FROM COSMIC BIRTH TO LIVING EARTHS

THE FUTURE OF UVOIR SPACE ASTRONOMY

AURA

Speakers

Matt Mountain

Sara Seager

David Schiminovich

Julianne Dalcanton

Panelists

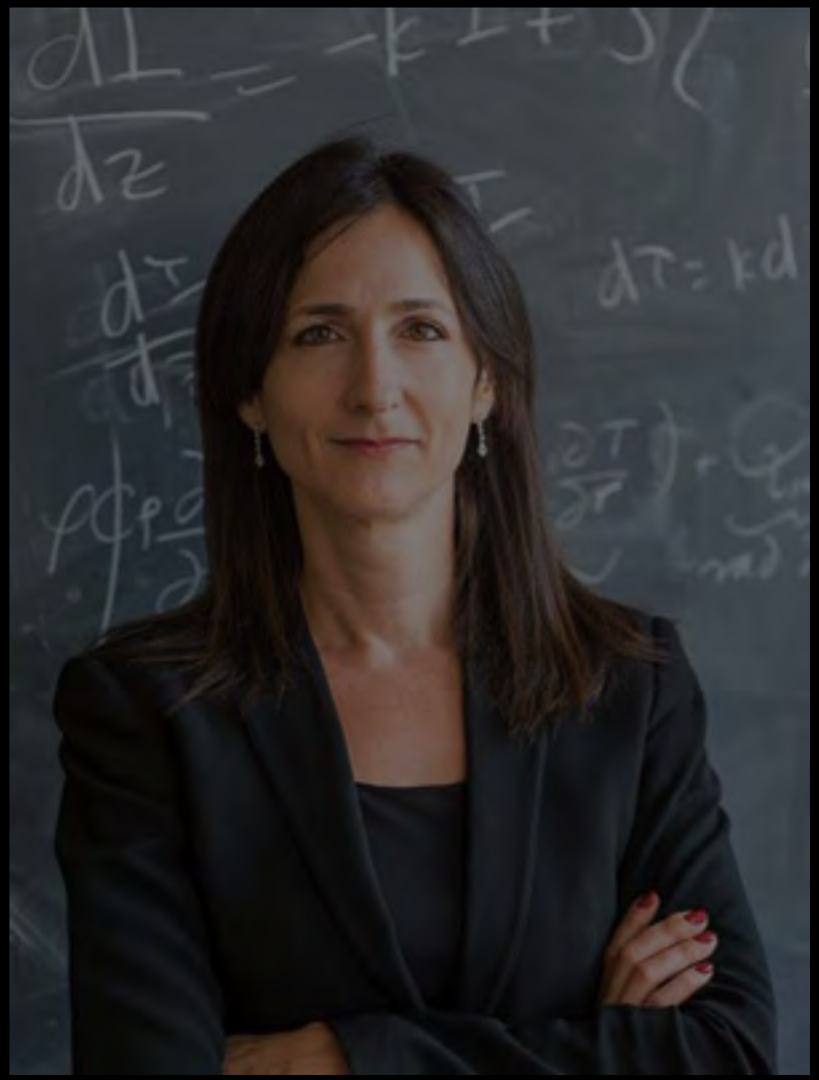
Marc Postman

Michael Shara

Jason Tumlinson

Speakers

Matt Mountain



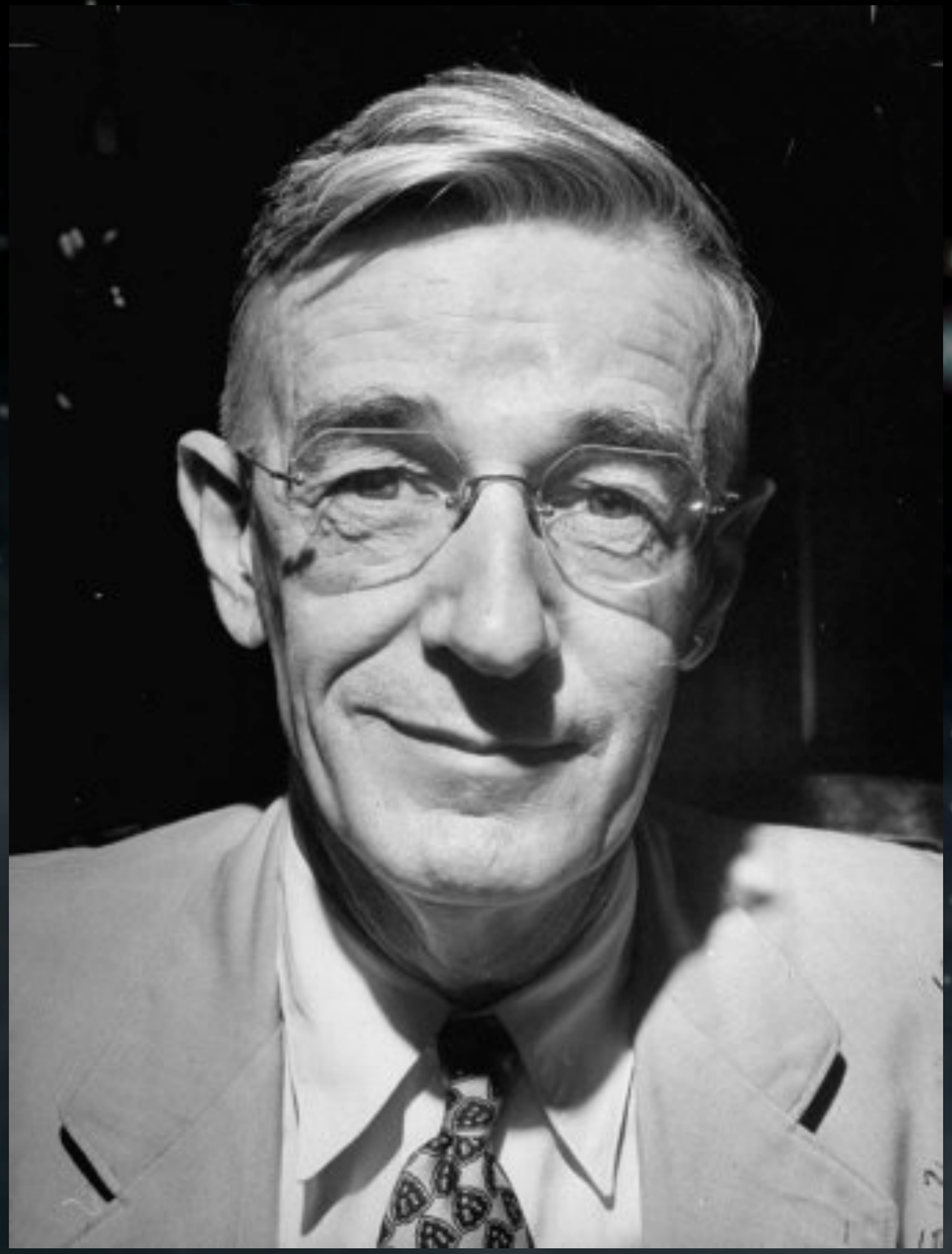
Sara Seager

David Schiminovich

Julianne Dalcanton

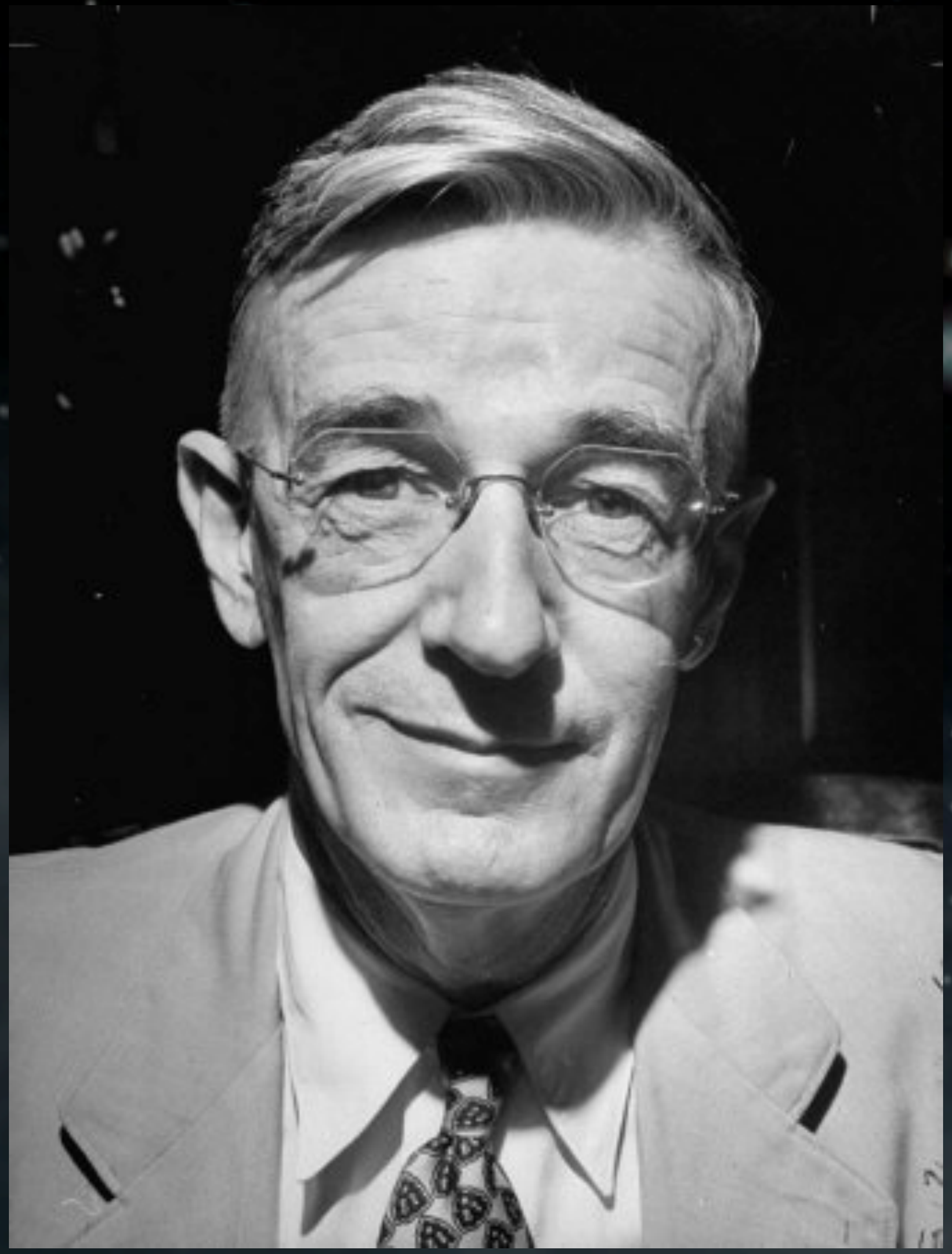
Dr. Matt Mountain
President
Associated Universities for Research in Astronomy

Science The Endless Frontier



A Report to the President by
Vannevar Bush,
Director of the Office of Scientific
Research and Development,
July 1945

Science The Endless Frontier



A Report to the President by
Vannevar Bush,
Director of the Office of Scientific
Research and Development,
July 1945

The National Science Foundation


NSF
AURA
Kitt Peak National Observatory
The Association of Universities for Research in Astronomy


NASA
AURA


NASA
AURA


SEAL OF THE PRESIDENT OF THE UNITED STATES

transformative science enabled by the Space Program

AURA Report
circa. 1996

The James Webb Space Telescope to launch in 2018

AURA Committee

"assess future space-based options … that can significantly advance our understanding of the origin and evolution of the cosmos and the life within it."

AURA Committee

Julianne Dalcanton, co-chair
University of Washington

Suzanne Aigrain
University of Oxford

Steve Battel
Battel Engineering, Inc.

Niel Brandt
Pennsylvania State University

Charlie Conroy
Harvard University

Lee Feinberg
NASA, Goddard Space Flight Center

Suvi Gezari
University of Maryland, College Park

Olivier Guyon
University of Arizona / NAOJ

Walt Harris
University of Arizona / LPL

Sara Seager, co-chair
Massachusetts Institute of Technology

Chris Hirata
The Ohio State University

John Mather
NASA, Goddard Space Flight Center

Marc Postman
Space Telescope Science Institute

Dave Redding
Jet Propulsion Laboratory / Caltech

David Schiminovich
Columbia University

H. Philip Stahl
NASA, Marshall Space Flight Center

Jason Tumlinson
Space Telescope Science Institute

Speakers

Matt Mountain

Sara Seager

David Schiminovich

Julianne Dalcanton

Prof. Sara Seager
Professor of Planetary Science and Physics
Massachusetts Institute of Technology

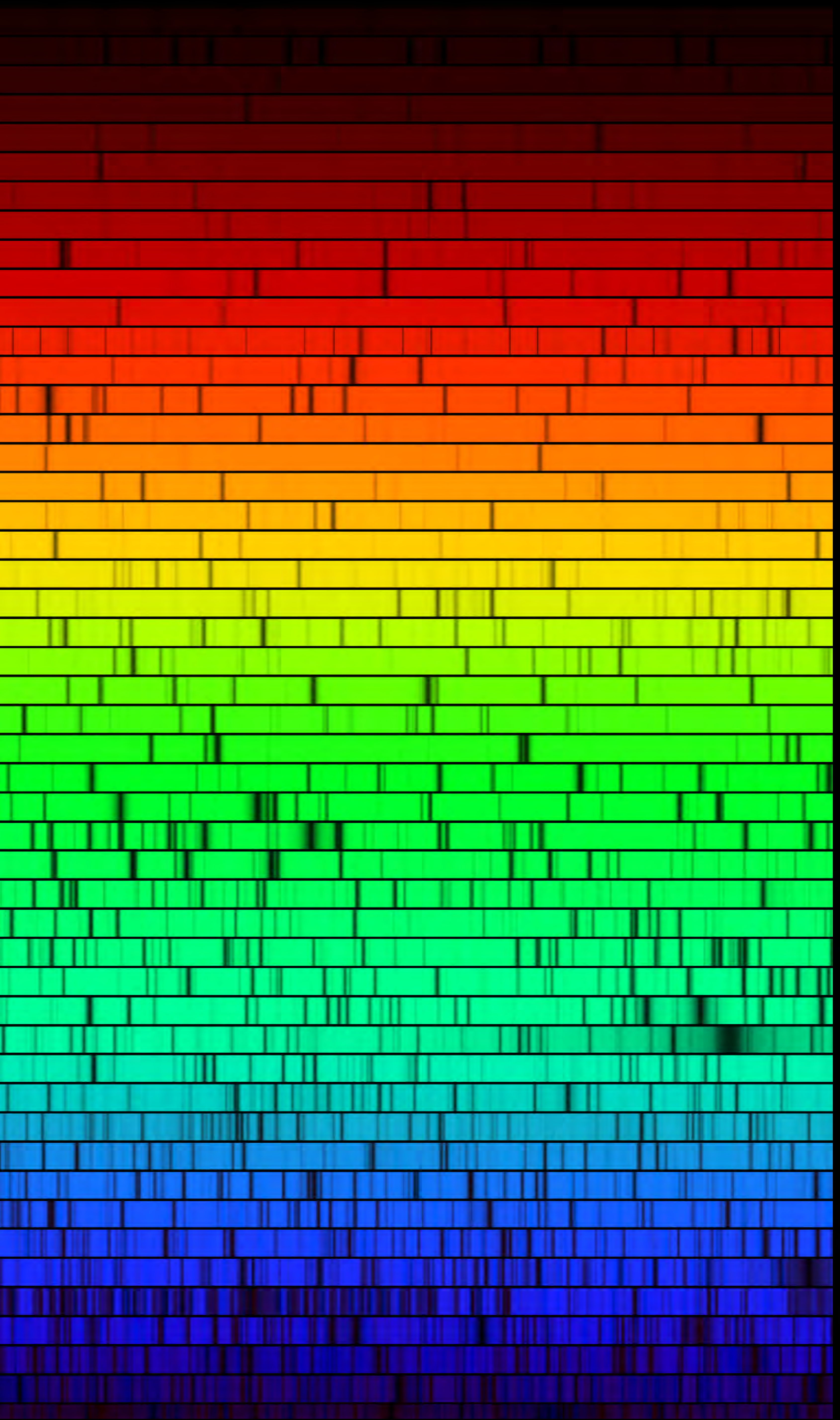
Where Did We Come From?


Are We Alone?

Earth as an Exoplanet

Earth as seen from Voyager 1, from 4 billion miles away

Earth's Spectrum



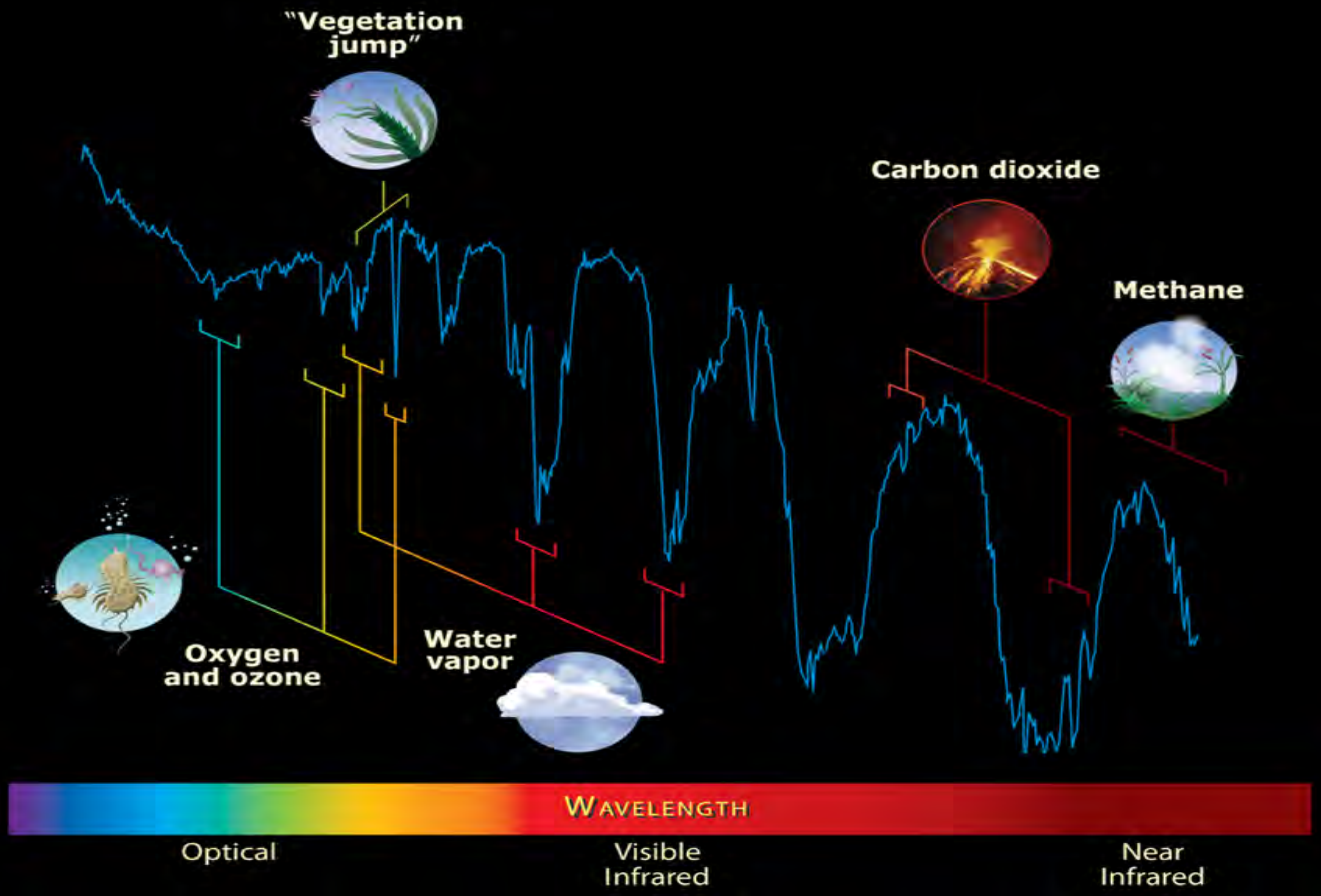
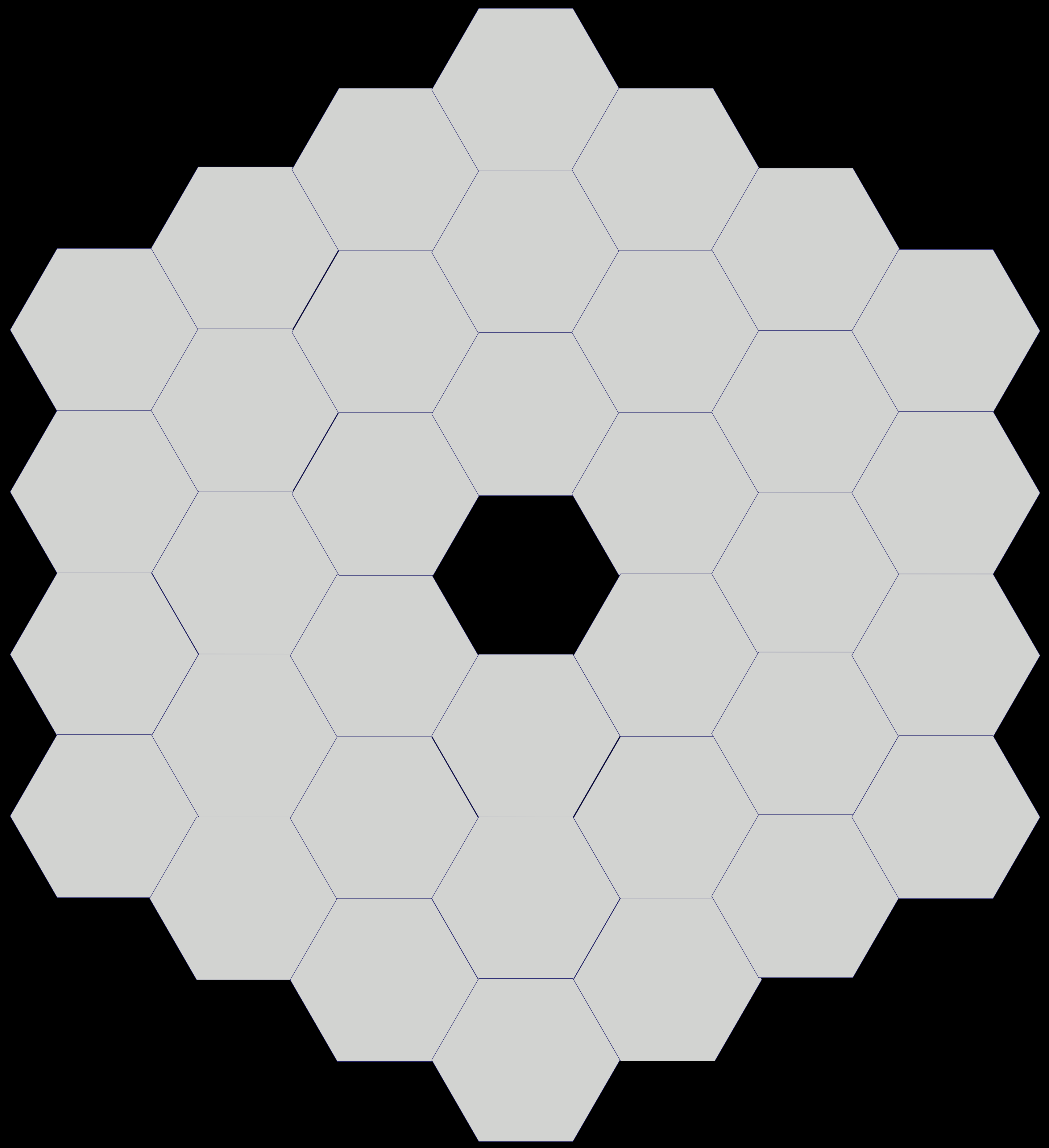
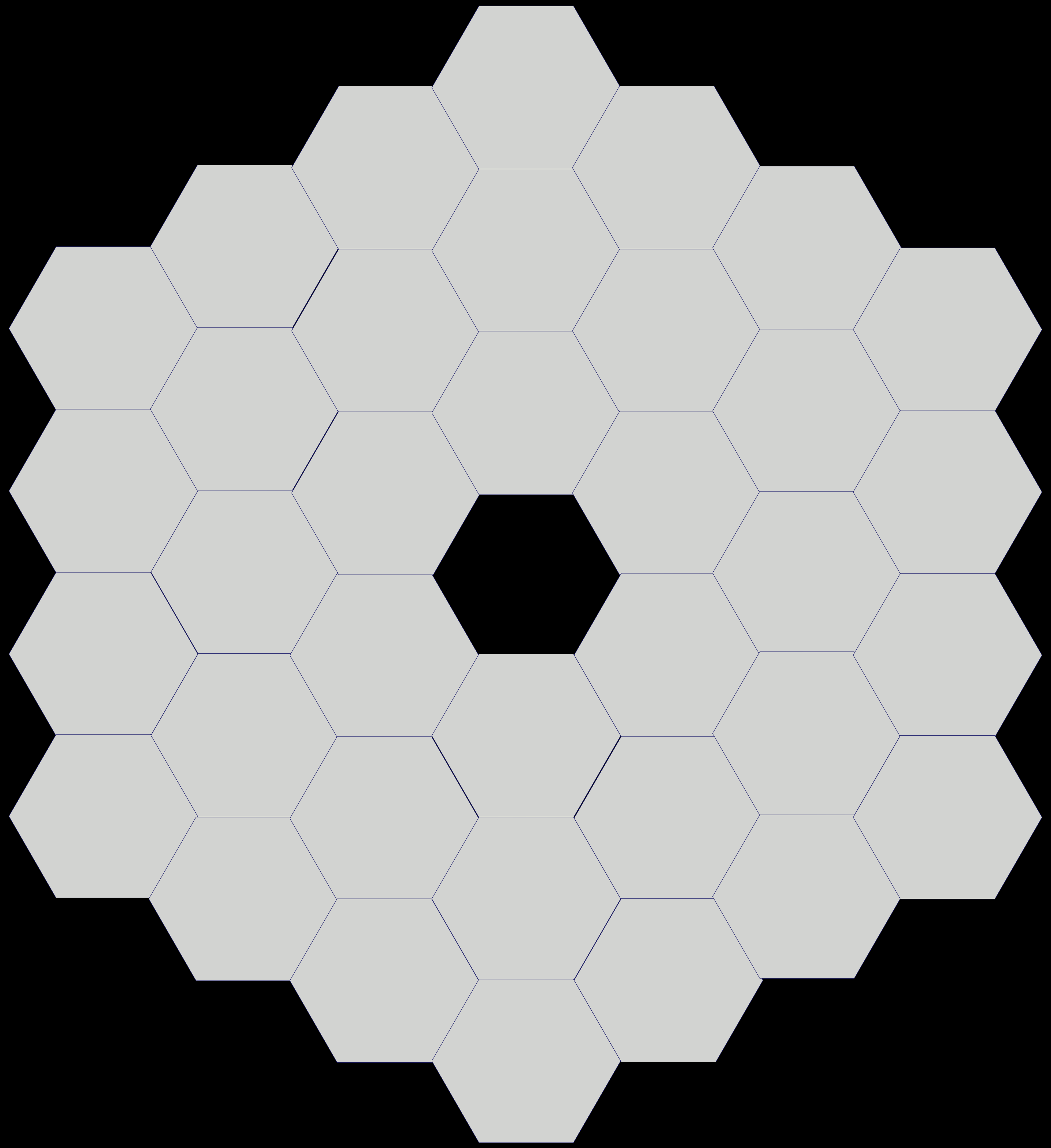
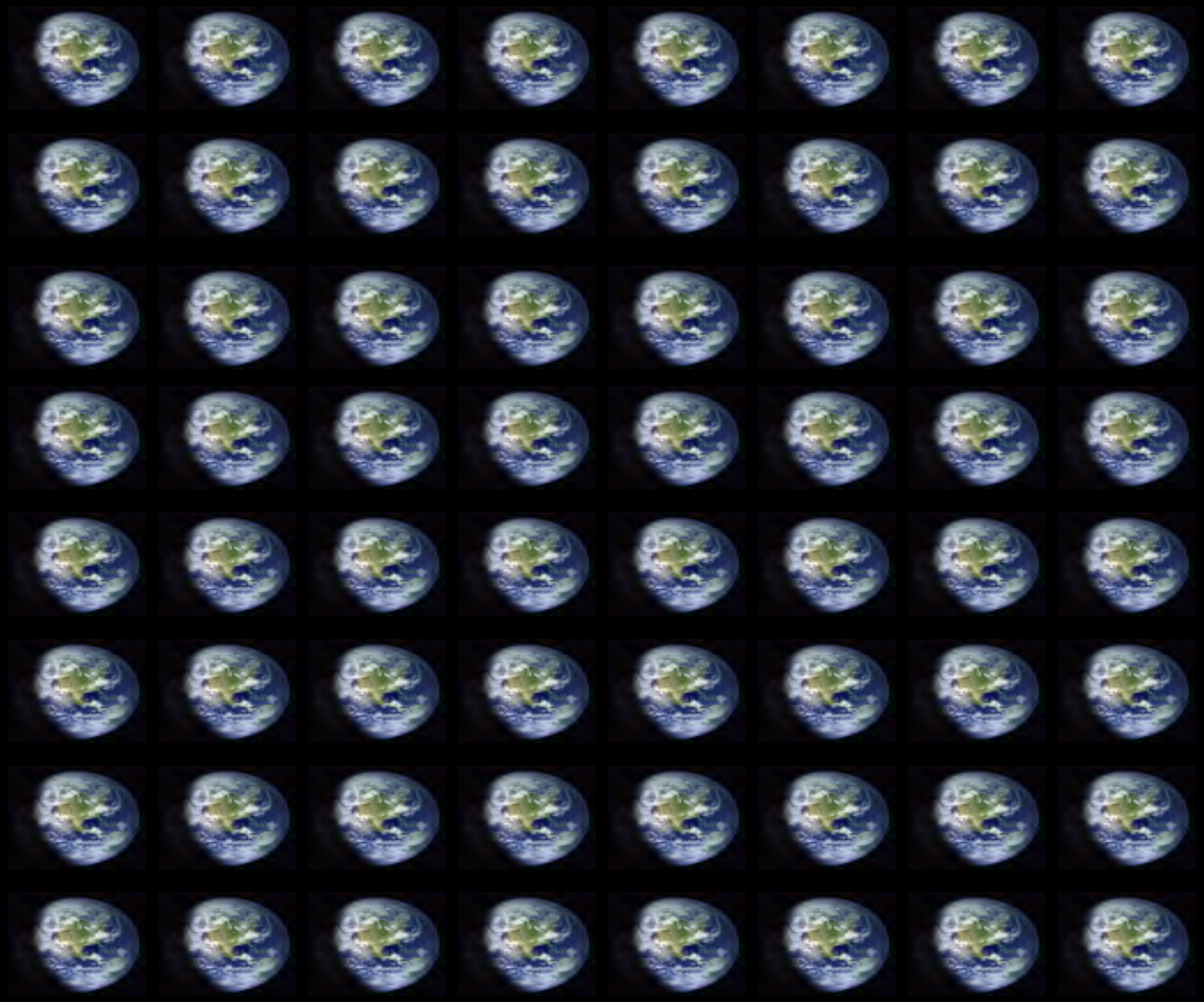


Image credit: : M. Turnbull and STScI



To find dozens of potential Earths, hundreds of stars must be searched, motivating a 12 m class telescope.

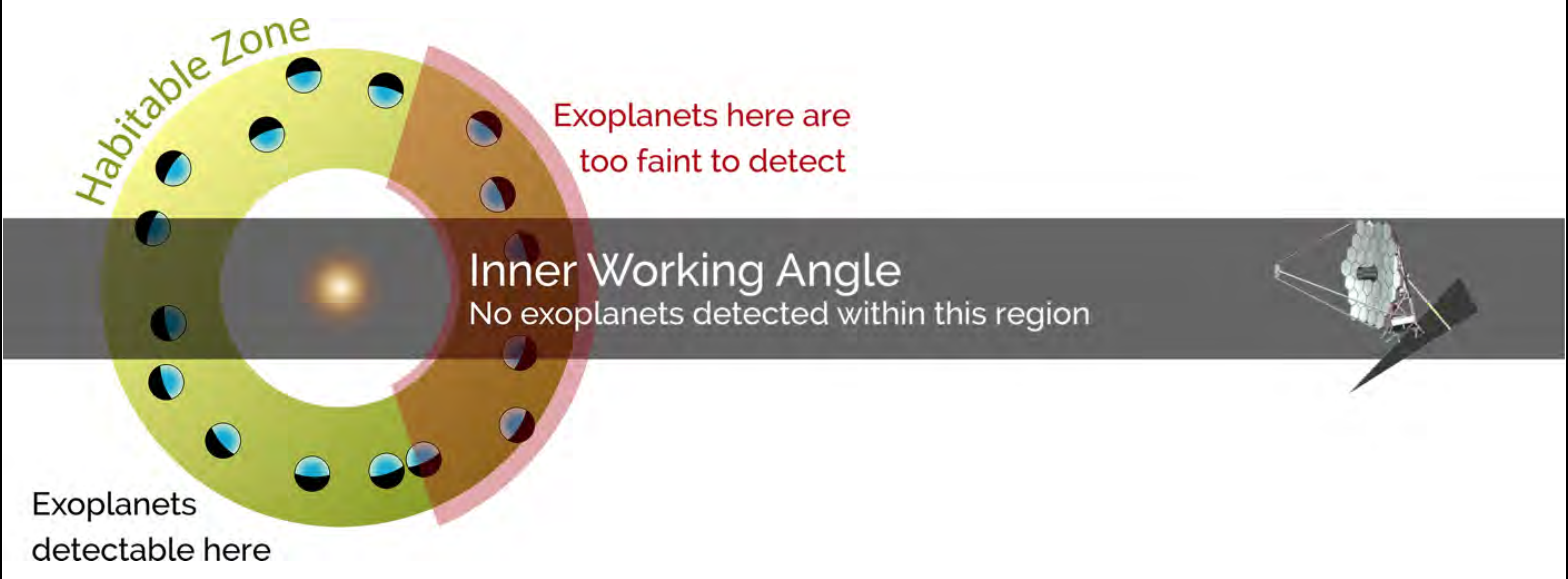




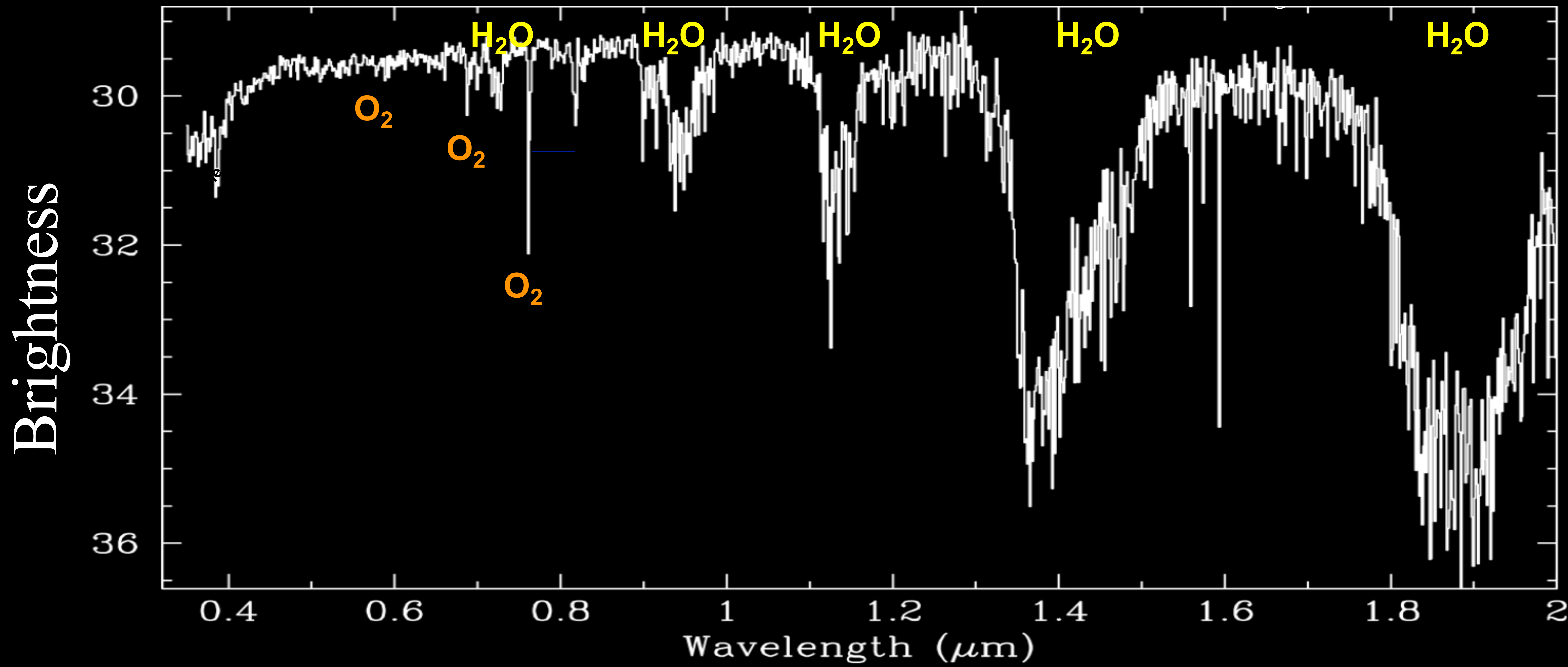
To find dozens of potential Earths, hundreds of stars must be searched, motivating a 12 m class telescope.

Starlight Suppression

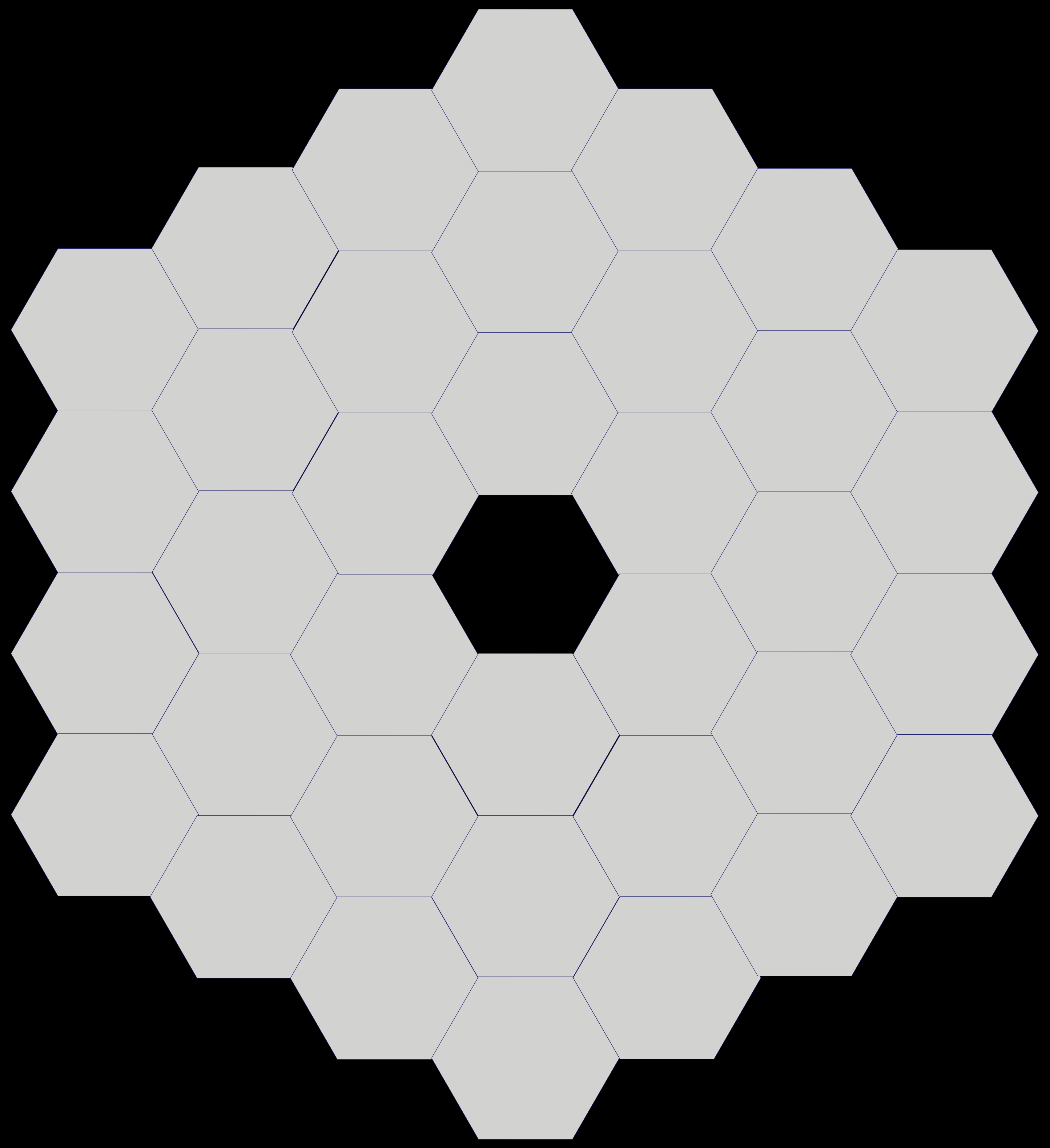
Why a Large Telescope?



Why a Large Telescope?

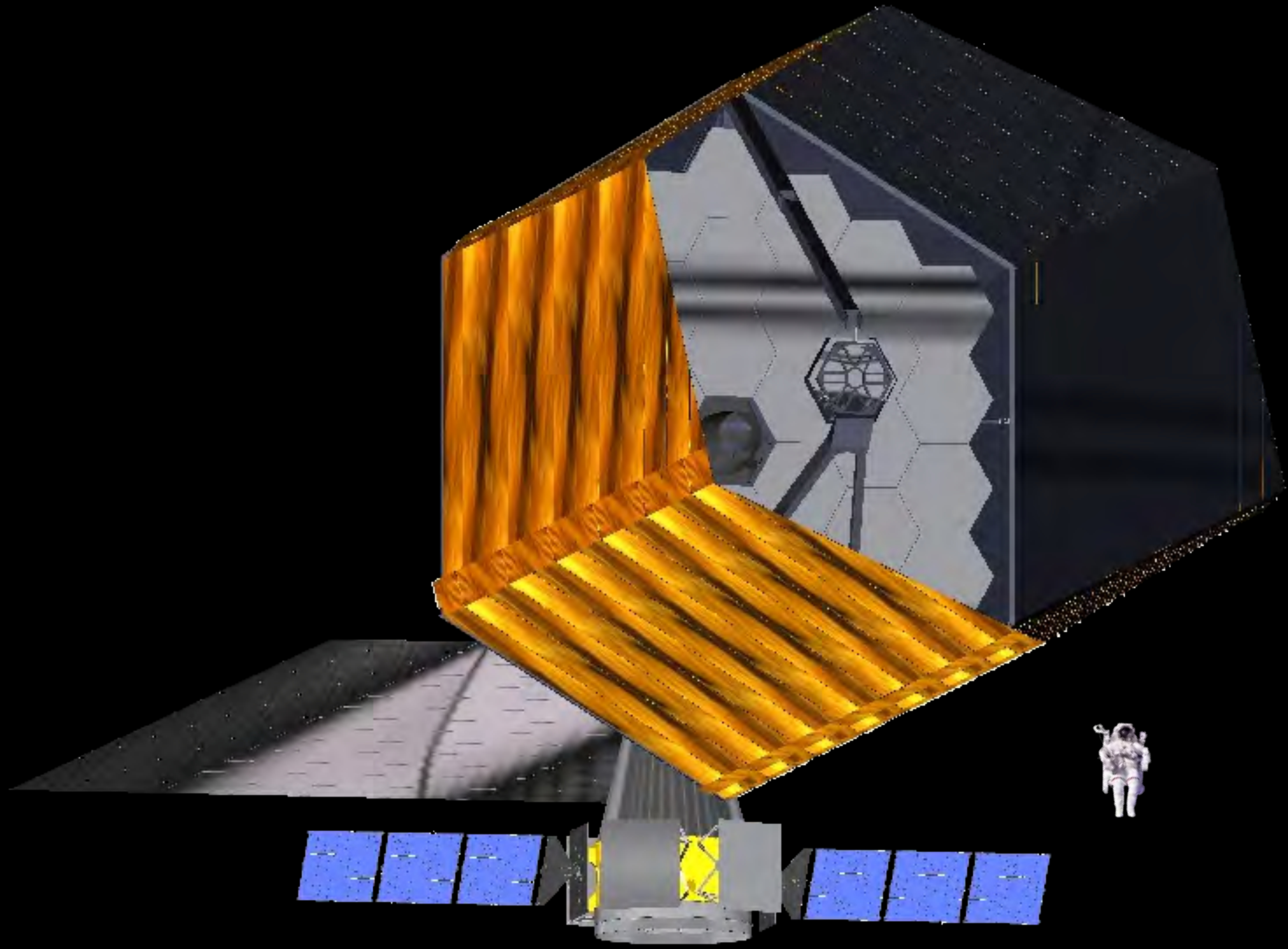


Even with a 12 meter telescope, it will take a week to obtain a "spectrum" of Earth 2.0.

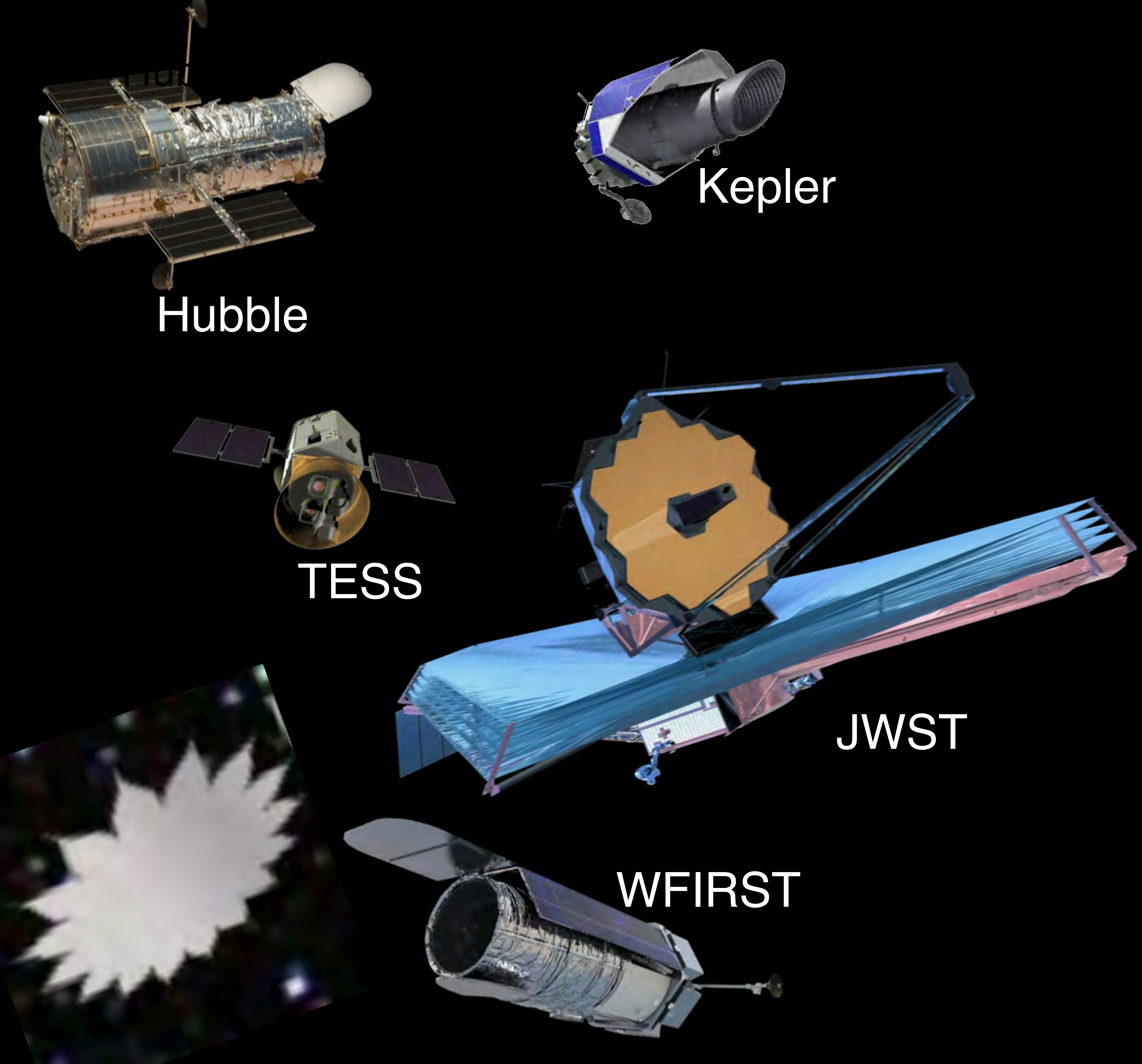


HDST
12 meters

No telescope has ever obtained a spectrum of an object as faint as a typical exoEarth

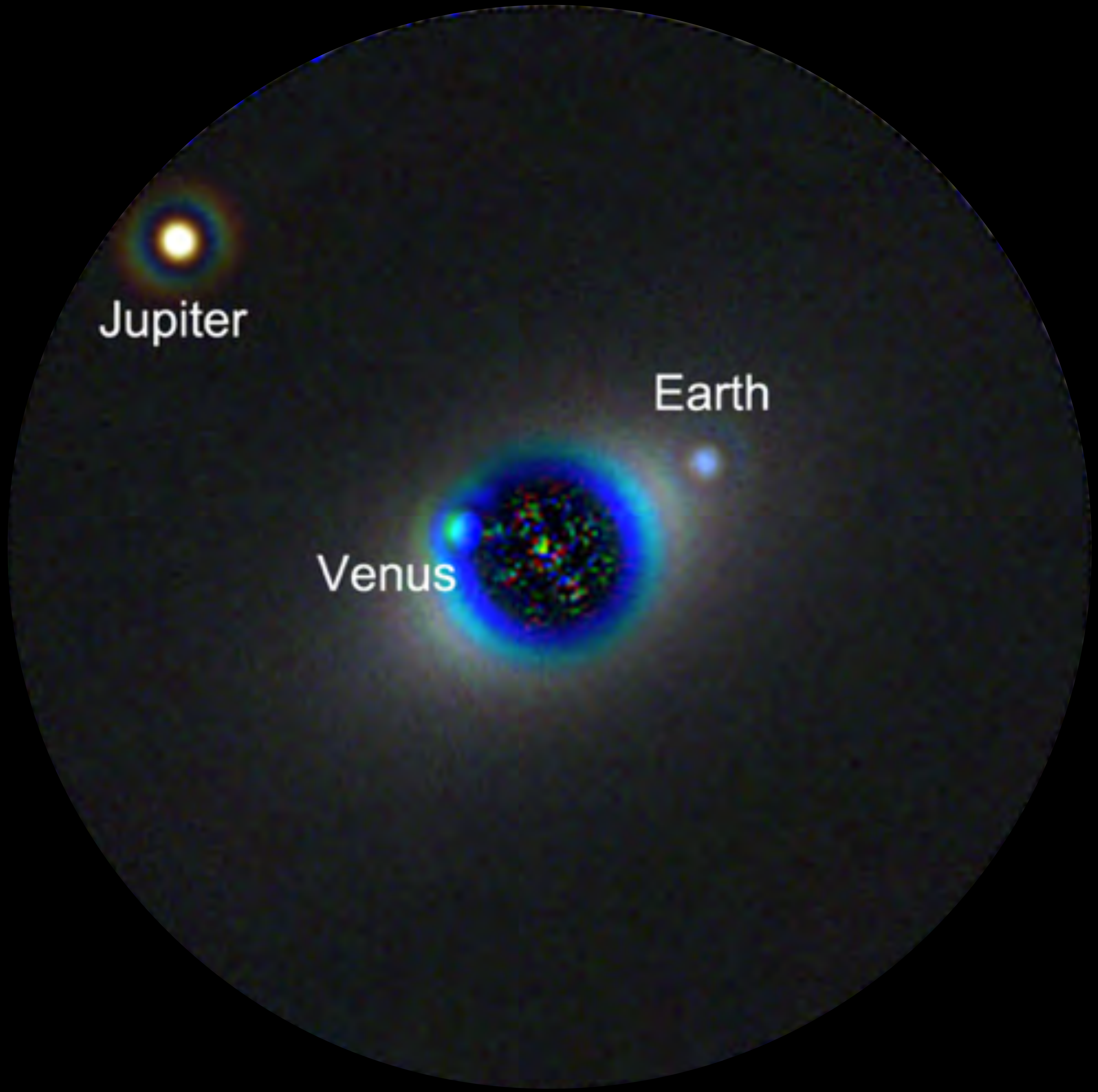


HDST
12 meters



Many telescopes existing or under construction will have a chance at finding one to a few exoEarths.

Only HDST will purposely make the search and yield a spectacular harvest.



HDST will survey planetary systems, including discovery and study of giant planets and dust belts.

