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AKARI data guide for beginners version 1.1
~ DESCRIPTION OF THE AKARI DATA PRODUCTS ~

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Contents

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ABSTRACT

This document aims to introduce the archival data (mainly highly processed data such as catalogue, images, and spectra) taken by the AKARI infrared astronomy satellite, primarily for professional astronomers who are not necessarily familiar with AKARI. AKARI was launched on February 22, 2006, carried out numerous pointing observations as well as all sky surveys, and completed all the operations on November 24, 2011.

Keywords: Astronomy, Infrared, AKARI, data products

概要

本ドキュメントは、2006 年 2 月 22 日に打ち上げられ、全天サーベイおよび、多数の指向観測を実施し、2011 年 11 月 24 日にすべての運用を終了した赤外線天文衛星「あかり」のアーカイブデータ（高次処理データ: カタログ、イメージ、スペクトル）を天文学の研究者に紹介することを目的としています。

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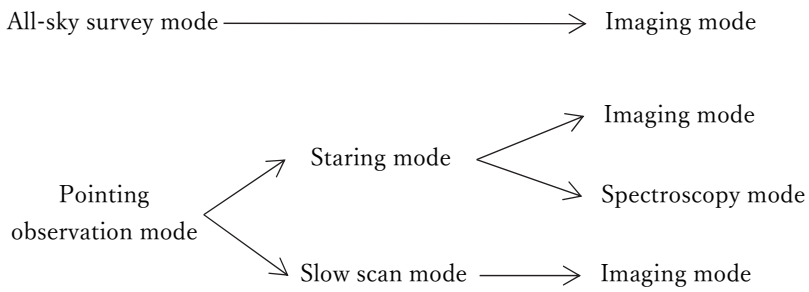
1. Summary of AKARI

Table 1 gives an overview of the "AKARI" satellite. Figure 1 shows the observation modes, wavelength-range and wavelength-resolution of two focal-plane instruments.

Table 1: Overview of the AKARI satellite.

Launch date	February 22, 2006 (JST)		
Observation period[N1)]	May 2006 - August 2007 (Phase1&2: refrigerator + liquid helium cooling) June 2008 - February 2010(Phase3: Cooling only with the refrigerator)		
Orbit	Sun-synchronous polar orbit along the twilight zone. Orbital period: 100 min. Orbital altitude: 700 km (circular orbit) Orbital inclination angle: 98 degrees		
Telescope	Effective diameter: 68.5 cm. Ritchey-Chretien type[2)].		
Cooling system	Liquid helium + Stirling cycle coolers[3)]. Liquid helium holding period: 550 days		
Attitude mode	•All-sky survey mode: Continuously scan 360 degrees at the orbital period of about 100 minutes (3.6 arcmin/s). Over 96% of the whole sky was covered in the end. •Pointing observation mode •Staring mode: Imaging/spectroscopic observations performed with the field of view fixed on specific targets. Maximum exposure is about 10 minutes within an orbit. •Slow scan mode: Scan back and forth on a particular area of sky at the maximum speed of 30 arcsec/s. This mode was mainly used for sensitive mapping by FIS.		
Observation modes	Observation modes are classified as follows: 		
Focal-Plane Instruments	1) Far Infrared Surveyor (FIS): Composed of Ge:Ga detector arrays. All-sky survey and imaging were conducted in 4 wavelength bands within the wavelength range of 50-180 μm. FIS also has a spectroscopic function by a Fourier spectroscope. 2) Near-mid infrared camera (IRC): Consists of three cameras with refractive optical system, where InSb and Si:As detector arrays are adopted. Imaging is made in 9 wavelength bands within the wavelength range of 2 to 26 μm. All-sky survey was conducted in two wavelength bands at around 9 and 18 μm. IRC also has a spectroscopic function by prism-grism.		
Valid number of Staring observations		Phase 1 & 2	Phase 3
	FIS imaging	1100	----
	FIS spectroscopy	550	----
	IRC imaging	3000	3800
	IRC spectroscopy	900	8800

