

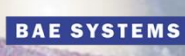
PRIMA

UNVEILING OUR COSMIC
ORIGINS IN THE INFRARED

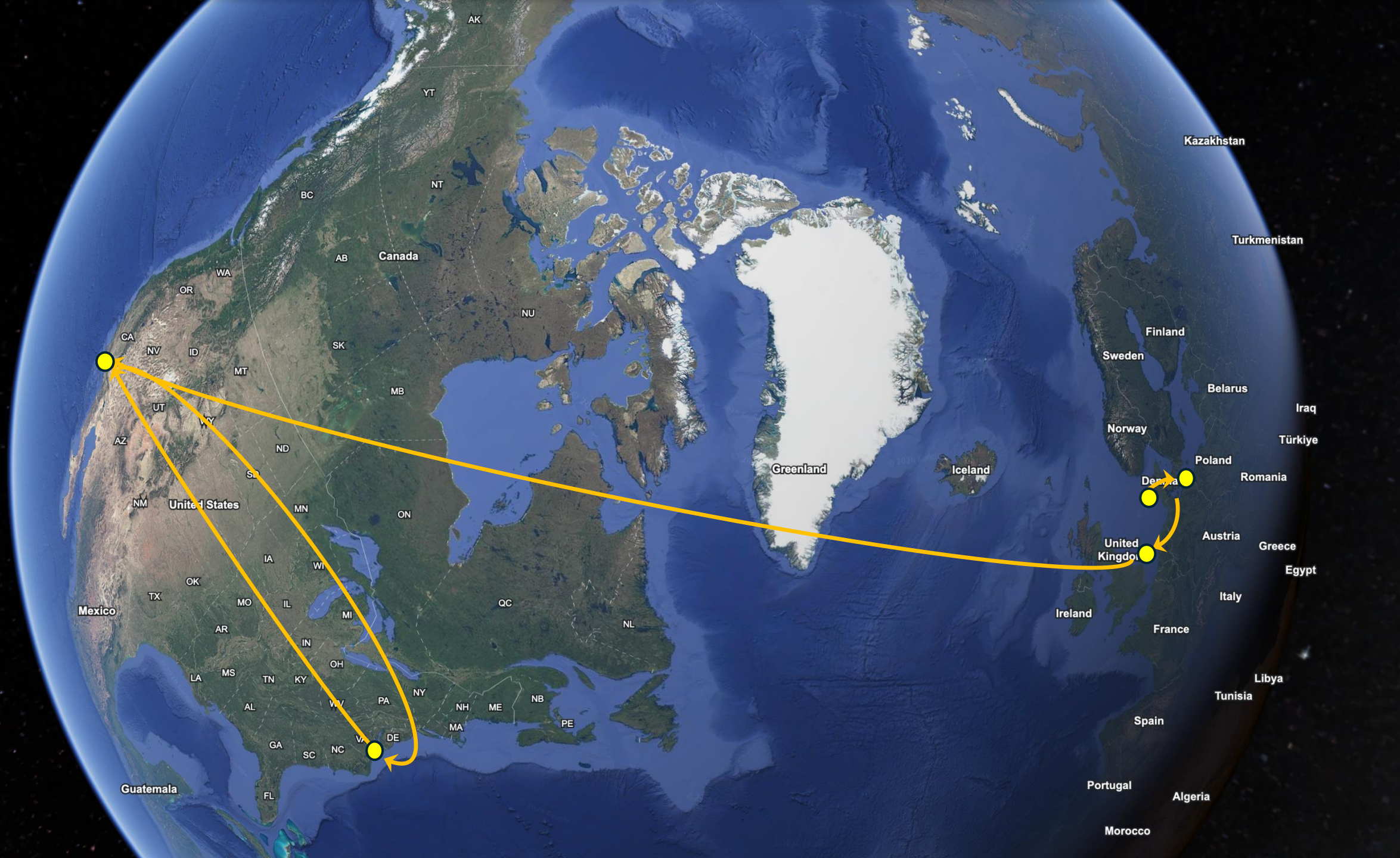


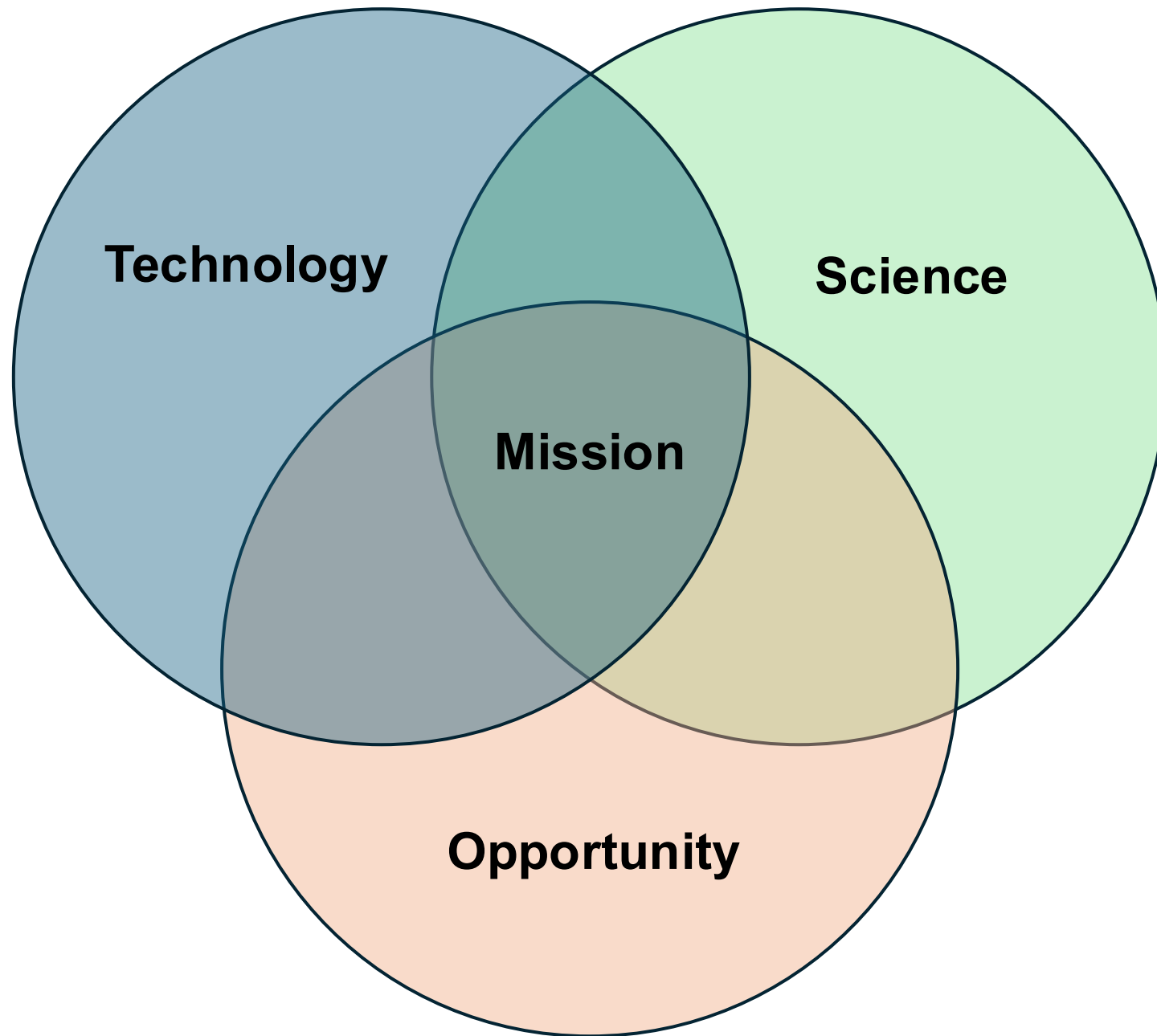
The Origins of Exoplanets with PRIMA

Klaus Pontoppidan (Caltech/JPL)

