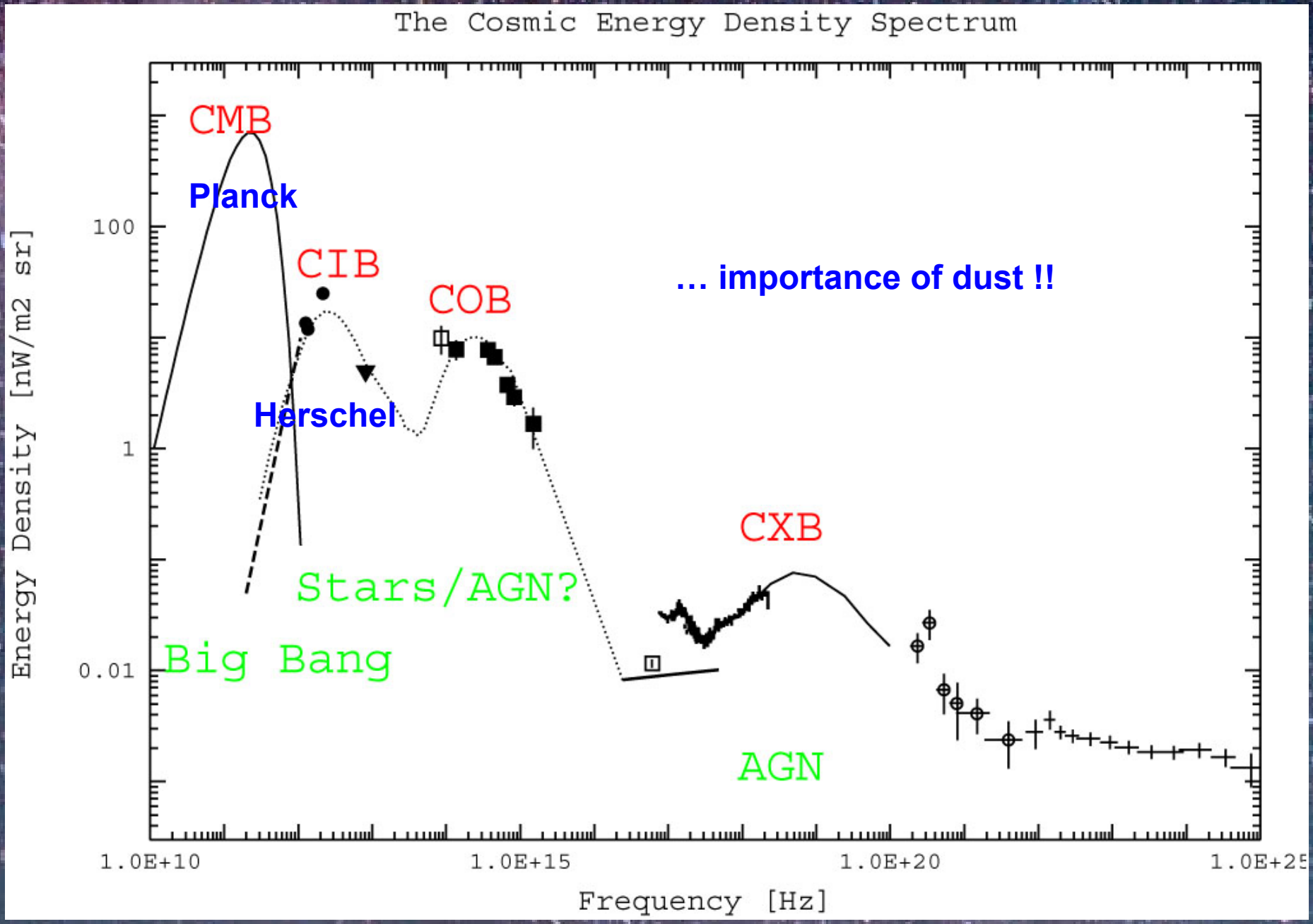
Herschel mission overview and status

Infrared Space Missions in the FIR and their Legacy to the Virtual Observatory

Konkoly Observatory, Budapest, 11 May 2006

Göran L. Pilbratt
Herschel Project Scientist
Astrophysics Missions Division
Research and Scientific Support Department


The Cosmic Energy Density Spectrum
CMB
Planck
CIB
COB
… importance of dust !!
Herschel
Stars/AGN?
Big Bang
CXB
AGN
Energy Density [nW/m2 sr]
100
1
0.01
1.0E+10
1.0E+15
1.0E+20
1.0E+25
Frequency [Hz]

FIRST to … Herschel

HERSCHEL SPACE OBSERVATORY

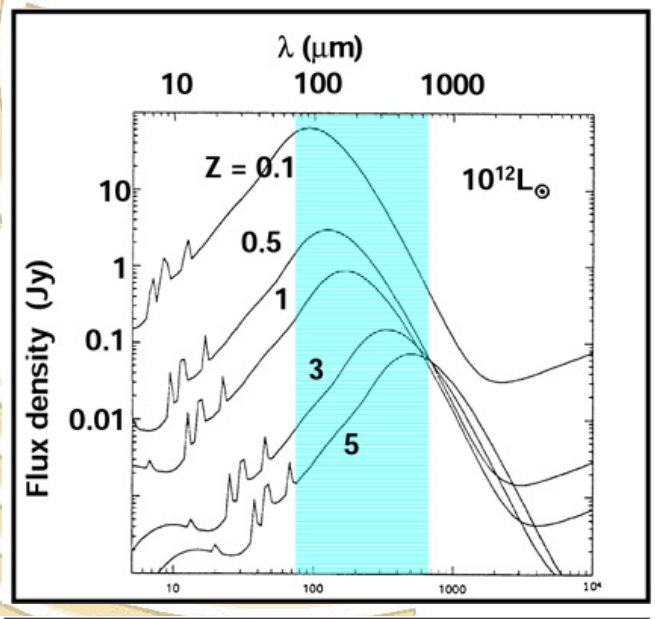
Herschel in a nutshell

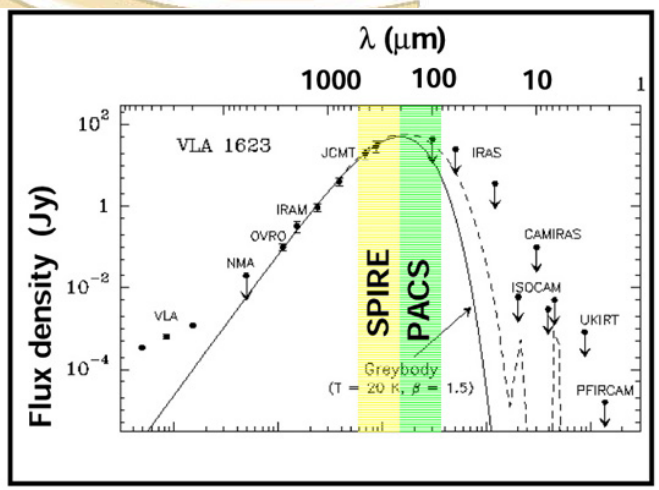
- **ESA cornerstone observatory**
  - instruments 'nationally' funded, int'l - NASA, CSA, Poland – collaboration
  - ~1/3 guaranteed time, ~2/3 open time
- **FIR (57 - 670 μm) space facility**
  - large (3.5 m) monolithic low emissivity passively cooled telescope
  - 3 focal plane science instruments
  - 3 years routine operational lifetime
  - full spectral access
  - low and stable background
- **Unique and complementary**
  - for λ < 200 μm larger aperture than cryogenically cooled telescopes (IRAS, ISO, Spitzer, Astro-F,…)
  - more observing time than balloon- and/or air-borne instruments (~1000 SOFIA flights per year)
  - larger field of view than interferometers
- **Launch in 2008**
  - **initial observing AO in late 2006**

HERSCHEL SPACE OBSERVATORY

The Cool Universe

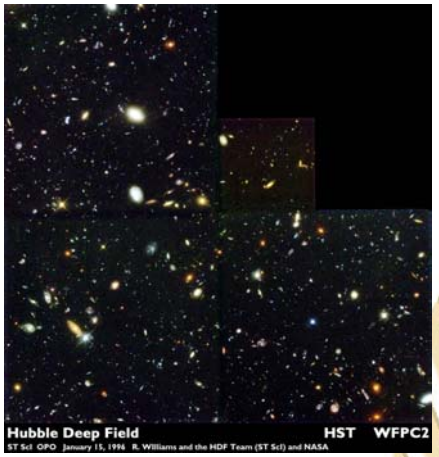
- **Herschel spectral coverage**
  - black-bodies 5-50 K
    - continuum radiation
    - dust grains (re-)radiating
  - gases 10-few100 K
    - brightest atomic/molecular lines
- **Herschel strengths**
  - covers IR dominated galaxies & protostar SED peaks
  - wide area mapping
  - full coverage spectral scans & particular (water) lines
- **Herschel emphasis**
  - formation and evolution of galaxies & stars
  - ISM physics & chemistry
  - solar system bodies

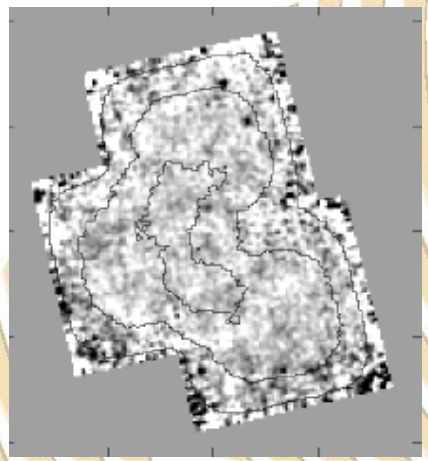


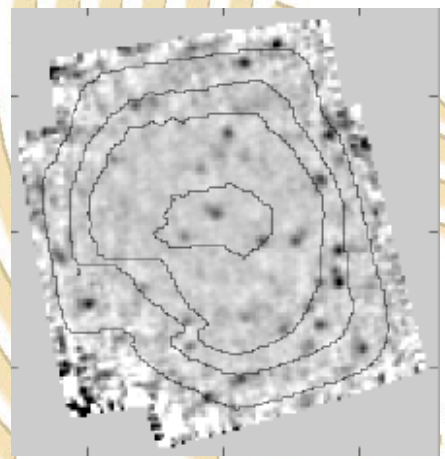


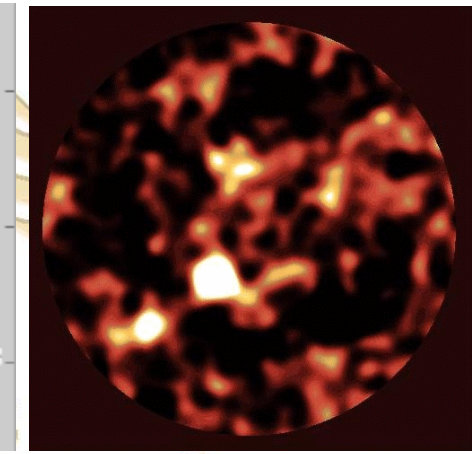
HERSCHEL SPACE OBSERVATORY

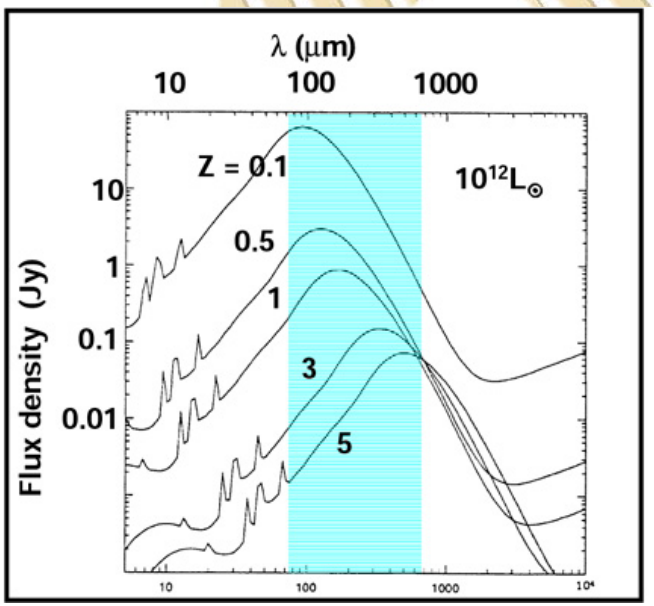
Galaxy formation & evolution









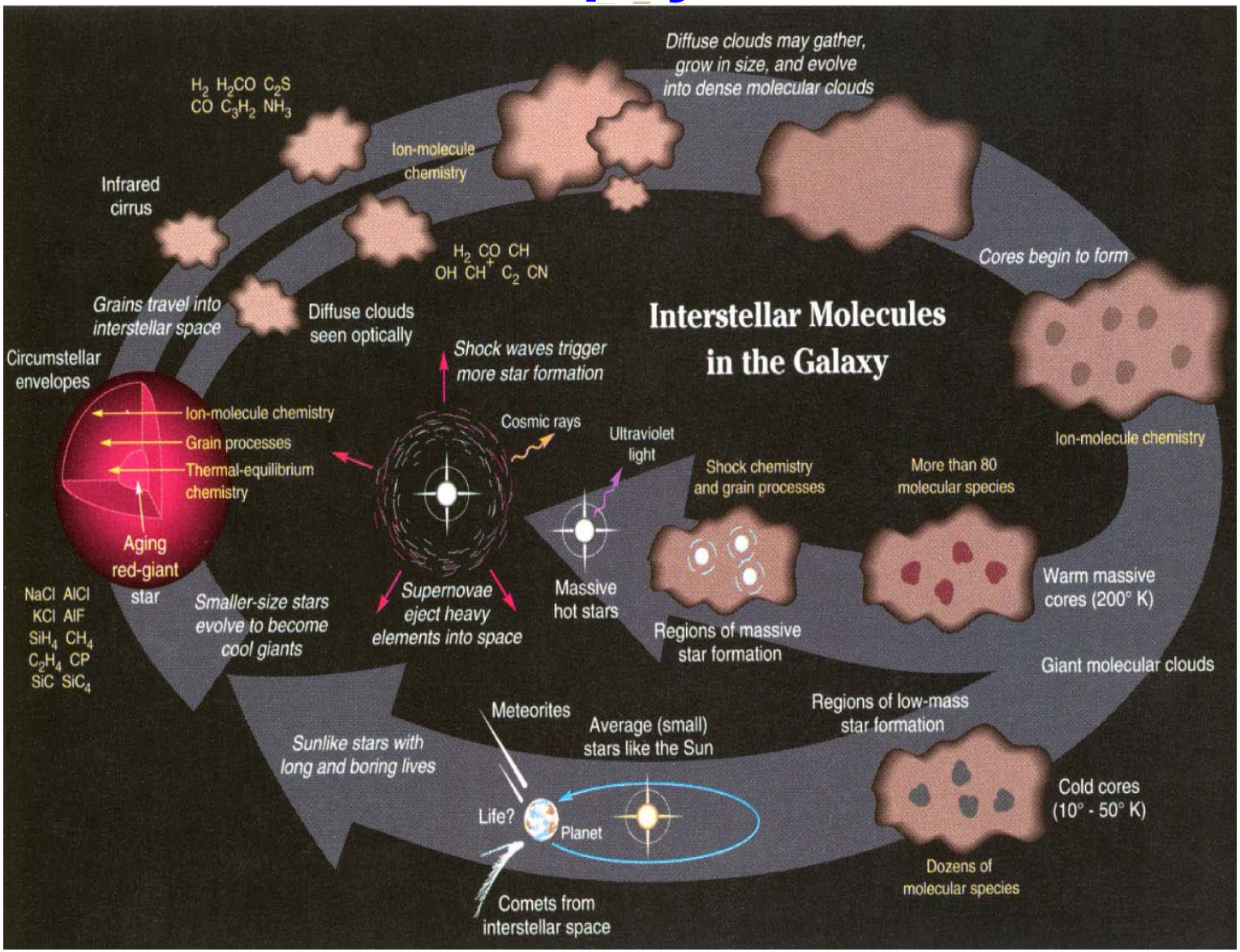


Spitzer results:

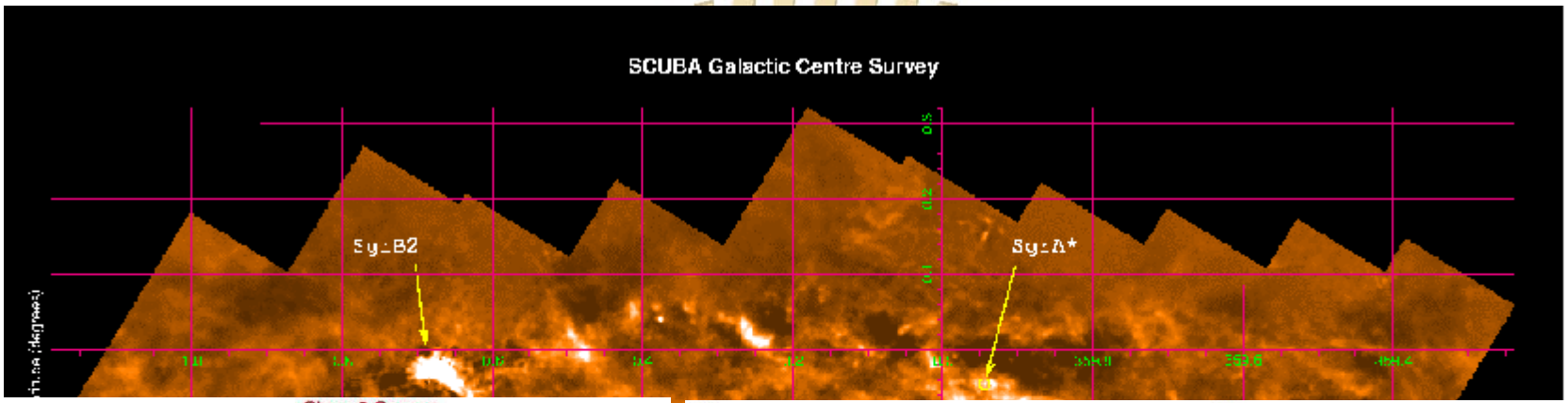
- 24 μm – 70%
- 70 μm – 23%
- 160 μm – 7%

