Herschel mission: Overview and observing opportunities

Observing opportunities with *Herschel*: A window to the far-infrared universe – an ASTROCAM workshop

ESAC, Villafranca, 14-15 December 2006

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

HERSCHEL SPACE OBSERVATORY

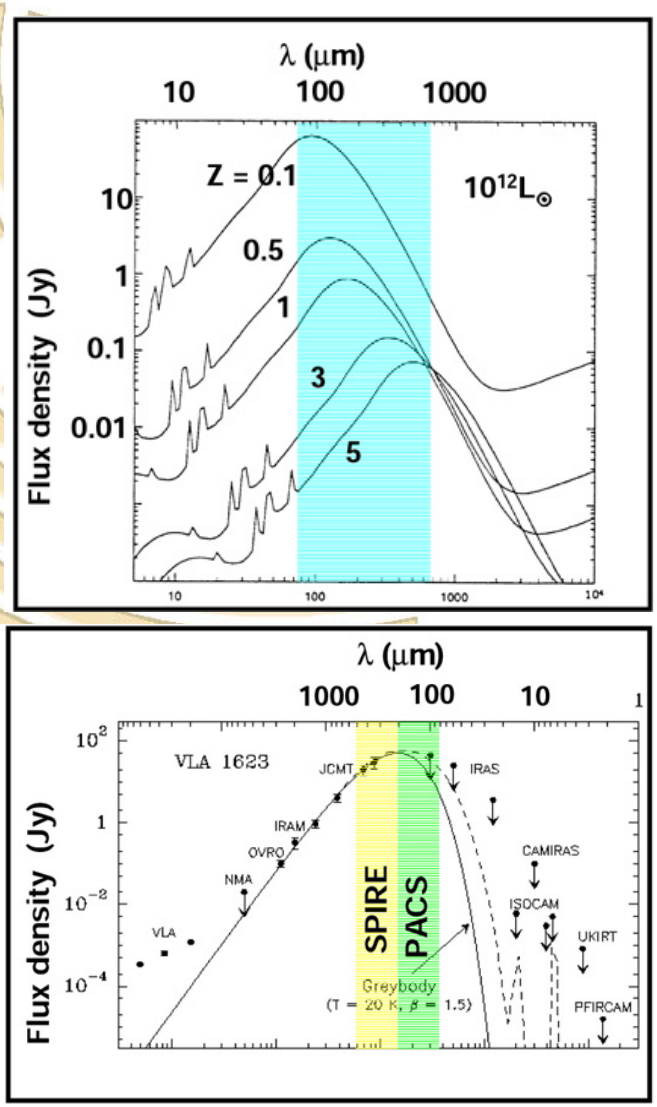
Herschel in a nutshell

- **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

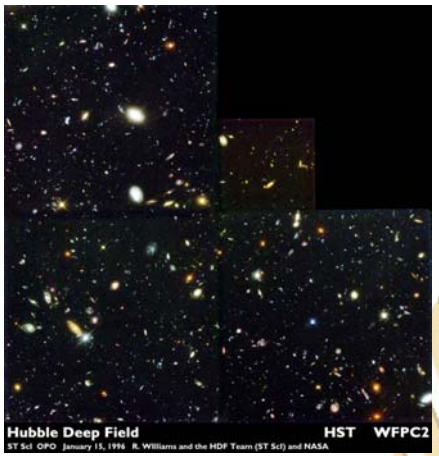
The Cool Universe

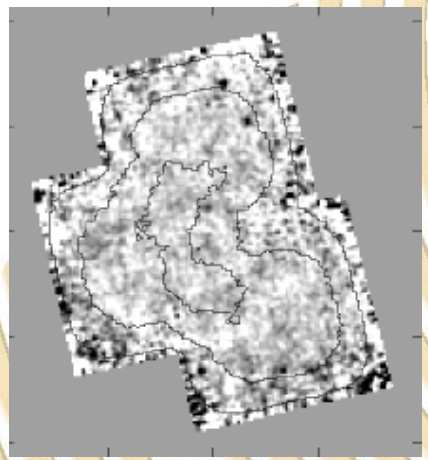
- **Herschel spectral coverage**
  - black-bodies 5-50 K
    - continuum radiation
    - dust grains (re-)radiating
  - gases 10-few100 K
    - brightest atomic/molecular lines
- **Herschel strengths**
  - covers IR dominated galaxies & protostar SED peaks
  - wide area mapping
  - full coverage spectral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

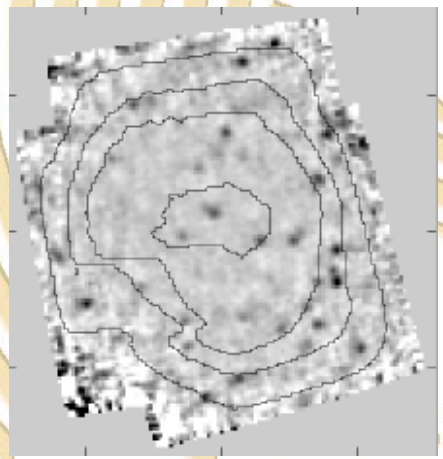


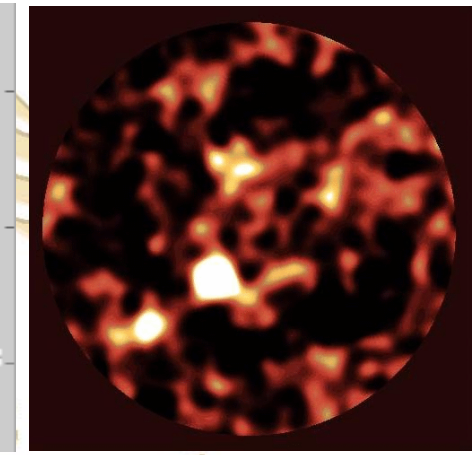
HERSCHEL SPACE OBSERVATORY

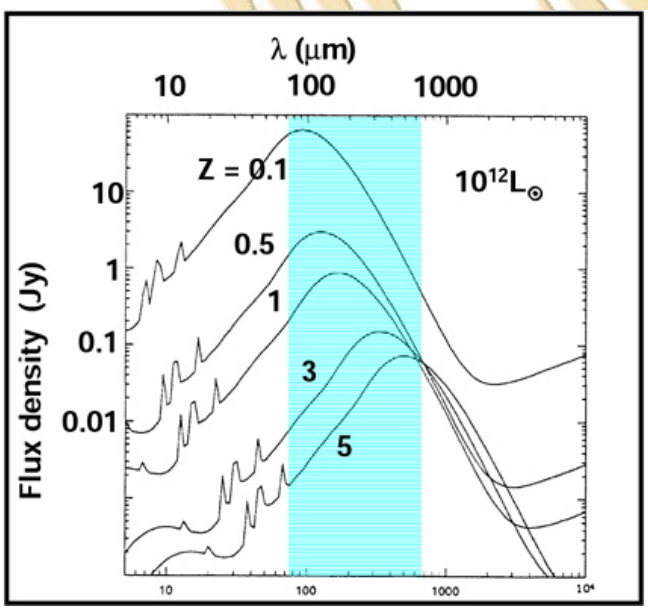
Galaxy formation & evolution











Early Spitzer results:

- 24 μm – 70%
- 70 μm – 23%
- 160 μm – 7%
- but now claiming all resolved!

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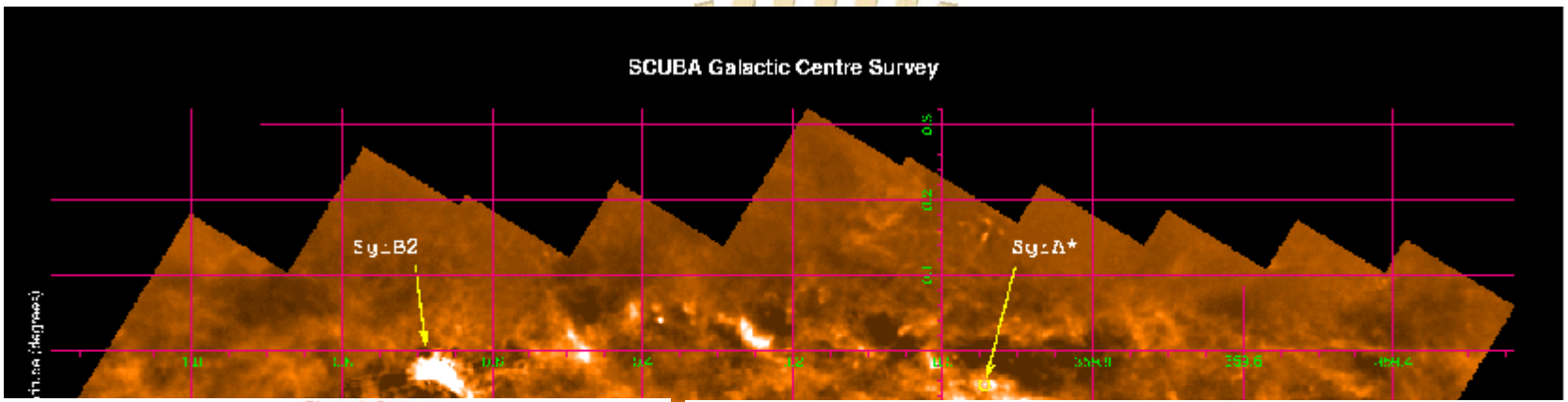
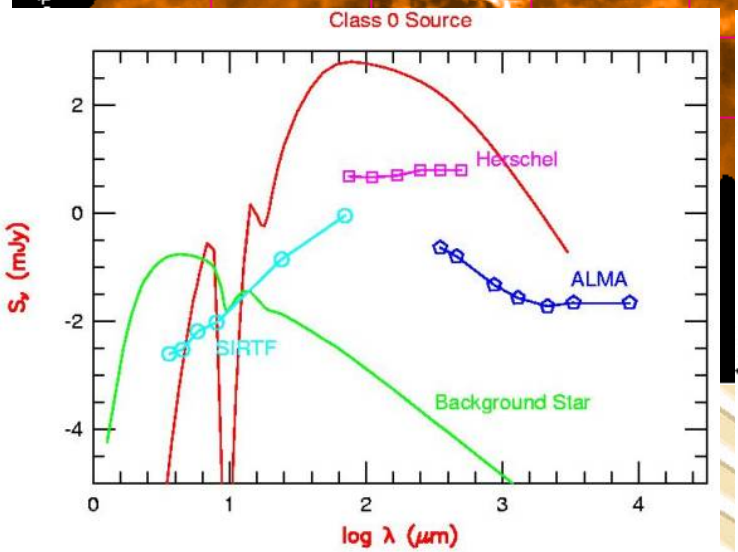
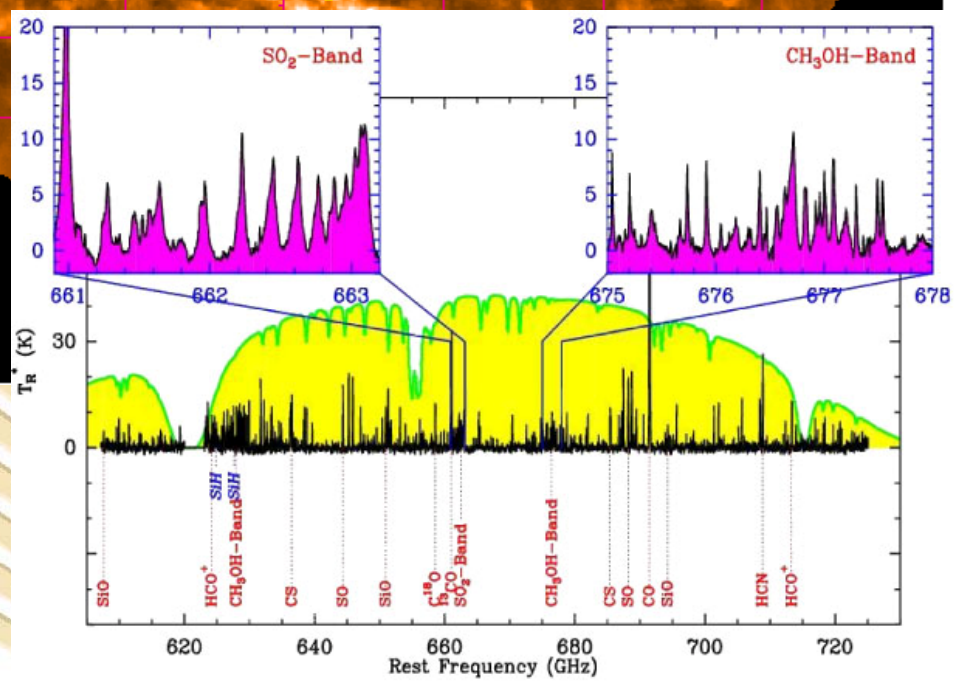
Surveys & follow-up







