StarFormation & AGN Activities in LIRGs@$z < 2$

H. Hanami & T. Ishigaki (Iwate Univ.),

+ AKARI ExtraGalactic Survey Team

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Why & **How** to study **LIRGs** up to$z \sim 2$

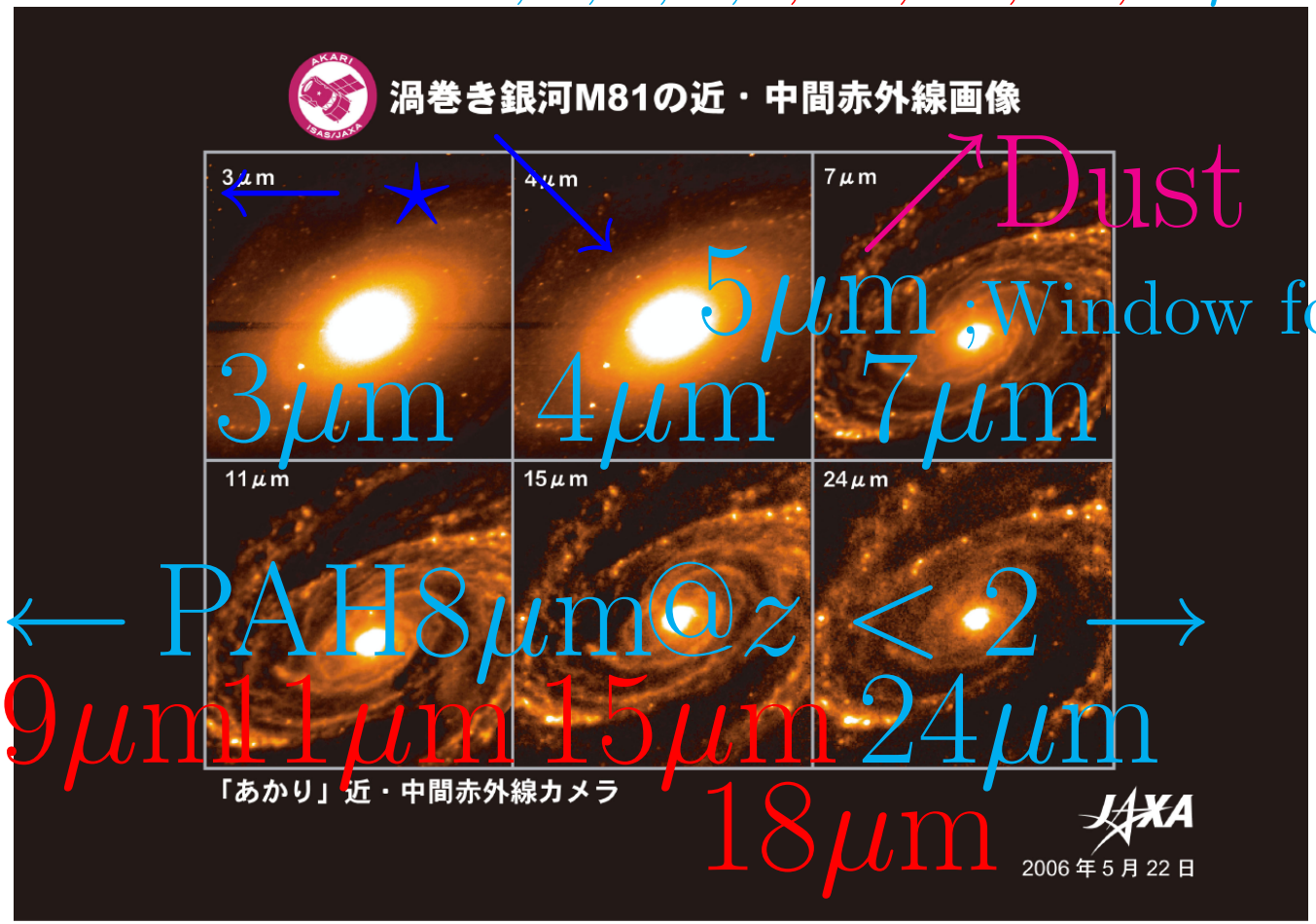
- **Why** SF & AGN decline @$z < 2$
  - LIRGs **@$z \sim 1-2$ near Main Seq.**
    - Consist of ★ + ISM(Dust) + AGN
- **How**: A Deep Survey with Subaru+AKARI
  - Subaru/SC→ ★ & z_{phot}
  - AKARI/IRC→ $> 1,000$LIRGs up to $z \sim 2$
    →Distinction between SF/AGN-LIRGs
    →**Co-Evolution of SF & AGN**

Hanami+, 2012, PASJ, 64, 4

Confirming with +**Herschel/PACS** &**CXO**

in Ishigaki+2014 in prep.

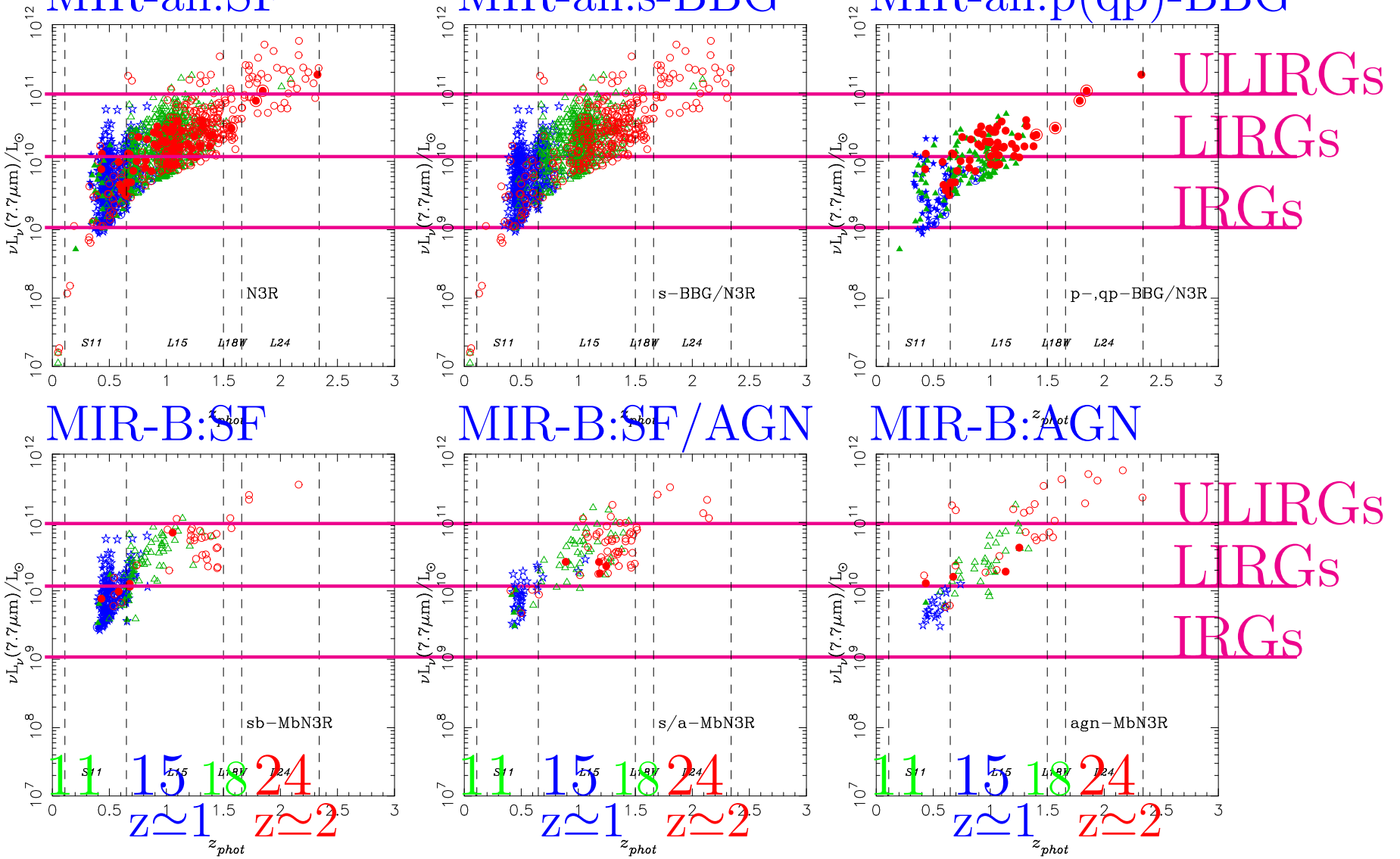
AKARI covers 2, 3, 4, 7,9, 11, 15, 18,24μm



