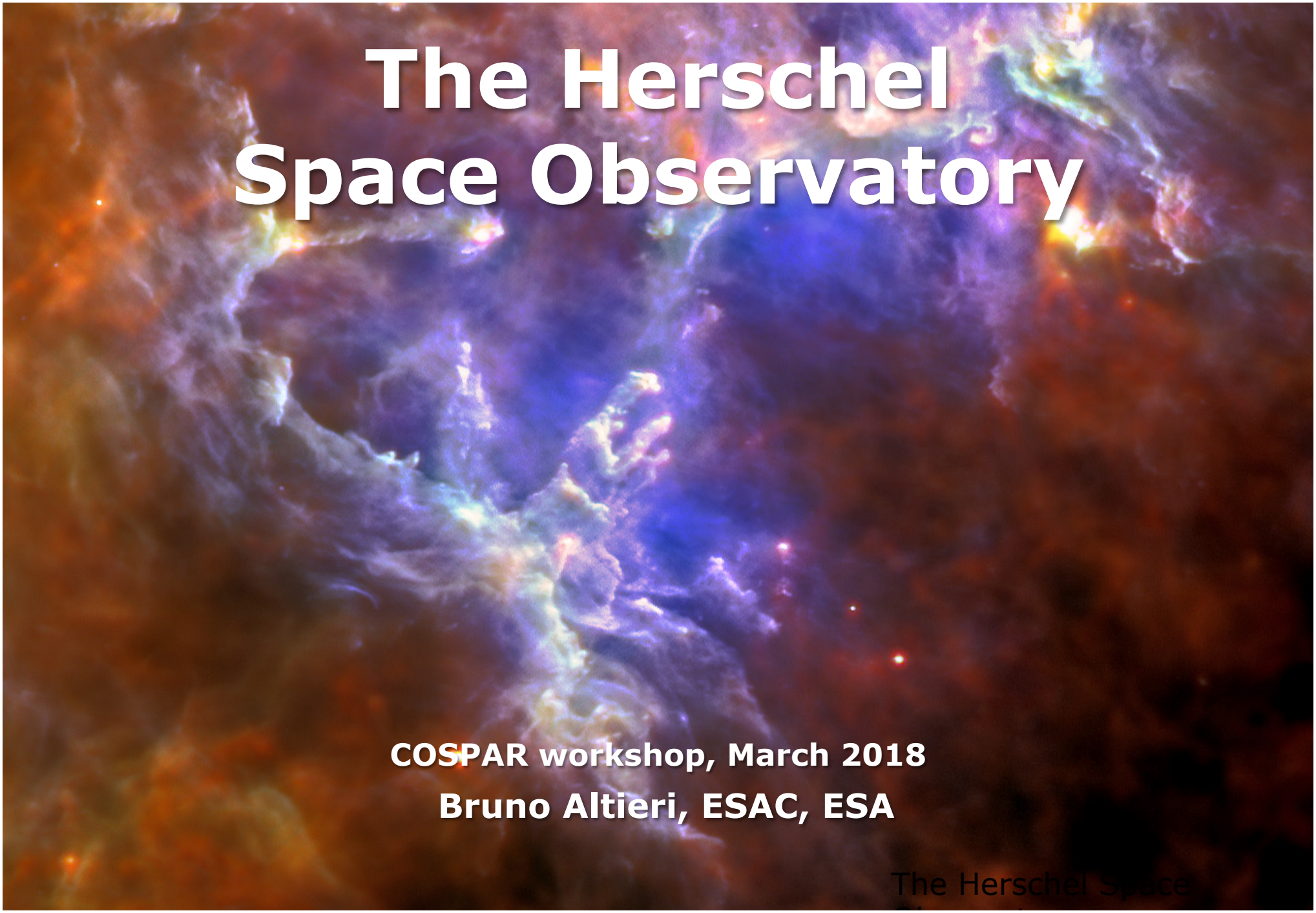
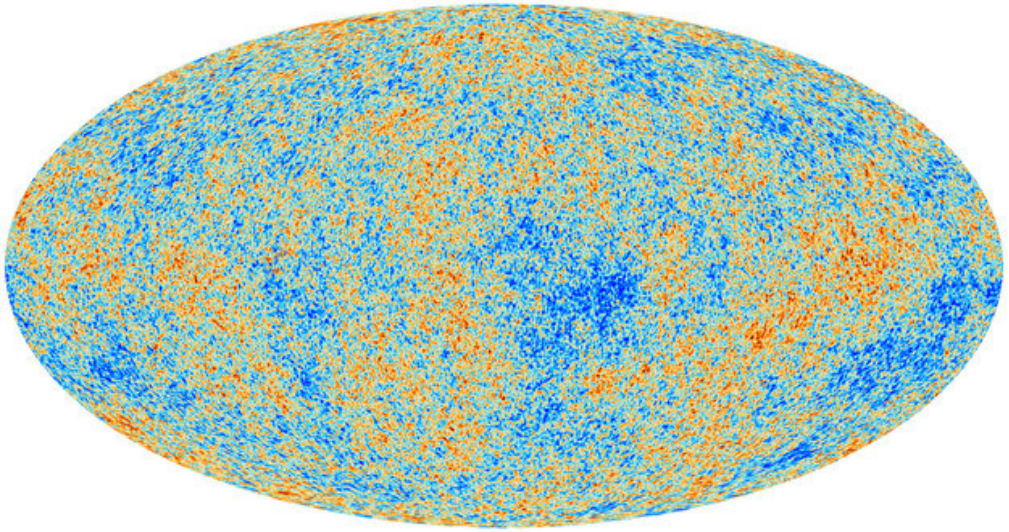


