SPICA IN THE INTERNATIONAL CONTEXT

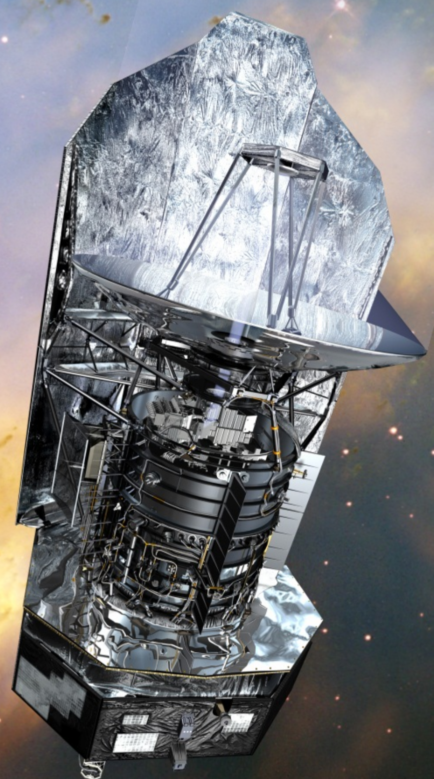
Alberto Franceschini

Padova University

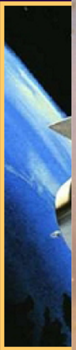
Italian SPICA Workshop 2016

INAF Monte Mario Observatory - Rome

The last of the series: the Herschel Observatory



3.6 m, 100-500 µm



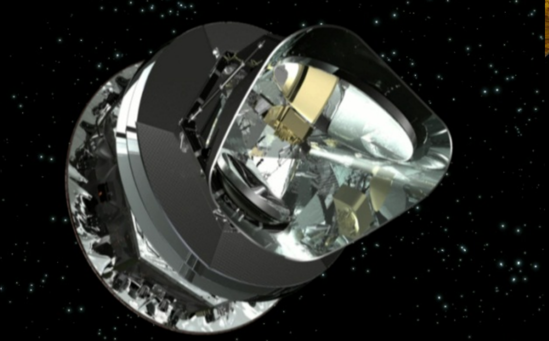
1983: IRAS (I
Satellite) is lau
scans more tha
times, providi
all-sky map at
and 100 micro
of cataloged a
detecting abou
IRAS discove
grains around
comets, and v
from interacti
of warm dust
could be foun
space. IRAS a
the central core of our galaxy, the Milky
Way.

y
vatory
serves a
engths
ch wider
s also
than
with
nces in
ect data
than
lium runs
to

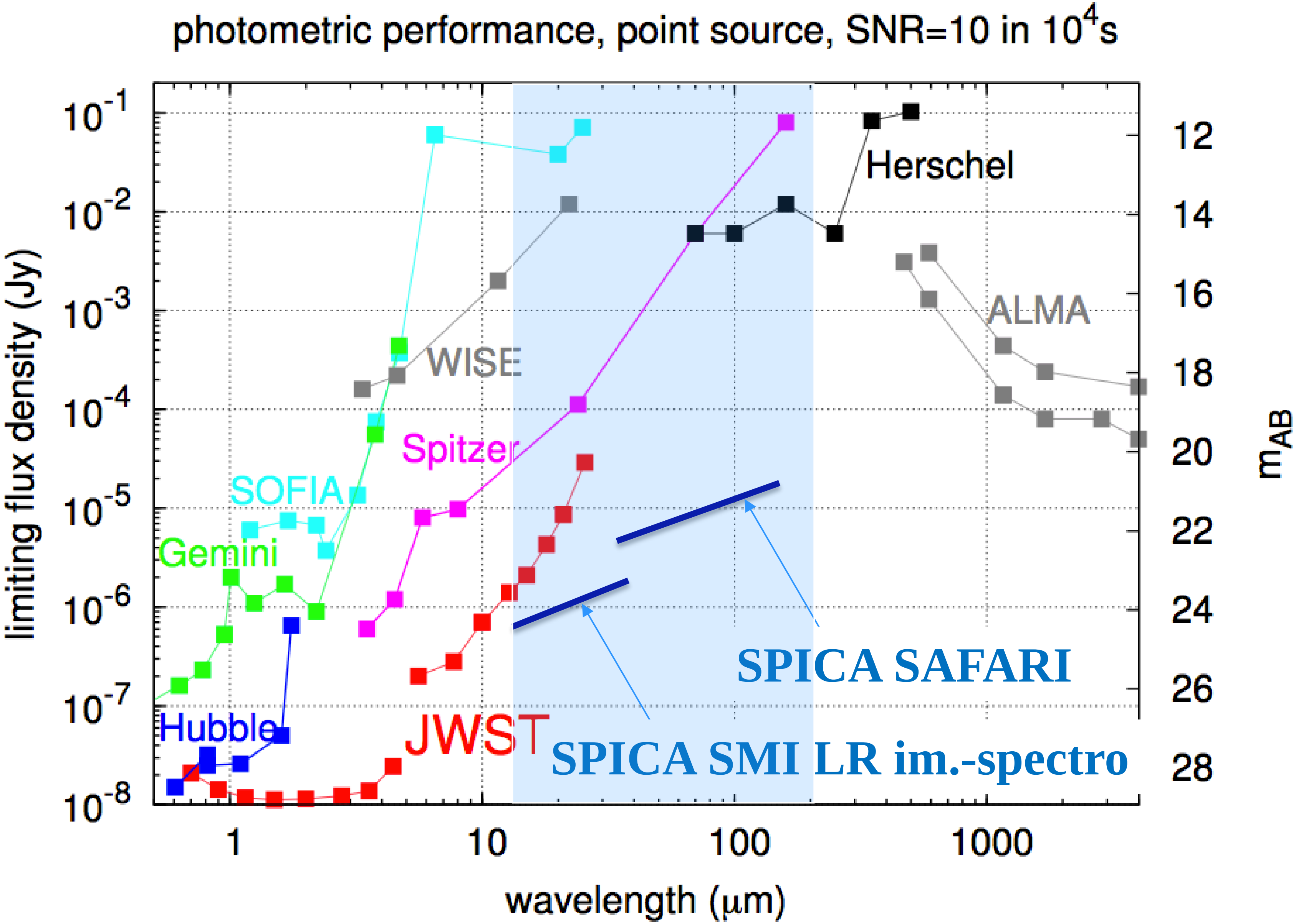
– 1.7-180 µm
– +3 years warm

2003: The Spitzer Space Telescope was launched in August 2003. It is the last of NASA's "great observatories" in space. Spitzer is be much more sensitive than prior infrared missions and will study the universe at a wide range of infrared wavelengths. Spitzer will concentrate on the study of brown dwarfs, super planets, protoplanetary and planetary debris disks, ultraluminous galaxies, active galaxies, and deep surveys of the early universe.

WMAP



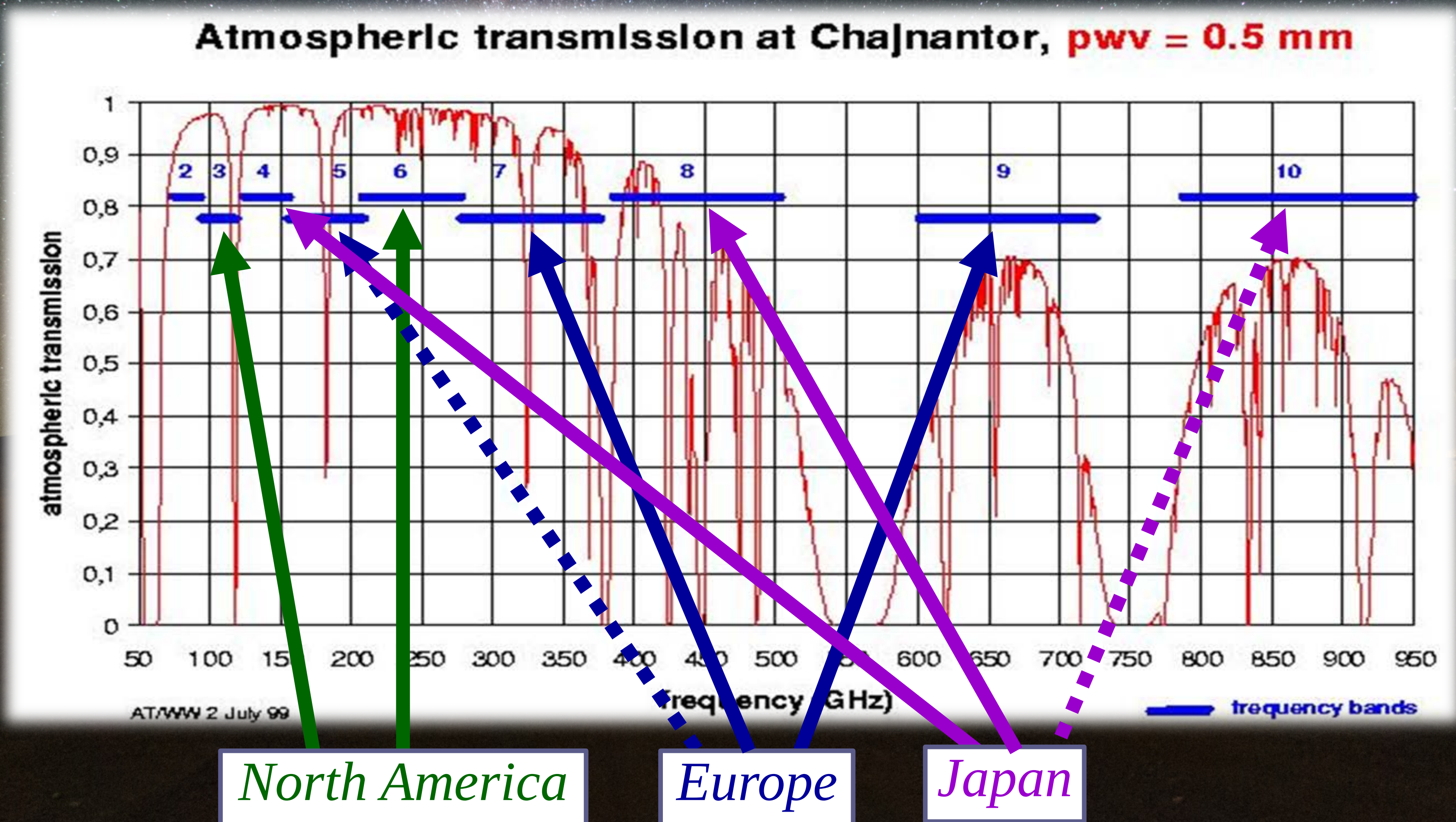
Planck



photometric performance, point source, SNR=10 in 10^4s
limiting flux density (Jy)
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
1
10
100
1000
wavelength (μm)
m_{AB}
12
14
16
18
20
22
24
26
28
Herschel
ALMA
WISE
Spitzer
SOFIA
Gemini
Hubble
JWST
SPICA SAFARI
SPICA SMI LR im.-spectro

