Circumstellar Disks in Young and Old Main-Sequence Stars

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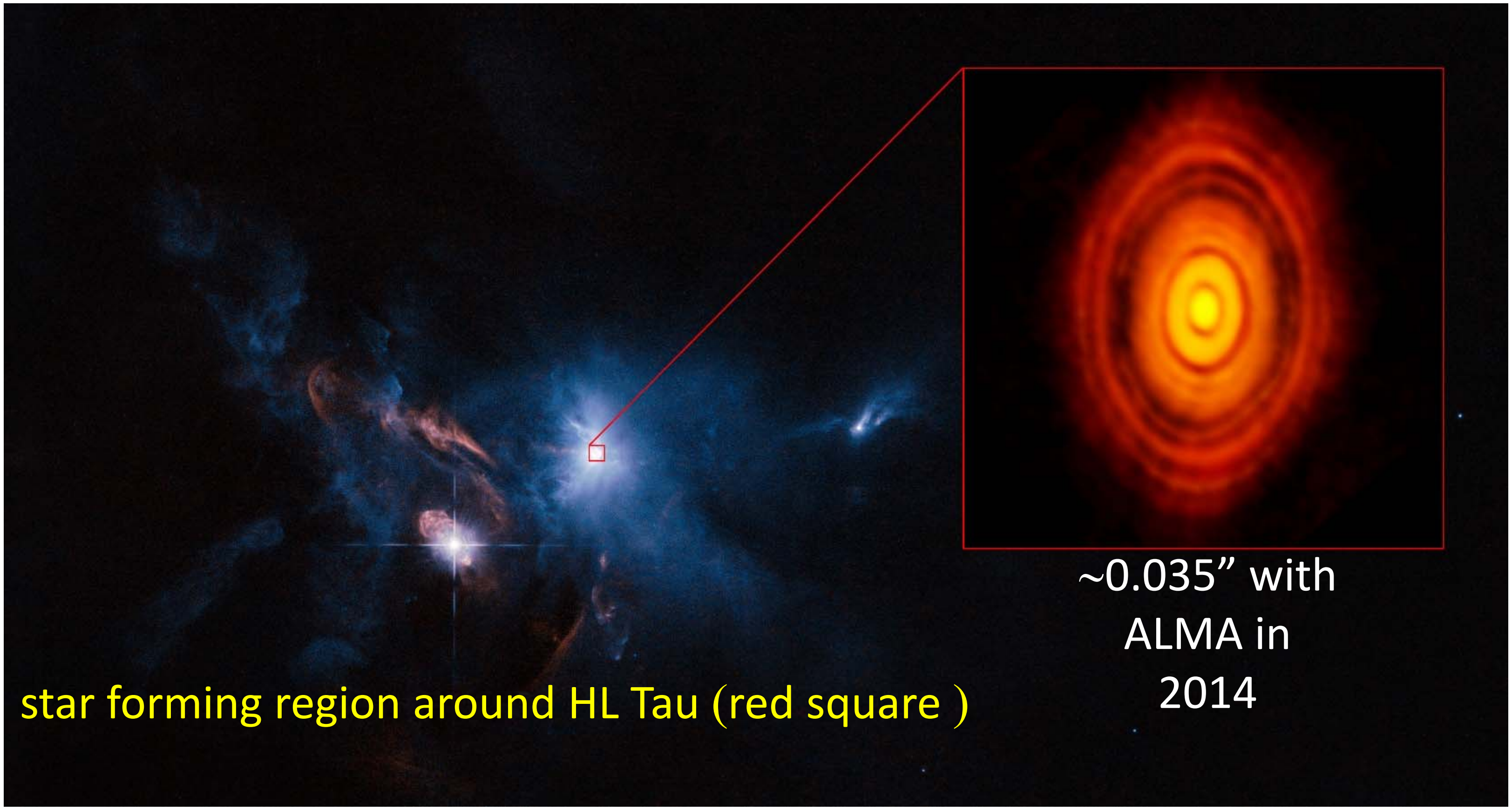
Circumstellar Disks at All Stages of Stellar Evolution

- Pre-Main Sequence: protoplanetary disks (see review by Andrews+2015)