The Herschel Space Observatory

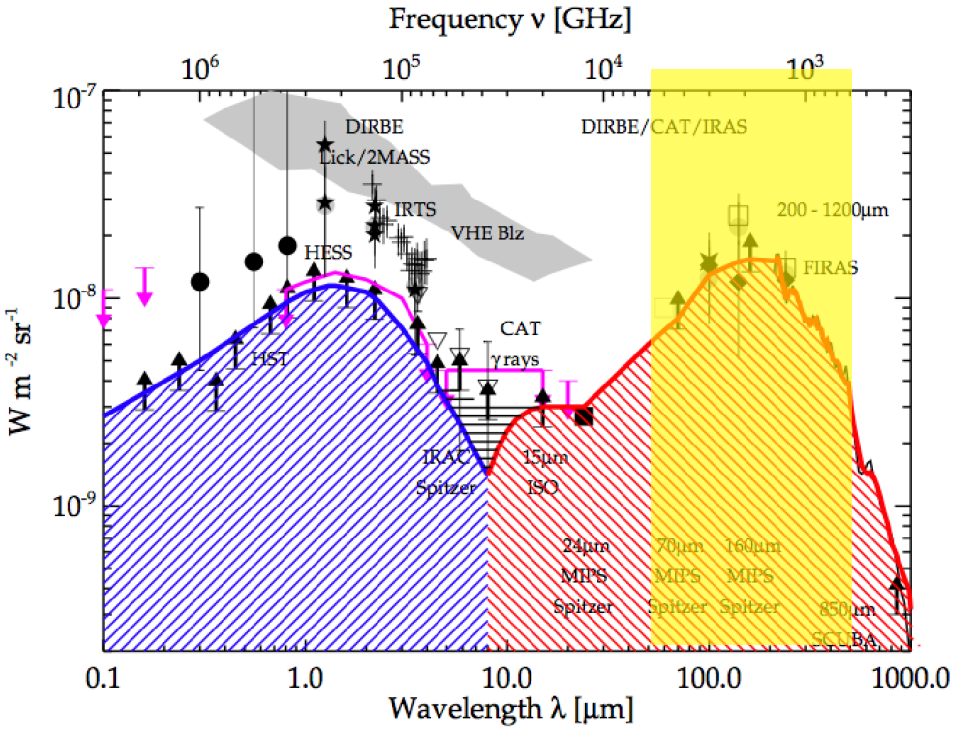
COSPAR workshop, March 2018

Bruno Altieri, ESAC, ESA

Importance of the FIR & submm

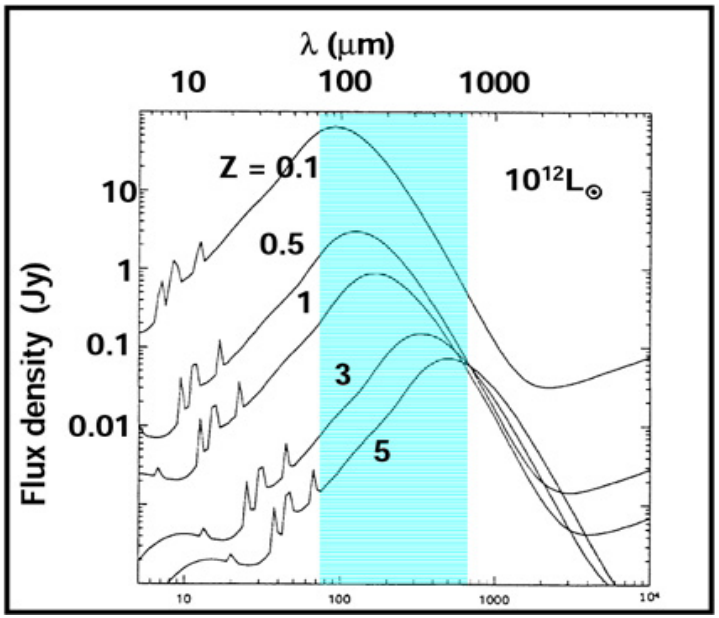


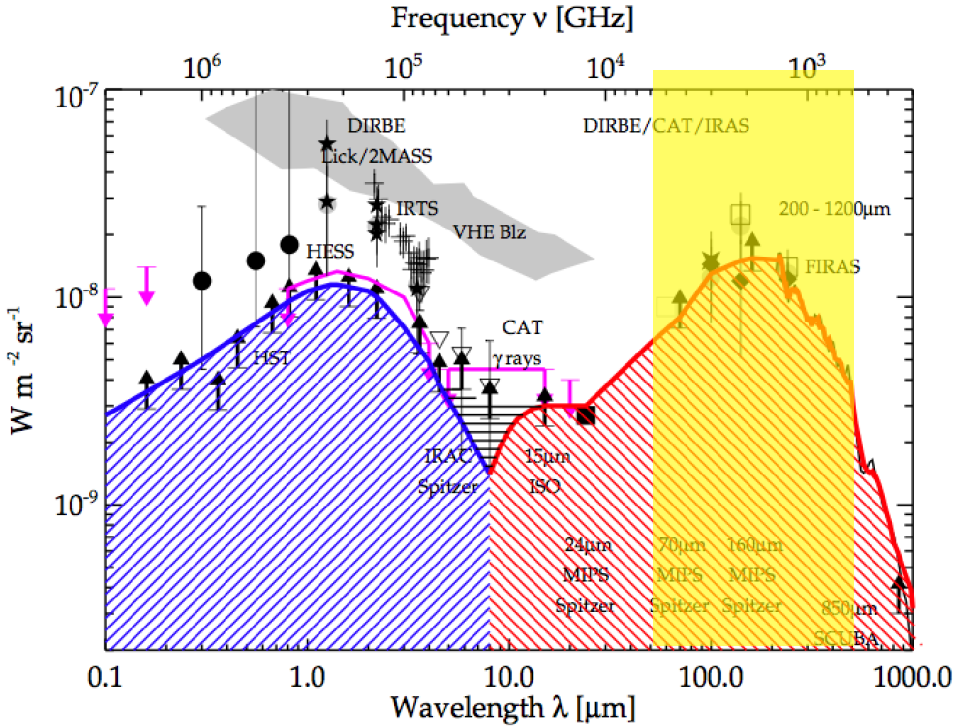
Credit: Planck



- **Half of the energy created in the Universe since the CMB has been reprocessed into the IR**
- **Herschel covers the IR peak and pushes into the submillimetre**

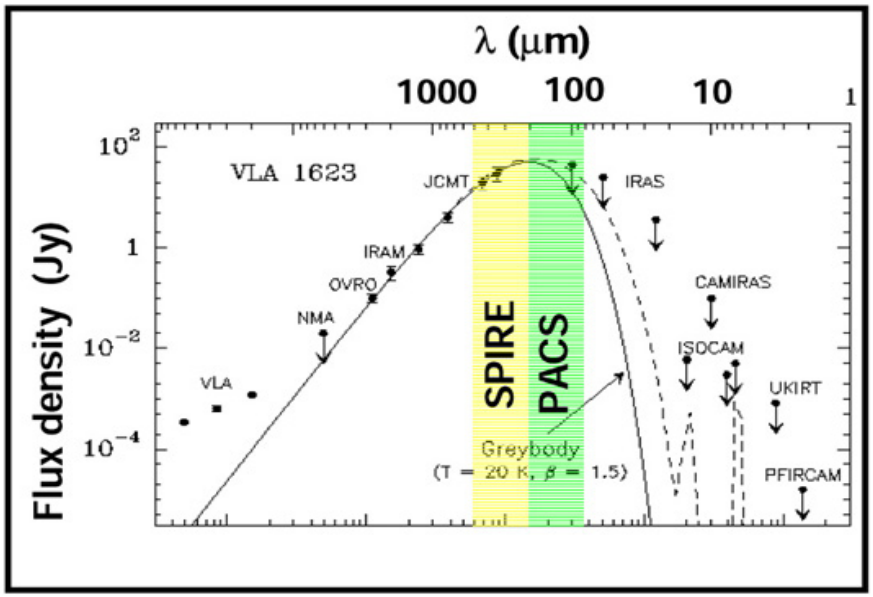
Importance of the FIR & submm

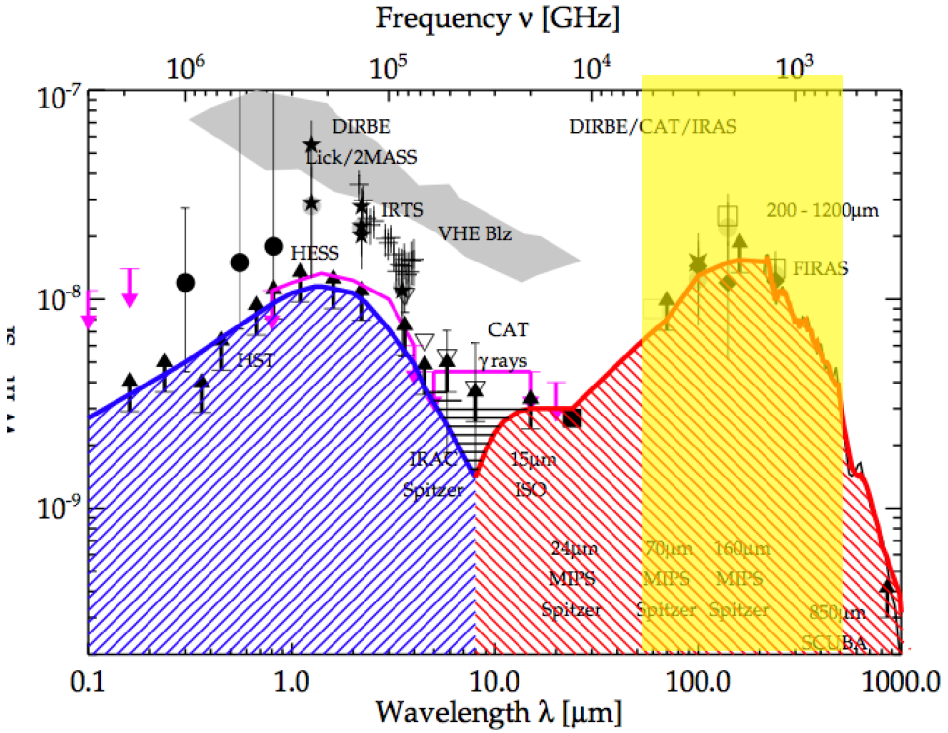




- **Half of the energy created in the Universe since the CMB has been reprocessed into the IR**
- **Herschel covers the IR peak and pushes into the submillimetre: IR-bright galaxies (SF & AGN)**

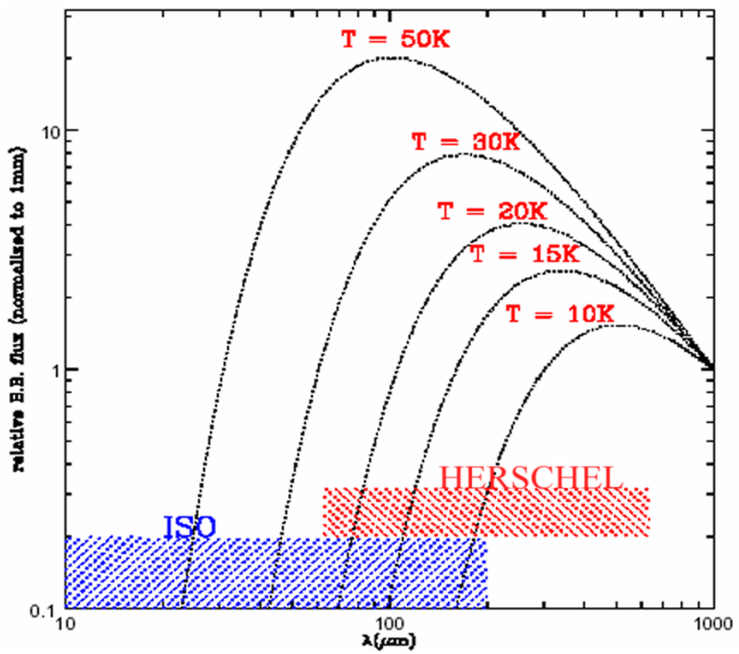
Importance of the FIR & submm

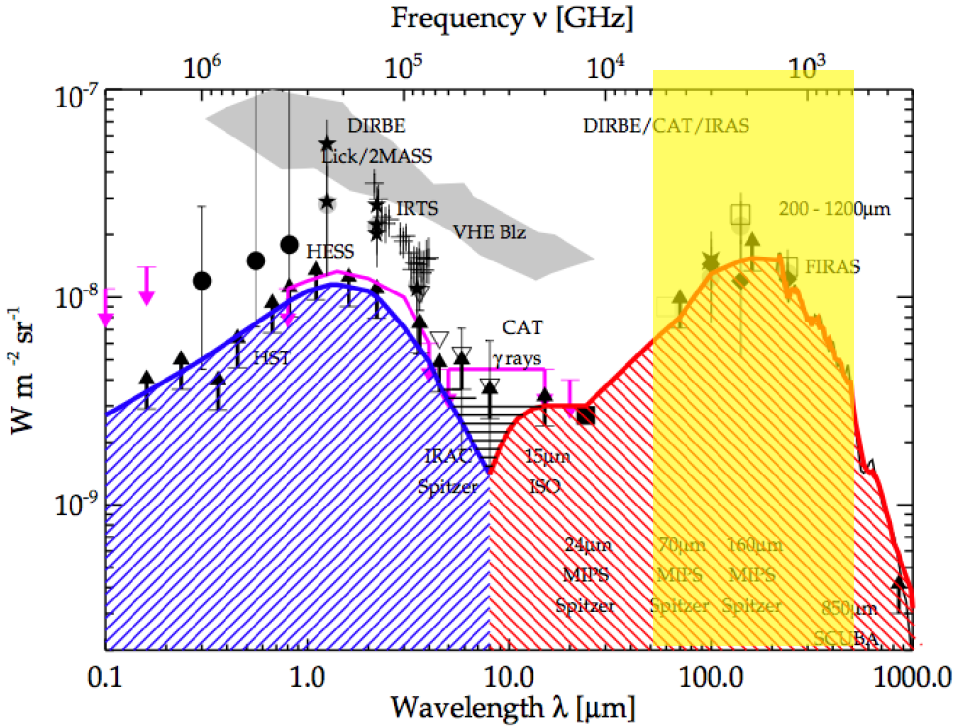




- **Half of the energy created in the Universe since the CMB has been reprocessed into the IR**
- **Herschel covers the IR peak and pushes into the submillimetre: IR-bright galaxies & SF early phases**

