



THE MICRO-OPTICS SUPPLIER



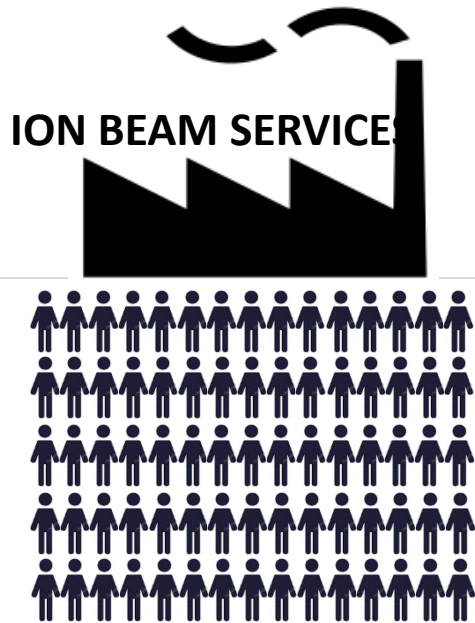
Hybridization of Multispectral Filters: Emergence and Deployment of an integrated technology for Spectrometry & Multispectral imaging



Thierry BERTHOU

EPRISE Roadshow – BARCELONA 2019
Photonics in Agriculture, Packaging and Food

WHO ARE WE?

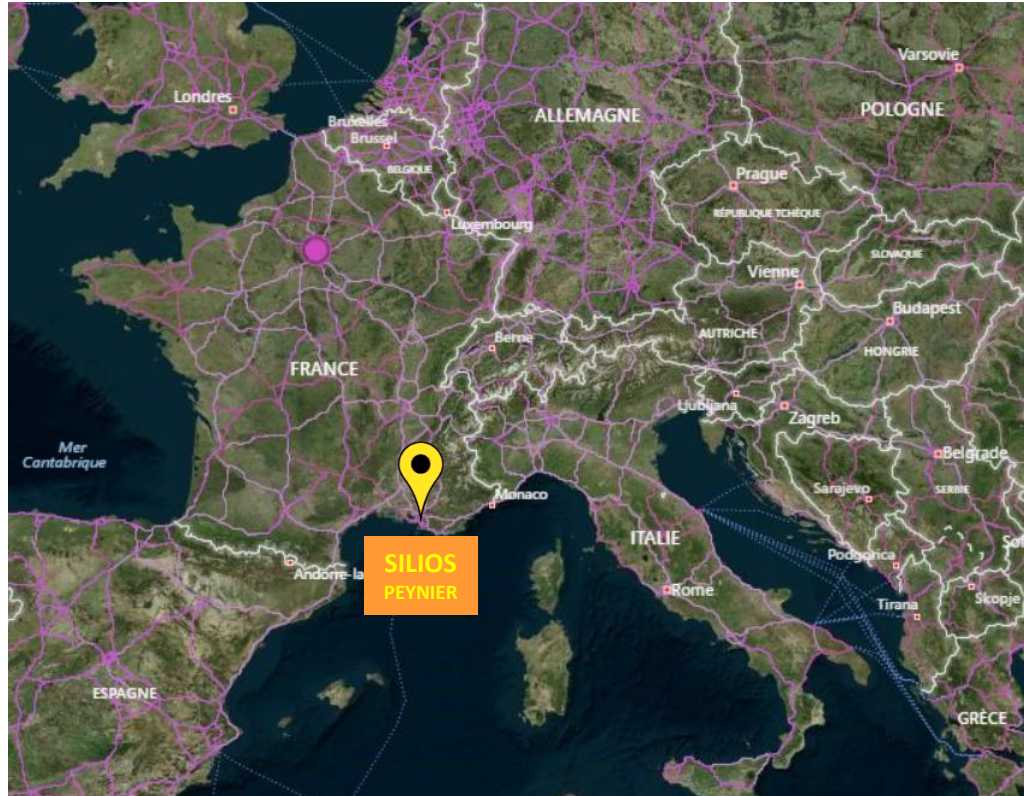


Spin-off

10 people
Established in 2001
Photonics

80 people
Established in 1987
Semiconductor

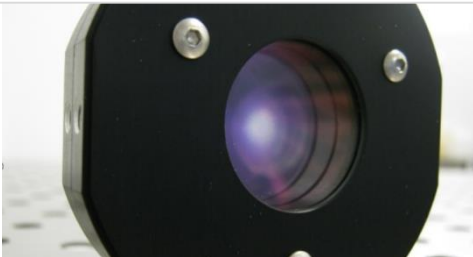
WHERE ARE WE?



OUR CORE BUSINESS



... Two Product Ranges



MICRO-OPTICS (2001)
SCIENTIFIC & INDUSTRIAL LASERS, ASTRONOMY & SPACE

A single Process : Realization of Multilevel Phase Profiles thanks to a cumulative etching process



MULTISPECTRAL (2009)
MULTISPECTRAL IMAGING
First Multispectral Camera introduced end of 2015



