The Origins Space Telescope (OST)

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The OST NASA Decadal Study

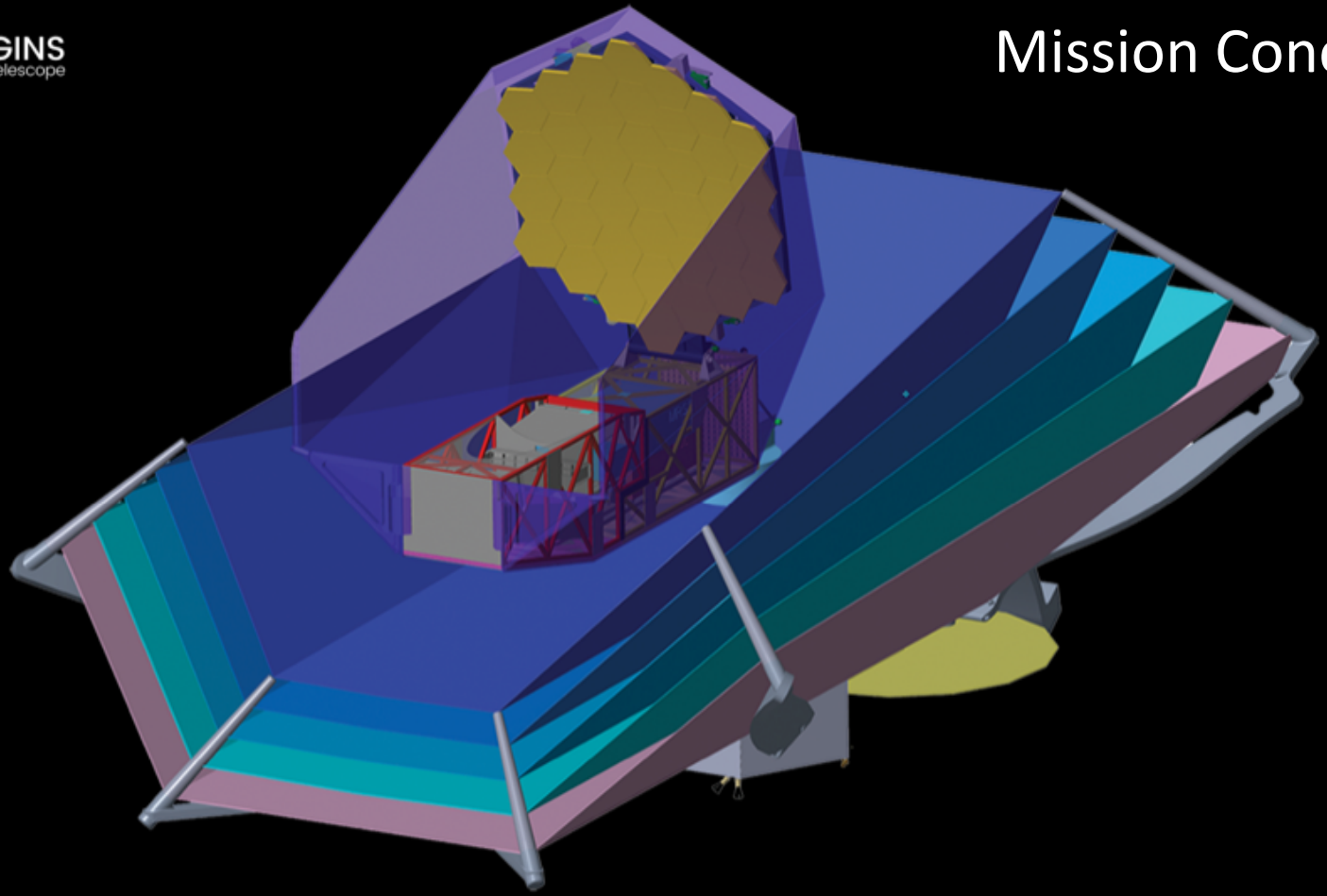
- NASA Astrophysics Roadmap Enduring Quests, Daring Visions: formerly known as Far-Infrared Surveyor
- Origins Space Telescope: 5-660 μm
- Goal: large general astronomy mission with exciting science that is technologically executable in 2030s
- Both Science Definition & Technological Implementation important
- OST study has two concepts:
  - Mission Concept 1, completed, described here
  - Mission Concept 2, started – optimization

