Current status of the Subaru AO imaging program for z~3.3 quasars

Toshihiro Kawaguchi 川口 俊宏 (Yamaguchi Univ)
Y.Minowa, T.Morokuma, Y.Saito, M.Imanishi, N.Oi,
T.Minezaki, T.Nagao, N.Kawakatu, K.Matsuoka

1. Project overview: Constraining
   the black hole – galaxy coevolution at high-z

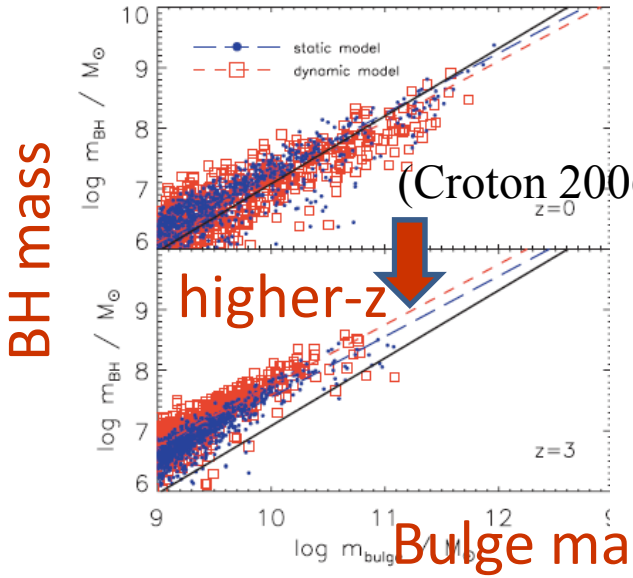
2. Spectroscopic & Imaging observations

3. Initial results for 3 objects with good data quality (FWHM~0.15”)

(Subaru User’s meeting, Jan21—23, 2014)

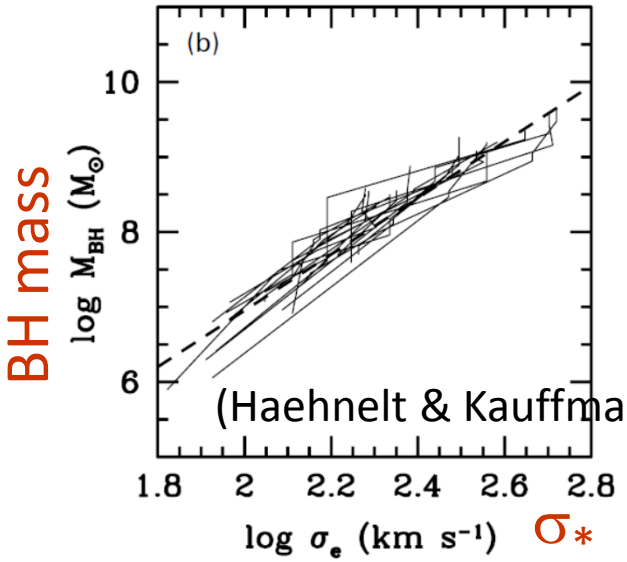
1. Coevolution of galaxies and supermassive black holes: theory

= Various predictions after the discovery of local M_{BH}-σ_* correlation (Kormendy & Richstone 1995).

