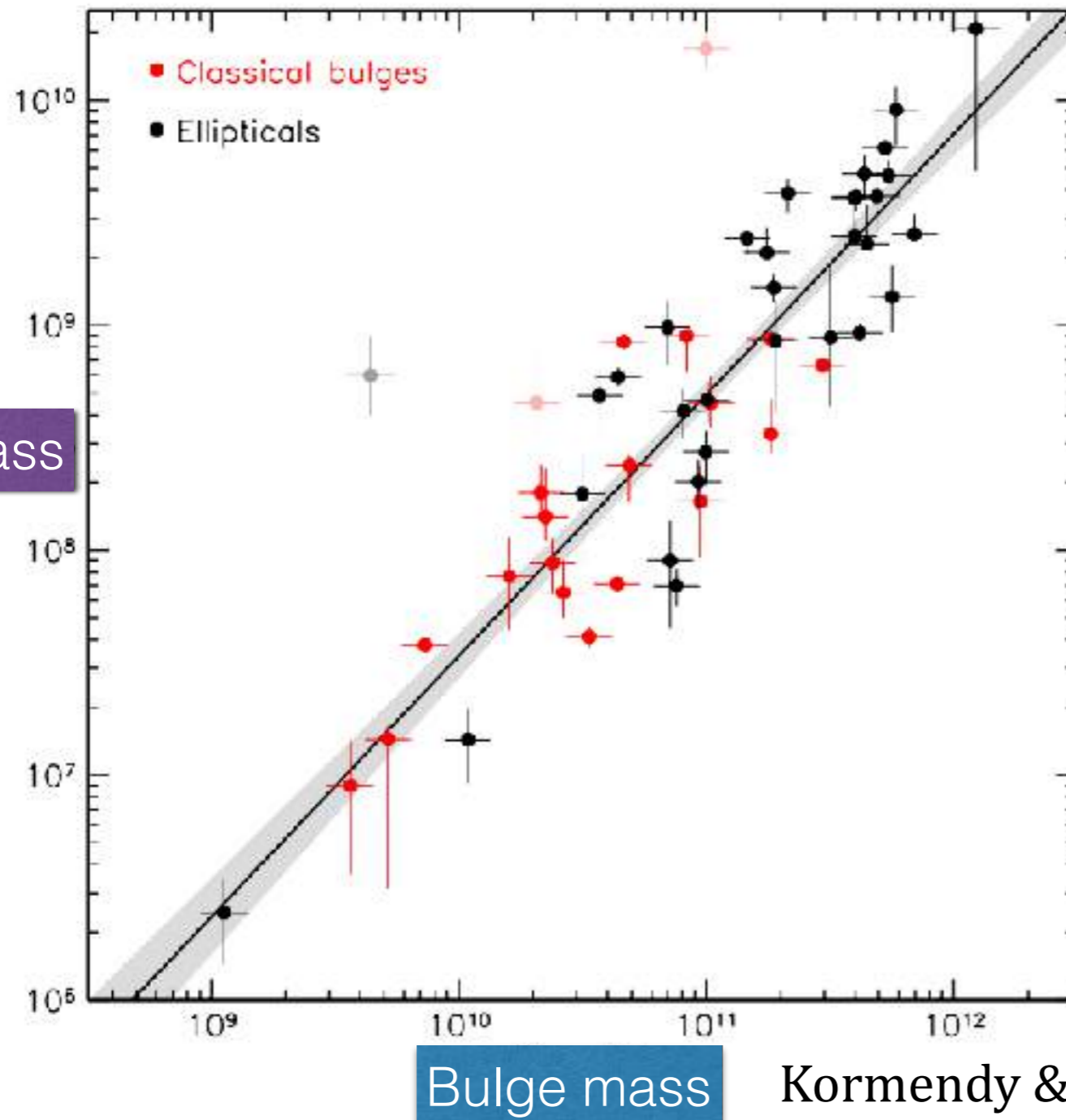# Connection Between Stellar Growth and Black Hole Growth in AGN Hosts

Minjin Kim (KNU)

