Near infra-red variability found in the local young star-forming dwarf galaxy SBS 0335-052E

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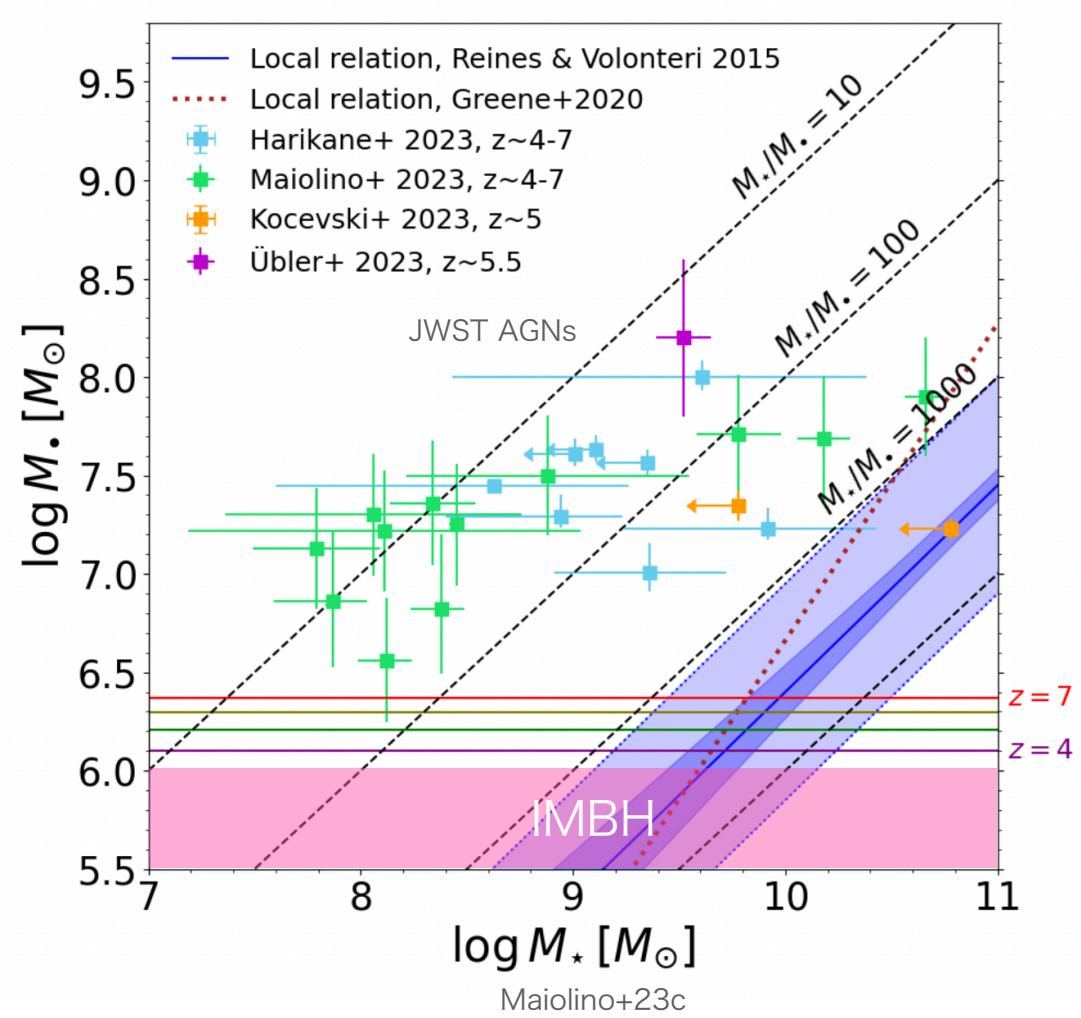
Hatano+23a: https://arxiv.org/pdf/2304.03726.pdf
Hatano+23b: https://arxiv.org/pdf/2305.02189.pdf

IMBH is key to understand SMBH origin

- Origin of supermassive black hole (SMBH; $M_{\rm BH} \gtrsim 10^6 M_\odot$) unknown
- Key: Intermediate-mass black hole (IMBH; $M_{\rm BH} \sim 10^{2-5} M_\odot$)



