Evaluation of "The *AKARI*/FIS Bright Source Catalogue Vers.2": Comparison with the *Herschel*/PACS Point Source Catalogue

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ABSTRACT

We compare the all-sky *AKARI*/Far-Infrared Surveyor (FIS) Bright Source Catalogue (BSC) Version 2 with the *Herschel*/Photodetector Array Camera and Spectrometer (PACS) Point Source Catalogue (PSC), in order to investigate condition for correct matching. We define a "fake"-match rate based on the *AKARI*-*Herschel* flux ratio and study the dependence of this rate on the source density of the region (Ndens), *AKARI*-*Herschel* separation (D), Galactic latitude ($|b|$), and the *AKARI* flux. We find that the "fake"-match rate depends on Ndens, D, and $|b|$ and not strongly on the *AKARI* flux where the sources with smaller Ndens and D and larger $|b|$ result in lower "fake"-match rate. In our analysis, if we limit the *AKARI* sources with FQUAL = 3, Ndens = 0 and $|b| > 30$ degrees, and adopt a searching radius of < 10 arcsec, the source is likely to be matched with an appropriate counterpart in a catalogue of astronomical data whose position accuracy is better than that of the *AKARI* catalogue.

Keywords: catalogs — surveys — infrared: general

1. INTRODUCTION

Many All-sky surveys have been conducted mainly in optical and near infrared wavelengths with grand-based telescopes and revealed a shape of the universe which is not heavily obscured by dust. In 1983, the *Infrared Astronomical Satellite (IRAS)* has been launched and shed light on the nature of the dusty universe (Neugebauer et al. 1984). The Japanese infrared astronomical satellite *AKARI* conducted an all-sky survey from 2006 to 2007 in six infrared bands with central wavelengths of 9, 18 (InfraRed Camera, IRC; Onaka et al. 2007), 65, 90, 140, and 160 μm (Far-Infrared Surveyor, FIS; Kawada et al. 2007). The spatial resolution and the sensitivity for *AKARI* have been improved by more than a factor of 10, compared to those of *IRAS*, allowing us to investigate detailed nature of star, planet and galaxy formation.

In this study, we compare the all-sky *AKARI*/Far-Infrared Surveyor (FIS) Bright Source Catalogue (BSC) Version 2 with the *Herschel*/Photodetector Array Camera and Spectrometer (PACS) Point Source Catalogue (PSC), aiming for investigating parameters to be paid attention to for the use of the *AKARI*/FIS BSC. The first version of the *AKARI*/BSC was released in 2010 (Yamamura et al. 2010). This catalogue contained 427,071 point sources in the four FIS bands. In 2016, the 2nd version of the FIS BSC has been released (Yamamura et al. in prep.) and the number of the sources increases to 918,056 (501,444 in the main catalogue and 416,612 in the supplemental catalogue) owing to several optimizations of detection strategy (see Yamamura et al., this volume).

2. CROSSMATCH BETWEEN *AKARI*/FIS BSC AND *HERSCHEL*/PACS PSC

We conduct a one-to-one crossmatch between the all-sky *AKARI*/FIS BSC and the *Herschel*/PACS PSC with a matching radius corresponding to the approximate point source size in each *AKARI* band. Within the matching radius, the closest source is considered as a counterpart. The *Herschel*/PACS PSC was released in 2017 (Marton et al. 2017), which combines Level 2.5/Level 3 *Herschel*/PACS photometric observations in 70, 100, and 160 μm including 682 Parallel Mode, 12,932 nominal mode and 1,644 Solar System Object (SSO) maps. The catalogues and crossmatch parameters are summarized in Tables 1 and 2, respectively. Here, we limit the *AKARI* sample with a quality flag (FQUAL) of 3, whose detection and flux value are judged to be reliable (see the Release Note of the *AKARI*/FIS BSC Vers.2 for more detailed classification). As a result, we obtain 22,380 sources for a crossmatch between *AKARI* 65 μm vs *Herschel* 70 μm, 4,903 for *AKARI* 90 μm vs *Herschel* 100 μm, and 77,122 for both *AKARI* 140 μm vs *Herschel* 160 μm and *AKARI* 160 μm vs *Herschel* 160 μm (Table 2).