$0.1L_{sun}$ protostar at 300 pc

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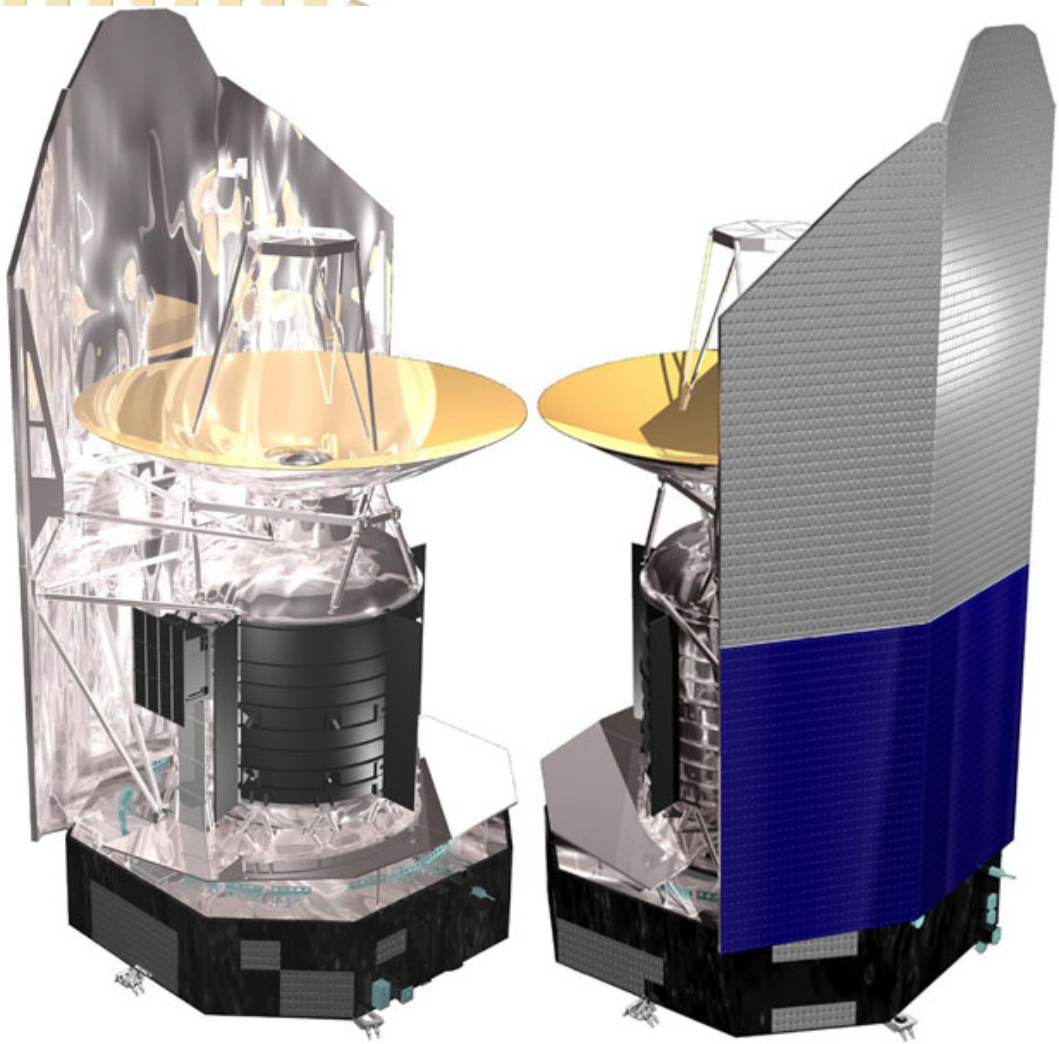
Herschel spacecraft *specs*

- telescope (eff) diam (3.3) 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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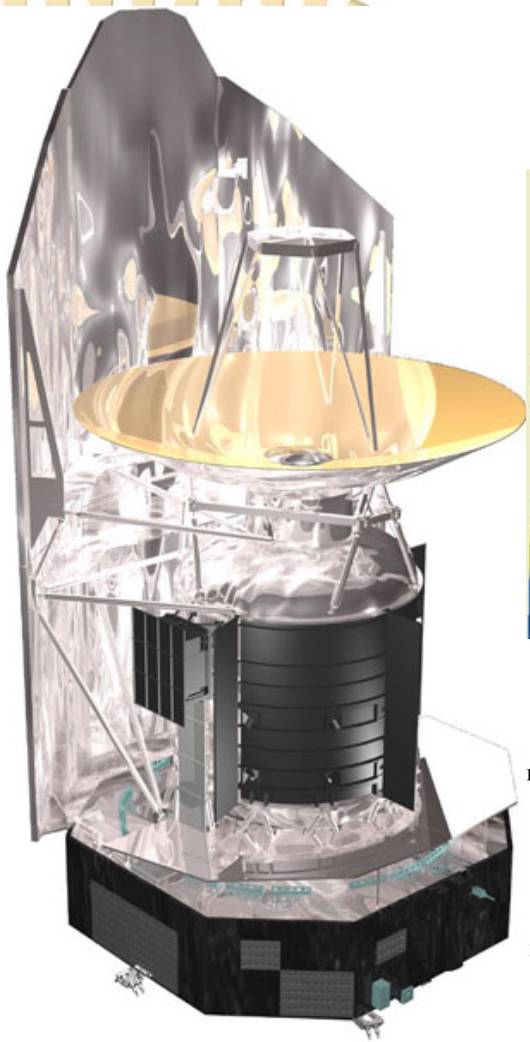
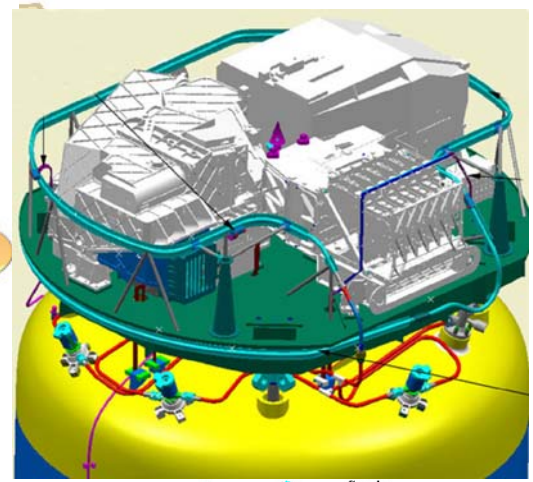
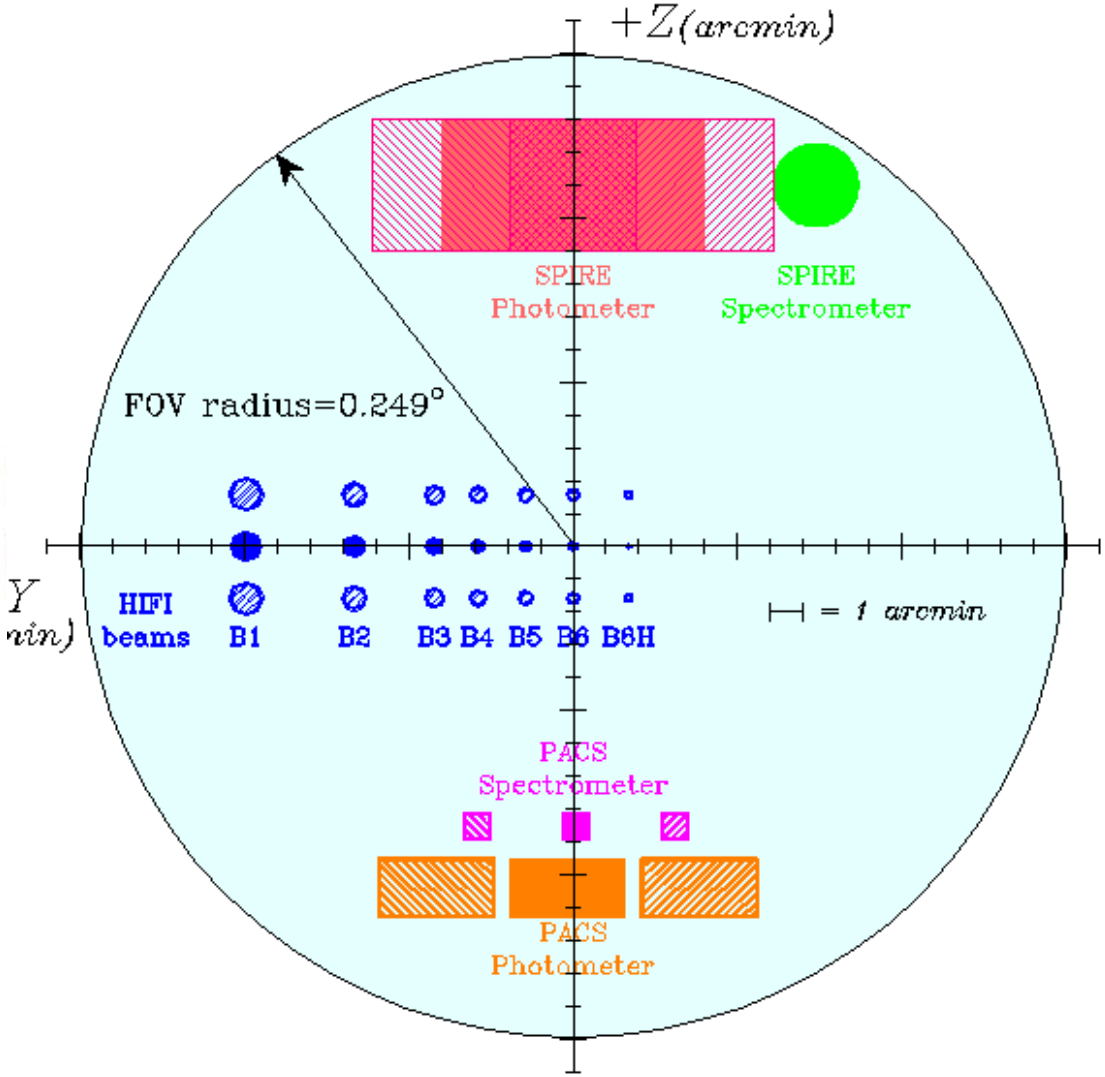