Maiolino+23c

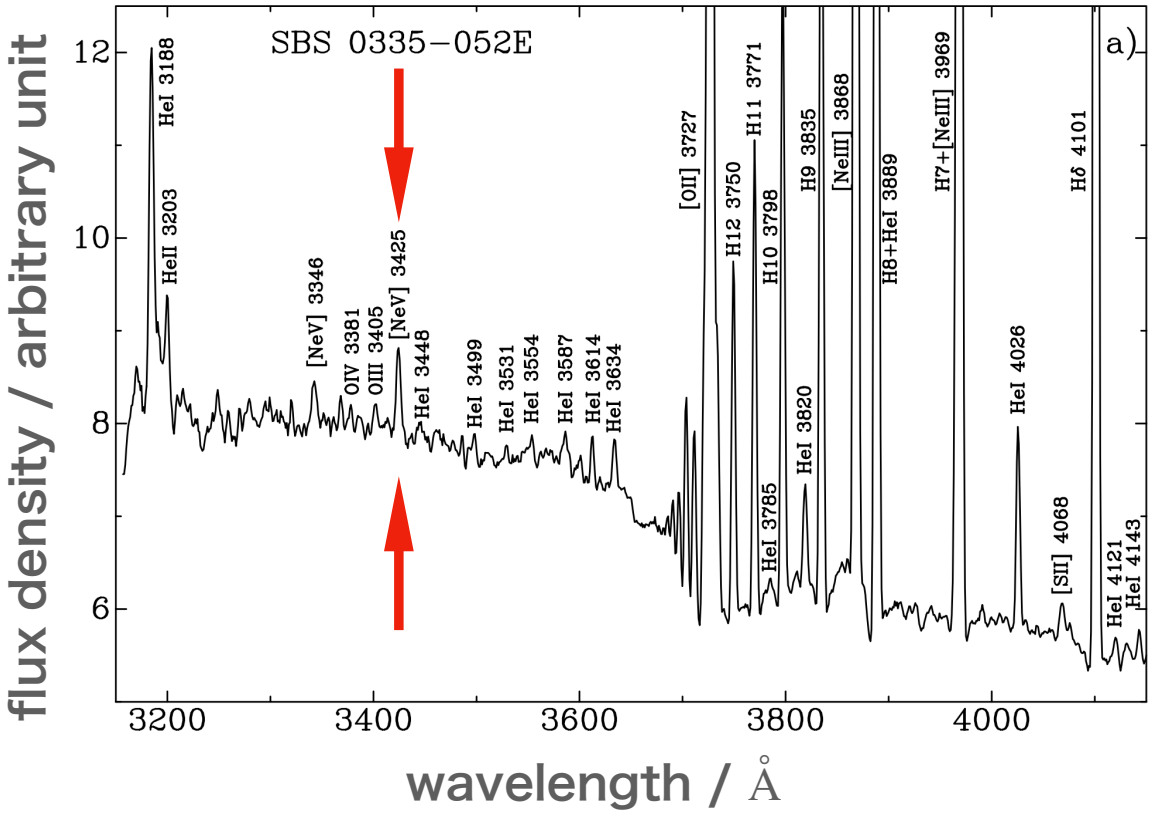
[Ne V] line: Possible AGN signatures in local dwarf galaxies

Hatano+23b (submitted to ApJ) Sample

~10 local young dwarf galaxies;

- Z ~ 0.02-0.5 Zo
- Stellar mass $M_* \sim 10^{7-9} M_\odot$
- **[Ne V]3426 (>100 eV)** line detection
  (e.g. Izotov+04, Thuan&Izotov 05)
- However,
  Long thought to be simple **star forming dwarf galaxies**
  (based on BPT diagram etc.)

→ IMBH in dwarf galaxies?