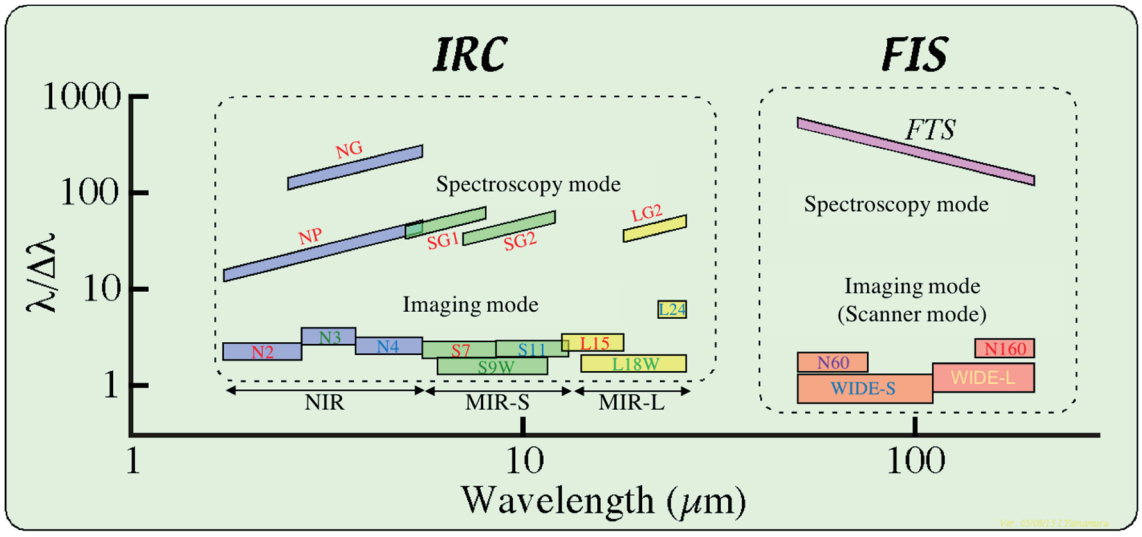


Figure 1: Observation modes, wavelength-range and wavelength-resolution of each of the two focal-plane instruments[1)].

2. AKARI data products

Below, we introduce AKARI data products (=high-order processing data such as catalogue, images, spectra) created by the AKARI data processing and analysis team.

The AKARI data product is primarily classified according to the nature of the products: raw data (FITS format) or high-level data products (catalogue, images, spectra). Next, they are separated by the detectors used, FIS[4)] or IRC[6)]. Furthermore, they are divided into three attitude modes (All-sky survey mode, Staring mode, or Slow scan mode)[1)]. Figure 2 gives such a classification of the AKARI data products.

The AKARI position determination accuracy of a celestial object is within 5-6 arcsec. Table 2 gives explanation of all the data products, summarizing information on the official name of each product, the number of registered celestial bodies and detection sensitivity, etc.

The point source catalogue, all-sky images and spectra shown in Fig. 2 and Table 2 were first published on the homepage of the AKARI project team[N2)] at ISAS/JAXA. They are permanently archived at DARTS[N3)], which is the science data archive of ISAS/JAXA. [N4)]

