COLOR CONFORMANCE CONFERENCE ‘25

New Port Richey, FL (Tampa North)
January 28–30, 2025

COLOR CONFORMANCE
CONFERENCE '25

When use which Instrument

45/0, 0/45, D8, SPIN, SPEX, Spot, Scan, UV, no UV

January 28, 2025

Presented by

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Agenda

Printing devices are imaging on all types of materials today

- Paper, Plastic, Acrylic, Fabrics, Leather, Velour, Metal, Aluminum,
- Many with different textures, depth, gloss, sheen and weaves

Each combination influences how eye perceives resultant color

- Challenge is to measure sample and capture what eye perceives
- Very challenging, hence industry has provided a lot of options

This Overview provides methodology to qualify instrument choice

You will not find this information any where else, we will be reserving this content for ChromaChecker users only

Key Instrument's properties

Geometry Paper, Plastic, Acrylic, Fabrics, Leather, Velour, Metal, Aluminum,

- 45˚/0˚, 0˚/45˚, d/0˚, d/8˚ (Sphere), 0˚/180˚ or MultiAngle...

Illumination Methods:

- Annular Ring, Single/Multiple Points, Diffuse

Automation and movement method:

- Single, Manual Scan, Auto Scan, Step up-and-down, Contactless

Measurement Conditions:

- M0, M1, M2, M3, SPIN, SPEX with or w/o UV

Aperture Size

- related to screen ruling of print quality, surface effects, patch size...

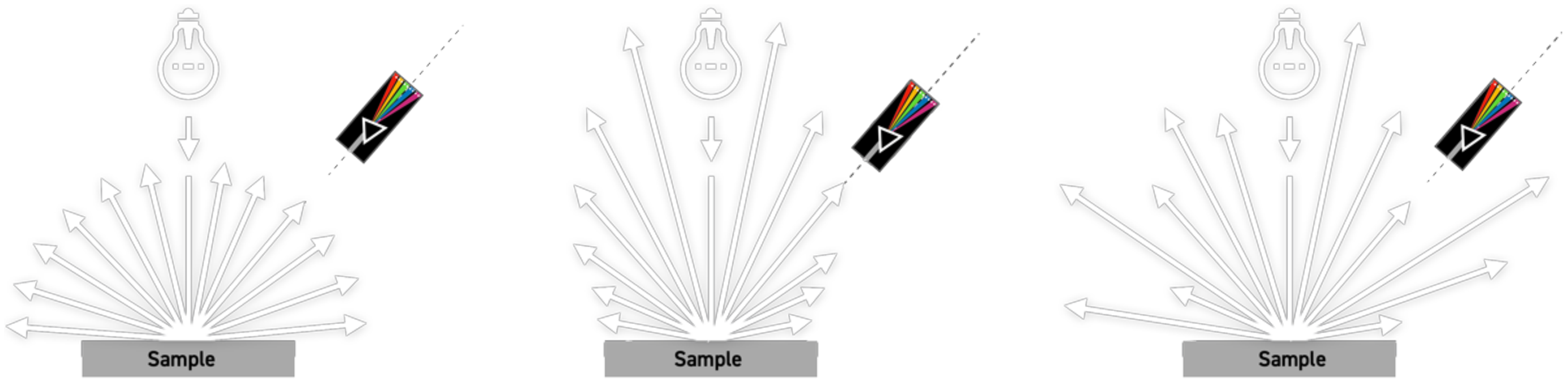
Monochromator

- filter wheel, diffraction grating,

Sources of the light

- Gas filled tungsten (illuminant type A), UV LED, multispectral LEDs,...

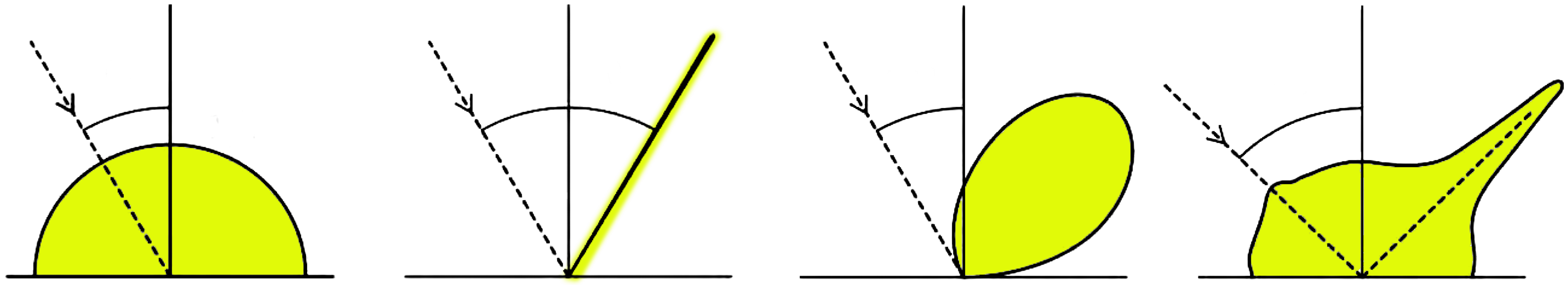
Reflection by various surfaces



Matt surface **Glossy surface** **Irregular surface**

Whenever printing is performed on the metalised substrate, film, or final product has sophisticated finishing like structural varnish, or /and is calendared or/and as a result of postproduction, the final surface is not flat and matt finished — regular printing spectrophotometer may not work correctly.

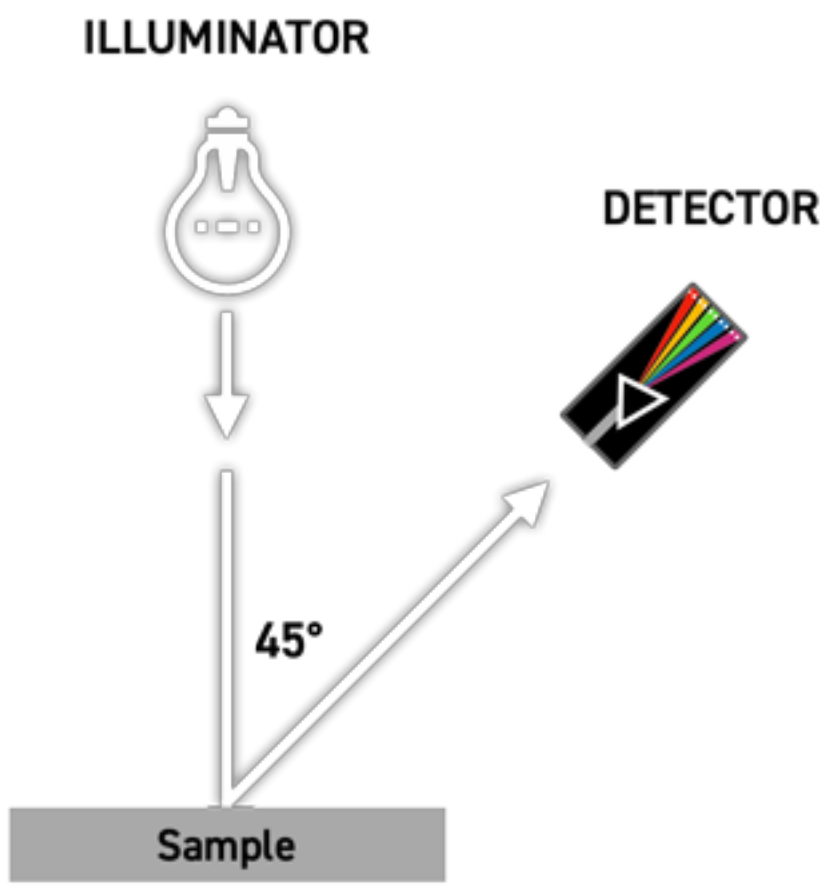
Reflection by various surfaces



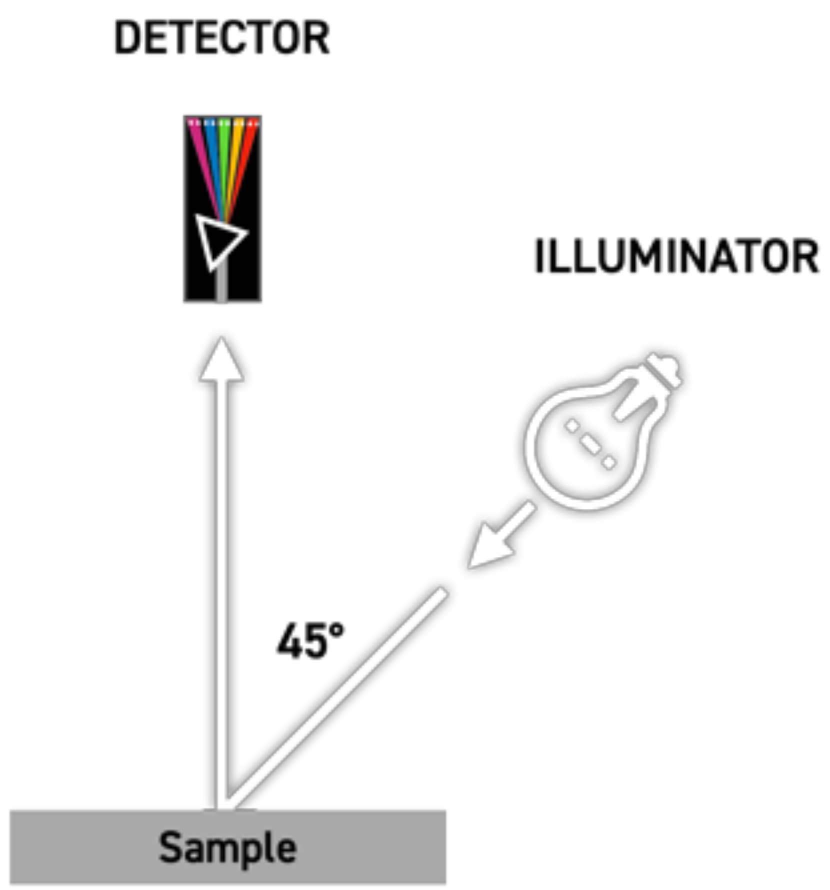
a Lambertian reflector	a smooth surface	a roughened aluminum	a glossy paper
Lambertian reflectance is the property that defines an ideal "matte" or diffusely reflecting surface. It is theoretical model.	mirror or perfect glossy finishing (coloured glass, piano varnish,...)		

(based on: Fundamentals of Optics and Radiometry for Color Reproduction, Mathieu Hébert, Roger D. Hersch, Patrick Emmel, hal-01179588.)

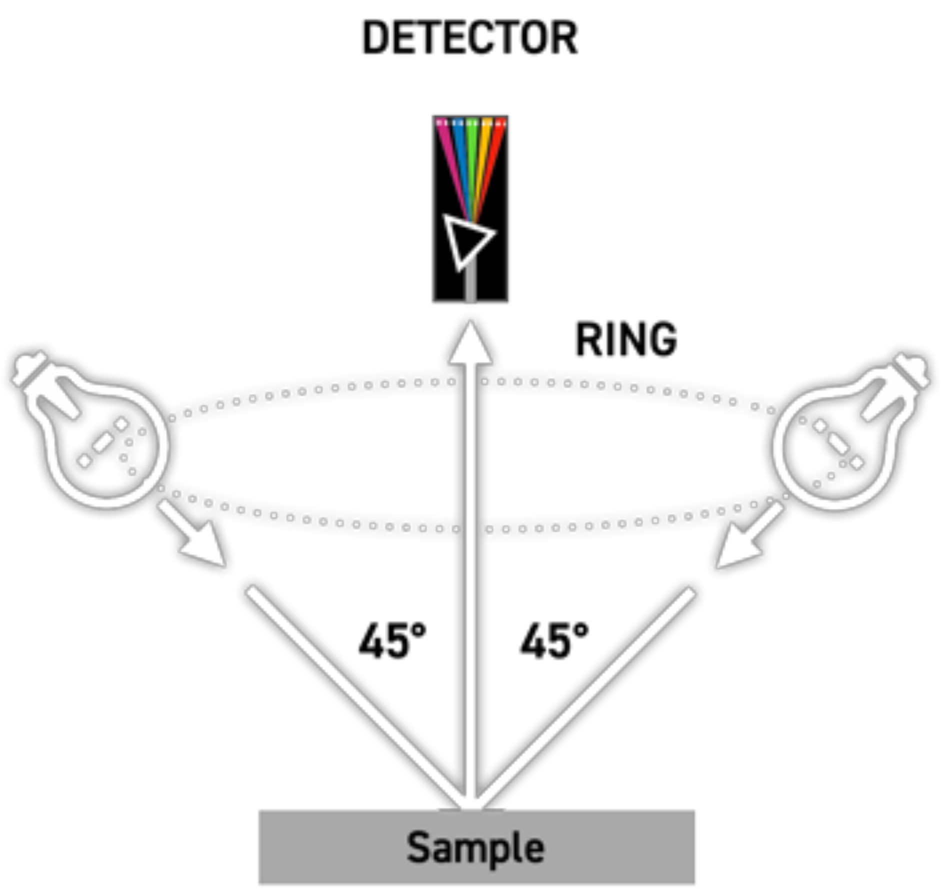
45°/0°, 0°/45°



0°/45°



45°/0°

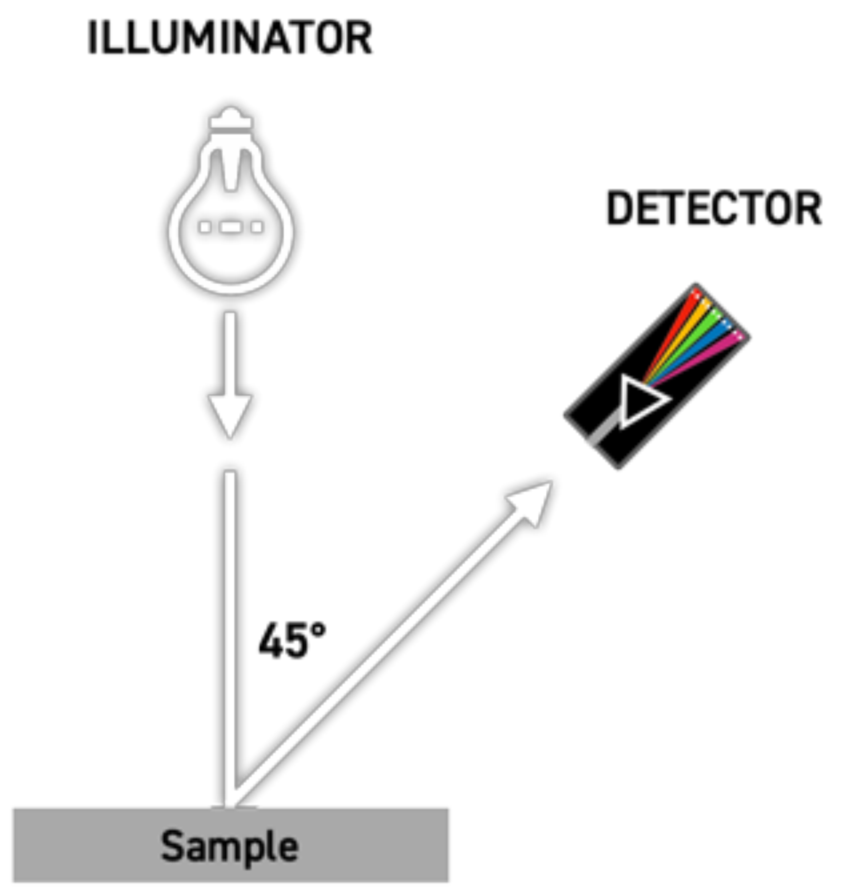


45°/0° Annular

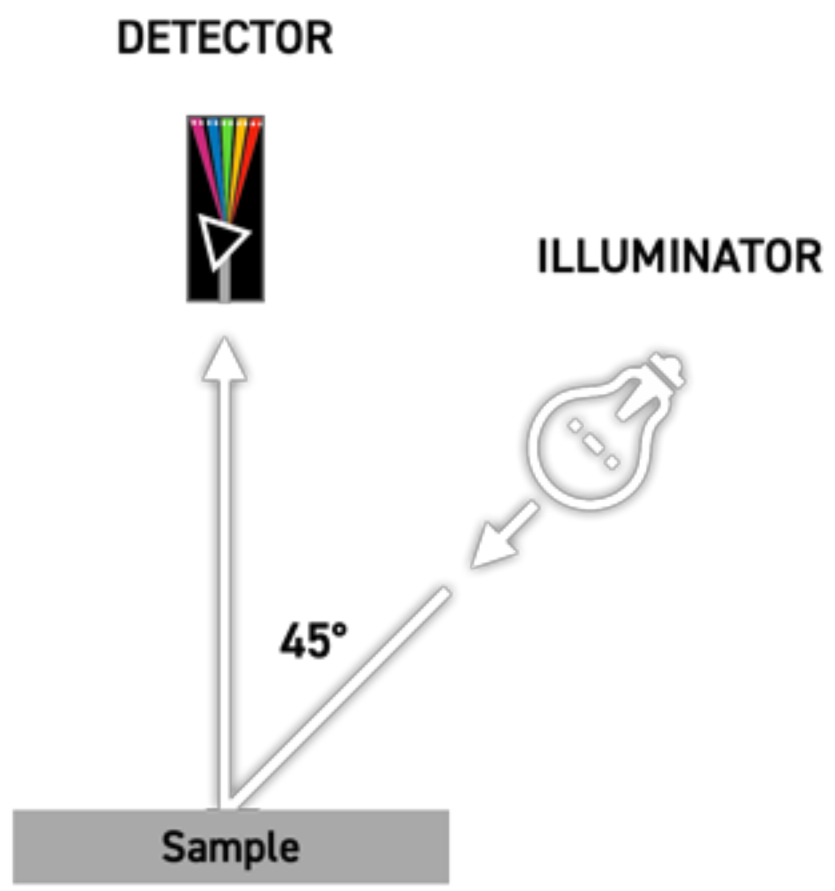
Measuring ink on paper- Flat, regular surface

