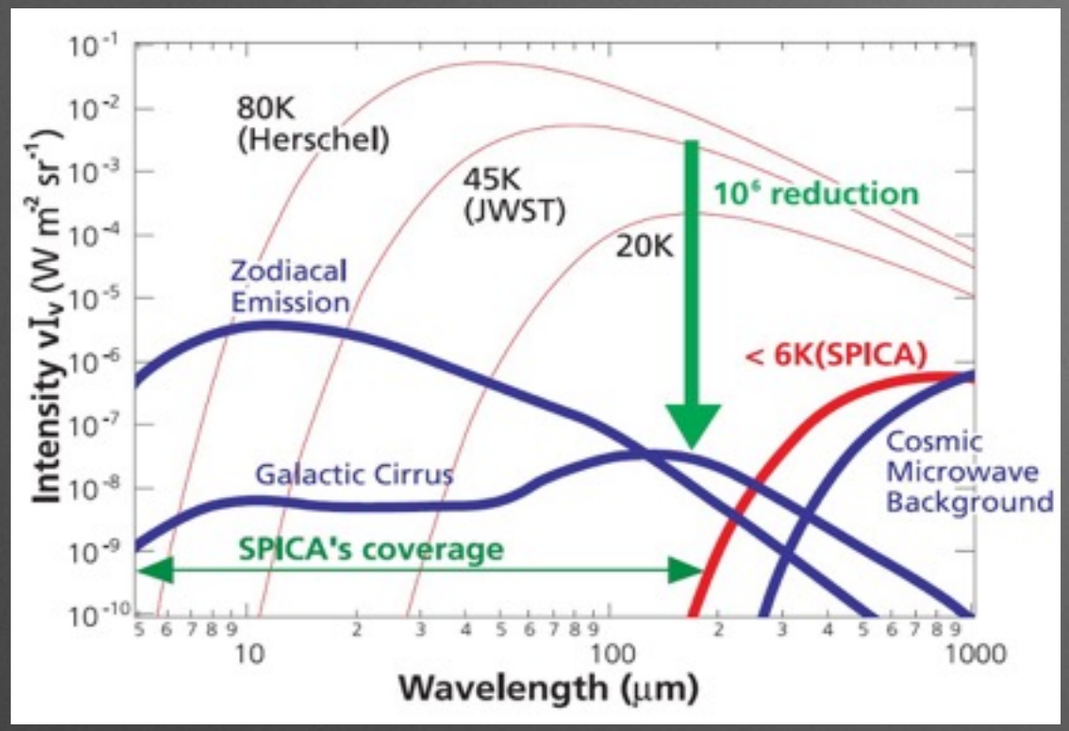
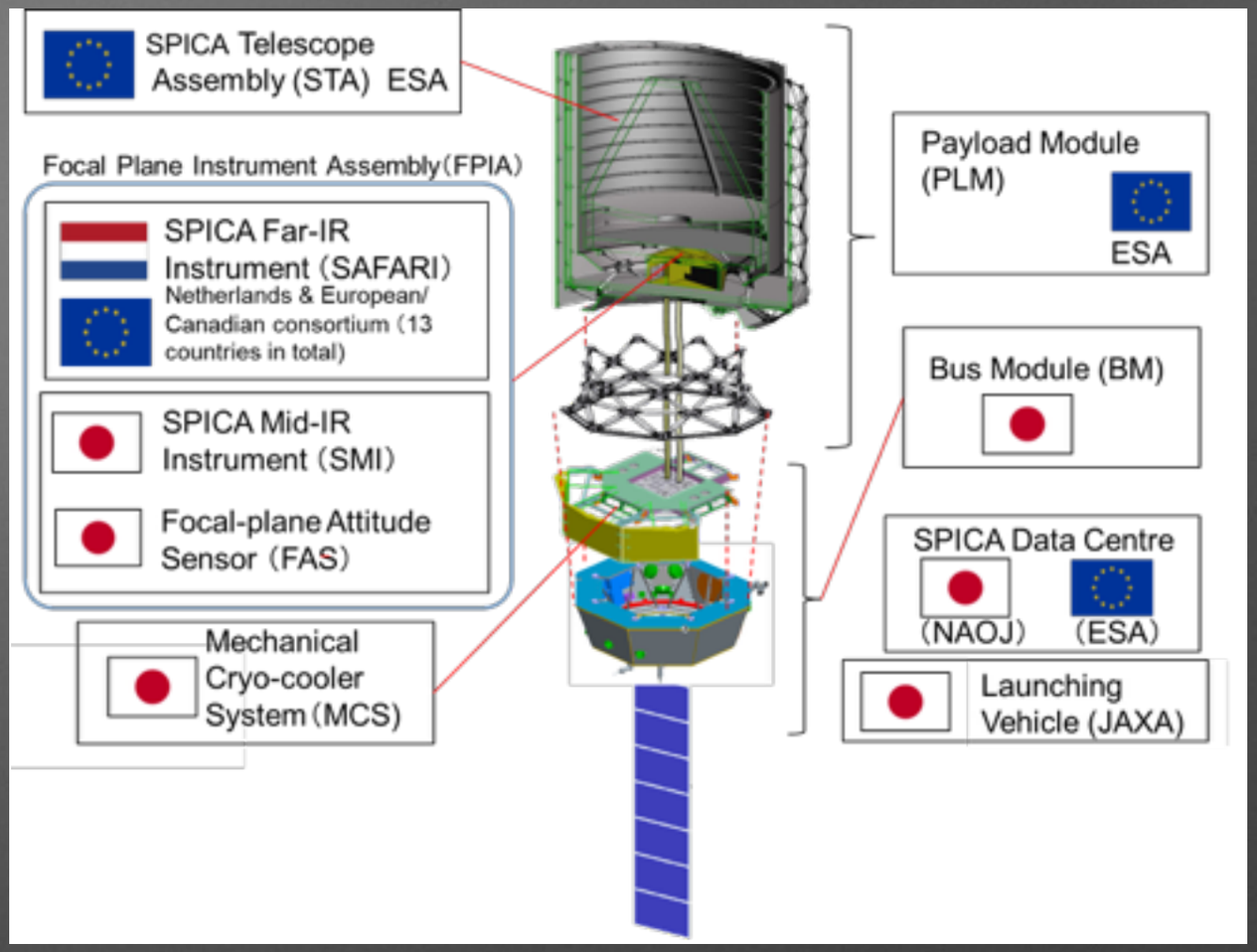
SPICA : the concept pre-2013