The OST Study Team

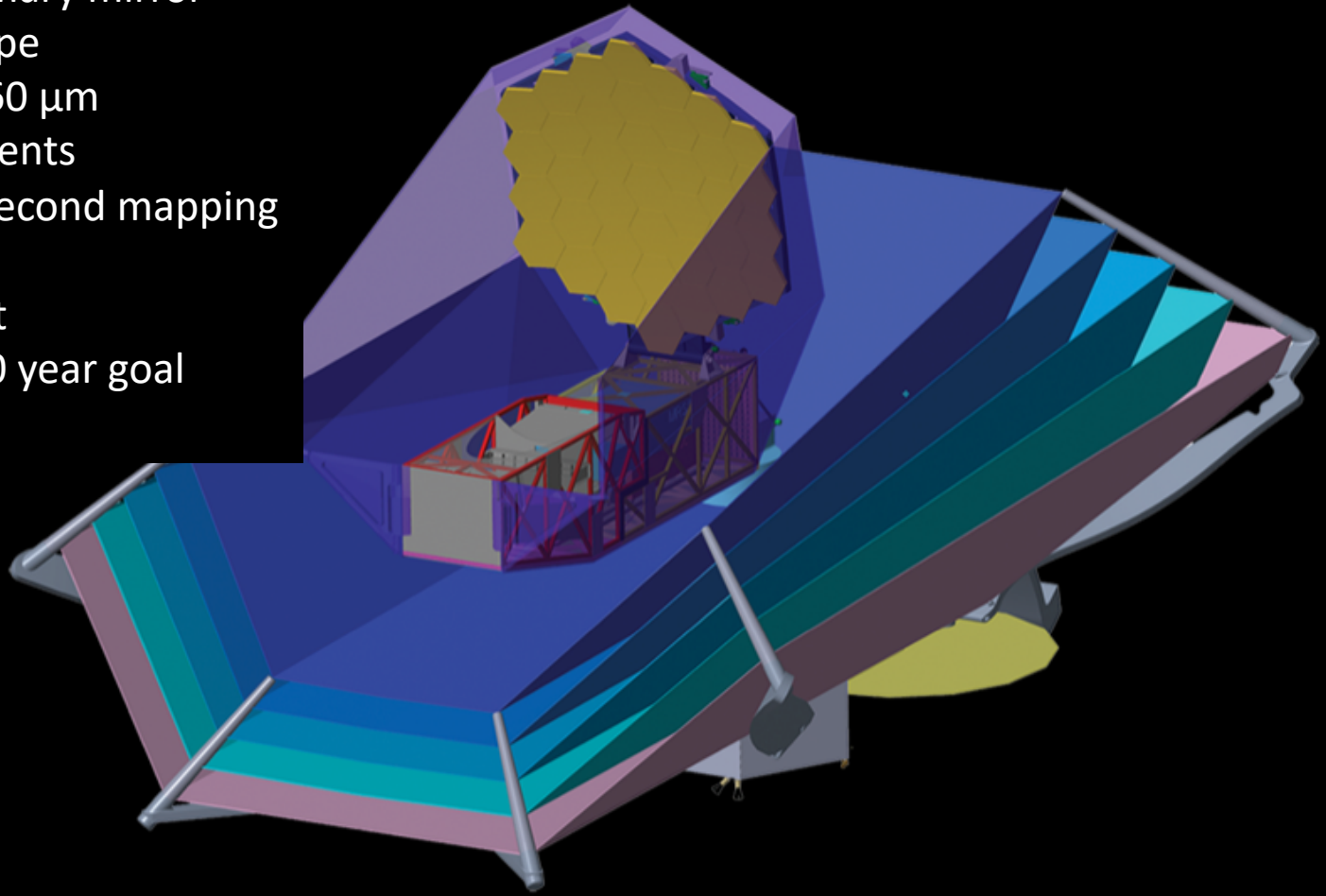
Full team list: asd.gsfc.nasa.gov/firs/

ORIGINS
Space Telescope

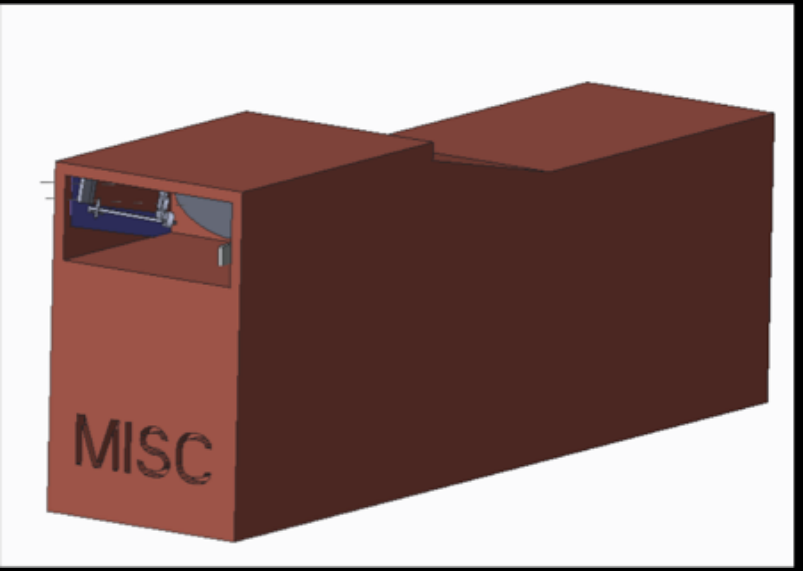
Mission Concept 1



- 9.1 m off-axis primary mirror
- Cold (4 K) telescope
- Wavelengths 5-660 µm
- 5 science instruments
- 100 arcseconds/second mapping
- Launch 2030s
- Sun-Earth L2 orbit
- 5 year lifetime, 10 year goal

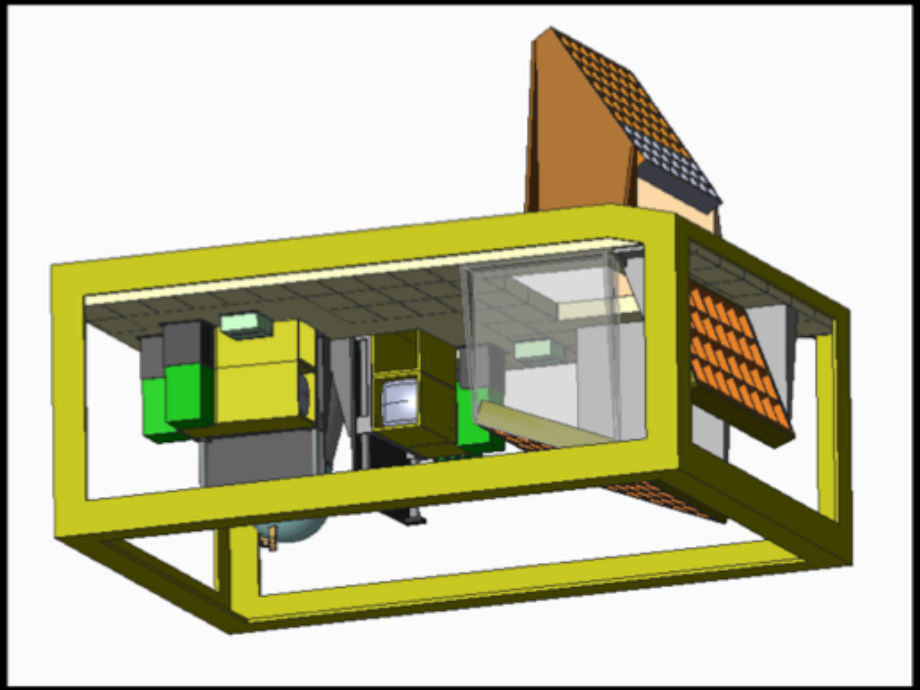


MISC: Mid-Infrared Imager, Spectrometer, Coronagraph



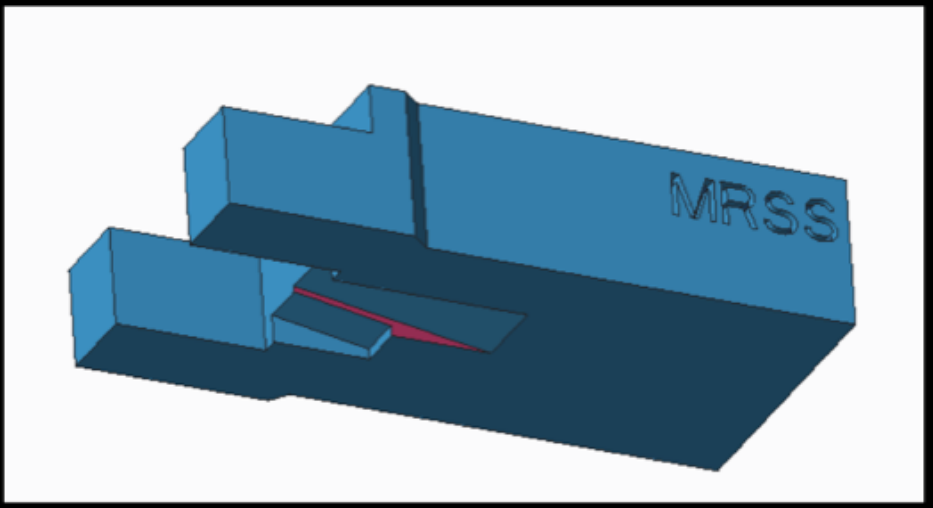
- 5-38 µm
- $\lambda/\Delta\lambda$ ~ 15, 300, 1200, 10^4
- Imaging
- Spectroscopy
- Coronagraphy 10^6 contrast
- Transit spectrometer <10 ppm stability

FIP: Far-Infrared Imager and Polarimeter



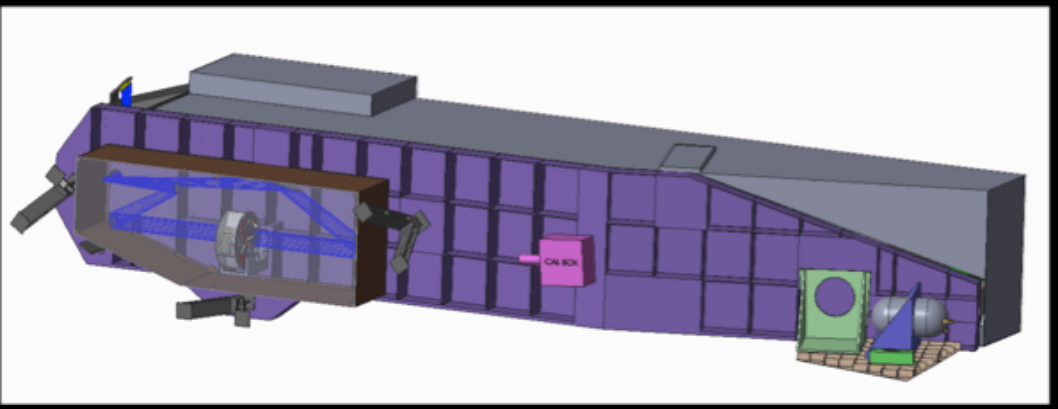
- 40, 80, 120, 240 μm
- λ/Δλ ~ 15
- 4 band Simultaneous Imaging
- Differential Polarimetric Imaging

