

FIRST 'carrier' spacecraft

Height	9 m
Width	4.5 m
Launch mass	3300 kg
Power	1 kW
Launch vehicle	Ariane 5
Orbit	Lissajous around L2
Science data rate	100 kbps
Telescope diameter	3.5 m
Telescope WFE	10 μm (<i>goal</i> 6 μm)
Telescope temperature	70-90 K
Abs pointing (68%)	<3.7" (<i>goal</i> <1.5")
Rel pointing (68%)	<0.3" (<i>goal</i> <0.3")
Helium II temperature	< 1.65 K
Lifetime in L2 (spec)	> 3 yrs

Toledo, 12-15 December 2000
Göran L. Pilbratt

<http://astro.esa.int/FIRST>

Viewgraph 1
7/12/2000

Unique characteristics of FIRST:

- FIRST is the first space facility to completely cover the entire far infrared and submillimetre (60 - 670 μm) range
 - Low emissivity (few %), passively cooled (70-90 K), large telescope (3.5 m)
 - Total absence of atmospheric absorption - full access to this poorly explored spectral range
 - Total absence of atmospheric emission - low and stable background across the whole range
 - Deep photometry & full spectral coverage !
- For $\lambda < 200 \mu\text{m}$ FIRST has much larger - and admittedly much warmer - telescope than earlier cryogenic telescope missions ISO / SIRTf / Astro-F
- In the FIRST band, the SOFIA airborne facility has warmer, smaller, higher emissivity telescope, and residual atmospheric absorption and emission
- FIRST will offer a large amount of observing time: longer lifetime (specification >3 years) than ISO - very roughly 1000 SOFIA flights a year - approx 2/3 open time

Toledo, 12-15 December 2000
Göran L. Pilbratt

<http://astro.esa.int/FIRST>

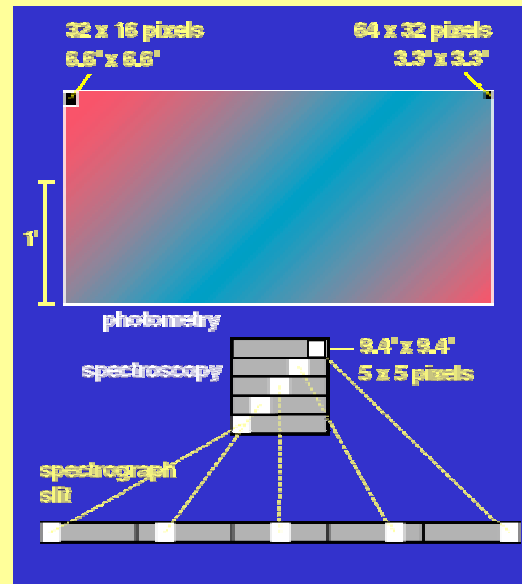
Viewgraph 2
7/12/2000

Photodetector Array Camera & Spectrometer (PACS): 60 - 210 μ m Imaging Photometry and Spectroscopy

Instrument Concept

- **Imaging photometry**
 - two bands simultaneously (60-90 or 90-130 μ m and 130-210 μ m) with dichroic beam splitter
 - two filled bolometer arrays (32x16 and 64x32 pixels)
 - point source detection limit ~ 3 mJy (5σ , 1h)
- **Integral field line spectroscopy**
 - range 57 - 210 μ m with 5x5 pixels, image slicer, and long-slit grating spectrograph ($R \sim 1500$)
 - two 16x25 Ge:Ga photoconductor arrays (stressed/unstressed)
 - point source detection limit $2 \dots 8 \times 10^{-18}$ W/m² (5σ , 1h)