The vision of unique new science!

What again is unique about SPICA?

…why is it so worthwhile??

- The ***COLD***, ***big*** mirror:
  - Unique wavelength domain
    → ~20 to ~350 μm ***inaccessible for any observatory***
    - Filling the void between JWST and ALMA @ R~ few 1000
    - R>10000 would be unique over full 10 - 350 μm domain
  - > ***2 orders of magnitude*** more sensitive than e.g. Herschel
    → *background limited* Far-IR observations

Note – *very much* in line with US workshop on future IR missions;
either *big and cold* **or** *high spatial resolution*

SPICA from 1.0 to 2.0…

Fundamental boundary condition:
agencies have limited resources available for SPICA
→ many 'iterations' to assess how those can be used best

- Until 2013 – JAXA/L mission + ESA/'mission of opportunity'
- Summer/Fall 2013 – JAXA/L + ESA/M4 → replan for SPICA 2.0
  - December 2013 - May 2014 – SPICA core science definition
  - January 2014 – ISAS/SRON/SAFARI discussions on M4 context
    - *Strong ISAS-SRON commitment for SPICA!*
- May 2014: significant worry at agency level (ESA and JAXA) about feasibility of SPICA within joint resource limits
  - Note – in Europe M4 scale was being reduced at that time
- ESA proposed CDF to see what kind of cold IR mission could be doable within ESA/M + JAXA/M context

And onwards to …. SPICA-X?…

- Summer 2014 – M4 likely not viable → SPICA to consider M5
  - September 2014 – SAFARI consortium
    - Note - attended/supported by both ESA and JAXA

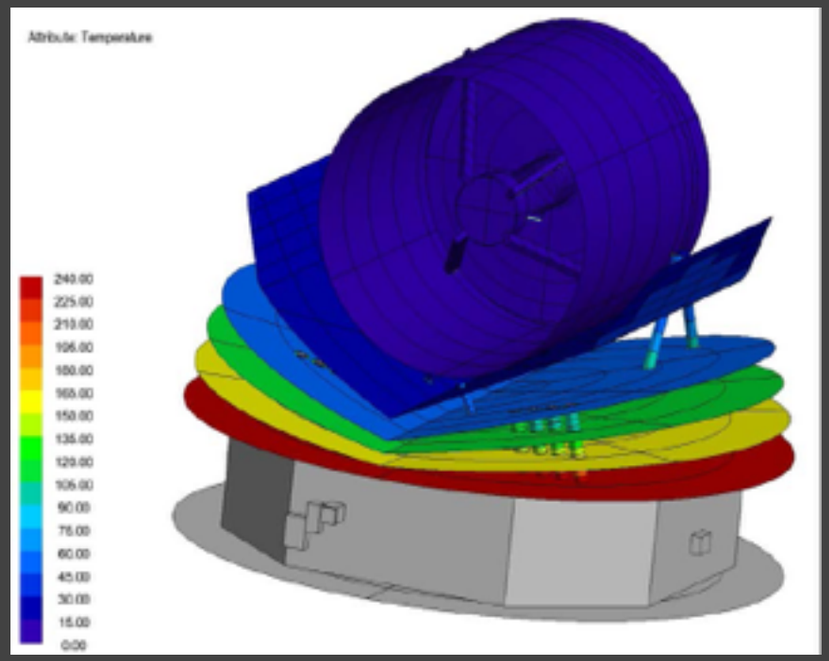
  → consortium unanimously *positive* about *considering M5*
- Fall 2014 – CDF study NG-CryoIRTel
- January-March – interactions between JAXA, ESA and SAFARI
  - What does the CDF outcome imply for SPICA
    (…open for different interpretations…)
  - Revisit science requirements → revisit instrument concepts

And ….now; here we are… Go/NoGo for an M5 proposal?