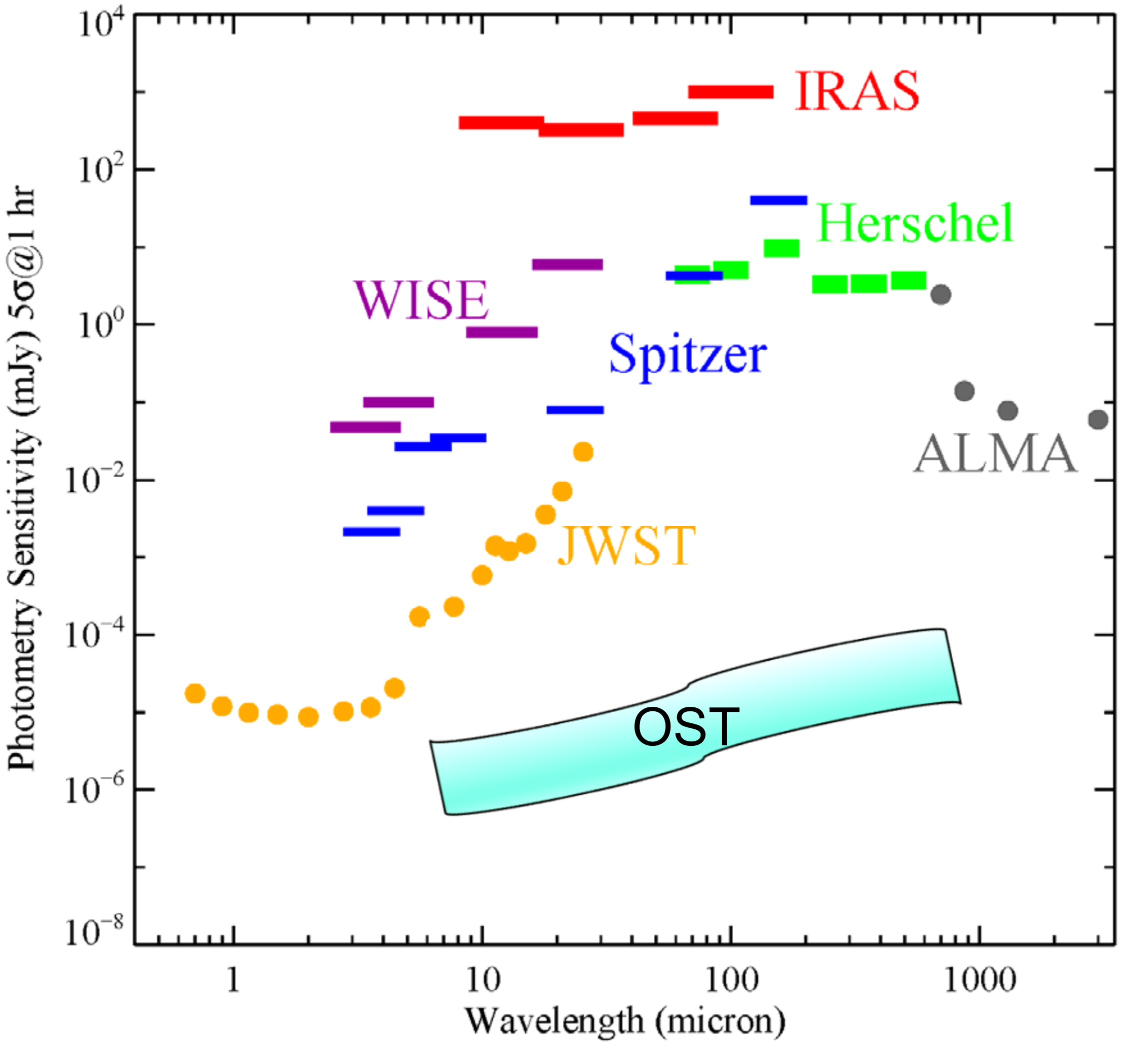


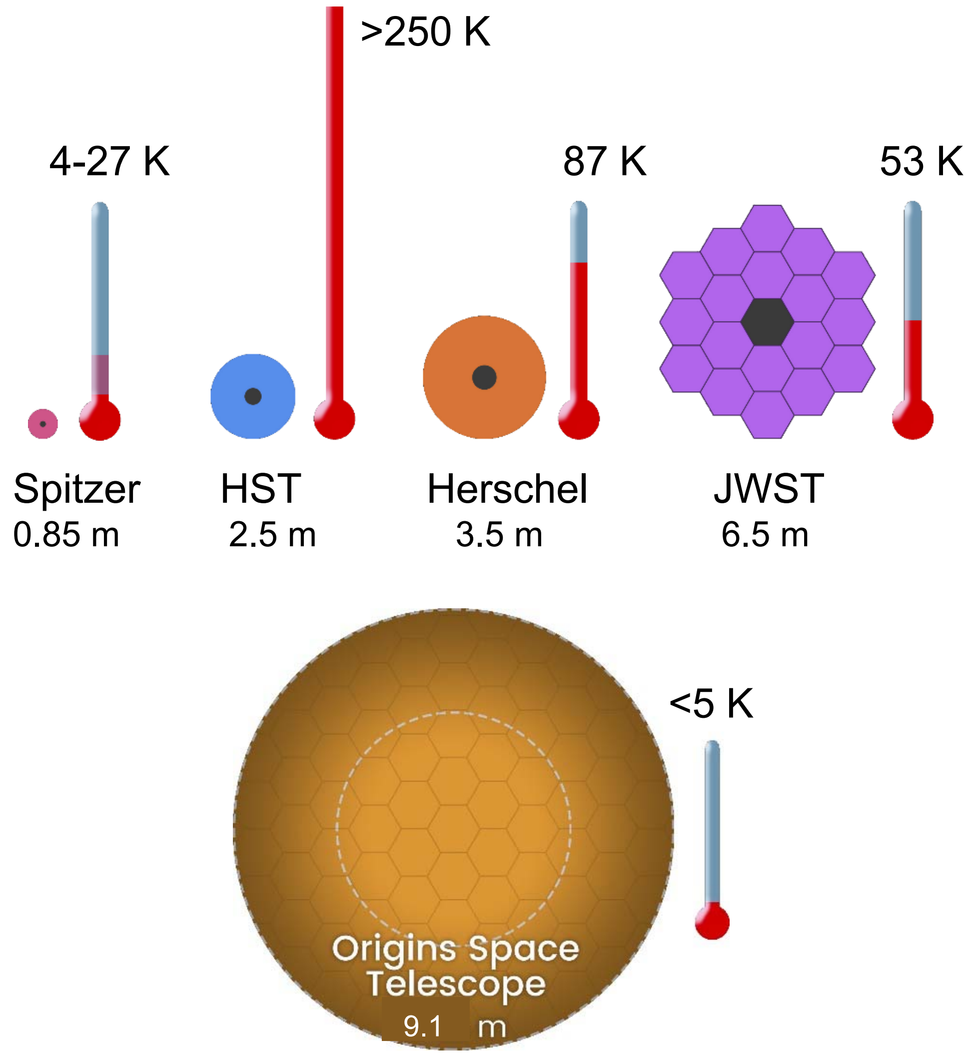
- **Main Sequence: debris disks** (see review by Matthews+2014)
- Post-Main Sequence: dusty disks around white dwarfs (see review by Farihi2016)

Also see "Circumstellar Disks: What will be next?" by Kral, Clarke & Wyatt, astroph/1703.08560

New Capabilities Enable New Discoveries

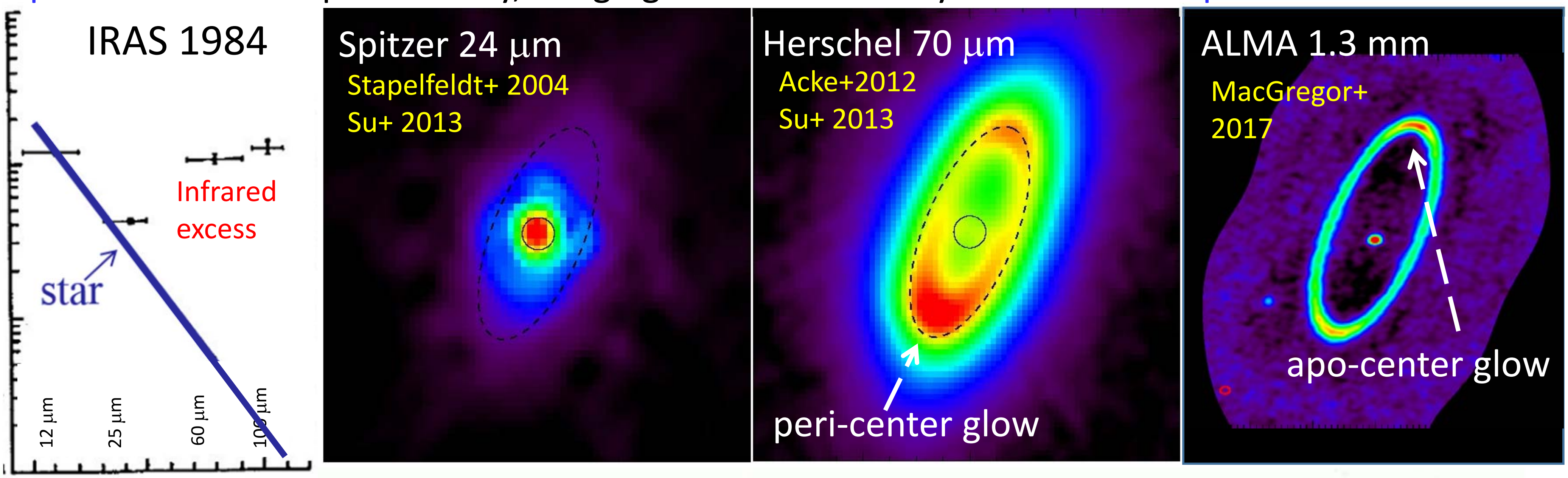
- Wavelength Coverage
- Sensitivity ← telescope size + mirror temperature
- Resolution in both spectral and spatial
- Time Domain