Herschel focal plane



HERSCHEL SPACE OBSERVATORY

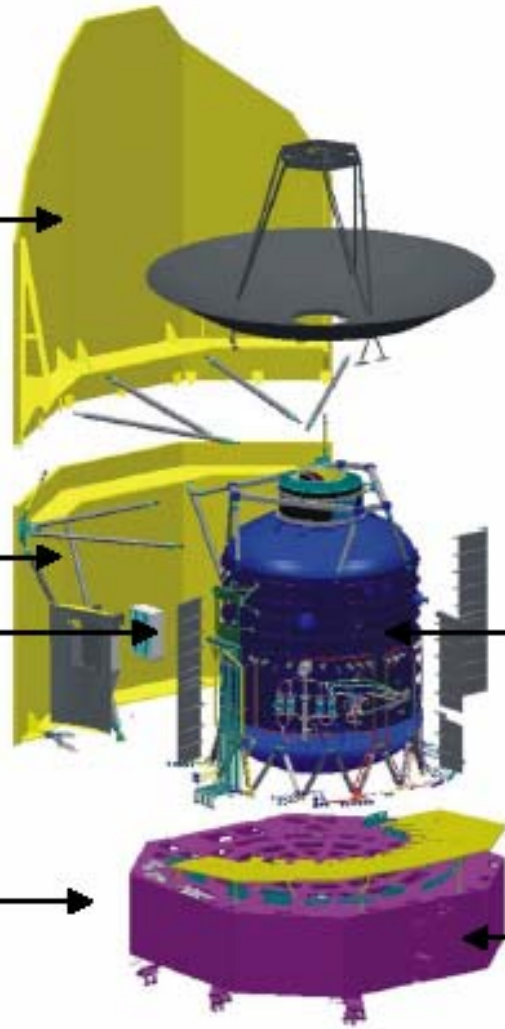
Herschel observatory capabilities

- **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 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

Following talks !!

