New generation of imaging colorimeters and spectrophotometers

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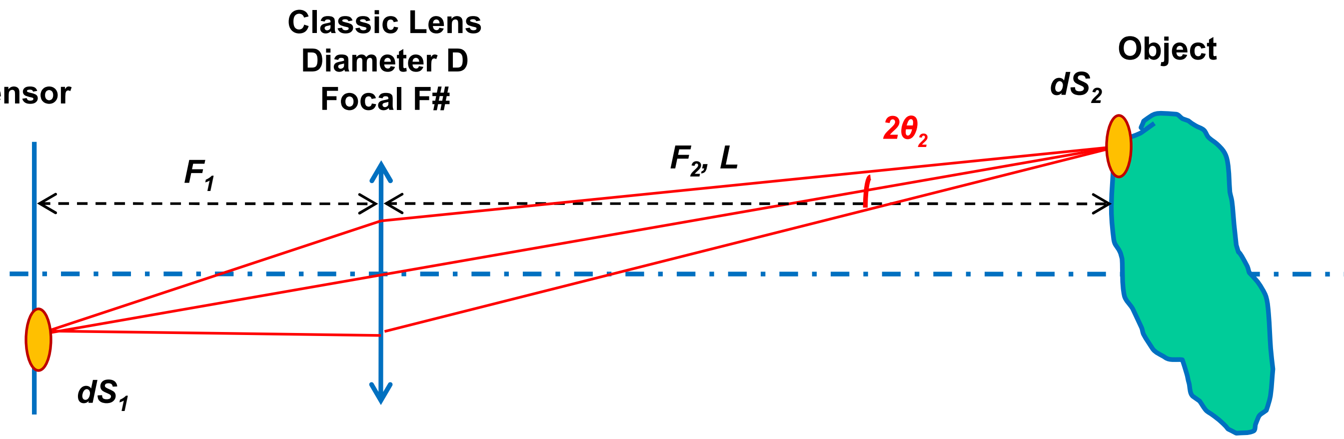
Agenda

1.	Imaging optics	
2.	Luminance & Colorimetry	=> UMaster
3.	Polarimetry	=> UMasterPz
4.	Multispectral imaging	=> UMasterMS
5.	High spatial resolution	=> Additional optics
6.	Ultrahigh spatial resolution	=> MVP
7.	Normal incidence measurements	=> TTO optics

Imaging optics: why telecentric optics ?

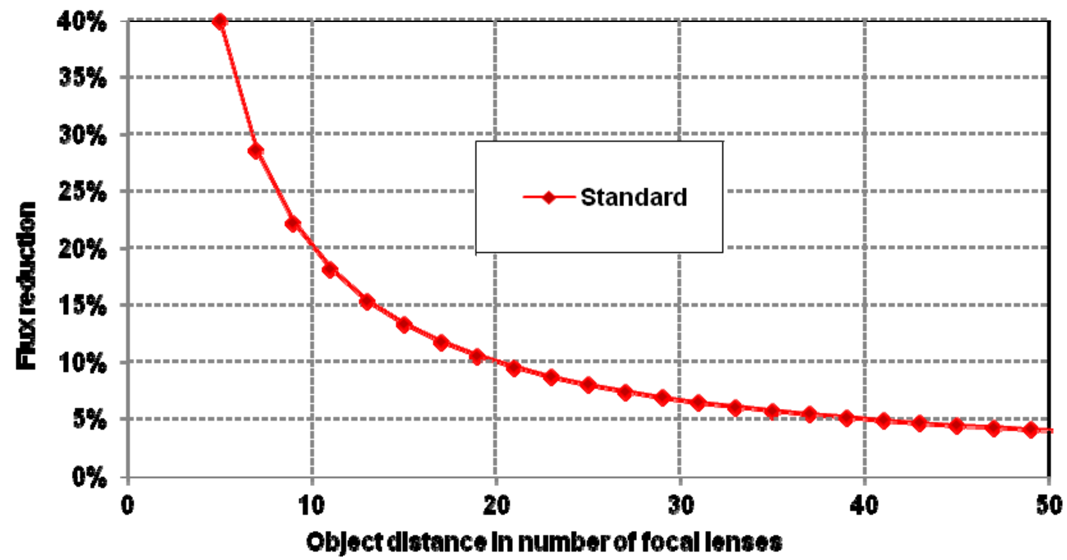
Standard imaging objective



Flux collected by one element surface of detector

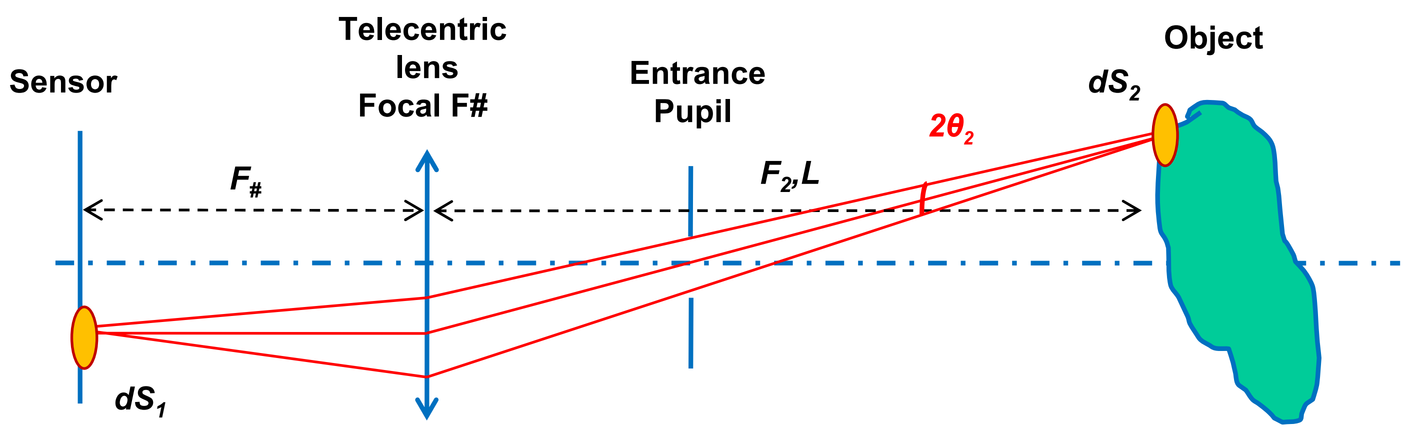
$$d\phi_1 = M_\infty \left(1 - \frac{2F\#}{F_2}\right) dS_1$$

First order dependence with distance



Flux reduction versus working distance

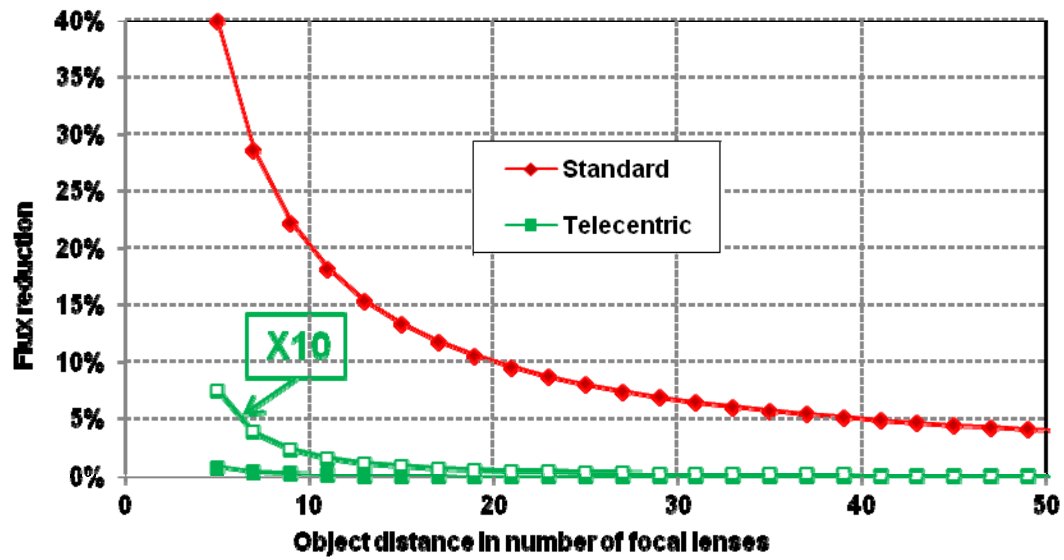
Telecentric imaging objective on sensor side



Flux collected by one element surface of detector

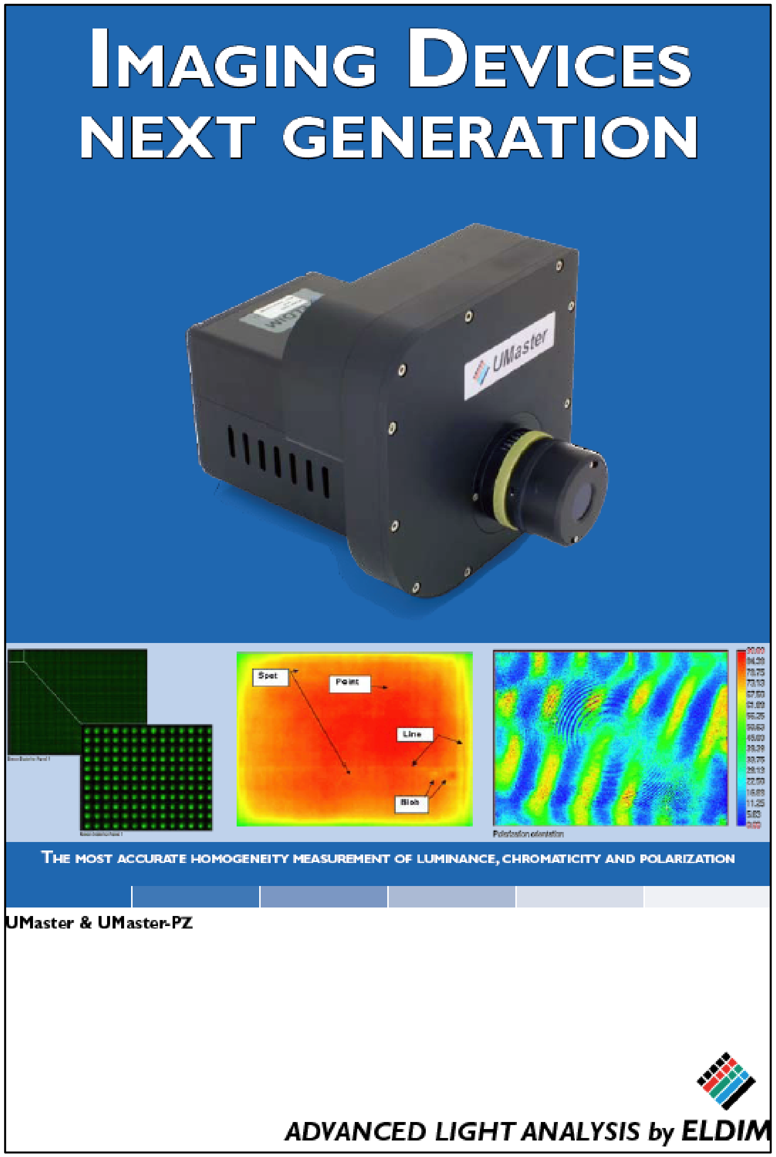
$$d\phi_1 = M_\infty \left(1 - \frac{3F\#^2}{16F_2^{\,2}}\right) dS_1$$