Thuan&Izotov 05

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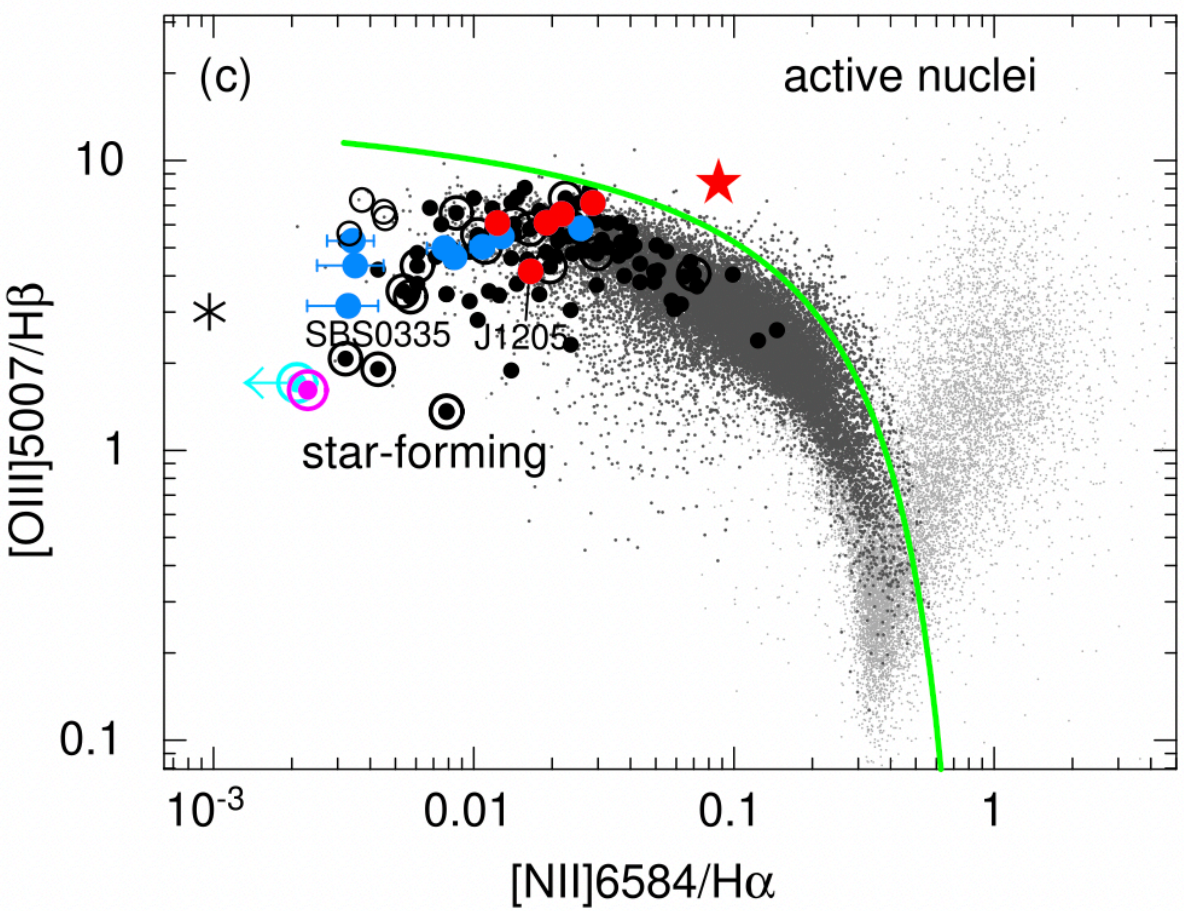


