# The use of the M3 measurement condition in colour management

ICC Color Experts' Day, Bressanone

Colour Management and Colour Measuremnet

- **Colour Management has the goal of obtaining desirable colour matches across different devices and media.**
  - **Want the colour we see on screen to match the colour that is printed**
  - **Colour management relies on accurate colour measurements of the devices and media so that the desired match can be achieved**
- **Differences between devices and media make colour measurement challenging**
  - **Can't measure a display and a printout in the same way**
  - **UV?**
  - **Surface reflections**
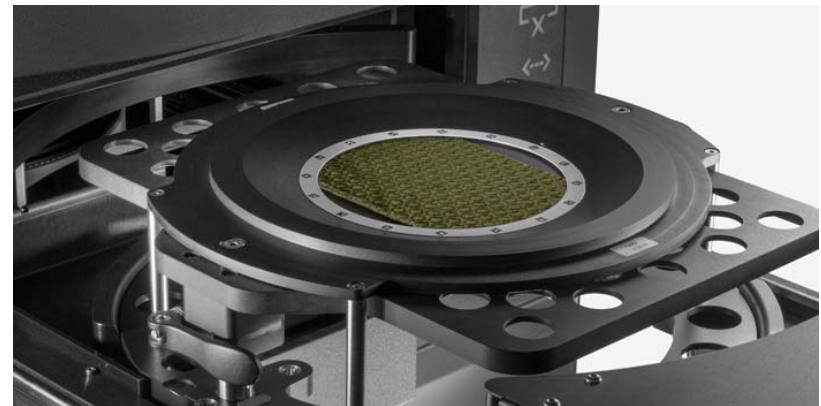
Colour Measurements

- **Colour Measurements need to be made in a way that is appropriate for what is being measured and how the colours will be viewed.**
  - **Larger aperture for Textiles**
  - **Spherical vs 0/45**
  - **UV content of measurement light should match UV content of viewing environment if OBA is present**

ISO 13655: 2009/2017 – MEASUREMENT CONDITIONS

Specifies spectral measurement conditions for graphic arts

- **Measurement illumination conditions**
  - **M0: Should be CIE Illuminant A (many legacy spectrophotometers)**
    - **undefined UV amount**
    - **covers unknown illuminants as well**
  - **M1: CIE Illuminant D50, 1 for paper (OBA) only**
    - **Part 1 is D50 match use for all fluorescence (ink, papers, etc)**
    - **Part 2 Calculated UV response to emulate UV excitation of OBA's (for paper only)**
    - **Use with ISO 3664:2009 viewing condition**
  - **M2: UV cut**
    - **Little energy below 420 nm, continuous illumination above**
  - **M3: Polarization Filter with UV cut equal to M2**
    - **Special use cases**

M3 – POLARIZATION

Colour Assessment independent of the surface

- **Polarization reduces reflections caused by the surface reflection or bronzing**
- **One method of density comparison between wet and dry inks.**
- **It also removes UV equivalent to M2.**
- **Is used in ISO 12647 as an option for density process control.**

Attention: **There is no viewing condition that matches this measurement condition**

M3 and Colour Management

- **M3 measurements can be used to build an ICC profile**
- **Supported in the measurementType tag in iccMAX**
- **What happens to colour management when M3 is used?**
  - **Do colours printed using an M3 based profile match colours on an ICC profiled screen?**
  - **Do colours printed using an M3 based profile match colours printed using a M2 profile?**
  - **Do colours printed using a M3 profile for one type of media match colours printed using a M3 profile for a different type of media?**
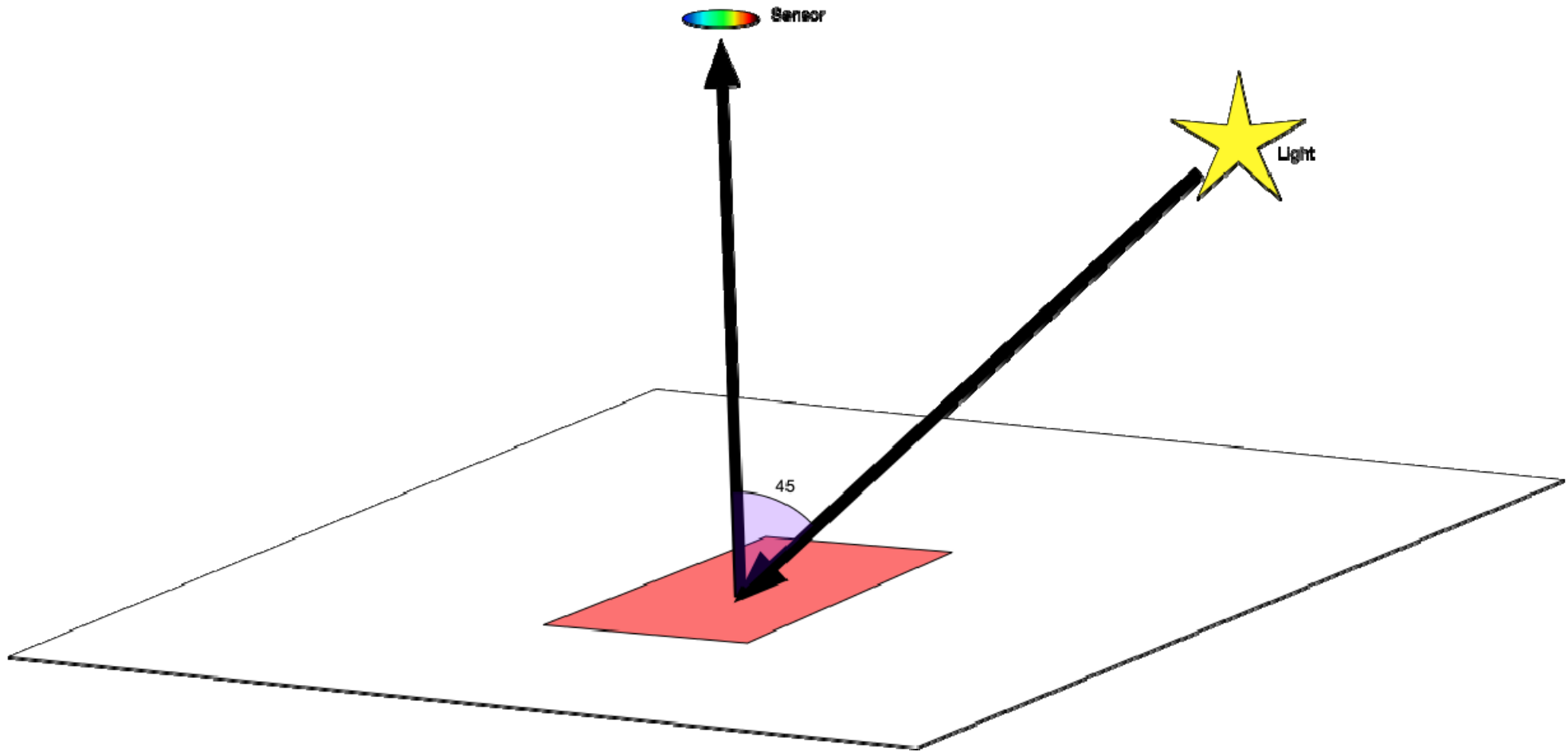
Polarization

