Measuring black – an easy task ?

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VILF Jahrestagung

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Cooperation between two leading companies

- 150 years of experience
- 16 offices and 34 authorized agents worldwide
- 350 experts around the globe

- More than 160 years of experience
- 15 plants and 4 technical centers
- 1.475 employees

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Carbon Black

Carbon black is an essential material made to customers' exacting specifications. It serves as an additive for:

- Tires & rubber goods
- Polymers
- Adhesives & Sealants
- Coatings
- Ink
- Batteries
- Numerous other specialty. high-performance applications






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Are all Carbon Blacks the same?

Black measurement – continuous improvement for ~ 50 years

- **1976:** W. Schumacher (Degussa) introduced the index "M" for measuring blackness
- **1986**: K. Lippok-Lohmer (Degussa) introduced the new $\mathbf{M_Y}$ and $\mathbf{M_C}$ indices based on the study by W. Schumacher
  - Two existing procedures were combined by :
    - Black measurement based on optical density (Printing industry)
    - Black measurement based on light reflection (Coating/Plastic industry)
- **1989**: „DIN 55979: Pigments – determination of the black value of carbon black pigments"
- **2022**: „DIN 5033-10: Colorimetry – Part 10: Reflectance black standard for calibration in colorimetry and photometry"
- **2022**: „DIN EN ISO 18314-3: Analytical colorimetry –Part 3: Special indices"

Coloristic formulas for black coatings

Light source: D65
10° Observer angle

L*a*b*- Values

Norm color values X Y Z

Blackness Values

Hue dependent blackness value

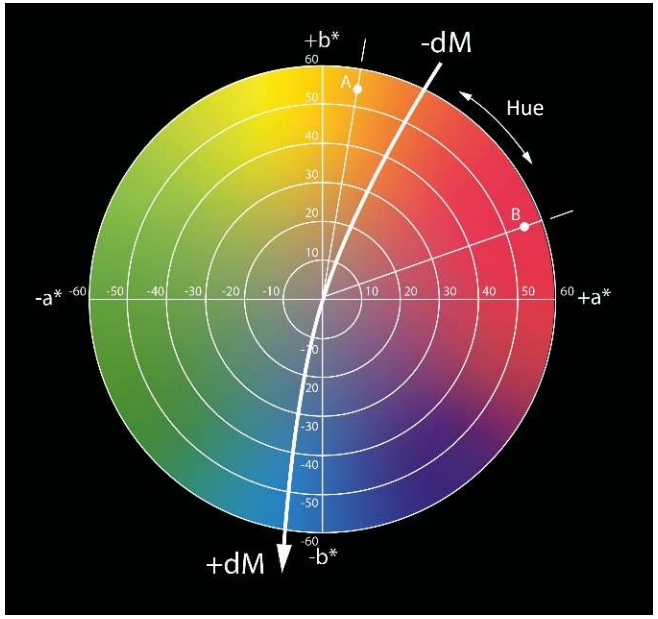
$$M_C = 100 \cdot \left[\log\left(\frac{X_n}{X}\right) - \log\left(\frac{Z_n}{Z}\right) + \log\left(\frac{Y_n}{Y}\right)\right]$$

Hue independent blackness value

$$M_Y = 100 \cdot \left[\log\left(\frac{Y_n}{Y}\right)\right]$$

Absolute contribution of hue

$$dM = 100 \cdot \left[\log\left(\frac{X_n}{X}\right) - \log\left(\frac{Z_n}{Z}\right)\right]$$



