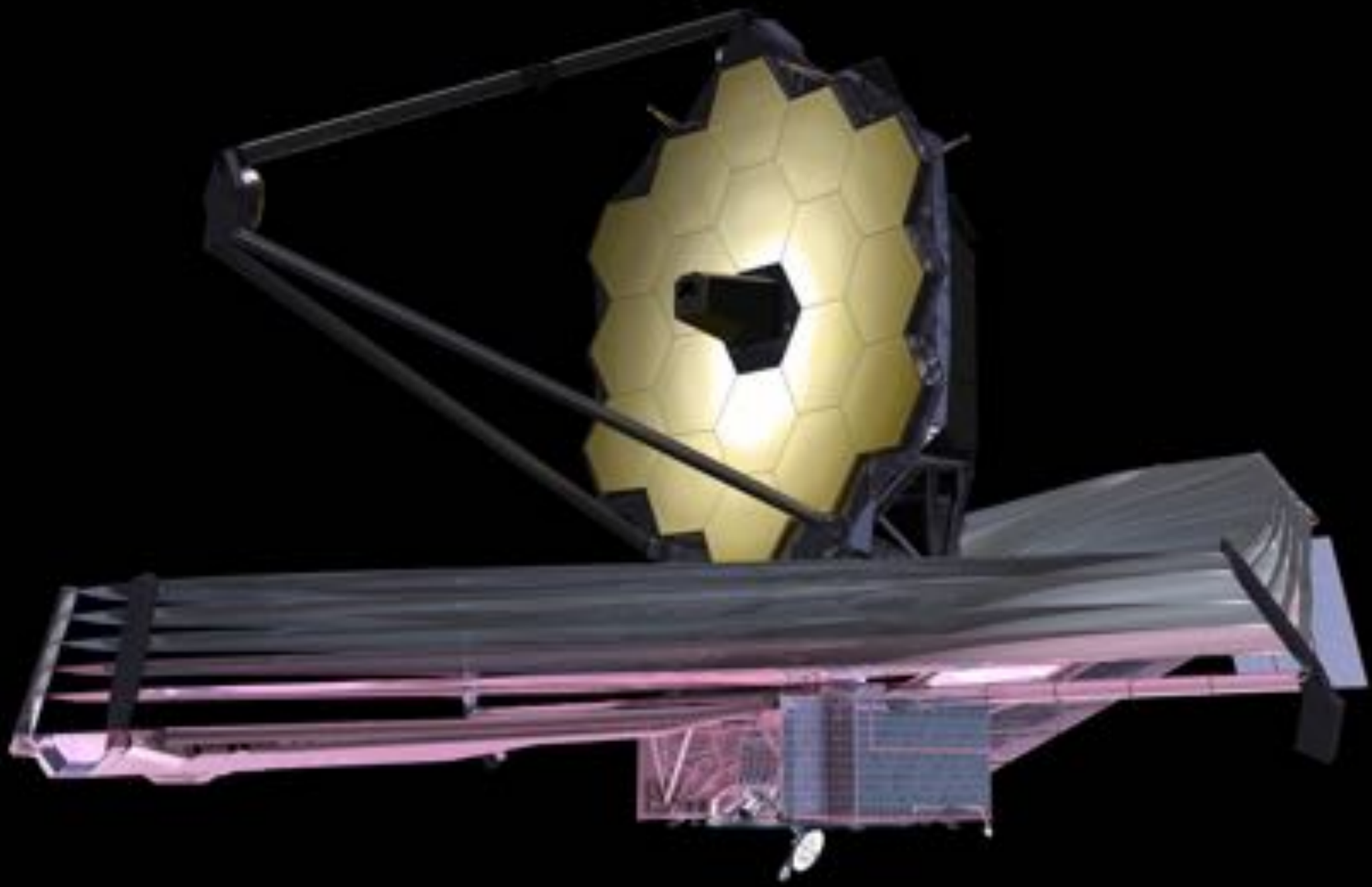
James Webb Space Telescope



Planned launch:
30 March 2021

Proposal Planning for the James Webb Space Telescope

Dana Anderson & Christian Eistrup

ASTR 8500

February 11, 2020

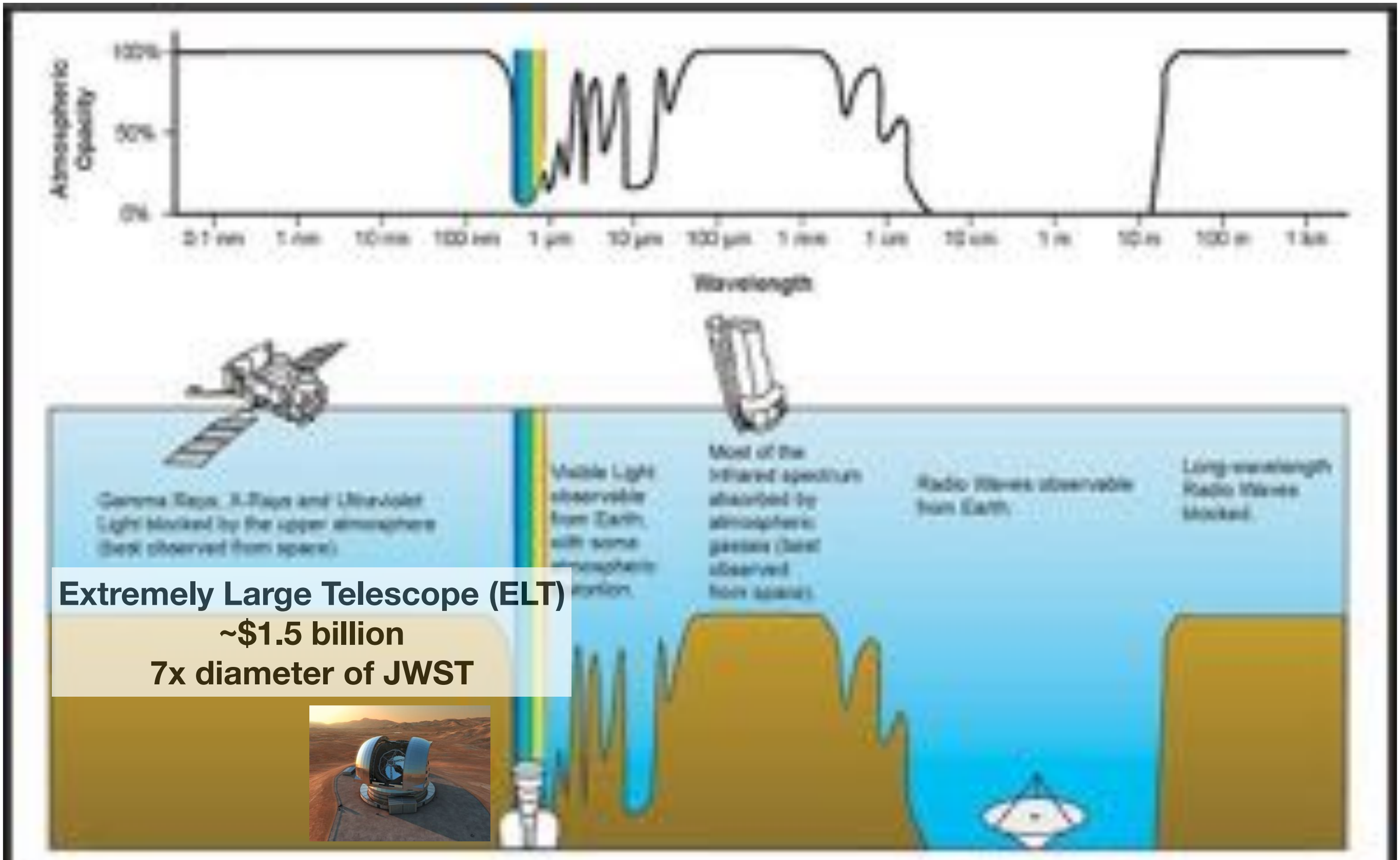
Artist conception from NASA

The Hubble Space Telescope successor

Introduction to JDox

https://jwst-docs.stsci.edu

Space vs. Ground Telescopes



History of Space Missions

Cold War

1837
Discussions of Moon-based observatory

1946
Lyman Spitzer proposed sending a large telescope to space

1965-1968
Soviet Proton program

1968-1972
NASA sent the Orbiting Astronomical Observatory (OAO) satellites

1970s-1980s
Post-Apollo era, more effort was focused on space observatories and by more nations

