



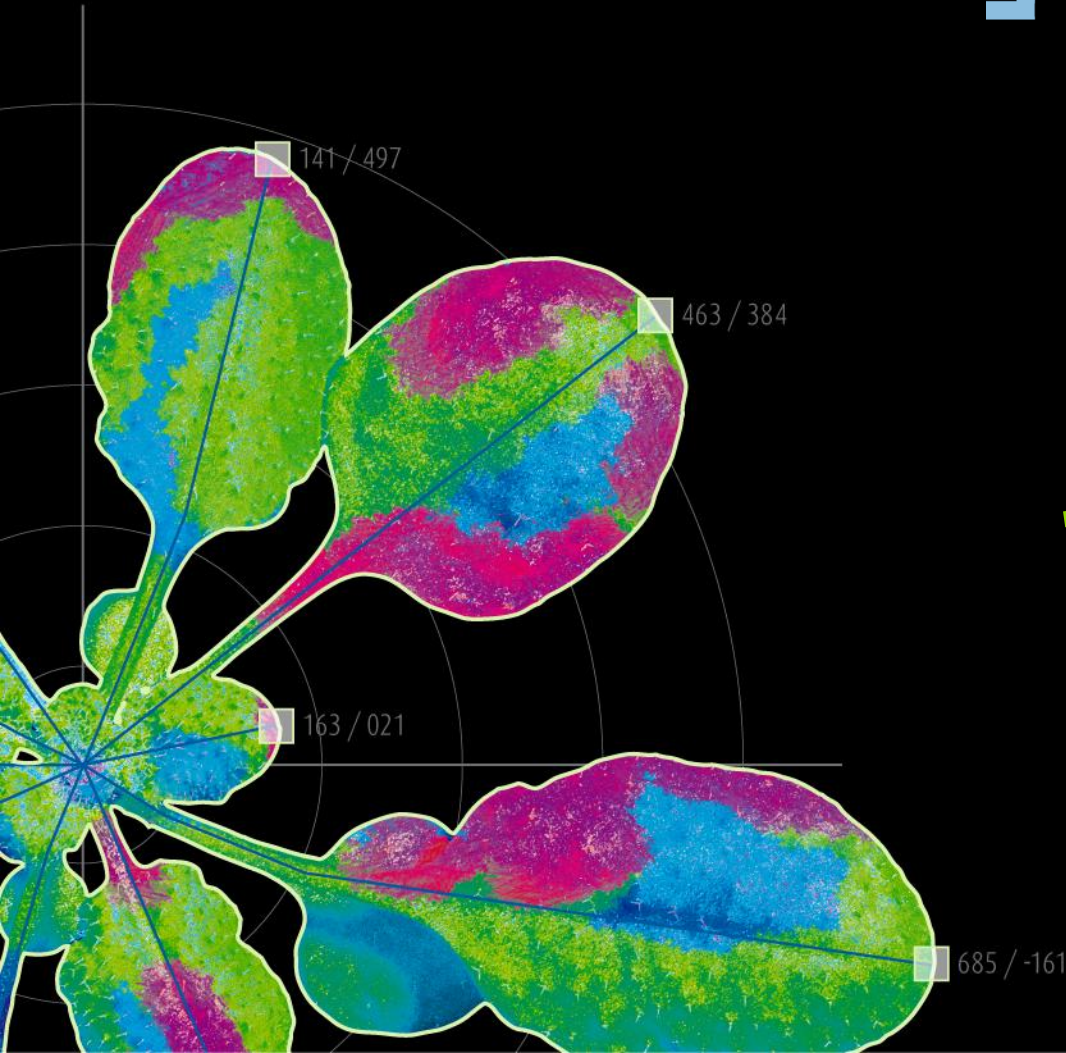
## Hyperspectral Imaging for scanner Systems

