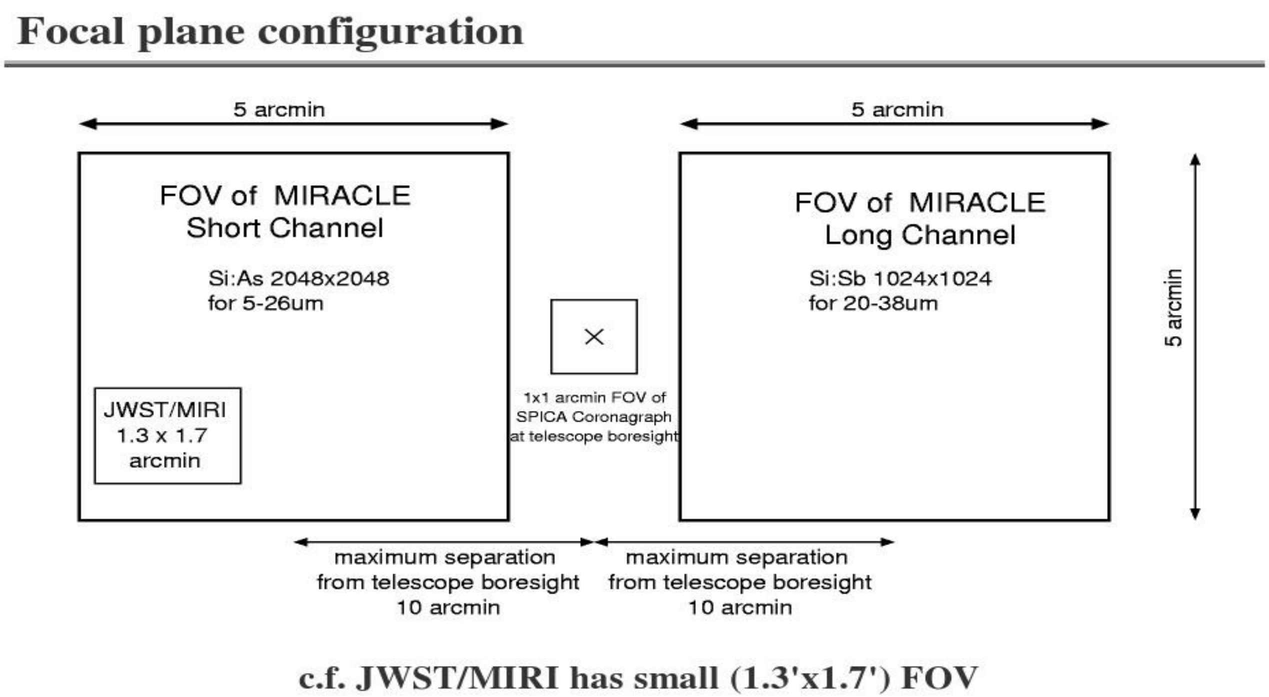
MIRACLE imaging proposal



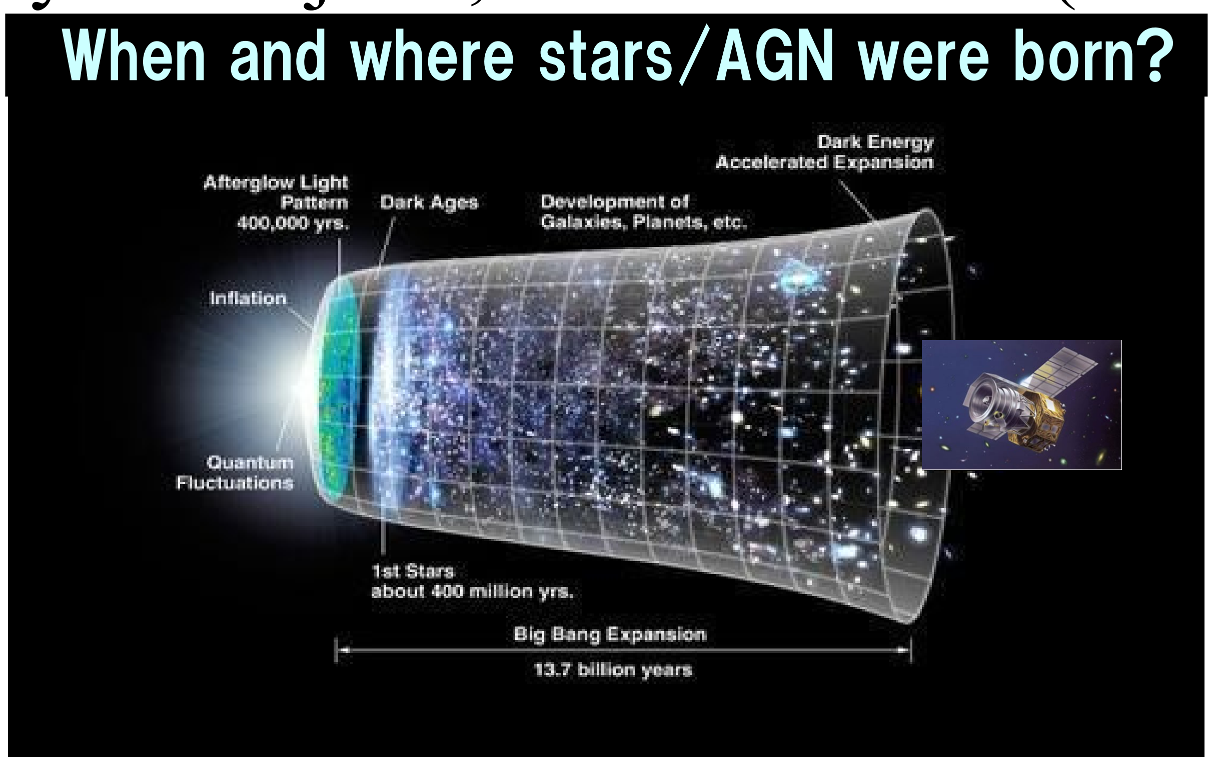
5-35μm image/spectroscopy, 5'x5' Fov

T. Goto, T.Wada, Matsuhara, Oyabu, Tsumura, Koyama, Egami, and many others

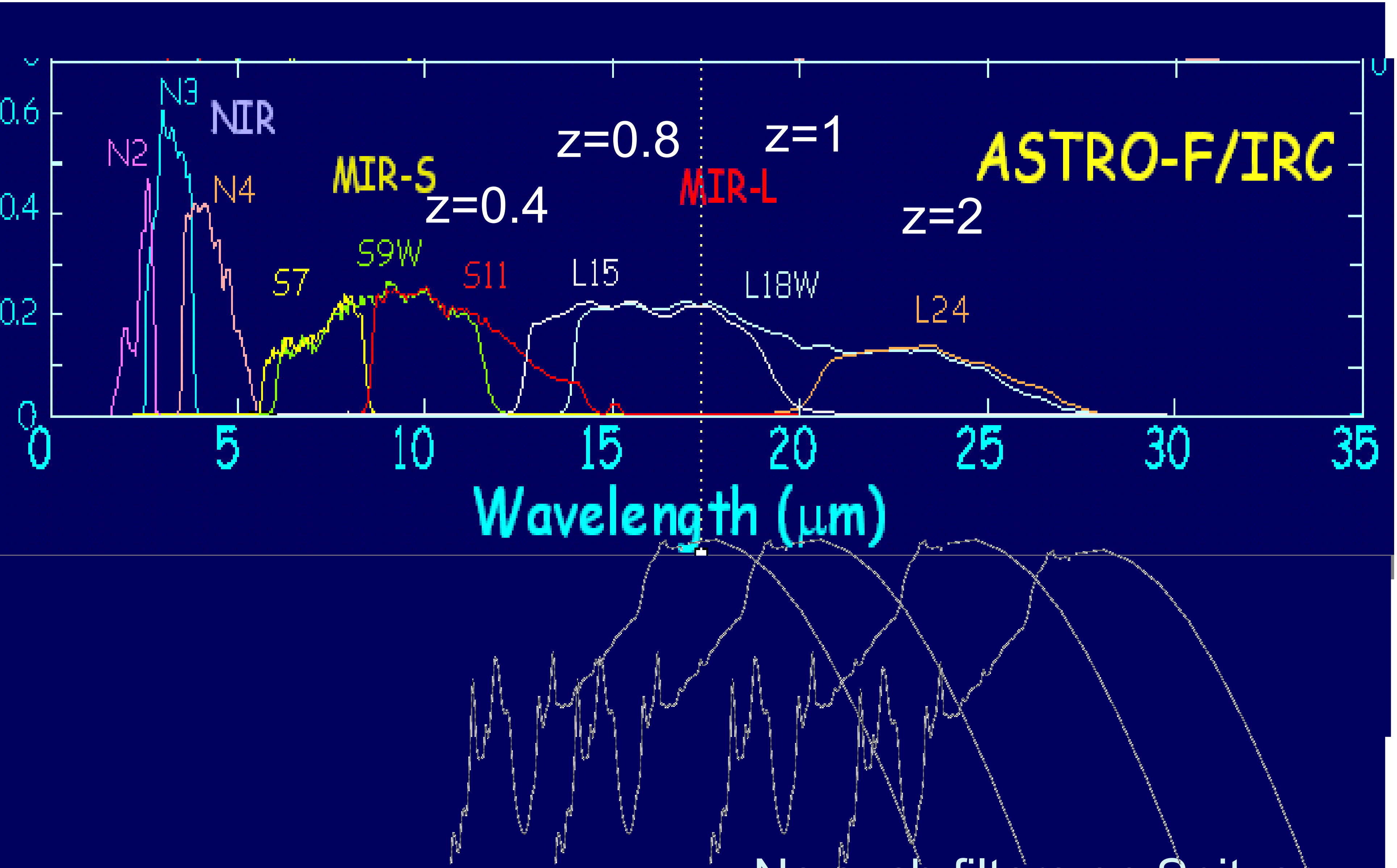
Lessons from AKARI/IRC:

AKARI/IRC has unique, continuous filters in mid-IR.

- Evolution of restframe 8μm LF
- **Cosmic star formation/BH accretion history**
- PAH emission in cluster (Koyama+2010)
- Understanding nature/evolution of PAH (Takagi+2010)
- Extremely red objects, obscured AGN (Matsuhara et al.)

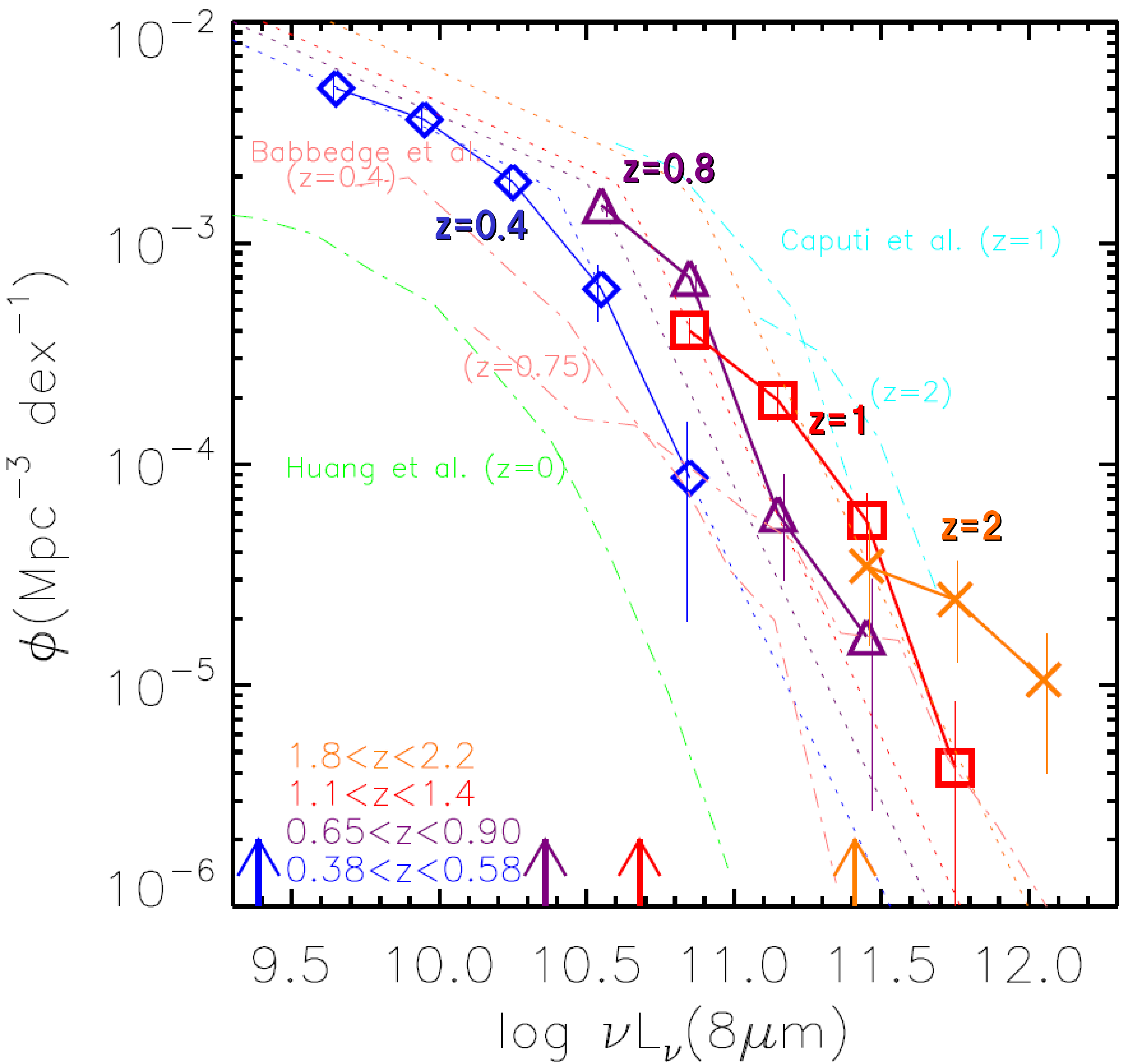


AKARI MIR filters can trace $L_{8\mu m}$ evolution without using extrapolation from SED models



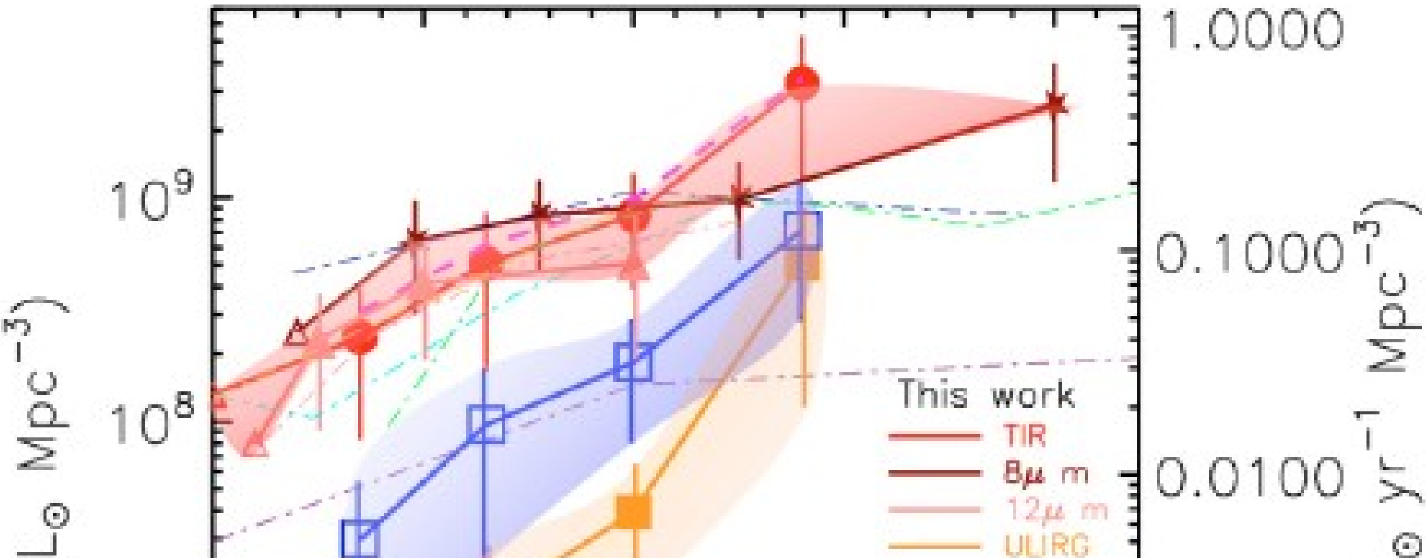
No such filters on Spitzer.