- It is basic geometry for print industry

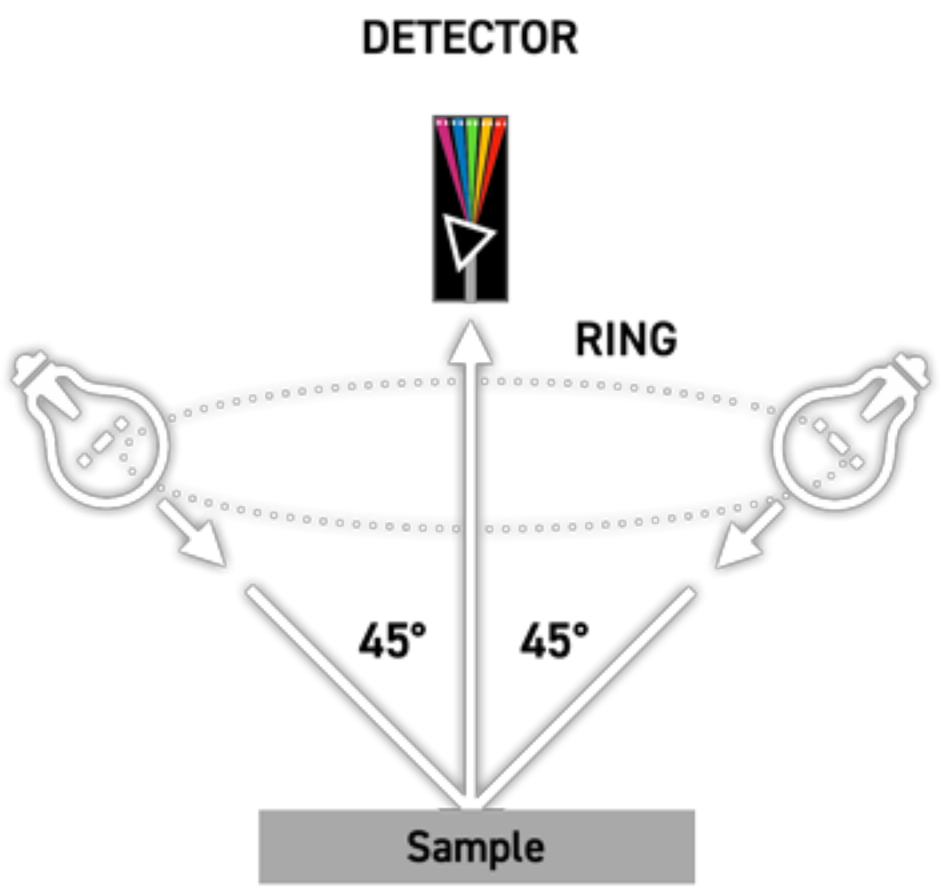
45°/0°, 0°/45°



0°/45°



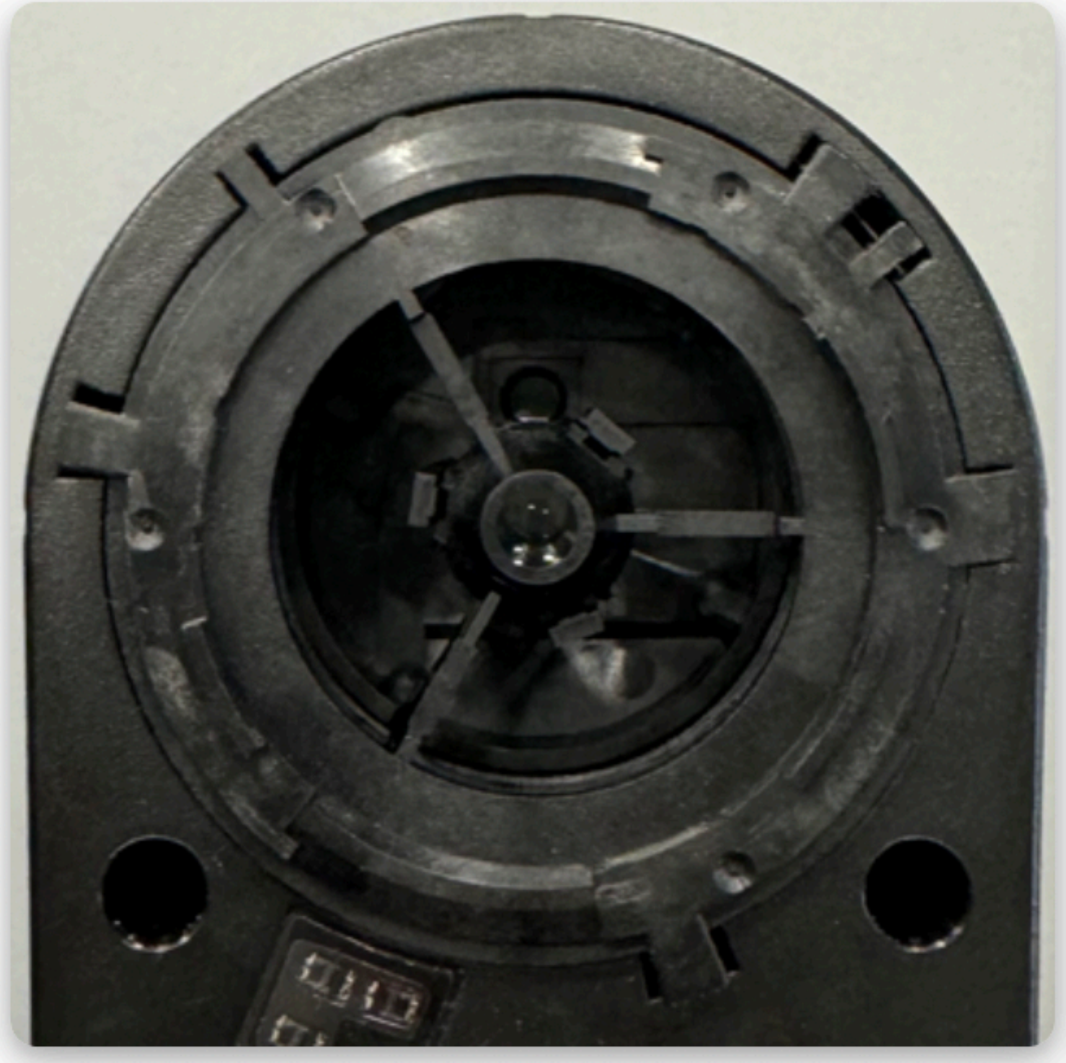
45°/0°



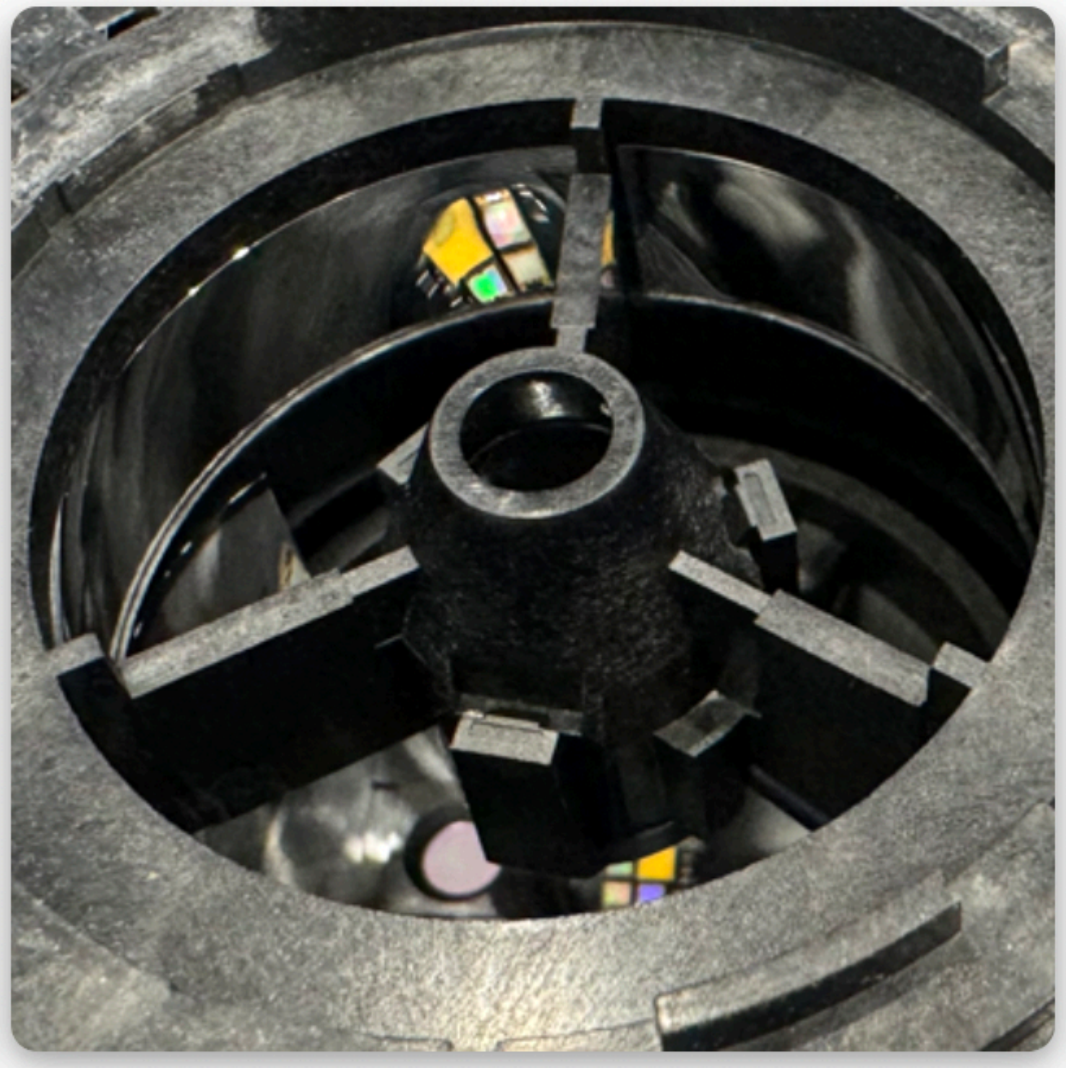
45°/0° Annular

45°/0° Annular - real world cases

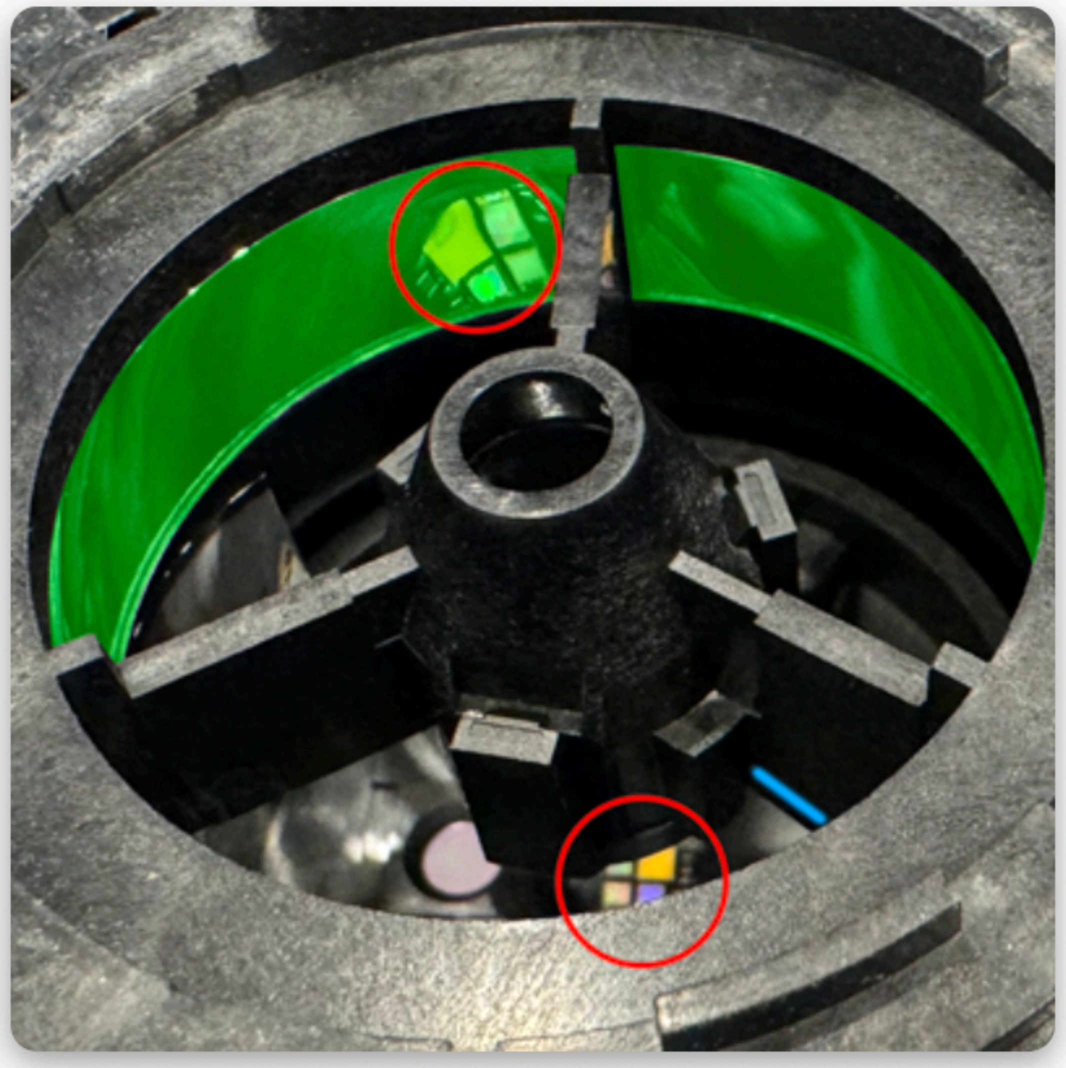
X-Rite i1Pro3 - state of art technology!



In the center,
we can see the lens supported by three arms.
The multi-LED module is fully covered by the lens.



The angle view shows the multi-LED module
located at the bottom.



green area - curved mirror
upper red circle - a reflection of a multi-LED module
lower red circle - a multi-LED module
blue line - fiberglass transiting light from lens to sensor

Annular geometry perfection.

In theory, three arms cover approximately 4% of the ring's circumference, providing 96% coverage. Arms are located halfway - no sharp shadows - finally, the real impact seems to be unmeasurable. We can classify this annular geometry as 100% efficient.

