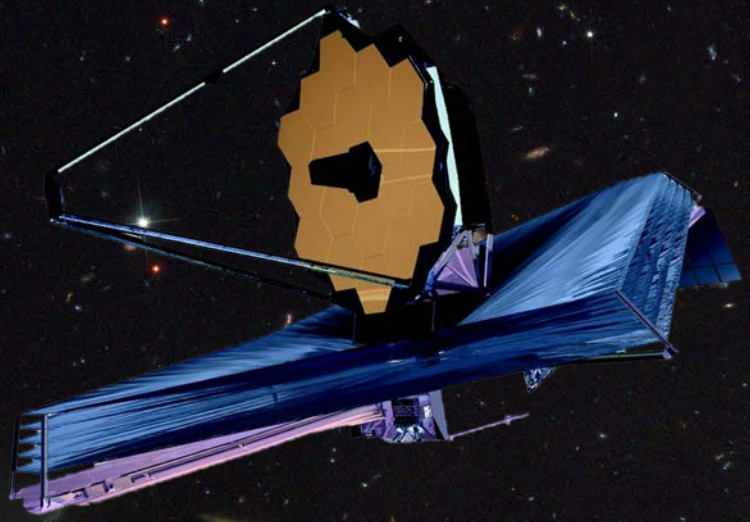
The James Webb Space Telescope



Jonathan P. Gardner

NASA's Goddard Space Flight Center

http://jwst.nasa.gov

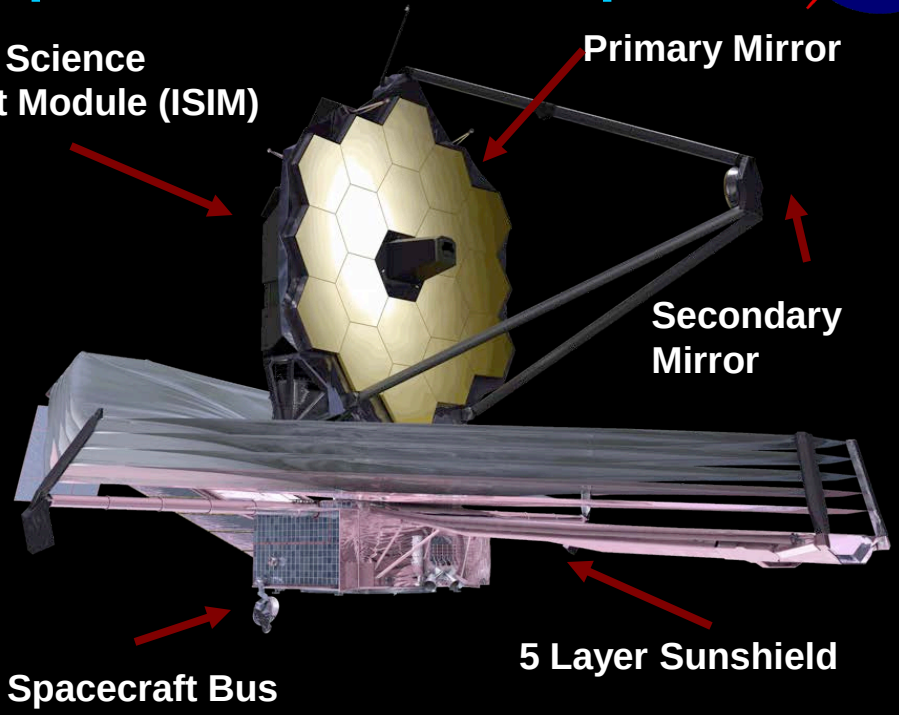
Space Science Reviews, 2006, 123/4, 485

Agenda

Jonathan Gardner	Deputy Senior Project Scientist	Science
Amber Straughn	Deputy Project Scientist for Communications	Outreach
Mark Clampin	Observatory Project Scientist	Observatory Progress
Matt Greenhouse	ISIM Project Scientist	ISIM Progress

James Webb Space Telescope

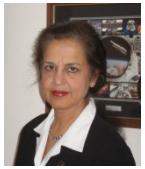
- 6.6m Telescope
- Successor to Hubble & Spitzer.
- Demonstrator of deployed optics.
- 4 instruments: 0.6 to 28.5 μm
- Passively cooled to < 50 K.
- Named for 2nd NASA Administrator
- Launch late 2018



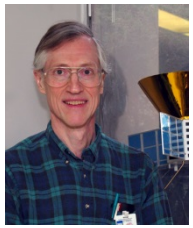
- Complementary to GMT, ALMA, WFIRST, etc
- NASA + ESA + CSA: 14 countries
- Lead: Goddard Space Flight Center
- Prime: Northrop Grumman
- Operations: STScI
- Senior Project Scientist:
  Nobel Laureate John Mather

Science Personnel Changes

- HQ:
  - Geoff Yoder left JWST to become SMD Deputy AA for Programs
  - Eric Smith is Acting JWST Program Director
  - Hashima Hasan continues as Deputy Program Scientist for JWST within the Astrophysics Division

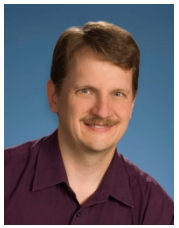


- STScI
  - Massimo Stiavelli is Head of JWST Mission Office
  - Jason Kalirai is JWST Project Scientist at STScI
  - Rachel Osten is JWST Deputy Project Scientist



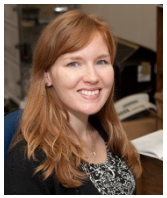
Mather

Senior Project Scientist
Deputy Senior Project Scientist
Deputy Senior Project Scientist/Technical