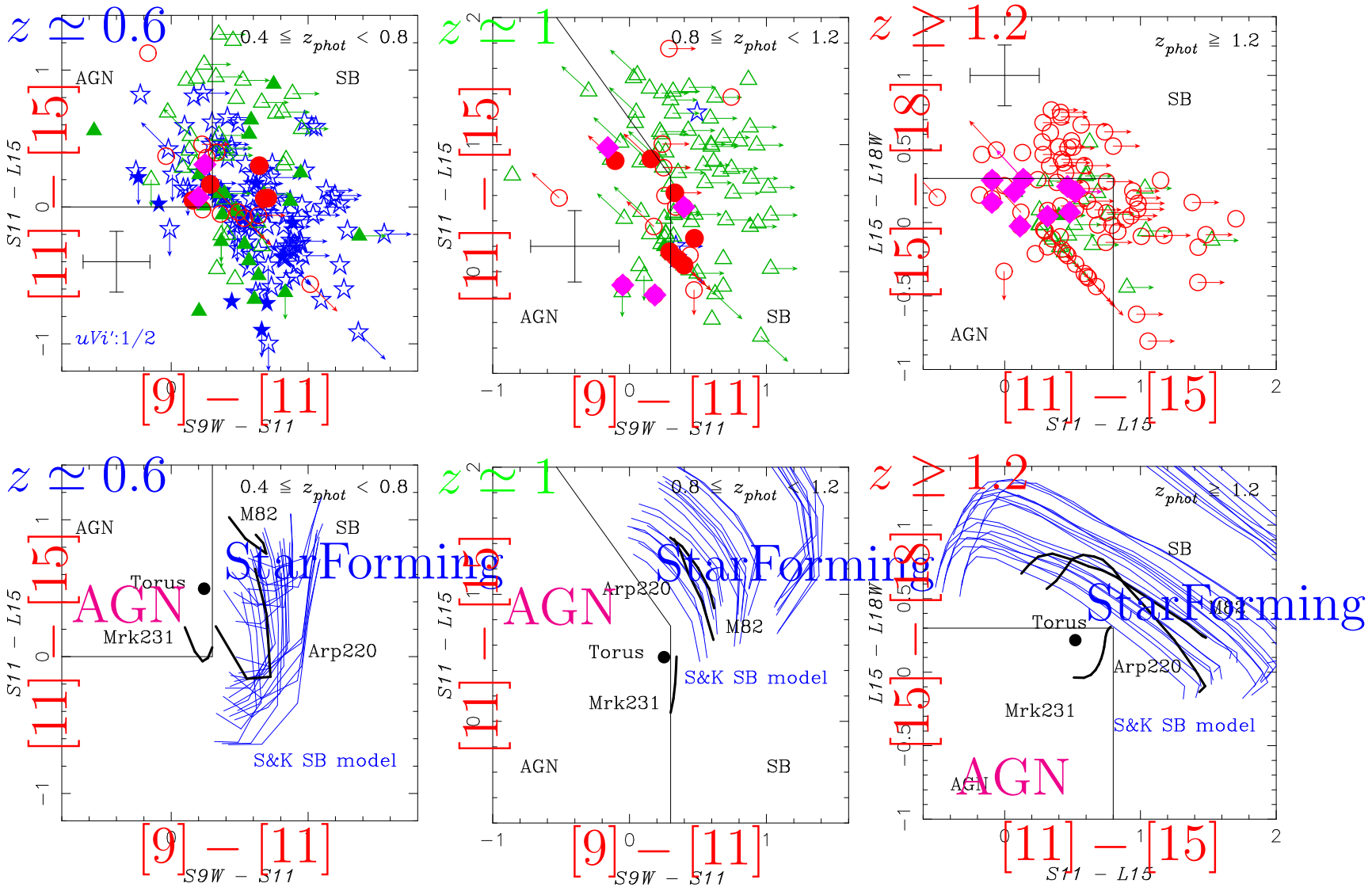
- PAH@8μm $\rightarrow$ SFR @$z < 2$
- $\bigstar \searrow$ before Dust $\nearrow$ @5μm$\rightarrow$ Window for AGN

$\rightarrow$ Distinction between SF/AGN-LIRGs

z **vs.** $\nu L_\nu(8\mu m)$**:** $\nu L_\nu(8\mu m) \simeq 0.1 L_{tIR}$



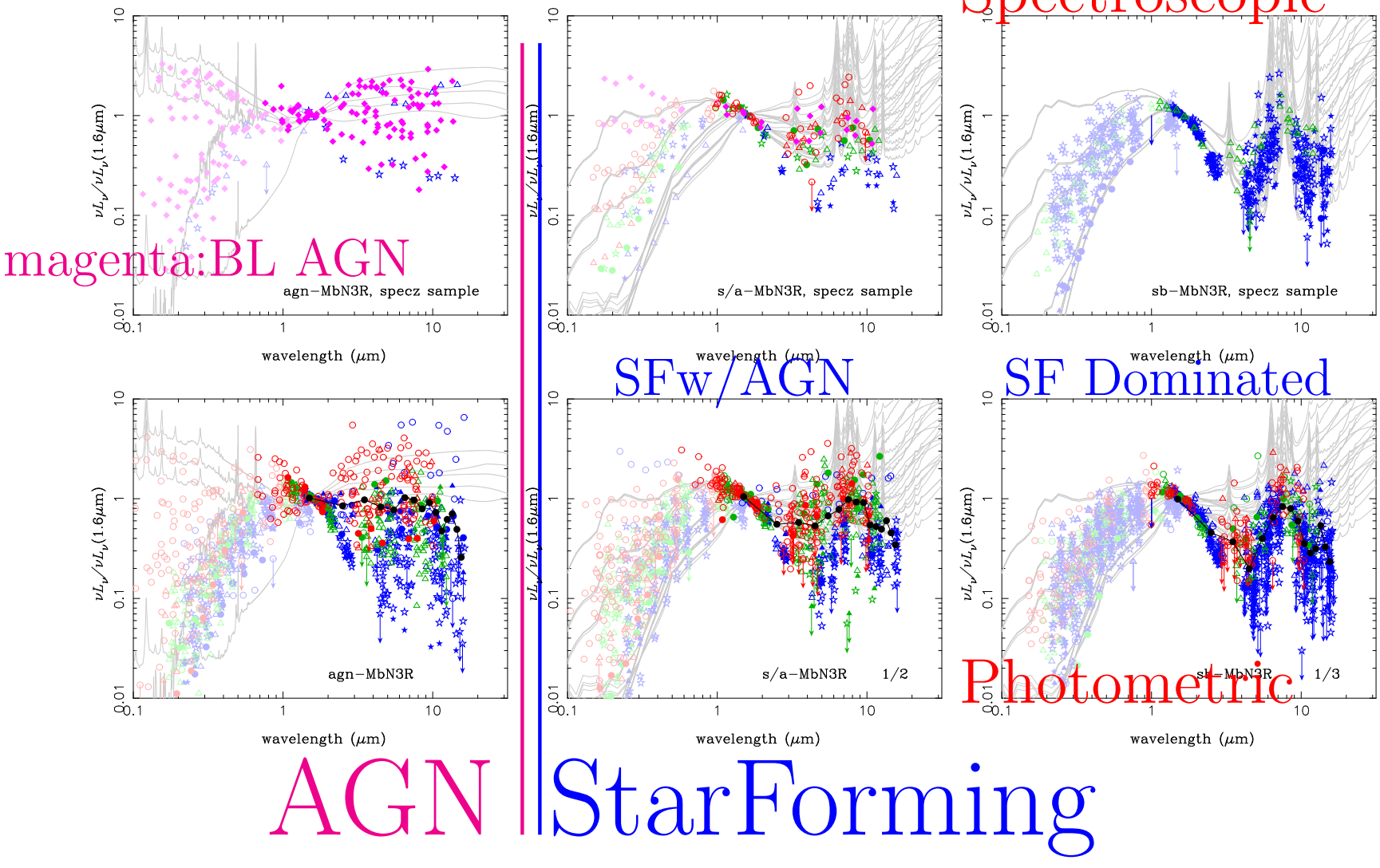
MIR Color-Color Diag.@$z \simeq$0.6,1.0, $>$ 1.2



7.7μm PAH @$z \simeq 1(1.5)$ detected with L15(L18W)