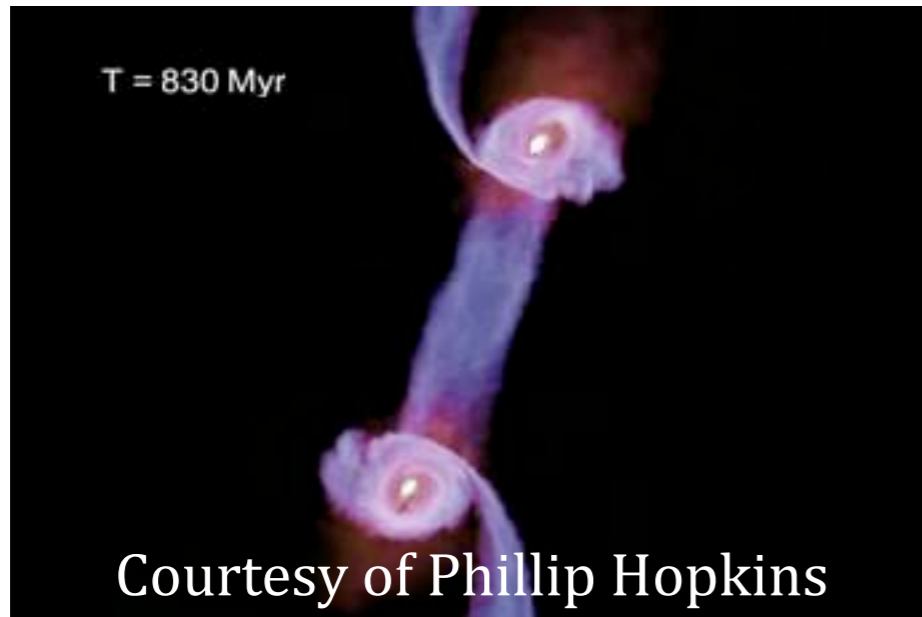# SMBH-Host connection

BH mass

Bulge mass

Kormendy & Ho 2013

- SMBHs and galaxies know each other in some extent during the evolution.

- Physical Origin :
  (1) AGN Feedback?
  (2) Natural Consequence of LCDM cosmology?
  (3) Something else?

SMBH-Host connection
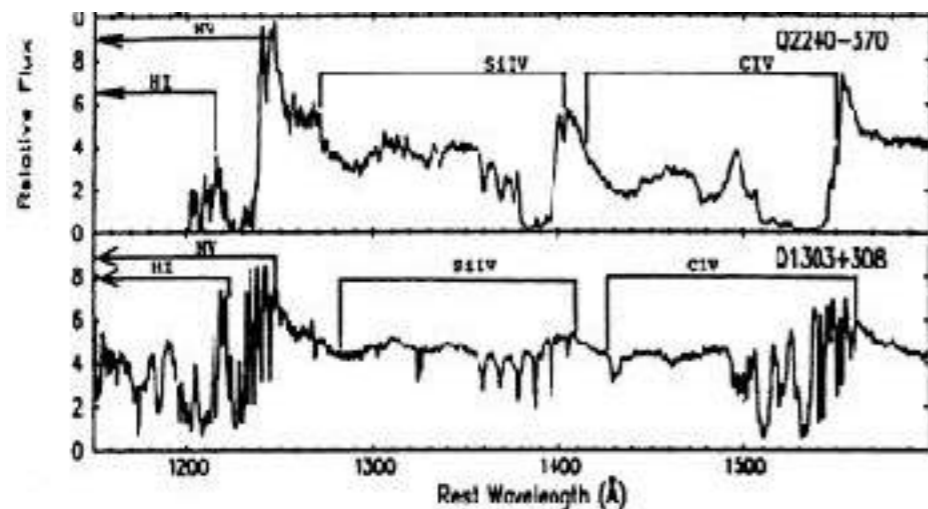
- AGN feedback may or may not play an important role.