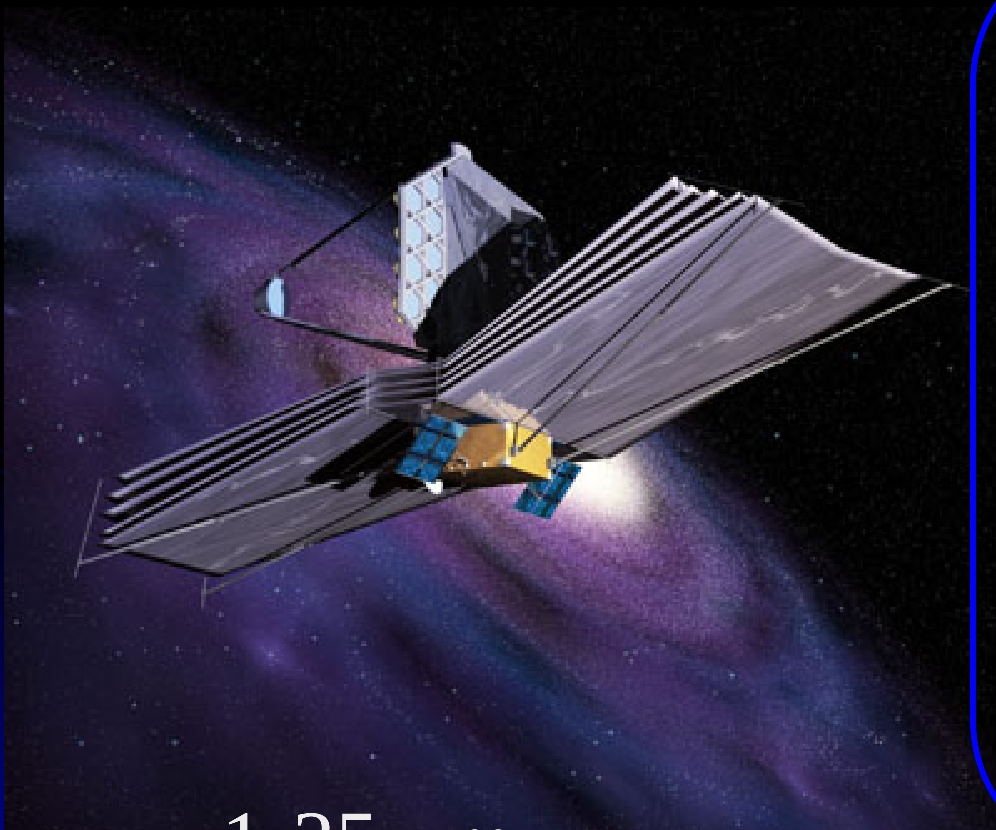
Facilities in operation by the SPICA time

ALMA



Atmospheric transmission at Chajnantor, pwv = 0.5 mm
atmospheric transmission
frequency (GHz)
AT/WW 2 July 99
frequency bands
2
3
4
5
6
7
8
9
10
North America
Europe
Japan

James Webb Space Telescope

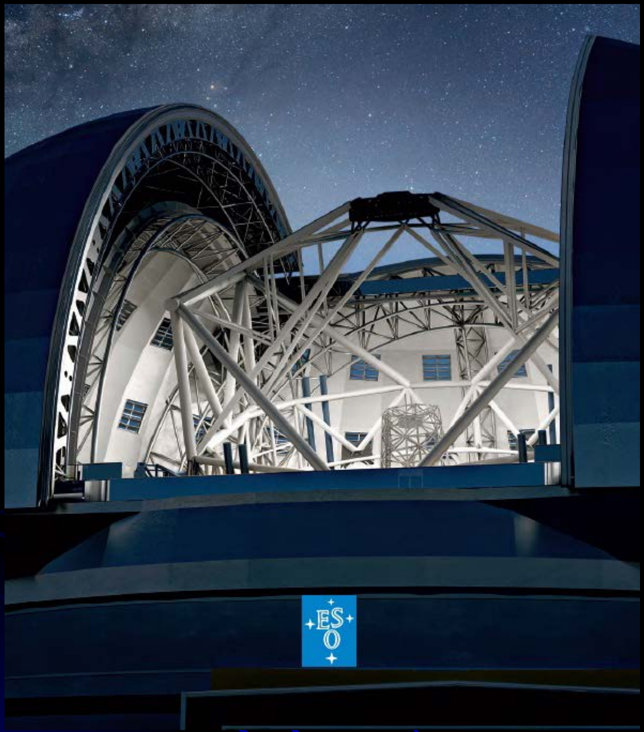


1-25 µm

- Diffraction-limited performance of a 6.5 metre telescope at 2 microns.
- Observations from the optical to mid-infrared wavebands.
- Pointing stability of 0.01 arcsec.

NASA

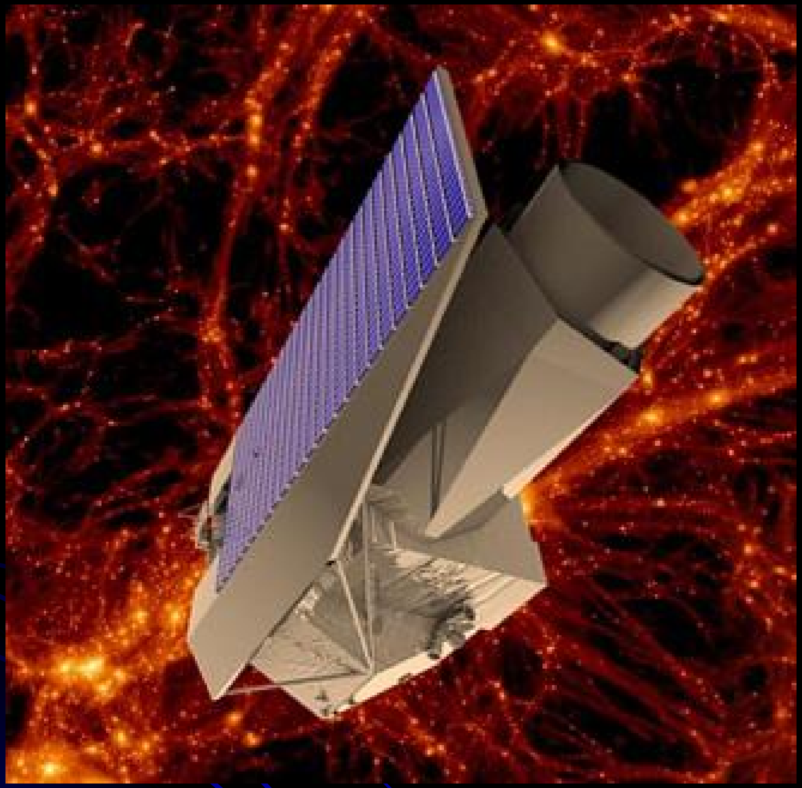
European Extremely Large Telescope (E-ELT)



39-m optical-infrared telescope

- Large redshift type 1a supernovae, γ-ray bursts
- Dark Matter and Dark Energy probes
- Astrophysics of galaxies at very large redshifts
- Growth of perturbations during and after reionation era
- Variations of fundamental constants with cosmic epoch

