



GLAO レガシープロジェクト

TMT 時代にすばるの時間の a few 10s (50) % を5年間程度使う (~1,000 夜) ことで、何をするか。

単純な発想だと、、、

- SDSS-like survey at $z \sim 1$ with imaging (rest u, b, v, i, z) and MOS-mode (rest 3600-9000Å) ~1,000,000 galaxies
- MANGA-like survey at $z \sim 1$ with IFU-mode (kpc resolution) ~10,000 galaxies

(TMT に最適化したプロジェクトか?)

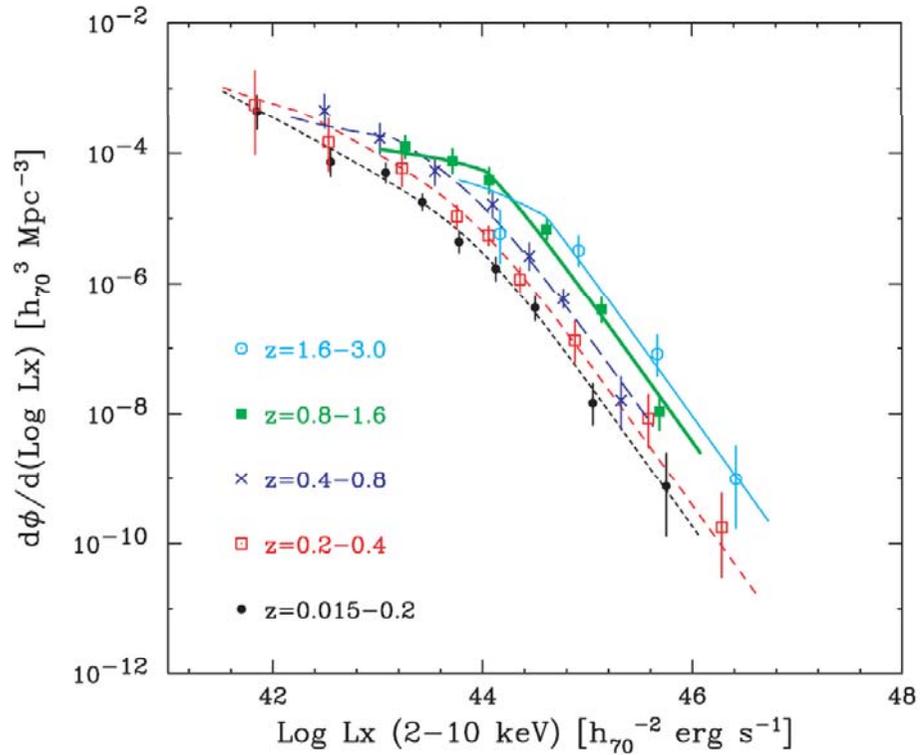
秋山 正幸 (東北大学)



超巨大ブラックホール SMBH の成長

- SDSS-like survey at $z \sim 1$ with imaging (rest u,b,v,i,z) and MOS-mode (rest 3600-9000Å) ~1,000,000 galaxies
 - X線で見えられない活動銀河中心核探査
 - **Narrow-line Type-1 AGNs**
 - Compton-thick Obscured AGNs
- MANGA-like survey at $z \sim 1$ with IFU-mode (kpc resolution) ~10,000 galaxies
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Evolution of X-ray LF of AGNs



Ueda, MA, et al. 2003

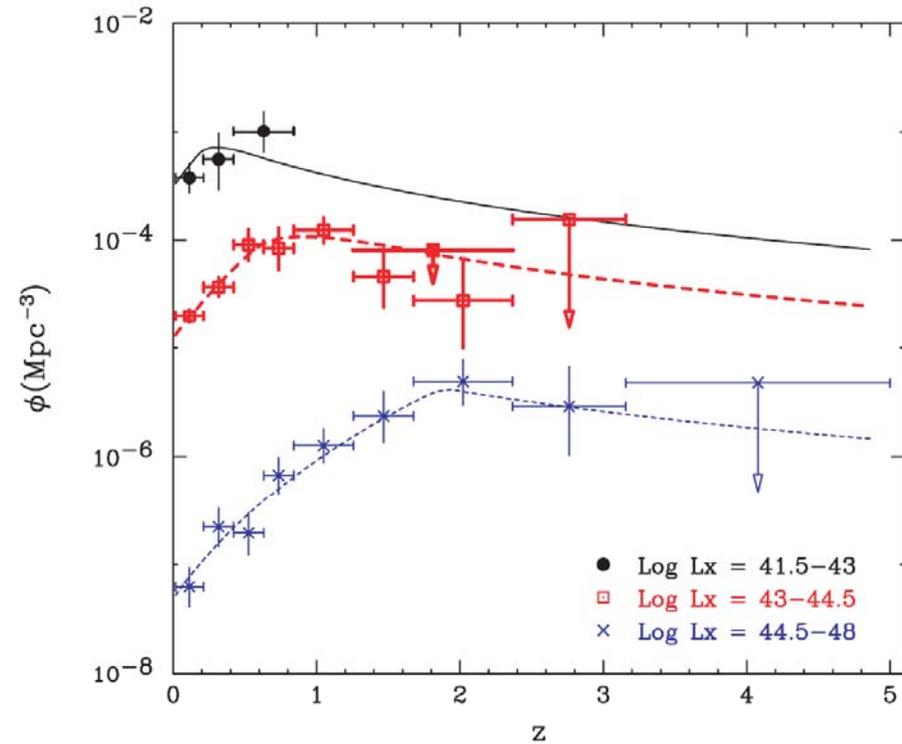
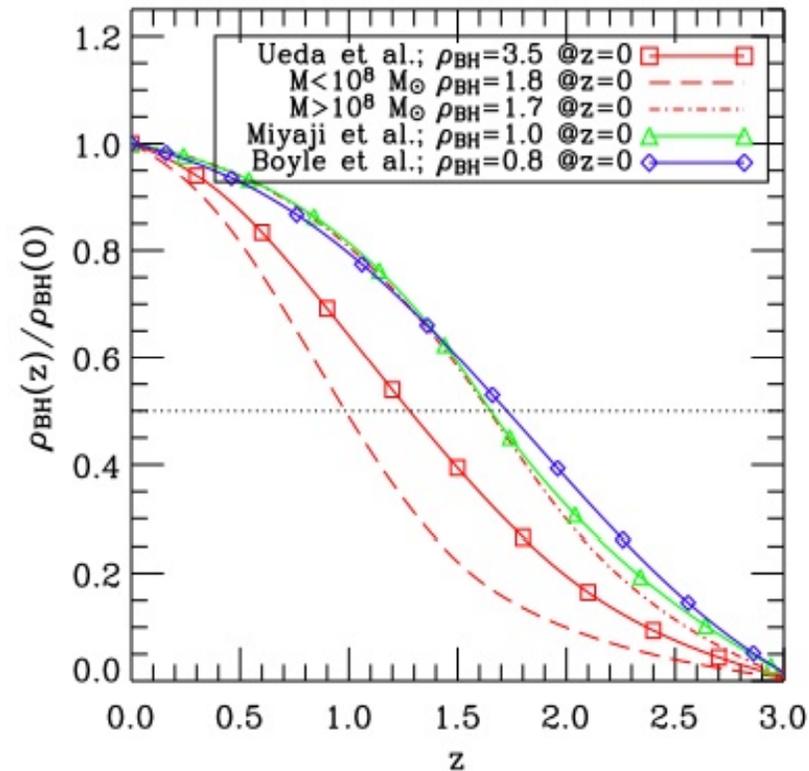


FIG. 12.—Comoving spatial density of AGNs as a function of redshift in three luminosity ranges, $\log L_X = 41.5\text{--}43$ (upper black curve), $43\text{--}44.5$ (middle red curve), and $44.5\text{--}48$ (lower blue curve). The lines are calculated from the best-fit model of the HXLF. The errors are 1σ , while the long arrows denote the 90% upper limits (corresponding to 2.3 objects). The short arrow (marked with a red filled square) corresponds to the 90% upper limit on the average spatial density of AGNs with $\log L_X = 43\text{--}44.5$ at $z = 1.2\text{--}2.3$ when all the unidentified sources are assumed to be in this redshift bin.



Growth curve of Super Massive BHs



Marconi et al. 2004

Based on redshift evolution of X-ray luminosity function of AGNs, average growth curve of SMBHs has been evaluated (e.g. Marconi et al. 2004).

But such calculations are done assuming constant Eddington ratio for the entire AGN population. Under the assumption, luminosities of AGNs are directly correlated to the masses of their SMBHs. For quantitative understanding of growth curves of SMBHs, mass and accretion rate of each AGN which consists the X-ray LFs need to be examined.



SXDS AGNs at $z=1-2$

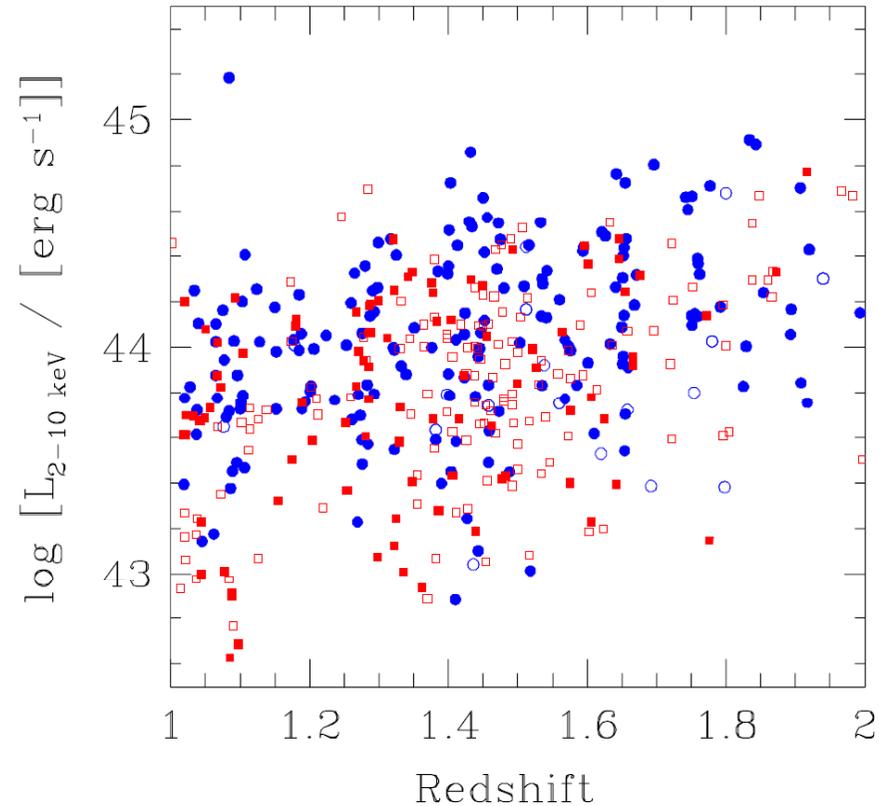


FIG. 2.— Redshift vs. absorption-corrected 2–10 keV luminosity of X-ray-selected AGNs in the SXDS. *Filled circles* and *squares* represent broad-line and narrow-line AGNs with spectroscopic identification, respectively. Broad-line (narrow-line) AGN candidates with photometric redshifts are shown with *open circles* (*open squares*).

