The Herschel Space Observatory
Potential, Plans, and Current Status

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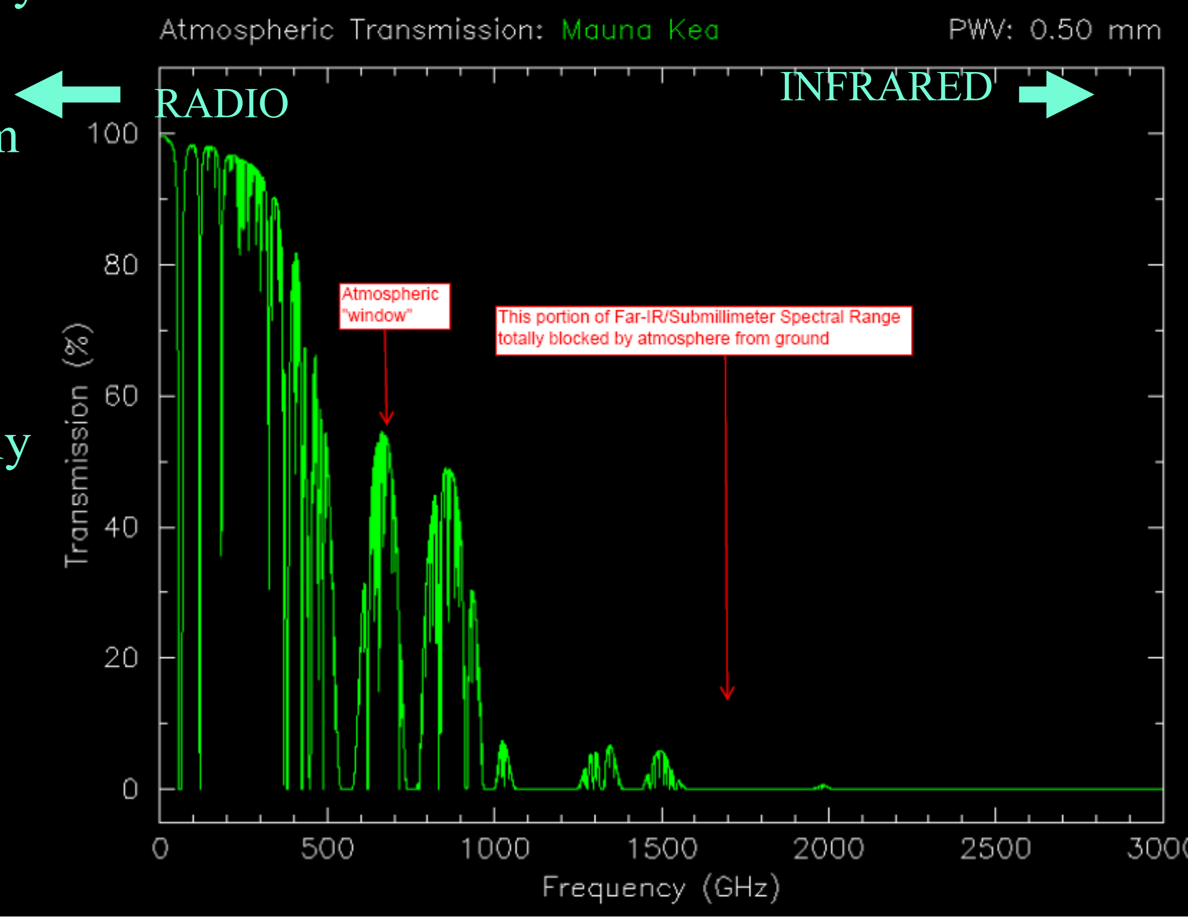
Space Based Observations Are Essential to

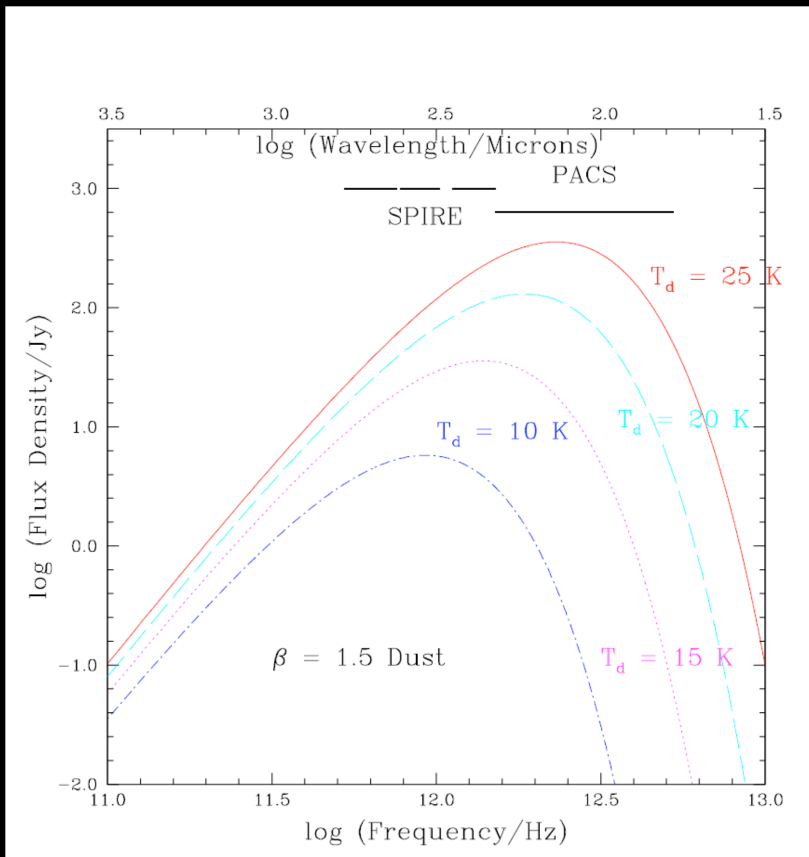
Overcome the strong absorption of Earth's atmosphere

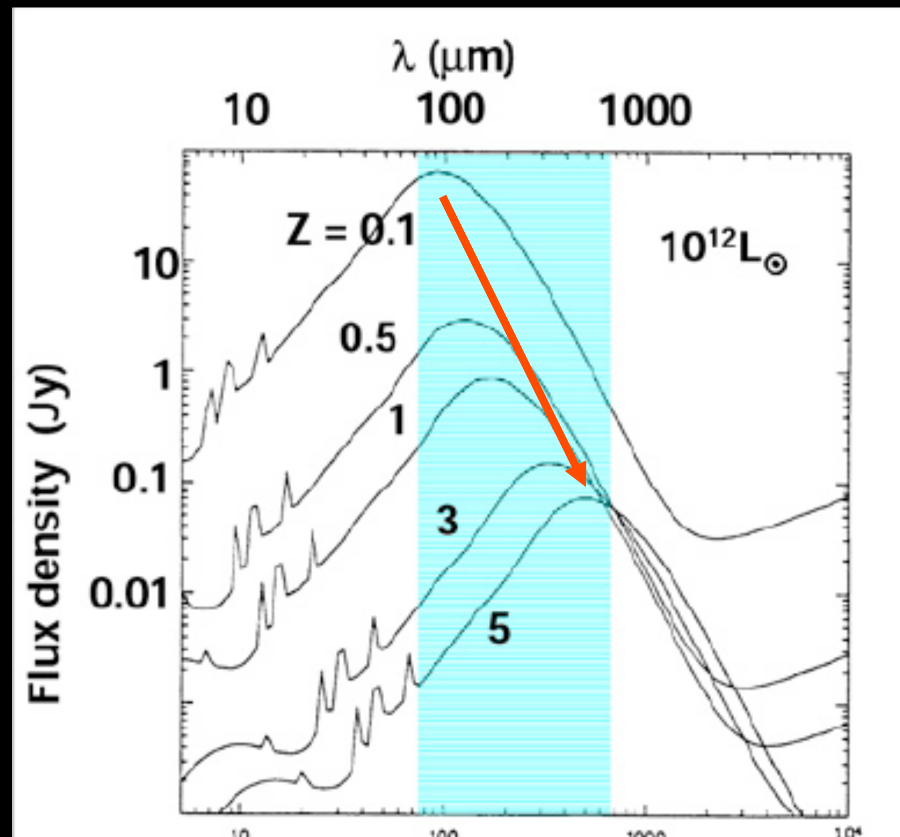
Get access to complete Far IR - submm spectral range

