”SAFARI” — a far-IR imaging spectrometer for SPICA

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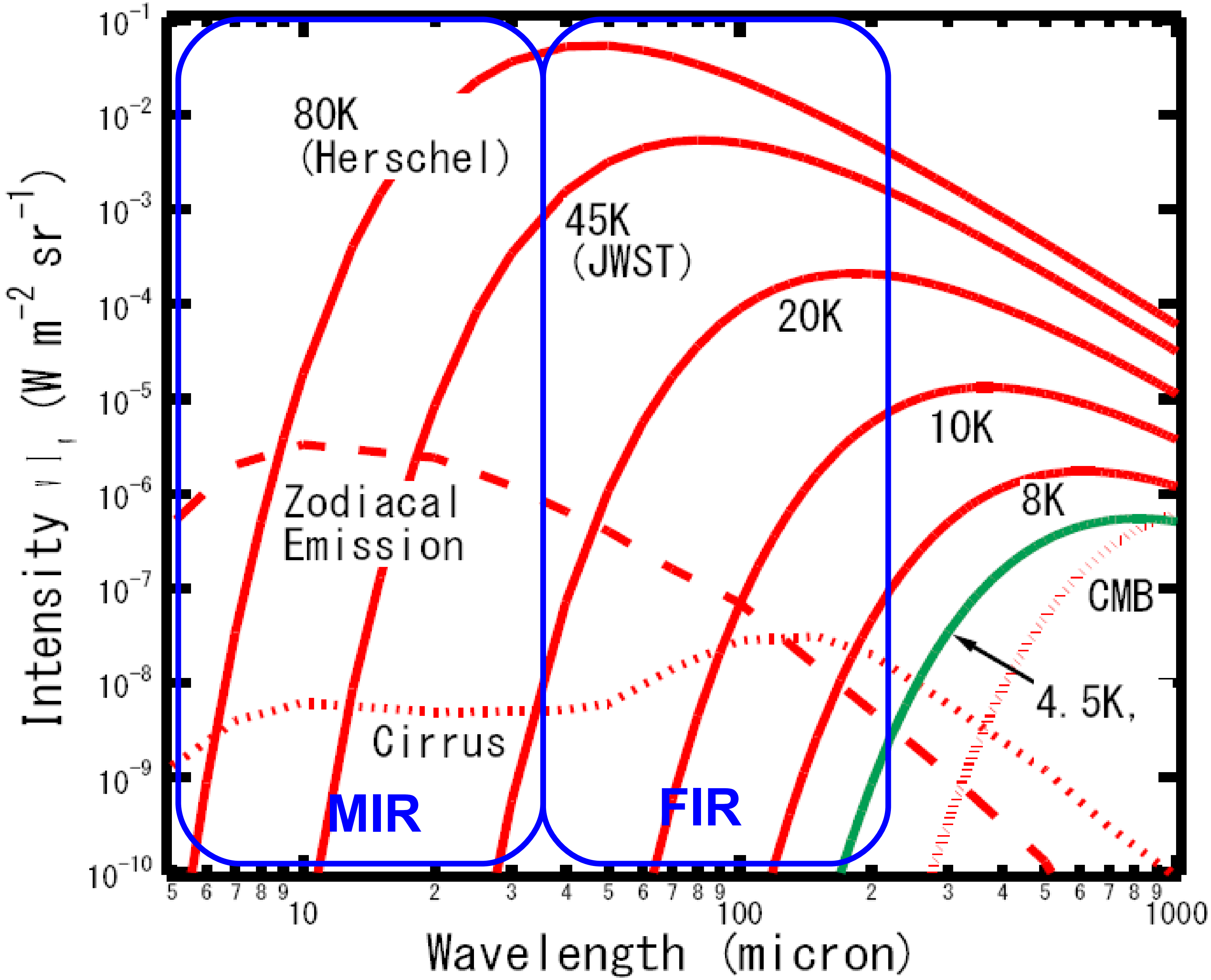
SPICA — a **Cooled** Telescope!