A twin of our solar system at 30 light years as seen with a possible HDST coronagraph.

Image Credit: L. Peuyo (STScI)

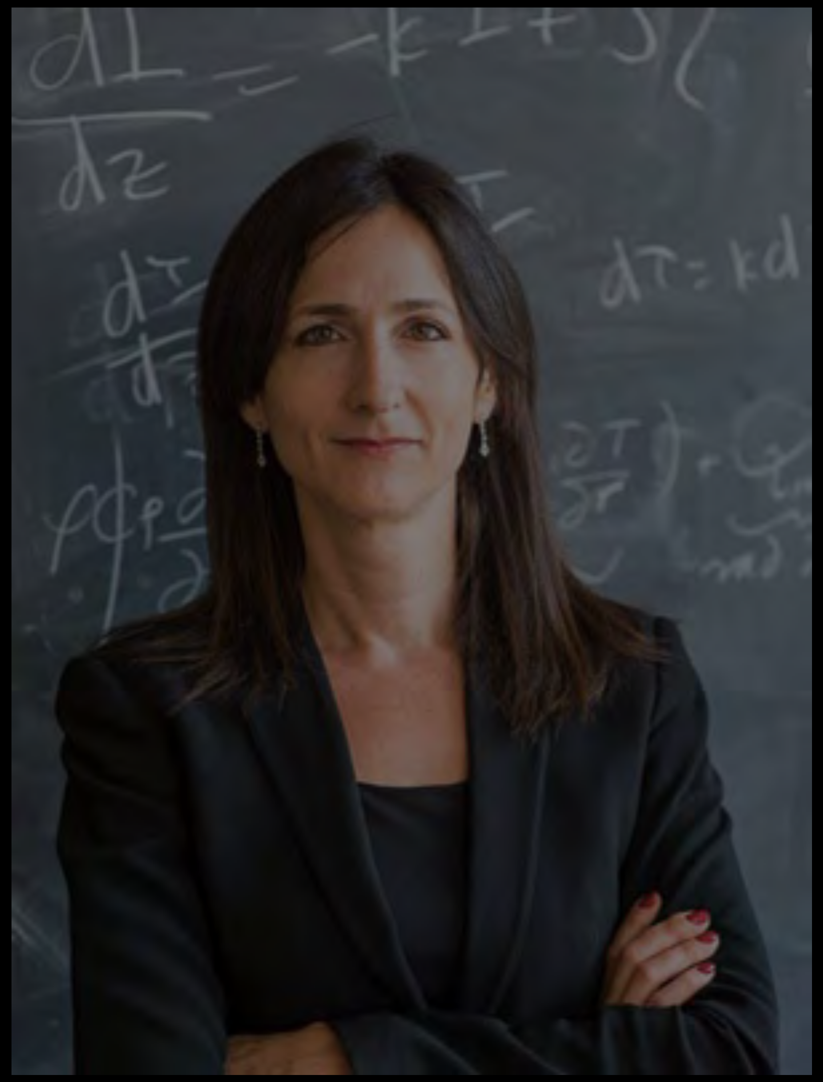
Stars with Potentially Habitable Planets

Stars with an Earth-like Planet

Observable with HDST

Speakers

Matt Mountain



Sara Seager

David Schiminovich

Julianne Dalcanton

Prof. David Schiminovich
Professor of Astrophysics
Columbia University

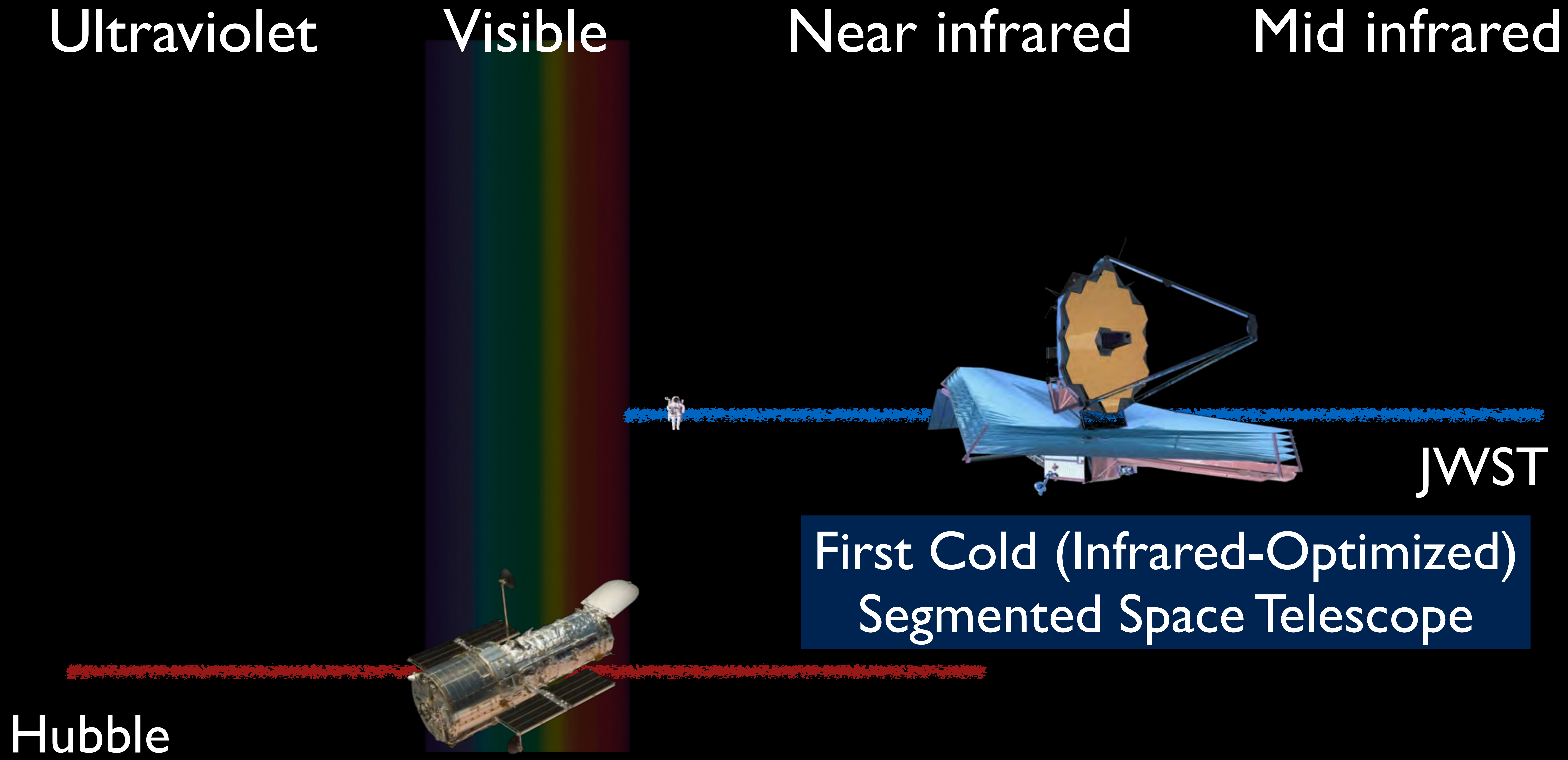
Observatory Technology

Ultraviolet | Visible | Near infrared | Mid infrared

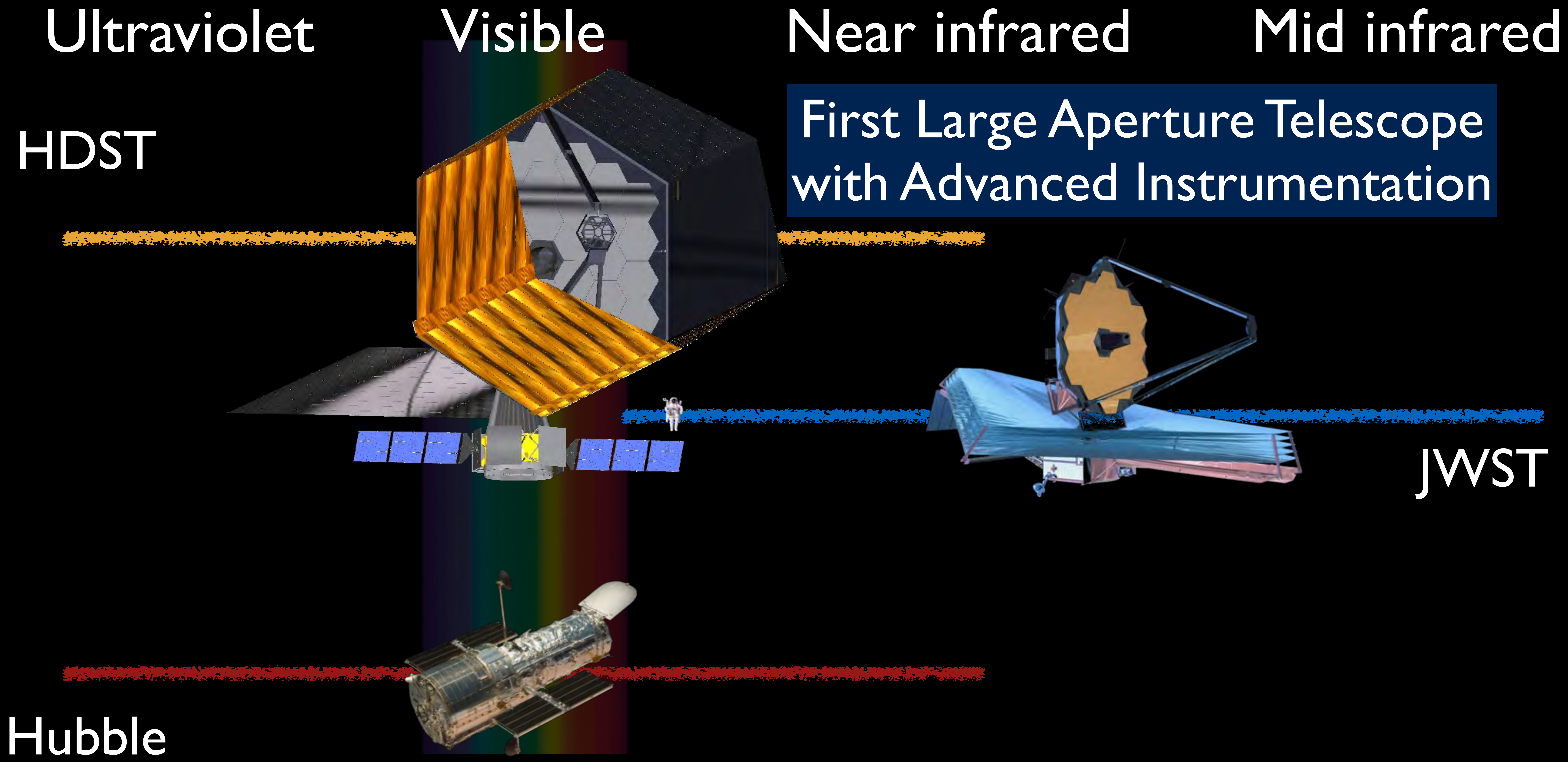
Hubble

First Large Space Telescope

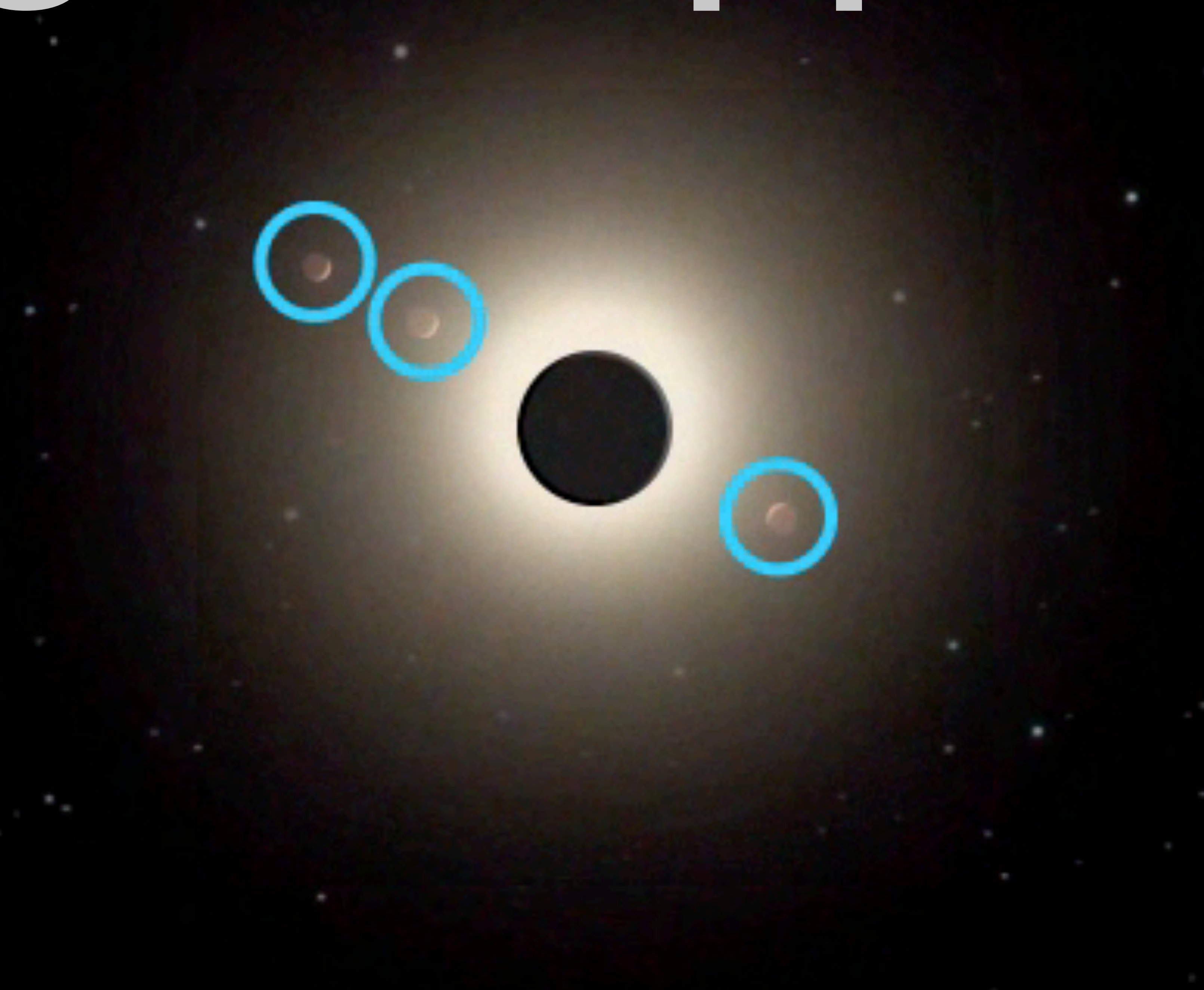
Observatory Technology



Observatory Technology



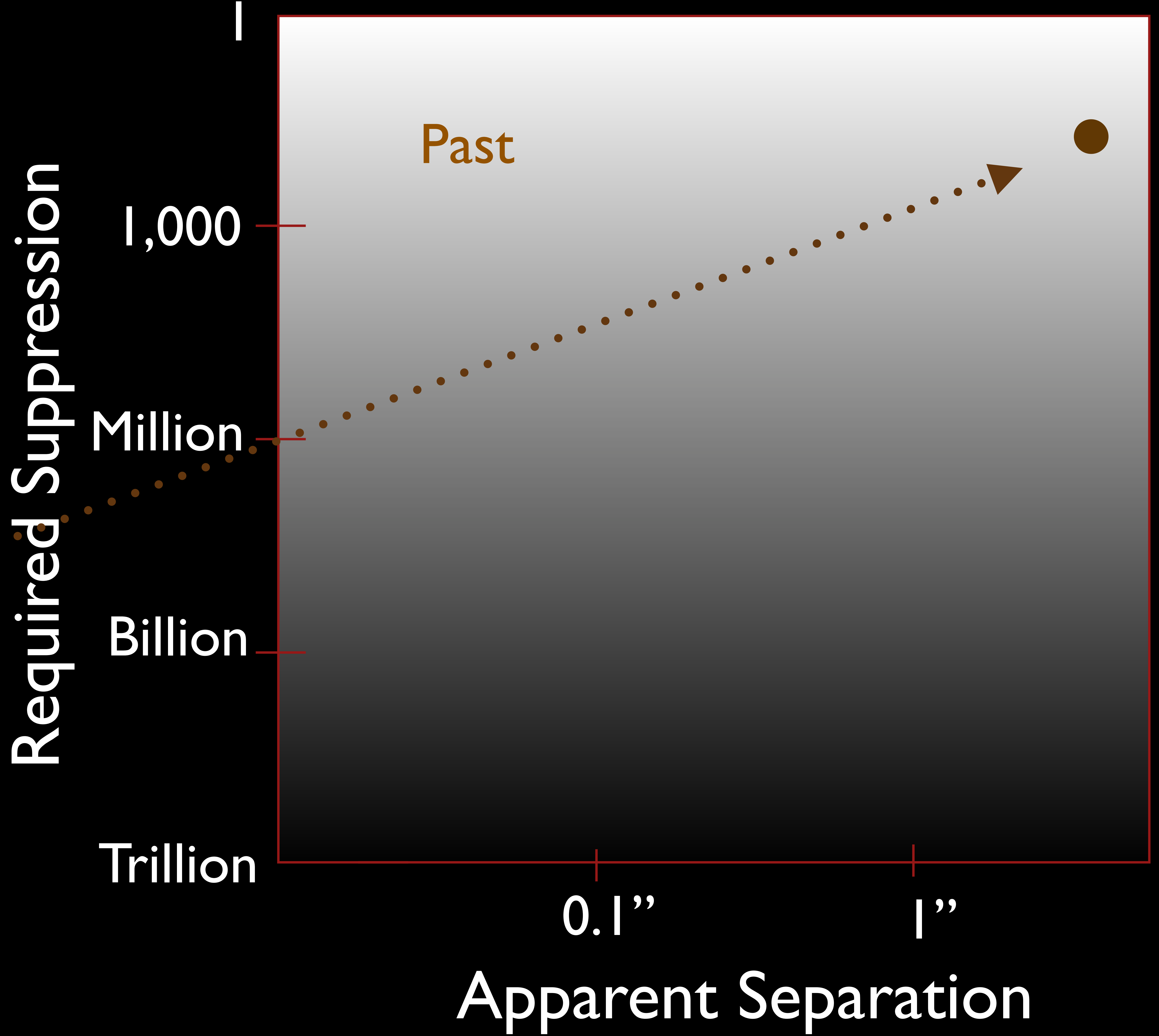
Advanced Instrumentation
Starlight Suppression

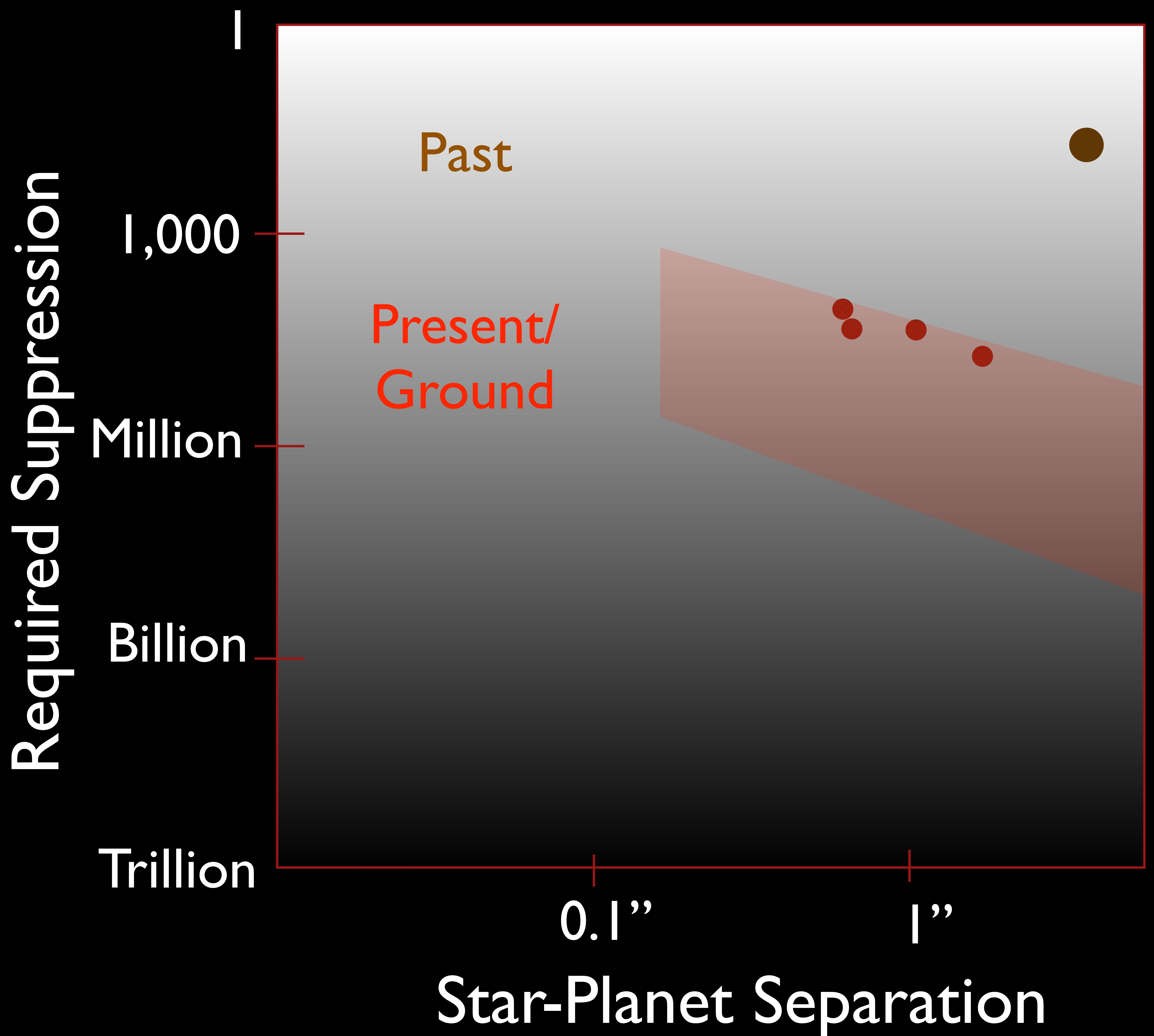


Advanced Instrumentation
Starlight Suppression

Starlight Suppression: Past

Image Credit: Nakajima, et al. (1995)





Required Suppression
1
1,000
Million
Billion
Trillion
Past
Present/
Ground
0.1”
1”
Star-Planet Separation

Starlight Suppression: Present

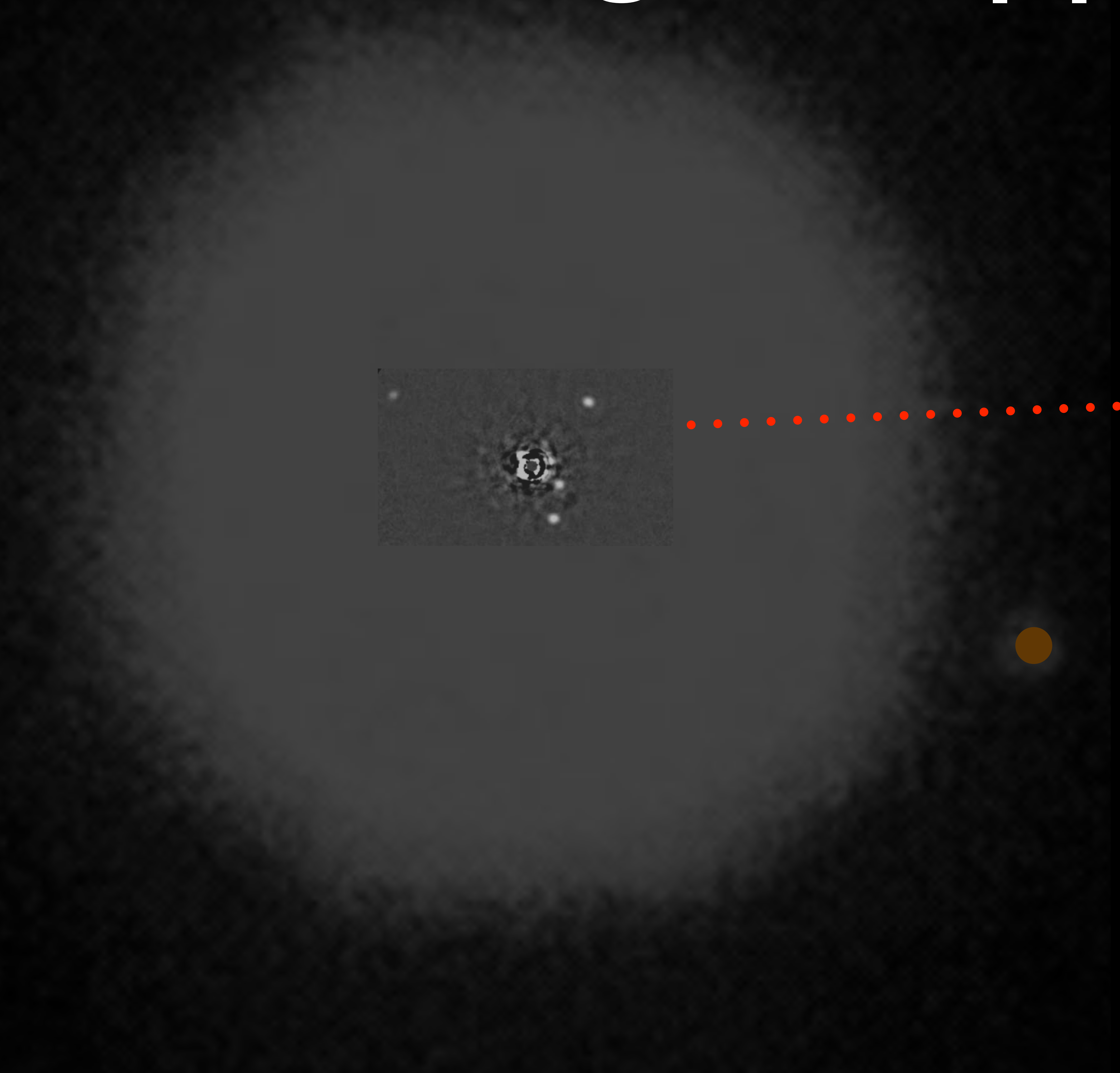
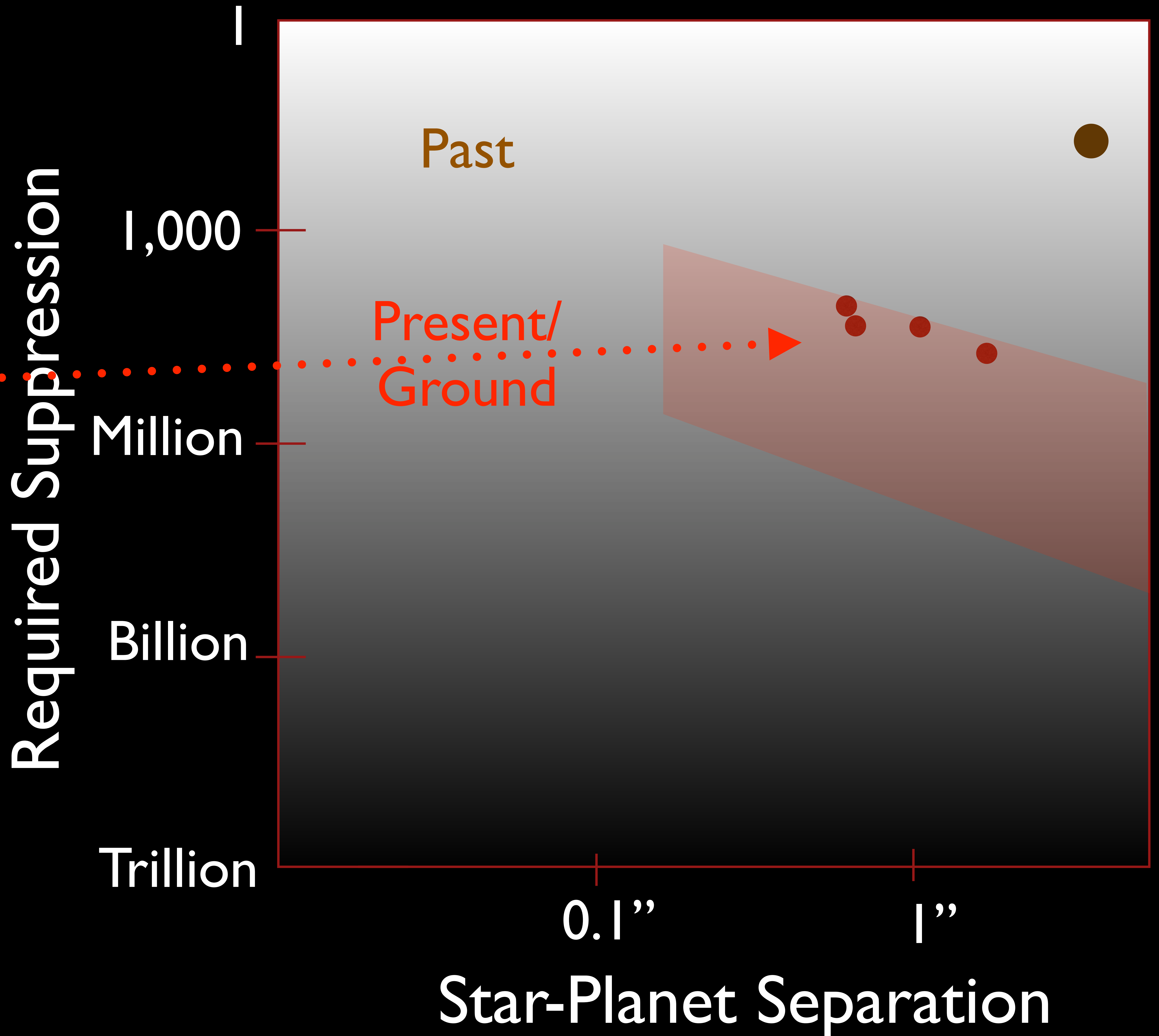
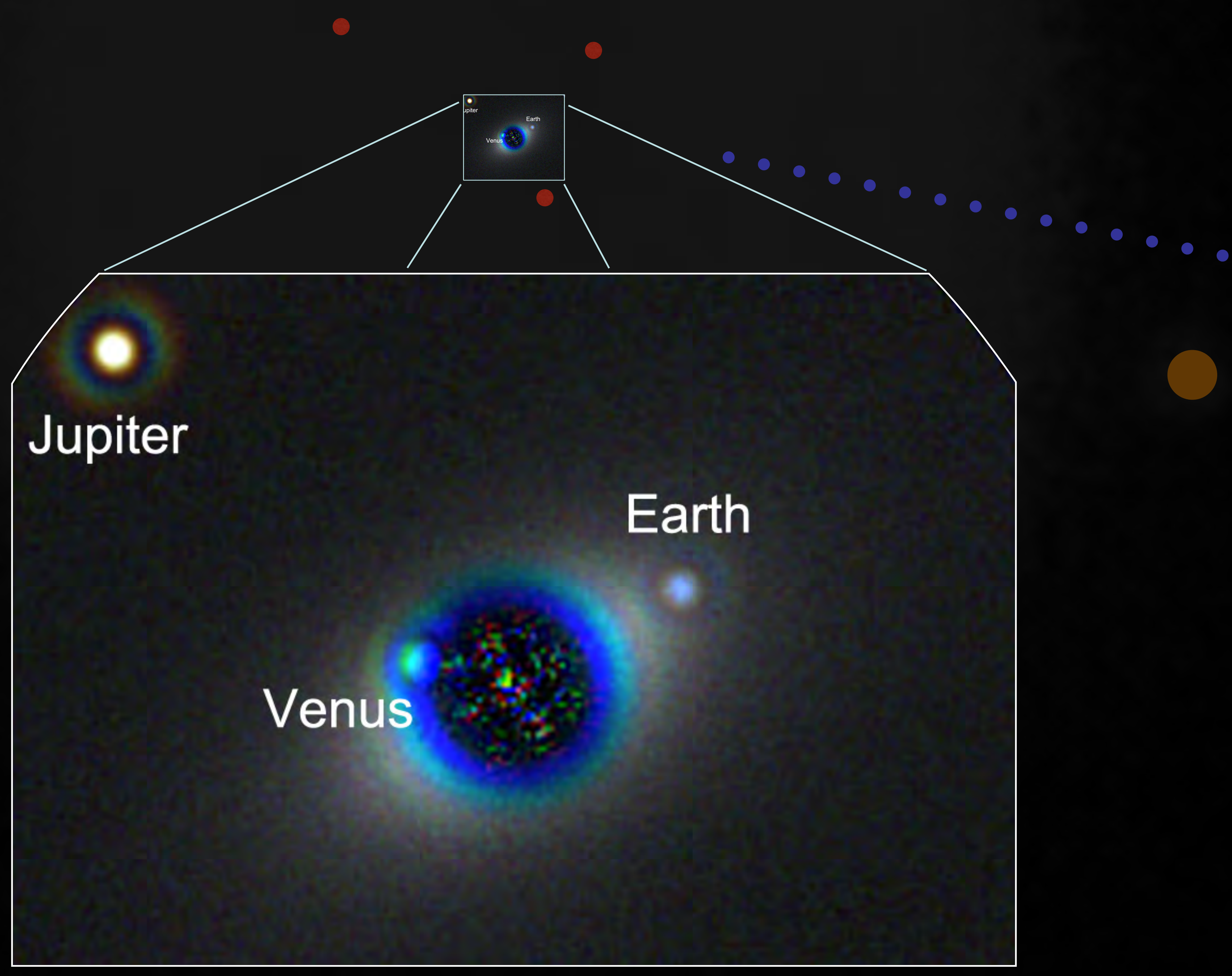


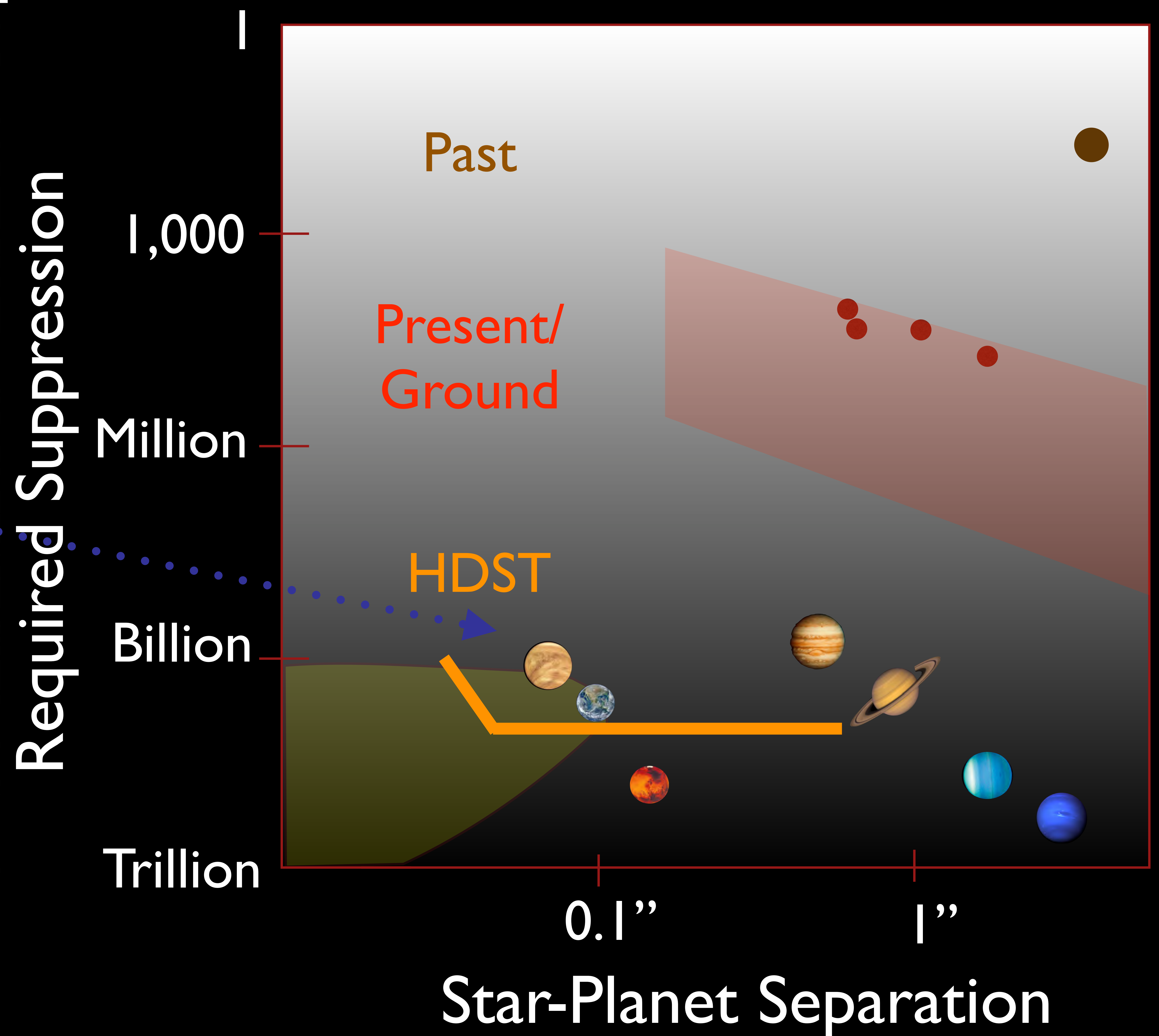
Image Credit: Marois, et al. (2010)



1
1,000
Million
Billion
Trillion
Required Suppression
Past
Present/
Ground
HDST
0.1”
1”
Star-Planet Separation

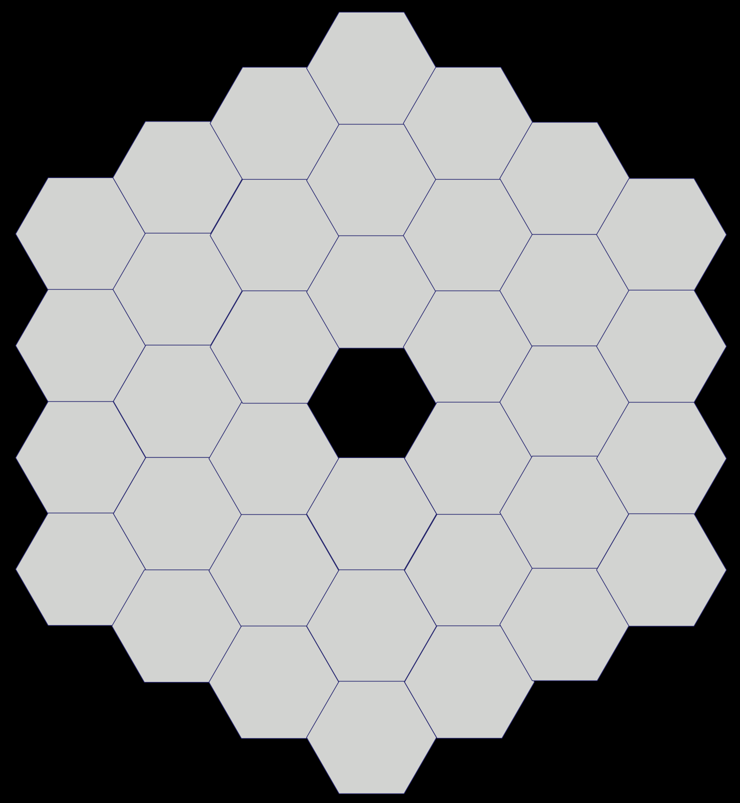
Starlight Suppression: Future

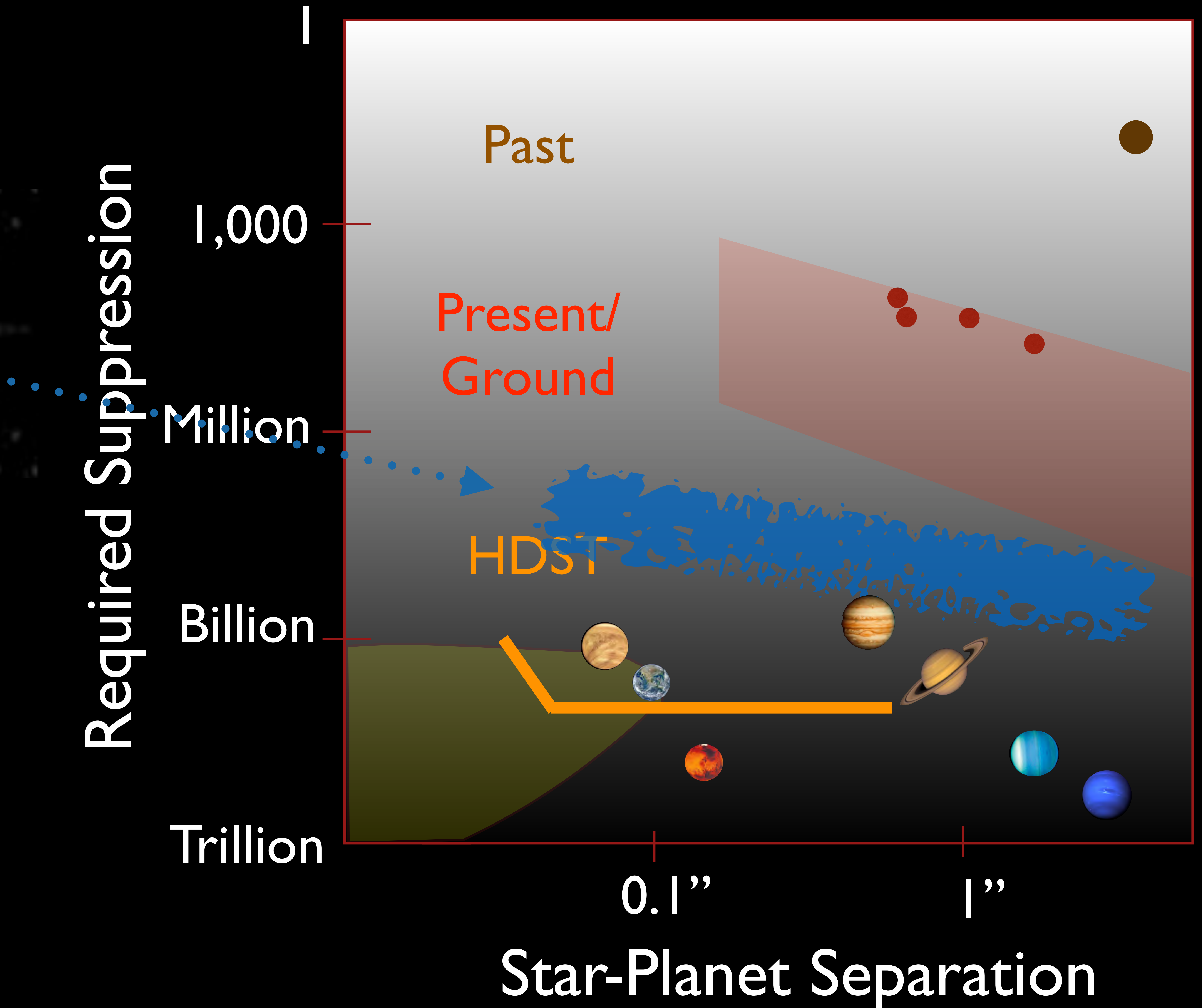




Starlight Suppression: Progress

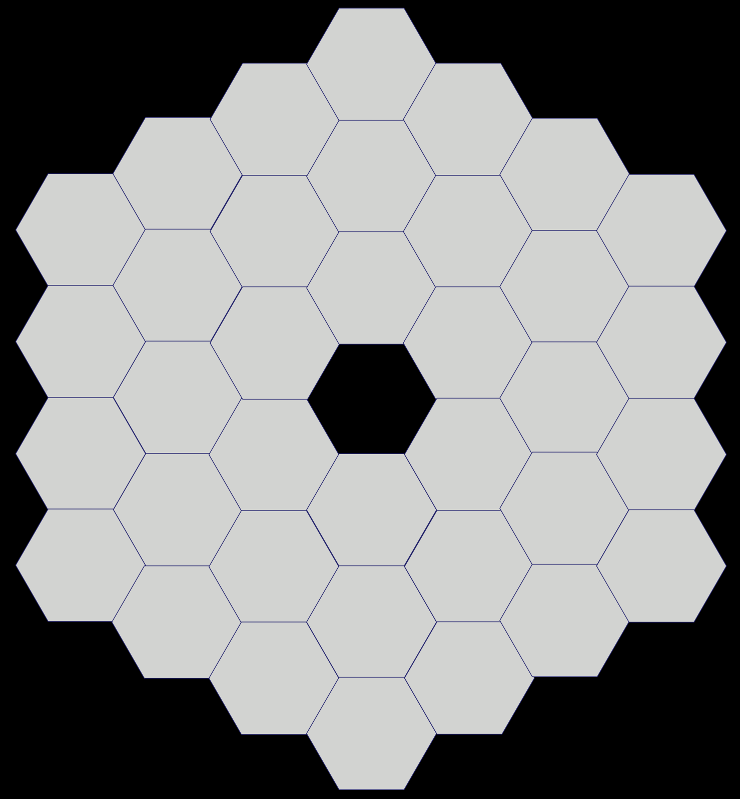
HDST-Specific Designs
for Segmented Mirrors

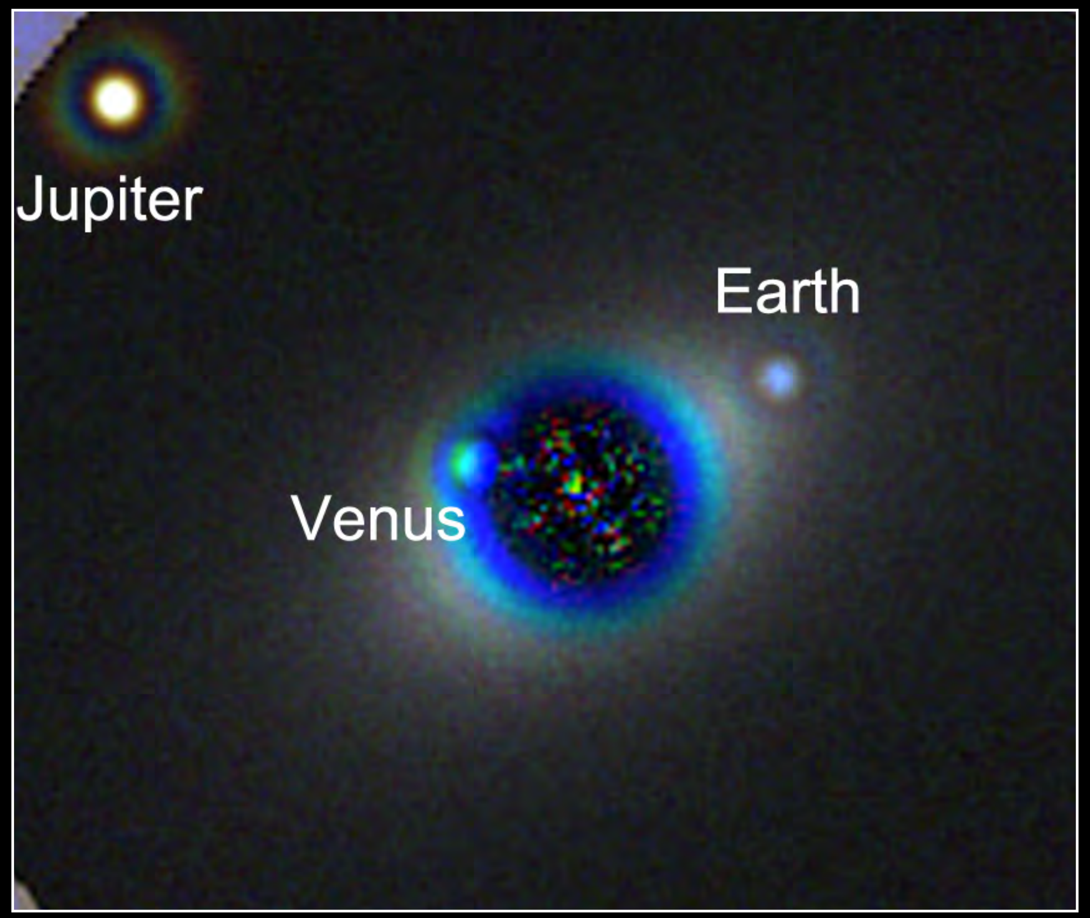


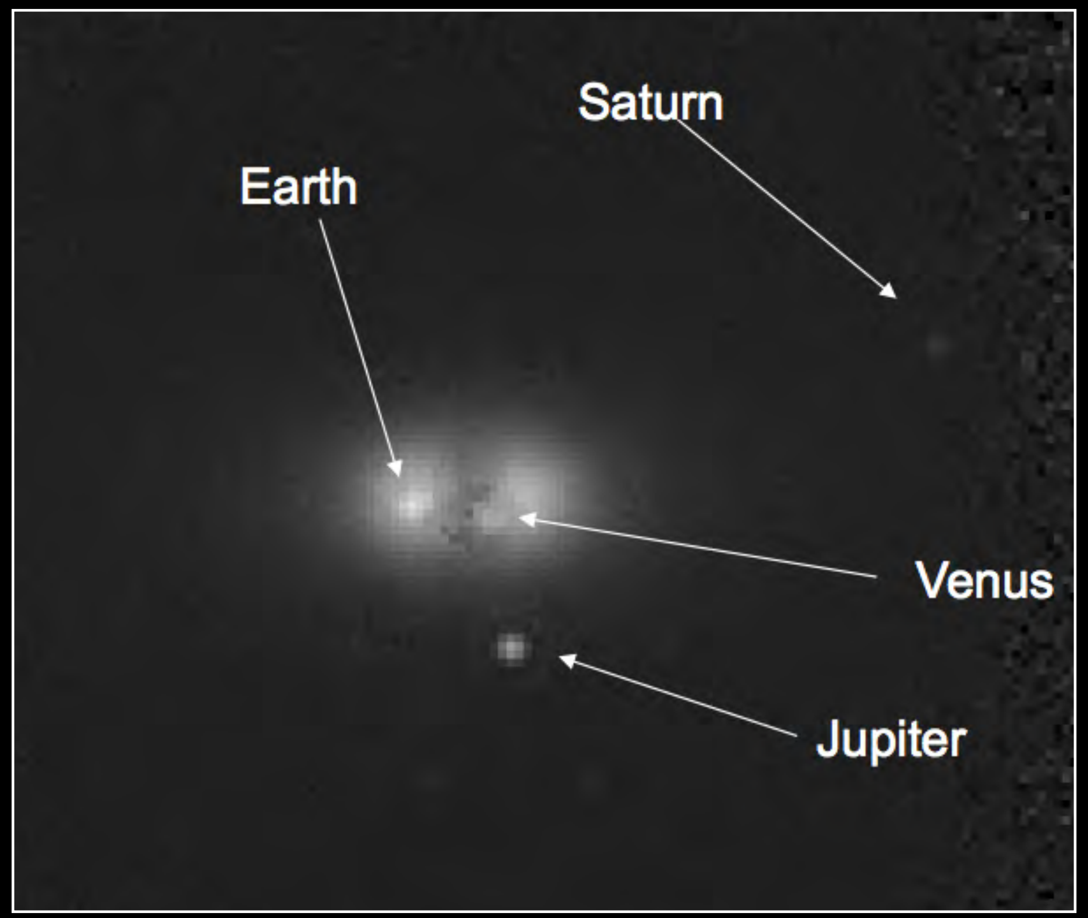


Starlight Suppression: Progress

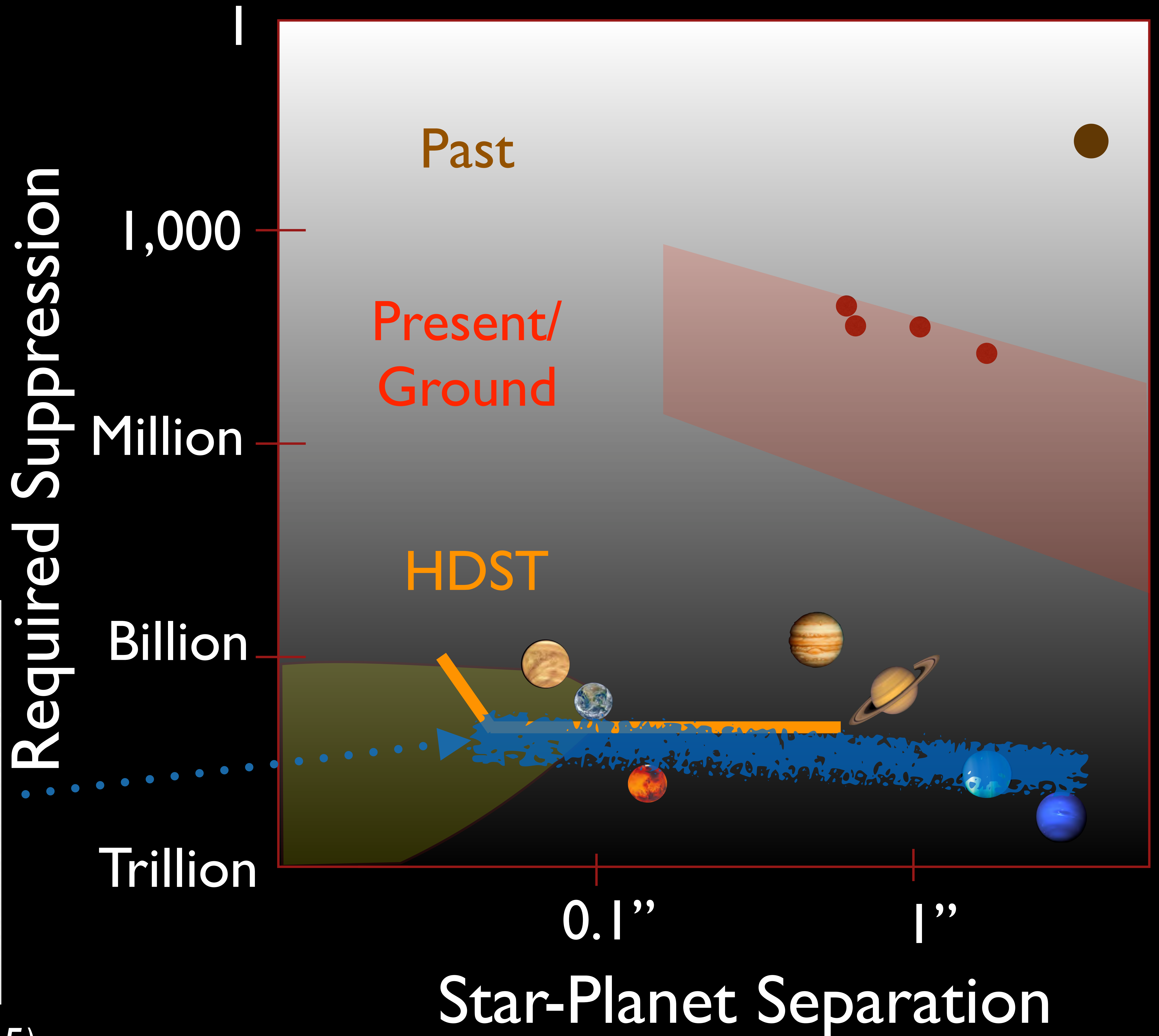
HDST-Specific Designs for Segmented Mirrors





