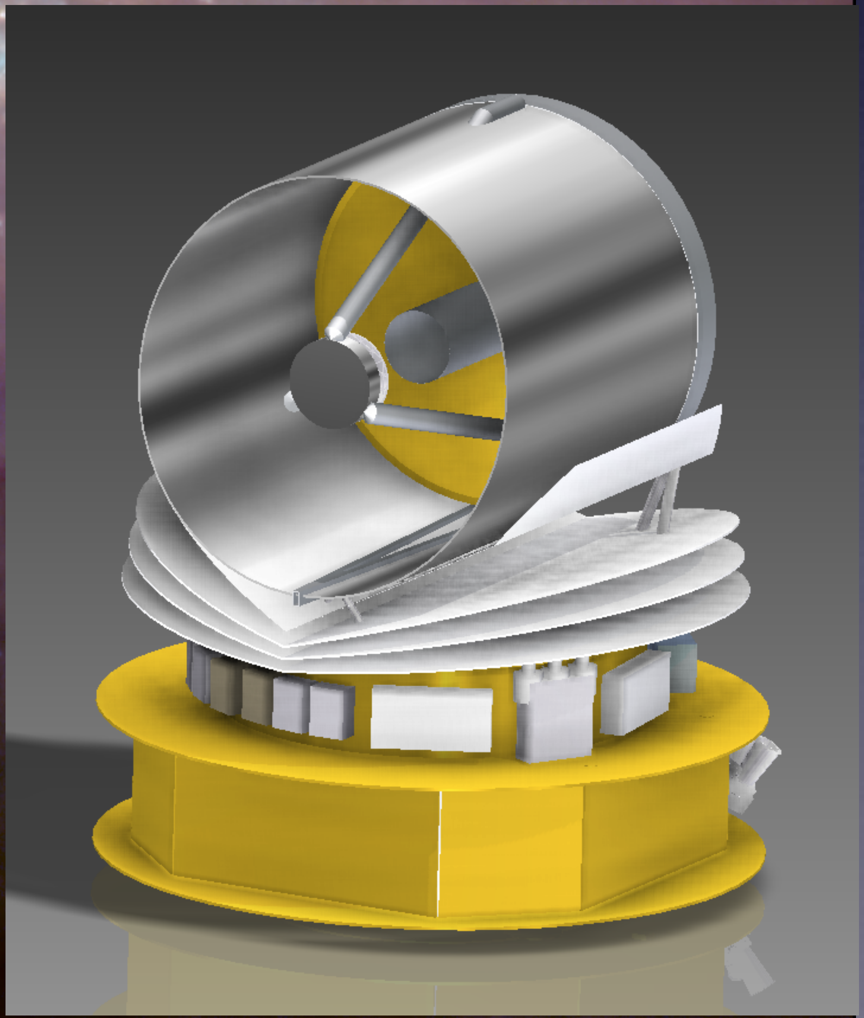
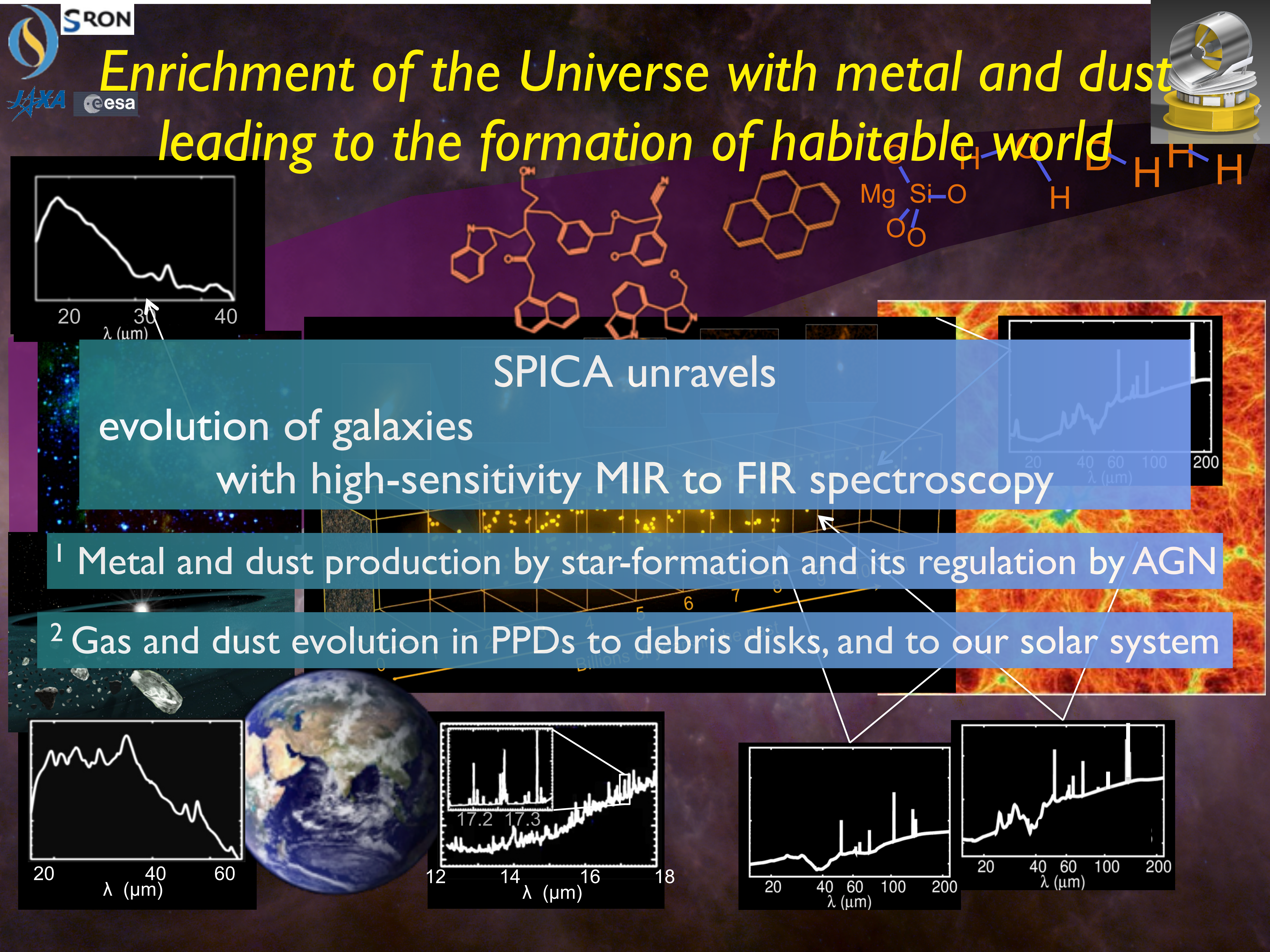
SPICA

Space Infrared Telescope for Cosmology and Astrophysics
Current Status

Takashi Onaka (University of Tokyo) and Peter Roelfsema (SRON)
on behalf of SPICA team



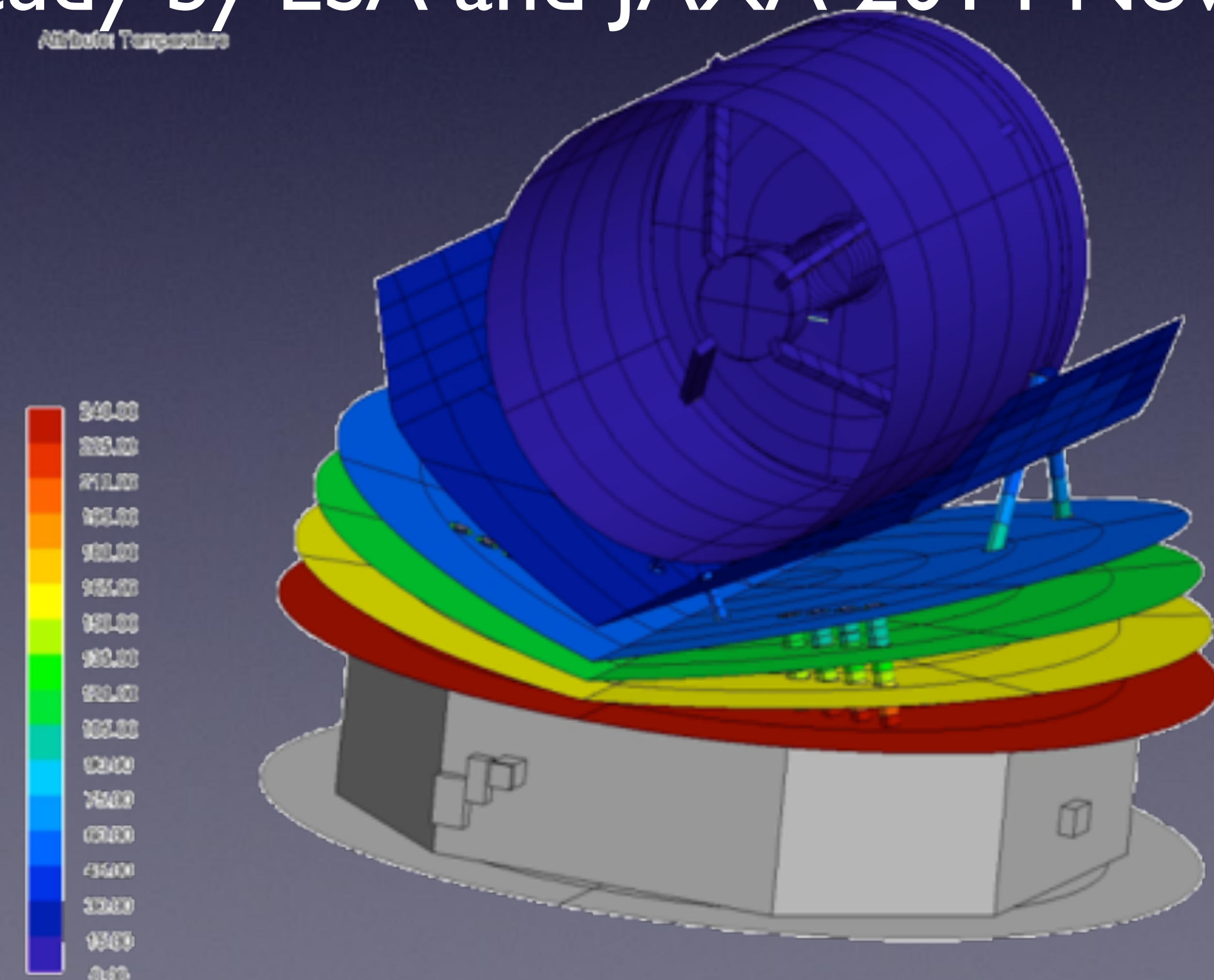
AKARI FIS map released last December
to be on IRSA


SRON
JAXA
esa
Enrichment of the Universe with metal and dust
leading to the formation of habitable world
Mg Si O
SPICA unravels
evolution of galaxies
with high-sensitivity MIR to FIR spectroscopy
1 Metal and dust production by star-formation and its regulation by AGN
2 Gas and dust evolution in PPDs to debris disks, and to our solar system
20 30 40
λ (μm)
20 40 60
λ (μm)
12 14 16 18
λ (μm)
17.2 17.3
20 40 60 100 200
λ (μm)
20 40 60 100 200
λ (μm)
20 40 60 100 200
λ (μm)

Current baseline plan for SPICA

SPICA is a joint mission between ESA and JAXA, optimized for MIR and FIR spectroscopy with a cryogenically cooled telescope. SPICA is an observatory open to the astronomical community and will have guest observer time as well as guaranteed time.