HERSCHEL SPACE OBSERVATORY

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

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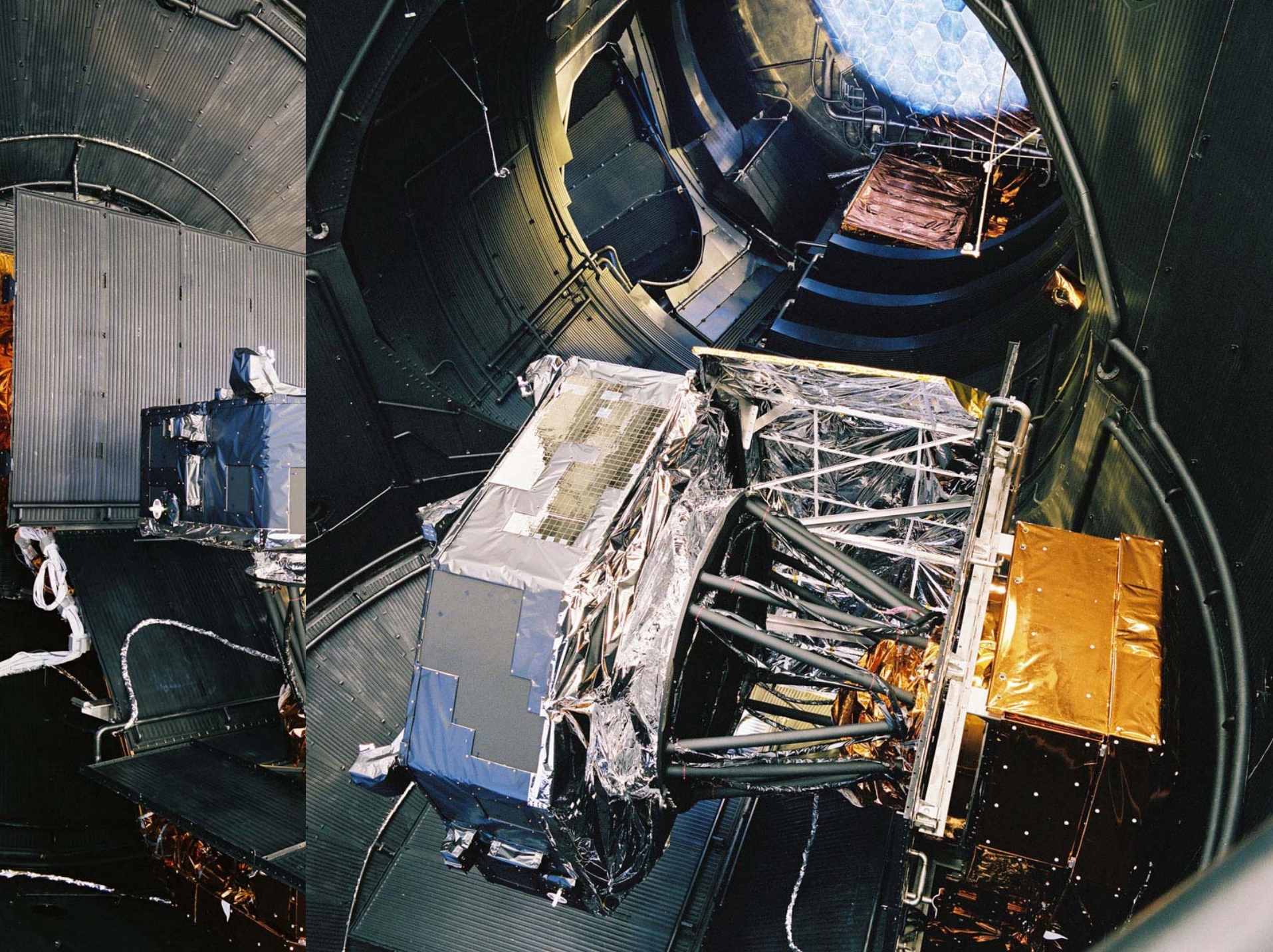
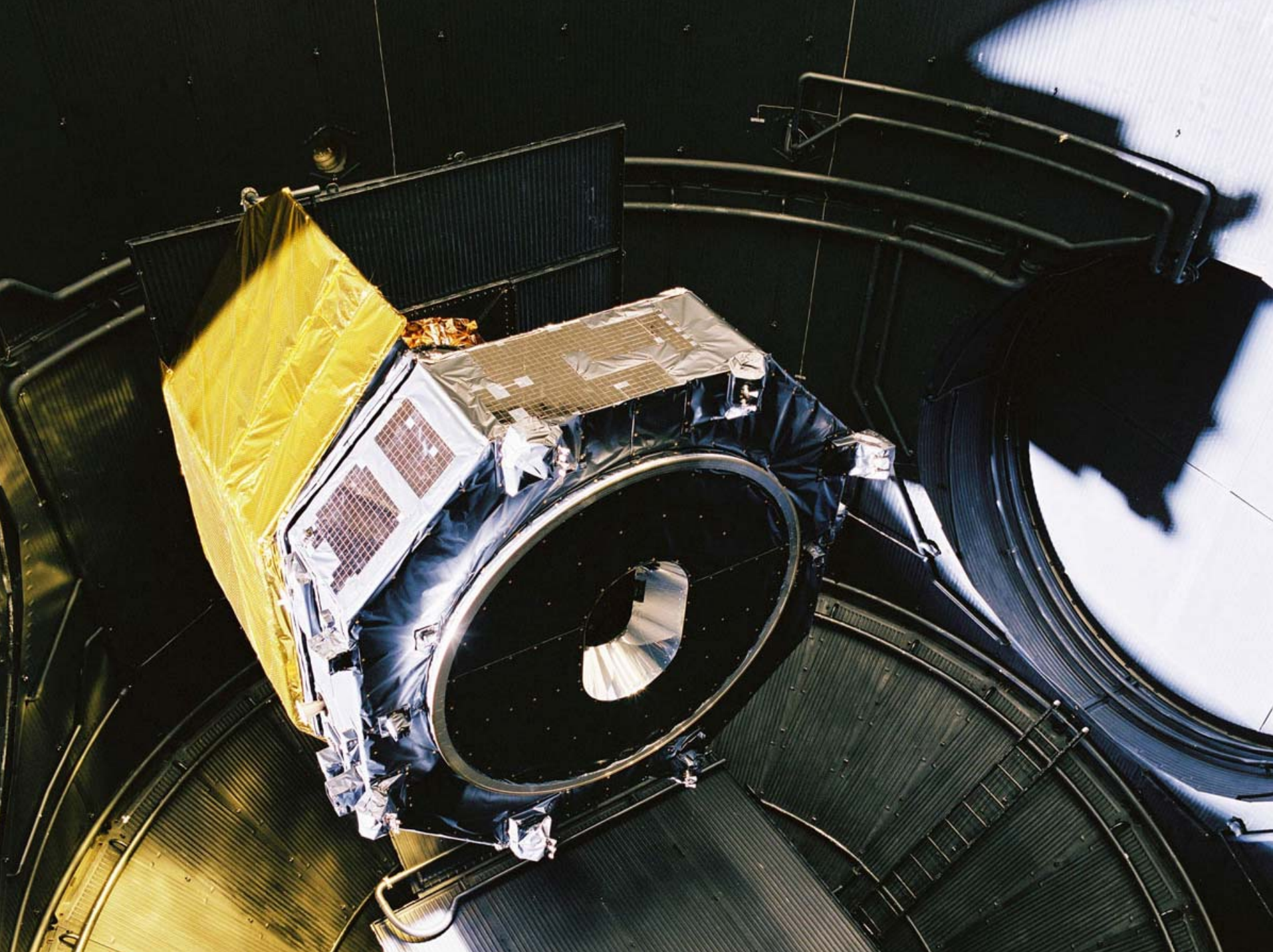
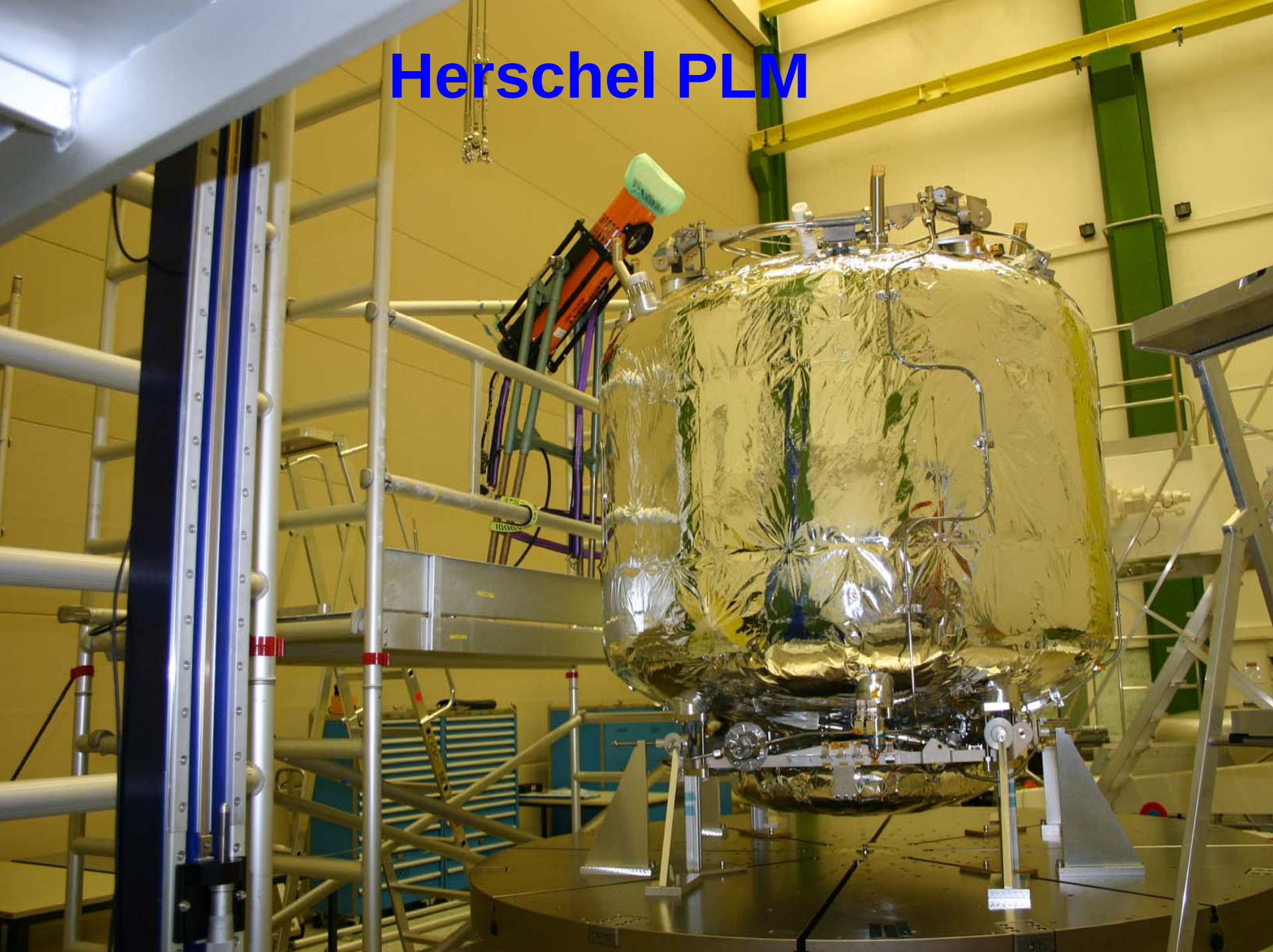
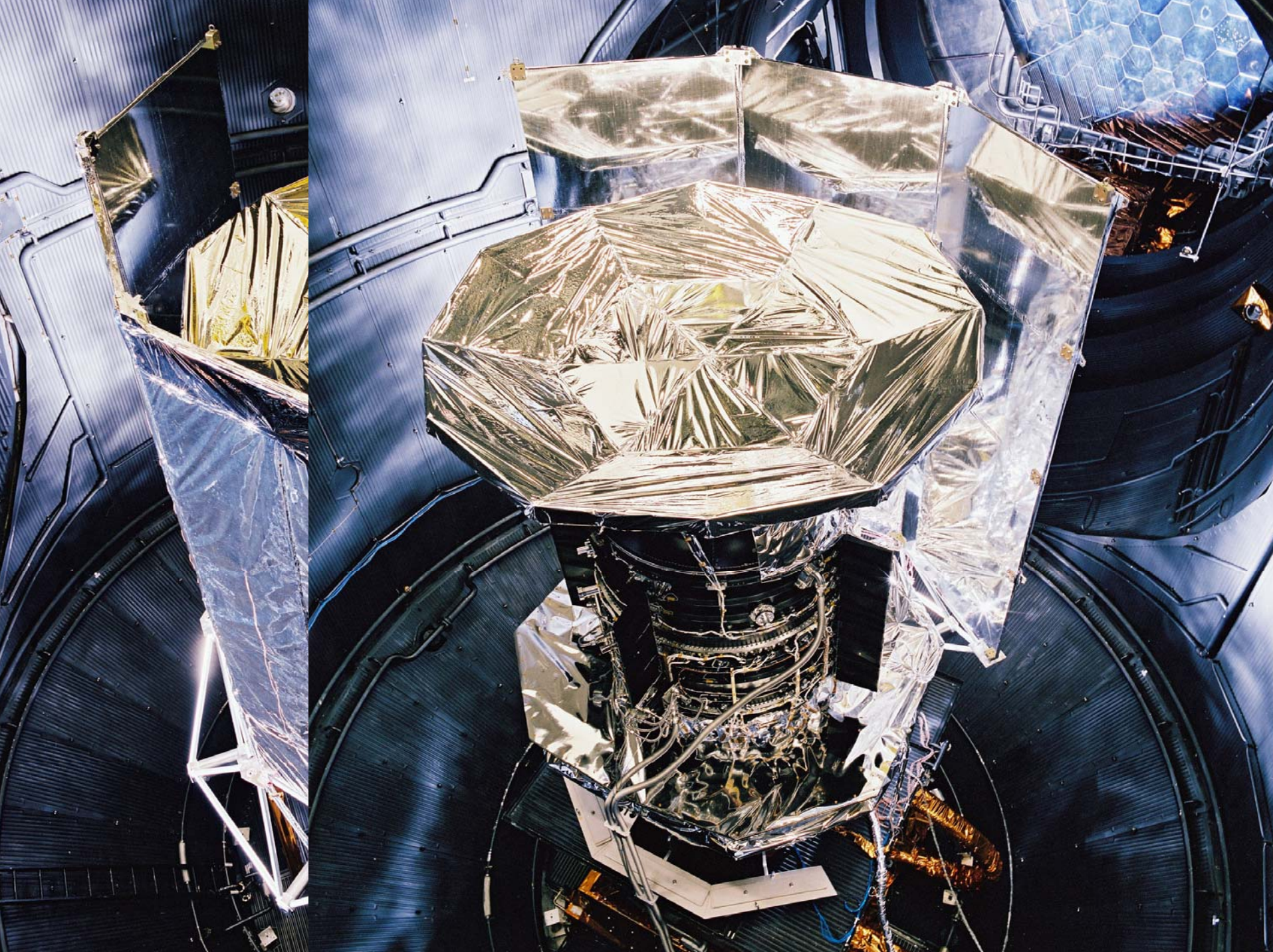
Herschel SVM/STM





