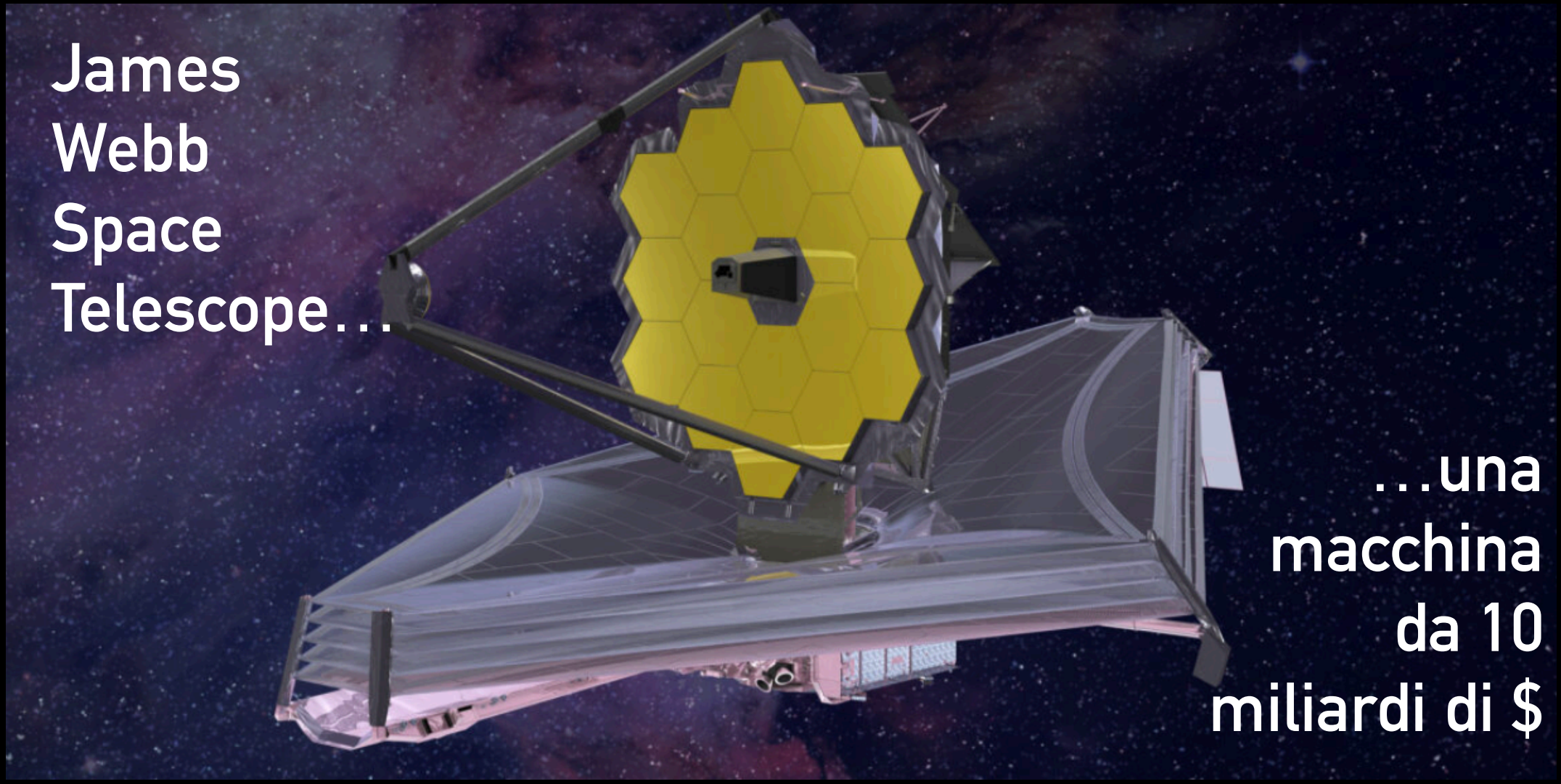
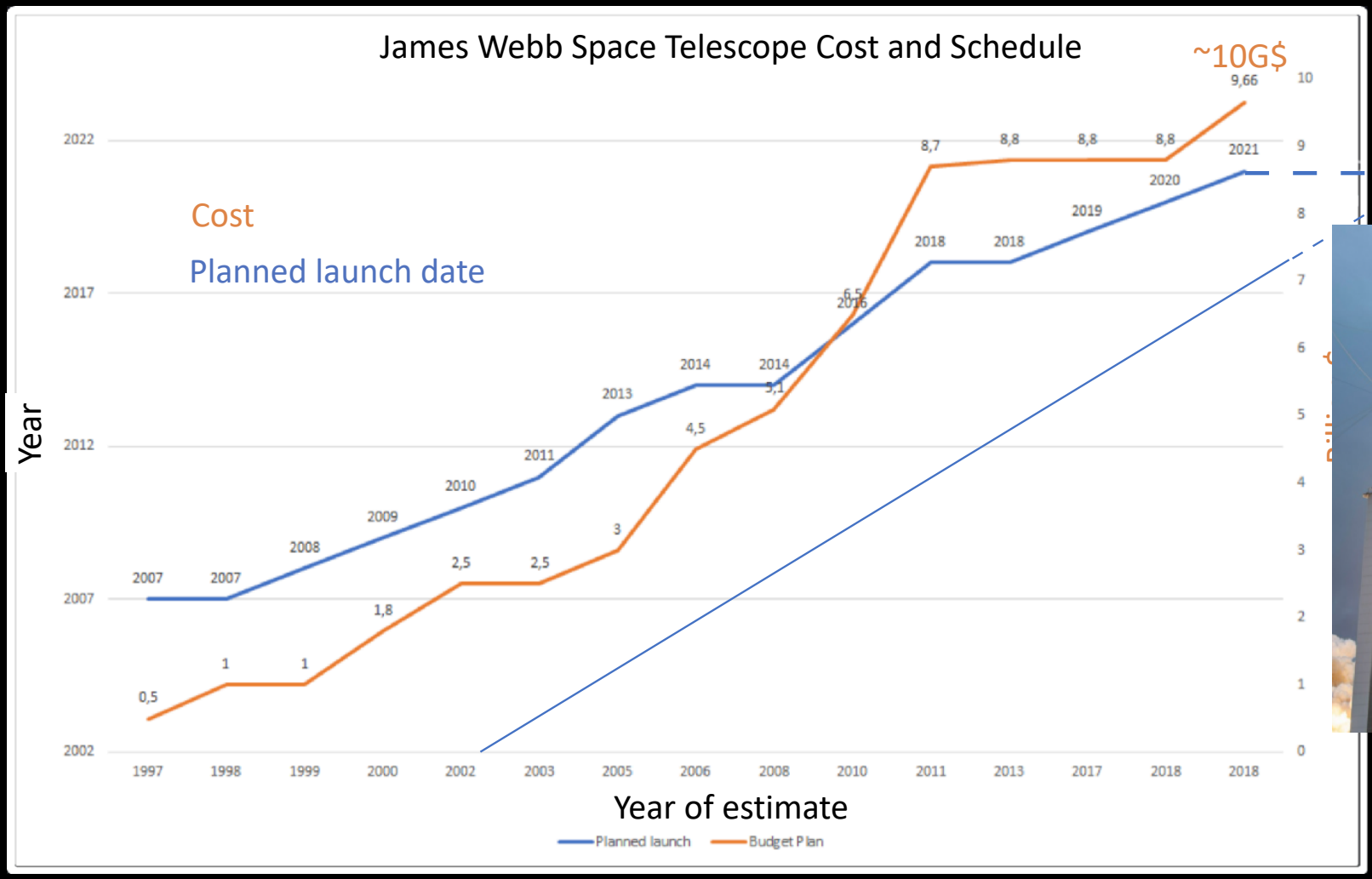
Il più grande Telescopio Spaziale mai costruito

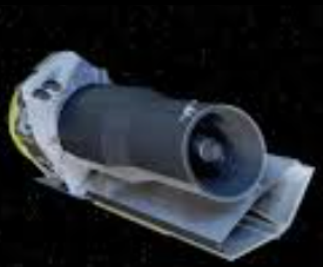
Adriano Fontana
Istituto Nazionale di Astro Fisica


James
Webb
Space
Telescope…
…una
macchina
da 10
miliardi di $

A long-awaited-for telescope.



Spitzer

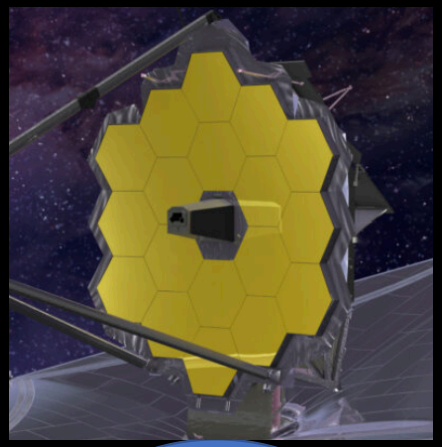


85cm

Hubble Space Telescope

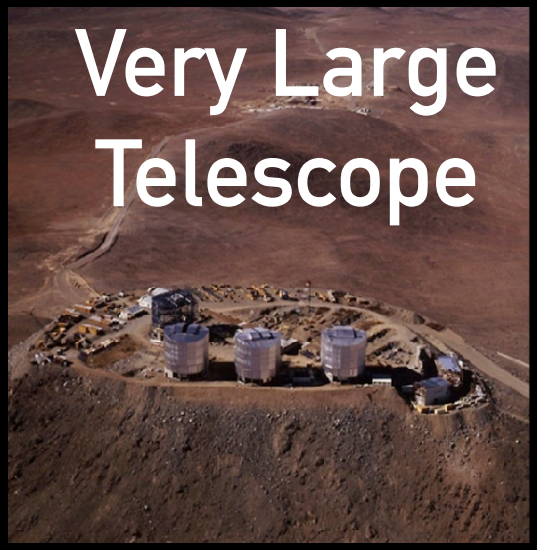
2,40m

James Webb



6,5m

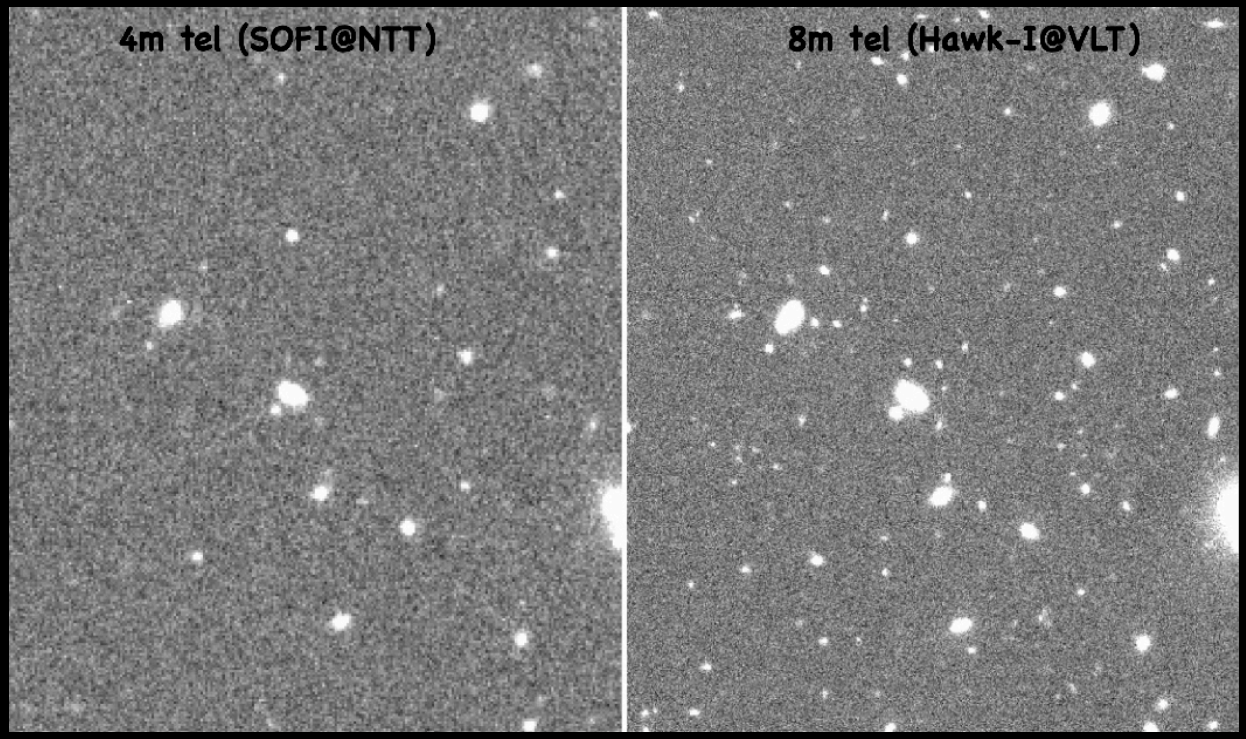
Very Large Telescope



8 m

Perchè costruiamo telescopi sempre più grandi?

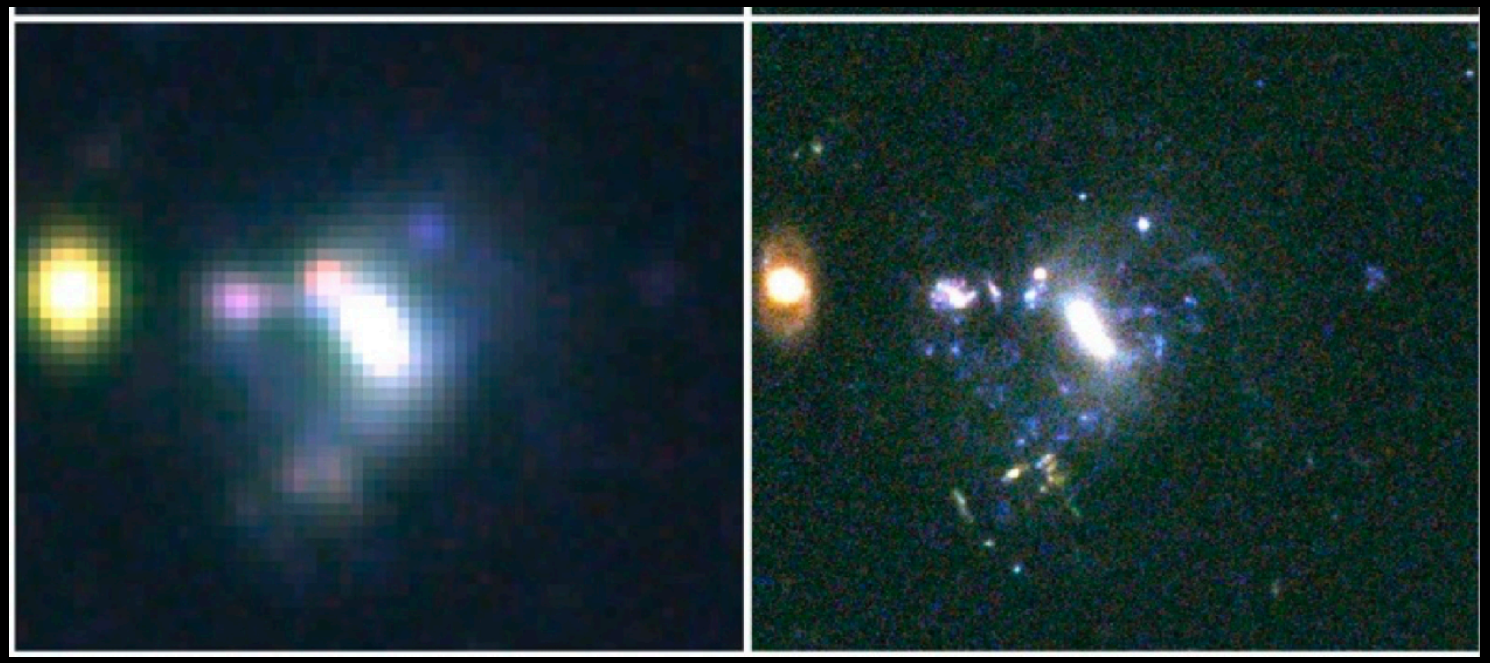
1) Per raccogliere più luce, e quindi vedere oggetti più deboli e lontani.



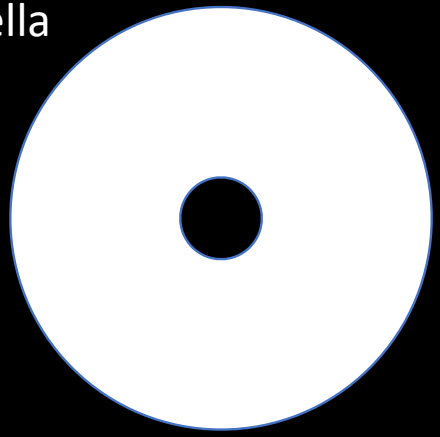
Perchè costruiamo telescopi sempre più grandi?

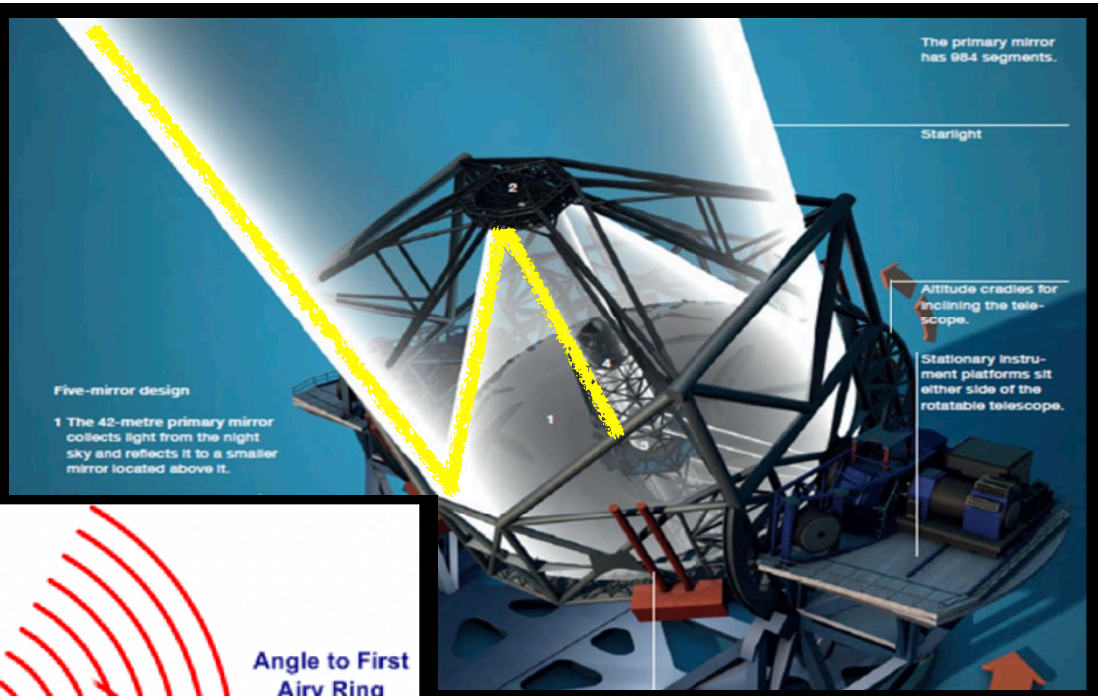
2) Perchè la risoluzione aumenta con il diametro D