CMS series

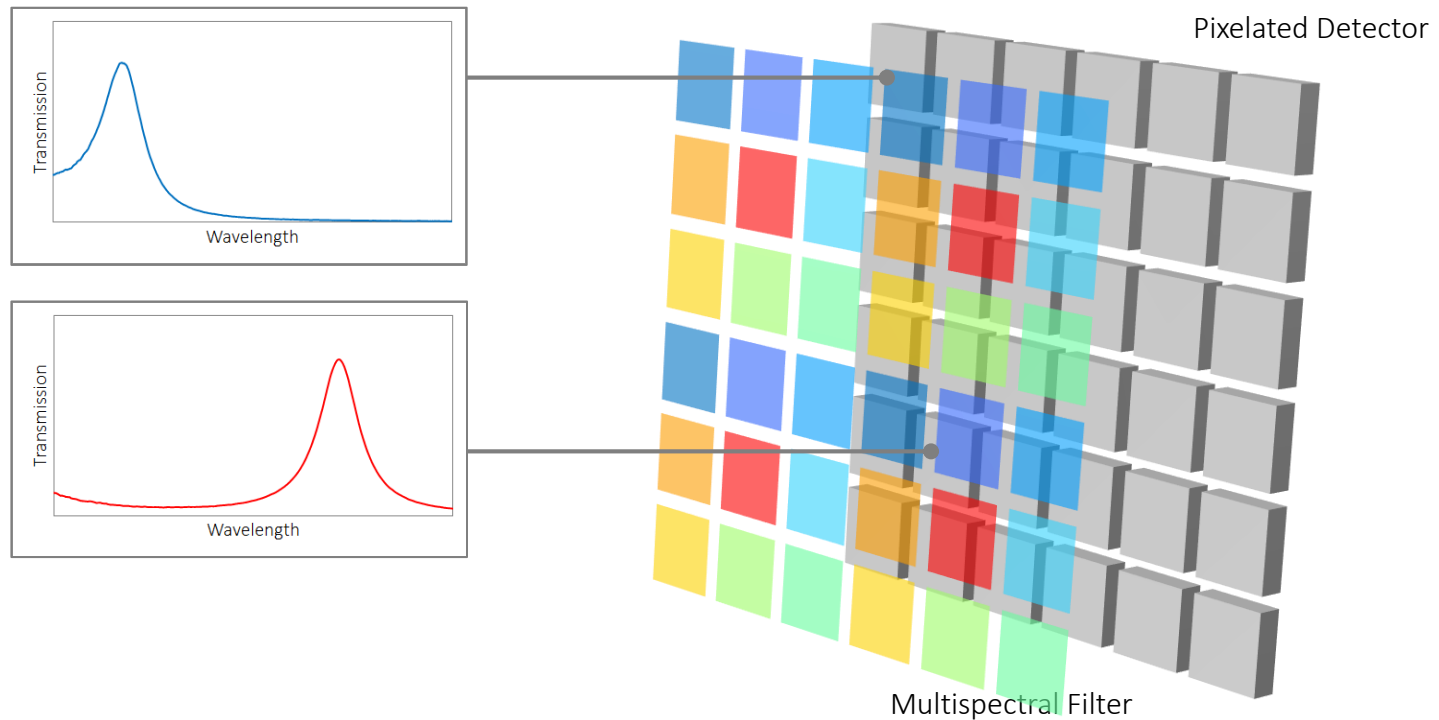


Area : 600 m²
Class : 100 down to 10 (FS209)
5 down to 4 (ISO)

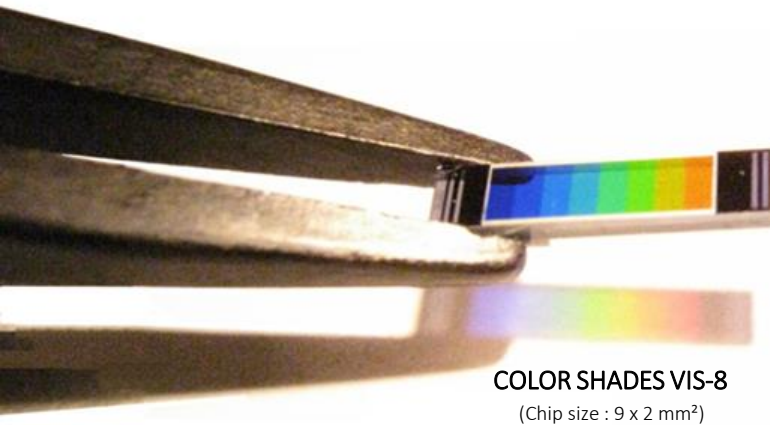


COLOR SHADES[®] Technology

Technology for Multispectral Filters



COLOR SHADES® Multispectral Filters



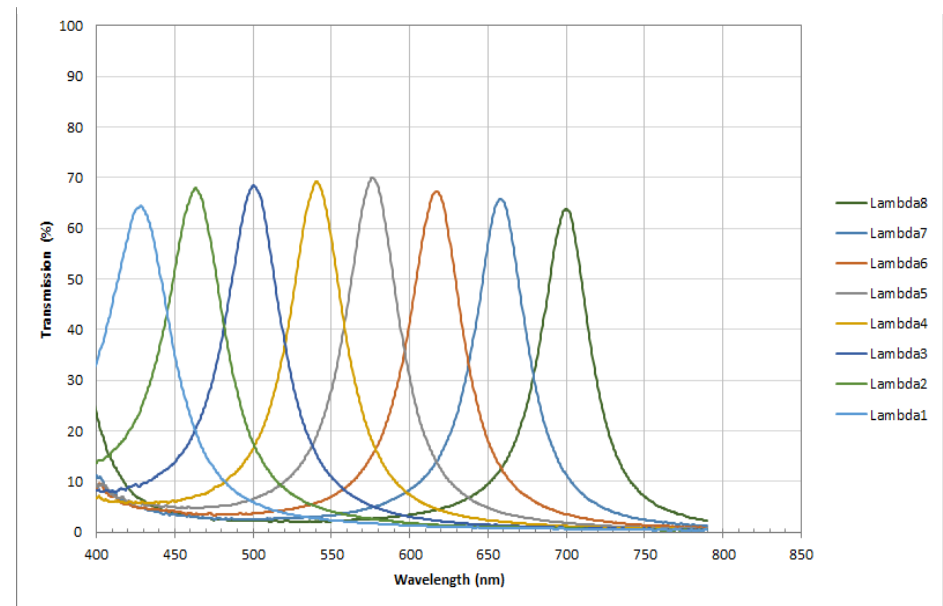
The COLOR SHADES® filters show low resonance level (low Q factor).

- Low sensitivity to the incident angle.

The filters can be used with optic apertures up to F/2 (+/-15°)

- High sensitivity (high integrated transmission).

