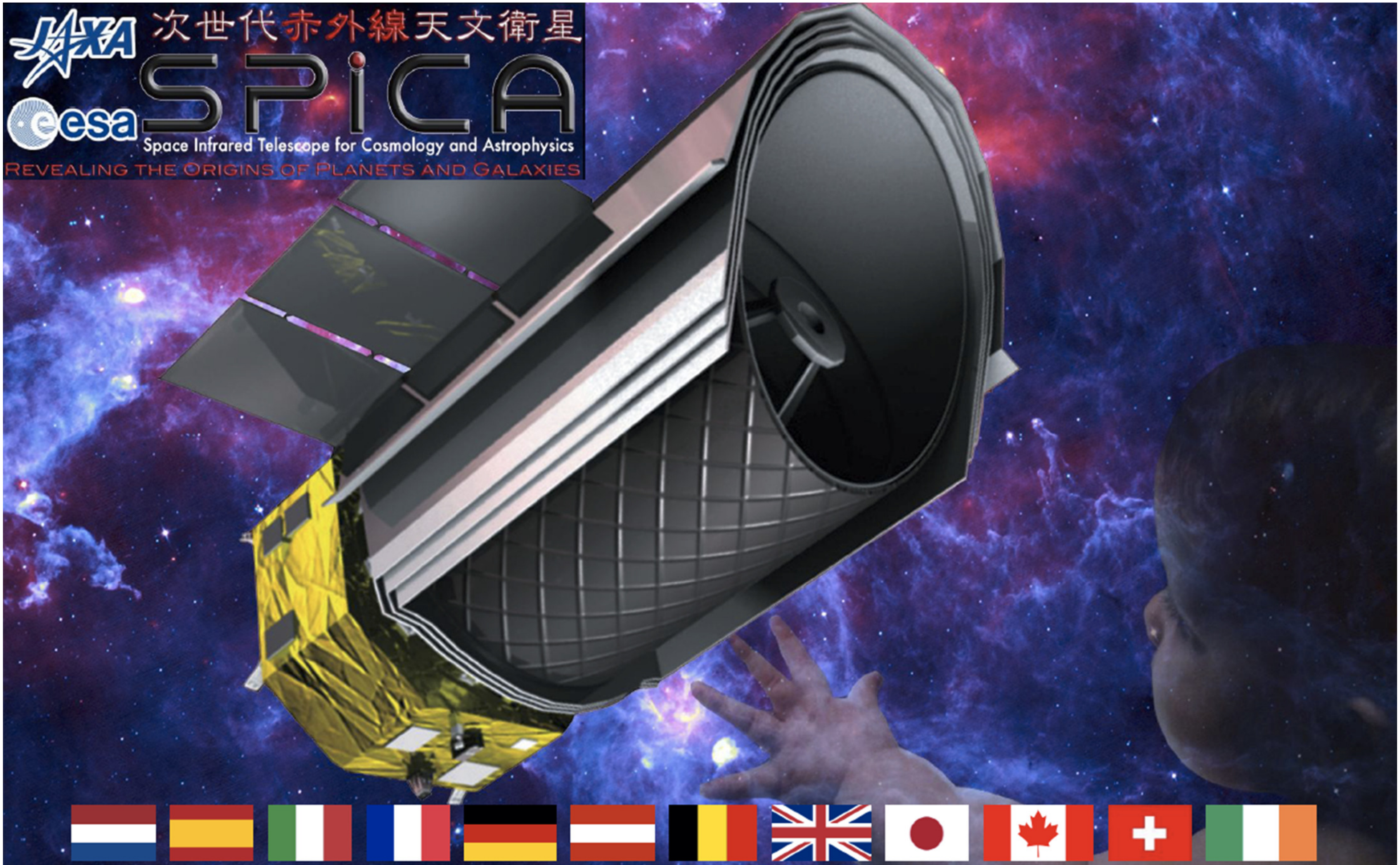
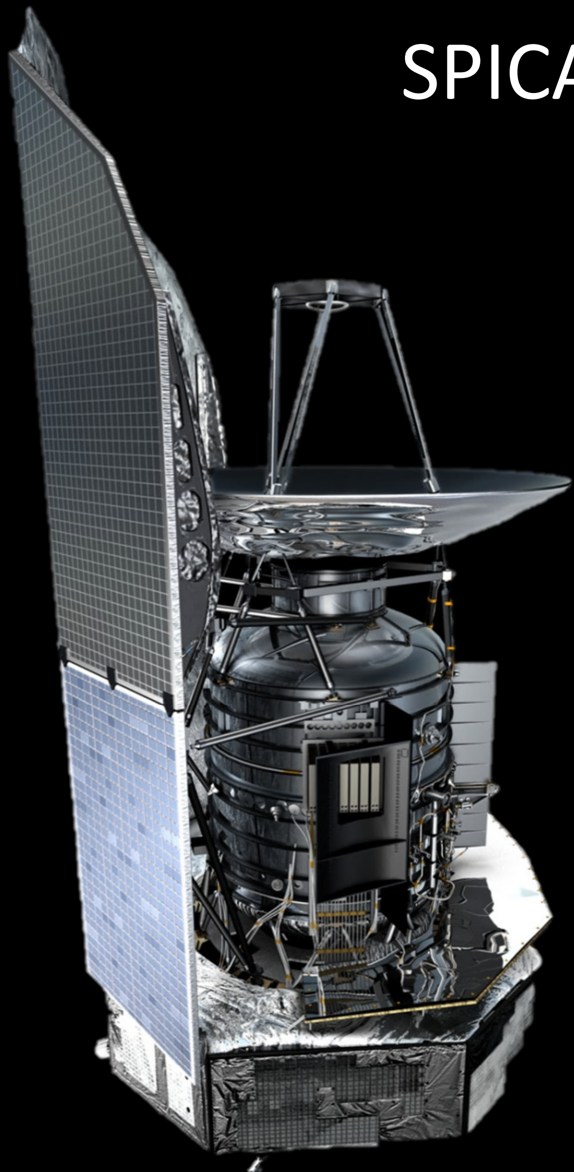


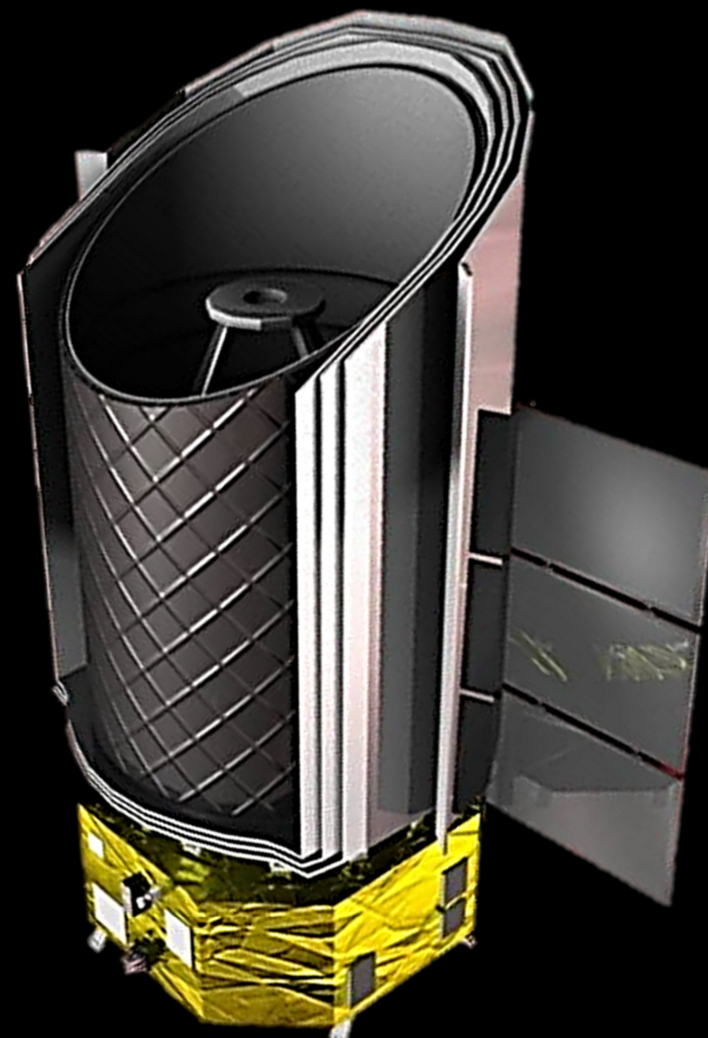
The next-generation infrared astronomy mission SPICA and its SAFARI instrument

