Herschel mission -
overview and observing opportunities

SPIE Astronomical Telescopes and Instrumentation:
Space Telescopes and Instrumentation I: Optical, Infrared, and Millimeter

Orlando, FL, 24-31 May 2006

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

HERSCHEL SPACE OBSERVATORY

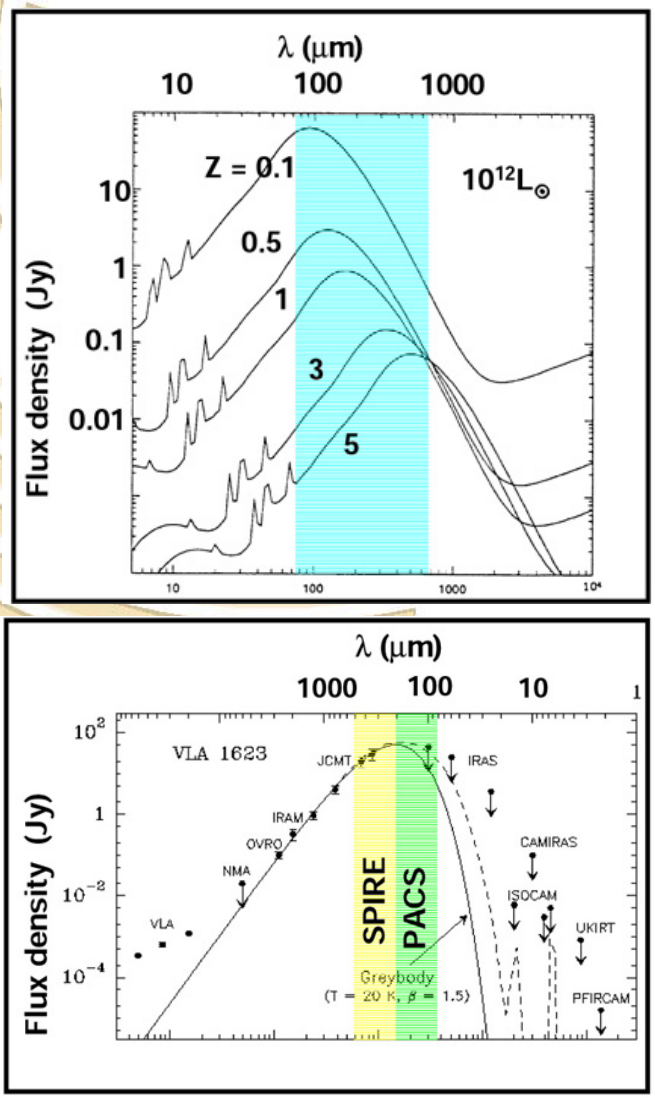
Herschel in a nutshell

- **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, Akari,…)
  - more observing time than balloon- and/or air-borne instruments
  - larger field of view than interferometers
- **Launch in 2008**
  - **initial observing AO on 1 Feb 2007**

HERSCHEL SPACE OBSERVATORY

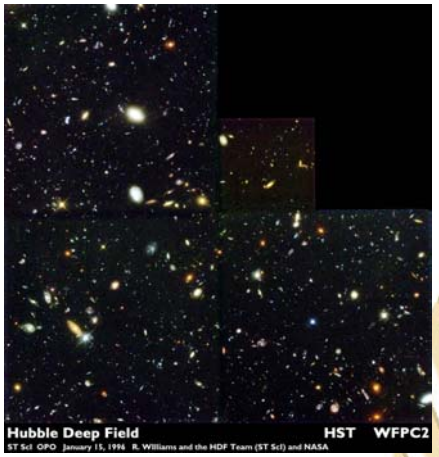
The Cool Universe

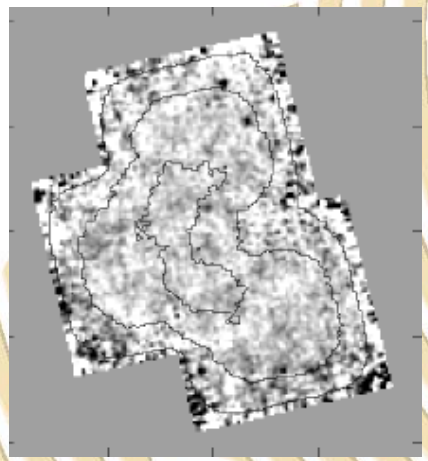
- **Herschel spectral coverage**
  - black-bodies 5-50 K
    - continuum radiation
    - dust grains (re-)radiating
  - gases 10-few100 K
    - brightest atomic/molecular lines
- **Herschel strengths**
  - covers IR dominated galaxies & protostar SED peaks
  - wide area mapping
  - full coverage spectral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

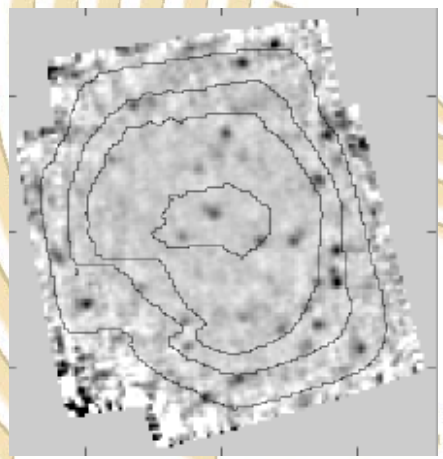


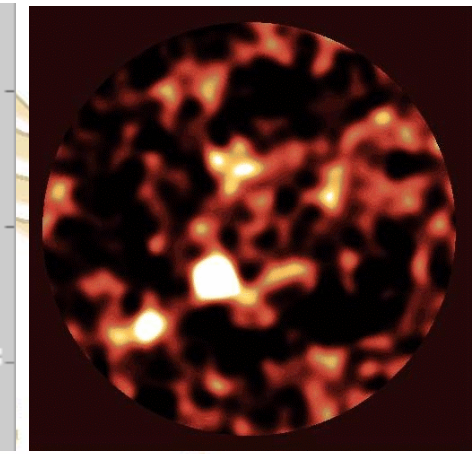
HERSCHEL SPACE OBSERVATORY

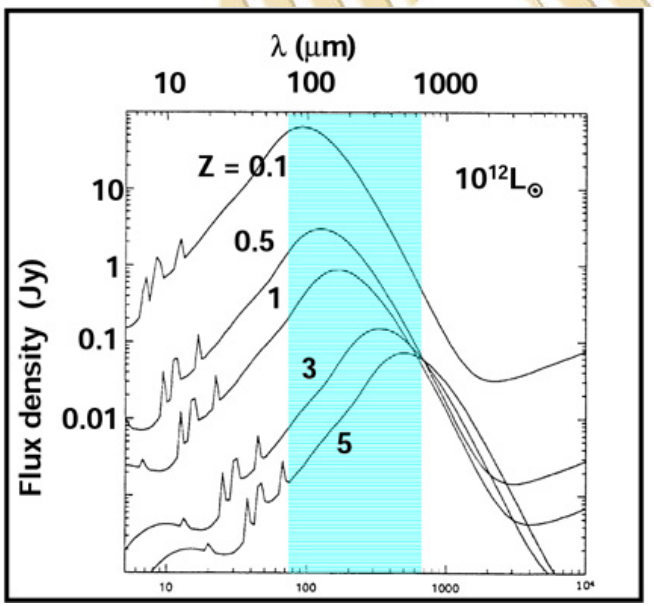
Galaxy formation & evolution









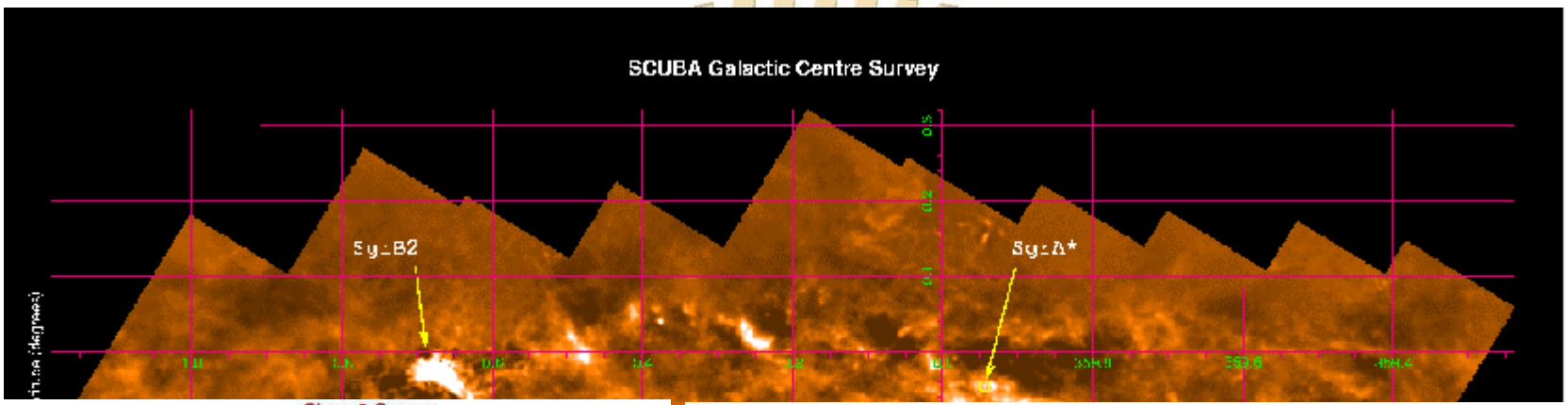


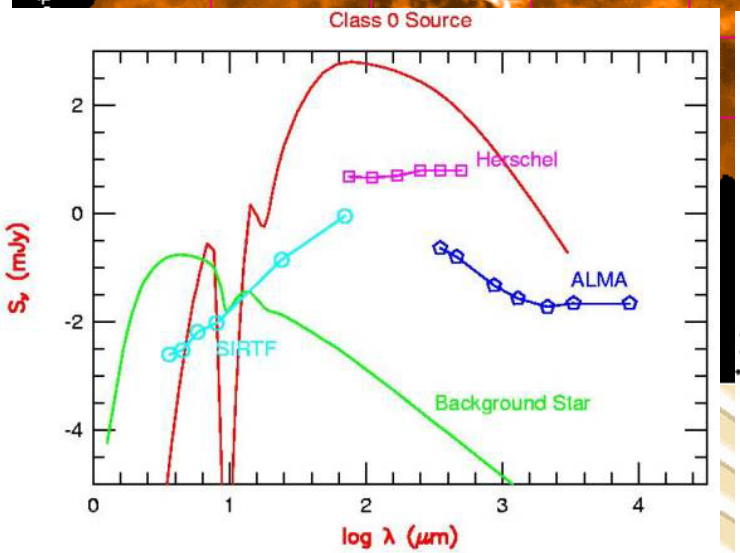
Early Spitzer results:

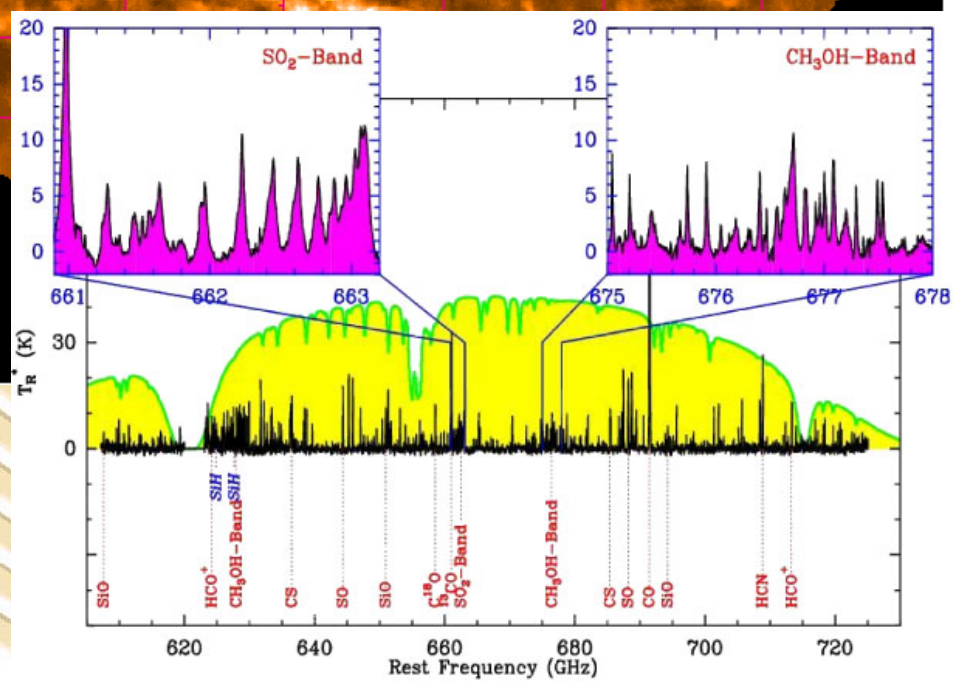
- 24 μm – 70%
- 70 μm – 23%
- 160 μm – 7%