Lyman Spitzer lobbied US Congress

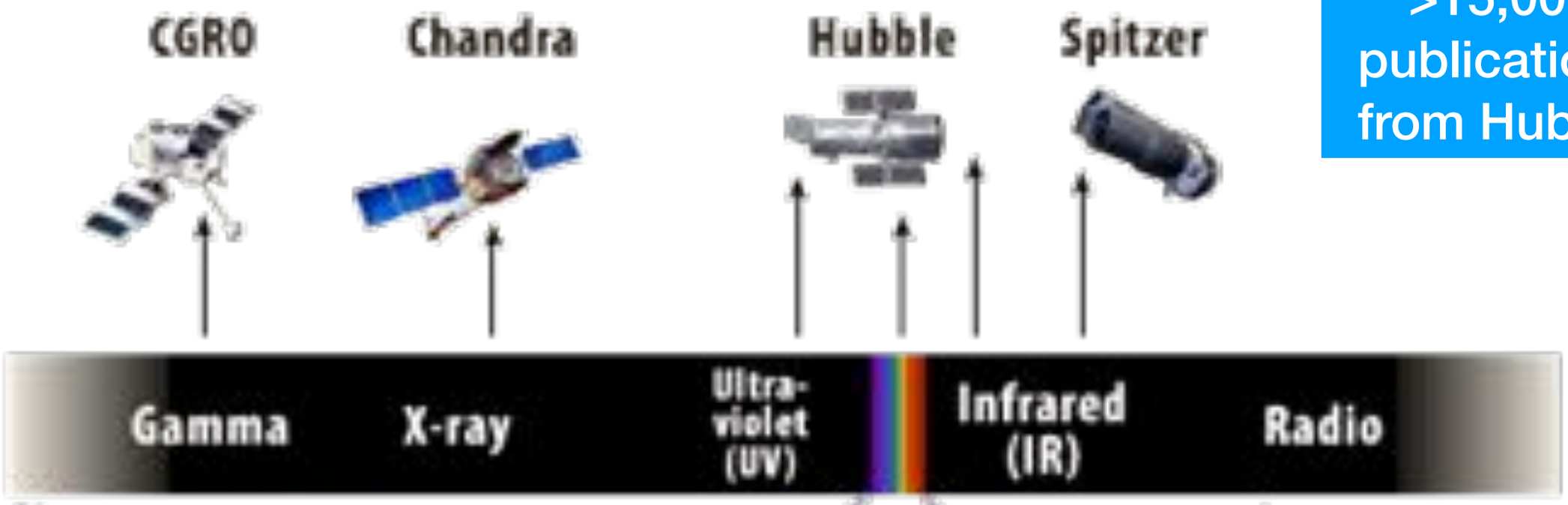
History of Space Missions

1983 IRAS

2009
Herschel
WISE
Planck
Kepler

2013 Gaia
2015 LISA Pathfinder
2018 TESS

1990-2003
“NASA’s Great Observatories”