O. Krause

SPICA is a cold HERSCHEL

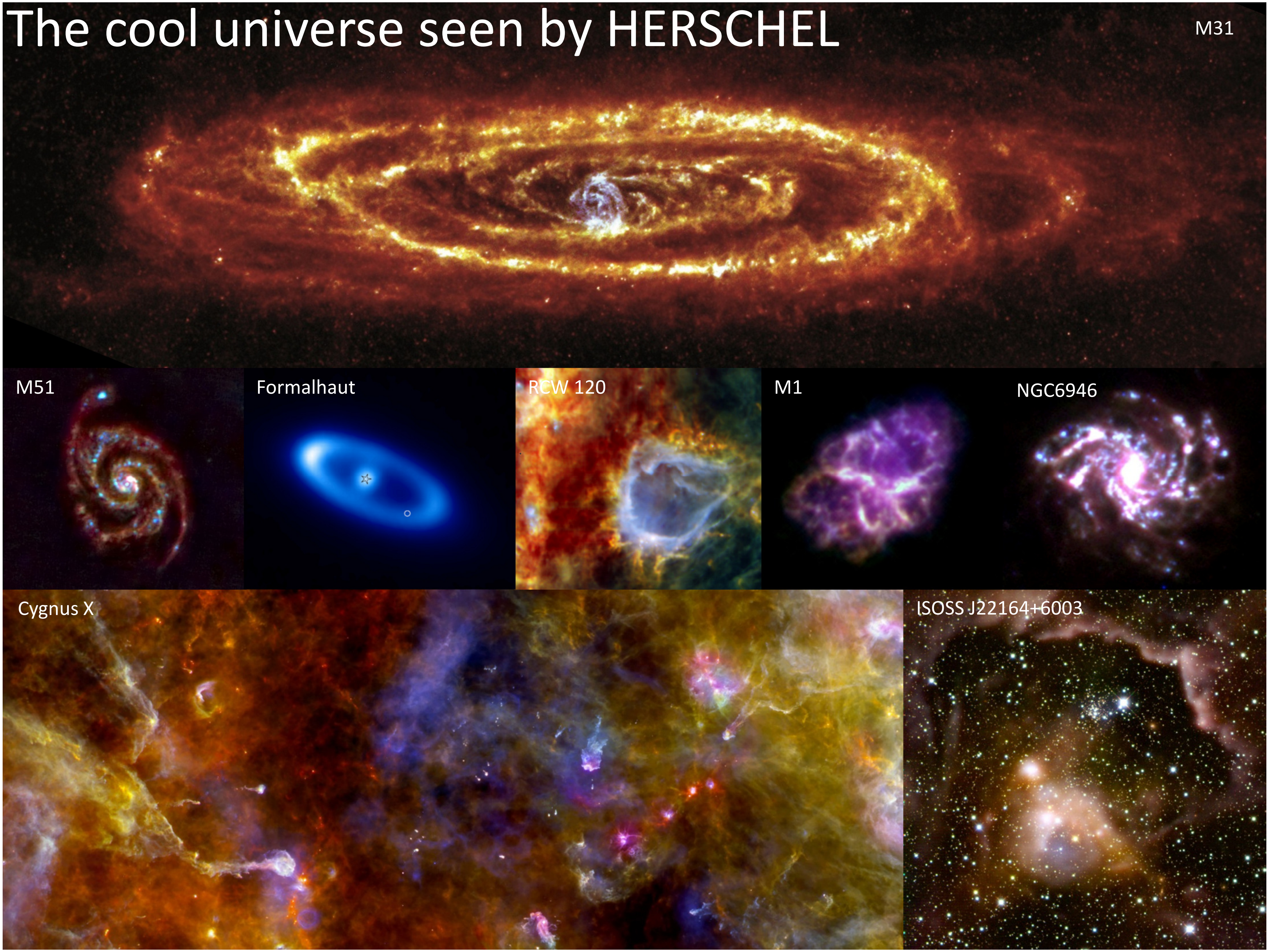


D = 3.5 m
T ~ 80 K passively cooled
57 µm < λ < 670 µm
Launch 2009

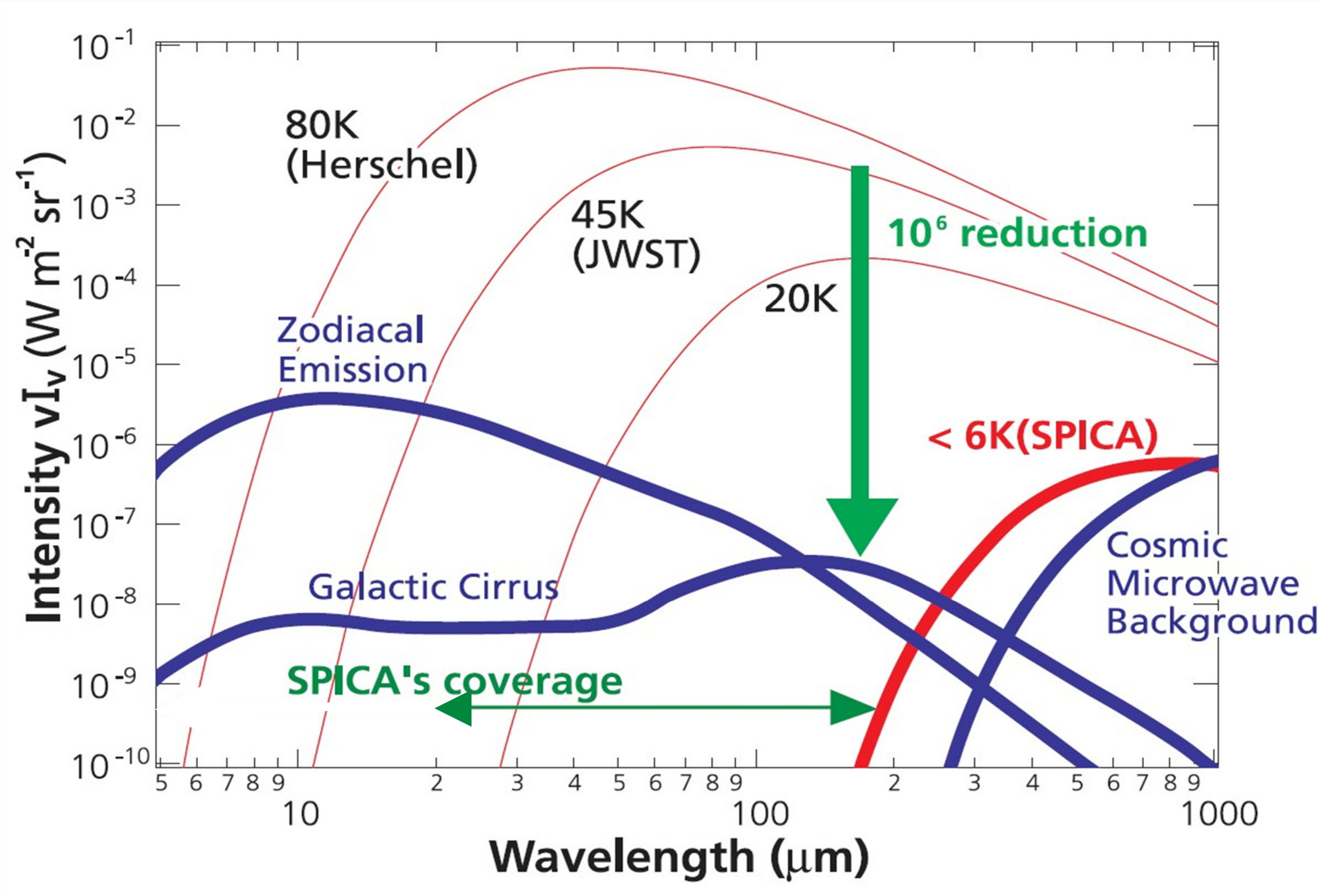


D = 3.2 m
T ~ 6 K actively cooled
20 µm < λ < 210 µm
Launch 2028 (tbc)