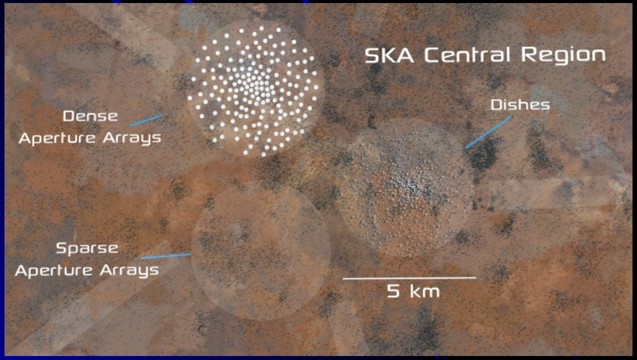
ESA Euclid Mission



Approved October 2011
Launch 2021

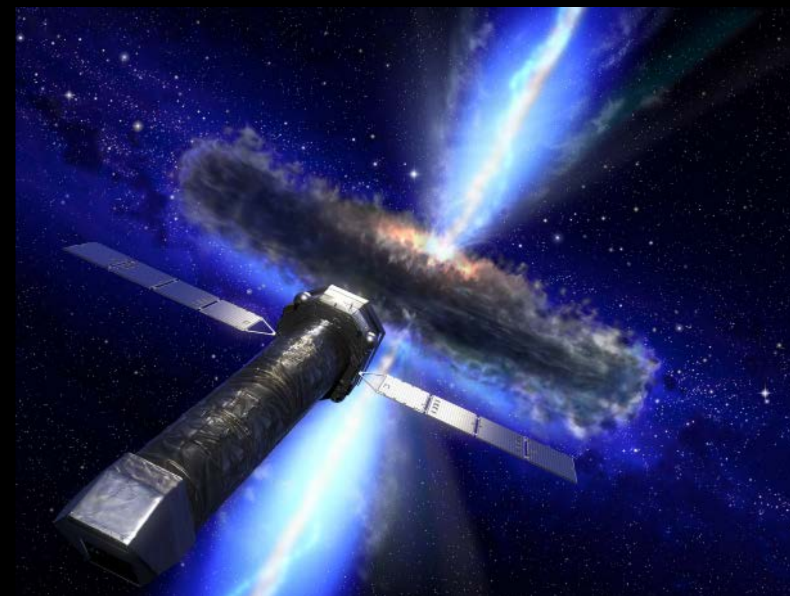
- Baryon Acoustic Oscillations (BAO), Weak Gravitational Lensing.
- Variation of dark energy with cosmic epoch
- Deviations from GR
- Huge samples of galaxies with colours/spectra

Radio Square Kilometre Array



- The epoch of re-ionisation
- HI redshifts out to z = 2.
- BAO, weak lensing, deviations from GR
- Huge samples of pulsars – test of GR
- Astrophysics of galaxies/radio sources at early epochs

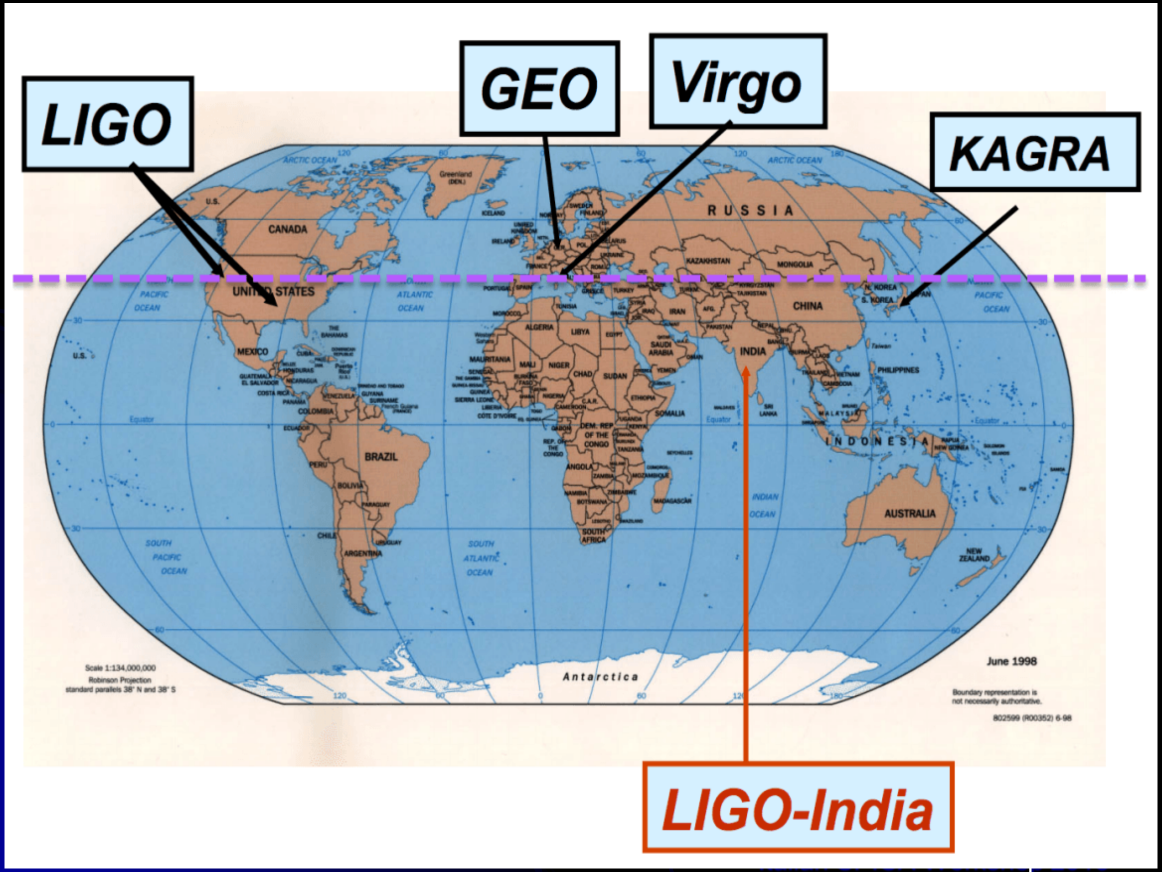
Advanced Telescope for High Energy Astrophysics (ATHENA)



- The history of Gravitational Accretion
- Tests of General Relativity in the strong field limit

Multi-messenger astronomy

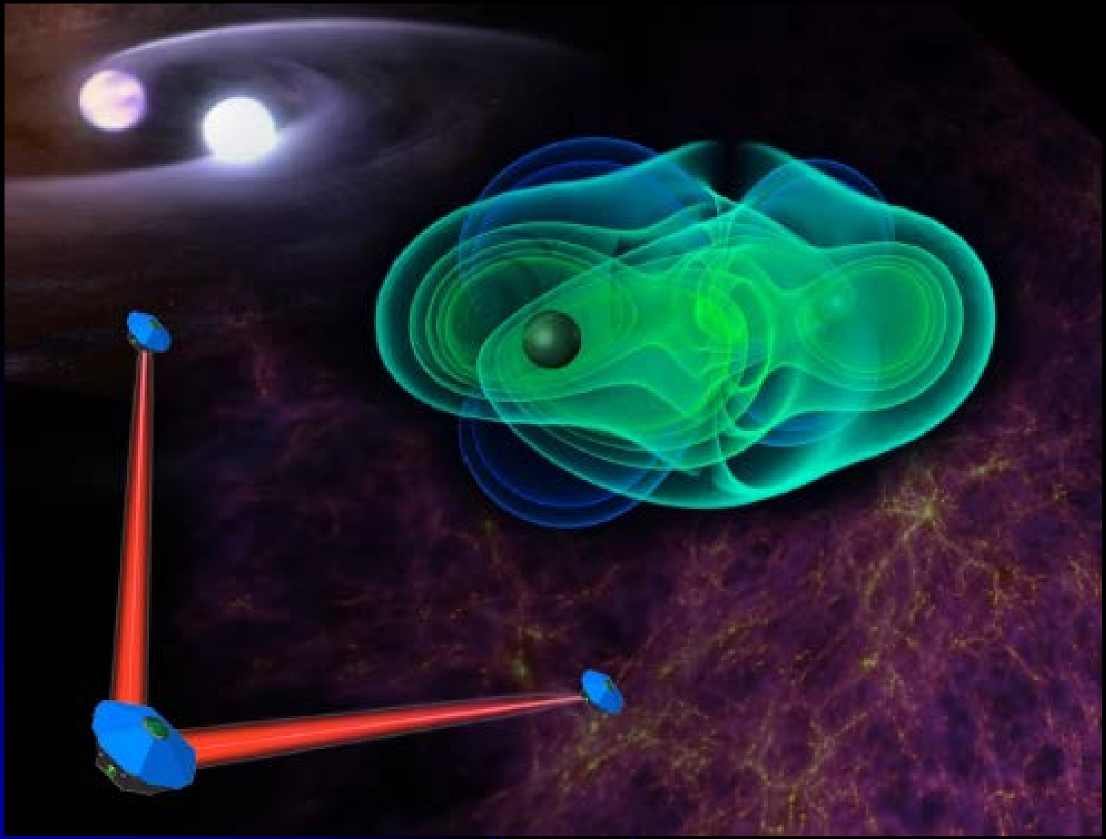
Gravitational Wave Antennas on ground: the dynamically violent Universe



- Signals at high frequencies from coalescing stellar mass binary BHs
- Tests of General Relativity

Multi-messenger astronomy

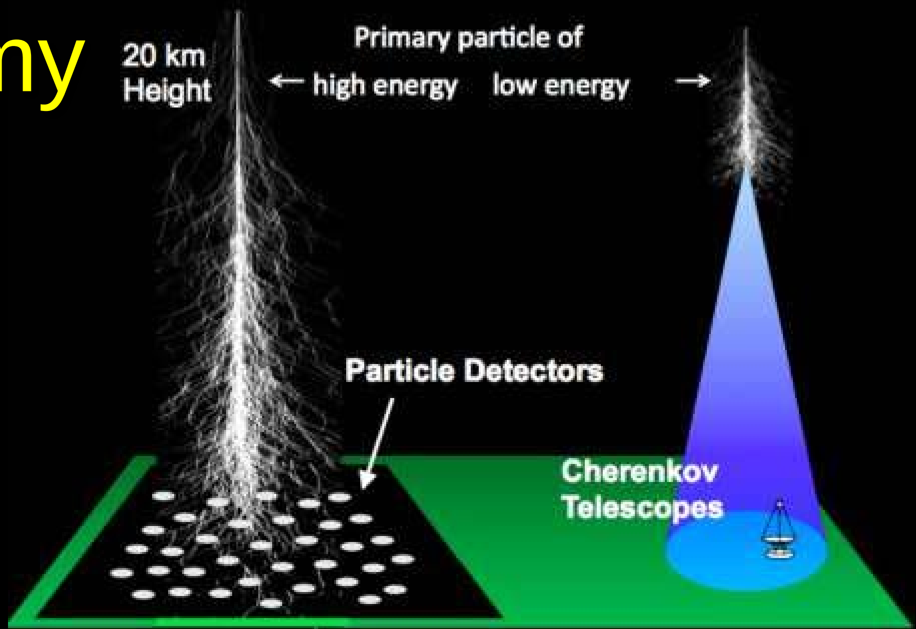
Gravitational Wave Observatory in space - eLISA



