ASTRO-F SATELLITE & MISSION

ASTRO-F is an infrared survey mission from the Institute of Space and Astronautical Science (ISAS) of the Japan Aerospace eXploration Agency (JAXA) with the participation of the European Space Agency (ESA).

ISAS/JAXA's ASTRO-F Satellite, due for launch in early 2006, will perform an all-sky survey in six wavebands between 6 and 180 µm, at higher sensitivity, spatial resolution and larger wavelength coverage than IRAS. The resulting catalogues are expected to contain more than a million sources. Deep imaging and spectroscopic surveys with pointed observations will also be performed in selected areas of the sky.

Launch	January-February 2006
Orbit	Sun-synchronous polar Altitude: 745 km Period: 100 min
Telescope Diameter	68.5 cm
Telescope Temperature	5.8 K
Wavelength Coverage	1.7 – 26 µm (IRC) 50 – 180 µm (FIS)
Cryogenic Lifetime	1.5 years Near-IR observations possible after cryogen loss

Focal Plane Configuration:

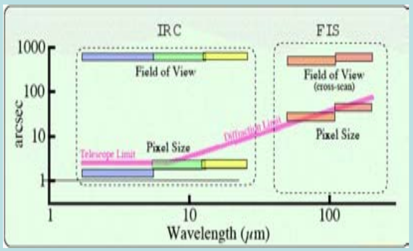
2 Focal Plane Instruments (13 photometric bands +6 spectroscopy elements)

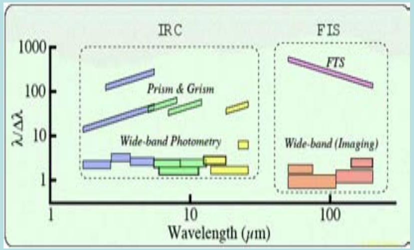
Far Infrared Surveyor (FIS)

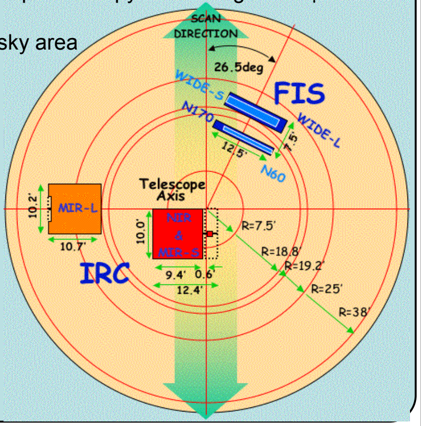
- 4 photometric filters covering 50-180 µm in 2 short & 2 long wavelength bands
- Fourier Transform Spectrometer (FTS) covering the range 50-180 µm
- The FIS channels share the same sky area

Infrared Camera (IRC)

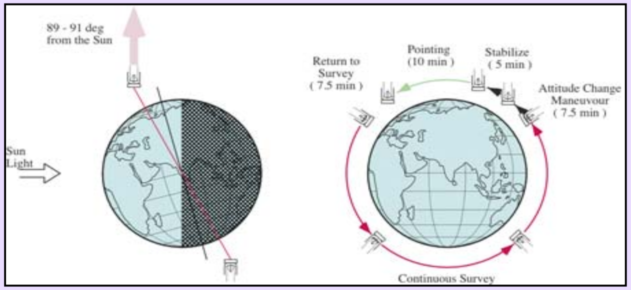
- 3 Cameras (NIR, MIR-S, MIR-L) x 3 = 9 NIR-MIR bands covering 2-26 µm
- Dispersion elements on cameras for spectroscopy in the range 2-26 µm
- Wide FoV (~10'x10')
- NIR & MIR-S cameras share same sky area
- MIR-L camera offset by 20'

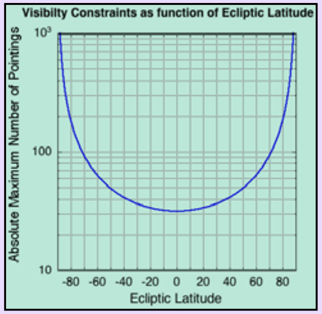






Observation Modes: ASTRO-F operates either in survey mode or pointed mode. In survey mode, a continuous scan of the sky is performed while the satellite orbits around the Earth. The whole sky is thus covered in half a year. In pointed mode, ASTRO-F stares or scans at a **single** defined target, **for an effective observation time of 10 min**, at a cost of 30 min operation including maneuver and stabilisation. The observation parameters are specified in predefined Astronomical Observation Templates (AOTs). One pointed observation corresponds to 1 AOT.