- Telescope
  2.5m aperture & temperature < 8K
  based on the reference design study by ESA and JAXA 2014 Nov.
- Core wavelengths:
  17 - 230 μm
- Thermal design
  Based on the Planck design (V-grooves) with cryocoolers inherited from IRTS and AKARI. Mechanical coolers enable a warm launch of a 2.5m cooled telescope.



Current baseline

- Orbit: S-E L2 Halo orbit
- Launcher: H-X Vehicle of JAXA

- Focal plane instruments
  SAFARI (34 - 230μm)
  SMI (17 - 37μm) + HRS (12 - 18μm)
  SPEChO (5 -20μm) (under consideration)

- Schedule
  In JAXA SPICA is now in the redefinition phase
  and will go to the M-class competition in ESA

  2015 June International preview by JAXA
  2015 Sept Mission Definition Review by JAXA
  2016 ESA M5 proposal submission
  2027-2028 Launch (>3 year operation: goal >5 years)

Work-share plan

Telescope

Cryocooler

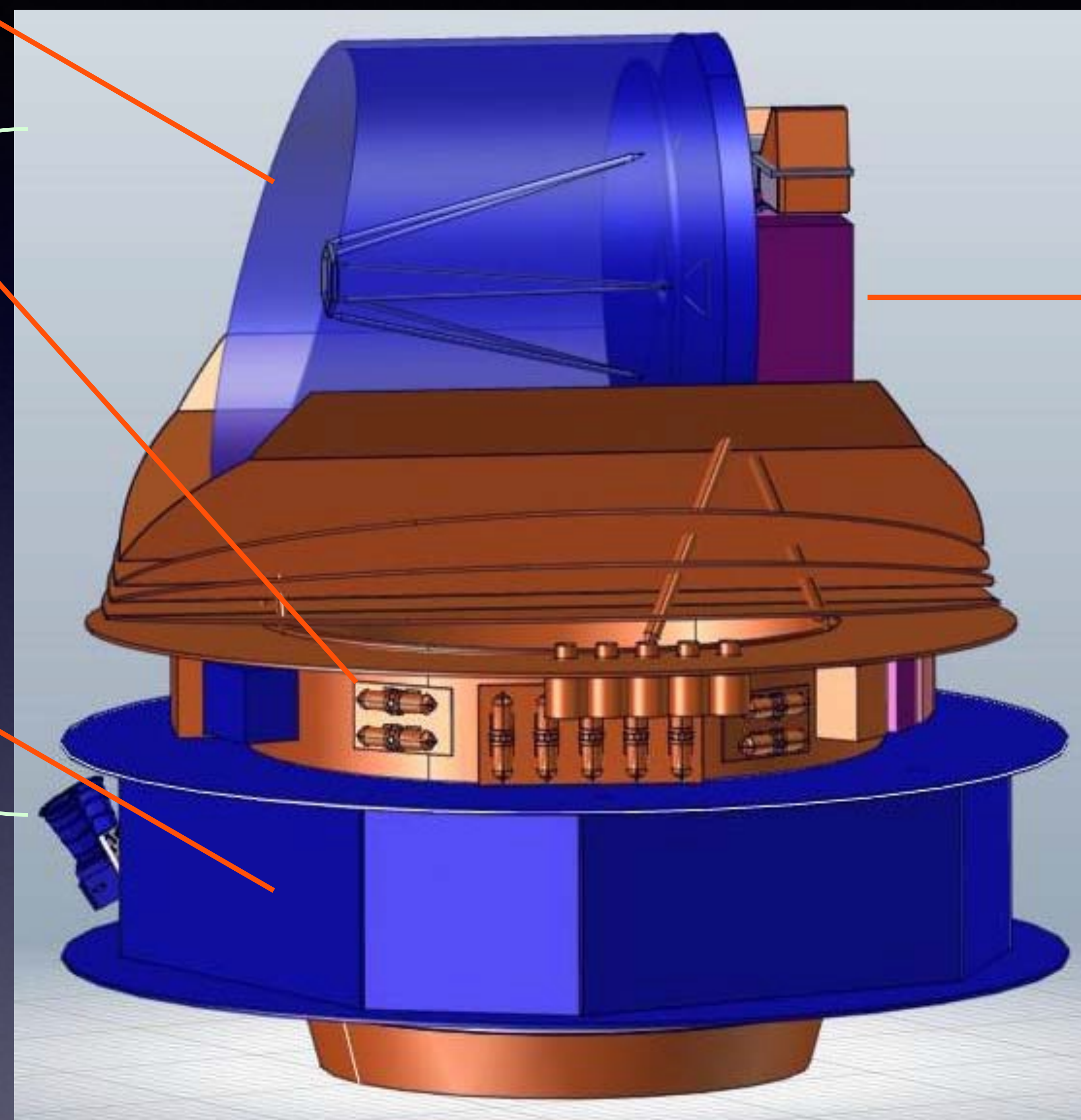
Payload module

Bus module

Launcher

SPICA data center

(NAOJ)



Focal plance attitude sensor

Focal plane instrument assembly

FIR spectrometer (SAFARI)

NL + European countries + Canada +US

MIR instrument (SMI)

Exoplanet spectrometer (SPECh0)

U.K. + European countries

Science community

Europe, Japan, US, Canada, KR, TW, ..

Focal plane instruments

- SAFARI
  - Three band grating spectrometer
  - Continuous spectroscopic capability for 34 - 230μm
  - R = ~300 & ~3000
  - Limiting flux for point sources (5σ-1hr)
    - (4.5-6.5) x10^{-20} Wm^{-2} (R=300)
    - (24 - 29) x10^{-20} Wm^{-2} (R=3000)
  - Limiting flux for mapping (5σ-1hr)
    - (22 - 59) x10^{-20} Wm^{-2} (R=300)
    - (120-340) x10^{-20} Wm^{-2} (R=3000)
  - ~2'x2' mapping capability with BSM
  - Teaming: Europe, north-America, and Japan
  - P.I.: P. Roelfsema (SRON, NL)

Focal plane instruments

- SMI

  Prism and grating spectrometer of three channels

  LRS (17 - 37μm; R ~ 50) 600" x 3.7" x 5 slits (multi-slit)

  MRS (18 - 36μm; R~1000) 60" x 3.7" slit

  HRS (12 - 18μm; R>20000) 6" x 1.4" slit

  Line sensitivity for point source

  (6 - 23) $\times 10^{-20}$ Wm^{-2} (LRS)

  (3 - 40) $\times 10^{-20}$ Wm^{-2} (MRS)

  (1.5 -3) $\times 10^{-20}$ Wm^{-2} (HRS)

  Survey speed to achieve 3 $\times 10^{-19}$ Wm^{-2}

  ~45 $arcmin^2$/hr (LRS)

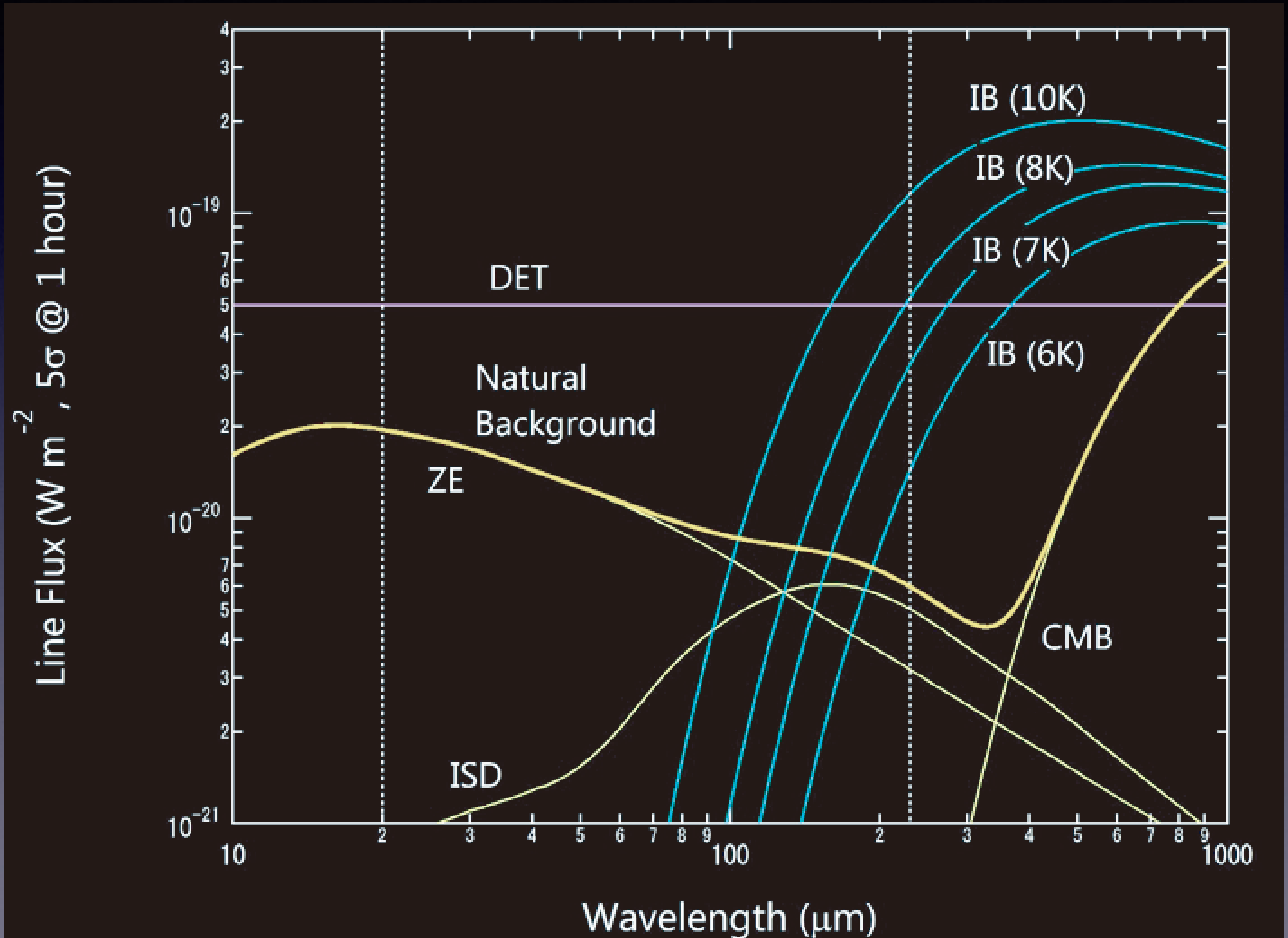
  ~1.5 $arcmin^2$/hr (MRS)