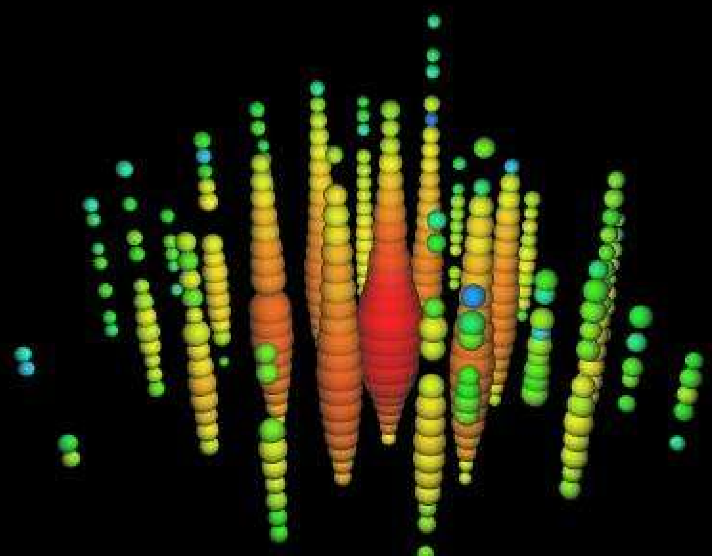
- Search for low frequency gravitational waves
- Merging of super-massive BHs

Multi-messenger astronomy

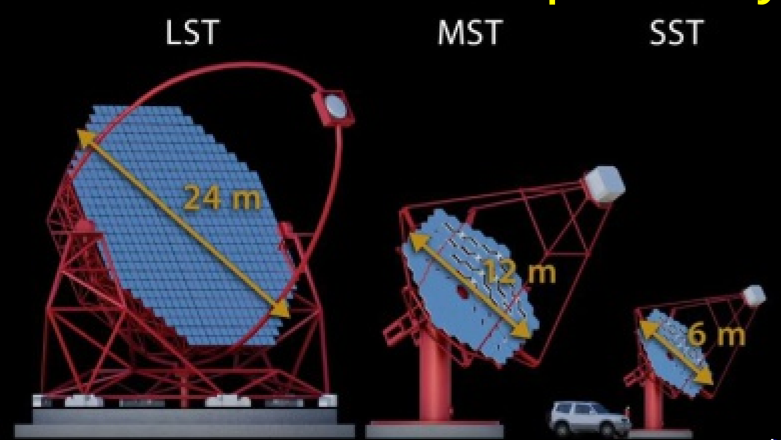
VHE Astronomy



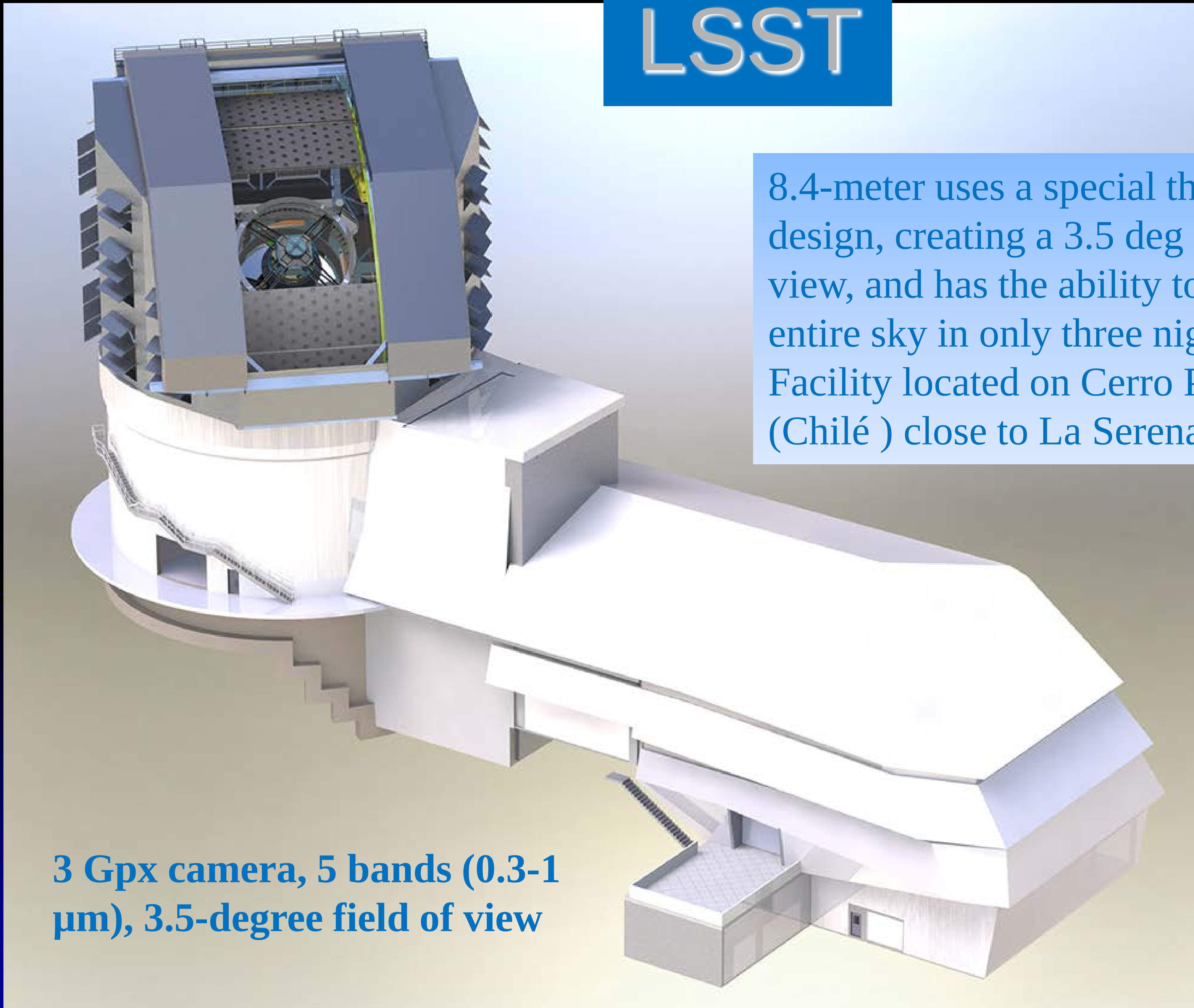
Neutrino Observatories



Cherenkov Telescope Array



LSST



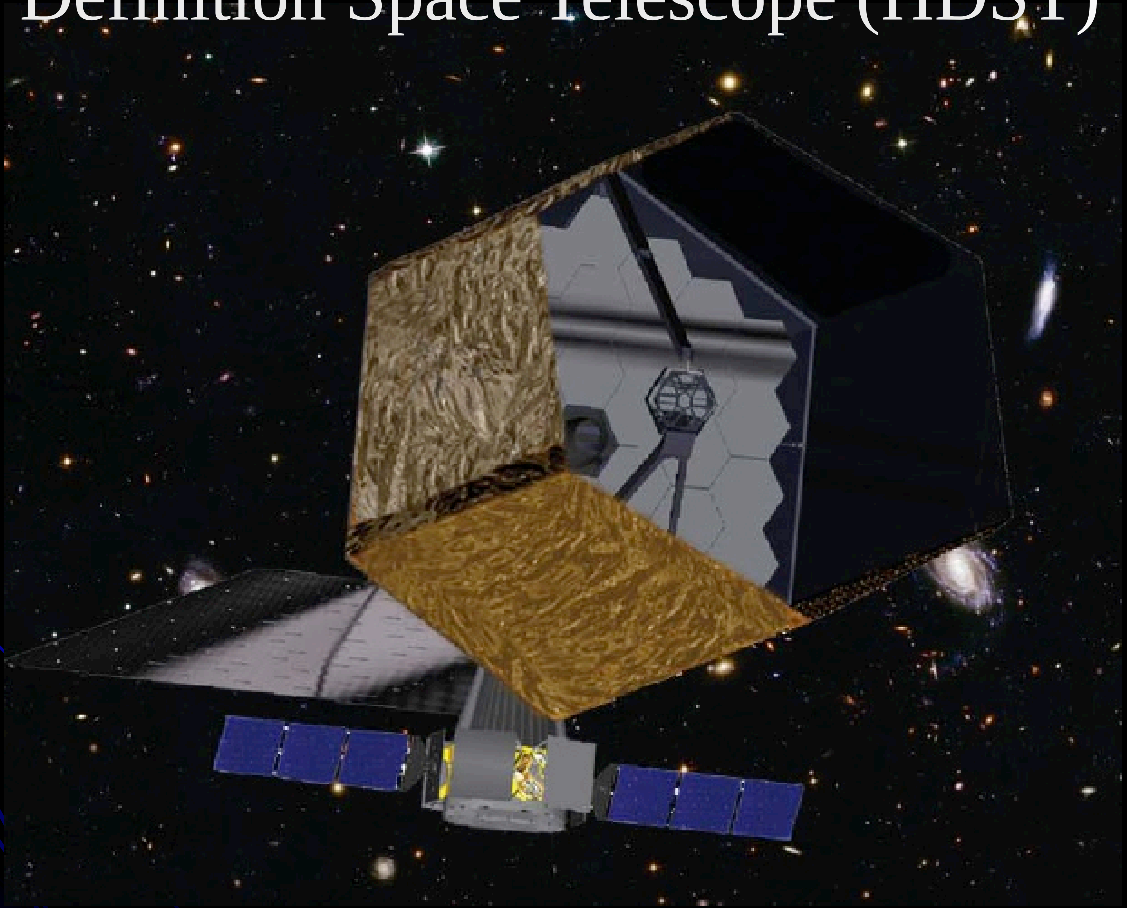
8.4-meter uses a special three-mirror design, creating a 3.5 deg field of view, and has the ability to survey the entire sky in only three nights. LSST Facility located on Cerro Pachón (Chilé) close to La Serena.