HERSCHEL SPACE OBSERVATORY

Surveys & follow-up





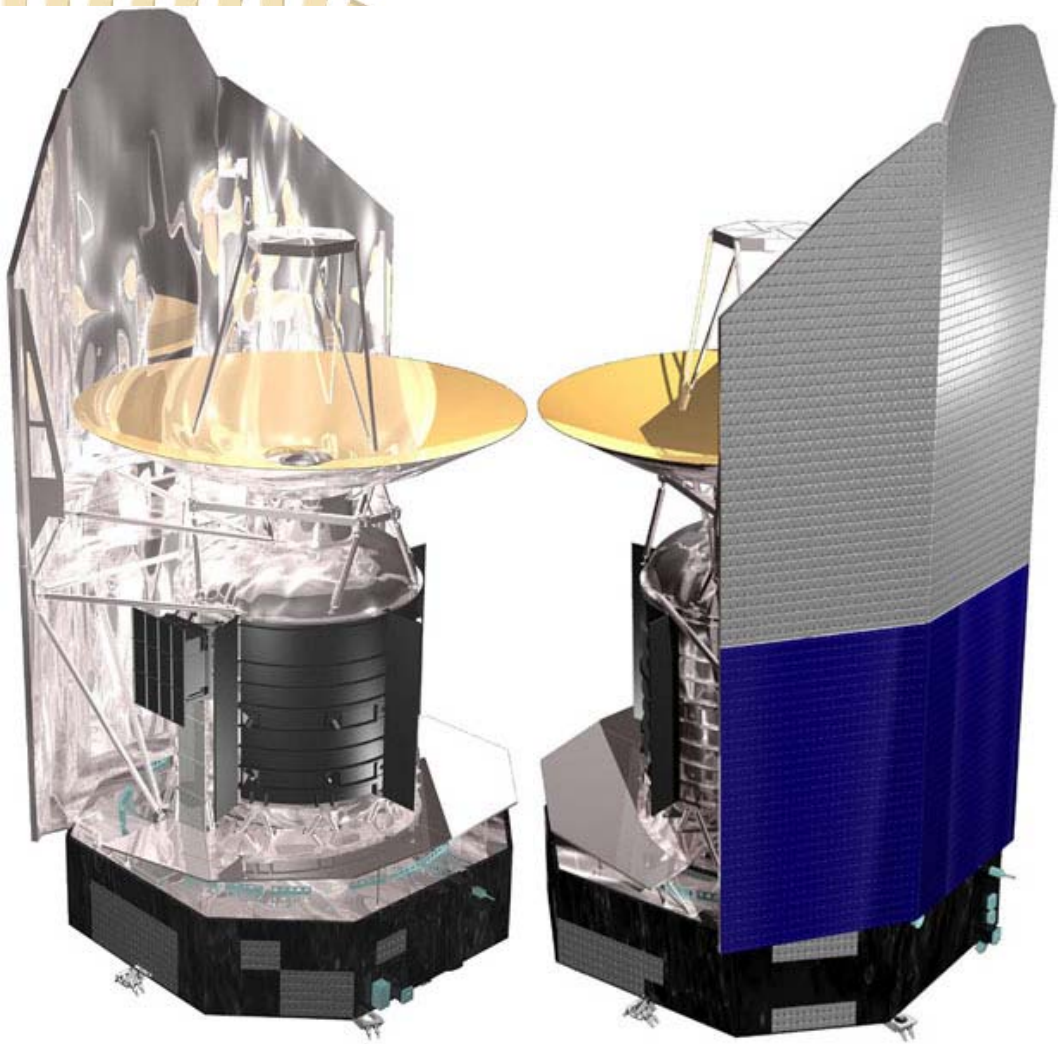


0.1L_{sun} protostar at 300 pc

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



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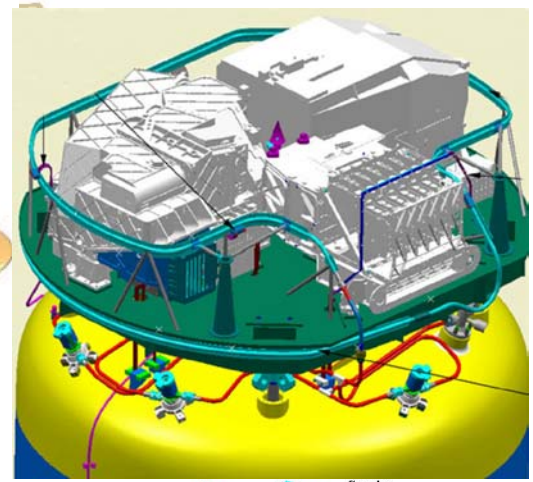
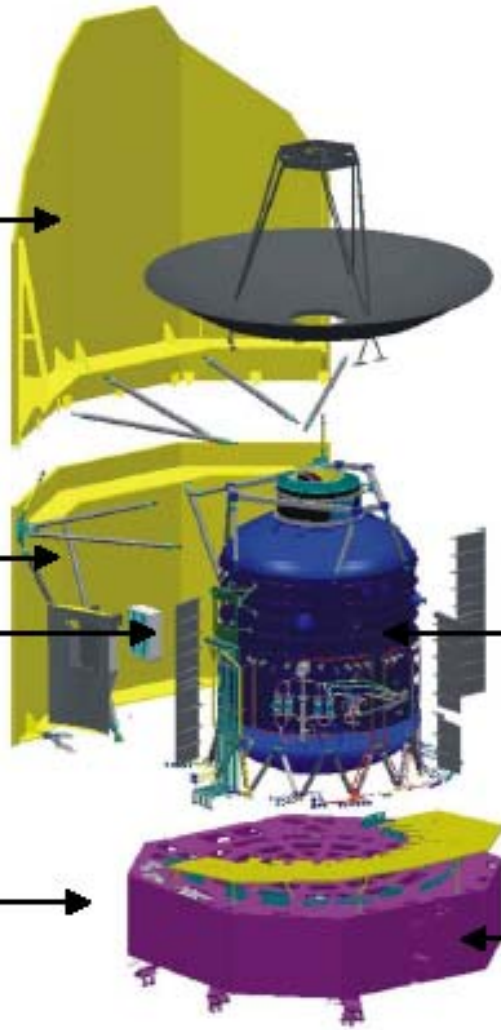


Herschel observatory capabilities

- **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 and R~2.5 centred at 75/110 and 170 μm
  - **SPIRE** – simultaneous 3 colour 2Fλ imaging with FOV 4x8 arcmin and 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** – grating spectrometer, 5x5 spatial x16 spectral pixels, FOV 0.8 arcmin, R ~ 1500-4000, 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

