



# THE PROPERTIES OF AGN IN (ULTRA)LUMINOUS INFRARED GALAXY

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# Merger scenario

(c) Interaction/"Merger"



- now within one halo, galaxies interact & lose angular momentum
- SFR starts to increase
- stellar winds dominate feedback
- rarely excite QSOs (only special orbits)

(b) "Small Group"



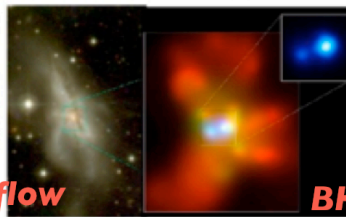
- halo accretes similar-mass companion(s)
- can occur over a wide mass range
- $M_{halo}$  still similar to before: dynamical friction merges the subhalos efficiently

(a) Isolated Disk



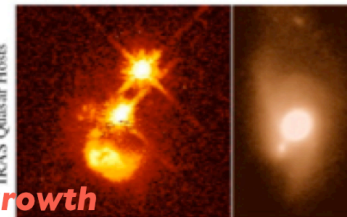
- halo & disk grow, most stars formed
- secular growth builds bars & pseudobulges
- "Seyfert" fueling (AGN with  $M_{\odot} > 23$ )
- cannot redden to the red sequence

(d) Coalescence/(U)LIRG



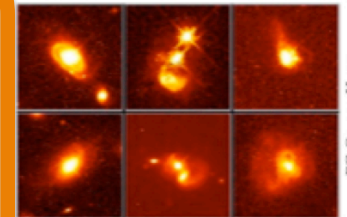
- galaxies coalesce: violent relaxation in core
- gas inflows to center: starburst & buried (X-ray) AGN
- starburst dominates luminosity/feedback, but, total stellar mass formed is small

(e) "Blowout"



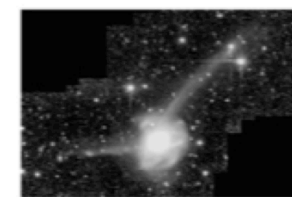
- BH grows rapidly: briefly dominates luminosity/feedback
- remaining dust/gas expelled
- get reddened (but not Type II) QSO: recent/ongoing SF in host
- high Eddington ratios
- merger signatures still visible

(f) Quasar



- dust removed: now a "traditional" QSO
- host morphology difficult to observe: tidal features fade rapidly
- characteristically blue/young spheroid

(g) Decay/K+A

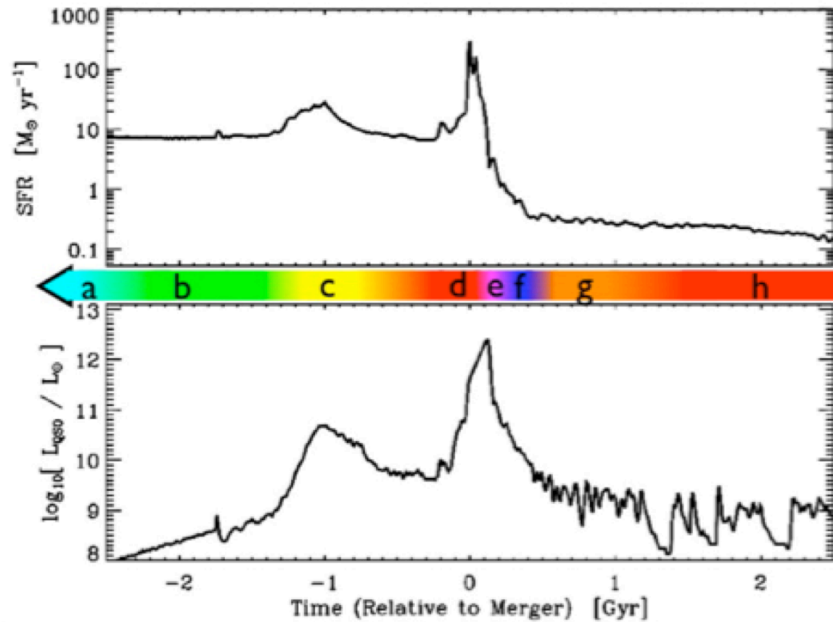


- QSO luminosity fades rapidly
- tidal features visible only with very deep observations
- remnant reddens rapidly (E+A/K+A)
- "hot halo" from feedback
- sets up quasi-static cooling

(h) "Dead" Elliptical

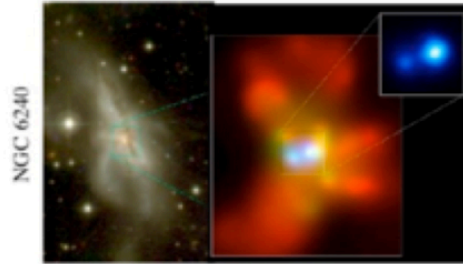


- star formation terminated
- large BH/spheroid - efficient feedback
- halo grows to "large group" scales: mergers become inefficient
- growth by "dry" mergers