3 Gpx camera, 5 bands (0.3-1 µm), 3.5-degree field of view

Within the SPICA horizon...

A new 12-metre Space Telescope

High Definition Space Telescope (HDST)



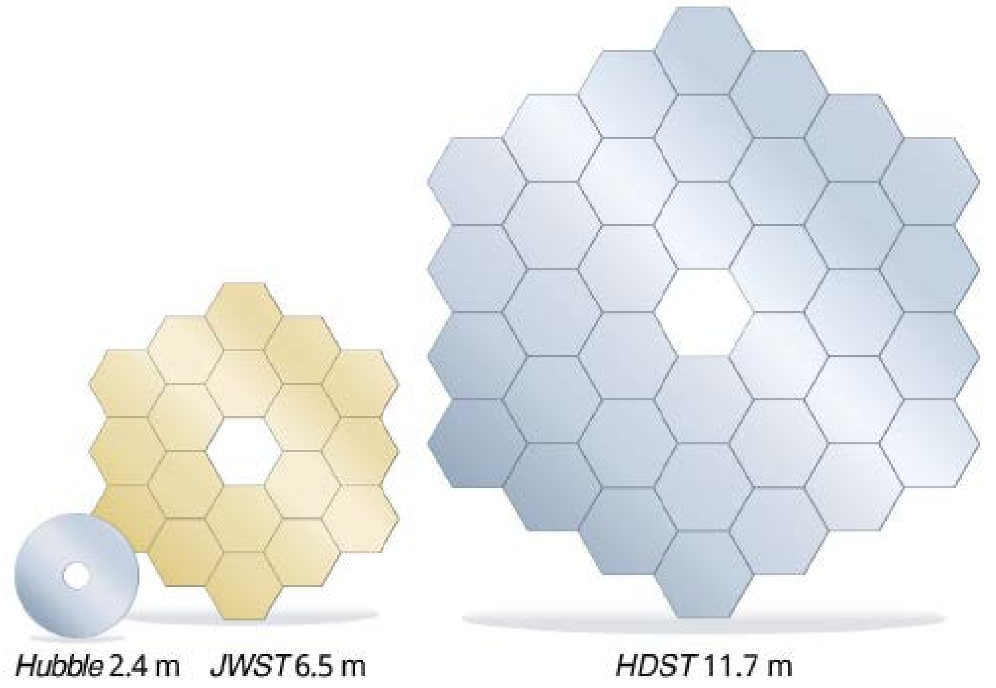


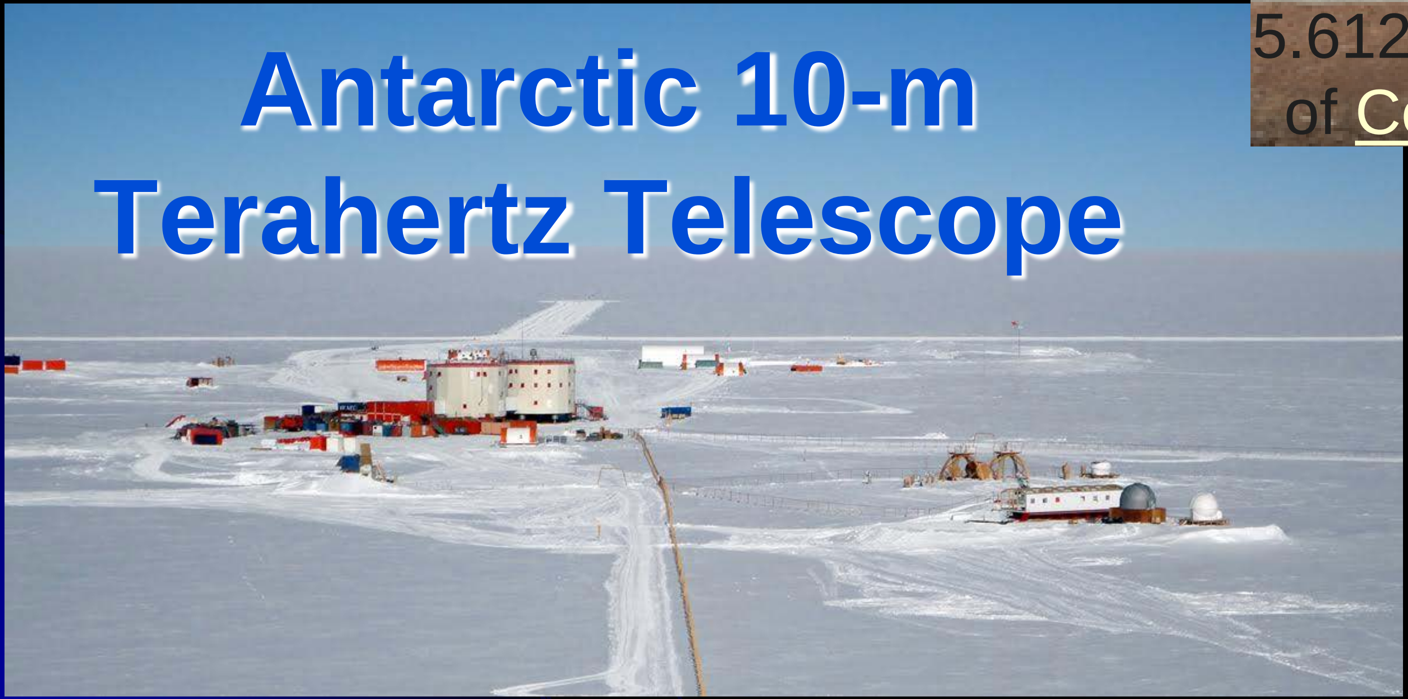
Figure 5-1: A direct, to-scale, comparison between the primary mirrors of *Hubble*, *JWST*, and *HDST*. In this concept, the *HDST* primary is composed of 36 1.7 m segments. Smaller segments could also be used. An 11 m class aperture could be made from 54 1.3 m segments.

Could be launched by NASA's proposed Ares-V launch vehicle

Figure 5-2: A folded 11 m primary mirror, constructed with 54 1.3 m segments, is shown inside a Delta 4-H shroud.

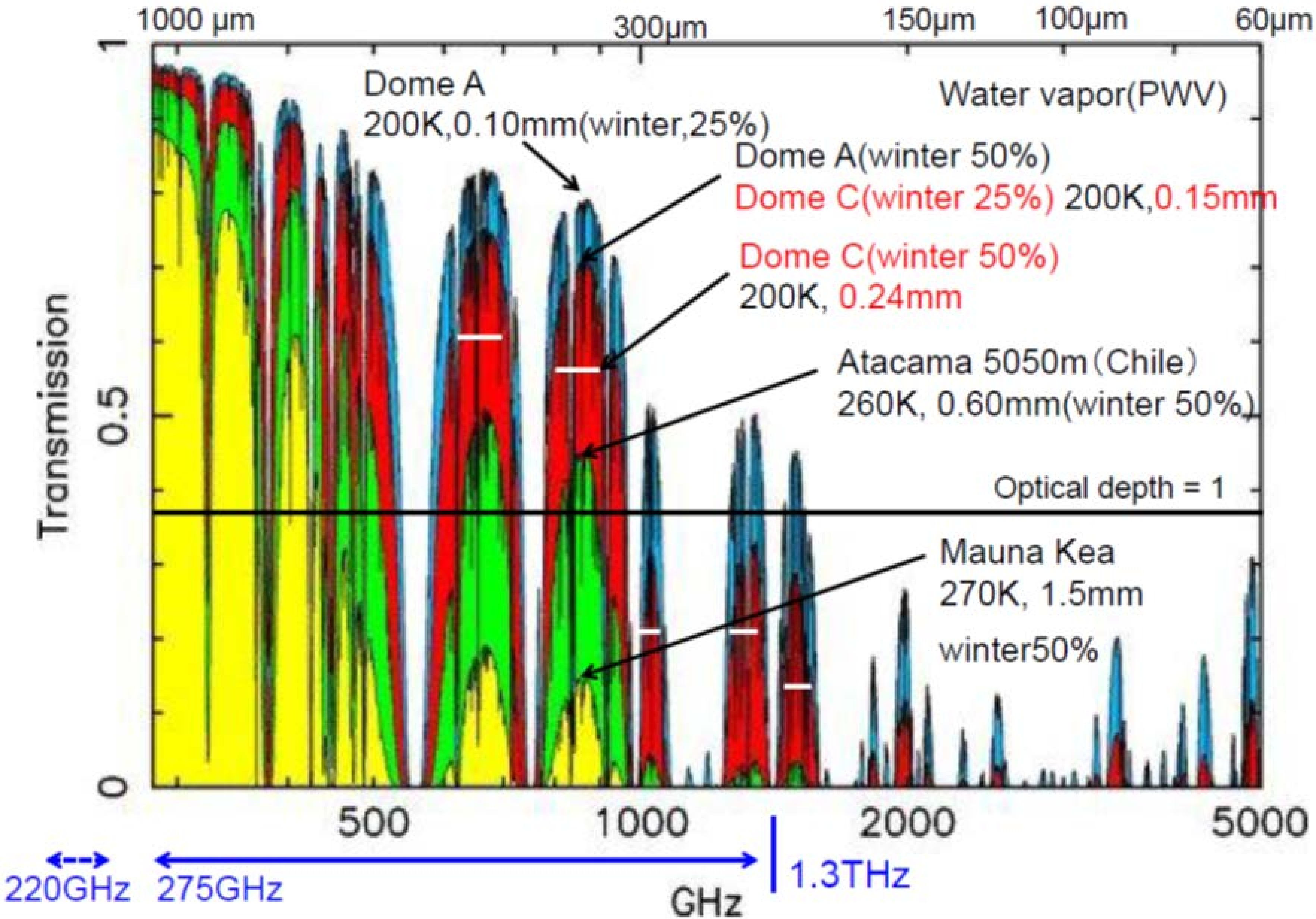
- Mission mostly devoted to UV-optical observations
- … and mostly targeted to exo-planet characterization.