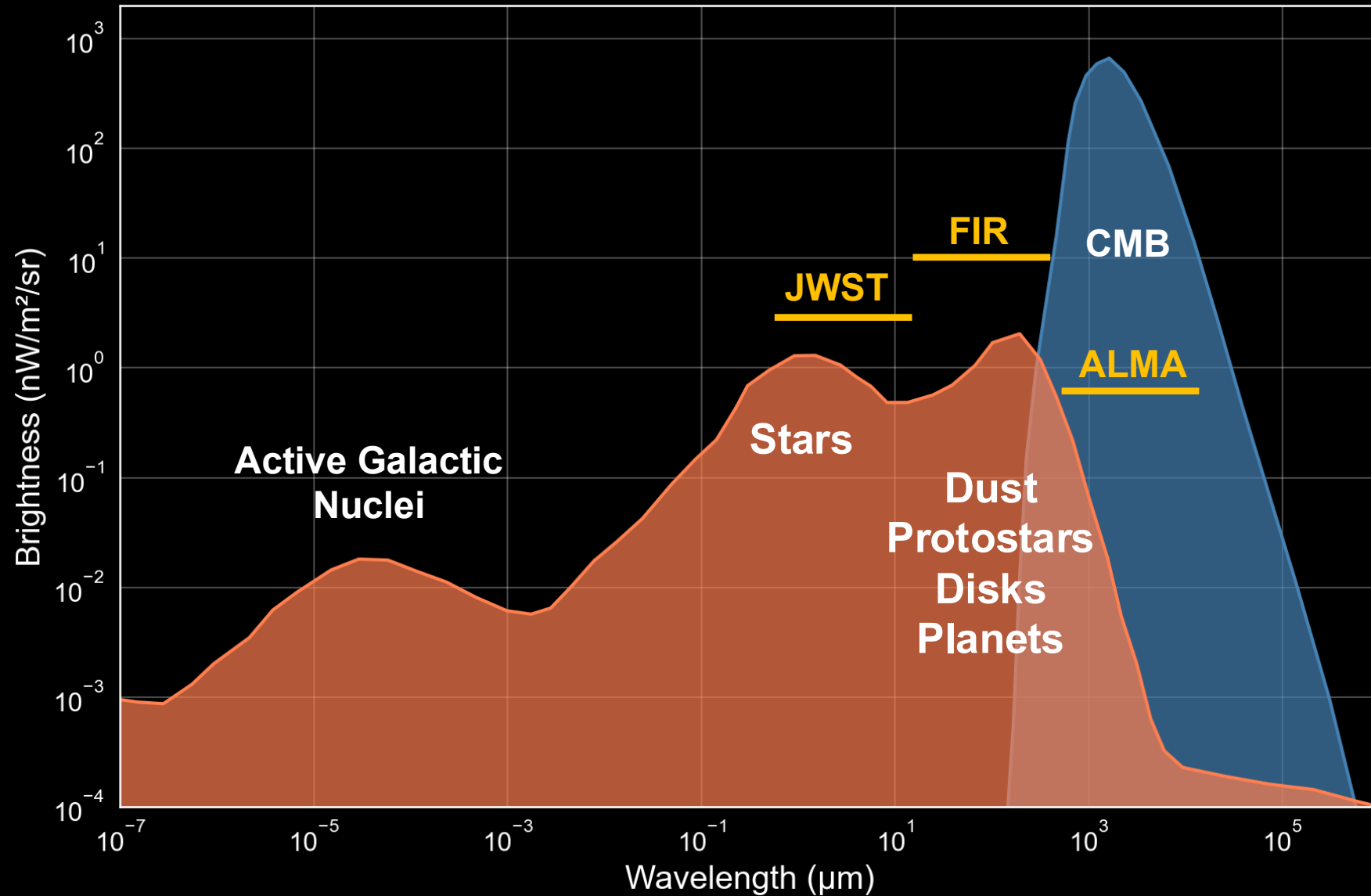








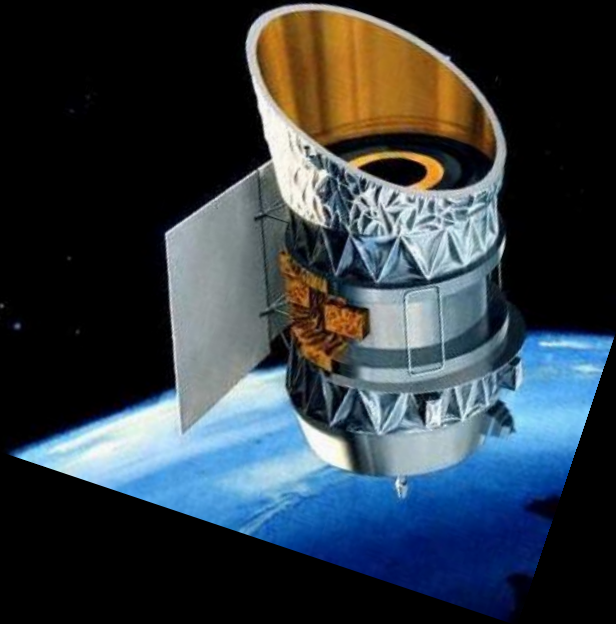
Cosmic background spectrum







IRAS



1983

57 cm
4K

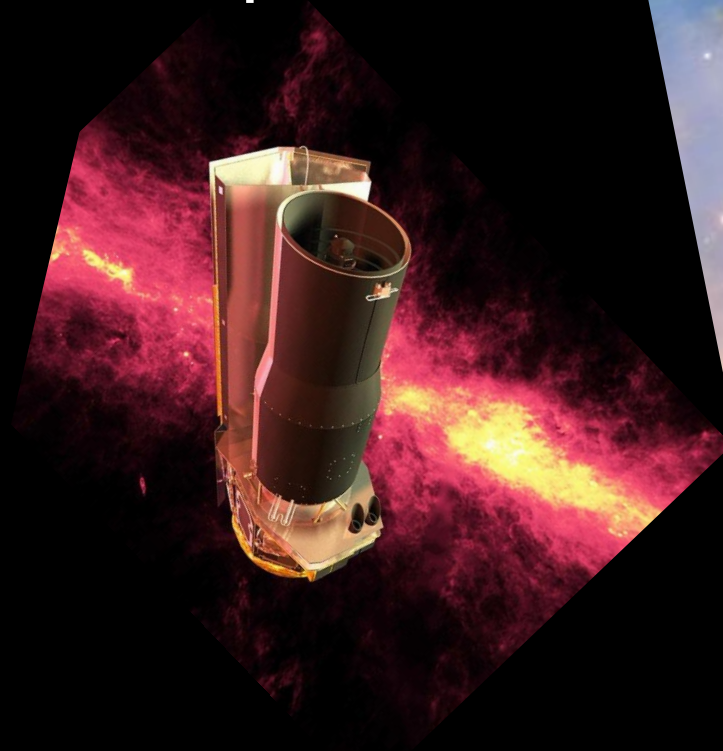
ISO



1995

60 cm
1.7K

Spitzer



2003

85 cm
5.5K

Herschel



2009

350 cm
70K

Star-formation in Ophiuchus / Herschel



Another Far-Infrared Opportunity

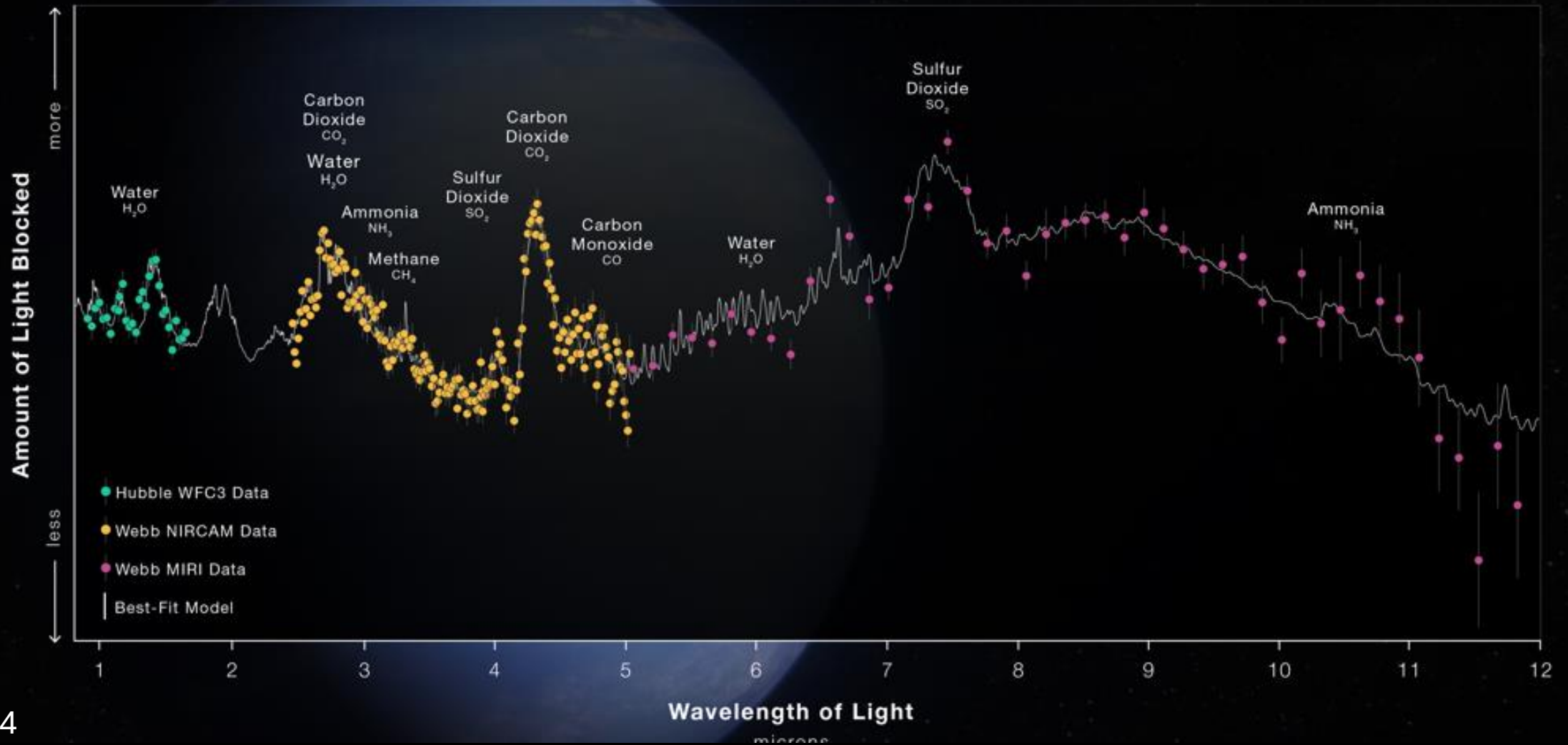
What are the origins of planetary atmospheres and biospheres?



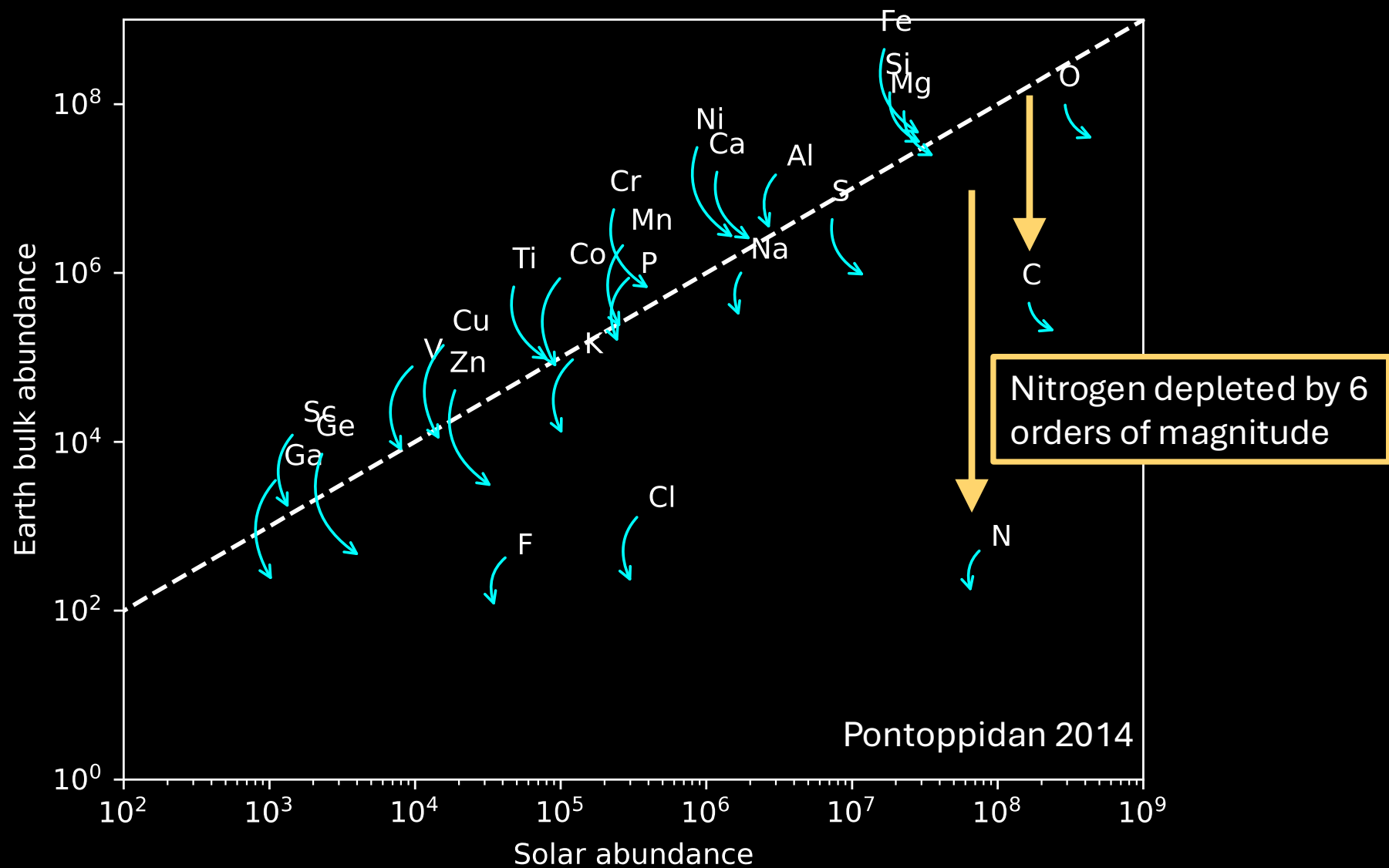
GAS-GIANT EXOPLANET WASP-107 b

TRANSMISSION SPECTRUM

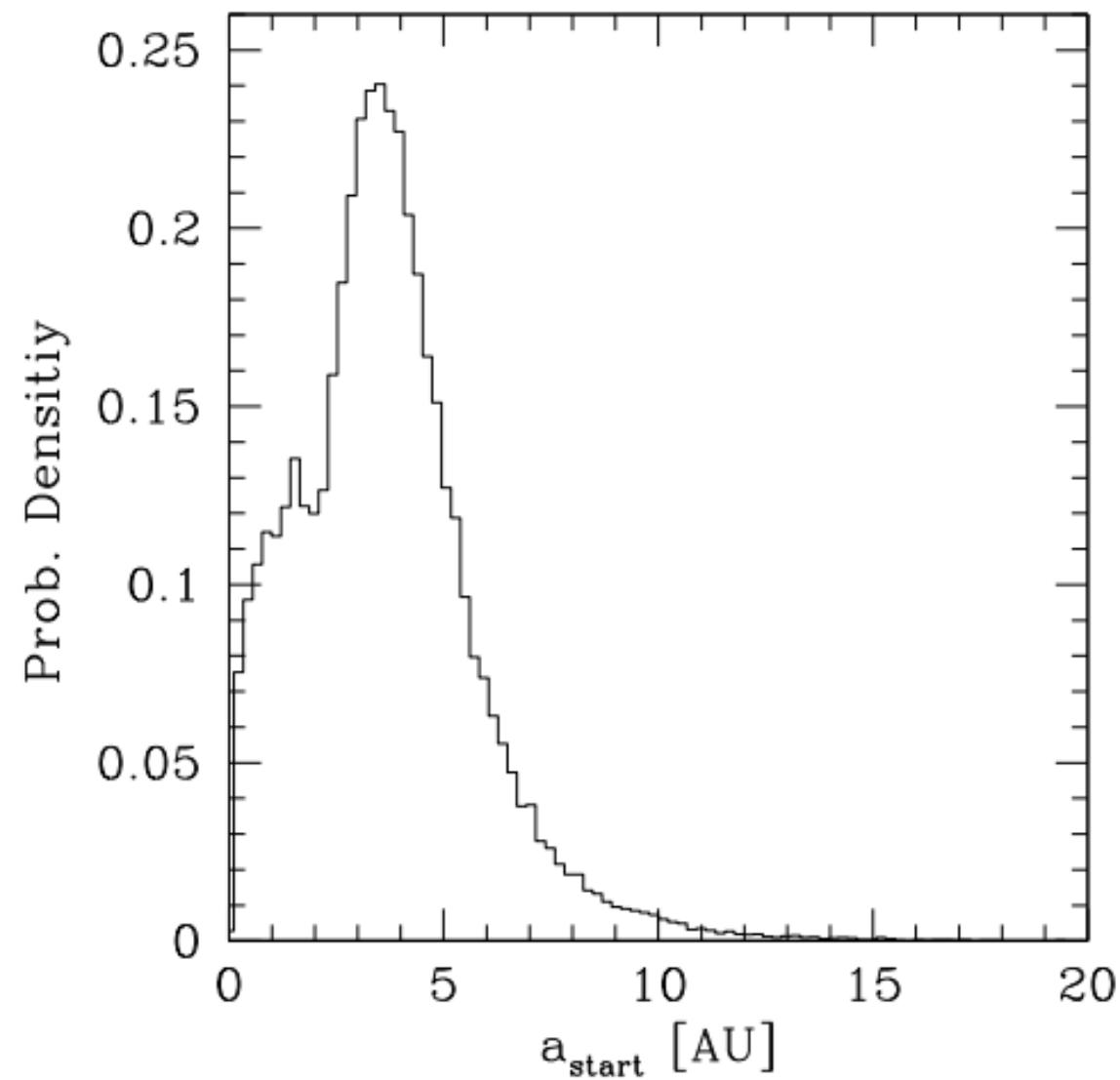
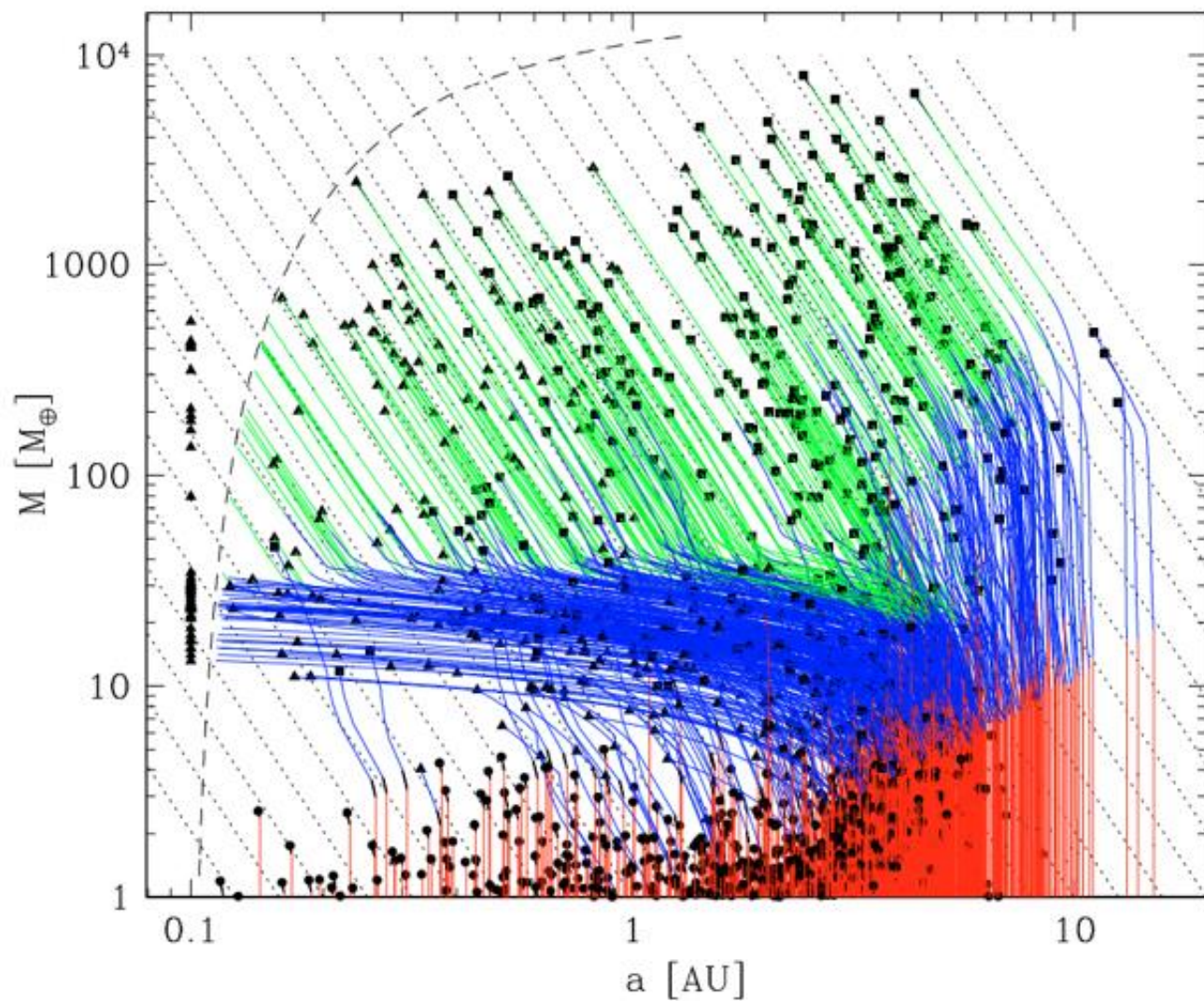
Hubble WFC3	Grism Spectroscopy
Webb NIRCам	Grism Spectroscopy
Webb MIRI	Low-Resolution Spectroscopy