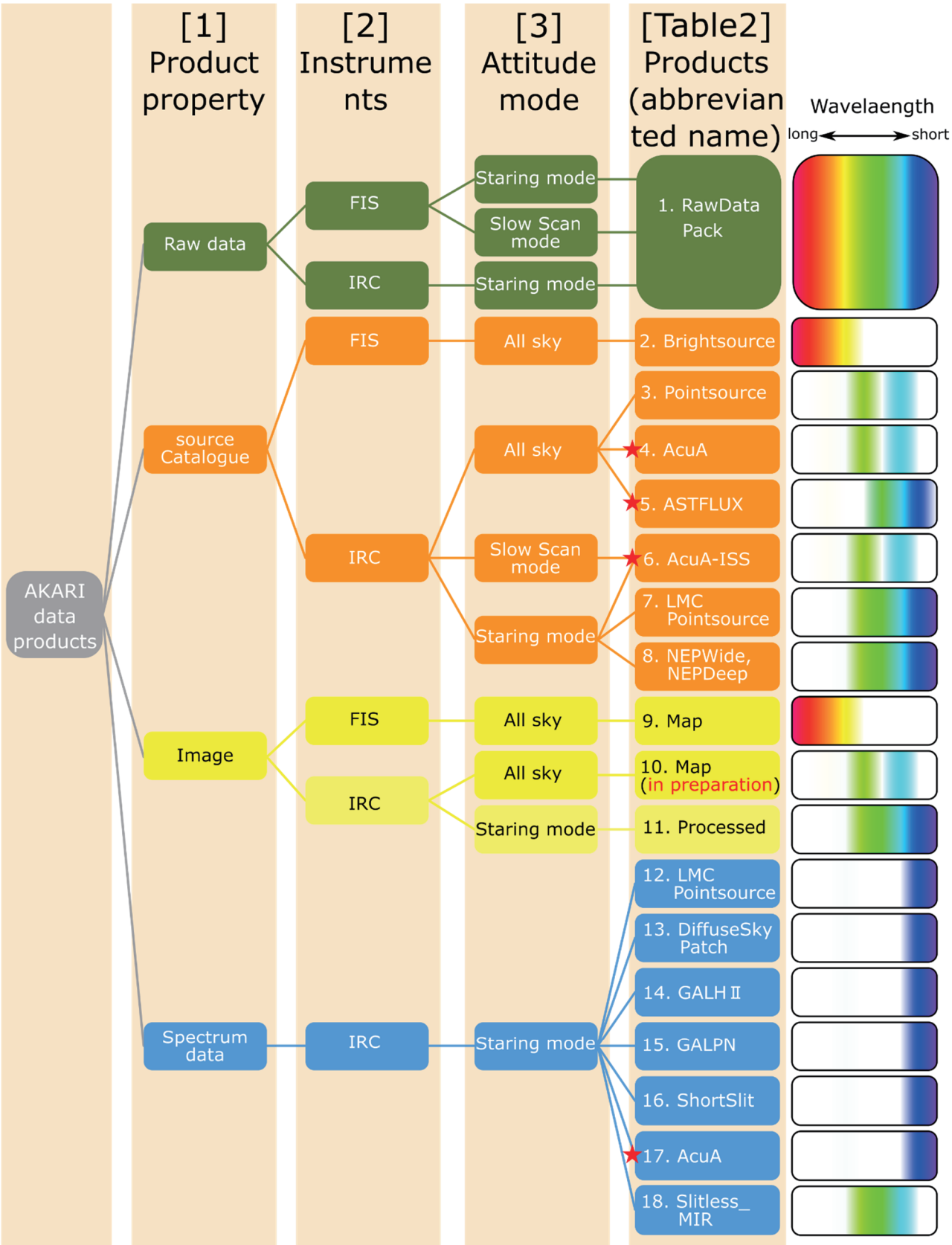


Figure 2: Classification of the AKARI data products. Raw data, catalogs, images and spectra are indicated in orange, yellow, and blue, respectively. The red stars represent products of the asteroids. The right-end column represents approximate wavelength range of each product. See Table 2 for explanation of each data product.

Table 2: Explanation for the data products.

	Product name [Product key★]	Product property [1]	Instruments [2]	Attitude modes [3]	wavelength[N5)]	Number of objects	Sensitivity	Description
1	AKARI Pointed Observation Data v.1 (Phase1 and 2) [AKARI__Pointed_RawDataPack_1.0]	Raw data	FIS & IRC	Staring and Slow scan mode	all band	---		FIS and IRC Raw data of pointing observation (imaging and spectroscopy) before helium depletion.
	AKARI Pointed Observation Data v.2 (Phase3) [AKARI__Pointed_RawDataPack_2.0]		IRC		2, 3 and 4 μm/1.7-5.4μm	---	Number of objects	IRC Raw data of pointing observation (imaging and spectroscopy) after helium depletion.
2	AKARI/FIS Bright Source Catalogue Version 1.0 [AKARI-FIS_Catalogue_AllSky_BrightSource_1.0]	Catalogue	FIS	All sky	65, 90, 140 and 160 μm	427,071	0.55 Jy@90μm	Bright point source all sky catalog using FIS.
	AKARI/FIS Bright Source Catalogue Version 2.0 [AKARI-FIS_Catalogue_AllSky_BrightSource_2.0]		FIS	All sky	65, 90, 140 and 160 μm	501,444	～0.5 Jy@90μm	Bright point source all sky catalog version 2 using FIS, reflecting improvements in processing method and detectors calibration.
3	AKARI/IRC Point Source Catalogue Version 1.0 [AKARI-IRC_Catalogue_AllSky_PointSource_1.0]		IRC	All sky	9 & 18 μm	870,973	0.045 Jy@9μm	Bright point source all sky catalog using IRC.
4	AKARI Asteroid Catalog Version 1.0 [AKARI-IRC_Catalogue_AllSky_AcuA_1.0]		IRC	All sky	9 & 18 μm	5,120		Asteroid catalog with all-sky survey data by IRC.
5	AKARI Asteroid Flux Catalog Ver.1 [AKARI-IRC_Catalogue_AllSky_ASTFLUX_1.0]		IRC	All sky	3, 4, 7, 9, 11, 15, 18 and 24 μm	5,201		Asteroid Flux Catalog contains photometric data of 5201 asteroids observed with the IRC.
6	Asteroid Catalog Using AKARI IRC Slow-Scan [AKARI-IRC_Catalogue_Pointed_AcuA-ISS_1.0]		IRC	Slow scan	9 & 18 μm	88		Asteroid catalog by using slow scan observation data by IRC.
7	The AKARI-LMC Point Source Catalogue [AKARI-IRC_Catalogue_Pointed_LMCPointSource_1.0]		IRC	Staring mode	3, 7, 11, 15, 24 μm	802,285	The 10 sigma limiting magnitudes are estimated as 17.9, 13.8, 12.4, 9.9 and 8.6 mag at N3, S7, S11, L15, and L24, respectively	IRC point source catalog in LMC (Large Magellanic Cloud).
8	The AKARI-NEP-Wide Source Catalogue Version 1 [AKARI-IRC_Catalogue_Pointed_NEPWide_1.0]		IRC	Staring mode	2, 3, 4, 7, 9, 11, 15, 18 and 24 μm	114,794		IRC point source catalog of wide-field (5.4 square degrees) celestial bodies near the North Polar Spur.
	The AKARI-NEP-Deep Source Catalogue Version 1 [AKARI-IRC_Catalogue_Pointed_NEPDeep_1.0]		IRC	Staring mode	7, 9, 11, 15 and 18 μm	7,284		IRC point source catalog in the narrow area (0.67 square degree) near the North Polar Spur.
	The AKARI-NEP-Deep Source Catalogue Version 2 [AKARI-IRC_Catalogue_Pointed_NEPDeep_2.0]		IRC	Staring mode	2, 3, 4, 7, 9, 11, 15, 18 and 24 μm	27,770		IRC source catalog version 2 in the narrow area near the North Polar Spur, reflecting improvements in processing method and detectors calibration.