First order dependence with distance



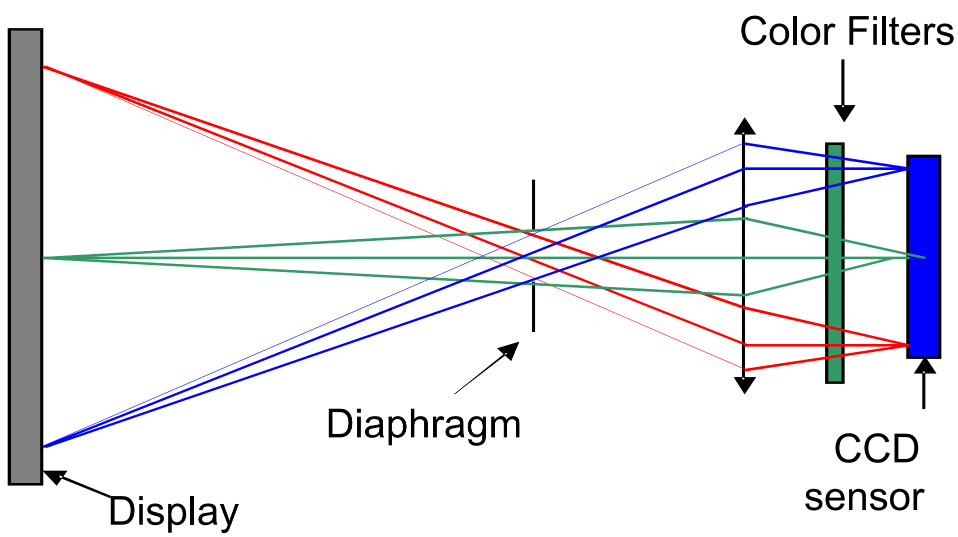
Flux reduction versus working distance

Imaging colorimetry : UMaster

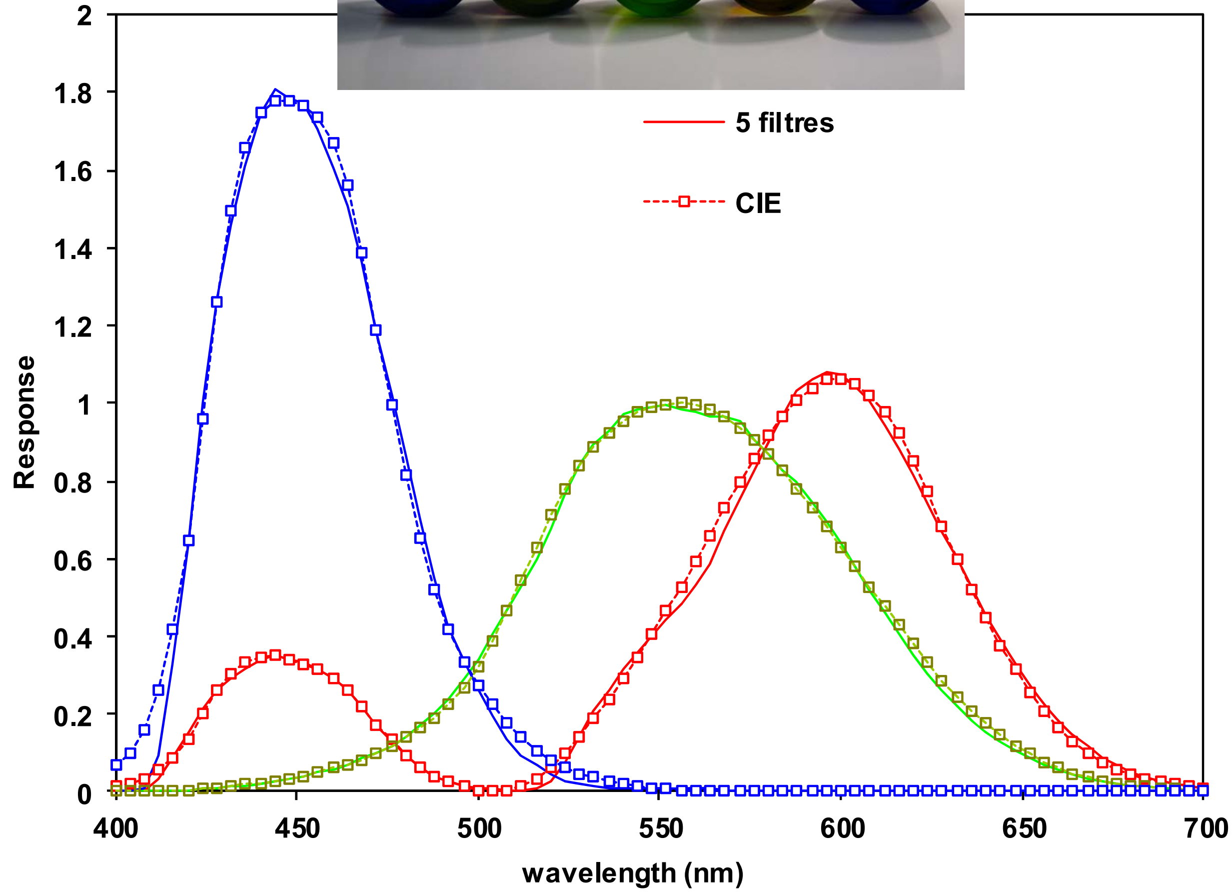


UMaster imaging colorimeter

- **Luminance or color measurements**
- **High resolution & high sensitivity**
- **Low stray light**
- **Entrance iris comparable to human pupil**
- **Polarization state measurements**



Imaging colorimetry : UMaster



Each system is matched closely with the CIE curves !

Imaging polarimetry : UMasterPZ

The electric field can be separated in two parts:

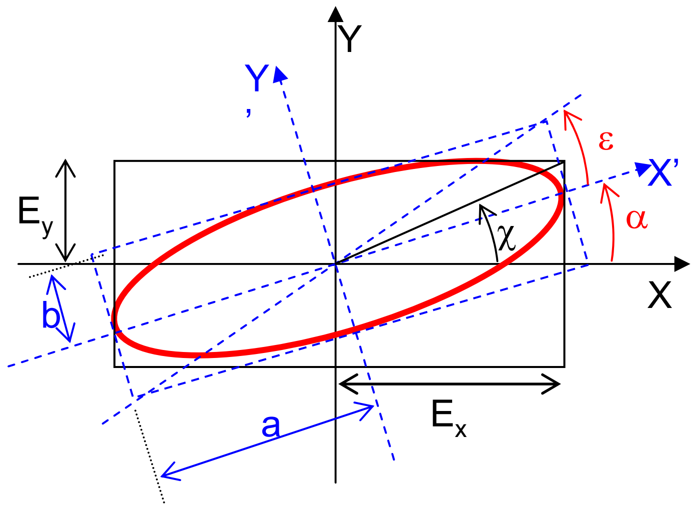
Unpolarized — Polarized

$$E_t = E_{np} + E_p$$

$$\rho = \frac{E_x^{\,2} + E_y^{\,2}}{I_t} = \frac{I_p}{I_t}$$

Degree of polarization ρ

$$\frac{X^2}{E_x^{\,2}} + \frac{Y^2}{E_y^{\,2}} - 2\frac{XY}{E_x E_y}\cos\varphi = \sin^2\varphi$$



Definition of the ellipticity ε=tan(b/a)

To define completely the light polarization state we need:

- The polarization direction α
- The ellipticity ε=tan(b/a)
- The degree of polarization ρ

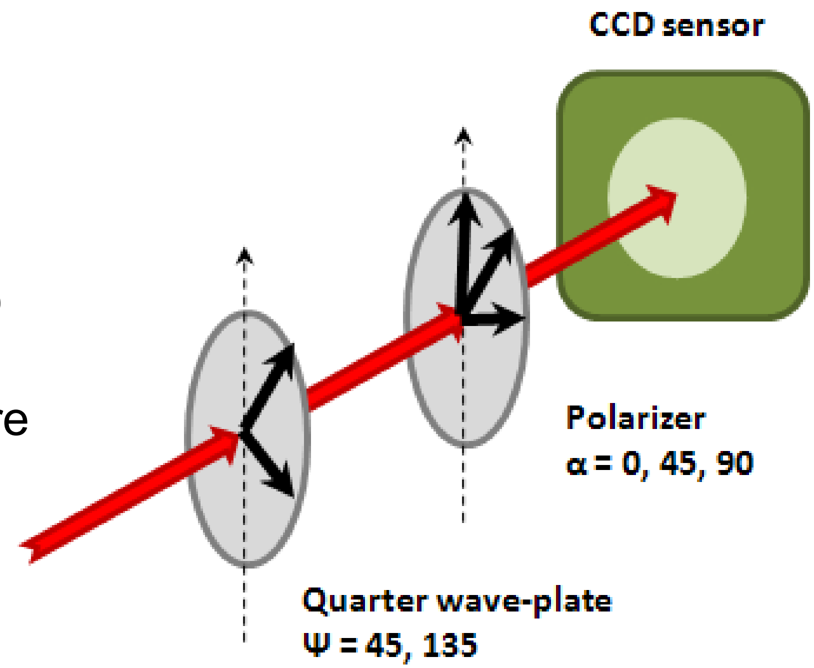
Imaging polarimetry : UMasterPZ

The system makes automatically the following measurements for a given wavelength :

➢3 measurements with 3 polarizer orientations
M(0°),M(45°) and M(90°)