Herschel spacecraft



Sun Shade

Telescope

Solar Array

Local Oscillator Unit

Cryo Vacuum Vessel

Service Module

Thermal Shields

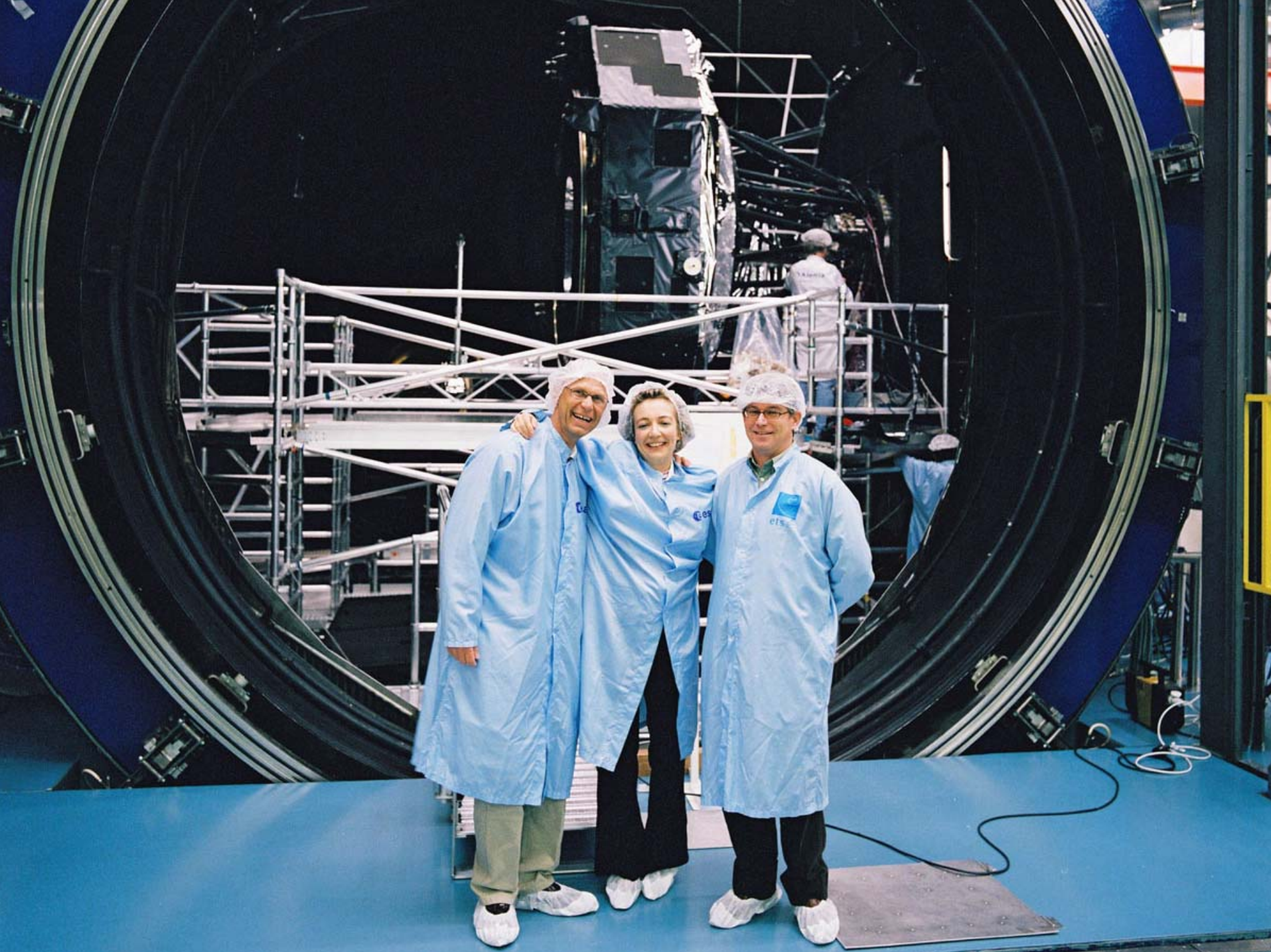
Instrument Warm Units

Herschel spacecraft programmes

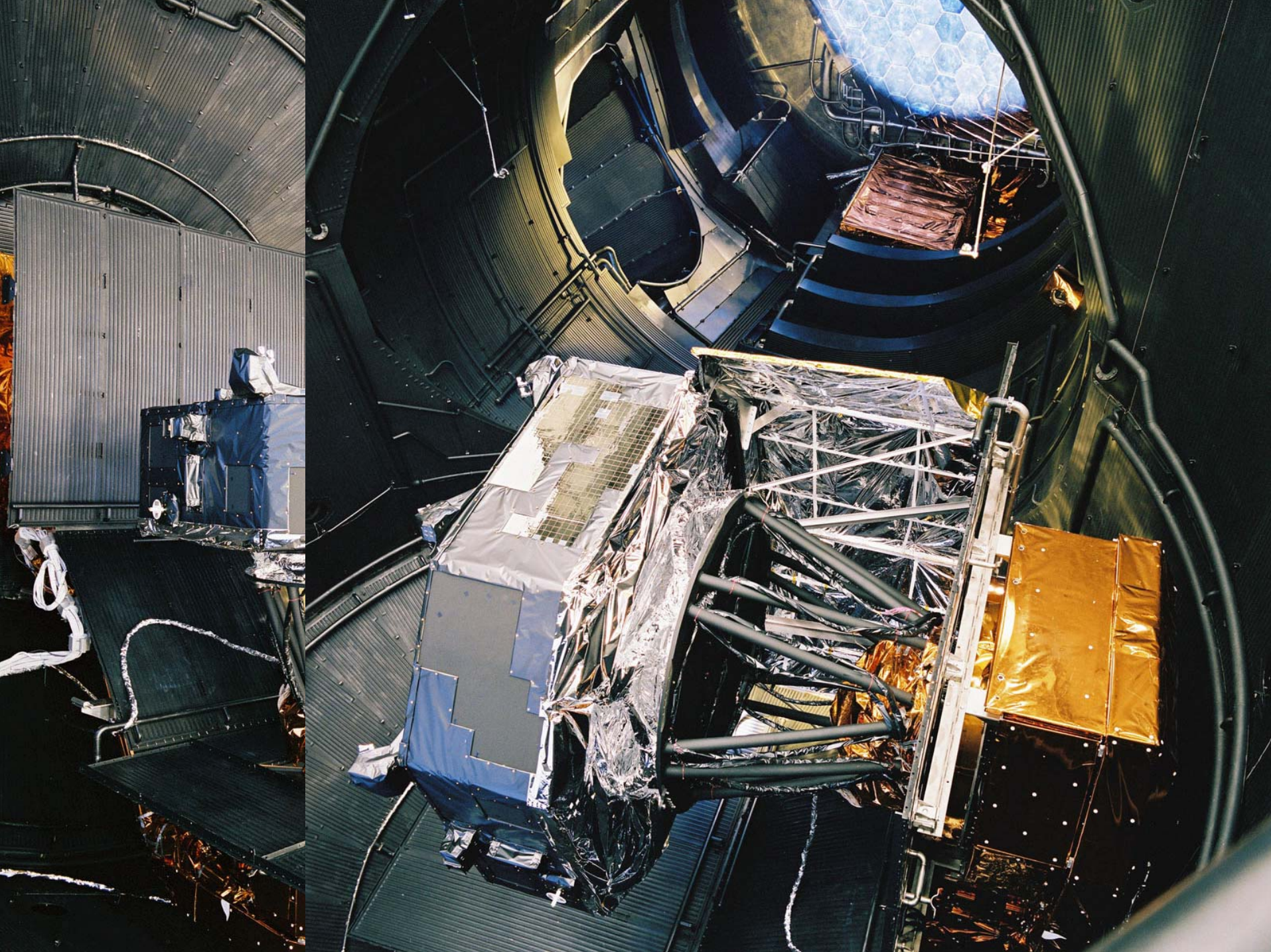
- **Satellite PFM programme**
  - two SVMs – QM and FM – with many common parts
  - only one cryostat/PLM is built
  - only one satellite is built – tested in STM configuration
    - FM cryostat
    - STM models of everything else
- **Telescope PFM programme**
  - telescope manufacture complete – has undergone lengthy cryo-testing and characterisation campaign in CSL
  - spare parts exist for FS
- **EQM programme – completed**
  - ISO hardware refurbished to provide 'Herschel OB simulator'
  - science instrument CQMs
- **AVM programme**
  - one physical setup – configurable as either Herschel or Planck
  - test procedures and OBSW development

