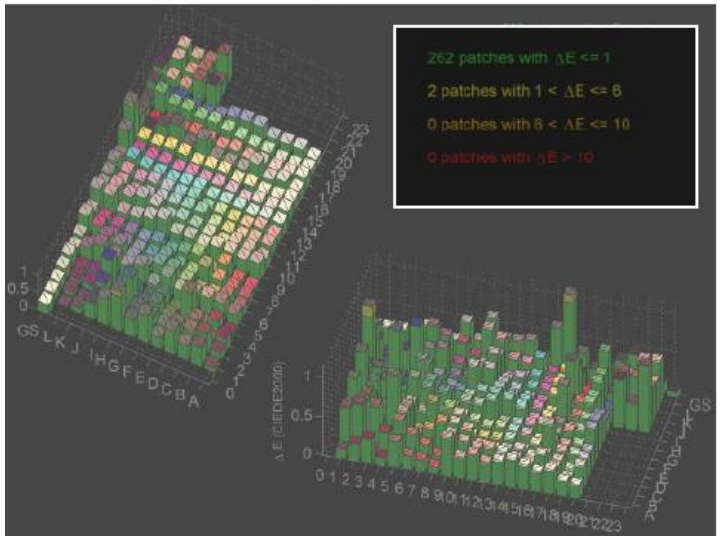
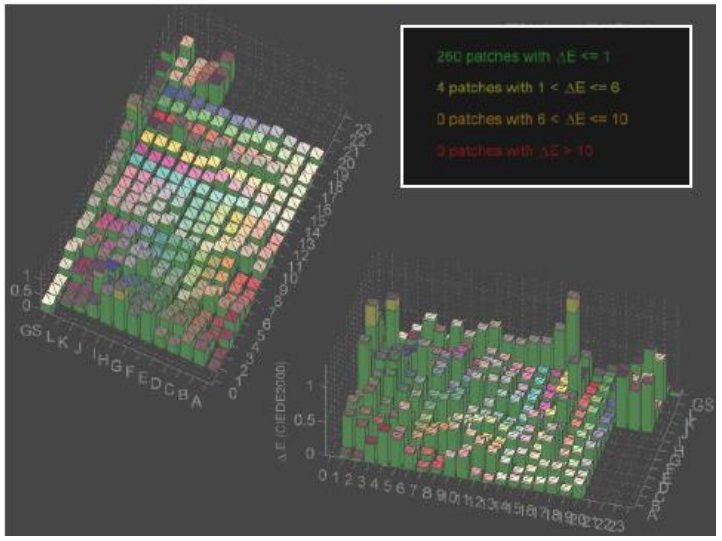


(b)





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How similar are calibration targets?

Table 7 Number of patches with E > 1 for several calibration targets, with ΔE relative to all other targets.

		Calibration target				
		Orig.	13	16	17	19
Calibration target	Orig.	0	161	171	167	186
	13	161	0	58	44	48
	16	170	56	0	0	2
	17	165	44	0	0	4
	19	182	46	2	4	0

Good targets!

