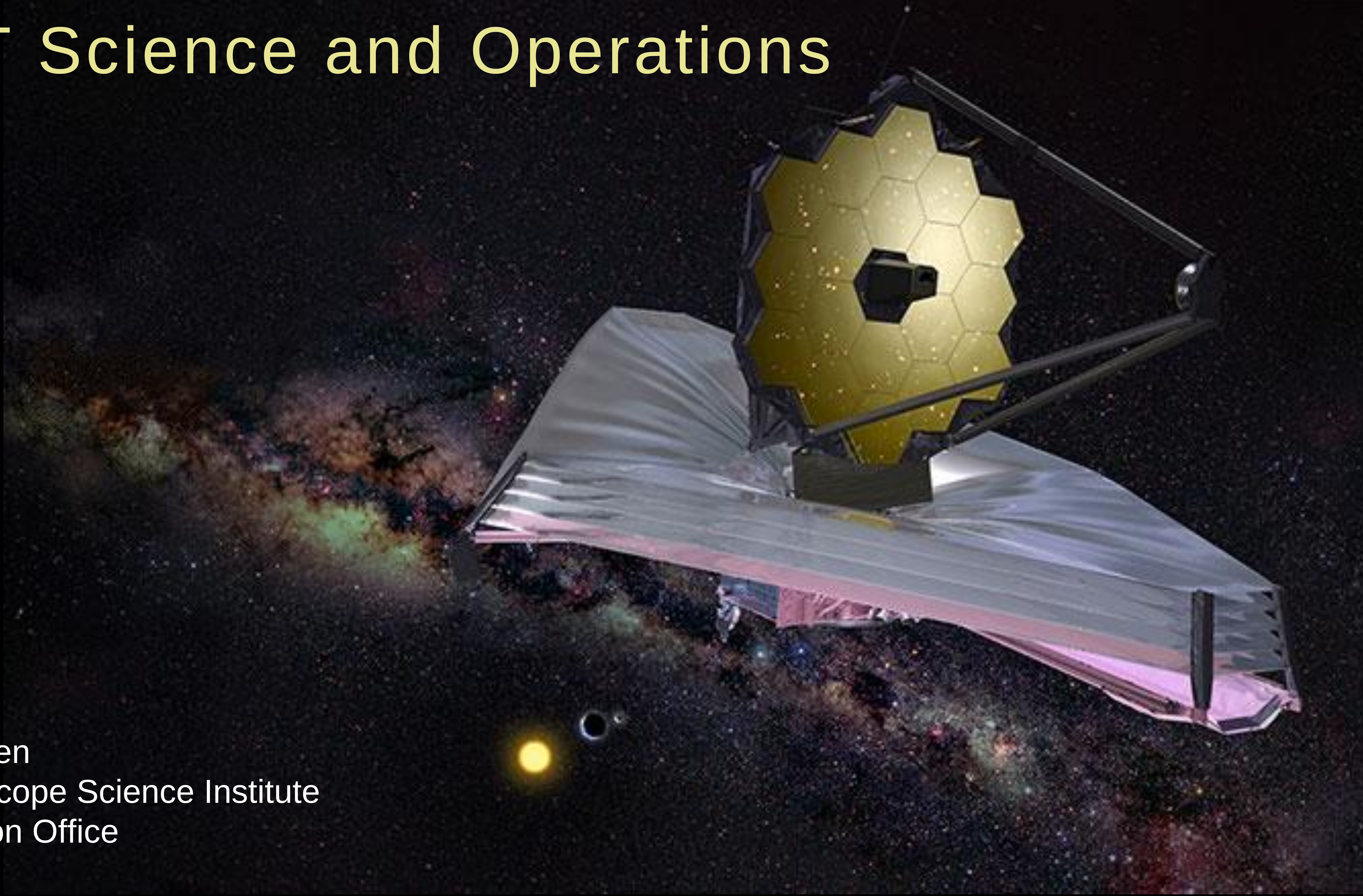
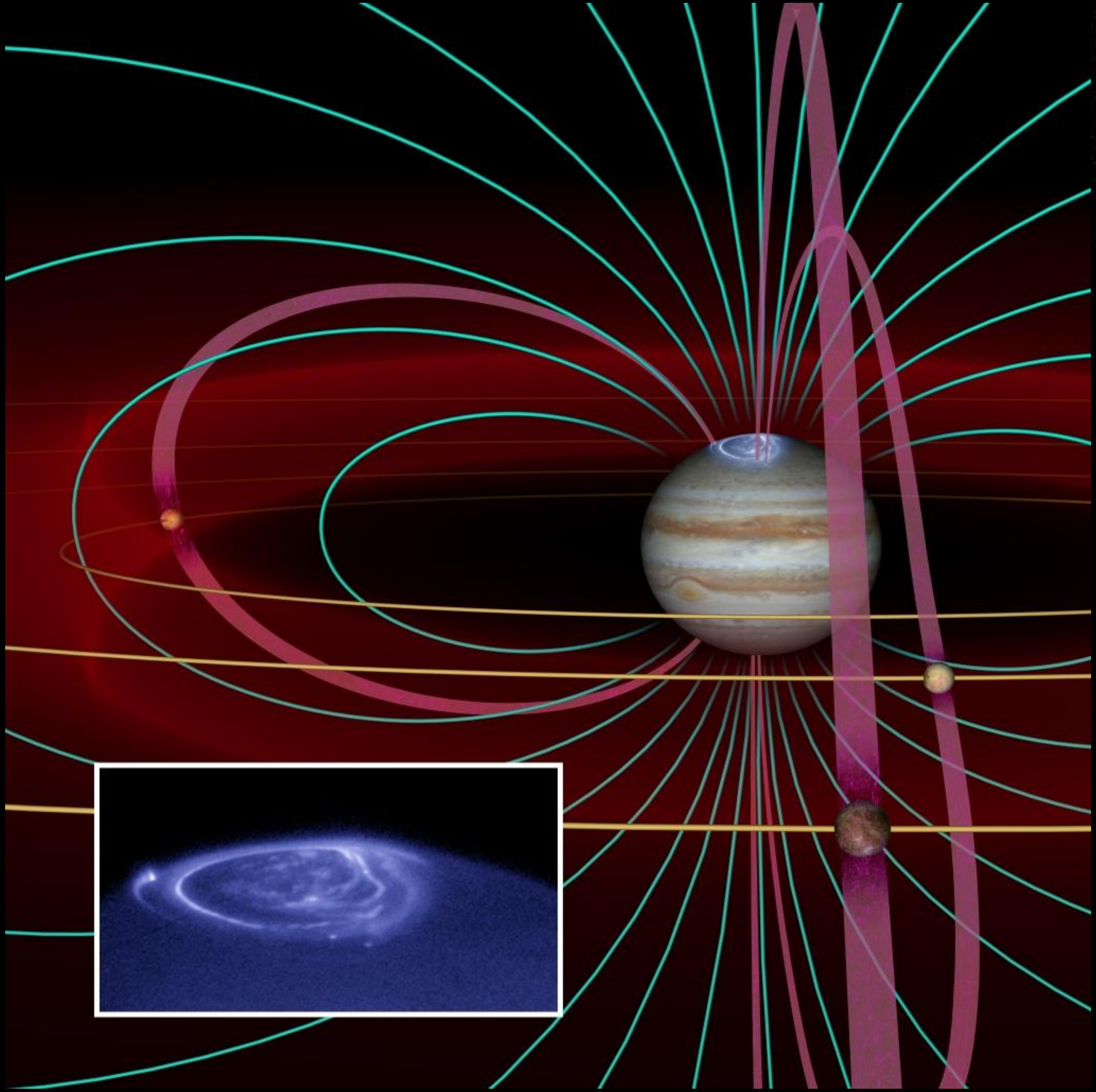
JWST Science and Operations



Christine Chen
Space Telescope Science Institute
JWST Mission Office

Hubble and Juno Observations of Aurora on Jupiter



Auroras on Jupiter are generated by interactions between the solar wind and Jupiter's magnetosphere

Juno arrived at Jupiter in June 2016 and began measuring properties of solar wind

HST has begun a several month long campaign to observe the auroras

Space Telescope Science Institute

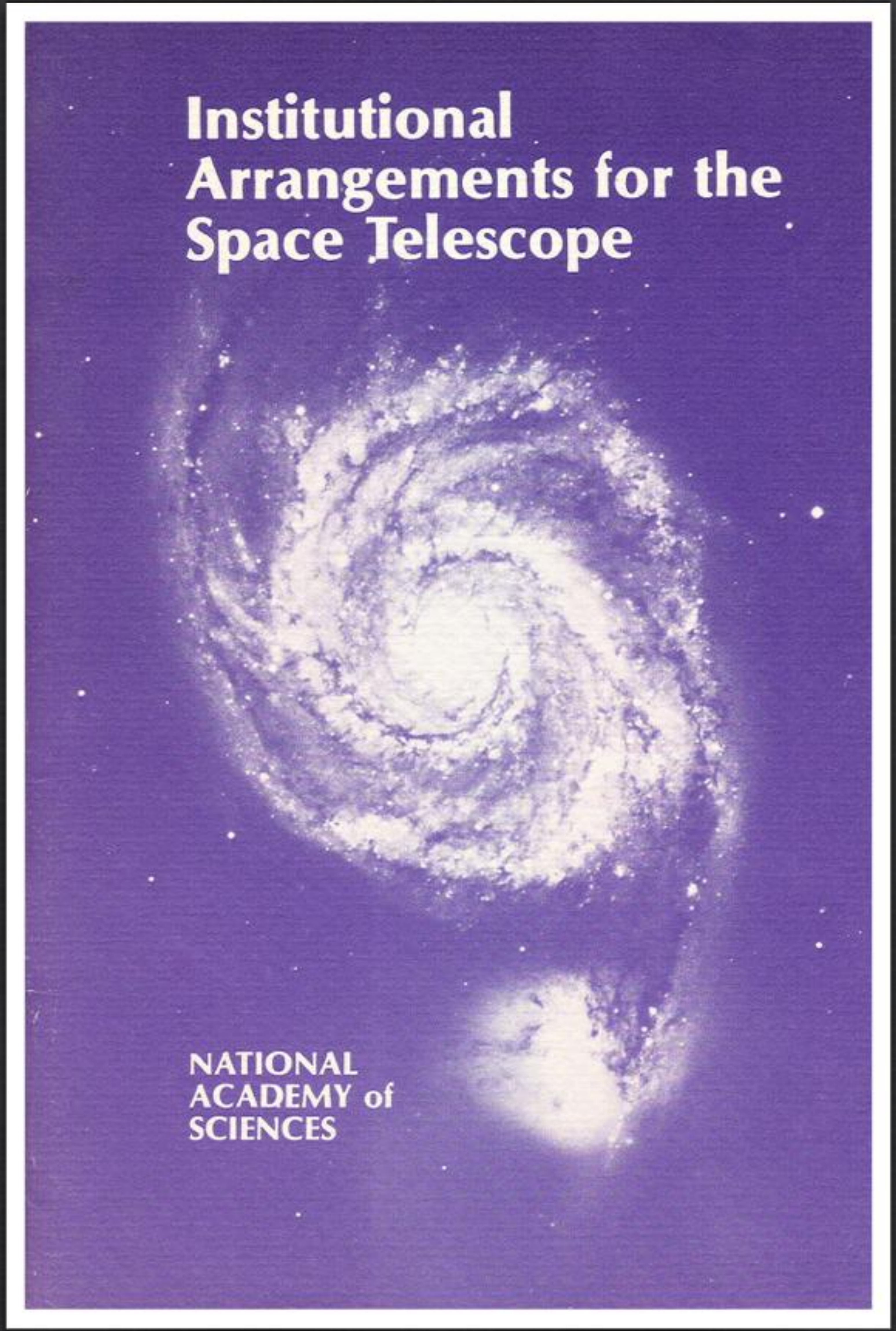
About Us

A free-standing science center, operated by the Association of Universities for Research in Astronomy (AURA) for NASA

Located at The Johns Hopkins University; collaborates with, and has science staff affiliated with the University

Total staff ~650: Scientists, Engineers, Programmers, Educators, Outreach Experts, Business Resource Specialists

STScI Links NASA to the Astronomical Community



1976

The Hornig Report - 1976

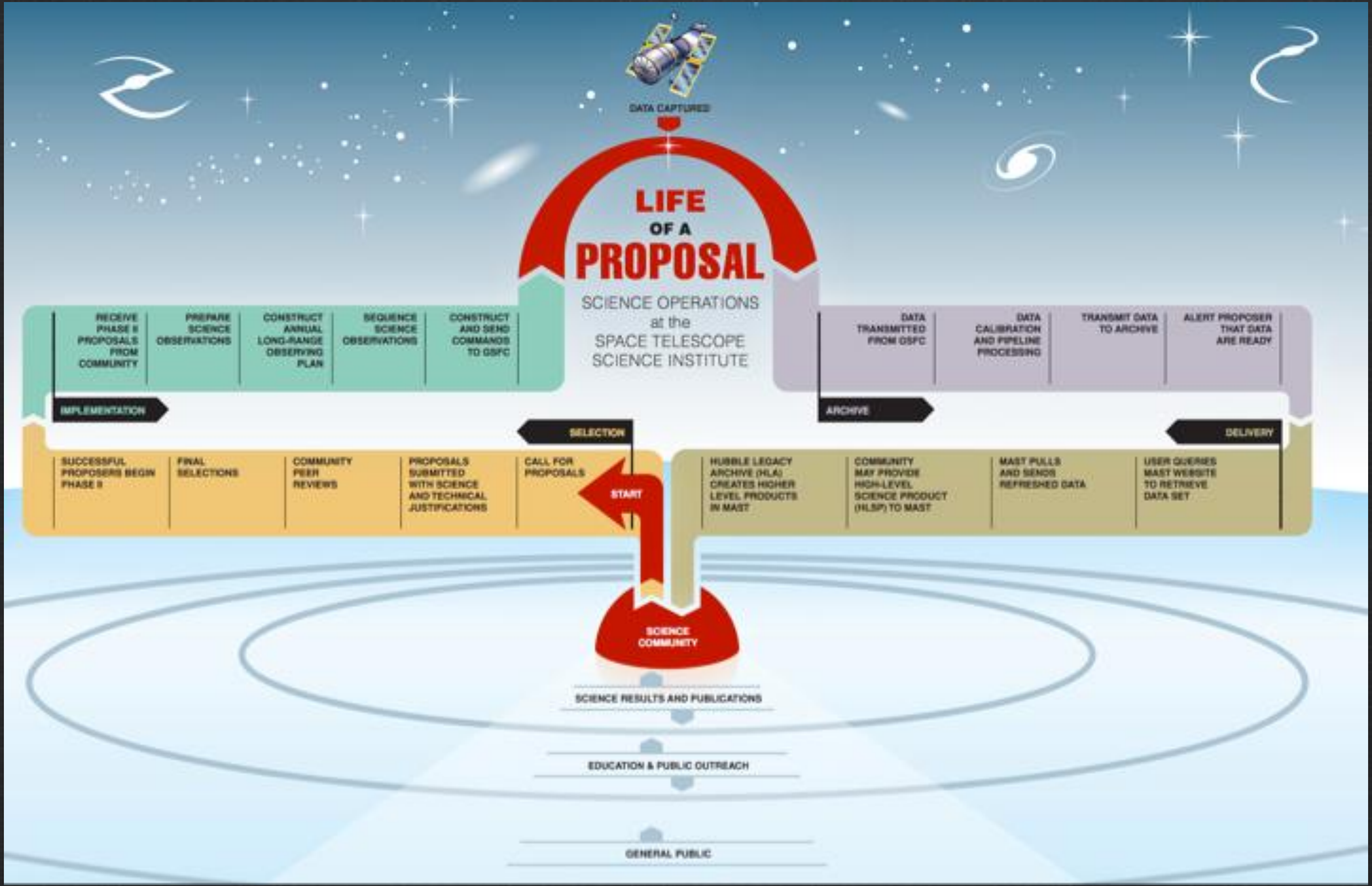
"Whereas the operation of the ST and its associated systems is best carried out by NASA, optimum scientific use of the ST requires the participation of the astronomical community."

"An institutional arrangement, which we call the Space Telescope Science Institute (STSI), is needed to provide the long-term guidance and support for the scientific effort, to provide a mechanism for engaging the participation of astronomers throughout the world, and to provide a means for the dissemination and utilization of the data derived from the ST."

"We recommend that the STSI be operated by a broad-based consortium of universities and non-profit institutions... The consortium would operate the institute under a contract with NASA."