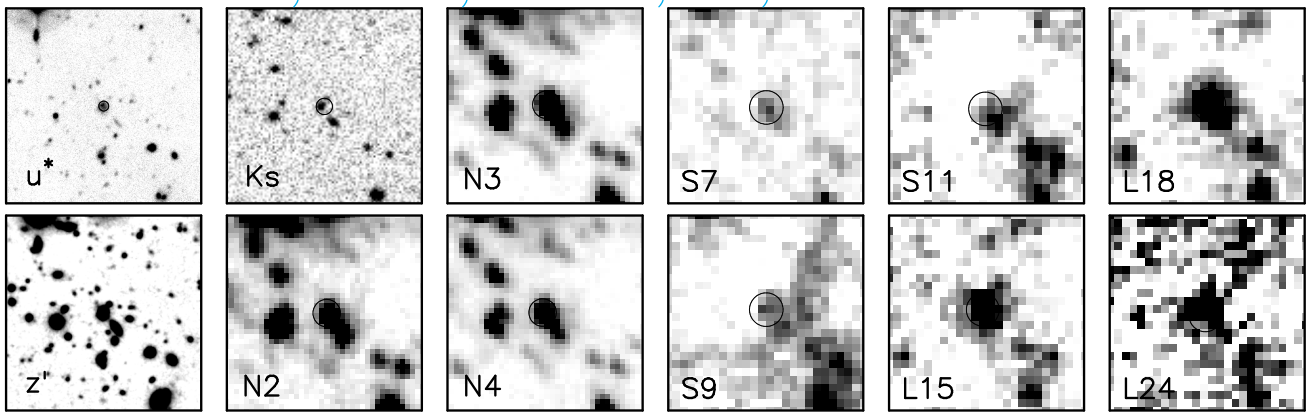
Rest Frame SEDs of AGN,SFw/AGN,SF

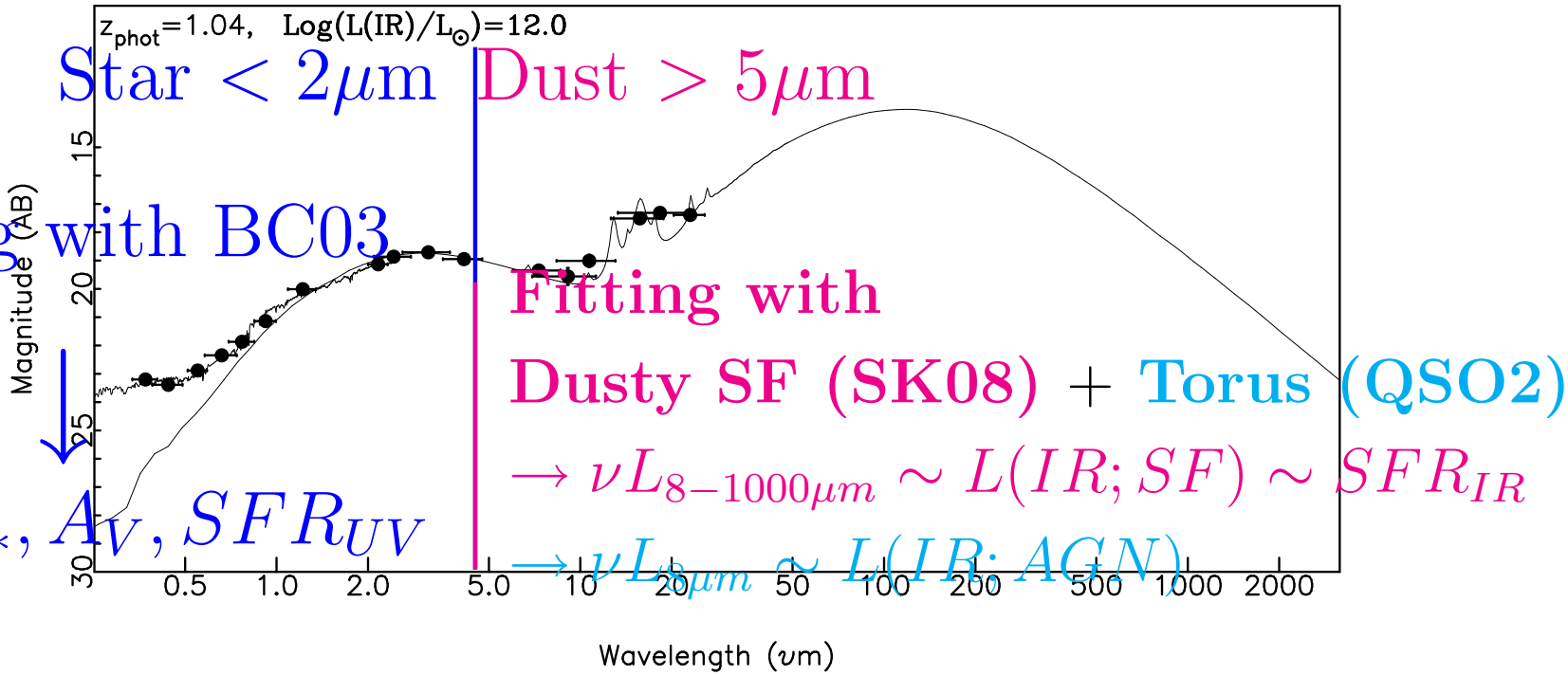
$@z \simeq$0.6,1.0, $>$ 1.2



z_{phot}, M_*, SFR_{IR}, f(AGN) for $>$ 1000 LIRGs

Hanami+, 2012, PASJ, 64, 4





Star $< 2\mu$m

Dust $> 5\mu$m

Fitting with BC03

z_{phot}, M_*, A_V, SFR_{UV}

Fitting with

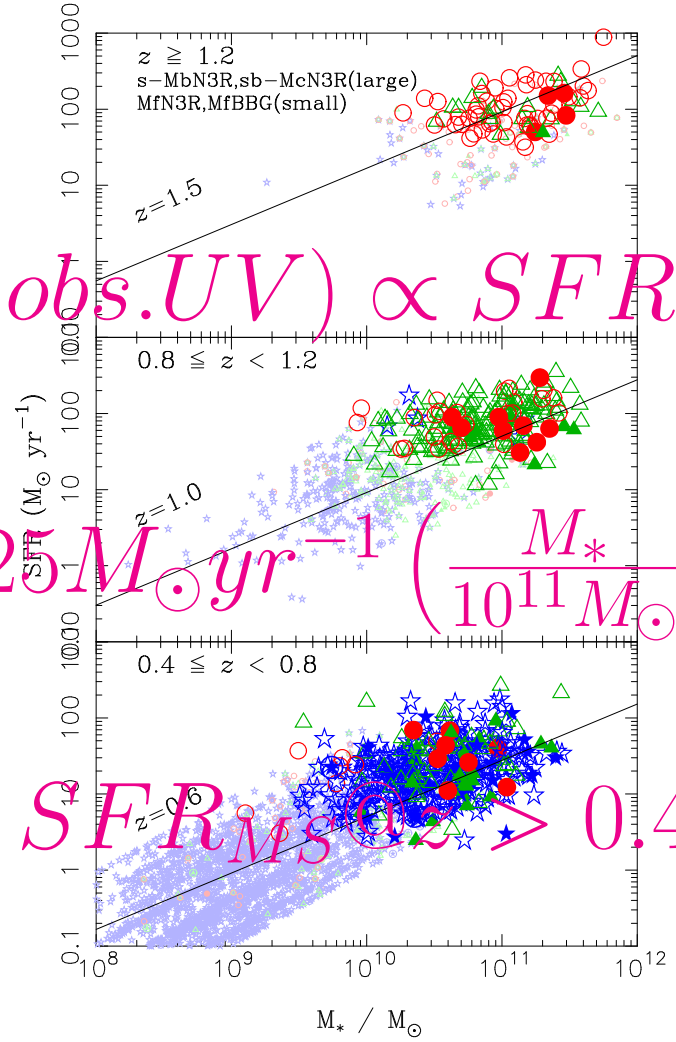
Dusty SF (SK08) + Torus (QSO2)

$\rightarrow \nu L_{8-1000\mu m} \sim L(IR; SF) \sim SFR_{IR}$

$\rightarrow \nu L_{8\mu m} \sim L(IR; AGN)$

$M_* - SFR$ @$z \simeq$0.6,1.0, $>$ 1.2

Thick;SFR(IR+obs.UV), Thin;SFR(Corr.UV)

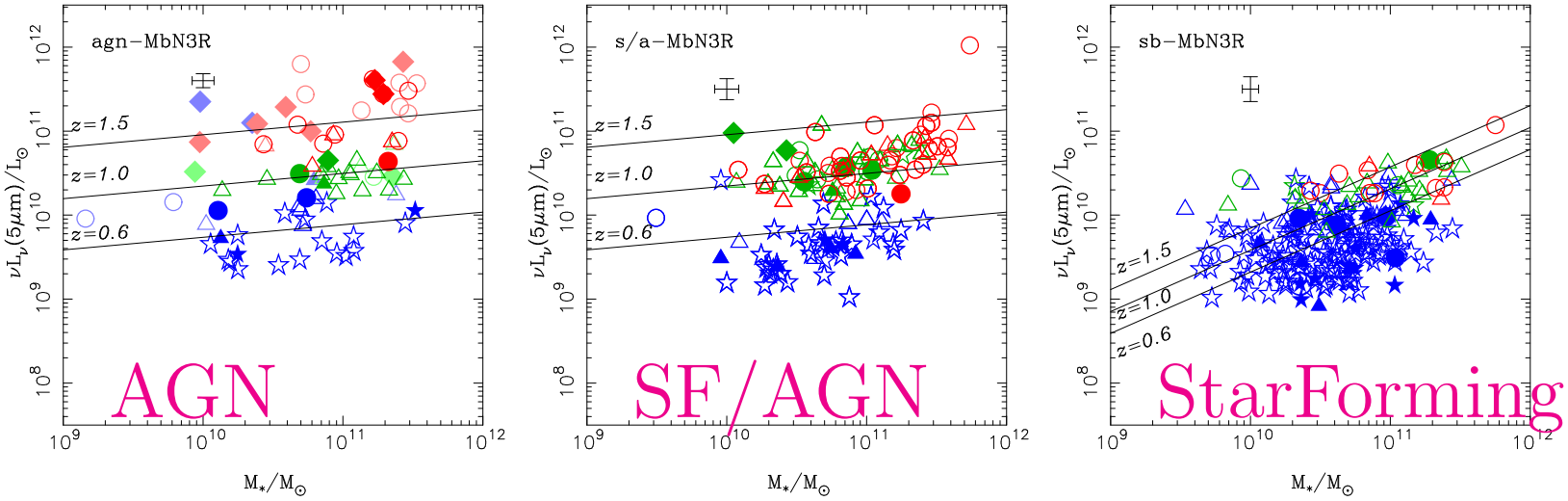


$$SFR(IR + obs.UV) \propto SFR(Corr.UV)$$

$$SFR_{MS} \simeq 25 M_\odot yr^{-1} \left(\frac{M_*}{10^{11} M_\odot}\right)^{0.7} (1+z)^2$$

$$\langle SFR_{IR} \rangle > SFR_{MS} @z > 0.4$$

5μm between ★ and Dust→ **Window for AGN**



@$z \simeq$0.6,1.0, > 1.2

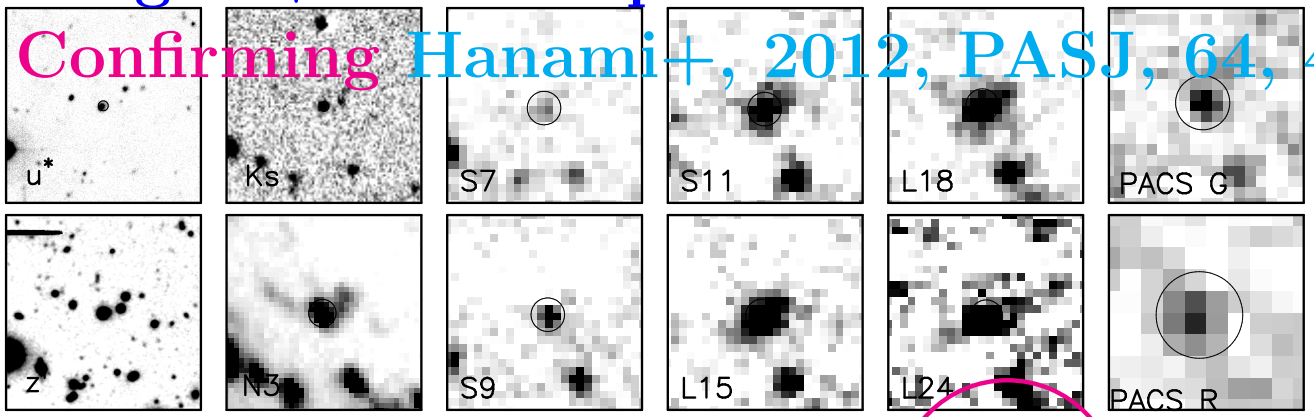
$$\nu L_\nu(5\mu m) \simeq 2 \times 10^9 L_\odot \left(\frac{M_*}{10^{11} M_\odot}\right)^{0.5} (1+z)^4$$

