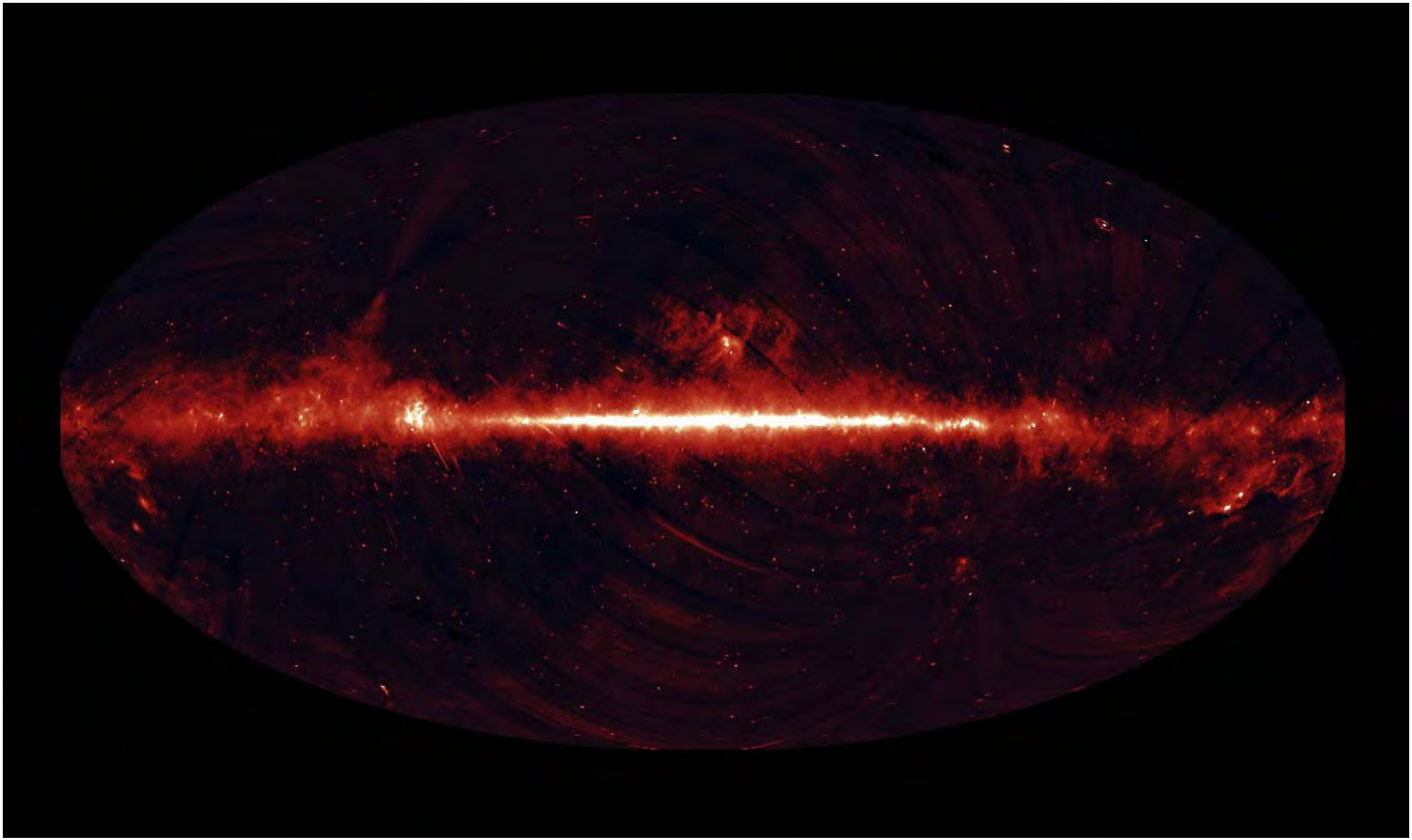
AKARI All-sky Survey Catalogues

Alberto Salama & Angelo Cassatella

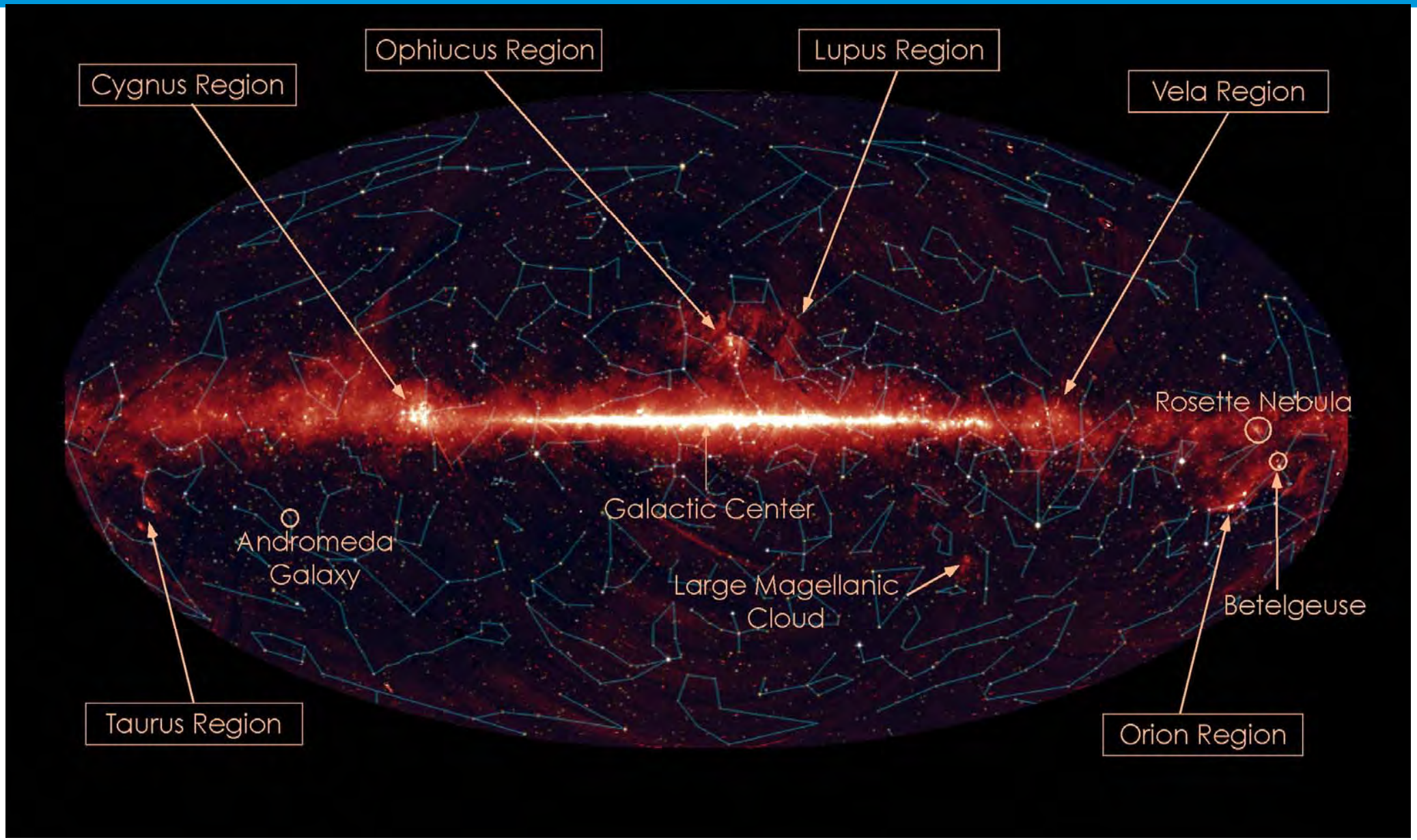
Outline

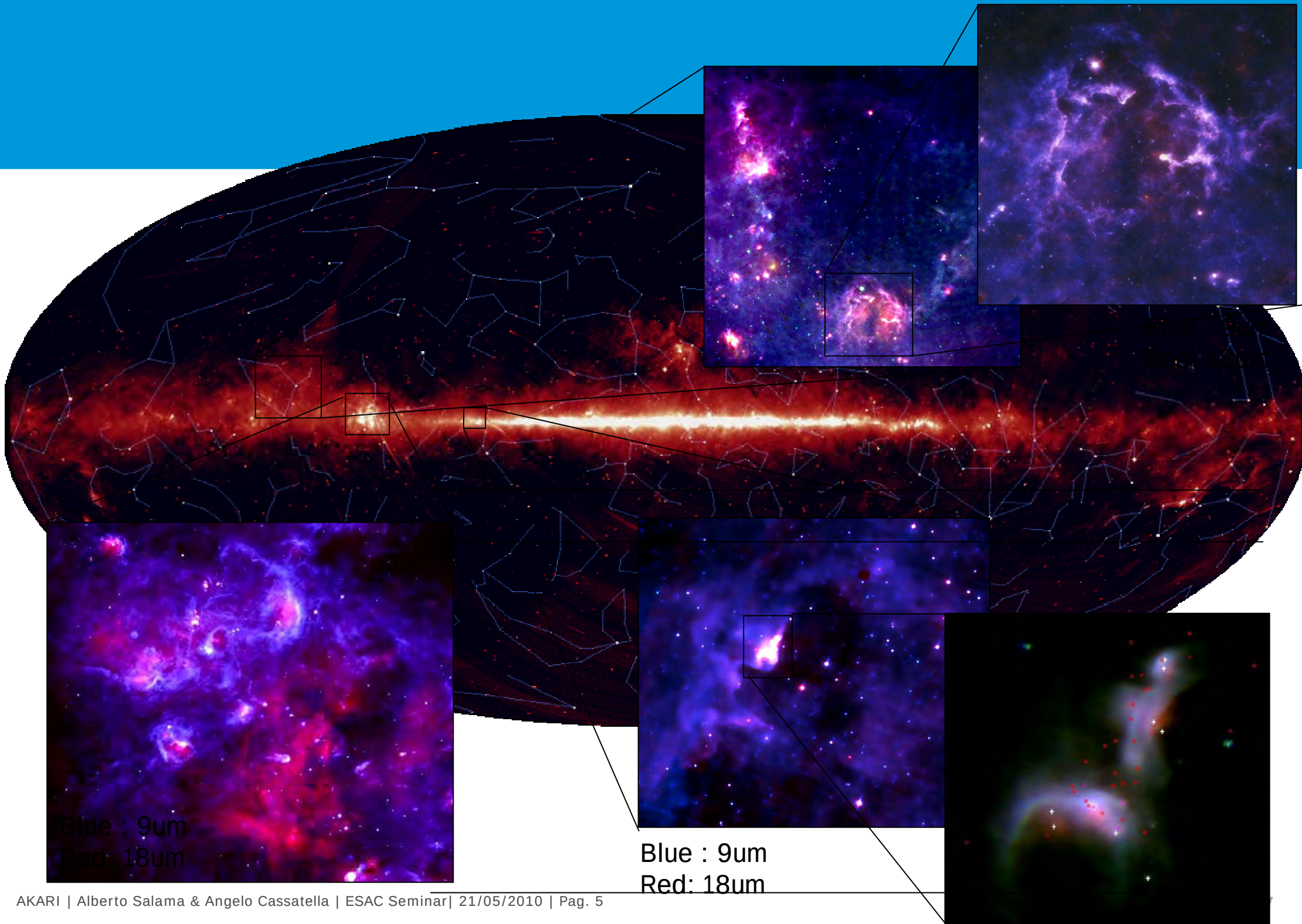
- Introduction
- Mission Overview
- ESA contribution
- The All-sky Survey Catalogues
- Science highlights from the literature
- Science with AKARI at ESAC

All-sky Survey Image (9 micron)

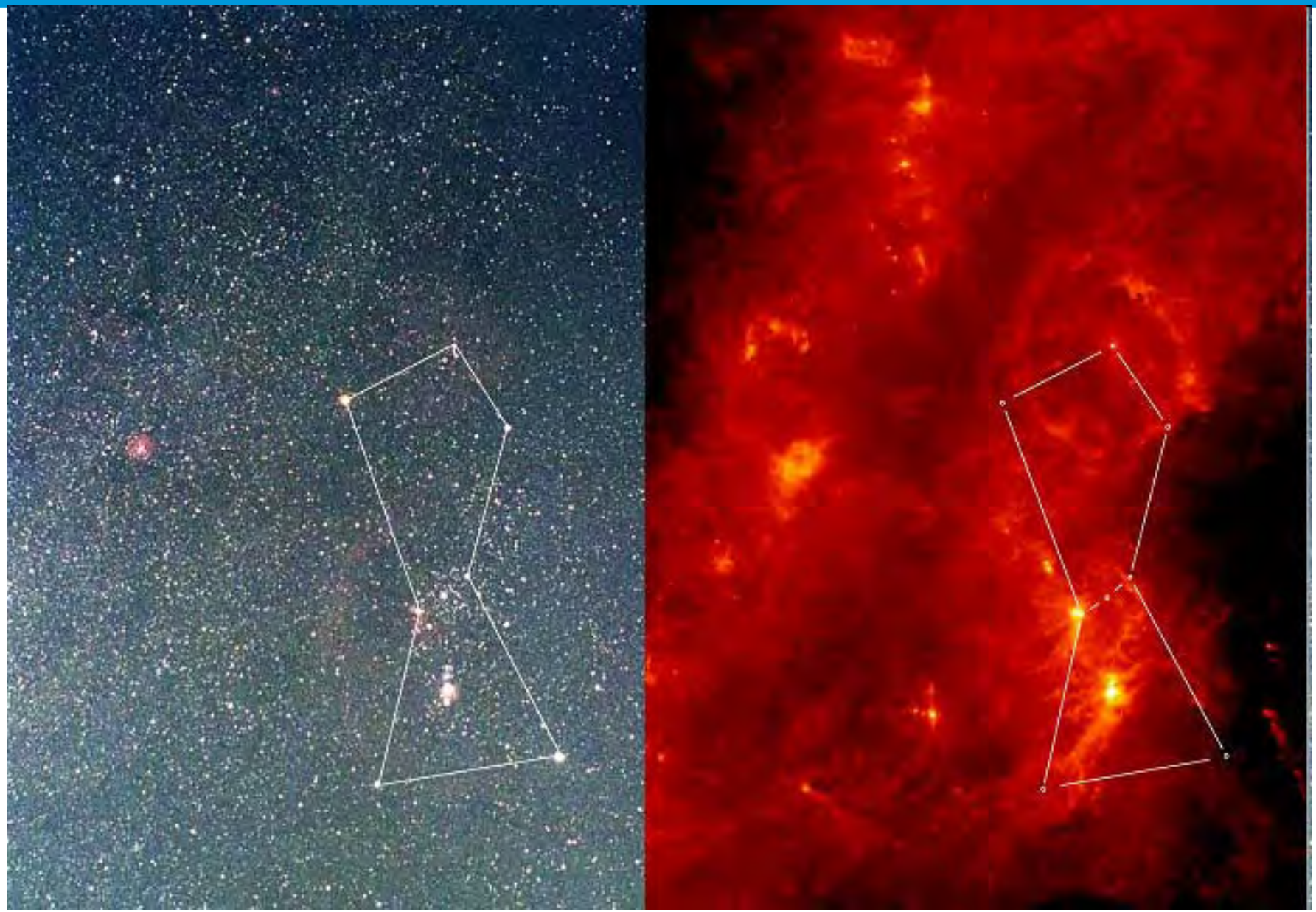


All-sky Survey Image (9 micron)

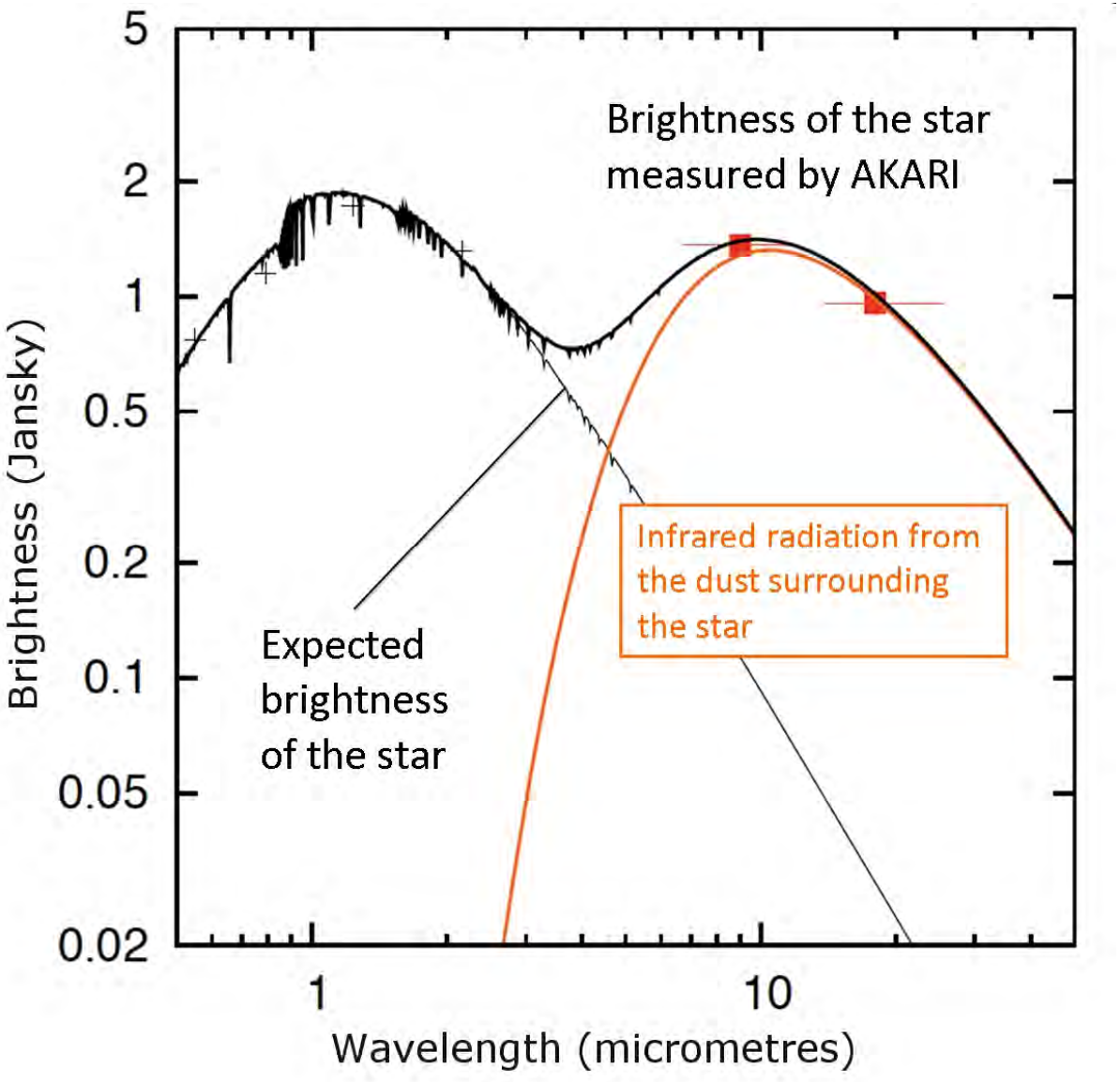



Blue : 9um
Red: 18um
Blue : 9um
Red: 18um

Orion (140 micron)



Star with infrared excess



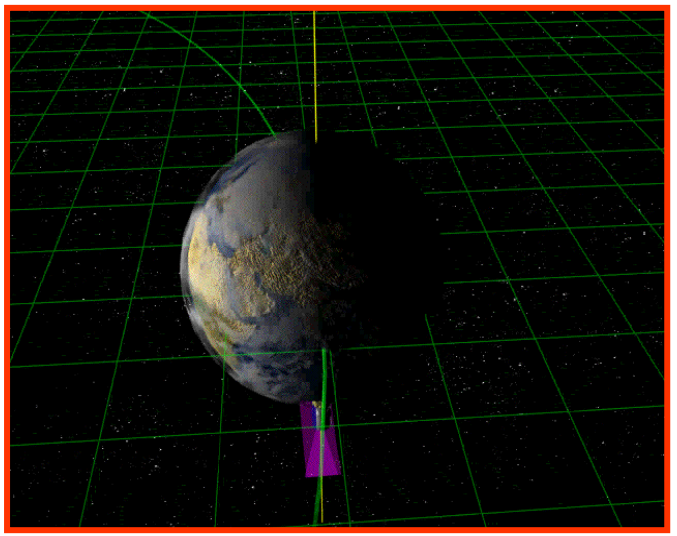
Mission Overview

- JAXA-led project, international collaboration
- Sky survey at IR wavelengths (25 yrs after IRAS)
  - Also partly an observatory (thousands of pointed observations)
- ESA contribution
  - set up by Martin Kessler in 1999, approved by SPC in 2000 "*to accelerate the production of the sky catalogues, which will be extremely valuable in the preparation and exploitation of the FIRST and Planck missions*".
  - Tracking support and pointing reconstruction for survey, in return for 10% of pointed observations
  - ESOC:
    - Tracking support (Kiruna), during survey (ended in Oct 07)
  - ESAC:
    - Community support
    - Pointing reconstruction
- About 4M EUR, used in 2003-2010
- Two instruments, IRC (2-26 μm) and FIS(45-180 μm)
  - 13 bands, photometry and spectroscopy

Mission Phases

Checkout PV Phase	Phase-1	Phase-2	Phase-3	
2 Month	6 Months	10 Months		
Orbit Control	All-Sky Survey	Mission Programs (~3150 ptgs)		63%
Satellite Chekout	NEP Survey	(~900 ptgs)		
Performance Verification	LMC Survey (~930 ptgs)	Open-Time Programs (1500 ptgs)		27%
	Mission Programs (~410 ptgs)			
	Director's Time Calibration			10%

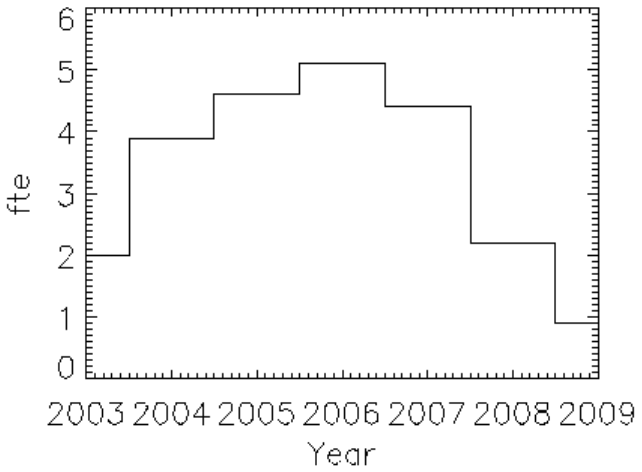
Launch	22 Feb 2006
Phase 1 (Mainly survey)	8 May 2006
Phase 2 (Mainly Pointed Observations)	8 Nov 2006
Helium depletion	26 Aug 2007
Phase 3 (Post-He - only NIR detector)	1 Jun 2008



SOC Elements Description

- AKARI tasks at ESAC performed by ISO Data Centre during last phase of ISO (Active Archive Phase), from 2003-2006, then by smaller dedicated team until today, as most people moved to Herschel

- Pointing Reconstruction (improving position accuracy X10)
- IRC Survey Catalogue generation, validation, documentation



- User Support
  - 3 AO's (total=1200 observations!)
    - Proposal technical feasibility
    - Additional AO tools and documentation
    - TAC formation and aid
    - Close monitoring of observing programmes implementation
      - Scheduling is an issue for the low-earth orbit satellite
      - Additional operational constraints arose during the mission
    - Web, Helpdesk
  - Data reduction documentation (Instrument Data User Manuals: 200 pages)
    - Initially for Open Time users, then valid for the world as data become public
  - Workshops at ESAC (with Japanese experts attendance)
    - Observation planning in September 2005
    - Hands-on data reduction in September 2007
  - Outreach

Team snapshots

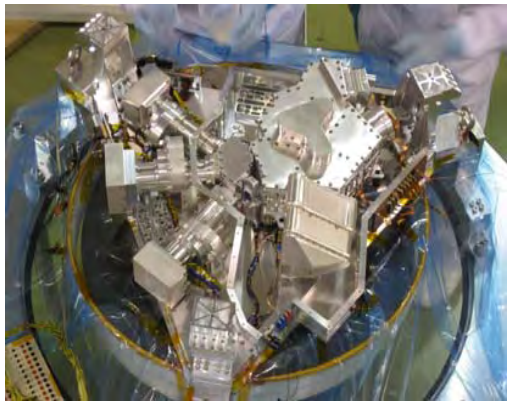
- In 2007
  - User Support (2 fte)
    - A. Salama (ISO and AKARI Project Scientist and User Support)
    - R. Lorente (ISOCAM and IRC expert, also ramping up on Herschel)
    - E. Verdugo (ISOPHOT and FIS expert, also ramping up on Herschel)
    - C. Pearson (with AKARI since 1997, collocated at ISAS)
  - Pointing Reconstruction (2 fte)
    - P. Garcia-Lario (Pointing reconstruction & Herschel Observatory scientist)
    - C. Stephenson (software engineer)
    - C. Alfageme (software engineer, also partly on User Support)

- In 2009 (1 fte)
    - A. Salama
    - C. Alfageme
    - N. Cox
    - A. Cassatella

Focal Plane Instruments

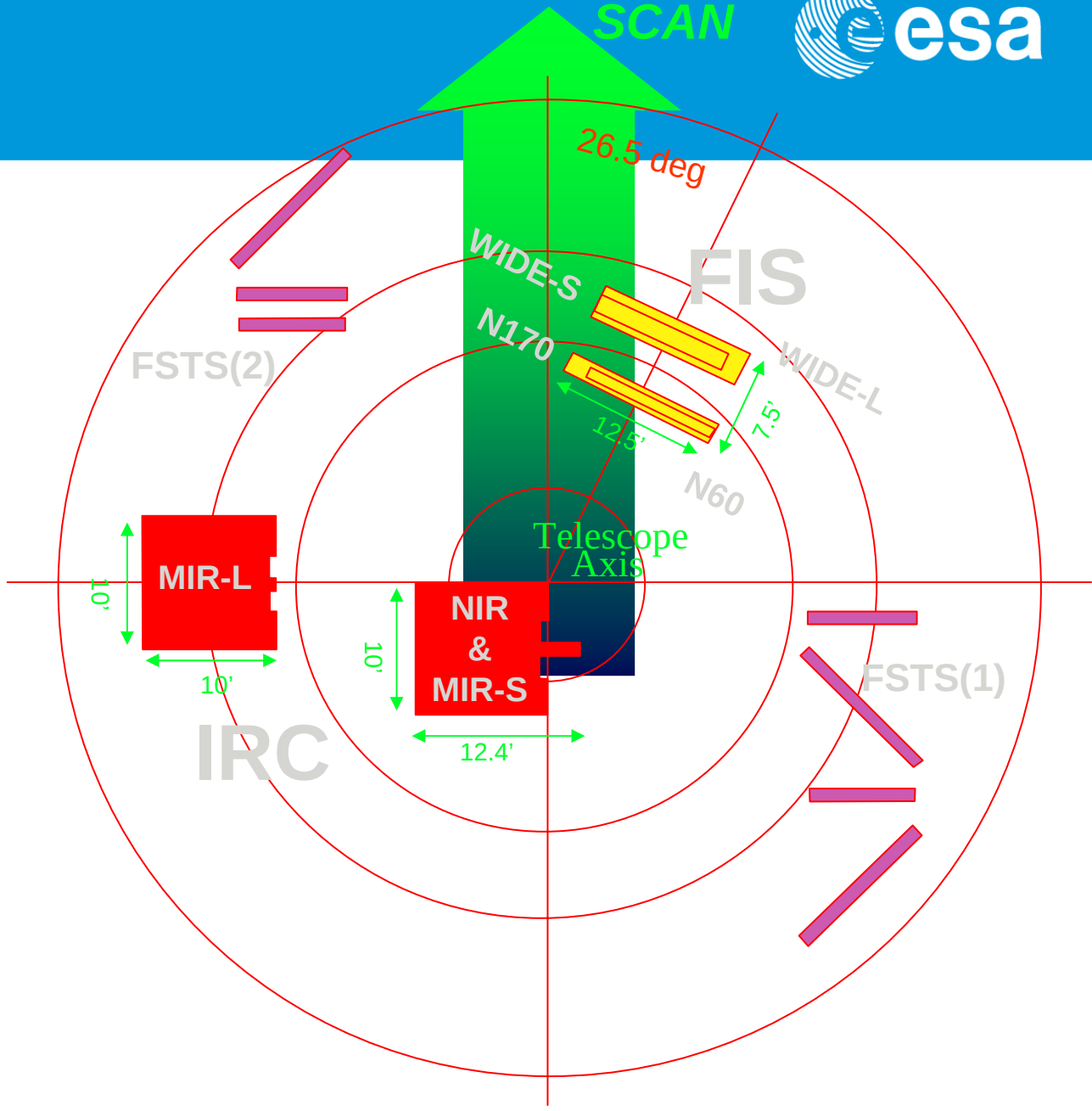
FIS (Far-Infrared Surveyor)

- 50 – 180 μm (4 photometric bands)
- All-Sky Survey (4 bands)
- Deep imaging and spectroscopy