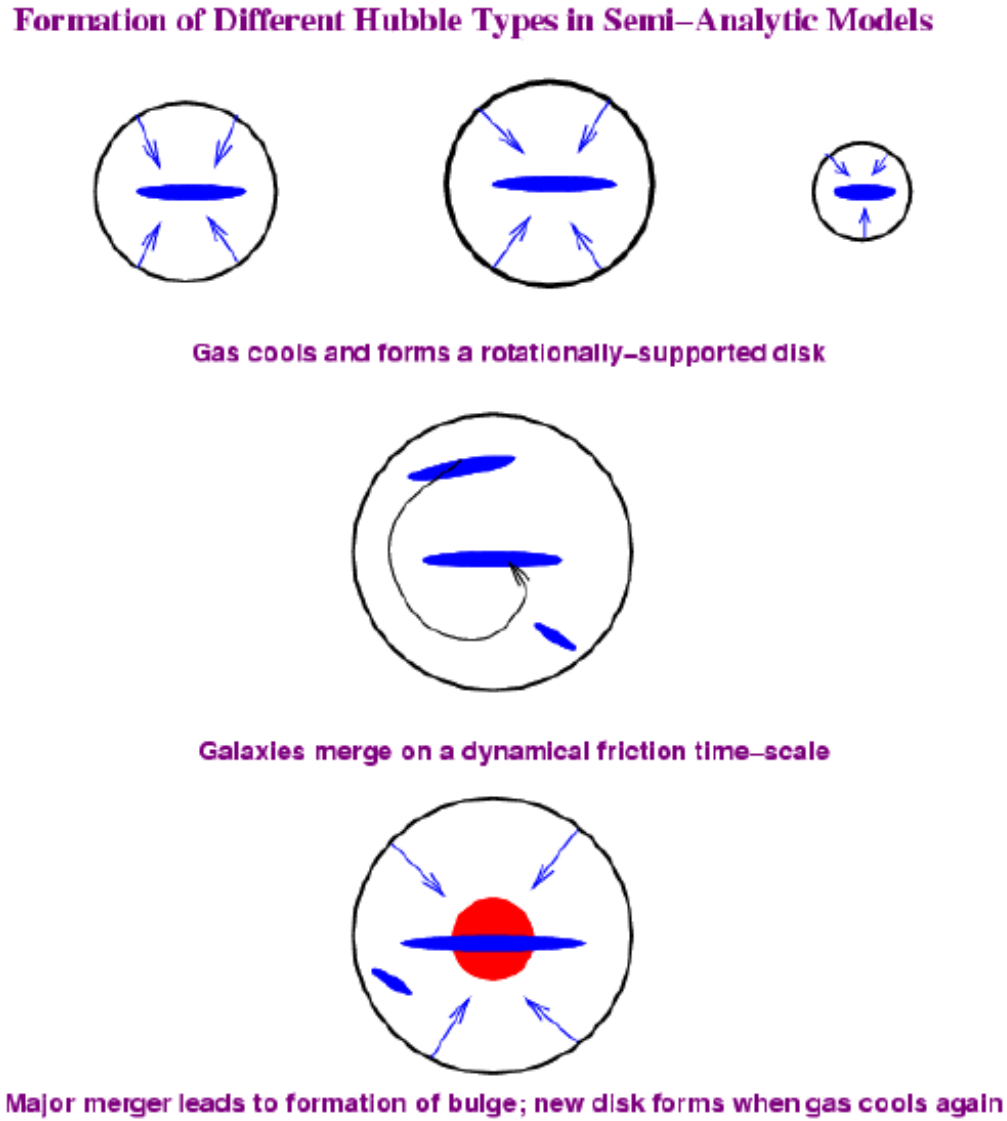


(Croton 2006)

higher-z



(Haehnelt & Kauffmann 2000)