- Which concept has ***the best chance*** in the M5 ***competition***
- Different concepts with pros and cons, science cases, telescope parameters, instrument complement, instrument consortia

If Go … → ***prepare to start writing process***

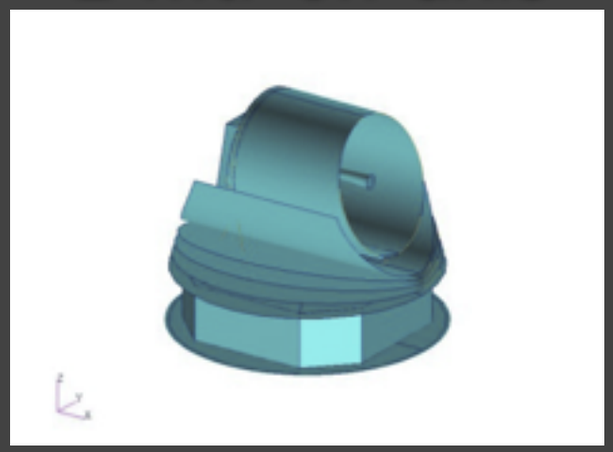
The NG-CryoIRTel study



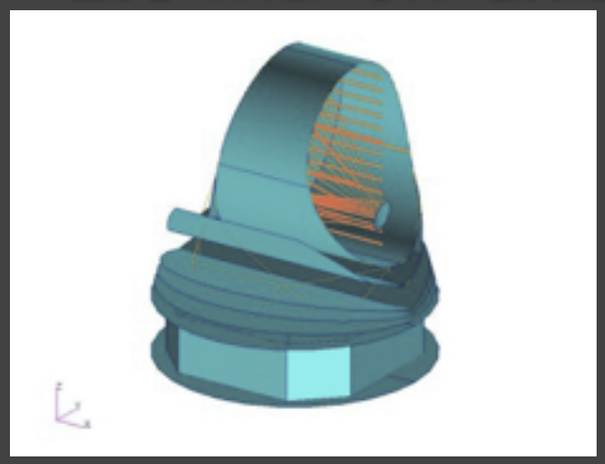
Main changes with respect tor SPICA 2.0

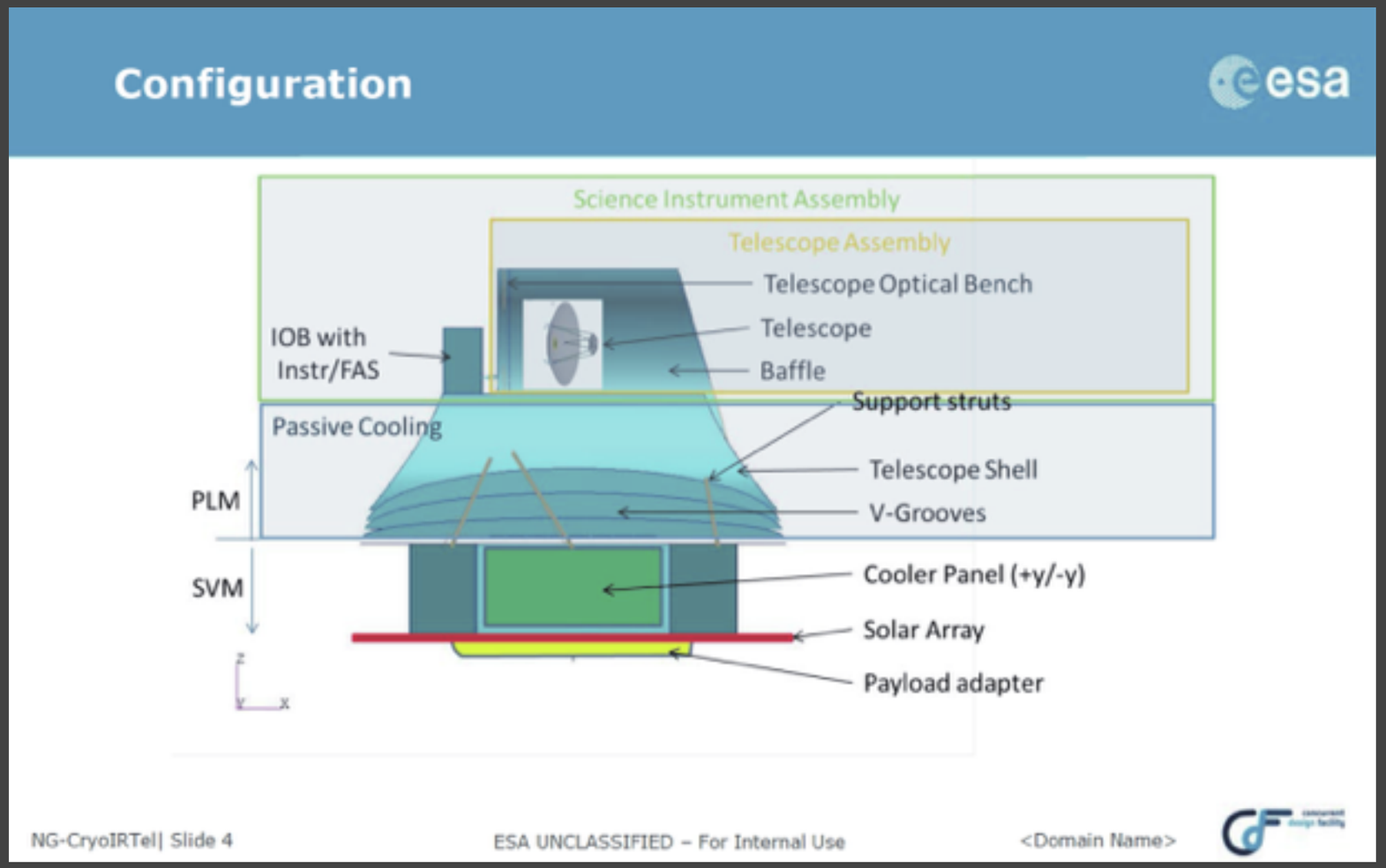
- PLANCK configuration → well understood at ESA
- Passive cooling to ~ 40K i.s.o. 20K
- ESA-led, bias to ESA technology/processes

