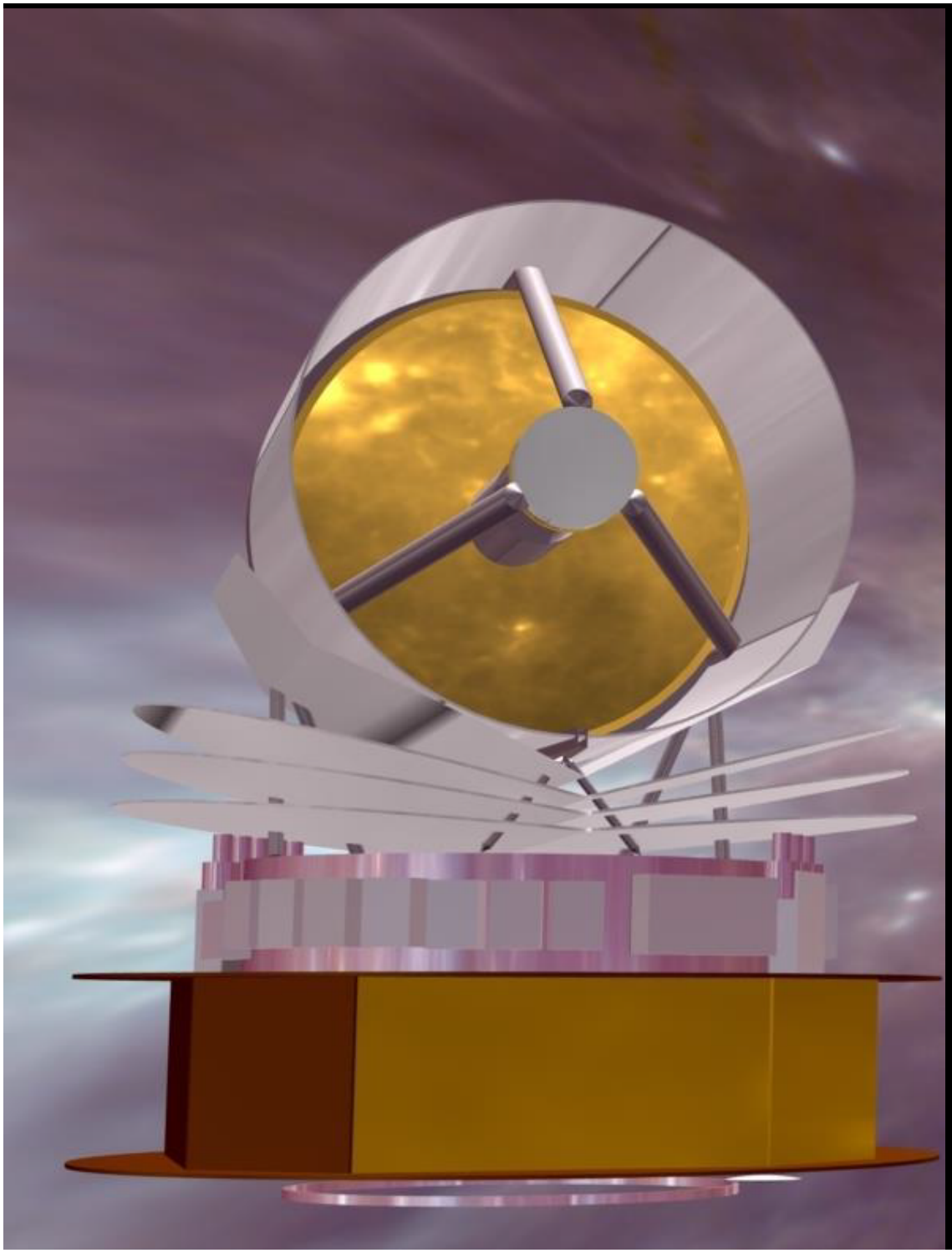
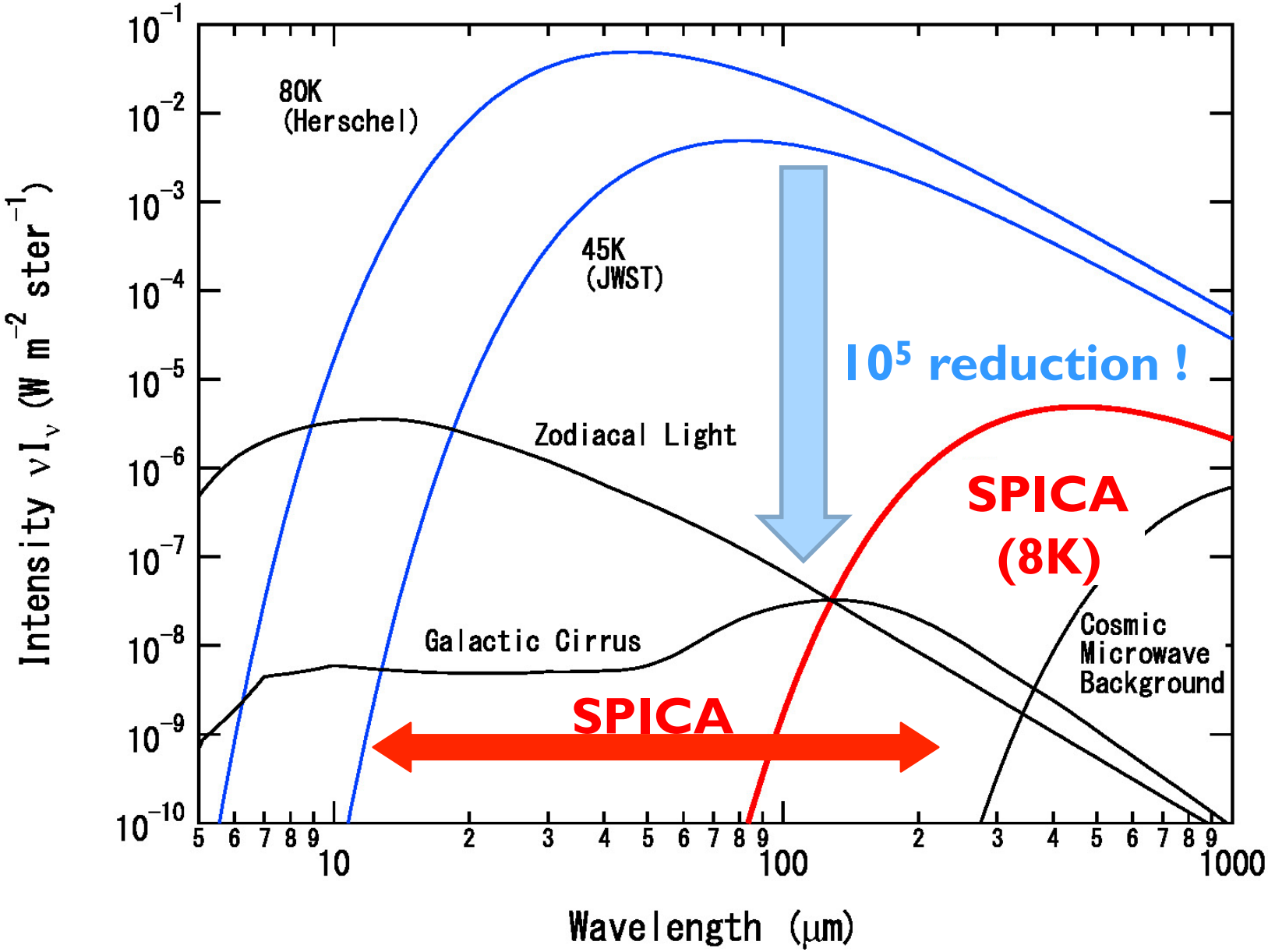