**NEW!**

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CEO

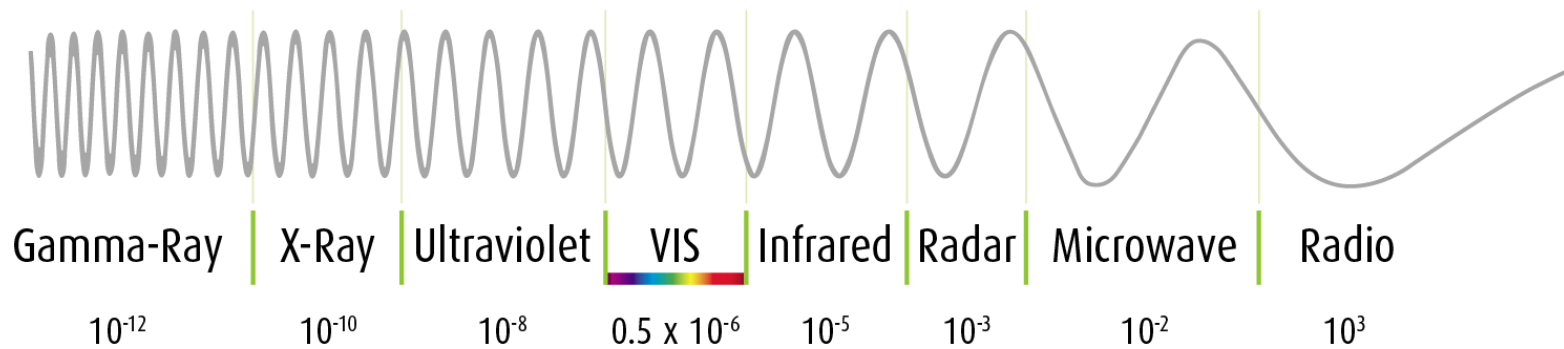
[dirk.vandenhirtz@lemnatec.com](mailto:dirk.vandenhirtz@lemnatec.com)