Focal Plane Footprint



Observing Modes

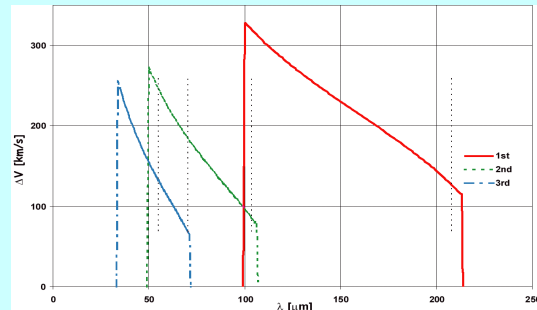
- Combinations of *instrument modes* and *satellite pointing modes*
- Instrument modes:
 - dual-band photometry
 - full spatial sampling in each band
 - long-wave bolometer array imaging 130-210 μ m band
 - short-wave bolometer array imaging 60-90 or 90-130 μ m band
 - single-band photometry
 - long-wave bolometer array imaging 130-210 μ m band or
 - short-wave bolometer array imaging 60-90 or 90-130 μ m band
 - standard mode for PACS/SPIRE parallel mode
 - line spectroscopy
 - observation of individual lines
 - long-wave photoconductor array in 105-210 μ m band
 - short-wave photoconductor array in 57-72 or 72-105 μ m band
 - wavelength in primary band determines wavelength in secondary band
 - range spectroscopy
 - observation of extended wavelength ranges
 - continuous scan (full resolution) or steps (SED sampling)
 - long-wave photoconductor array in 105-210 μ m band
 - short-wave photoconductor array in 57-72 or 72-105 μ m band
- Pointing modes:
 - stare/raster/line scan
 - with/without nodding

Photodetector Array Camera & Spectrometer (PACS): 60 - 210 μ m Imaging Photometry and Spectroscopy

Instrument Performance Parameters

Spectral resolution as a function of wavelength (spectroscopy) for the three used grating orders:

1st order (red detector) 210 - 105 μ m
2nd order (blue detector) 105 - 72 μ m
3rd order (blue detector) 72 - 55 μ m

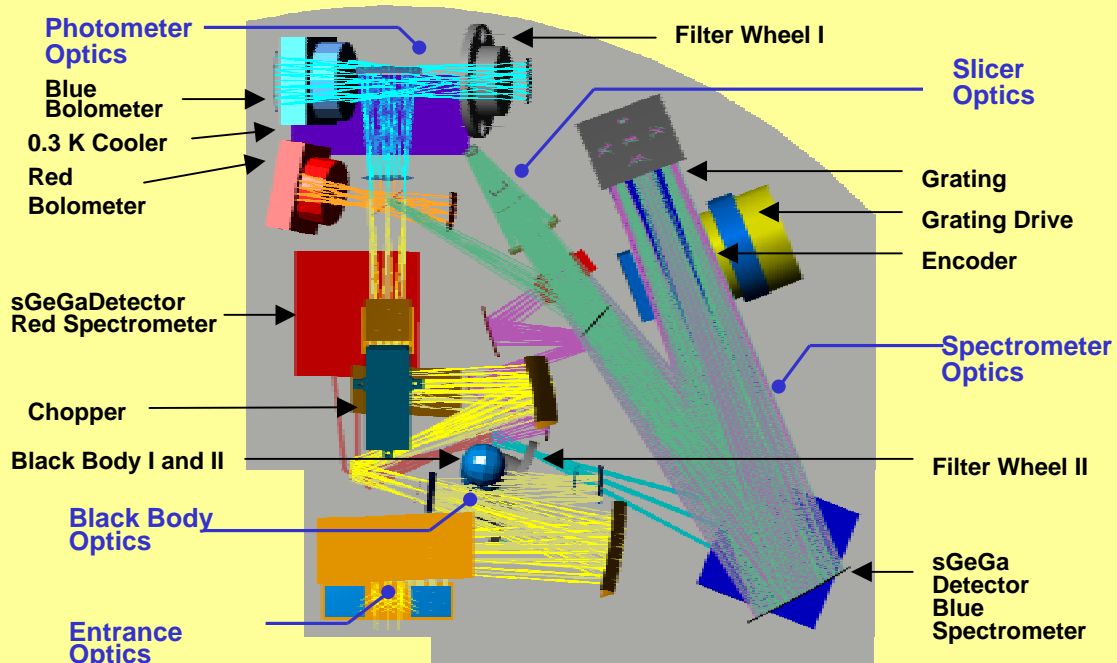


$\lambda(\mu\text{m})$	spectroscopy				photometry		
	60	90	130	180	60-90	90-130	130-210
Point source detection limit (5 σ , 1 hour)	7.8 (5.5)* $\times 10^{-18} \text{ W m}^{-2}$	4.0 (2.8)* $\times 10^{-18} \text{ W m}^{-2}$	2.8 (2.0)* $\times 10^{-18} \text{ W m}^{-2}$	2.5 (1.8)* $\times 10^{-18} \text{ W m}^{-2}$	3.1 (2.2)* mJy	3.0 (2.1)* mJy	3.2 (2.3)* mJy

*) with on-array chopping

Point source detection sensitivity in photometry and spectroscopy modes. Due to the high thermal background of the FIRST telescope, all photometric observations require spatial modulation, either with the internal chopper or by scanning of the satellite. For compact objects, on-array chopping effectively doubles the integration time on source compared to conventional off-source chopping, as indicated by the values given in parentheses. It is advisable to use the more conservative sensitivity numbers for estimates of required observing times.

