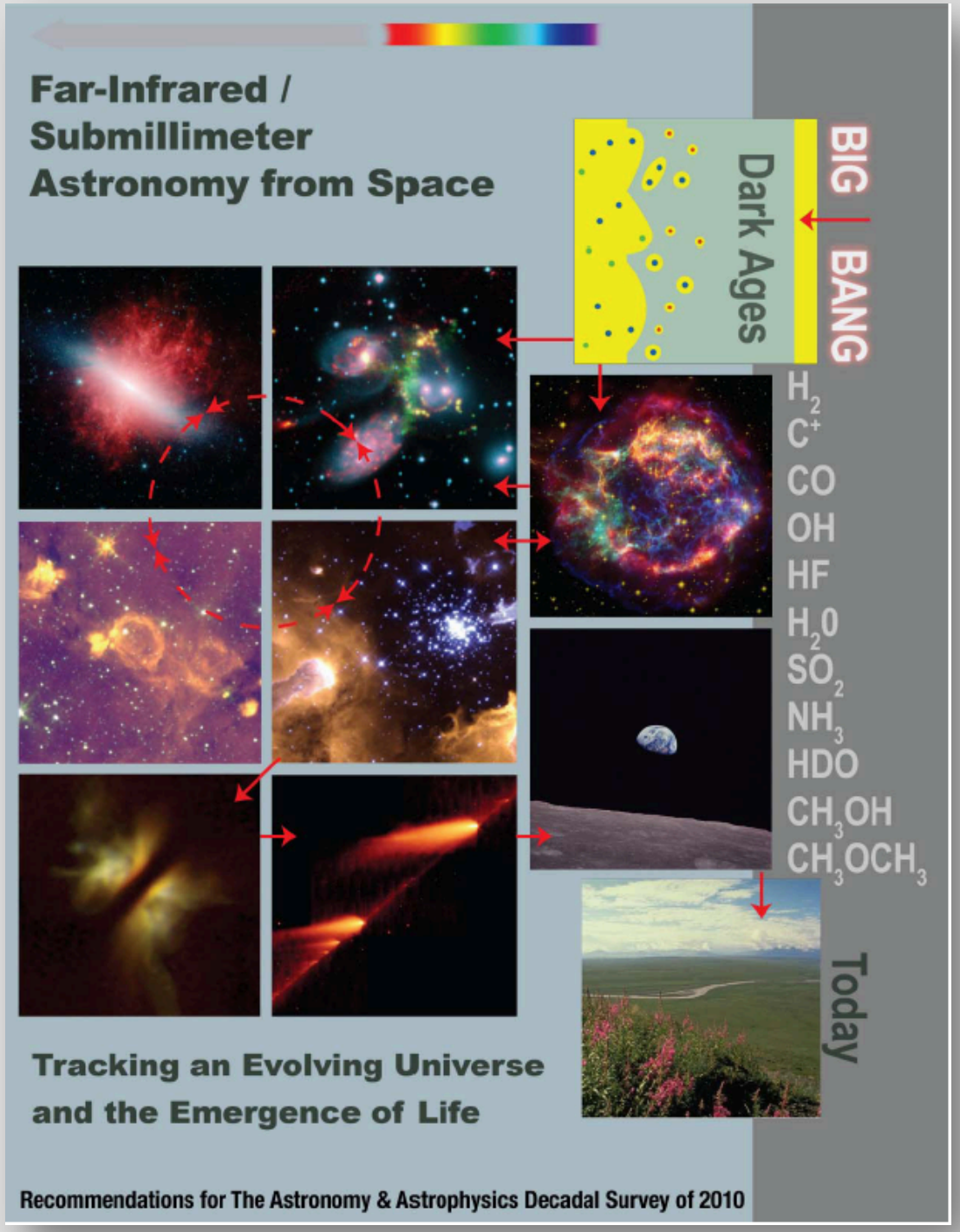
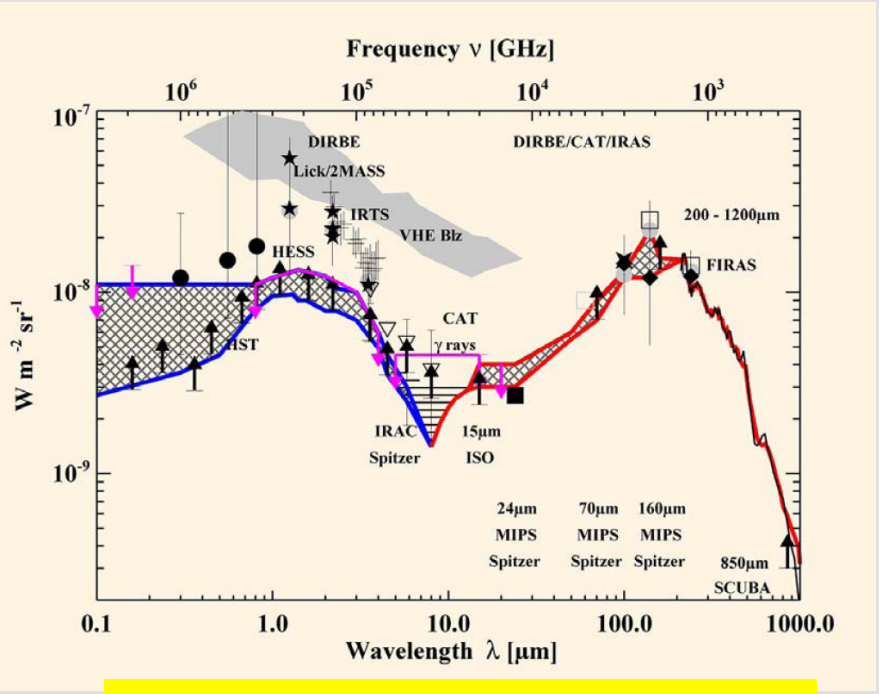
The Far-IR Community Plan