- **Polarization is a property of light (and other transverse waves) that specifies the orientation of the oscillations**

Direction of polarization
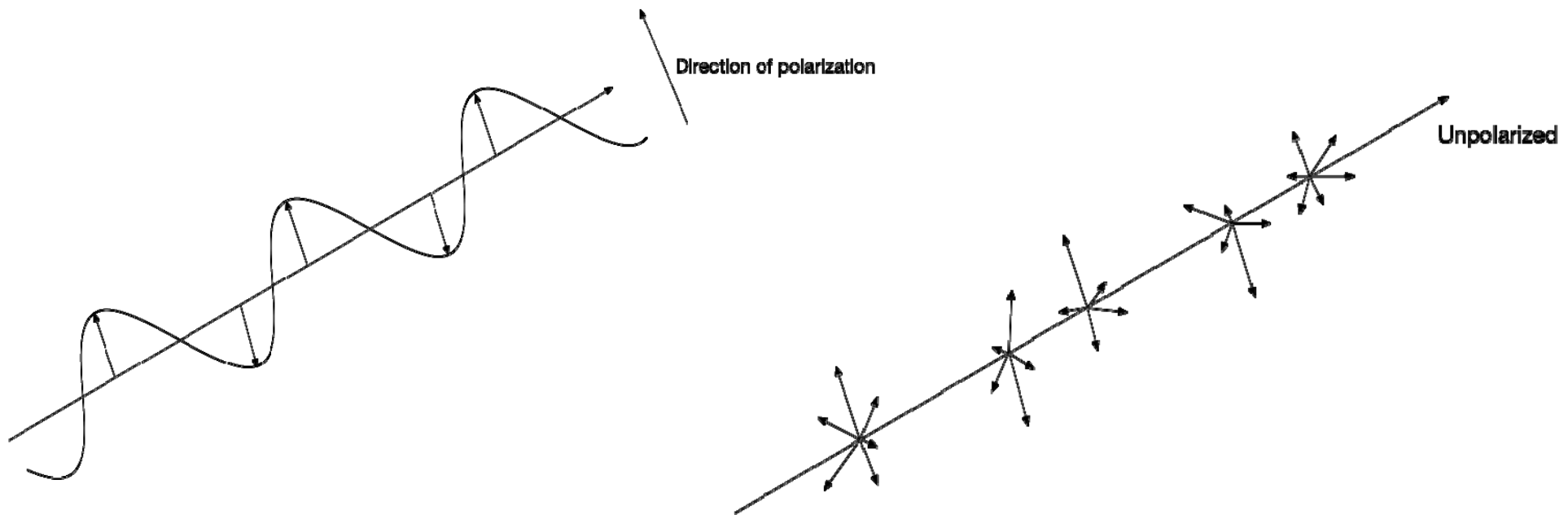
Unpolarized

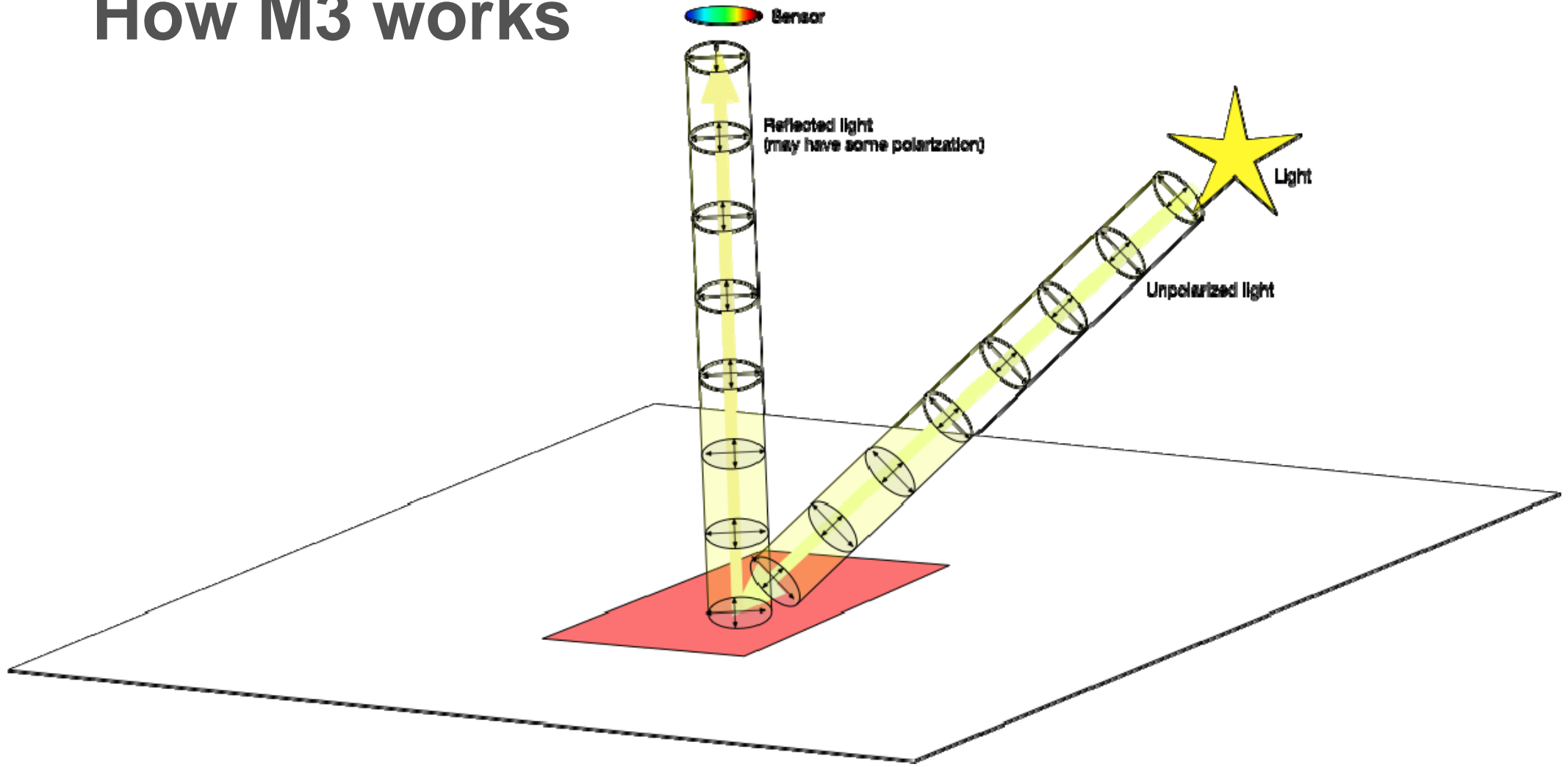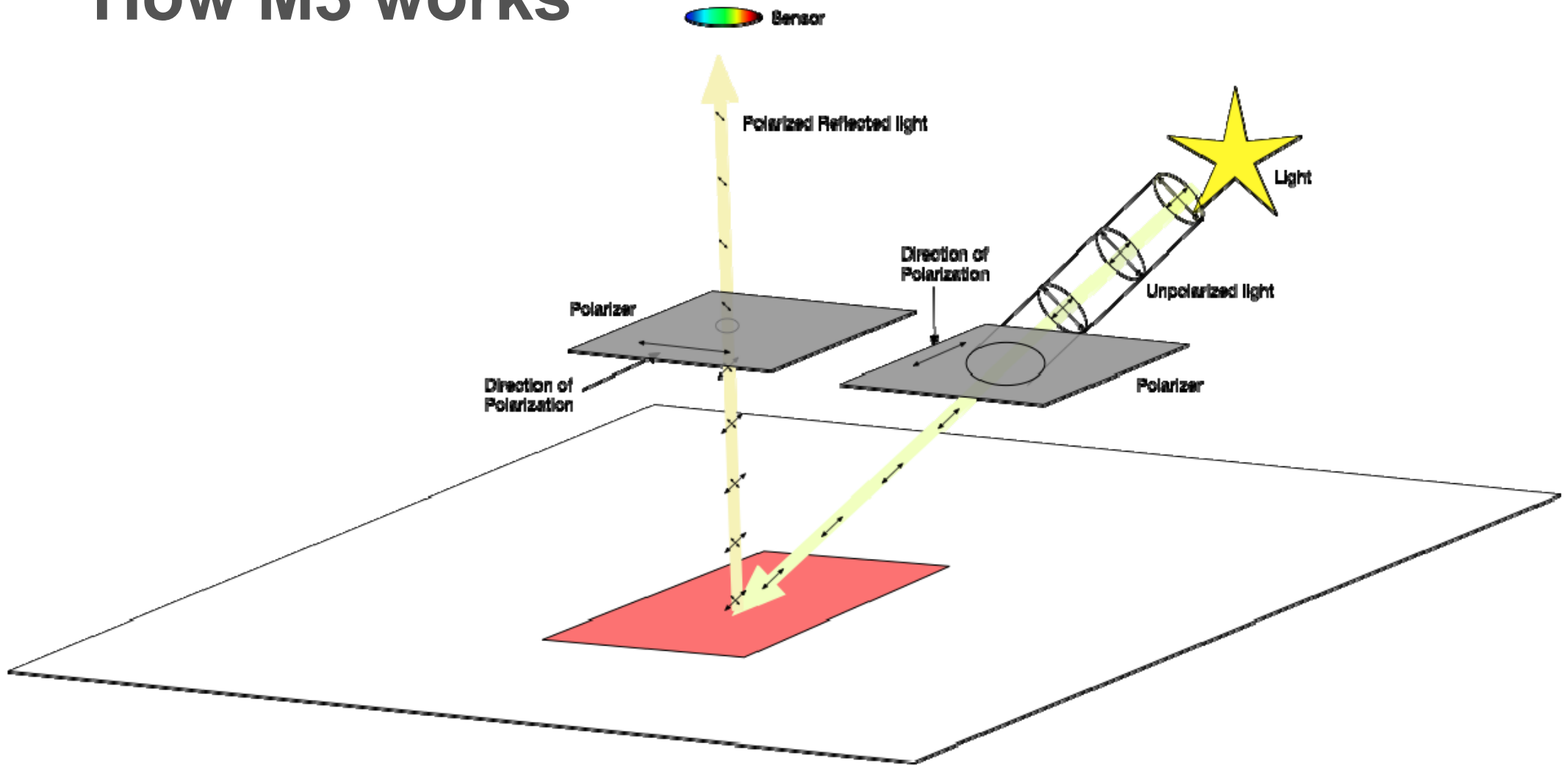- Also Elliptical and circular polarization