Herschel PLM






-Z
APCO
APCO

Herschel STM satellite

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

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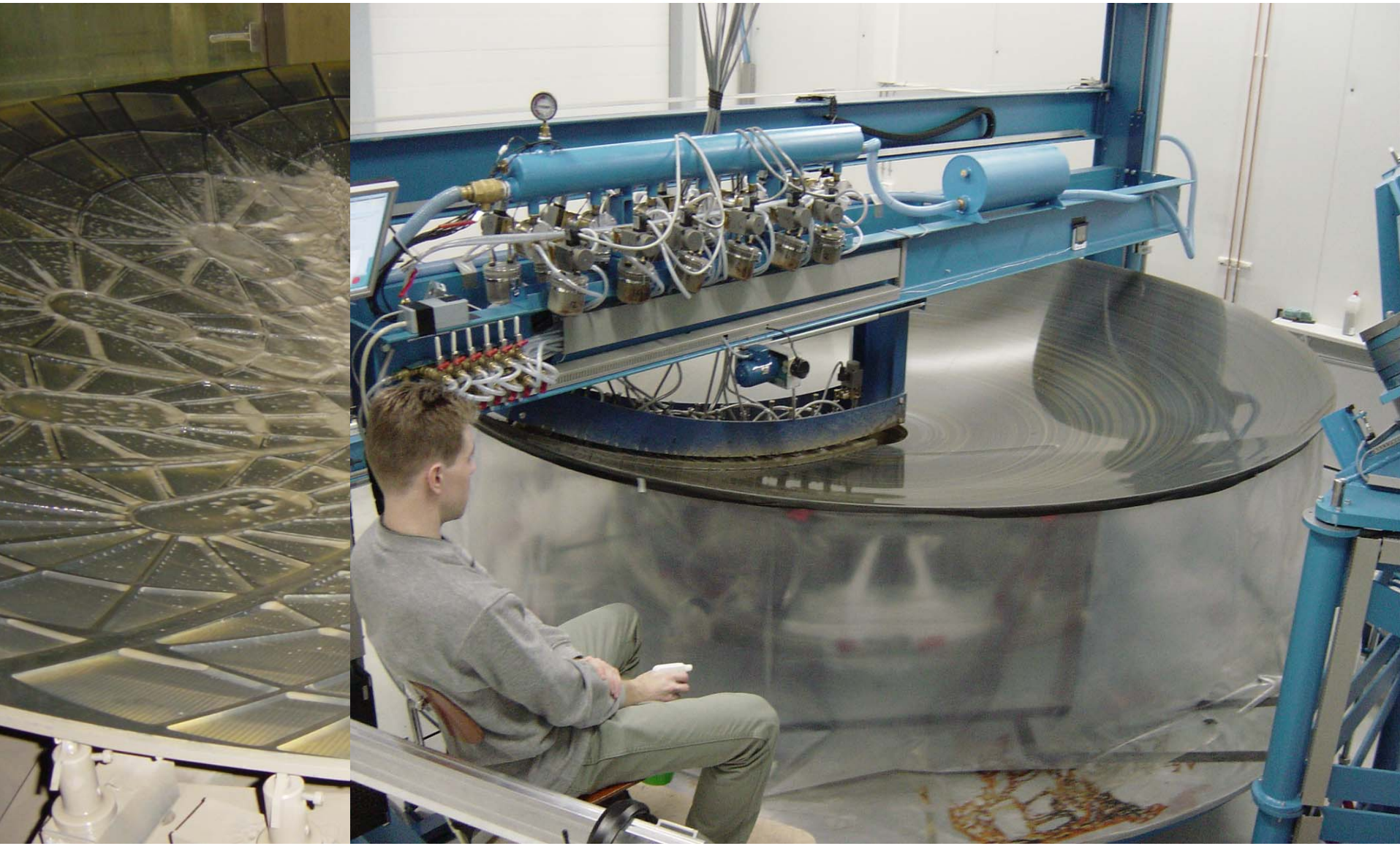
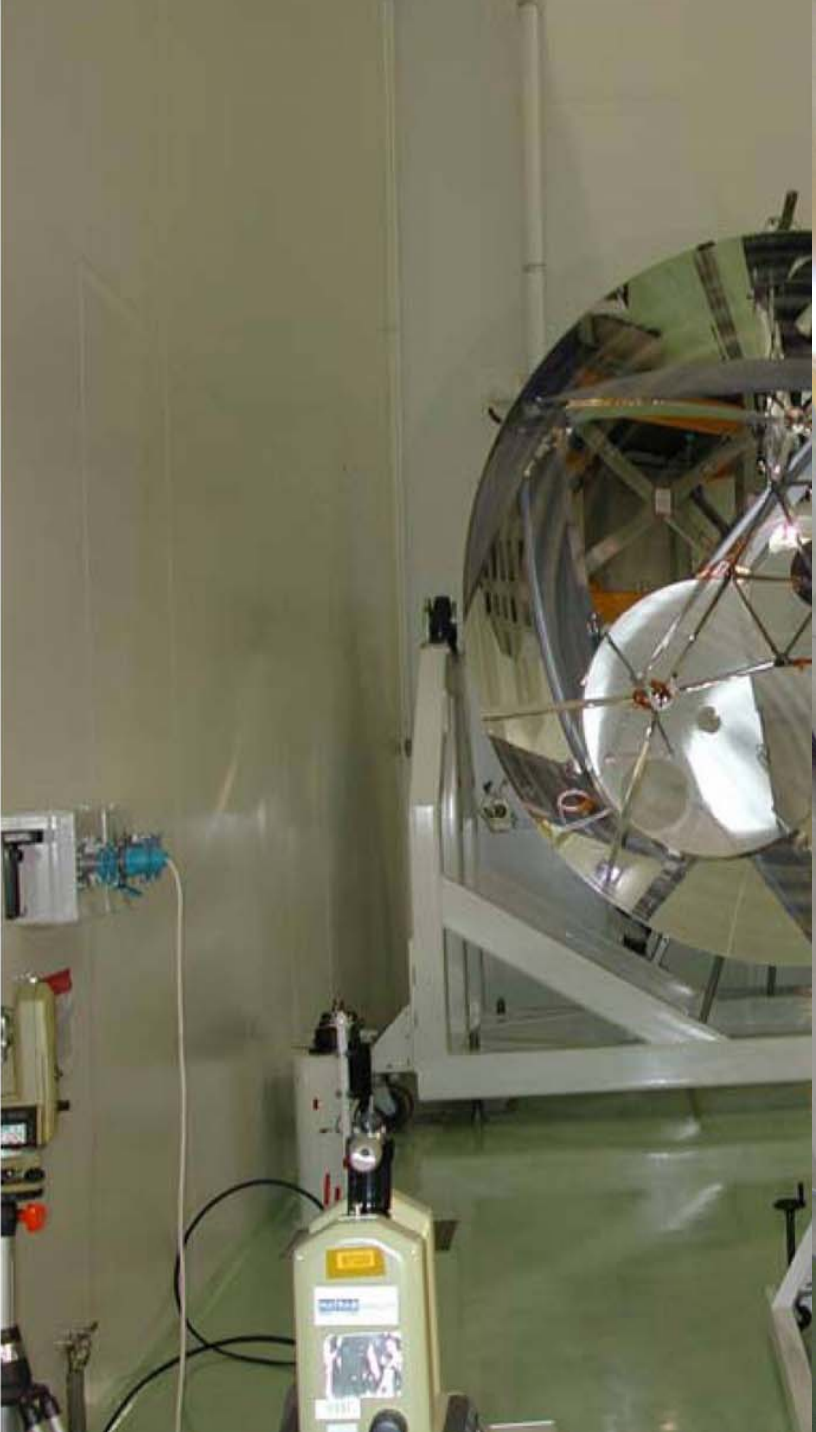
esa

Brazing of primary mirror ‘blank’