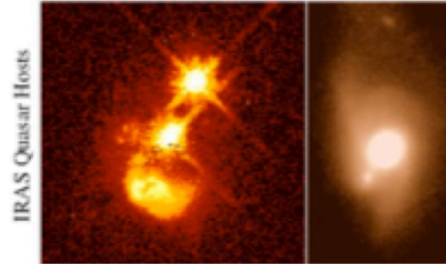


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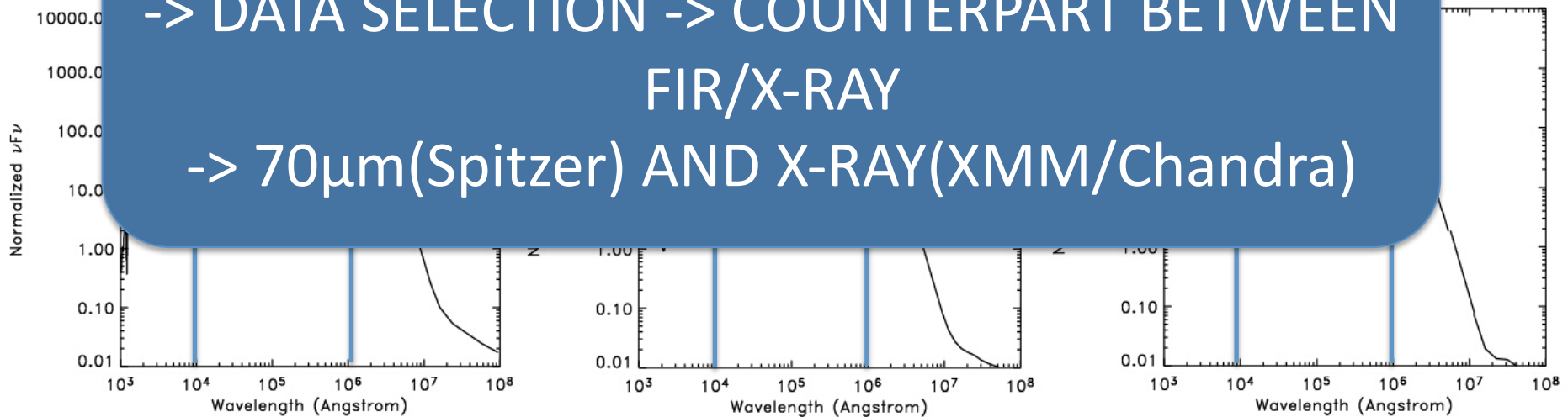
SF dominated  $\xrightarrow{\hspace{15em}}$  AGN dominated

Arp 220

NGC 6240

Mrk 231

AGN FORMATION DURING ULIRG PHASE  
 -> DATA SELECTION -> COUNTERPART BETWEEN  
 FIR/X-RAY  
 -> 70 $\mu$ m(Spitzer) AND X-RAY(XMM/Chandra)



Swire template

# DATA – COSMOS FIELD

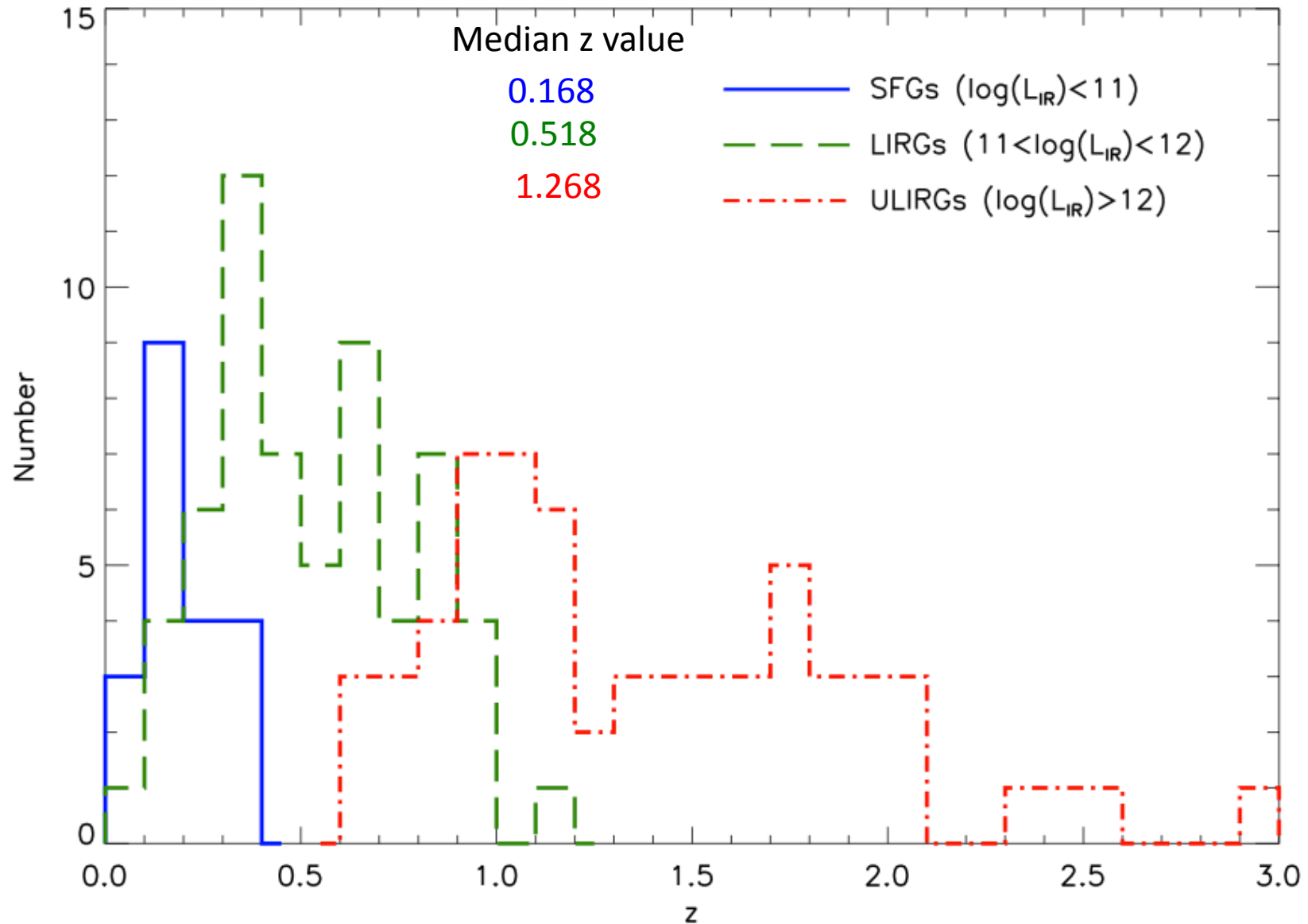
From Kartaltepe et al. 2010 70 $\mu$ m dataset, we found there are **142** sources have both 70 $\mu$ m/X-ray detection.