Gardner

Niedner



Straughn

Deputy Project Scientist for Communications

Solar System Scientist

Milam

Clampin

Greenhouse

Sonneborn

Kimble

Observatory Project Scientist

ISIM Project Scientist

Operations Project Scientist

I&T Project Scientist

Deputy Observatory Project Scientist

Bowers

Deputy ISIM Project Scientist

Rauscher

Deputy Operations Project Scientist

Rigby

Microshutter PI

Moseley

JWST Project Science Team at Goddard

JWST Science Working Group

John Mather,
Senior Project Scientist,
Chair

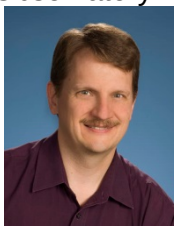
Mark Clampin,
Observatory PS

Rene Doyon,
CSA PS

Pierre Ferruit,
ESA PS

Kathy Flanagan,
SOC

Marijn Franx,
NIRSpec Science



Jonathan Gardner,
Dep Sr PS

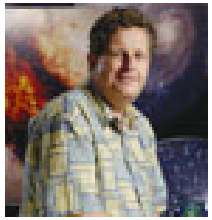
Matt Greenhouse,
ISIM PS

Heidi Hammel,
IDS

Simon Lilly,
IDS

Jonathan Lunine,
IDS

Mark McCaughrean,
IDS



Matt Mountain,
Telescope Scientist

Mal Niedner,
DSPS/Technical

George Rieke,
MIRI Science Lead

Marcia Rieke,
NIRCam PI

George Sonneborn,
Ops PS

Massimo Stiavelli,
IDS

Rogier Windhorst,
IDS

Chris Willott,
NIRISS Science

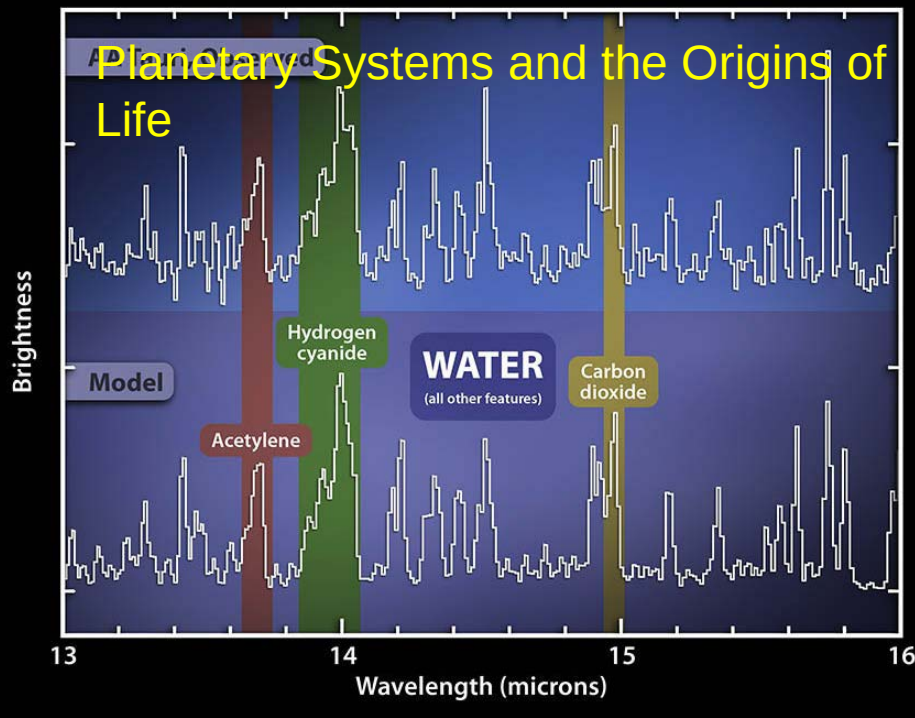
Gillian Wright,
MIRI European Lead

End of the Dark Ages:
First Light and Reionization

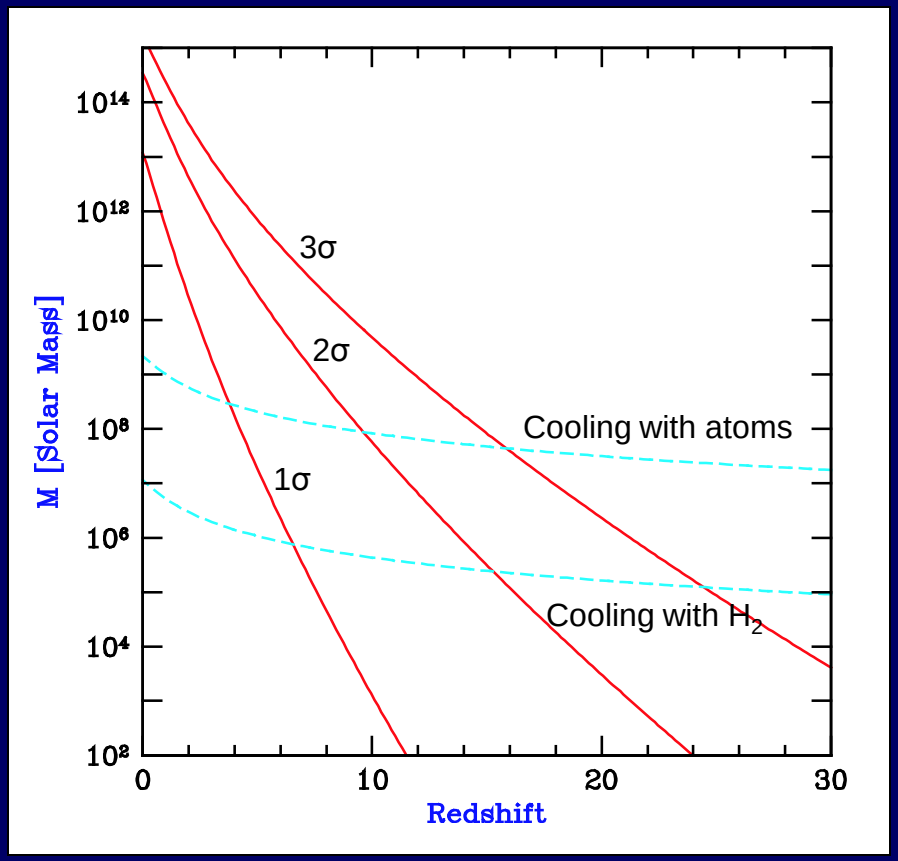
The Assembly of Galaxies

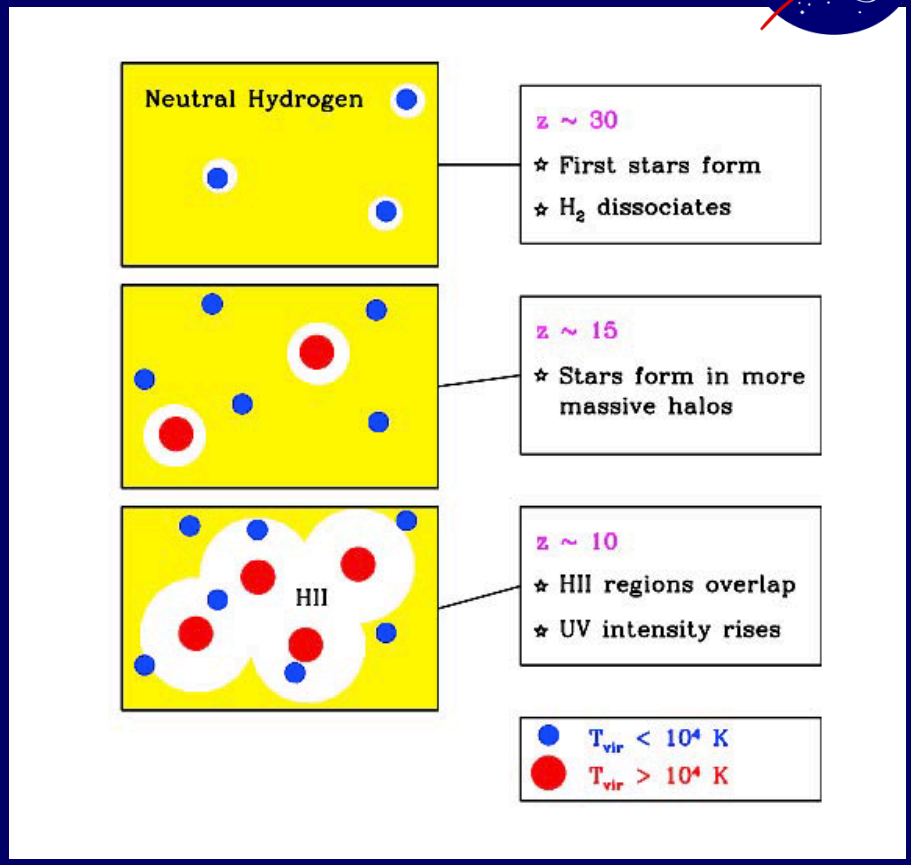
Birth of Stars and Protoplanetary Systems

Planetary Systems and the Origins of Life



What are the first galaxies?





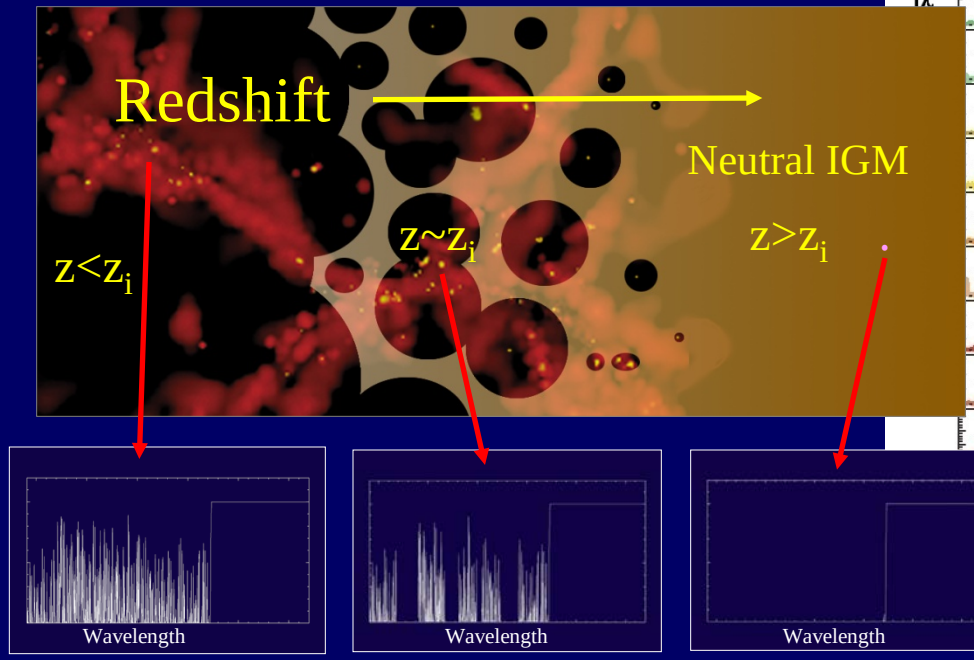
Barkana & Loeb 2001, Physics Reports, 349, 125

- Observations:
  - Ultra-deep NIR field, find z>15 H-band dropouts, 1.4 nJy
  - Follow-up Spect, MIR
  - Timing for transients to find SNe

6.42

What was re-ionization?