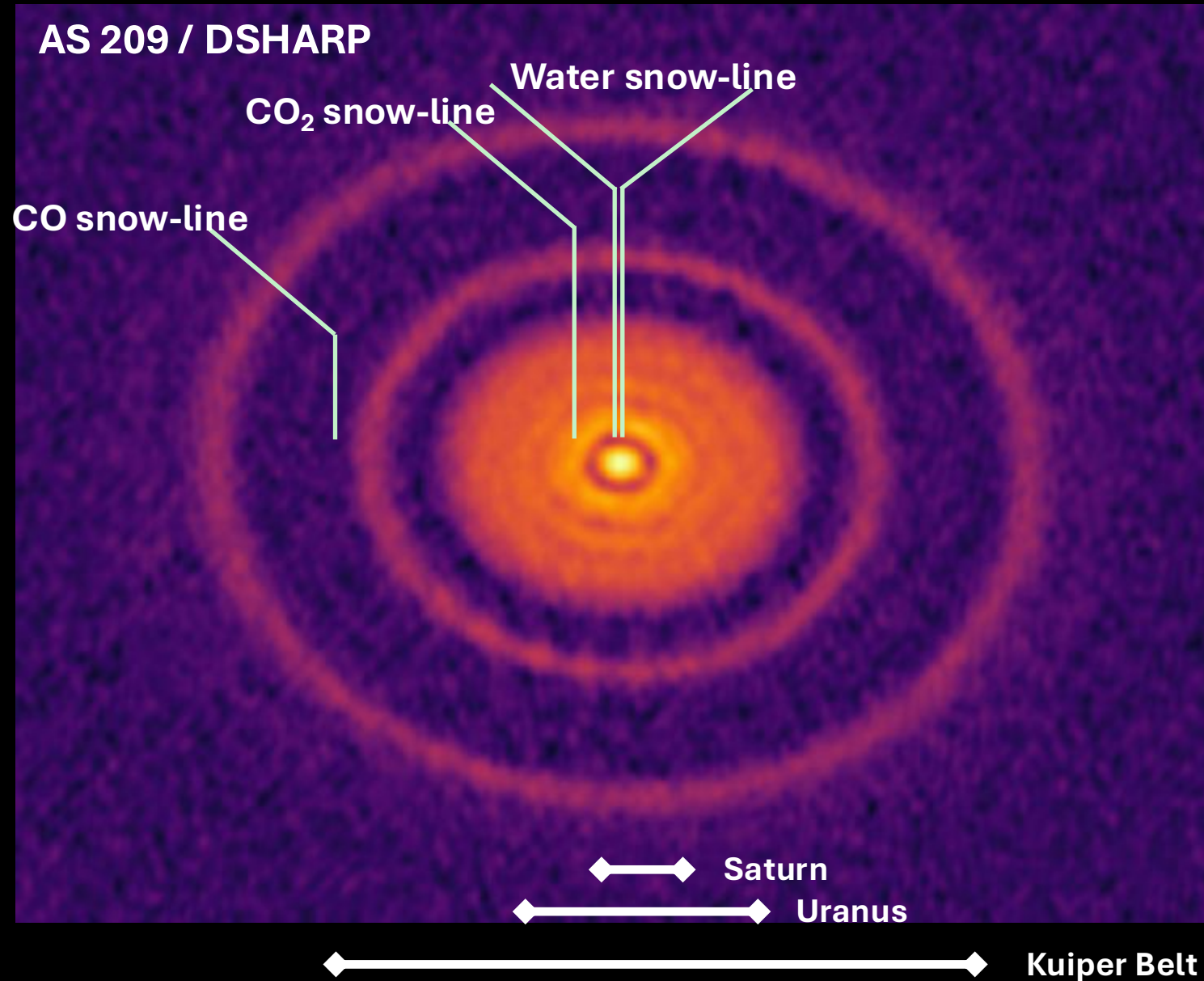
Volatile depletion in the Earth's mantle

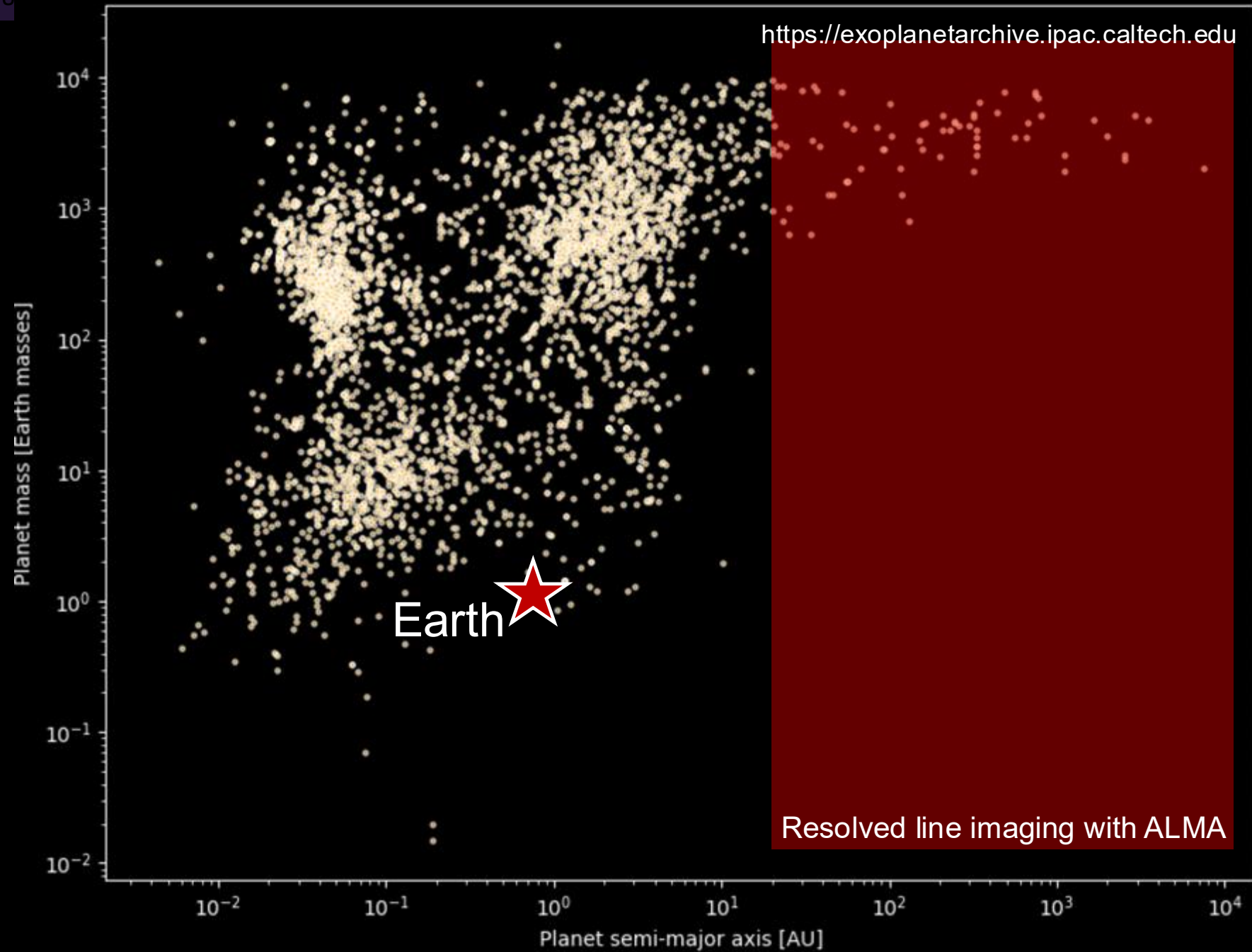


Where is the planet-forming region?