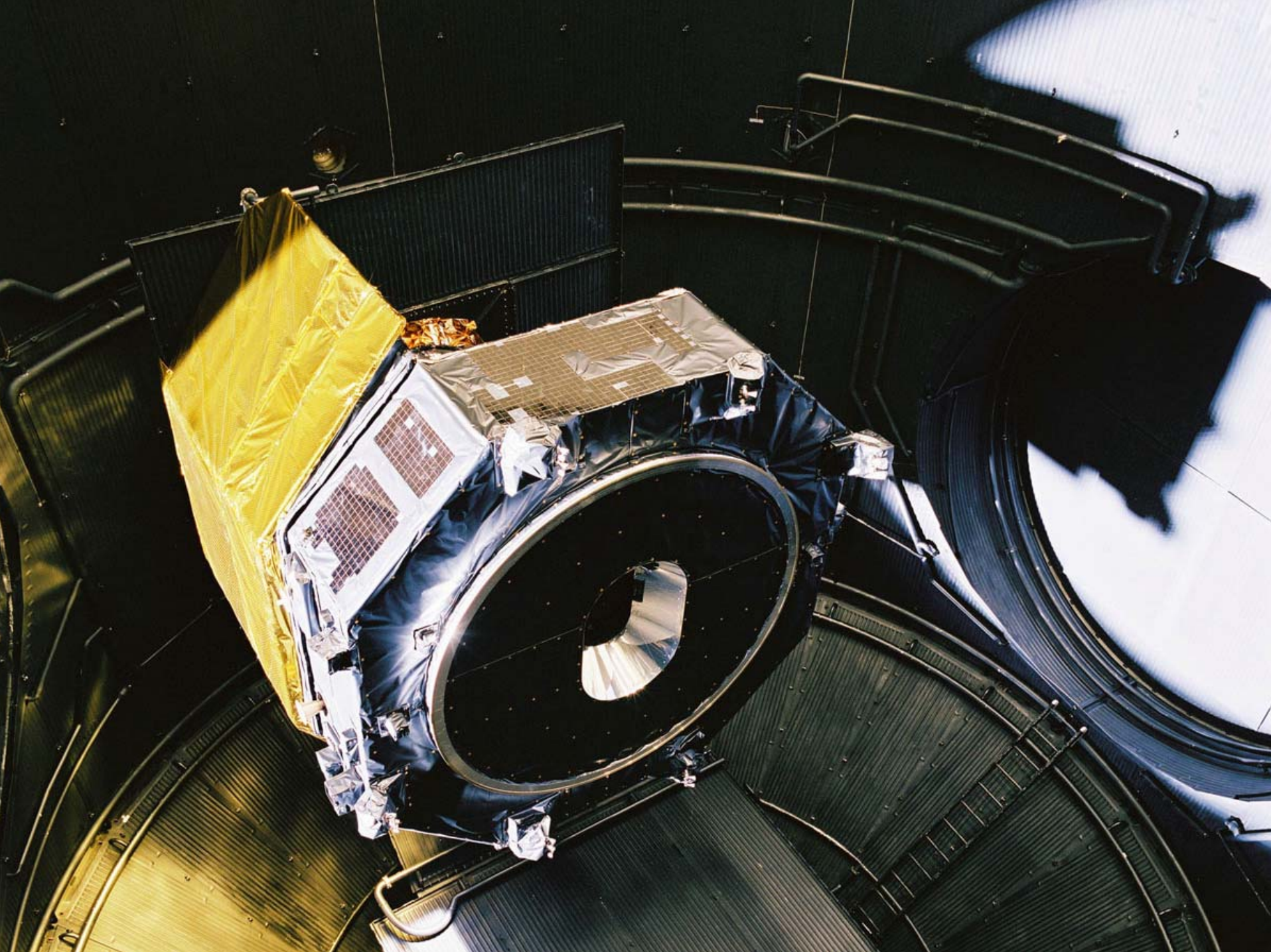
HERSCHEL SPACE OBSERVATORY

Herschel SVM/STM

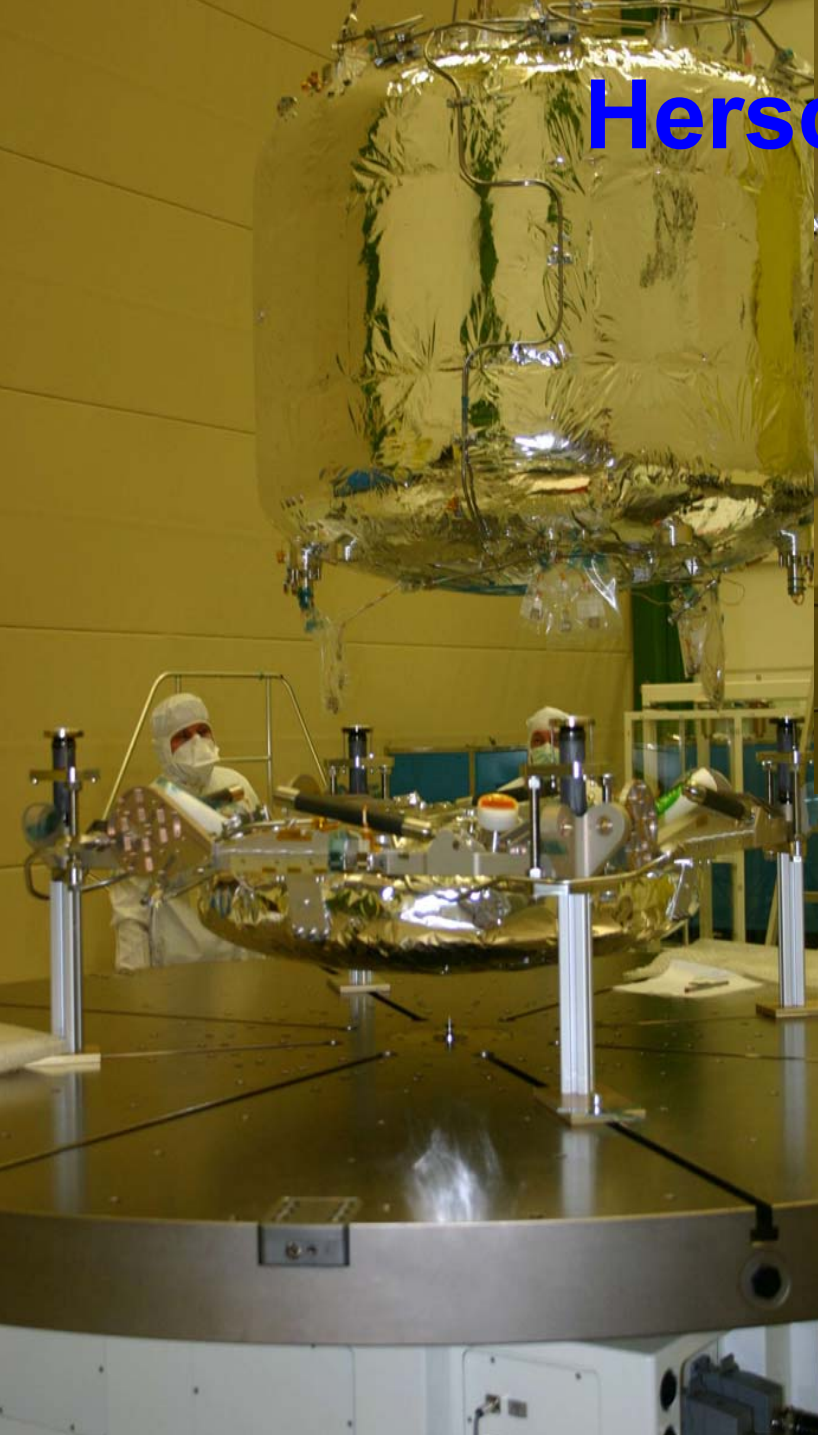


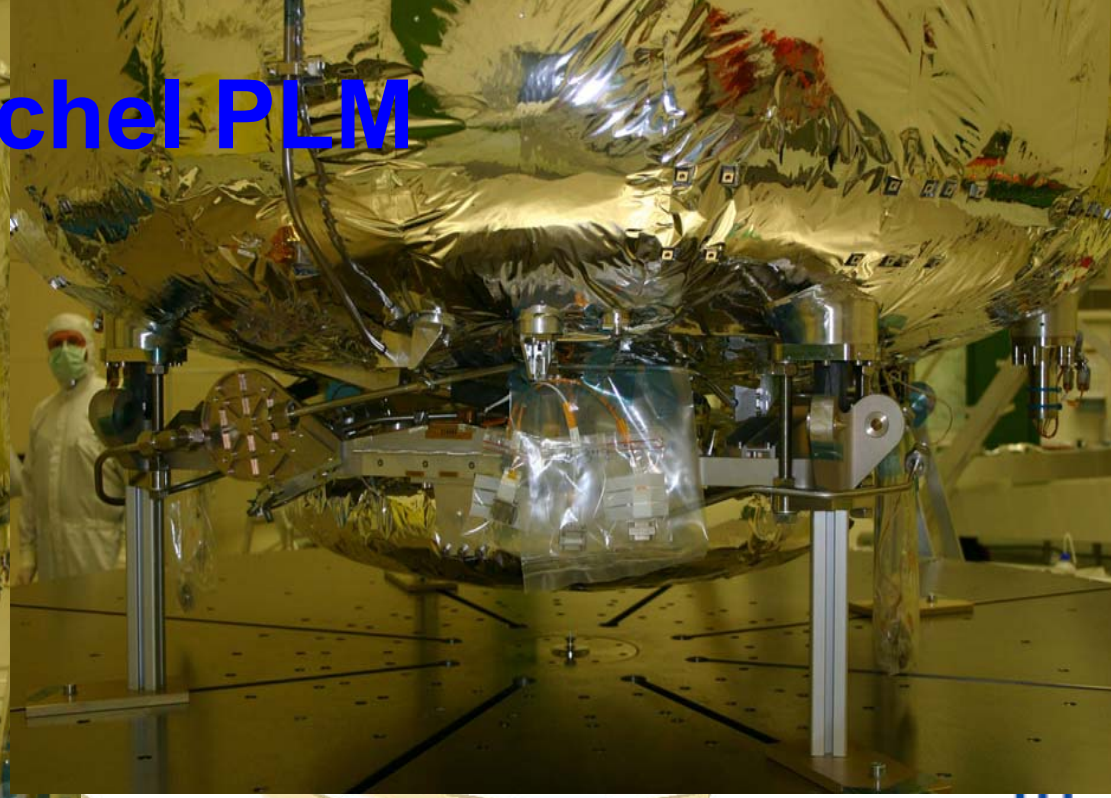
HERSCHEL SPACE OBSERVATORY





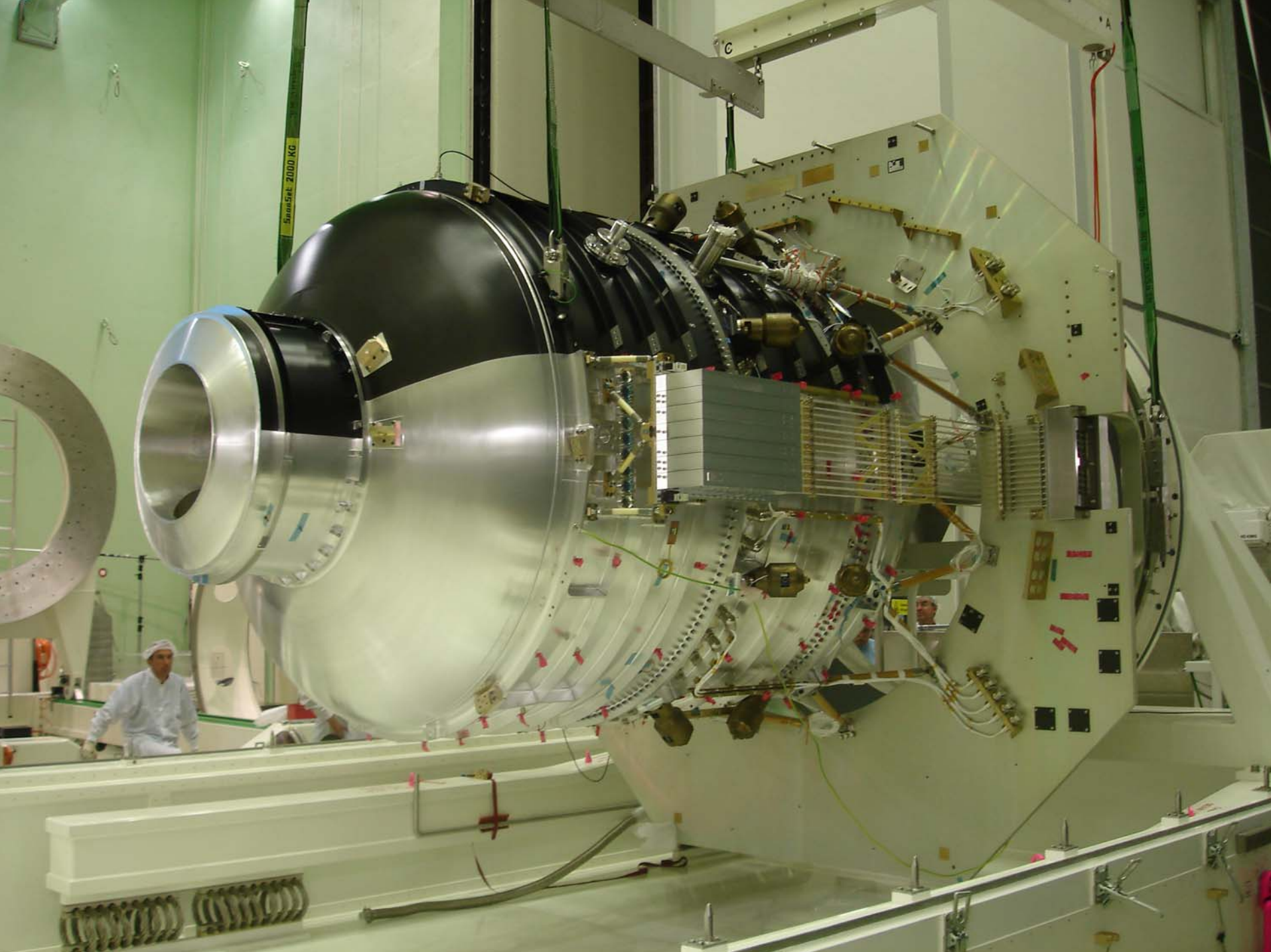
Herschel PLM

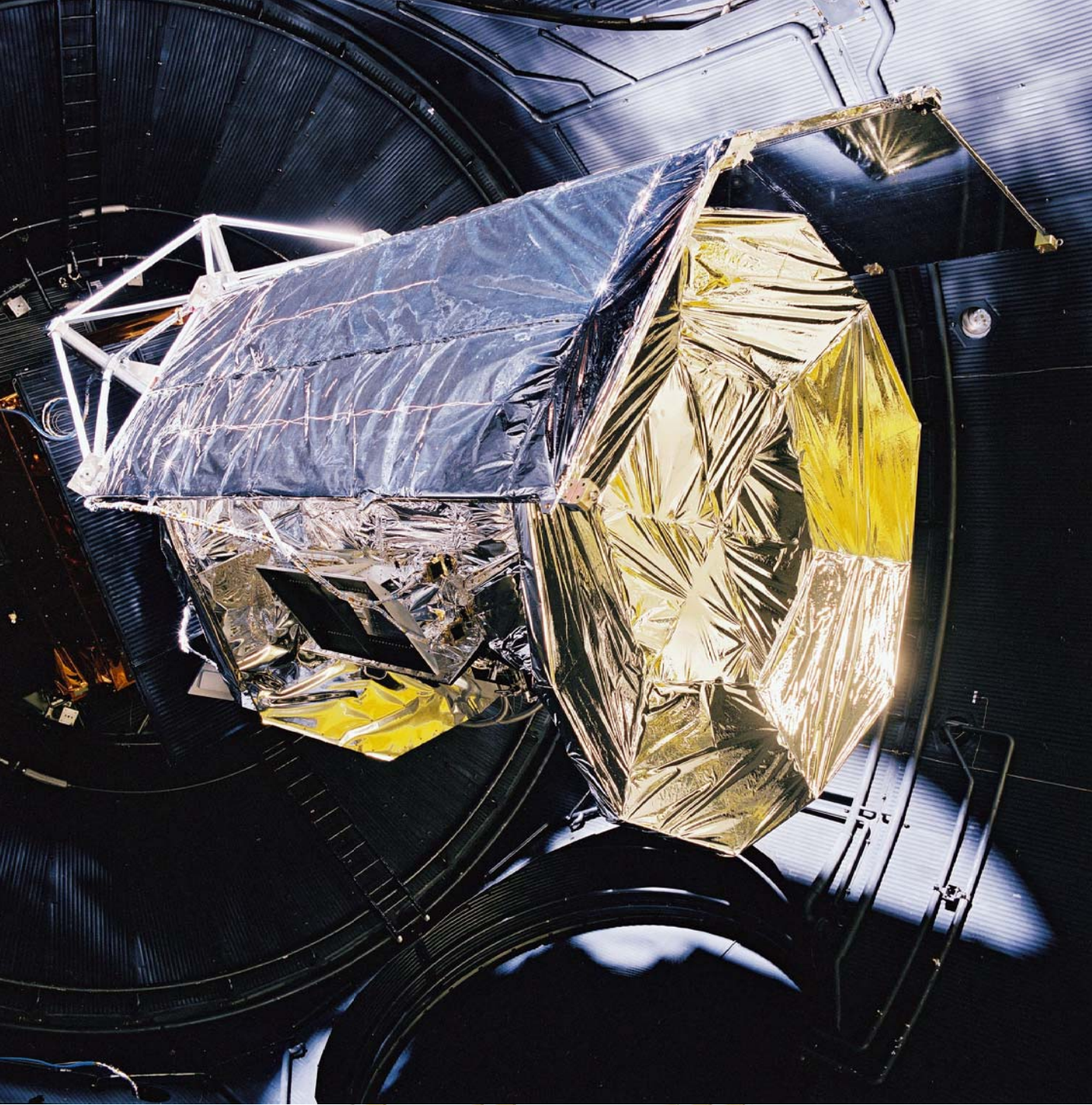




Herschel PLM

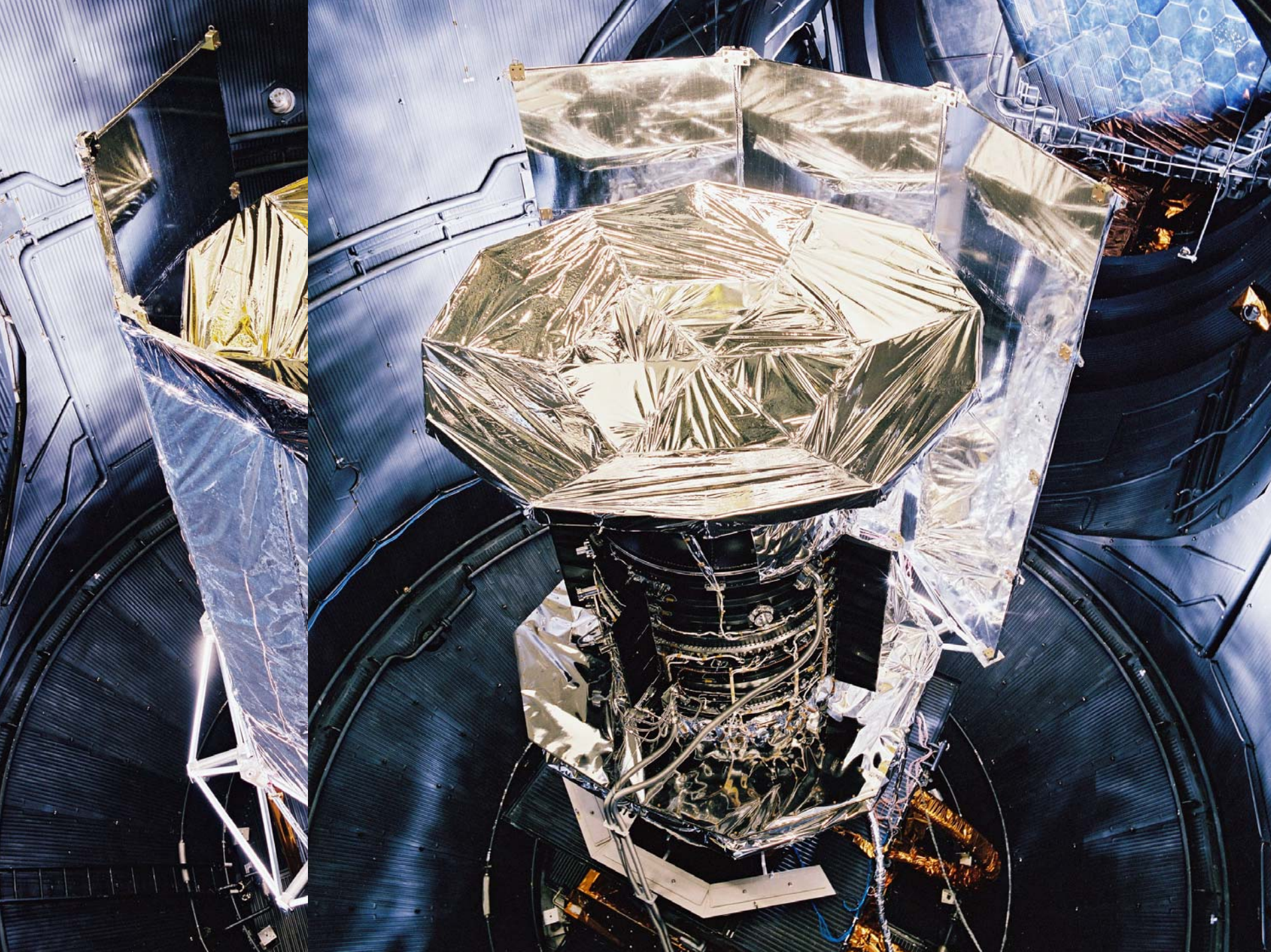

BAY 3
Test Centre
All the space you need
EADS
ASTRIUM