For black hole mass function, we limit the sample within the redshift range between $1.18 < z < 1.68$. There are

Broad-line AGN : with z_{spec} 118 objects, z_{phot} only 10 objects

Narrow-line AGN : with z_{spec} 66 objects, z_{phot} only 92 objects



MgII FWHM measurements

With optical spectroscopic data.

(188 objects in total) 97 objects out of 118 broad-line AGNs at $z=1.18-1.68$

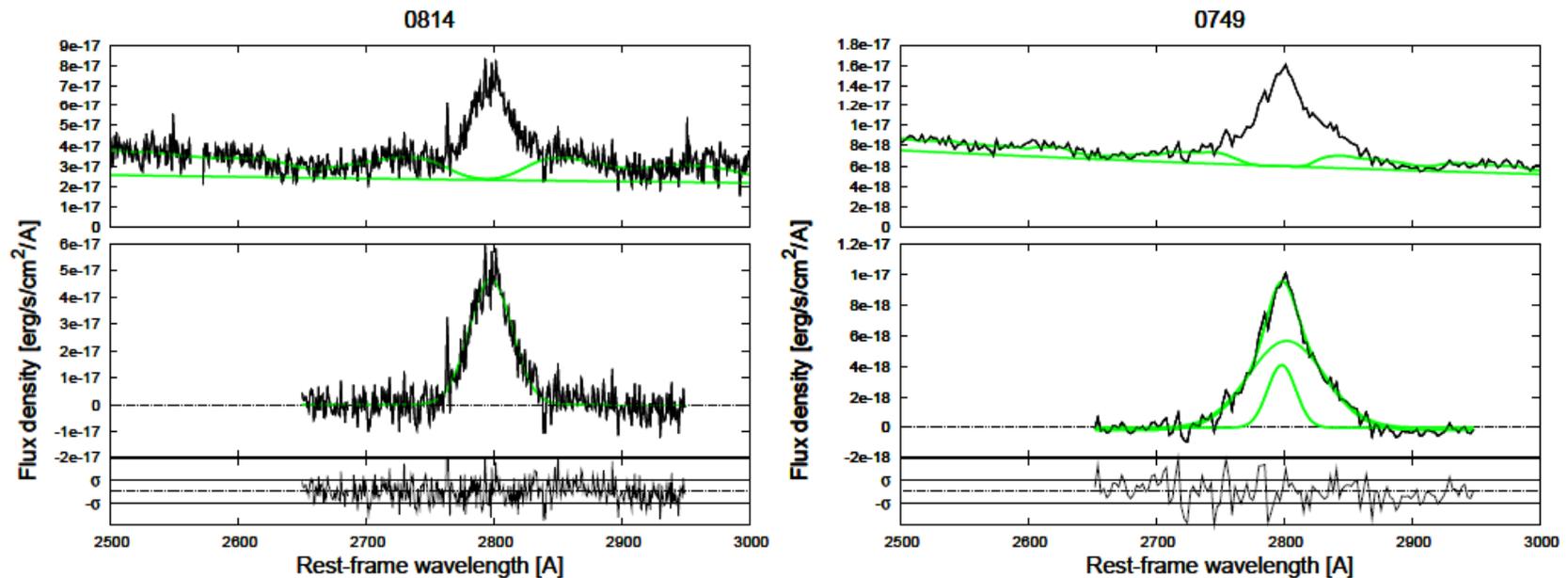


FIG. 3.— Examples of broad Mg II fitting. Upper panels show the observed data (*thin solid line*) and the best fit model from the power-law continuum and Fe II fitting (*thick solid line*). Power-law component of the best fit model is also shown separately. Middle panels show the results of the broad Mg II line fitting. Pure Mg II component after subtracting the power-law continuum and Fe II components and best fit model from the Mg II fitting are shown with *thin solid line* and *thick solid line*, respectively. Each component of the best fit model is also shown. Only the wavelength range used for the broad-line fitting is plotted. Bottom panels show the residual after fitting. Left) SXDS0814 with single broad-line, and right) SXDS0749 with 2 components.



H α FWHM

(81 objects in total) 19 additional objects out of 21 broad-line AGNs at $z=1.18$ - 1.68 w/o MgII FWHM measurement

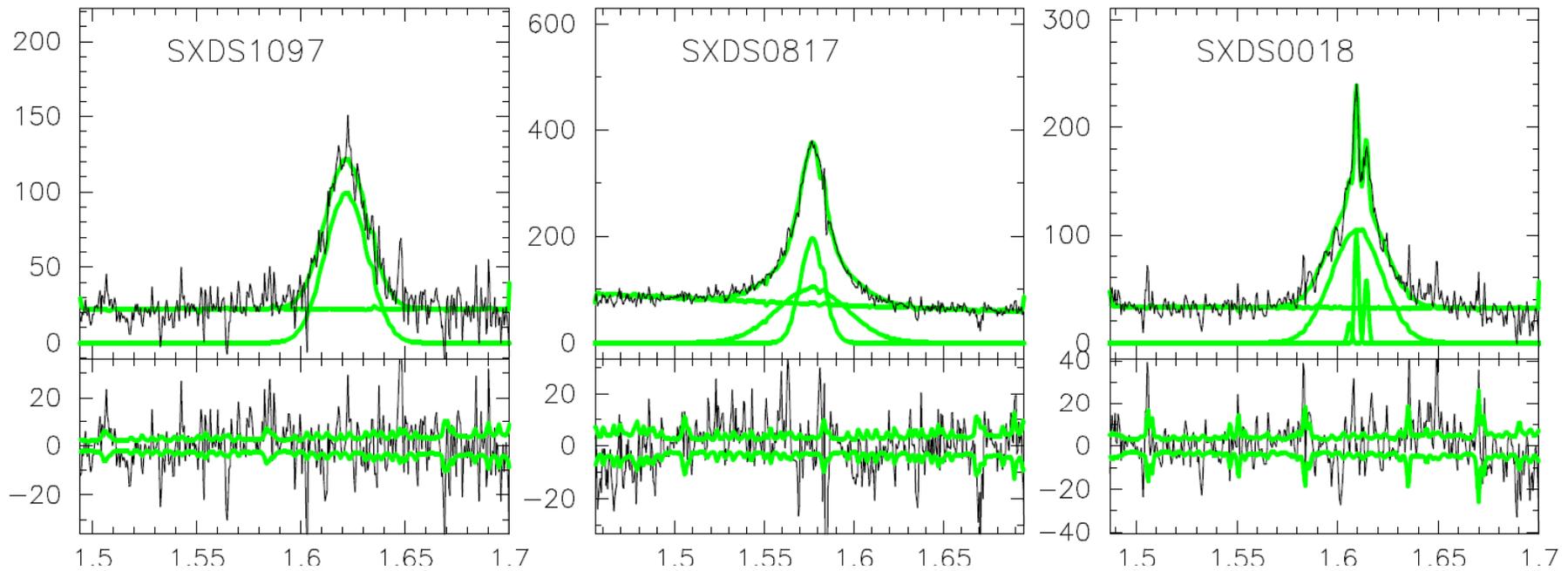


FIG. 5.— Examples of broad H α fitting. Upper panels show the observed data (*thin solid line*) and the best fit model with each component (*thick solid lines*). Lower panels show the residual from the fitting (*thin solid line*). *Thick solid lines* in the panel enclose the estimated 1σ noise level at each wavelength. Left) SXDS1097 with single broad-line, middle) SXDS0817 with 2 broad-lines, and right) SXDS0018 with broad-line and narrow H α and [N II] $\lambda\lambda$ 6548, 6583 lines.



Black Hole Mass and Eddington Ratio

Plotted only broad-line AGNs in the redshift range $1.18 < z < 1.68$

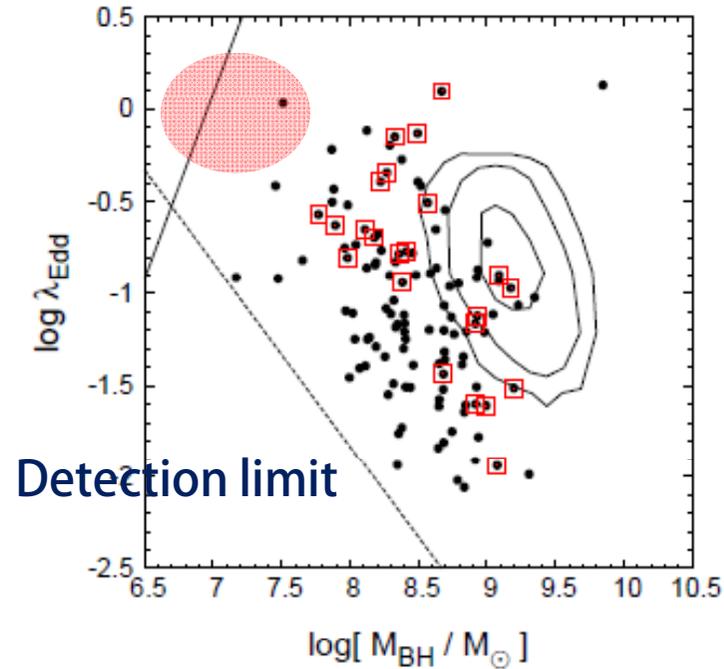
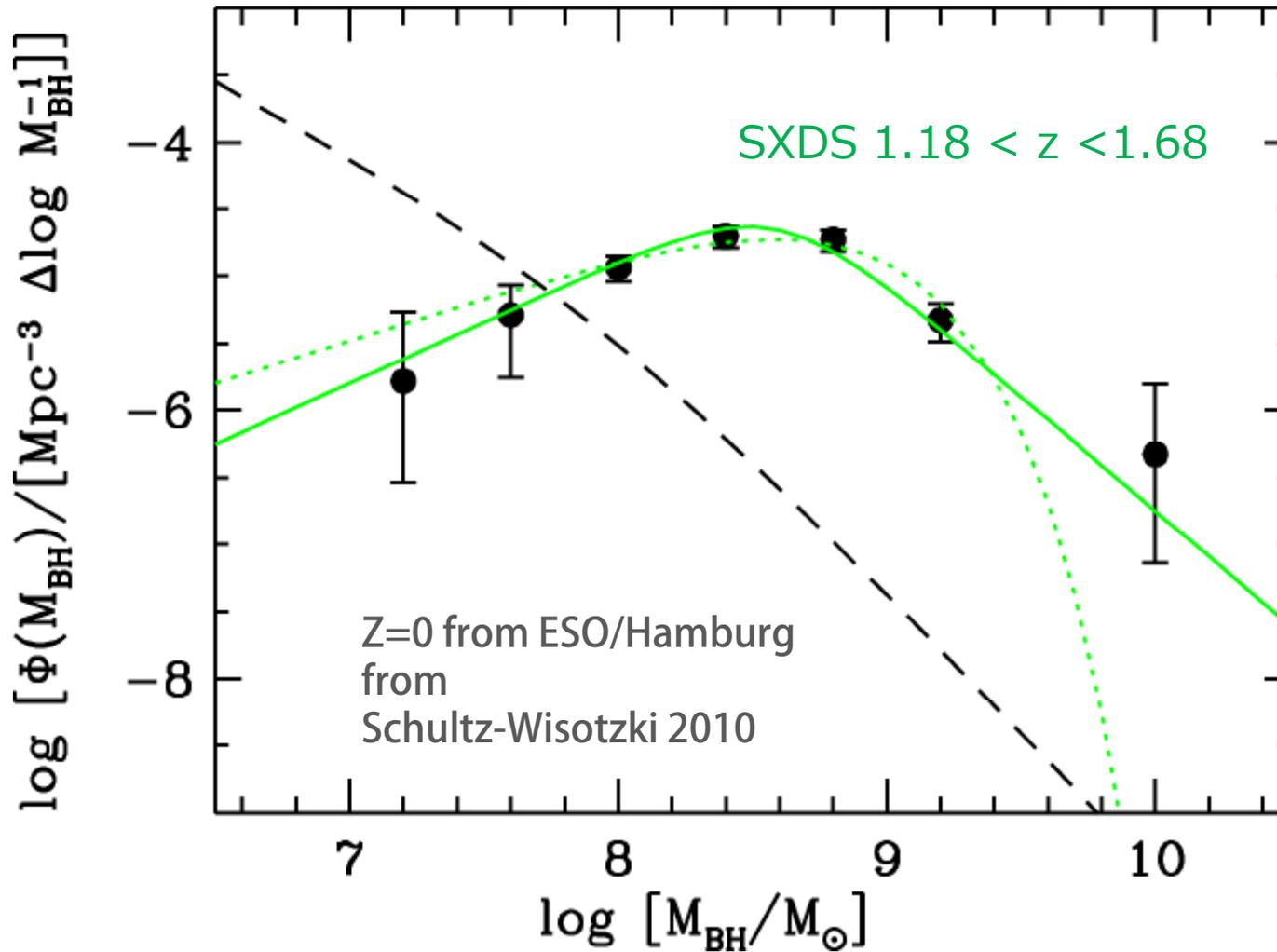


