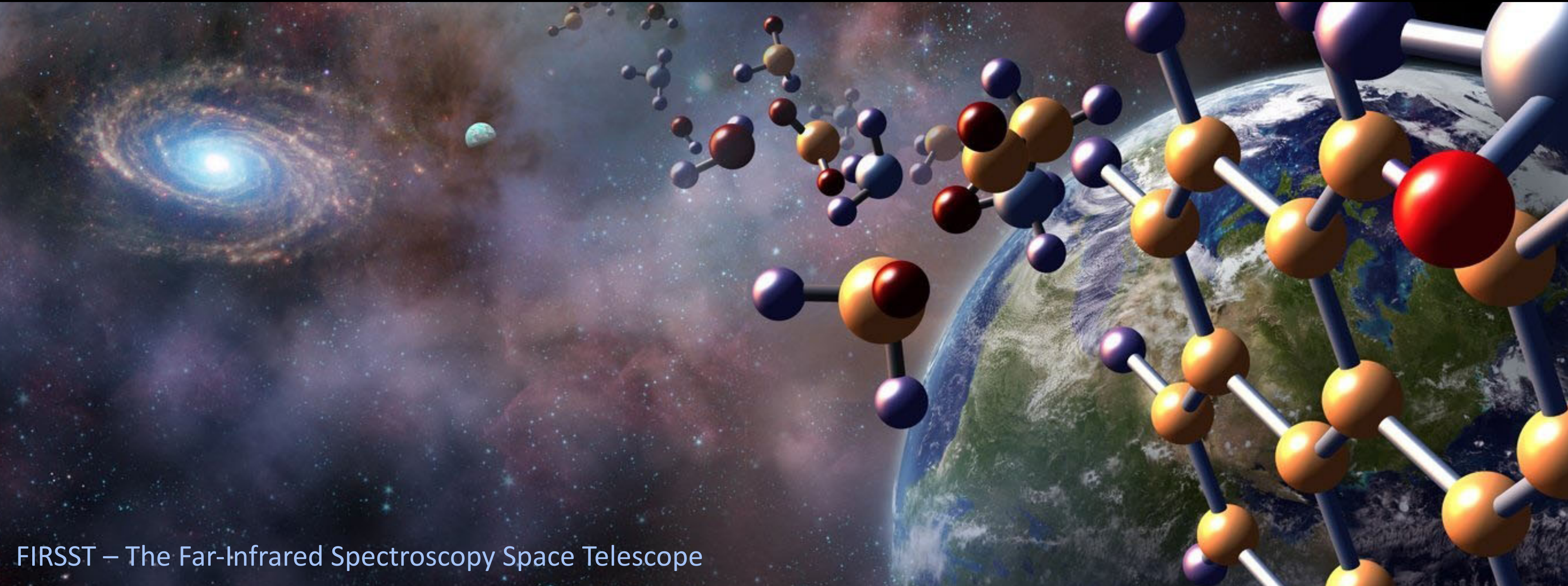
FIRSST

Far InfraRed Spectroscopy Space Telescope

Asantha Cooray for the FIRSST Science and Design Team

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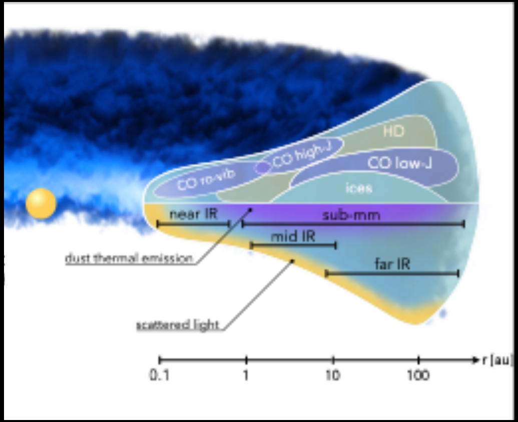
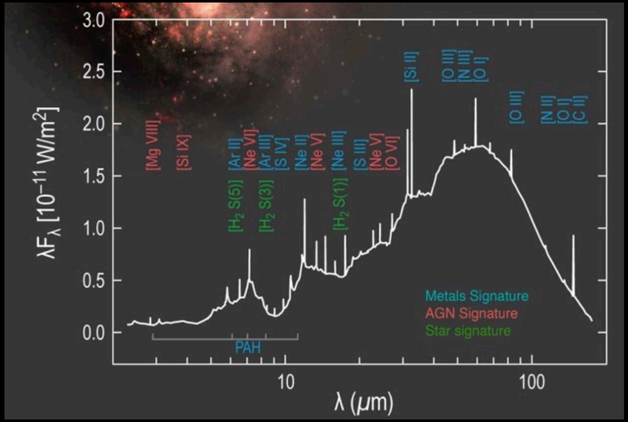
FIRSST addresses key Astro2020 science questions