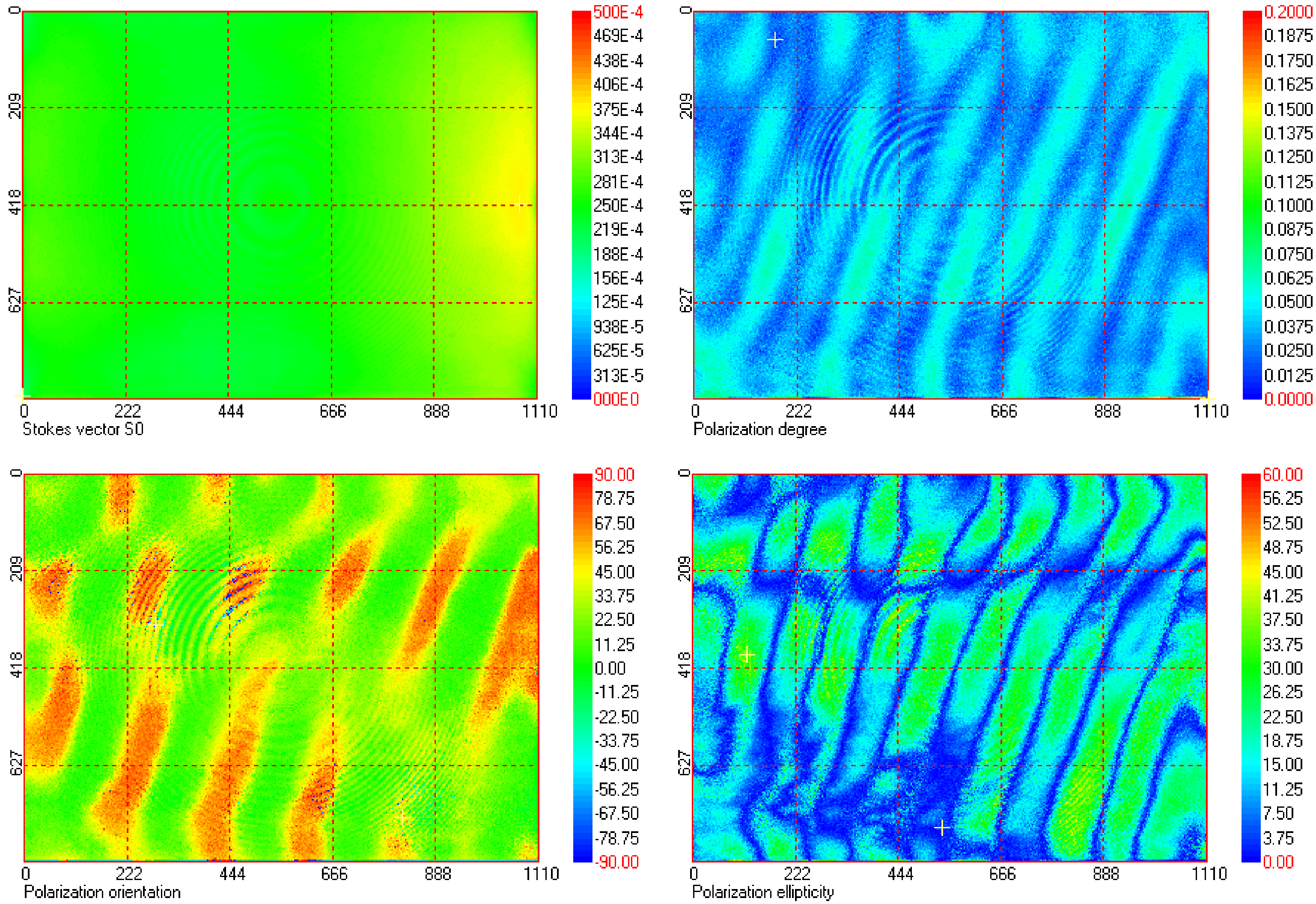
➢4measurements with additional 1/4 wave-plate
M(0°, 45°), M(0, 135°), M(90°, 45°) and M(90°, 135°)

The polarization parameters and the Stokes are deduced for each pixel of the image:



$$S = \begin{bmatrix} I \\ Q \\ U \\ V \end{bmatrix} = I.\begin{bmatrix} 1 \\ \rho.\cos 2\varepsilon.\cos 2\alpha \\ \rho.\cos 2\varepsilon.\sin 2\alpha \\ \rho.\sin 2\varepsilon \end{bmatrix}$$

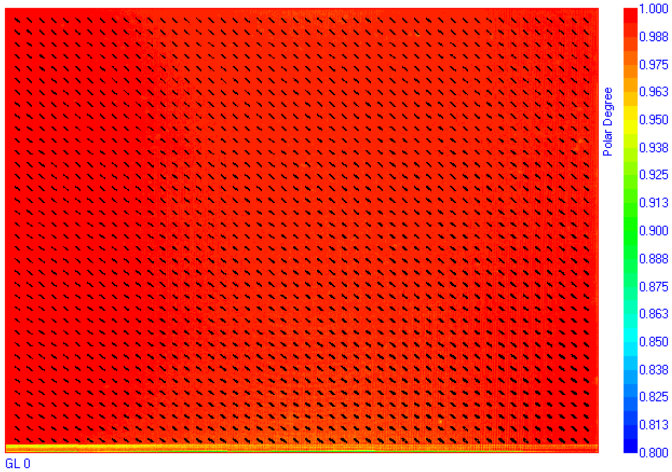
Imaging polarimetry : UMasterPZ



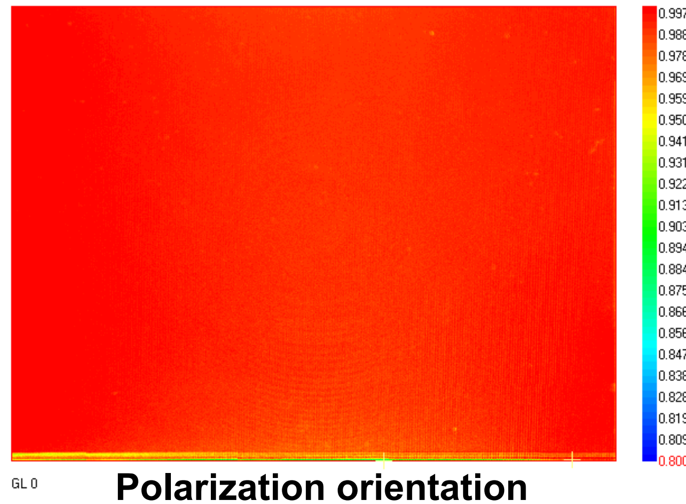
Imaging polarization of a LCD backlight with BEF film