FIG. 9.— Black hole mass versus Eddington ratio of AGNs at redshifts between 1.18 and 1.68. AGNs whose Mg II FWHM are estimated from H α FWHM are marked with *large open squares*. The *dotted line* shows the relationship between $\log M_{\text{BH}}$ and λ_{Edd} for an AGN with $L_{2-10 \text{ keV}} = 10^{43} \text{ erg s}^{-1}$, corresponding to the faintest object in the sample. The *thick solid line* indicate the constant Mg II FWHM of 1000 km s^{-1} . The distribution of the SDSS DR5 sample (Shen et al. 2008a) in the same redshift range is shown with the contours.

Broad-line AGNs in SXDS (points) and SDSS (contour)
Lack of high Eddington ratio AGNs with $10^7 M_{\text{solar}}$?



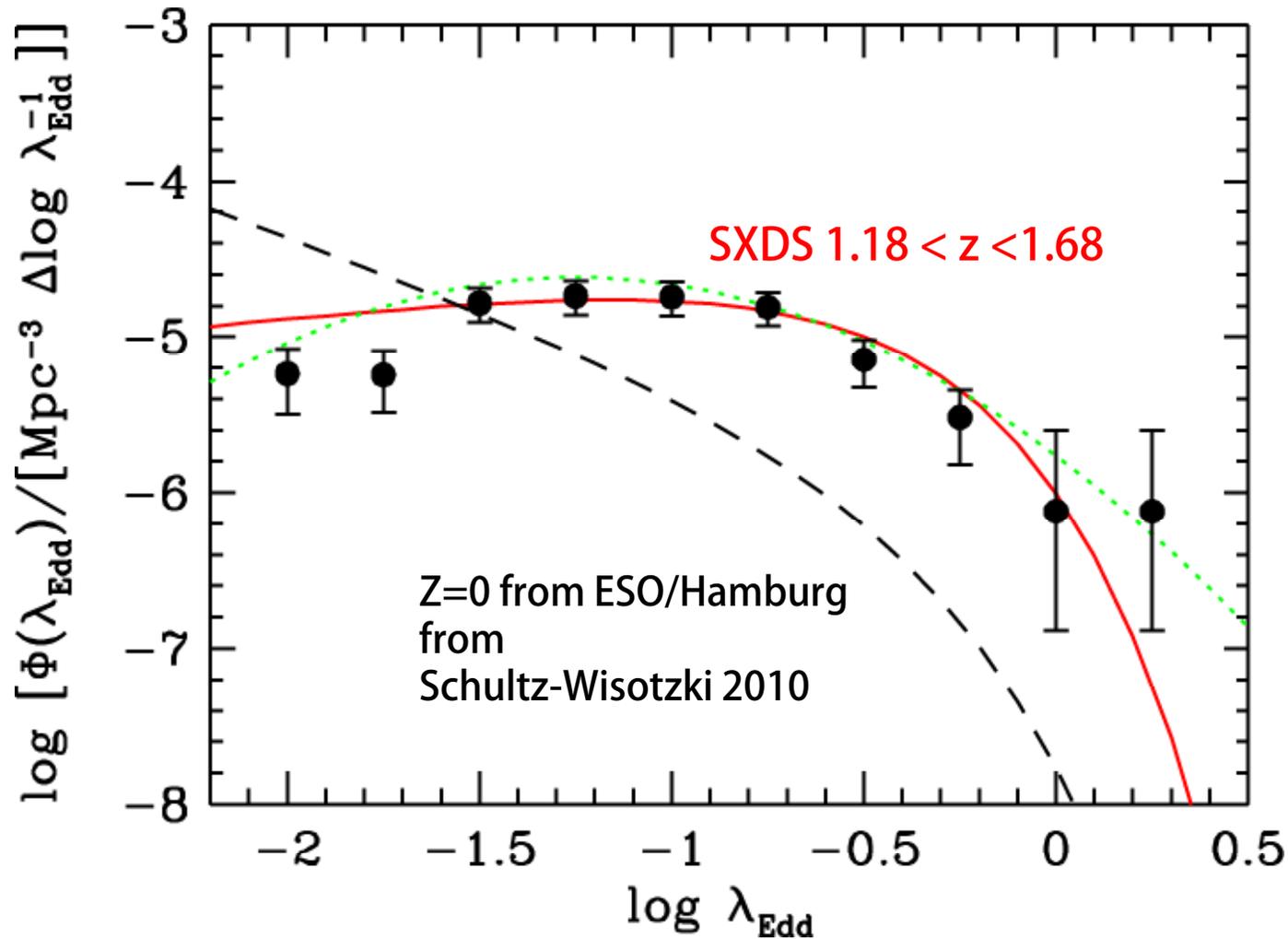
Evolution of active BHMF from $z=1.4$ to $z=0$



$z \sim 1.4$ active BH mass function has a higher number density above $10^8 M_{\odot}$ but a lower number density below that mass range than that in the local Universe. The evolution may be indicative of a down-sizing trend of accretion activity among the SMBH population.



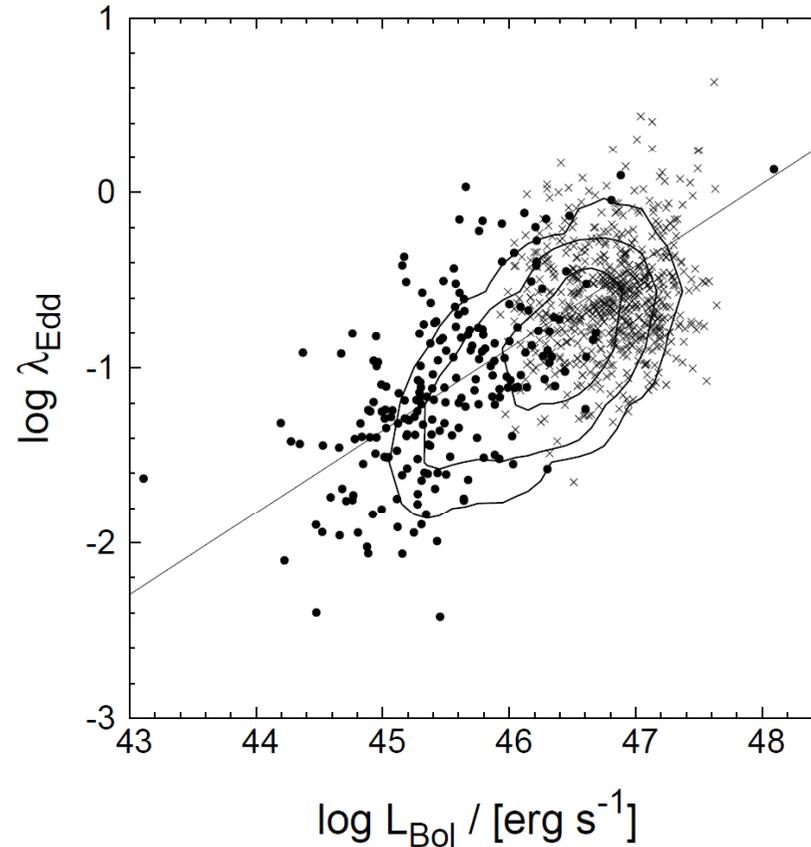
Evolution of ERDF from $z=1.4$ to $z=0$



The evolution of ERDF from $z=1.4$ to $z=0$ indicates that the fraction of AGNs with accretion rate close to the Eddington-limit is higher at higher redshifts.