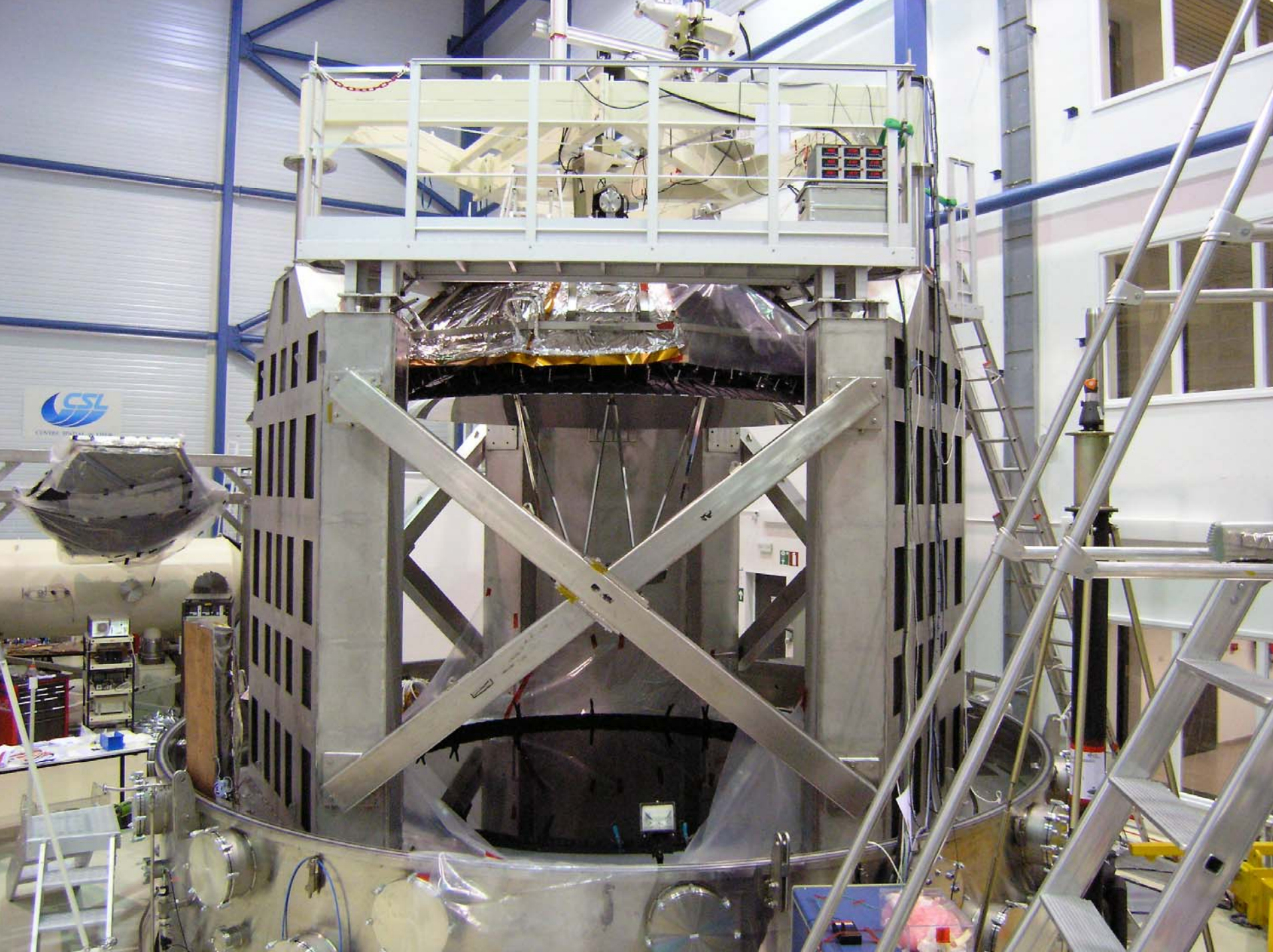
HERSCHEL SPACE OBSERVATORY

Grinding and lapping/polishing

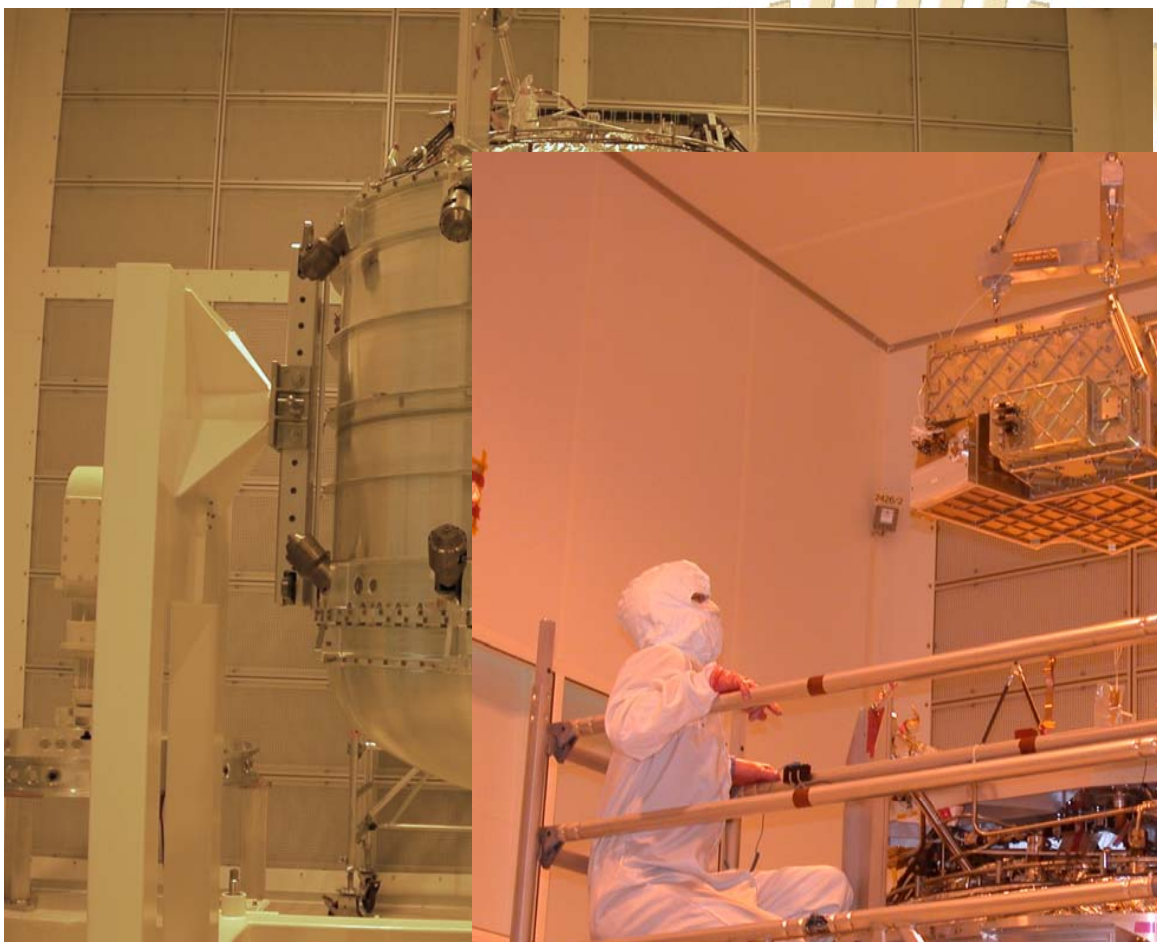




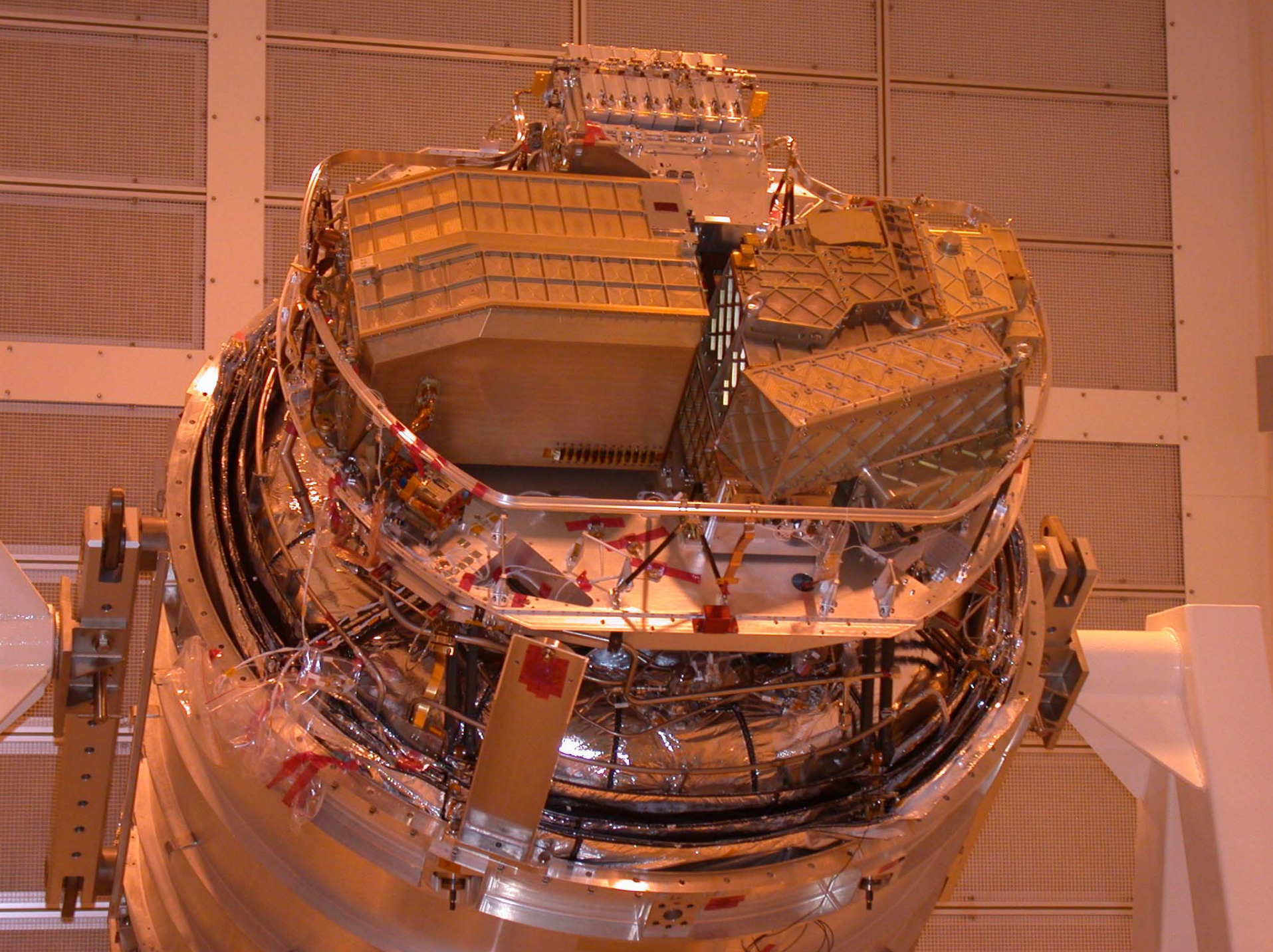

ADC
125kN

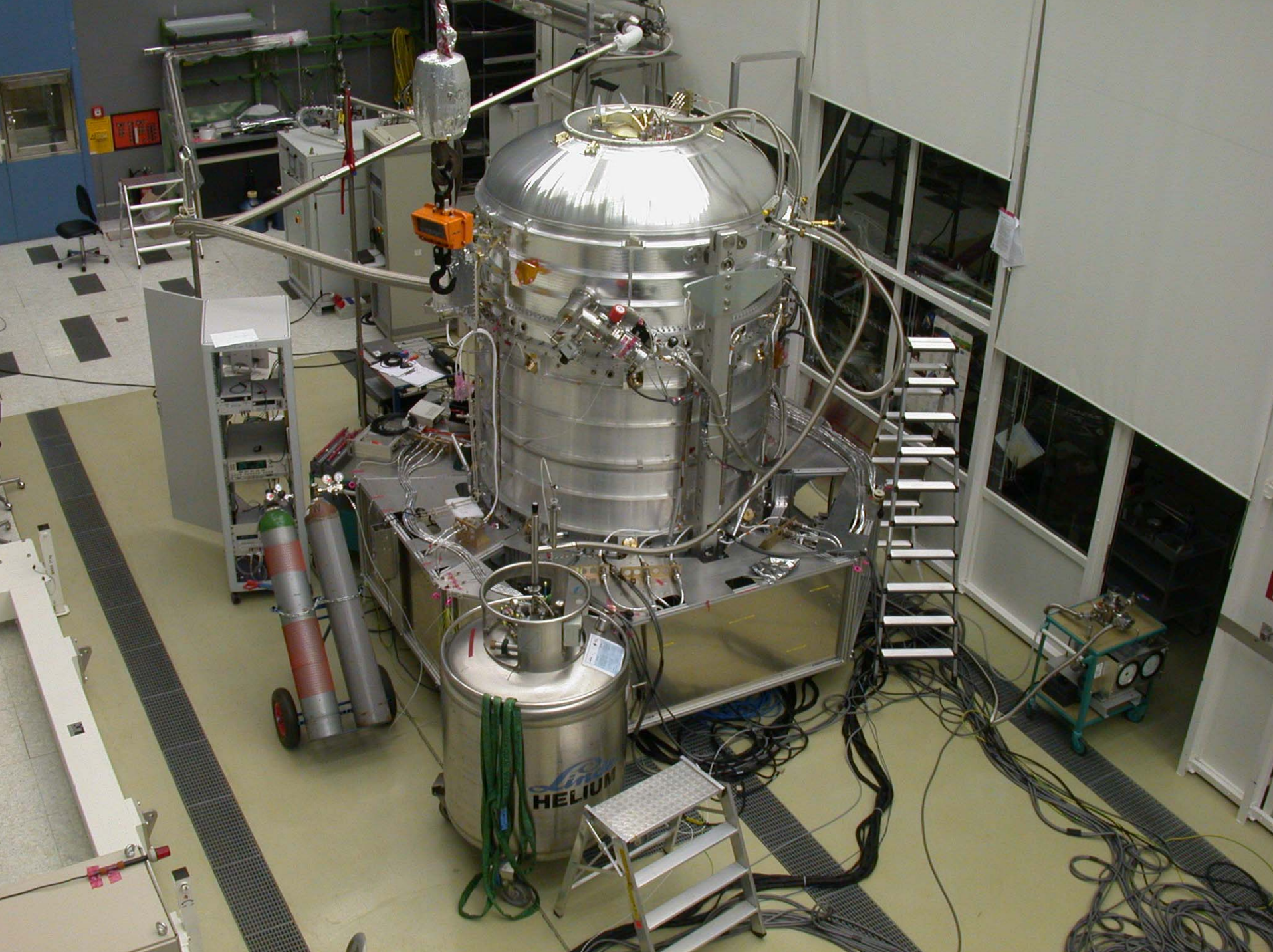


Herschel EQM



HERSCHEL SPACE OBSERVATORY



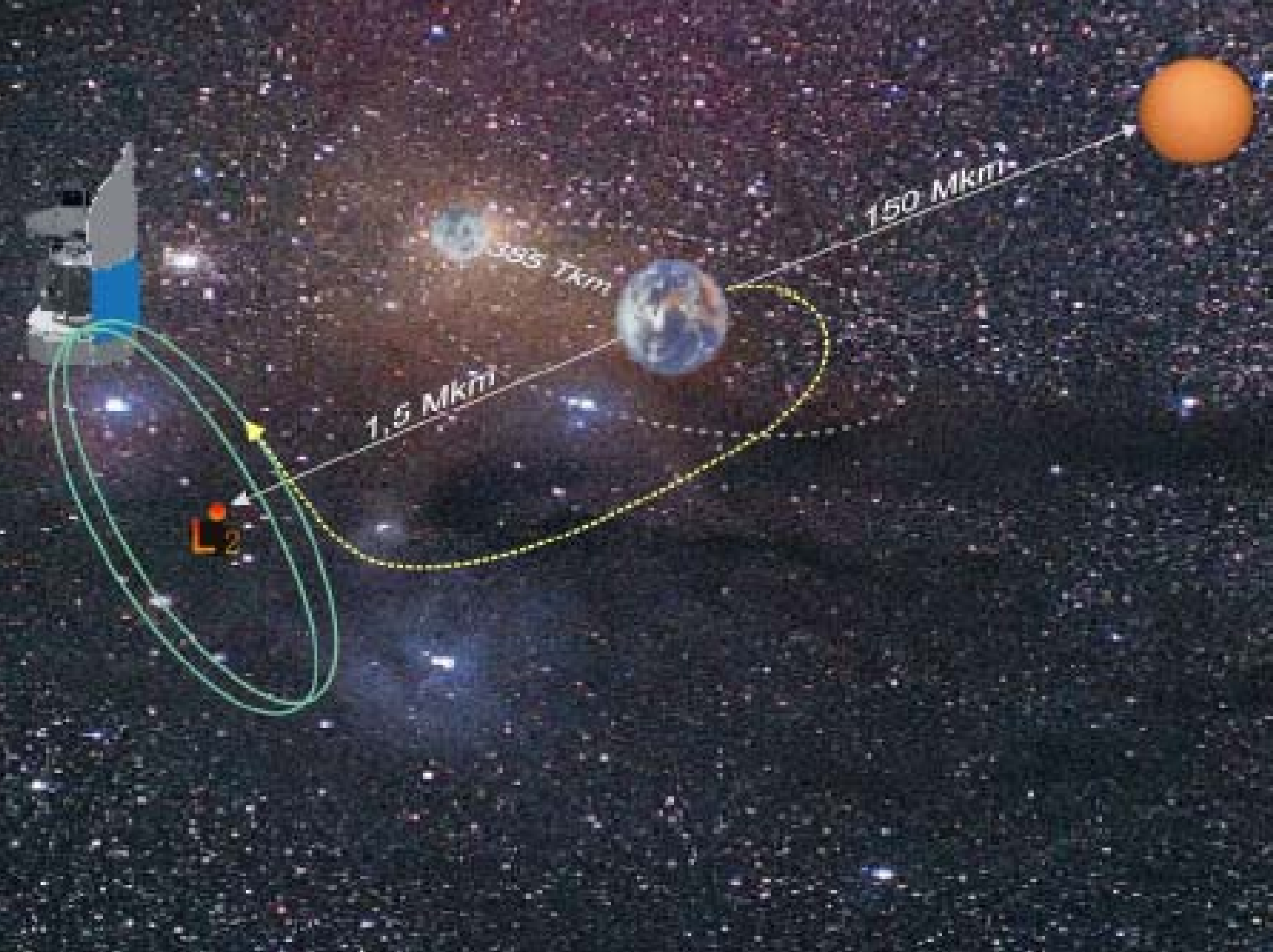

HELIUM

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
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
  - 'effective' AO date for open time proposers
- **25 Oct 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

AO doc package