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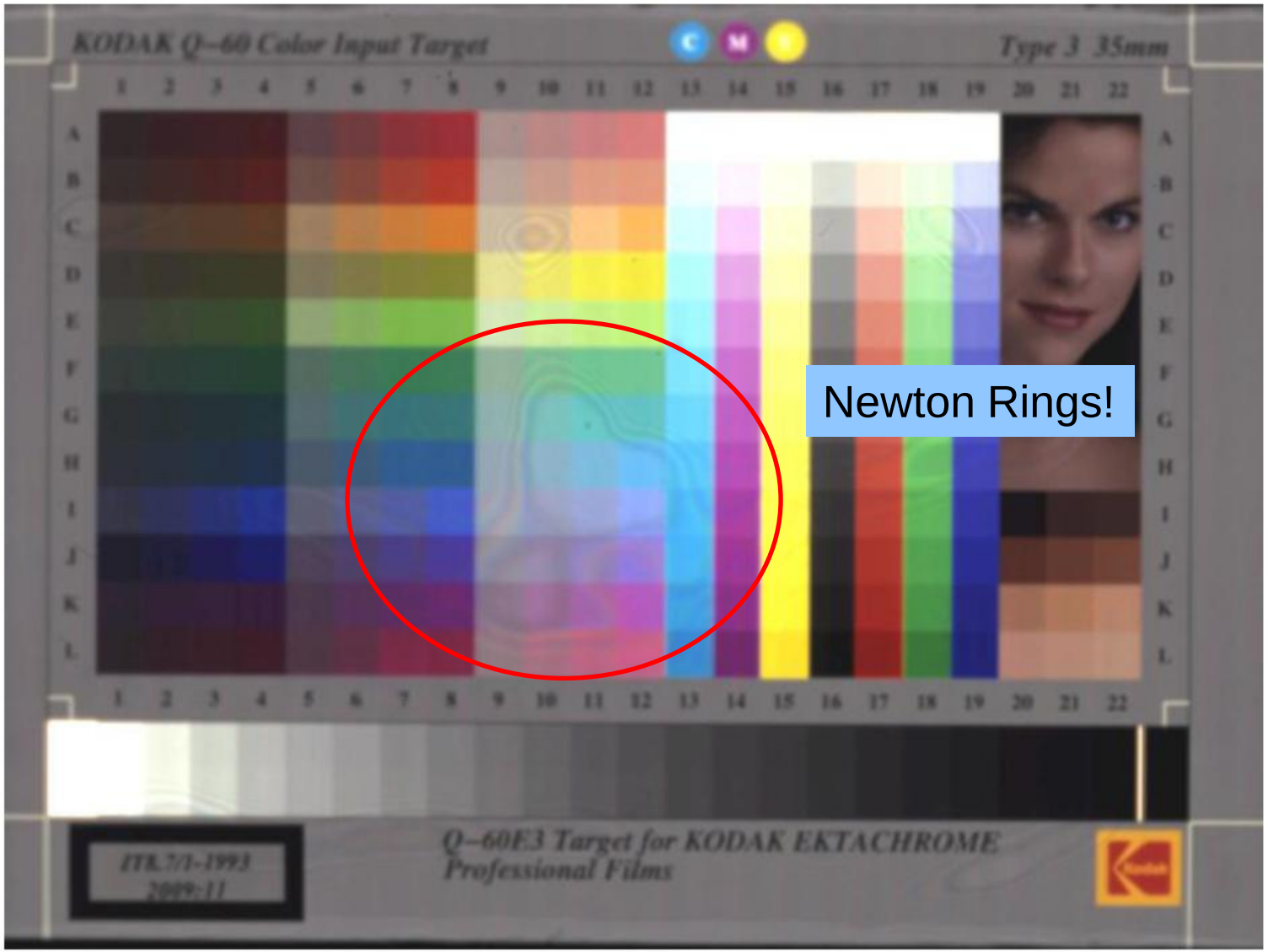
How to manufacture a color target