The cool universe seen by HERSCHEL



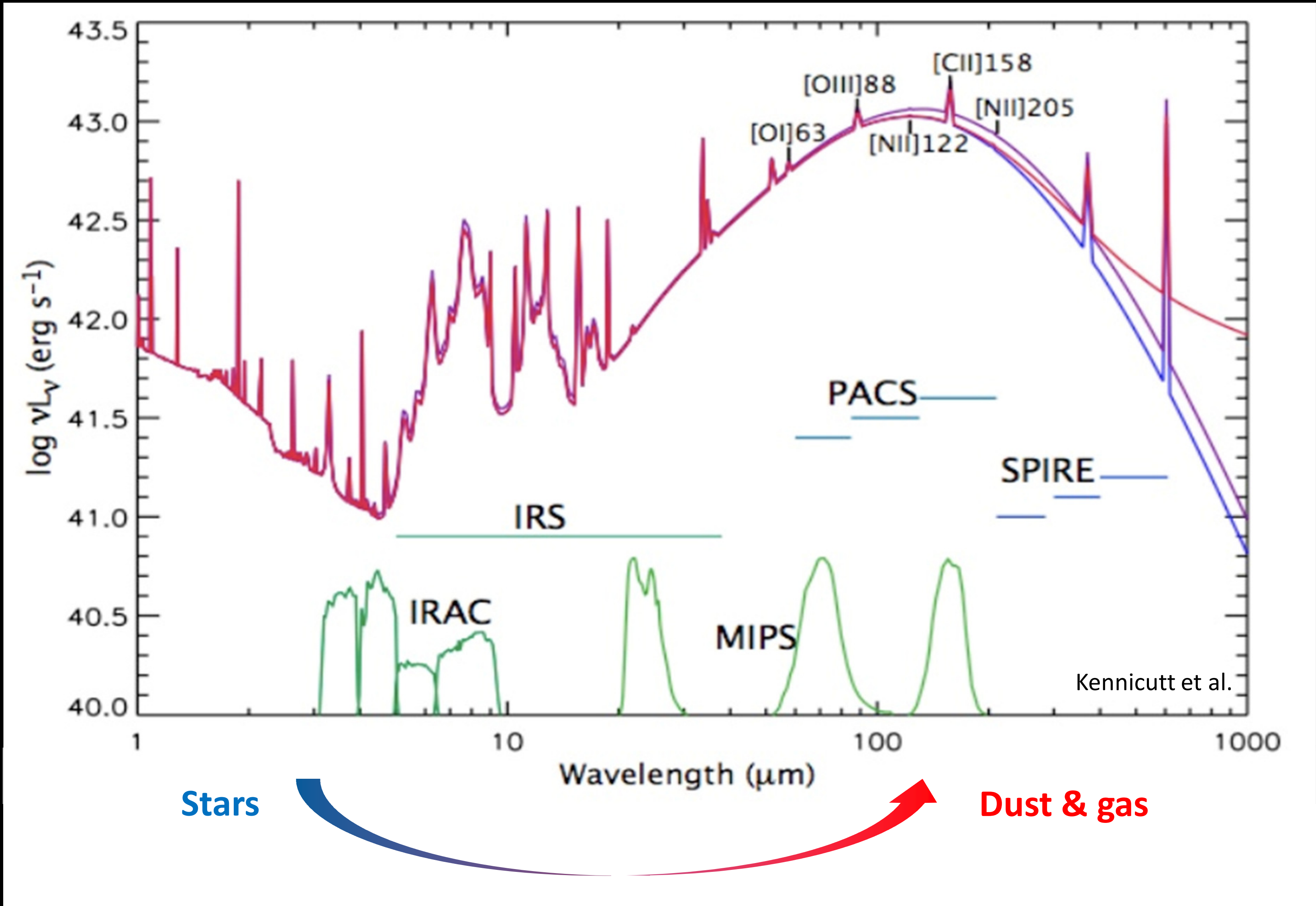
Zodiacal light limited sensitivity



Background limited < 200 μm if T_{tel} <~ 6 K

Herschel sees distant galaxies via colors
SPICA can go deeper and take spectra

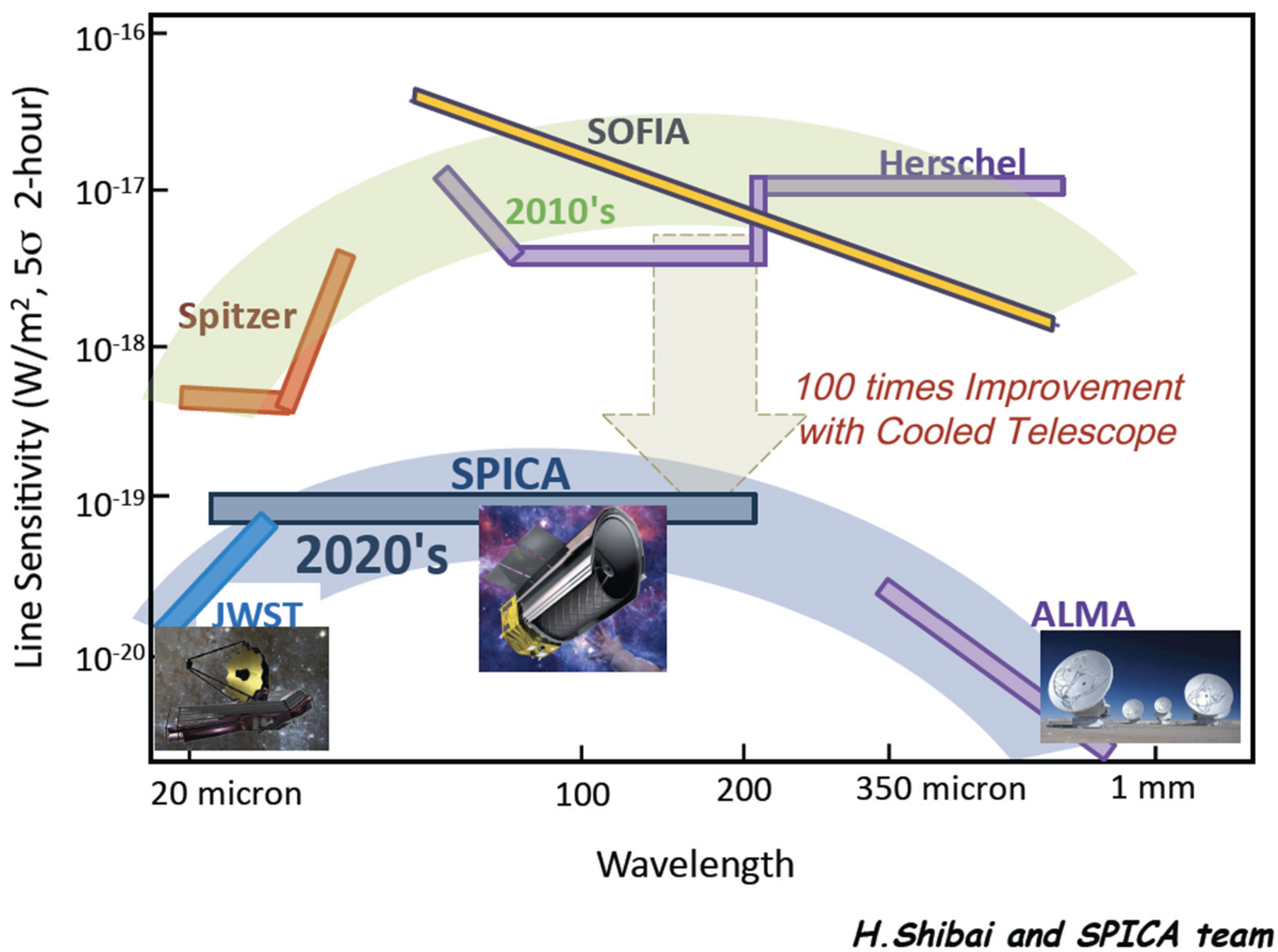
Why observe in the far-infrared



Starlight “recycled” by gas and dust

Complete picture only seen by observing in the MIR/FIR

Spectral line senstivity in 2020´s



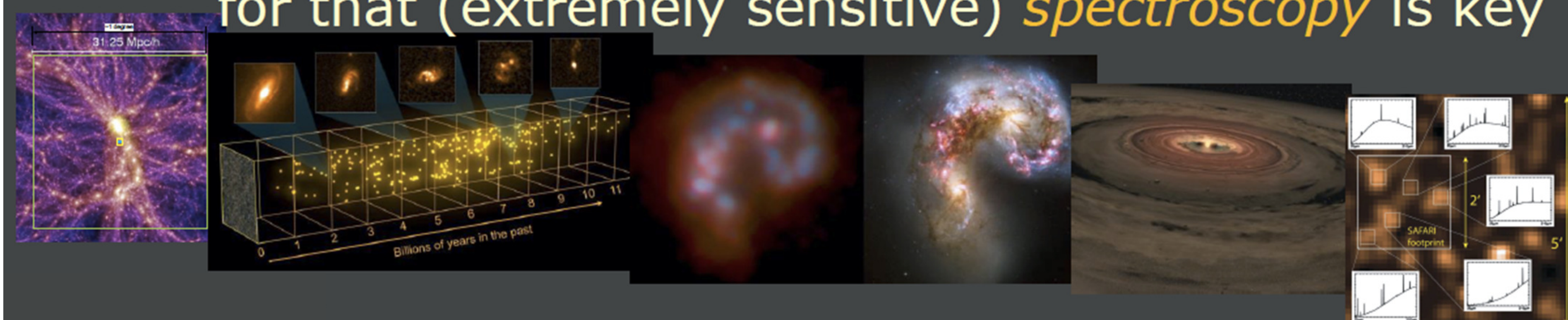
The ‘origins’ questions – key science drivers for SPICA *and* SAFARI

- *How do stars and galaxies form and evolve over cosmic ages?*
  SAFARI will observe thousands of obscured, far away galaxies and determine what processes govern their evolution