1. observation

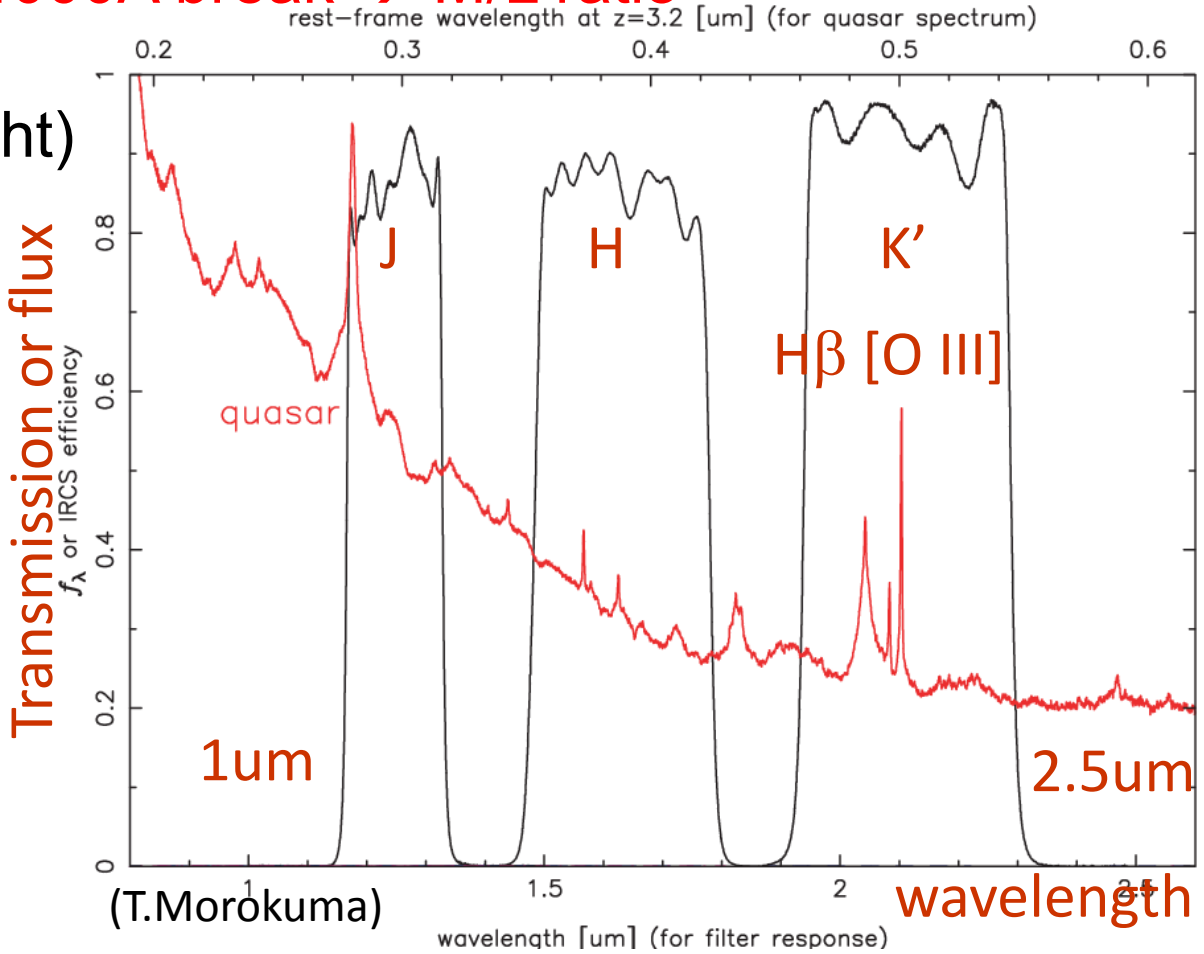
M_{BH} / M_{bulge} or
M_{BH} / $M_{stellar}$ ratios
= various
observational
results.
(controversial)

(Most data are for
bulge--dominated
galaxies (E/S0).
(cf. blue square for
disk-dominated
galaxies)

Our goal
= accurate measurements
at higher-z. Common IMF (Chabrier) used (M.Schramm+13)

1. Our selection criteria for target quasars from SDSS DR5

0. Higher-z: larger differences in model predictions
1. Hβ width (for BH mass estimation, as low-z studies)
   measurable at K' band (cf. C IV width suffered from outflow)
   → 3.11 < z < 3.50 (age of Universe ~ 2Gyr)
   → J-K' color measures 4000A break → M/L ratio
2. Bright (but not too bright)
   (r < 18)
3. >4hr at 50deg or
   higher elevation
4. Bright tip-tilt guide
   star within 60"