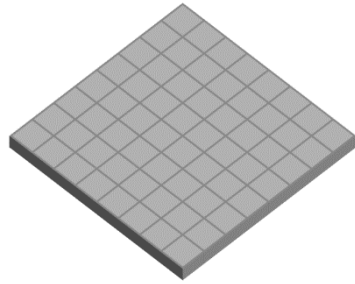
Typical transmission curves



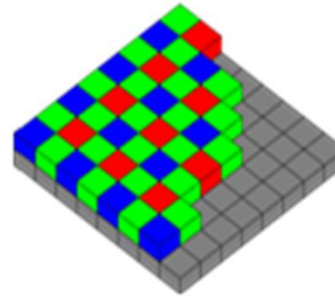
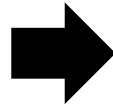
Tmax :	40% to 60%
FWHM :	20nm à 40nm
Max Spectral Range :	300nm (shiftable)

Multispectral Imaging Sensors and CMS Cameras

MULTISPECTRAL IMAGING



Monochrome standard imager
Resolution : $N \times M$

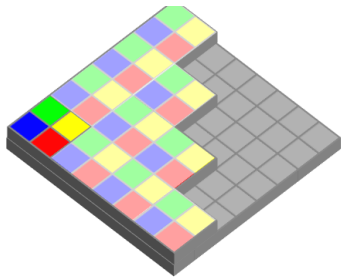


Standard RGB imager
Resolution : $N \times M$
(after demosaicing)

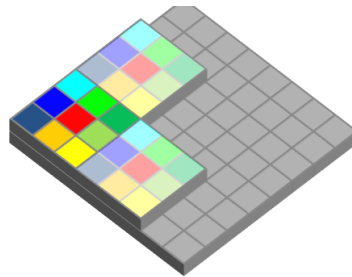
Regular Color Imaging
(RGB).

SILIOS multispectral approach : filtering at the pixel scale

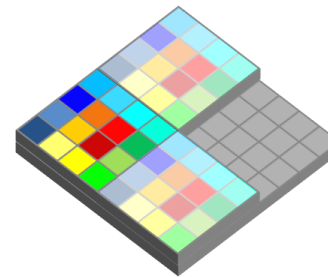
SNAP SHOT



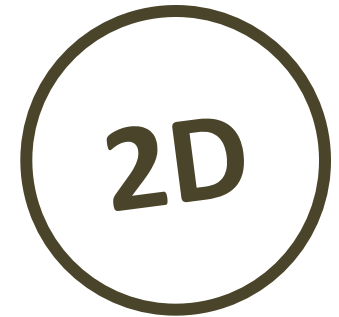
4 interleaved images
Resolution : $N/2 \times M/2$



9 interleaved images
Resolution : $N/3 \times M/3$

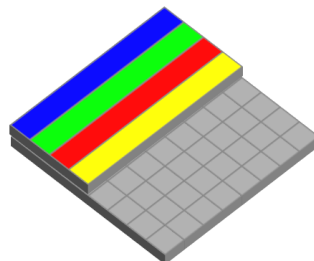


16 interleaved images
Resolution : $N/4 \times M/4$



Multispectral Imaging.

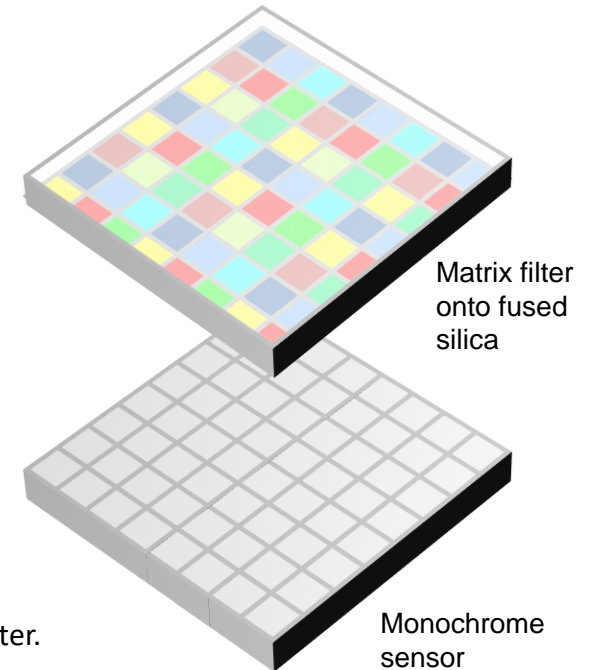
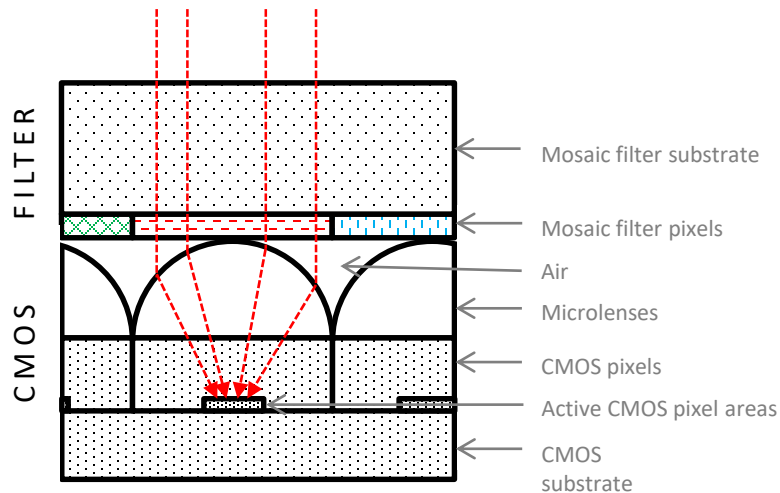
PUSH BROOM