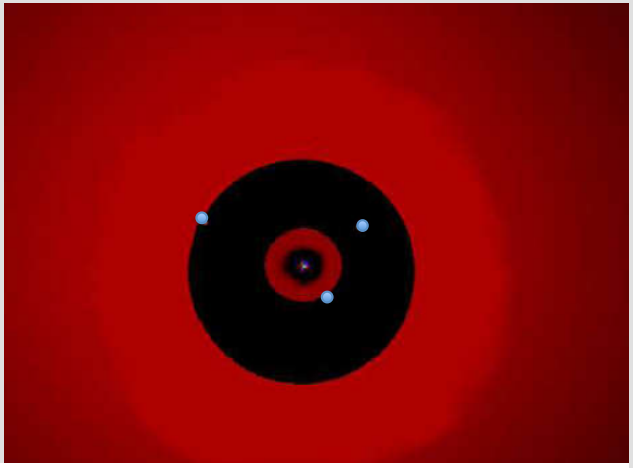
Dr. Michael Werner
JPL

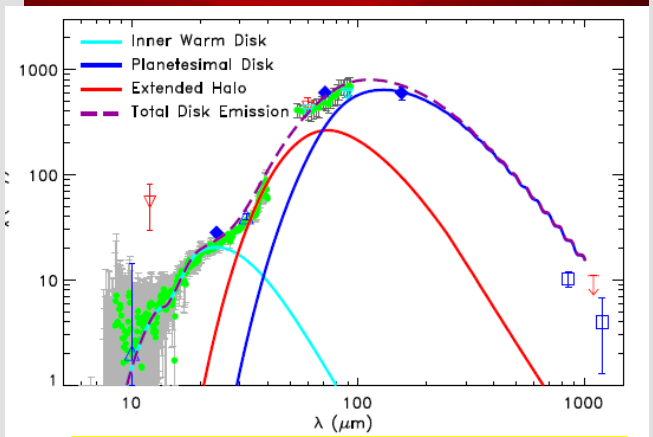


Far Infrared Astronomy 101

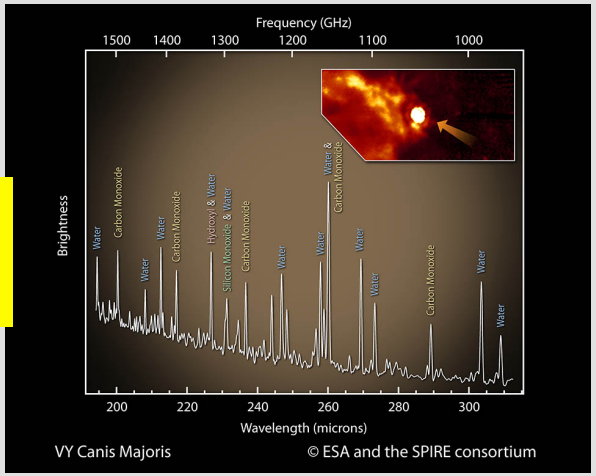


Energy content of the Universe





Planetary systems architecture



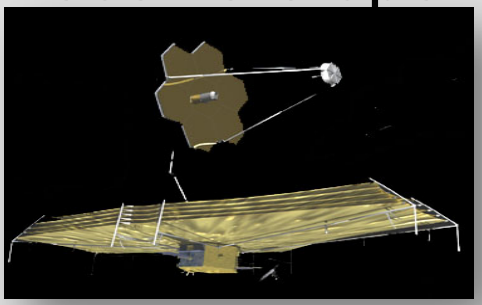
Chemical evolution and Dynamics of the ISM

2000 Decadal Survey Recommendations

- “A rational coordinated program for space optical and infrared astronomy would build on the experience gained with JWST to construct [a JWST-scale filled-aperture far-IR telescope] SAFIR, and then ultimately, in the decade 2010 to 2020, build on the SAFIR, TPF, and SIM experience to assemble a space-based, far-infrared interferometer.”
- SAFIR new start by end of decade
- Investment in enabling technology
- Community plan developed in 2002 consistent with 2000 decadal recommendation.
  - Both 2002 and 2008 plans represent consensus of large number of contributors

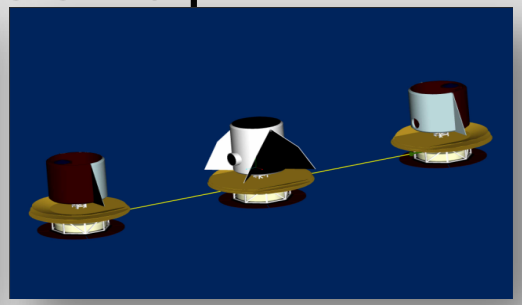
Progress, 2000 – 2010 (I)

- Spitzer, Herschel, Planck, Akari et al have opened the far-infrared as never before
- SOFIA operating as instrument/science/scientist incubator
- Balloon payloads with new generation heterodyne receivers operating and proposed [GUSSTO]



CALISTO (4 x 6 m)

SPIRIT (36 m max baseline)

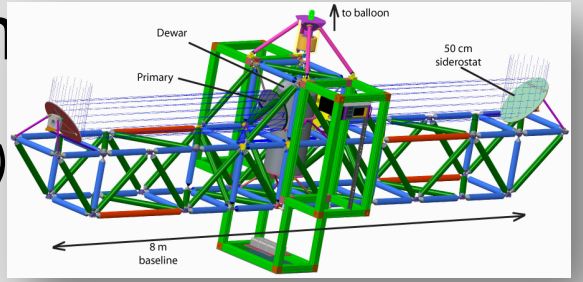


SPECS (1 km max baseline)