# ROI (Region of Interest)



## Radiation Type and Wavelength [m]



## Spectral Range of Hyperspec Cam: VNIR 400 – 1000 nm



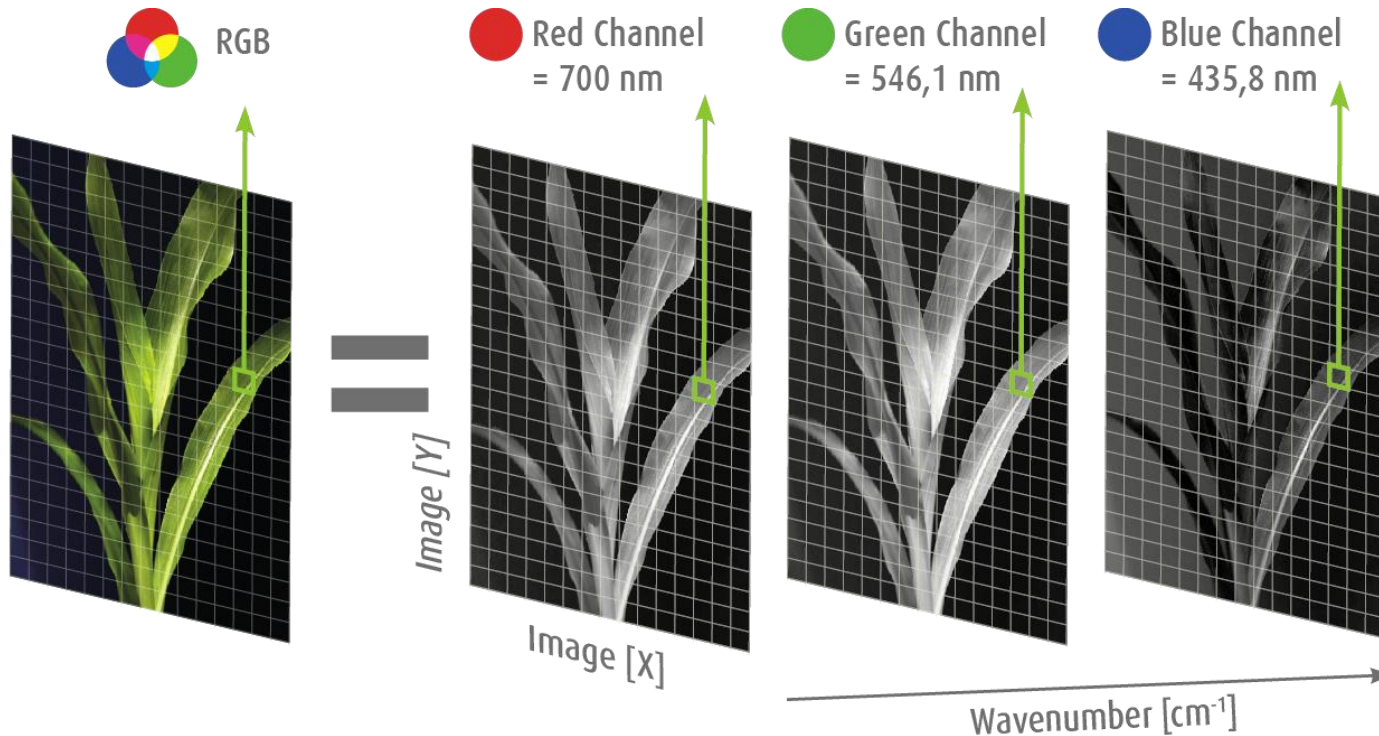
ROI (Region of Interest) 400 – 1000 nm

# 3 Wavelengths of RGB

- 1 Pixel measured at 3 wavelength bands
- All images span the same area
- All images are taken simultaneously