Ex: 4 interleaved spectral lines for push broom camera system

Supply of a set of 4, 9 or 16 sub-images filtered or lines @ different λ

Hybrid Approach



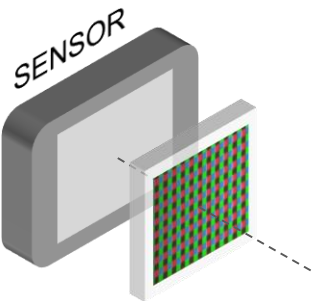
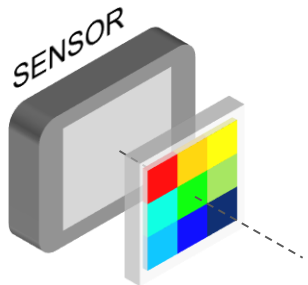
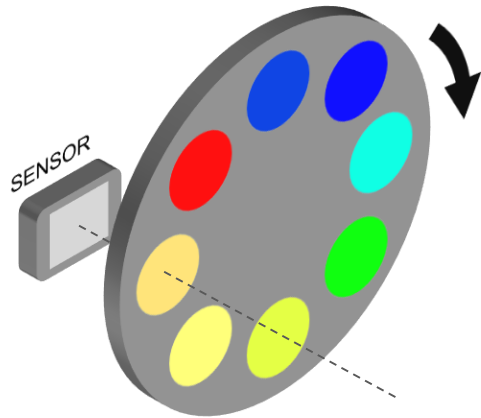
Advantages :

- ✓ Almost any CMOS sensors usable.
- ✓ The microlens function is preserved (+50% photons).
- ✓ The filter is placed above the microlens avoiding high incidence angle onto the filter.

Drawback :

- ✓ Geometrical crosstalk (light from a filter N collected by a pixel M)
Post-processing method that suppress the crosstalk can be applied.

Multispectral Imaging Technics Comparison



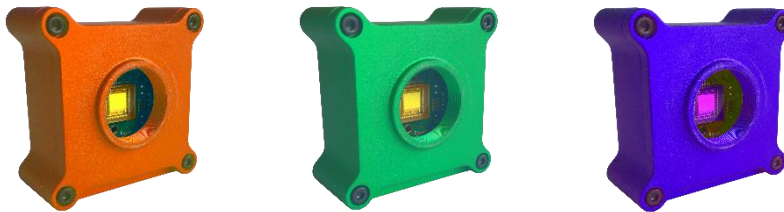
Technology	Space	Time
Filter Wheel	Field of view =	Sequential
Sub-images	Field of view \neq	Synchronous
Pixelated Filter (custom Bayer Matrix)	Field of view =	Synchronous

CMS MULTISPECTRAL CAMERAS

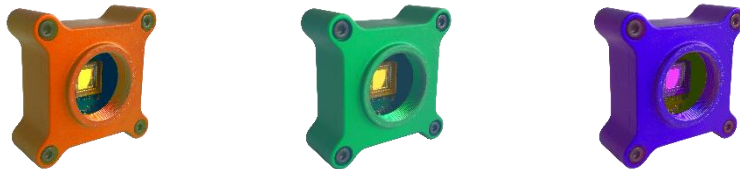
The CMS Series (Low cost off the shelf cameras)

1.3 Mpx CMOS sensor

GigE



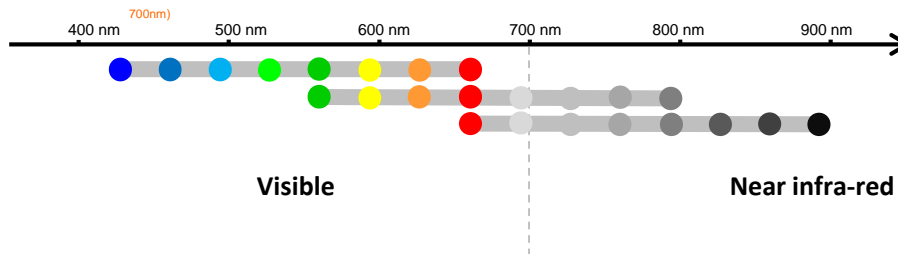
USB3.0



CMS-C (400-700nm)

CMS-V (550-800nm)

CMS-S (650-900nm)