- NASA supported studies of all three recommended future missions – SAFIR (CALISTO), SPIRIT, and SPECS.
  - SAFIR/CALISTO and SPECS as “vision missions”

Progress, 2000 – 2010 (II)

- Investments were made in key enabling technology through ROSES/APRA and for other missions
  - Detectors (MKIDs and TES bolometers)
  - Cryocoolers (Planck; JWST MIRI; IXO ADR)
  - Active optical systems
  - Wide-field spatio-spectral interferometry
- The BETTII balloon far-IR interferom
development (S. Rinehart/GSFC, PI)



BETTII (8 m fixed baseline)

- US Participation in Japanese SPICA mission studied through BLISS Origins Probe (M.Bradford, JPL, PI)

Far-IR Community Plan, c. 2009

- The program we propose for the decade 2010-2020 is both scientifically farsighted and technologically responsible.
- It is critical for the realization of a dedicated thrust in the era of 2020-2035 to bring far-infrared/submillimeter capabilities in space to a level where some of the deepest scientific questions of all time will be answered:
  - How did the first cosmic structures form?
  - Where and when did the heavy chemical element abundances begin to rise?
  - How did they influence the dynamics of stellar system and black hole formation?
  - Where did the biogenic molecules, the seeds that led to the appearance of life, originate?

"Far-Universe Infrared/Submillimeter Astronomy from Space: Tracking an Evolving and the Emergence of Life," M. Harwit et al.