2 mtr on-axis



~2.8 mtr off-axis





Mid-infrared instrument : from MCS to SMI

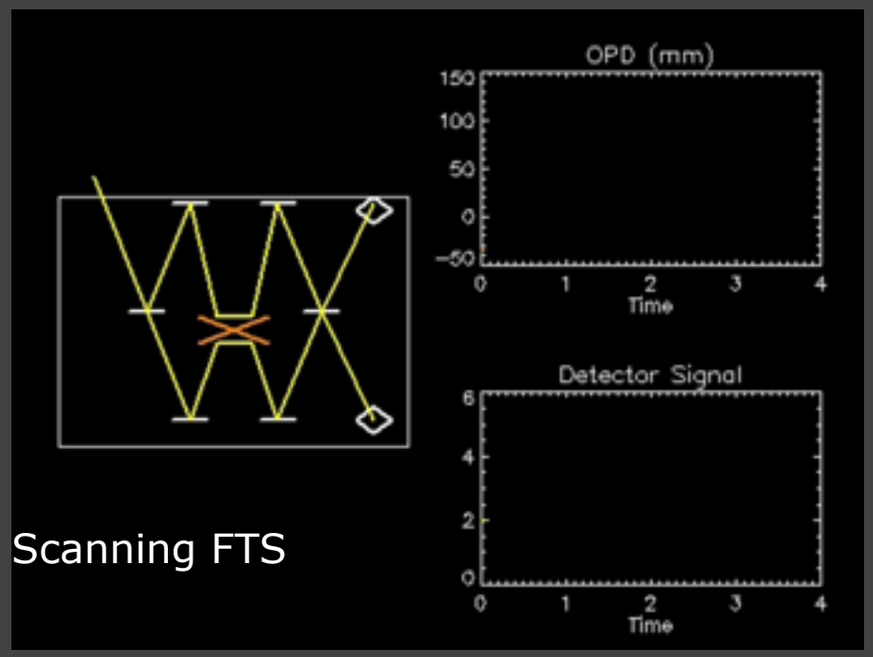
SMI: **S**PICA **M**id-infrared **I**nstrument, refined for new SPICA.

MCS	
Cam / Low-R Spec	5 – 37 μm FoV: 5'x5' R = 5 & 50
Mid-R Spec	12 – 37 μm FoV: 12" x 8" R = 1000–3000
High-R Spec	12 – 18 μm Slit size: 6"x1" R = 20000

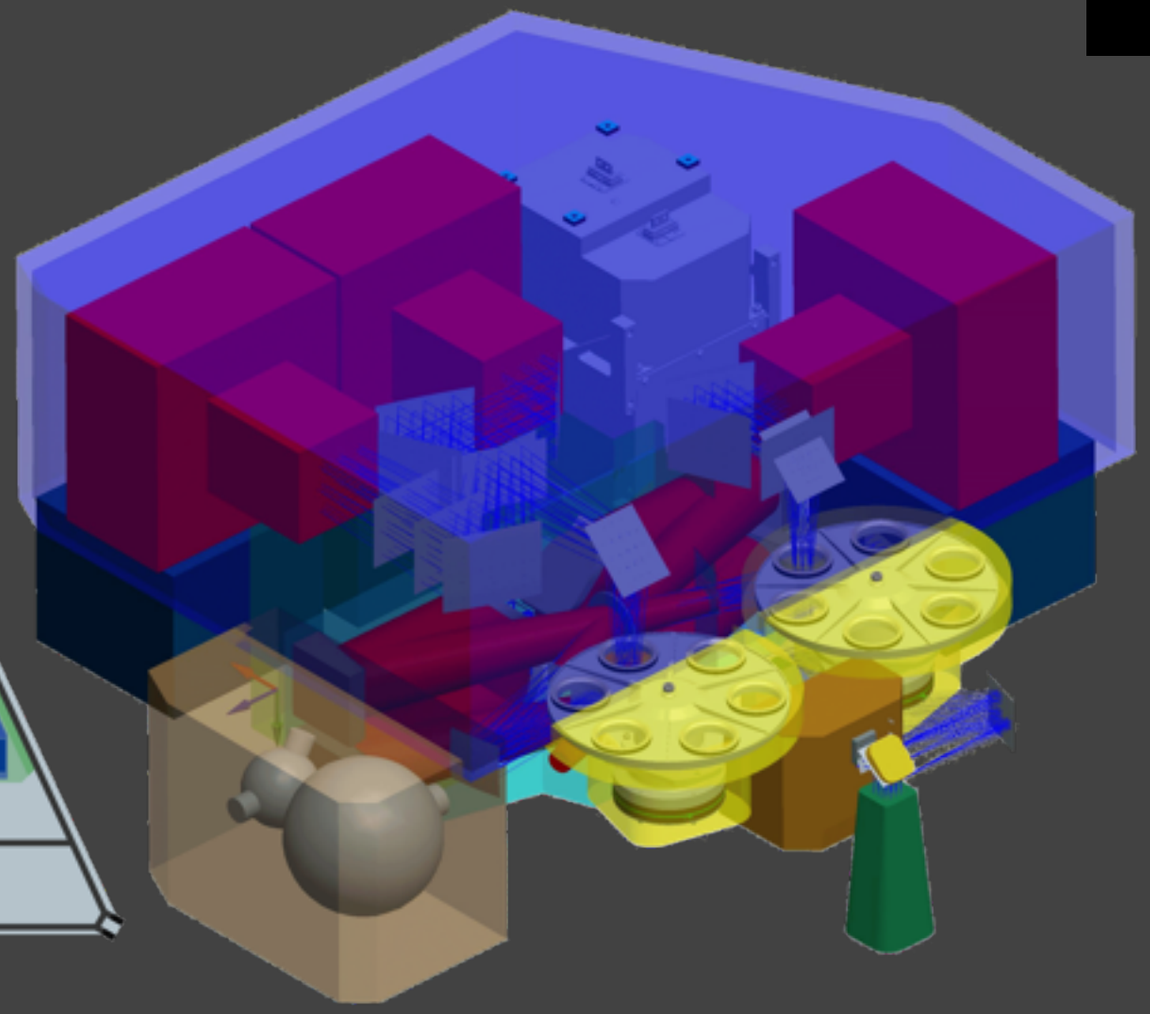
SMI	
20 – 37 μm FoV: 5'x5' R = 20	**Cam**
20 – 37 μm (17-20 μm optional) slit size: 150" x 3" R = 1000	**Spec**
N/A under discussion	