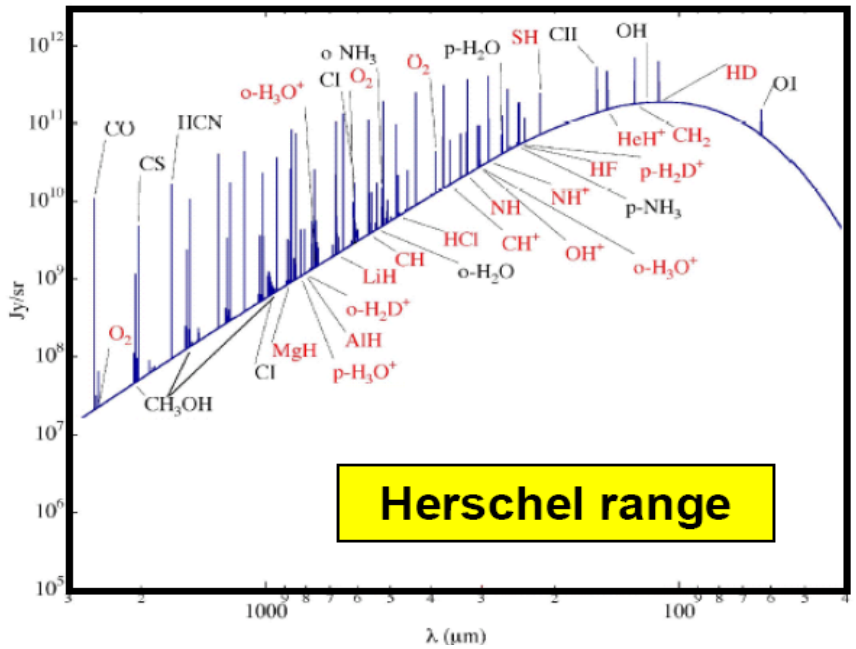
Importance of the FIR & submm

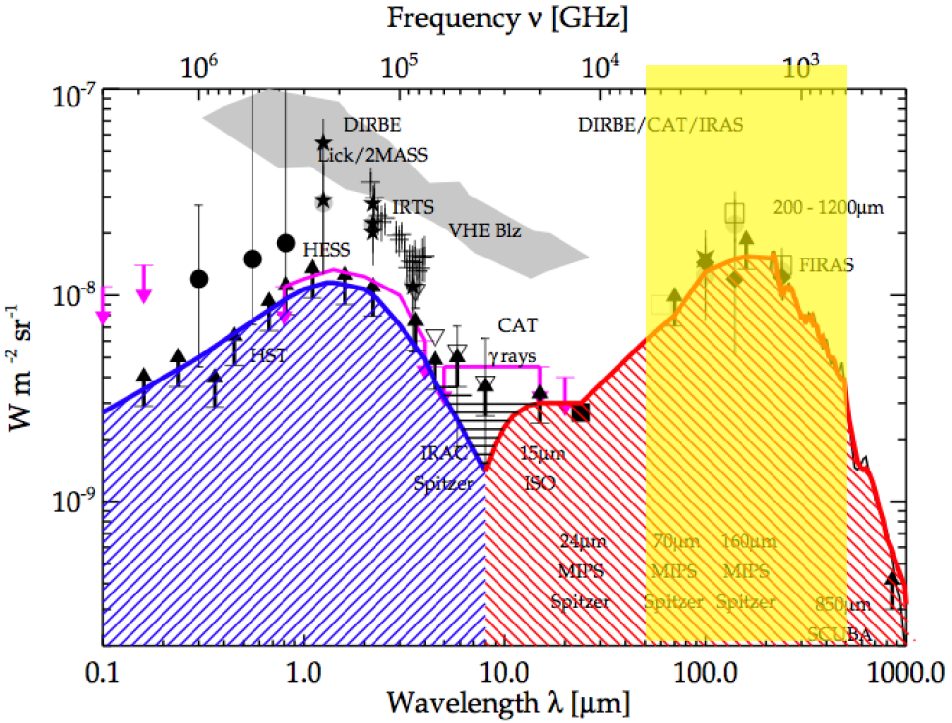




- **Half of the energy created in the Universe since the CMB has been reprocessed into the IR**
- **Herschel covers the IR peak and pushes into the submillimetre: cold black-bodies – dust (tracing gas)**

Importance of the FIR & submm





- **Half of the energy created in the Universe since the CMB has been reprocessed into the IR**
- **Herschel covers the IR peak and pushes into the submillimetre: cold black-bodies & spectral lines**

Previous infrared space missions

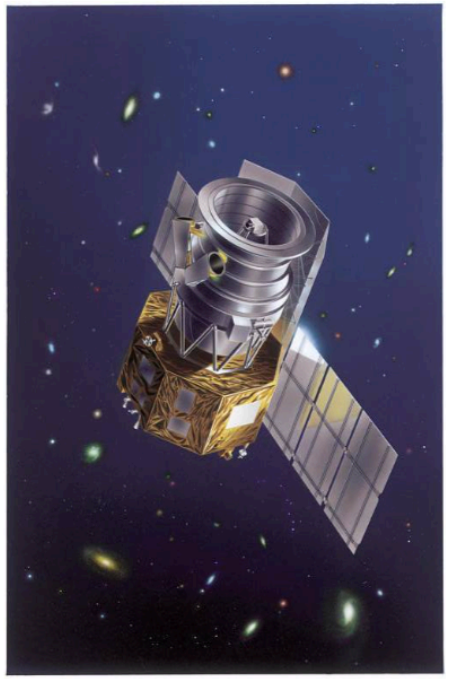
IRAS (1983)

- 0.6-m telescope
- T = 2 K
- λ = 12, 25, 60, 100 μm

ISO (1995)

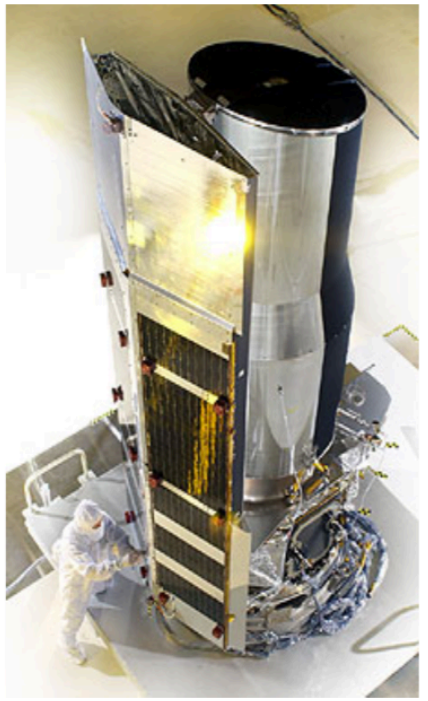
- 0.6-m
- T = 2 - 3 K
- λ = 3 – 200 μm

AKARI (2006)



- 0.6-m
- T = 6 K
- λ = 2 – 200 μm

Spitzer (2003)



