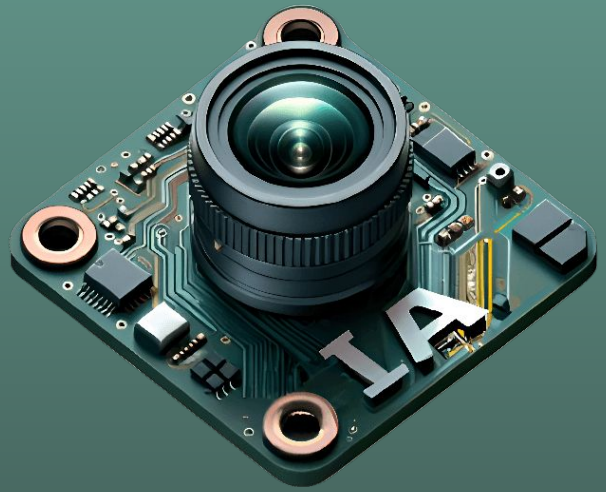
Universidad Industrial de Santander

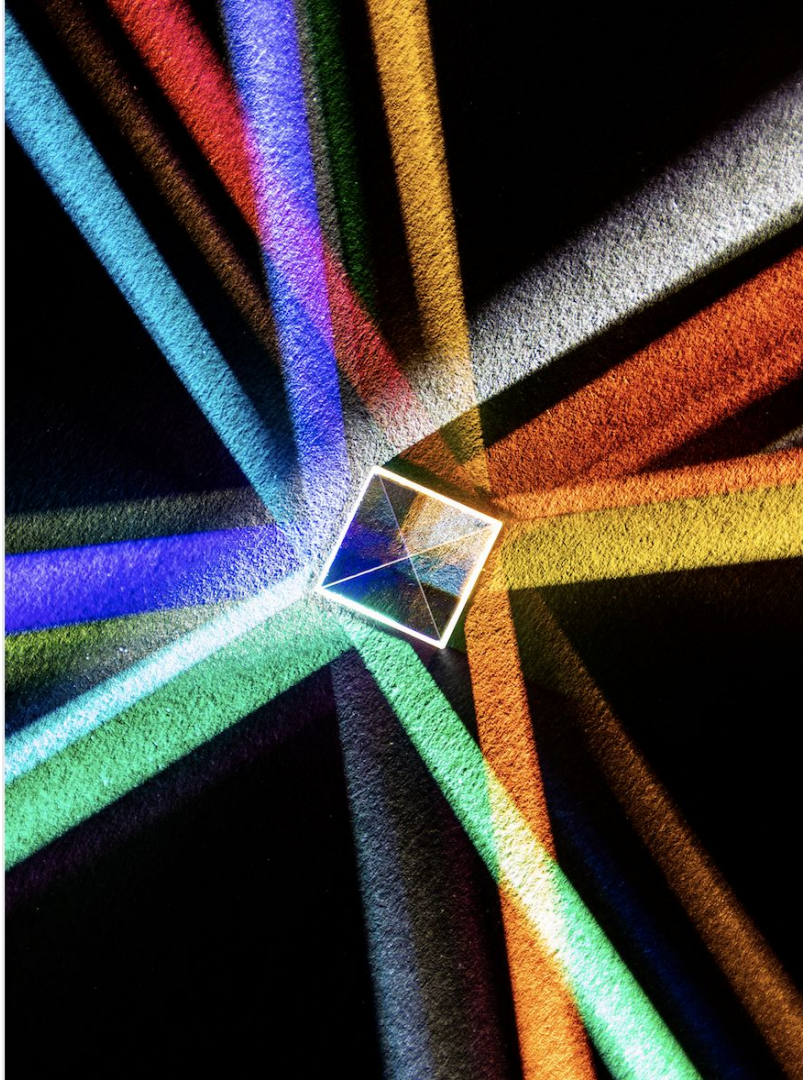


Semillero de Investigación
"Hands - on"
Computer Vision


SESIÓN 4:
IMÁGENES
ESPECTRALES

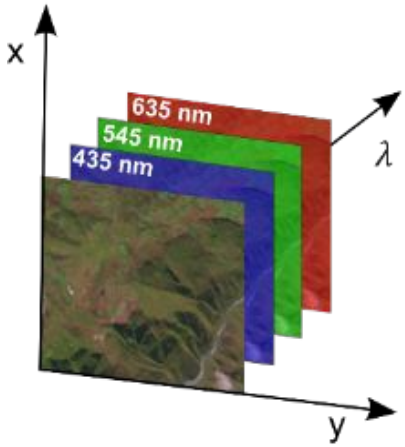
Contenidos

1. Imágenes espectrales
2. Adquisición de imágenes espectrales
3. Dispersión vs Difracción
4. Hands-on experience

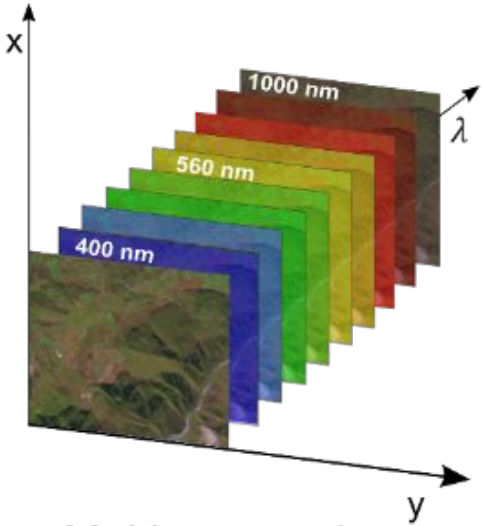


1. Imágenes Espectrales

Imágenes de Color vs Espectrales

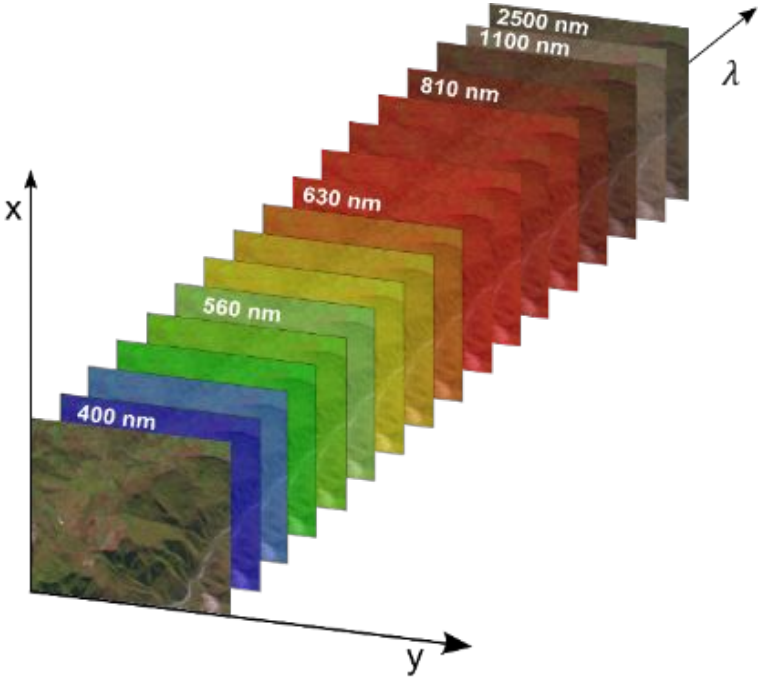


RGB - VIS



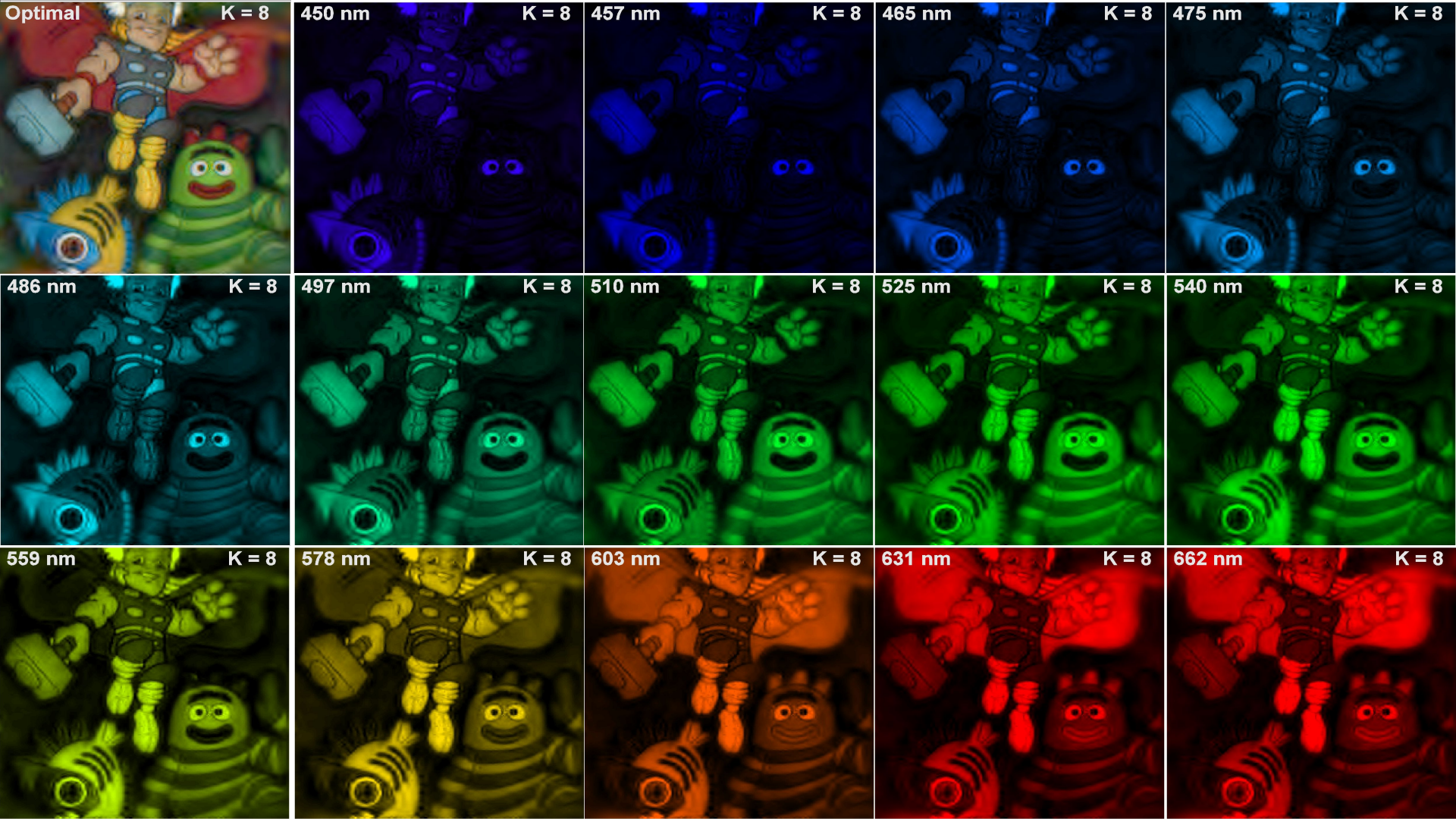
Multiespectral

~ 10 bandas

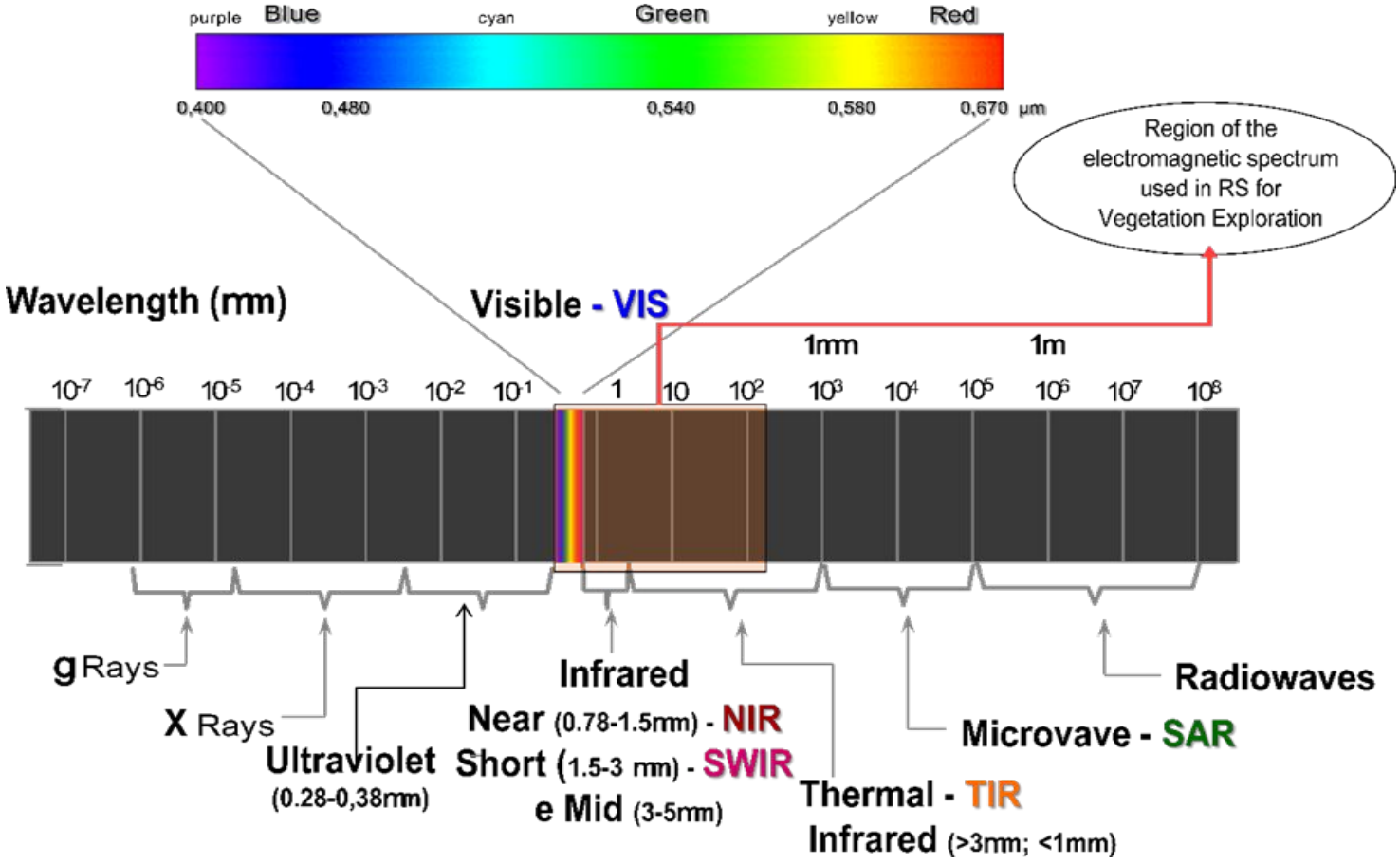


Hiperespectral

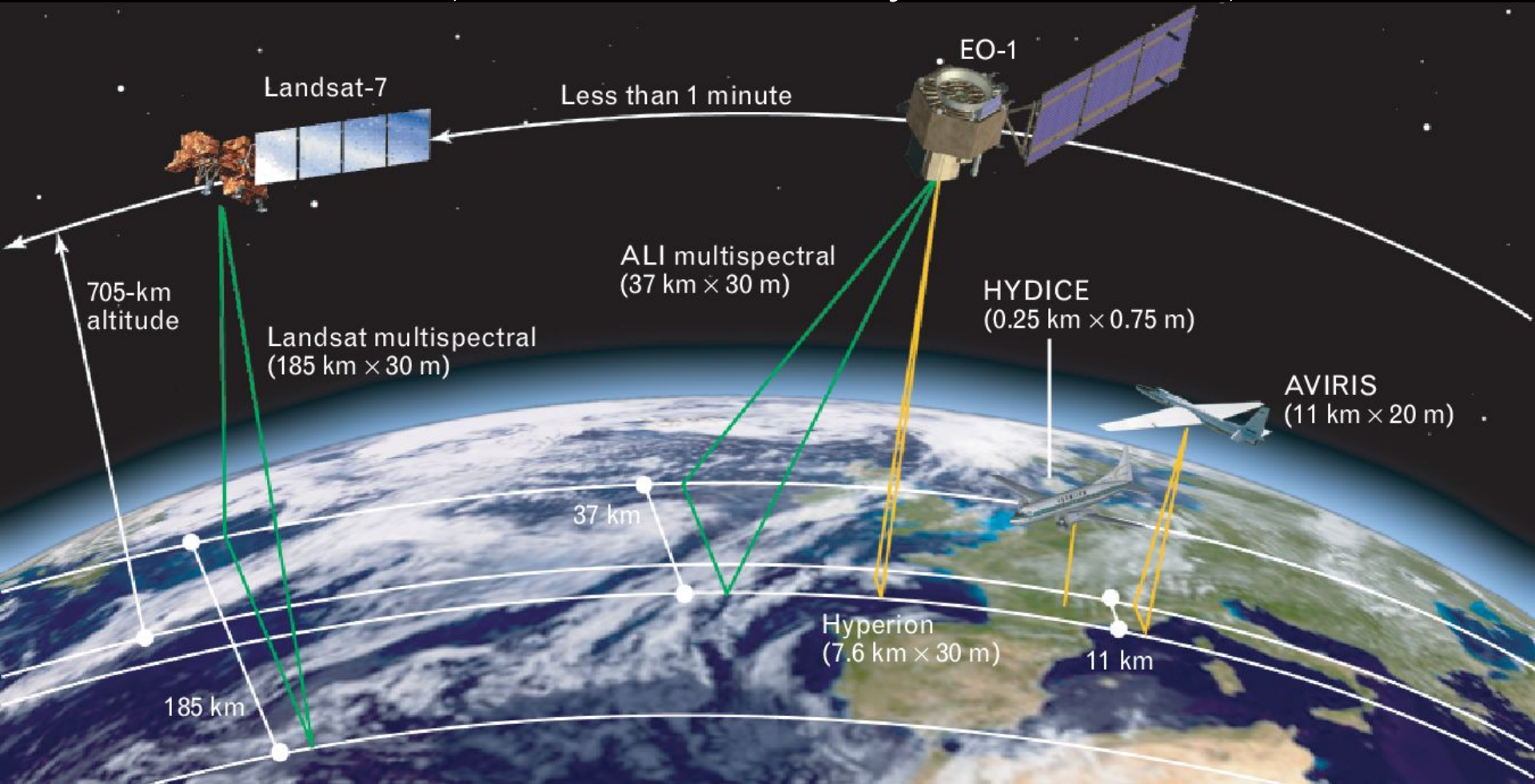
> 100 bandas


Optimal
K = 8
450 nm
K = 8
457 nm
K = 8
465 nm
K = 8
475 nm
K = 8
486 nm
K = 8
497 nm
K = 8
510 nm
K = 8
525 nm
K = 8
540 nm
K = 8
559 nm
K = 8
578 nm
K = 8
603 nm
K = 8
631 nm
K = 8
662 nm
K = 8

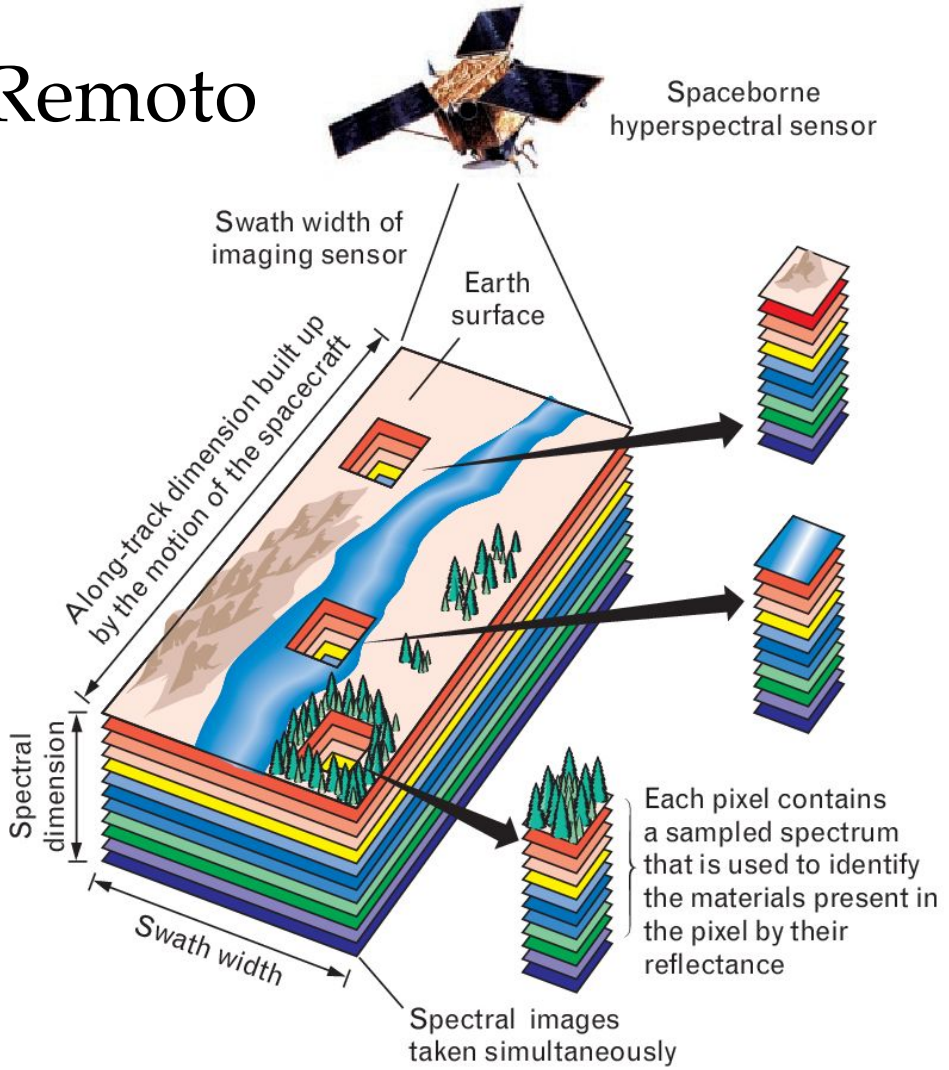
Espectro Electromagnético

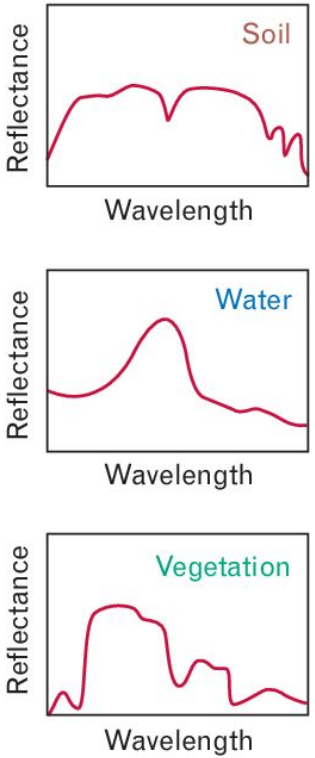


Sensores remotos (Satélites, aviones, y muchos más)