| Wavelength - Telescope         | Band                            |
|--------------------------------|---------------------------------|
| UV - GALEX                     | NUV, FUV                        |
| Optical – Subaru, CFHT, UKIRT  | u*, B, V, g+, r+, l+, z+, J, Ks |
| Infrared – Spitzer IRAC        | 3.6, 4.5, 5.8, 8.0 $\mu$ m      |
| Infrared – Spitzer MIPS        | 24, 70, 160 $\mu$ m             |
| X-ray – XMM<br>X-ray – Chandra | Soft, Hard, Full                |

| Redshift estimation | Reference                                  |
|---------------------|--|
| Spec-z ~ 60%        | zCOSMOS, Magellan, SDSS<br>Keck/DEIMOS     |
| Photo-z ~ 40%       | Ilbert et al. 2009<br>Salvato et al. 2009. |

# REDSHIFT DISTRIBUTION

Redshift distribution



# QUESTION

Part I - Which mechanism drives those objects?  
AGN or SF ?

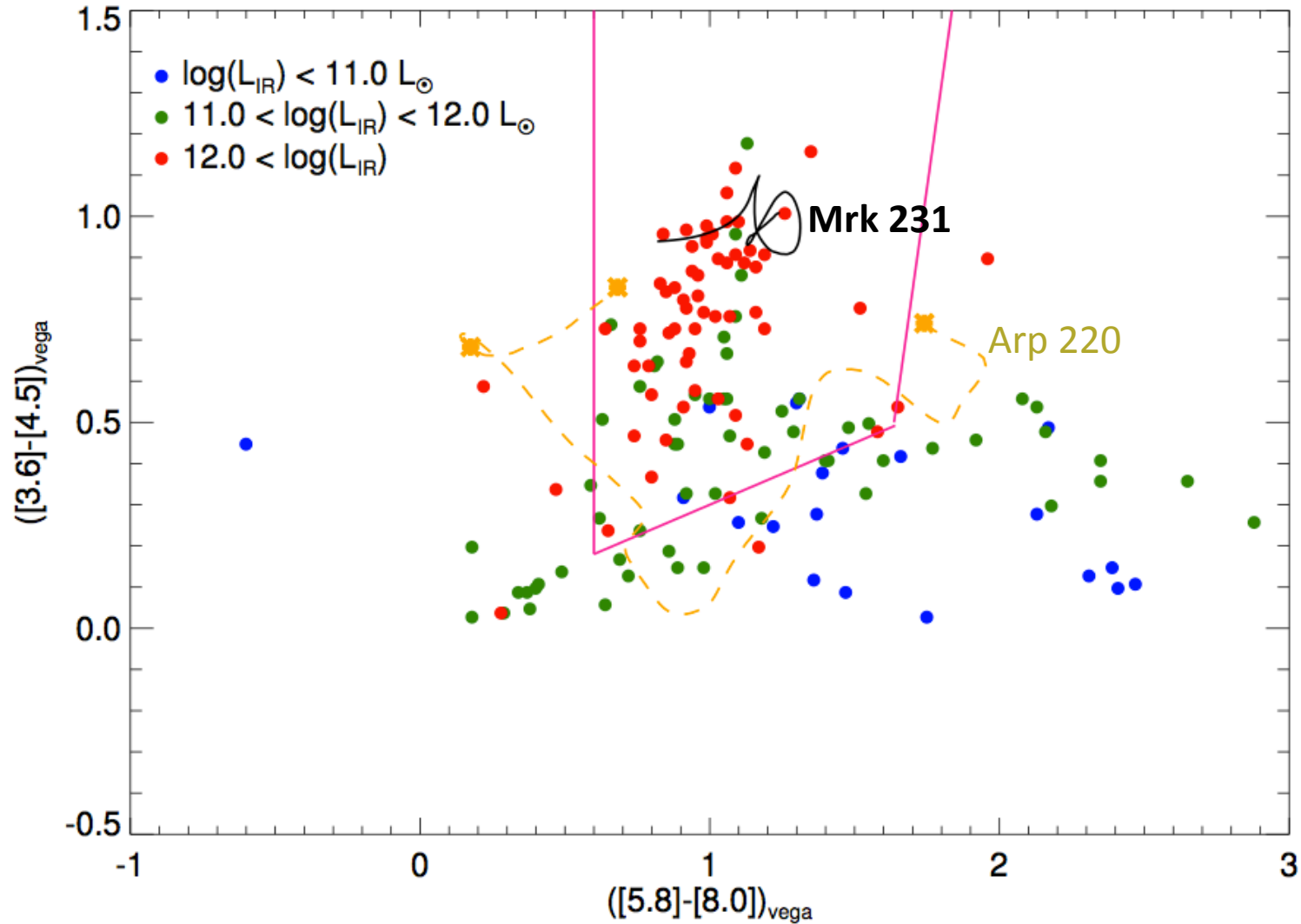
- AGN diagnosis from color-color selection
- LX\_LIR relation
- SED fitting