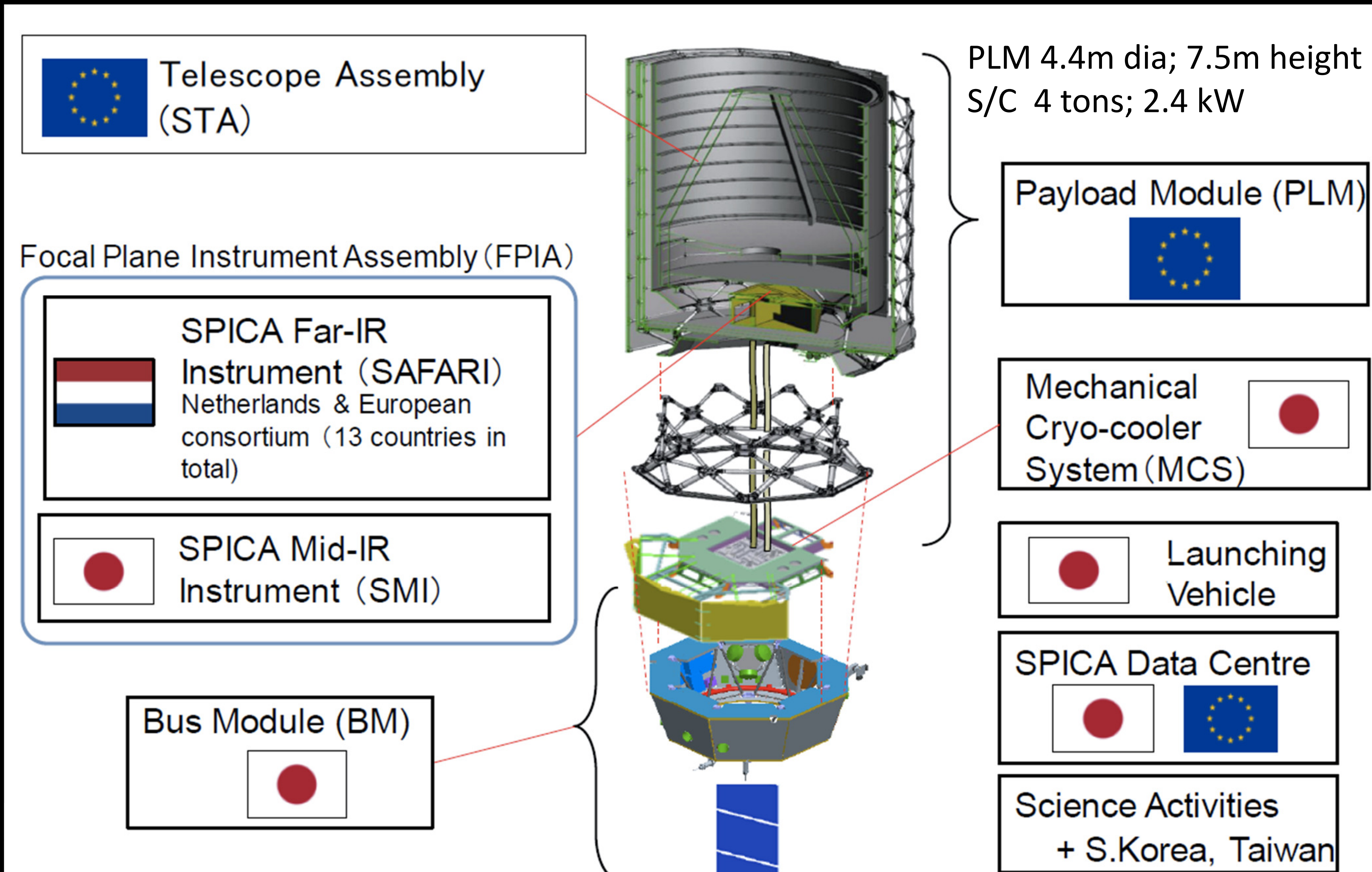
- *How does our solar system relate to other planetary systems and could life evolve elsewhere?*
  SAFARI will characterize oxygen, water, ice and rock in young planet forming systems and study their relation to the rocks and ice in our own Solar System

- We want to understand the *physical characteristics*,
  and *link the different size-scales*

for that (extremely sensitive) *spectroscopy* is key



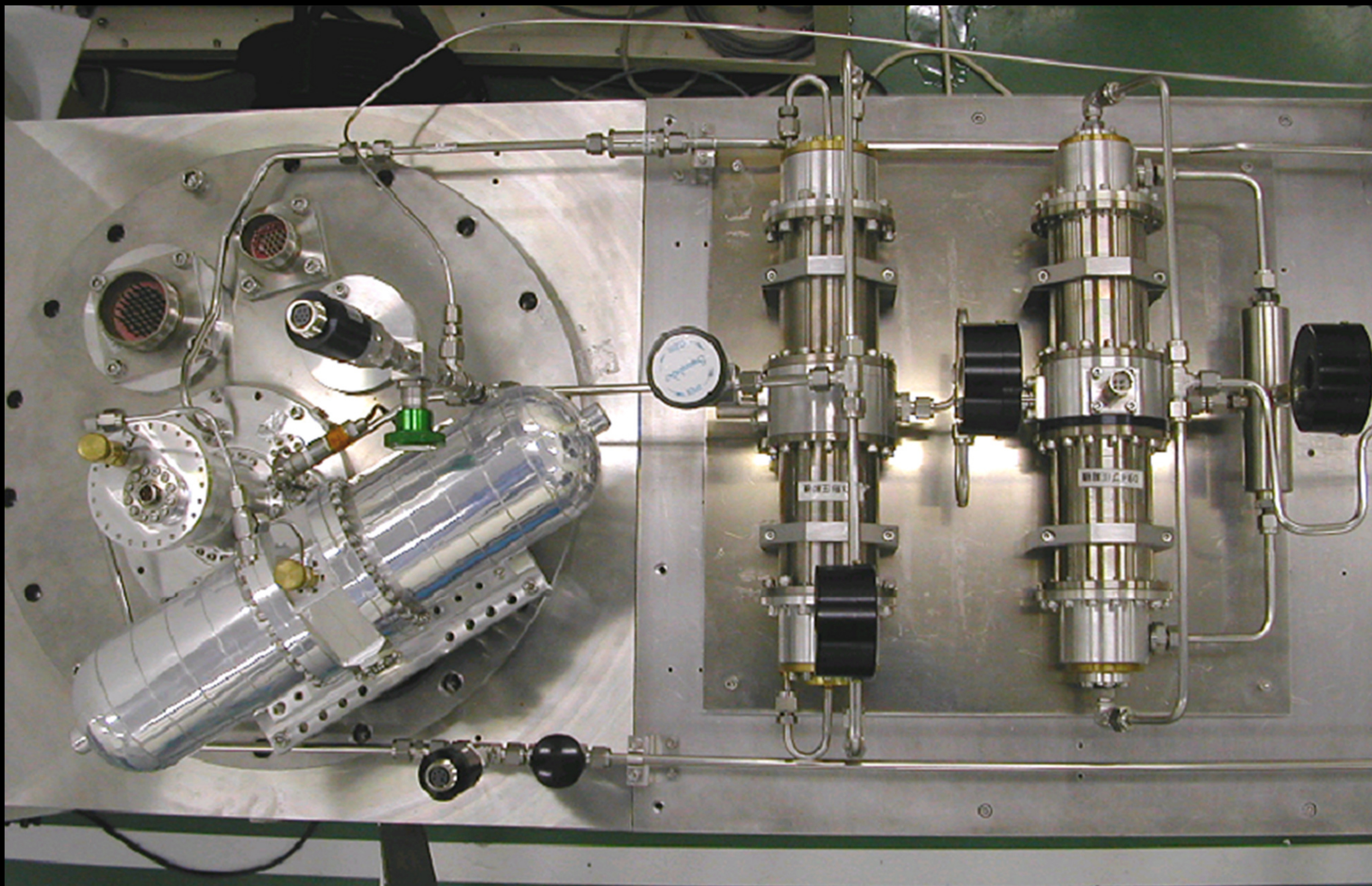
A Japanese – European endeavour …



SPICA Status

- Original Plan
  - JAXA preproject since 2008
  - ESA CV MoO candidate since 2007
  - Approval in 2014 by JAXA and ESA for the launch in 2023.
- SPICA FY 2014 budgetary proposal in Japan
  - R&D activity going on, but difficulty for the whole project.
  - SPICA has the top priority among the future science missions in Japan
- Discussion on new framework started
  - To establish a more feasible plan (programmatic & technical)
  - To increase the role of European contribution
    SPICA as a JAXA-led project.
  - The scope of a European-led SPICA mission within the Cosmic Vision M5 call is currently being studied by ESA

Japanese cryocooler developments



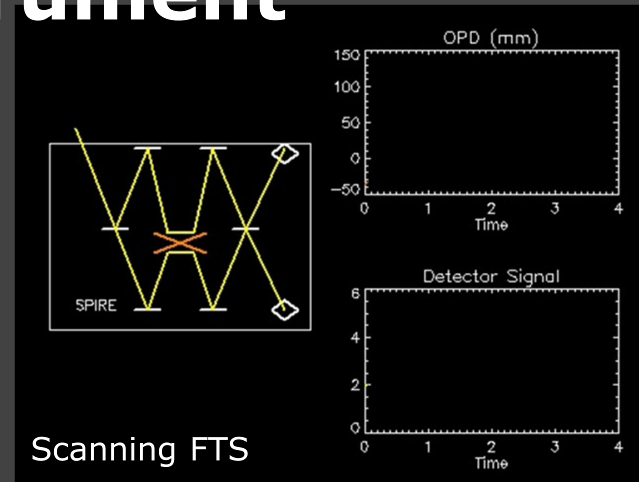
^{3}He JT cooler with 2-stage Stirling developed for Astro-H