8 μm LF (via Vmax, completeness correction)



- Continuous & strong evolution
- Larger than Babbedge+, smaller than Caputi+
- **No SED extrapolation like Spitzer. (largest uncertainty).**

Cosmic star formation history
(Goto et al. 2010)



circles), 8 μm LFs (stars), and 12 μm LFs (filled triangles). The blue open
so based on our L_{TIR} LFs. Overplotted dot-dashed lines are estimates from
nzález et al. (2005), Caputi et al. (2007), and Babbedge et al. (2006) are in
ed line shows UV estimate by Schiminovich et al. (2005). The pink dashed
al. 2005).

SFRD was x20 at z=2

Continuous increase to z=2

$\Omega_{IR}/\Omega_{IR}+\Omega_{UV}$ >0.9 at z=1.3,

...rtant for SFRH.

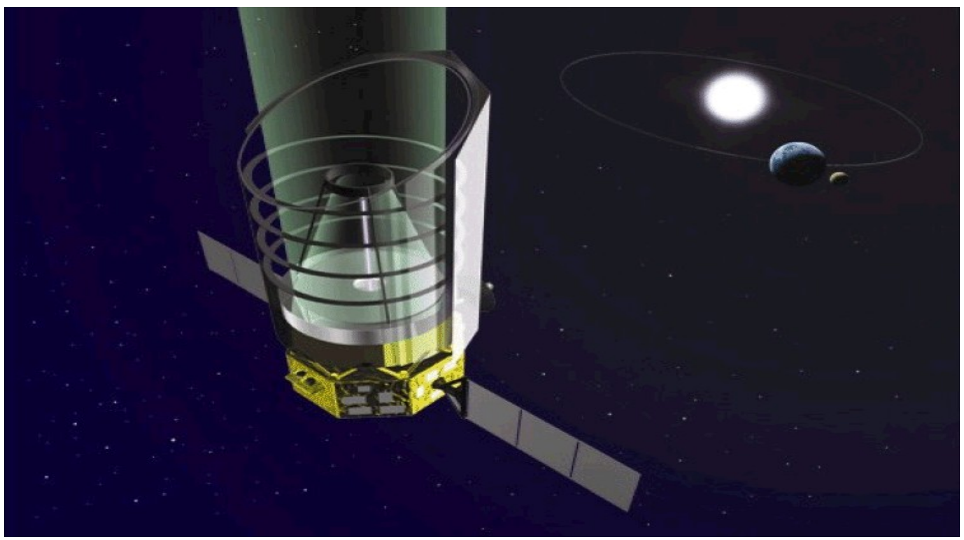
Not hampered by dust.

AKARI was later,
but had unique features over Spitzer.

歴史は繰り返される、、、

AKARI was later, but had unique features over Spitzer.