Part II - Would AGN influence host galaxy's  
property, and vice versa?

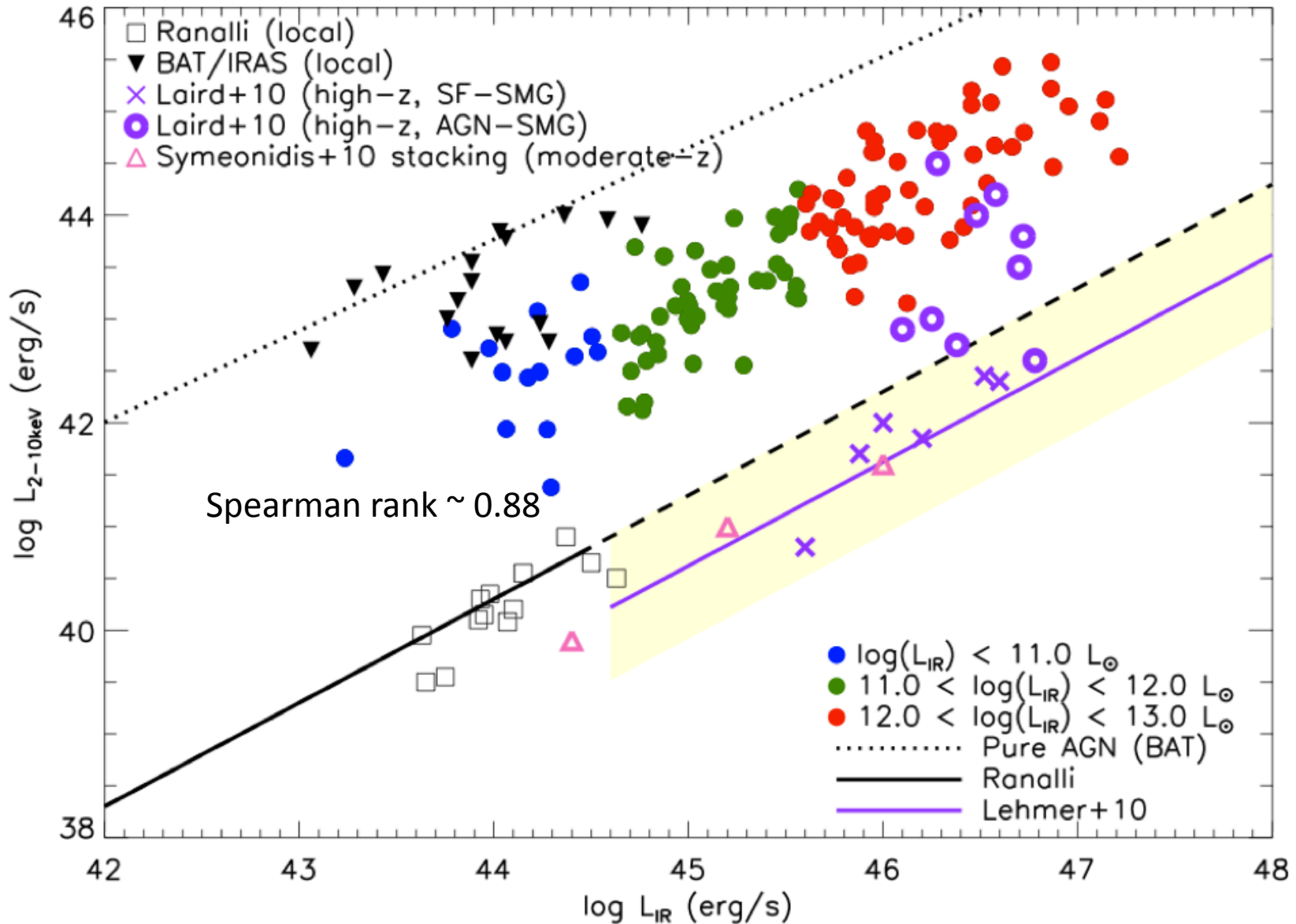
- Whether ISM in host galaxy heated by AGN? (Luminosity-Temperature diagram)
- Is there more neutral hydrogen absorption by host galaxy rather than torus component? (Hardness ratio)