MRSS: Medium Resolution Survey Spectrometer



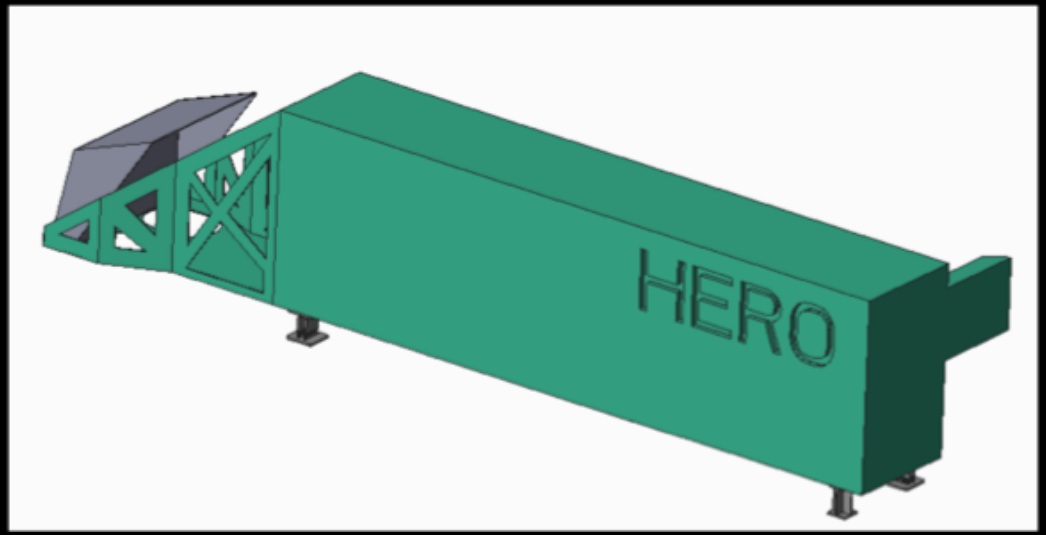
- 30-660 µm
- $\lambda/\Delta\lambda$ ~ 500, $4x10^4$
- Multi-band Spectroscopy
- Survey
- Single Target

HRS: High Resolution Spectrometer

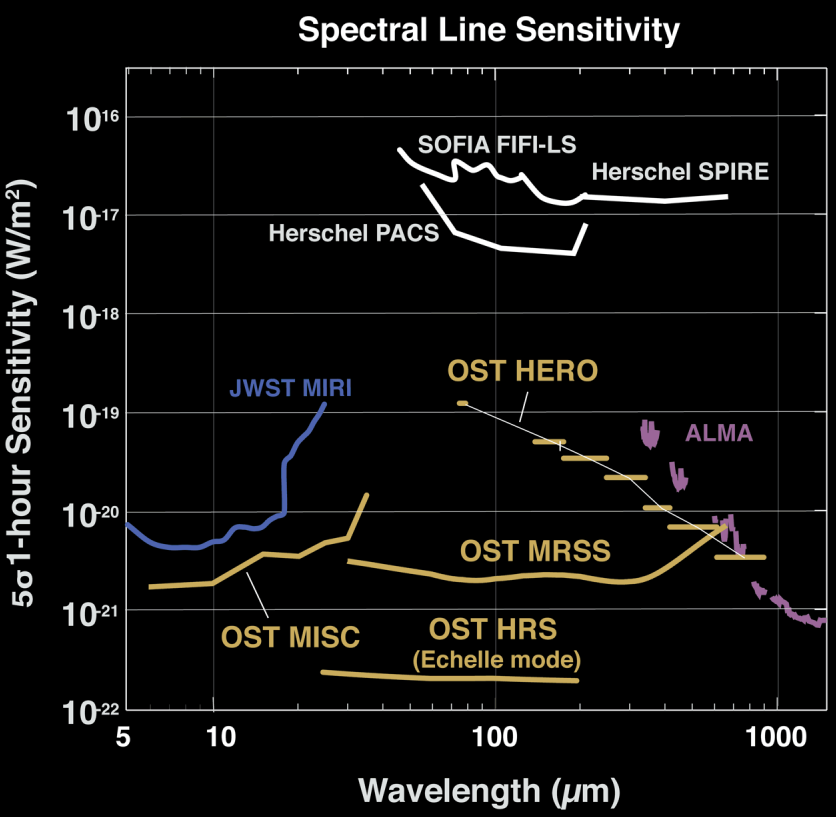


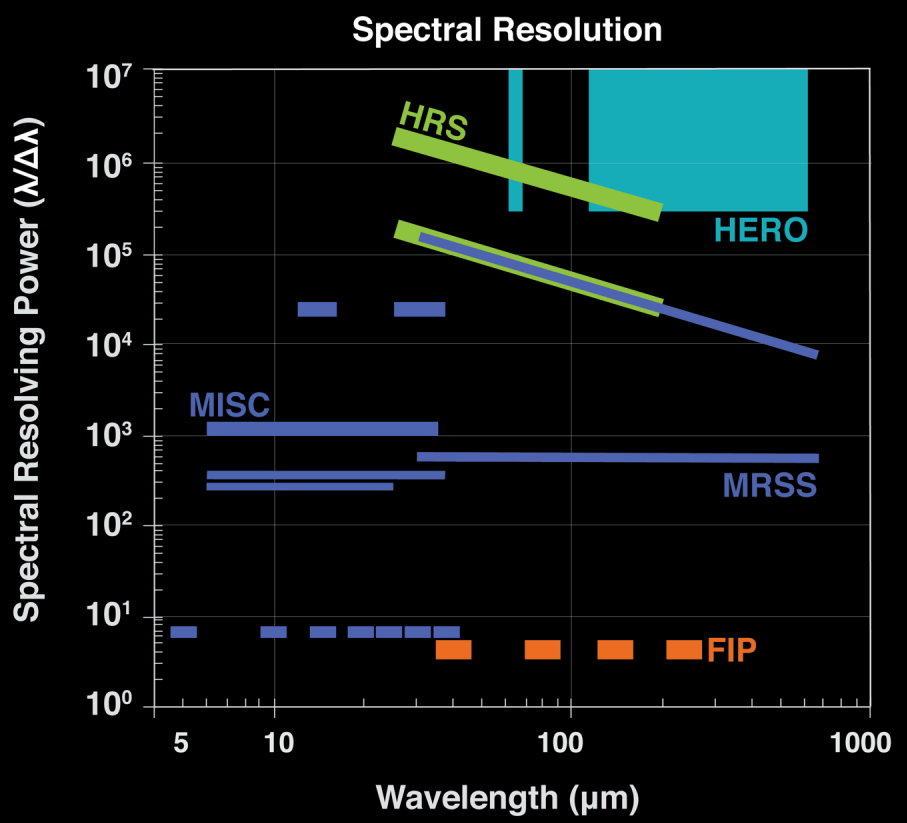
- 25-200 μm
- $\lambda/\Delta\lambda$ ~ $5x10^4$, $5x10^5$
- Spectroscopy
- Single Target
- Small maps

HERO: Heterodyne Receiver for OST

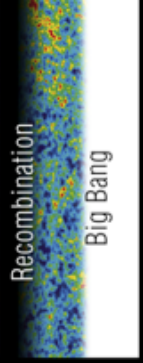


- 63-66, 111-610 µm
- $\lambda/\Delta\lambda \sim 10^7$
- Multi-beam Spectroscopy
- Small maps

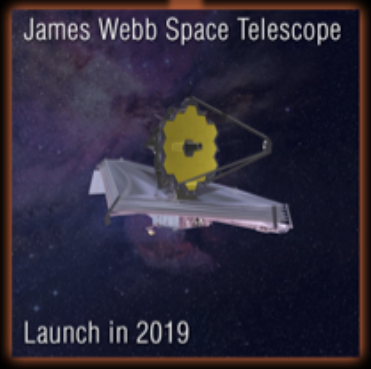

Spectral Line Sensitivity
5σ1-hour Sensitivity (W/m²)
10^16
10^17
10^18
10^19
10^20
10^21
10^22
SOFIA FIFI-LS
Herschel SPIRE
Herschel PACS
JWST MIRI
OST HERO
ALMA
OST MRSS
OST MISC
OST HRS
(Echelle mode)
5
10
100
1000
Wavelength (μm)


Spectral Resolution
Spectral Resolving Power (λ/Δλ)
10^7
10^6
10^5
10^4
10^3
10^2
10^1
10^0
HRS
HERO
MISC
MRSS
FIP
5
10
100
1000
Wavelength (μm)