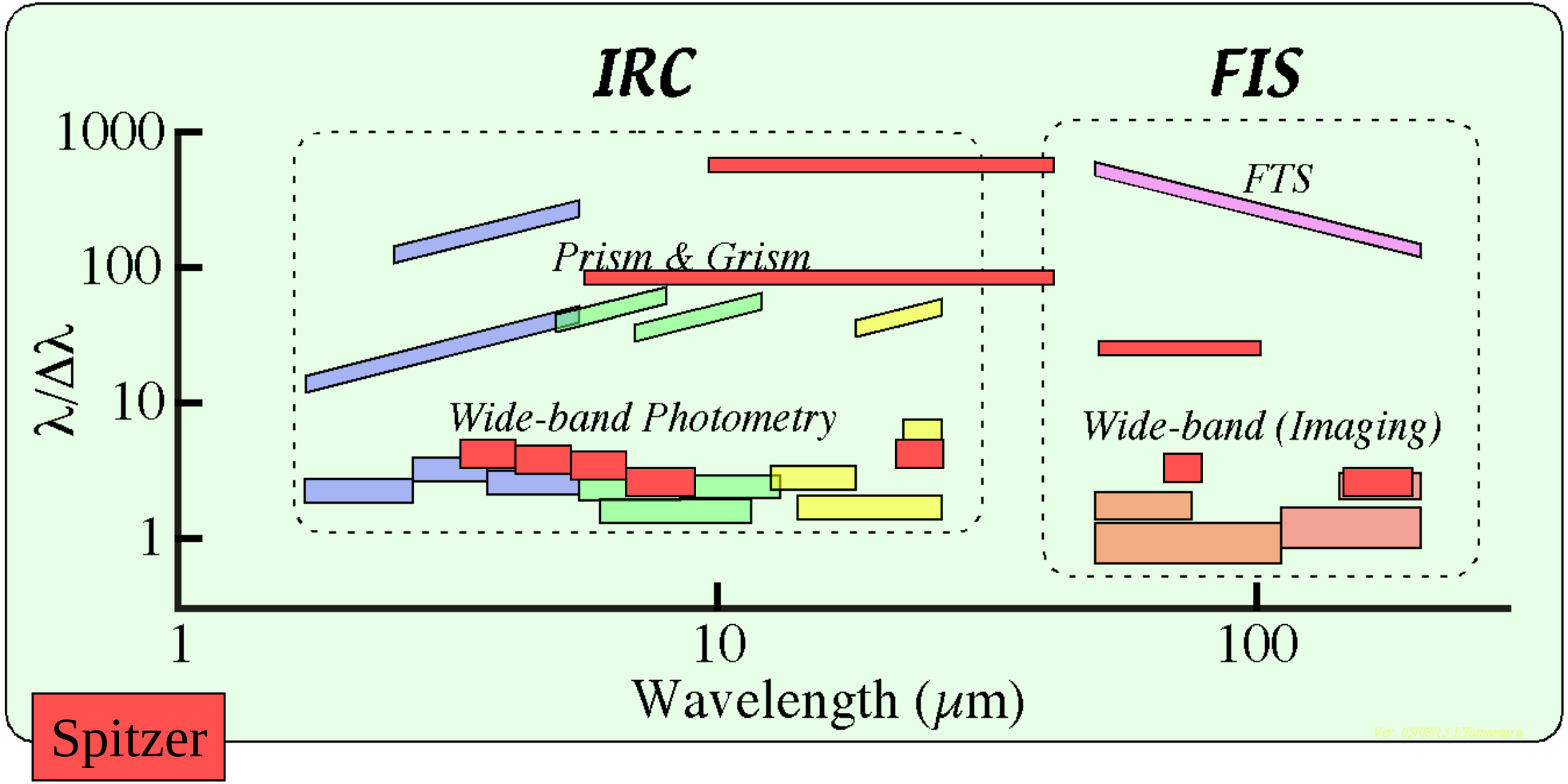


IRC (Infrared Camera)

- 1.7 – 26 μm (9 bands, 3 cameras)
- All-Sky Survey in 2 bands
- Imaging and spectroscopy



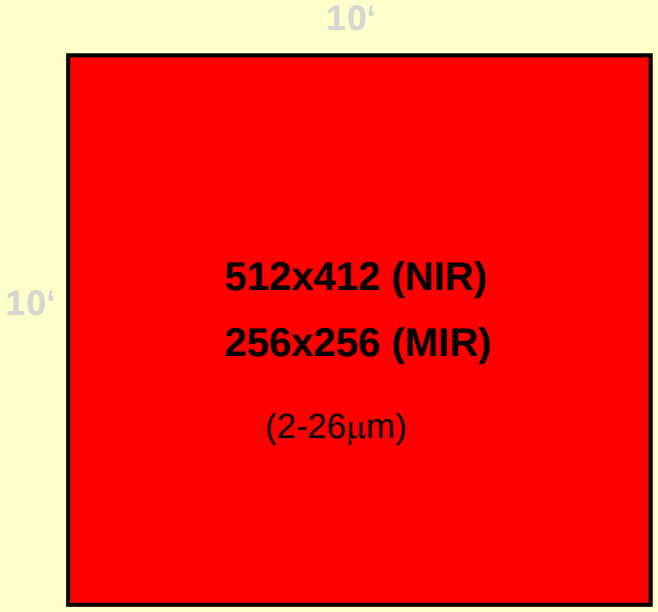
Photometric & Spectroscopic Capabilities



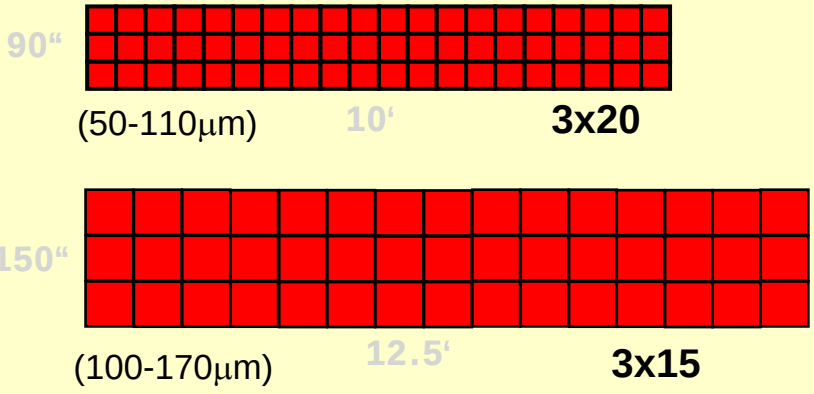
Detector sizes

AKARI

IRC

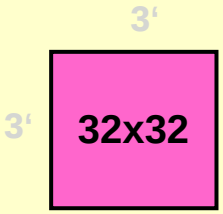


FIS

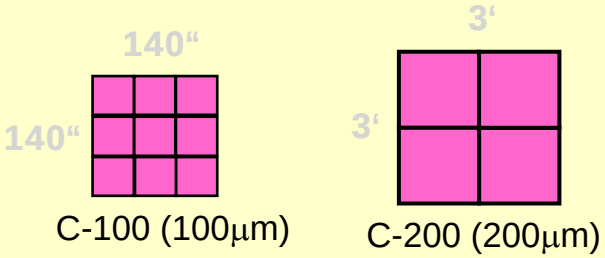


ISO

ISOCAM

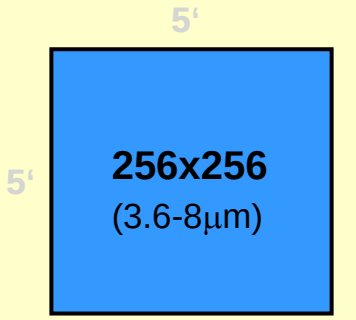


ISOPHOT

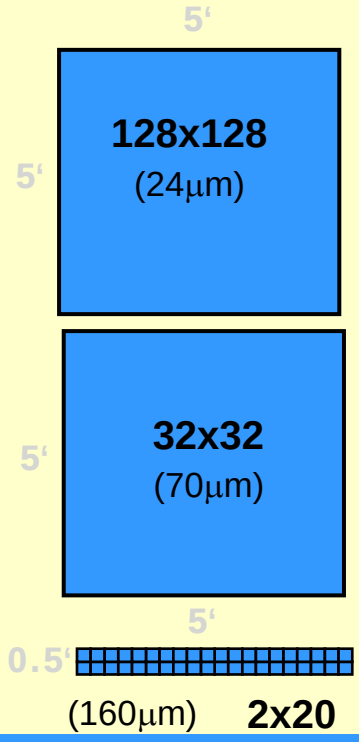


SPITZER

IRAC



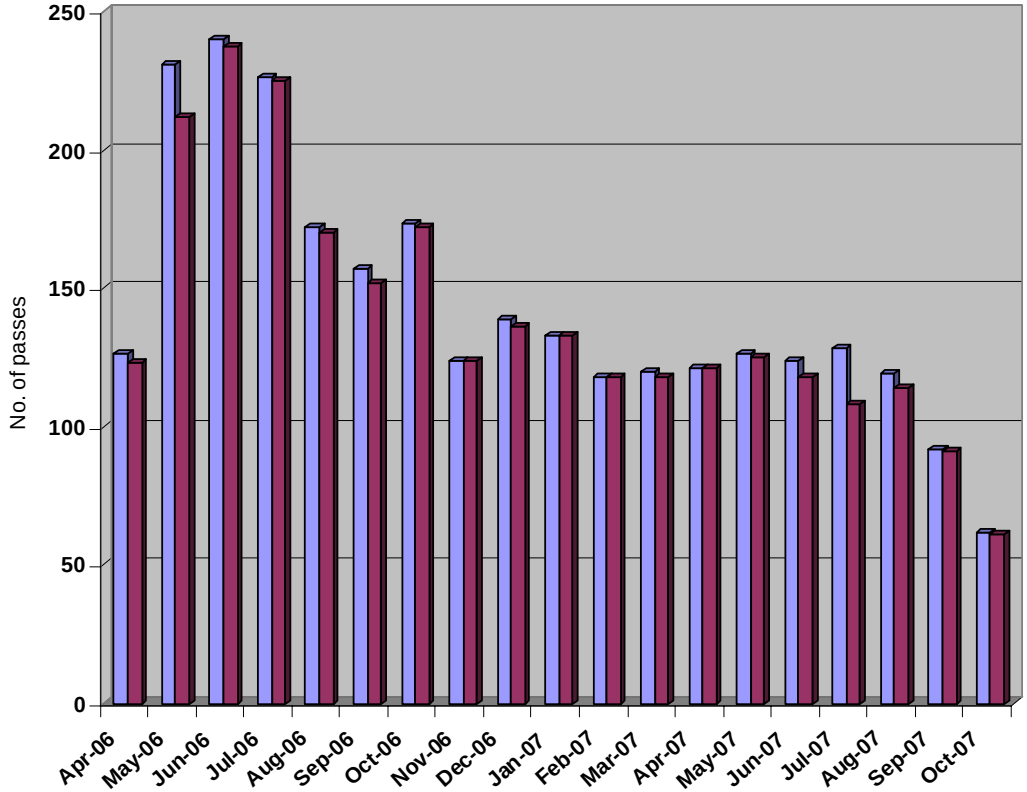
MIPS



ESOC Ground station support

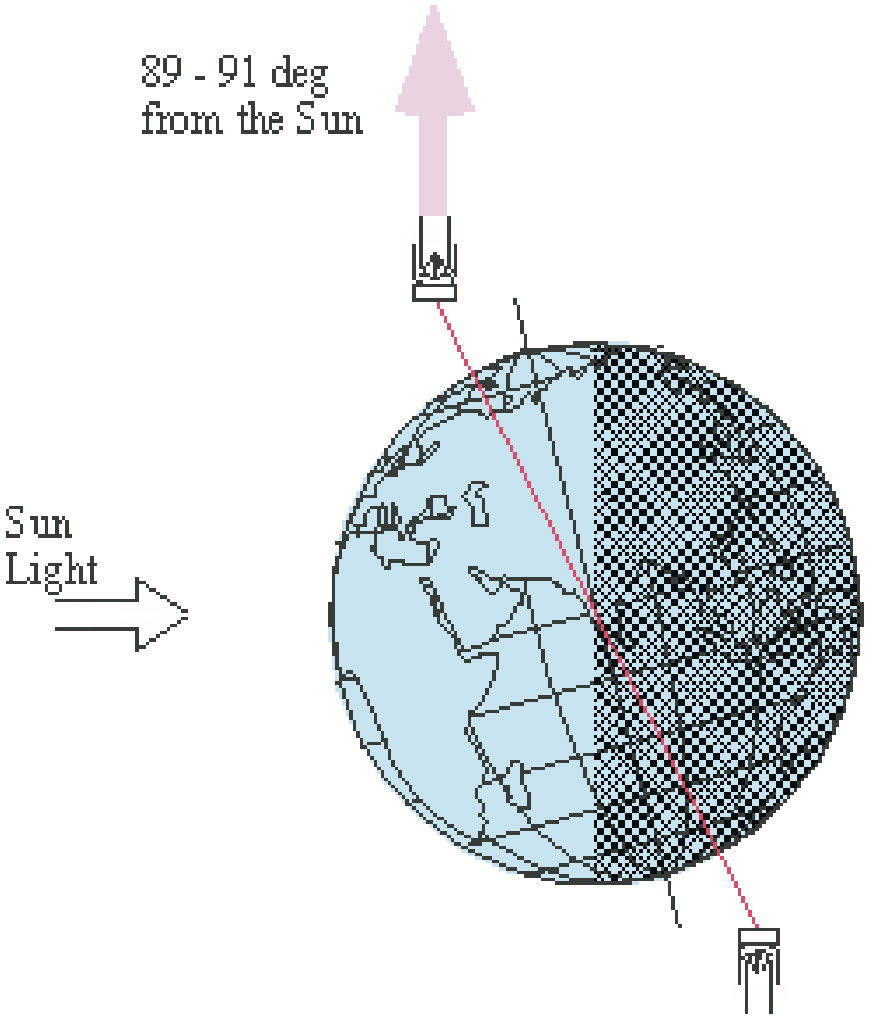
- Ground station (downlink) support with the Kiruna Antenna
  - in the X-band
  - for several passes per day.

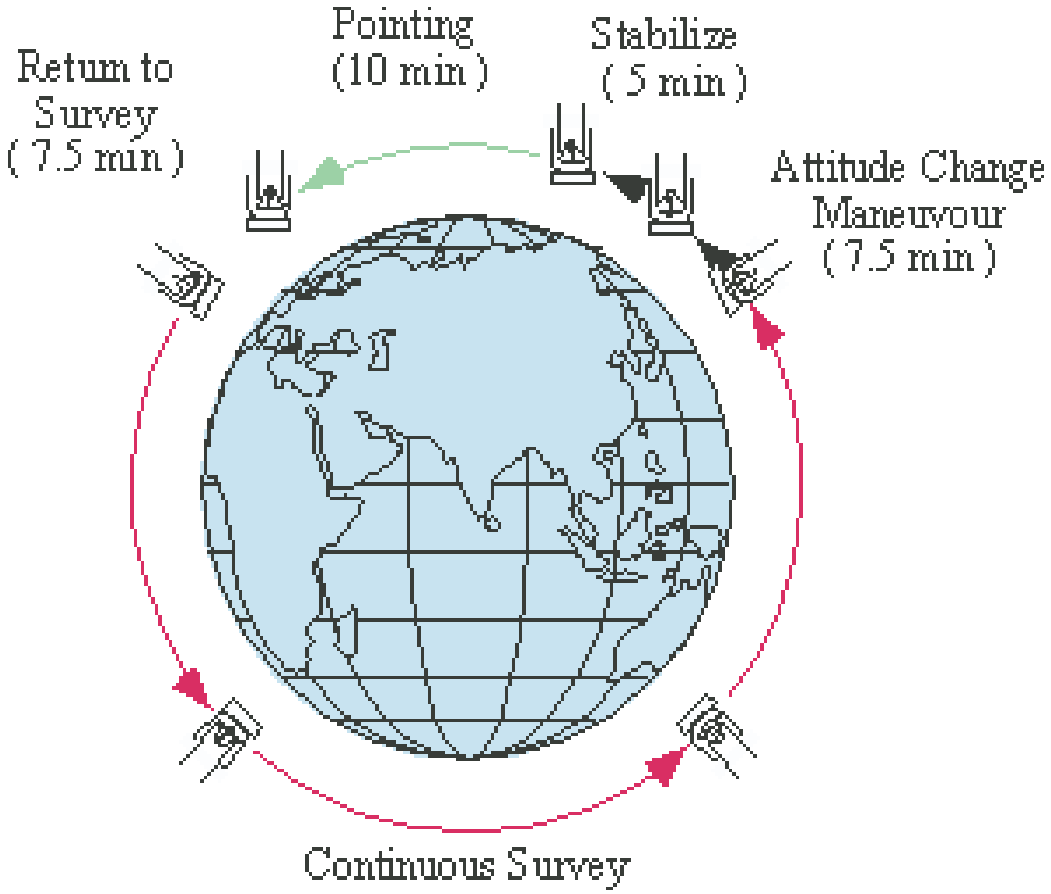
Requested (blue) and Successful (red) passes per month



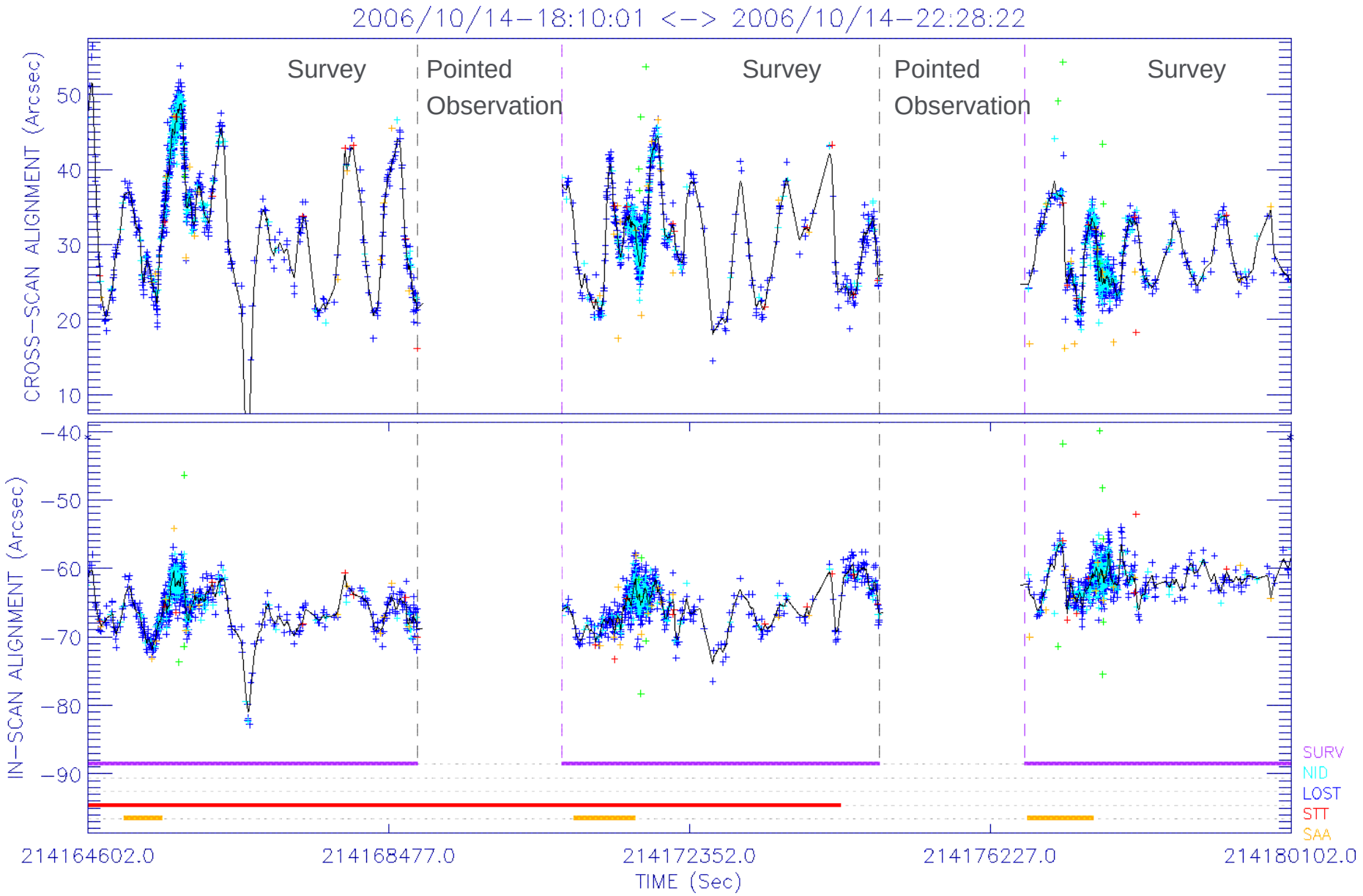
The rate is 97% overall
(vs. 95% required).

Survey mode and pointed mode





ESAC Pointing Reconstruction

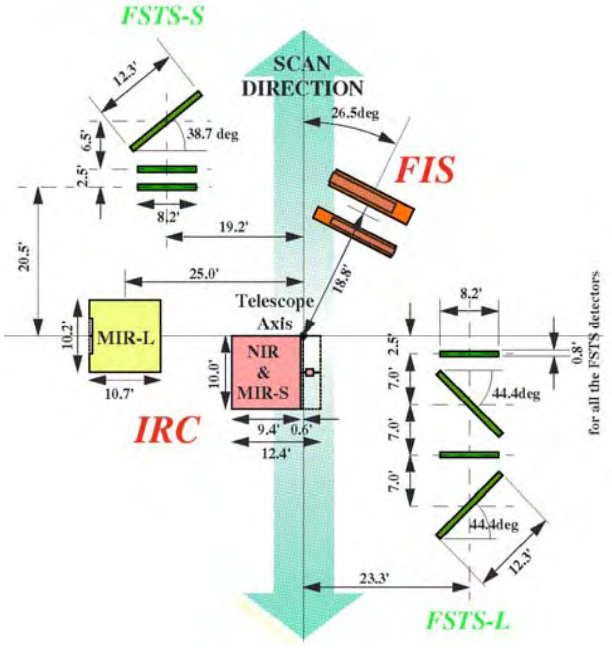


PRESA Input Reference Catalogues

- Actually a collection of two completely independent astrometric catalogues constructed to support AKARI pointing reconstruction

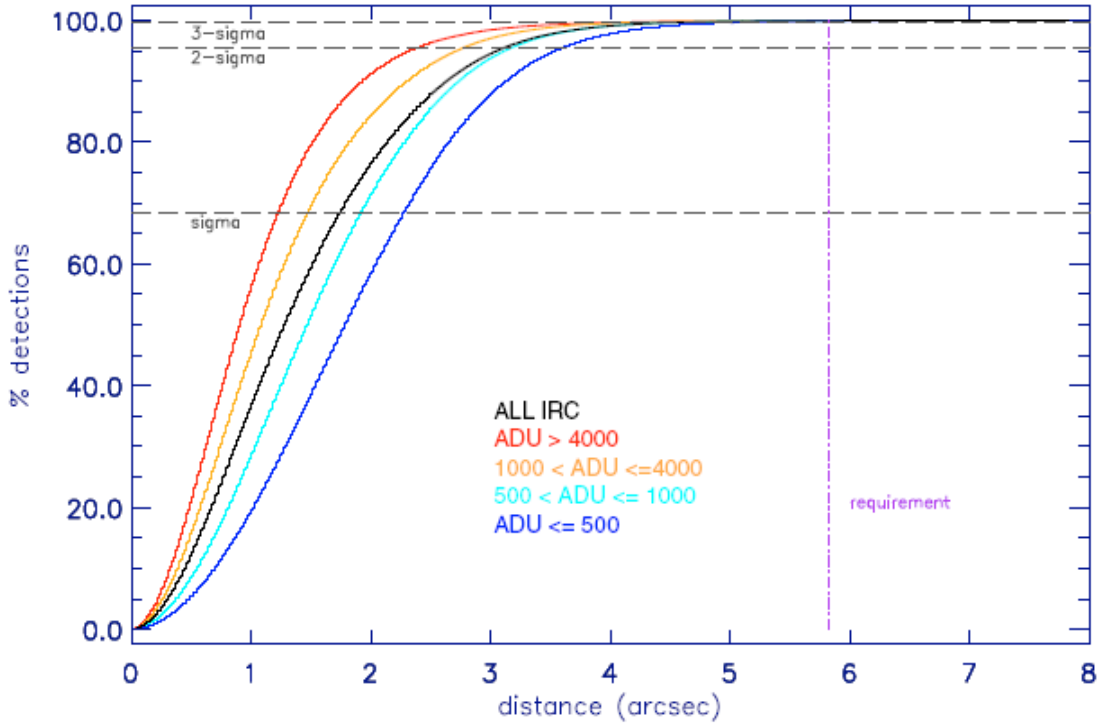
  - FSTS Reference Catalogue (2,862,152 sources)
  - IRC Reference Catalogue (670,995 sources)

- Containing astrometric information (+proper motion if known) and photometric information (predictions or real measurements)

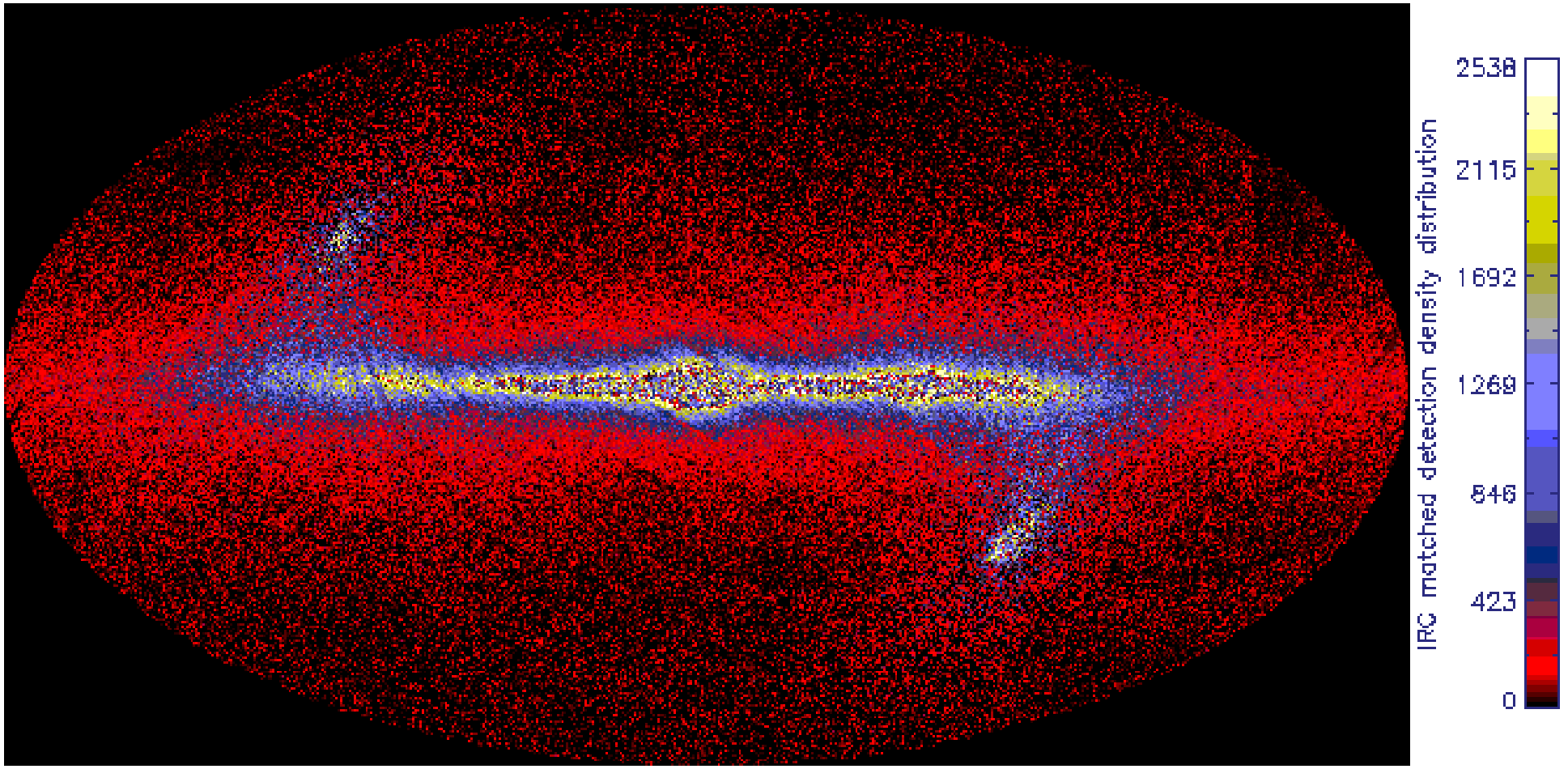


Accuracy evaluation

1. Run the pointing reconstruction software with randomly selected sources amounting to half of the catalogue
2. Determine the positions of the sources from the other half catalogue, which thus result unmatched.
3. Calculate distance between the two quantities