# AGN DIAGNOSIS

- Applying Stern et al. 2005 color-color selection.

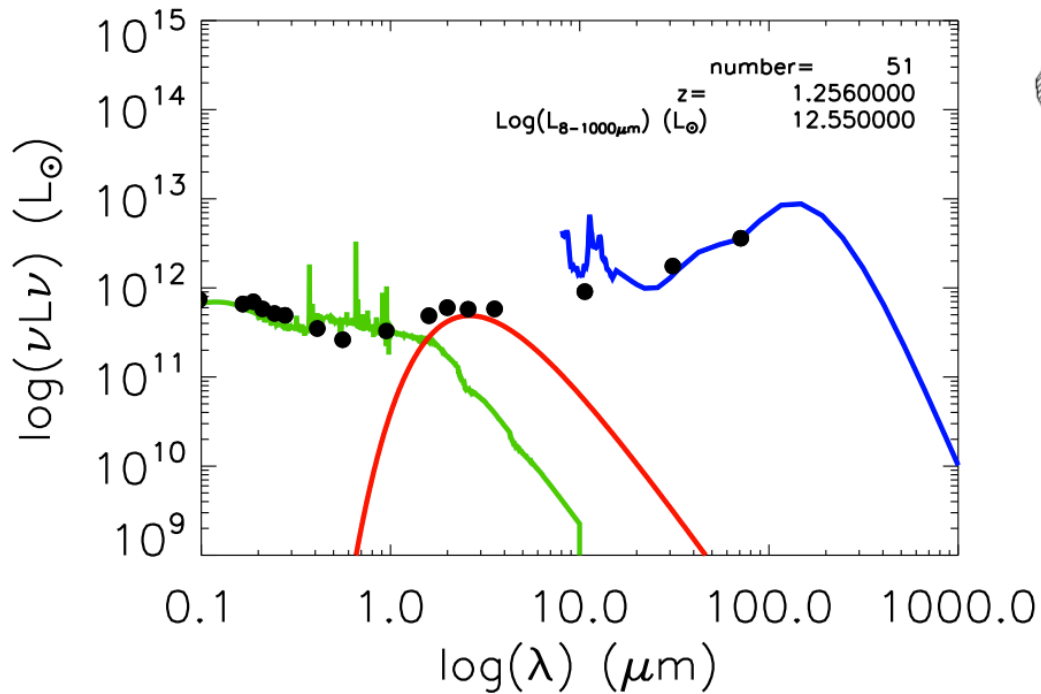
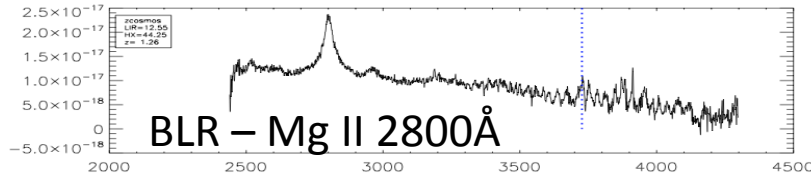


# LX\_LIR RELATION



# SED FITTING

VIMOS spectroscopy from VLT

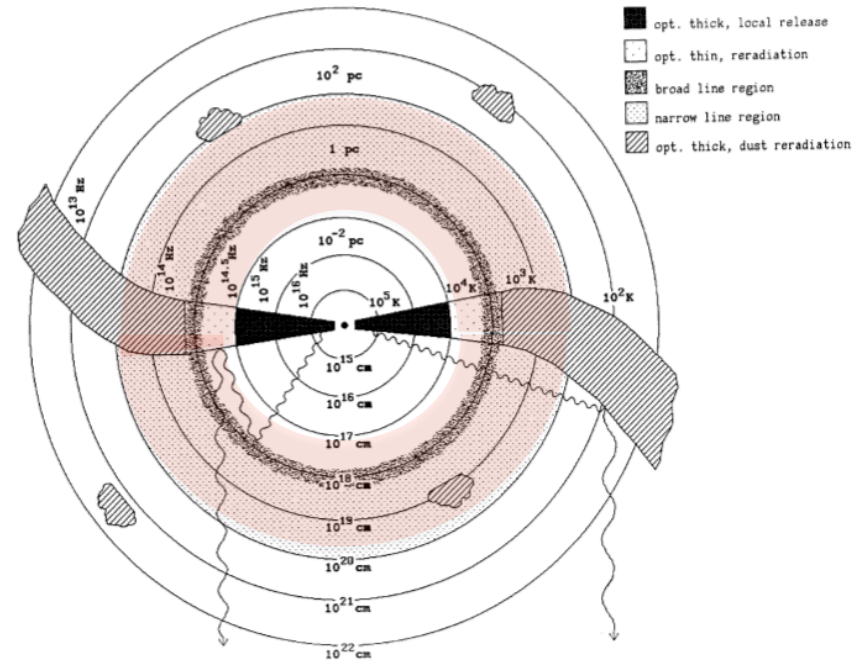


Stellar component.