Non-stellar source found in 55-100 eV

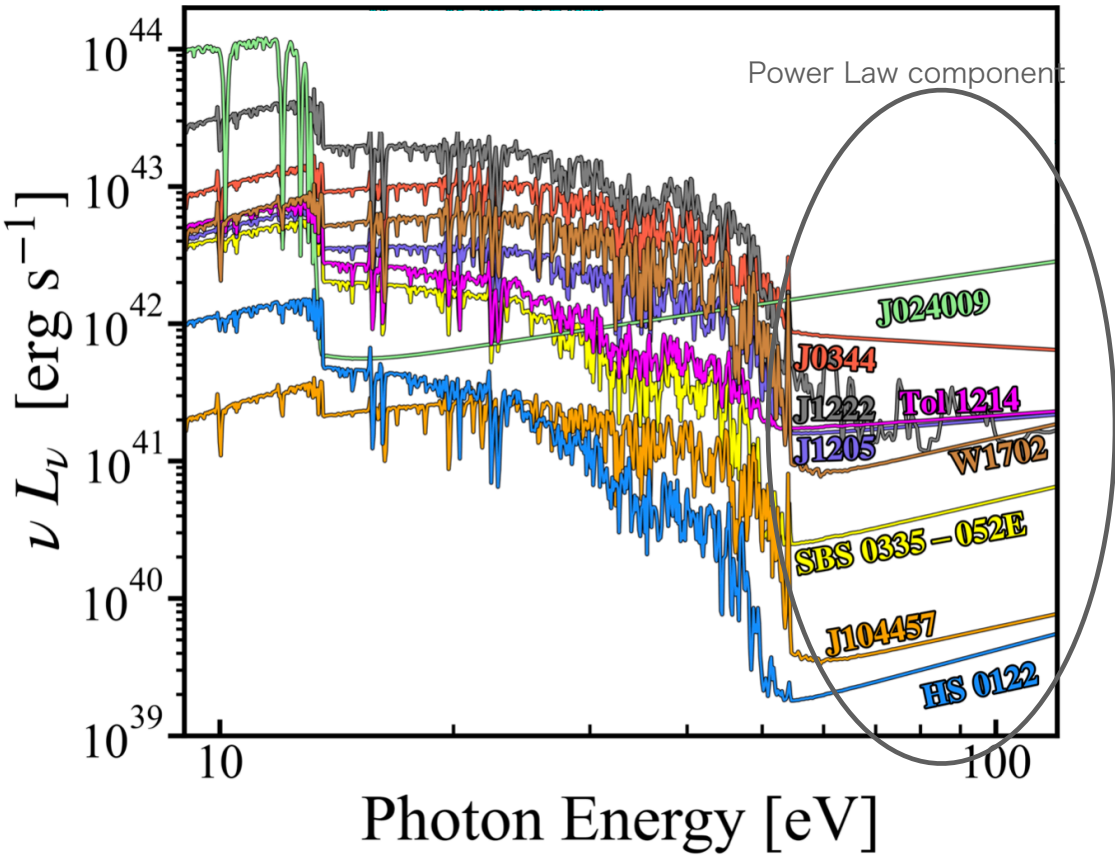
Hatano+23b

Line ratios of > 10 emission lines

↓ photoionization model + MCMC

ionizing spectra

if MBH, BH mass is related to power-law index and power-law luminosity (Kawaguchi 03)



Estimated Ionizing spectra of 10 dwarf galaxies (Hatano+23b)

BH mass estimation with BH accretion disk model

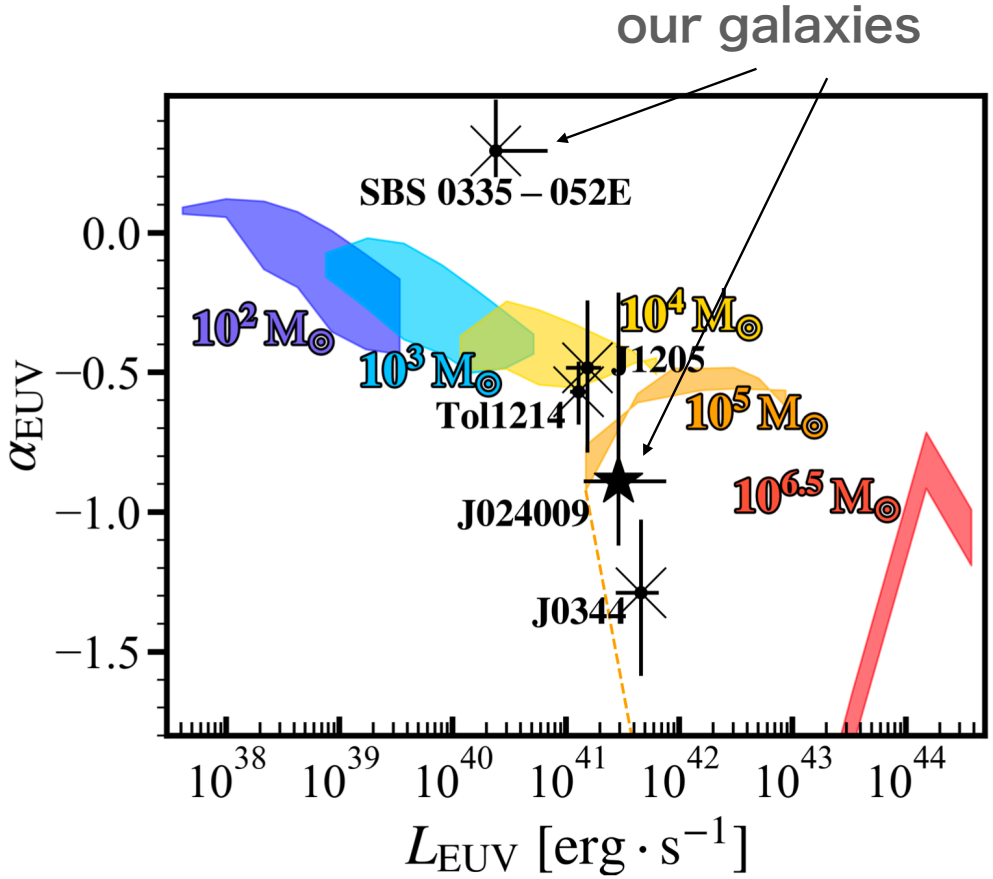
Hatano+23b

- Exclude 4 dwarf galaxies with poor power-law determination

→ Comparison with accretion disk models (color; Kawaguchi 03)

include uncertainties of
accretion rate: $\dot{m} = 1 - 1000$
Viscosity parameter: $\alpha = 0.01 - 1$

Ionizing spectra consistent with IMBHs!



