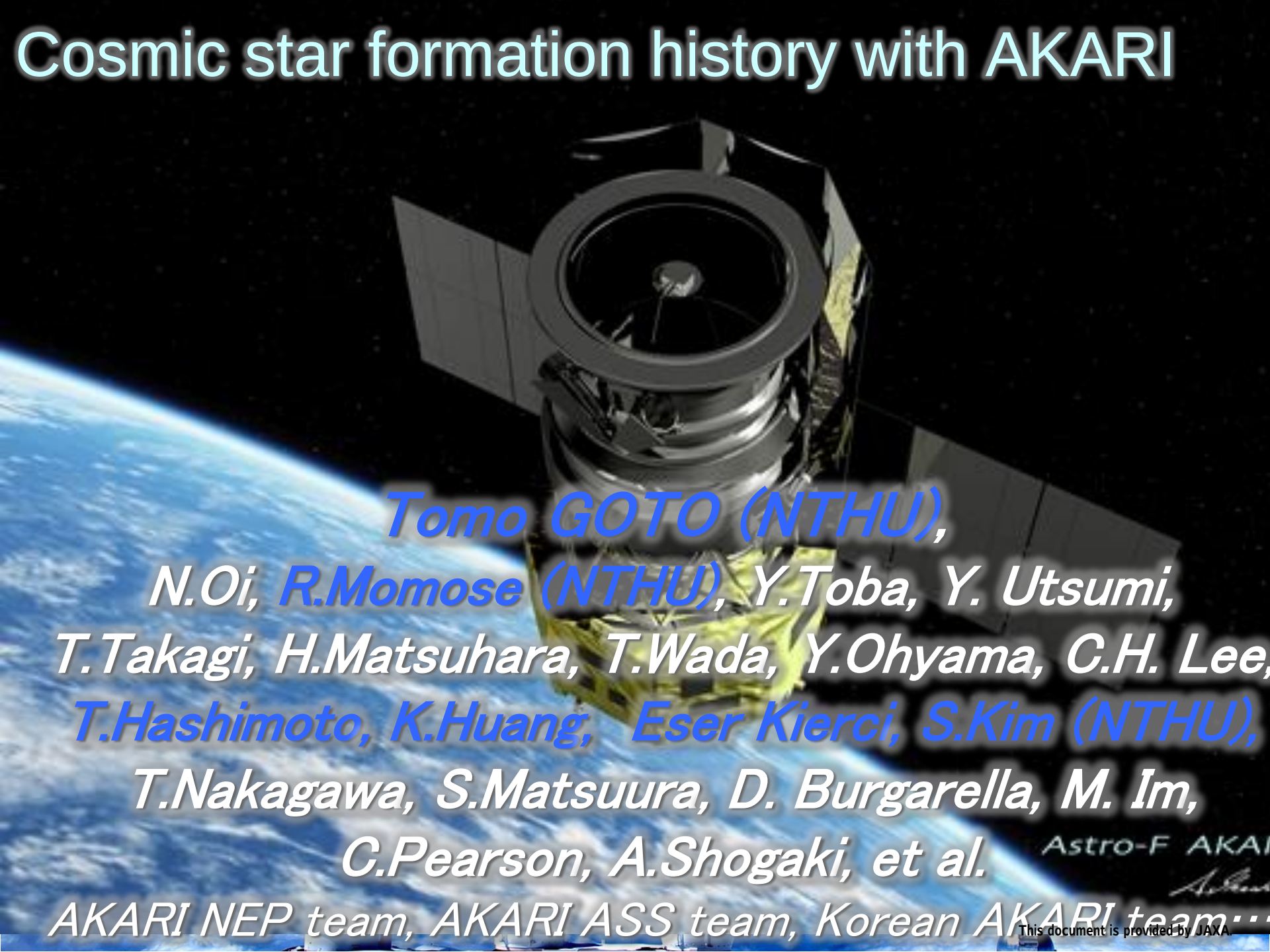
Cosmic star formation history with AKARI



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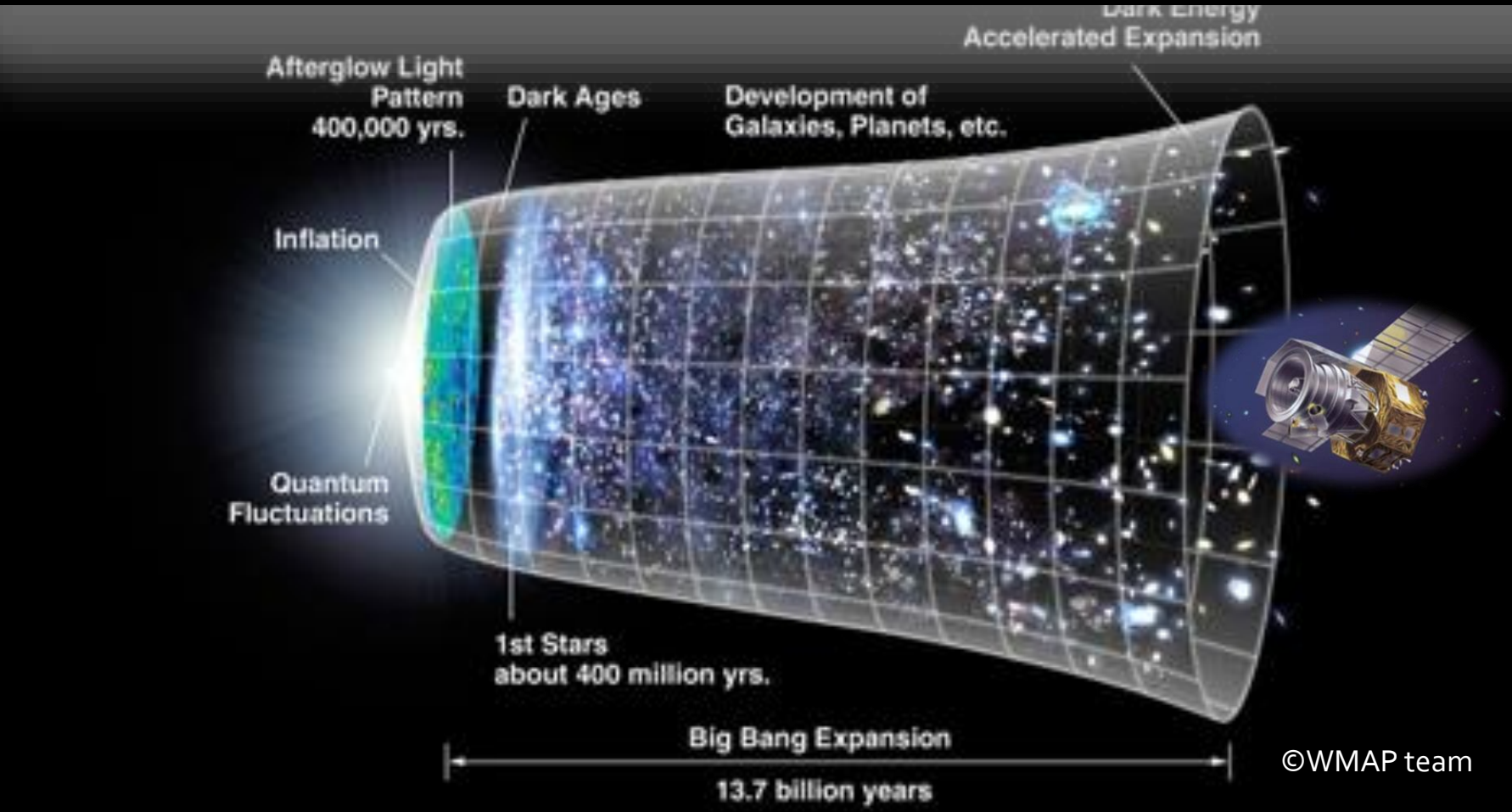
N.Oi, R.Momose (NTHU), Y.Toba, Y. Utsumi,
T.Takagi, H.Matsuhara, T.Wada, Y.Ohyama, C.H. Lee,
T.Hashimoto, K.Huang, Eser Kierci, S.Kim (NTHU),
T.Nakagawa, S.Matsuura, D. Burgarella, M. Im,
C.Pearson, A.Shogaki, et al.
AKARI NEP team, AKARI ASS team, Korean AKARI team…