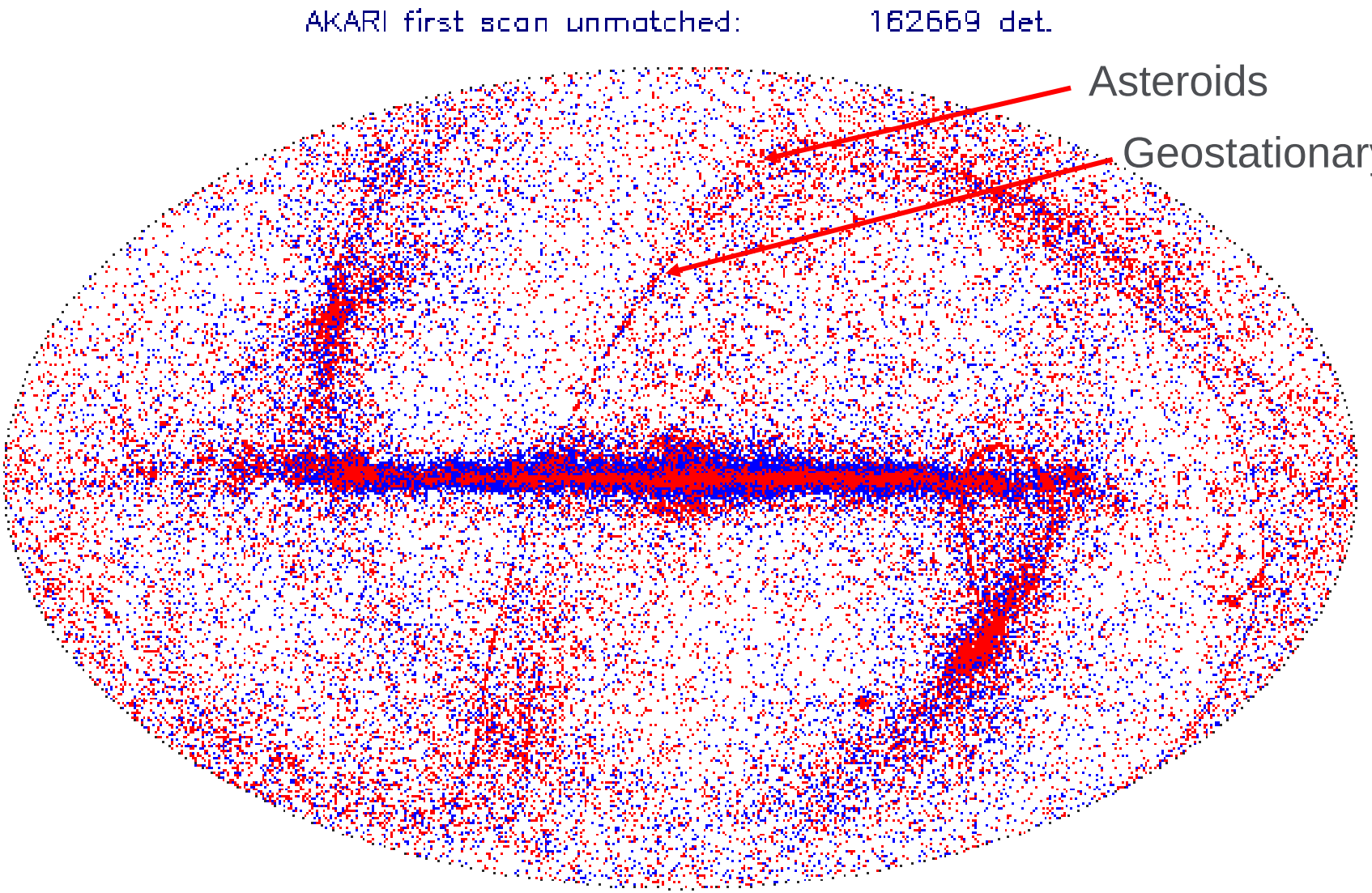


Matched detections

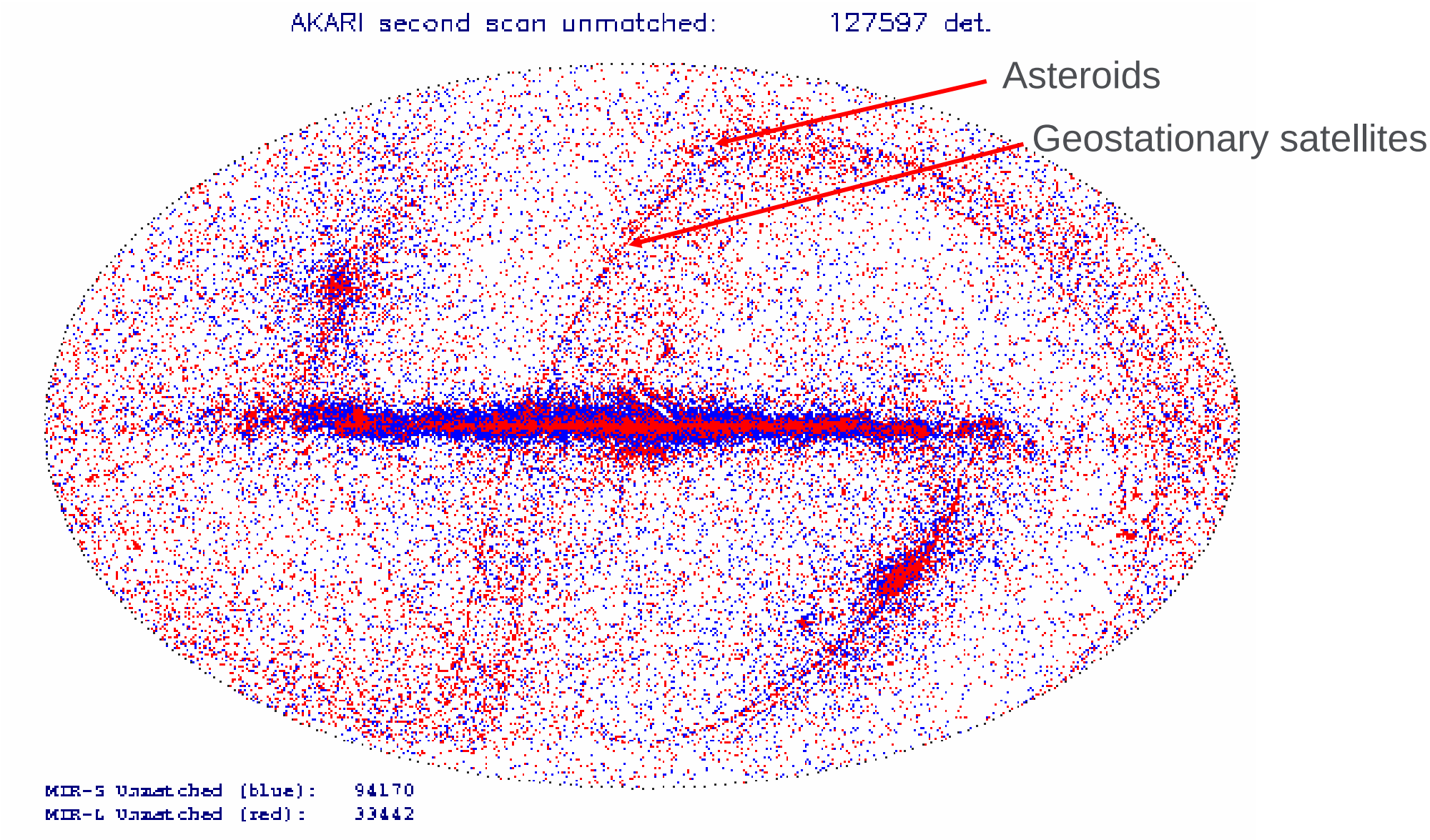


90% matches of the 6 millions events over the mission

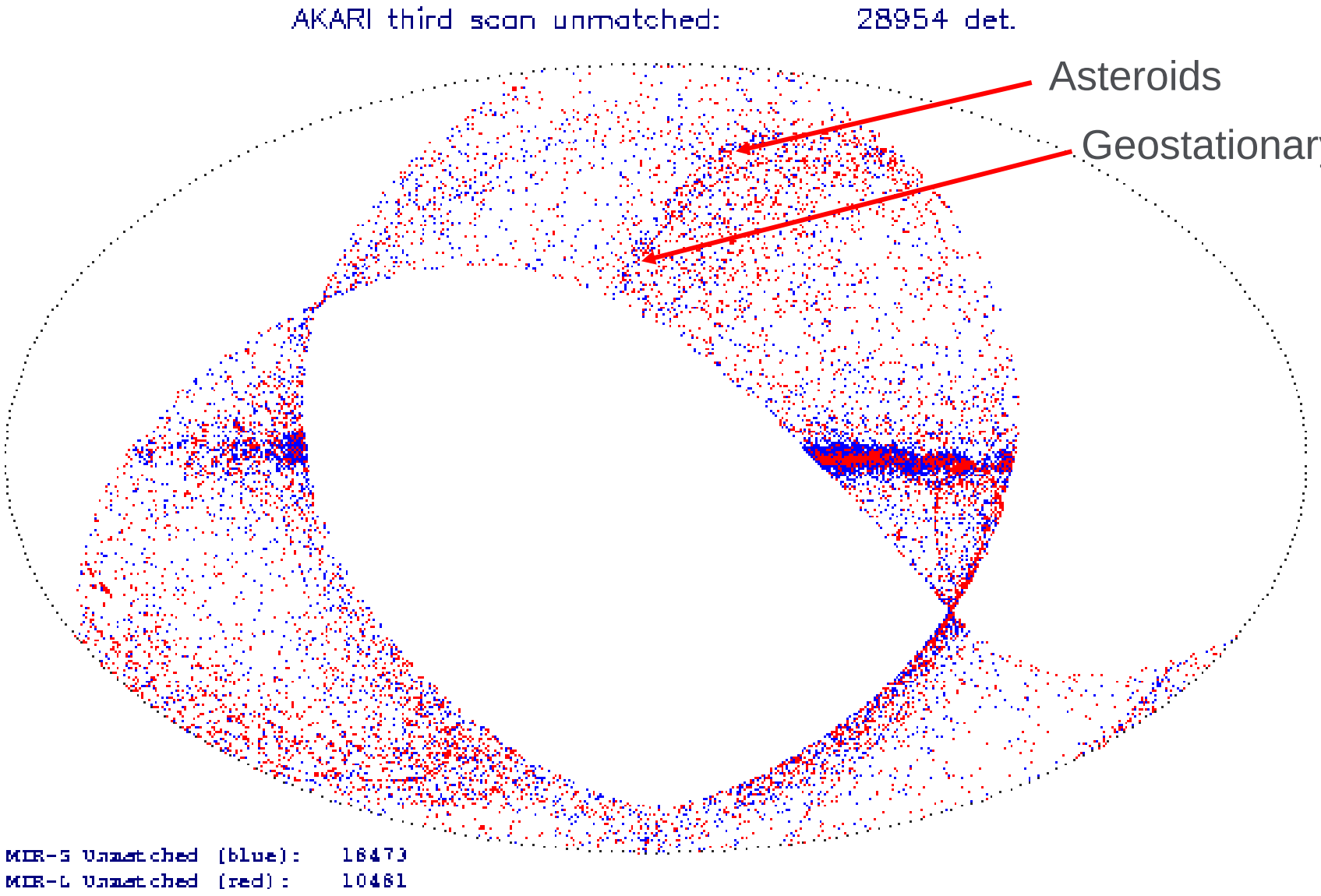
Unmatched detections 1st scan



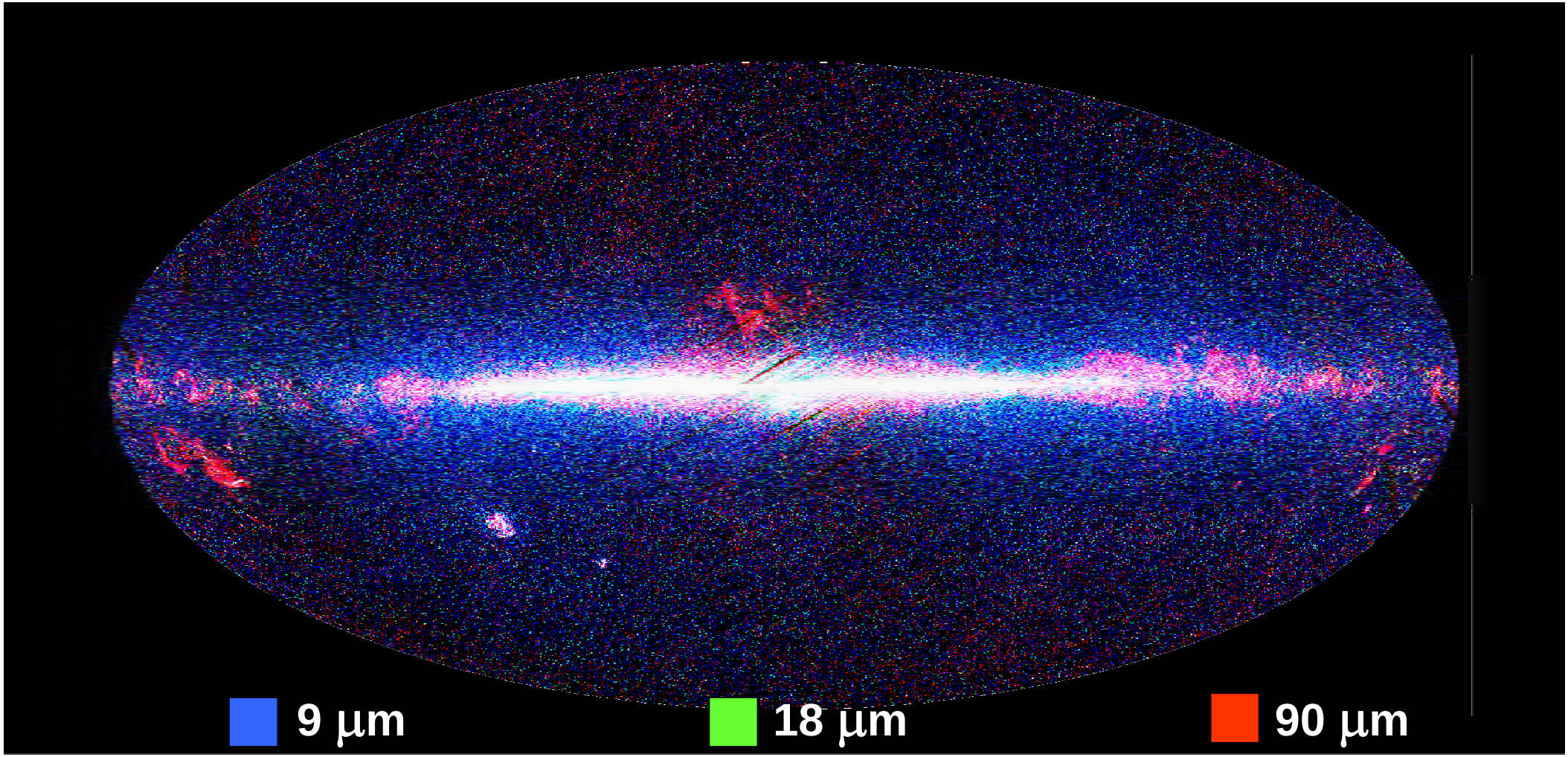
Unmatched detections 2nd scan



Unmatched detections 3rd scan



AKARI All-sky survey catalogues



IRC Point Source Catalogue (9,18 μm): 870,973 sources
FIS Bright Source Catalogue (65,90,140,160 μm): 427,071 sources

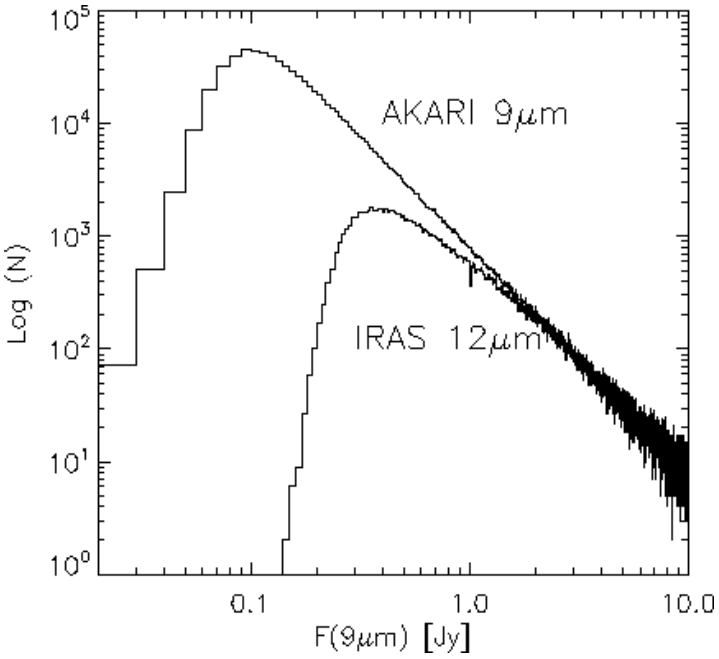
Catalogues derivation

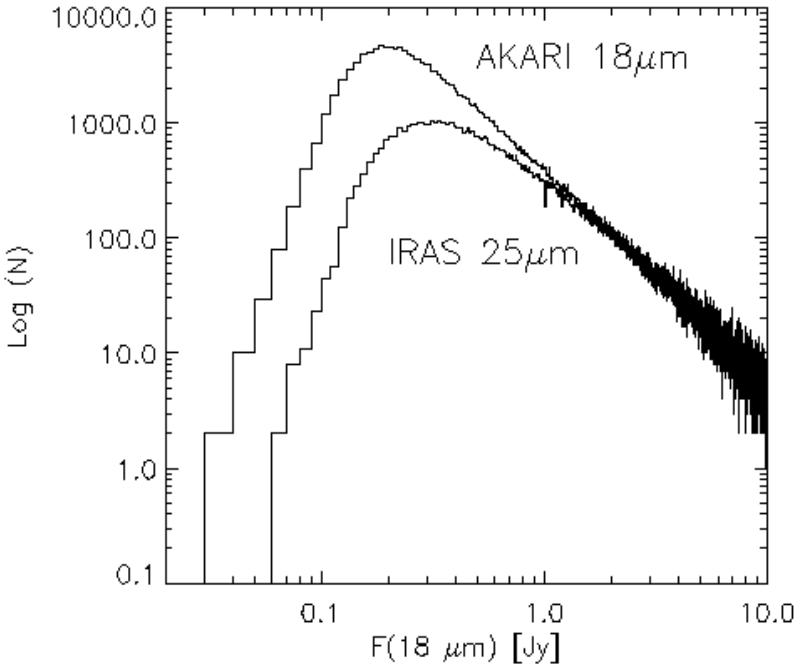
- FIS Catalogue
  - Main output of the AKARI mission
  - Pipeline developed by a consortium including Imperial College University of London, Open University, University of Kent, Sussex University, and SRON-Groningen with University of Groningen and Seoul National University, Korea.

- IRC Catalogue
  - Two MIR bands added later in the development phase
  - Catalogue derivation in the hand of one Japanese post-doc, no public schedule
  - ESAC supported the catalogue production with parallel derivation and validation

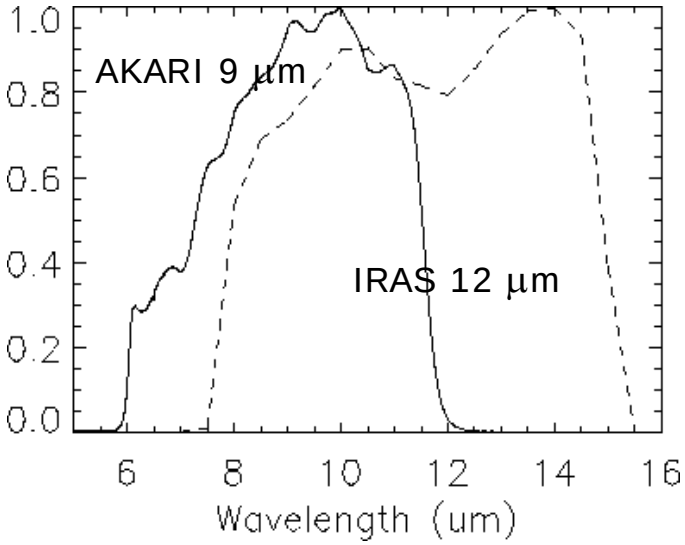
AKARI Survey Catalogues Sensitivities (vs IRAS)

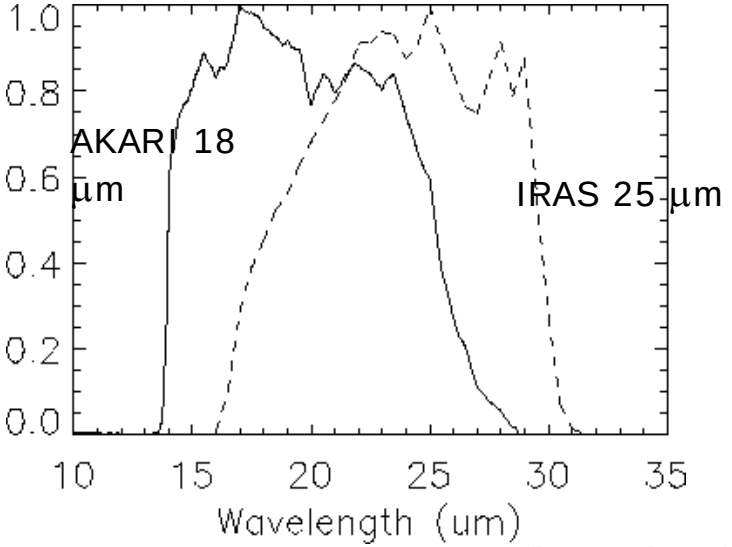
Differential Source counts





System Transmissions (RSFR)





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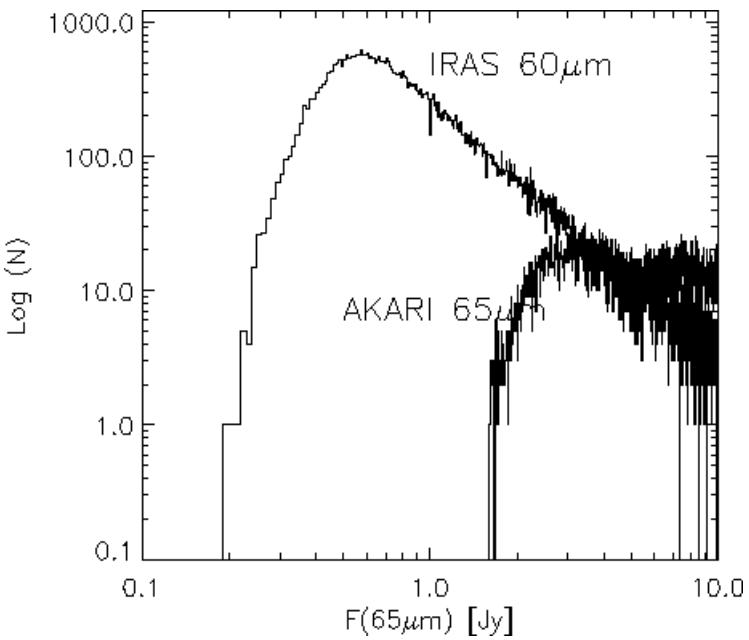
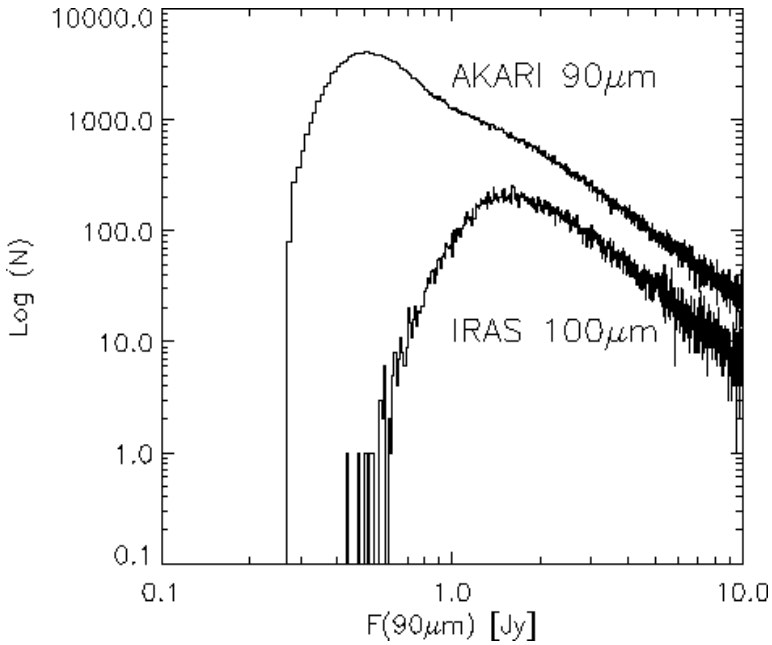
Differential Source counts





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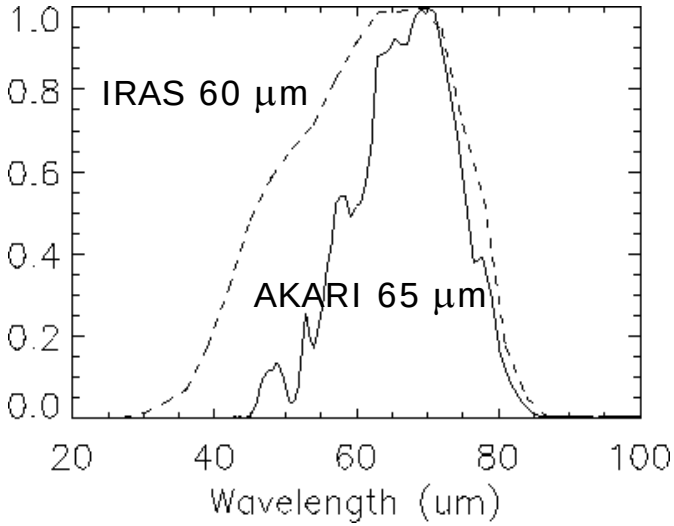
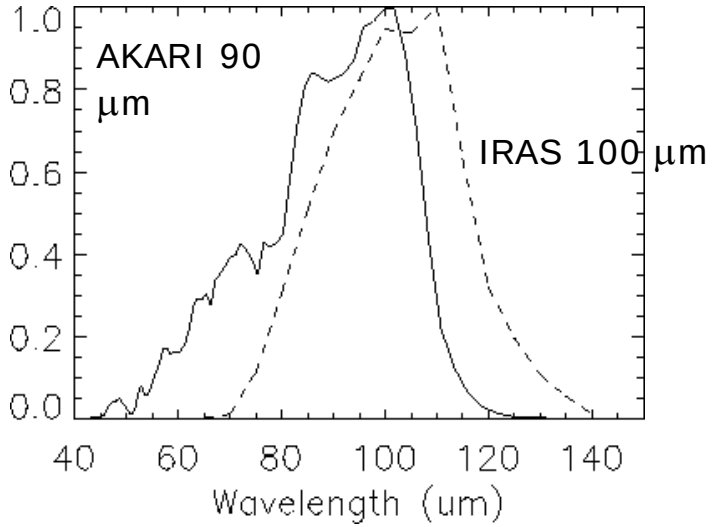
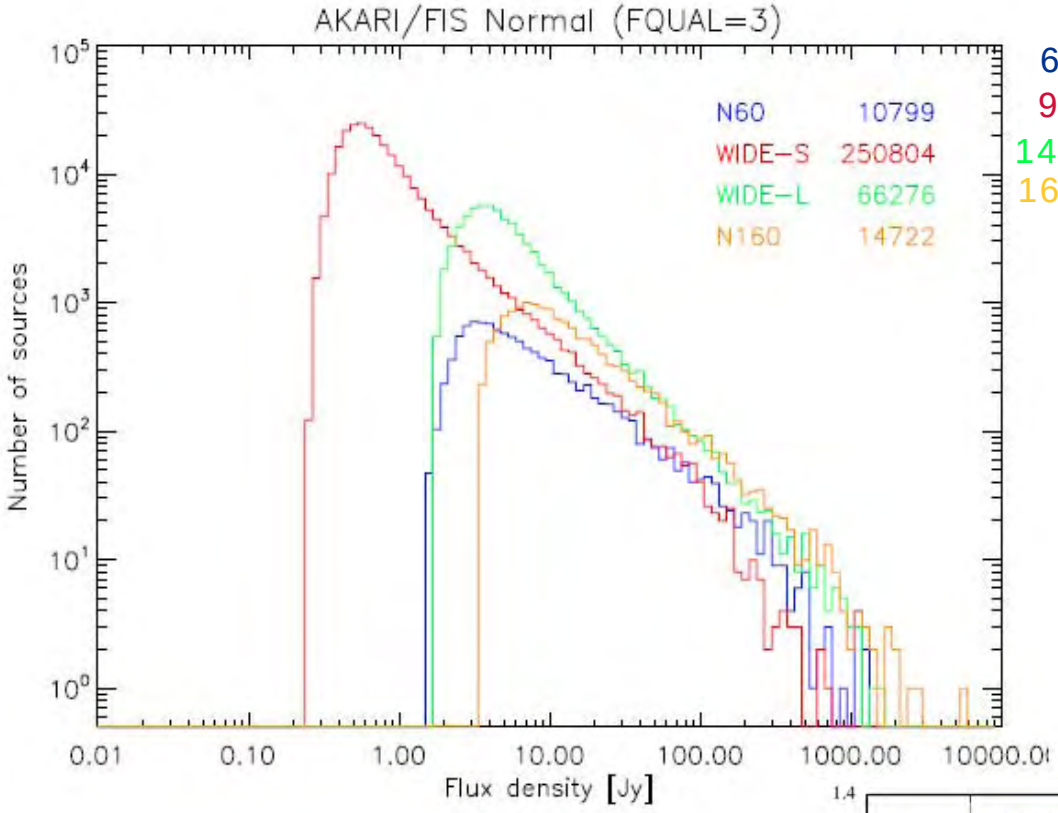
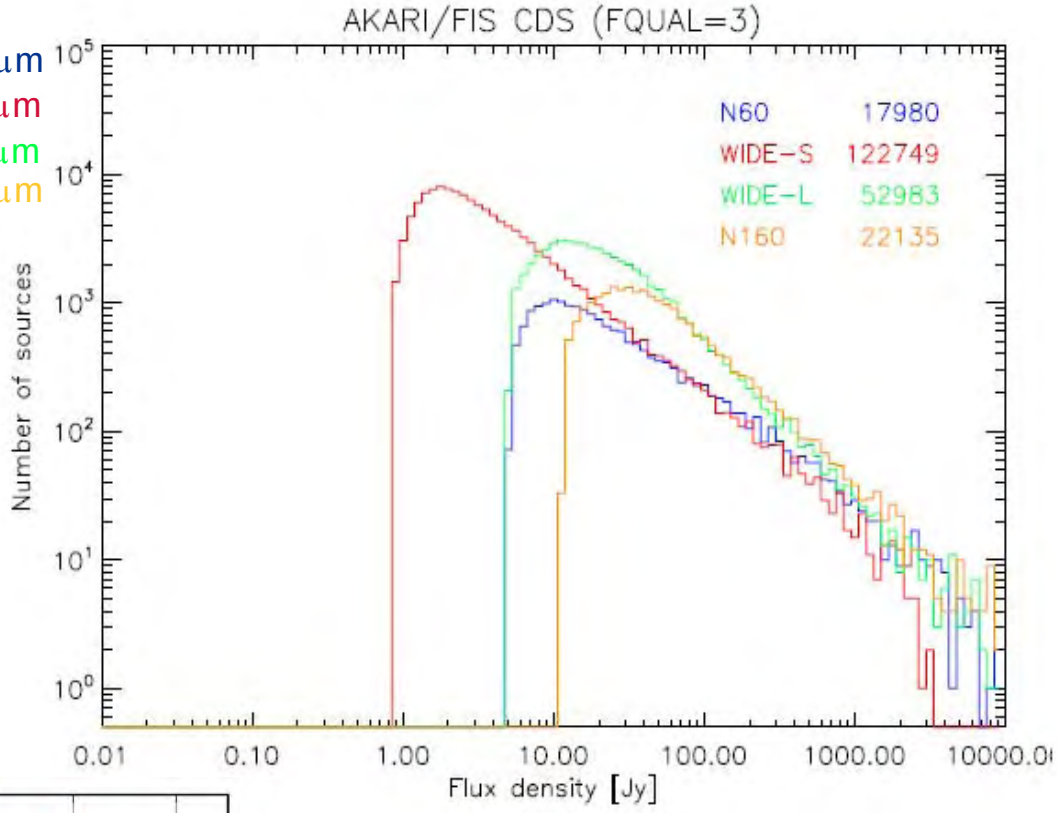


