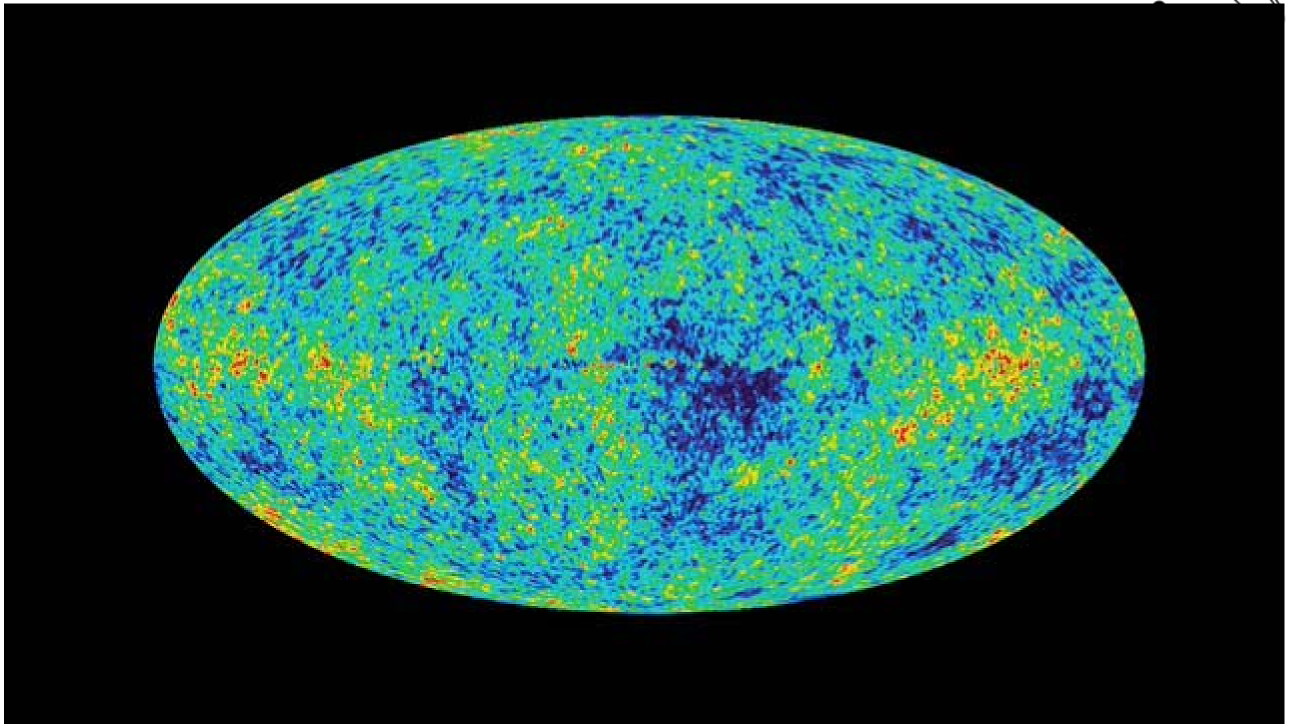
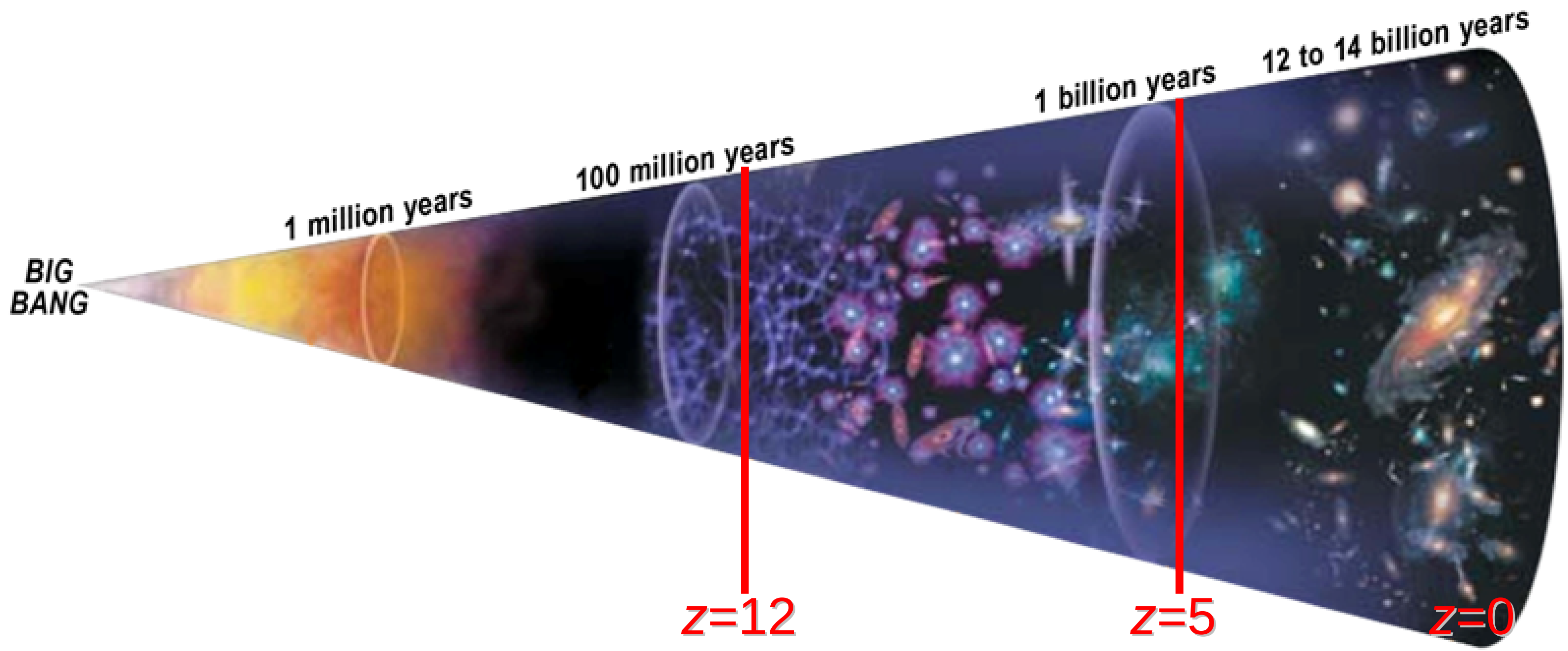
PLANCK Reflector Programme

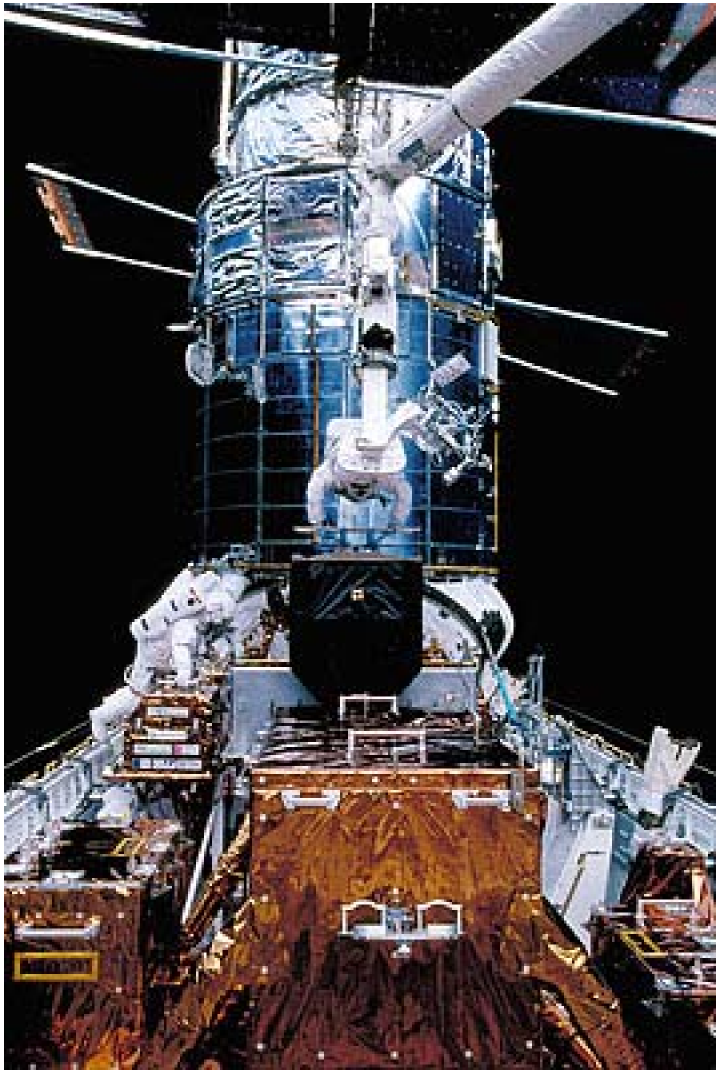
Penzias and Wilson Nobel Price in Physics 1978

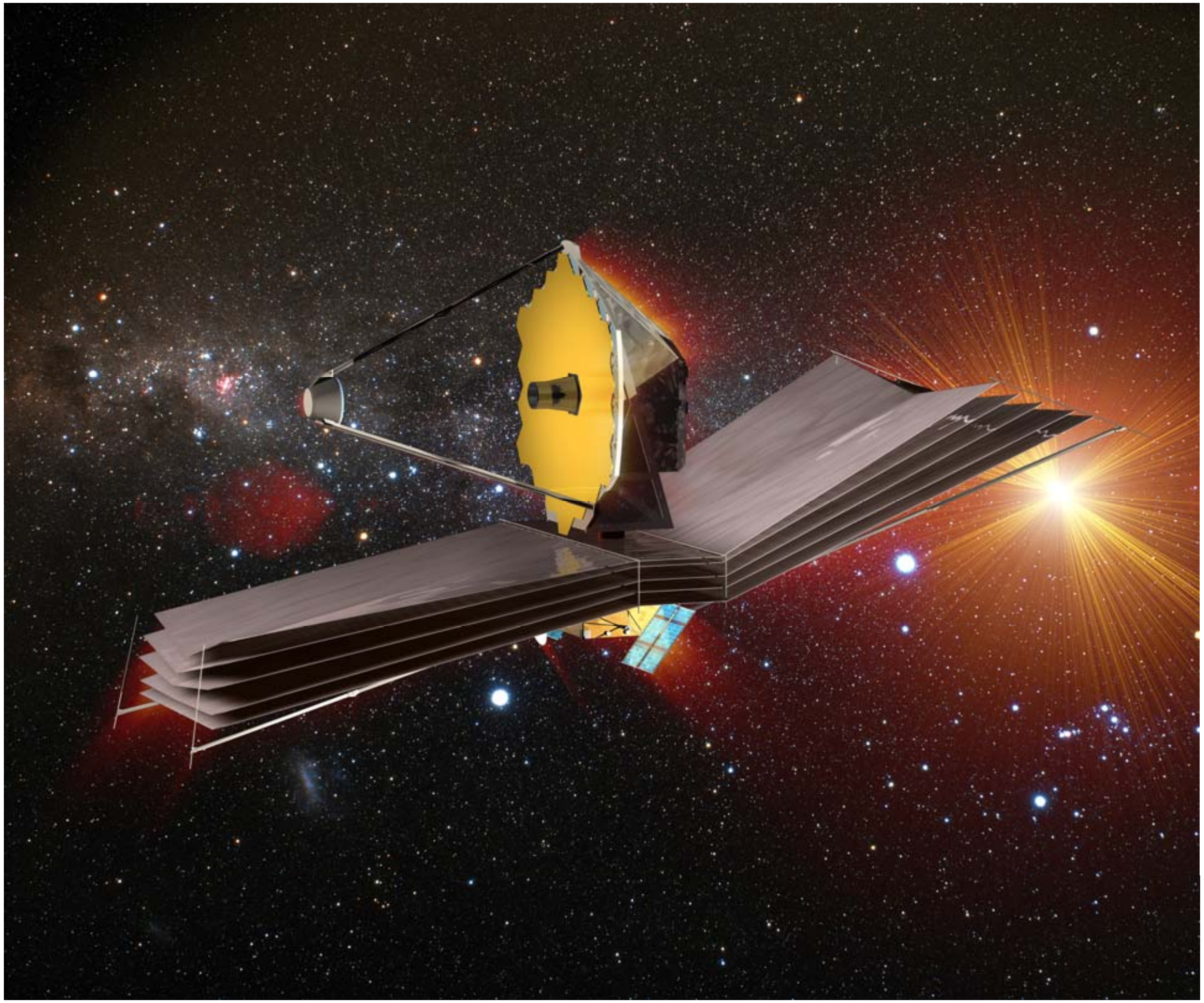
PLANCK Reflector Programme

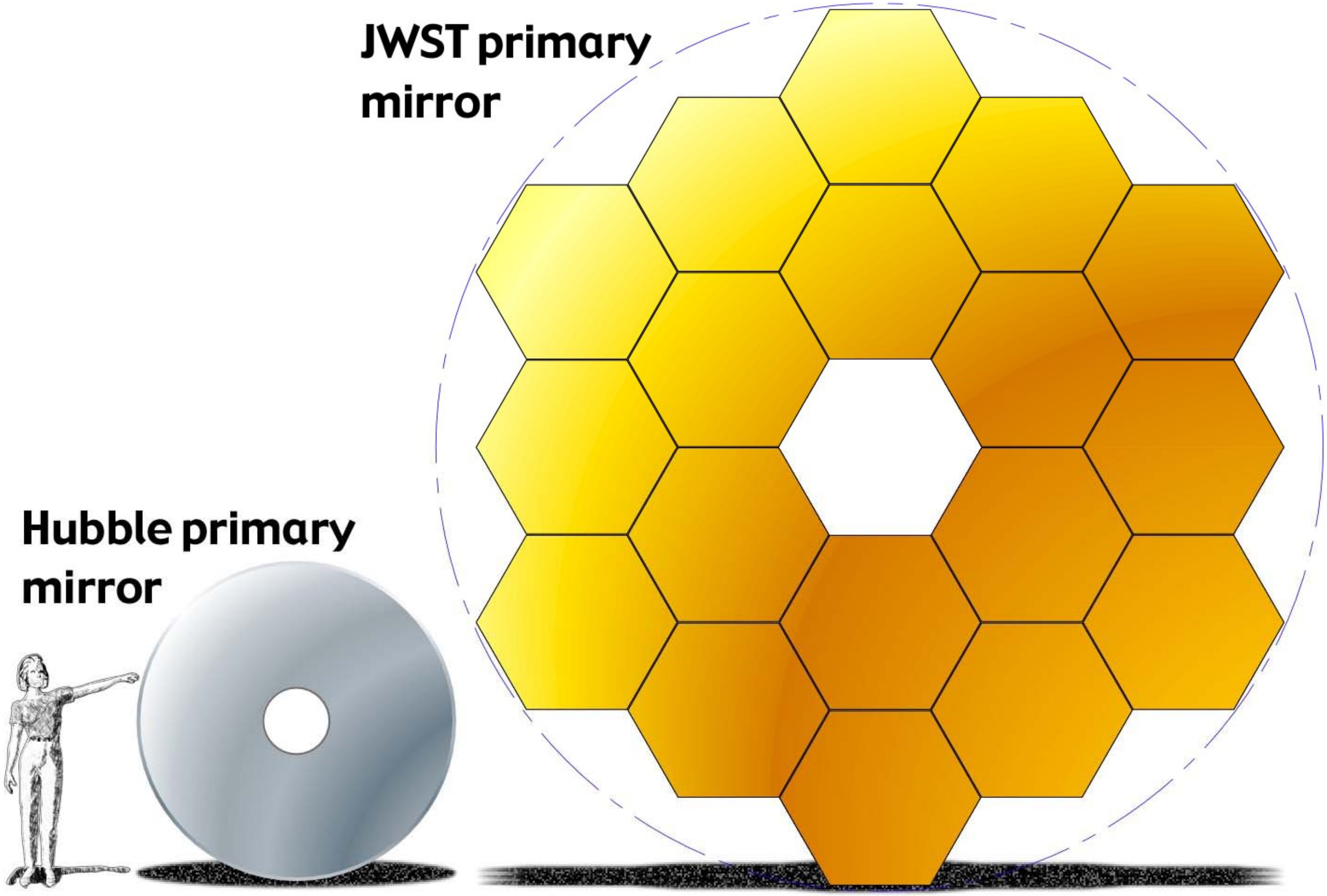


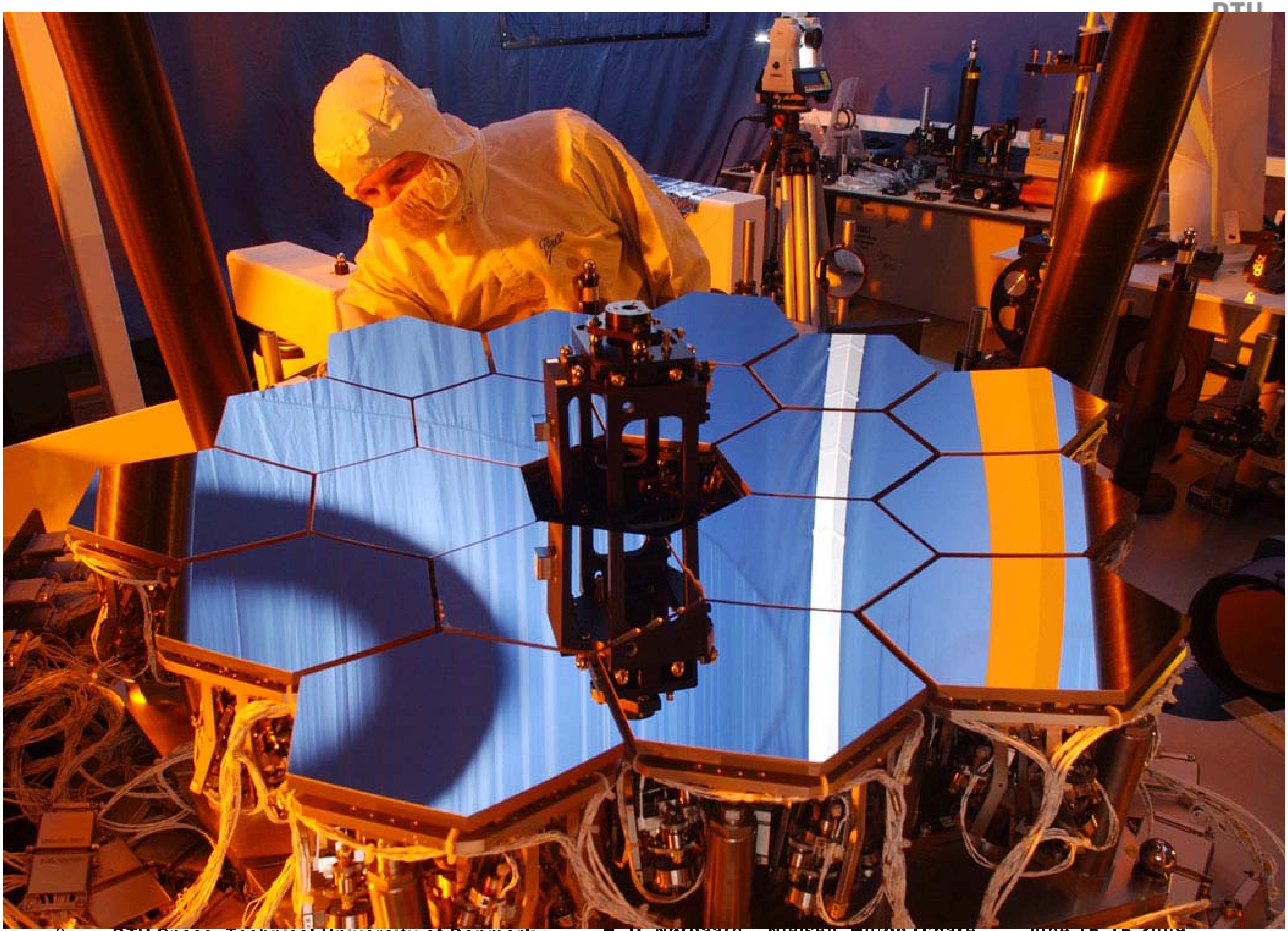
A trip from Big Bang to present day Universe