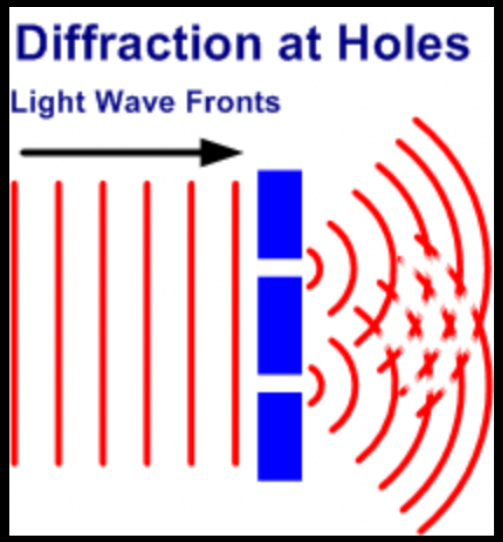
D → D

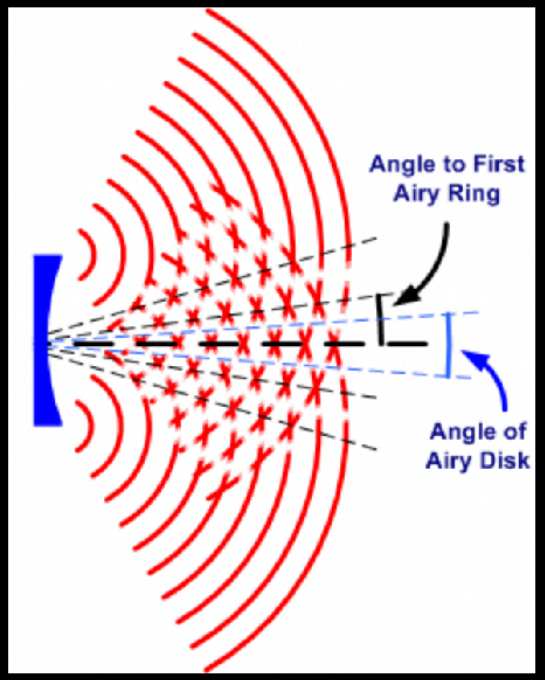


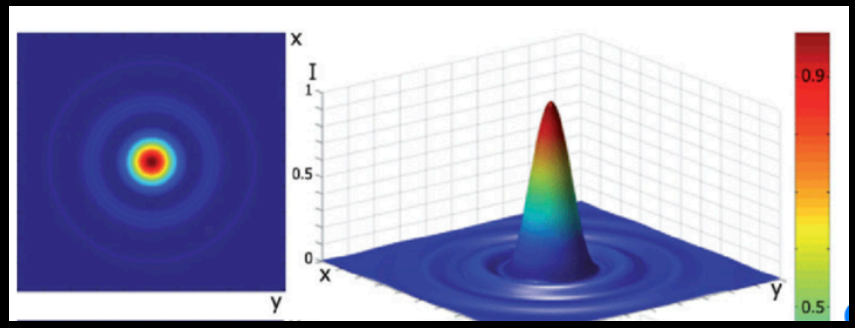
Ad un raggio di luce, un telescopio sembra un’apertura a forma di ciambella





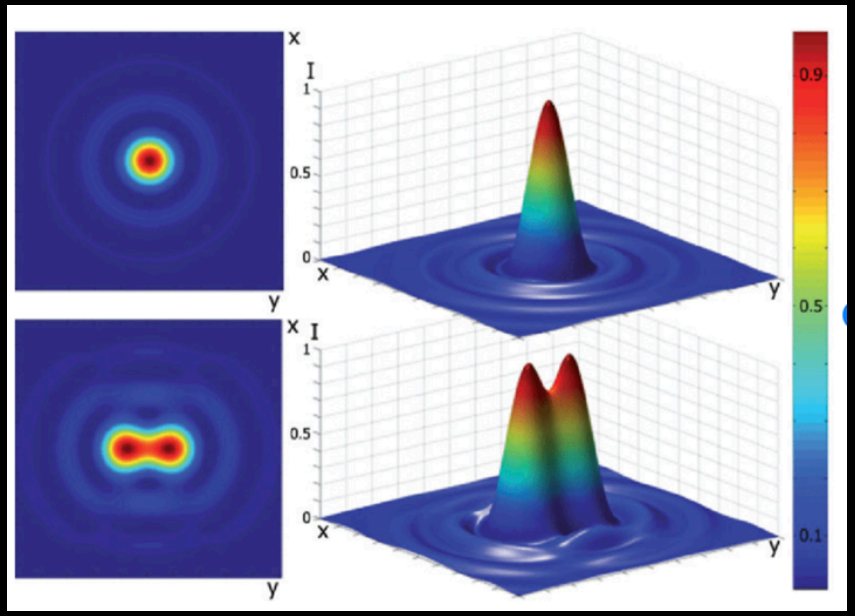


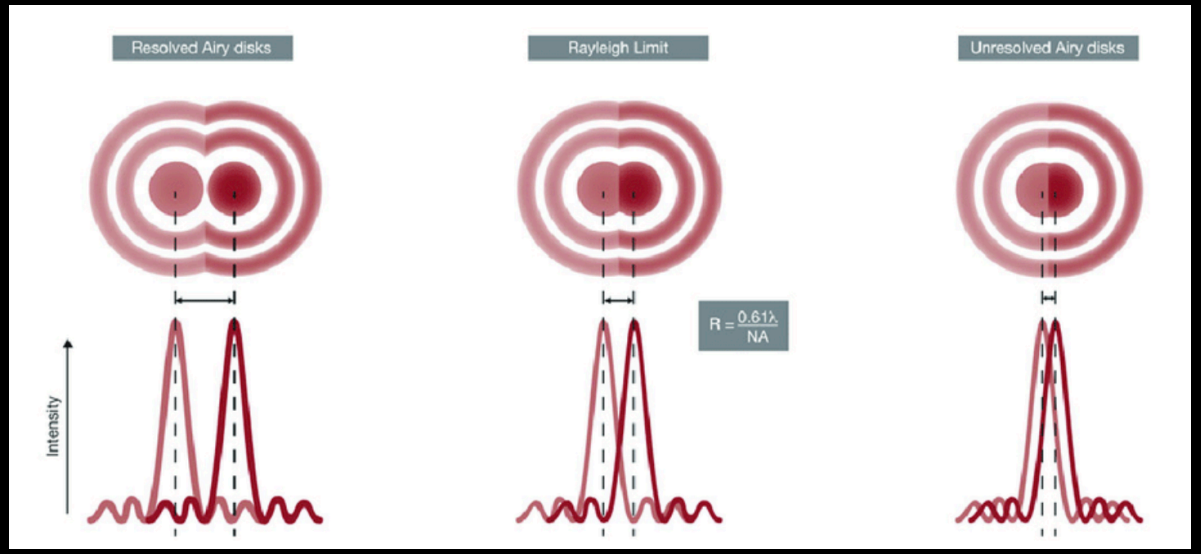


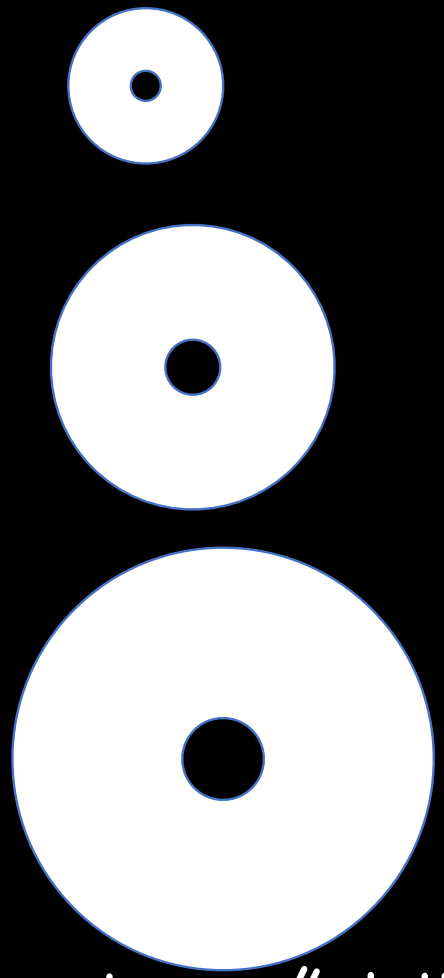


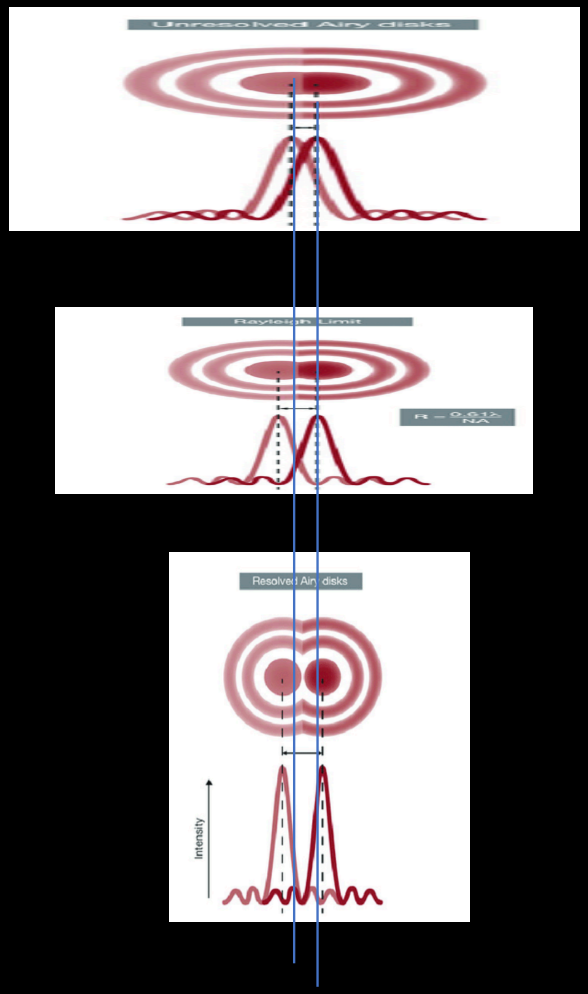
Anche per un telescopio “perfetto”, una stella NON è puntiforme

La "larghezza" della campana è la risoluzione
non posso vedere due oggetti che siano molto piu' vicini









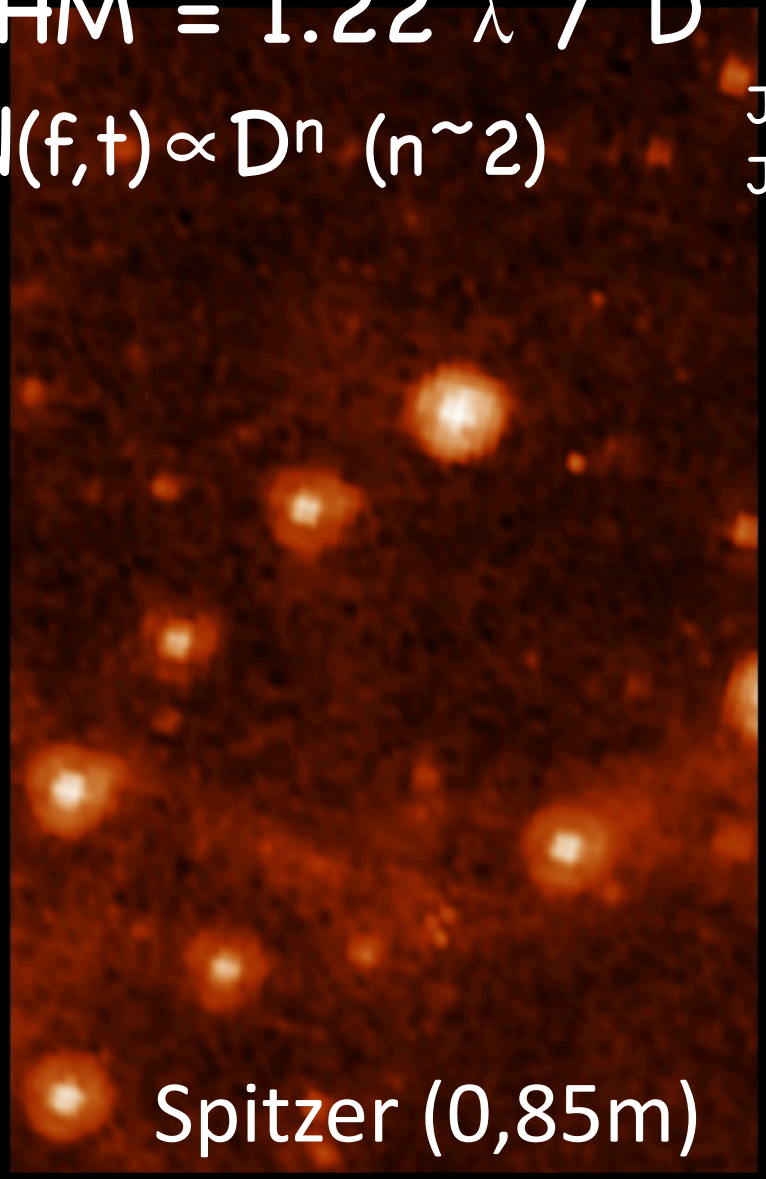
La "larghezza" della campana diminuisce con l'aumentare del diametro

$$FWHM = 1.22\ \lambda\ /\ D$$

$FWHM = 1.22\ \lambda / D$

$S/N(f,t) \propto D^n$ $(n \sim 2)$

JWST/HST: 6 (2mags).
JWST/Spitzer: 66 (4.5mags)



Spitzer (0,85m)

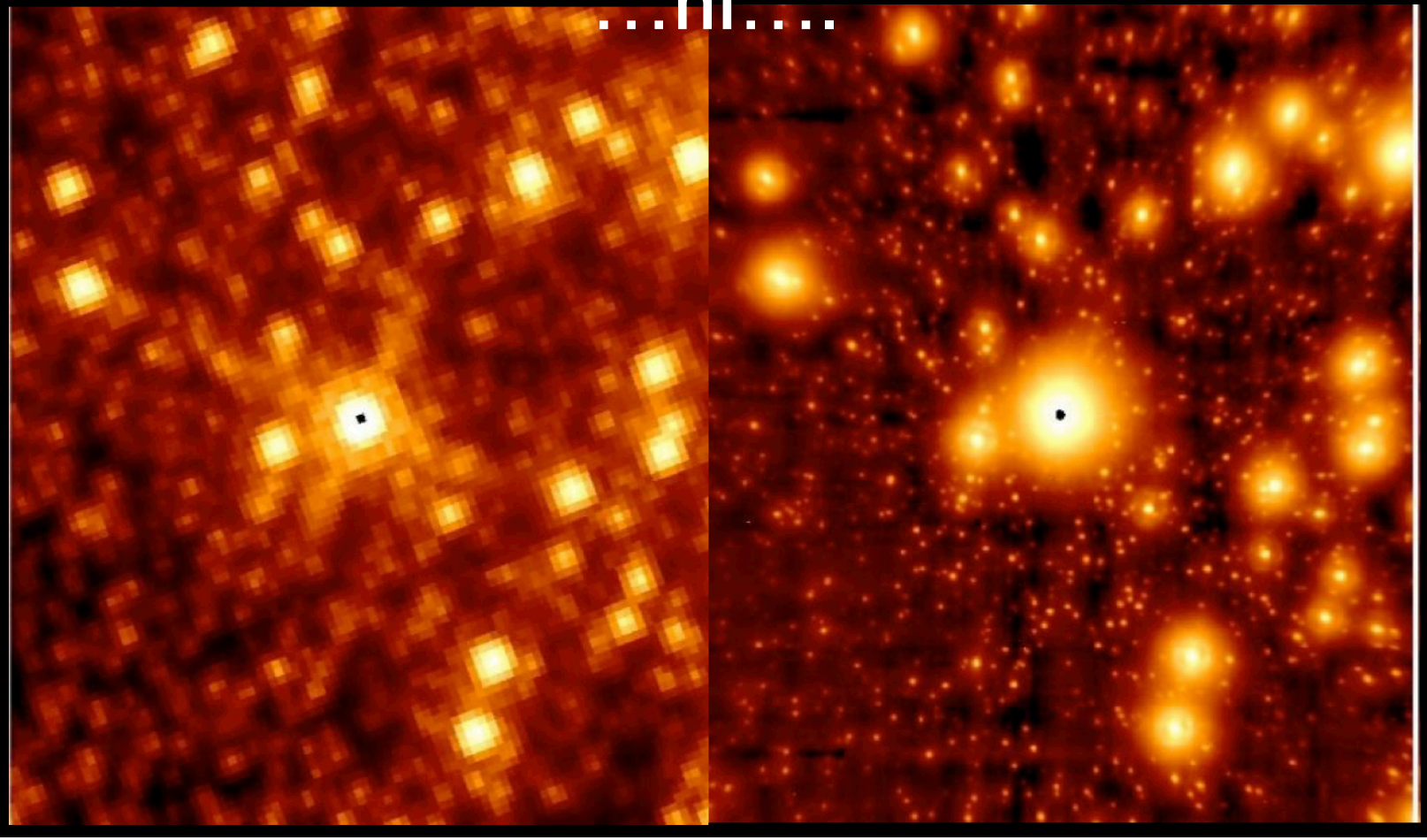
Webb (6,5m)

Perchè mandiamo i telescopi in orbita?

Perchè senza l'atmosfera le immagini sono più nitide..?

...ni....

Hubble
(2.5m)

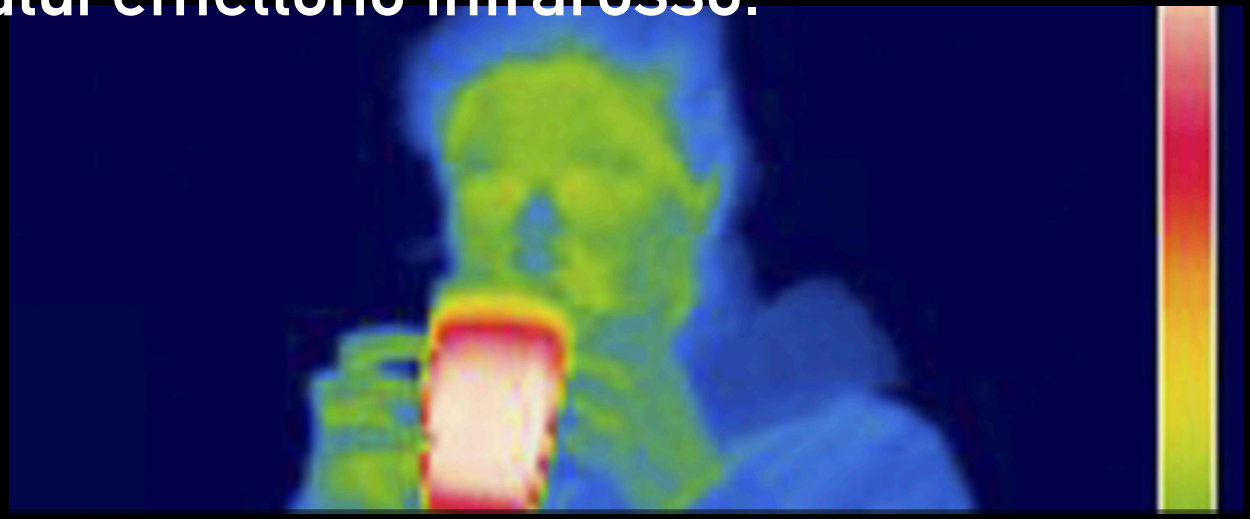


LBT
(8.4m)

Perchè mandiamo i telescopi in orbita?

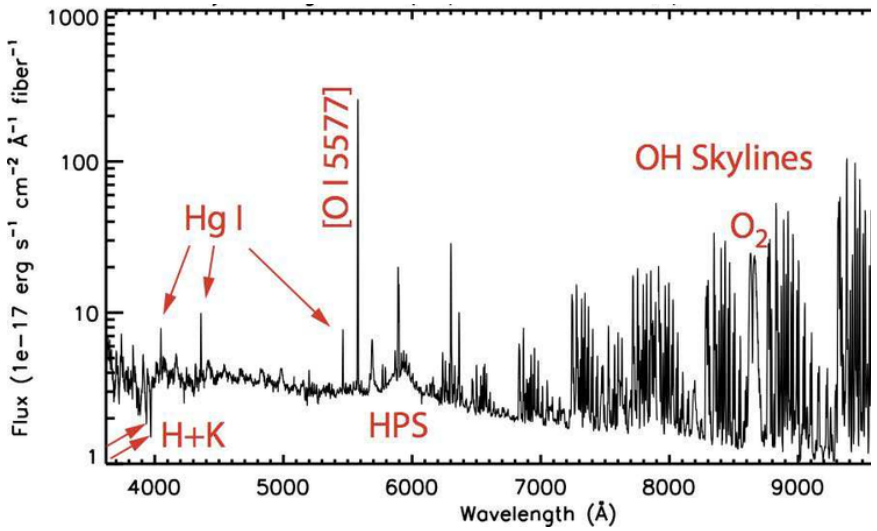
Perchè vogliamo osservare nell'infrarosso.