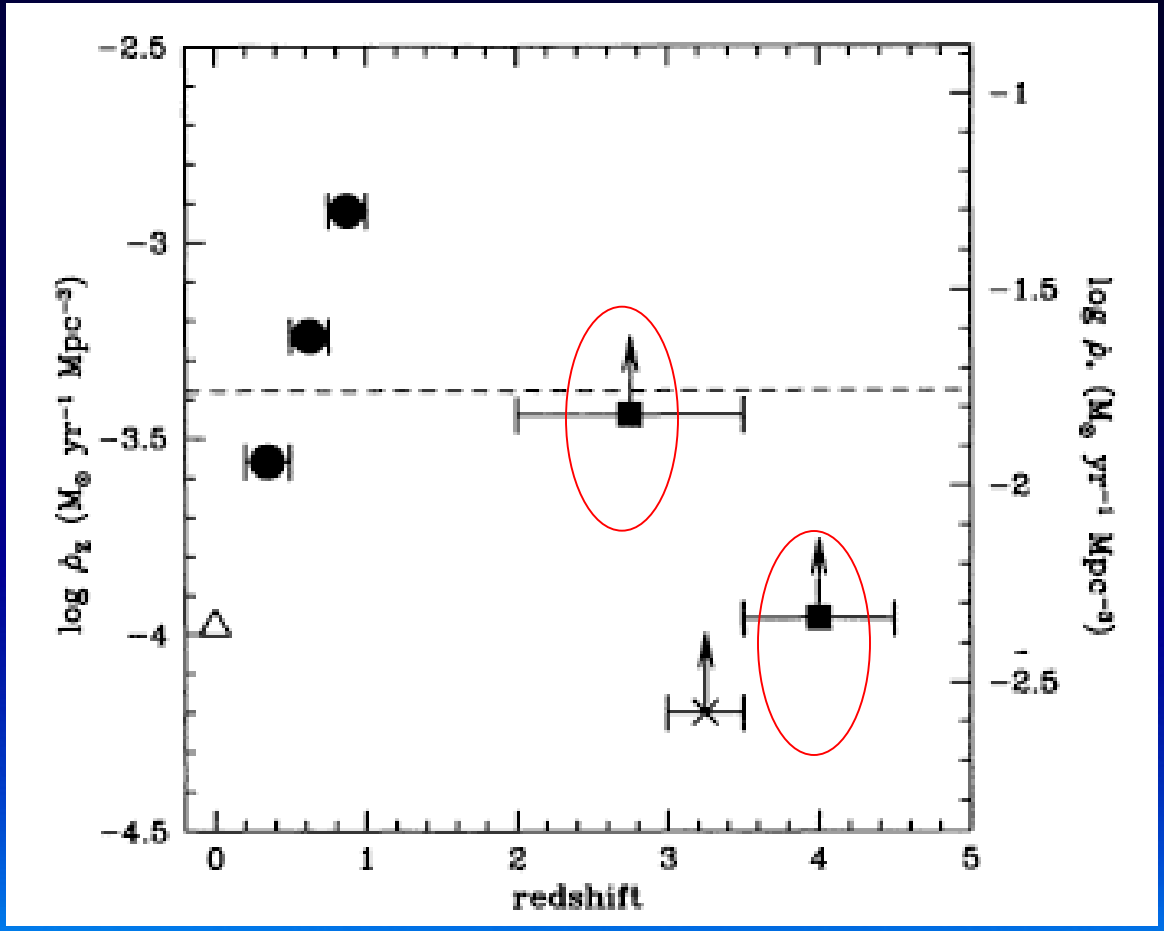
When and where stars/AGN were born?



©WMAP team

We want to reveal cosmic star formation history.

Understanding star formation history of the Universe is one of the major goals, however…



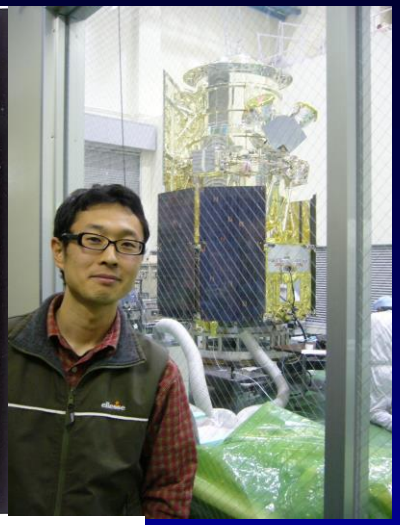
Madau et al. (1996)
Lilly et al. (1996)

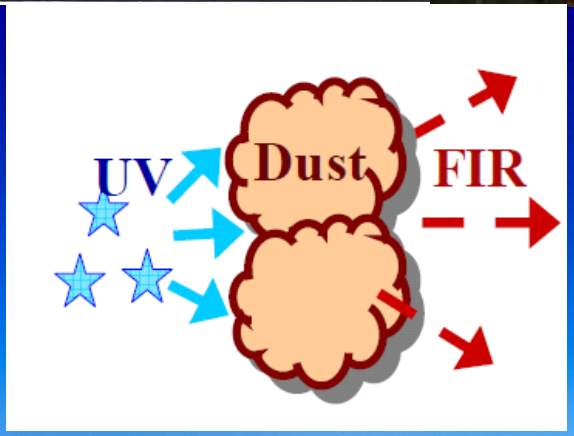
UV estimates are lower limits.