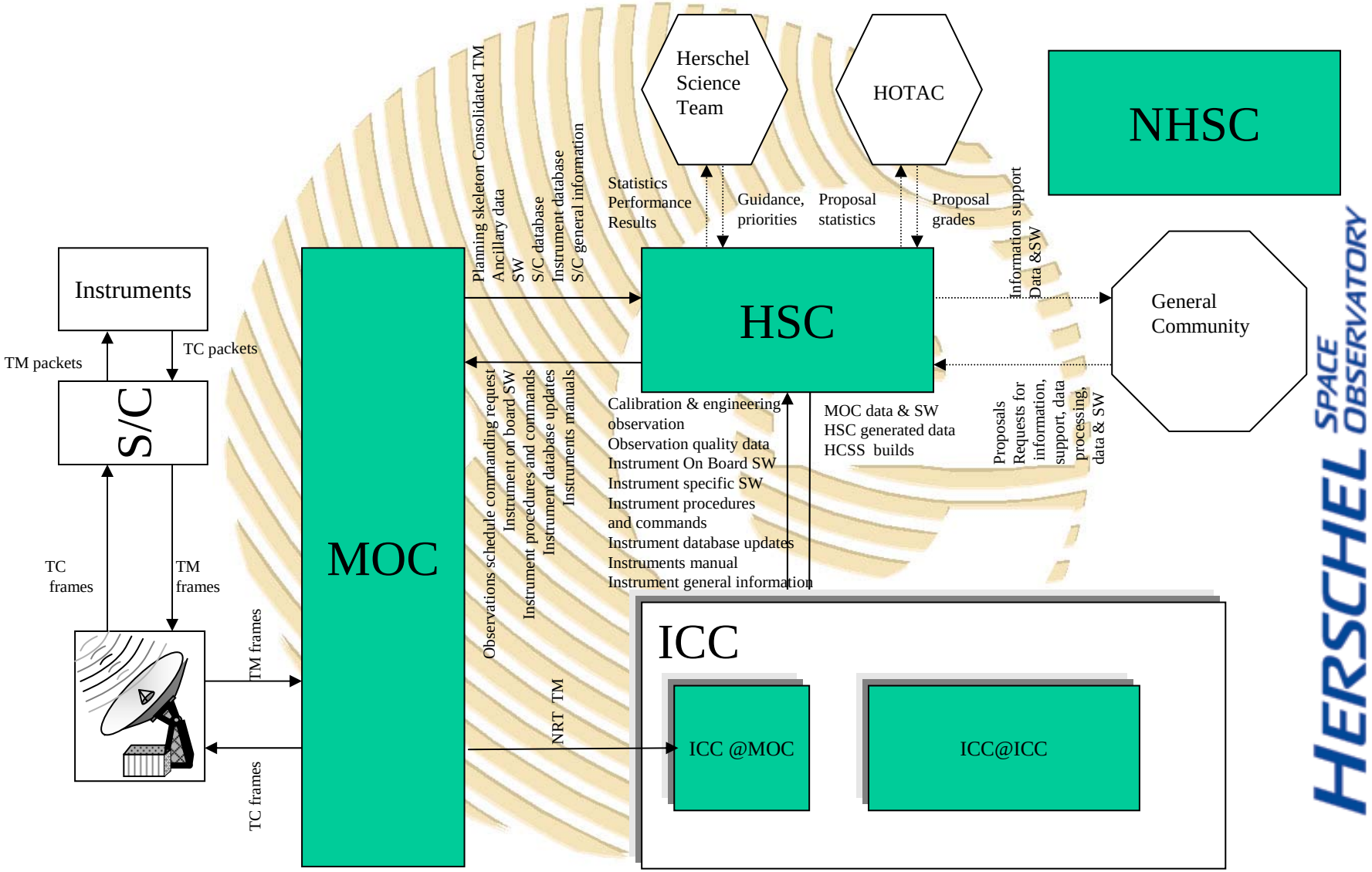
- **Cover letter – formal Call by D/SCI**
- **Executive summary**
  - duplicates as ‘AO manual’
  - points to online package with latest news
- **Policies and procedures**
  - politics / policies etc.
- **Herschel Observers’ manual**
  - spacecraft matters (pointing, visibility, etc)
- **3 x Instrument Observers’ manual**
  - PACS, SPIRE, HIFI – ultimately HSC responsibility
- **HSpot manual**
  - + additional tools (background noise estimator, confusion noise estimator, …)
- **Guaranteed time programme description**
  - with reserved observations lists