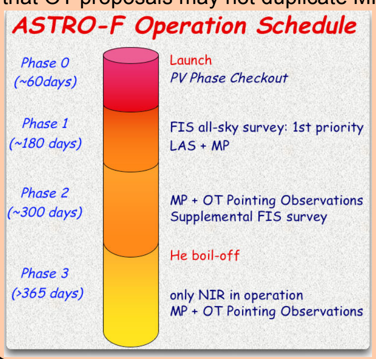


Visibility Constraints: ASTRO-F's orbit is sun-synchronous polar with the telescope always pointed in a plane perpendicular to the Sun, with an **offset control** allowance of only two degrees. Thus the visibility is a function of ecliptic latitude. Targets near the ecliptic poles are observable on a large number of orbits. Targets on the ecliptic plane are visible only on a limited number of orbits .

(Figure above shows visibility constraints with offset control of +/- 1 degree assuming a detector size of 10arcmins pointed. This is the absolute maximum visibility and in reality will be lower)

Visibility Tool http://www.ir.isas.jaxa.jp/ASTRO-F/Observation/vis/

Mission Phases: The main objectives of the ASTRO-F Mission are legacy observations in the form of **Large Area Surveys (LAS)** and the conduction of large **mission programs (MP)**. In addition, a significant phase of the mission will be dedicated to pointed observations of astronomical targets. 30% of these opportunities are available to the general astronomical community as **Open Time (OT)**, via the traditional route of Call for Proposals, followed by peer-review. Resulting from ESA's collaboration in this mission, 10% are open to European users, the other 20% are for Japanese and Korean astronomers. These OT observations will be scheduled after the survey prioritised part of the mission, starting at about eight months after launch. Note that OT proposals may not duplicate MP proposals. In addition, European & Japanese proposals may not duplicate each other.



Observers Manual : http://astro-f.esac.esa.int/docs/afobsman31.pdf
Duplication check tool : http://astro-f.esac.esa.int/tools/duplcheck.shtml

ASTRO-F Data Products:

Survey Data Products: several catalogues sequentially produced with incremental contents that will become public around one year after they are internally released.

- *All Sky Survey FIS/IRAS Catalogue (Known IRAS Sources Catalogue)*
- *All Sky Survey Bright Source Catalogue (BSC)*
- *All Sky Survey Faint Source Catalogue*

Pointed Legacy Programs: have a one year proprietary period from receipt of data.

- *Large Area Surveys*
- *Mission Programs*

Open Time Programs: have a one year proprietary period from end of Phase 2.

ASTRO-F Optimized Observations (Recommended):

- Observations that take one ~ few pointings over single/few FoV
- Observations that require multiband coverage without gaps
- FIR observations of bright regions requiring high saturation limit
- Observations at high ecliptic latitudes
- Near-infrared spectroscopy

ASTRO-F Non-Optimized Observations (Not Recommended):

- Targets of Opportunity
- Time Critical Observations and chained observations
- Tracking Moving Objects

FAR INFRARED SURVEYOR (FIS)

The Far Infrared Surveyor (FIS) instrument will carry out an All Sky Survey and deep scans in pointed mode in 4 far infrared bands from 50-180 μm and is also equipped with a Fourier Transform Spectrometer

Basic FIS Capabilities:

The FIS is designed primarily to perform the All-Sky Survey in 4 photometric bands at wavelengths between 50 and 180 μm (two broad bands and two narrow bands). The instruments are operated such that data acquisition is continuous as the telescope scans the sky, resulting in sets of strip data of sky brightness. This operation can also be used for pointed observations in a slow-scan mode for deeper observations. The FIS is also equipped with a Fourier Transform Spectrometer (FTS) that enables imaging spectroscopy over the full FIS wavelength range with the two wide-band arrays (WIDE-S and WIDE-L) and a resolution of ~0.36 cm^{-1} (R = 450 – 170) or 2.4 cm^{-1} (R = 75 – 30). FTS observations are performed in staring pointing mode.