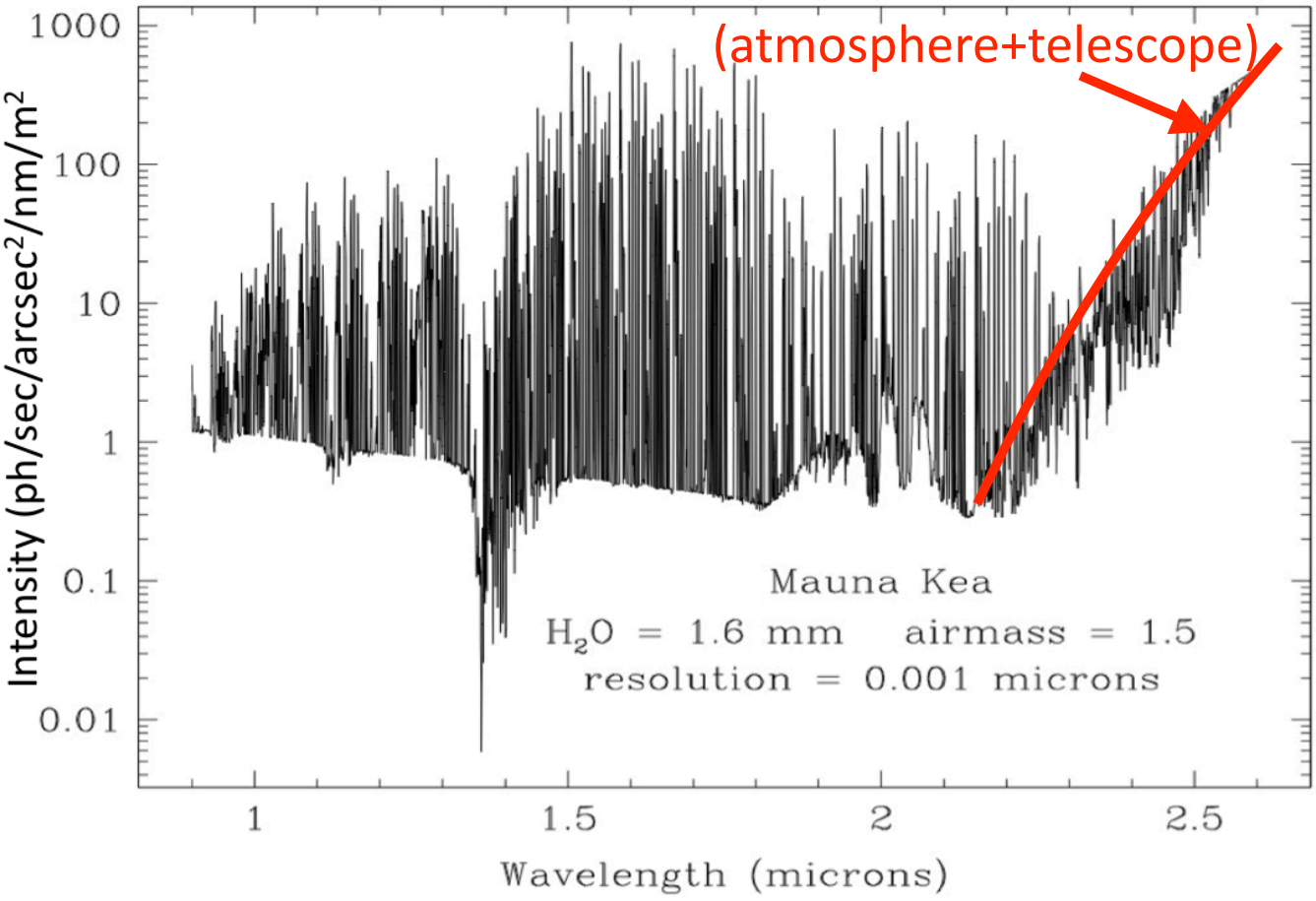
Problema: tutti i corpi caldi emettono infrarosso.



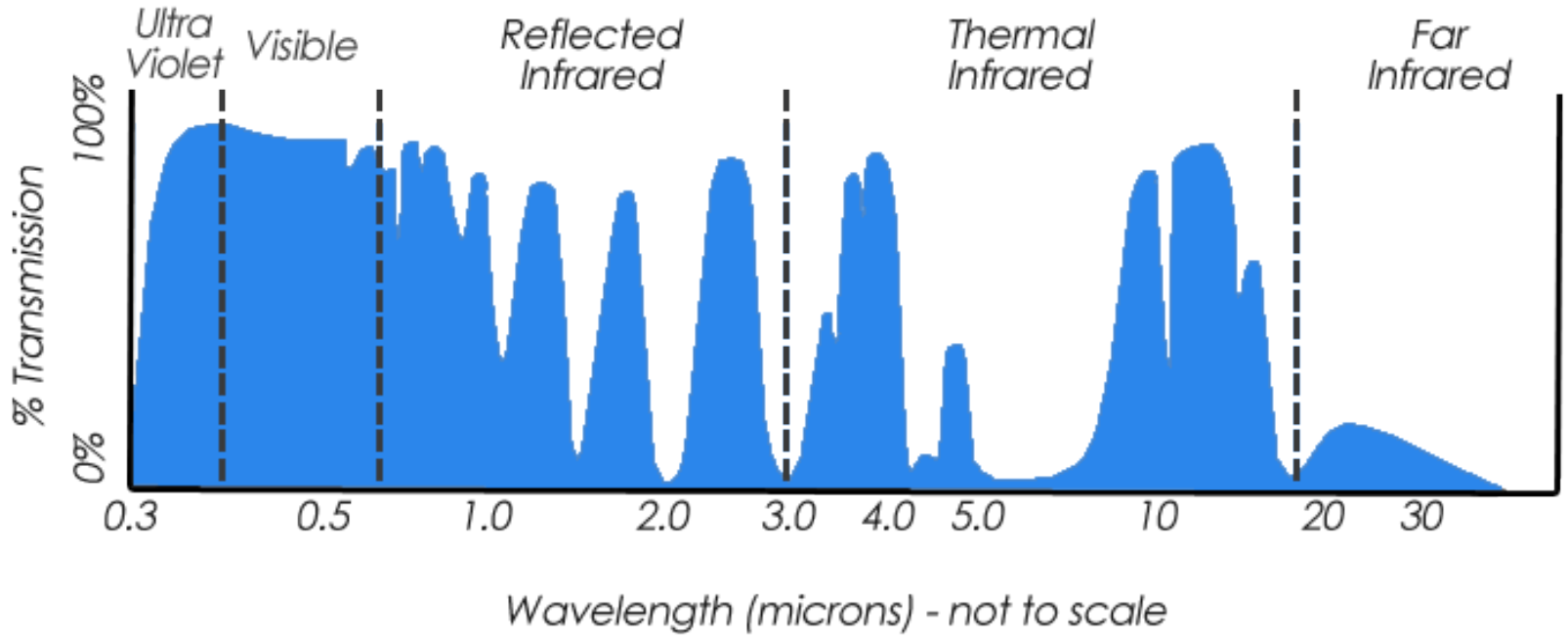
Anche l'atmosfera!
E anche il telescopio!
Per non esserne accecati
dobbiamo uscire dall'atmosfera stessa
e raffrreddare tutto il telescopio..

Why in Space? Atmospheric and thermal background





Why IR? To overcome atmospheric absorption/emission



Insomma vogliamo un telescopio:

-Il più grande possible
-Nello spazio
-Freddo

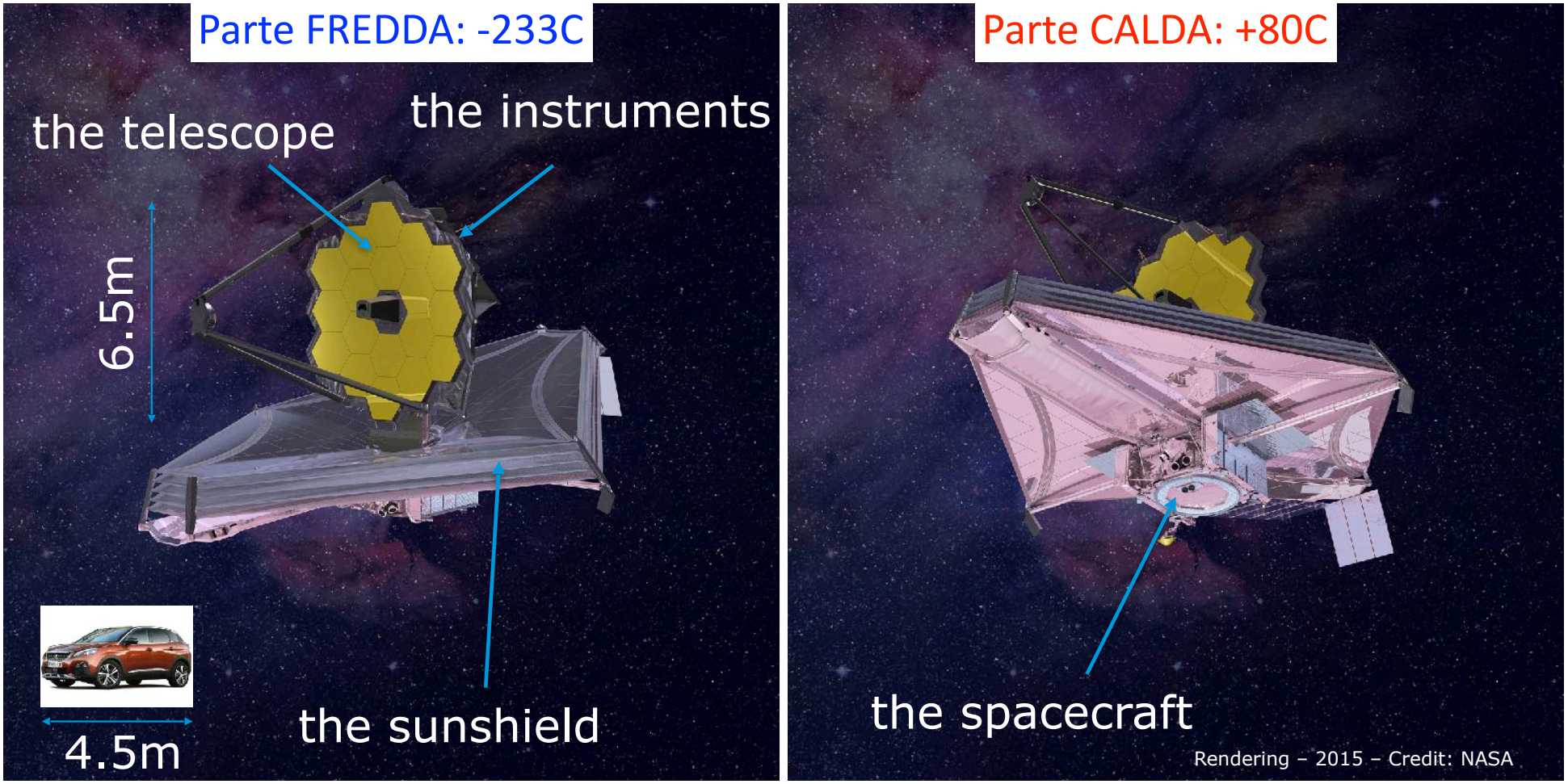
Insomma vogliamo un telescopio:

-Il più grande possible;
-Nello spazio
-Freddo

Schermi solari


SRS
IN SPACE 2001

JWST's fantastic hardware

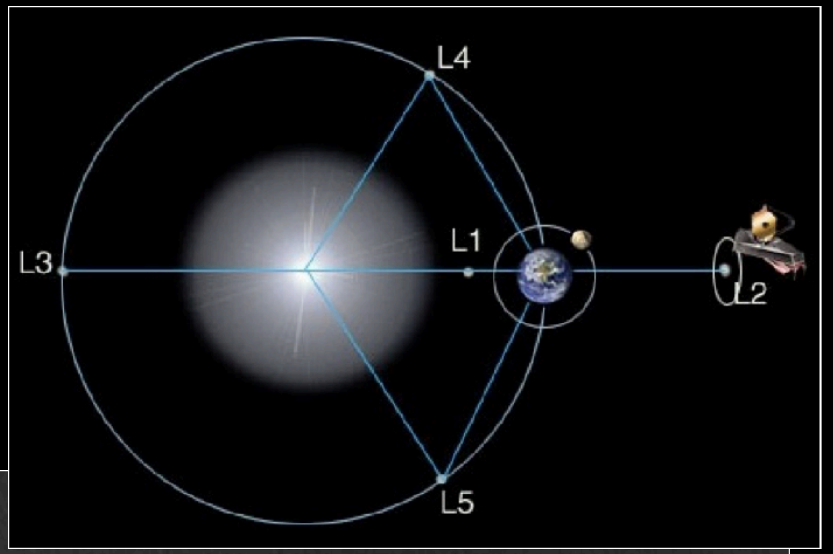


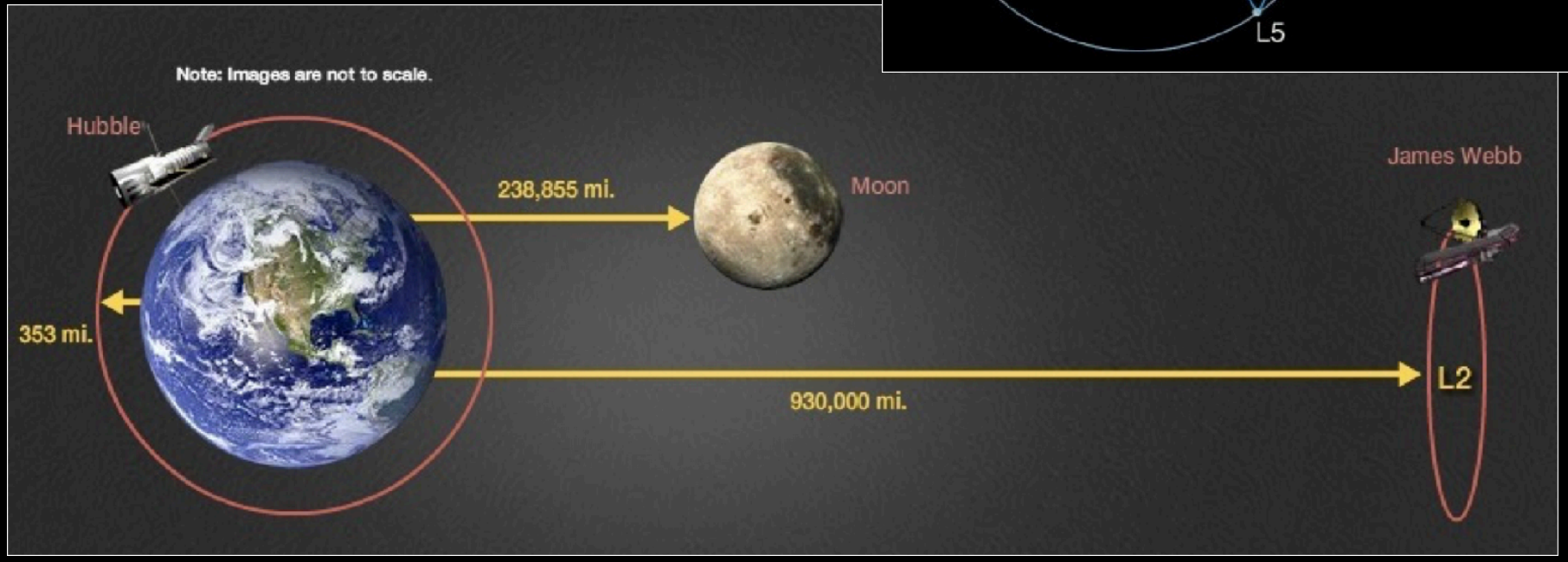
Insomma vogliamo un telescopio:

-Il più grande possible

-Nello spazio

-Freddo

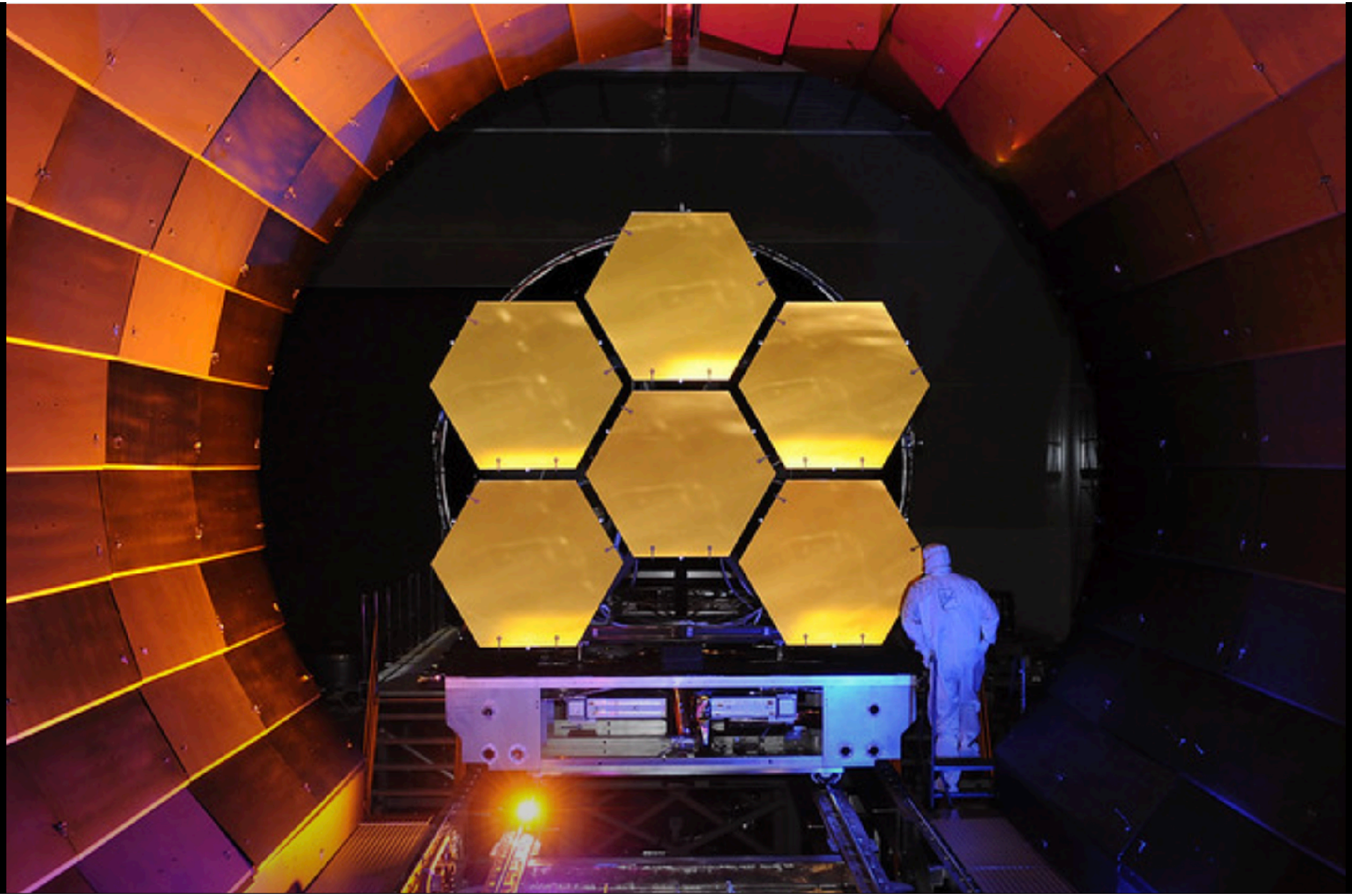


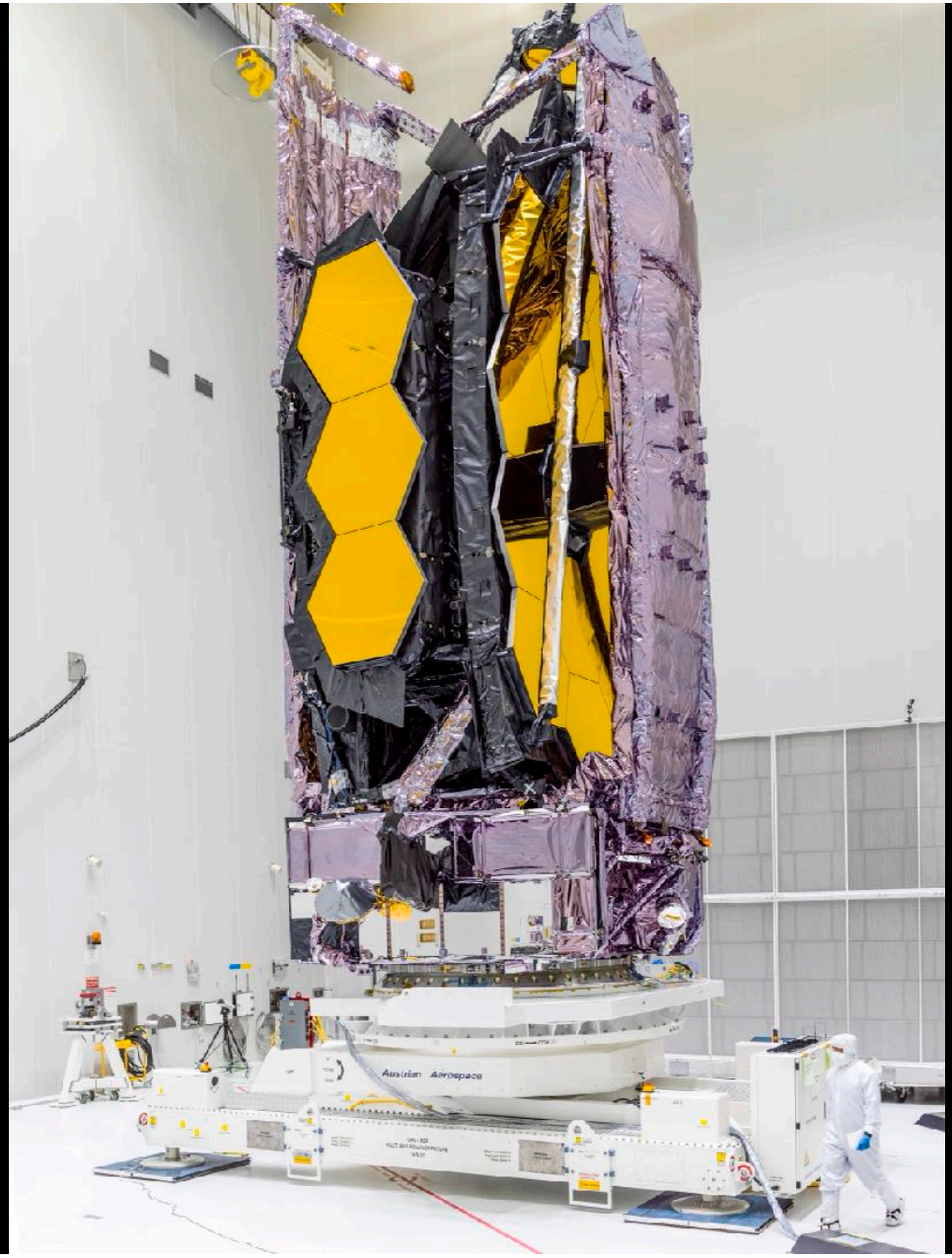


Insomma vogliamo un telescopio:

-Il più grande possible;
-Nello spazio
-Freddo

Uno specchio troppo grande non si può lanciare nello spazio: si rompe, si deforma..
Soluzione: si costruisce in segmenti.