Distribution of our targets

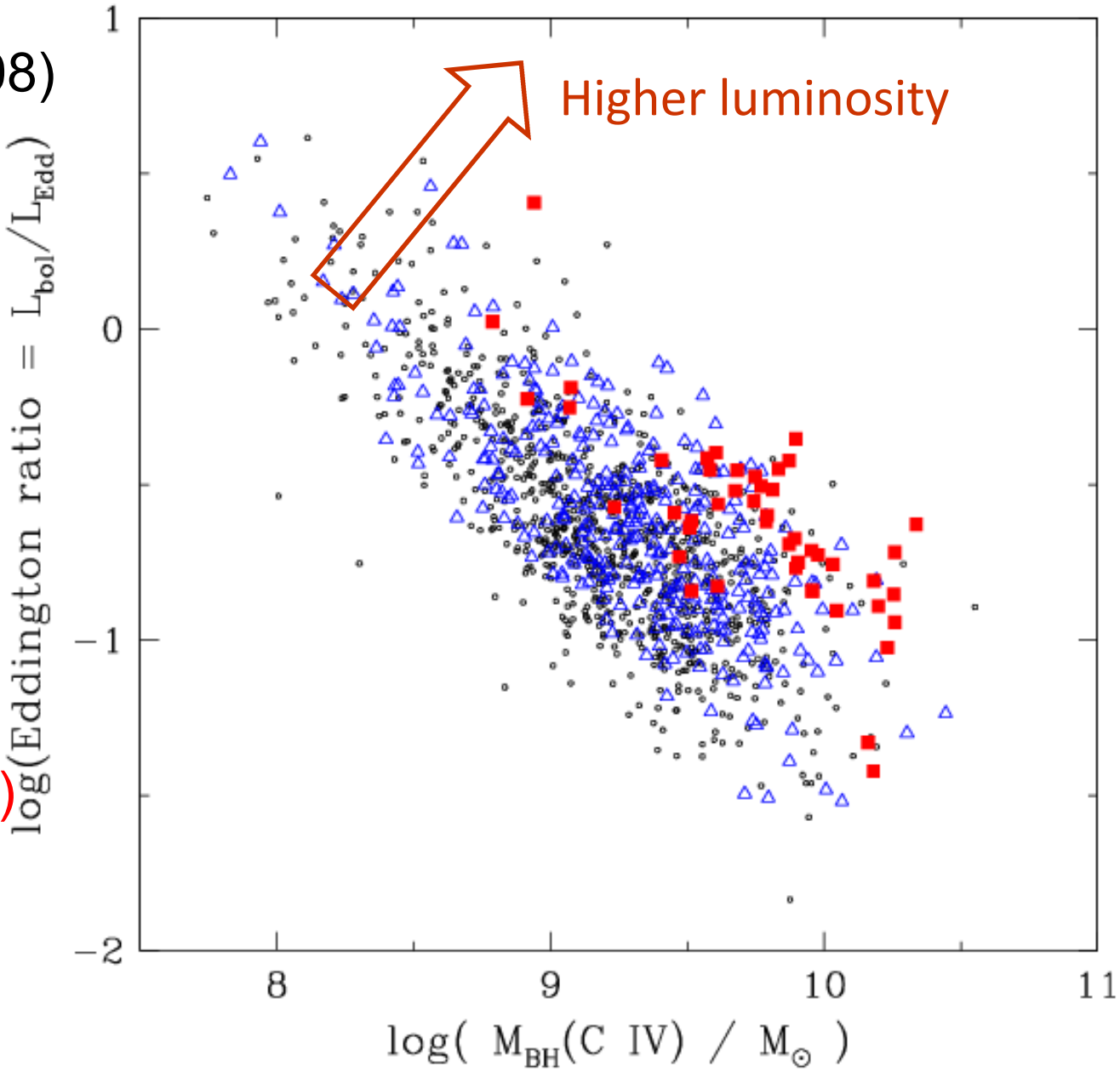
SDSS DR5 (Shen+08)

Black = all redshift
(0 < z < 4.5)

Blue = 3.11<z<3.50

Red = our targets

○ not biased to heaviest BHs (cf. Lauer+07)



2. Spectroscopic & Imaging observations: Spectroscopy

Observations at 2-4m telescopes (IRTF/SpeX, UKIRT/UIST, WHT/LIRIS)
and Subaru/IRCS (backup obs of imaging run) proposed since 2008

- PIs: Y.Minowa, N.Oi, Y.Watabe, T.Morokuma, Y.Saito
- Observers: Y.Minowa, N.Oi, M.Imanishi, T.Morokuma, Y.Saito,
T.Kawaguchi

- Band: HK
- Spectral resolution: 375—1000
- Typical exposure time ~ 3600sec

- Measurement of Hβ width
→ BH mass

- >30 objects, summarized in
M-thesis (Y.Saito),
Y.Saito et al. (in prep)

2. Subaru/IRCS+AO188 Imaging observations

- Observations begun in May 2012
- PIs: T.Kawaguchi, Y.Saito
- Observers: Y.Minowa, M.Imanishi, Y.Saito, T.Kawaguchi, T.Morokuma, T.Minezaki

- Band: K' and J
- Mode: LGS, NGS, 1pix=52mas
- typical exposure time: ~5000--10000sec
- deconvolve to
  PSF(=nucleus)
  + Sersic profile(=host galaxy)

→ luminosity of host galaxies

→ mass of host galaxies

3. Initial results from this imaging/spectroscopic project: BH mass

- 3 objects with good data quality (exp time, seeing, ..)
- $3.18 < z < 3.48$
- Spectral data (UKIRT, Subaru)
  collected in 2009 Jan – 2013 Apr

→ BH mass via Hβ width

⇒ $\log(M_{BH}) = 8.82—8.88$

Distribution of our targets

SDSS DR5 (Shen+08)

Black = all redshift
(0 < z < 4.5)

