

Accurate calibration of dark field microscopy systems

Dr. Sc. Yves Vander Haeghen
Dept. ICT, University Hospital Gent, Belgium
Yves.VanderHaeghen@ugent.be

Introduction

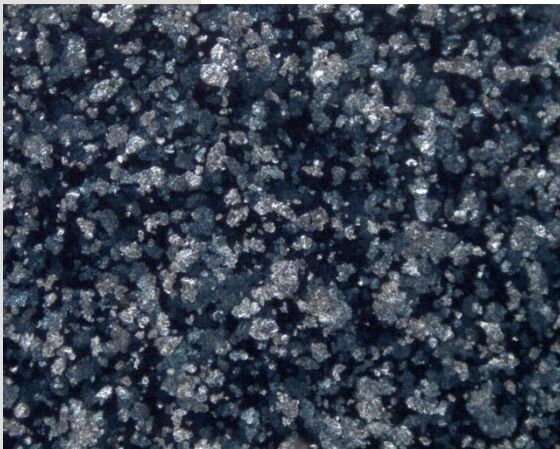
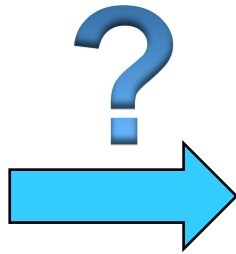


- ➔ **Use case: provide a better classification of forensic automotive paint samples at the national institute of crime and criminology (NICC). The current system based on spectroscopy returns too many matches ...**
- ➔ **Funded under an IMinds grant MMIQQA (see <http://www.iminds.be/en/projects/2014/03/13/mmiqqa>).**
- ➔ **Based on an my existing color calibration framework CIPF (see also previous presentations by John Penzcek). Mainly a shaper – CLUT type transform directly to sRGB.**
- ➔ **Charts are manufactured by DSC Labs, see <http://dsclabs.com/>**

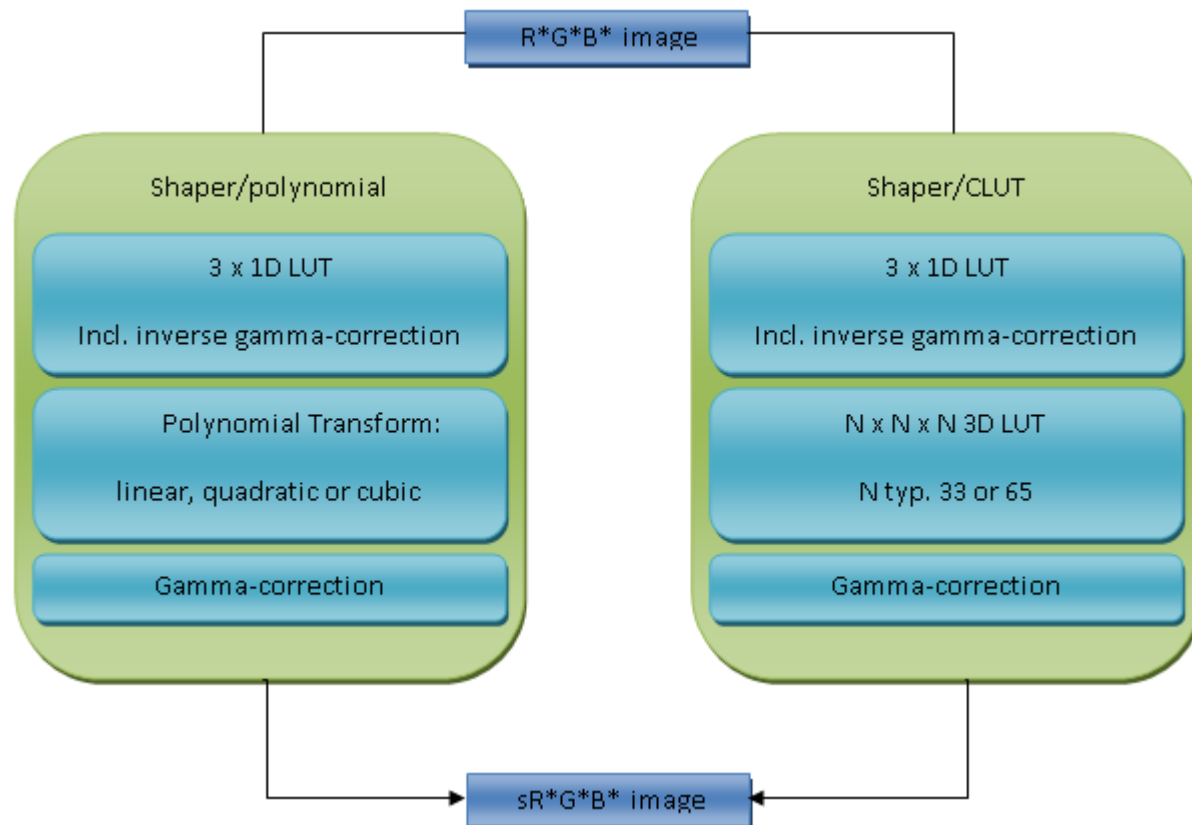
Introduction: Use case



Reflective,
dark field



Color calibration (CIPF)



The MicroCol chart

- ➔ During a previous IMinds project a new chart called MediCol had been created with a large gamut ($\simeq 50\%$ of sRGB) and specially located patches for optimal calibration.
 - ➔ Print technology, worked very well
 - ➔ Too many patches for this use case (no motorized stage yet)
 - ➔ Improvements in patch color selection



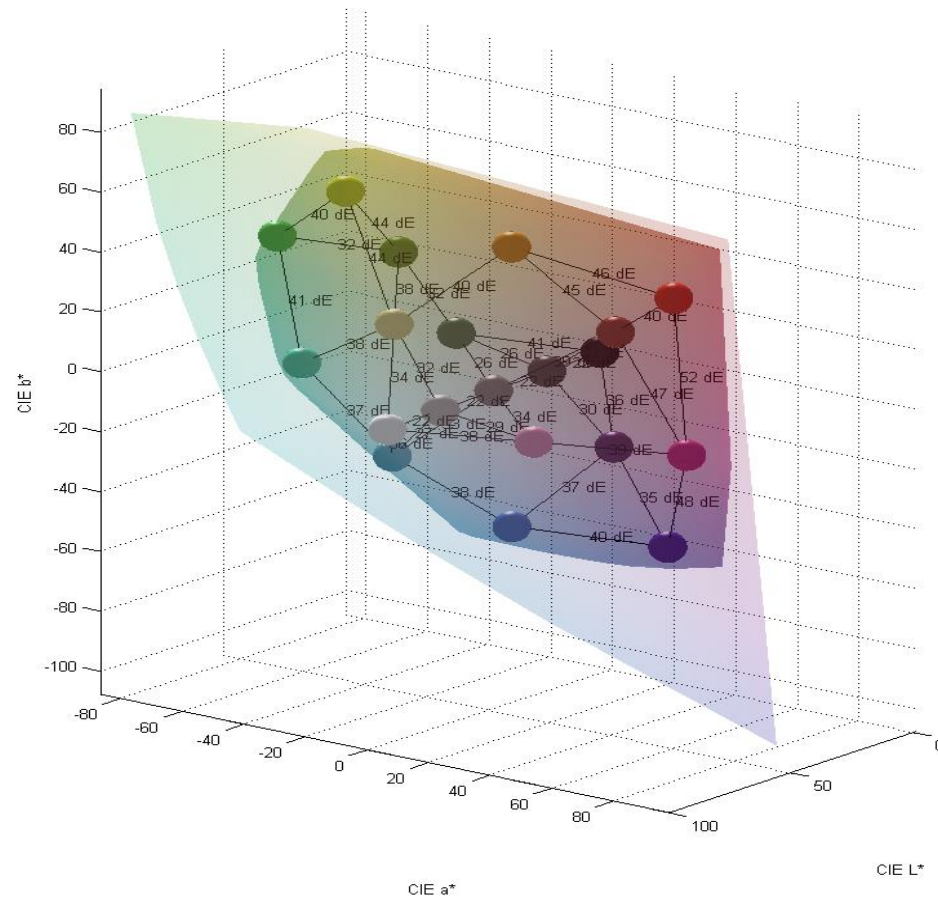
The MicroCol chart

➔ MicroCol

- ➔ Reflective, printed chart,
- ➔ 20 optimally spaced patches (≈ 31 dE₂₀₀₀^{*} spacing),
- ➔ 50% of sRGB gamut, with an estimated 89% of sRGB 'influence' zone (low error mapping)