	Product name [Product key★]	Product property [1]	Instruments [2]	Attitude modes [3]	wavelength[N5)]	Number of objects	Sensitivity	Description
9	AKARI Far-infrared All-Sky Survey Maps Version 2.1 [AKARI-FIS_Image_AllSky_Map_2.1]	Image	FIS	All sky	65, 90, 140 and 160 μm	---		All-sky image of 4 bands by FIS. Spatial resolution about 5 times compared with IRAS.
10	AKARI/IRC All-Sky Image Maps Version 1.0 [in preparation]		IRC	All sky	9 & 18 μm	---		All-sky image of 2 bands by IRC.
11	IRC Pointed Observation Images [AKARI-IRC_Image_Pointed_POI_1.0]		IRC	Staring mode	2, 3, 4, 7, 9, 11, 15, 18 and 24 μm	---		Higher order imaging data of IRC pointing observation.
	IRC Pointed Observation Images (Post-Helium Mission) [AKARI-IRC_Image_Pointed_POI_2.0]		IRC	Staring mode	2, 3, and 4 μm	---		Higher order imaging data of IRC pointing observation after helium depletion.
12	The AKARI-LMC Near-infrared Spectroscopic Catalogue [AKARI-IRC_Spectrum_Pointed_LMCPointSource_1.0]	Spectrum	IRC	Staring mode	2.5–5.0 μm	2,111	The saturation limits are~0.1 and ~0.5--1.0 Jy	Spectroscopic data of LMC point sources (stars) by IRC.
13	AKARI-IRC NIR Low-resolution Spectral Catalogue of Diffuse Sky Patches [AKARI-IRC_Spectrum_Pointed_DiffuseSkyPatch_1.0]		IRC	Staring mode	1.8–5.3 μm	278		Low dispersion spectroscopic data of zodiac light and background light by IRC.
14	AKARI Near-infrared Spectral Atlas of Galactic HII regions [AKARI-IRC_Spectrum_Pointed_GALHII_1.0]		IRC	Staring mode	1.7–5.4 μm and/or 2.5–5.0 μm	464		Spectroscopic data of HII region (gas nebula) in the galaxy by IRC.
15	AKARI/IRC NIR Spectral Atlas of Galactic Planetary Nebulae [AKARI-IRC_Spectrum_Pointed_GALPN_1.0]		IRC	Staring mode	2.5–5 μm	72		Spectroscopic data of the planetary nebula in our galaxy by IRC.
16	IRC Point Source Spectroscopy Data [AKARI-IRC_Spectrum_Pointed_ShortSlit_1.0]		IRC	Staring mode	1.7–5.4 μm and/or 2.5–5.0 μm	---		Phase 1 and 2 NG; 217 pointing data Phase 3 NG, NP; 5495 pointing data
17	AKARI Near Infrared Asteroid Spectral Catalog Ver.1 [AKARI-IRC_Spectrum_Pointed_AcuA_1.0]		IRC	Staring mode	2.5–5 μm	64		Spectroscopic data of 64 asteroids by IRC.
18	AKARI/IRC MIR-S slit-less spectroscopic catalogue [AKARI-IRC_Spectrum_Pointed_Slitless_MIR_1.0]		IRC	Staring mode	5.5-12.5 μm	604		Mid infrared slit-less spectroscopic data by IRC.

★ DARTS defines product keys according to the following rule: "Satellite name - Instrument _ Product property _ attitude mode _ Product abbreviation _version".
These product keys are used in URLs for the data products and the corresponding web pages as follows:
data URL https://darts.isas.jaxa.jp/pub/akari/ [Product Key]
web page URL https://darts.isas.jaxa.jp/astro/akari/data/[Product Key].html

3. data product classification

3.1. Product property

The AKARI data products are divided into the following 4 categories.

(1) Raw data

Binary Table or Image FITS data.