- Measure energy radiated by molecular clouds and galaxies in dust continuum and key tracers
- Obtain full inventory of molecules
- Observe key species totally blocked by atmosphere, particularly H_2O and O_2



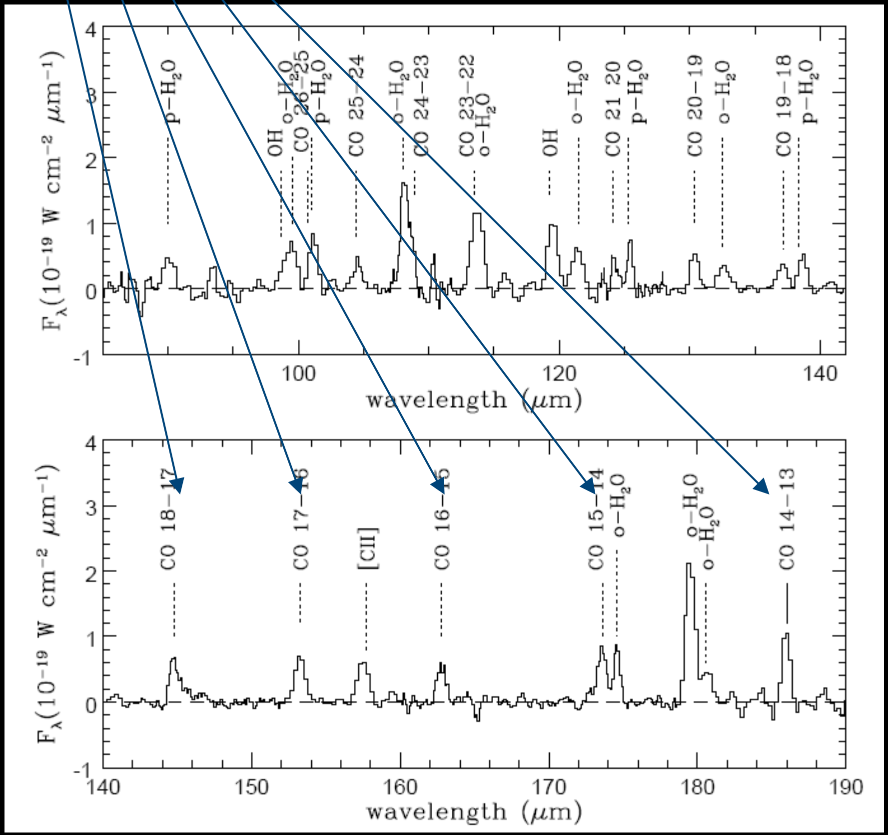
Herschel's Target: The Cool Dusty Universe

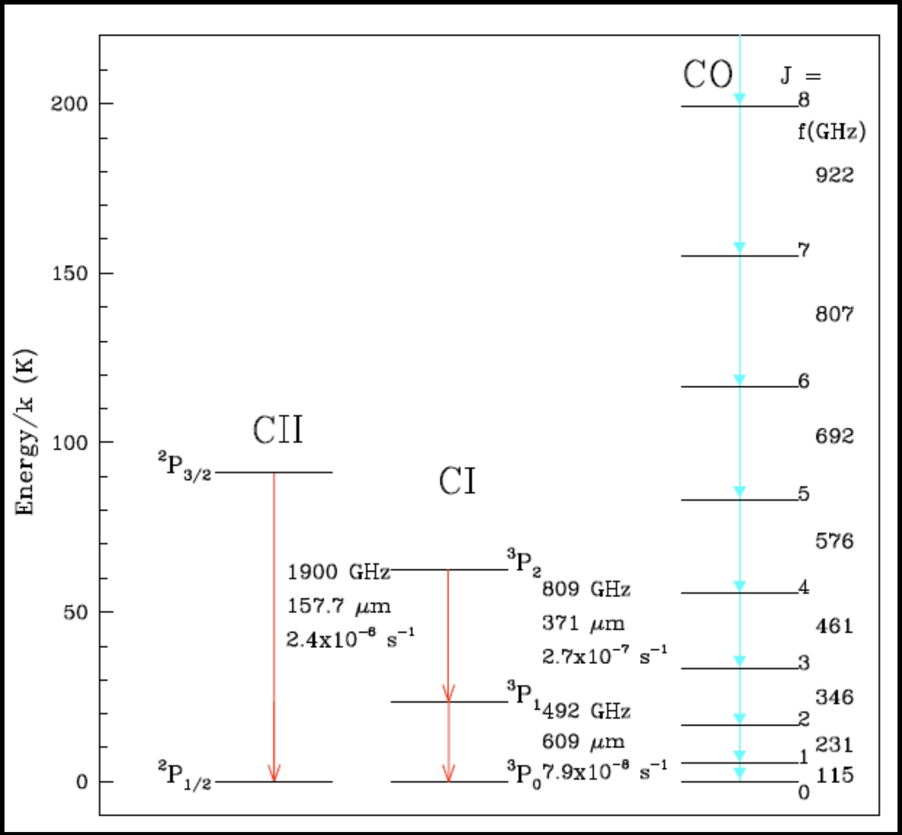




Probed by IRAS (1983), ISO (1995-98), Spitzer (2003-), Akari (2006-07) with broadband photometry and low resolution spectroscopy

Herschel Will Observe Numerous Spectral Lines of Many Key Atoms and Molecules





One problem is confusion from numerous interfering lines from a few species ("weeds") which will hamper identification of new species and identification of weak lines