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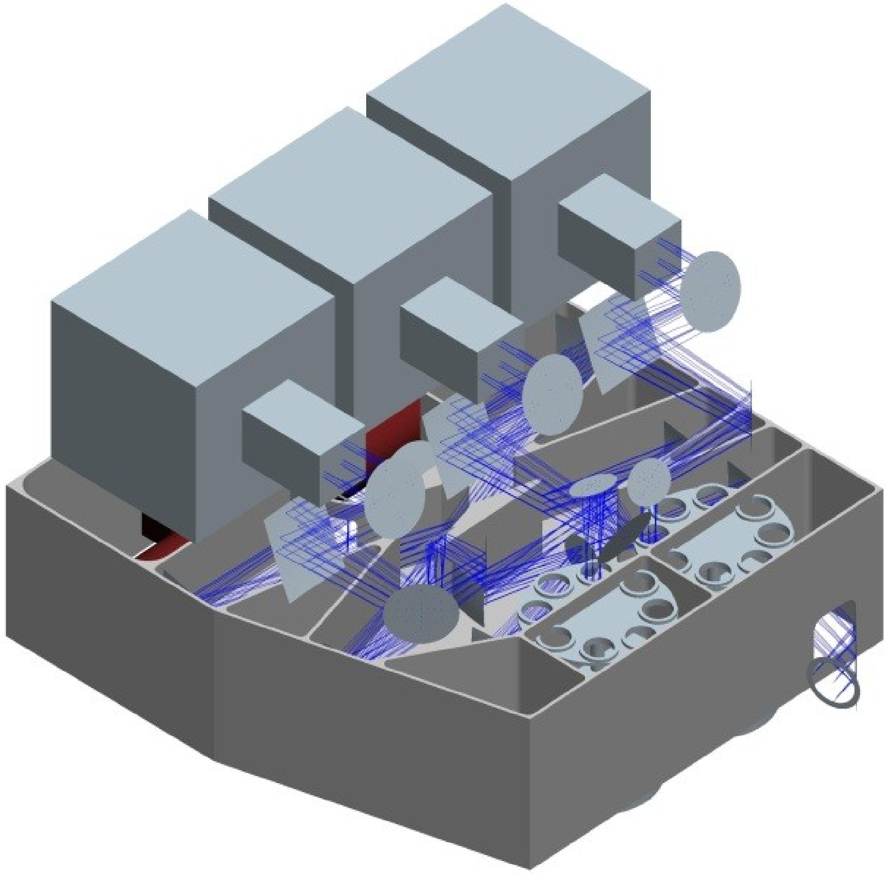
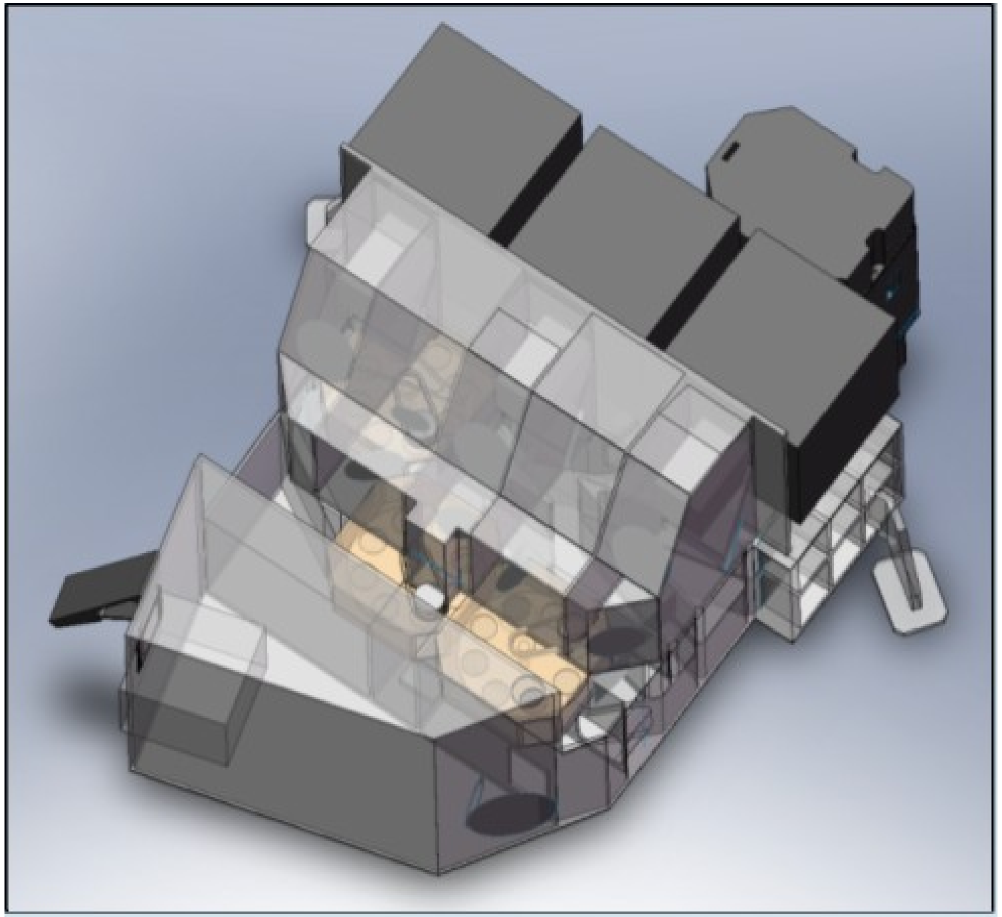
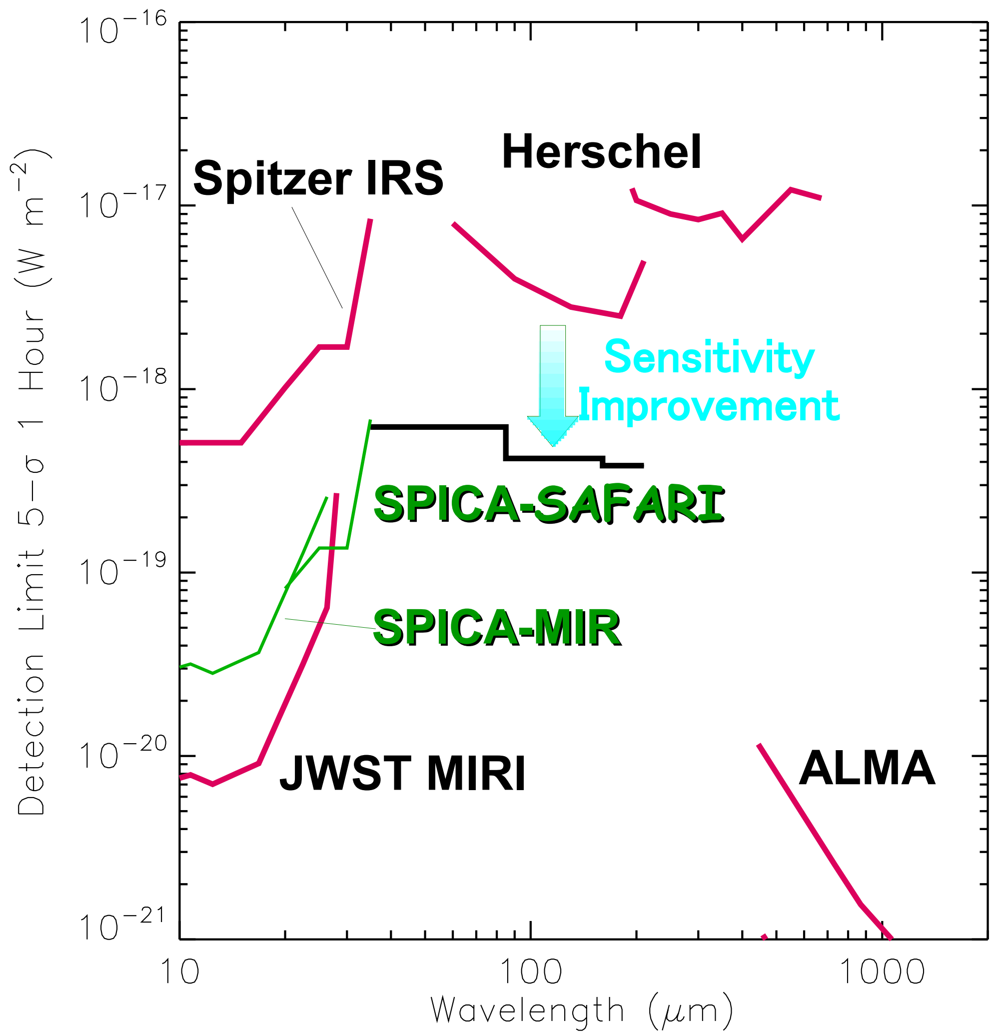
SAFARI – SPICA FIR Instrument Requirements and Specifications