45°/0° Annular - real world cases

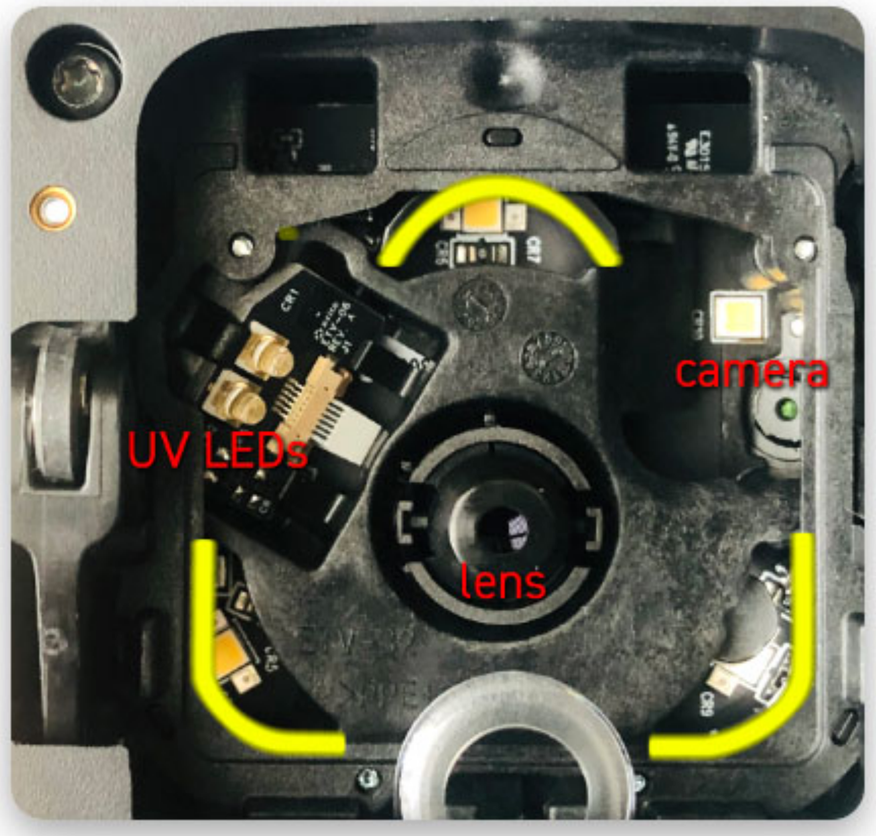
X-Rite eXact (1) - compromise

X-Rite eXact v.1 has a series of light sources - tungsten gas-filled lamps and LEDs (UV 375nm and UV 405nm) located at 45% but this is not a ring but a series of few points. In fact, the main source of the light is based on three gas-filled tungsten lamps located every 120 degrees. Visible LEDs emit UV components and make post-measurement calculations to calculate different M-condition data.

Such a solution might be very sensitive to angles - if the sample is not uniform and matt-finished results might be not reliable. This instrument is not designed to measure metallic, pearlescent, or any very complex surfaces. even if it passes ISO specification and geometry is classified as a ring - don't expect that 3-points are equal to a real ring.

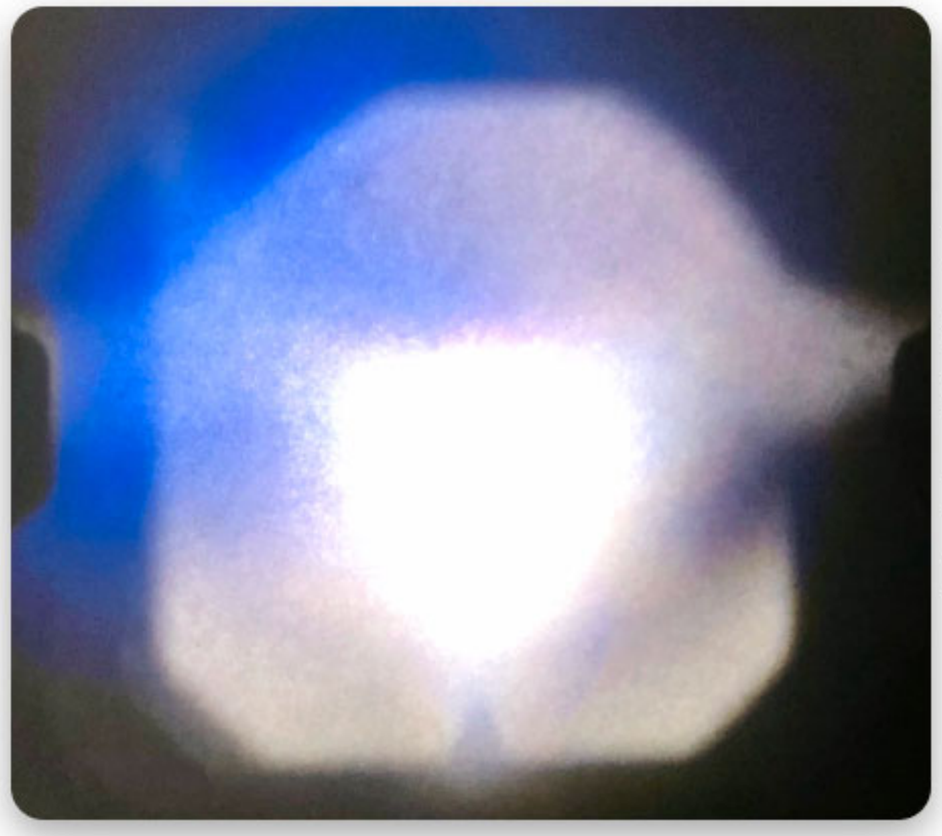
45˚/0˚Annular - real world cases

X-Rite eXact 2 - brilliant engineering with some compromises.



In this case, the complexity of instrument design is a compromise where segments of the ring light the sample.

In the picture, we can see a camera with a dedicated LED.

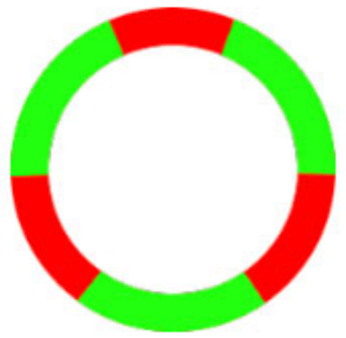


The complex shape of curved mirrors finally produces an illuminating ring (annular 0/45 geometry) thanks to brilliant engineering.

The only UV comes from a single direction - but this is precisely what is in the instrument specification.

Version 2 of eXact has a completely new design. This instrument is dedicated to typical print industry substrates. A sophisticated system of curved mirrors allows for typical paper-based measurements and very good ring reconstruction, but for most complex samples this instrument is not recommended.

Annular geometry perfection



A system of three curved mirrors extends three points giving about 50% of the ring in the mirror plane. It produces finally pretty nice ring, however, mirrored rays come still from three single points, and for structural, complex surfaces it is not an equal homogenous mix of all ray angles.

This brilliant engineering solution is perfect for matt-finished printed samples on regular paper substrate. Consult the results of our test on brushed polyester film.

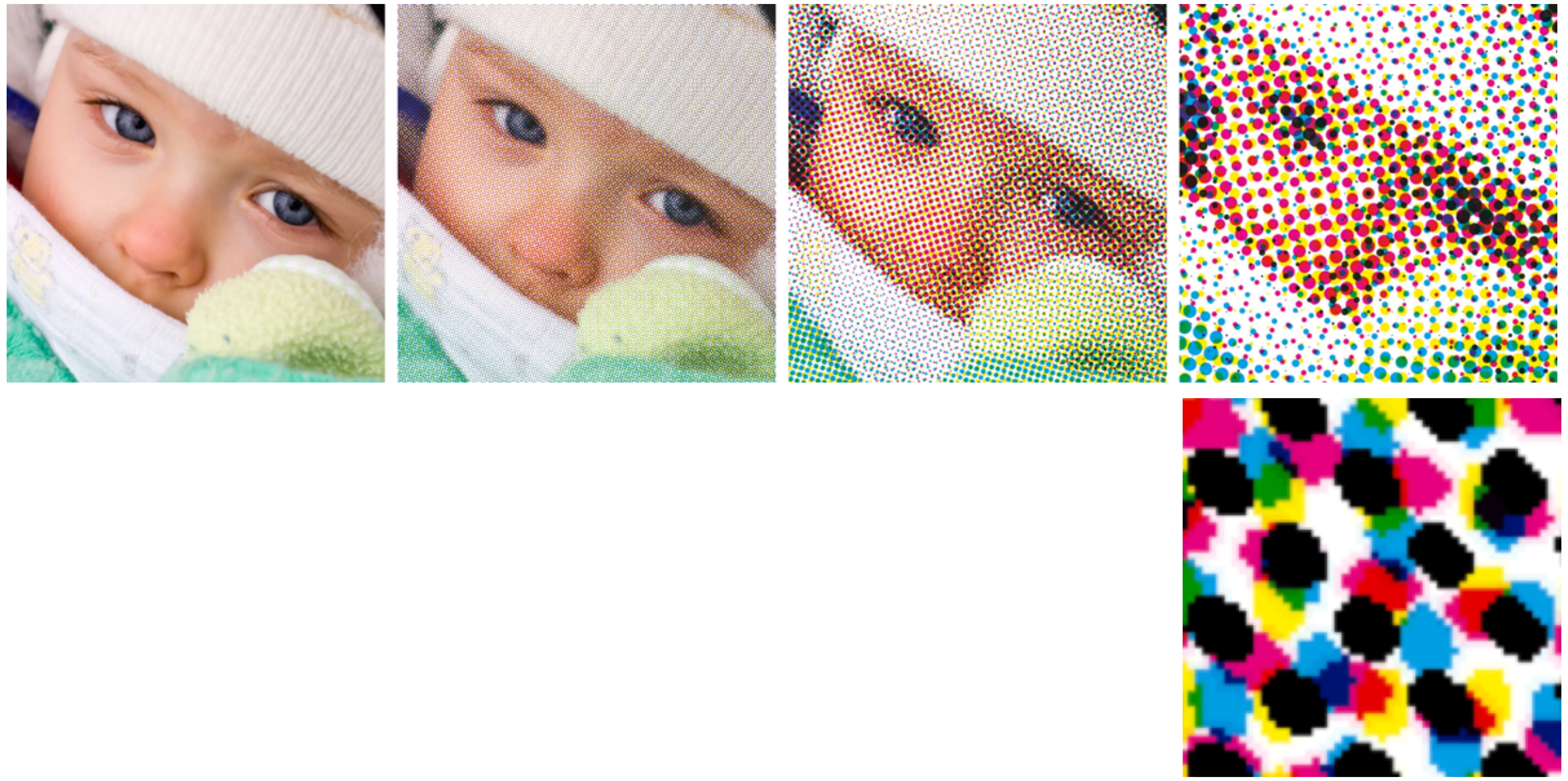
45˚/0˚Annular - Conclusion

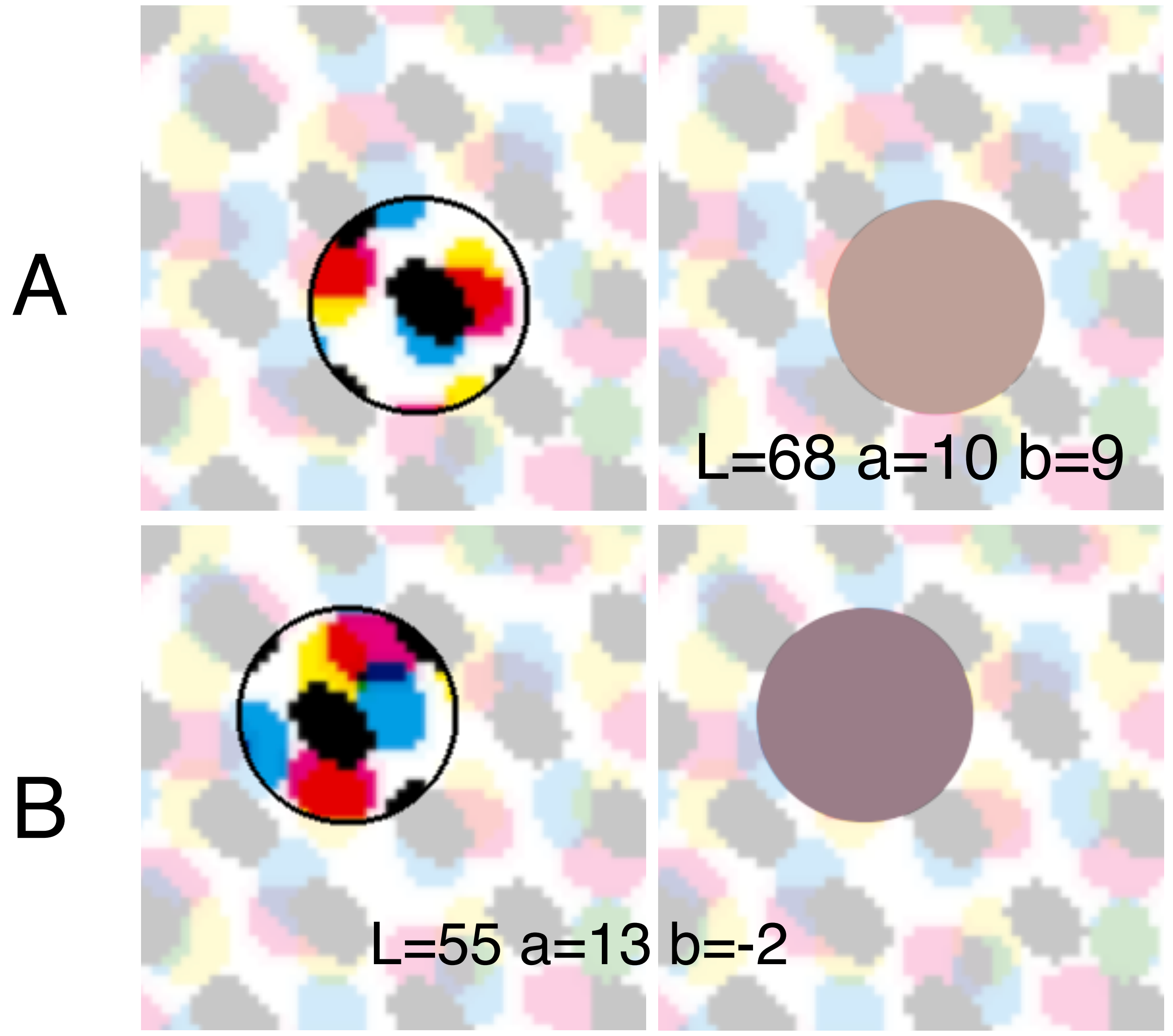
For most measurements tasks in Print Industry 45˚/0˚Annular geometry is the best choice.

- It has some limitations but for mat or semi -mat surfaces it is very effective
- 45˚/0˚Annular based Instrument can use relatively hight speed measurements
- This geometry makes it possible to create contactless solution.
- Control bars or test charts can be scanned very fast, without destroying
- In some cases can measure non flat, not uniform surfaces like textiles (bigger aperture)
- Not recommended for metalic surfaces
- Annular geometry - declared by manufacturer might be not perfect - instrument can be very sensitive to angles of sample pattern if exist.

Aperture size • Screen ruling • Patch size

Select the aperture based on the characteristics of the measured samples, especially in the case of AM rasterized print. It is a complex multicolor structure (rosette) built from CMYK RGB and White elements. Statistically, the selected aperture has to "see" enough elements that cropping will not affect results.