Far IR Surveyor
Decadal Mission
F2F Meeting
May 12-13, 2016

SPICA

Itsuki Sakon
(University of Tokyo)
on behalf of
the SPICA Team

Advantage of a cryogenically-cooled IR telescope

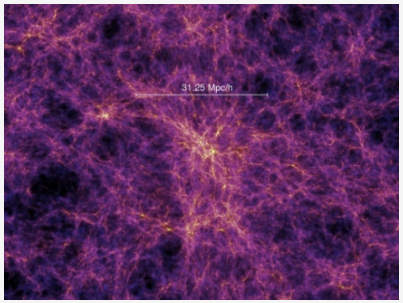


Science Goals

Enrichment of the Universe with metal and dust, leading to the formation of habitable worlds

Metal and dust enrichment through galaxy evolution

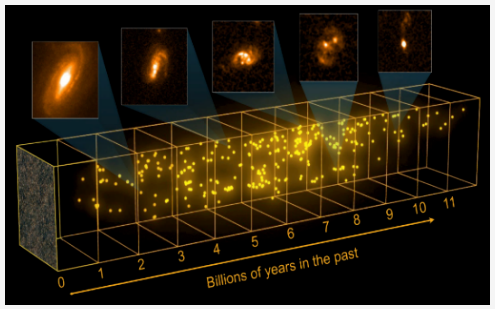
Star/Galaxy formation
First mineral, aromatics



Star formation in distant galaxies

Dust-obscured AGNs and AGN outflow

Over the peak of the cosmic star-formation history



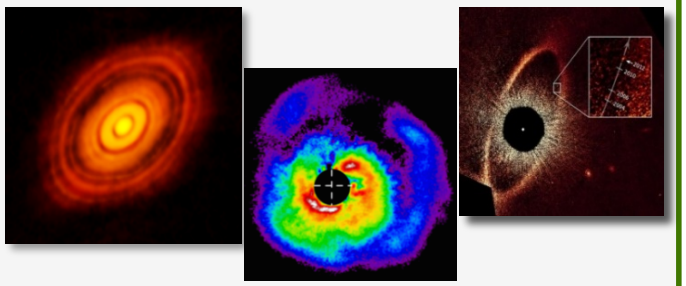
Star formation in nearby galaxies

Spatially-resolved, high-z analogs or relics

Planetary formation to habitable systems

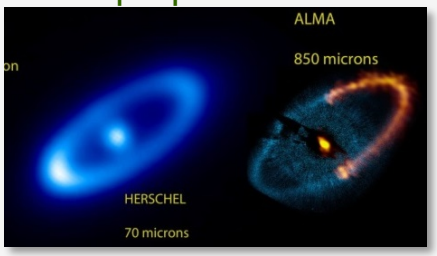
Gas dissipation in planet-forming disks

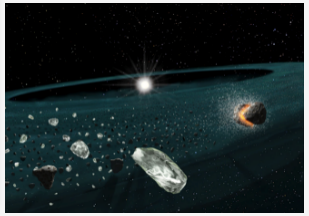
Gas dissipation in proto-planetary disks



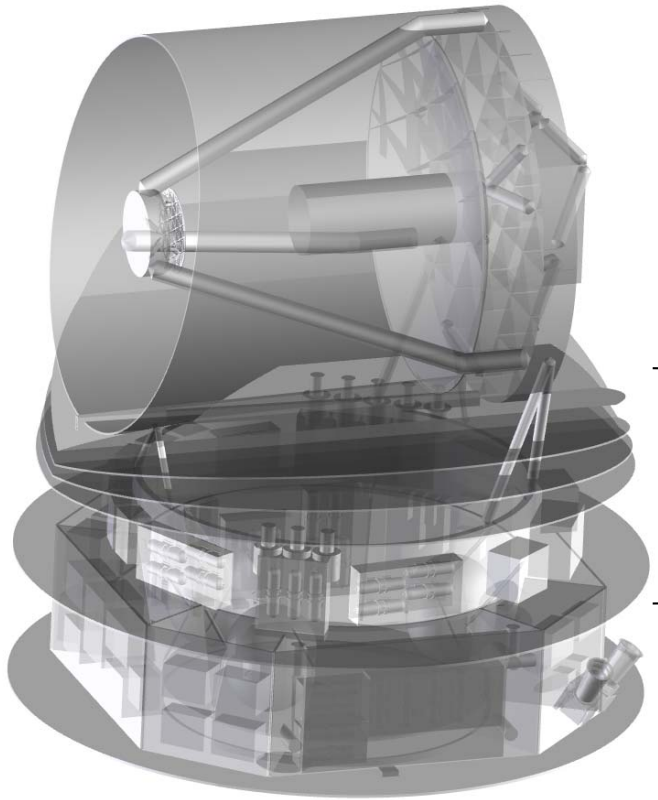
Dust evolution in planet-forming disks to solar system analogues