Absolute contribution of hue dM displayed in CIE a*b* color coordinate system

dM > 0: bluish undertone
dM < 0: brownish undertone

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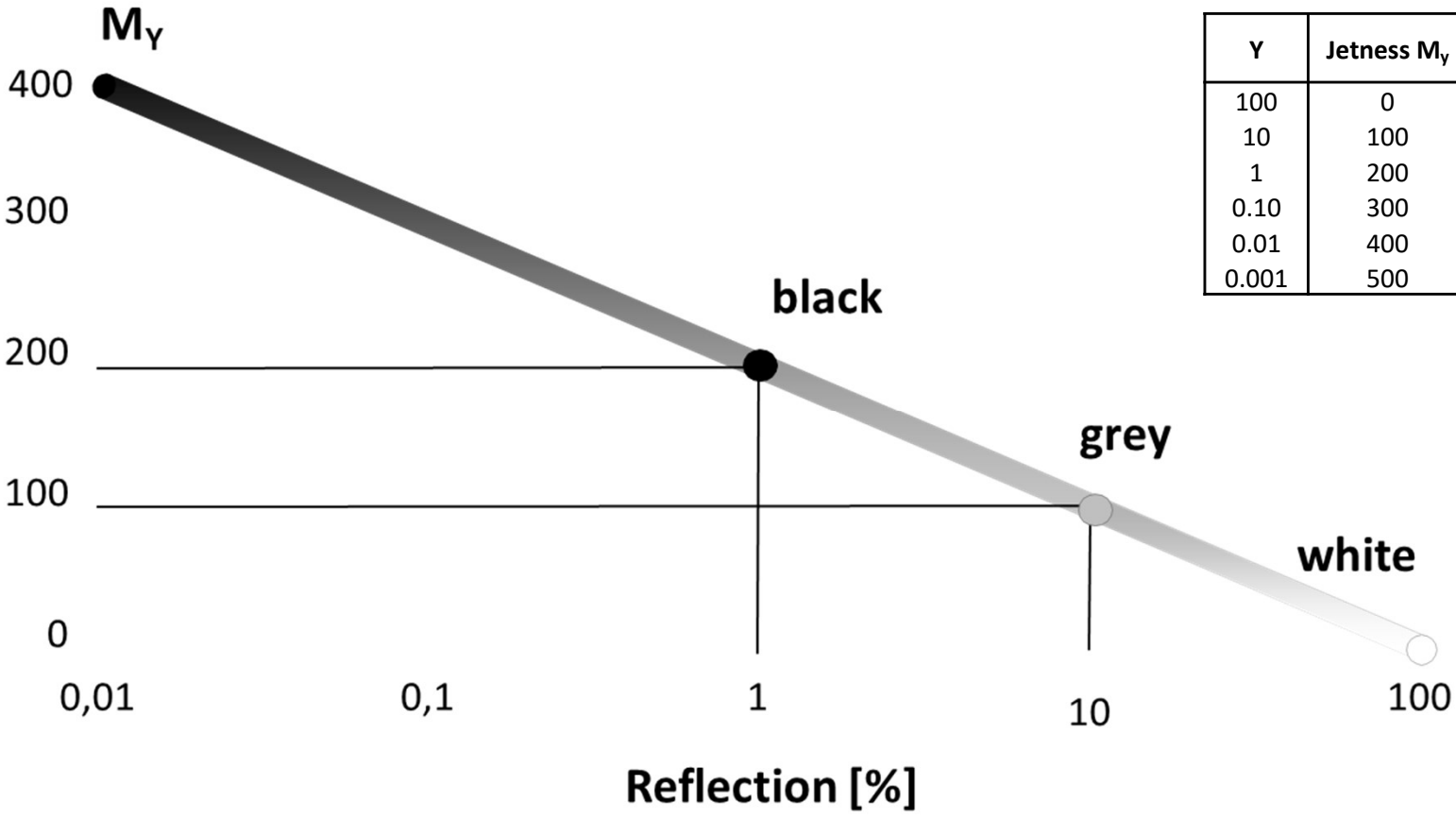
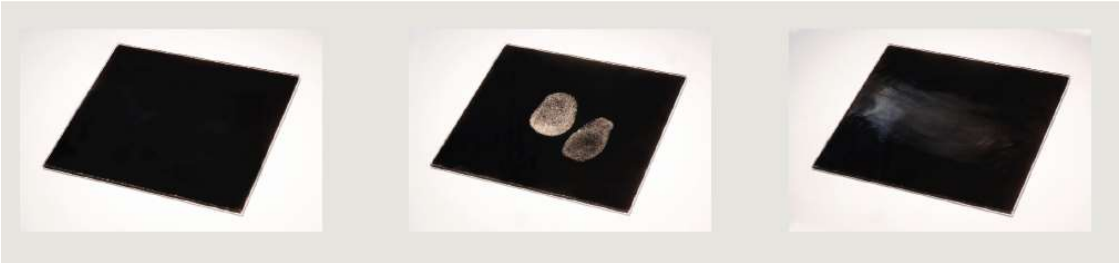
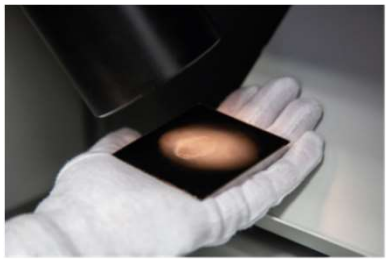
Blackness M_Y as a function of the degree of reflection



Y	Jetness M_y	L* (CIELAB)
100	0	100.00
10	100	37.84
1	200	8.99
0.10	300	0.90
0.01	400	0.09
0.001	500	0.01

Measuring blackness on a scientific level





- High demands on sample preparation as well as the measurement technology and calibration
- The use of calibration panels usually does not suffice, as they are not black enough. Instead, light trap (black hollow body) should be used which absorbs virtually all the light
- As deep black can only be measured on high-gloss and clean surfaces, any contaminants must be very thoroughly removed and the panel must be absolutely free from scratches, fingerprints, etc. before measuring
- 45°/0° device to be preferred compared to d/8° device if highest jetness is being measured, d/8° leads to higher values, but is not reproducible