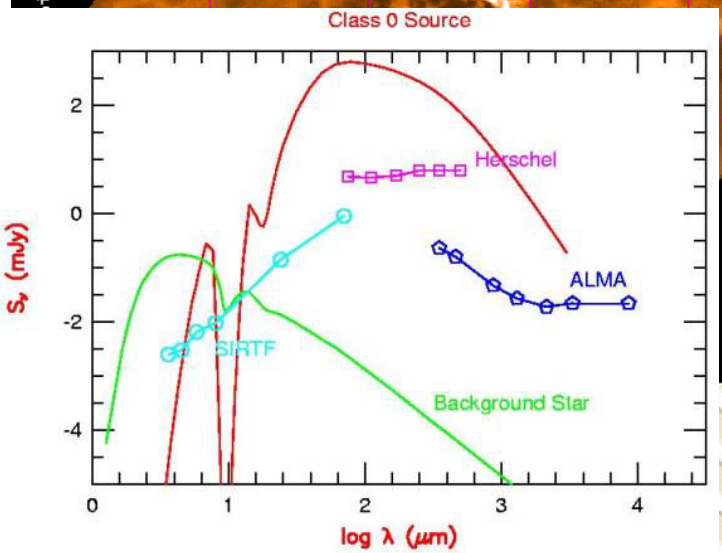
HERSCHEL SPACE OBSERVATORY

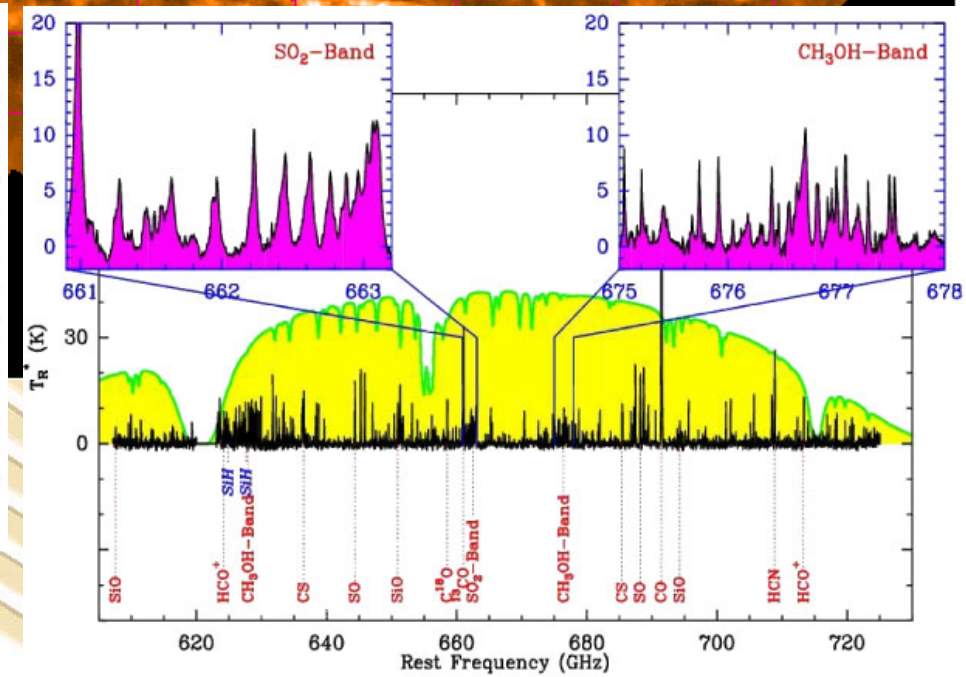
Galactic ISM physics & SF



Surveys & follow-up

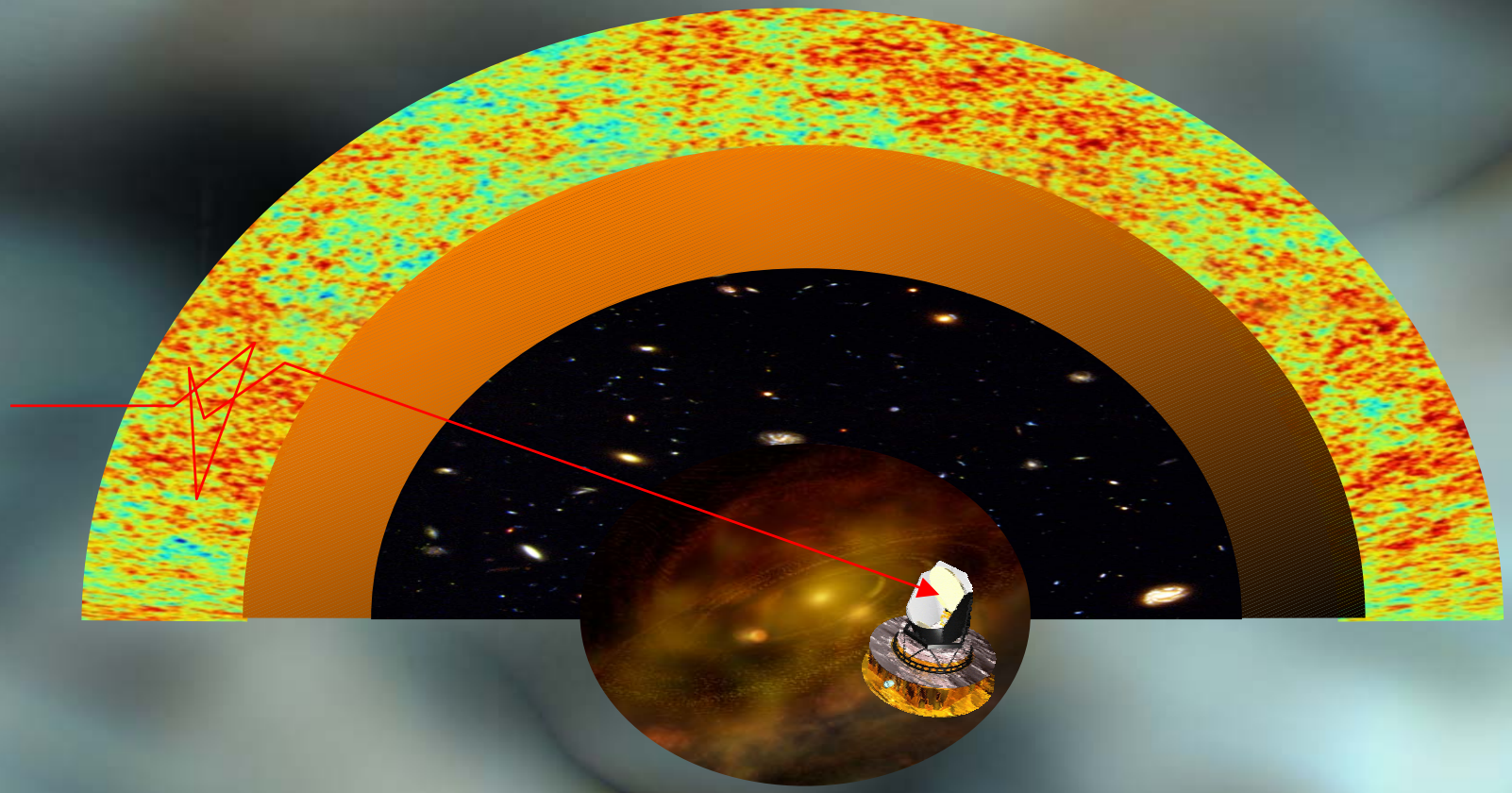




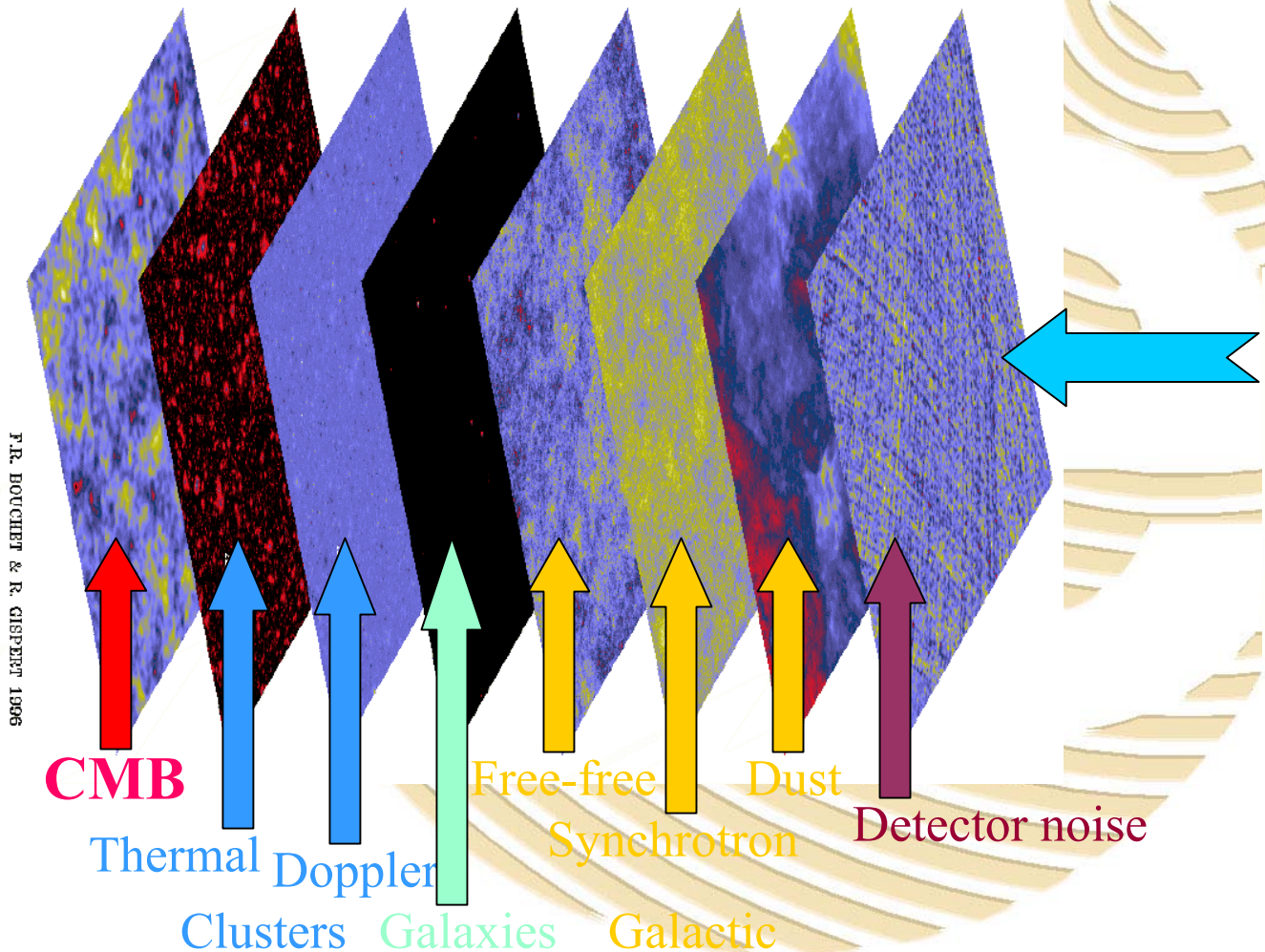


0.1L_{sun} protostar at 300 pc

Looking back in time



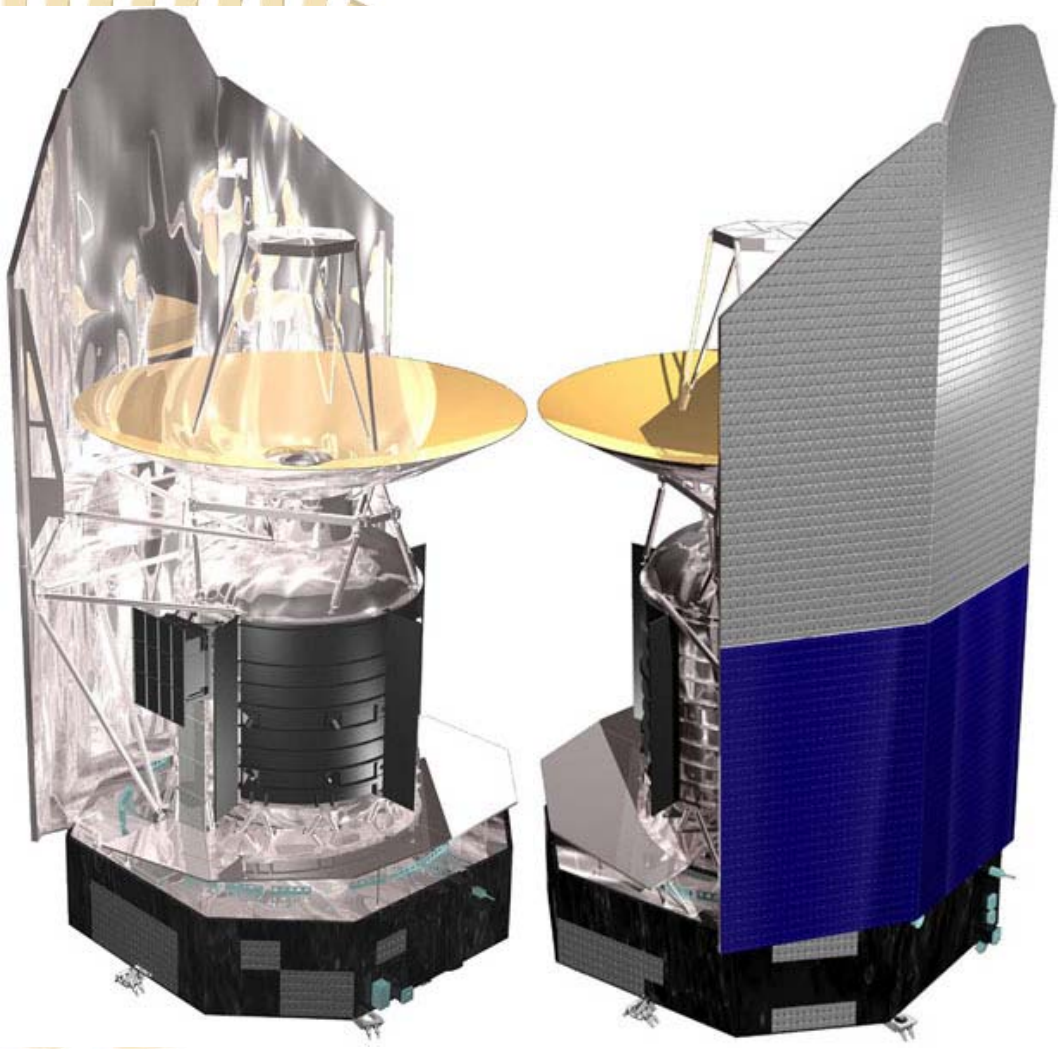
Foreground separation



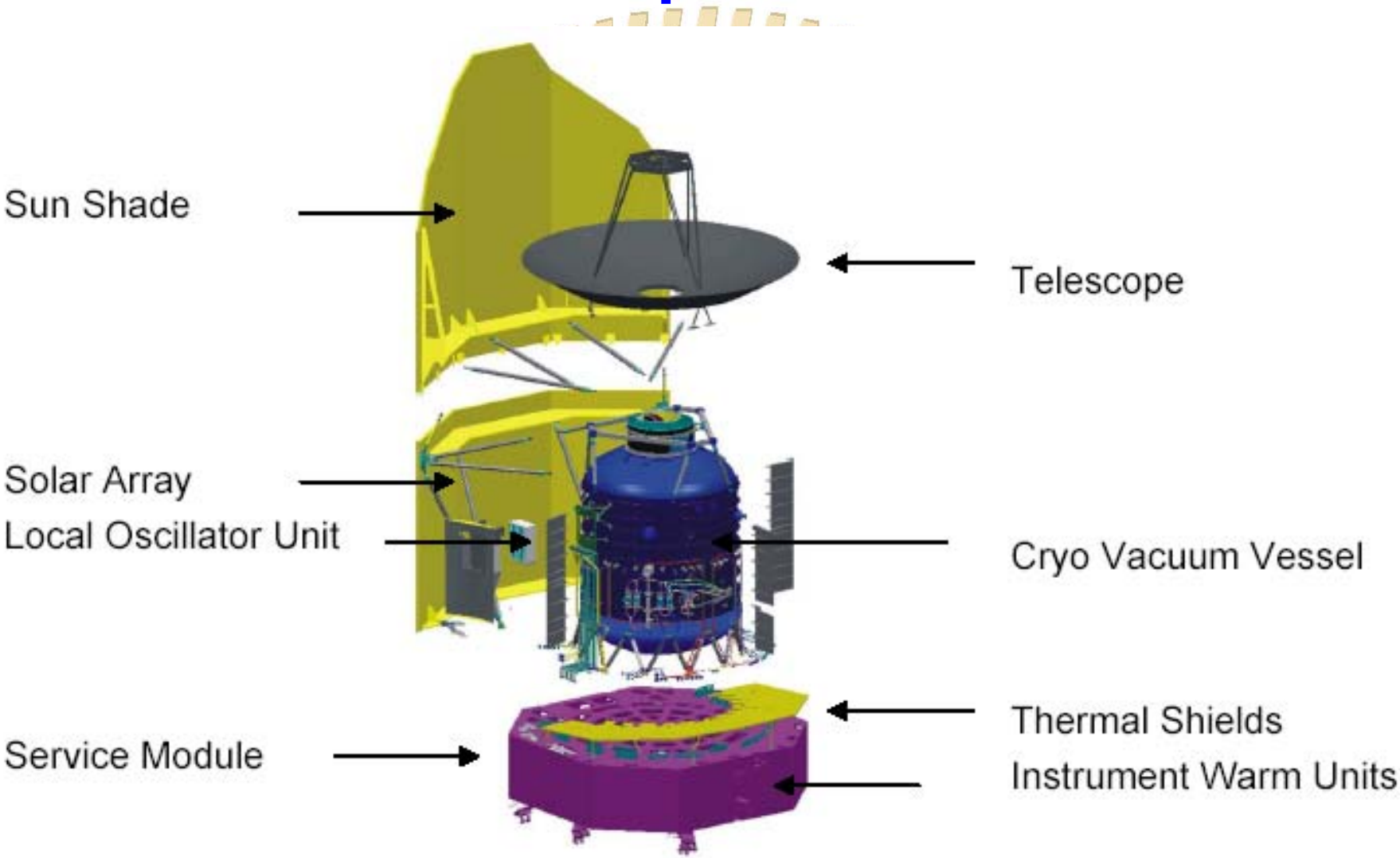
HERSCHEL SPACE OBSERVATORY

Herschel spacecraft

- telescope diameter 3.5 m
- telescope WFE < 6 μm
- telescope temp < 90 K
- telescope emissivity < 4%
- abs/rel pointg (68%) < 3.7” / 0.3”
- science instruments 3
- science data rate 130 kbps
- cryostat lifetime > 3.5 years
- height / width ~ 7.5 / 4 m
- launch mass ~ 3200 kg
- power ~ 1500 W
- orbit ‘large’ Lissajous around L2
- solar aspect angle 60-120 deg
- launcher (w Planck) Ariane 5 ECA