How M3 works

45/0 Geometry

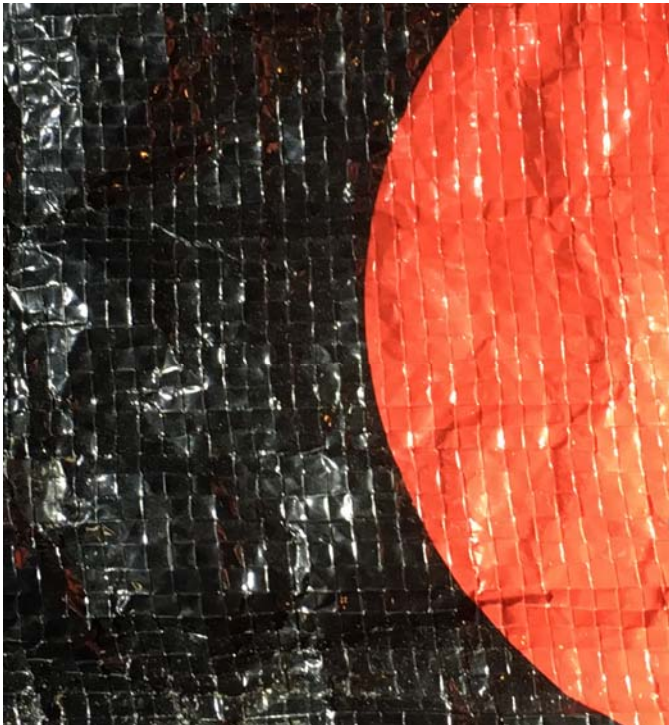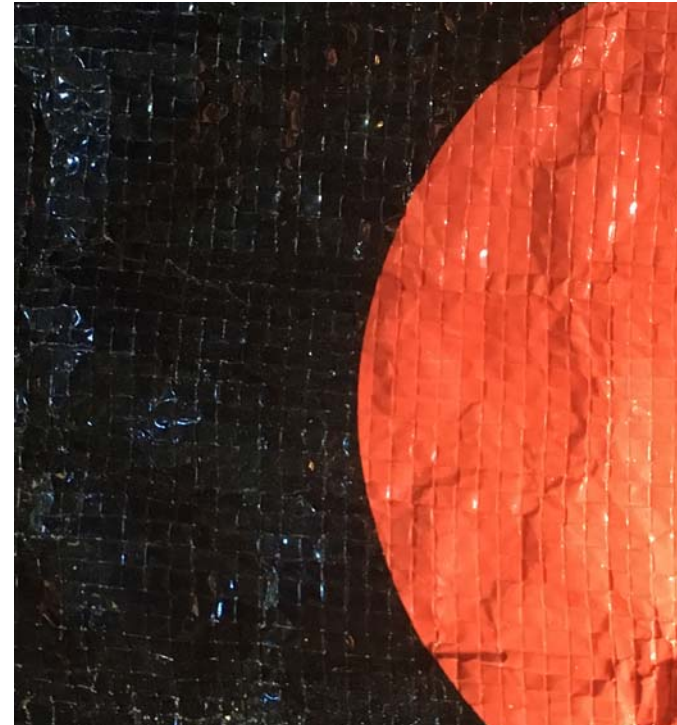How M3 works

M0/M1/M2

How M3 works

M3

Removing Reflectances with Polarization

- **Specular reflections retain polarization direction and can be eliminated by using polarization.**
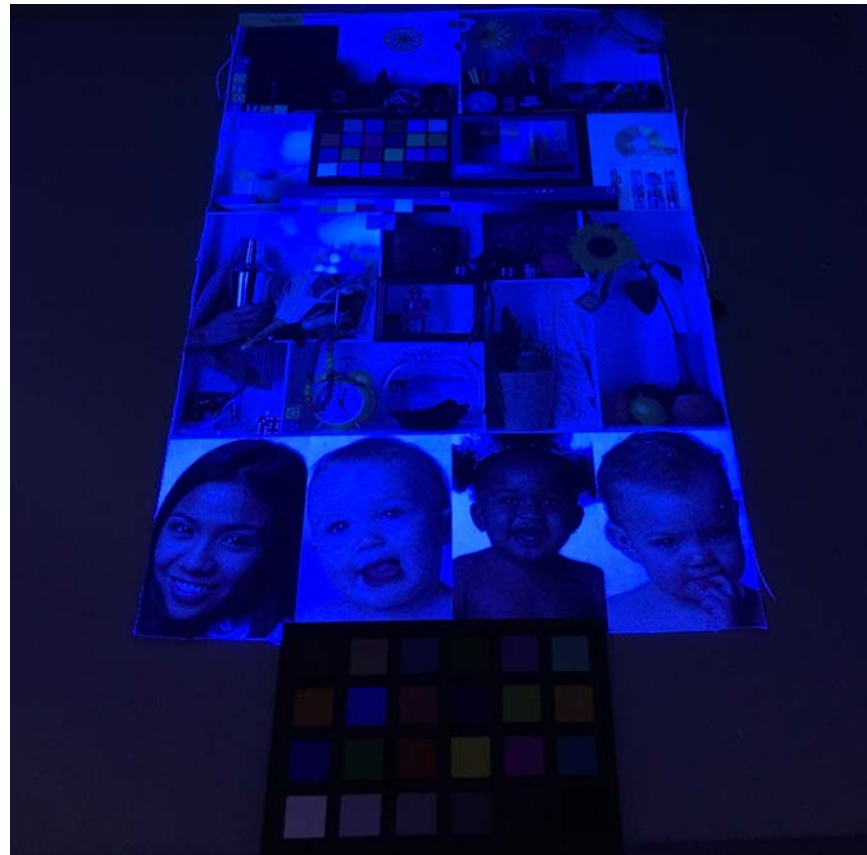
Polarized light source