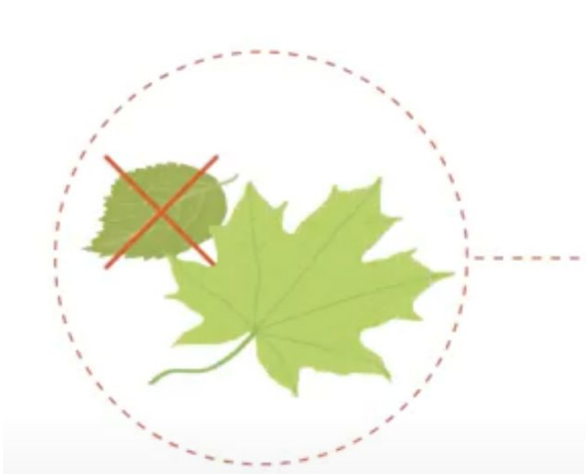


Sensado Remoto

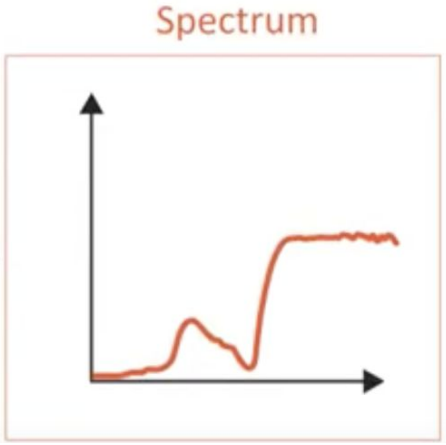




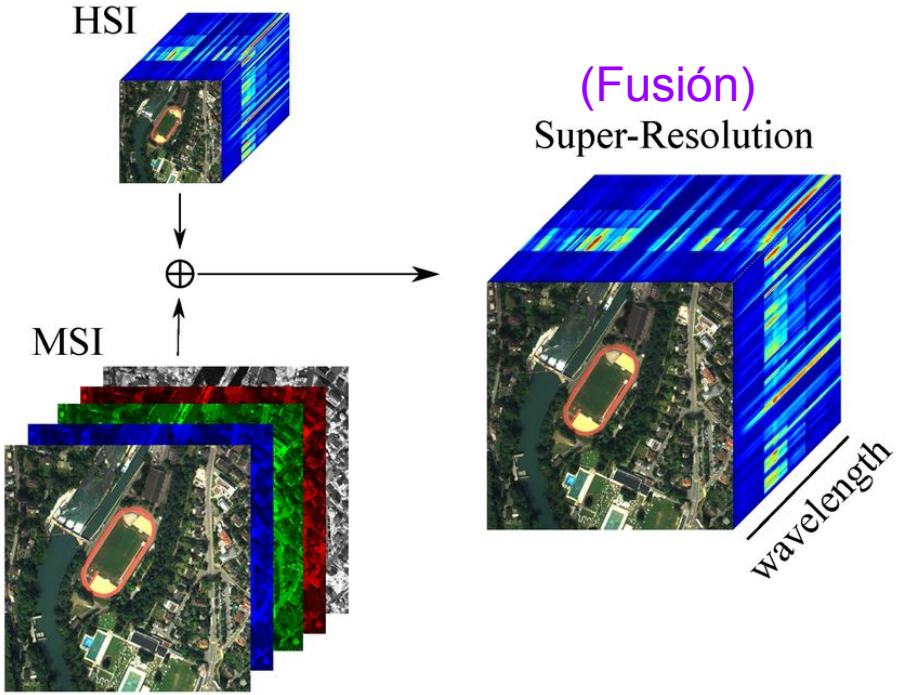
Firma Espectral = Huella dactilar

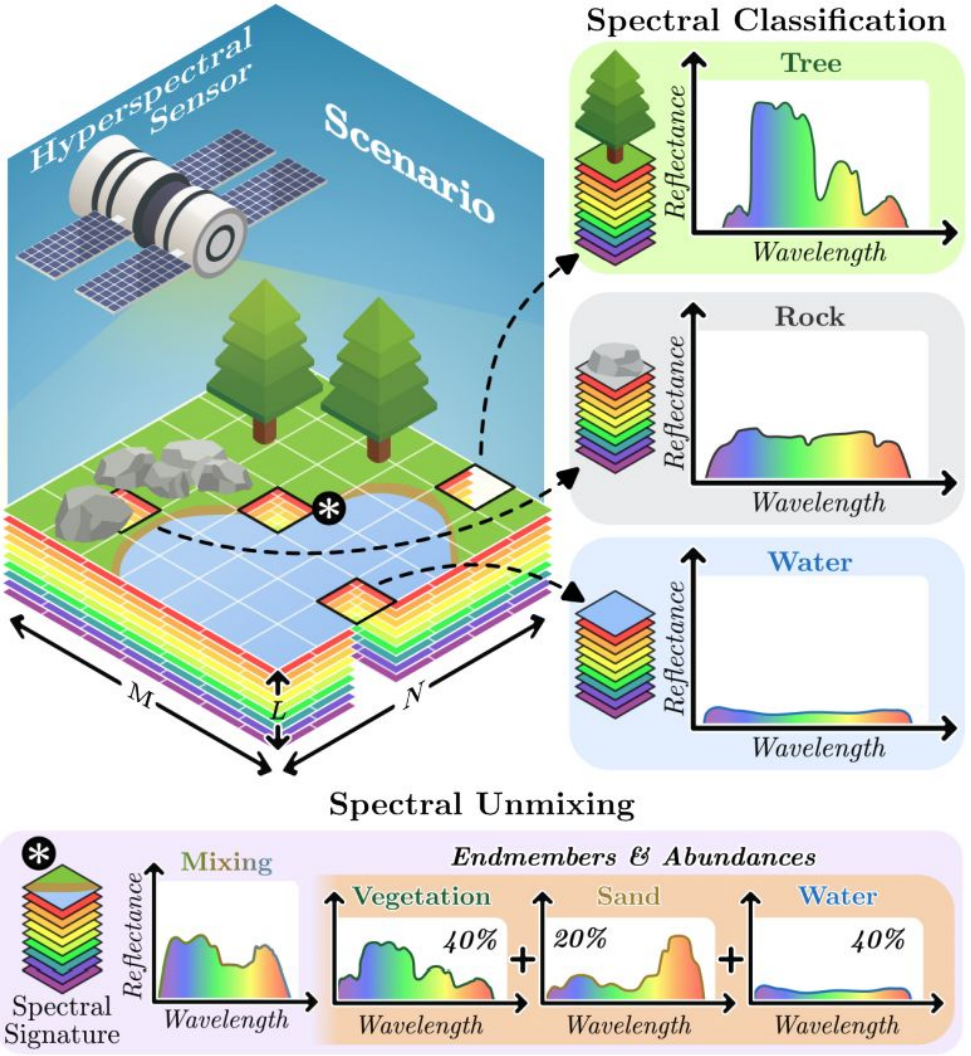


Identifica materiales



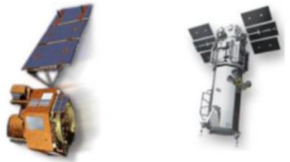
Áreas de investigación
(Hands-on)





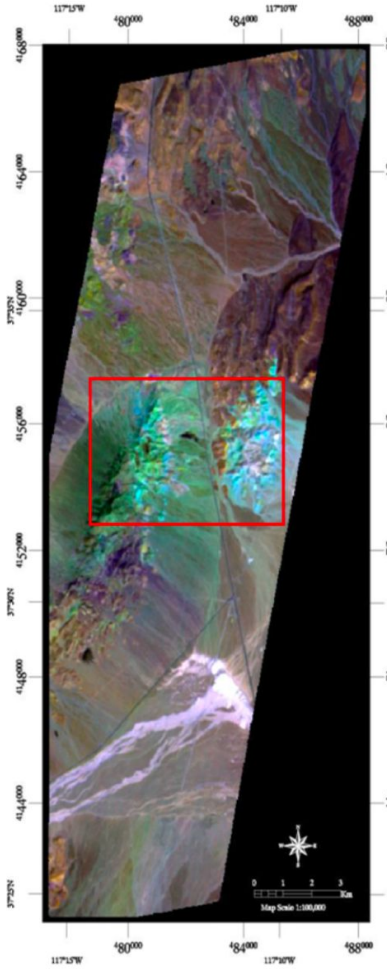
HYPERION AND WV3
FUSION

Cuprite, Nevada, US

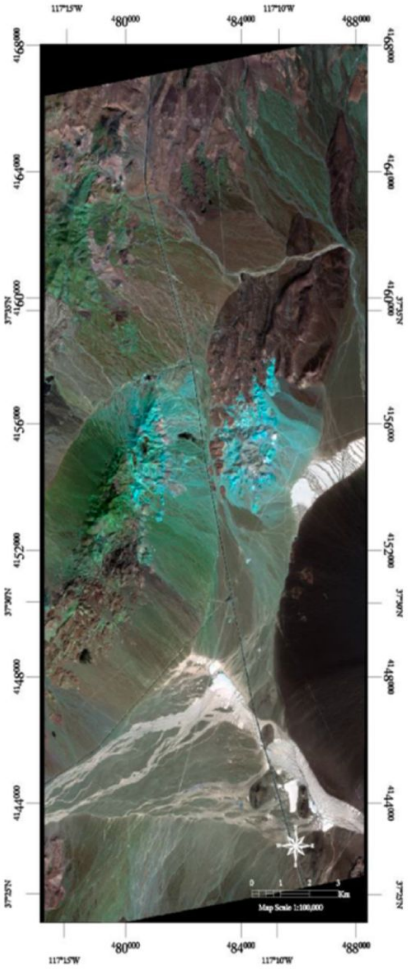


© DigitalGlobe

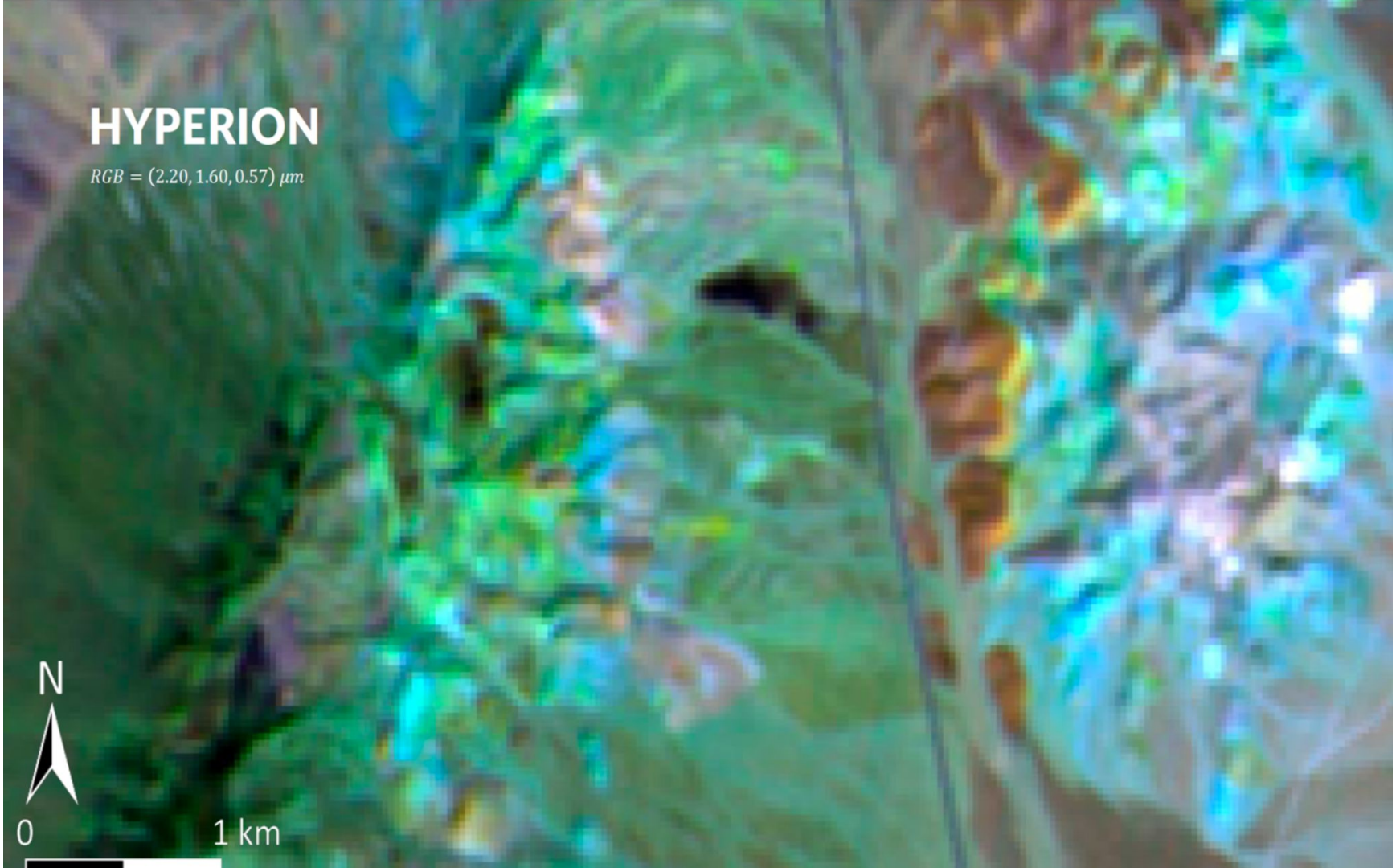
		Hyperion	WorldView-3
Number of bands	VNIR	50 (70)	8
	SWIR	117 (172)	8
GSD (m)	VNIR	30	1.24
	SWIR	30	7.5 (3.7)
Swath width (km)		7.7	13.1

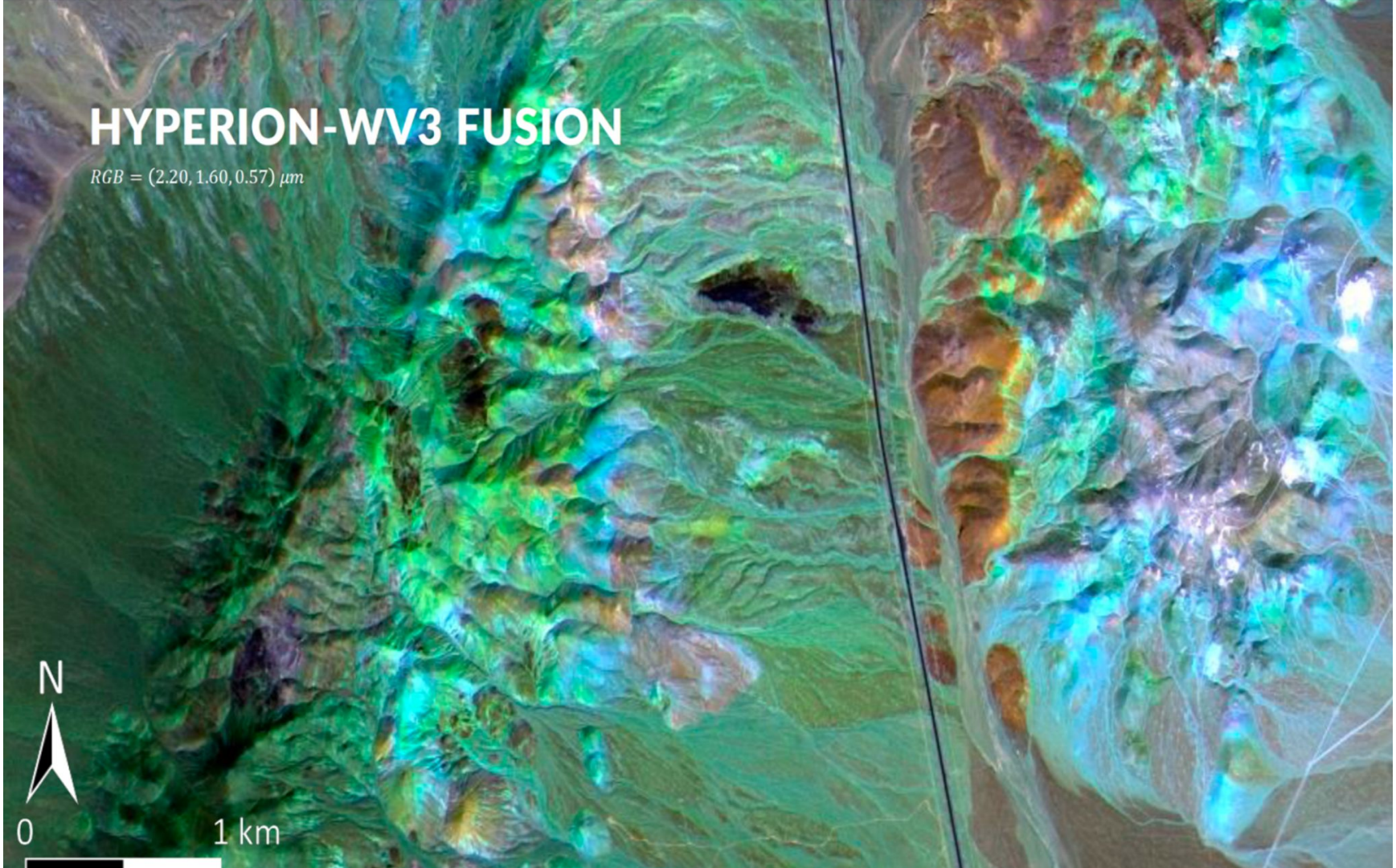


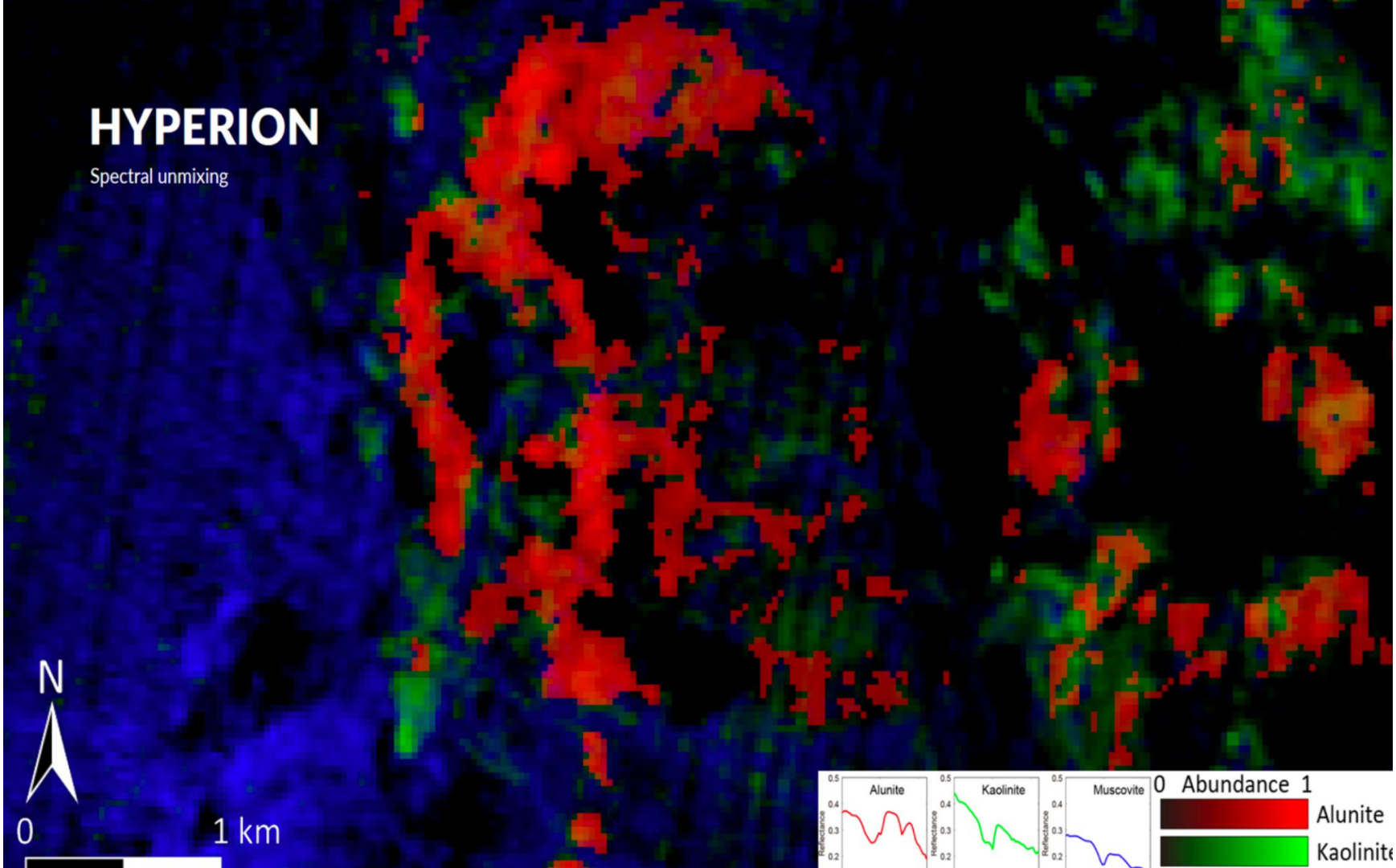
Color composite of Hyperion
$RGB = (2.20, 1.60, 0.57)\ \mu m$
2011-09-19

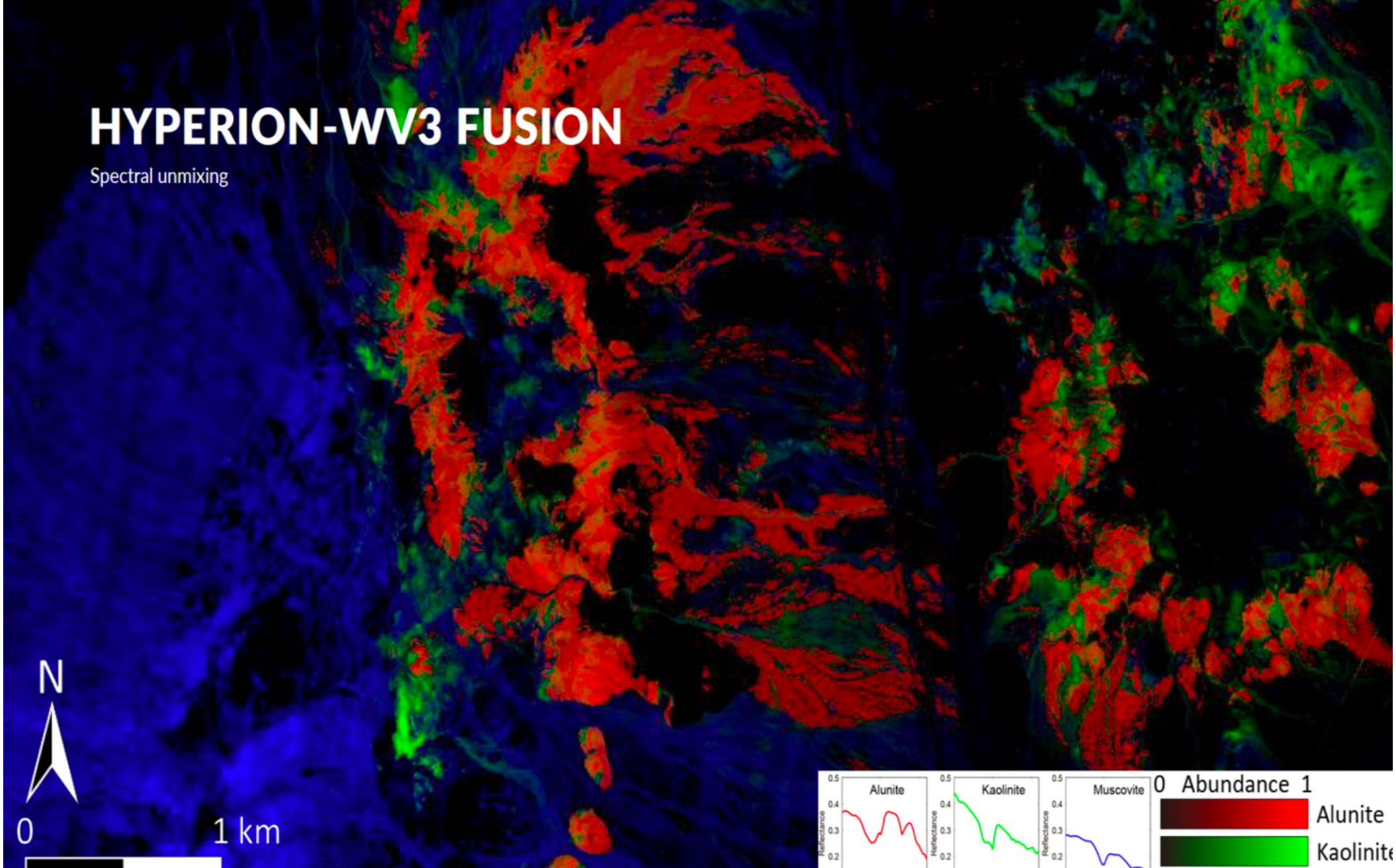


Color composite of WV3-SWIR
$RGB = (2.20, 1.57, 1.21)\ \mu m$
2014-09-19 © DigitalGlobe


HYPERION
$RGB = (2.20, 1.60, 0.57)\ \mu m$
N
0
1 km


HYPERION-WV3 FUSION
$RGB = (2.20, 1.60, 0.57)\ \mu m$
N
0
1 km

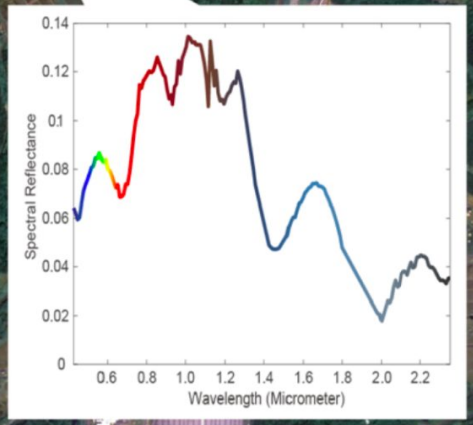

HYPERION
Spectral unmixing
N
0
1 km
Alunite
Kaolinite
Muscovite
Reflectance
0.5
0.4
0.3
0.2
0 Abundance 1
Alunite
Kaolinite


HYPERION-WV3 FUSION
Spectral unmixing
N
0
1 km
Alunite
Kaolinite
Muscovite
Reflectance
0.5
0.4
0.3
0.2
0 Abundance 1
Alunite
Kaolinite