Seeing into the dark ages with Origins Space Telescope (OST)



	Today		Reionization	First Galaxies	First Stars	Dark Ages		
REDSHIFT	1		6	8	12		16	1100
BILLIONS of YEARS AGO			12.6	13.1	13.4		13.5	13.8

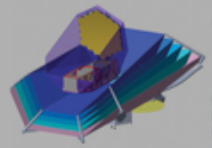


DIAMETER	2.4 meter	6.5 meter	9 meter
WAVELENGTH	0.1–2.4 μm	0.6–27 μm	5–660 μm
TEMPERATURE	260 K	50 K	4 K

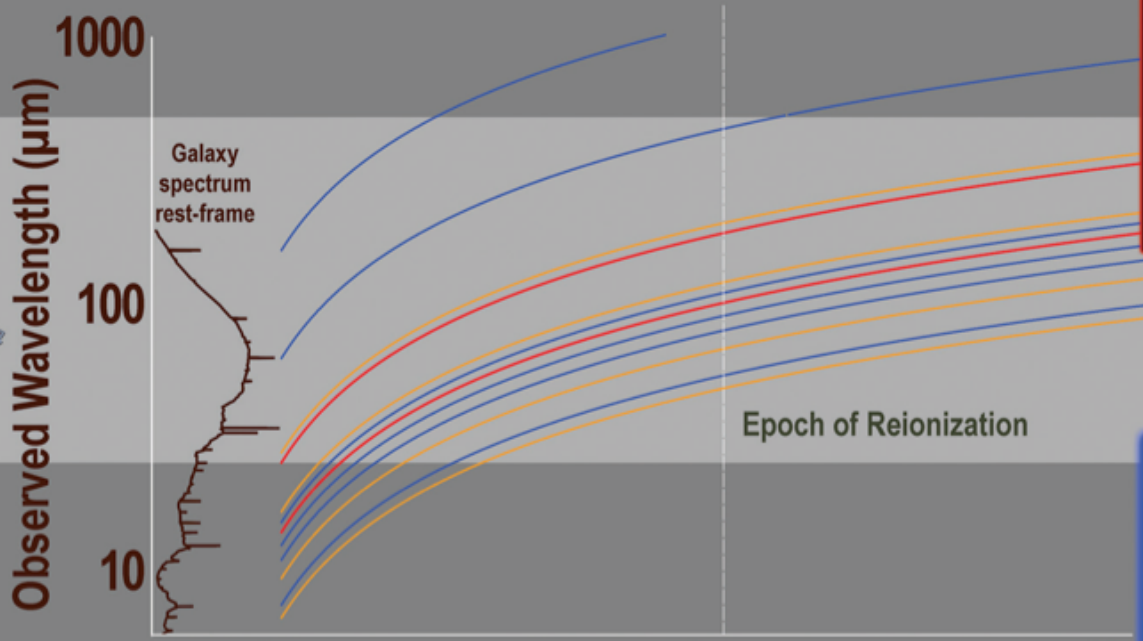
Tracing key diagnostics across cosmic time