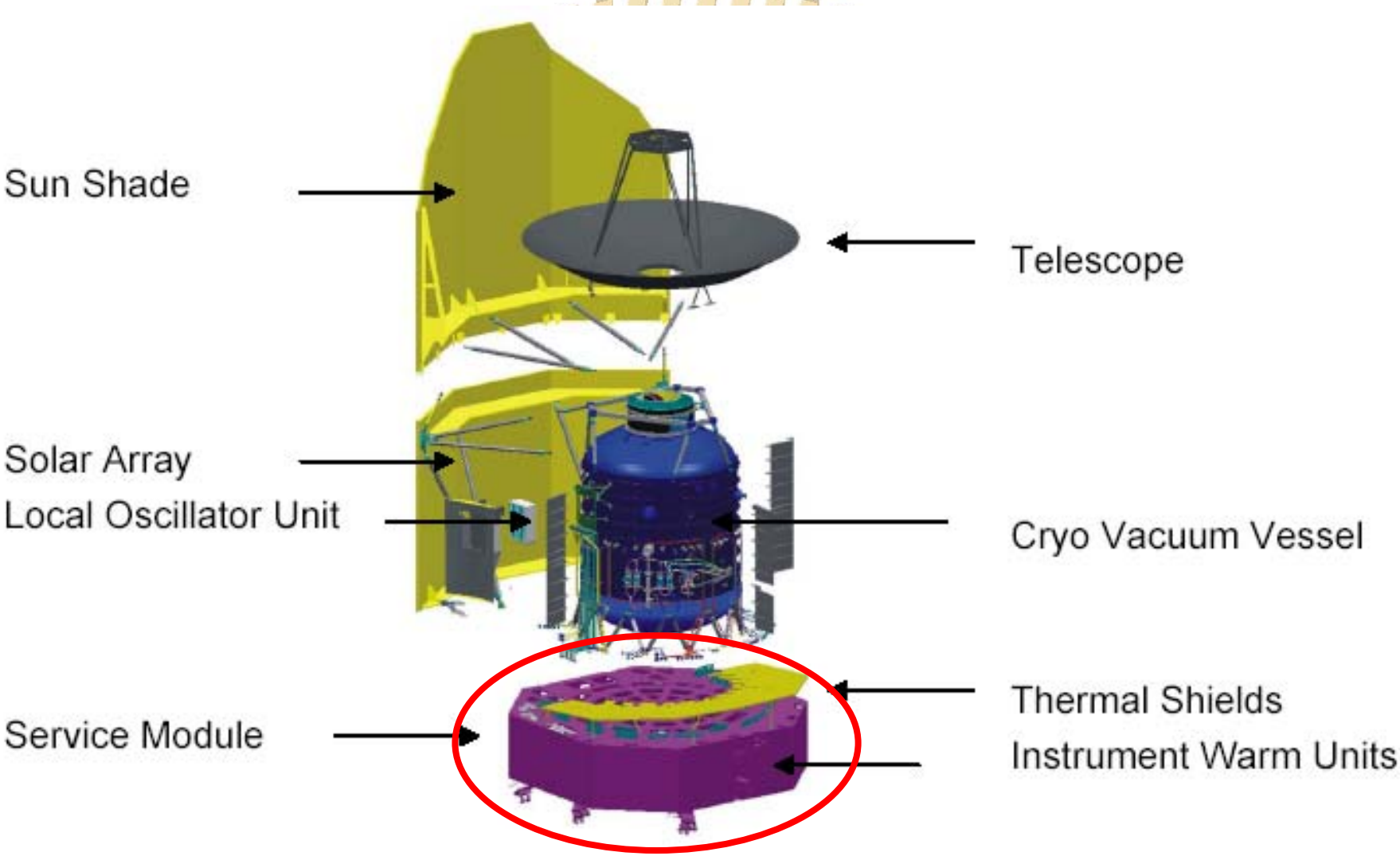
Herschel spacecraft



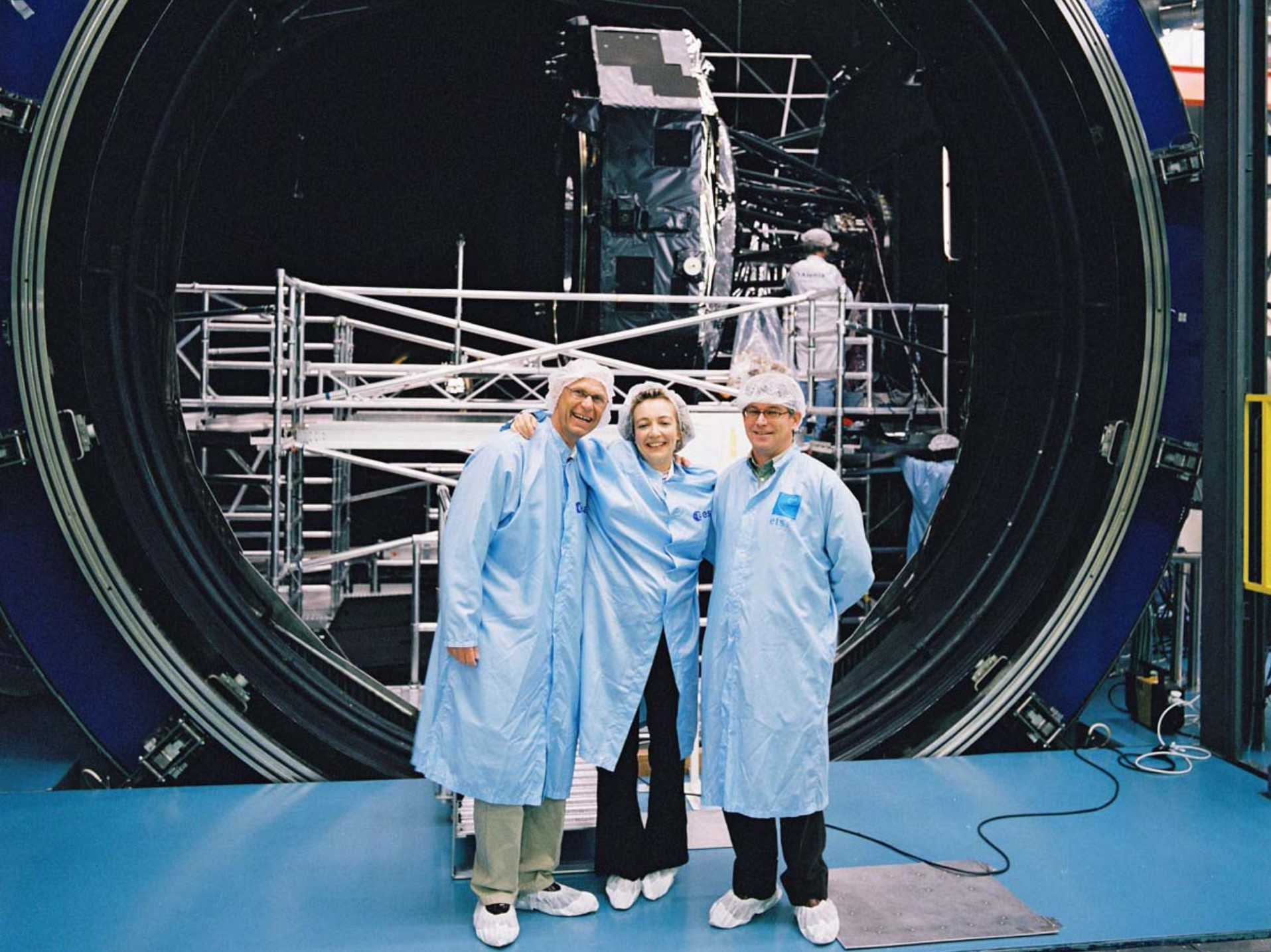
Herschel spacecraft - programmes

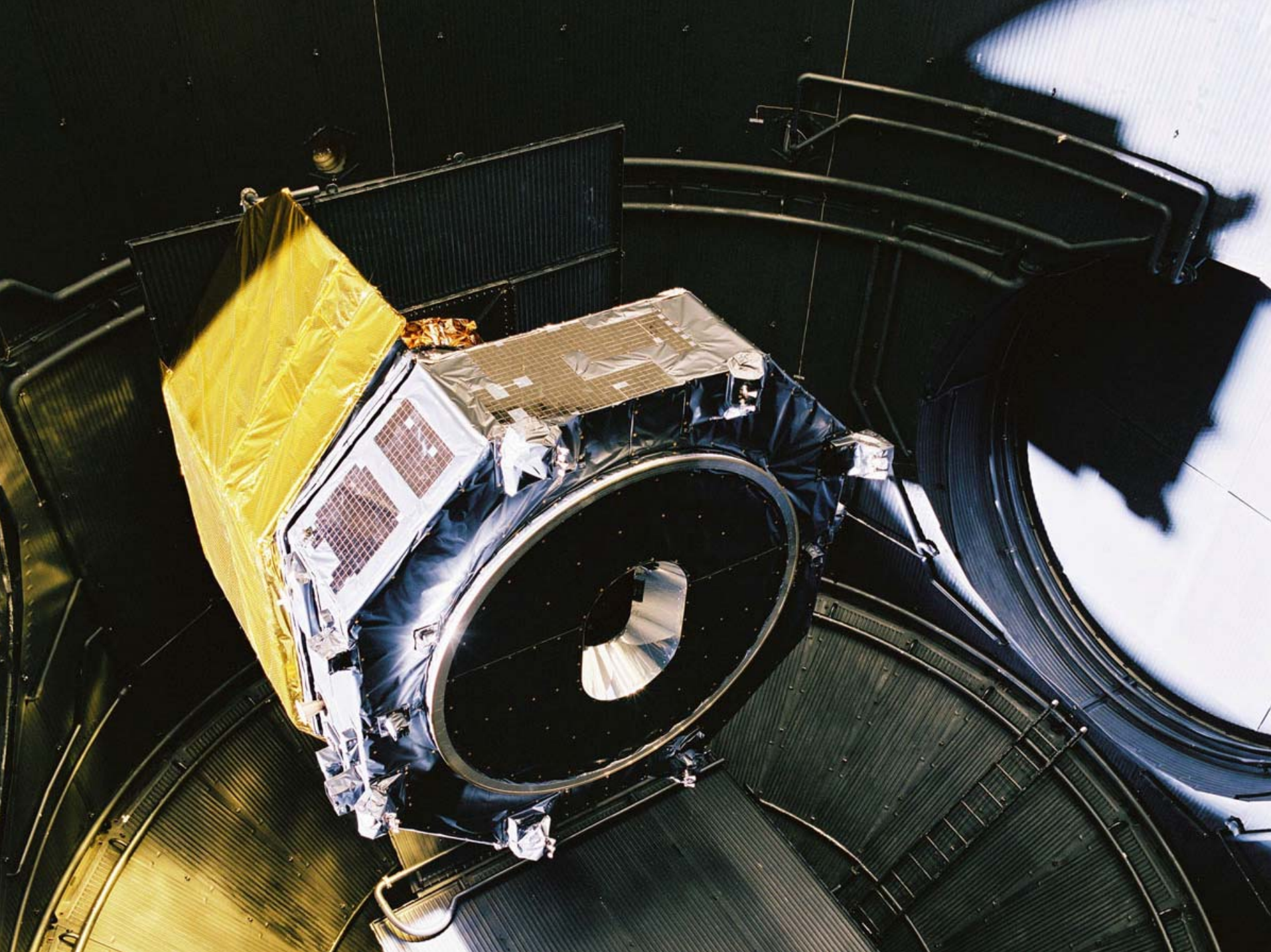
- **Satellite PFM programme (EADS Astrium, D)**
  - only one satellite is built – in STM configuration until recently
    - FM cryostat
    - STM models of most of else – but with many flight parts
  - only one cryostat/PLM is built – has been tested in LSS
  - QM and FM SVMs
- **Telescope PFM programme (EADS Astrium, F)**
  - telescope manufacture complete – currently under lengthy cryotesting campaign in CSL
  - spare parts exist for FS – but M1 not lapped/polished/coated
- **EQM programme – completed (EADS Astrium, D)**
  - ISO hardware refurbished to provide 'Herschel OB simulator'
  - science instrument CQMs
- **AVM programme (Alenia Spazio, I)**
  - one physical setup – configurable as either Herschel or Planck
  - test procedures and OBSW development

Herschel spacecraft



Austrian Aerospace
Austrian Aerospace

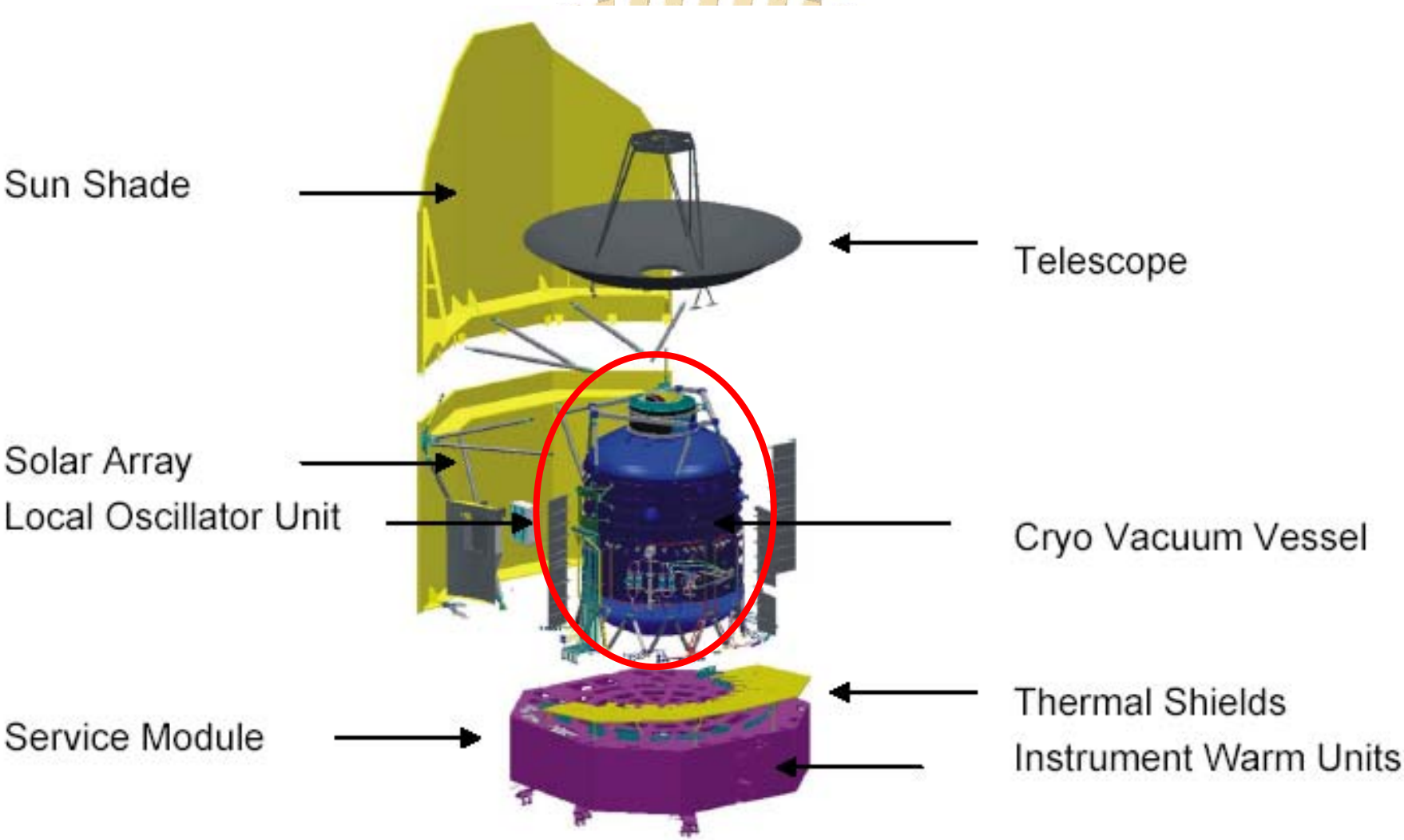




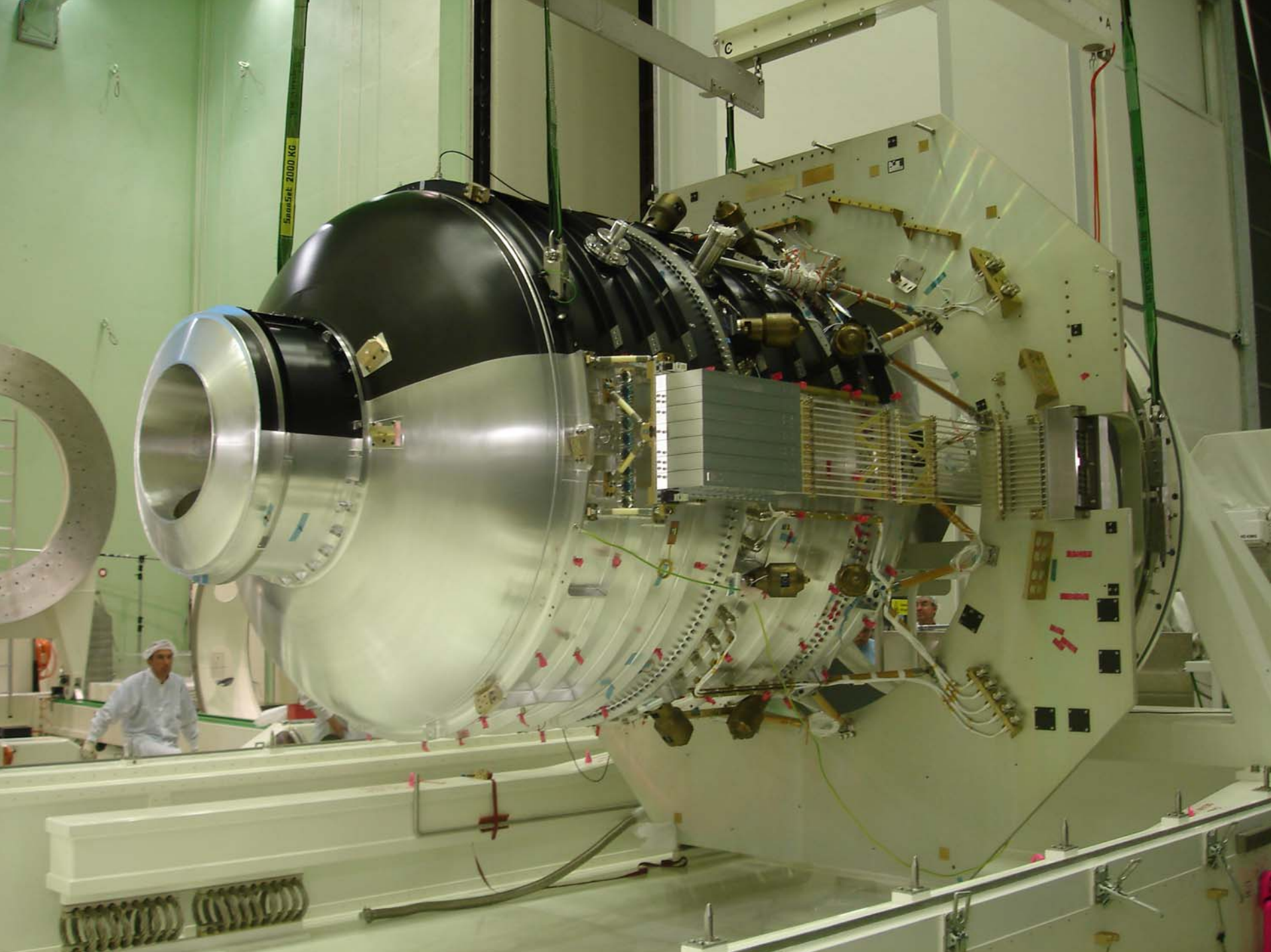
Herschel SVM

- **SVM STM arrived in ESTEC in April 2005**
  - first spacecraft hardware to be arrive in ESTEC
- **Tested in Large Space Simulator (LSS) in May 2005**
  - contains many flight items
- **Integrated with PLM to produce spacecraft STM in November 2005**
  - returned to Alenia in March 2006
- **Main results**
  - fit checks
  - TB/TV tests

Herschel spacecraft



ADS
ASTRIUM


SwanSyst. 2000 KG

Herschel PLM

- **PFM PLM arrived in ESTEC August 2005**
  - this is the flight cryostat!
- **TB/TV test in Large space Simulator (LSS) with STM instrument FPUs in Oct/Nov 2005**
  - discovered unexpected heatloads!
- **Integrated with SVM to produce spacecraft STM in November 2005**
- **Returned to EADS Astrium Friedrichshafen for 'refurbishment' in March 2006**
- **Main results**
  - unexpected heatloads discovered inTB/TV tests – would have cut lifetime in two (routine ops to one third)
  - ESA/Industry 'Tiger Team' put in place to address
  - recovery activity introduced – currently underway
  - verification details being finalised

Herschel STM satellite

- **PFM PLM mated with STM SVM in November 2005**
- **Mated with sunshade structure in December 2005**
- **Environmental qualification Jan/Feb 2006**
  - vibration, acoustic, and shock tests
- **Demated in March 2006**
  - PLM back to EADS Astrium Friedrichshafen
  - SVM back to Alenia in Torino
- **Main results**
  - mechanical qualification basically successful

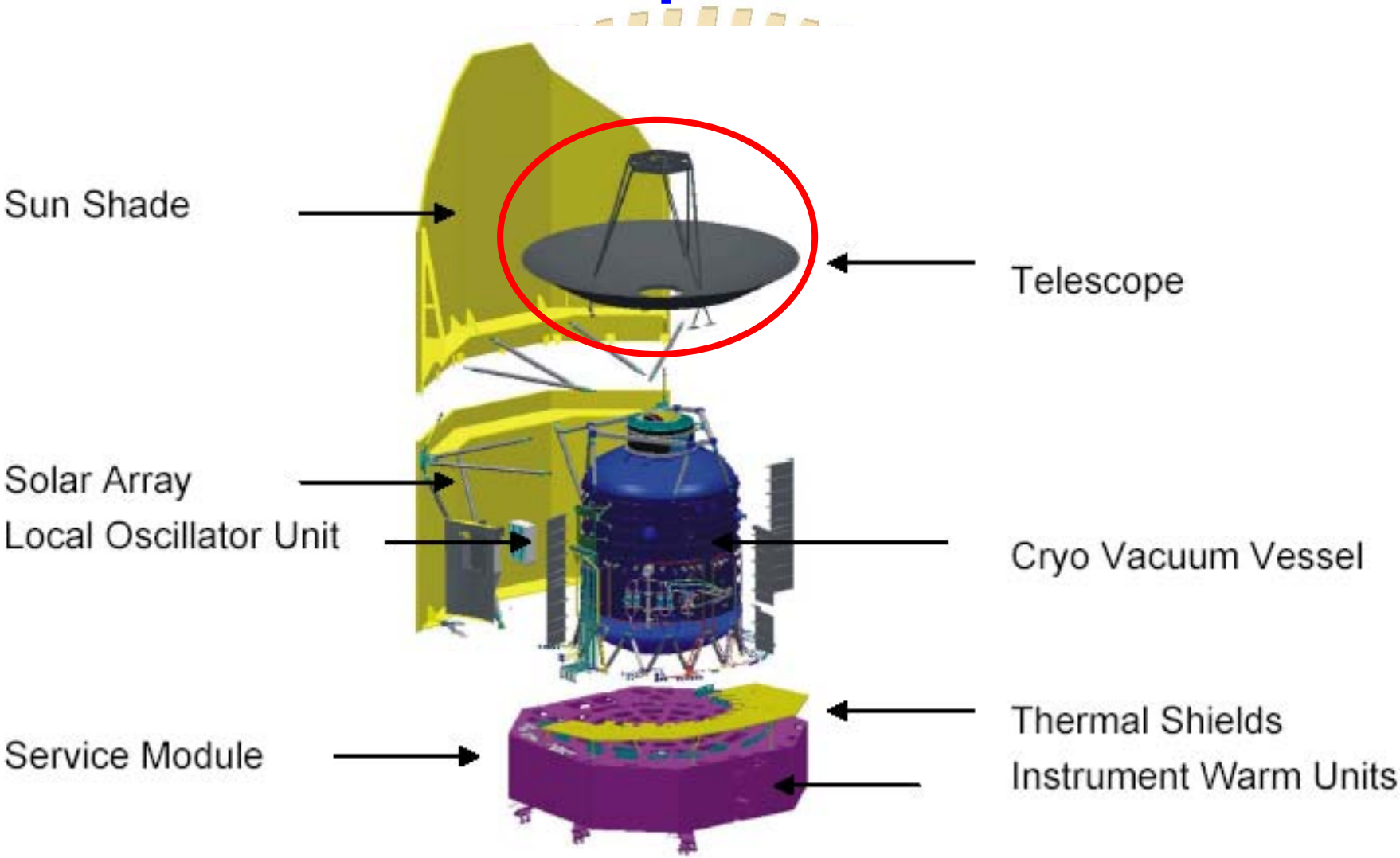
APCO
APCO

Herschel STM satellite

Herschel Science Team visited the ESTEC Test Centre to view the Herschel STM satellite on 1 Feb 2006

HERSCHEL SPACE OBSERVATORY

Herschel spacecraft



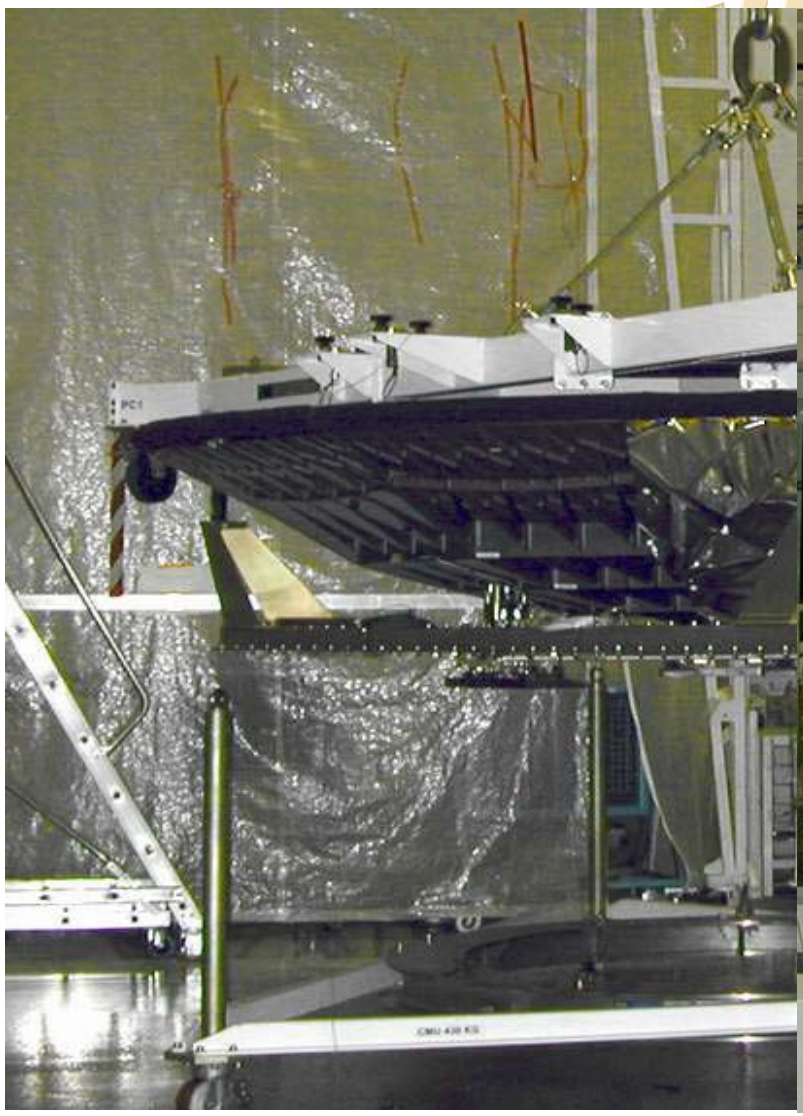
Brazing of primary mirror ‘blank’