$L_{\rm EUV}$: Extreme UV (EUV; 55-100 eV) luminosity

$\alpha_{\rm EUV}$: EUV power-law index

Investigation for AGN signatures

- a. Mid Infra-red (MIR) colors
- b. Times variabilities
- c. Ha broad lines
- d. Spectral fitting (SED fitting)

a. MIR colors

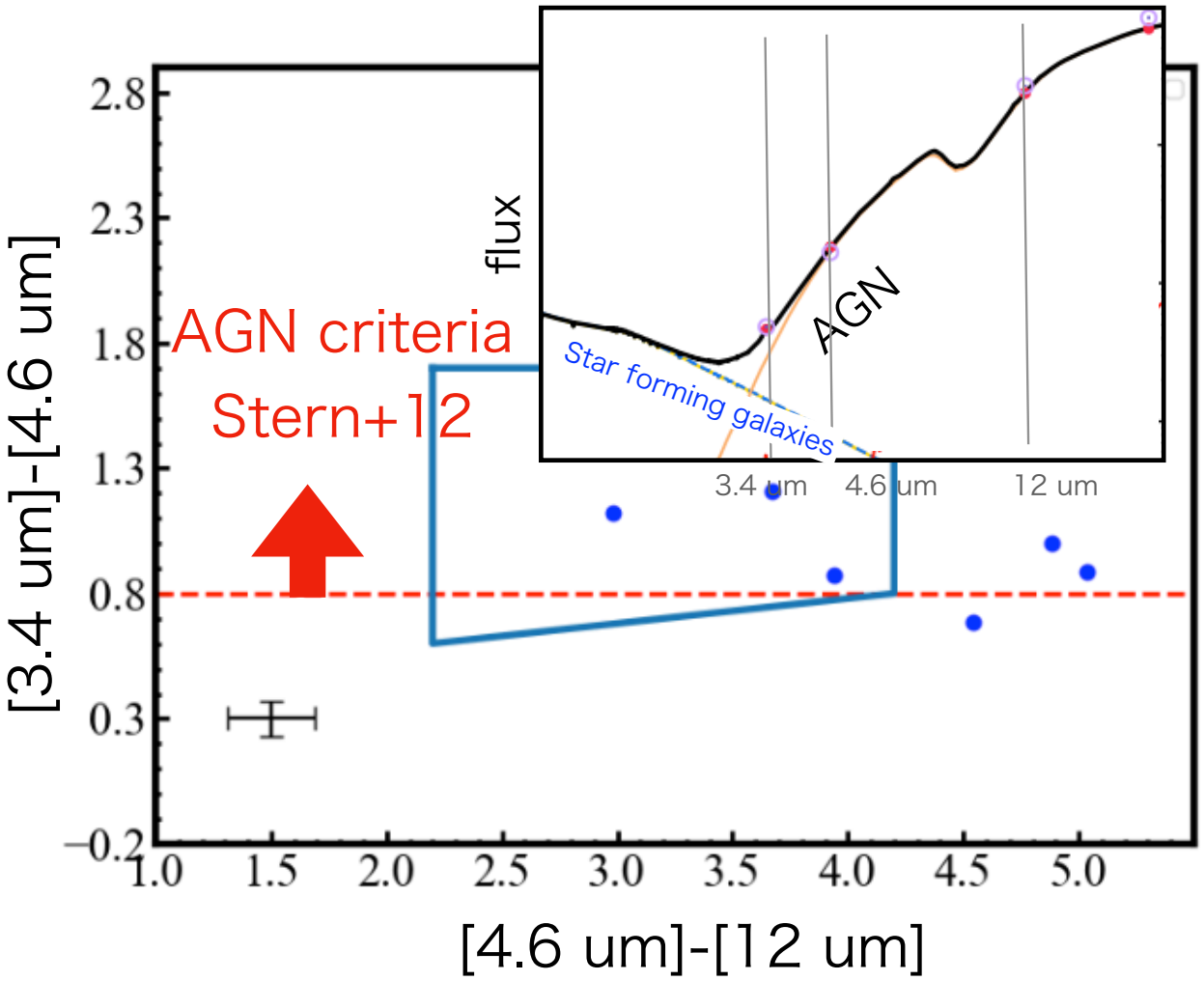
AGN hot dust emission → red MIR colors

<u>Compare</u>

・AGN criteria (Stern+12)