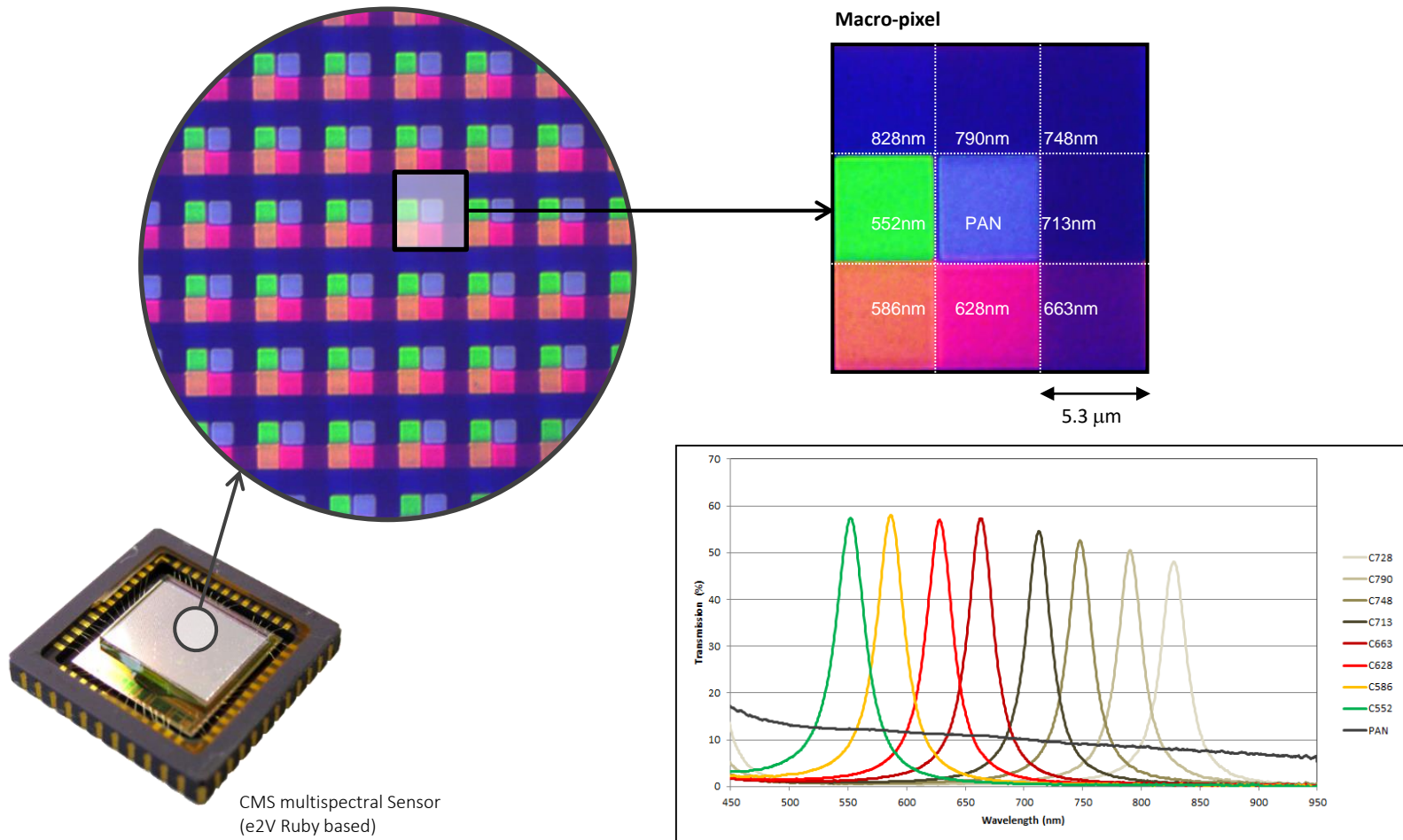


COLOR SHADES Lab (SDK)