Projects from “ground” at neighbouring wavelengths



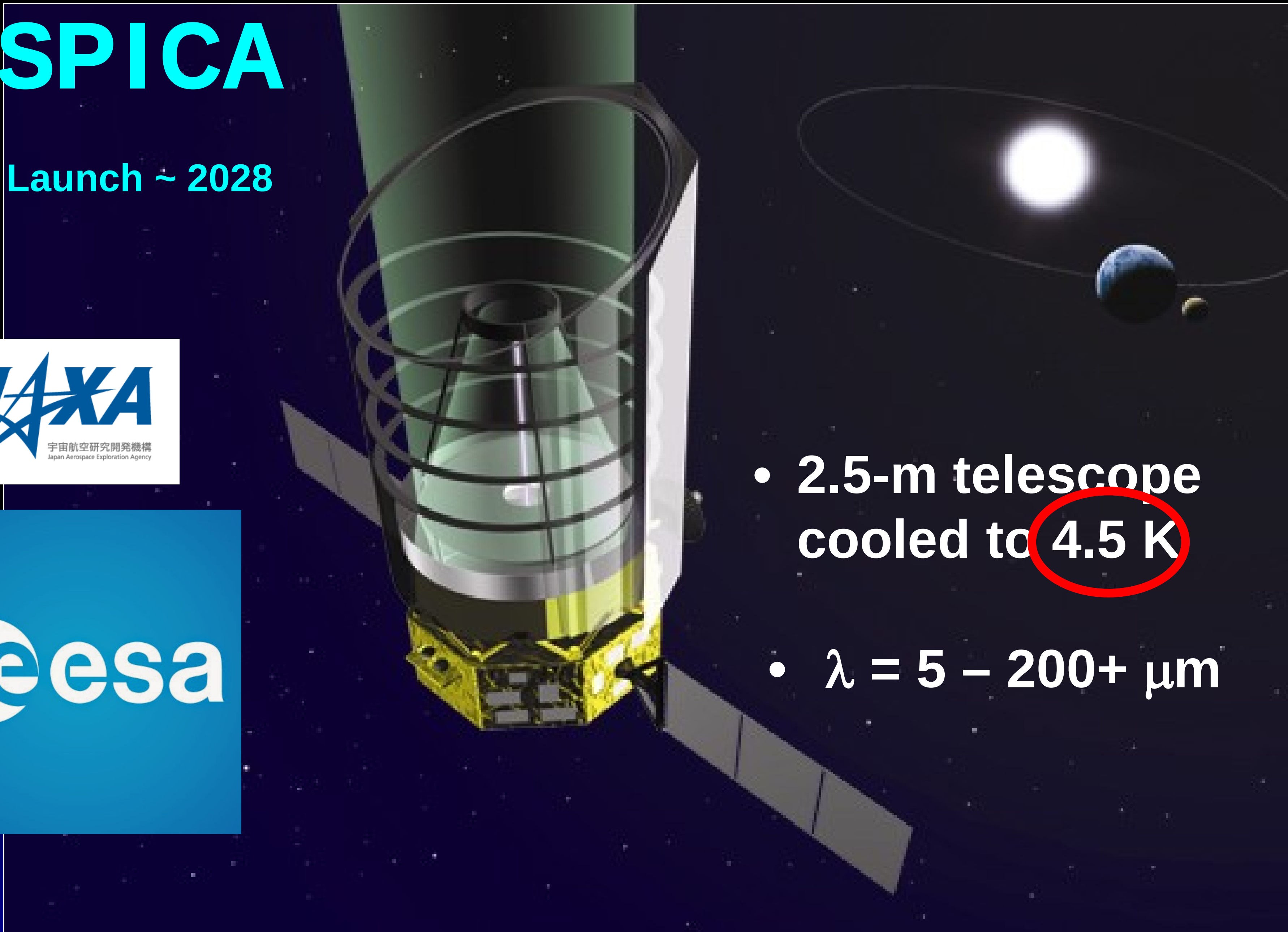
Partial coverage down to $\lambda \approx 200\ \mu m$

Atmospheric transmission



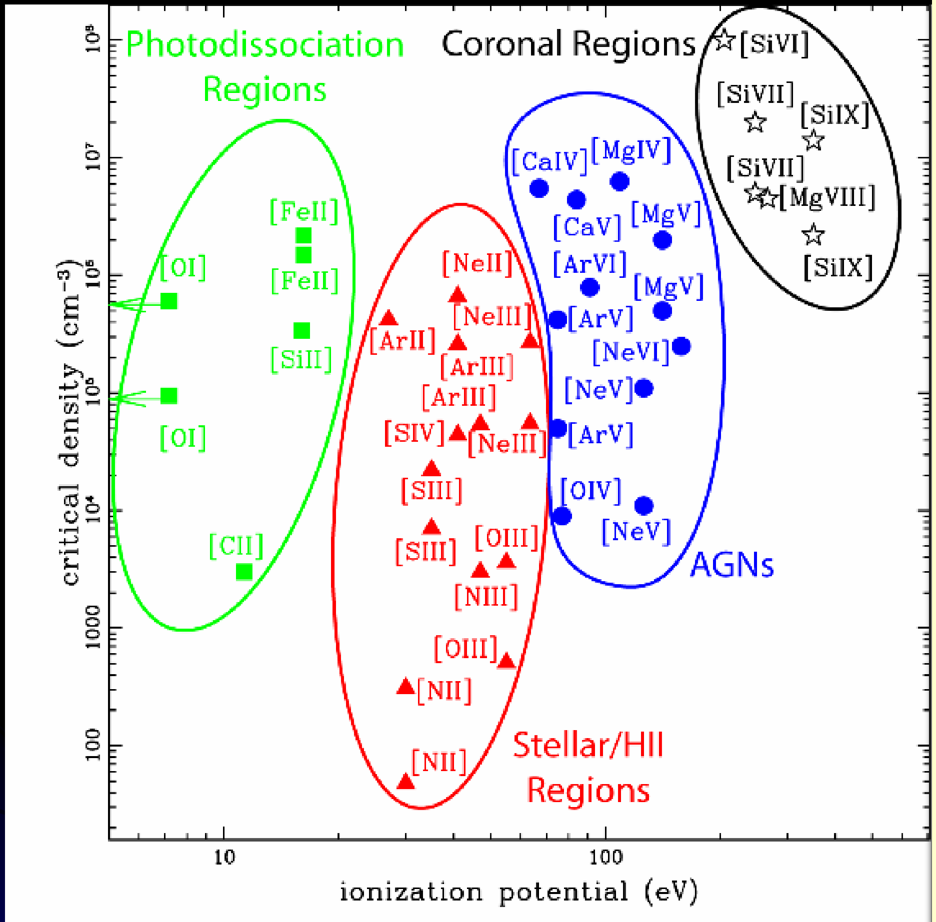
SPICA

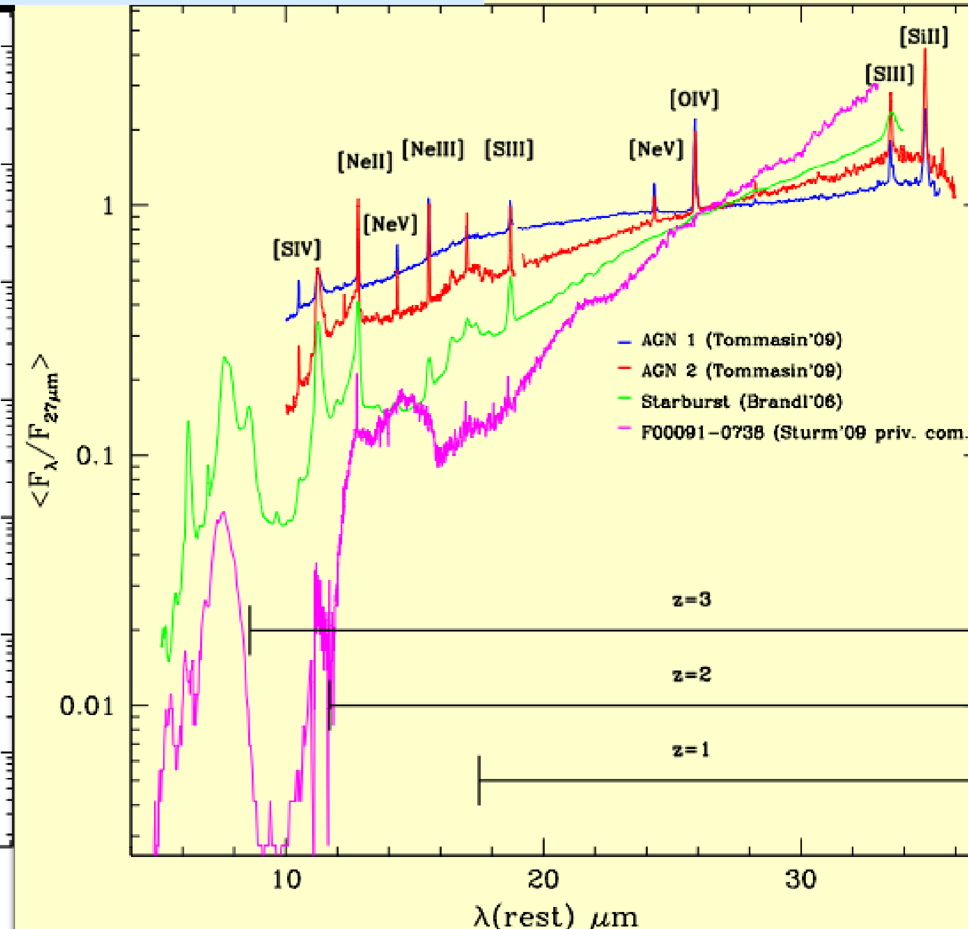
Launch ~ 2028



- 2.5-m telescope cooled to 4.5 K
- λ = 5 – 200+ μm

The power of IR spectroscopy





(a: Left) IR fine-structure lines covering the ionization-density parameter space (Spinoglio & Malkan 1992). (b: Center:) Starburst and AGN template spectra (normalized at 25µm) showing the key diagnostic emission lines in the mid-IR, all of which will be detected by SPICA.