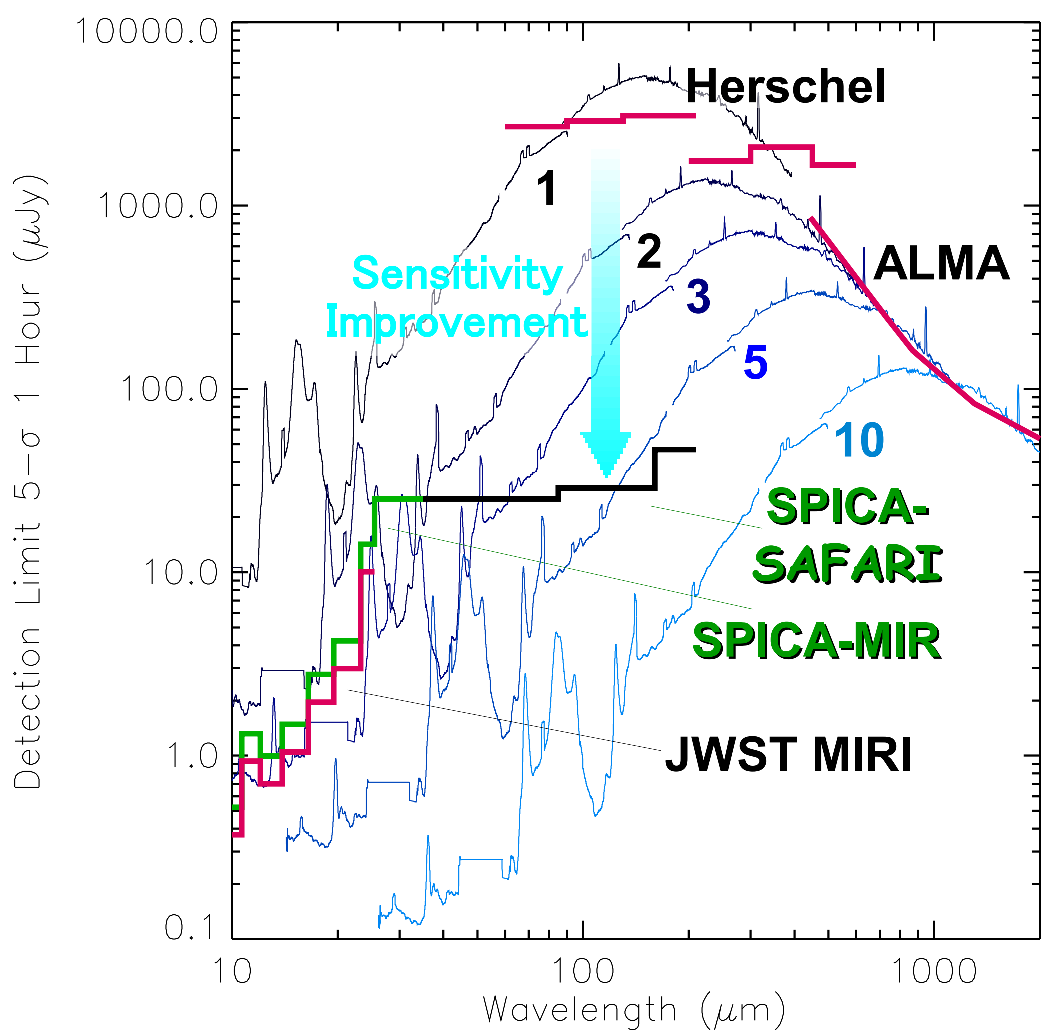




- Instantaneous wavelength coverage **35 to 210 micron**
- Camera mode with **R~3 to 5**
- Multiple spectroscopy mode **R = 2000** @ 100 micron
- Diffraction-limited spatial resolution (**3.6~11.5 arcsec**)
- Field of view **2x2 arcmin**
- Continuum sensitivity of **20-50 uJy**