*For Hubble and the James Webb Space Telescope, this is accomplished through a longstanding **partnership** between STScI, JHU, and GSFC*

Turning Great Science Ideas into Great Science Through **Science Systems Engineering**



First STScI Director
Riccardo Giacconi

Some of our Many Tasks for Hubble and JWST

Champion Hubble science

Instrument performance trending and characterization

Development of new instrument modes

General observer and archival research grant administration

Science program selection

World-class education and public outreach office

Observatory planning and scheduling

Science instrument commanding

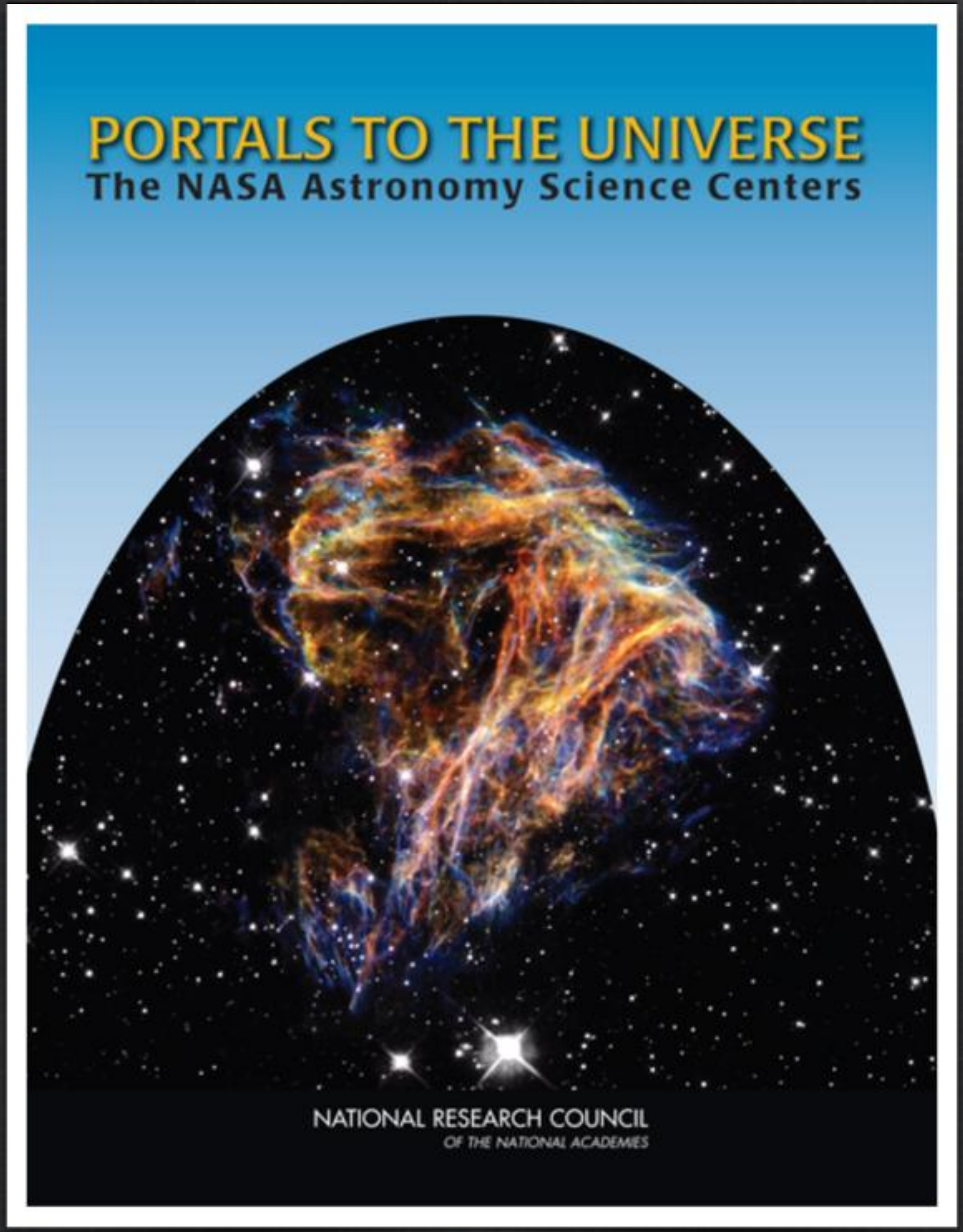
Archiving of science data and high-level science products

Anomaly resolution

Observer support and documentation

Calibration of science data

Reaffirming the Role of the Science Centers



2007

Testing and Refining the Model

"The astronomy science centers established by the National Aeronautics and Space Administration (NASA) to serve as the interfaces between astronomy missions and the community of scientists who utilize the data have been enormously successful in enabling space-based astronomy missions to achieve their scientific potential. These centers have transformed the conduct of much of astronomical research, established a new paradigm for the use of large astronomical facilities, and advanced the science far beyond what would have been possible without them."

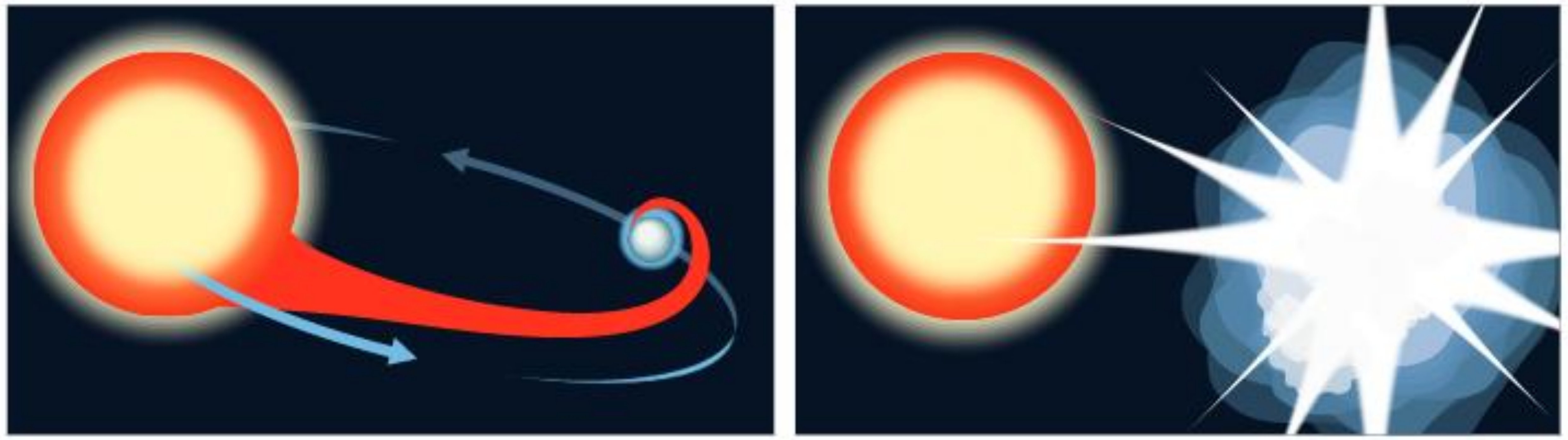
The model has been successfully applied to other Great Observatories

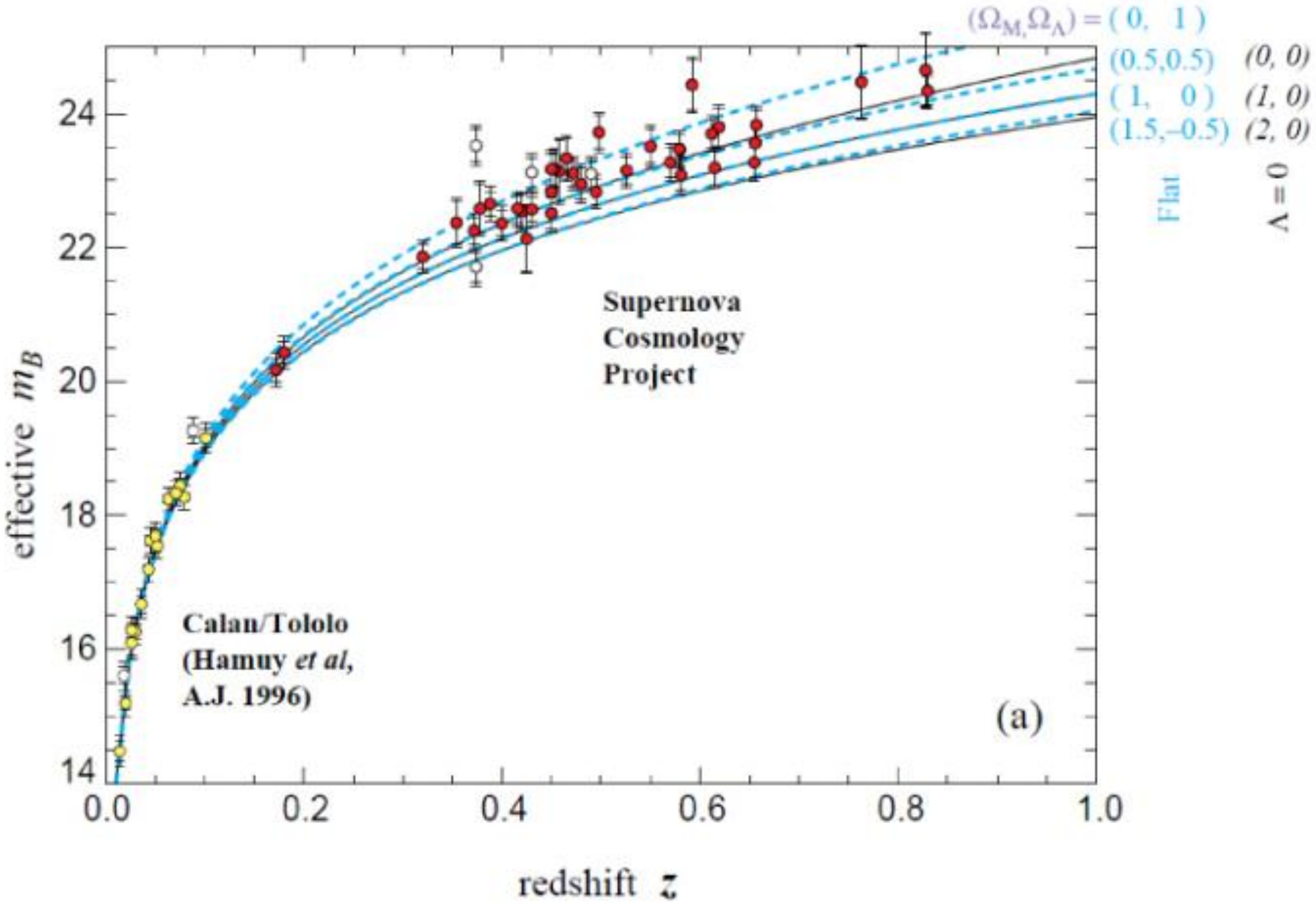
- The Chandra X-ray Center
- The Spitzer Science Center

The Expansion of the Universe is Accelerating

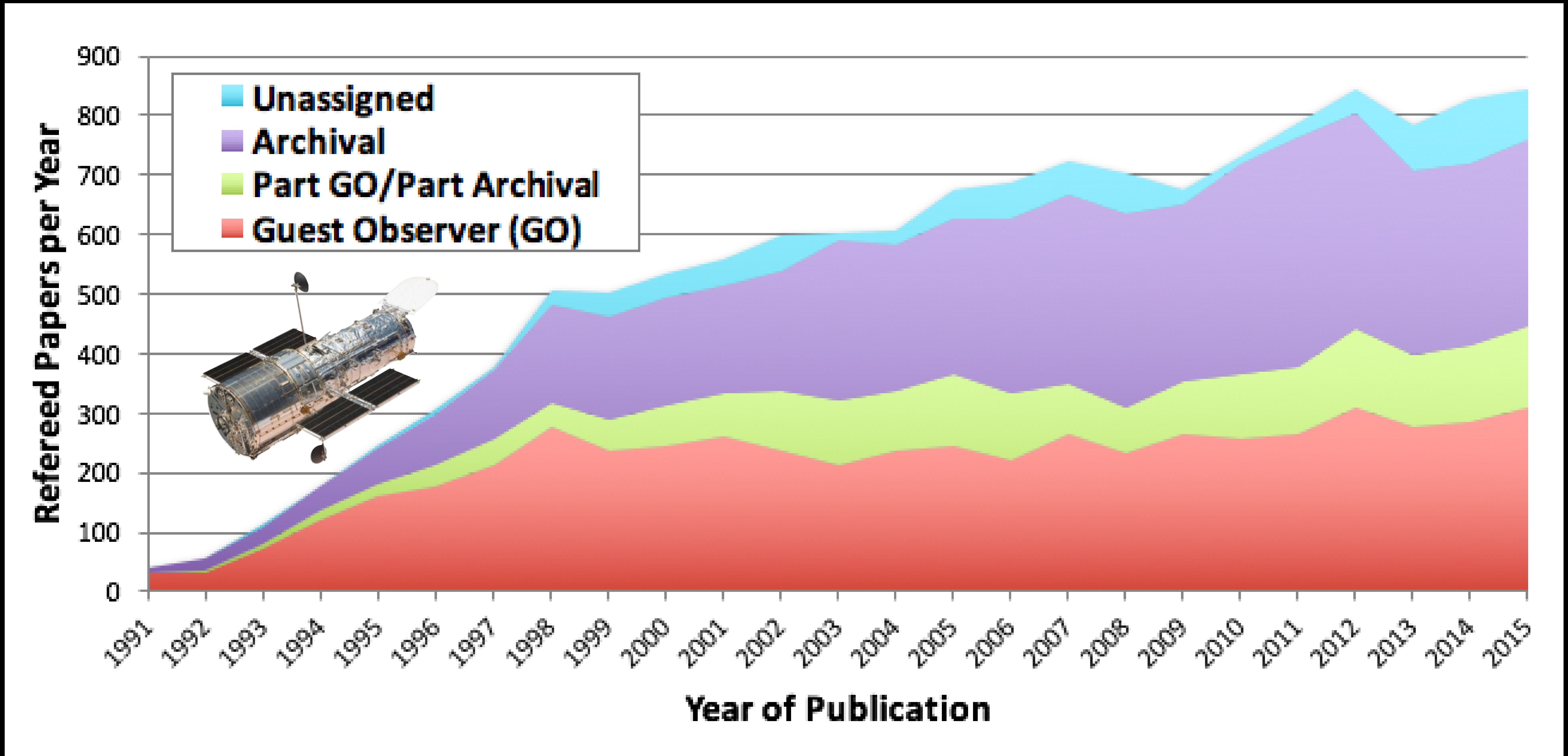
Hubble observations of Type Ia supernova at cosmological distances contributed to the discovery that the expansion of the universe is increasing with time.

This observation implies that the universe is not closed but must be flat or open.