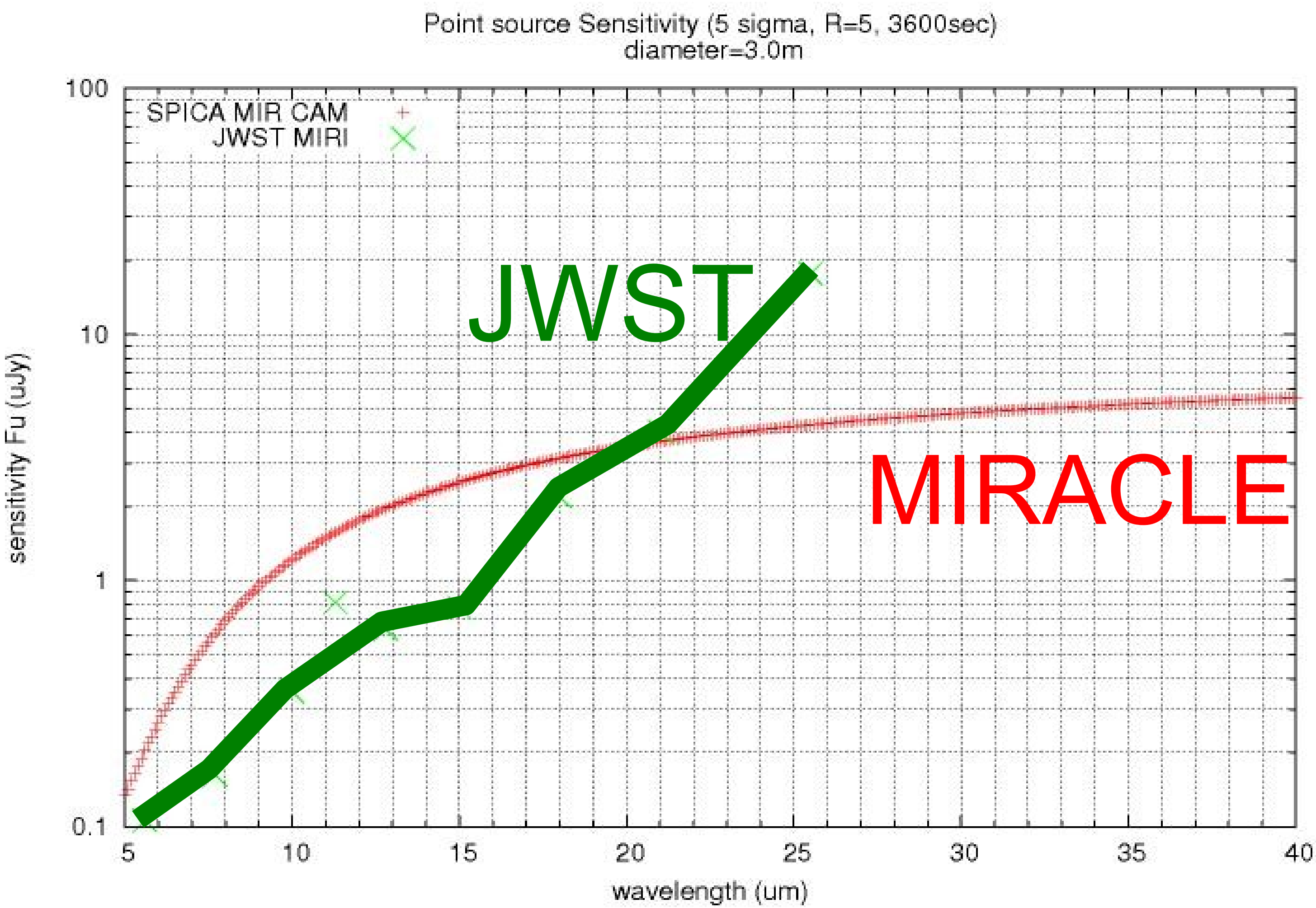
MIRACLE vs JWST/MIRI



2018 launch, 3m

2014 launch, 6.5m

Conparison with JWST/MIRI: sensitivity

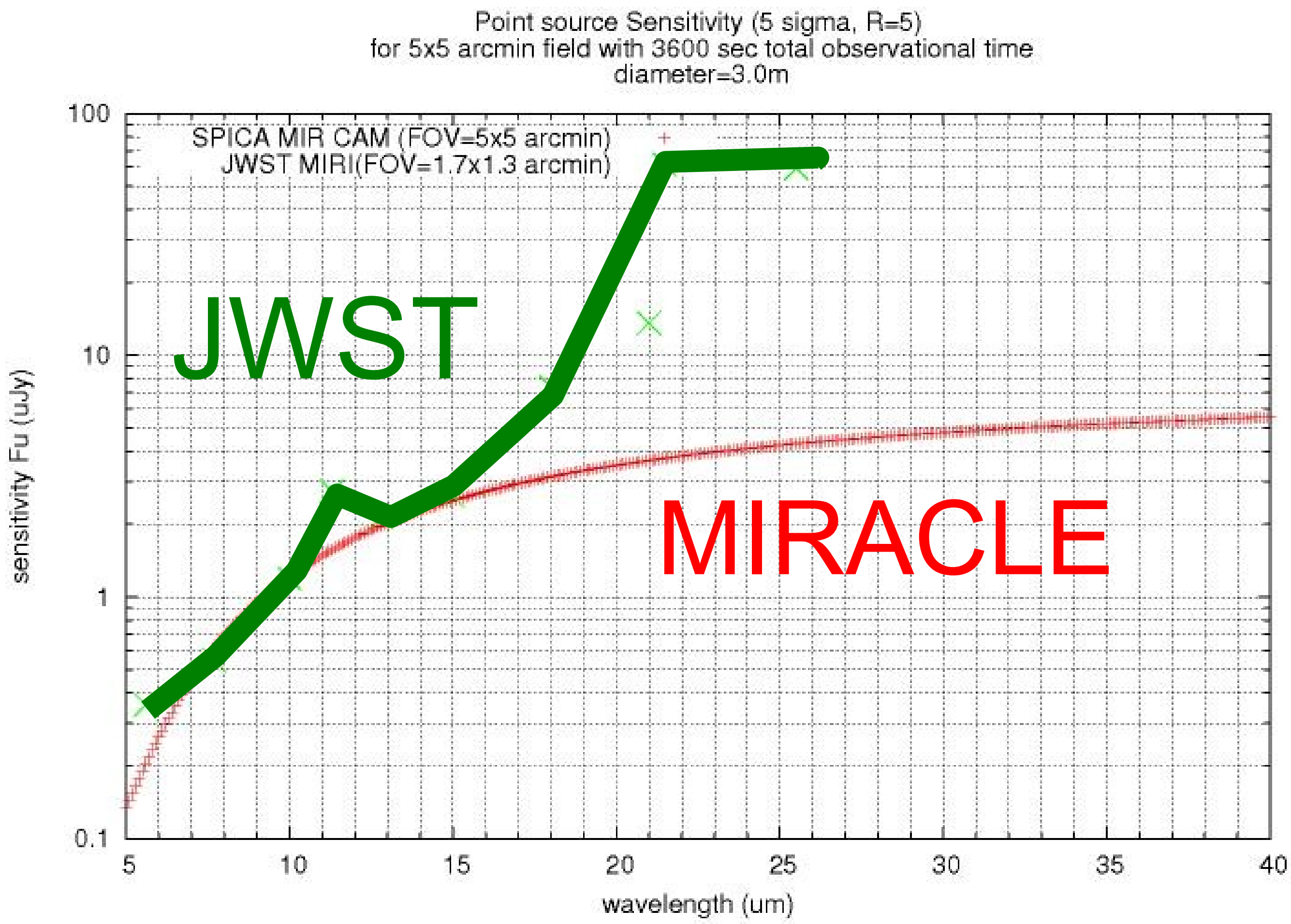


better sensitivity than JWST/MIRI over 20um
Advantage of cryogenic telescope!

At <20μm, JWST is more sensitive. However,
Fov. JWST/MIRI: 1.7’x1.3’ vs SPICA/MIRC:5’x5’

MIRACLE vs. JWST: survey speed

Conparison with JWST/MIRI: Survey speed

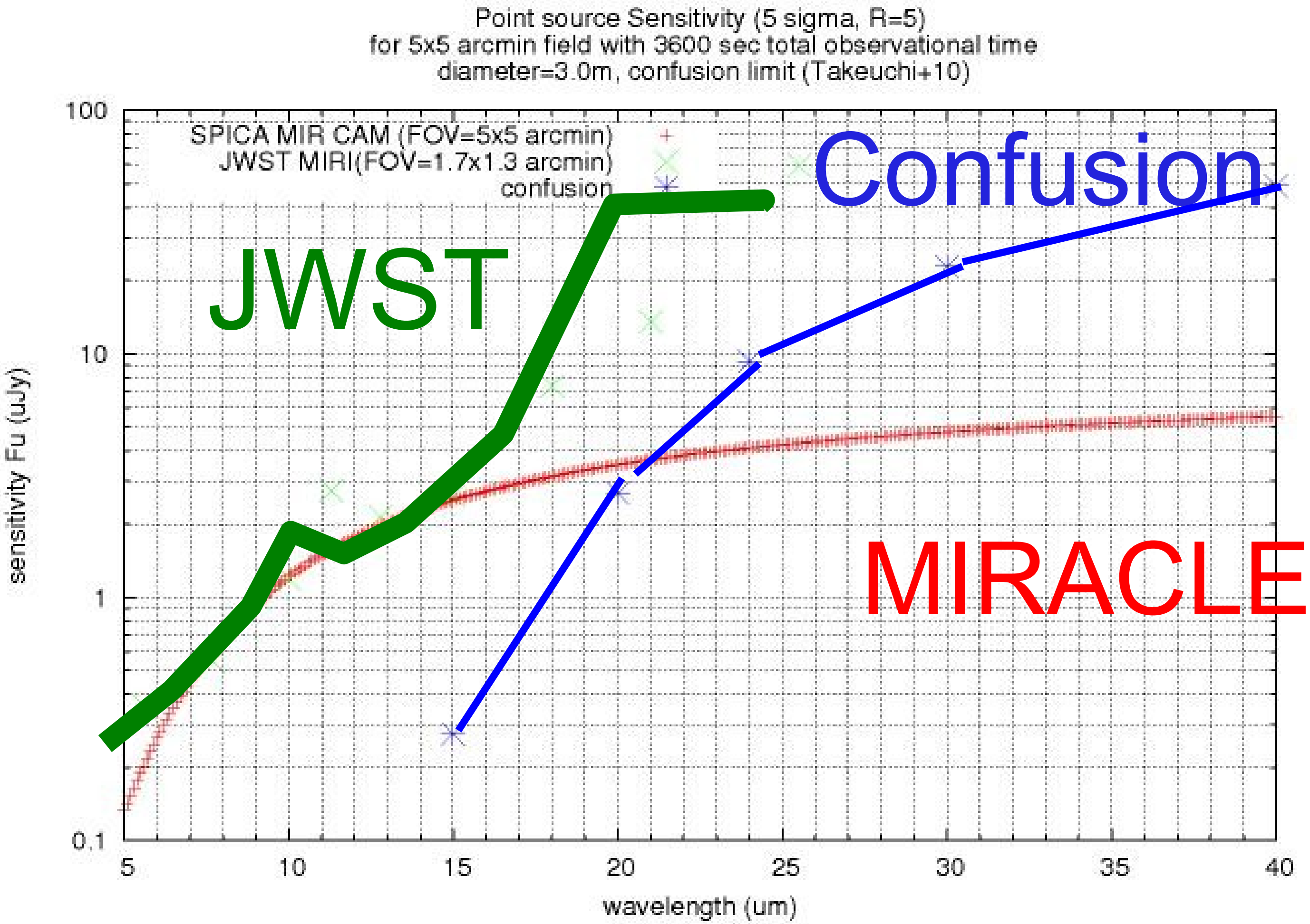


same or faster mapping speed than JWST/MIRI in all band

Advantage of a wider field of view!

- At <20μm, the survey speed is comparable to JWST. (but JWST launch in 2014)

Confusion limit dominates at 20-35μm, where MIRACLE is more sensitive than JWST.



(Takeuchi et al. 2010)

- **MIRACLE may reach confusion limit in a few minites at 30um.**
- **The result tightly depends on models.**