Color target with index matching fluid

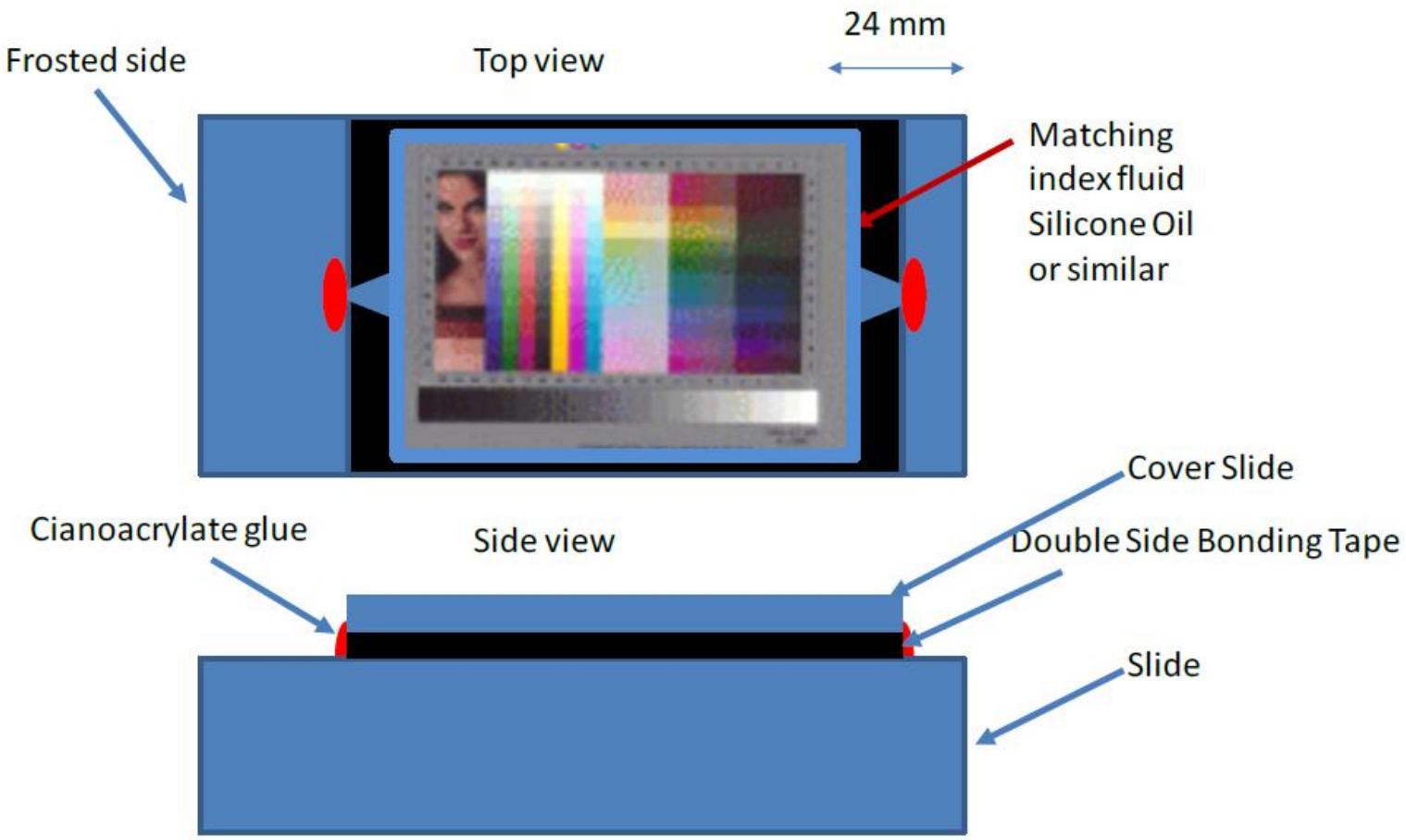


Figure 46 Color Calibration Target manufacturing with double side tape and index matching fluid.