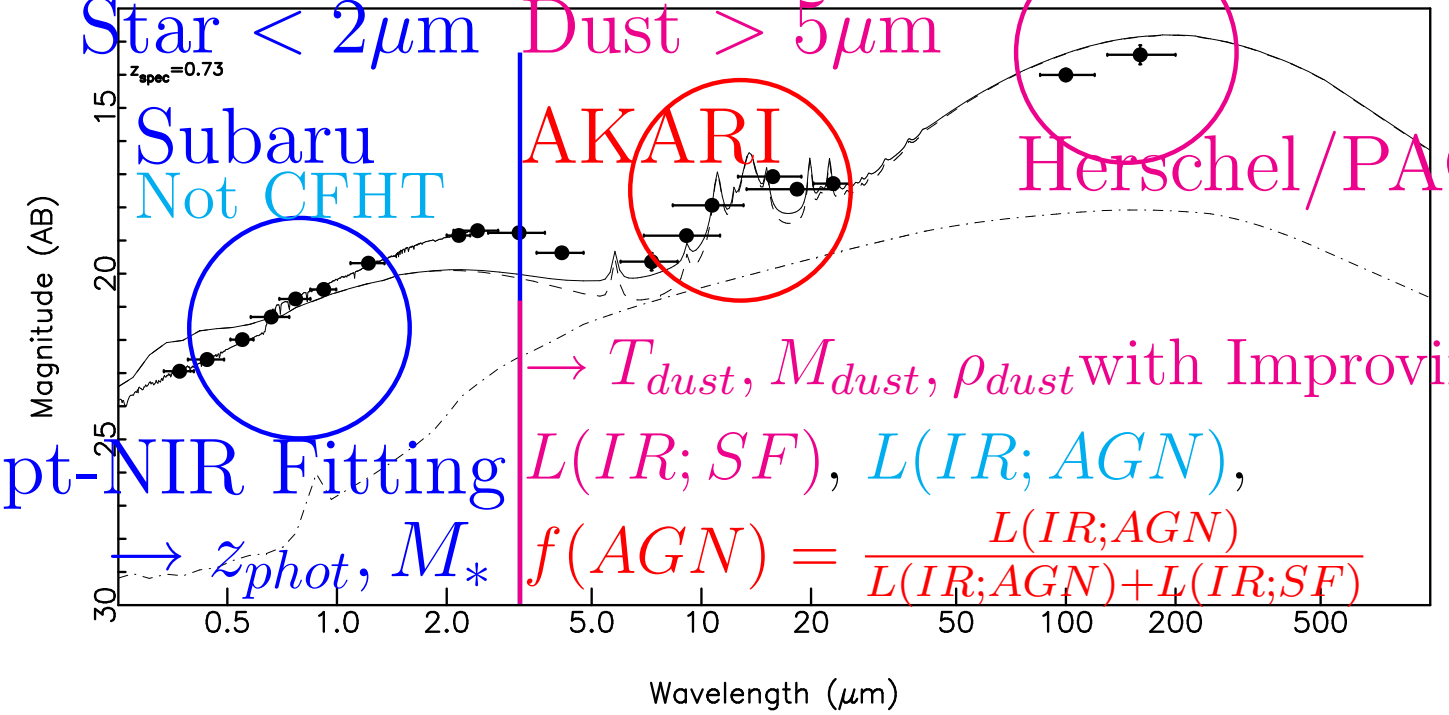
AGN activities are Weak mass depedence, More rapid evolution than SFR

Synergy with Herschel/PACS

Ishigaki+14 in Preparation

Confirming Hanami+, 2012, PASJ, 64, 4





Star $< 2\mu$m Dust $> 5\mu$m

Subaru
Not CFHT

AKARI

Herschel/PACS

$\rightarrow T_{dust}, M_{dust}, \rho_{dust}$ with Improving

Opt-NIR Fitting

$\rightarrow z_{phot}, M_*$

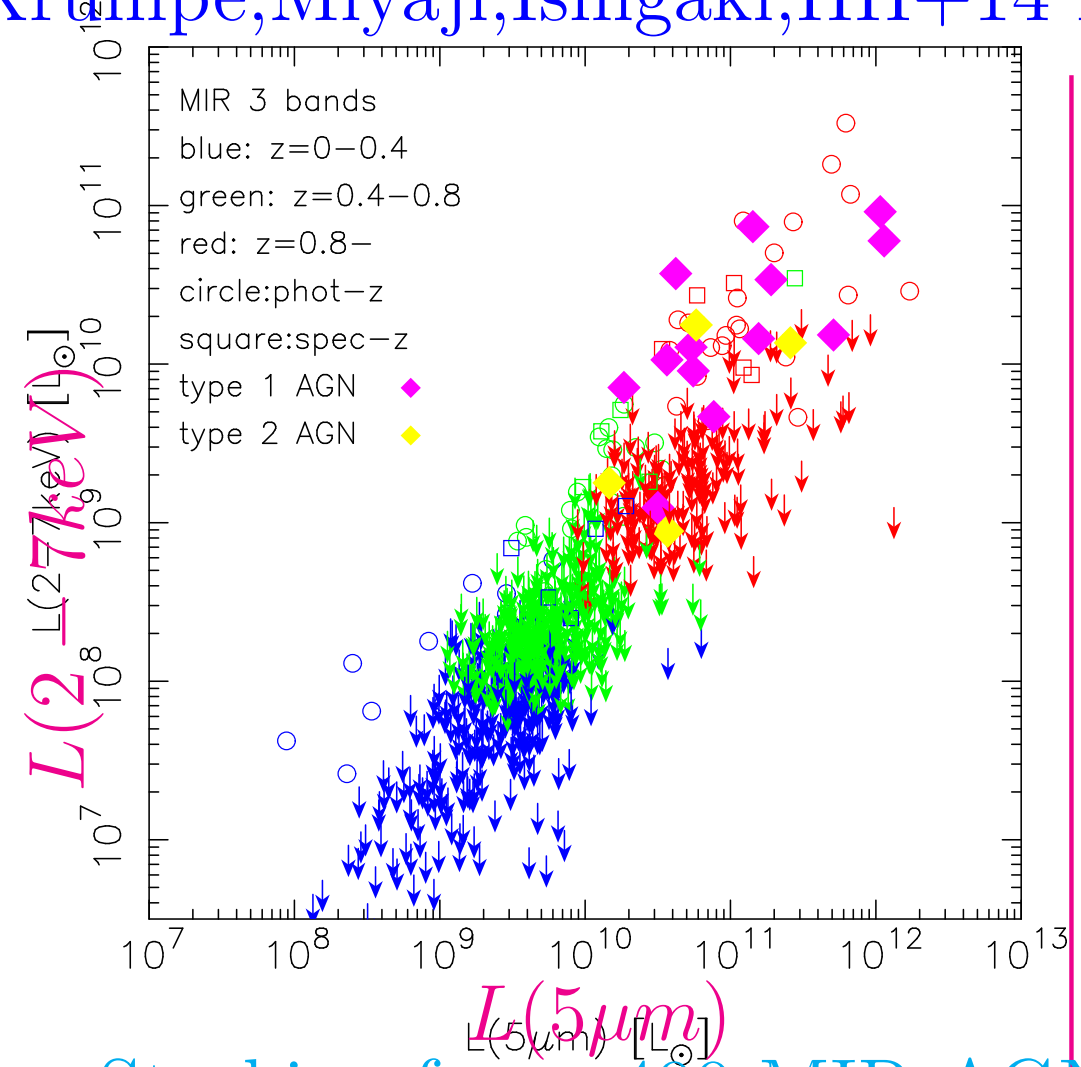
$L(IR;SF)$, $L(IR;AGN)$,

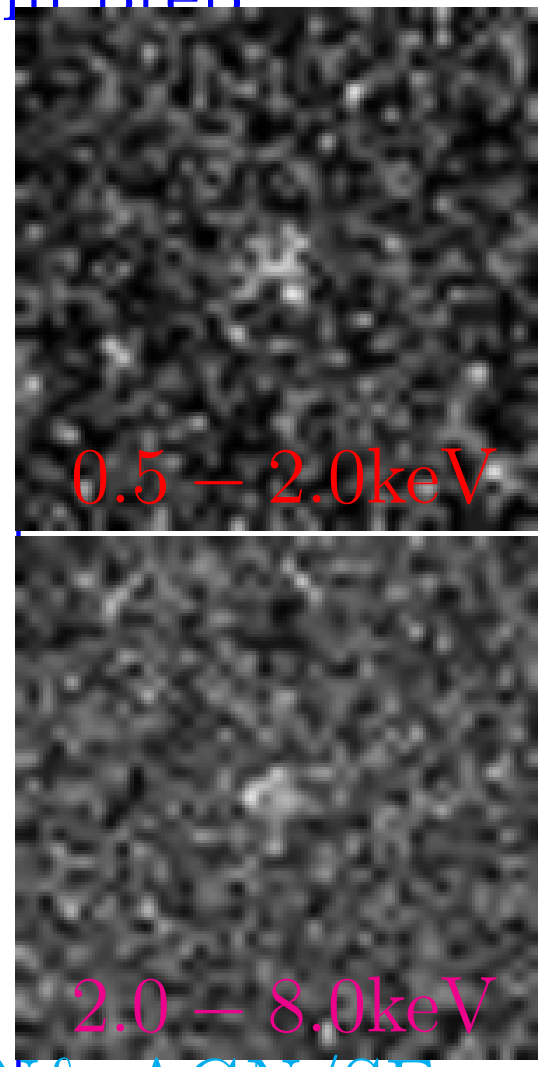
$f(AGN) = \frac{L(IR;AGN)}{L(IR;AGN)+L(IR;SF)}$