BIG BANG
1 million years
100 million years
1 billion years
12 to 14 billion years
z=12
z=5
z=0

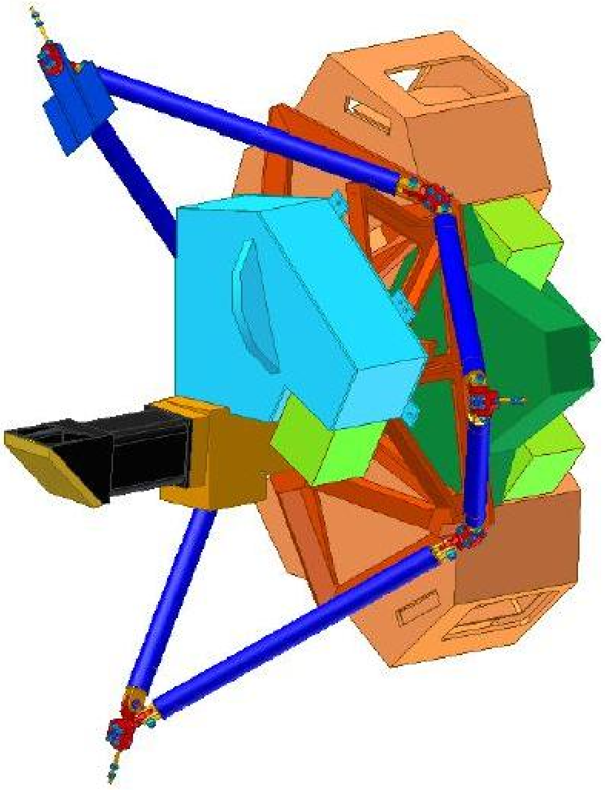





JWST primary
mirror
Hubble primary
mirror



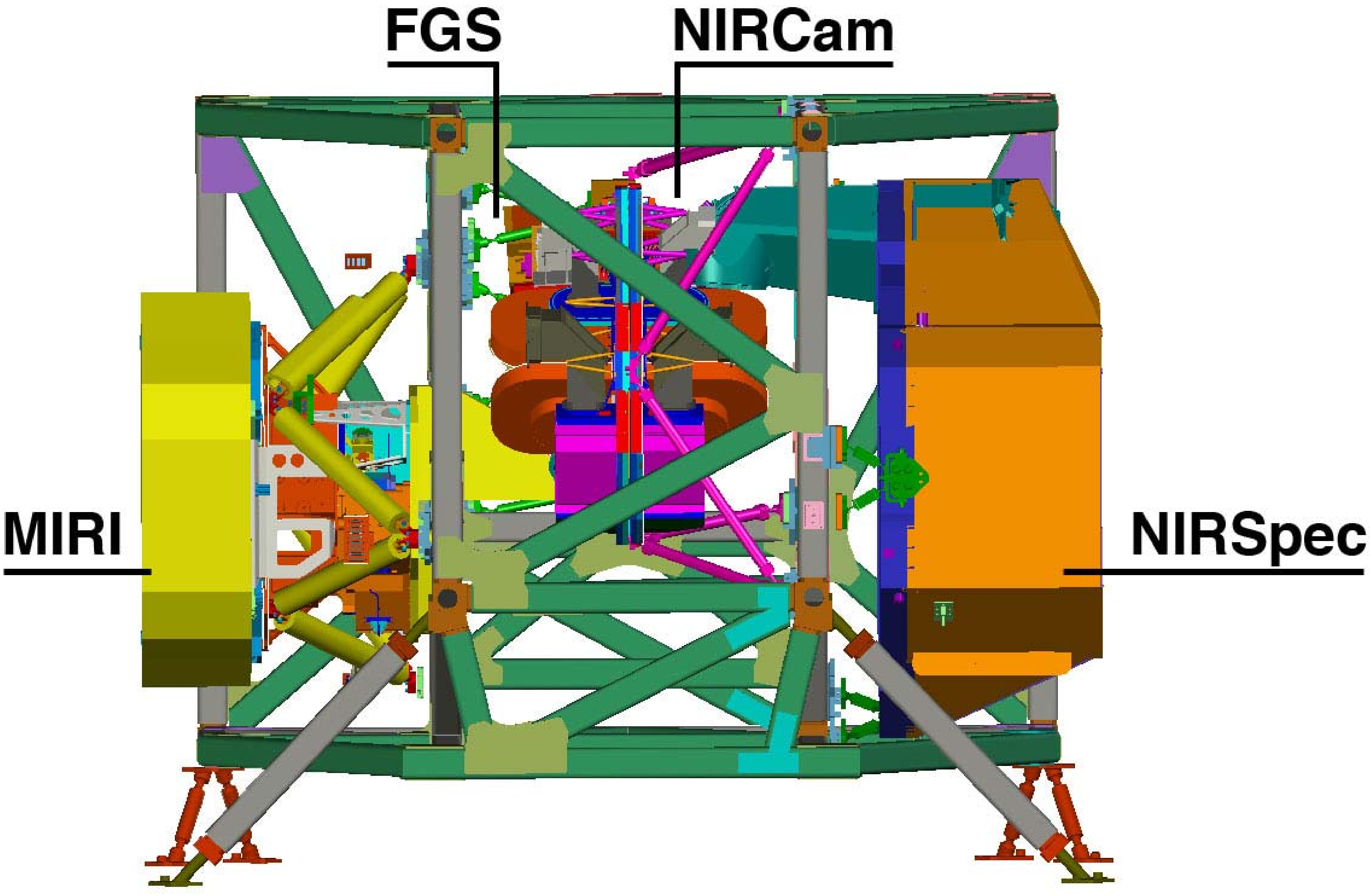
MIRI / JWST
Infrared spectrograph



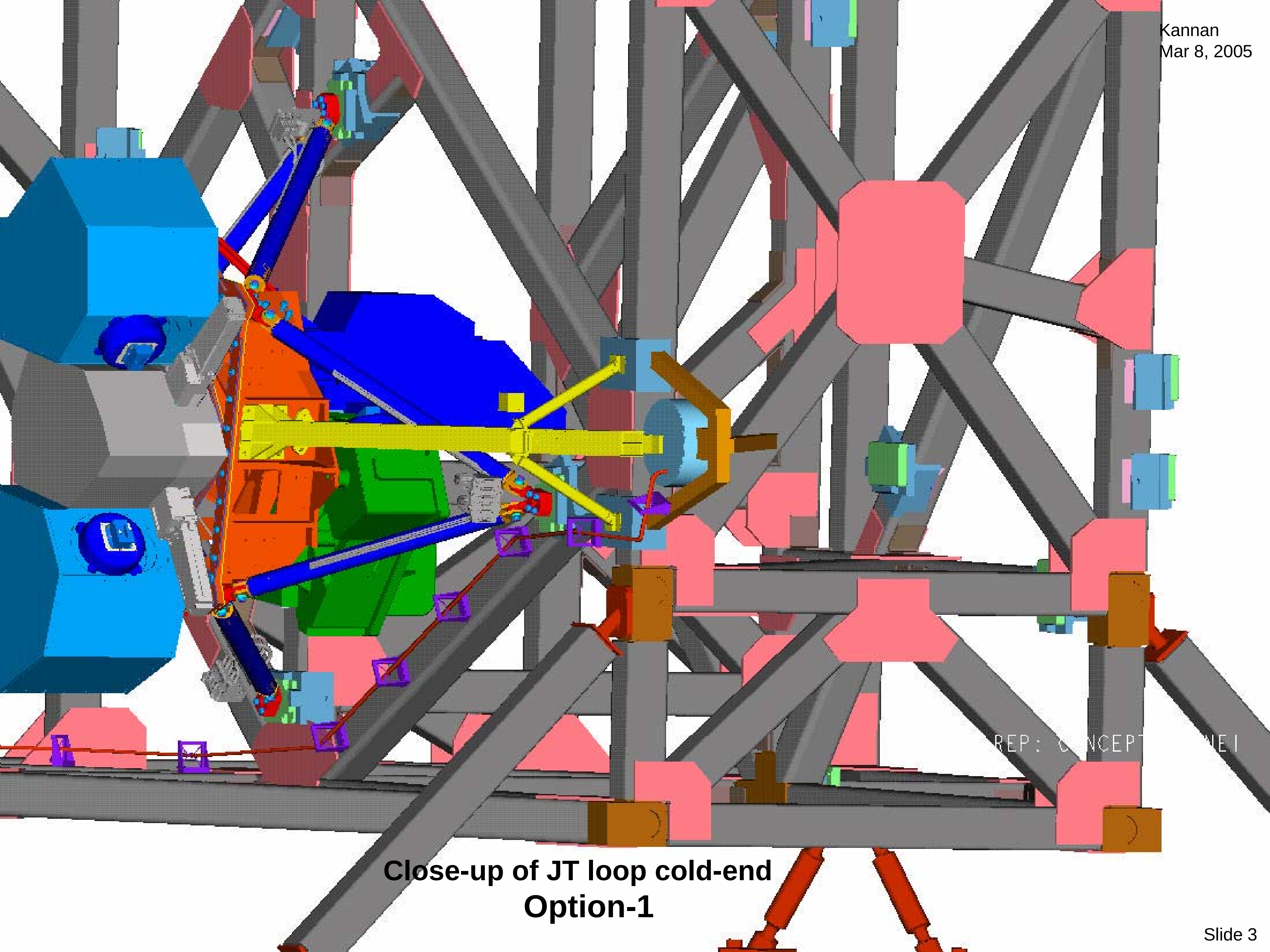
MIRI

A combined mid infrared camera and spectrograph covering wavelengths 5-27 µm.

DTU Space delivers the Primary structure.

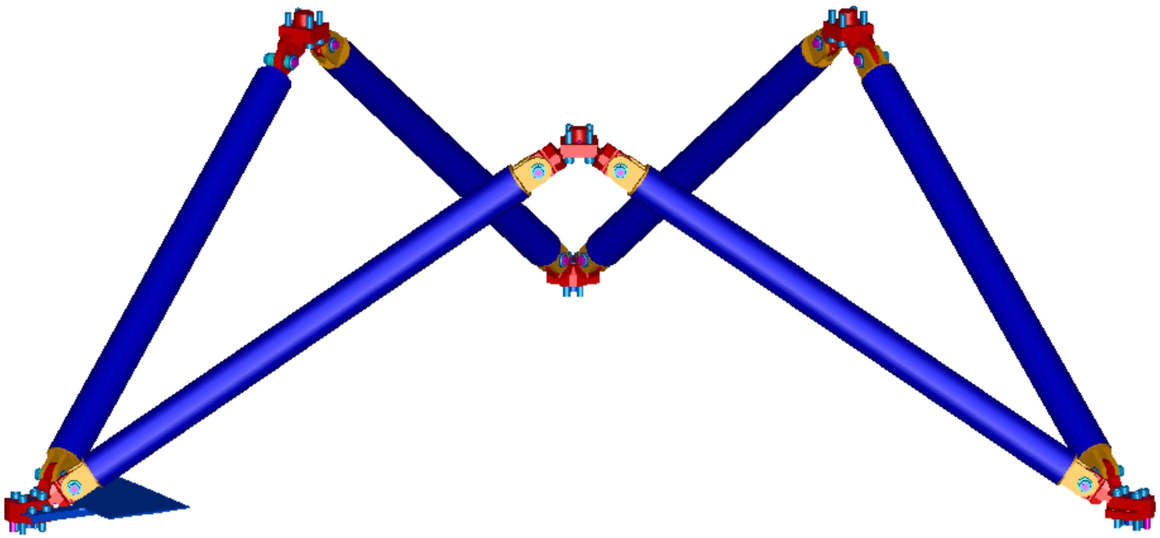

FGS
NIRCam
MIRI
NIRSpec

Kannan
Mar 8, 2005



Close-up of JT loop cold-end
Option-1

MIRI / JWST
Primary Structure



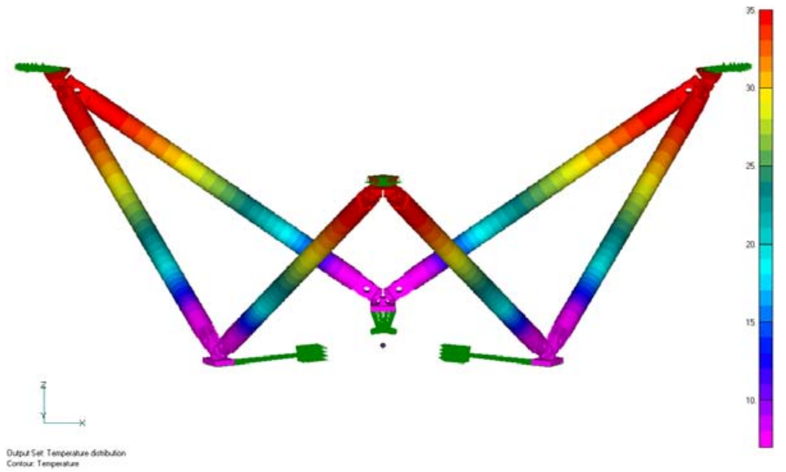
Design drivers

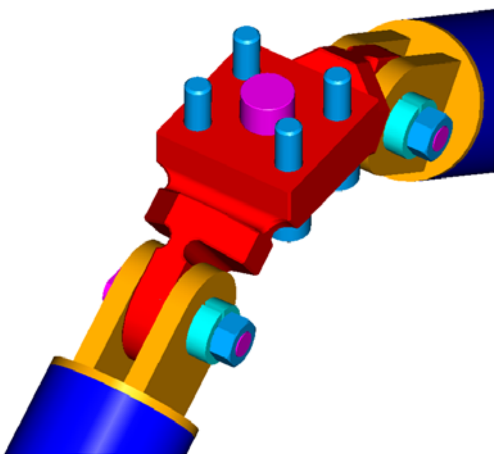
Low thermal conductivity between the 7K cold instrument and the 35 K 'hot' telescope.

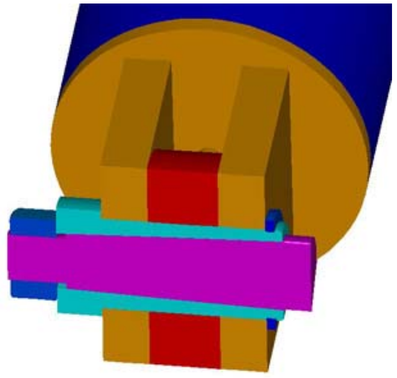
Lowest eigenfrequency above 60 Hz with a 103 Kg instrument

Max g-load 20

MIRI / JWST
Primary Structure







CFRP

Low thermal conductivity at cryogenic temperatures

High stiffness

High strength

Invar

Coefficient of thermal expansion same as CFRP

MIRI / JWST
Infrared spectrograph

MIRI

A combined mid infrared camera and spectrograph covering wavelengths 5-27 µm.

DTU Space:
Responsible of the Primary Support Structure.

MIRI / JWST
Primary Structure

Tests

Thermal cycling from Room Temperature to 7 K

Strength Test

Vibration

Material properties:

Young's module

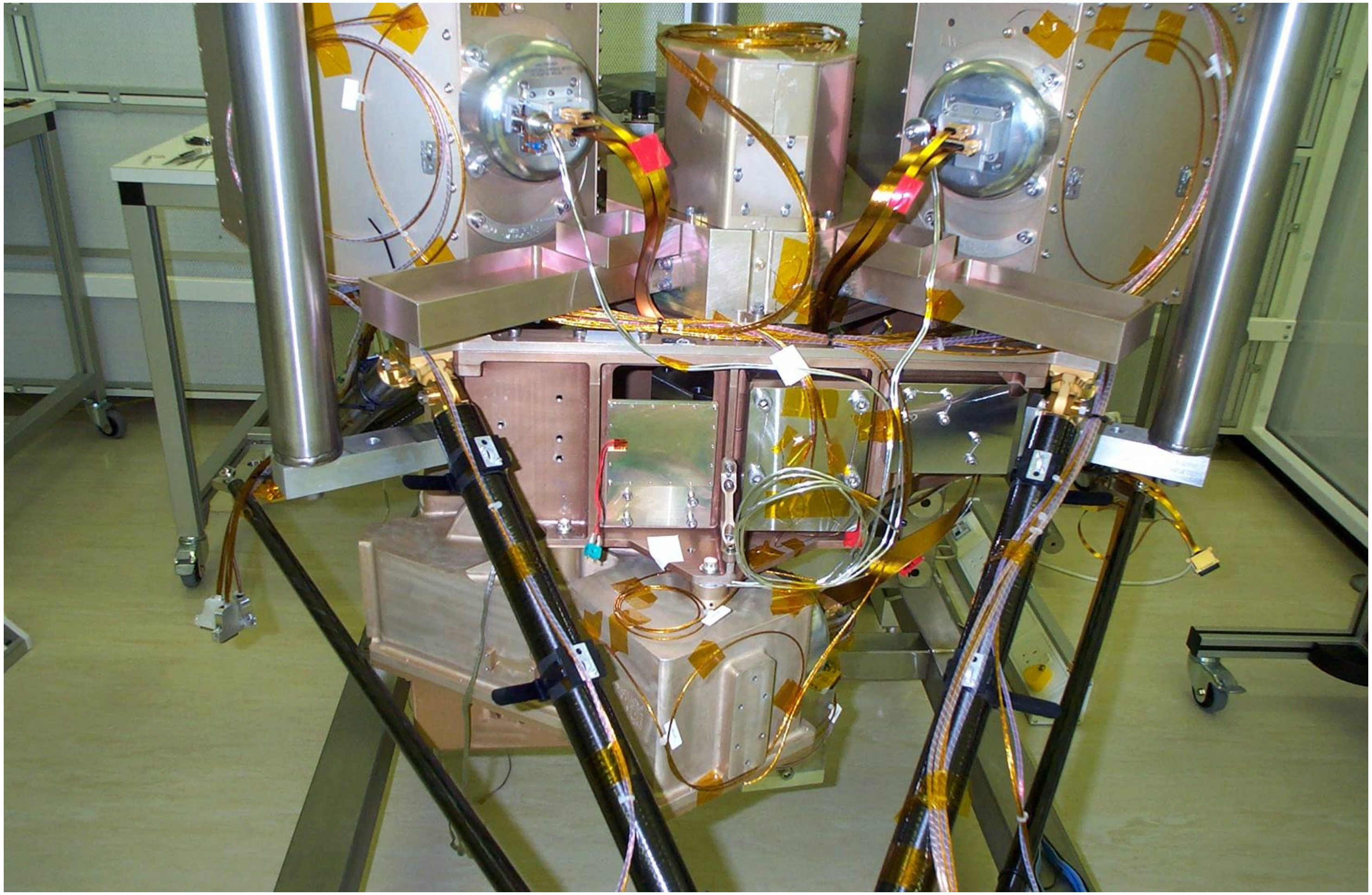
Coefficient of thermal expansion

Coefficient of moisture expansion

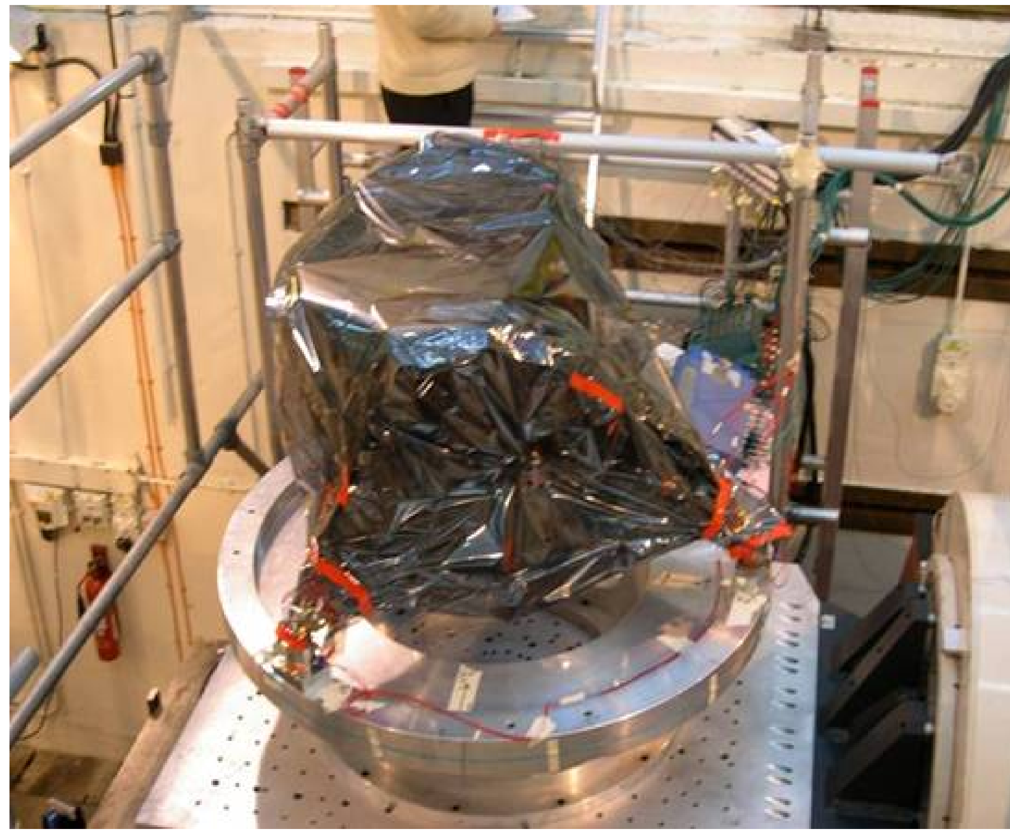
Thermal conductivity

Outgassing

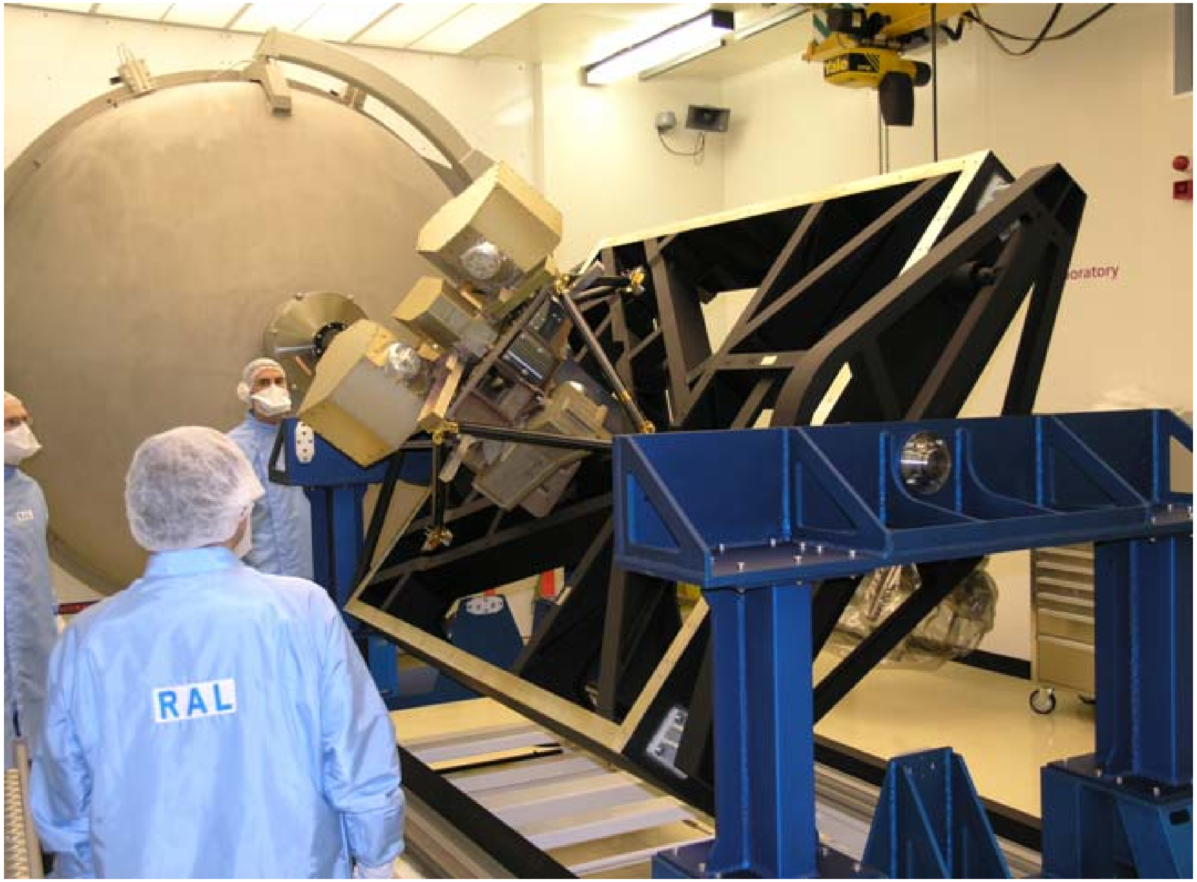
Integration of STM Spectrometer detectors and flight-like Harness with STM MIRI

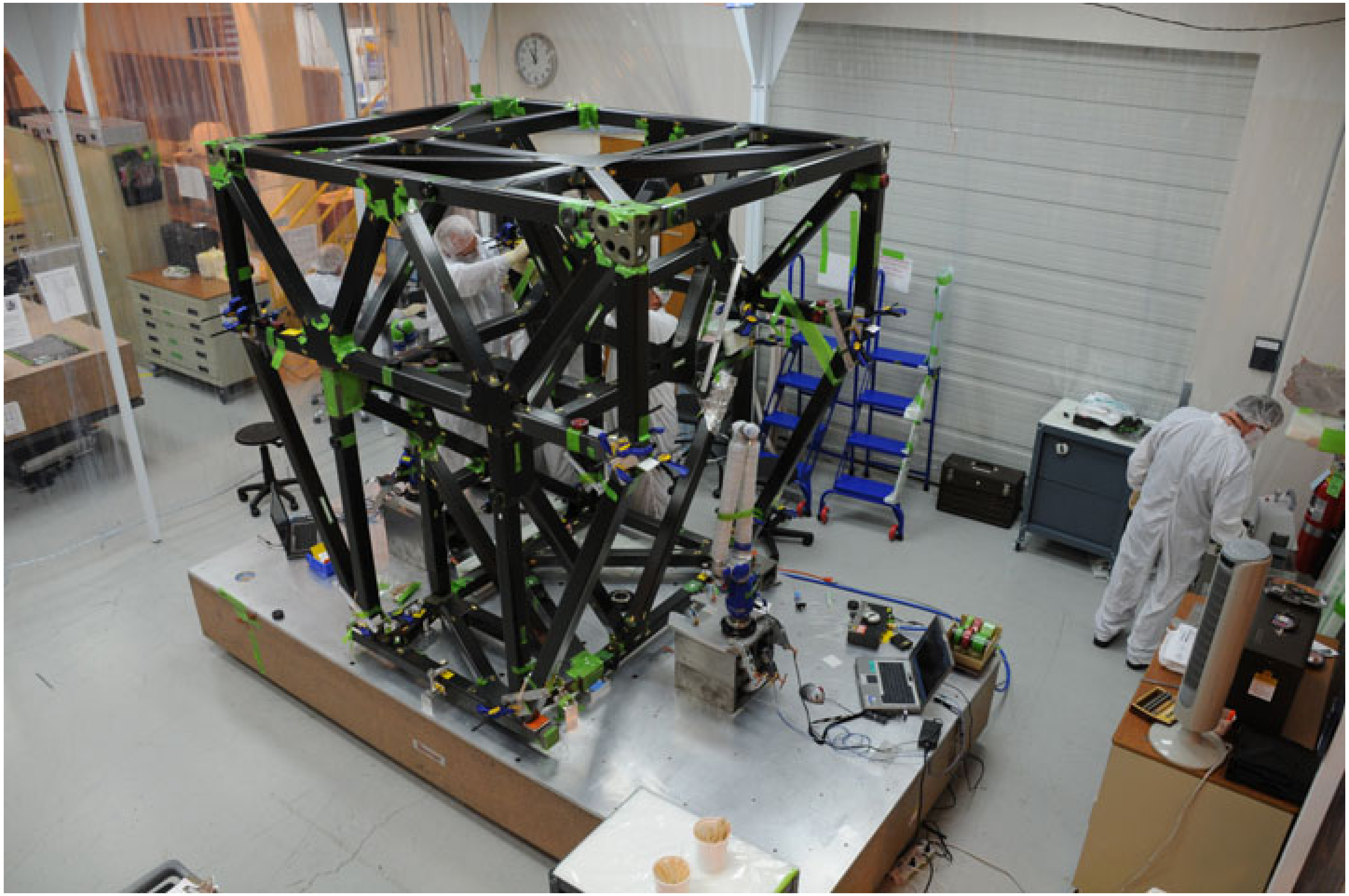


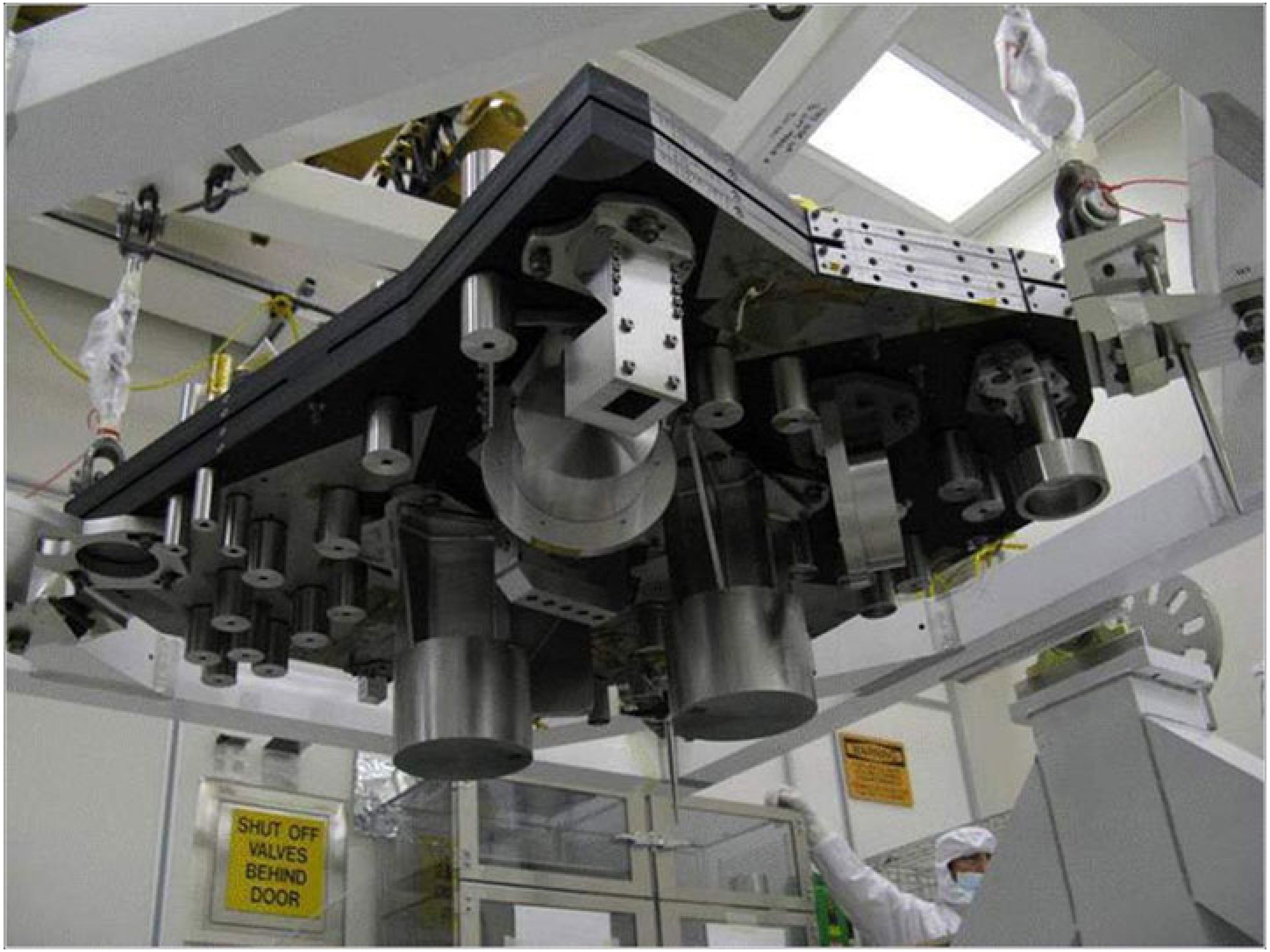
MIRI SM Vibration Test at AWE



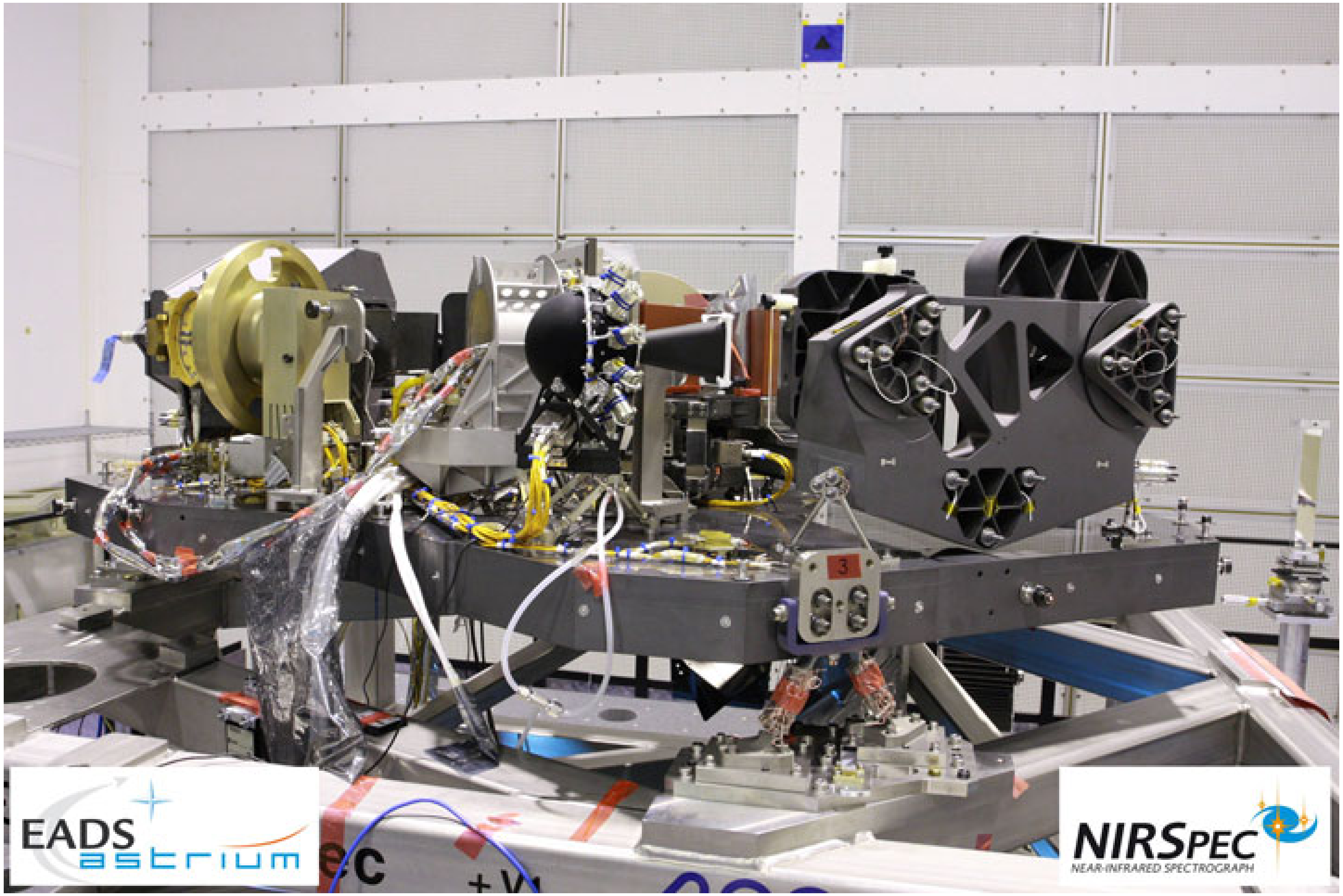
MIRI STM Integration Test with Cryo-test Facility