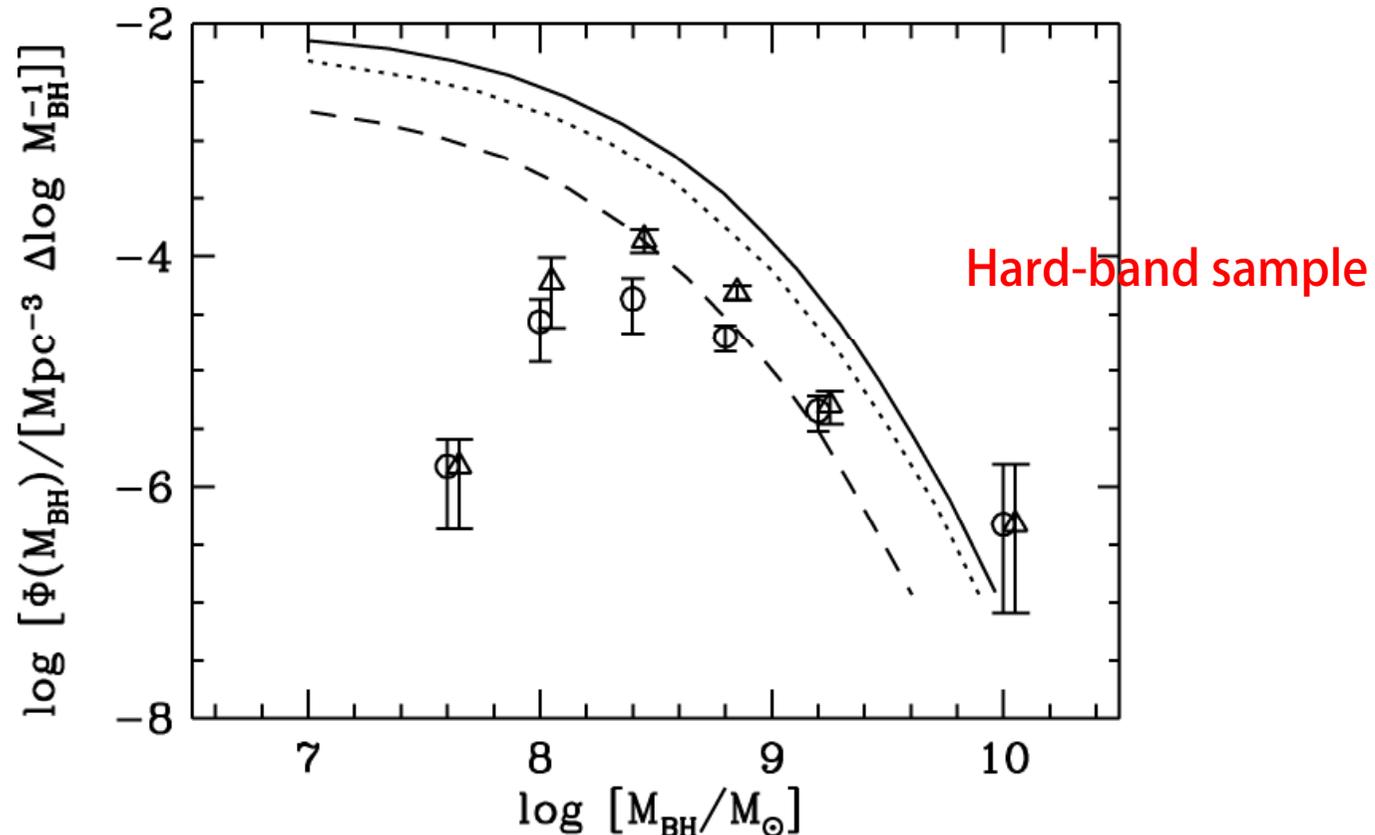
Contribution of obscured narrow-line AGNs



Among the X-ray-selected AGNs in the redshift range, more than half of the AGNs are obscured narrow-line AGNs. The contribution of these obscured narrow-line AGNs to the active binned BHMF is evaluated using the hard-band sample. BH mass of obscured narrow-line AGNs are estimated assuming constant Eddington ratio for each luminosity range.



Contribution of obscured narrow-line AGNs



Black hole mass function for 2-10keV selected sample.

Open circles: BHMf for broad-line AGNs only

Open triangles: BHMf including contribution of obscured narrow-line AGNs.

The solid, dotted, and dashed lines are non-active BHMf at $z=0, 1, 2$ from K-band LF of galaxies (Li et al. 2011).



Narrow-line Seyfert 1s missed ?

- (Hard) X-ray selection may miss a population of AGNs with low black hole mass, like narrow-line Seyfert 1 galaxies with a steep X-ray spectrum.
 - 0.5-2.0keV still corresponds to rest-frame 1.25-5.0keV at $z=1.5$.
 - Supplement with variability-selection ? With UV-selection ?

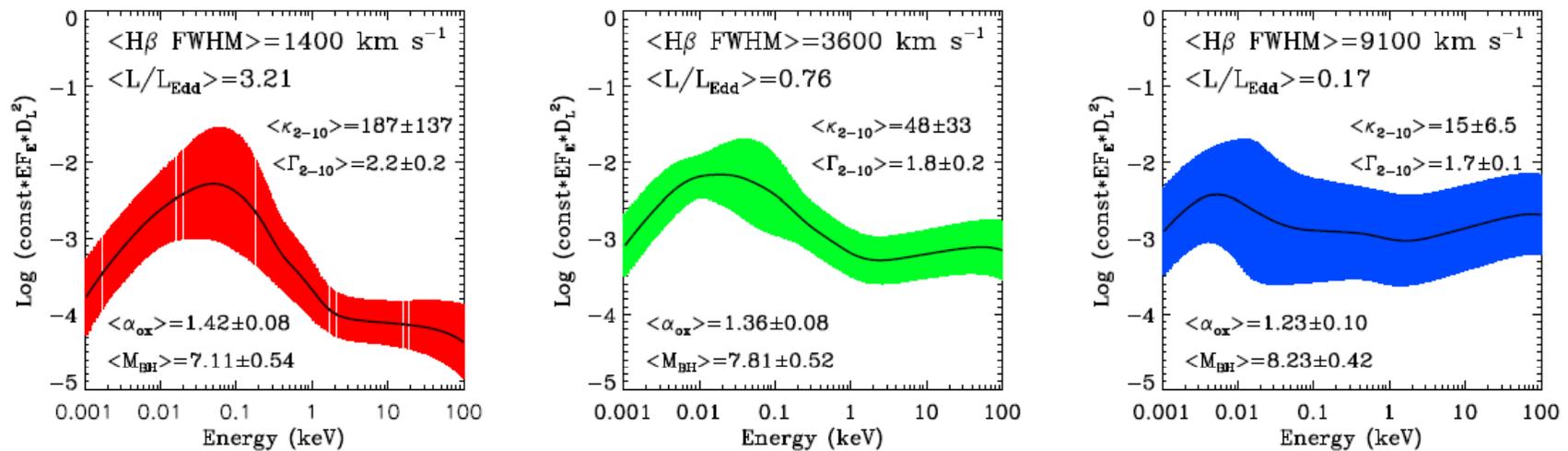
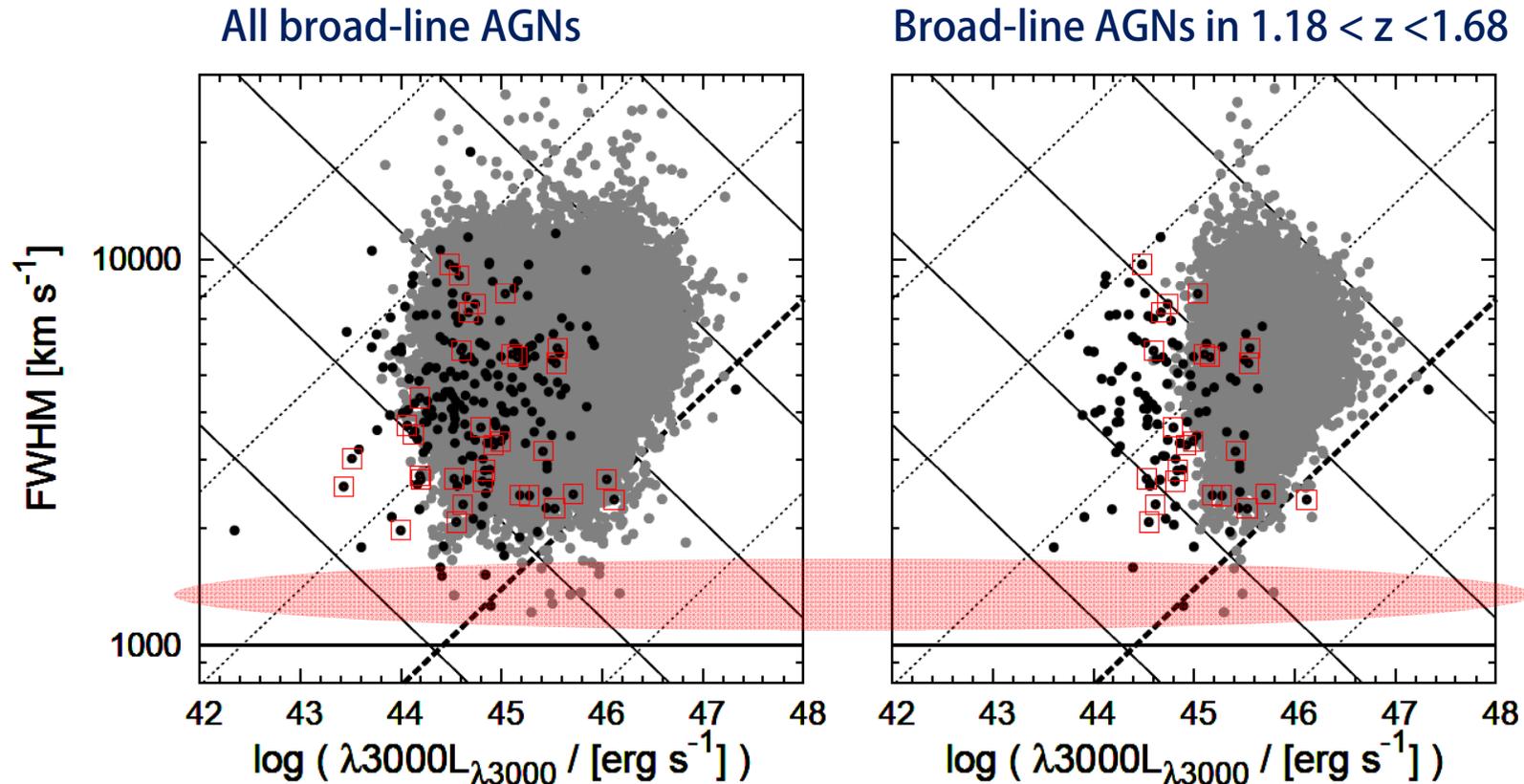


Figure 12. The average SED of our sample. The panel on the left shows the averaged SED for the 12 NLS1s (including two marginal NLS1s, 2XMM 112328.0+052823 and 1E 1346+26.7). The average $H\beta$ FWHM is $1400 \pm 500 \text{ km s}^{-1}$. The red area indicates a one standard deviation region on either side of the average spectrum. The central panel is for 12 objects with moderate line width. The average FWHM is $3700 \pm 600 \text{ km s}^{-1}$. The green region indicates one standard deviation. The panel on the right is the mean SED for the 12 broadest line objects in our sample, including the one double-peak source. The average FWHM is $9800 \pm 2900 \text{ km s}^{-1}$. We also show the average value of the 2-10 keV powerlaw photon index, the 2-10 keV bolometric correction, and the α_{ox} value with a one sigma error. D_L on the Y-axis title is the luminosity distance. The unit of Y-axis is 'keV (ergs $\text{s}^{-1} \text{ keV}^{-1}$)' in logarithm. The same arbitrary constant of 1.31×10^{-46} is used for rescaling each plot.