At z～1, 80% of SF is obscured by dust. (Takeuchi+2007)

How do we measure obscured star formation?

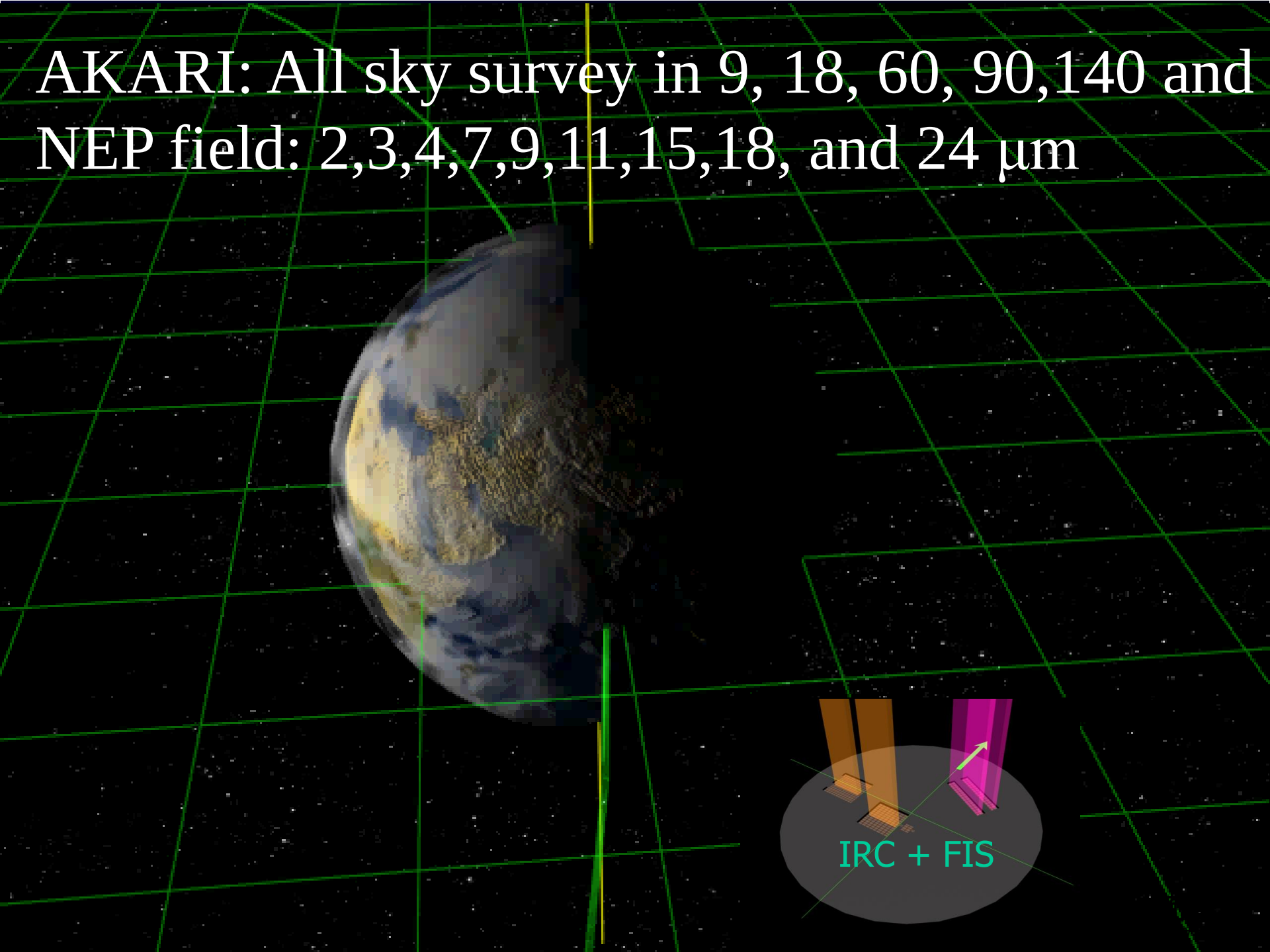
AKARI infrared telescope can probe dusty star formation