Aerospace

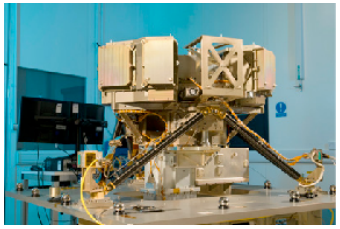

esa
esa
cnes
cnes


esa
cnes

https://www.youtube.com/watch?v=RzGLKQ7_KZQ

La strumentazione di James Webb

JWST's instruments



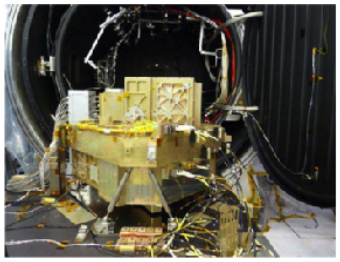
MIRI = Mid-InfraRed Instrument

50/50 partnership between a nationally funded consortium of European institutes (MIRI EC) under the auspices of ESA and NASA/JPL.

PIs: G. Wright and G. Rieke

NIRSpec = Near-infrared Spectrograph

Provided by the European Space Agency. Built for ESA by an industrial consortium led by Airbus Defence and Space.

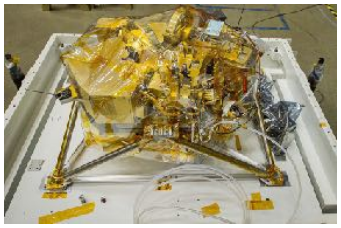


NIRISS = Near-infrared Imager and Slit-less Spectrograph

FGS = Fine Guidance Sensor

Provided by the Canadian Space Agency.

PIs: R. Doyon & C. Willott

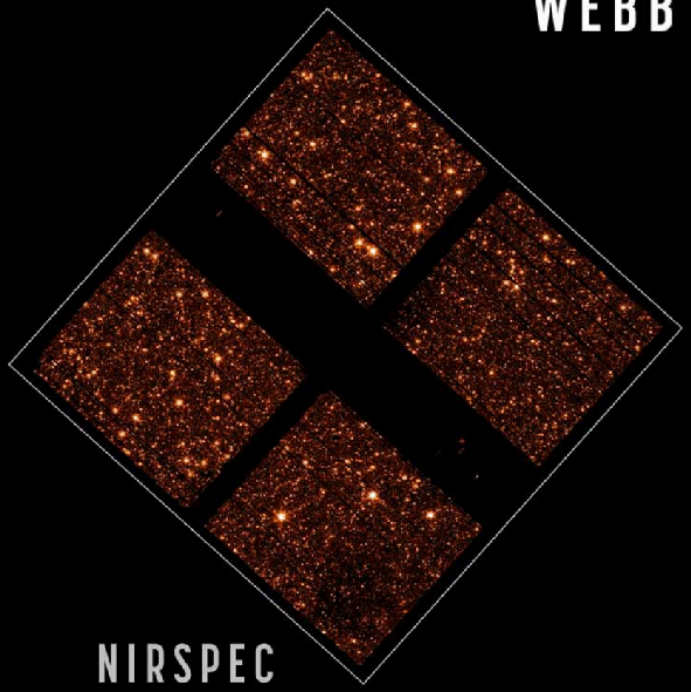


NIRCam = Near-InfraRed Camera

Developed under the responsibility of the University of Arizona.

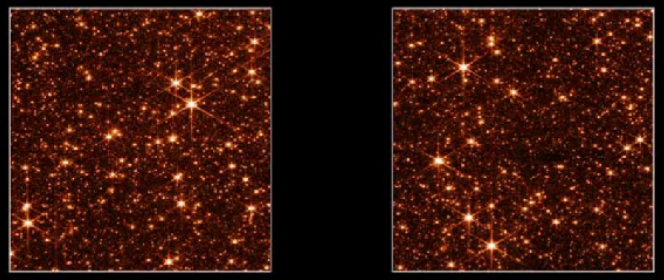
PI: M. Rieke

WEBB TELESCOPE IMAGE SHARPNESS CHECK



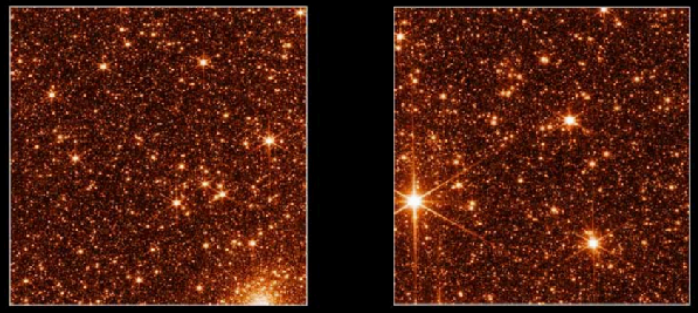
NIRSPEC

NIRCAM

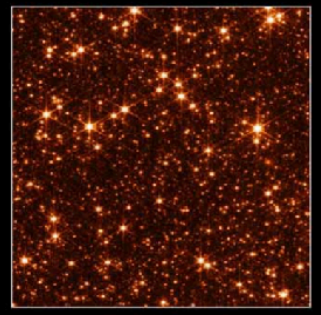


MIRI

FINE GUIDANCE SENSOR

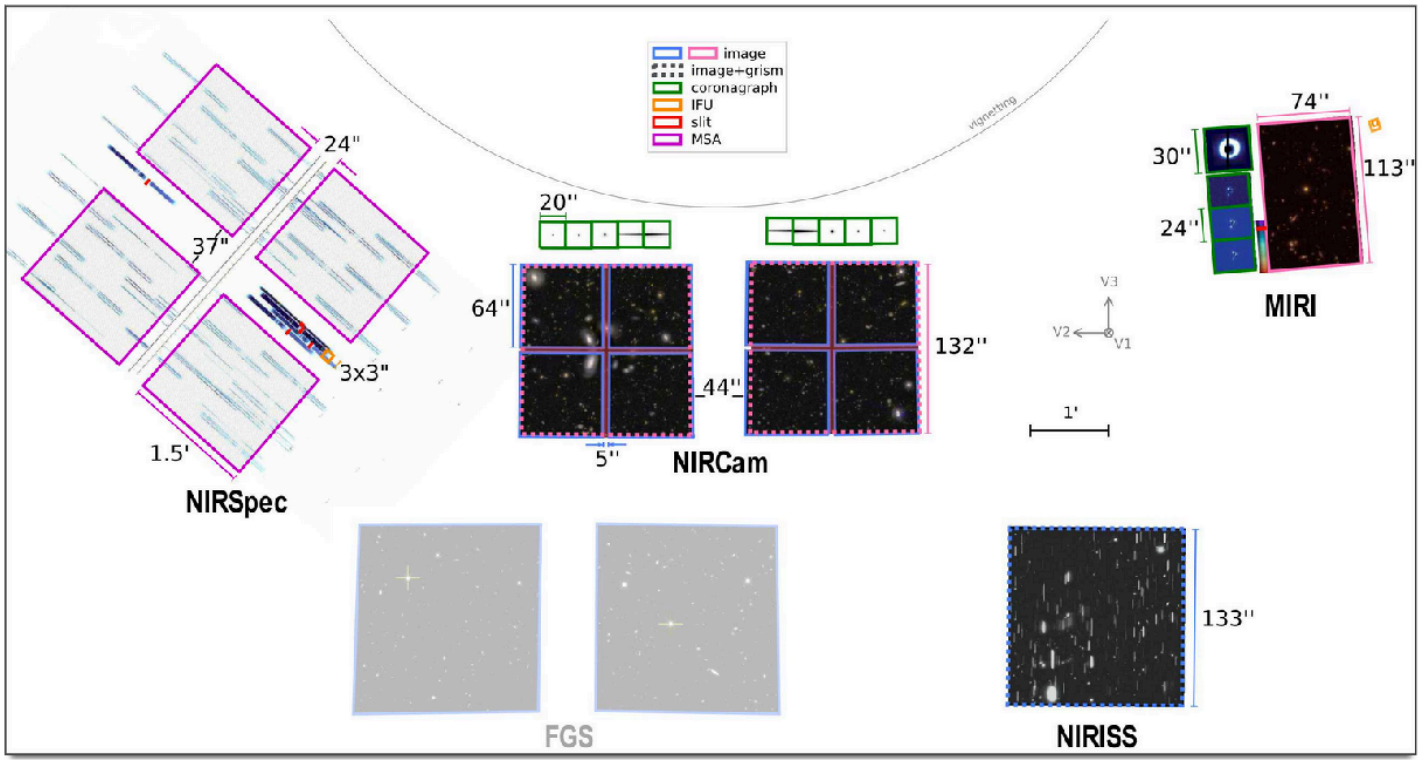


NIRISS



Il ”piano focale” di James Webb

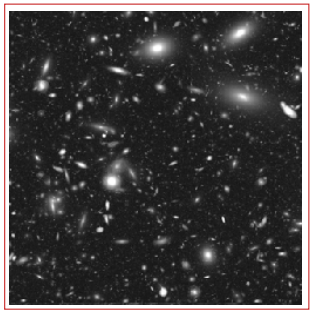
5 strumenti che si possono usare 2 alla volta



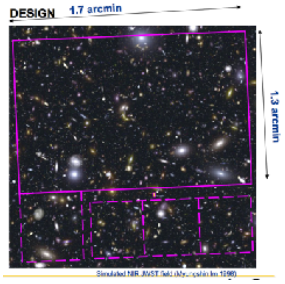
Credit: STScI

JWST: camera per immagini

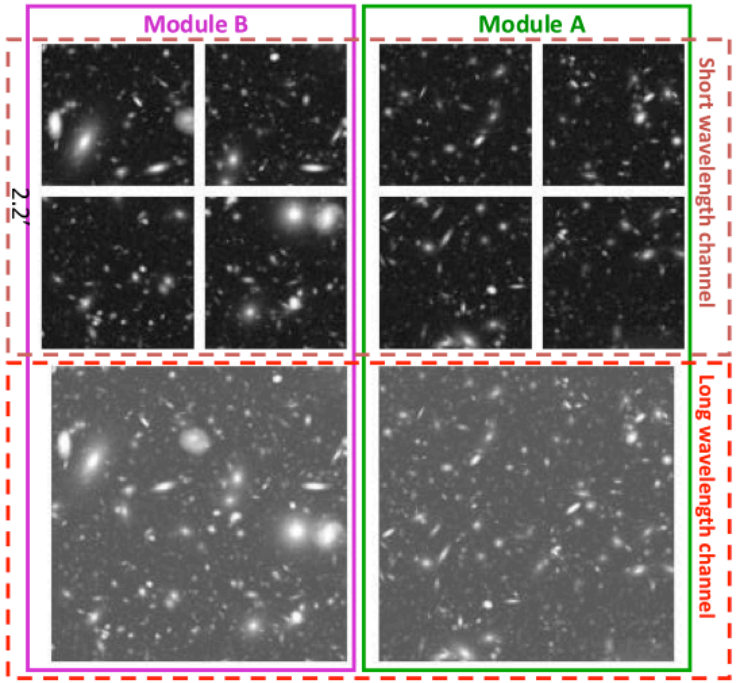
NIRISS (2.2’ x 2.2’)



MIRI (1.7’ x 1.3’)

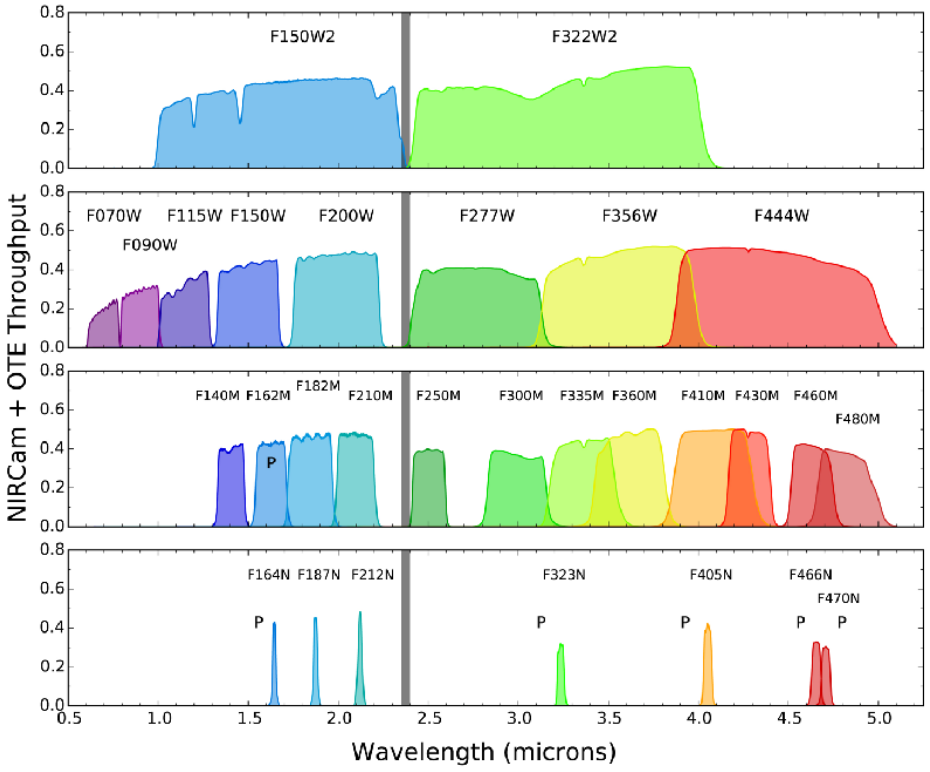


NIRCam (4.4’ x 2.2’)

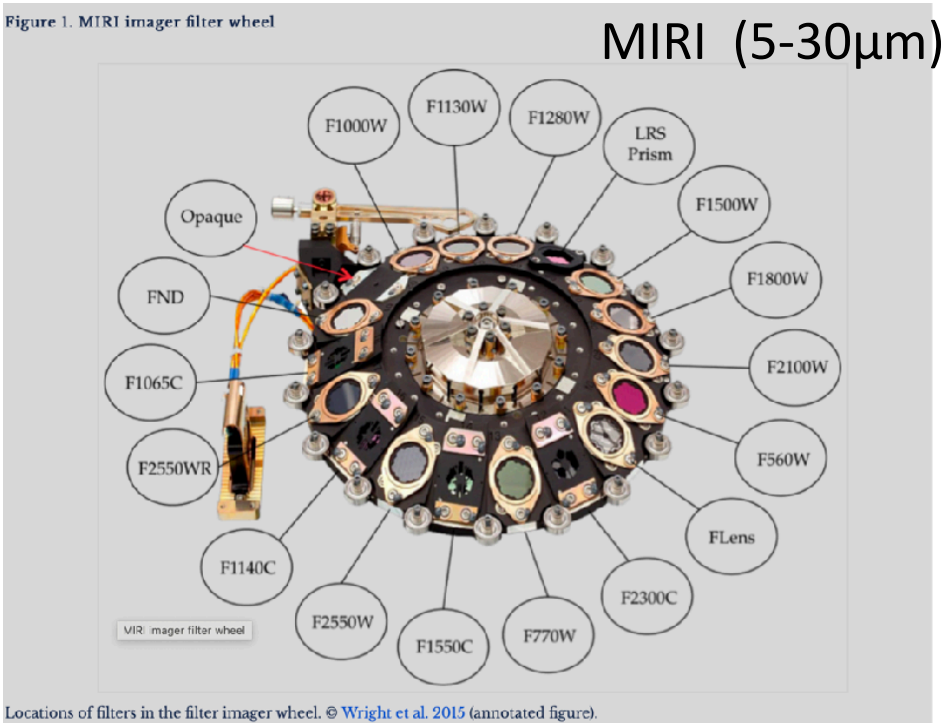


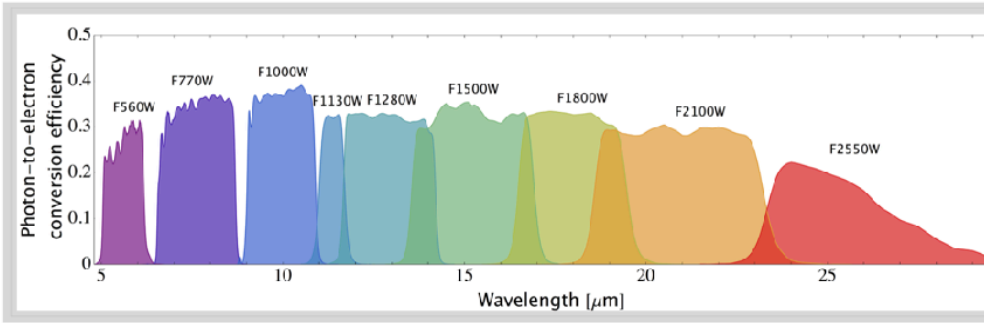
JWST ottiene immagini InfraRosse

NIRCam (0.7-5µm)



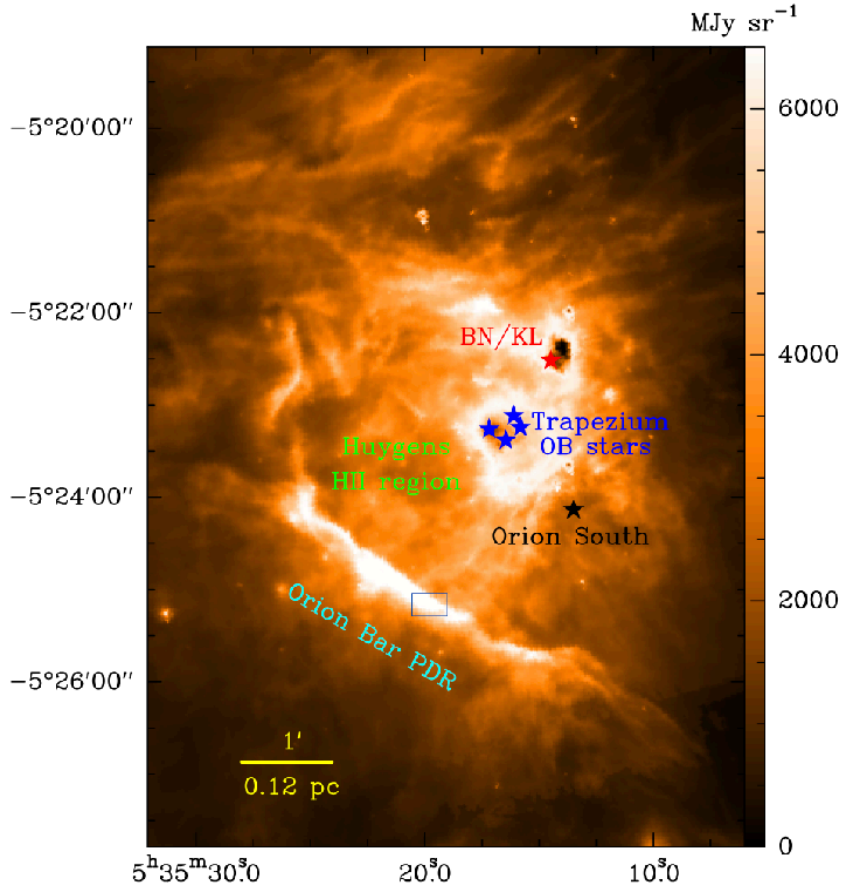
MIRI (5-30µm)