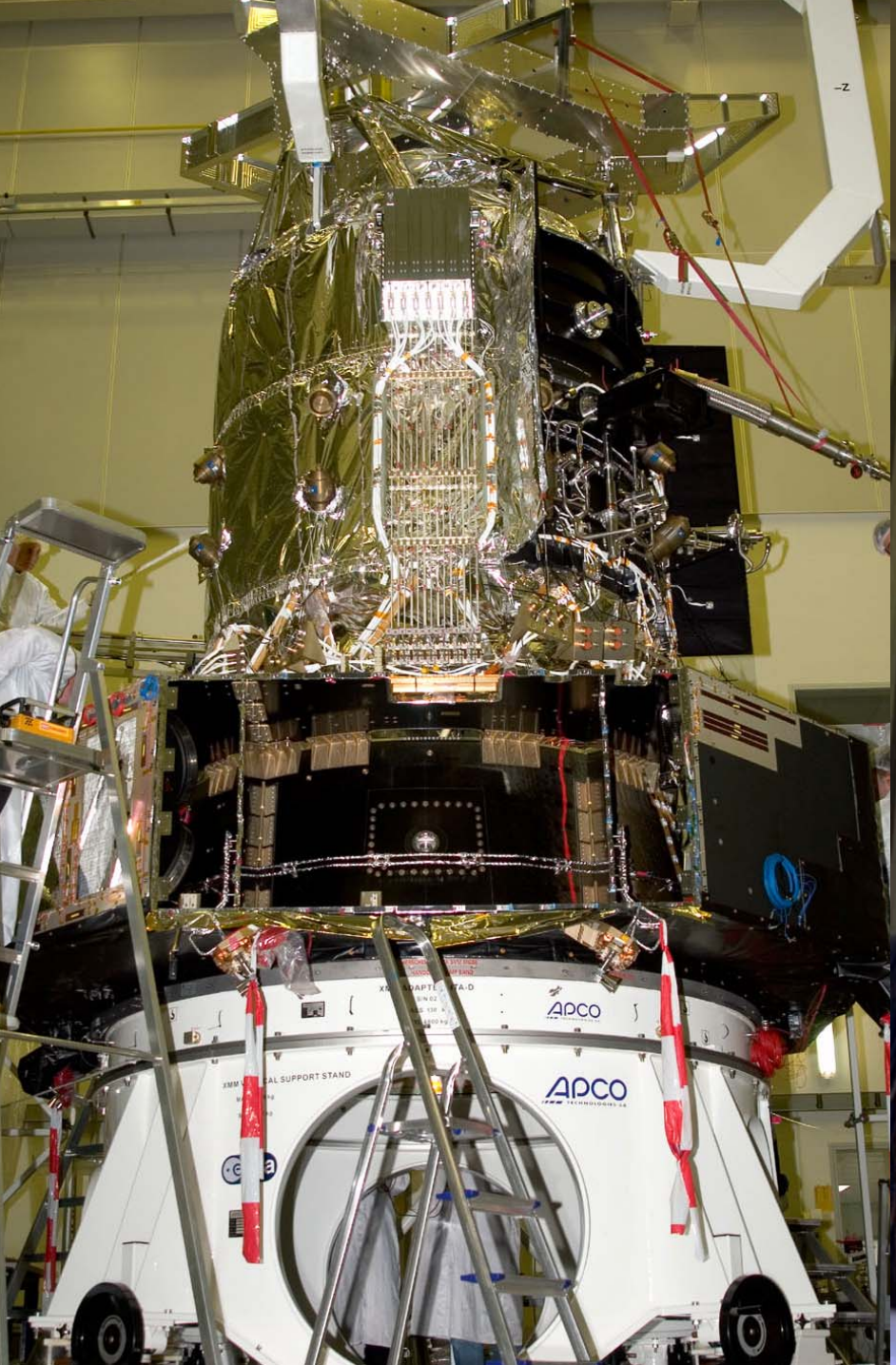

2000 KG



HERSCHEL SPACE OBSERVATORY

SPIE, Orlando 24 May 2006
Göran L. Pilbratt VG # 22
http://www.rssd.esa.int/herschel




APCO
APCO

Herschel STM satellite

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

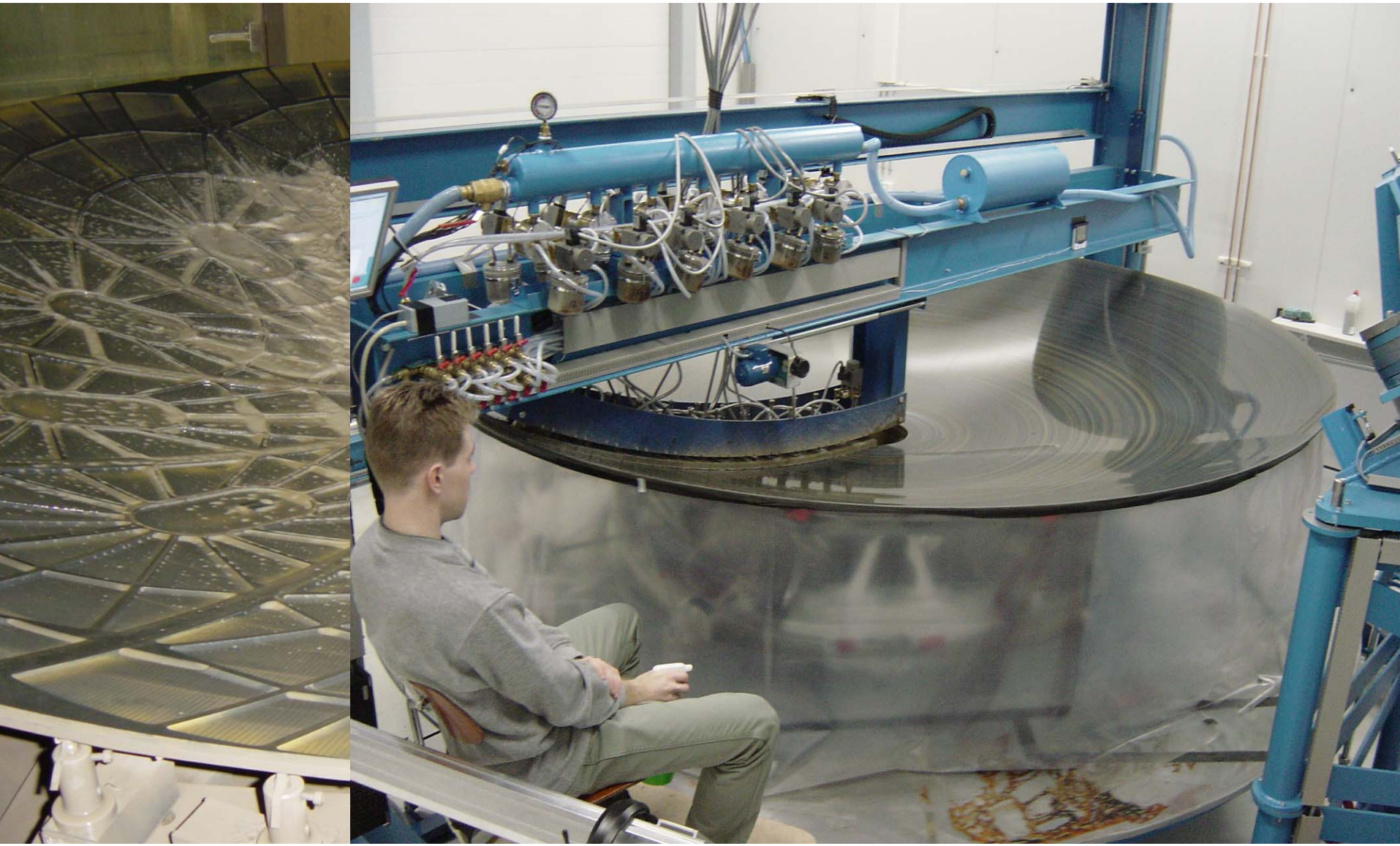
HERSCHEL SPACE OBSERVATORY

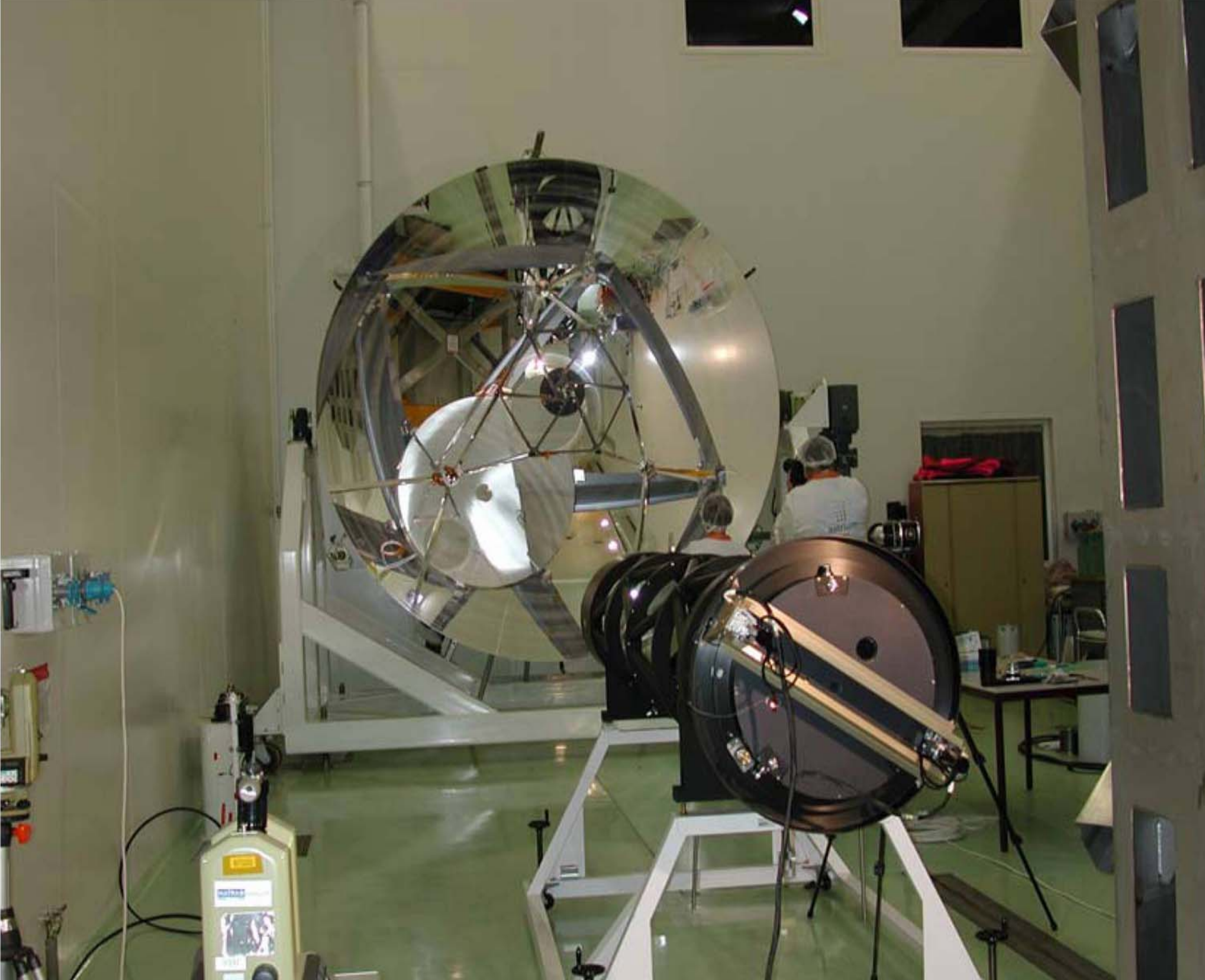
esa

Brazing of primary mirror ‘blank’