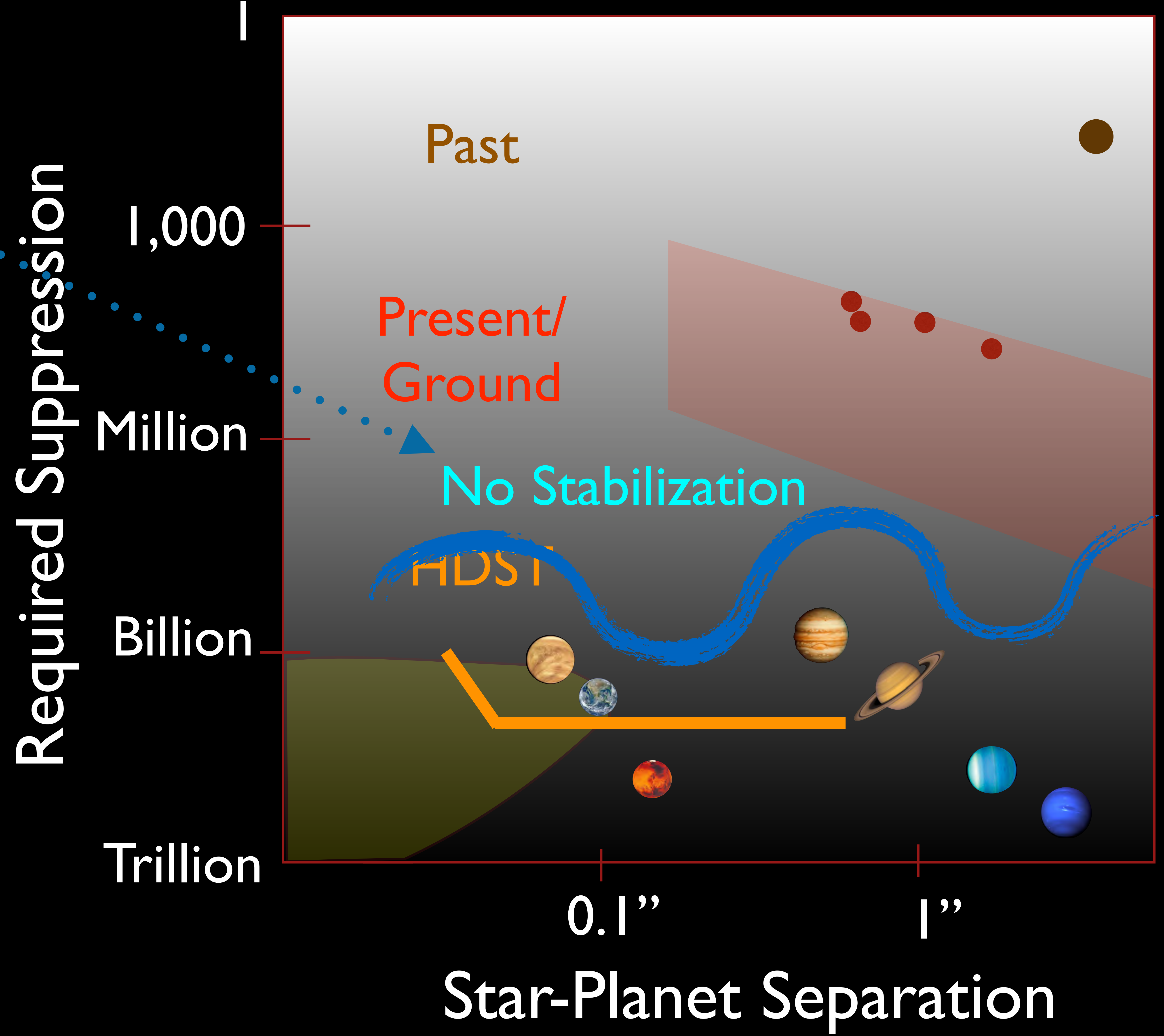


N'Daiye, et al. (2015), Guyon (2015) and Lyon, et al. (2015)



Starlight Suppression: Progress

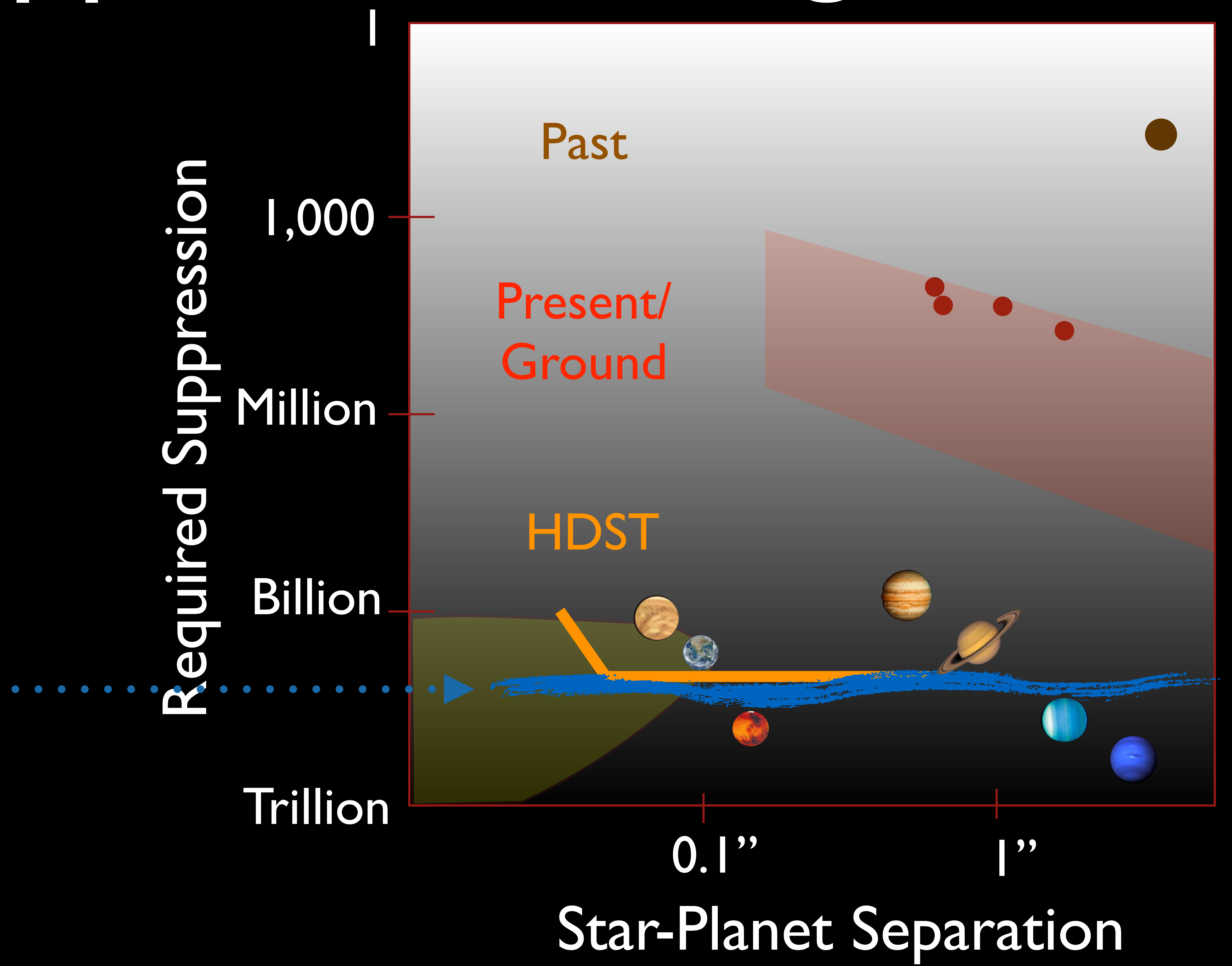
Thermal and Vibrational Stability



Starlight Suppression: Progress

Thermal and Vibrational Stability

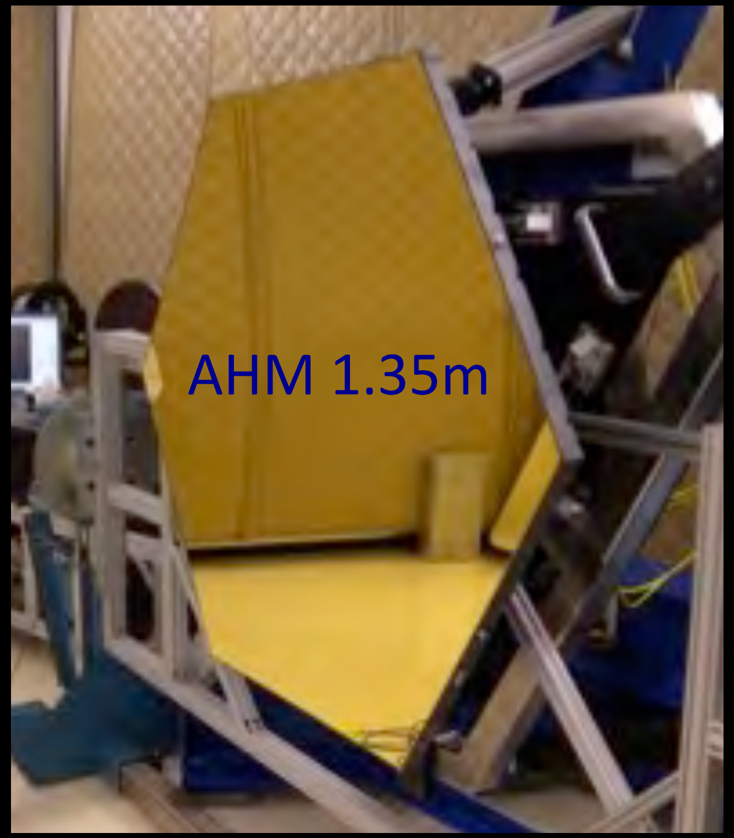
Sun-Earth L2 Orbit

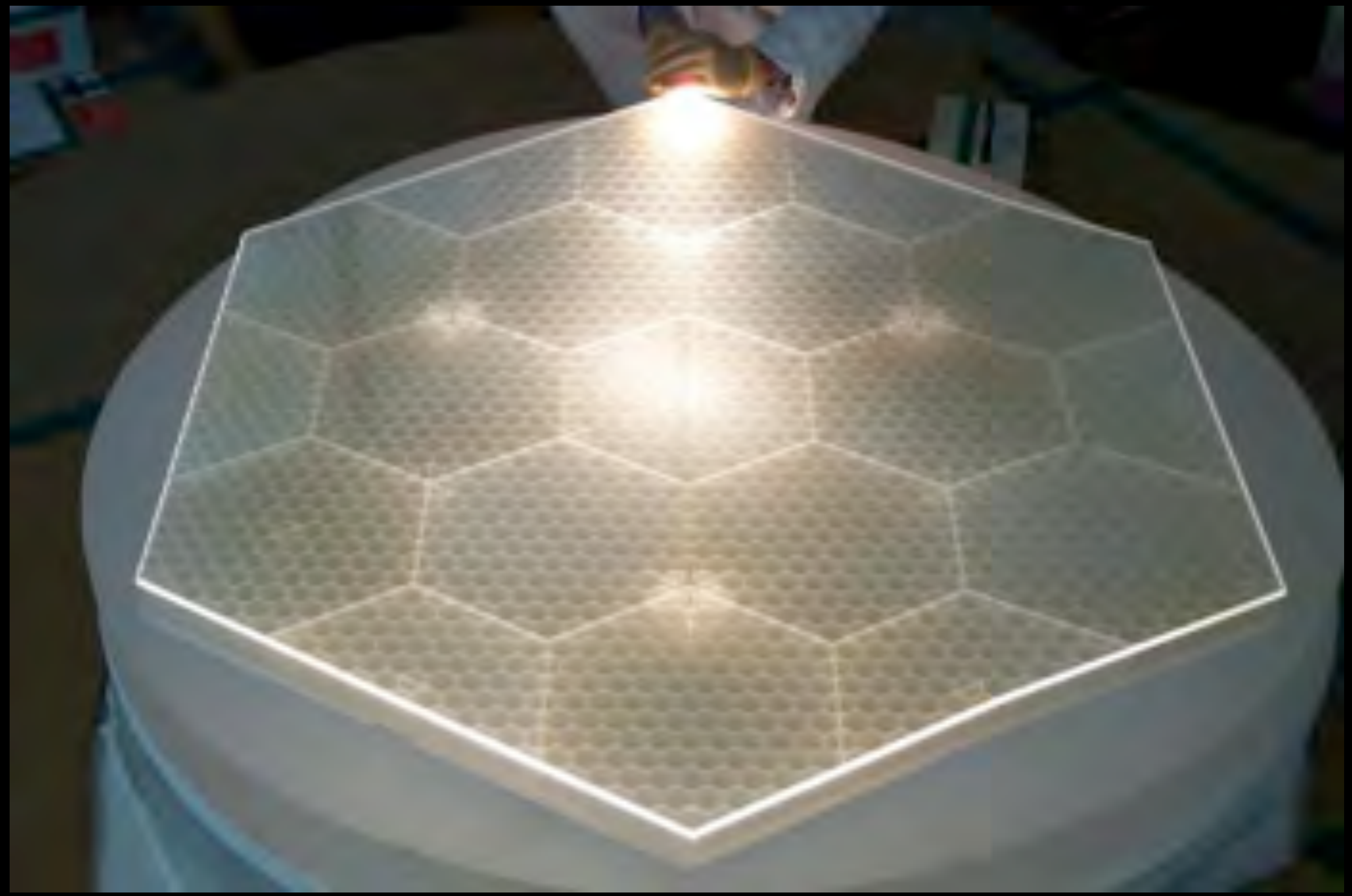


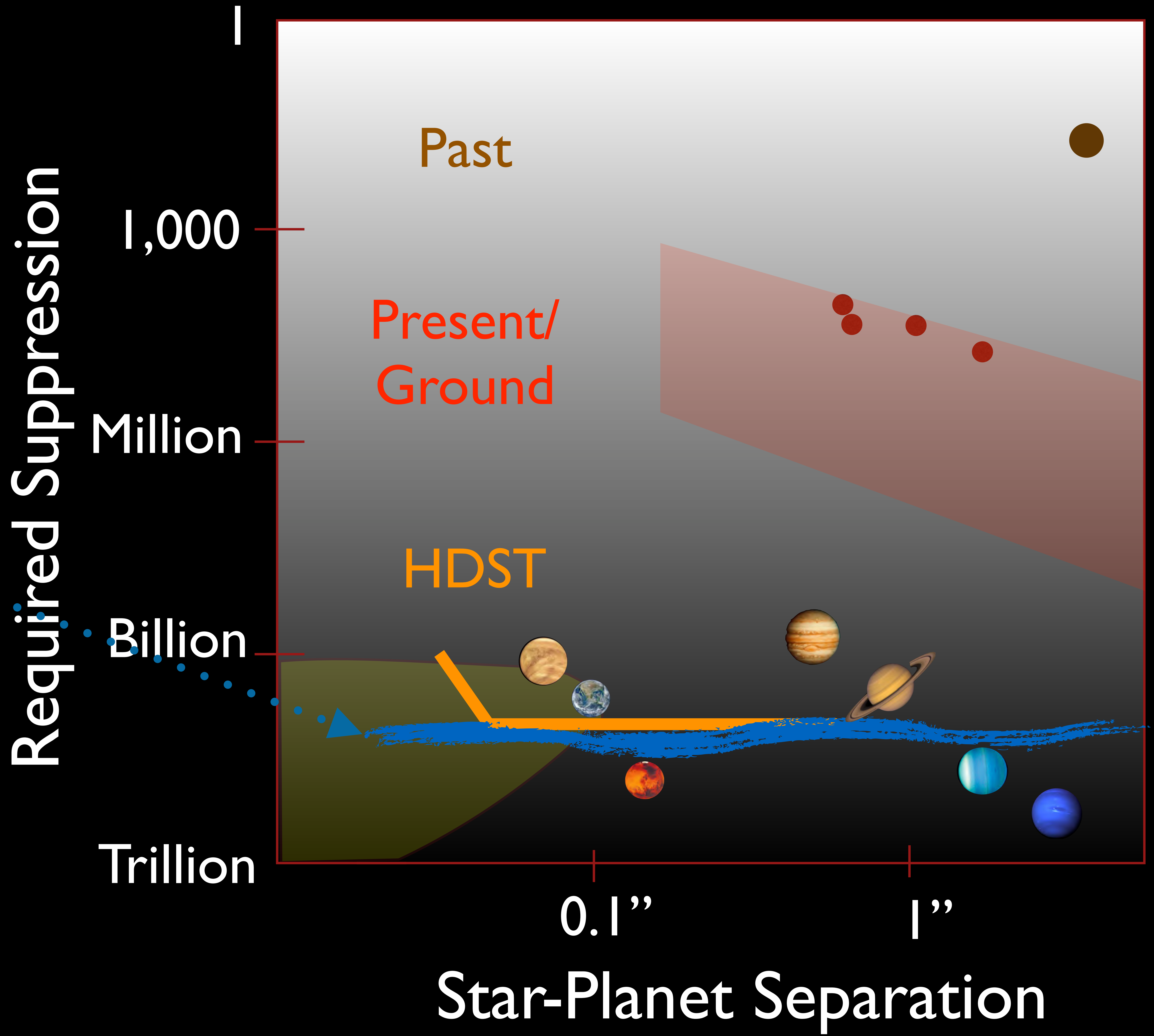
Starlight Suppression: Progress

Thermal and Vibrational Stability

Active Mirror Technology

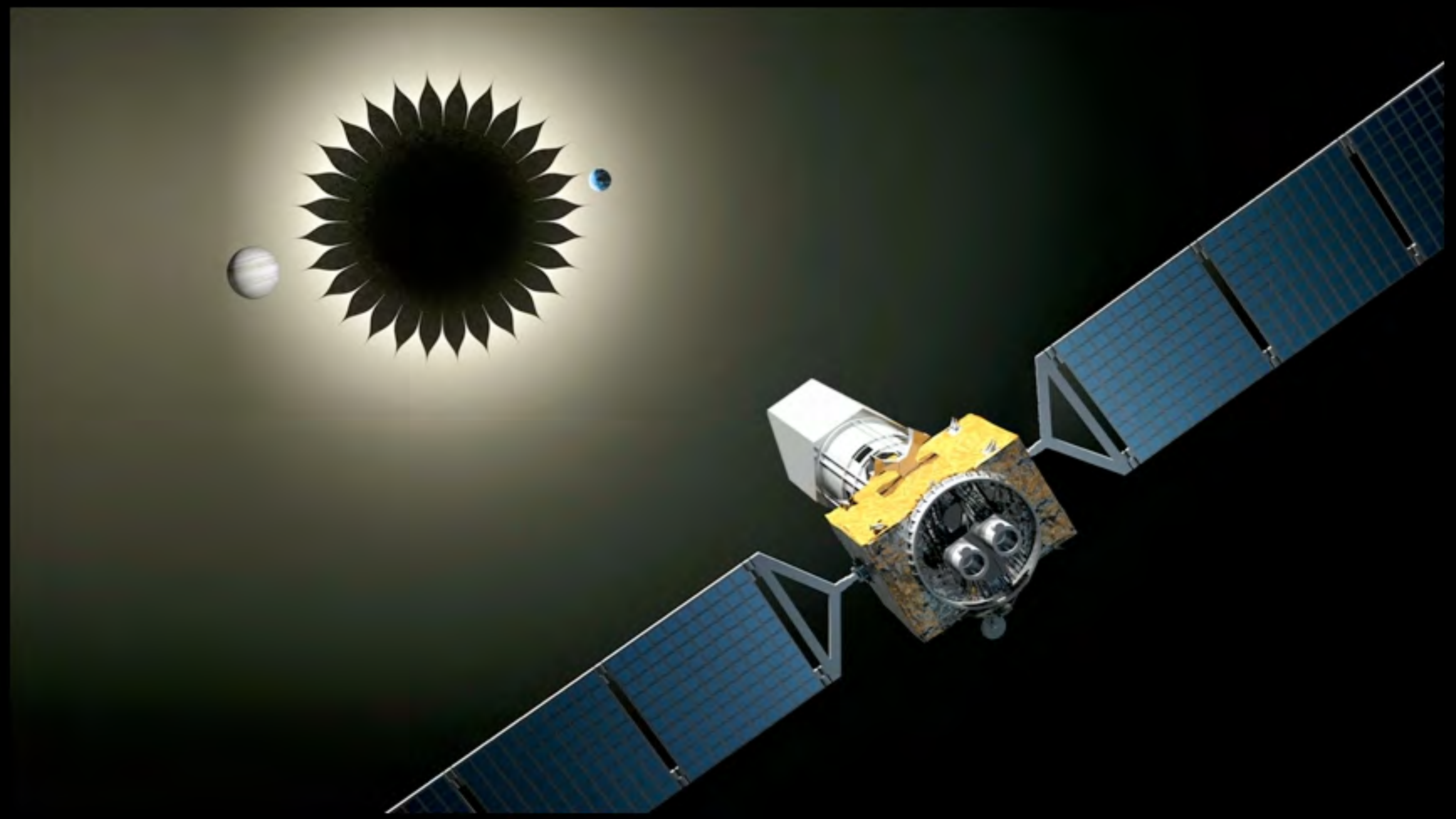






Starlight Suppression: Progress

Starshade Technology



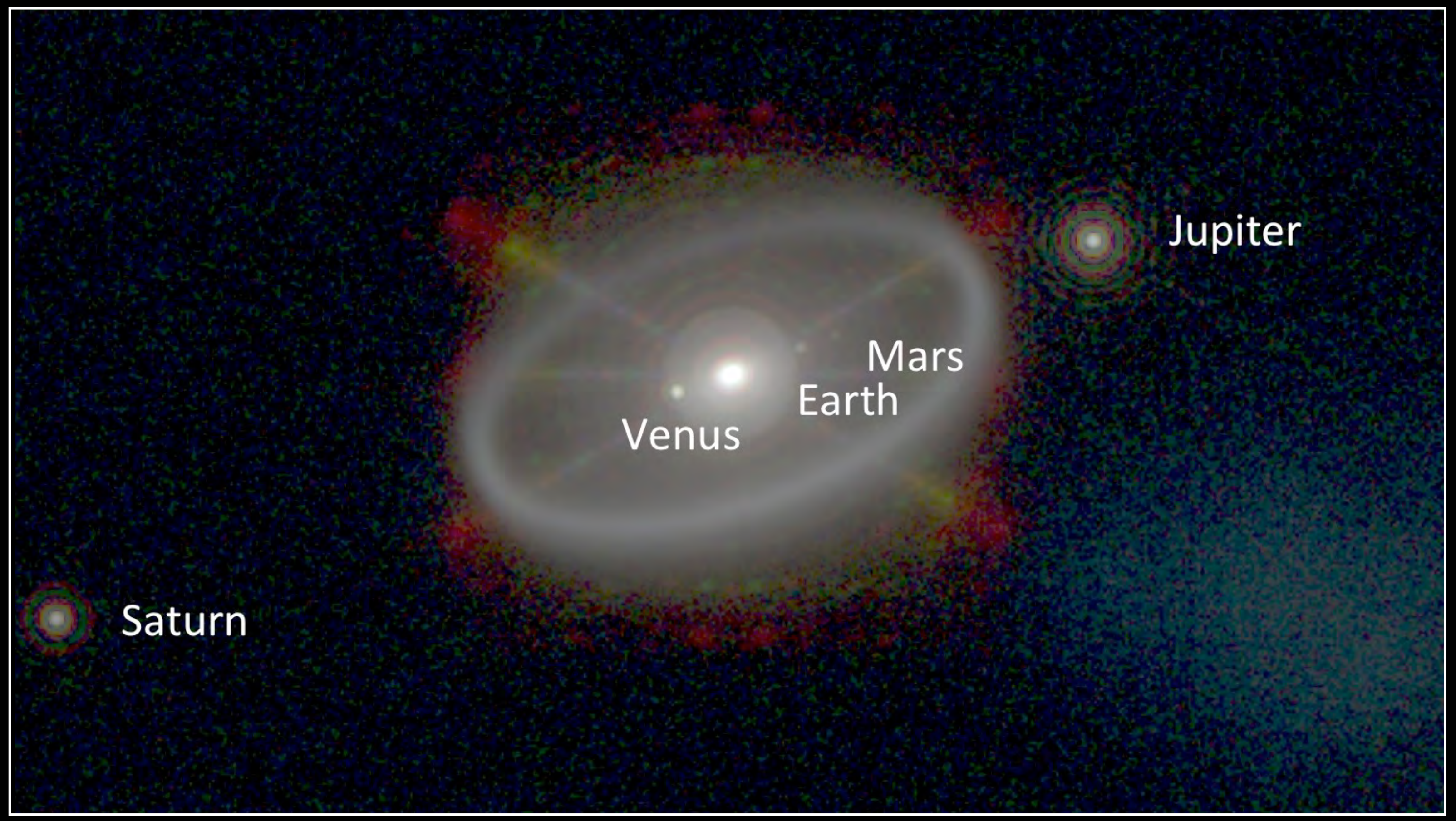
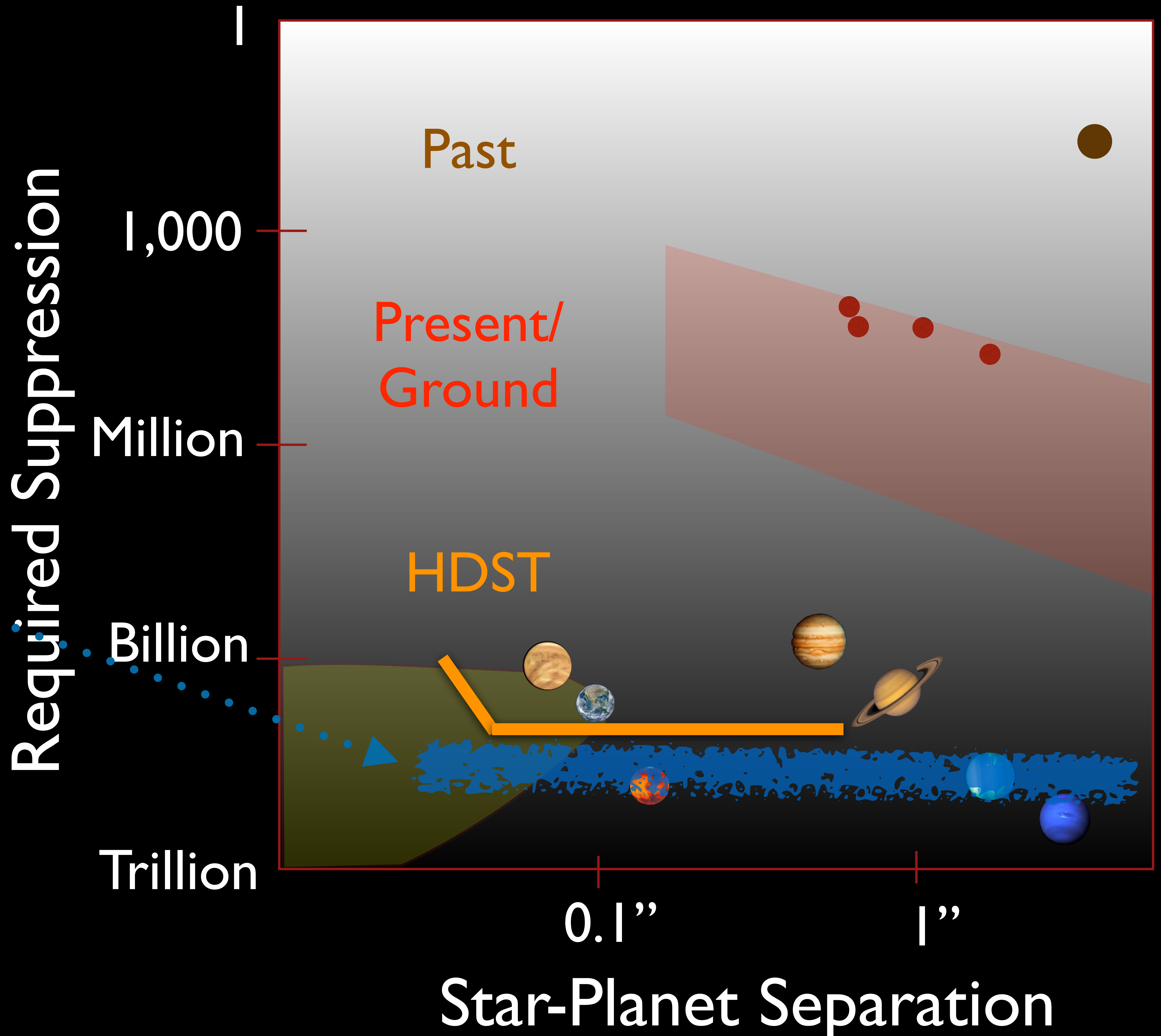
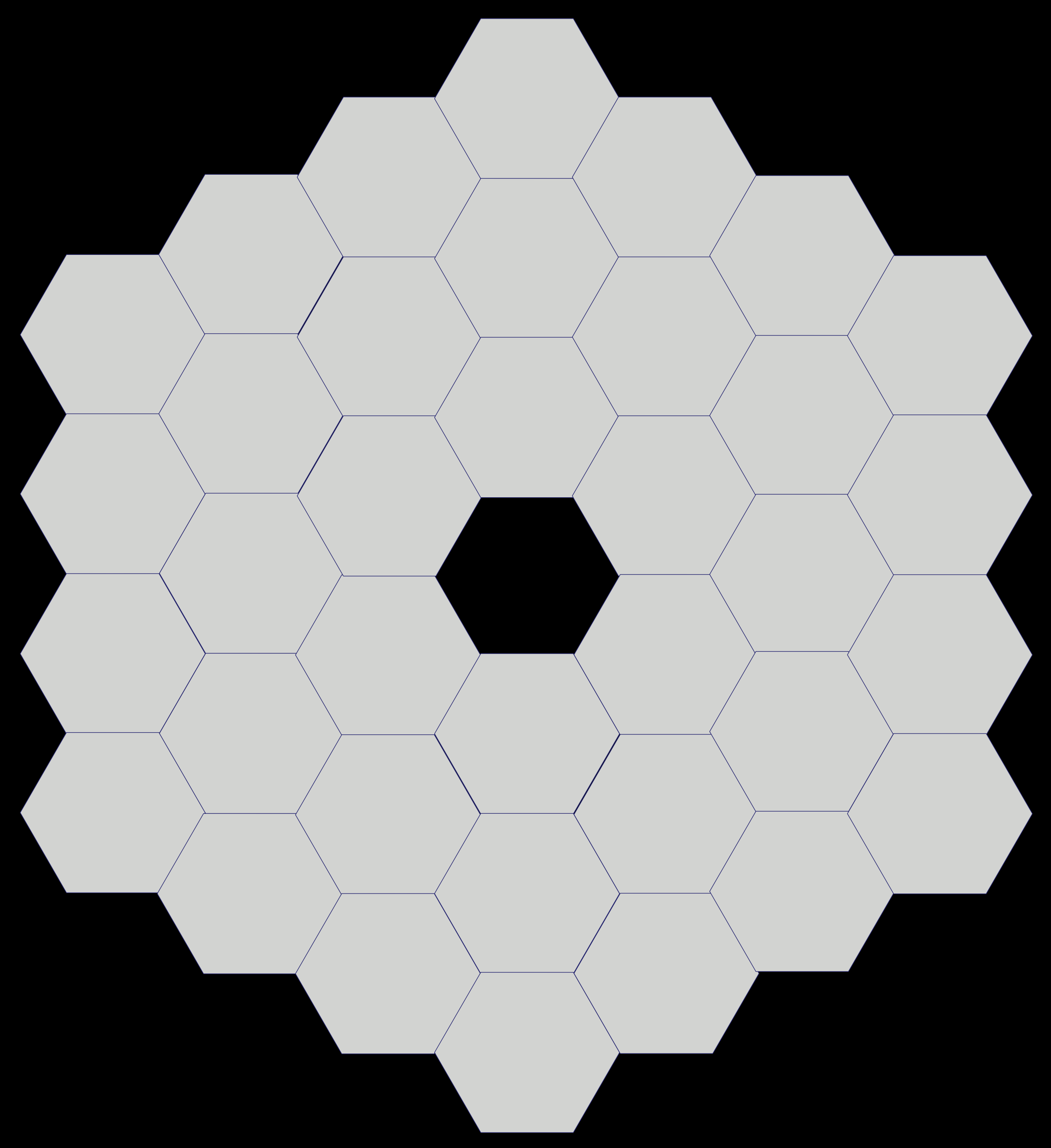


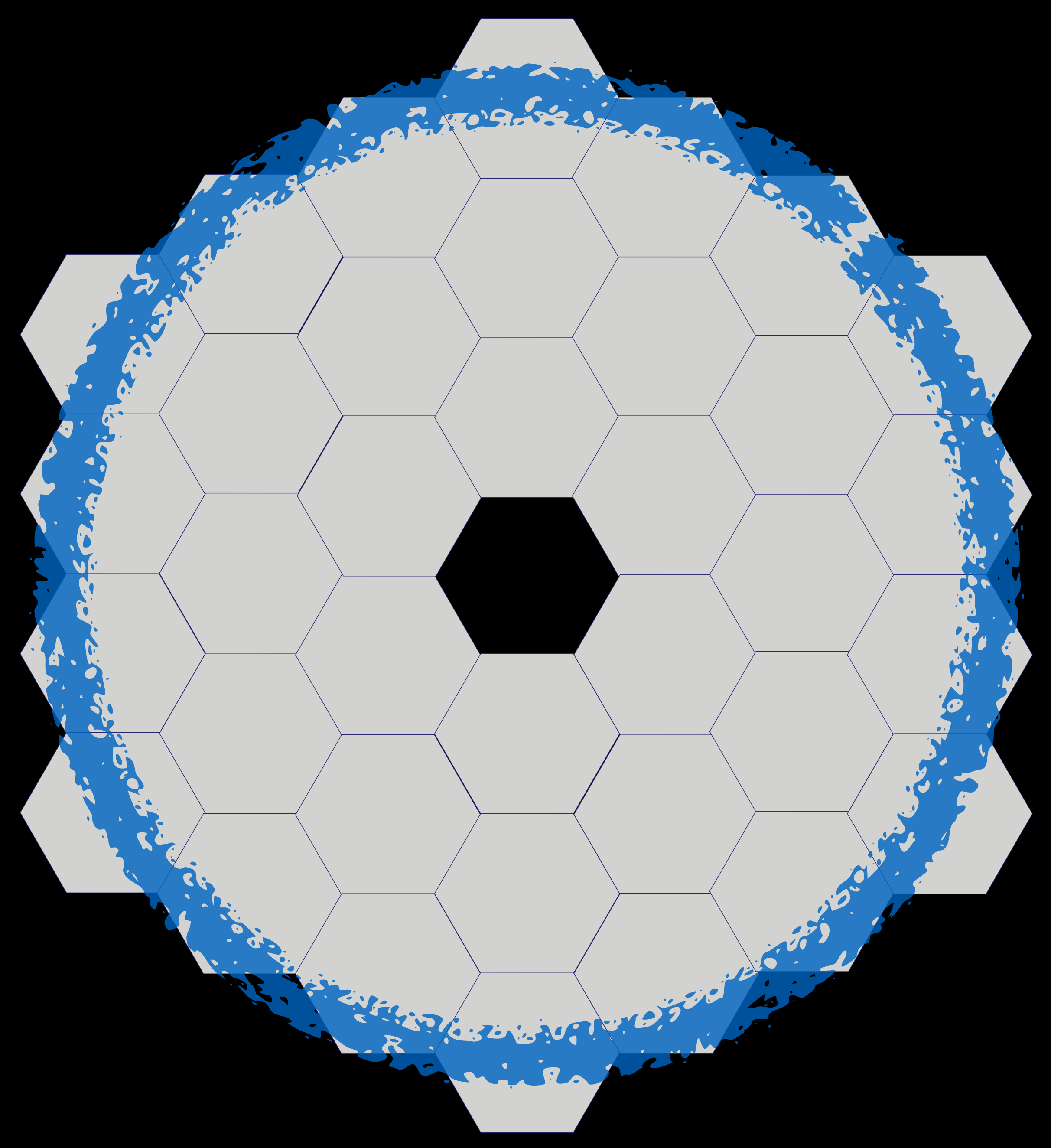
Image Credit: Kuchner (2015)