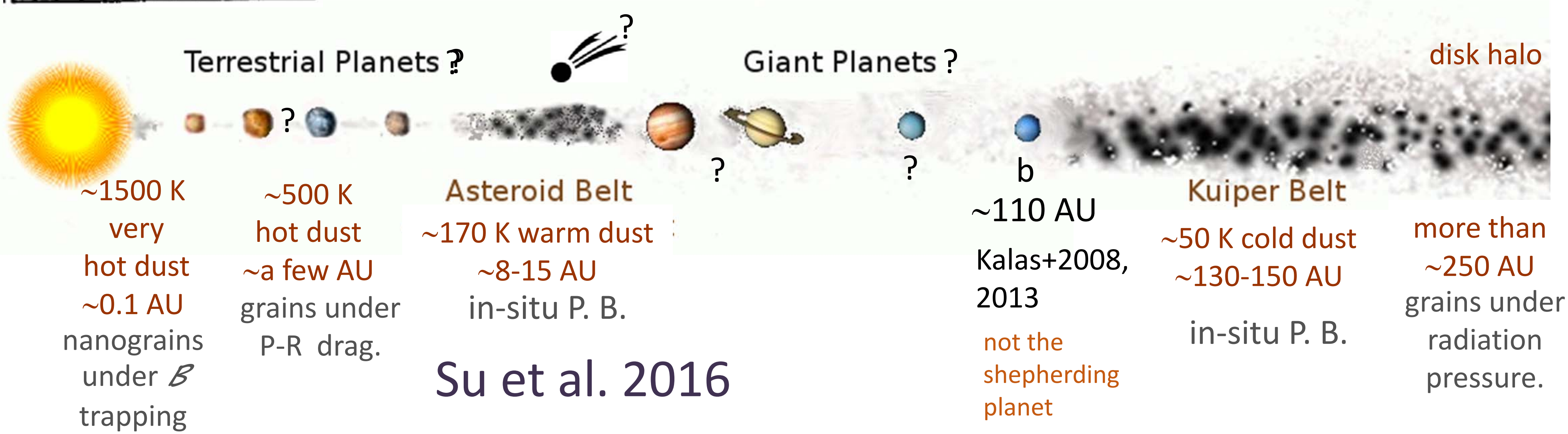




Tremendous Strides in the Last Three Decades

The Fomalhaut debris disks: a wealth of observations at a wide range of wavelengths and spatial scales from photometry, imaging to interferometry reveal the complex disk structures.

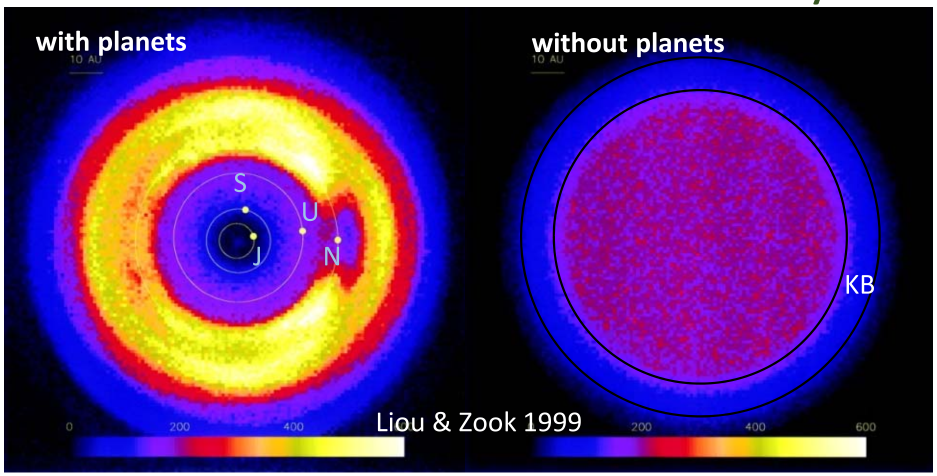




The Need for Spatial Resolution

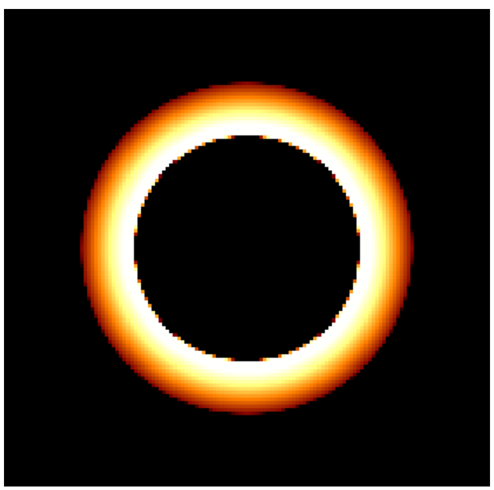
Planets determine the planetesimals distribution in a planetary system. Dust debris, generated by planetesimals, also influences by non-gravitational forces, and their resultant emission is temperature dependent.

- Particle Distribution for Solar System

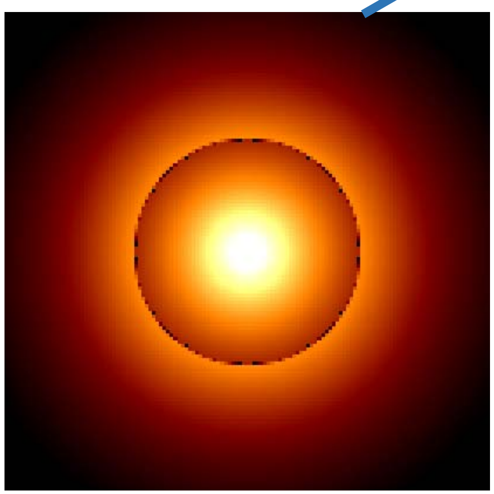


The dilemma in
ε Eri using Spitzer
observations:
multiple belts?
or one belt?