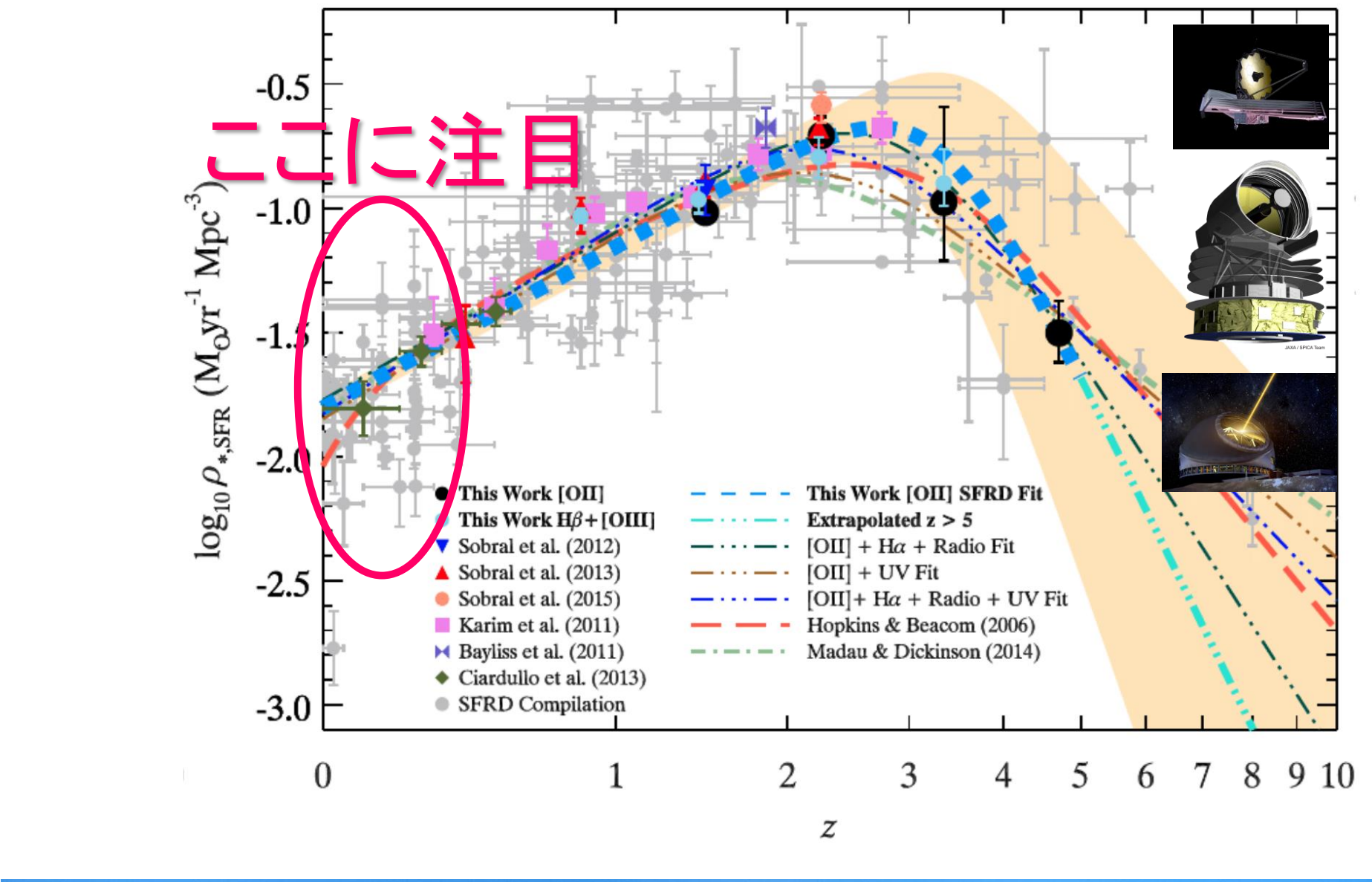




To observe infrared, we need a space telescope. ➙AKARI

AKARI: All sky survey in 9, 18, 60, 90,140 and
NEP field: 2,3,4,7,9,11,15,18, and 24 μm





What AKARI can do

JWST, SPICA, TMT, ELT…
They all need local benchmark to study evolution

→AKARI ASS can do best!

The Infrared Luminosity Function of AKARI 90μm Galaxies in the Local Universe

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Accepted XXX. Received YYY; in original form ZZZ

RACT

red (IR) luminosity functions (LFs) are necessary benchmarks for high-
alaxy evolution studies. Any accurate IR LF evolution studies require
urate local IR LFs.

nfrared galaxy LFs at redshifts of $z \leq 0.3$ from *AKARI* space tele-
rmed an all-sky survey in six IR bands (9, 18, 65, 90, 140 and 160
better sensitivity than its precursor **IRAS**. Availability of 160 μm
portant in accurately measuring total IR luminosity of galaxies,
peak of the dust emission. By combining data from Wide-field
plorer (*WISE*), Sloan Digital Sky Survey (SDSS) Data Release 13
ield Galaxy Survey (6dFGS) and **the 2MASS Redshift Survey**
ted by a factor of **7** larger sample of **15,638** local IR galaxies with
shifts. After carefully correcting for volume effects in both IR and
ined IR LFs agree well with previous studies, but comes with much
Measured local IR luminosity density is $\Omega_{IR} = 0.63 \pm 0.03 \times 10^8 L_\odot$
e contributions from luminous infrared galaxies and ultra luminous in-
laxies to Ω_{IR} are very small, **6.0 percent and 0.4 percent**, respectively.
exists no future all sky survey in far-infrared wavelengths in the foreseeable
future. The IR LFs obtained in this work will **therefore** remain an important bench-
mark for high-redshift studies for decades.

Local IR LF
from AKARI all sky survey(9,18,65,90,140,169μm)

Previous local IR LF (Sanders+03) :

IRAS is only up to 100μm, missing the peak of dust emission.

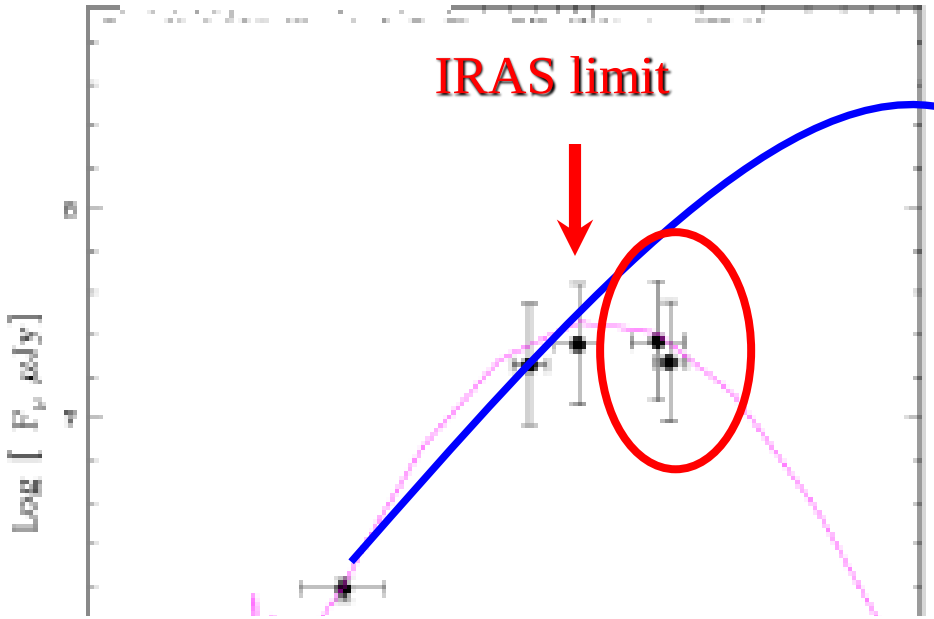
AKARI reaches 160μm,

Better measurement of L_{TIR}

Revised Bright Galaxy Sample(Sanders+03):

a complete sample of 629 galaxies with spec-z at S_{60}>5.24Jy

SED fit



160μm is critical!

AKARI is the only satellite to provide 160μm to all sky.

160μm is critical to accurately measure L_{IR}.

Figure 2. An example of the SED fit. We fit the AKARI 6-band photometry to the SED model of Chary & Elbaz (2001) to estimate L_{TIR}.

600 galaxies, too few!