- 0.85-m
- T = 4 K
- λ = 3 – 180 μm

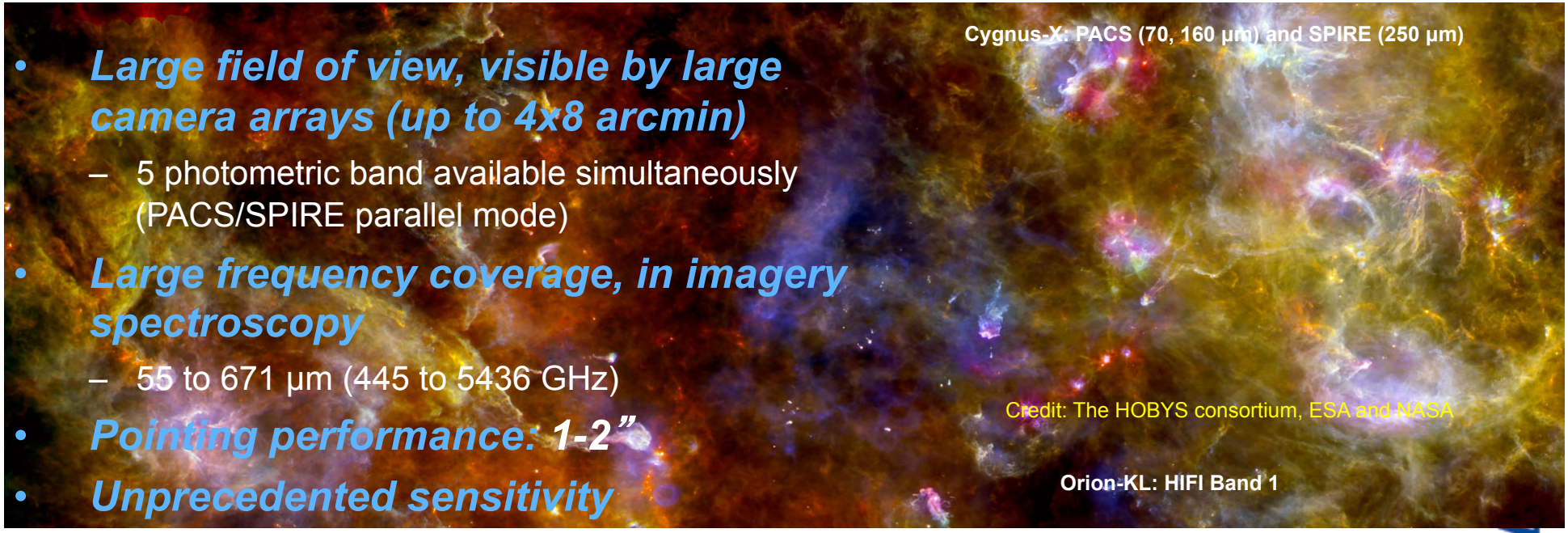
The Herschel main objectives

The Herschel main objectives

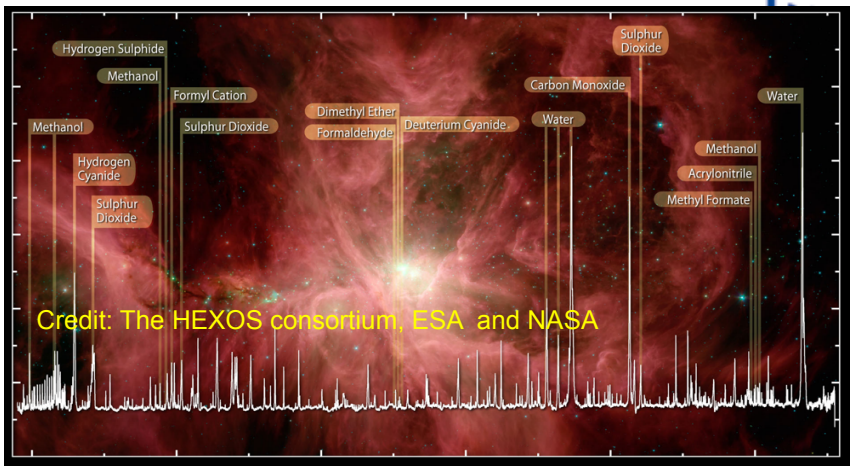
- ***Wide-area photometric surveys of the extragalactic and galactic sky***
  - to measure dust-enshrouded star formation activity
  - throughout cosmic time and in our own and nearby galaxies today
- ***Detailed studies of the physics and chemistry of the interstellar medium***
  - both locally in our own Galaxy as well as in external galaxies
  - by means of photometric and spectroscopic surveys
- ***Observational astro-chemistry of gas and dust as a quantitative tool for understanding the stellar/interstellar lifecycle***
  - investigating the physical and chemical processes involved in star formation, early and late stages in stellar evolution
  - Including gas and dust disks around young and mature stars
- ***Spectroscopic and photometric study of solar system objects and their atmospheres***
  - also crucial as calibration sources

HERSCHEL SPACE OBSERVATORY

The Herschel capabilities



- ***Large field of view, visible by large camera arrays (up to 4x8 arcmin)***
  - 5 photometric band available simultaneously (PACS/SPIRE parallel mode)
- ***Large frequency coverage, in imagery spectroscopy***
  - 55 to 671 μm (445 to 5436 GHz)
- ***Pointing performance: 1-2”***
- ***Unprecedented sensitivity***
  - Large collecting area !
  - State-of-the art detectors (at the time of design…)
- ***Excellent calibration performance***
  - Unique space environment, no atmosphere !
  - Setting up a new reference



Herschel – the machine

Novel science instruments:
PACS, SPIRE, HIFI

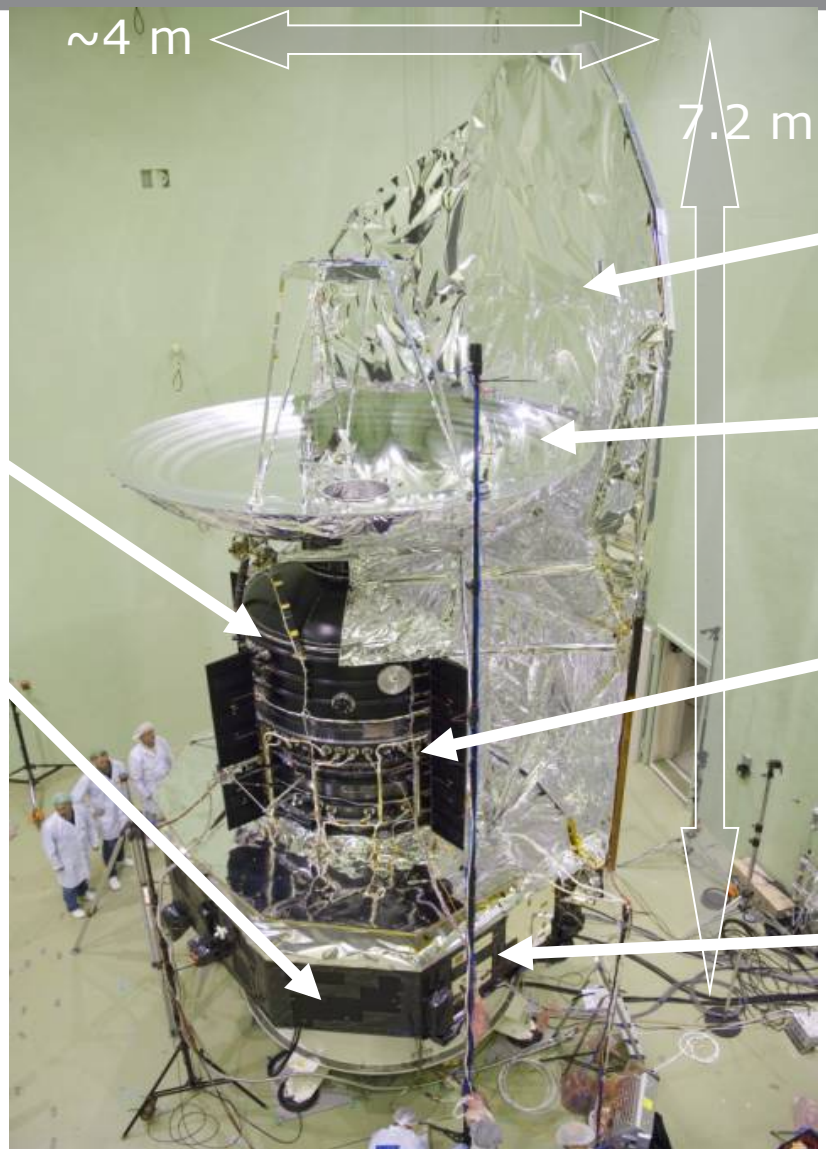
Detectors at:
~2 K & ~300 mK

Warm electronics at ambient ~300K

Launch mass:
~3400 kg

Power: ~1200 W

3-axis stabilisation



Sunshade (upper) & solar array (lower)

Cassegrain telescope with 3.5 m primary

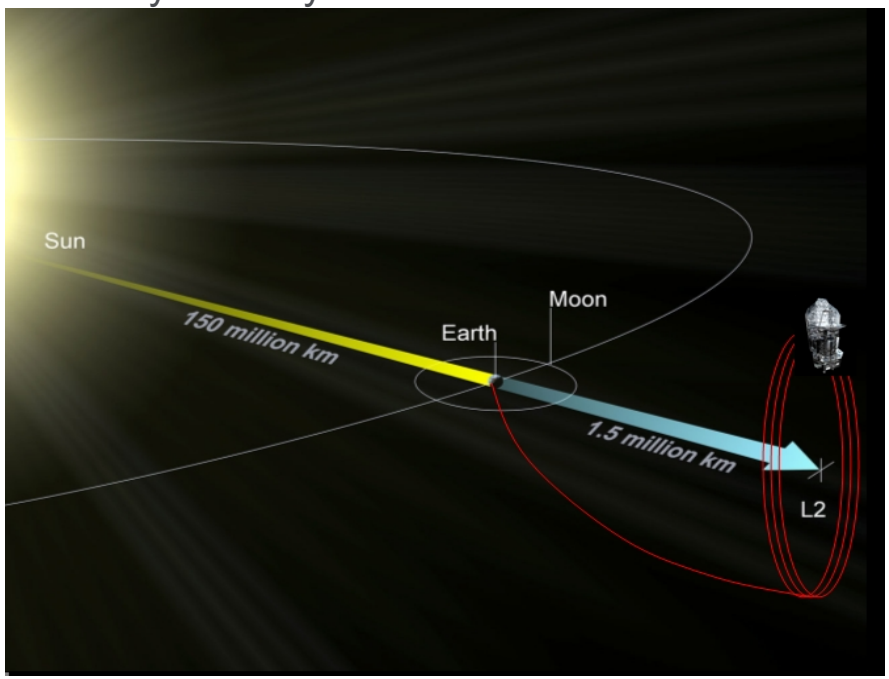
Superfluid liquid helium cryostat (~2300 l, ~335 kg)
3.5+ yr lifetime