Upcoming: JWST

>15,000 publications from Hubble

Originated 1996:
Next Generation Space Telescope
(NGST)
2002-: JWST

Collaboration among NASA,
European Space Agency and
Canadian Space Agency

Administrator:1961-1968

Space Race

Named after NASA's 2nd Administrator

Designing and building it

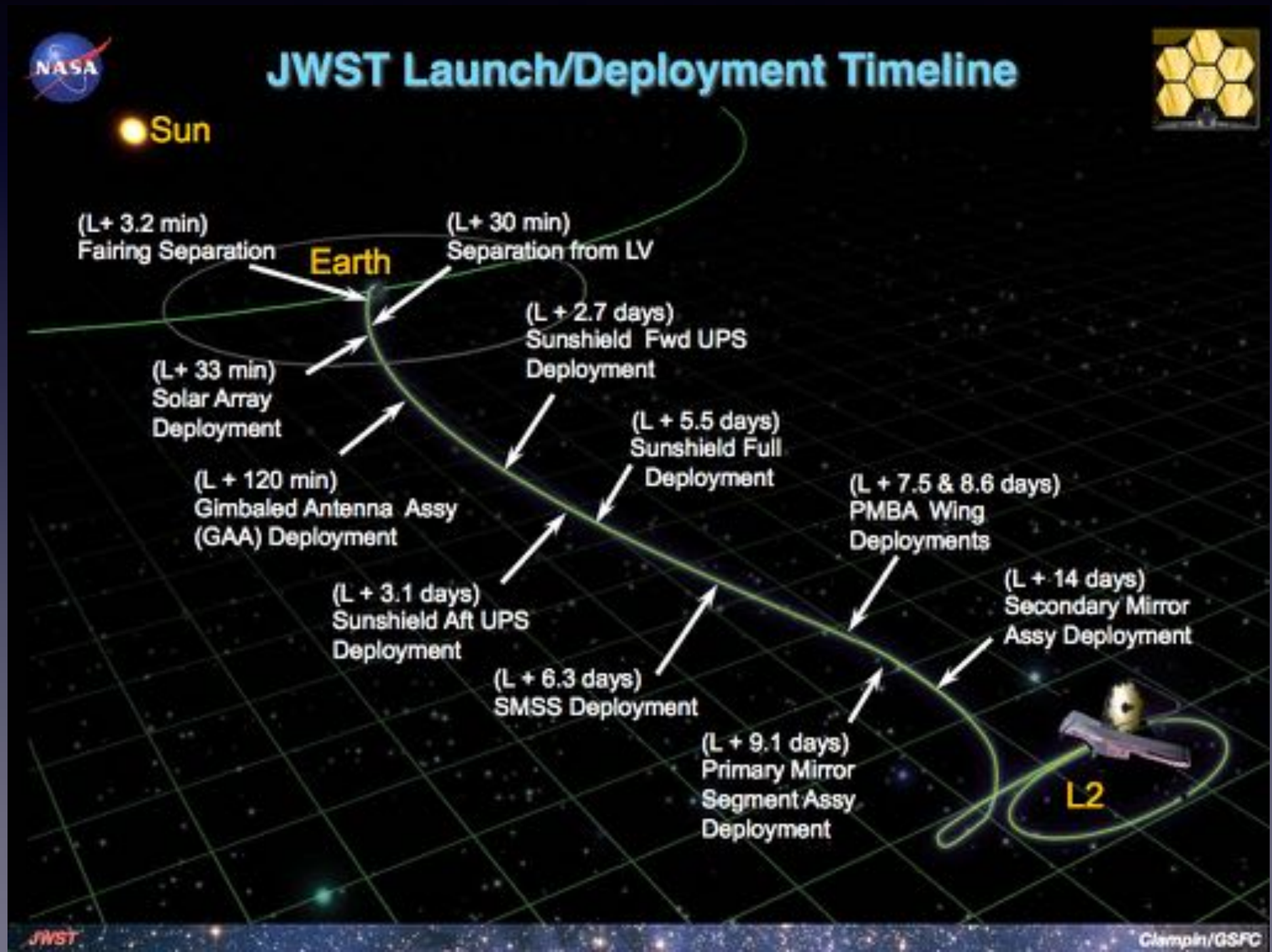
Then-planned launch and costs

Year	Planned launch	Budget Plan (Billion USD)
1997	2007[75]	0.5[75]
1998	2007[80]	1[50]
1999	2007 to 2008[81]	1[50]
2000	2009[38]	1.8[50]
2002	2010[82]	2.5[50]
2003	2011[83]	2.5[50]
2005	2013	3[84]
2006	2014	4.5[85]
2008, Preliminary Design Review		
2008	2014	5.1[86]
2010, Critical Design Review		
2010	2015 to 2016	6.5[*citation needed*]
2011	2018	8.7[87]
2013	2018	8.8[88]
2017	2019[89]	8.8
2018	2020[90]	≥8.8
2018	2021[91]	9.66

10 years out

Now: 1 year out

Getting out there

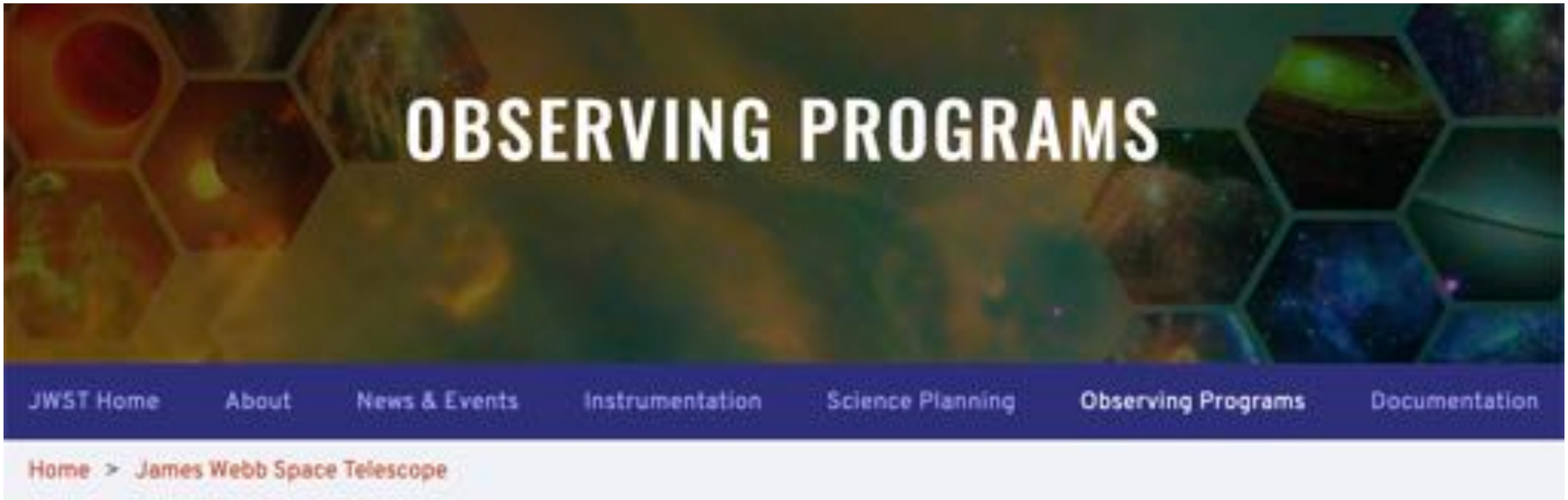


Science goals

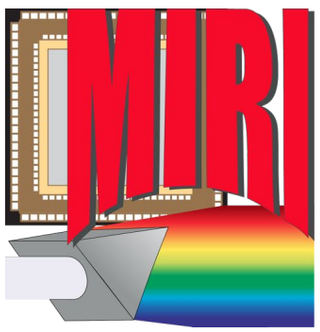
- The primary aim is to examine the first light in the Universe - those objects which formed shortly after the Big Bang.
- Further aims include: looking at how galaxies form and evolve, studying the birth of stars and planets, looking at our own Solar System, and studying the properties of exoplanets.

Activity: Select an Observing Program

http://www.stsci.edu/jwst/observing-programs

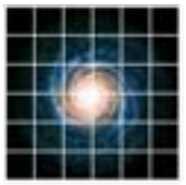


JWST Instruments & Observing Modes



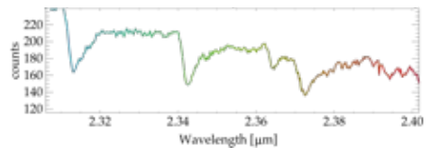
NIRISS

- Imaging



  - Time Series Imaging
  - Coronagraphy
  - Aperture Masking Interferometry

- Spectroscopy

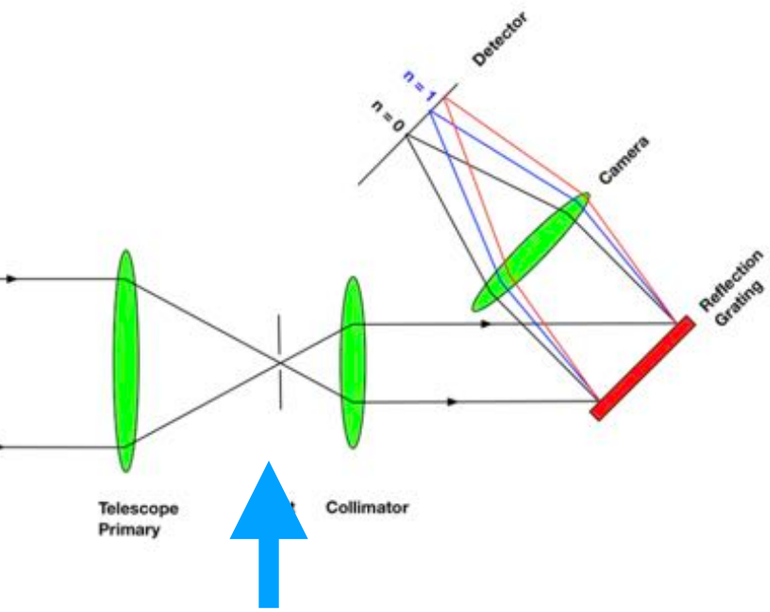


  - Integral Field Spectroscopy
  - Multi-Object Spectroscopy
  - Single-Object & Time-Series Spectroscopy
  - Wide-Field Slitless Spectroscopy