⇒15,000 galaxies with AKARI
(データーアーカイブのパワー)

Far infrared from AKARI

DARTS Astrophysics

Hitomi | MAXI | SUZAKU | ASCA | GINGA | TENMA | AKARI | IRTS | BICE | HALCA

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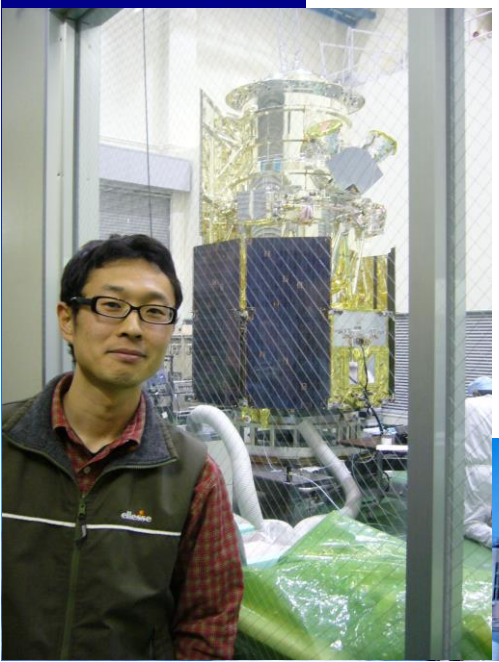
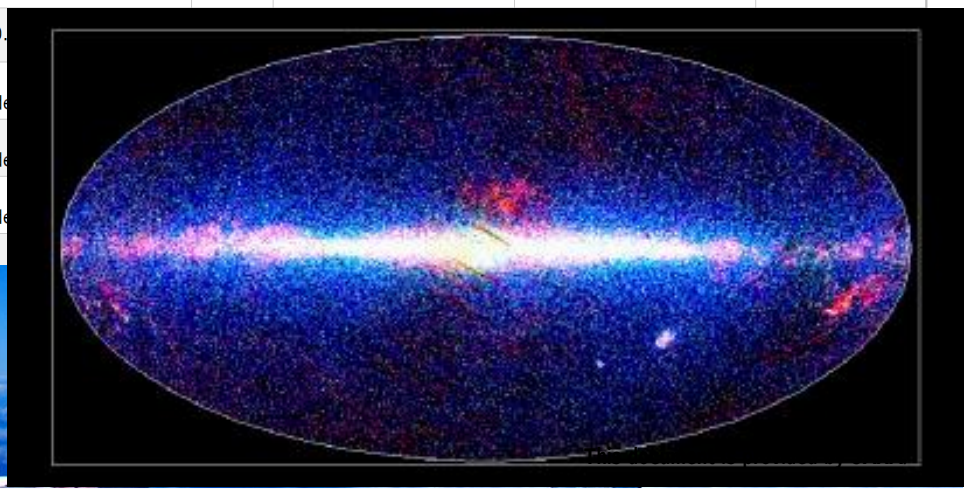
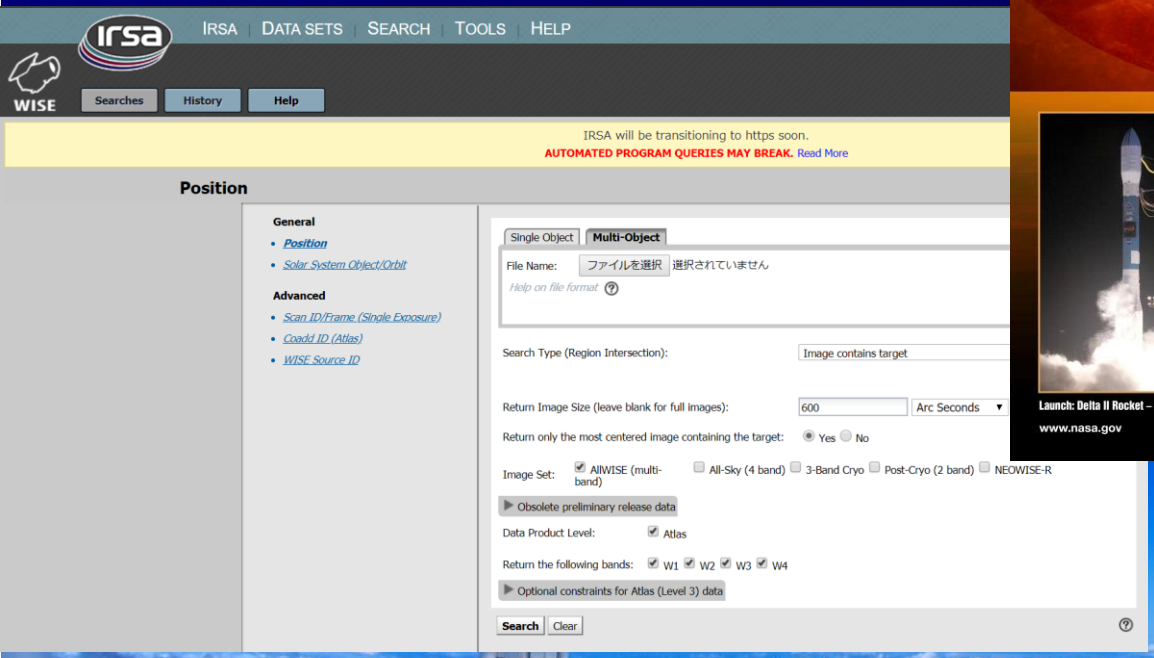
No.	SELECT	QL	DL	FITS_NAME	BAND	MAP REFERENCE POINT RA(Equatorial J2000)	MAP REFERENCE POINT DEC(Equatorial J2000)	DISTANCE(deg.)
1	☑		DL	l079.99_b-25.00_ecl_6deg_N60	N60	80.936	-1.875	4.545
2	☑		DL	l080.83_b-30.00_ecl_6deg_N60	N60	82.009	-6.815	2.297
3	☑		DL	l085.51_b-25.00_ecl_6deg_N60	N60	85.931	-1.624	4.315
4	☑		DL	l086.60_b-30.				
5	☑		DL	l079.99_b-25.00_ecl_6de				
6	☑		DL	l080.83_b-30.00_ecl_6de				
7	☑		DL	l085.51_b-25.00_ecl_6de				
8	☑		DL	l086.60_b-				