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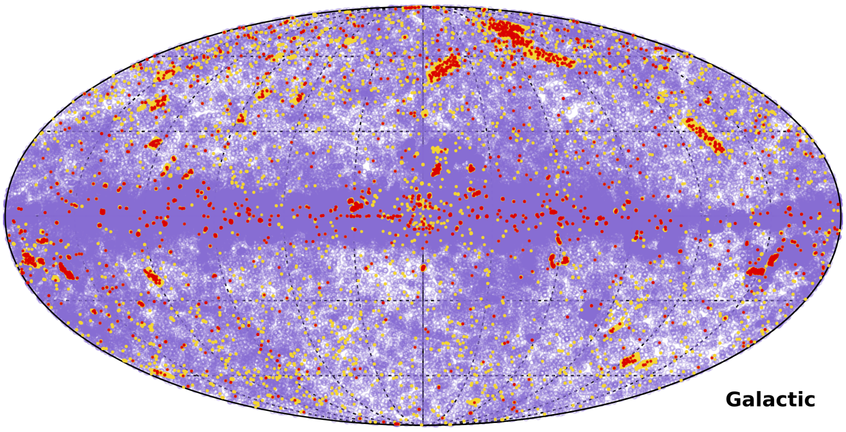

Figure 1. Sky distribution of the sources listed in *AKARI*/FIS BSC (purple) and *Herschel*/PACS PSC (yellow). The matched sources in this study are indicated as red symbols.

Table 1. Catalogue summary

Telescope	Wavelength [μm]	# of source^a	PSF^b	Position accuracy	Flux accuracy	References^c
AKARI	65	59,443	$40'' \times 50''$	$3''.5 \times 2''.5$	13–16%	1, 2
AKARI	90	461,842	$40'' \times 50''$	$3''.5 \times 2''.5$	13%	1, 2
AKARI	140	203,594	$70'' \times 90''$	$3''.5 \times 2''.5$	27%	1, 2
AKARI	160	71,836	$70'' \times 90''$	$3''.5 \times 2''.5$	32%	1, 2
Herschel	70	108,319	$5''.5$	$1''.5$	1%	3
Herschel	100	131,322	$6''.7$	$1''.5$	1%	3
Herschel	160	251,392	$11''$	$1''.7$	1%	3

NOTE— [a] For *AKARI*, only FQUAL = 3 sources are considered. [b] The values for *AKARI* are the point source size assumed for source extraction. [c] 1: Yamamura et al. (2010), 2: Yamamura et al. in prep., 3: Marton et al. (2017)

Table 2. Crossmatch summary

AKARI vs *Herschel*	Search radius [arcsec]	# of match
65 μm vs 70 μm	50	10,874
90 μm vs 100 μm	50	4,389
140 μm vs 160 μm	90	41,470
160 μm vs 160 μm	90	26,627

2.1. *AKARI-Herschel* Flux Ratios

We investigate correctness of the source matching as functions of characteristics of the *AKARI* sources. In this contribution, the *AKARI-Herschel* flux ratio calculated with the catalogued values is adopted as a measure of the matching accuracy (no correction for color and PSF differences between *AKARI* and *Herschel*). With the flux ratio, we first check the dependence of matching accuracy on the *AKARI* "Ndens" (number of objects within 5 arcmin of the source), *AKARI-Herschel* separation (D), absolute value of the Galactic latitude ($|b|$), and *AKARI* flux.

In Figures 2, we can see trends where the sources with lower Ndens (= 0), smaller D (< 10 arcsec) and higher $|b|$ (> 30 degrees) tend to have the *AKARI-Herschel* Flux ratio of ~1.0. Most sources with the *AKARI-Herschel* flux ratio that deviates from unity have a higher *AKARI* flux than *Herschel* flux. These *AKARI* sources are suspected to have multiple

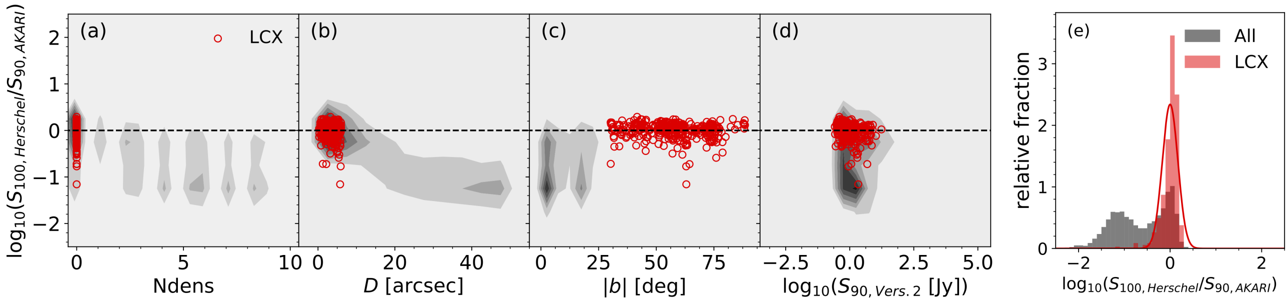

Figure 2. *AKARI* (90 μm)-*Herschel* (100 μm) flux ratio as a function of (a) Ndens, (b) *AKARI-Herschel* separation, (c) Galactic latitude, and (d) *AKARI* flux. Figure (e) is a histogram of the *AKARI-Herschel* flux ratio. Gray and red contour, symbols and histograms indicate the whole sources and the "Likely-to-be-Correct-Xmatch (LCX)" sources (for its definition, see Section 2.2), respectively.