  Teaming: Japanese university consortium

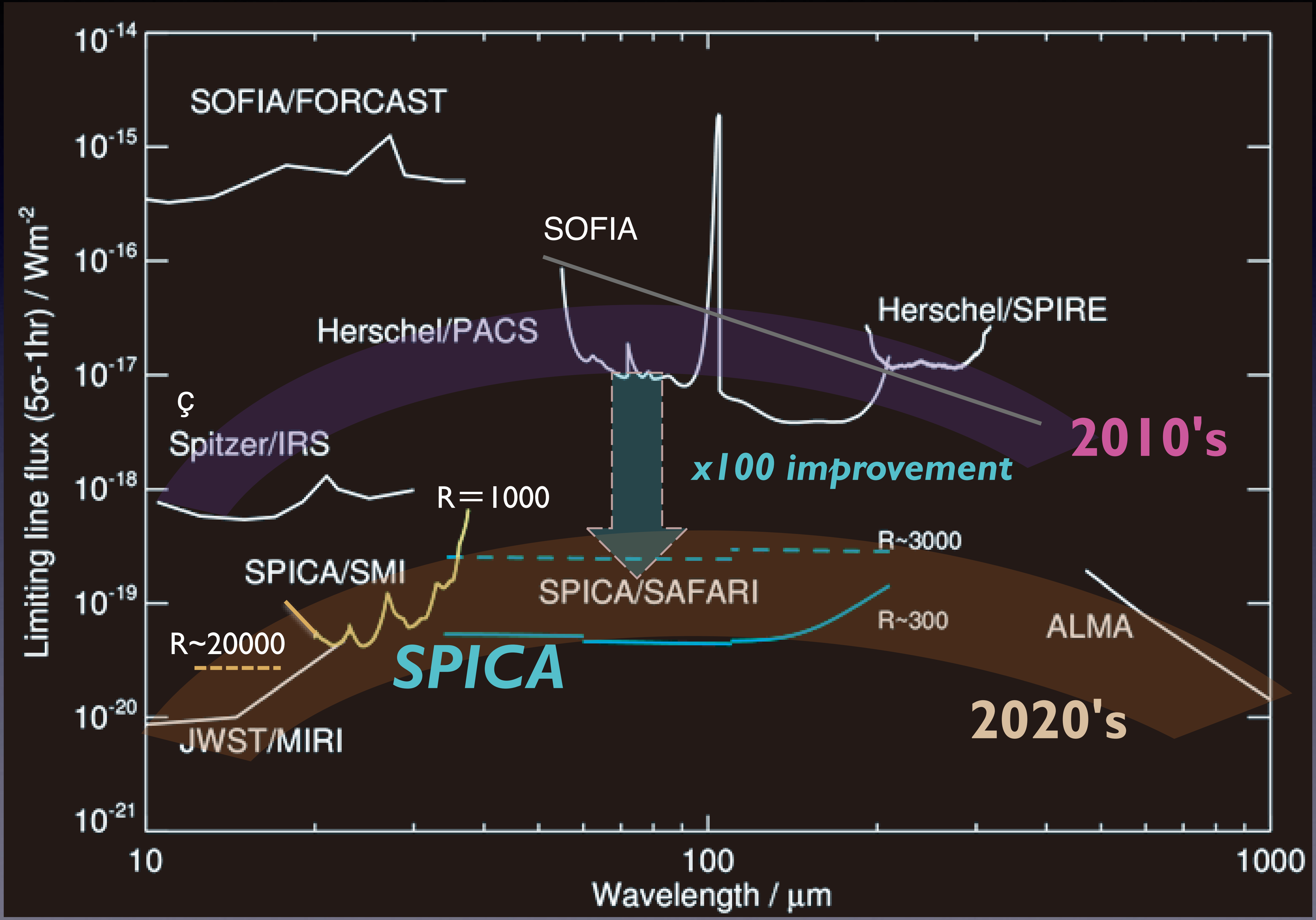
  P.I.: H. Kaneda (Nagoya Univ.)

Effects of telescope temperature

Cooled telescope is required for high line detection sensitivity



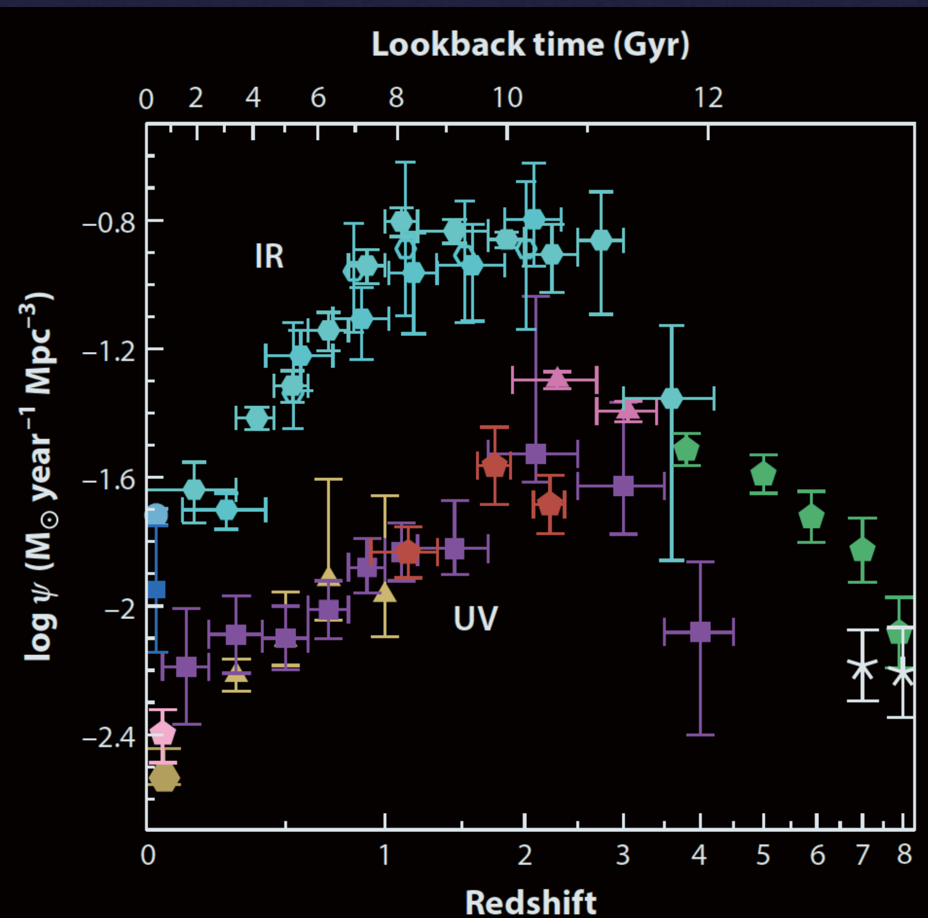
SPICA sensitivity and other facilities



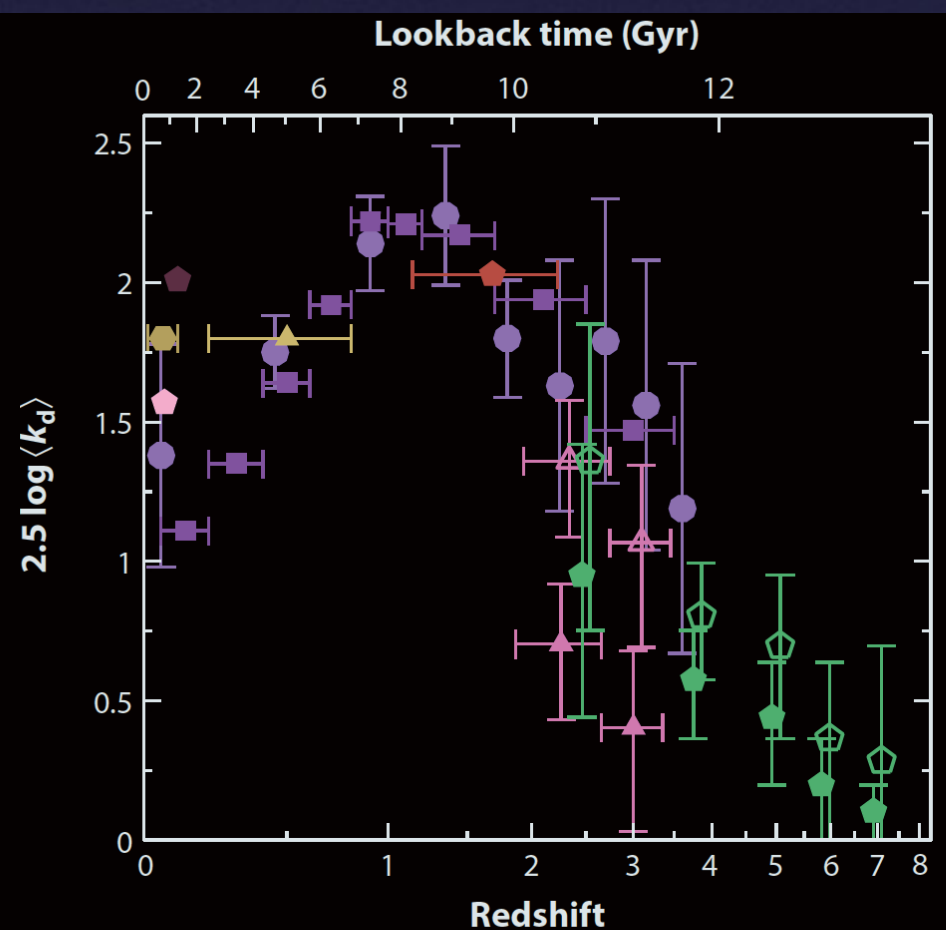
Unveiling obscured universe

SPICA unveils the properties of IR luminous galaxies and the origin of IR luminosity around the peak of cosmic SRFD (z=1-3) with MIR to FIR spectroscopy using diagnostics of PAH band and gas line emission.