Planet formation: FIRSST provides key observational capabilities to solve a number of outstanding issues on planet formation, including the missing gas mass problem of current disk observations.

Water trail: FIRSST traces the path of water from the interstellar medium to planet forming disks, and to planets in the habitable zone, while also establishing the origin of Earth's oceans.

Galaxy formation: FIRSST captures the peak galaxy emission, filling the wavelength gap between JWST and ALMA, in a wavelength band where space observations are essential.

FIRSST Science Objectives

What is the origin and evolution of planet-forming disks?

Q1: How many disks have enough mass to form a Jupiter?
Q2: Does planet formation have to be fast or can it be slow?
Q3: What is the origin of gas in debris disks?

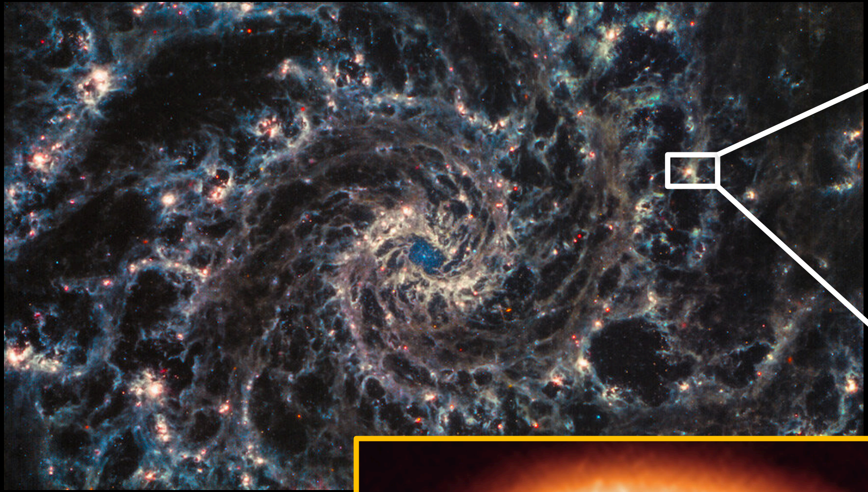
What is the trail of water from molecular clouds to oceans?

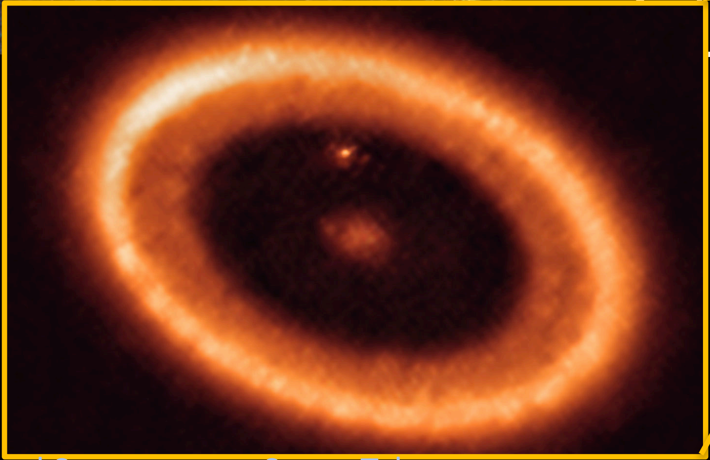
Q4: How does the ISM environment impact water formation?
Q5: What is the origin of water in planet-forming disks?
Q6: How did Earth end up with its oceans?