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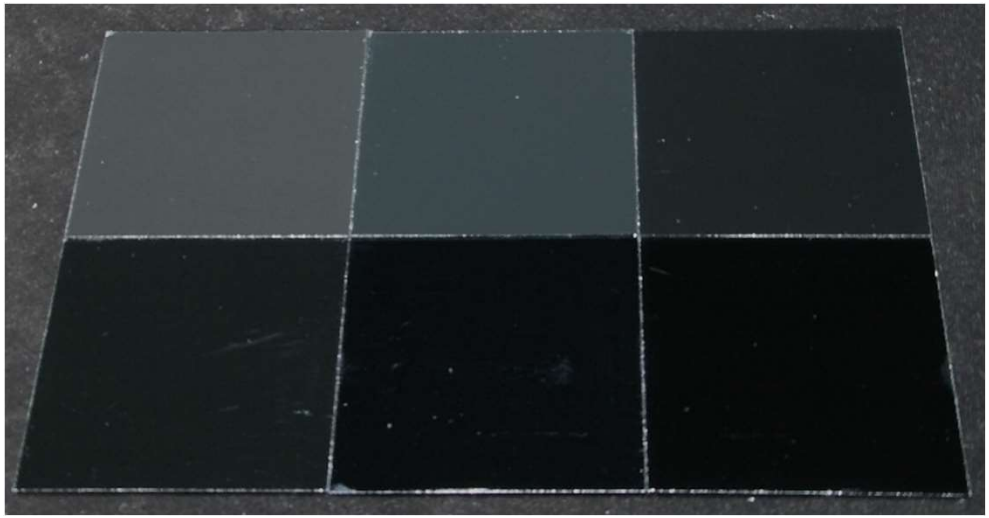
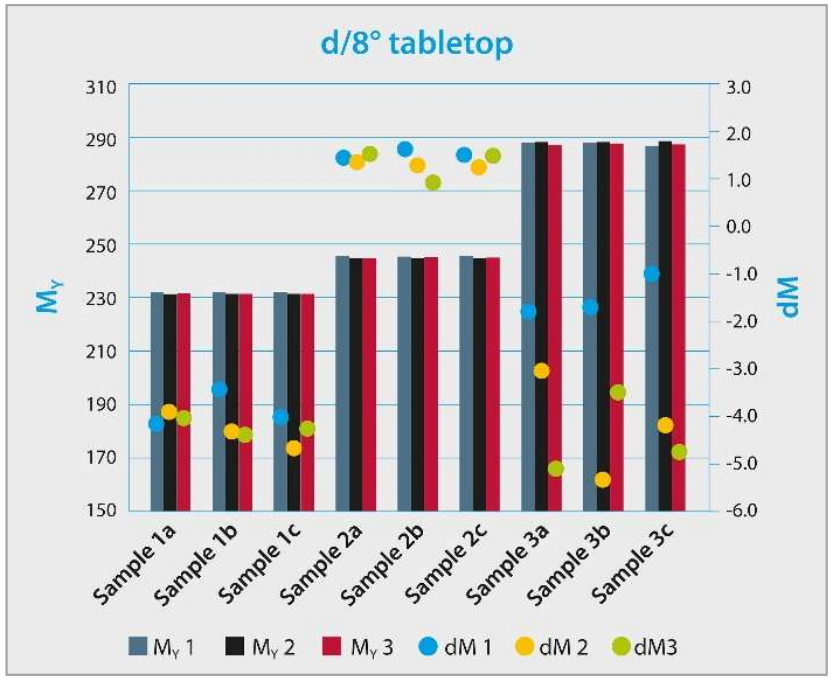
Measuring blackness on a scientific level