(2) Source catalogue

Infrared source catalogue. There are all-sky catalogue, local region catalogue (LMC and NEP), and catalogue for asteroids.

(3) Images

FITS format image files. According to observation modes, they are classified into map images (All sky survey mode), pointing images (Staring mode), scan images (Slow scan mode).

(4) Spectra

Spectral data for various objects or fields.

3.2. Focal-Plane Instruments

At AKARI's telescope focal plane, two instruments, FIS[4] and IRC[5] were installed (Figure 3).

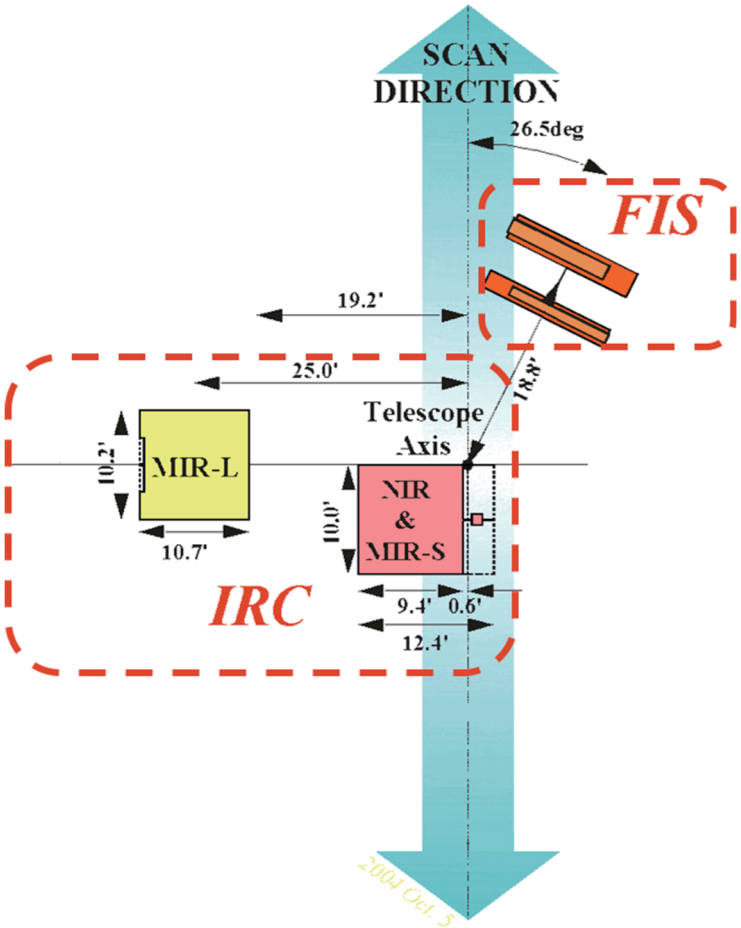


Figure 3: AKARI focal plane layout[1]. FIS is placed at the second focal point (see Figure 6), and IRC is placed at the first focal point (see Figure 7).