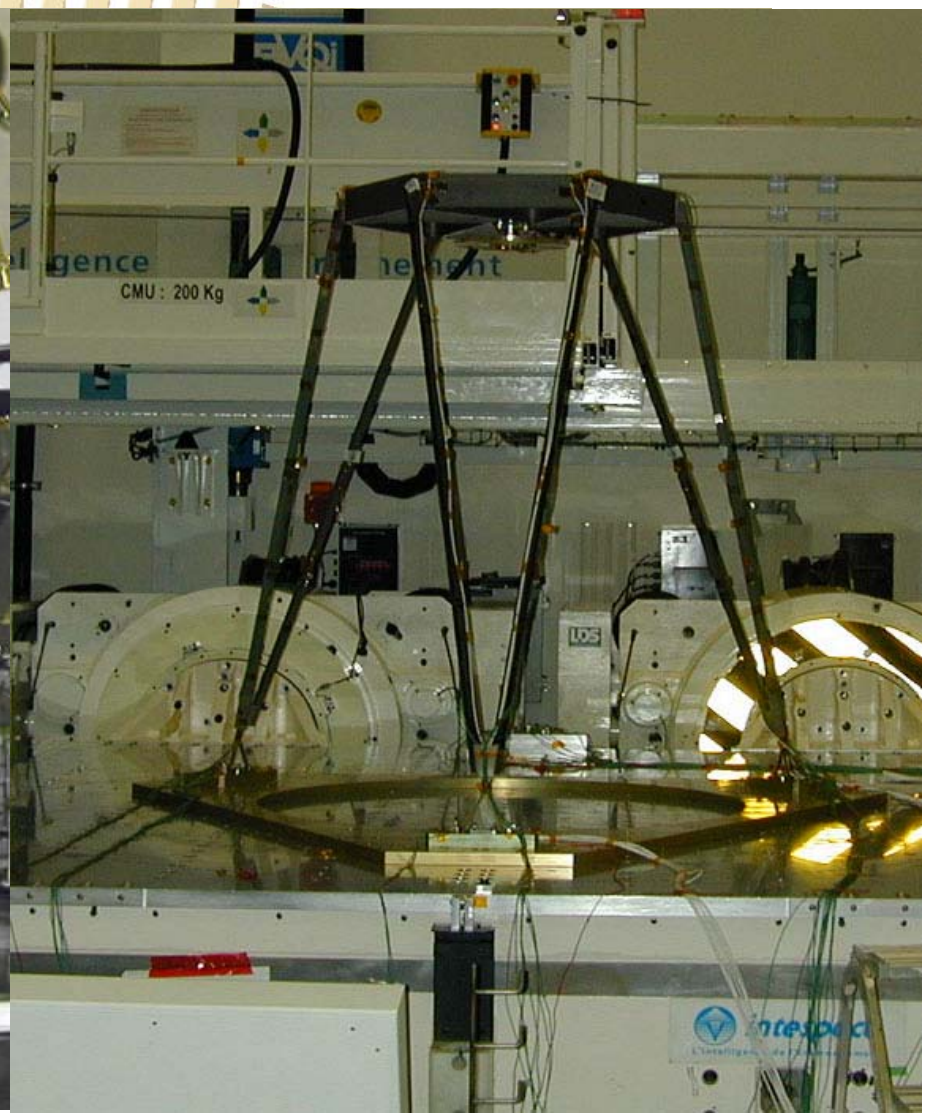
HERSCHEL SPACE OBSERVATORY

Grinding of primary mirror finished

HERSCHEL SPACE OBSERVATORY

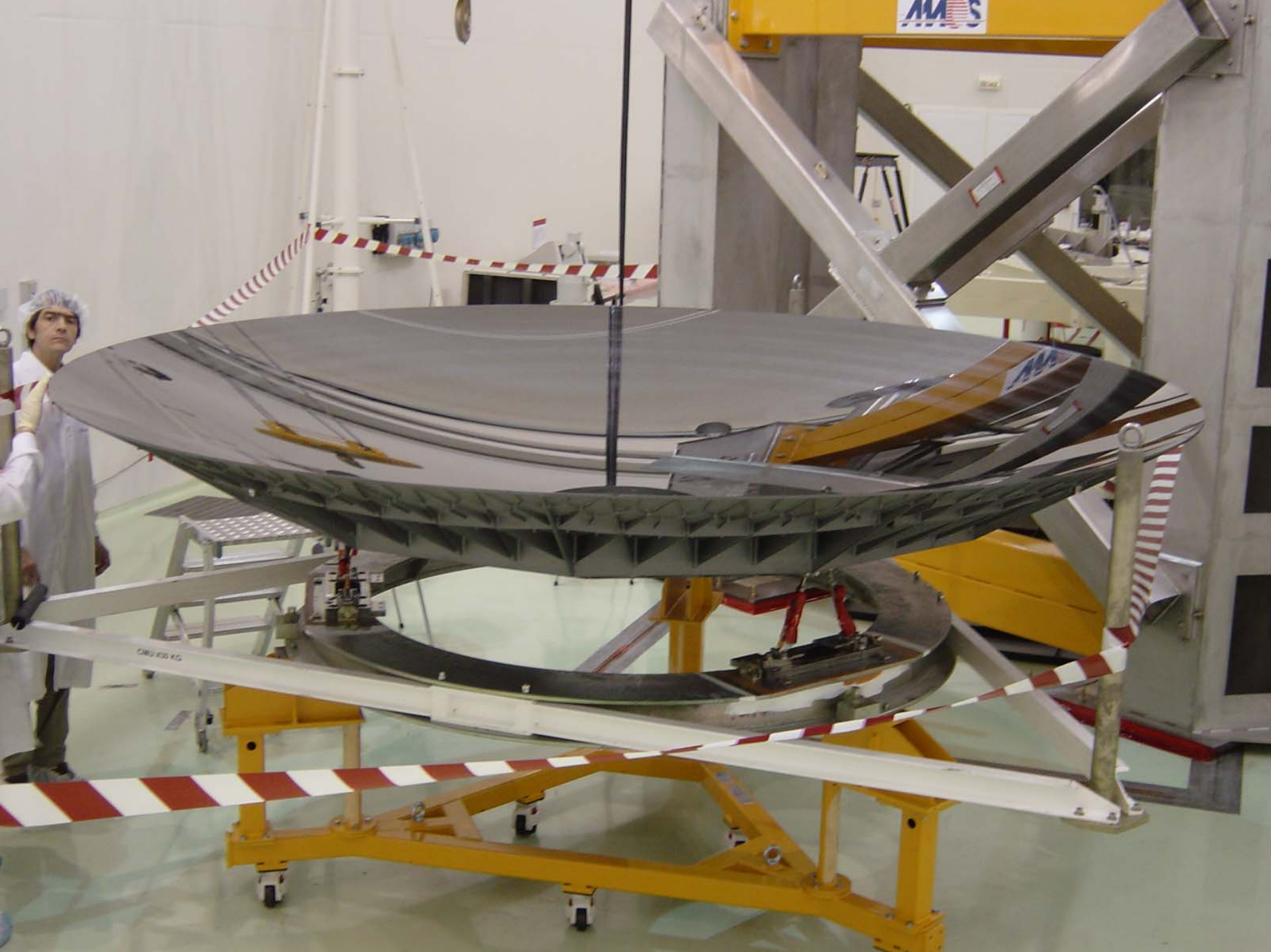
Warm vibration





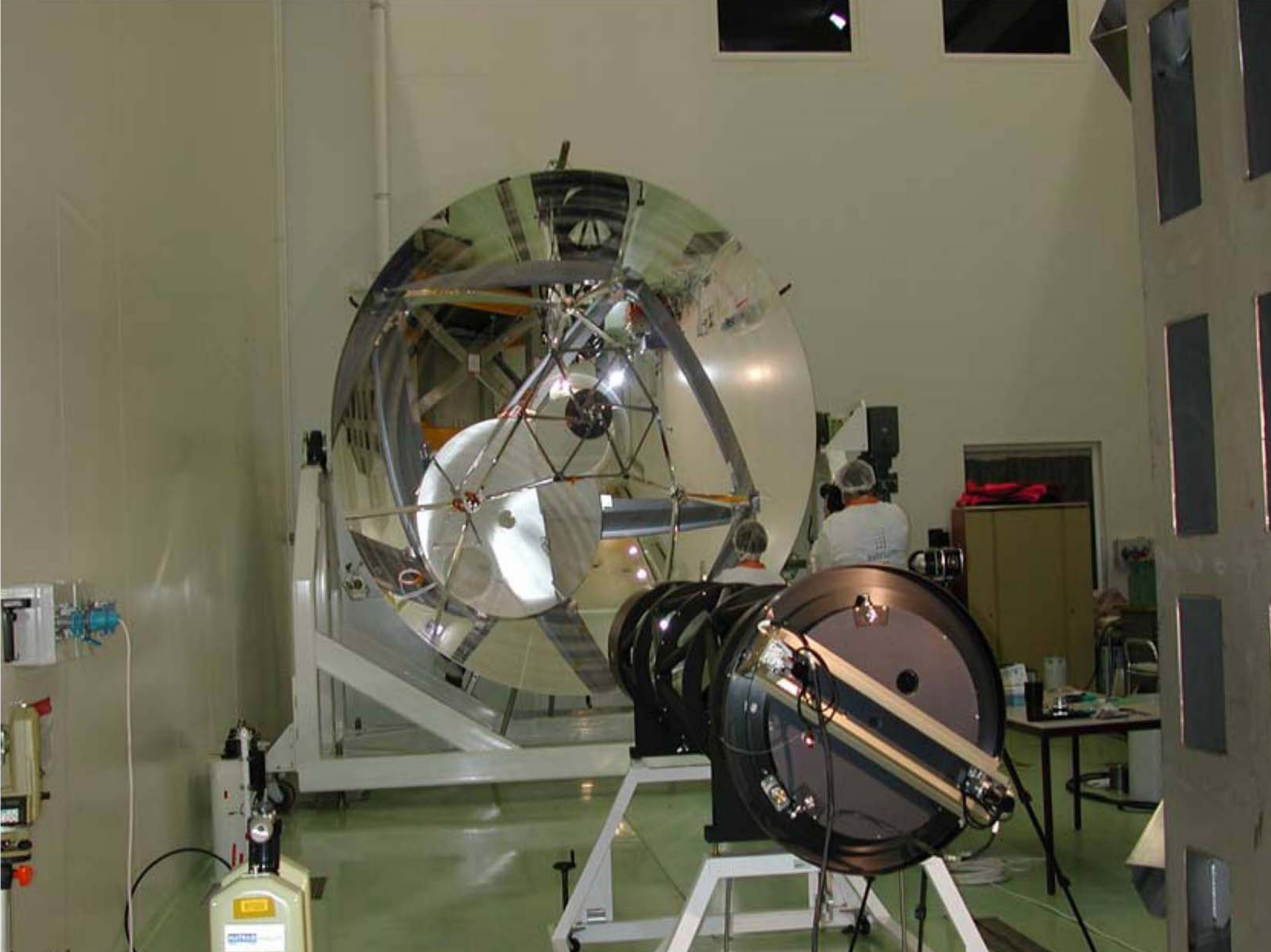
HERSCHEL SPACE OBSERVATORY

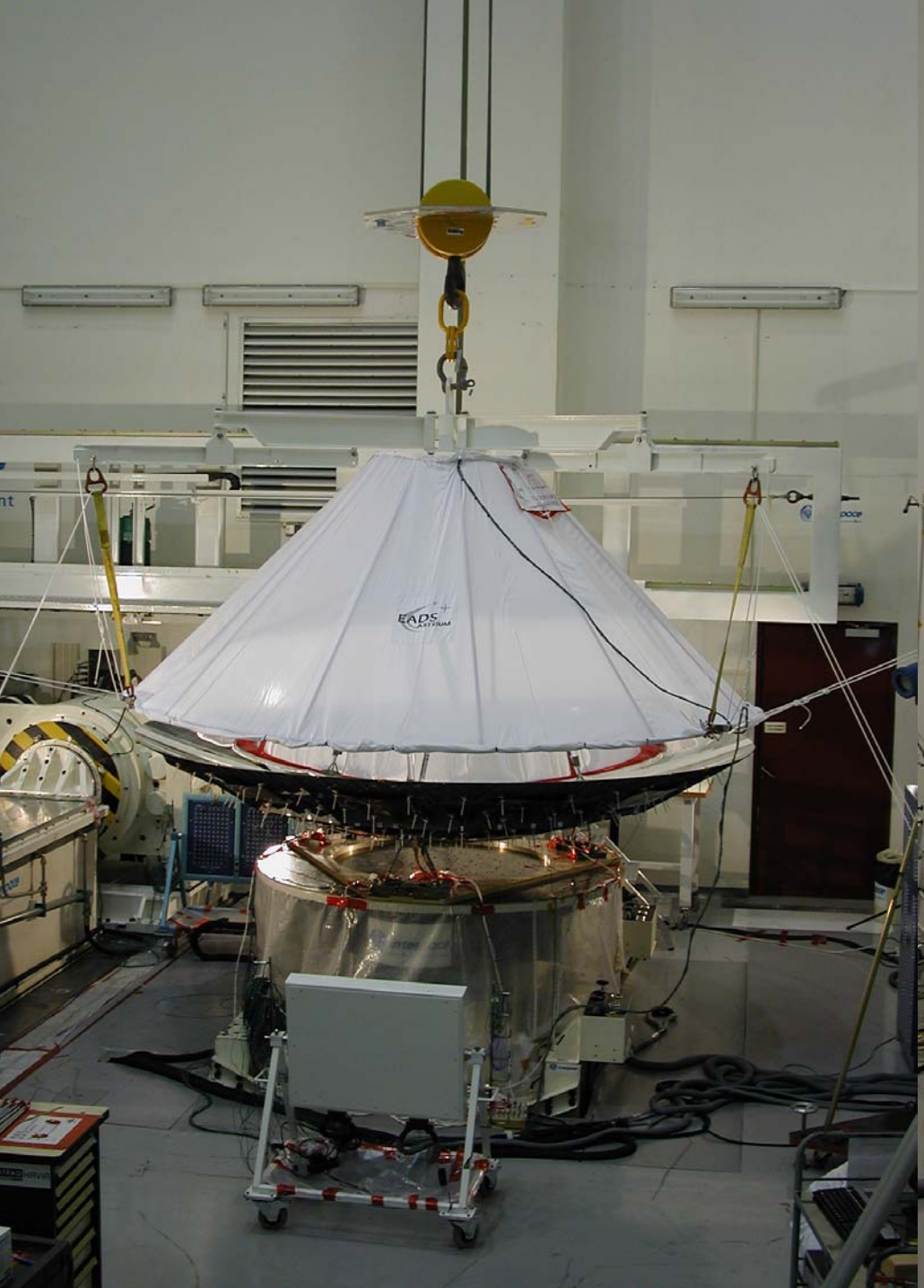
Polishing



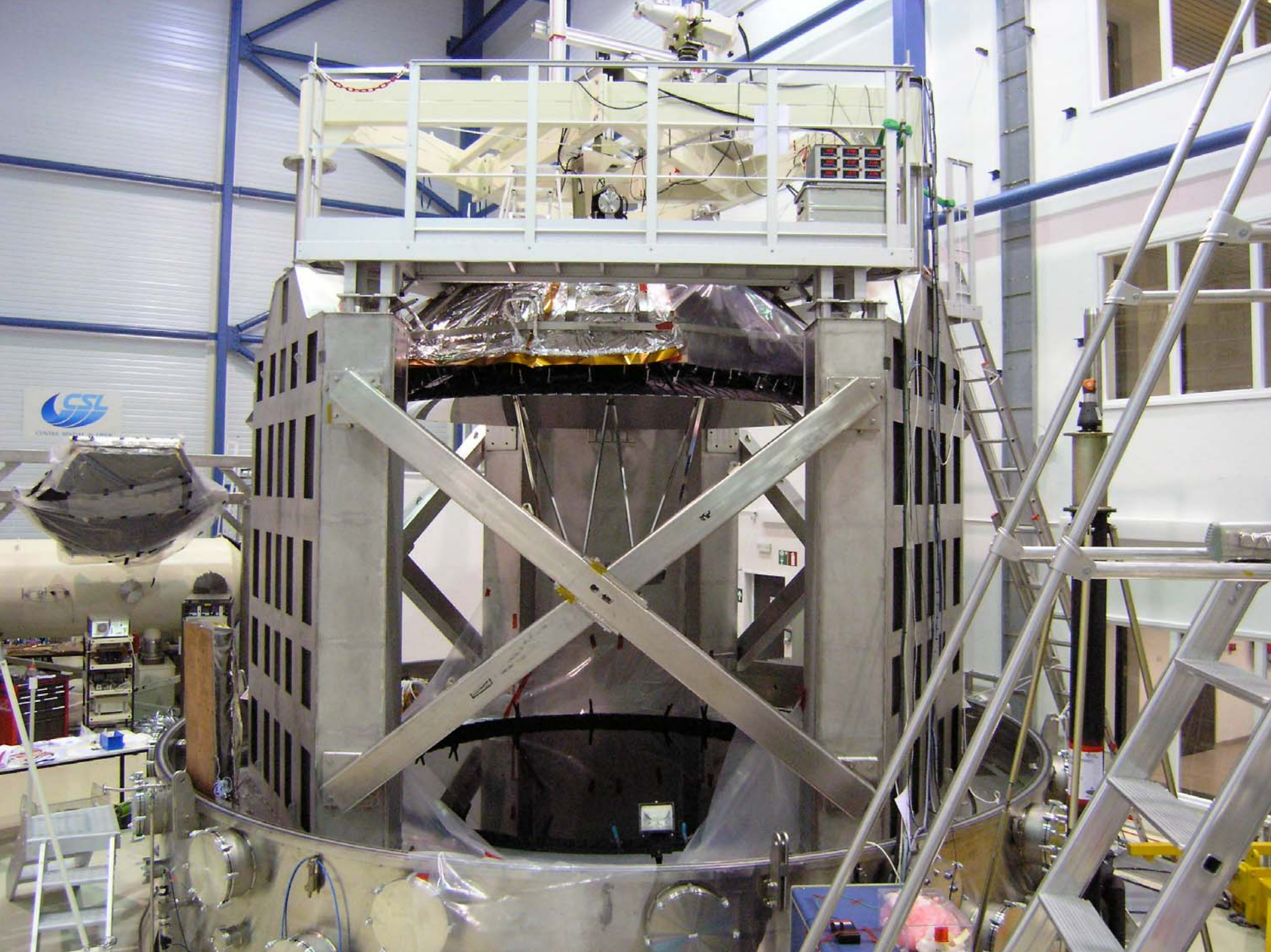
Coating campaign

HERSCHEL SPACE OBSERVATORY




EADS
ASTRIUM

intespace

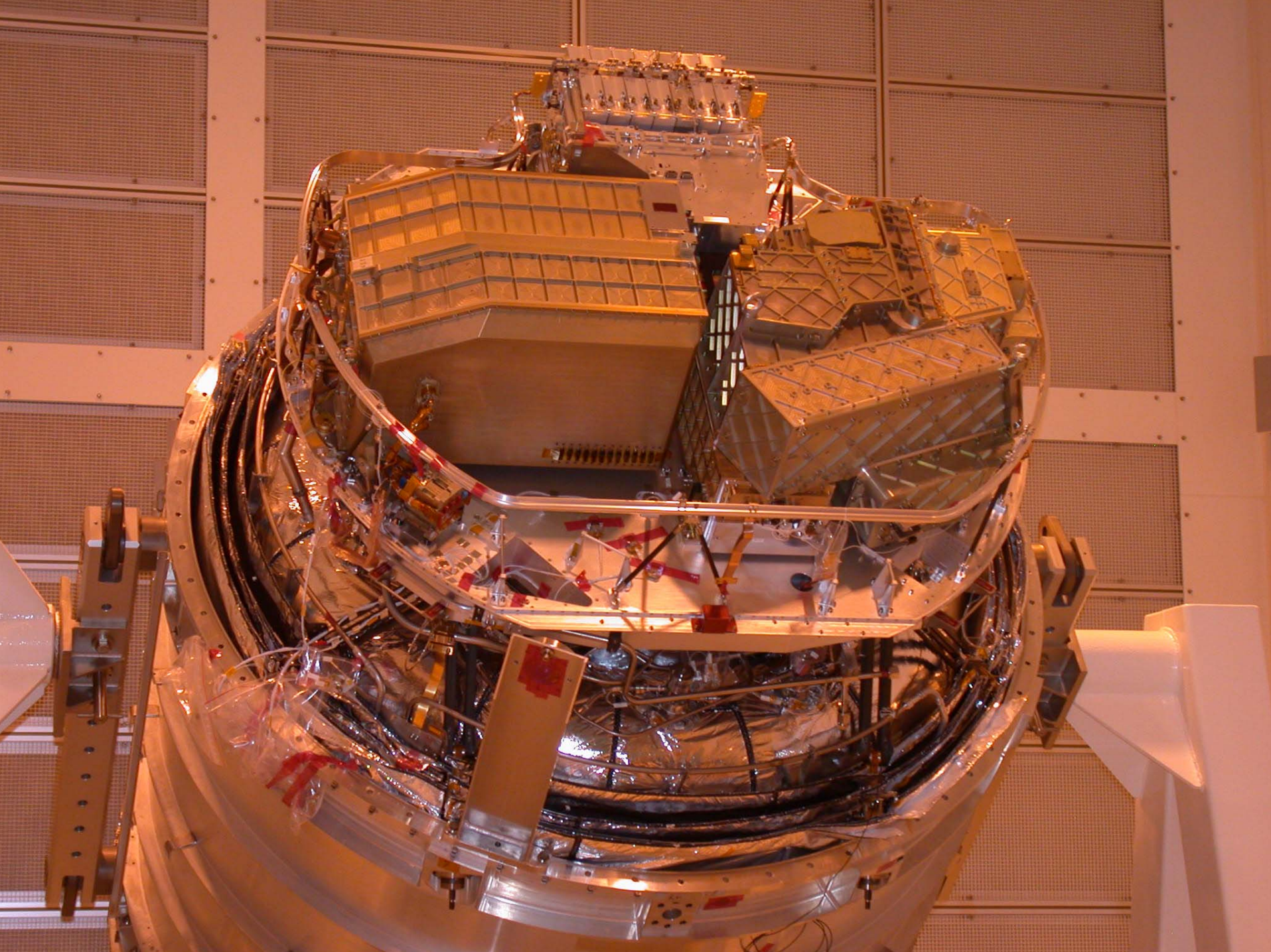


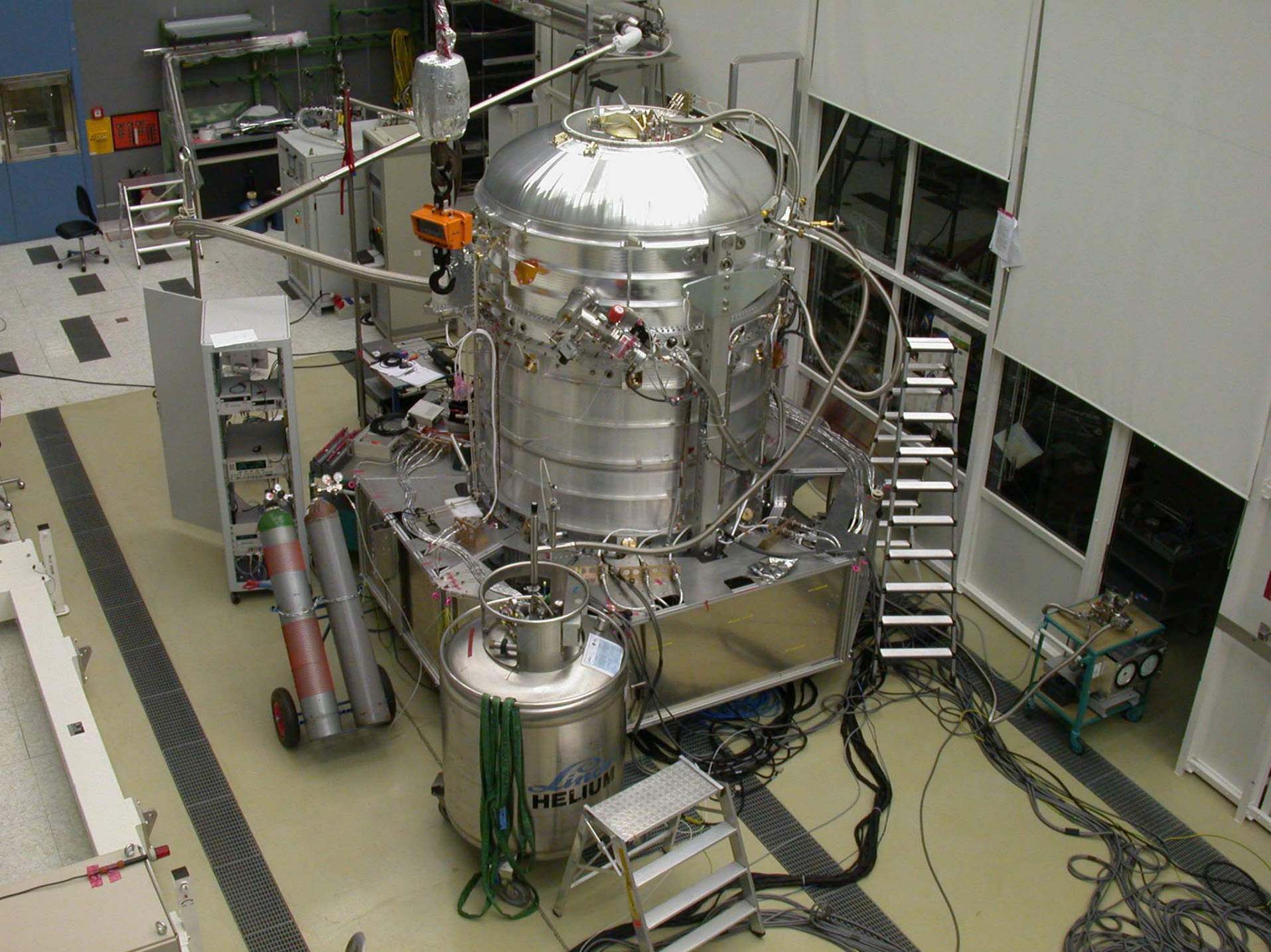
Herschel telescope

- **PFM telescope completed in August 2005**
  - warm aligned and characterised
  - fulfils all requirements
- **Vibrated warm in Intespace**
- **Undergoing lengthy cryo-testing campaign in CSL**
- **Main results**
  - ‘focus-shift’ issue discovered on first cooldown
  - confirmed on subsequent cooldowns
  - systematic cause-tree analysis
  - considered a telescope feature – not a measurement problem
  - initial ‘explanation’ proven wrong – confidence issue
  - current favourite explanation CTE issues – sample tests being performed – healthy scepticism
  - investigations are still ongoing

Herschel EQM

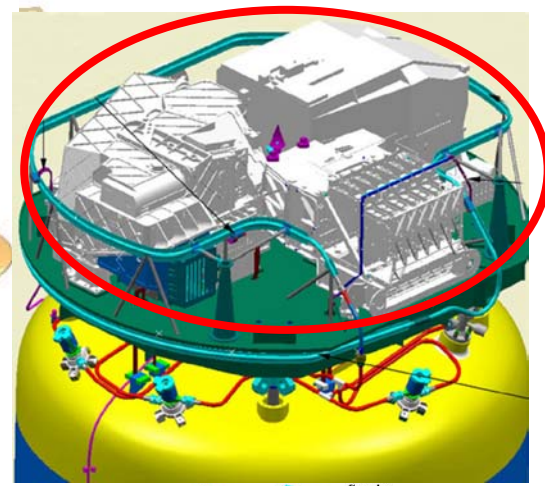
- **EQM campaign conducted in 2nd half 2005**
  - original objective was testing/validating flight-like instruments under flight-like conditions
  - using 'refurbished/rebuilt' ISO hardware to provide a Herschel 'optical bench environment simulator'
  - using science instrument FPU CQMs
  - useful tests performed, partial fulfilment of objectives
- **Main results**
  - we can operate the instruments – but the whole testing campaign needs to be much better prepared and supported