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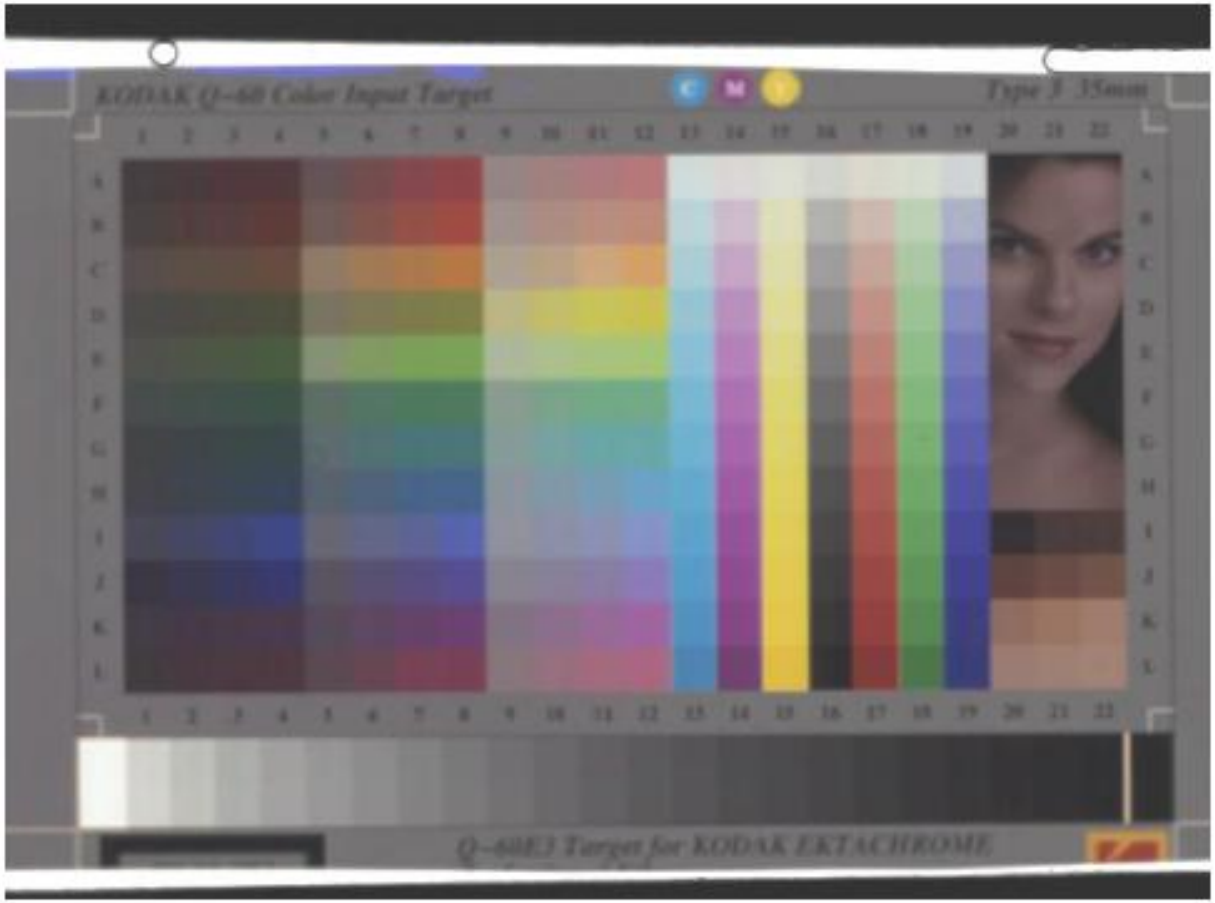
Color target with index matching fluid