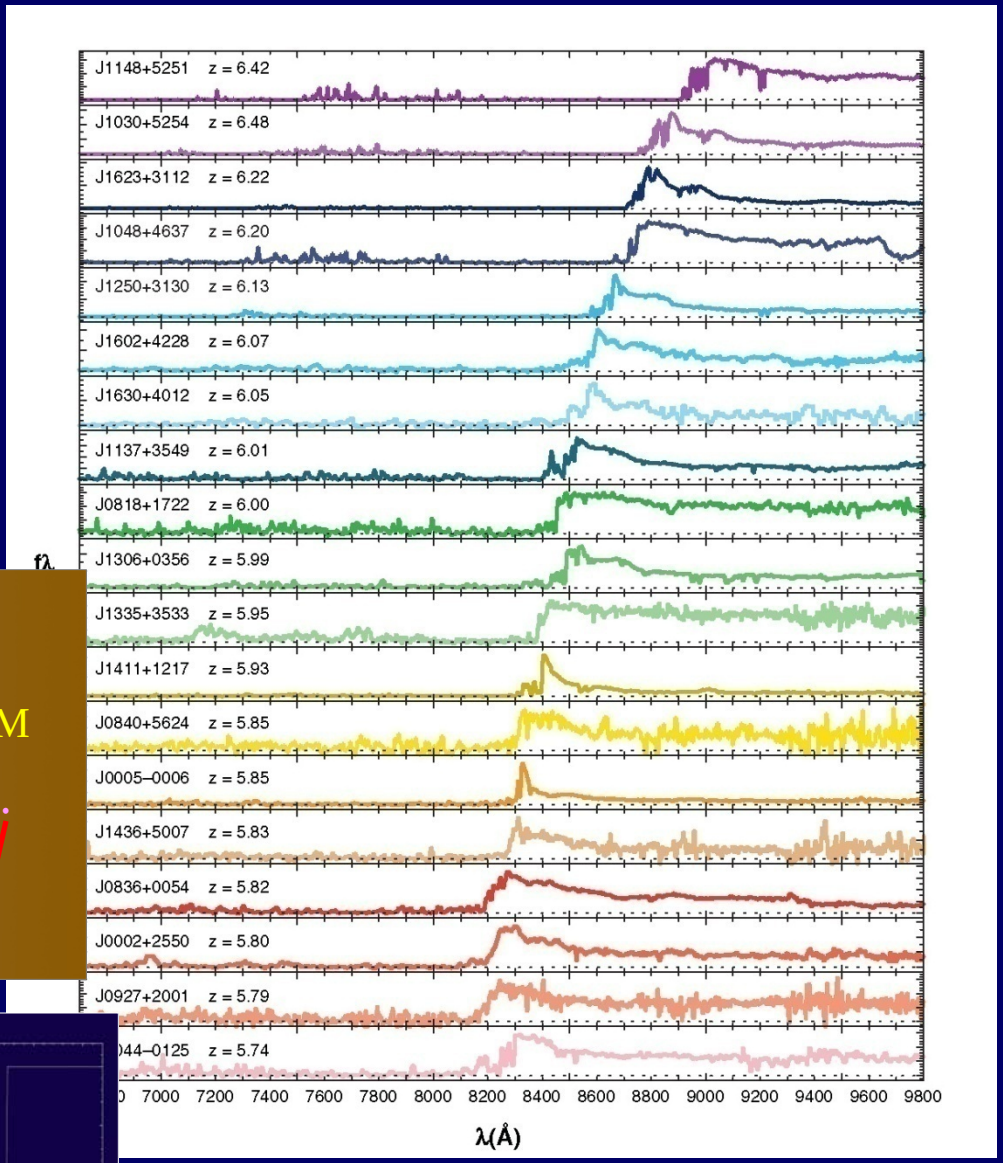
6.00



Lyman Forest Absorption

Patchy Absorption

Black Gunn-Peterson trough

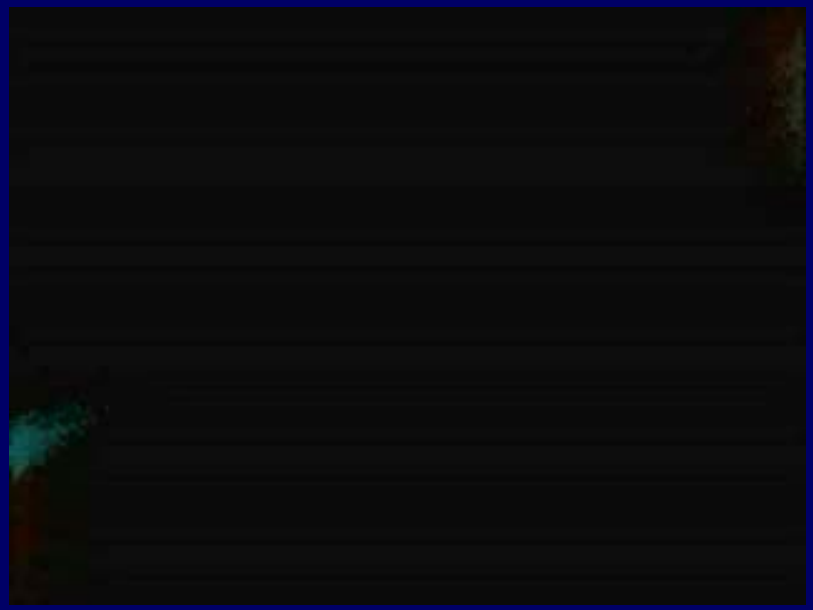


5.74

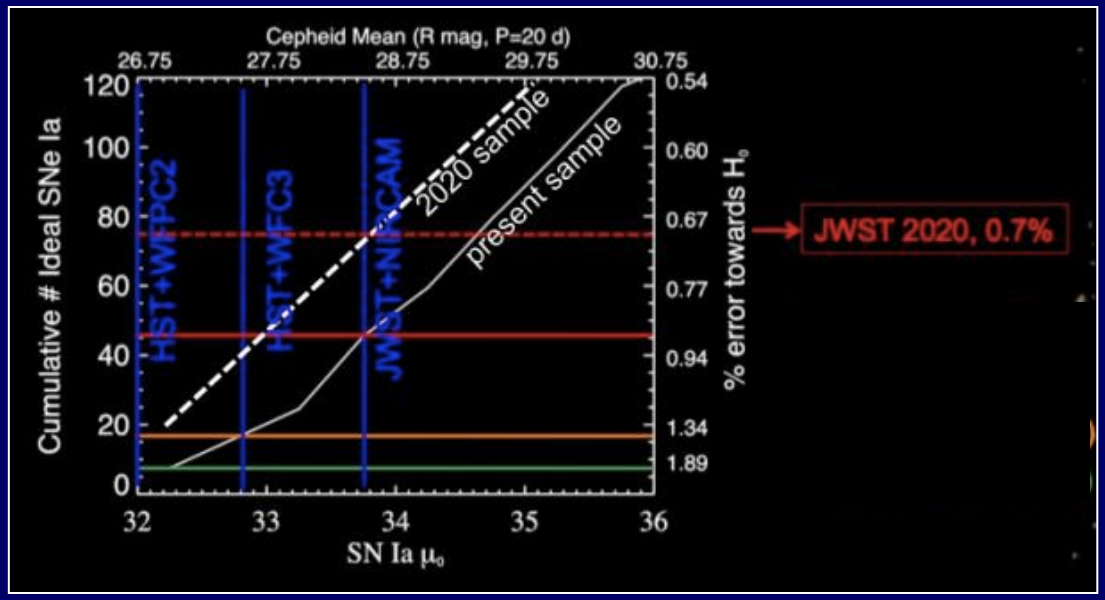
Fan, Carilli & Keating 2006, ARAA, 44, 415

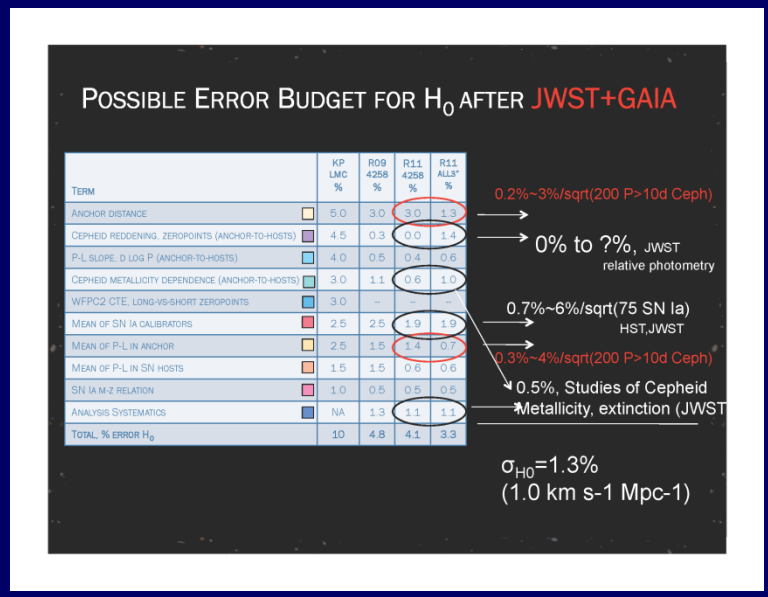
Where and when did the Hubble Sequence form? How did the heavy elements form?

- Galaxy assembly is a process of hierarchical merging
- Components of galaxies have variety of ages & compositions
- Observations:
  - NIRCam imaging
  - Spectra of 1000s of galaxies



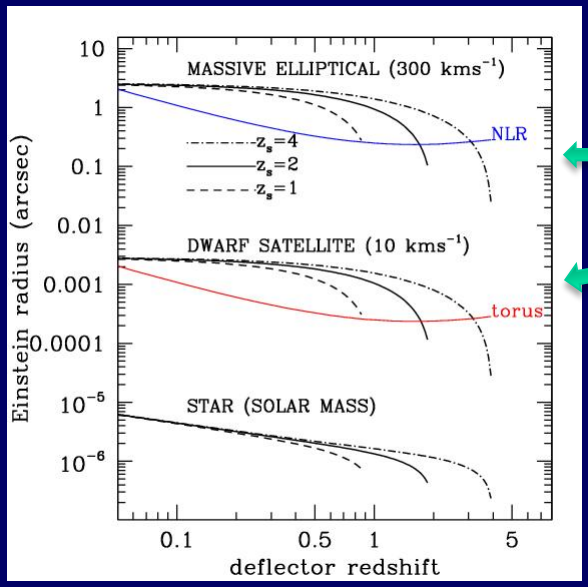
The dark Universe

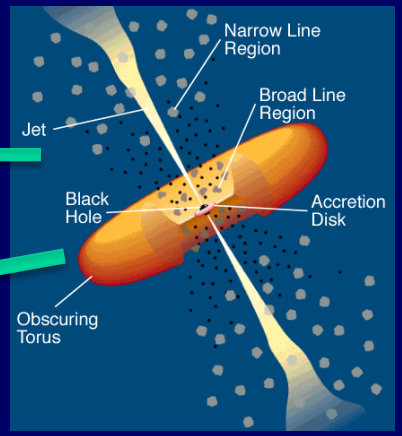




Cepheid distances to SNIa host galaxies constrains H0

Riess et al





Lensing of AGN in the MIR picks out dwarf satellite mass without microlensing by stars

Treu et al

What are the physical processes that determine galaxy properties? What about starbursts and black holes?

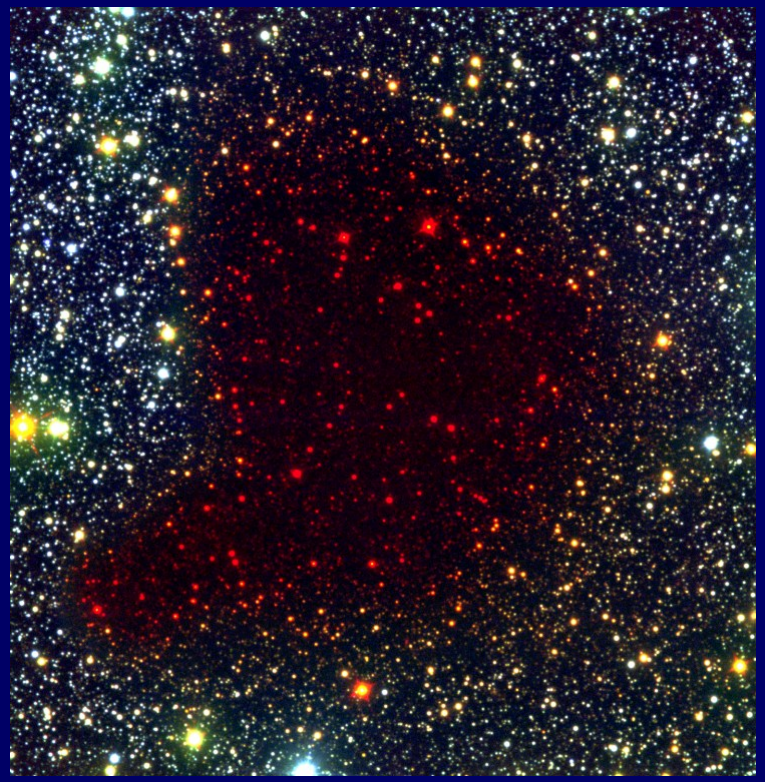
- Observations:
  - MIR spectroscopy
  - Velocity dispersion
  - MIR emission lines

- Global scaling relations between luminosity, size, kinematics and metallicity.
- Tight correlation between mass of central black holes and surrounding galaxy

HST + radio image of active galaxy

How do proto-stellar clouds collapse?