Imaging polarimetry : UMasterPZ

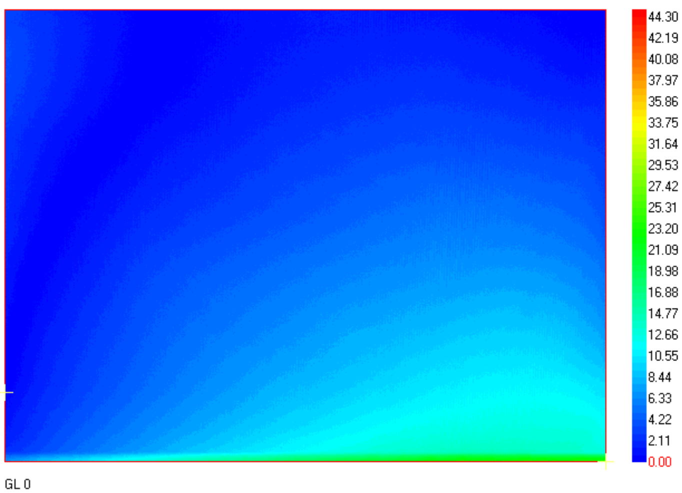
Full polarization



Polarization degree

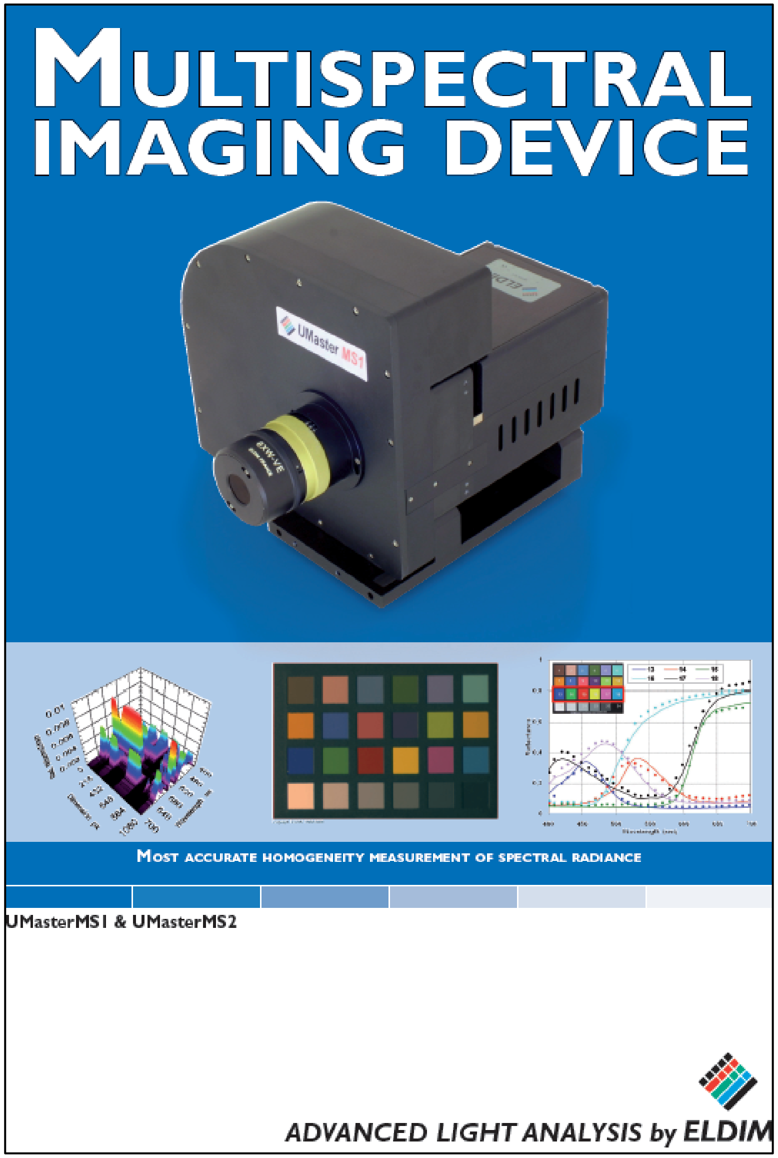


Polarization ellipticity



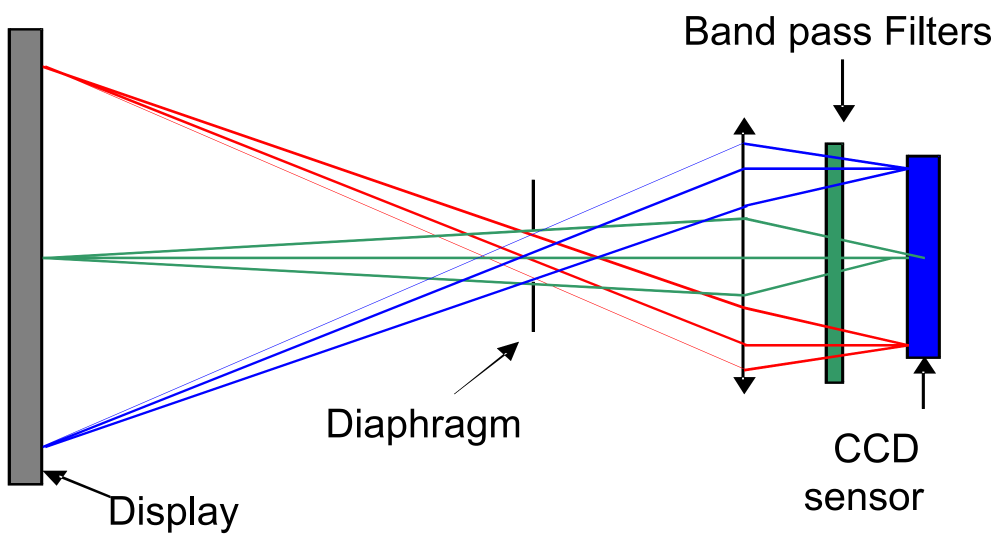
Polarization orientation

Imaging polarization of a LCD without top polarizer versus grey level

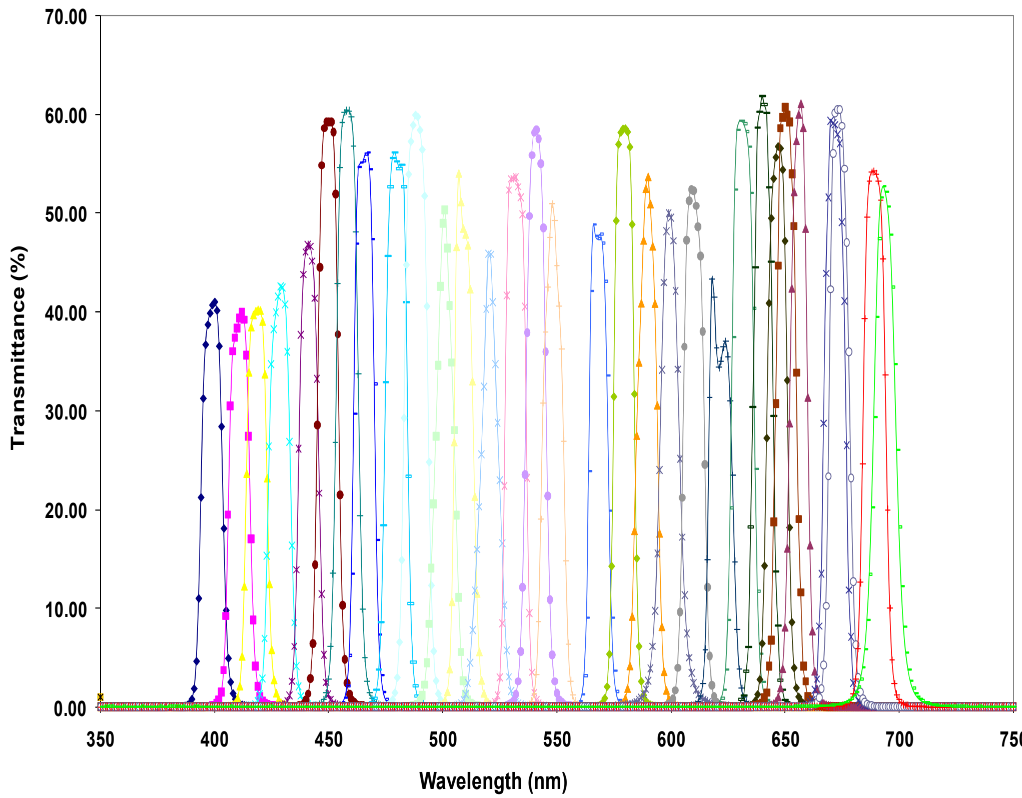


UMasterMS imaging spectrophotometer

- **Radiance measurements**
- **High resolution & high sensitivity**
- **Low stray light**
- **Entrance iris comparable to human pupil**
- **Polarization state measurements**



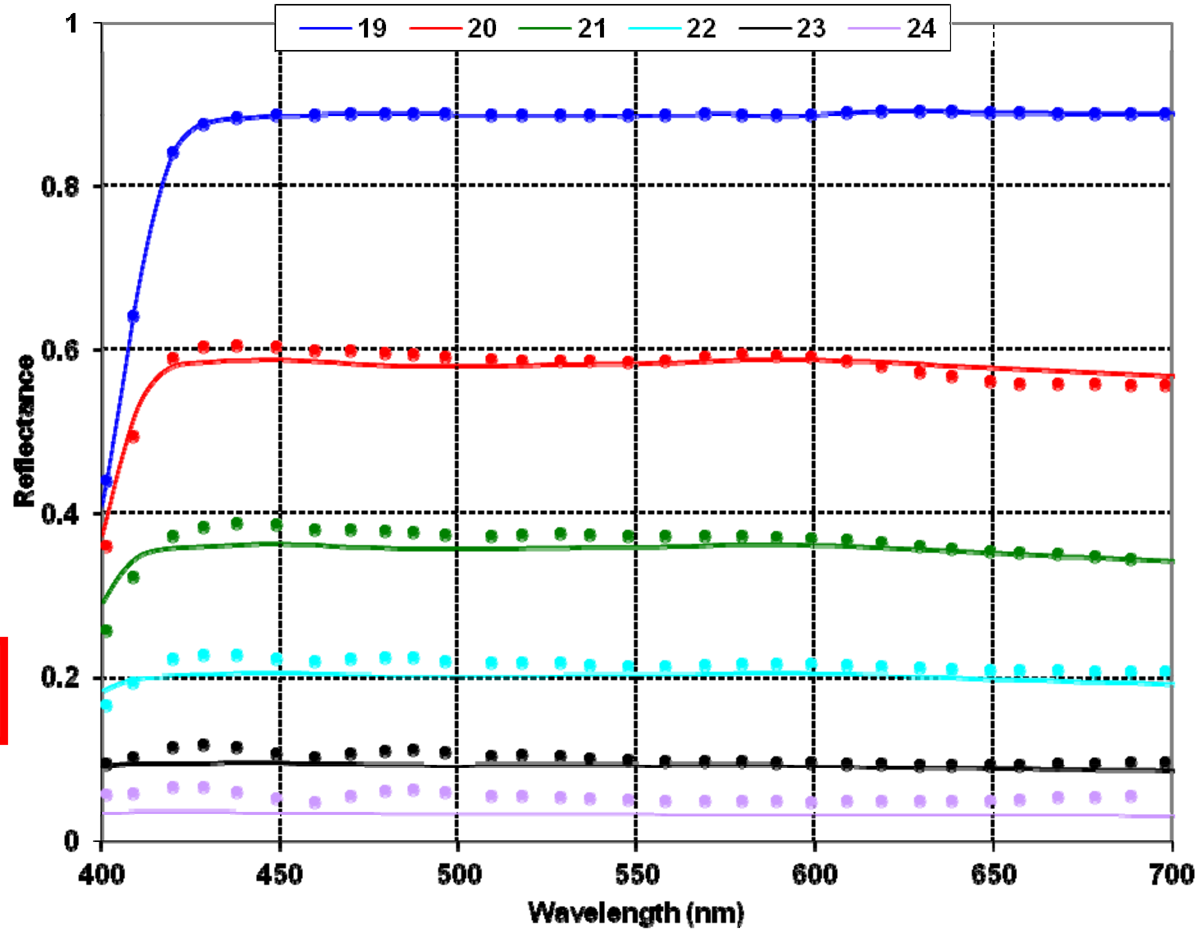
Multispectral imaging : UMasterMS



Filter wheel and transmittance of the 31 interference filters

Multispectral imaging : UMasterMS

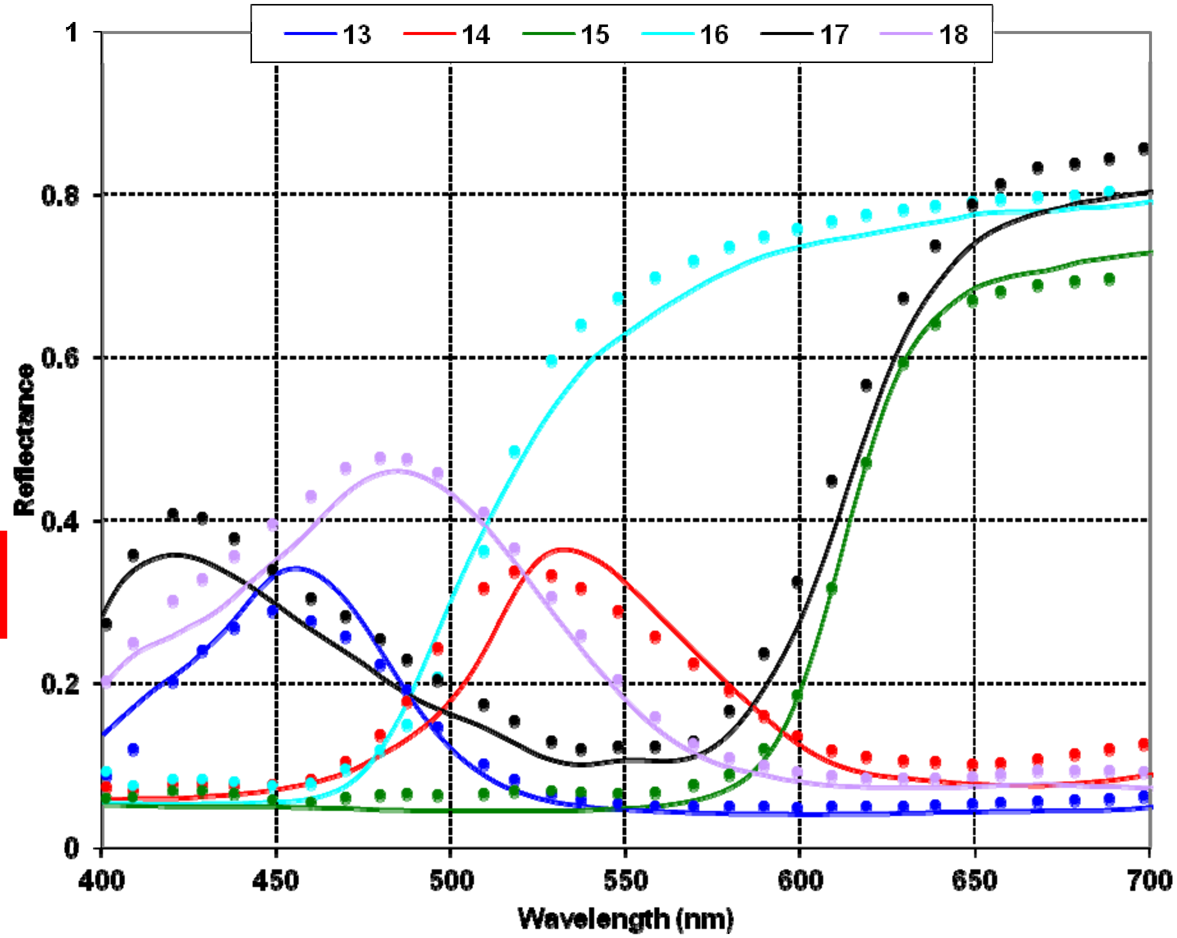
GretaMacbeth color checker 24 natural object, chromatic, primary and gray scale colors



Measured reflection coefficients versus wavelength GretaMacbeth characteristics are also reported

Multispectral imaging : UMasterMS

GretaMacbeth color checker
24 natural object, chromatic, primary and gray scale colors



Measured reflection coefficients versus wavelength
GretaMacbeth characteristics are also reported