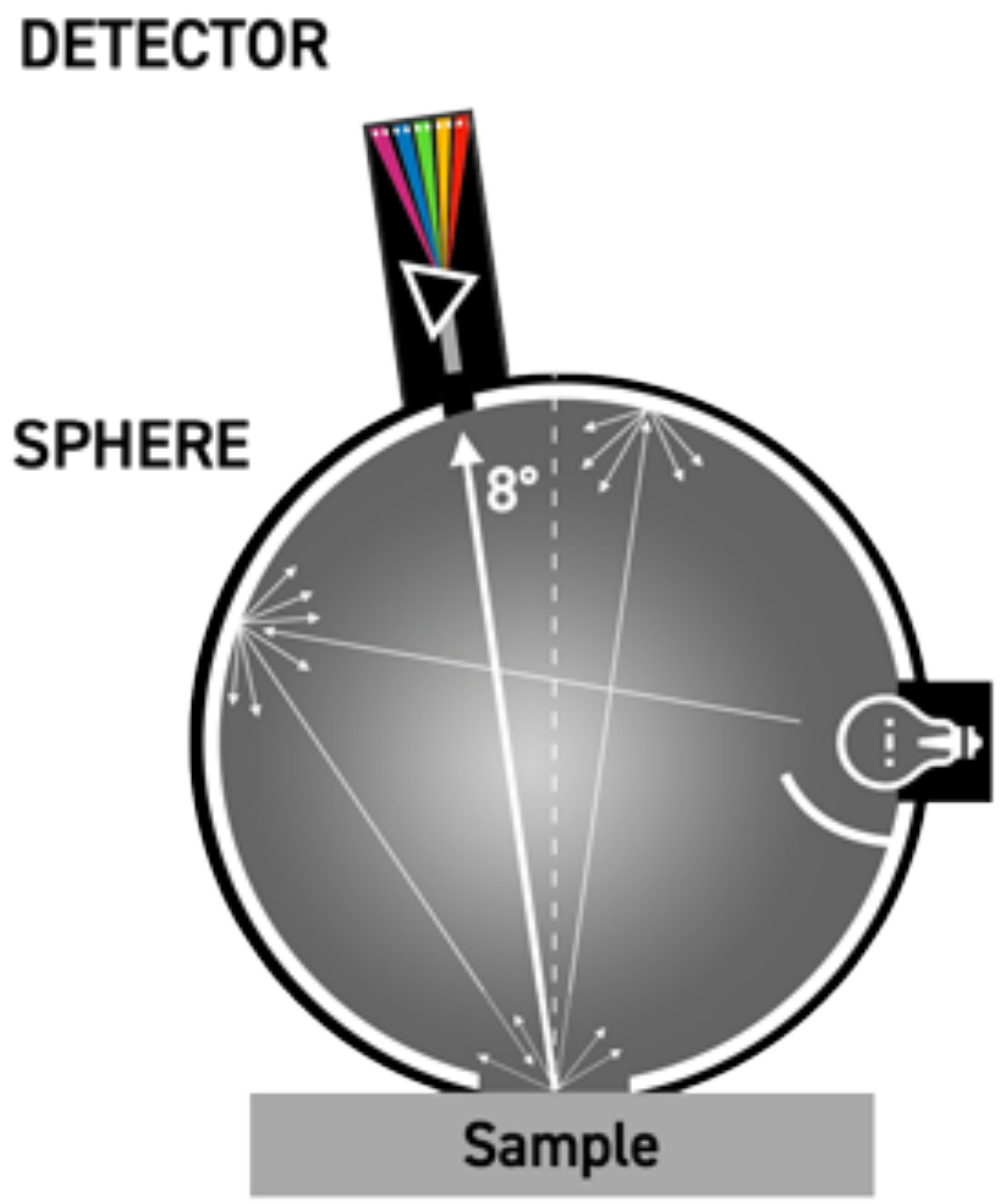
$\Delta E_{76} = 17.3$

Aperture — sizes versus line screen

Aperture Specifications

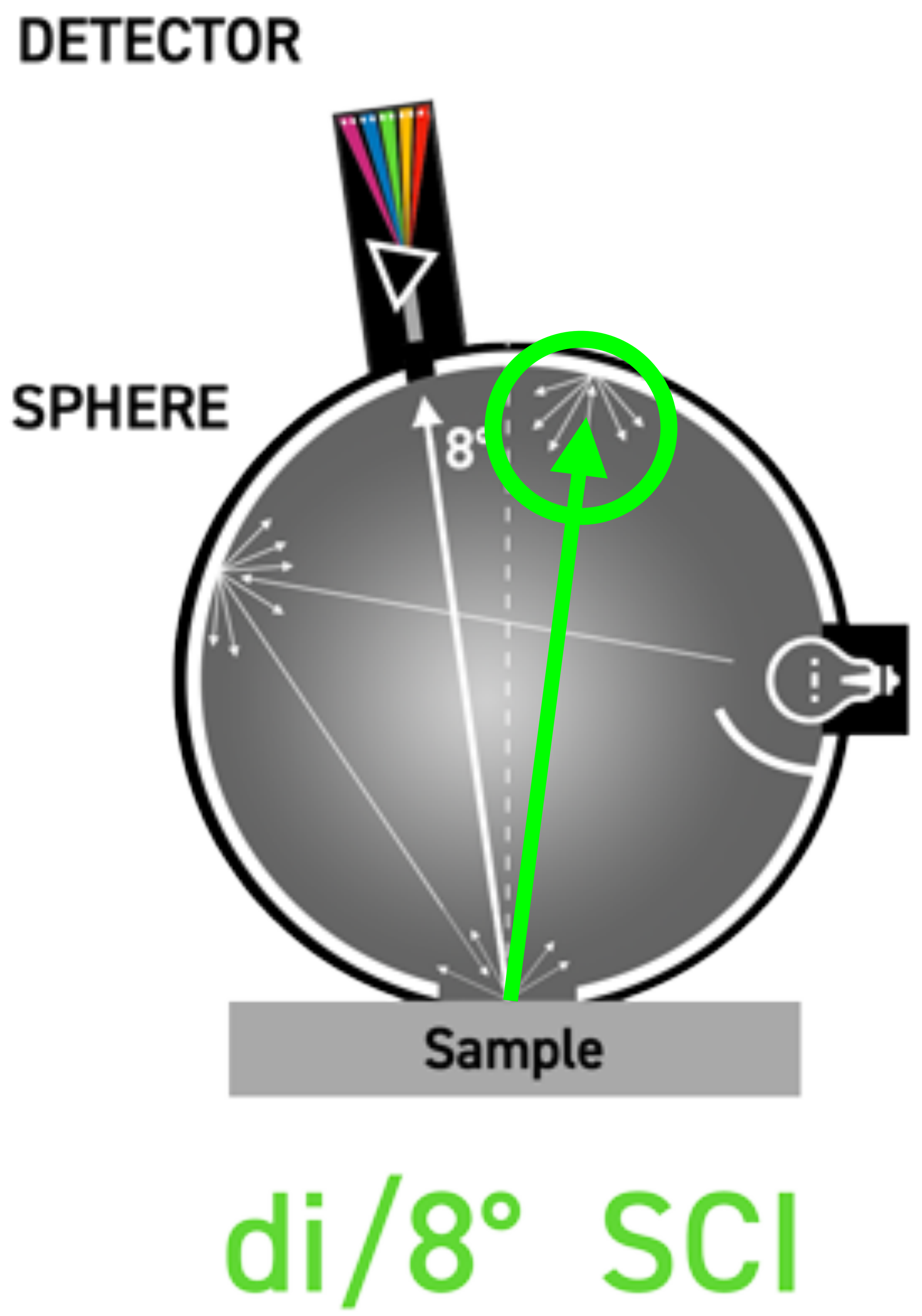
Aperture Size	Measurement area size	Opening in target window**	Opening in scan chassis target window	Screening Range
1.5mm	1.5mm	3.5mm	4.0mm	175 lines/inch or 69 lines/cm or above
2mm	2.0mm	4.0mm	4.5mm	133 lines/inch or 52 lines/cm or above
4mm	4.0mm	6.0mm	6.5mm	65 lines/inch or 26 lines/cm or above
6mm	6.0mm	8.0mm	8.5mm	

d/8° - Spherical Diffusion



In Spherical Diffusion Geometry instead of a single direction, the sample is exposed by a spherical chamber that mixes light finally using all possible directions.

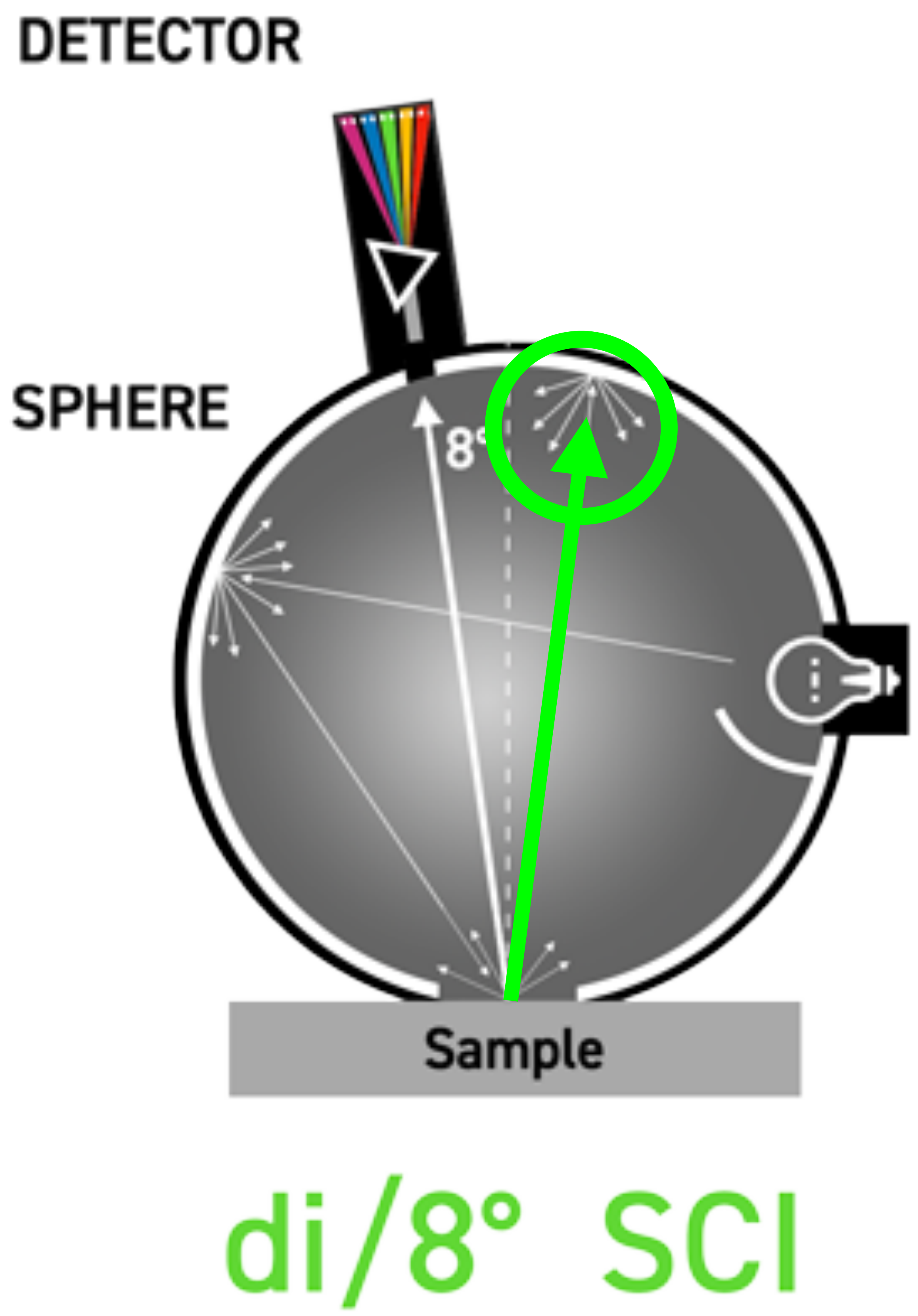
d/8° - Spherical Diffusion



In Spherical Diffusion Geometry instead of a single direction, the sample is exposed by a spherical chamber that mixes light finally using all possible directions.

I f we measure mirror - perfect glossy object - the instrument will see reflected white surface of the sphere - our sample will be perceived as WHITE.

d/8° - Spherical Diffusion



It is so-called Specular Included (SCI, SPIN, di/8°) Geometry

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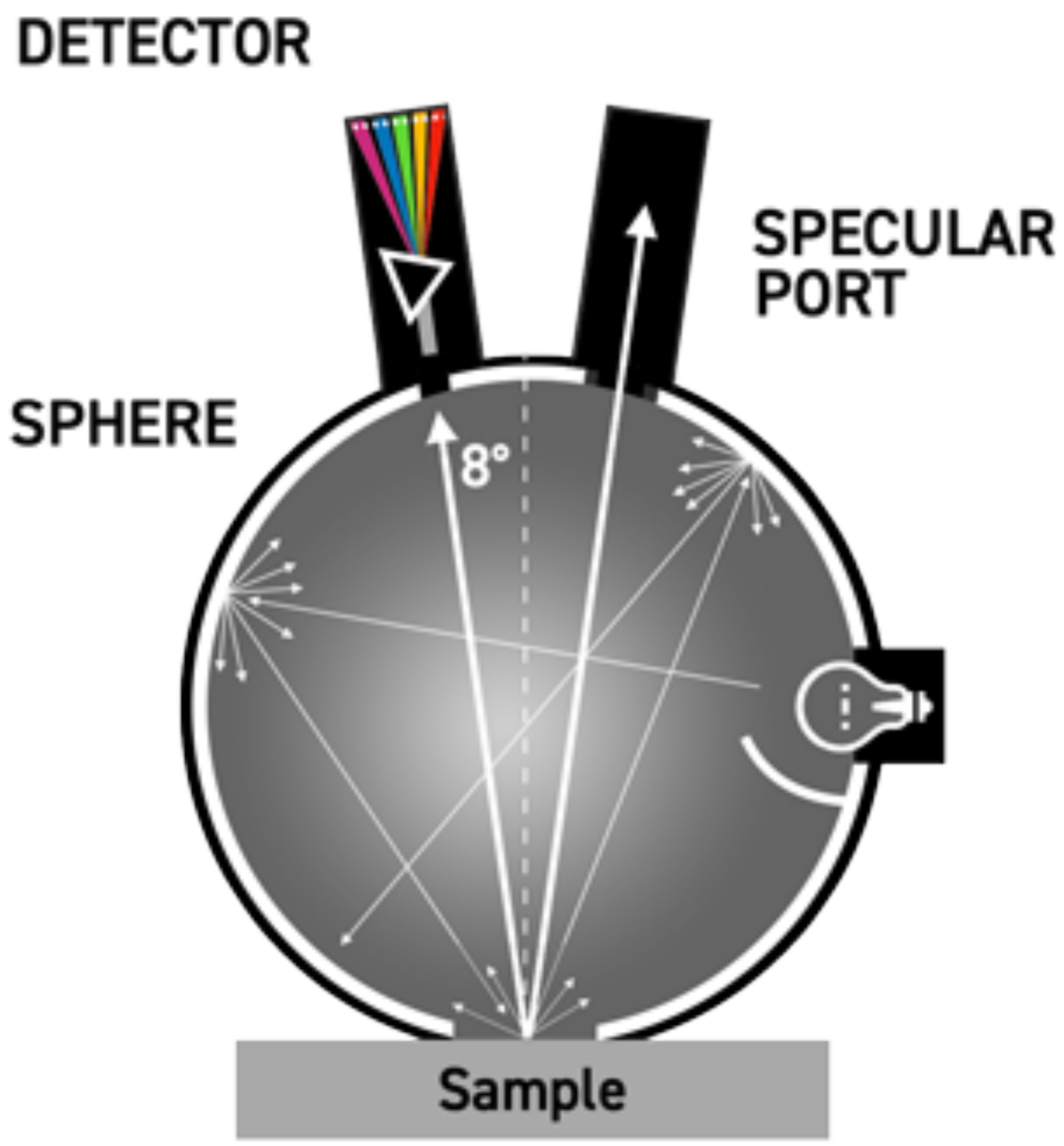
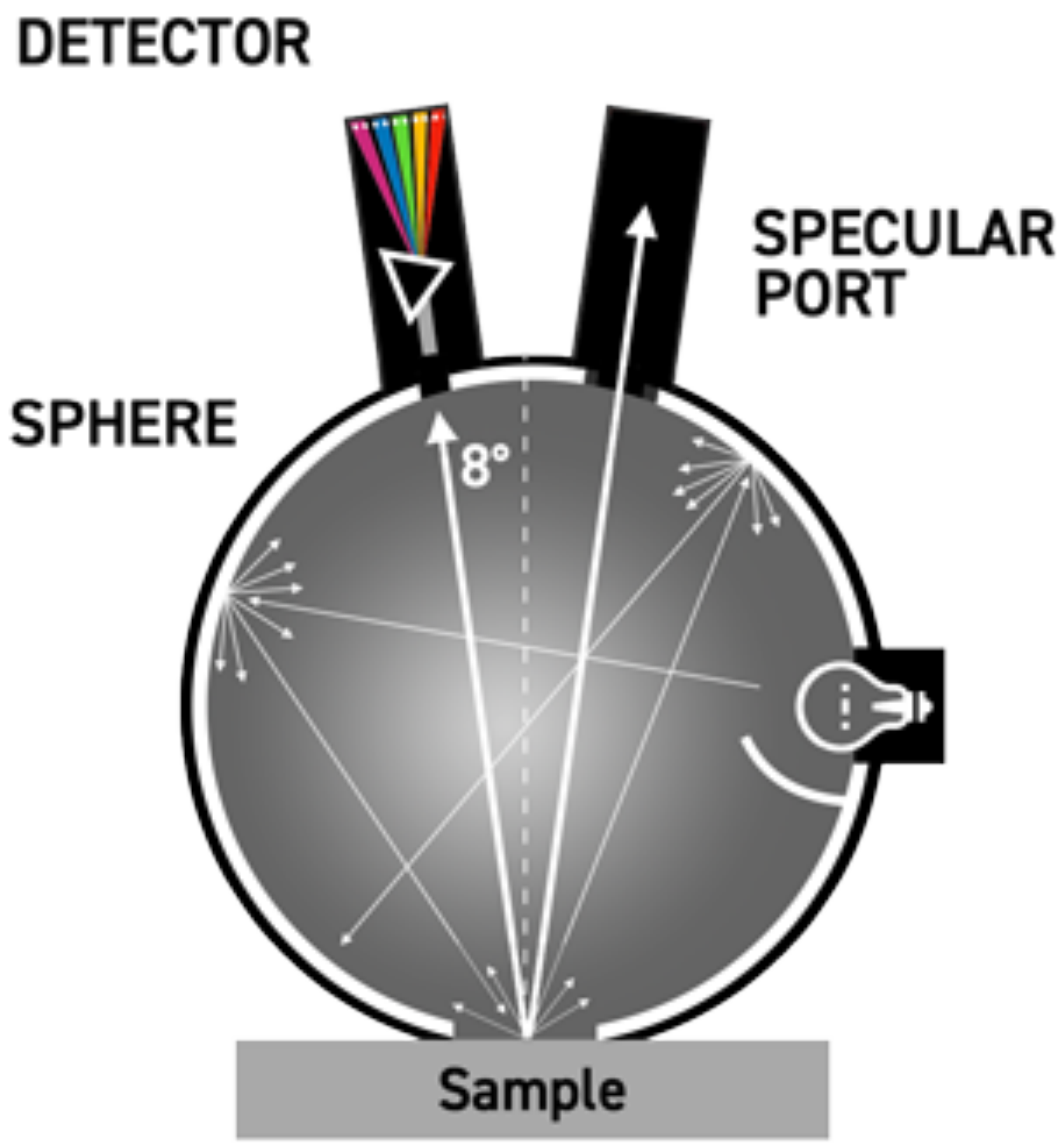


If at 8 degree (symetrucaly to detector we place black trap (specular port) ...