Hubble's Unprecedented Scale and Breadth of Science

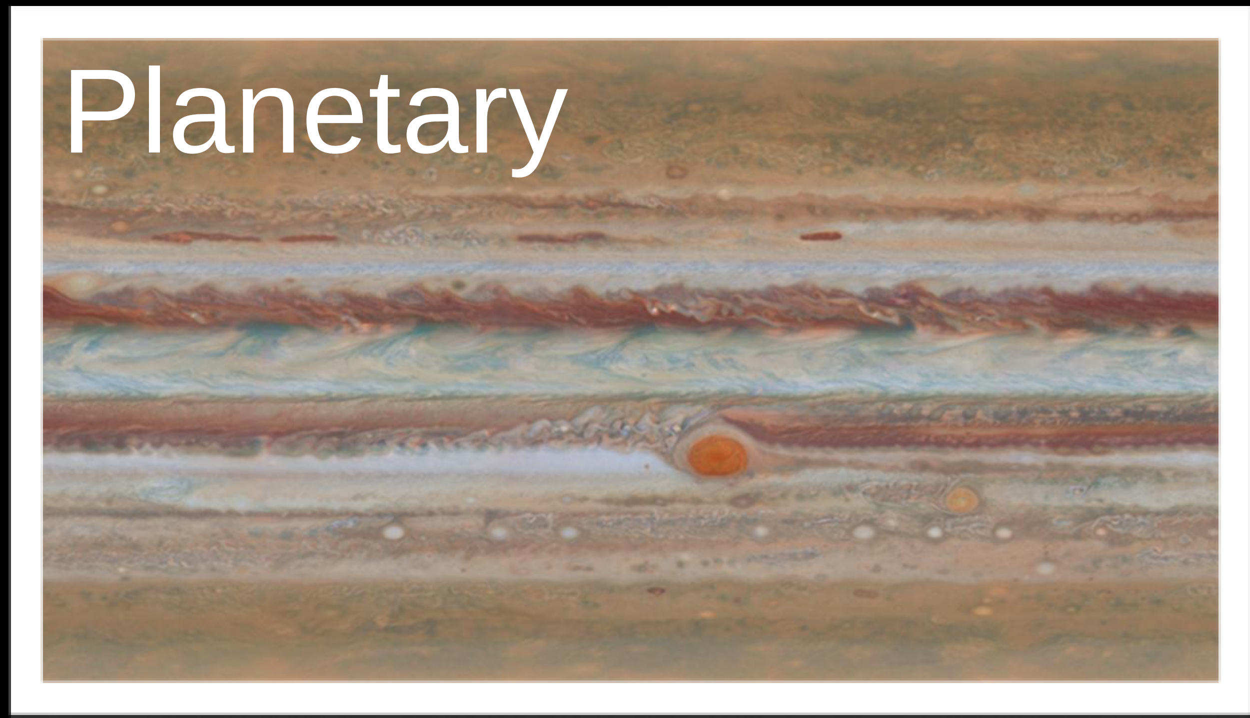


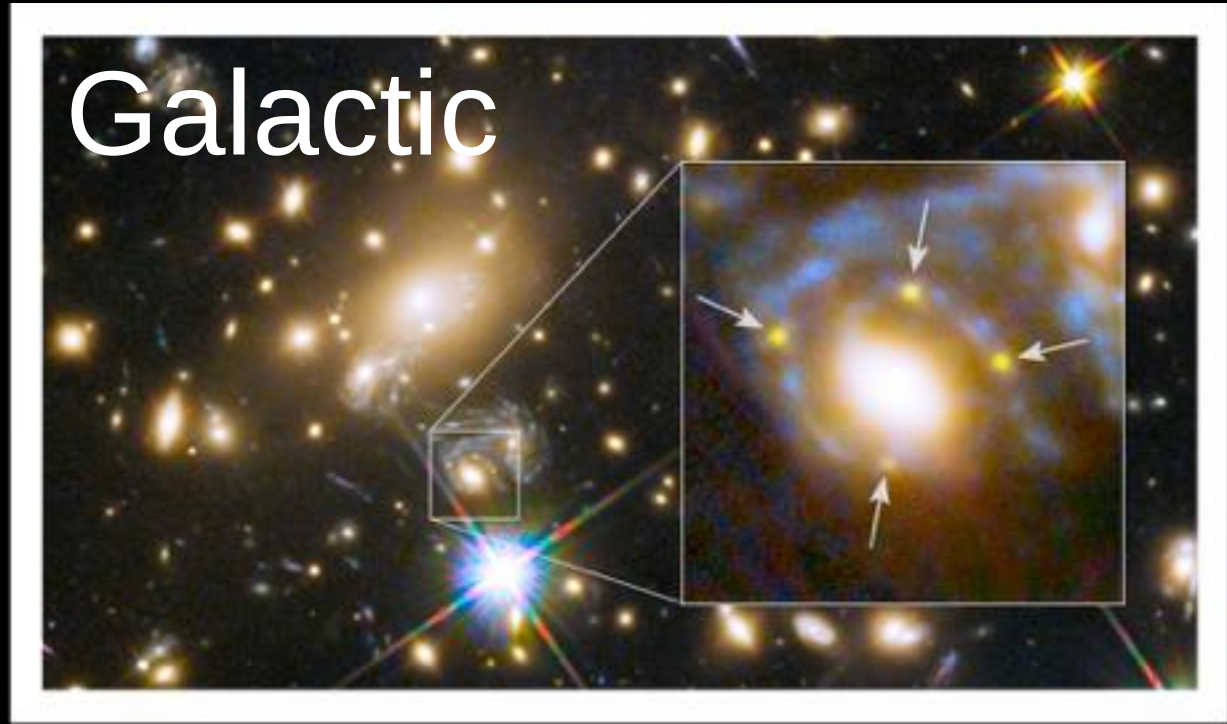
Breadth of Hubble Science

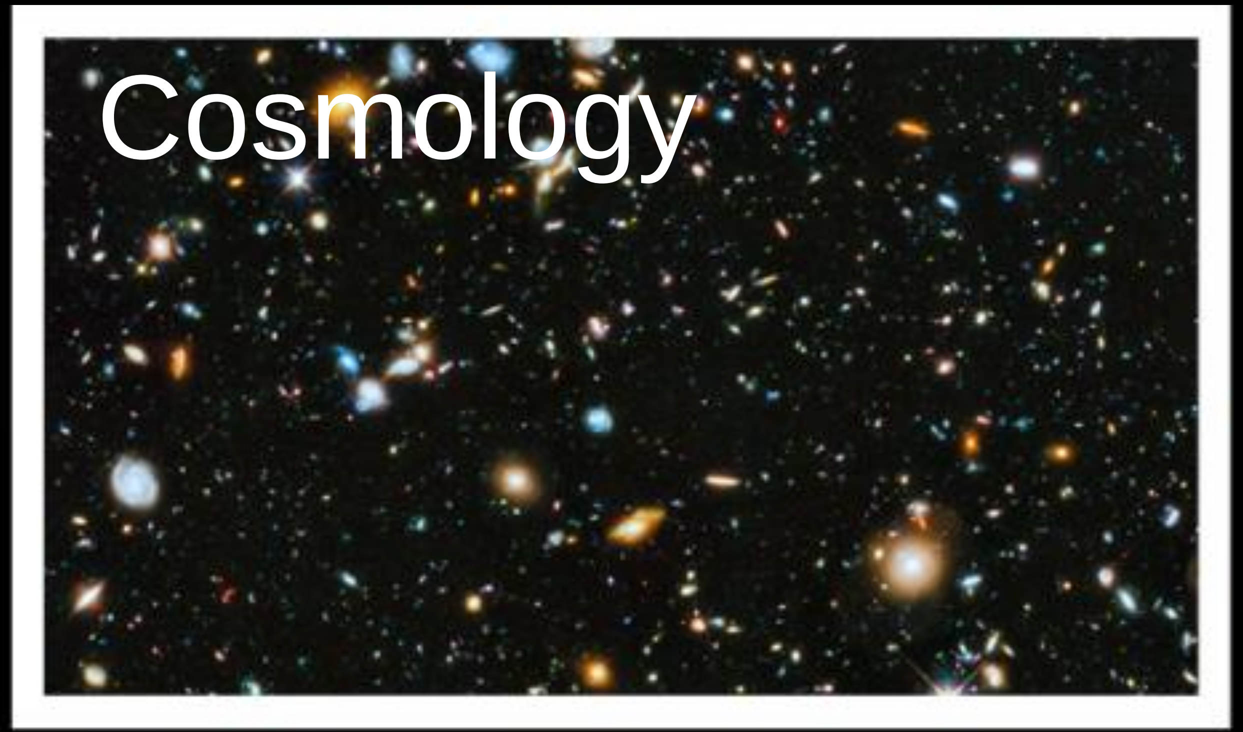
13,900 publications to date
600,000 citations
2 new published papers per day
20% of all astronomy papers reference Hubble

Distribution of Science Programs

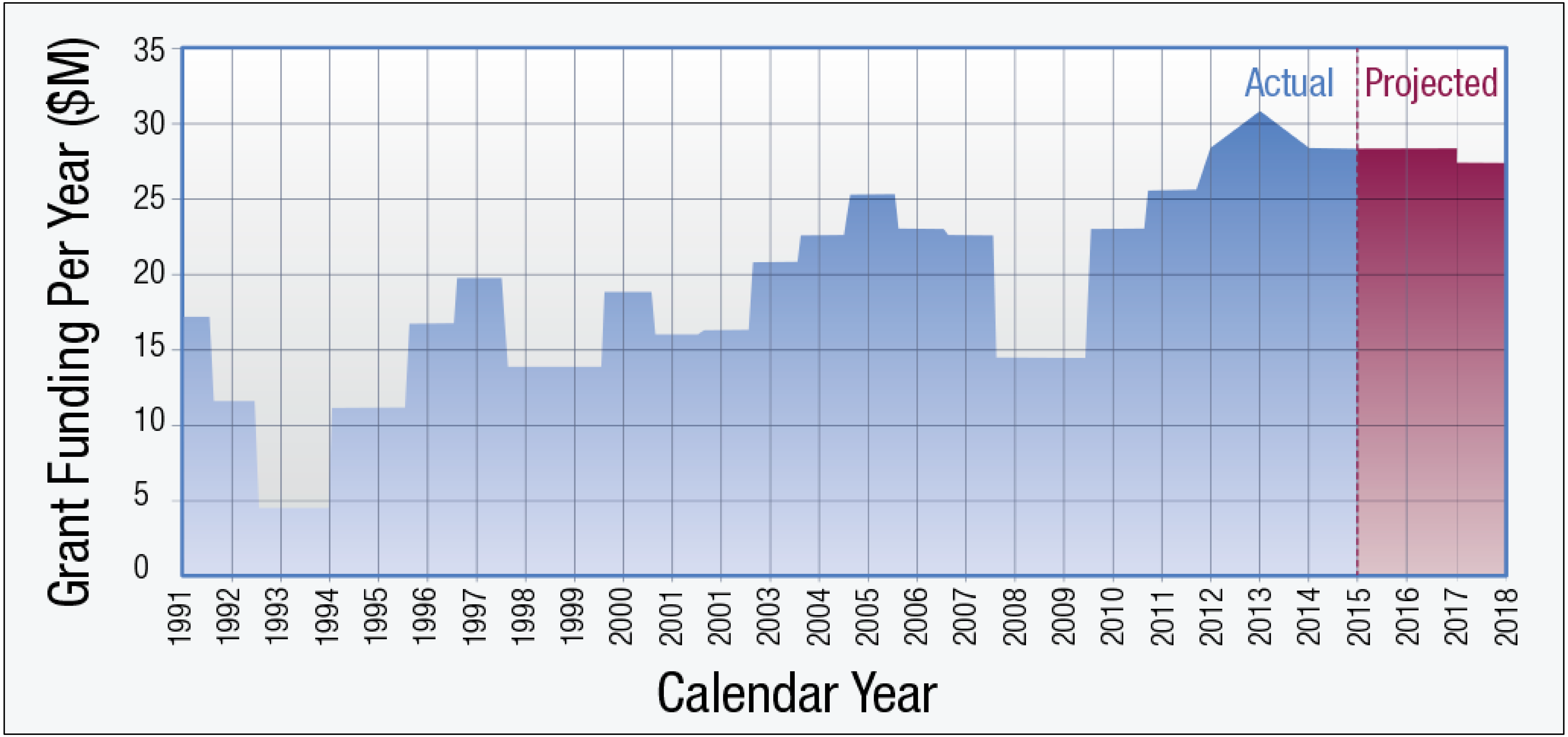
Solar System, Exoplanets, Debris Disks - 15%
Resolved Stellar Pops and Star Formation - 13%
Hot and Cool Stars - 14%
Intergalactic Medium - 12%
Interstellar Medium - 12%
Unresolved Stellar Pops and Galaxies - 12%
AGN and Quasars - 6%
Cosmology - 23%