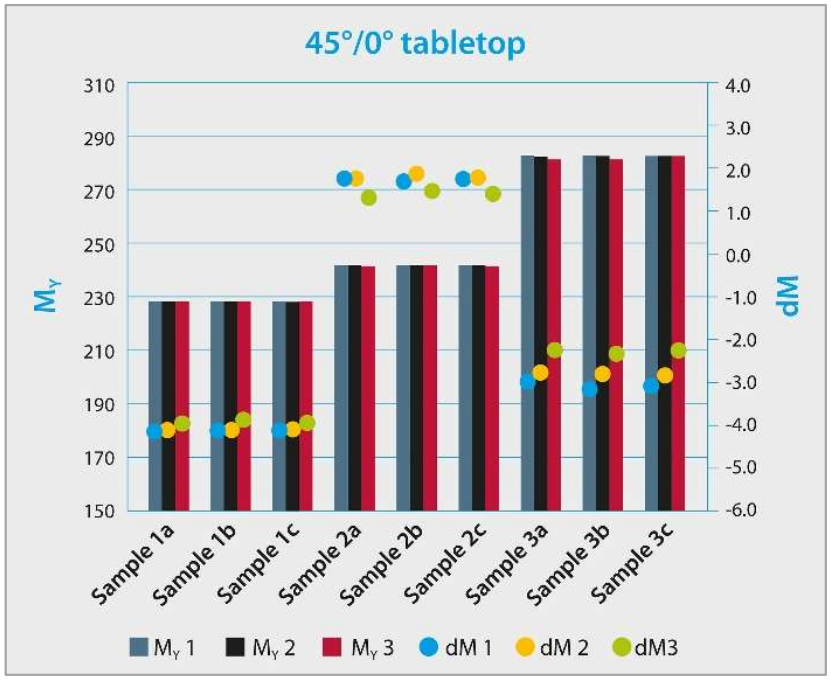
Calibration and adjustment

Test panels to register the entire jetness area and check the calibration



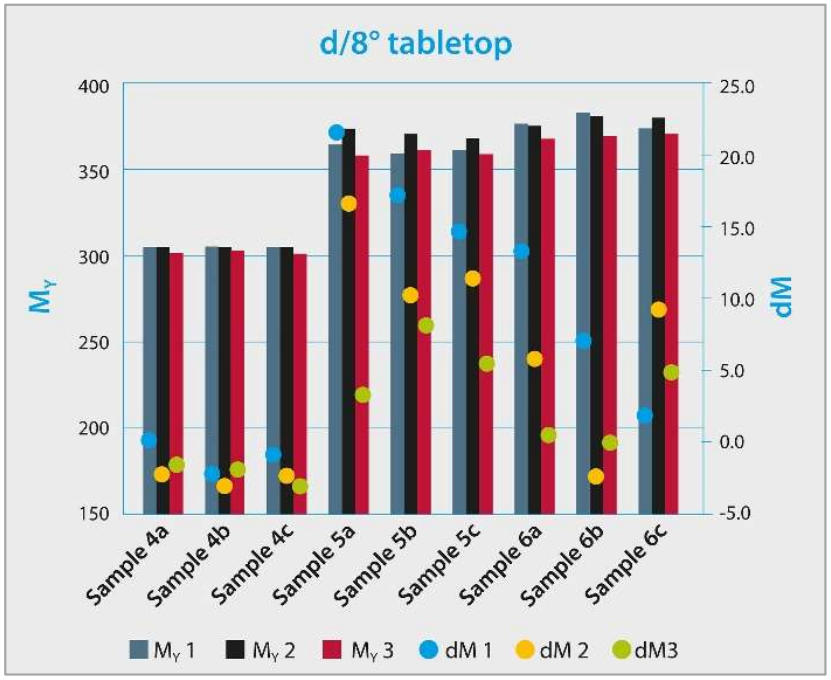
Why 45°/0° geometry for black measurements – Test panel 1 - 3

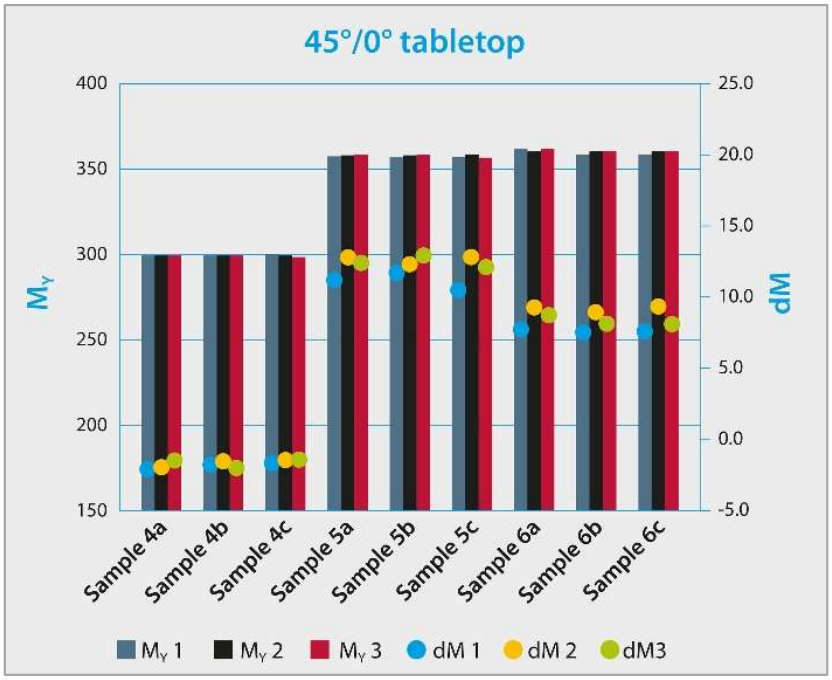




- Till M_Y = 290 (medium to high jetness), de/8° geometry is capable of measuring jetness
- But dM is already difficult to measure precisly
- 45°/0° geometry is much more precise and reproducible