… some of the most profound Cosmic Origins questions

The 2009 Request

1. The US has an unparalleled opportunity to participate in the Japanese-led Great-Observatories-class mission, SPICA, to be launched in 2017. SPICA will have a cryogenically cooled 3.5-m telescope and thus unsurpassed Far-Infrared/Submillimeter sensitivity. The astronomical insights enabled by a highly sensitive, background-limited spectrometer on this mission will profoundly affect our understanding of cosmic evolution. US participation, at a fraction of the SPICA mission total cost, is also a logical step toward two other more advanced missions, previously recognized in the 2000 Decadal Review.[40]

Endorsed by NWNH as recommended small NASA space activity.

2. We propose a dedicated effort, during 2010 – 2020, to advance several technologies essential to these two other powerful next-generation missions to be launched between 2020 and 2035. The 10-m class cryogenically-cooled Single Aperture Far Infrared Telescope, SAFIR, and a Michelson spatial interferometer, both of which are natural successors to SPICA and all other ongoing efforts, will probe the Universe to greater distances and earlier epochs, with far higher sensitivity and spatial resolution than ever possible before.

NWNH recommended Inflation Probe technology development as high priority medium class activity for NASA. This has some commonality with the technology needs of FIR missions; support also sought through SAT and ROSES proposals

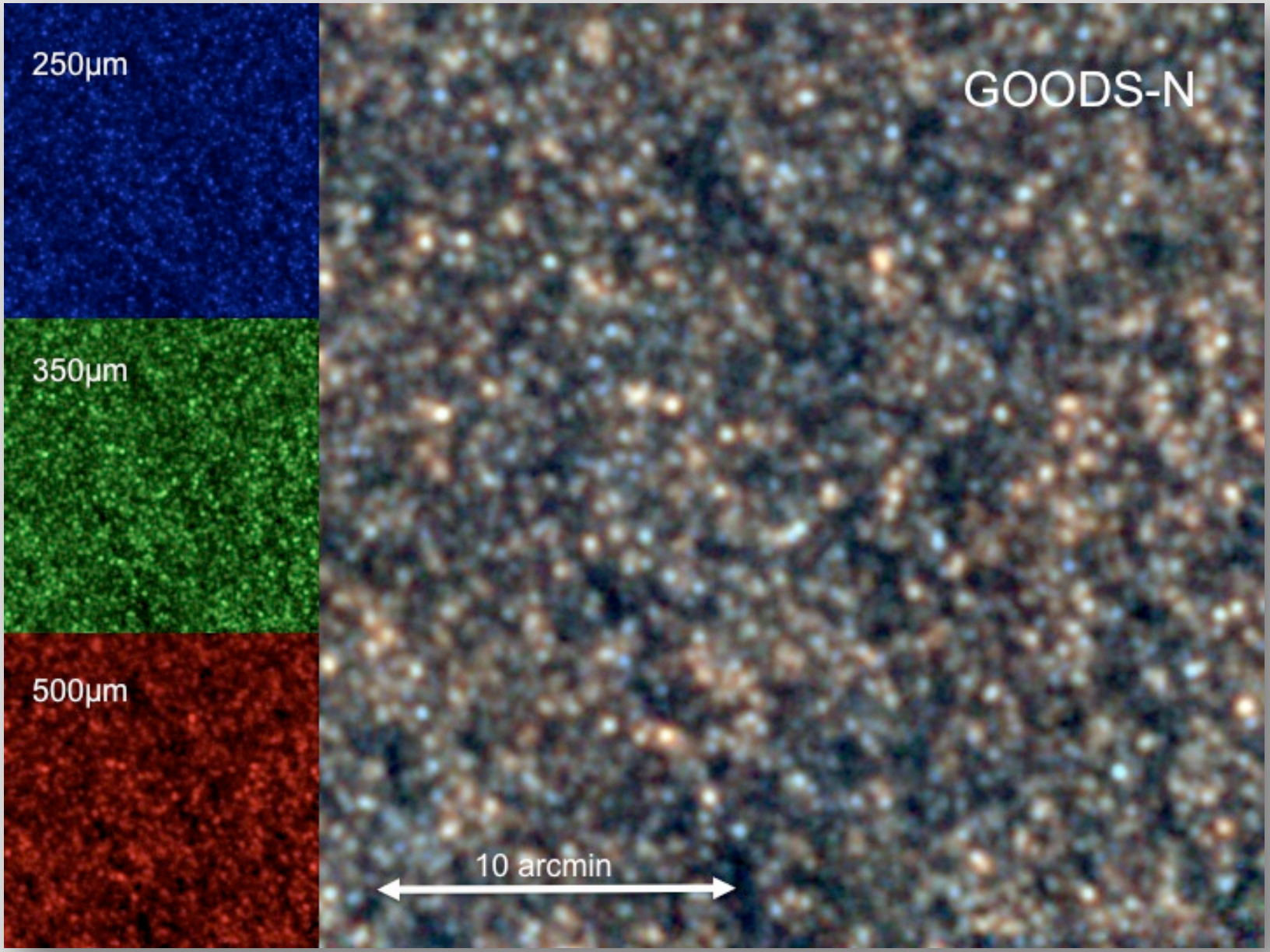
"Far-Universe Infrared/Submillimeter Astronomy from Space: Tracking an Evolving and the Emergence of Life," M. Harwit et al.