ALMA

Origins Space Telescope



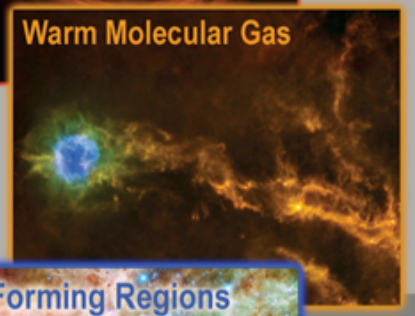
JWST

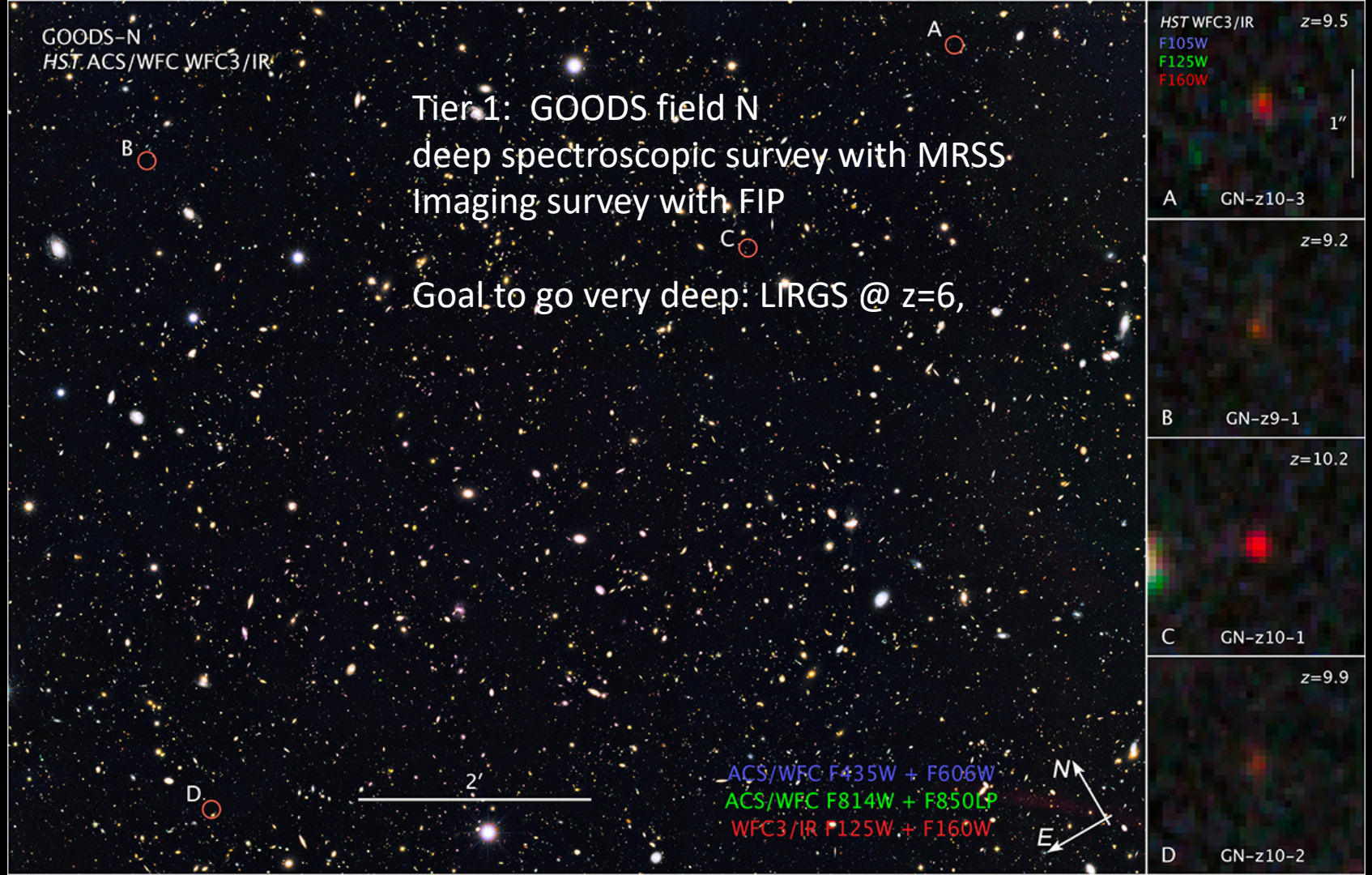


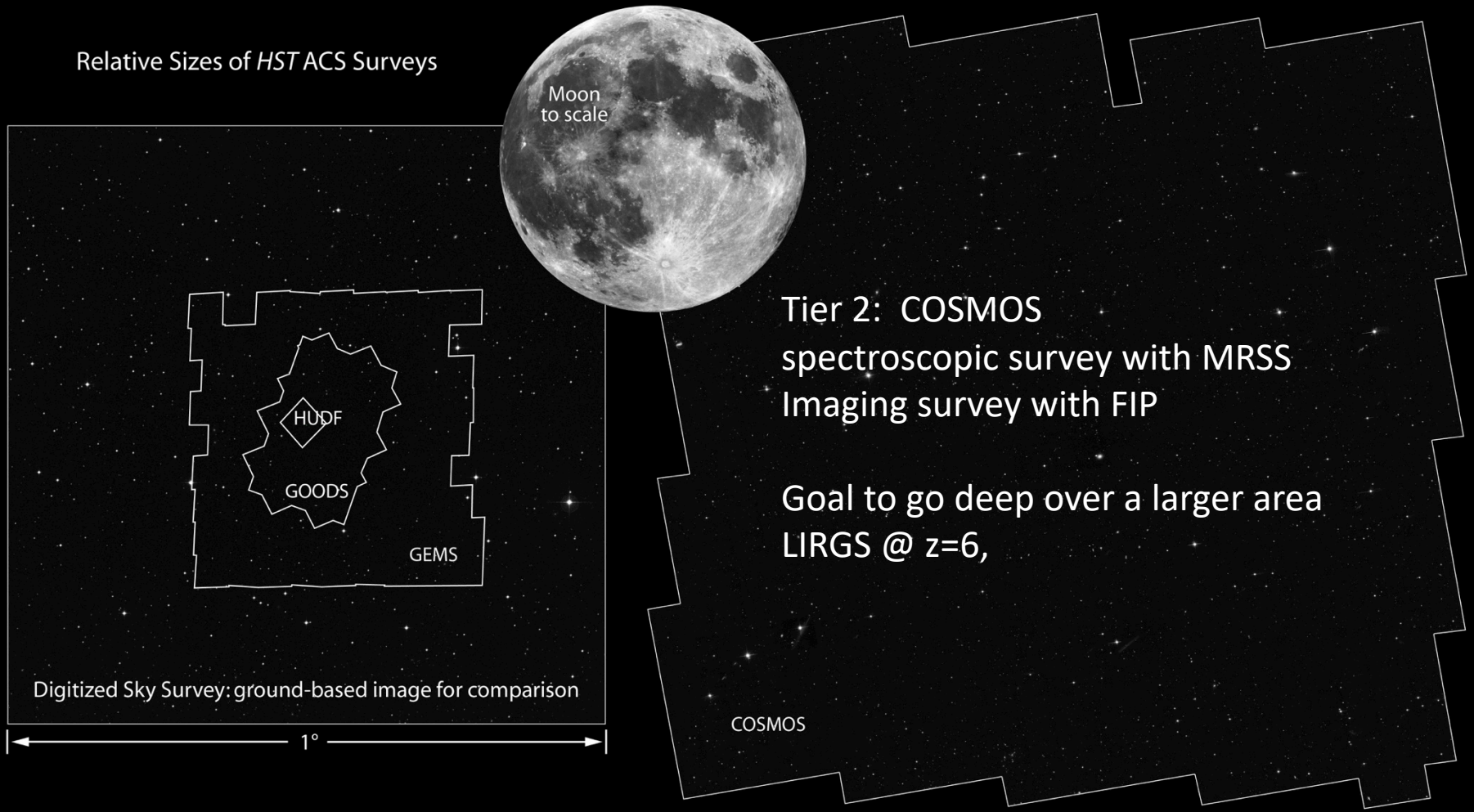
H_2 (S(5),S(3),S(1),S(0)

PAH(6.2,7.7,11.3 μm), [NeII],[SiII], [OI],[CII]

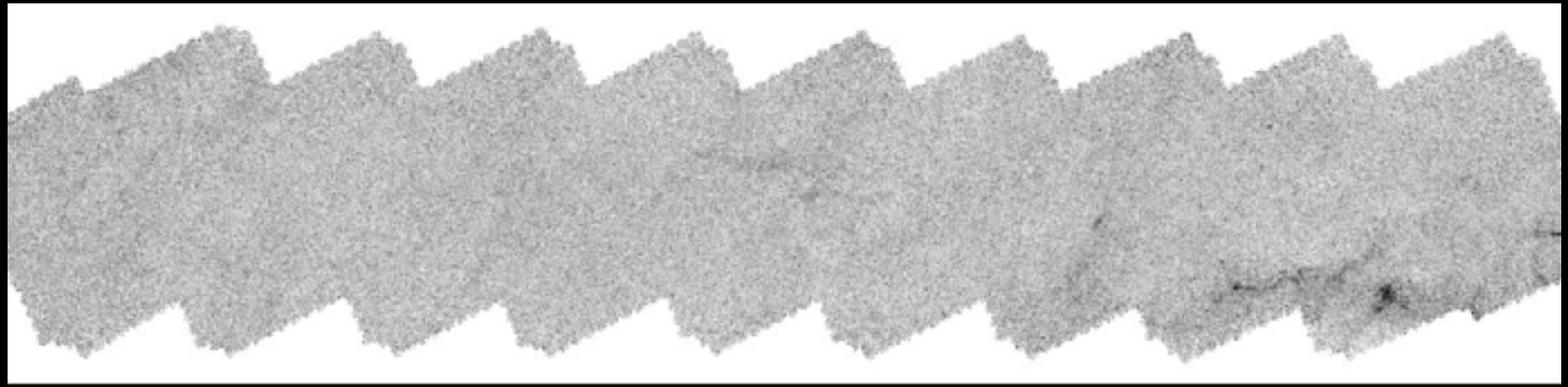
[NeV],[OIV]