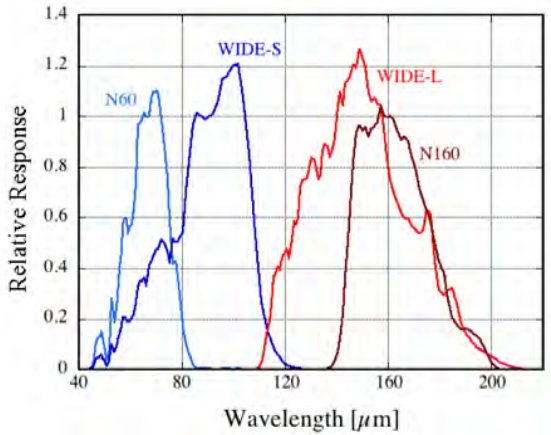


AKARI Survey Catalogues Sensitivities (vs IRAS)



65 μm
90 μm
140 μm
160 μm





Key numbers

	IRC PSC V1		FIS BSC V1			
Band	9 µm	18 µm	65 µm	90 µm	140 µm	160 µm
Number of sources	844,649	194,551	29,336	373,819	117,994	36,646
	870,973		427,071			
Detection Limit	50 mJy	130 mJy	3.2 Jy	0.55 Jy	3.8 Jy	7.5 Jy
Flux Uncertainty	5~20 %	7~20 %	20 %			
Spatial Resolution	~7 arcsec		~48 arcsec (source extraction)			
Position Uncertainty	1~3 arcsec		~ 6 arcsec			

Cross matching AKARI MIR & FIS catalogues

FIS Bright Source Catalogue: 427.071 sources @ 25, 60, 60 and 160 um

MIR Point Source Catalogue: 870.973 sources @ 9, and 18 um

There are only 24700 common sources within 20”

➔ **The MIR PSC contains mostly “Normal” stars which are not detectable in the FIS survey (they behave approx. as BB and fall below the FIS sensitivity limit)**

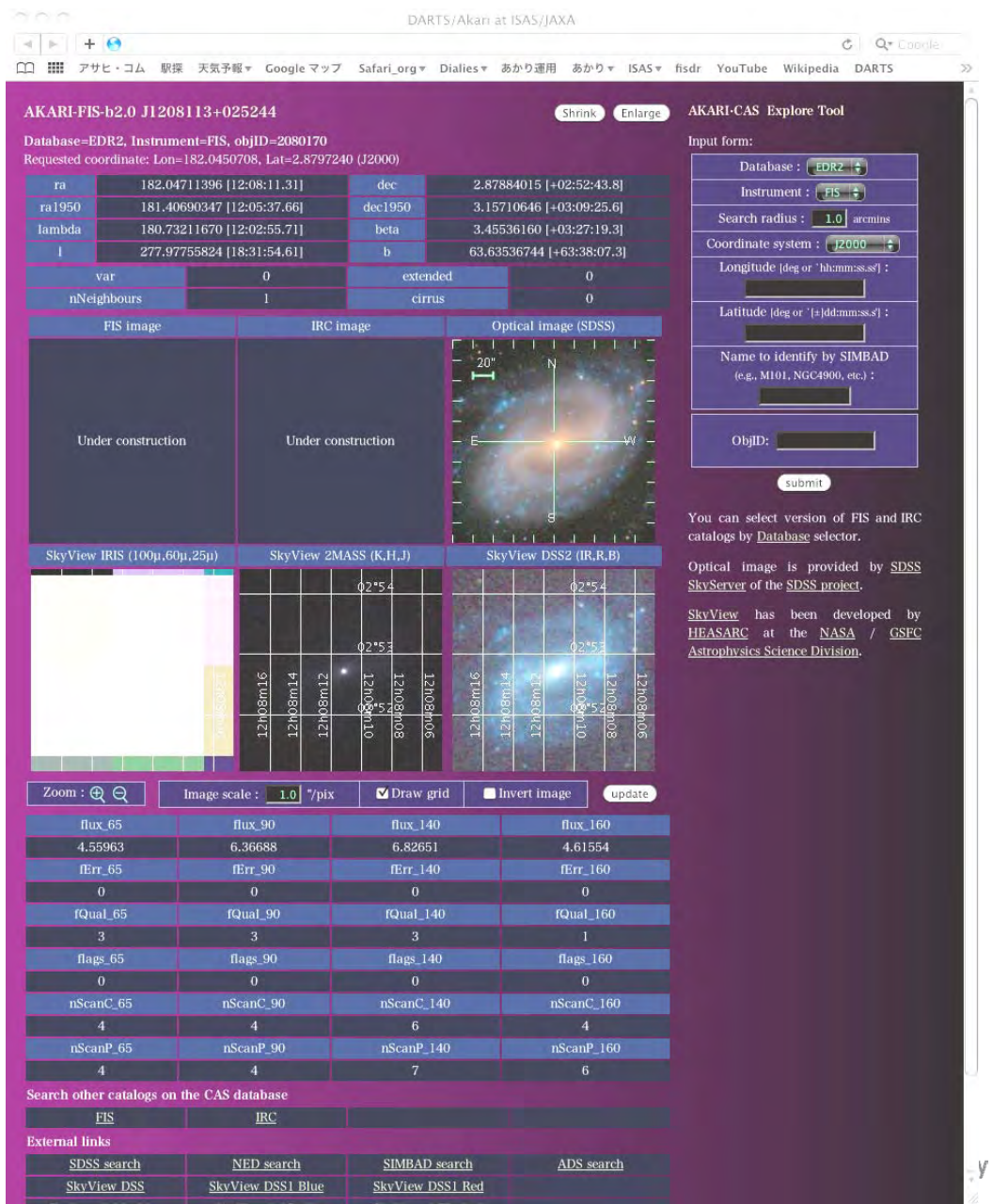
➔ **The FIS BSC contains very many “Galaxies” and stars with infrared excess.**

Next foreseen releases

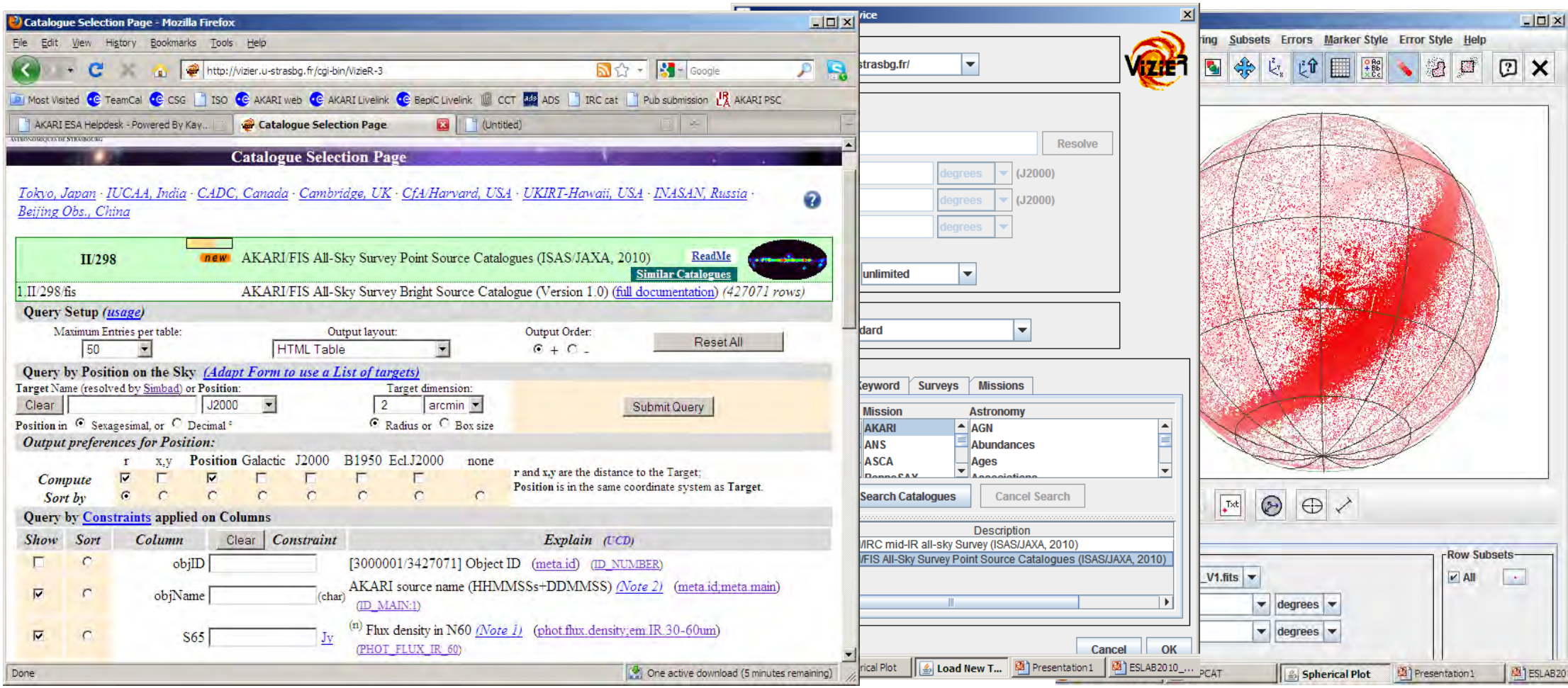
FIS Bright Source Catalogue V2: Upgraded version
FIS Faint Source Catalogue V1 : Fainter detection limit

Expected in a few months

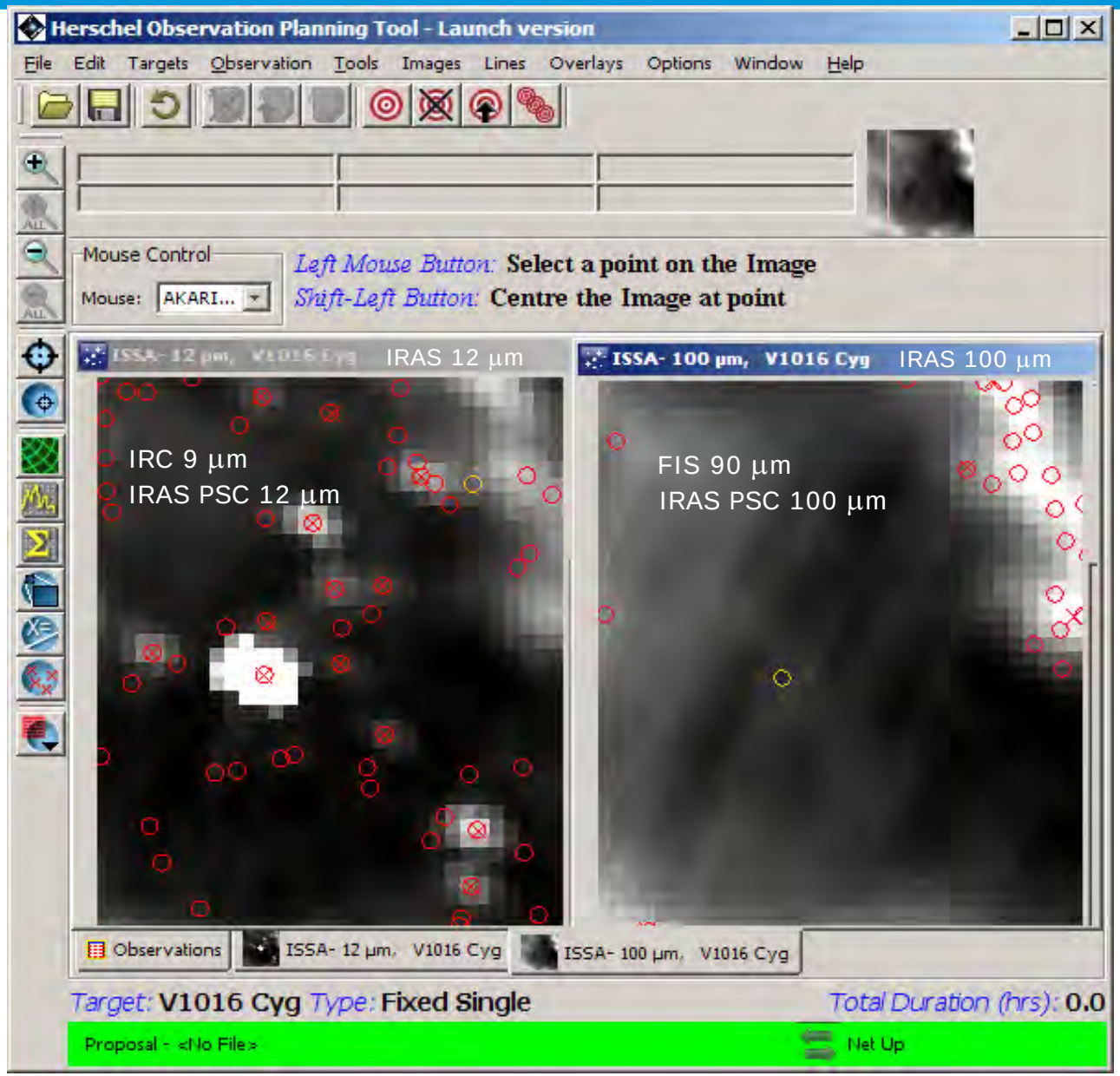
The ISAS Catalogue server

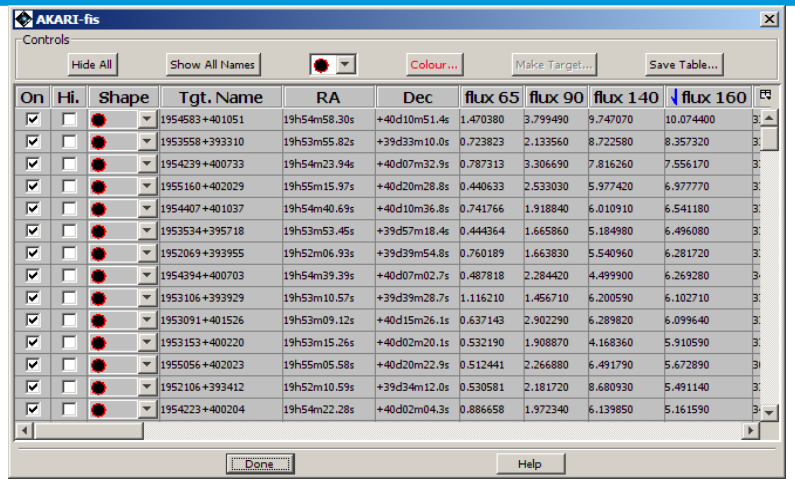


The Catalogues are in Vizier, Aladin, Topcat…



Catalogues in HSPOT

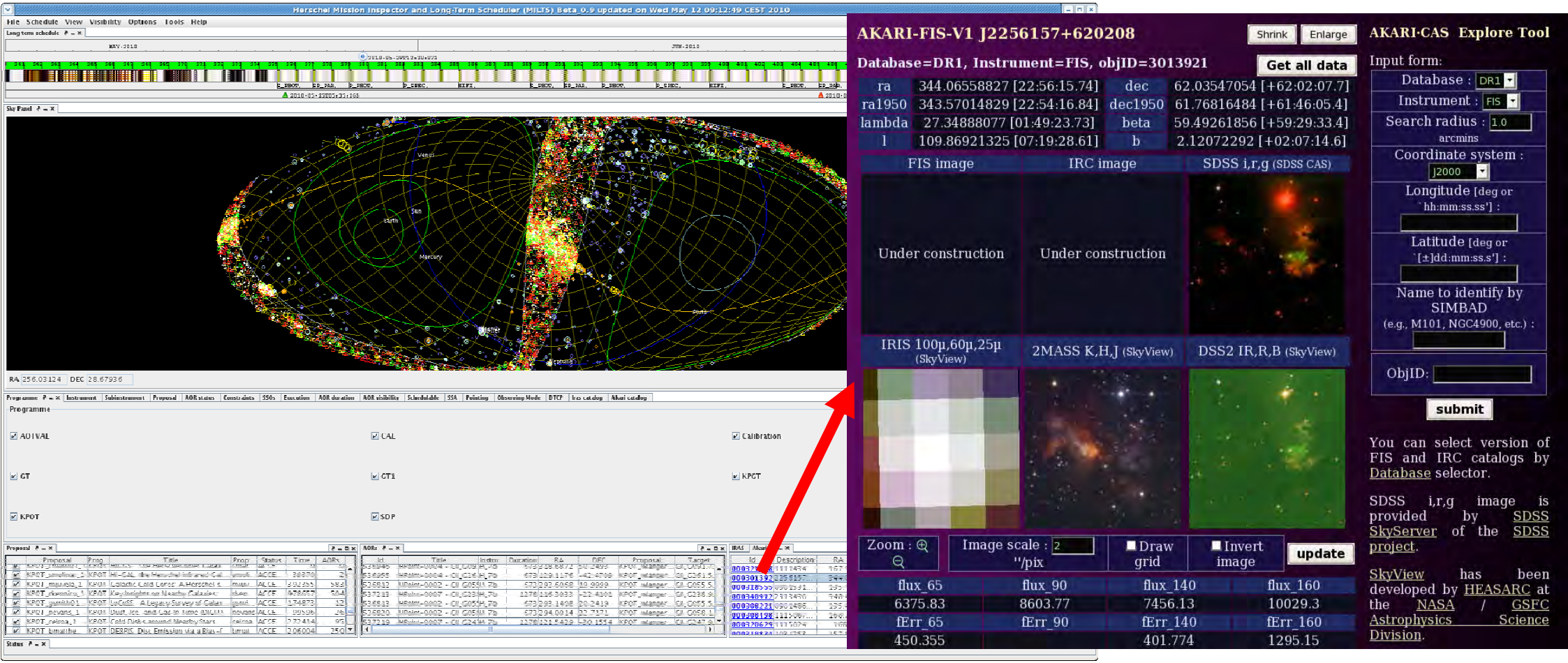




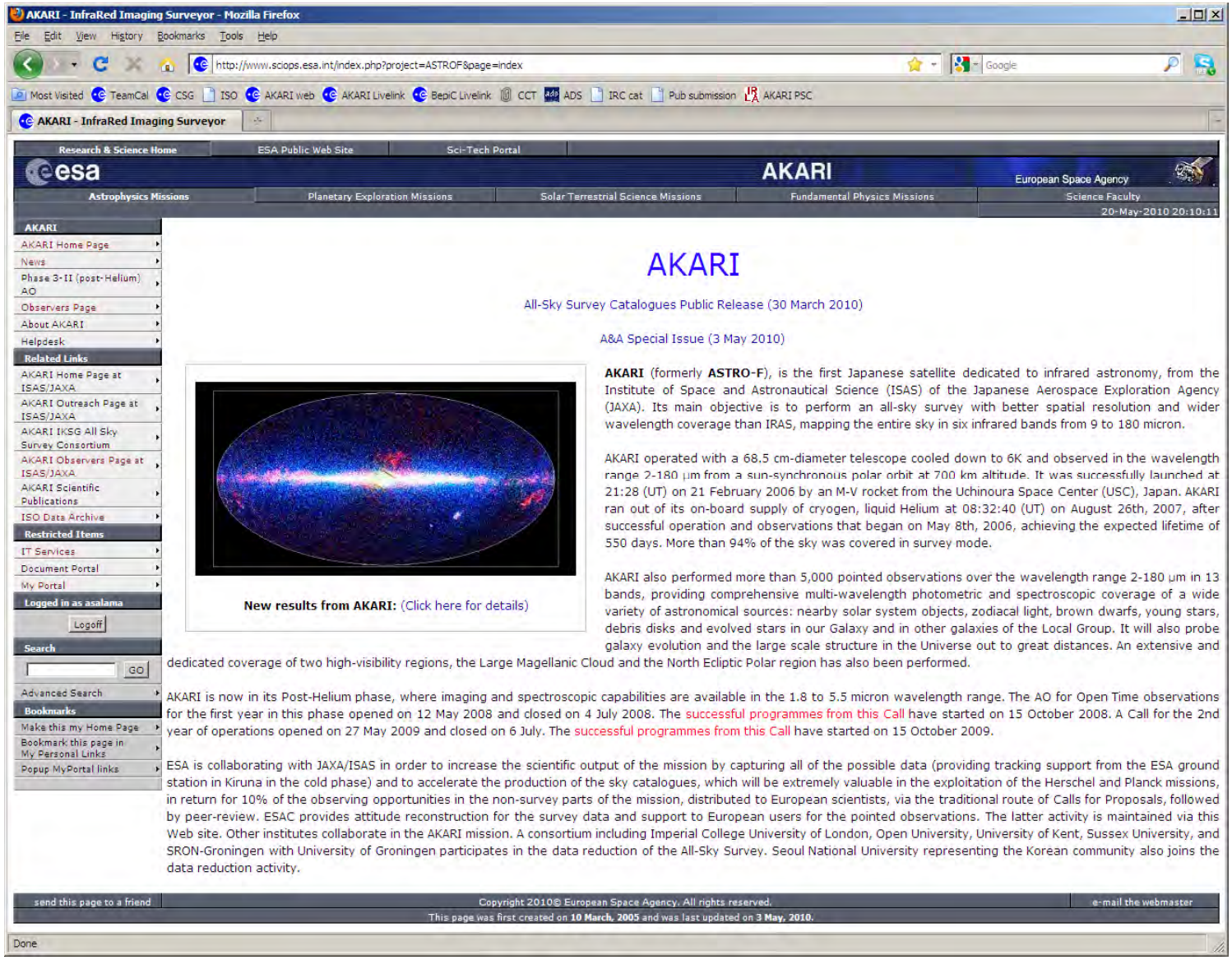
O : AKARI
X : IRAS PSC sources overlaid on IRAS/ISSA images

AKARI Catalogues for Herschel mission planning

MILTS: Mission Inspector and long Term Scheduler



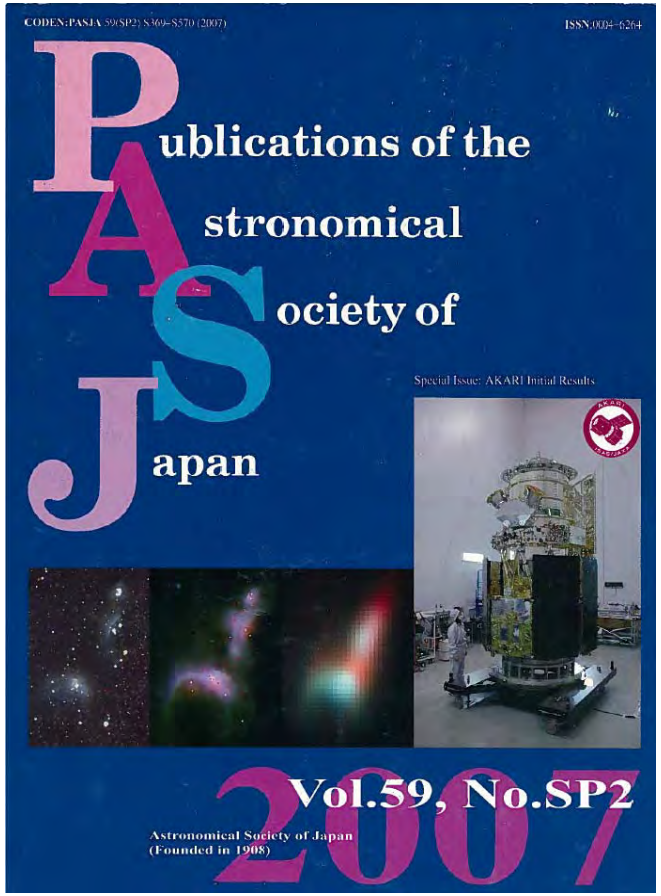
http://akari.esac.esa.int

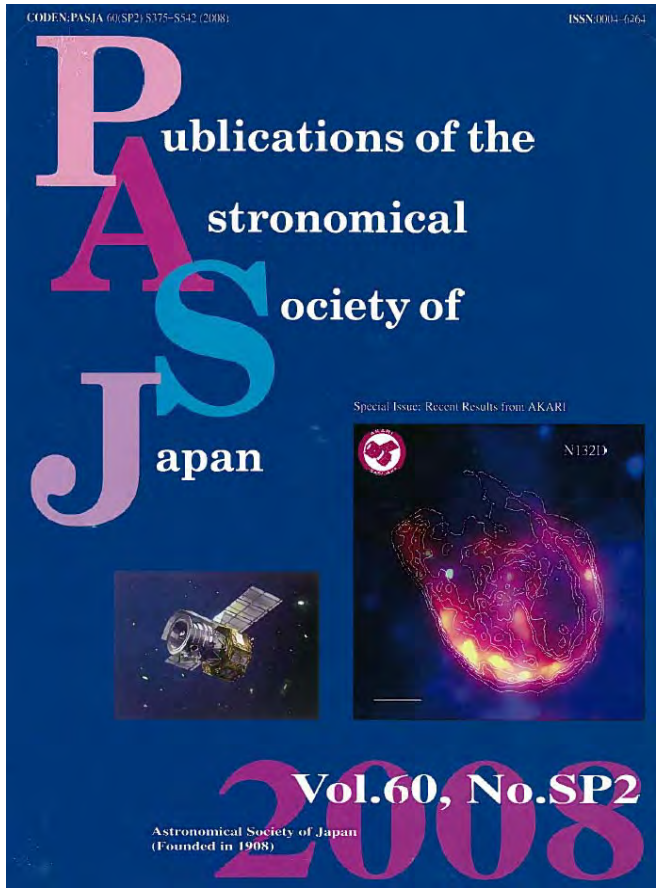


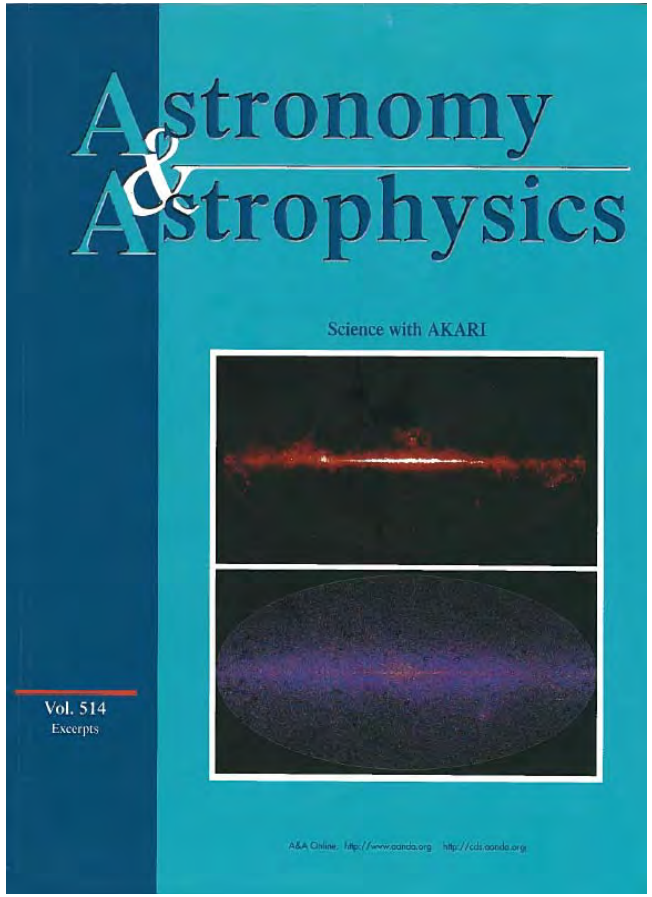
AKARI refereed publications

- About 100 papers in total, 24% with European participation
- 2 PASJ Special Issues, 1 A&A Special Issue