Synergy with CXO

All MIR AGNs emit X-ray? @$z<.4$,$\sim.6$,~1.0,>1.2

Krumpe,Miyaji,Ishigaki,HH+14 in prep

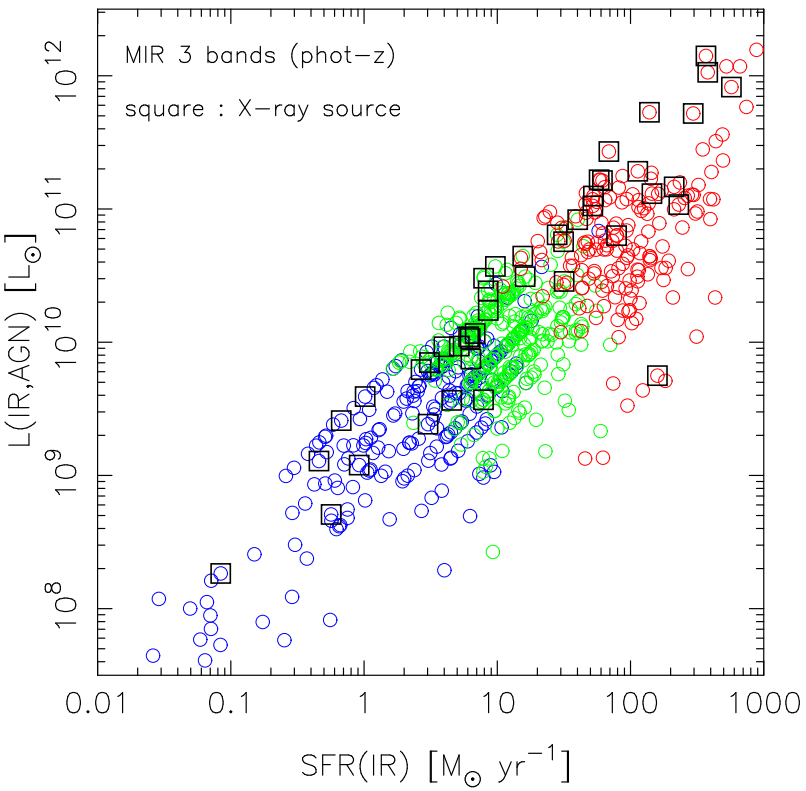


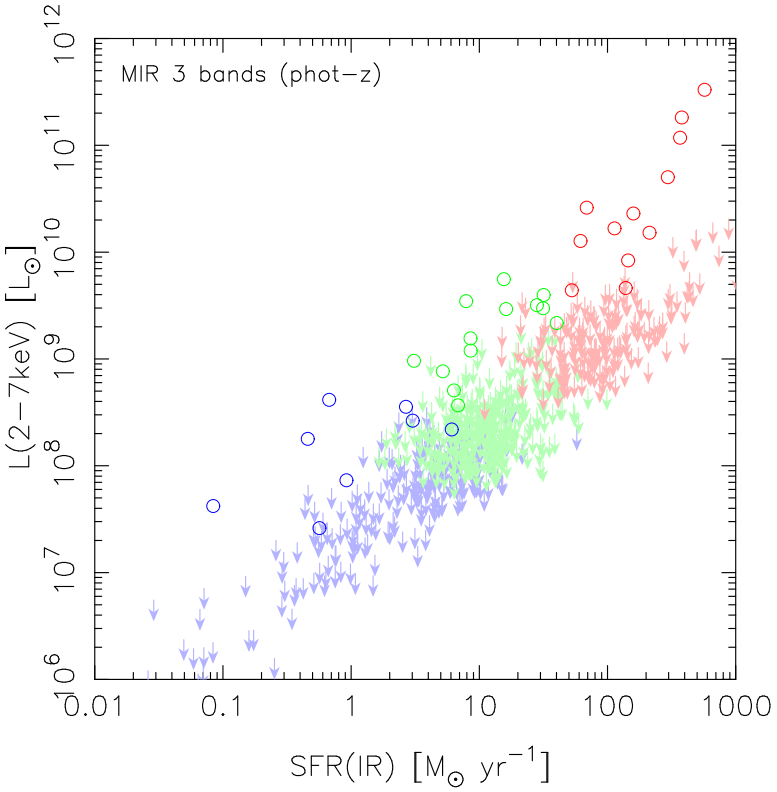


Stacking for $\sim$ 400 MIR AGN& AGN/SF w/o X-ray

AGNs Co-Exist with SF

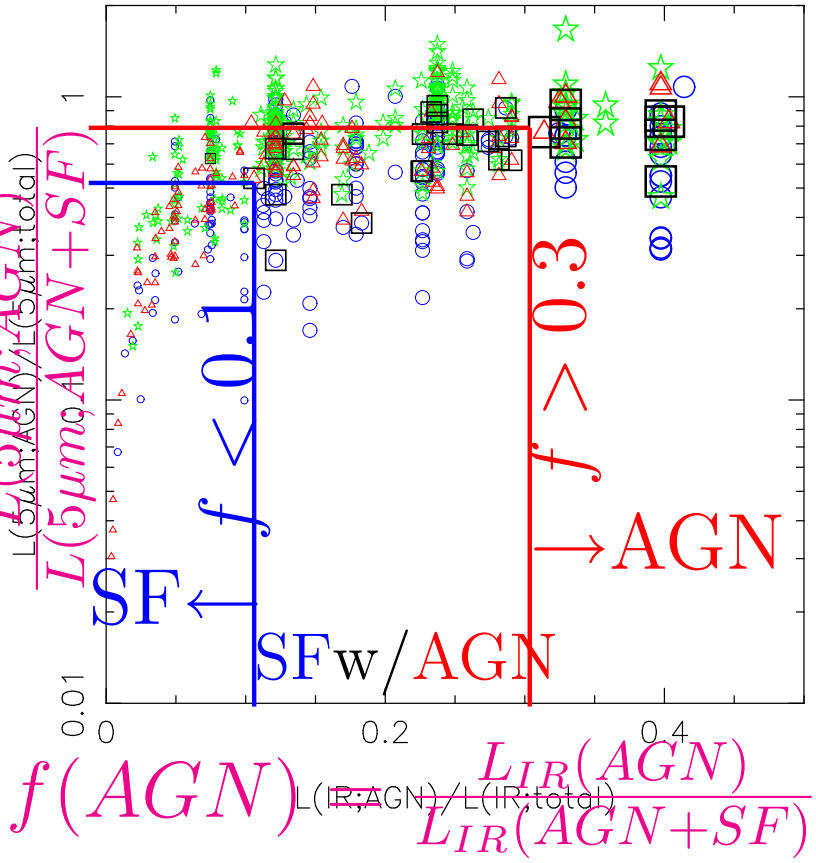
@$z\sim$ 0.6,$\sim$ 1.0,$>$ 1.2

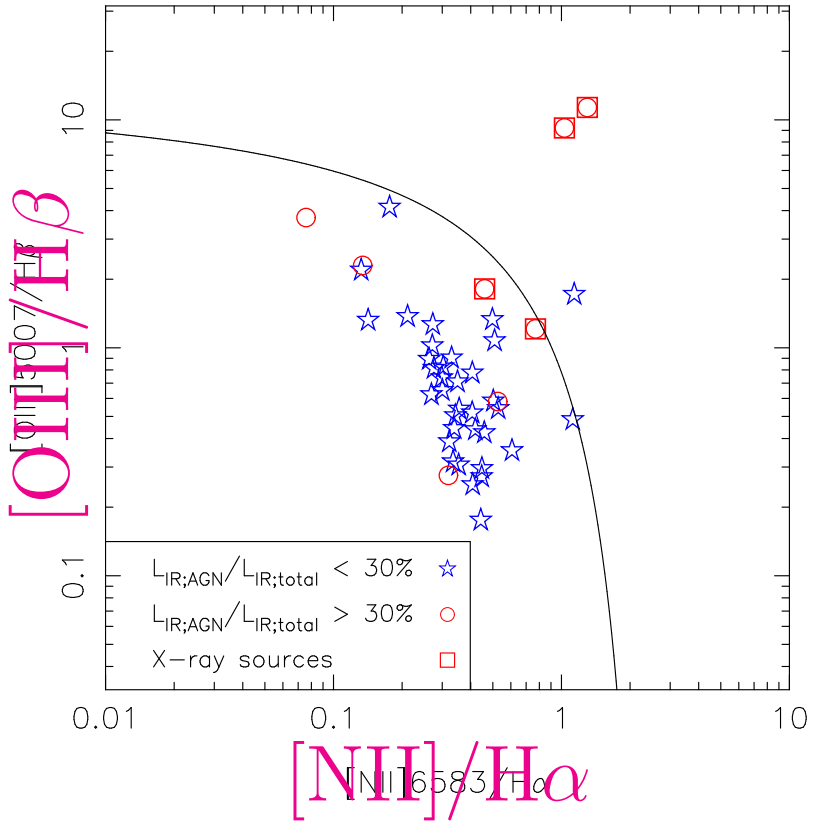




MIR &X-ray AGNs with SF