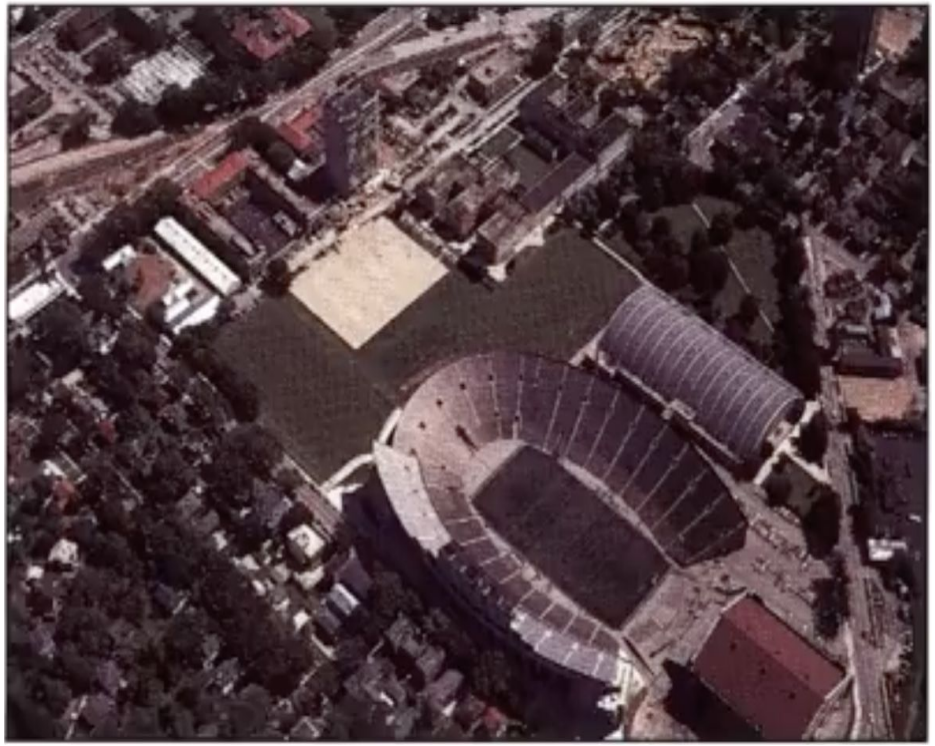

HYPERION
Fukushima, Japan

HYPERION-WV2 (GSD RATIO: 15)

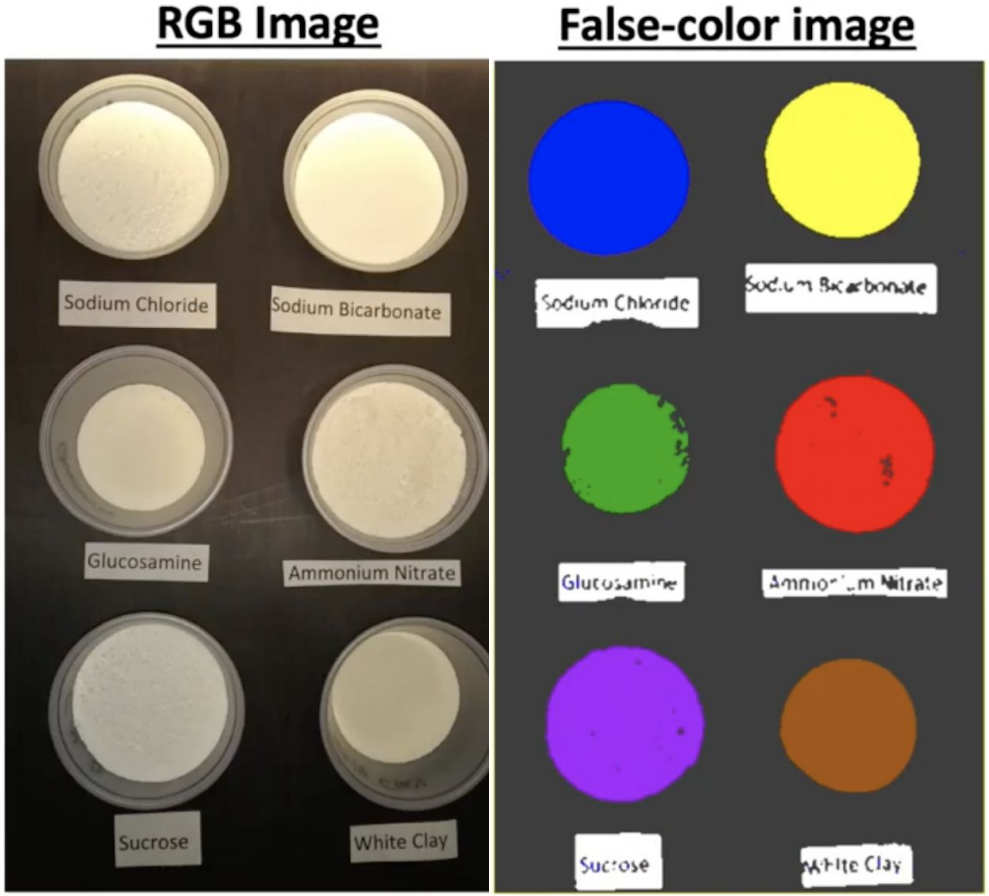
Fukushima, Japan

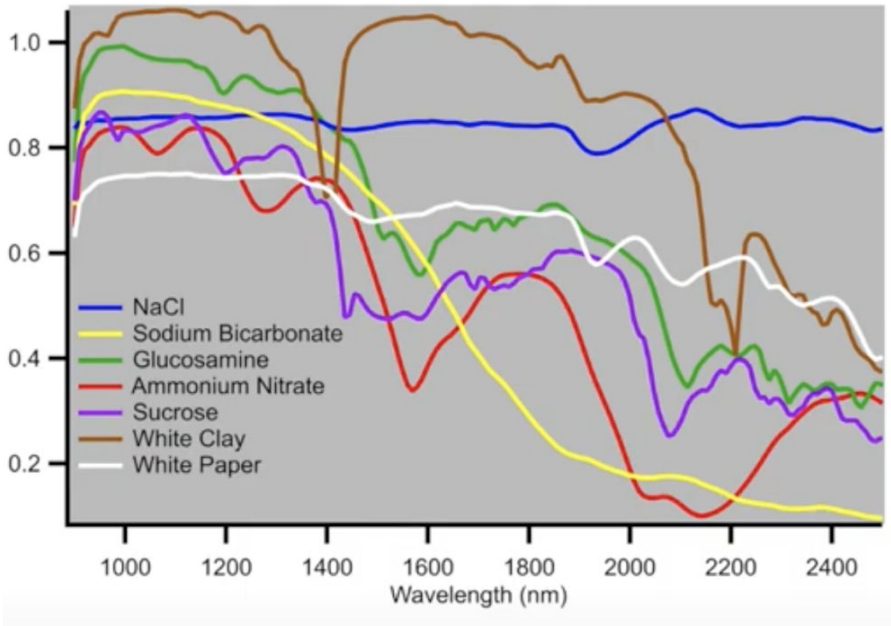


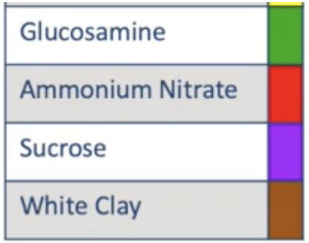
Usos: Vegetación vs Pasto Sintético



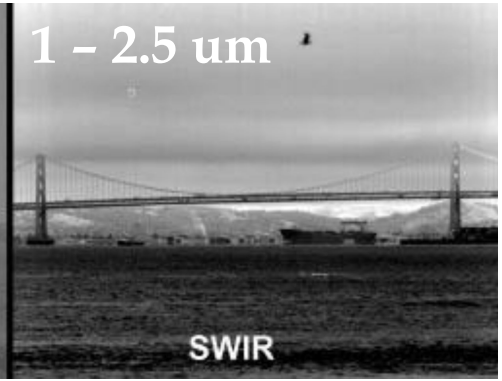
Usos: Materiales

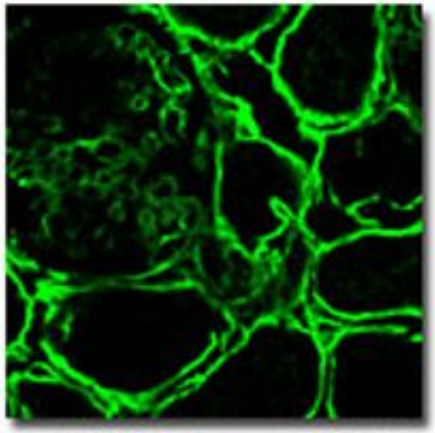


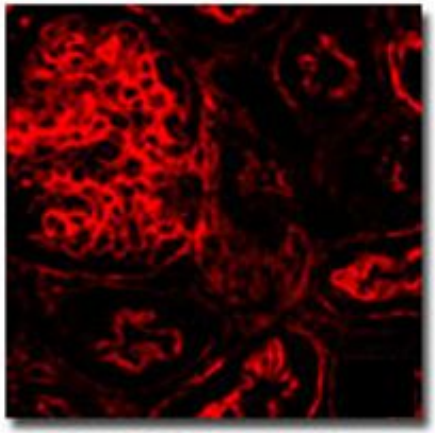


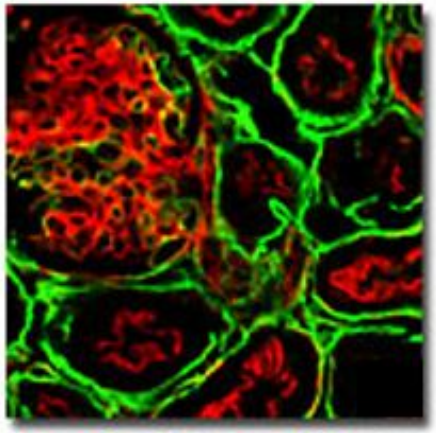


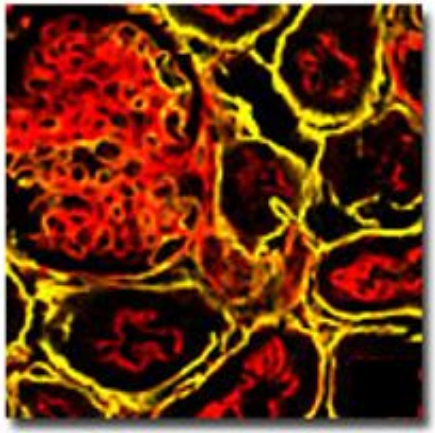
Aplicaciones de Imágenes Espectrales



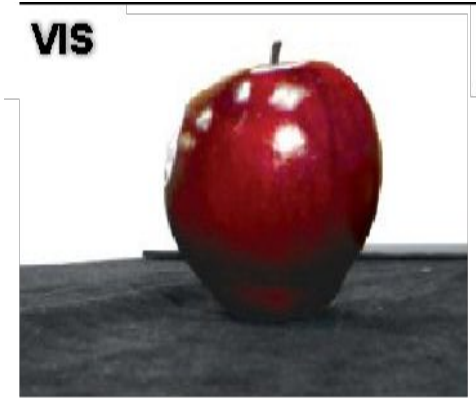


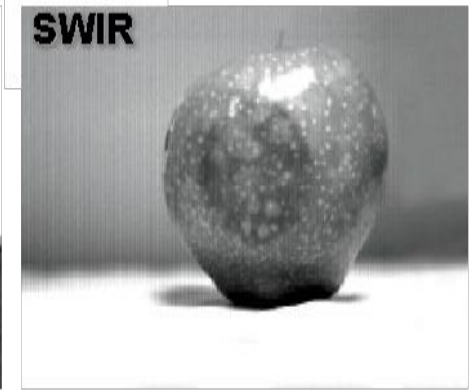




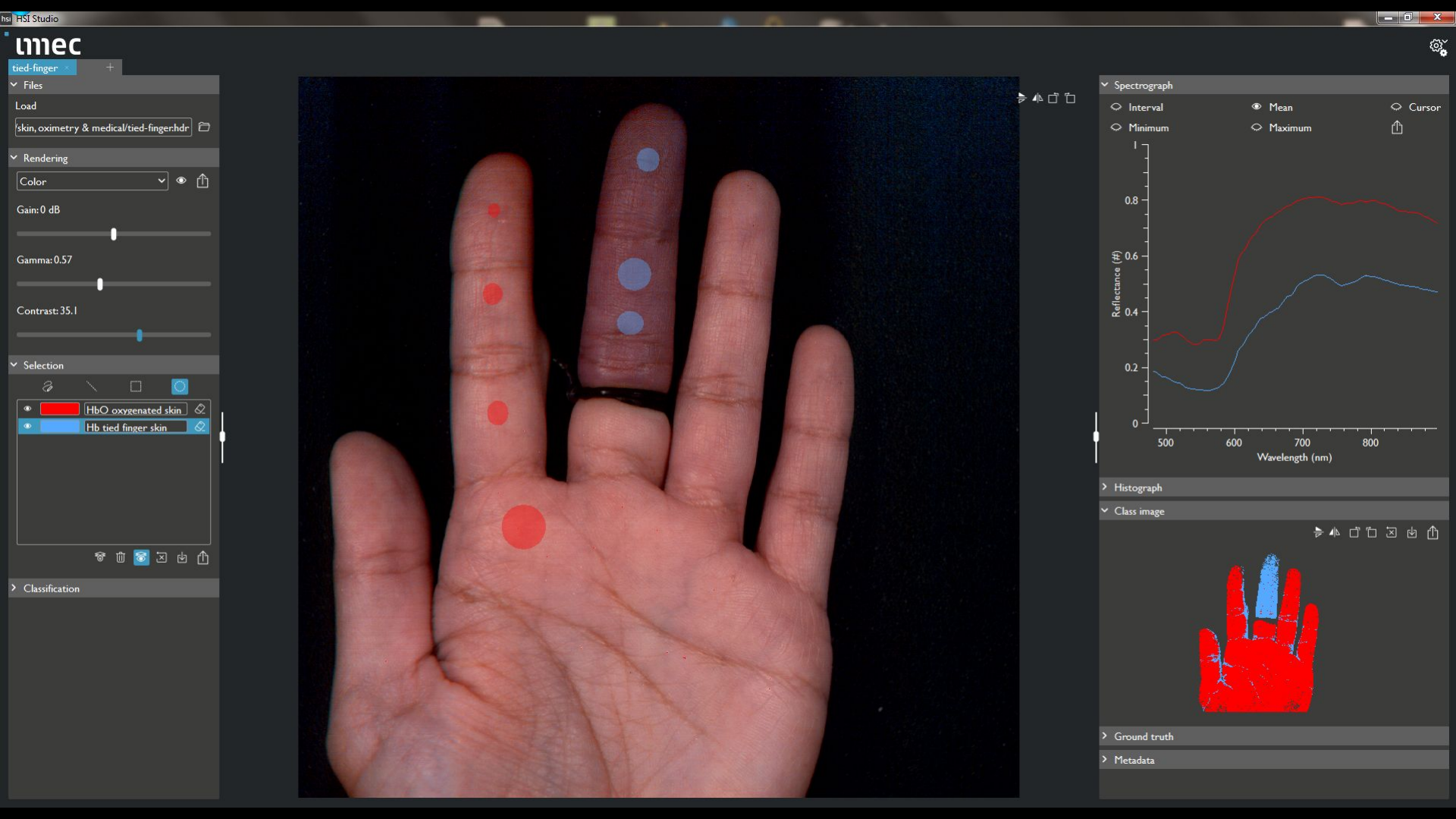


Aplicaciones de Imágenes Espectrales

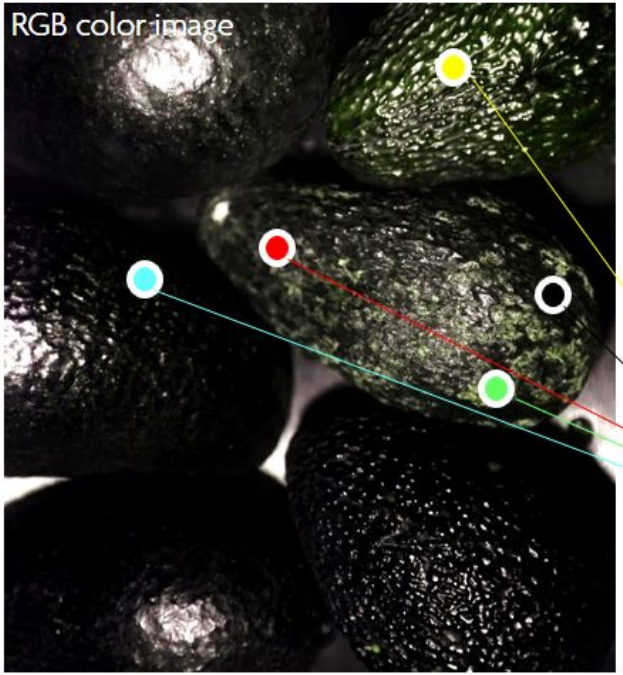


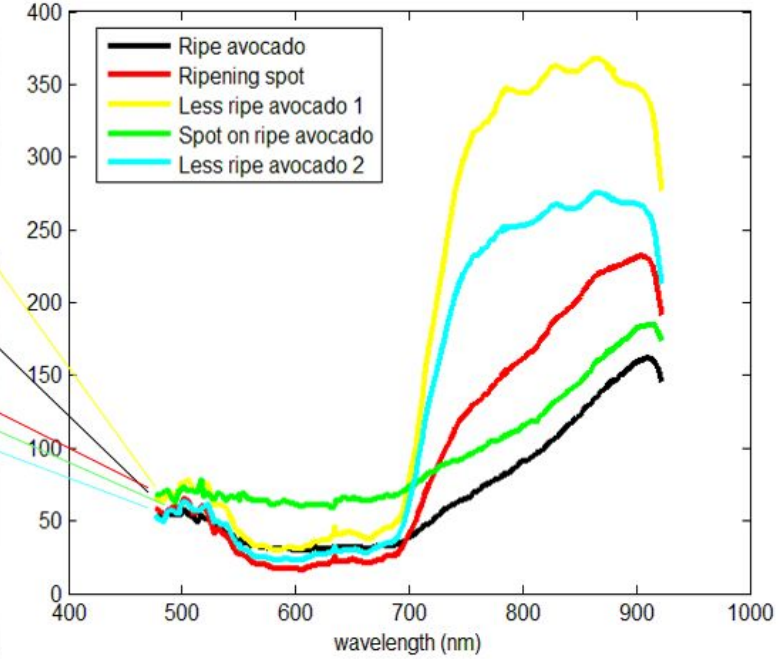


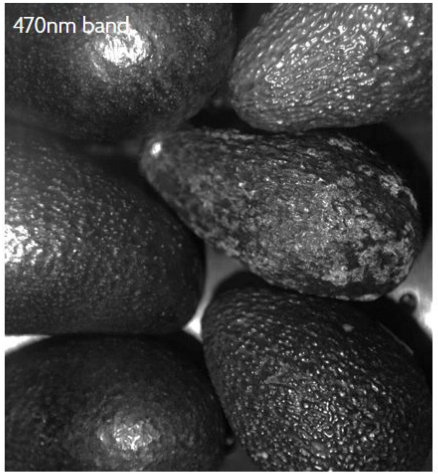
UV vs VIS vs IR

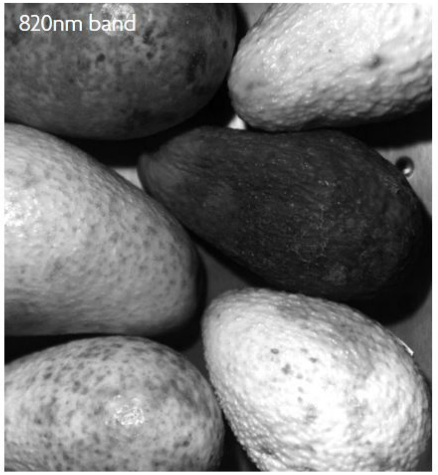

HSI Studio
imec
tied-finger
Files
Load
skin, oximetry & medical/tied-finger.hdr
Rendering
Color
Gain: 0 dB
Gamma: 0.57
Contrast: 35.1
Selection
HbO oxygenated skin
Hb tied finger skin
Classification
Spectrograph
Interval
Mean
Cursor
Minimum
Maximum
Reflectance (#)
Wavelength (nm)
Histograph
Class image
Ground truth
Metadata

Aplicaciones: Madurez de frutos

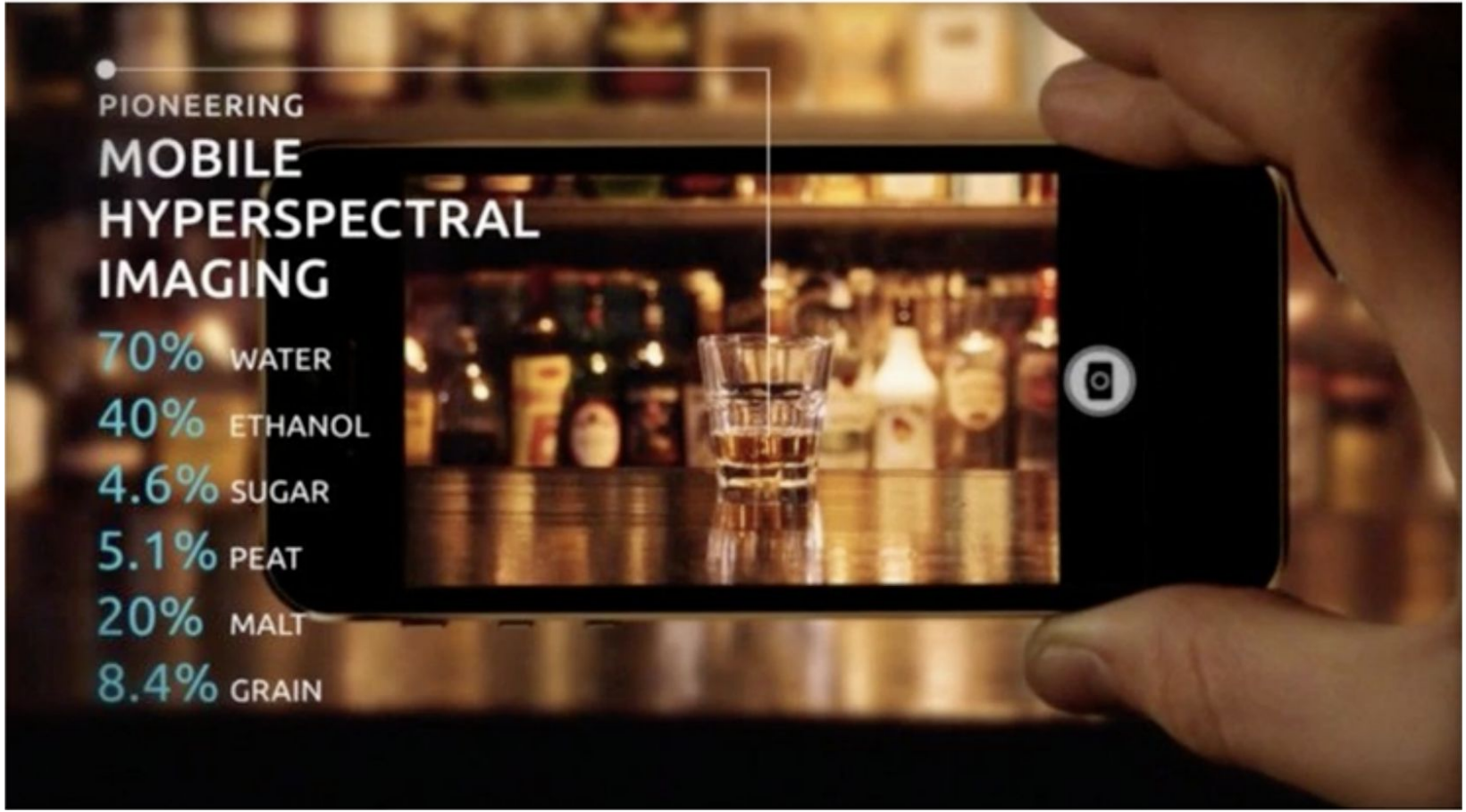




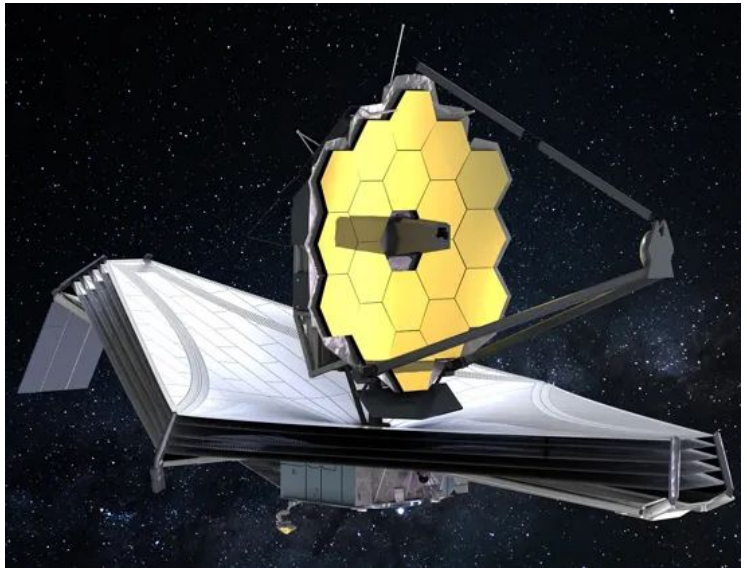




¿Futuro?