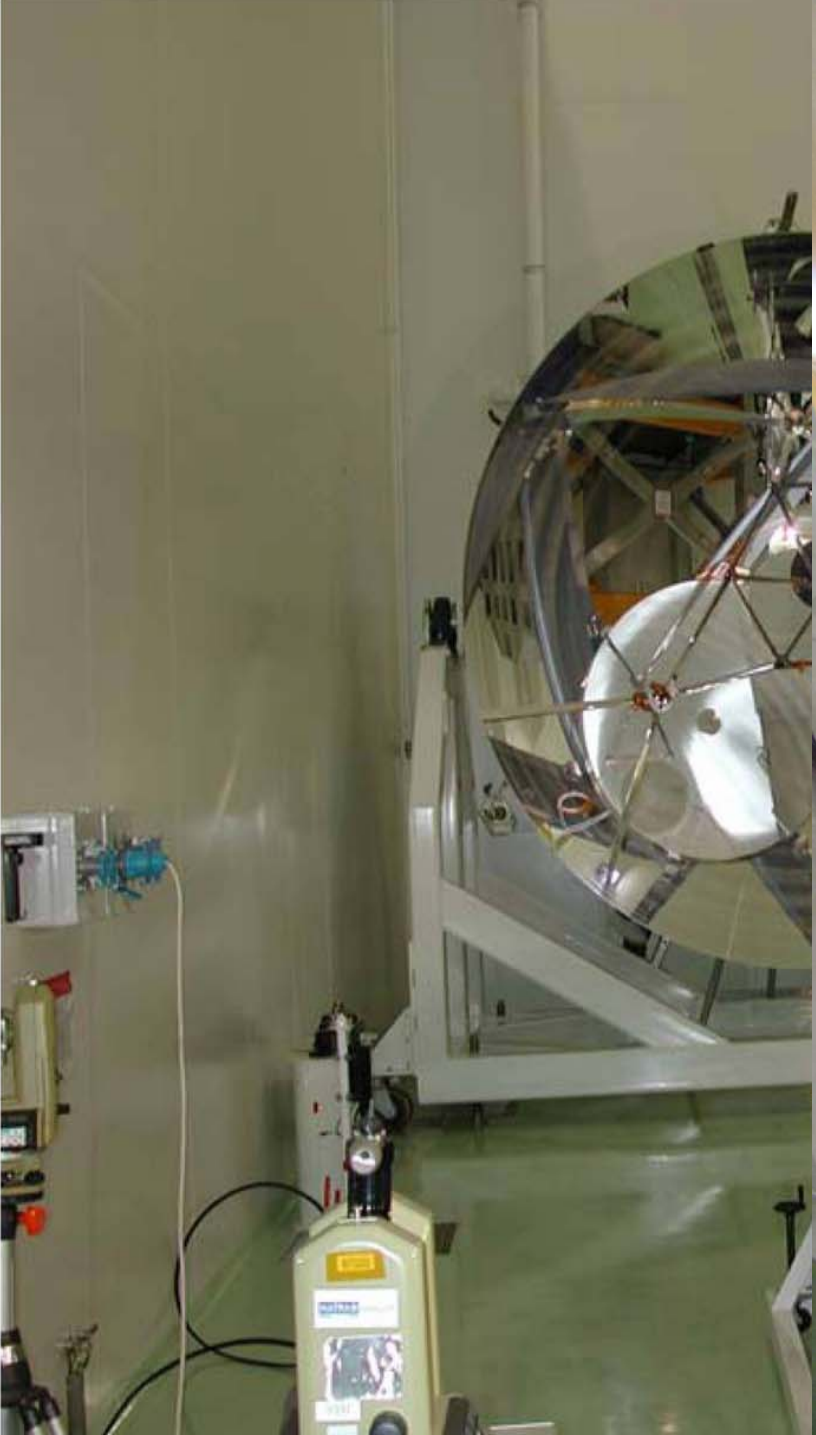
HERSCHEL SPACE OBSERVATORY

Grinding and lapping/polishing

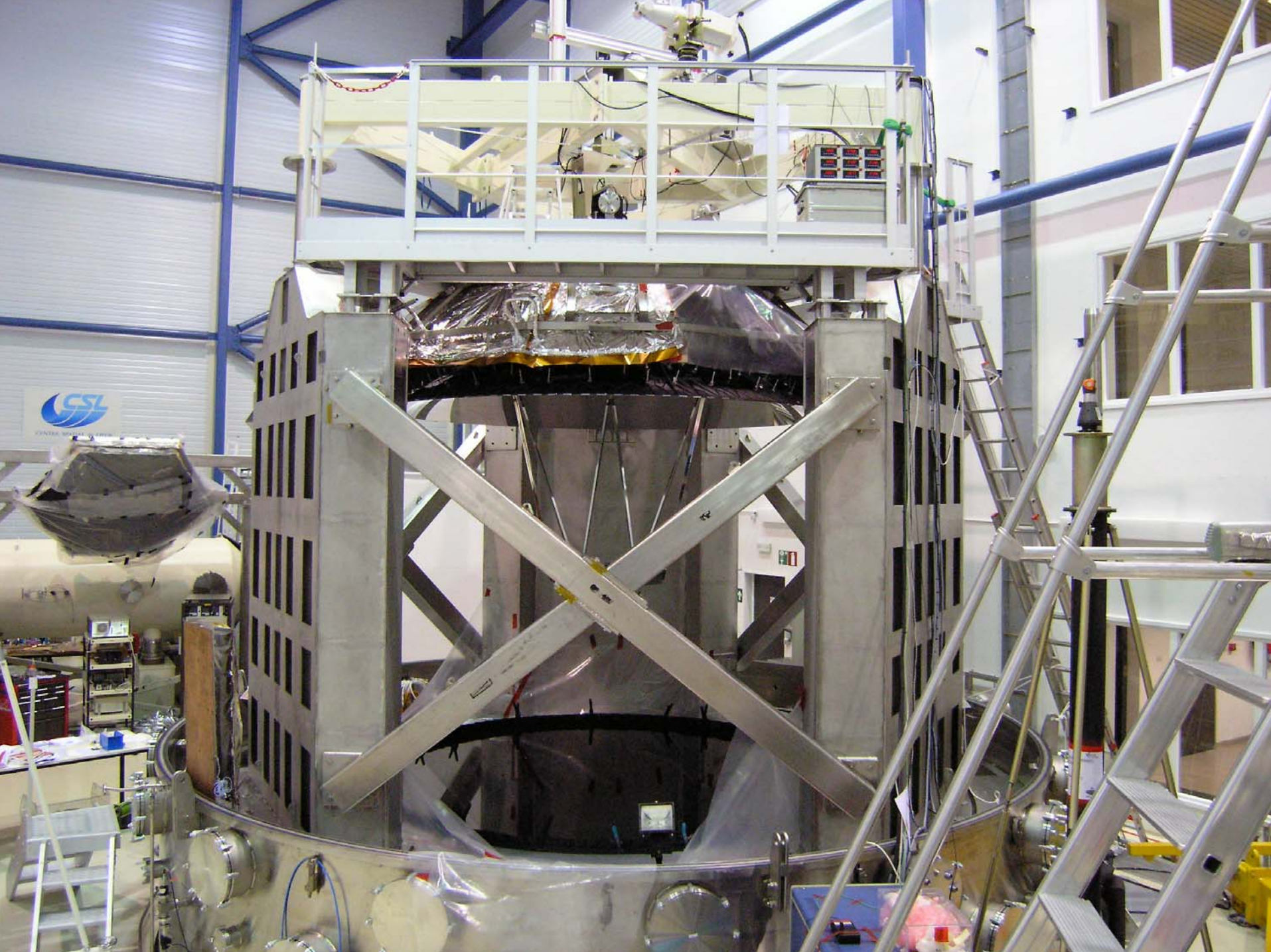




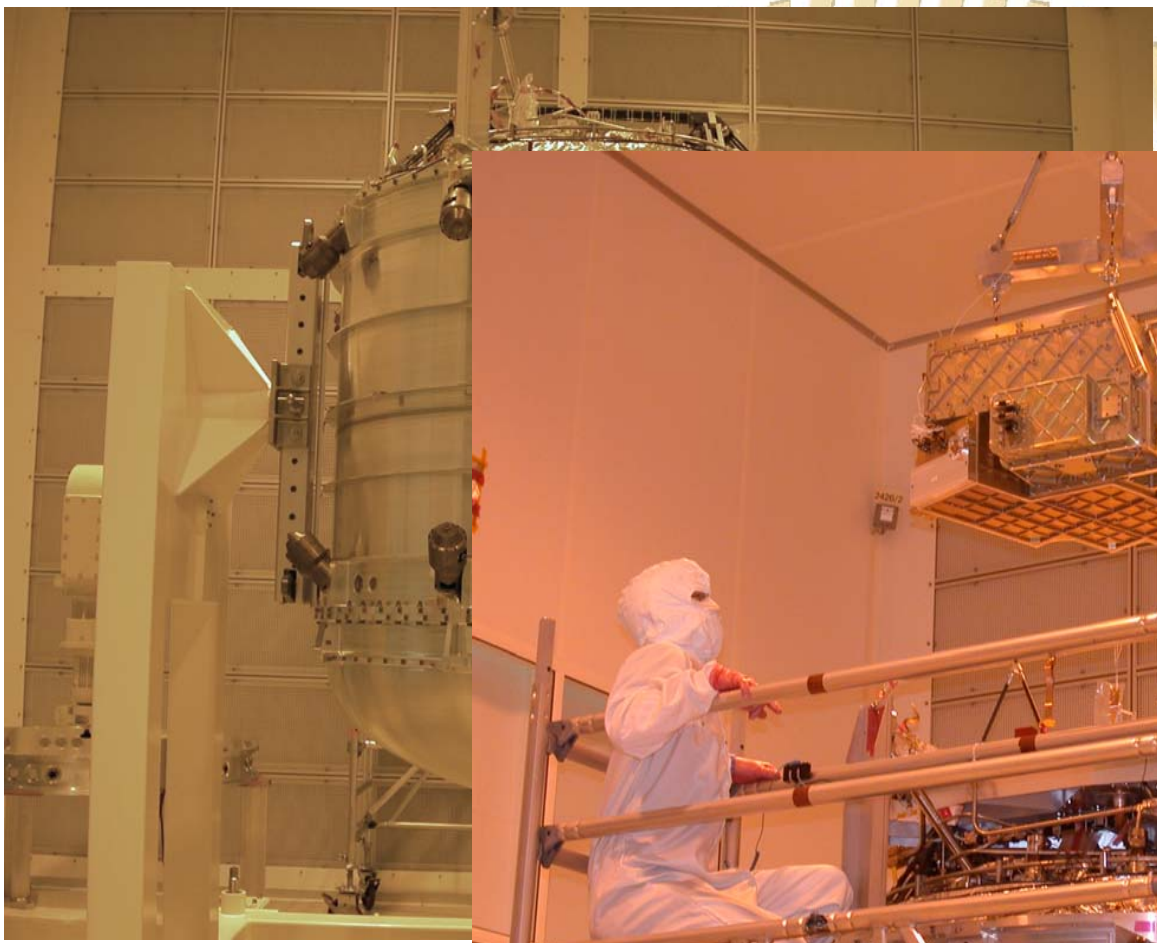
HERSCHEL SPACE OBSERVATORY




ADC
125kN



Herschel EQM



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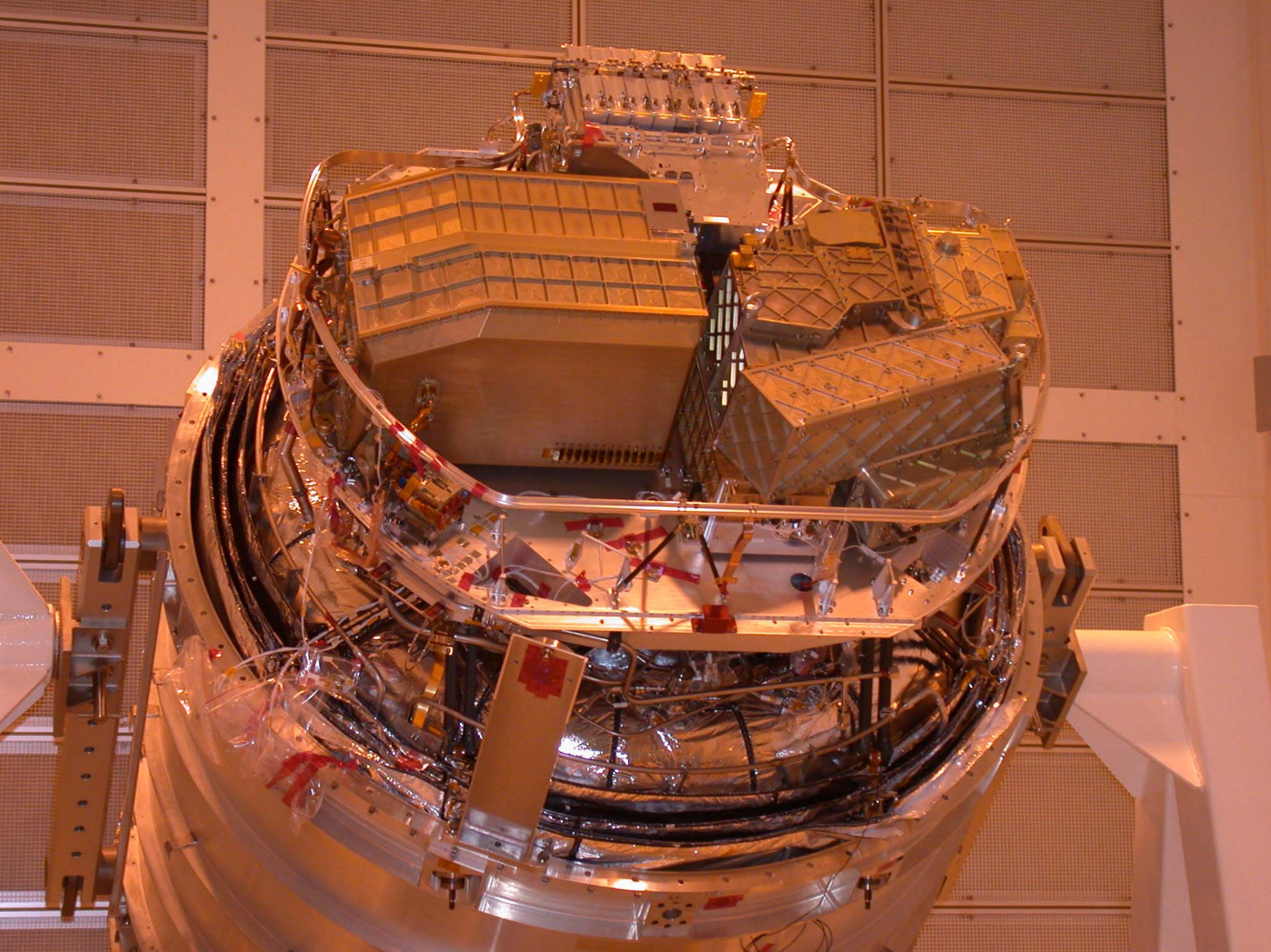
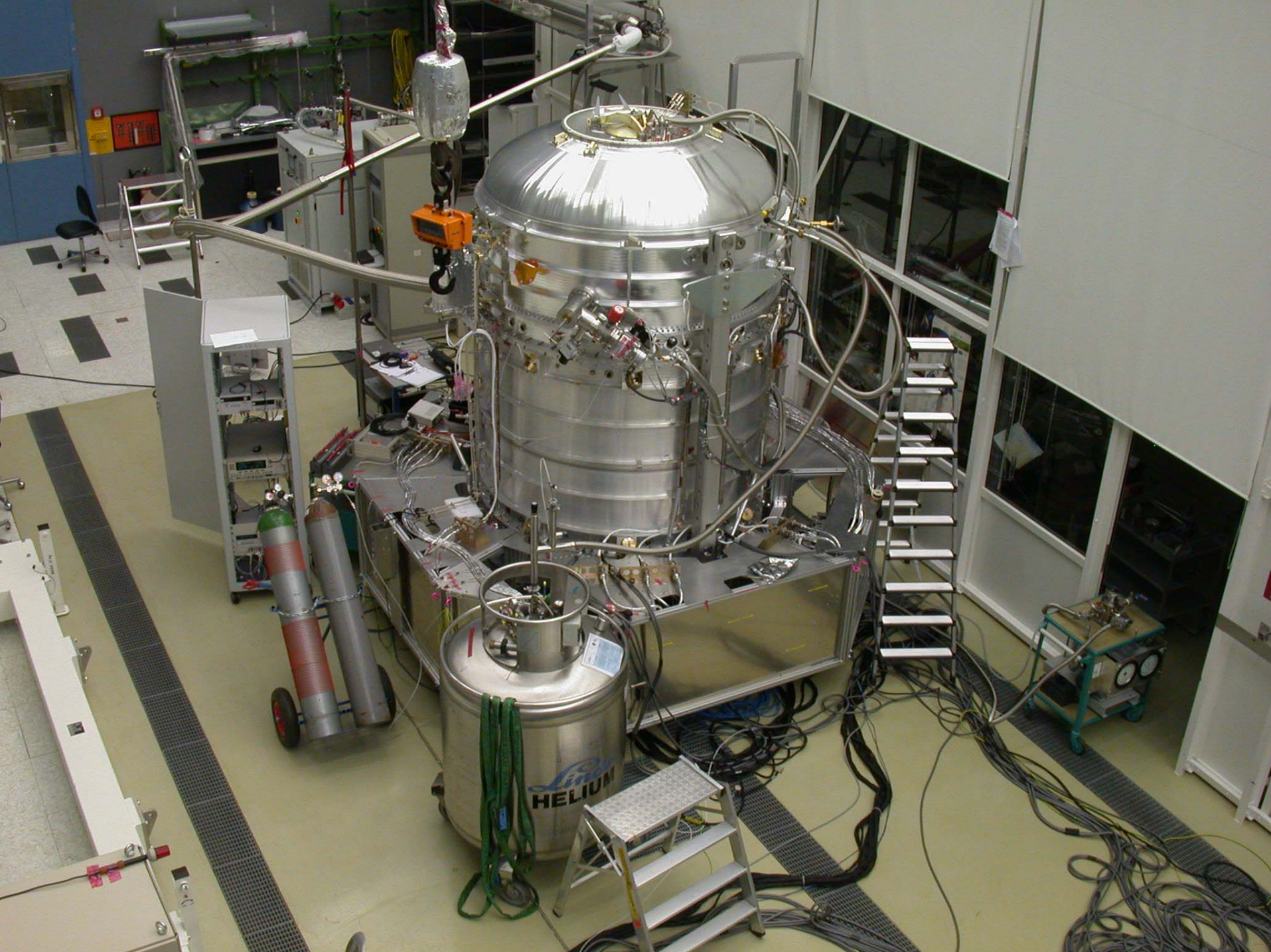


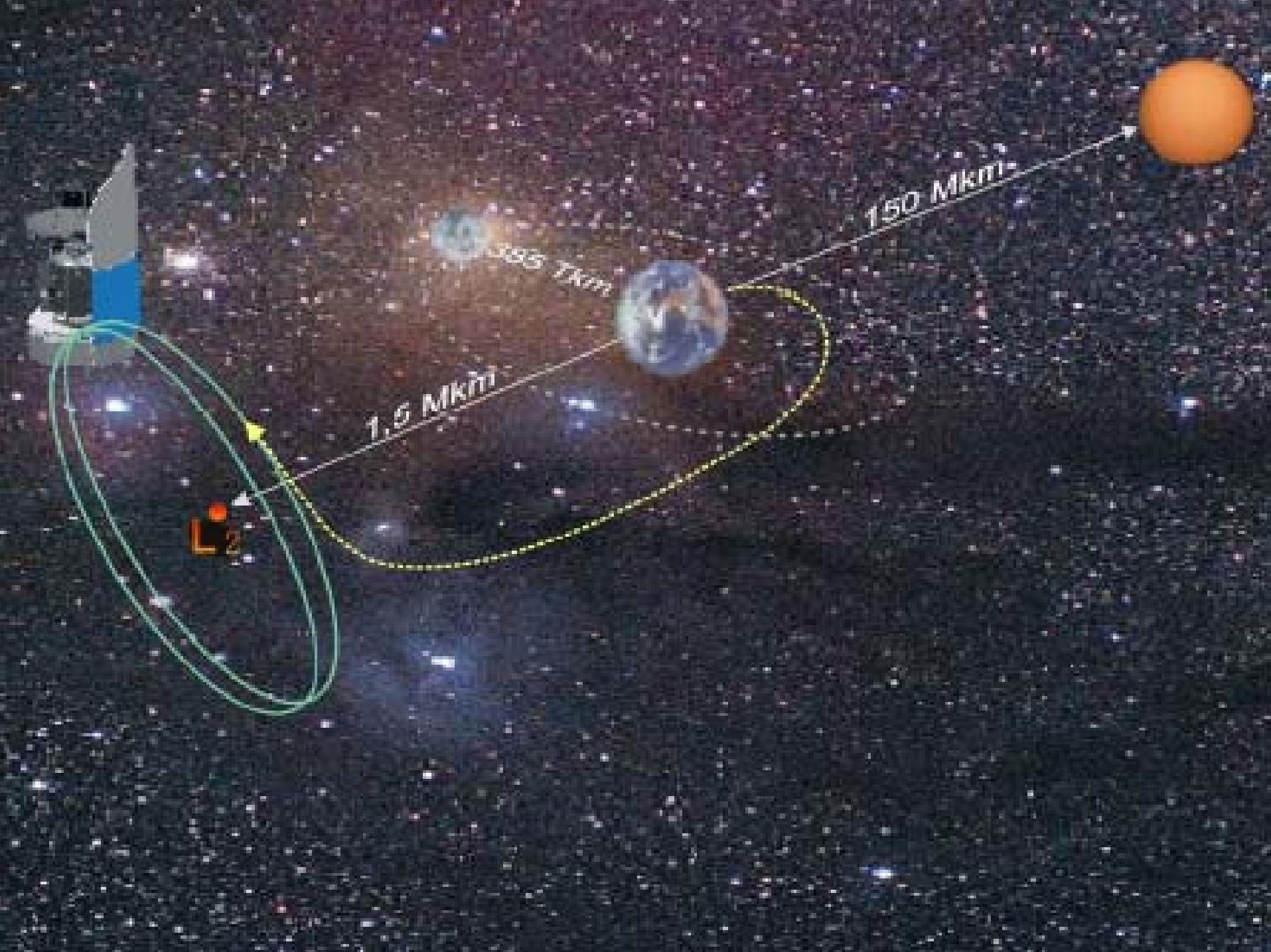

HELIUM

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 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

HERSCHEL SPACE OBSERVATORY

Overall AO schedule

- **Logic: Issue 'Call for Proposals' (AOs) as late as possible**
  - for pure scientific reasons
  - and for performance knowledge reasons
  - but early enough for observers and HSC to prepare
  - to have observations available for scheduling
  - and enable community support staff 'training on the job'

- **1 Feb 2007: Issue AO for 'Key Projects' proposals**
- **5 Apr 2007:** Submission deadline for GT KP proposals
- **5 Jul 2007:** Selection & announcement of GT KP programmes
- **1 Nov 2007:** Submission deadline for OT KP proposals
- **28 Feb 2008:** Selection & announcement of OT KP programmes

- **28 Feb 2008: Issue AO for 'Cycle 1 Regular GT' proposals**
- **3 Apr 2008:** Submission deadline for GT1 proposals
- **5 Jun 2008:** Selection & announcement of GT1 programme