Changes of mineral and ice properties in debris disks





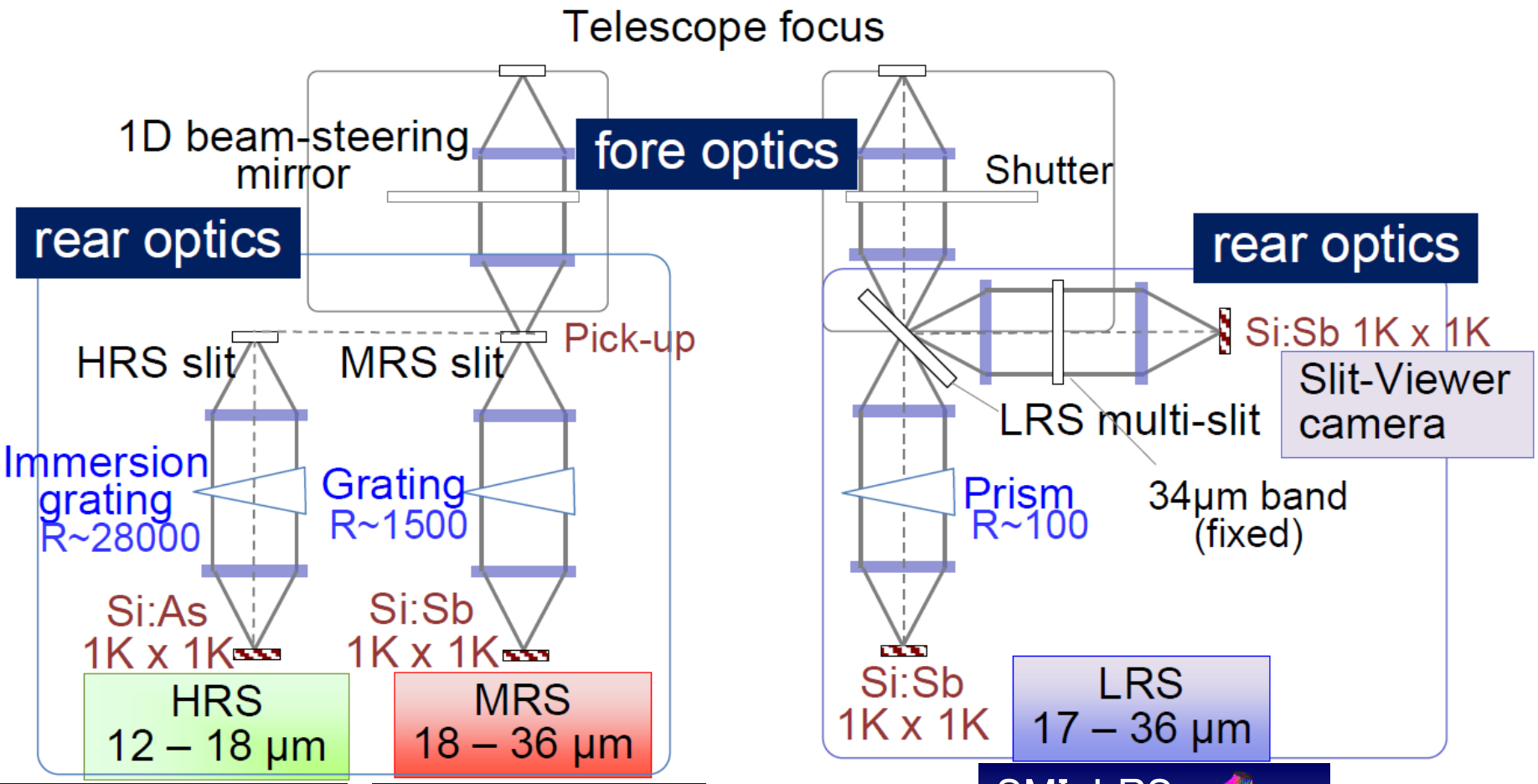
Baseline Specifications

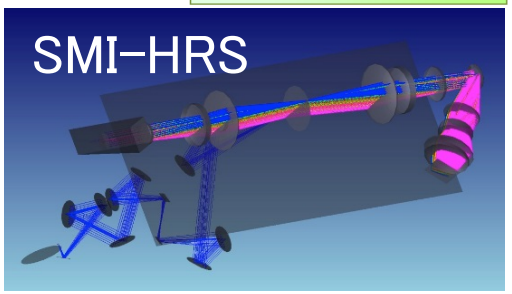


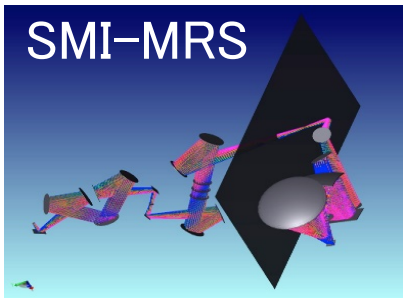
- Outer size:
  - Φ4500 mm x 5285 mm
  - Fit in the H3 rocket fairing
- Weight:
  - 2614 kg (dry, nominal)
  - 3450 kg (wet, with margin)
  - Compliant with launching capacity of the H3 rocket. (3700 kg to L_2 transfer orbit)

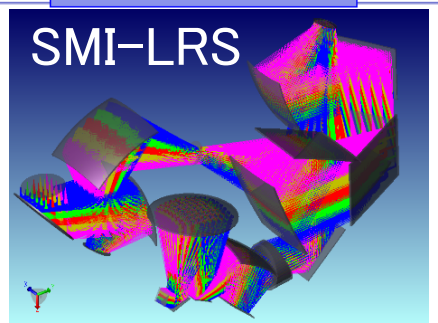
Parameter	Description
Telescope	2.5 m aperture, cooled below 8 K
Core Wavelength	17 – 230 μm
Orbit	Halo around S-E L2
Launcher	JAXA H3
Launch Year	2027-2028

SPICA Mid-infrared Instrument (SMI) Block Diagram







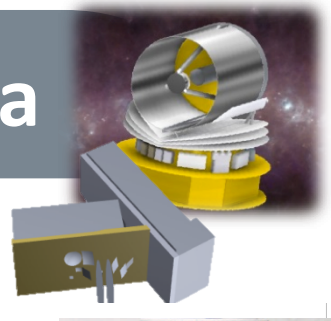


Basic Specification of SMI/LRS, MRS, and HRS

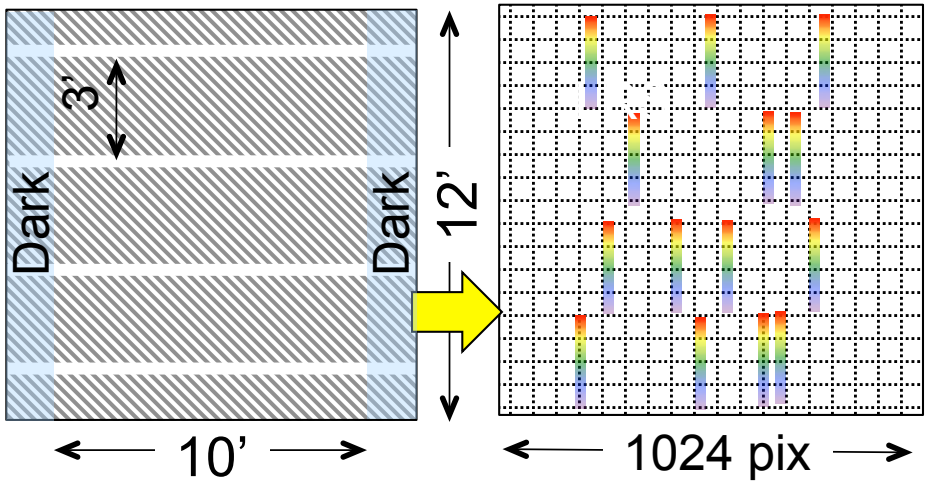
	LRS	MRS	HRS
Detector (Array Size) Pixel Pitch	Si:Sb (1kx1k) 18μm/pix	Si:Sb (1kx1k) 18μm/pix	Si:As (1kx1k) 25μm/pix
wavelength range (μm)	17μm – 37μm	18μm – 36μm (m = 6th – 11th)	12.14μm – 17.08μm (m = 84th – 118th) [fully covered] 17.08μm – 18.7μm (m=77th –84th) [intermittently]
spectral resolution ($R=\lambda/\Delta\lambda$)	50—100 (prism)	~1000 (echelle grating)	~28000 (imergion grating)
plate scale (arcsec/pix)	0.”70	0.”725	0.”67
Slit configuration	Multi (n=4) Long Slits slit length; 600” slit width; 3.”7 (5.3pix)	Long Slit length; 60.”0 width; 3.”7 (5.1pix)	Short Slit slit length; 4” width; 1.”7 (2.5pix)