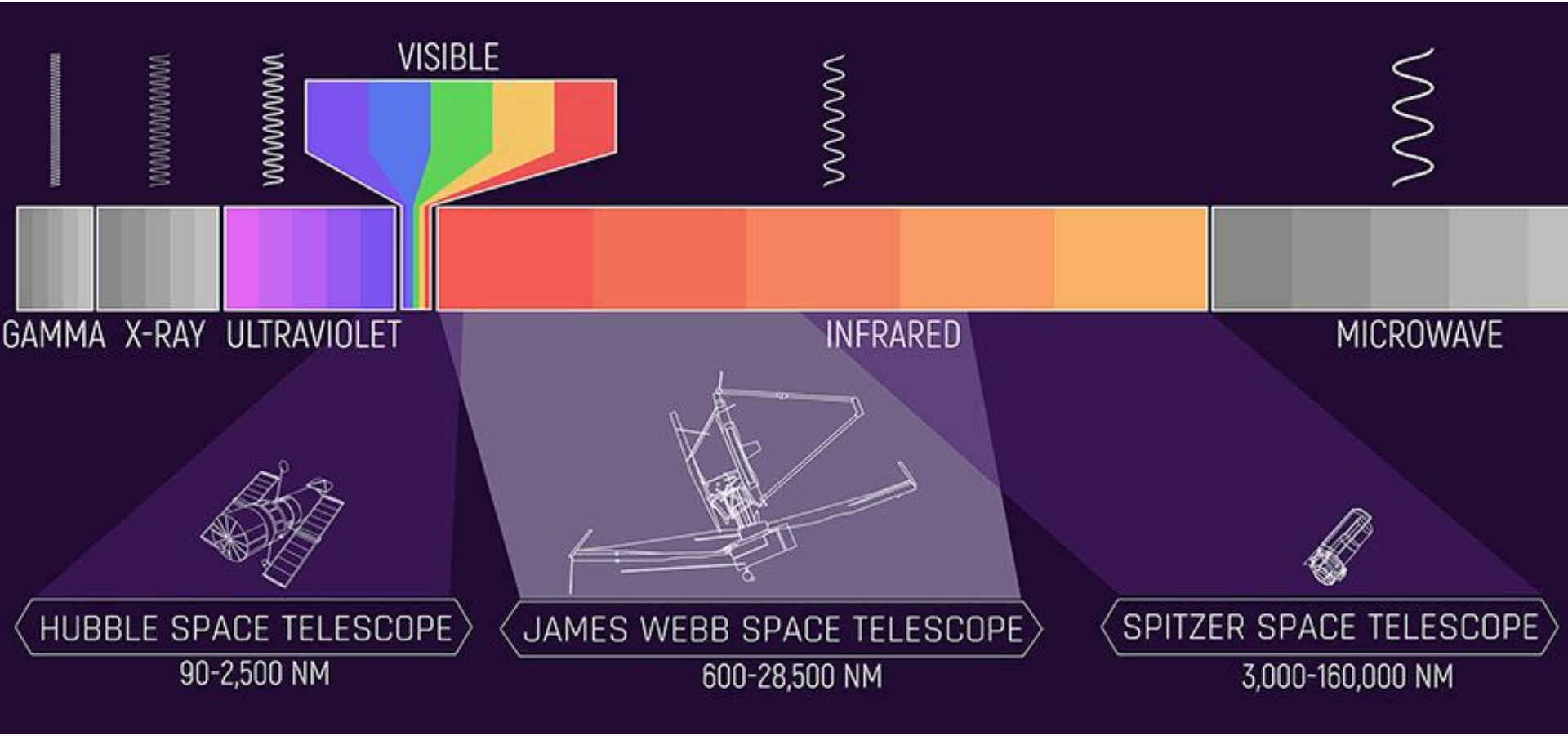

PIONEERING
MOBILE
HYPERSPECTRAL
IMAGING
70% WATER
40% ETHANOL
4.6% SUGAR
5.1% PEAT
20% MALT
8.4% GRAIN

Deep Space

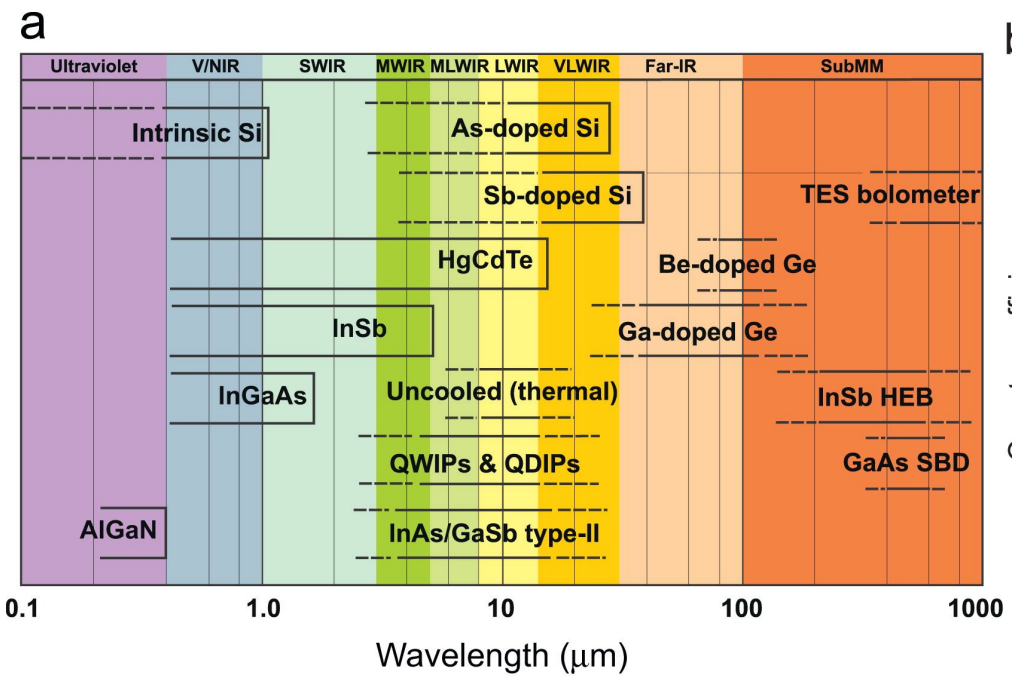


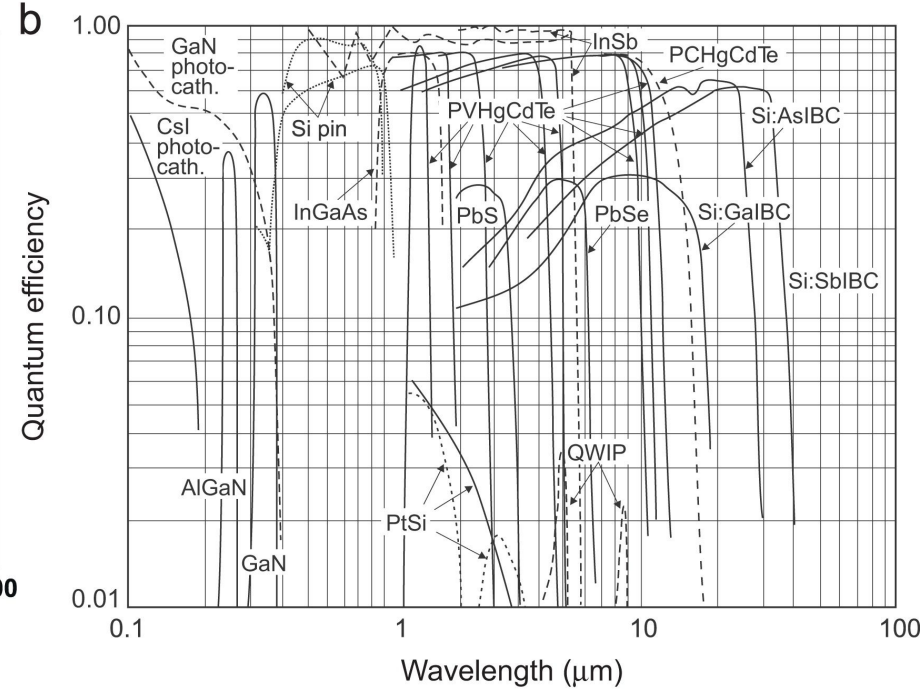
James Webb Space Telescope
(10 USD billion camera)

Sensibilidad del JWST



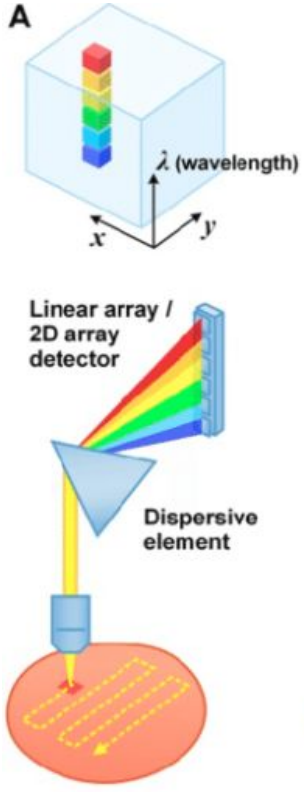
Diferentes sensores para diferentes rangos espectrales



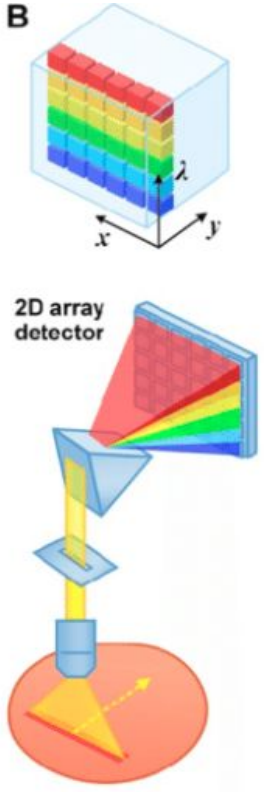


2. Métodos de Adquisición de Imágenes Espectrales

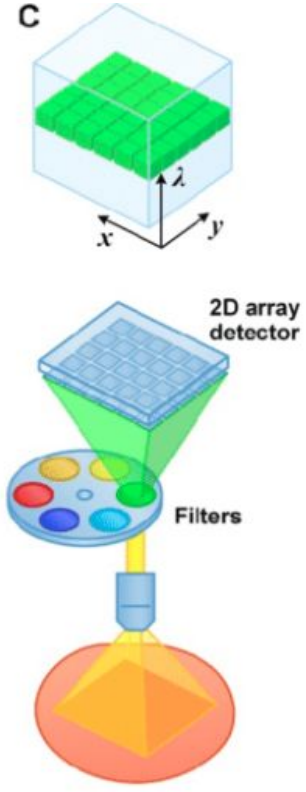
Whiskbroom
(pixel a pixel)



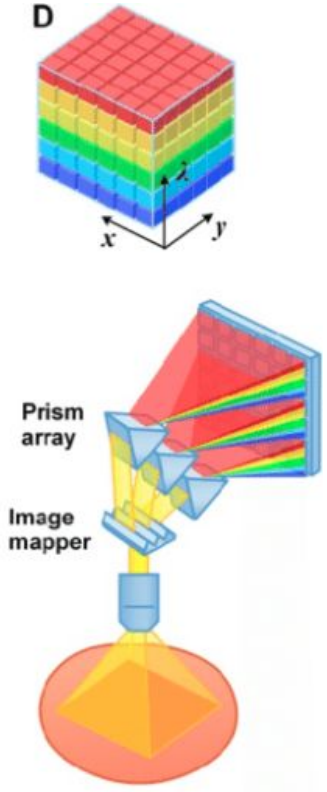
Pushbroom
(linea a linea)



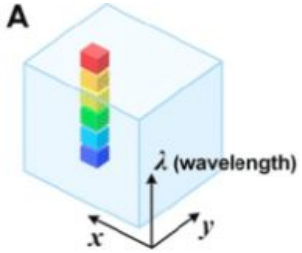
Filter-based
(banda a banda)

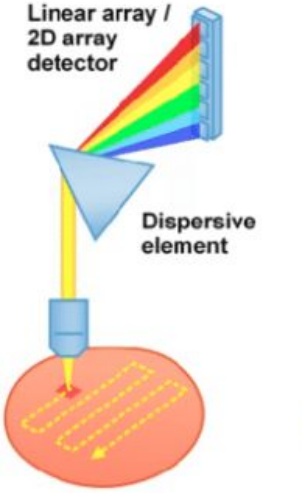


Snapshot
(todo en uno)



Métodos de adquisición: Whiskbroom

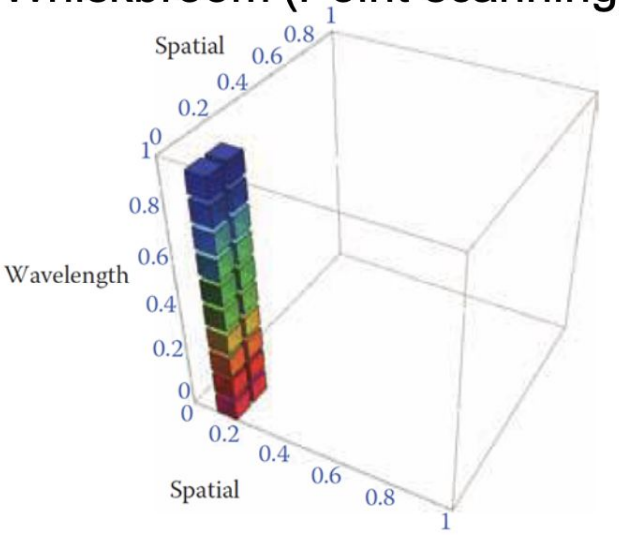


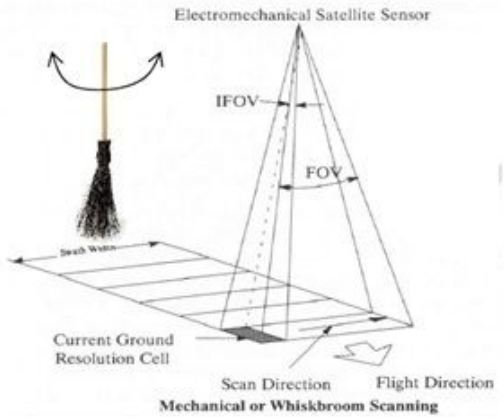


Point scan

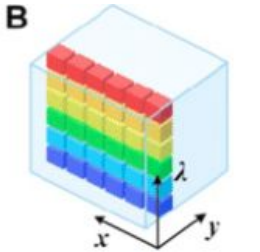
Spectral res: high
Speed: low

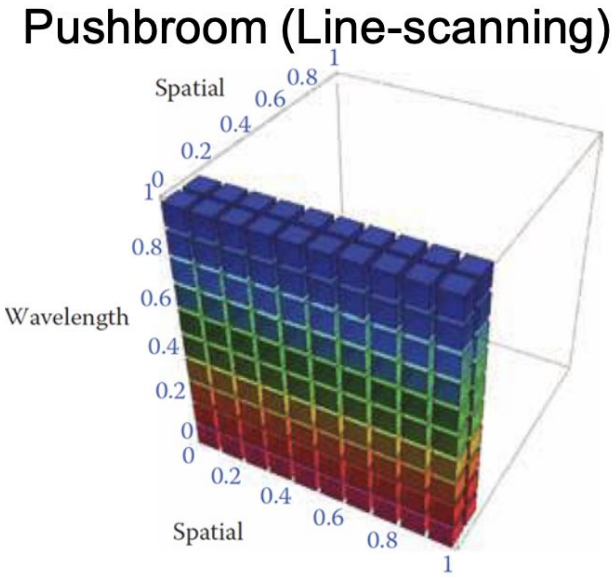
Whiskbroom (Point-scanning)

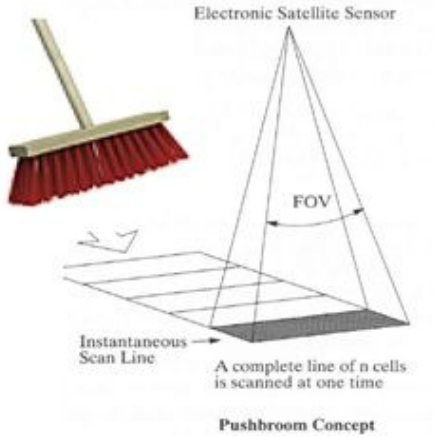




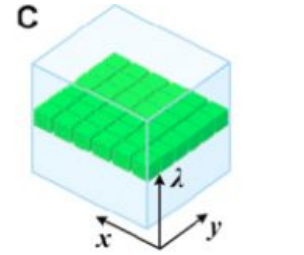
Métodos de adquisición: Pushbroom

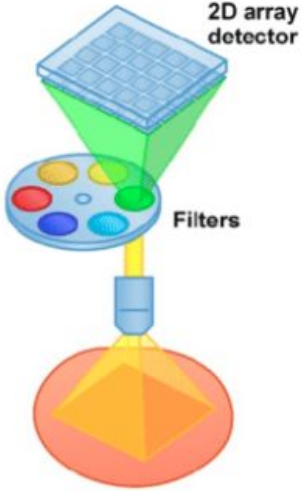






Métodos de adquisición: Filter-based

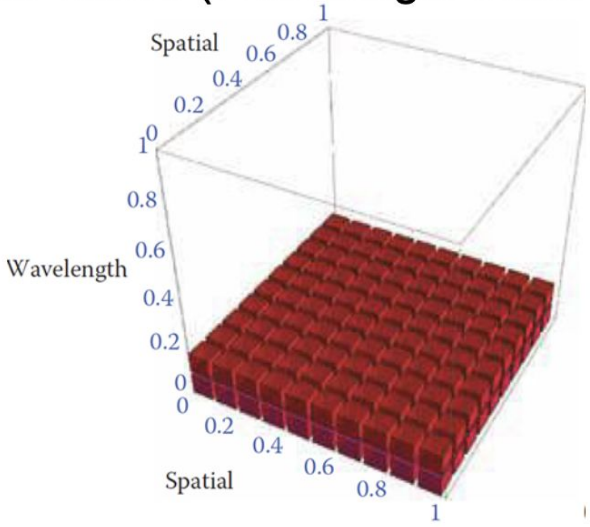


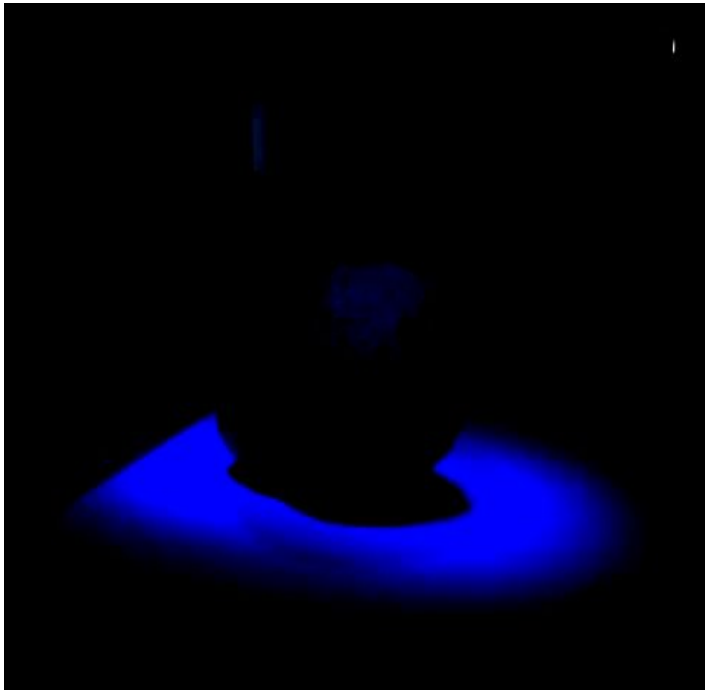


Wavelength scan

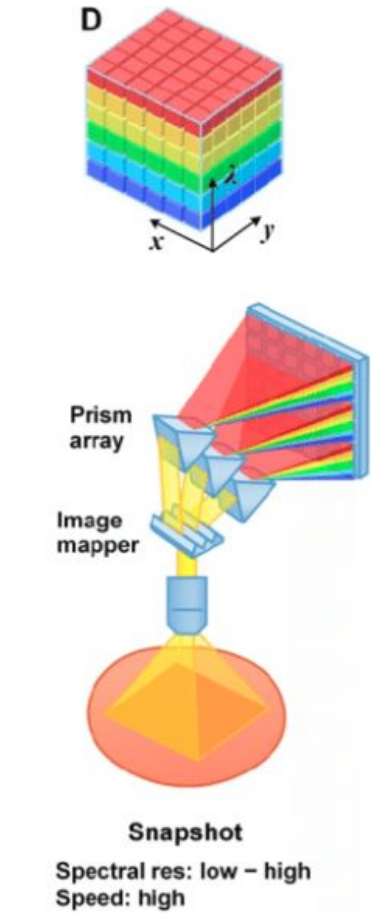
Spectral res: low – high
Speed: medium / high

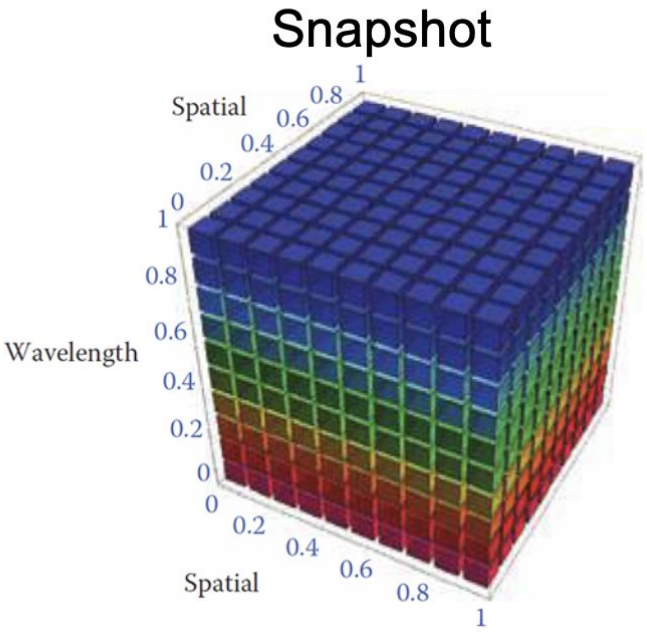
Filter-based (Wavelength-scanning)

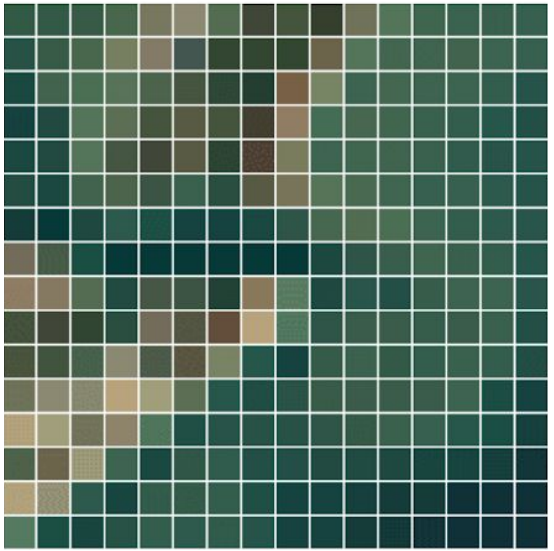




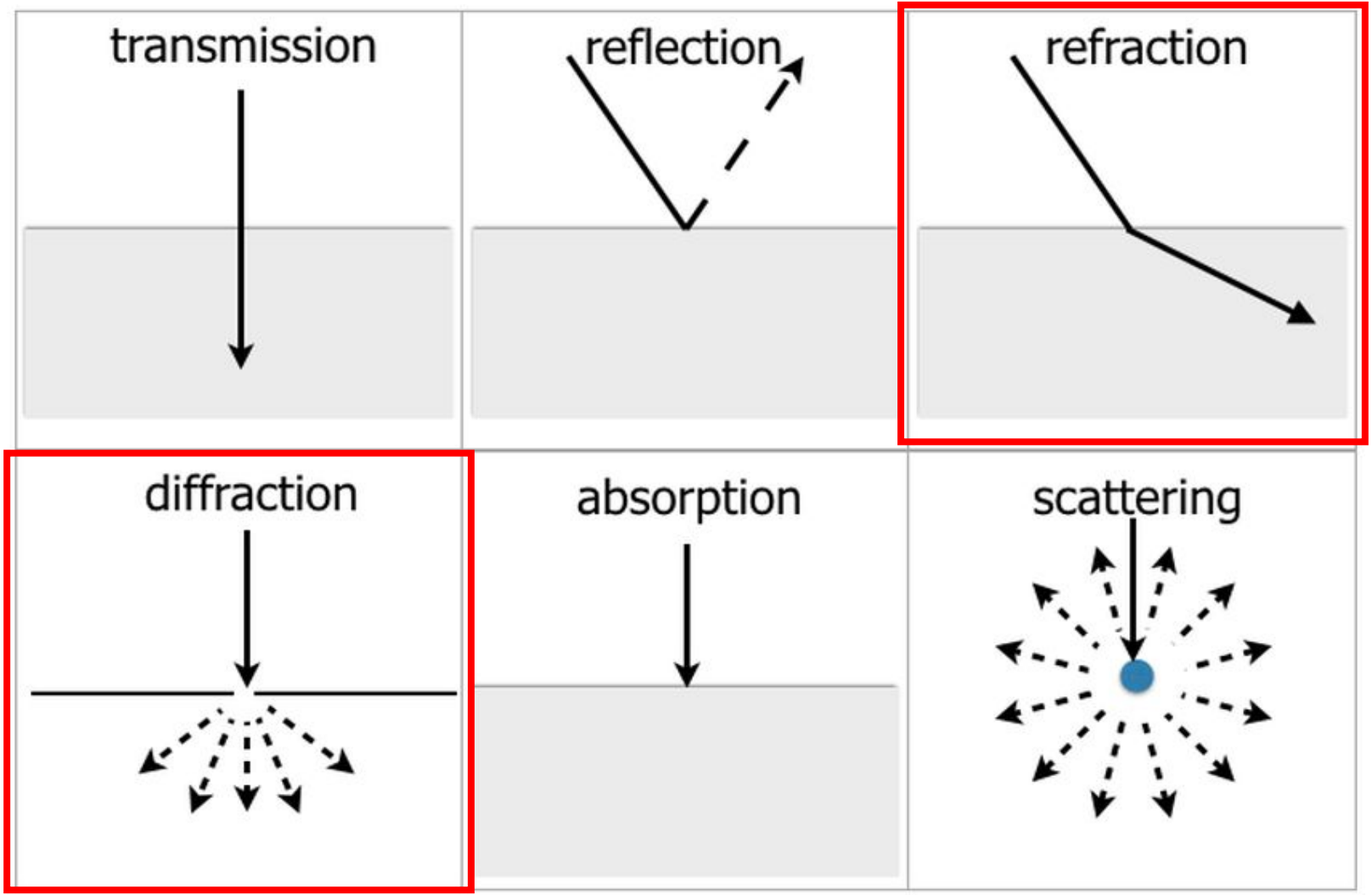
Métodos de adquisición: Snapshot







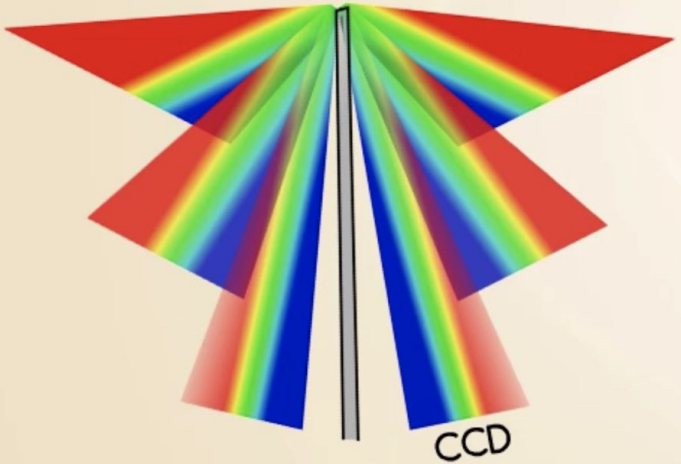
3. Dispersión vs Difracción (Prisma vs Rejilla)


transmission
reflection
refraction
diffraction
absorption
scattering

Conceptos: Difracción (Rejilla vs Prisma)