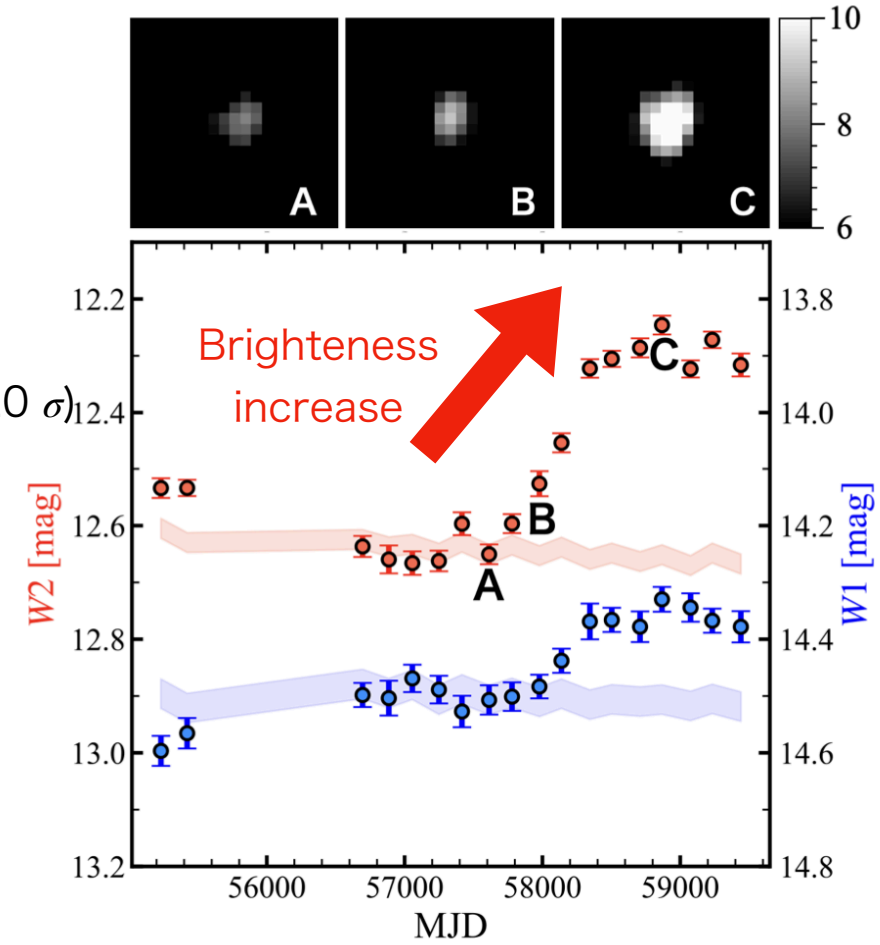
・Our Sample (ALLWISE catalogue)

→ Almost all the galaxies satisfy AGN criteria



b. AGN signatures: Time Variabilities

- If AGN→ time variabilities may exist
- WISE satellite NEOWISE database (NIR time domain data)
- Detection of variability in bright 2 (out of 8) galaxies (S/N~20 σ)
- Variability fraction 25%
  (>> Typical value for dwarf galaxies$0.19\% \pm 0.02\%$;Ward+22)
- Albeit the possibilities of Type IIn supernovae