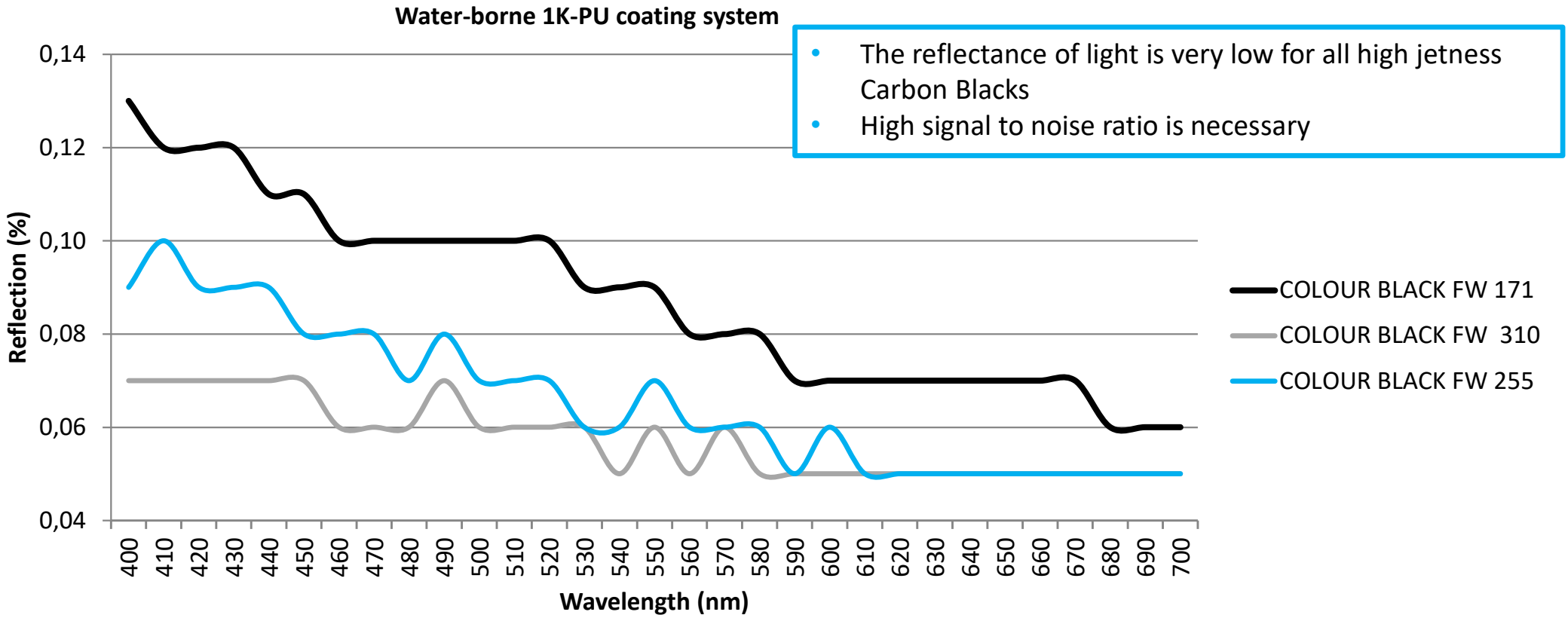
Why 45°/0° geometry for black measurements – Test panel 4 - 6





- Above M_Y = 290 (high to highest jetness), de/8° geometry is not capable of measuring jetness and dM accurate and reproducible
- 45°/0° geometry is much more precise and reproducible

Reflectance of high jet Carbon Blacks



- The reflectance of light is very low for all high jetness Carbon Blacks
- High signal to noise ratio is necessary

The coloristic data are for guidance purposes only.

Cooperation with BYK-Gardner

Current measurement device:

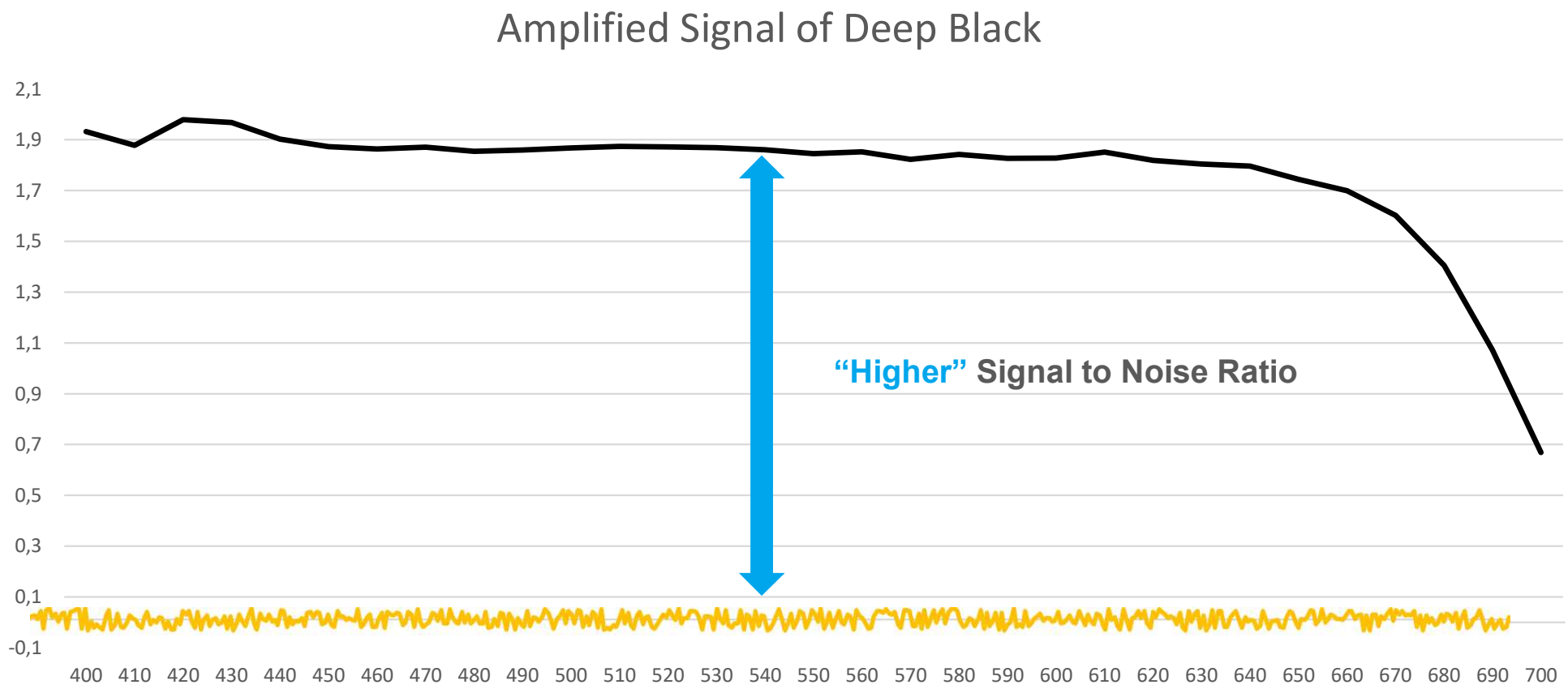
- Very old, hard to get spare parts
- Uses traditional light source, which needs to be changed oftenly

- Highest demands with regarding sensitivity and reproducibility
  → Develop a new device to measure as well highest jetness

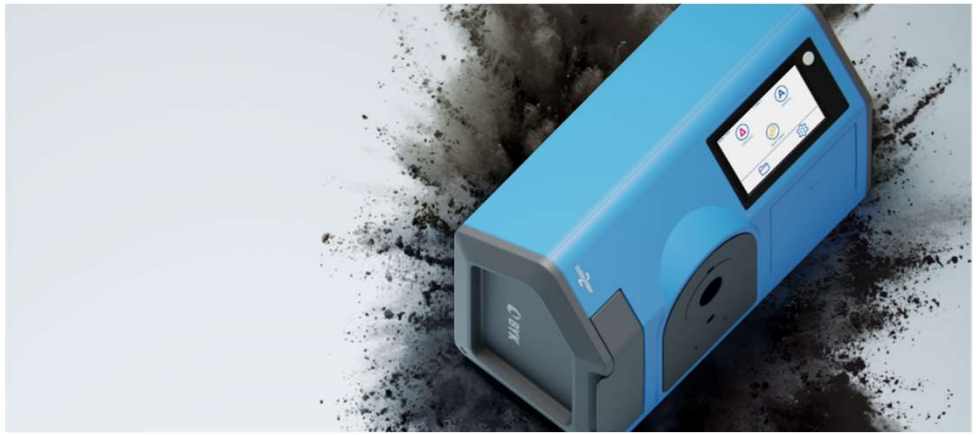
New measurement device:

- „Ready for the future“
- LED lightsource

color2view Pro – Signal to Noise Ratio



color2view Pro – Technical Improvements



Repeatable data for deepest blacks - very low remission

Optimization of signal to noise ratio

Reduce Noise ↓

- Highest precision electronic and optical components
- Adapted production process

Amplify Signal ↑

- LEDs powered with more energy → higher light intensity
- Extended illumination time

Zero calibration with perfect light trap

- Elimination of black glass standard for ZERO-calibration
- Optical construction of PRO-family without any detectable diffused light → Black calibration set at original manufacturing process

Special calibration mode for Black

- Color calibration on white standard
- Black calibration on dark grey standard to define max lightness for black measurement.