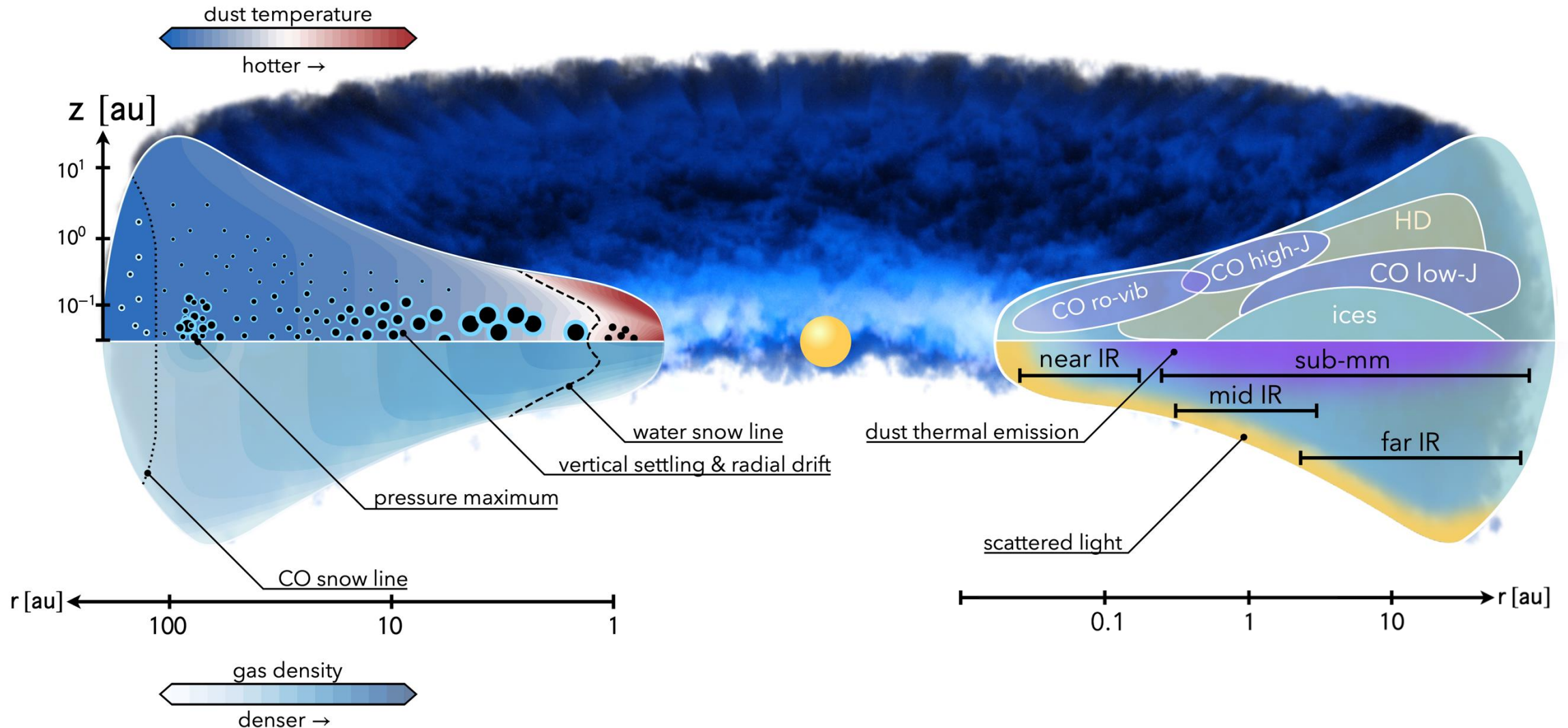


ALMA does not resolve water snowlines

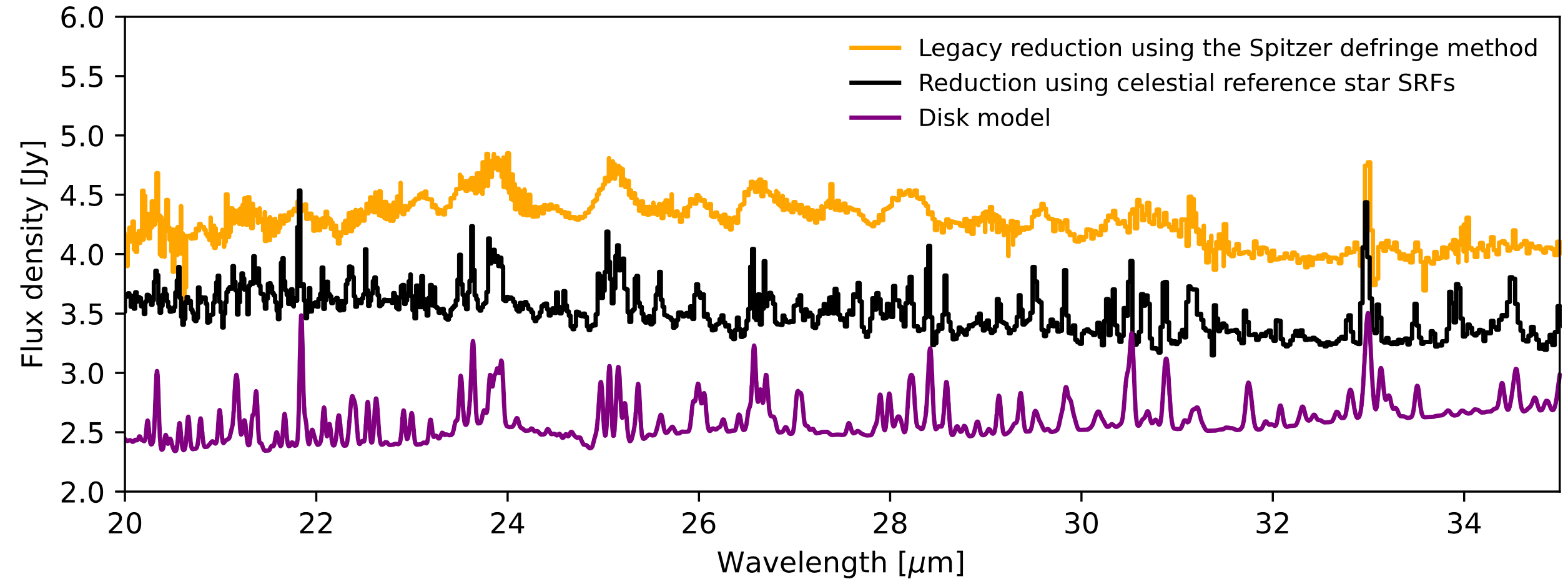




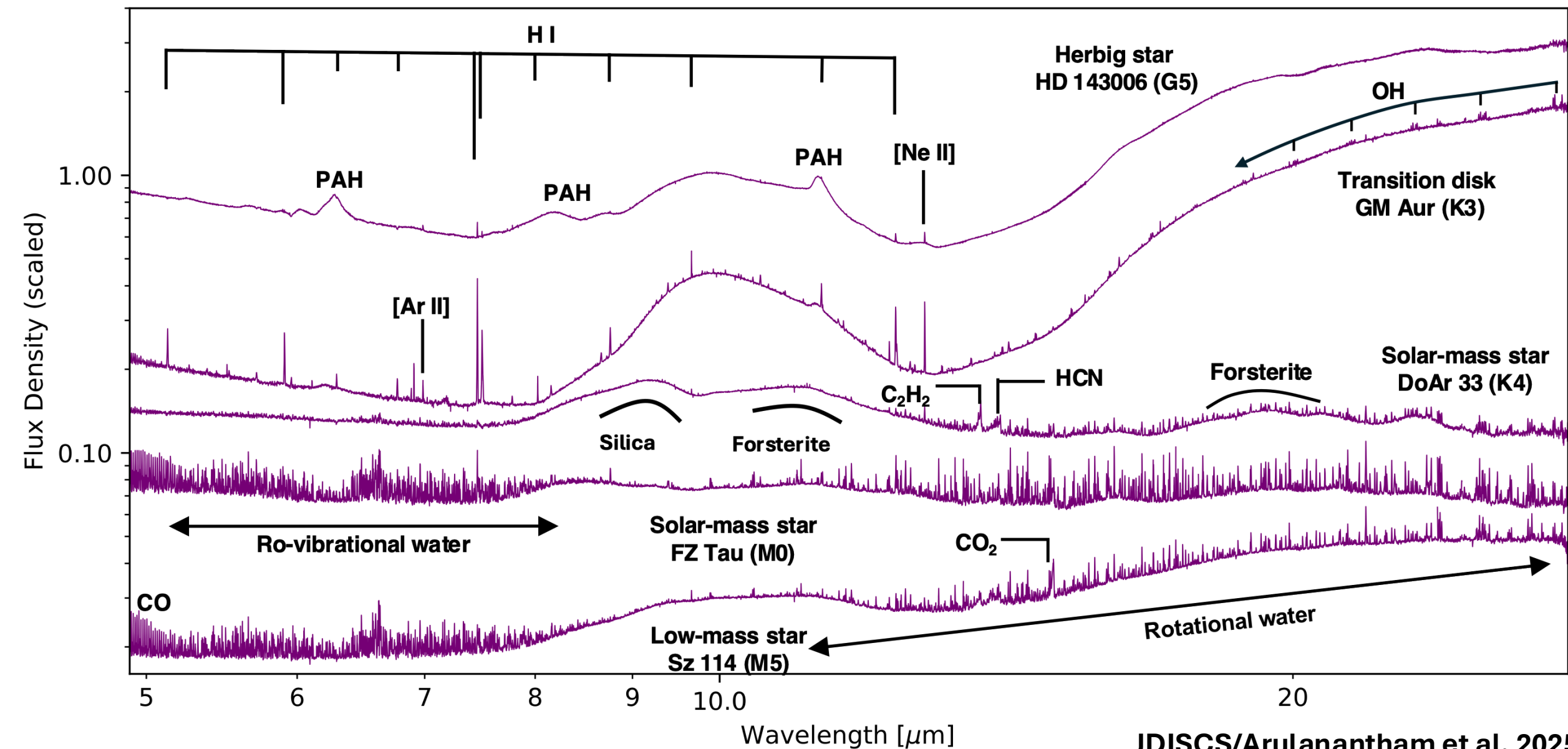
Anatomy of a protoplanetary disk



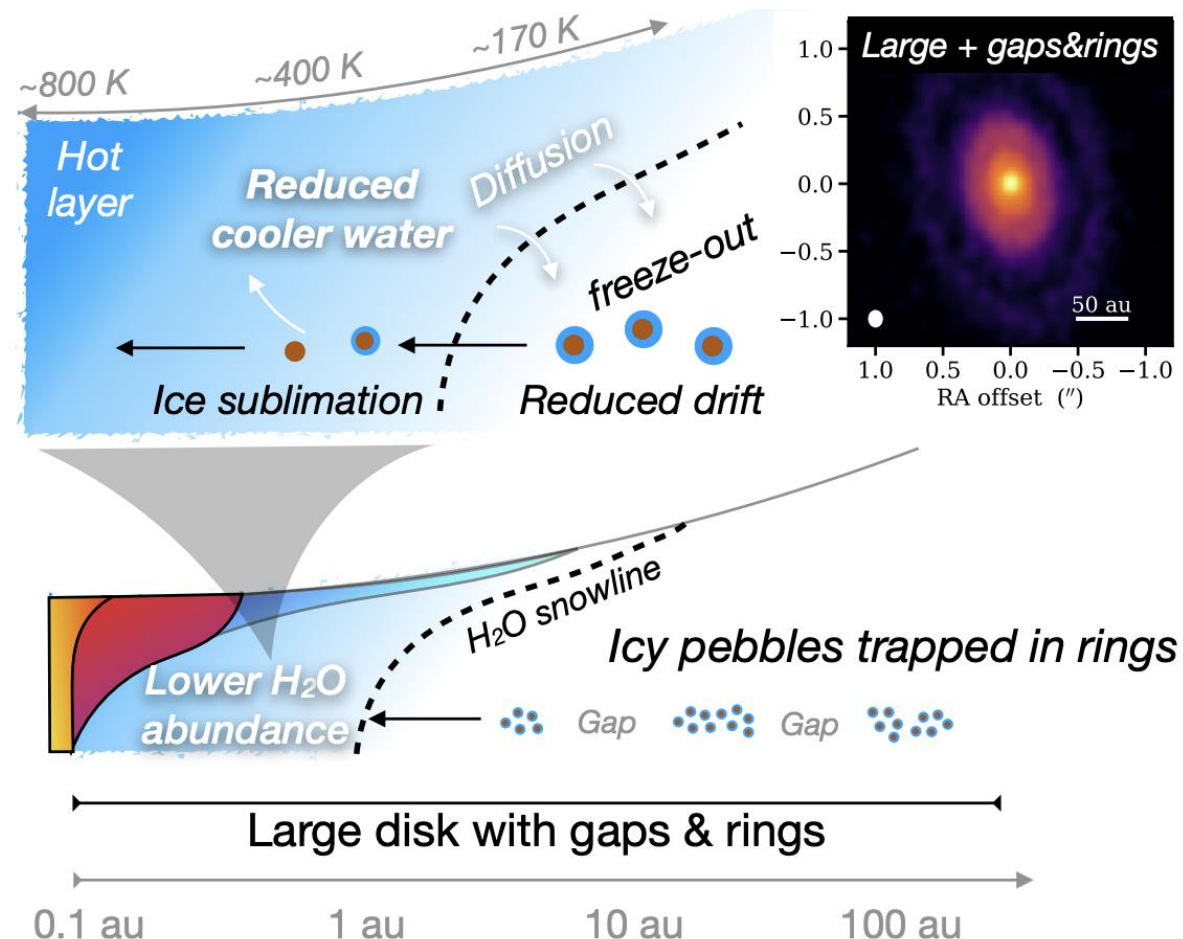
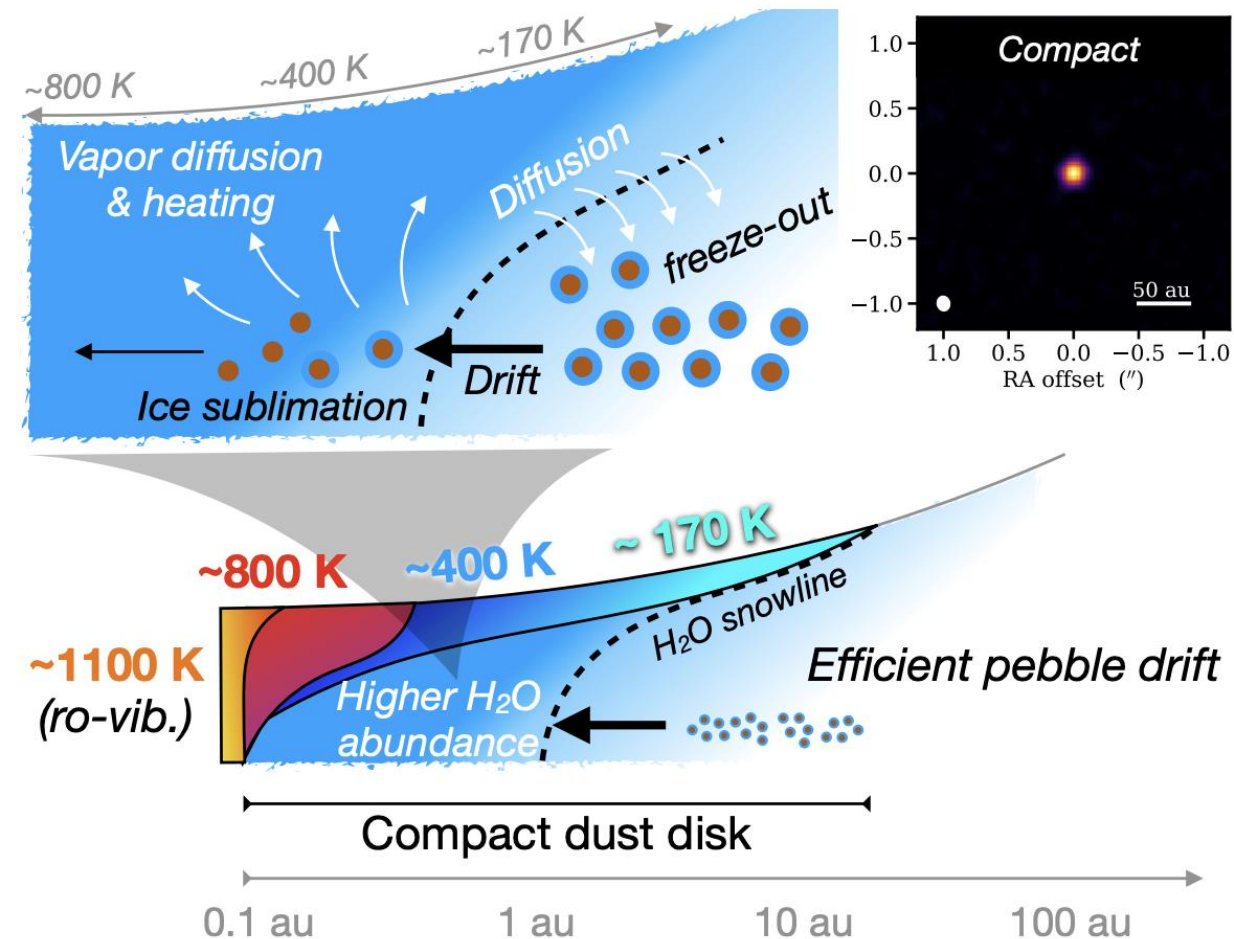
Revealing the planet-forming water in the Spitzer legacy surveys