Focal Plane Unit Layout



Summary of SPIRE Scientific Capabilities

Main scientific design drivers

- Wide-area extragalactic and galactic photometric surveys with spectroscopic follow-up
- Imaging medium resolution spectroscopy of the ISM and star-forming regions in own and nearby galaxies.

3-band imaging photometer (simultaneous observation in 3 bands)

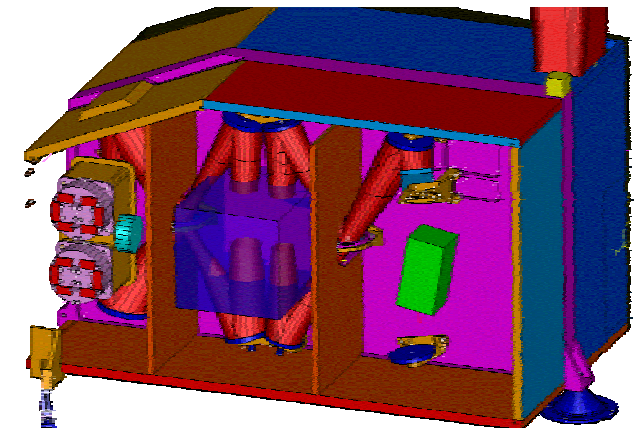
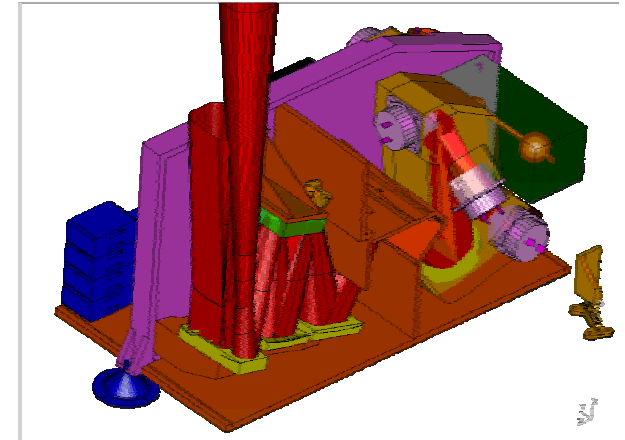
Wavelengths (μm)	250	350	500
Beam FWHM (arcsec.)	17	24	35
Field of view (arcmin.)	4 x 8		
<u>Estimated sensitivity (mJy, 5-σ; 1 hr)</u>			
Point source	4.0 (req.)	2.0 (goal)	in all bands
Fully-sampled map	16 (req.)	8.0 (goal)	in all bands

Imaging Fourier Transform Spectrometer (FTS)

Wavelength range (μm)	200-400 (req.)	200-670 (goal)
Simultaneous imaging observation of the whole spectral band		
Field of view (arcmin)	2.0 (req.)	2.6 (goal)
Max. spectral resolution (cm^{-1})	0.4 (req.)	0.04 (goal)
Min. spectral resolution (cm^{-1})	2 (req.)	4 (goal)
<u>Estimated Sensitivity (200-400 μm): Line flux ($\text{W m}^{-2} \times 10^{-17}$, 5-$\sigma$; 1 hr)</u>		
Point source	6.0 (req.)	3.0 (goal)
Map	18 (req.)	9.0 (goal)

<u>Estimated Sensitivity (200-400 μm): Spectrophotometry at $\Delta\sigma = 1 \text{ cm}^{-1}$ (mJy, 5-σ; 1 hr)</u>		
Point source	200 (req.)	100 (goal)
Map	600 (req.)	300 (goal)