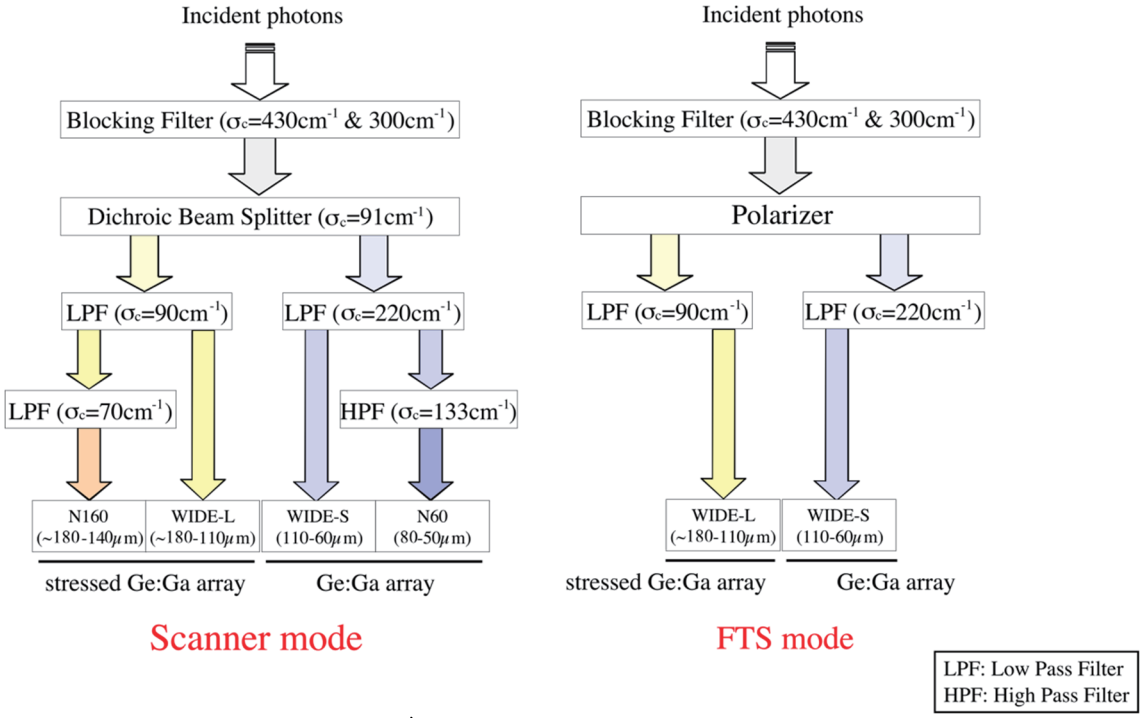


Figure 4: diagram of FIS optical path[6]. Either left or right pattern of the optical path was possible.

3.2.1. FIS: Far-Infrared Surveyor

FIS was operational only when the liquid helium cooling was available, namely, from 7th May 2006 to 26th August 2007. It was mainly used for all-sky survey. As shown in Fig. 4, the light incident on the telescope passes through a beam splitter or interferometer (polarizer). Lights from different paths are collected by two different detectors. The optical paths and filters are different depending on the imaging and spectral modes. The following two modes were available:

(1) Scanner mode

Imaging observation was carried out with 4 band (wavelength band) of 65 (N60), 90 (WIDE - S), 140 (WIDE - L) and 160 (N160) μm using different filters. Figure 5 shows the transmittance of each filter. In addition, as shown in Fig. 6, it was possible to capture 4 band images at once at two different fields of view. The scan direction was designed so that the same sky-area was scanned by the two fields of view successivly. This mode was usually used for all-sky survey observation, but also used for pointing observations.

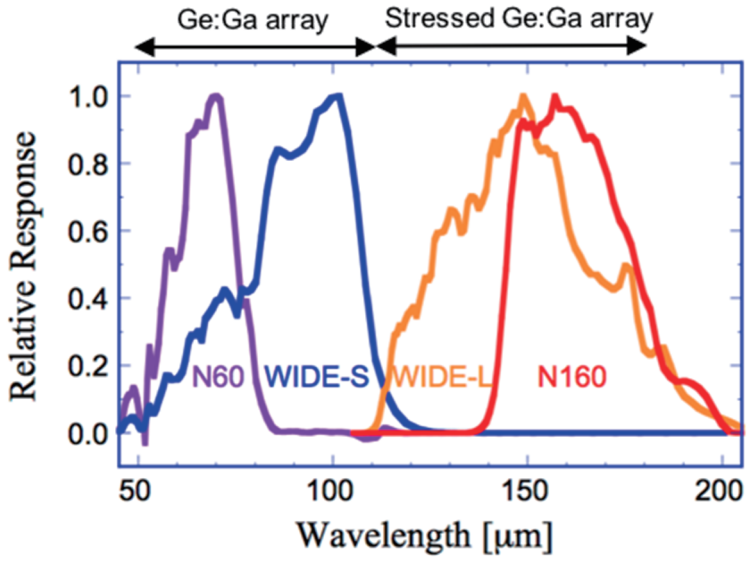


Figure 5: Transmittance of FIS filter[4].

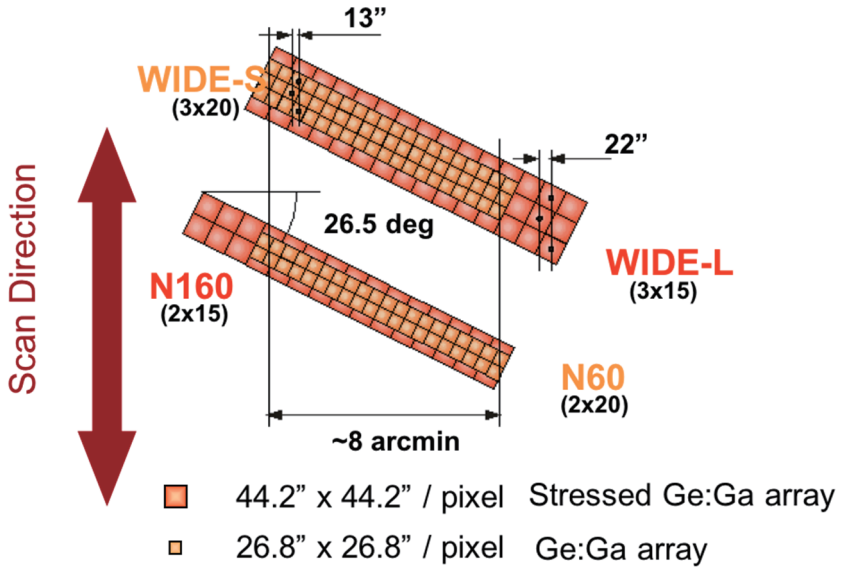


Figure 6: Fields of view of FIS projected on the celestial sphere[4]. Detectors having overlapping fields of view are placed in different optical paths separated by the Dichroic Beam Splitter (see Figure 4).