SPICA/SAFARI Fact Sheet

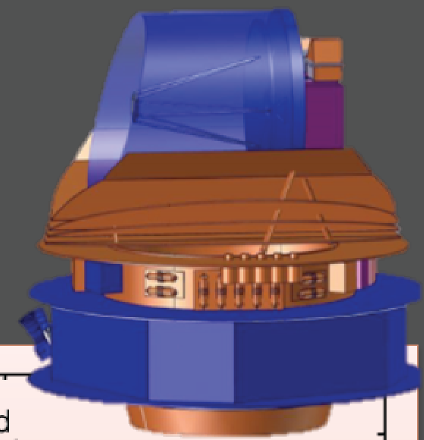
SAFARI Overview

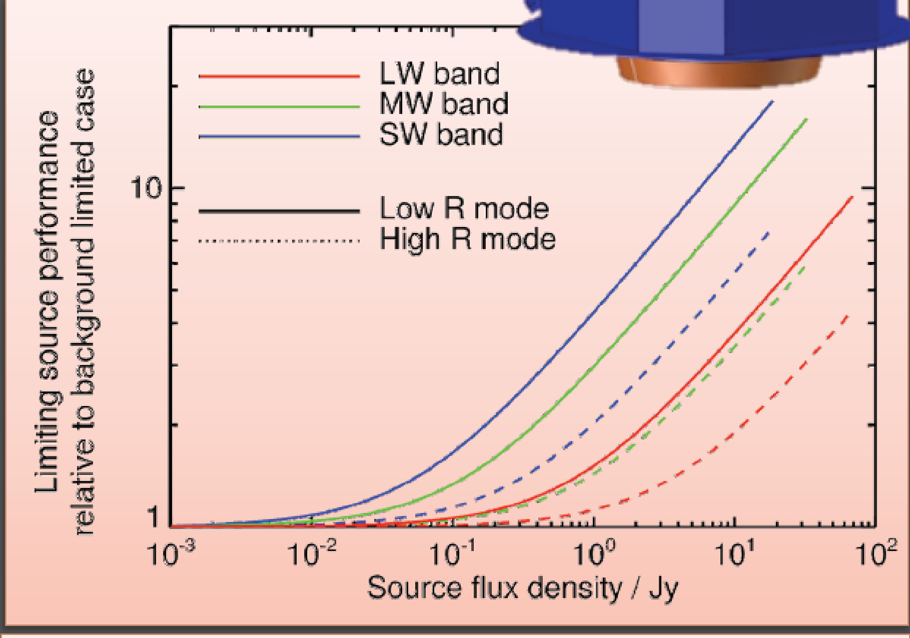
- Three band ***grating spectrometer***
- Continuous spectroscopic capability from 34-210 μm

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
R~300*	**Limiting flux density** / mJy	0.25	0.36	0.92
R~3000*	**Limiting flux** / x10^{-20} Wm^{-2}	25	24	29
R~3000*	**Limiting flux density** / mJy	12	20	41
Mapping spectroscopy ** (5σ-1hr)**				
R~300*	**Limiting flux** / x10^{-20} Wm^{-2}	59	28	22
R~300*	**Limiting flux density** / mJy	2.8	2.3	3.0
R~3000*	**Limiting flux** / x10^{-20} Wm^{-2}	340	190	120
R~3000*	**Limiting flux density** / mJy	170	150	170
Photometric mapping ** (5σ-1hr)**				
Limiting flux density / mJy		0.15	0.12	0.16

SPICA Mission

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



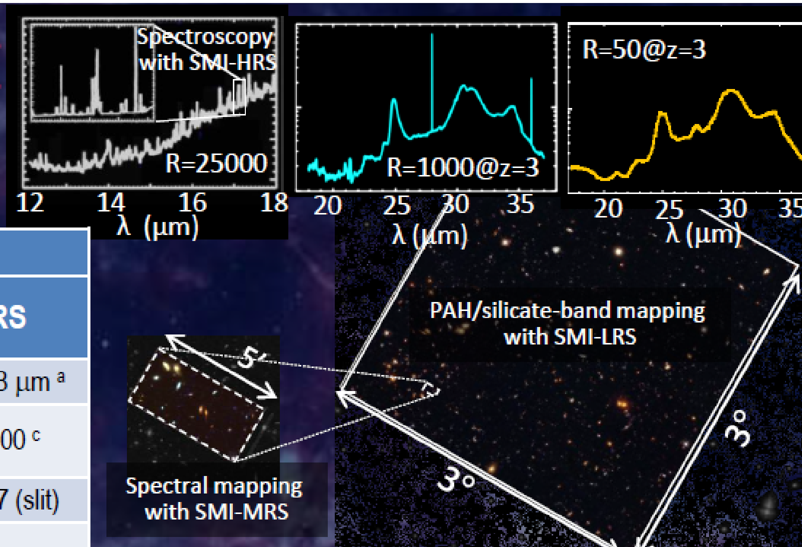


- Change in system performance, as a function of target flux density, relative to the background limited case.
- The decrease in sensitivity is a result of the increased photon noise from the target source
- Data given up to the instrument saturation limits for each band (22, 37 and 73 Jy for the SW,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

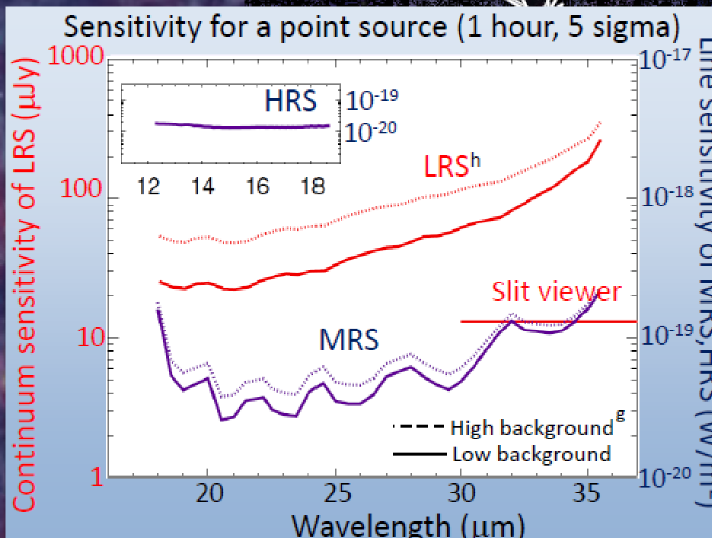
* Resolving powers are all calculated at band centre
** Mapping performance is for a reference area of 1 arcmin^2

SPICA / SMI Fact Sheet

SPICA Mid-infrared Instrument (SMI) covers the wavelength range of 12–36 μm with three spectroscopic channels: LRS, MRS, and HRS.