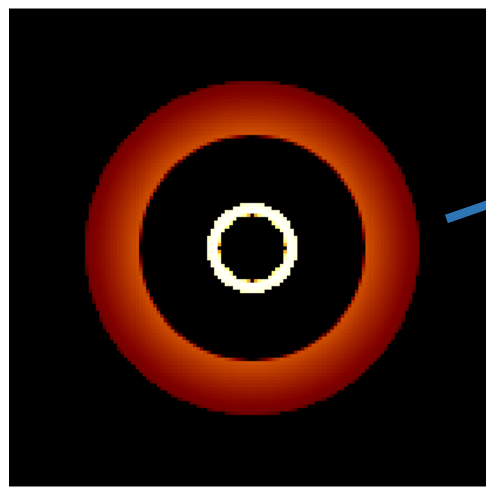
- Mid-Infrared Emission Distribution



one belt w/ planets

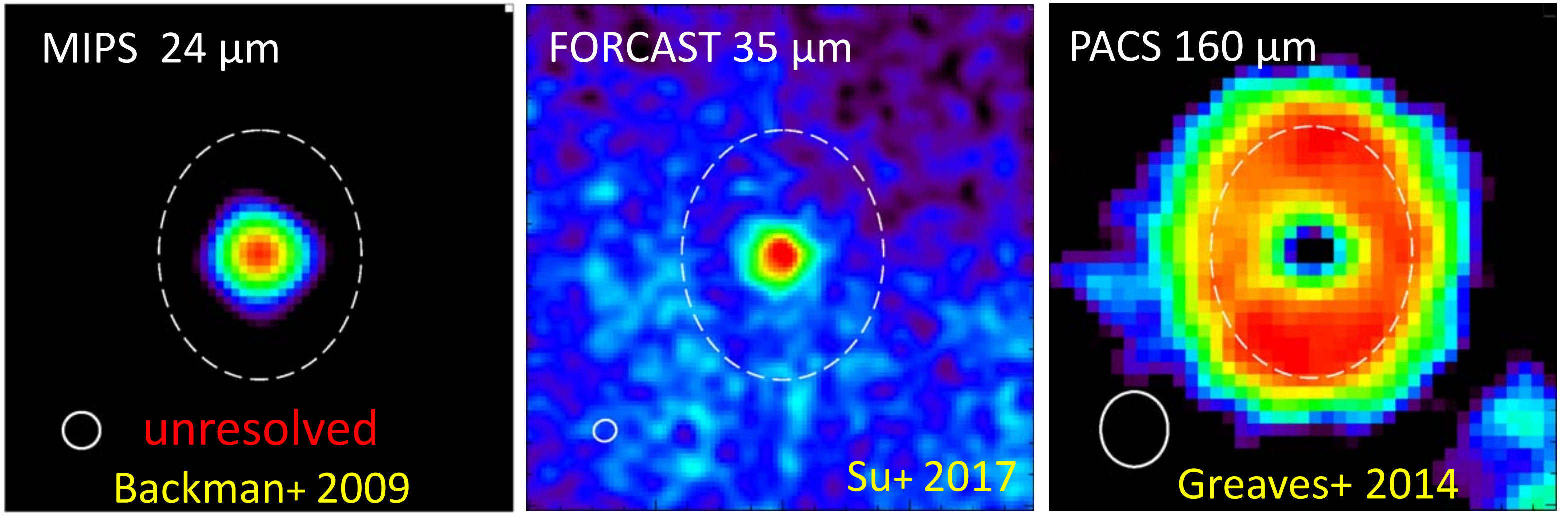


one belt w/o planet



two belts w/ planets

The Inner Debris Structure in ε Eri?

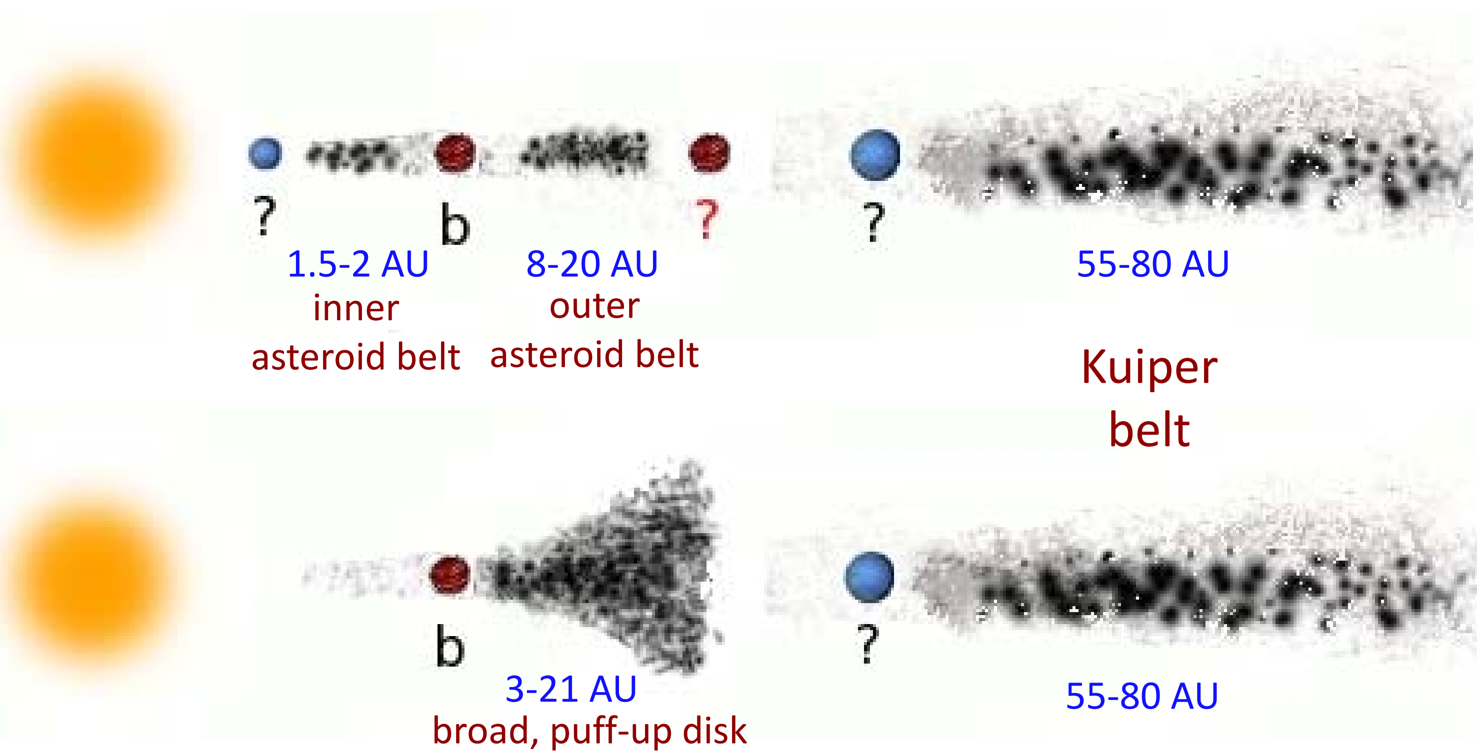


two narrow inner belts?

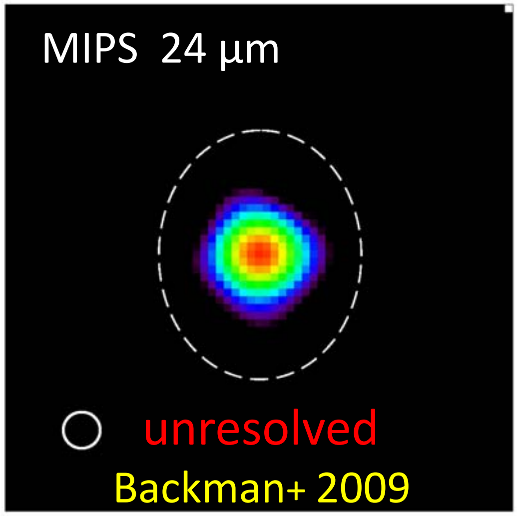
Backman+ 2009
Su+ 2017

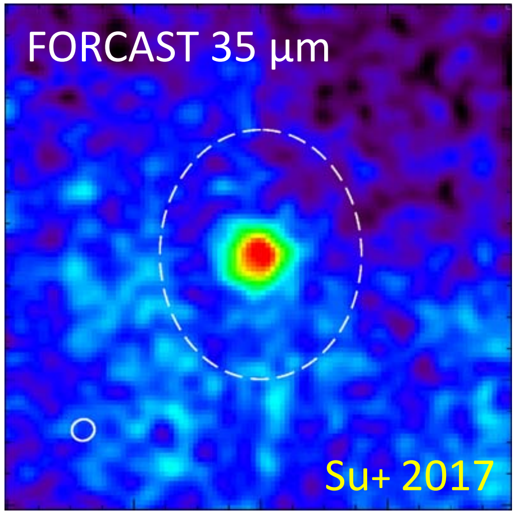
one broad puff-up disk?