- +
DLL for :
- ✓ Hypercube extraction
 - ✓ Crosstalk correction

4.2 Mpx CMS4 Cameras are now available !

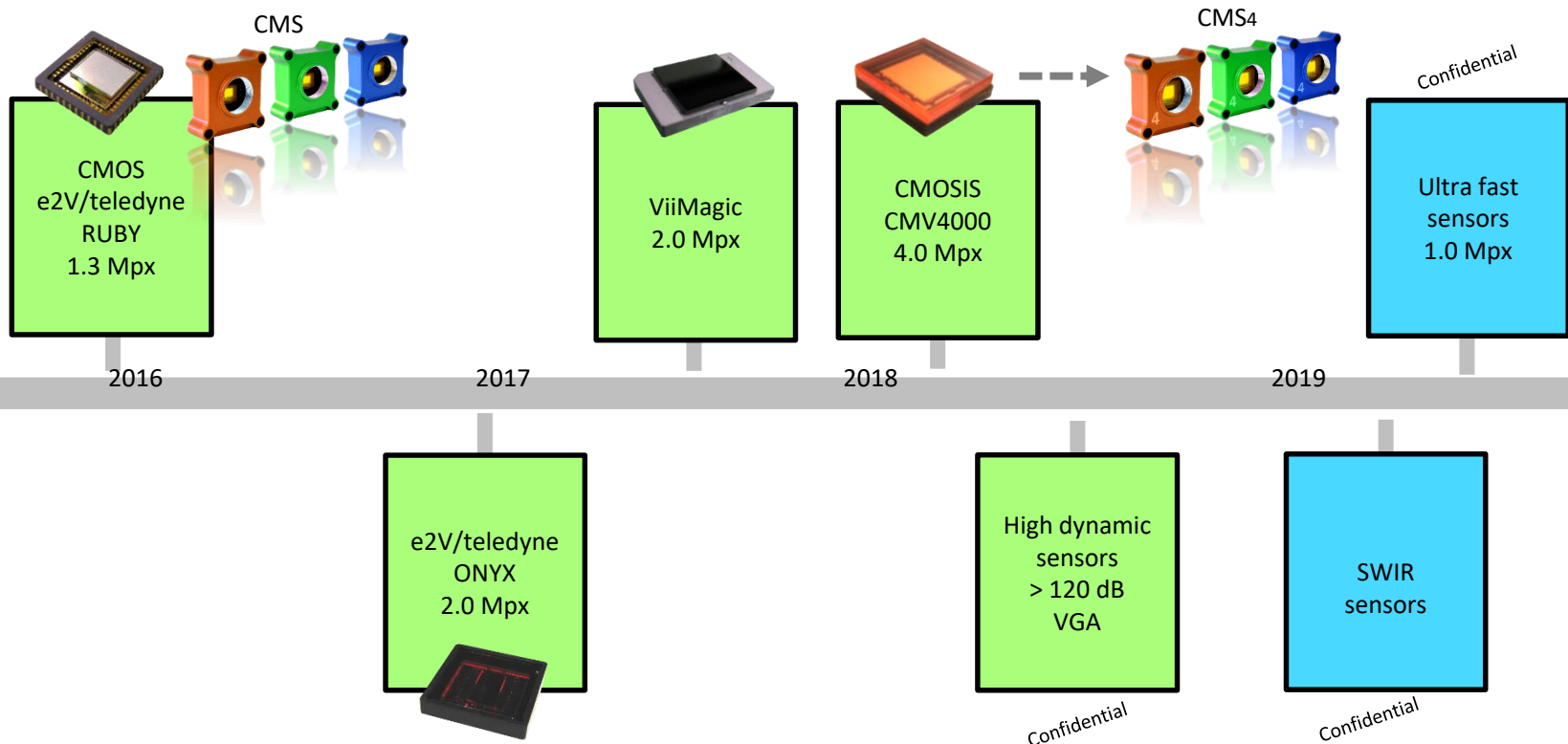
CMS-V Case



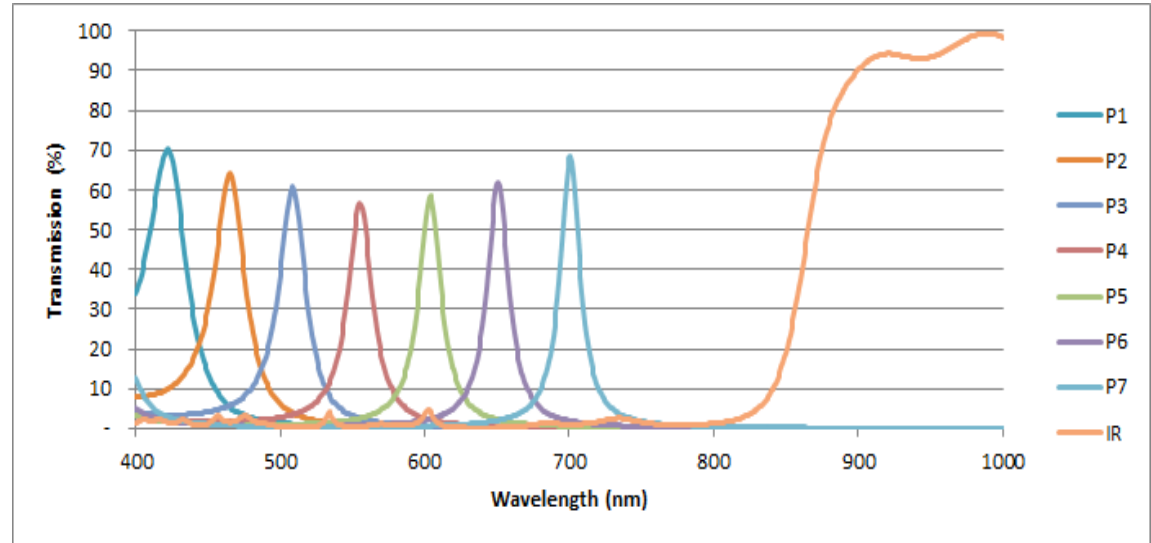
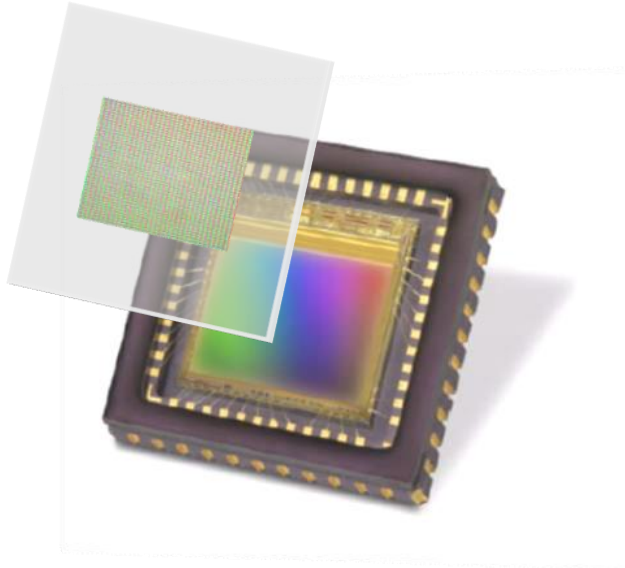
CUSTOM MULTISPECTRAL CAMERAS / SENSORS



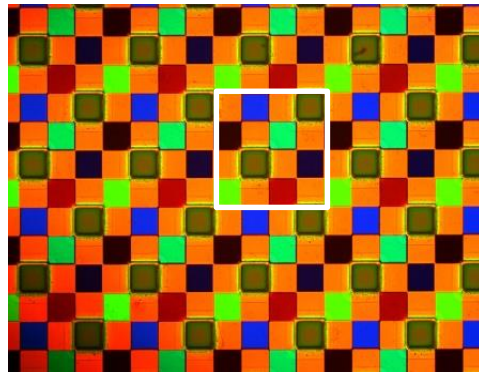
Already worked on a Large Diversity of Sensors



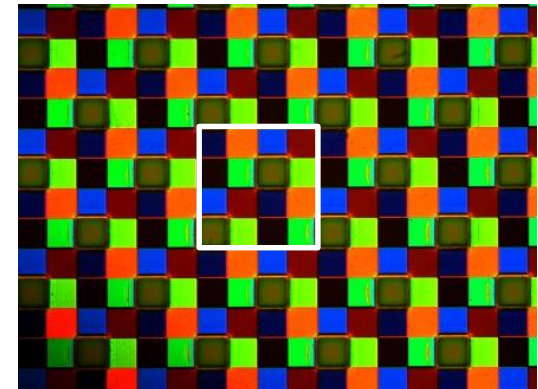
CUSTOM MULTISPECTRAL IMAGER



P5	P1	P5	IR
P6	P5	P4	P5
P5	IR	P5	P2
P3	P5	P7	P5



P1	P5	P2	P6
P7	P3	IR	P4
P2	P6	P1	P5
IR	P4	P7	P3



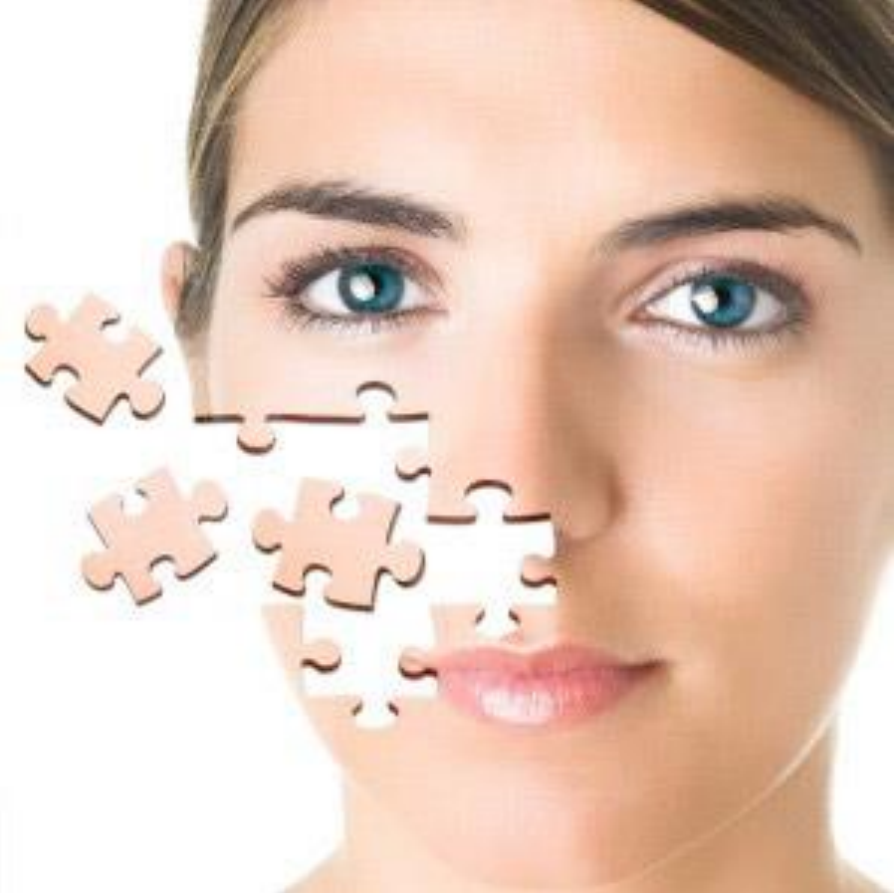
Filtering at the CMOS pixel scale: any matrix organization is possible

Some Applications



MEDICAL

Dermatology / Endoscopy / ...