No polarizer on camera

Polarizer on camera

M3 has no UV

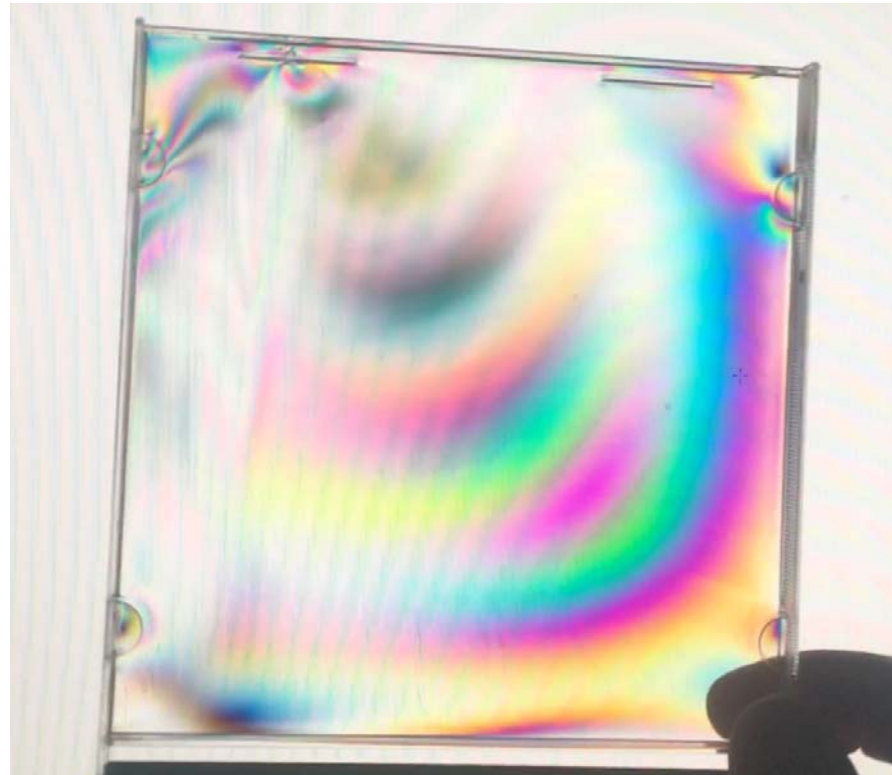- **Textiles and Papers often have optical brightness**
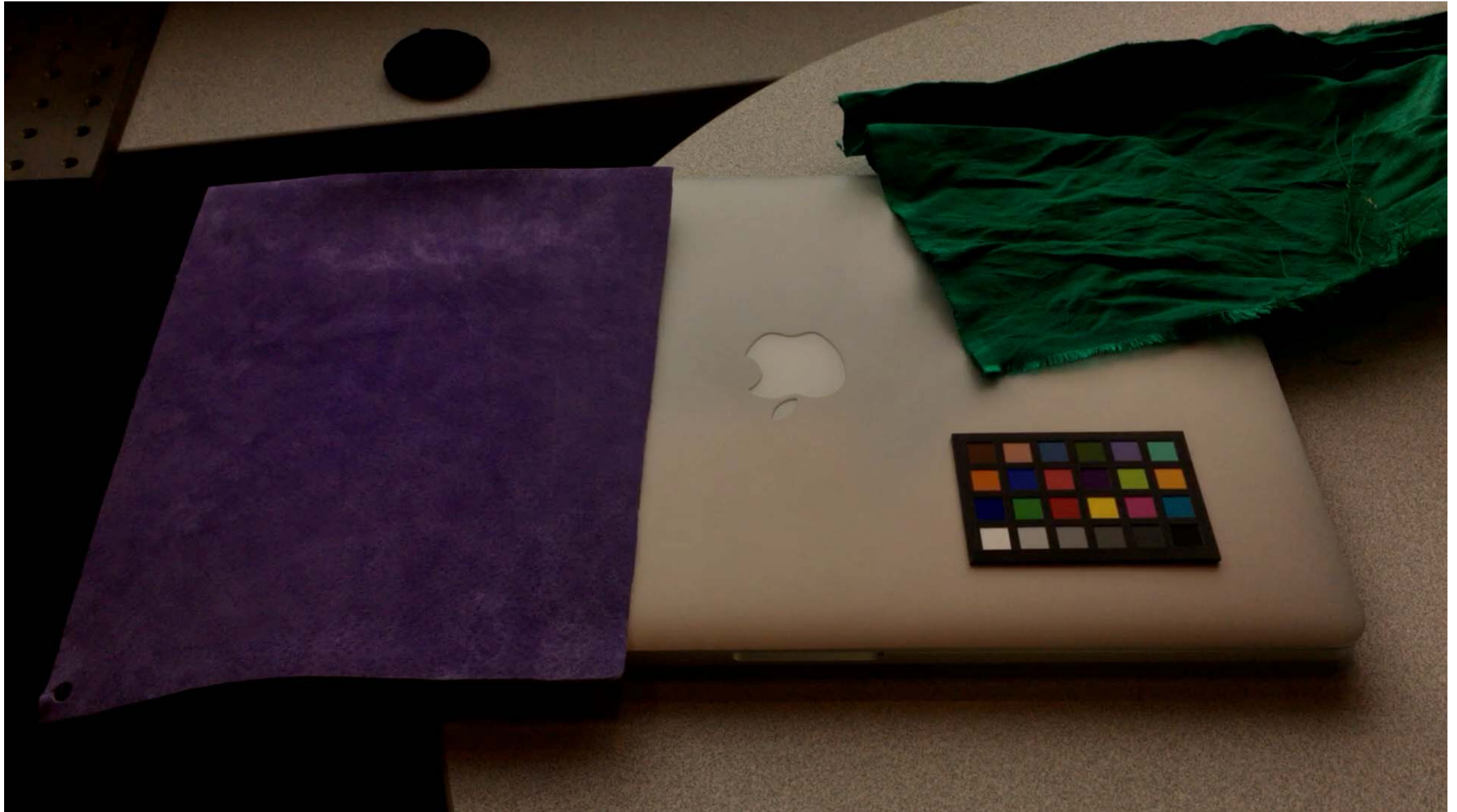
Other Effects of Polarization

- **Polarization is used to analyze stress in objects. Photoelasticity is illustrated here.**

- **Polarization effects can occur internally in an object**
  - **When measuring in M3 mode the internal polarization effects can impact the measured colour**

What does the M3 look like?