Multispectral imaging : UMasterMS

GretaMacbeth color checker
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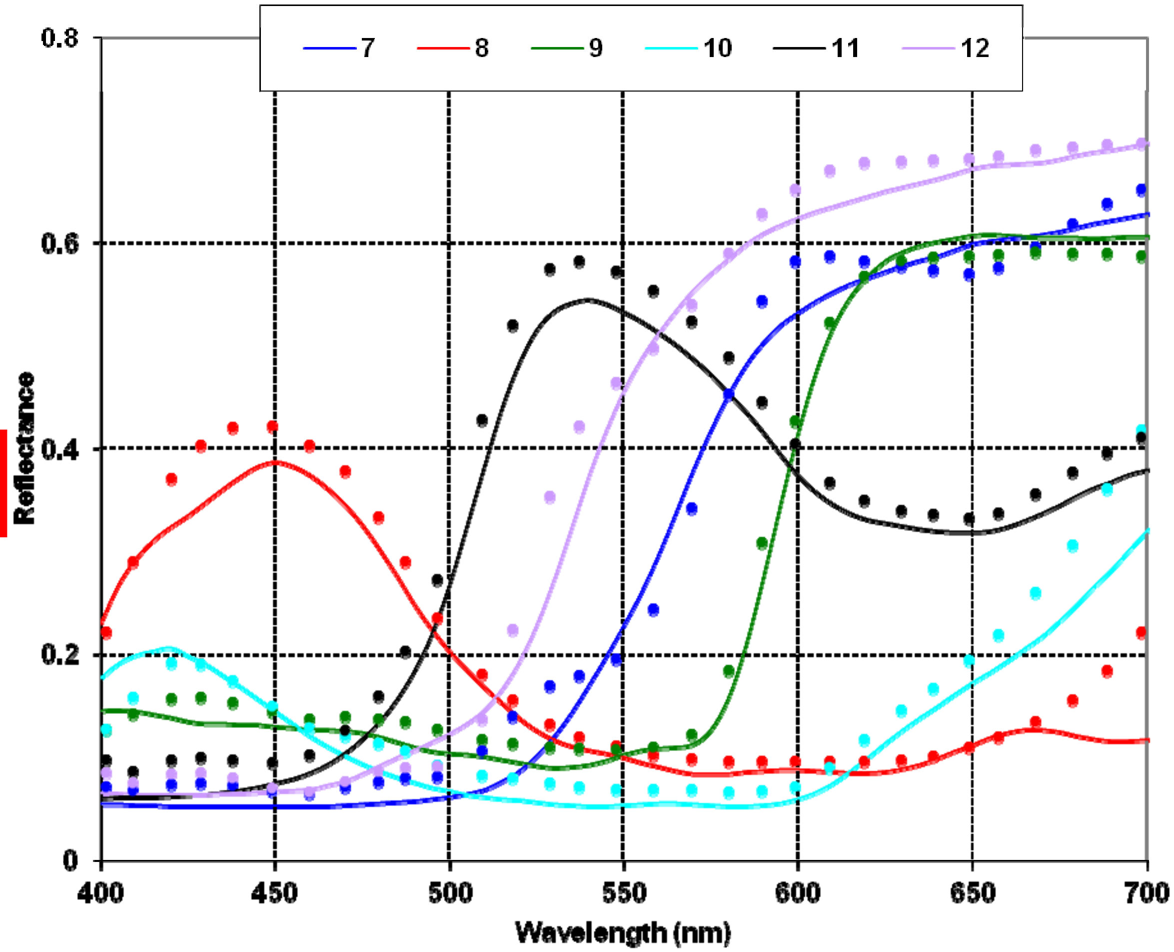

Measured reflection coefficients versus wavelength
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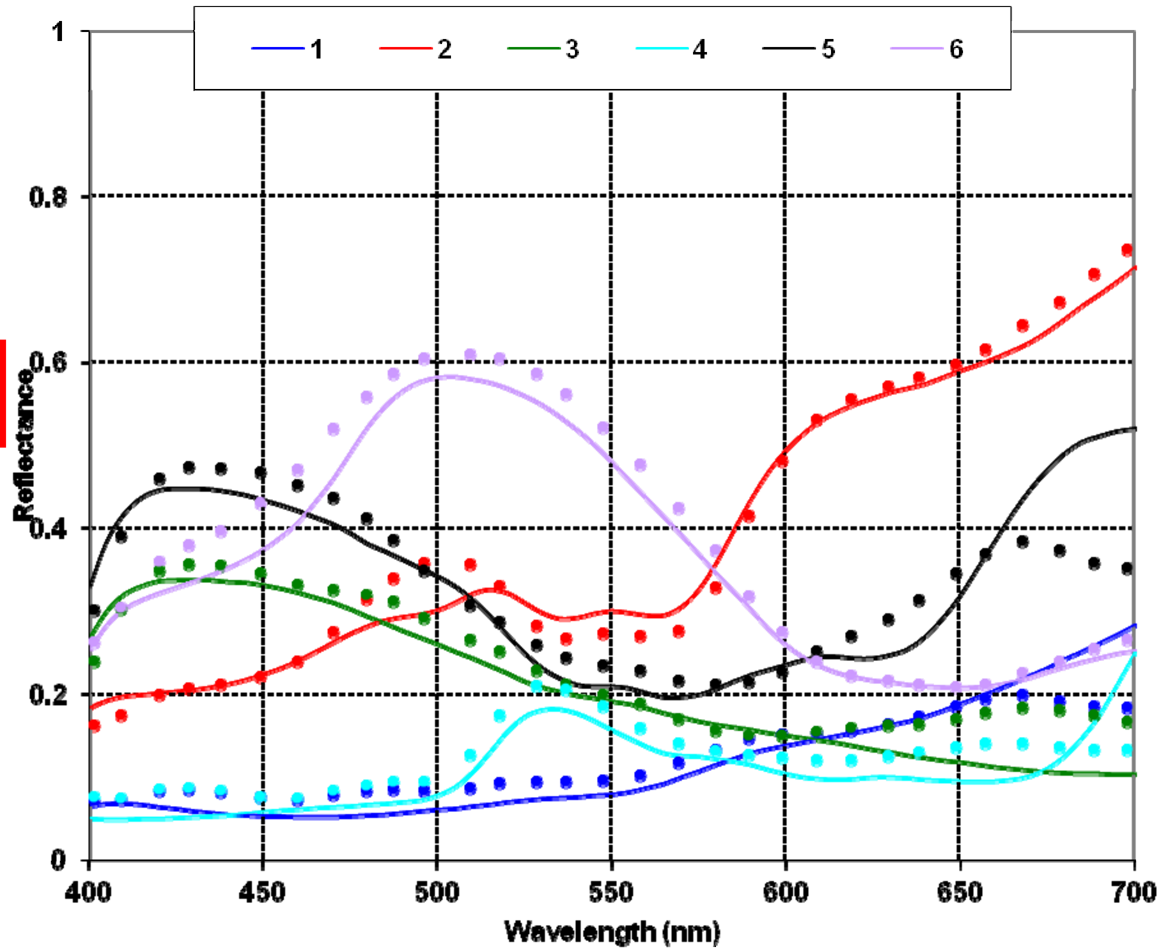
Multispectral imaging : UMasterMS

GretaMacbeth color checker 24 natural object, chromatic, primary and gray scale colors



Measured reflection coefficients versus wavelength GretaMacbeth characteristics are also reported

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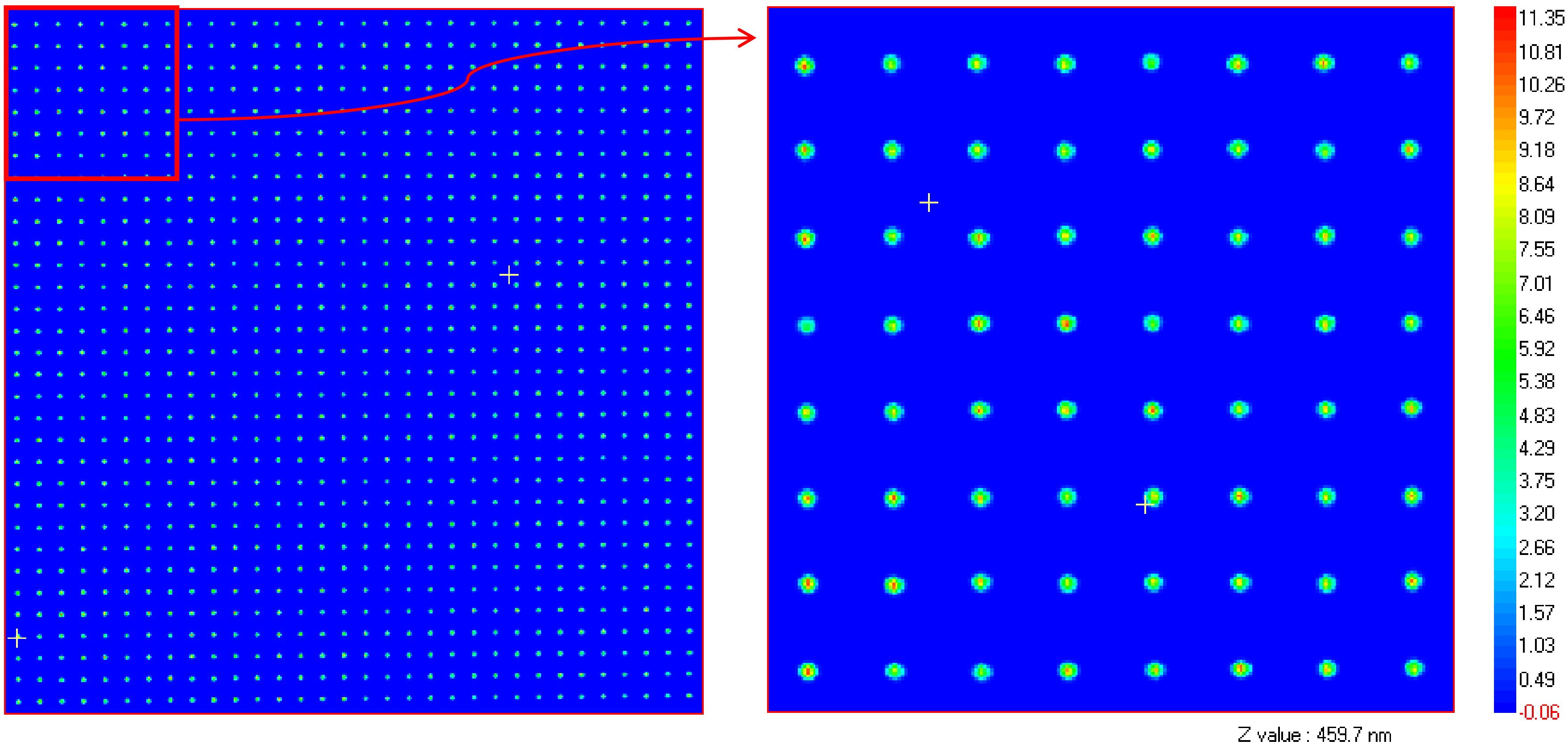
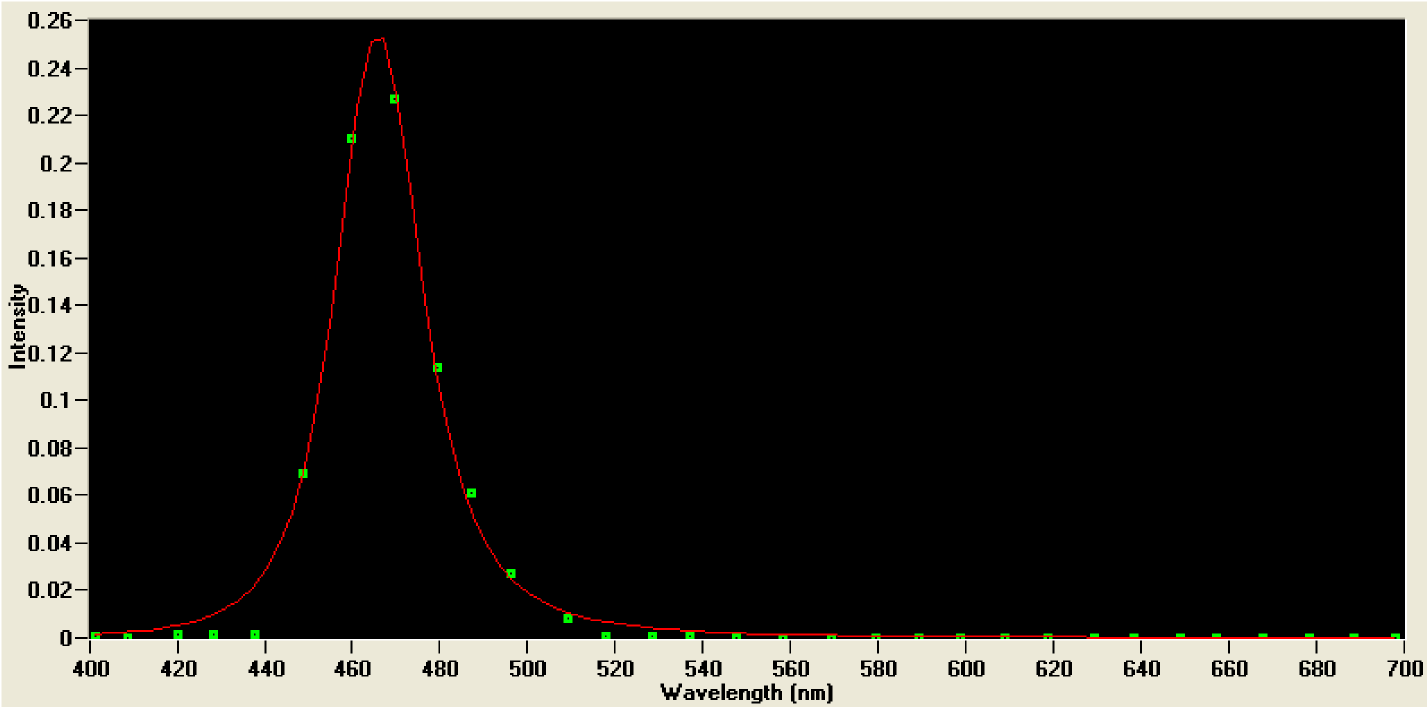
Multispectral imaging : UMasterMS