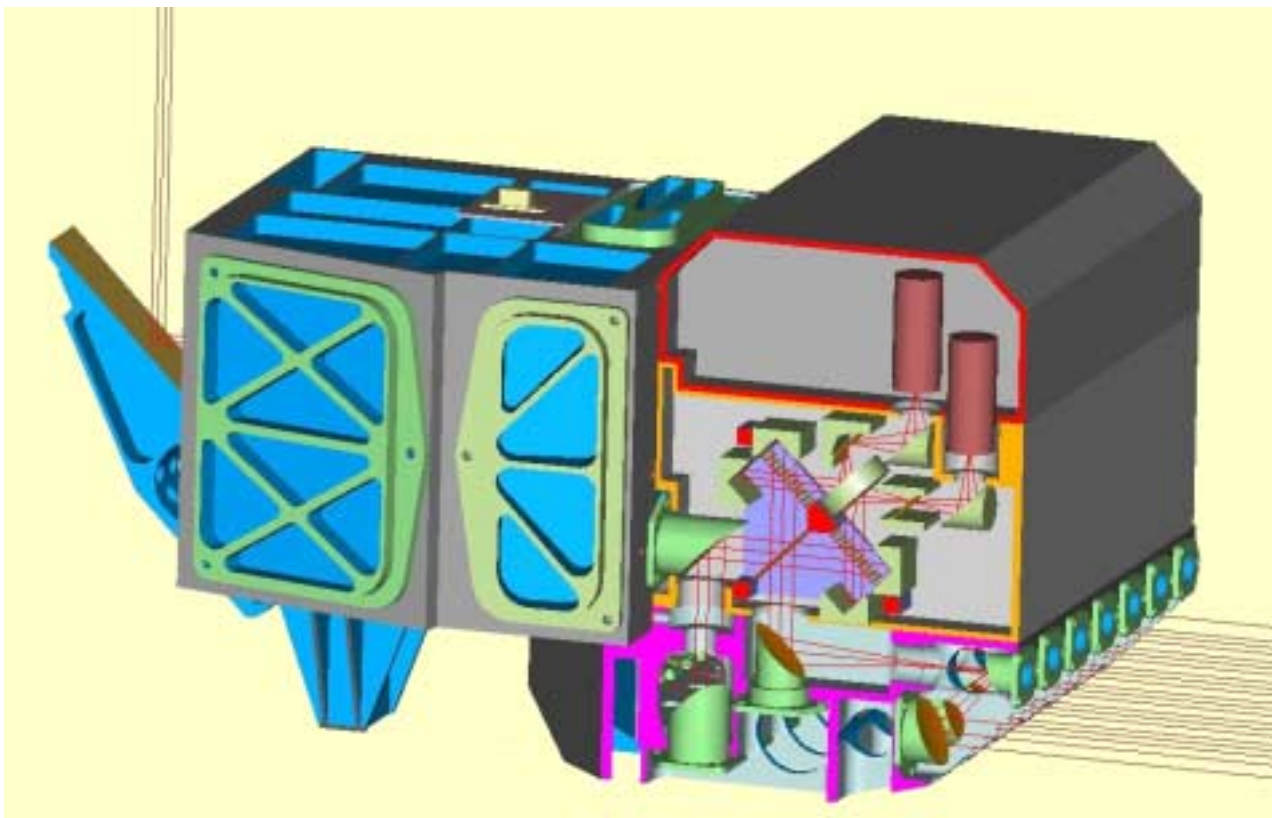
The FTS is optimised for $\lambda < 400 \mu\text{m}$. Sensitivity is expected to decline by roughly a factor of two between 400 and 670 μm (approximately linearly with wavelength).



The Heterodyne Instrument for FIRST – HIFI

Science Capabilities

- Frequency coverage:
 - 480 – 1250 GHz (625-240 μm) [Bands 1-5]
 - 1410 – 1910 GHz (212-157 μm) [Bands 6L, 6H]
- Near-quantum noise limit sensitivity (goal $<3h\nu/k$)
- Instantaneous IF bandwidth: 4 GHz
- Frequency Resolution 140 kHz – 280 kHz – 1 MHz
- Calibration Accuracy: 10% baseline; 3% goal



HIFI Focal Plane Unit

Expected Performance

Noise levels:

- Setting 4 GHz
- Resolution 1 MHz
- DSB