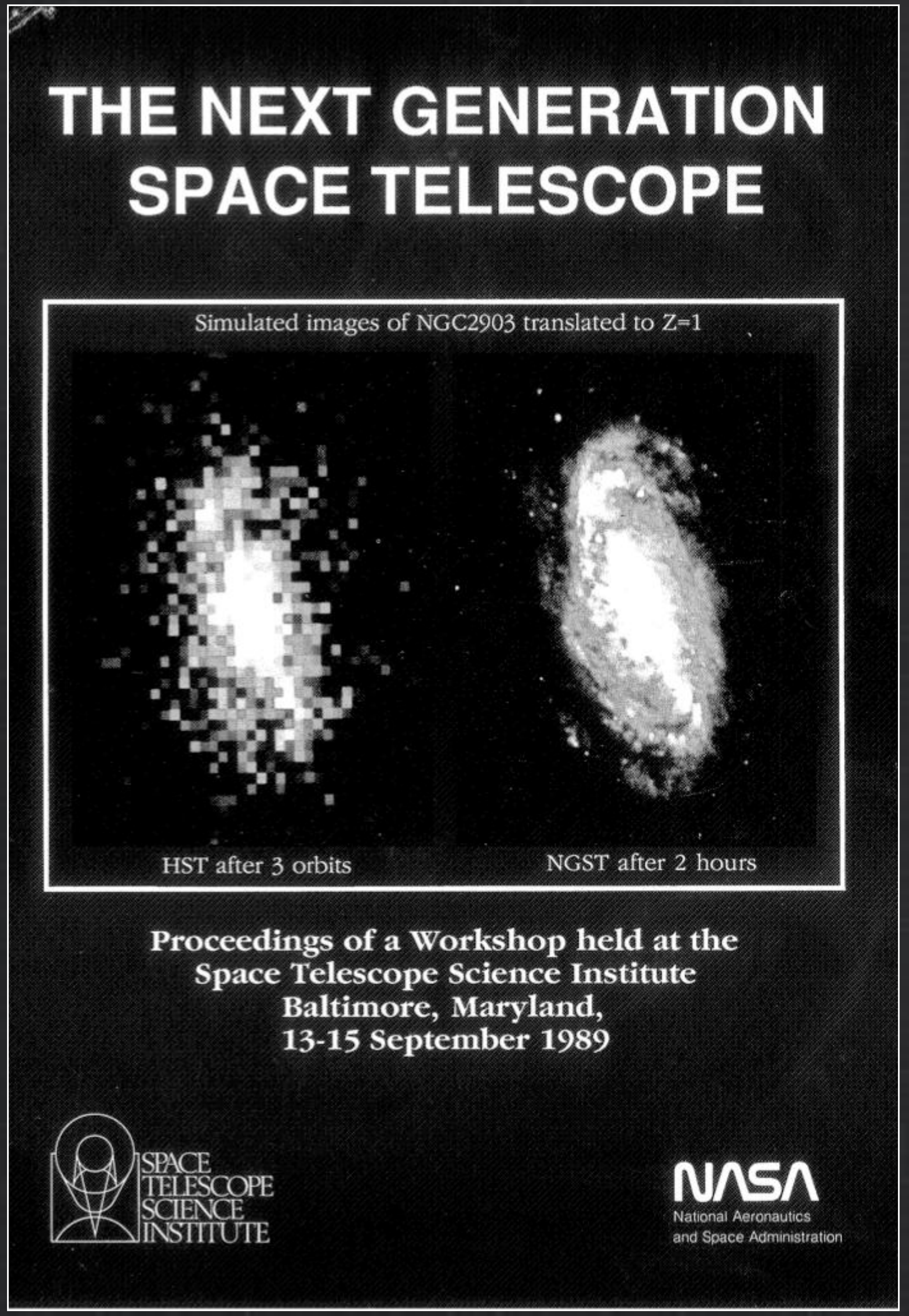




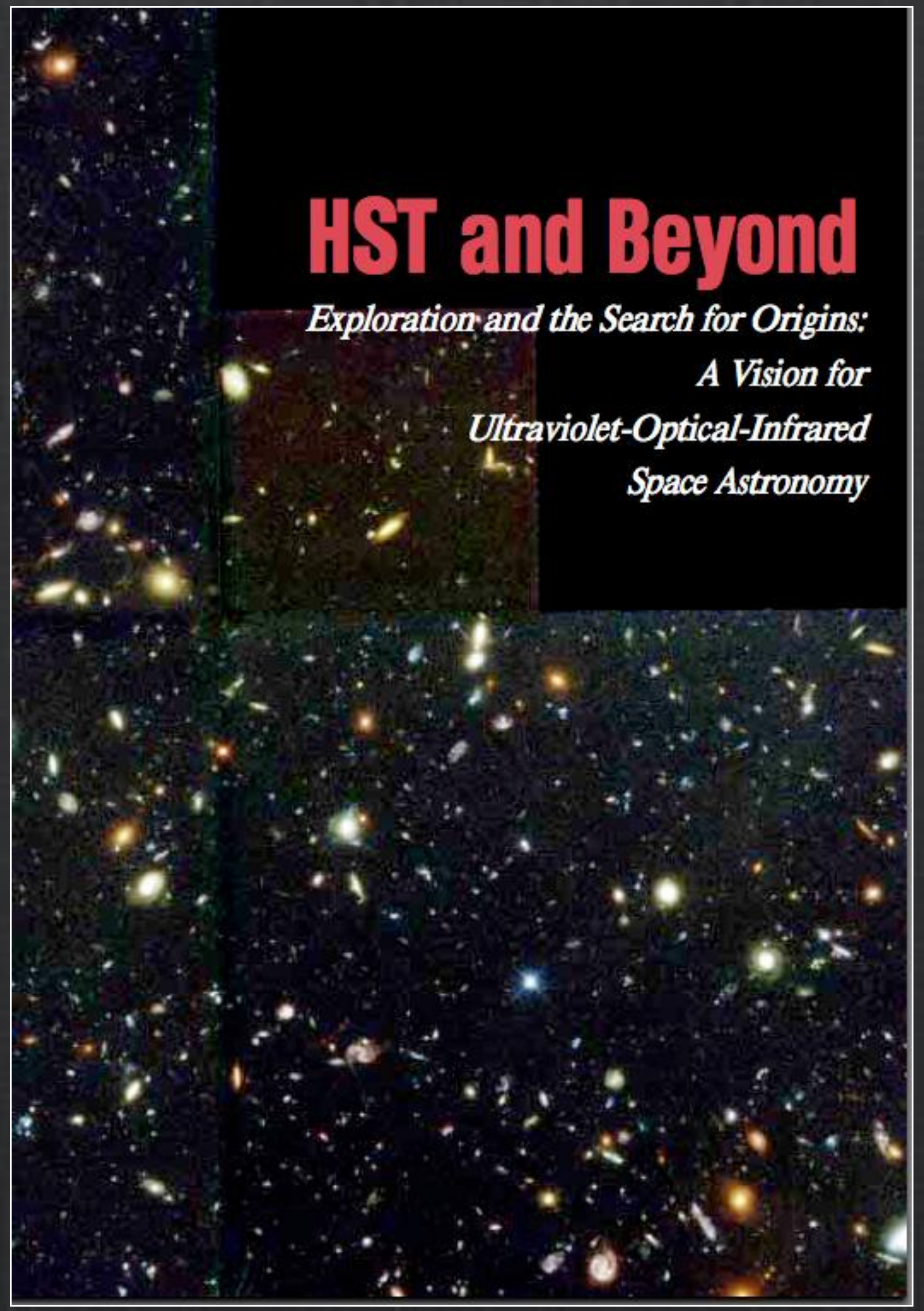
Enabling Dissemination of Hubble Data



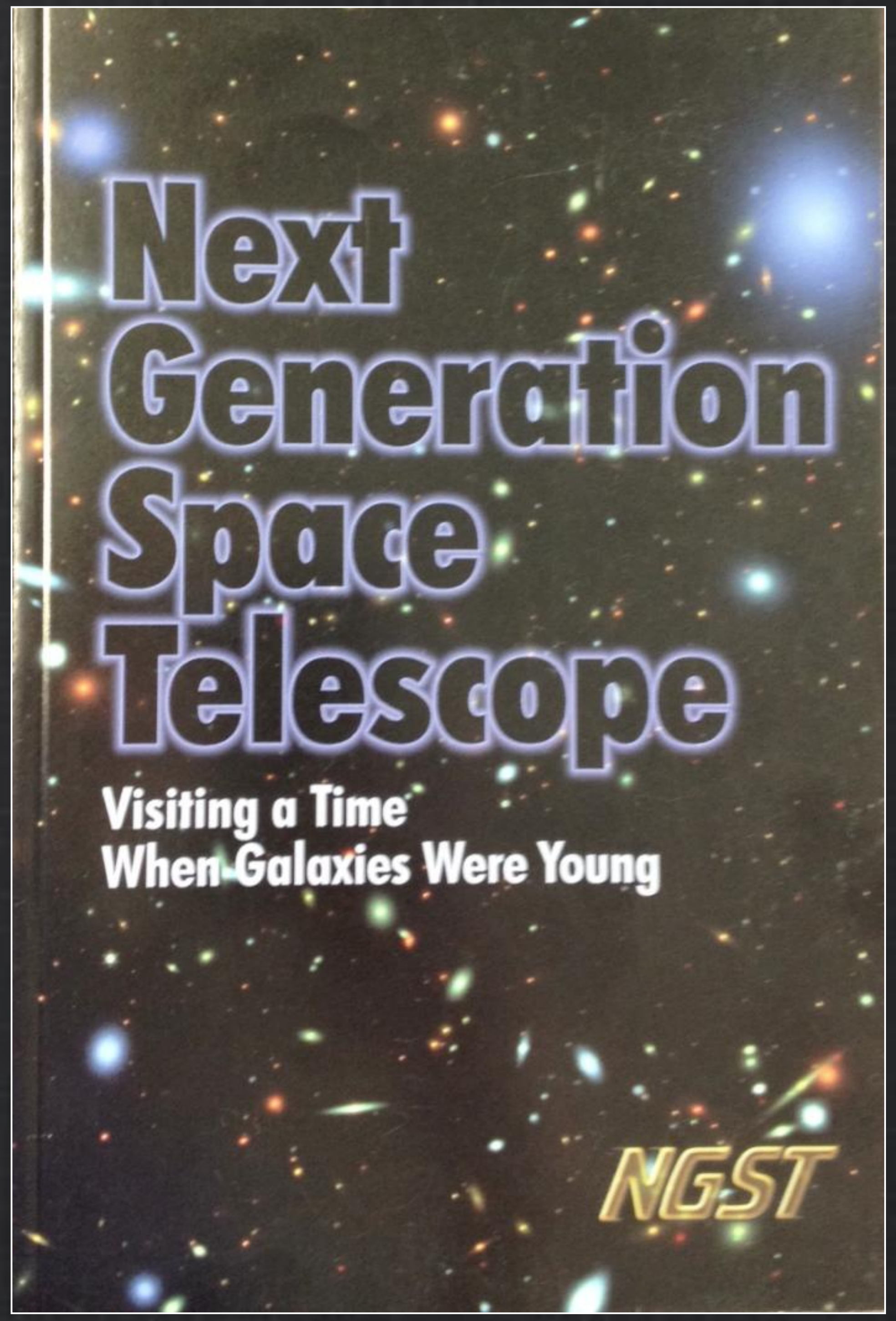
STScI's Role in the Development of JWST



The Next Generation Space Telescope (1989)



HST and Beyond (1996)



Next Generation Space Telescope (1997)

1997 – A joint NASA-STScI study developed a mission concept and established that the Next Generation Space Telescope was feasible

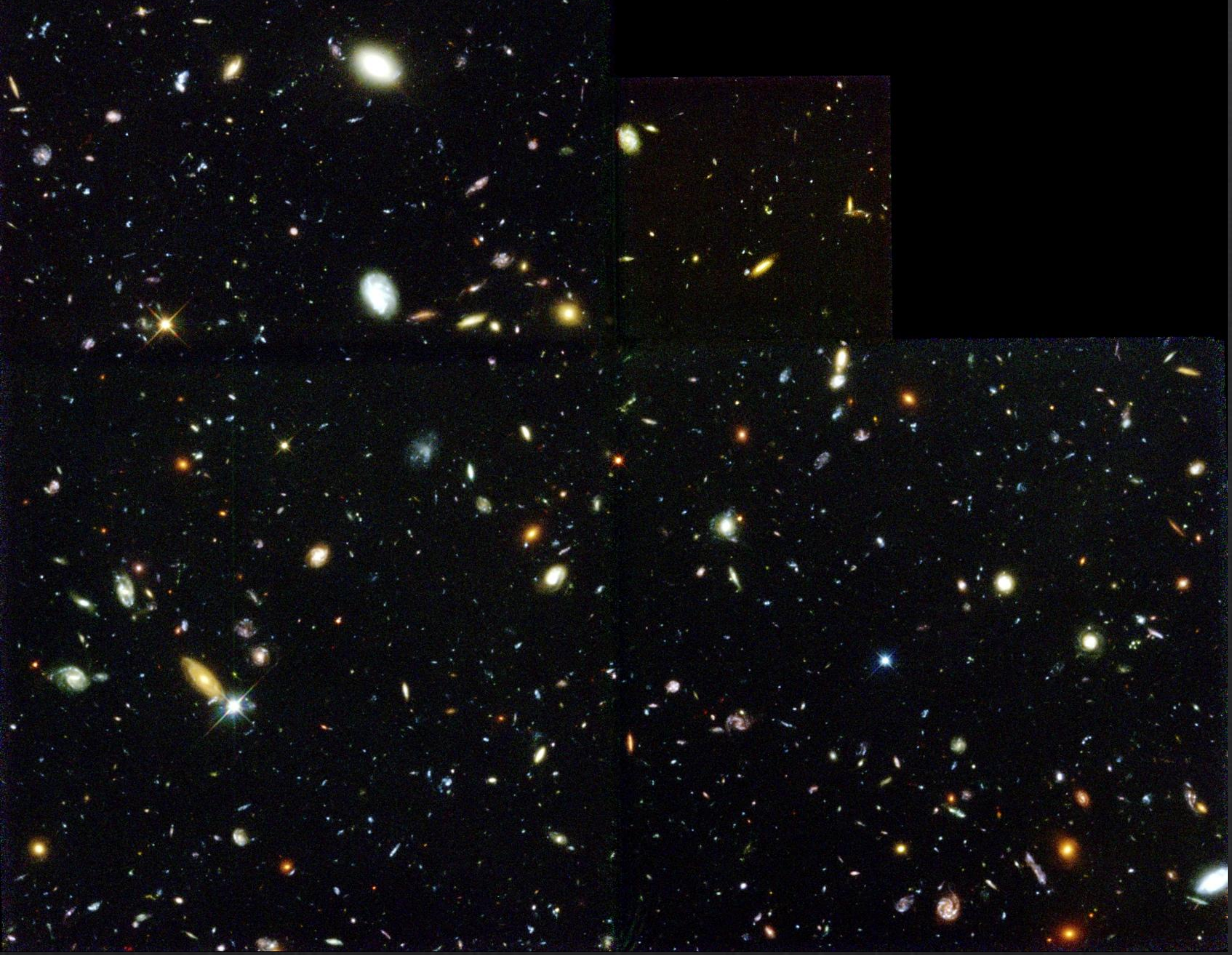
1993 – AURA appoints an independent "HST & Beyond Committee" to study possible missions and programs for future UV, optical, and infrared space astronomy

"The scientific potential of "a space observatory of aperture 4m or larger, optimized for imaging and spectroscopy over the wavelength range 1-5 µm [near-infrared]" is enormous"

Committee proposes an HST follow-up mission with enhanced flux collecting power and spatial resolution, and with spectral coverage extended through the near-infrared.

Hubble Deep Field

Over a 10 day period in late 1995, Robert Williams, then director of STScI, used his Director's Discretionary time to point Hubble at a dark region of the sky in the constellation Ursa Major within the Continuous Viewing Zone (CVZ).



The HDF revealed…

(1) 3000 distinct galaxies, with a range of morphologies from irregular and spiral
(2) Including large numbers of galaxies at very high redshift
(3) Many with disturbed morphologies indicating that galaxy collisions and mergers were more common when the universe was young and that star formation peaked at 8-10 billion years ago

Discovery suggested that distant galaxies were more compact than anticipated and could be resolved to very high redshift

NASA's Great Observatories are the Foundation of Astrophysics Decadal Surveys

1972 - Hubble

1982 - Chandra

1991 - Spitzer

2001 - JWST

2010 - WFIRST

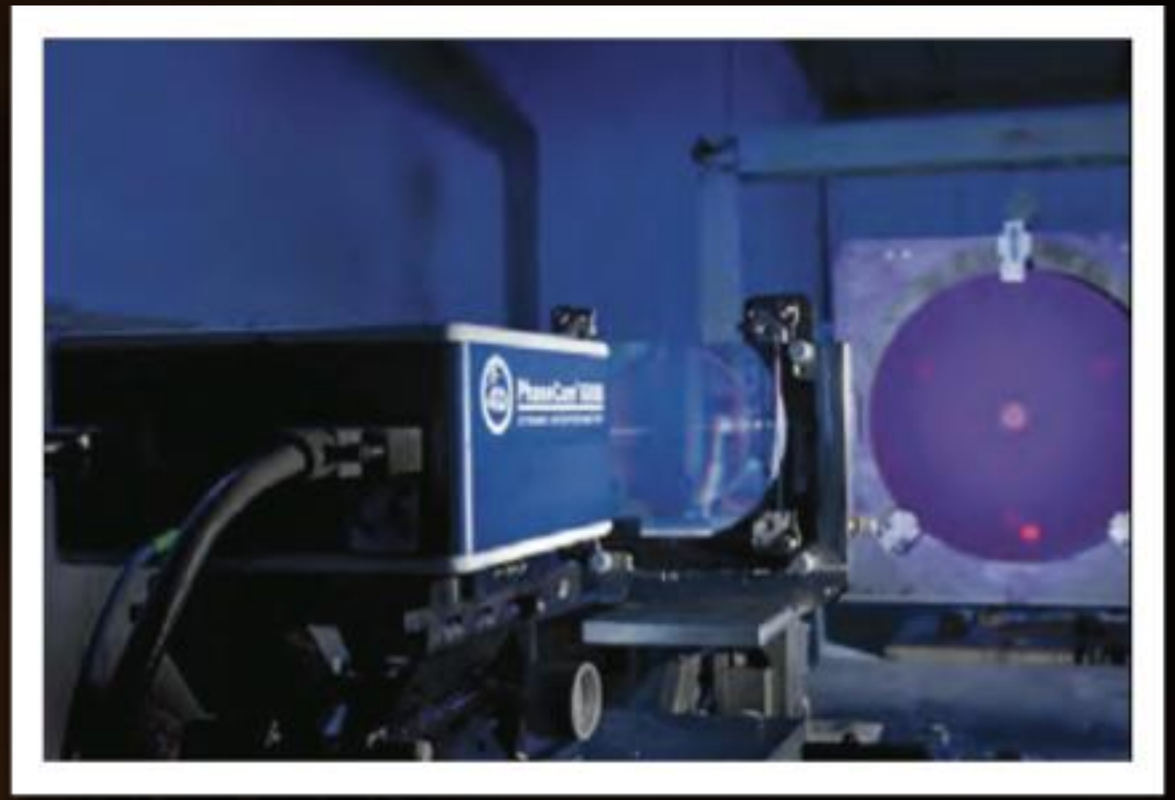
The James Webb Space Telescope (JWST)

6.6 m diameter primary mirror,
composed of 18, deployable segments
protected from the sun by a large sunshield
located at the Sun-Earth L2 point

JWST Societal Impacts

JWST Wavefront Sensing **Medical Spinoffs**
Diagnosis of occular diseases
Improvements in laser eye surgery

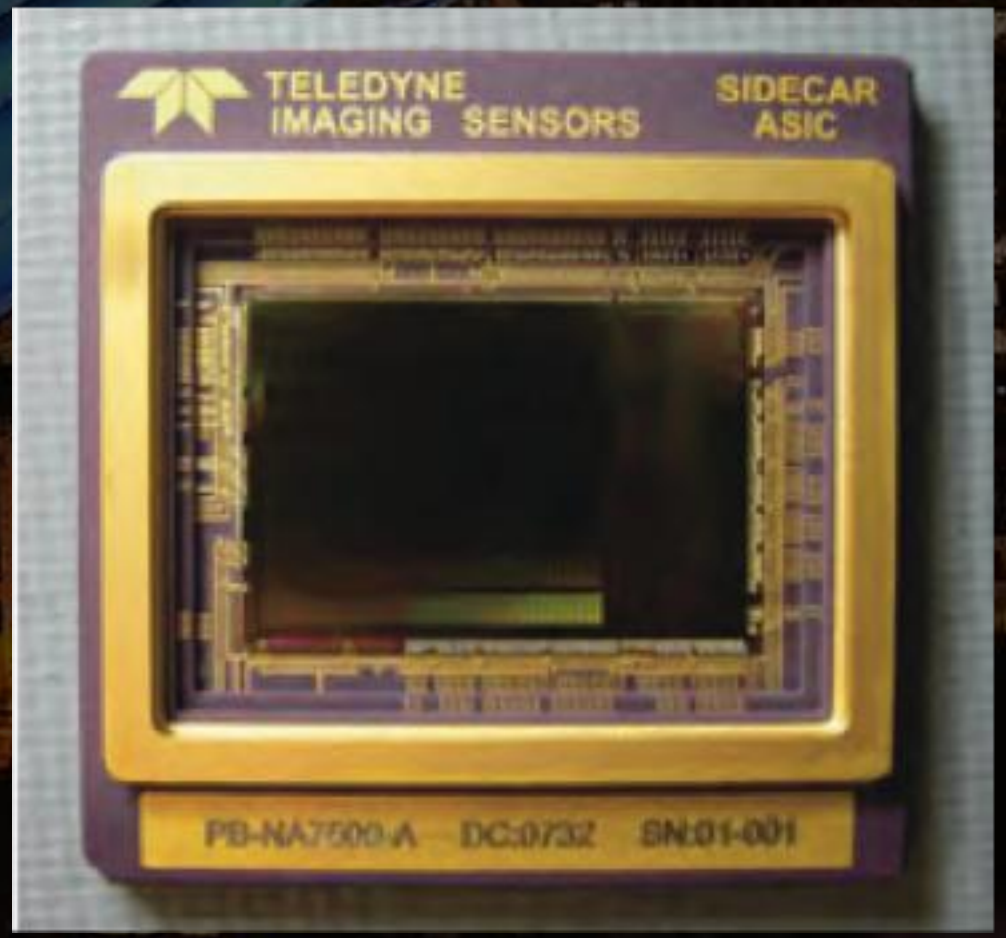
JWST Science and Technology **Public**
Public Inspiration



JWST Cryogenic Mirror Testing
Commercial Spinoffs
Laser interferometry
Semiconductors

JWST Cryogenic Integrated Circuits
Science Spinoffs
Hubble electronics
Servicing Mission 4 repairs

JWST STEM Engagement **Students**
Next generation space science leaders



JWST Infrared Sensors
National Security Spinoffs
National Security missions
Earth Science missions