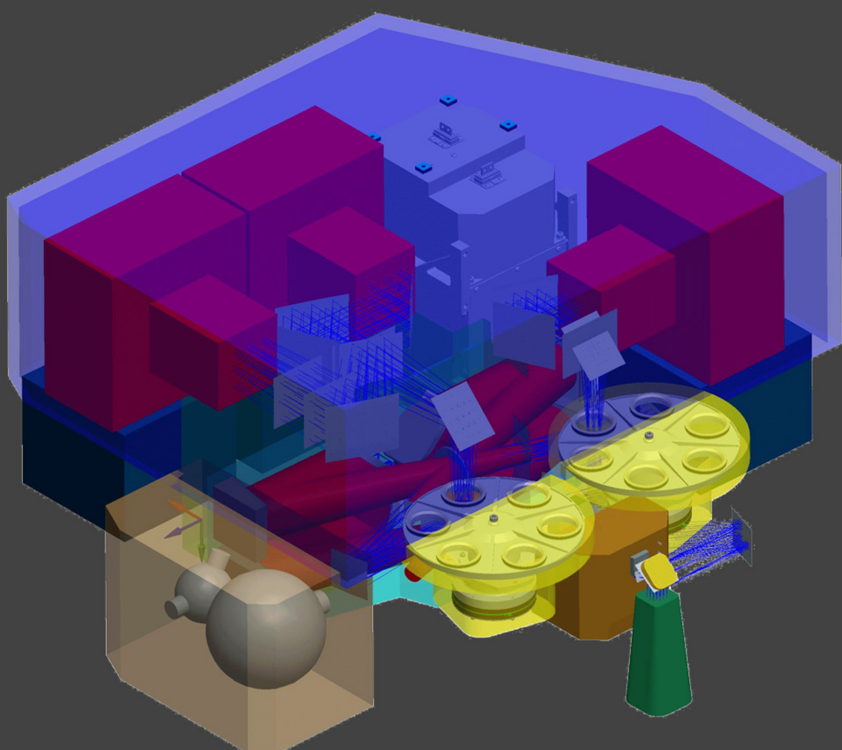
SPICA instrument suite

	SMI SPICA Mid-Infrared Instrument	**SAFARI** SPICA Far-Infrared Instrument
Wavelength	20-37 μm	34-210 μm
FoV	5' × 5' (Imaging) 2.5' × 3" (Spectroscopy)	2' × 2'
Spatial Resolution (FWHM)	1.4" @ 20 μm 2.6" @ 37 μm	4" @ 47 μm 7" @ 85 μm 13" @ 160 μm
Imaging	R~20 9-50 μJy	34-60, 60-110, 110-210 μm 14 -32 μJy
Spectroscopy	R=1000-2000 0.2-1 × 10^{-19} W/m^2	R=1000 @ 210 μm R=5000 @ 35 μm 3-4 × 10^{-19} W/m^2 (R~50 mode)

The SpicA FAR-infrared Instrument instrument SAFARI

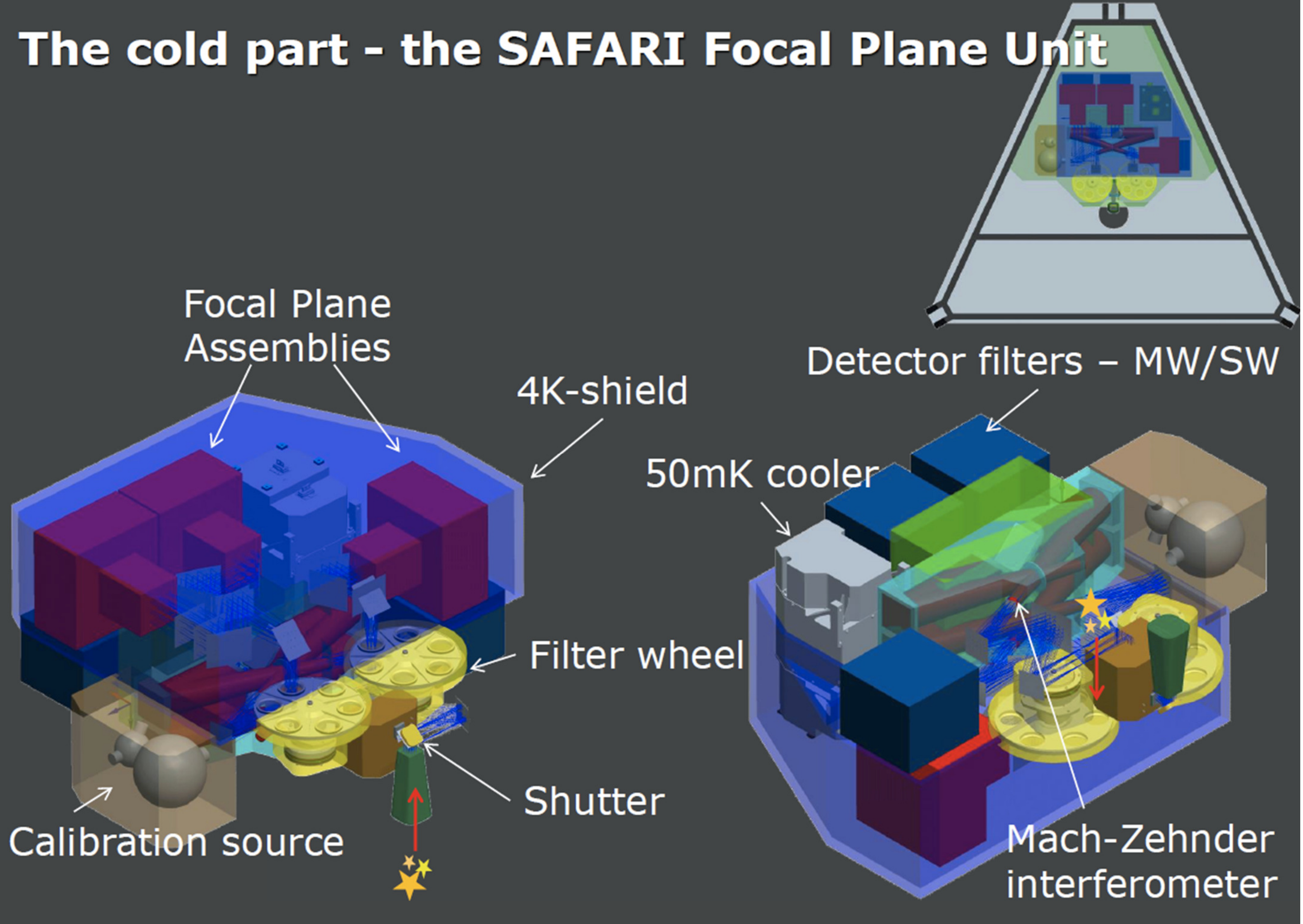
- Scanning Fourier Transform Spectrometer with 2'x2' FoV
- Simultaneously observing in 3 bands → 34-210μm
- TES detectors/SQUID read out at 50 mK
- Frequency Domain Multiplexing
- Dispersive element; slit/grism to reduce background
- To be built by an SRON-led consortium
  - ~15 institutes in Europe, Canada, Japan - cost ~170M€