UV X-ray SEDs of AGNs
From Jin et al. 2012

FWHM vs. continuum luminosity



Broad-line AGNs in SXDS (black) and SDSS (gray scale)
 Red open squares indicate broad-line AGNs whose FWHM is estimated with H α emission line.

Lack of AGNs with FWHM < 2000km/s ?



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A Search for Heavily-obscured AGNs at $z=1-2$ with rest-frame optical emission lines

Masato Fujii, Masayuki Akiyama (Tohoku University)
FMOS GTO members

Fujii, MA, et al. in preparation

非常に大きく隠されたAGNの探査

大質量銀河に見られるAGN。

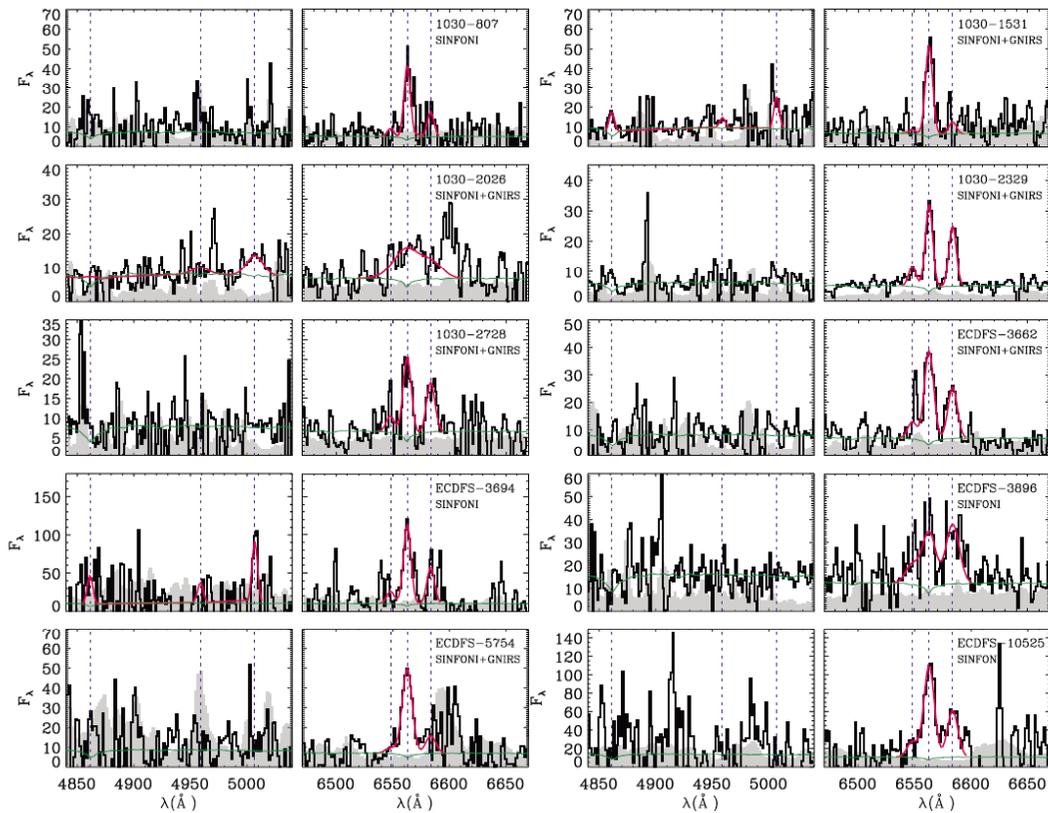


FIG. 1.—One-dimensional spectra in the wavelength region around $H\beta$ and $[O III] \lambda\lambda 4959, 5007$ and $H\alpha$ and $[N II] \lambda\lambda 6548, 6583$ of 10 K -selected emission-line galaxies at $2.0 < z < 2.7$. The wavelength is presented in rest frame and the flux is given in $10^{-19} \text{ ergs s}^{-1} \text{ cm}^{-2} \text{ \AA}^{-1}$. The vertical dotted lines present the positions of the expected $H\beta$, $[O III] \lambda\lambda 4959, 5007$, $[N II] \lambda 6548$, $H\alpha$, and $[N II] \lambda 6583$ lines. The red line presents the best fit to the three emission lines. The green line is the best continuum fit to the low-resolution GNIRS spectra. Gray shaded areas present the noise spectrum. For several galaxies we combined the SINFONI with the GNIRS spectra for reasons explained in the text.

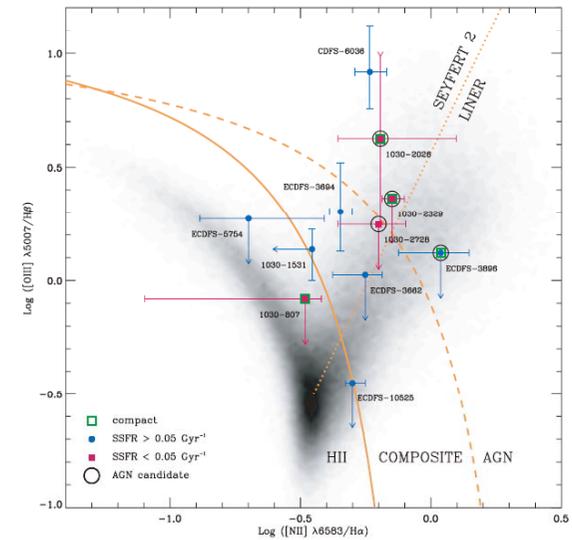


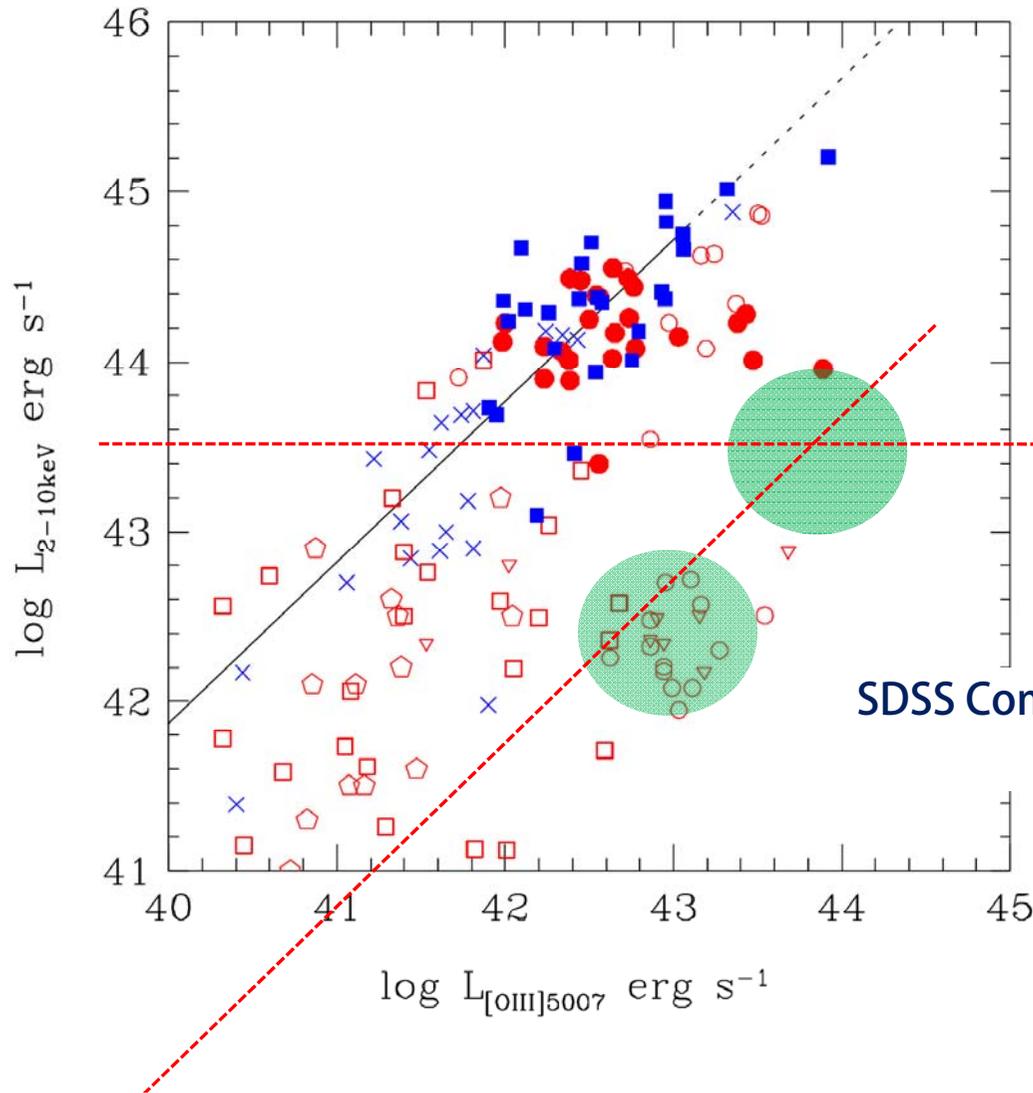
FIG. 3.—Diagnostic diagram for spectral classification of AGNs and star-forming galaxies. The gray scale presents the locus of $\sim 400,000$ SDSS galaxies (Kaufmann et al. 2003b; Tremonti et al. 2004). The orange solid line is the empirical division between galaxies for which the line emission originates from H II regions and AGNs for the SDSS galaxies by Kaufmann et al. (2003b). The orange dashed line presents the theoretical upper limit by Kewley et al. (2001) for star-forming galaxies. Galaxies between these two dividing curves are classified as composite H II + AGN galaxies by Kewley et al. (2006). The orange dotted line presents the division between Seyfert 2s and LINERs by Kaufmann et al. (2003b). The red filled squares present galaxies with a specific SFR (derived from modeling the continuum spectra) less than 0.05 Gyr^{-1} , and the blue filled circles galaxies with higher specific SFRs ($> 0.05 \text{ Gyr}^{-1}$). Furthermore, the green squares indicate galaxies with compact line emission. The galaxies with black circles are identified as AGN candidates, based on their $[N II] \lambda 6583 / H\alpha$ ratios, spatial extent of the line emission, and ancillary data. Further details are in the text. All upper limits are 2σ and the error bars are all 1σ . For 1030-2026 we have both a 2σ upper and lower limit.

Kriek et al. 2007, ApJ, 669, 776



Heavily-obscured AGNs at z=1-2

- A search for heavily-obscured AGNs that are not detected in the X-ray observations with [OIII] line selection.