JWST Science Themes

First Light & Reionization

Assembly of Galaxies

Birth of Stars & Protoplanetary Systems

Planets & Origins of Life

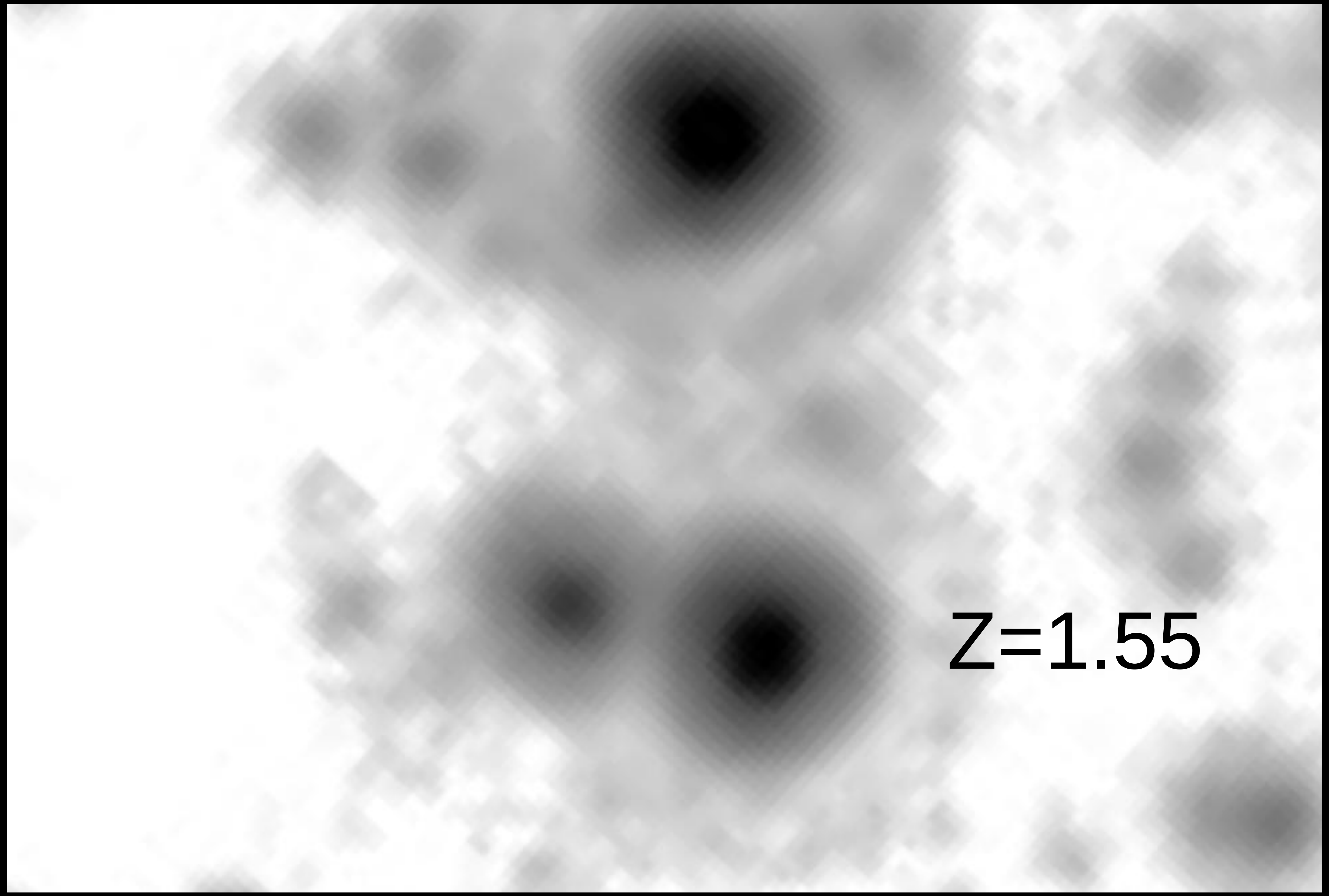
First Light and Reionization: Enabling Observations of the First Galaxies

HST deep extragalactic surveys (HDF, HUDF, GOODS, AEGIS, COSMOS, CLASH, CANDELS) have probed galaxy assembly over 95% of the universe's lifetime…

JWST deep extragalactic observations will enable observations of the first galaxies

Assembly of Galaxies:
When Did the First Bulges Appear?

Ultra Deep Field 2012/XDF
WFC3/IR 0.9-1.6 μm

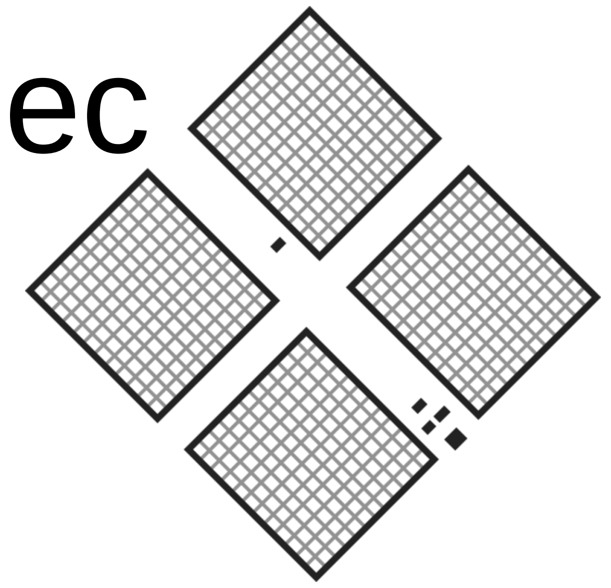


IRAC Ultra Deep Field 3.6 μm
(Labbe et al. 2015)

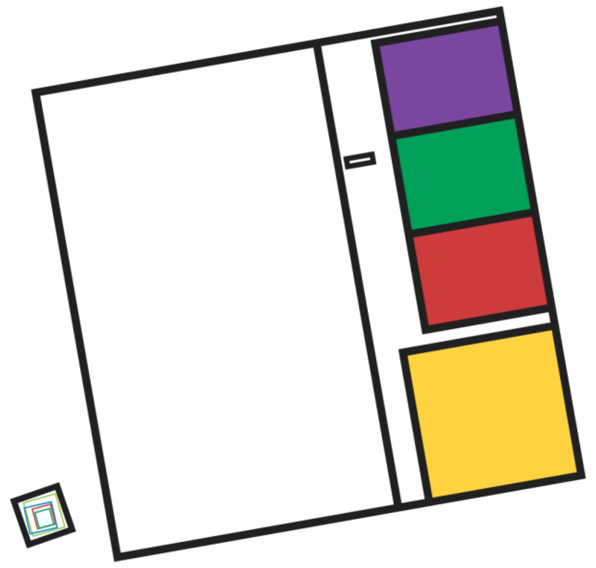
From J. Lotz

Assembly of Galaxies:
Physics of Galaxy Mergers at z>1

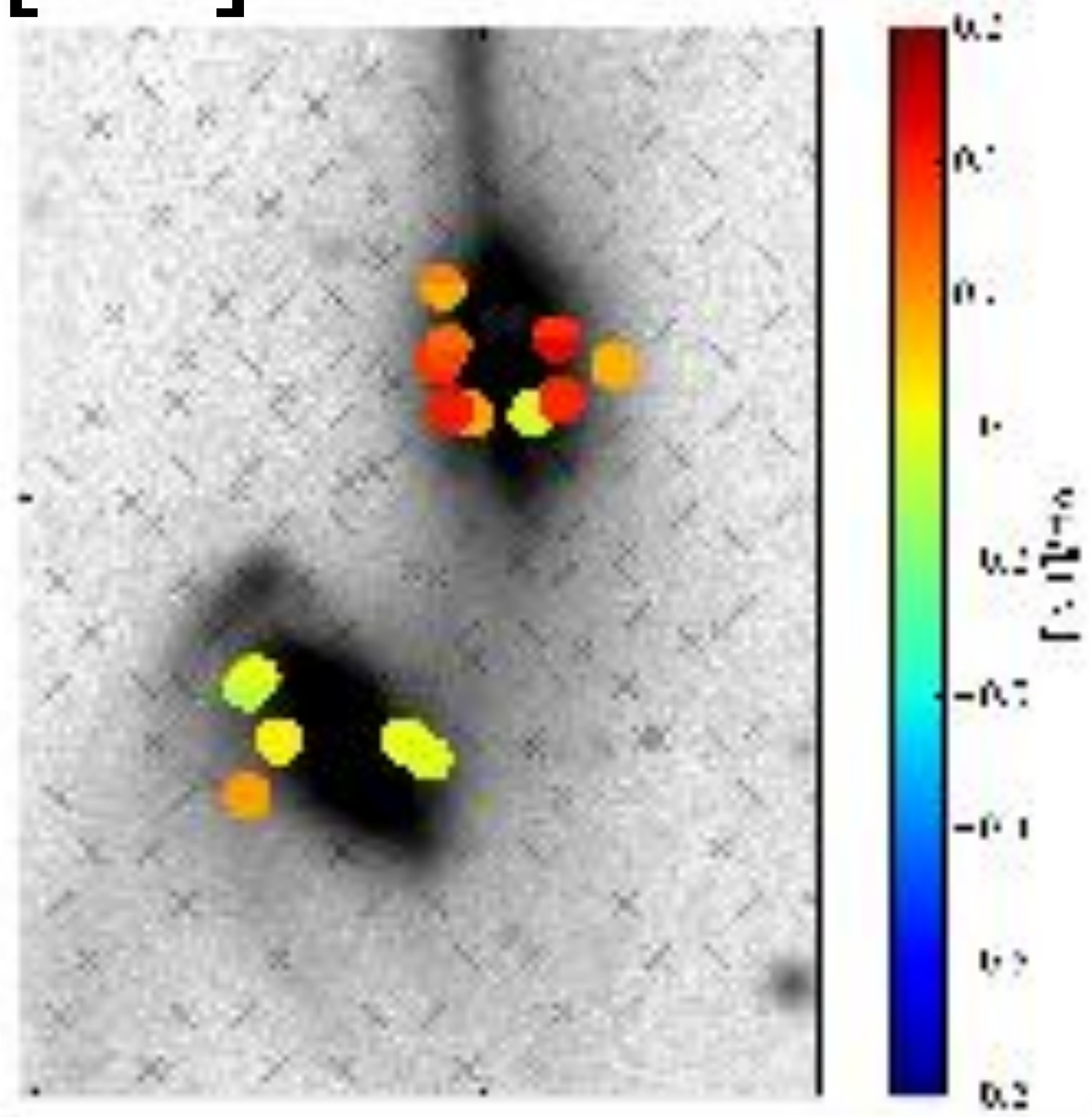
NIRSpec



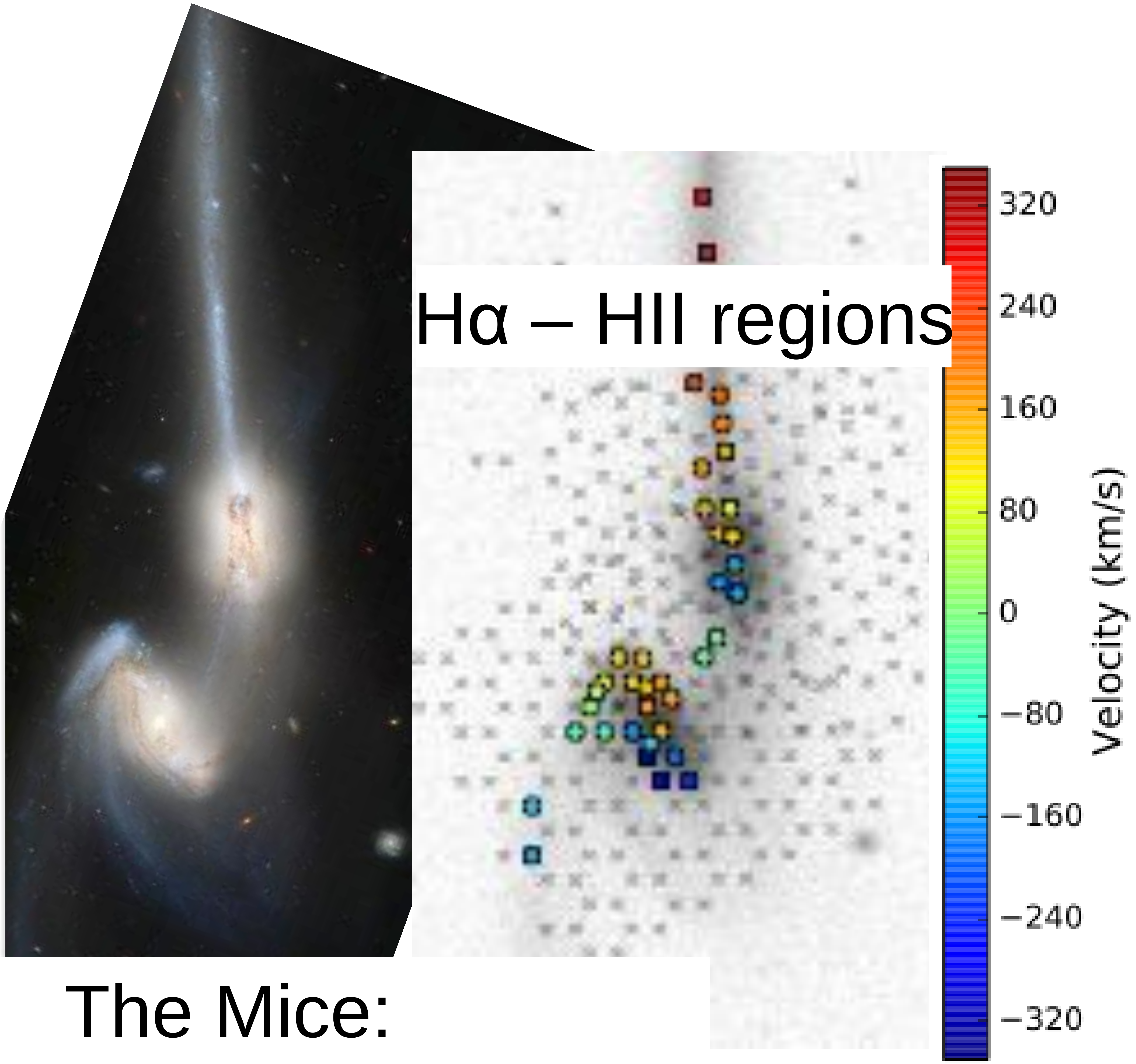
MIRI



[NII]/Hα shocks



Hα – HII regions



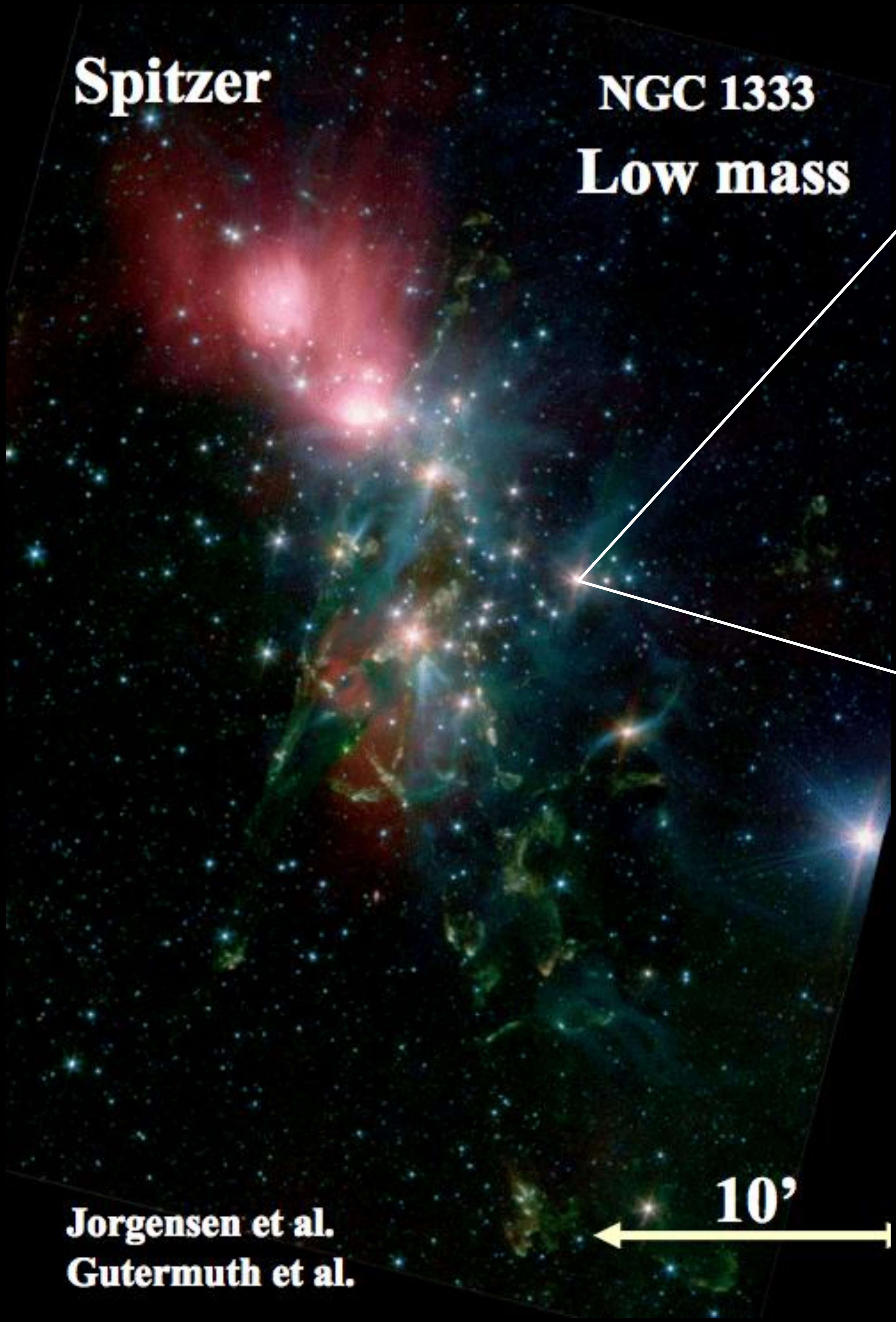
The Mice:
Mortazavi & Lotz 2016, in prep