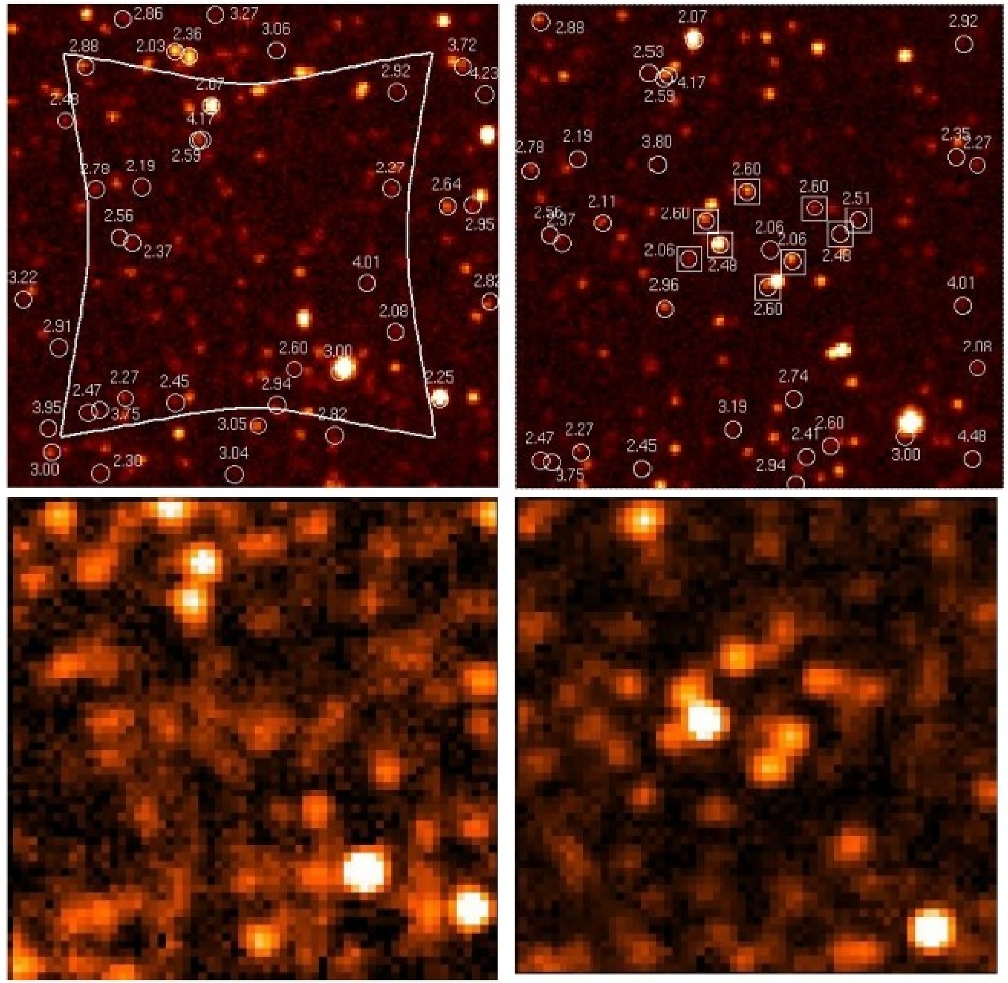
How do we overcome confusion limit?

Herschel Simulated Images of massive cluster cores

PACS 100um

SPIRE 250um

Without lensing



7'x7'

Squares - m>5

With lensing

Clusters act as transparent lens

c. Egami

lower source density, + magnification

⇨ Lensing eases confusion.

SPICA/MIRACLE survey strategy

At <20μm, JWST always wins.

-Concentrate on >20μm, confusion limited survey.

Confusion limited at >20μm.
-target lensed cluster as well, for confusion & magnification

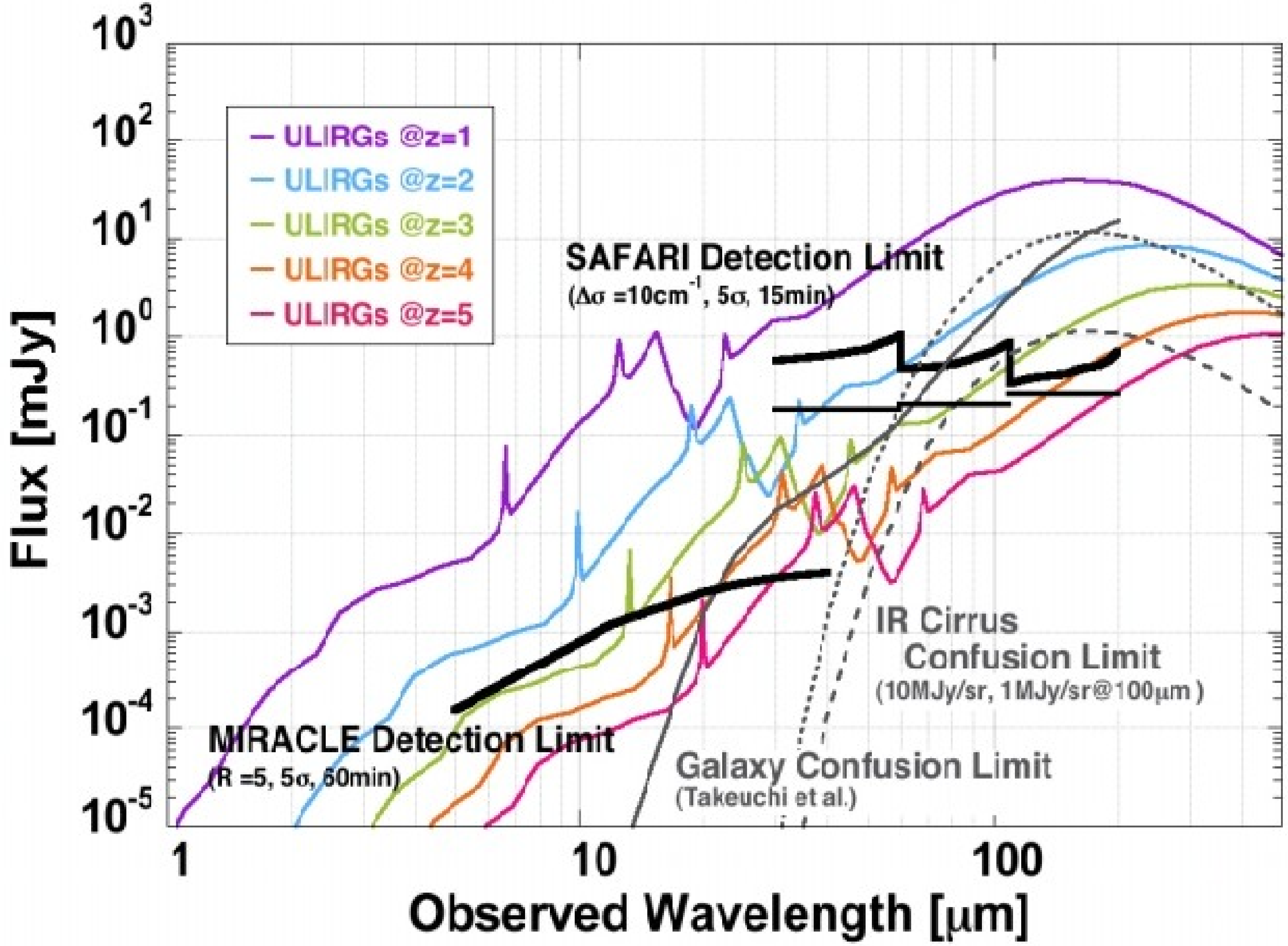
At 20-35μm, MIRACLE will be deepest.
-Science with PAH emission (~8μm), at $1.6<z<3.5$
-Direct extrapolation of AKARI/IRC NEP science to higher-z.

SPICA MIRACLE survey

- 1-2deg^2 to investigate cluster core to field (10^7Mpc^3 at z~3). (~72hr x N_{filter})
  - Existing ancillary data (COSMOS, HSC, JWST field)
- Lensing clusters (to overcome confusion limit. Flux boost. ~25 clusters/pointings c.f. HLS, HST/MST) (~13hr x N_{filter}), MACS MIRACLE
- MIRACLE S/L (5-35μm) ,FPC(1-5μm), efficient all filter imaging (parallel observing).
- SAFARI(35-200μm) FIR for bright sources.
  - Need to be low cirrus region (for >70μm,<1MJy/sr)
  - Source ID of SAFARI detections (z~3 obscured AGN...etc).
- Beats JWST at 20-35μm