The MicroCol chart



The MicroCol evaluation: photographic

- ➔ Non-microscopic, i.e. with a camera, light booth and no magnification (48 images)

Exposure Settings	White balance settings	Camera	Light sources	Workflow
-1/3 f	Auto	Canon 550 D	3000 K	24 bpp
0f	Manual		4000 K	raw - 48 bpp
+1/3 f	Warm (20 mired)		54000 K	
	Cold (20 mired)		6000 K	

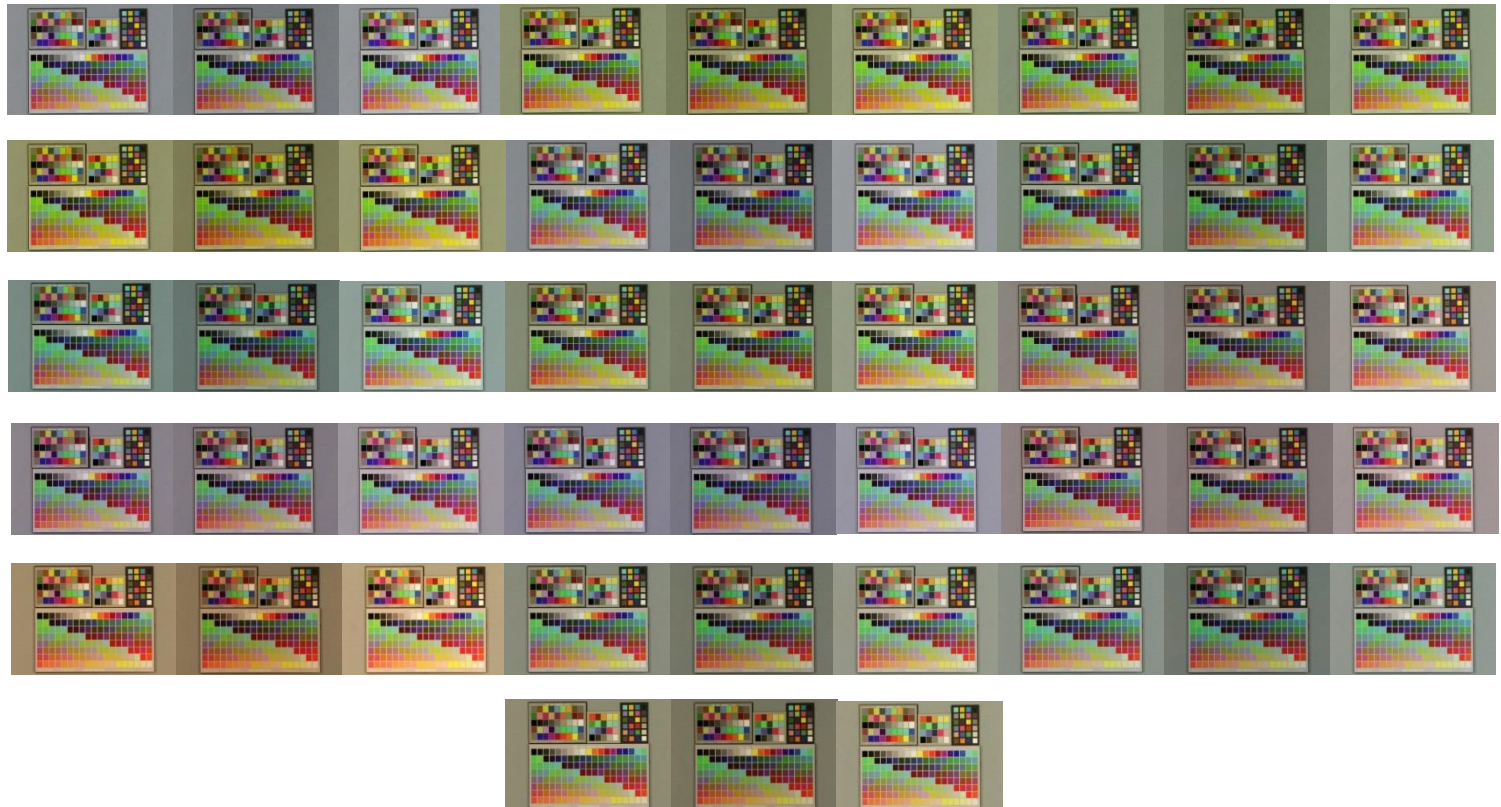


The MicroCol evaluation: photographic

- ➔ **Both 24 and 48 bpp RAW workflow tested!**
- ➔ **The Test chart**
 - ➔ 152 finely spaced patches (\neq from calibration patches), spanning 55% of sRGB gamut