- Line sensitivity of **$4\text{-}6\times10^{-19}$ W m^{-2}** (5-σ 1 hour)

Expected sensitivity
Spectroscopic (left) & photometric (right)





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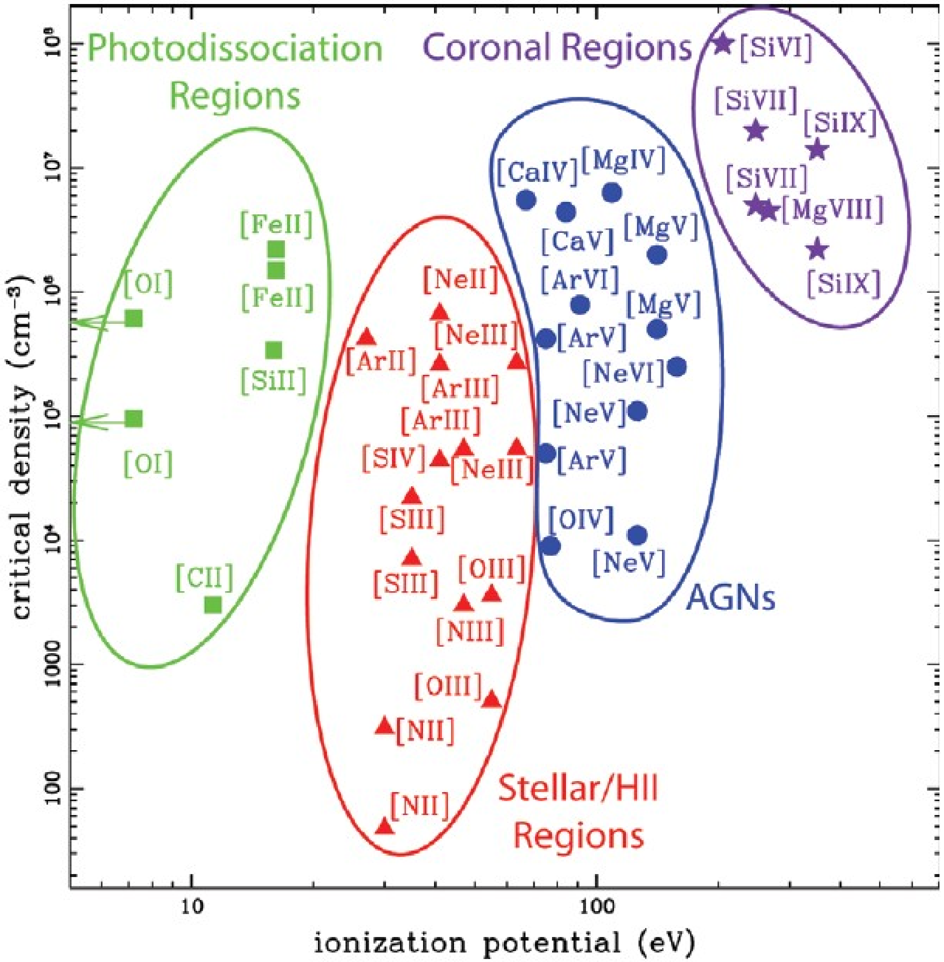
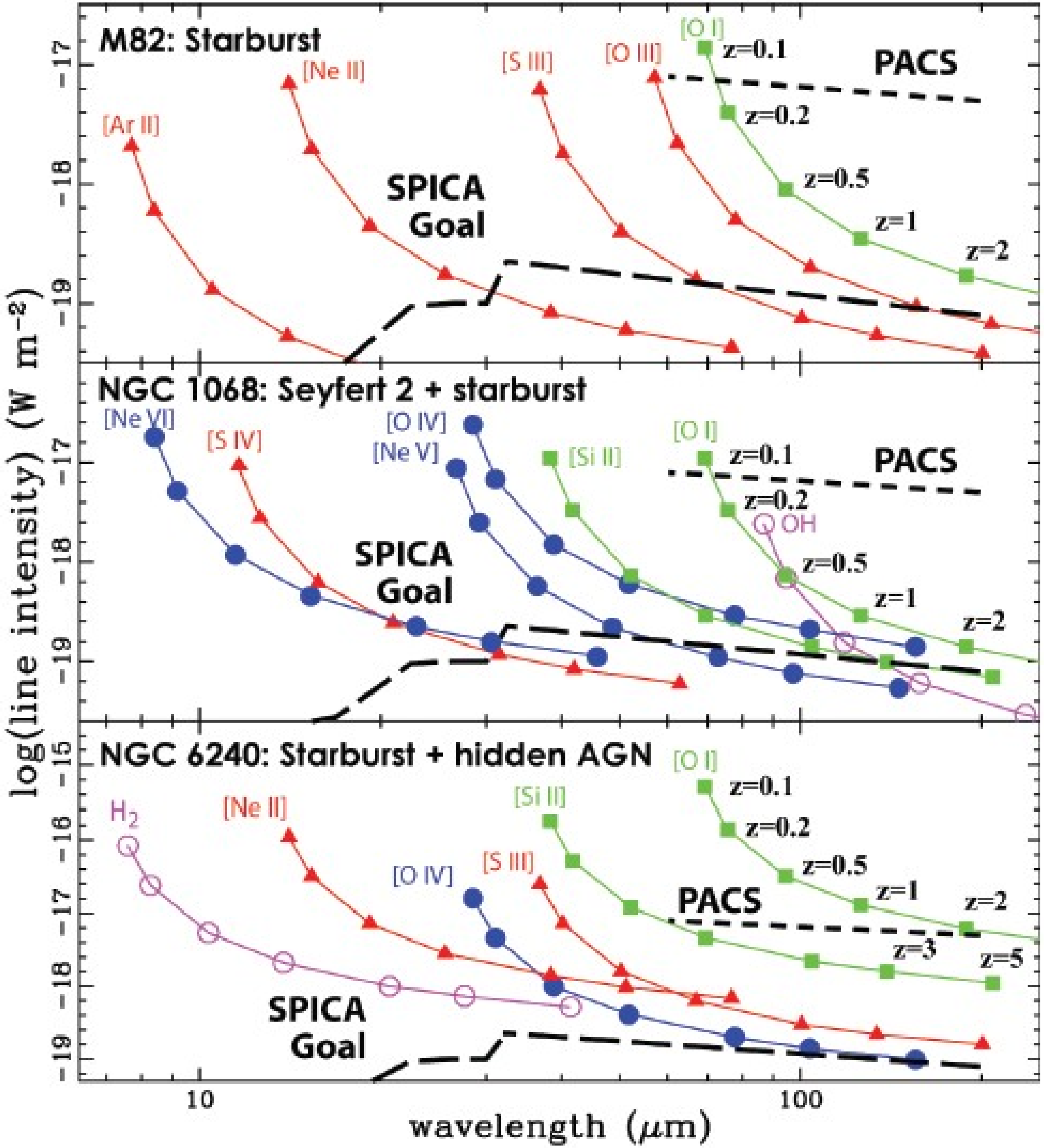
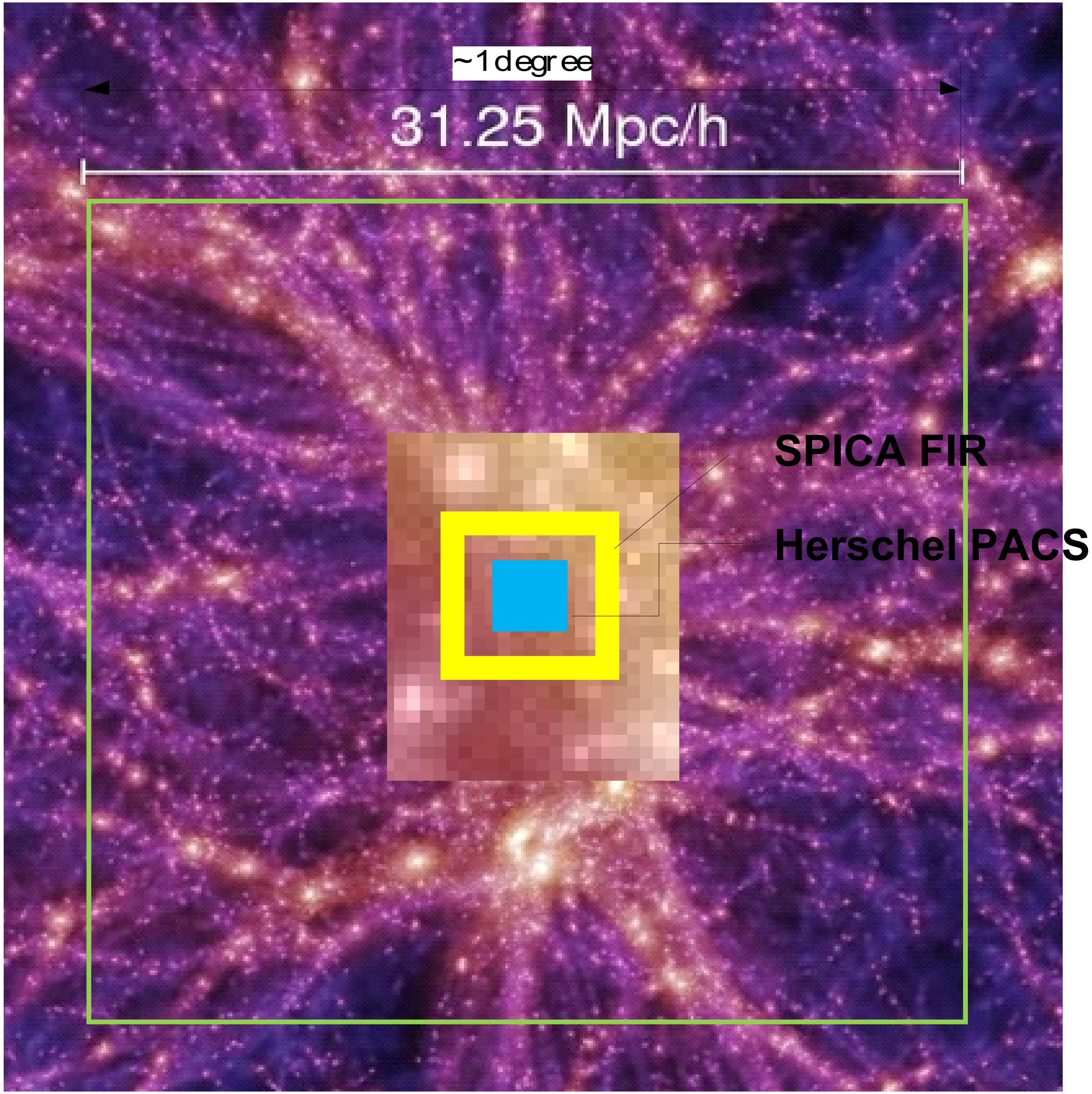
Tagetted Spectroscopy @z=1 galaxies:





Though dwarf SB (M82: $4x10^{10}$Lsu is hard to be detected, LIRGs can be detected with SAFARI

SAFARI 900 hour spectral survey



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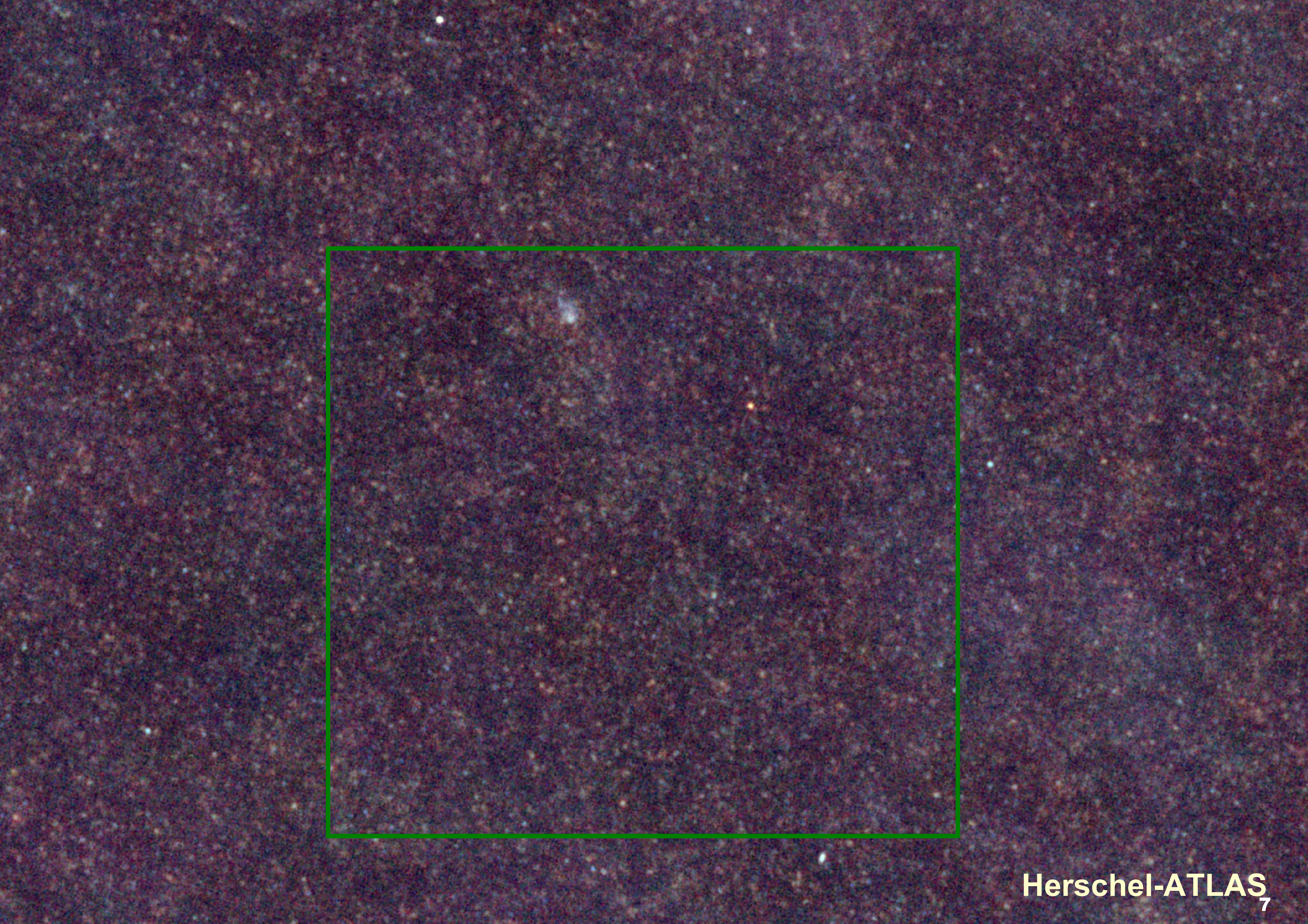
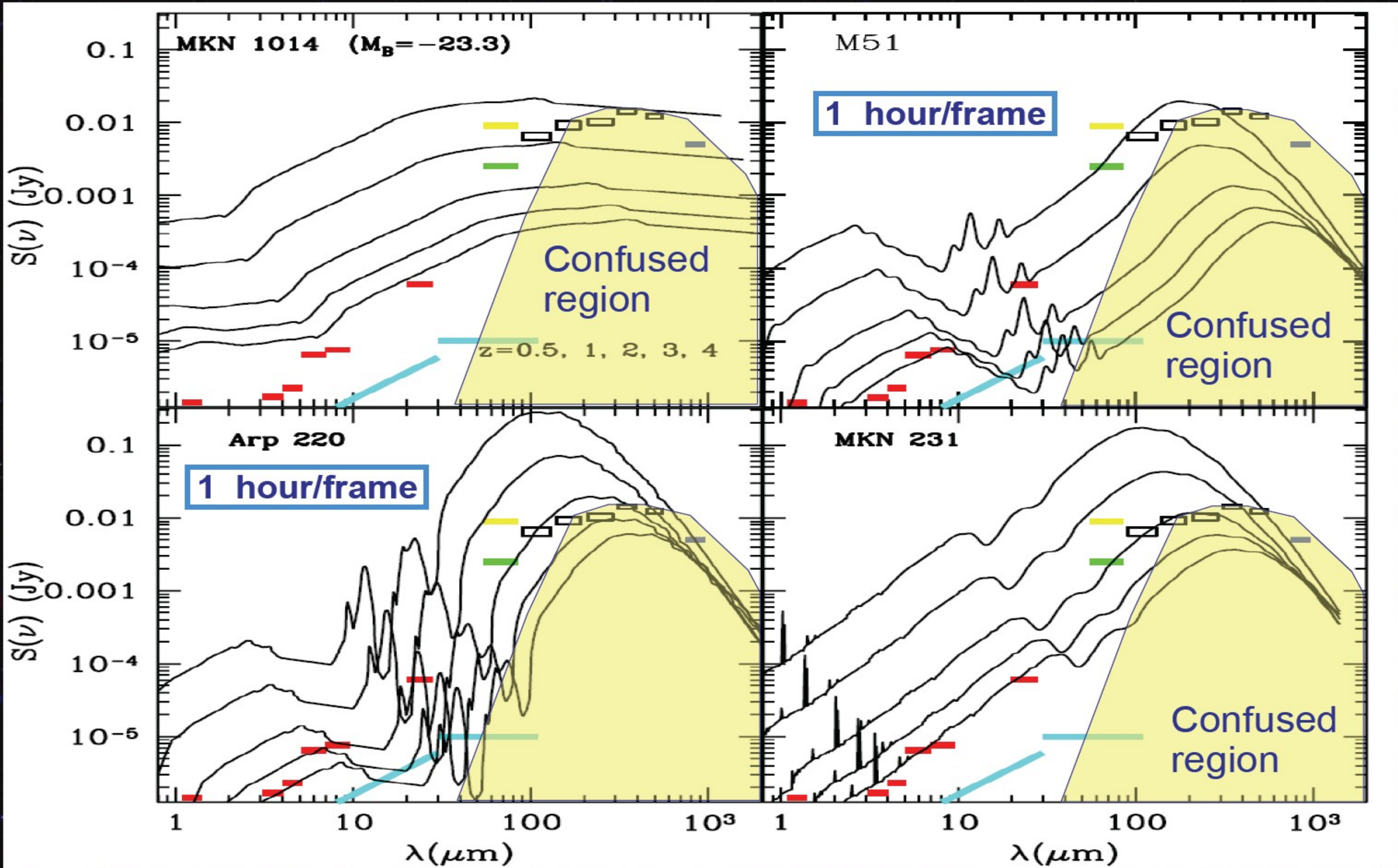