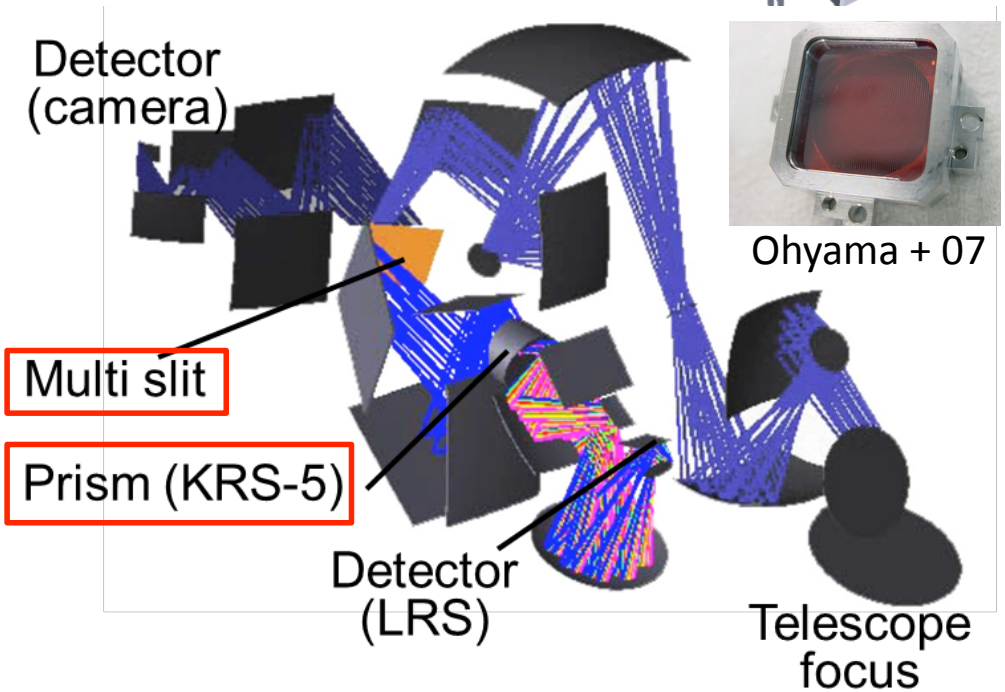
LRS; excellent continuum sensitivity ~30μJy (1h5σ @30μm), high spectral mapping efficiency (R=50--100)
MRS; excellent line sensitivity ~4×10^{-20}W/m2 (1h5σ @30μm), high spectral mapping efficiency (R~1000)
HRS; excellent line sensitivity ~1×10^{-20}W/m2 (1h5σ @15μm), high resolution spectroscopy (R~28000)

(1) Low-resolution spectrometer and camera



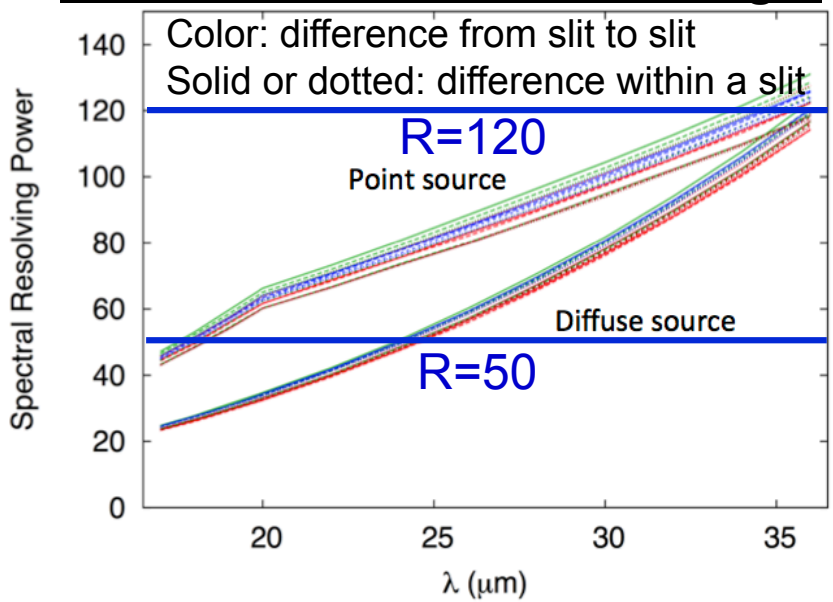
multi-slit format (4 long slits) **LRS** Detector: **Si:Sb**, 1K x 1K





Ohyama + 07

$\lambda/\Delta\lambda$ as a function of wavelength

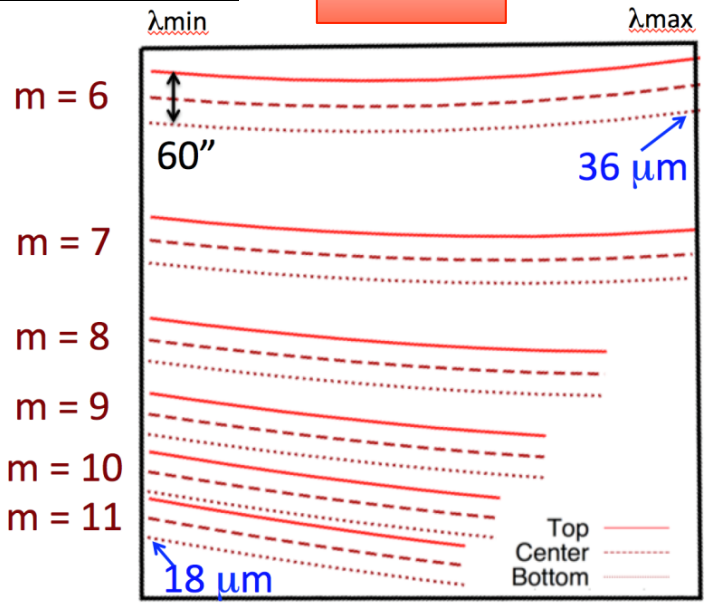


- Wide FoV (4 slits, slit length 10')
- high continuum sensitivity
  ~30 μJy (1hr, 5σ)
- 0.7"/pixel
- R = 50–120 spectral mapping
- 10'x10' slit viewer (34 μm, R = 5)
  sensitivity: ~10 μJy (1hr, 5σ)