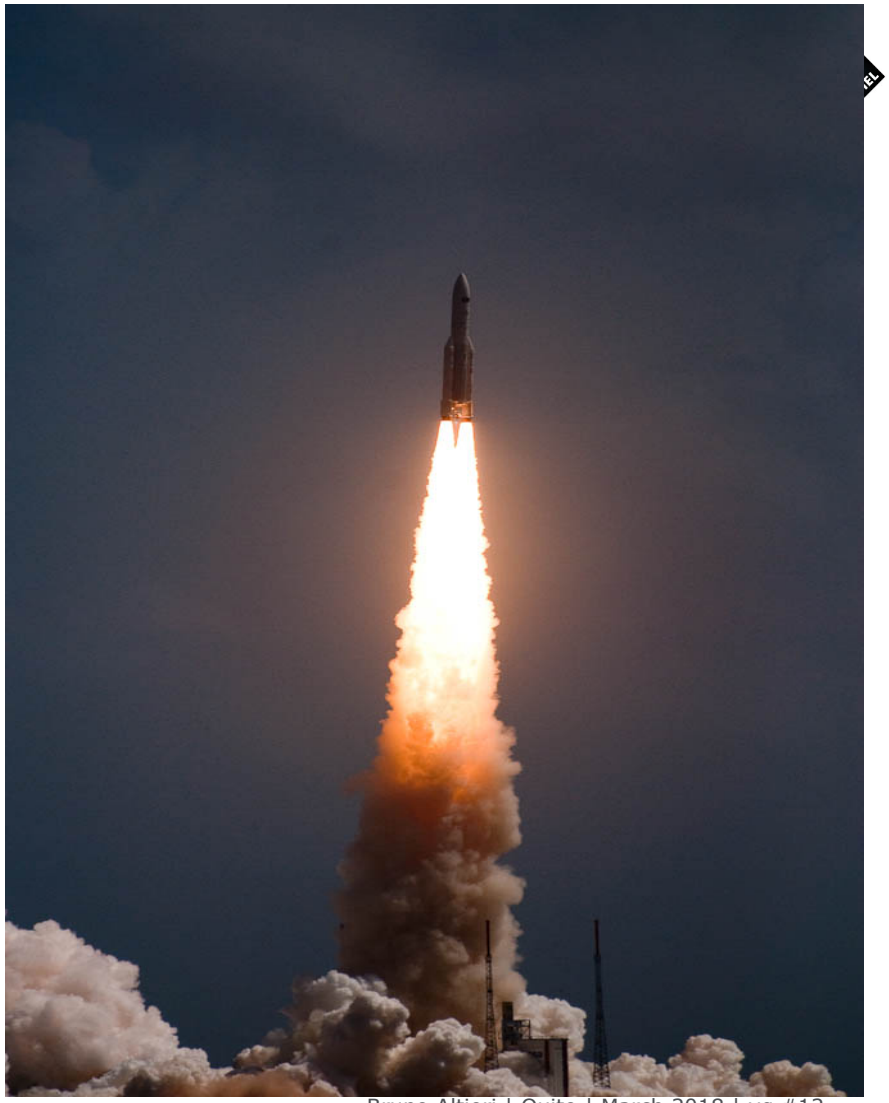
Service Module

HERSCHEL SPACE OBSERVATORY

Herschel launch & orbit

- ***Launched on 14 May 2009, together with Planck on an Ariane 5 rocket***
- ***Orbit around the second Lagrange point (L2)***
  - Provides a uniquely stable thermal, radiation-benign environment, with good sky visibility at all time





Launch on 14 May 2009

Launch on 14 May 2009 at 13:12 UT

Herschel – the machine

Large telescope

- 3.5 m diameter
- collecting area and resolution

'New' spectral window

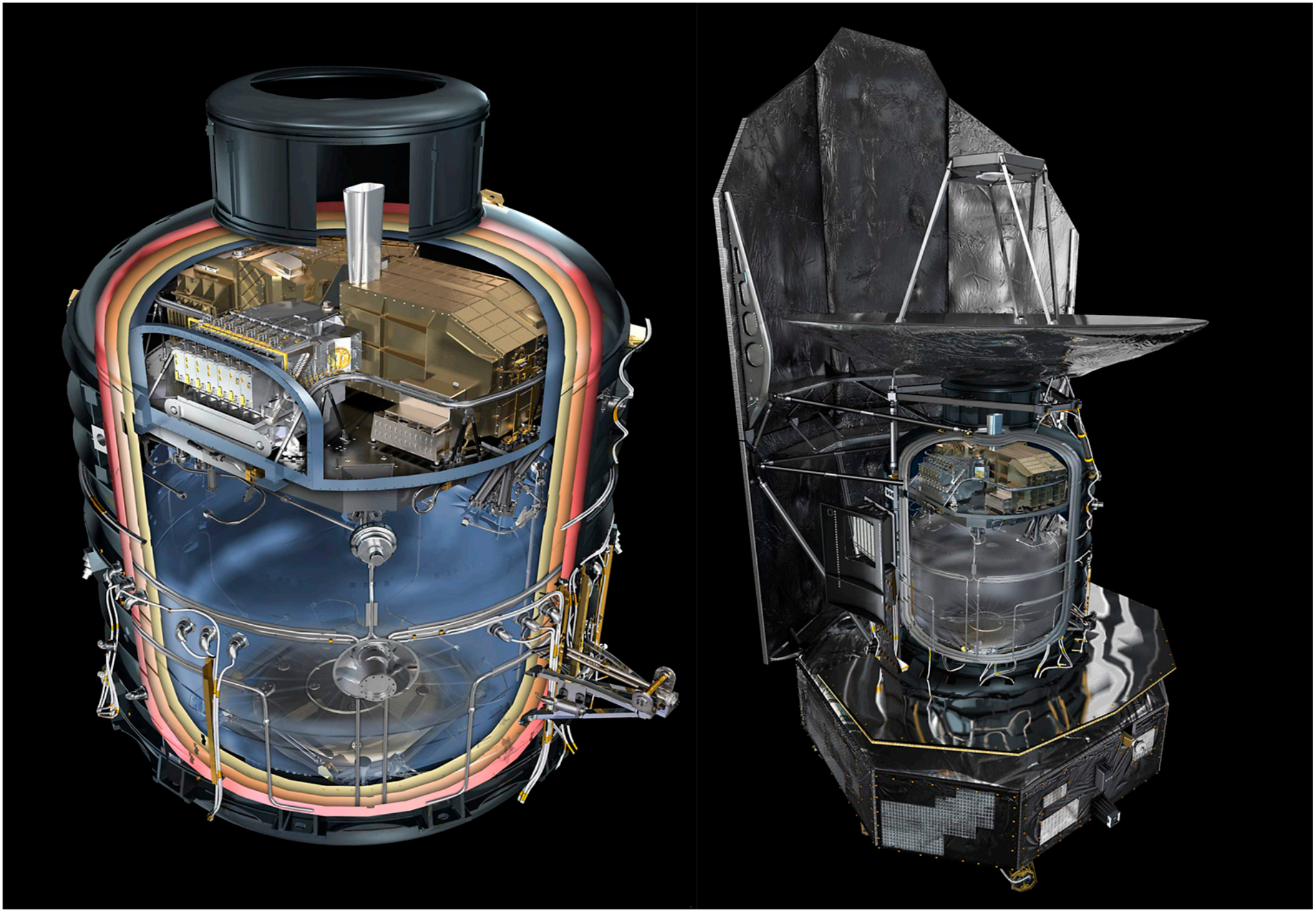
- 55-671 μm – bridging the far infrared & submillimetre – the 'cool' universe

Novel instruments

- wide area mapping in 6 'colours'
- imaging spectroscopy
- very high resolution heterodyne spectroscopy

Herschel objectives

- star formation near and far
- galaxy evolution over cosmic time
- ISM physics/chemistry
- our own solar system
- provide 3 years of routine observing
- observatory offered to community



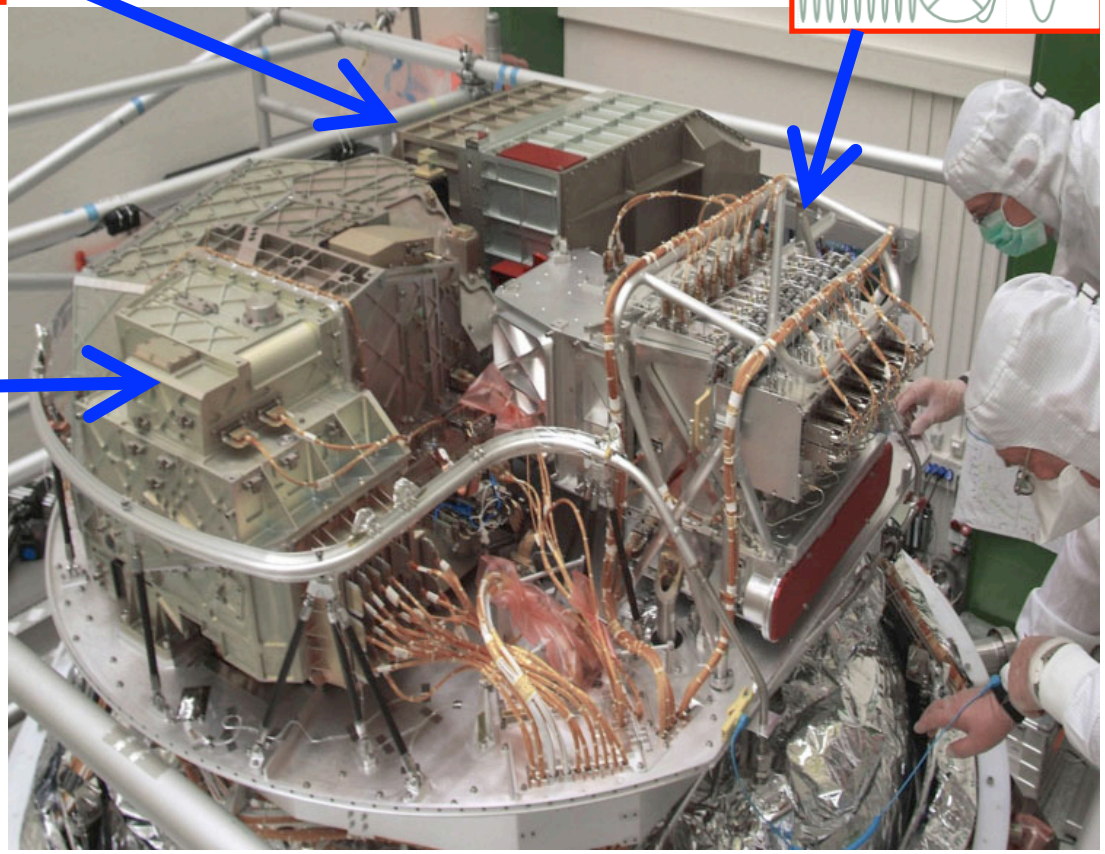
Herschel – the science instruments

3-band camera

250 + 350 + 500 μm
4 x 8 arcmin FOV

Imaging FT spectrometer
194 - 671 μm (simultaneously)
λ/Δλ = 1300 – 370 (high-res)
= 60 – 20 (low-res)