Spectroscopy Pathfinder Mission in the Submillimeter – SWAS

Submillimeter Wave Astronomy Satellite

54 x 68cm offset Cassegrain antenna

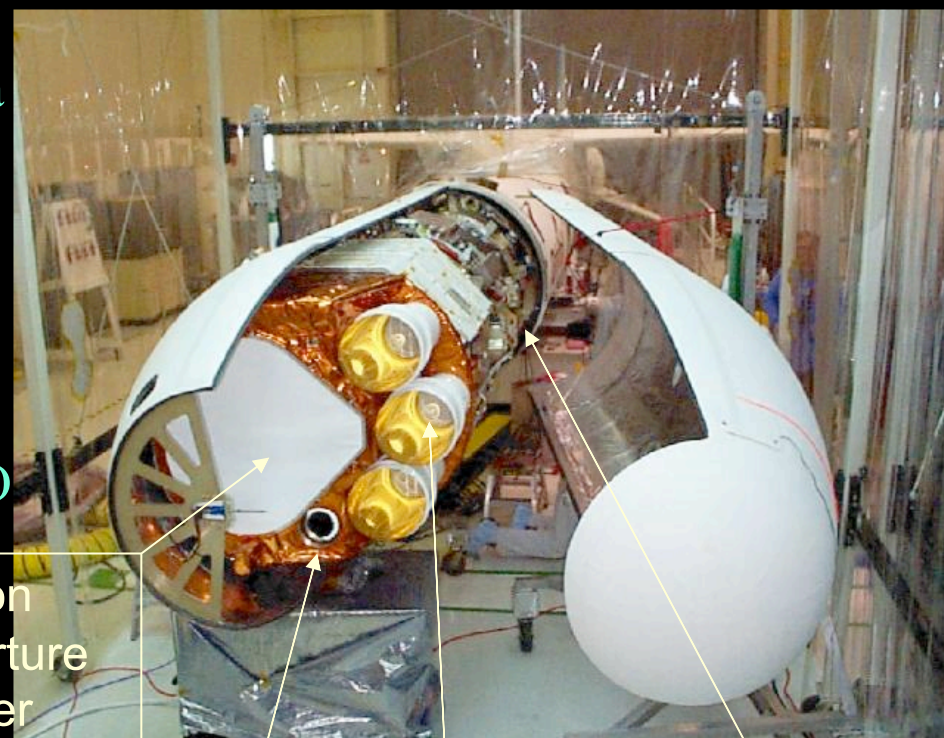
Passively cooled front end with 2 fixed tuned **Schottky diode 2nd harmonic mixers**

Observe O_2, CI, H_2O, $H_2{}^{18}O$, & ^{13}CO

Launched 5 Dec 1998

Operated until 21 July 2004

Important results on water & molecular oxygen in dense Clouds in interstellar space



Herschel –ESA Cornerstone Submm Space Mission

3.5m diameter SiC Cass telescope – largest monolithic astronomical space telescope

3 L-He cooled instruments

670 μm → 60 μm range

Wavefront error < 6μm rms

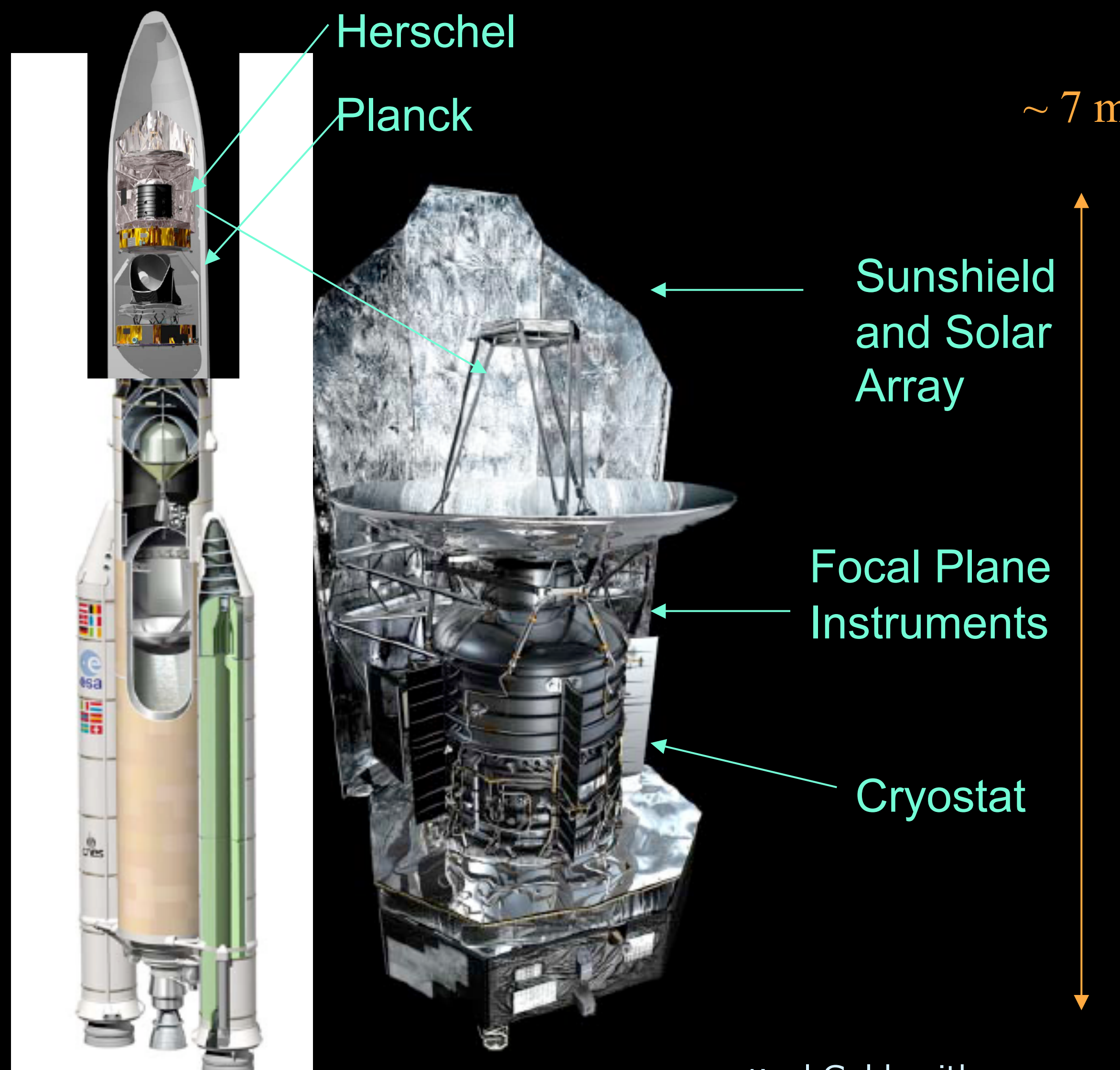
$\Delta\theta = 50" \rightarrow 9"$

L2 halo orbit

Minimum 3.5 yr mission lifetime

Ariane 5 ECA Launch

NASA (JPL) has made major contributions to 2 instruments



Three Herschel Instruments

Two imaging photometers and spectrometers

- Photodetector Array Camera and Spectrometer (PACS)
  60 μm – 210 μm PI = Albrech Poglitsch, MPE, Garching [Germany]
- Spectral and Photometric Imaging Receiver (SPIRE)
  200 μm – 670 μm PI = Matt Griffin, Cardiff Univ. [UK]; US PI = Jamie Bock, JPL