Diffraction grating

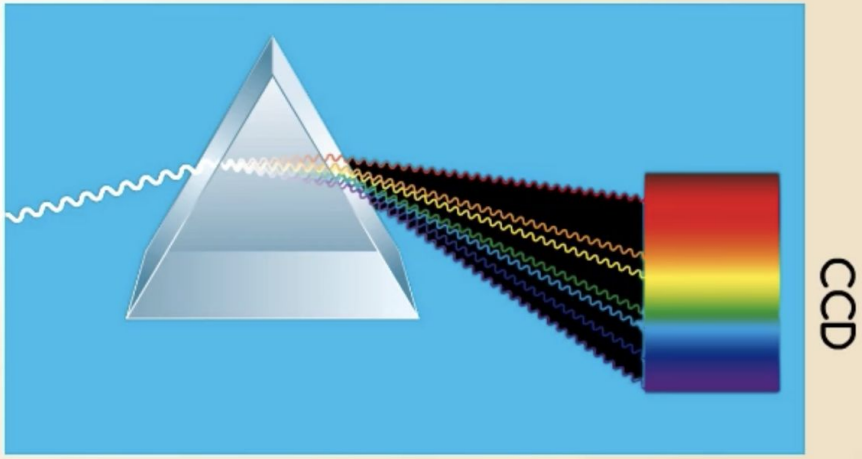
Splits the sample spectrum into multiple "orders"



Light that fails outside the CCD is wasted

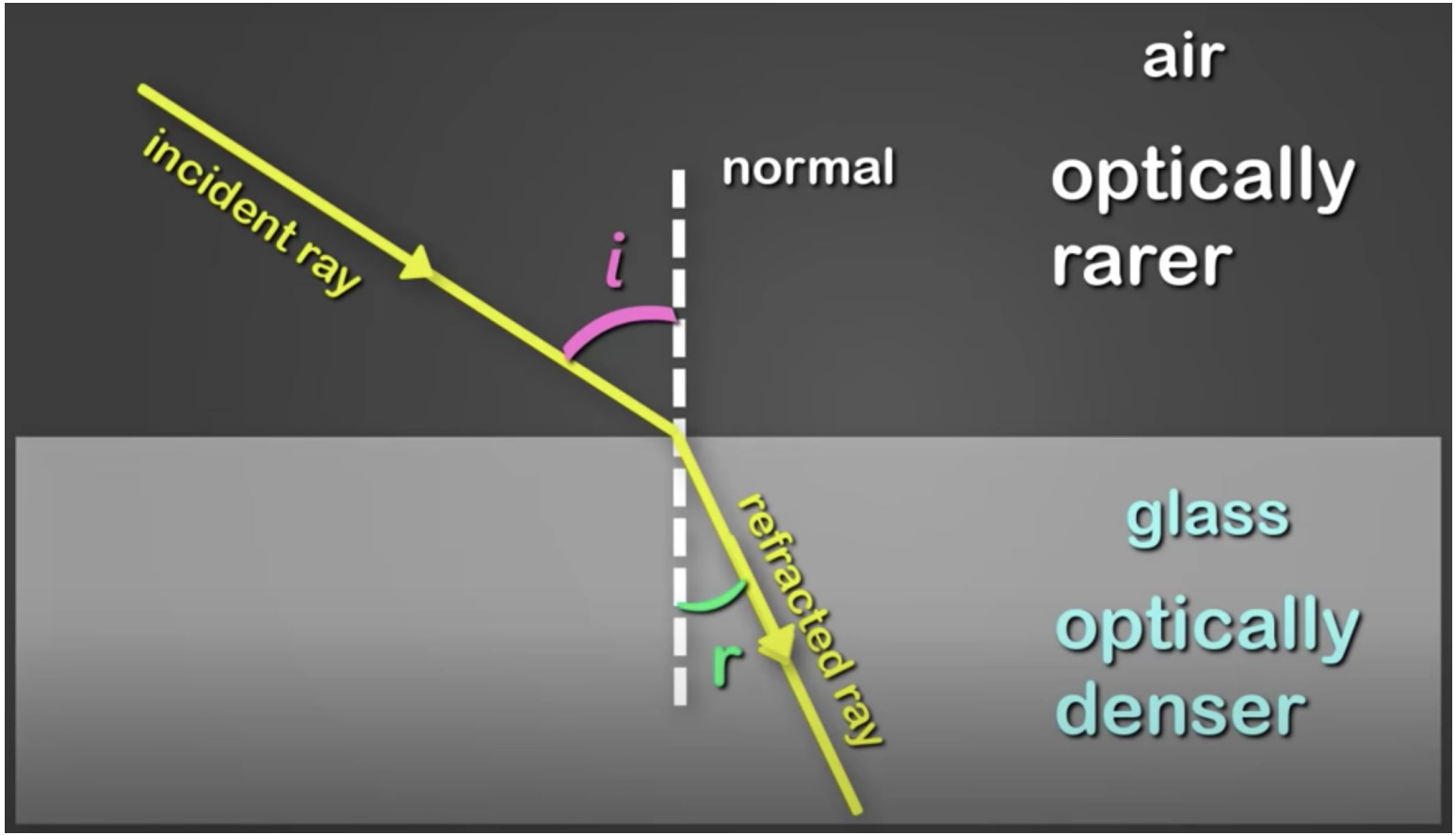
Prism

Refracts ALL light to the CCD

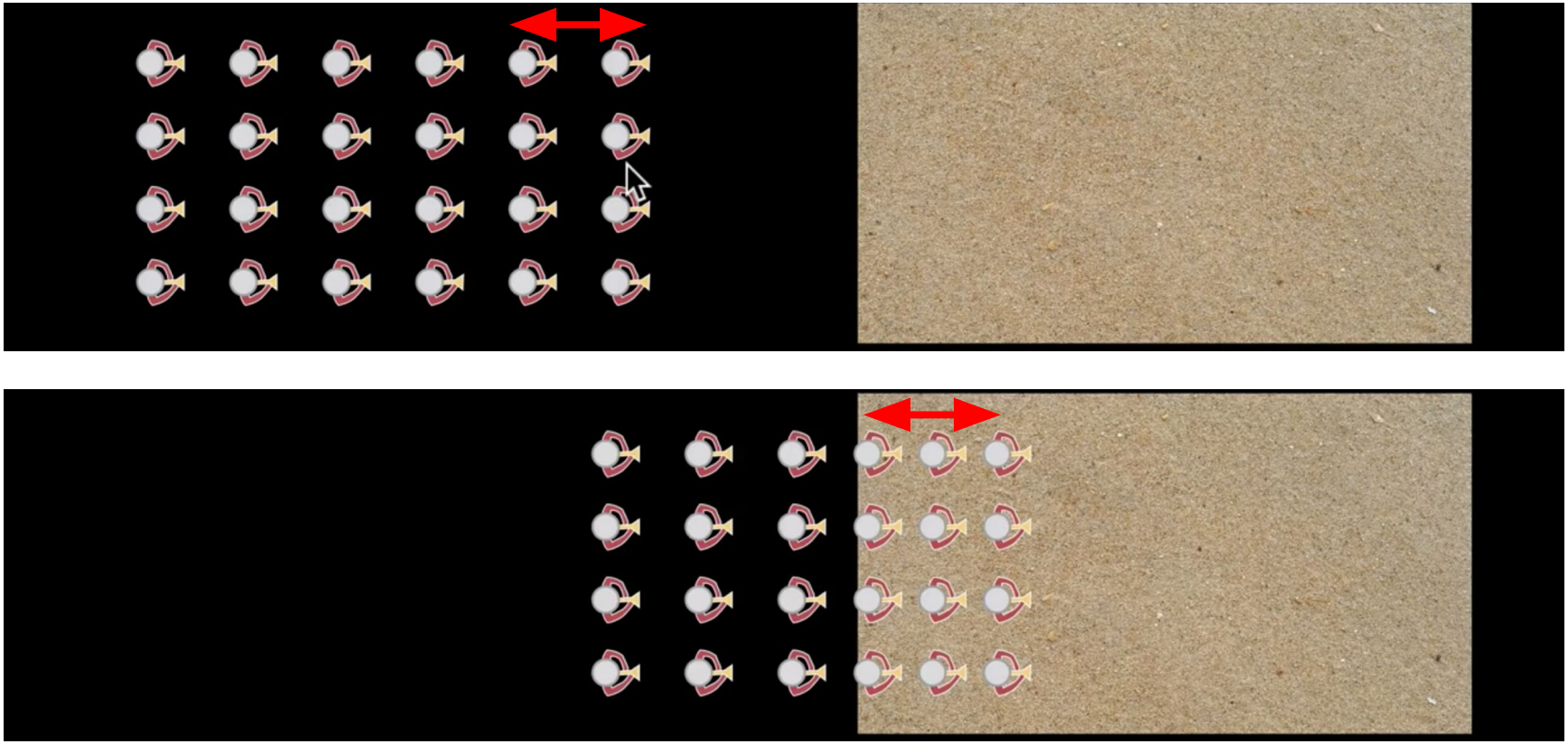


Light transmission through a prism significantly increases sensitivity (S/N ratio)

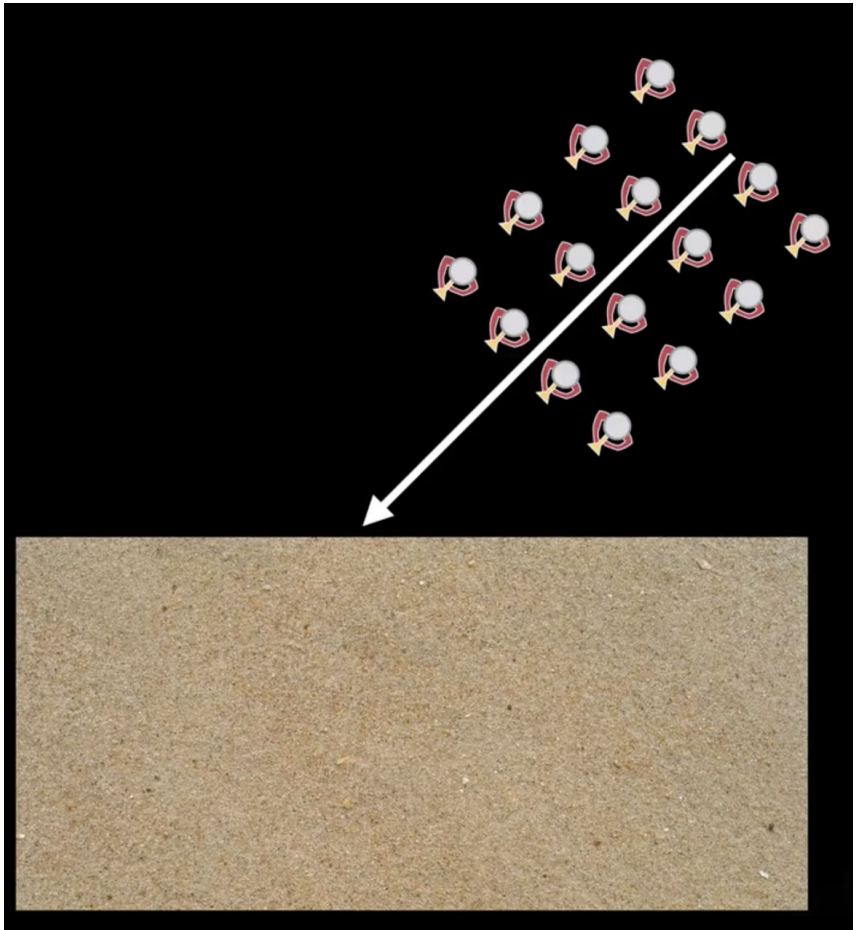
Conceptos: Refracción

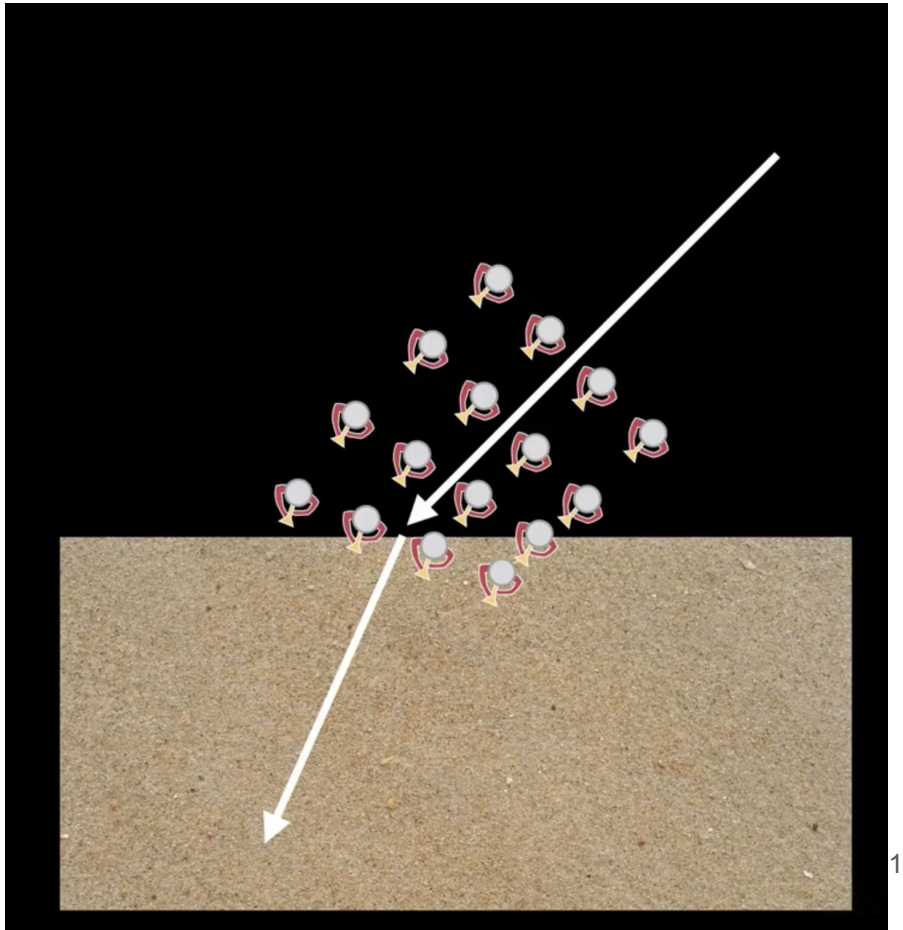


Conceptos: Refracción (Analogía)

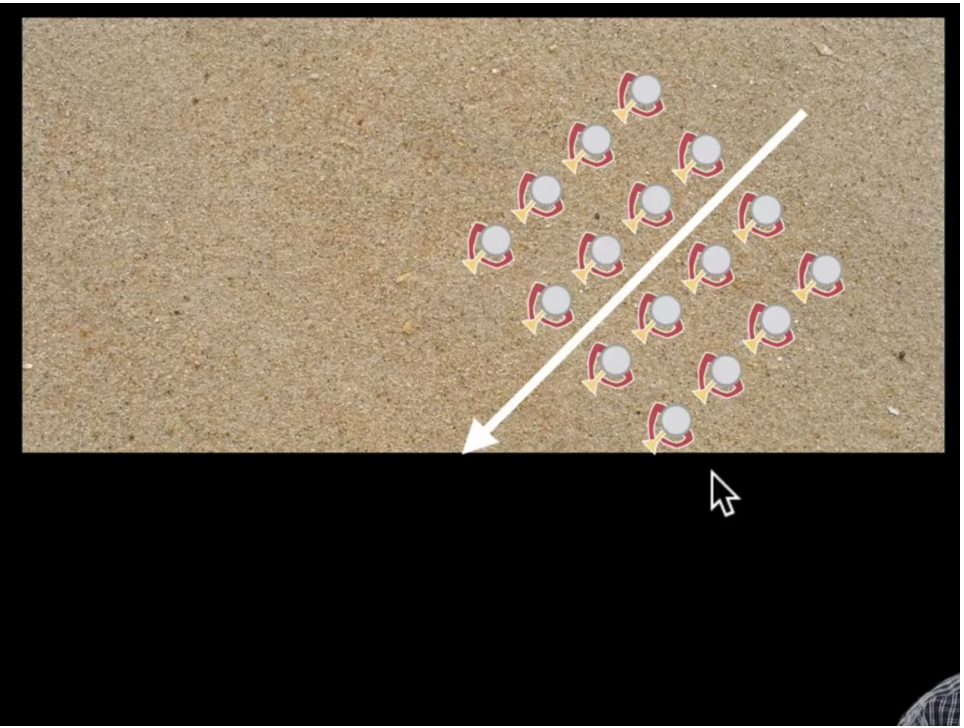


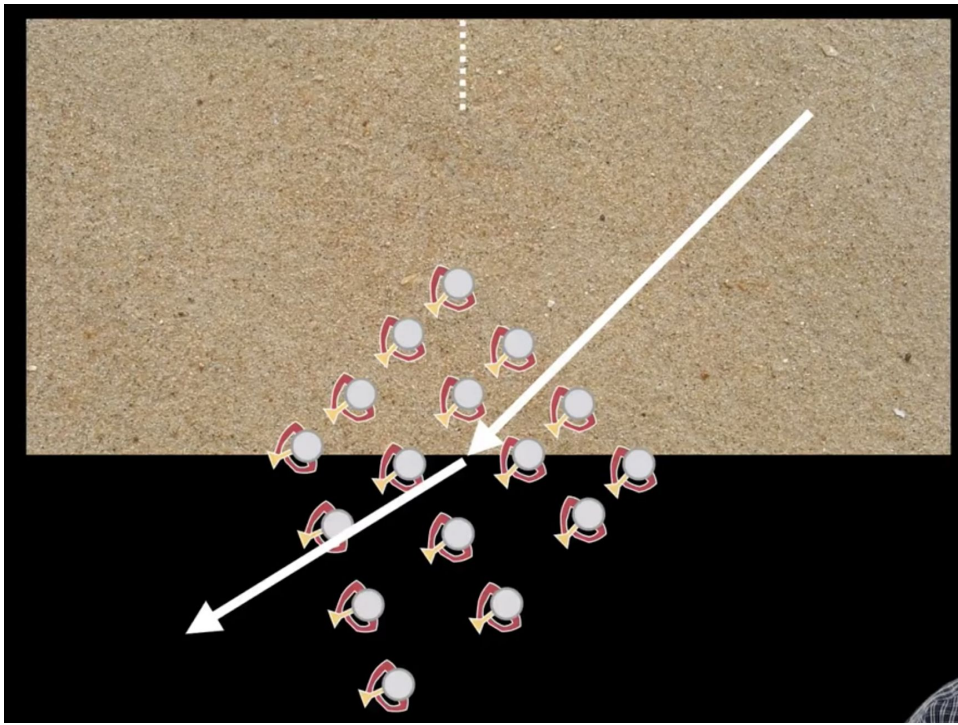
Conceptos: Refracción (Analogía)





Conceptos: Refracción (Analogía)