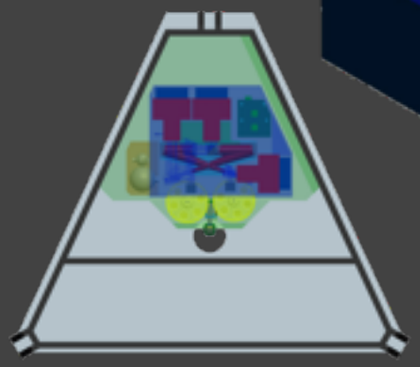
Previous SAFARI reference design

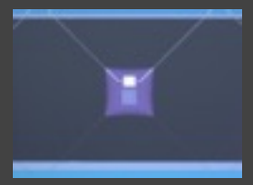
- Scanning Fourier Transform Spectrometer with 2'x2' FoV
- Simultaneously observing in 3 bands → 34-210μm
- TES detectors/SQUID read out at 50 mK
- Frequency Domain Multiplexing
- Dispersive element; slit/grism/FP to reduce background
- To be built by an SRON-led consortium
- ~15 institutes in Europe,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

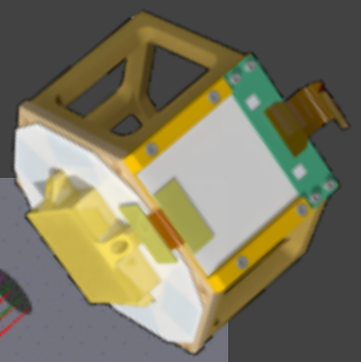


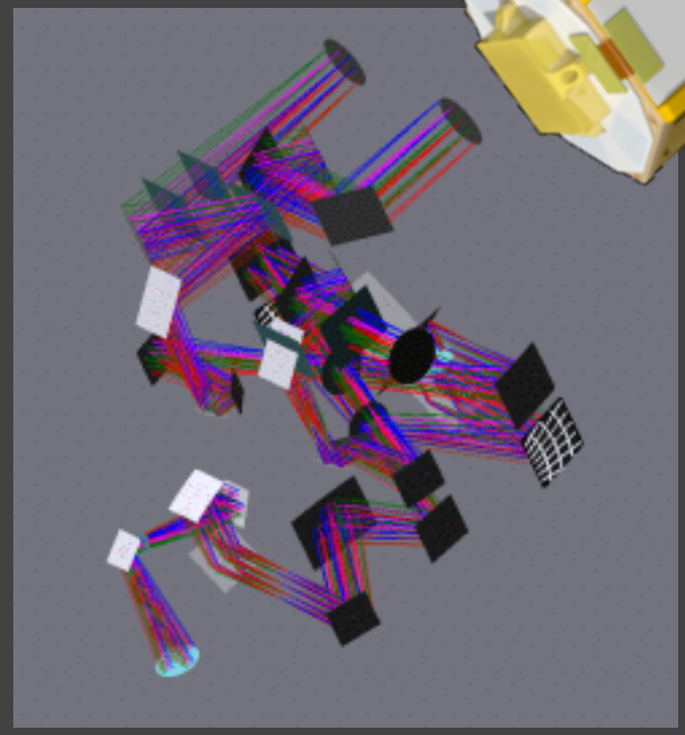
Scanning FTS











The new SAFARI concept

- Grating based spectrometer
  - Basic R~300 mode → 1hr/5σ ~**4-6×10^{-20} W/m^2** (6m^2)
  - FP enhanced R~3000 mode
  - 3 bands covering 35-210 micron, operated sequentially
  - 4 pixels simultaneous on-sky
- Some of the questions and conceivable options
  - Is R ~300/3000 OK?
  - Is sequential operation OK?
  - A fourth band → LLW?
  - An imaging channel → what wavelength?

  …much ongoing development and refinement

…Science… what is **your** priority??