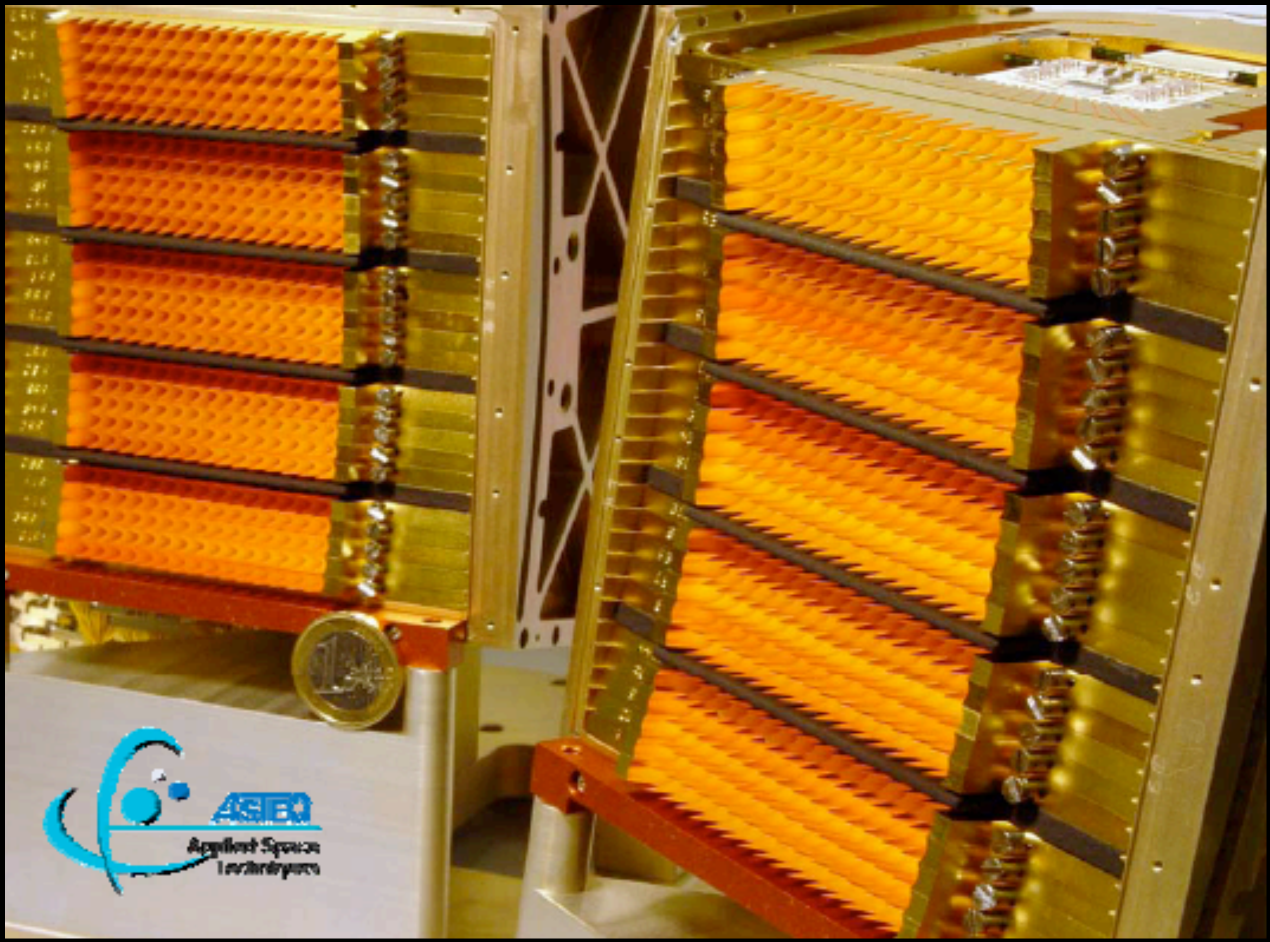
One high resolution heterodyne spectrometer

- Heterodyne Instrument for the Far Infrared (HIFI)
  157 μm – 212 μm & 240 μm – 625 μm PI = Thijs de Graauw, SRON [Netherlands]; US PI = Tom Phillips, CIT

PACS Spectrometer Detector Arrays

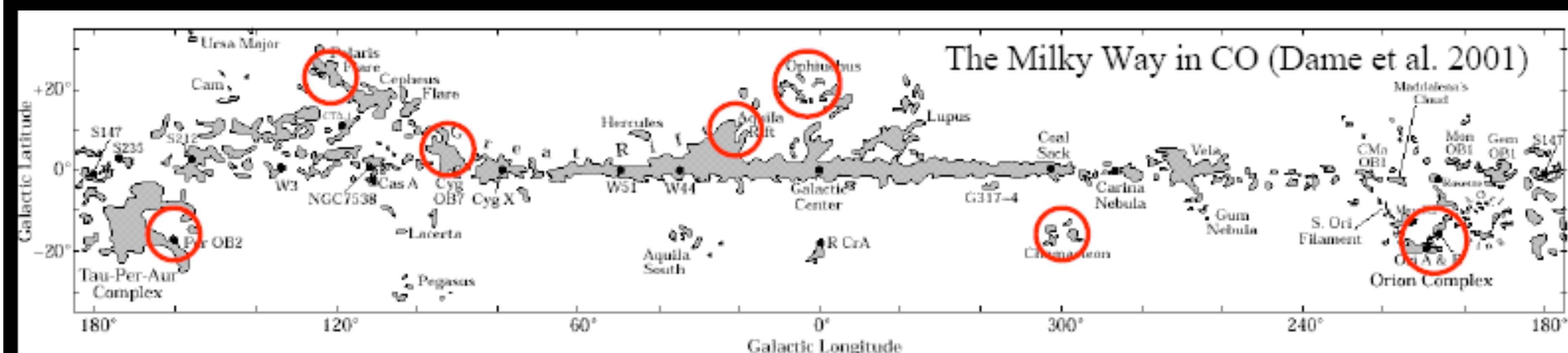
Two 25x16 "handcrafted" arrays

Extends technology used very successfully on Spitzer



Herschel Star Formation Survey

- Gould's Belt Survey:140 sq. deg. SPIRE + 16 sq. deg. PACS pointed PACS follow up
  - Census of cloud cores, inventory of very young class 0 protostars
  - Resolve nearby star forming cores
  - Study dust properties
  - Relationship of stellar masses to cloud core masses
  - Sensitive Mapping of Individual Regions (Low and High Mass)



Spectral and Photometric Imaging Receiver (SPIRE)