Images from STScI JDox

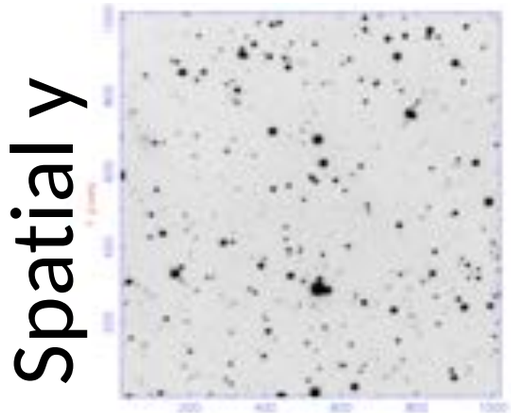
Single-Slit & Slitless Spectroscopy

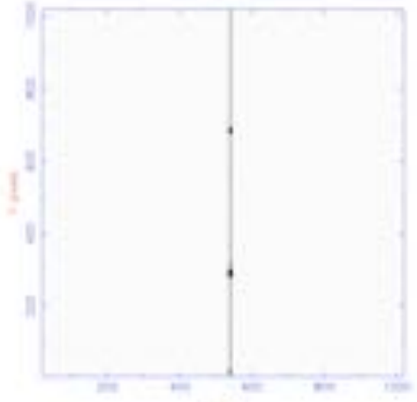
Generic
(not JWST-based)
spectrograph:



Slit

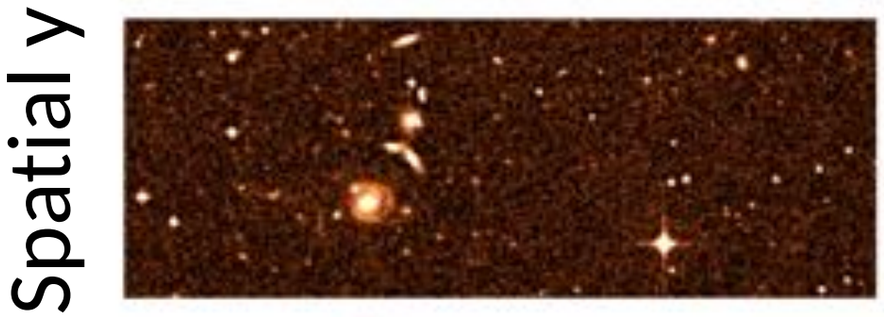
Generic example (not JWST-based) using a slit:





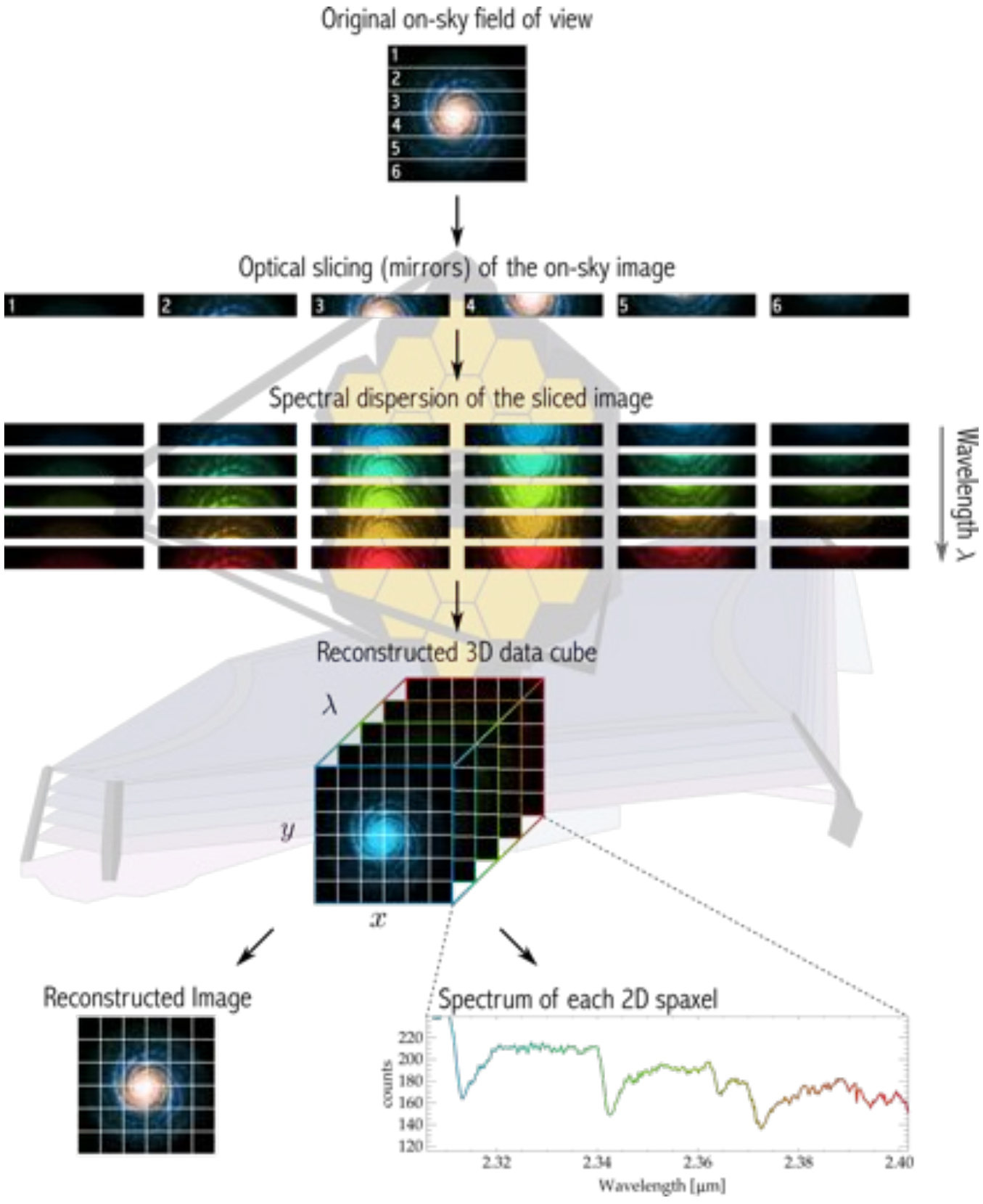
Generic example (not JWST-based) w
using a slit:

NIRCam
NIRISS
MIRI



http://slittlefair.staff.shef.ac.uk/teaching/phy217/lectures/instruments/L16/index.html