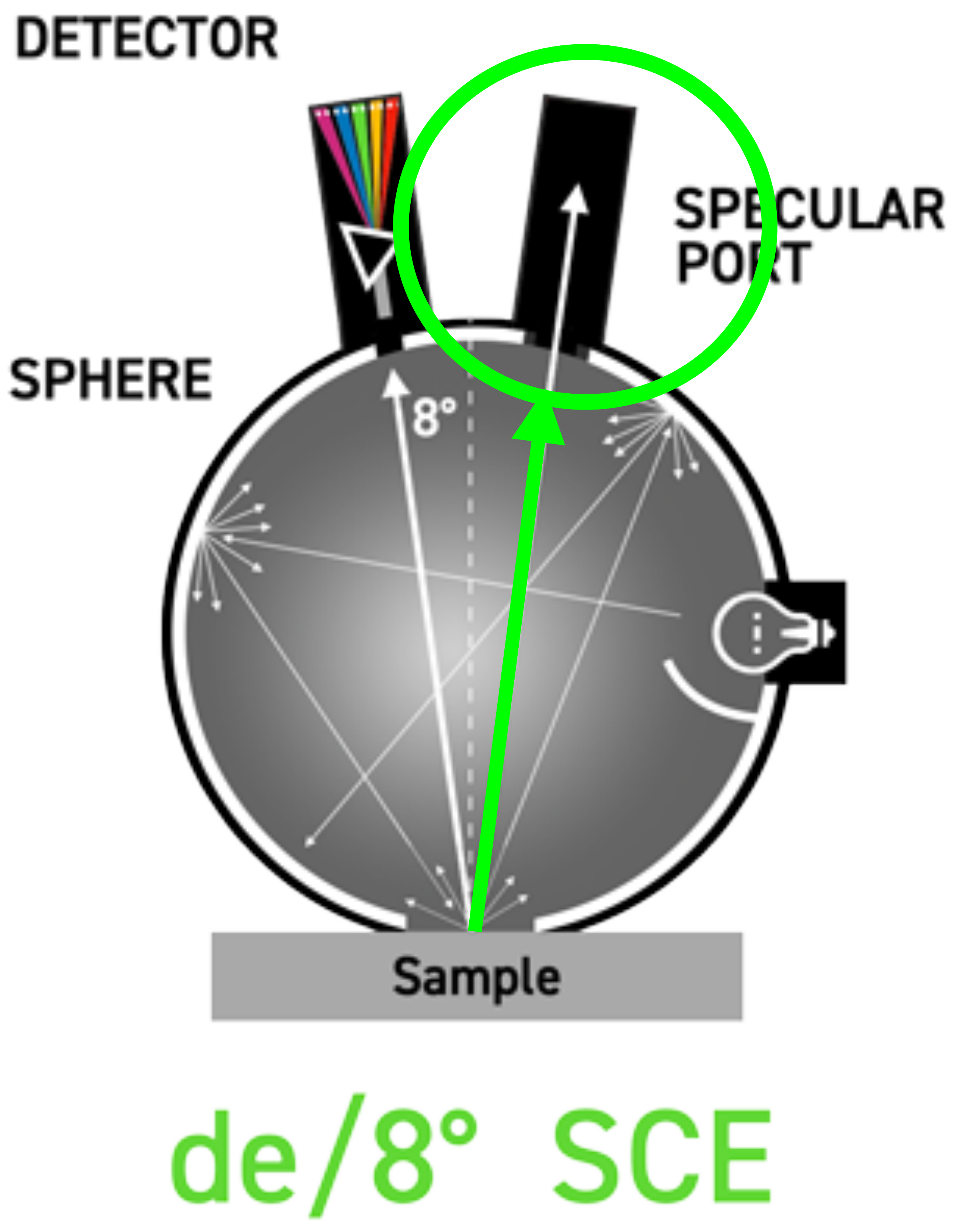
d/8° - Spherical Diffusion



de/8° SCE

If at 8 degree (symetrucaly to detector we place black trap (specular port), mirror used as sample reflects BLACK - as trap is design to absorb light.

d/8° - Spherical Diffusion

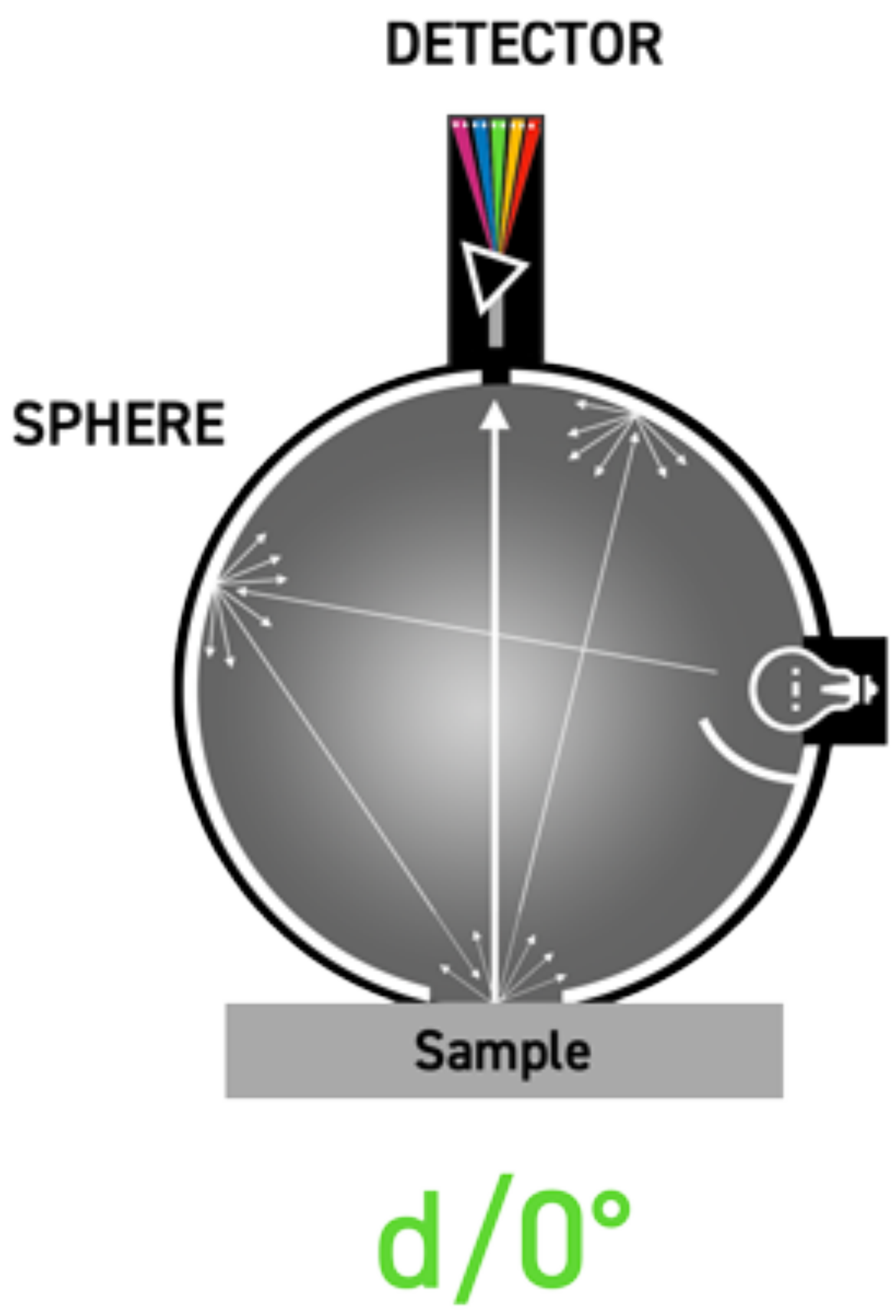


This is Specular Excluded (SCE, SPOUT, de/8°) Geometry

If at 8 degree (simetricaly to detector we place black trap (specular port), mirror used as sample reflects black trap (designed to absorb light).

Our sample (mirror) now is BLACK. Depending on geometry same sample might be WHITE or BLACK

d/0° - Spherical Diffusion



Spectro 1 by Variable offers non-typical d/0° Geometry

Two options that corresponds to SPIN ans SPOUT are offered

M2-M1 — evaluates fluorescence

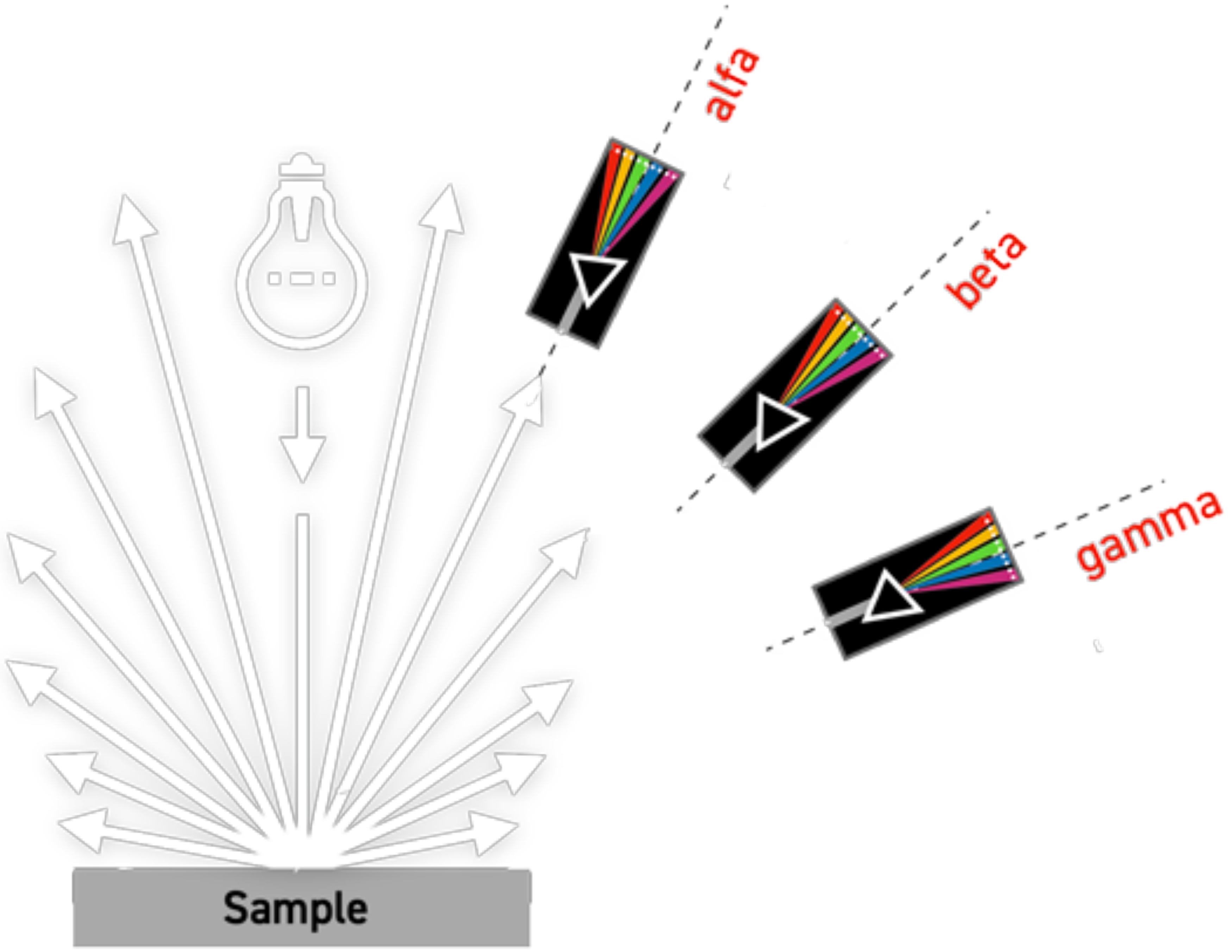
Check for Optical Brighteners or Fluorescents

Measuring same sample with different instruments

Instrument	OBA Index	Fluorescence Index	M1-M2 Spectral Δ @ 430 nm	M1-M2 ΔE_{00}
i1 Pro 3	8.8	9.5	0.24@ 430 nm	8.71
i1 Pro 2	7.2	7.4	0.21@ 430 nm	7.24
eXact M1 Part 2 export on	5.8	5.8	0.16 @ 430 nm	5.72
eXact M1 Part 2 export off	6.2	5.9	0.15 @ 430 nm	6.08
Techkon SpectroDens	7.9	7.4	0.16 @ 440 nmn	7.25

Measuring same sample with different instruments

Multi-angle geometry



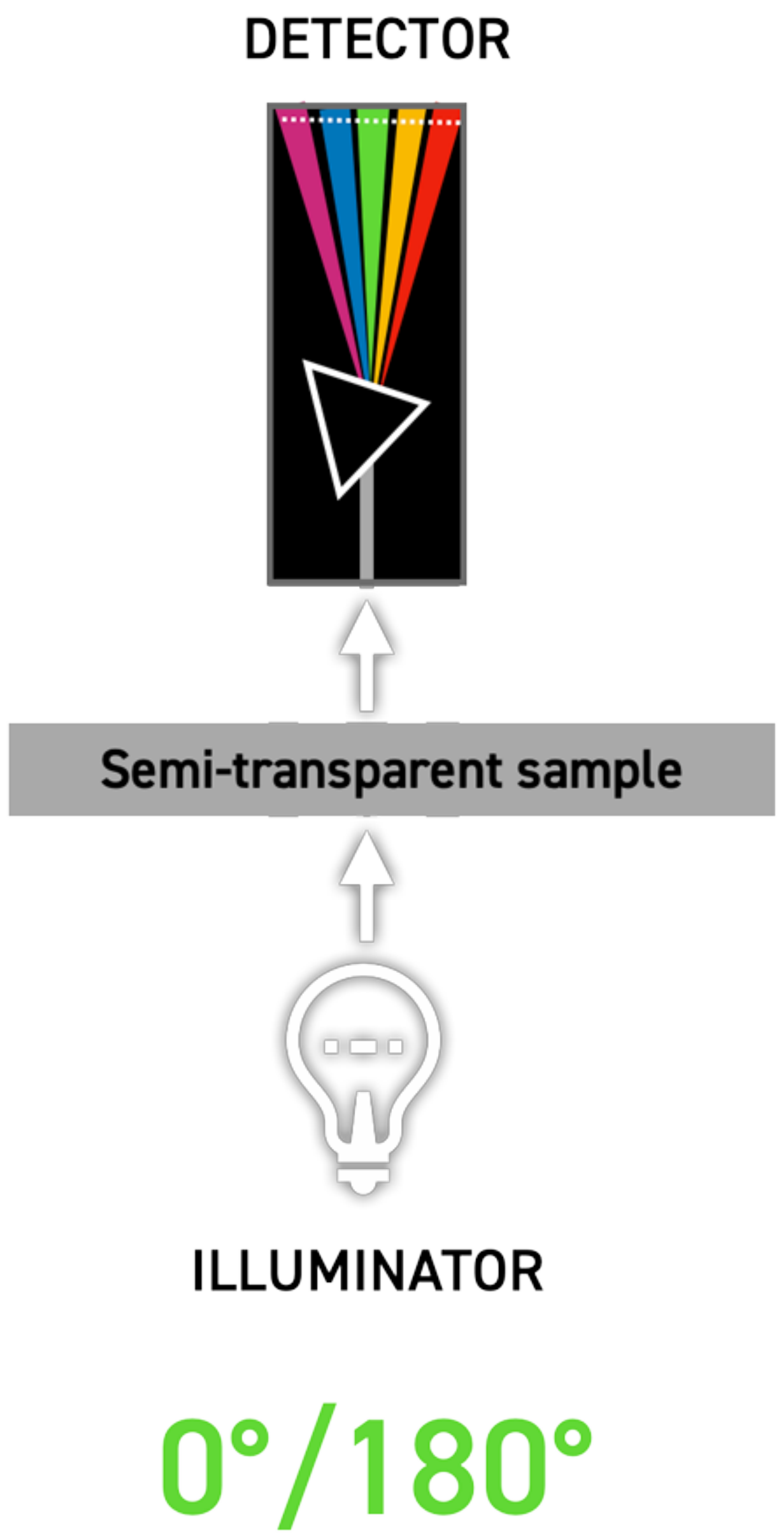
Multi-Angle Application

- Measuring Unpredictable surfaces
- Metallic flakes, lenses
- One or more Light sources, multiply angles
- Very proprietary
- Very expensive
- Very unique, typically automotive paints