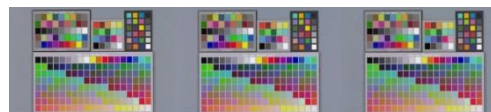


The MicroCol evaluation: photographic



Uncalibrated
images

The MicroCol evaluation: photographic



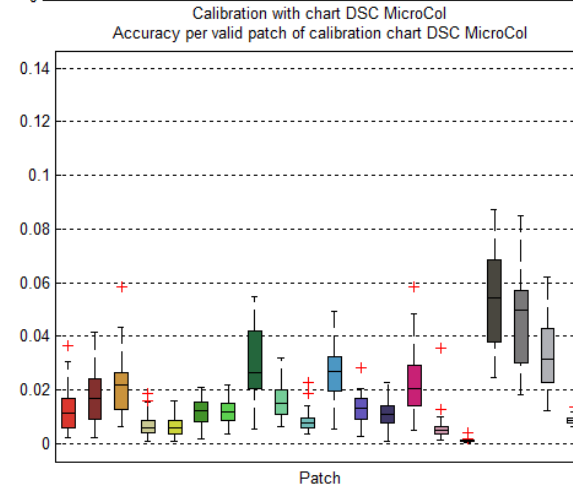
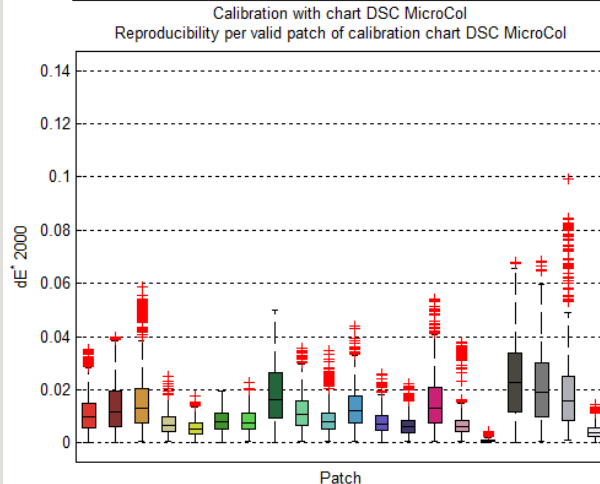
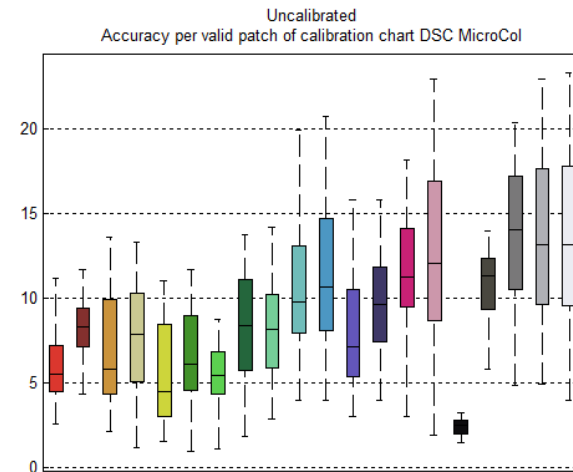
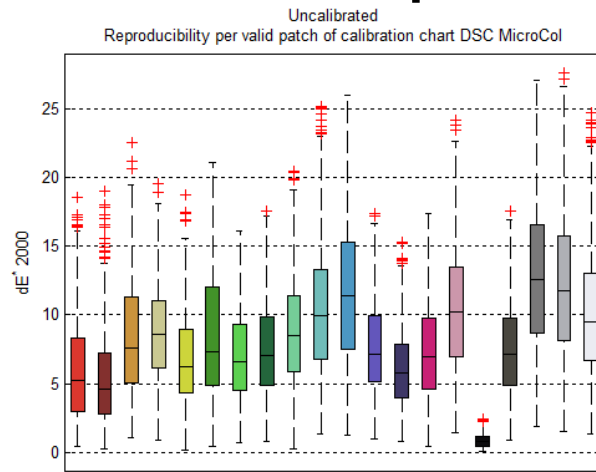
Calibrated
sRGB images

The MicroCol evaluation: photographic

- ➔ **The numbers: obtained by computing pairwise statistics**
 - ➔ Between measurements for reproducibility
 - ➔ Between measurements and spectrophotometric data (D65, 2 degree observer) for accuracy
 - ➔ Always dE^*_{2000}