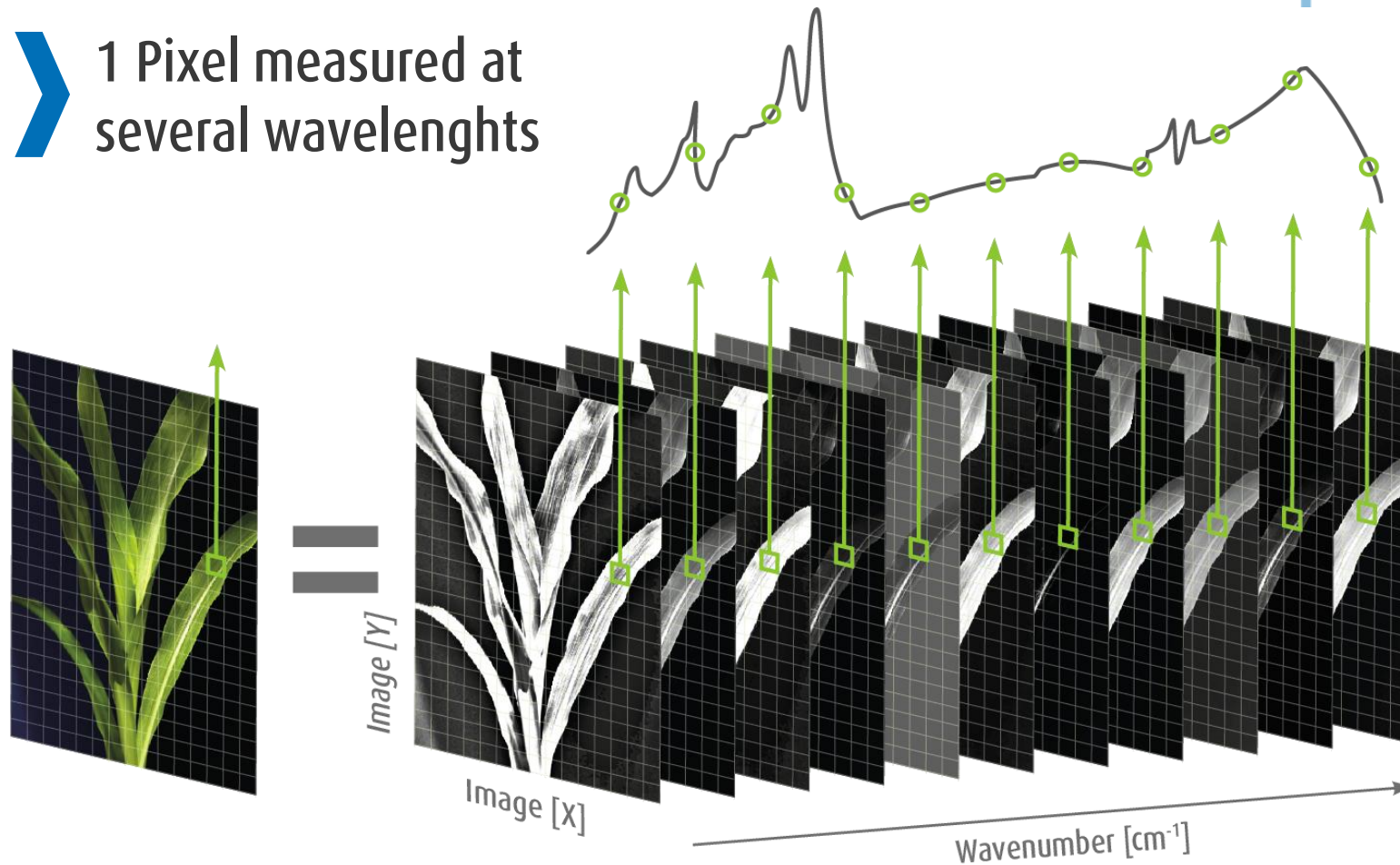


Differences attributed to purely spectral feature



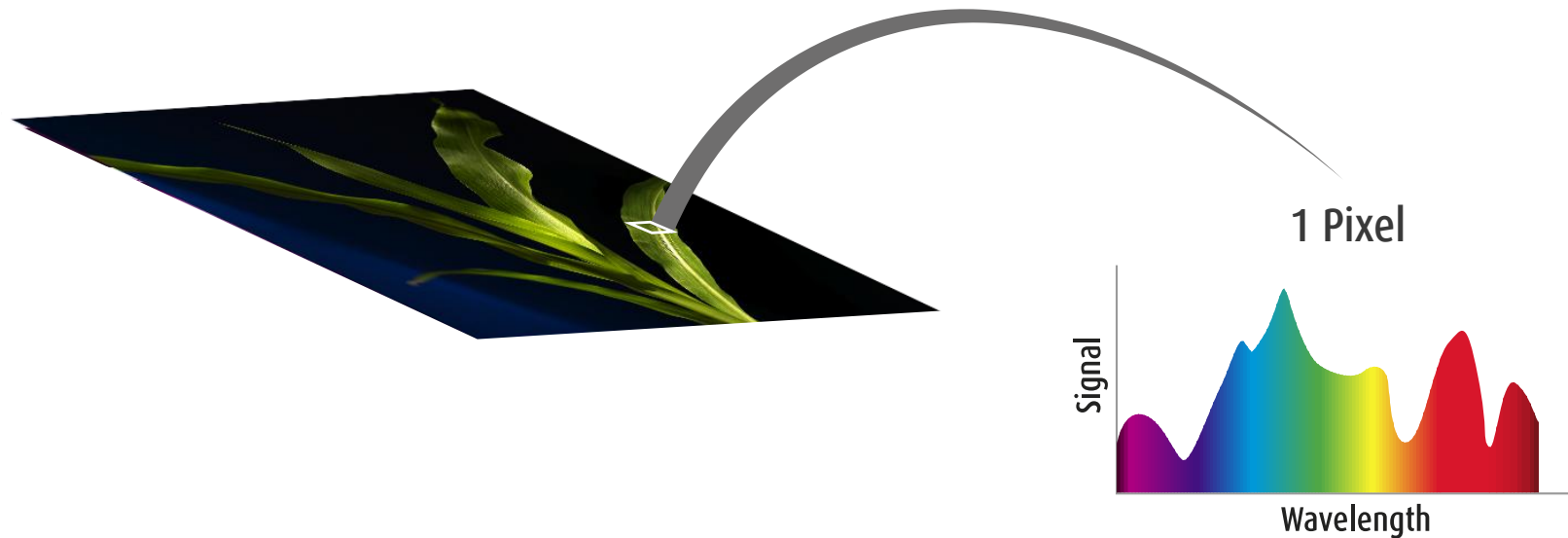
# Multiple Wavelengths of Hyperspec

1 Pixel measured at several wavelengths



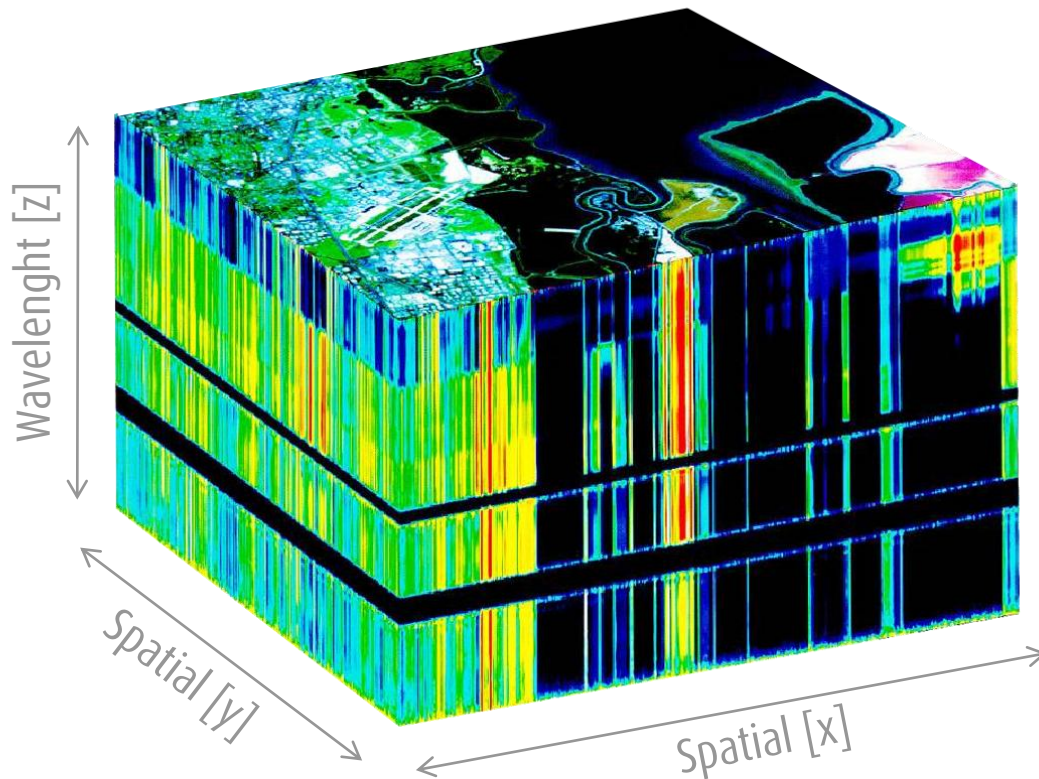