How do galaxies assemble their material?

Q7: What are the abundances of stars, dust and gas in galaxies?
Q8: How do galaxies grow their central supermassive blackholes?
Q9: How is star-formation activity regulated in nearby galaxies?

FIRSST will put planet formation into a universal context

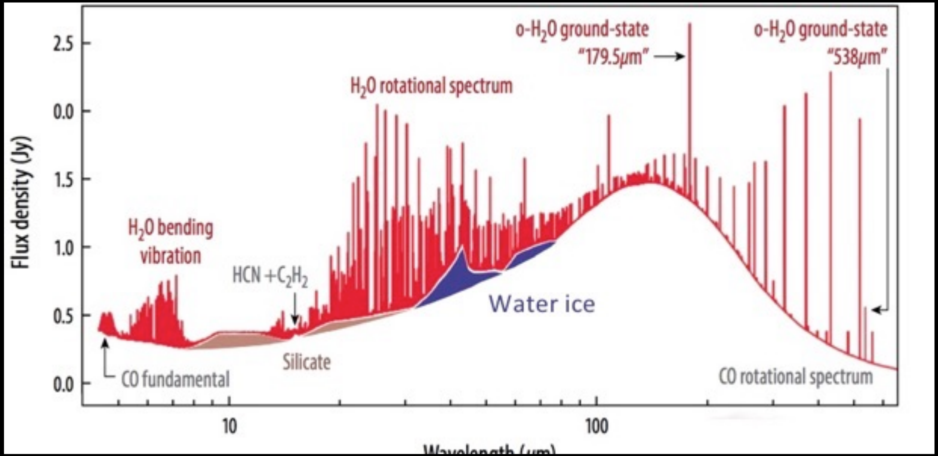


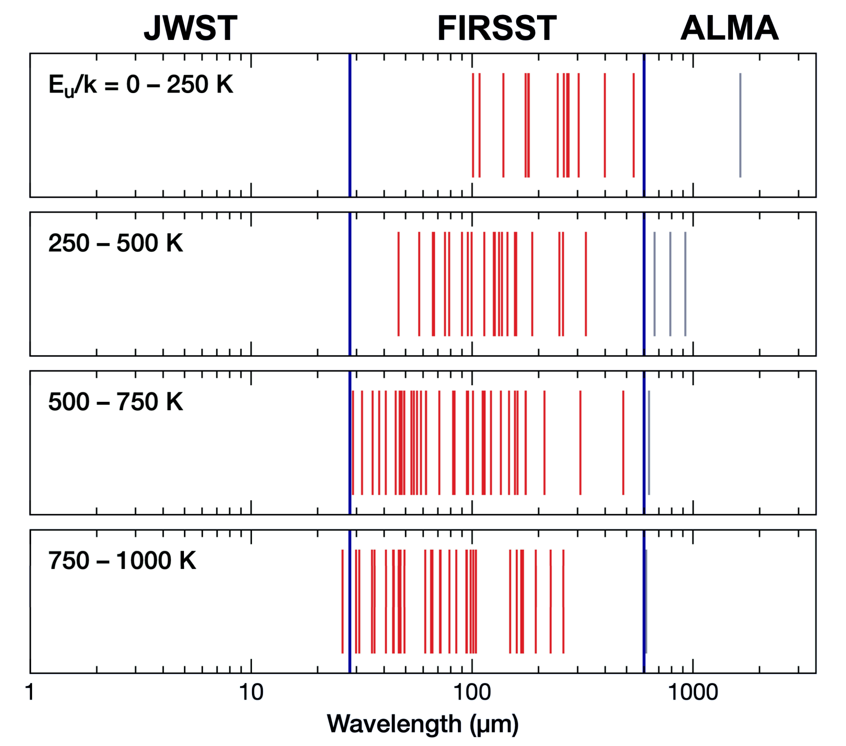


Low- and high-resolution spectroscopy will reveal how planets are enriched with the elements required for life

What is the trail of water and volatiles from molecular clouds to oceans?