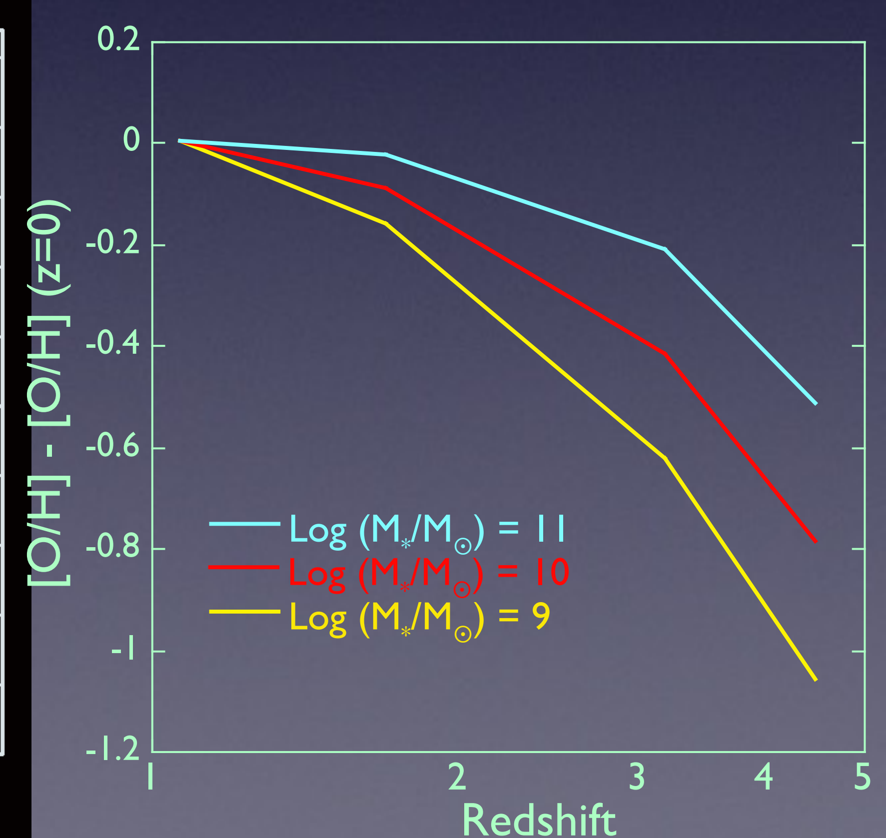
Star formation rate density



Dust attenuation



Metallicity (optical)

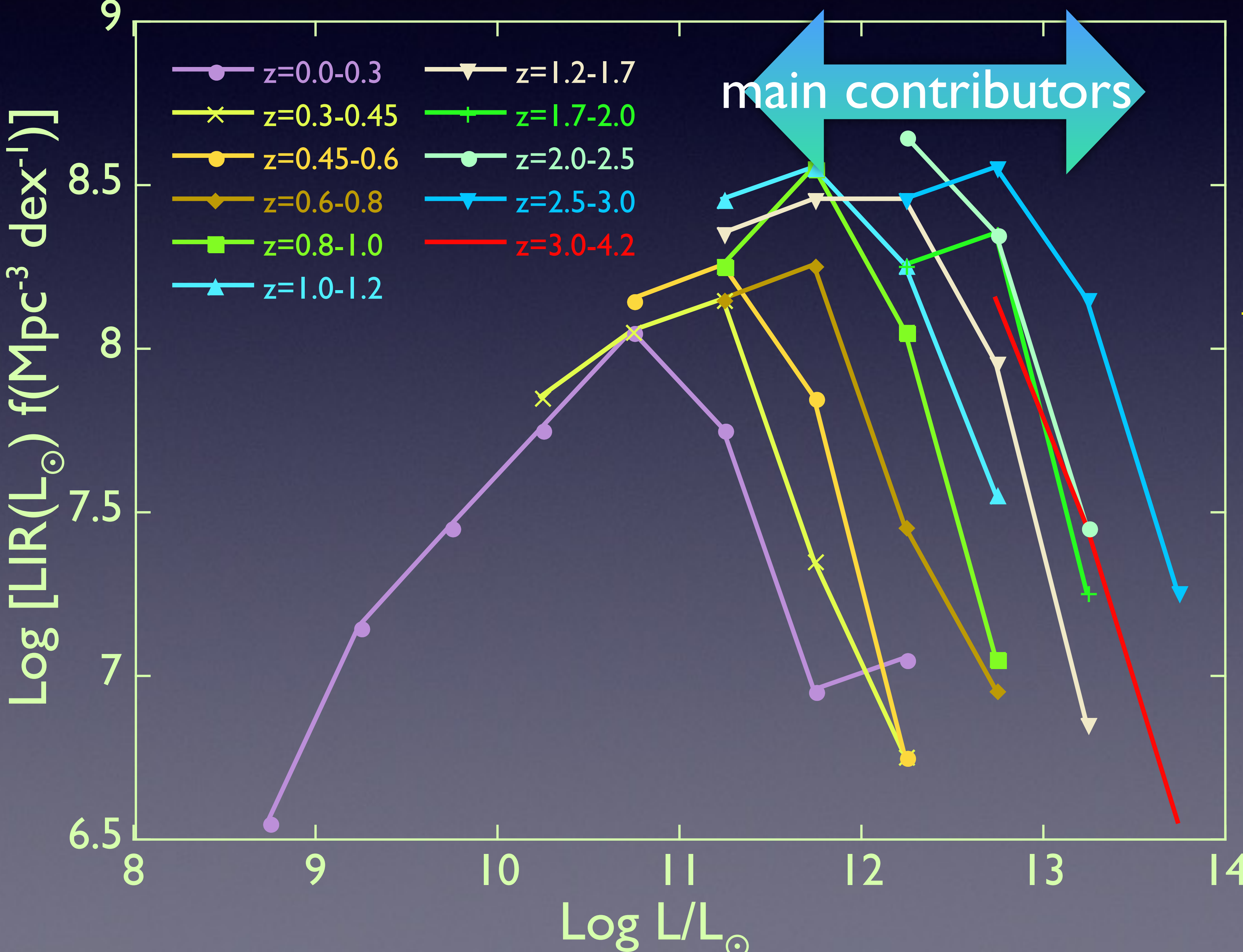


Madau & Dickinson 2014, ARAA, 52, 415 Maiolino et al. 2008, A&A, 488, 463

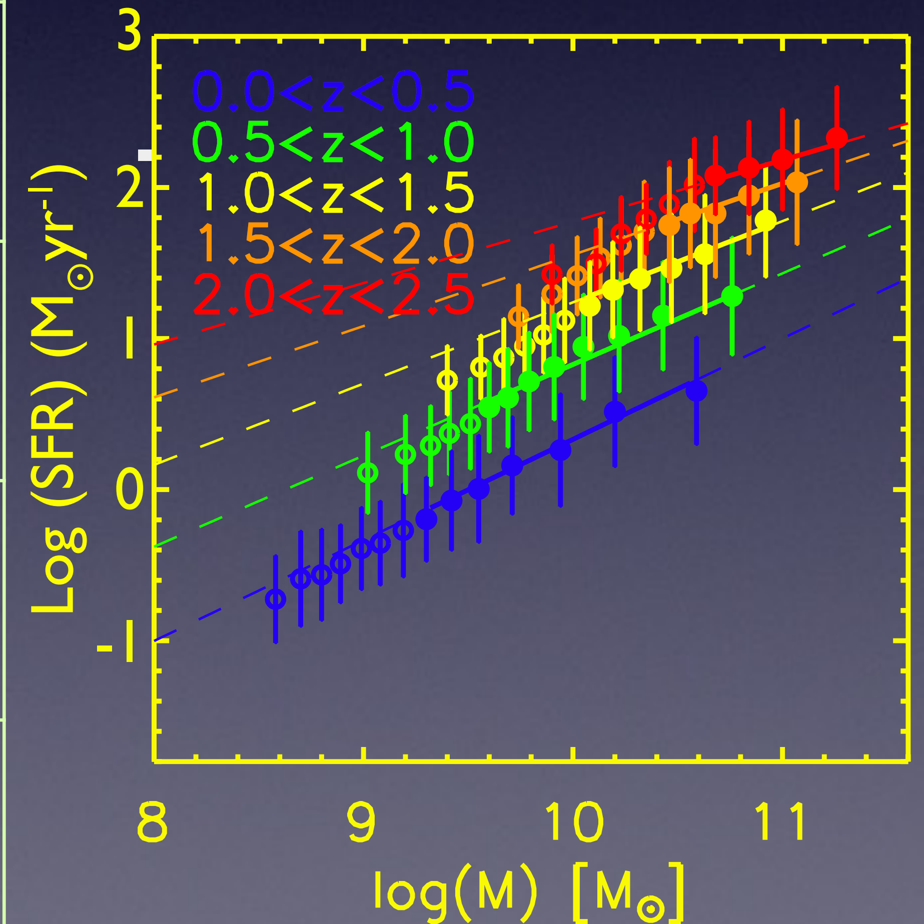
How deep do we need to observe?

To study the origin of the major fraction of IR luminosity, we need to observe main-sequence (MS) galaxies of $L>10^{12}L_\odot$ at z=3.