- Better transmission
- No Newton Rings
- Scratches less visible

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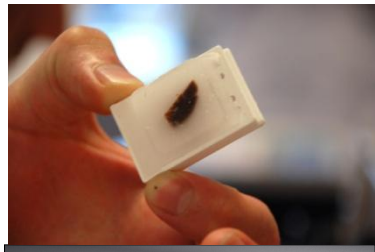


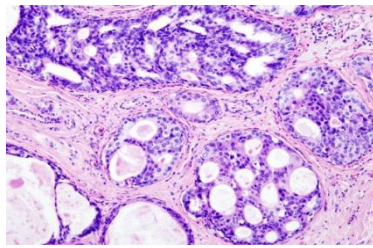

Effect of temperature on colors

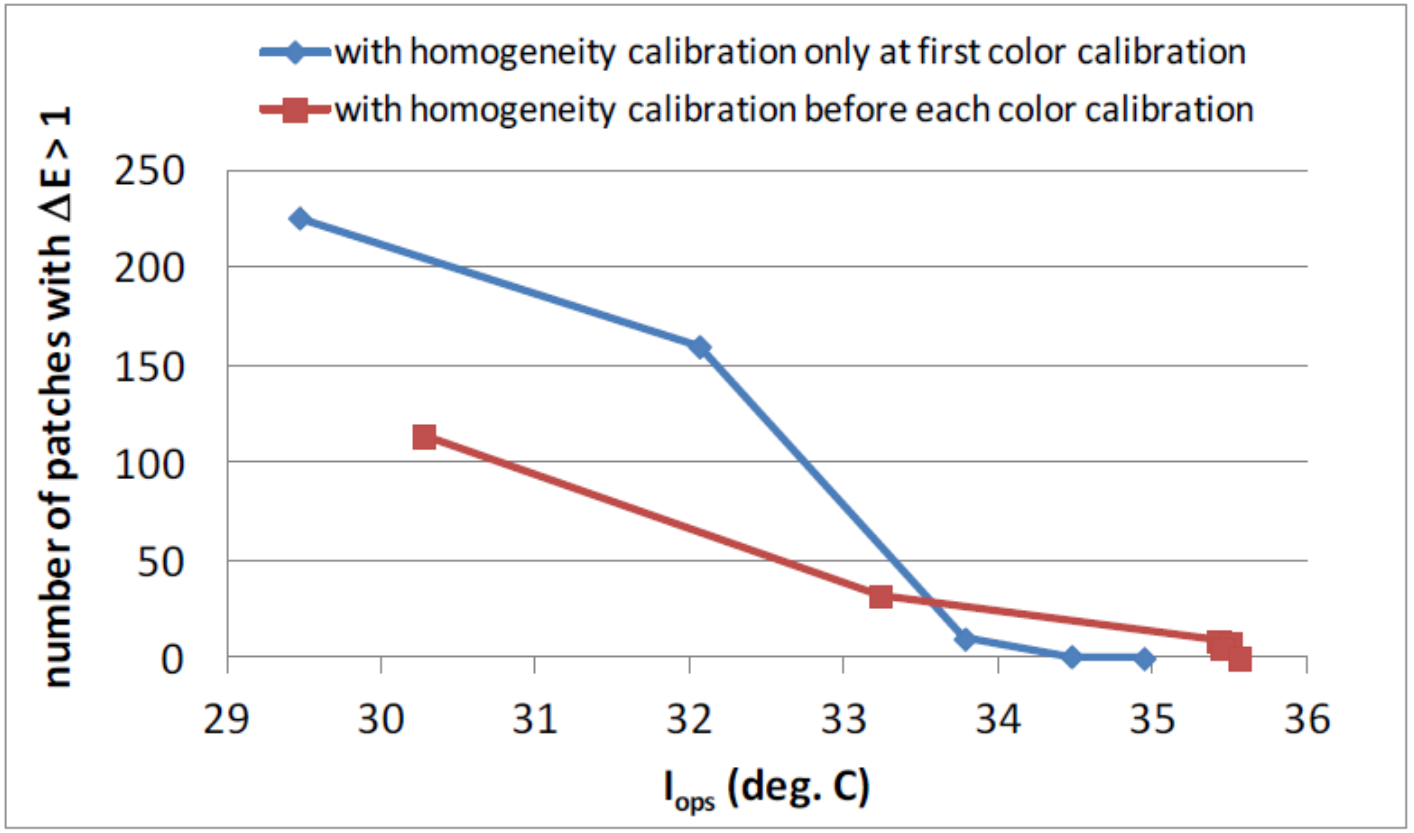

Figure 30 Number of patches with $\Delta E > 1$ when comparing