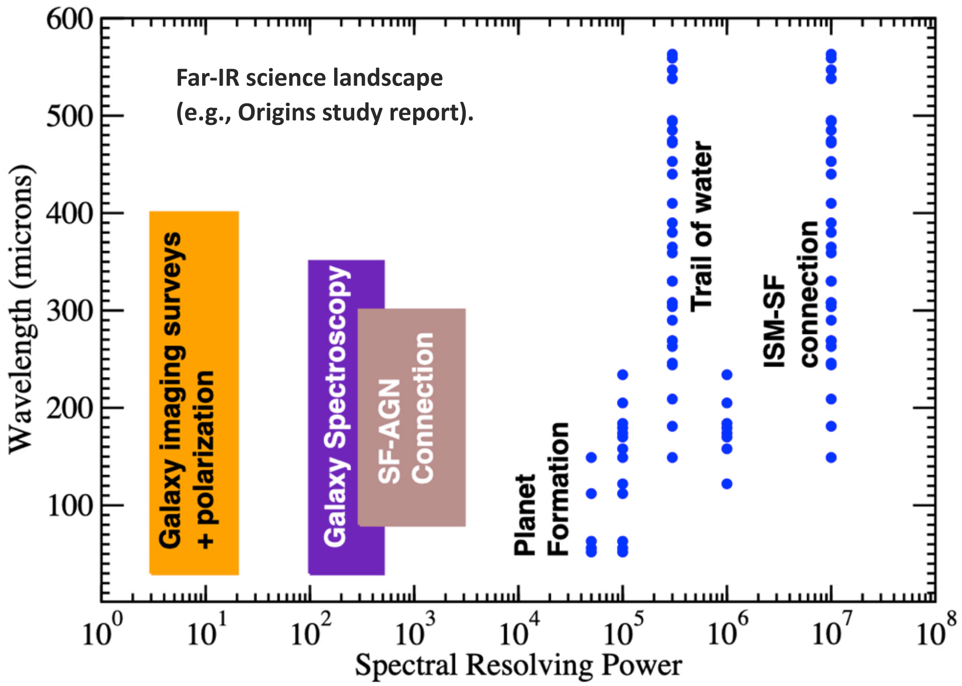
How do habitable environments arise and evolve within the context of their planetary systems?





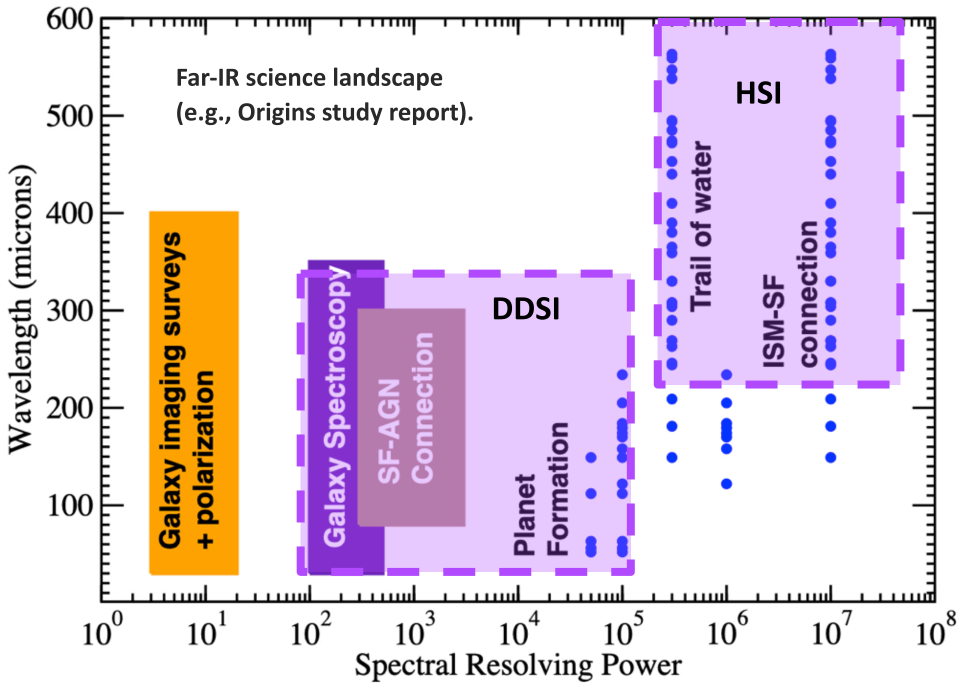
FIRSST enables a key subset of the far-infrared science discovery space

Probe mission cost cap of $1B limits what FIRSST can cover.