Why M3 might be used for colour management

- **Measurement of first surface reflections is undesirable**
  - **Causes too much noise in measurements**
  - **First surface reflections are discounted when colour is being viewed**
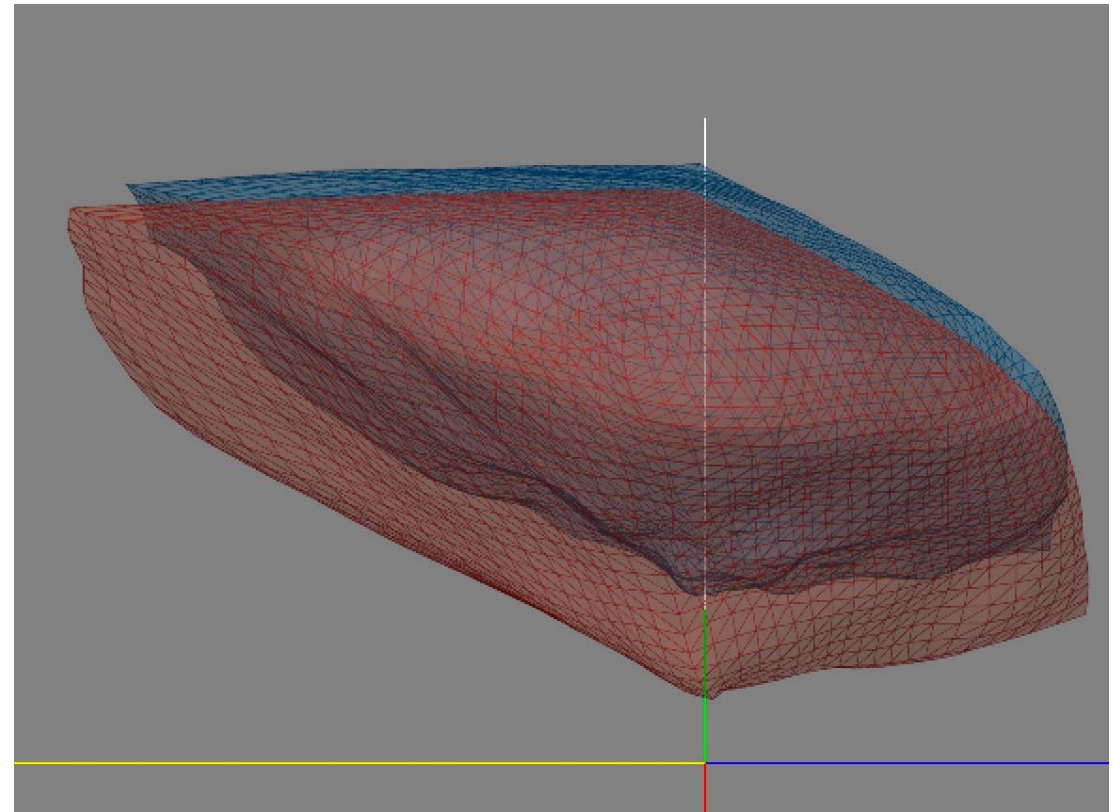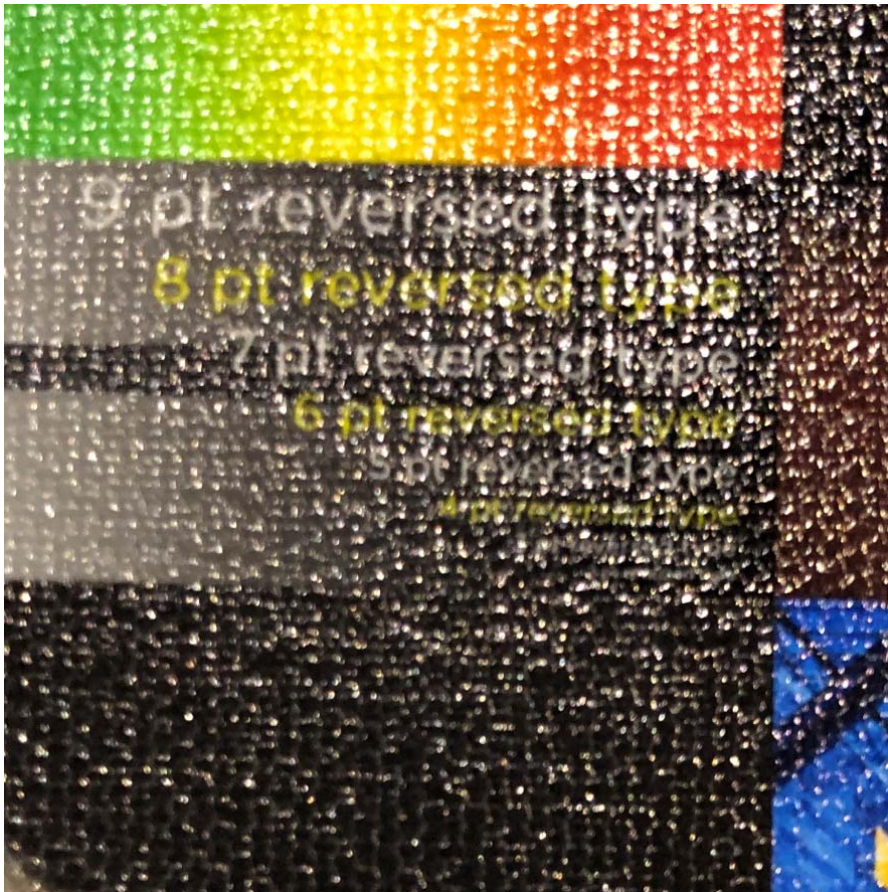 - **Ink is still wet**