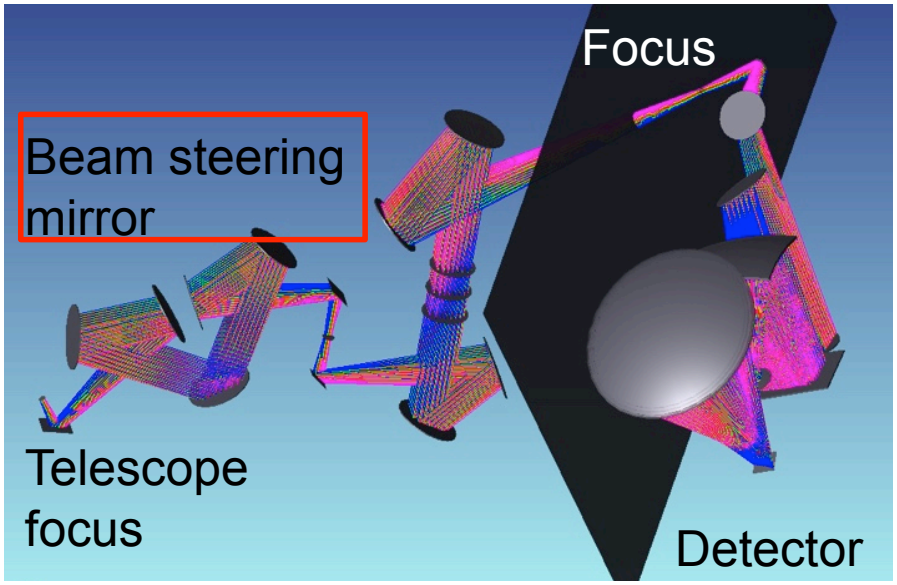
(2) Mid-resolution spectrometer

Echelle format

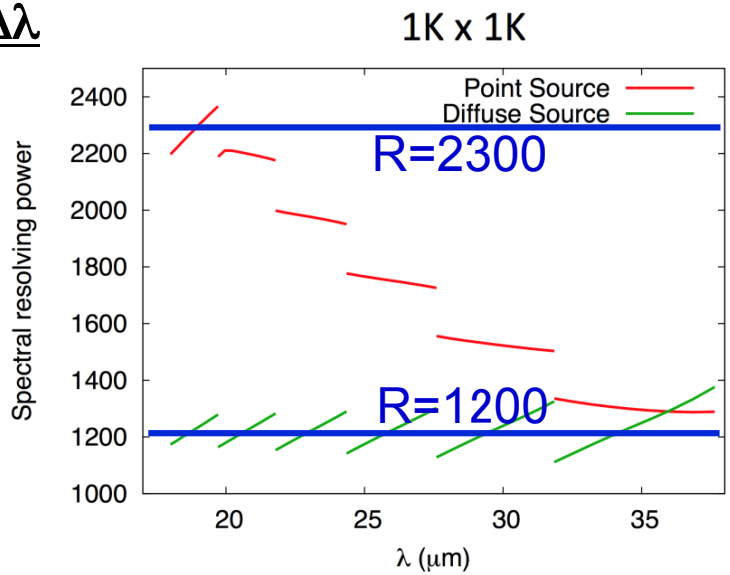
MRS



Detector: 1 **Si:Sb**, 1K x 1K

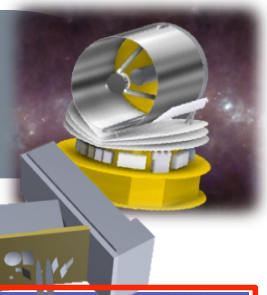


λ/Δλ



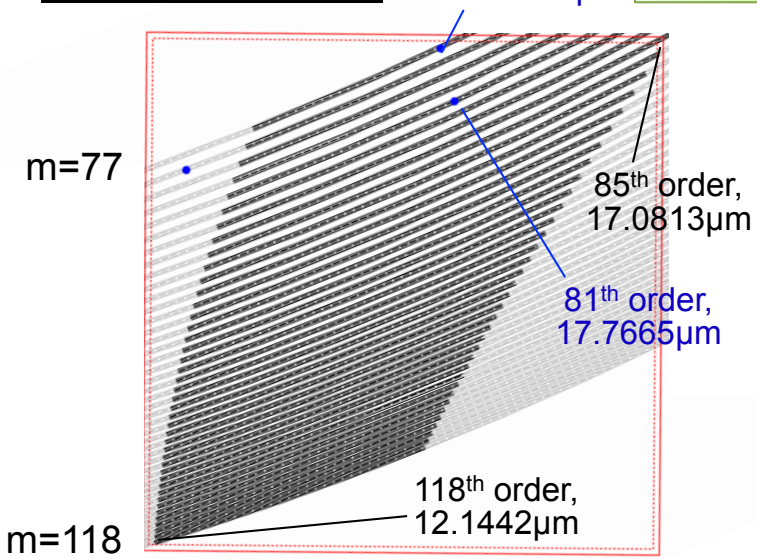
- wide FoV (slit length 60”
  + beam steering mirror)
- high line sensitivity
  ~4 x10^{-20} W/m^2 (1 hr, 5σ)
- good spectral resolution
  R = 1200 – 2300
- spectral mapping