0°/180° - transmissive

When semi-transparent object have to be measured:

- Colored glass
- Printed transparent film
- Back-Lit substrates
- Liquids



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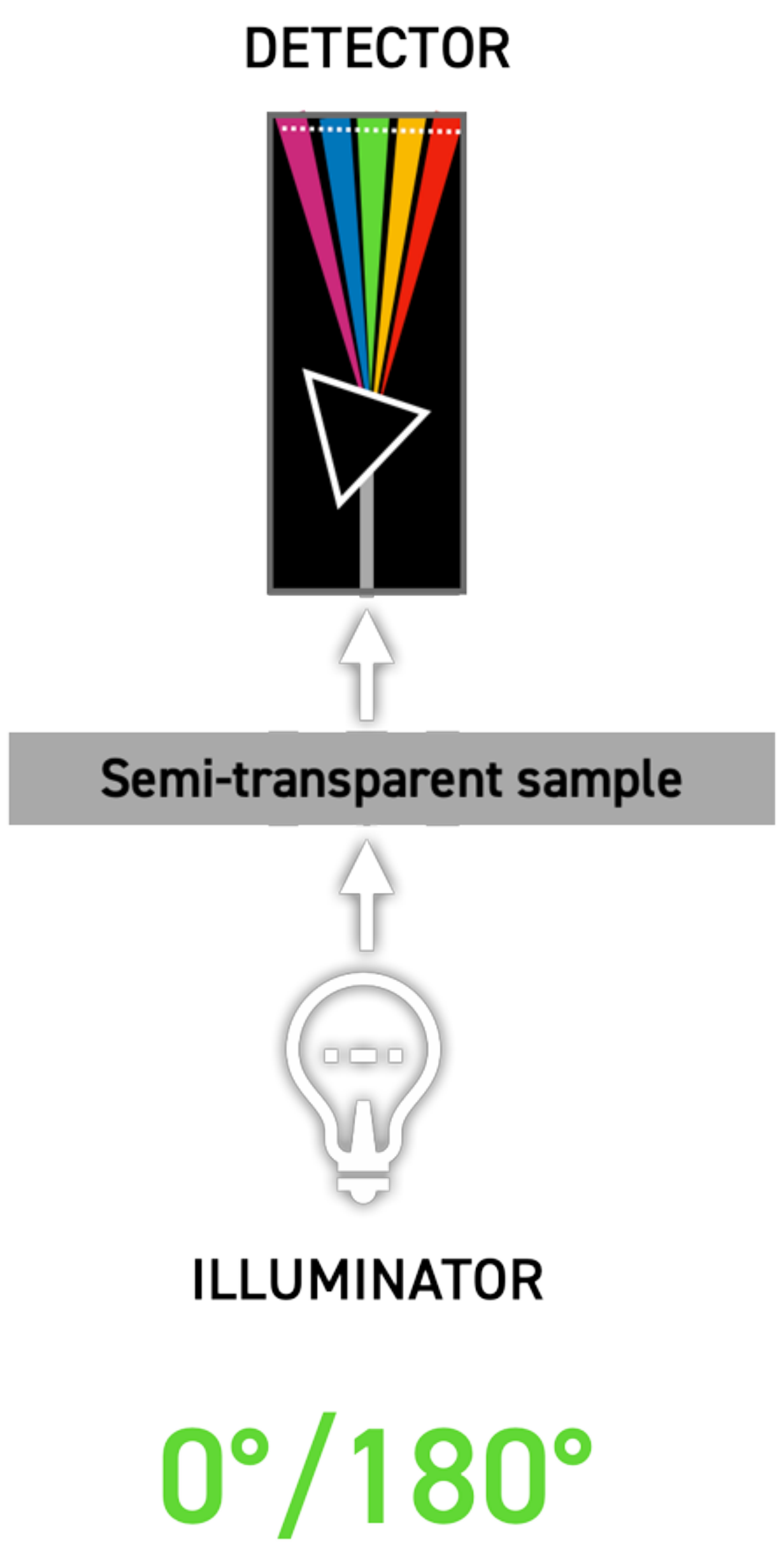
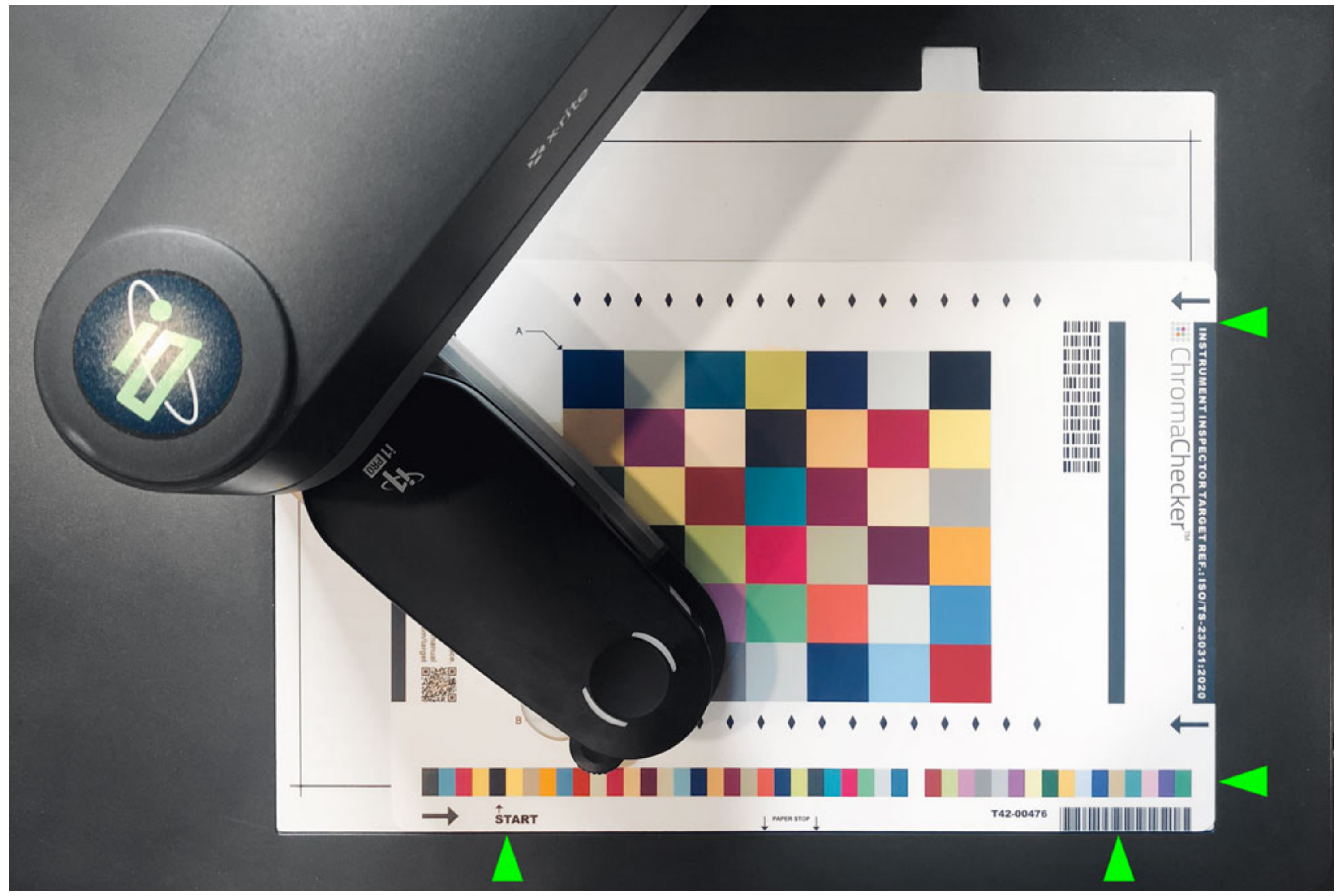
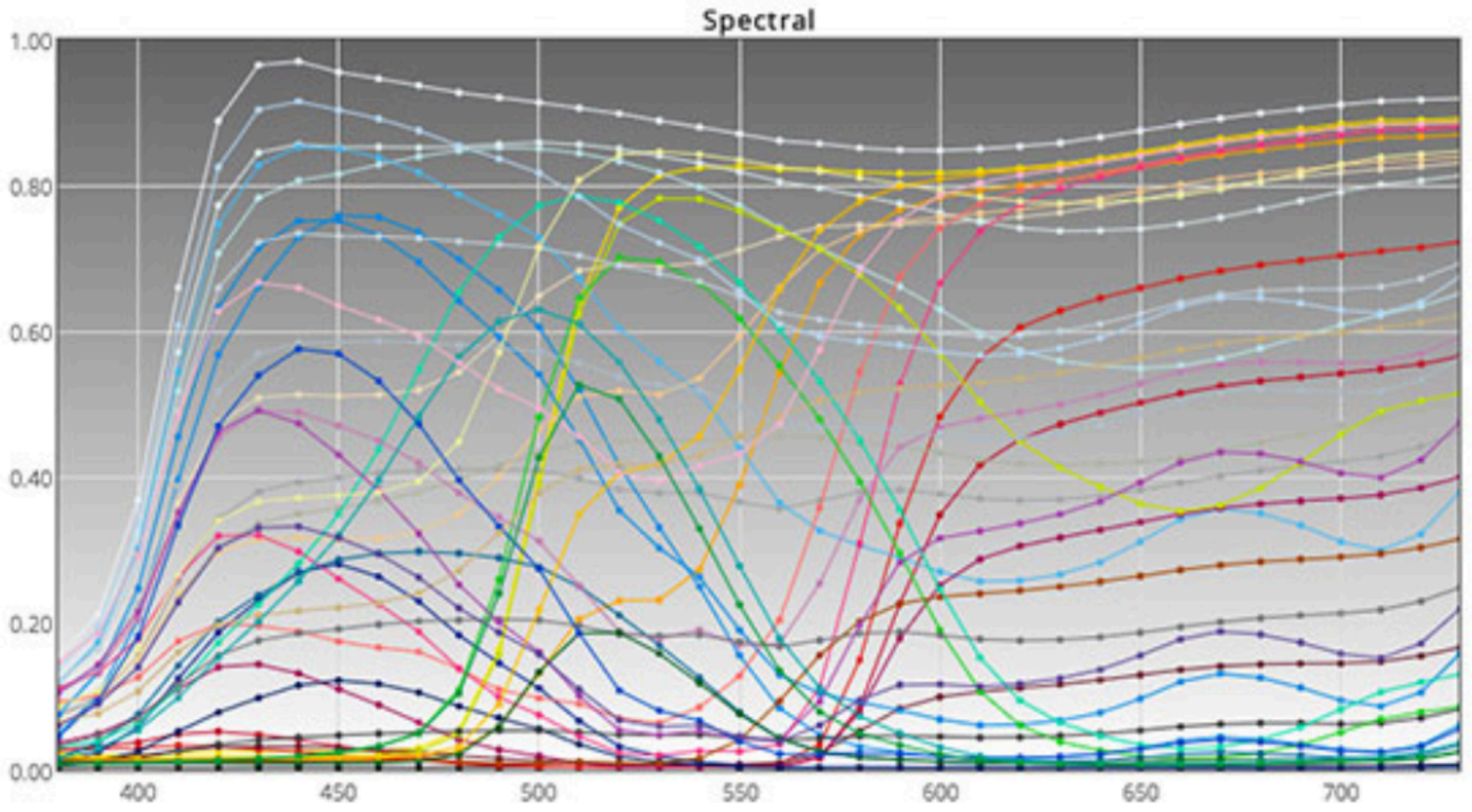


Instrument Inspector — key to the knowlege

Features:

- Know instrument is consistent and accurate to factory specifications
- Ensure the E-Factor is within your Expectations for Color Matching
- Compare different Instruments baselines at different condition (M-condiontion, Spot versus Scan, …)





M0, M1, M2, M3

M0 — simulates illumination of Standard Illuminant A (gas-filled tungsten lamp)

This is an older standard which, in fact, is all before new standards have been developed. When the older instrument was developed, there was no official standard to match.

M1 — simulates illumination of Standard Illuminant D50 (theoretical daylight)

Today is achieved using D50 LEDs with high CRI. If the Substrate contains OBAs, it is recommended to apply M1.

M2 — simulates illumination with a UV-cut filter.

In practice, some instruments use M0/A or M1/D50 illuminant to be UV- filtered - which alters the results!

M3 — simulates illumination with a UV-cut filter with light polarization.

This is not corresponding to any human viewing conditions, measurements are typically darker than M2, and differences depend on substrate and inks. This method reduces some reflections, and that is why works in some situations better for wet inks.

M3 - Polarized mode

Polarizing filter has impact on measurements

- Eliminates light reflections from wet ink
- Used for press stability control - not for QC
- A separate reference can be required
- Reduces amount of light - longer integration time — lower accuracy
- Data exchange between different instruments might be a problem
- It is always M2 based (no UV, OBAs stay inactive)
- None of industry-standard uses M3 for defining reference values!
- No standard defines wet ink references!
- M3 is used in Offset and LFP when printing on high glossy material.
- M3 is not dedicated to Color Management.
- M3, compared to M2, may bring some kind of information related to glossiness.

More about M-conditions

- Most of the instruments dedicated to prints today support more than one M-condition. Especially new handhelds can measure all M-conditions in a single scan; however, integrated systems usually only support one condition. Some systems measure in dual scan mode, for example, M3 for process control and M1 for evaluating against references.

- There are two standards (M1 Part 1 or M1 Part 2) of how M1 data are calculated by the instrument - some of the Instruments (X-Rite eXact 1) give to users the ability to select their preferred one. The results are not the same.