COSMETICS

Personalized Skin care and Make-up



Face mapping



Care personalization

DEFENSE

Decamouflage

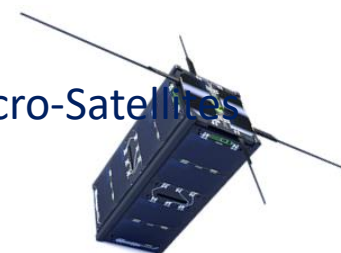


NEW SPACE

Earth Observation



Nano-/Micro-Satellites

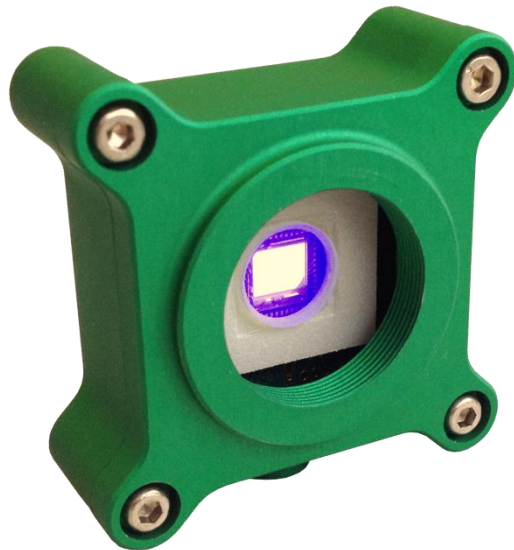


AGRICULTURE

Drone Field Mapping



EXAMPLES OF AGRO-APPLICATIONS



CMS-V Camera

(wavelength range : 550-800 nm)

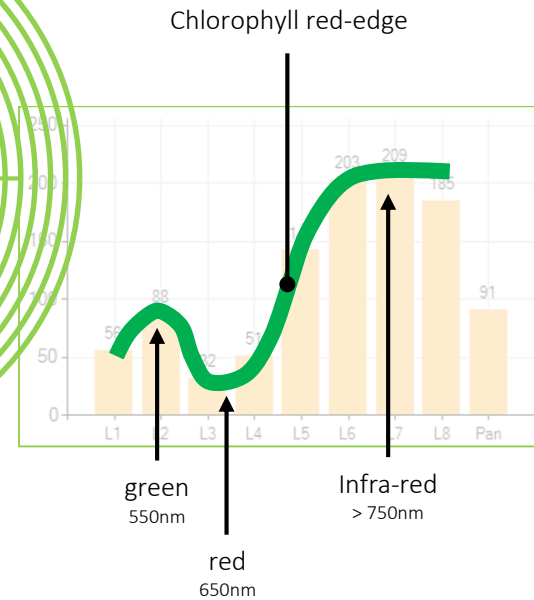
Chlorophyll Signature Detection

Chlorophyll detection : outside scene

SPECTRUM EXTRACTION CAPABILITY



Spectrum extraction



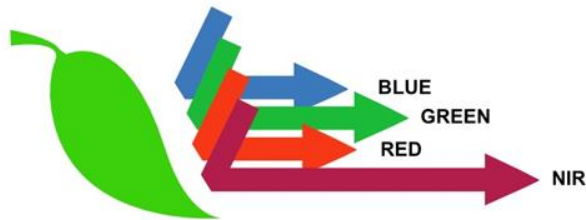
Chlorophyll signature

FALSE COLOR INFORMATION



The Chlorophyll-rich objects of this scene are highlighted in Red Color.