- Stars form in small regions collapsing gravitationally within larger molecular clouds.
- We can see through thick, dusty clouds in the infrared.
- Protostars begin to shine within the clouds, revealing temperature and density structure.
- Observations:
  - Deep NIR and MIR imaging of dark clouds and proto-stars



Barnard 68 in infrared

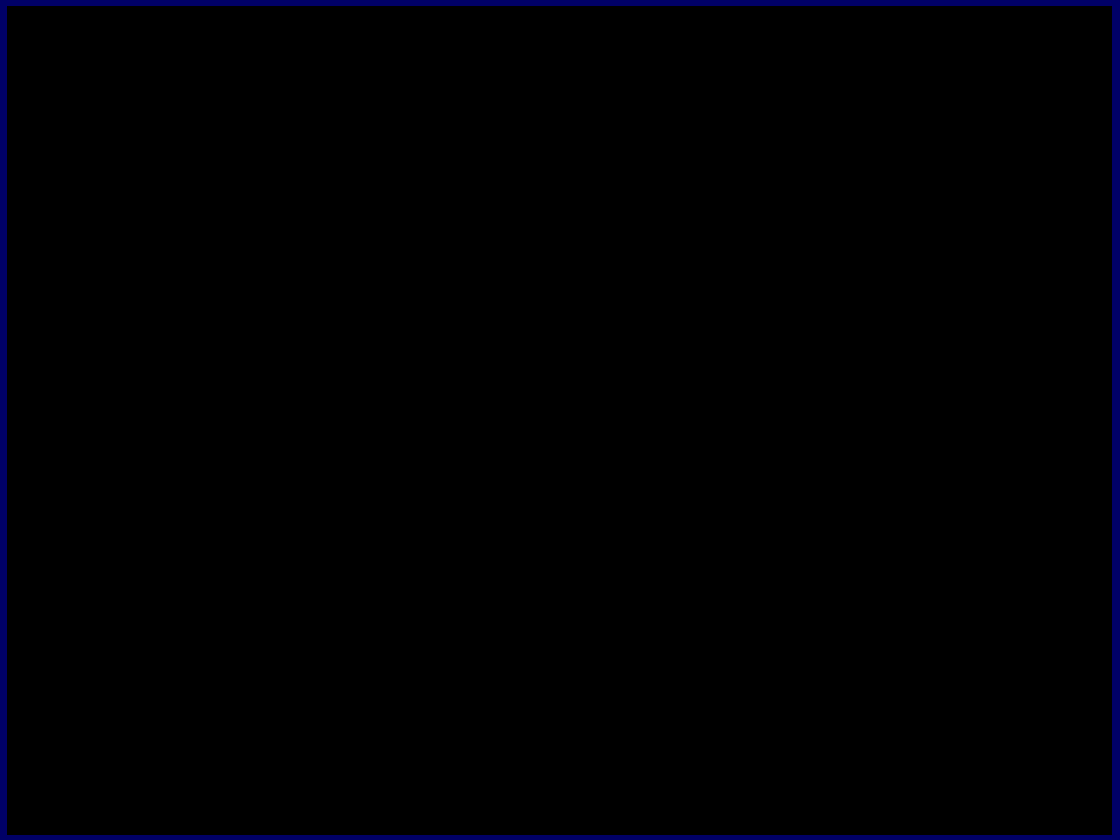
How does environment affect star-formation and vice-versa?
What is the sub-stellar initial mass function?

- Massive stars produce winds and radiation
  - Either disrupt star formation, or causes it.
- The boundary between the smallest brown dwarf stars and planets is unknown
  - Different processes? Or continuum?
- Observations:
  - Survey dark clouds, “elephant trunks” and star-forming regions

The Eagle Nebula
as seen in the infrared

How do planets form?
How are habitable zones established?

- Hundreds of known exoplanets show wide variety of properties.
- Measure constituents of exoplanet atmospheres.
- Compare circumstellar disks to our own Kuiper Belt



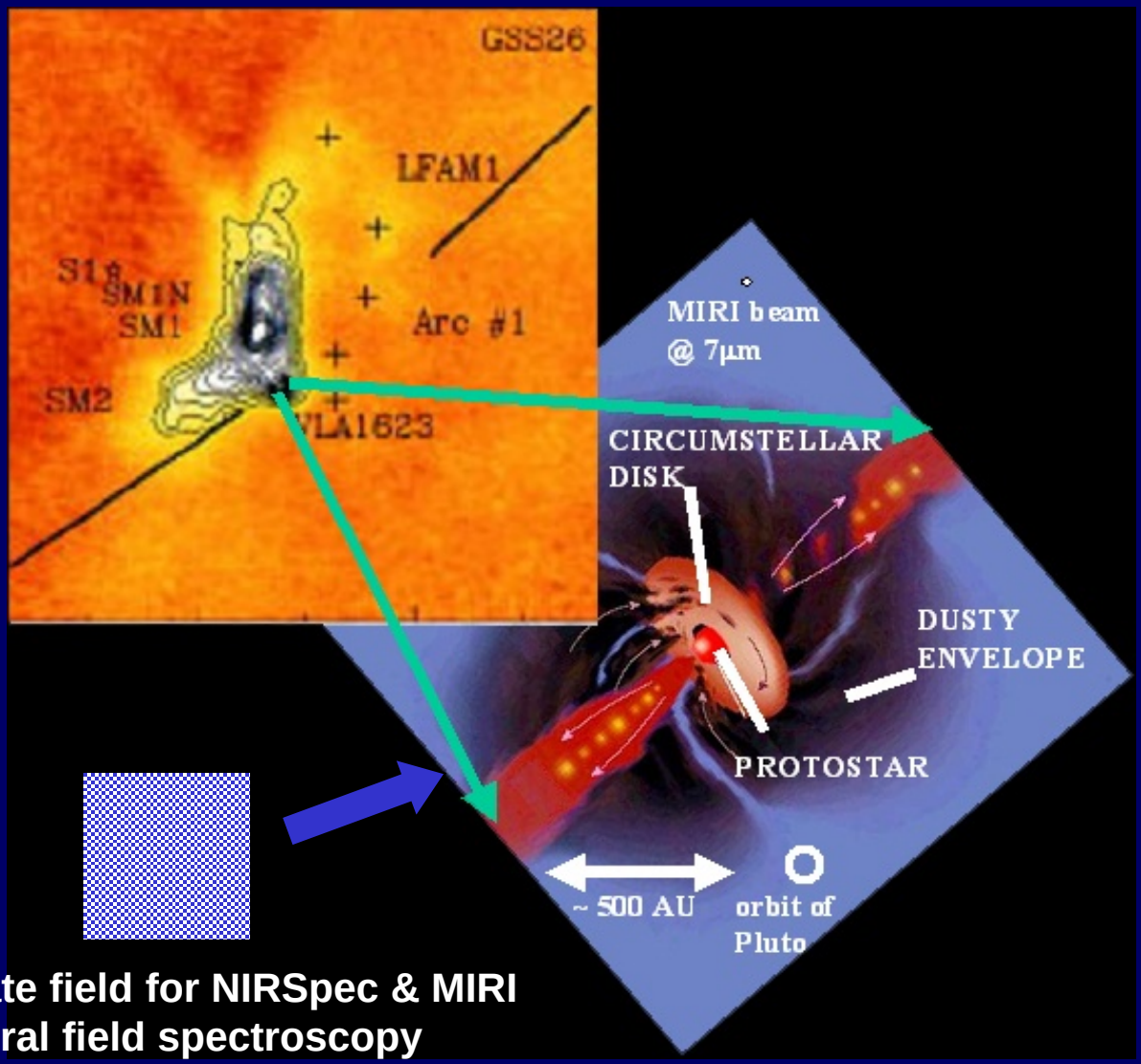
STEREO observation of the Moon transiting the Sun

- Observations:
  - Coronagraphy of exosolar planets
  - Transits
  - Kuiper Belt objects, satellites of outer planets, comets

How are circumstellar disks like our Solar System?

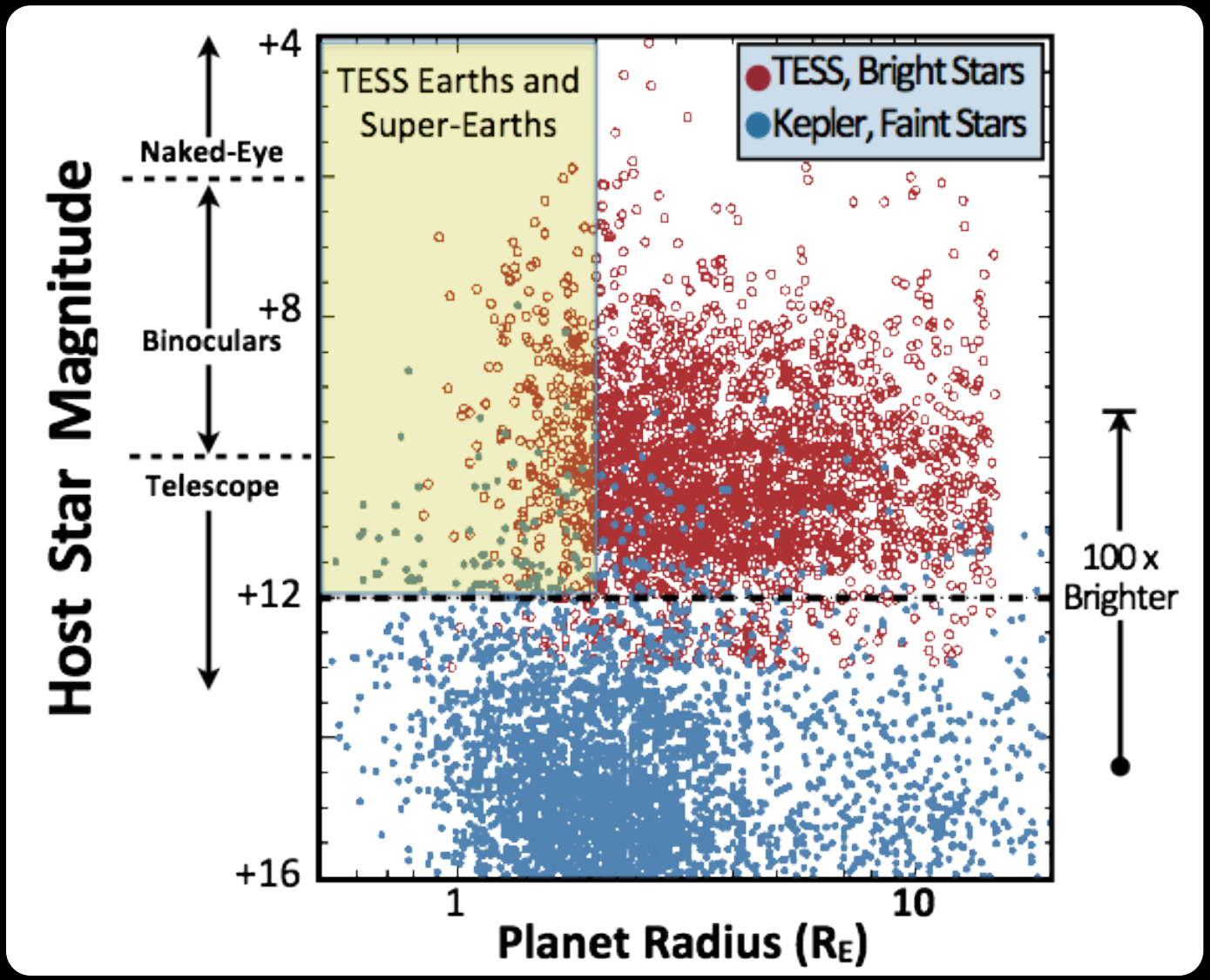
Here is an illustration of what MIRI might find within the very young core in Ophiuchus, VLA 1623