with the stabilized end situation, as function of the temperature I_{ops}, for the cases of homogeneity calibration only before the first color calibration and homogeneity calibration before each color calibration.

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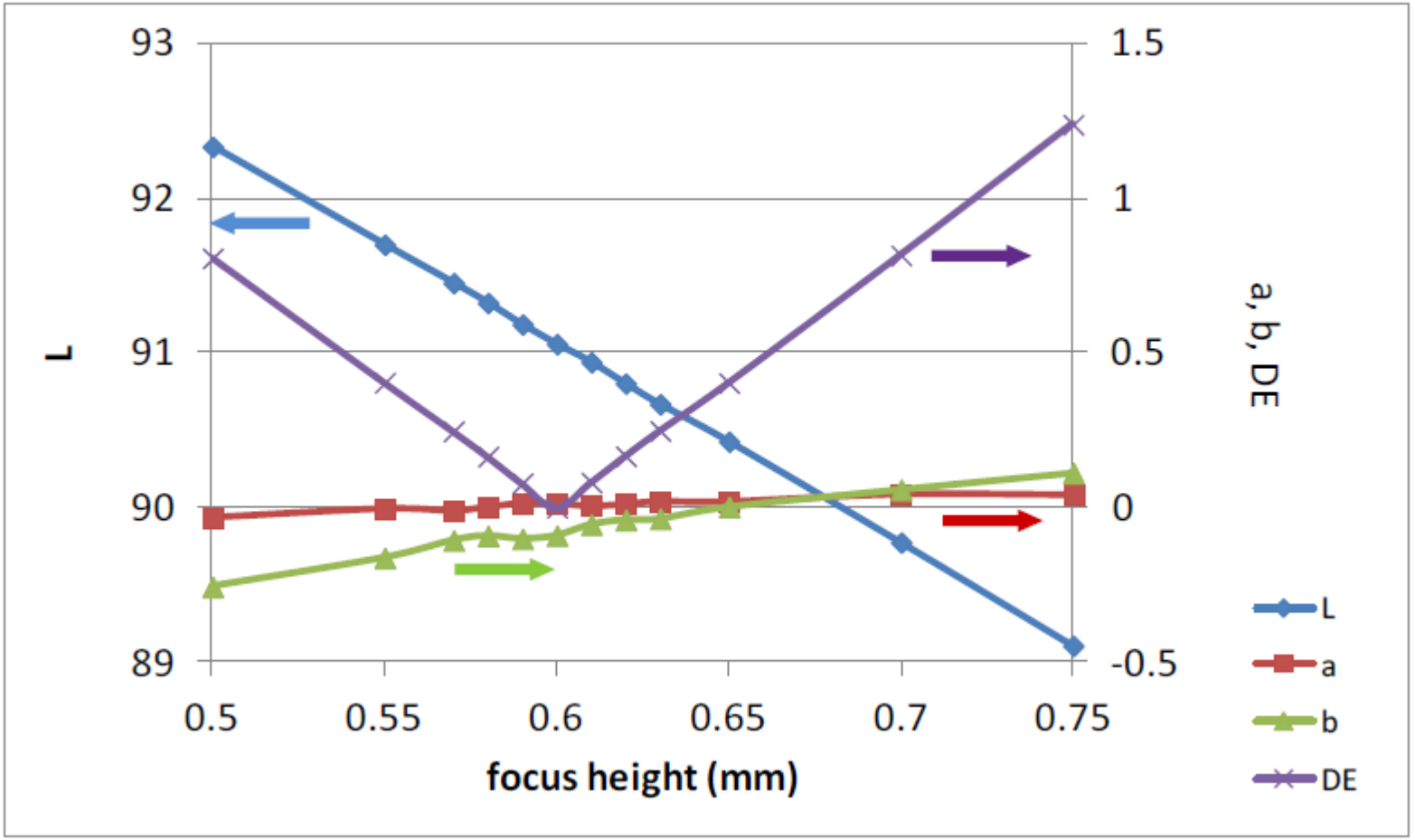
Effect of focus position on color