Integrated IR luminosity function



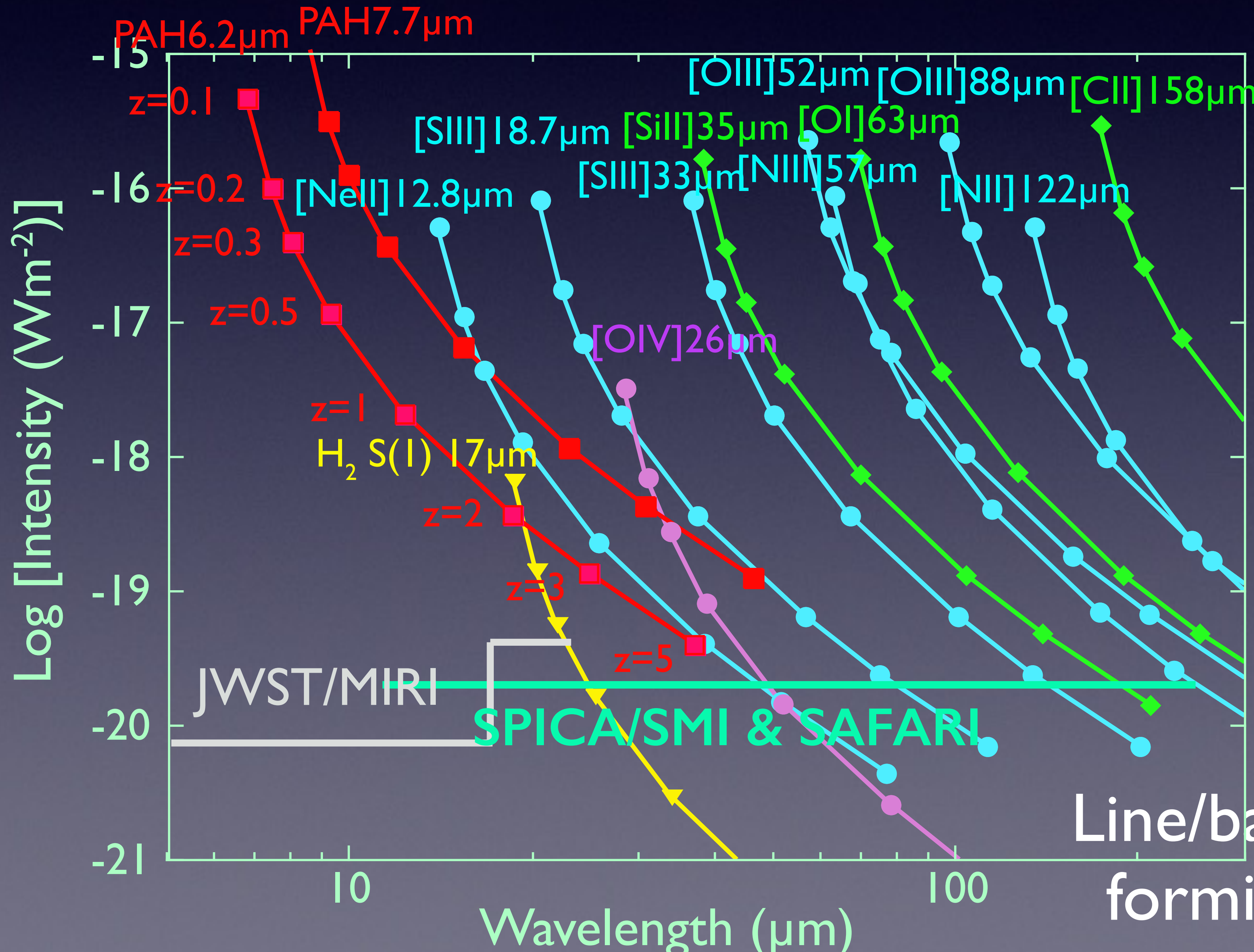
Evolution of MS galaxies



Whitaker+ 2012 ApJ 754 L29

SPICA sensitivity

- PAH bands are good indicators for star-formation rate and AGN fraction as well as a reliable redshift estimator.
- SMI R=50 PAH survey is efficient to detect MS star-forming galaxies up to z~4 thanks to strong PAH bands.



Sensitivity of ~2×10^{-20} Wm^{-2} is required to make efficient multi-line diagnosis of IR galaxies of $10^{12} L_\odot$ at z=3.

Line/band intensities for a star-forming galaxies with $10^{12} L_\odot$

SPICA studies planet forming regions

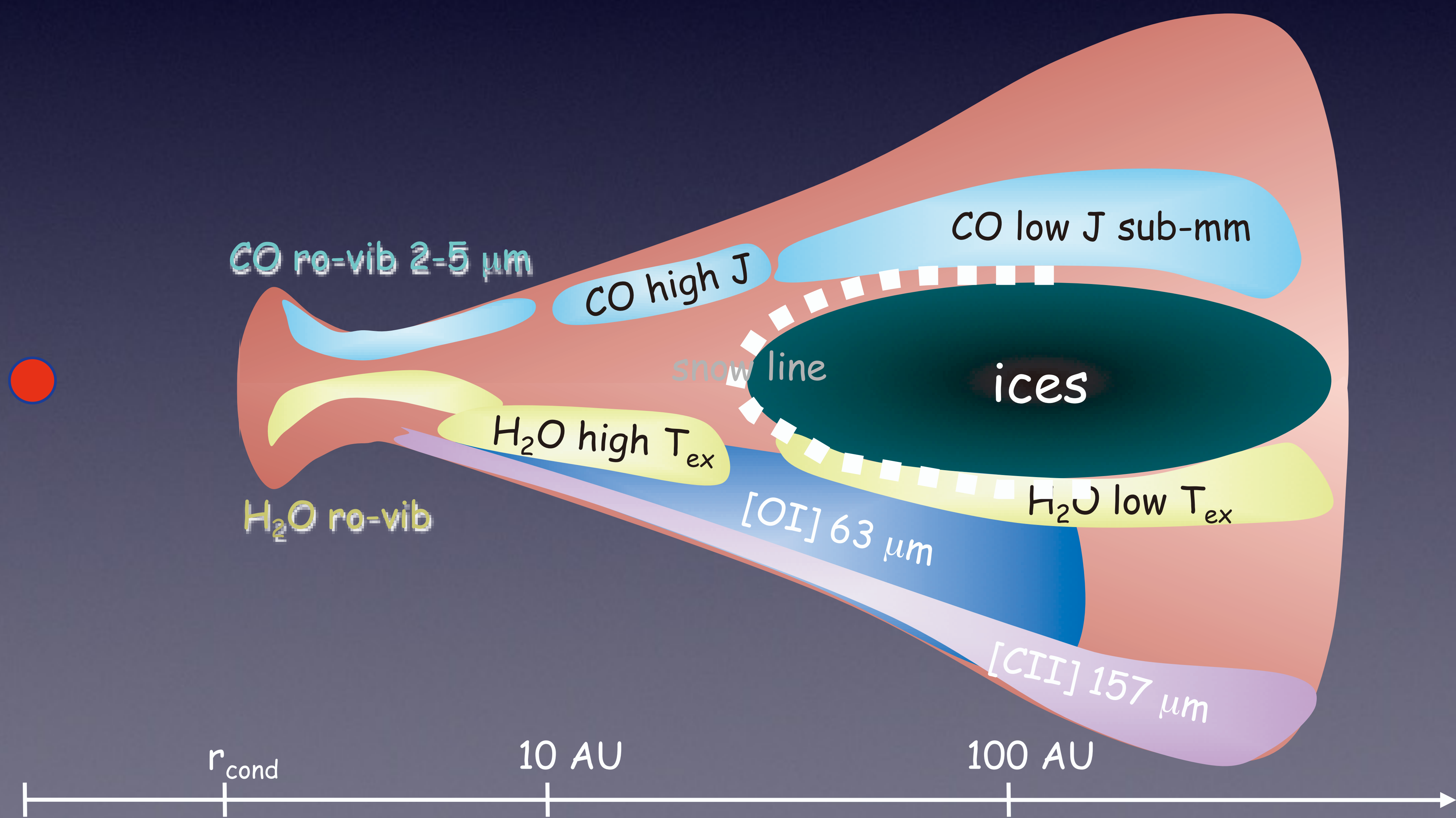
SPICA observes innermost regions of planet formation

SPICA/HRS studies warm gas kinematics

SPICA/SAFARI studies molecular gas & water trail

JWST studies warm gas and dust

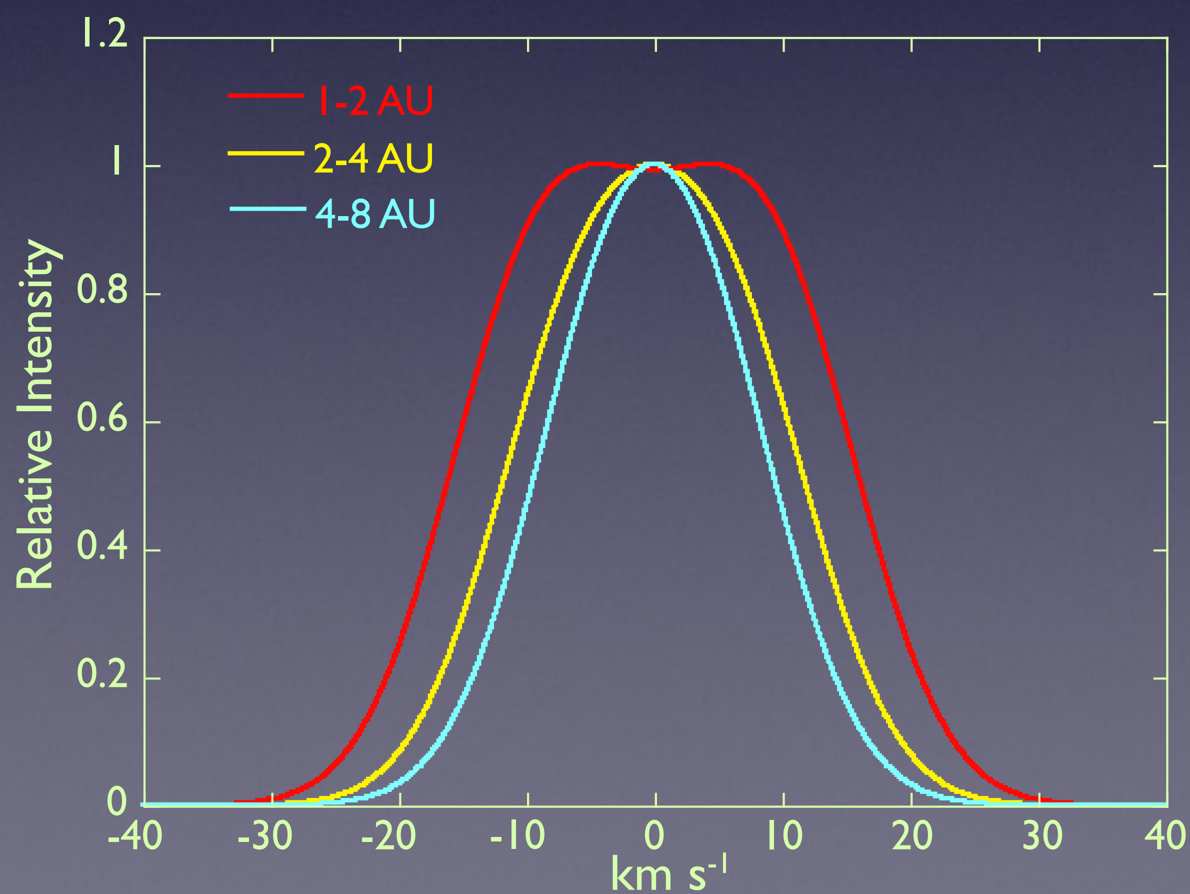
ALMA studies disk structure with dust & cold gas