Herschel-ATLAS

SPICA photometric mode sensitivity

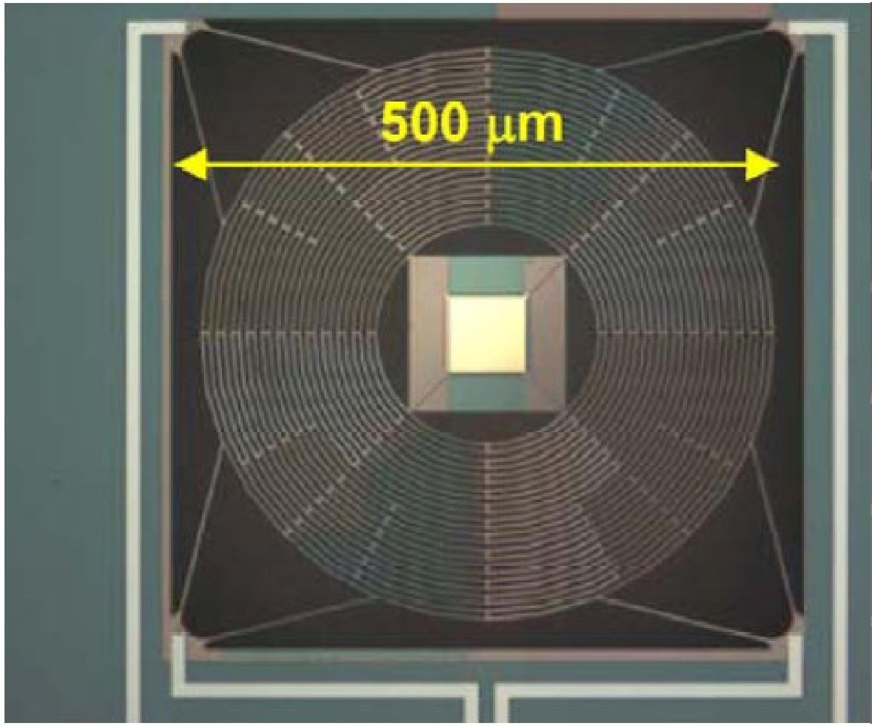


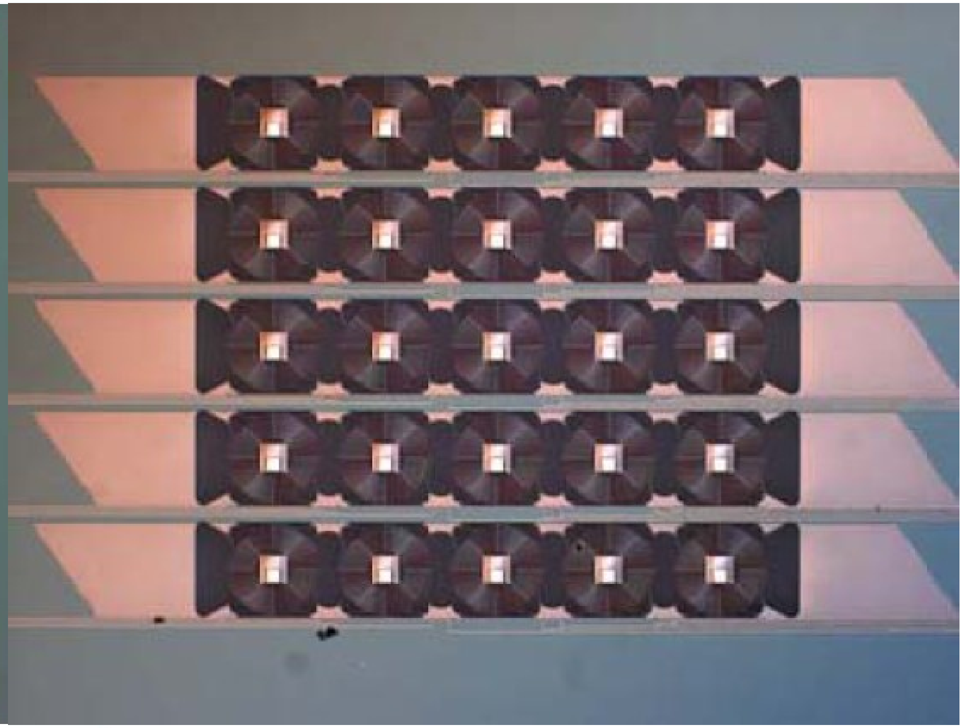
SAFARI Pointing Requirements

Requirements	Values
Pointing Control Accuracy	12 arcsec (3σ)
Pointing Stability	0.15 arcsec / 20min (0-P, 3σ)
Pointing Determination Accuracy	0.15 arcsec (3σ)
Step Scan	Step Angle : 108 arcsec Accuracy : 12 arcsec Settling : 100 sec
Slow Scan	Scan Speed : 10~72 arcsec/sec Accuracy : 1% Duration : 600 sec
NS Tracking	Tracking Speed :<10 arcsec/min Duration : <1200 sec

Detector array wavelength bands

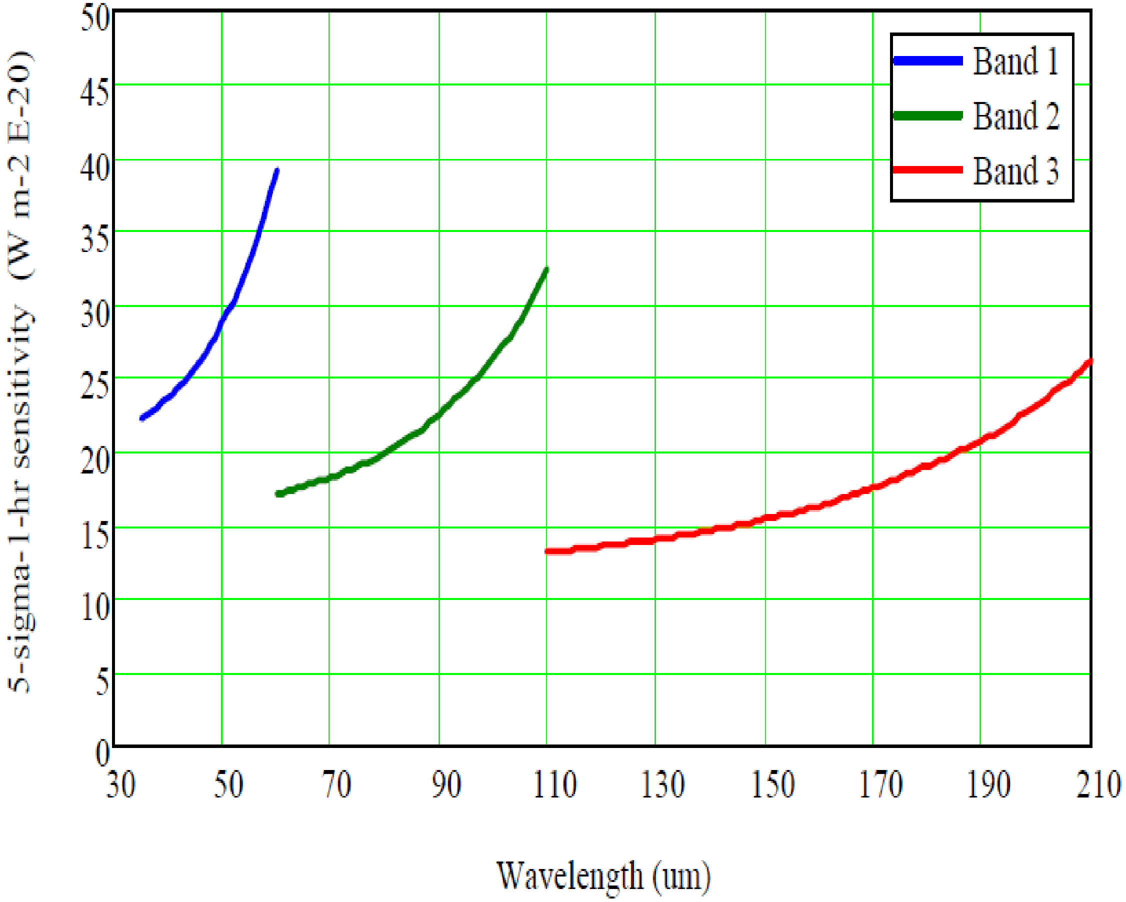
	Band	λ_c	Pixel Size on sky	Number of pixels	Field size
	μm	μm	arcsec		Arcmin
SW	34-60	48	1.8	64x64	1.92
MW	60-110	85	3.05	38x38	1.93
LW	110-210	160	5.75	20x20	1.917