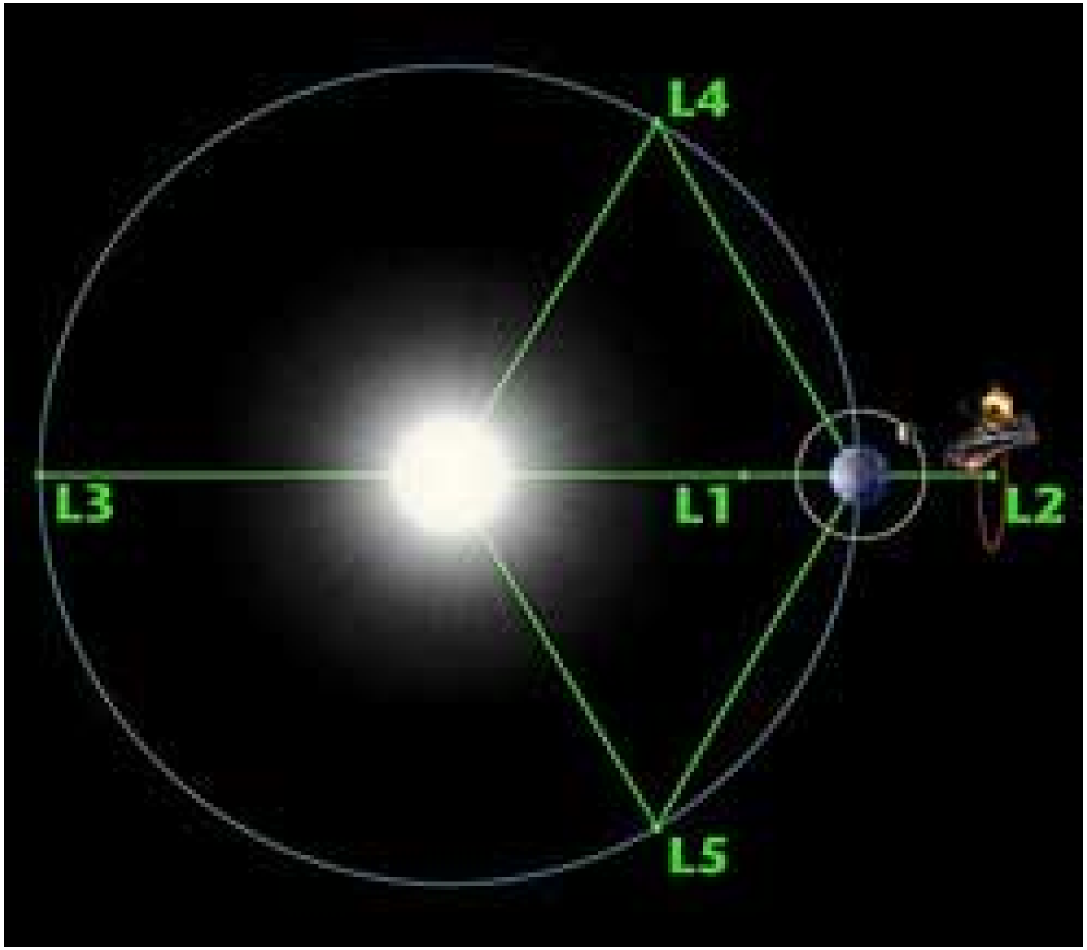


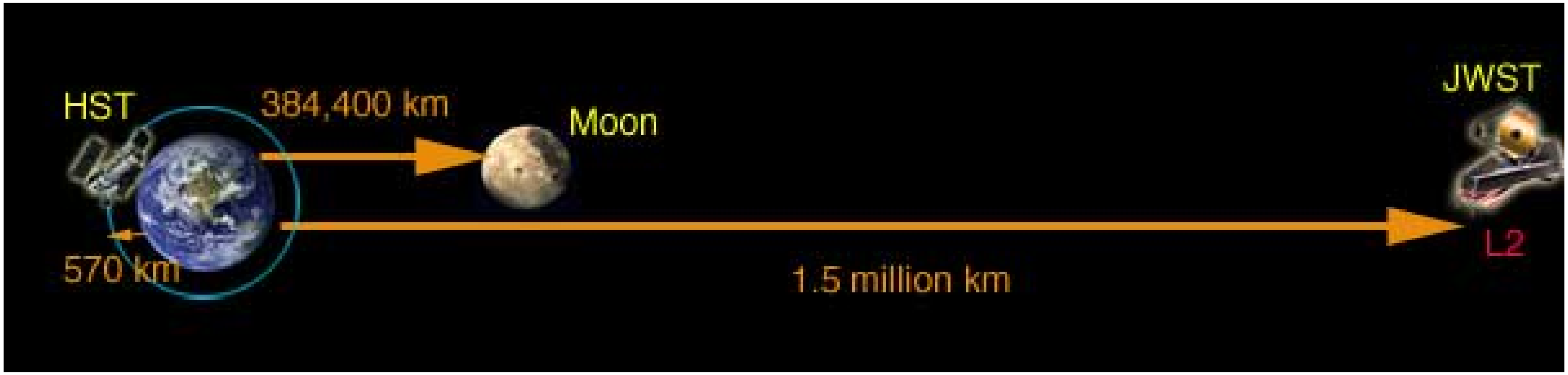


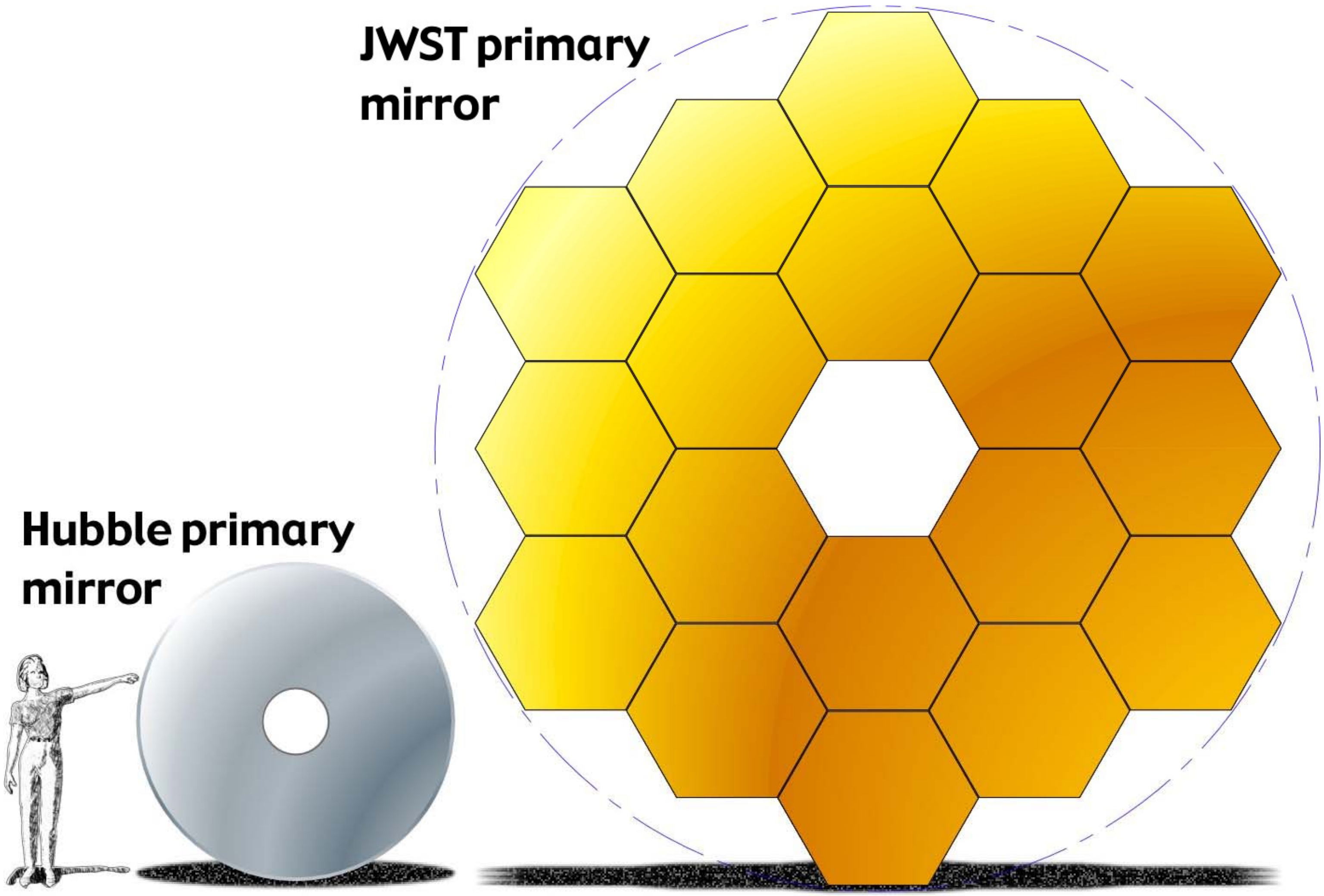
NIRCam: 0.6 – 5.0 µm

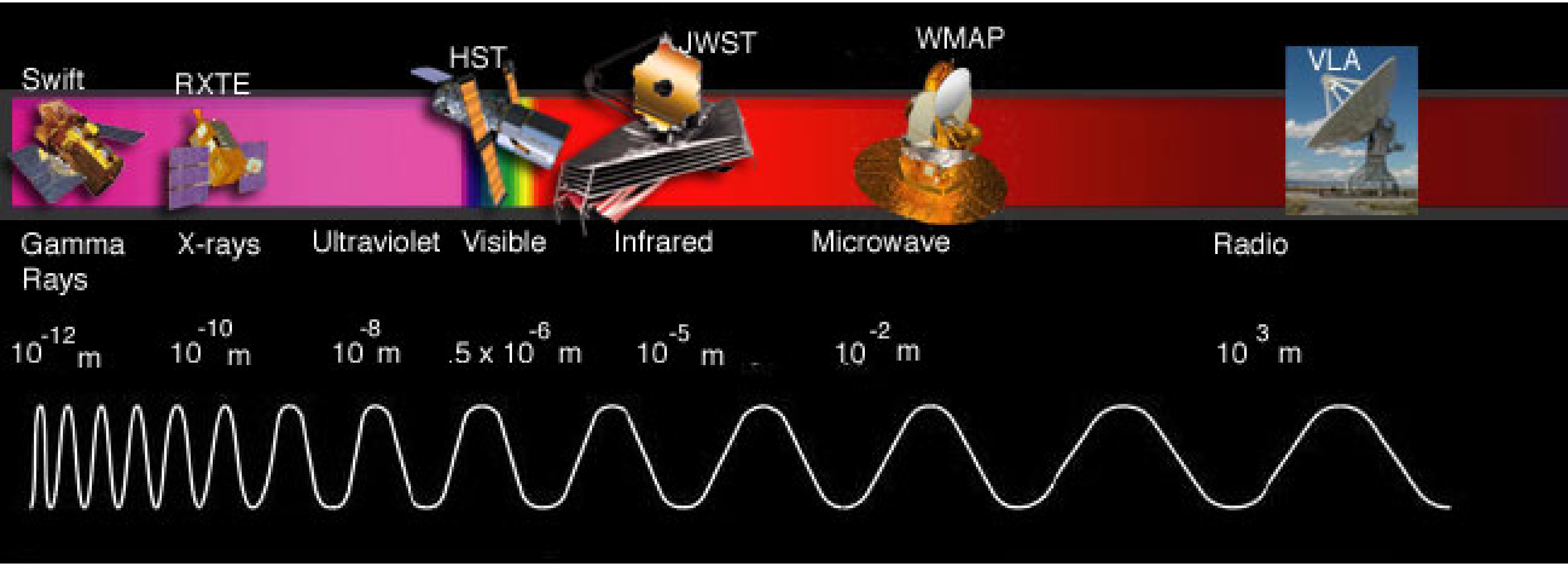


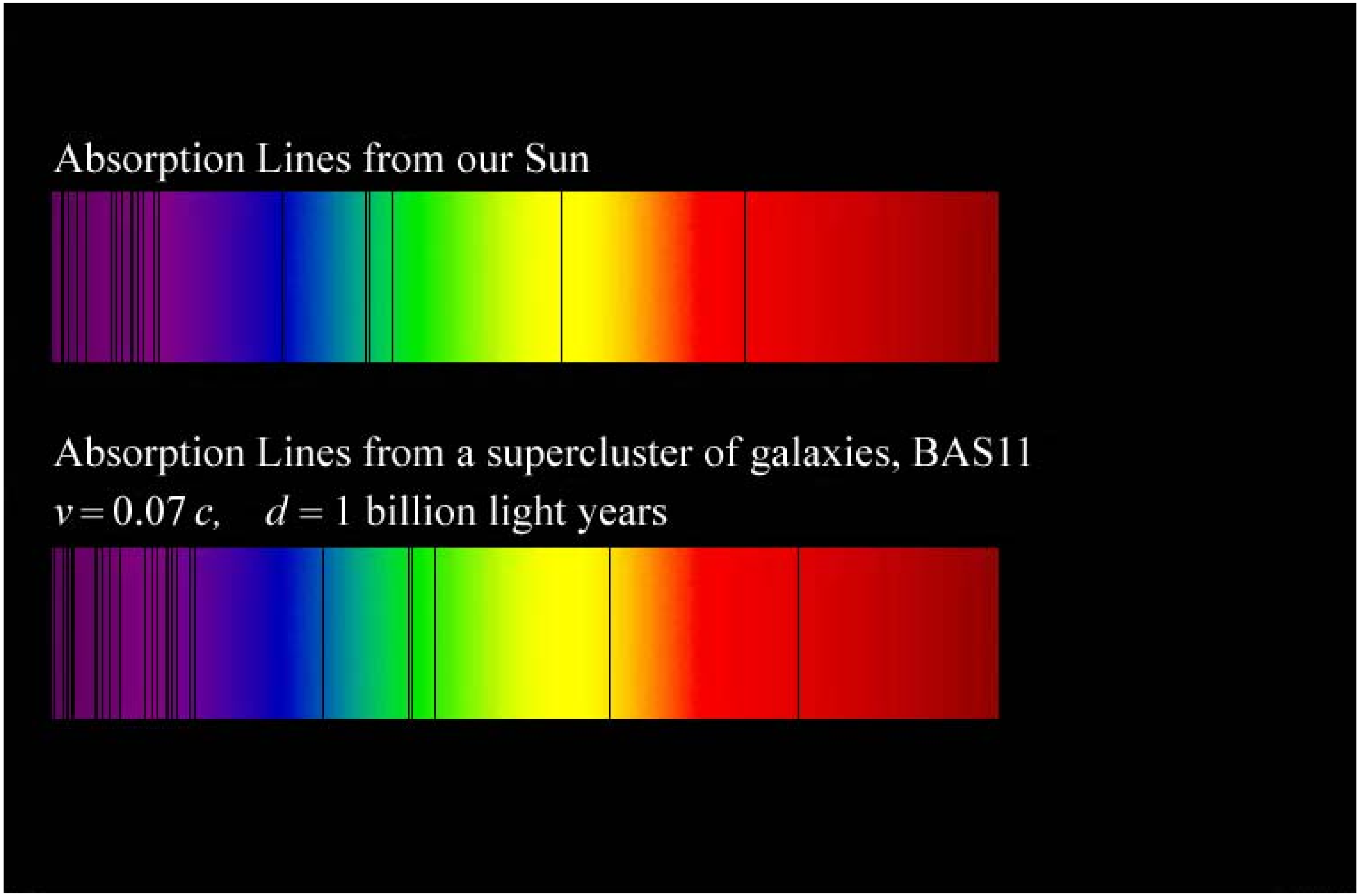
1 - 5 µm, 100 objects

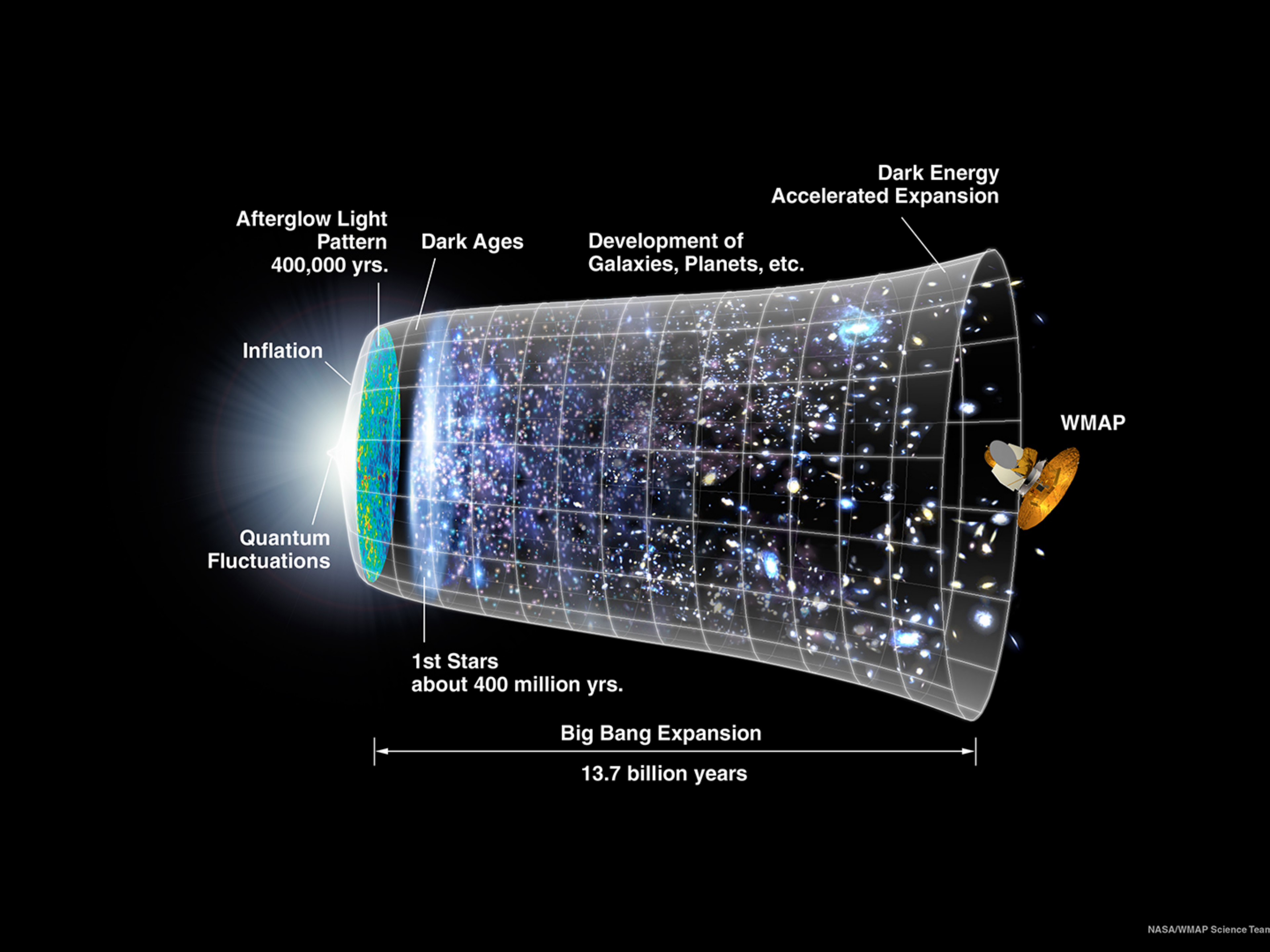

L4
L3
L1
L2
L5

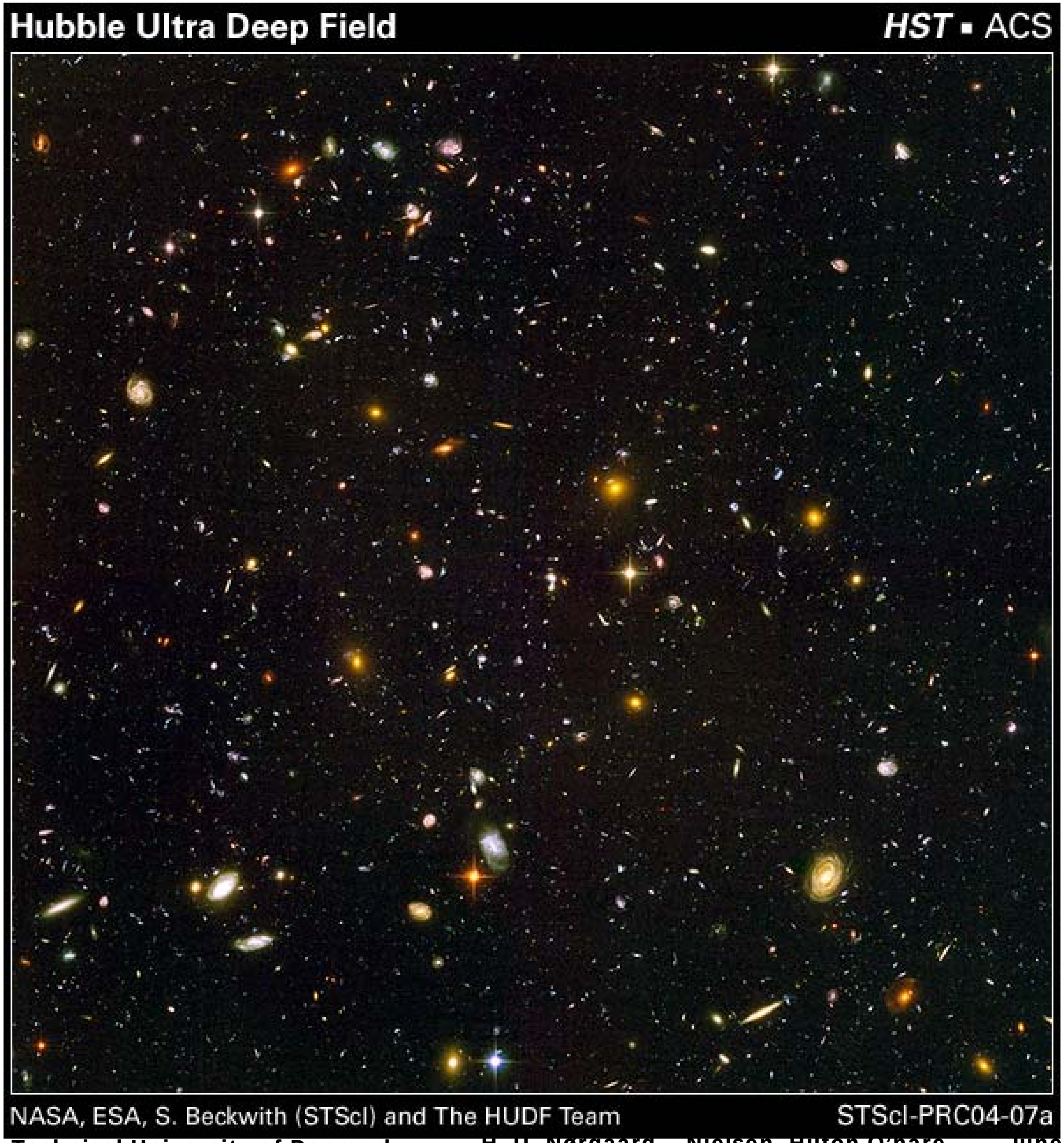

HST
384,400 km
Moon
JWST
570 km
L2
1.5 million km

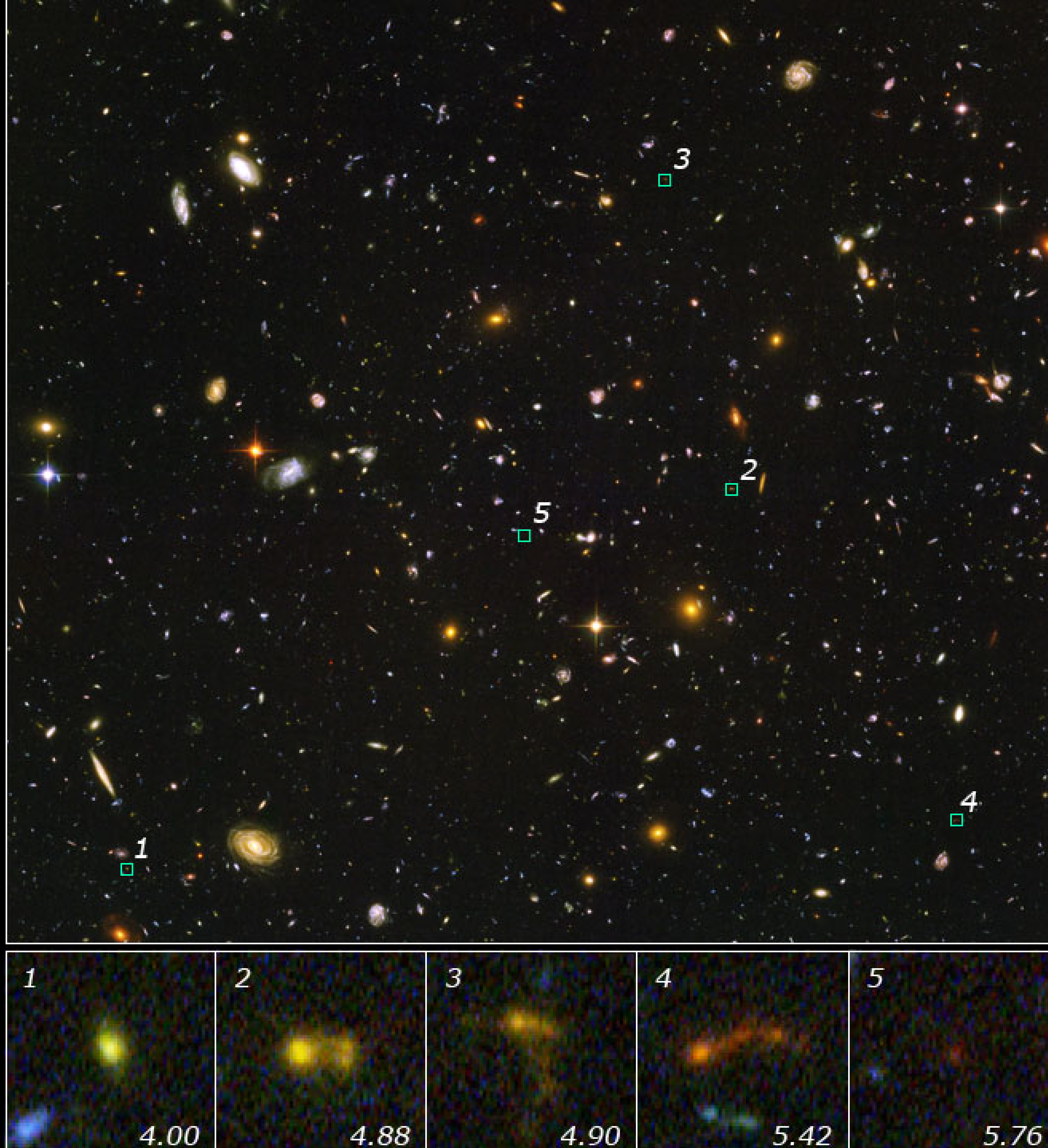

JWST primary mirror
Hubble primary mirror

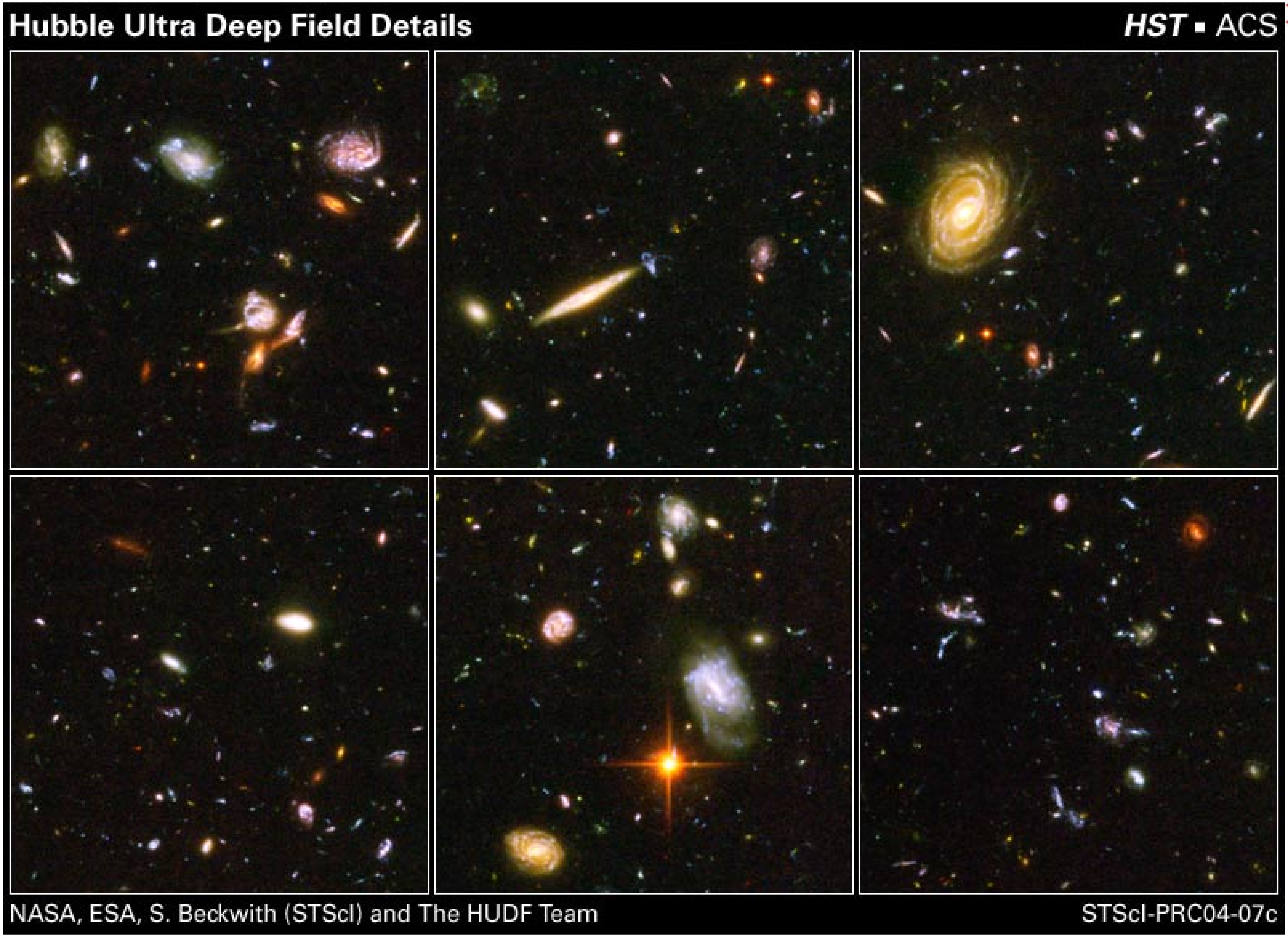

Swift
RXTE
HST
JWST
WMAP
VLA
Gamma Rays
X-rays
Ultraviolet
Visible
Infrared
Microwave
Radio
10^{-12} m
10^{-10} m
10^{-8} m
.5 x 10^{-6} m
10^{-5} m
10^{-2} m
10^{3} m


Absorption Lines from our Sun
Absorption Lines from a supercluster of galaxies, BAS11
$v = 0.07\,c$, $d = 1$ billion light years


Dark Energy
Accelerated Expansion
Afterglow Light
Pattern
400,000 yrs.
Dark Ages
Development of
Galaxies, Planets, etc.
Inflation
WMAP
Quantum