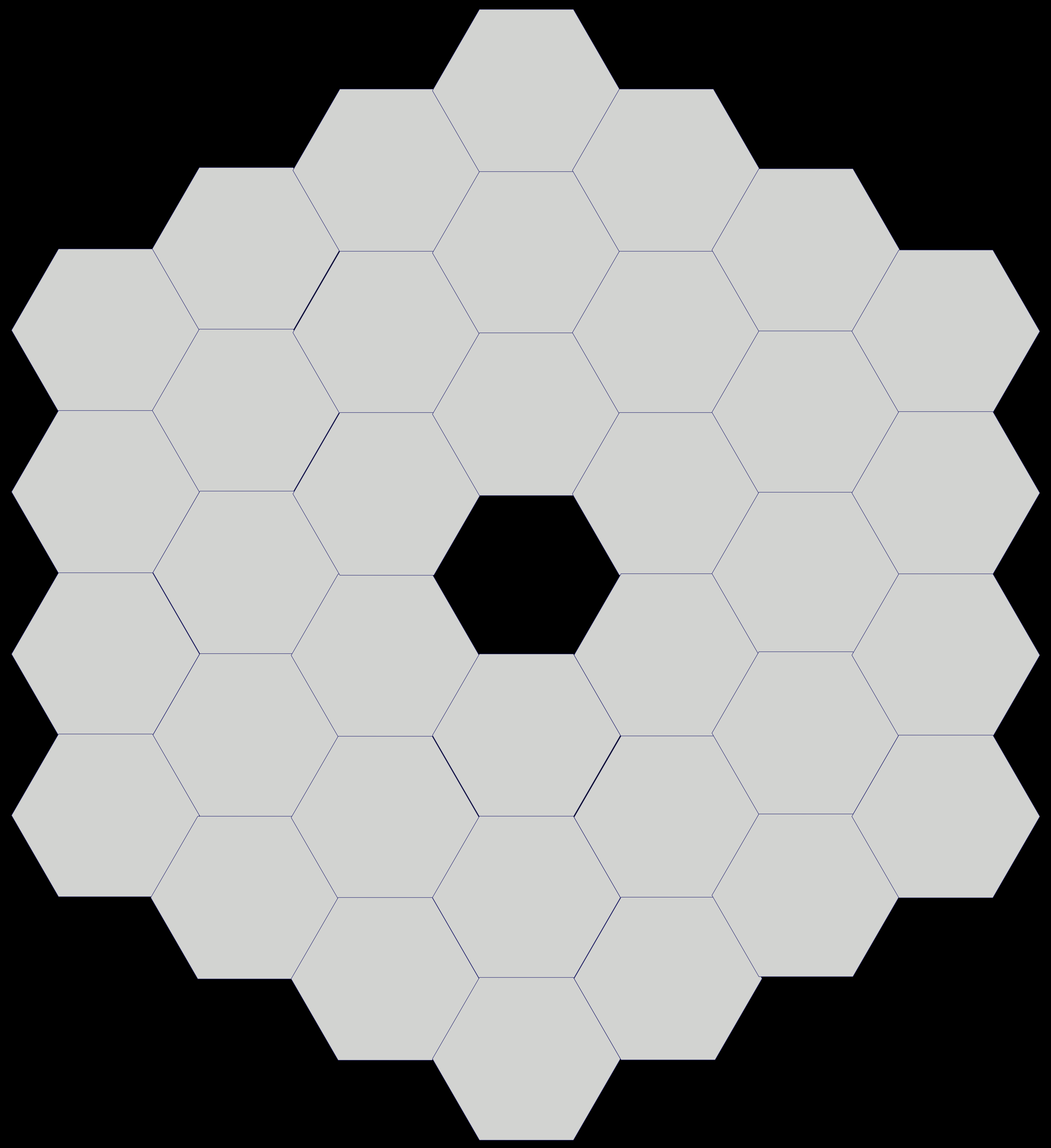
Leveraging JWST



Leveraging JWST

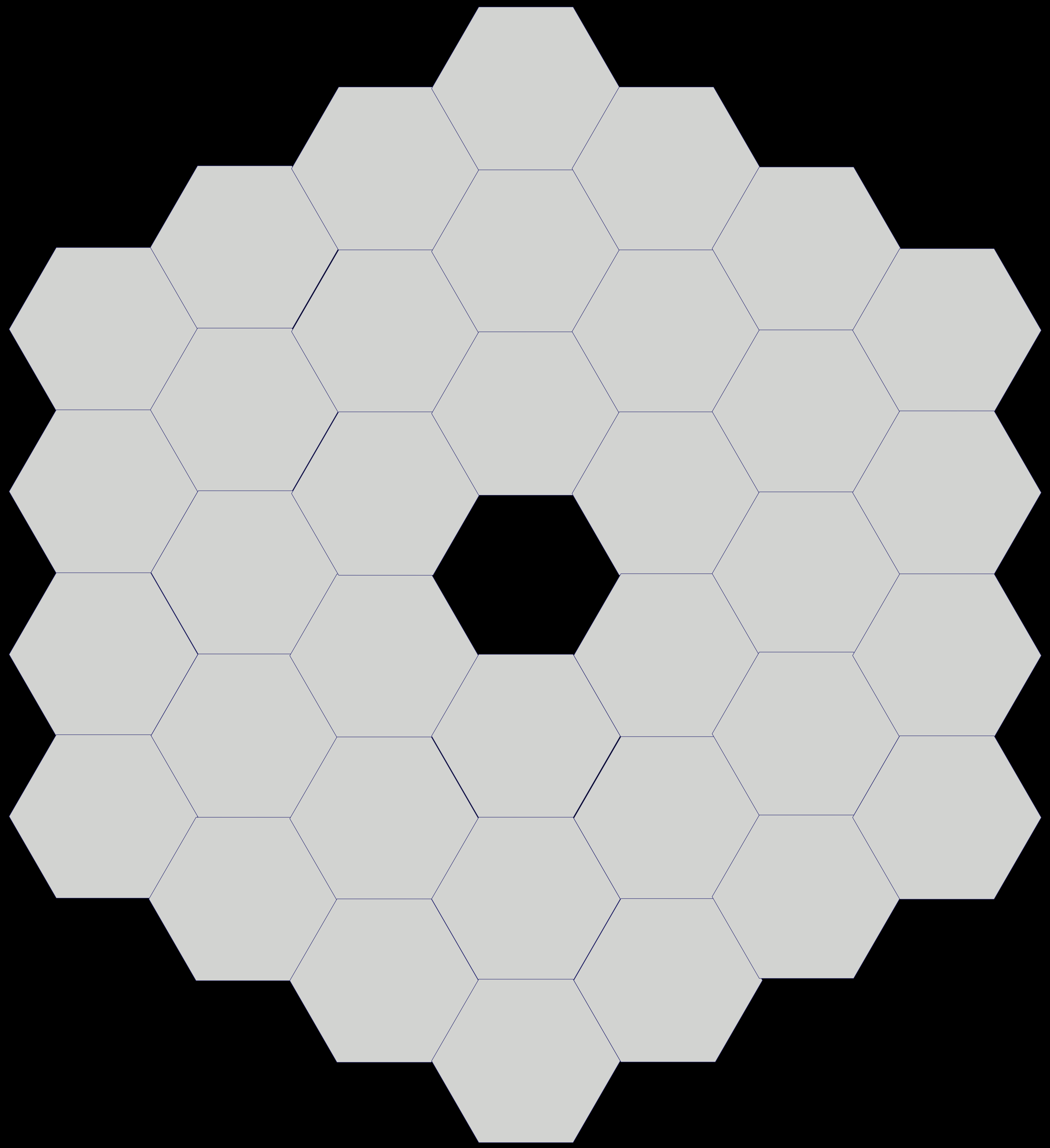


Large Collecting Area



exoEarths

Large Collecting Area



exoEarths

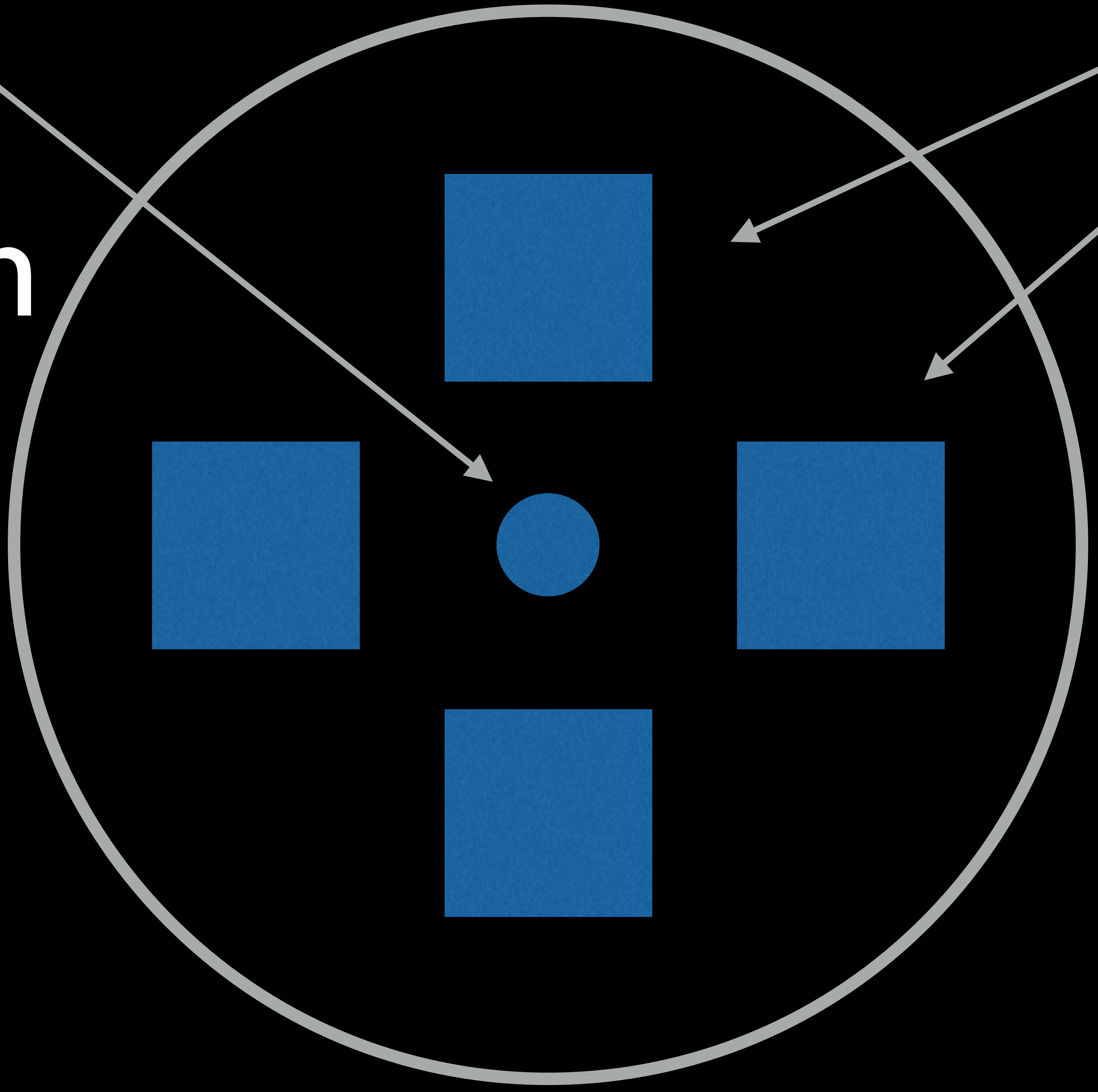
Transform Astronomy in the 21st Century

HDST Instruments

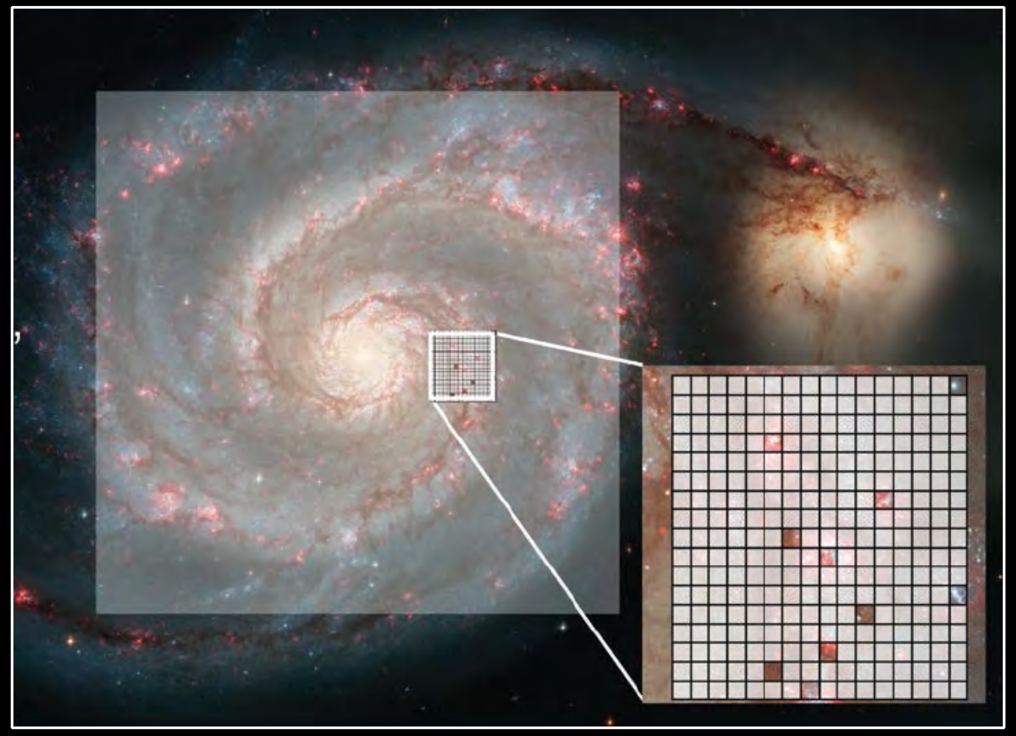
Narrow Field

exoEarth
Starlight Suppression

Wide Field

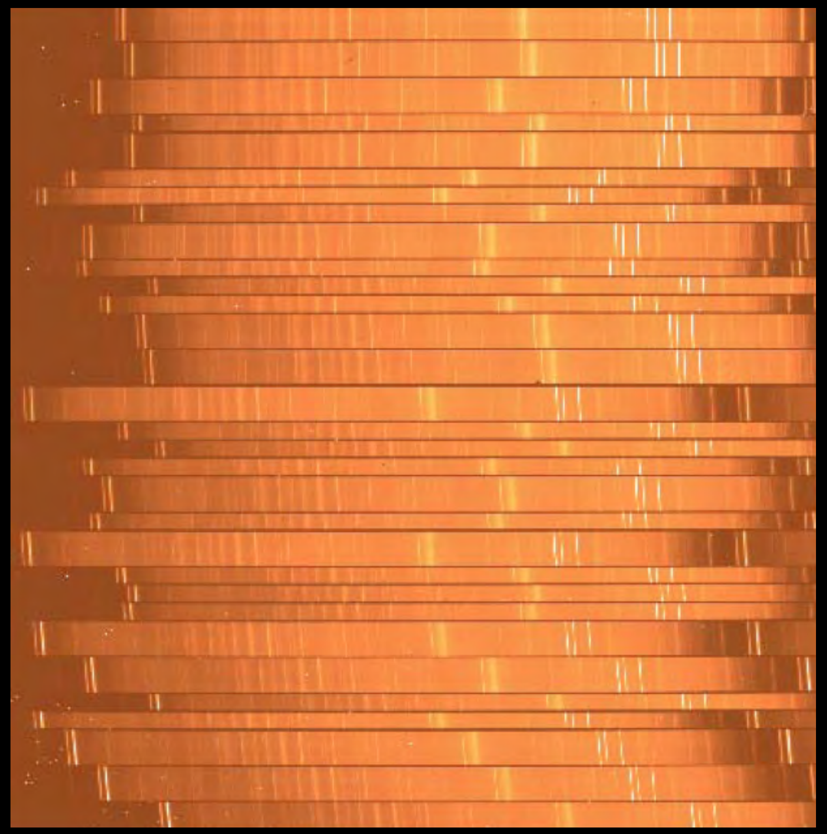


Imaging



UV
Spectra

Spectra

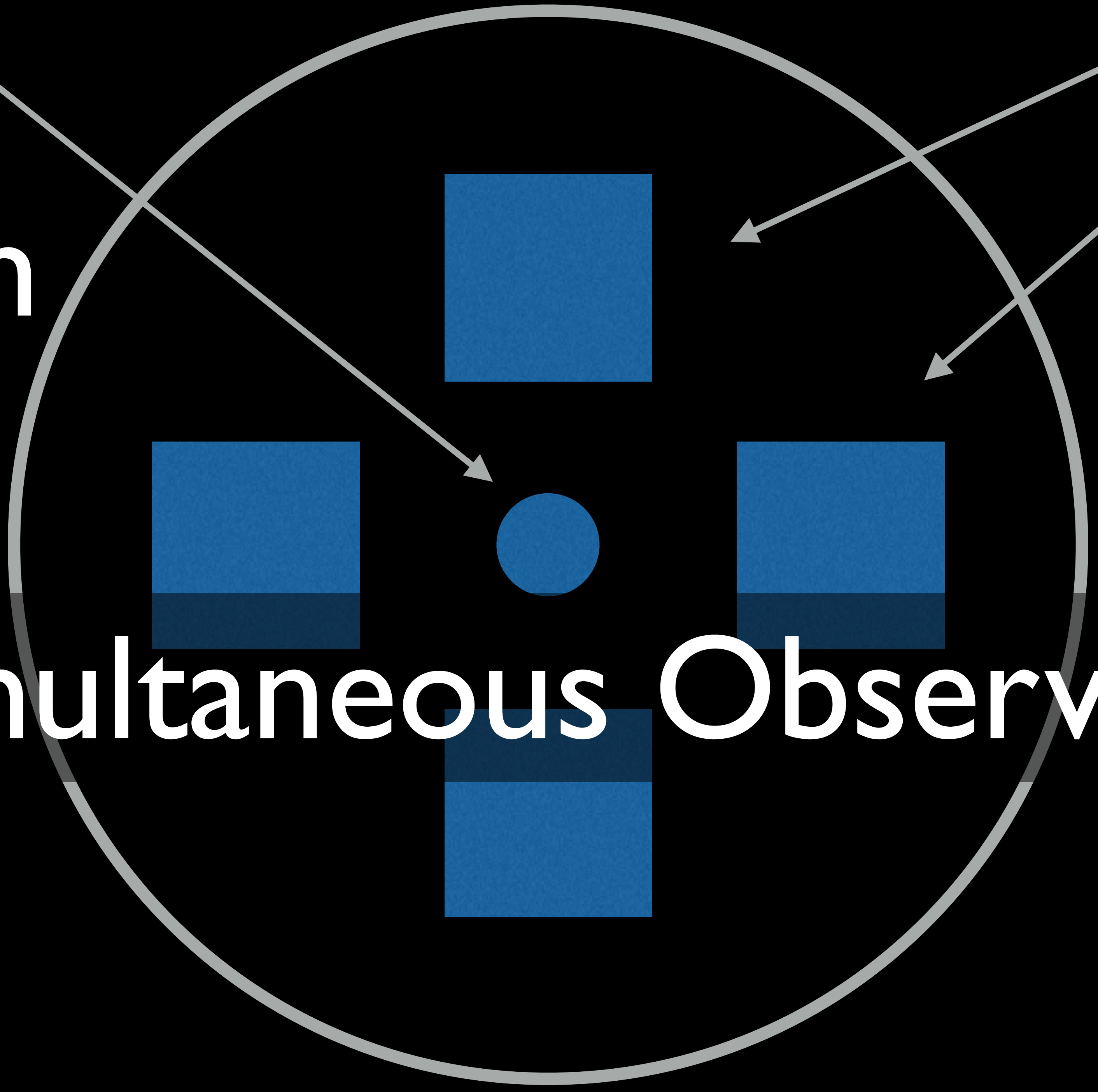


HDST Instruments

Narrow Field

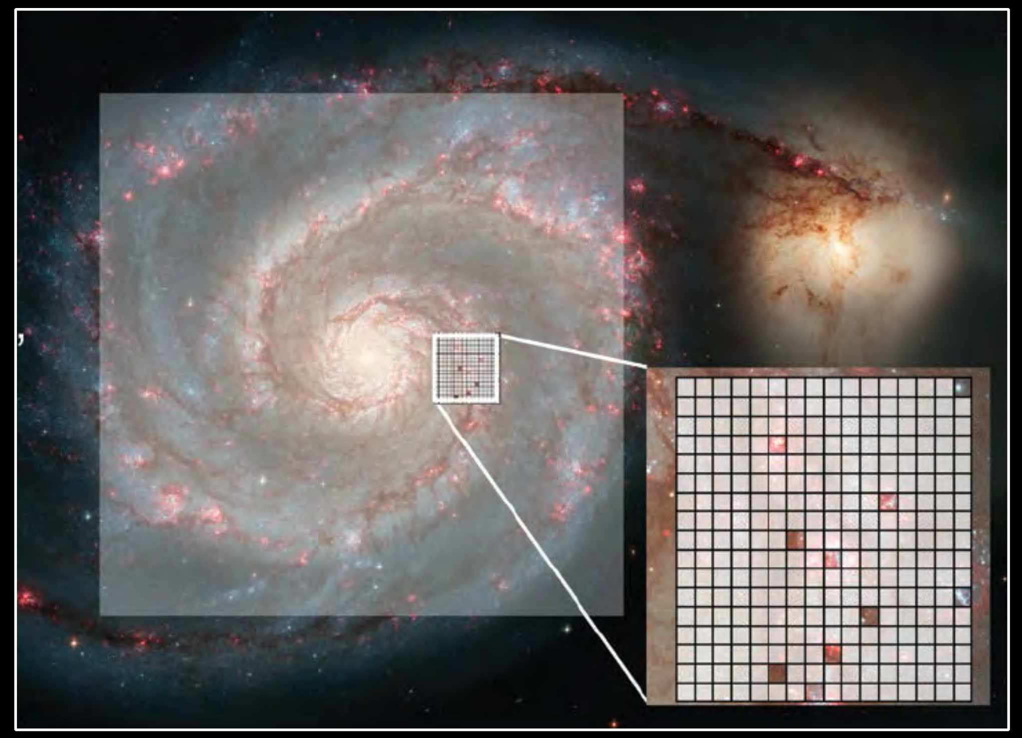
exoEarth
Starlight Suppression

Wide Field



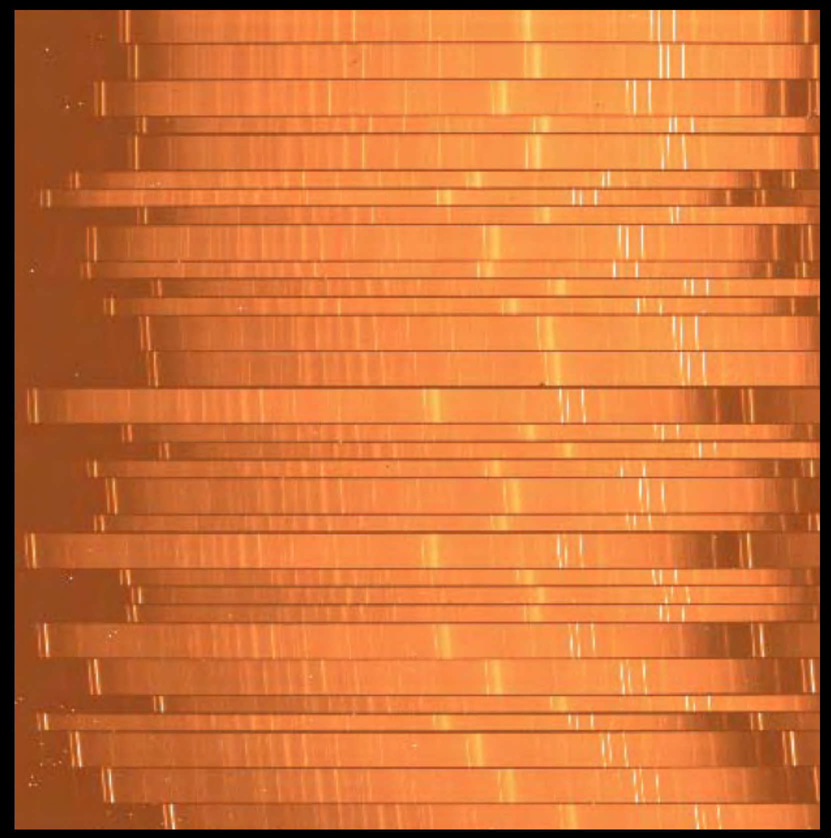
Imaging

Simultaneous Observing

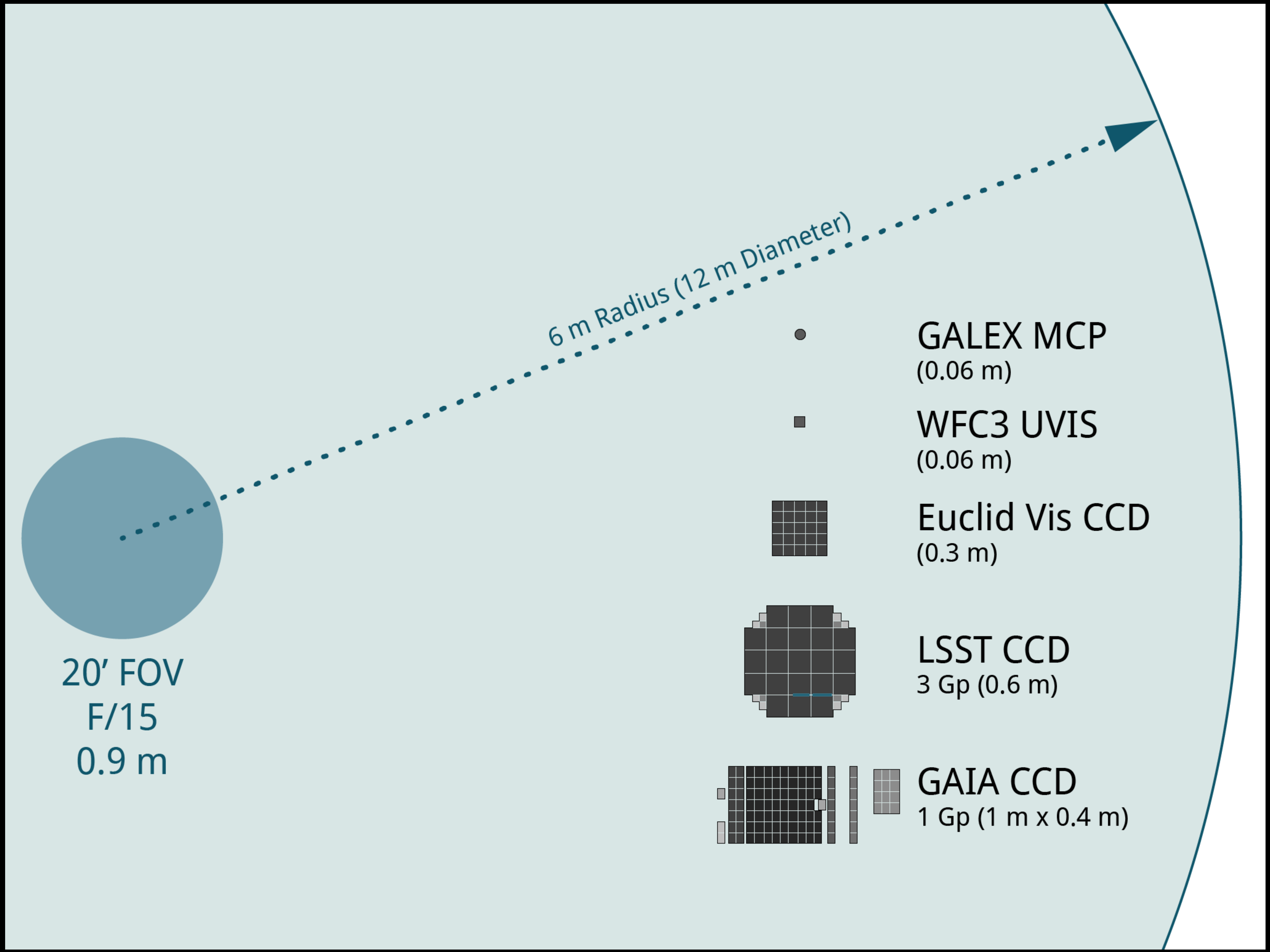


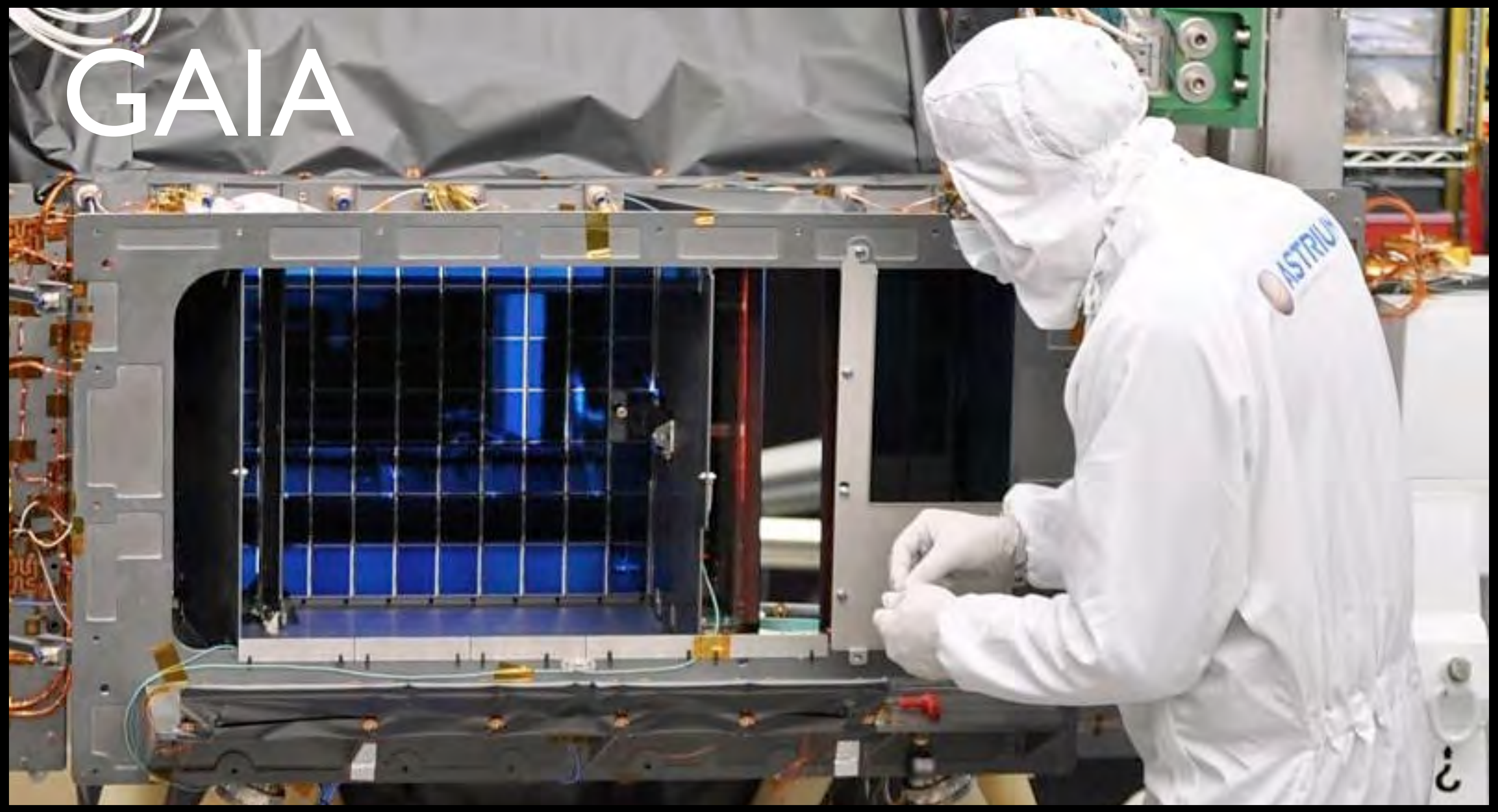
UV
Spectra

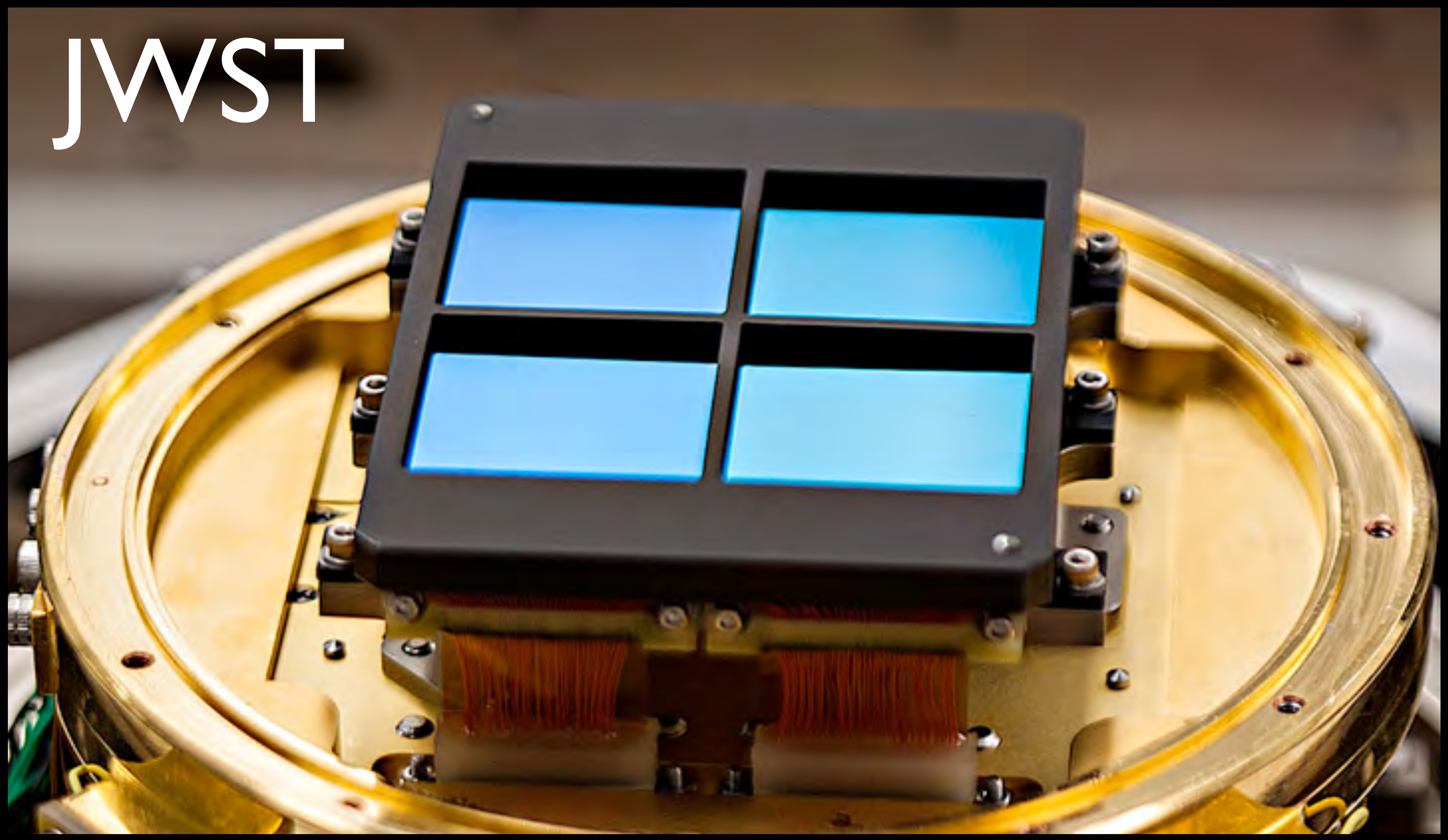
Spectra



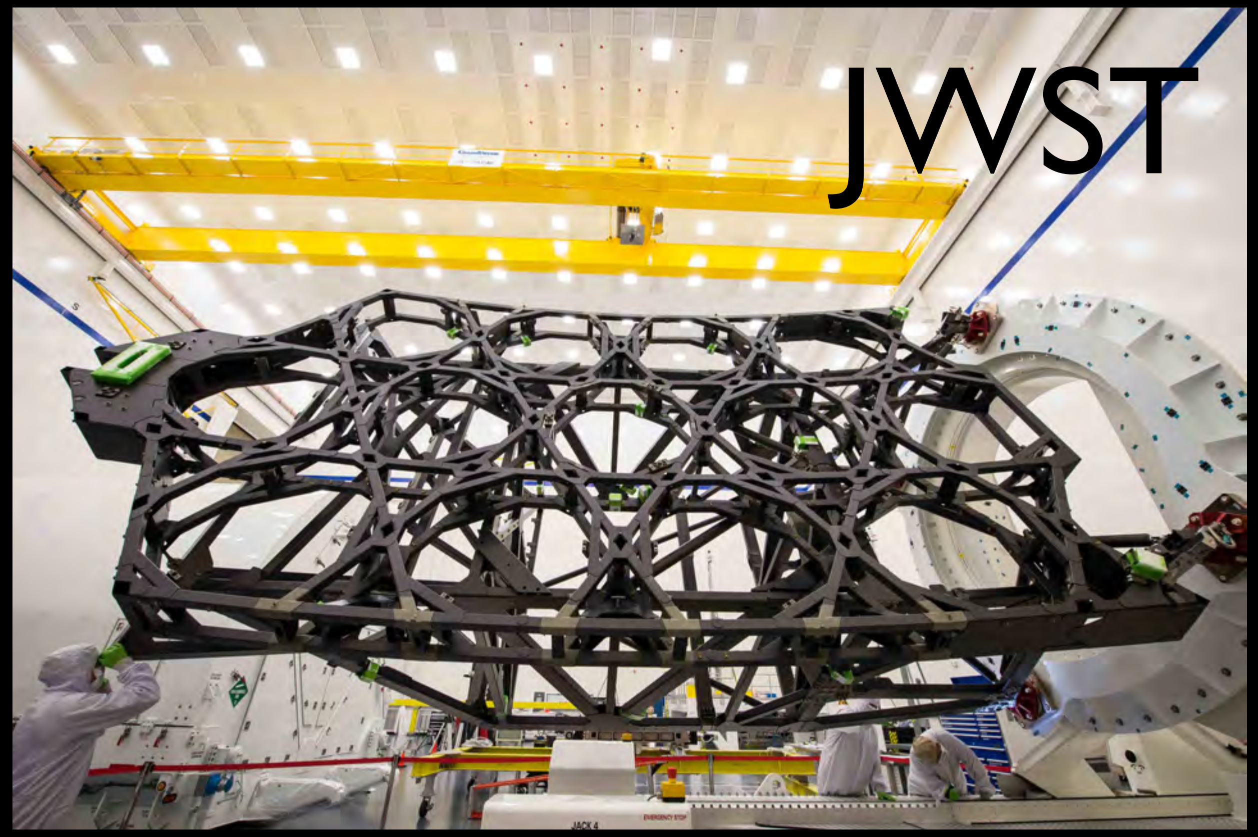
HDST Detectors

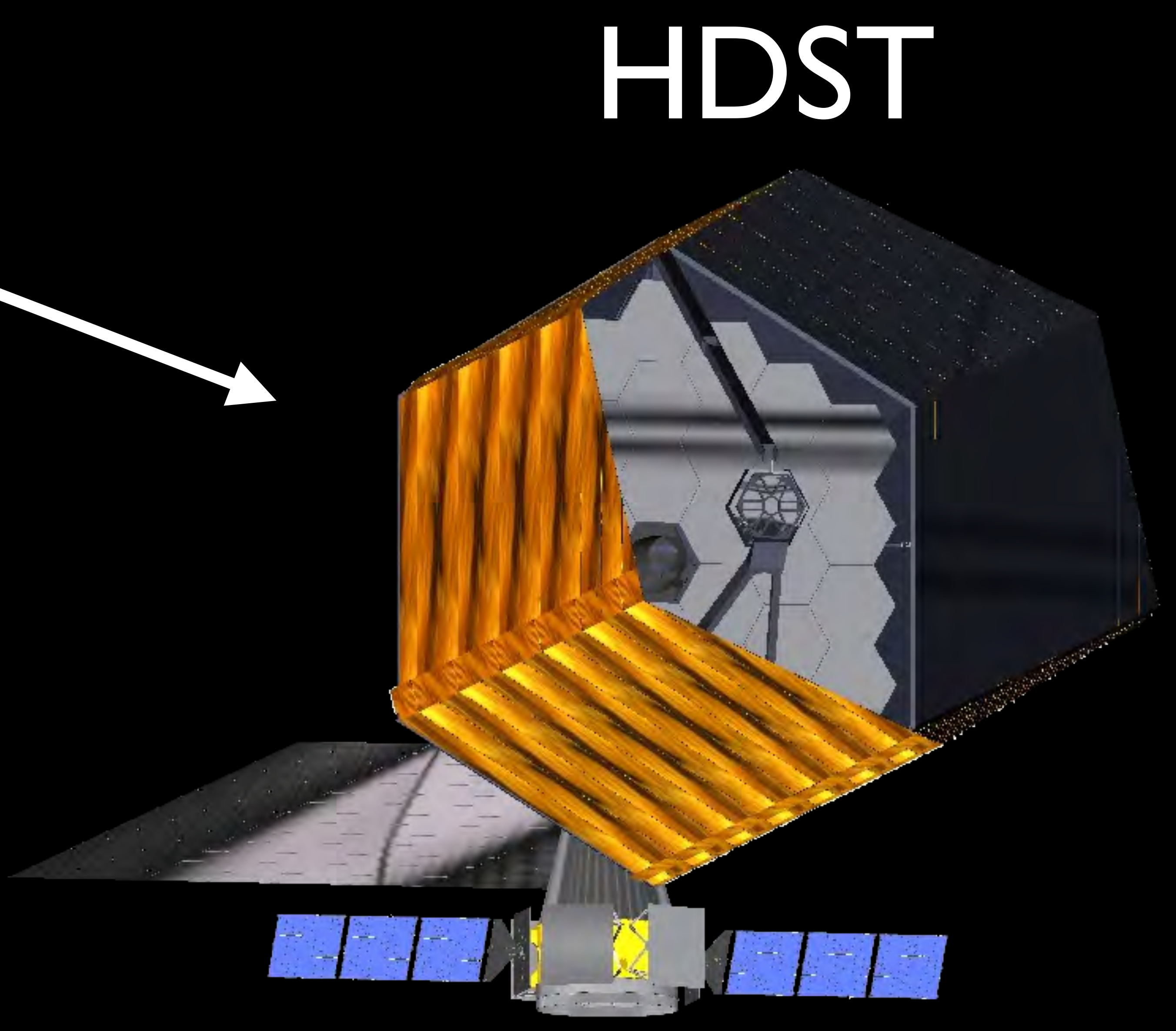


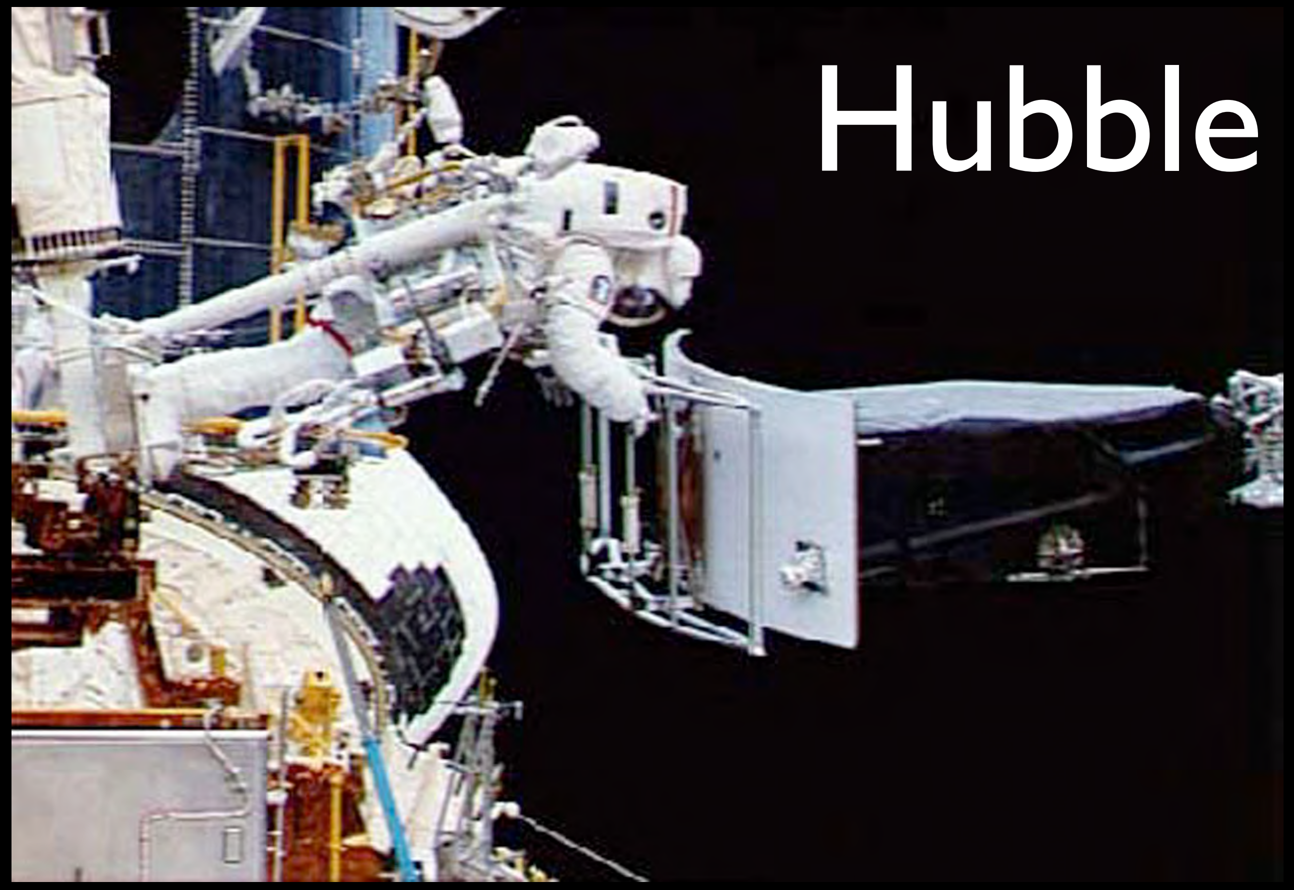


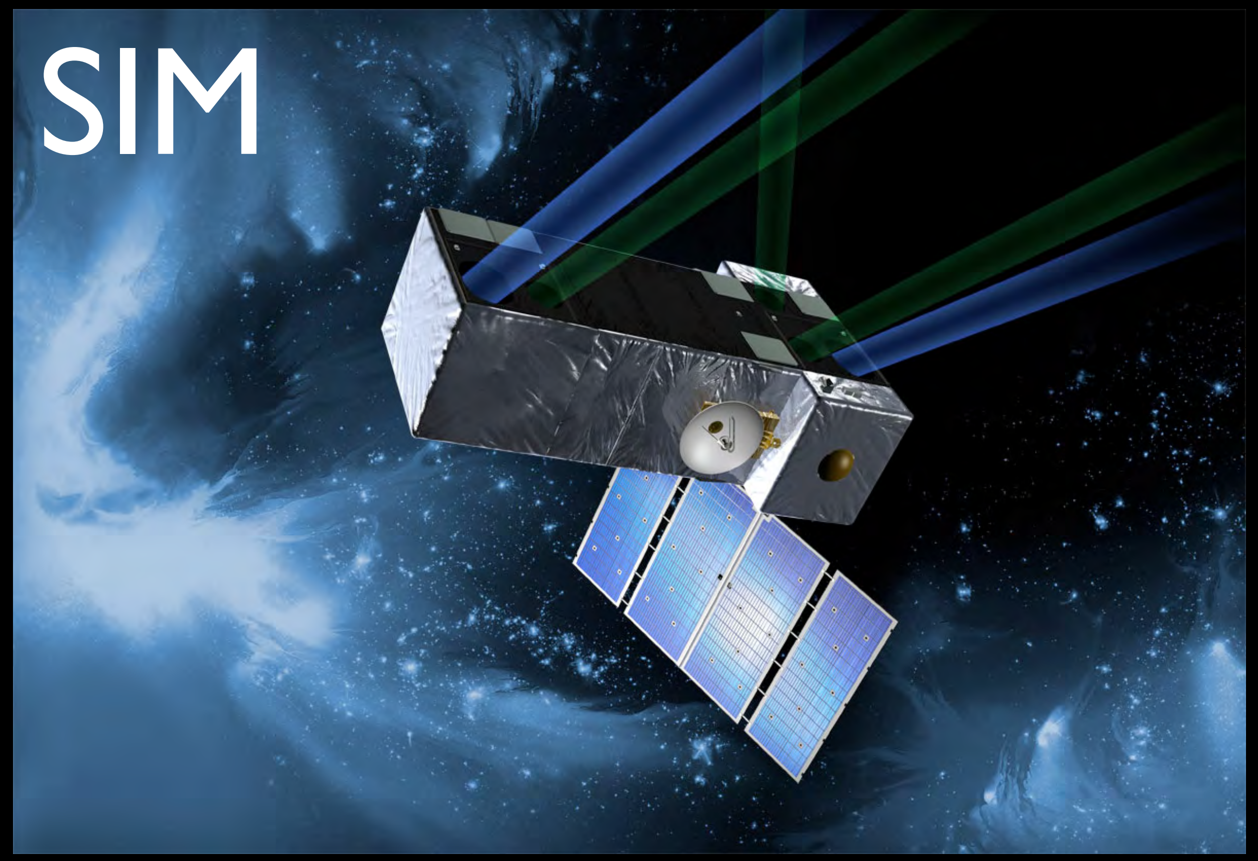


Dream Big, but Dream Smart





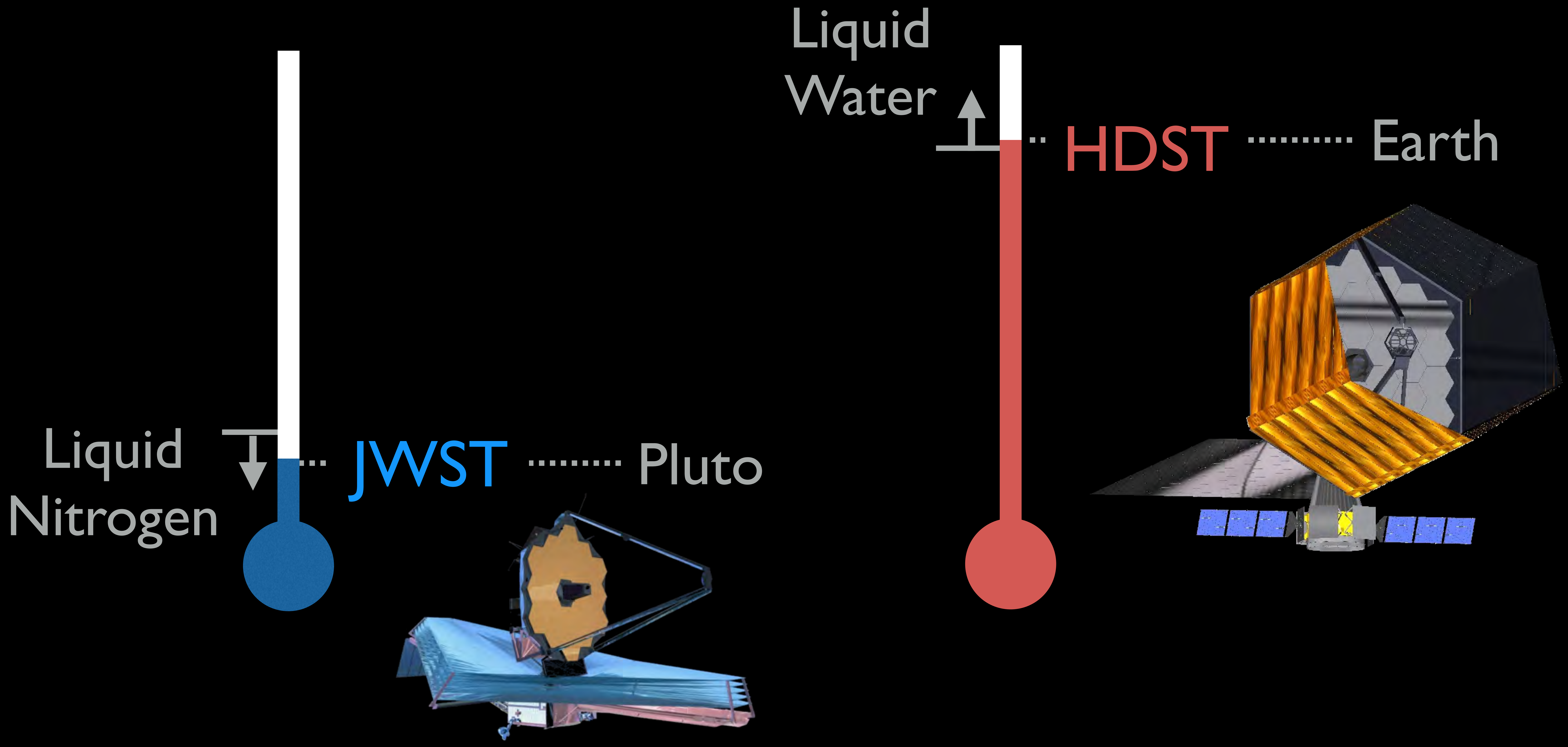




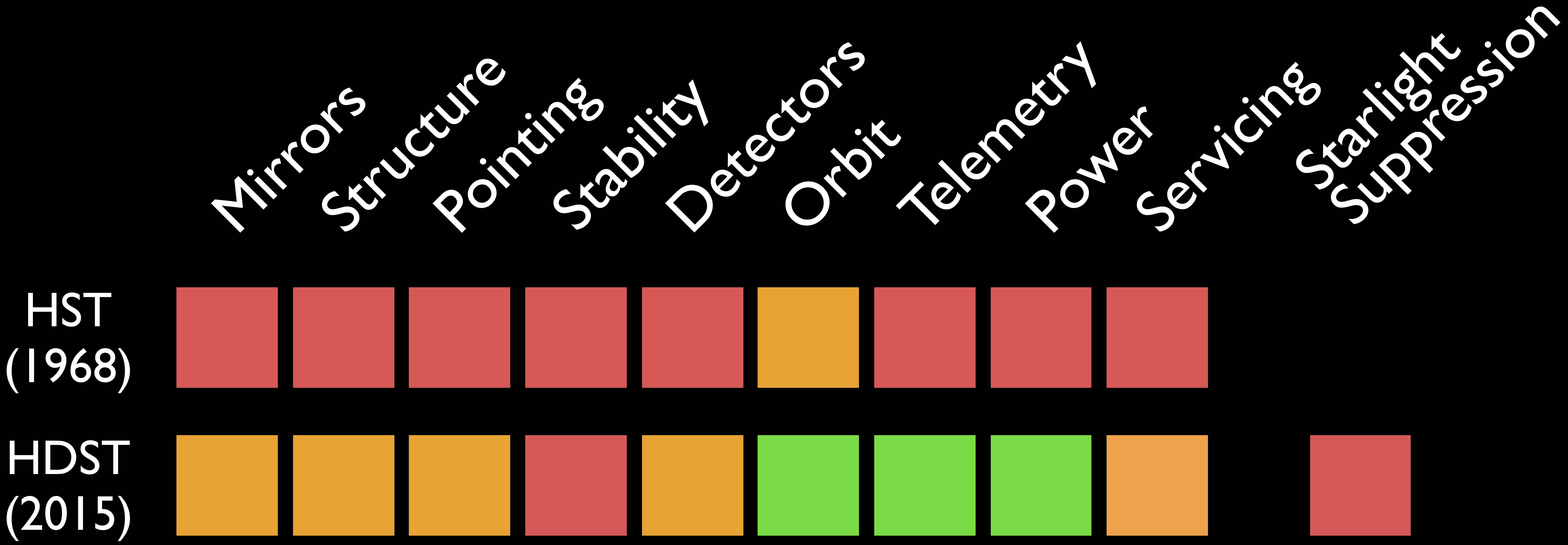
Flight Technologies

Technology Development

Room-Temperature Telescope

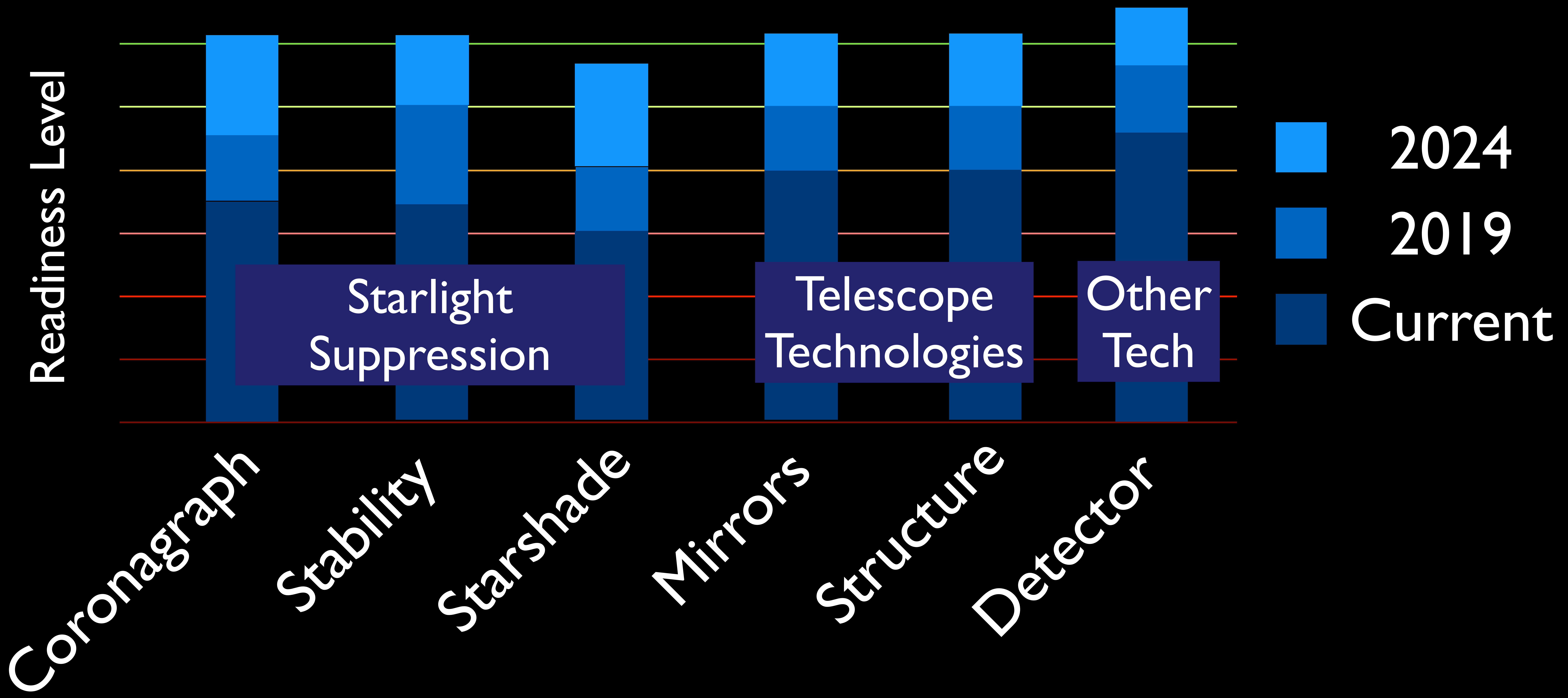


We Can Build It

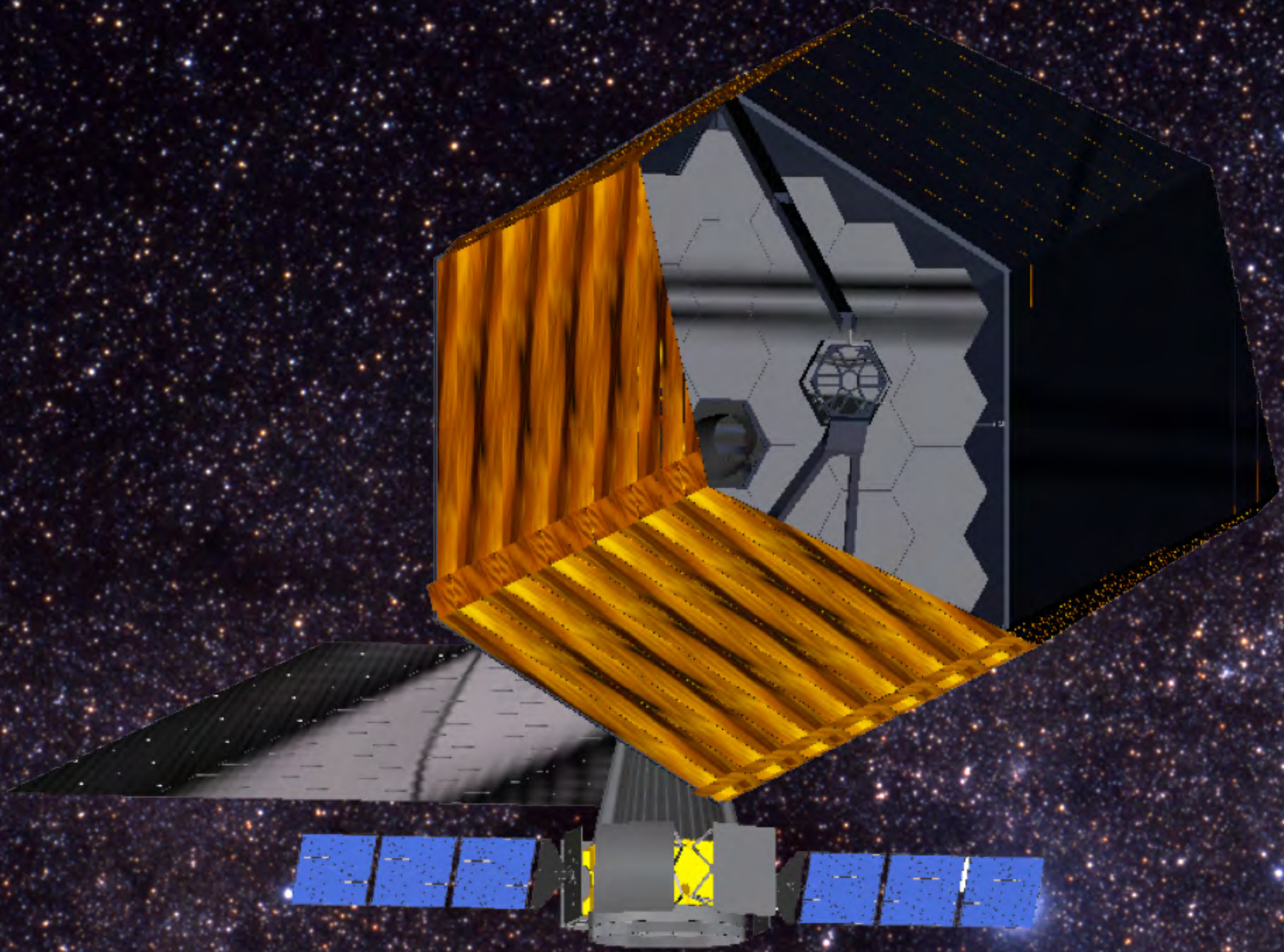


15-20 years prior to launch

The Path Forward

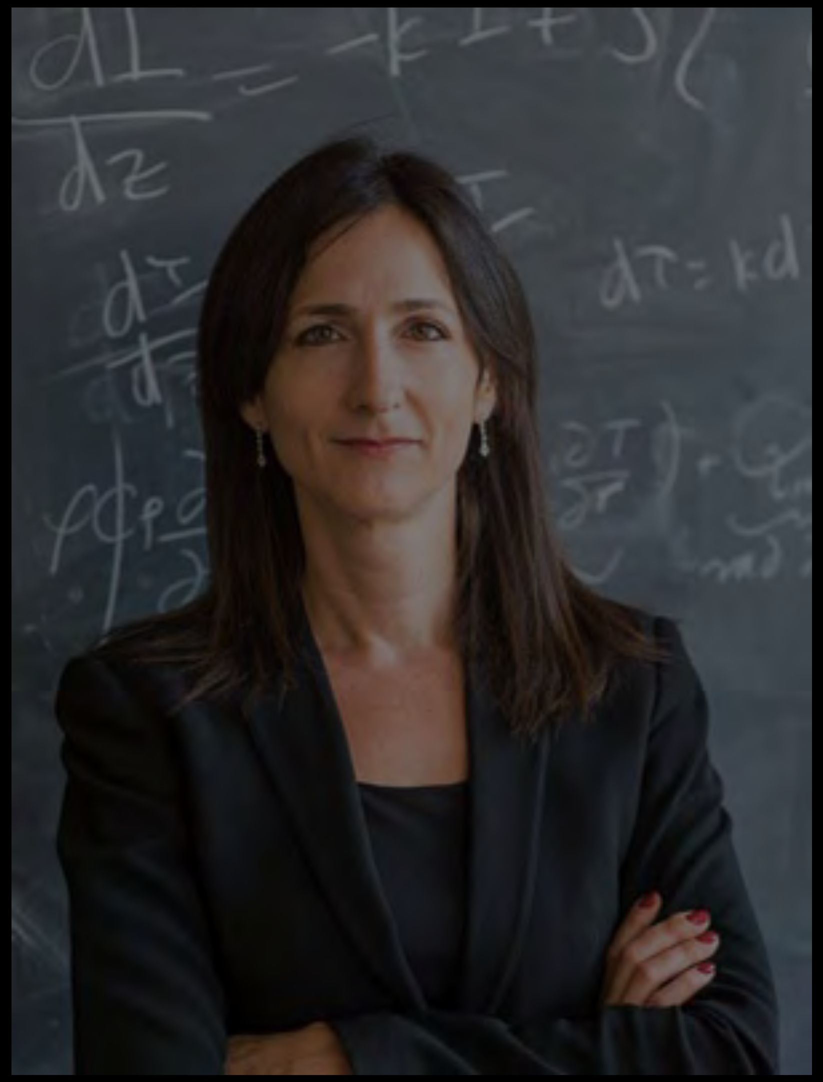


Transform Astronomy



Speakers


Matt Mountain


Sara Seager


David Schiminovich

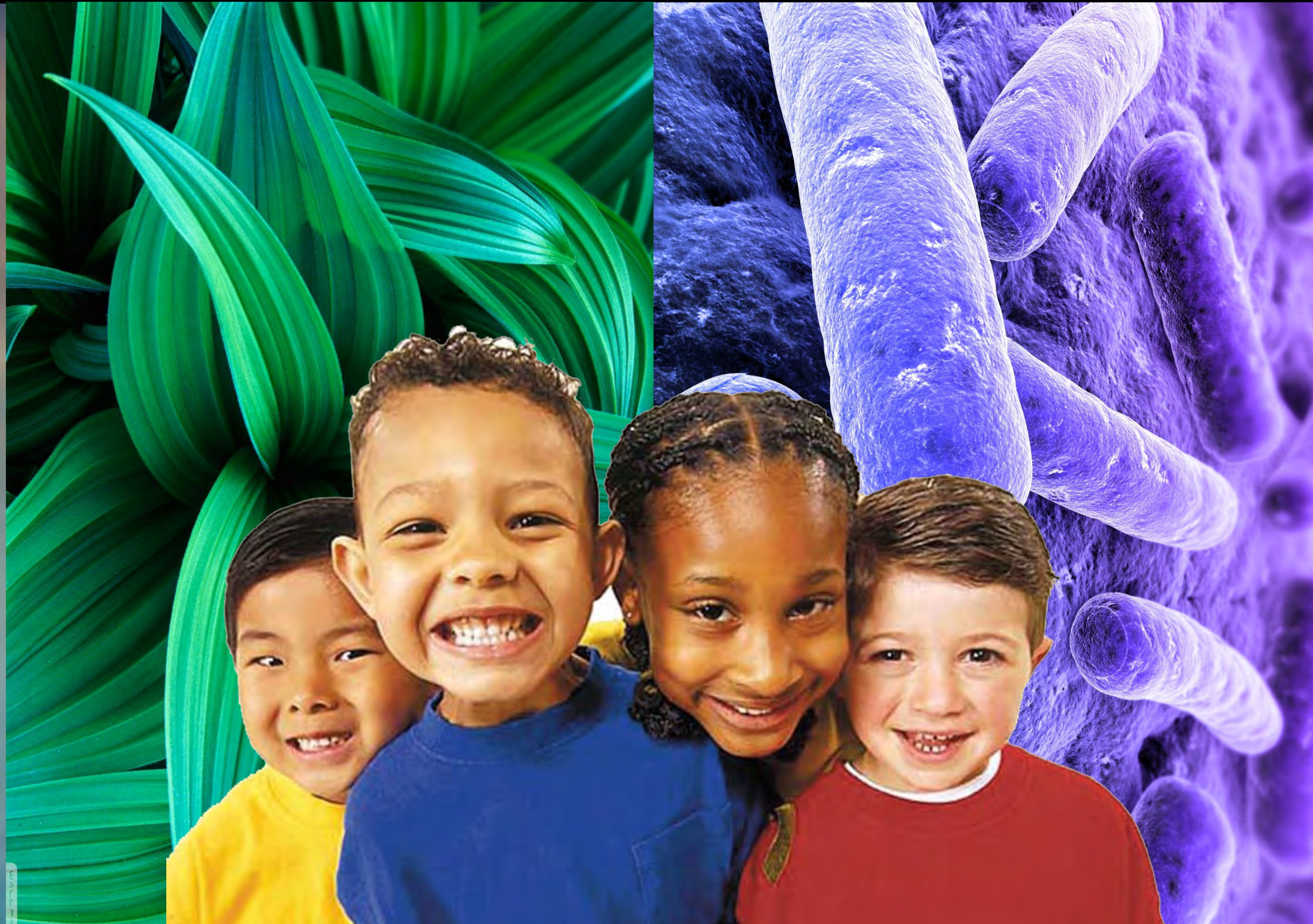

Julianne Dalcanton

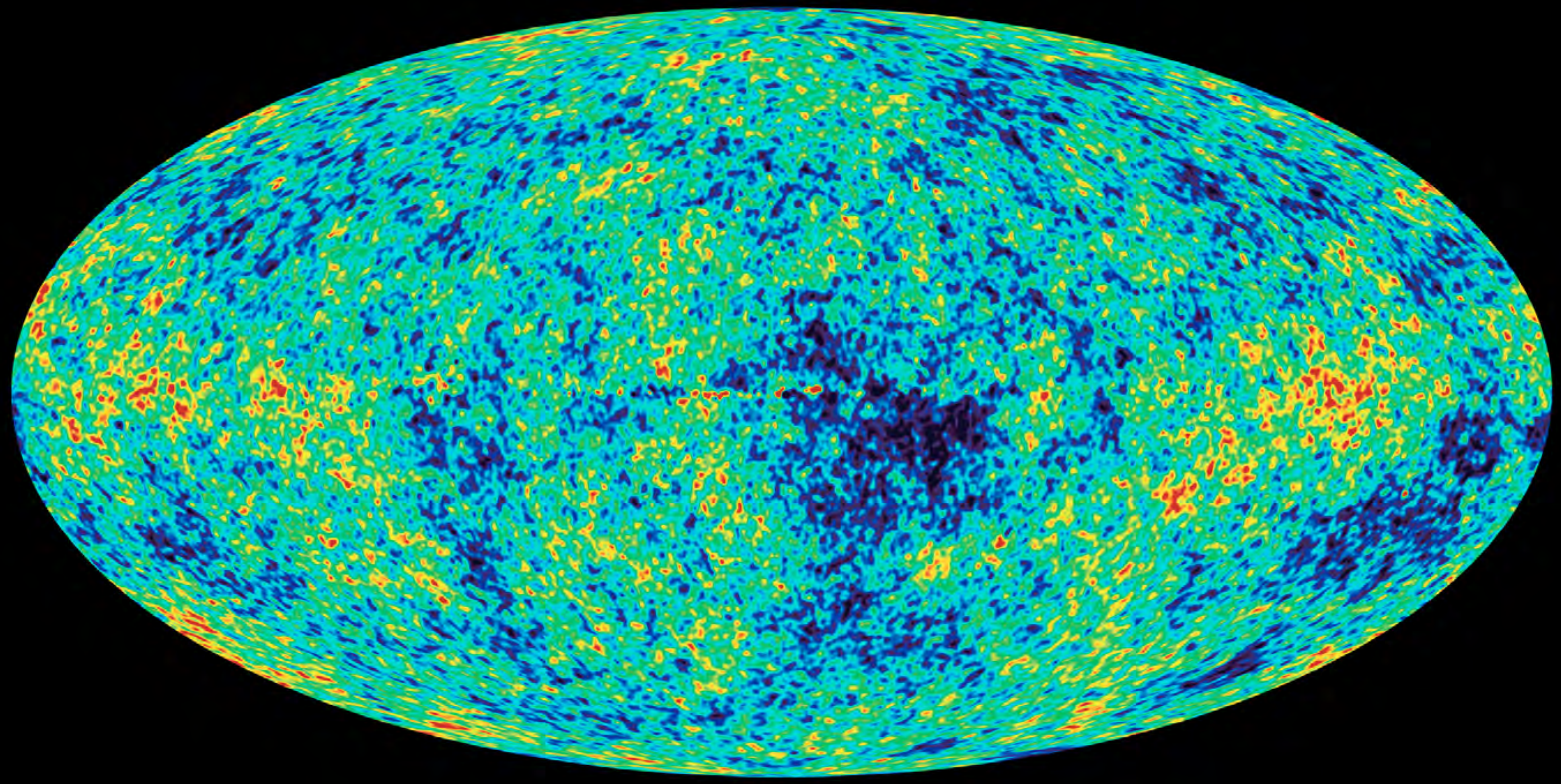
Prof. Julianne Dalcanton
Professor of Astronomy
University of Washington