# Hyperspectral Imaging Concept

- Each Pixel contains a continuous spectrum that is used to identify the condition of the plant or fruit



➤ E.g.: Good signal at 450 nm means good Chlorophyll

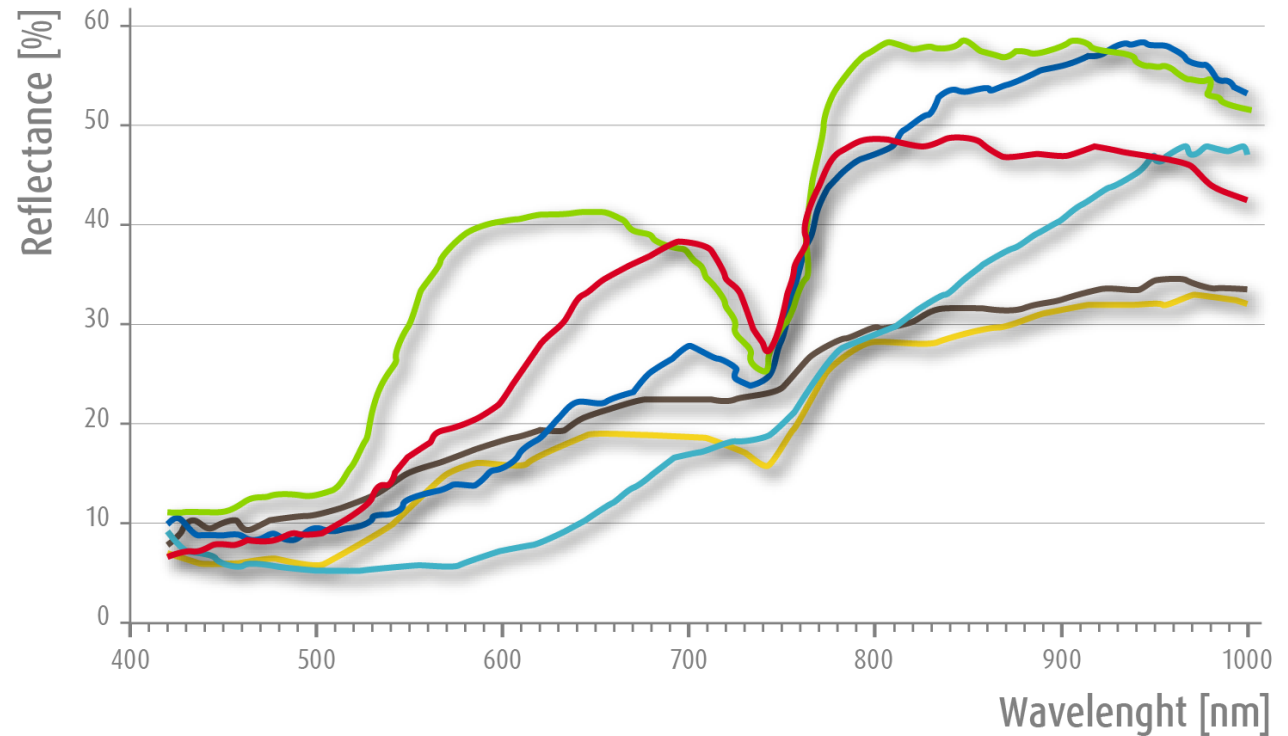
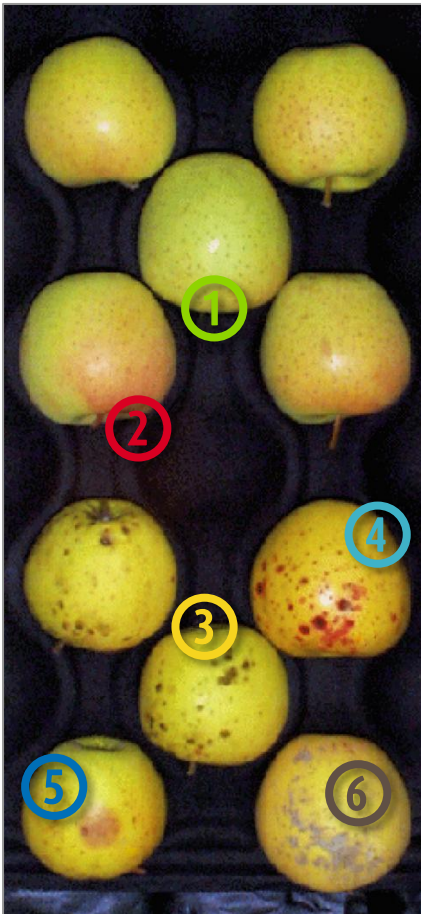
# Hyperspectral Imaging Cube