MIR bump  $\sim 1500\text{K}$   $\rightarrow$  dust in NLR heated by AGN

Cold dust component from host galaxy.

SANDERS ET AL.



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AGN dominated significantly!!!

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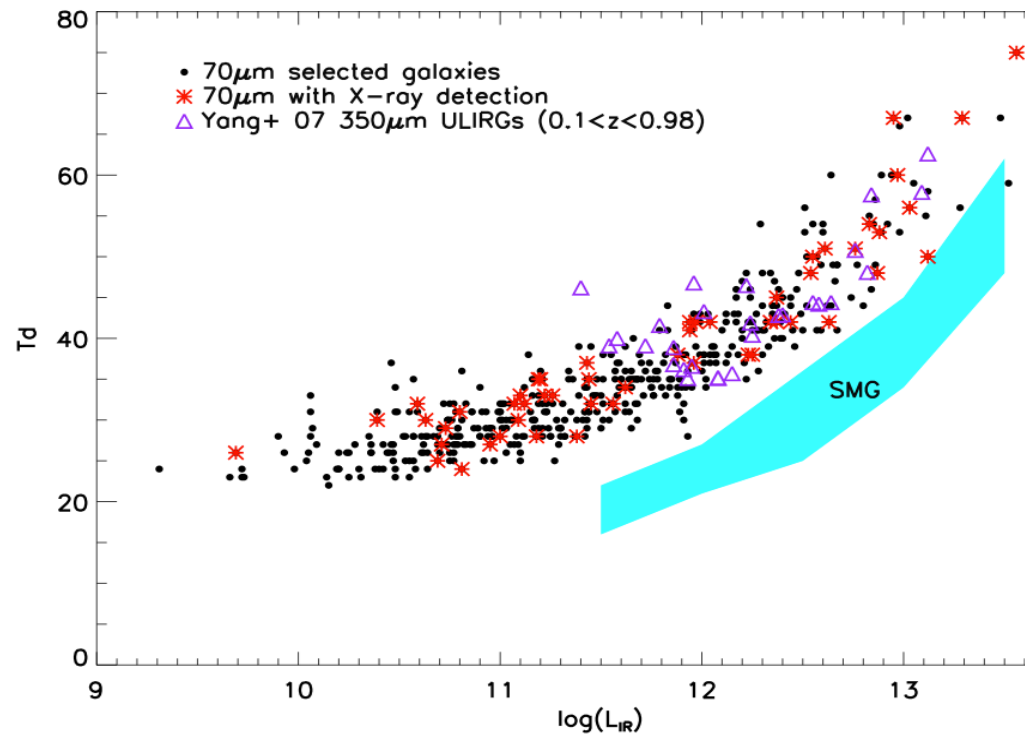
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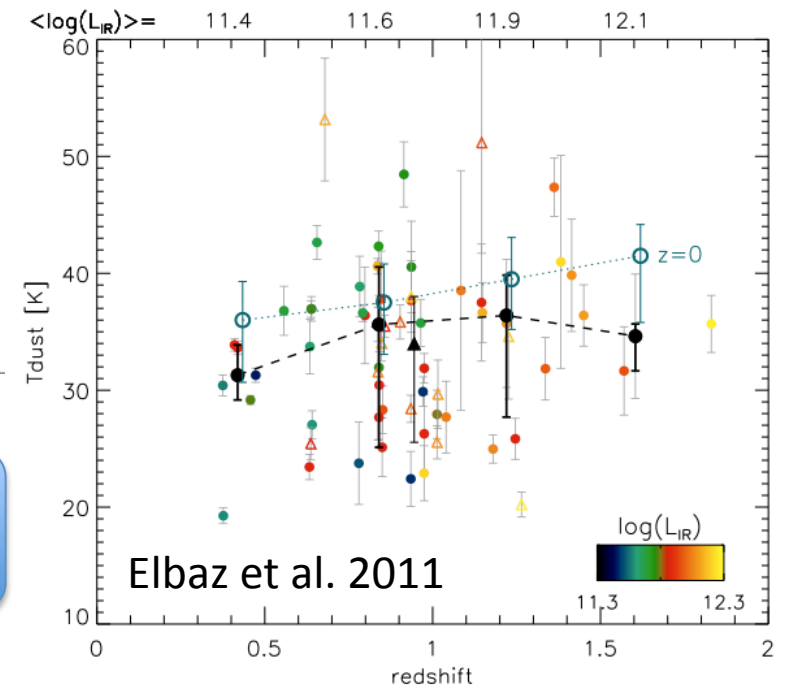
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# L-T DIAGRAM

- Using simple graybody-fit by assuming a constant emissivity  $\beta = 1.5$  with equation:  $F_\nu = \nu^\beta B_\nu(\nu, T)$ .