7-channel heterodyne receiver
480 - 1250 GHz (625 - 240 μm)
1410 - 1910 GHz (212 - 157 μm)
λ/Δλ = 10^5-10^6 w. BW = 4 GHz

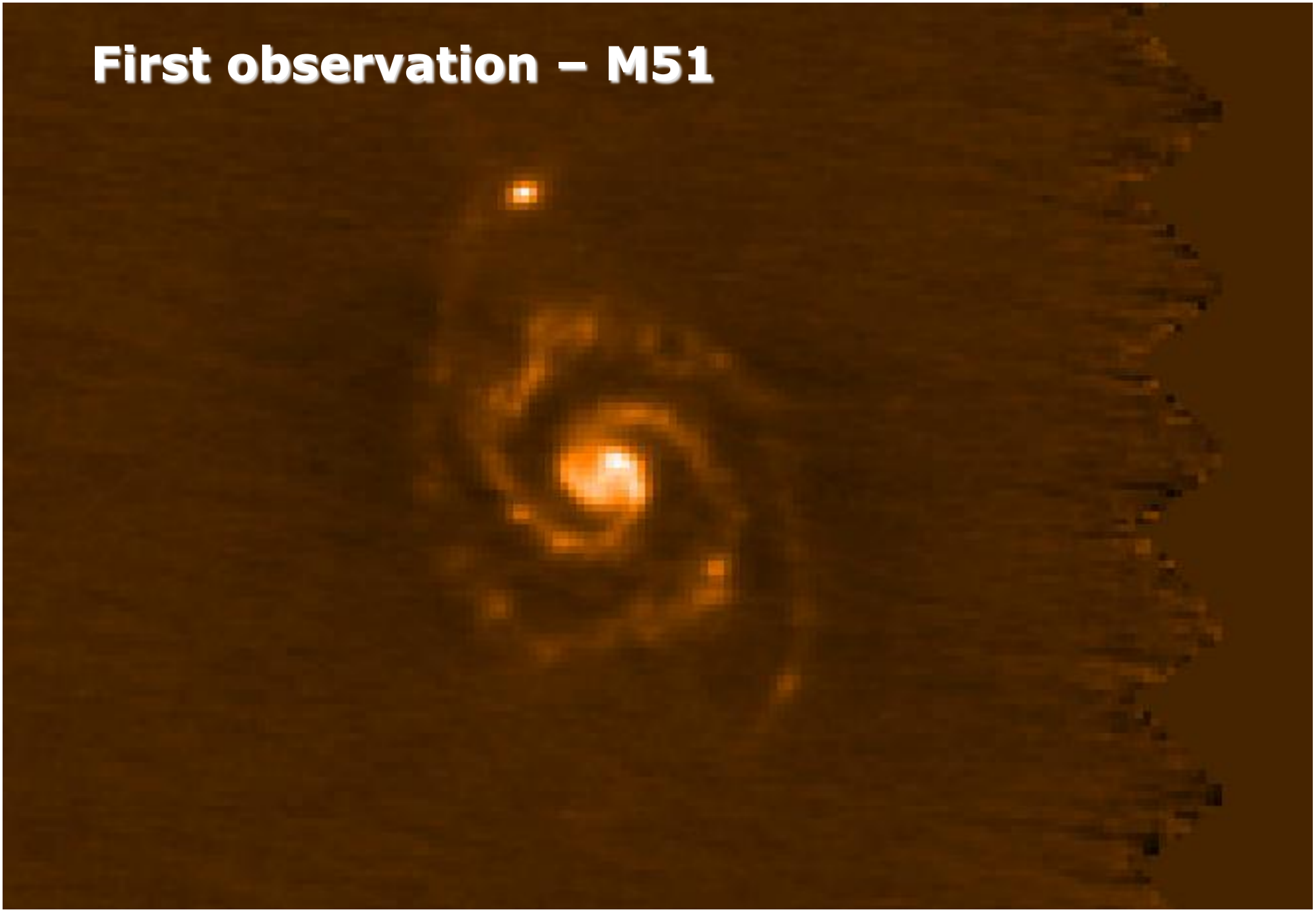


3-band camera
70 or 100 + 160 μm
1.75 x 3.5 arcmin FOV

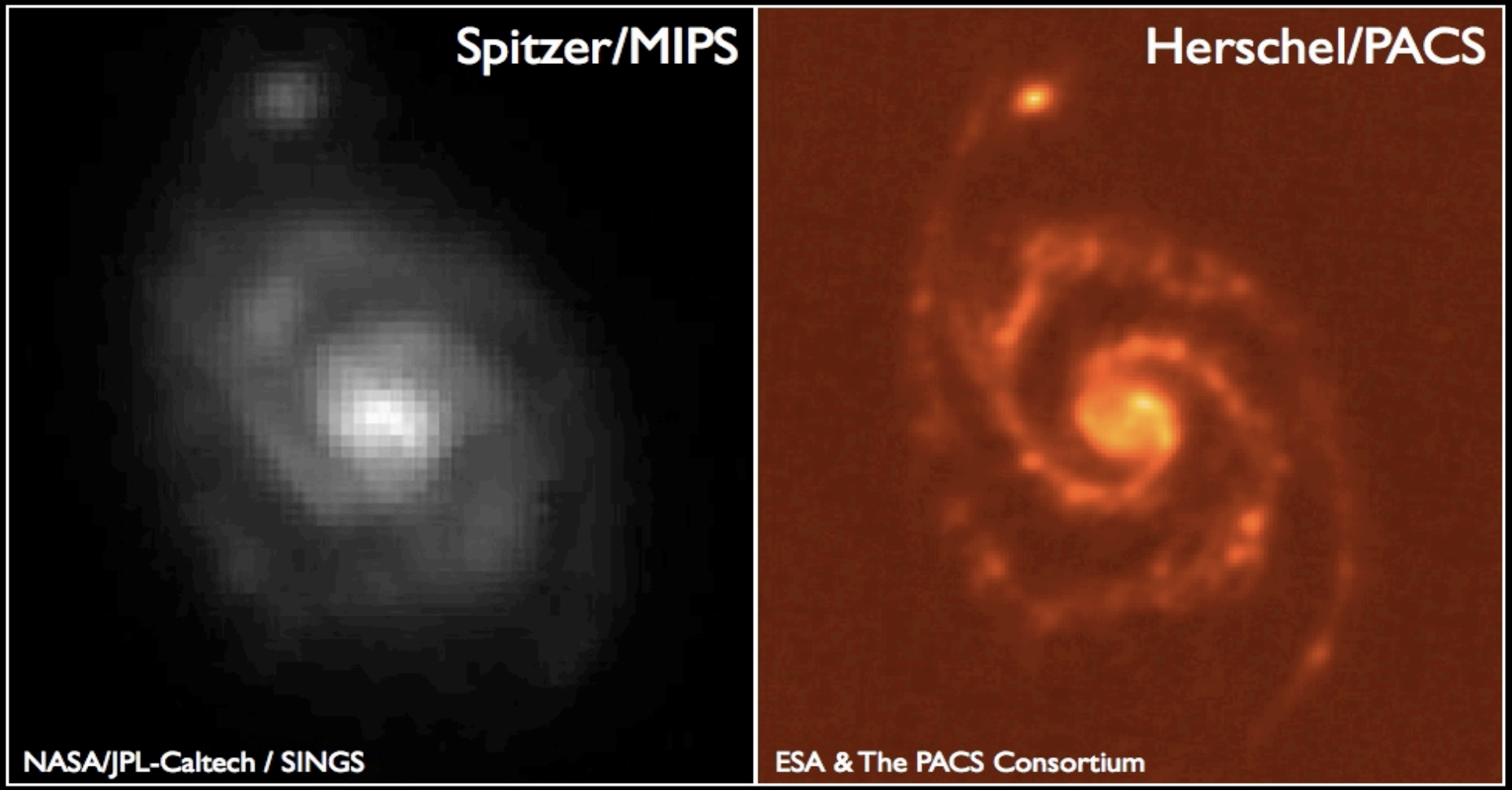
Imaging grating spectrometer
55 - 210 μm (3 orders)
λ/Δλ = 1000 – 4000