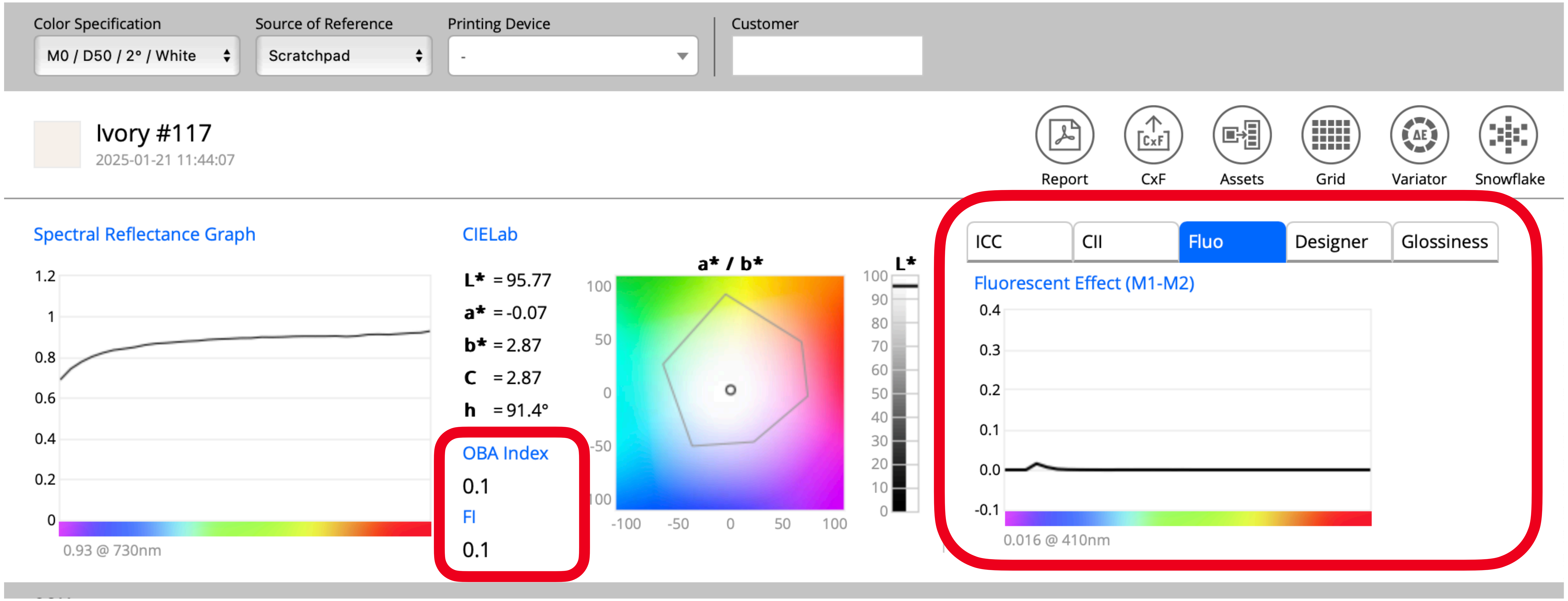
- M1 minus M2 detects fluorescence (presence of OBAs)

- Profiles are often used as a reference data source - when using an existing one or creating a new one, it is critical not to mismatch M-condition!

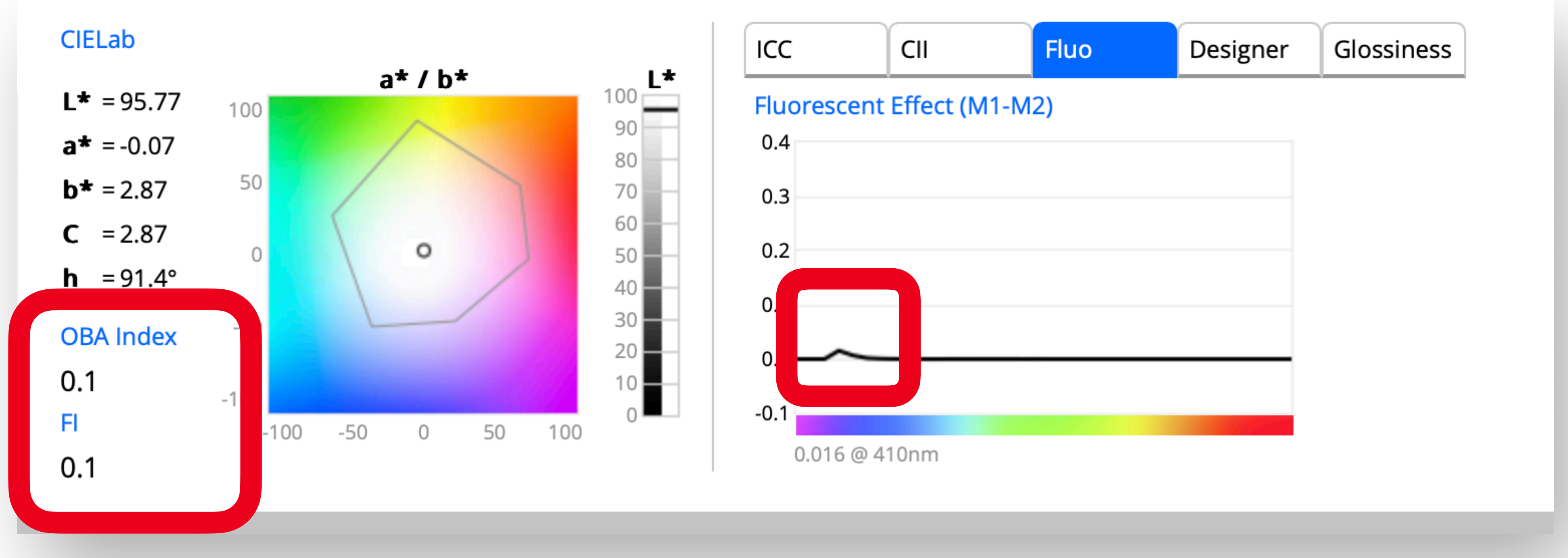
- Please note that another standard: ISO 3664:2009 - which defines Lighting Conditions for visual judgments - is correlated to the same topic.

Check for Fluorescence

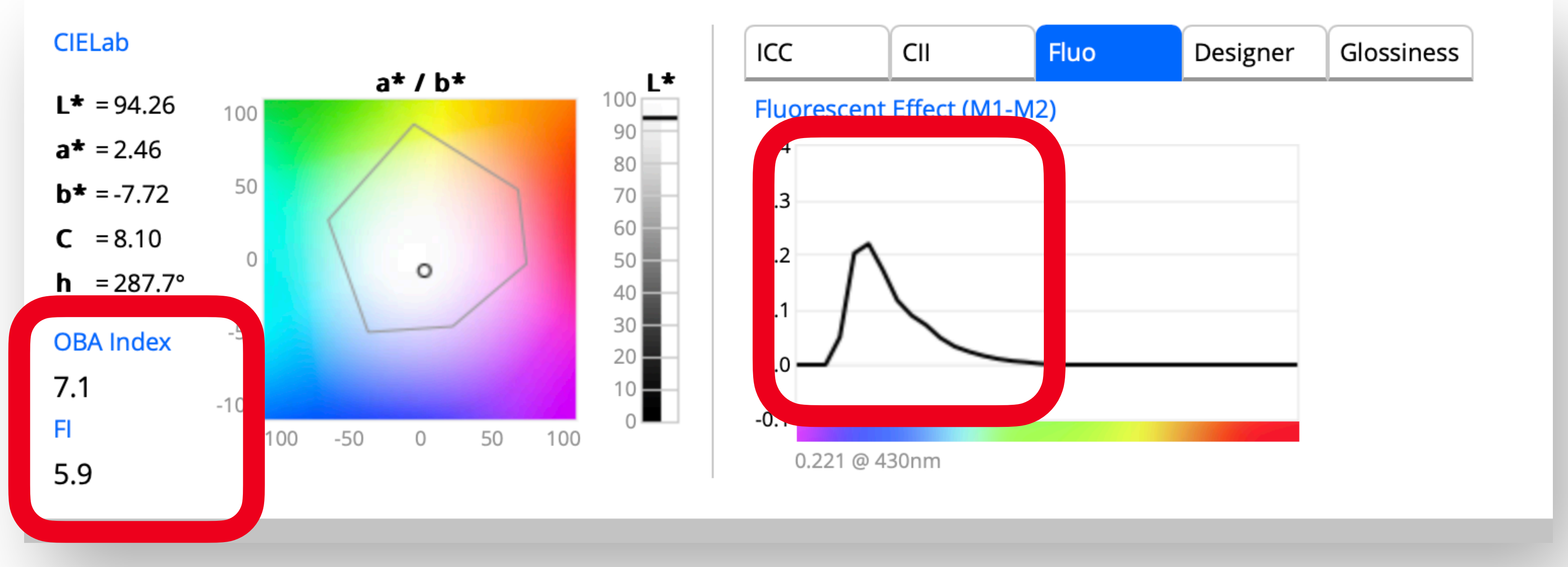
- Check OBA Index/ Fluoresce Index, Fluorescence tab in QuickChecker



Check for Fluorescence



Very low OBA Index/ FI
M1, M2 or M0 are very similar



High OBA Index/ FI
M1, M2 or M0 are very different

Sample Classification: Determine Instrument

First determine if sample falls into which category

- Flat, matte, uniform color- Ink, Paint on flat even surface
  - ➡ Use 45˚/0˚ Instrument, check for fluorescence

Sample Classification: Determine Instrument

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- Flat, matte, uniform color- Ink, Paint on flat even surface
  - ➡ Use 45˚/0˚ Instrument, check for fluorescence
- Flat, High Gloss
- Textured surfaces, shadows, roughness- Fabrics, natural fibers
- Offset surfaces, multi-layered depth- Acrylic, print bottom glass
  - ➡ Test 45˚/0˚ if fail, test Spherical

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- Mirrored materials- Silver, Gold, Foil, Aluminum, Metal
    - ➡ Test Spherical

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  - ➡ Test 45˚/0˚ if fail, test Spherical
- Mirrored materials- Silver, Gold, Foil, Aluminum, Metal
  - ➡ Test Spherical
- Metallic, Pearl colors
  - ➡ Test Spherical if fail test Multi Angle

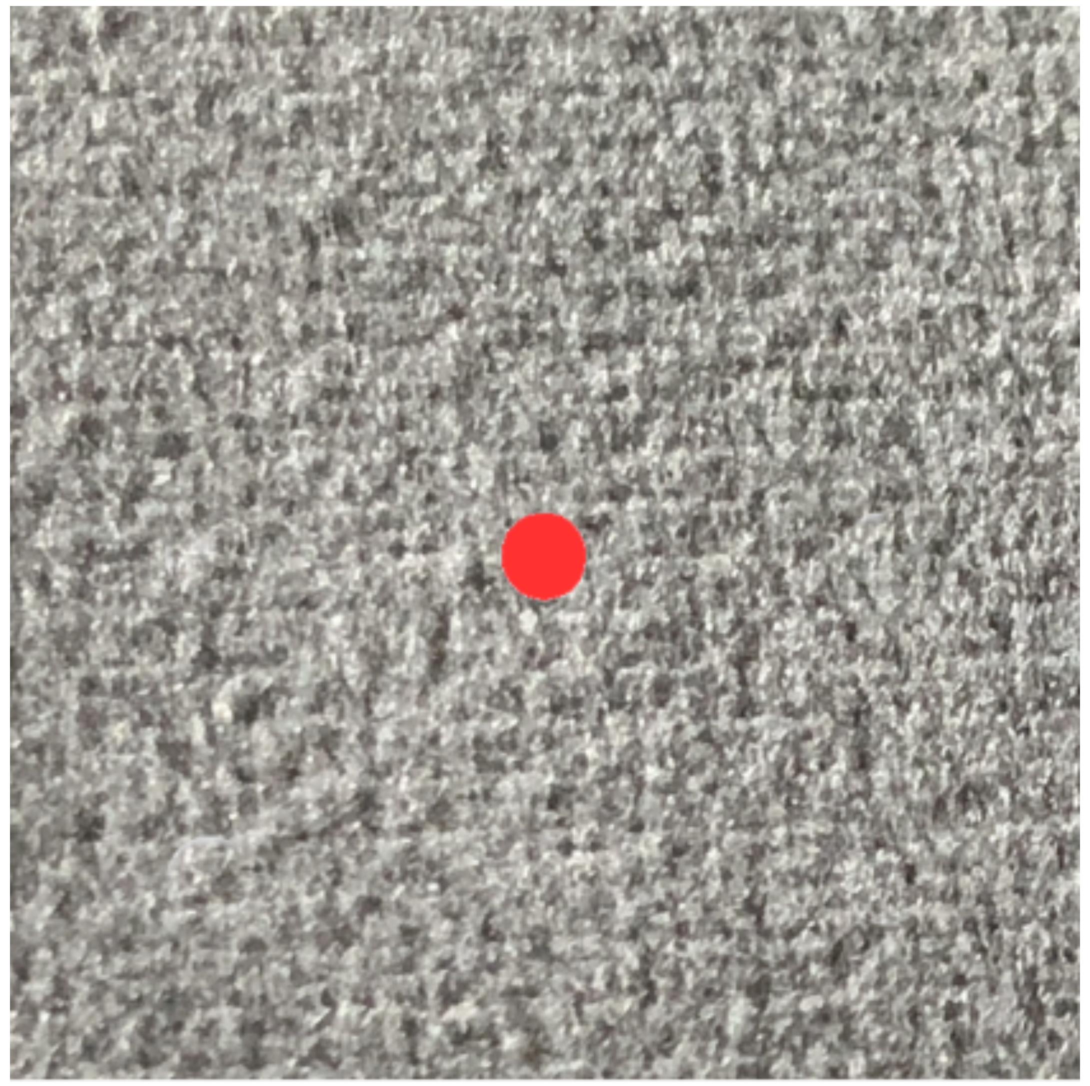
Test given Instrument/Sample combination

Simple 3 Step Process using CC Capture Variation

- Step 1- Measure the same spot 12-15 times,
  not moving instrument at all, use software to
  trigger measurement

- How to know if measurement fails to measure the sample within
  expectations?

- Try different options, modes, settings on same instrument
- Try different instruments to see if any can pass, if not- buy new

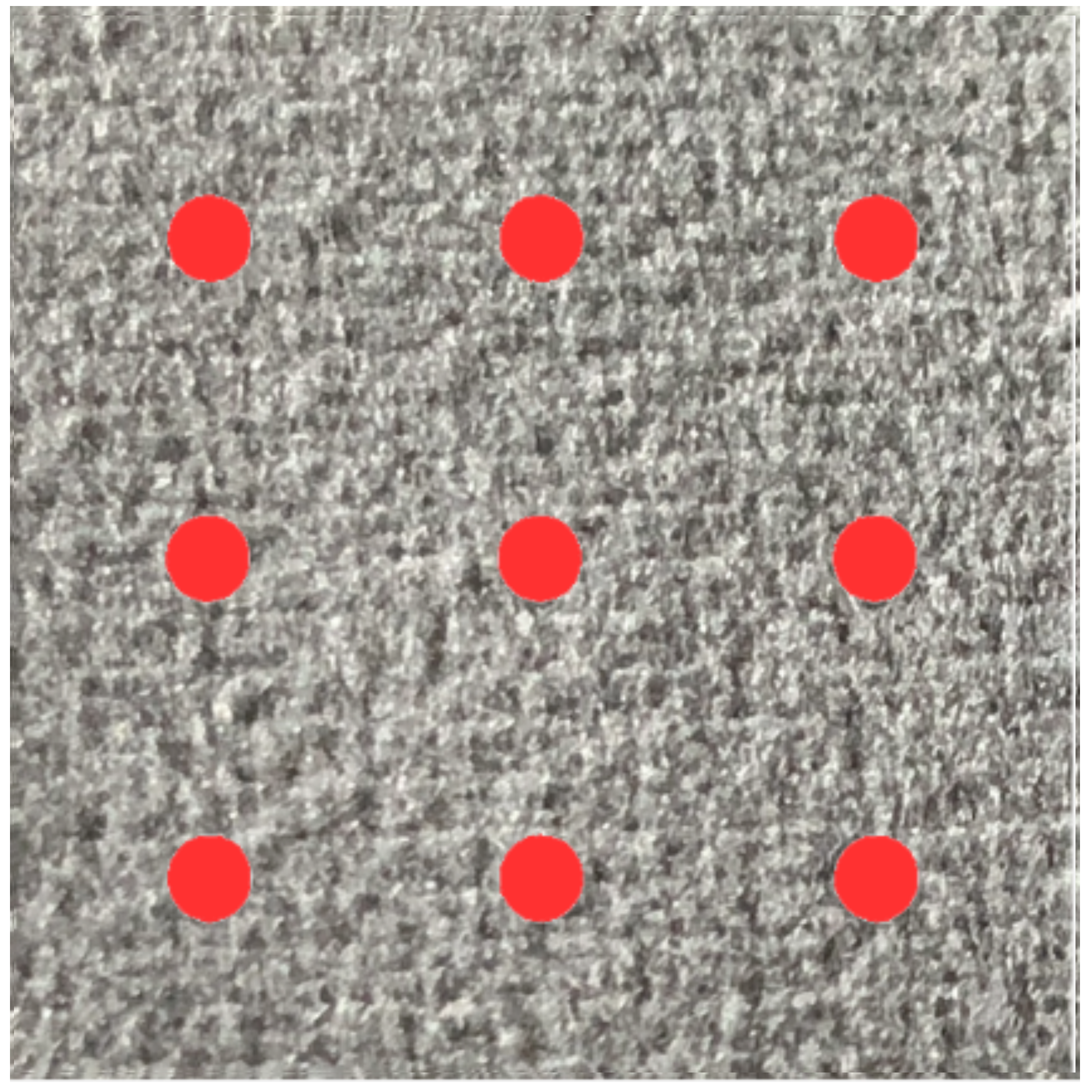


Test given Instrument/Sample combination

Simple 3 Step Process using CC Capture Variation

- Step 2- Measure 9 different locations on sample offset by at least 0.5”

- How to know if measurement fails to measure the sample within expectations?