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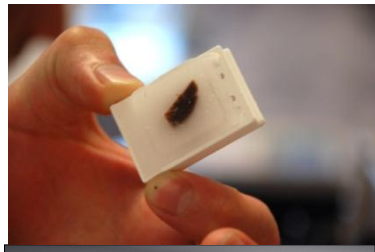


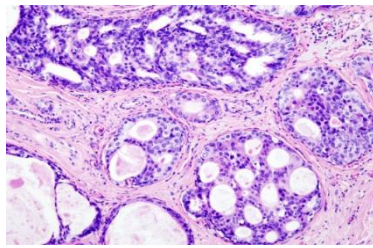

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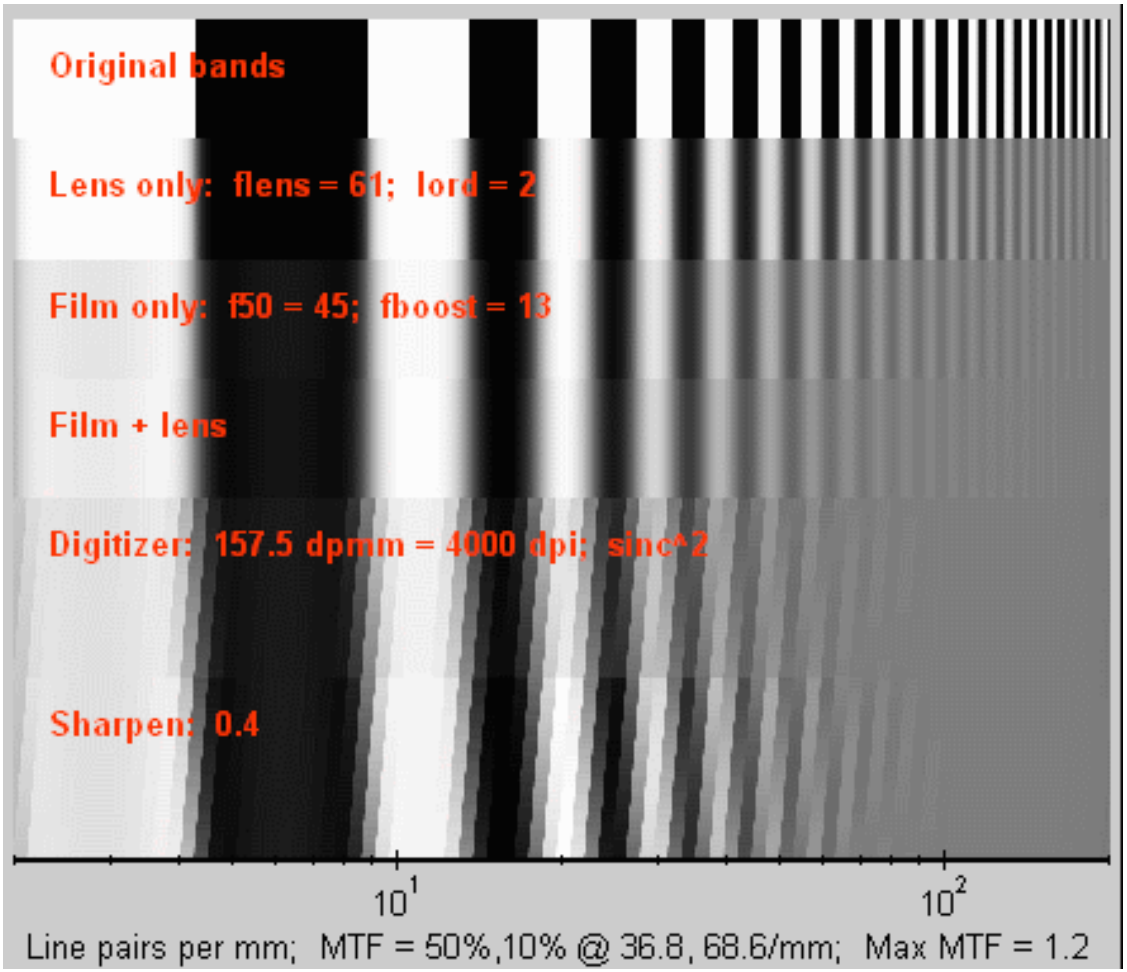
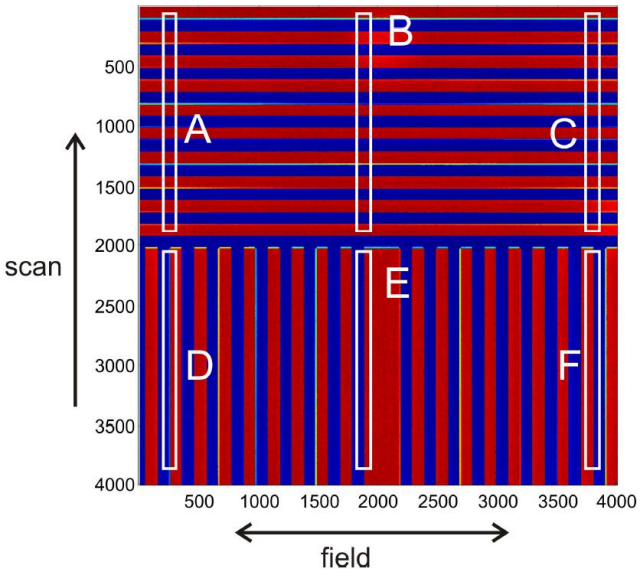
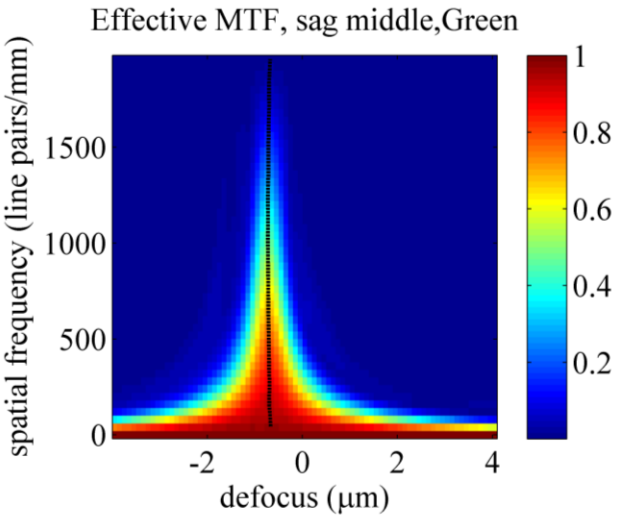
Resolution = Modulation Transfer Function (MTF)