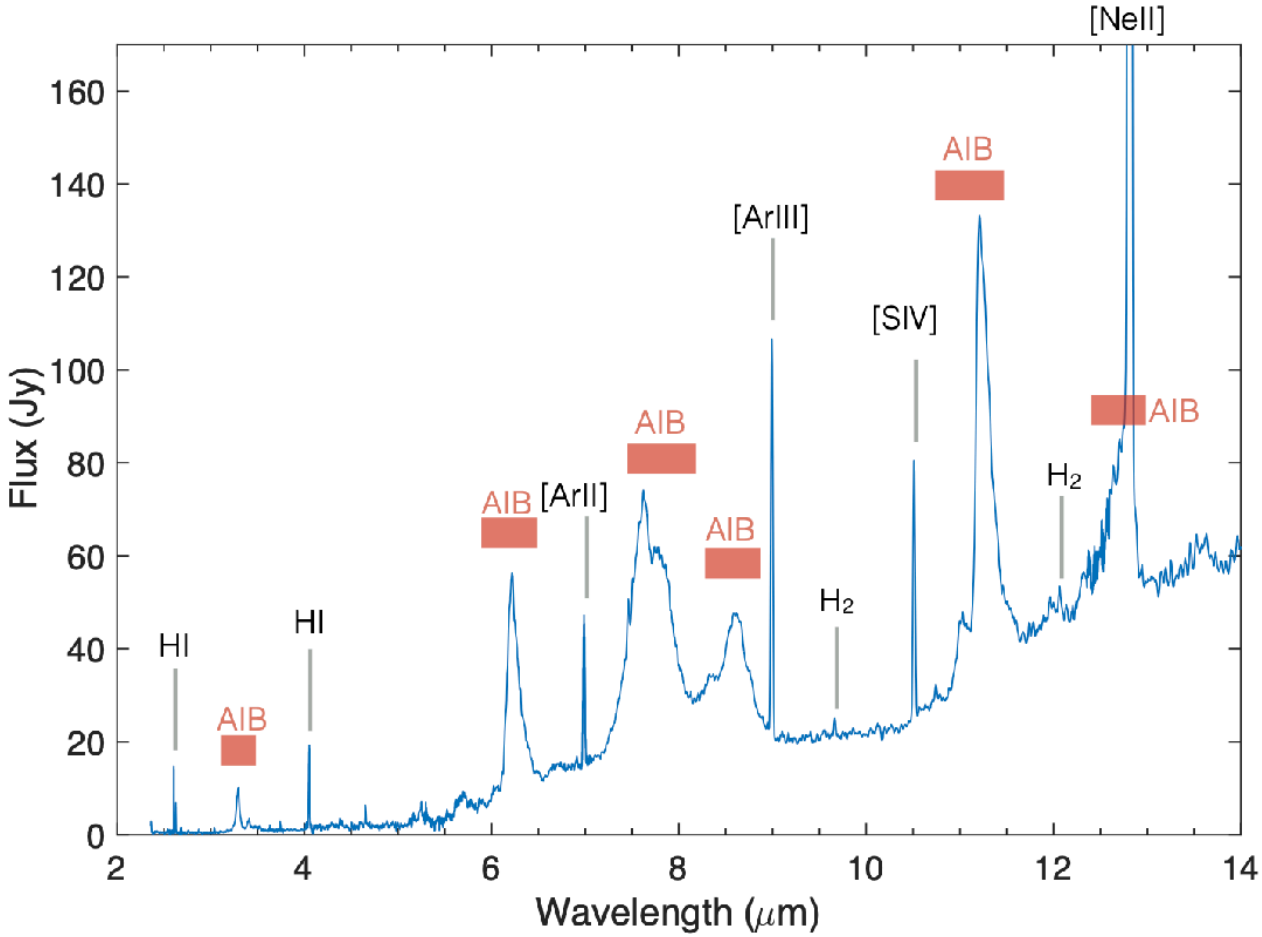




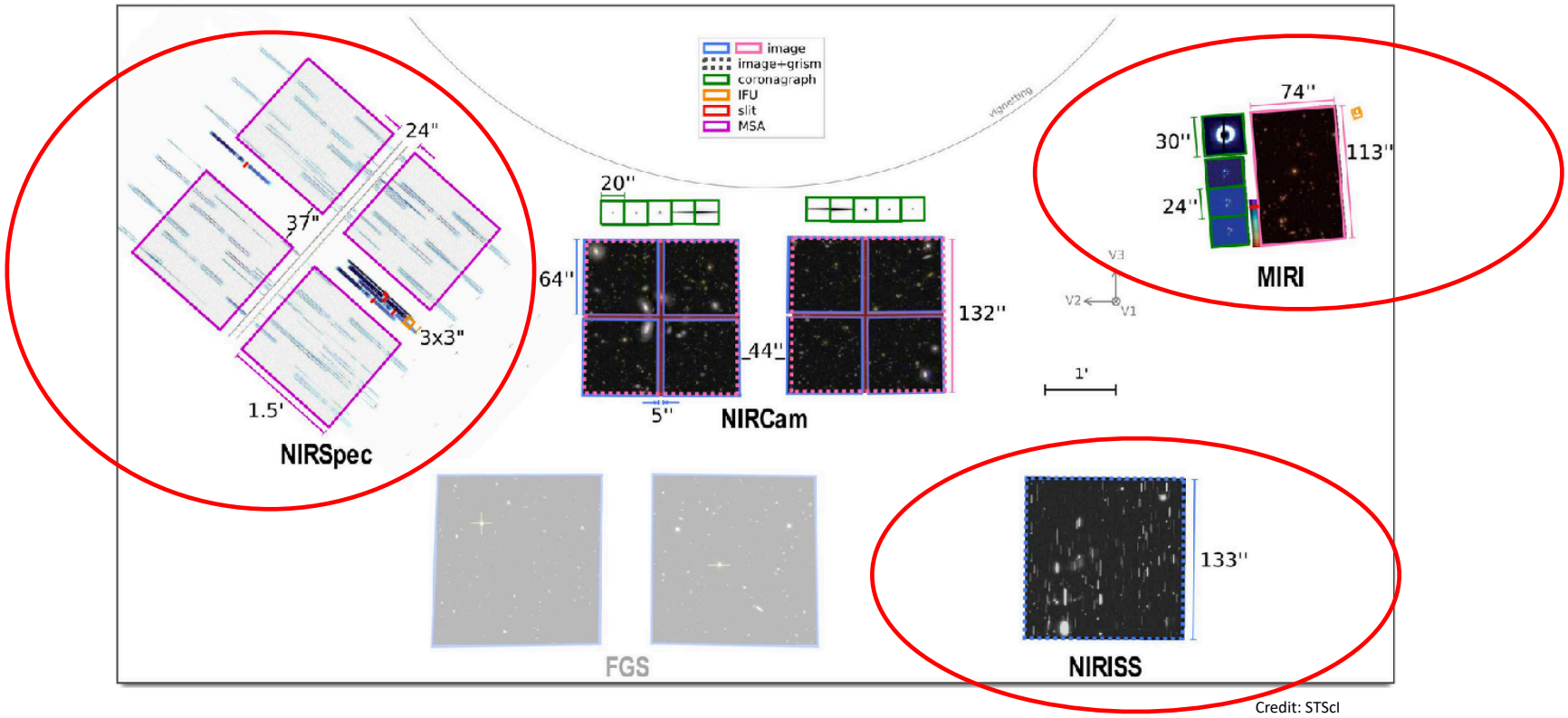
Fare immagini non basta… serve fare un *spettro*

Spettroscopia: decomporre la luce nei suoi colori, cioè misurare l'intensita' alle diverse lunghezze d'onda


MJy sr^{-1}
6000
4000
2000
0
−5°20′00″
−5°22′00″
−5°24′00″
−5°26′00″
5^{h}35^{m}30.^{s}0
20.^{s}0
10.^{s}0
BN/KL
Trapezium
OB stars
Huygens
HII region
Orion South
Orion Bar PDR
1′
0.12 pc

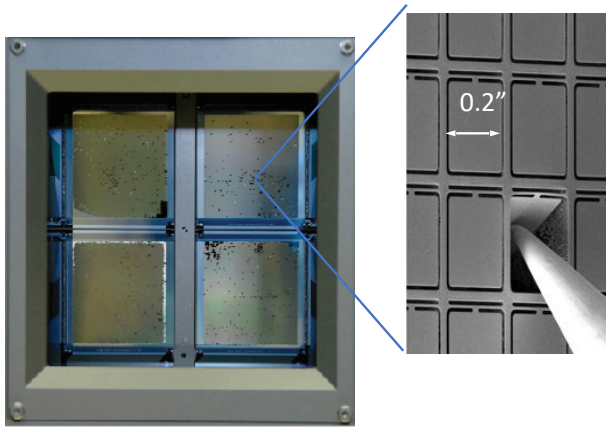

[NeII]
AIB
[ArIII]
[SIV]
AIB
AIB
[ArII]
AIB
AIB
H$_2$
H$_2$
AIB
HI
HI
AIB
Flux (Jy)
Wavelength (μm)
0
20
40
60
80
100
120
140
160
2
4
6
8
10
12
14

JWST ha 3 spettrografi



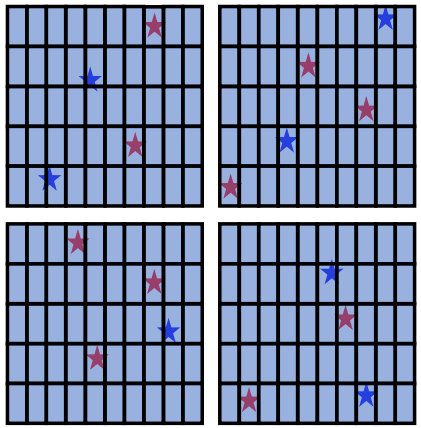
Credit: STScI

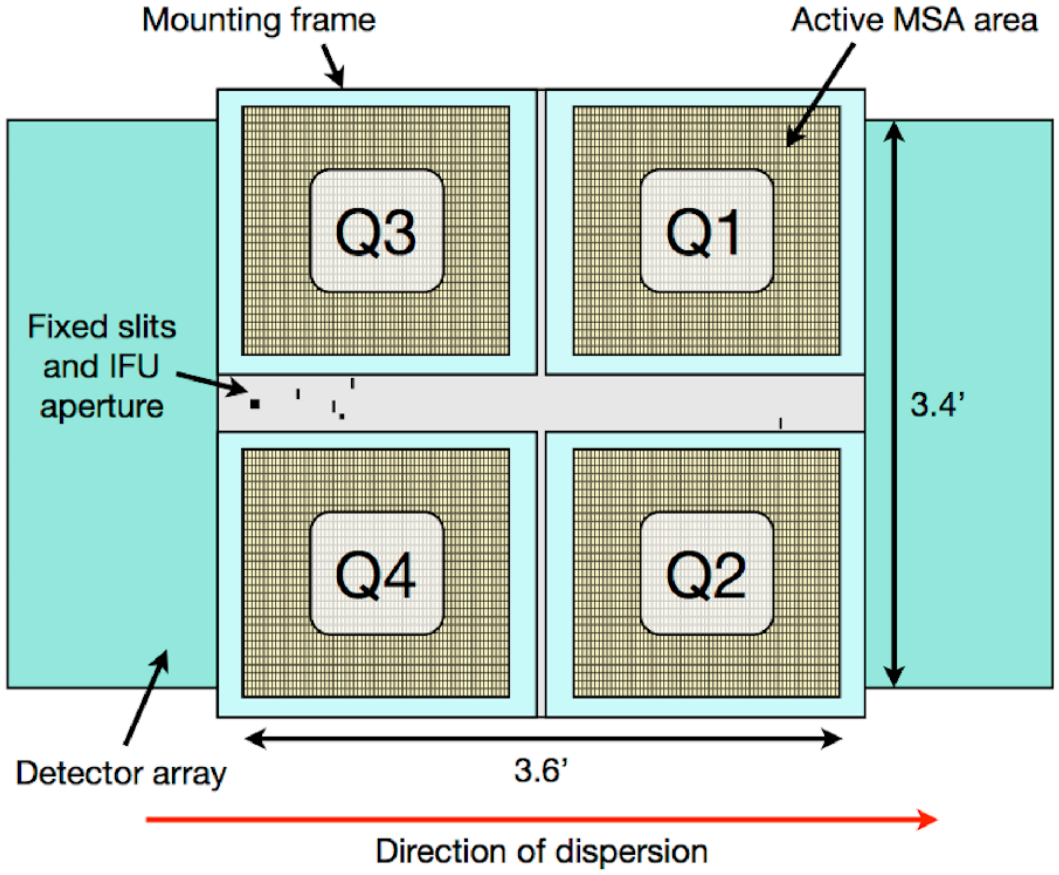
NIRSpec: forse lo strumento più complesso mai lanciato nello spazio
Costruito da ESA



~250,000 shutters

Each shutter is 0.46” x 0.2”

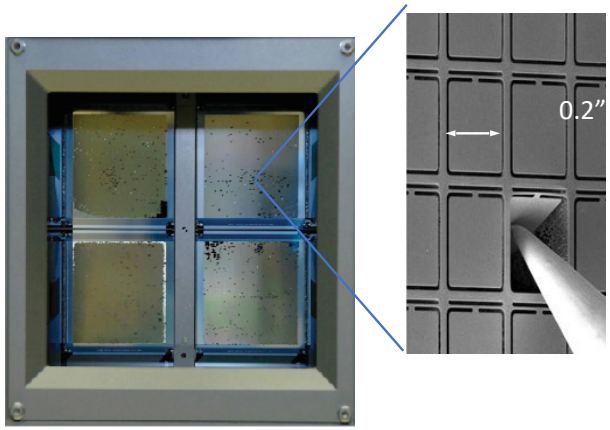




RIGID ARRAY

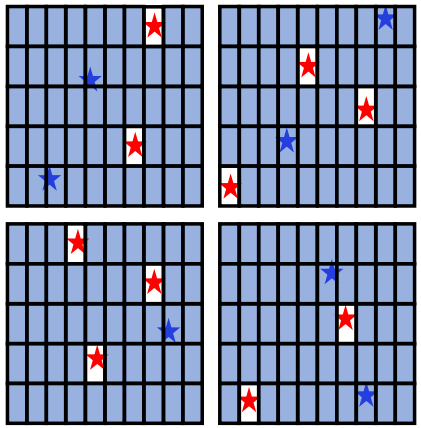
⇒ implications

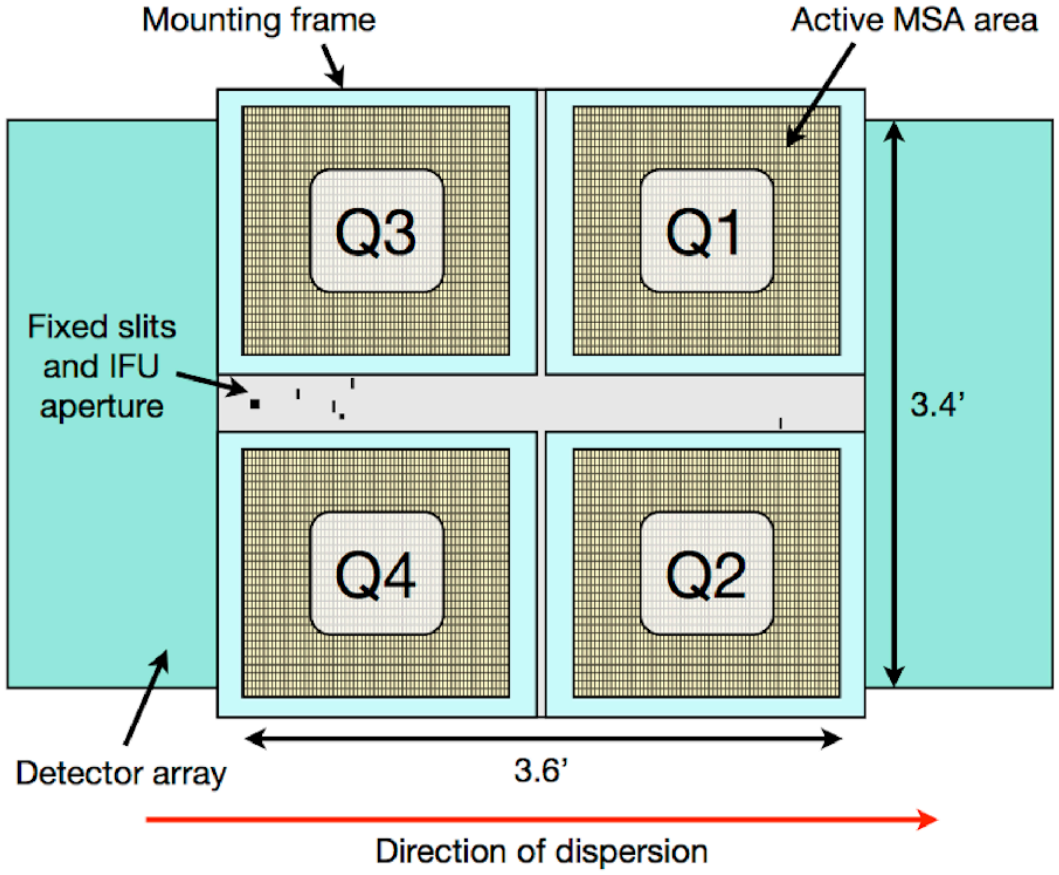
for observing plan



~250,000 shutters

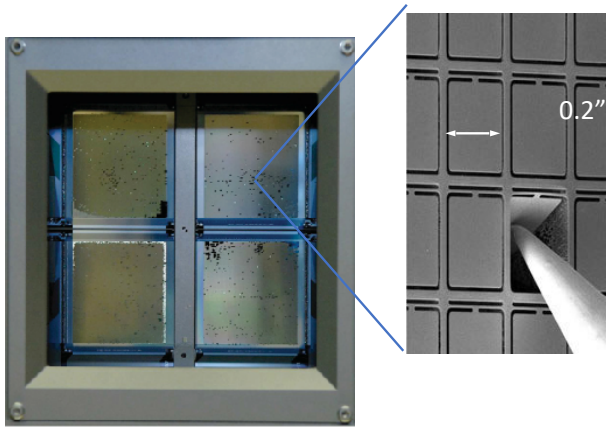
Each shutter is 0.46” x 0.2”





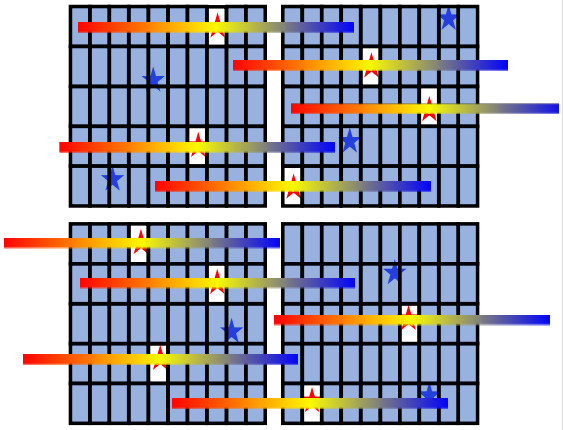
RIGID ARRAY

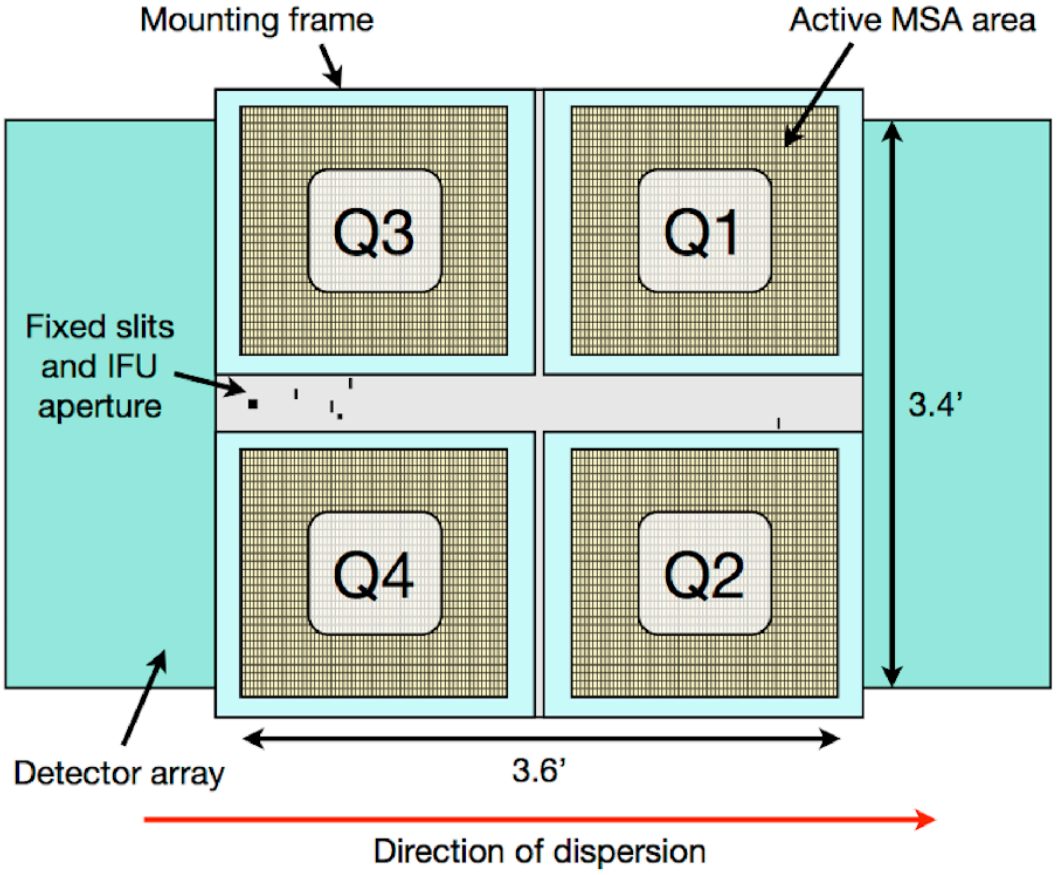
⇒ implications for observing plan



~250,000 shutters

Each shutter is 0.46” x 0.2”