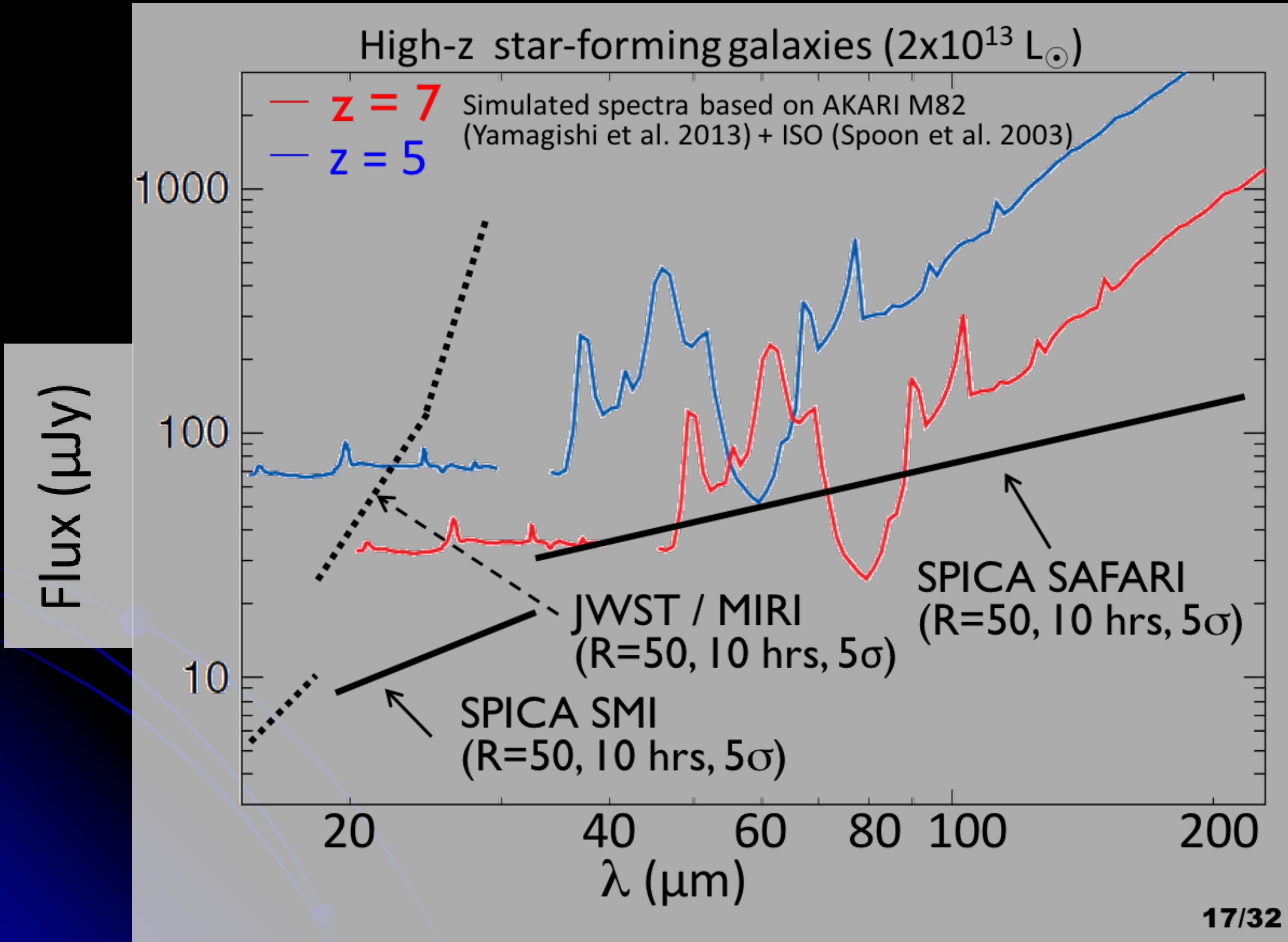


Parameter		Function			
		LRS		MRS	HRS
		Multi slit spec.	Slit viewer		
Wavelength range		17 – 36 μm	34 μm	18 – 36 μm	12 – 18 μm [a]
Spectral resolution		50 – 120 [b] (point source) 20 – 110 (diffuse)	5	1300 – 2300 [b] (point source) 1100 – 1400 (diffuse)	28000 [c]
Field of View		600"x 3."7 x 4 slits	600" x 600"	60" x 3."7 (slit)	4"x1."7 (slit)
FWHM		2."0 (20 μm) – 3."6 (36 μm), 2."0 (12 – 20 μm)			
Pixel scale		0."7x 0."7	0."7 x 0."7	0."7	0."5
Detector		Si:Sb 1K x 1K	Si:Sb 1K x 1K	Si:Sb 1K x 1K	Si:As 1K x 1K
Point source	Cont. sensitivity (1 hr, 5 sigma)	20 – 200 μJy	13 μJy	300 – 3000 μJy	2 – 3 mJy
Point source	Line sensitivity [d] (1 hr, 5 sigma)	(8 – 20) x 10^{-20} W/m^2	-	(3 – 20) x 10^{-20} W/m^2	(1.5 – 2) x 10^{-20} W/m^2
Point source	Survey speed [e]	~16 arcmin^2/hr	~5900 arcmin^2/hr	~1.5 arcmin^2/hr	-
Diffuse	Sensitivity [f] (1 hr, 5 sigma)	Continuum		Line	
Diffuse		0.02– 0.1 MJy/sr	0.05 MJy/sr	(0.7 – 4) x 10^{-10} W/m^2/sr	(1.5 – 2) x 10^{-10} W/m^2/sr
Saturation limit		~20 Jy	~1 Jy	~1000 Jy	~20000 Jy



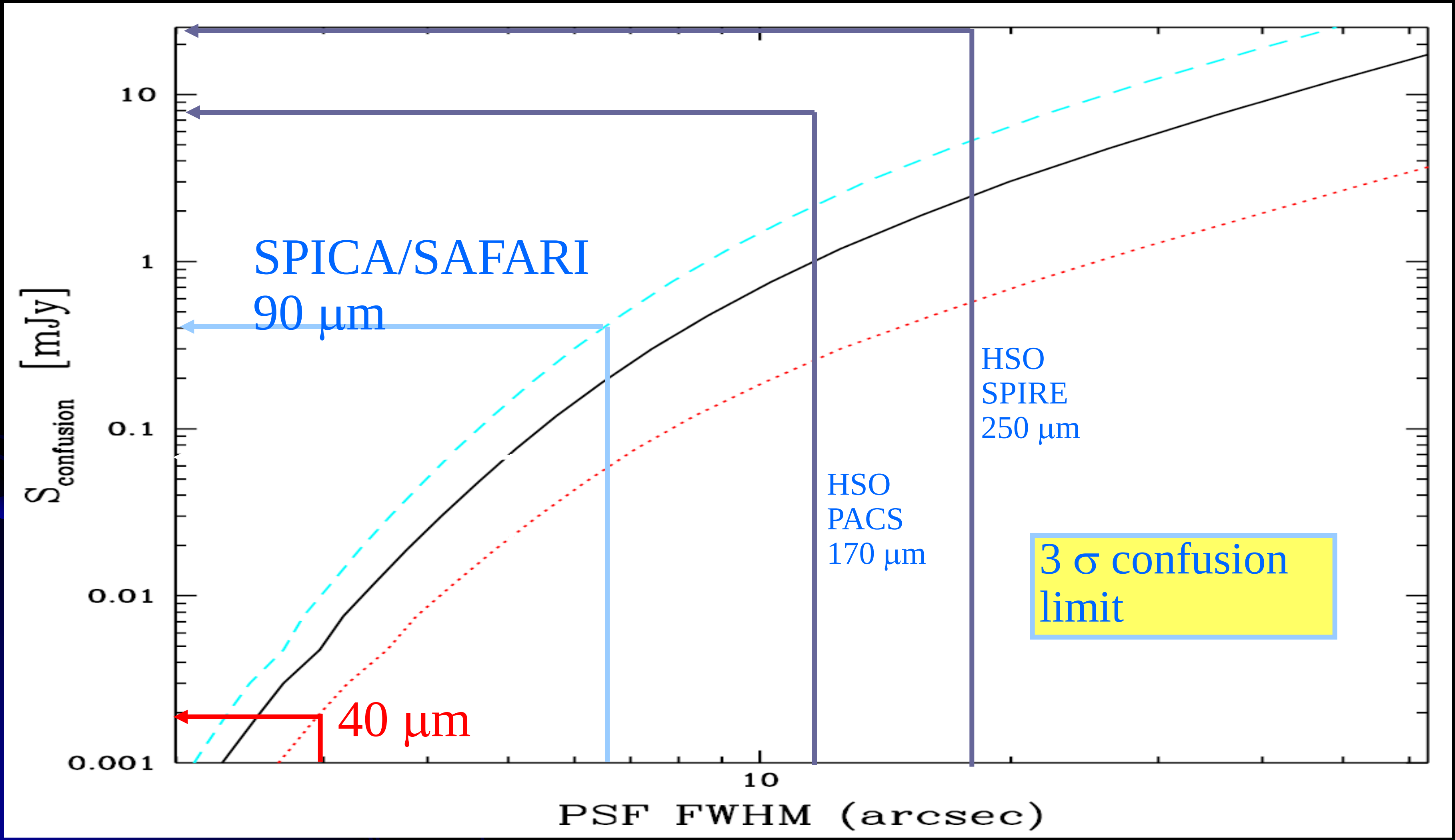
a: continuous coverage up to 17.3 μm + partial coverage for H_2O 17.77 and 18.66 μm
b: λ/δλ = 120 (LRS) and 1300 (MRS) at λ = 36 μm.
c: designed for λ20 μm diffraction limited PSF.
d: sensitivity for an unresolved line.
e: survey speed for the 5 sigma detection of a point source with the continuum flux of 100 μJy for LRS at λ = 30 μm (slit viewer at 34 μm) and the line flux of 3×10^{-19} W/m^2 for MRS at λ = 28 μm, both in the low background case (see the right-hand figure).
f: sensitivity for a diffuse source in a 4" x 4" (LRS & MRS) or 2" x 2" area (HRS)
g: background levels are assumed to be 80 MJy/sr (High) and 15 MJy/sr (Low) at 25 μm.
h: continuum sensitivity rescaled with R=50

SMI Factsheet v10 – 4 Jan 2016



High-z star-forming galaxies (2x10^13 L☉)
z = 7
z = 5
Simulated spectra based on AKARI M82
(Yamagishi et al. 2013) + ISO (Spoon et al. 2003)
1000
100
10
Flux (μJy)
JWST / MIRI
(R=50, 10 hrs, 5σ)
SPICA SAFARI
(R=50, 10 hrs, 5σ)
SPICA SMI
(R=50, 10 hrs, 5σ)
20
40
60
80
100
200
λ (μm)
17/32

SPICA's SOURCE CONFUSION vs. HSO's: a great improvement! …



SPICA

- Natural heritage of many previous missions
  - technological
  - scientific
  - => full exploitation of european know-how

- Filling an information gap 20 yrs after Herschel

- Unique value of IR spectroscopy
  - for obscured phases of gal & star formation
  - for the uniquely rich physical conditions probed

- New paradigm of global collaboration for astronomy