artist's concept of protostellar disk from T. Greene, Am. Scientist



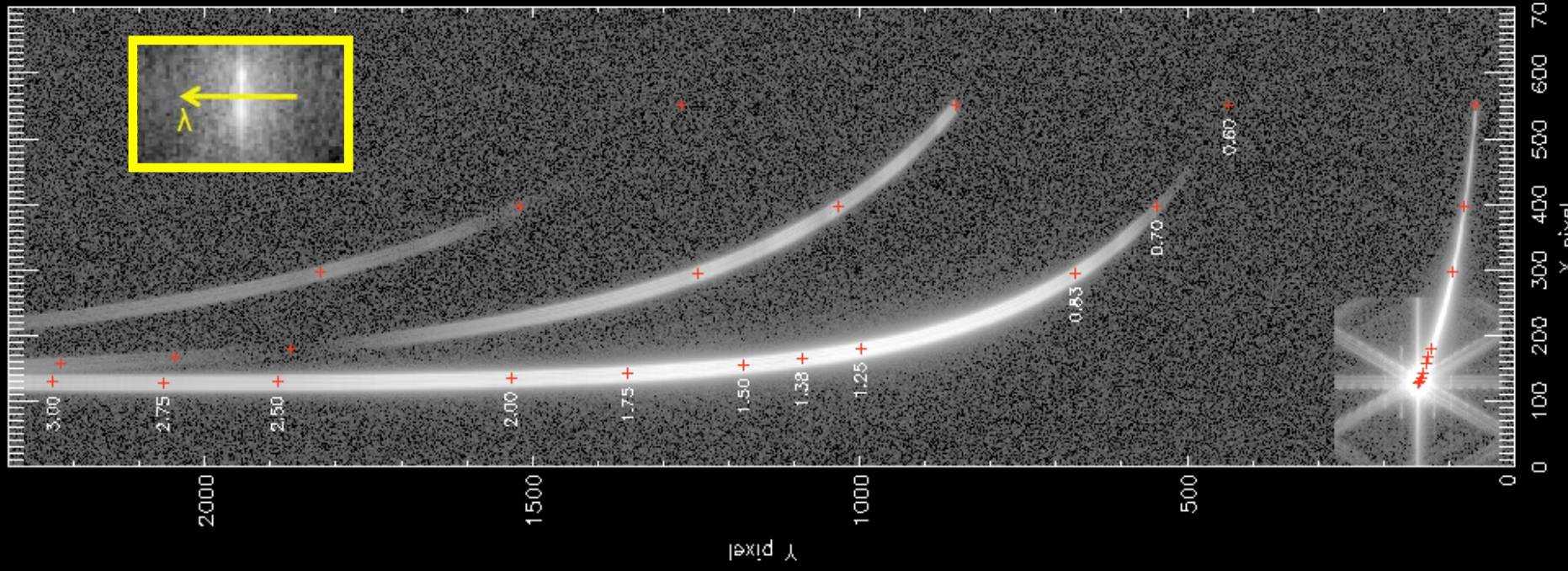
approximate field for NIRSpec & MIRI integral field spectroscopy

TESS will find bright Targets for JWST



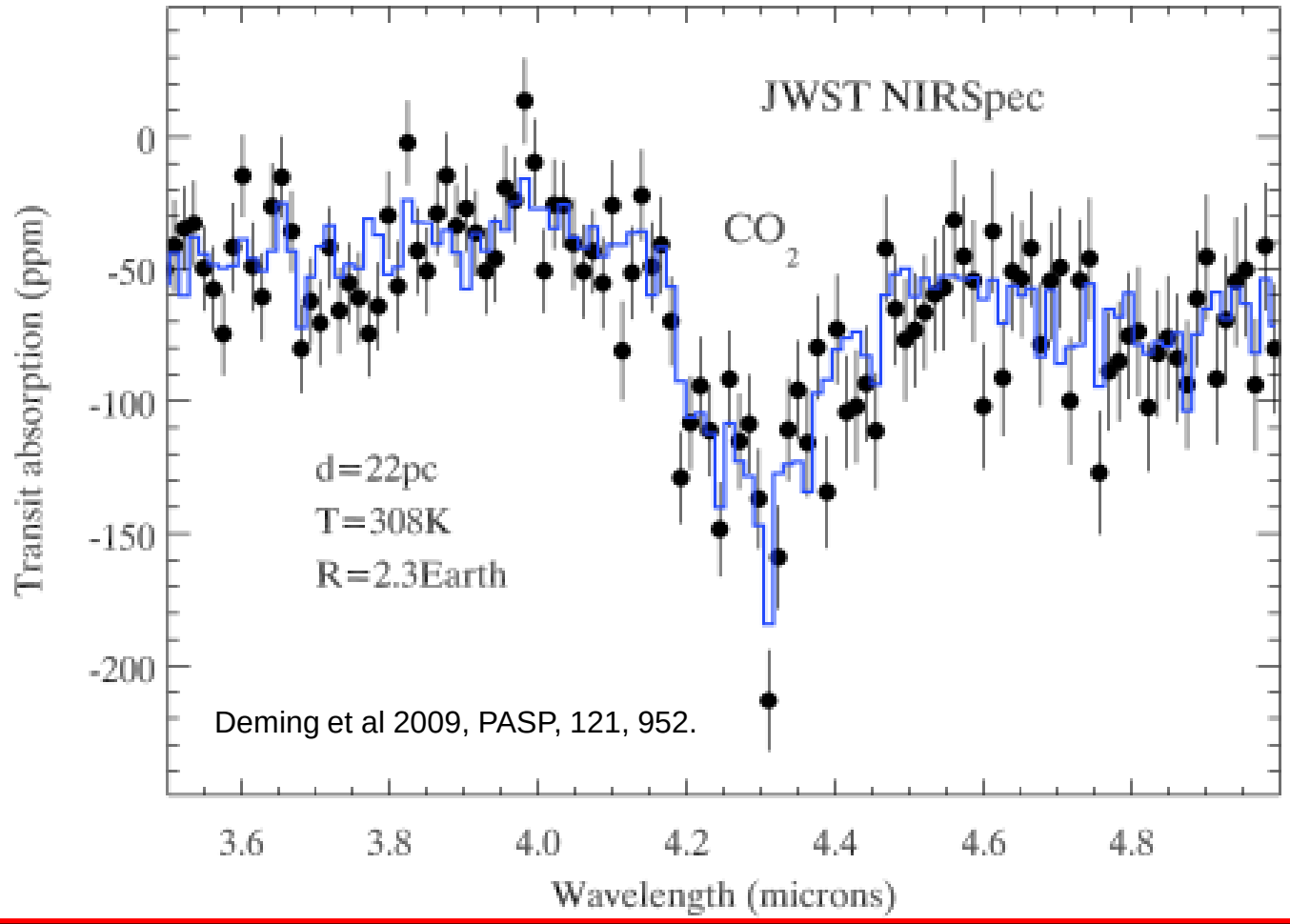
Bright Object Spectroscopy: NIRISS

Defocused spectroscopy: 0.7 - 3.0 μm



JWST Superearth Simulation: CO_2

- **85 hour observations of 2.3 R_{earth}**

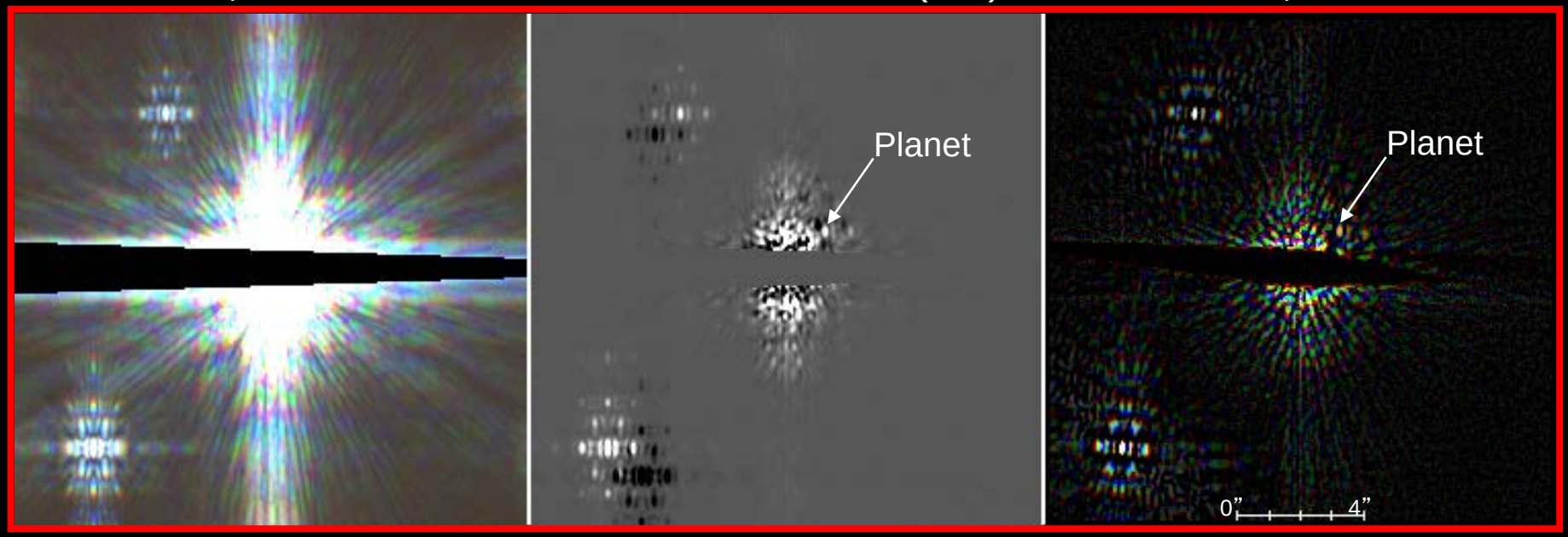


Deming et al 2009, PASP, 121, 952.