Astro2010 white papers

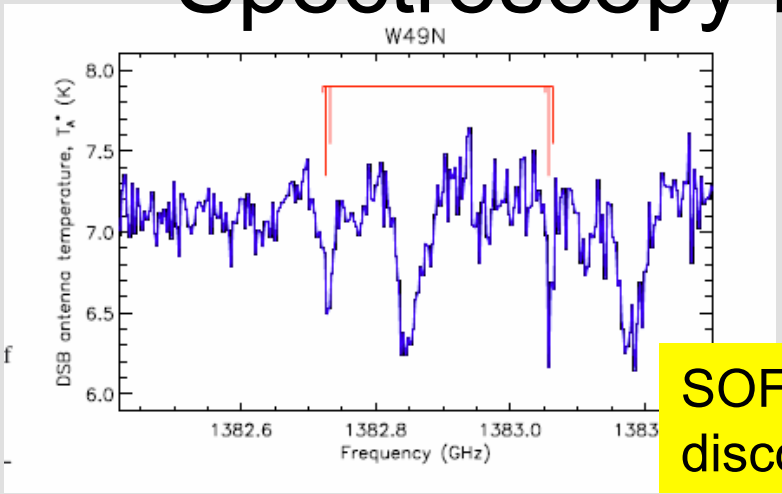
- The Community Plan: “Far-Universe Infrared/ Submillimeter Astronomy from Space: Tracking an Evolving and the Emergence of Life” (Harwit et al.)
- Science papers on extrasolar planets, star and planet formation, H_2O in planet-forming disks, AGN and galaxy formation, galaxy evolution, ...
- Mission papers:
  - “CALISTO: The Cryogenic Aperture Large Infrared Space Telescope Observatory” (Goldsmith et al.)
  - “The Space Infrared Interferometric Telescope (SPIRIT): A Far-IR Observatory for High-resolution Imaging and Spectroscopy” (Leisawitz et al.)
  - “U.S. Participation in the JAXA-led SPICA Mission: The Background-Limited Infrared-Submillimeter Spectrograph (BLISS)” (M. Bradford, et al.)
- Technology papers, including “Superconducting Detector Arrays for Far-Infrared to mm-Wave Astrophysics” (Bock et al.)

- See http://www.ipac.caltech.edu/page/31 for links to papers

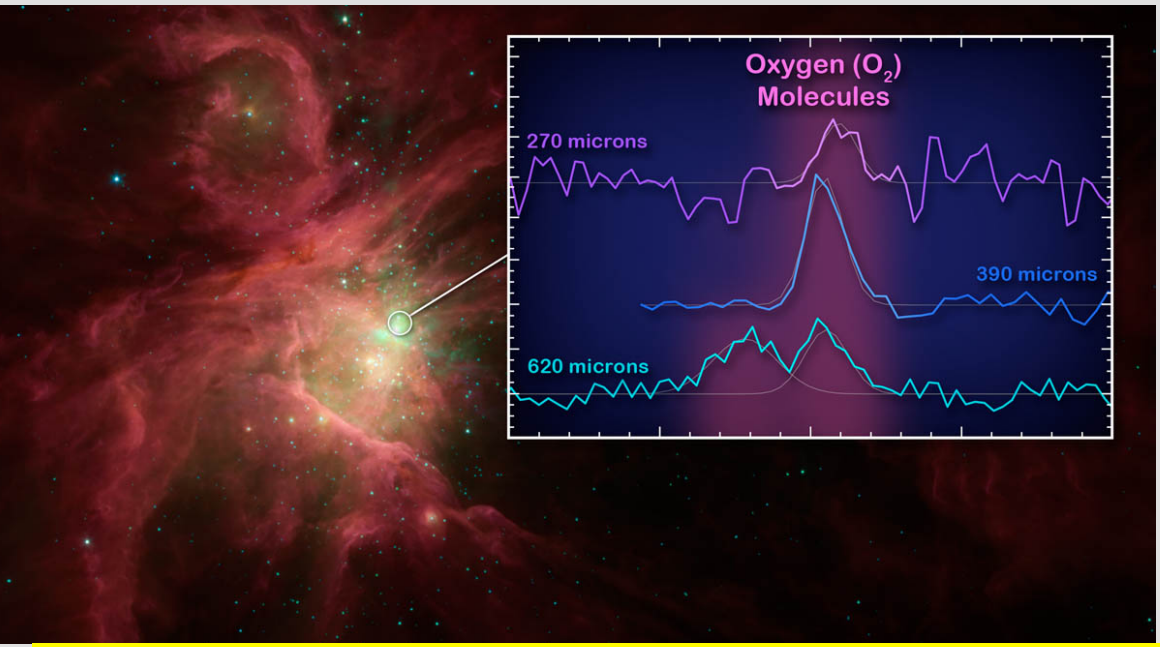
Where are we now? - Herschel Deep Field Is Confusion Limited