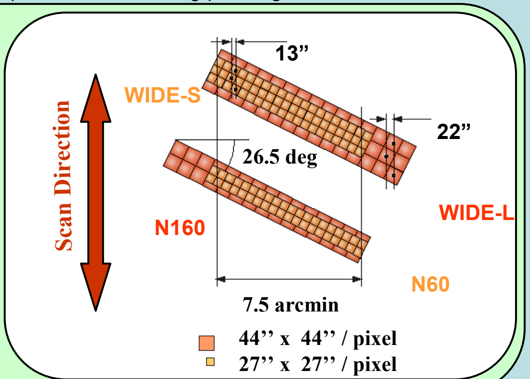
FIS Photometric Mode

FIS Band	N60	WIDE-S	WIDE-L	N160
Wavelength [μm]	50 - 75	50 - 110	110 - 180	140 – 180
Central Wavelength [μm]	65	80	140	160
Array format	20 x 2	20 x 3	15 x 3	15 x 2
Pixel size [$arcsec^2$]	27 x 27	27 x 27	44 x 44	44 x 44

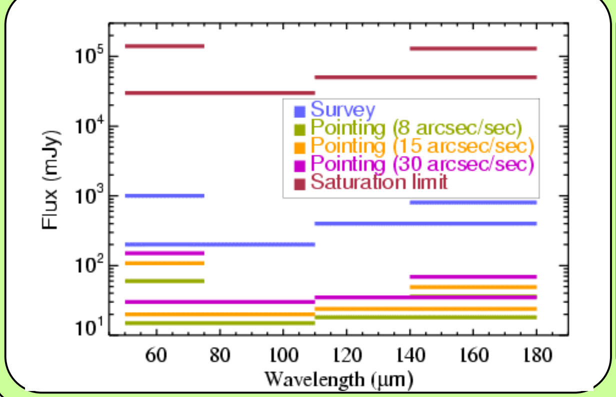
FIS Detectors

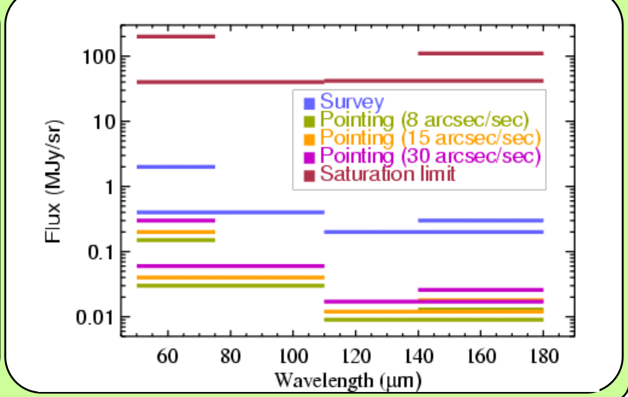
WIDE-S: 3x20
N60: 2x20
N160: 2x15
WIDE-L: 3x15

Overlap each other



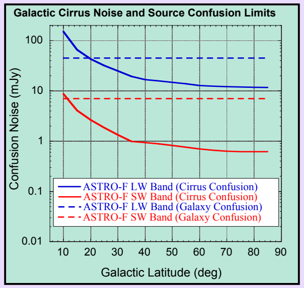
FIS Imaging: 5σ detection and saturation limits for a point (*left*) and an extended (*right*) source (reset interval = 1.0).