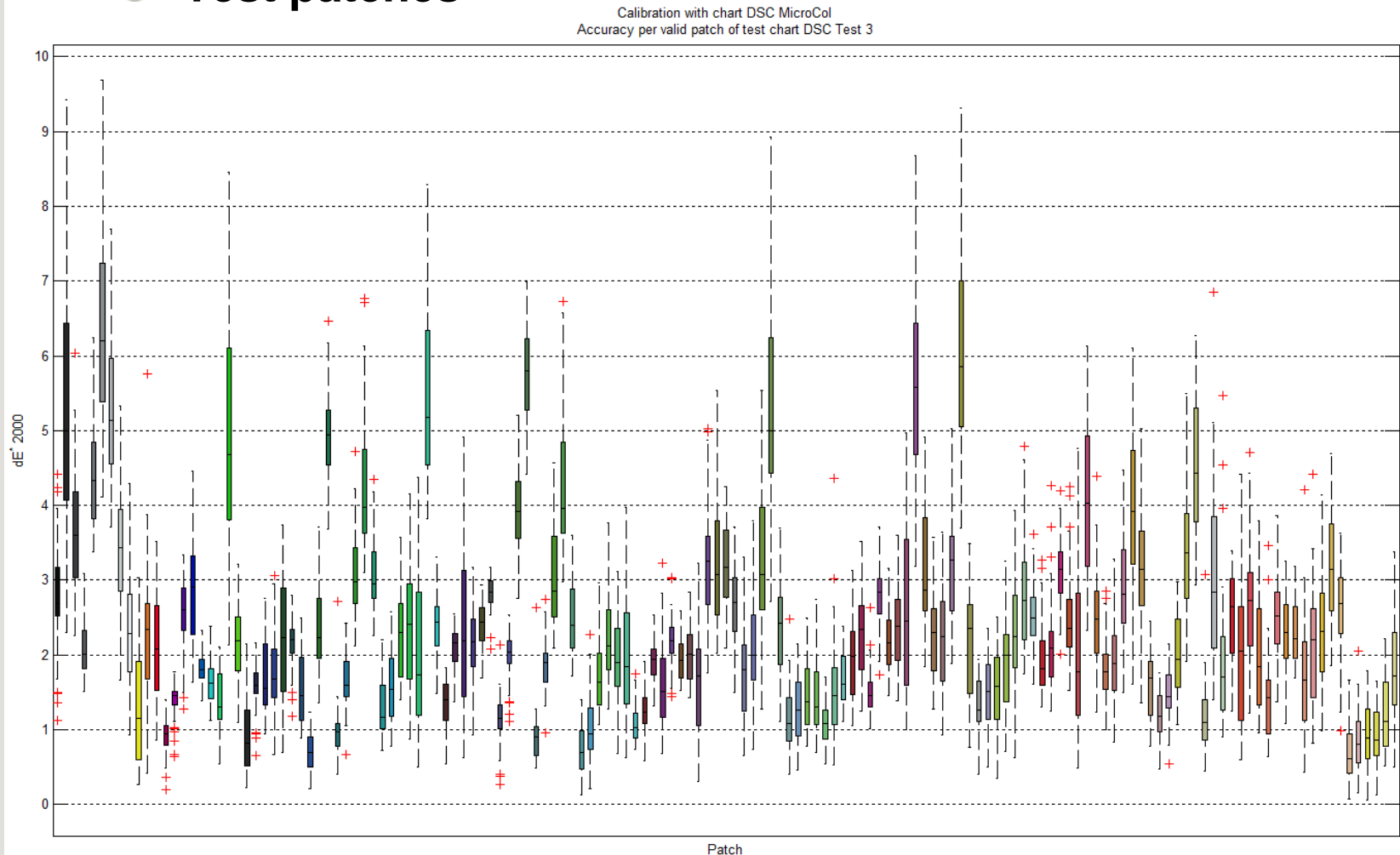
The MicroCol evaluation: photographic

➔ Calibration patches



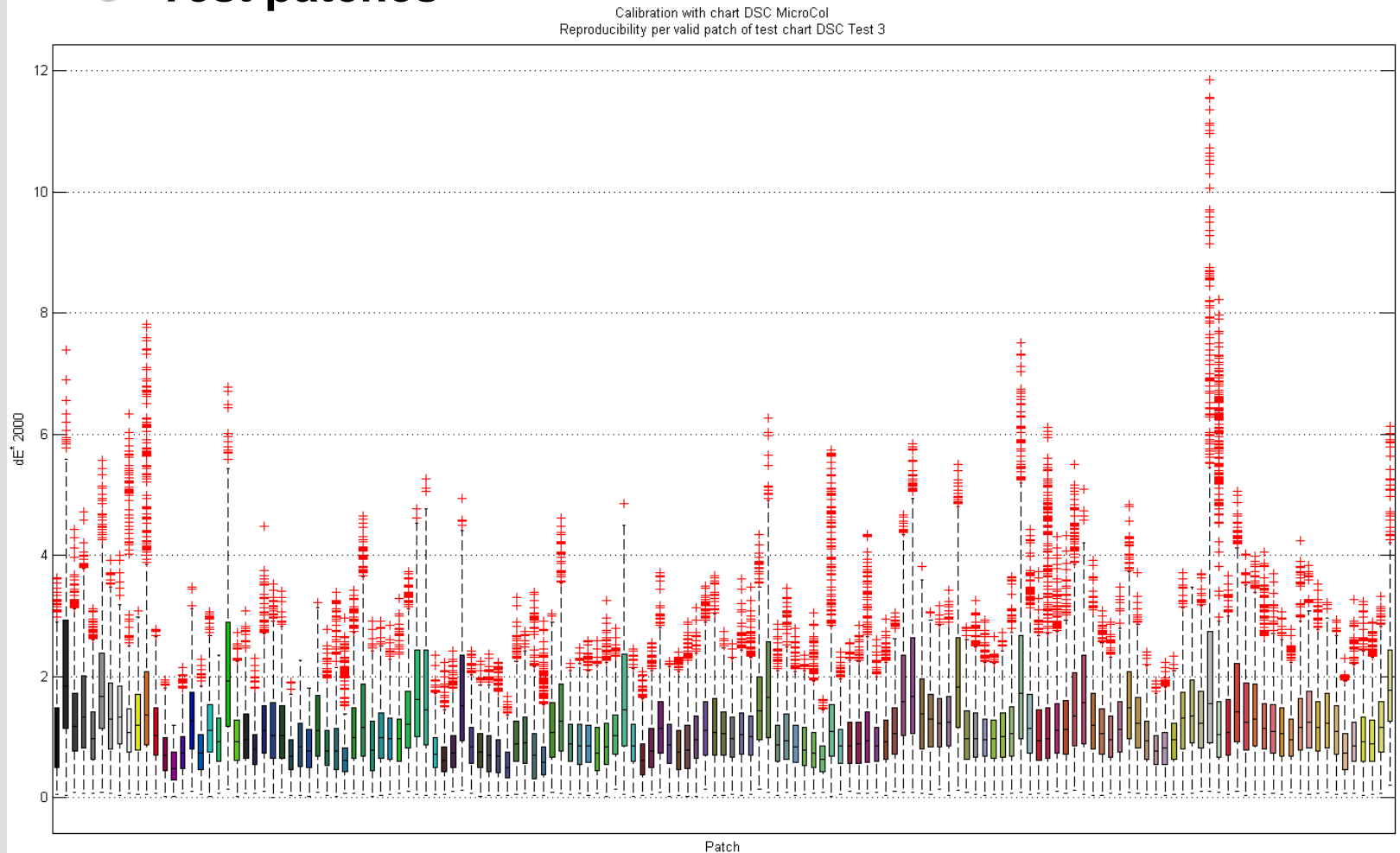
The MicroCol evaluation: photographic

➔ Test patches



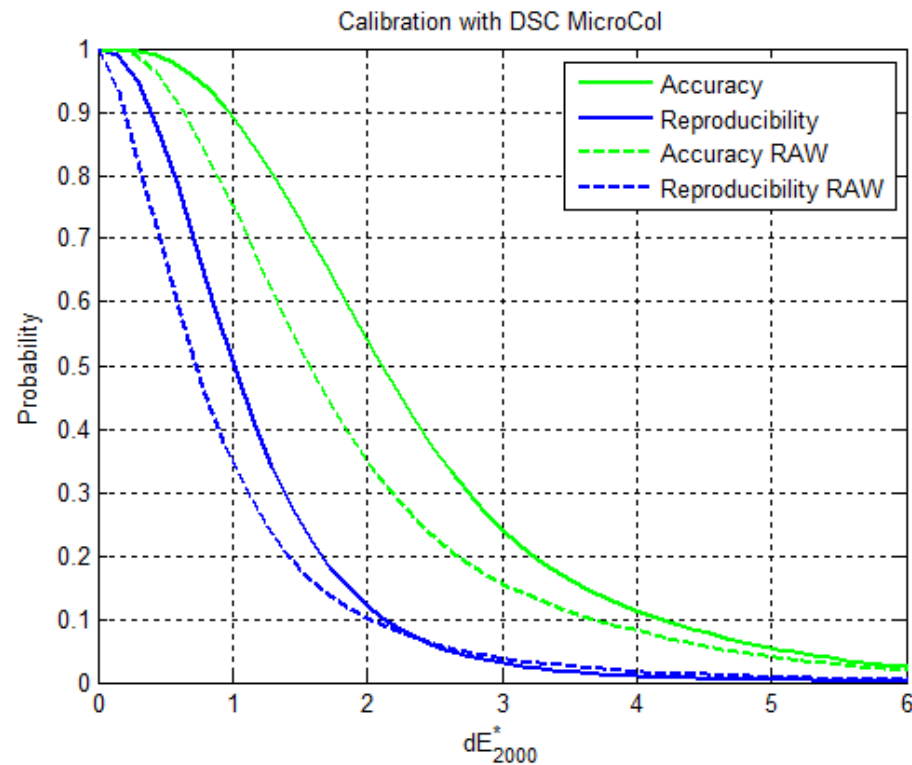
The MicroCol evaluation: photographic

➔ Test patches



The MicroCol evaluation: photographic

➔ All together now



The MicroCol evaluation: photographic

24 bpp

		1 st quartile dE^*_{2000}	Median dE^*_{2000}	3 rd quartile dE^*_{2000}	99 th percentile dE^*_{2000}	Maximum dE^*_{2000}
Uncalibrated	Reproducibility	4.79	7.60	11.16	21.40	27.62
	Accuracy	5.51	8.60	11.74	20.92	23.35
Calibrated	Reproducibility	0.64	1.00	1.48	3.79	11.85
	Accuracy	1.46	2.10	2.93	6.92	9.68

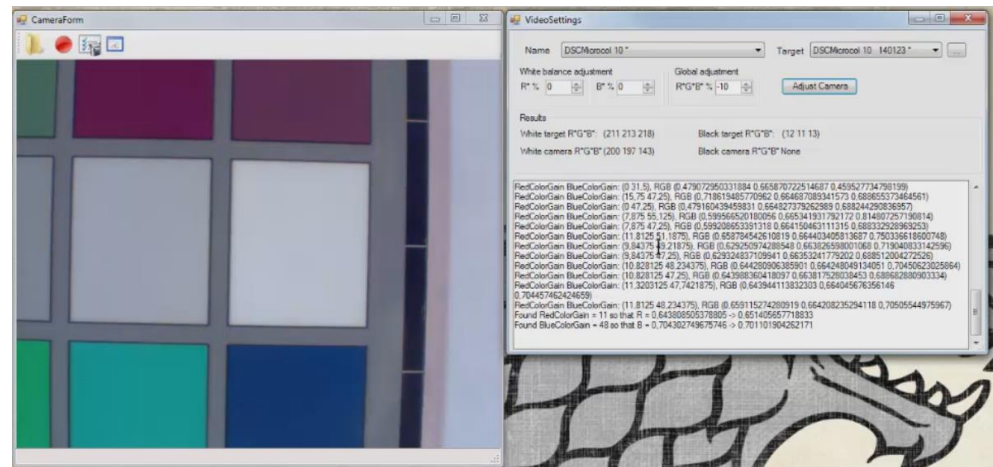
48 bpp

		1 st quartile dE^*_{2000}	Median dE^*_{2000}	3 rd quartile dE^*_{2000}	99 th percentile dE^*_{2000}	Maximum dE^*_{2000}
Uncalibrated	Reproducibility	3.87	6.13	9.07	20.02	30.58
	Accuracy	15.99	19.34	23.92	32.86	35.33
Calibrated	Reproducibility	0.37	0.68	1.13	3.51	6.15
	Accuracy	1.00	1.52	2.28	6.21	8.34

The MicroCol evaluation: microscopic

- ➔ **Microscopic: 100 x, 'cheap' camera (Pixelink PL-A662), few settings (9 sets of images), computer control providing optimal dynamic range (neutral balancing)**