Greaves+ 2014



The Inner Debris Structure in ε Eri?





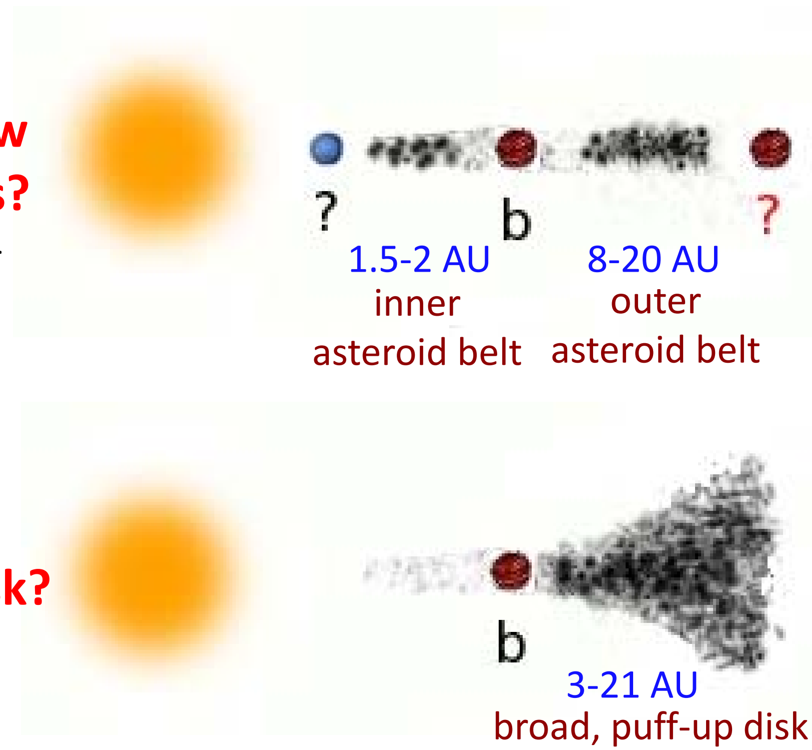
The sub-arcsec resolution enabled by JWST observations will resolve the inner debris structure in ε Eri, and settle the long debate between two inner belts or one broad disk.

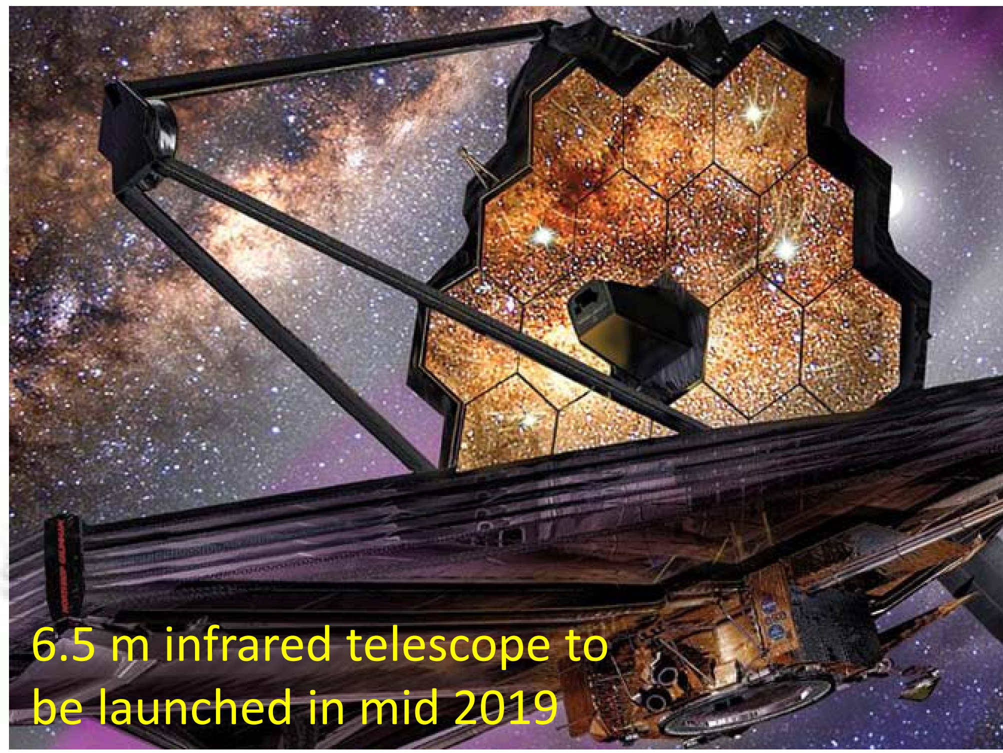
two narrow inner belts?

Backman+ 2009
Su+ 2017

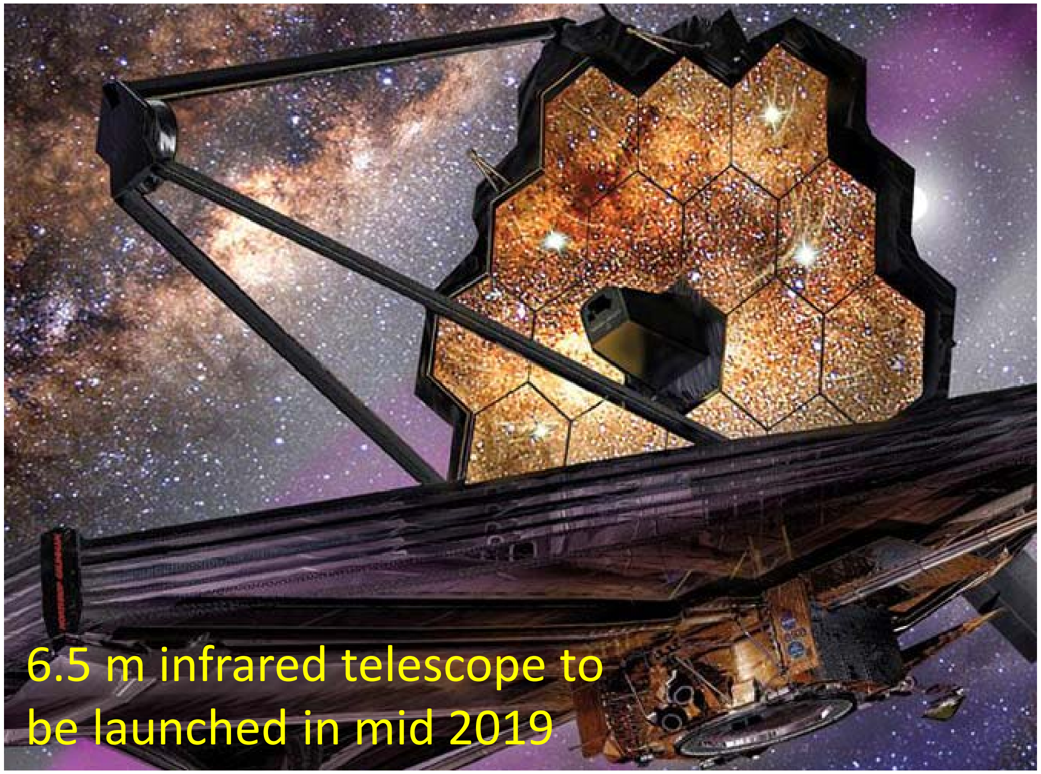
one broad puff-up disk?