  - straylight environment in EQM unacceptable – implications for the FM being assessed
  - predicted PACS H-field susceptibility confirmed
  - unexpected SPIRE E-field susceptibility discovered




HELIUM

Herschel science payload

- telescope diameter 3.5 m
- telescope WFE < 6 μm
- telescope temp < 90 K
- telescope emissivity < 4%
- abs/rel pointg (68%) < 3.7” / 0.3”
- science instruments 3
- science data rate 130 kbps
- cryostat lifetime > 3.5 years
- height / width ~ 7.5 / 4 m
- launch mass ~ 3200 kg
- power ~ 1500 W
- orbit ‘large’ Lissajous around L2
- solar aspect angle 60-120 deg
- launcher (w Planck) Ariane 5 ECA



PACS

- **PACS - Photodetector Array Camera and Spectrometer**
  - PI: Albrecht Poglitsch, MPE, Garching, Germany
  - Co-PI: Christoffel Waelkens, KU Leuven, Belgium

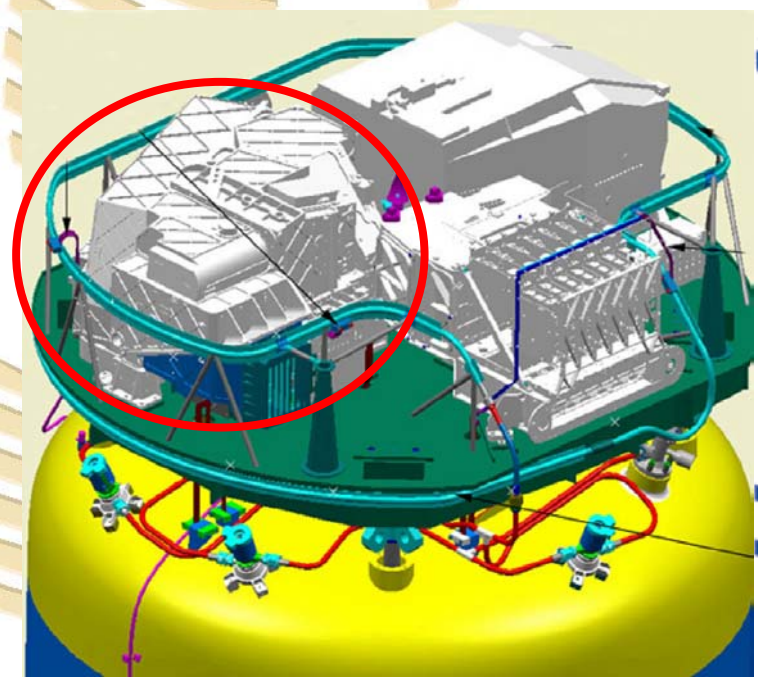
3-band imaging photometer

λ (μm)	**75**	**110**	**170**
FWHM (arcsec)	**6**	**8**	**12**
λ/Δλ	**2.5**	**2.8**	**2.1**

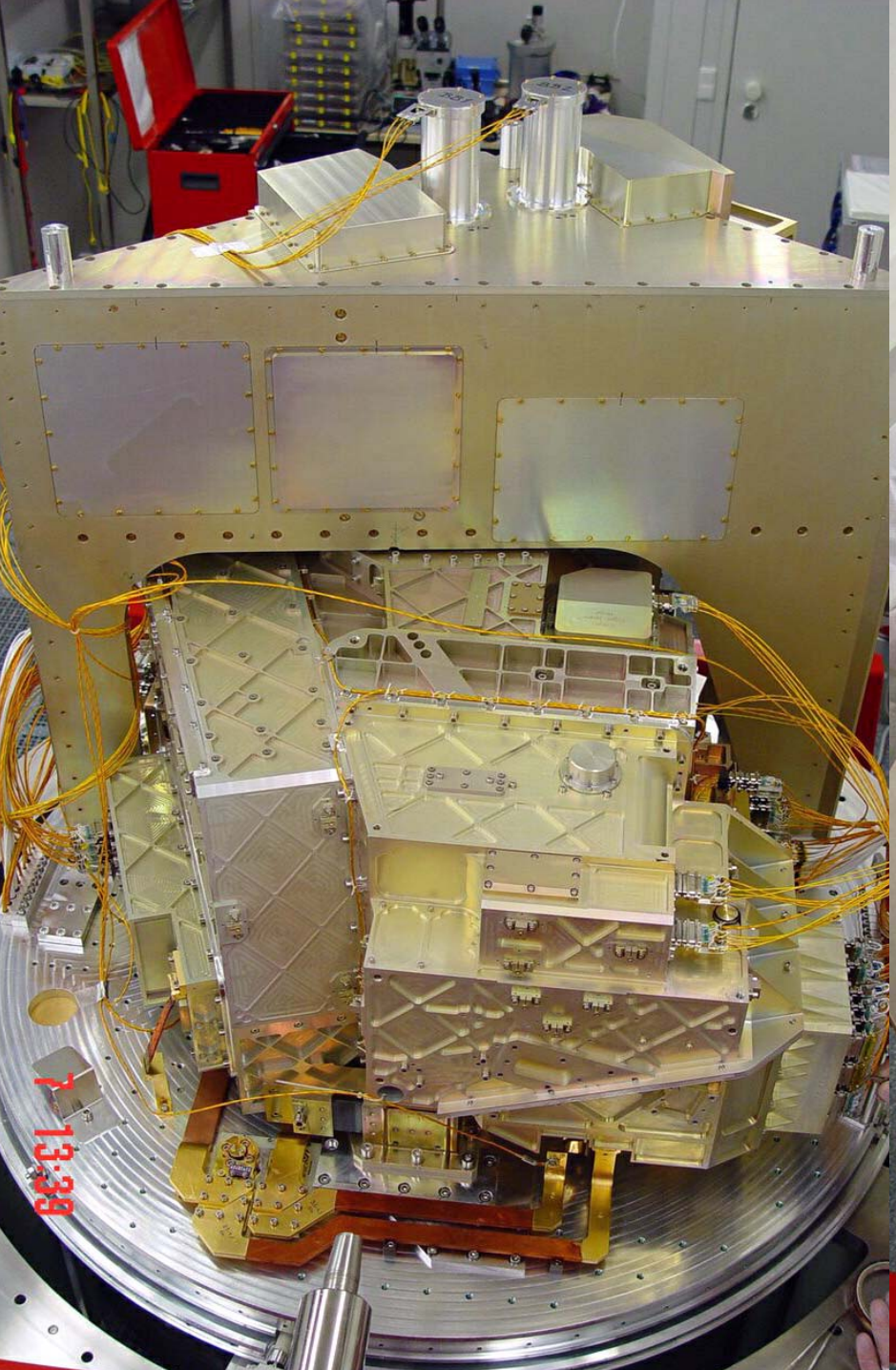
- **Simultaneous 170 μm and (75/110) μm**
- **3.5 x 1.75 arcmin field of view**

Imaging line spectrometer

- **Field of view (arcmin) 0.8 x 0.8**
- **Wavelength range 57 - 210 μm**
- **λ/Δλ 1500-3000**



HERSCHEL SPACE OBSERVATORY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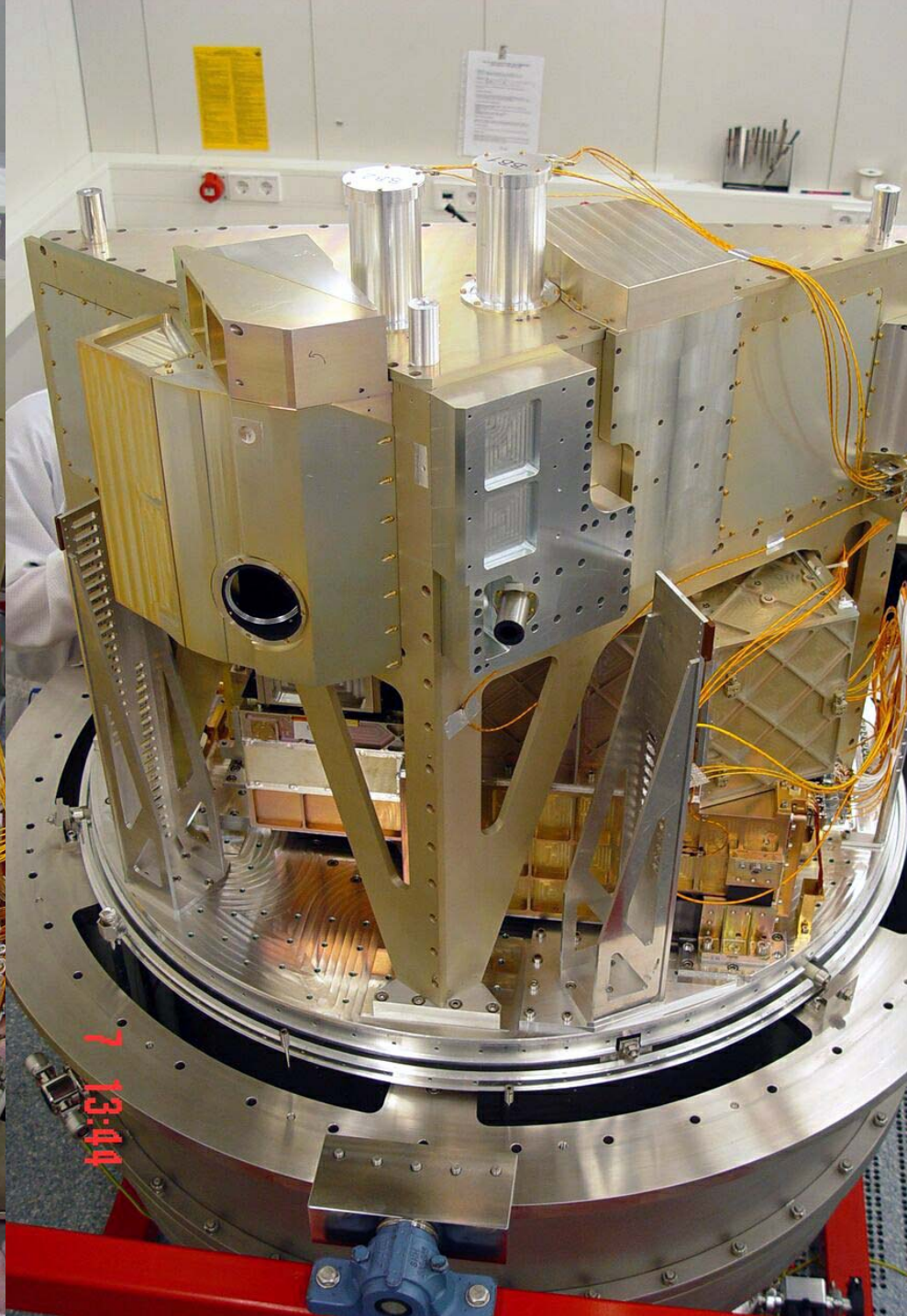
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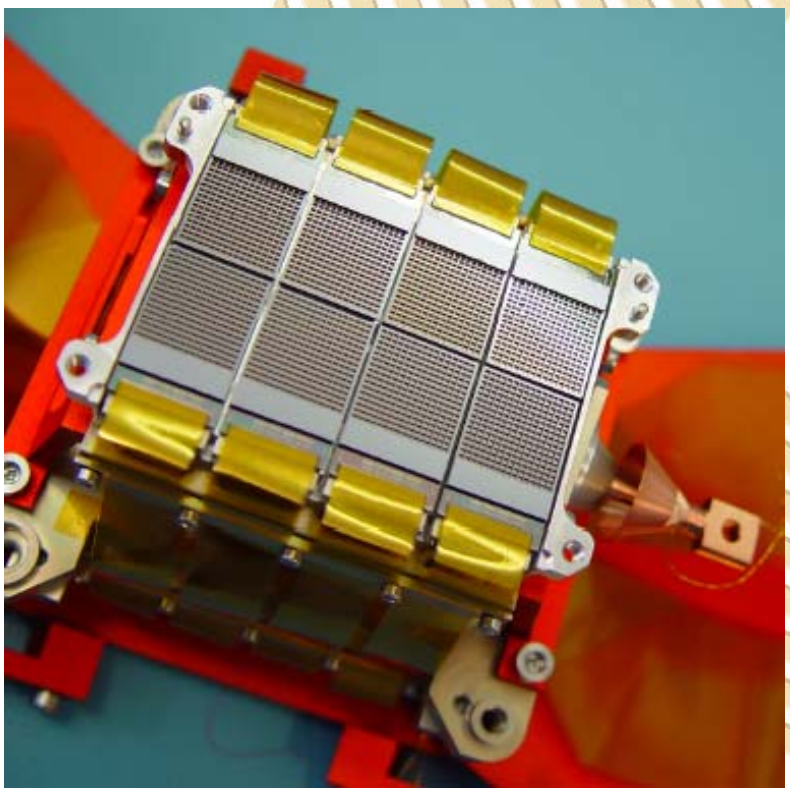
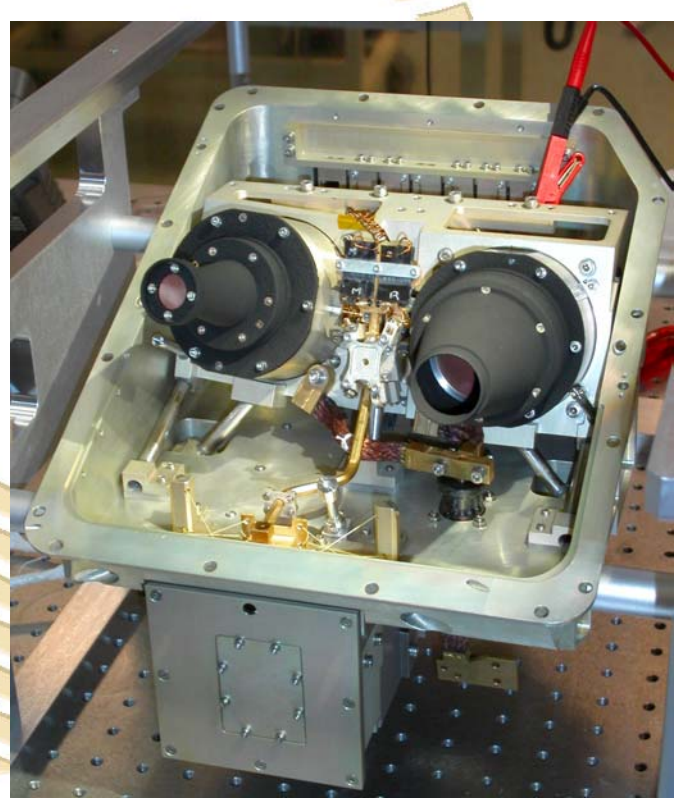
Bolometer arrays for photometry

- filled arrays: 64x32 pixels (blue) and 32x16 pixels (red)
- bolometers and multiplexing cryogenic (0.3 K) readout electronics
- internal 0.3 K sorption cooler with 48 hr hold time
- ~near background-noise limited performance demonstrated