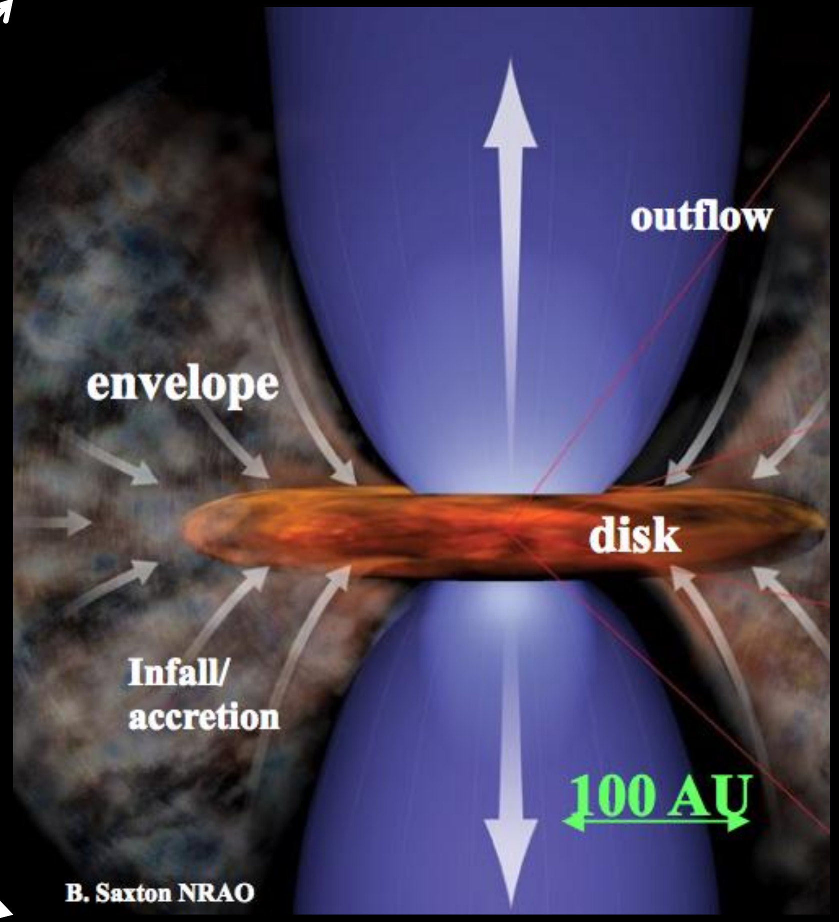
Star-formation, shocks
And kinematics of z>1 mergers with JWST spectroscopy

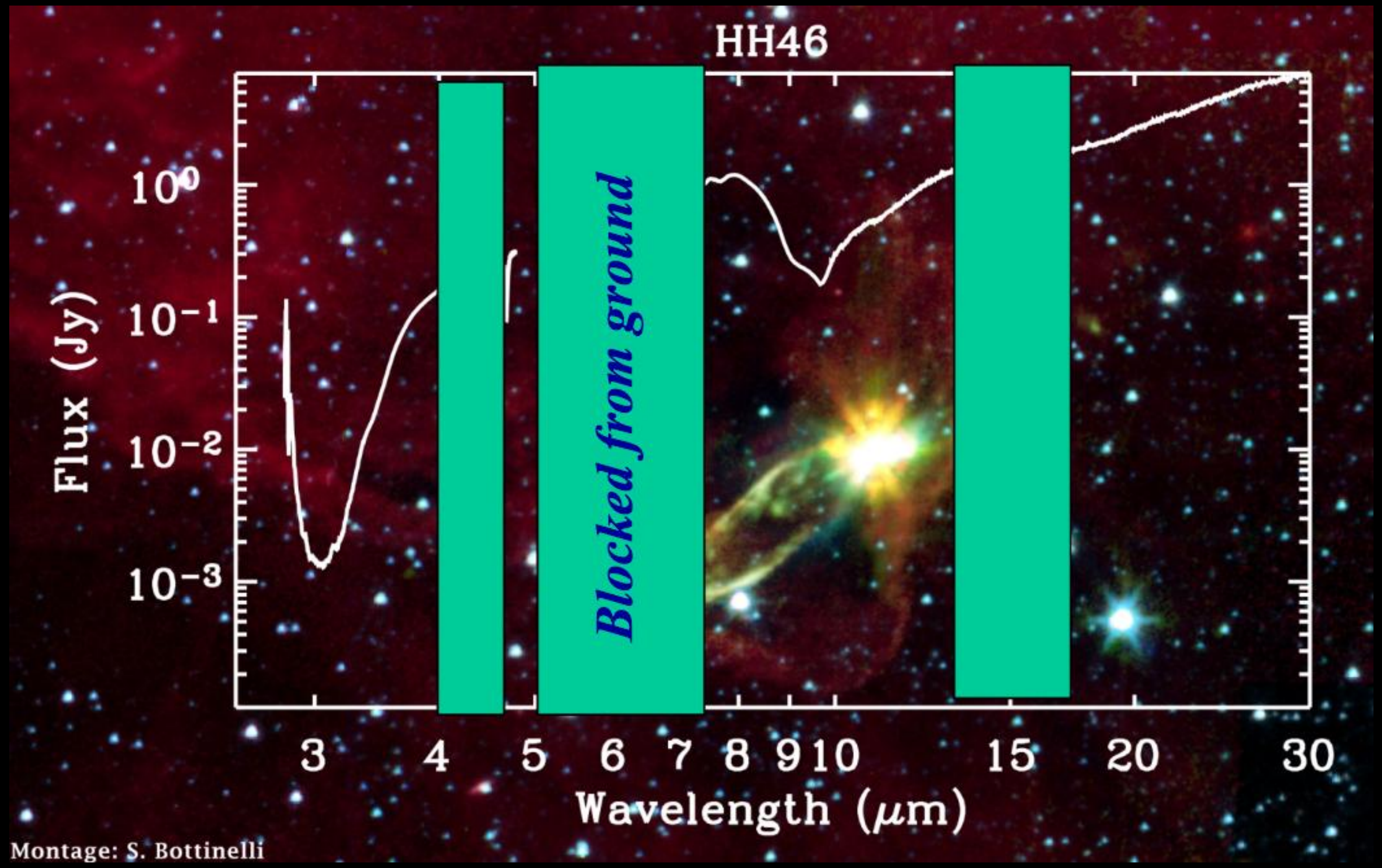
From J. Lotz

Birth of Stars and Protoplanetary Systems

The Embedded Phase of Star Formation







JWST spectroscopy will enable characertization of the physics and chemistry of few 10 to few 1000 AU scales.

How does matter flow from core to disk to star?

What are the properties of young disks?

From E. van Dishoeck

Planets & Origins of Life: Transiting Exoplanet Science

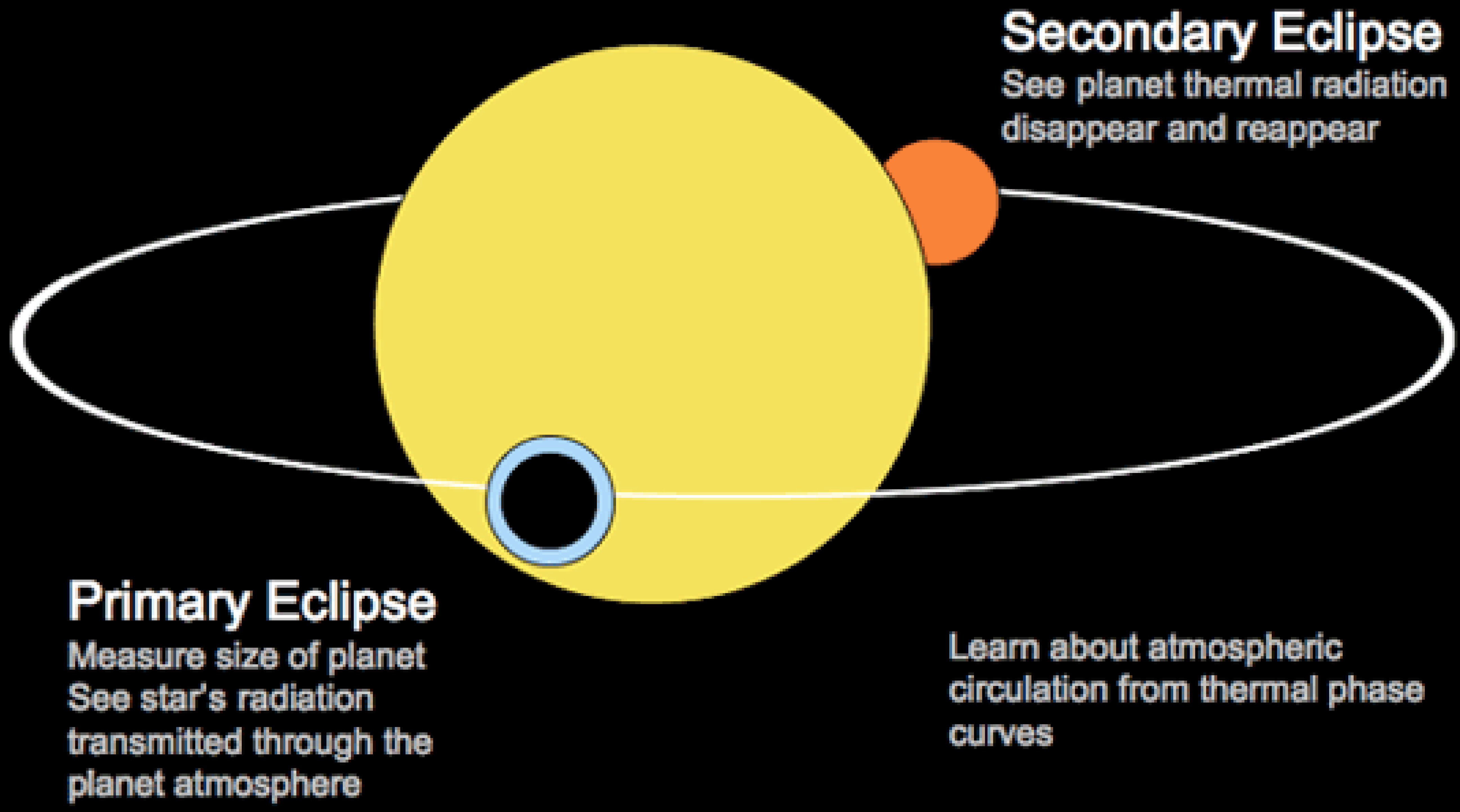
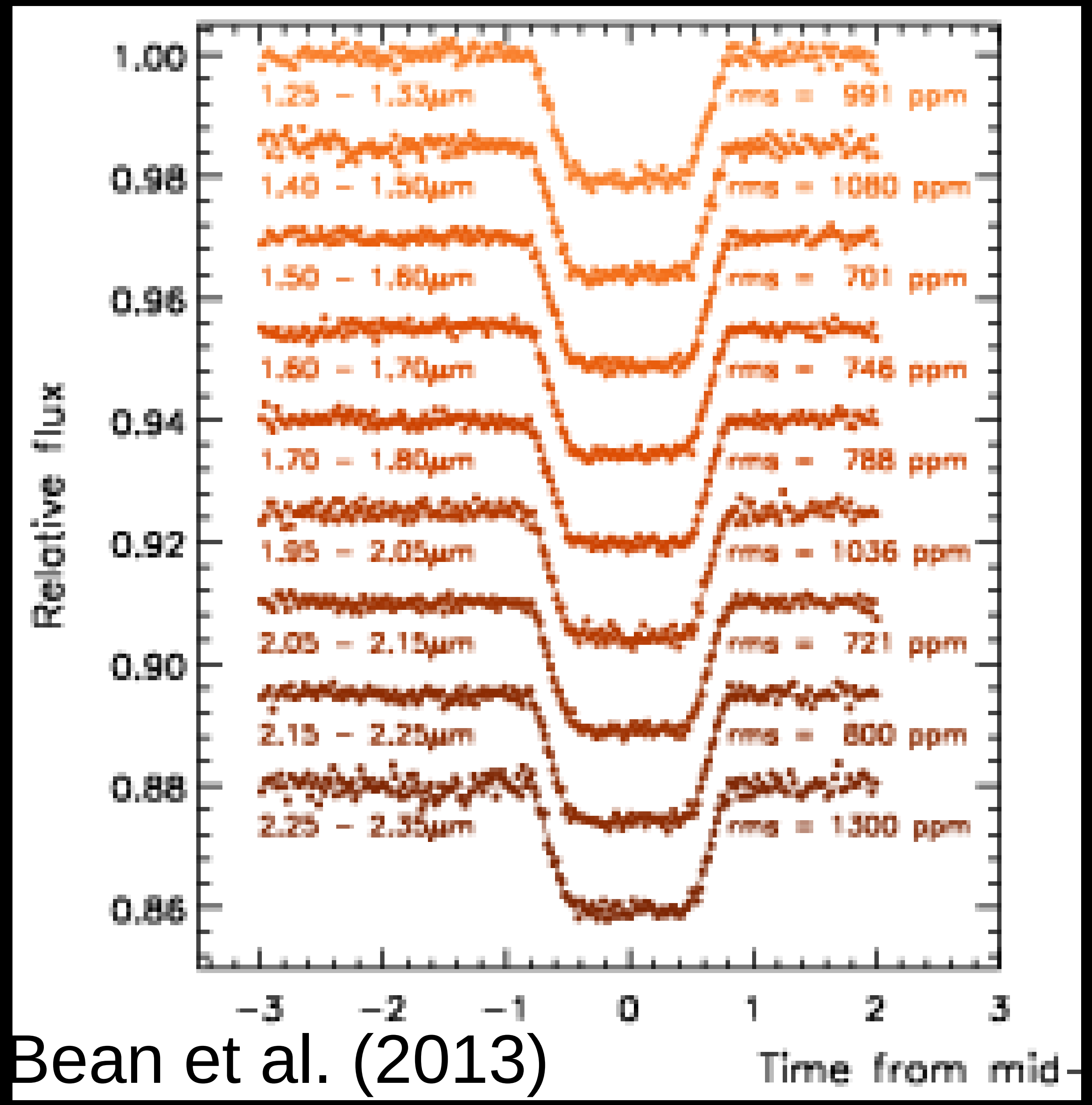


Figure by S. Seager



Bean et al. (2013)

JWST will measure secondary eclipses for transiting exoplanets

Planets & Origins of Life: Characterizing Exoplanet Atmospheres

JWST will enable

- observations of H_2O, CH_4, CO, and CO_2 molecules in exoplanetary atmospheres. Detections of these molecules will provide constraints on planet/star metallicity and C/O abundance ratios,and therefore constraint planet formation mechanisms.