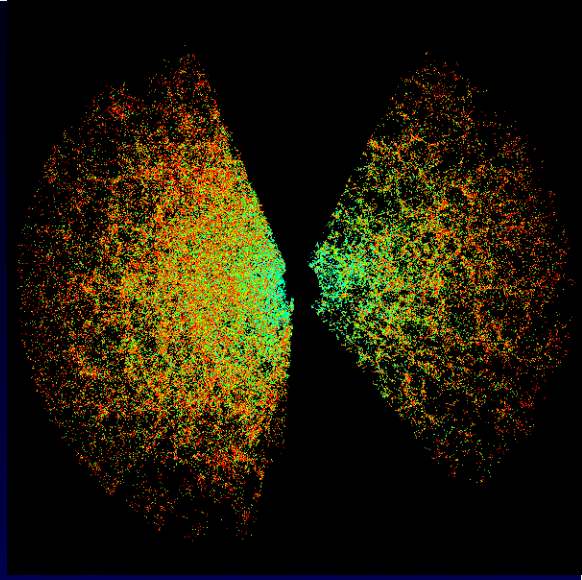




WISE mid infrared



Specz from SDSS



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( ) Spectra (SpecObj)	(•) Nearest Primary Spectrum ( ) Nearest Spectrum ( ) All Nearby Primary Spectra ( ) All Nearby Spectra	(•) RA, dec ( ) plate-MJD-fiberID	[ ] Images
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name  ra      dec
A1    15.5    0.5
A2    14.5    0.6
A3    13.9    0.8
```

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SELECT
   p.objID, p.ra, p.dec, p.run, p.rerun, p.camcol, p.field,
   dbo.fPhotoTypeN(p.type) as type,
   p.modelMag_u, p.modelMag_g, p.modelMag_r, p.modelMag_i, p.modelMag_z
FROM #upload u
      JOIN #x x ON x.up_id = u.up_id
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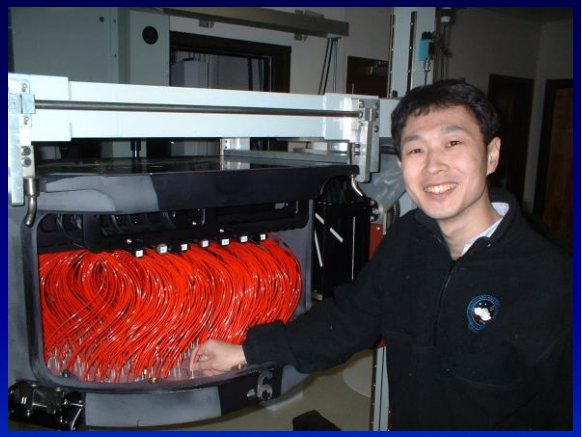
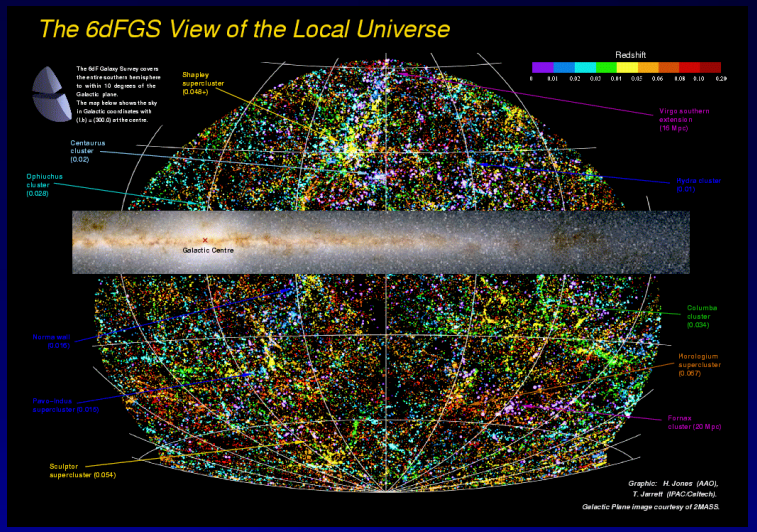
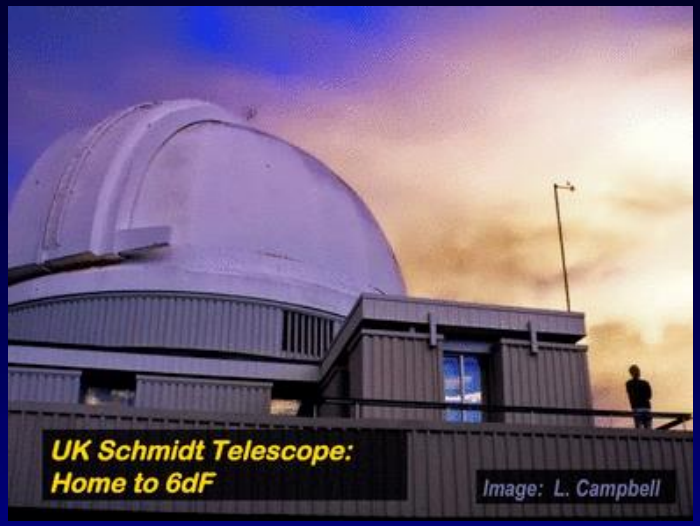
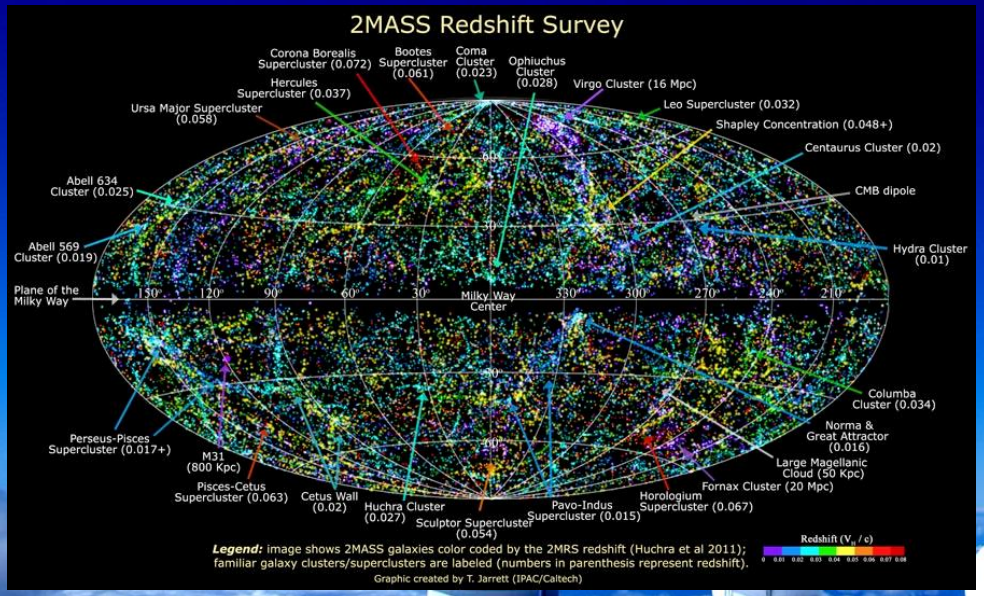


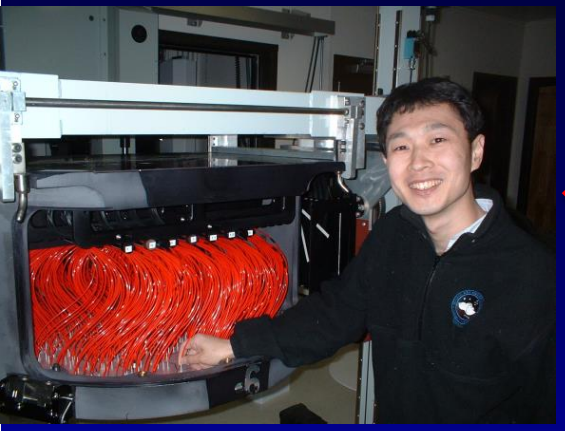
Further spec-z from 6dF and 2MRS



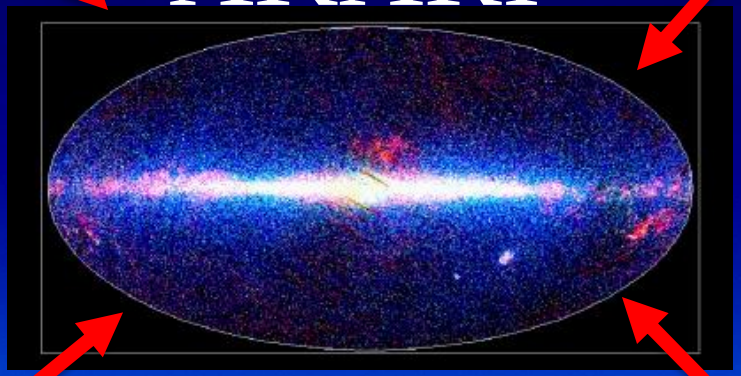




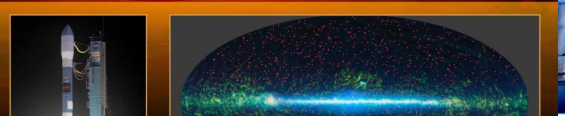
AKARI+SDSS+WISE+2MRS+6dF ⇒15000 galaxies