Light source setting	0	-1	-2
Red gain	-2 %	0 %	+2%
Blue gain	-2 %	0 %	+2%

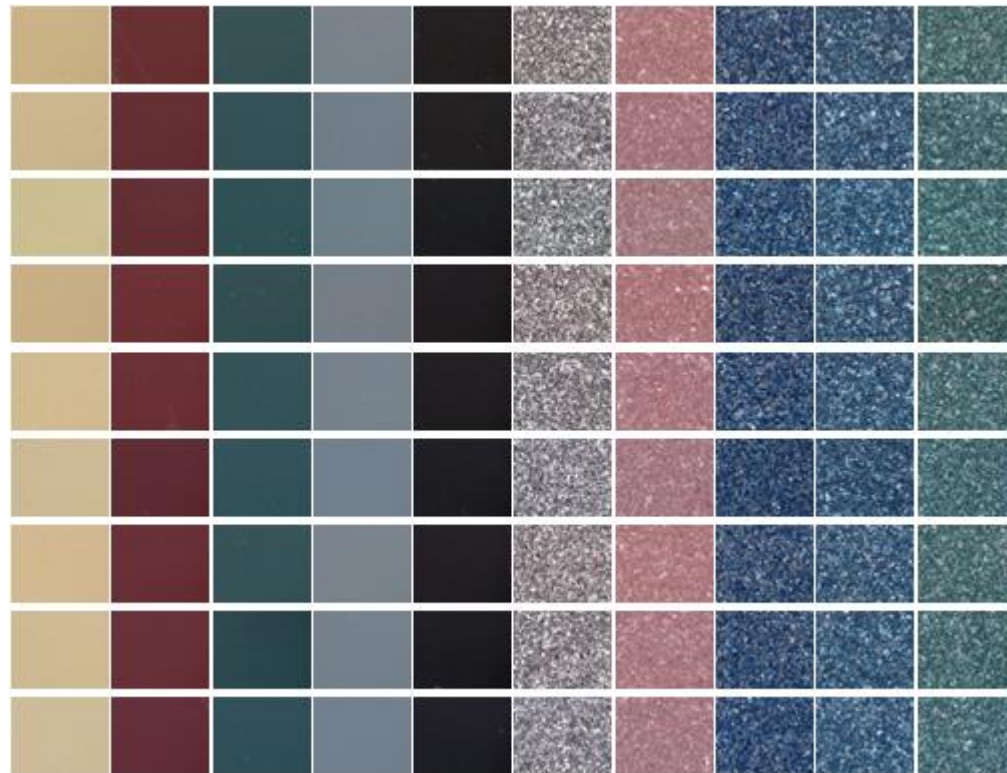


The MicroCol evaluation: microscopic

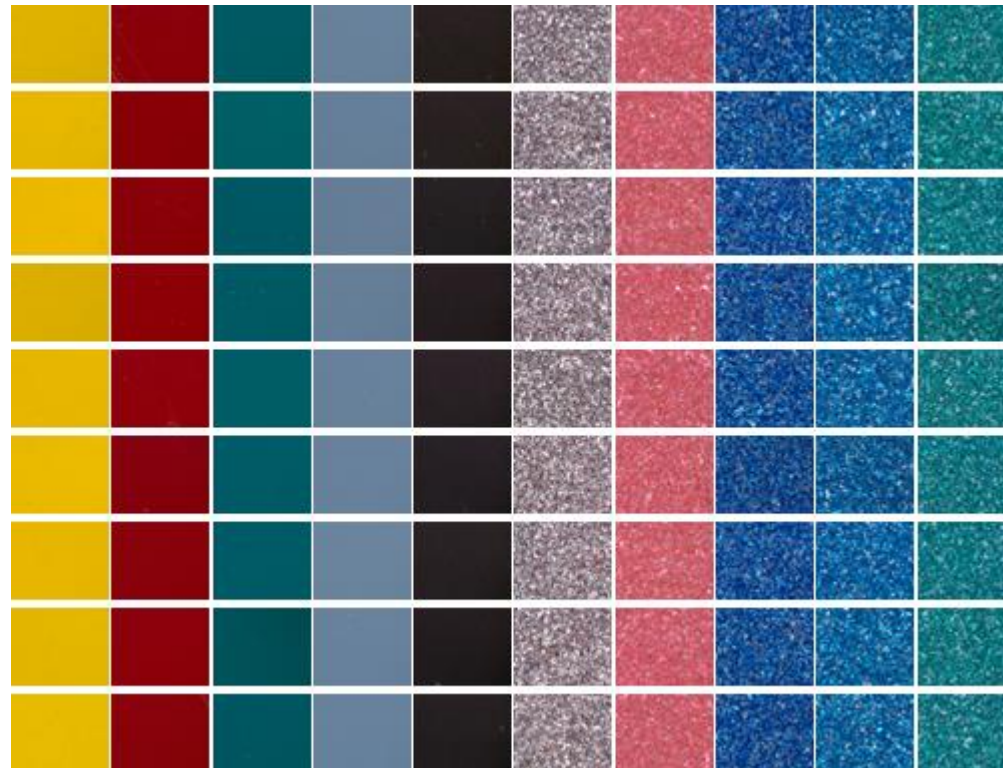
- ➔ Test chart imaged for 1 set of settings
- ➔ 12 automotive paint samples for all sets of settings (6 normal and 6 metallic)



The MicroCol evaluation: microscopic



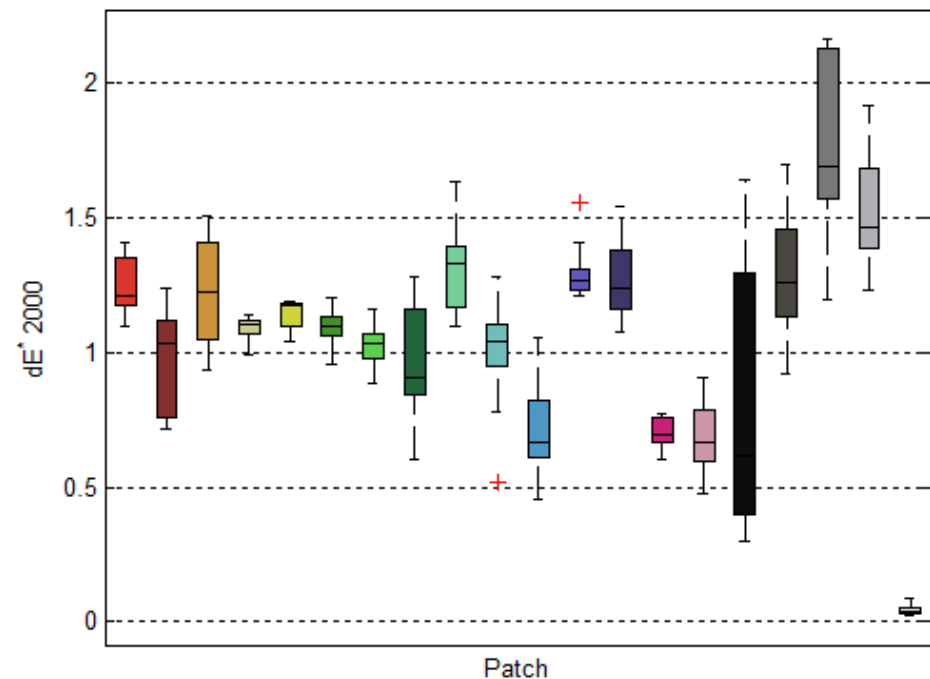
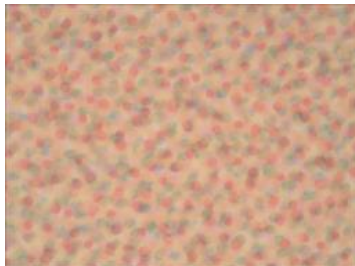
The MicroCol evaluation: microscopic