Greaves+ 2014



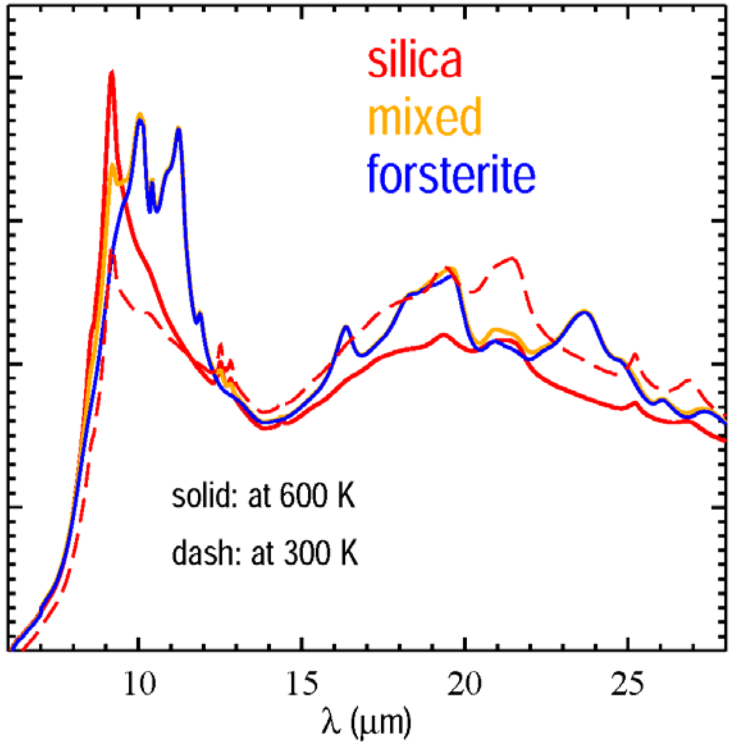


High Spatial & Spectral Resolutions of JWST



A suite of instruments (NIRCam, NIRSpec, MIRI, FGS/NIRISS) capable of performing high-resolution imaging and spectroscopy from 0.6 to 28 μm.

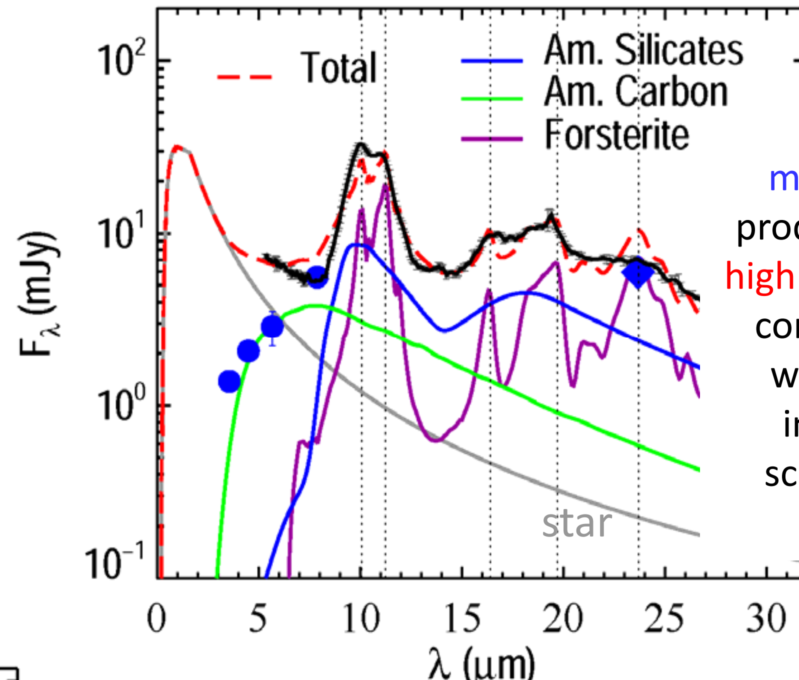
In addition to new discoveries, JWST will provide a great opportunity to extend and follow-up the legacy started by Spitzer with much more powerful capabilities.



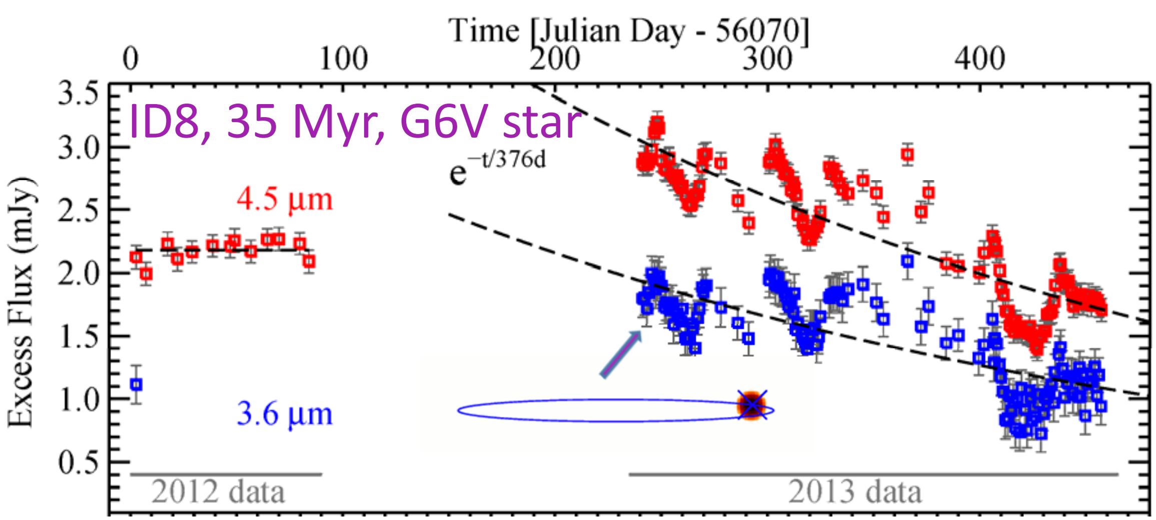
Mid-infrared spectra from thermodynamically altered minerals (various forms of crystalline silicates) can probe the physical conditions of violent events in the disks.