May 2010

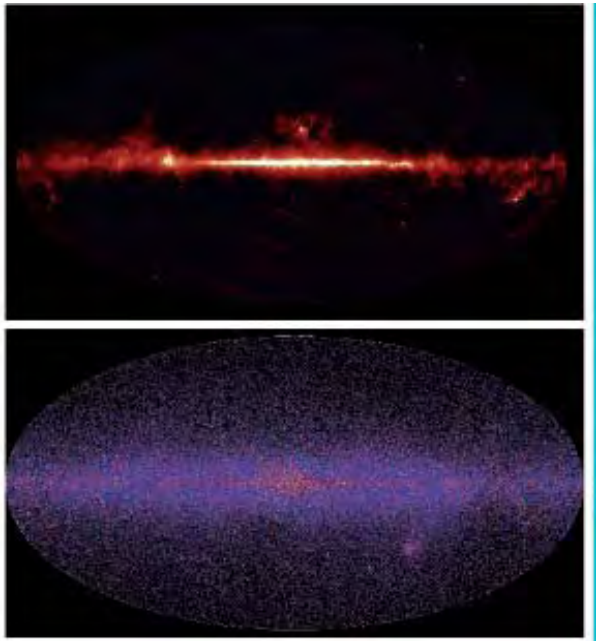


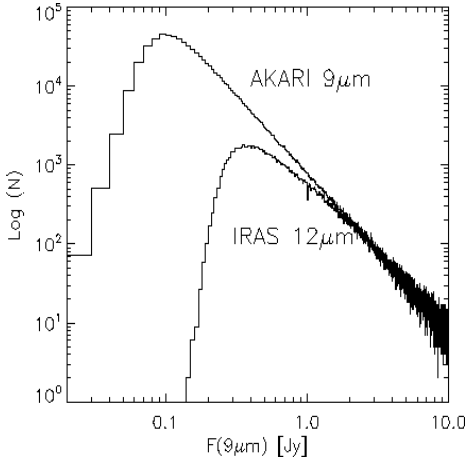


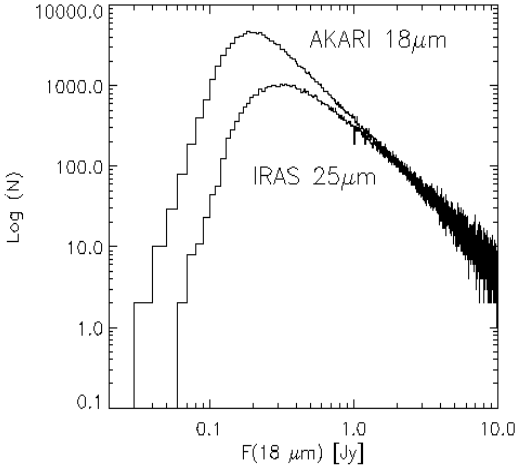


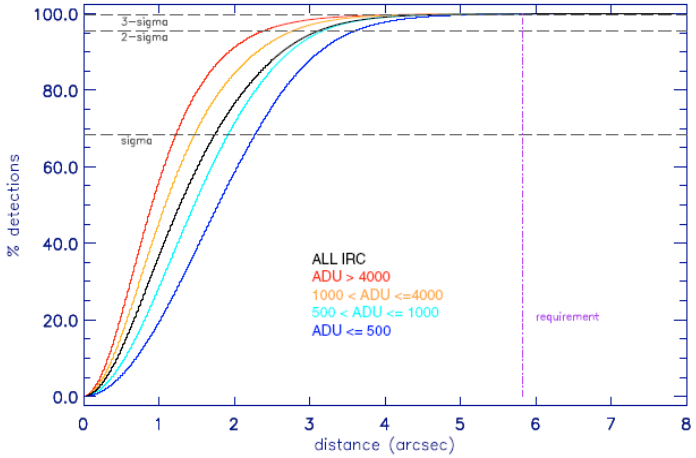
The AKARI/IRC mid-infrared all-sky survey*

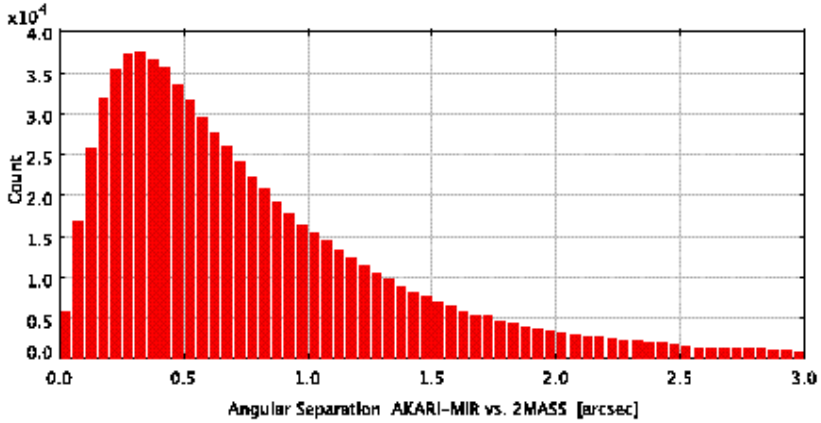
D. Ishihara[1,2], T. Onaka[2], H. Kataza[3], A. Salama[4], C. Alfageme[4,**], A. Cassatella[4,5,6], N. Cox[4,***], P. García-Lario[4], C. Stephenson[4,†], M. Cohen[7], N. Fujishiro[3,8,‡], H. Fujiwara[2], S. Hasegawa[3], Y. Ita[9], W. Kim[3,2,§], H. Matsuhara[3], H. Murakami[3], T. G. Müller[10], T. Nakagawa[3], Y. Ohyama[11], S. Oyabu[3], J. Pyo[12], I. Sakon[2], H. Shibai[13], S. Takita[3], T. Tanabé[14], K. Uemizu[3], M. Ueno[3], F. Usui[3], T. Wada[3], H. Watarai[15], I. Yamamura[3], and C. Yamauchi[3]







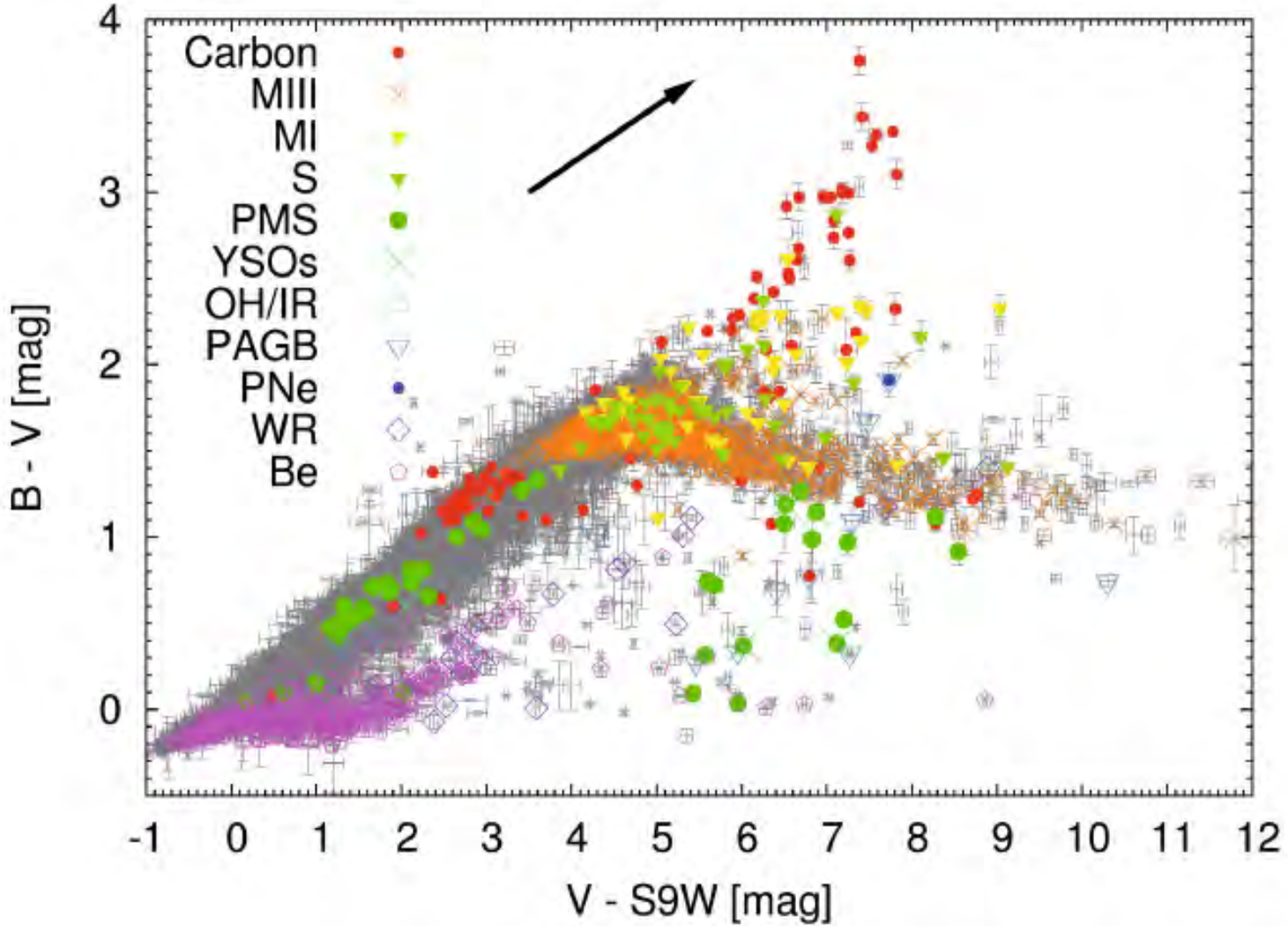




AKARI's infrared view on nearby stars

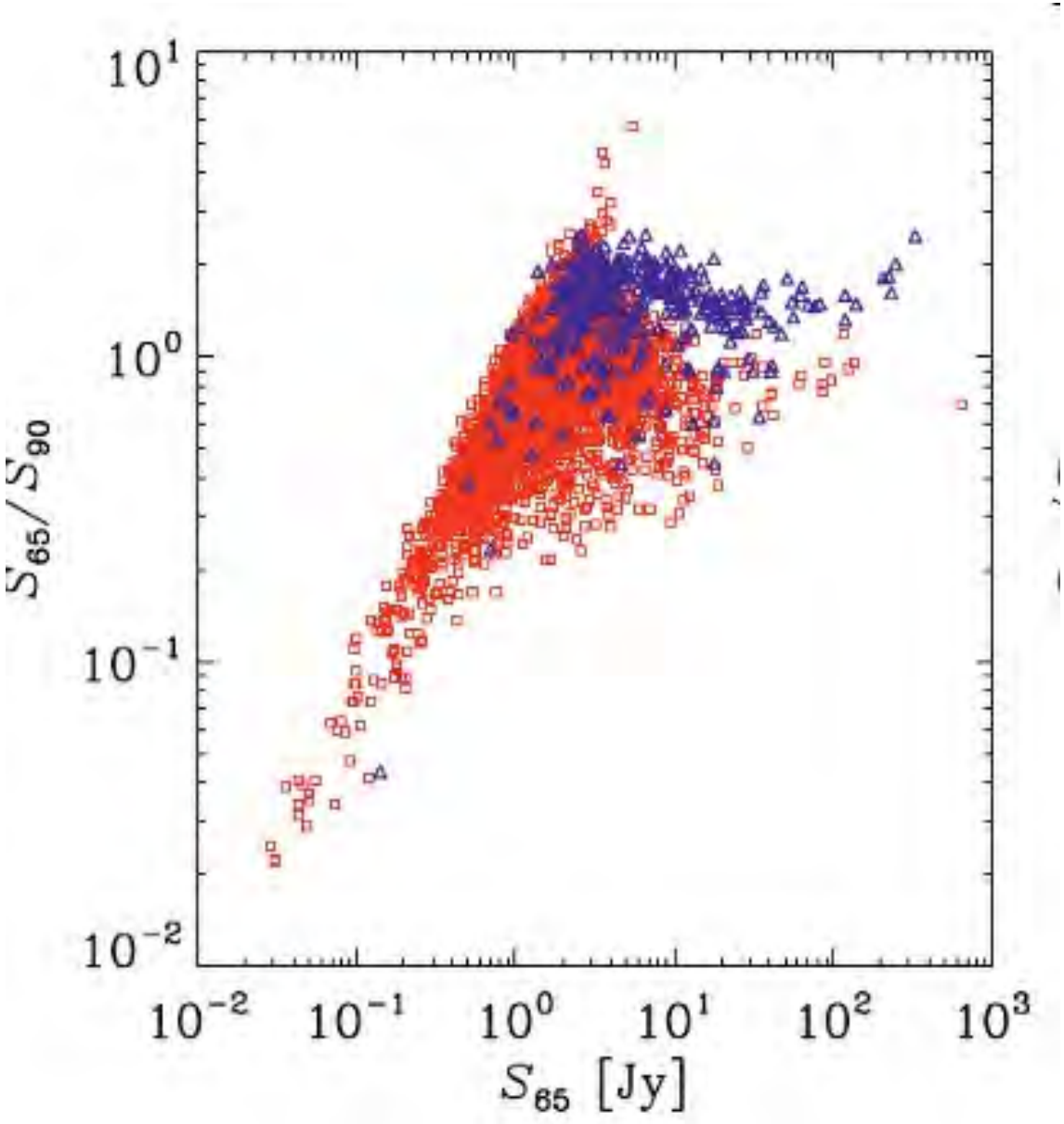
Using AKARI infrared camera all-sky survey, 2MASS, and Hipparcos catalogs*

Y. Ita[1,2], M. Matsuura[3,4], D. Ishihara[5], S. Oyabu[2], S. Takita[2], H. Kataza[2], I. Yamamura[2], N. Matsunaga[6], T. Tanabé[6], Y. Nakada[6], H. Fujiwara[7], T. Wada[2], T. Onaka[7], and H. Matsuhara[2]

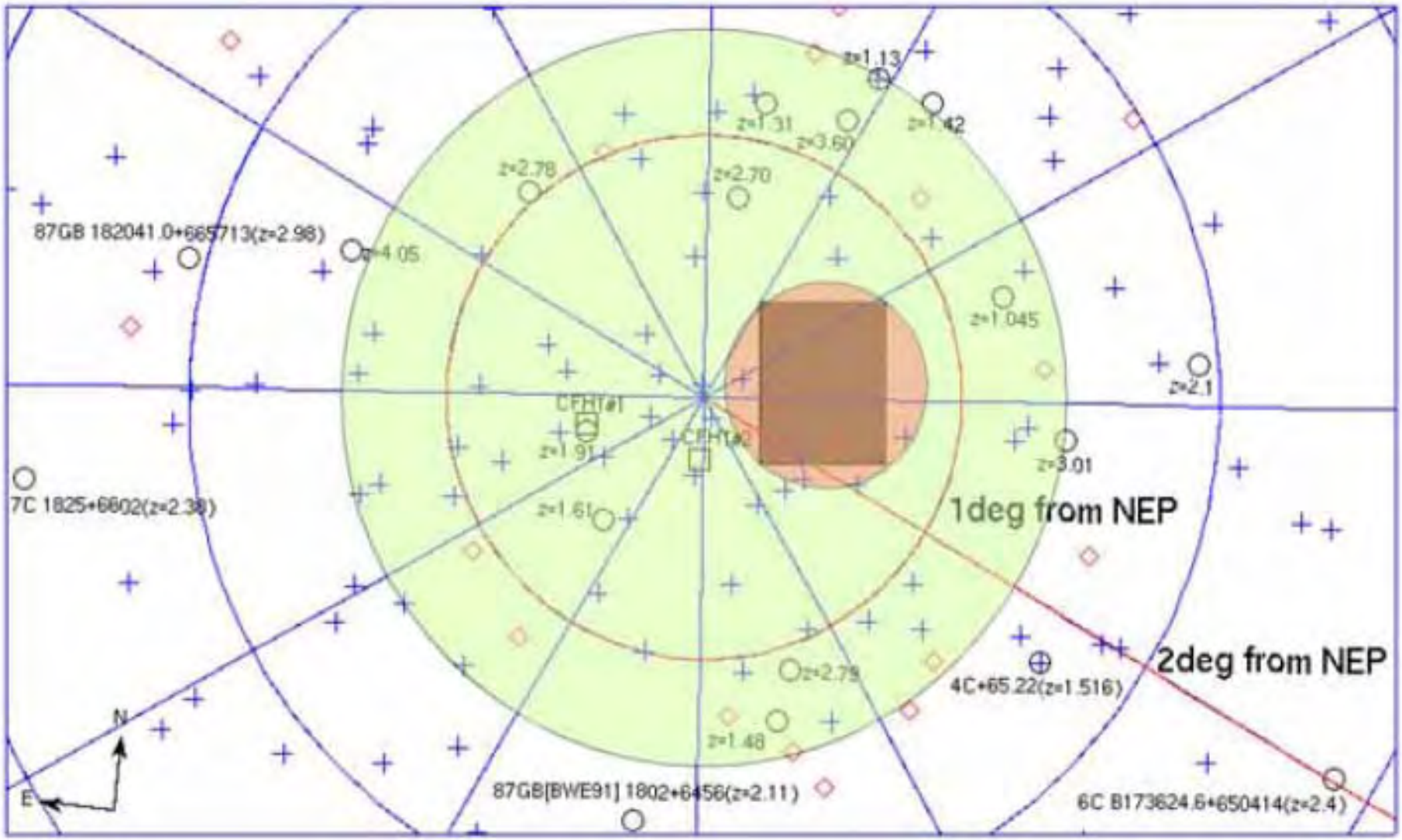


Star-galaxy separation by far-infrared color-color diagrams for the AKARI FIS all-sky survey (bright source catalog version β-1)*,**

A. Pollo[1,2], P. Rybka[2], and T. T. Takeuchi[3]



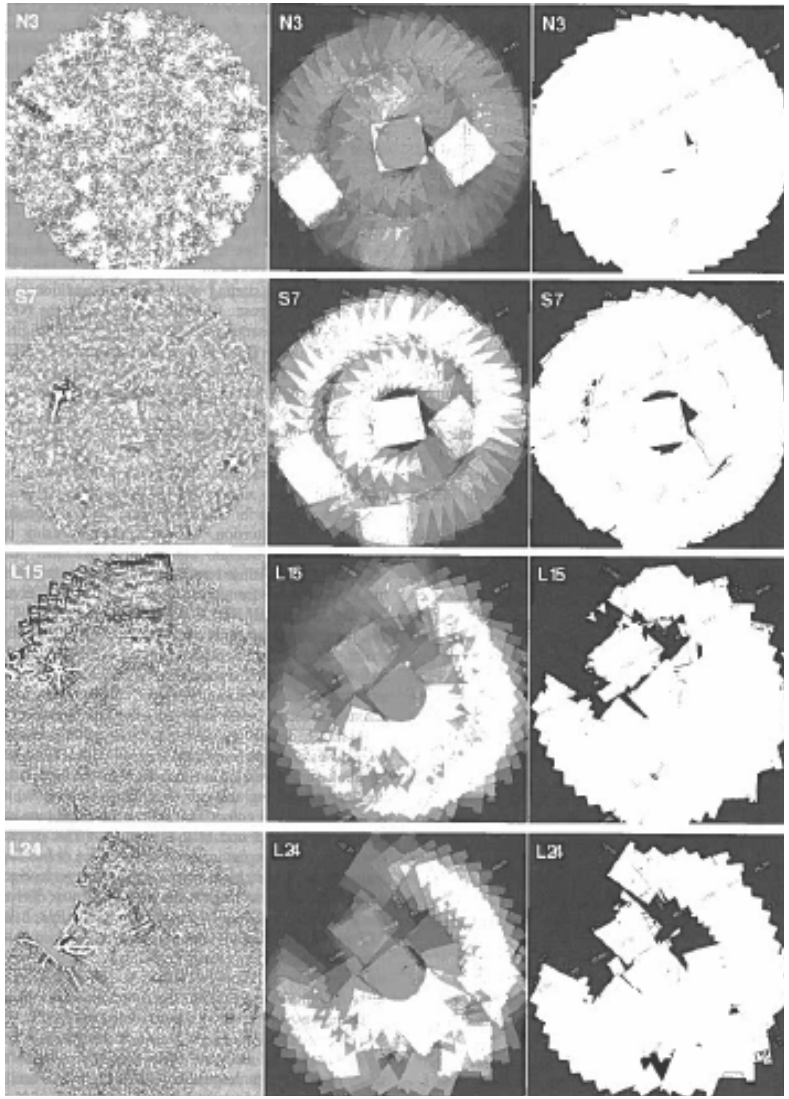
THE NEP Deep Surveys

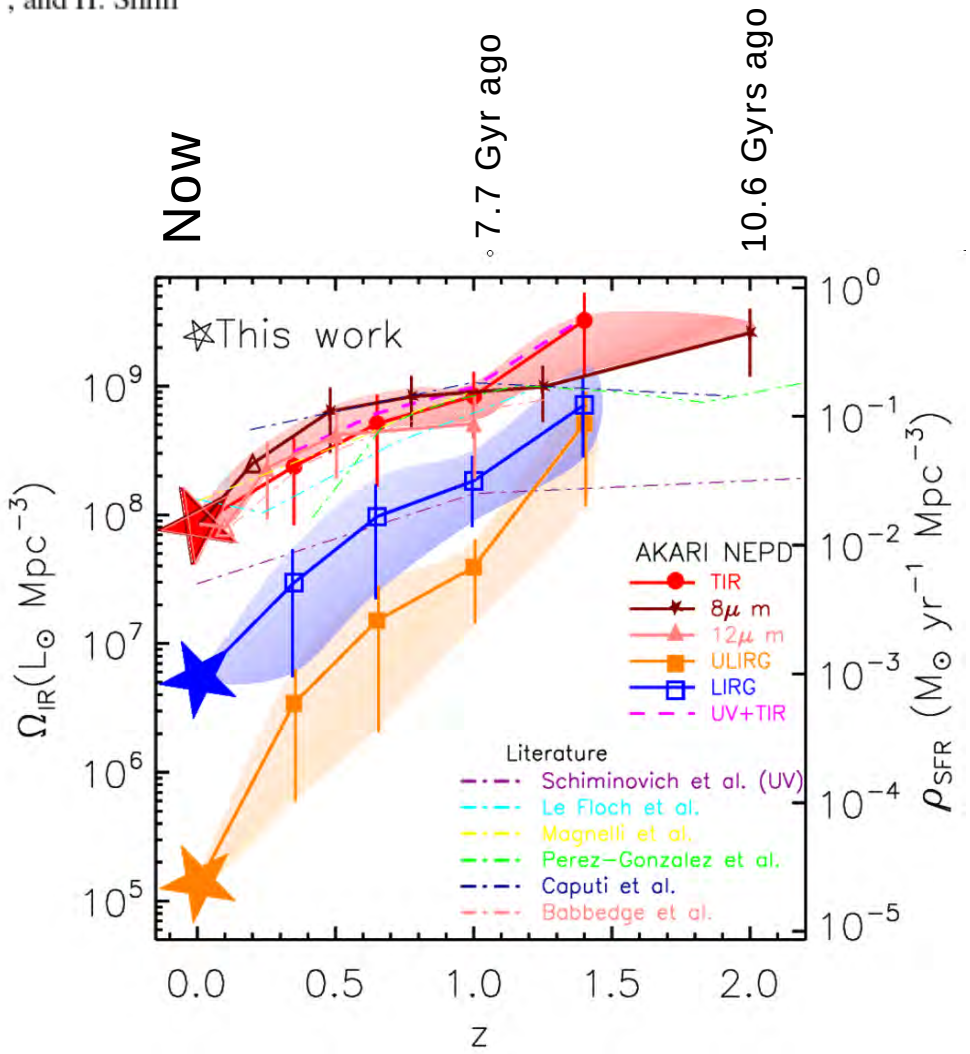


Evolution of infrared luminosity functions of galaxies in the AKARI NEP-deep field

Revealing the cosmic star formation history hidden by dust★,★★

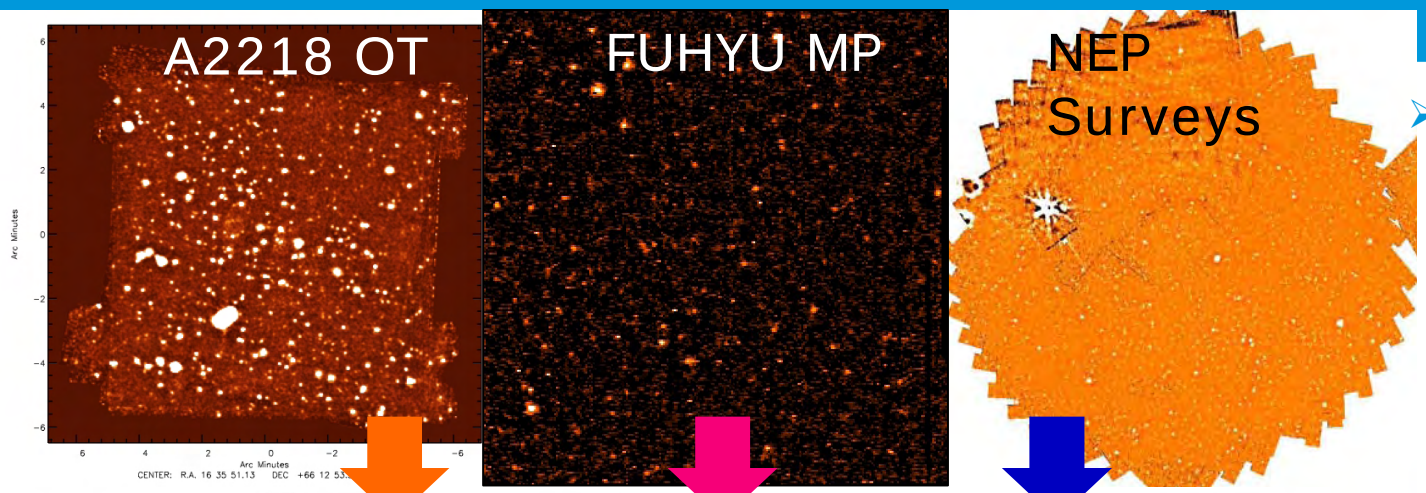
T. Goto[1,2,★★★], T. Takagi[3], H. Matsuhara[3], T. T. Takeuchi[4], C. Pearson[5,6,7], T. Wada[3], T. Nakagawa[3], O. Ilbert[8], E. Le Floc'h[9], S. Oyabu[3], Y. Ohyama[10], M. Malkan[11], H. M. Lee[12], M. G. Lee[12], H. Inami[3,13,14], N. Hwang[2], H. Hanami[15], M. Im[12], K. Imai[16], T. Ishigaki[17], S. Serjeant[7], and H. Shim[12]

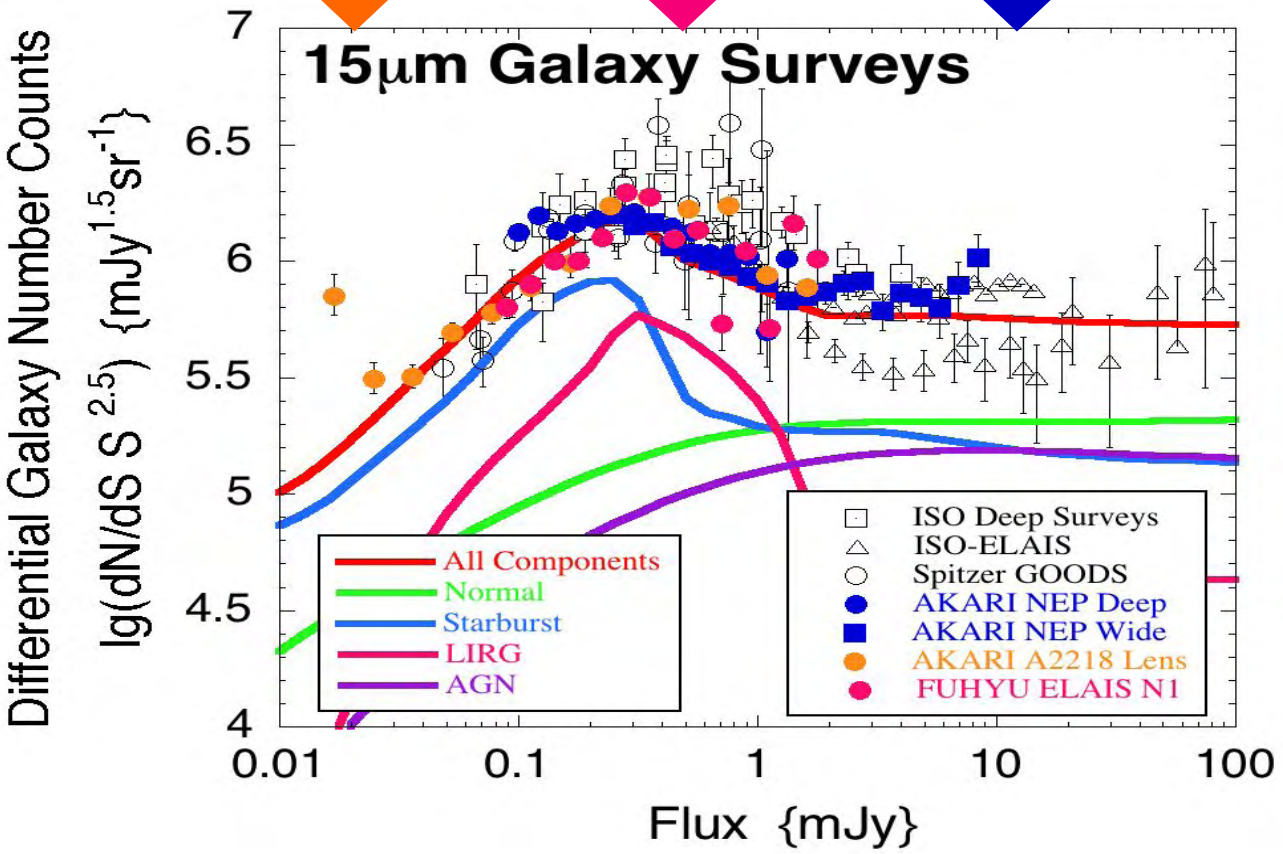




Source counts at 15 microns from the AKARI NEP survey

C. P. Pearson[1,2,7], S. Oyabu[3], T. Wada[3], H. Matsuhara[3], H. M. Lee[4], S. J. Kim[4], T. Takagi[3], T. Goto[5,6], M. S. Im[4], S. Serjeant[7], M. G. Lee[4], J. W. Ko[4], G. J. White[7], and O. Ohyama[8]