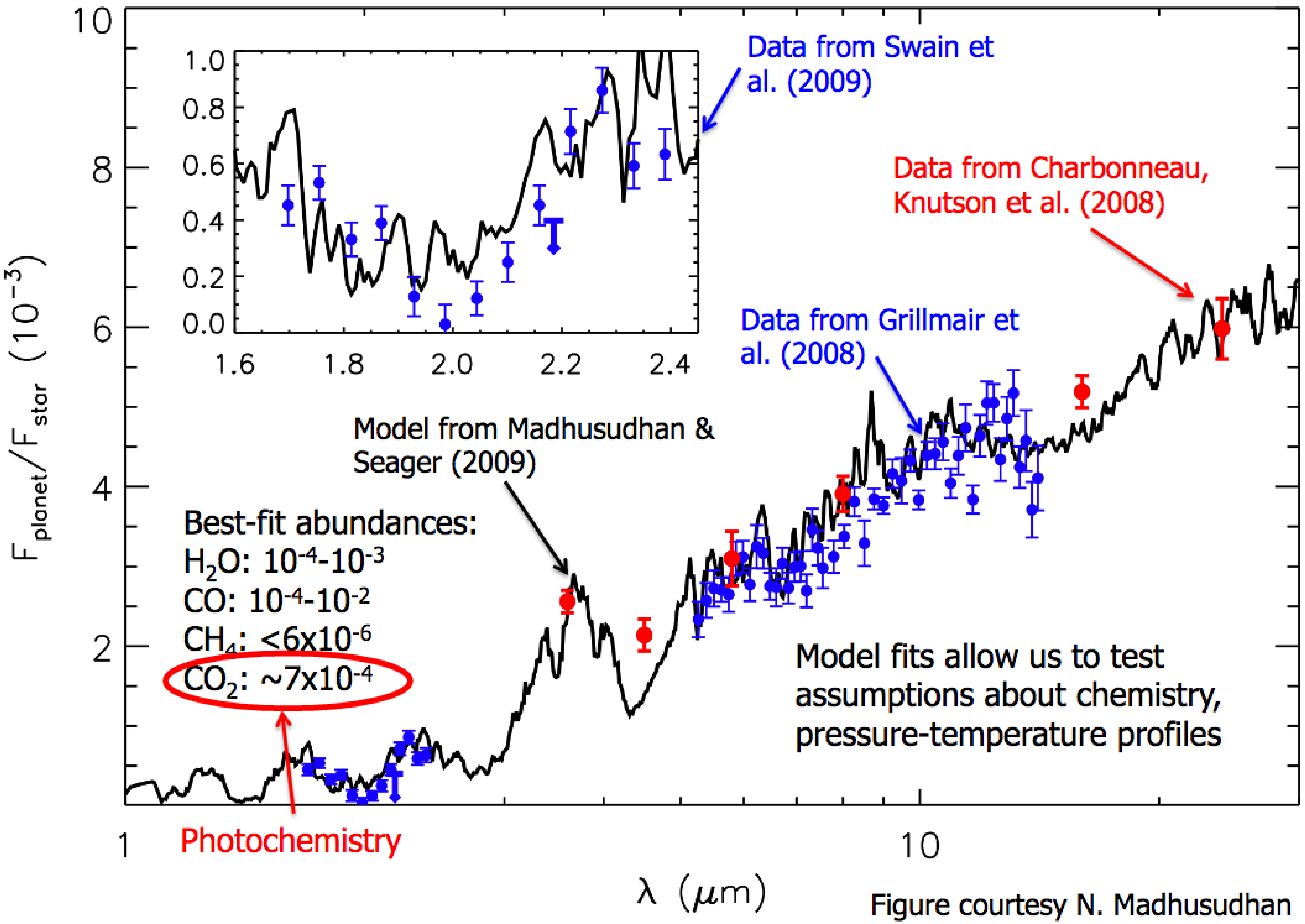
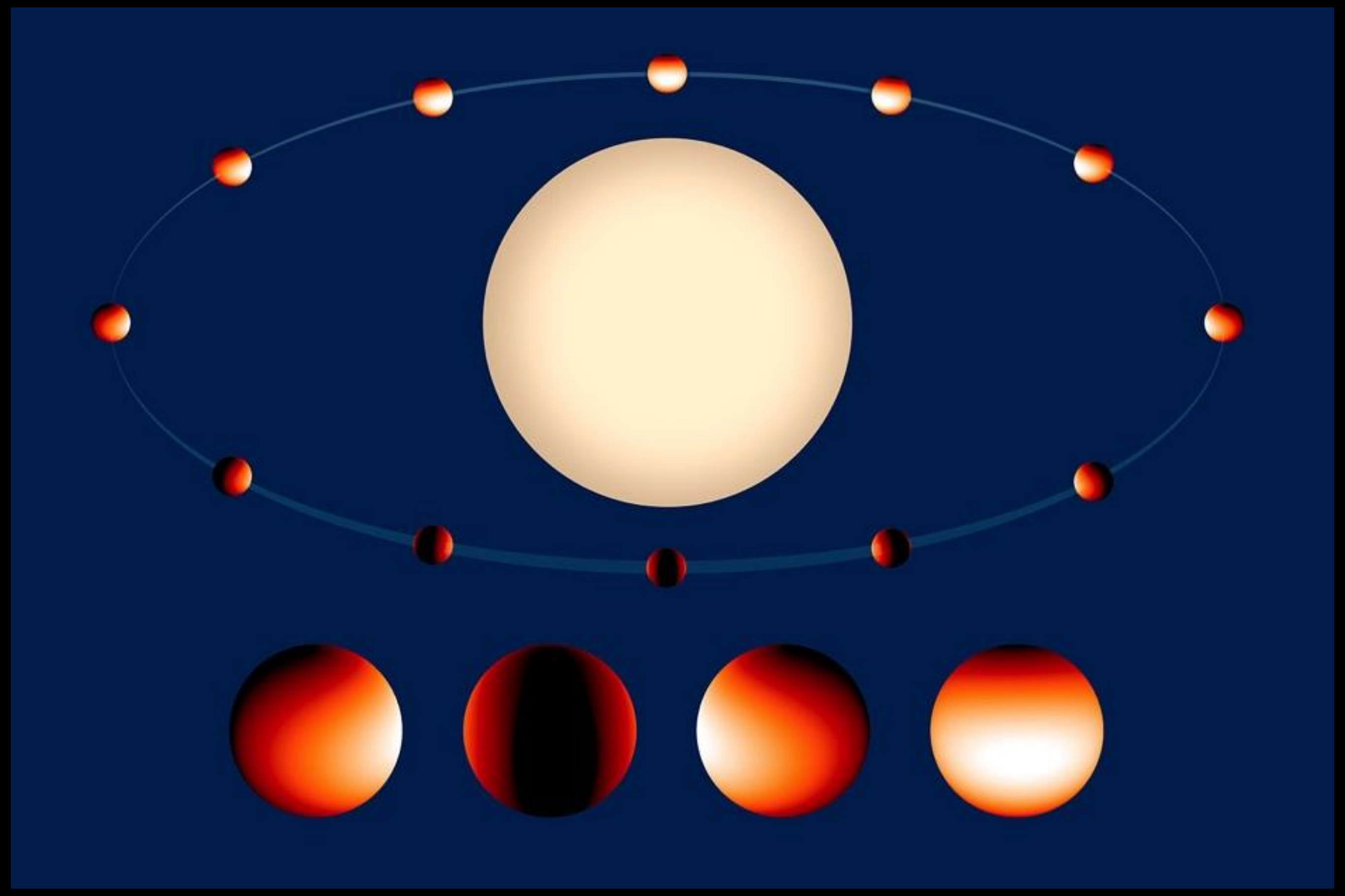


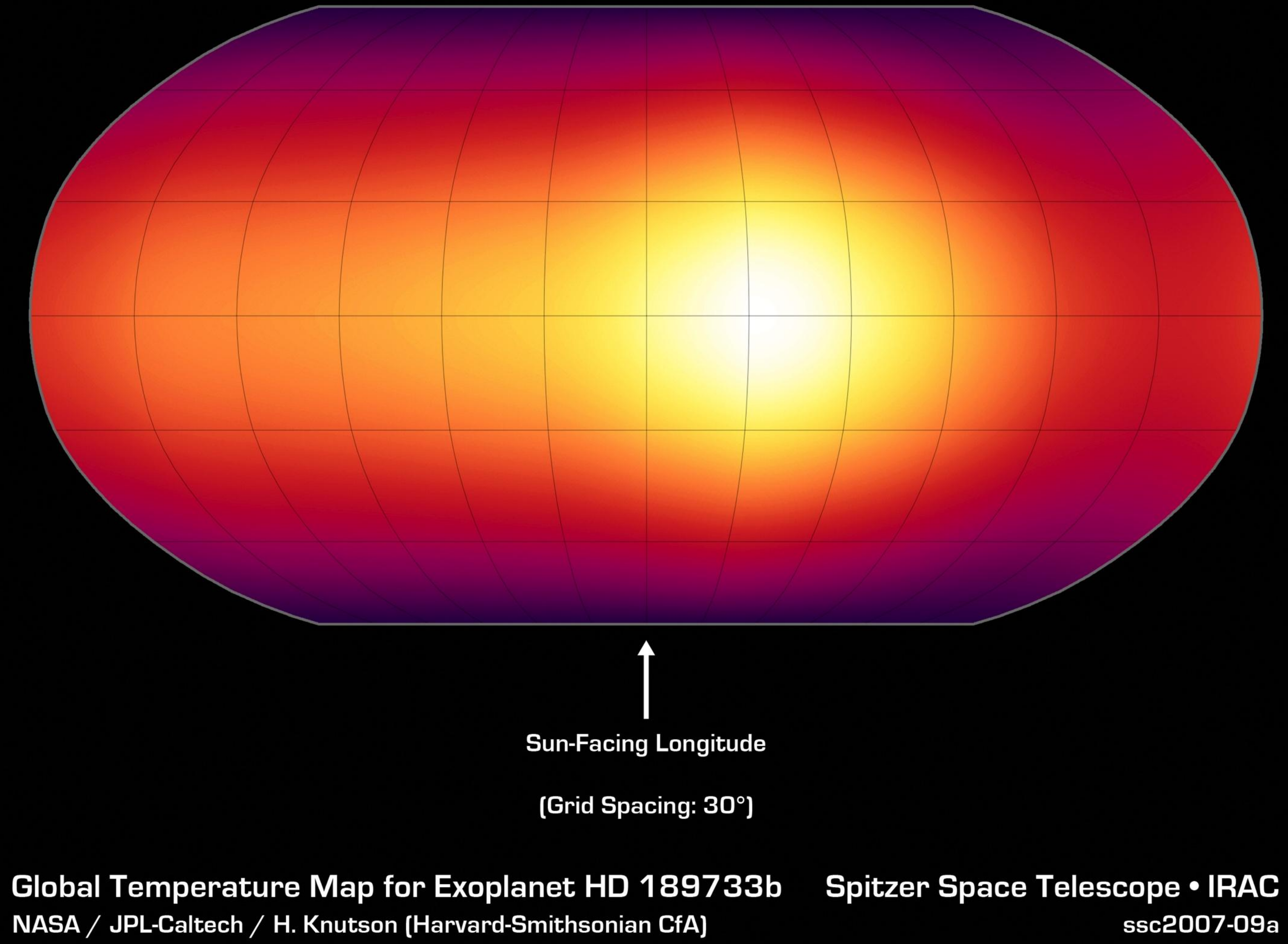
Figure courtesy N. Madhusudhan

Planets & Origins of Life: Measuring Heat Transport



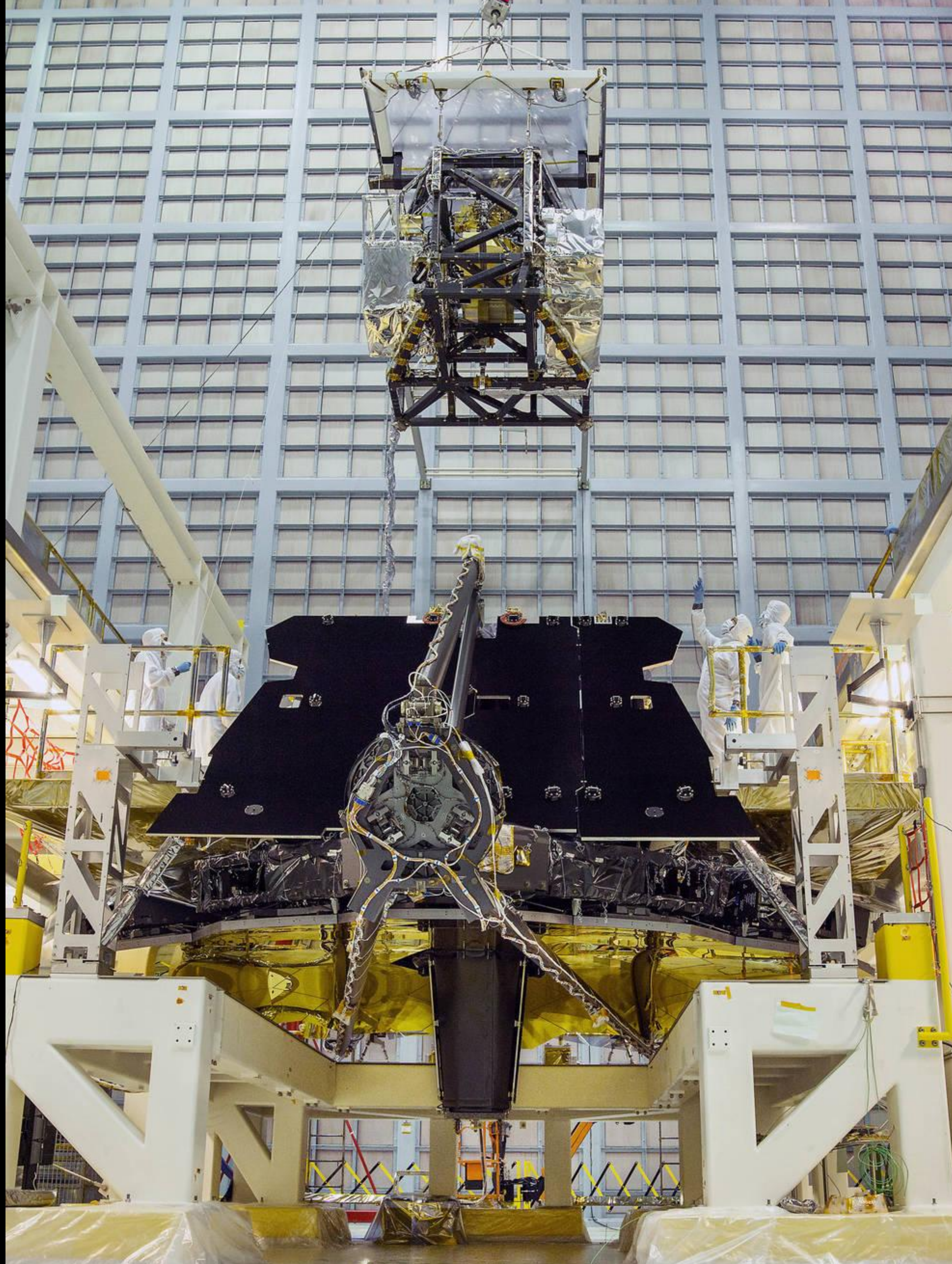
JWST will enable

- thermal mapping of the day and night-side temperatures. Such maps will constrain energy transport mechanisms



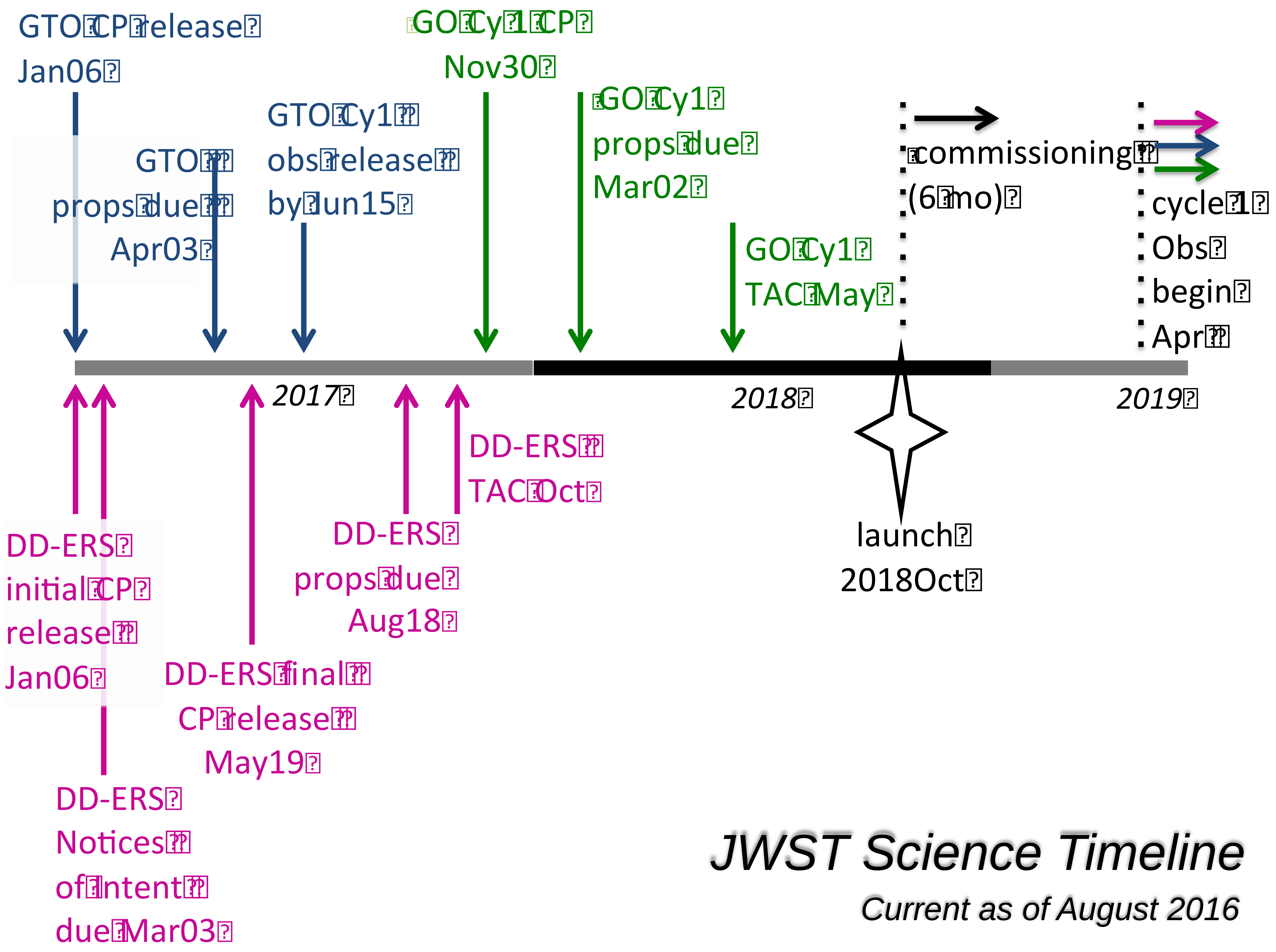
2016 Milestones

- January 2016: ISIM Cryovac 3 Testing Complete
- February – April 2016: Installed 18 primary mirror segments and Aft optics system including fixed tertiary mirror and Fine Steering Mirror
- May 2016: Installed Science Instrument Package into Optical Telescope Element