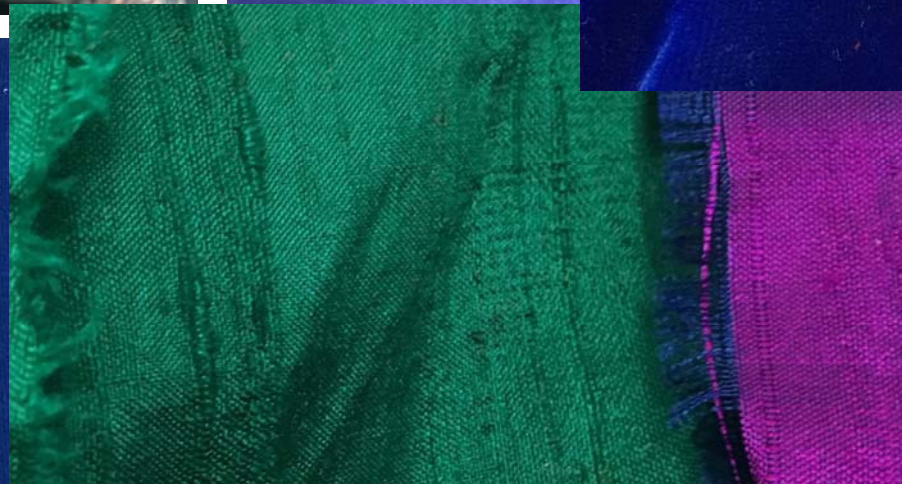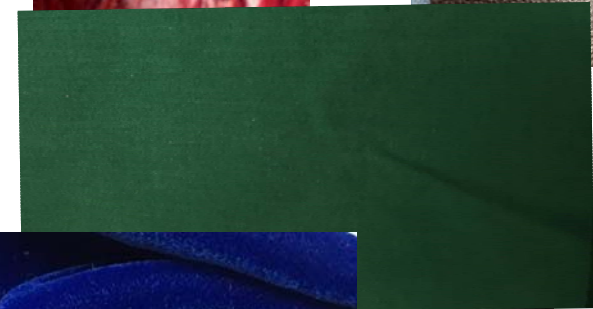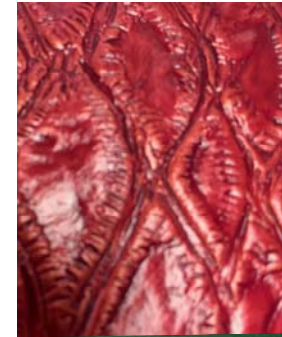# Why M3 might be used for colour management
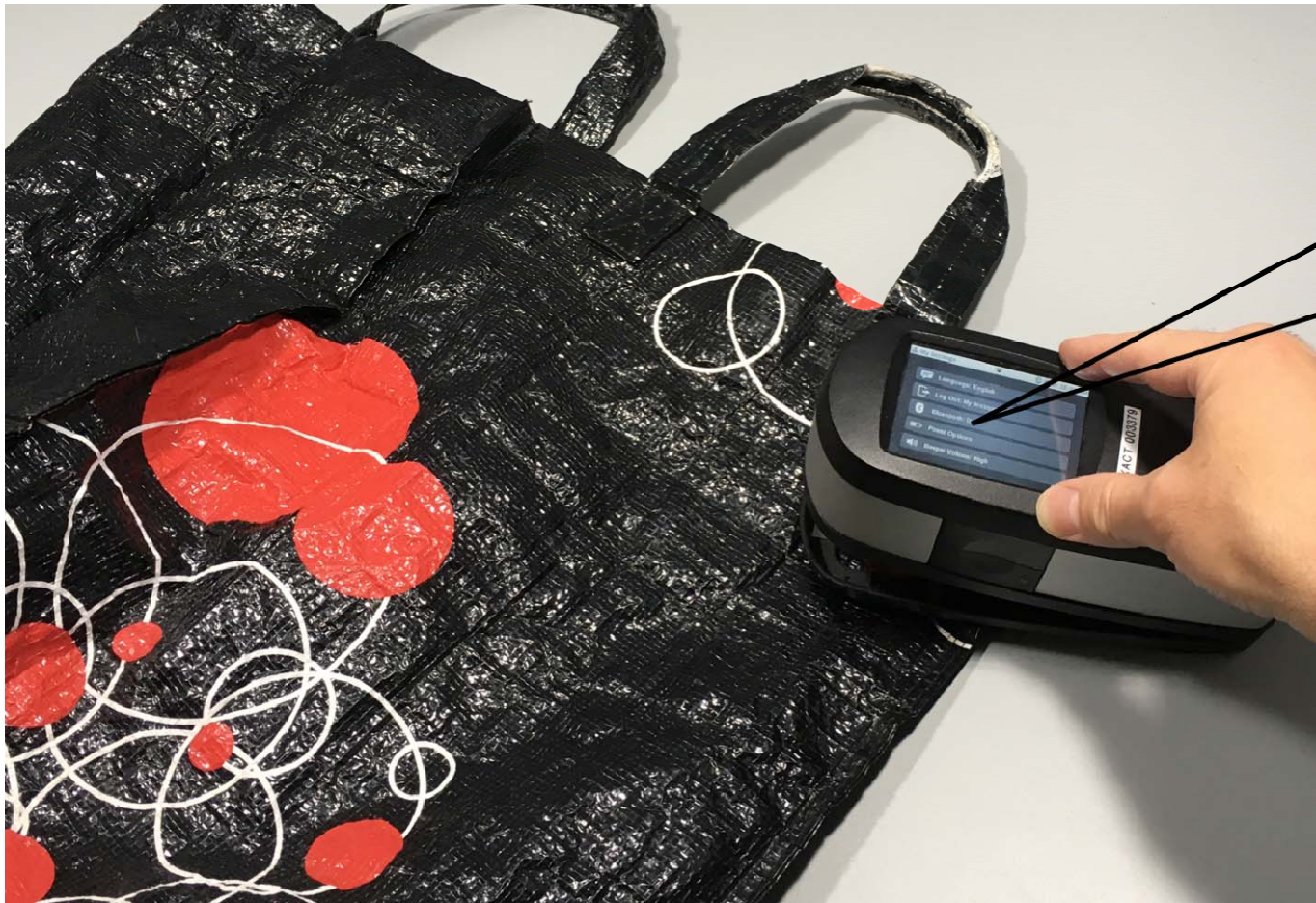
M2 & M3 profile of rough and glossy material