Extreme Debris Disks: Tracers for Large Impacts

Systems around young stars (~10 Myr to 200 Myr) with large amounts of dust in the terrestrial zone and prominent silicate features. ~50% of them show disk variability at 3.6/4.5 μm (Meng, Su+ 2015; Su+ 2018, in prep.).



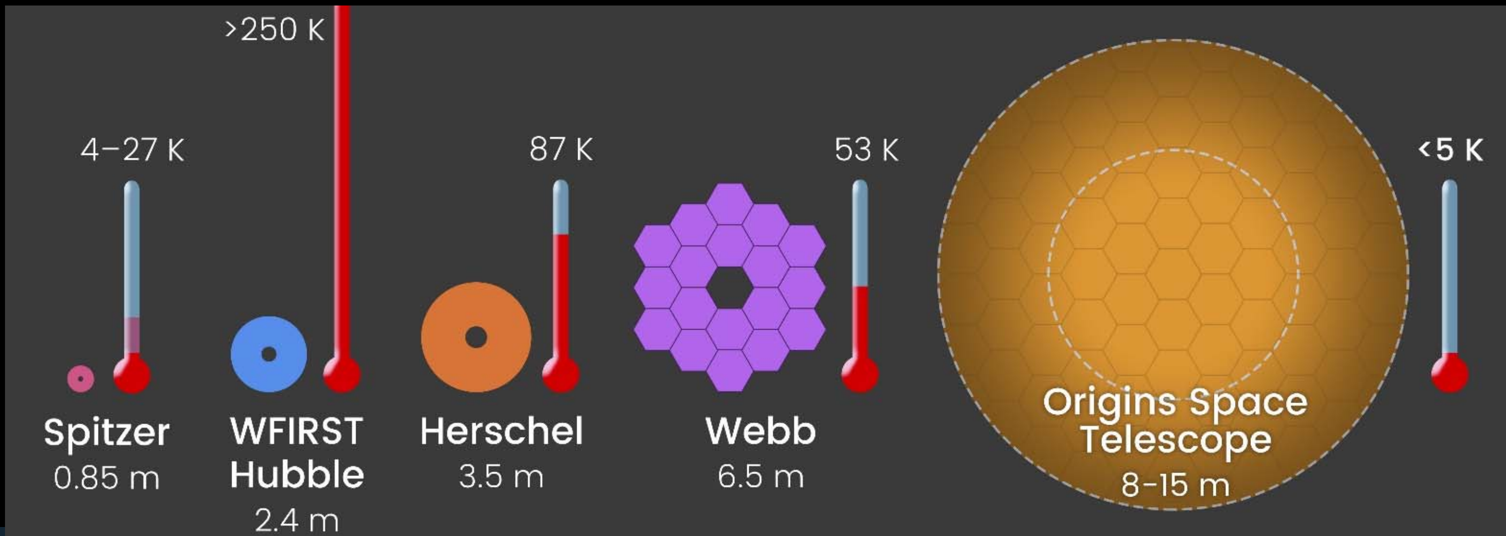
minerals produced by high T events, consistent with the impact scenario.



Mid-infrared spectra from Spitzer and JWST will enable time-series study in extreme debris disks, providing much needed constraints on terrestrial planet formation theories.

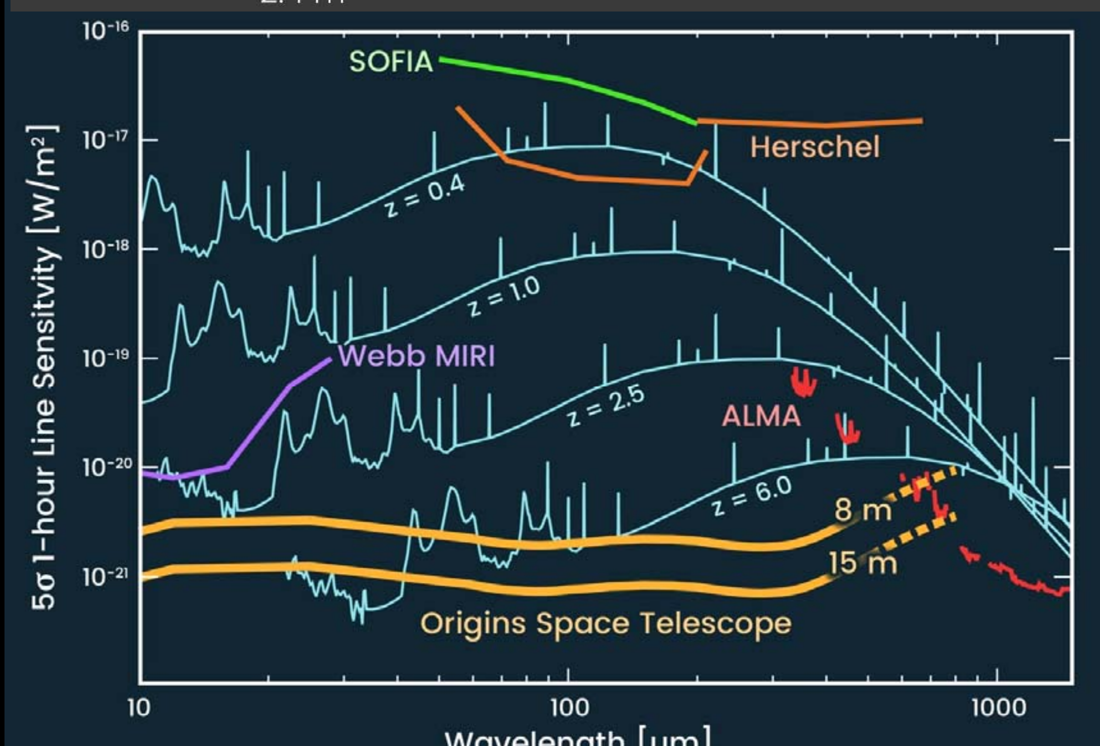
ORIGINS Space Telescope

Technical Specifications



Actively-Cooled Large Aperture

- Attain sensitivities 100-1000x greater than any previous far-IR telescope.
- Diffraction limited at ~30 μm