LEDWall tile measurement of blue LEDs

Multispectral imaging : UMasterMS

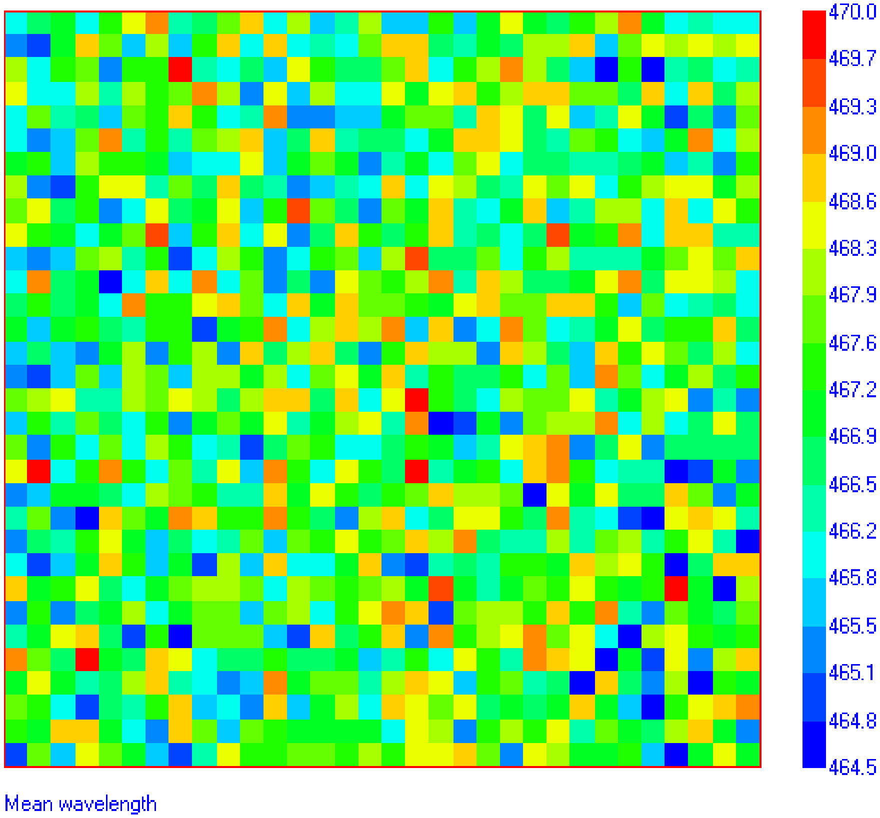


$$f = \frac{1}{\left[1 + \left(\frac{2(x-x0)\cdot\sqrt{2^{1/M}-1}}{w}\right)^2\right]^M}$$

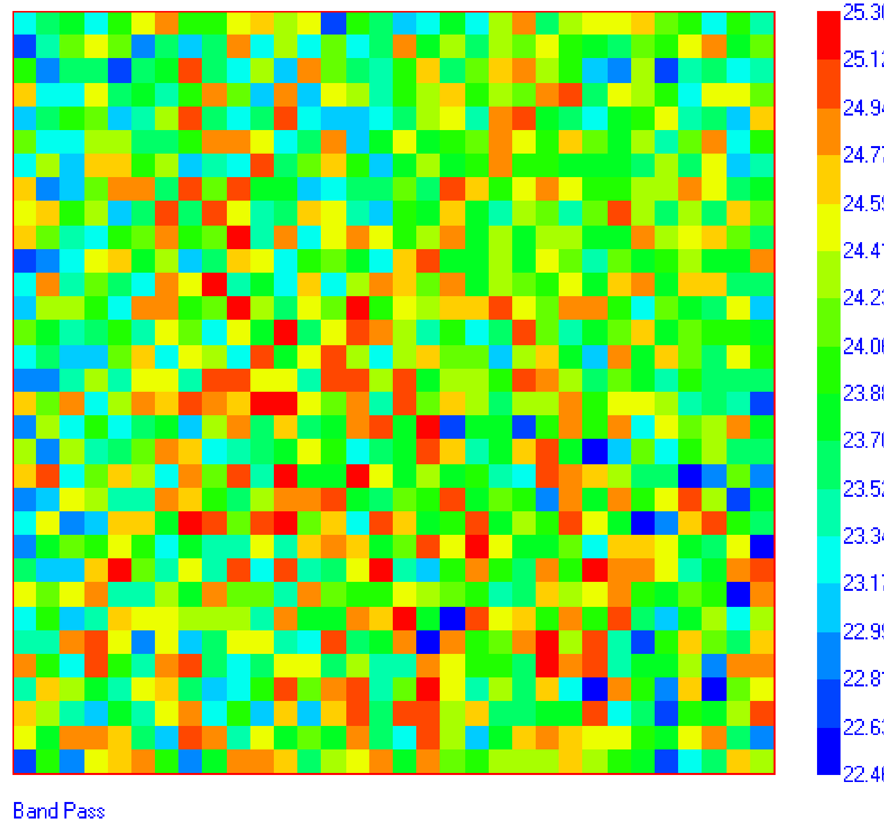
X_0 = wavelength mean position
ω = wavelength band pass