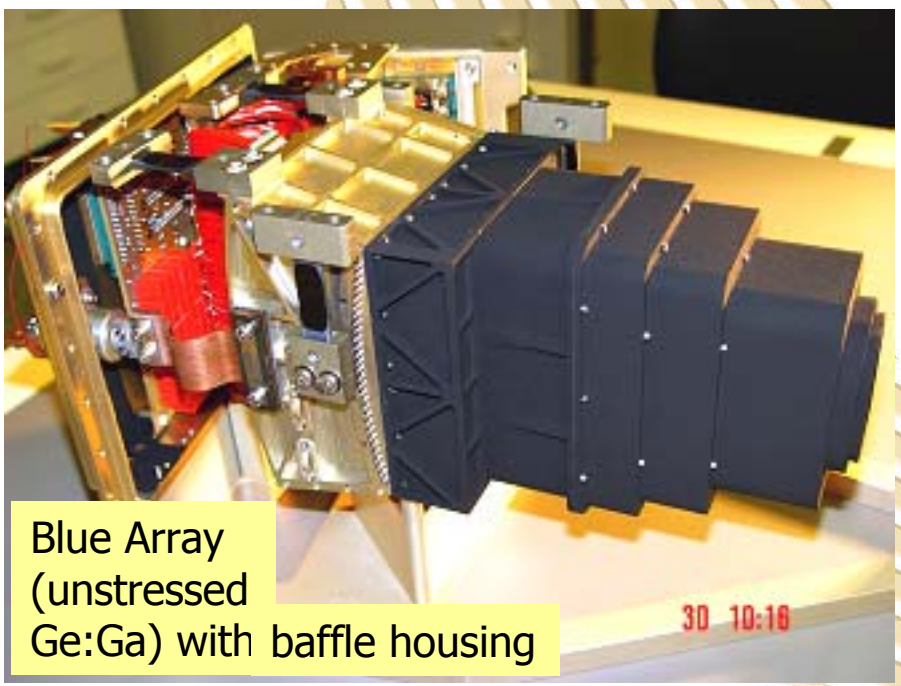




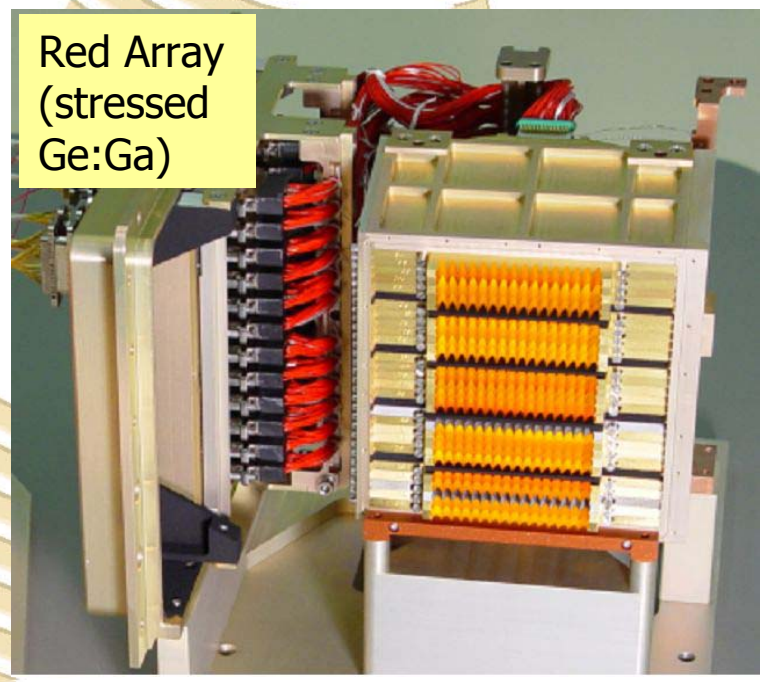
HERSCHEL SPACE OBSERVATORY

Photodetectors for spectroscopy

- 16x25 pixel Ge:Ga extrinsic photoconductor filled arrays
- 25 linear modules of 16 pixels (stressed/unstressed
- integrated cryogenic readout electronics (CTIA/multiplexer)
- near background-noise limited performance (read array)
- noise x2 above background-noise limited perf (blue array)



Blue Array (unstressed Ge:Ga) with baffle housing

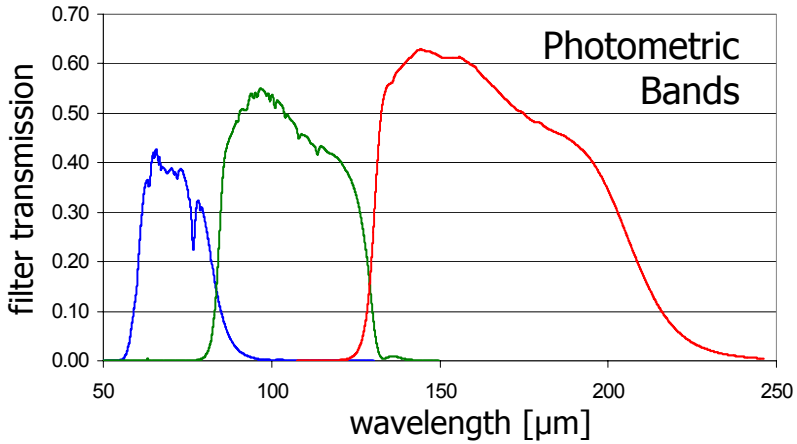


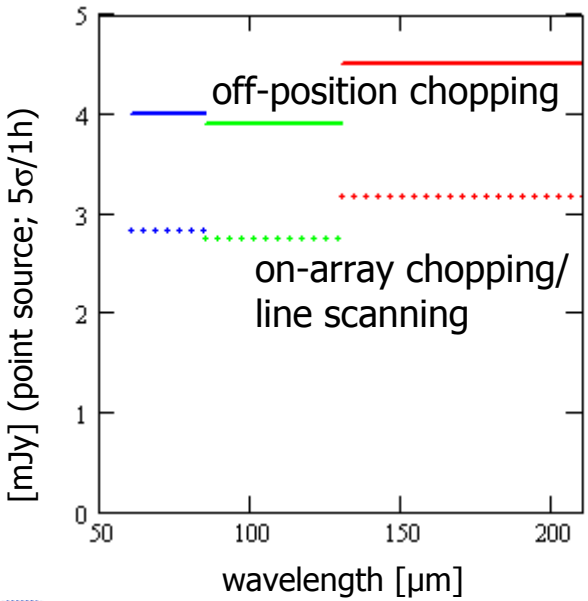
Red Array (stressed Ge:Ga)

HERSCHEL SPACE OBSERVATORY

Predicted performance

Photometry

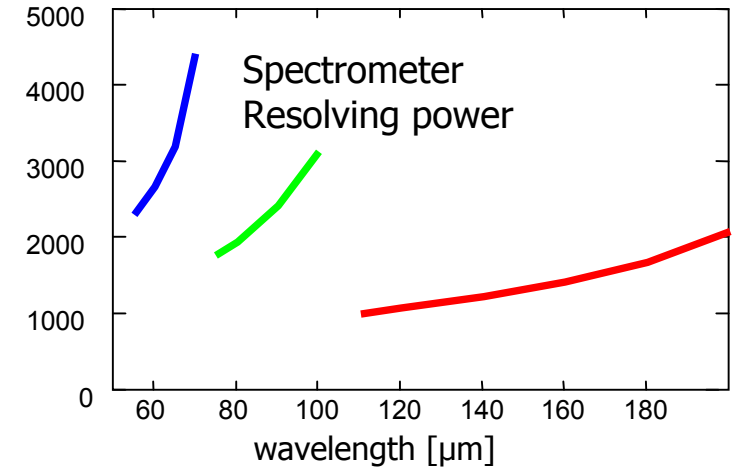


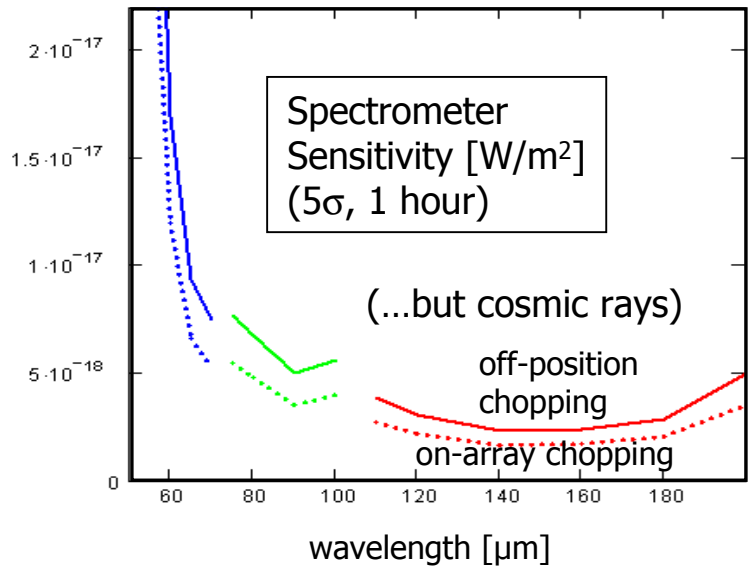


Photometer
Sensitivity

(10'x10'
in 1 day)

Spectroscopy





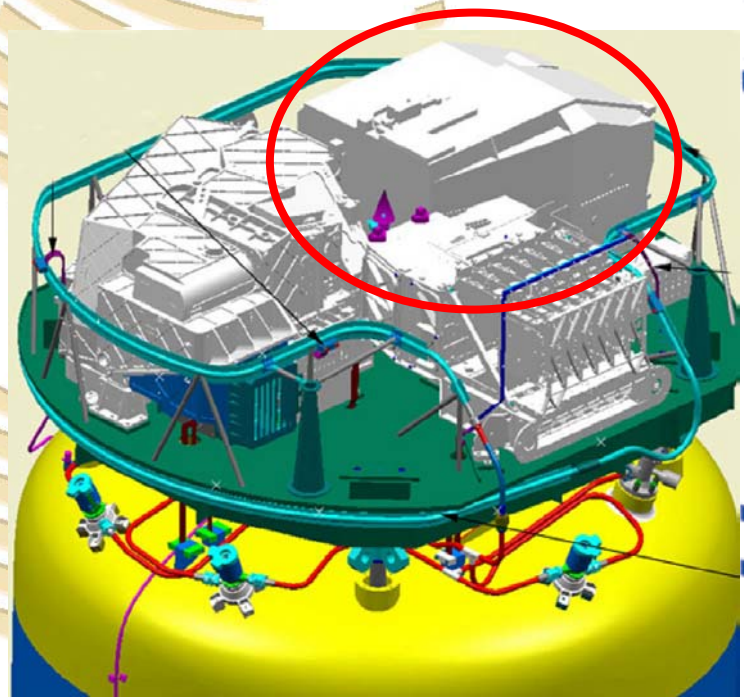
HERSCHEL SPACE OBSERVATORY

SPIRE

- **SPIRE - Spectral and Photometric Imaging REceiver**
  - PI: Matt Griffin, U Cardiff, Cardiff, United Kingdom
  - Co-PI: Laurent Vigroux, CEA, Saclay, France

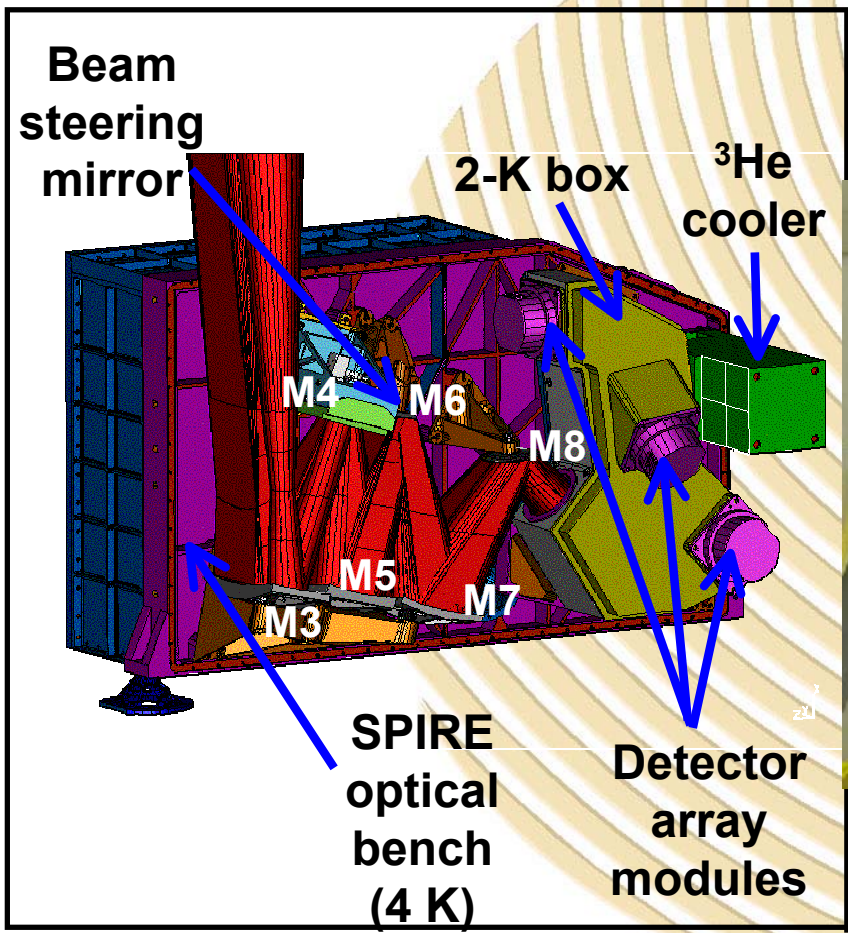
- **3-band imaging photometer**
  - **250, 360, 520 μm (simultaneous)**
  - **$\lambda/\Delta\lambda \sim 3$**
  - **4 x 8 arcminute field of view**
  - **Diffraction limited beams (18, 25, 36")**

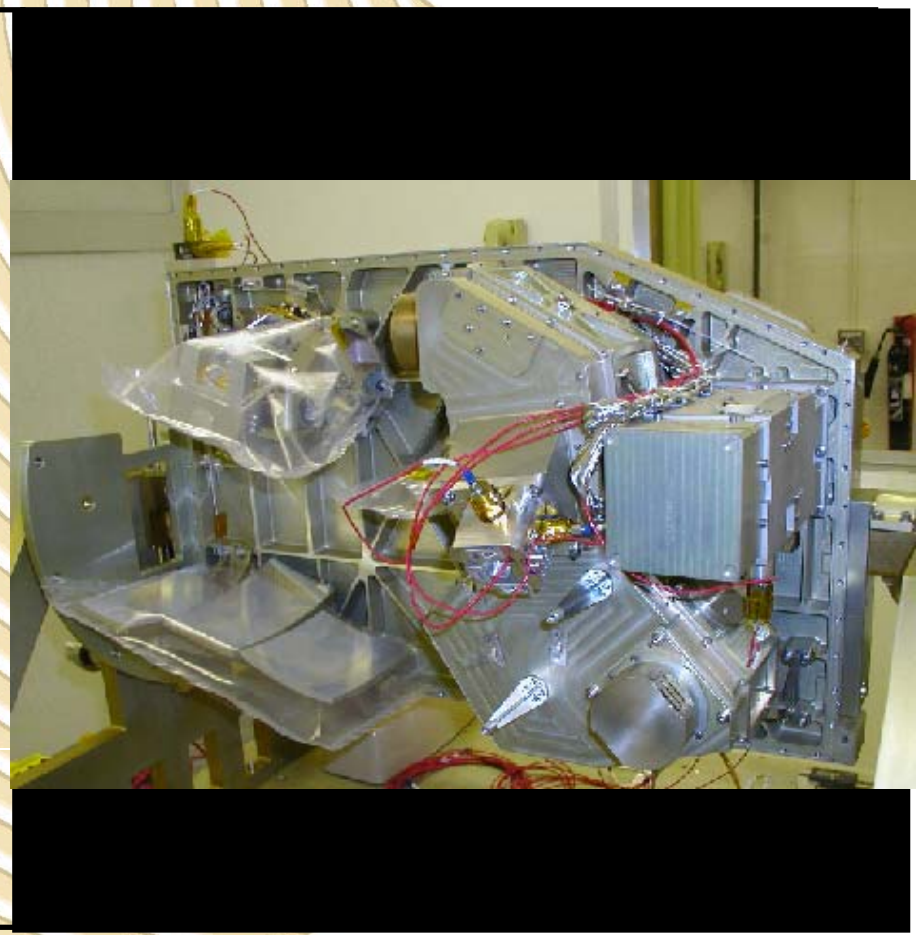
- **Imaging Fourier Transform Spectrometer**
  - **200 - 670 μm**
  - **2.6 arcminute field of view**
  - **$\Delta\sigma = 0.04\ cm^{-1}$ ($\lambda/\Delta\lambda \sim 20 - 1000$ at 250 μm)**