Fluctuations
1st Stars
about 400 million yrs.
Big Bang Expansion
13.7 billion years
NASA/WMAP Science Team


Hubble Ultra Deep Field
HST ▪ ACS
NASA, ESA, S. Beckwith (STScI) and The HUDF Team
STScI-PRC04-07a


3
2
5
4
1
1
4.00
2
4.88
3
4.90
4
5.42
5
5.76


Hubble Ultra Deep Field Details
HST ▪ ACS
NASA, ESA, S. Beckwith (STScI) and The HUDF Team
STScI-PRC04-07c

Pello et al.
astro-ph 0403025

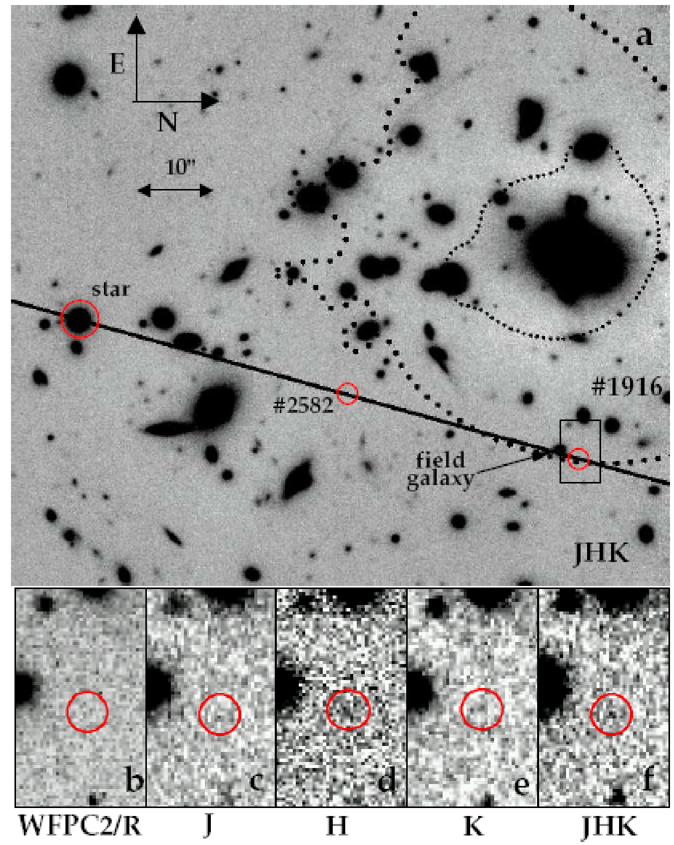
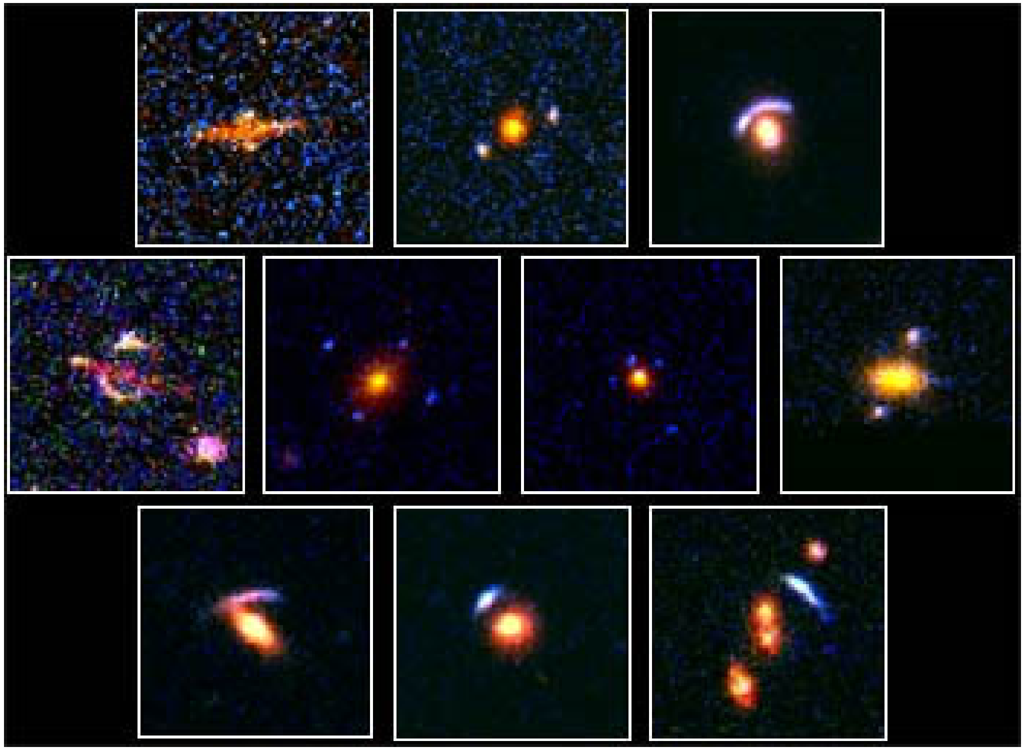
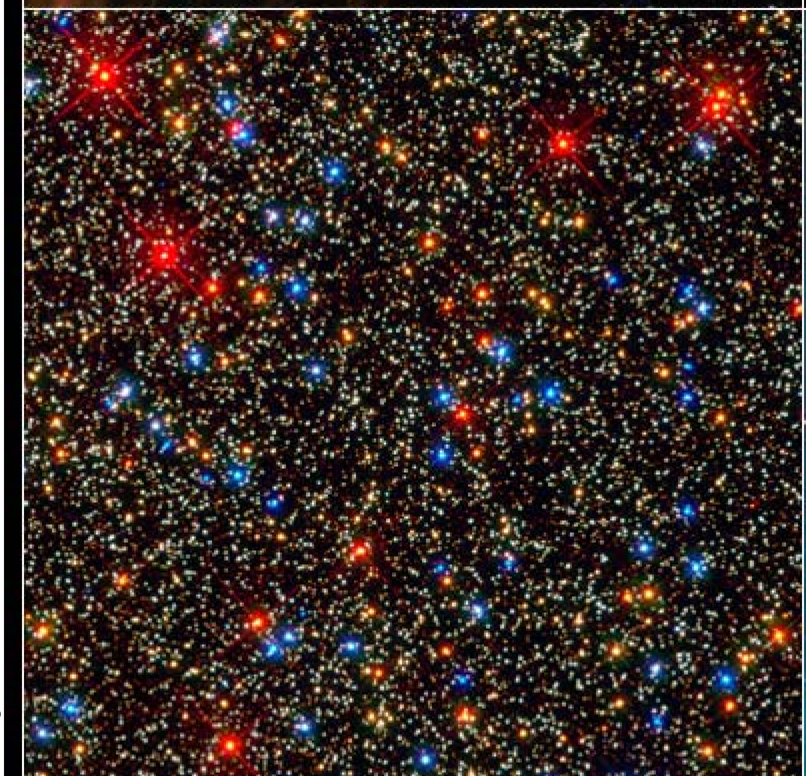


Fig. 1. Composite $JHKs$ ISAAC image showing: **a)** The core of the lensing cluster A1835, with the position of the long slit used during our spectroscopic survey with ISAAC/VLT, together with the location of objects #1916 and #2582, the reference acquisition star (circles), and a nearby field galaxy seen on the 2D spectra. Large and small dots show the position of the external and internal critical lines at $z = 10$. **b)** Thumbnail image in the HST-