Catch AGNs with MIR, X-ray, & BPT

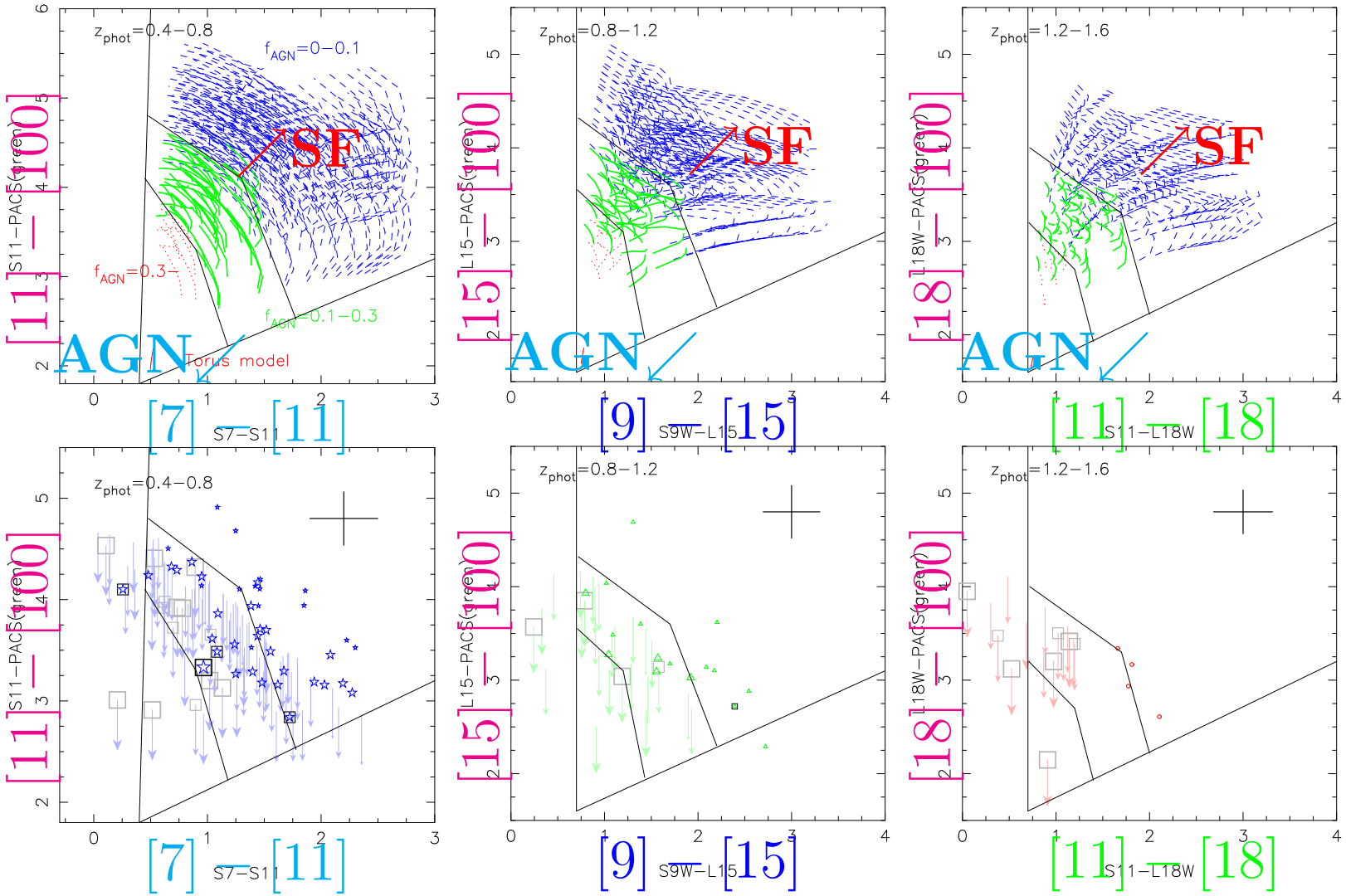




$L(5\mu m)$ is sensitive to detect AGN

X-ray(square) $\sim$ AGNs in BPT $\sim f(AGN) > 0.3$

f(AGN) → AKARI+Herschel Colors

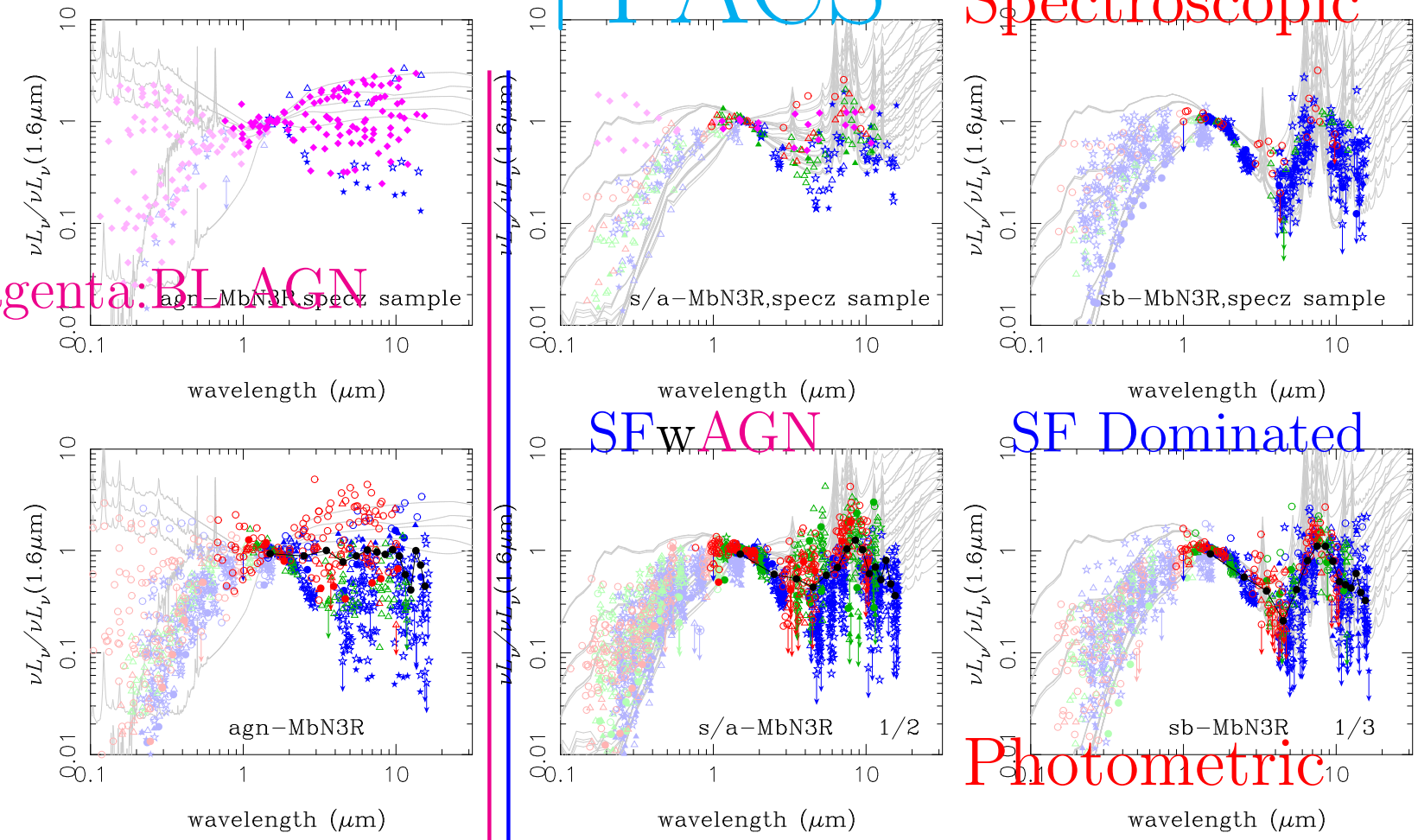


Rest Frame SEDs, Again @$z \simeq 0.6, 1.0, > 1.2$

+PACS

Spectroscopic

magenta:BL AGN



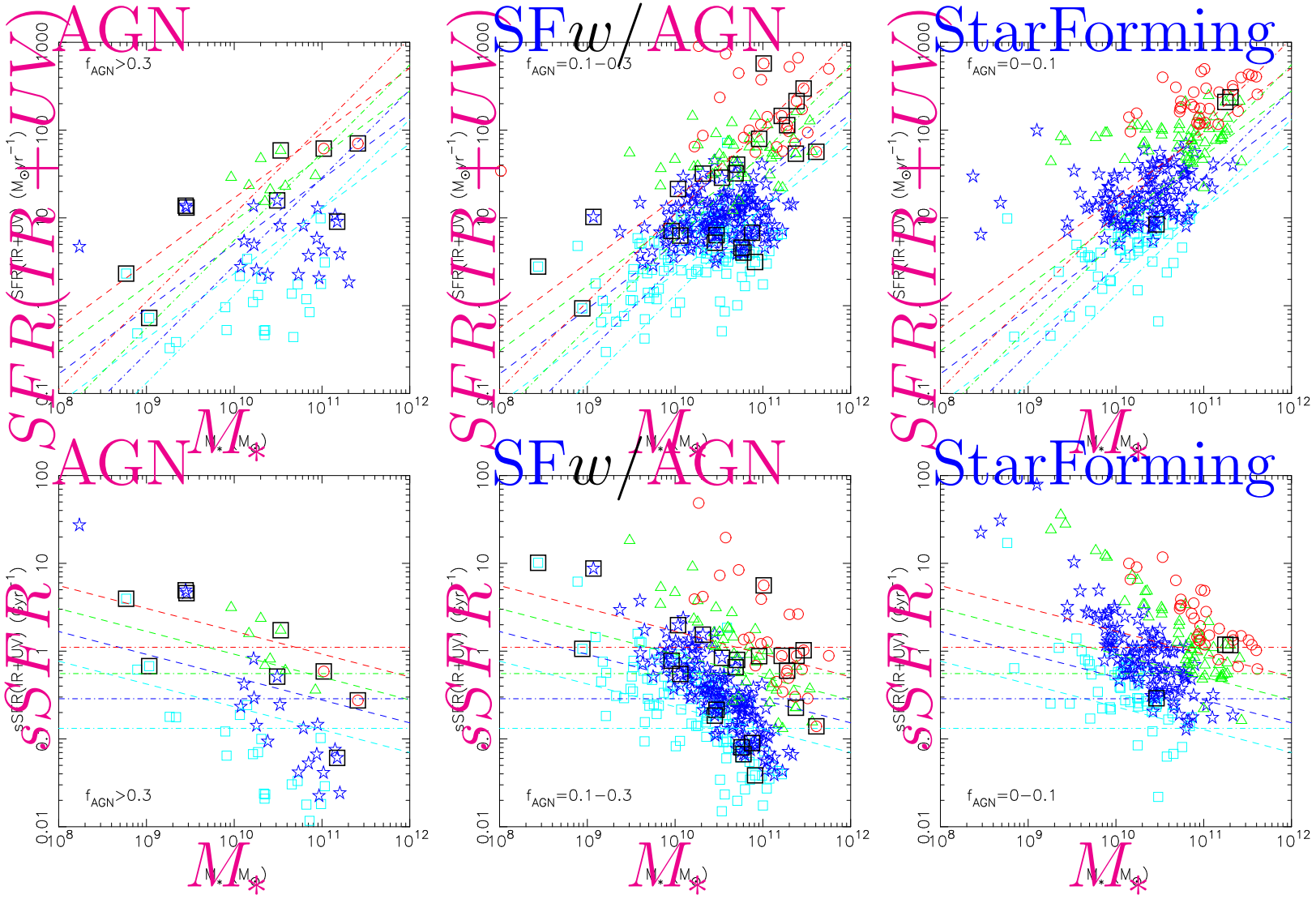
SFwAGN

SF Dominated

Photometric