Low-G detector targeted to SAFARI sensitivity goal requirements

Detector Sensitivity vs. NEP



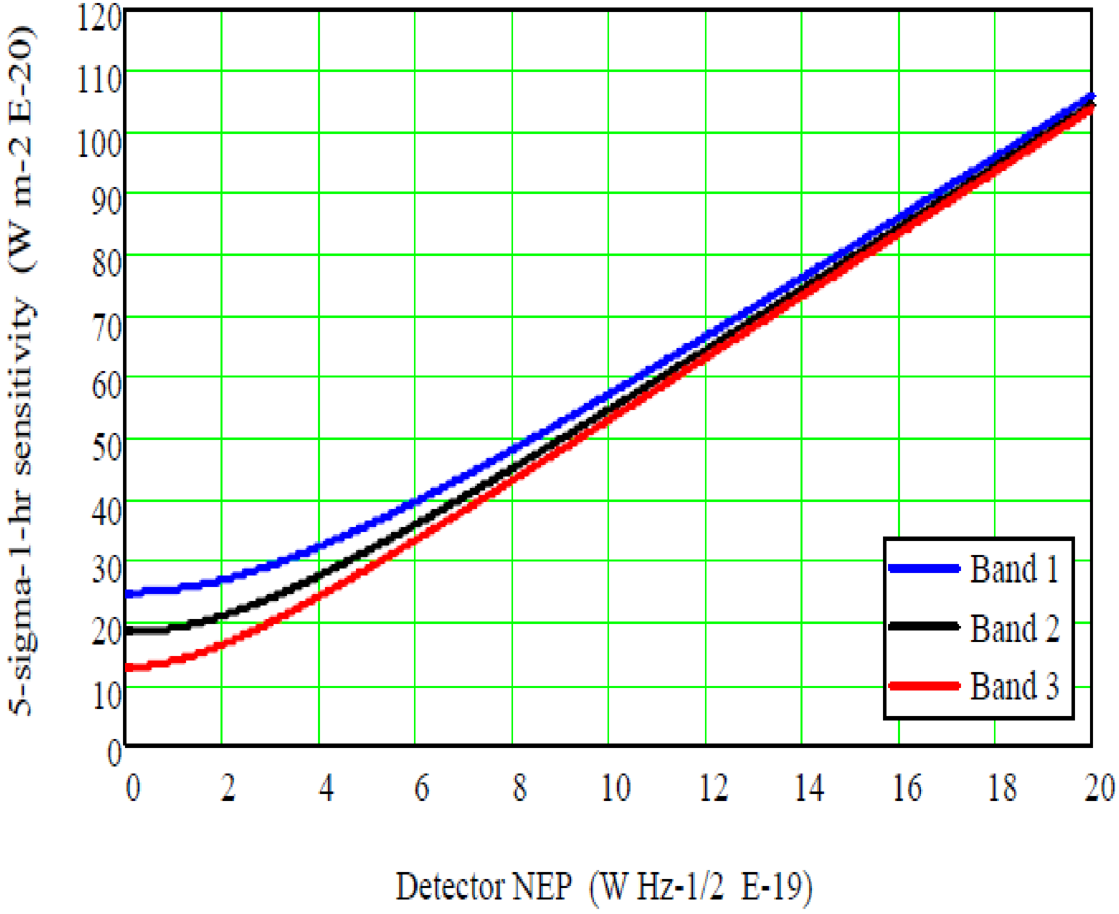


Figure 3: Impact of detector NEP on the resolved line sensitivity

NEP = 2×10^{-19} $WHz^{-1/2}$ is good enough.

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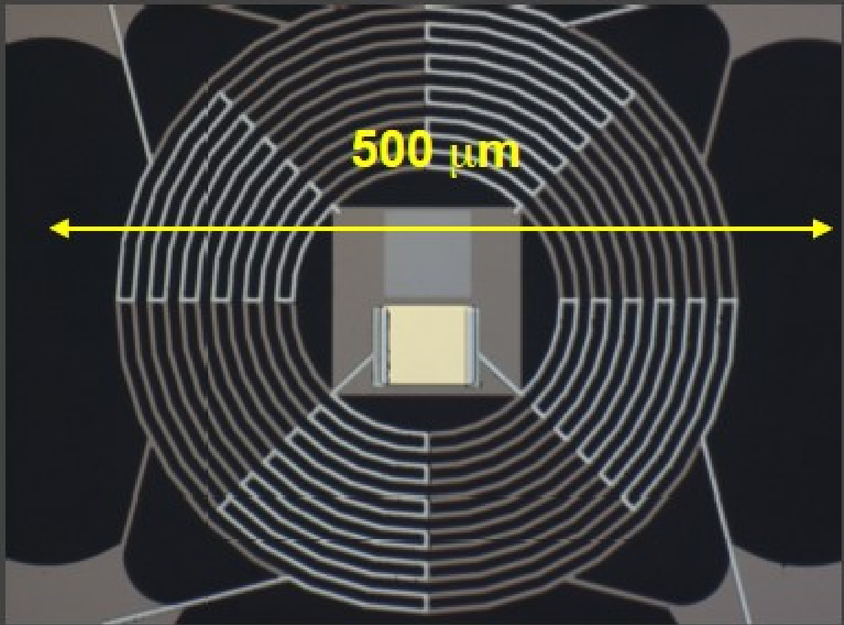
Detector design: Ring structures



- Photograph of a low G TES fabricated at SRON.
- Estimated phonon noise limited NEP is ~ 3 x 10^{-19} W/√Hz.
- Saturation power is 8 fW.
- Time constant < 2 ms

Saturation level: ~1Jy (~500MJy/sr)

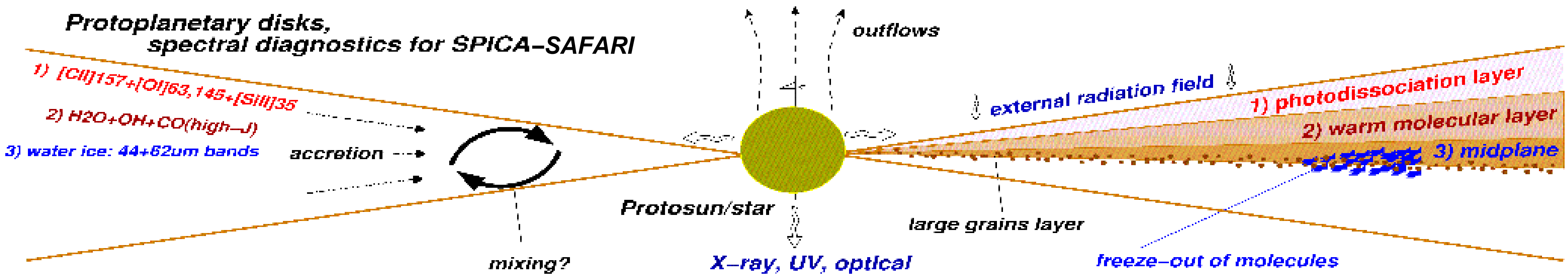
*Table 3.2 Chip assignment for test structures suspended with **ring type** geometry.*

Chip nr	Length [μm]	Width [μm]	Nb	SiN Island [um]	TES [um]	Abs	pitch [μm]	Nom. G*	NEP*	Ring distance	What to measure?
12 and 25	650	4	LO	120x120	50x50	55x55	480	6,75E-13	3,8 E-19	10	G and NEP for a ringstructure as a funtion SiN thickness
7 and 24	650	4	Etch	120x120	50x50	55x55	480	6,67E-13	3,8 E-19	10	
4 and 34	1250	**3**	LO	**210 x 210**	50x50	**140x140**	**840**	2,64E-13	2,4E-19	12	
33	1250	**3**	Etch	**210 x 210**	50x50	**140x140**	**840**	2,64E-13	2,4E-19	12	
18 and 19	1250	**6**	LO	**210 x 210**	50x50	**140x140**	**840**	5,1E-13	3,4E-19	9	
13	1250	**6**	Etch	**210 x 210**	50x50	**140x140**	**840**	5,1E-13	3,4E-19	9	

* = based on a SiN suspension thickness of 1 micron and T_c ~100mK. All the samples are also planned to be fabricated on 0.25 and 0.5 micron suspension

The formation of planetary systems

Several hundred exo-planets discovered to-date, however the formation and evolution of planetary systems is poorly understood