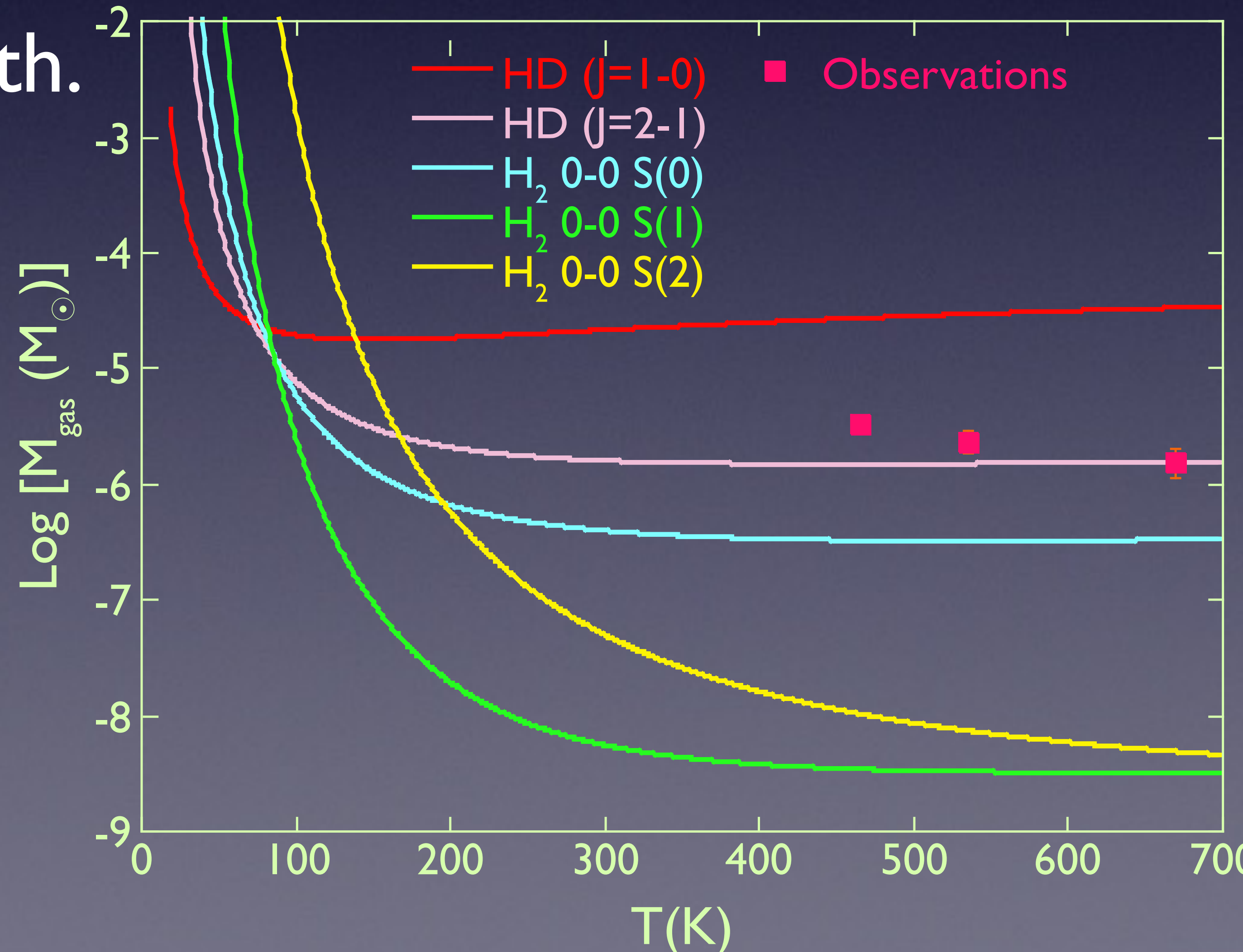
SPICA probes gas dissipation

SPICA studies the dissipation of warm (T>100K) molecular gas by H_2 and tepid (T=60-80K) molecular gas by HD.
HD is a robust molecular mass estimator compared to CO.

HRS (R>20000) reveals gas dynamics in the innermost region and determines the location of H_2 emitting region from the line width.

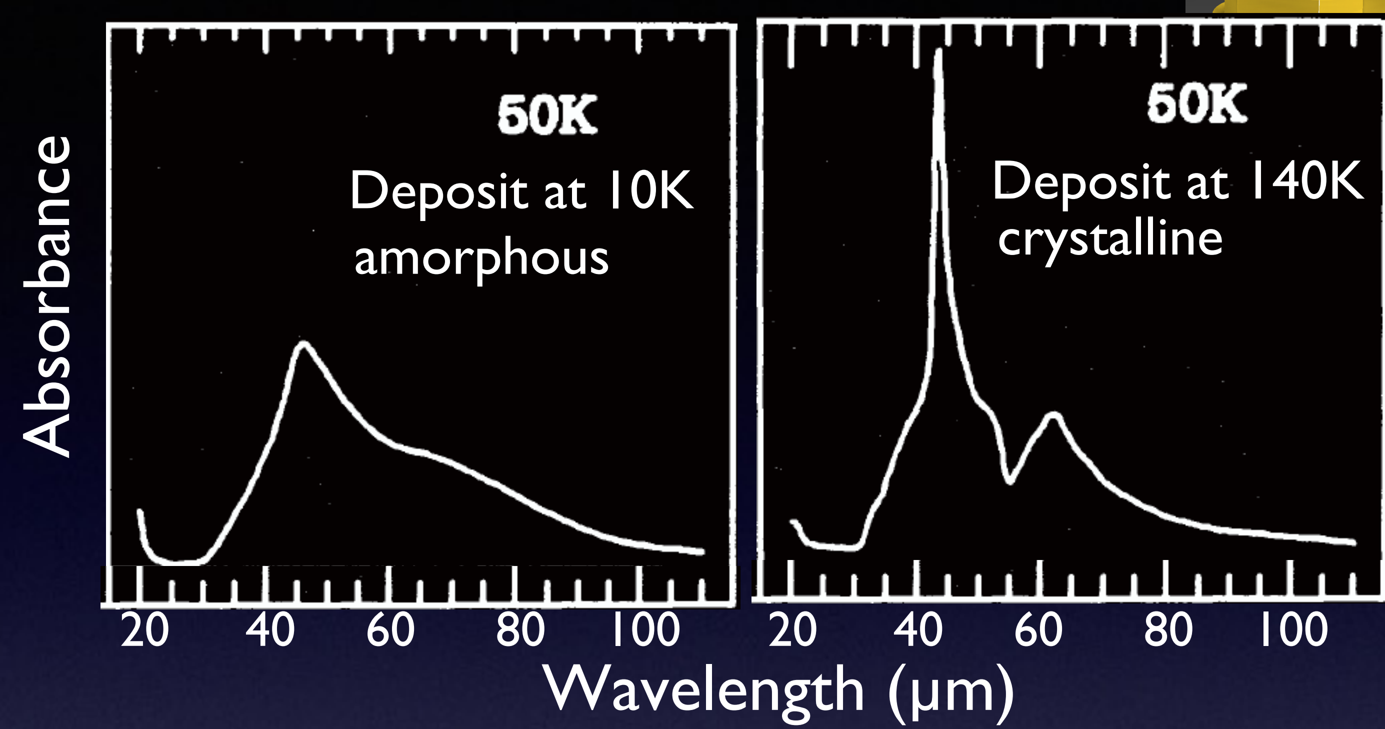


Detectable mass at 140pc with $(2 - 5)\times10^{-20}$W m^{-2}



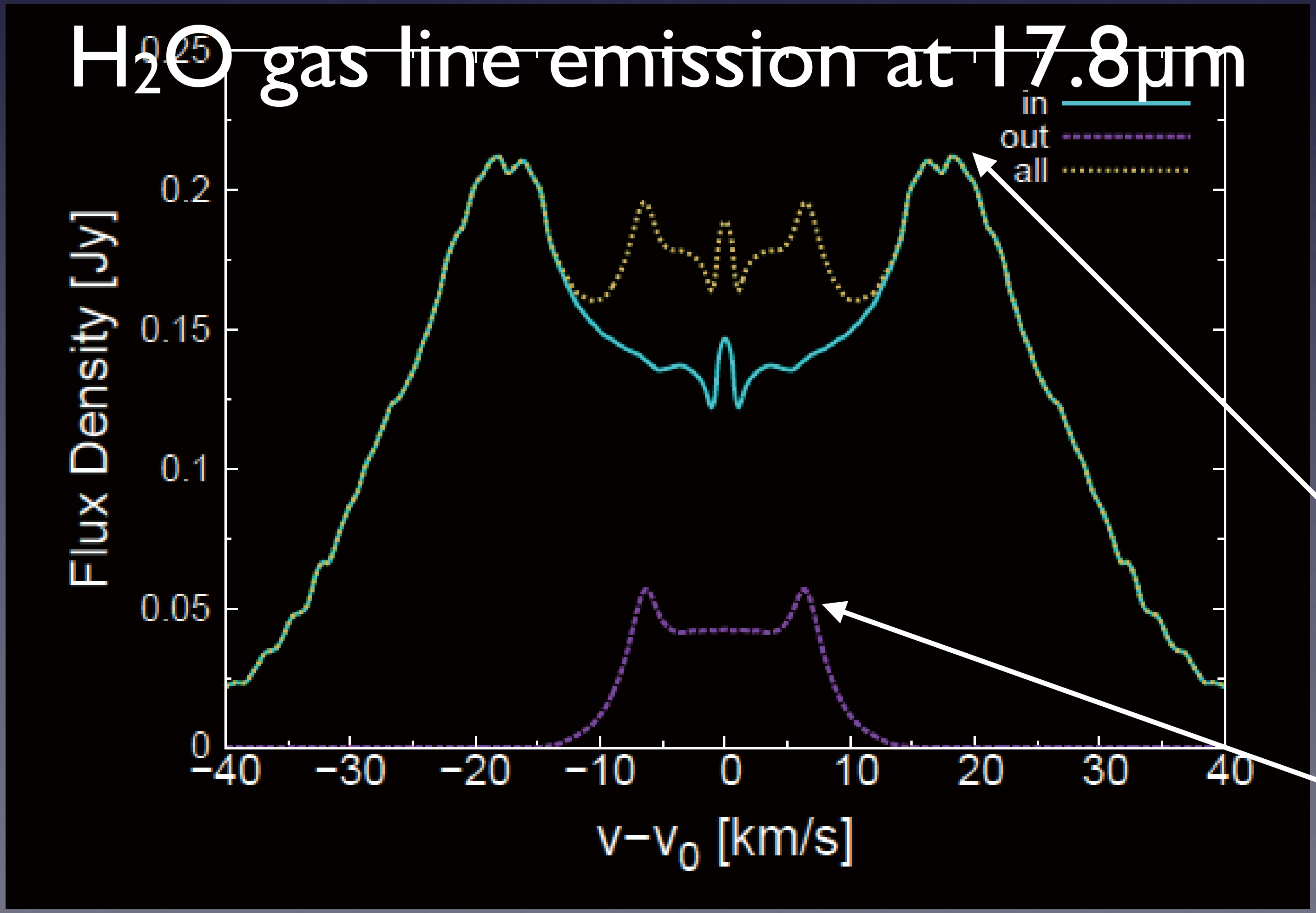
SPICA studies water trail

SPICA observes a number of water lines as well as crystalline and amorphous water ice features at ~43 and ~62μm to study thermal history and material transportation in the outer region of PPDs.



Smith+ 1994, MNRAS 271, 481

H_2O gas line emission at 17.8μm



HRS high resolution spectroscopy detects snow line and estimates its location using Keplerian motion.