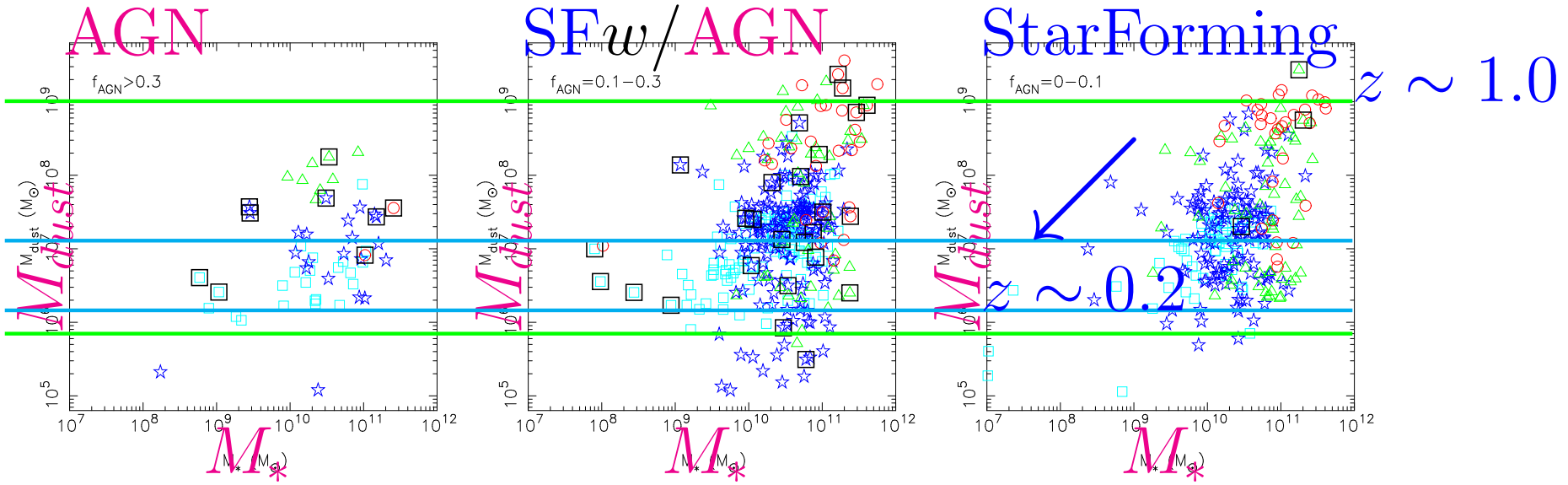
AGN || StarForming

M_*, SFR, sSFR @z< .4,~ .6,~ 1.0,> 1.2



· **SFR ↓ as f(AGN) ↑ → AGN Quenches SF?**

M_* **vs.** M_{dust} @z< .4,∼ .6,∼ 1.0,> 1.2

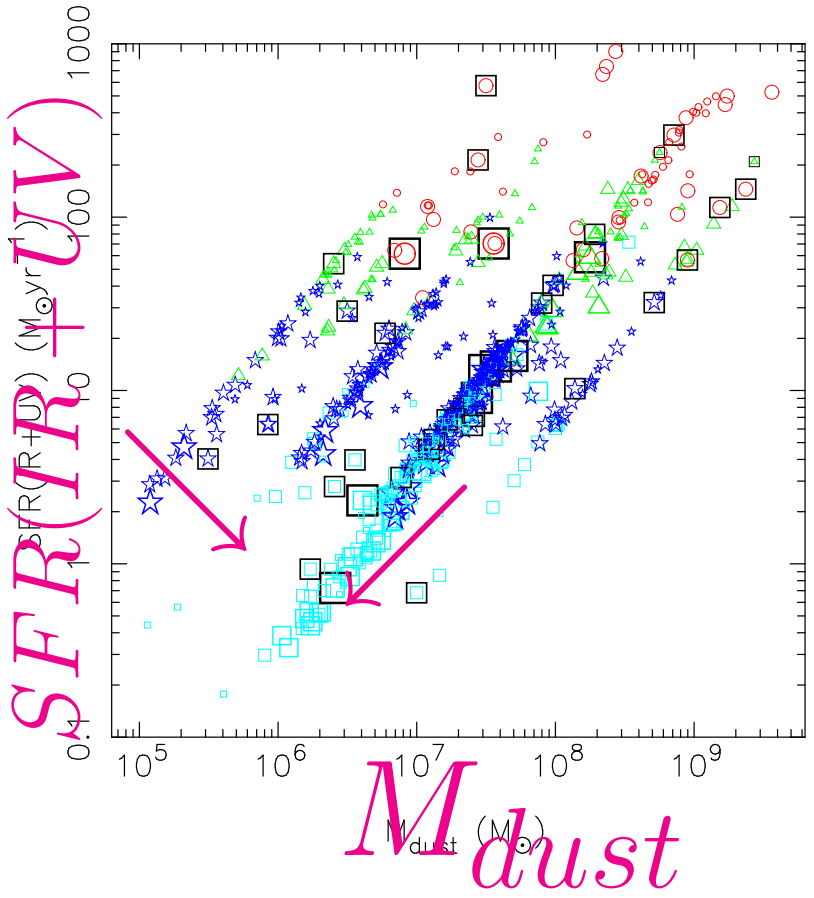


ΔM_{dust} ↗↘ **as f(AGN)** ↑

$\Delta M_{dust} \sim 10^7 \leftarrow 10^9 M_\odot$@$z \sim 0.2 \leftarrow 1.0$

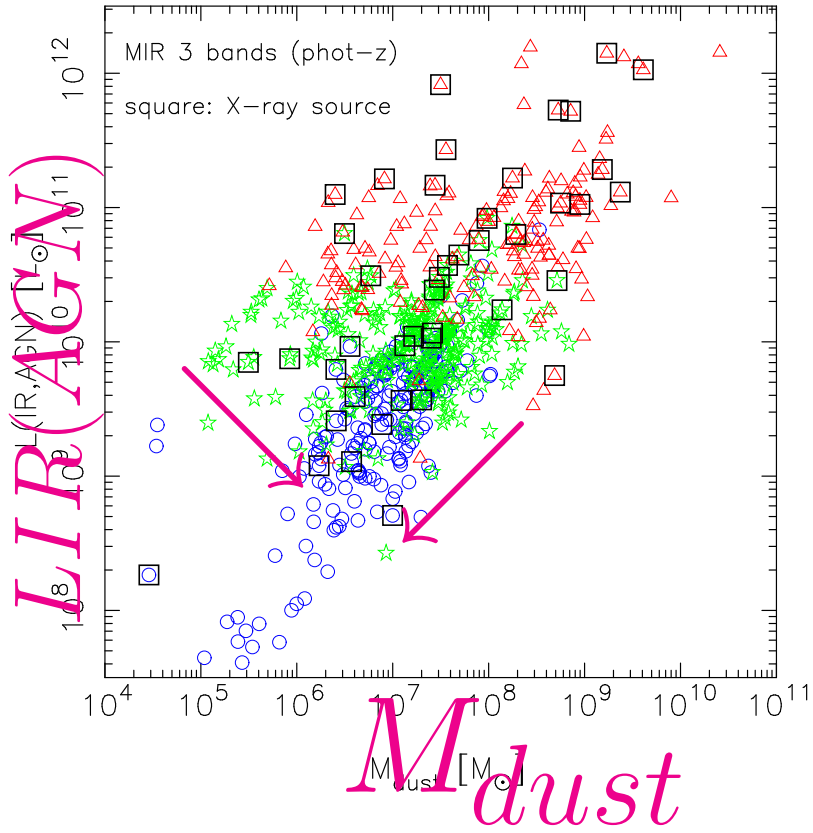
M_{dust} vs. SFR, LIR(AGN)