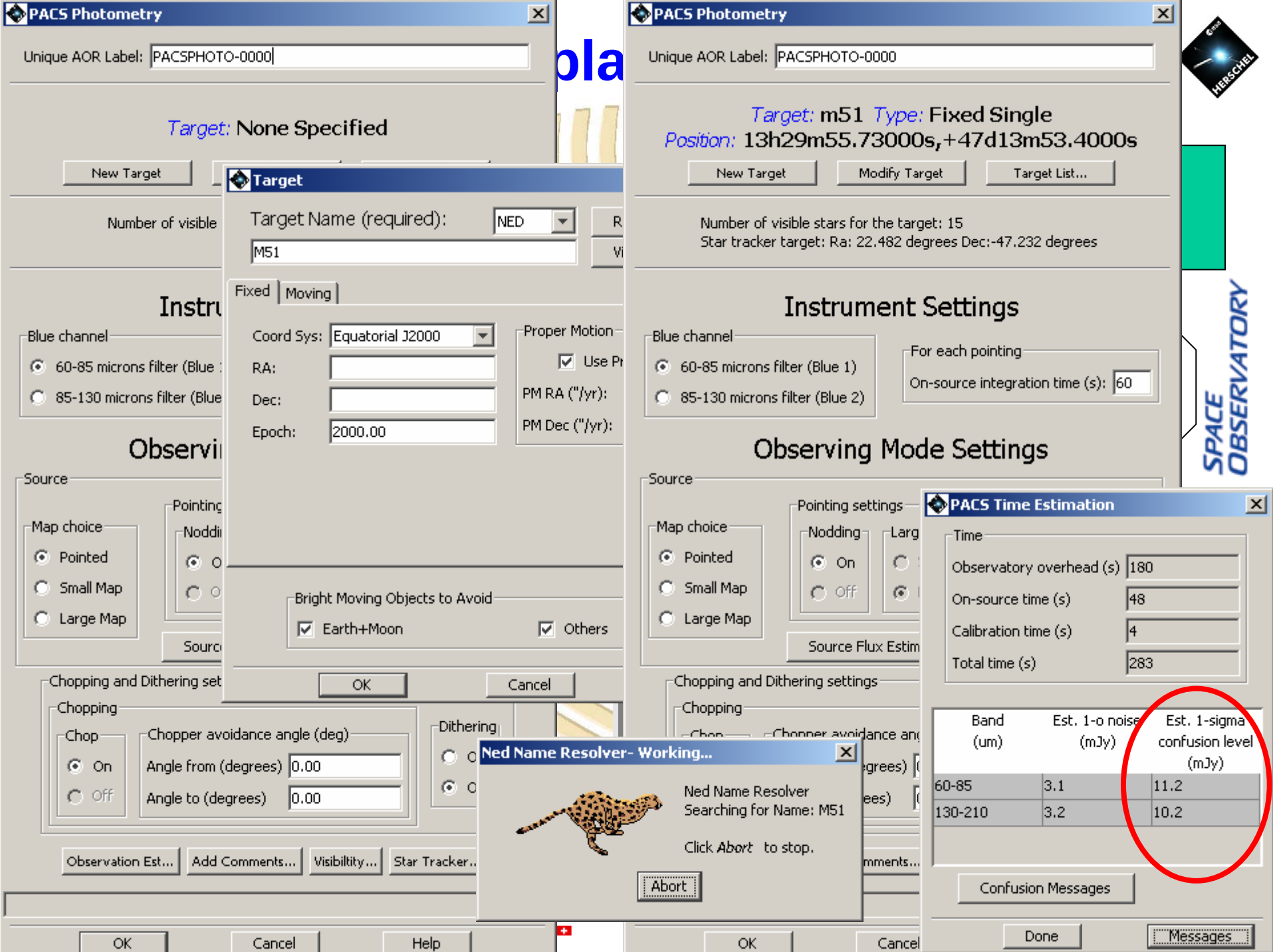
Herschel 'Key Projects'

- **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



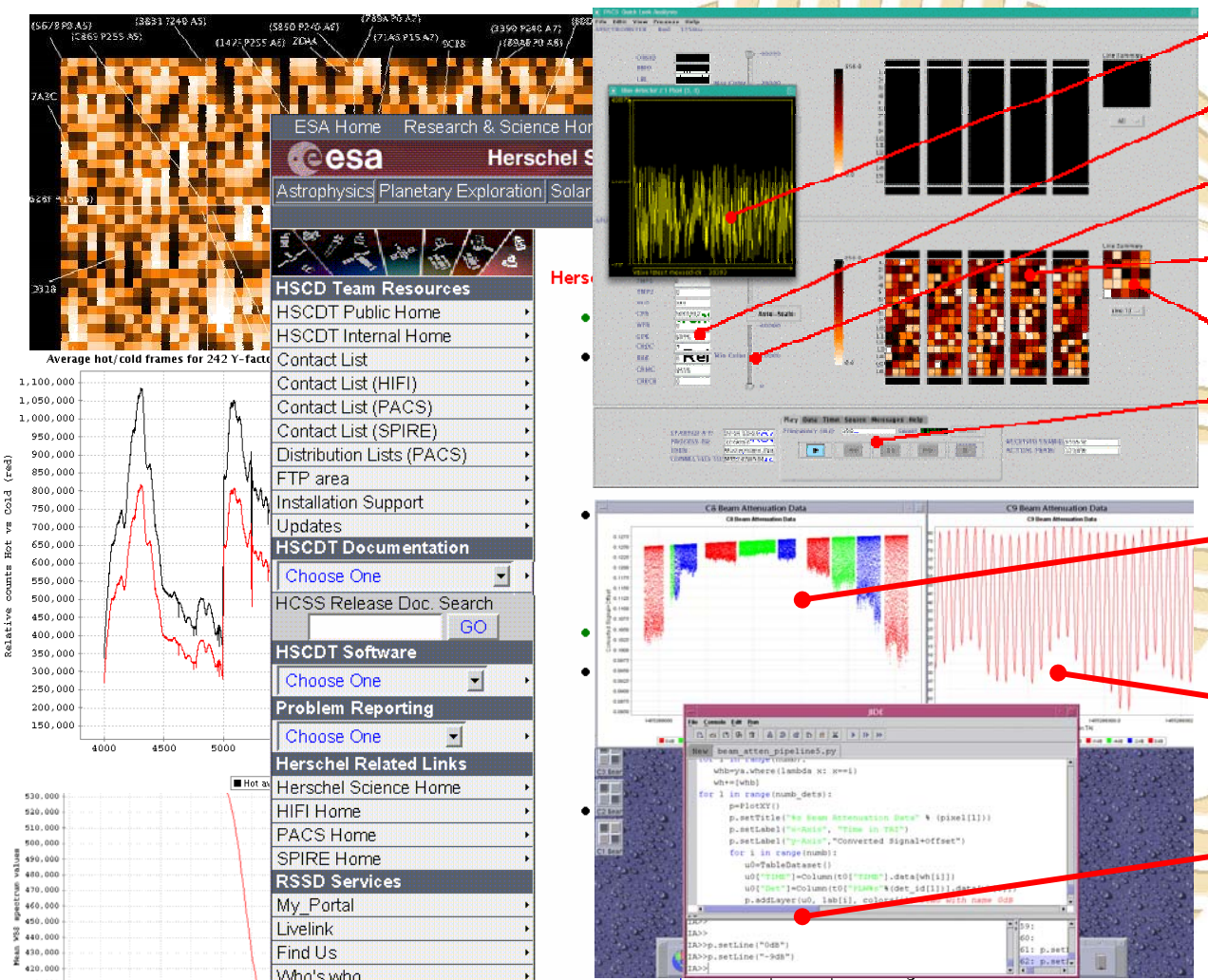

PACS Photometry
Unique AOR Label: PACSPHOTO-0000
Target: None Specified
New Target
Number of visible
Instru
Blue channel
60-85 microns filter (Blue
85-130 microns filter (Blue
Observi
Source
Map choice
Pointed
Small Map
Large Map
Pointing
Noddi
Sourc
Chopping and Dithering set
Chopping
Chop
On
Off
Chopper avoidance angle (deg)
Angle from (degrees) 0.00
Angle to (degrees) 0.00
Dithering
Observation Est...
Add Comments...
Visibiltity...
Star Tracker...
OK
Cancel
Help
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
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
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-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



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: 2006/07
- Integration & tests/verification: 2007
- Issue of first AO for proposals: 1 Feb 2007
- Launch: (not before 31 Jul) 2008
- Early operations: first 6 months
- Routine Science Operations: 2009 - 2012

HERSCHEL SPACE OBSERVATORY

Herschel Sci

Herschel Science Centre - Mozilla Firefox

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esa Herschel Science Centre European Space Agency

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Herschel Latest News

PACS FM instrument first light! PACS photometer first light was achieved on 15 November 2006 (left picture). The moments after was witnessed among others (middle picture, left to right) Marc Sauvage, Koryo Okumura, and Roland Vavrek (standing). The photometer first light video is available here (avi, 11Mb). The PACS spectrometer first light was achieved only two days later, on 17 November 2006 (right picture). This was a spectrometer grating scan looking at a 30K optical ground support equipment black body source. In the picture 25 simultaneous spectra can be seen (confirming all 25 modules working!) and in the inset the time evolution of the signal in a single pixel. [November 2006]

Herschel FM telescope at Flight Qualification Review (FQR). The telescope being inspected in the Astrium, Toulouse facilities as part of the FQR on 9 November 2006. In left picture from left to right: Dominic Doyle, Dominique Pierot, Jacqueline Fischer, Göran Pilbratt, Yves Toulemont, Gerald Crone, Pierre Olivier, and Jean-Luc Varin. In middle picture M2 and its supporting structure is inspected, in right picture the 'scatter cone' can be seen. [November 2006]

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