The MicroCol evaluation: microscopic

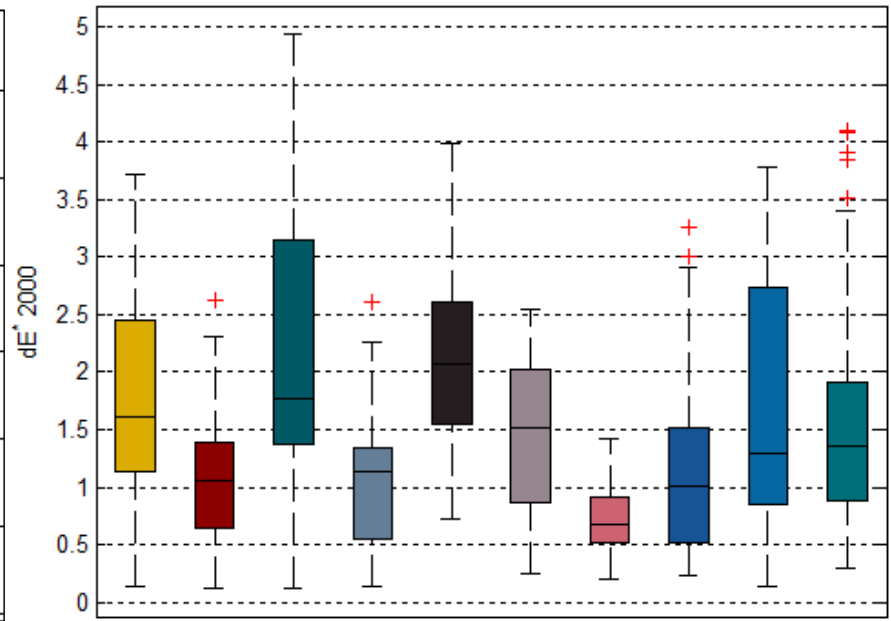
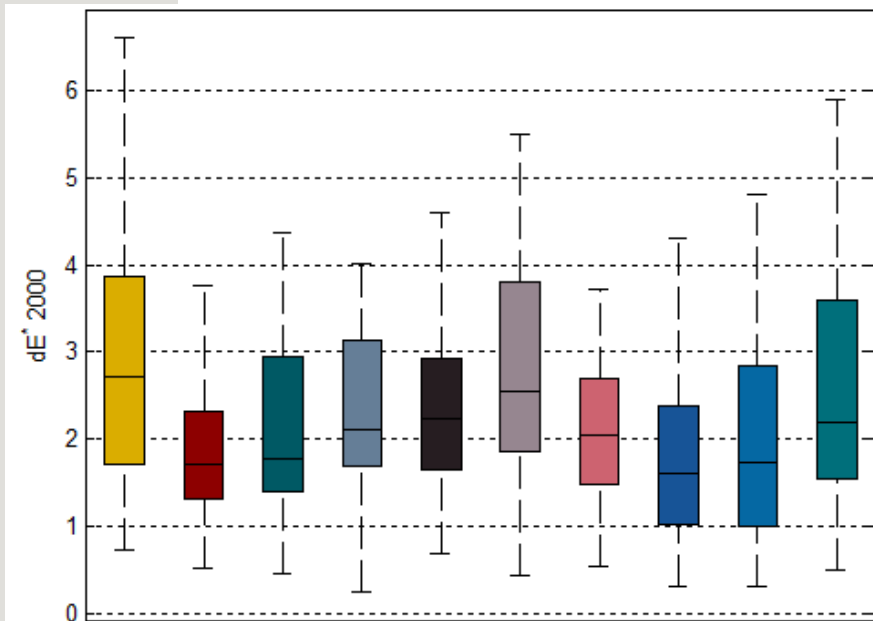
➔ Calibration chart patches: accuracy not very good?

Due to non-uniformity of patches
at 100 x magnification



The MicroCol evaluation: microscopic

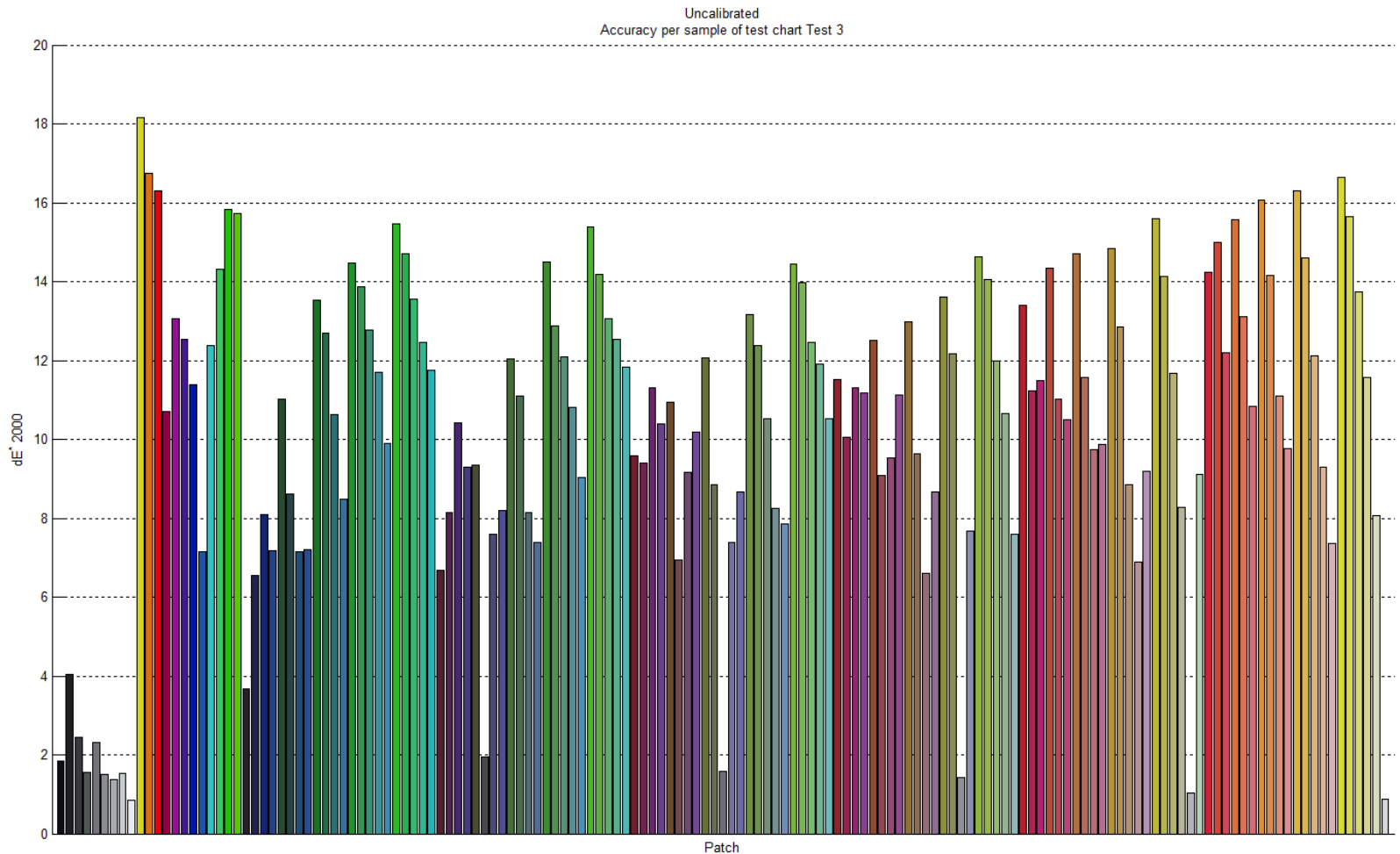
- ➔ Reproducibility of paint samples: uncalibrated (left) – calibrated (right)



Camera control already removed a lot of the variability!