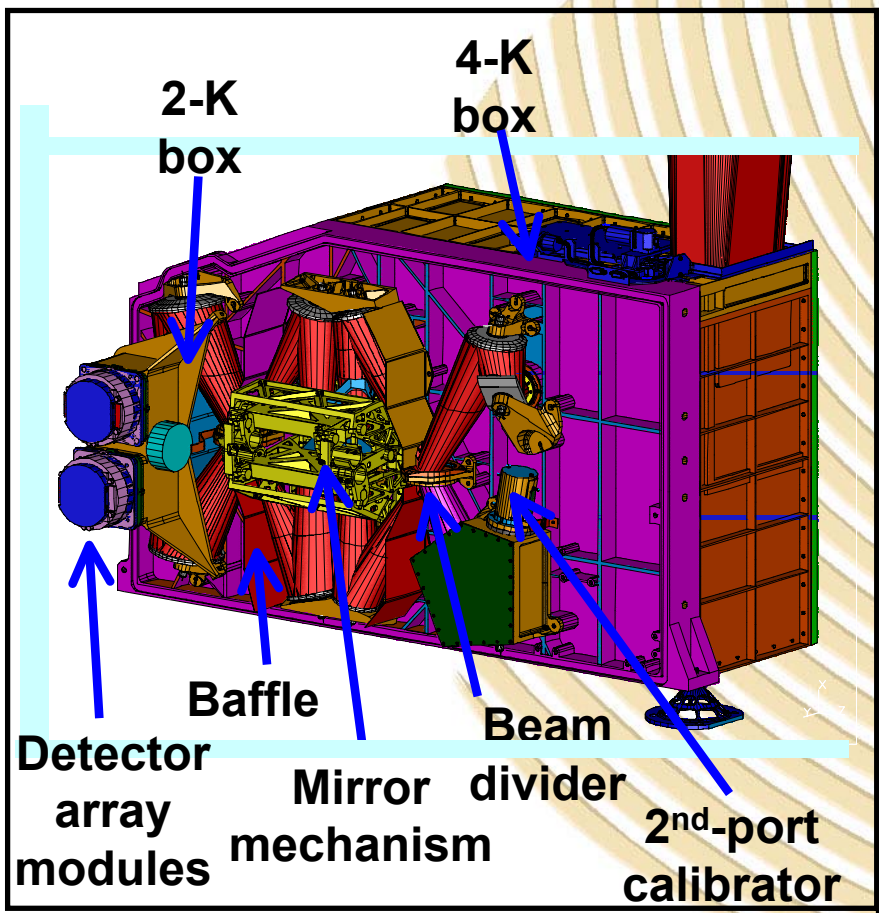
HERSCHEL SPACE OBSERVATORY

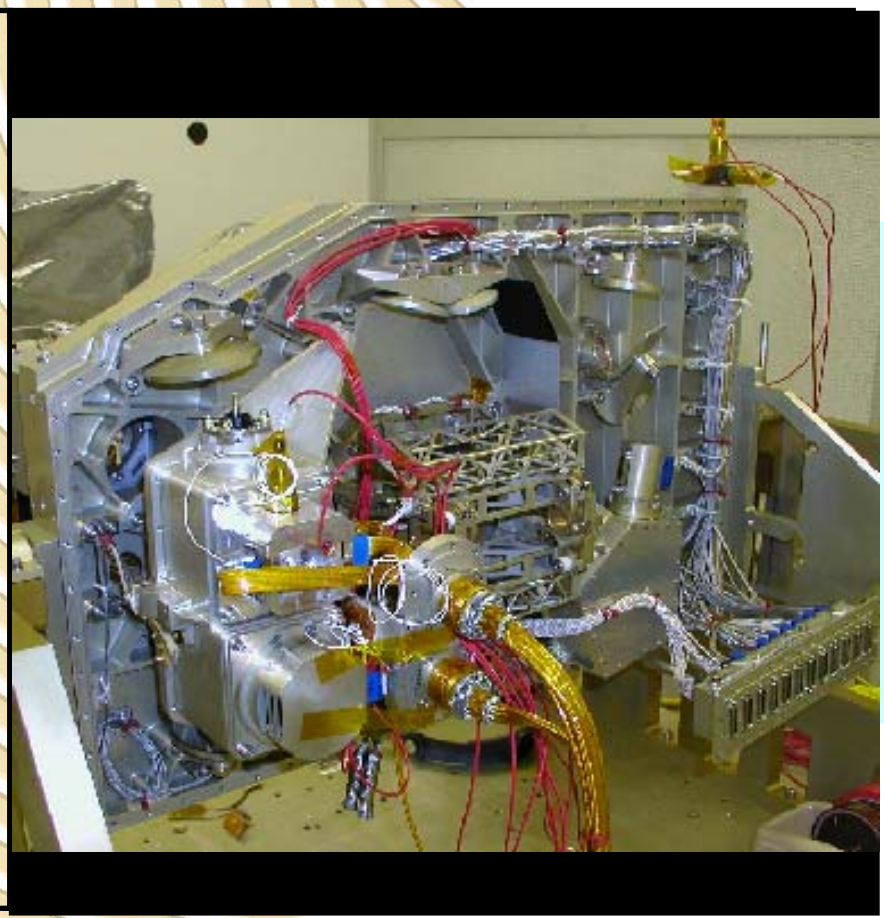
Photometer layout & optics



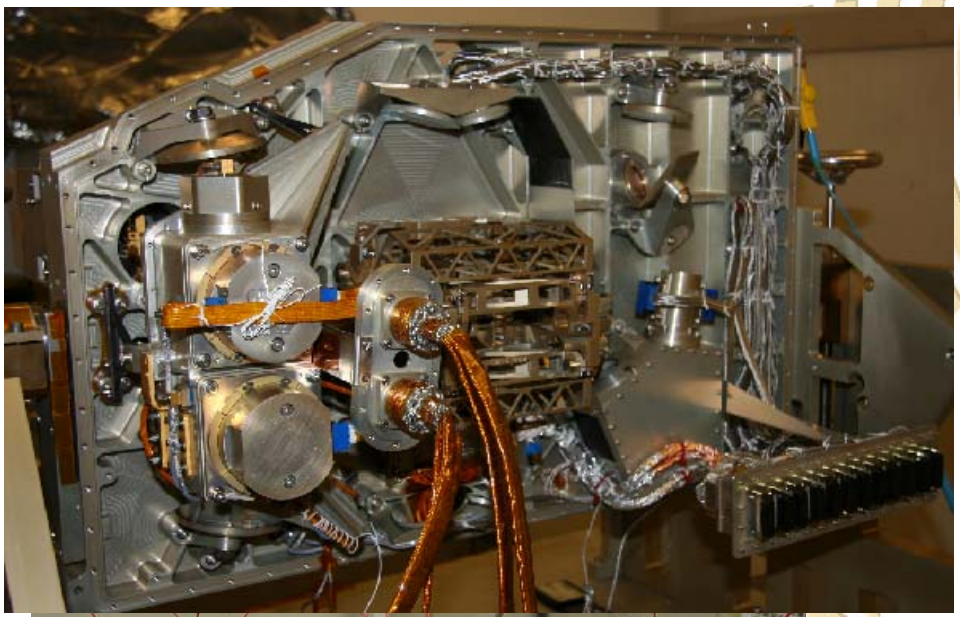


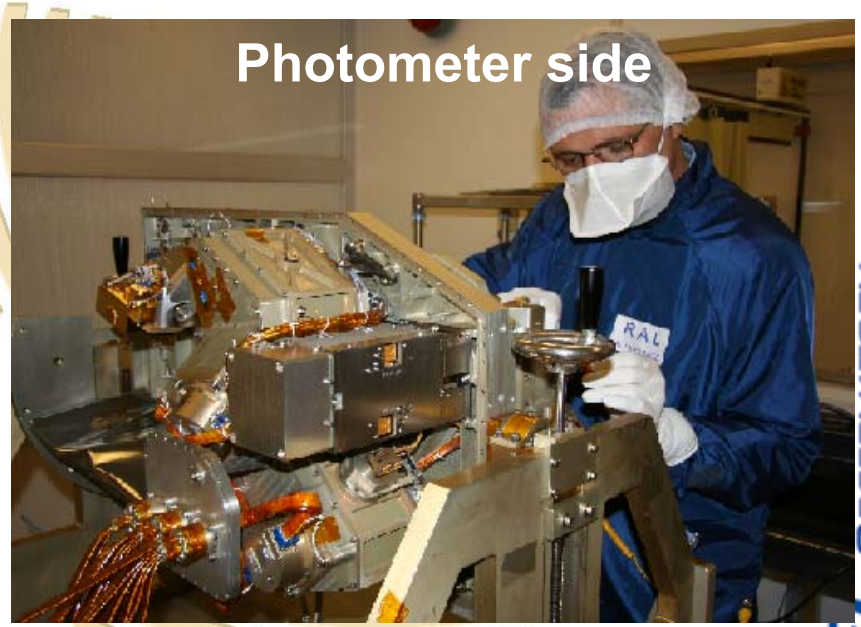
Spectrometer layout & optics

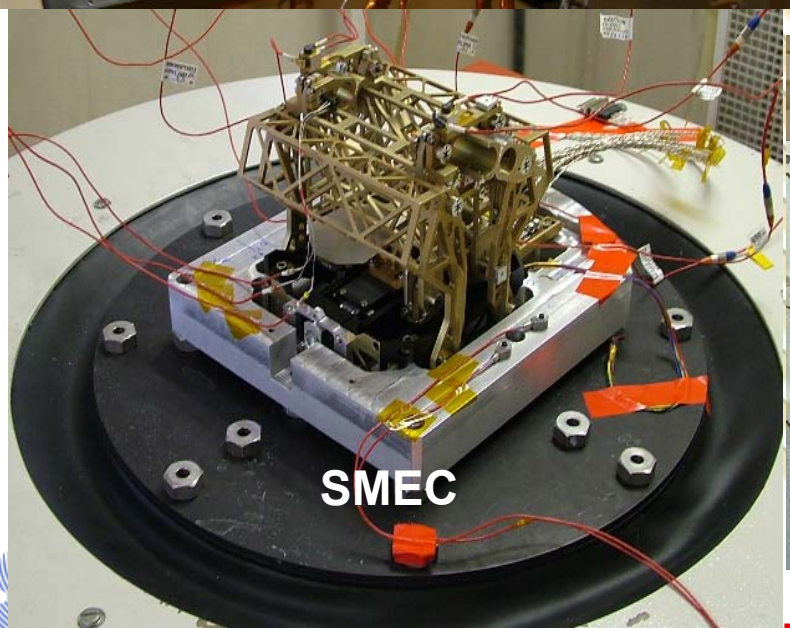


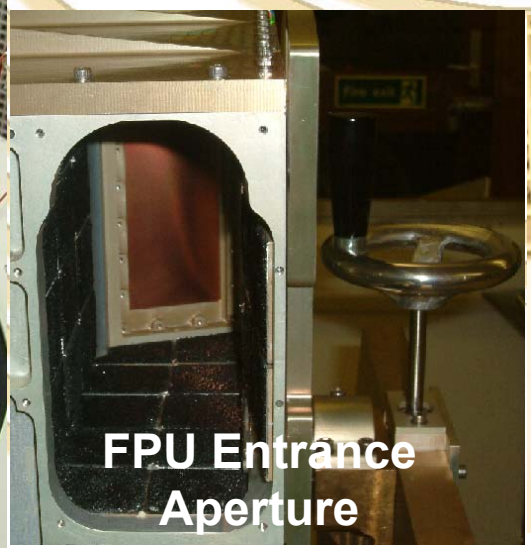


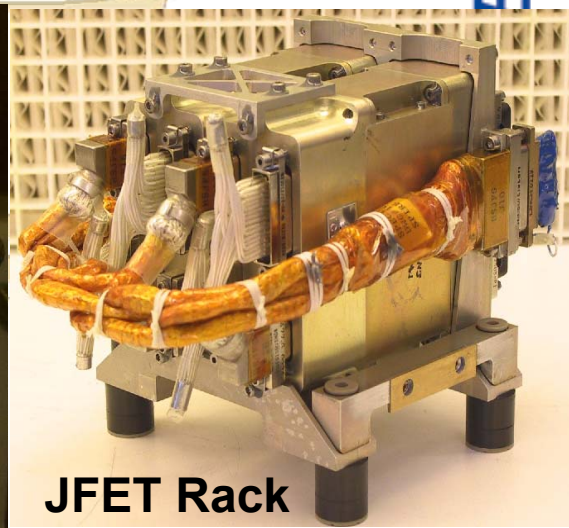
SPIRE flight instrument



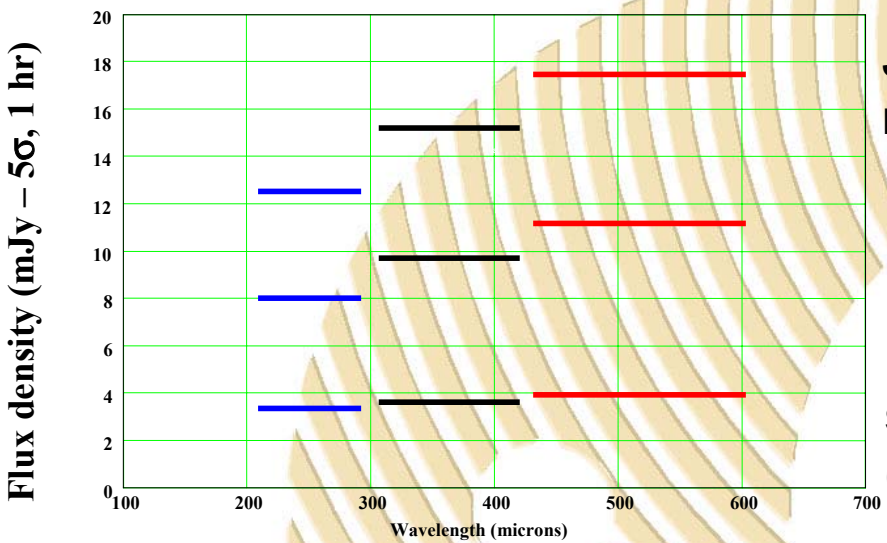








Predicted performance

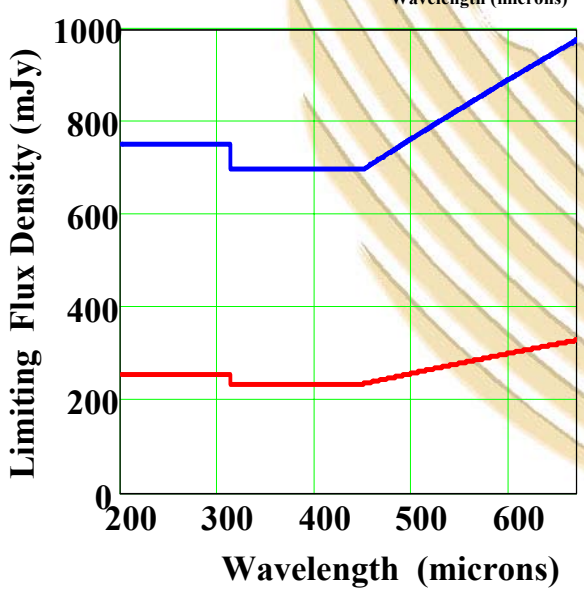


Jiggle map

Scan map

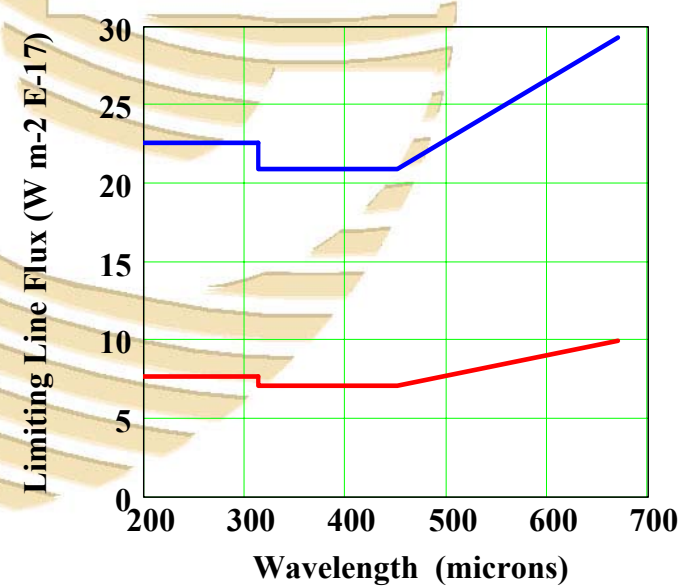
Point source (7-point)

- Photometry
- Spectrophotometry
- Line spectroscopy
- at 5σ, 1 hr



Fully-sampled map

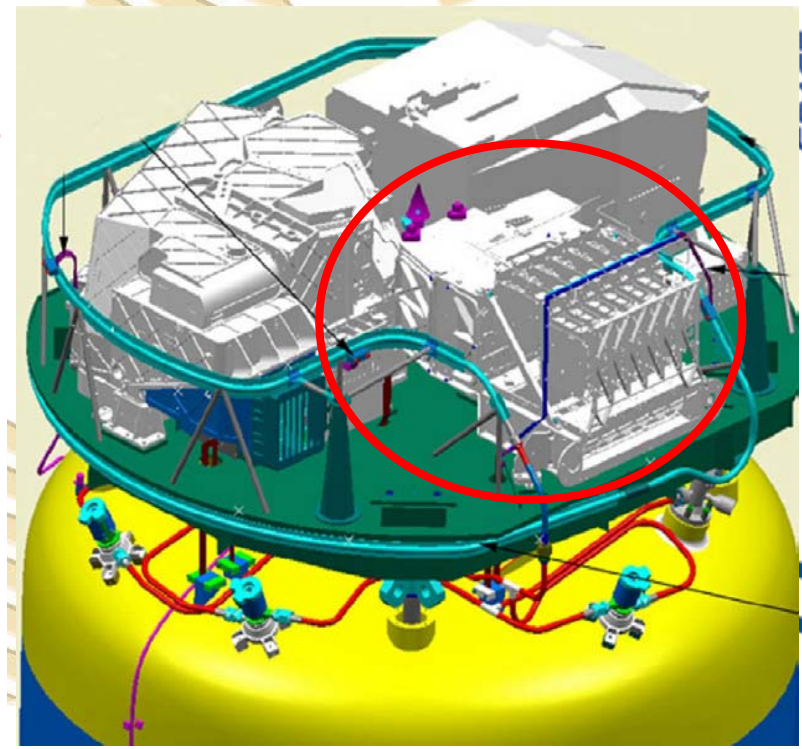
Point source/ sparse map



HERSCHEL SPACE OBSERVATORY

HIFI

- **HIFI - Heterodyne Instrument for the Far Infrared**
  - PI: Thijs de Graauw, SRON, Groningen, The Netherlands
  - Co-PIs: Tom Phillips, Caltech, USA; Jürgen Stutzki, U Köln, Germany; and Emmanuel Caux, CESR, France



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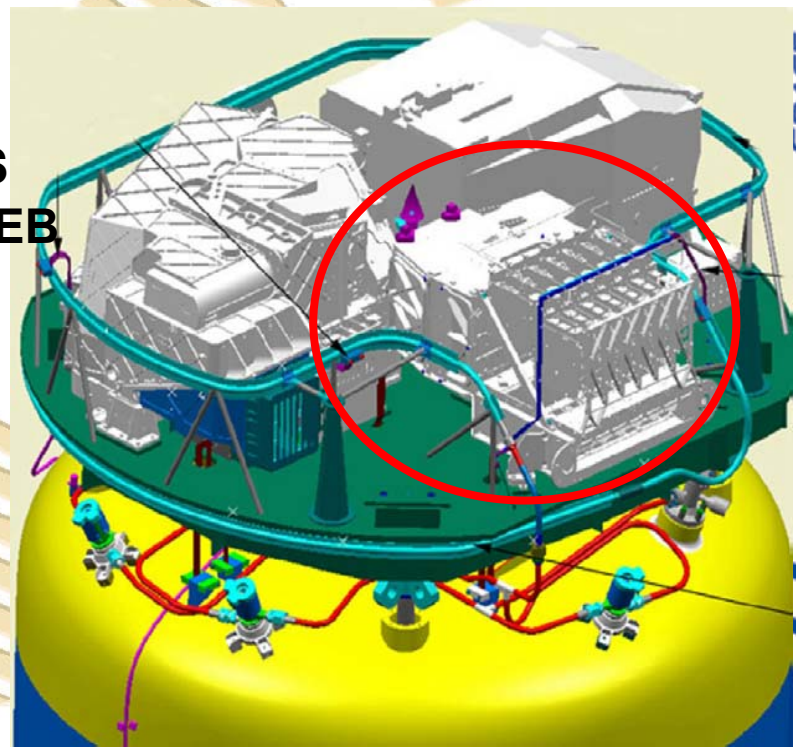
  - Co-PIs: Tom Phillips, Caltech, USA; Jürgen Stutzki, U Köln, Germany; and Emmanuel Caux, CESR, France

- **Seven-channel heterodyne receiver (non-imaging, single pixel on sky)**

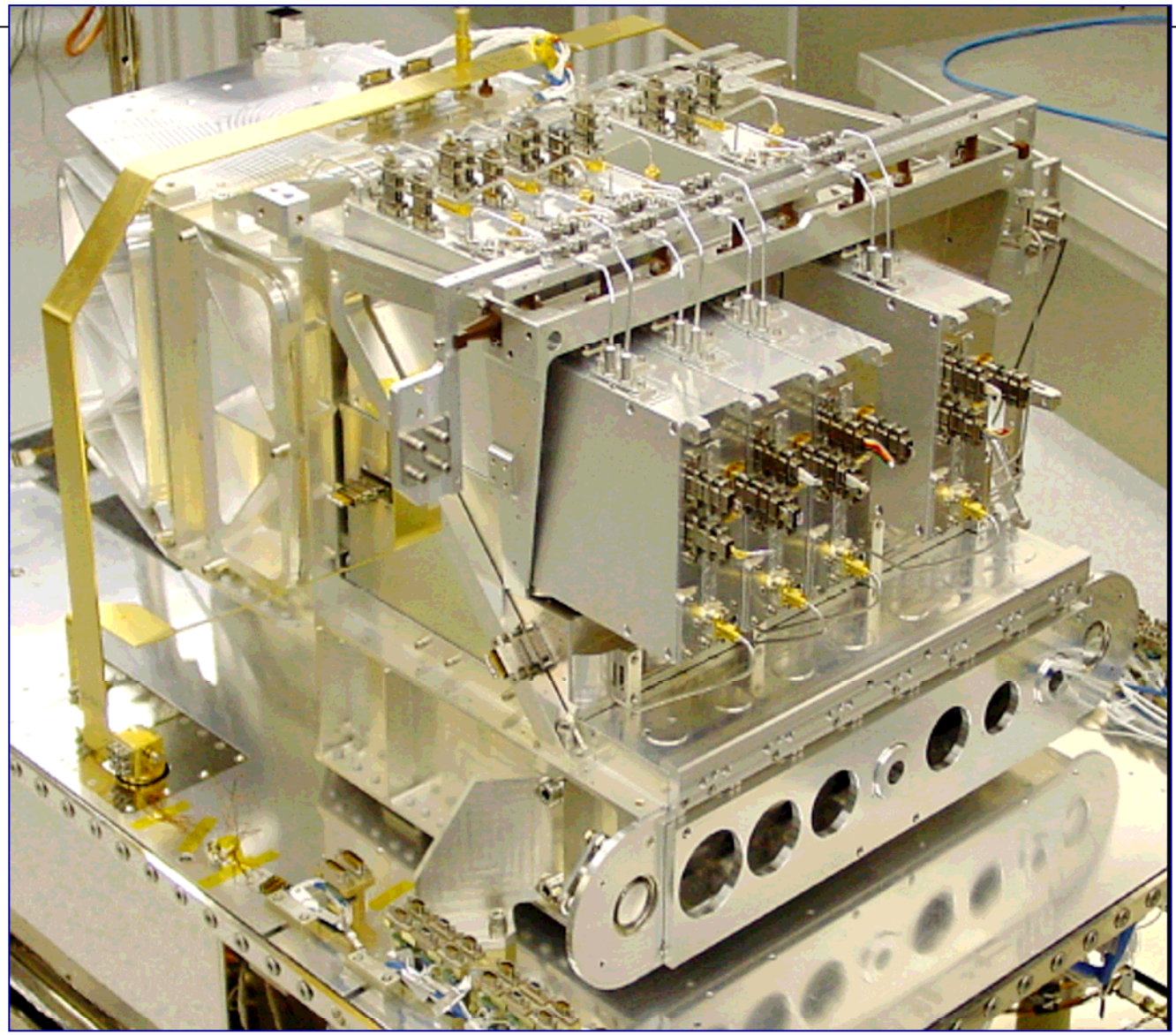
- **Frequency coverage:**
  - **480 - 1250 GHz (625 - 240 μm) SIS**
  - **1410 - 1910 GHz (212 - 157 μm) HEB**
- **Frequency res. 140 kHz - 1 MHz**
  - **auto-correlator spectrometer**
  - **acousto-optical spectrometer**