Gravitational lenses

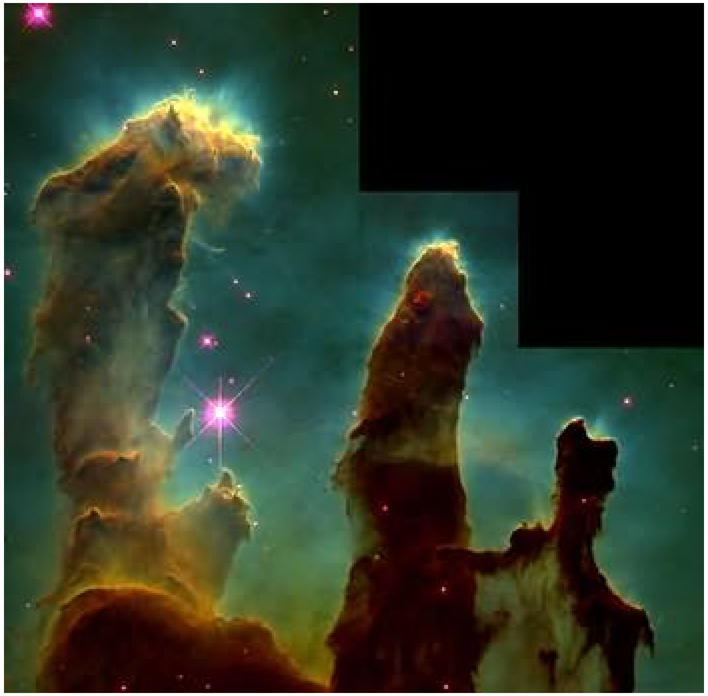

NGC 6302

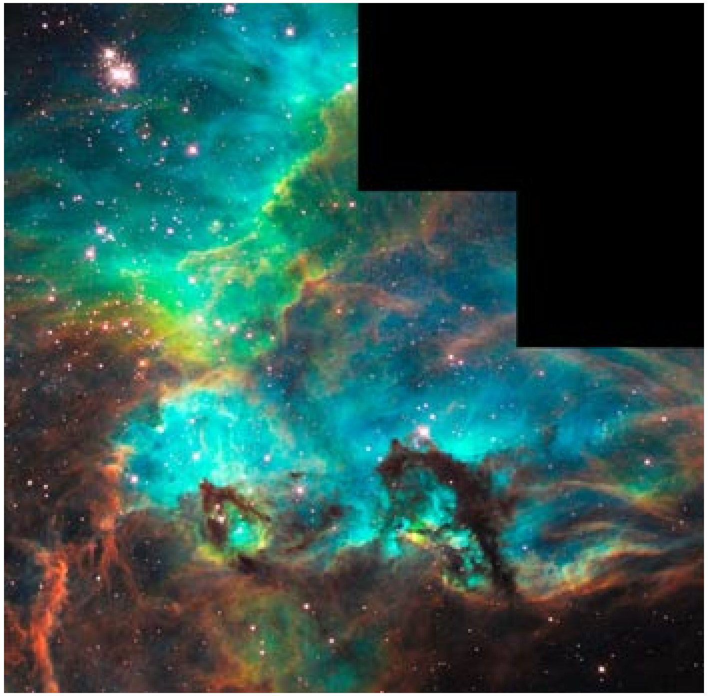
STEPHAN'S QUINTET


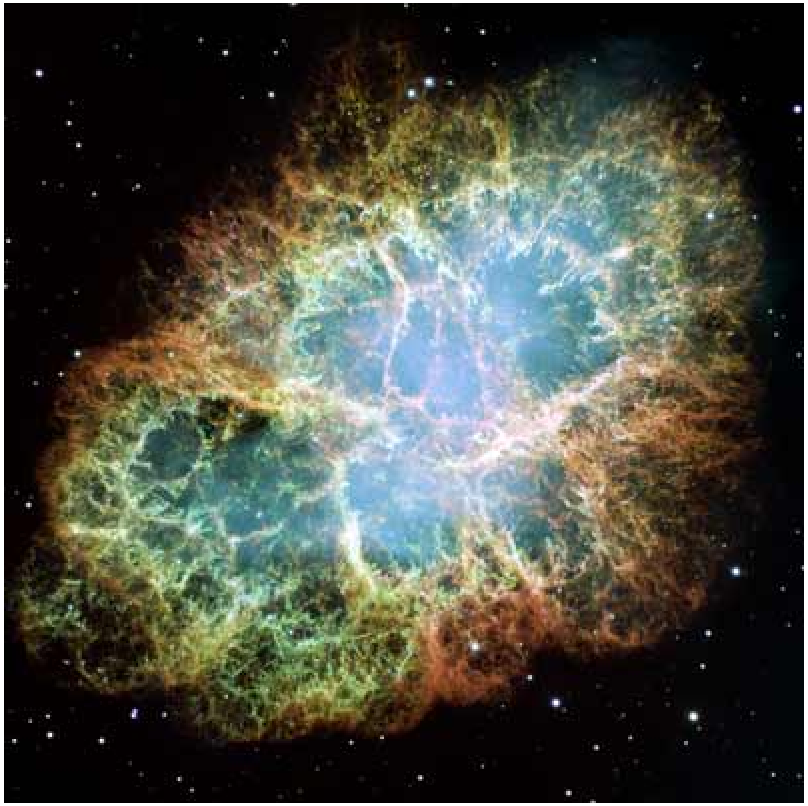


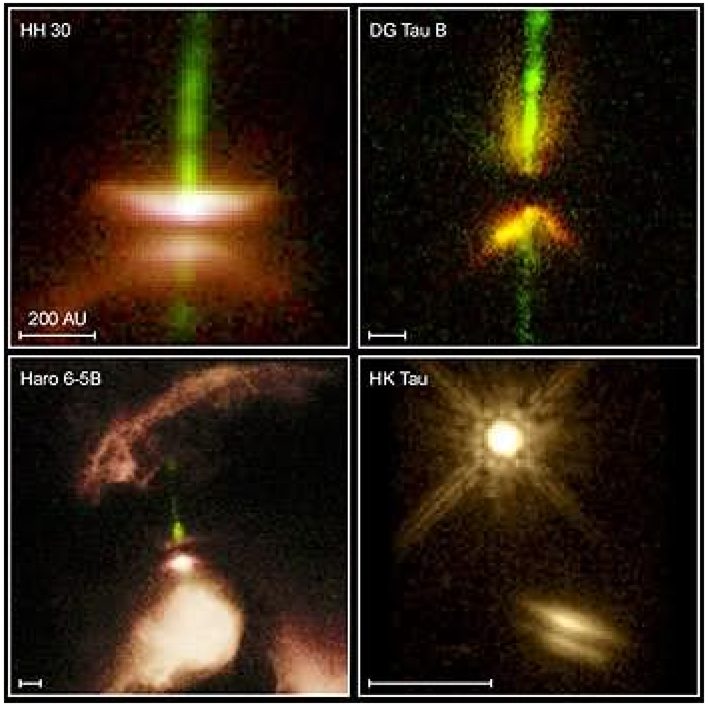
Star-Forming Region 30 Doradus
HST • WFC3/UVIS
NASA, ESA, F. Paresce (INAF-IASF, Italy), and the WFC3 Science Oversight Committee
STScI-PRC09-32a

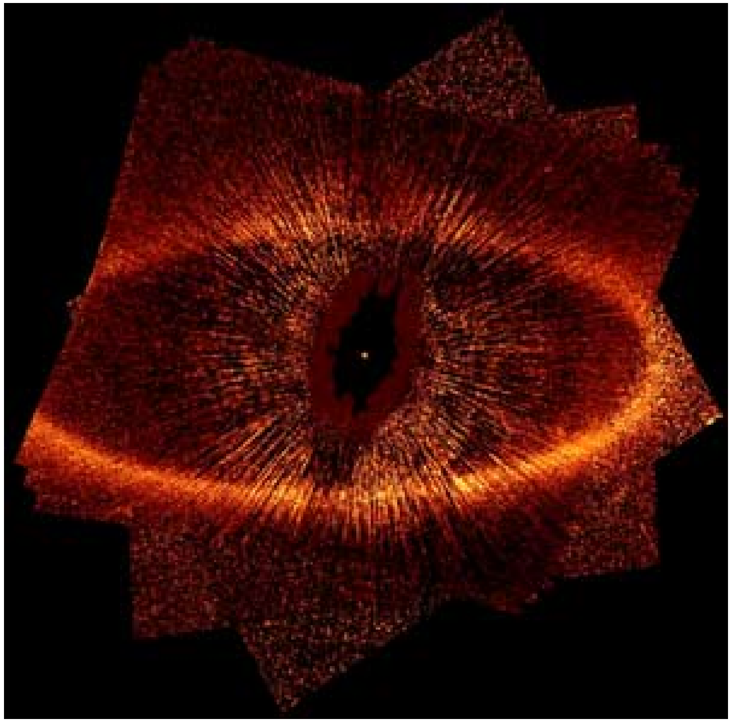

CENTRAL REGION OF THE MILKY WAY
NASA'S GREAT OBSERVATORIES
NASA, ESA, CXC, SSC, AND STSCI
STScI-PRC09-28A

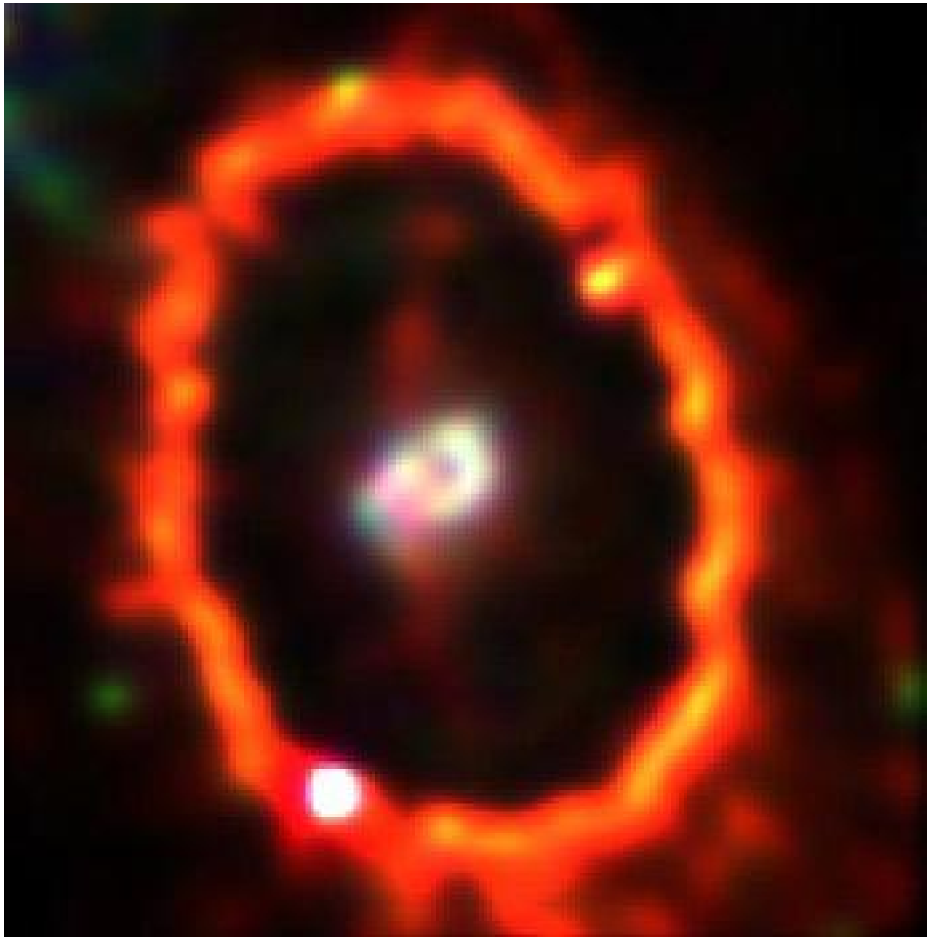




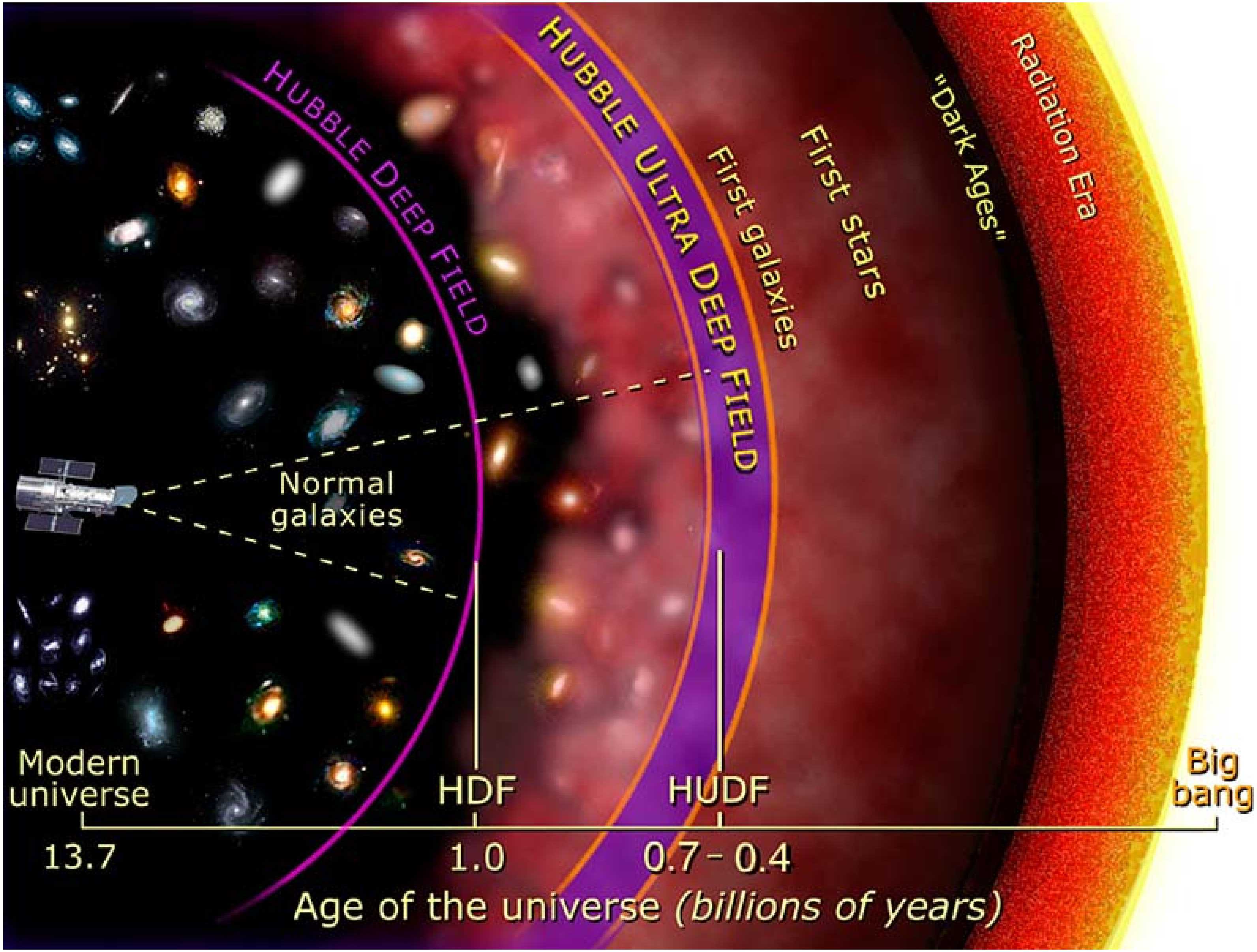


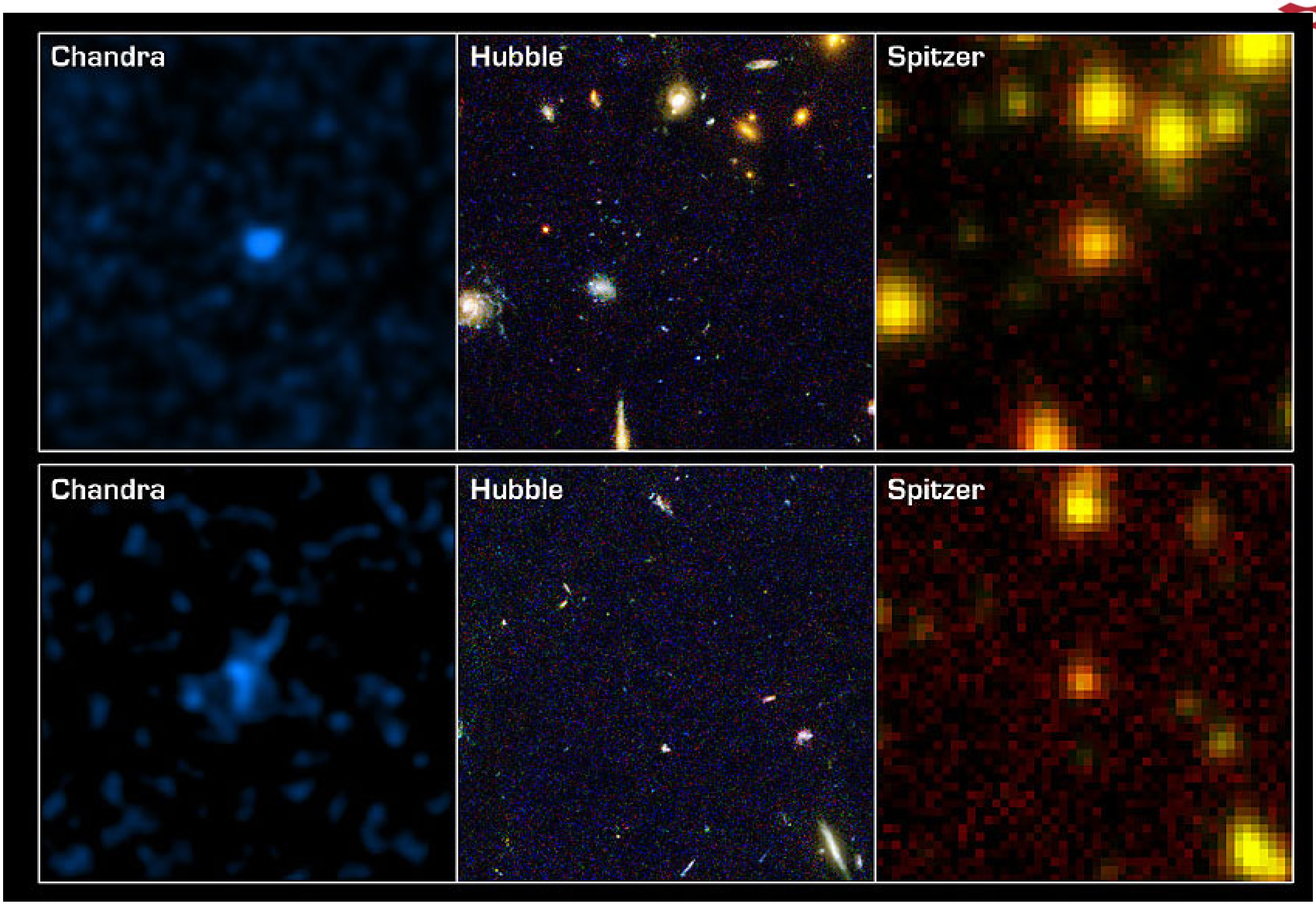

HH 30
200 AU
DG Tau B
Haro 6-5B
HK Tau





SN 1987 A observed in 1997


HUBBLE DEEP FIELD
HUBBLE ULTRA DEEP FIELD
First galaxies
First stars
"Dark Ages"
Radiation Era
Normal galaxies
Modern universe
HDF
HUDF
Big bang
13.7
1.0
0.7 – 0.4
Age of the universe (billions of years)


Chandra
Hubble
Spitzer
Chandra
Hubble
Spitzer

Prospects for studying First Light Objects

Primordial Gas: H, He, no metals
-> cooling much less efficient

Gravitational unstable clouds:

Jeans Mass:

$$M_J = (\pi\ k\ T/\mu\ G)^{3/2}\ 1/\rho^{1/2} \quad ->$$

$$M_* > 100\ M_0$$

Panagia
astro-ph 0209346

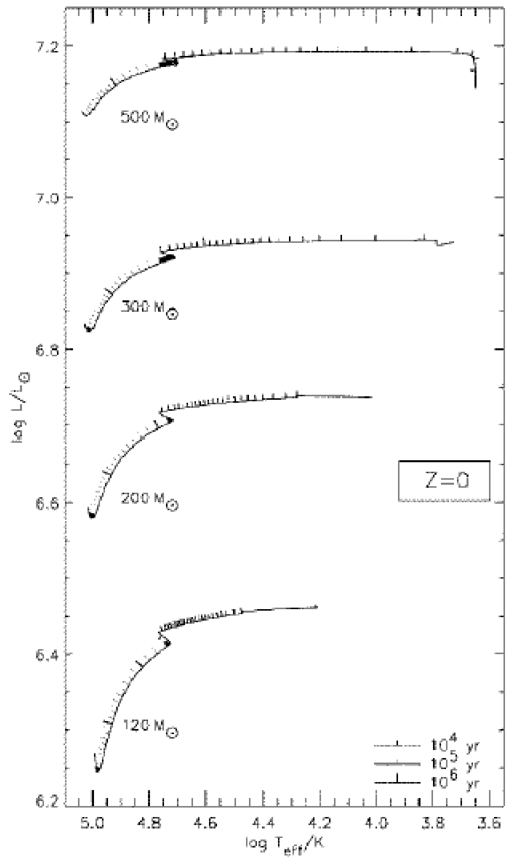


Figure 1. The HR diagram for zero-metallicity massive stars (adapted from Baraffe *et al.* 2000).