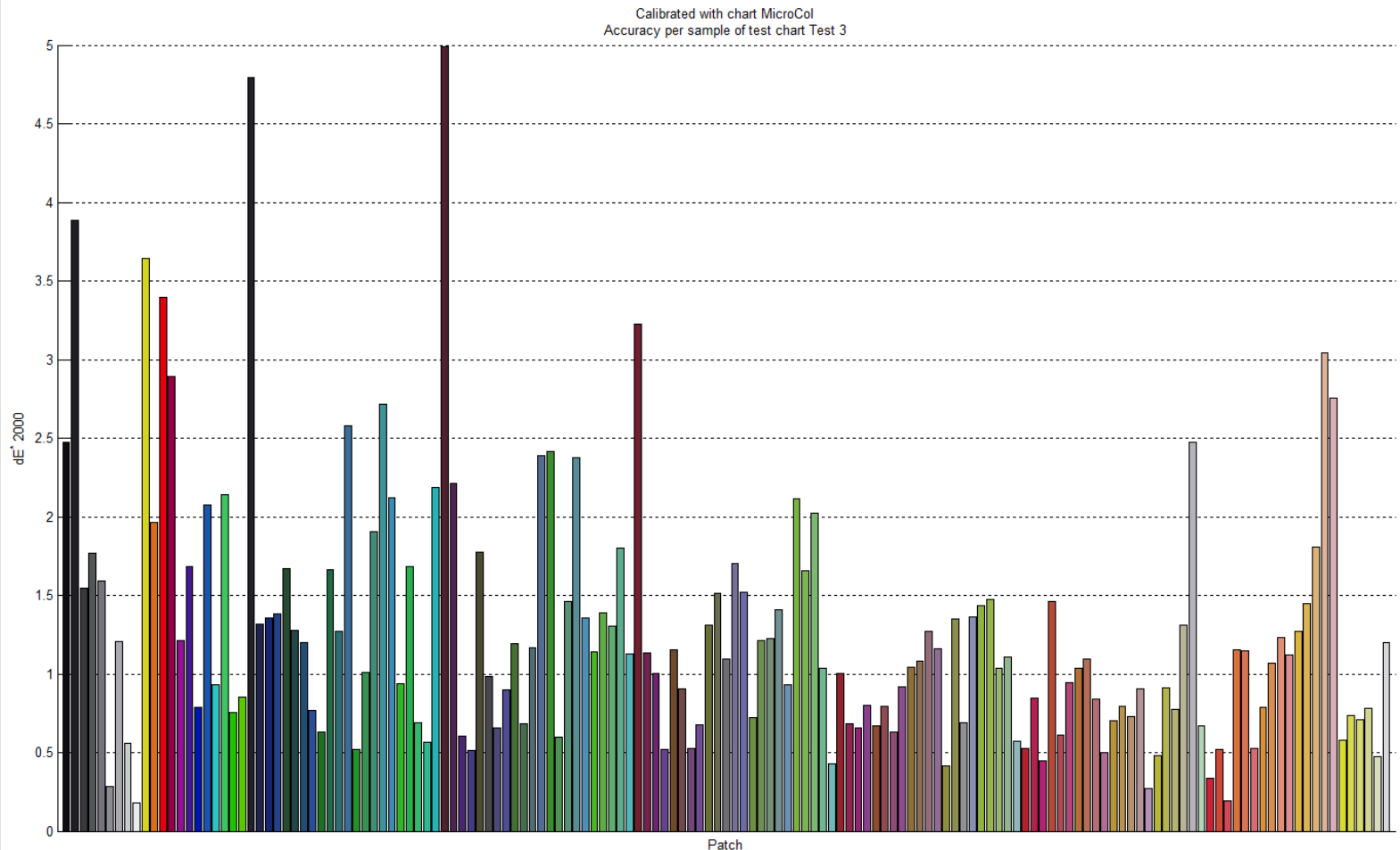
The MicroCol evaluation: microscopic

➔ Accuracy of test chart before calibration



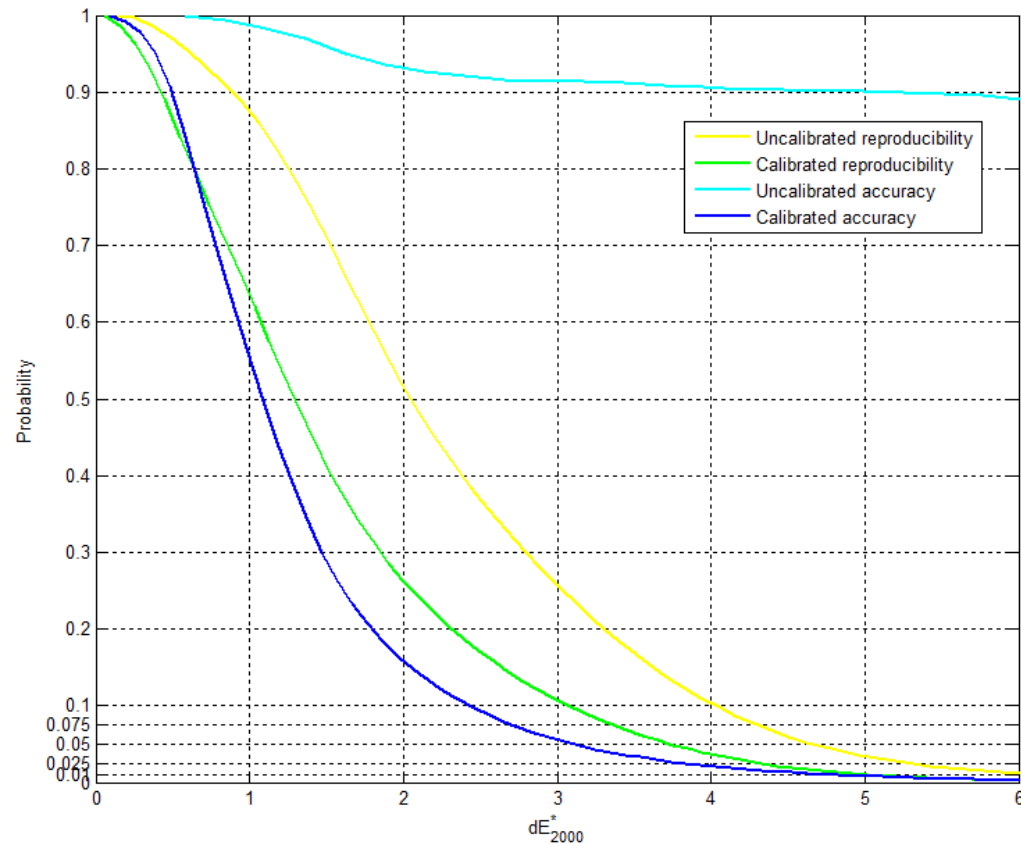
The MicroCol evaluation: microscopic

➔ Accuracy of test chart after calibration



The MicroCol evaluation: microscopic

➔ All together



The MicroCol evaluation: microscopic

➔ All together

			1 st quartile dE ⁺ ₂₀₀₀	Median dE ⁺ ₂₀₀₀	3 rd quartile dE ⁺ ₂₀₀₀	99 th percentile dE ⁺ ₂₀₀₀	Maximum dE ⁺ ₂₀₀₀
Uncalibrated	Reproducibility		1.42	2.07	3.05	5.70	6.61
	Accuracy		8.33	11.11	13.09	16.74	18.17
Calibrated	Reproducibility	Transform	1.05	1.53	2.35	4.27	5.12
		Image	0.78	1.31	1.98	4.20	4.95
	Accuracy	Transform	0.92	1.37	2.14	5.46	5.49
		Image	0.71	1.12	1.52	4.79	4.99