Existence of AGN is not affect the cold dust temperature of host galaxy in our samples.



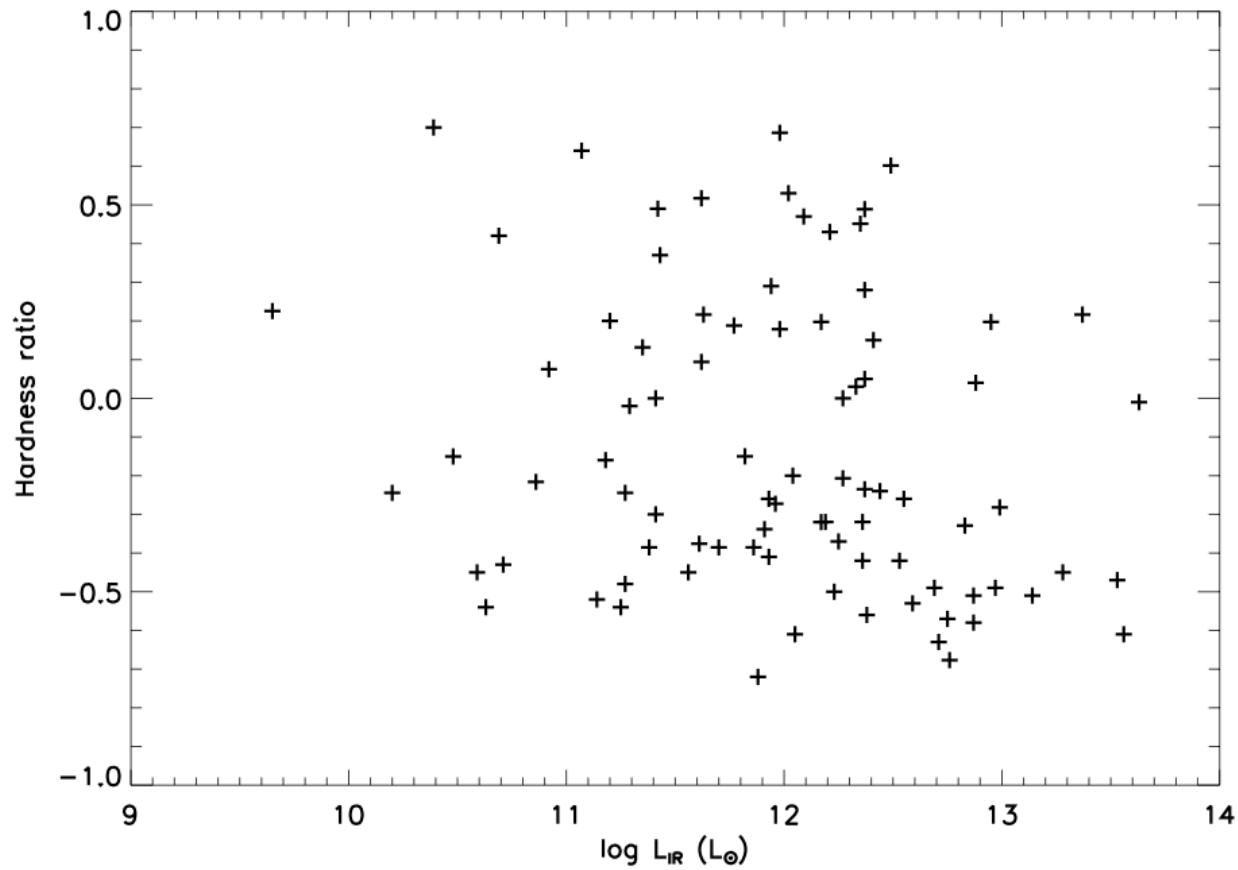
# HARDNESS RATIO

- Central Engine obscuration indicator :