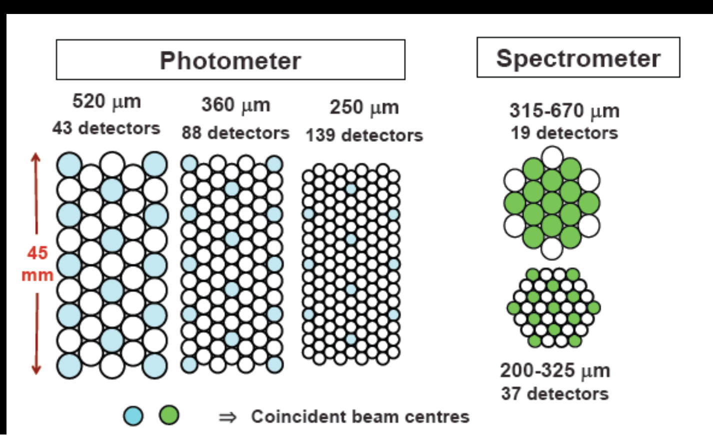
Three Band Photometer

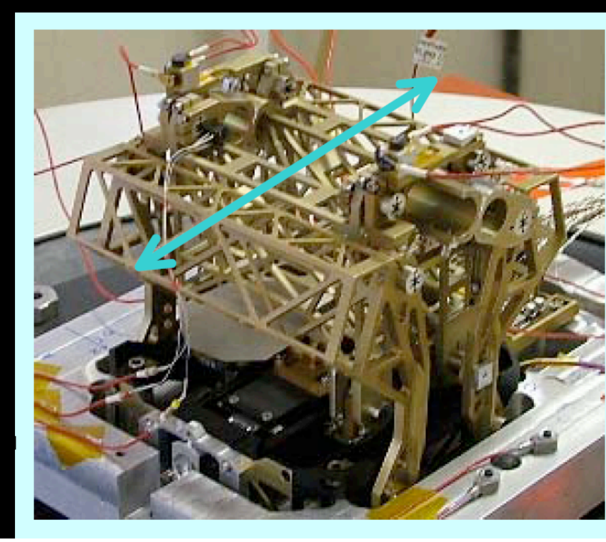
- 250, 350, 500 µm simultaneously

Imaging Fourier Transform Spectrometer

- 194 – 672 µm; R ~20-1200

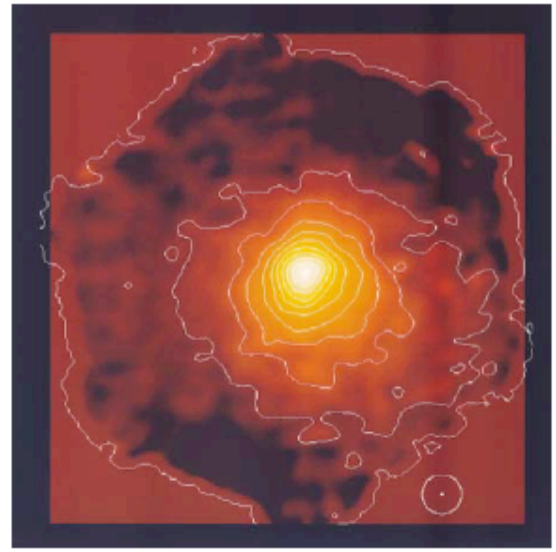
Detectors: NTD Germanium spider web bolometers (JPL)

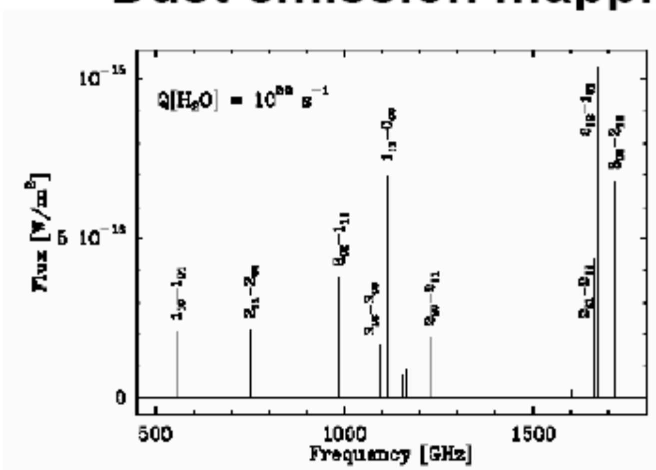




SPIRE + HIFI Program on Water in the Solar System

- SPIRE observations of
  - Uranus and Neptune
    - Full-resolution spectroscopy
  - Titan
    - Full-resolution spectroscopy
  - Comets
    - High resolution spectroscopy
    - Dust emission mapping





Heterodyne Instrument for the Far Infrared (HIFI)

Receivers use SIS or HEB mixers and frequency multiplied local oscillator. Individual mixers developed at laboratories throughout Europe & JPL. Much of the common LO system developed at JPL.

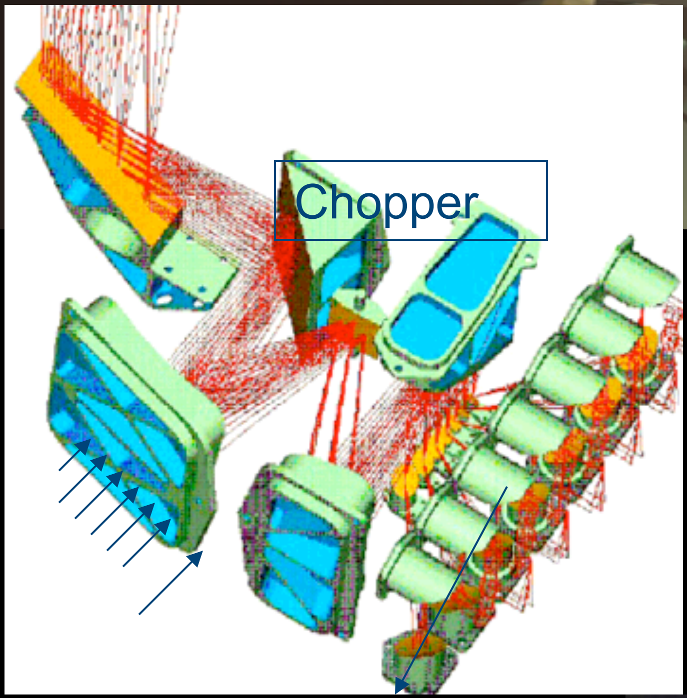
Covers much for Submm/FIR spectral range

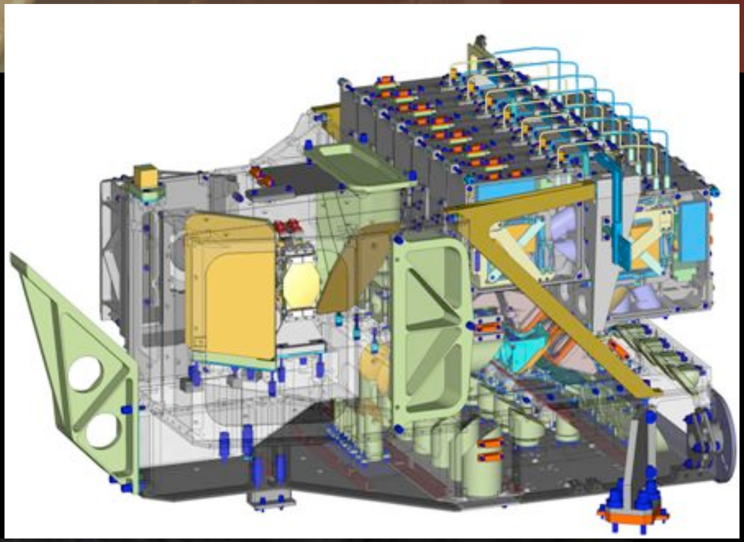
480   – 1250 GHz (SIS)