POP III (Z = 0)

Single star with M = 1000 M_o

At z = 30 F_ν ~ 0.01 nJy

Not detectable with JWST

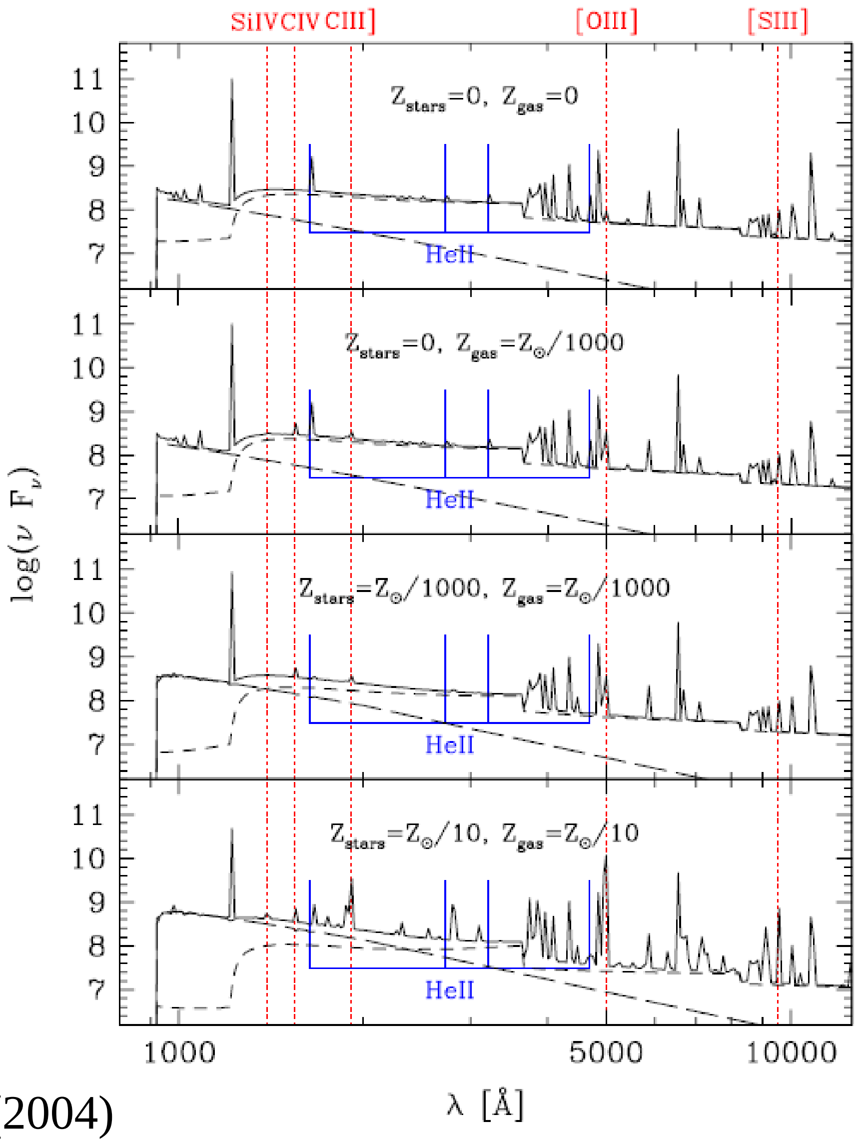
Teff > 90.000 K ,

HeII ionized for ~1Myr,

HeII 1640 Å as strong as H_β

Z(First Light) ≤ 0.001 Z_o

[OIII] 5007Å/H_β strong dependence on Z



Panagia (2004)

Figure 1. The synthetic spectrum of a zero-metallicity HII region (top panel) is compared to that of HII regions with various combinations of stellar and nebular metallicities (lower panels). The long-dashed and short-dashed lines represent the stellar and nebular continua, respectively.

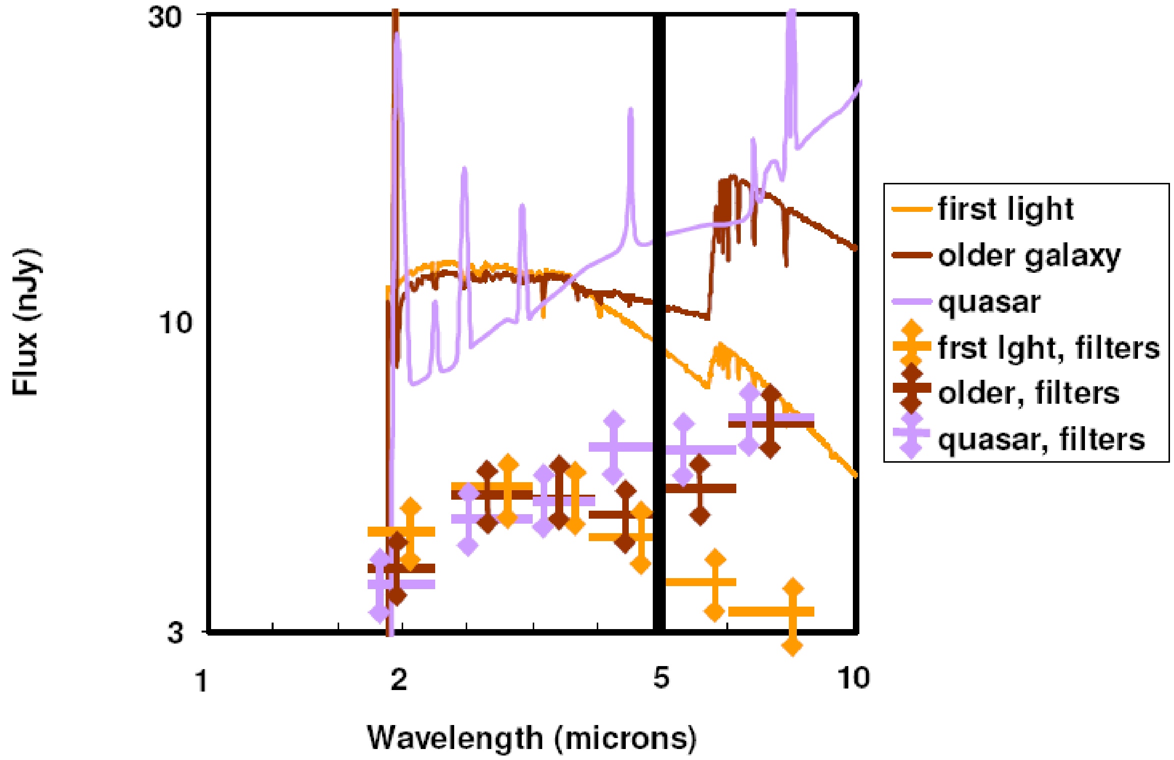


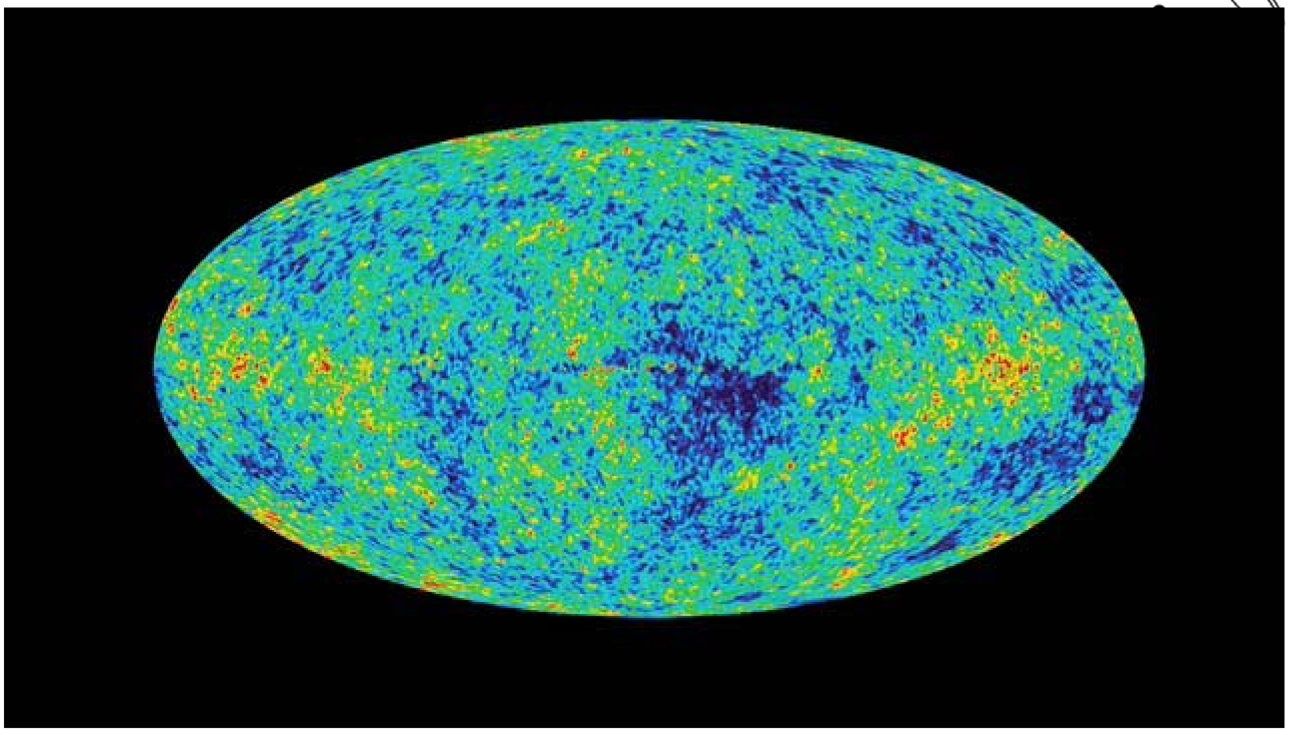
Figure 2. Modeled young galaxies and a typical quasar. All the sources are at a redshift of z = 15, and it has been assumed that the Lyman α forest strongly attenuates their outputs short of Ly α. It is assumed that there is a foreground damped Lyman α system that causes reddening of $A_V = 0.6$ for the first light object and $A_V = 0.4$ for the older galaxy. The horizontal bars indicate the NIRCam and

JPL D-24157
SciRD Preliminary

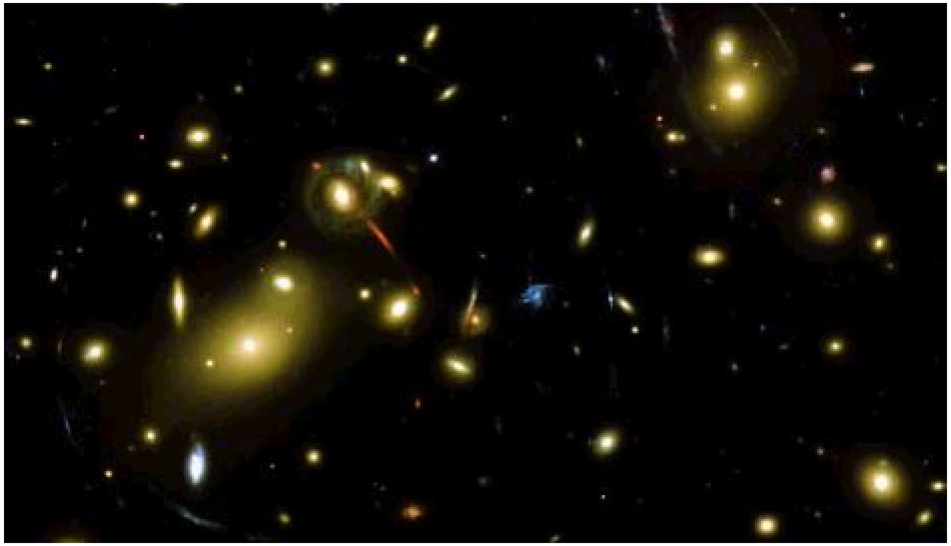
first light:
burst at z=15

older galaxy:
burst at z=20 and z = 15

PLANCK Reflector Programme



A trip from Big Bang to present day Universe



Pello et al.
astro-ph 0403025

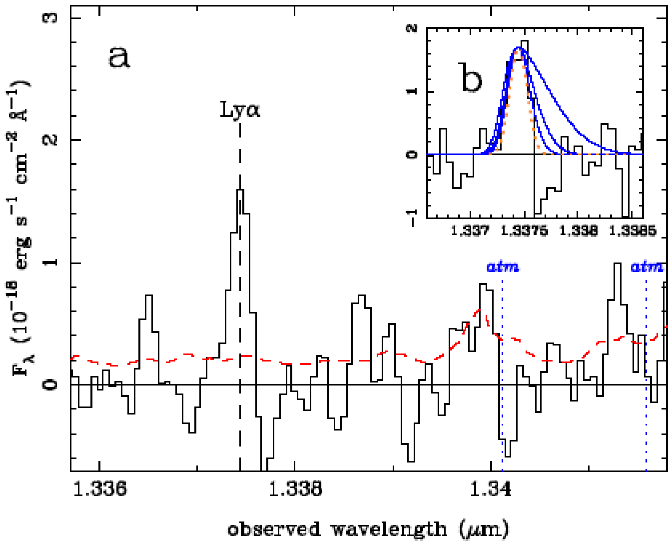


Fig. 5. a) 1D spectrum of #1916, extracted from the composite 2D spectrum of the 1.315 and 1.365 μm bands.

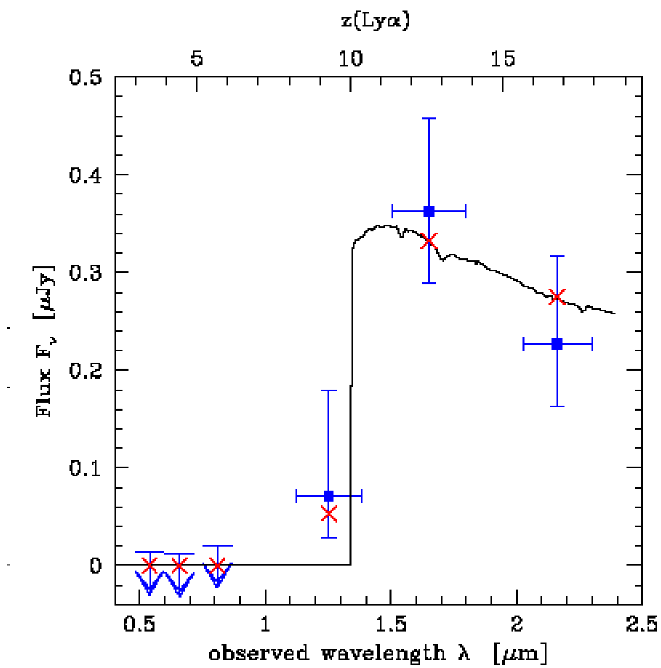


Fig. 3. Optical to near-IR spectral energy distribution of the galaxy #1916. Shown are the broadband photometric measurements and associated 1 σ uncertainties for $JHKs$. Three σ upper limits on 4 pixels are given for

Pello et al.

astro-ph 0403025

SED

$Z = 0.2\ Z_0$

age 3 Myr

SFR ~ 20 – 120 M_0/yr

Corr.

SFR ~ 0.8 – 4.8 M_0/yr

Pello et al. object z = 10
(Pello et al. astro-ph 0410132 object variable QSO ?)

magnification factor μ = 25 - 100

Ω_m= 0.3, Ω_Λ=0.7, H_0= 70 km/s/Mpc: t ~ 460 Myr

Salpeter IMF:
SFR(Lyα) = 0.8 – 2.2 M_0/yr (no lensing corr)
SFR(UV) = 47 – 75

SED model, corr.
M_* ~ 8 x 10^6 M_0 similar to the most massive GC and super star clusters

young protogalaxy experiencing a burst of star formation ?

POPIII stars:

end product

SNe

Pair creation

SNe ??

Only single

Stars to be

Observable ???

2 Alexander Heger et al.

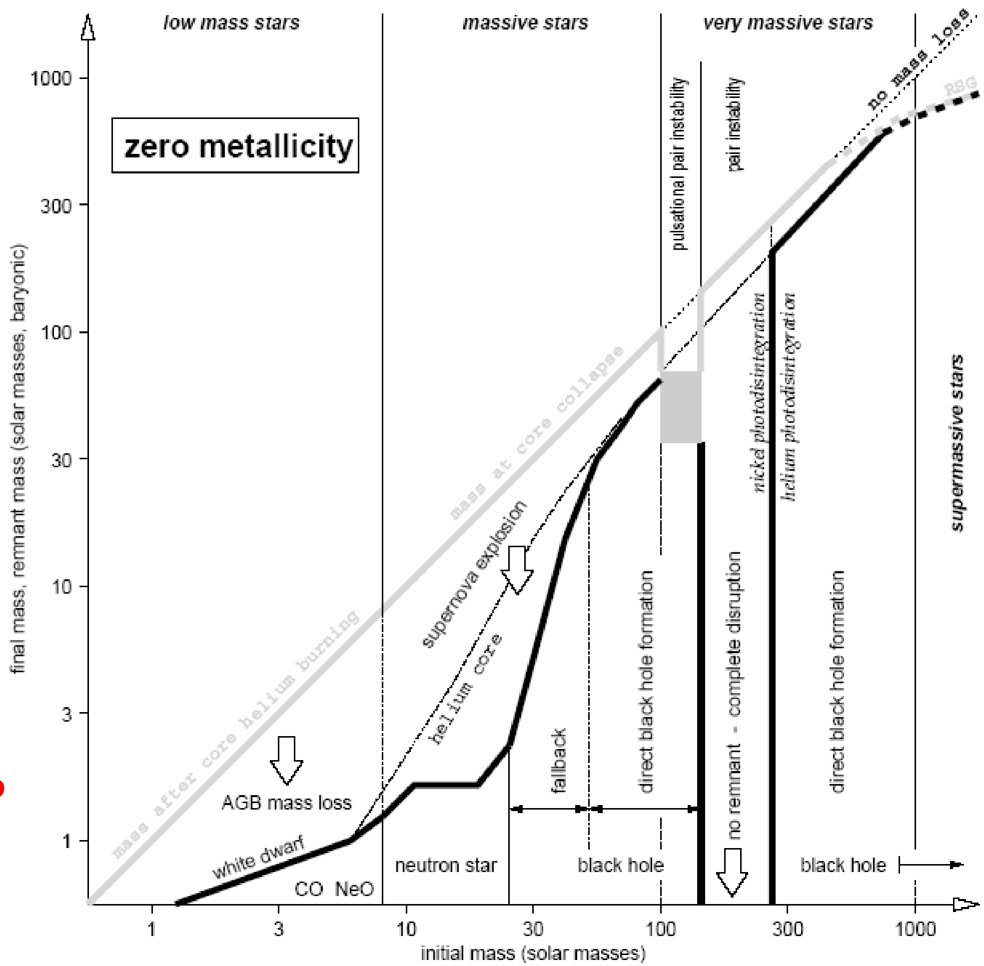


Fig. 1. Initial-final mass function of non-rotating Pop III stars. The *x-axis* gives the initial mass. The *y-axis* gives both the final mass of the collapsed remnant (*thick black*

Heger et al.
astro-ph 0112059

Very Massive Primordial Stars 5

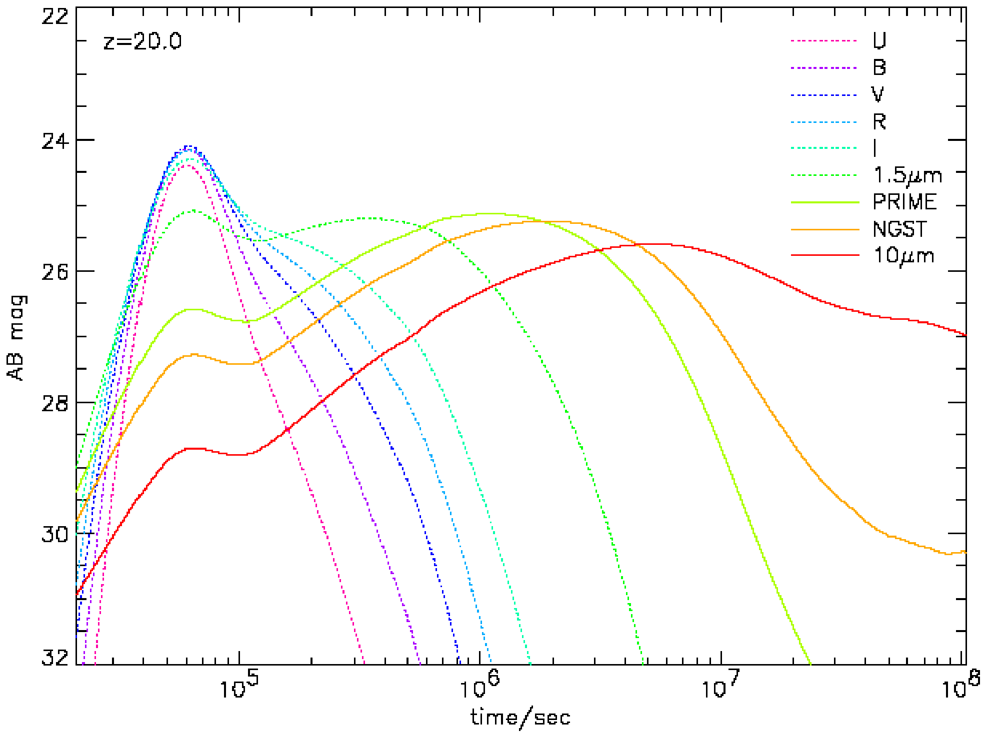


Fig. 3. Preliminary light curve of pair-creation supernova from a 250 $M_\odot$ star at $z = 20$ as computed by the KEPLER code [17]. Time, wave lengths and magnitudes (without internal or intergalactic extinction) are given in observer rest frame. Wave lengths that are beyond the IGM Ly$-\alpha$ absorption (2.55μm) are displayed as *dotted lines*. "PRIME" and "NGST" corresponds to 3.5 and 5.0μm. The "spherically symmetric" emission has been folded to account for the extent of the "photosphere". The first "bump" at $\sim 10^3$ s is from the shock breakout, the right "peak" is the peak of the SN light curve.