~400 protoplanetary disks observed with JWST by cycle 4 (>1000 hours)



Enrichment of water by pebble drift



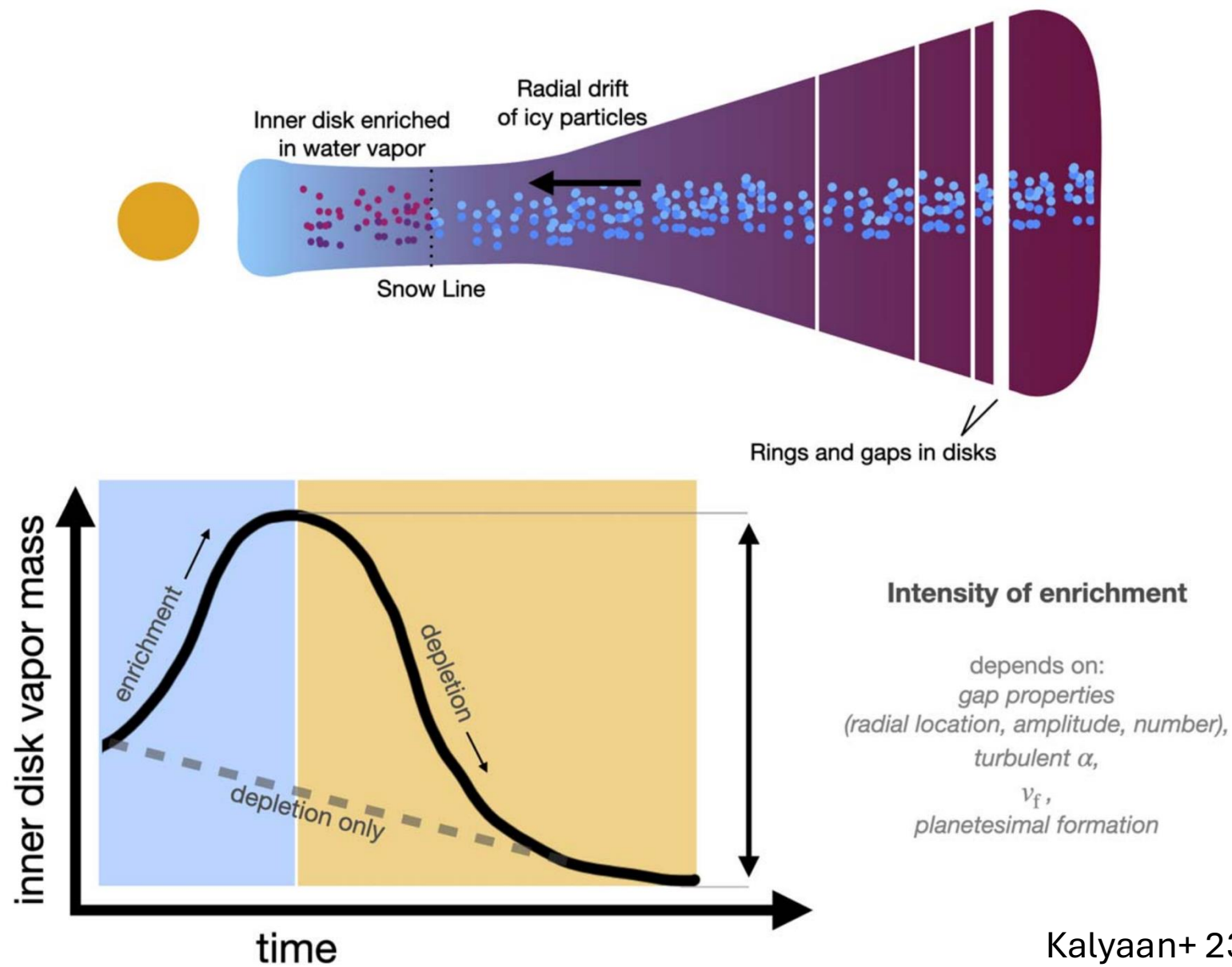
Pebble drift relative to small grains

VLT SPHERE – micron dust/gas
Avenhaus+ 2018

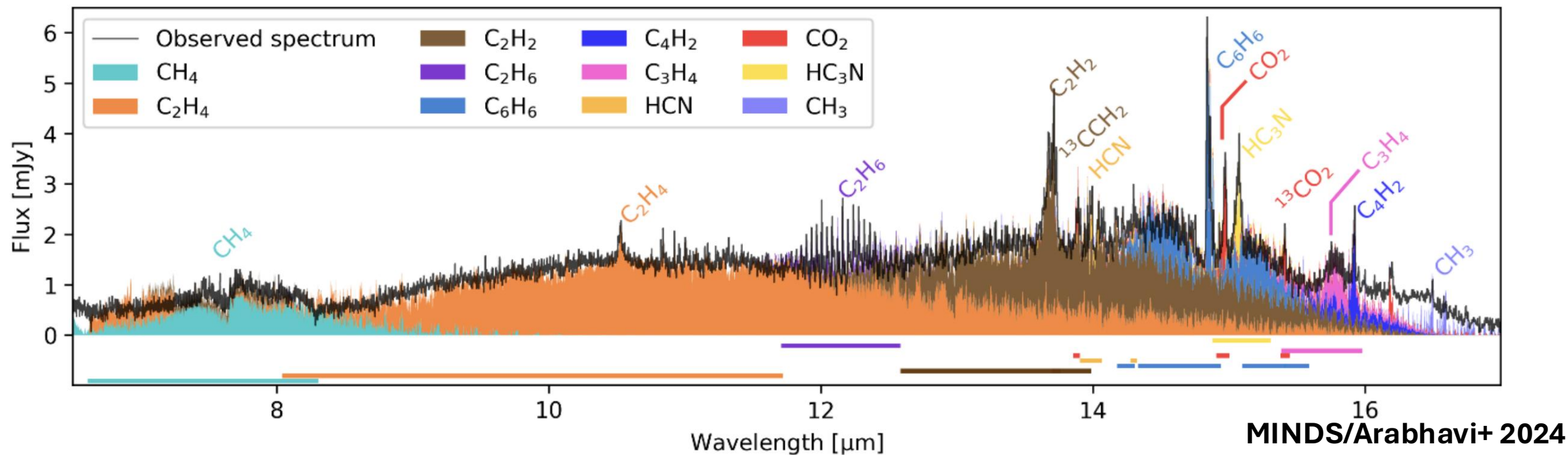


ALMA/DSHARP – mm dust

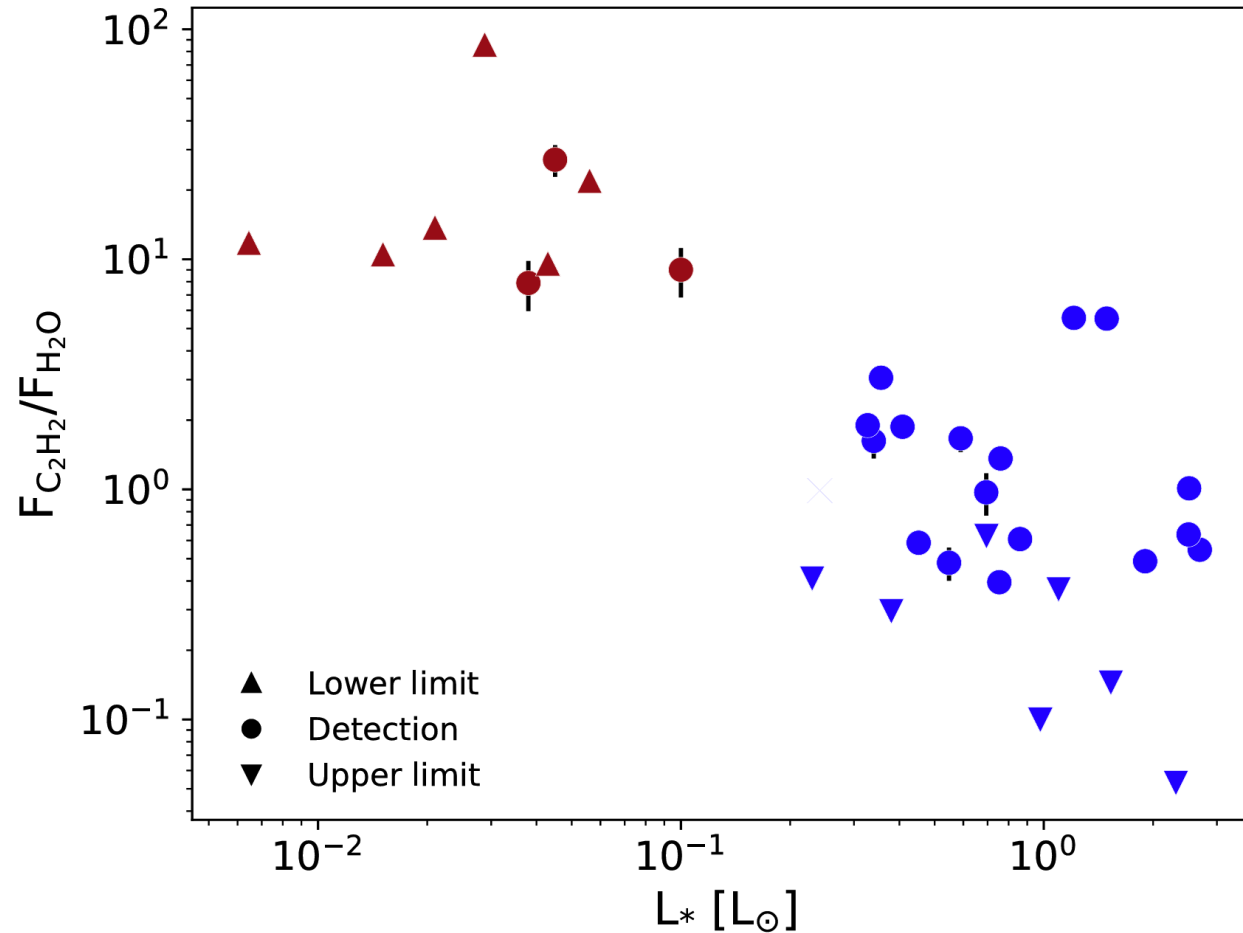
Evolution of volatile reservoir



Different carbon-chemistry in very low-mass disks



Different carbon-chemistry in very low-mass disks

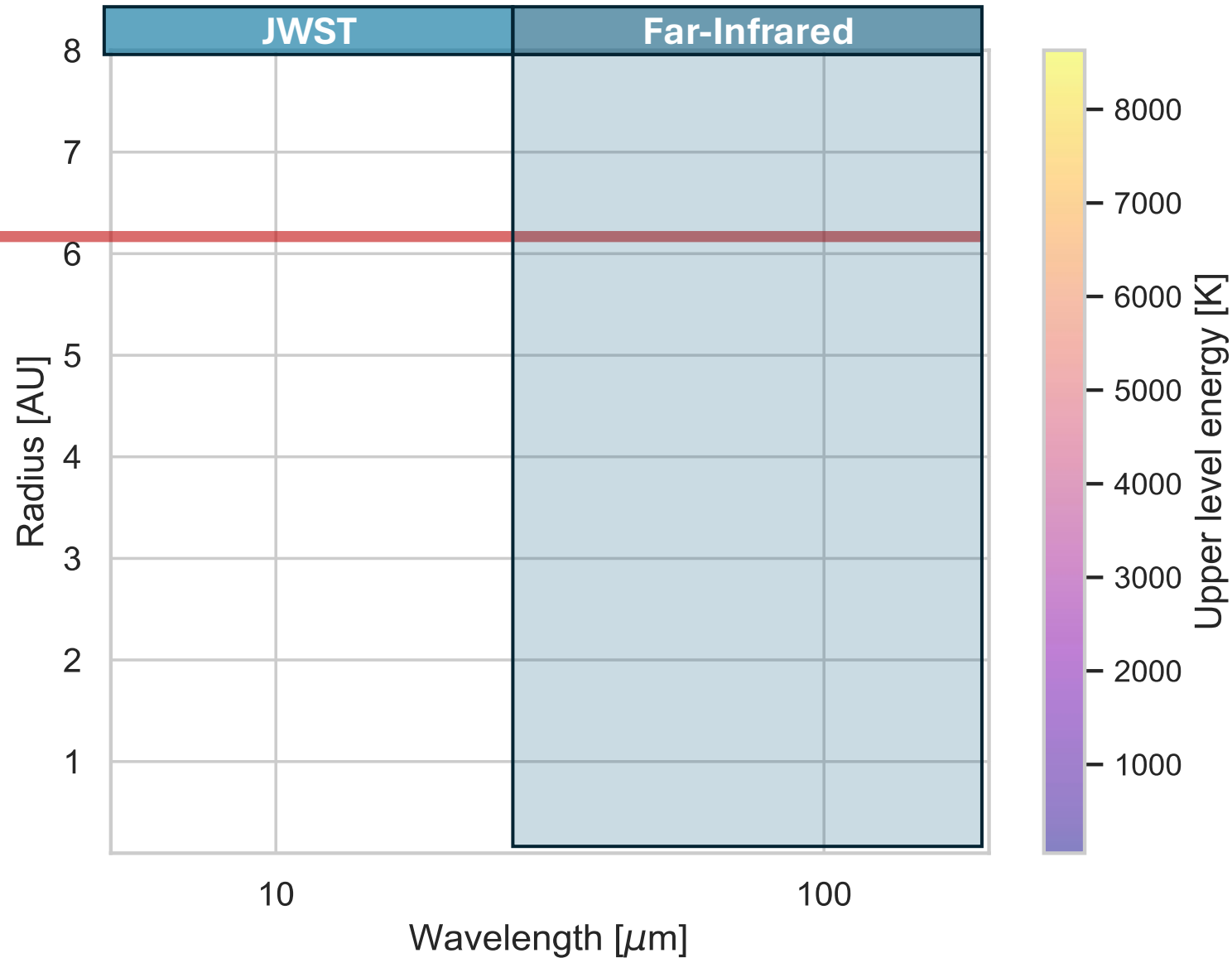


MINDS/Grant+ 2025

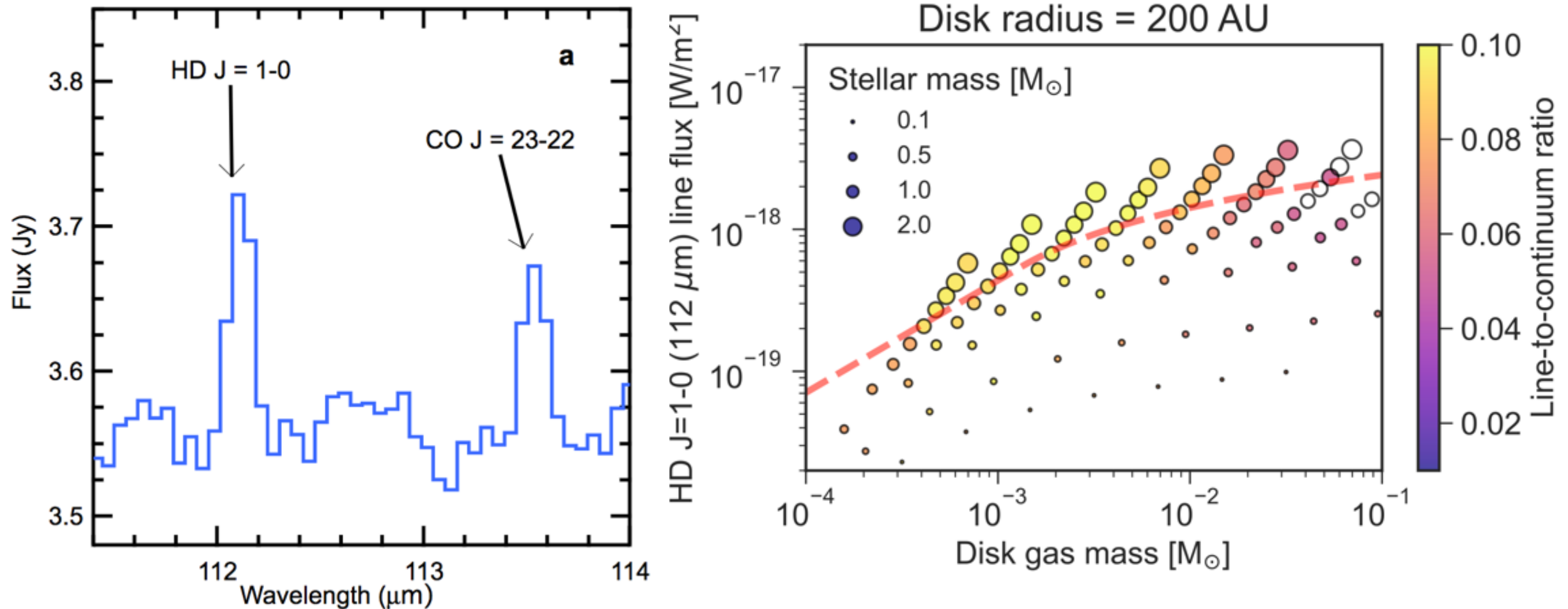


JWST does not trace the snowline / giant planet-forming regions

Snowline

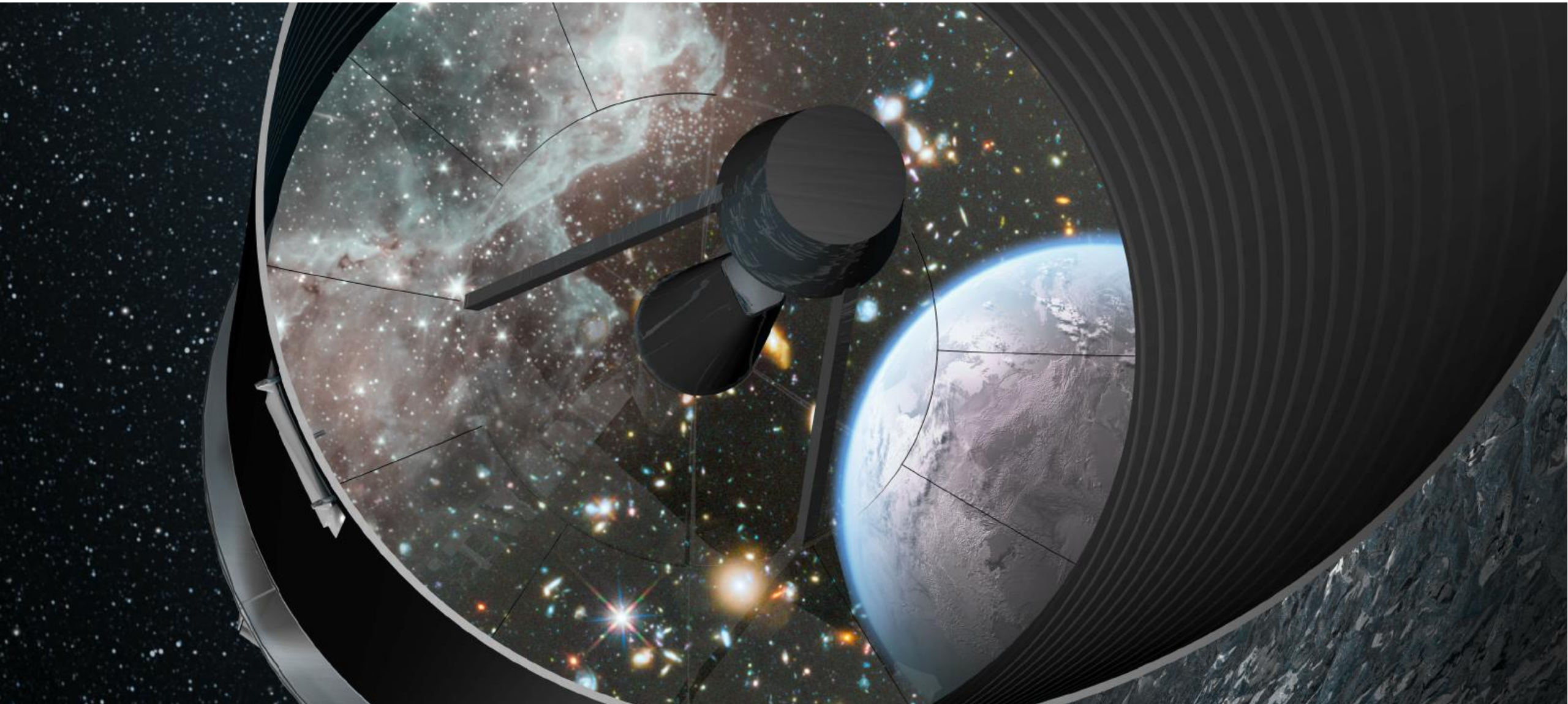


Total disk gas masses are uncertain – 112 micron HD best mass tracer



3 detections of HD with Herschel-PACS / Bergin+ 2013

2020 Astrophysics Decadal Origins Space Telescope concept



Origins: A Far-Infrared Flagship Observatory

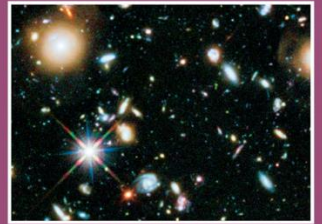
Origins Observatory Level Parameters	
Mission Parameter	Value
Telescope: Aperture Diameter/Area	5.9 m/25 m ²
Telescope Diffraction Limited at	30 μm
Telescope Temperature	4.5 K