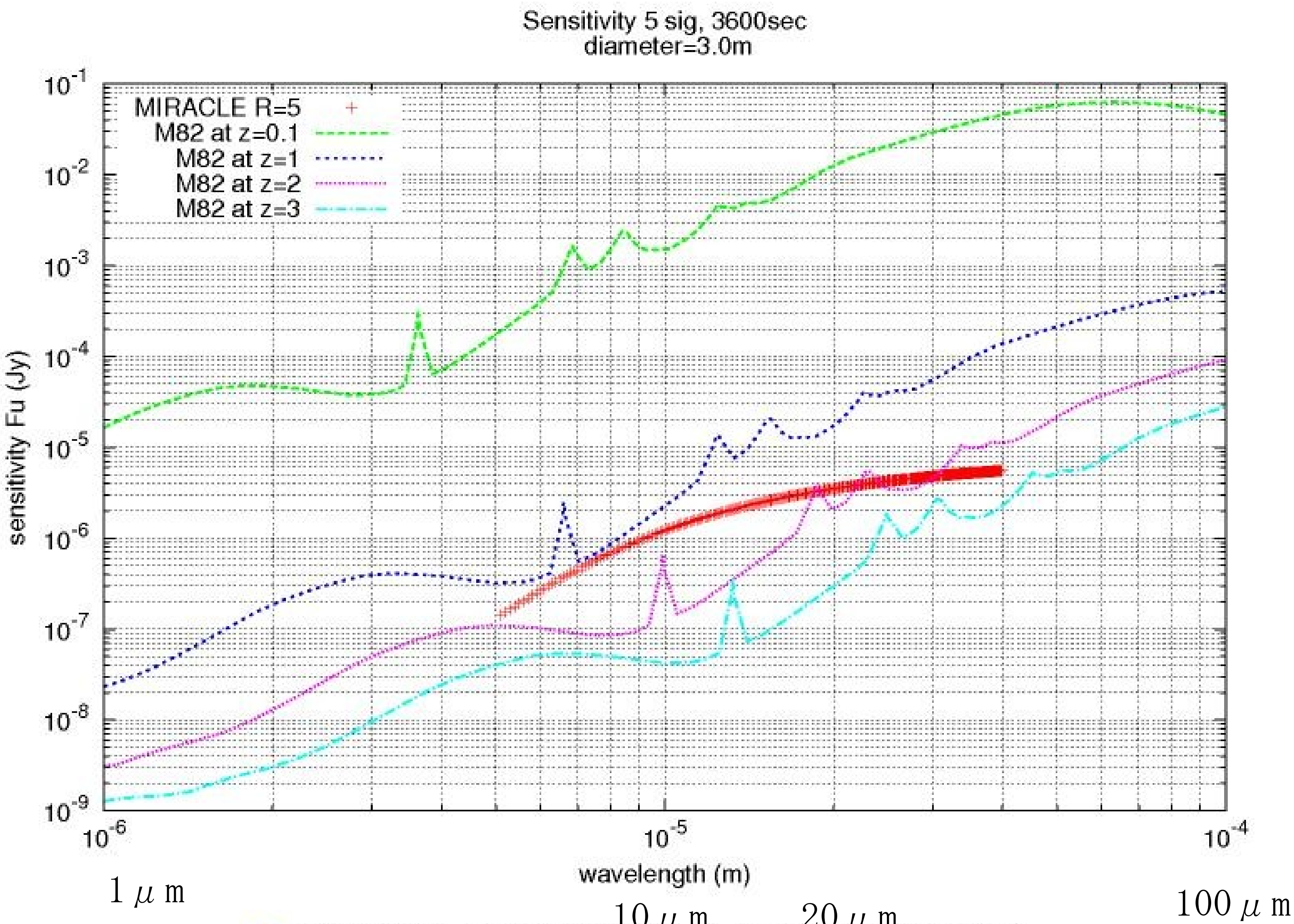
What can be detected?

ULIRG at z=4



ULIRGs @z=1
ULIRGs @z=2
ULIRGs @z=3
ULIRGs @z=4
ULIRGs @z=5
SAFARI Detection Limit
(Δσ =10cm-1, 5σ, 15min)
IR Cirrus
Confusion Limit
(10MJy/sr, 1MJy/sr@100μm)
MIRACLE Detection Limit
(R =5, 5σ, 50min)
Galaxy Confusion Limit
(Takeuchi et al.)
Flux [mJy]
Observed Wavelength [μm]
10^3
10^2
10^1
10^0
10^-1
10^-2
10^-3
10^-4
10^-5
1
10
100

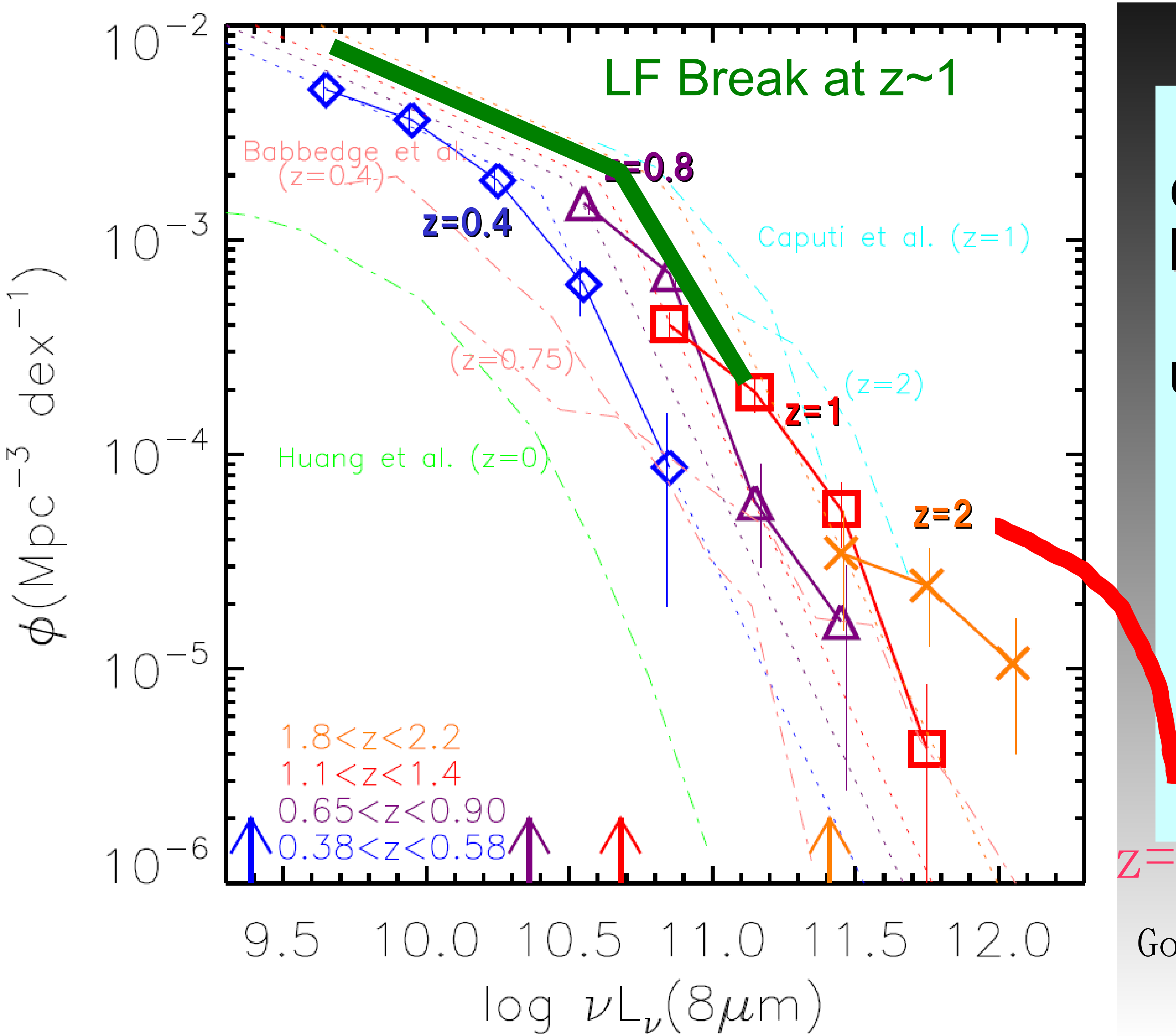
M82 (star-forming galaxy) to z~1



- **M82-like galaxies at z=1-2 can be detected.**

Example sciences

8 μm LF (via Vmax, completeness correction)