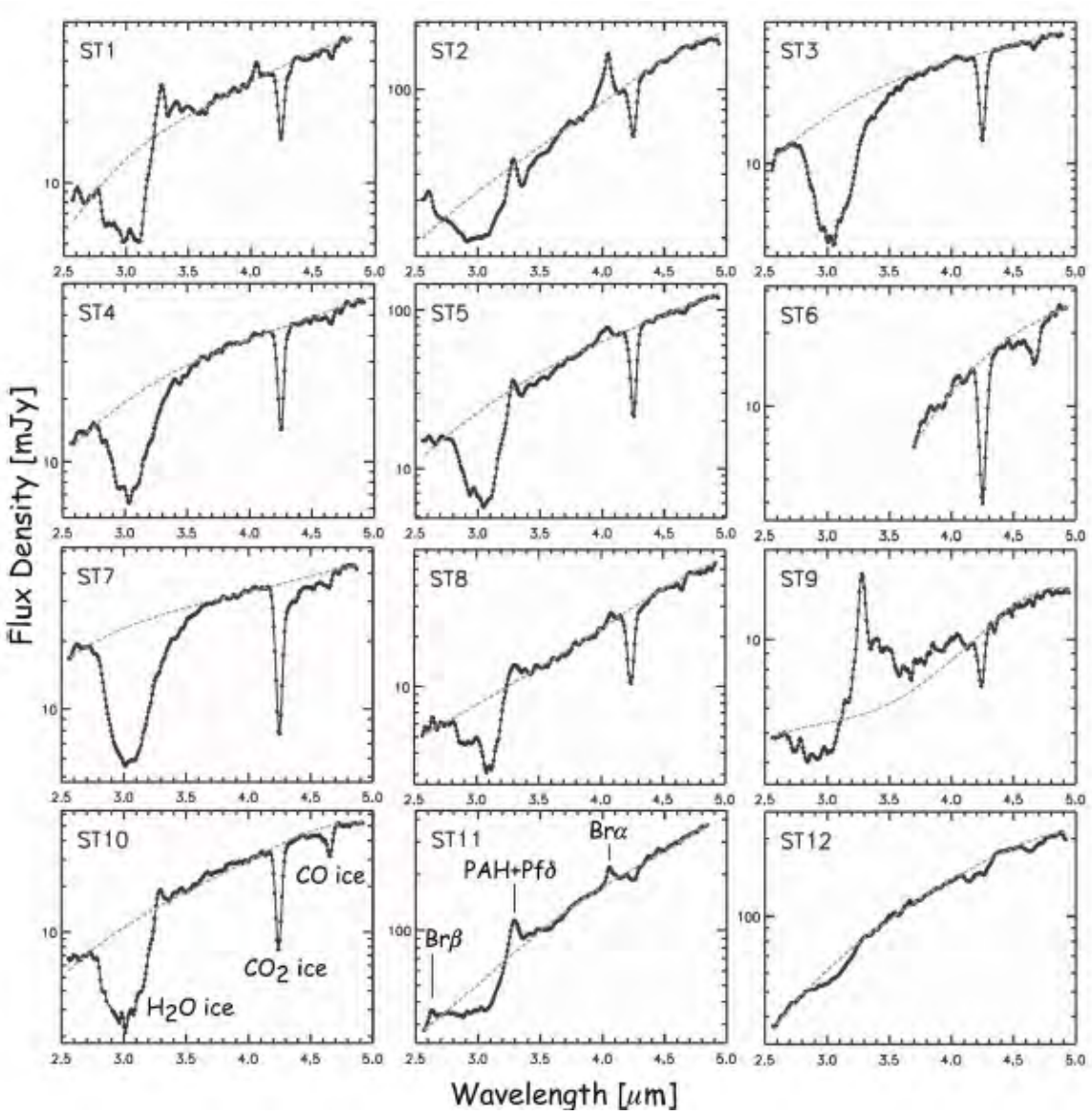


- Source counts in 15 micron band
  - Exhibit strong evolution
  - Agree with ISO, Spitzer
  - Extends previous counts to both brighter and fainter flux levels

AKARI galaxy counts point to the emergence of a population of luminous infrared galaxies that dominate the galaxy counts & star formation history of the Universe at faint flux levels

Spectroscopic observations of ices around embedded young stellar objects in the Large Magellanic Cloud with AKARI

T. Shimonishi[1], T. Onaka[1], D. Kato[1], I. Sakon[1], Y. Ita[2], A. Kawamura[3], and H. Kaneda[3]



Large-scale distributions of mid- and far-infrared emission from the center to the halo of M 82 revealed with AKARI

H. Kaneda[1], D. Ishihara[1], T. Suzuki[2], N. Ikeda[3], T. Onaka[4], M. Yamagishi[1], Y. Ohyama[5], T. Wada[3], and A. Yasuda[1]

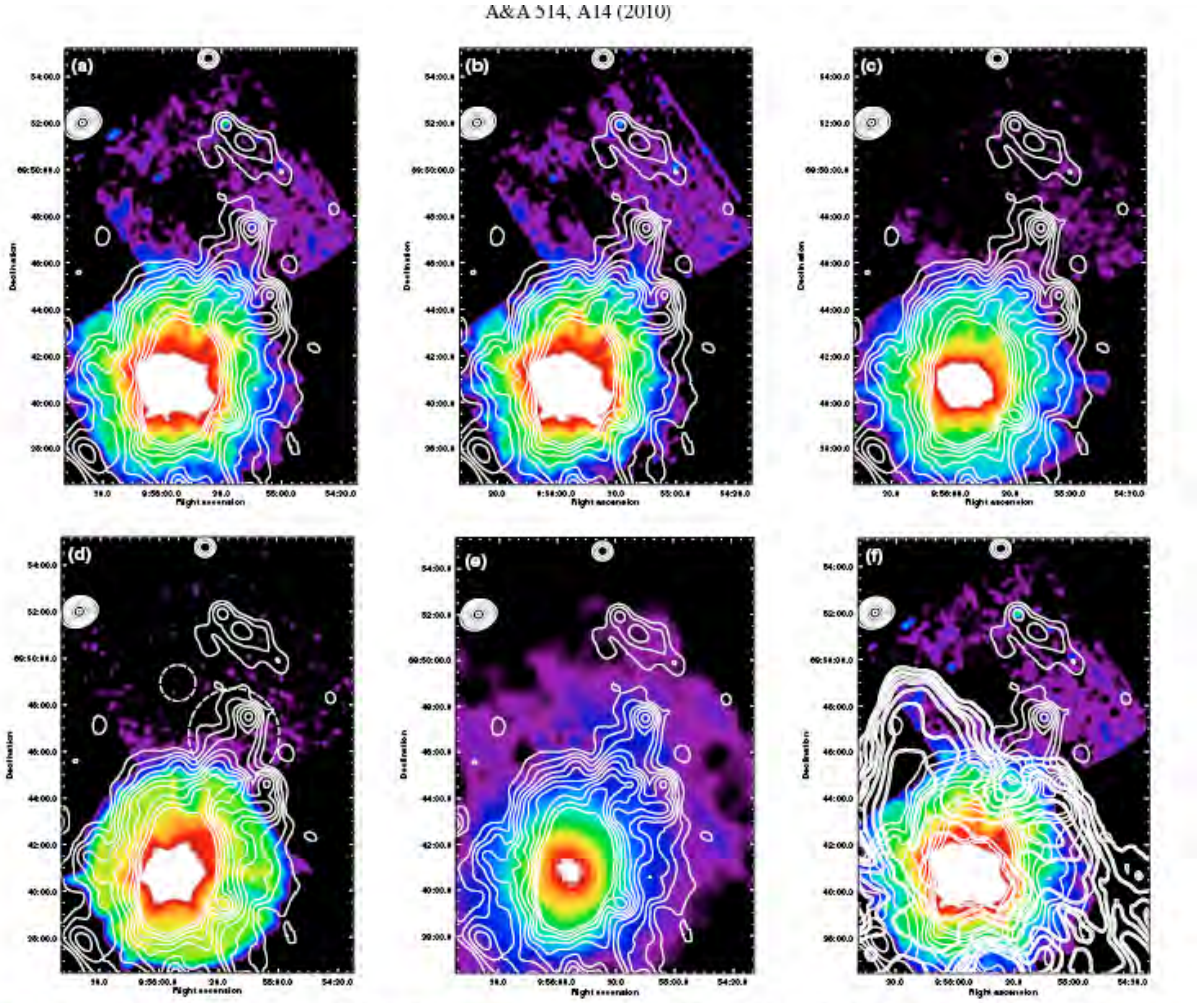


Fig. 3. Low-level MIR and FIR images of M 82 including the Cap region in the a) *S*7, b) *S*11, c) *L*15, d) *L*24, e) *N*160 bands, overlaid on the XMM/Newton X-ray (0.2−10 keV) contour map on a logarithmic scale. f) The H I contour map of M 82 in the thick lines, taken from Yun et al. (1994), is superposed on the panel a) image. The color scales of the MIR and FIR images are logarithmically scaled from 0.2% to 0.0007% of the peak surface brightness for all the panels except e) and from 80% to 0.1% for the panel e). The two circular apertures are shown in panel d), where the larger one is used to obtain the flux densities from the halo ($d \leq 4'$) regions and the smaller one to estimate the background level and its fluctuation from the darkest nearby blank sky.

Distribution of dust and PAHs

Galactic Planetary Nebulae in the AKARI Far-Infrared Surveyor Bright Source Catalog

Nick Cox,[1] Arturo Manchado,[2,3] Pedro García-Lario,[1] Ryszard Szczerba[4]

- study of all known Galactic PNe
- SEDs provide information on cold dust

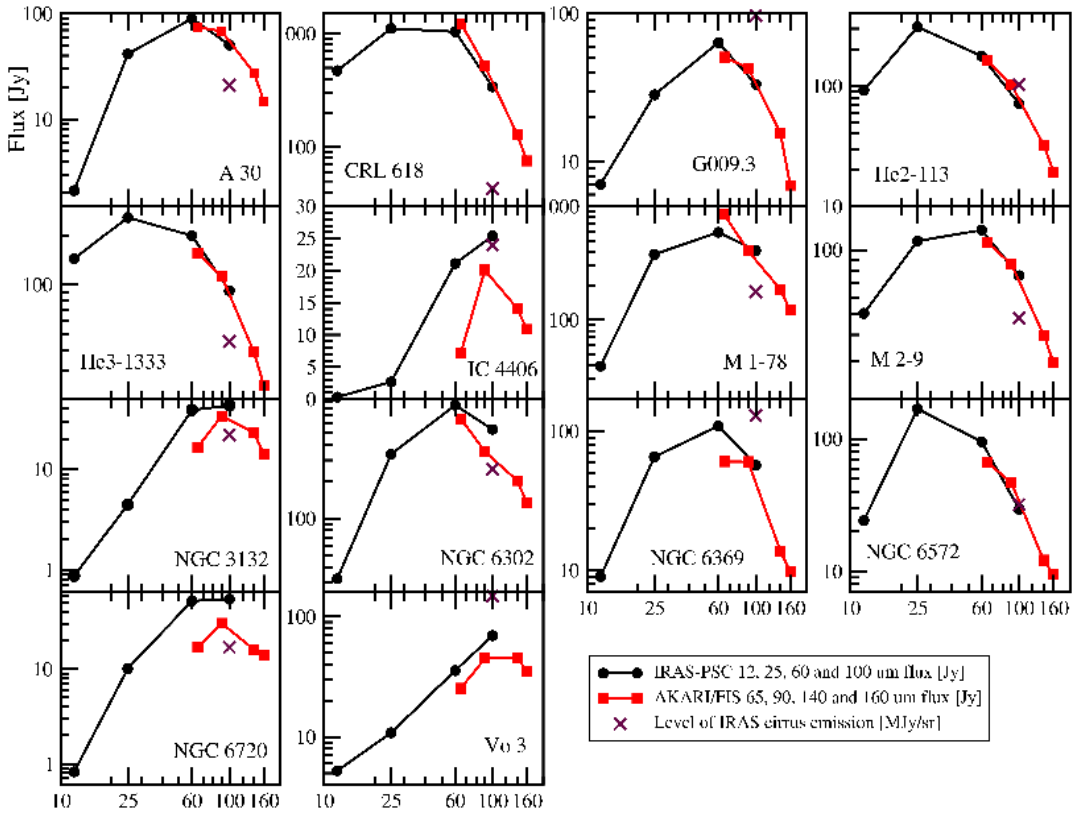
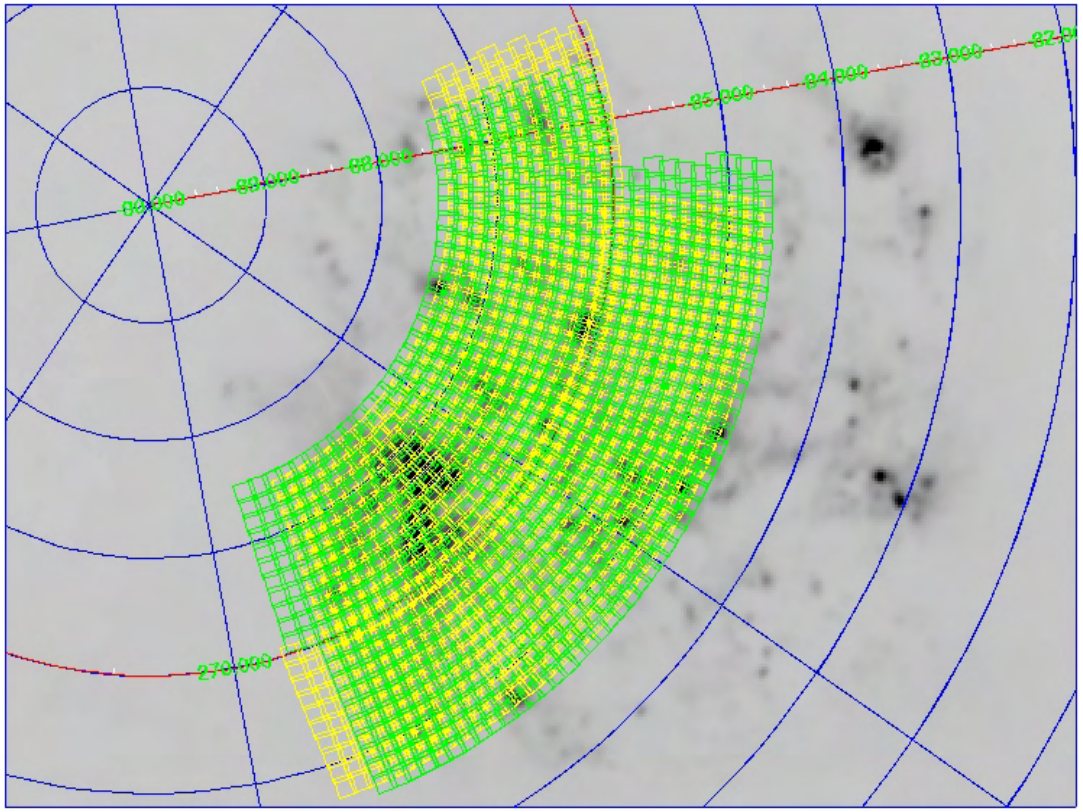


Figure 5. IRAS+AKARI spectral energy distribution of the 14 PNe detected in all bands. The cirrus emission values from IRAS (at 100 μm in MJy/sr) are also indicates (crosses).

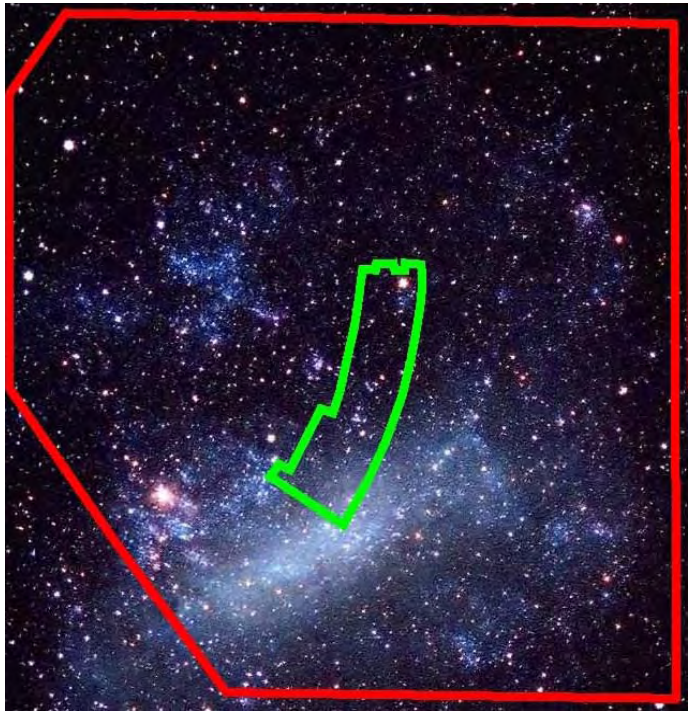
From "AKARI: a light to illuminate the dusty Universe" Proceedings (Conference held in Tokyo in Feb 2009)

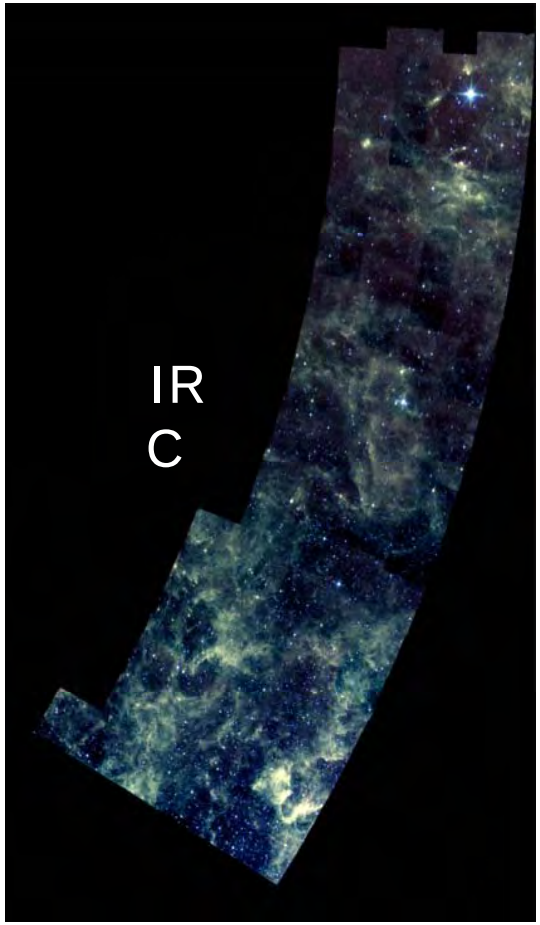
The LMC Survey

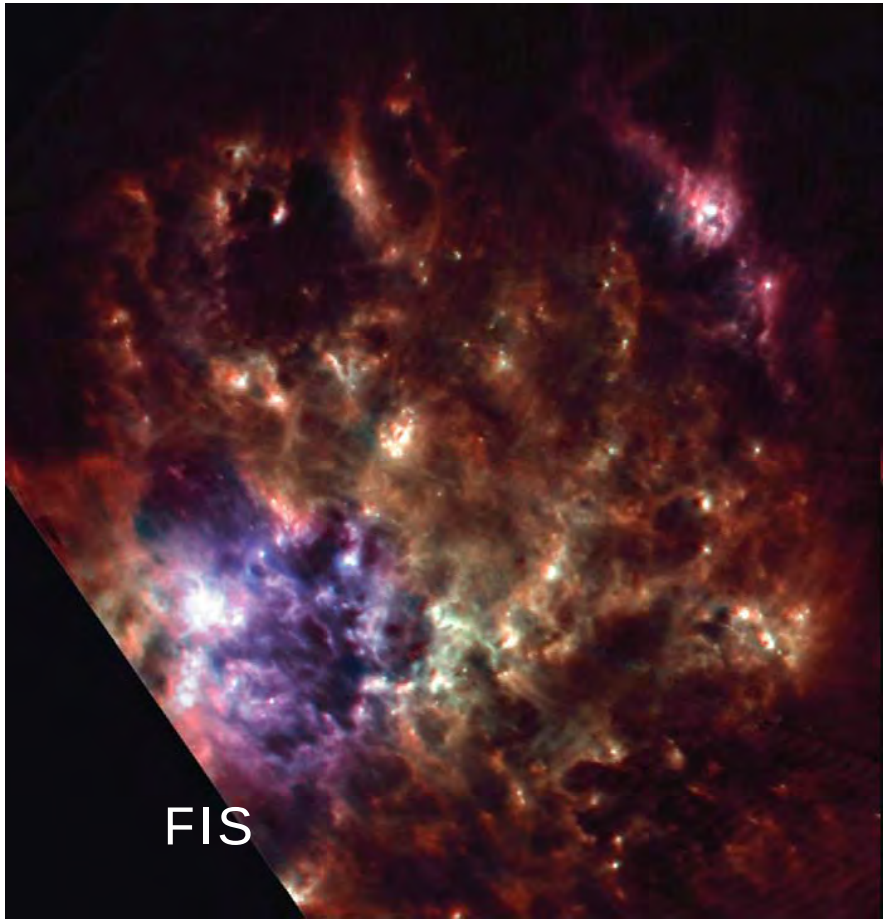


~15deg^2 prism + 5 filters (NP, N3, S7, S11, L15, L24)
+ spectroscopy (MIR-FIR) at selected areas
~900 pointing observations

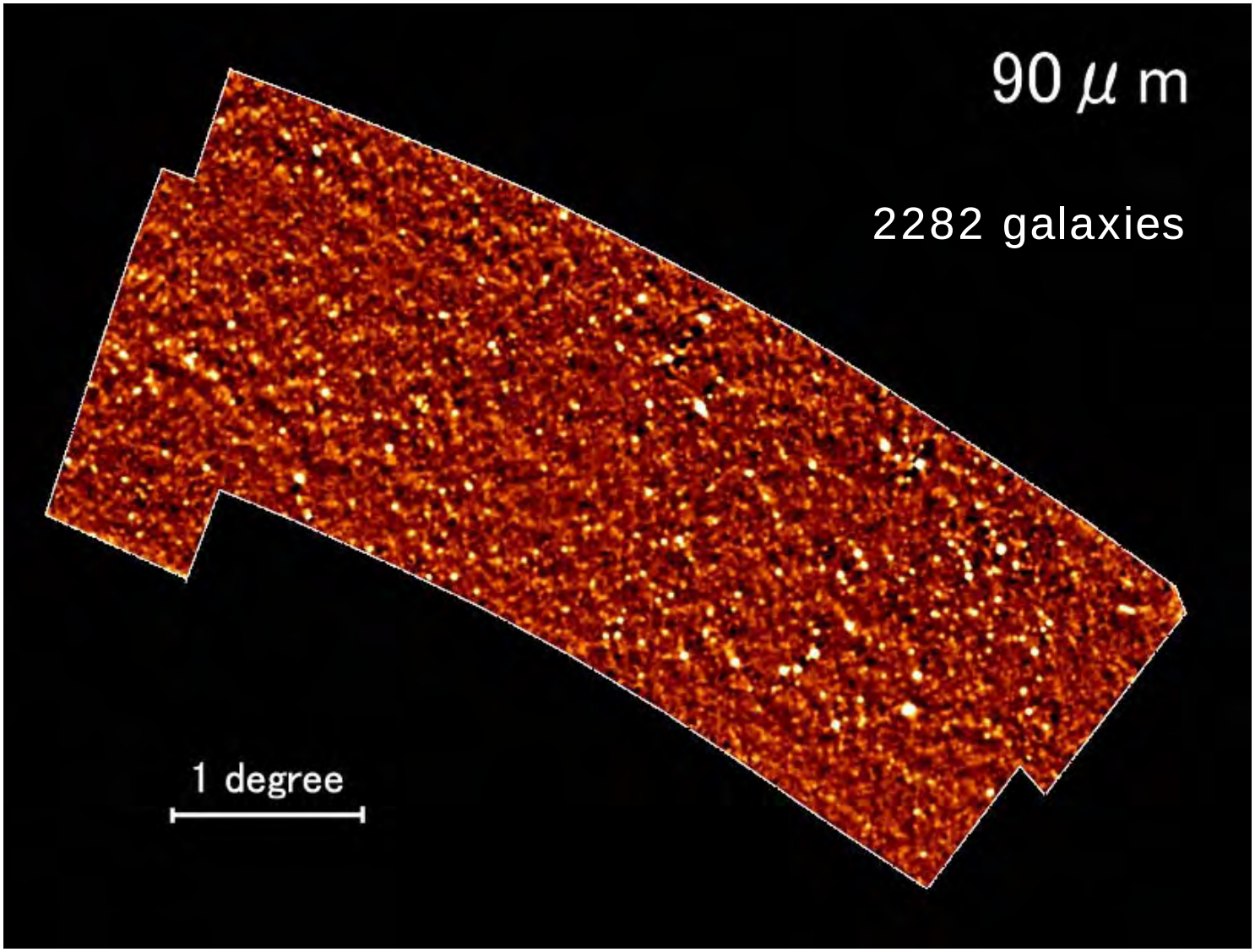
The LMC Survey







Infrared primordial galaxies



Generations of stars forming

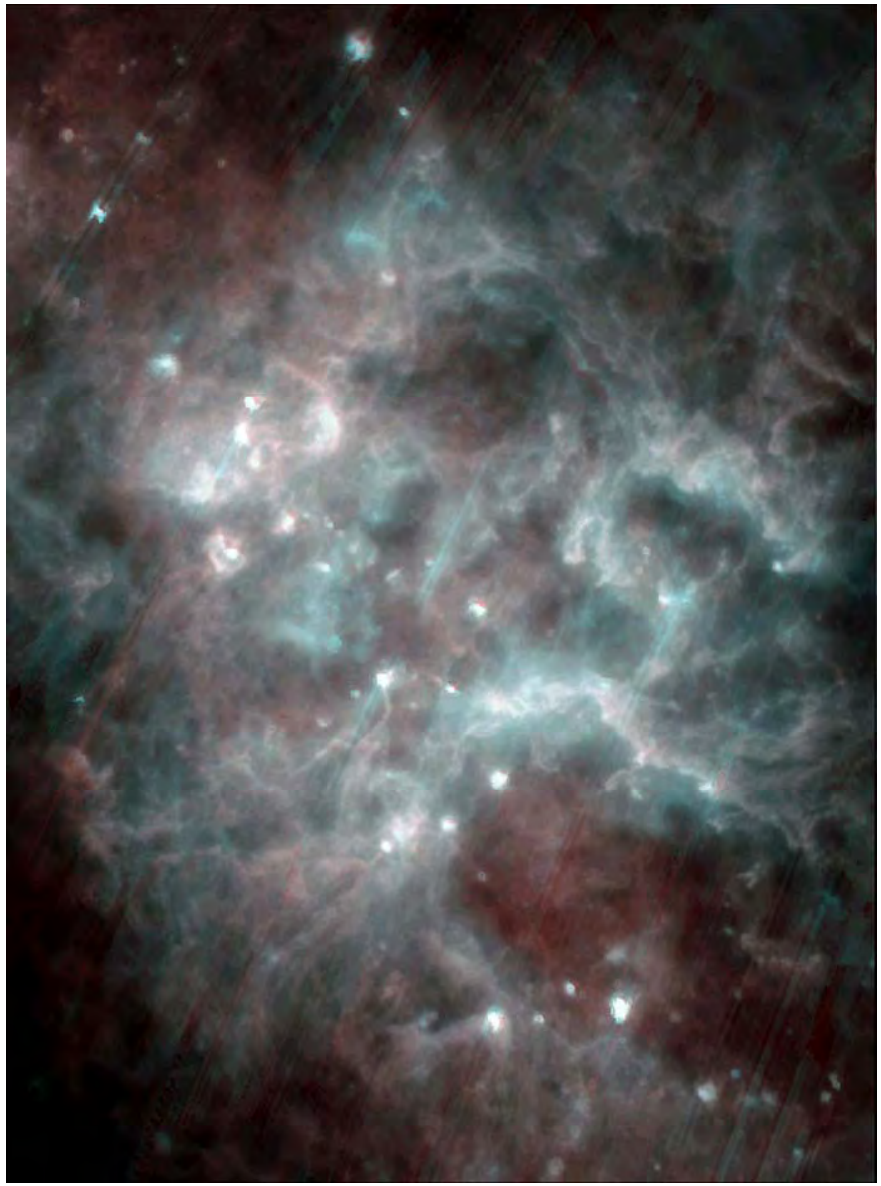
IC 1396

Visible

Infrared (9,18 µm)