QSO mode feedback

T = 830 Myr

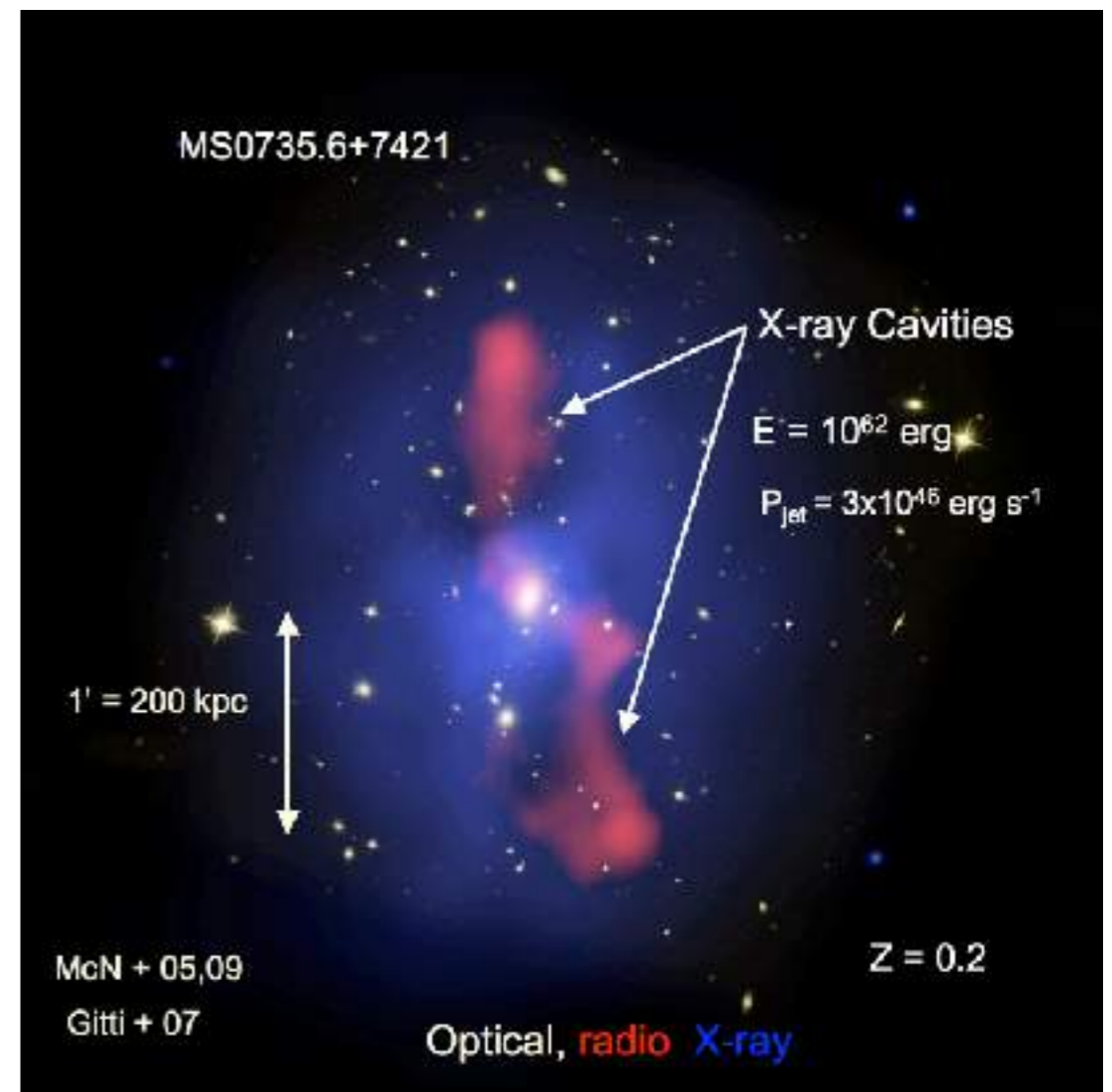Courtesy of Phillip Hopkins

AGN winds (Choi et al. 2015)