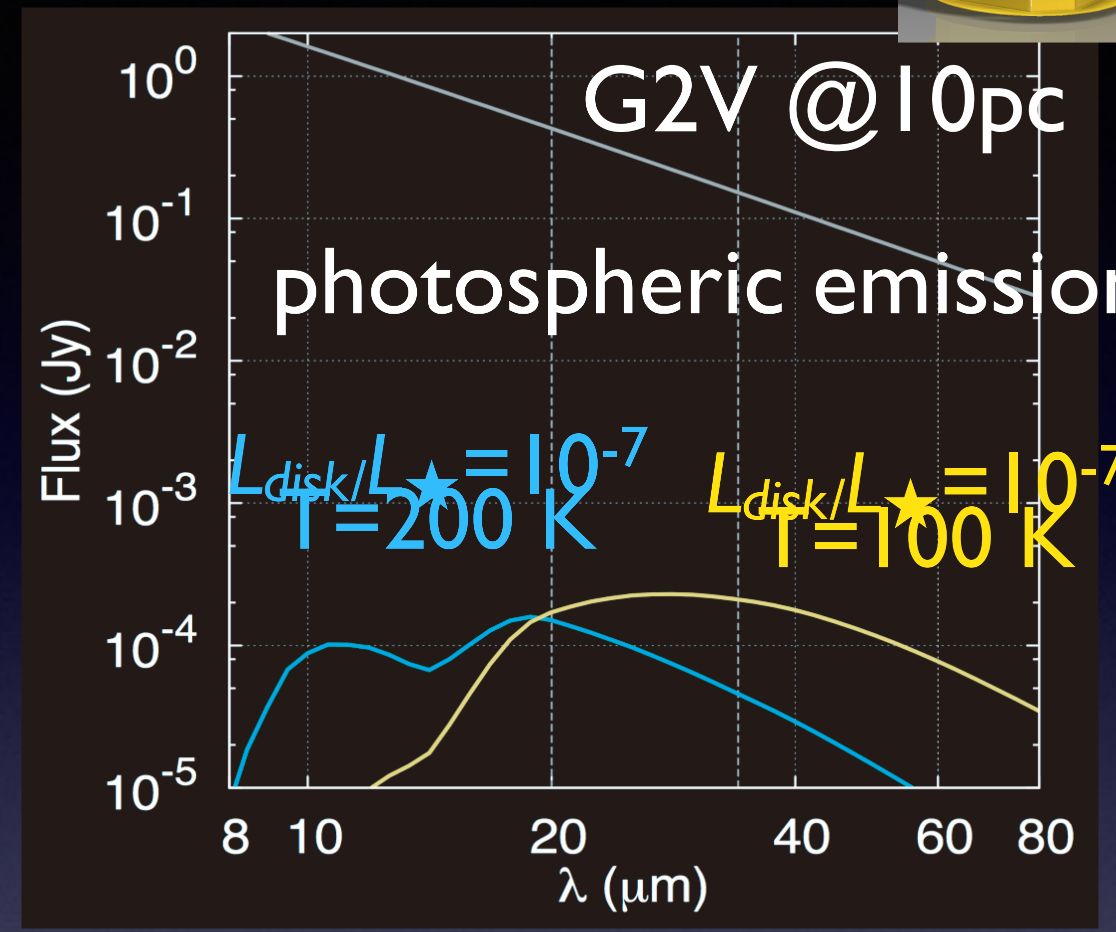
Emission near the snow line

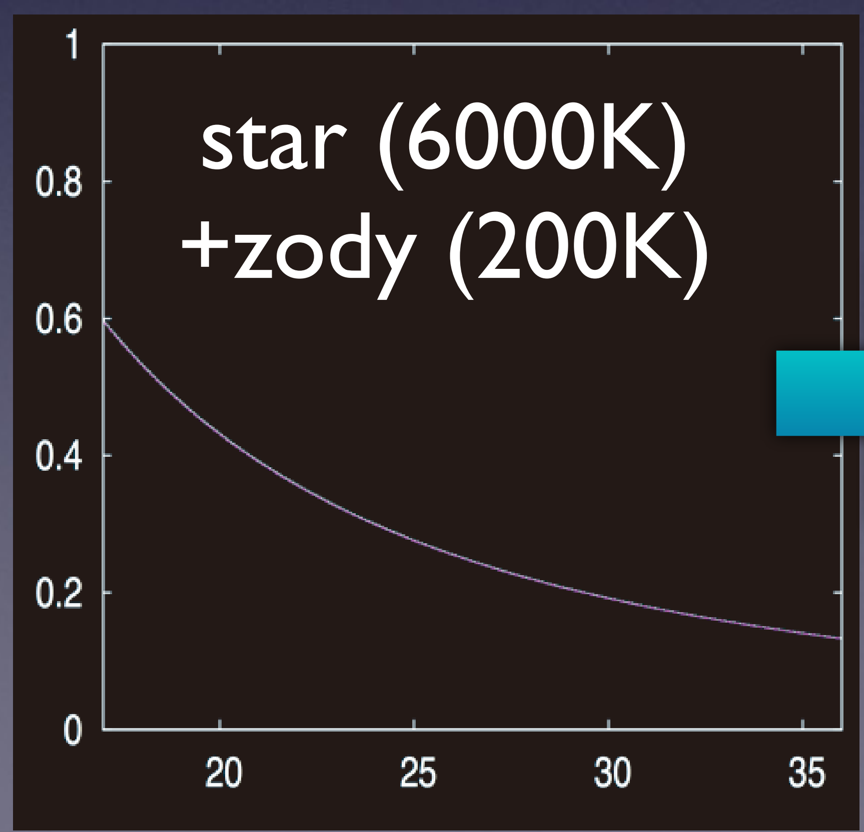
Emission from surface of outer regions

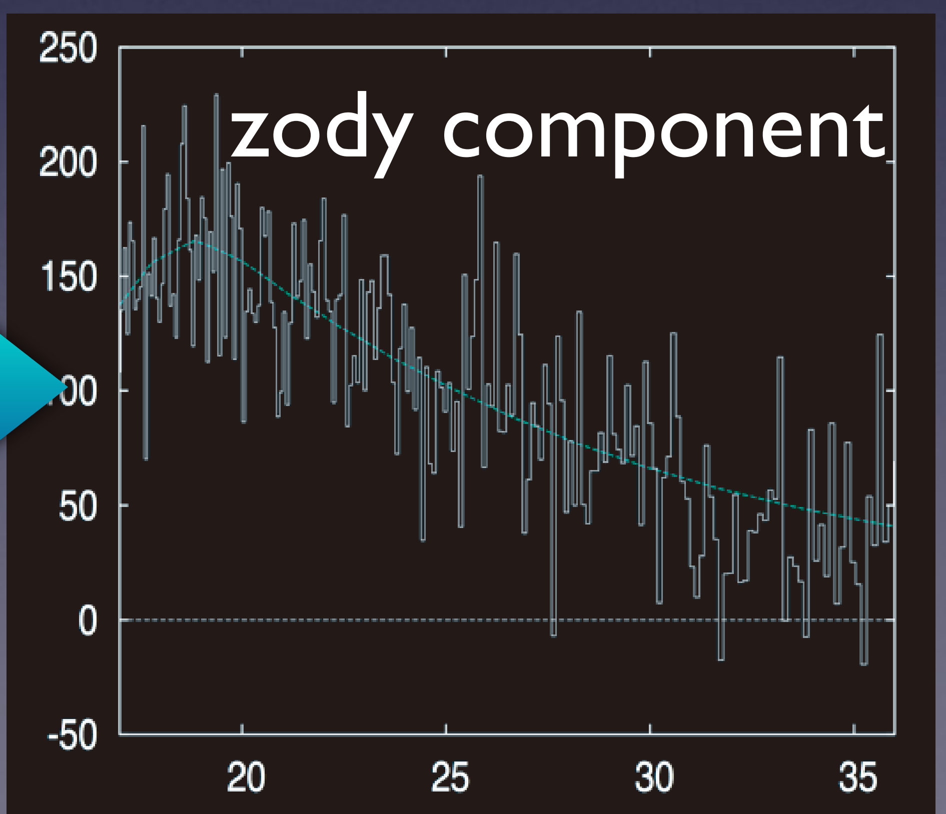
Search for zodiacal cloud analogues

SMI/LRS detects true zodiacal cloud analogues, which enables to study the evolution of debris disks to our solar system

SAFARI & SMI spectroscopy studies mineralogy of debris disks and their evolution







Summary

- SPICA is a joint mission between ESA and JAXA, optimized for MIR and FIR spectroscopy with a cryogenically cooled telescope. Target launch date is in 2027 - 2028.
- Current baseline design is a 2.5m aperture with T< 8K, cooled by mechanical coolers.
- SPICA improves the line detection by 1-2 orders of magnitudes relative to past facilities in the MIR to FIR.
- SPICA challenges two major issues in present astronomy; evolution of galaxies and formation planetary systems with its unprecedented line sensitivity.
- SPICA unveils the origin of IR luminosity at the peak of cosmic SFRD. The major targets are main-sequence galaxies at z=1-3.
- SPICA reveals the physical conditions and dynamics of terrestrial planet forming regions and studies the gas dissipation process in PPDs.

Dr. Bruce Swinyard

May his soul rest in peace.