$$\text{HR} = (H - S) / (H + S)$$

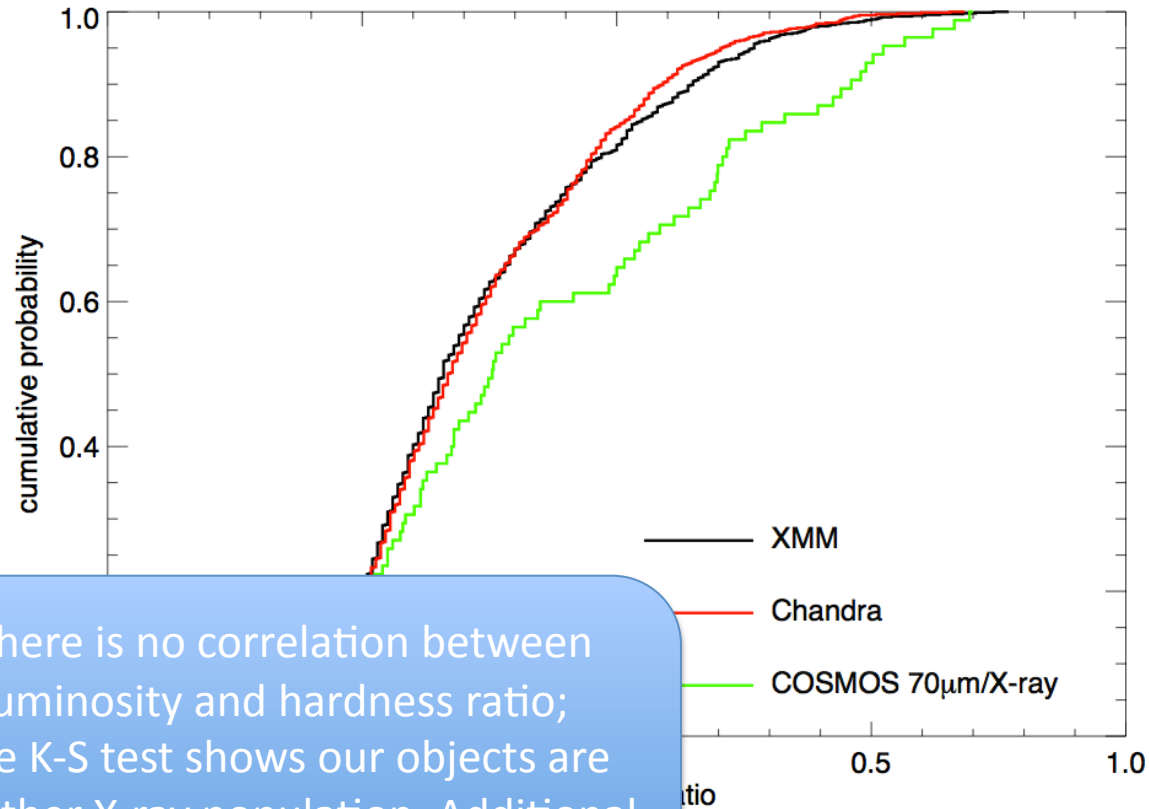
S : 0.5 – 2 keV

H : 2.0 – 10.0 keV



# HARDNESS RATIO

- K-S Test Hypothesis : Samples come from same population.

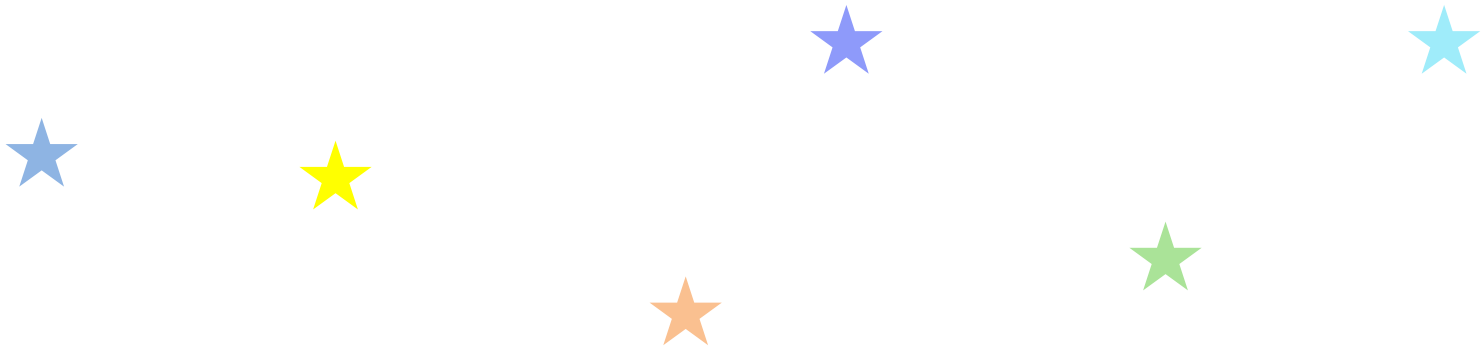


Although there is no correlation between infrared luminosity and hardness ratio; however the K-S test shows our objects are different to other X-ray population. Additional neutral hydrogen generate by mergers could produce more X-ray obscuration.

|                   |                         |
|-------------------|-------------------------|
| Significant level | Hypothesis: same        |
|                   | Can not reject (99% CL) |
|                   | Reject (99% CL)         |
|                   | Reject (99% CL)         |

# SUMMARY

- ★ AGN diagnosis shows the AGN fraction increases as LIR increases; LX-LIR indicates that although the HMXB/ULX could contribute to hard X-ray, AGN dominates the hard X-ray significantly.
- ★ SED fitting exhibits the evidence of hot gas component, which is considered be heated by AGN. Co-existence of AGN and star formation is common in our samples.
- ★ Although Infrared luminosity does not apparently affect hardness ratio, a K-S test indicates that at 99%CL the  $70\mu\text{m}/\text{X-ray}$  targets have larger obscuration than the whole X-ray population.
- ★ Disregarding the presence of AGN, the temperature of galaxy do not differ from pure star-forming galaxy, which is consistent with recent Hershel results but in contrast of our HR K-S test result.



♪ THANKS FOR YOUR LISTENING ♪