(3) High-resolution spectrometer

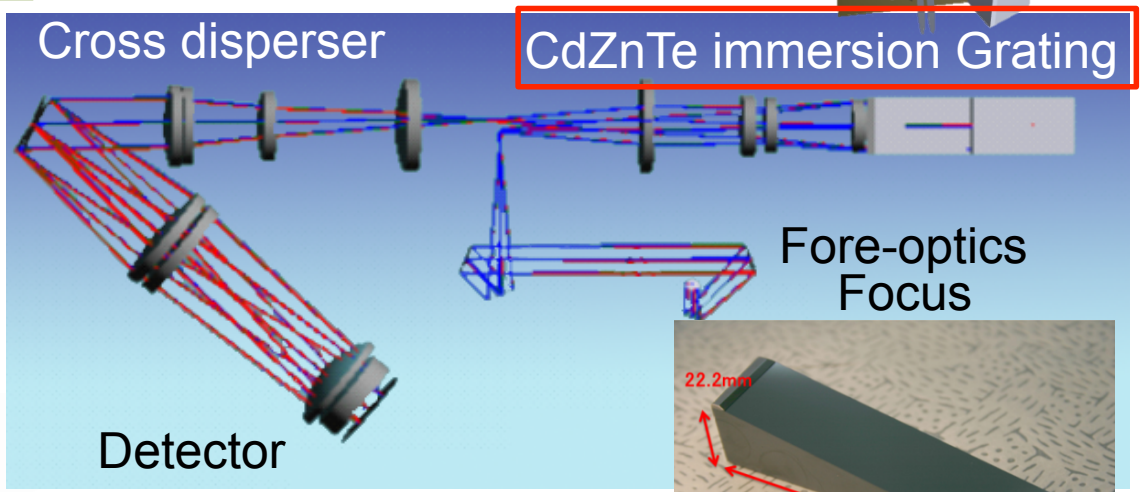


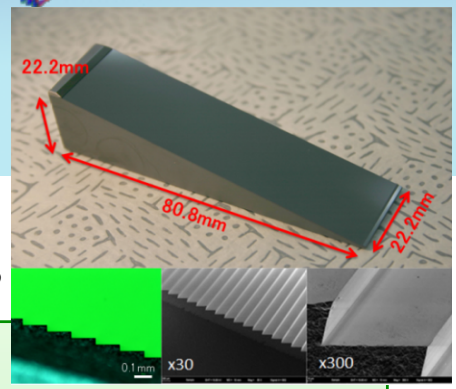
HRS Detector: 1 **Si:As** 1K x 1K

Echelle format

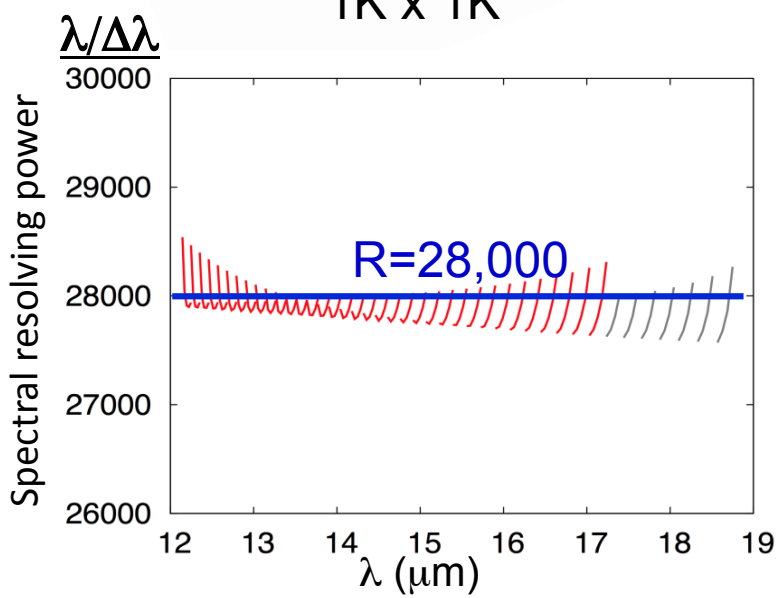


1K x 1K





Ikeda et al. 2015
Applied Optics 54, 5193



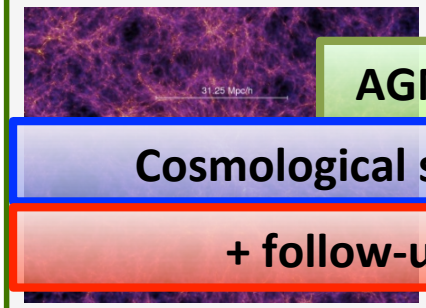
- slit length ~4”
- very high line sensitivity
  ~1 x10^{-20} W/m^2 (1 hr, 5σ)
- high spectral resolution
  R = 28,000
- Continuous coverage from 12.1 to 17.3 μm, plus partial coverage up to 18.9 μm for H_2O 17.77 & 18.66 μm.

Roles of SMI in the Science Goals

Enrichment of the Universe with metal and dust, leading to the formation of habitable worlds

Metal and dust enrichment through galaxy evolution

Star/Galaxy formation
First mineral, aromatics



Star formation in distant galaxies

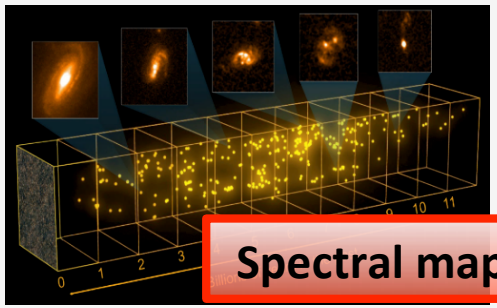
AGN Outflows with HRS

Cosmological surveys with LRS

+ follow-up with MRS

Dust-obscured AGNs and AGN outflow

Over the peak of the cosmic star-formation history



Star formation in nearby galaxies

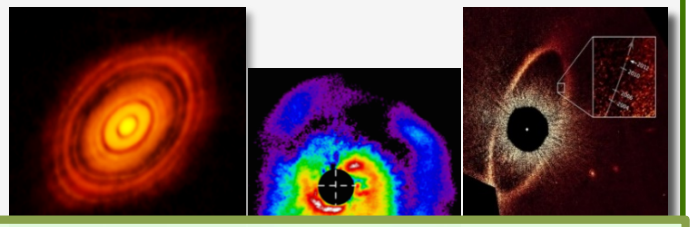
Spatially-resolved, high-z analogs or relics

Spectral mapping with MRS

Planetary formation to habitable systems

Gas dissipation in planet-forming disks

Gas dissipation in proto-planetary disks



Resolving gas Kepler motion with HRS

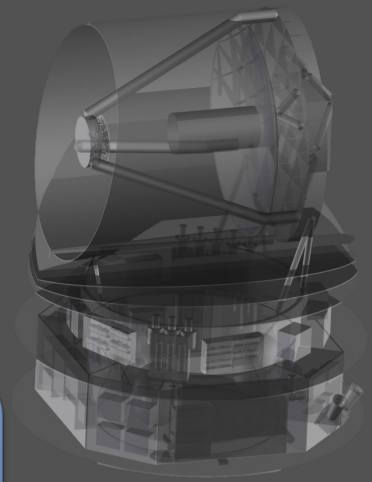
Dust evolution in planet-forming disks to solar system analogues