@z< .4,∼ .6,∼ 1.0,> 1.2



$SFR(FIR+UV)$

M_{dust}

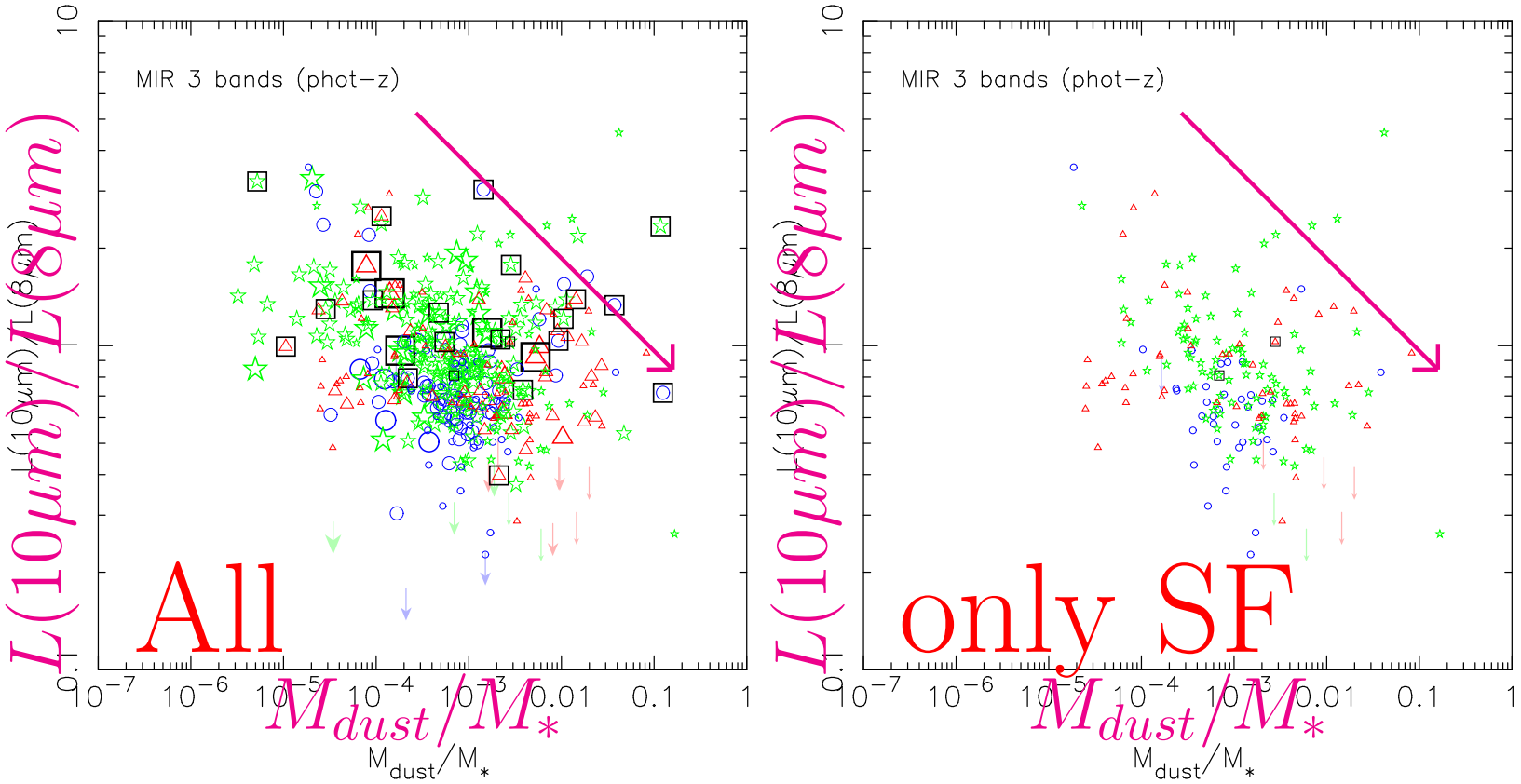


$LIR(AGN)$

M_{dust}

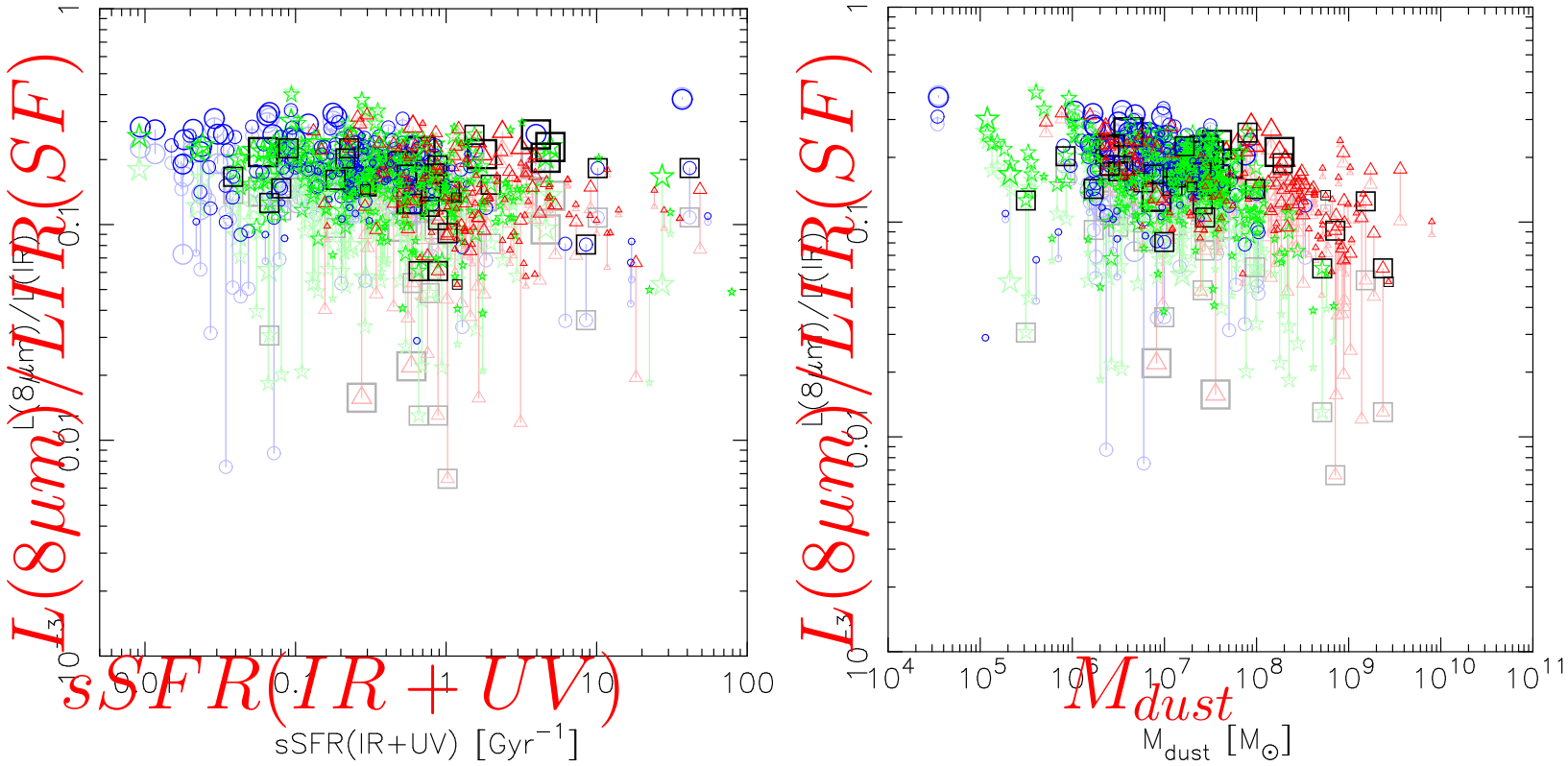
M_{dust} is Essential for Tracing Evolution

M_{dust}/M_* **vs.** $L(10\mu m)/L(8\mu m)$



Si Abs.@10μm $\leftrightarrow$ $M_{dust} \sim M_{ISM}$

M_{dust} vs, $L(8\mu m)/LIR(SF)$



M_{dust} Tracing PAH Defict? $\leftrightarrow$

IRS+MIPS+PACS@$z \sim 2$; Nordon+13

Summary

- Studying LIRGs @$z < 2$
  with Opt.+MIR+FIR+X-Ray
  - MIR diagnostics $\rightarrow$ Passfinder for JWST/MIRI
    - **SF** $\leftrightarrow 8\mu m$
    - **AGN** $\leftrightarrow 5\mu m$
    - $M_{dust} \leftrightarrow 10\mu m$
  - Adding FIR
    - Rapid Ev. of $M_{dust} \searrow$ during $z = 0.4 - 0.8$
    - M_{dust} tracing CoEv. of $\bigstar$, ISM(Dust), AGN
- Correct understanding for **Radiation Transfer**
  - Do not extrapolate Screen model picture!