RIGID ARRAY

⇒ implications

for observing plan

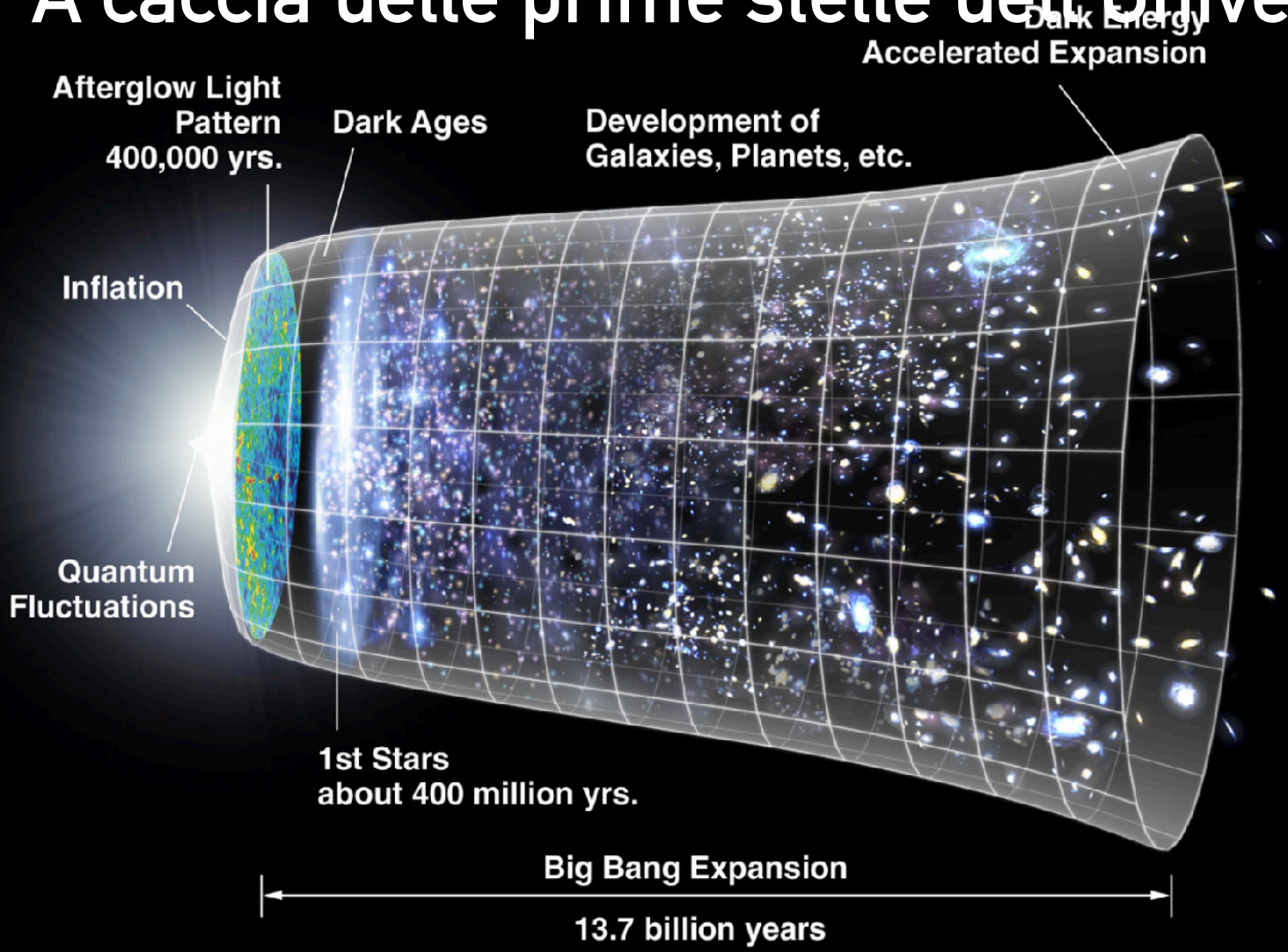
Alla fine abbiamo un telescopio:

-Il più grande possible (6.5m)
-Nello spazio profondo
-Freddo
-Che si lancia impacchettato e si apre dopo il lancio..
- Con un insieme di strumenti straordinari…

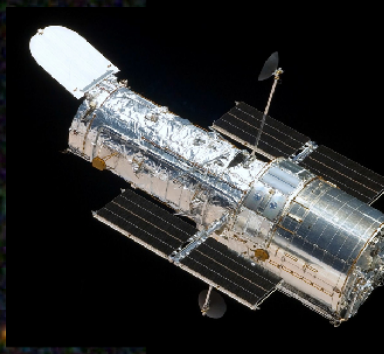
Che ci facciamo con James Webb?

Rivoluzioniamo la nostra visione dell'Universo!

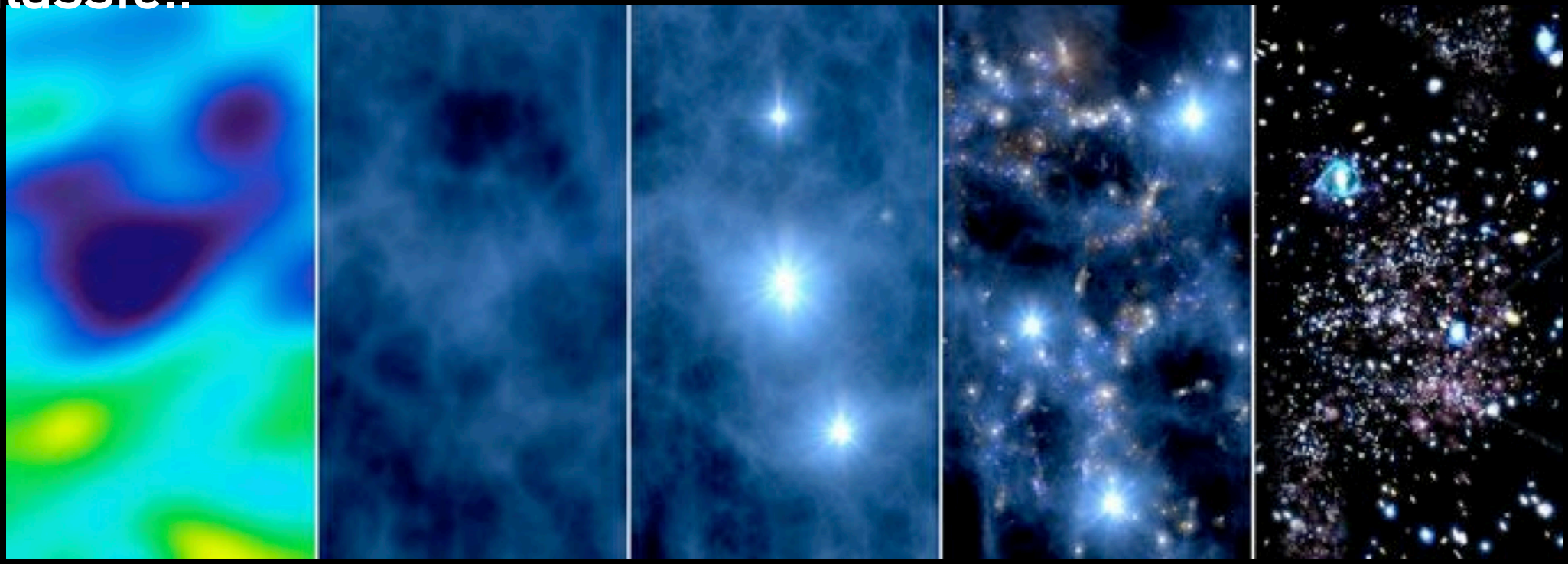
A caccia delle prime stelle dell'Universo



HST si e’ “fermato” a circa 1 miliardo di anni dal Big Bang..

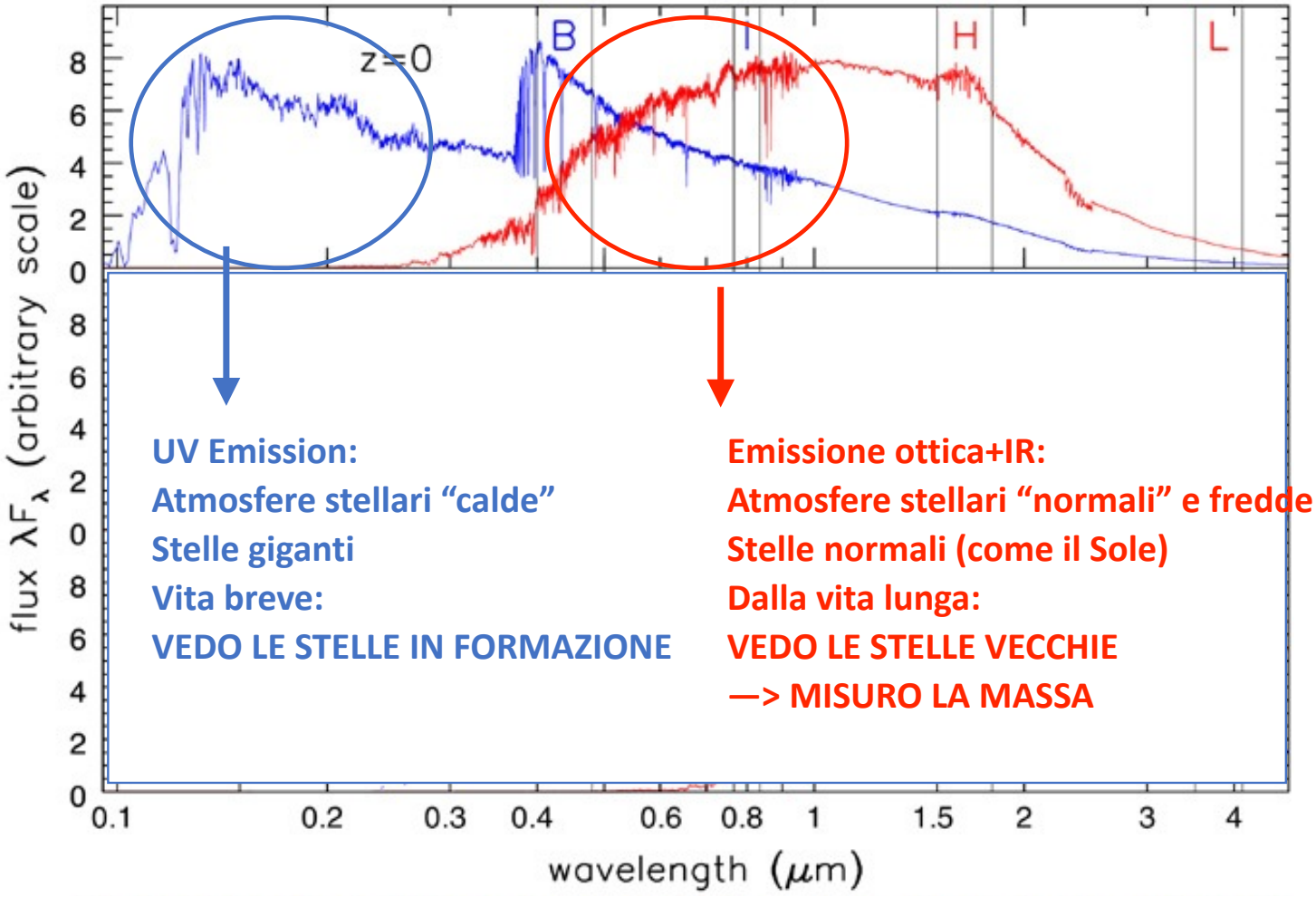


James Webb ci permetterà di vedere le prime stelle e galassie..

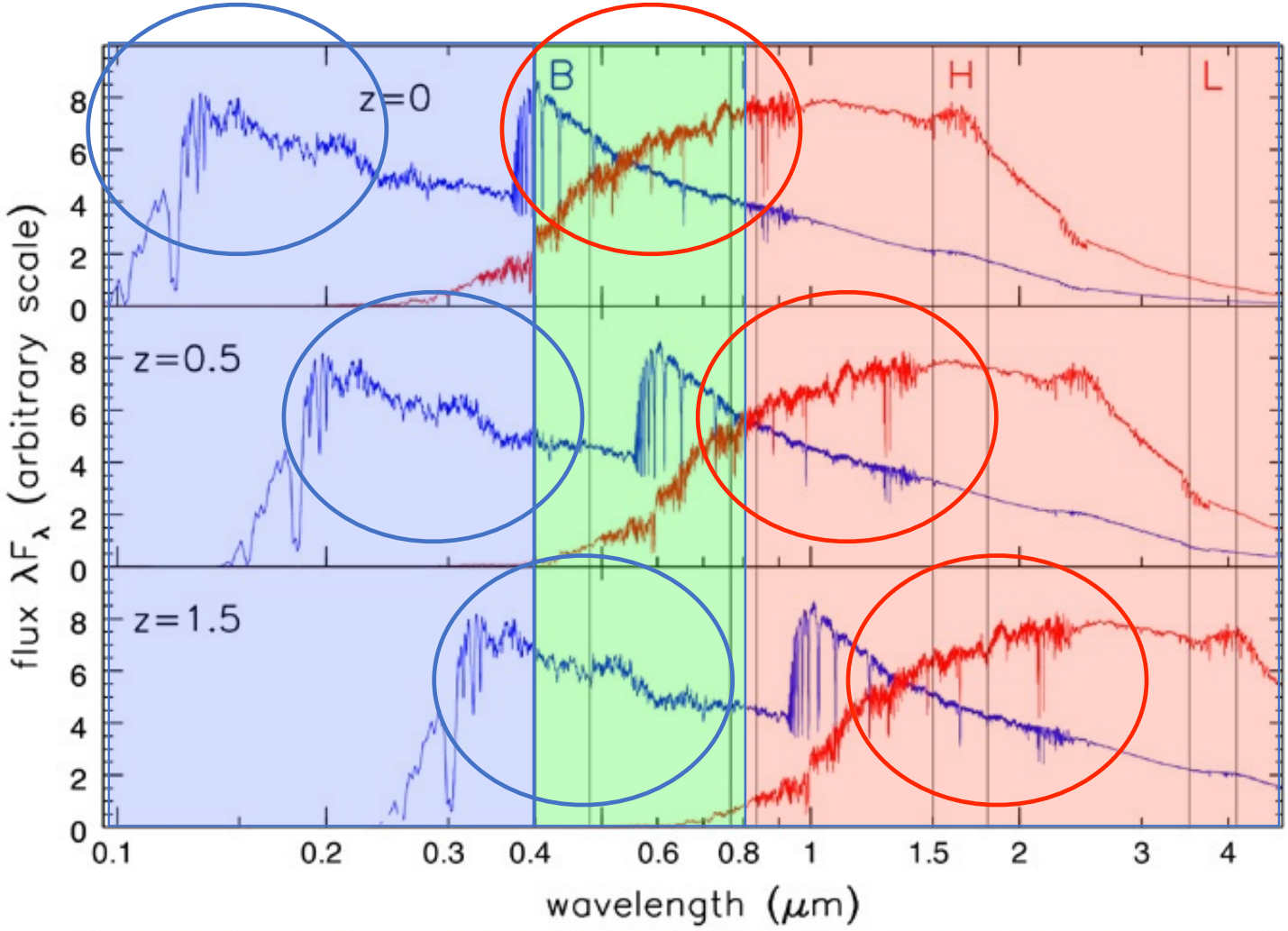


300.000 100.000.000 300.000.000 310.000.000 700.000.000

Le Galassie possono avere popolazioni stellari diverse, che producono spettri diversi

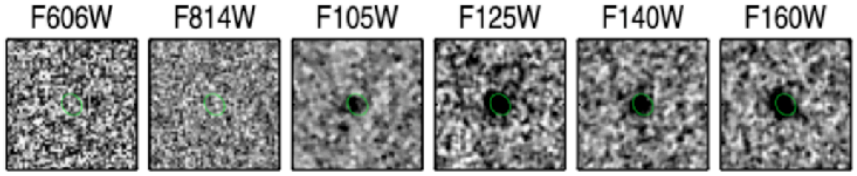


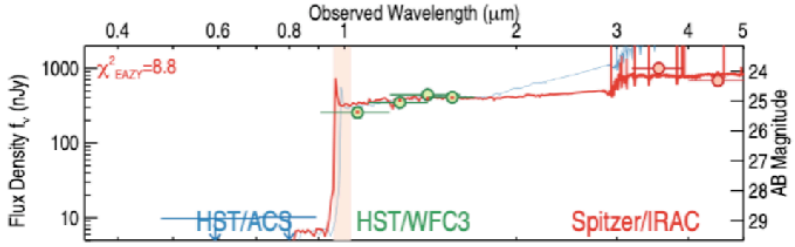
L'Universo si espande: quelle lontane si "allontanano" e il loro spettro si "arrossa"
Redshift Cosmologico $\lambda_{osservata} = (1+z)\,\lambda_{emessa}$



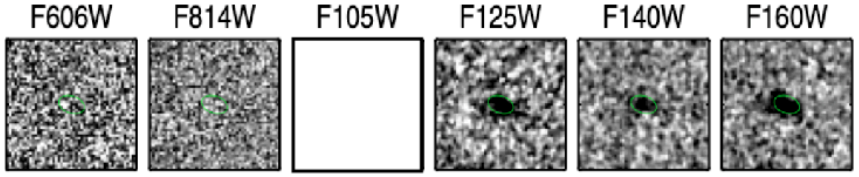
Lyman α (121.567nm)