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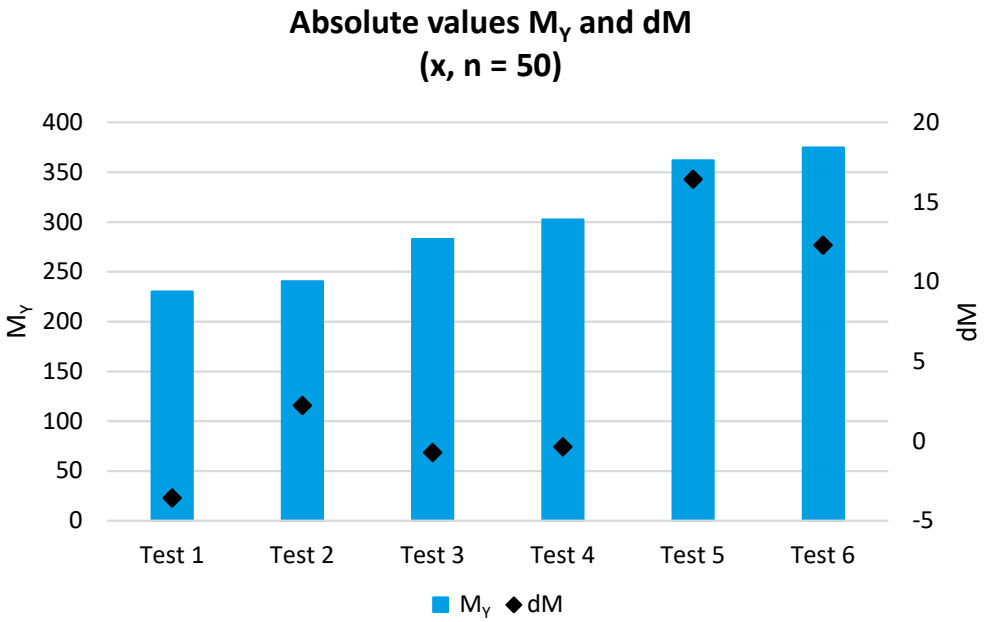
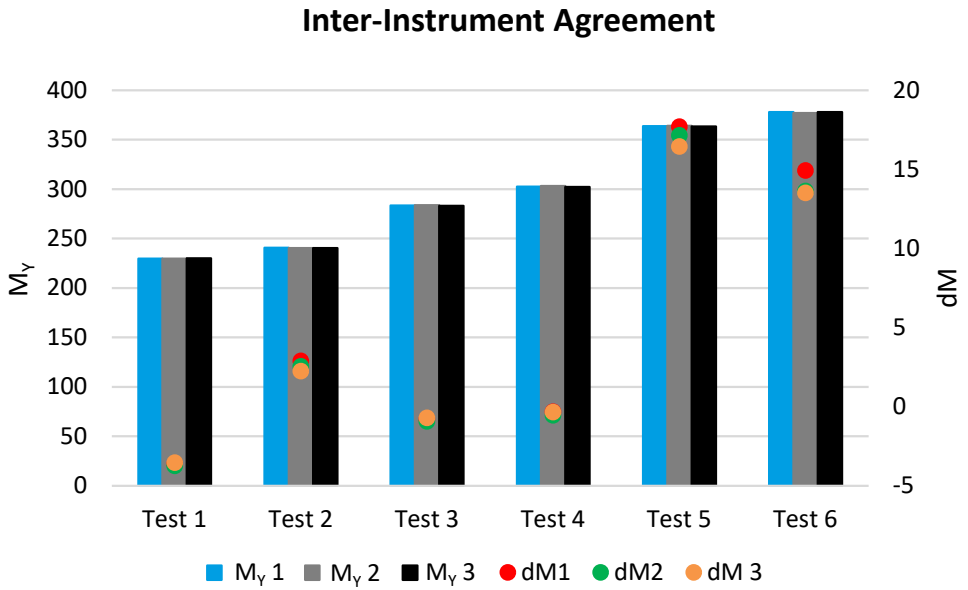
Cooperation with BYK-Gardner - results