AKARI



15000 galaxies



Huge statistical improvements: 15,638 local galaxies with spec-z x20 larger than Sanders+03 (#629)

This work

	$N_{galaxies}$	area (deg^2)
$AKARI_{ver2}$+WISE +$SDSS_{DR13}$+6dF+2MRS	**15638**	**37000**
Goto+11($AKARI_{ver1}$+$SDSS_{DR7}$)	x20 2357	10000
Sanders+03	629	

→Power of archives.

L_{TIR}

$$L_{TIR}(L_\odot) \equiv 4.93 \times 10^{-22}[13.48L_\nu(12\mu m) + 5.16L_\nu(25\mu m) + 2.58L_\nu(60\mu m) + L_\nu(100\mu m)](ergs^{-1}Hz^{-1})$$

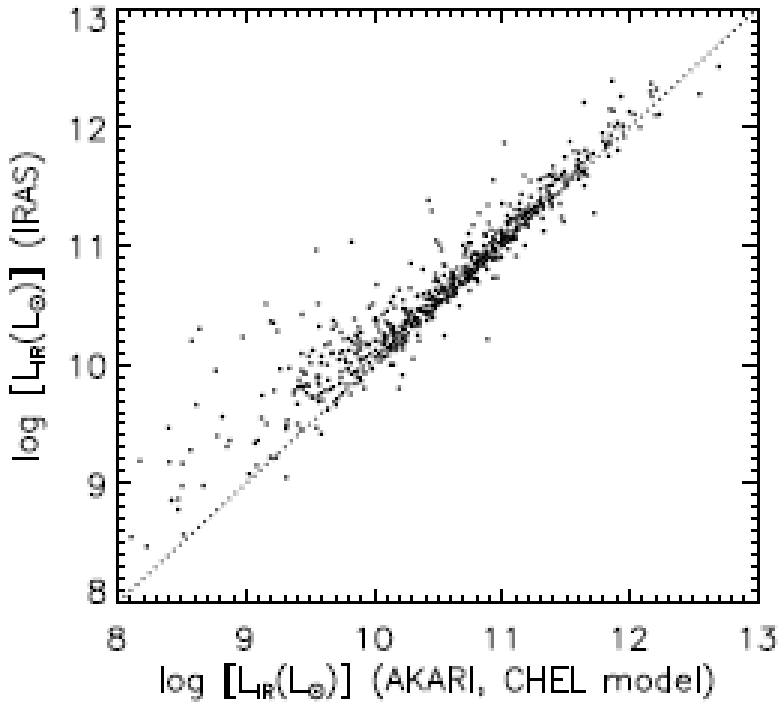


Figure 3. L_{TIR} measured by the AKARI is compared with those measured by the IRAS (Eq.1) for the RBGS.

AKARI can better resolve cirrus, nearby sources(Jeong+07).

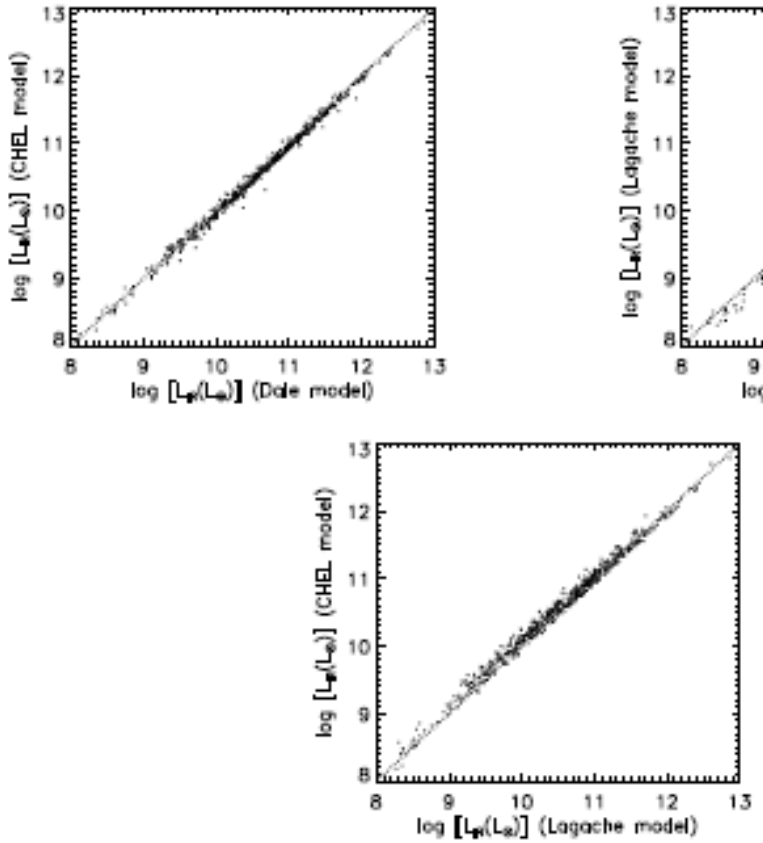


Figure 4. Comparing L_{TIR} measured using three different SED models (Chary & Elbaz 2001; Dale & Helou 2002; Lagache, Dole, & Puget 2003). Scatter and offsets between the models are summarized in Table 1.

Models agree well, within 24%, thanks to FIR bands.

c.f. factor 2-5 with only MIR

Table 1. Comparison of L_{TIR} estimates with different SED models (Chary & Elbaz 2001; Dale & Helou 2002; Lagache, Dole, & Puget 2003). Fig.4 presents corresponding plots.