Wavelength Coverage	2.8–588 μm
Maximum Scanning Speed	60" per second
Mass: Dry/Wet (with margin)	12000 kg/13000 kg
Power (with margin)	4800 W
Launch Year	2035
Launch Vehicle (large vehicle)	SLS or Space-X BFR
Orbit	Sun-Earth L2
Propellant lifetime	10 years, serviceable



HOW DOES THE UNIVERSE WORK?

How do galaxies form stars, make metals, and grow their central supermassive black holes from reionization to today?

Using sensitive spectroscopic capabilities of a cold telescope in the infrared, Origins will measure properties of star-formation and growing black holes in galaxies across all epochs in the Universe.



HOW DID WE GET HERE?

How do the conditions for habitability develop during the process of planet formation?

With sensitive and high-resolution far-IR spectroscopy Origins will illuminate the path of water and its abundance to determine the availability of water for habitable planets.



ARE WE ALONE?

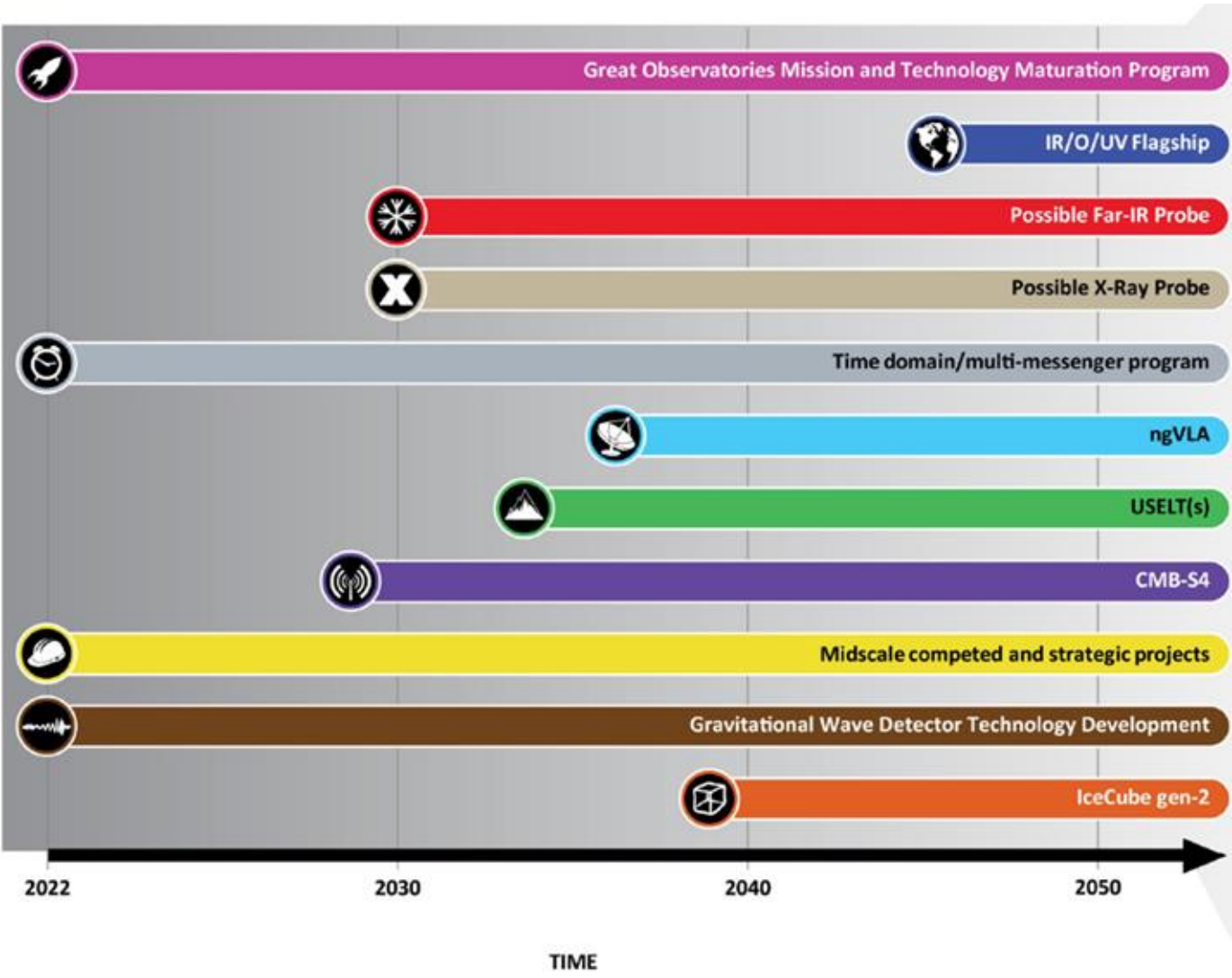
Do planets orbiting M-dwarf stars support life?

By obtaining precise mid-infrared transmission and emission spectra, Origins will assess the habitability of nearby exoplanets and search for signs of life.