Cygnus-X Star forming region nebula

- 90, 140 um

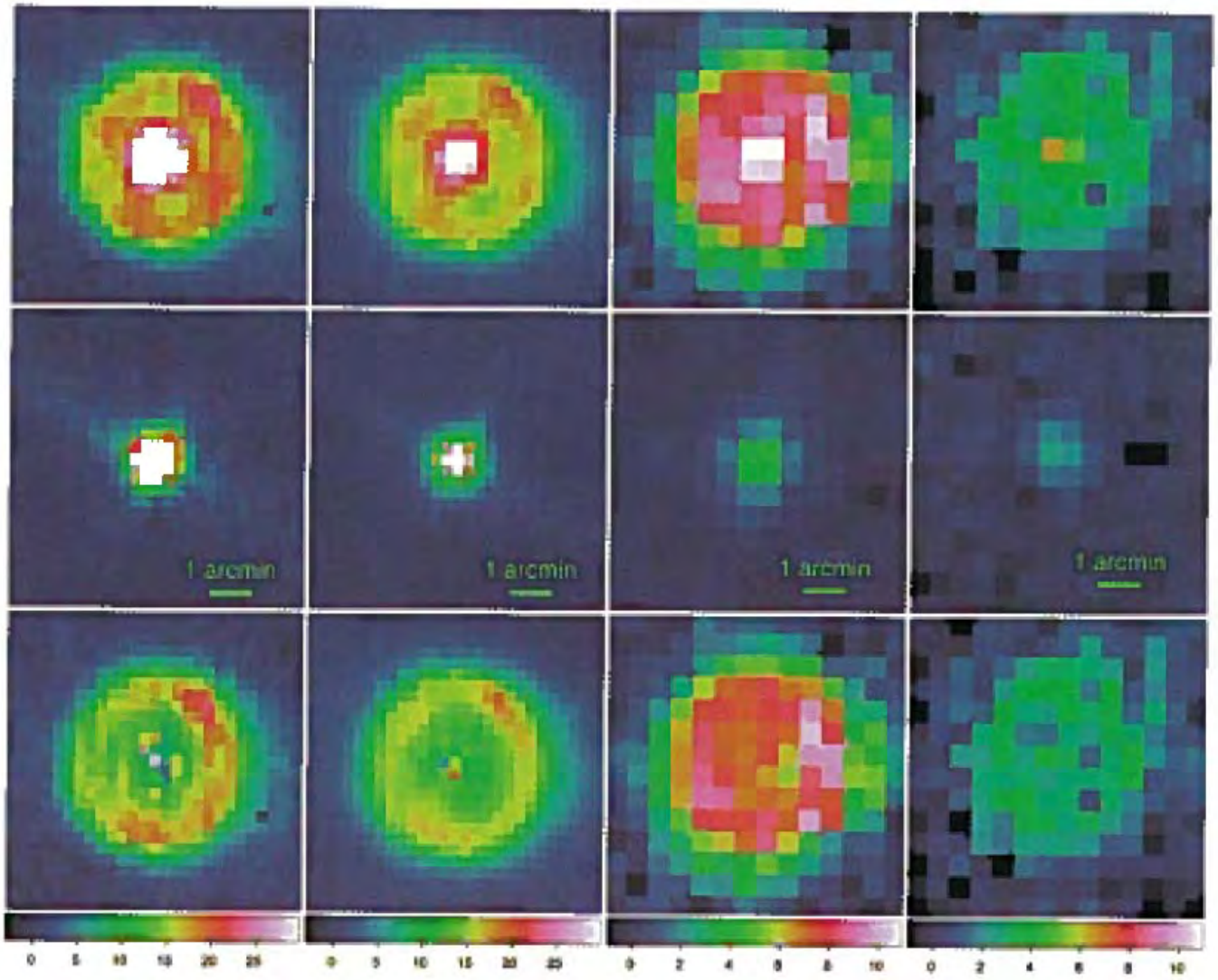


Imaging a debris disk

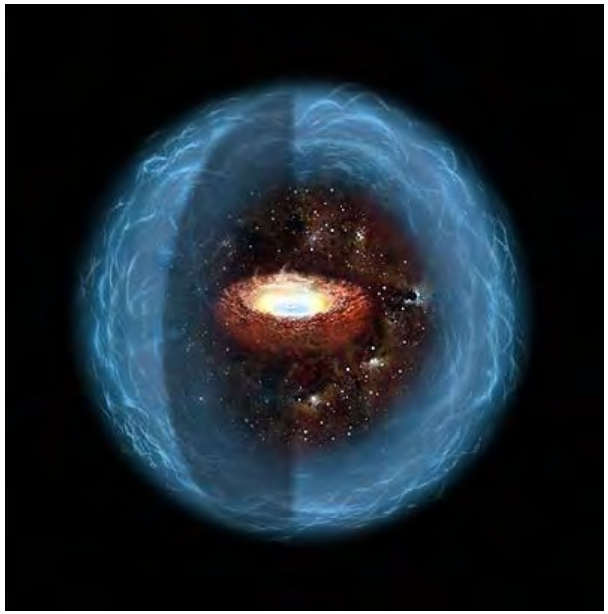
- U Hydrae, AGB star, Mass loss

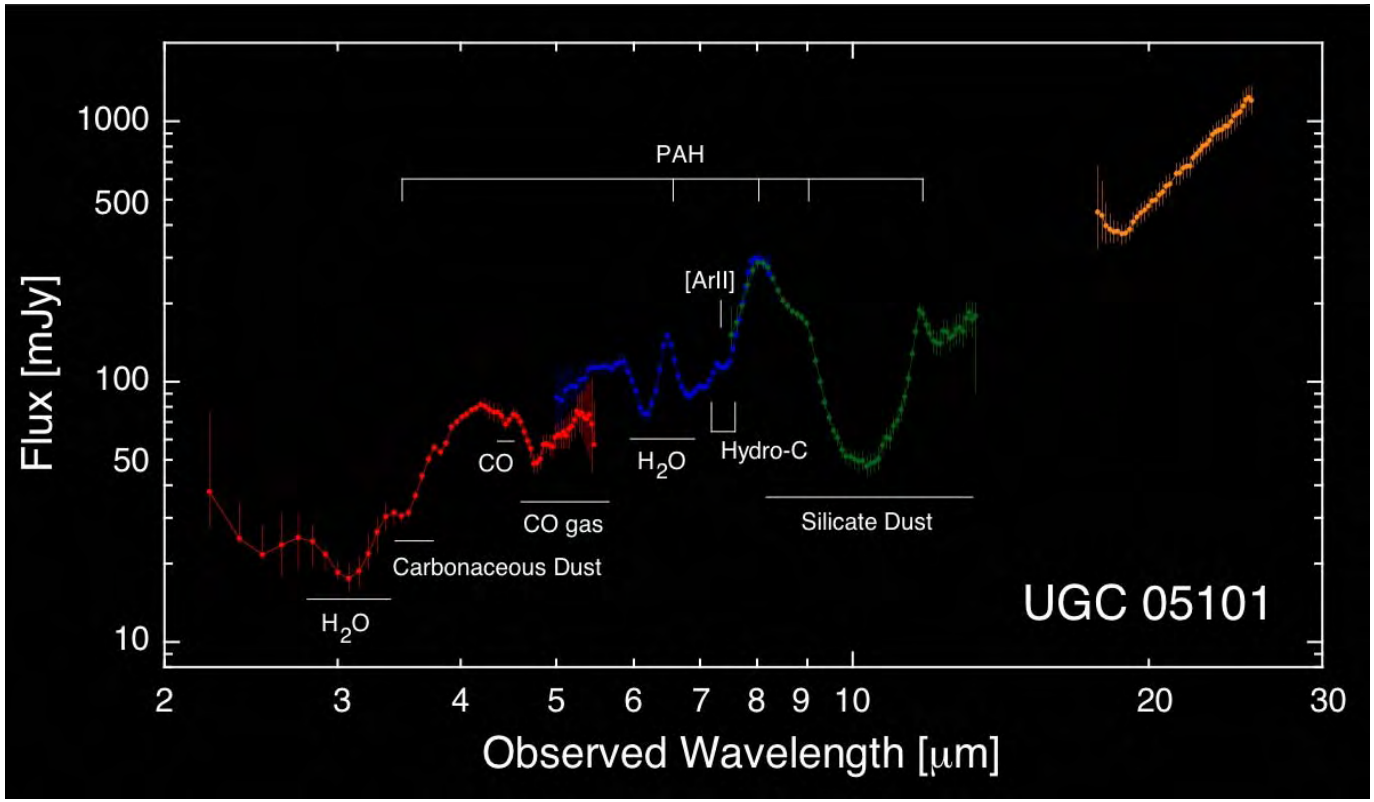
star

shell



ULIRG UGC 5101





Science with AKARI at ESAC

(A. Cassatella, R. González-Riestra, M. Santos-Lleò, A. Salama et al.)

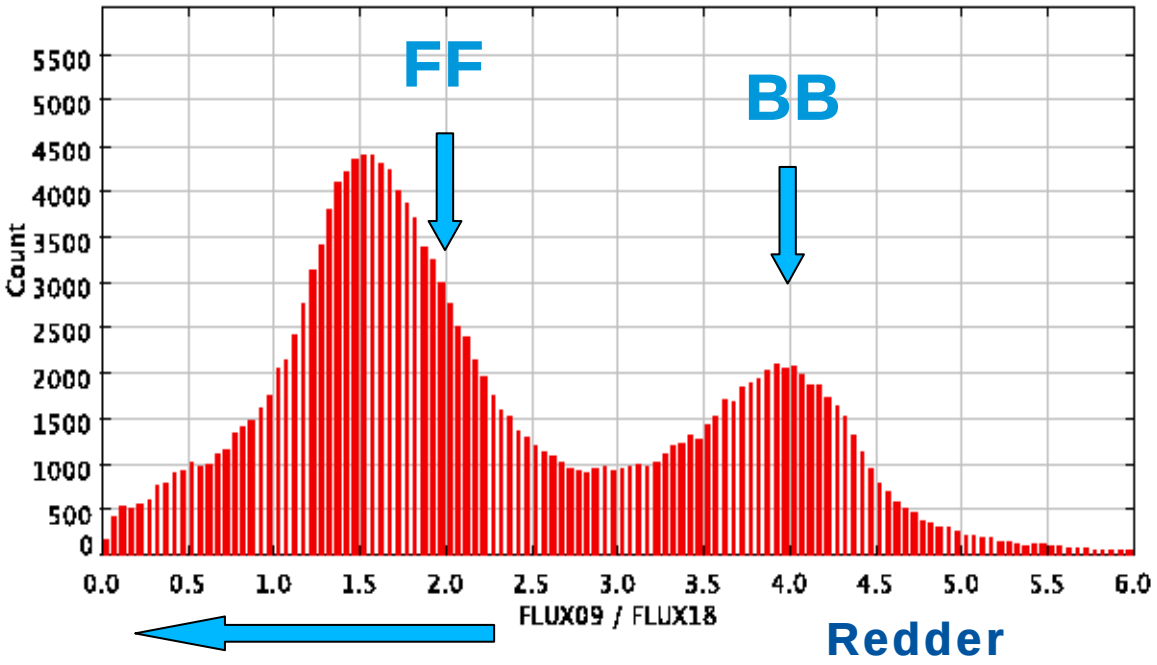
What we can learn from:

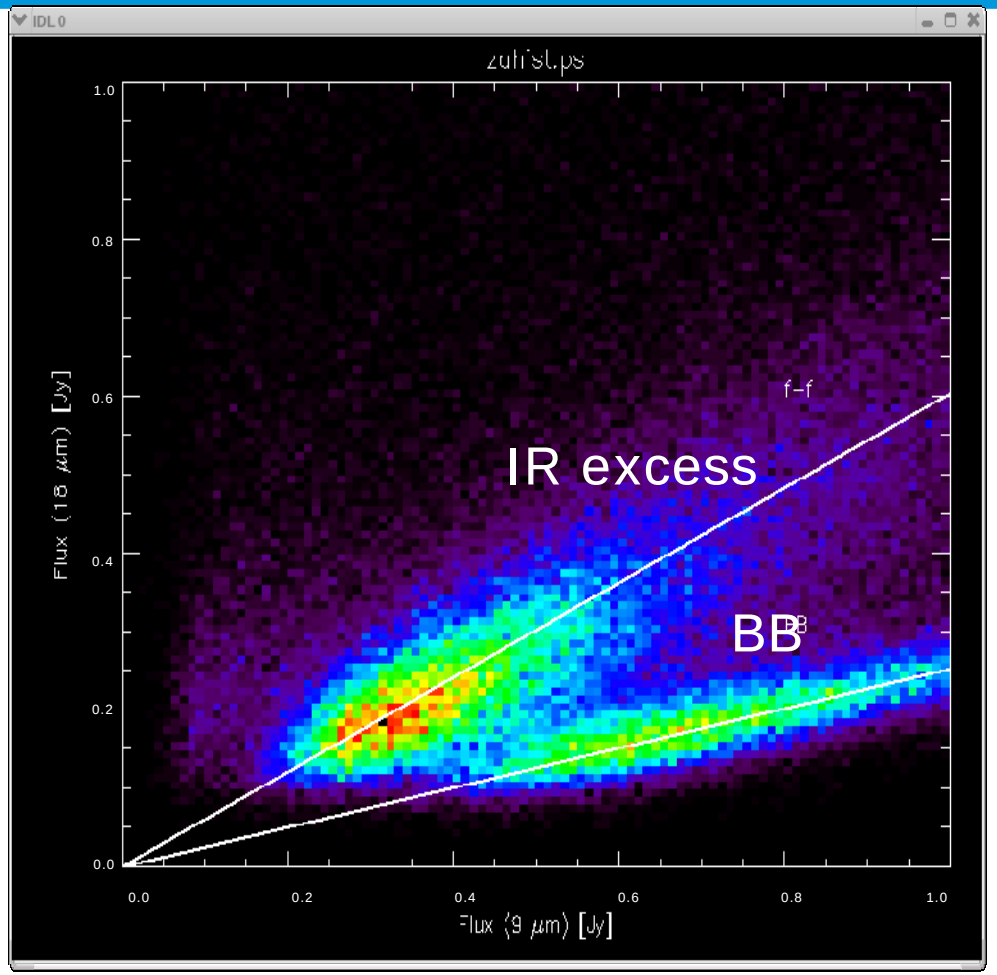
- AKARI/MIR FLUX-FLUX CORRELATIONS (9 & 18 μm)

- CROSS CORRELATION WITH XMM-OM and XMM-EPIC DATA

- CROSS CORRELATION WITH AKARI/FIS

AKARI /MIR: two population of sources





Total: N = 870 973 sources

@ 9 μm N=844 649 (97%)

@18 μm N=194 551 (22%)

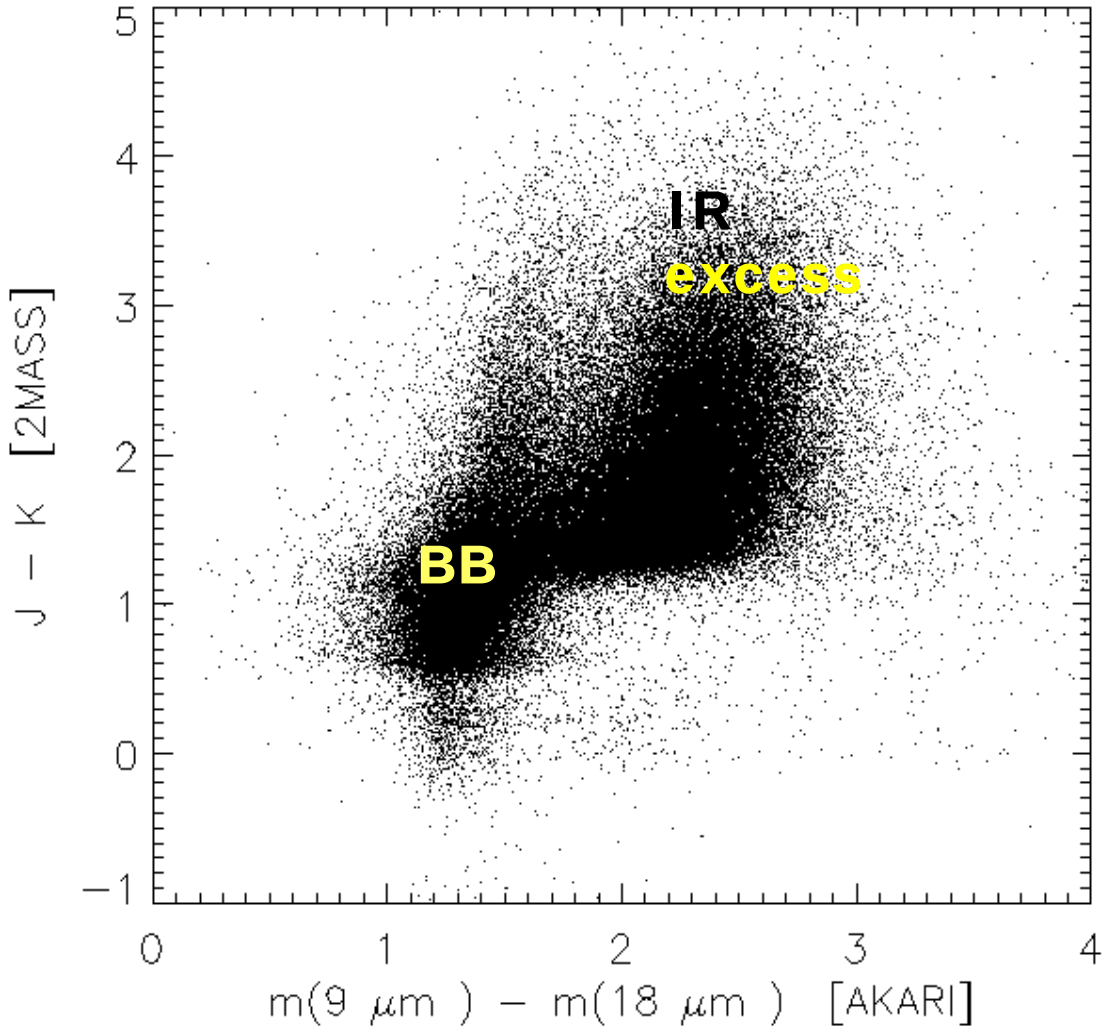
Both bands: N= 168 227 (19%)

IR excess:
Comparison with 2MASS colours

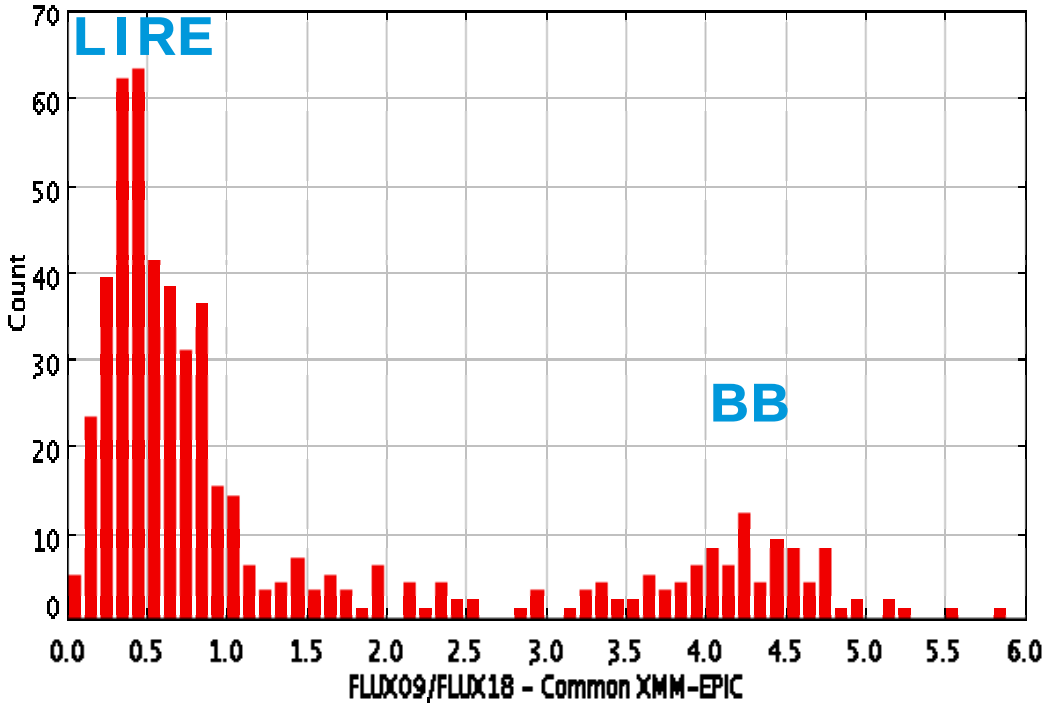
The reddest objects J-K > 1.5

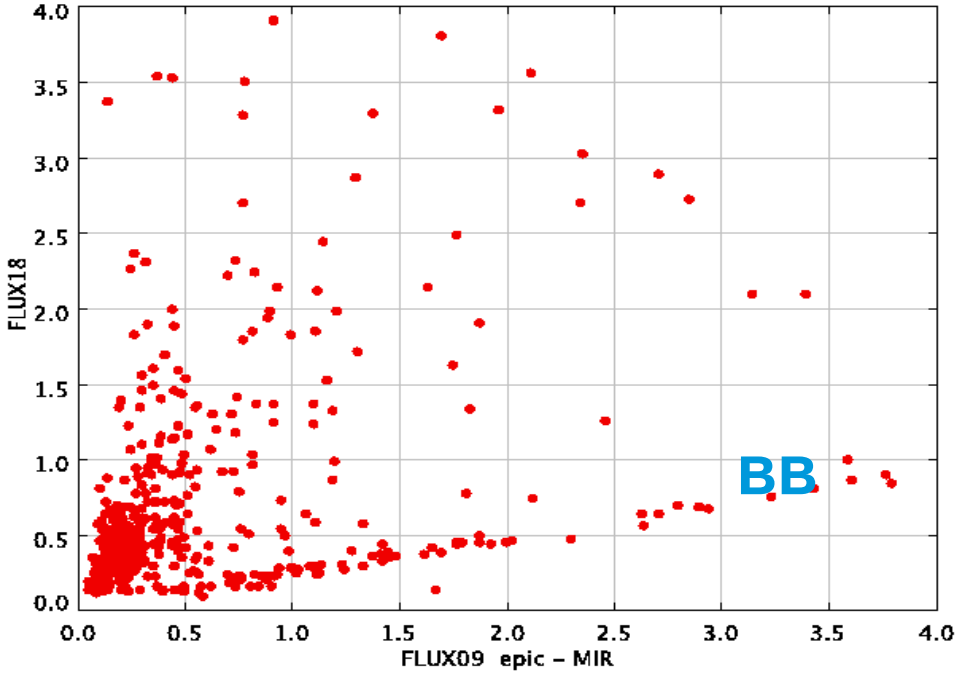
A) galaxies
- **light dominated by red bulge & core stars**
- **redshift**
- **dust absorption in Galactic plane**

B) stars with
- **100-400 K dust**
- **large mass loss**



AKARI/MIR vs. XMM/EPIC: a third population of X-ray sources with large IR excess





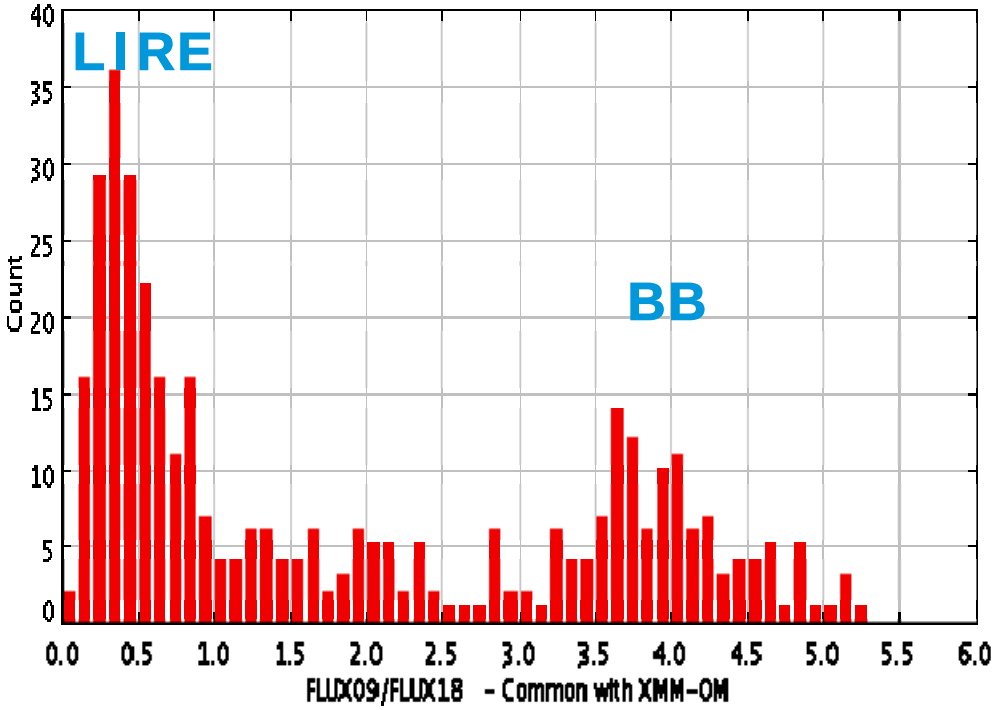
AKARI MIR
No. Sources = 870 973
2 bands @ 9 μm & 18 μm

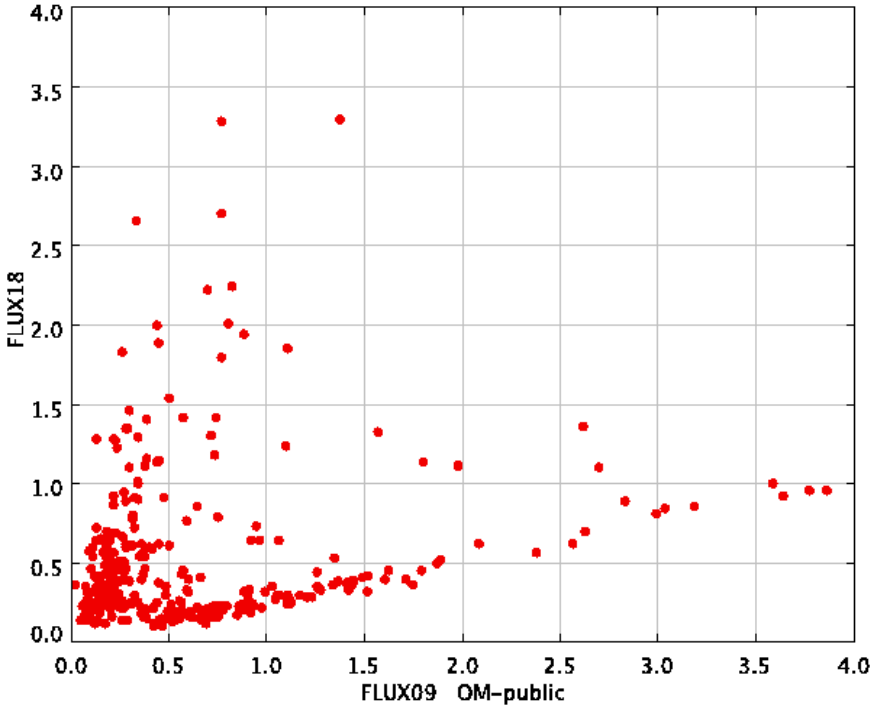
XMM EPIC
No. Sources= 221 012
8 bands 0.2 to 4.5 KeV

Common sources: 1174 (r = 5")

Large IR excess: AKARI / MIR vs. XMM / OM

Common sources: 1321 (r = 5”)





XMM OM **No. Sources = 753 578**

6 bands:

1894 Å	(N= 119805)	3275 Å U	(N= 177569)
2205 Å	(N= 145210)	4050 Å B	(N= 81119)
2675 Å	(N= 618266)	5235 Å V	(N= 78160)

Cross correlating AKARI MIR & FIS catalogues with XMM EPIC, OM and RGS catalogues