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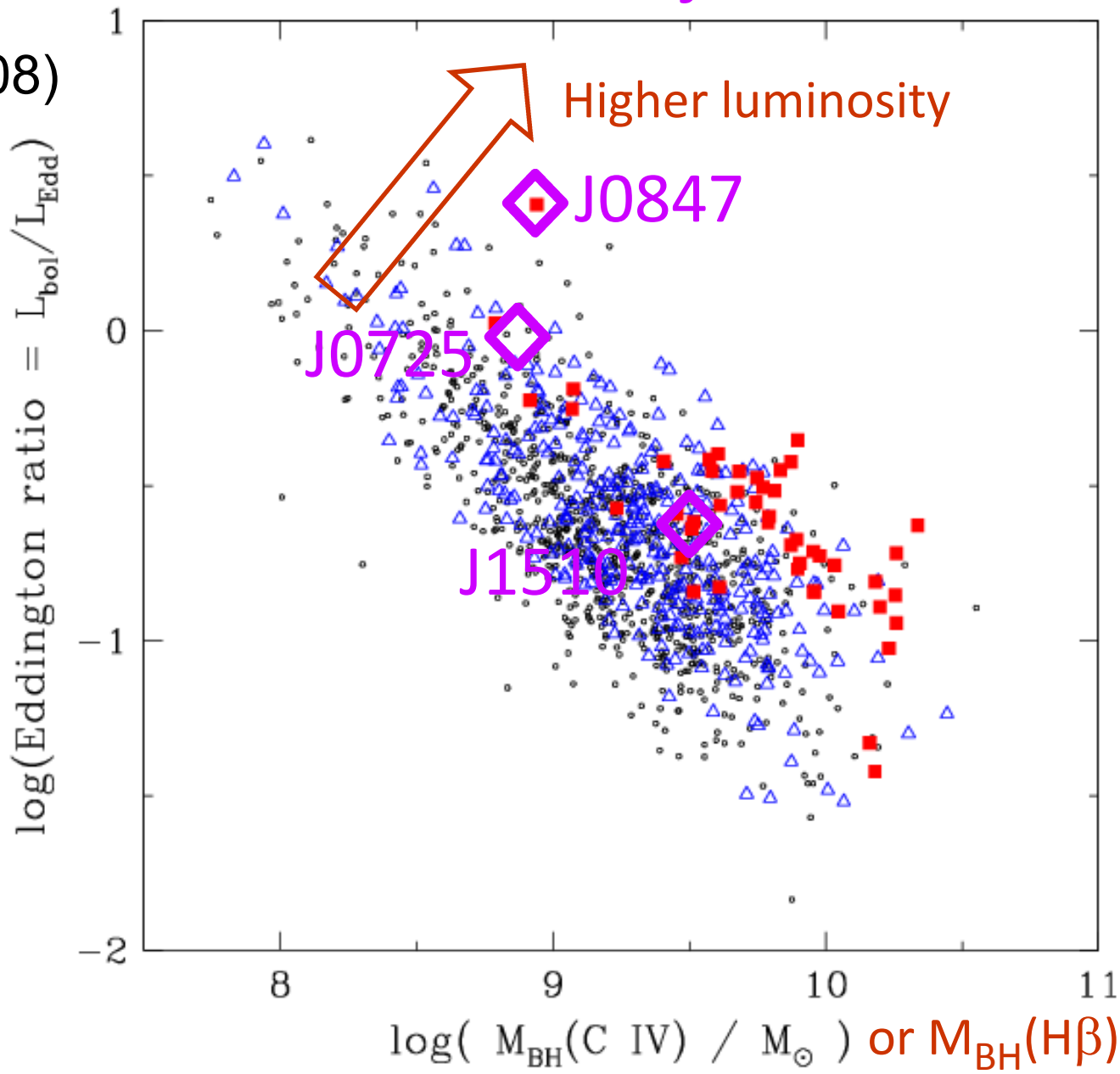
Red = our targets



3. Initial results from this imaging/spectroscopic project: images

- Subaru/IRCS+AO188 Imaging data collected
  in 2013 Jan--Apr
- on-source exposure time: 5560—11160sec
  (3800—7980sec with good quality
  ⇒ 0.15-0.17” FWHM)

Preliminary

More detailed analysis is in prgoress, and will be presented elsewhere by Minowa-san.