Blue squares:
SXDS X-ray broad-line AGN @z=1-2
Blue crosses:
PG-QSOs

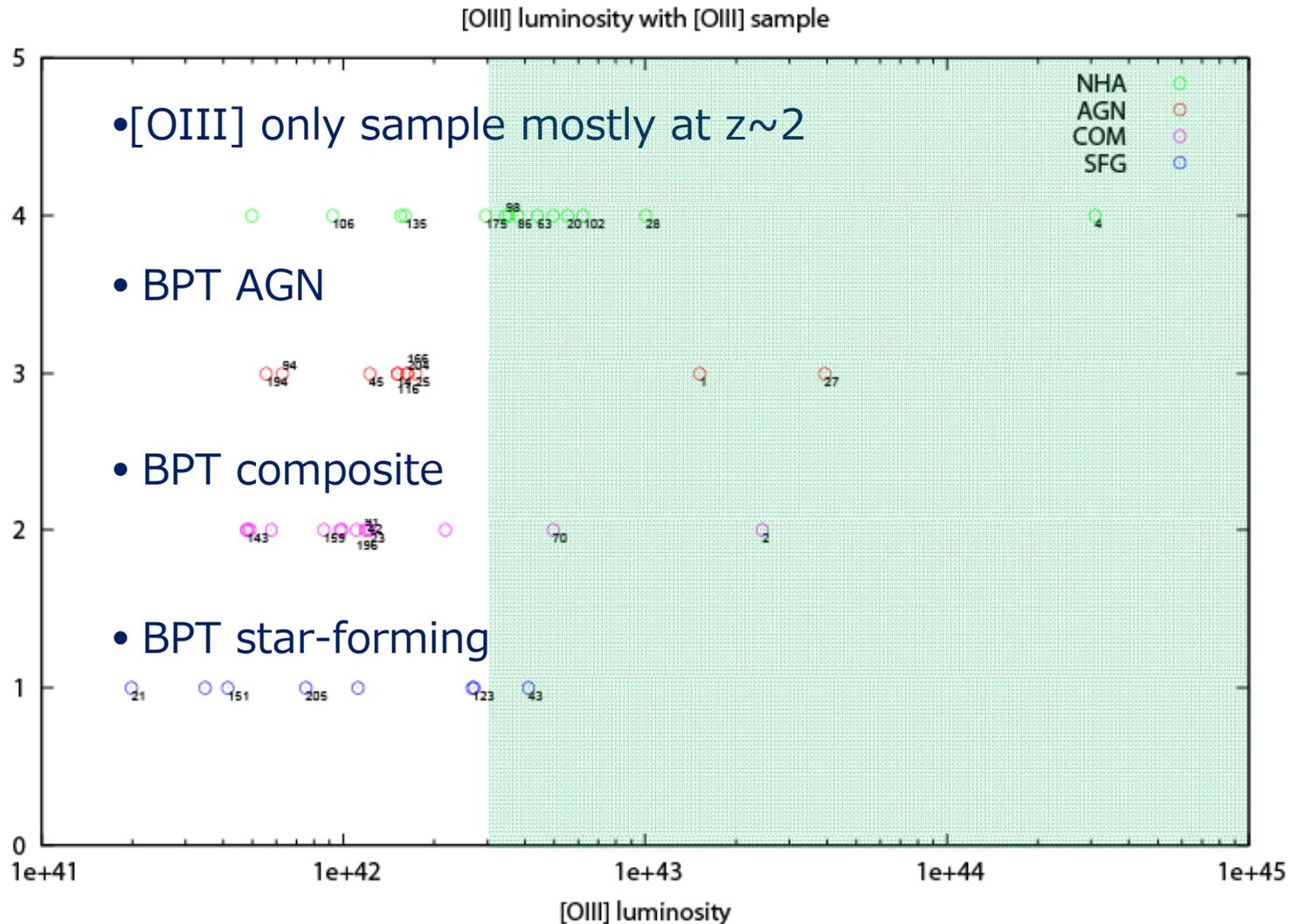
Red circles:
SXDS X-ray narrow-line AGN @z=1-2
Red open symbols:
Narrow-line AGNs from literatures

SDSS Compton-thick AGN candidates at $z \sim 0$
From Vignali et al. 2010



Distribution of [OIII] luminosity

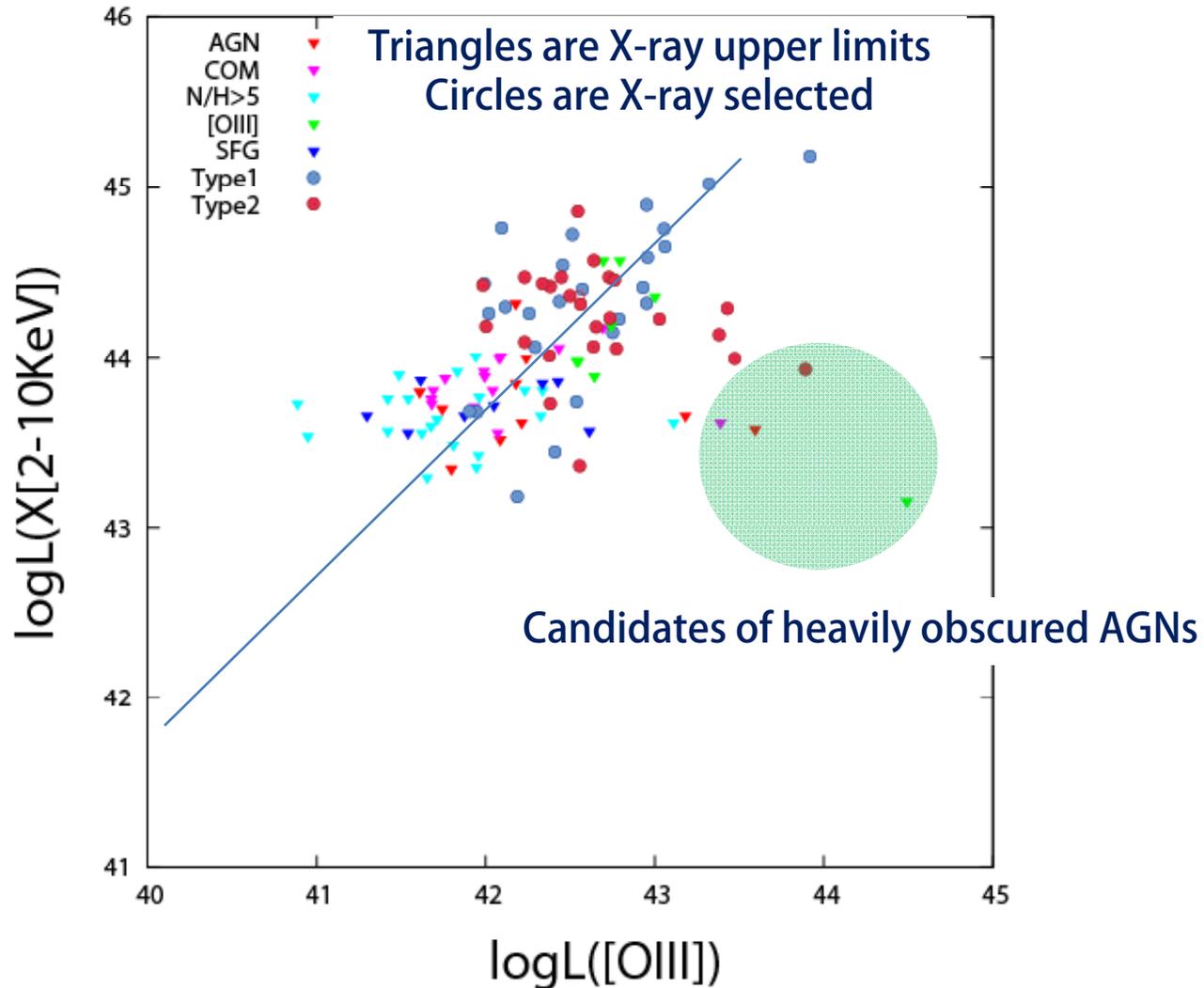
[OIII] luminosity selection for objects whose [OIII] line is detected.





Heavily-obscured AGNs

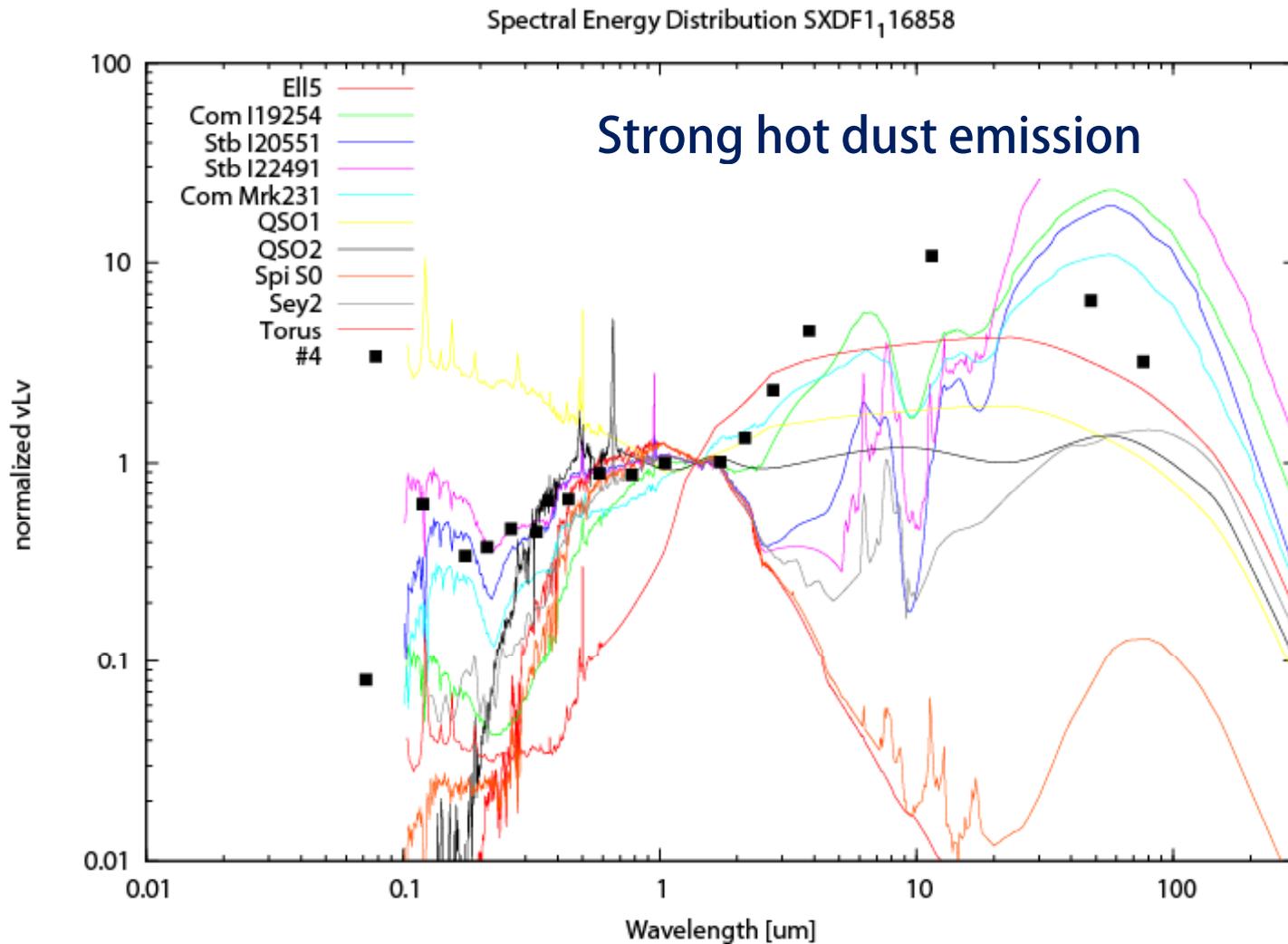
- We found several candidates of heavily-obscured AGNs.
- If we correct for the X-ray obscuration, they may be more luminous than the most luminous X-ray AGNs at $z=1-2$.