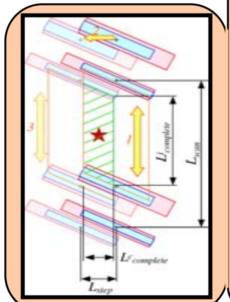




Sky Confusion Estimates: Very likely, FIS observations will be affected by galactic cirrus noise and background source confusion. Users are encouraged to take confusion into account when planning observations, it may save significant amount of observing time. The sky confusion noise due to galactic diffuse emission (cirrus) is a function of Galactic Latitude as shown in the figure.

Sky confusion tool:
http://www.ir.isas.jaxa.jp/ASTRO-F/Observation/Confusion/





FIS Astronomical Observation Templates (AOT):

Three AOTs are available for the FIS pointed observations.

- **FIS01:** Photometry of point sources and/or mapping of small areas of sky of up to around ~25 x 10 $arcmin^2$. All four bands are available. Scan pattern: two round-trip scans with a cross-scan shift. Scan speed is either 8 or 15 arcsec/sec. Two parameters can be specified: the readout mode (Nominal/CDS) and reset interval (0.5, 1.0 or 2.0) if the Nominal mode is selected. The scan sequence of AOT FIS01 is shown in the figure below.
- **FIS02:** Mapping of large areas (~1 deg x 8 arcmin). All four bands are available. Scan pattern: one round-trip scan with fixed speed of either 15 or 30 arcsec/sec. No cross-scan shift is operated during a pointed observation to maximize the scan length. Sampling mode and reset interval as in FIS01.
- **FIS03:** Imaging spectroscopy with the FTS. In FULL or SED mode. Pointing mode: staring. For accurate spatial-spectroscopic information, the AOT must be repeated with a slightly shifted target position. Observations of a wider area require the repetition of the AOT on diferent orbits. **The FTS mode is subject to several constraints, as specified in the Observers Manual and in the Call For Proposal Policies and Procedure document.**

Instrument Performance tool:
http://astro-f.esac.esa.int/tools/IPT.shtml

INFRARED CAMERA (IRC)

The Infrared Camera (IRC) instrument will carry out an All-Sky Survey at 9 and 18 μm and will perform pointed observations in 9 photometric bands and 5 spectroscopic elements in the 2 – 26 μm range.

Basic IRC Capabilities: The IRC consists of three cameras: NIR, MIR-S & MIR-L. Each camera is equipped with a set of filters and dispersion elements. The filters can be chosen from a limited number of pre-determined combinations defined in each AOT. Only NIR and MIR-S share the same FoV. This means that at least two pointed observations in different revolutions are needed to observe a particular position with all three cameras.

An IRC pointed observation consists of an *n* times repeated exposure cycle and various operations between them (micro-scan and filter changes). One exposure cycle takes about 70 s in the current design, during which NIR carries out one short and one long exposures, and MIR cameras carry out one short and three long exposures.

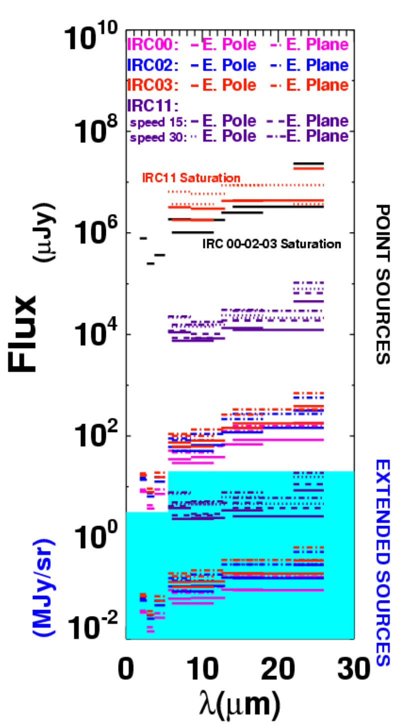
Instrument Performance tool: http://astro-f.esac.esa.int/tools/IPT.shtml

Channel	FoV (arcmin^2)	Array size (pixel^2)	Pixel size (arcsec^2)
NIR	9.5x10.0	512x412	1.46x1.46
MIR-S	9.1x10.0	256x256	2.34x2.34
MIR-L	10.3x10.2	256x256	2.51x2.39

IRC Imaging: 5σ detection and saturation limits for a pointed observation in imaging mode (IRC 00-02-03 and 11), computed at the ecliptic pole and at the ecliptic plane.