One month after launch
PACS
ICC
The Herschel Space

First observation – M51

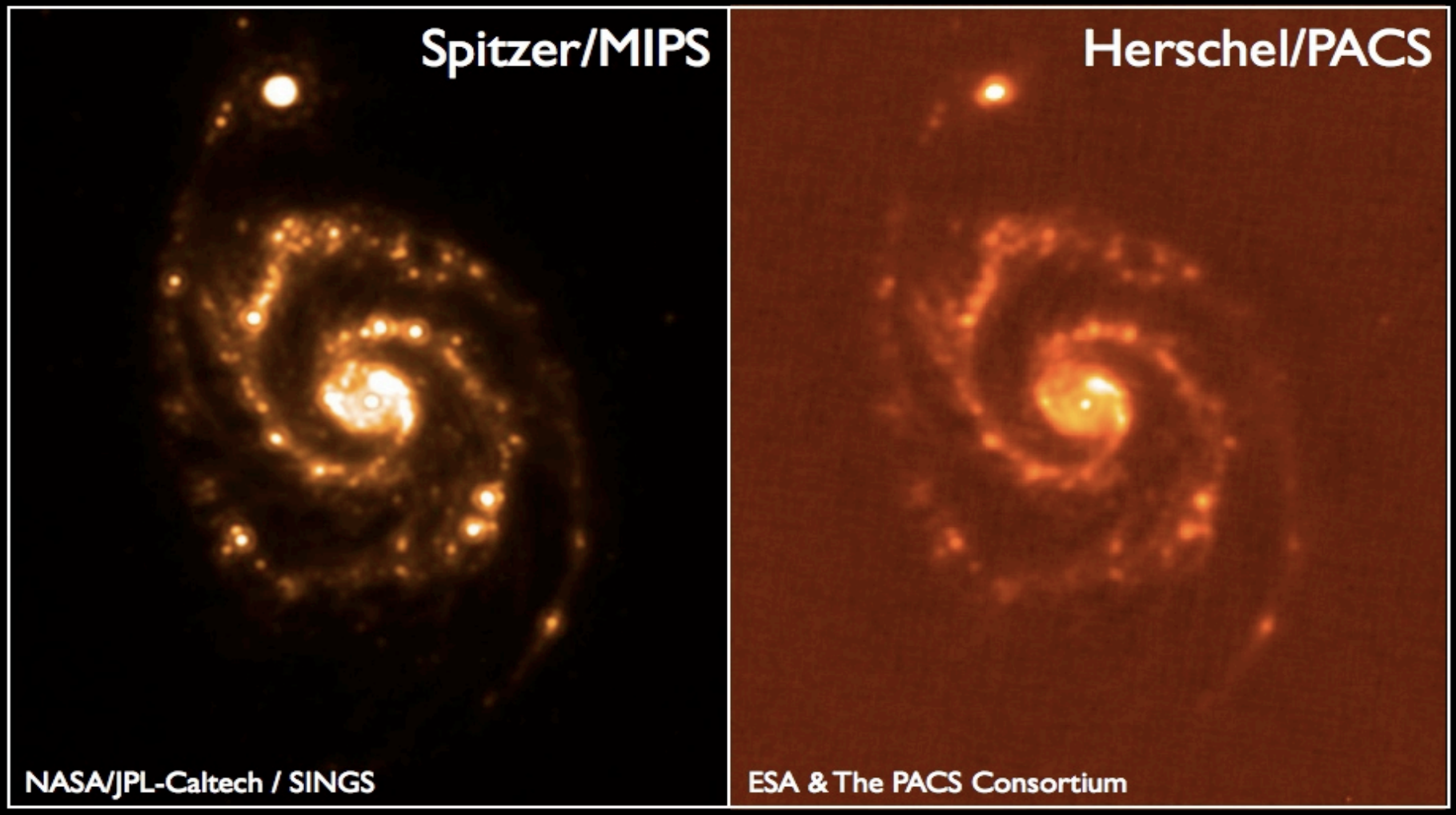


Spitzer/MIPS & Herschel/PACS at 160 um



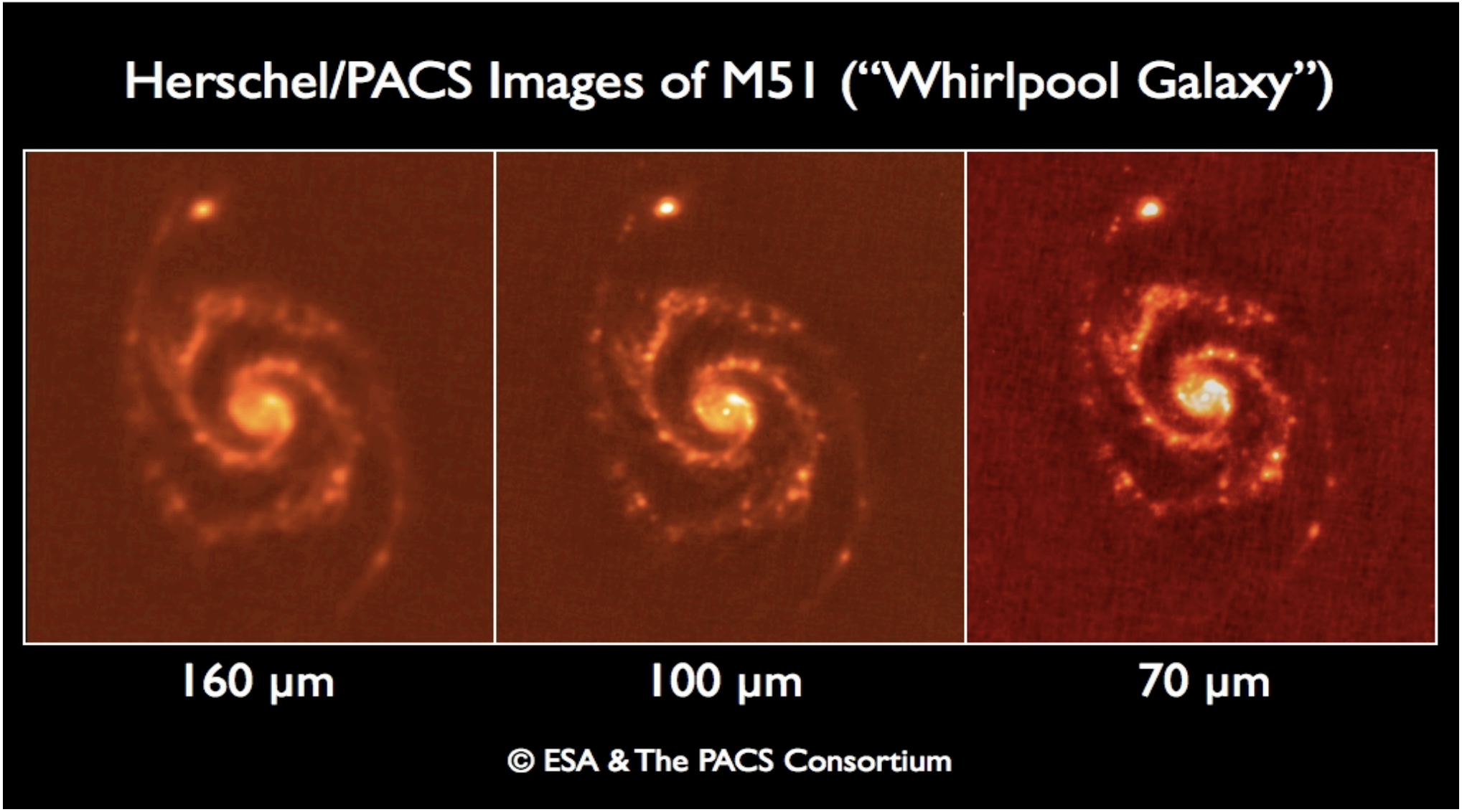
Spiral Galaxy M51 ("Whirlpool Galaxy") in the Far Infrared (160μm)

Spitzer 24 um and Herschel 100 um



Spiral Galaxy M51 ("Whirlpool Galaxy") at 24μm (MIPS) and 100μm (PACS)

Herschel at 160, 100 , and 70 um




People!

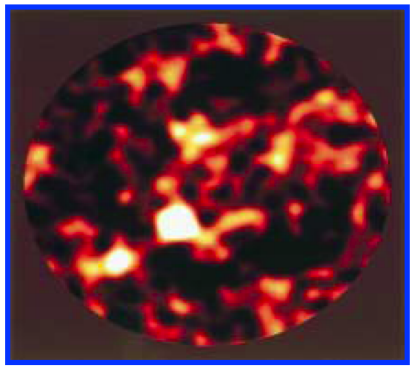
Progress in submm observations

1998

SCUBA HDF:

5 sources after 20 exceptional nights

To scale!