FIS catalogue: 427.071 sources @ 25, 60, 60 and 160 um

MIR catalogue: 870.973 sources @ 9, and 18 um

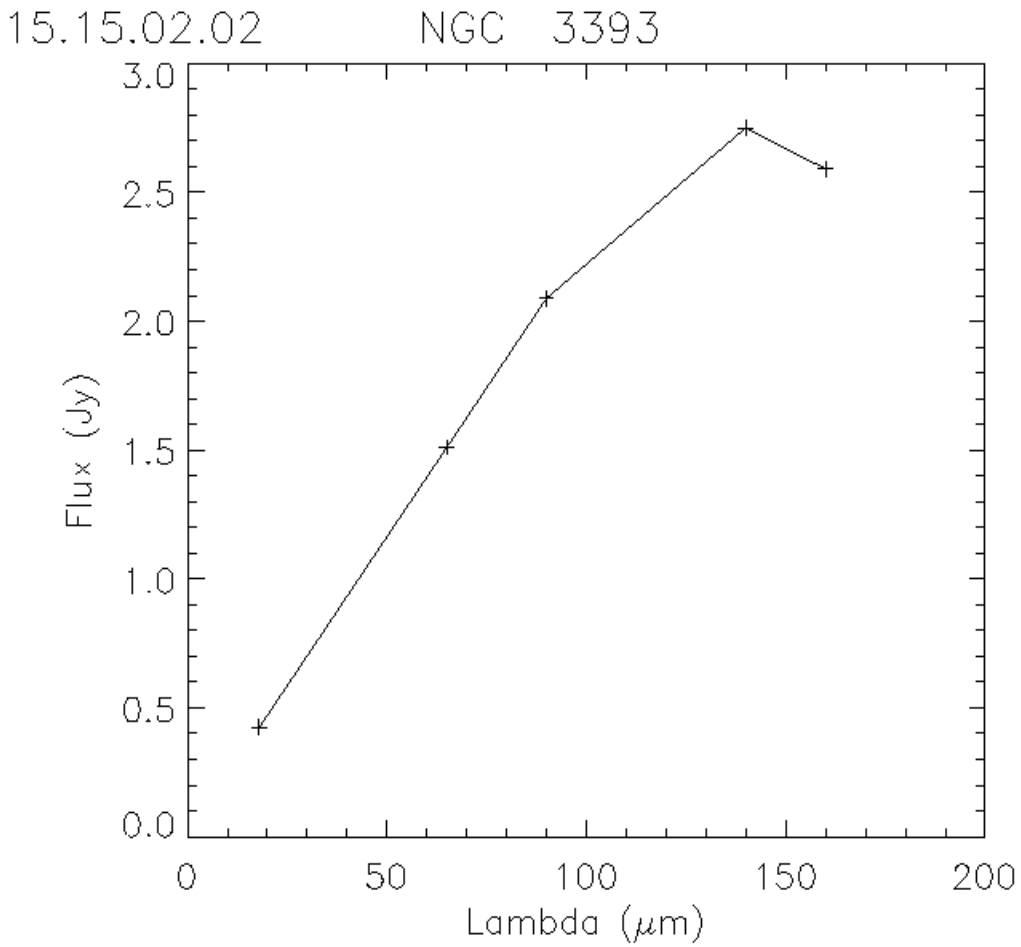
Also observed with XMM EPIC: 1174

Also observed with XMM OM: 1321

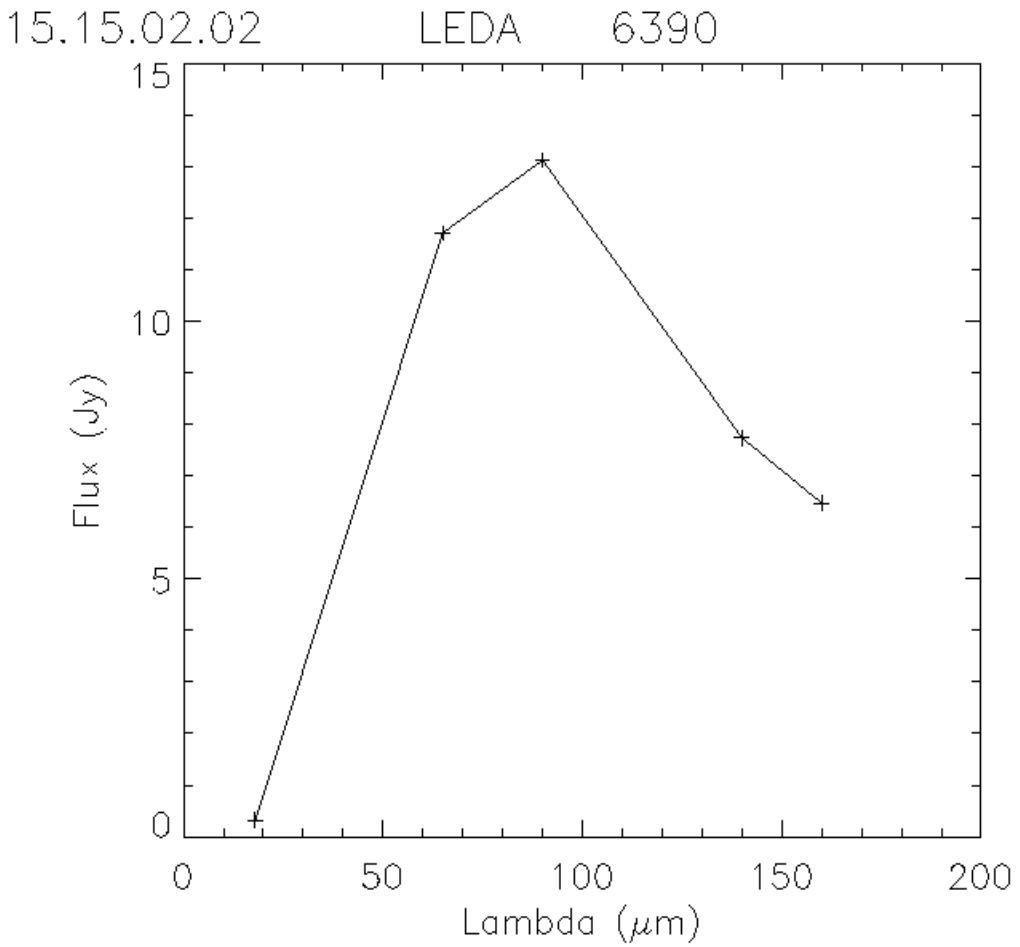
Also observed with XMM RGS: 305

Examples of sources common to the AKARI/MIR, AKARI/FIS & XMM/RGS catalogues.... Looking for correlations

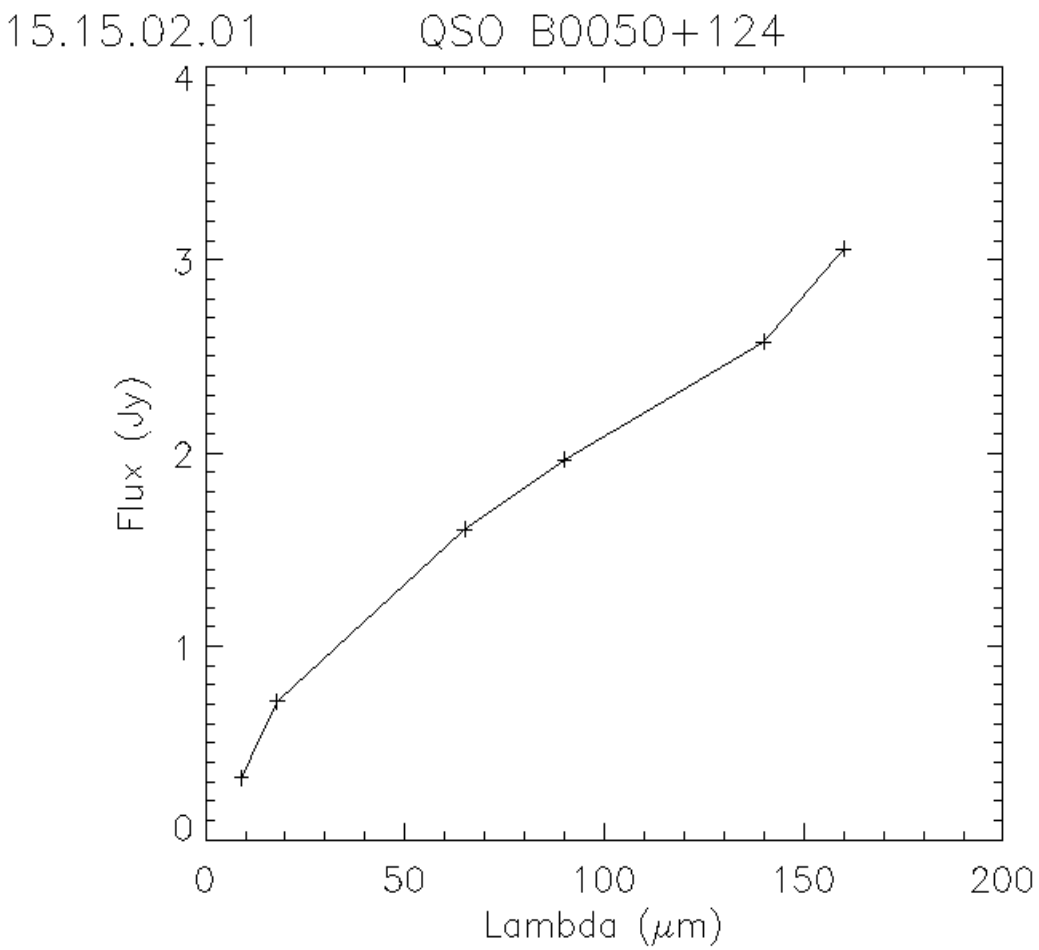
Seyfert 2



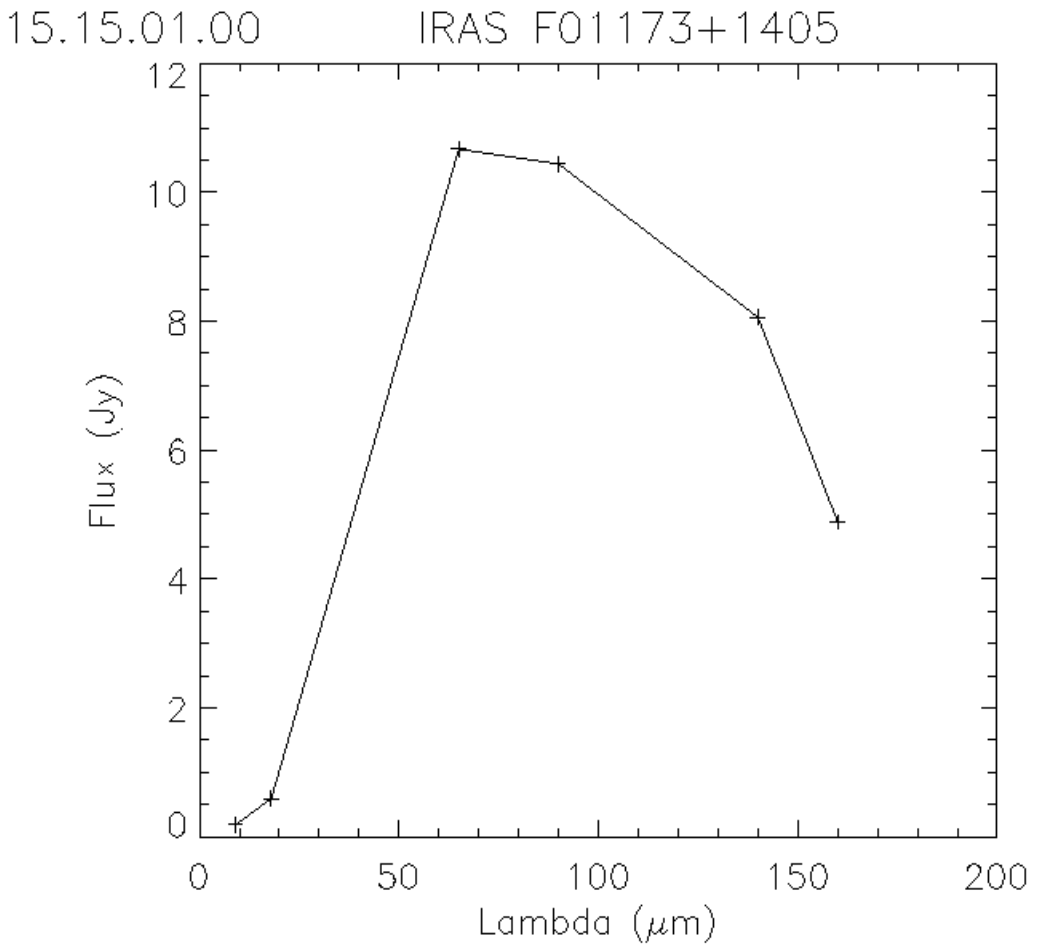
Seyfert 2



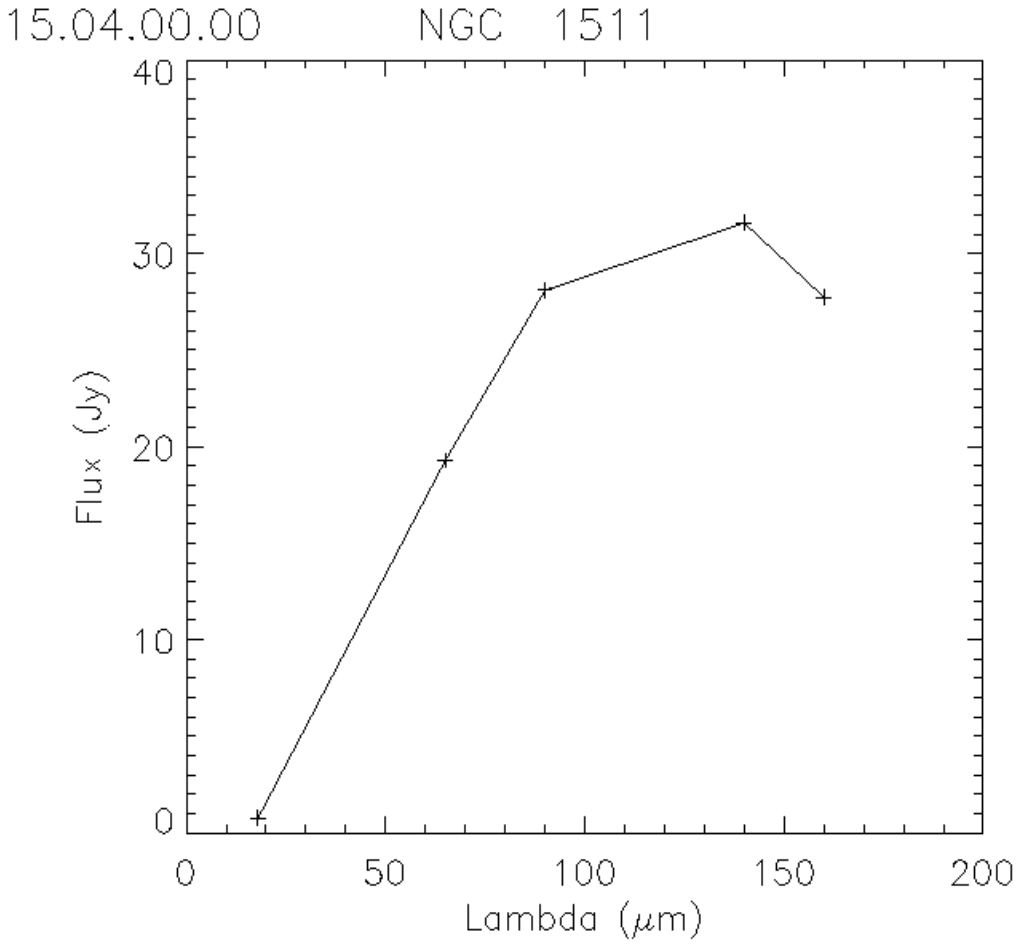
Seyfert 1



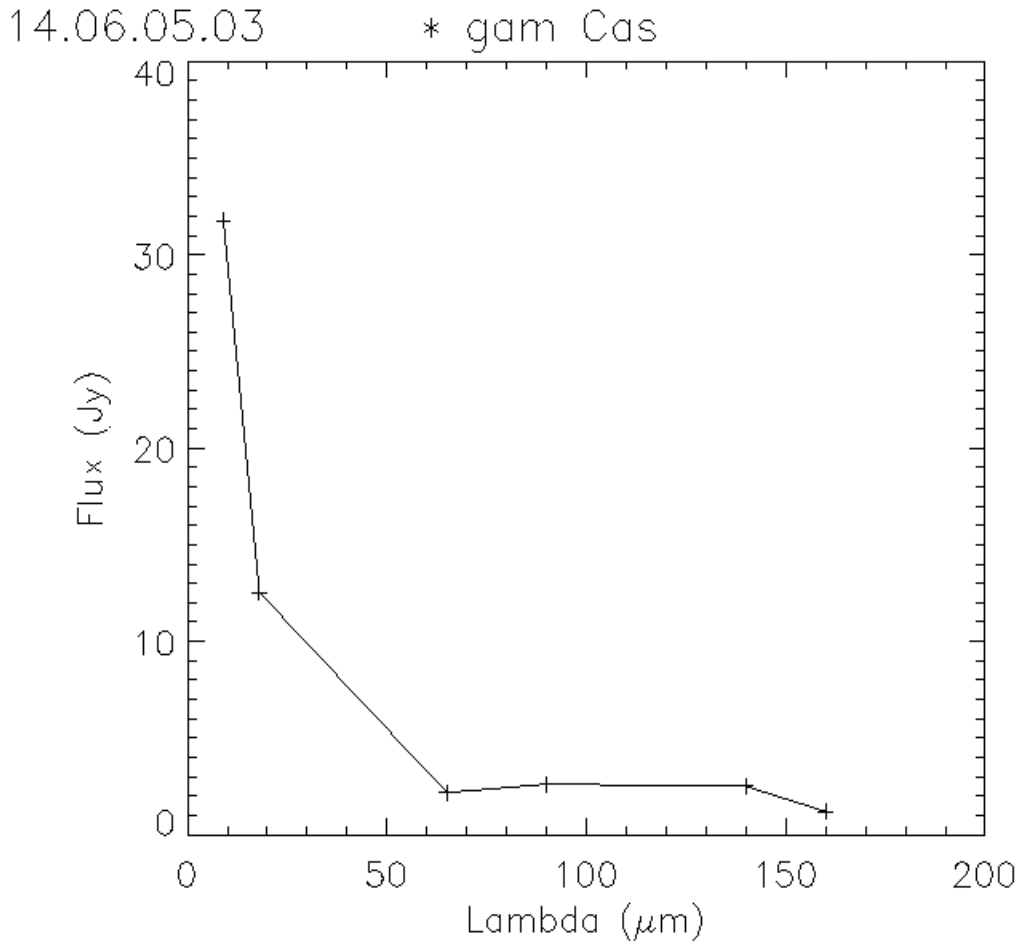
Liner



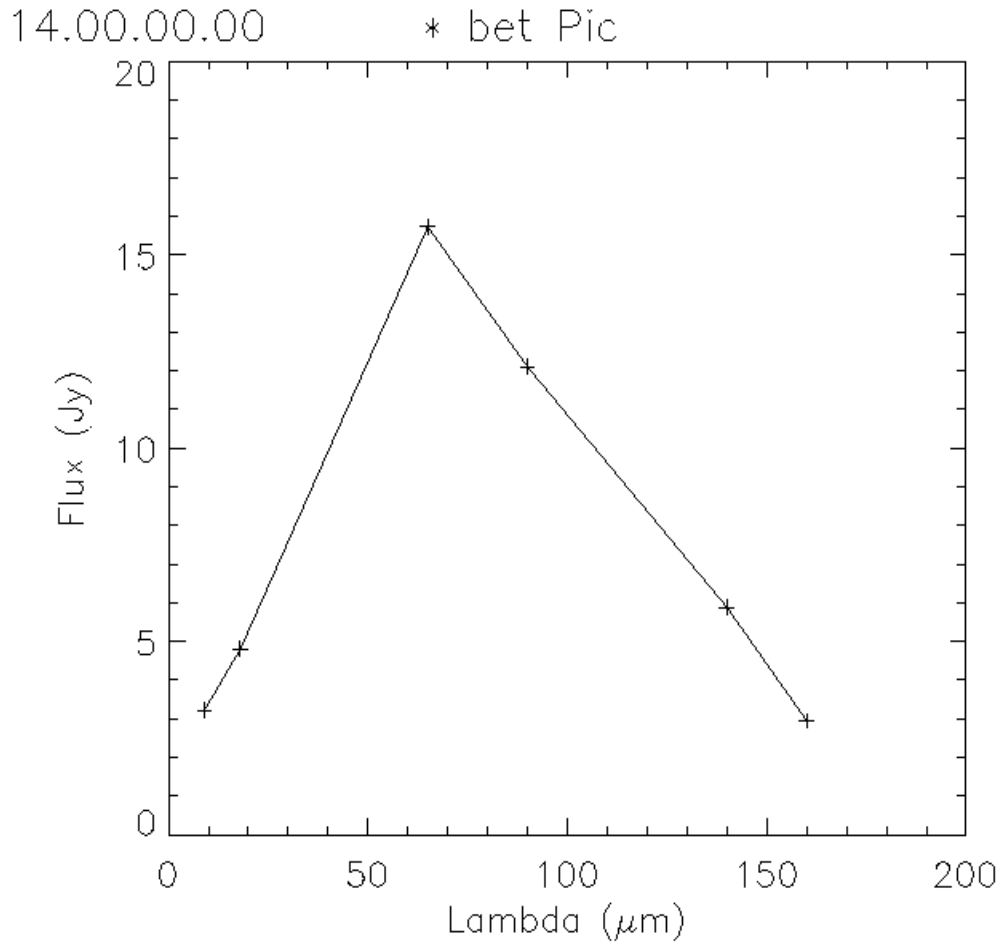
Galaxy in a pair



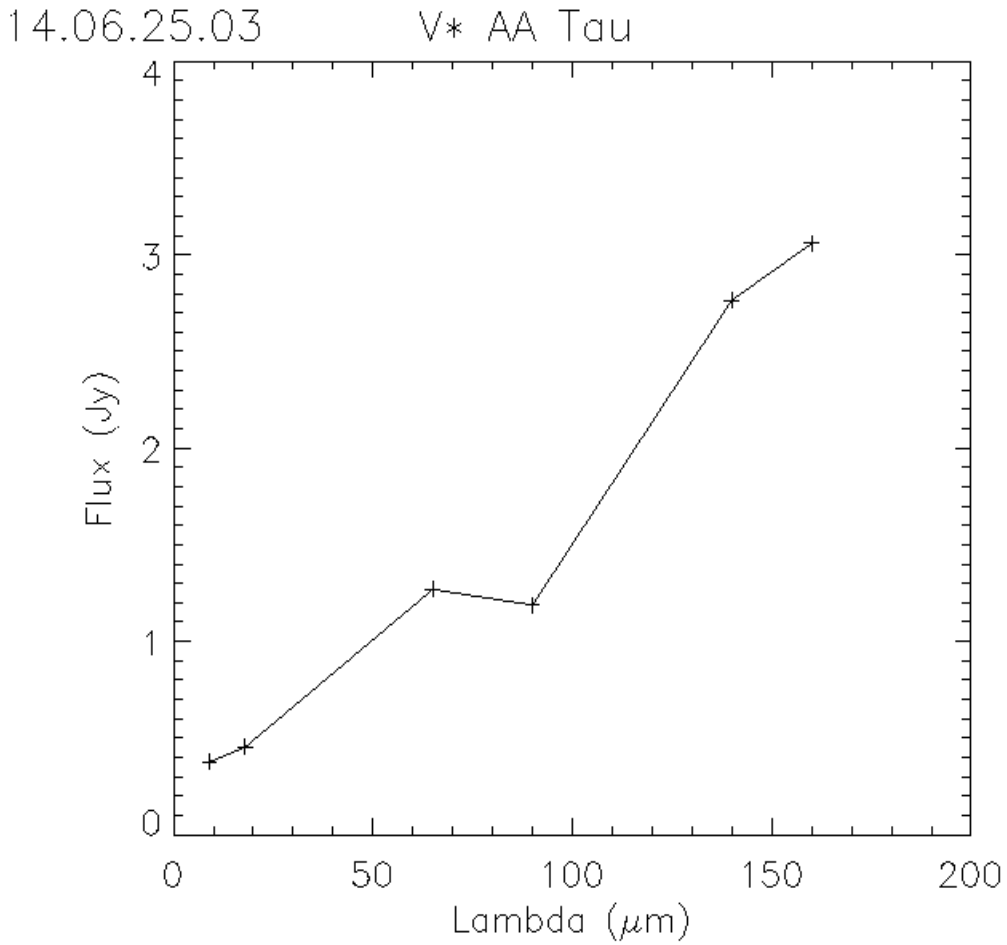
Be star



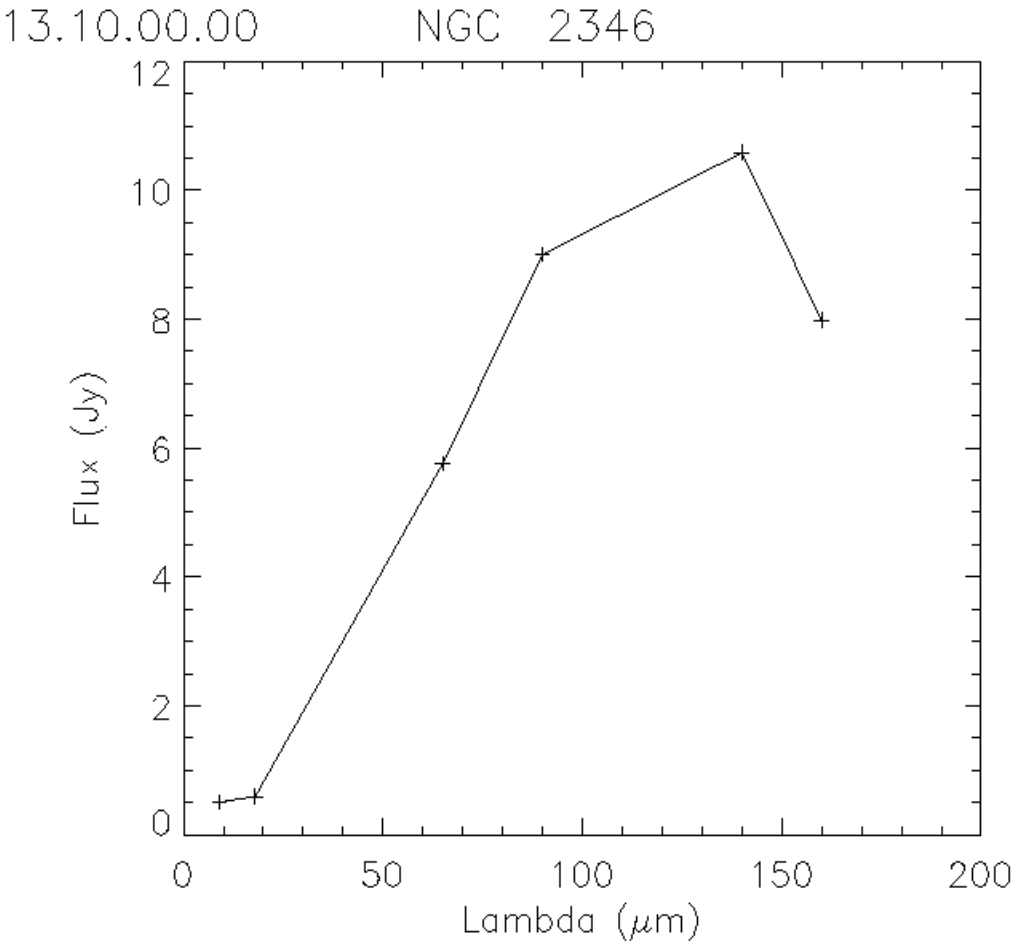
Star A6V



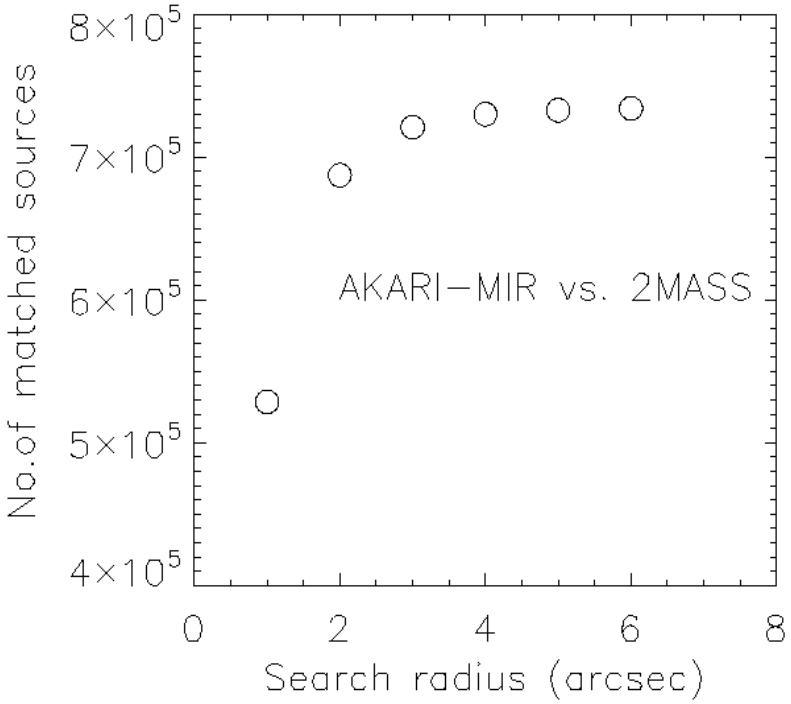
M0V variable star

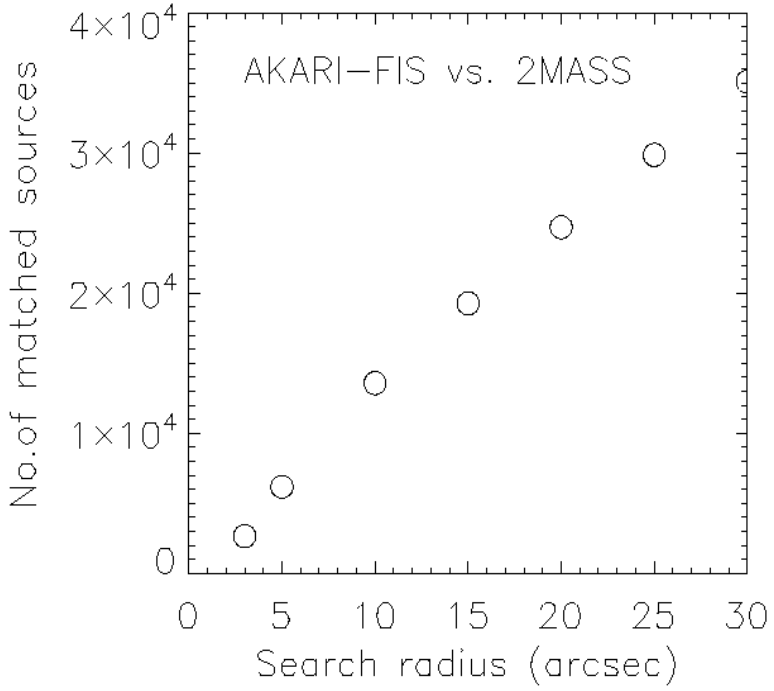


Planetary Nebula



AKARI /MIR & AKARI/FIS versus 2MASS: Same sources are seen ?





Cross correlation of AKARI/MIR with 2MASS (J, H, K) saturates within 2-3 times the instrumental PFS ➔ mostly the same objects are seen.
Cross correlation of AKARI/FIS with 2MASS (J, H, K) does not saturate ➔ presence of a large population of FIR sources not seen in the mid infrared.

Any correlation between E(B-V) (dust absorption) and Infrared Excess (dust emission)?

Area of the 2200 Å dust absorption bump ~ E(B-V)

XMM – OM

No. Sources = 753 578

6 bands peaking at:

1894 Å		N= 119805
2205 Å		N= 145210
2675 Å		N= 618266
3275 Å	U	N= 177569
4050 Å	B	N= 81119
5235 Å	V	N= 78160

No. Common to AKARI-MIR :
1321 sources (r = 5”)