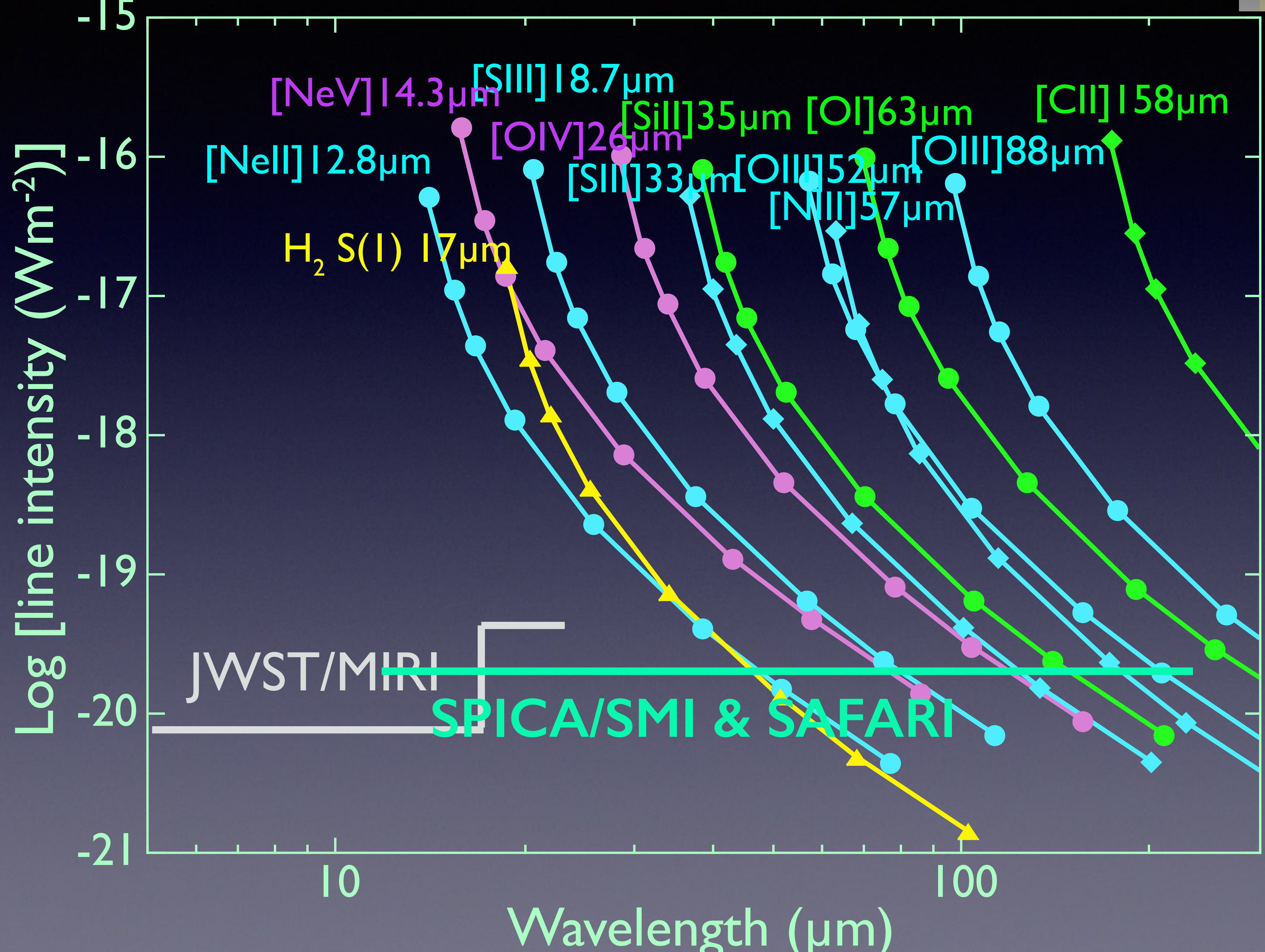
Thank you for your attention

η Carina region by AKARI

Measurement capabilities

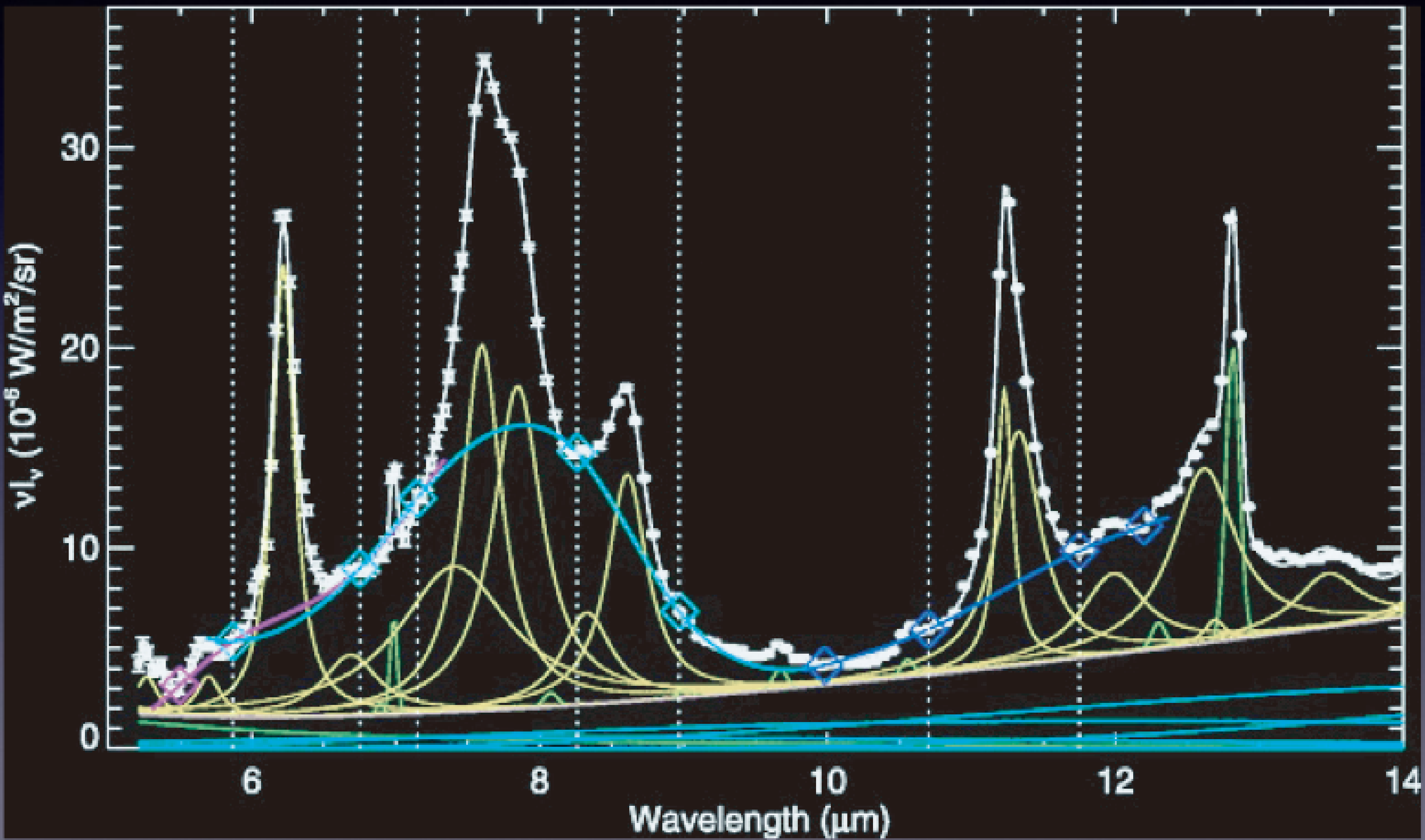
Parameter	Units	Value or range
Wavelength	µm	17 - 230 (5 -20 considered)
Angular resolution	arcsec	1.2” (17µm) - 16” (160µm)
Spectral resolution (Δλ/λ)		50 - 20000
Continuum sensitivity	µJy	20-140 (17-37µm) 250 - 920 (34 - 230µm)
Spectral line sensitivity	10^{-19} Wm^{-2}	0.2 - 0.6
Instantaneous FoV	armin	600” x 5 (LRS)
Number of target fields		5
Field of Regard	sr	~10’ (SMI) & ~2’ (SAFARI)

AGNs with $10^{12}L_\odot$



PAH bands

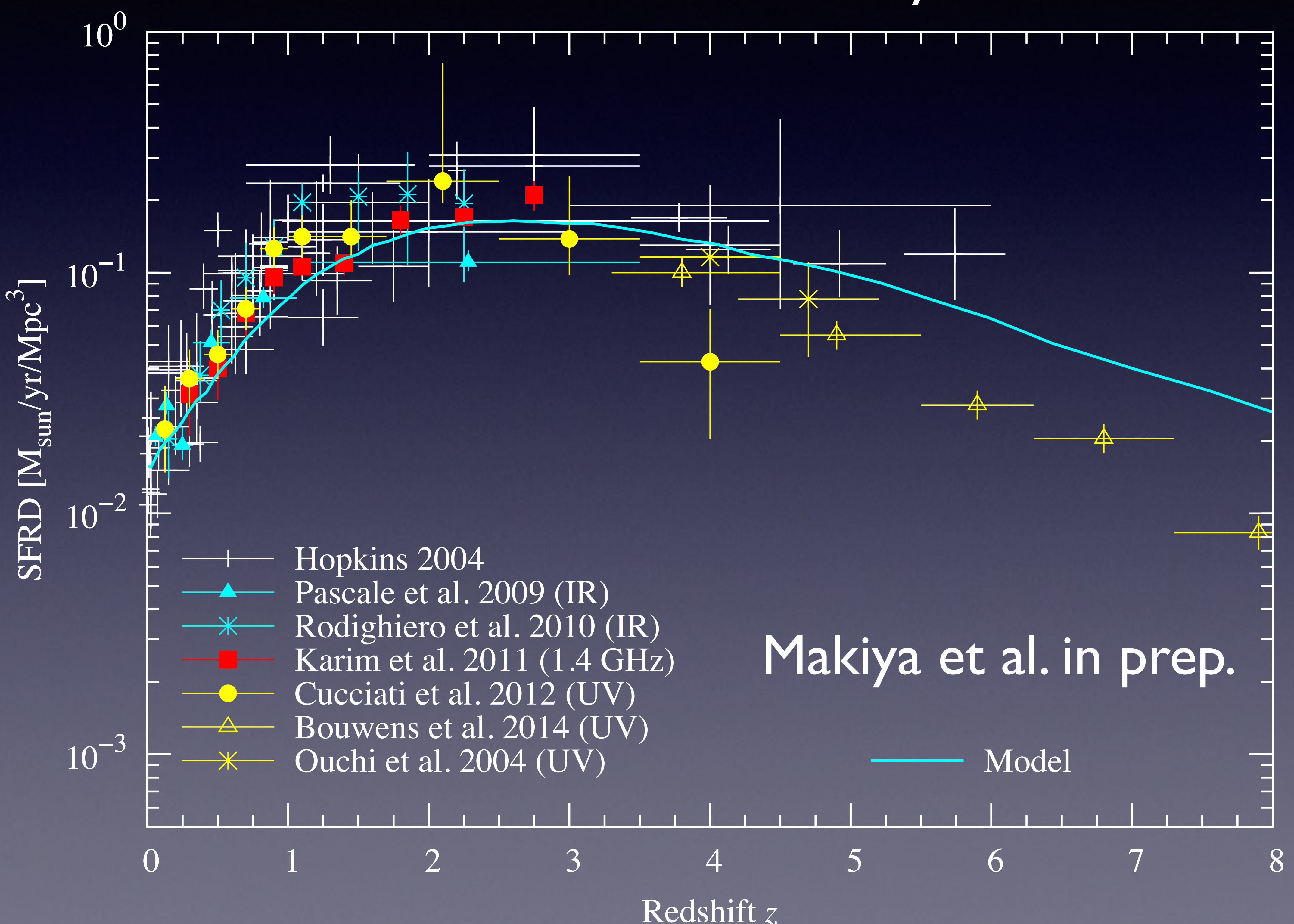
Distinct pattern of multi-band determines the redshift reliably



Smith+ 2007, ApJ, 656, 770

Cosmic SFRD

Model (Semi-analytic simulation) accounts for the observed SFRD relatively well.



IR luminosity density

Model (Semi-analytic simulation) cannot explain the large IR luminosity at z = 1-2