AVIRIS image of Moffet Field, CA (courtesy R Green, JPL)

- One example of a well-calibrated HS sensor is Airborne Visible/Infrared Imaging Spectrometer (AVIRIS)
- AVIRIS images 224 contiguous bands of 10-nm bandwidth from 380 to 2400 nm

# Example: Fruit Quality

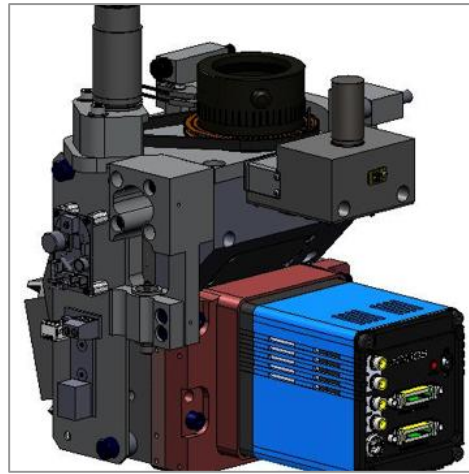


- 1 Greenish Skin
- 2 Reddish Skin
- 3 Fungal (Scooty Blotch)
- 4 Diseased (Black Pox)
- 5 Bruised
- 6 Soil Contaminated

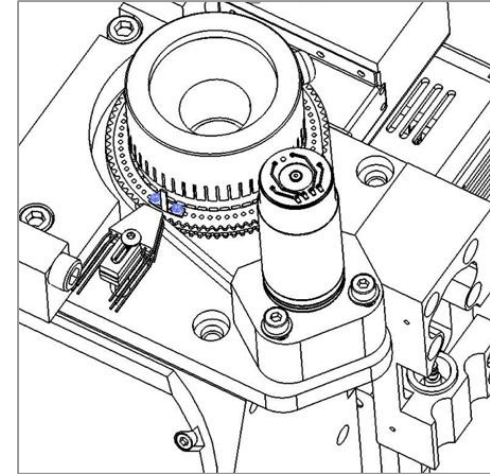
# Hyperspec<sup>®</sup> Inspector E-Series