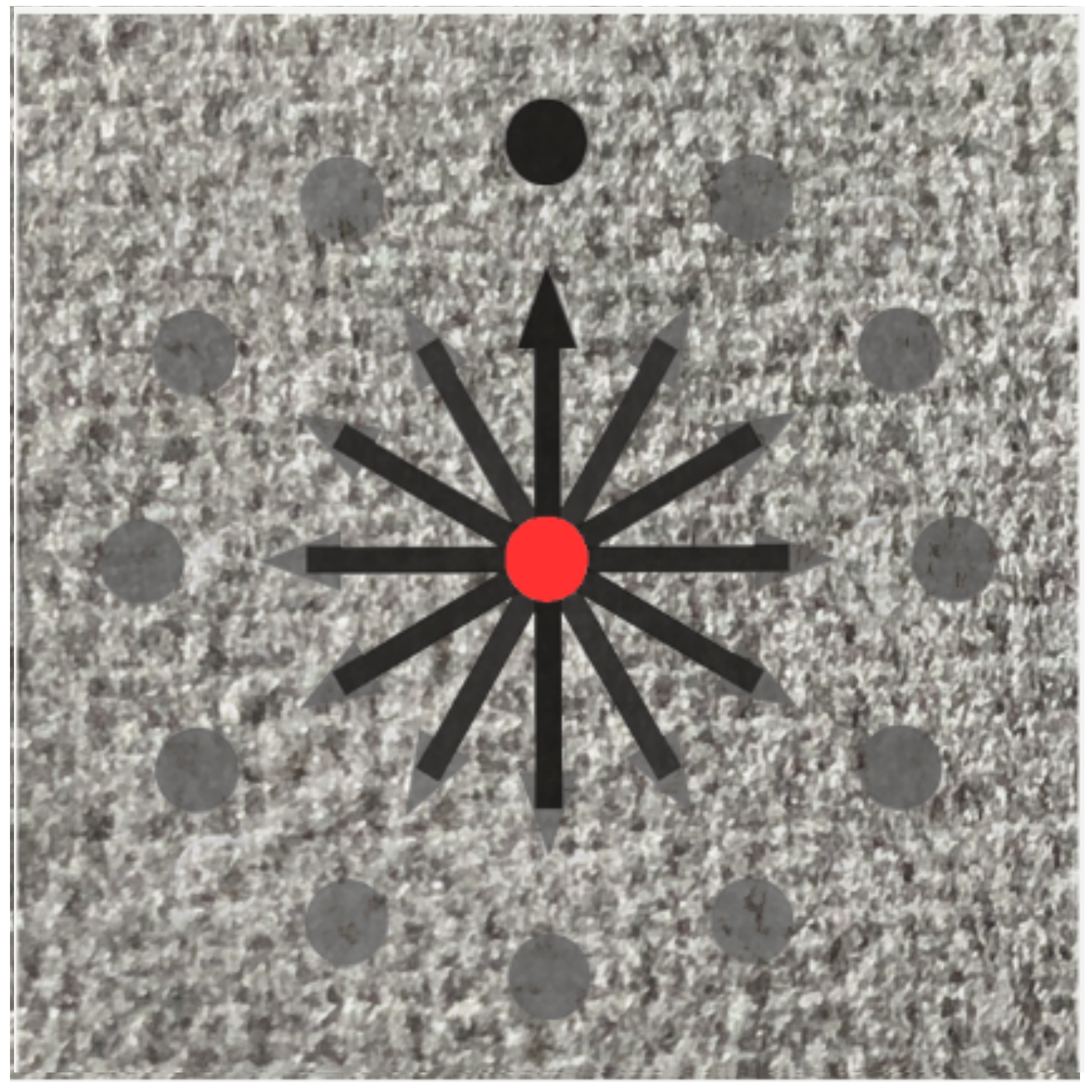


Test given Instrument/Sample combination

Simple 3 Step Process using CC Capture Variation

- Step 3- Measure same spot 12 times rotating instrument around the same spot

- Determine if result fails outside of expectations?



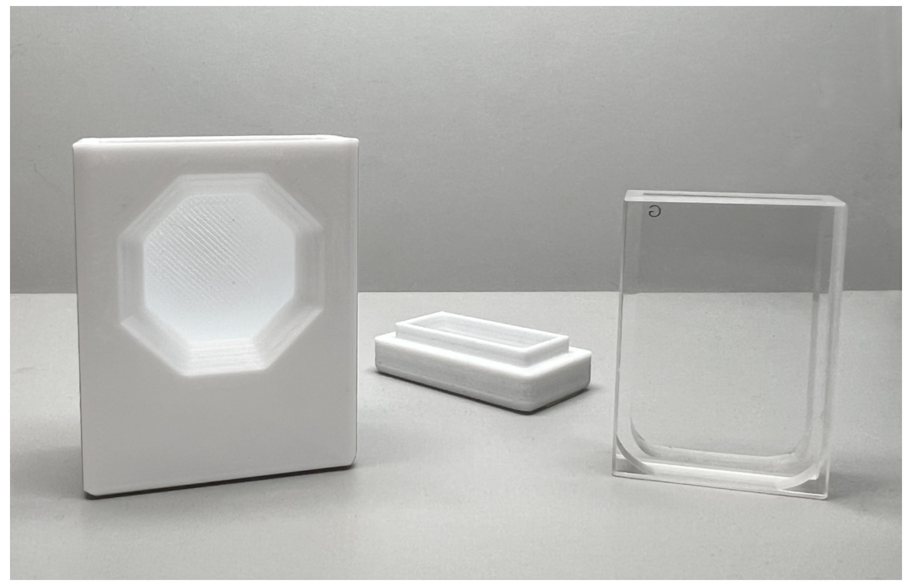
Measurements of the liquids.

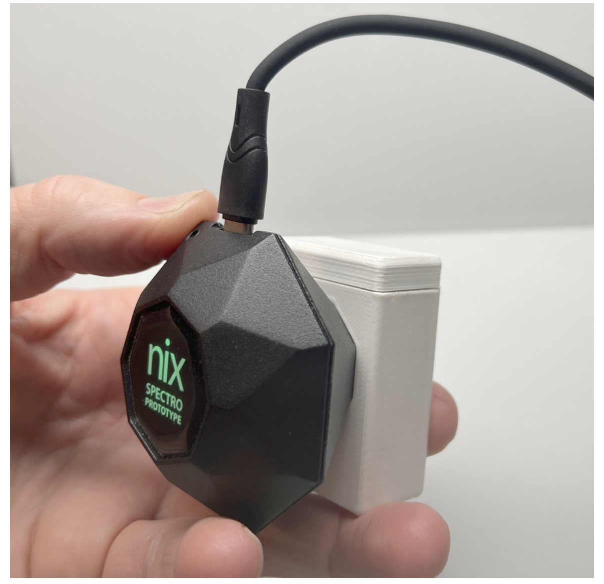
What if you need to measure the color of the liquid?

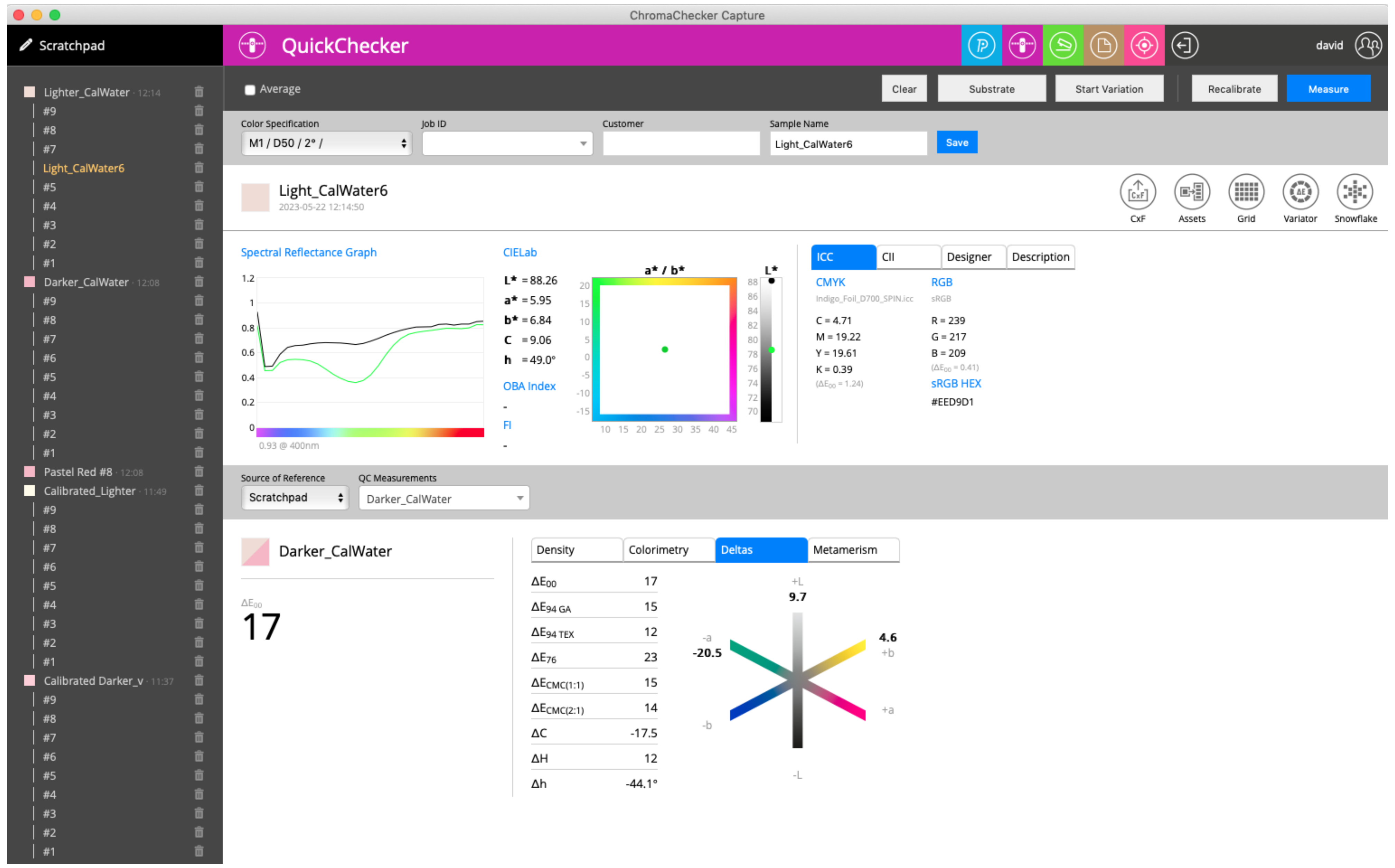
Nix offers a dedicated adapter that enables liquid measurements.
This is unique **custom geometry 45°/180°**

Instrument require a custom calibration
on the cuvette filled with fresh water!

This is way to control unusual white point!







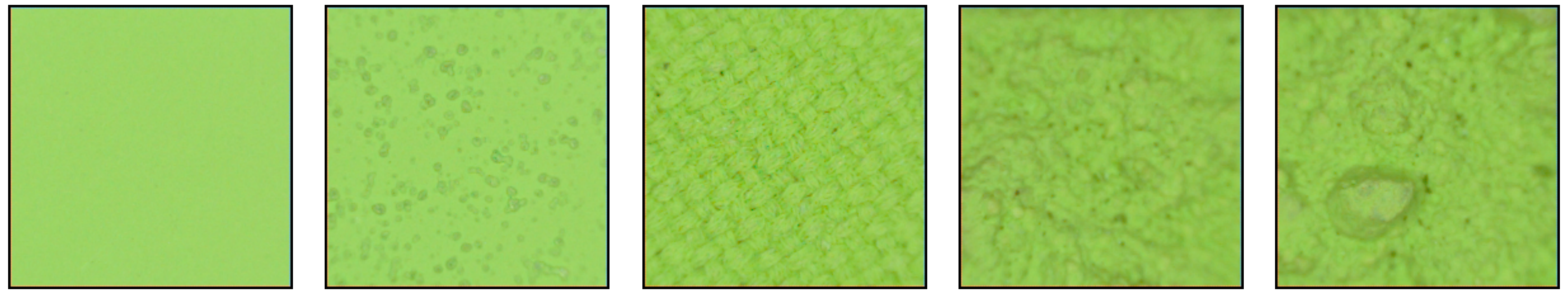
 ChromaChecker

COLOR CONFORMANCE CONFERENCE '25

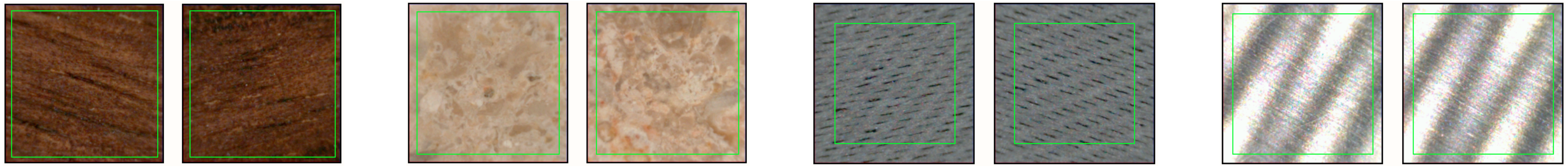
Nano Instrument

Unique Instrument: Measures Texture/Appearance

- It is not a Spectrophotometer, but a Camera with Colorimeter
- Color Match for Average and Dominant Color:

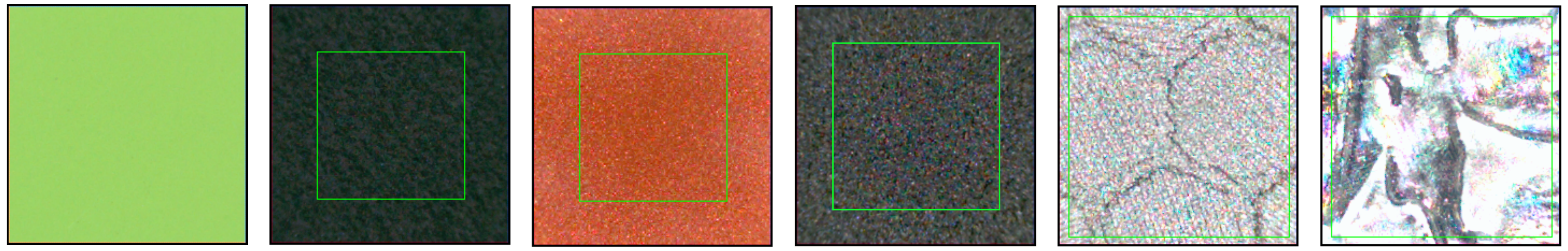


- Surface Match for texture/pattern:



Wood 85% **Marble 89%** **Textile 92%** **Aluminum 82%**

- Uniformity of patch values



U=0.6 **U=3.0** **U=6.0** **U=7.7** **U=11.2** **U=13.2**

Conclusion

Learn instrument and technology limitations

- There is no one perfect instrument - experiment to understand.
- There is no industry absolute colour standard to match.
- A lot of properties are not standardised and there is no inter-instrument agreement (OBA Index).

Try different setting - select the best

- Some instruments come with many options. Test best for your needs.
- Always try to make a compromise that works for your scenario. Accept imperfections.

Even if there is no visual match Instrument can still be useful

- By applying a relative instead of absolute approach, you can use your current instrumentation.
- Think about applying Instrument/dependent references to manage differences.

Adopt methodology to productivity

- The solution is good if it effectively collects data with minimal effort from the operator.
- Automation is a key to errorless operation.

Resources – Thank You

Helpful links

- PDF version of this presentation

- Instrument Geometry, What You Need to KnowInstrument Geometry, What You Need to Know
- Instrument Geometry
- Velvet, velour type fabrics
- Choosing the Right Instrument
- Unusual Measurement surfaces- Polyester Film - Chrome Brushed 907 - ORACAL® 352
- Super Black — Gloss Calibration Standard
- Color Specifications and Measurement Conditions
- Liquids
- Spectrophotometer vs Colorimeter

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