Heger et al.
astro-ph 0112059

pair- creation SN
M_{SN} = 250 M_0
z = 20

AB = 26.5 <->
F_ν = 0.1 µJy

MIRI / JWST
Primary Support Structure

Design drivers:

Low thermal conductivity between the 7K cold instrument and the 35 K 'hot' telescope.

Lowest Eigenfrequency above 60 Hz with a 103 Kg instrument.

Max g-load 20.

MIRI / JWST
Primary Support Structure

Tests

Thermal cycling from Room Temperature to 7 K.

Strength Test.

Vibration.

Material properties:

Young's module.

Coefficient of thermal expansion.

Coefficient of moisture expansion.

Thermal conductivity.

Out gassing.

Struts ATP


ratory

MIRI / JWST
Primary Support Structure

Tests

Thermal cycling from Room Temperature to 7 K.

Strength Test.

Vibration.

Material properties:

Young's module.

Coefficient of thermal expansion.

Coefficient of moisture expansion.

Thermal conductivity.

Out gassing.

MIRI / JWST
Infrared spectrograph

MIRI

A combined mid infrared camera and spectrograph covering wavelengths 5-27 µm.

DTU Space:
Responsible of the Primary Support Structure.

MIRI / JWST
Primary Support Structure

Design drivers:

Low thermal conductivity between the 7K cold instrument and the 35 K ’hot’ telescope.

Lowest Eigenfrequency above 60 Hz with a 103 Kg instrument.

Max g-load 20.

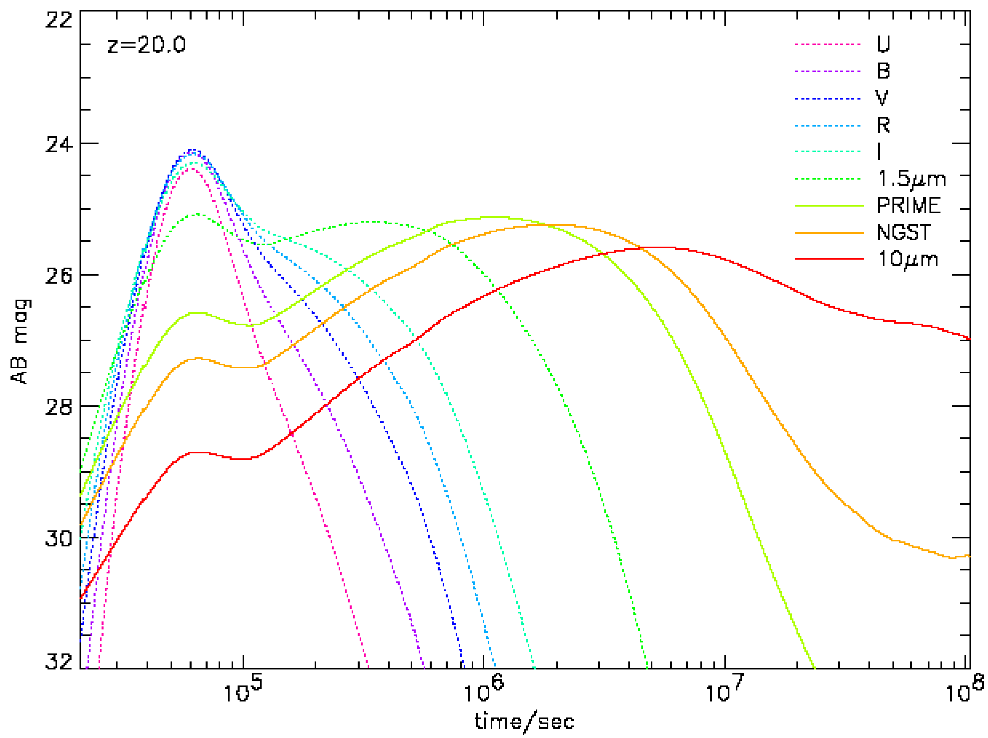


Fig. 3. Preliminary light curve of pair-creation supernova from a 250 $M_\odot$ star at $z = 20$ as computed by the KEPLER code [17]. Time, wave lengths and magnitudes (without internal or intergalactic extinction) are given in observer rest frame. Wave lengths that are beyond the IGM Ly$-\alpha$ absorption (2.55μm) are displayed as *dotted lines*. "PRIME" and "NGST" corresponds to 3.5 and 5.0μm. The "spherically symmetric" emission has been folded to account for the extent of the "photosphere". The first "bump" at $\sim 10^3$ s is from the shock breakout, the right "peak" is the peak of the SN light curve.

Heger et al.
astro-ph 0112059

pair- creation SN
M_{SN} = 250 M_0
z = 20

AB = 26.5 <->
F_{υ} = 0.1 μJy

First Light Objects

Primordial Gas: H, He, no metals
-> cooling much less efficient

Gravitational unstable clouds:

Jeans Mass:

$$M_J = (\pi\ k\ T/\mu\ G)^{3/2}\ 1/\rho^{1/2} \quad \rightarrow$$

$$M_* > 100\ M_0$$

Panagia
astro-ph 0209346

Long dashed: stellat cont
Short dashed : nebula cont

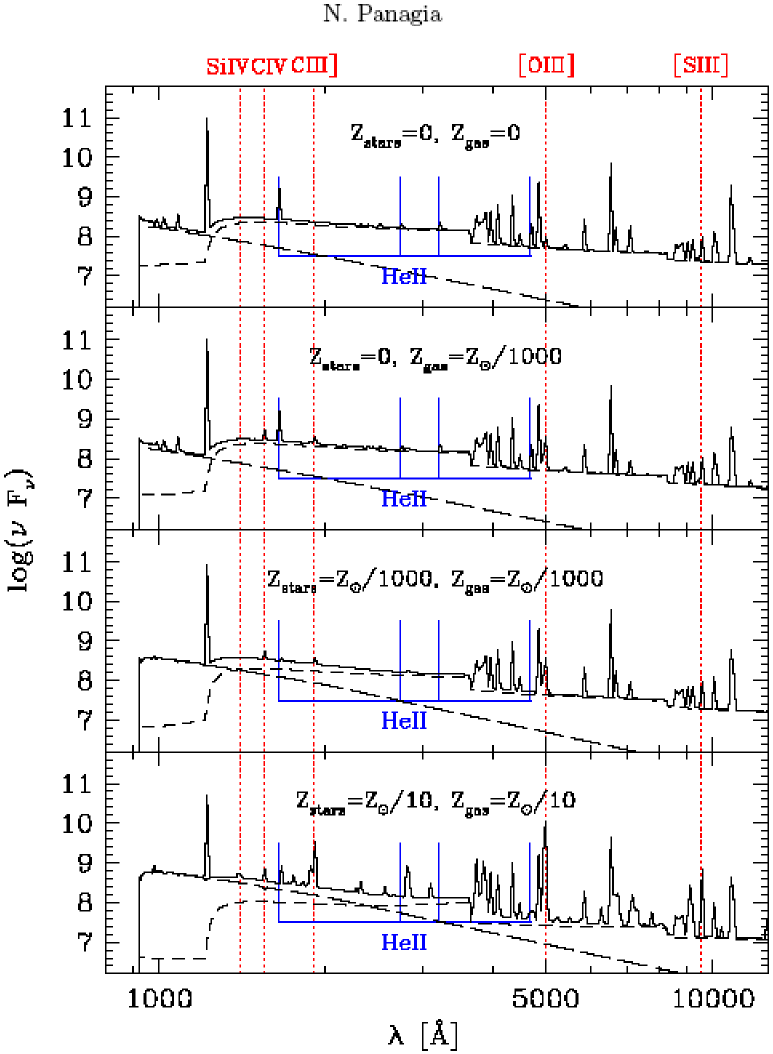


Fig. 2 The synthetic spectrum of a zero-metallicity HII region (top panel) is

Heger et al.
astro-ph 0112059

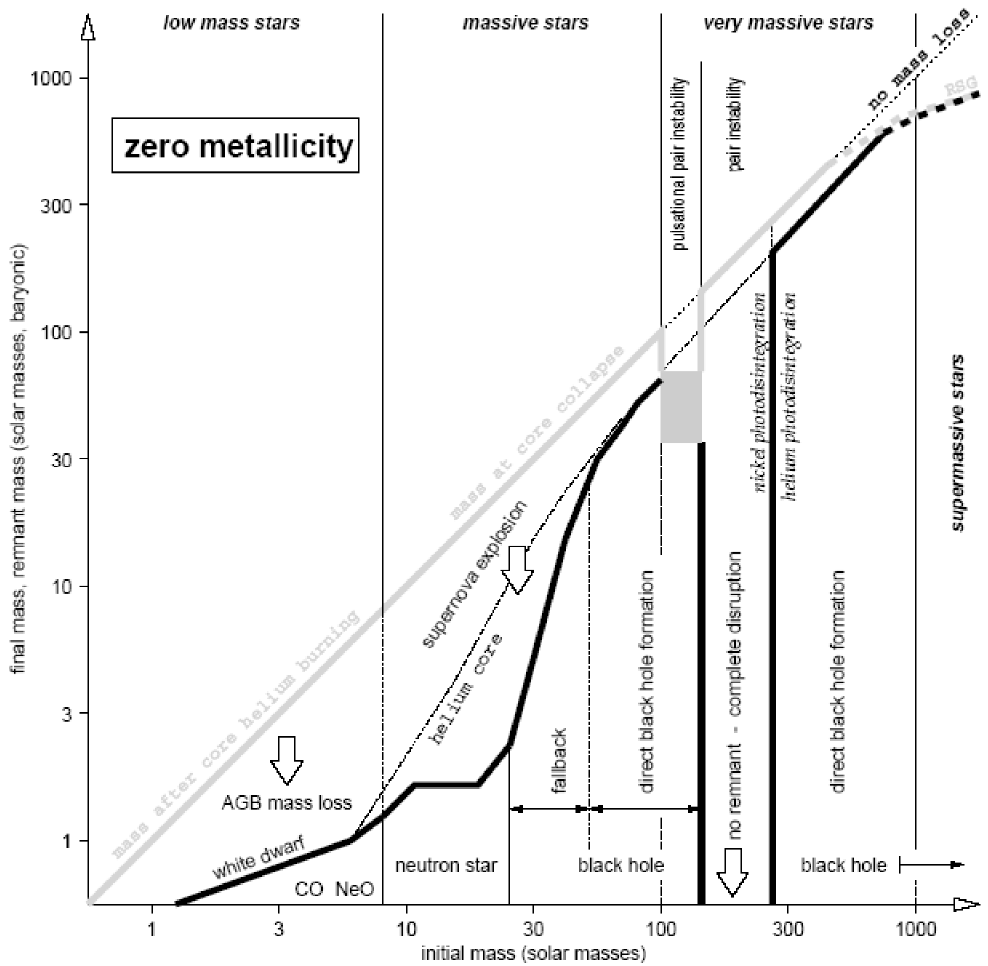
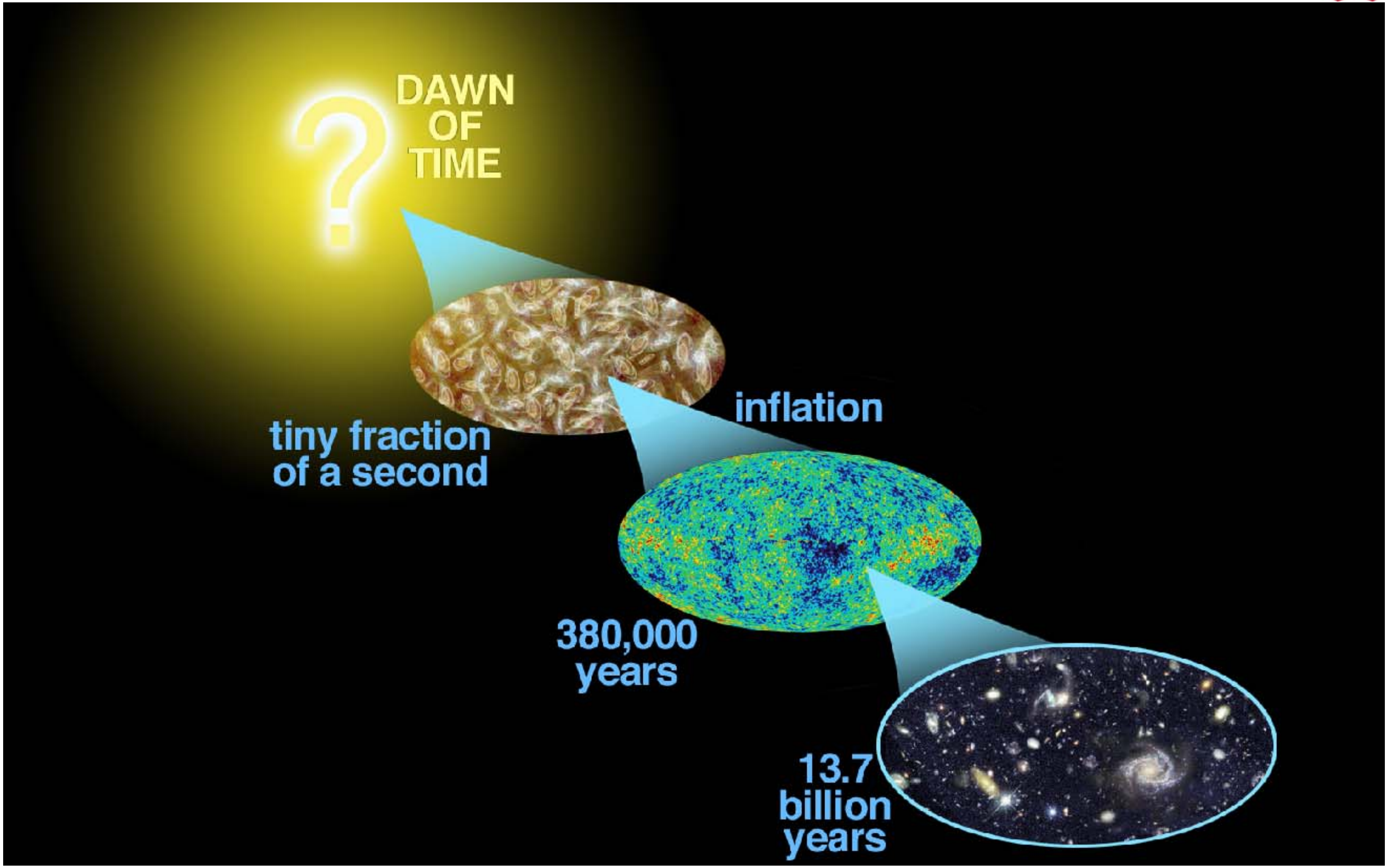
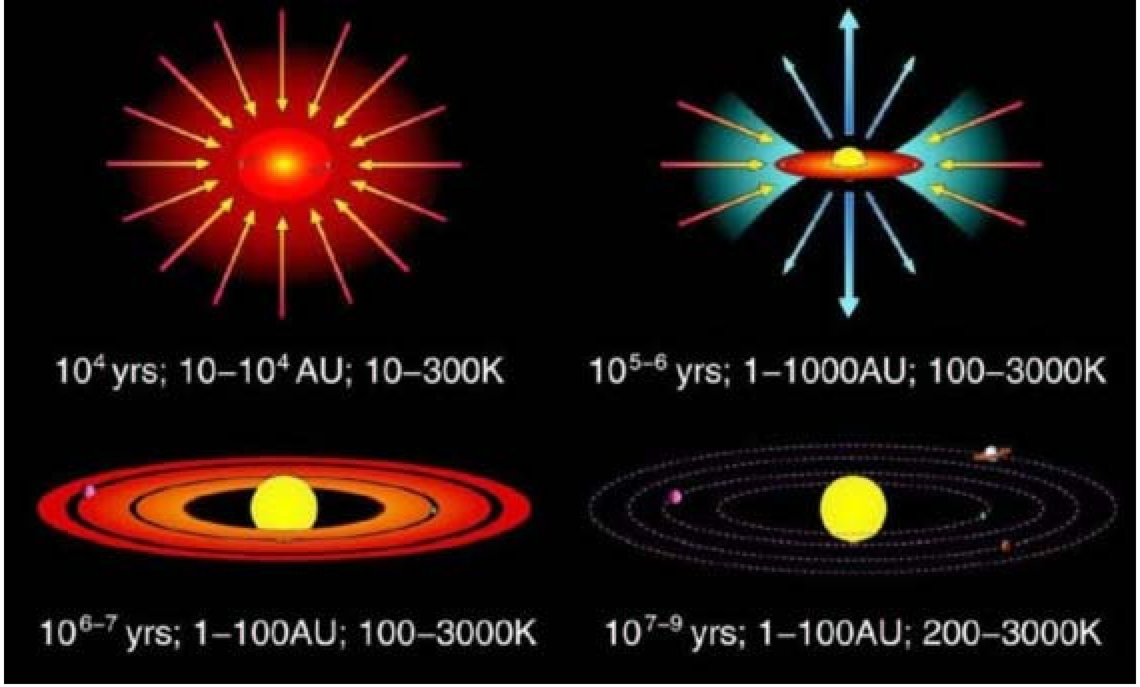


Fig. 1. Initial-final mass function of non-rotating Pop III stars. The *x-axis* gives the initial mass. The *y-axis* gives both the final mass of the collapsed remnant (*thick black*

MIRI / JWST
Primary Structure


DAWN
OF
TIME
tiny fraction
of a second
inflation
380,000
years
13.7
billion
years


10^4 yrs; 10–10^4 AU; 10–300K
10^{5-6} yrs; 1–1000AU; 100–3000K
10^{6-7} yrs; 1–100AU; 100–3000K
10^{7-9} yrs; 1–100AU; 200–3000K