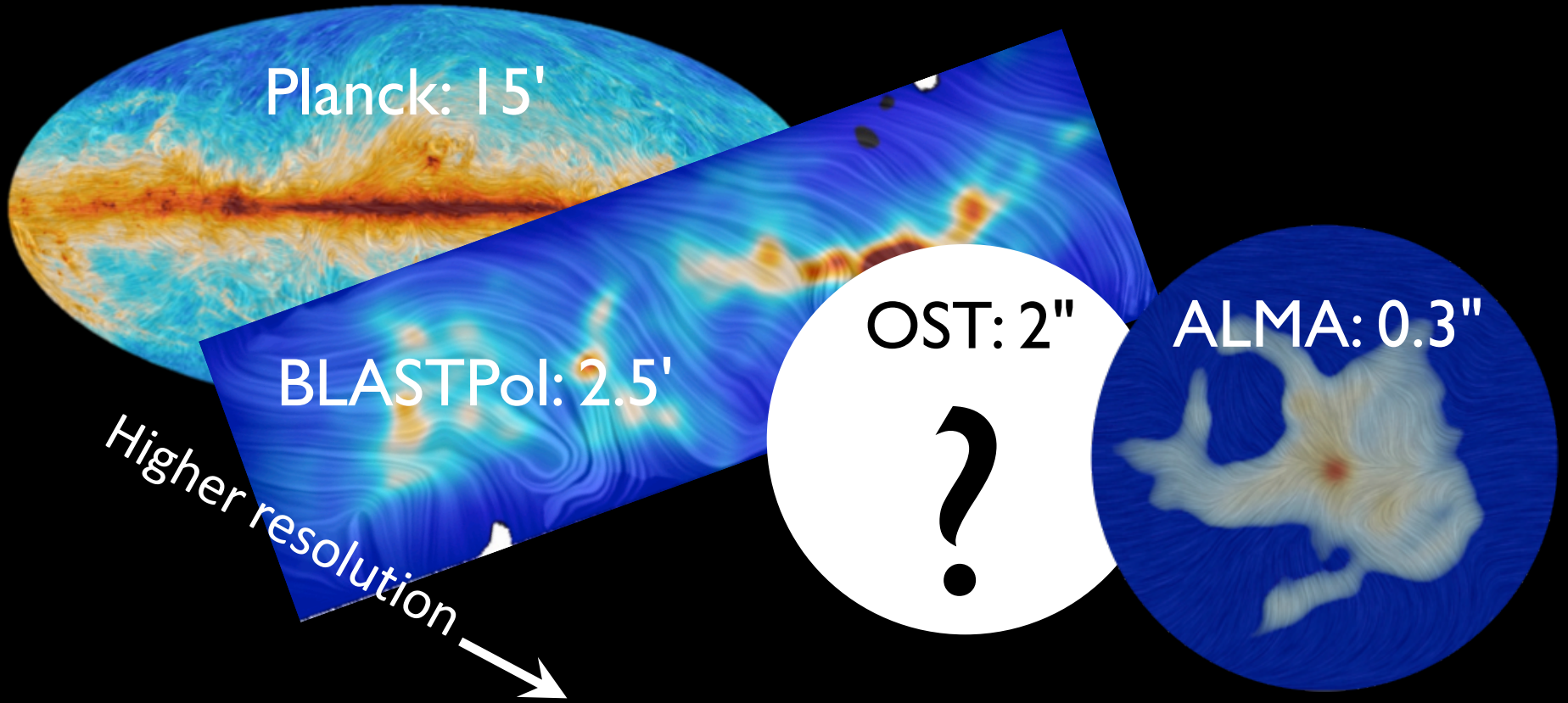

GOODS–N
HST ACS/WFC WFC3/IR
A
B
C
D
Tier 1: GOODS field N
deep spectroscopic survey with MRSS
Imaging survey with FIP
Goal to go very deep: LIRGS @ z=6,
2′
ACS/WFC F435W + F606W
ACS/WFC F814W + F850LP
WFC3/IR F125W + F160W
N
E
HST WFC3/IR
F105W
F125W
F160W
z=9.5
1″
A GN–z10–3
z=9.2
B GN–z9–1
z=10.2
C GN–z10–1
z=9.9
D GN–z10–2


Relative Sizes of *HST* ACS Surveys
Moon to scale
HUDF
GOODS
GEMS
Digitized Sky Survey: ground-based image for comparison
1°
COSMOS
Tier 2: COSMOS
spectroscopic survey with MRSS
Imaging survey with FIP
Goal to go deep over a larger area
LIRGS @ z=6,

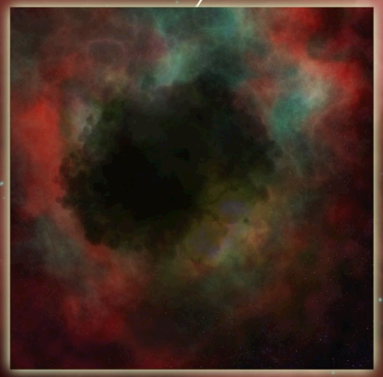
Tier 3: Stripe 82
spectroscopic survey with MRSS
Imaging survey with FIP
Goal to cover a larger area: ULIRGS @ z=6, millions of galaxies



Magnetic fields (FIP) and turbulence (HERO, HRS)

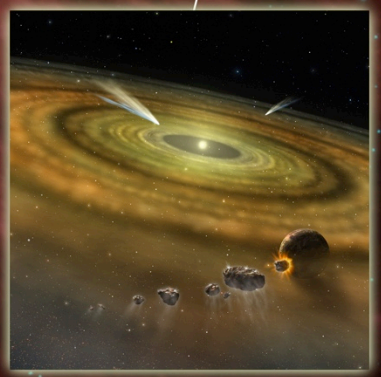


Following the formation of planetary systems from the interstellar medium to life-bearing worlds

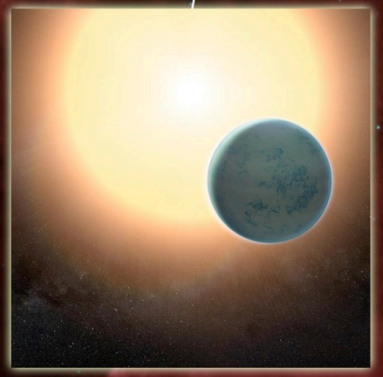


Interstellar medium

Protoplanetary disks



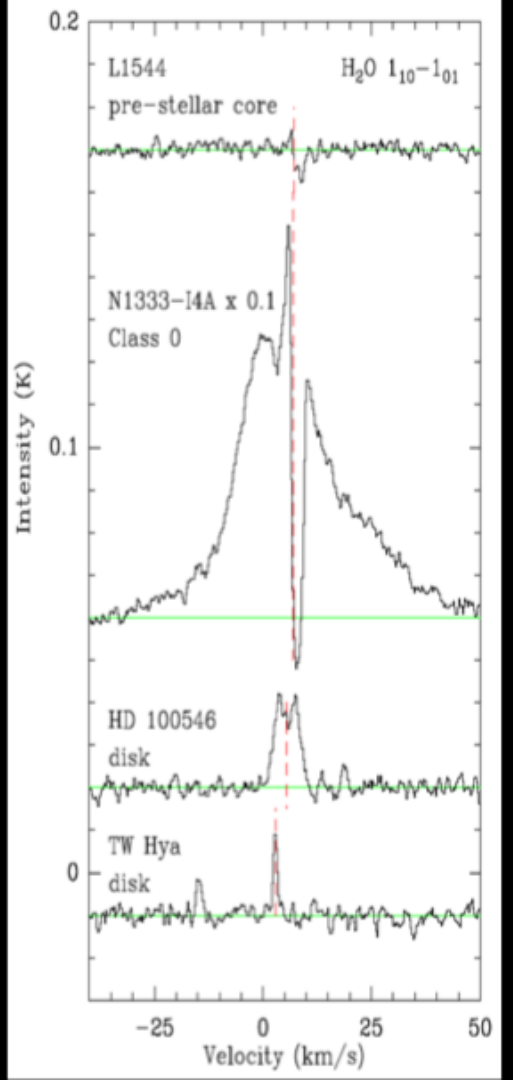
Planetary systems



Exoplanets

Water Transport to Terrestrial Planetary Zone (HRS, MRSS, HERO)

Science Goal: Observe gas-phase water in interstellar clouds and dense star-forming cores to probe critical processes related to formation and transport of water to the terrestrial planet zone, as a key input to habitability.

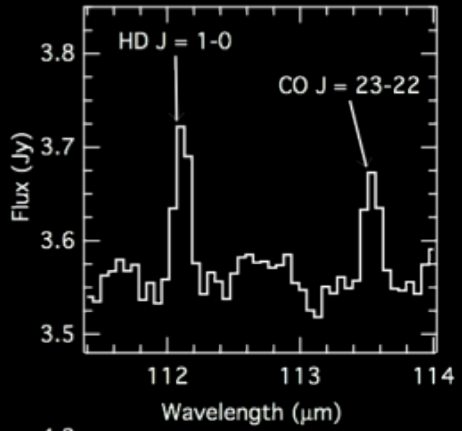


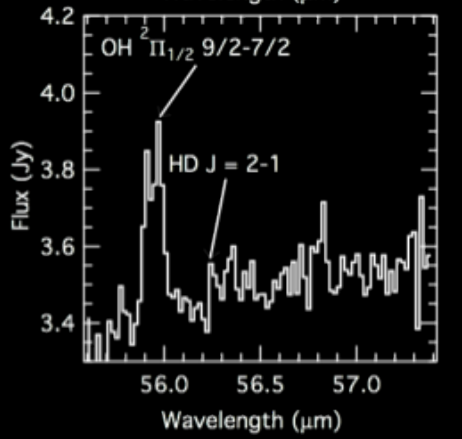
What are ProtoPlanetary disk gas masses? (HRS,MRSS HERO)

- ➡HD is a million times more emissive than H_2 at T ~ 20 K.
- ➡Atomic D/H ratio inside the local bubble is well characterized (~1.5 x 10^{-5})
- ➡HD will follow H_2 in the gas