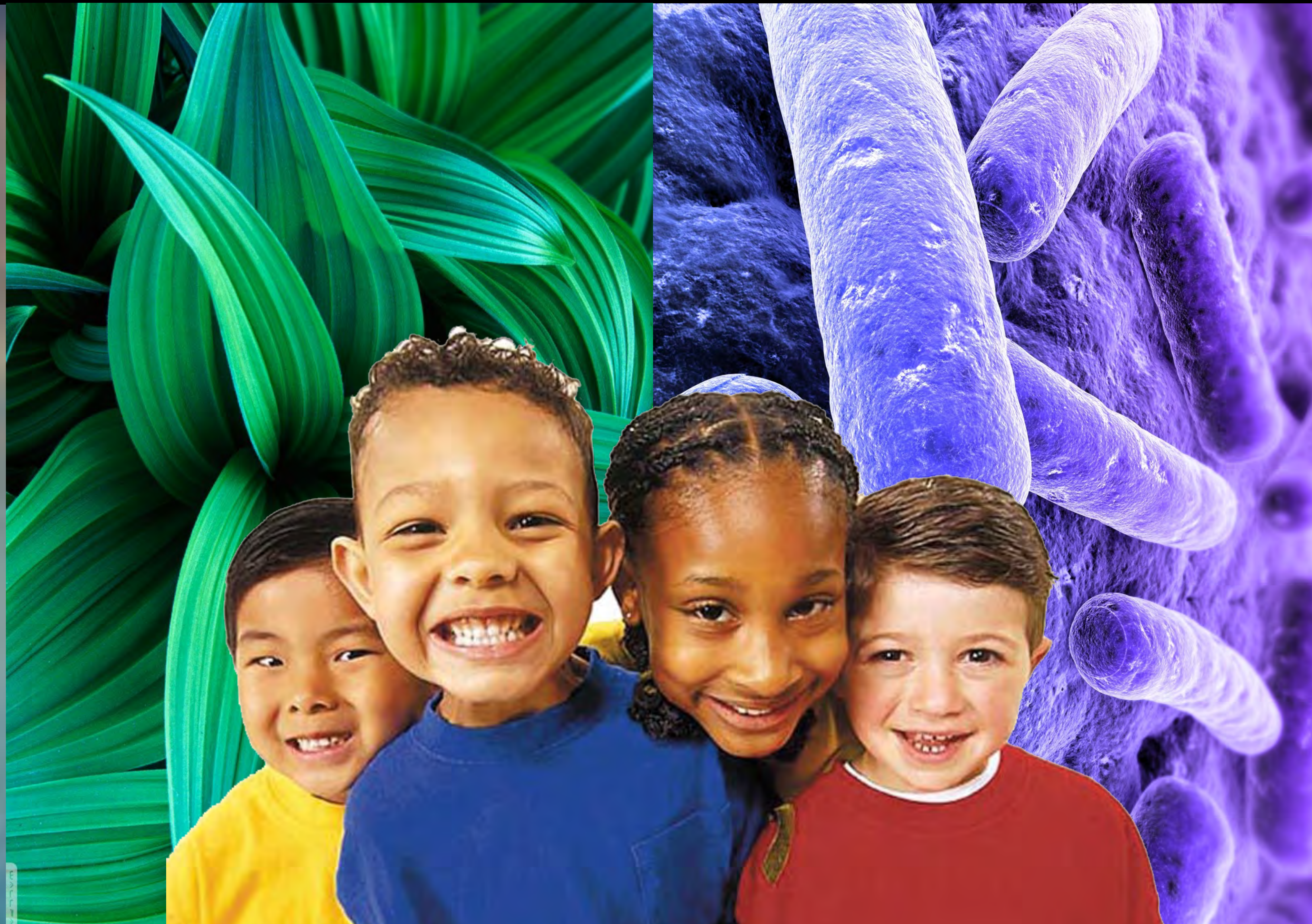
The search for life here…

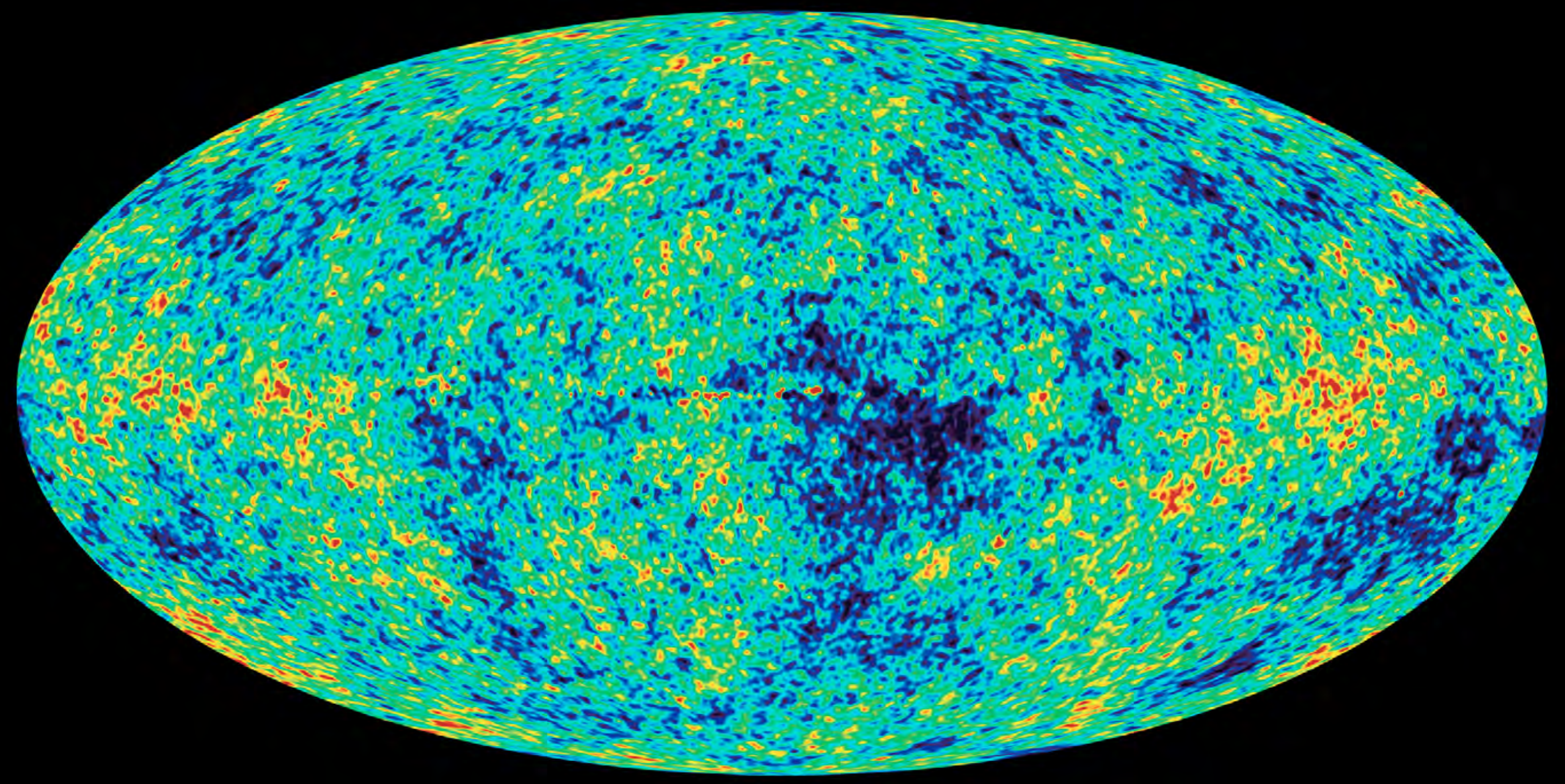
The search for life here…

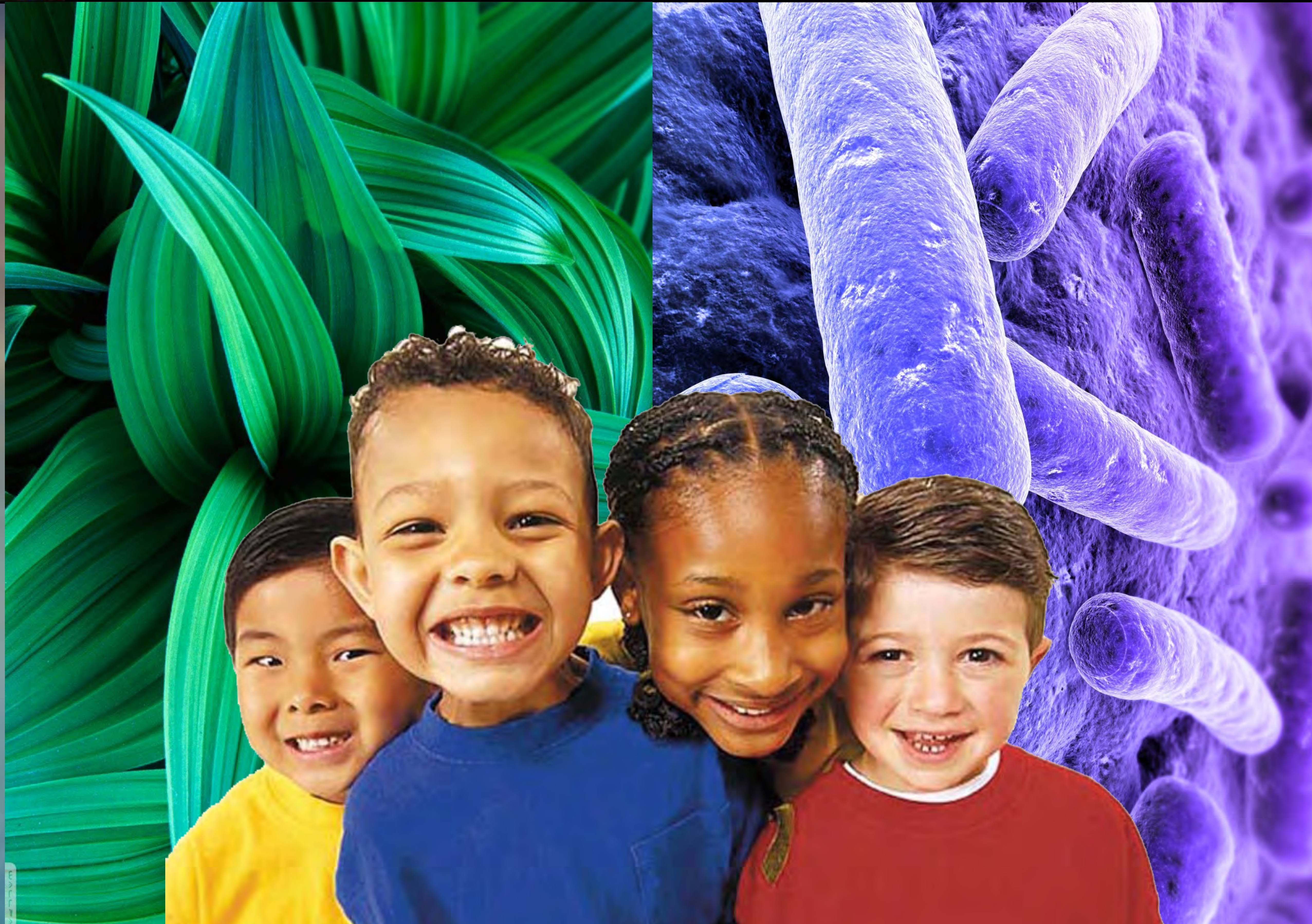
…will transform understanding of life’s origins, Here.

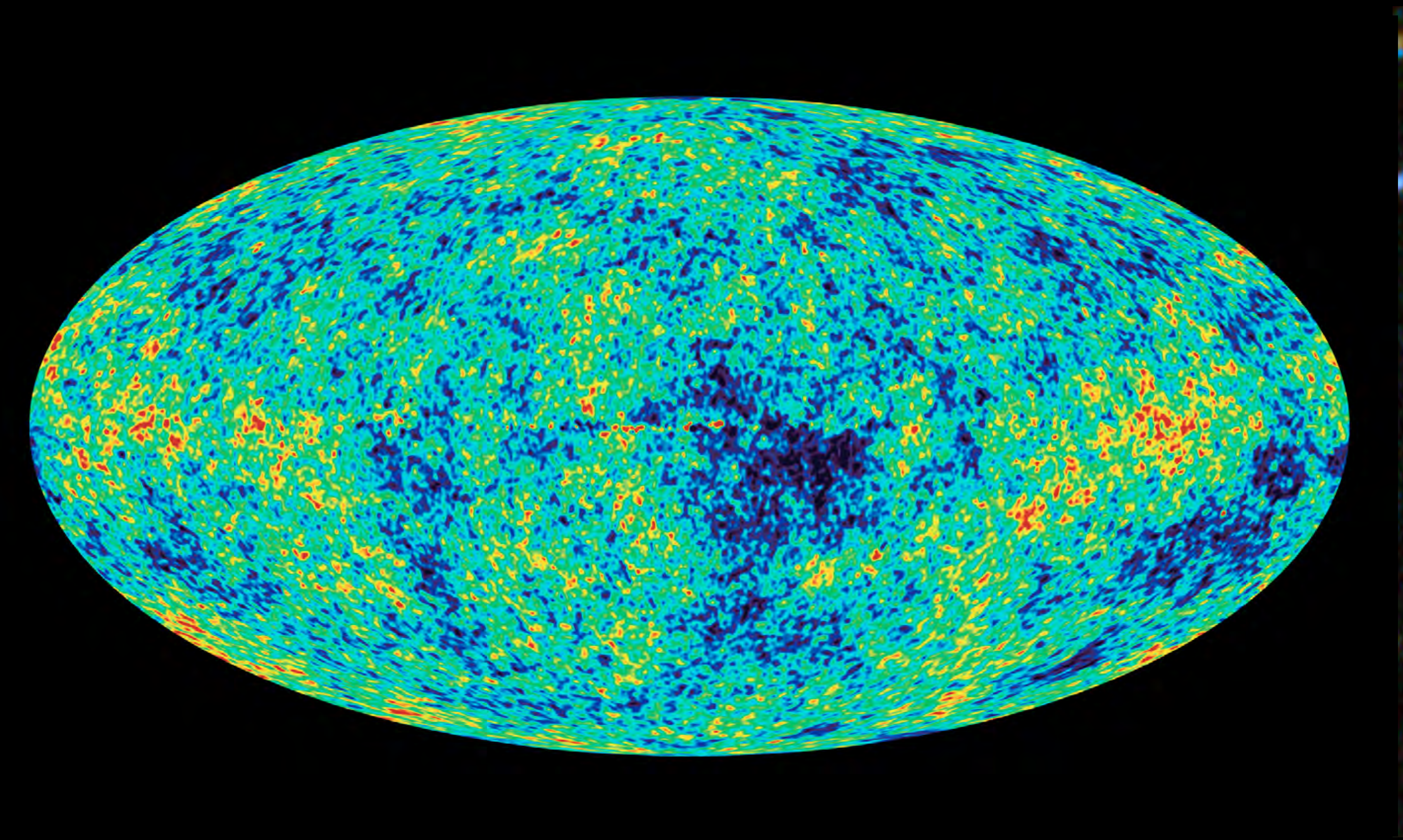






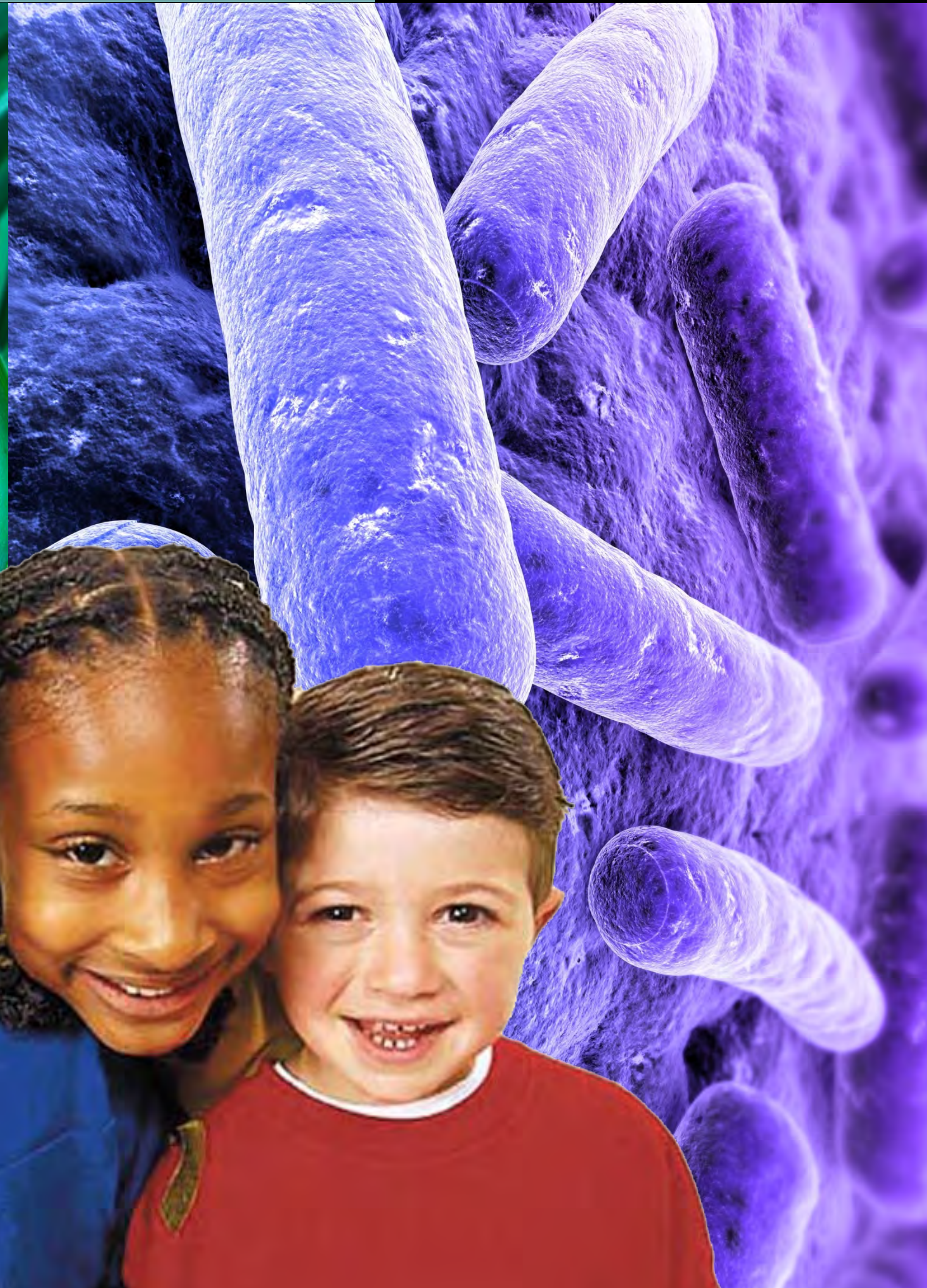


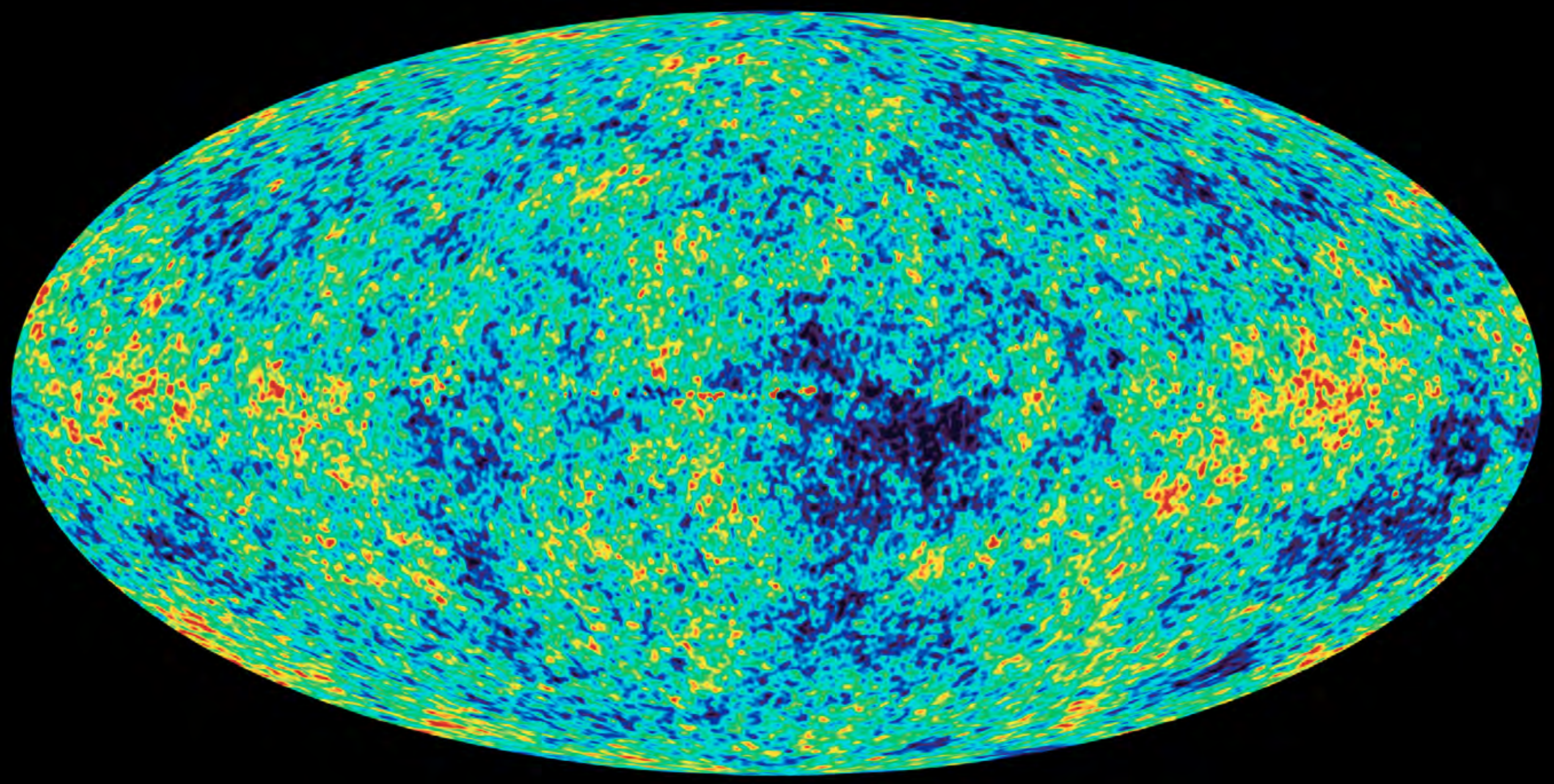



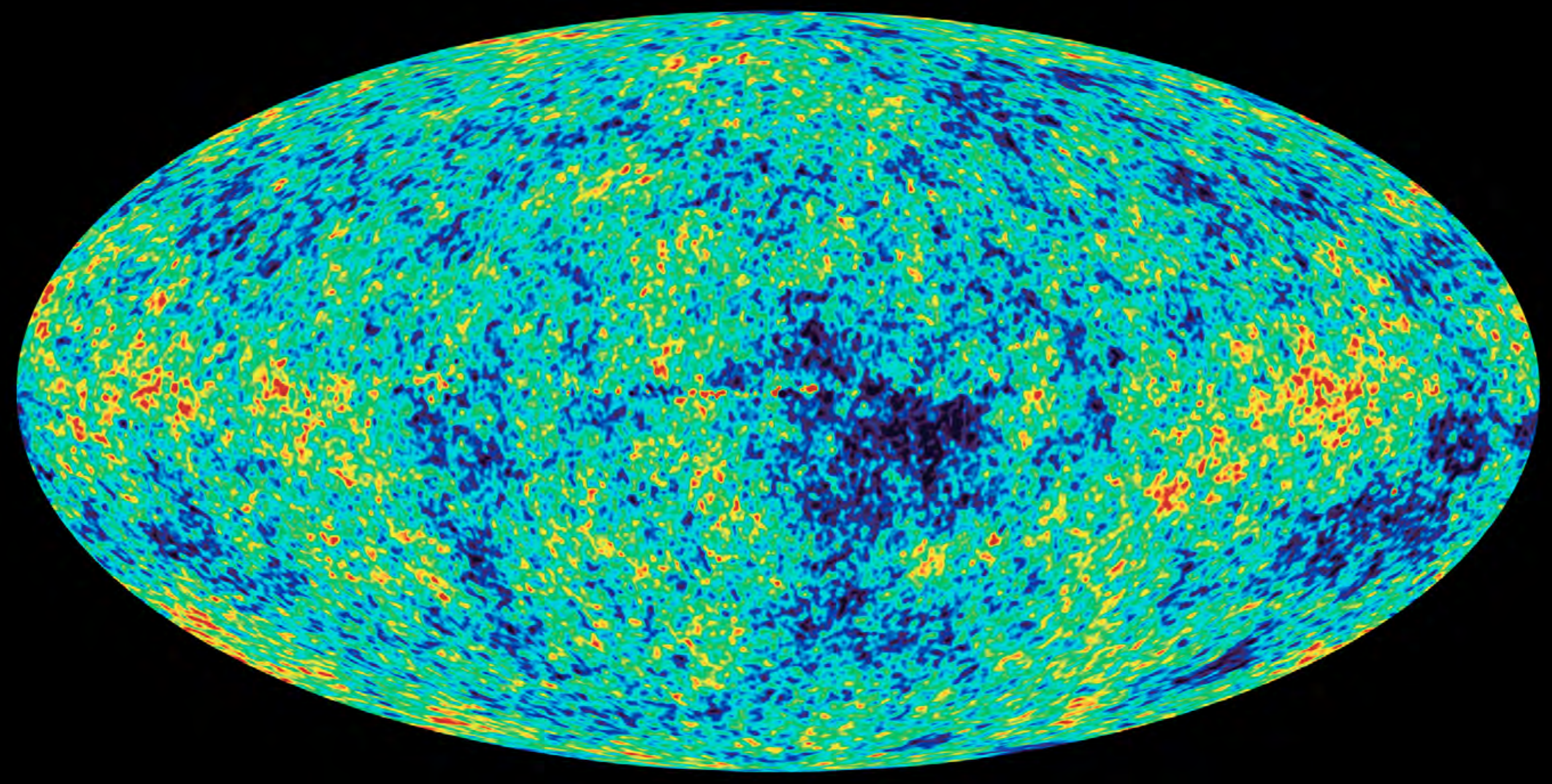












A shared origin story, told by HDST

Credit: Eagle Collaboration

…comes complexity, and us.