Defining the SPICA core science

- Over the last year high priority joint European-Japanese activity
  - December 2013 – April 2014; core science team meetings
  - April 2014 – draft white papers
  - May 2014 – Leiden open SPICA science workshop
  - December 16/17 2014 – workshop in Bologna
  - January 12/13 – workshop in Osaka

Now – quite clear ***joint*** view on major SPICA themes:

- Deep extragalactic mid-to-far IR ***spectroscopic surveys*** combined with ***spectral imaging*** of nearby/local group galaxies
- ***Spectroscopy*** of protostars and planet-forming discs

Concluding; points to keep in mind

The mission – ***SPICA-X*** ?– is now in a decisive Go/NoGo phase

- ***The one*** (and only?) IR mission in the (any?) mid term
  - Science case is now well understood/defined
  - Big telescope required by European and US astronomers
  - Medium size telescope acceptable to Japanese astronomers
- ***Significant*** (strong?) ***desire*** on side of agencies to cooperate
  - Both ESA and JAXA strongly support proposal preparatory activities
  - Need to fully unify European and Japanese views
- Mission and instrument re-configuration ***shows great promise***
  - Telescope size, on or off-axis, thermal configuration, JAXA-ESA split
  - System trades; e.g. telescope size vs. instrument capabilities
  - FTS → grating, far-IR camera, SMI → ?, SPEcHO, BLISS?

So shall we go on?

....yes? ...then there is work to do!

- Near-ish term milestones
  - Summer; ***Mission Definition Review*** in Japan
  - ~fall/winter; ***M5 call***

→ both need clear science goals and instrument/mission concepts

- Parallel tasks – with (lots) of cross-fertilization
  - Science team → revisit science goals in 'new' R~300/3000 configuration, revisit requirements (high R?)
  - SAFARI/instrument → further detail grating option(s?), grating detector system study
  - SMI/instrument → further detailing (e.g. FTS)
  - SAFARI project → revisit consortium task distribution

The first order timeline

What	When	Who
CDF report	***~February (?)***	
Science evaluation	***January – February***	***SPICA science team***
Consortium meeting → M5 Y/N?	Now	(SPICA) consortium
Refine mission/instrument definition	***Spring/summer 2015***	***SPICA + SAFARI + M5 team***
SPICA reviews in Japan	***Summer 2015***	
M5 call	***late 2015 /early 2016?***	***ESA***
Write M5 proposal	***Spring 2016***	***M5 team +consortium***
M5 candidate selection	***Q2/Q3 2016***	***SPC***
.		
M5 mission selection	***2018/2019***	***SPC***
Launch	***… 2028***	

***VERY tentative**, not consolidated with SPICA, ESA..*

SPICA/SAFARI Fact Sheet

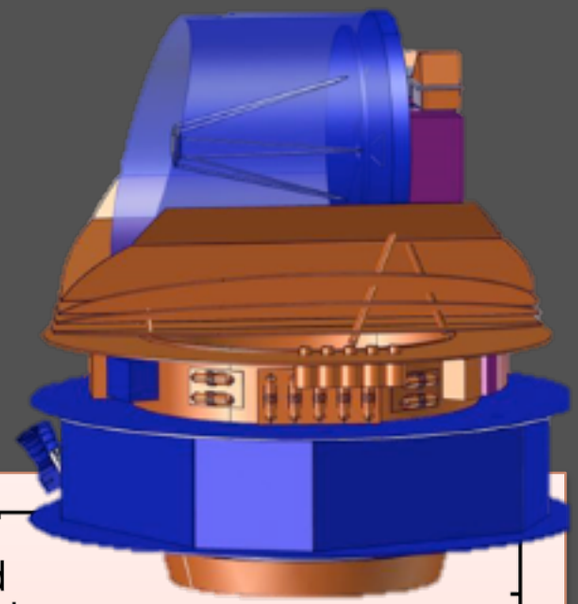
SAFARI Overview

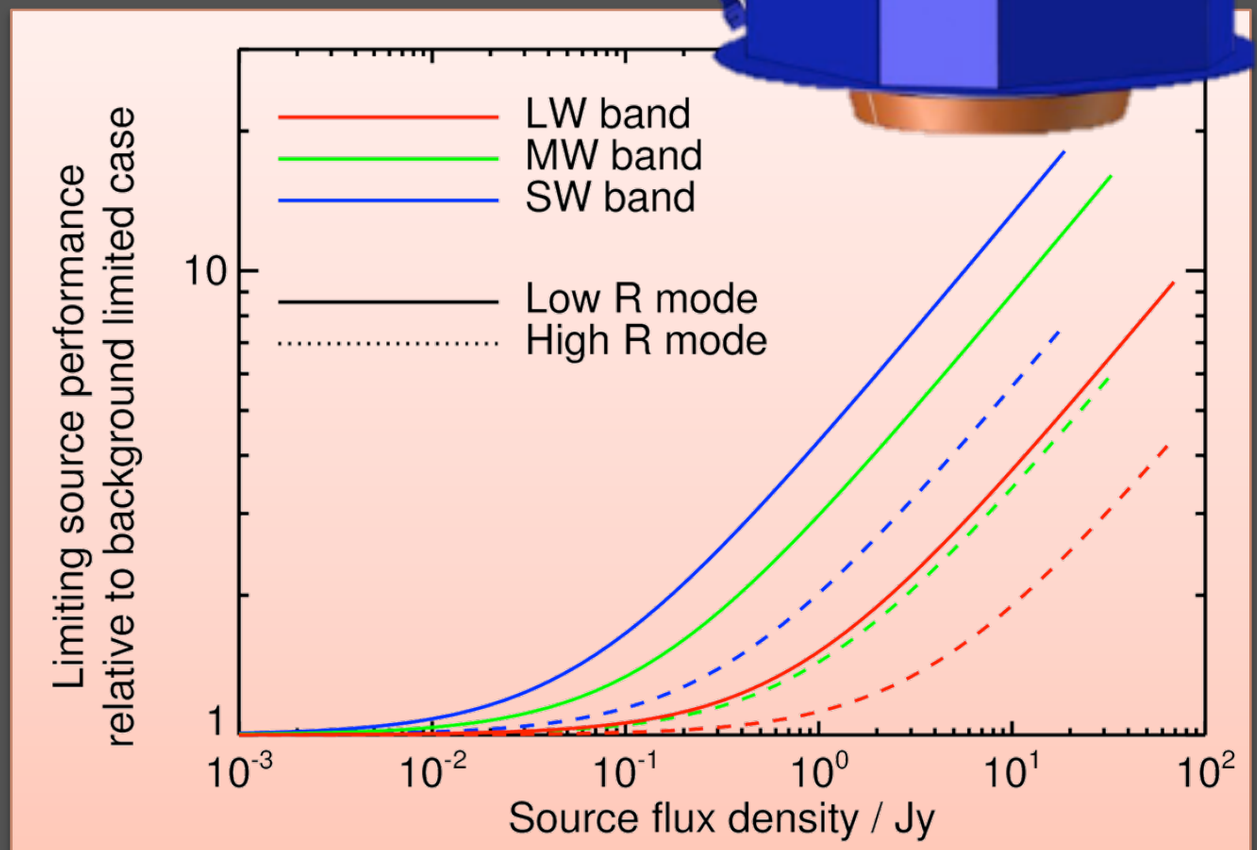
- Three band ***grating spectrometer***
- Continuous spectroscopic capability from 34-210 μm