Plant health analysis – chlorophyll status



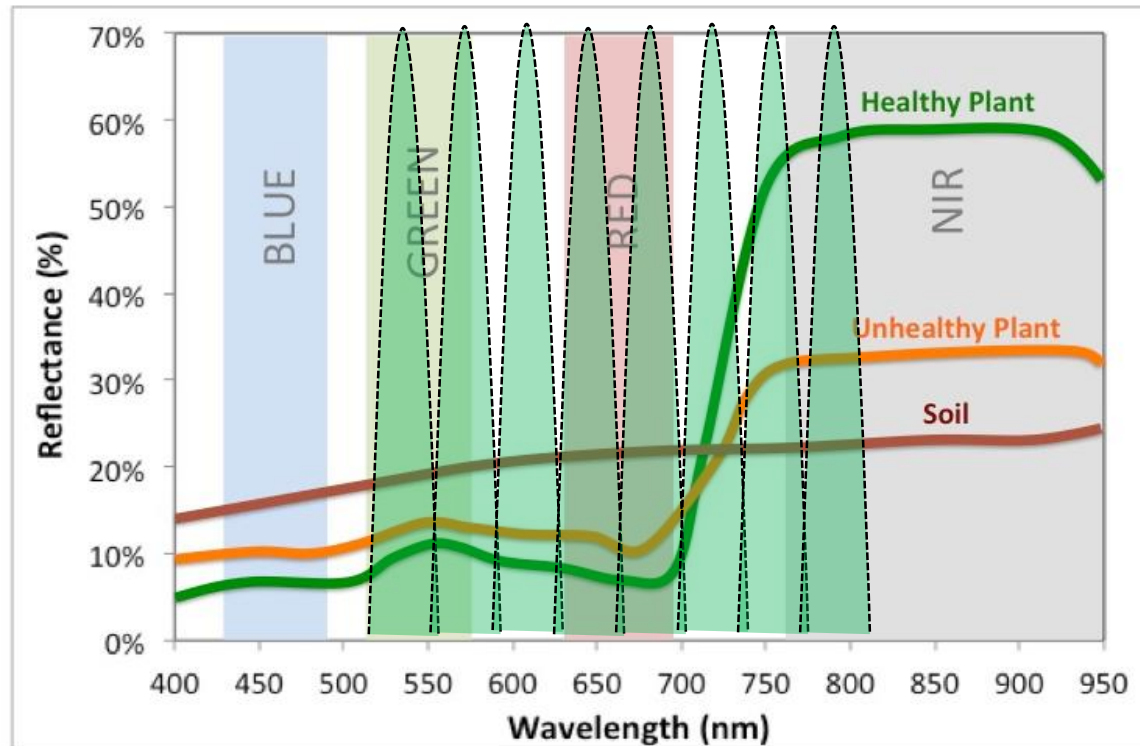
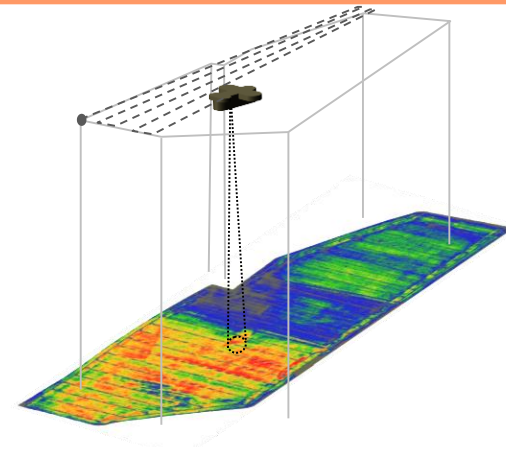
Healthy Leaf



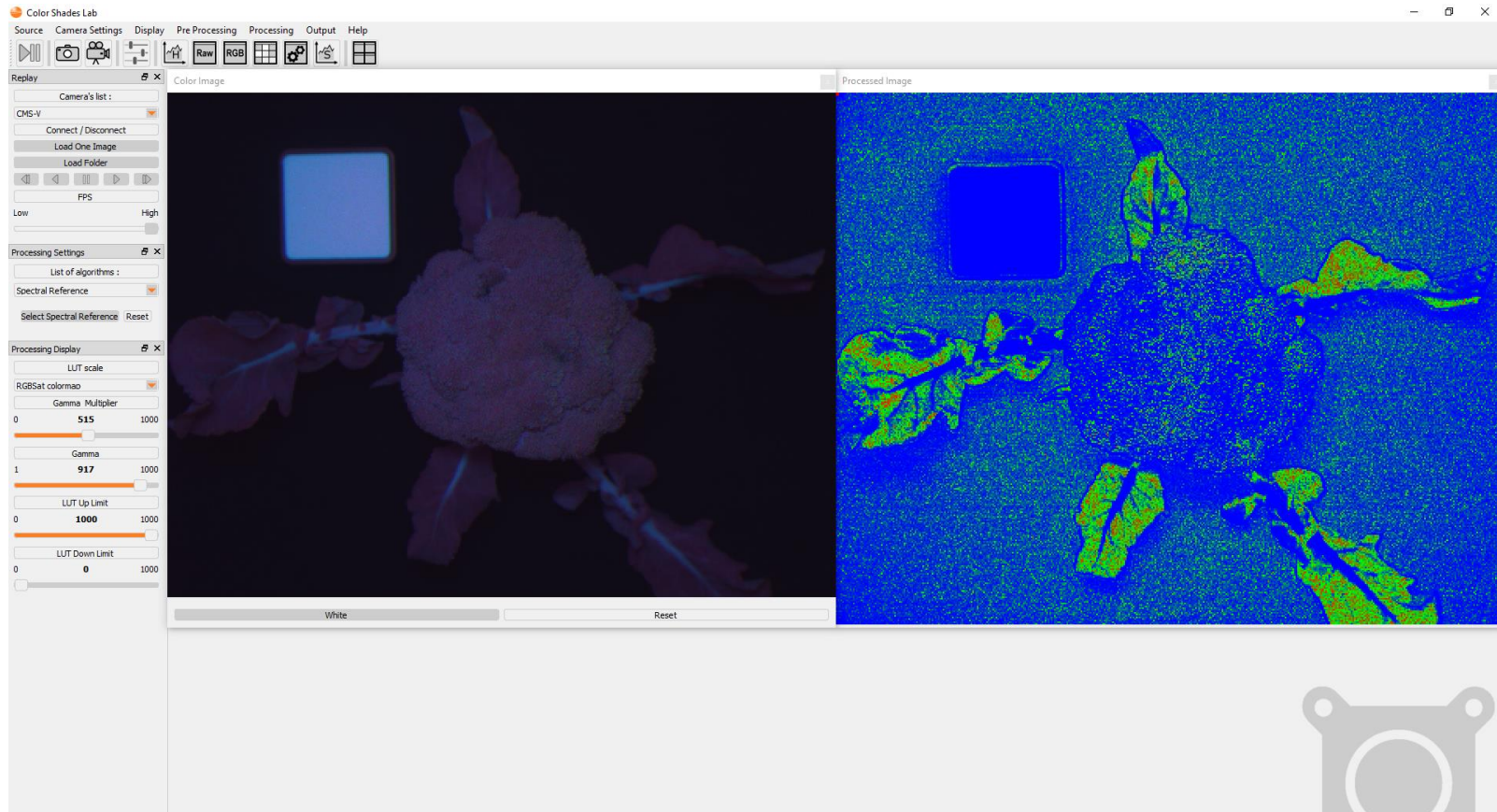
Stressed Leaf



Dead Leaf



Distinction Broccoli Head from Leaves



We've also worked on other Agro & Environment applications with our CMS cameras such as:

- Sorting of rice grains from white pebbles
- Earth observation / Environment monitoring on board of Cubesat
- Detection of small (1mm size) aphid in vineyards

Thank you for your attention

www.silios.com