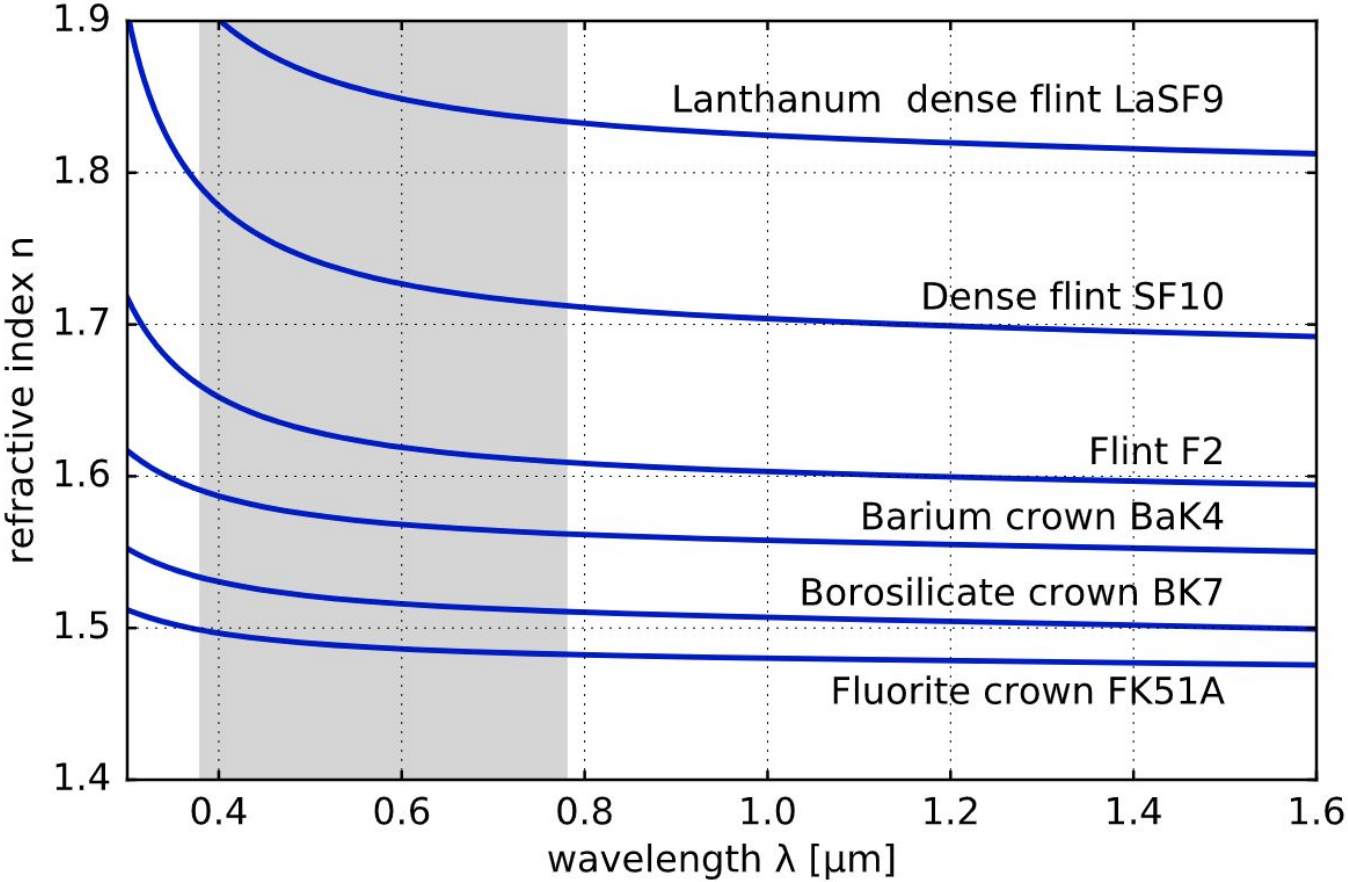




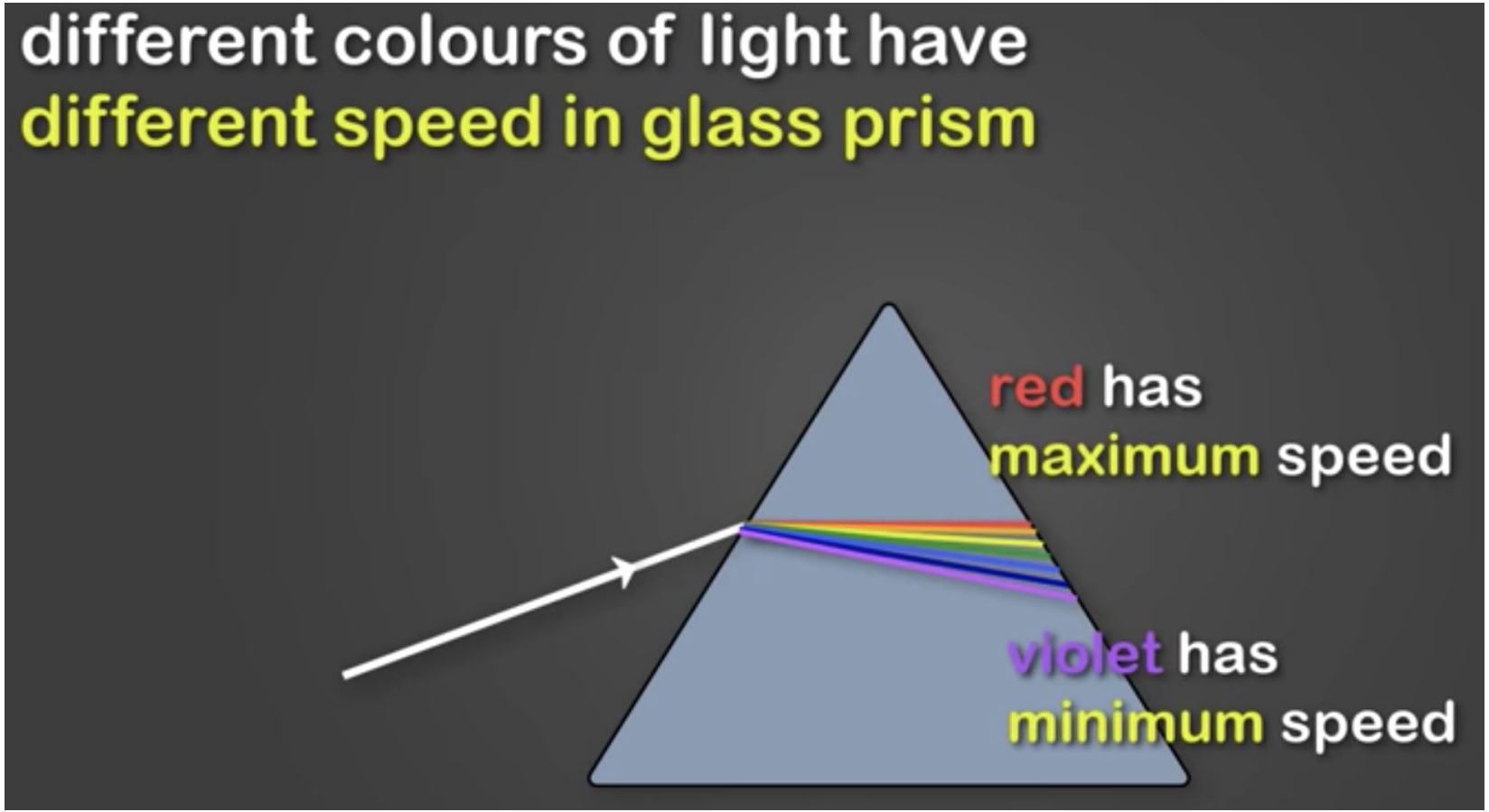
Conceptos: Índice de Refracción

$$n = \frac{c}{v}$$

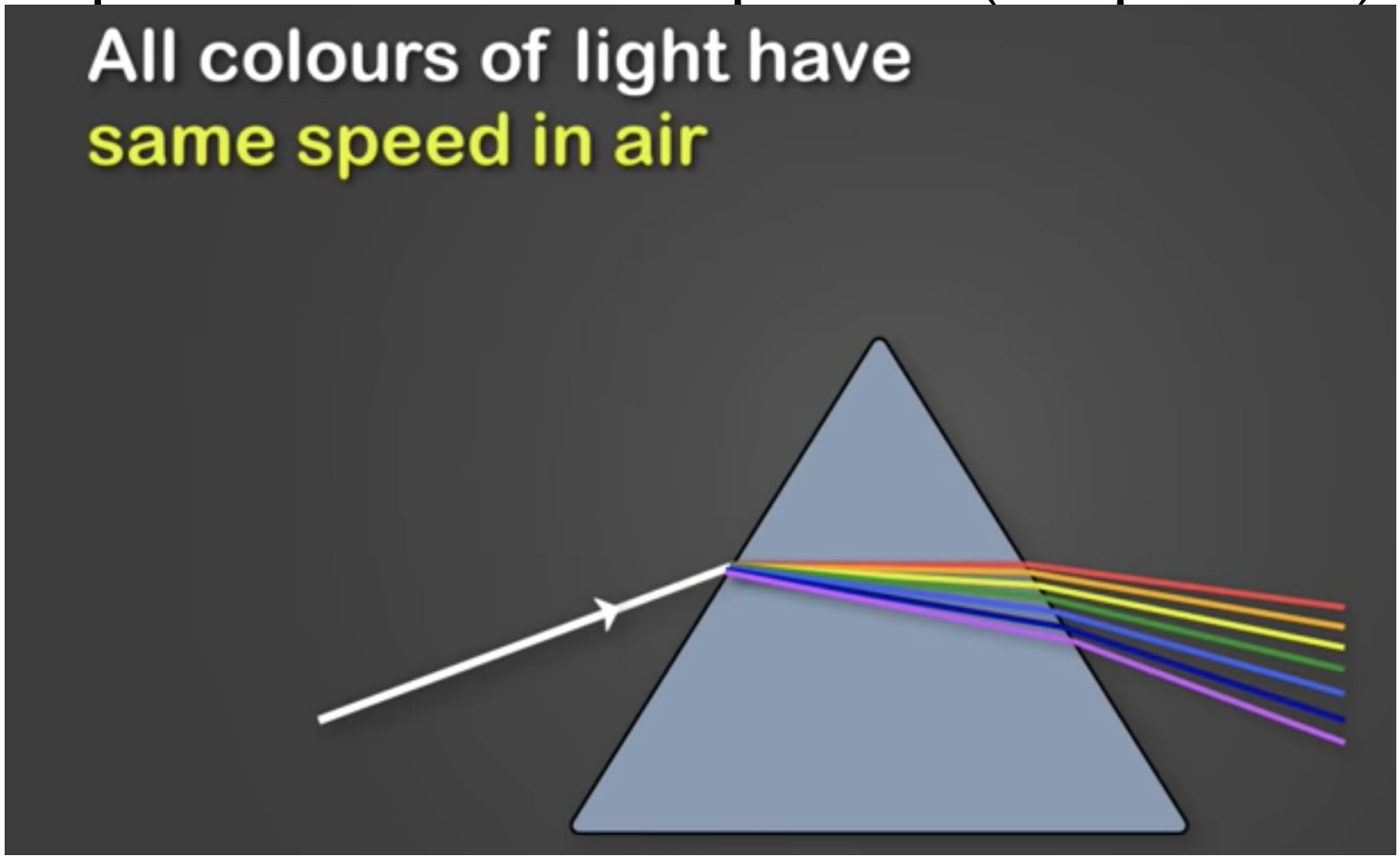
Material	*n*
Vacuum	1
Gases at 0 °C and 1 atm	
Air	1.000 293
Helium	1.000 036
Hydrogen	1.000 132
Carbon dioxide	1.000 45
Liquids at 20 °C	
Water	1.333
Ethanol	1.36
Olive oil	1.47
Solids	
Ice	1.31
Fused silica (quartz)	1.46[11]



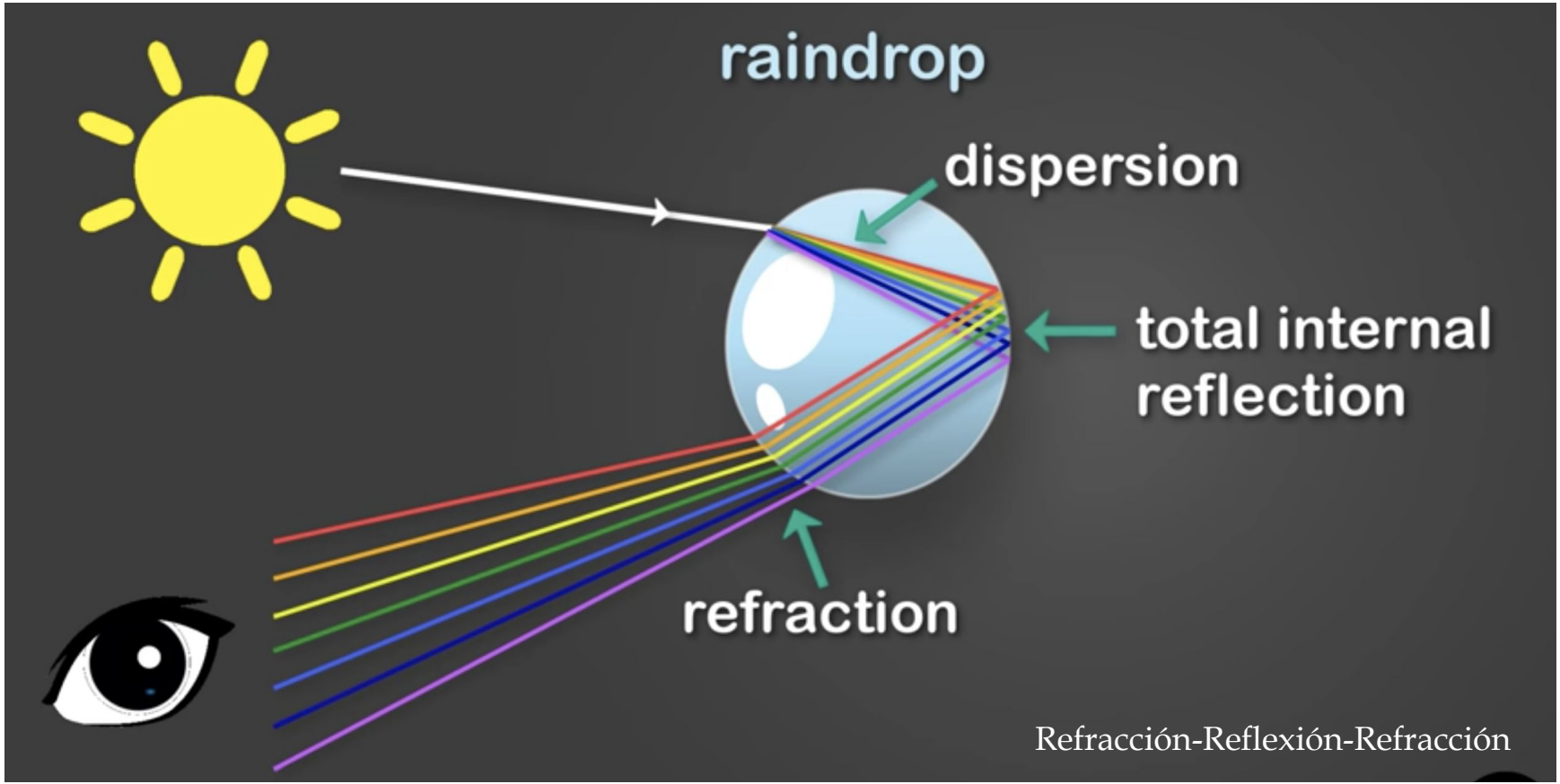
Conceptos: Refracción en prisma (Dispersión)



Conceptos: Refracción en prisma (Dispersión)



Conceptos: Refracción Arcoiris

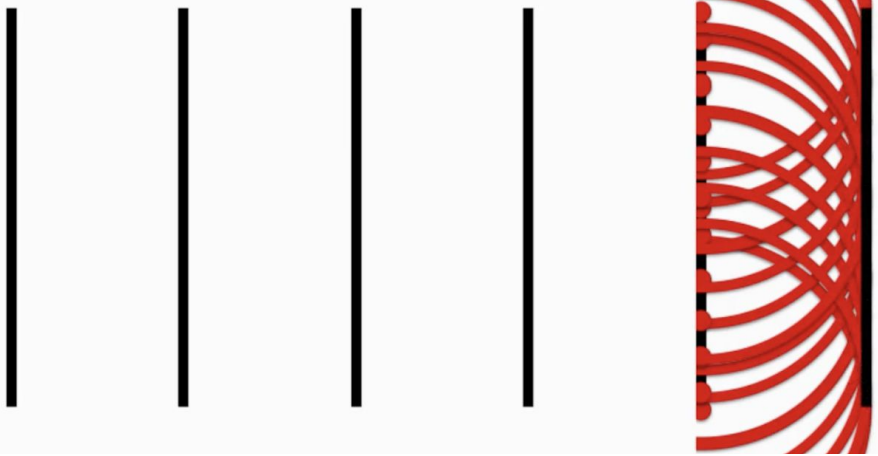


Refracción-Reflexión-Refracción

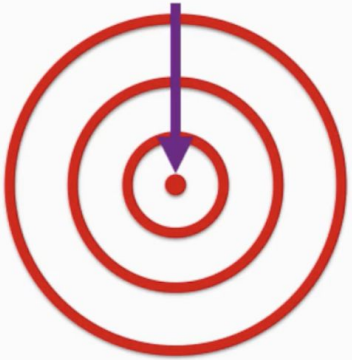
Principio de Difracción

Huygens's Principle

"Every point of an advancing wavefront is a new center of disturbance from which emanate independent waves in all directions"

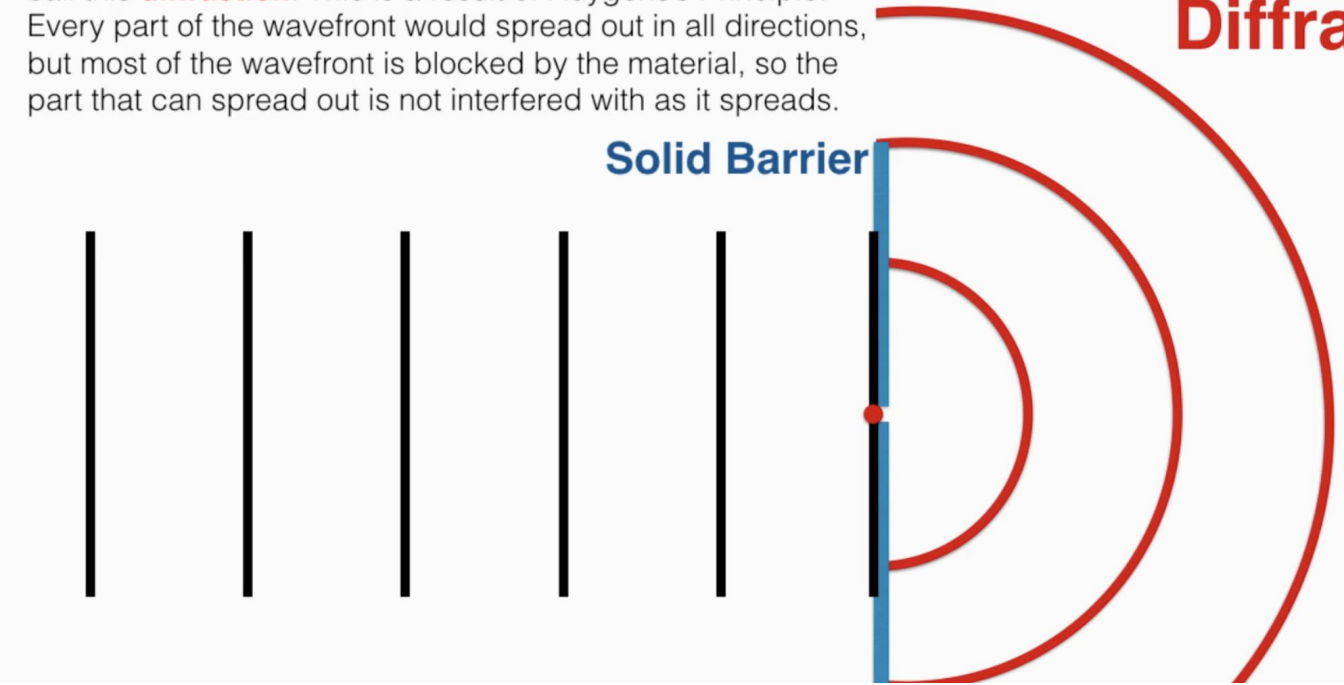


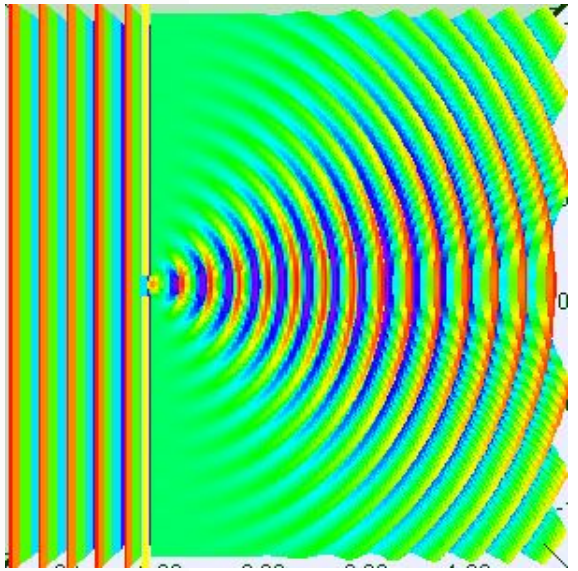
Center of Disturbance



Difracción con barrera externa

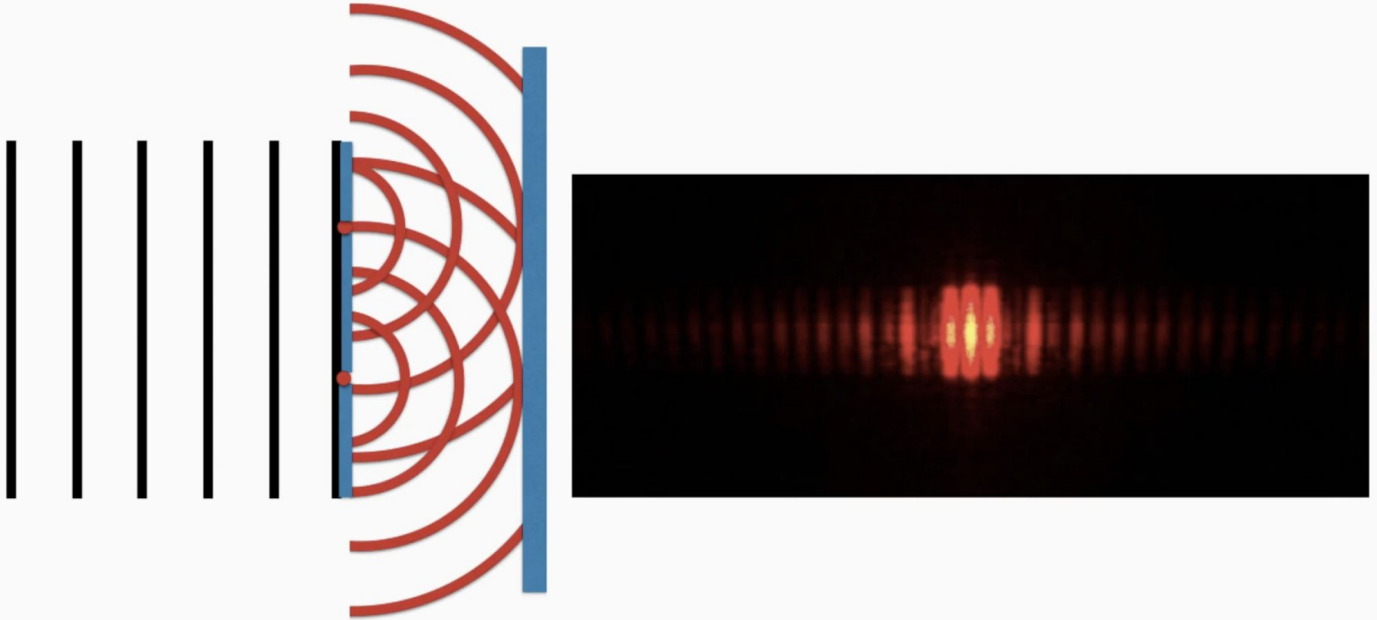
When waves of light pass through a small opening in a barrier and as a result radiate out in all directions on the other side, we call this **diffraction**. This is a result of Huygens's Principle. Every part of the wavefront would spread out in all directions, but most of the wavefront is blocked by the material, so the part that can spread out is not interfered with as it spreads.





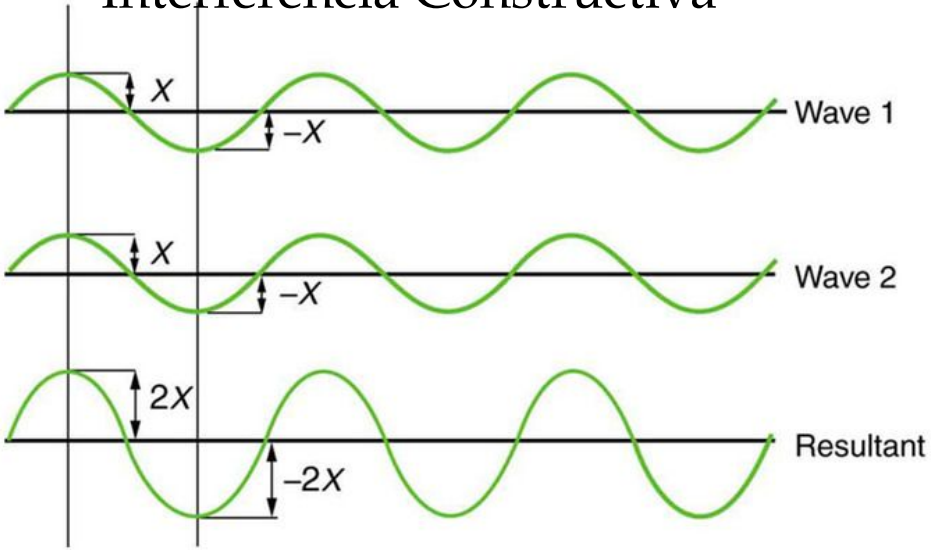
Difracción (Dual-slit)

There is a way of observing the effects of diffraction in light by passing the light through a barrier with two slits cut out, and observing the pattern the light forms on a second barrier beyond the first. The pattern shows clear maxima (points of constructive interference) and minima (points of destructive interference)