Hyperspec<sup>®</sup> body



Hyperspec<sup>®</sup> Imaging Module



Lens Focus

- State of the art camera
- Retrofit to all existing scanalyzer 3D and HTS possible
- Optimized for VNIR (400-1000nm)

# Detector Specifications



Detector Material	sCMOS
Acquisition Methods	Rolling Shutter
Detector Cooling	Peltier with forced air (fan)
Firmware	Proprietary
Detector geometry	2560 x 2160
Pixel size	6.5 $\mu\text{m}$ square
FPA	16.6 mm x 14.0 mm
Binning	ROI only
Frame speed	> 100 fps
Pixel well depth	30,000 e <sup>-</sup>
Read Noise	1.4-2.0 e <sup>-</sup> @ 285 MHz
Interface	Cameralink

# Hyperspec<sup>®</sup> E-Series Specifications



Hyperspec <sup>™</sup> Design	Reflective, concentric with aberration correction
Spectral Range	400-1000 nm
Dispersion	100 nm/mm
Spectral Resolution	3 nm (25 um slit width)
Maximum Resolution	2 nm (12 um slit width)
Slit Height (Available/Utilized)	16 mm / 8 mm
Slit width	25 um (or as required)
Lens Mount	C-Mount
Peak wavelength	575 nm
Image Space NA (F#)	> 0.208 ( F/2 )
TMAG	1.00 +/- 0.03
Max Smile	< 0.1 pixel (FPA limit)
Max. Keystone	< 0.1 pixel (FPA limit)
Encircled Energy	> 70% for 25 μm pinhole onto 30 μm square slit (FPA limit)
Vignetting	< 5% (FPA Limit)

# Scan Specifications



Category	Description	Specification
Acquisition Parameters (f/17 mm FL lens )	FOV <sub>S</sub> (Scan direction, $\Delta\theta_M$ - max scan range of mirror)	30°
	Ifov <sub>S</sub> (scan direction, w <sub>S</sub> = 25 μm slit width)	1.47 mrad
	FOV <sub>CS</sub> (cross-scan direction)	26.6° (use of 8mm slit height)
	Ifov <sub>CS</sub> (cross-scan, w <sub>D</sub> = 8 μm detector pixel)	0.38 mrad
Point-And-Stare Angular Specs.	Angular Accuracy	± 0.04 mrad
	Angular Reproducibility (scan to scan)	± 0.04 mrad

1. Scan speed is for image acquisition only and does not include any times required for image manipulation and storage

# Scanner Specifications



Scanner Type	Servo-scanner
Scanner Mounting	Directly to hyperspectral imager
Angular Scan Range	+/- 15° [ +/- 0.262 rad]
Angular Accuracy (short term)	+/-0.001° [ +/- 3.6 arc-sec]
Repeatability (short term)	+/-0.002° [ +/- 8 arc-sec]
Small Angle Step Response	20 ms
Seek time (any angle)	200 ms
Positioning Feedback	Optical Positioning detector
Control Electronics	Digital control
Scanning Modes	Scanned or Point and Peck (software control)

# Focus Specifications



Focus Type	Electronic Controlled
Focus Control	EZ4-Axis Microstepper Controller
Focus Motion	Faulhaber Servo (Spec on Request)
Gear Ratio	1:22
Angular Accuracy (short term)	+/-0.001° [ +/- 3.6 arc-sec]
Repeatability (short term)	+/-0.002° [ +/- 8 arc-sec]
Small Angle Step Response	20 ms
Seek time (any angle)	200 ms
Positioning Feedback	Optical Positioning detector
Power	> +5V

# Aperture Module



Aperture Type

Electronic Controlled

Lens Type

Schneider DC Aperture Controlled Lens

Aperture Signal

Voltage Signal Level sent from HPI I/O

Aperture Range

8000 Counts (Full Open) to  
-8000 Counts (Full Close)

Positing Feedback

None

Power

+5V

# Wavelength and Radiometric Calibration



Calibration Standard Optics	Integrating Sphere and fore-optic
Wavelength/Radiometric standard Controls	ON/OFF, Servo-Mirror
Wavelength Calibration Standard	Mercury-argon
Wavelength Calibrator accuracy	+/- 0.005 nm
Radiometric Standard (secondary)	Continuum, Tungsten-Krypton
Radiometric Standard Color T	2800 K