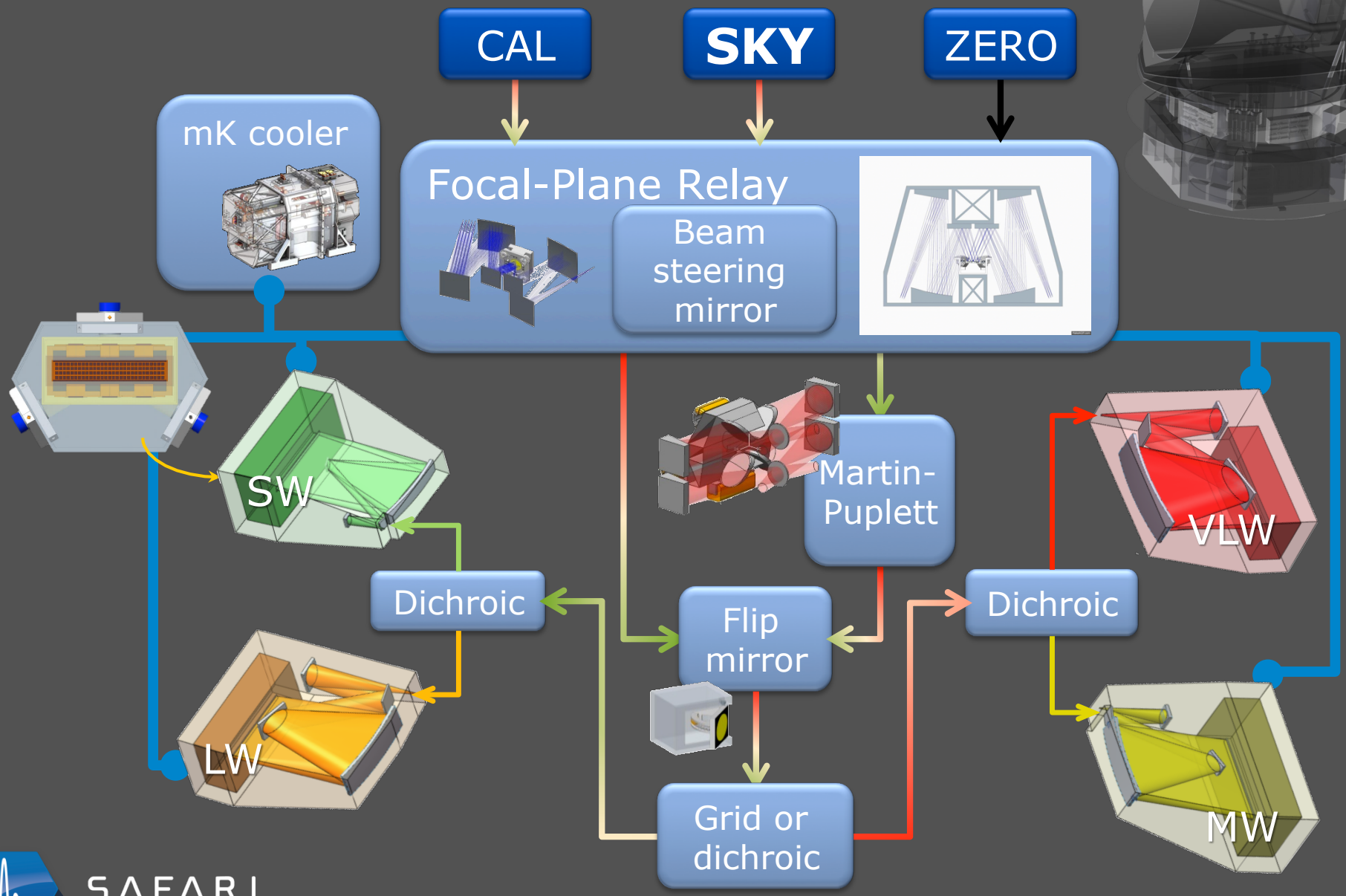
Changes of mineral and ice properties in debris disks

Mineralogy with LRS

+ follow-up with MRS

SAFARI Block Diagram





SPICA/SAFARI Fact Sheet

SAFARI Overview

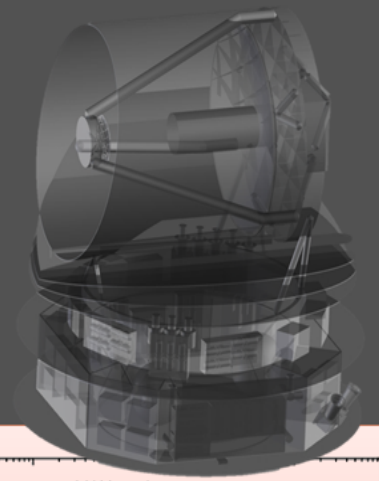
- Four band ***grating spectrometer***
- Continuous spectroscopic capability from 34-230 μm

Parameter		Waveband			
		SW	MW	LW	LLW
Band centre / μm		45	72	115	185
Wavelength range / μm		34-56	54-89	87-143	140-230
Band centre beam FWHM		4.5″	7.2″	12″	19″
Point source spectroscopy (5σ-1hr)					
R~300	**Limiting flux** / x10^{-20} Wm^{-2}	7.2	6.6	6.6	8.2
R~300	**Limiting flux density** / mJy	0.31	0.45	0.72	1.44
High R	**Limiting flux** / x10^{-20} Wm^{-2}	13	13	13	15
High R	**Limiting flux density** / mJy	18	17	17	19
Mapping spectroscopy* (5σ-1hr)					
R~300	**Limiting flux** / x10^{-20} Wm^{-2}	84	49	30	23
R~300	**Limiting flux density** / mJy	3.6	3.3	3.3	4.1
High R	**Limiting flux** / x10^{-20} Wm^{-2}	189	113	73	51
High R	**Limiting flux density** / mJy	253	151	97	67
Photometric mapping* (5σ-1hr)					
Limiting flux density / μJy		209	192	194	239
Confusion limit (5σ)		15 μJy	200 μJy	2 mJy	10 mJy

Sensitivities based on detector NEP 2×10^{-19} W/√Hz
* Mapping performance is for a reference area of 1 arcmin^2