SCIENCE DRIVERS FOR MISSION DESIGN

PRIMA is the Far-IR probe mission concept



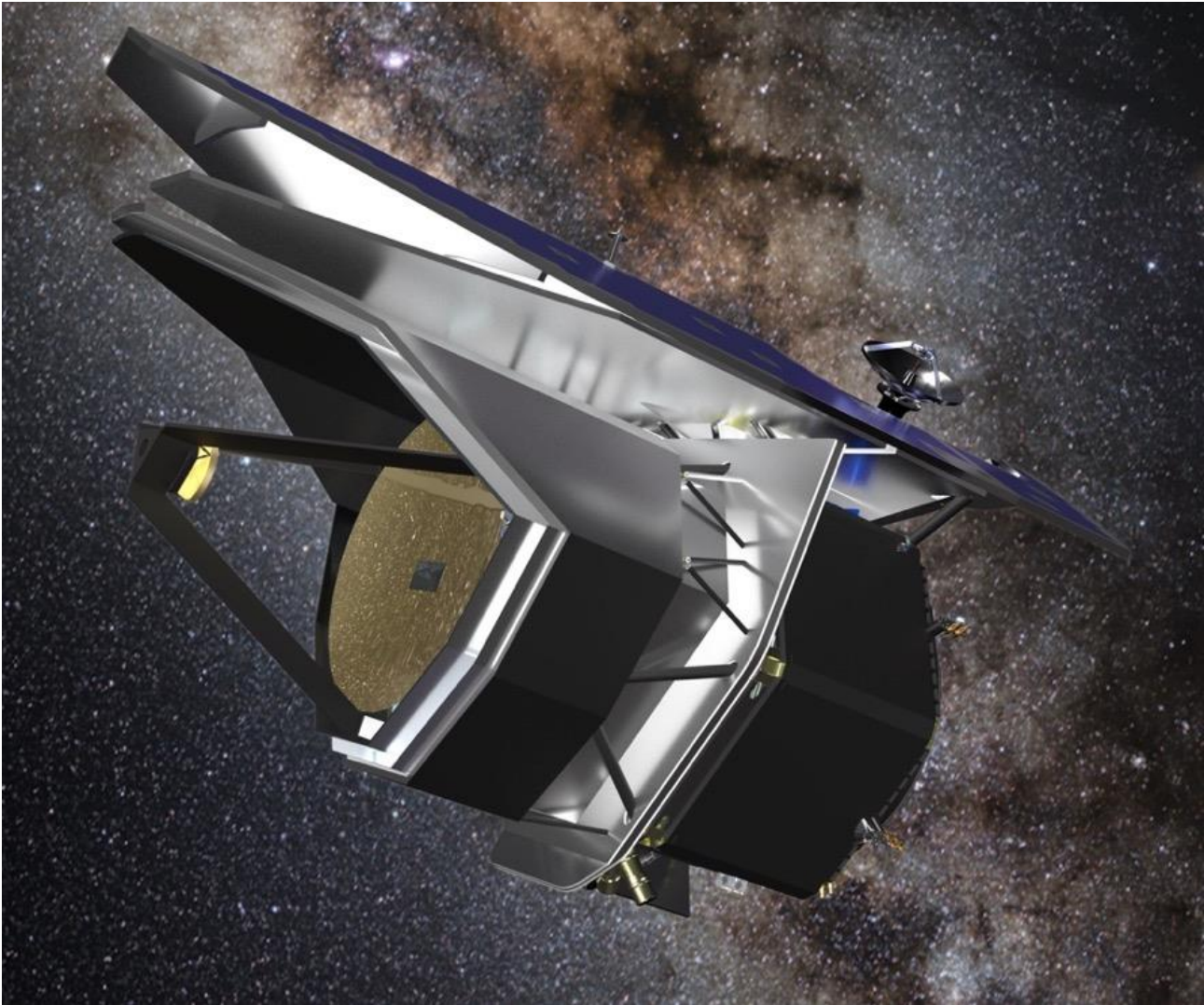
HWO



PRIMA

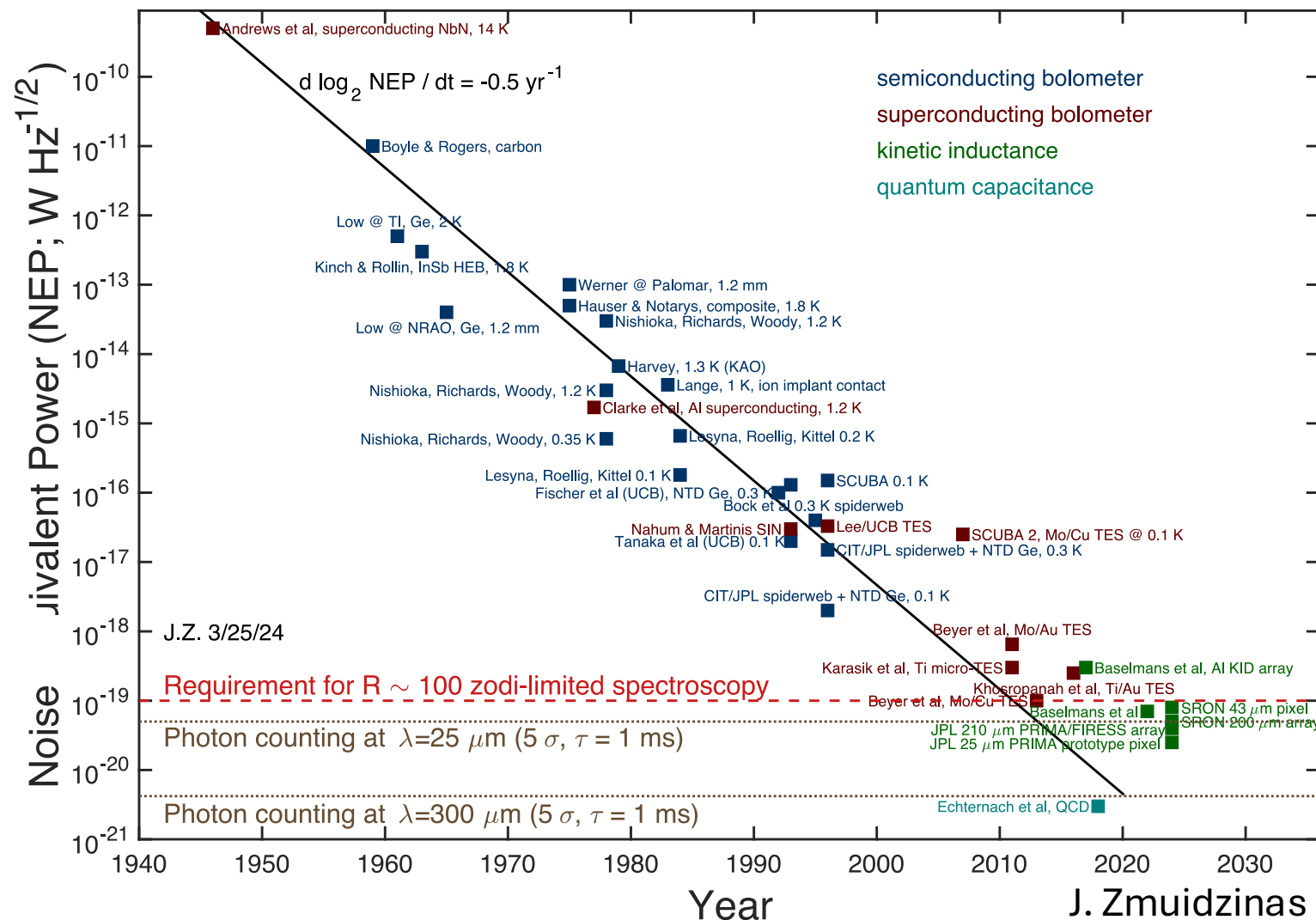
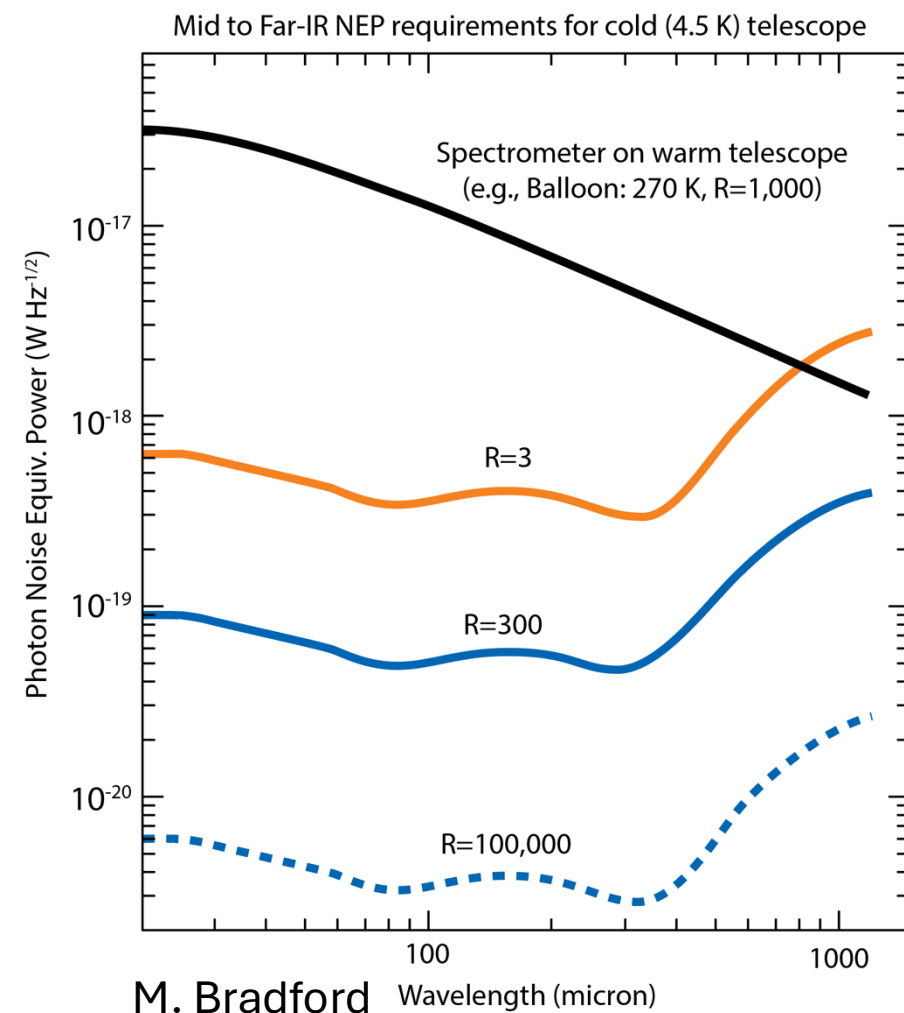