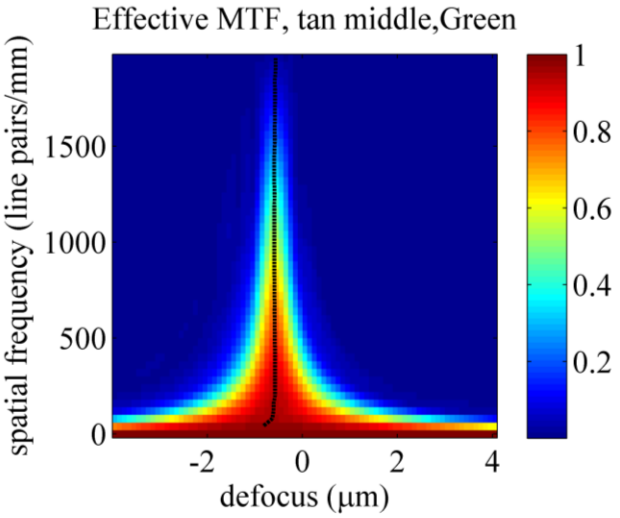


source: www.normankoren.com

Measuring scanner resolution







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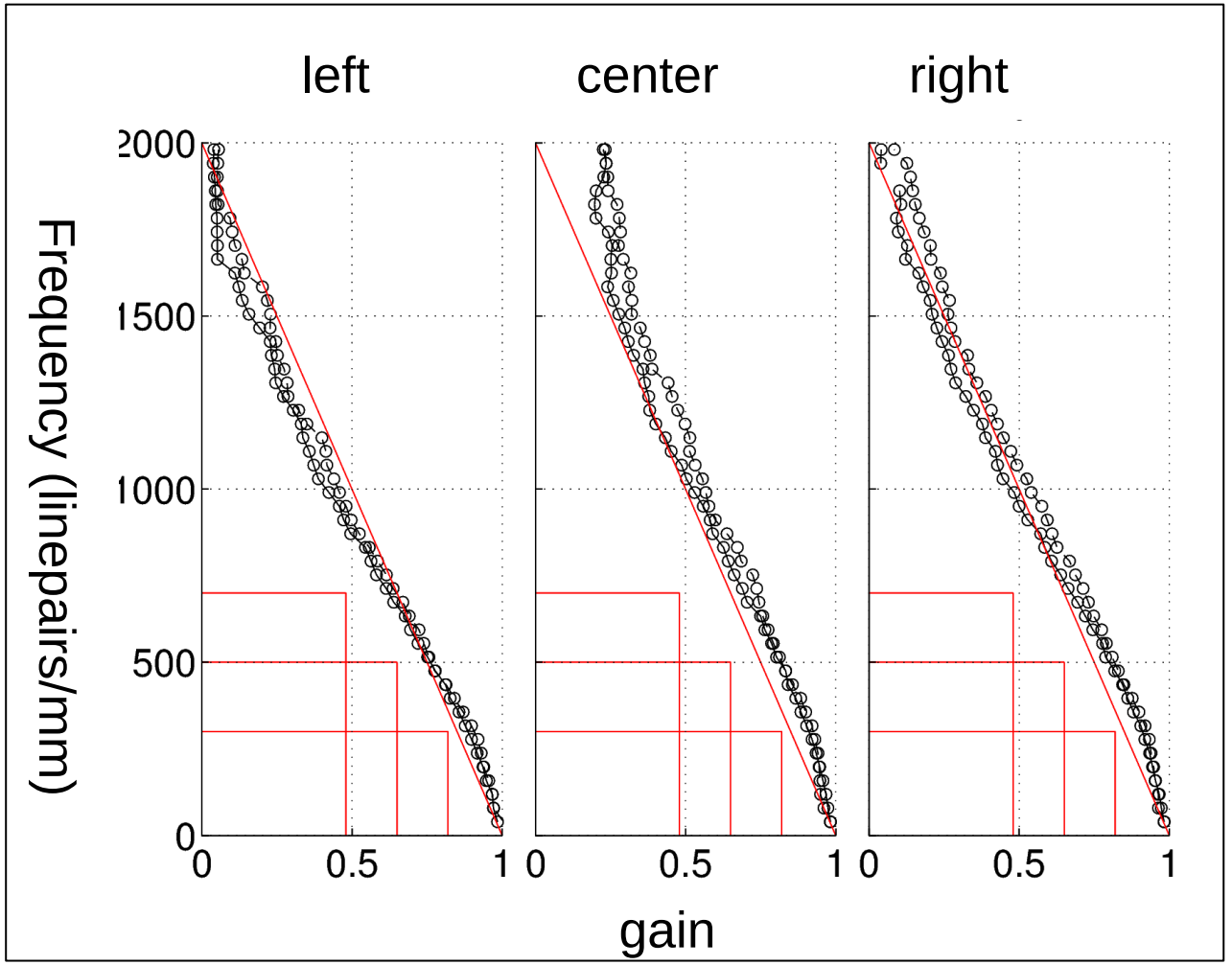
Monitoring Resolution, MTF target in Scanner



Lessons Learned

- Existing color targets are Film
  - You need to make a microscope slide from it
    - Substrate, Cover Slip, Index matching mounting medium
  - Film is less transparent than a tissue slide
  - Trying too hard to make Film targets look similar over your devices might make tissue slides look less similar
  - Film dyes are not the same (spectrally) as histopathology dyes
- Reproducibility
  - Film based targets reproduce well, but you need a test in your quality system to validate manufactures calibration slides.
  - May aspects in a scanner system influence color reproduction, you need continuous monitoring and calibration in your scanner
- Non color aspects that do influence color perception
  - Resolution and contrast and noise influence color perception (and overall image quality perception) even if they don't quantitatively influence color.