Integral Field Spectroscopy

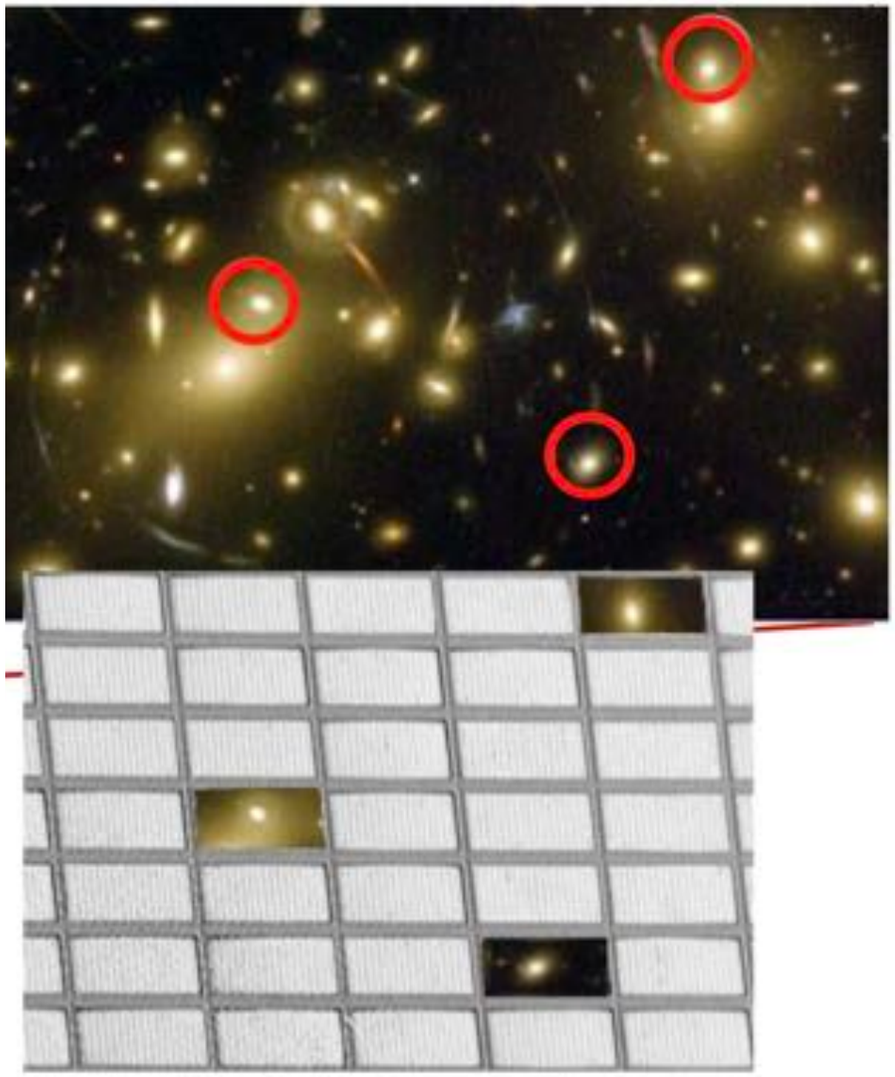


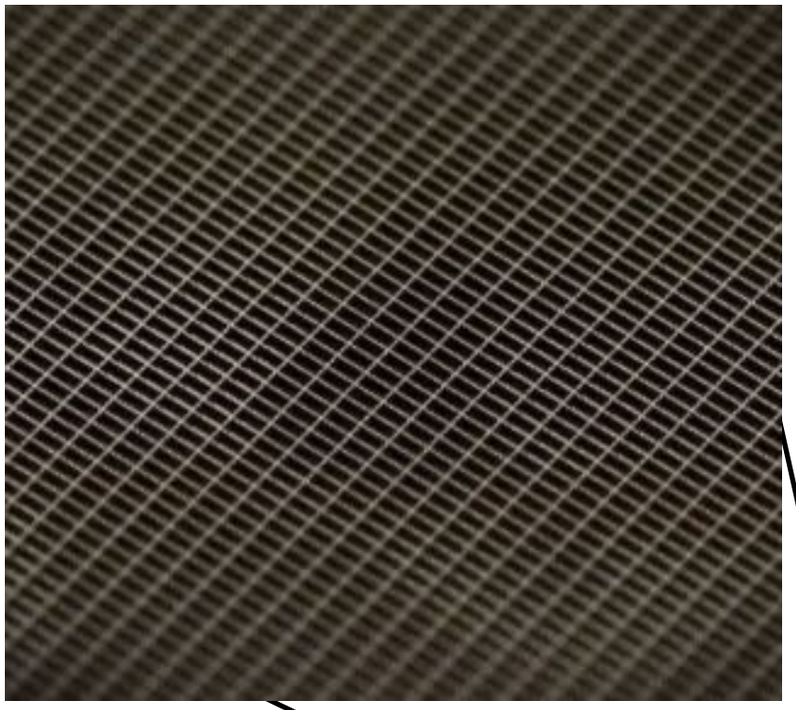
MIRI
NIRSpec

Figure from STScI JDox

Multi-Object Spectroscopy

Micro-Shutter Assembly (MSA)





NIRSpec

Each shutter is 80 x 180 microns in size

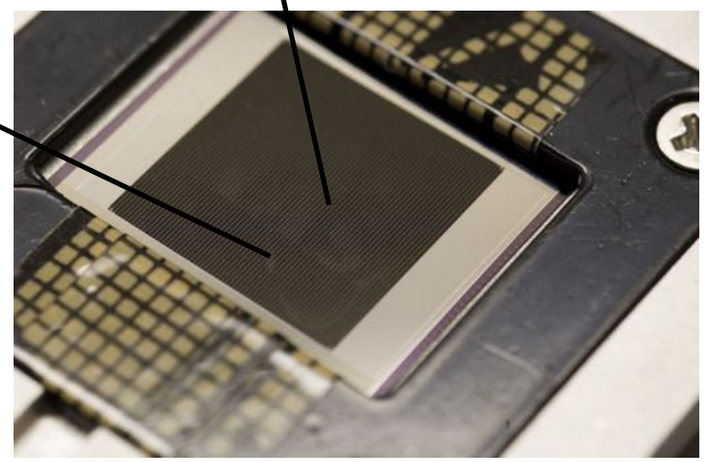
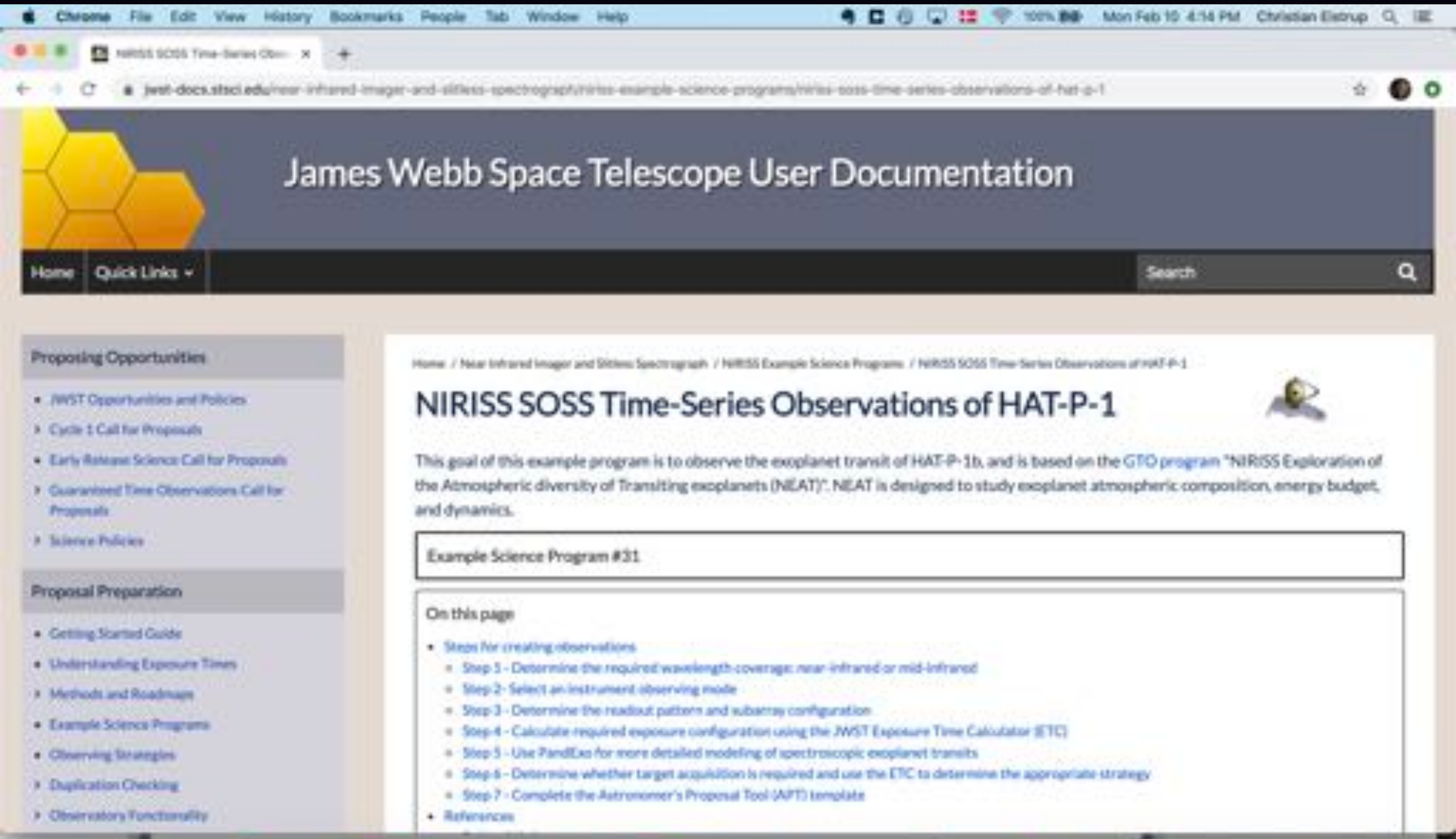