Use case: automotive paint

- ➔ **Different research group (University of Antwerp)**
 - ➔ Classification using color and texture
 - ➔ No details, dataset not 100% correct, but still improvement of classification after calibration

Lessons learned

- ➔ **Lot's of problems acquiring proper microscope images:**
 - ➔ microscope technicians seem to be bad at it,
 - ➔ existing acquisition software is often confusing.
 - ➔ In the end we had to provide both camera and control software
- ➔ **The camera control software, simple dynamic range optimization, greatly improved quality!**

What about ICC profiles?

➔ Work in progress

- ➔ Uses LittleCMS to create profiles, IrfanView or Gimp to display
- ➔ CIPF profiles can now be converted to shaper/matrix or 16 bit shaper/CLUT profiles (AToBx), but I would like to use floats (D2Bx Tag).
- ➔ Not 100% correct, still some questions about the different encodings and tags, intents and tags, chromatic adaptation, ...

What about ICC profiles?



Original image: Canon D550,
6500K lighting, exposure 0f,
+20 mired white balance



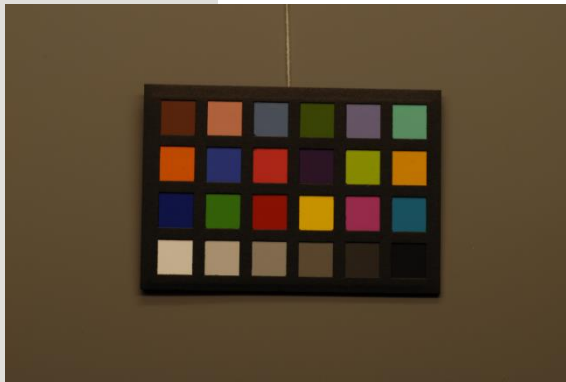
Calibrated sRGB
image

Original image with
shaper/clut input
ICC profile

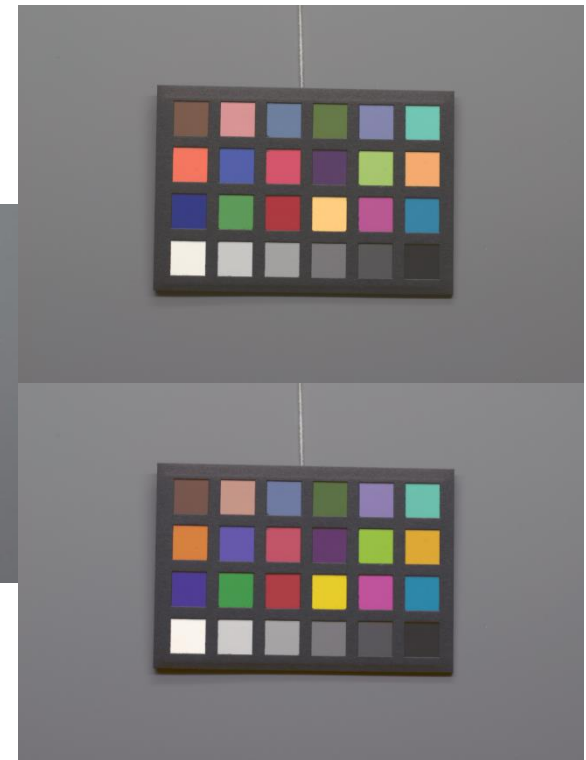
What about ICC profiles?

Original image,
shaper/matrix ICC profile

Original image

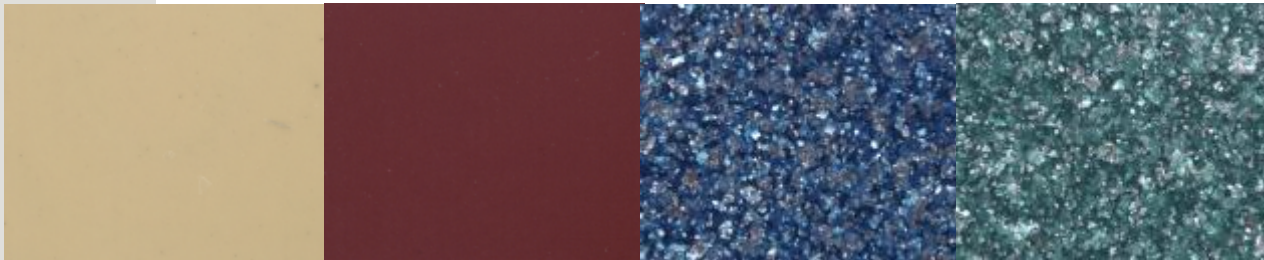


Calibrated sRGB
image

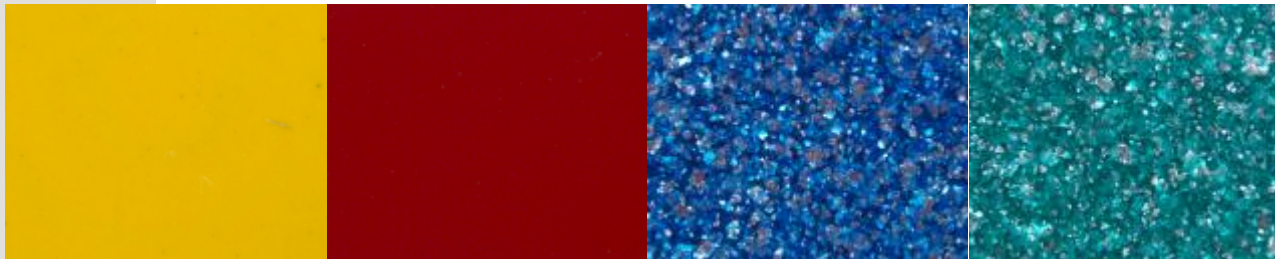


Original image, shaper/clut input
ICC profile

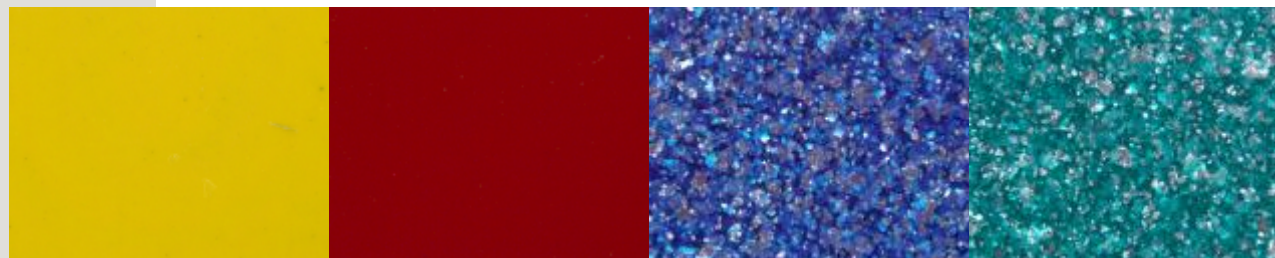
What about ICC profiles?



Original image



Calibrated sRGB
image



Original image with
ICC profile