Emission peak adjustment using Pearson VII model

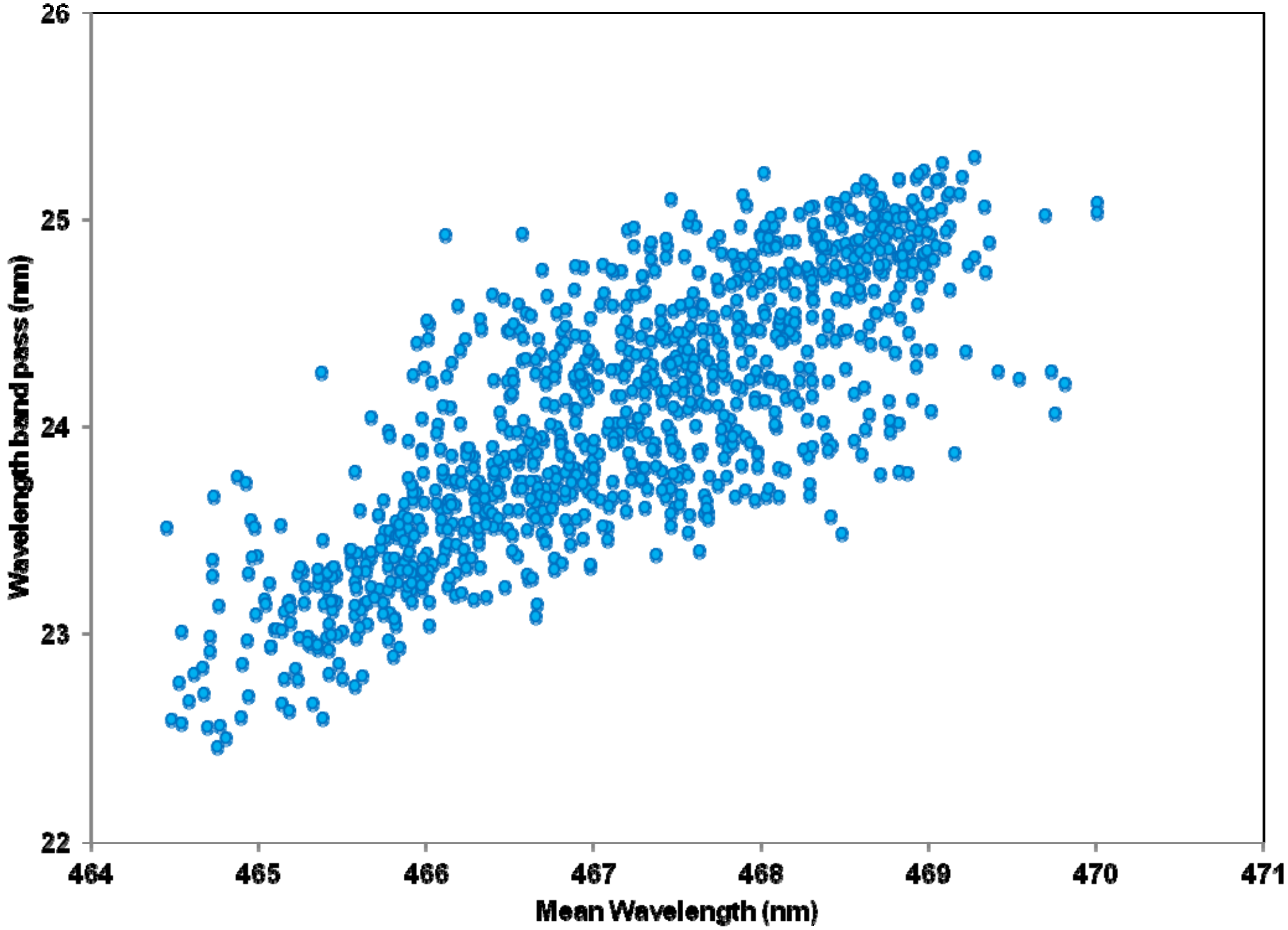
Multispectral imaging : UMasterMS



Mean wavelength of blue LEDs

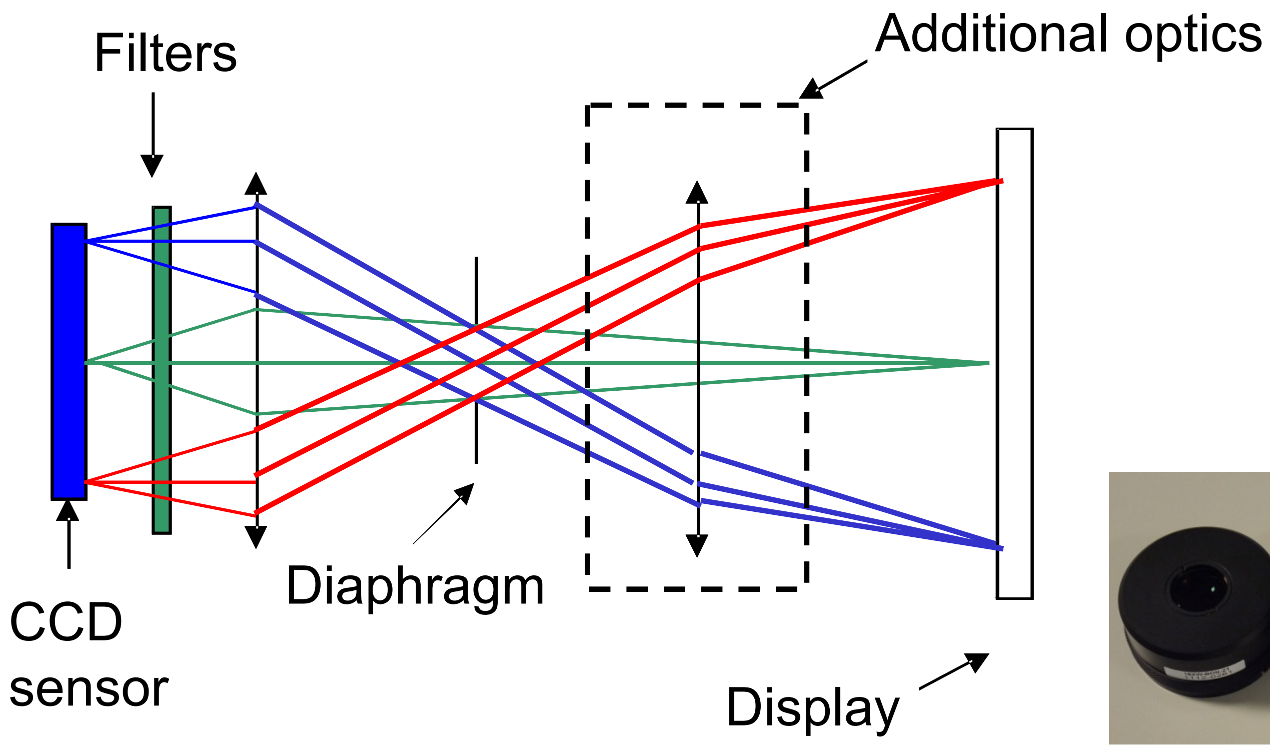


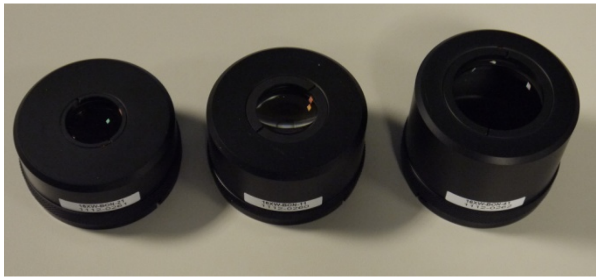
Band pass of blue LEDs



Correlation between mean wavelength and band pass for blue LEDs

High spatial resolution imaging : UMaster + add. optics

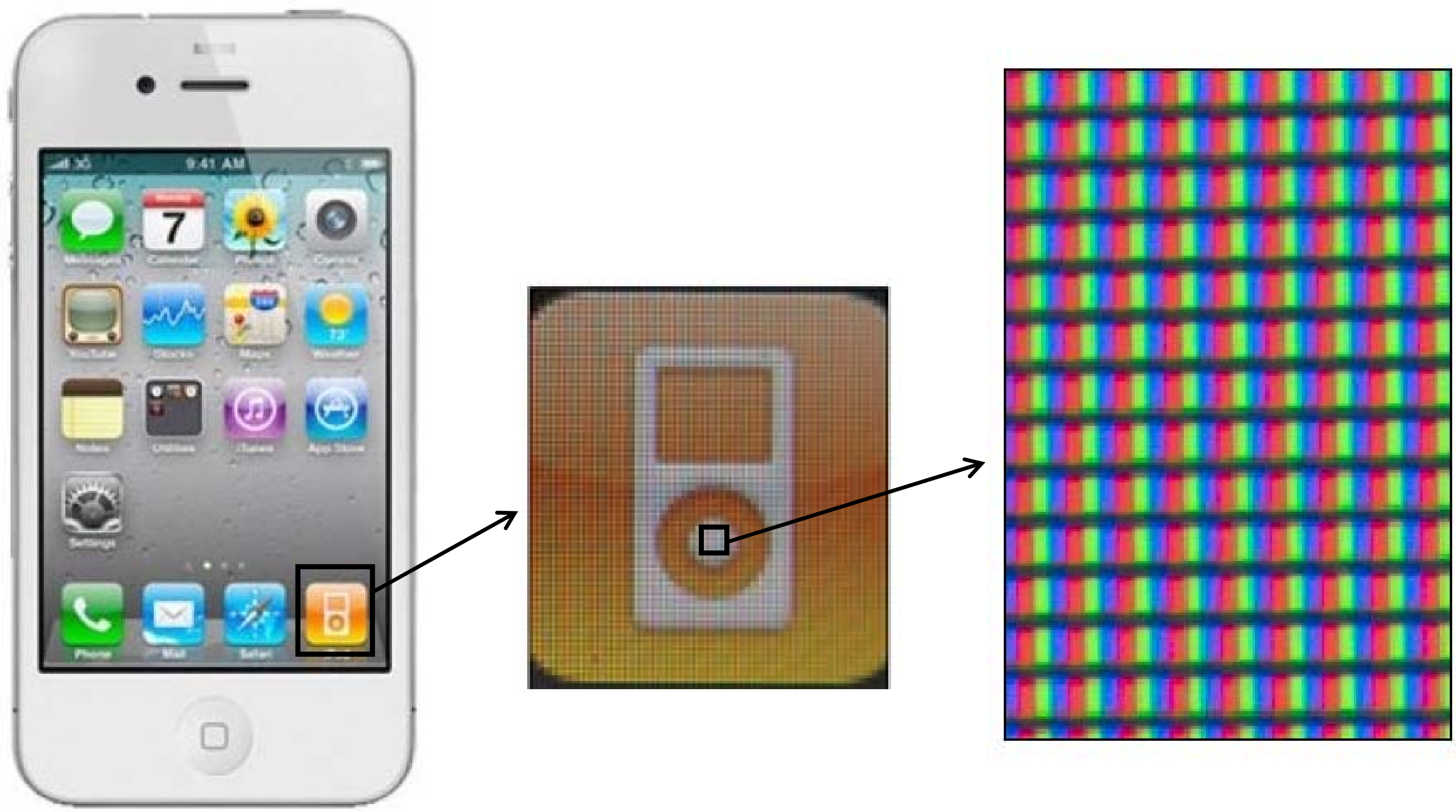




3 additional optics available for UMaster

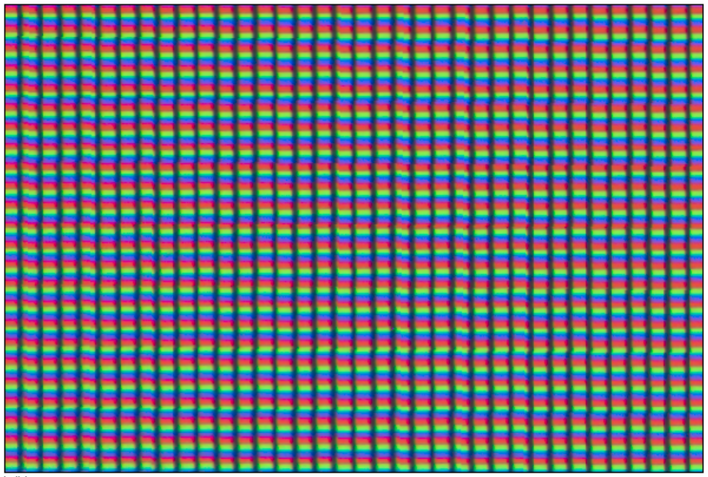
Magnification	Spatial resolution	Field of view	Working distance
X1	9x9µm	13.5x9mm	30mm
X2	18x18µm	27x18mm	60mm
X4	36x36µm	54x36mm	120mm

High spatial resolution imaging : UMaster + add. optics

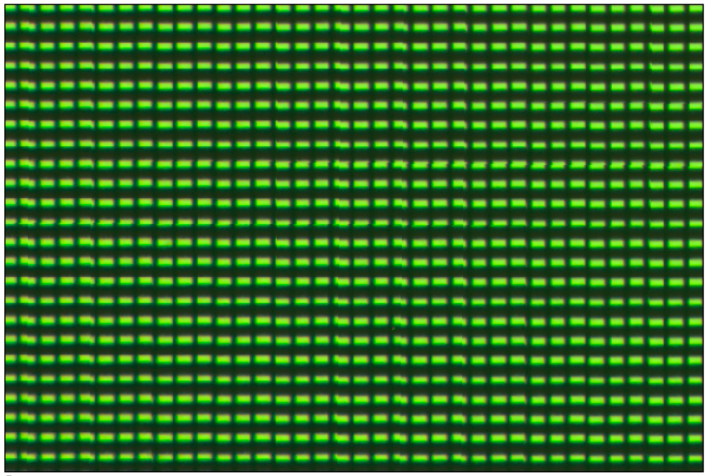


Individual pixels can be measured precisely

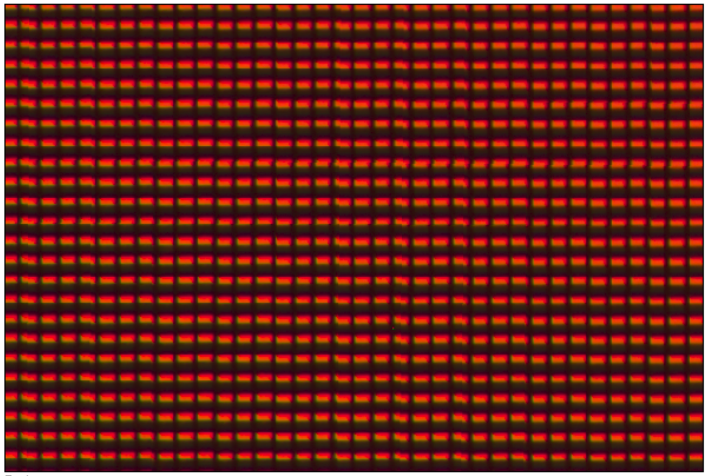
High spatial resolution imaging : UMaster + add. optics