Image credits: NASA

Time Series Observations

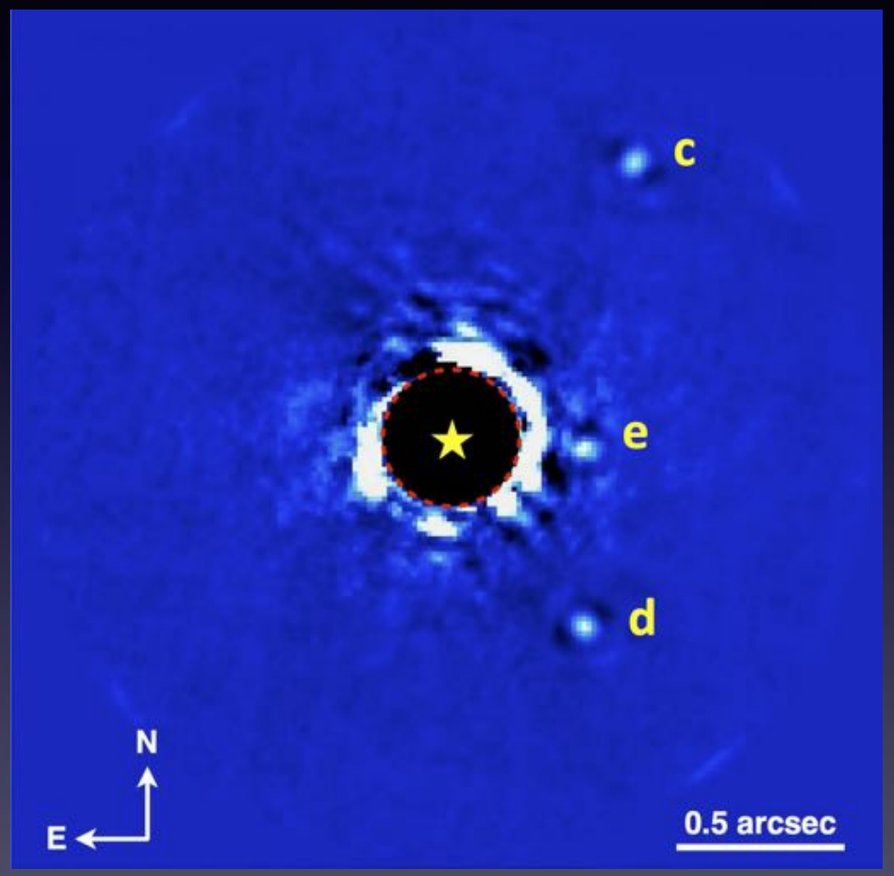
- When the duration of an astronomical event is setting the conditions for observations
- NIRCam, NIRSpec, NIRISS and MIRI all have this mode
  - NIRCam/NIRSpec/NIRISS: 0.6-5μm
  - MIRI: 4.8-28.5μm
  - Different spectral resolving powers
  - Different signal/noise achieved for same observing time

NIRISS Single Object Slitless Spectroscopy

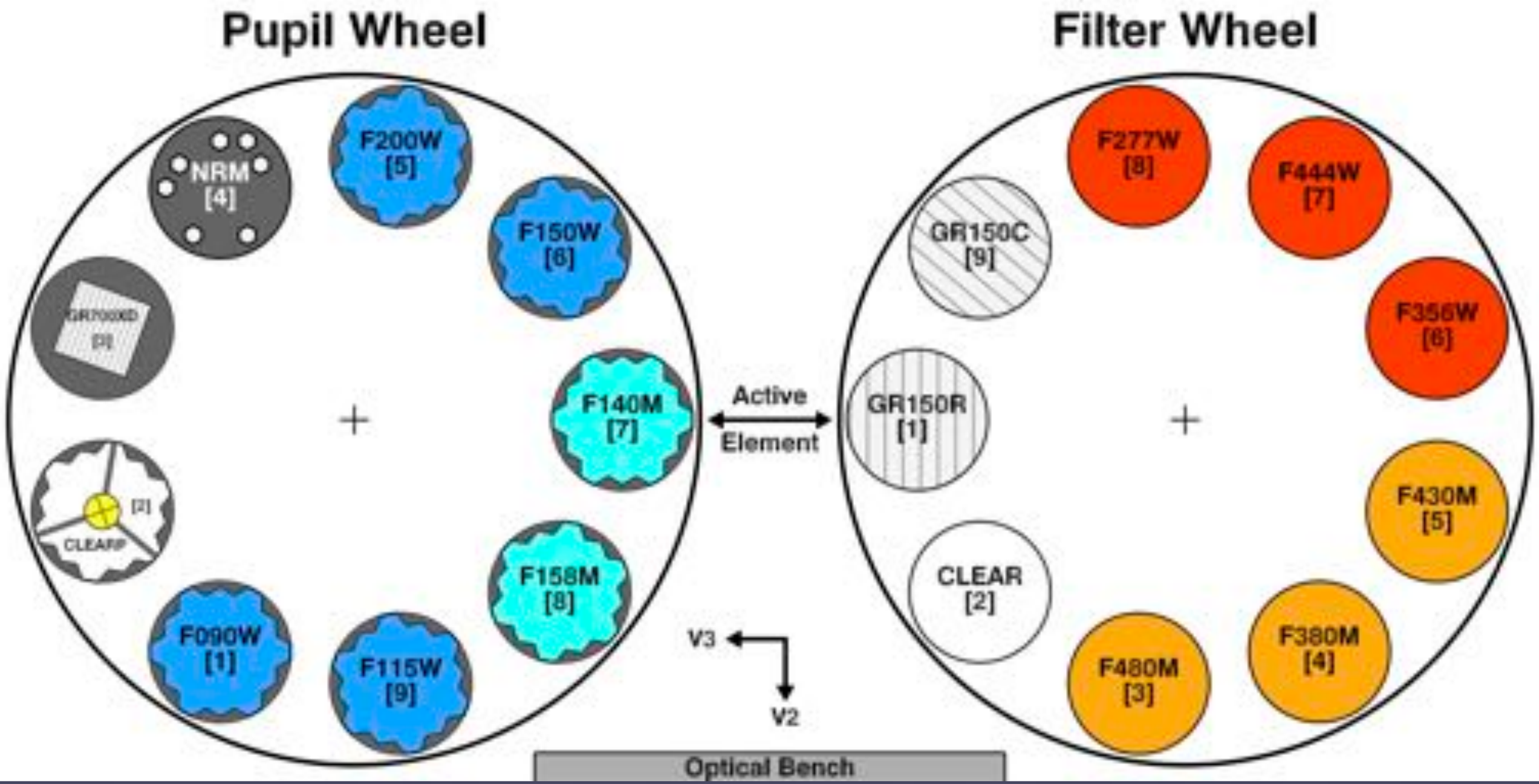


Coronagraphy/HCI

- "Masking out"/removing signal from star
- NIRCam:
  Planet/star contrast 10^{-8}-10^{-7}
- MIRI:
  Planet/star contrast 10^{-6}-10^{-5}