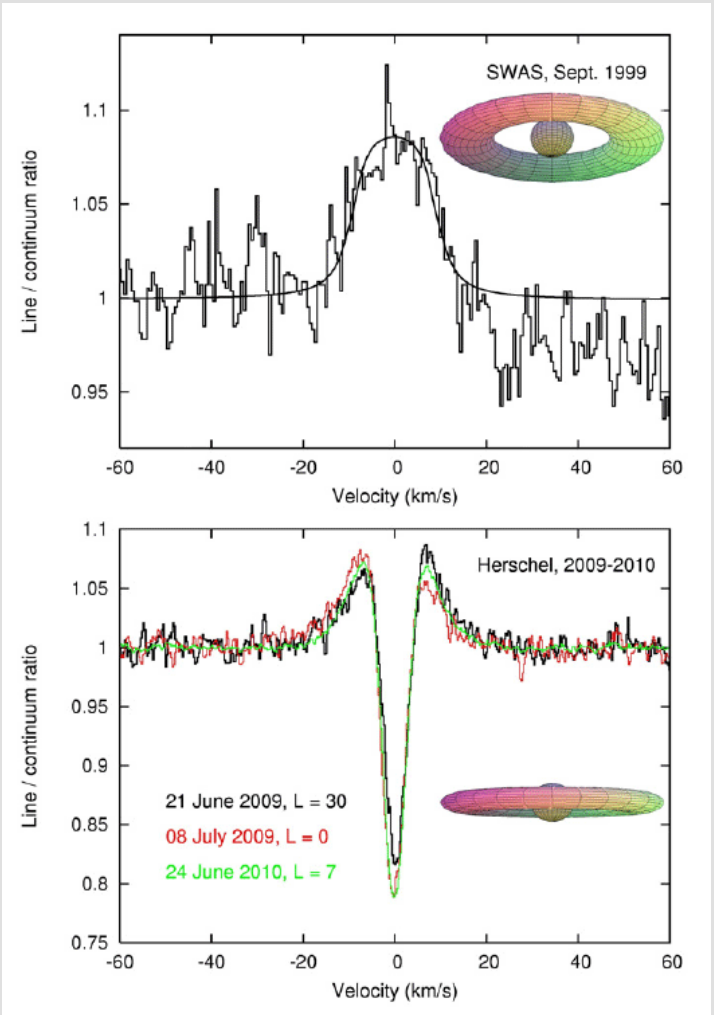


Where are we now? – Herschel, SOFIA Spectroscopy Raises Intriguing Questions



SOFIA's discovery of SH in the ISM





Oxygen in Orion HERSCHEL RESULTS Water in Saturn

The Future – In Uncertainty is There Opportunity?

- Scientific/technical progress in FIR space astronomy has been astounding over the past two decades
- With end of Herschel and Planck in sight, the progress will slow considerably by this time next year
  - SOFIA and balloons provide important bridging capabilities – scientific, technical, and work force
  - Ground-based facilities – ALMA and CCAT – will continue to sharpen the scientific questions
- SPICA [launch 202?] appears to be next opportunity
  - Major strategic missions more than a decade away
- We are looking forward to defining and promoting probe class missions in this critical spectral window