Initial AO foreseen 1 Feb 2007

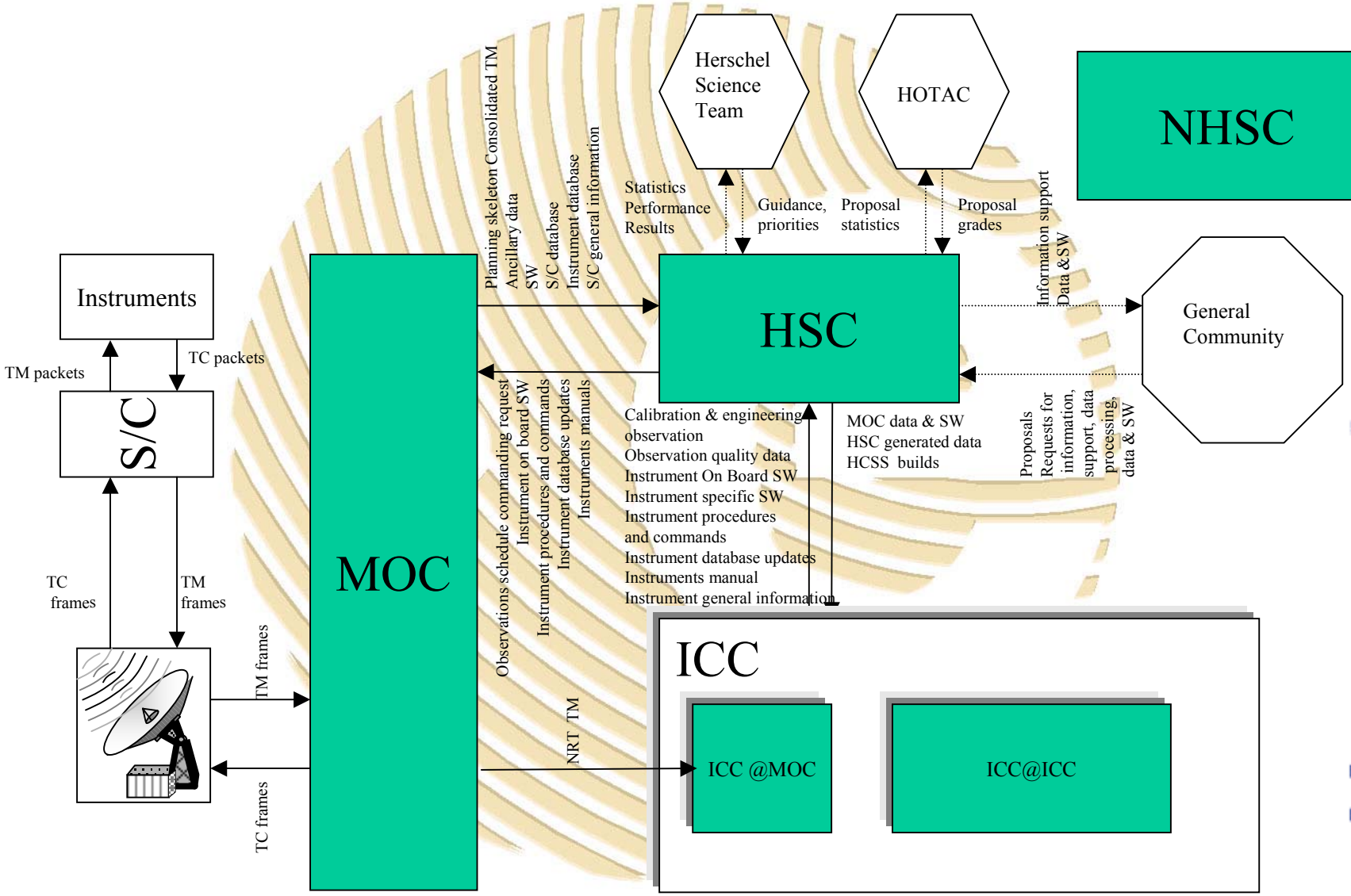
HERSCHEL SPACE OBSERVATORY

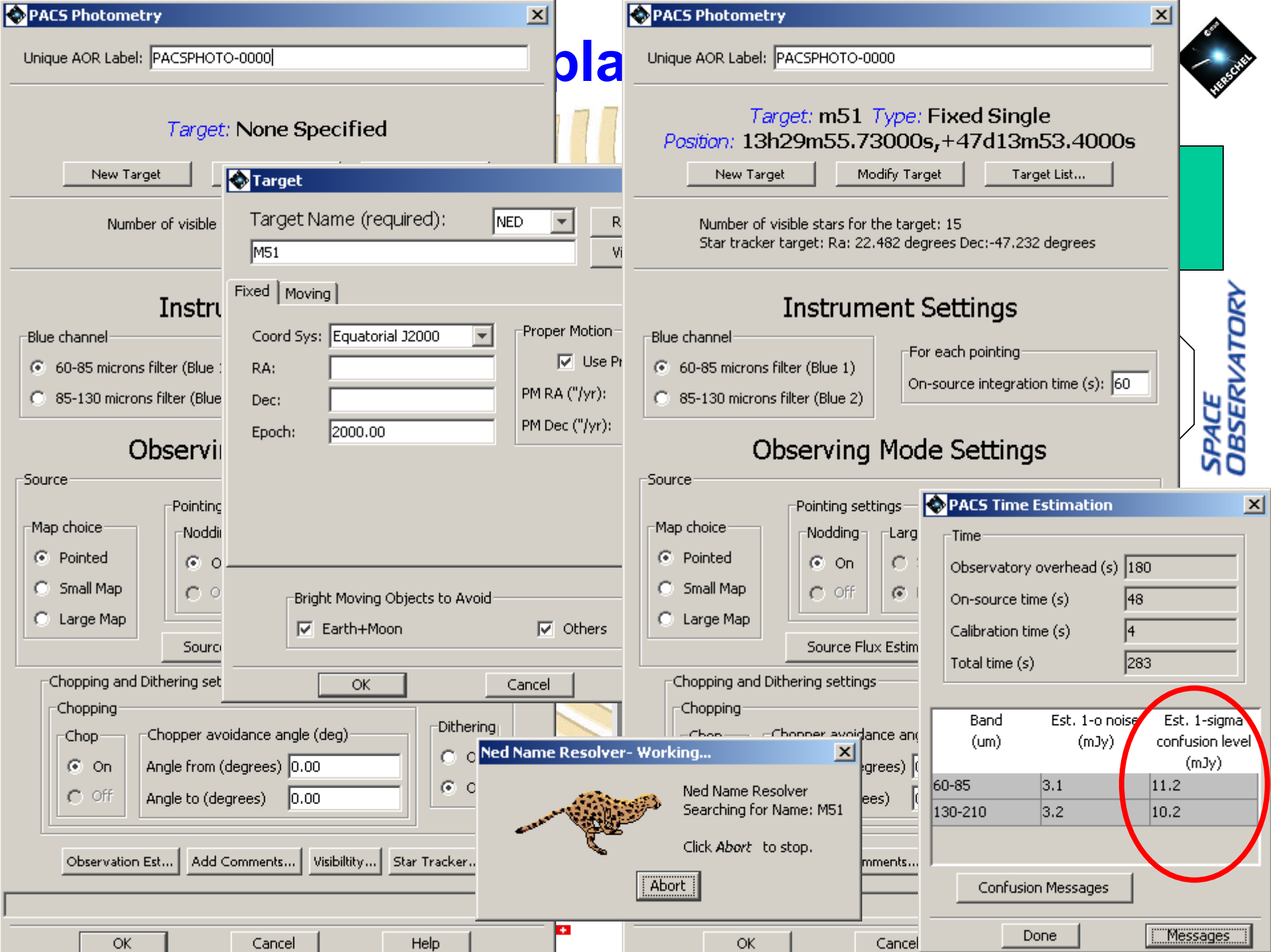
Herschel 'Key Projects'

- **Foreseen to be important upfront (SMP/instrument AO)**
  - introduced to ensure that 'unusually large' observing programmes can be proposed, selected, and observed
  - need 'pre-identified' due to the nature of the foreseen science objectives and the lack of 'precursor' (IRAS-type) mission
- **Definition of a 'Key Project' programme - it must**
  - exploit unique Herschel capabilities address (an) important scientific issue(s) in a comprehensive manner
  - require a large amount of observing time to be used in a uniform and coherent fashion
  - produce a resulting well characterised dataset of high archival value
- **Data reduction**
  - it is recognised that there is a legitimate science return interest that
    - the data generated by the observations are timely reduced, and
    - the data products and tools are made public
  - therefore 'Key Project' consortia must demonstrate commitment and ability to perform data reduction, and must make data products and tools publicly available at the end of the proprietary time period

HERSCHEL SPACE OBSERVATORY

Ground segment



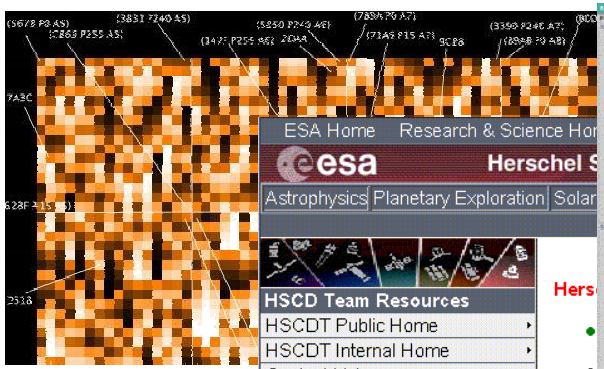

PACS Photometry
Unique AOR Label: PACSPHOTO-0000
Target: None Specified
New Target
Number of visible
Target
Target Name (required):
NED
M51
Fixed
Moving
Coord Sys: Equatorial J2000
RA:
Dec:
Epoch: 2000.00
Proper Motion
Use Pr
PM RA ("/yr):
PM Dec ("/yr):
Bright Moving Objects to Avoid
Earth+Moon
Others
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
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
OK
Cancel
Ned Name Resolver- Working...
Ned Name Resolver
Searching for Name: M51
Click Abort to stop.
Abort
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-o noise (mJy)
Est. 1-sigma confusion level (mJy)
60-85 3.1 11.2
130-210 3.2 10.2
Confusion Messages
Done
Messages
HERSCHEL
SPACE OBSERVATORY

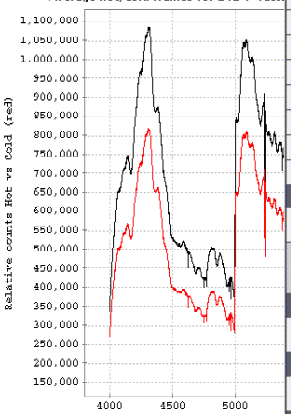
Data processing – HCSS/DP

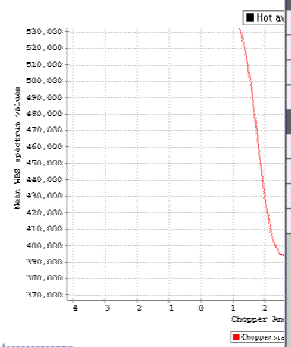
- Ensemble of services in a single, coherent platform-independent system – HCSS/DP
- Offering the astronomical community the means (data, products, software) to do science without the need to buy licenses
- Source of software, calibration and documentation to reduce and do science with Herschel data ('Observer IA')
- Source of software and documentation to support the commissioning of the instruments, the validation of the observing modes and the calibration of satellite pointing and instruments ('Calibration IA')
- Toolbox to develop data processing algorithms
- Generation of standard observation products and quality information by using IA modules ('SPG' & 'QC' pipelines)
- On-line, context-sensitive and printable help documentation for end-users and developers based on XML/DocBook
- Data and services Virtual Observatory compliant + FITS

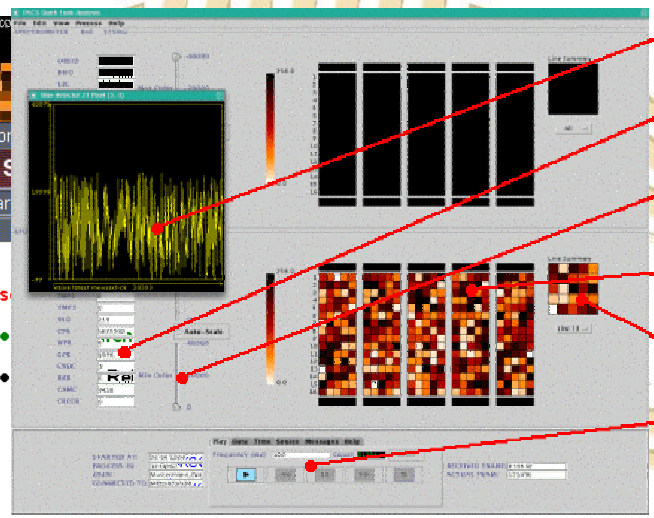
HERSCHEL SPACE OBSERVATORY

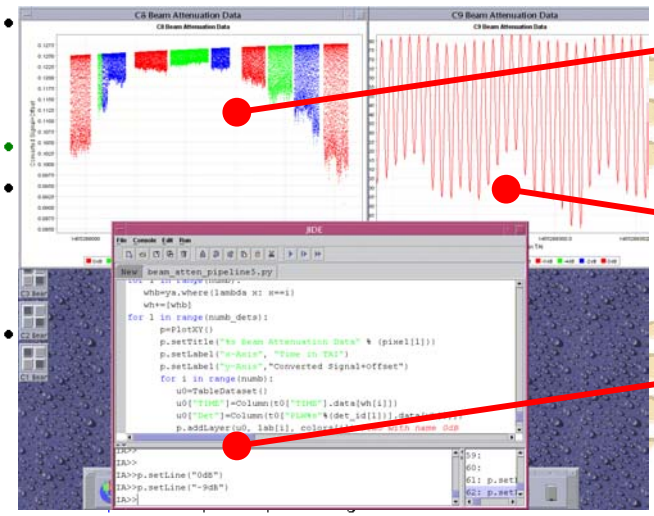
Herschel data processing











- DP-WG MoM: DP Working Group Minutes of Meetings
- Livelink documents: Other related documents under Livelink, including DP CCB and User Group documentation.

Last updated: Friday, 26-Aug-05 13:02:20

Strip chart

Dec Mec

Colour range

Instrument array

Line summary

Data selector

Linearity test

Demodulated signal

Script debugger for Interactive Analysis

HERSCHEL SPACE OBSERVATORY

Herschel key dates

- FIRST feasibility study: 1982-83
- …
- FIRST confirmed 4th Cornerstone: Dec 1993
- …
- Selection of science instruments/PIs: 1997-98
- FIRST becomes Herschel: Dec 2000
- Start of spacecraft Phase B: mid 2001
- Start of spacecraft Phase C/D: early 2003
- SVM, PLM, telescope, CQM/EQM testing 2005
- SVM, PLM, instruments, telescope deliveries: 2006
- Integration & tests/verification: 2007
- Issue of first AO for proposals: 1 Feb 2007
- Launch: 2008
- Early operations: first 6 months
- Routine Science Operations: 2008 - 2011

HERSCHEL SPACE OBSERVATORY


Herschel Science Centre - Mozilla Firefox
File Edit View Go Bookmarks Tools Help
http://www.rssd.esa.int/Herschel/links.shtml
ESA Home
Research & Science Home
Sci-Tech Portal
Herschel Portal
Herschel Science Centre
European Space Agency
Astrophysics
Planetary Exploration
Solar Terrestrial Science
Science Operations
Herschel Resources
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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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Initial AO foreseen 1 Feb 2007