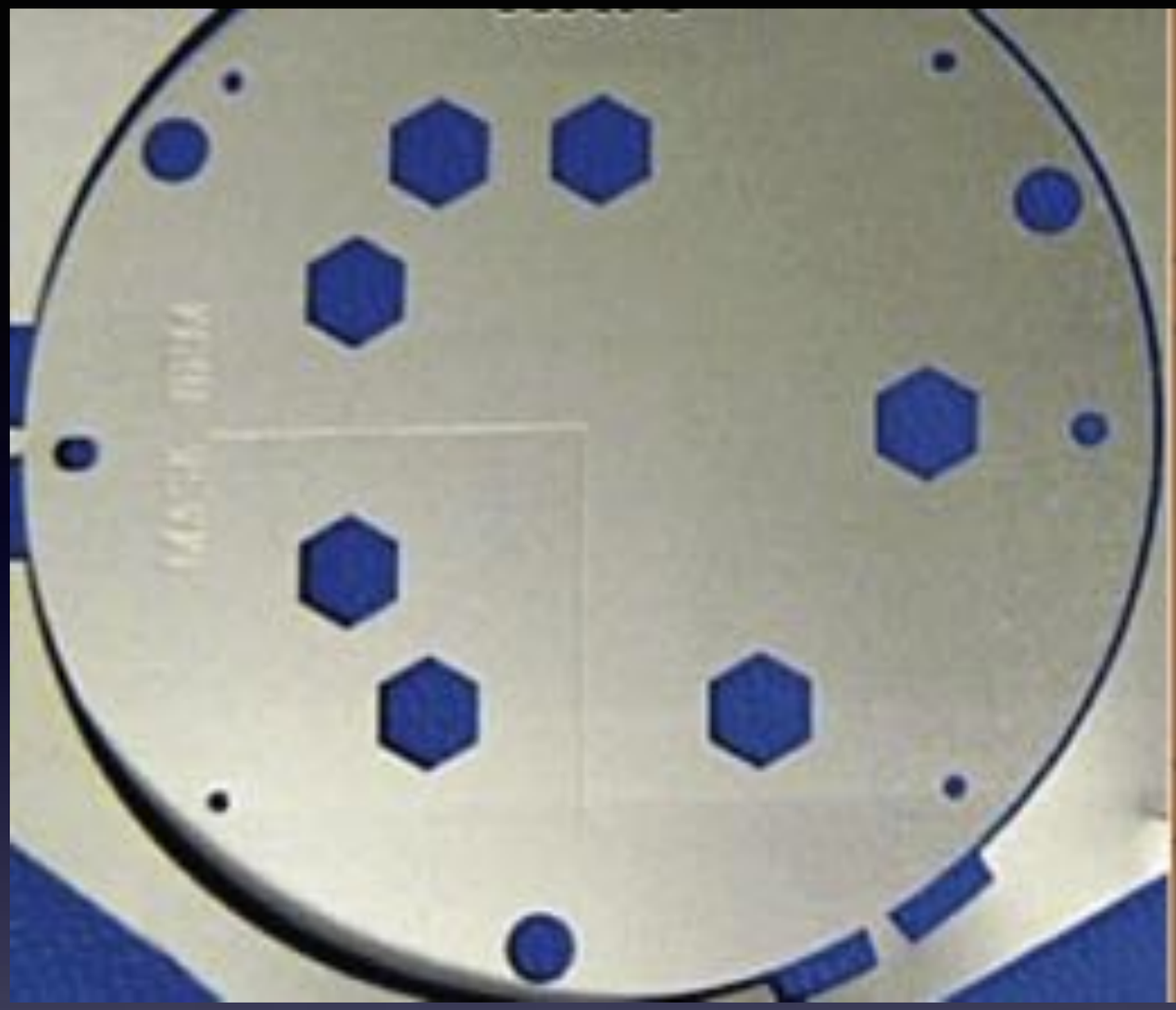


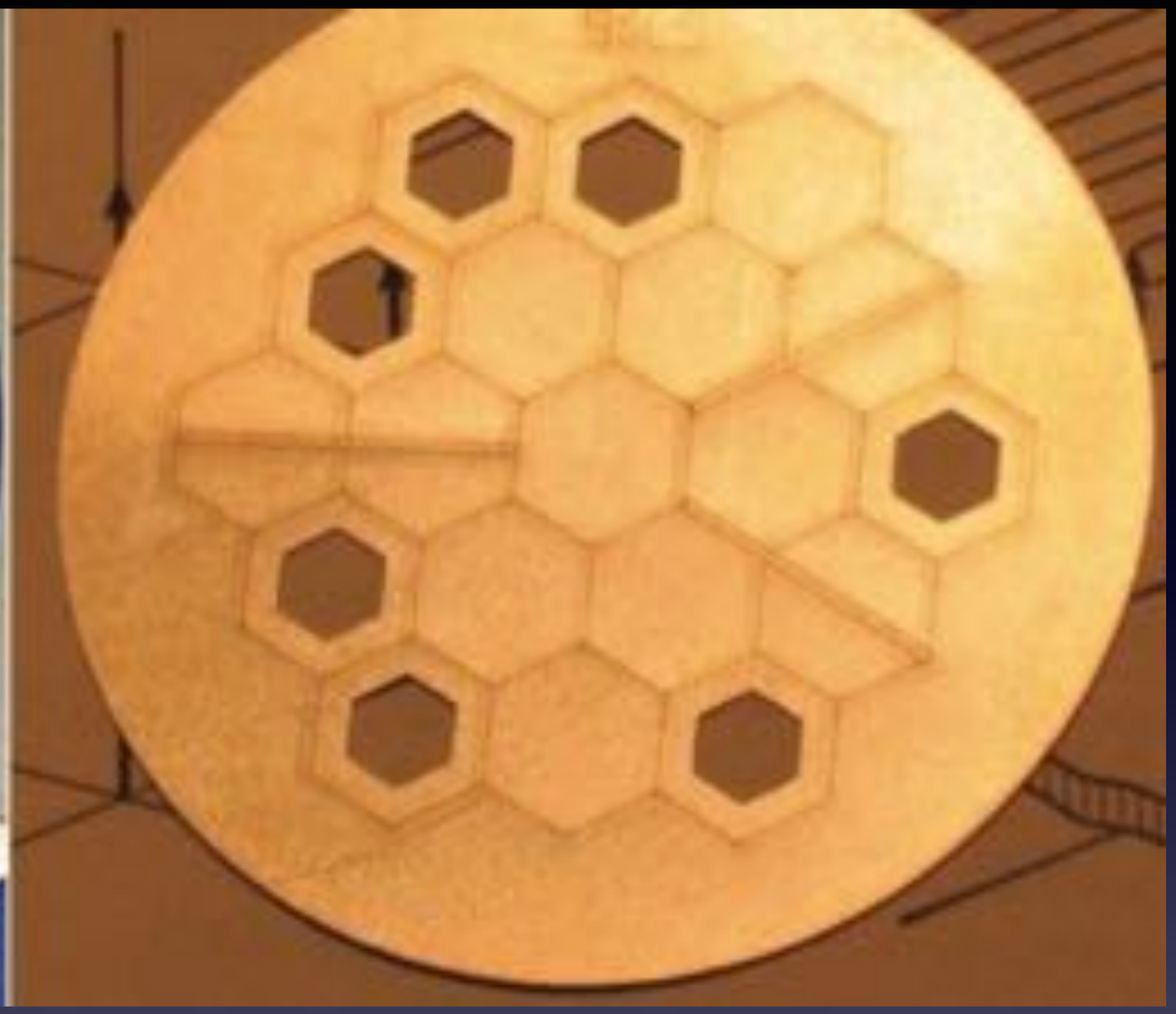
HR 8799 by GPI
Contrast: 10^{-5}



Aperture-Masked Interferometry

NIRISS





Aperture-Masked Interferometry

- Transforms JWST into an interferometer like ALMA or VLA
- Light lost, but spatial resolution gained!
- From Rayleigh diffraction limit (1.22 x wavelength/diameter)
- To Michelson diffraction limit (~0.5 x wavelength/diameter)

Activity: Exploring Observing Programs

http://www.stsci.edu/jwst/observing-programs

1. What are the main science questions that the observations will address?

2. What objects and/or phenomena are being targeted?

3. What instruments and observing modes are used?

4. Can you find a corresponding Example Science Program on JDox that walks you through the process of setting up similar observations?

JWST General Observing Proposals

What is expected in a proposal?

- **Science case** – motivating questions to address, concrete science goals and observations to address them, why this observatory is necessary to address the questions
- **Observational settings** to achieve goals – sensitivity, spectral/spatial resolution, field of view, overall time of observations
- **Source selection** – select targets, source visibility, check for duplicates