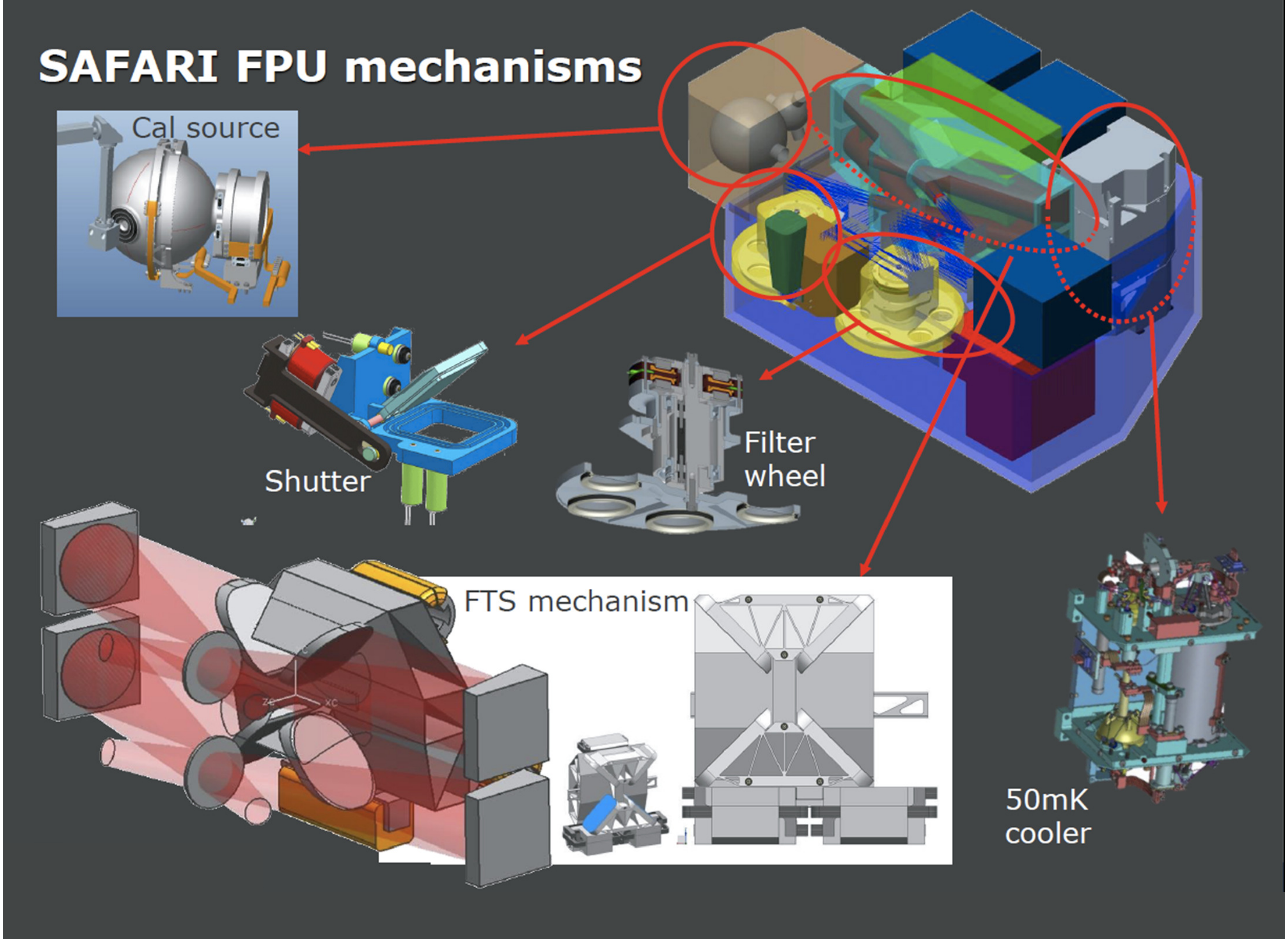


Parameter		Waveband SW	Waveband MW	Waveband LW	
Band centre		47 μm	85 μm	160 μm	General
Wavelength range		34-60 μm	60-110 μm	110-210 μm	General
Band centre beam FWHM		4"	7"	13"	General
Number of detectors		43 x 43	34 x 34	18 x 18	General
Confusion limit		0.015 mJy	0.5 mJy	5 mJy	Photometry
Minimum Zodiacal background		8.0 MJy sr^{-1}	3.8 MJy sr^{-1}	2.1 MJy sr^{-1}	Photometry
Limiting source flux density (5σ-1hour)*		20 μJy	30 μJy	45 μJy	Photometry
Time to reach confusion limit at 5σ*		6000 s	13 s	0.3 s	Photometry
Limiting line flux* (5σ-1hour)		5.3×10^{-19} Wm^{-2}	4.8×10^{-19} Wm^{-2}	4.1×10^{-19} Wm^{-2}	Spectroscopy
Limiting* line flux density 5σ-1hour	High Res. (R~2000)	17 mJy	29 mJy	46 mJy	Spectroscopy
	Medium Res. (R~500)	4.2 mJy	6.9 mJy	11 mJy	Spectroscopy
	Low Res (R~50)	0.42 mJy	0.69 mJy	1.1 mJy	Spectroscopy

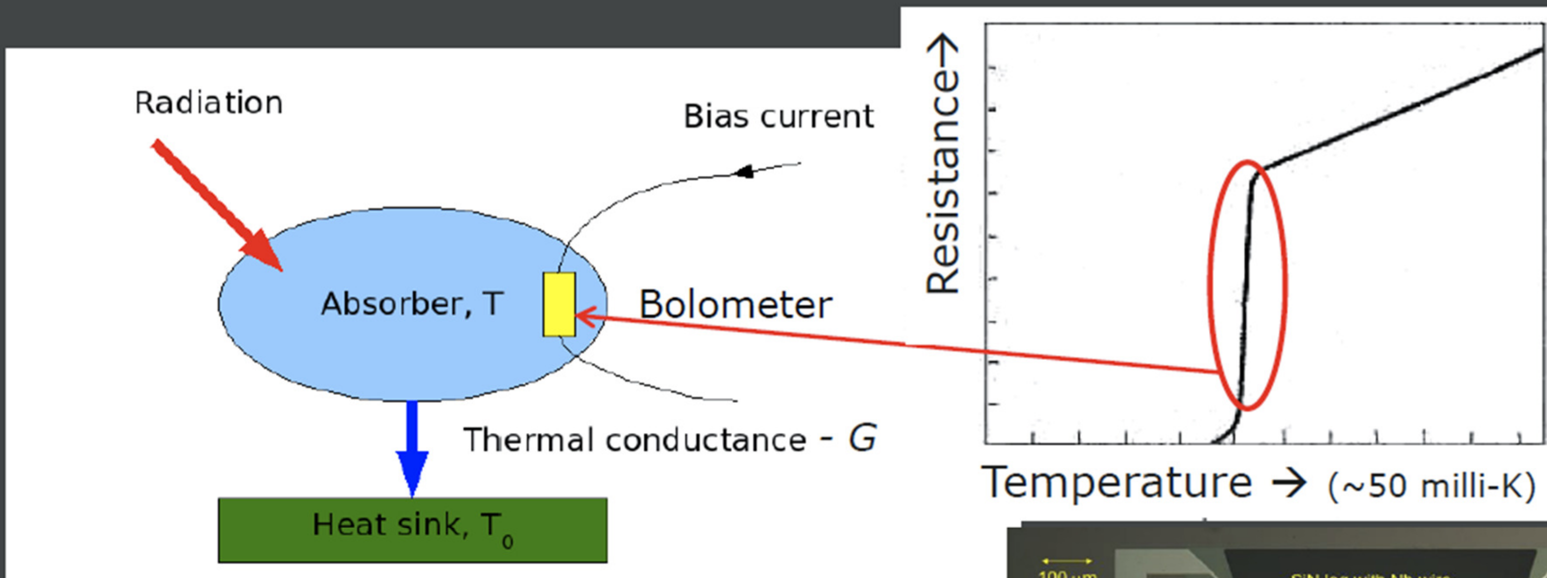
The cold part - the SAFARI Focal Plane Unit

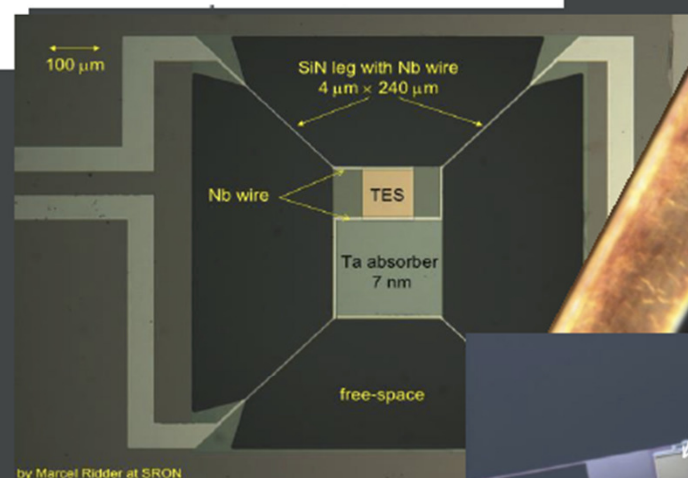


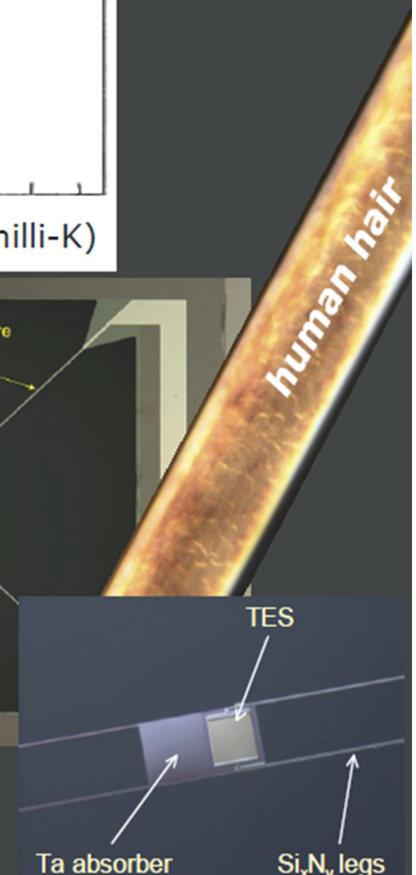
SAFARI FPU mechanisms



Ultimate sensitivity – Transition Edge Sensors







- Limit in NEP: phonon-noise ~T√*G*
  NEP=2.5±0.4 x 10^{-19} W/√Hz

Challenges:

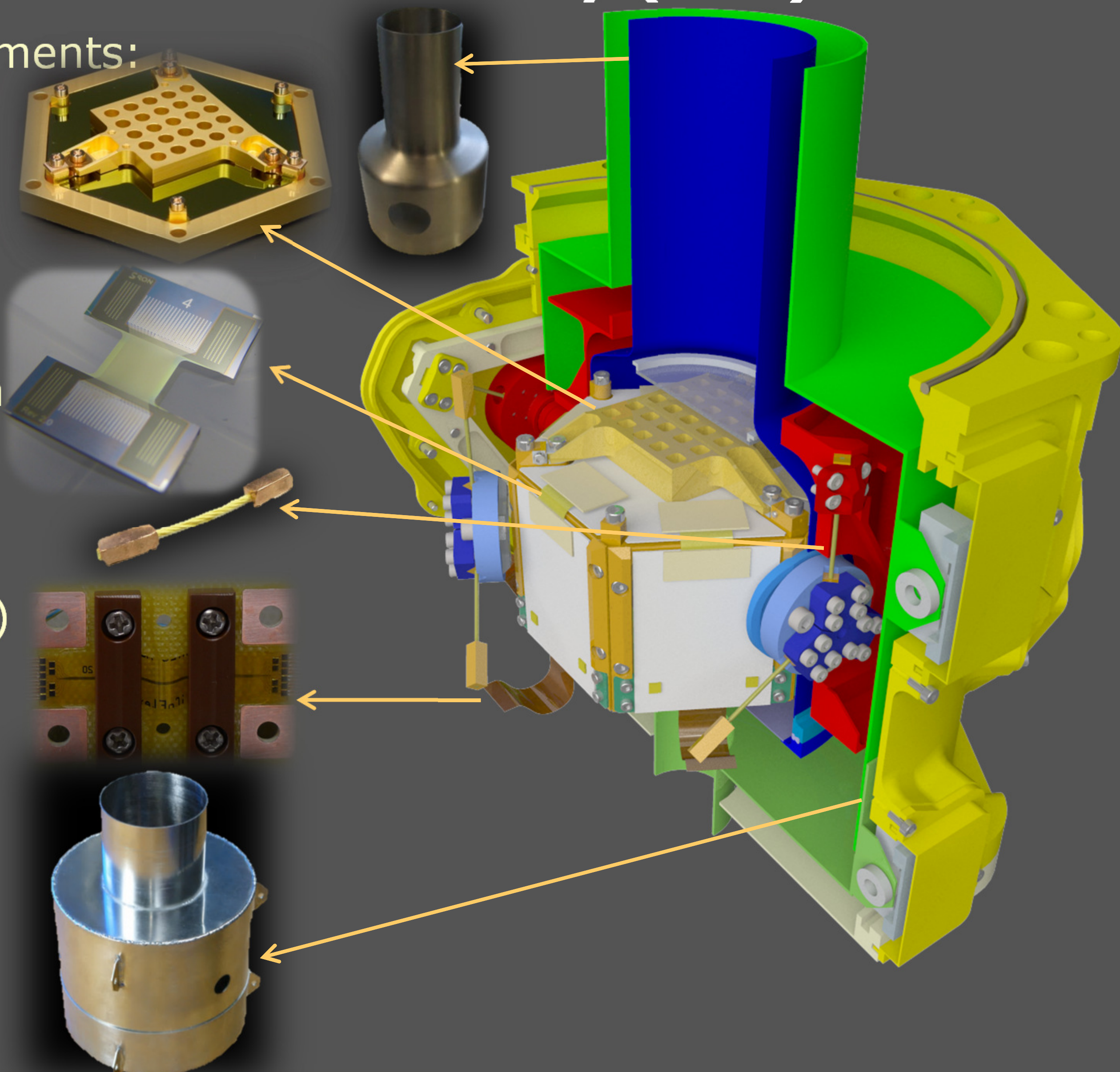
- *~milli-K* environment
- *Very sensitive* to E/B fields
- *Small* pixels (480 µm), *low thermal conductance G*

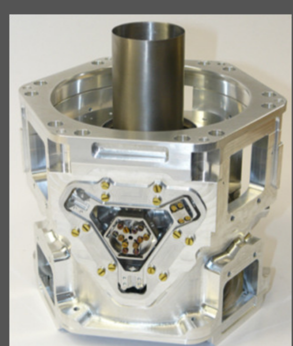
→ trying layout with 'long thin legs'

TES detector Focal Plane Assembly (FPA)

FPA technology developments:

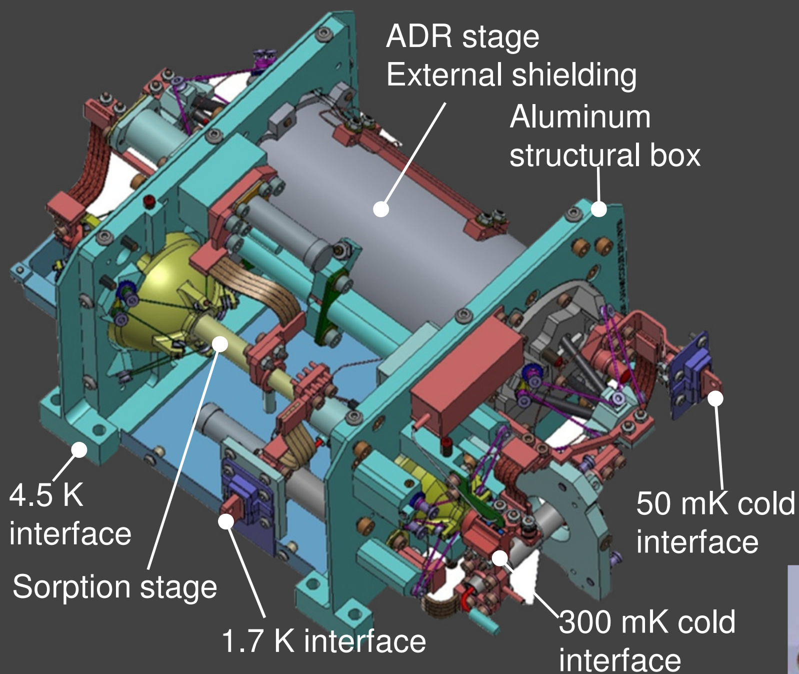
- Interconnects
- Detector mounting
- Kevlar thermal insulating suspension
- Magnetic shielding:
  - Niobium (superconducting)
  - Cryoperm 10

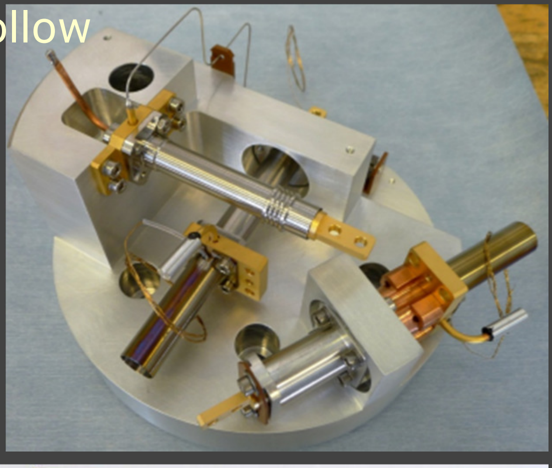


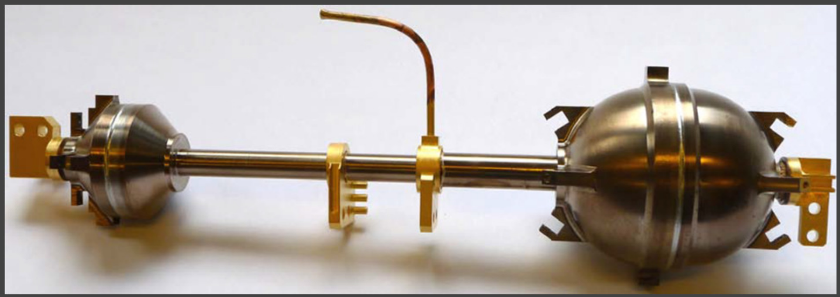


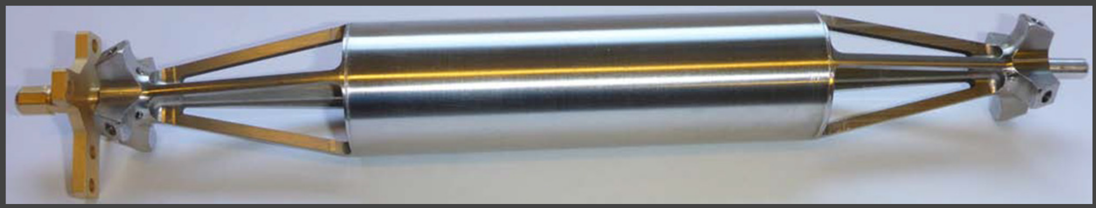
SAFARI cooler - engineering model

- *EM fabrication started*
- Heat switches: successful thermal / mechanical / thermal test campaign
- Sorption core: proof tested at 190 bar, thermal test to follow
- Salt pill ready to be integrated