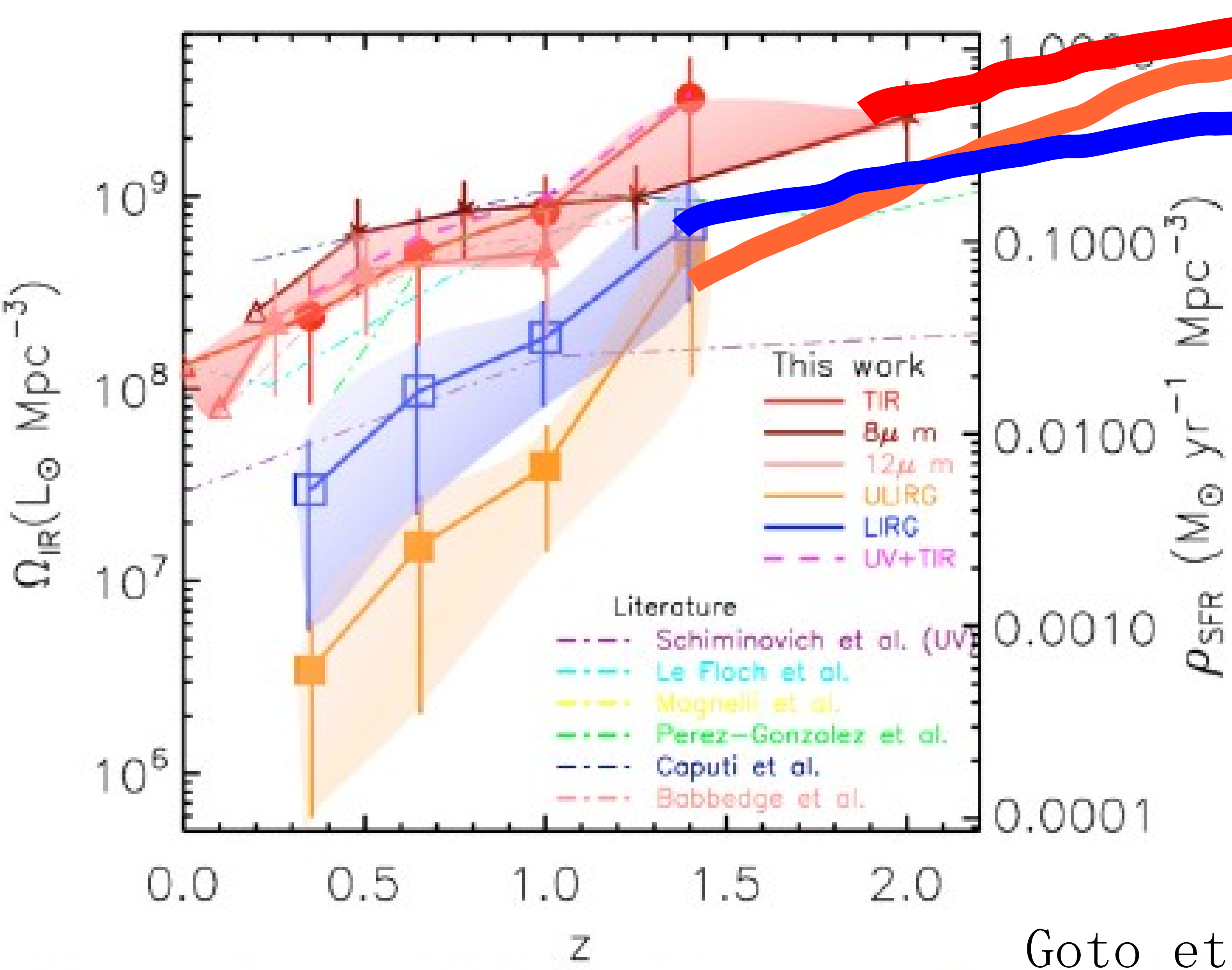
No SED extrapolation like Spitzer. (largest uncertainty).

z=3 by SPICA

Goto et al. 2010

Cosmic star formation history

z=3 by SPICA



Continuous increase to z=2

ULIRG contribution x10 larger by z=2

ΩIR/ΩIR+ΩUV >0.9 at z=1.3,

ΩIR is important.

ΩIR=(1+z)4.4±1.0

Goto et al. 2010

tion of TIR luminosity density based on TIR LFs (red circles), 8 μm LFs (stars), and 12 μm LFs (filled triangles). The blue open
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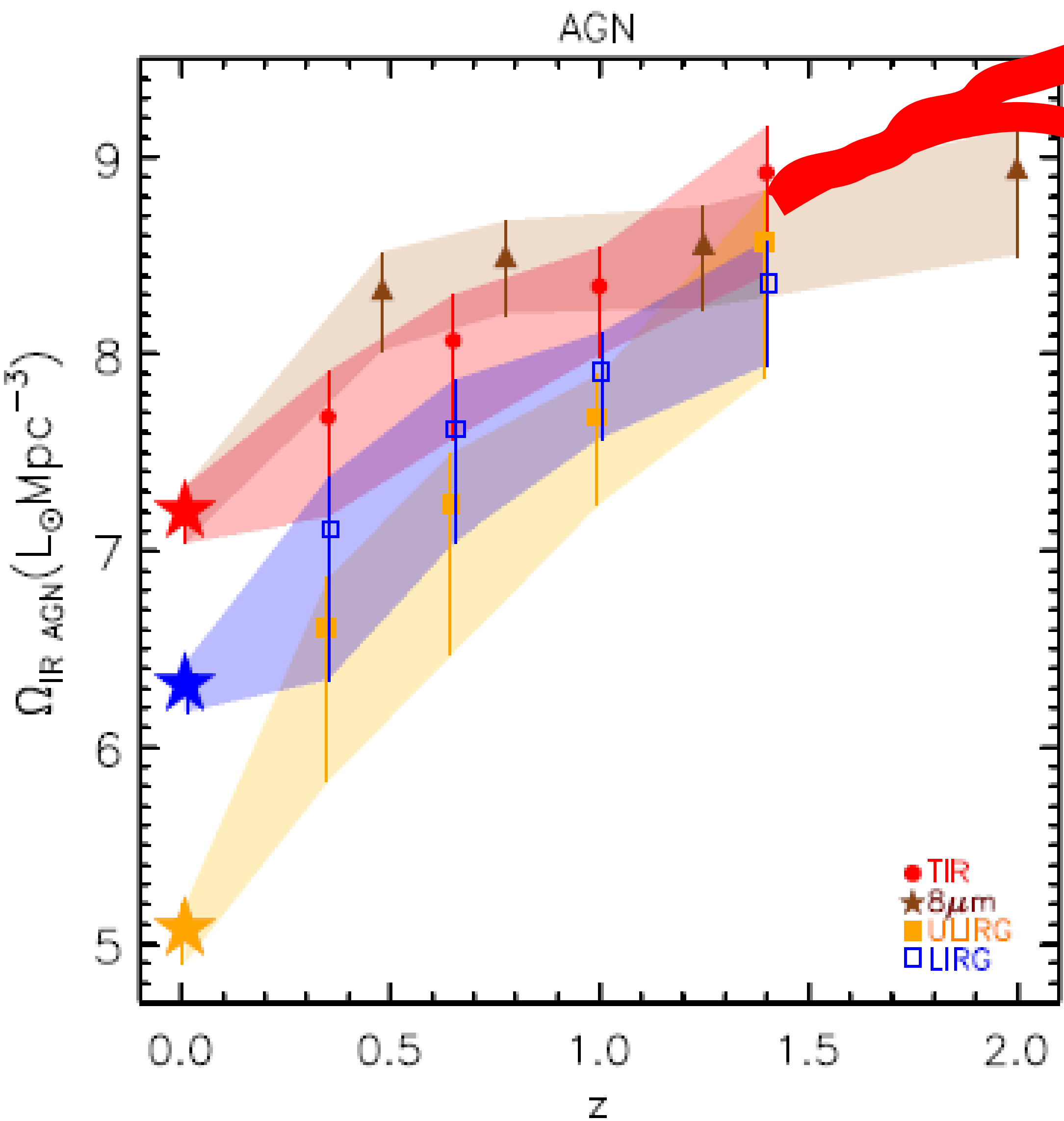
AGN evolution

z=3 by SPICA



Start to decline?

$$\Omega_{IR\ AGN} \propto (1+z)^{4.4\pm0.4}$$

$$\Omega_{ULIRG} > \Omega_{LIRG} \text{ at } z\sim1$$

Goto et al. 2010

on of TIR luminosity density by AGN. Results from this work is plotted with stars at z=0.0082. The red, blue and orange points show IR from all AGN, from LIRG AGN only, and from ULIRG AGN only. Higher redshift results are from the AKARI NEP deep field (Goto et ribution from star forming galaxies removed. Brown triangles are Ω_{IR}^{AGN} computed from the 8μm LFs (Goto et al. 2010).