IRC11 values correspond to two different scan speeds (15 and 30 arcsec/sec).

Point source detection limits are given in μJy and extended source detection limits in MJy/sr.



Channel	Filters	λ (μm)
NIR	N2	1.7-2.7
	N3	2.7-3.7
	N4	3.7-5.5
MIR-S	S7	5.8-8.4
	S9W	6.5-11.6
	S11	8.6-14.1
MIR-L	L15	12.4-19.4
	L18W	13.9-25.3
	L24	20.4-26.5

IMAGING AOTs & FILTER SELECTION

IRC AOTs & Purpose	Filters/ channel	Dithering Pos/filter	Requested #pointing
00 Deep imaging	1	No	≥ 3
02	2	3	≥ 1
03	3	2	≥ 2
11 Slow-Scan	1	N/A	≥ 1

	NIR	MIR-S	MIR-L
IRC00	OPTIONS (one of the tree sets)		
	N2	S9W	L18W
	N3	S7	L15
	N4	S11	L24
IRC02	N3&N4	S7&S11	L15&L24
IRC03	N2&N3&N4	S7&S9W&S11	L15&L18W&L24
IRC11	OPTIONS (one of the three sets)		
	N/A	S9W	L18W
	N/A	S7	L15
	N/A	S11	L24

IRC Spectroscopy: The MIR-S and MIR-L cameras always observe with the available dispersion elements (2 GRISM for MIR-S and one for MIR-L), while only one of the NIR dispersion elements (NP: PRISM; NG: GRISM) can be selected at a time.

A short exposure image will be taken for pointing alignment.

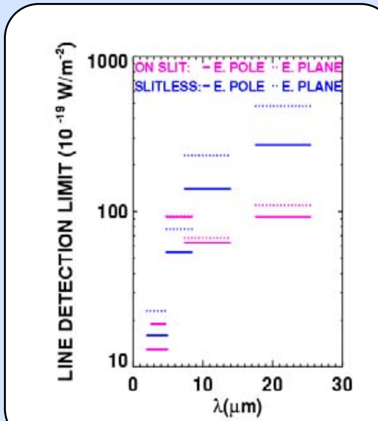
A slit is provided in each camera in order to observe diffuse radiation. The NIR camera has also an entrance aperture (slit) for point source confusion-less spectroscopy.

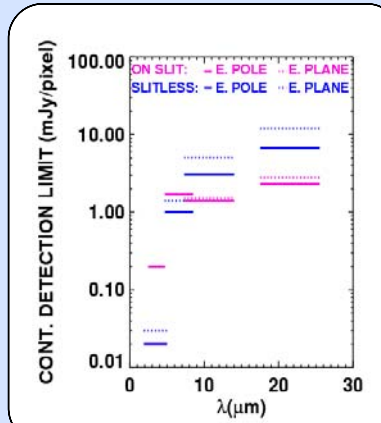
Channel	Dispersion elem.	λ (μm)	Resolution (λ/Δλ)
NIR	NP	1.7-5.5	22@3.5μm
	NG	2.5-5.0	135@3.6μm
MIR-S	SG1	5.5-8.3	47@6.6μm
	SG2	7.4-13.0	34@10.6μm
MIR-L	LG2	17.7-25.0	27@20.2μm

SPECTROSCOPIC AOT & DISPERSION ELEMENT SELECTION

IRC AOT	Filters/ channel	Dithering Pos/filter	Requested #pointing
04	1(NIR&MIR-L) 2(MIR-S)	No	≥ 2

NIR	MIR-S	MIR-L
NP (N3)	SG1&SG2 (S9W)	LG2 (L18W)
NG (N3)	SG1&SG2 (S9W)	LG2 (L18W)





5σ detection limits for a pointed observation, in the ecliptic pole and the ecliptic plane. Line detection limits are given for integrated line fluxes. Continuum detection limits are given per pixel. Integrating over the area of the resolution bin and over the image size can improve the detection.