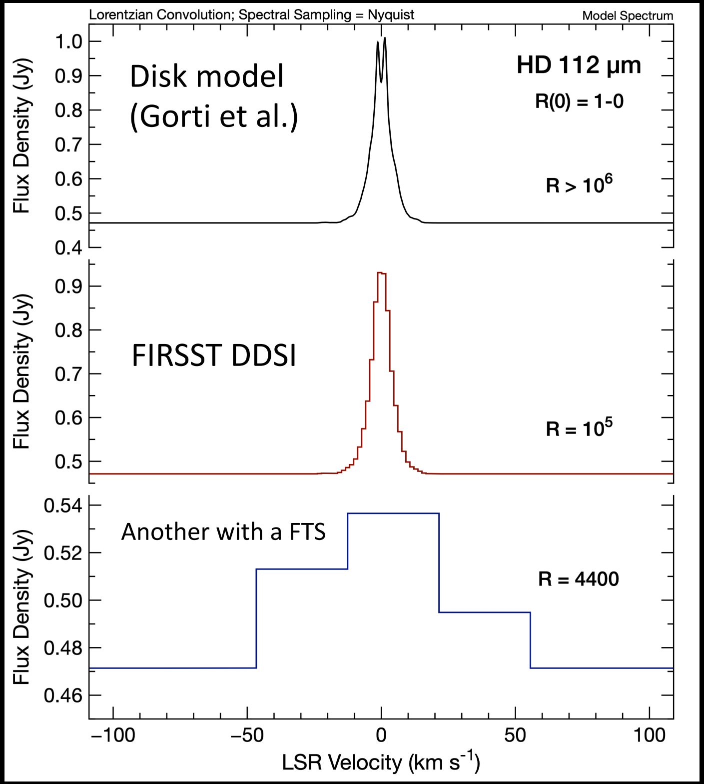


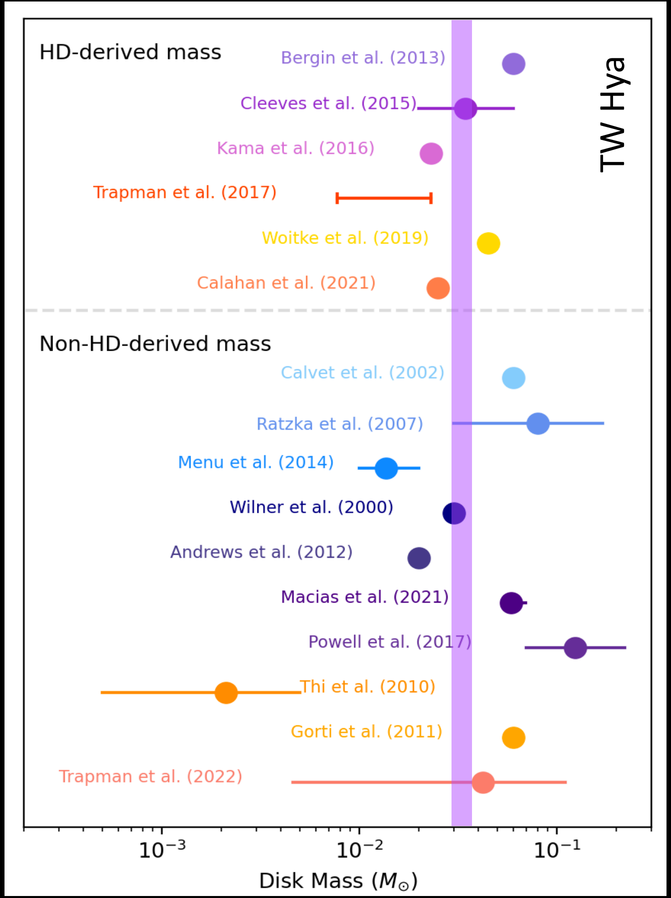
FIRSST enables a key subset of the far-infrared science discovery space

Science/instrument trade choices made by the science team aim to cover the broadest range of science.