JWST will Image Young Jupiters

Simulations by John Krist

Multi-filter Combined, Unsubtracted	F460M Orient 1 – Orient 2 (10º)	Multi-filter Combined, Subtracted



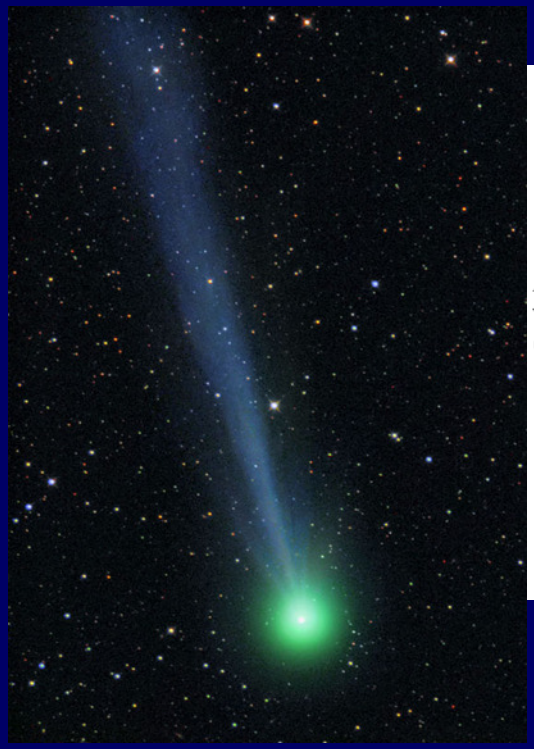
Red = F460M

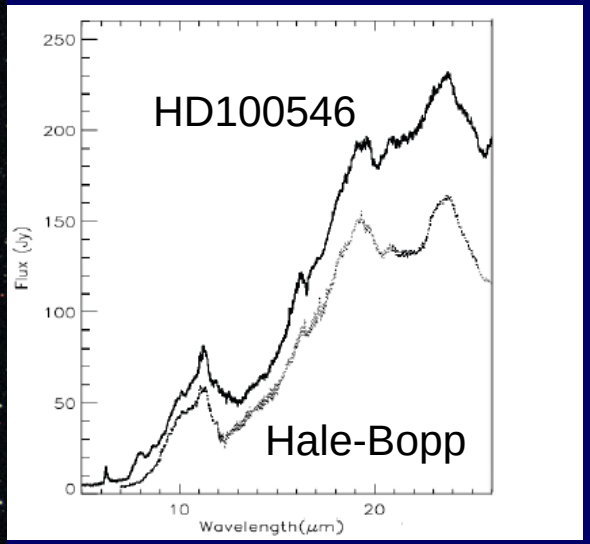
Green = F410M

Blue = F360M

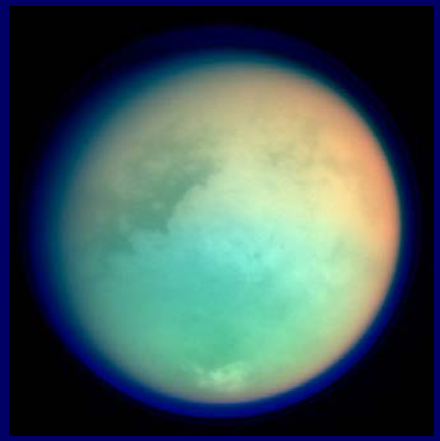
- 1 Gyr-old M0V star @ 4 pc
- 2 M_{Jup} planet @ 7 AU
- 5000 sec / filter / orientation

Within our Solar System: The Planets





KBOs



Titan

Mercury,
Venus,
Earth: no

Mars, Jupiter,
Saturn: some
modes

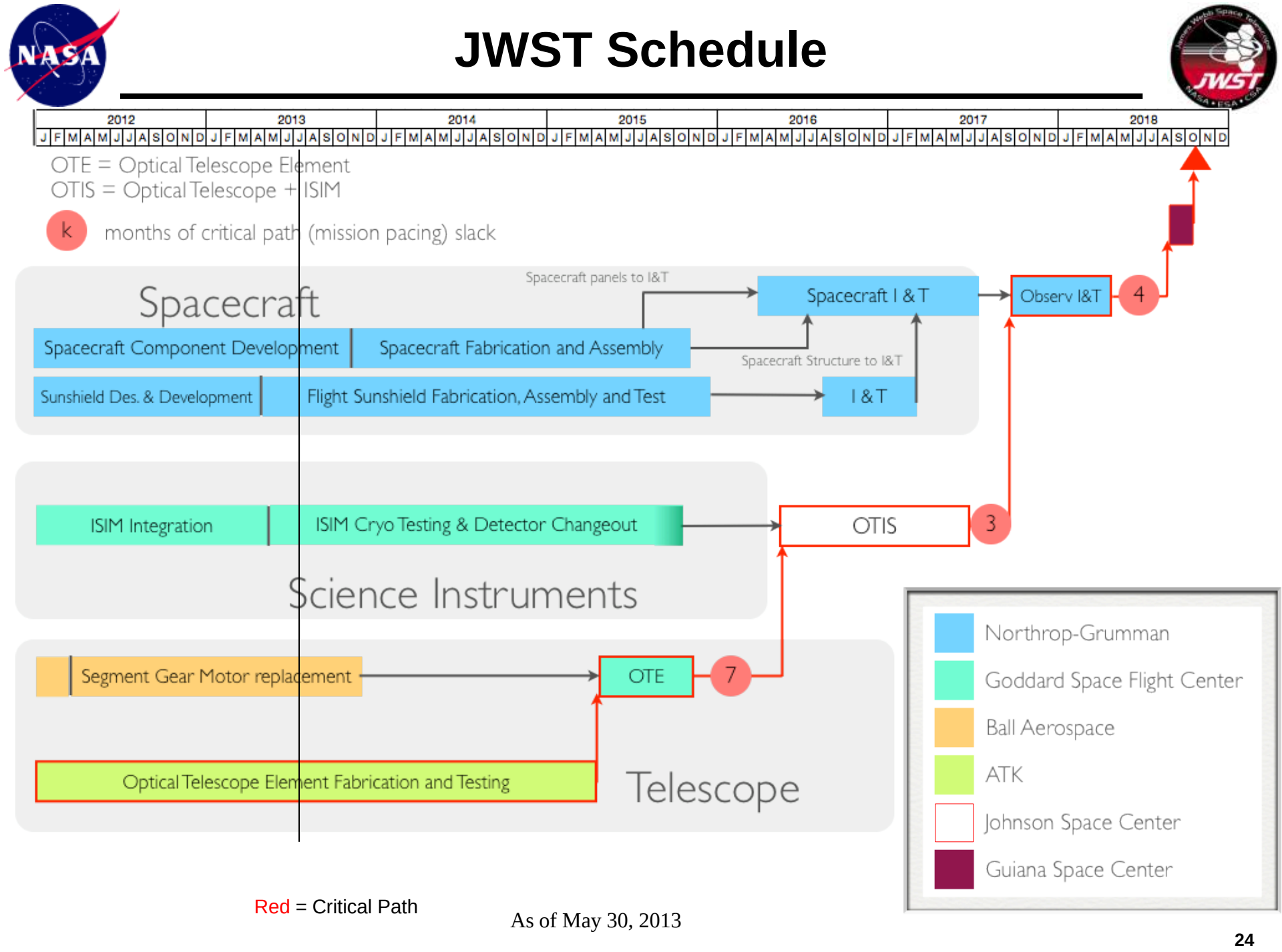
Uranus,
Neptune: yes

Can JWST observe:

Yearly Themes

- ✓ **2013: Instrument Integration**: The Science instruments will be finished and begin their testing as an integrated science payload
- ✓ **2014: Manufacturing the Spacecraft**: Construction will commence of the spacecraft that will carry the science instruments and the telescope
- ✓ **2015: Assembling the Mirror:** The mirror segments, secondary mirror and aft optics will all be assembled into the telescope
- ✓ **2016: Observatory Assembly**: The three main components of the observatory will be completed (instruments, telescope, spacecraft)
- ✓ **2017: Observatory Testing**: The three main components of the observatory will be tested and readied for assembly (instruments, telescope, spacecraft) into a single unit
- ✓ **2018: Kourou Countdown**: All parts of the observatory will be brought together, tested and readied for launch in Kourou, French Guiana

JWST Schedule



Red = Critical Path

As of May 30, 2013

Milestone Performance

- Since the September 2011 replan JWST reports high-level milestones monthly to numerous stakeholders

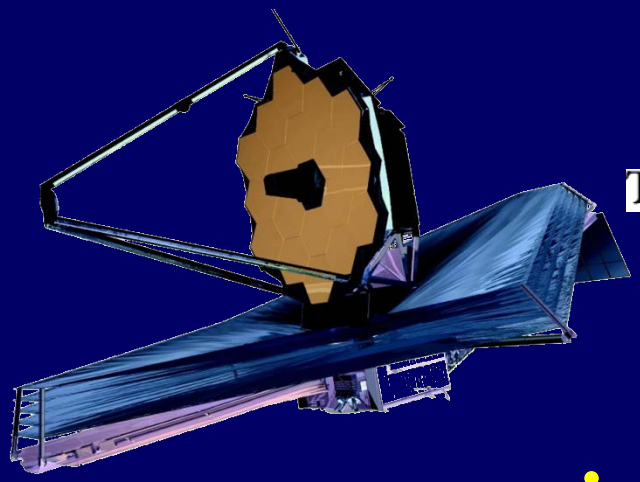
	Total Milestones	Total Milestones Completed	Number Completed Early	Number Completed Late	Deferred to Next Year
FY2011	21	21	6	3	0
FY2012	37	34	16	2	2
FY2013	41	30	15	5*	1

*Late milestones have been completed or are forecast to complete in FY13

Milestones reported monthly. Search “JWST Recent Accomplishments”.

6/7/2013

Operations

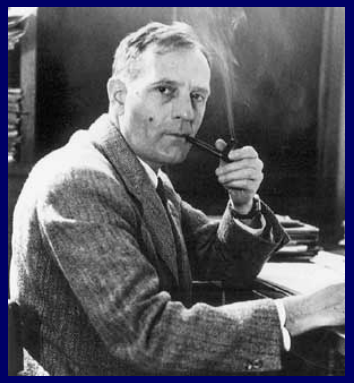


JWST at L2

Ka S

- STScI has been designated as Science Operations Center
- GO, Treasury and GTO programs similar to HST

THE ASTROPHYSICAL JOURNAL



Astronomer

DSN

STScI

TAC

Getting Ready to Observe

- **Science Operations Design Reference Mission (search JWST SODRM)**
  - Includes wide range of possible observations, all instruments, all modes
  - Includes detailed observing sequences
  - Starting point for improvements in efficiency, scheduling limitations, fuel consumption, slews, momentum, data volume, and thermal, etc.
- **Exposure Time Calculator online (search JWST ETC)**
  - http://jwstetc.stsci.edu/etc/
- **Workshops at STScI for future observers, starting March 2015**
- **Observing proposals due 1 year before launch**
  - Guaranteed Time Observers (instrument teams, interdisciplinary scientists) will declare plans before announcement of opportunity
  - Discussing Early Release Observations (EROs), Early Release Science
  - Community input via JSTAC (committee advising STScI)

SODRM: 1 year of realistic JWST science programs.