Credit: Eagle Collaboration

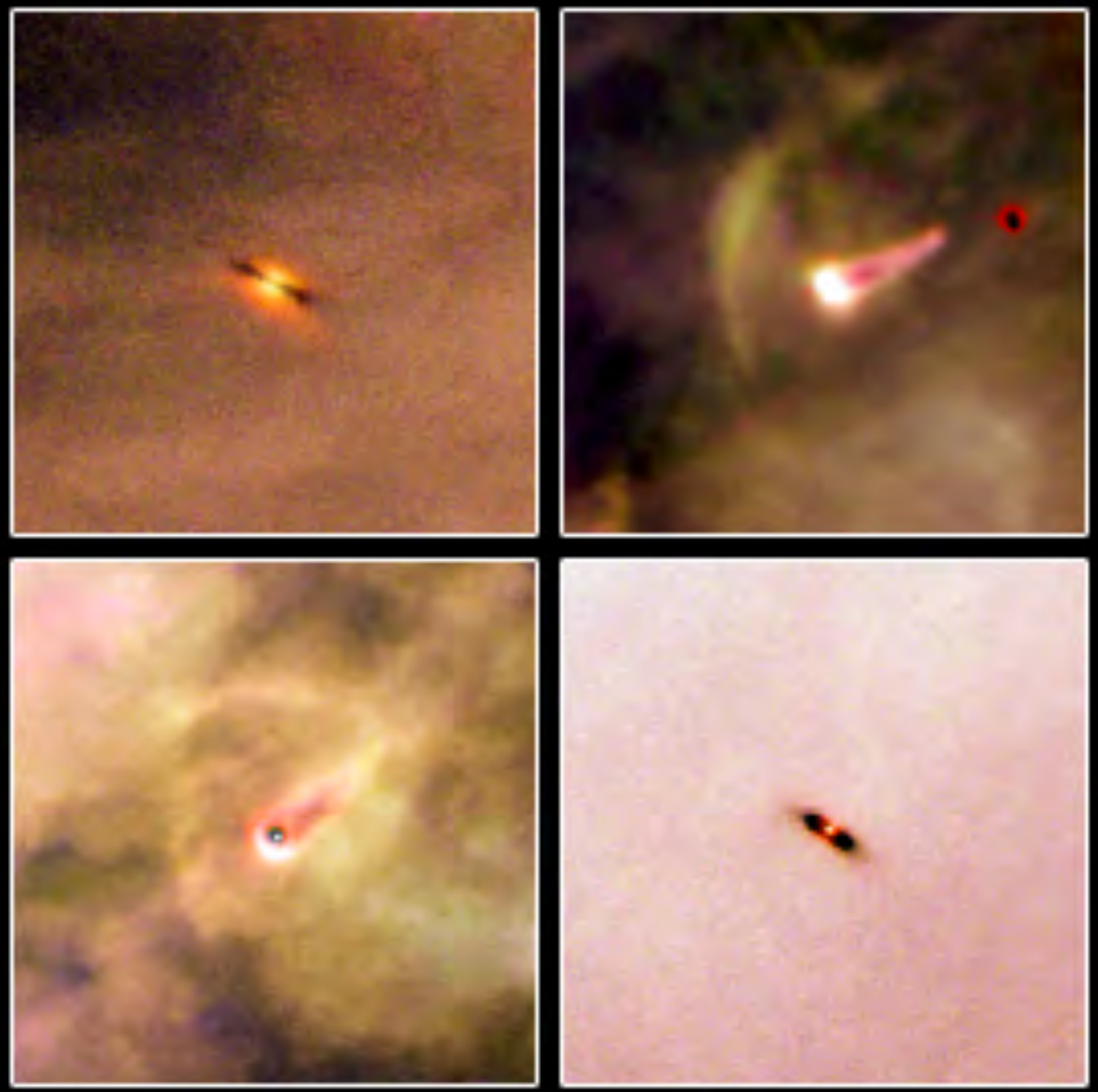
Credit: Eagle Collaboration

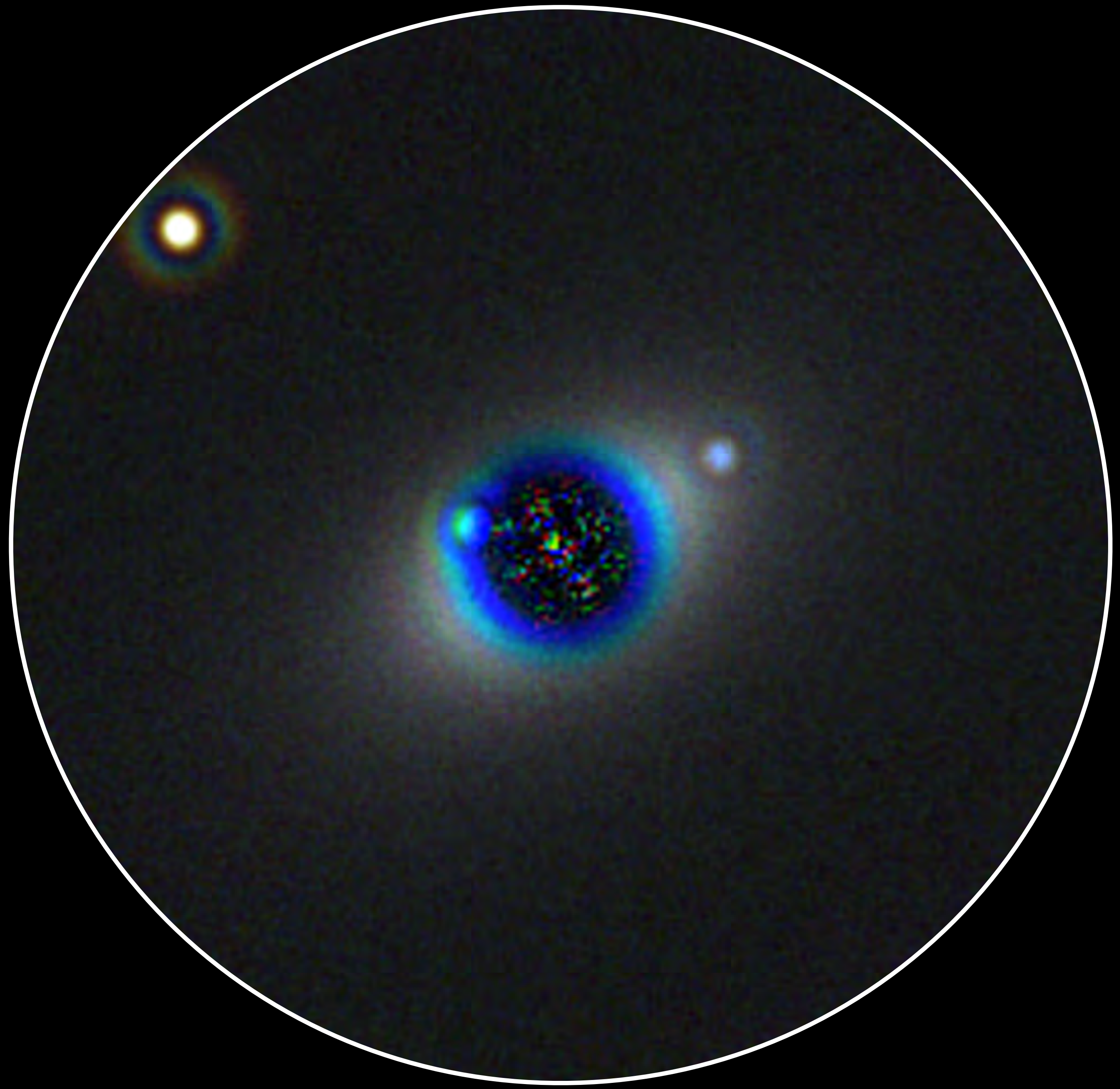
Dark Matter

Credit: Eagle Collaboration


Starbirth

Planetary nurseries





Revolutionary Technology
Brings
Revolutionary Science

Revolutionary Technology
Brings
Revolutionary Science

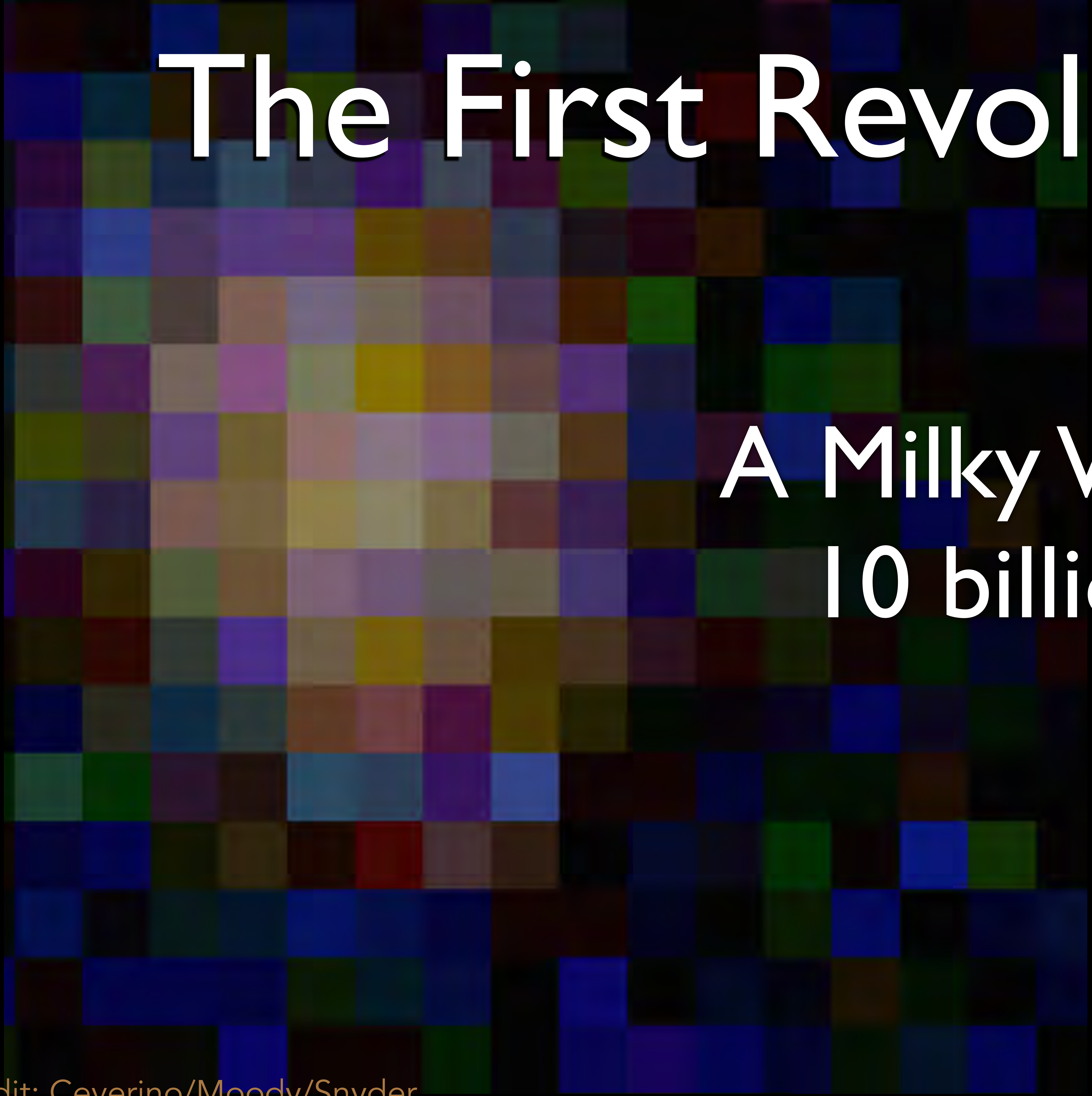
Fainter

Farther

Rarer

Finer

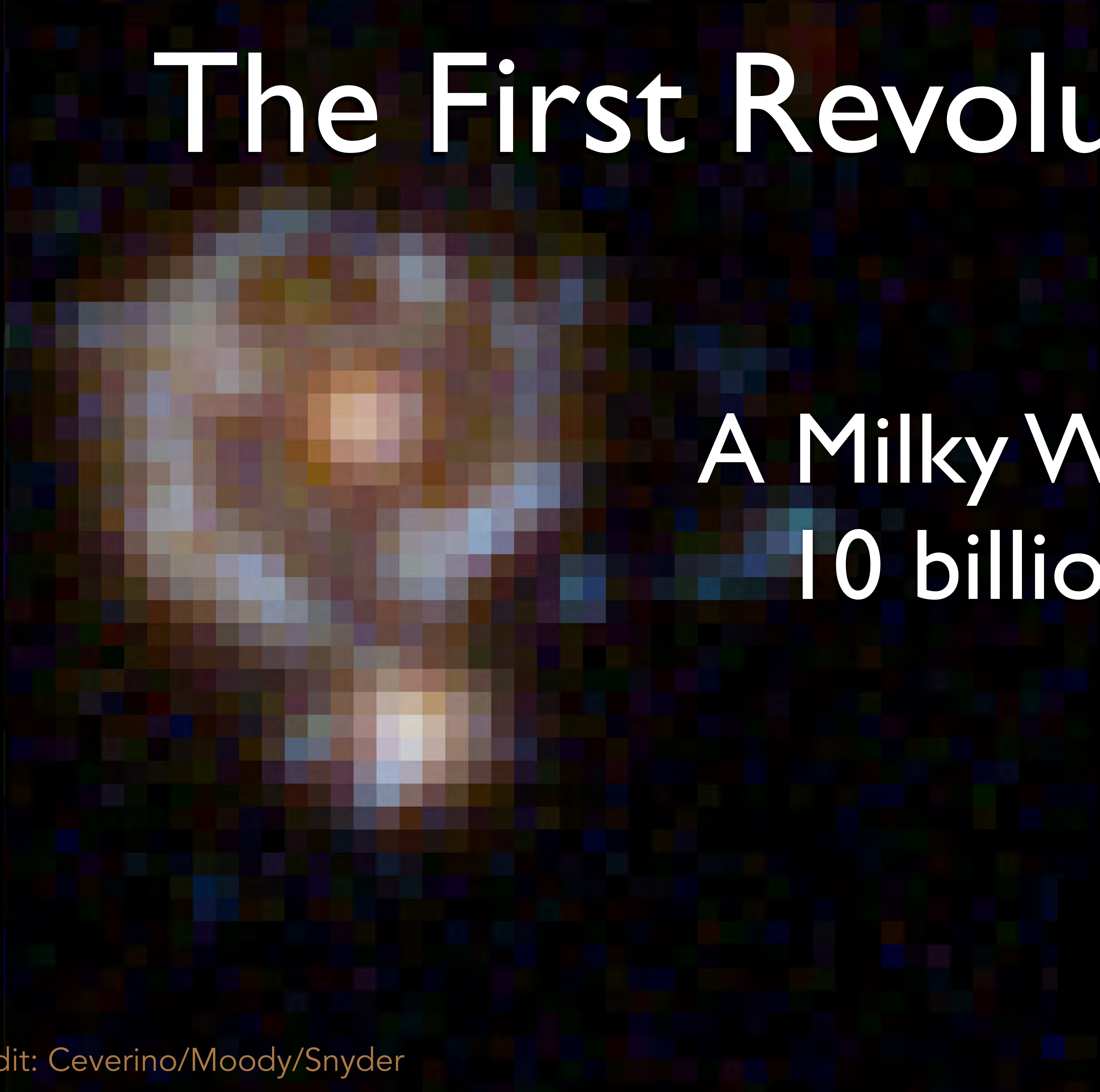
The First Revolution



A Milky Way-like galaxy
10 billion years ago

Image Credit: Ceverino/Moody/Snyder

The First Revolution

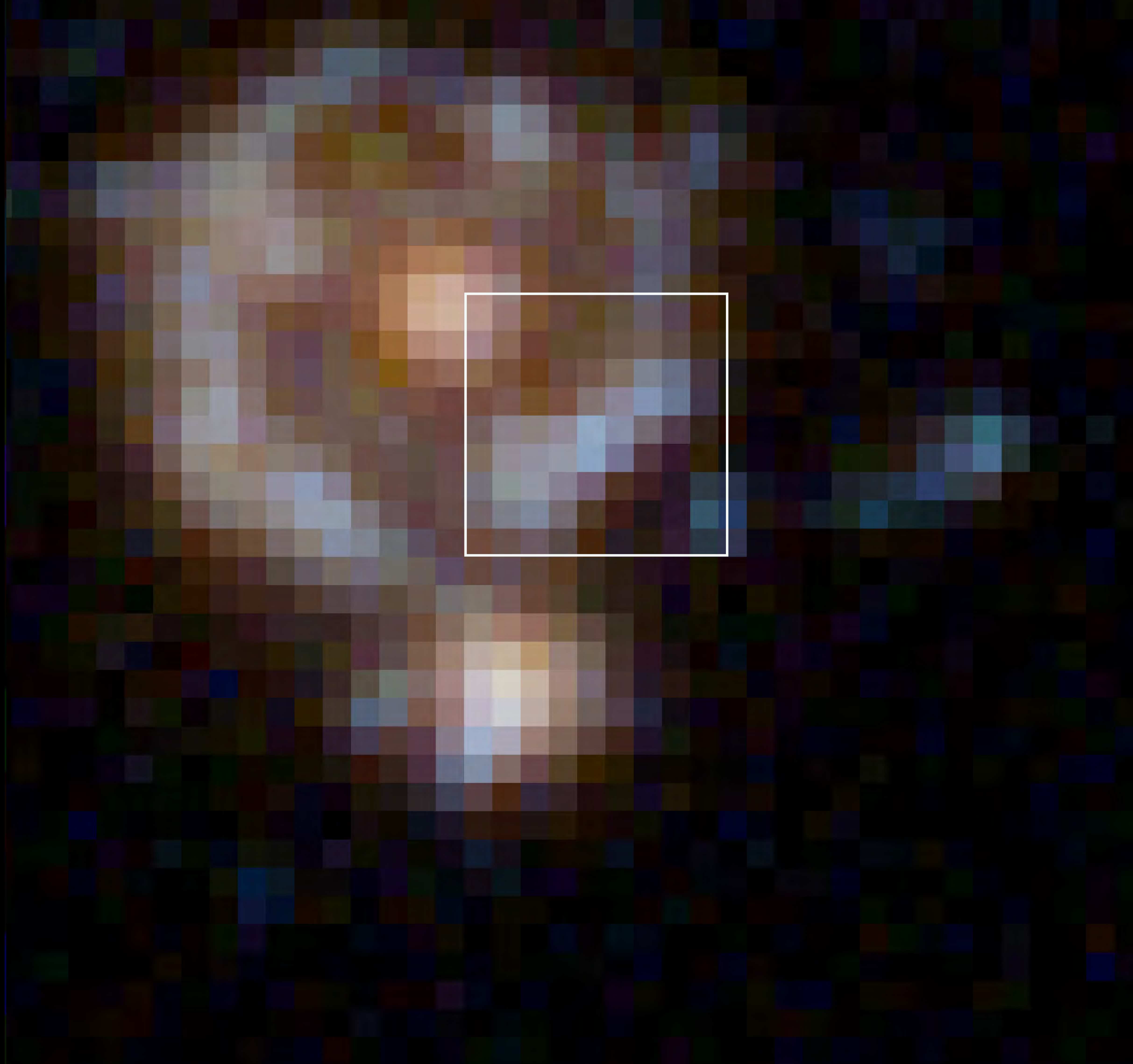


A Milky Way-like galaxy
10 billion years ago

Hubble

Image Credit: Ceverino/Moody/Snyder

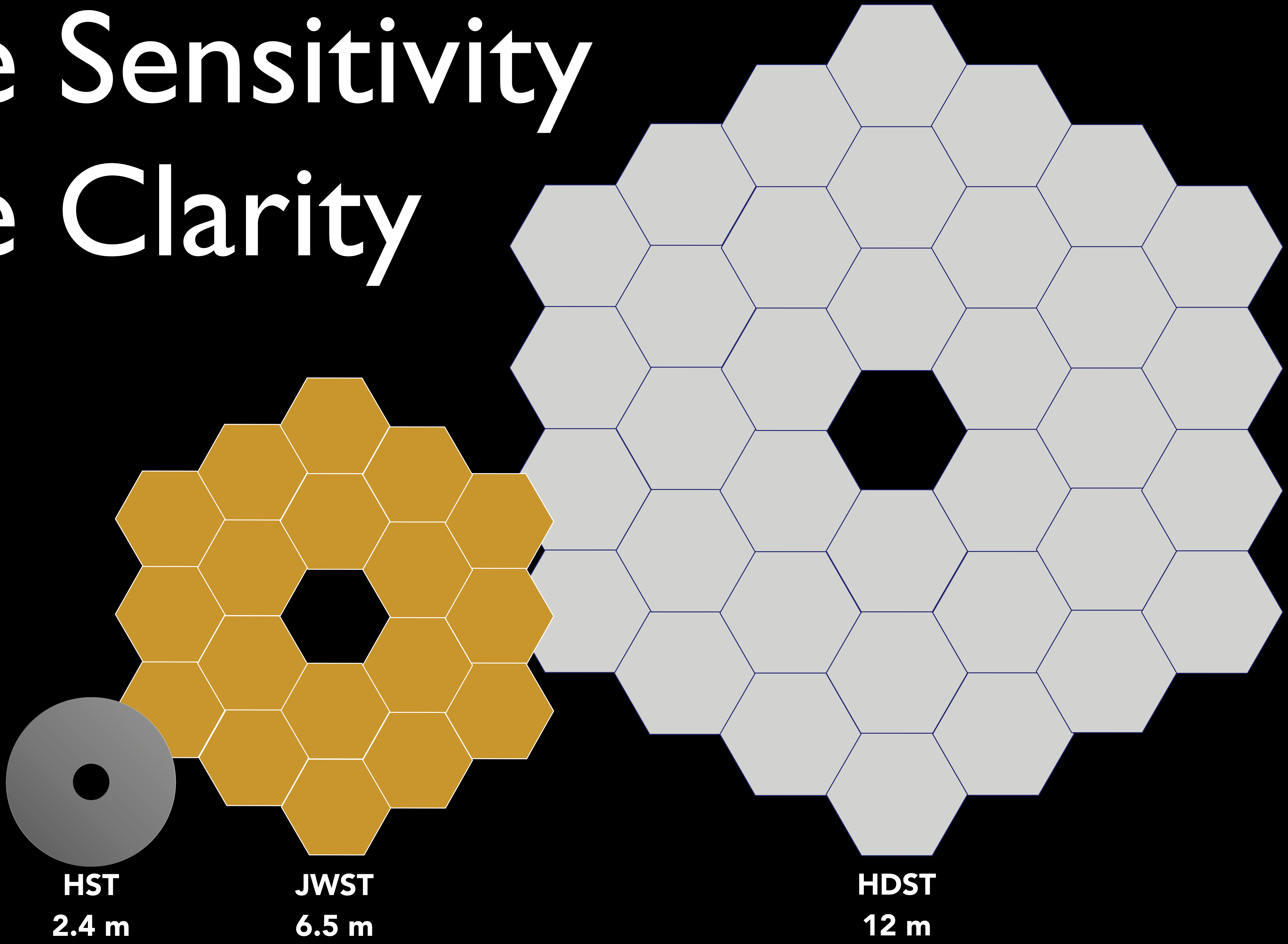
The First Revolution

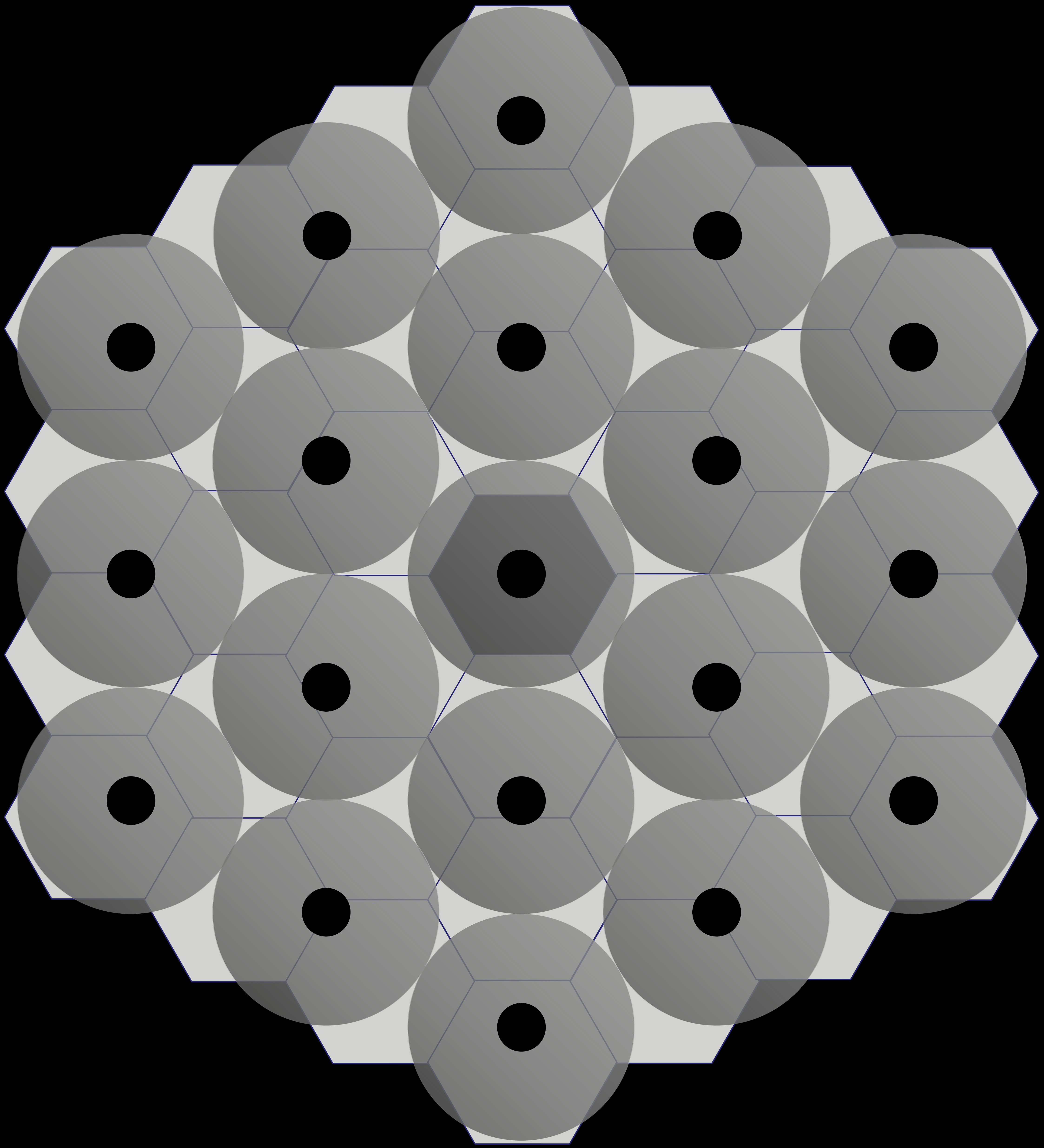


Hubble

Image Credit: Ceverino/Moody/Snyder

More Sensitivity
More Clarity

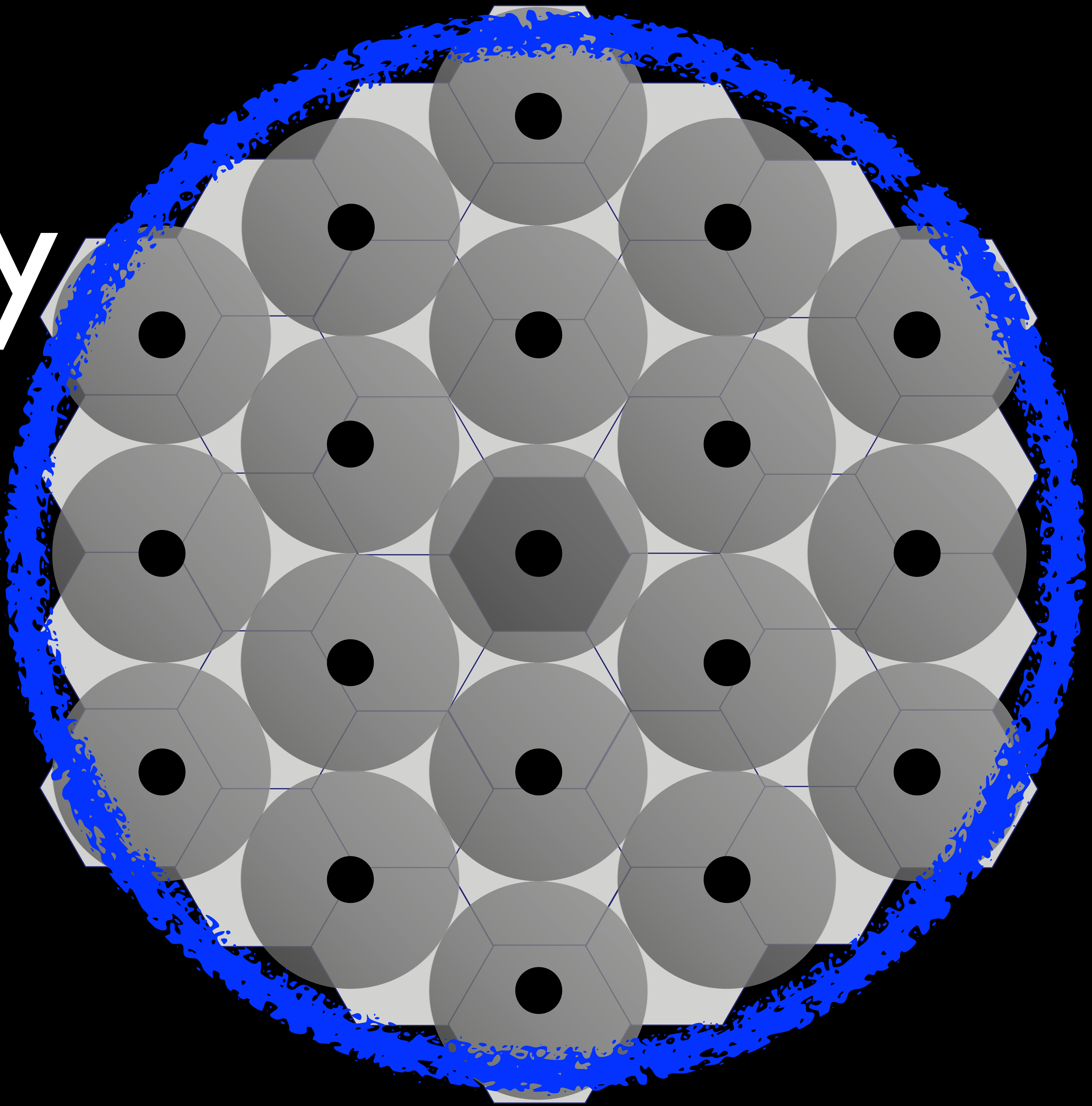




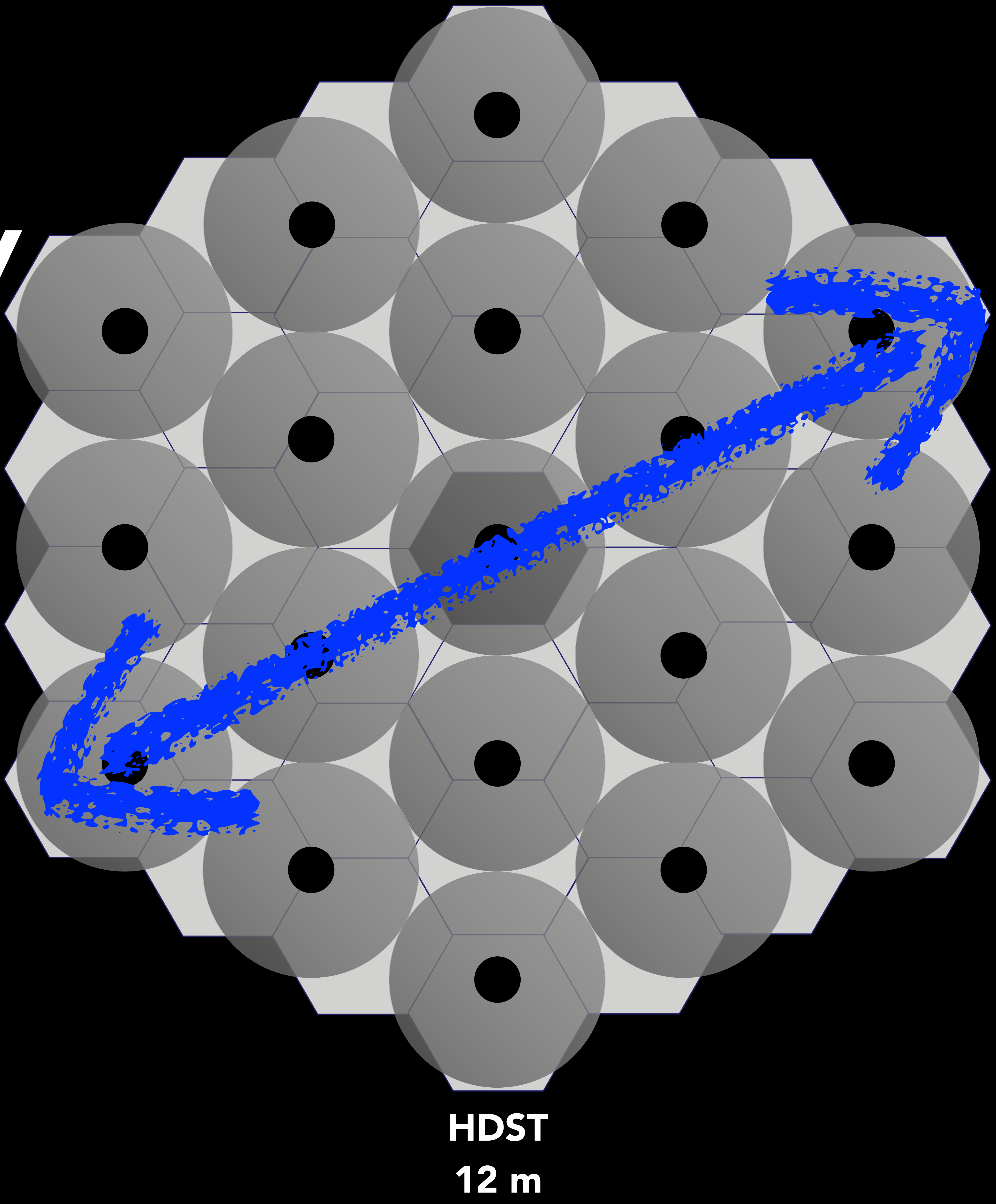
HDST

12 m

More Sensitivity



More Sensitivity



More Clarity

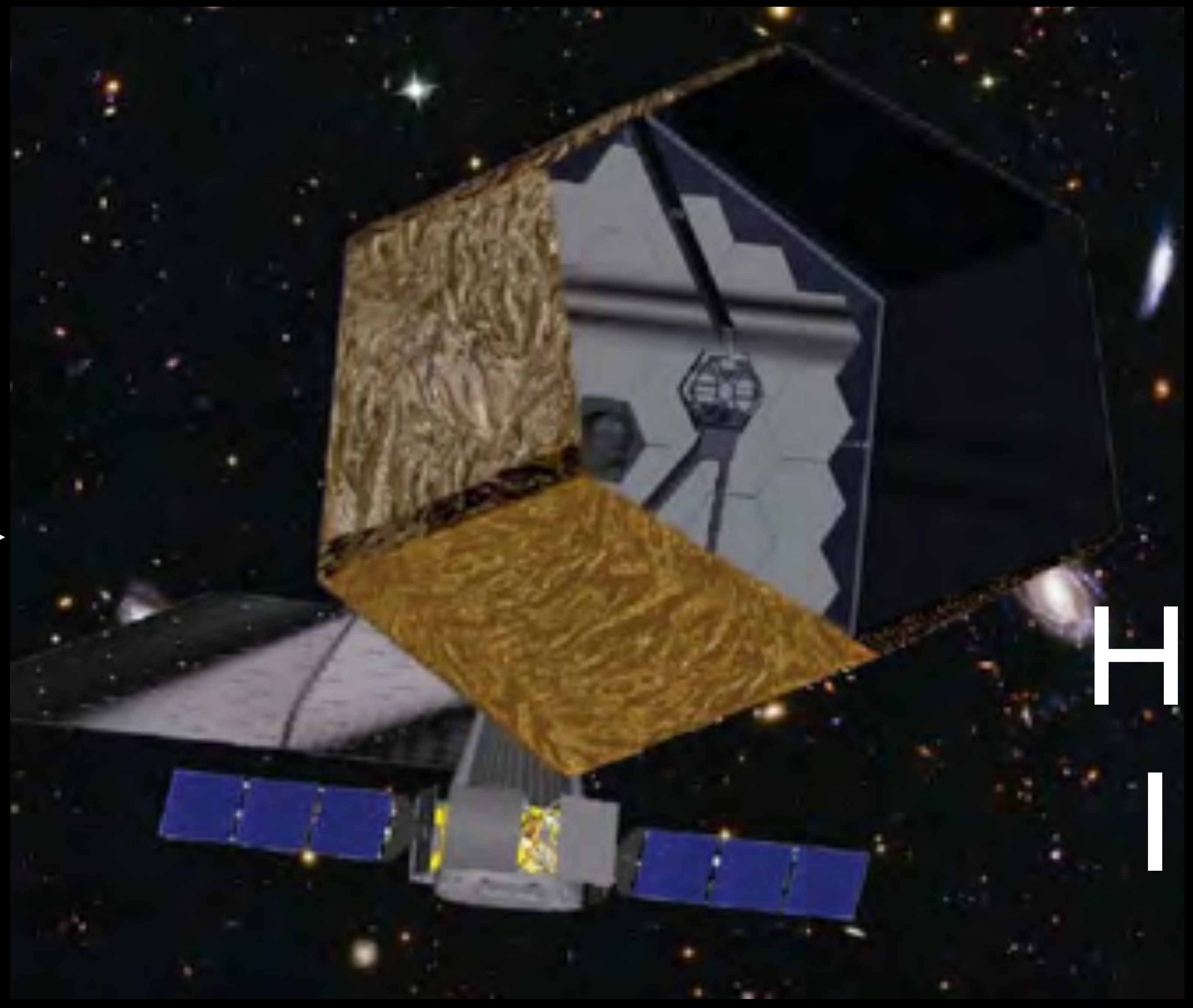
SDTV
720 x 480

25x pixel density

UltraHD
3820 x 2160

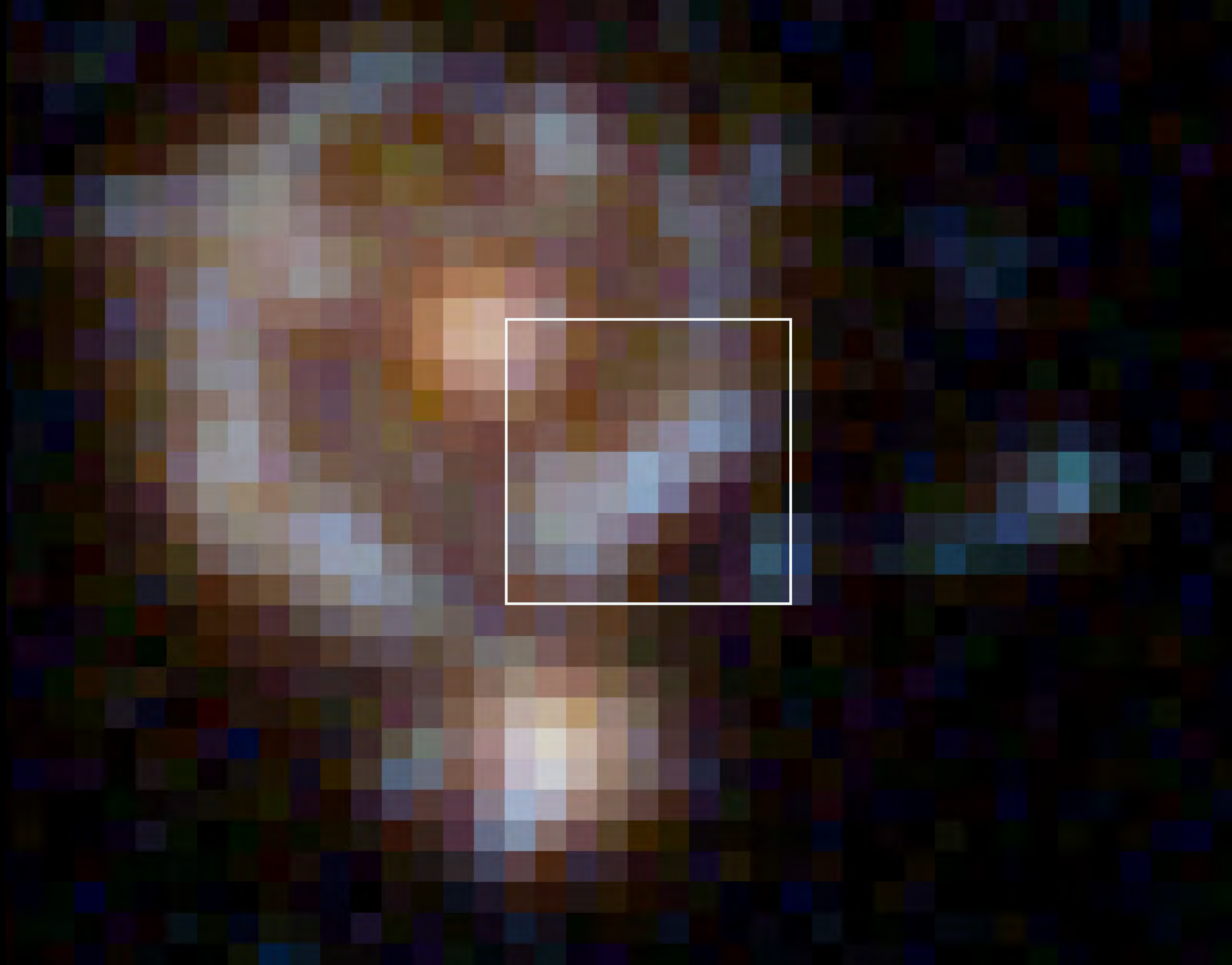
HST
2.4 m

25x image sharpness



HDST
12 m

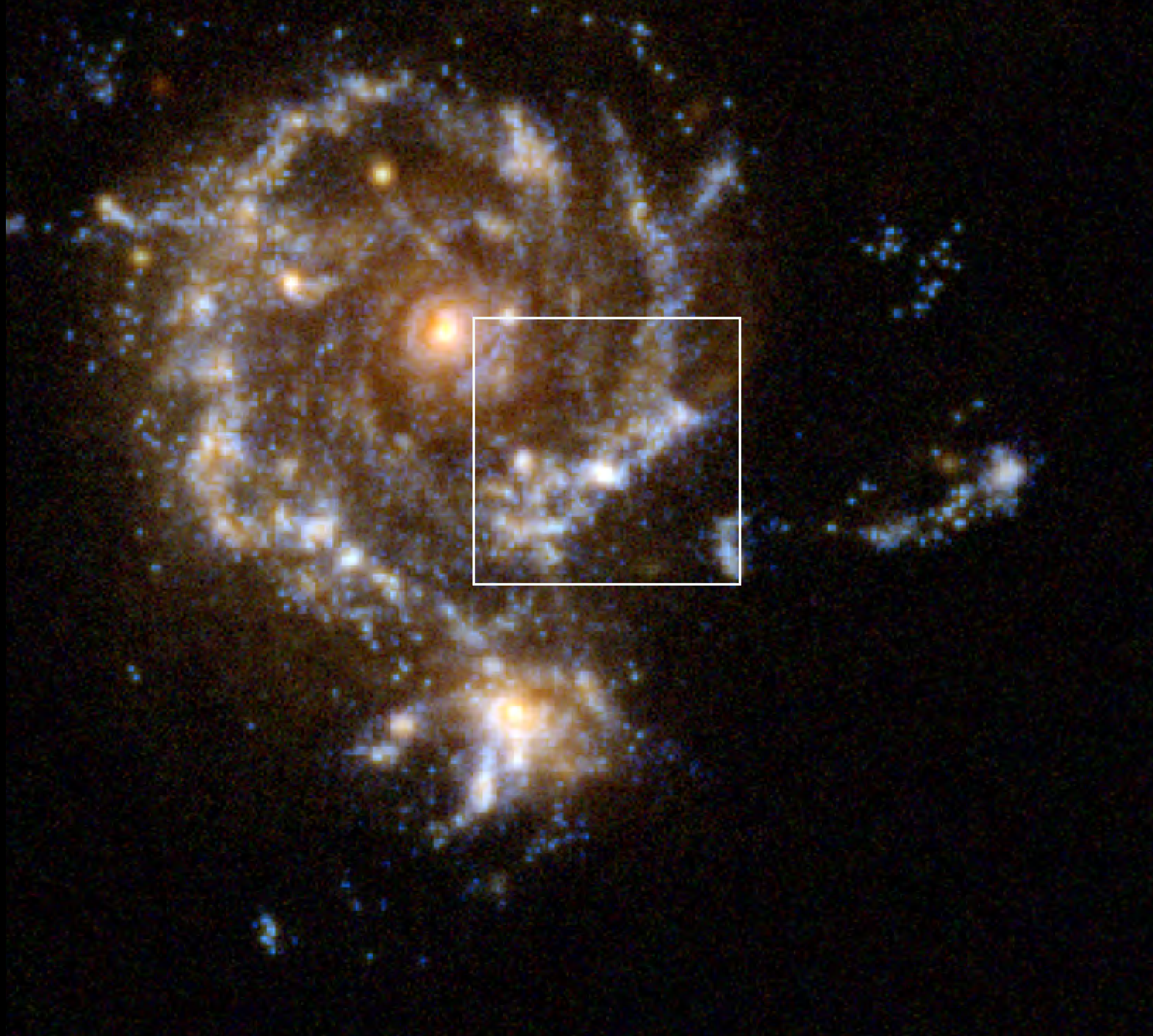
The Next Revolution

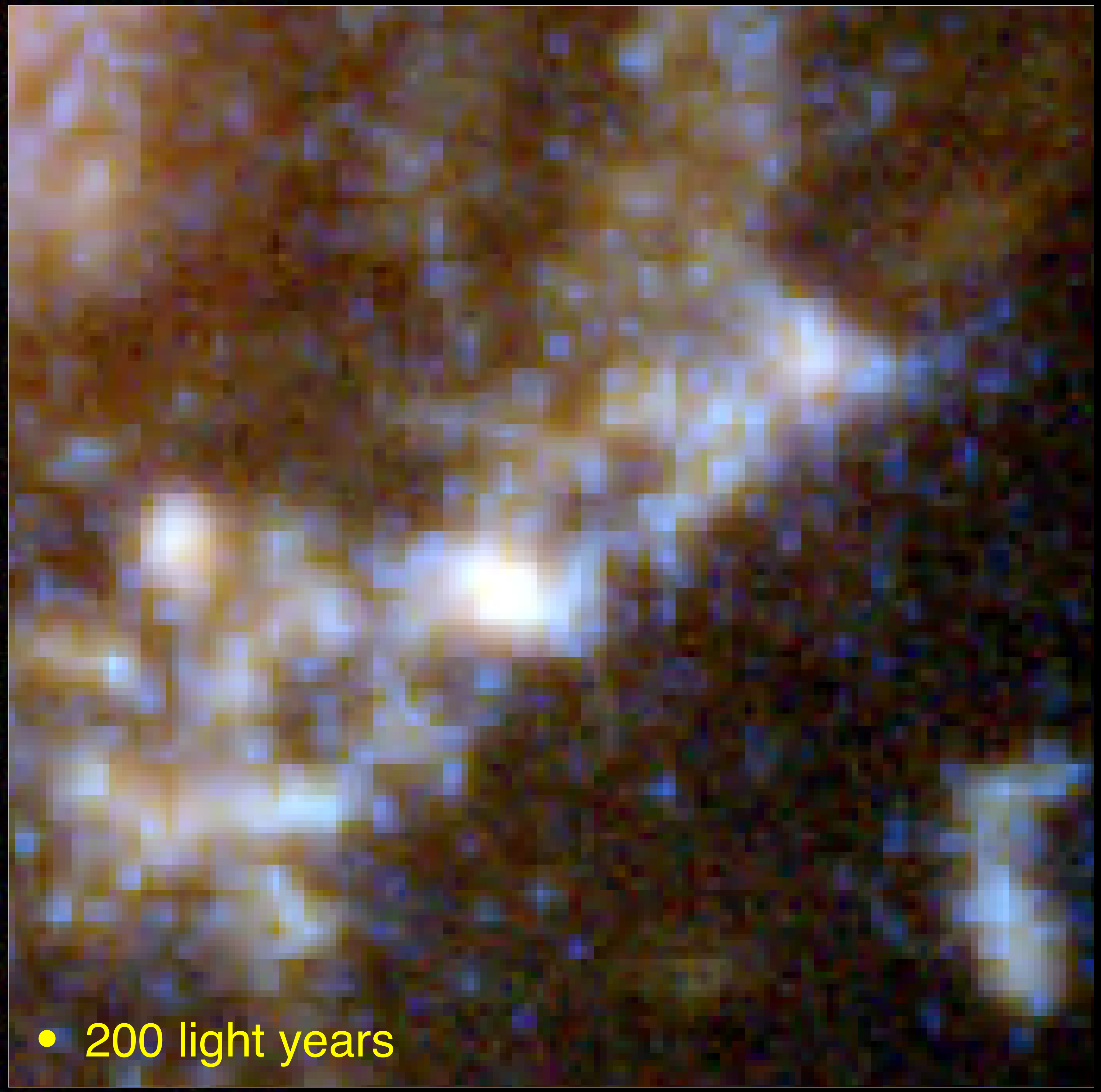


From Hubble to....

Image Credit: Ceverino/Moody/Snyder

...the Universe in High-Def

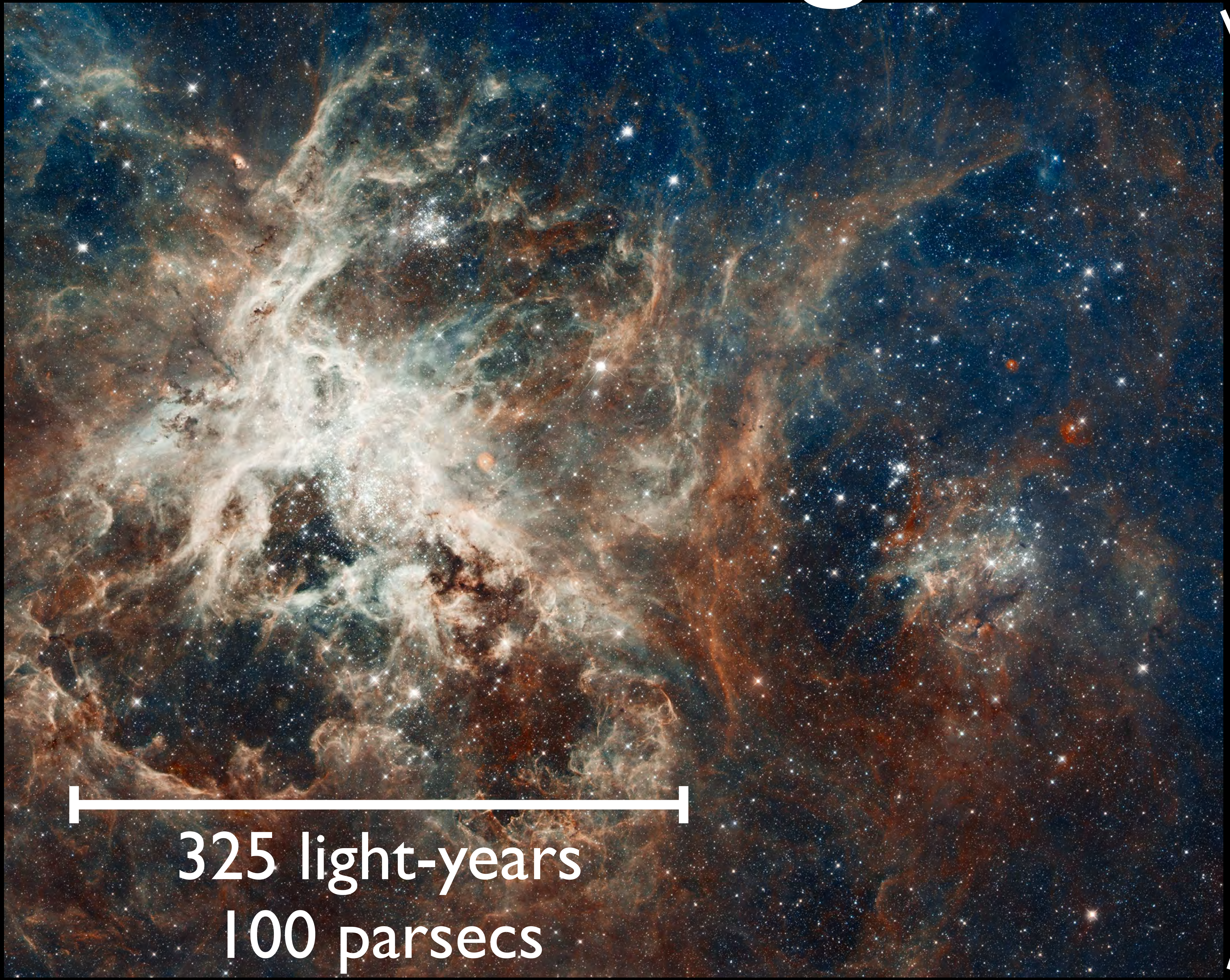


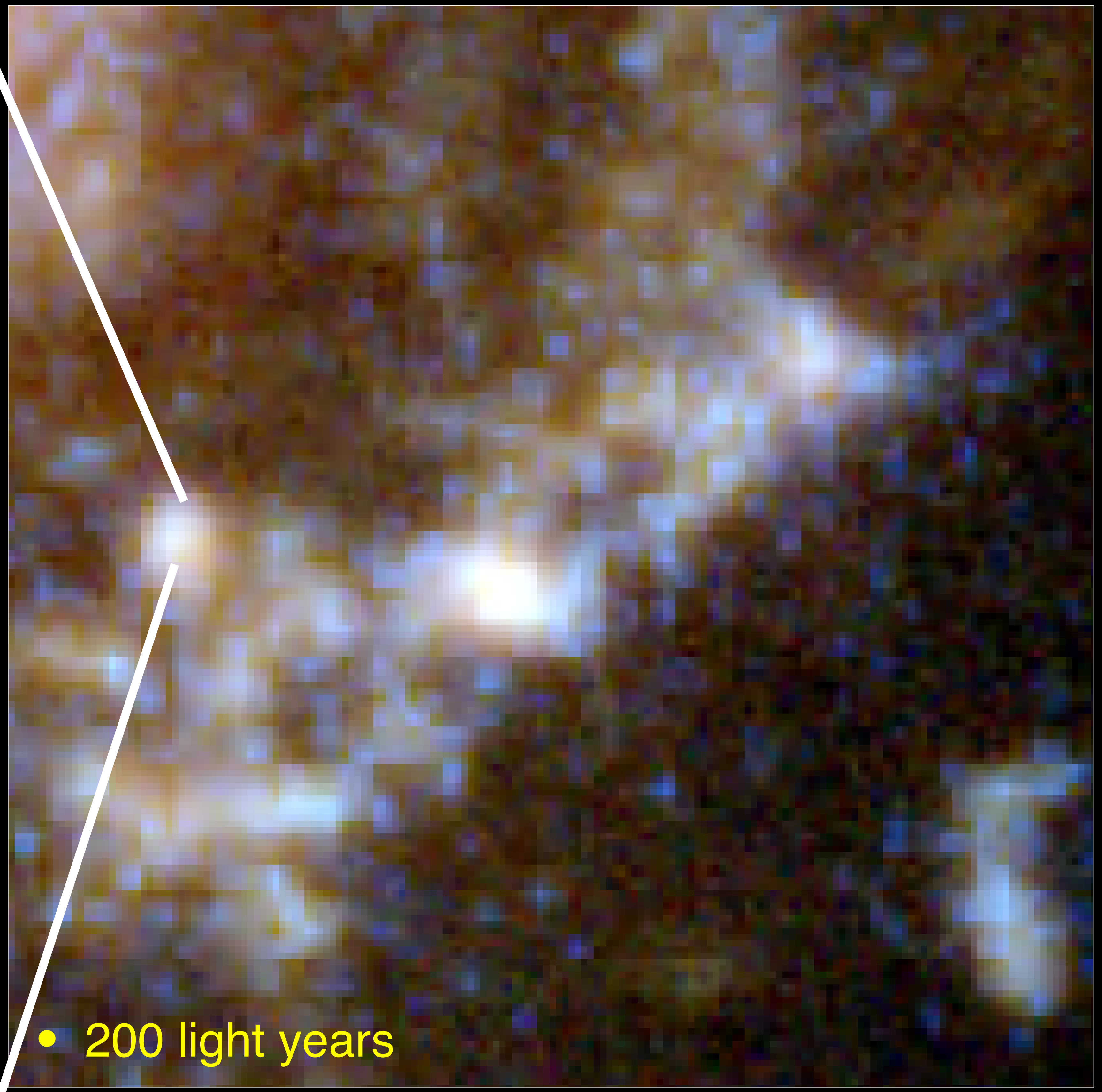


HDST

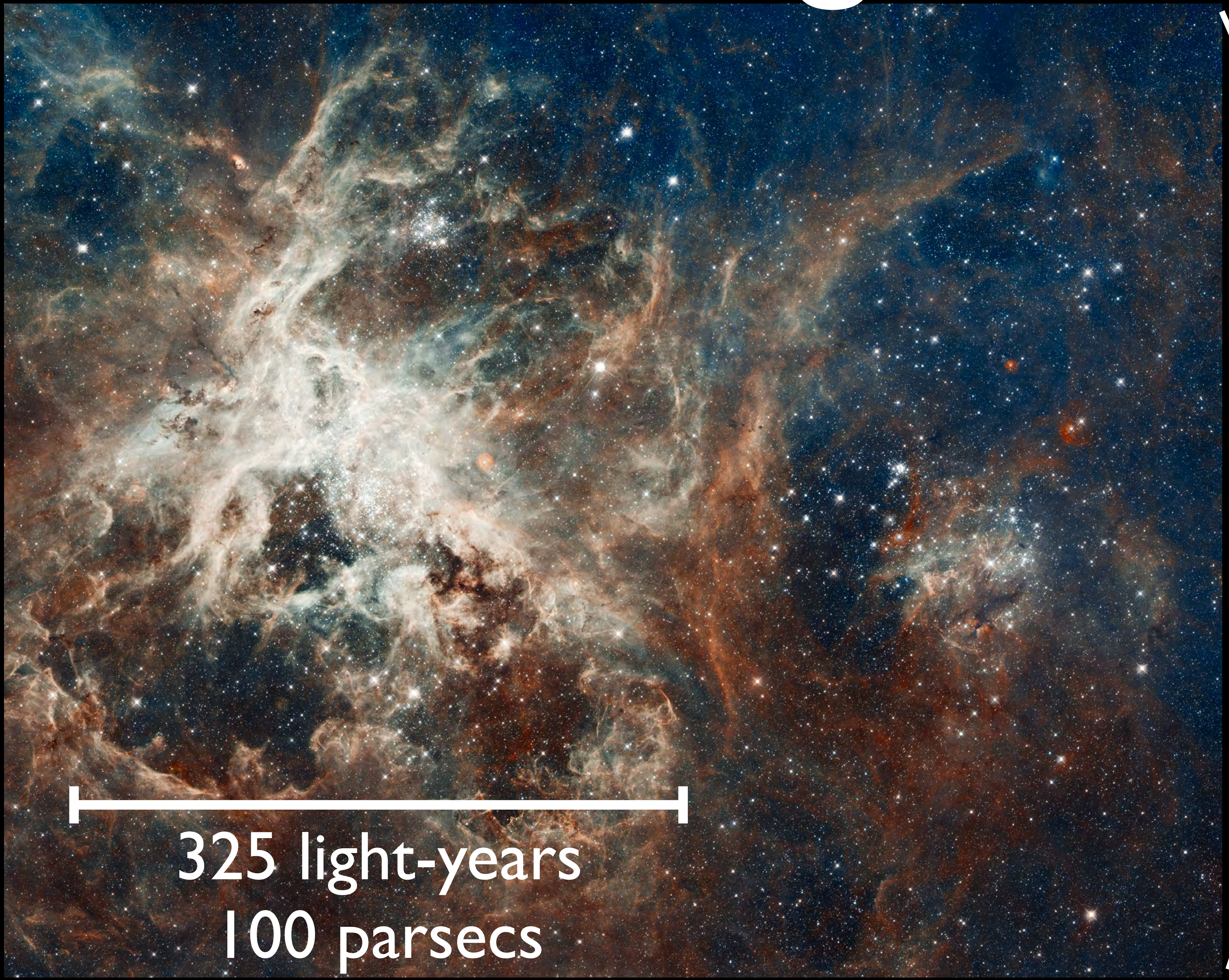
Image Credit: Ceverino/Moody/Snyder

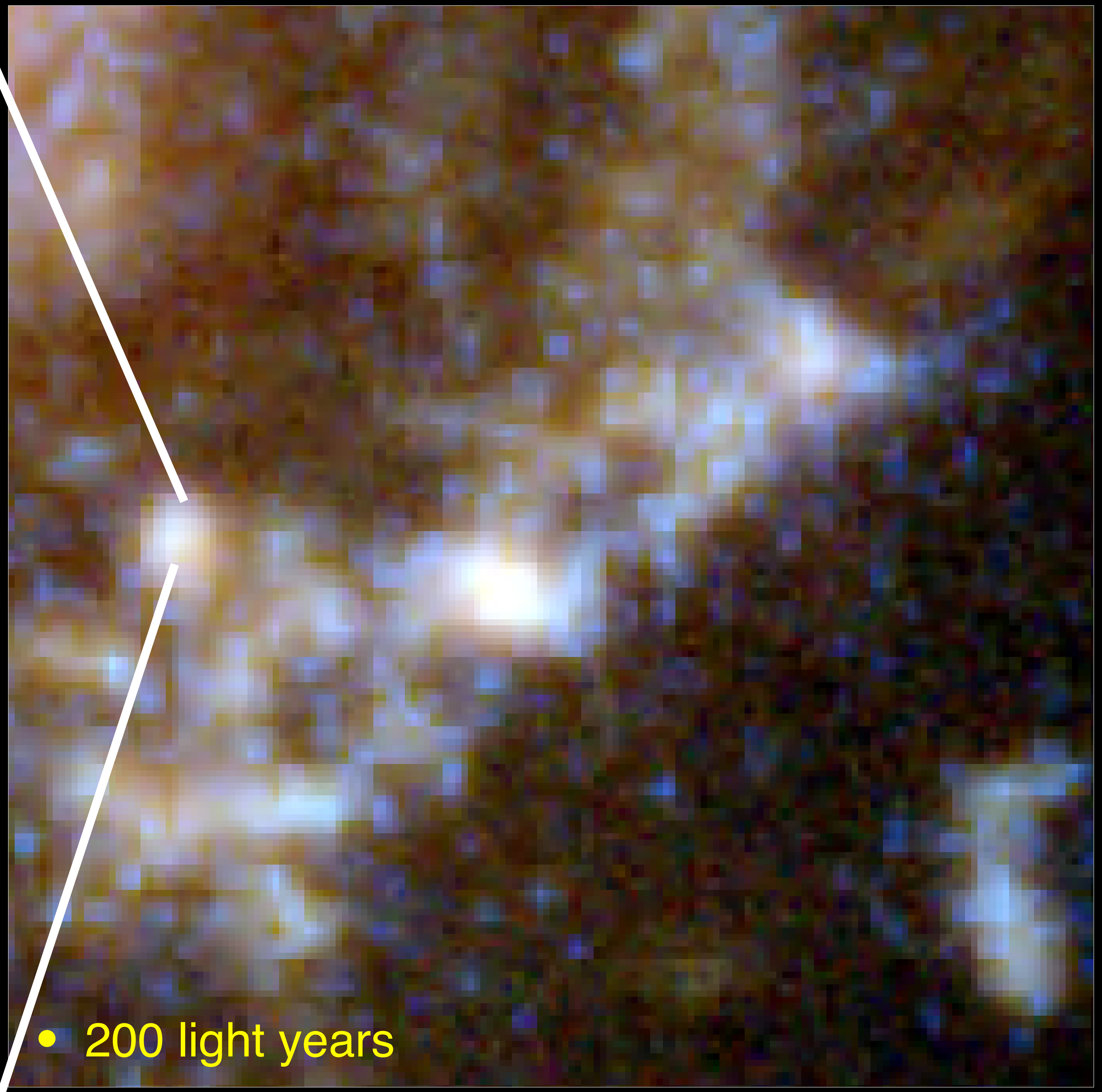
The building blocks of galaxies



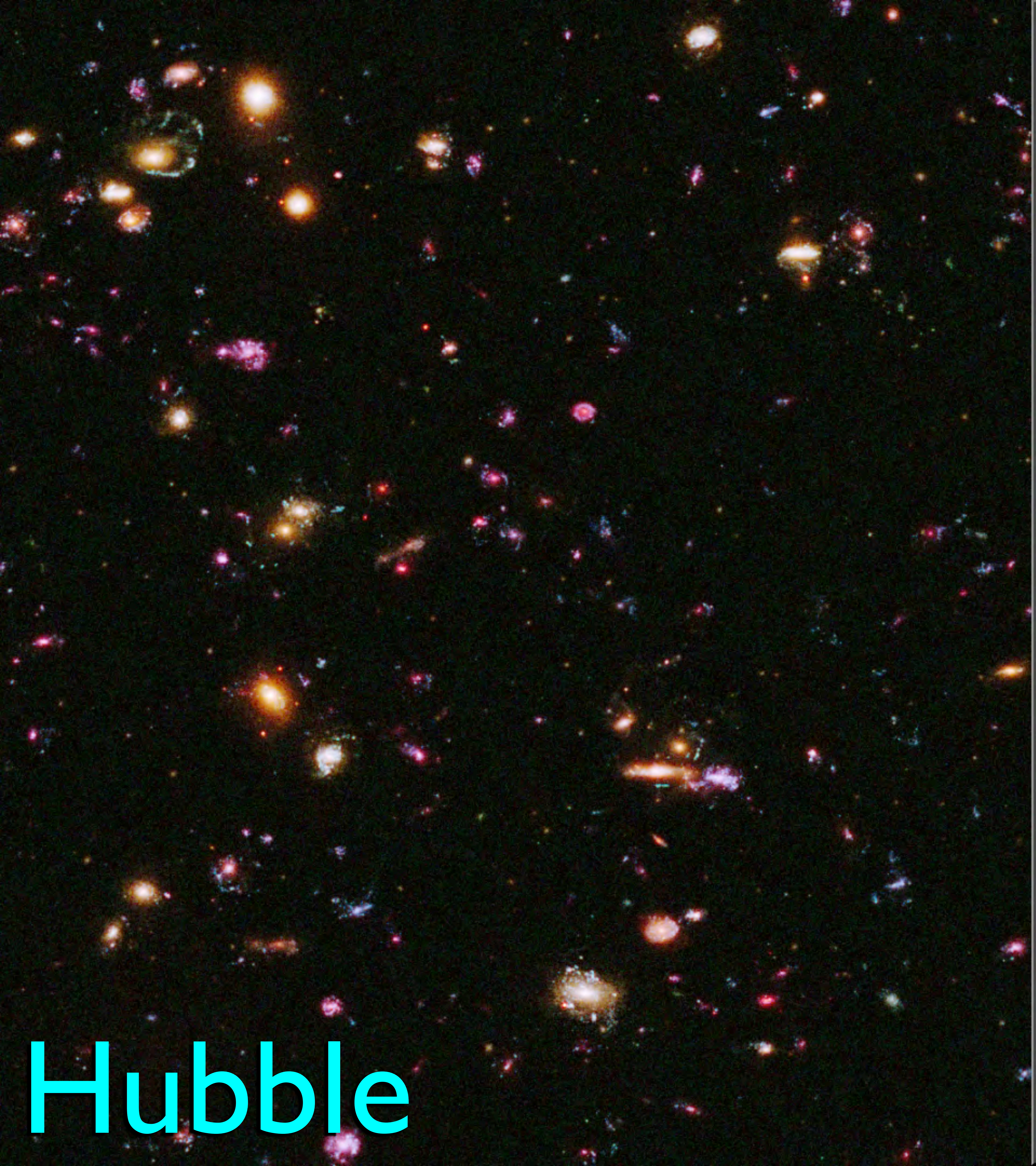


The building blocks of galaxies

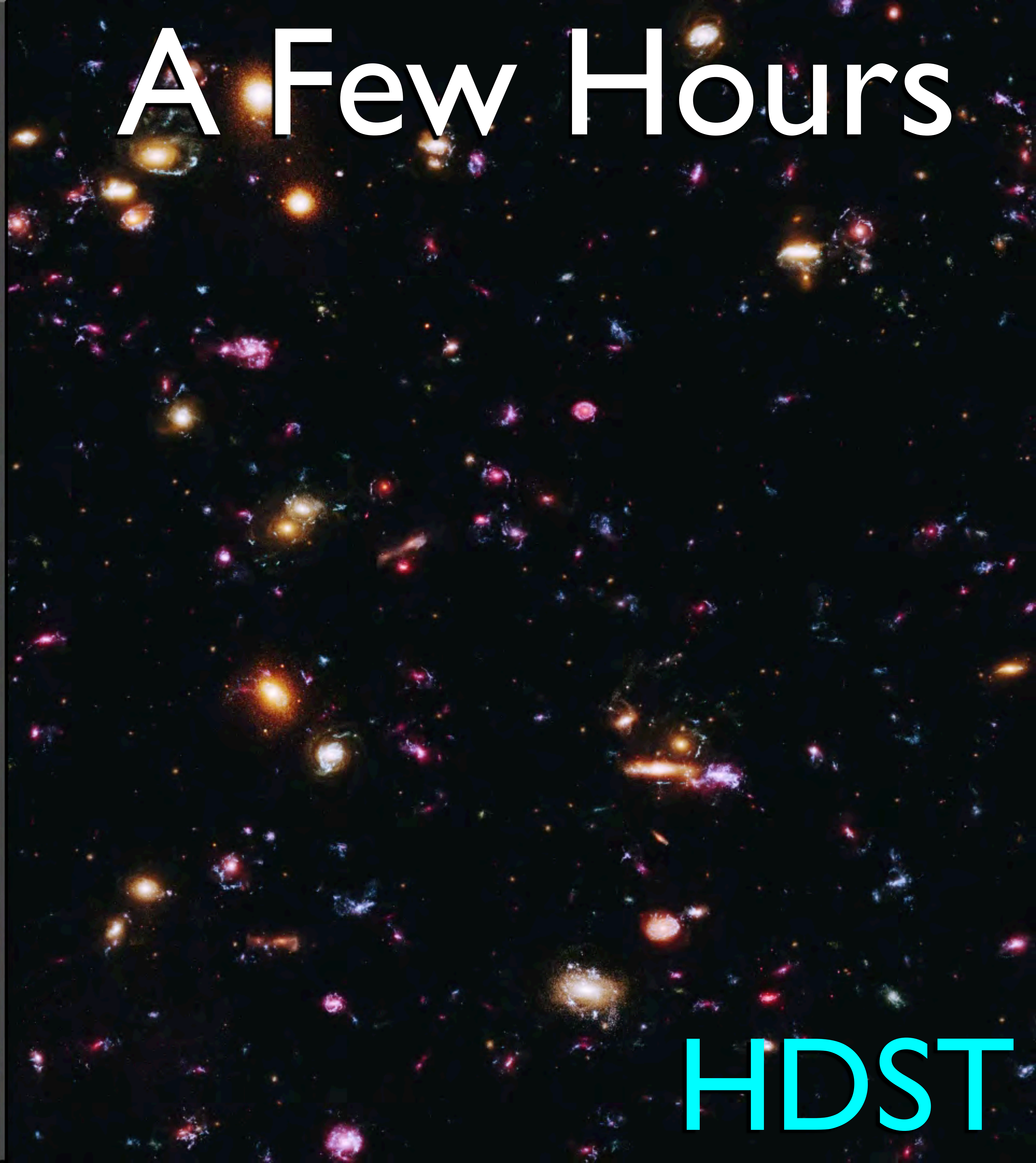




…anywhere in the Universe

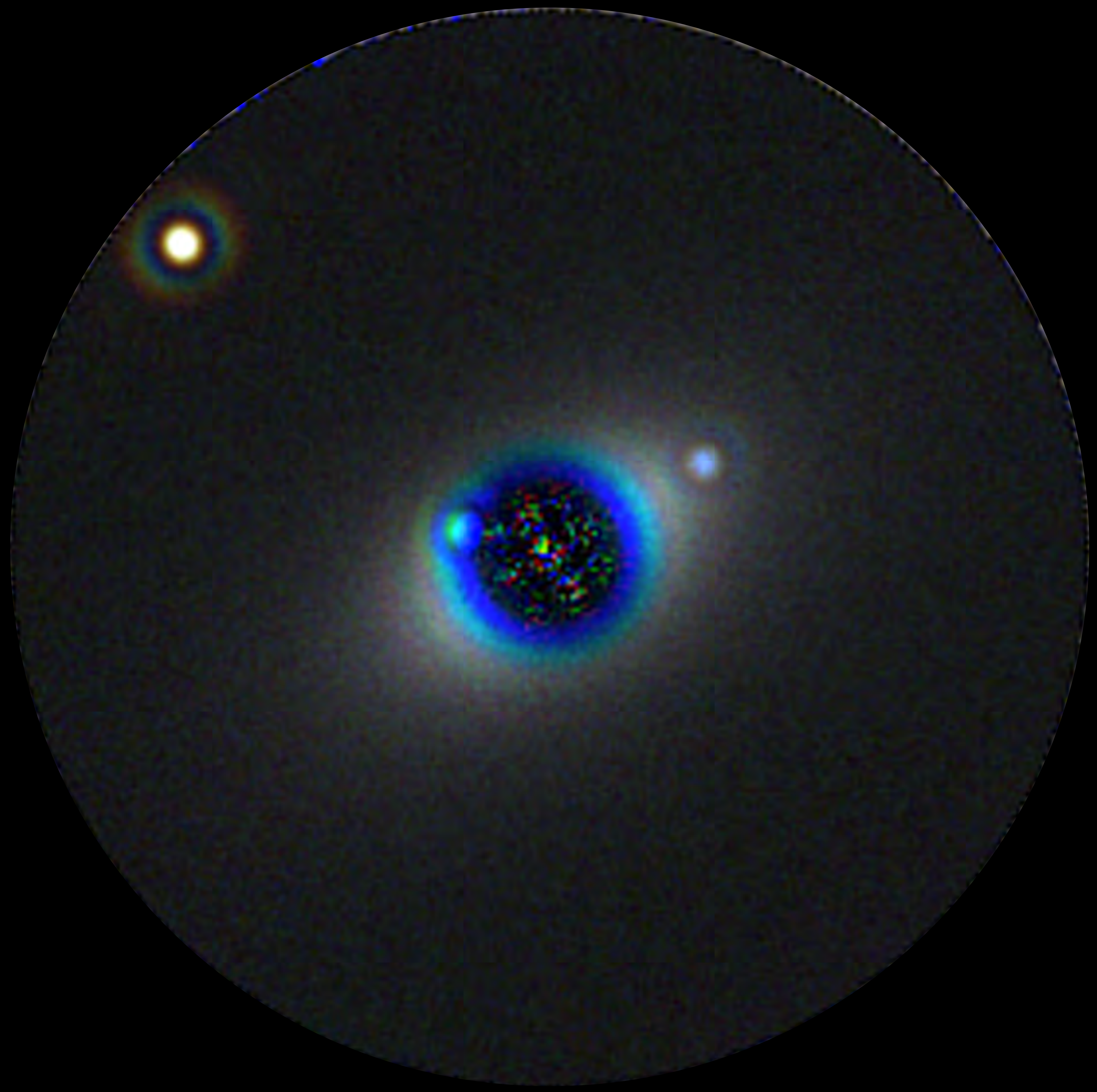

Hubble

HDST


~25 Days
Hubble

A Few Hours
HDST

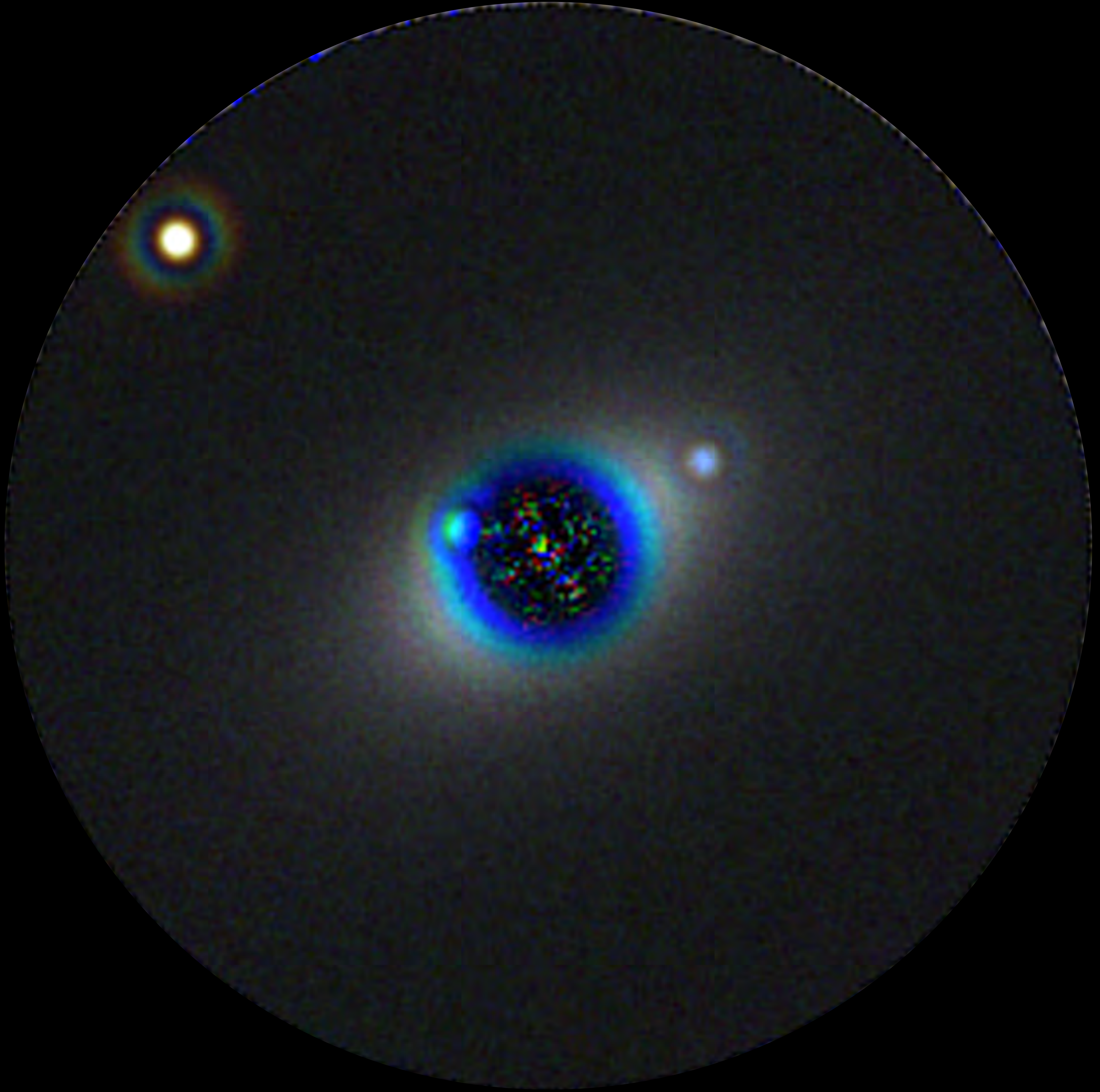
Every exoplanet observation…

…makes another deep field



Every exoplanet observation…

…makes another deep field



For free.