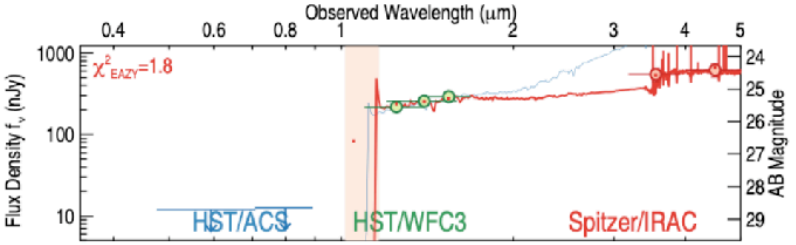
ID=13433, m=25, z=6.9



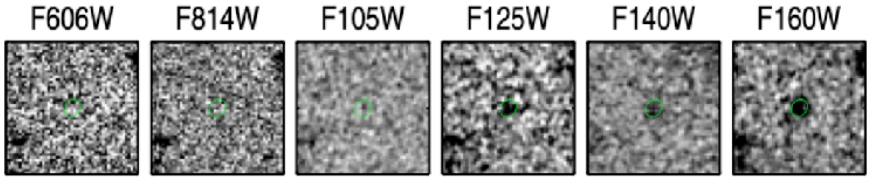


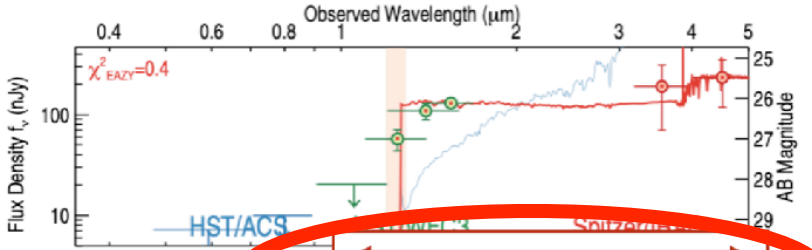
ID=7364, m=25.2, z=8.4





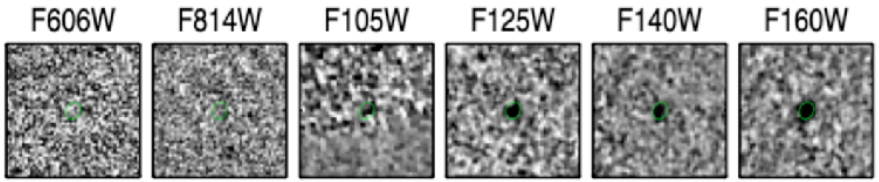
ID=26816, m=26.1, z=9.4

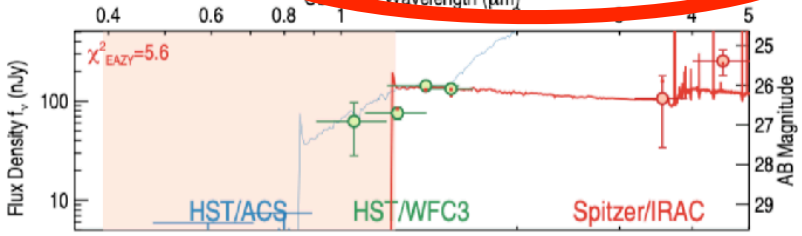




NIRCam/NIRSpec coverage

ID=26890, m=26.1, z=9.0

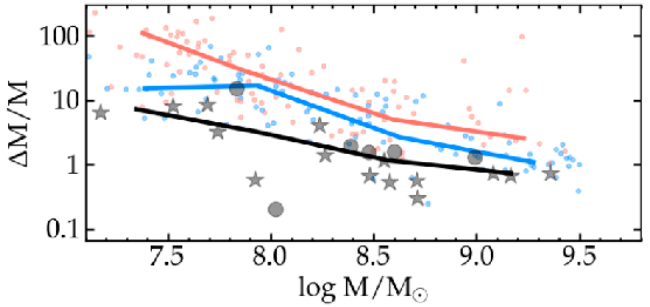




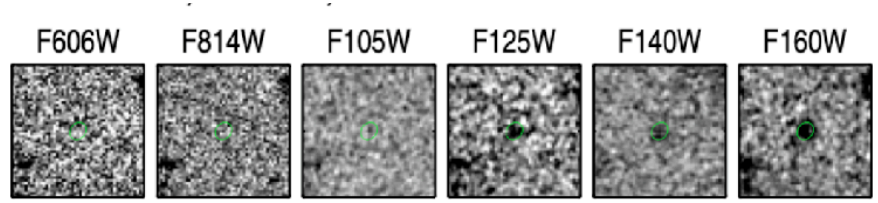
JWST extends the redshift search to z>10

AND

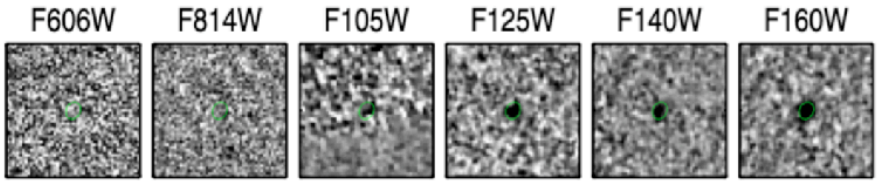
Allows us to sample the optical rest frame, i.e. to measure stellar masses and element abundance

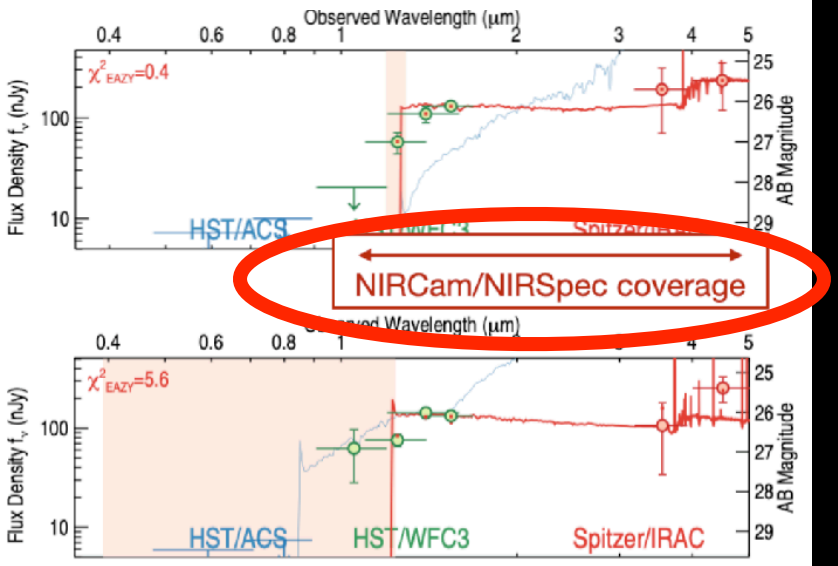


Santini, AF+22



ID=26890, m=26.1, z=9.0

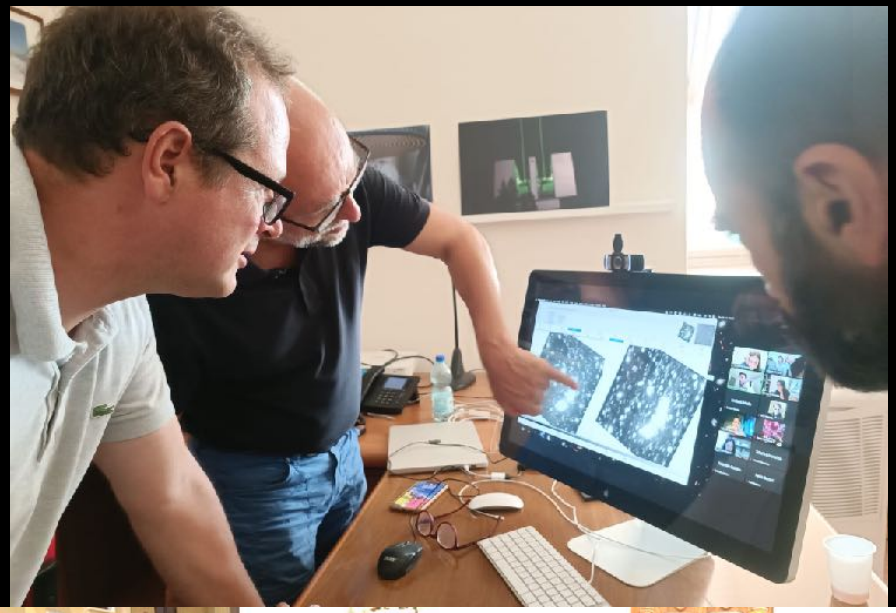


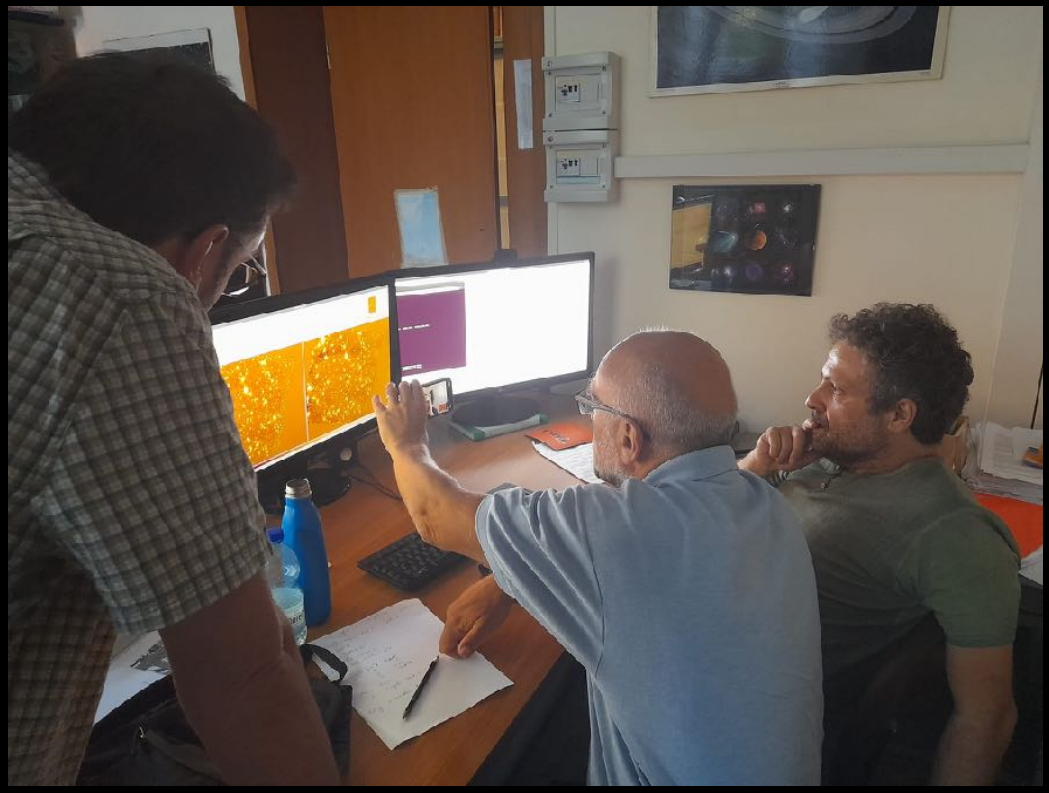


Il 14 luglio, i primi dati Webb sono stati rilasciati.. in formato jpg!

Il 16 luglio, una serie di dati scientifici sono stati rilasciati *pubblicamente*

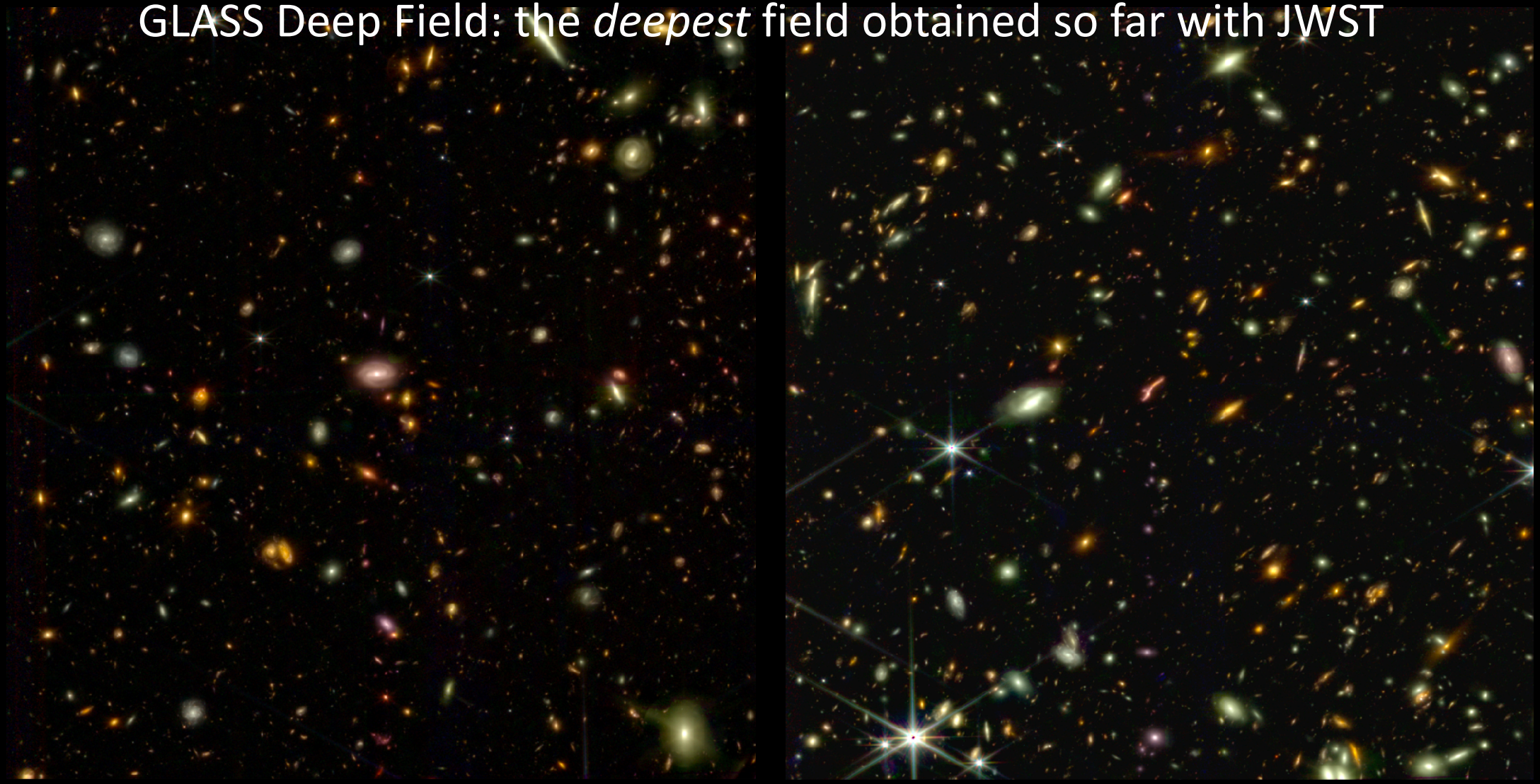
Inclusi quelli del progetto GLASS, una collaborazione US/Italia





Marco Castellano, Emiliano Merlin,
Diego Paris, Paola Santini

GLASS Deep Field: the *deepest* field obtained so far with JWST



The race started…. we lost it for 3 minutes! 😝😝😝🤣🤣🤣

[739] arXiv:2207.09434 [pdf, othe

Two Remarkably Lumin

Rohan P. Naidu, Pascal A. C … ker, Natalie Allen, Rachel Bezanson, Rychard Bouwen … erina Leonova, Jorryt Matthee, Sedona H. Price, David J. Se … r, Andrea Weibel

Comments: Submitted to ApJL. Fig … shows the morphology, Fig. 5 explores implications for the UVLF. Comme

Subjects: **Astrophysics of Galaxie**

[740] arXiv:2207.09436 [pdf, othe

Early results from GLA

Marco Castellano, Adriano … lichele Trenti, Uros Mestric, Eros Vanzella, Andrea Bonchi, D… ni, Kristan Boyett, Antonello Calabro, Karl Glazebrook, C… a, Themiya Nanayakkara, Laura Pentericci, Piero Rosati, Ber