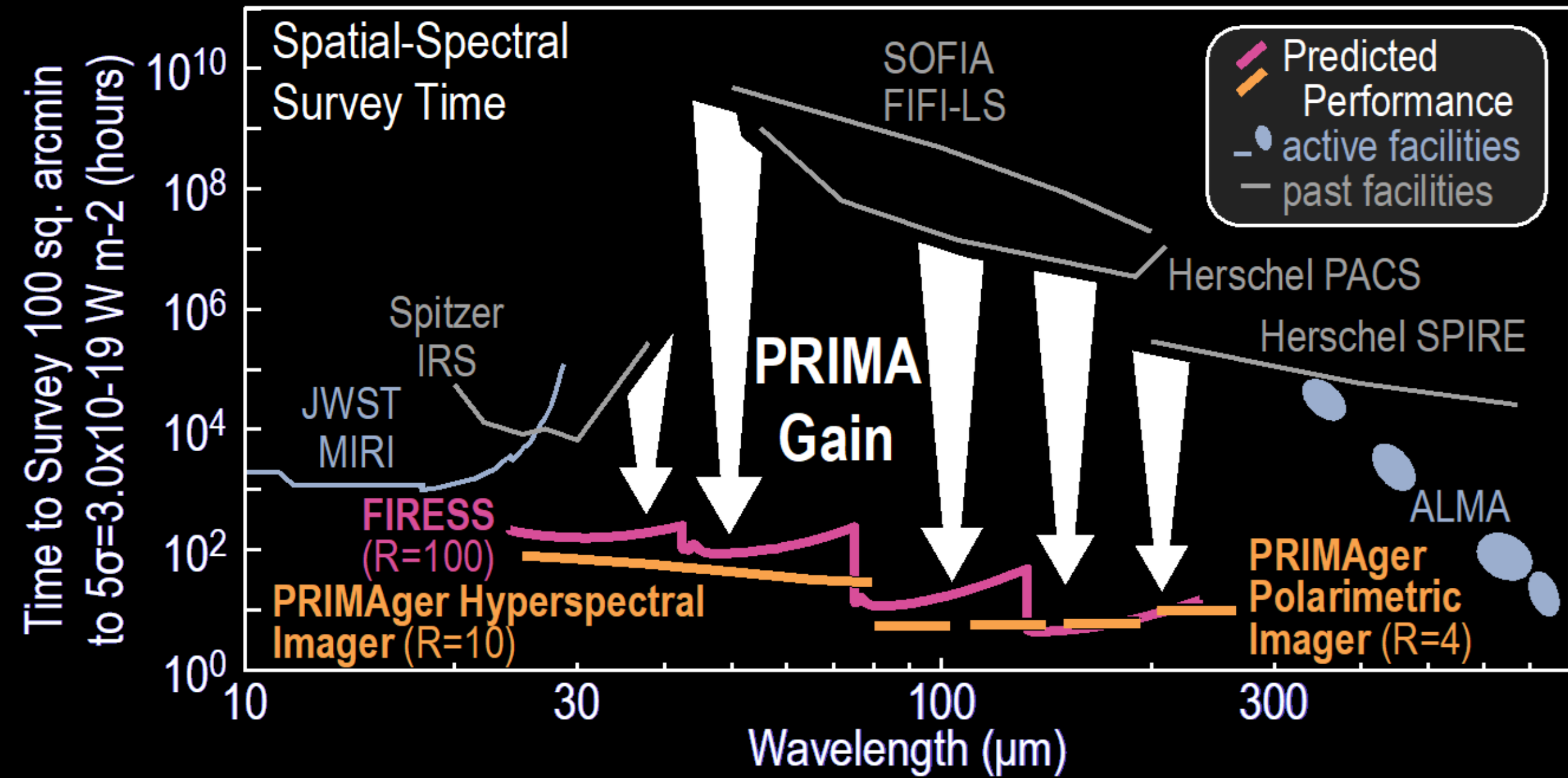
PRIMA



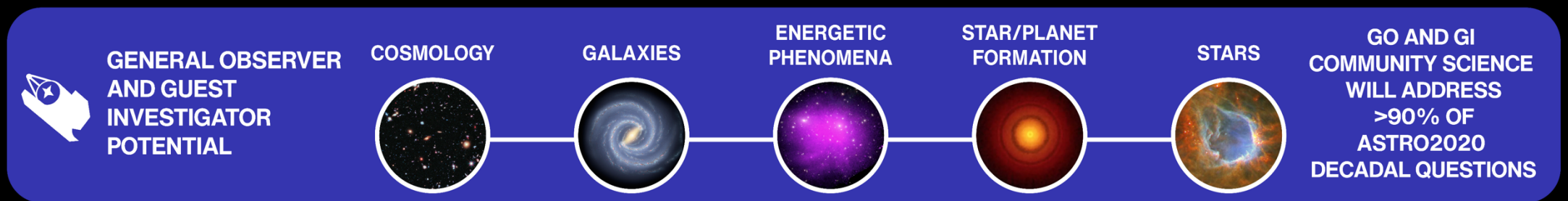
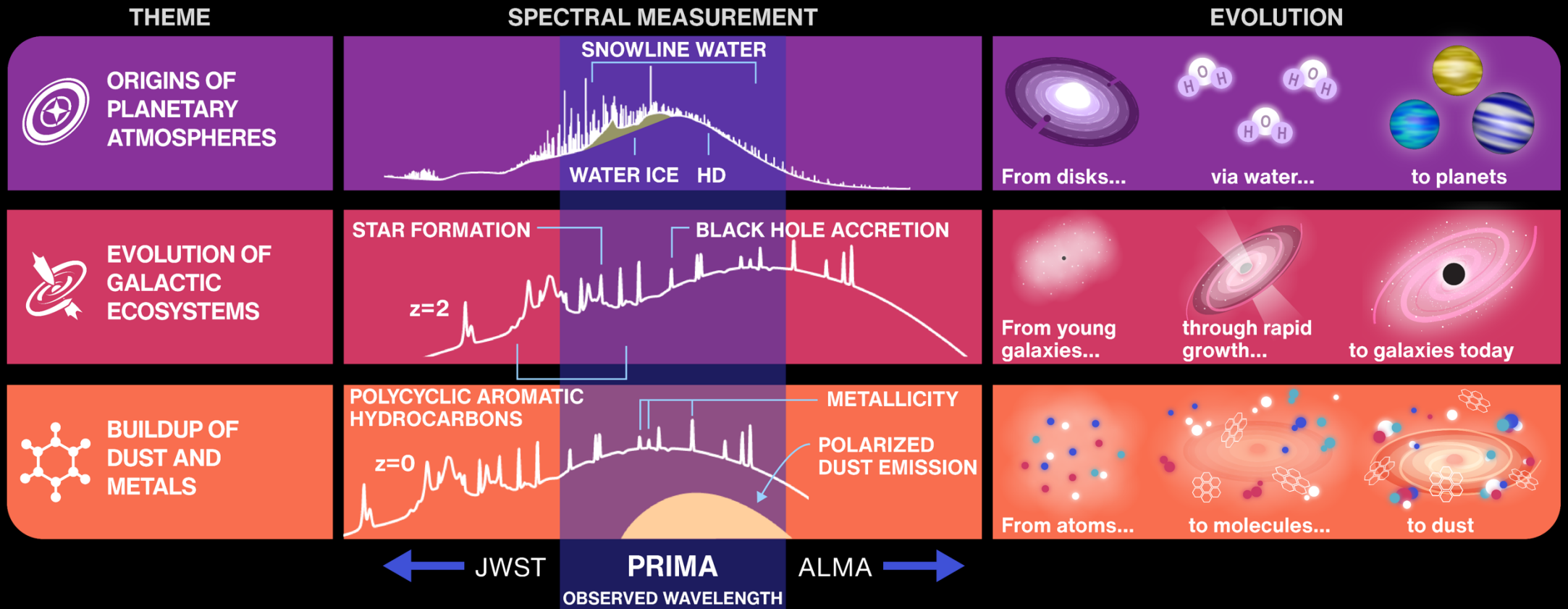
Telescope	1.8-m, all aluminum, 4.5 Kelvin
PRIMAger Imager & polarimeter	R = 8 hyperspectral imaging 25-80 μm R= 4 imaging & polarimetry 91-261 μm
FIRESS Spectrometer	R > 85 spectroscopy 24-235 μm High-Res mode R = 4,400 $\times$ ($112\mu\text{m}/\lambda$)
Detectors	100 mK KID arrays (~12k total)
Data	IPAC
Orbit	Earth-Sun L2
Launch	2032
Observations	75% GO, 25% PI ($\rightarrow$ GI)

Far-infrared technology: Large cold telescope + sensitive detectors

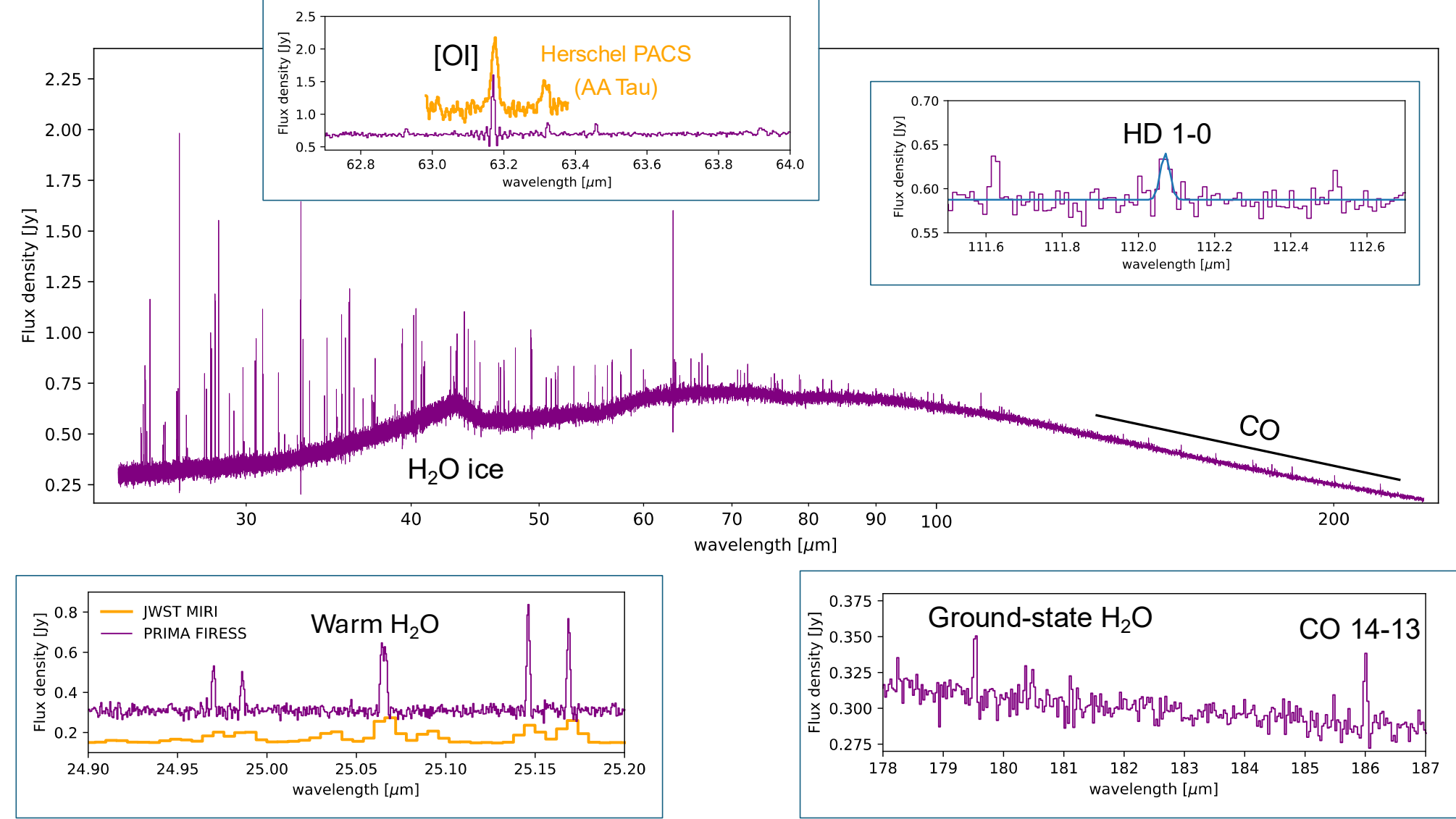


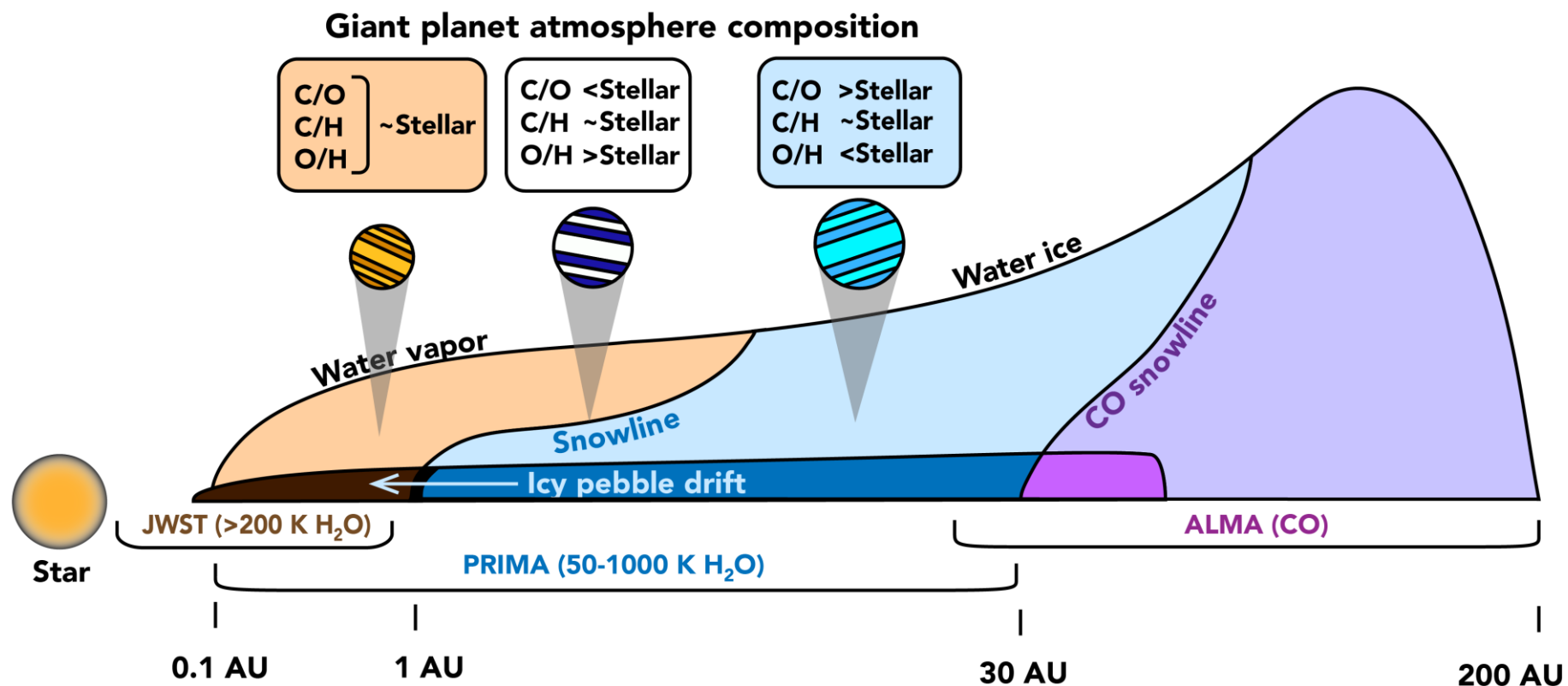
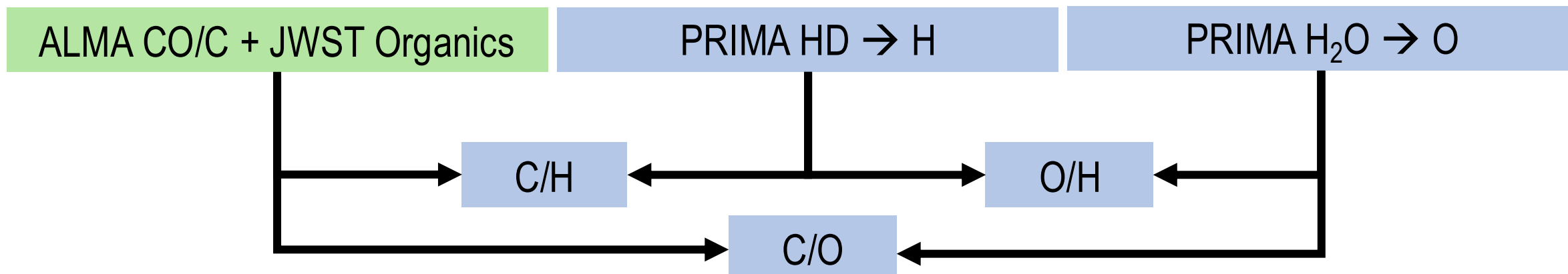


PRIMA Unveils our Cosmic Origins in the Far-Infrared



Simulated observation of a typical protoplanetary disk with PRIMA-FIRESS





Learn more

PRIMA webpage:
<https://prima.ipac.caltech.edu>

Quarterly newsletter (sign up on
website)

Monthly talks series P-CAST
(4th Monday of the month, 12pm
Eastern)

Jason Glenn, Principal Investigator, GSFC
Margaret Meixner, Deputy PI, JPL
Matt Bradford, Project Scientist, JPL
Klaus Pontoppidan, Deputy Project Scientist, JPL
Alexandra Pope, Science Lead, UMass Amherst
Tiffany Kataria, Deputy SL, JPL
Jenn Rocca, Proposal Capture Lead, JPL