A Few Hours
HDST

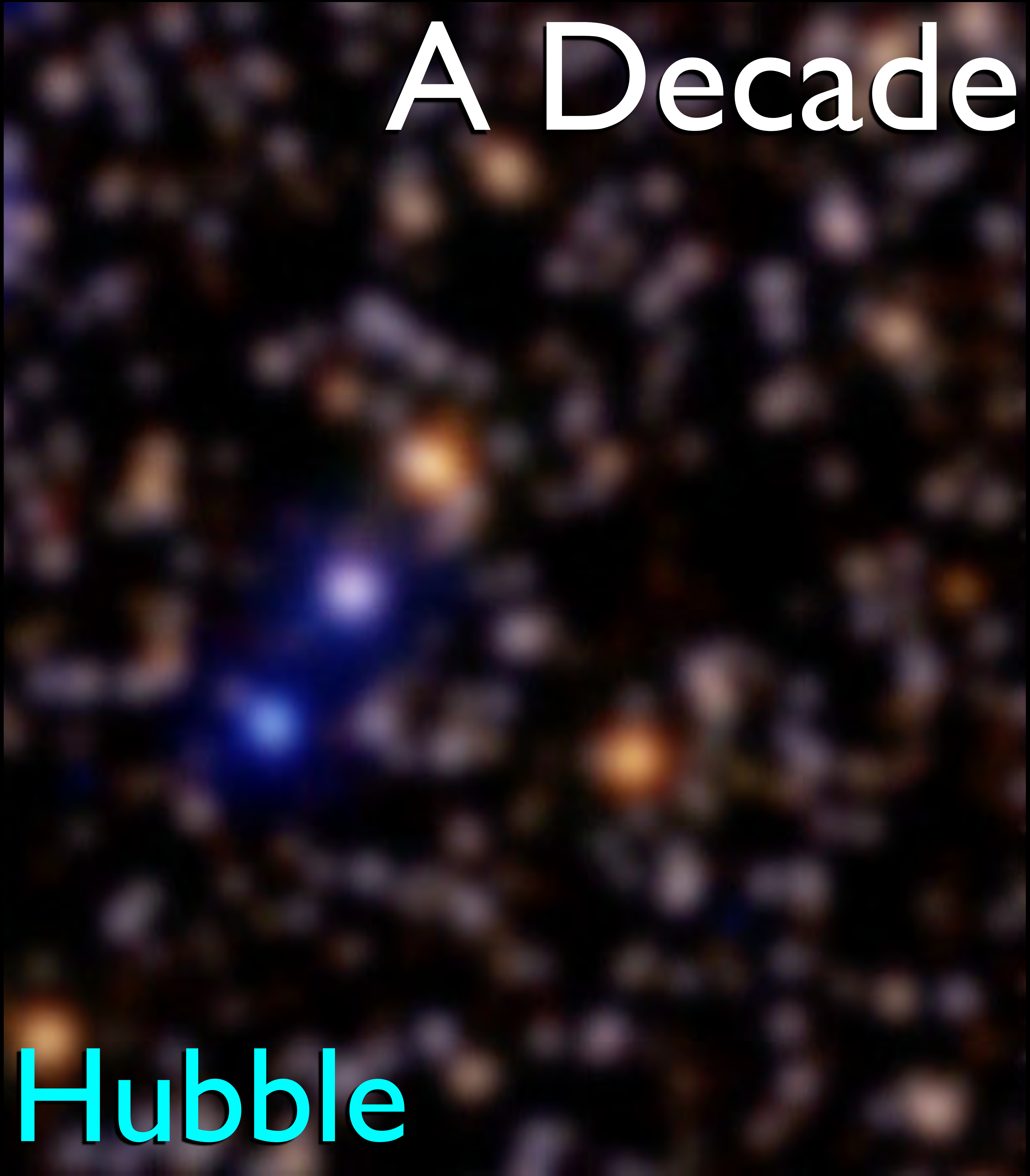
The only way
to know,
is to look.


The Cosmic Web
Intergalactic Gas


Stars in Motion
Tracers of Galaxy Formation & Dark Matter

A Decade of Motion

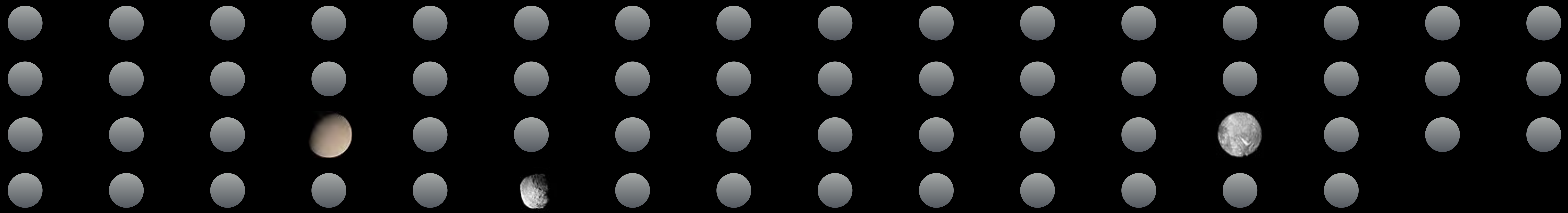
A Decade of Motion



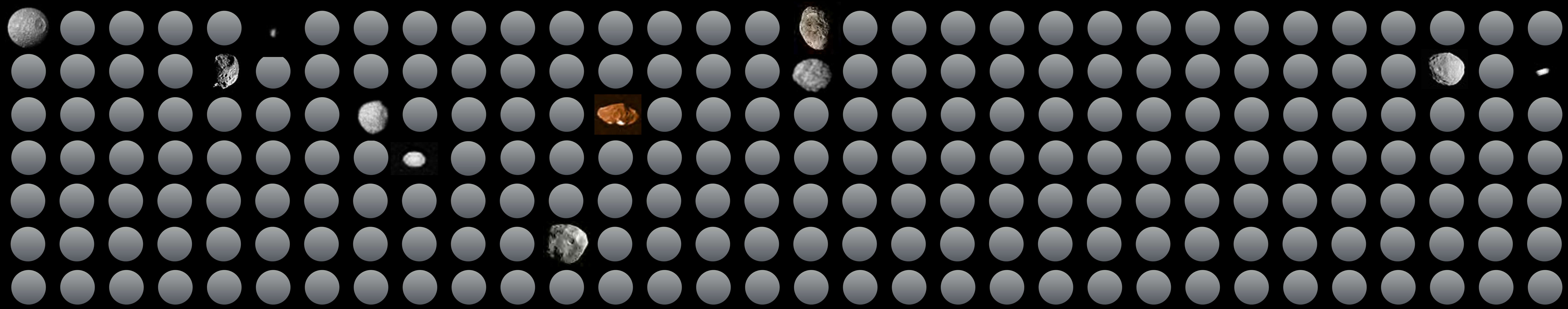

The Universe Nearby

>400 km in radius

>200 km in radius



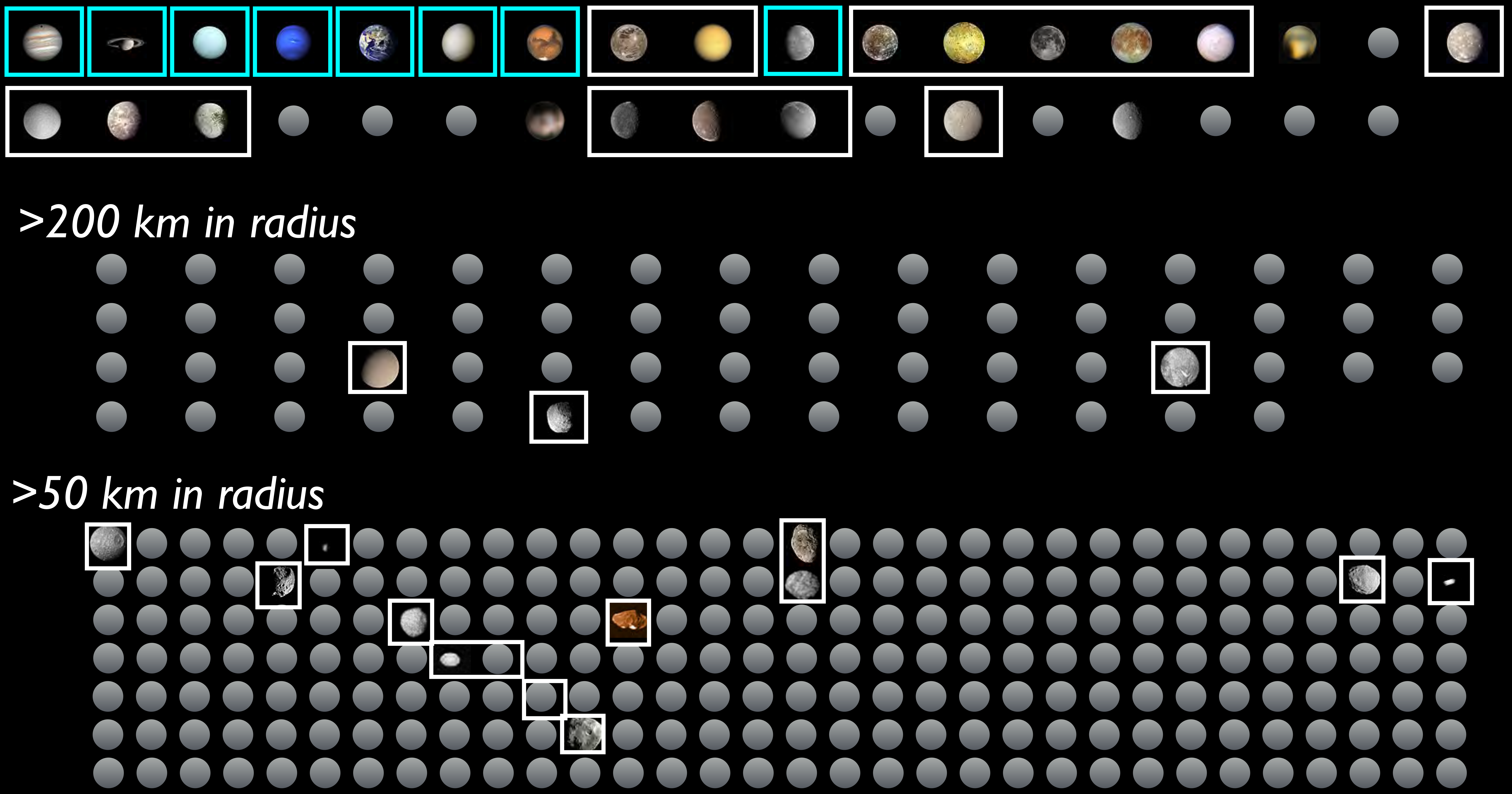
>50 km in radius




>400 km in radius
Major Planets
>200 km in radius
>50 km in radius

Moons of Major Planets

>400 km in radius



The Outer Limits

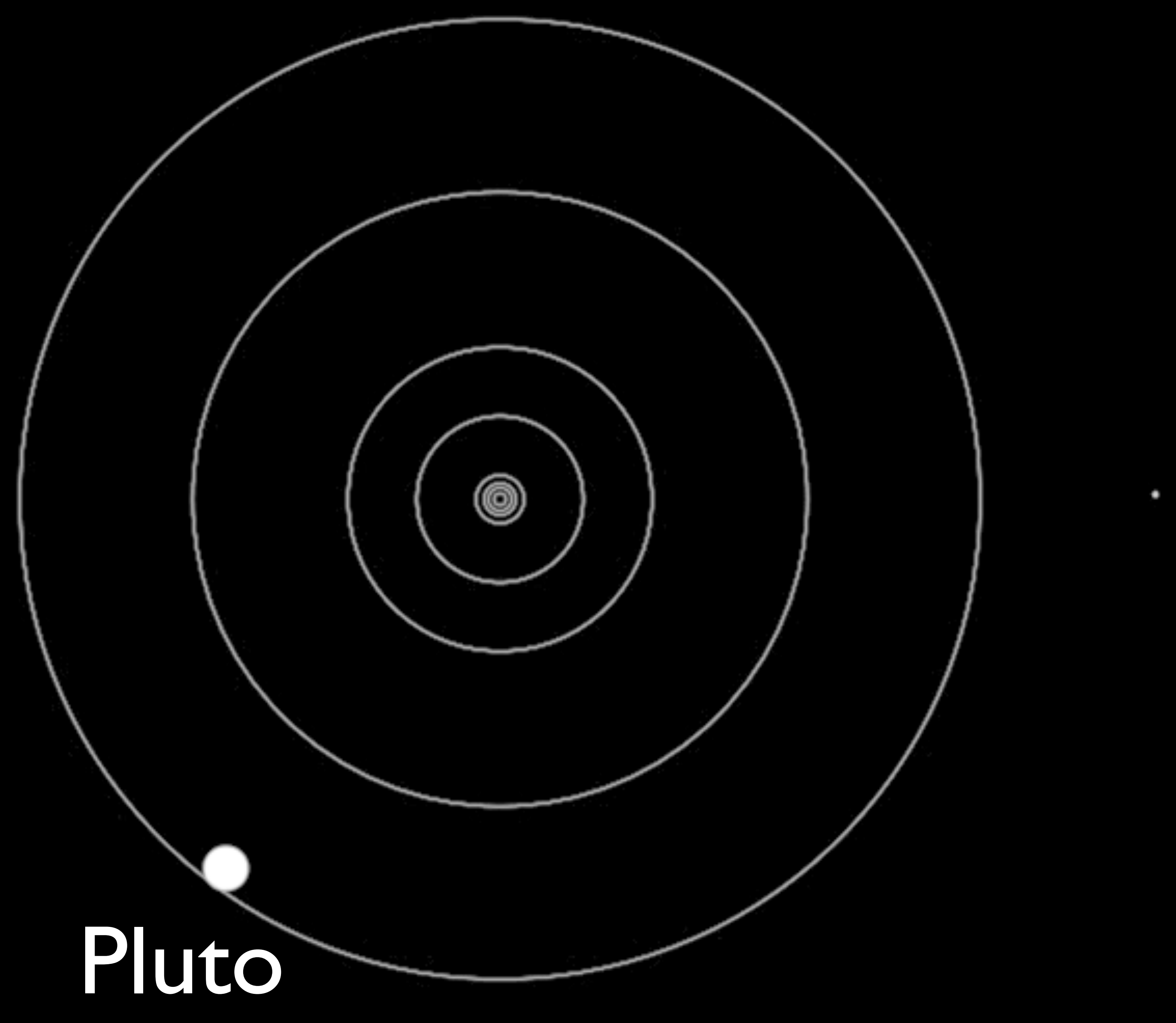


Image Credit: Alex Parker

1993.0

The Outer Limits

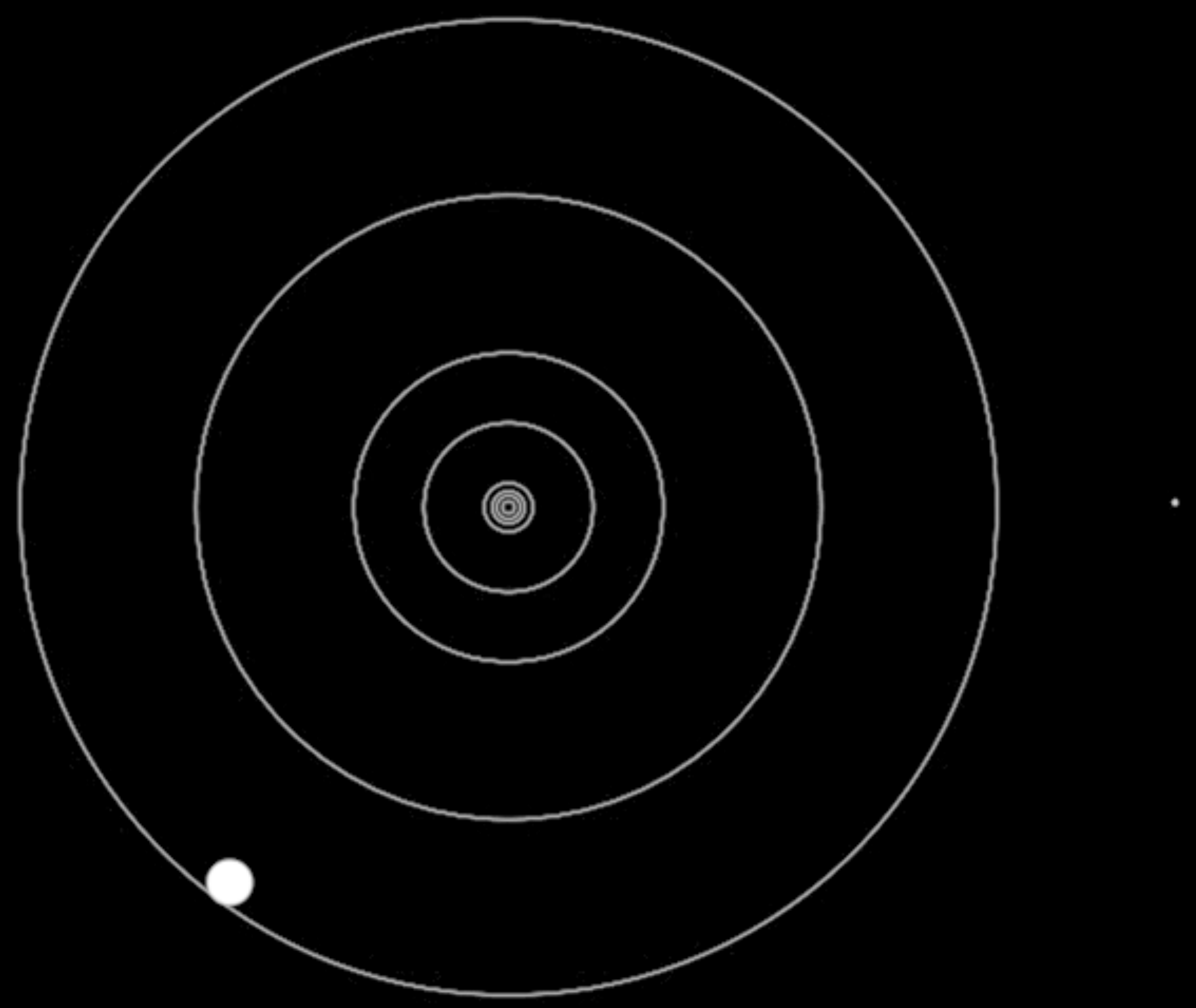


Image Credit: Alex Parker

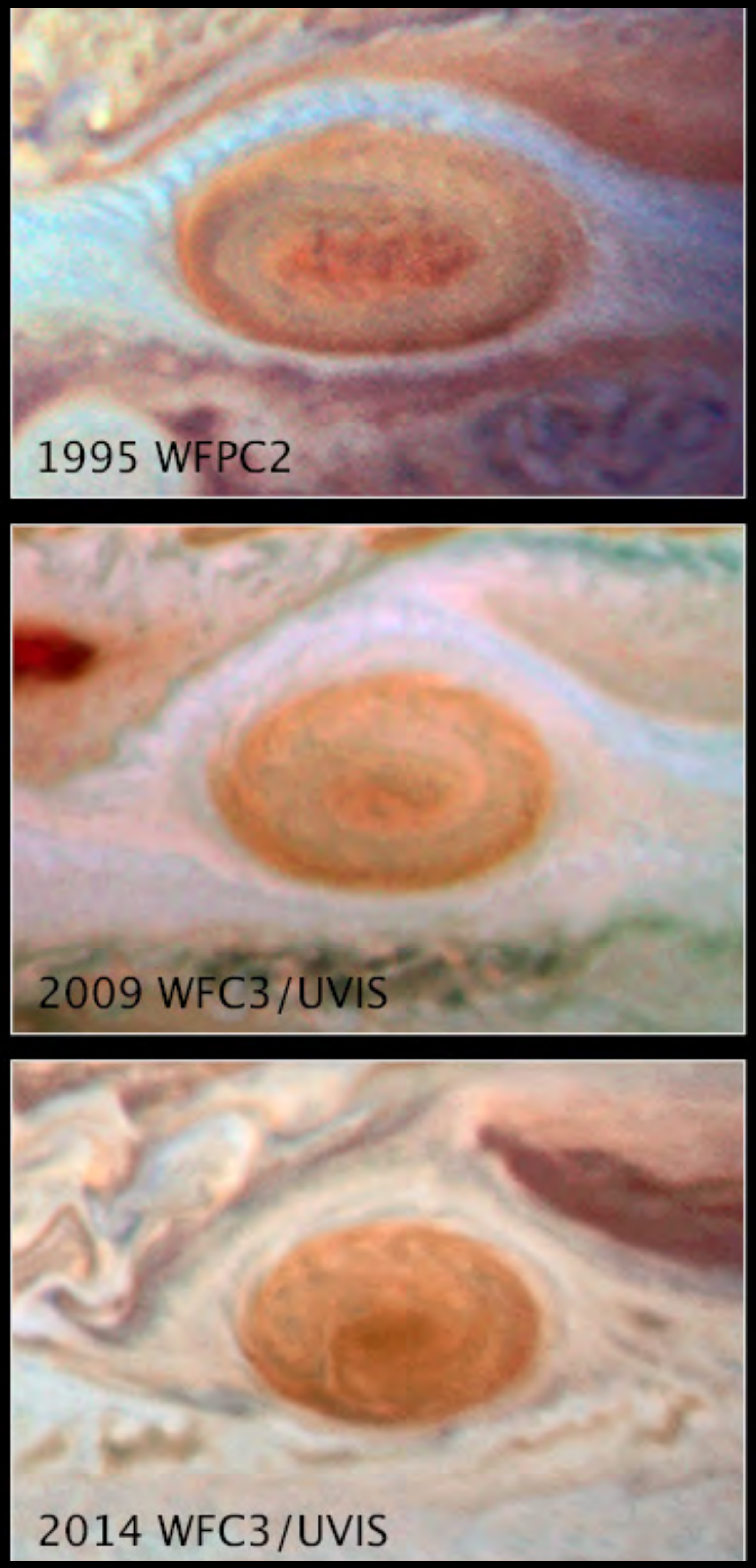
The Outer Limits

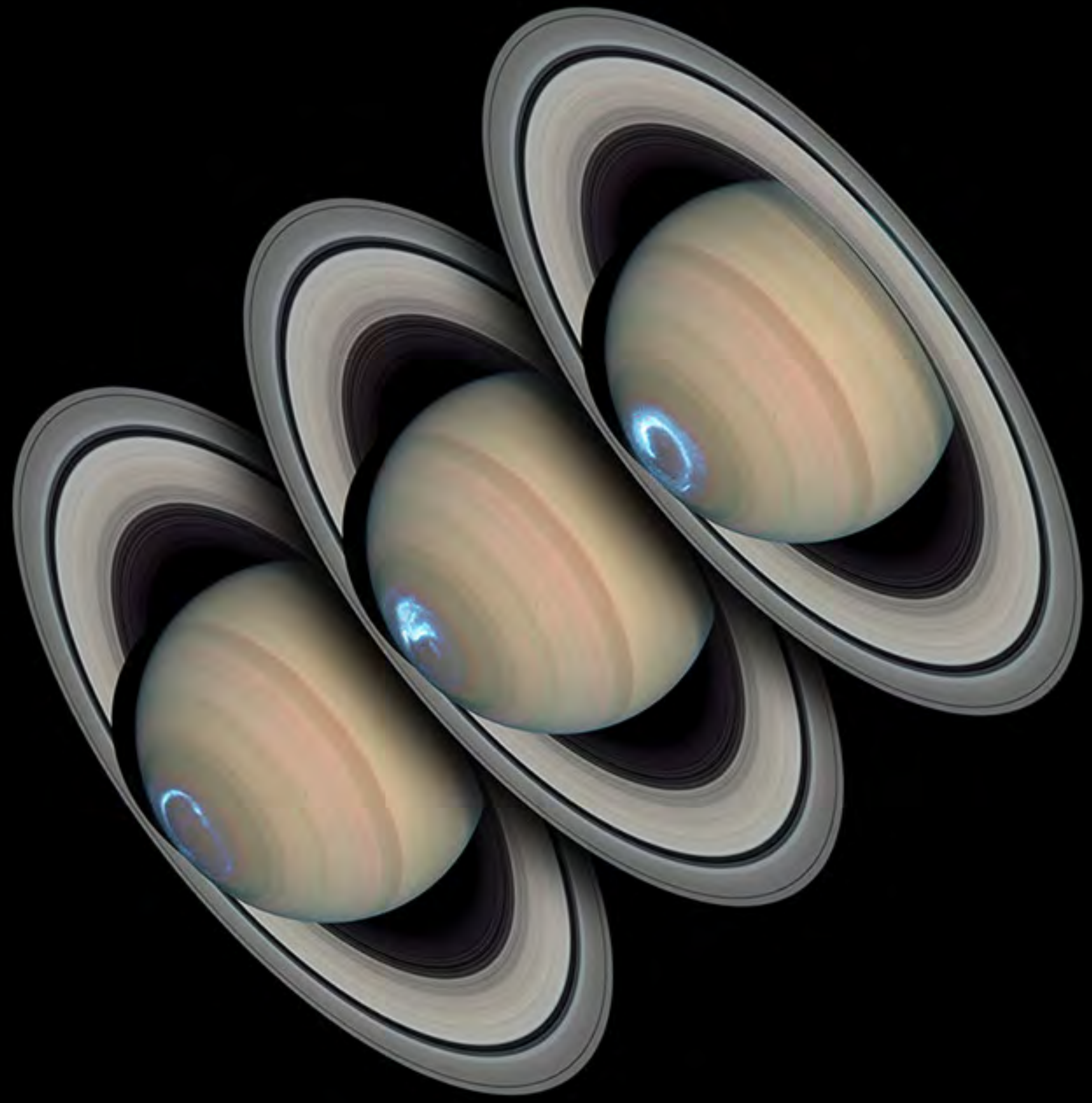
???

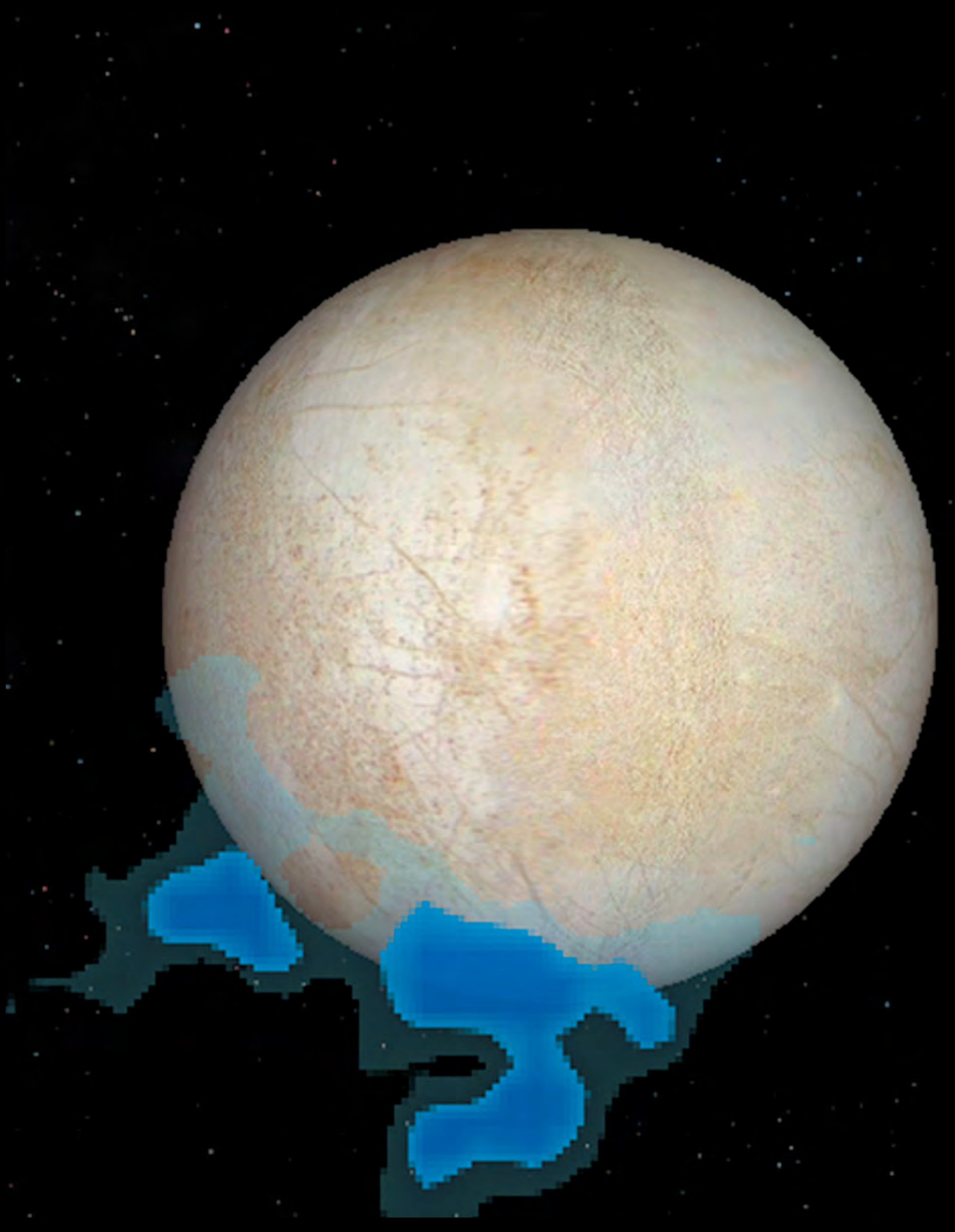
Image Credit: Alex Parker

1993.0

The Dynamic Solar System







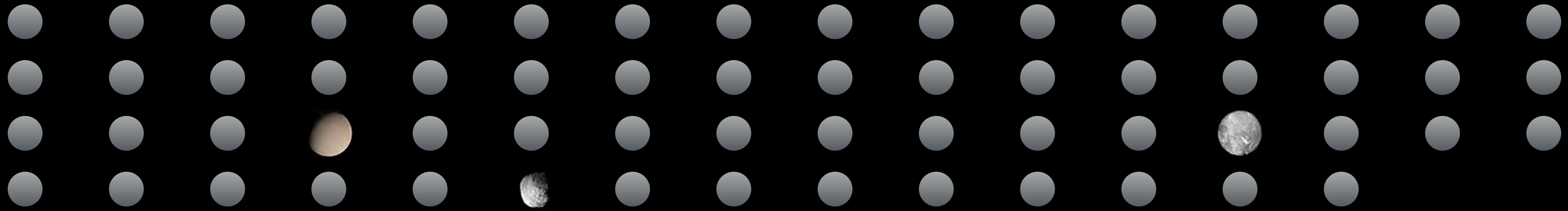
Weather

Aurorae

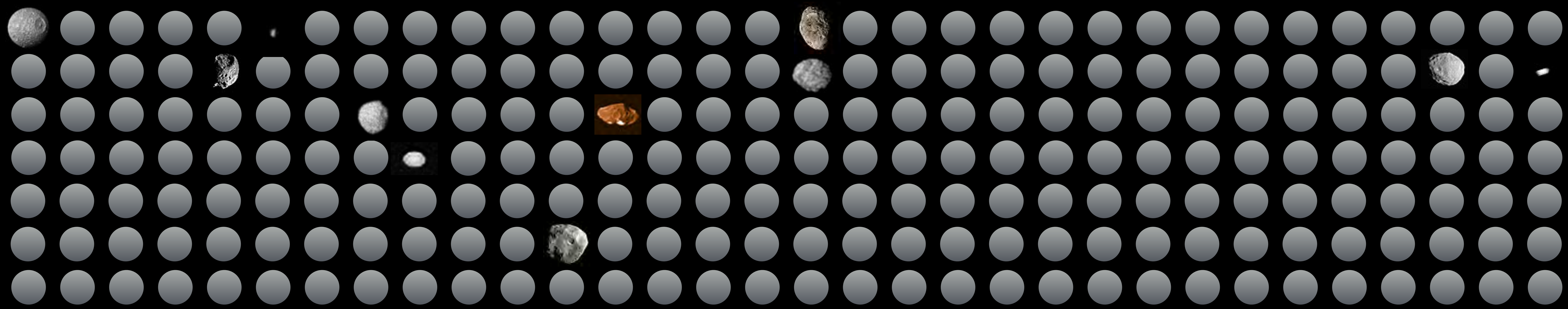
“Geysers”

>400 km in radius

>200 km in radius



>50 km in radius

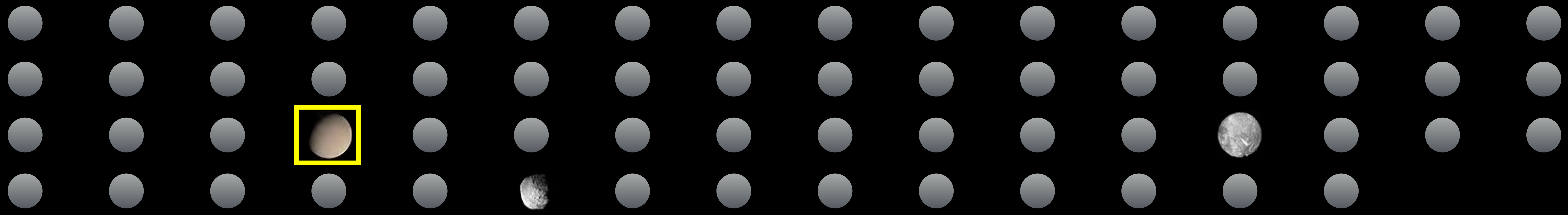



>400 km in radius
5 or more visits to host planet
>200 km in radius
>50 km in radius

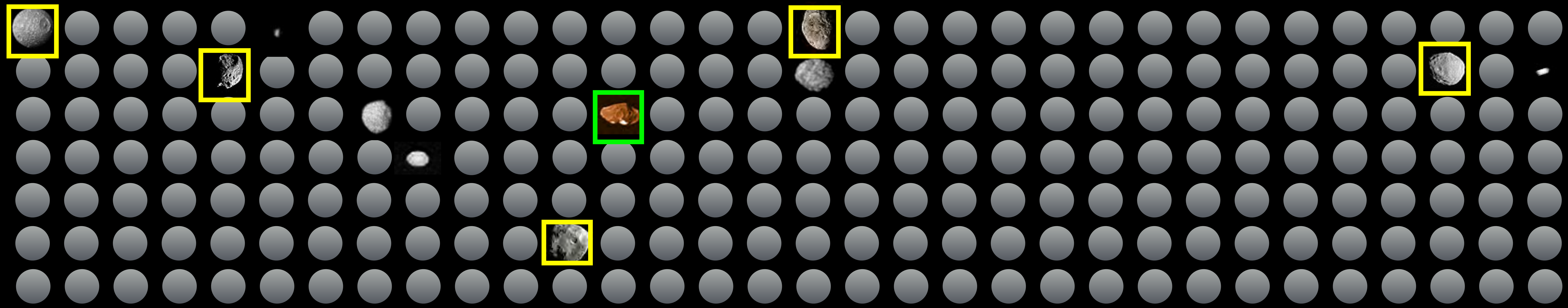
3 visits to host planet

>400 km in radius

>200 km in radius



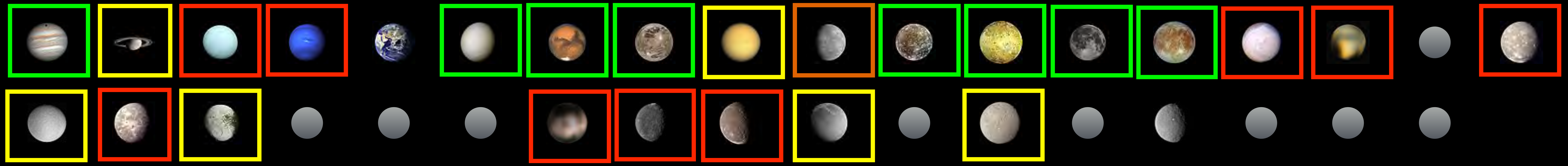
>50 km in radius



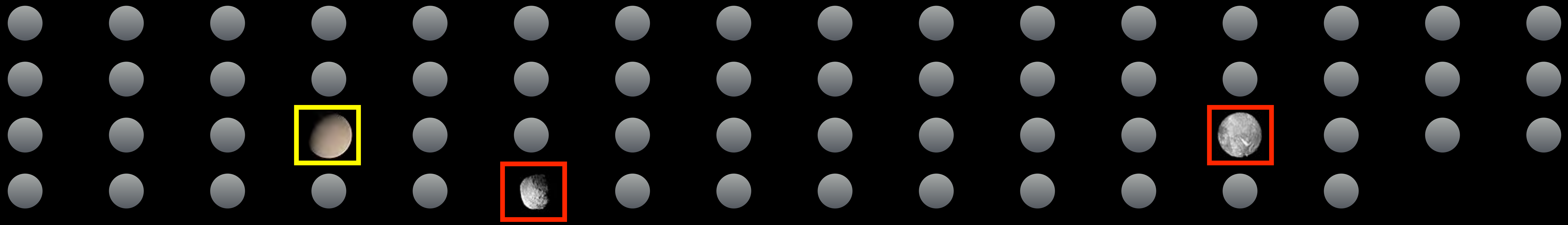
2 visits to host planet
>400 km in radius
>200 km in radius
>50 km in radius