High resolution spectroscopy is crucial to meet planet formation and habitability objectives:





FIRSST at a glance

★ Low-risk, Spitzer-like architecture with a ~2m-class aperture, actively cooled to 4.5K

★ Two instruments dedicated for spectroscopy:

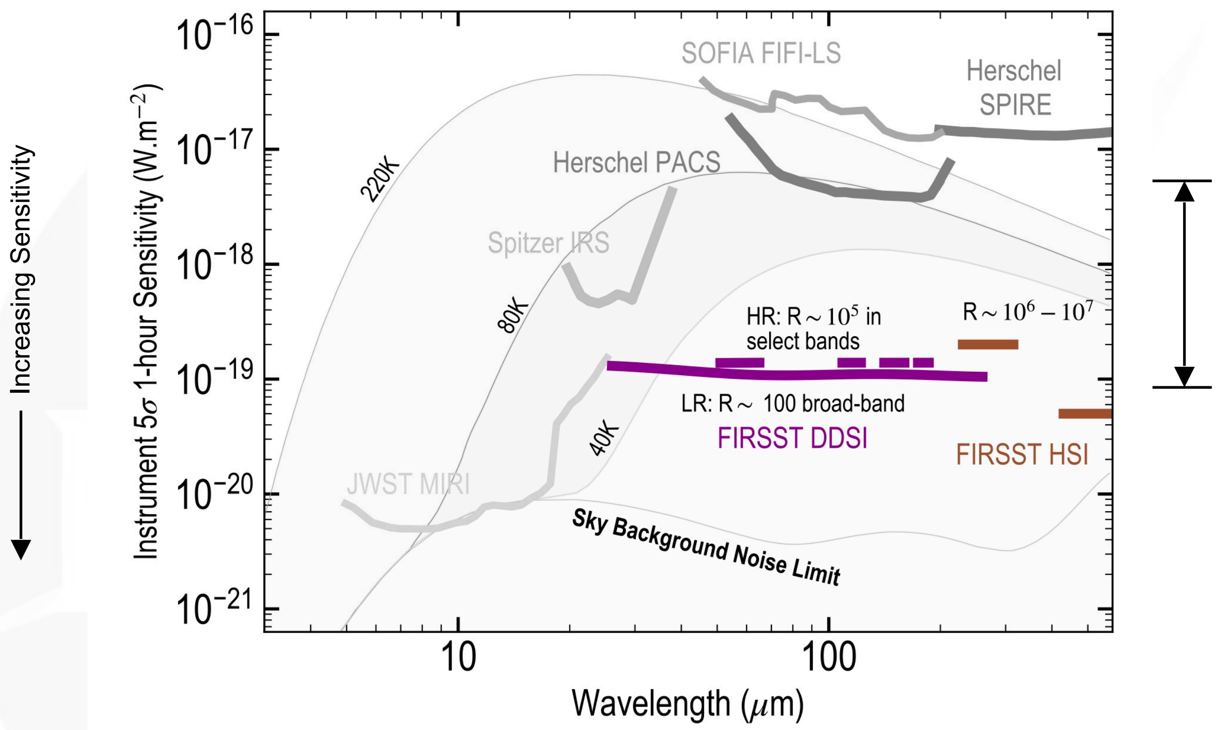
- ★ DDSI (direct detection spectroscopy instrument)
  - low (R=100) broad-band ~40-260 μm, medium (R=2000) 100-200 μm, and high (R=100,000) resolution in select bands with 15% BW (HD 112; HD 56/OI 63; CII 158; H20 179)
  - low resolution spectral mapping mode allowing wide area spectral surveys
  - high-resolution optimized for planet formation science objectives.
- ★ HSI (heterodyne spectroscopy instrument)
  - dual band, multi-pixel arrays allowing mapping capability, $R=10^6$-10^7 (<1 km/sec) spectroscopy
  - Optimized for the trail of water and multi-pixel allows wide area mapping in water lines

★ 5-year science mission operations with minimum 90% Community-led GO science

★ FIRSST is managed by Applied Physics Laboratory in Maryland. APL recently led New Horizons to Pluto, Parker Solar Probe, DART, and will launch Dragonfly in 2027.