(2) Fourier Transform Spectrometer mode (FTS mode)

By replacing the Dichroic Beam Splitter of Scanner mode with a Fourier spectrometer (polarizer), it is possible to perform spectroscopic observation using WIDE-S and WIDE-L detectors (Figure 4). Wavelength resolution varies depending on the optical path (scan time). FIS has "Full-resolution mode" and "SED mode", where Table 3 shows the spectral performance of each.

Table 3: Performance in FIS spectroscopy mode[6].

detectors	wavelength [μm]	wavelength resolution λ/Δλ
WIDE-S	60-110	150~450 (Full-resolution mode; scan time 48 sec) or 23~75 (SED mode; scan time 12 sec)
WIDE-L	110-180	

3.2.2. IRC: InfraRed Camera

The IRC consists of three independent camera systems, NIR, MIR-S and MIR-L, which observe the wavelength bands of 1.7-5.5 μm, 5.8-14.1 μm, and 12.4-26.5 μm, respectively. IRC was used both for pointing observations and all sky survey.

Figure 7 shows the IRC fields of view. NIR and MIR-S cover the same field of view, where the same lights are split by the beam splitter for the two instruments. MIR-L has a different field of view and optical path. The fields of view of NIR/MIR-S and MIR-L do not overlap during scan.

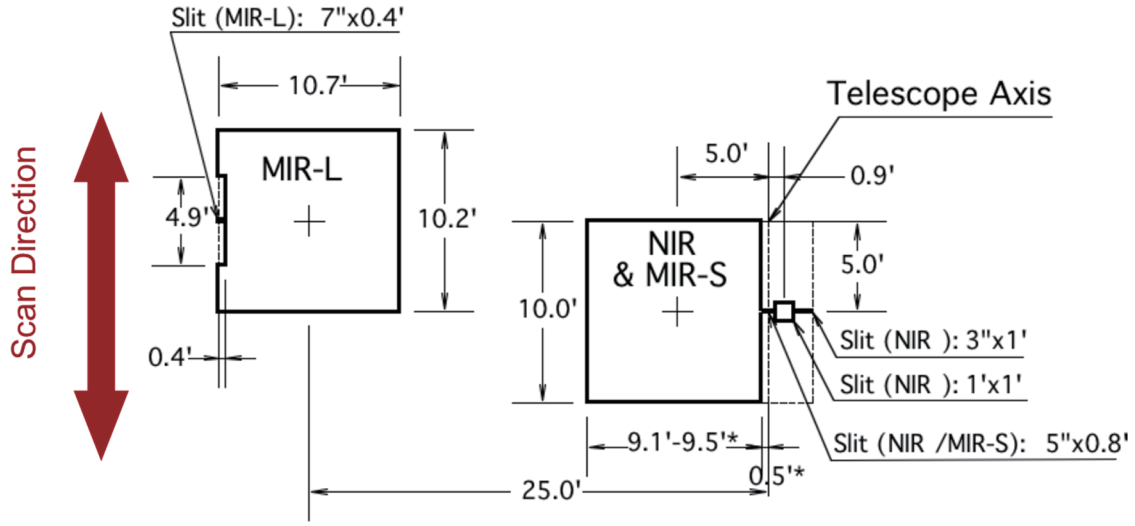


Figure 7: Fields of view and slit locations of the IRC[5].

(1) Imaging mode

Three kinds of imaging filters are mounted on each camera; NIR (N2, N3, N4), MIR-S (S7, S9W, S11), MIR-L (L15, L18W, L24). Figure 8 shows the transmittance of each filter.