1 visit to host planet

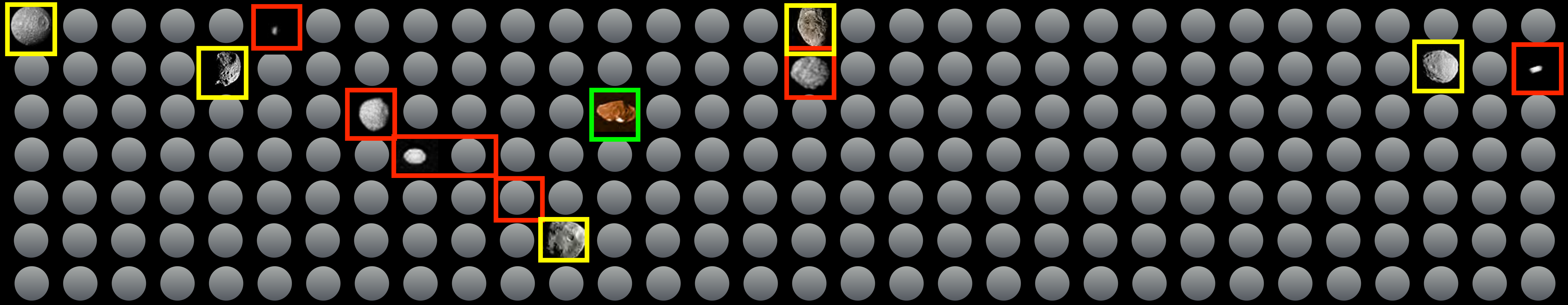
>400 km in radius



>200 km in radius



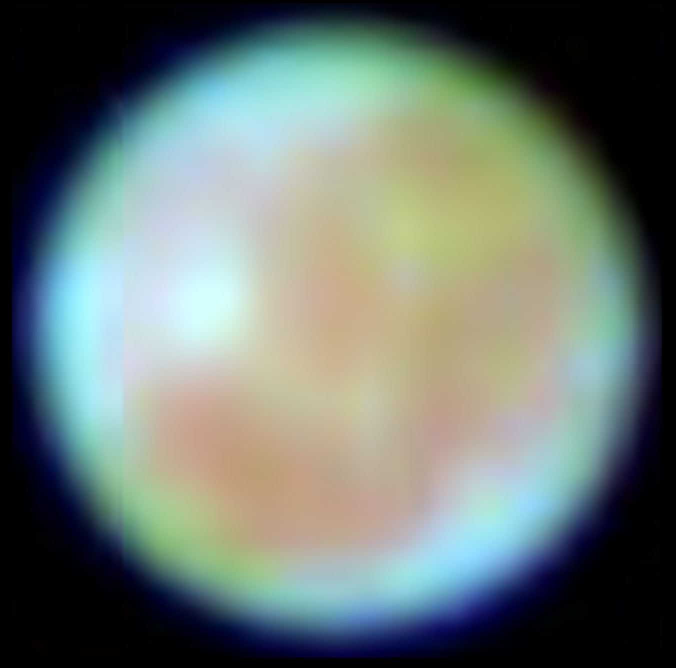
>50 km in radius

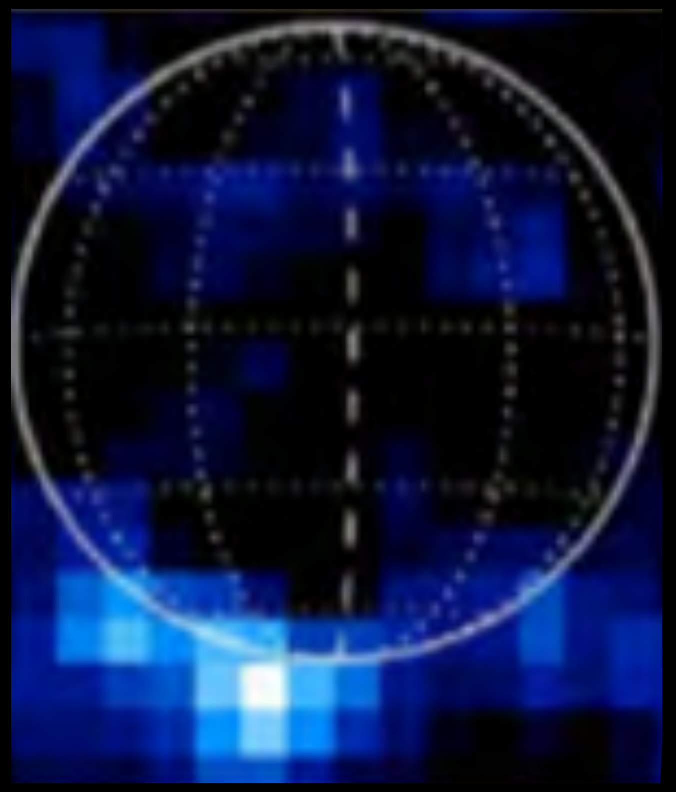


Geysers on Europa

Surface features on Pluto+Charon

Hubble





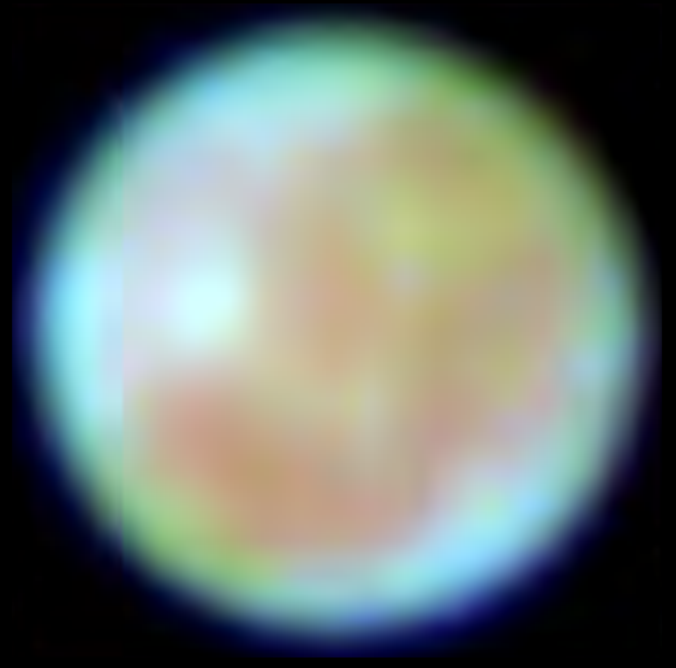
Pluto

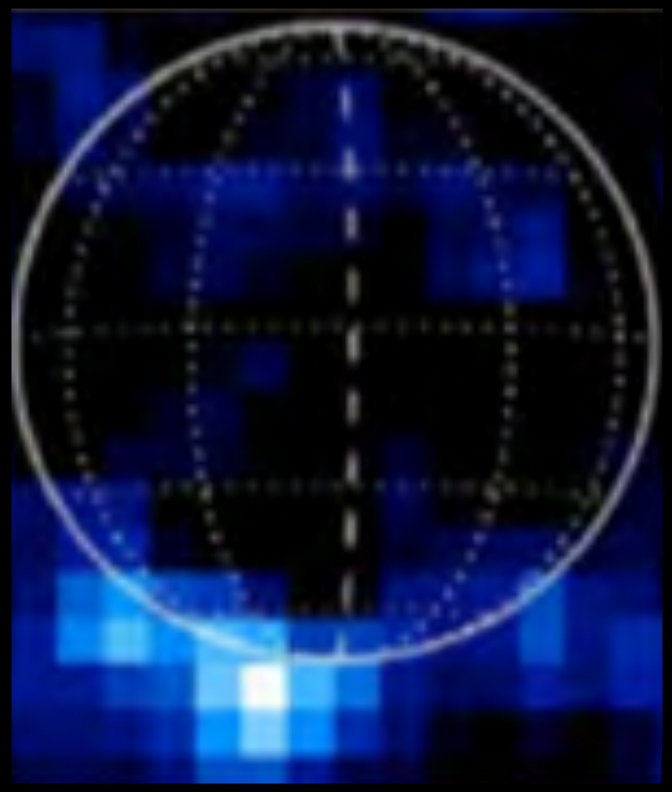
Charon

Geysers on Europa

Surface features on Pluto+Charon

Hubble

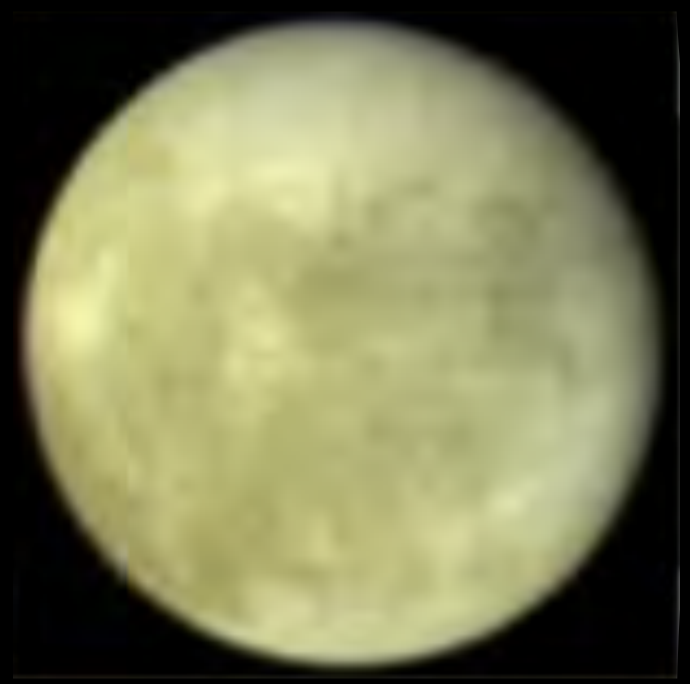




Pluto

Charon

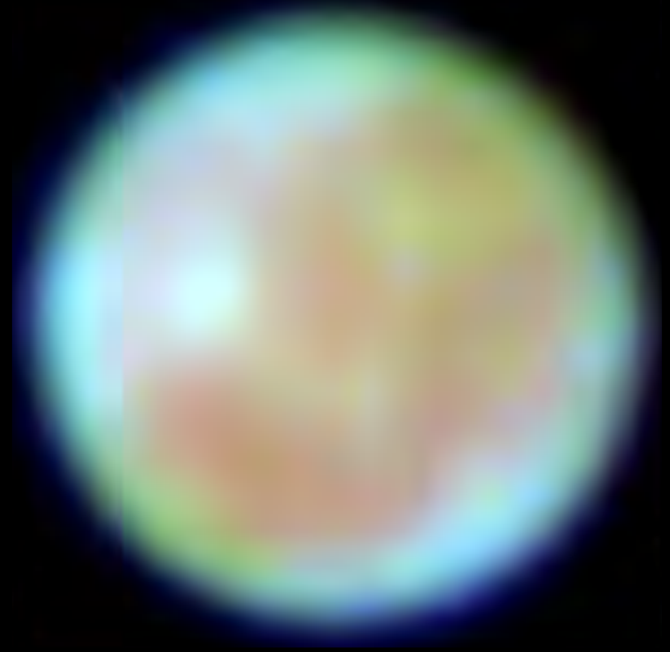
HDST

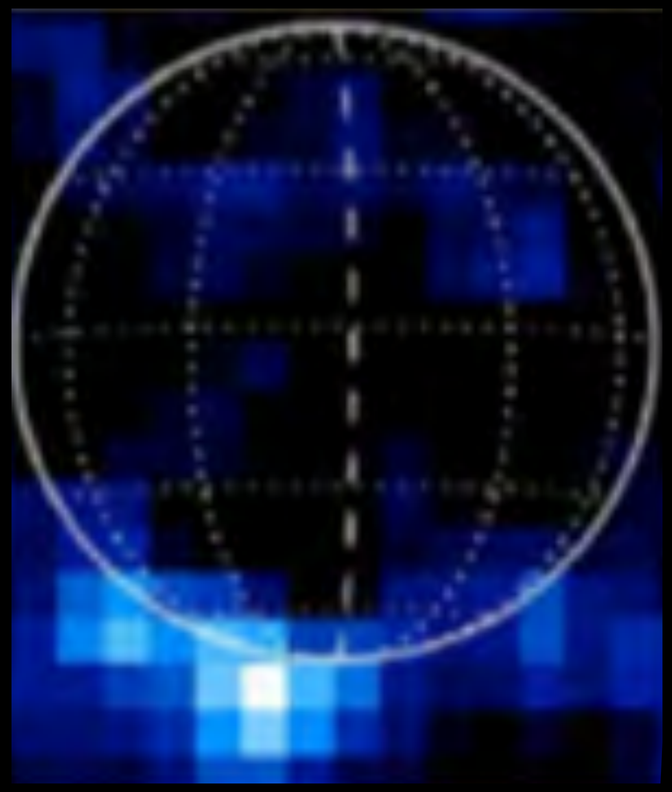


Geysers on Europa

Surface features on Pluto+Charon

Hubble

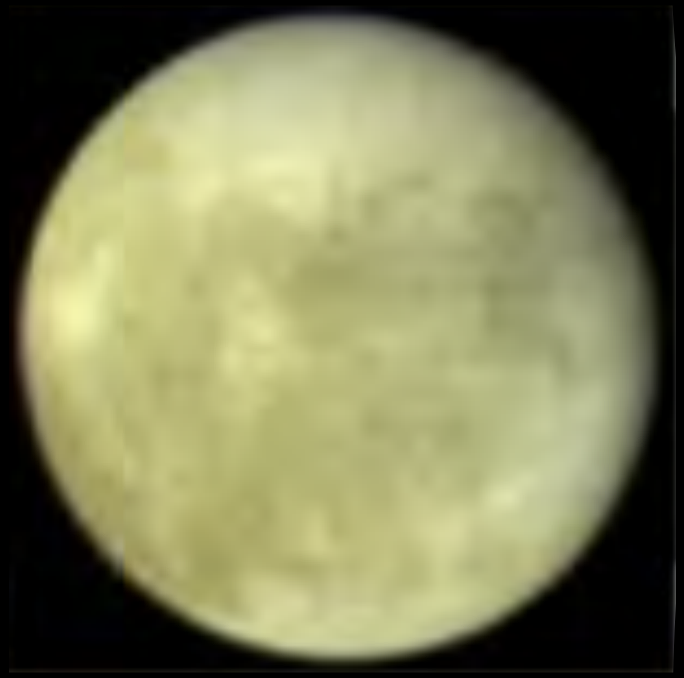




Pluto

Charon

HDST

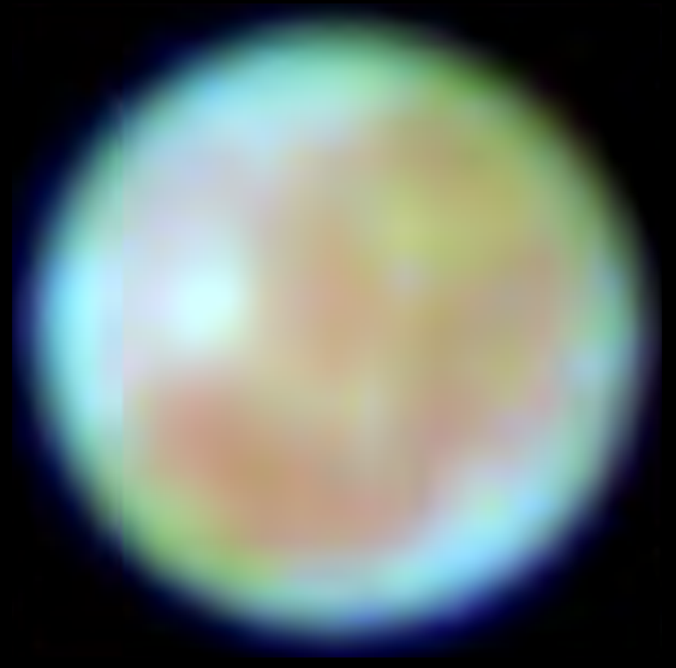


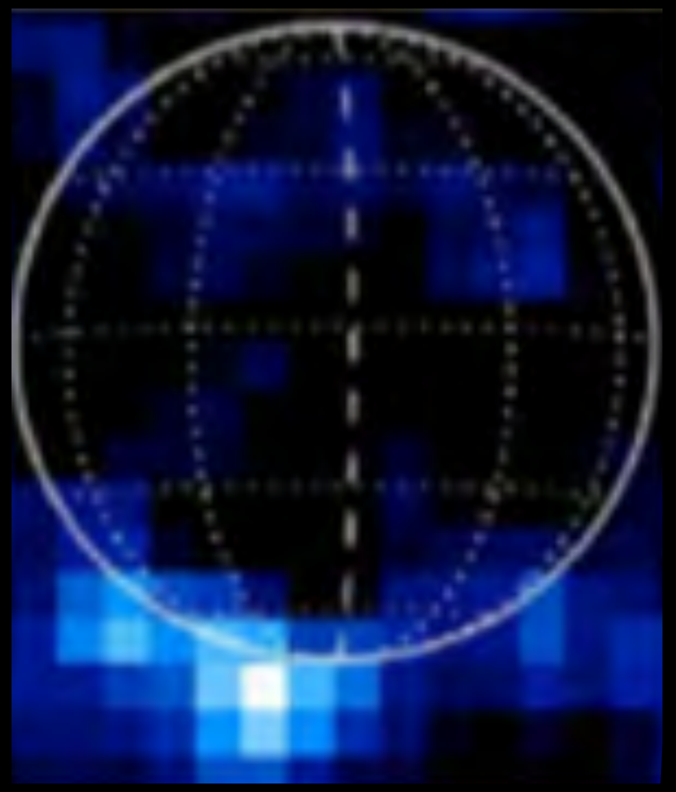
New Horizons
Two weeks out

Geysers on Europa

Surface features on Pluto+Charon

Hubble

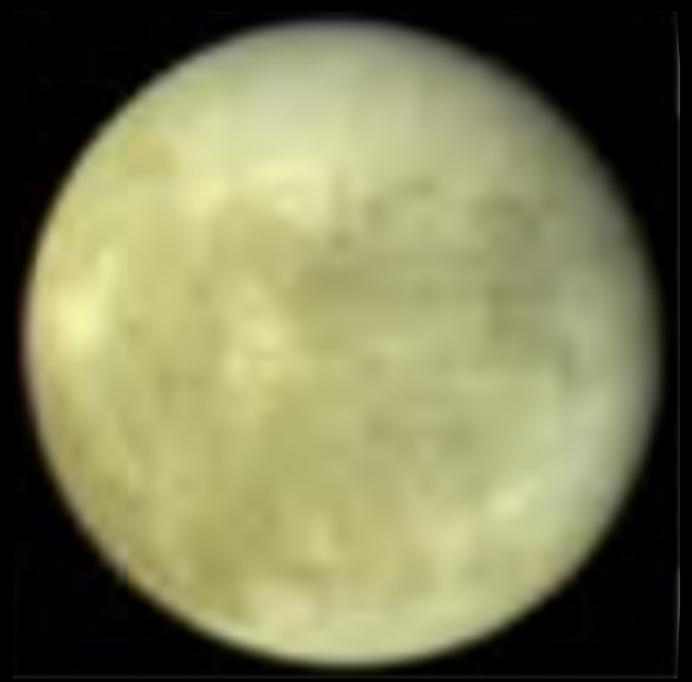




Pluto

Charon

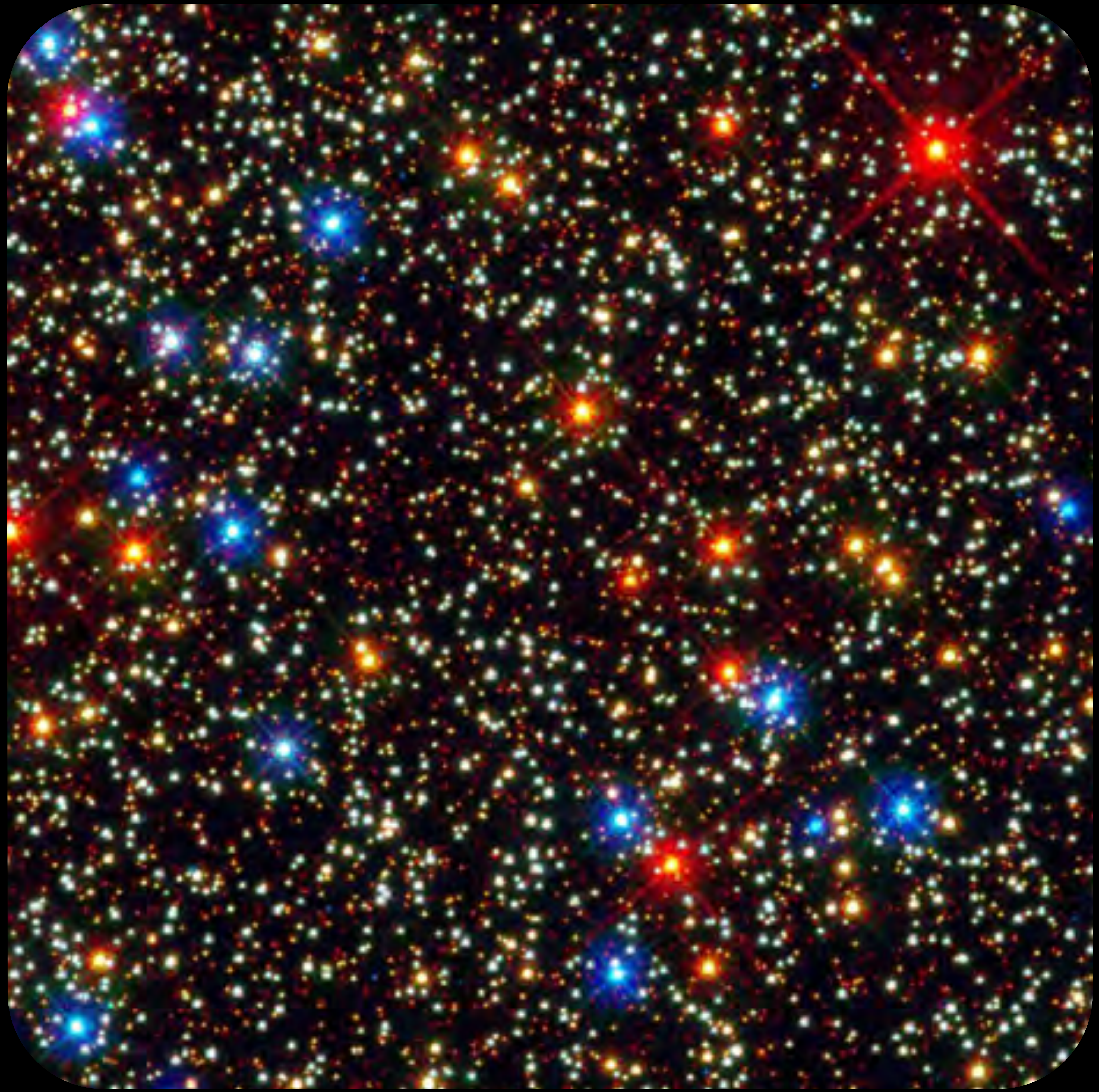
HDST



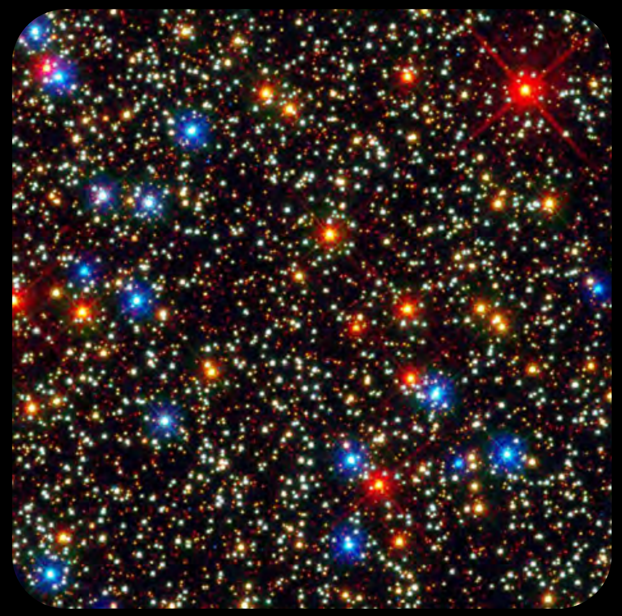
What will HDST do?

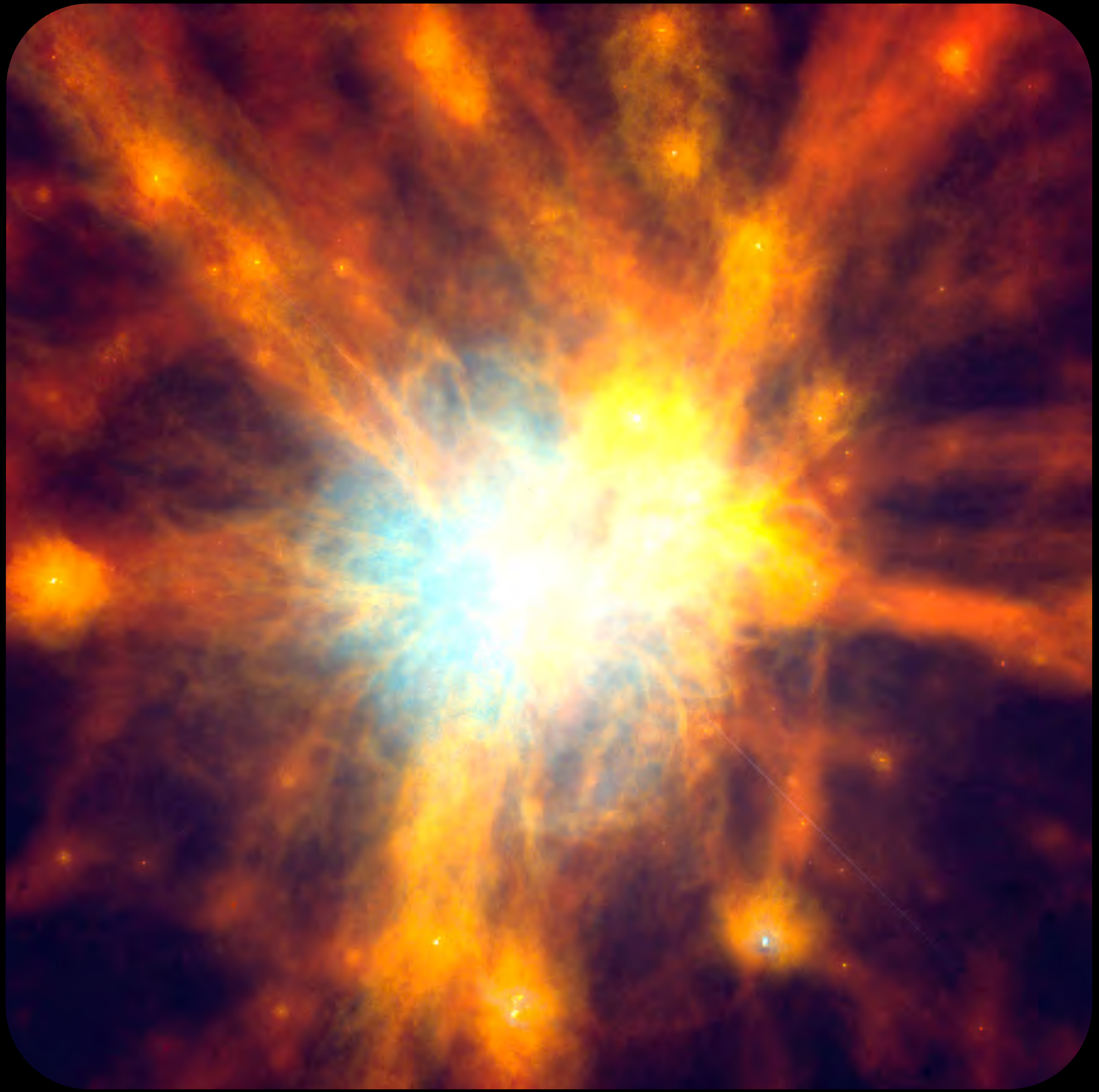
What will HDST do?

…observe structures the size of Manhattan at the orbit of Jupiter…

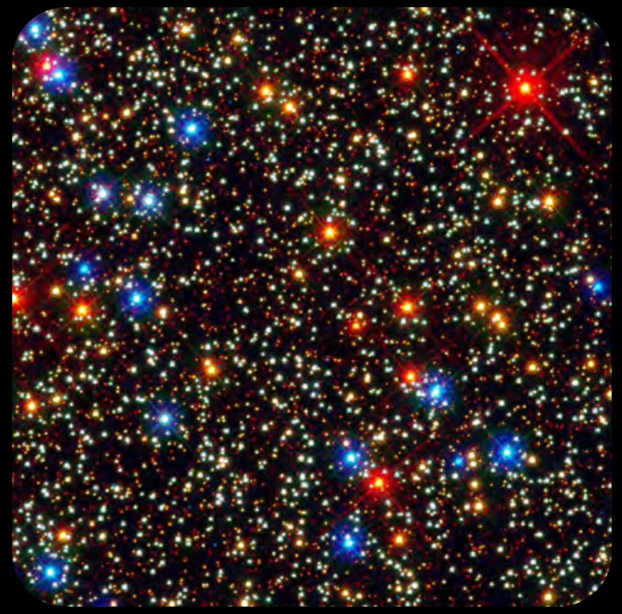


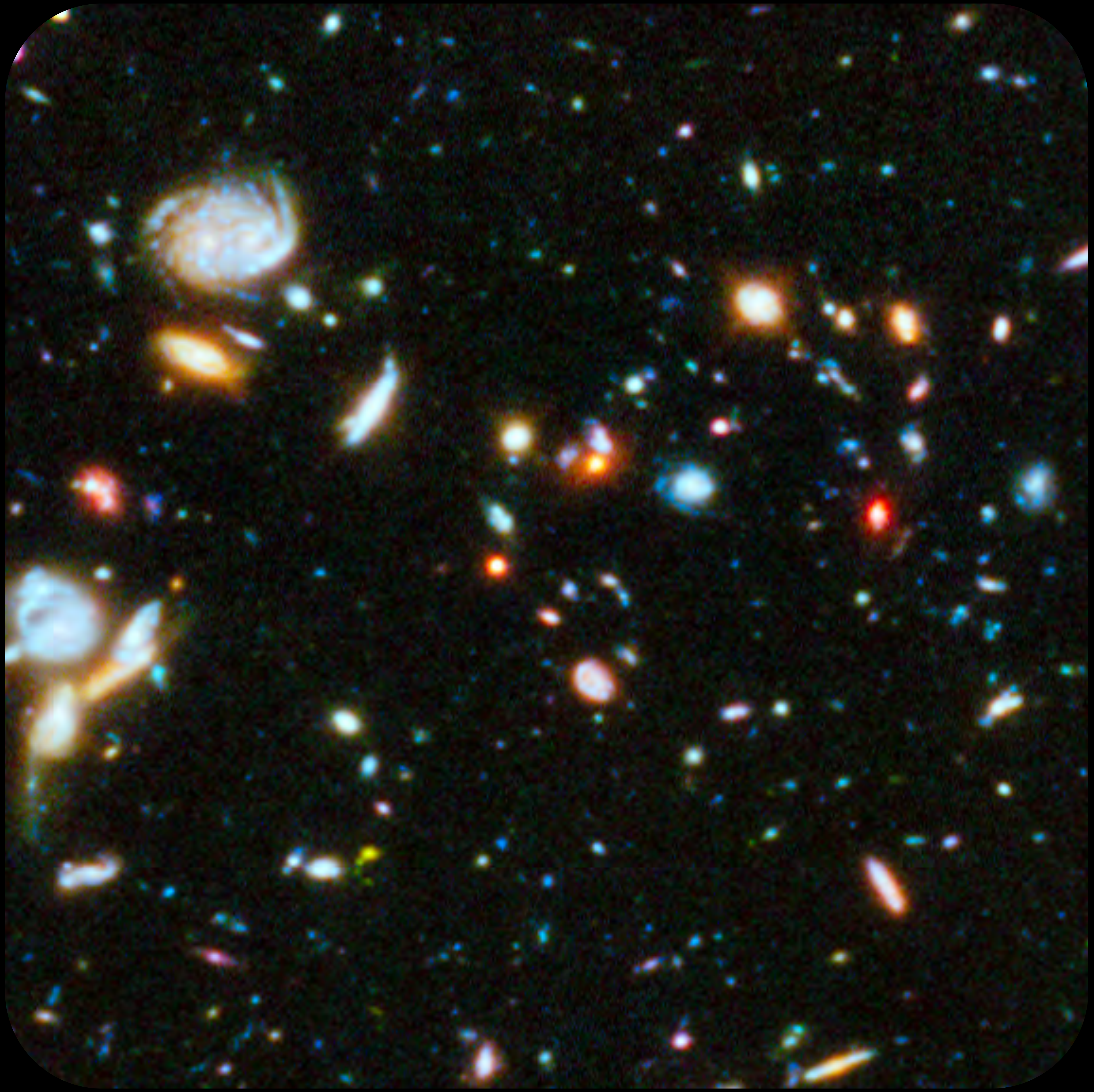
. . . track dark matter in the smallest, densest galaxies, by watching the motion of stars. . .

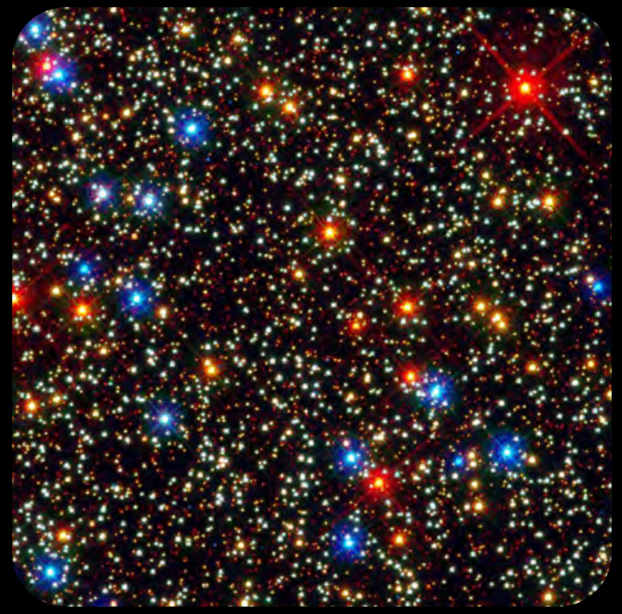


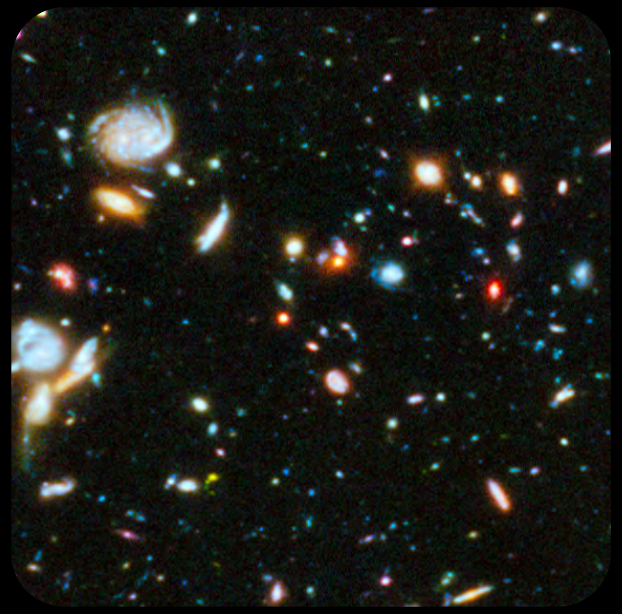
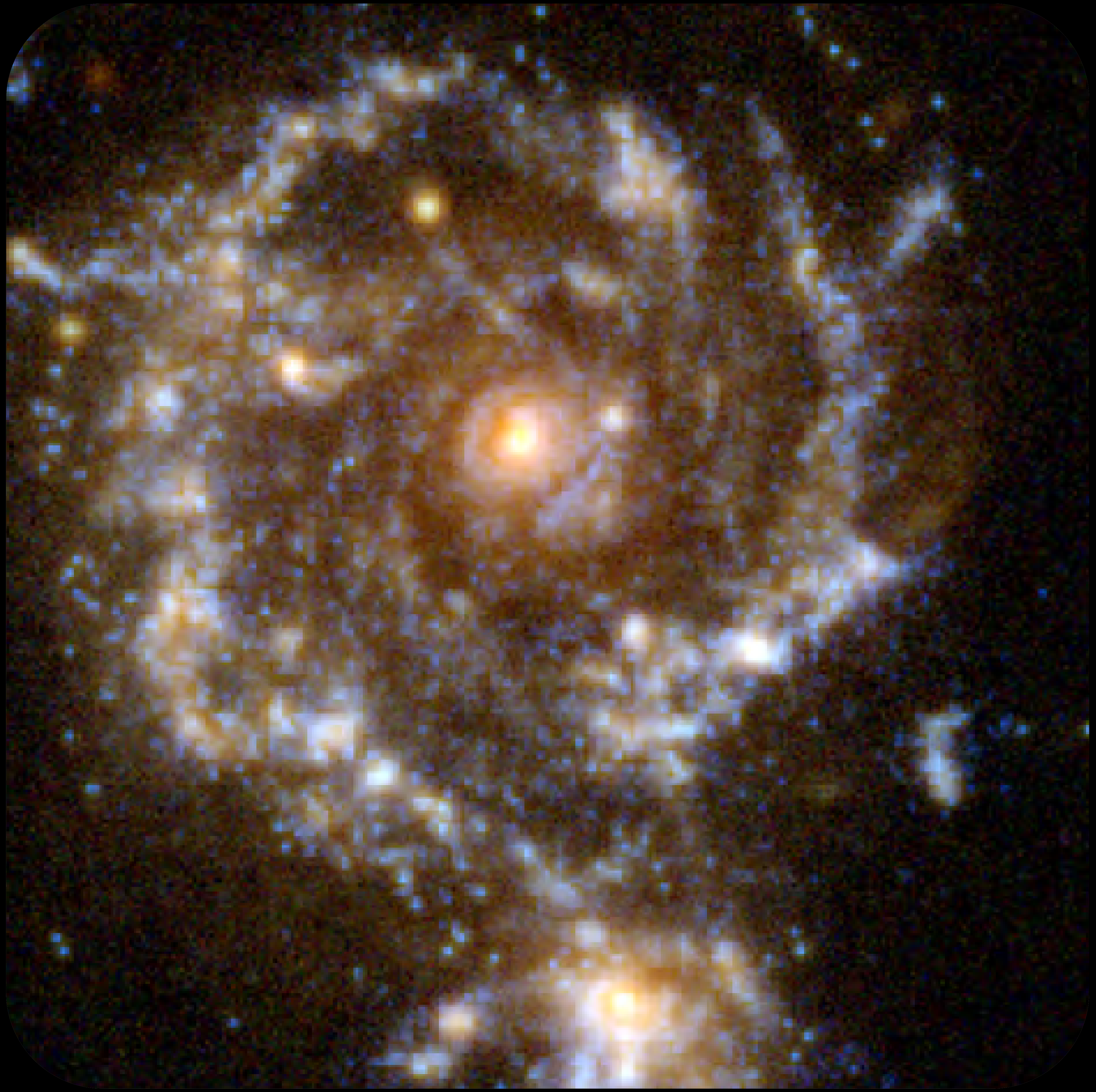
. . . map the nearly invisible diffuse gas that feeds the growth of galaxies. . .



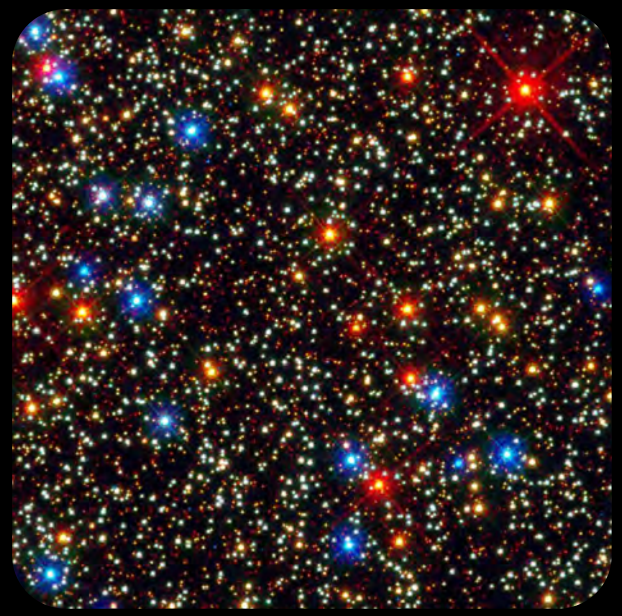
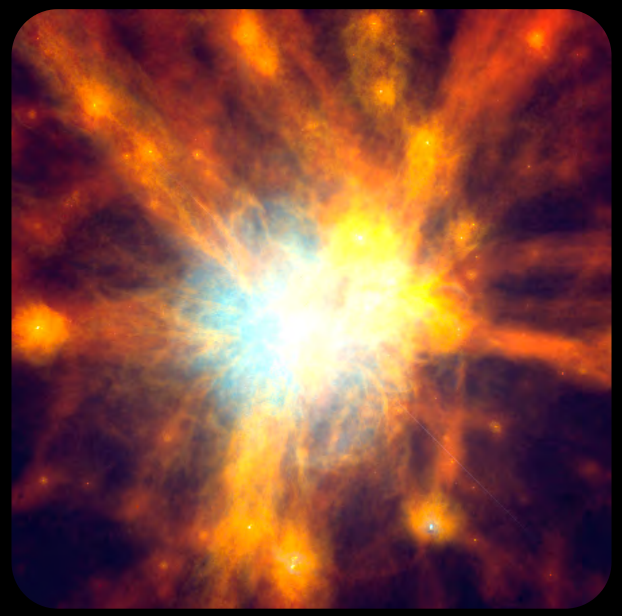
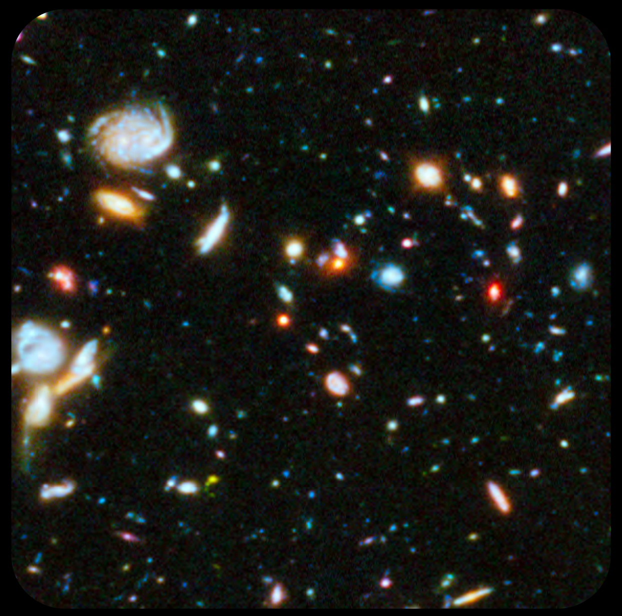


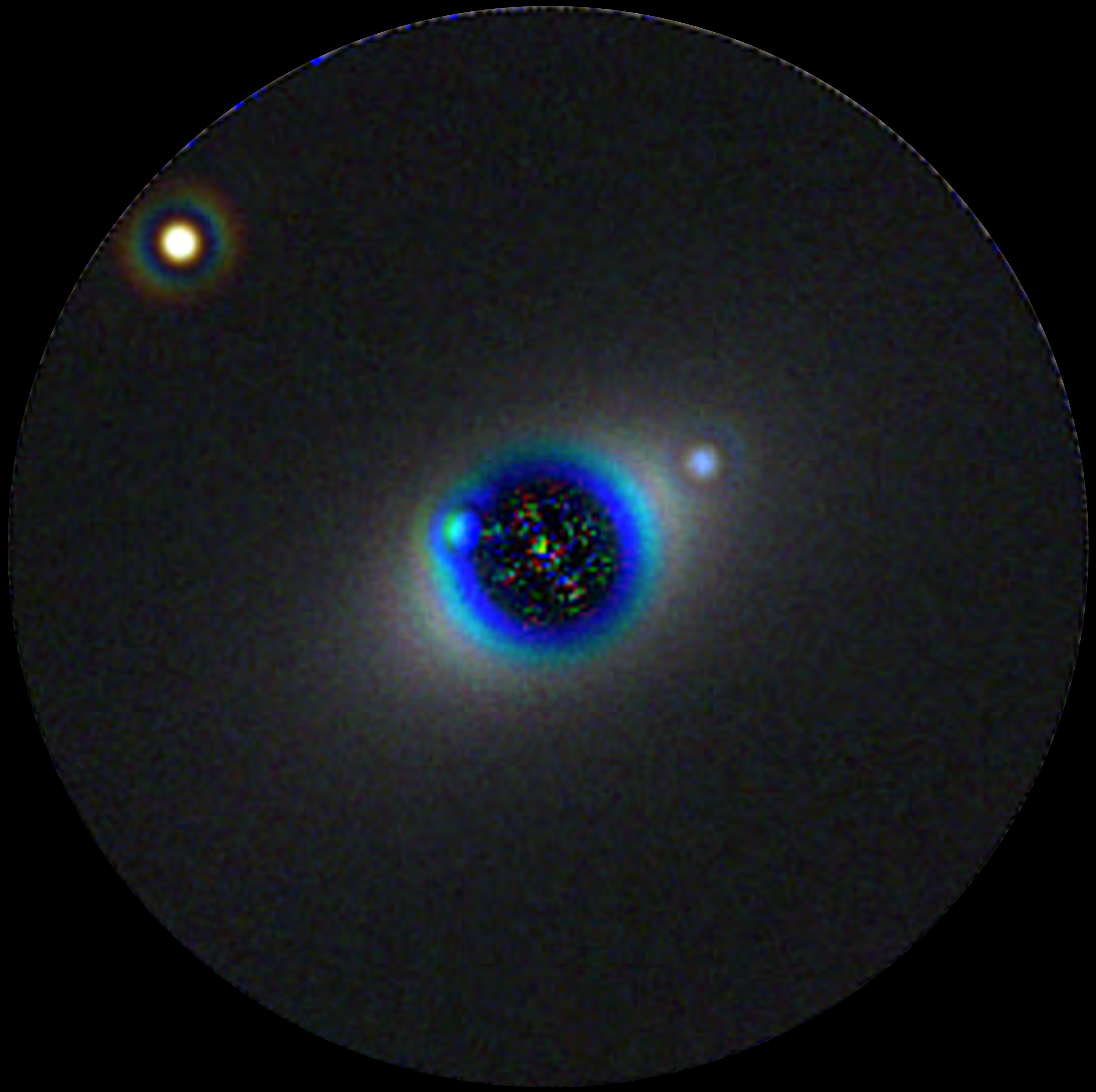
. . . detect every star-forming galaxy during the epoch when the Milky Way was forming. . .

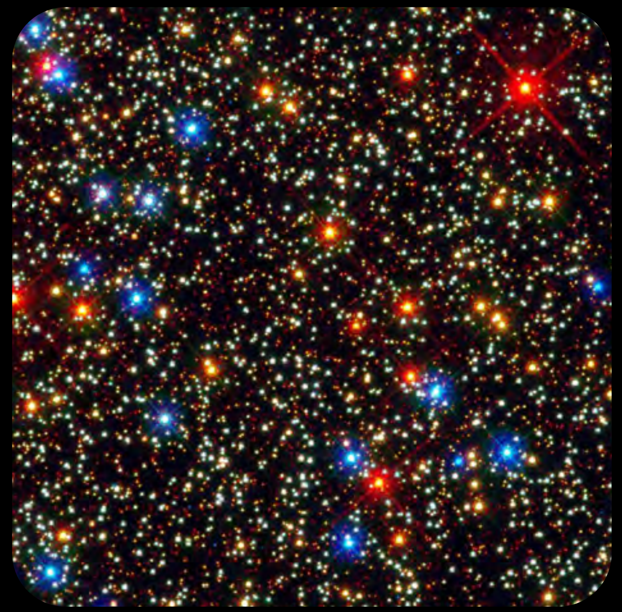



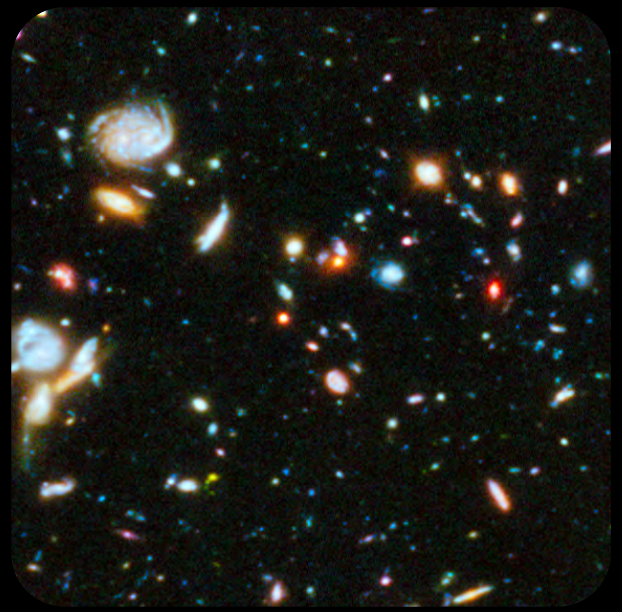
. . . resolve every galaxy in the Universe into its smallest building blocks . . .

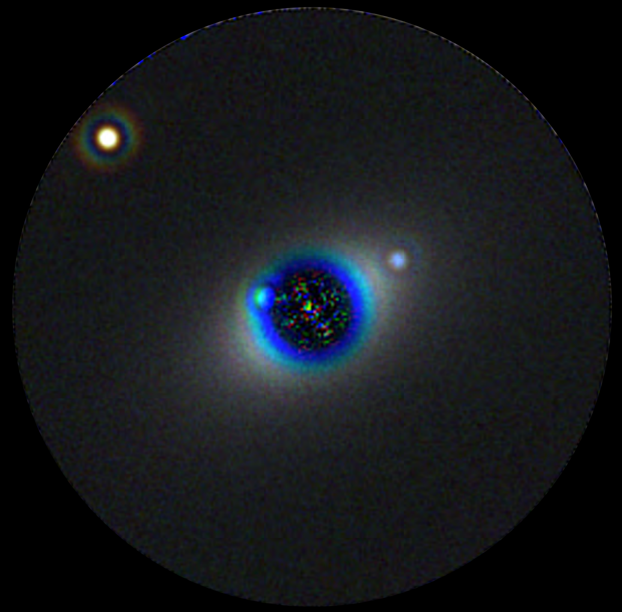





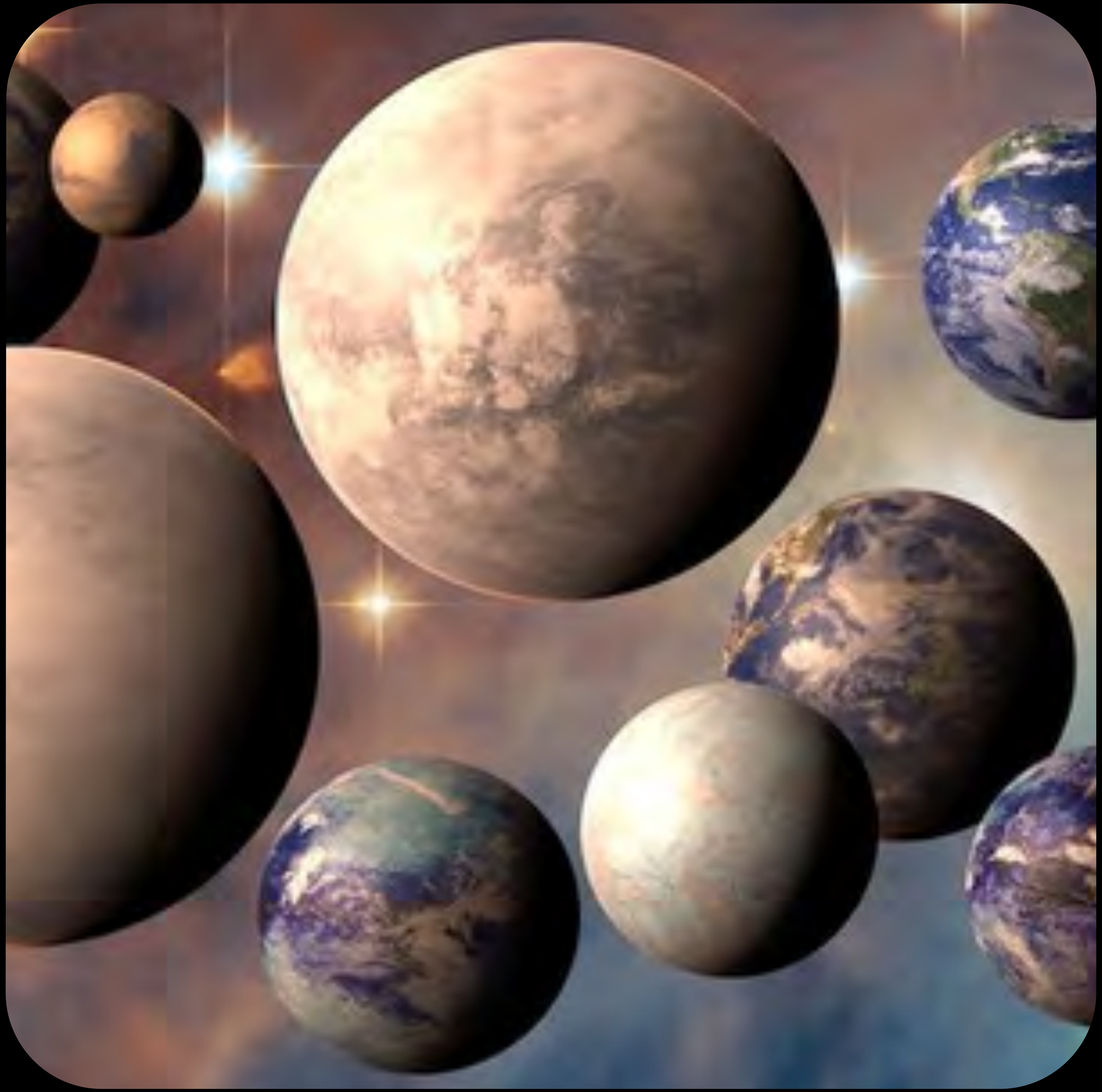


. . . unravel planet formation with hundreds of characterized systems. . .

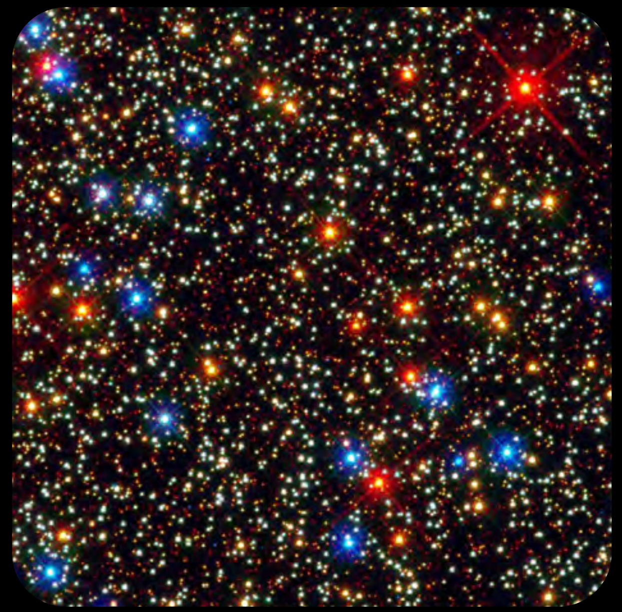



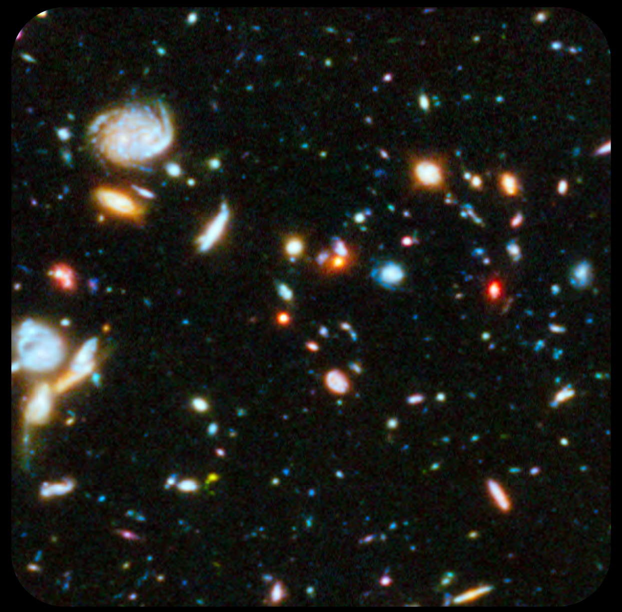


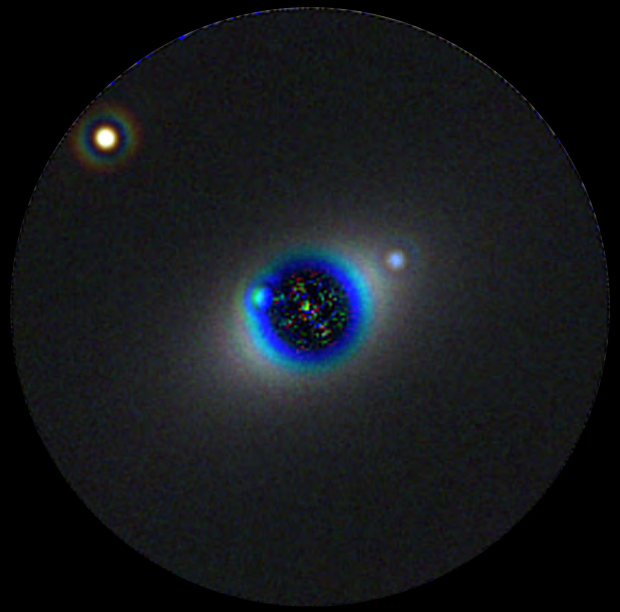




. . . detect dozens of Earth-like planets to search for evidence of life.

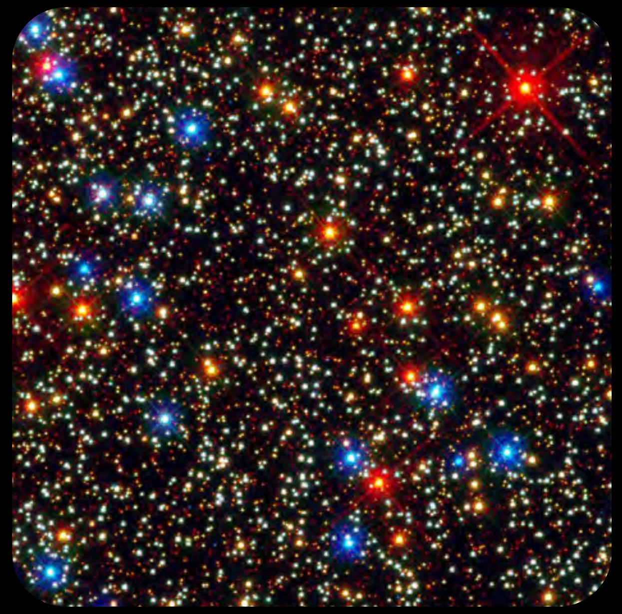
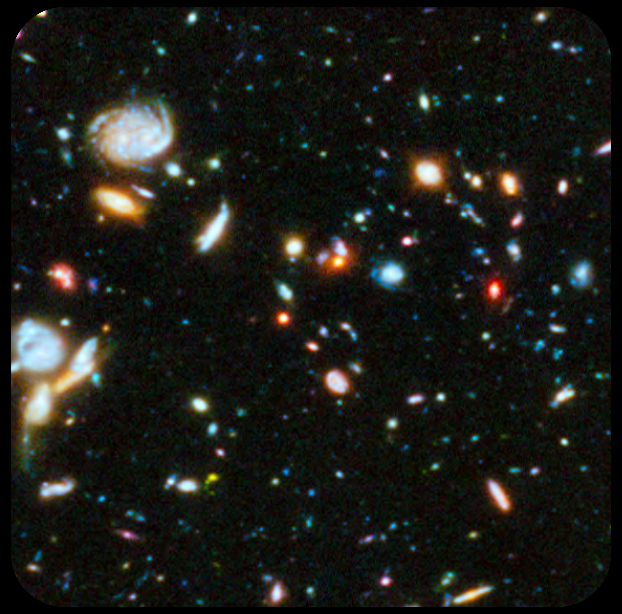
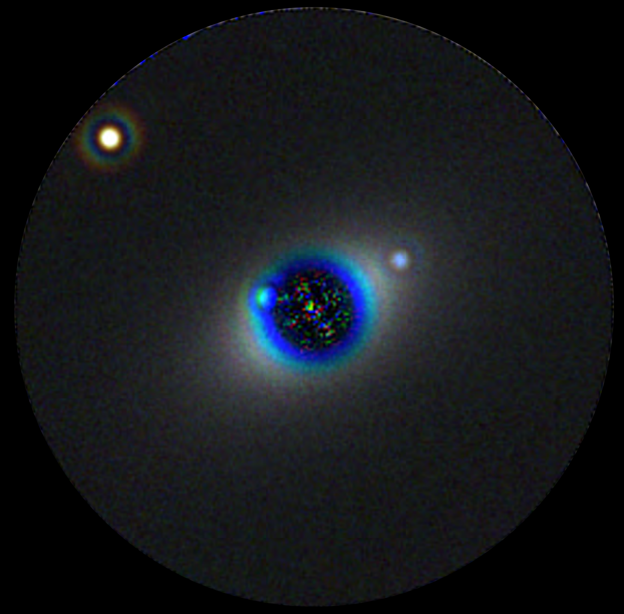








What will HDST do?

Drive revolutions across astrophysics

What will HDST do?

Answer profound questions.

HDST:
Your children's "Hubble"

Speakers

Matt Mountain

Sara Seager

David Schiminovich

Julianne Dalcanton

Panelists

Marc Postman

Michael Shara

Jason Tumlinson