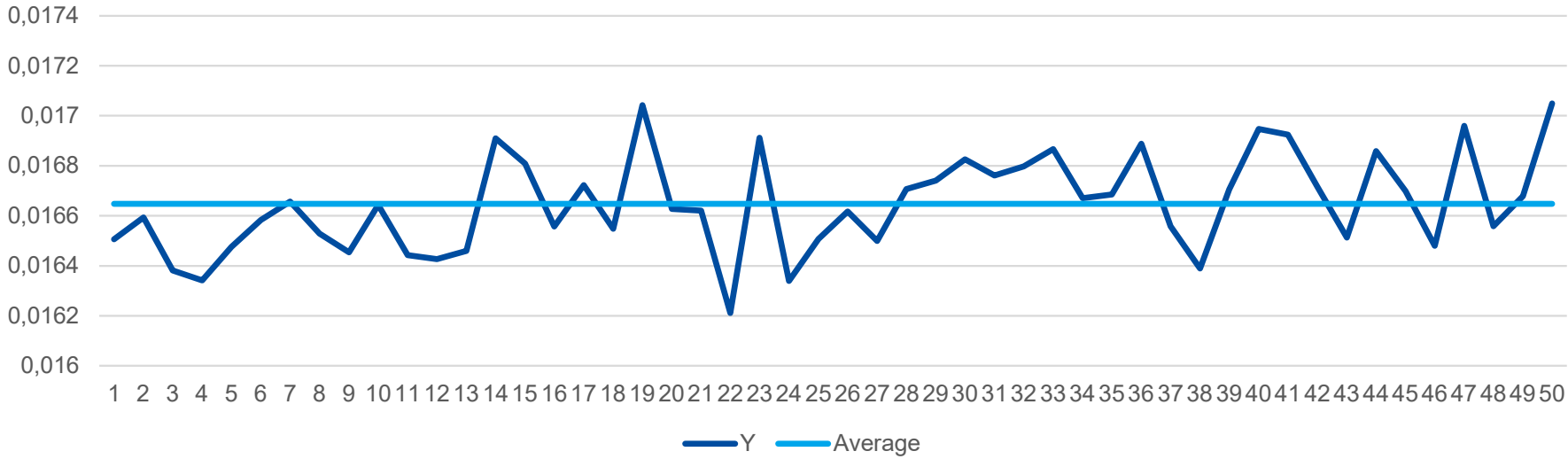




	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6
σ M_Y	0.02	0.04	0.05	0.07	0.23	0.35
σ dM	0.02	0.09	0.02	0.04	0.13	0.14

The coloristic data are for guidance purposes only.

Cooperation with BYK-Gardner - results



- Results:
  - Average Y = 0,0166
  - Range Y = 0,0008
  - STD DEV Y = 0,0002

Cooperation with BYK-Gardner - summary

- Deep blacks can be measured objectively, repeatably and reliably with the new instrument
- The measurement results obtained in the optimized “jetness mode” correlate perfectly with the visual evaluation of the test panels
- The benchtop spectrophotometer shows excellent repeatability ($\sigma = 0.0001$) for deepest blacks ($M_Y > 300$; reflectance < 0.1 %)
- The inter-instrument agreement of the three tested instruments was below $Y \leq \pm 0.003$ in the test series


40 TECHNIK // MESSTECHNIK

Schwarzmessung – neu gedacht

KOLORISTIK // OB BEI AUTOMOBILEN, BEI DER INNENEINRICHTUNG ODER GEGENSTÄNDEN DES TÄGLICHEN BEDARFS, LÄNGST IST SCHWARZ NICHT MEHR WEGZUDENKEN UND AUCH AKTUELLE BERICHTE VERSCHIEDENER AUTOMOBILLACKHERSTELLER BESTÄTIGEN DIESEN TREND (1). DAMIT KOMMT DEM ZUVERLÄSSIGEN UND REPRODUZIERBAREN MESSEN VON SCHWARZEN FARBTÖNEN EINE IMMER GRÖSSERE BEDEUTUNG ZU.

FARBE UND LACK // 10.2022

Thank you!

Thank you very much for your attention.

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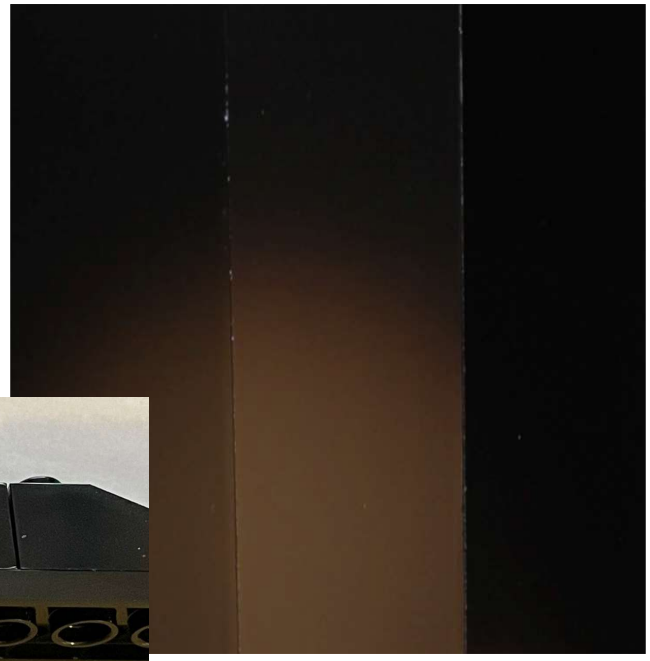
Backup

Differentiation of Carbon Blacks



Differentiation between standard and pro model