Understanding PAH at z=3

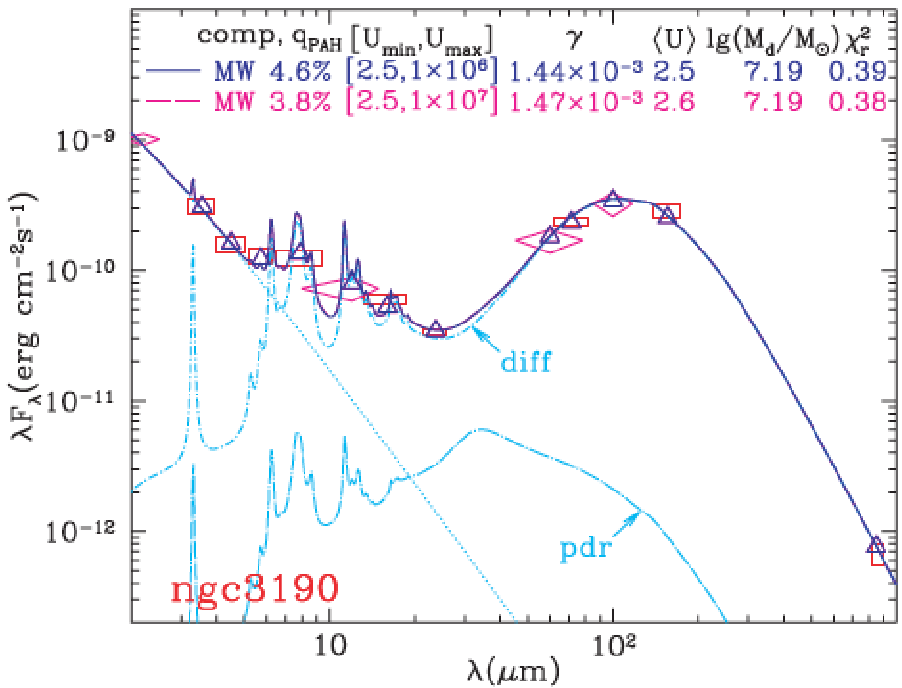


FIG. 3*a*

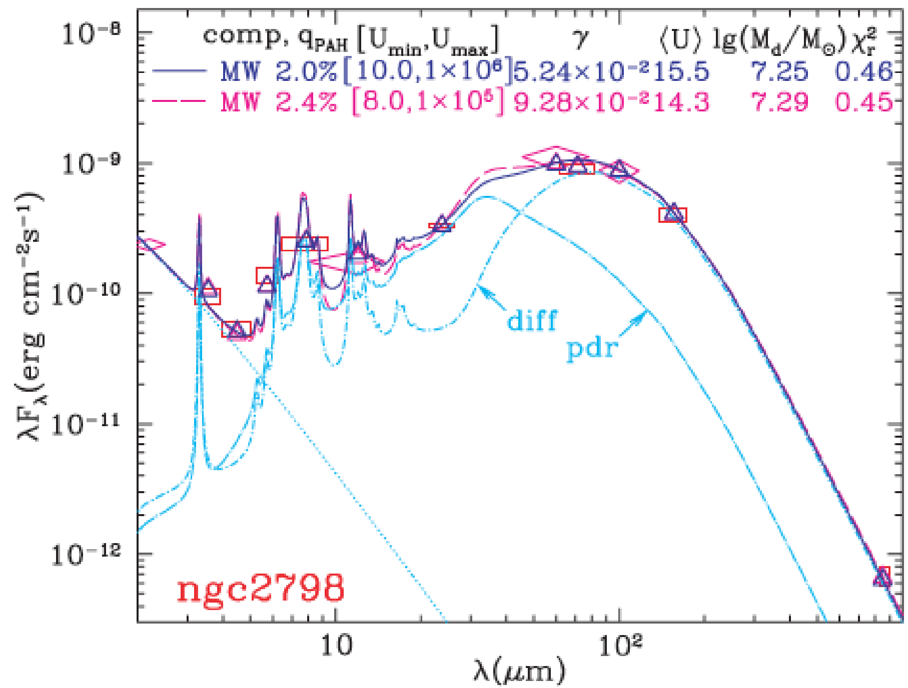


FIG. 3*b*

*Filters need to be narrow enough to tell PAH from AGN warm dust.

Summary

Imaging capability at 20-35μm is the most important,
even deeper than JWST

We propose multi-band deep imaging surveys with SPICA/MIRACLE.

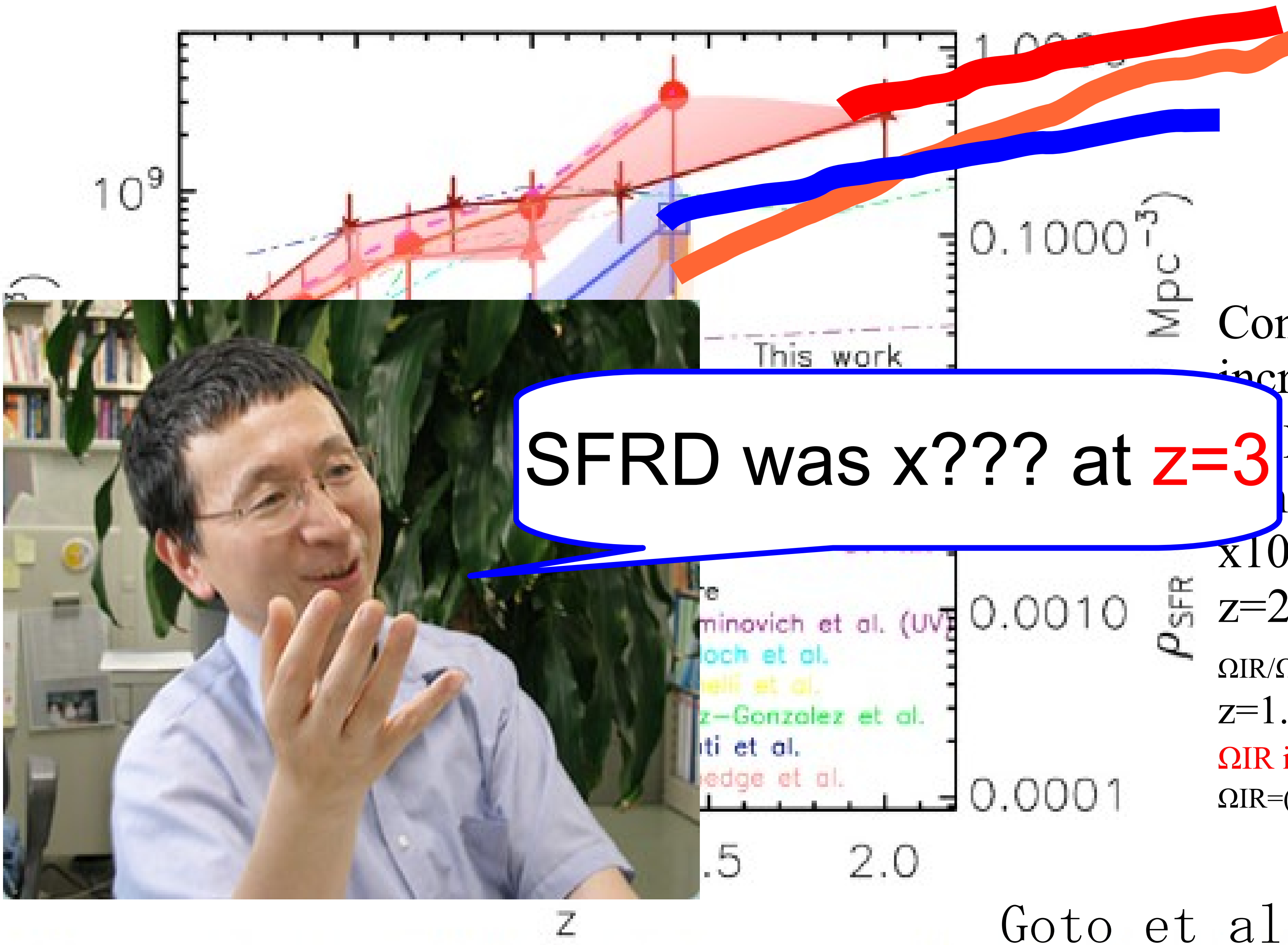
- A few deg^2 large area survey, efficient parallel observing with FPC and SAFARI (cluster to field).(~72hr x N_{filter})
- ~25 strongly lensed cluster survey to overcome confusion limit. (~13hr x N_{filter})

Example outcomes:

- PAH (8μm) luminosity functions at $1.6<z<3.5$
- Cosmic star formation history up to z=3.5, without hampered by dust.
- Cosmic BH accretion history up to z=3.5, without hampered by dust.
- Understanding nature/evolution of PAH at z=3.
- MIR-FIR SED evolution at z=3

Cosmic star formation history

z=3 by SPICA



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IRG
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Goto et al. 2010

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