- **Inst IF BW: 4 (SIS) /2 (HEB) GHz**

- **Beam FWHM 12'' – 45''**

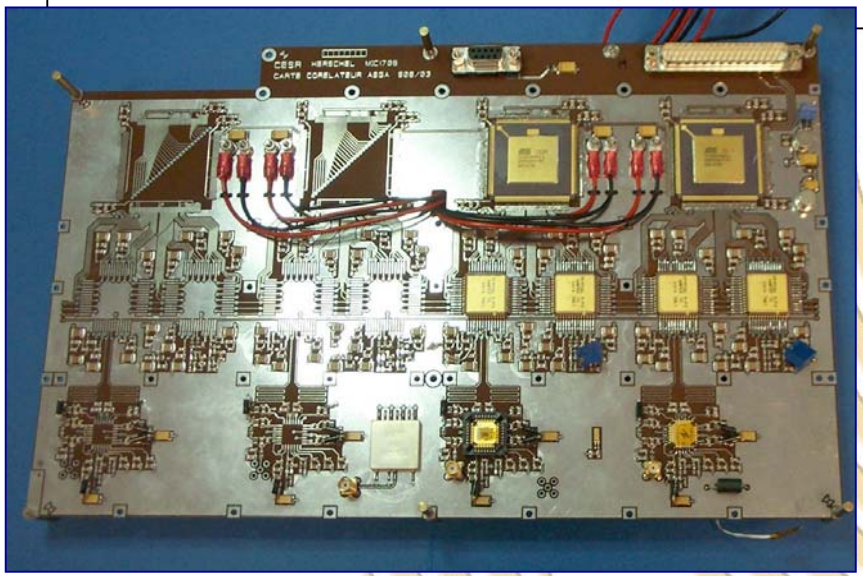


HIFI flight instrument FPU



HERSCHEL SPACE OBSERVATORY

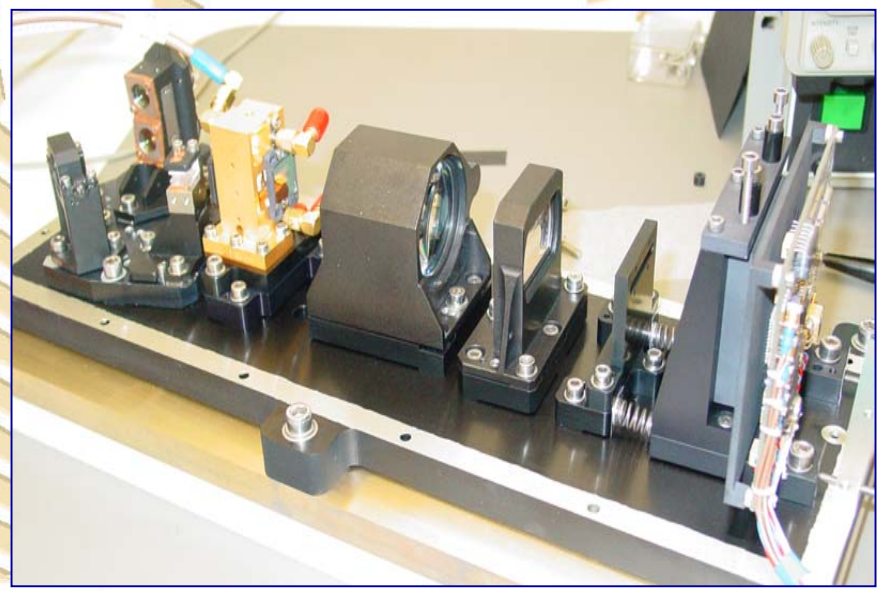
Spectrometers



HRS

Hybrid auto-correlator (del 7 April)

W: 2p x 4b x 500MHz ; 1 MHz
M: 2p x 4b x 250 MHz; 0.54 MHz
N: 2p x 4b x 250 MHz; 0.27 MHz
H: 2p x 1b x 250 MHz; 0.14 MHz



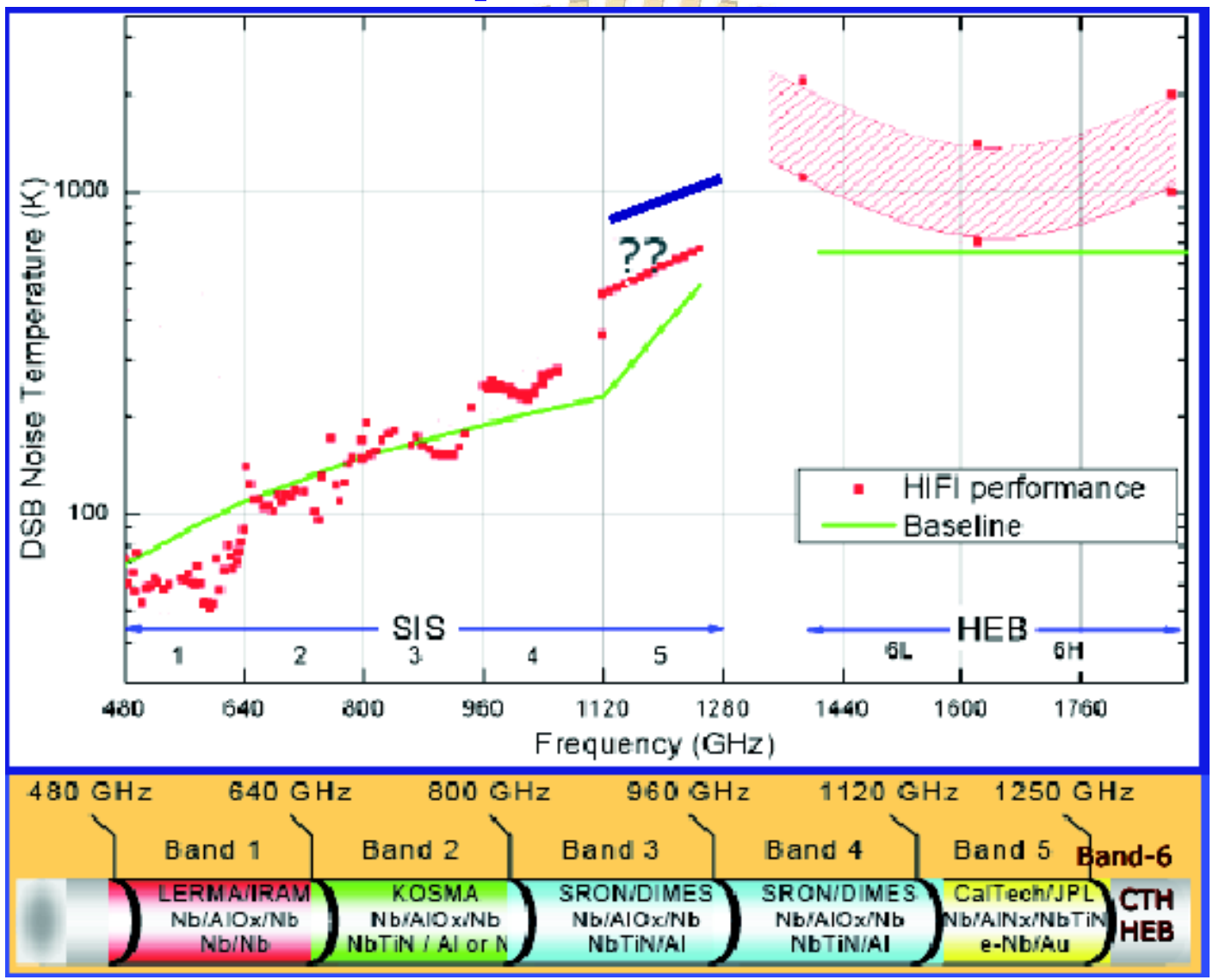
WBS

Acousto-optic spectrometer (redelivery 15 March)

- bandwidth 4 GHz
- resolution 1.1 MHz

HERSCHEL SPACE OBSERVATORY

Mixer performance



HERSCHEL SPACE OBSERVATORY

Herschel observatory capabilities

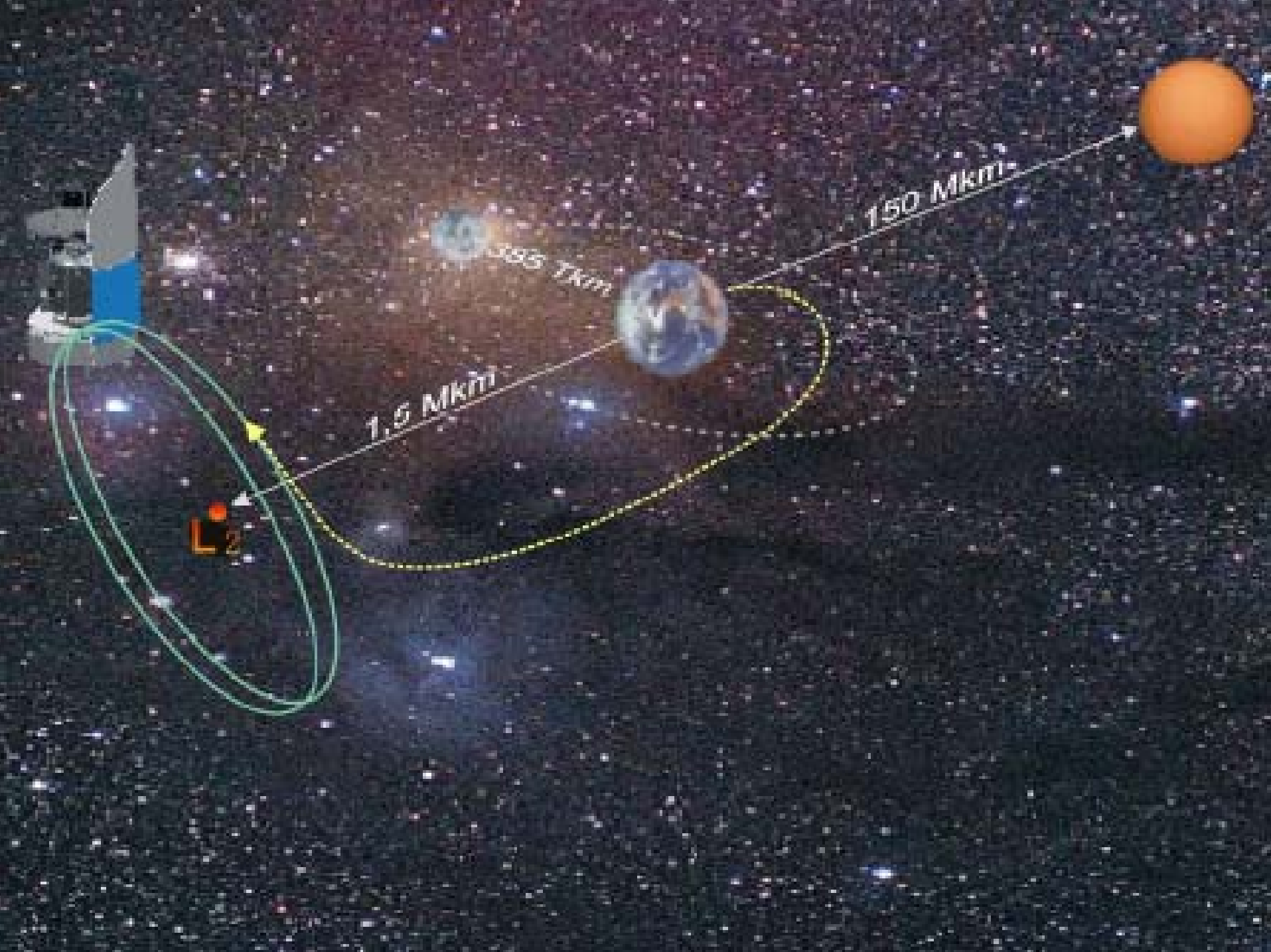
- **Photometry - imaging, 6 broad bands in 75-500 µm range**
  - **PACS** - simultaneous 2 colour fully-sampled (0.5Fλ) imaging with FOV 1.75x3.5 arcmin with R~2.5 centred at 75/110 and 170 µm
  - **SPIRE** - simultaneous 3 colour 2Fλ imaging with FOV 4x8 arcmin with R~3 centred at 250, 363, and 517 µm
  - for larger fields 'on-the-fly' mapping, mosaicing
  - sensitivity is somewhat wavelength and observing mode dependant, very roughly for point sources 1mJy - 1σ - 1 hour; for mapping confusion limit is important
- **Spectroscopy - in 57-670 µm range, varying R in 20-10^7 range**
  - **PACS** - 5x5 spatial x16 spectral pixels, FOV 0.8 arcmin, R~1500, λ ~57-210 µm
  - **SPIRE** - FTS spectrometer, R ~20-100+, FOV 2.6 arcmin, λ ~200-670 µm
  - **HIFI** - heterodyne spectroscopy with R up to 10^7, λ ~157-212 and 240-625 µm, 2 orthogonal polarisations, 4000 spectral channels per polarisation, single pixel on the sky, mapping by 'on-the fly' or mosaicing observations

Launcher

- Launcher version:
  - Ariane 5 - ECA (cryogenic upper stage)
  - qualification flight V164
- Payload configuration:
  - Planck in lower position
  - Herschel in upper position
  - Sylda5/ACU2624
  - Long fairing
- Launch Autonomy:
  - 25 hours
- L2 Injection strategy:
  - direct injection
  - 25 minutes powered phase
- L2 Injected mass capability:
  - ≥6273 kg including adaptors

©CNES-septembre 2002 / illust. D.Ducros

HERSCHEL SPACE OBSERVATORY

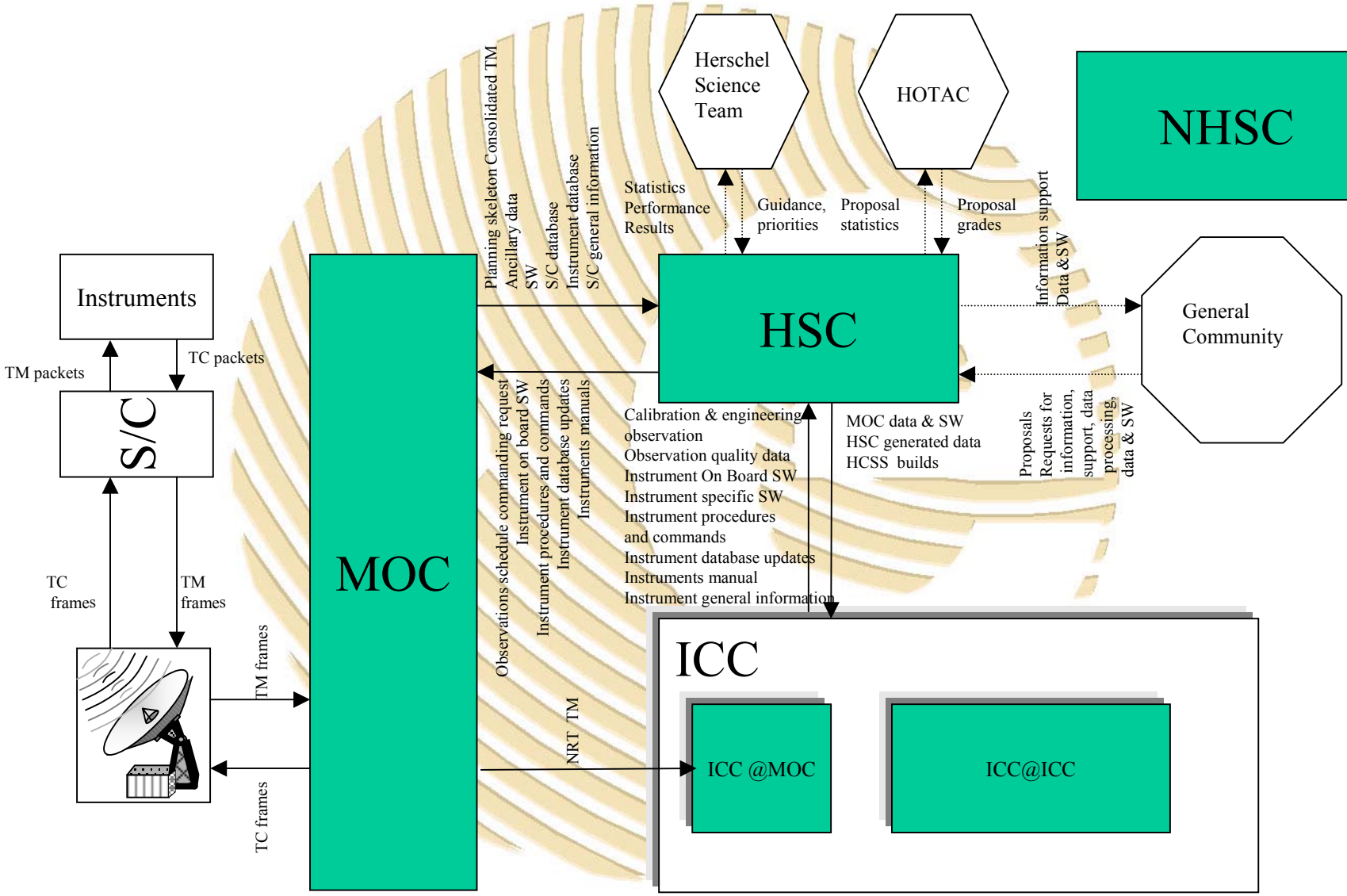

150 Mkm
385 Tkm
1,5 Mkm
L2

Herschel key dates

- FIRST feasibility study 1982-83
- …
- FIRST confirmed 4th Cornerstone Dec 1993
- …
- Selection of PIs 1997-98
- FIRST becomes Herschel, Dec 2000
- Start of spacecraft Phase B: mid-2001
- Start of spacecraft Phase C/D: beg-2003
- SVM, PLM, telescope module testing 2005
- Payload model deliveries: 2006
- Integration & tests/verification: 2007
- Launch: 2008
- Early operations: first 6 months
- Routine Science Operations: 2008 - 2011

HERSCHEL SPACE OBSERVATORY

Ground segment



PACS Photometry

Unique AOR Label: PACSPHOTO-0000

Target: None Specified

New Target

Target

Target Name (required): NED

M51

Fixed | Moving

Coord Sys: Equatorial J2000

RA:

Dec:

Epoch: 2000.00

Proper Motion

Use Pr

PM RA ("/yr):

PM Dec ("/yr):

Bright Moving Objects to Avoid

Earth+Moon

Others

OK

Cancel

Instru

Blue channel

60-85 microns filter (Blue

85-130 microns filter (Blue

Observi

Source

Map choice

Pointed

Small Map

Large Map

Pointing

Noddi

Sourc

Chopping and Dithering set

Chopping

Chop

On

Off

Chopper avoidance angle (deg)

Angle from (degrees) 0.00

Angle to (degrees) 0.00

Dithering

Observation Est... | Add Comments... | Visibiltity... | Star Tracker...

OK | Cancel | Help

Ned Name Resolver- Working...

Ned Name Resolver

Searching for Name: M51

Click *Abort* to stop.

Abort

PACS Photometry

Unique AOR Label: PACSPHOTO-0000

Target: m51 *Type:* Fixed Single

Position: 13h29m55.73000s,+47d13m53.4000s

New Target | Modify Target | Target List...

Number of visible stars for the target: 15

Star tracker target: Ra: 22.482 degrees Dec:-47.232 degrees

Instrument Settings

Blue channel

60-85 microns filter (Blue 1)

85-130 microns filter (Blue 2)

For each pointing

On-source integration time (s): 60

Observing Mode Settings

Source

Map choice

Pointed

Small Map

Large Map

Pointing settings

Nodding

On

Off

Source Flux Estim

Chopping and Dithering settings

Chopping

Chopper avoidance ang

OK | Cancel

PACS Time Estimation

Time

Observatory overhead (s) 180

On-source time (s) 48

Calibration time (s) 4

Total time (s) 283

Band (um)	Est. 1-σ noise (mJy)	Est. 1-sigma confusion level (mJy)
60-85	3.1	11.2
130-210	3.2	10.2

Confusion Messages

Done | Messages

SPACE OBSERVATORY

Herschel mission phases

- **Launch and early operations (LEOP)**
- **Commissioning and performance verification (SC + payload)**
- **Science demonstration phase**
- **Routine science operations phase (36 months)**
  - **Approx 1000 days / 20000 hours of schedulable science time**
  - **Guaranteed time programmes – GT (32%)**
    - open for GT holders only
  - **Open time programmes – OT (68%)**
    - including discretionary time and targets of opportunity
    - open for all – including GT holders
- **Three 'Call for proposals' (AO) cycles are foreseen**
  - one Call for 'Key Projects' programmes only (GT and OT)
  - two Calls for regular programmes (GT and OT)
- **Each AO will be divided in two parts**
  - GT awarded first
  - OT awarded after GT in same cycle

Initial AO foreseen late 2006

HERSCHEL SPACE OBSERVATORY

Herschel Science Centre - Mozilla Firefox

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http://www.rssd.esa.int/Herschel/links.shtml

Herschel Science Ce...

ESA Home | Research & Science Home | Sci-Tech Portal | Herschel Portal

esa — Herschel Science Centre — European Space Agency

Astrophysics | Planetary Exploration | Solar Terrestrial Science | Fundamental Physics | Operations | Research

10-May-2006 16:34:33

Herschel Resources
- Herschel Science Home
- Latest News
- Community Information
- Conferences/Workshops
- Links

About Herschel
- Mission Overview
- Science Instruments
- Science Team
- Bibliography

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- PACS Home
- SPIRE Home
- HIFI Home
- Planck Science Home

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GO

Select a Search Scope: Herschel

Advanced Search

Herschel (-related) websites

Site / URL	Short Description
ESA sites	
Herschel Science Centre http://www.rssd.esa.int/herschel	This site - **the Herschel Astronomers' website**. Provided and managed by the Herschel Science Centre, it is primarily aimed at the scientific community in general and (potential) future users of Herschel in particular. Herschel Science Centre Development Team pages. The Herschel Science Centre is part of the ESA Research and Scientific Support Department.
ESA SciTech Herschel http://sci.esa.int/herschel	Science & Technology Herschel website. Provided and managed by Science Communications, it is primarily catering for general interest in science and technology wrt Herschel. See also the SciTech Portal with Director's Desk, and Educational Support with a map of the ESA web structure.
ESA Science Herschel http://www.esa.int/science/herschel	General public Herschel site provided by ESA Corporate Communication. This is part of the general public ESA Science Portal which is part of the ESA Portal.
PACS sites	
PACS http://pacs.mpe.mpg.de/	PACS site at MPE, Garching, the PI institute.
PACS Consortium http://pacs.ster.kuleuven.ac.be/	PACS consortium site at KU, Leuven.
SPIRE sites	
SPIRE Project Office http://www.ssd.rl.ac.uk/SPIRE/	SPIRE Project Office site at the Space Science & Technology Department at the Rutherford Appleton Laboratory.
SPIRE U Cardiff URL here	SPIRE site at Cardiff University, the PI institute.
HIFI sites	
HIFI http://www.sron.nl/divisions/lea/hifi/	HIFI site at SRON in Groningen, the PI institute.
NASA sites	
NASA Herschel Science Center http://www.ipac.caltech.edu/Herschel/	NASA Herschel Science Center site at IPAC, Pasadena.
JPL Herschel http://herschel.jpl.nasa.gov/	NASA JPL Herschel site at JPL, Pasadena.

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Done