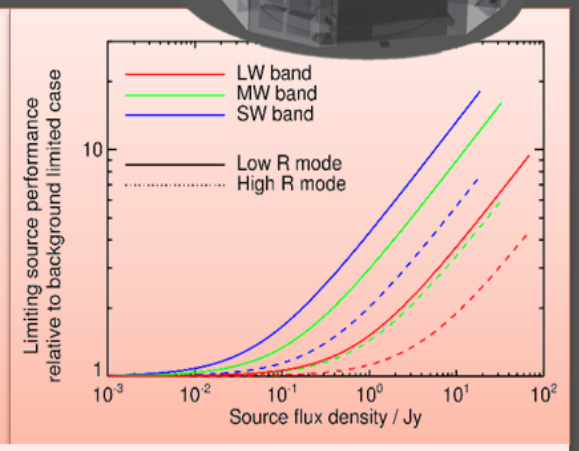
SPICA Mission

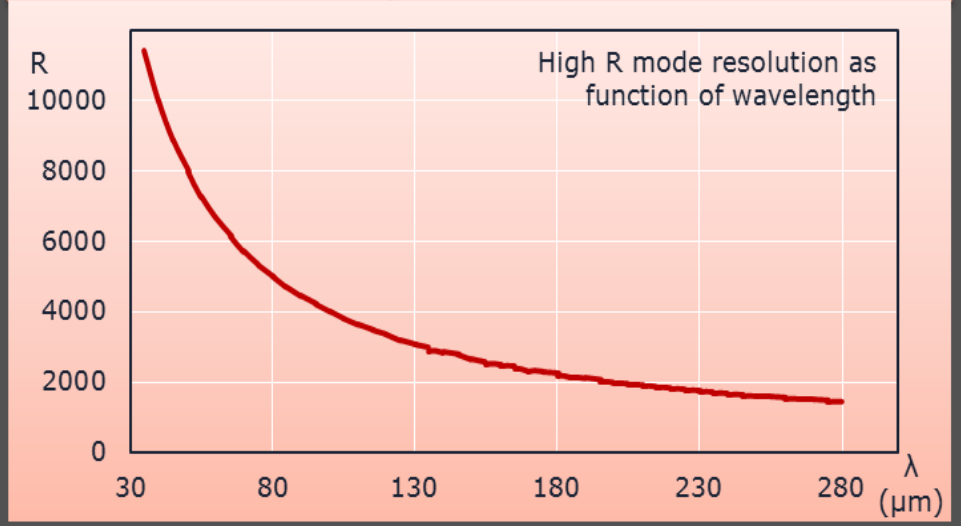
- ESA/JAXA collaboration
- Telescope effective area 4.6 m^2
- Primary mirror temperature 8K
- Goal mission lifetime – 5 years



System performance v.s. target flux density, relative to the background limited case

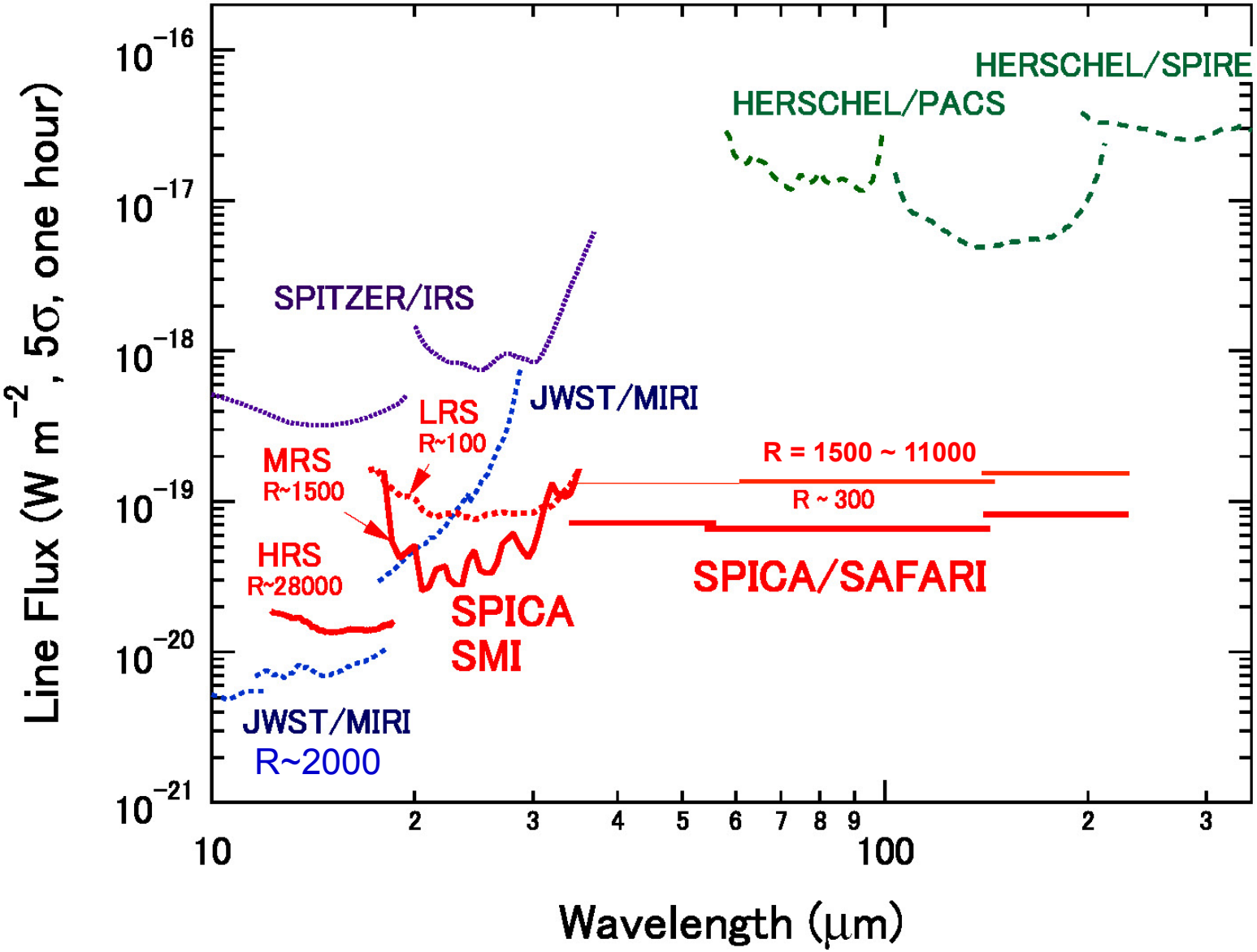
- The sensitivity decrease is due to the increased photon noise from the target source
- Data given up to the instrument saturation limits for each band (31, 51 and 87 Jy for the SW, MW and LW bands respectively.





SRON SAFARI

Sensitivity of SMI and SAFARI



Summary

SPICA Mission

Telescope Aperture is ***2.5m, cooled below 8K***
JAXA plans to launch ***in 2027-2028***
Three years for Nominal Operation, ***Five years*** for Goal
Current Status; Japan: ***Project Preparation*** Phase in JAXA
Europe: Writing a Proposal ***for ESA Cosmic Vision M5***

SPICA Mid-Infrared Instrument

(1) LRS (17–36 μm, R~100) w/ slit-viewer camera (34 μm)
10'-length multi (4) slits. Spitzer/IRS-LL-like with higher mapping speed
(2) MRS (18–36 μm, R~2000)
1'-length slit with beam-steering mirror. IRS-LH-like with better mapping
(3) HRS (12–18 μm, R~30000).
4"-length with beam-steering mirror. Unique (↔ JWST/MIRI R~2000)

SAFARI Grating Spectrometer

Wavelength Coverage 34μm − 230μm
Simultaneous observation of the whole waveband (SW, MW, LW, LLW)
- High-sensitivity R = 300 Spectral Resolution mode
- High-resolution R = 1500 − 11000 mode
~ 2′ × 2′ mapping capability with BSM
larger area mapping through combination of BSM and satellite pointing