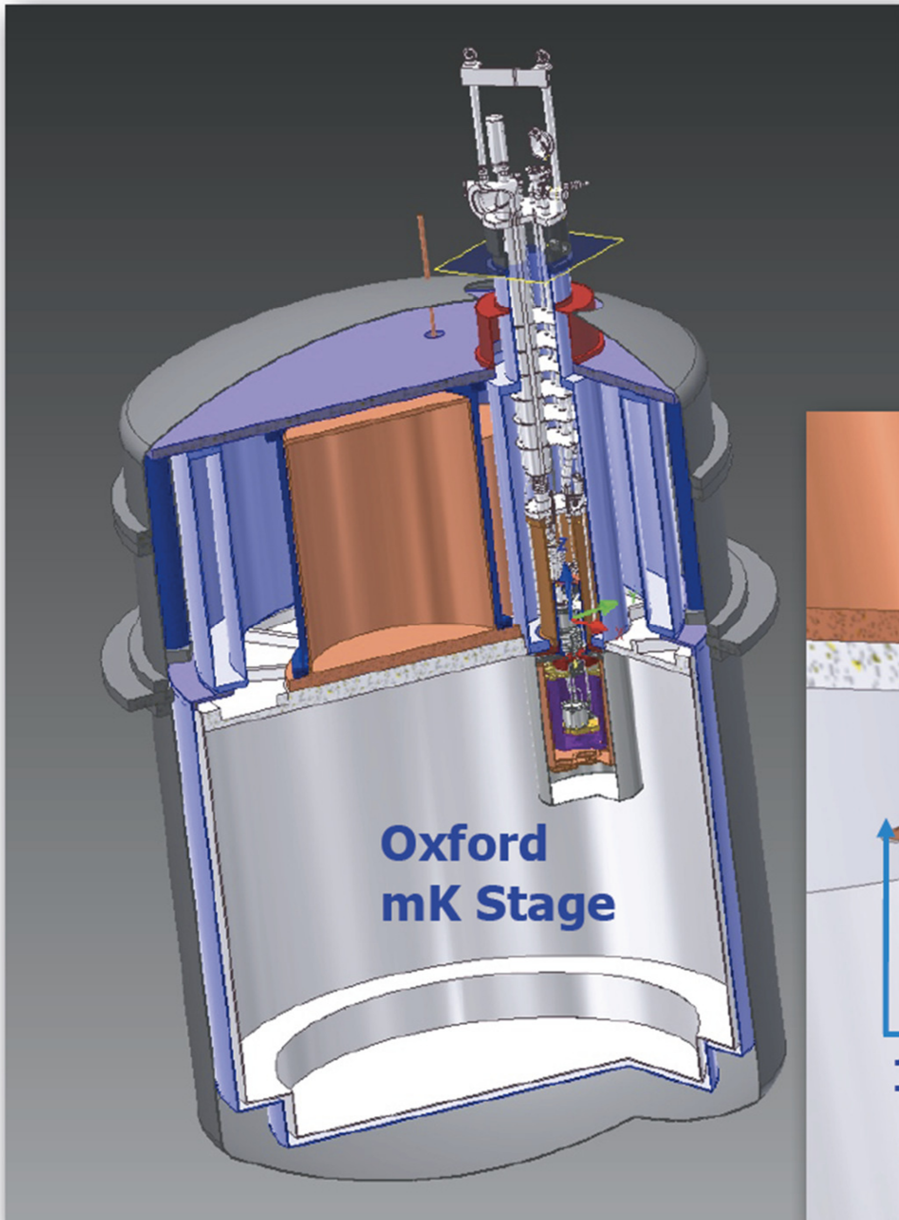






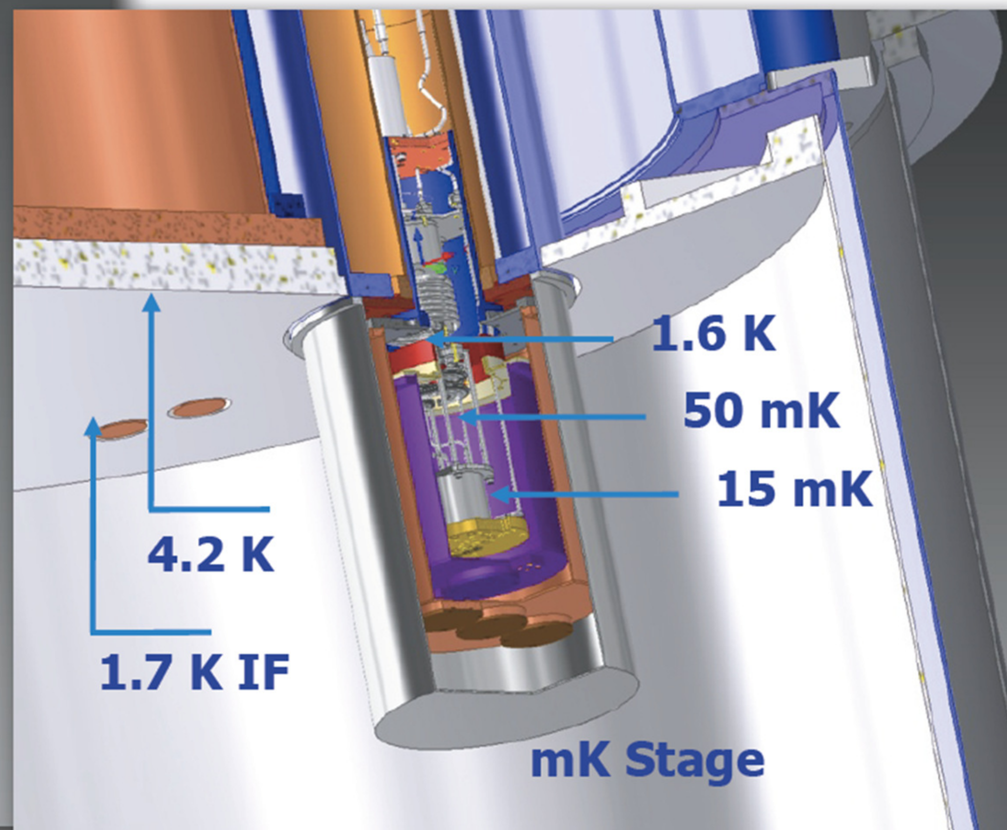


SAFARI FPA/cooler cryotest facility @ MPE

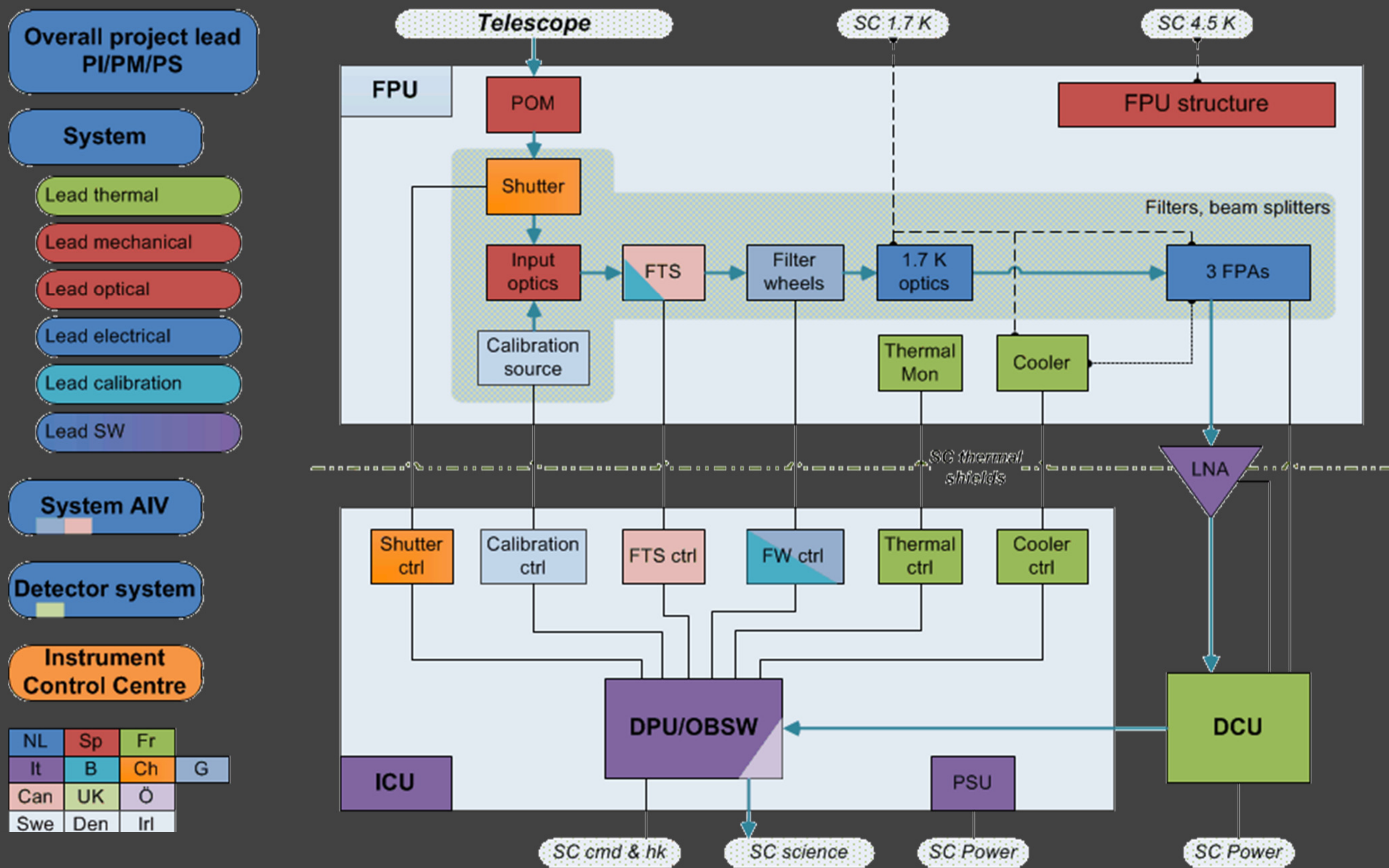


Latest Design Status

- Mounting interfaces ready
- Harness shielding/heat-sinking design fixed
- Harness routing in progress



The SAFARI project – who does what



Conclusion : Programmatic situation of SPICA

- Budgeted constraints
  - → M4 has changed very much in size and nature
    - →SPICA should apply for M5
- ESA:
  - M5 size ~550 M€
  - M5 call ~ 2nd half of 2015
  - ESA/JAXA CDF study: determine 'best achievable mission'
  - Note: all this is also input for November SPC meeting
- JAXA:
  - SPICA (only)one L-mission after ASTRO-H
  - Very good prospects – in principle no competition
  - Need to re-do MDR/SRR


SPICA -
…still a long way ahead until launch on a H2B rocket in 2028 …