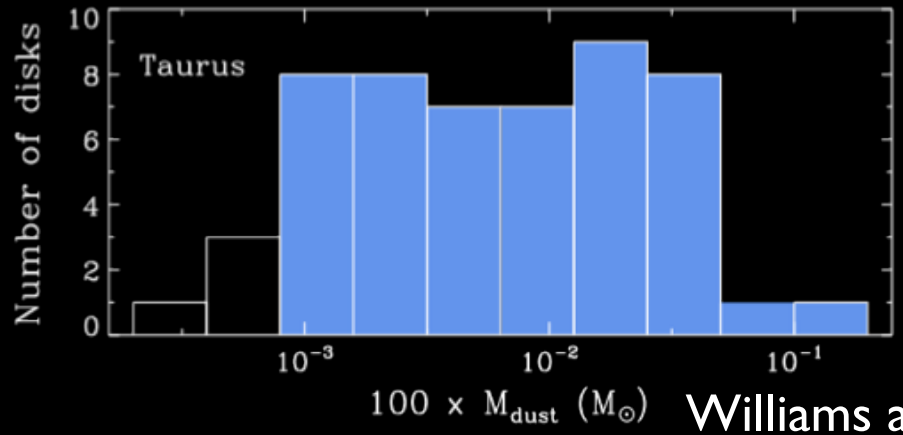
- ➡TW Hya disk mass

M_{disk} ~ 0.05 $M_\odot$





Bergin+ 2013



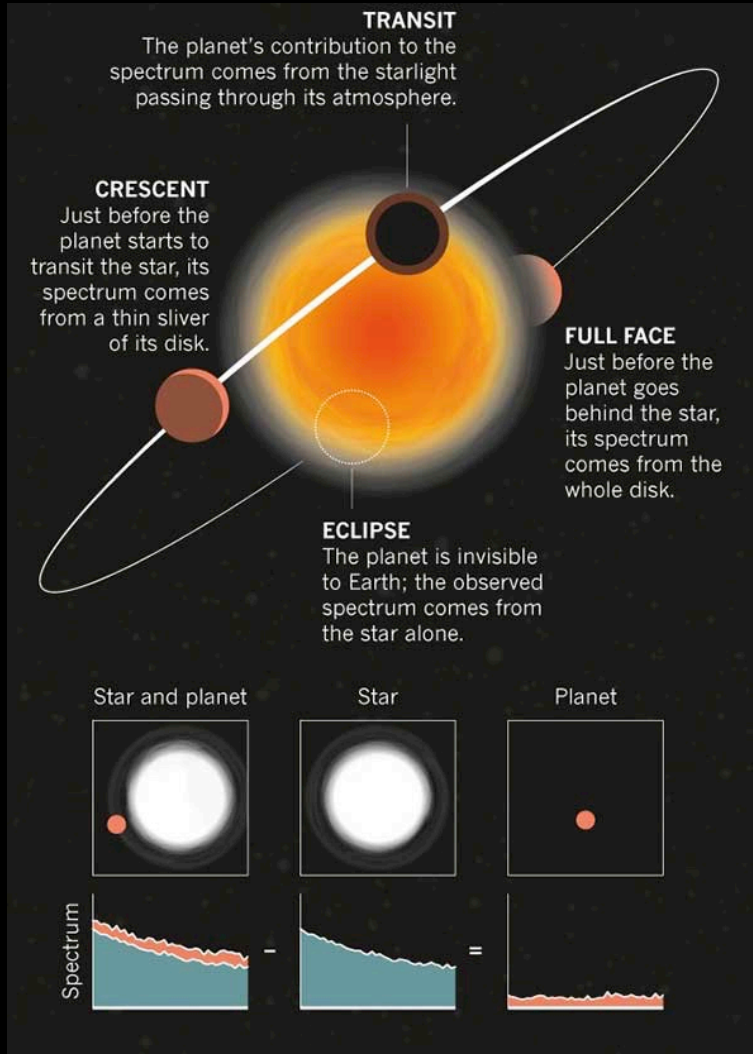
Williams and Cieza 2011

Exoplanets – Transits (MISC)

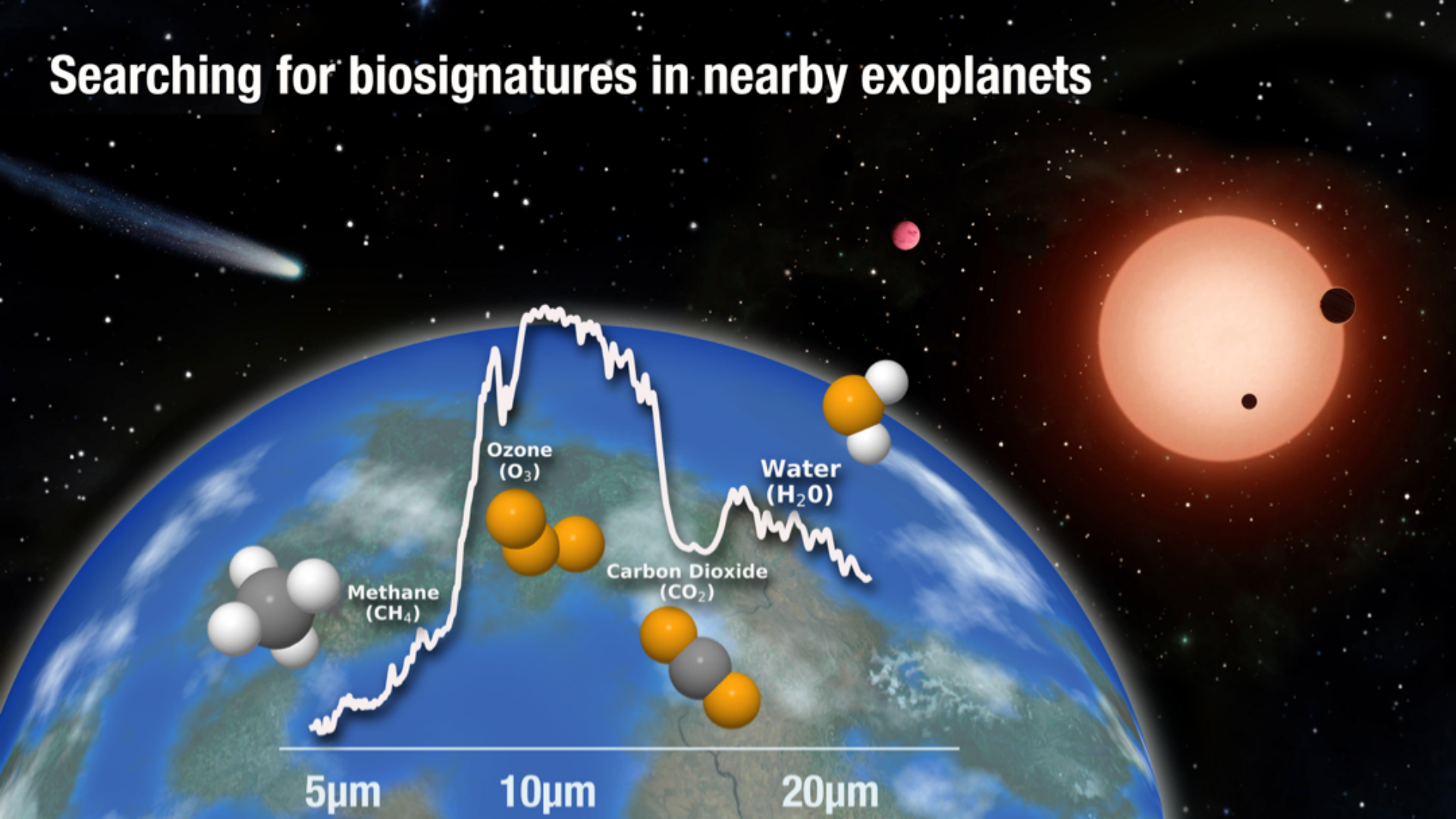
(See Stevenson: special session Wed.)