(Y.Minowa)

3. Initial results from this project: host galaxy luminosity

Host galaxy: M_V(AB)= -(25-26.1)mag

AGN:
+0.3 -- -1.7mag
w.r.t. host

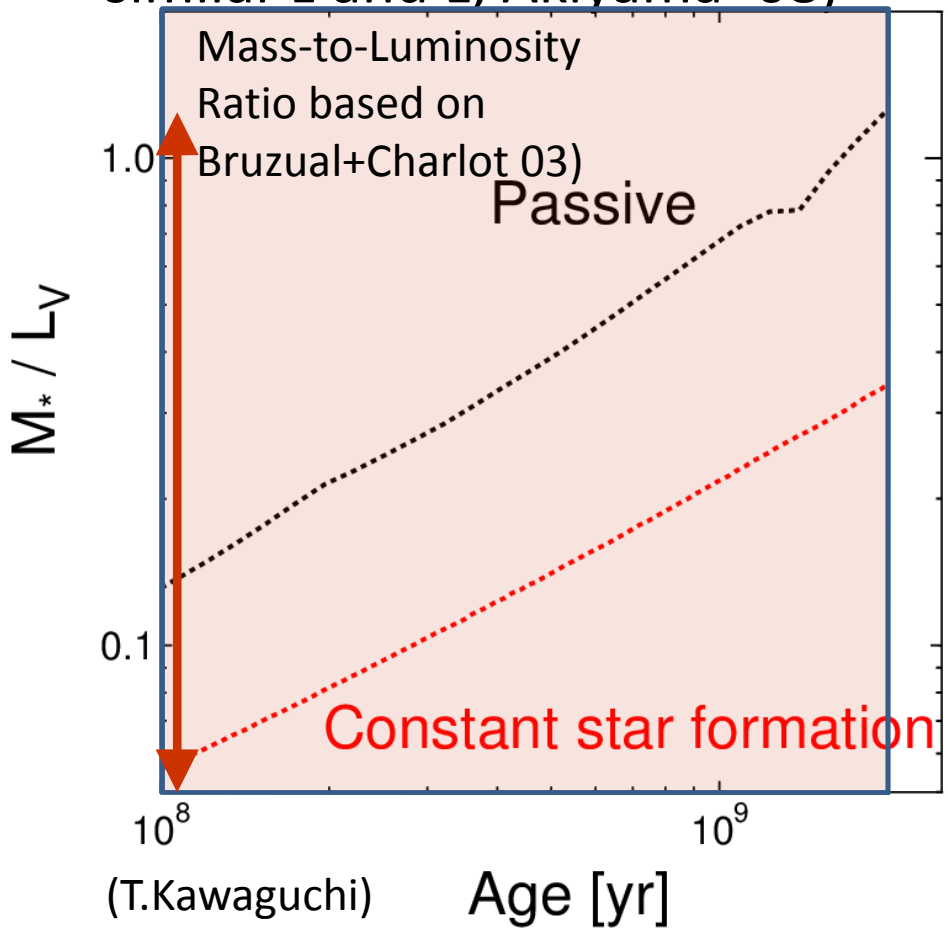
(Y.Minowa)

3. Initial results from this project: host galaxy mass

◆ For J1510 (with J & K' data), we take $(M_{Stellar}/L_V)_{sun}$ = 0.28 based on the observed J-K' color (1.47mag).

◆ For other 2 objects (K' data), we take the same $(M_{Stellar}/L_V)_{sun}$ (0.005—1.26).

(similar M/L ratio for LBGs at similar z and L; Akiyama+08)



(T.Kawaguchi)

3. Initial results from this project: BH--host galaxy relation

local:
galaxies
(Haering+Rix04)
AGNs (Bennert+11)

Z~1: Schramm+
Silverman13

Z~2.8: Schramm+08

Preliminary

At z~3.3 (our data),
No evolution (or slightly lower)
is indicated.
(No color info → large error)

3. Initial results from this project: BH--host galaxy relation

We obtained the highest-z record for the BH-galaxy relation with Hβ-based BH masses.

Preliminary

At z~3.3 (our data),

no evolution is indicated.

→ Outflow-regulated BH growth disfavored.

Summary

1. NIR spectroscopy (K') + Subaru/IRCS AO188 imaging (J & K')
   K' spectra: Hβ width measurement for BH mass
   (i.e., the same method as the local studies
   → minimize the uncertainty)

2. Aim = Constraining BH—galaxy coevolution back to higher-z

3. Initial results for 3 objects with good data quality (FWHM~0.15"),
   = indicating no evolution up to z = 3.5.
   = highest-z record for BH-galaxy mass ratio
   with Hβ-based BH masses.

4. Color (J – K') measurement is crucial to reduce the uncertainty.