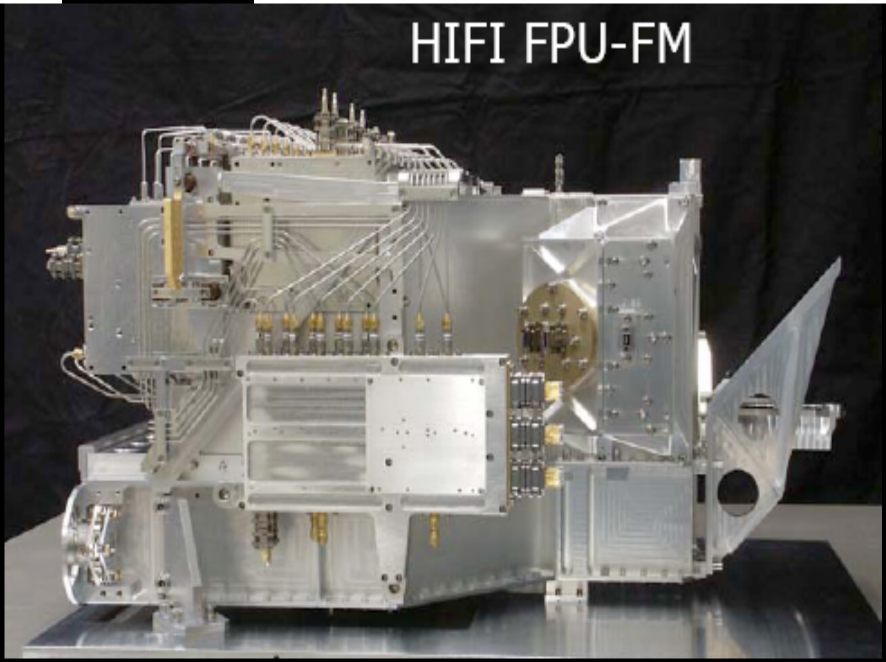
1410 – 1910 GHz (HEB)

Near quantum-limited sensitivity and high spectral resolution to observe spectral lines from atoms and molecules; measure detailed motions within these sources

HIFI

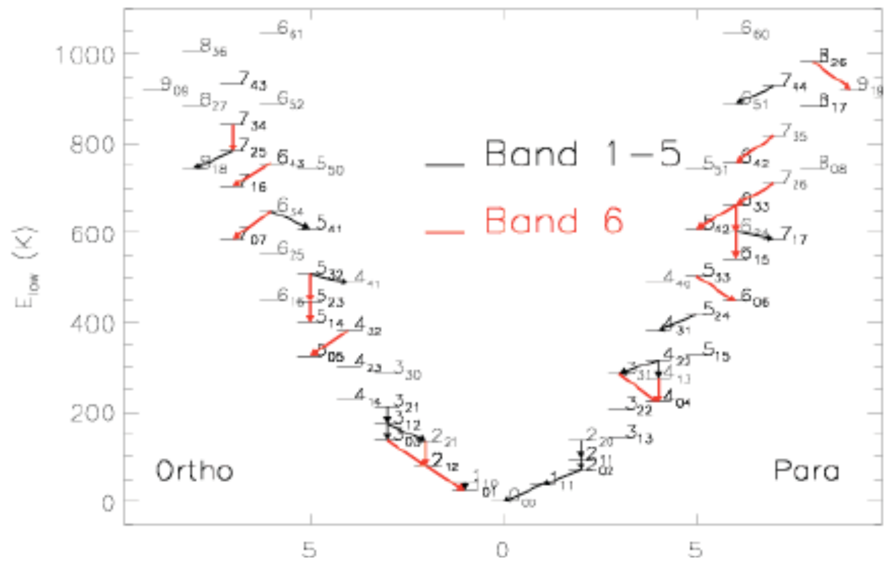






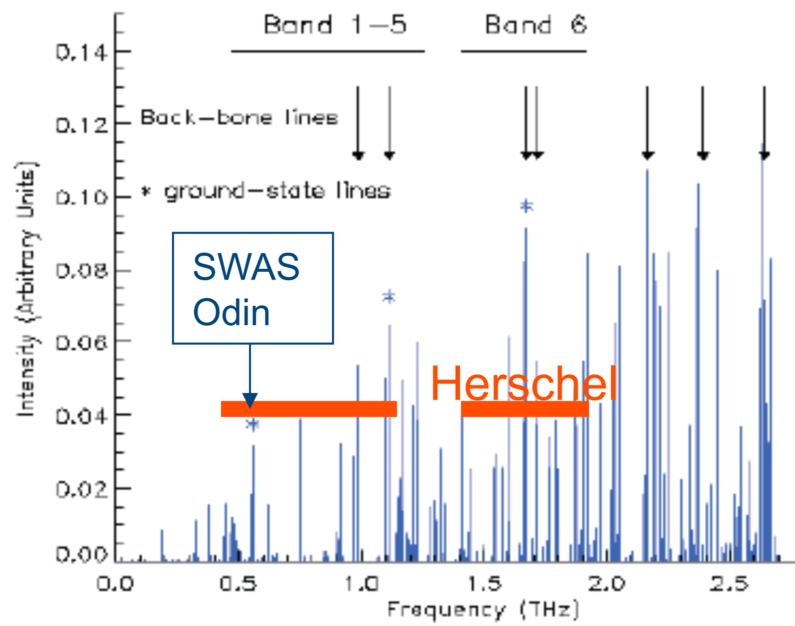
Water!

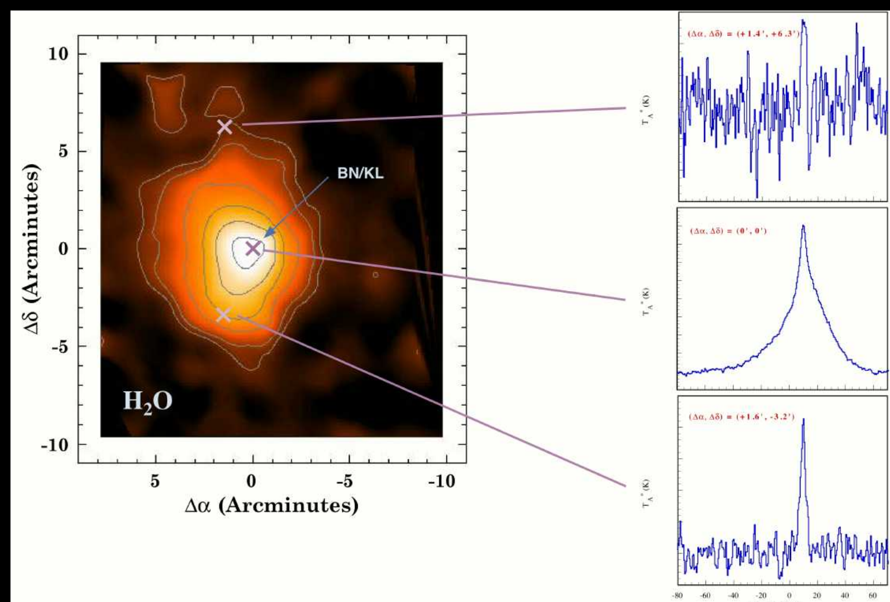
Water, water, every where,
And all the boards did shrink ;
Water, water, every where,
Nor any drop to drink.
Samuel Taylor Coleridge
The Rime of the Ancient Mariner



Rich Submm/FIR Spectrum

Energy levels readily populated in molecular clouds with star formation.