- We've* written >1year of mock JWST observations, anticipating the kinds of science we expect GOs and GTOs will propose.

- We call it "SODRM 2012" (Science Operations Design Reference Mission). On the web: http://www.stsci.edu/jwst/science/sodrm

- Includes 70 science programs, from solar system to exoplanets to cosmology. Exercises all 4 JWST science instruments, and all major modes.

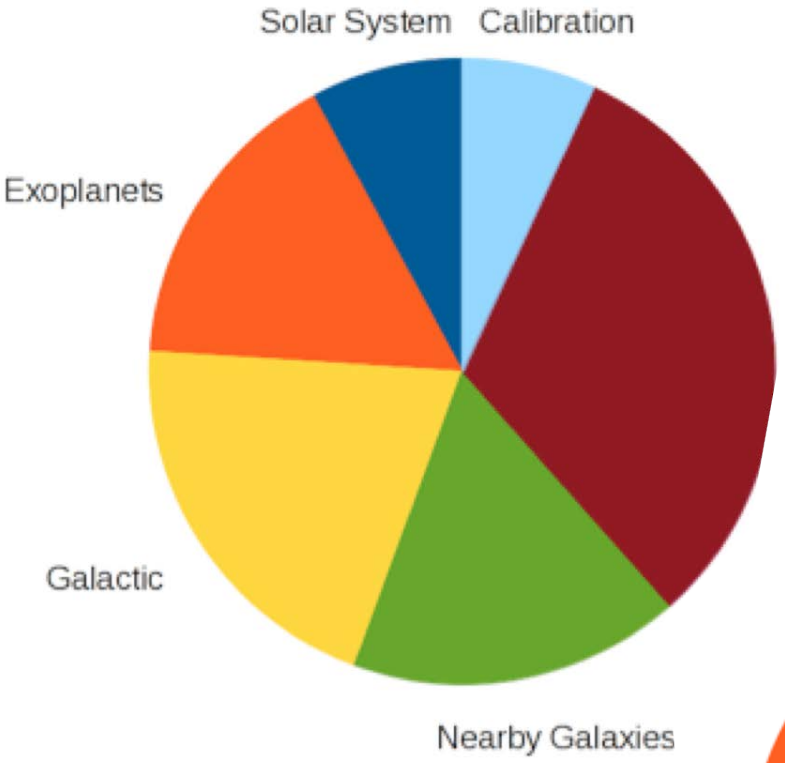
If you feel important science or observational technique are missing, please contact Jane.Rigby@nasa.gov, to contribute to the next update!

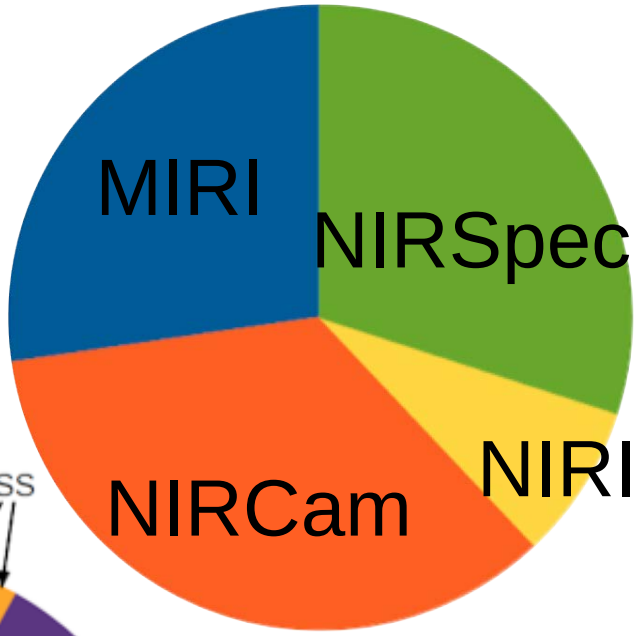
- Programs were designed with APT interface, & digested by early version of planning software. Provides early testing of in-development ground system.

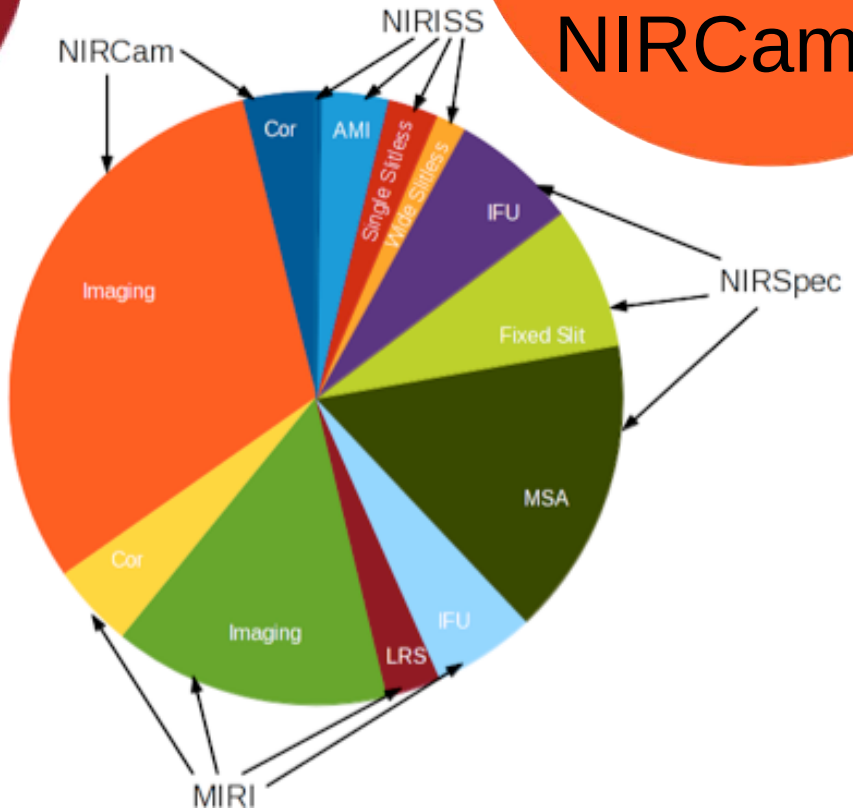
- We are now analyzing the daily data volume, efficiency, schedulability, and propellant use of the science programs in the SODRM.

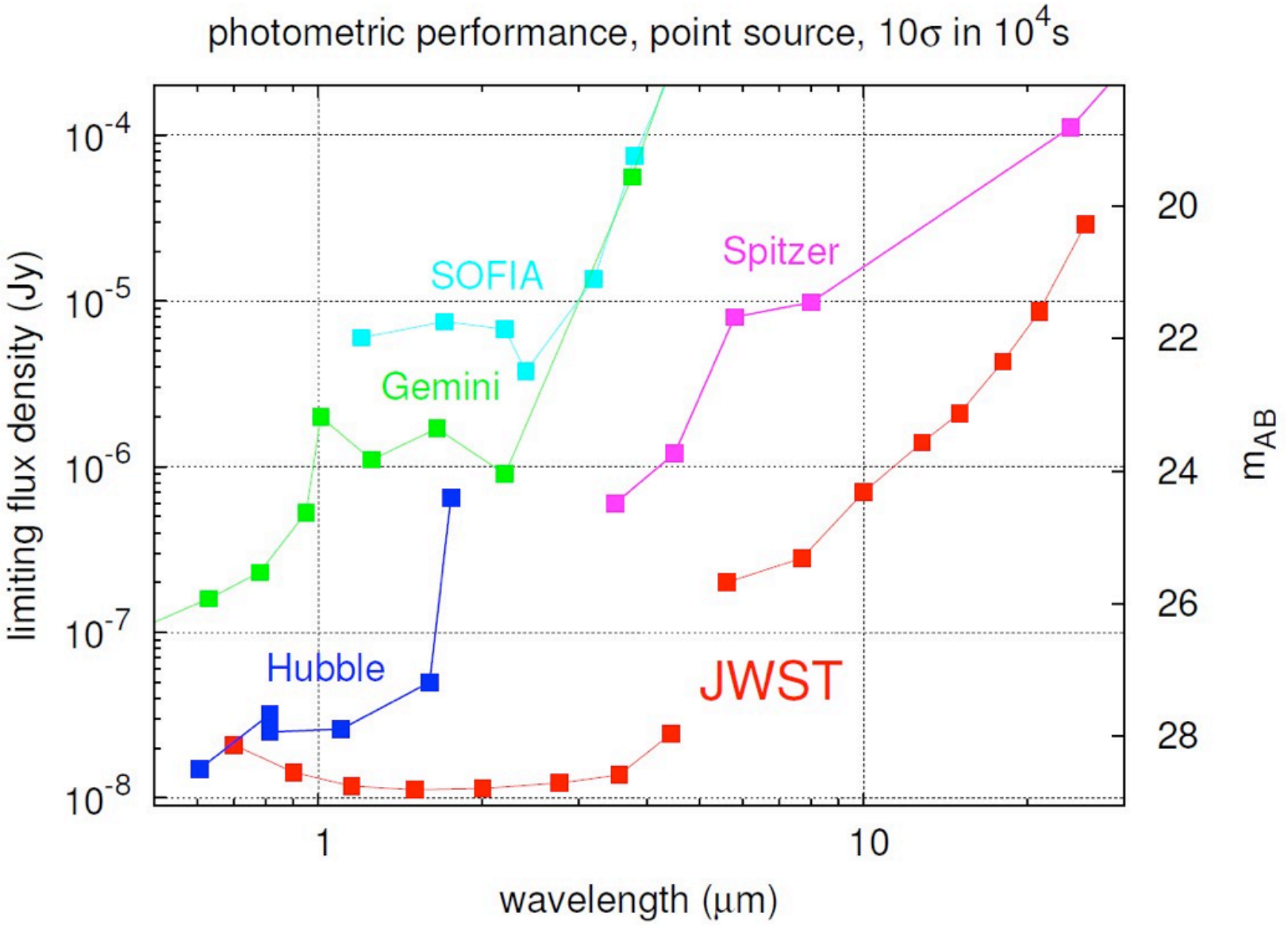
* (We = 50 scientists across the JWST community, led by STScI.)

SODRM uses all JWST instruments & modes.