Early JWST Observations

- **Director's Discretionary – Early Release Science**
  - Designed, executed by teams with broad representation of community; selected by peer-review
  - Spans key JWST observing modes and science areas. Coherent programs in multiple modes encouraged
  - Substantive, science –driven program of broad community interest in Cy 1, prep for Cy2
  - 500 hours of telescope time divided among 12-15 teams
  - Data have no proprietary period
  - Among first obs to execute after commissioning
  - ERS teams responsible for delivery of science enabling products to community
- **General Observer Cycle 1**
  - Use GO programs from HST, Spitzer and Chandra, etc. as models
  - Flexible to accommodate programs with a range of sizes
  - Support archival research
  - Details TBD

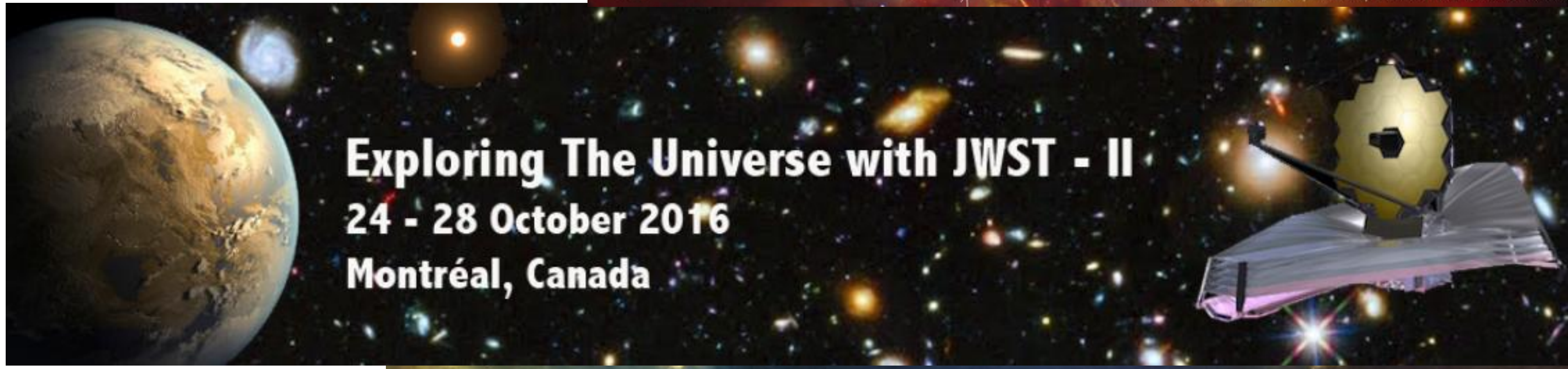


JWST Science Timeline

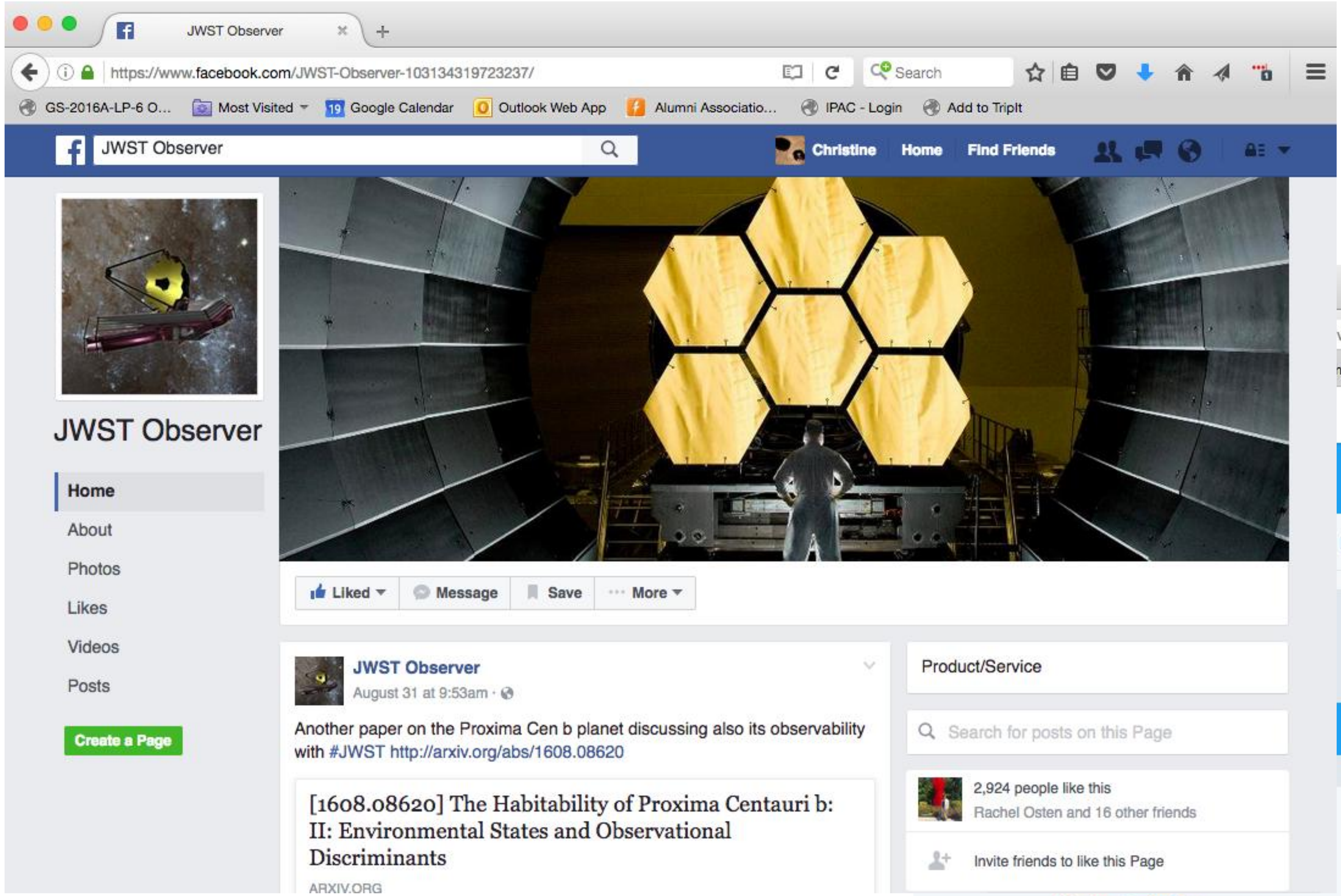
Current as of August 2016

Community Education: Workshops

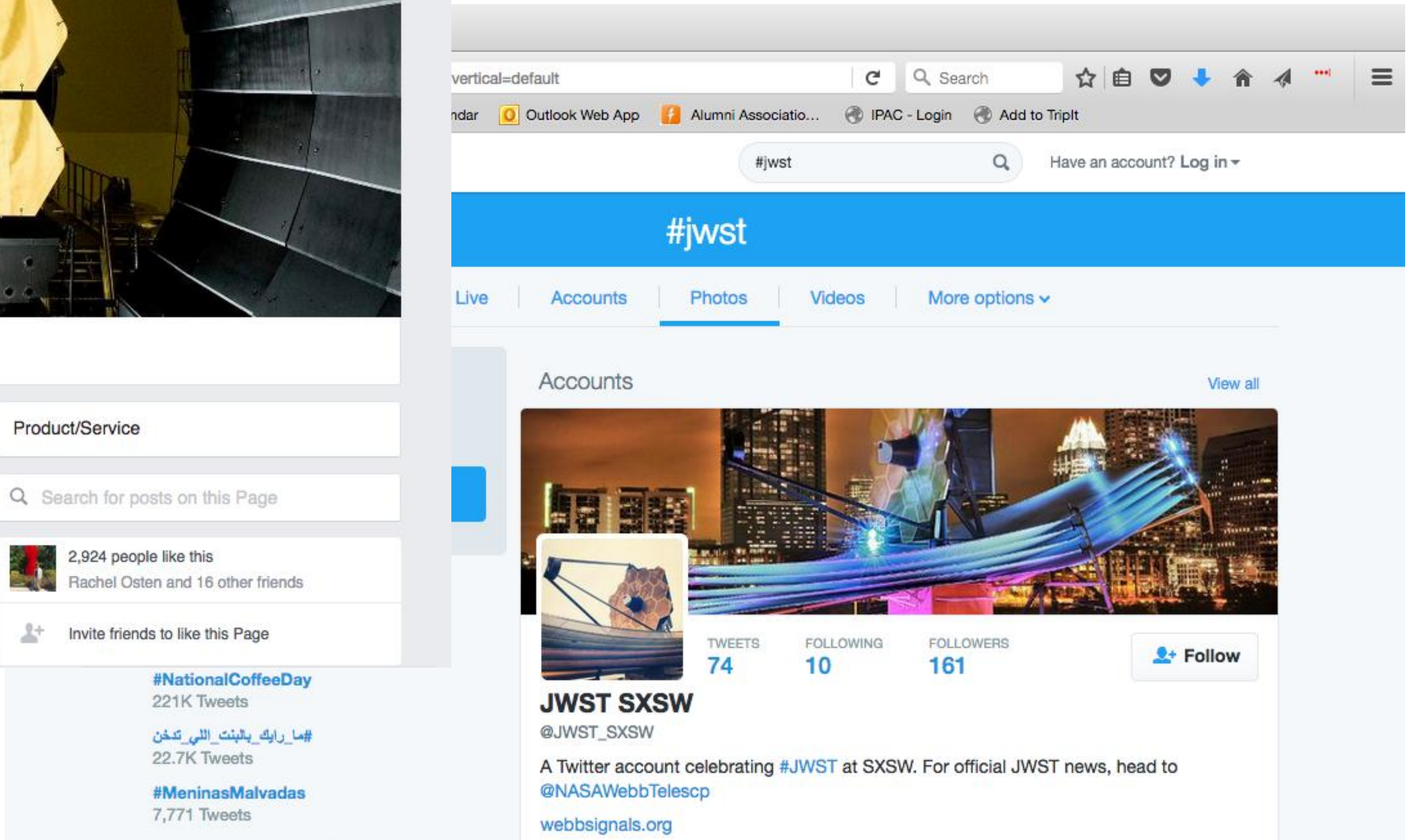
- **International Conferences**
  - Exploring the Universe with JWST II (Oct 2016 in Montreal, Canada)
  - Science with Hubble and JWST V (Mar 2017 in Venice, Italy)
  - Mastering the Science Instruments and the Observing Modes of JWST (Sep 2017)
- **Proposal and Planning Workshops**
  - May 2017 at STScI (Baltimore, MD)
  - Jun 2017 at the 230th AAS Meeting (Austin, TX)
  - Oct 2017 at the 49th DPS Meeting (Provo, UT)
  - Dec 2017 at Caltech (Pasadena, CA)
  - Jan 2018 at the 231st AAS Meeting (National Harbor, MD)
- **Topical Science Workshops**
  - Nearby Galaxies (Jan 2017 in Pasadena, CA)
  - Transiting Exoplanets II (Jul 2017 in Baltimore, MD)
  - Galaxy Evolution (Jul 2017 in Baltimore, MD)
  - Protoplanetary and Debris Disks (Oct 2017 in Baltimore, MD)
  - Solar System (Nov 2017 in Baltimore, MD)



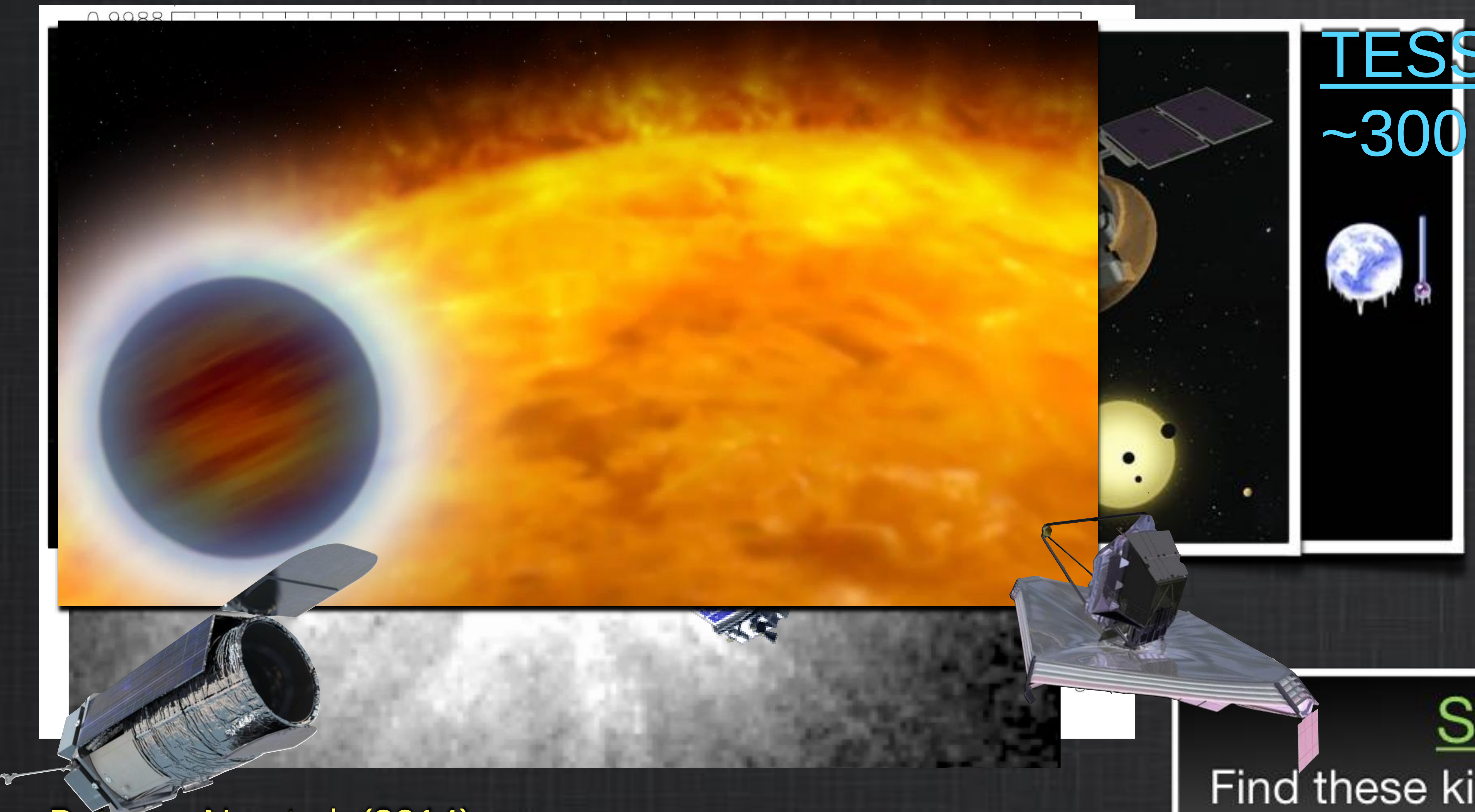
Find out more about JWST…



JWST Observer on Facebook



#JWST on Twitter



Batalha, N., et al. (2014)
JWST white paper

[TESS Yield](#)
~300 nearby Earth and Super-Earths

Step 5
Achieve high-performance coronagraphy in space

Step 4
Measure the atmospheric composition of these potentially habitable planets

Step 3
Find these kinds of star-planet systems within 50 pc of the Sun

Step 2
Find the long-lived stars with planets in the habitable zone

Step 1
Determine what percentage of stars have planets