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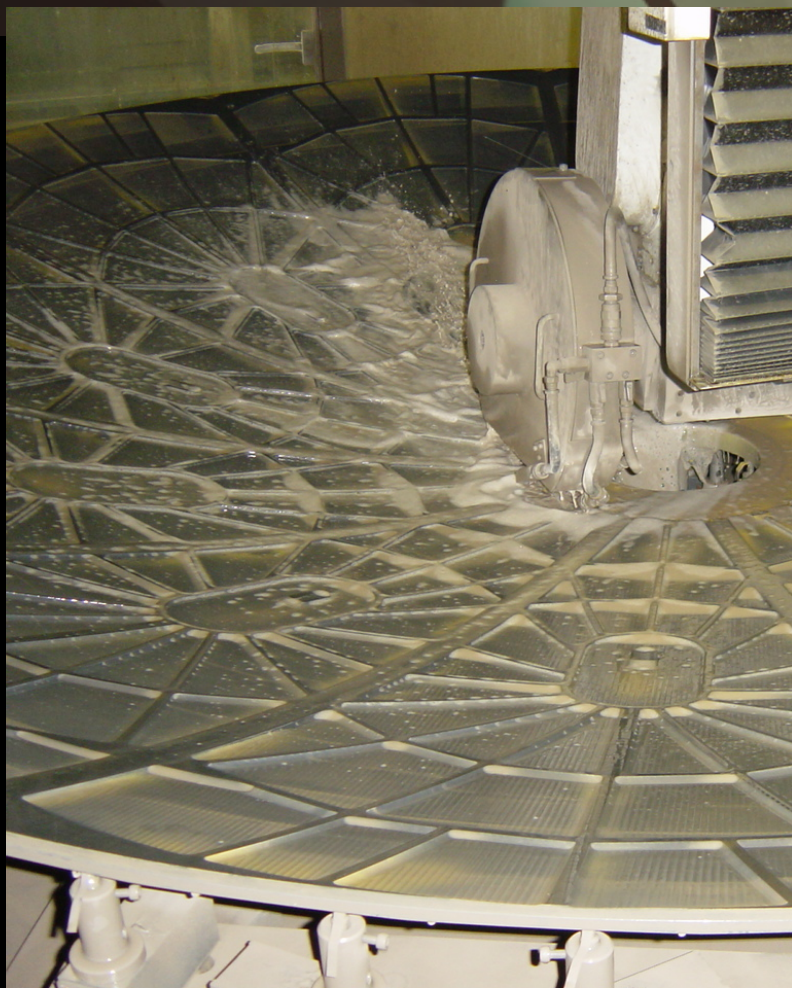
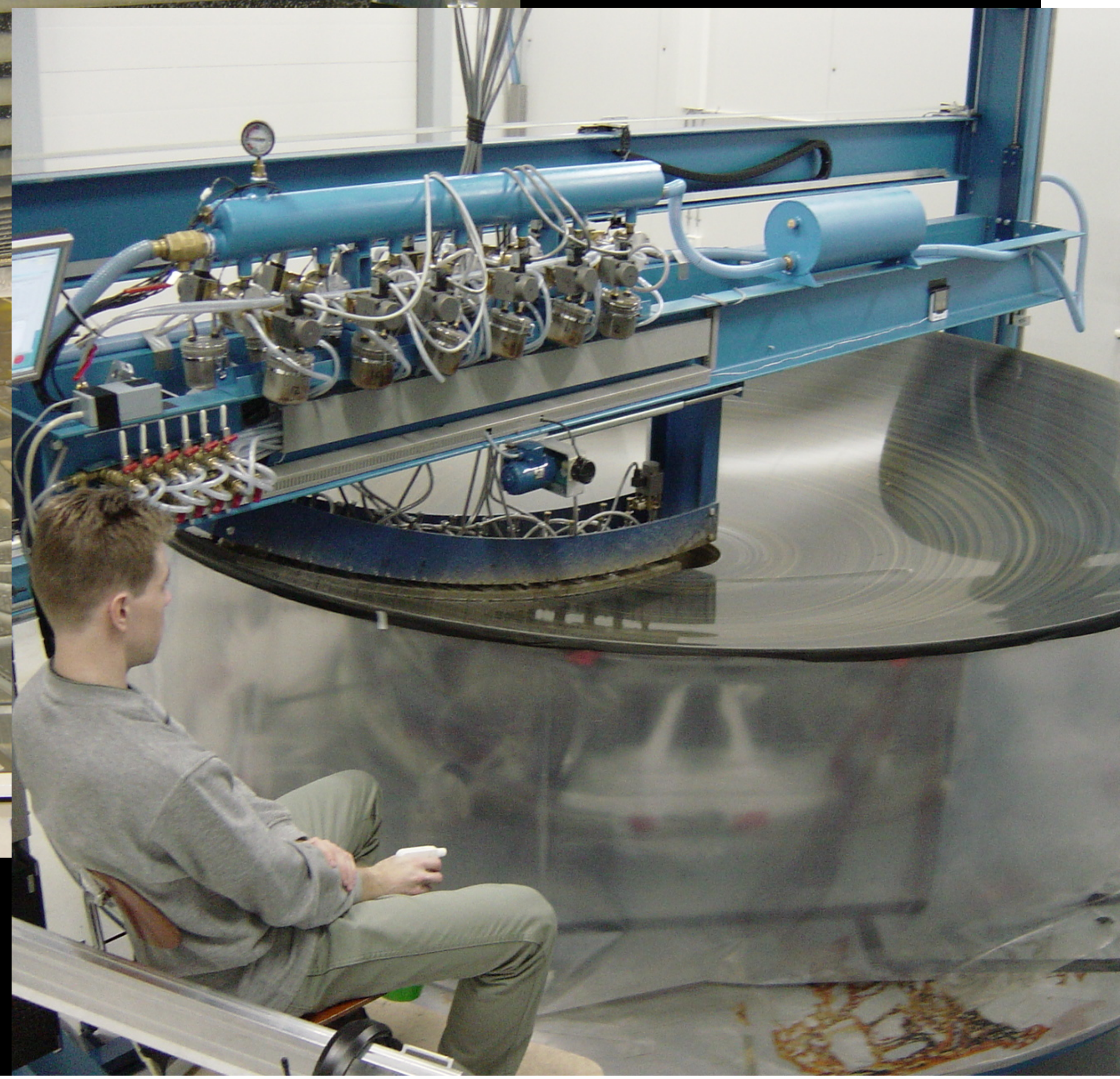
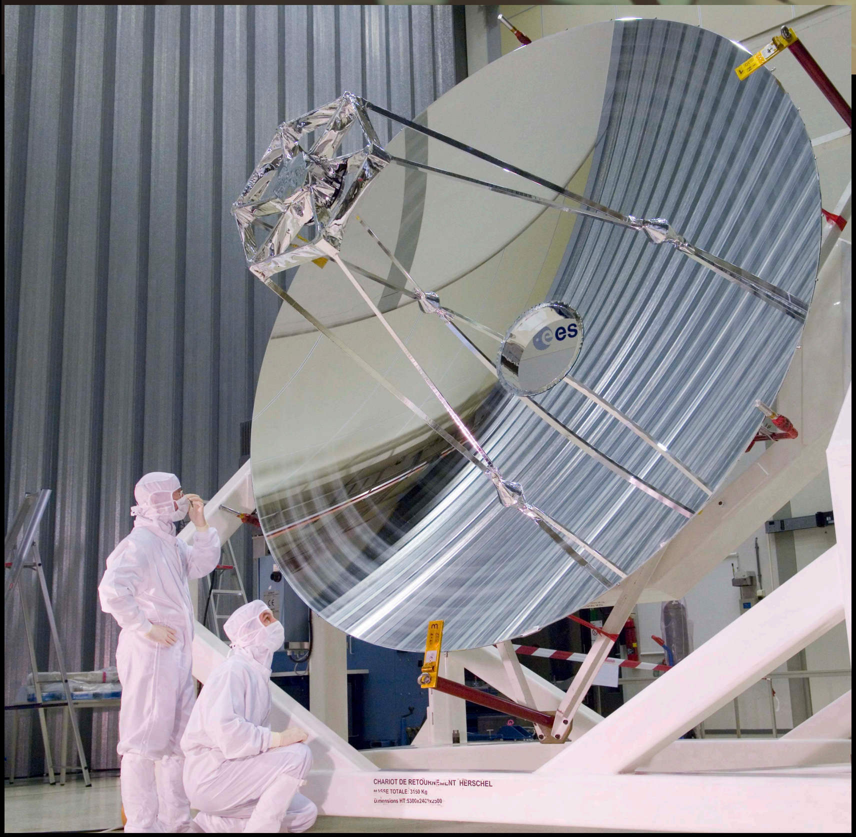
Assembling and Brazing SiC Panels of Herschel's Primary Reflector