★ Ball Aerospace is the prime industrial partner. Among IR missions, Ball has heritage from Spitzer and a number of astrophysics explorers and planetary missions.

Scientific Implementation Merit and Feasibility



- Observing time is proportional to the square of this ratio
- FIRSST opens deep discovery space beyond all prior far-infrared missions
- FIRSST is 400 – 1000 times faster than Herschel

IRAS

1983 - 10 month all sky survey with a 57cm/cryo telescope at 12, 25, 60 & 100 microns.

Discovered “starburst” galaxies, cirrus, disks around stars.

Spitzer

A NASA Great Observatory 2003-2020.

85cm/cryo telescope, 3 instruments (3.6-160 microns). $850M.

Community use just like Hubble (write proposals and get time for observations).

Lots of applications (exoplanets/distant galaxies, unanticipated)

Herschel

ESA Observatory (NASA ~ 10%) 2009-2013.

3.5m telescope, passive cooled to 70K-80K. 3 instruments. 1B Euro class.

Community use. Many new astronomical discoveries.

SOFIA

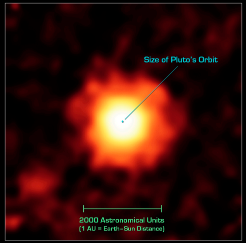
NASA/DLR ~2010-Oct 2022.

2.5m telescope, ambient temperature. Multiple instruments. “Flagship class”.

Community use. *Challenging science operations.*

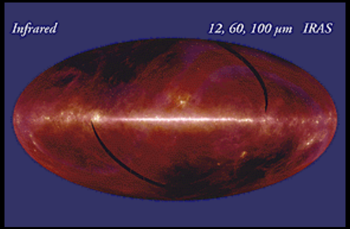
Unanticipated, Yet Transformative, Discovery Space

Significant gain in sensitivity in the infrared follows unanticipated discoveries!



debris disks

IR-bright galaxies

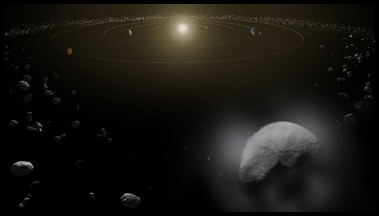


cirrus, dust bands, Earth trailing dust

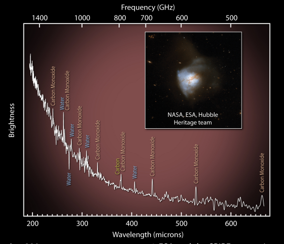
multi-planet systems

asteroidal dust rain on white dwarfs

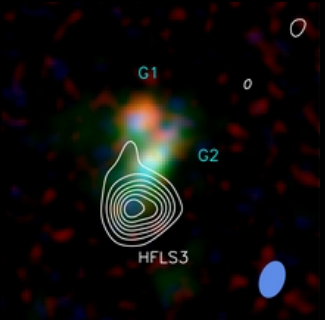
In-falling gas cools via H_2



Water vapor around Ceres



Water line cooling in galaxies, not just CO



Extraordinarily massive, starbursting galaxies 400Myr after big bang!

FIRSST Summary

What is the origin and evolution of planet-forming disks?

What is the trail of water from molecular clouds to oceans?

How do galaxies assemble their material?

Many of the biggest questions in planet star and galaxy formation today can only be answered with moderate to high resolution spectroscopic observations at far-infrared wavelengths.

A probe-mission like FIRSST would offer a unique and critical path forward to answer these questions.