Transits for exoplanets

- Primary transit (probes terminator)
- Secondary eclipse (probes dayside)
- Lightcurves can indicate further patterns (time consuming)
- Atmosphere Characterization
- Biosignatures



Searching for biosignatures in nearby exoplanets



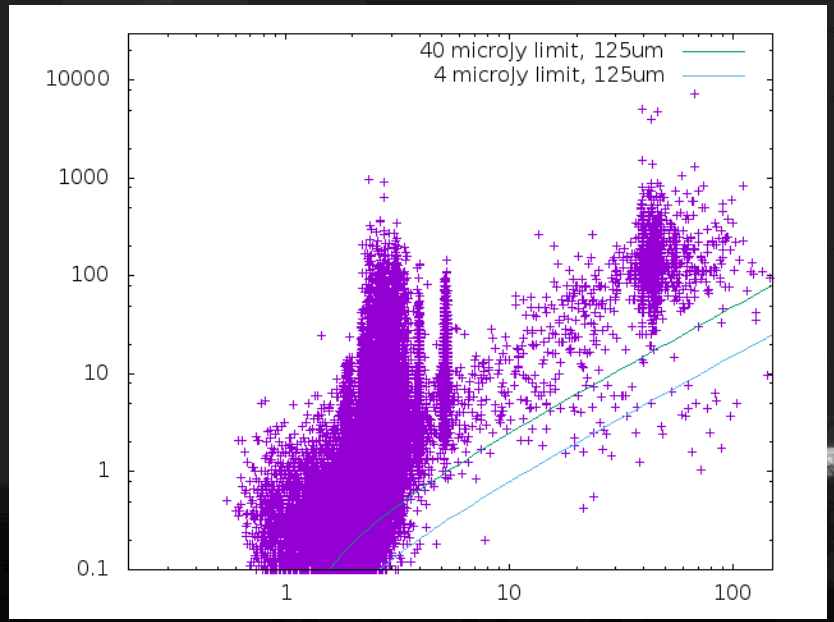
Exoplanets – Coronagraph (MISC)

Main targets: Warm Gas Giants & Jupiters
Interesting to help our view of whole Planetary systems

- because of the large IWA, no HZ planets
- Direct imaging doe not drive HZ planet case

Ground-based ELTs searches can provide complimentary VIS/NIR data for such planets

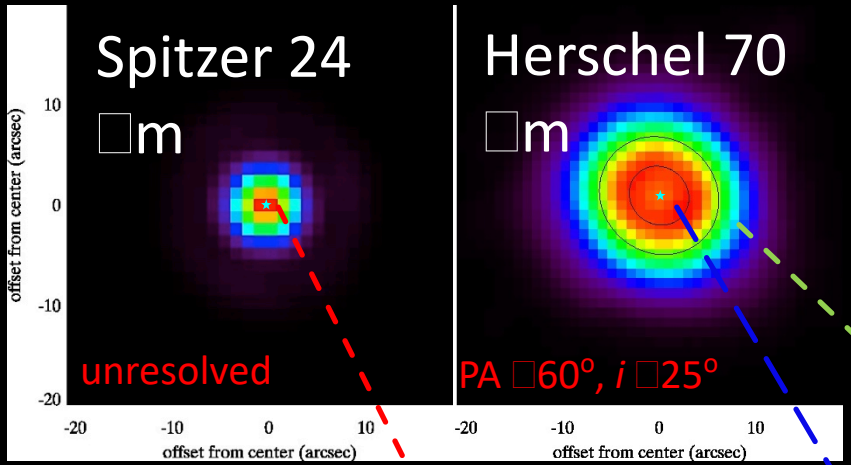
FIP mapping of Outer Solar System



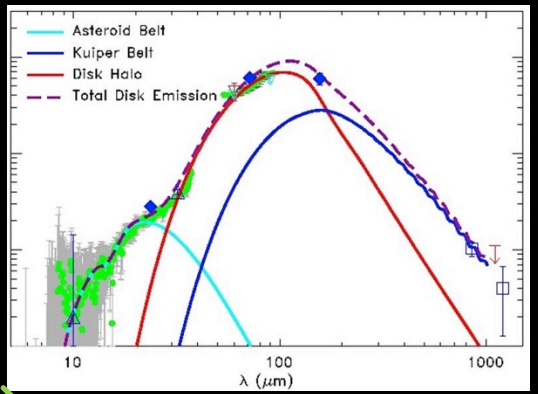
- Measure the thermal emission (FIP) of small bodies in outer Solar System – 1000's of targets
- **Constrain the thermal history and evolution of the Solar System.**
- Characterize Planet IX?

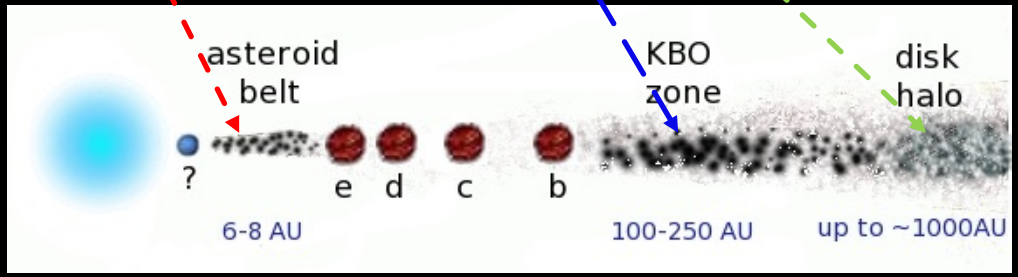
Lovell

Debris Disks and Giant Planets (FIP)

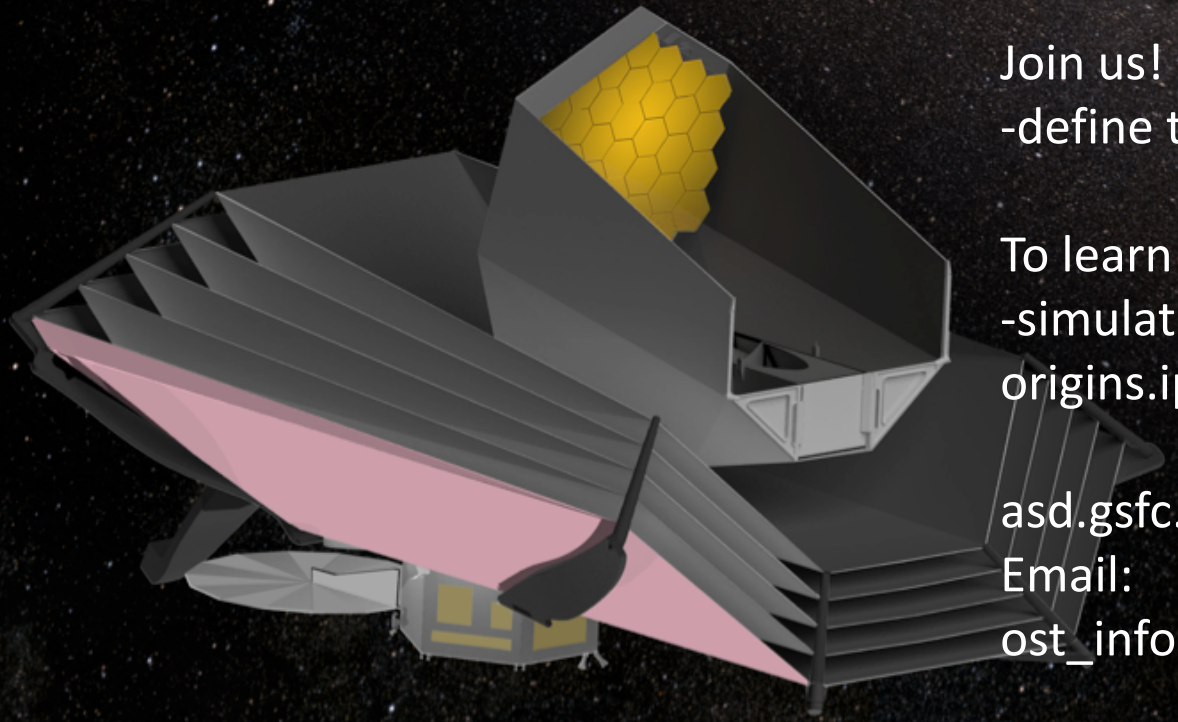


Spectral Energy Distribuion of HR8799





Su et al. 2009
Matthews et al. 2013
Marios et al. 2010



Join us!

ORIGINS Space Telescope

-define the science for OST

To learn more:

-simulation tools for OST

origins.ipac.caltech.edu

asd.gsfc.nasa.gov/firs/

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Secret word: OST@FIRSIG

tinyurl.com/OSTScavengerHunt