Example of galaxies with time variabilities

c. Ha broad lines

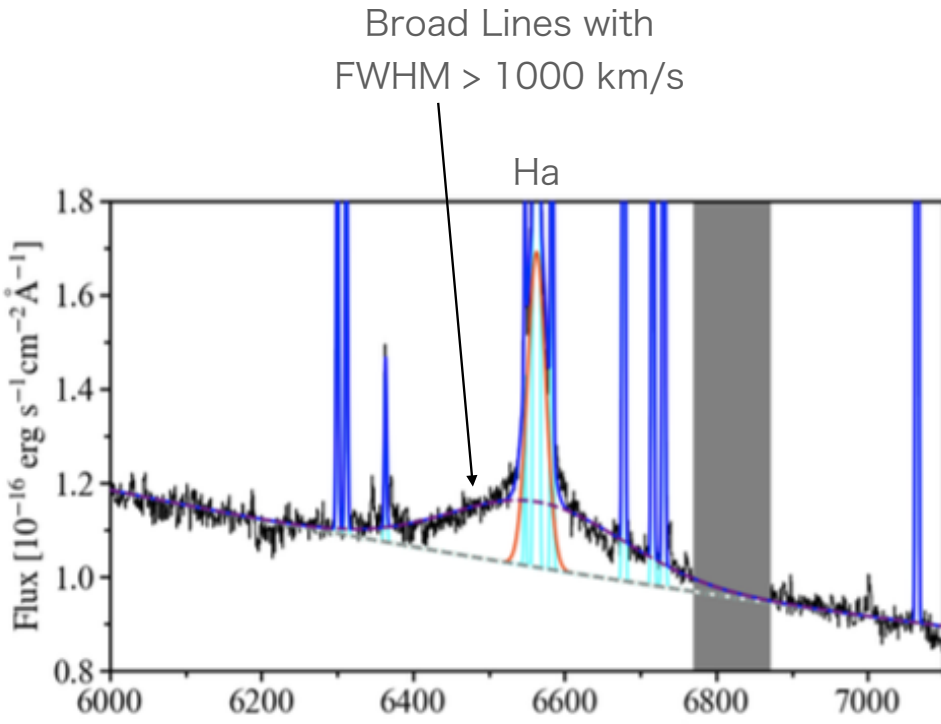
If AGN→ Ha broad may exist

All the galaxies (6 galaxies; Izotov+21, Hatano+23a)

Name	Broad line? FWHM
SBS 0335-052E	12400 km s^{-1}
J1222	1774 km s^{-1}
W1702	1857 km s^{-1}
Tol 1214	> 900 km s^{-1}
J1205	2233 km s^{-1}
J0344	1998 km s^{-1}

Broad emission lines with1500-10000 km/s

→ Likely AGN
Albeit the possibilities of Type IIn supernovae with precursors



Hatano+23a

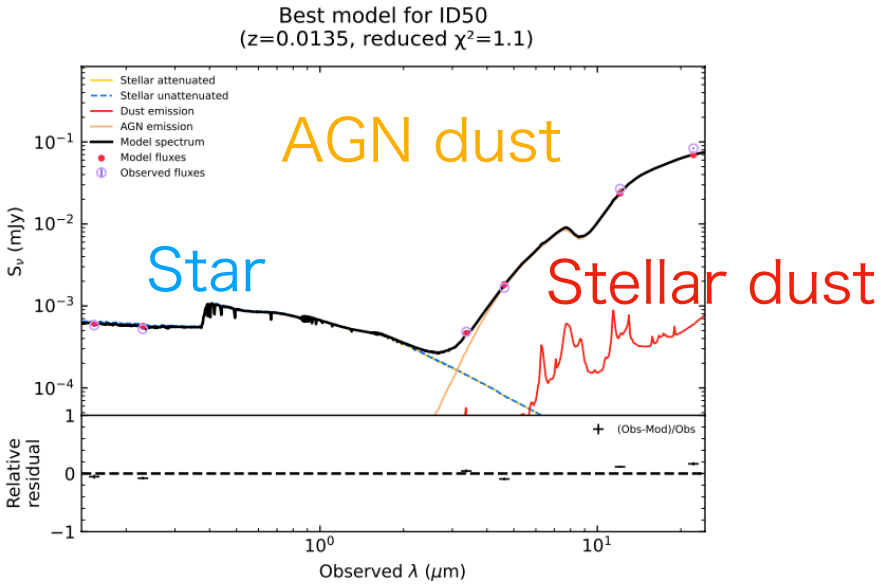
d. SED fitting

- If AGN→Strong IR emission: investigate SED
- CIGALE model
  Star + Stellar dust + AGN dust

Compare → best-fit models

All the galaxies

- AGN luminous in NIR-MIR
- inclination angle ~90 deg (Thick torus)