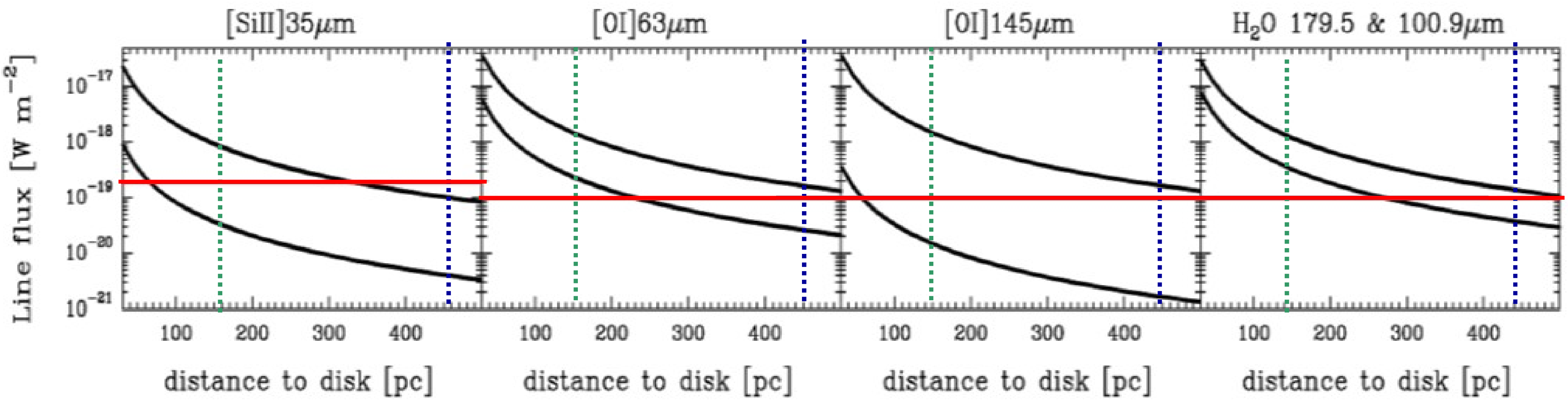


- **MIR/FIR hosts unique diagnostics of the different material phases (eg. gas, dust, ice) in planetary system formation**

- **SAFARI: traces all layers**
  - **Photodissociation layer →major FIR cooling lines**
  - **Warm molecular layer → CO, HCN, CN… ALMA; H_2O, OH.. SAFARI**
  - **Midplane → ices: site of dust coagulation planet formation**
    → dust mineralogy: history of dust

- **By tracing presence and distribution of the gas, dust and ices can:**
  - **Constrain physical conditions and processes in protoplanetary disks**
  - **Test planet formation and evolution theories**

Tracing gas in circumstellar disks



- **Key cooling lines e.g. [CII], [OI] [63,145], [SiII]**
- **Faint, but can detect out to >100pc**
  - **Covering many SFRs regions, low-mass (eg.Taurus) and high-mass (Orion)**
- **Extensive range of host stars and disks → test models**

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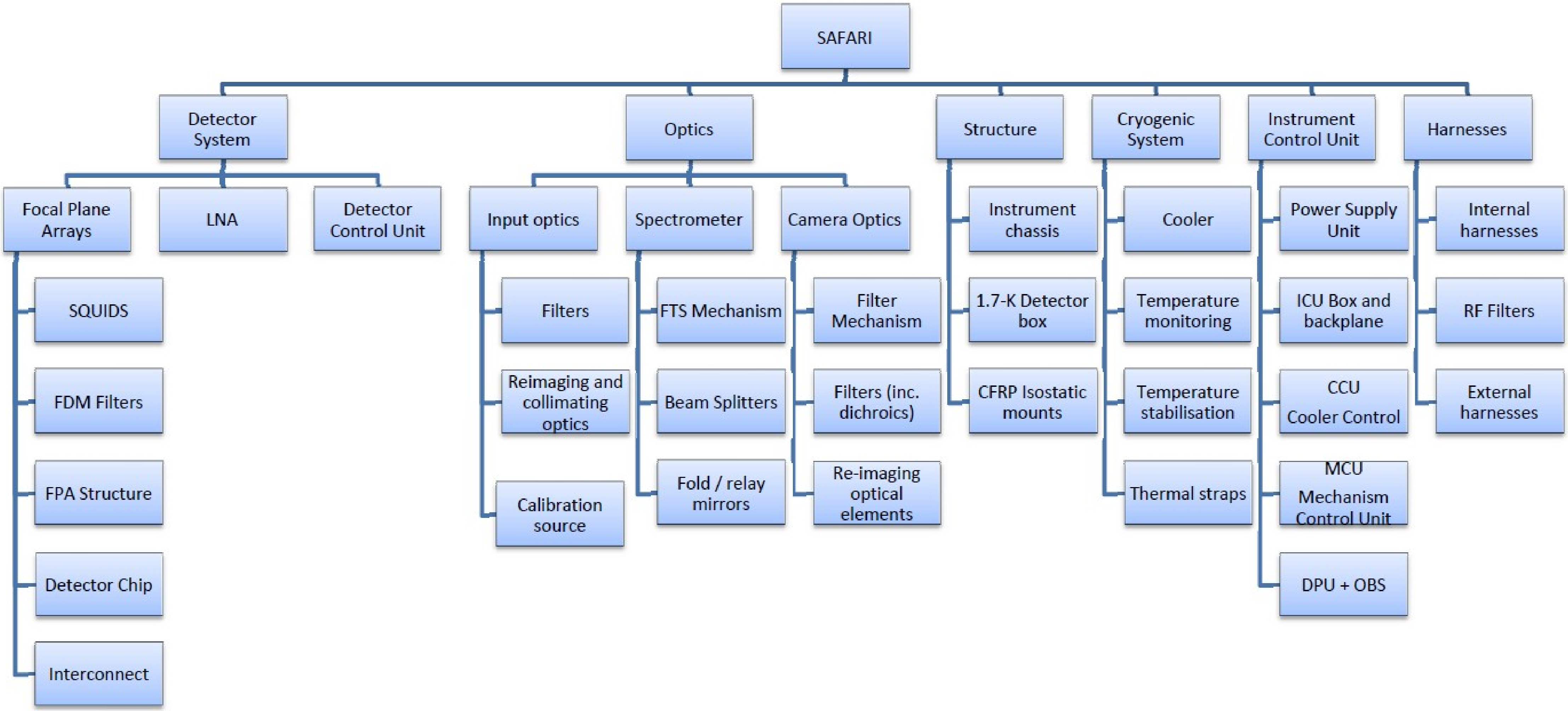
Many design-driving requirements are TBD or TBC

- SW array spatial sampling
- Cross-talk
- Stability
- Linearity and harmonics (anti-aliasing filtering)
- Yield / allowed dead pixels
- Goal vs. Minimum sensitivity requirements
- Band-specific speed, sensitivity, and saturation power requirements
- Cryo-harness definition and LNA interfaces
- Environment in the instrument / satellite
- Straylight, magnetic fields, micro-vibration, …
- Qualification vs. launch loads and AIV program
- Launch loads: Eigenfrequencies, vibration, accoustic testing, …
- AIV: Bakeout, thermal cycling, …
- Functionality for ground testing + in-flight operations and calibration

International Consortium

5.2.1 *System Design*



Space Infrared Telescope for Cosmology and Astrophysics

Persons of intention

Extragalactic Science

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Hideyuki IZUMIURA (NAOJ)
Takuya YAMASHITA (NAOJ)
Mitsuhiko HONDA (Kanagawa U.)

Schedule

- Detector Technology Selection (June 2010)
- Science Verification Review (October 2010～)
- Detector System Design Review (Jan/Feb 2011)
- Conceptual Design Review (March 2011)
- DM&STM unit delivery (December 2011)
- STM delivery to JAXA (October 2012)
- QM delivery to JAXA (April 2015)
- FM(&FS) delivery to JAXA (January 2017)
- Launch (2018)