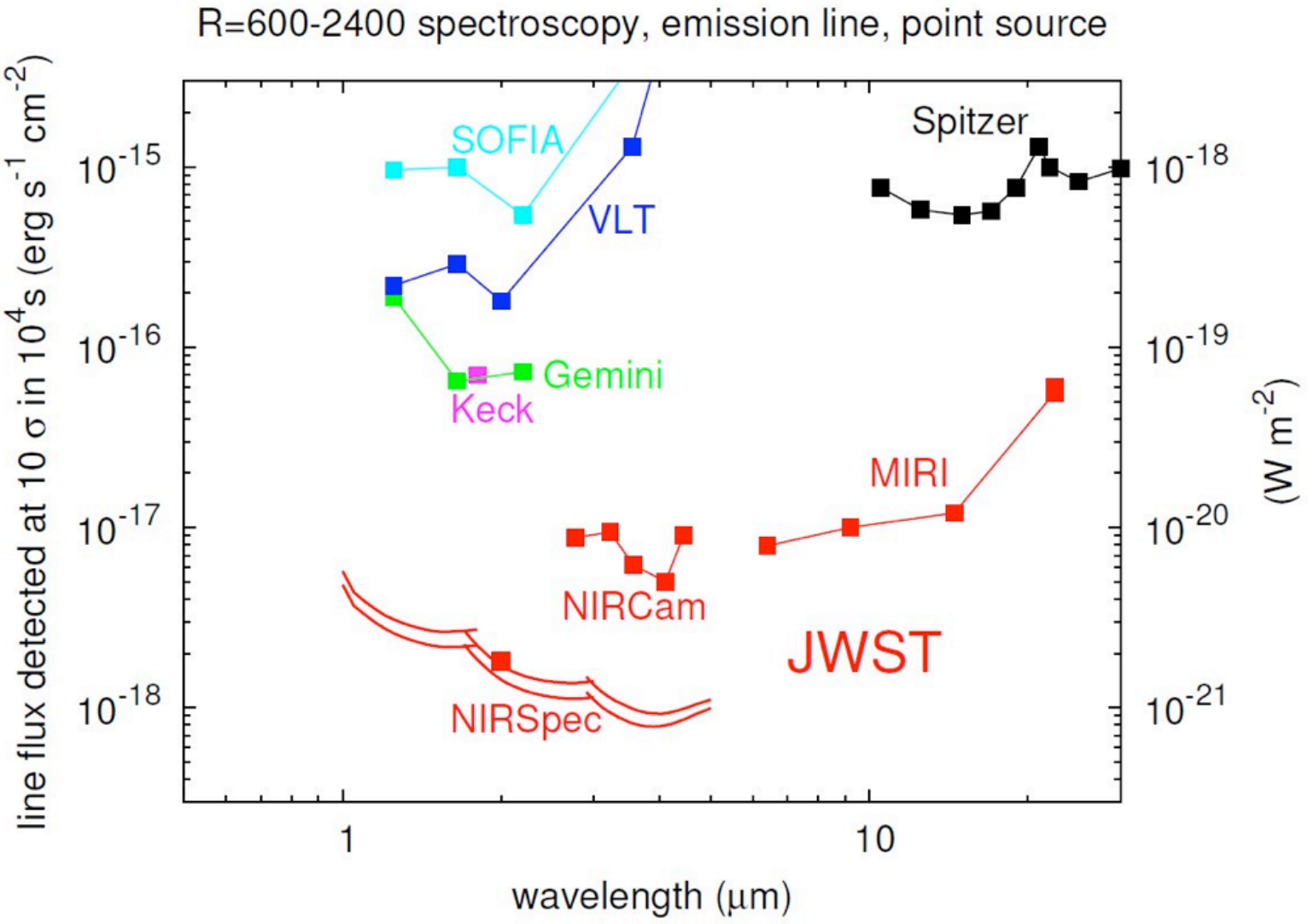








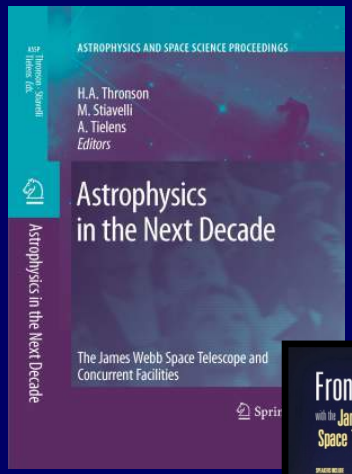
http://www.stsci.edu/jwst/science/sensitivity



http://www.stsci.edu/jwst/science/sensitivity

Want to Learn More about JWST?

Gardner et al. 2006,
Space Science Reviews, 123/4, 485
http://jwst.nasa.gov/scientists.html



2007 Conference
Proceedings
Read on-line

2011 Conference
Presentations
and video on-
line at STScI

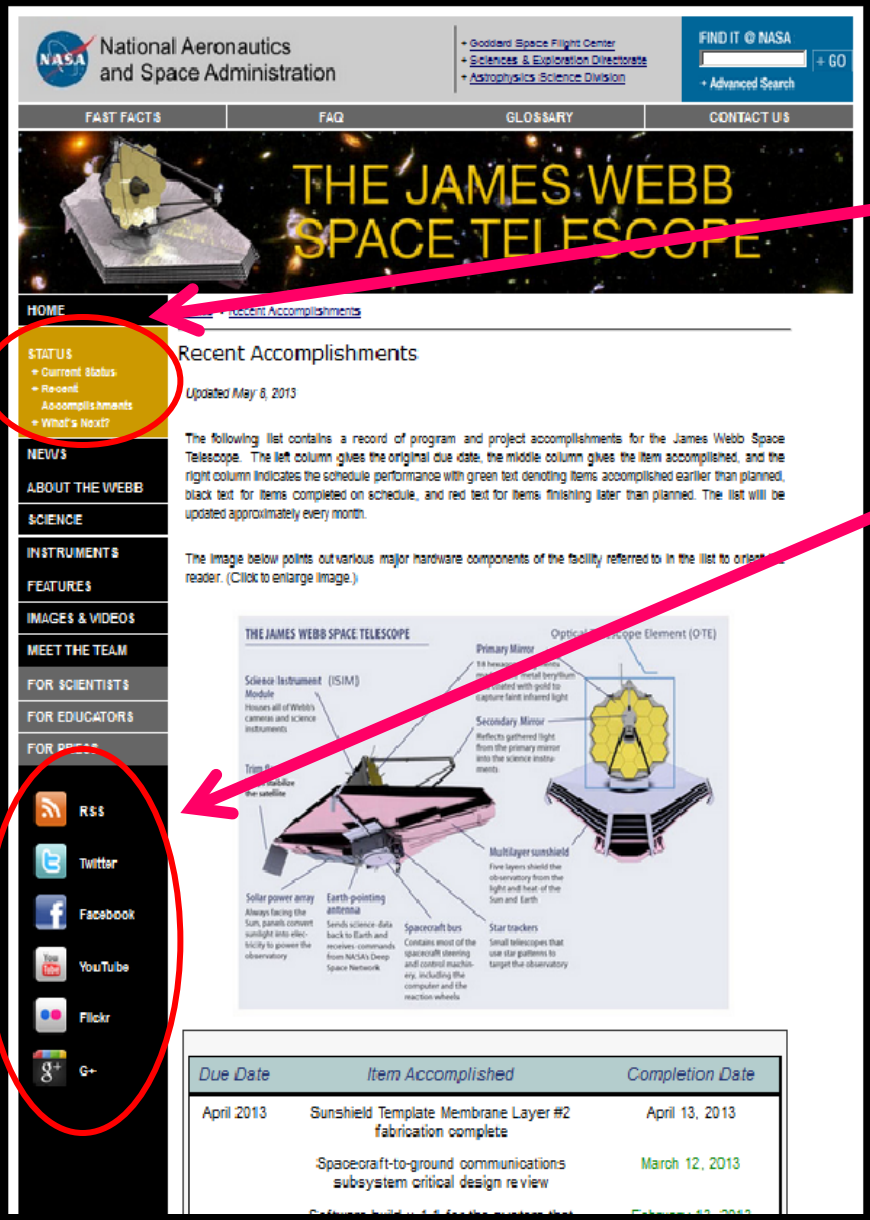
White Papers:

JWST in Decadal Survey
Solar System Objects
Dark Energy
Transiting Planets
Coronagraphy
Planetary Systems
Stellar Pops
Star Formation
Galaxy Assembly
First Light
Astrobiology
Scientific Capabilities
Observation Planning

Science White Papers
http://www.stsci.edu/jwst/science/whitepapers/

Latest News

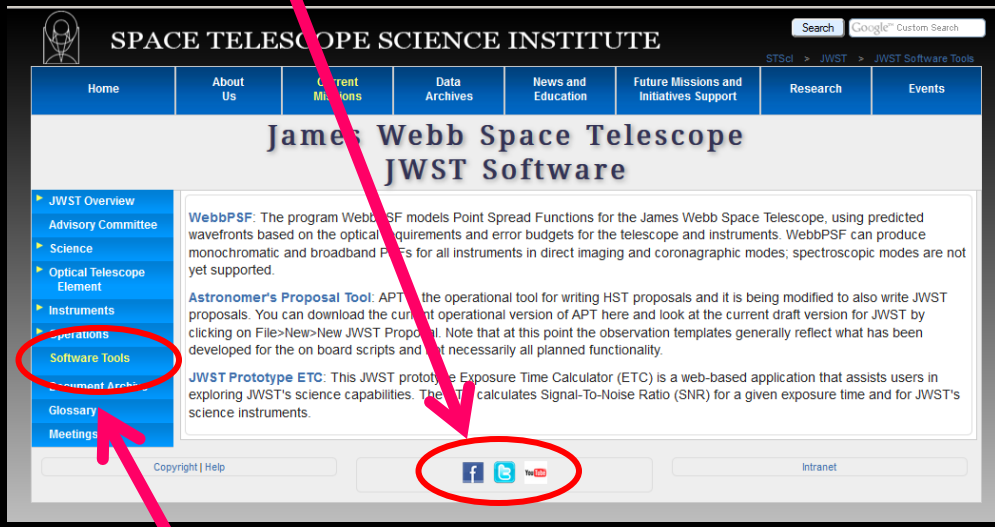
jwst.nasa.gov



Project Milestones
updated monthly

Social Media

www.stsci.edu/jwst



Astronomy Software Tools
ETC, PSF, APT

Agenda

Jonathan Gardner	Deputy Senior Project Scientist	Science
Amber Straughn	Deputy Project Scientist for Communications	Outreach
Mark Clampin	Observatory Project Scientist	Observatory Progress
Matt Greenhouse	ISIM Project Scientist	ISIM Progress