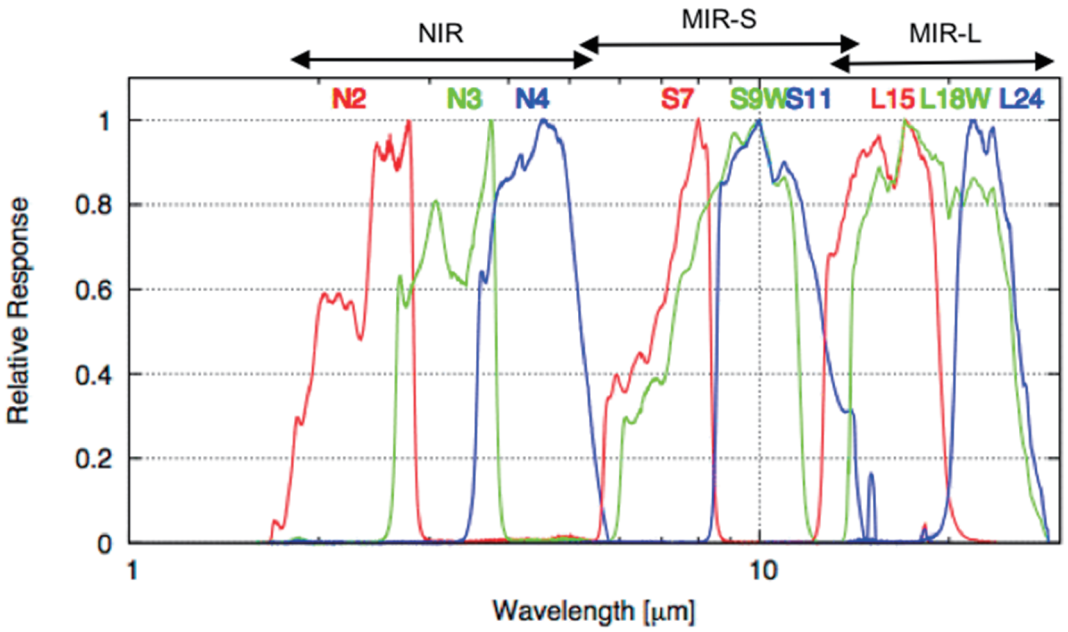


Figure 8: Transmittance of IRC filter[7].

(2) Spectroscopy mode

Each camera has two types of spectroscopic devices in addition to the imaging filters. Prism (NP) and grism (NG) can be selected in NIR by rotating the filter wheel. Either of two different types of grism can be selected for MIR-S (SG1, SG2), as well as for MIR-L (LG1, LG2). However, LG 1 of MIR - L was deteriorated in the ground test, so it was never used for observation. Table 4 shows spectral performance of each spectroscopic device.

Besides ordinary spectroscopic observation that introduces a point source in the slits (Figure 7), "slitless observation" which diffracts the entire imaging field of view was also carried out.

Table 4: Performance in IRC spectroscopy mode[7].

detectors	spectroscopic device	wavelength [μm]	wavelength resolution [μm pix^{-1}]
NIR	NP	1.8–5.2	0.06 @3.5 μm[N6]
	NG	2.5–5.0	0.0097
MIR-S	SG1	5.4-8.4	0.057
	SG2	7.5-12.9	0.099
MIR-L	LG1	(11-19)	(0.173)
	LG2	17.5-25.7	0.175

3.3. Attitude modes

AKARI conducted observations in the following three attitude modes. For details, please see Murakami et al. (2007)[1].

(1) All-sky survey mode

All-sky survey observation (3.6 arcmin/sec). In the end, more than 96% of the whole sky was covered.

(2) Staring mode

Pointing observation to observe specific sky-areas or objects with a fixed attitude. Pointing directions may be slightly shifted for dithering. Usually, staring mode spent up to about 10 minutes in an orbital period of about 100 minutes.

(3) Slow scan mode

Pointing observation to observe an extended region while slowly scanning (maximum 30 arcsec/sec). Sensitivity is several times higher than all-sky survey observation. As of October 2018, raw data of FIS and the asteroid catalog of IRC have been published for Slow scan mode.

4. Summary

AKARI was observed with two kinds of instruments, FIS and IRC. As of September 2019, two raw data sets, ten source catalogue, three-type images and seven spectrum sets have been published

REVISION HISTORY

Version 1.0 November 2018, First edition.

Version 1.1 September 2019, Correction of Figure 2 and Table 2.

-Introducing "product key".

-New spectral data added (AKARI Near Infrared Asteroid Spectral Catalog Ver.1 and AKARI/IRC MIR-S slit-less spectroscopic catalogue).

-Mistakes of instrument and wavelength of AKARI Asteroid Catalog fixed.

ACKNOWLEDGEMNETS

Advice and comments given by Prof. Ken Ebisawa and the AKARI data processing and analysis team members has been a great help.

Notes

N1) Phase1: Observation period of the whole sky survey during the first half year.
Phase2: Observation period until the liquid helium is depleted.
Phase3: Observation period after the liquid helium depletion.

N2) https://www.ir.isas.jaxa.jp/AKARI/Archive/

N3) https://darts.isas.jaxa.jp/astro/akari/products.html.

N4) Observational information of the staring observations is published from DARTS. Users can investigate when and in which modes the targets were observed.

N5) For catalogs and images, the center wavelengths (see Figures 5 and 8) are indicated. For spectra, the wavelength ranges are shown (wavelength resolution is shown in Tables 3 and 4).

N6) The dispersive power of the NIR prism (NP) depends on the wavelength.

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