- **Predict observations** – based on previous observations or theoretical models, estimate observing time needed

Brainstorming Proposal Ideas

- **Science case** – What scientific question would you like to answer? What observations could address this?
- **Observational settings** - Imaging? Spectroscopy? Time Series?
- **Source selection** – What types of sources would you need to observe?
- **Predict observations** – What information or models would you need to make predictions?

JWST Proposal Roadmap

Pick instruments(s) and observing mode(s)

Determine target visibility

Check for duplicates

Determine exposure settings using the Exposure Time Calculator (ETC)

Set up proposed observing program in the Astronomer's Proposal Tool (APT)

Prepare your proposal document
- Scientific justification
- Technical justification

Time Allocation Committee (TAC) meets

Accepted proposals:
- Optimize settings with STScI
- (US Investigators) Apply for funding in Oct. 2020

Get Involved with JWST

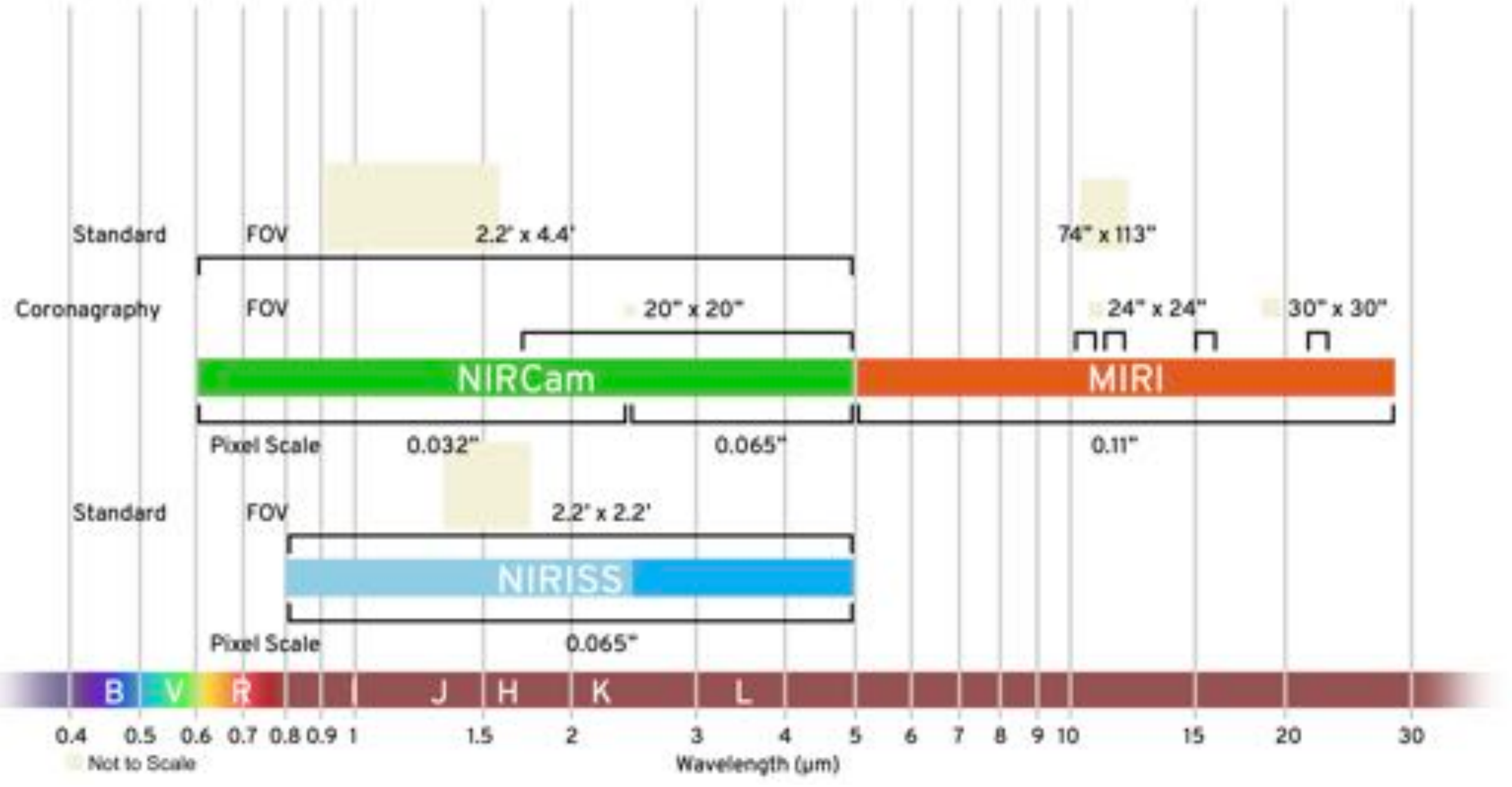
Resources:

- STScI Website & JDox

How to get involved:

- Talk to your advisors & mentors about opportunities to get involved with JWST
- NRAO/UVA Proposal Planning Workshop
  - Dates: Feb. 18 & 24 (Registration deadline tomorrow)
  - http://people.virginia.edu/~da4vn/jwst.html

Imaging Modes



Spectroscopy Modes