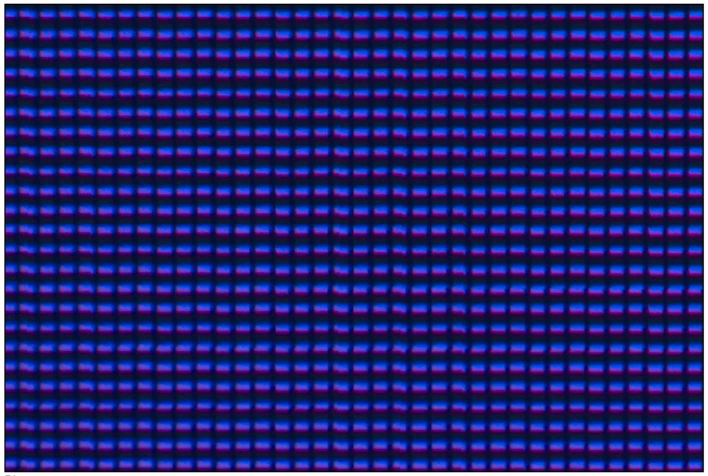
White



Green



Red

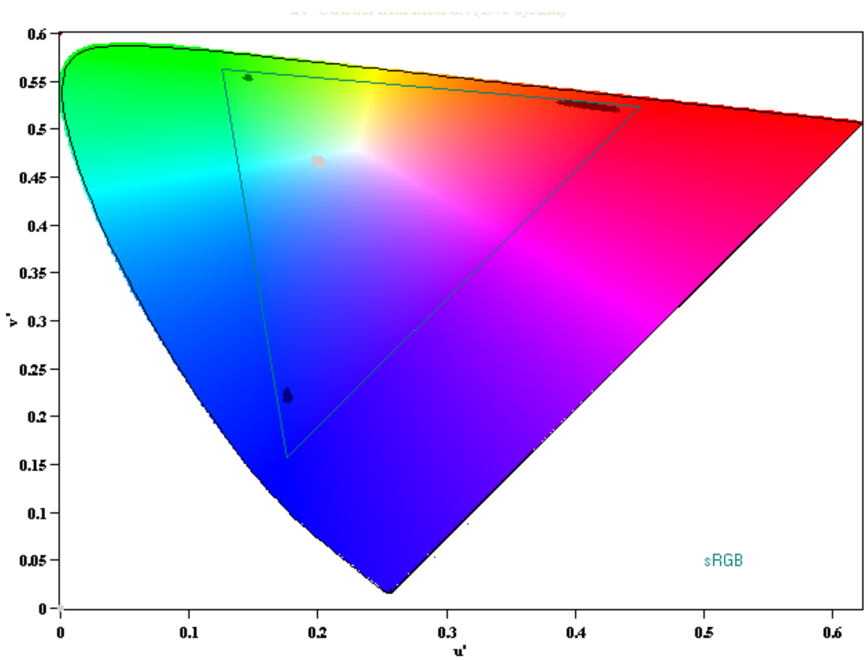


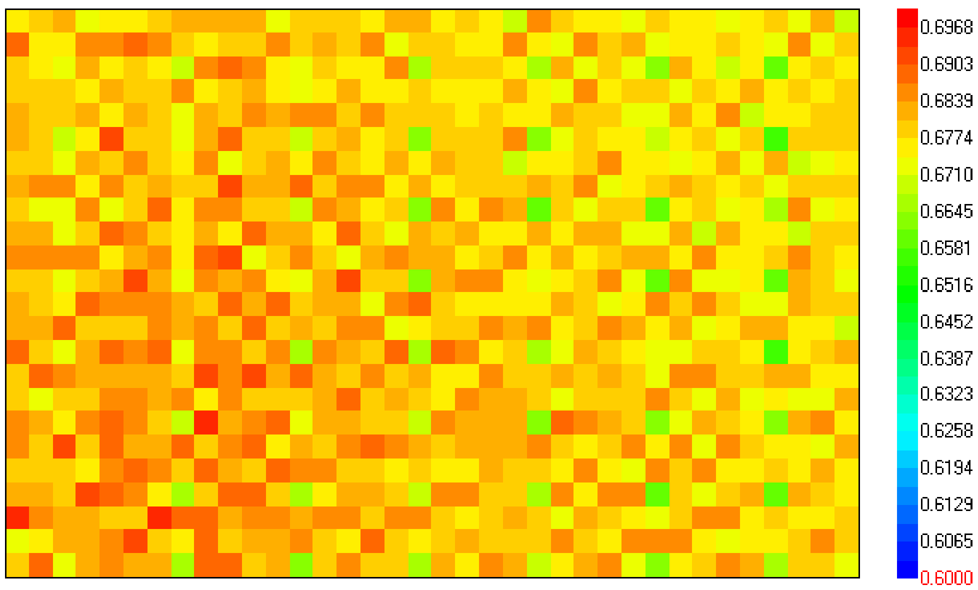
Blue

OLED display (250 ppi pixel density)

White, Red, Green & Blue

High spatial resolution imaging : UMaster + add. optics





Gamut distribution in the chromatic plane

Gamut distribution on the display surface

Single pixel characteristics can be extracted

Ultra high spatial resolution imaging : MURA MVP

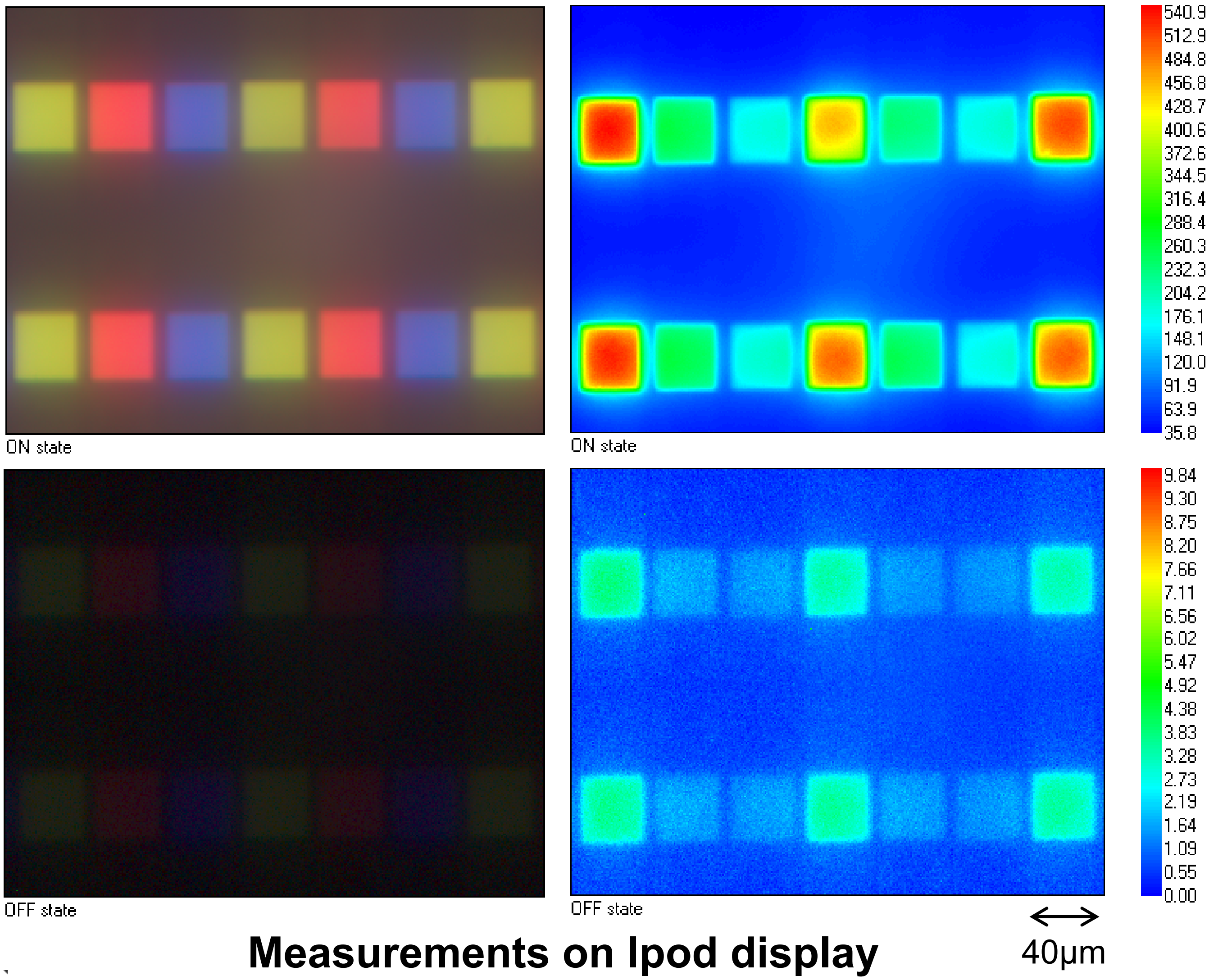
MURA MVP is the new generation of ELDIM Micro Video Photometer. The system uses the UMaster technology coupled to highh quality microscope objectives.

3 magnifications available:

Objective	Field of view	Max spatial Resolution
x20	650x440µm	0.5µm
x10	1300x880µm	1µm
x5	2600x1760µm	2µm

Ultra high spatial resolution imaging : MURA MVP

Color **Luminance**



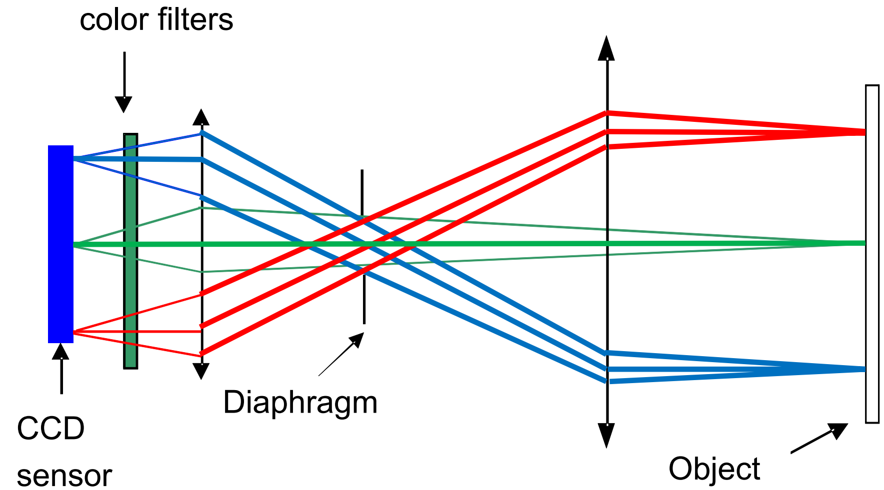
ON state

OFF state

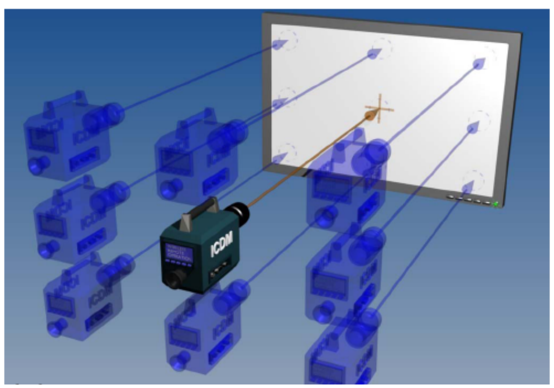
Measurements on Ipod display

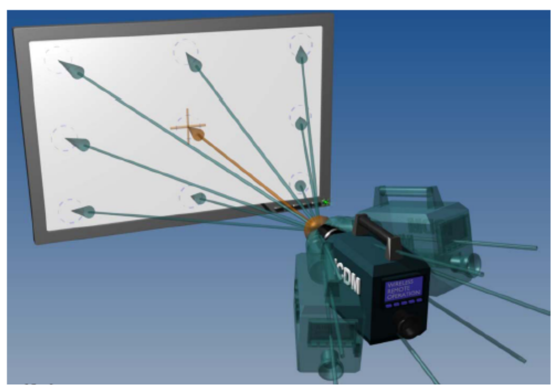
Normal incidence measurements : double telecentric

ELDIM proposes now a series of **double telecentric objectives** with various sizes that allow near normal incidence analysis of **small & medium display with unprecedented accuracy**. Luminance, color, polarization and radiance can be measured with the new generation of **UMaster** instruments and this new family of optics.



Available sizes:
- 9 inches
- 12 inches





Normal incidence measurements become possible

Thanks for your attention

Come to see us at booth 560

ELDIM

ELECTRONICS FOR DISPLAYS AND IMAGING DEVICES

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