Assortment of Measured Objects

Differences between M2 and M3 for various media that were measured

Differences between M2 and M3 for various media that were measured

	Fabrics	Leather	Ceramic	Brushed Metal	Plastics
Maximum DeltaE	14.6	24.0	2.76	45.8	5.8
Minimum DeltaE	3.2	1.4	0.5	45.8	2.9
Average L_{M2}-L_{M3}	5.6	8.3	0.27	45.8	2.2

- **The difference between a M2 & M3 measurement is dependent on the individual properties of the media**
- **The differences can be very small to extremely large**
- **M3 is typically darker than M2**
- **The collection of plastic, metal, and ceramic objects measured was limited**
  - **It is expected that a broader range of surface properties would produce much greater variation in results**

Two Gray objects

Ceramic tile and laptop computer

|	M2 L*	M3 L*
Laptop computer	75.2	29.4
Ceramic Tile	58.1	57.6

- The laptop computer appears to be lighter than the ceramic tile.
- The M2 measurements show the laptop as being lighter than the tile.
- The M3 measurements show the laptop as being darker than the tile.
  - Only a darker tile would have a matching M3 measurement, therefore if two different materials have the same M3 measurements, it doesn't guarantee that they will have the same appearance.

How well does M3 work in a colour managed workflow?

Matching colour patch

Printout from
inkjet on paper

Leather sample
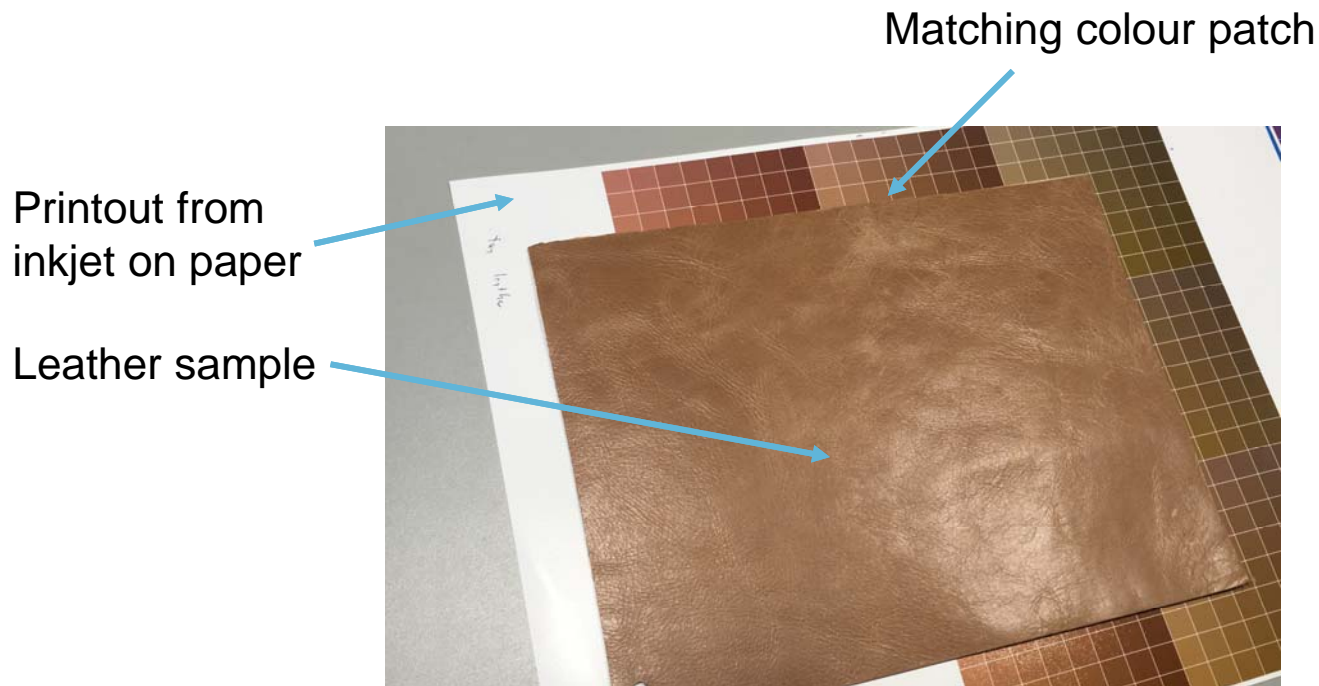
1. Find colour patch on printout that matches the sample
2. Compare M3 of sample to M2 of printout
3. Compare M2 of sample to M2 of printout

If M3 measurements can be correctly used for colour management, the M3 measurement of the sample should match the M2 measurement of the matching colour patch on the printout.

Differences between M2 & M3 measurements for different media that visually match

- **Media was chosen so that M0/M1/M2 measurements would be problematic**
- **Colors were chosen so that OBA impact was small**

	pink leather	purple leather	tan leather	green cloth	black cloth	pink cloth	red cloth	blue cloth	cyan plastic
DeltaE M3 & M2	3.9	8.7	8.2	3.5	7.3	2.9	4.8	4.9	0.92
DeltaE M2 & M2	3.3	4.1	1.8	2.8	7.2	6.1	3.1	2.5	1.12

- **For problematic media, neither M2 nor M3 is going to provide great results**
- **M2 seems more likely to produce better results, but in some cases M3 will work better.**

Conclusion

- **The M3 measurement condition doesn't correspond to a real viewing condition**
- **Two objects with the same visual appearance can have different M3 and M2 measurements**
- **M3 measurements should be used with caution when used for color management**

Questions?