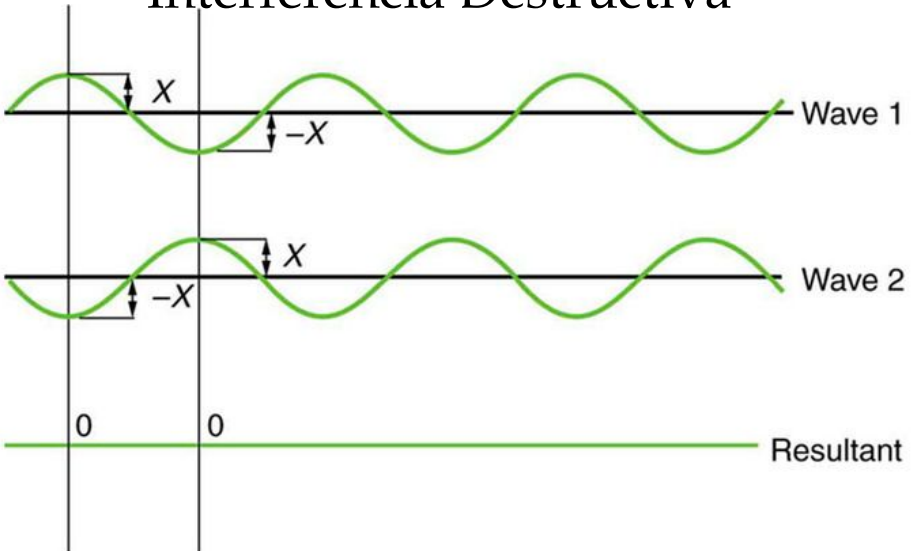


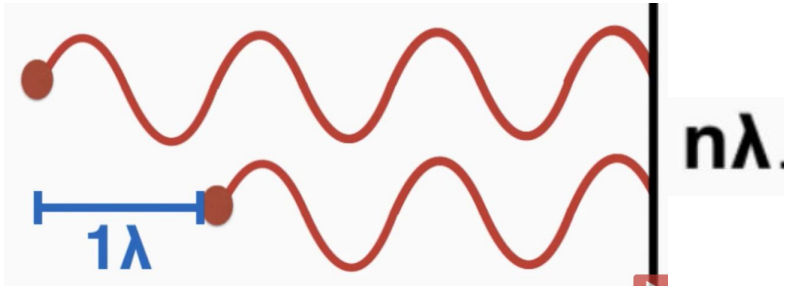
Interferencia

Interferencia Constructiva



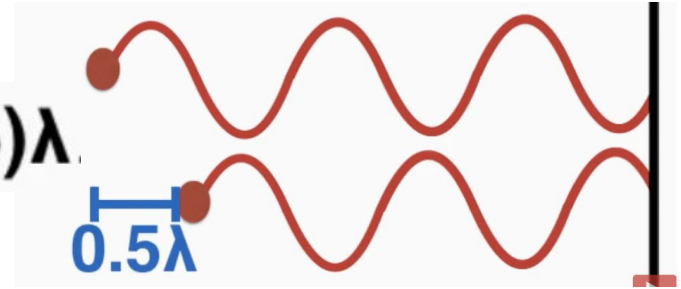
Interferencia Destructiva



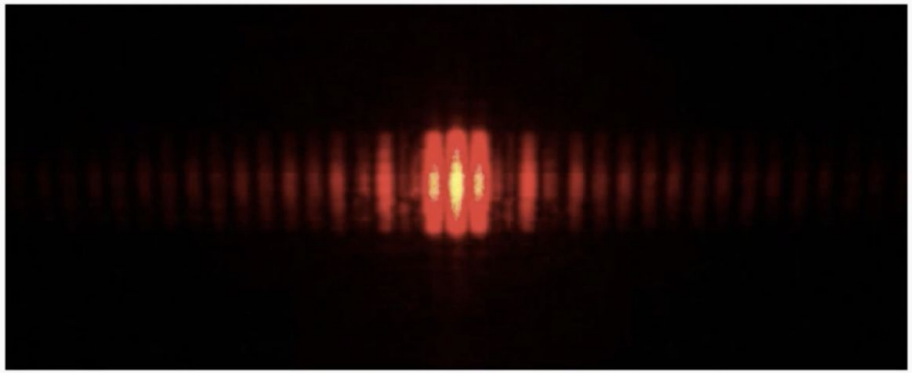


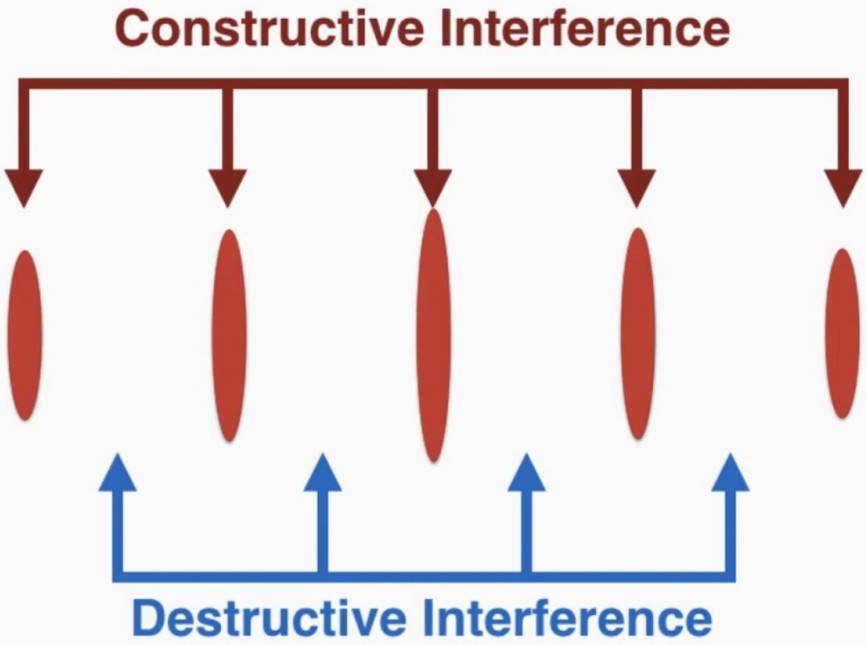
$n\lambda$

$(n + 0.5)\lambda$

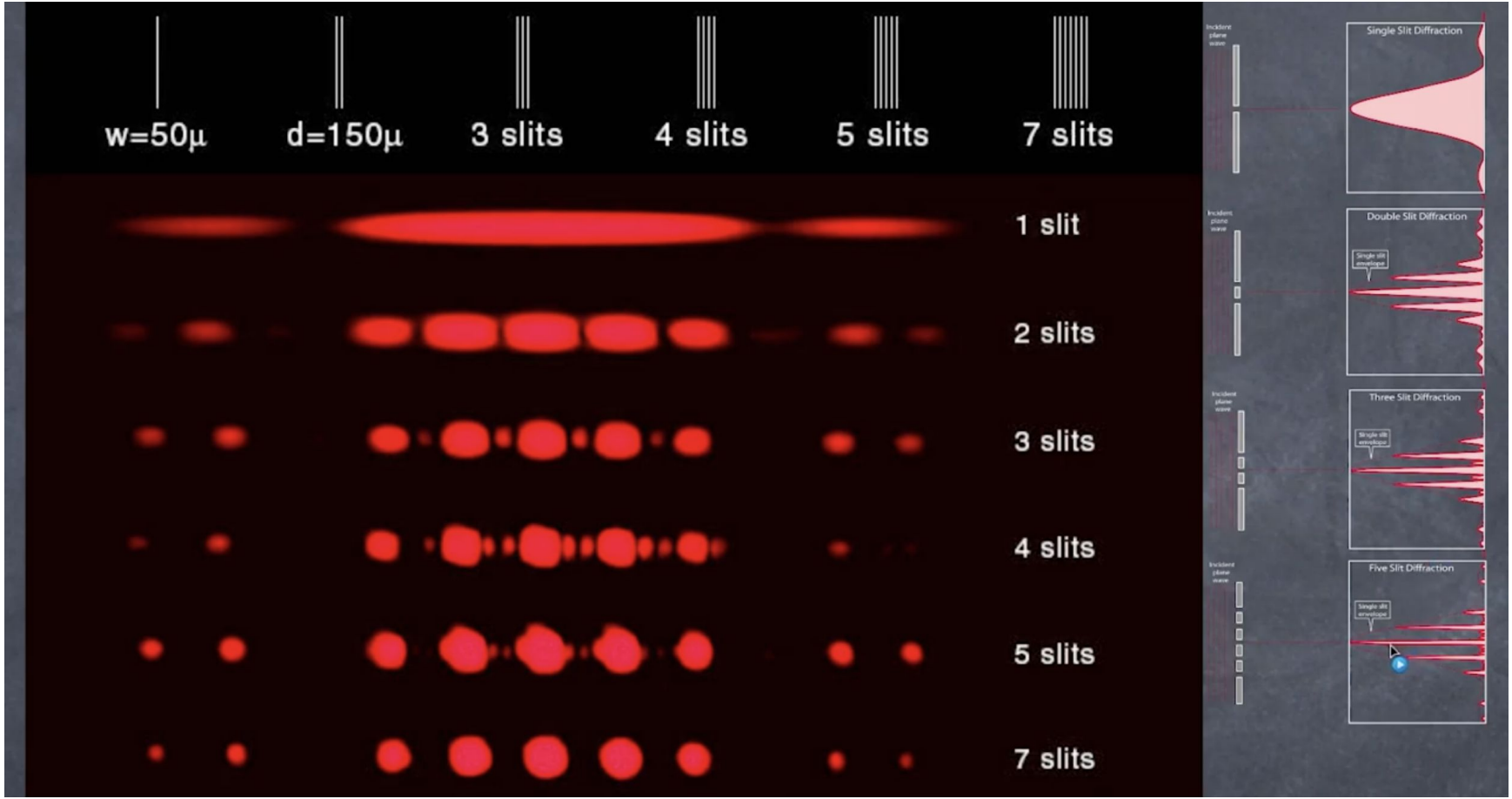


Difracción (interferencia)

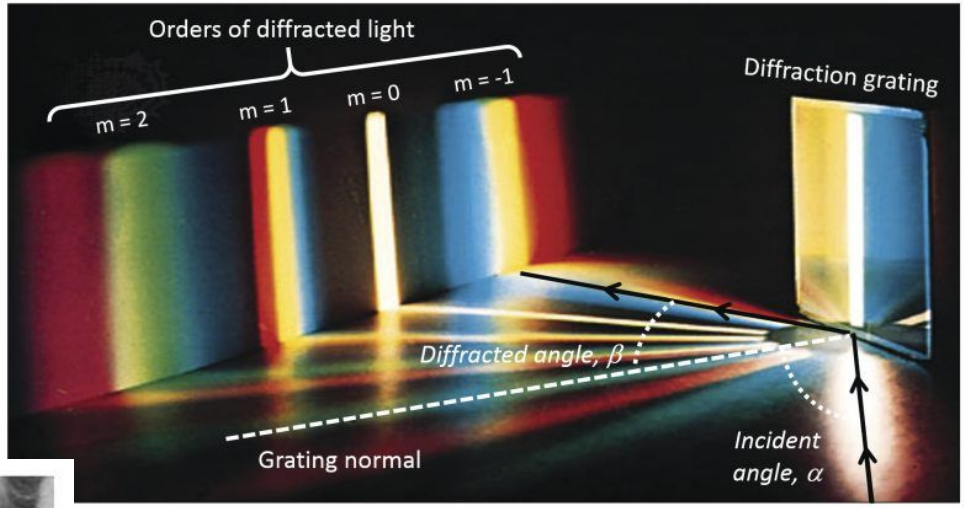


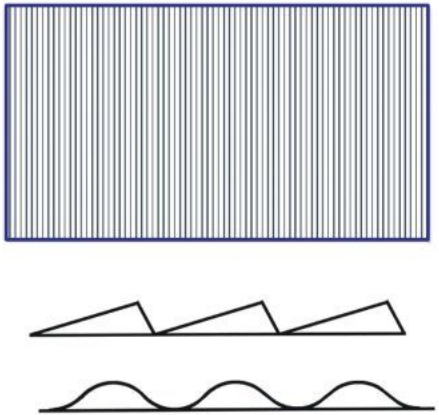


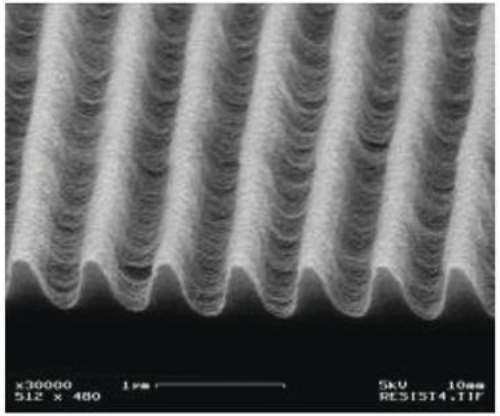
Difracción con múltiples ranuras

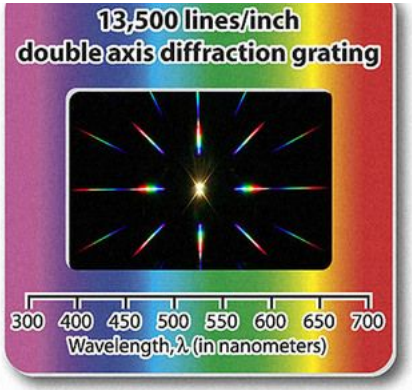


Rejilla de difracción









Arquitecturas ópticas reales

1. Whisk-broom Scanner (spectrometer)

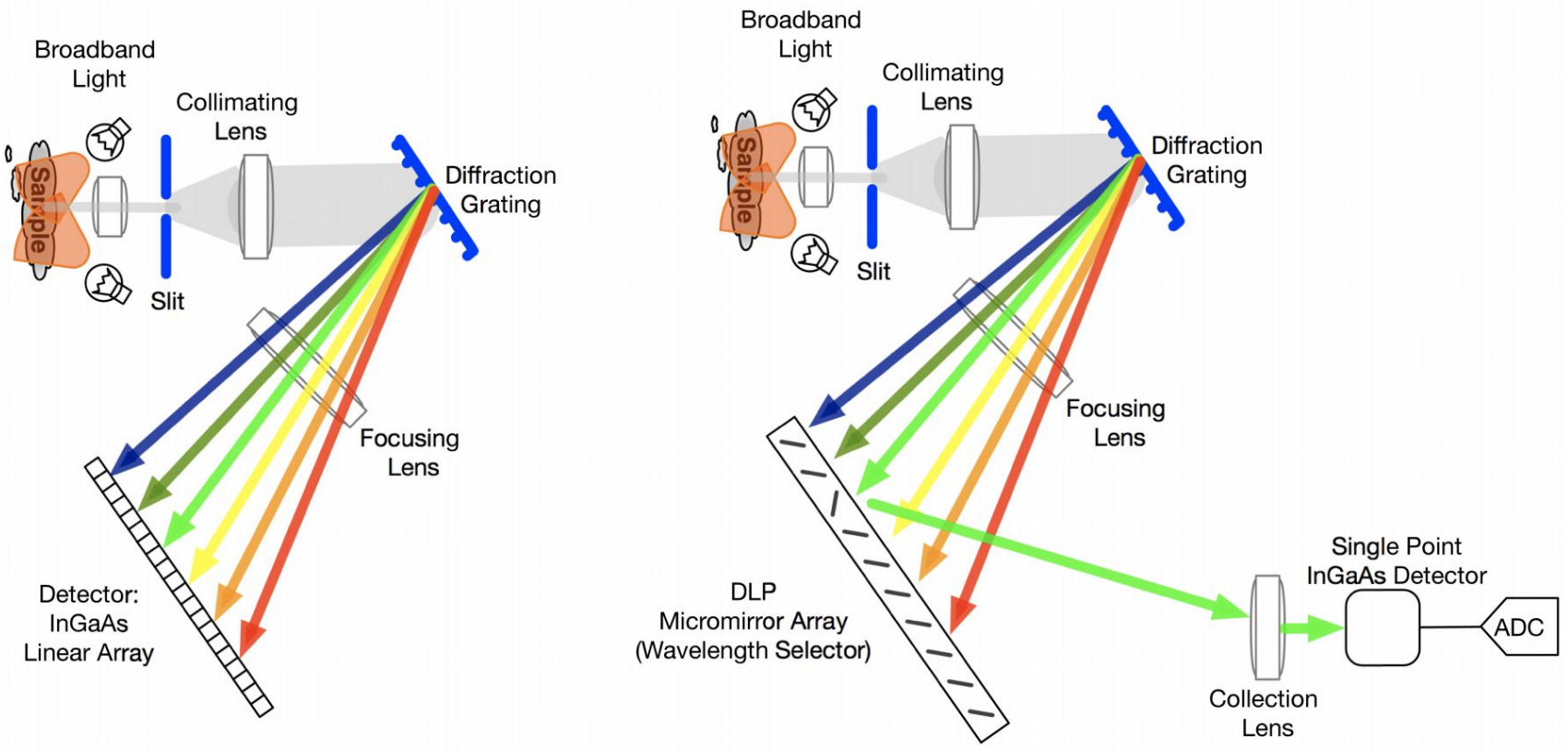


Figure 1-1. Traditional Versus DLP-based Spectrometer

1. Whisk-broom Scanner (spectrometer)

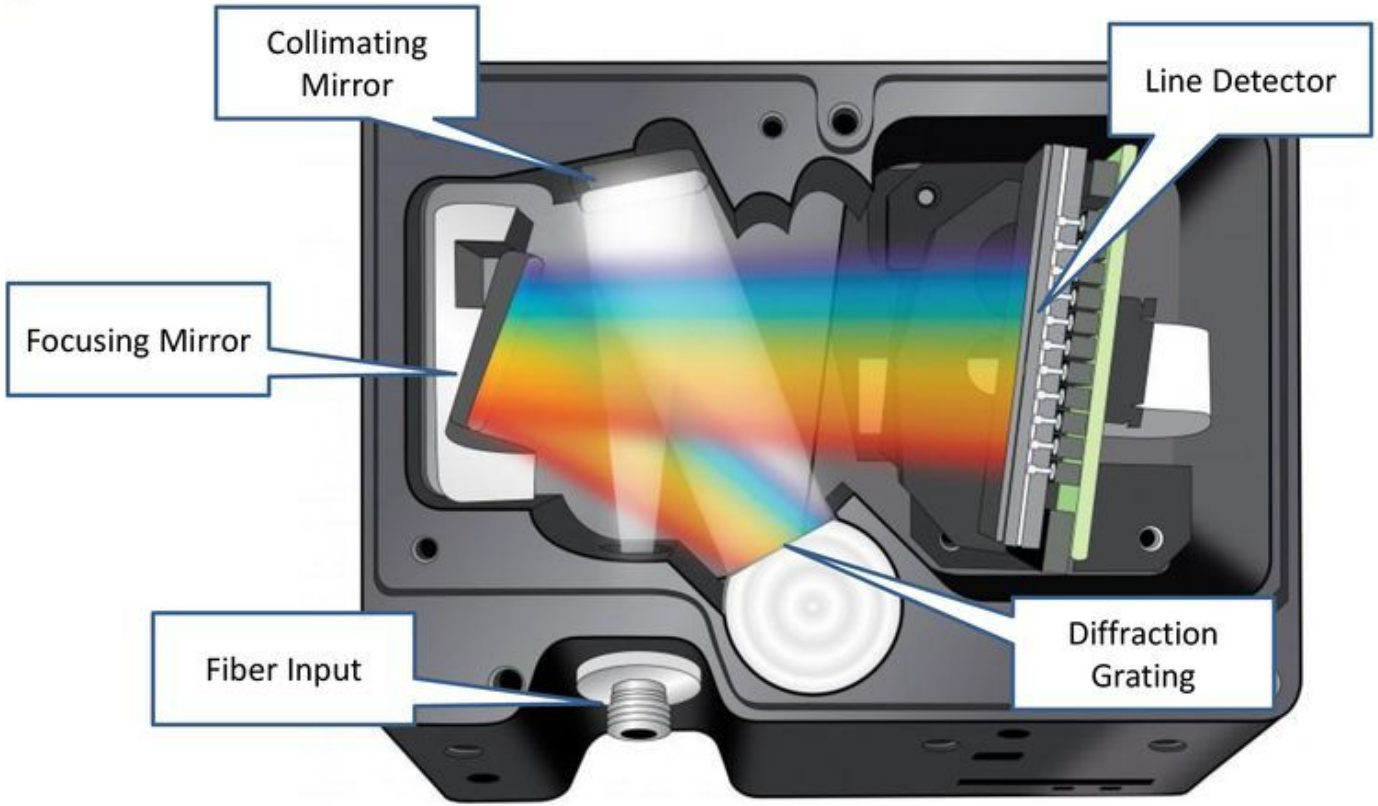
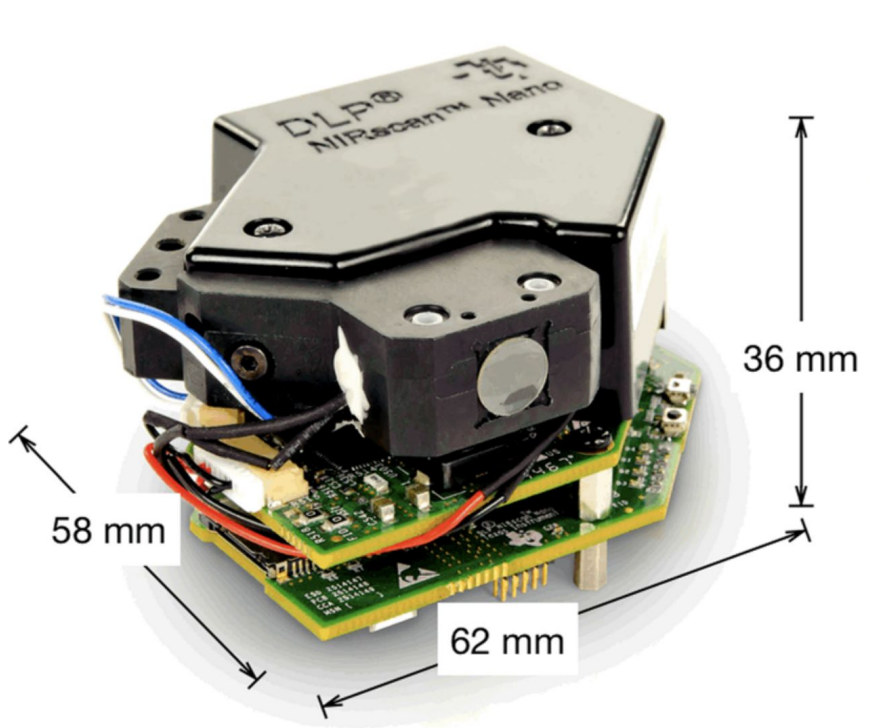


Image source: Ocean Optics, Inc.

https://www.youtube.com/watch?v=OI3pIvLhVcc

1. Whisk-broom Scanner (spectrometer)



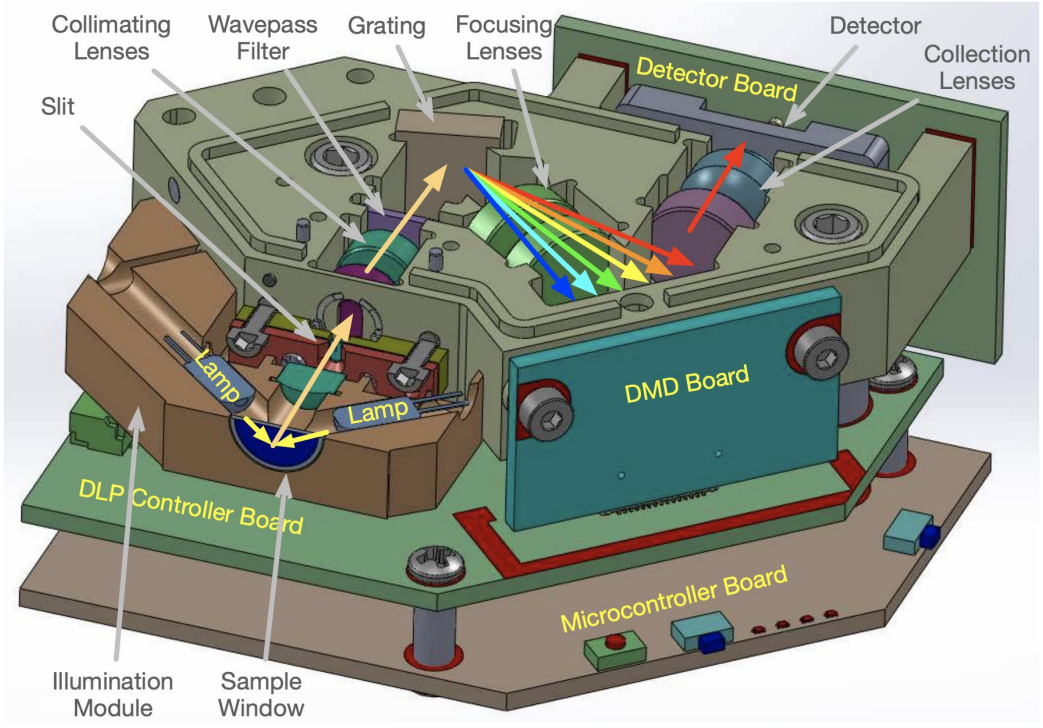
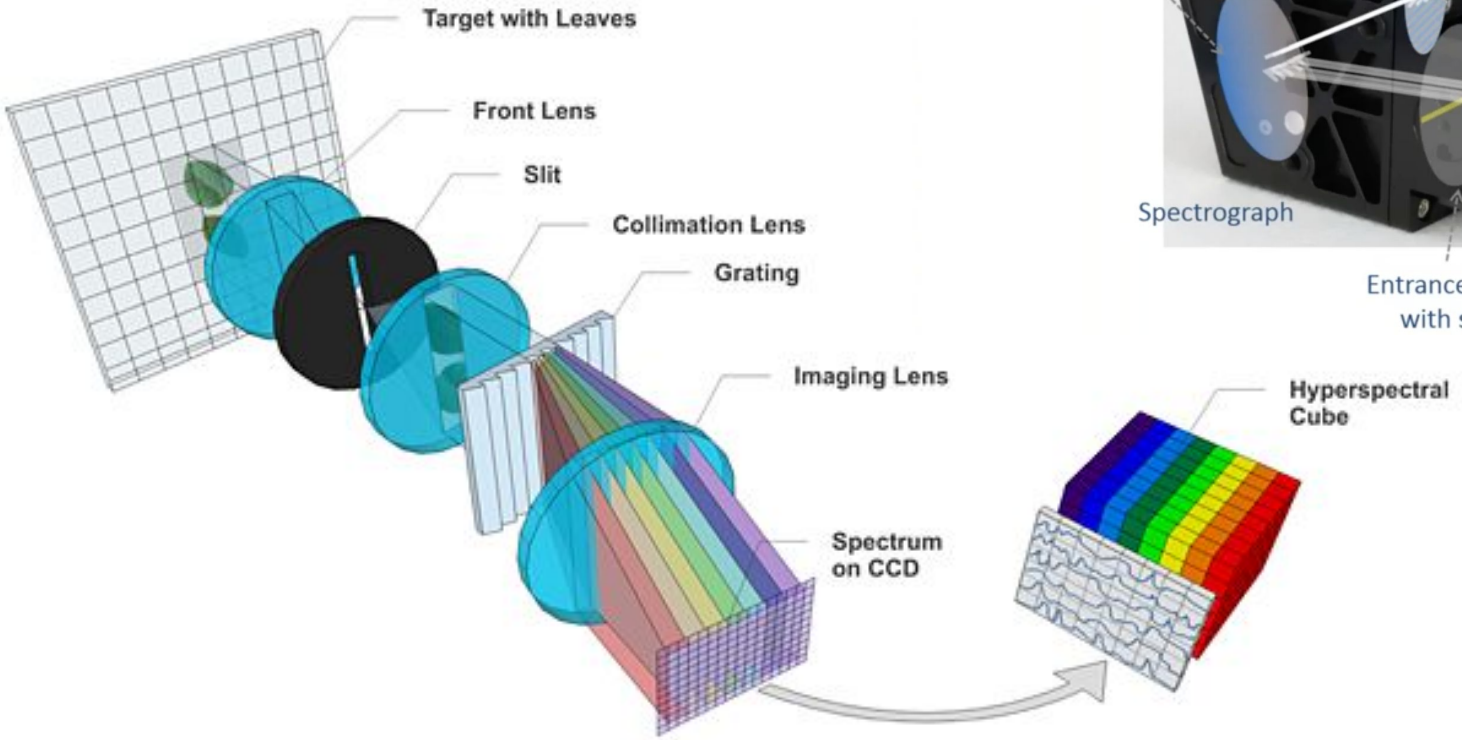
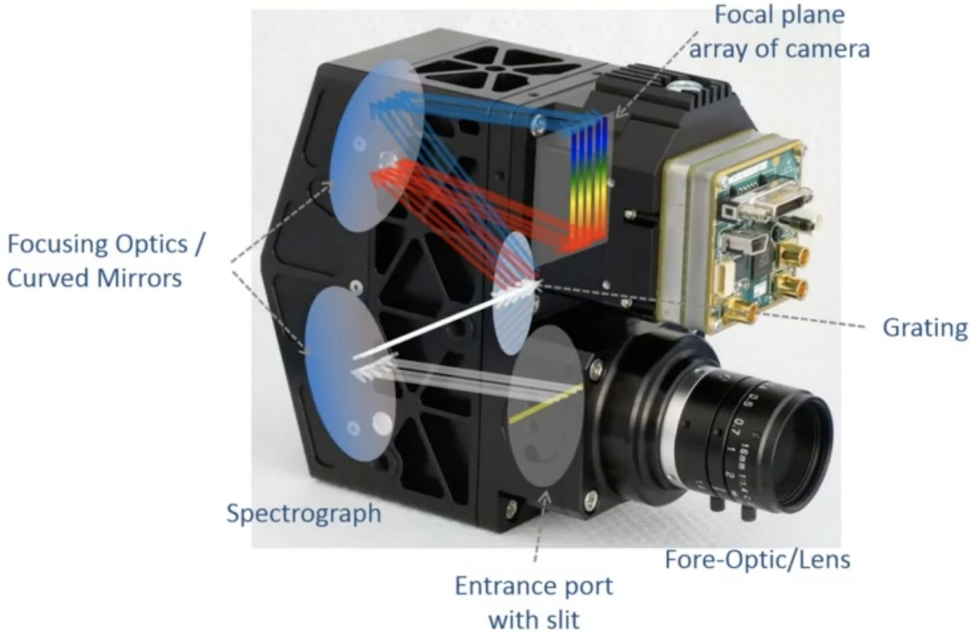