SEDs of heavily-obscured AGNs

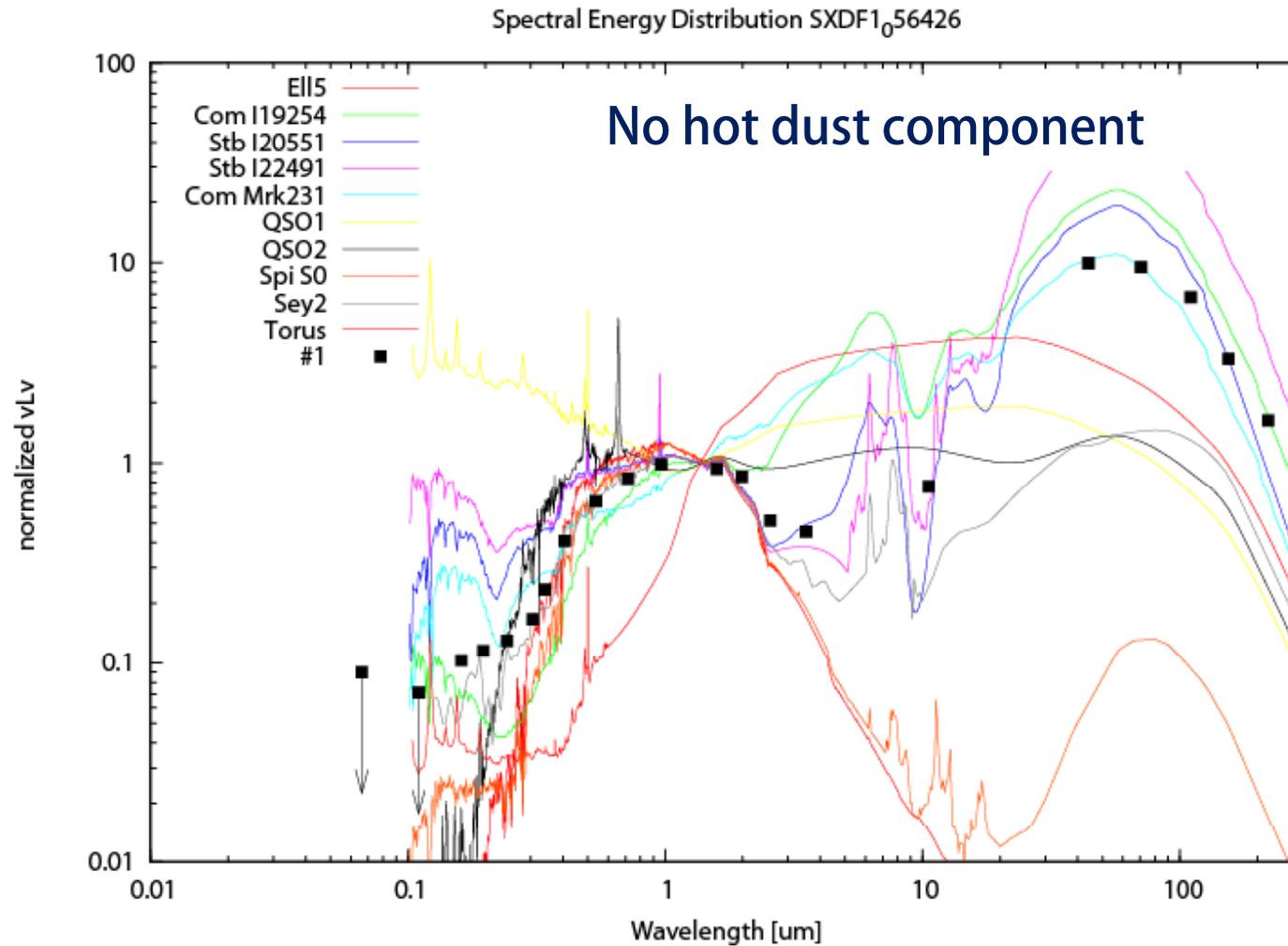
- Emission-line selected AGNs $z \sim 1.4$ sometimes show strong hot dust emission component. Sometimes no hot dust component, though they are [OIII] luminous.





SEDs of heavily-obscured AGNs

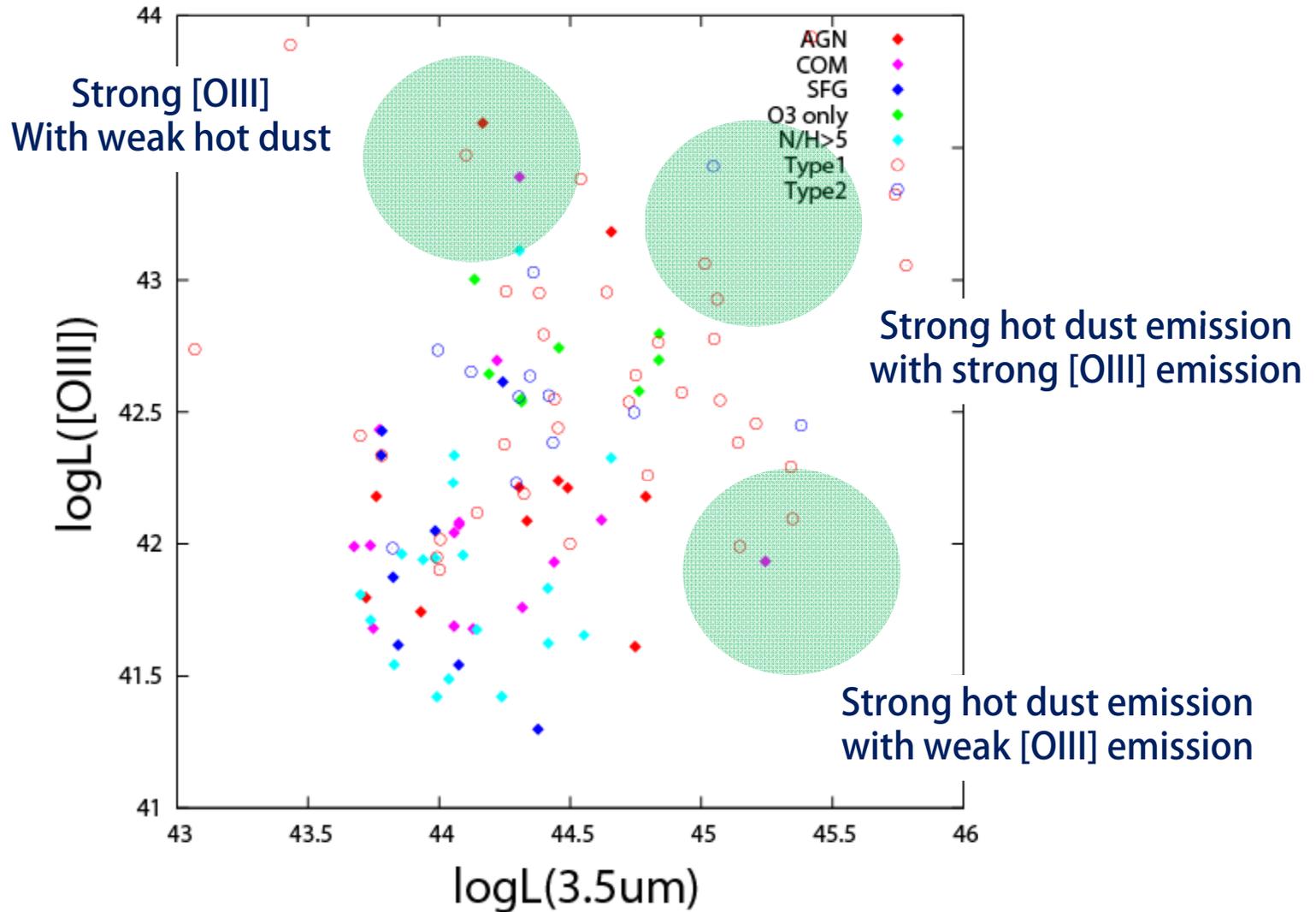
- Emission-line selected AGNs $z \sim 1.4$ sometimes show strong hot dust component in MIR. Sometimes no hot dust component, though they are [OIII] luminous.