Example of SED fitting result:
SBS 0335-052E

AGN signatures summary

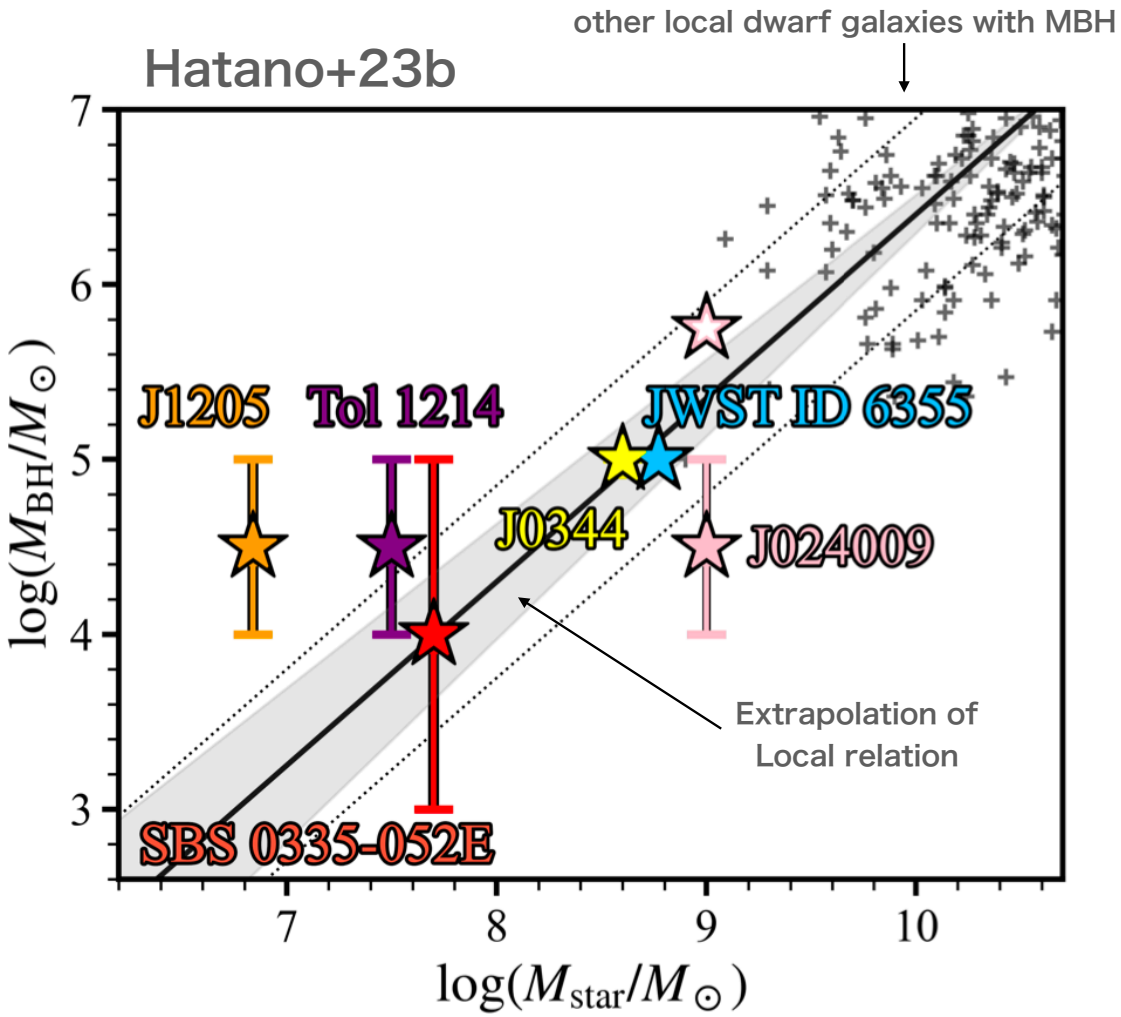
- likely AGNs albeit the possibilities of Type IIn SNe with precursors

	b.	c.	d.
Name	Variability?	Broad line? FWHM	Significant hot dust?
SBS 0335-052E	Yes	12400 km s^{-1}	Yes
HS 0122	No		Yes
J104457	No		Yes
J1222	Yes	1774 km s^{-1}	Yes
W1702	No	1857 km s^{-1}	Yes
Tol 1214	No	$>$ 900 km s^{-1}	Yes
J1205	Yes	2233 km s^{-1}	Yes
J0344	No	1998 km s^{-1}	Yes

M* vs. M_BH

- M* vs. M_BH relation based on emission line (Hatano+23b)

- The SBS object is consistent with extrapolation of local relation at higher M*.



Summary

- For ~10 dwarf galaxies with [Ne V] lines
- Ionizing spectra consistent with IMBH with M_BH ~ 10^3-5 Mo
- Investigated AGN signatures
  - a. MIR colors
  - b. Time variabilities
  - c. Ha broad lines
  - d. SED fitting

  → Likely AGNs albeit the possibilities of SNe

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