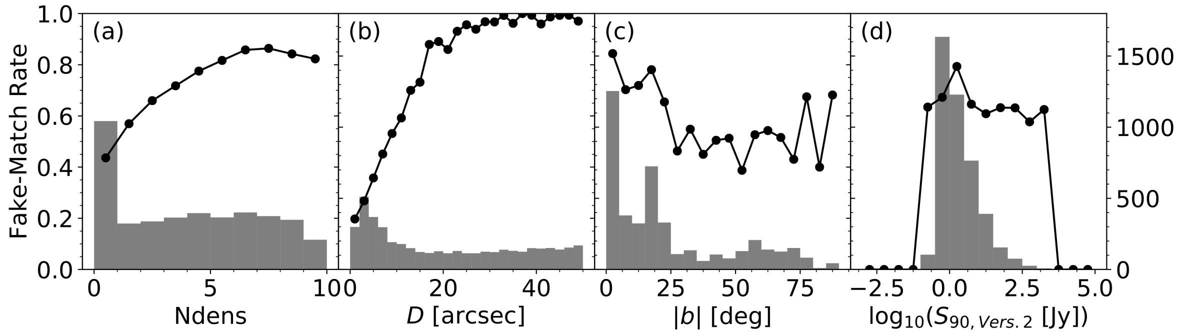

Figure 3. "Fake"-match rate (black solid line) and the number of sources (gray histogram) for the crossmatch between *AKARI* 90 μm and *Herschel* 100 μm data as a function of (a) Ndens, (b) *AKARI-Herschel* separation, (c) Galactic latitude, and (d) *AKARI* flux.

Herschel sources within the *AKARI* PSF to calculate the fluxes (PSF sizes are typically ~10 times larger for *AKARI* than *Herschel* in all the bands). For sources with larger *D*, it is also possible that the *AKARI-Herschel* ratios are lower because the matching itself goes wrong and the detection limit is predominantly higher for *AKARI* than *Herschel*.

2.2. "Fake"-match Rate

Next, we calculate a "fake"-match rate. We define the "Likely-to-be-Correct-Xmatch (LCX)" sources with criteria of (1) Ndens = 0, (2) $D < 6$ arcsec, and (3) $|b| > 30$ degrees. We assume that the *AKARI* sources, whose *AKARI-Herschel* flux ratios are within the range enclosing 80% of the LCX sources, are successfully crossmatched with a true counterpart in the *Herschel* catalogue. Conversely, the *AKARI* sources with the *AKARI-Herschel* flux ratio which is out of the range for the LCX sources are assumed to be crossmatched with "fake" sources. Then, the "fake"-match rate is calculated as a function of Ndens, *D*, $|b|$, and *AKARI* flux.

In Figure 3, we present the "fake"-match rate as the y-axis on the lefthand side and the number of the sources on the righthand side. As an overall trend, the "fake"-match rate is lower (~0.5) for the sources with Ndens = 0, $D < 10$ arcsec, and $|b| > 30$ degrees. The "fake"-match rate does not strongly depend on the *AKARI* flux. It should be noted that this "fake"-match rate is an upper limit for the true fake-match rate considering that some *AKARI* sources are coincidentally classified into the "fake"-match category since they have multiple *Herschel* counterparts within the *AKARI* PSF.

3. SUMMARY

In this contribution, we crossmatch the FQUAL = 3 sources in the all-sky *AKARI*/FIS BSC Version 2 with the objects in *Herschel*/PACS PSC, and investigate which crossmatch and source parameters affect the matching correctness. In our analysis, if we limit the *AKARI* sources with FQUAL = 3, Ndens = 0 and $|b| > 30$ degrees, and adopt a searching radius of < 10 arcsec, the source is likely to be matched with an appropriate counterpart in a catalogue of astronomical data whose position accuracy is better than that of the *AKARI* catalogue. These criteria are nominal and users should determine these values by checking the *AKARI* imaging data for more precise analysis according to their own purpose.

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