[OIII] vs. hot dust component

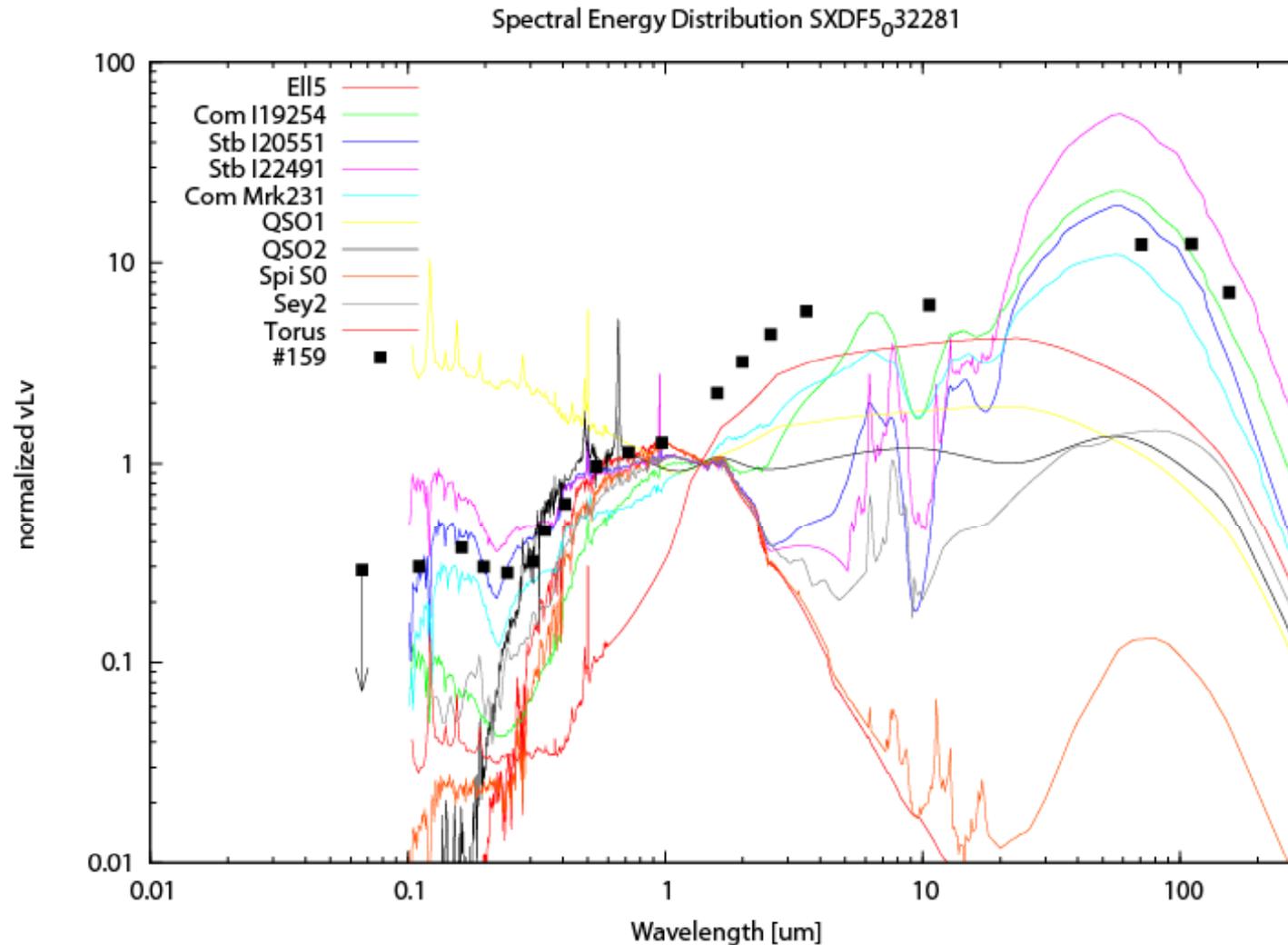
• Preliminary...





SEDs of heavily-obscured AGNs

- [OIII] less-luminous AGN candidates (“composite”) shows strong hot dust component.



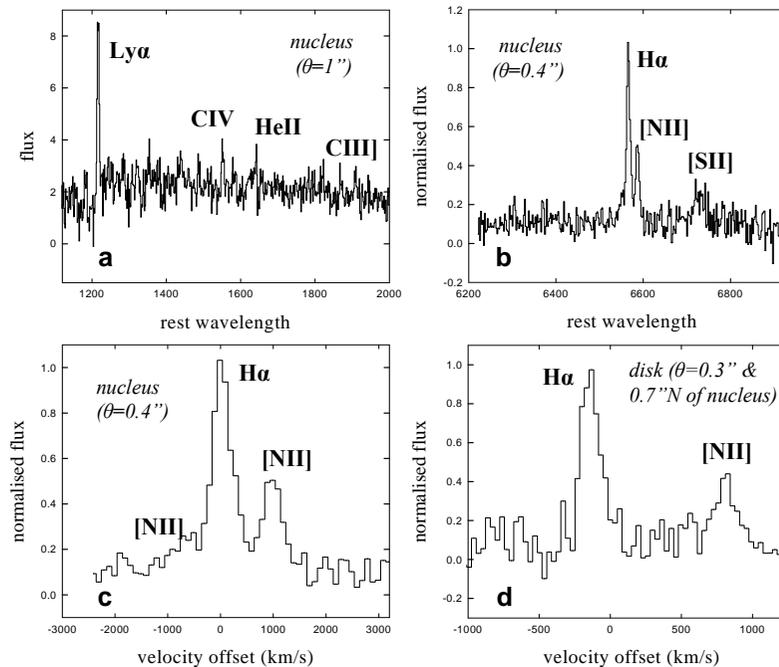
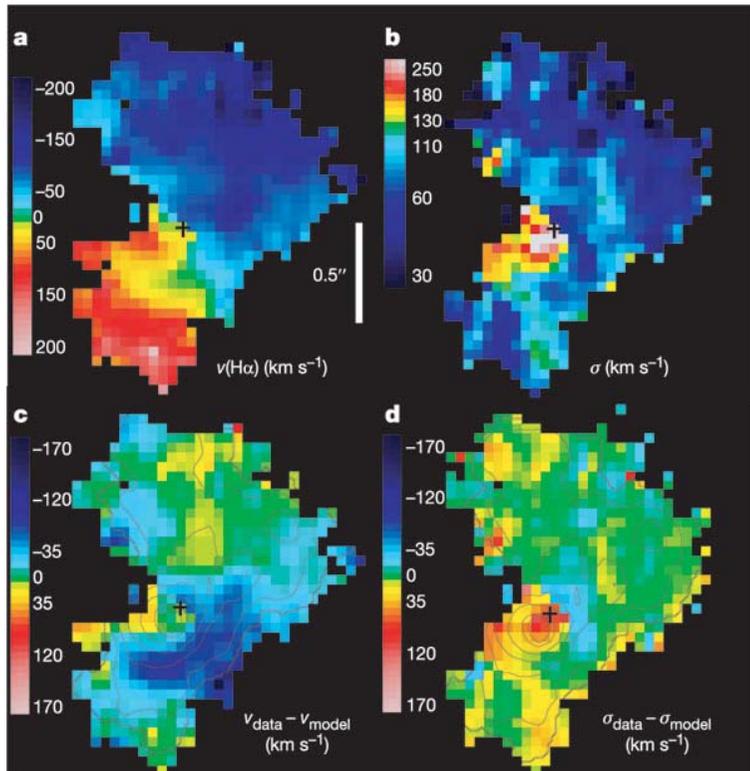


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非常に大きく隠されたAGNの探査

遠方銀河のサンプルを面分光することで中心にある隠されたAGNを系統的に探査することも必要。



AGN associated with massive galaxy revealed with AO+IFU observation (Genzel et al. 2006, Nature, 442, 786)



銀河に埋もれたAGNの探査

中心核のスペクトルのみを取り出すと AGN 的なライン比を示す。

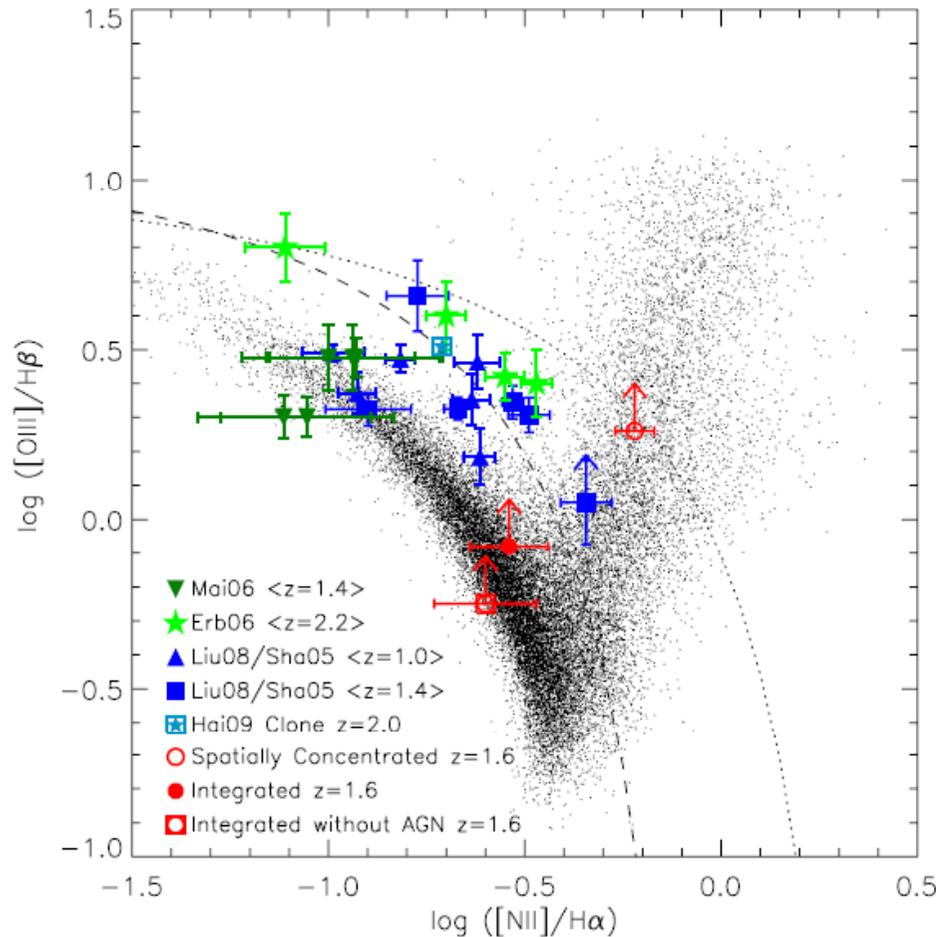


Figure 3. H II region and AGN diagnostic diagram for the emission ratios of $\log([O\ III]/H\beta)$ vs. $\log([N\ II]/H\alpha)$. SDSS local galaxies and AGN ($0.05 < z < 0.25$) are represented with black points, which illustrate the tight SFG sequence in the bottom left of the figure and the AGN Seyfert and LINER sequence rising to the top right. The dashed line is the empirical curve from Kauffmann et al. (2003) separating the local SDSS galaxies from AGN. The dotted line is the theoretical curve from Kewley et al. (2001) representing the limit for SFGs generating line emission from H II regions. Previous long-slit spectroscopy observations of individual high redshift galaxies with their emission line ratios; dark green upside down triangle for $z \sim 1.4$ from Maier et al. (2006), green star for $z \sim 2.2$ from Erb et al. (2006a), blue triangle for $z \sim 1.0$, and blue square for $z \sim 1.4$ from both Shapley et al. (2005) and Liu et al. (2008). Emission line ratios for BMZ1299 are over-plotted in red to illustrate how spatially concentrated and integrated ratios across the galaxy are highly dependent on the observed PSF. All $\log([O\ III]/H\beta)$ values for HDF-BMZ1299 are plotted as 2σ limits; increasing the assumed extinction of this source would increase the [O III]/H β ratios. The open red circle lying in the AGN SDSS distribution is the spatially concentrated ratios from a $0''.2 \times 0''.2$ region of BMZ1299 (as seen in Figure 2). The solid red circle represents the integrated ratios from the entire spatial extent of BMZ1299. The red square with open circle are the ratios for the integrated galaxy with estimated contribution of the AGN emission removed.

Wright et al. 2010



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