~3 arcmin

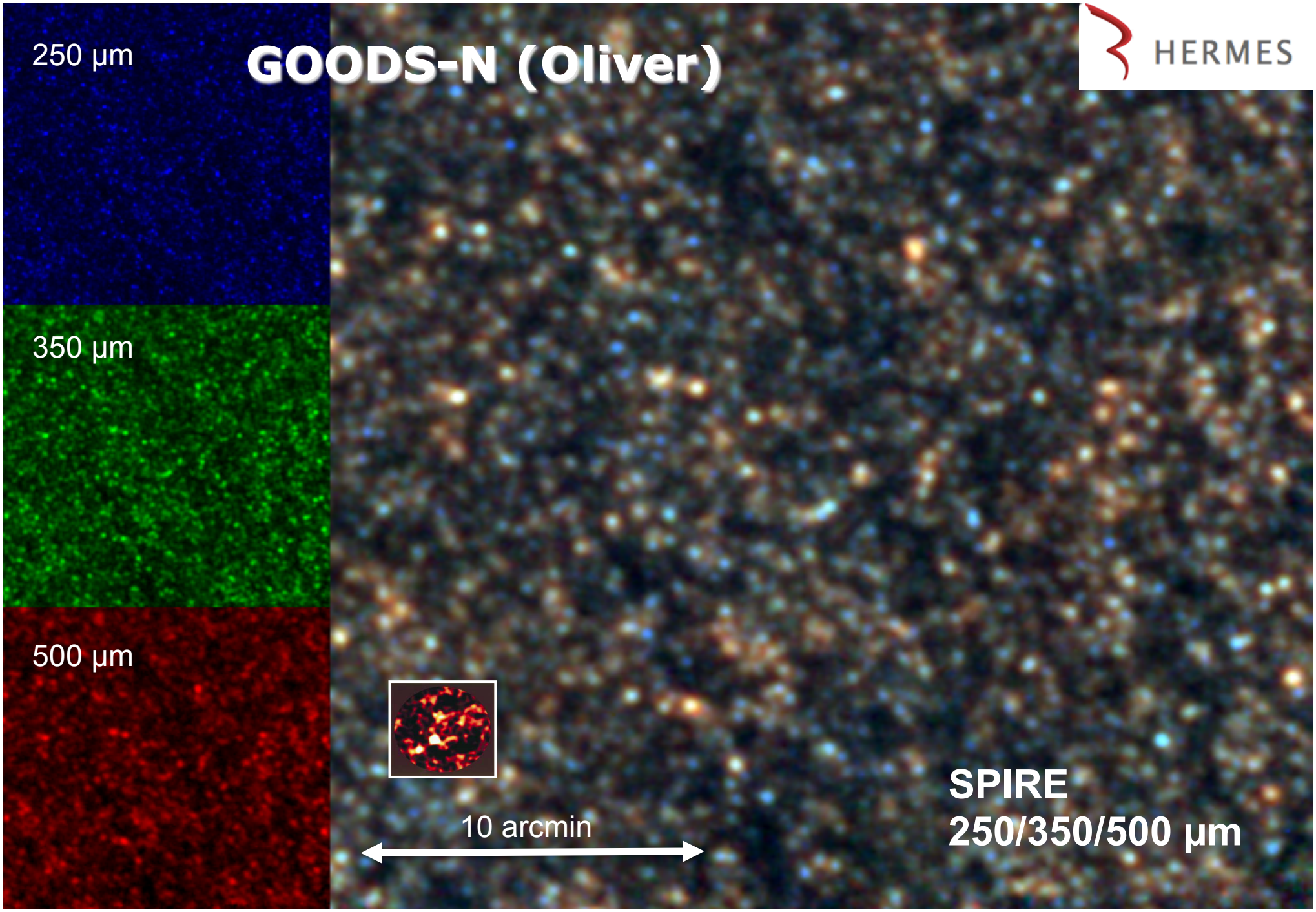
4×4^0

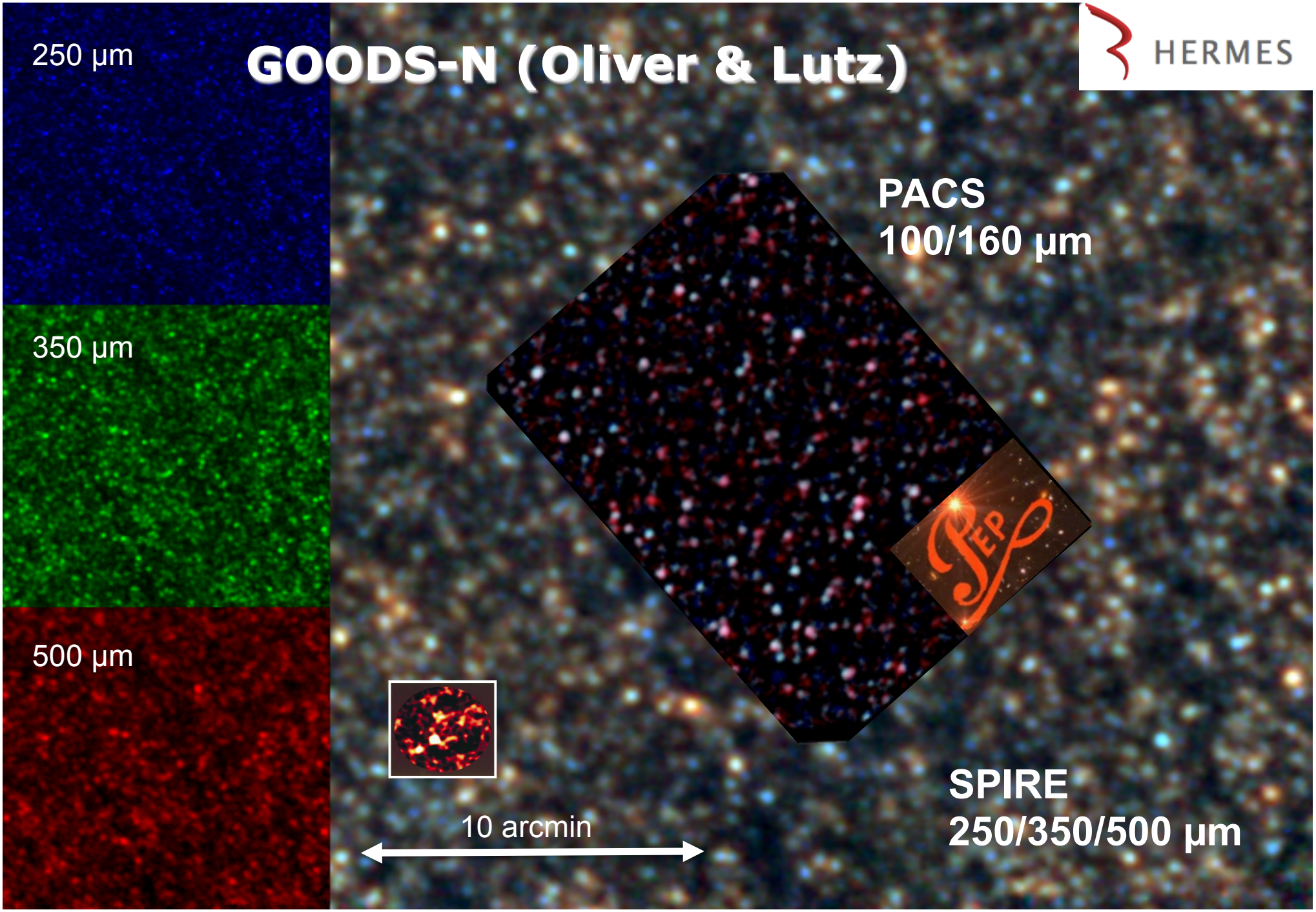
2009

Herschel-ATLAS SDP field:

~7,000 sources in 16 hours

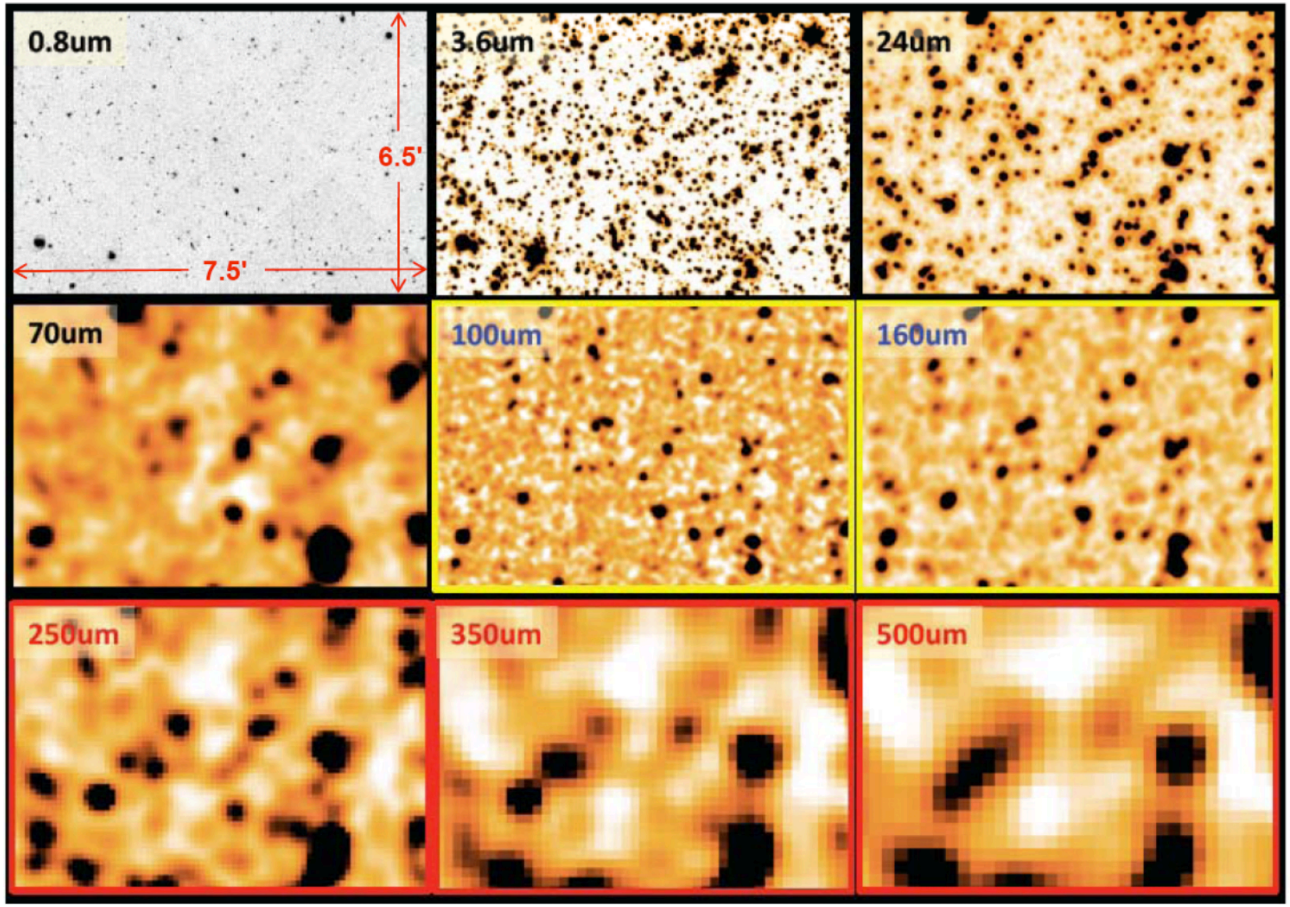
3% of total => 235,000 !!


250 μm
GOODS-N (Oliver)
HERMES
350 μm
500 μm
10 arcmin
SPIRE
250/350/500 μm


250 µm
350 µm
500 µm
GOODS-N (Oliver & Lutz)
HERMES
PACS
100/160 µm
SPIRE
250/350/500 µm
10 arcmin

Herschel: a diffraction-limited telescope

The Confusion Challenge



D. Elbaz

HERSCHEL SPACE OBSERVATORY