Parameter		Waveband		
		SW	MW	LW
Band centre / μm		47	85	160
Wavelength range / μm		34-60	60-110	110-210
Band centre beam FWHM		4.7″	8.6″	16″
Point source spectroscopy (5σ-1hr)				
R~300*	**Limiting flux** / x10^{-20} Wm^{-2}	5.3	4.5	6.5
	Limiting flux density / mJy	0.25	0.36	0.92
R~3000*	**Limiting flux** / x10^{-20} Wm^{-2}	25	24	29
	Limiting flux density / mJy	1.2	2.0	4.1
Mapping spectroscopy (5σ-1hr)**				
R~300*	**Limiting flux** / x10^{-20} Wm^{-2}	59	28	22
	Limiting flux density / mJy	2.8	2.3	3.0
R~3000*	**Limiting flux** / x10^{-20} Wm^{-2}	340	190	120
	Limiting flux density / mJy	17	15	17
Photometric mapping (5σ-1hr)**				
	Limiting flux density / mJy	0.3	0.2	0.3

SPICA Mission

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





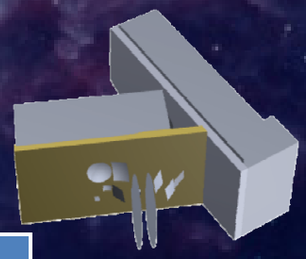
- Change in system performance, as a function of target flux density, relative to the background limited case.
- The decrease in sensitivity is a result of the increased photon noise from the target source
- Data given up to the instrument saturation limits for each band (22, 37 and 73 Jy for the SW, MW and LW bands respectively.

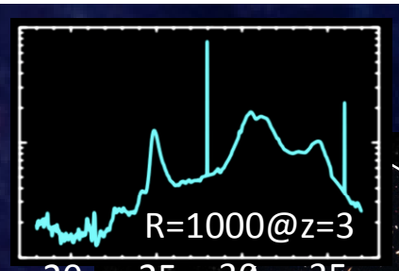
* Resolving powers are all calculated at band centre
** Mapping performance is for a reference area of 1 arcmin^2

SPICA / SMI Fact Sheet

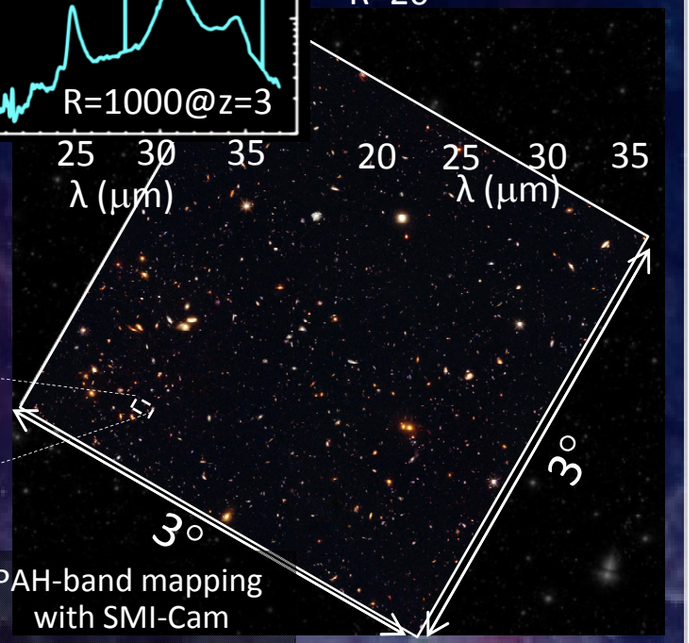
SPICA Mid-infrared Instrument (SMI) covers the wavelength range of 17−37 μm with one imaging channel and two spectroscopic channels.