Models	σ (%)	Offset (%)
CHEL vs IRAS	44	-23
Dale vs Lagache	24	24
Dale vs CHEL	10	11
Lagache vs CHEL	22	-13

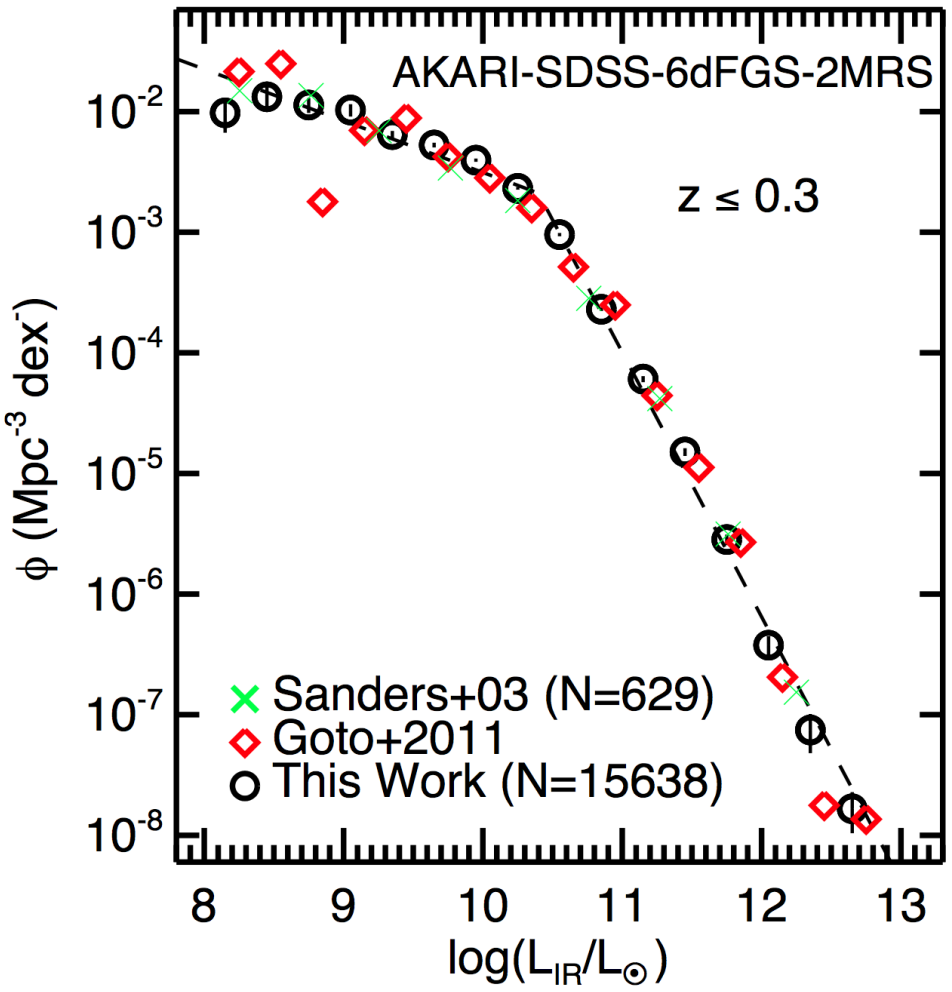


Figure 3. The IR LF of **15638** ***AKARI*–SDSS–6dFGS–2MRS** galaxies (open circles). The best-fitting double power law is shown as dashed line. For comparison the total IR LF derived from the *IRAS* RBGS is shown (crosses Sanders et al. 2003). The red diamonds are the $1/V_{max}$ data points of the RBGS sample adopted from Goto et al. (2011a).

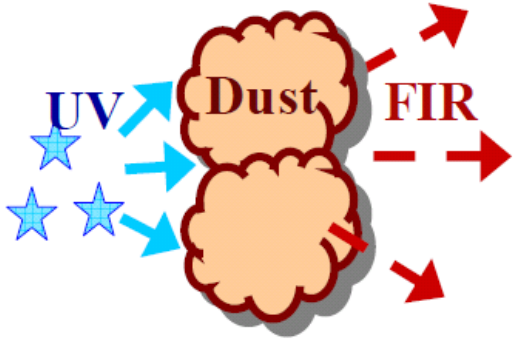
The best local infrared Luminosity Functions!

- $\Omega_{TIR}=6.3\pm0.3\times 10^{7}L_{sun}$
- 6.0% by LIRG,
- 0.4% by ULIRG

What about Star Formation History?

IR luminosity density (Ω_{IR})
= LF x luminosity integrated.

Ω_{IR} = SFR/AGN density

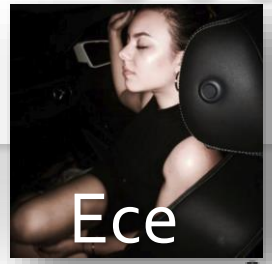


$$SFR(M_\odot\ \mathrm{yr}^{-1}) = 1.72 \times 10^{-10}\ L_{\mathrm{TIR}}(L_\odot)$$

Kennicutt+98

Cosmic star formation history

all by AKARI



No all sky FIR survey in the future.

→ AKARI's local data stay the best for decades!

（あかりとデーターアーカイブに感謝）