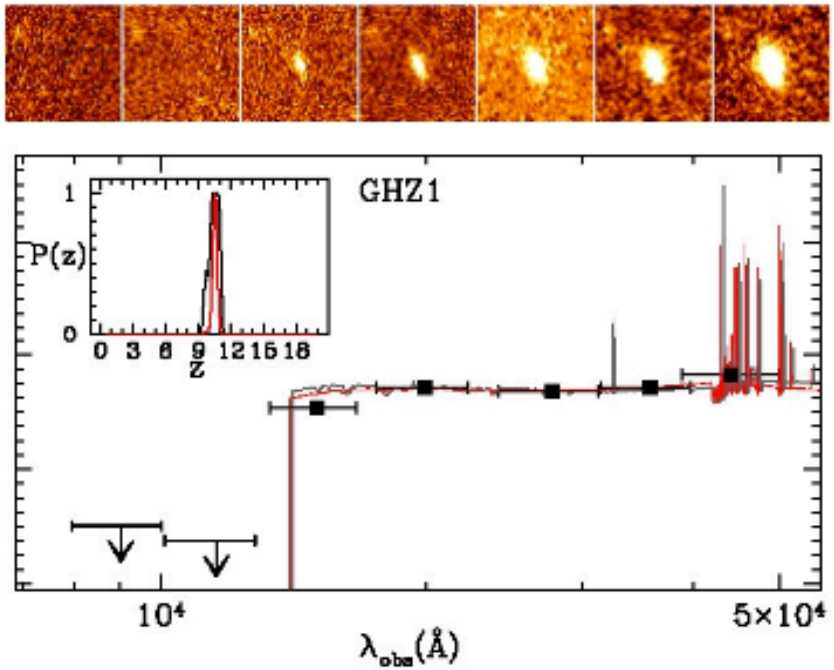
Comments: Submitted to ApJL, 9 p

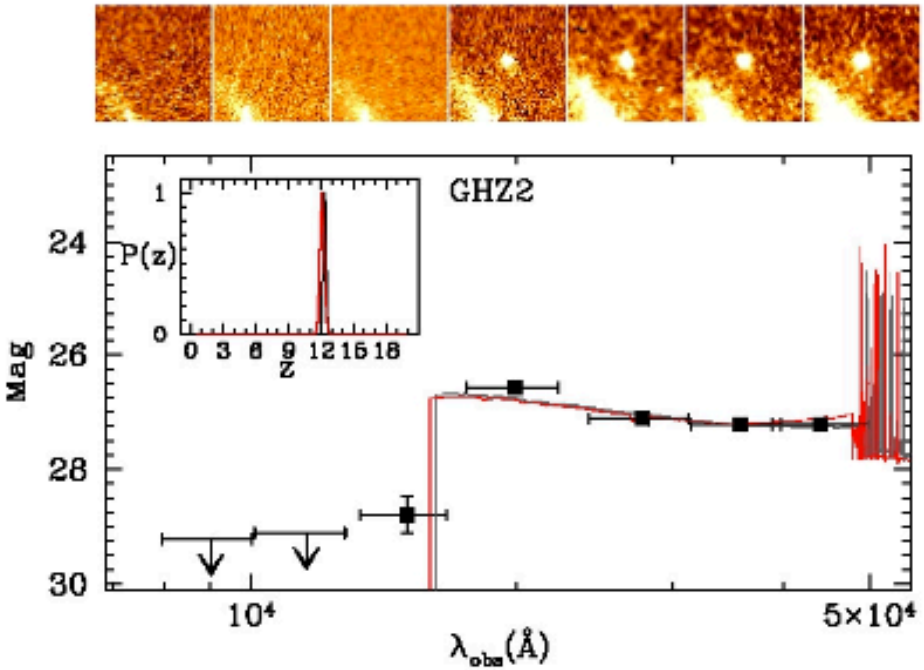
Subjects: **Astrophysics of Galaxie**

GHZ-2 is 10^9x fainter than the faintest star you can see by naked eye

Two bright & robust candidates in GLASS at redshift=10 and 12

SEARCH FOR GALAXY CANDIDATES AT z~9-15 IN GLASS-JWST–ERS





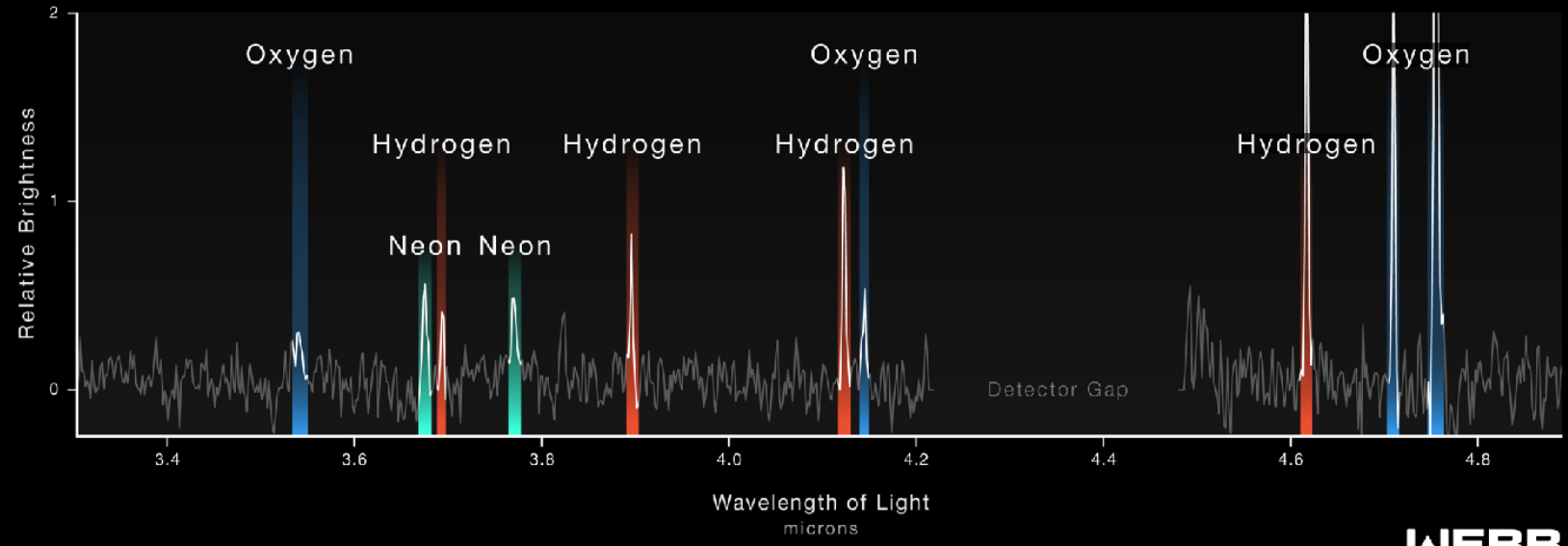
Castellano, AF+22

DISTANT GALAXY BEHIND SMACS 0723

WEBB SPECTRUM SHOWCASES GALAXY'S COMPOSITION

NIRCam Imaging

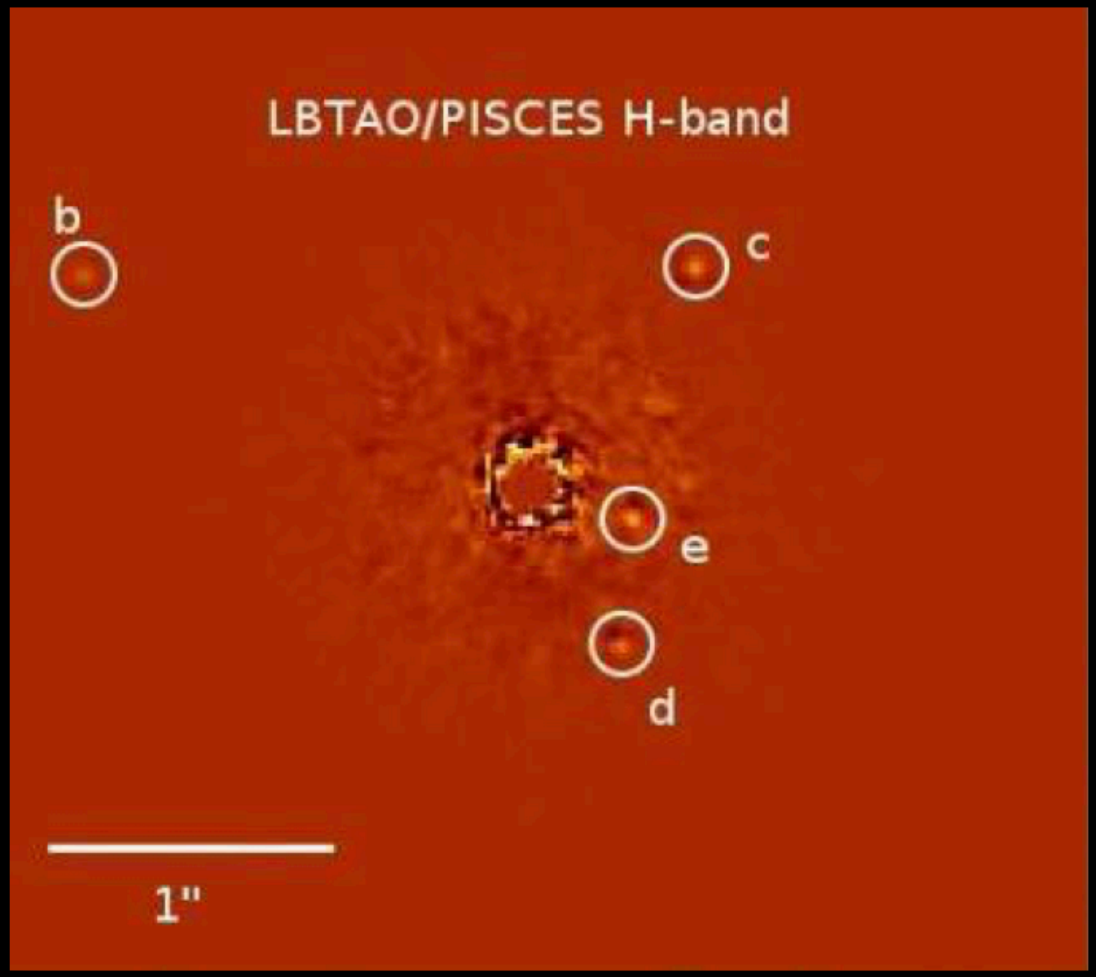
NIRSpec Microshutter Array Spectroscopy

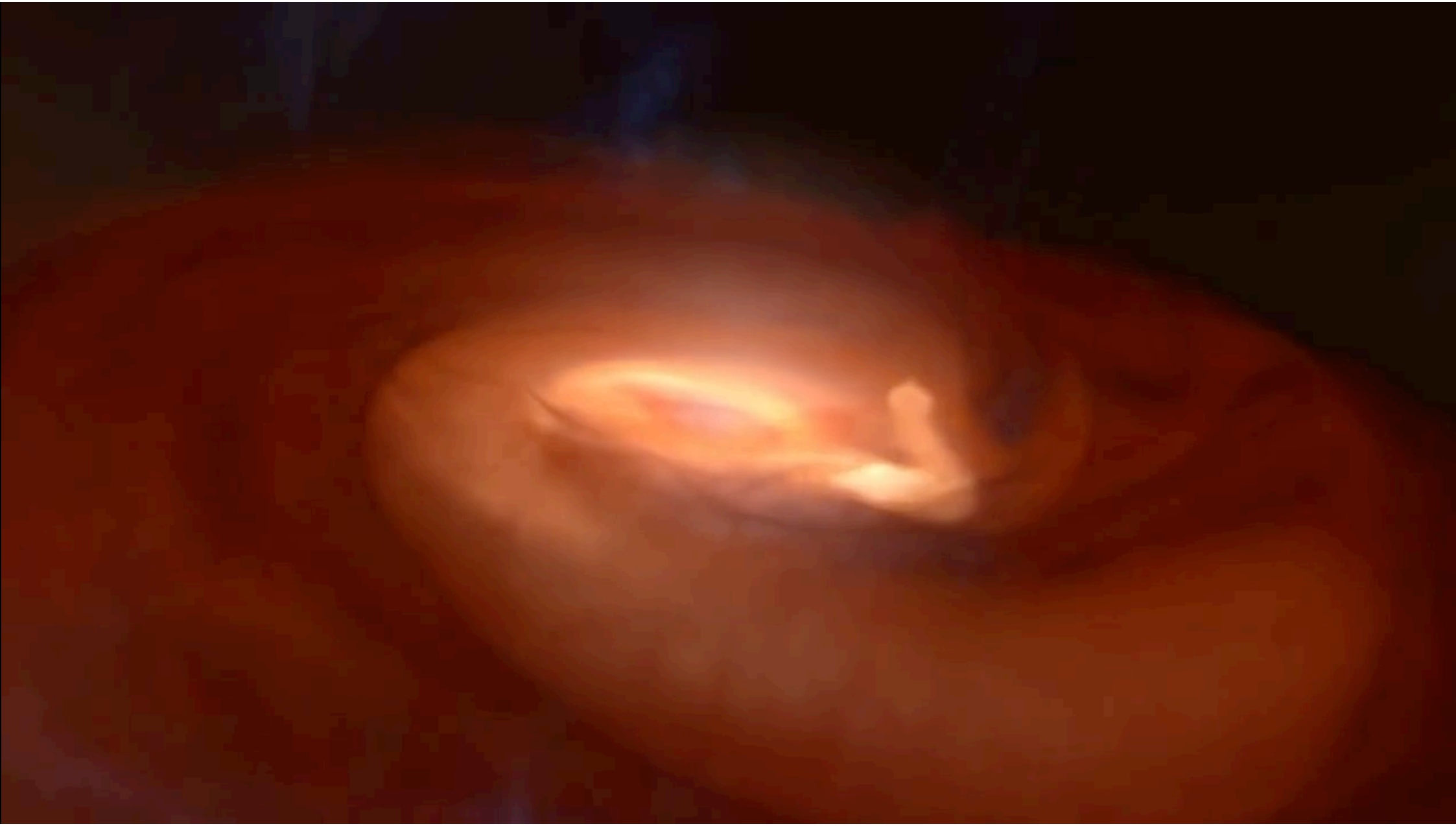


WEBB
SPACE TELESCOPE

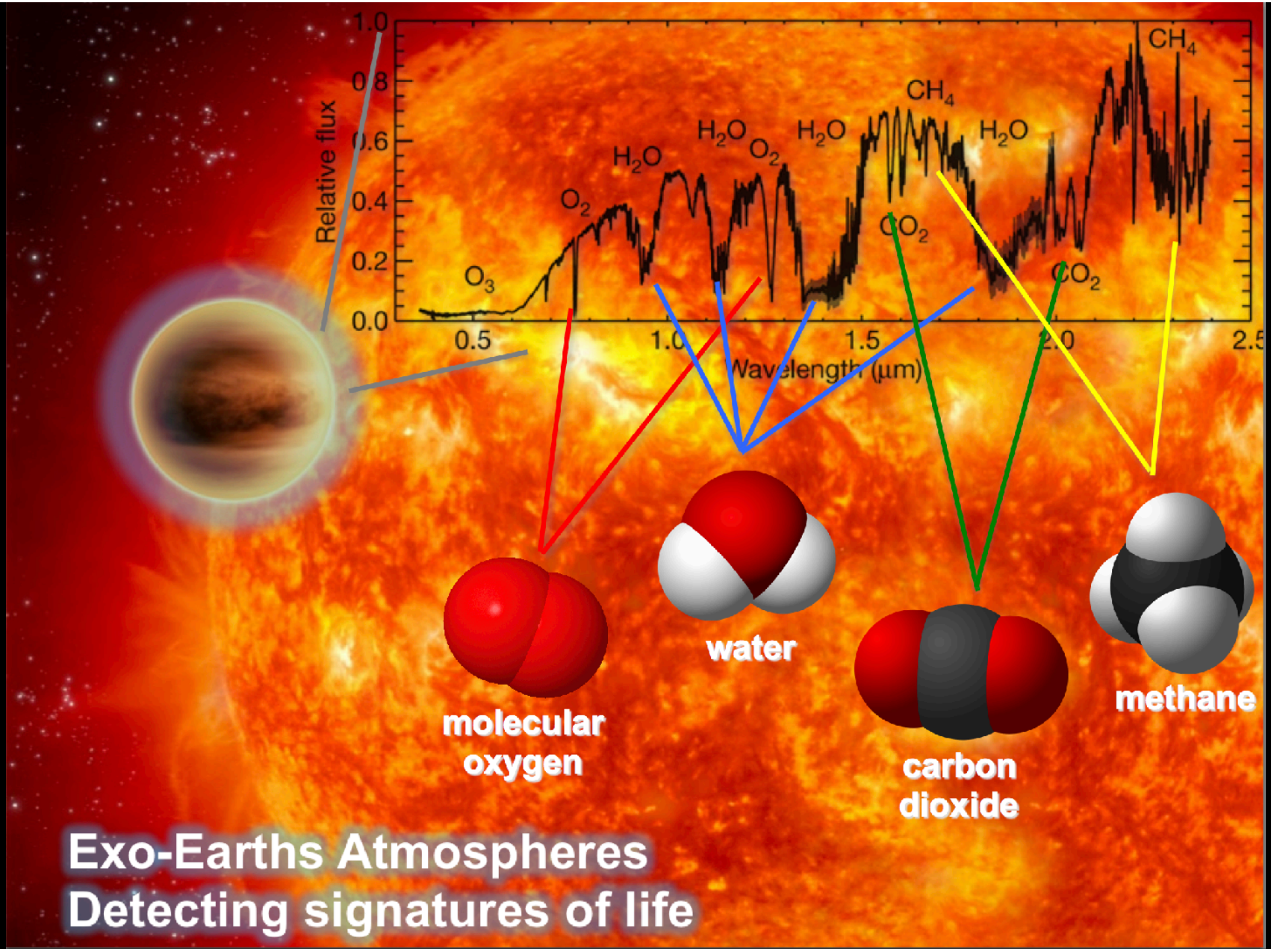
Possiamo studiare i pianeti intorno ad altre stelle!

Possiamo studiare i pianeti intorno ad altre stelle!

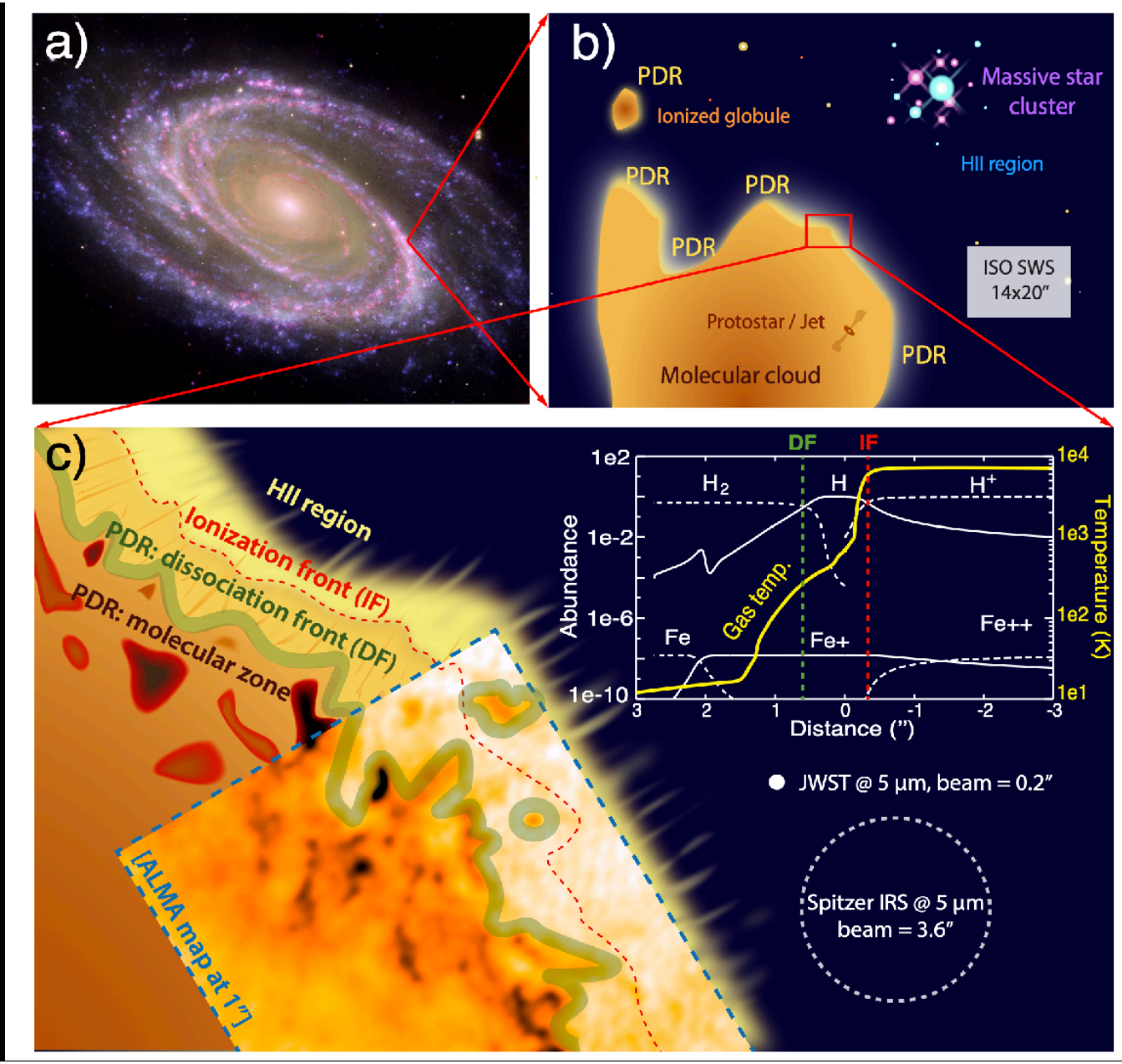




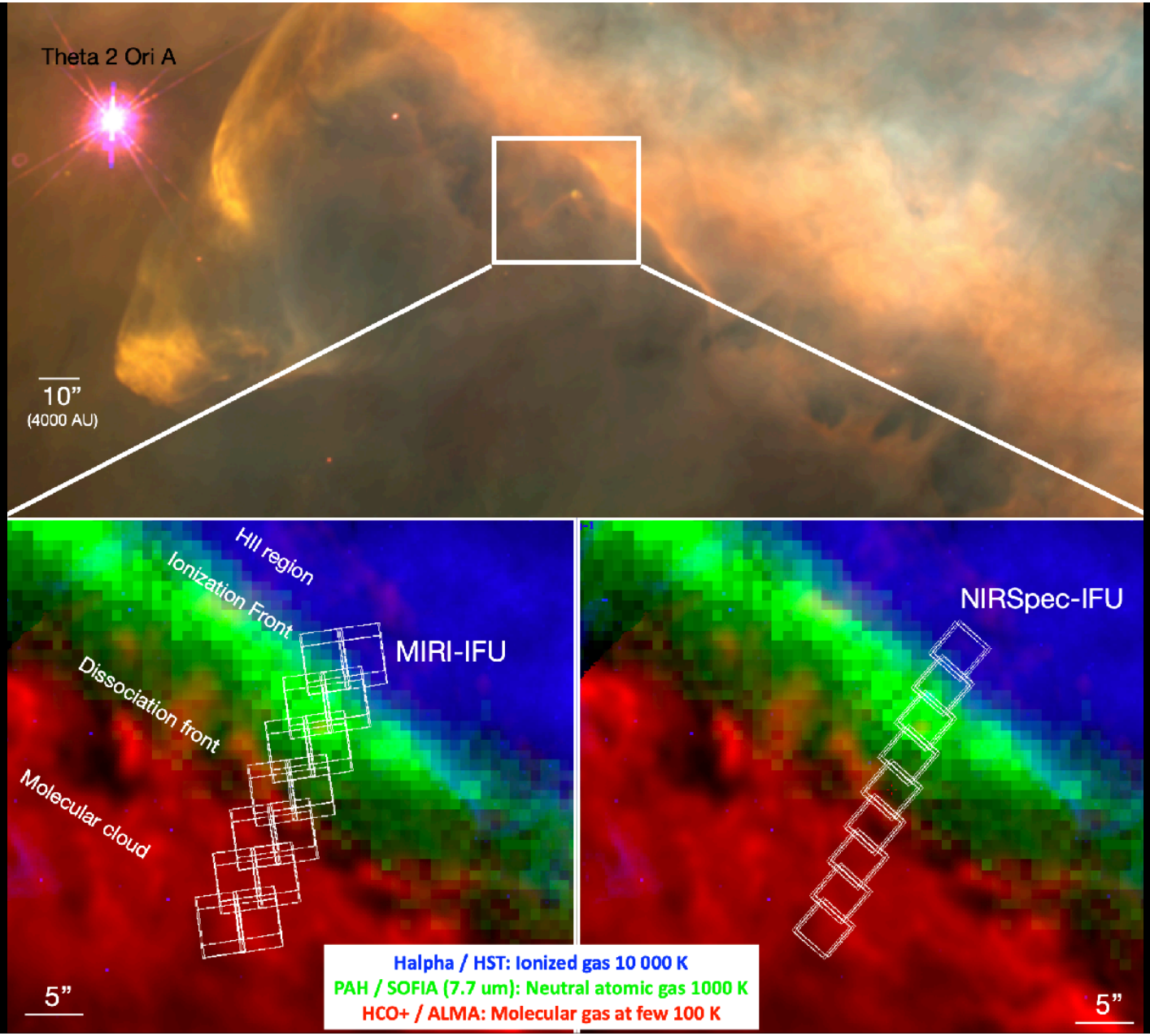
Con James Webb studieremo l’atmosfera dei pianeti extrasolari..


Relative flux
1.0
0.8
0.6
0.4
0.2
0.0
0.5
1.0
1.5
2.0
2.5
Wavelength (μm)
O_3
O_2
H_2O
H_2O
O_2
H_2O
CH_4
CO_2
H_2O
CO_2
CH_4
molecular oxygen
water
carbon dioxide
methane
Exo-Earths Atmospheres
Detecting signatures of life

Come si formano le nuove stelle?



Berne' et al 2022


Theta 2 Ori A
10”
(4000 AU)
HII region
Ionization Front
Dissociation front
Molecular cloud
MIRI-IFU
NIRSpec-IFU
Halpha / HST: Ionized gas 10 000 K
PAH / SOFIA (7.7 um): Neutral atomic gas 1000 K
HCO+ / ALMA: Molecular gas at few 100 K
5”
5”


E questo è solo l'inizio…
buona fortuna, James
Webb!