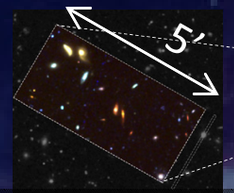
Parameter		Function		
		Cam (multi-slit low-R Spec)	Spec-S	Spec-L
Wavelength range		17-37 μm	17-27 μm	27-37 μm
Spectral resolution		50	1000-2000 [a] (point source), 1000 [b] (diffuse)	
Field of View		360” x 3.”7 x 4 slits	150” x 3.”7 (slit)	
FWHM		1.”7 (17 μm) - 3.”7 (37 μm)		
Pixel scale		0.”6x 0.”6	0.”6	
Detector		Si:Sb 1K x 1K	Si:As 1K x 1K	Si:Sb 1K x 1K
Point source	Cont. sensitivity (1 hr, 5 sigma)	20 – 110 μJy	200 – 700 μJy	300 – 4000 μJy
	Line sensitivity (1 hr, 5 sigma)	(6 – 18) x 10^{-20} W/m^2	(3 – 10) x 10^{-20} W/m^2	(5 – 40) x 10^{-20} W/m^2
	Survey speed [c]	~ 18 arcmin^2/hr	~ 4 arcmin^2/hr	~ 2 arcmin^2/hr
Diffuse	Sensitivity [d] (1 hr, 5 sigma)	Continuum	Line	
		0.1 – 0.5 MJy/sr	(0.5 – 2) x 10^{-9} W/m^2/sr	(0.7 – 2) x 10^{-9} W/m^2/sr
Saturation limit		~ 2 Jy	~ 140 Jy	~ 600 Jy





R=50@z=3
Cam
R=20

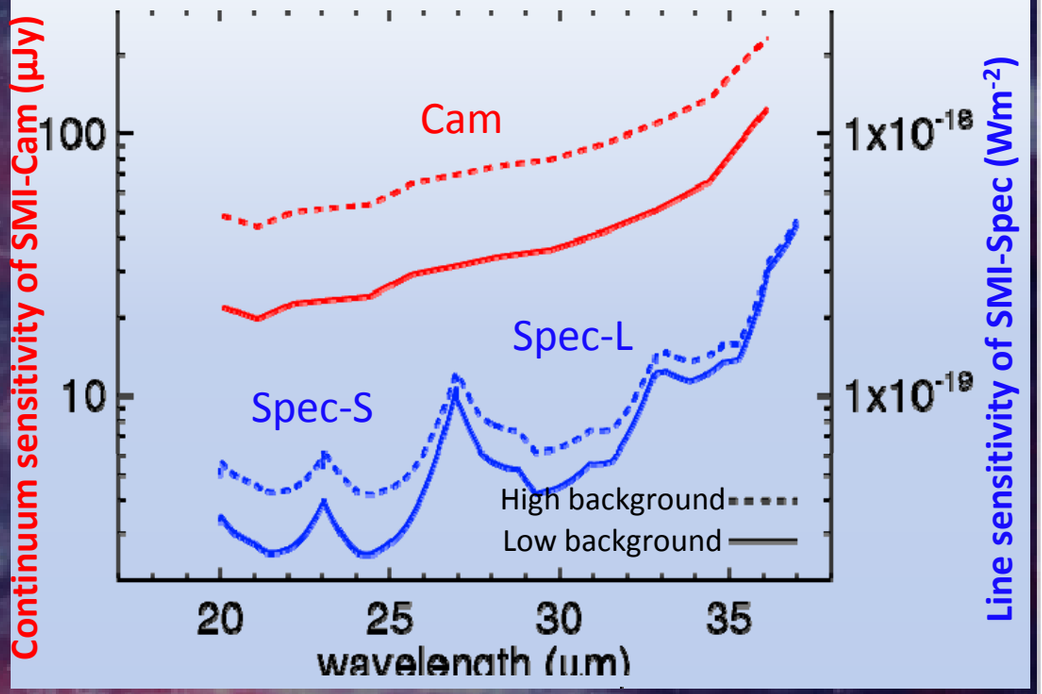




Spectral mapping with SMI-Spec

PAH-band mapping with SMI-Cam

Sensitivity for a point source [e] (1 hour, 5 sigma)



a: λ/δλ=2000 at λ=22 μm, λ/δλ=1000 at λ=35 μm b: for 17 − 37μm
c: survey speed for the 5 sigma detection of a point source with the continuum flux of 100 μJy and the line flux of 3x10^{-19} W/m^2 for Cam and Spec, respectively

d: sensitivity for a diffuse source in a 4” x 4” area
e: Background levels are assumed to be 80 MJy/sr (High) and 15 MJy/sr (Low) at 25 μm.

SMI Factsheet v2 – 10 March 2015

A possible change of the SMI configuration

Current configuration

SMI-Cam

R=50 (multi-slit prism)
Slit length: 6’
FoV: 6’ x 10’ (w/ spatial scan)
Detector: Si:Sb 1K x 1K
Wavelength: 17 – 37 μm
+ Slit viewer: 33 μm, R=5 (TBD)

SMI-Spec

R=1000 (long-slit grating)
Slit length: 2.5’
Si:Sb 1K x 1K + Si:As 1K x 1K
17 – 37 μm

New configuration if we add HRS.

SMI-LRS

Same as the current SMI-Cam

SMI-MRS

R=1000
Smaller FoV + beam steering mirror
(provided by SAFARI)
Si:Sb 1K x 1K
18 – 36 μm

SMI-HRS

R=20000 (TBD)
Slit length: 6” (TBD)
Si:As 1K x 1K (procured by SPeChO?)
12 – 18 μm (TBD)