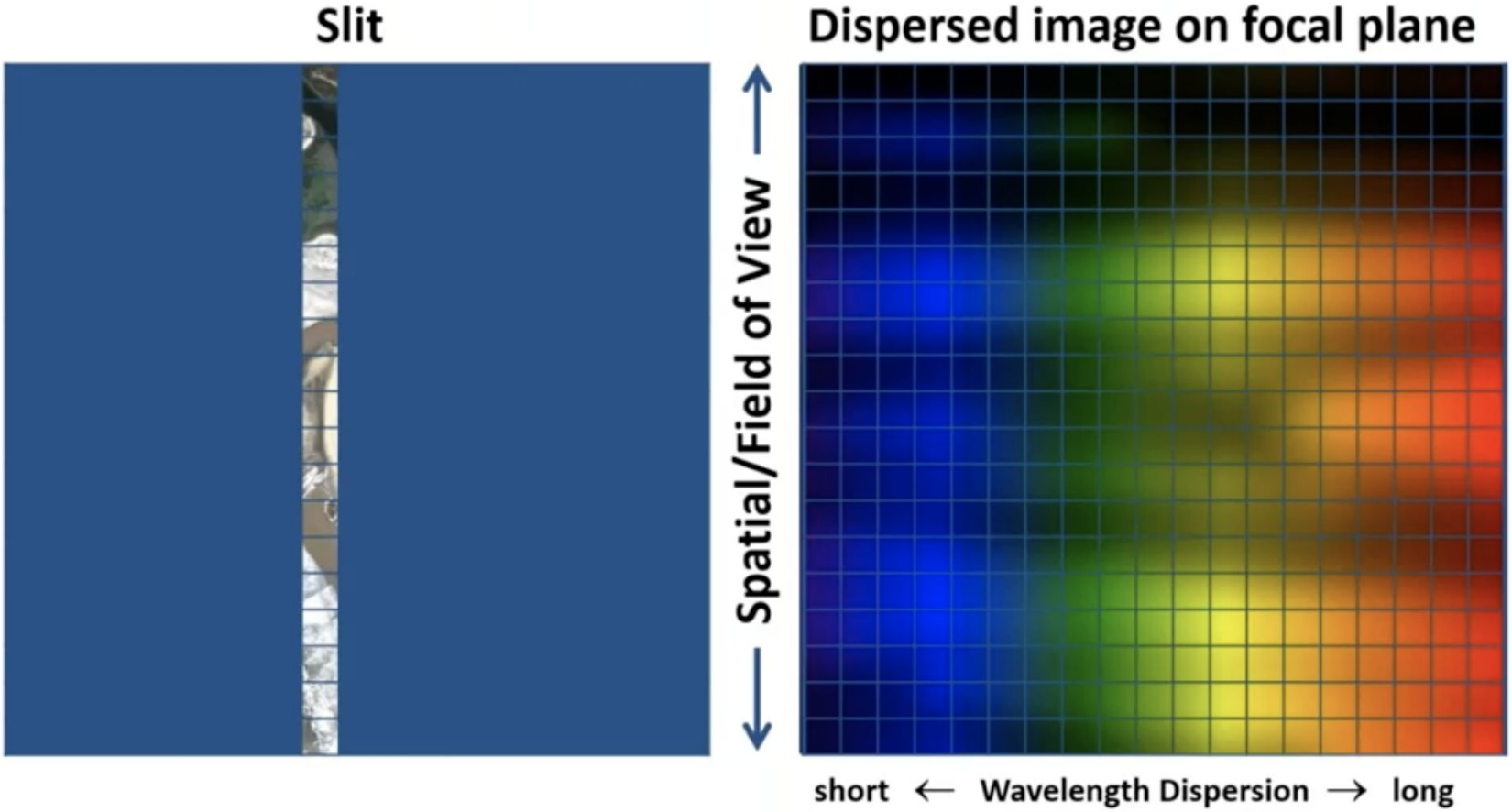
Figure 1-3. DLP NIRscan Nano Optical Engine

2. Push-broom Scanner

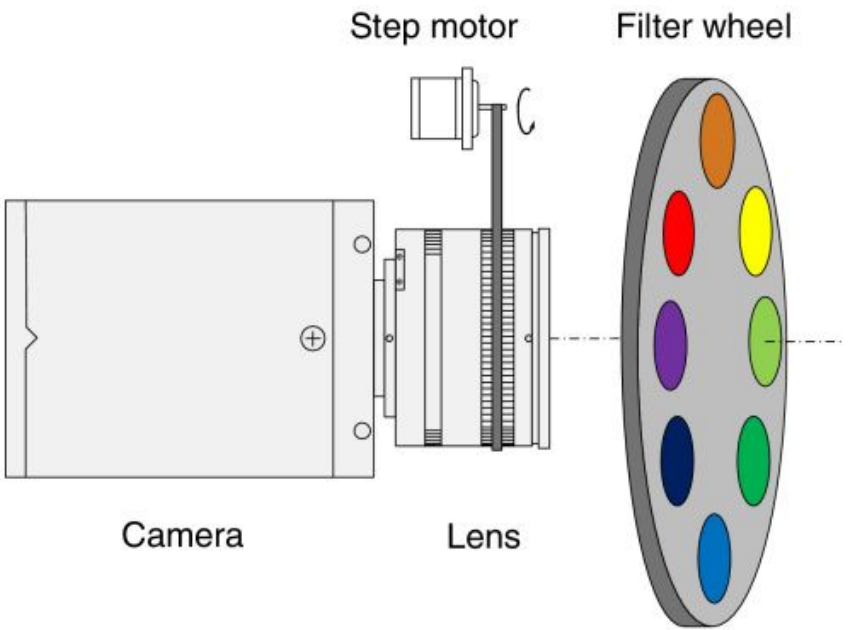


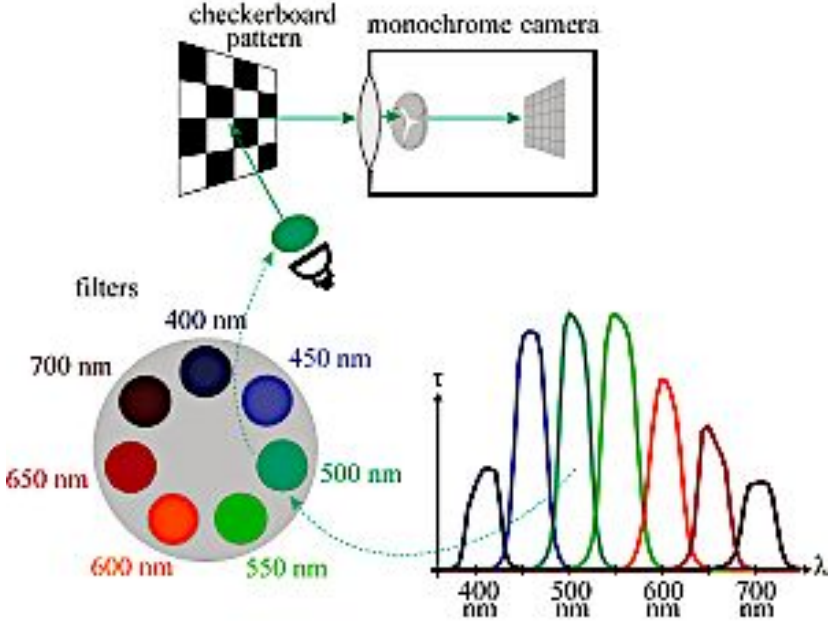


2. Push-broom Scanner

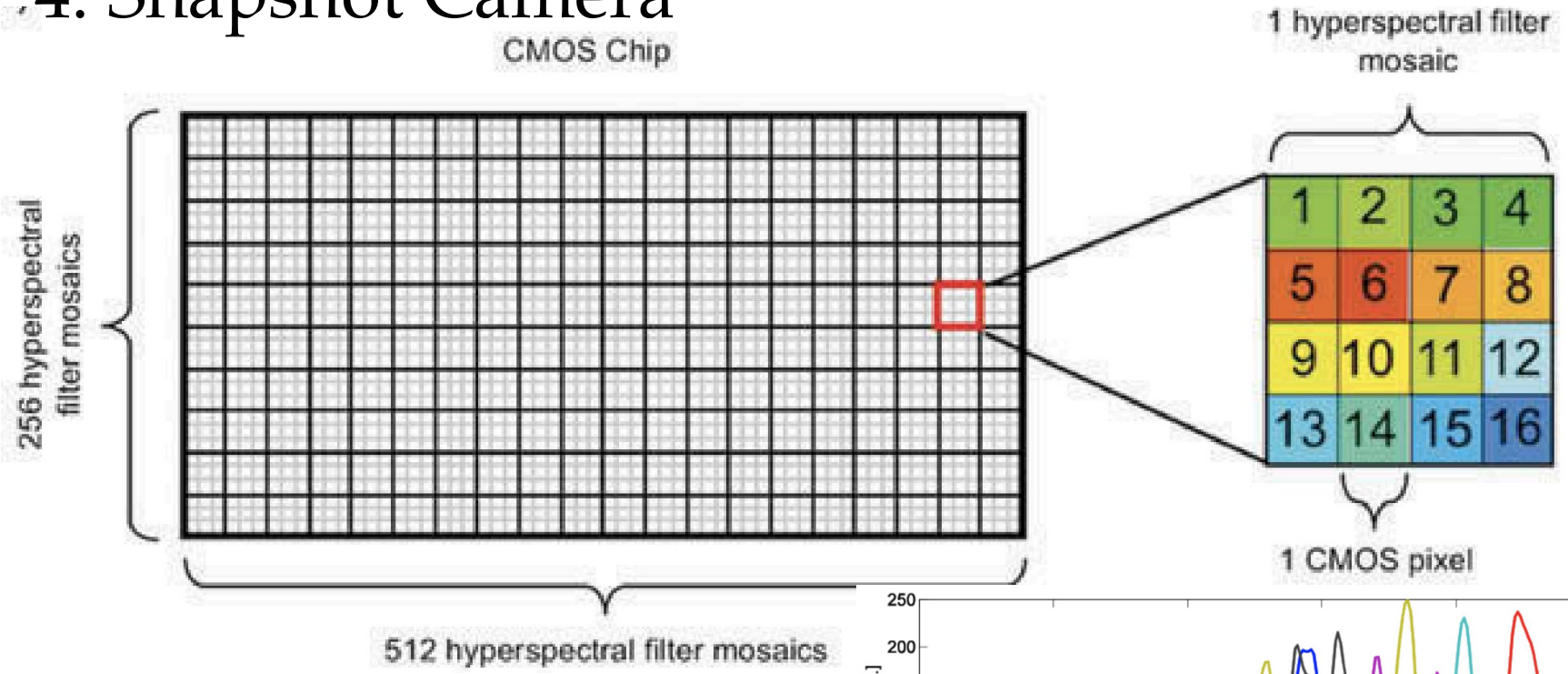


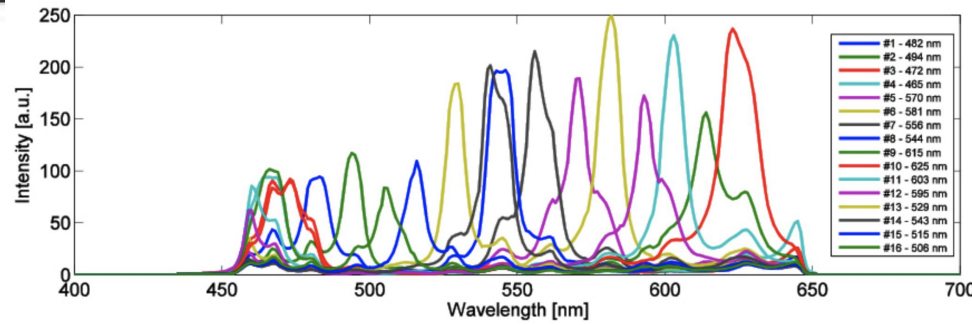
3. Filter-based Scanner



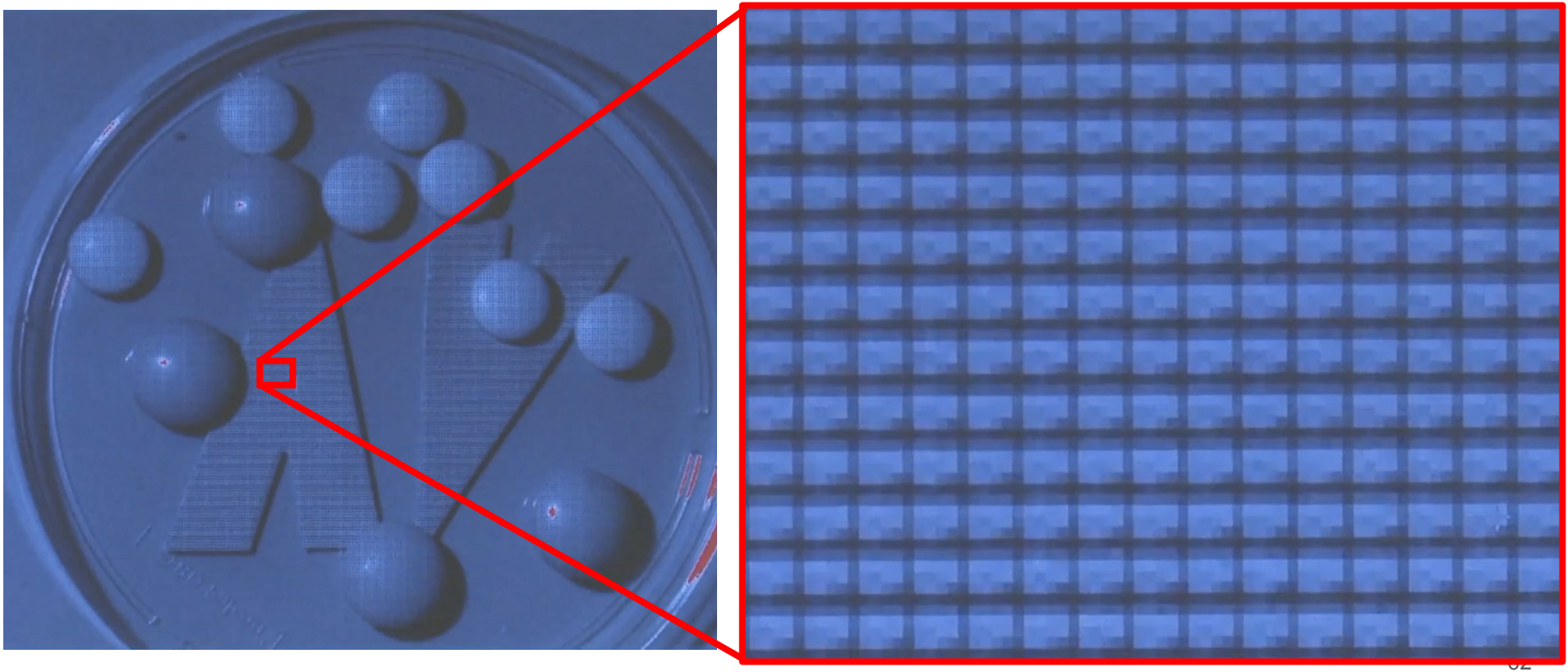


4. Snapshot Camera

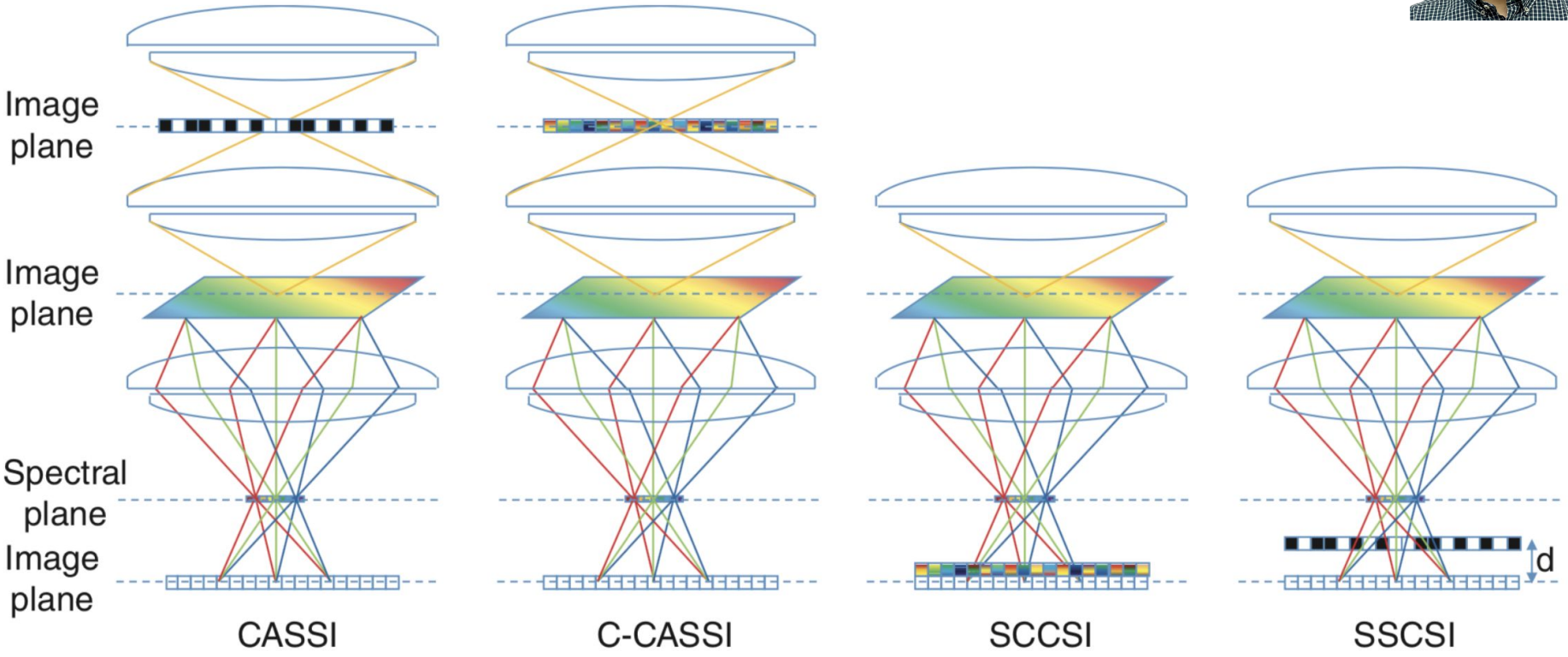




4. Snapshot Camera 5x5 CFA (Imec Inc.)



Compressive Snapshot Cameras (My Research)

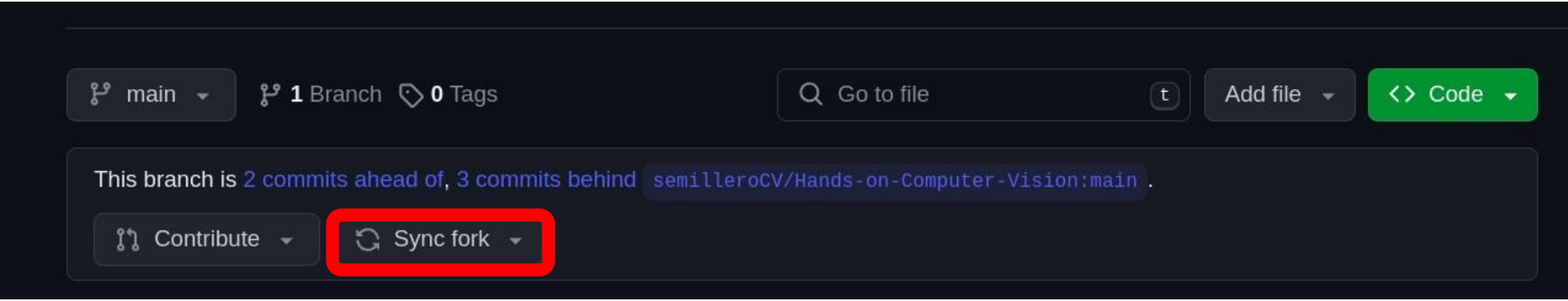


https://scholar.google.com/citations?user=seyRms4AAAAJ&hl=en

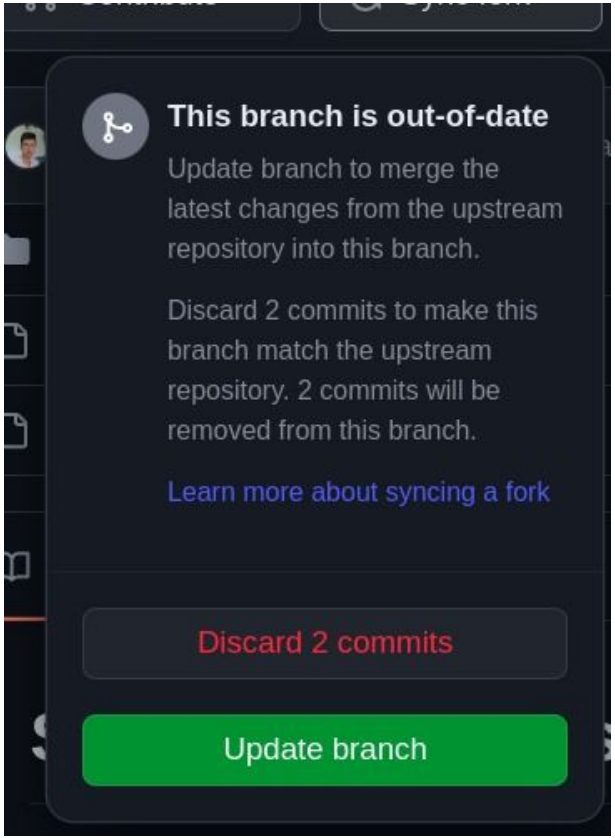
1. ¿Qué diferencia a una imagen multispectral de una hiperespectral?
2. ¿En qué se diferencia el fenómeno de la refracción del de la difracción?
3. ¿Puedes nombrar los componentes de una cámara whiskbroom?
4. ¿Puedes nombrar los componentes de una cámara pushbroom?
5. ¿Cuál método de adquisición es tu preferido y por qué?

4. Hands-on: Imágenes Espectrales

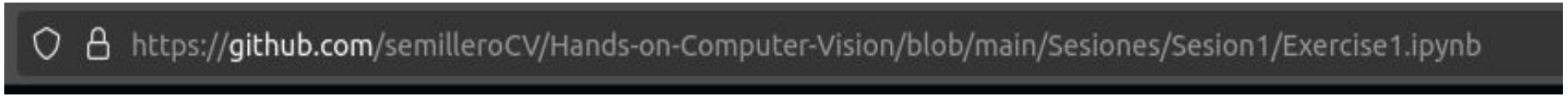
Actualicemos el repositorio!



Actualicemos el repositorio!



Abrelo en colab usando “**githubtocolab**”



Agrega la palabra “tocolab” y da ENTER