Grinding and Polishing Herschel's Primary Reflector





Herschel Telescope and Spacecraft



Primary mirror mass = 315 kg

Total launch mass = 3402 kg

Herschel & Planck

Final Assembly & Fairing Installation

Herschel Observing Time: 3.5 yr Lifetime = 20,000 Science Hrs

- Guaranteed Time assigned (Instr. Teams) 5879 hr
  unassigned 502 hr
- Open Time Key Projects (competed) 5379 hr

- Available Open Time 8069 hr

Assigned Time Breakdown by Instrument

PACS	5342 hr
SPIRE	1162 hr
PACS/SPIRE parallel	2267 hr
HIFI	2420 hr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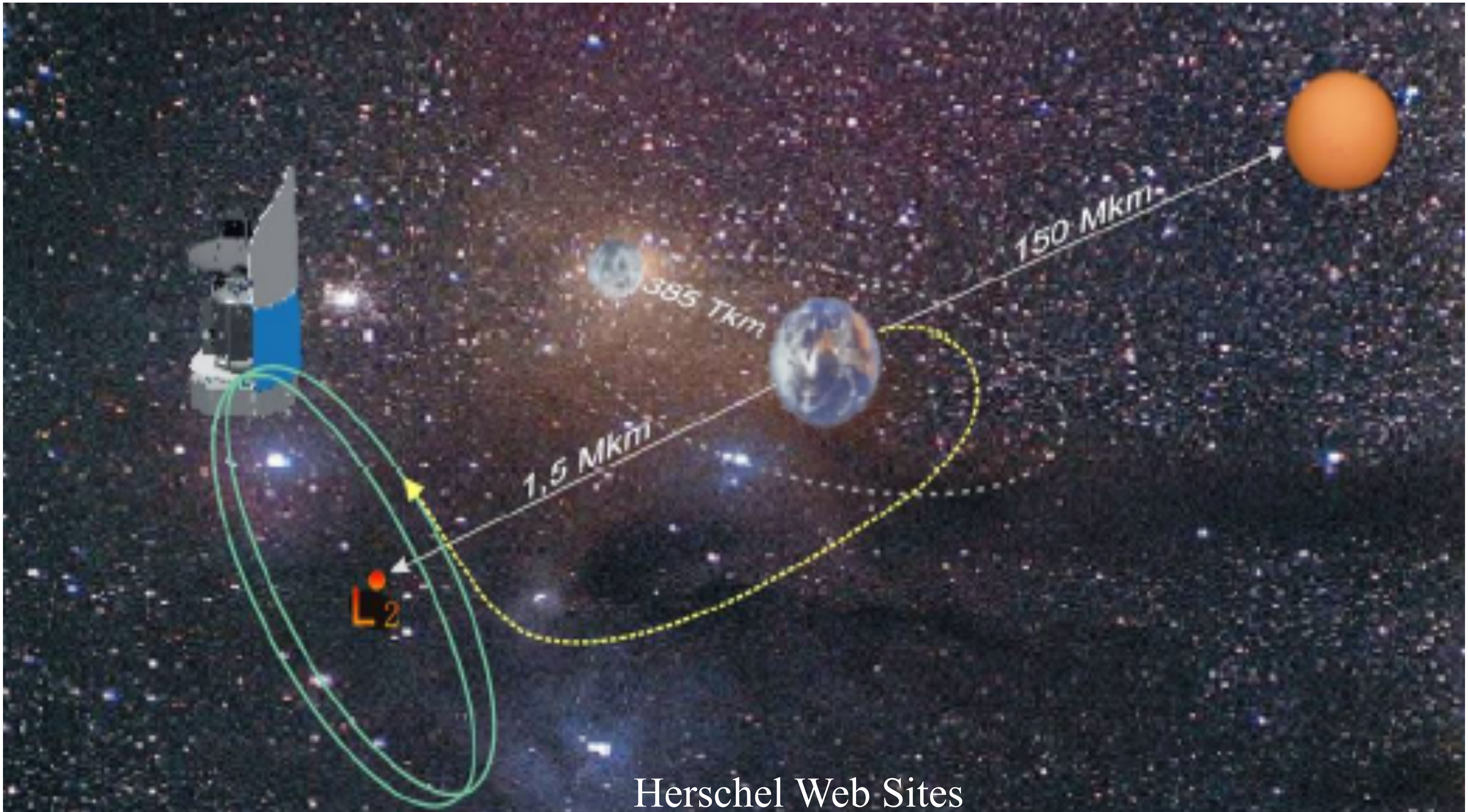
Herschel Mission Phases

- **Launch and early operations (LEOP) – month 1**
  - telescope kept warm during s/c cooldown (~20 days)
  - cryo-cover opening (first light!) ~1 month after launch
- **Commissioning and performance verification – months 2-4**
  - PV plans being worked on
  - telescope cooling down (~50 days)
  - availability of particular sources (often solar system objects)
- **Science demonstration phase – months 5-6**
  - optimise how to best operate the observatory using in-flight knowledge (sensitivities, stability, background, pointing, …)
  - demonstrate the capabilities of the observatory
  - convince ourselves we can achieve expected science objectives
  - generate ‘pretty pictures’ – and ‘pretty spectra’ – for PR
  - **workshop & observations updating for routine phase**
- **Routine science operations phase (month 7 onwards)**
  - initially Key Progs (GT & OT) and ‘regular’ GT progs
  - Herschel operates autonomously – poor ToO capability



Herschel Web Sites

herschel.ipac.caltech.edu IPAC/JPL web site
herschel.esac.esa.int General ESA Herschel web site with many links
herschel.esac.esa.int/operations_log.shtml Daily Operations Log

herschel.esac.esa.int/Key_Programmes.shtml GT and OT Key Projects