Timeline

Wavelength Coverage

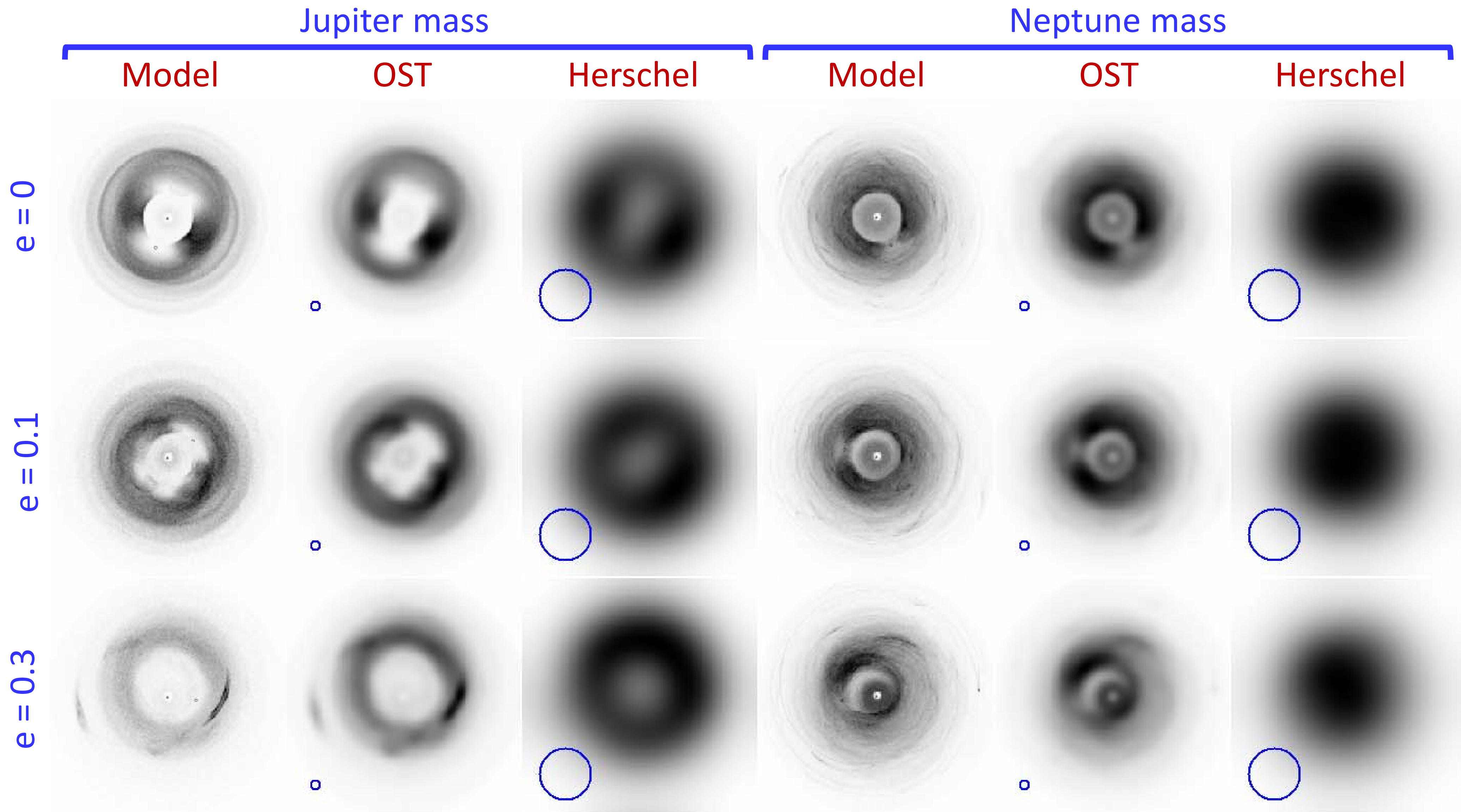
Visit our websites:

origins.ipac.caltech.edu

asd.gsfc.nasa.gov/firs

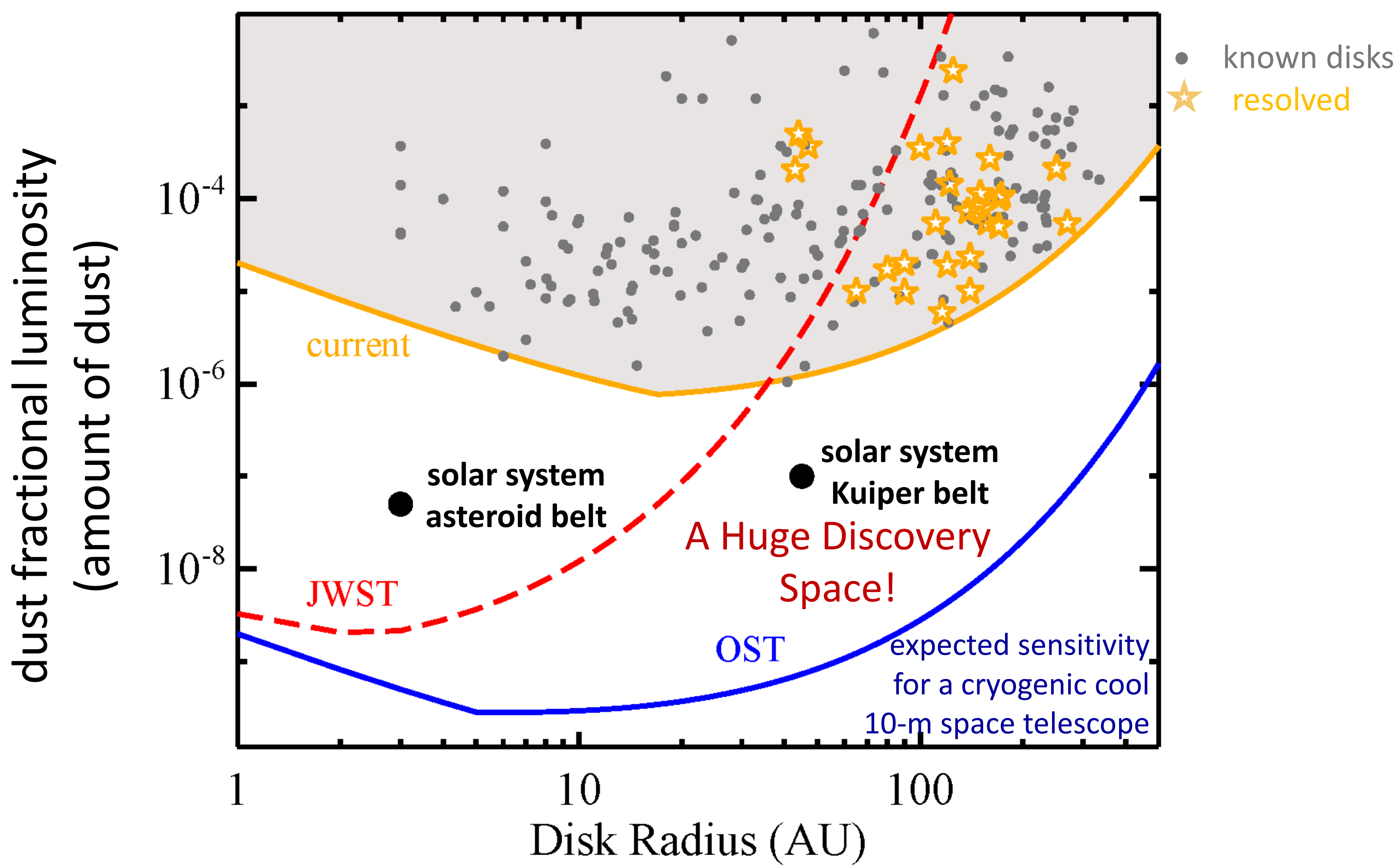
The Power of Spatial Resolution with OST

Planet-Disk Interaction - structures created by planet(s)



Models are the dust density distributions from Deller & Maddison (2005) with various planet masses and eccentricities, which are observed with 1” (OST, concept 1) and 5.6” (Herschel) resolutions.

The Power of Sensitivity with OST



A large, cryogenic cold telescope (like OST) can discover many more disks, and provide a census of true Kuiper-belt analogs, putting our Solar System into context.