Turnshek et al. 1980

Radio mode feedback

MS0735.6+7421

X-ray Cavities

$E = 10^{62}$ erg
$P_{jet} = 3 \times 10^{46}$ erg s^{-1}

1' = 200 kpc

McN + 05,09
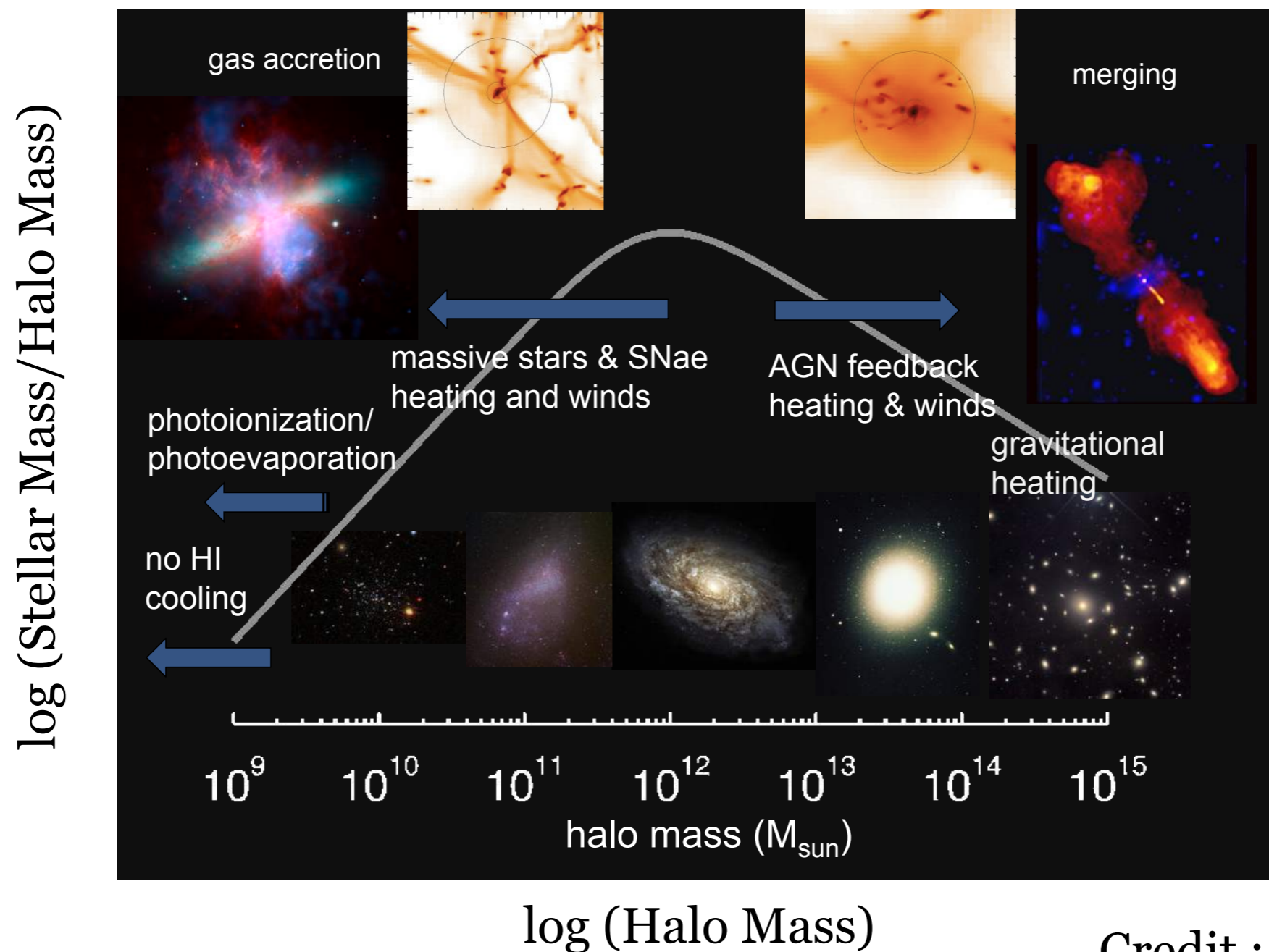Gitti + 07

Z = 0.2

Optical, radio X-ray

SMBH-Host connection

- AGN feedback

  - BH activity suppresses (regulates) star formation in host galaxies

  - probably important mechanism to make dead elliptical galaxies
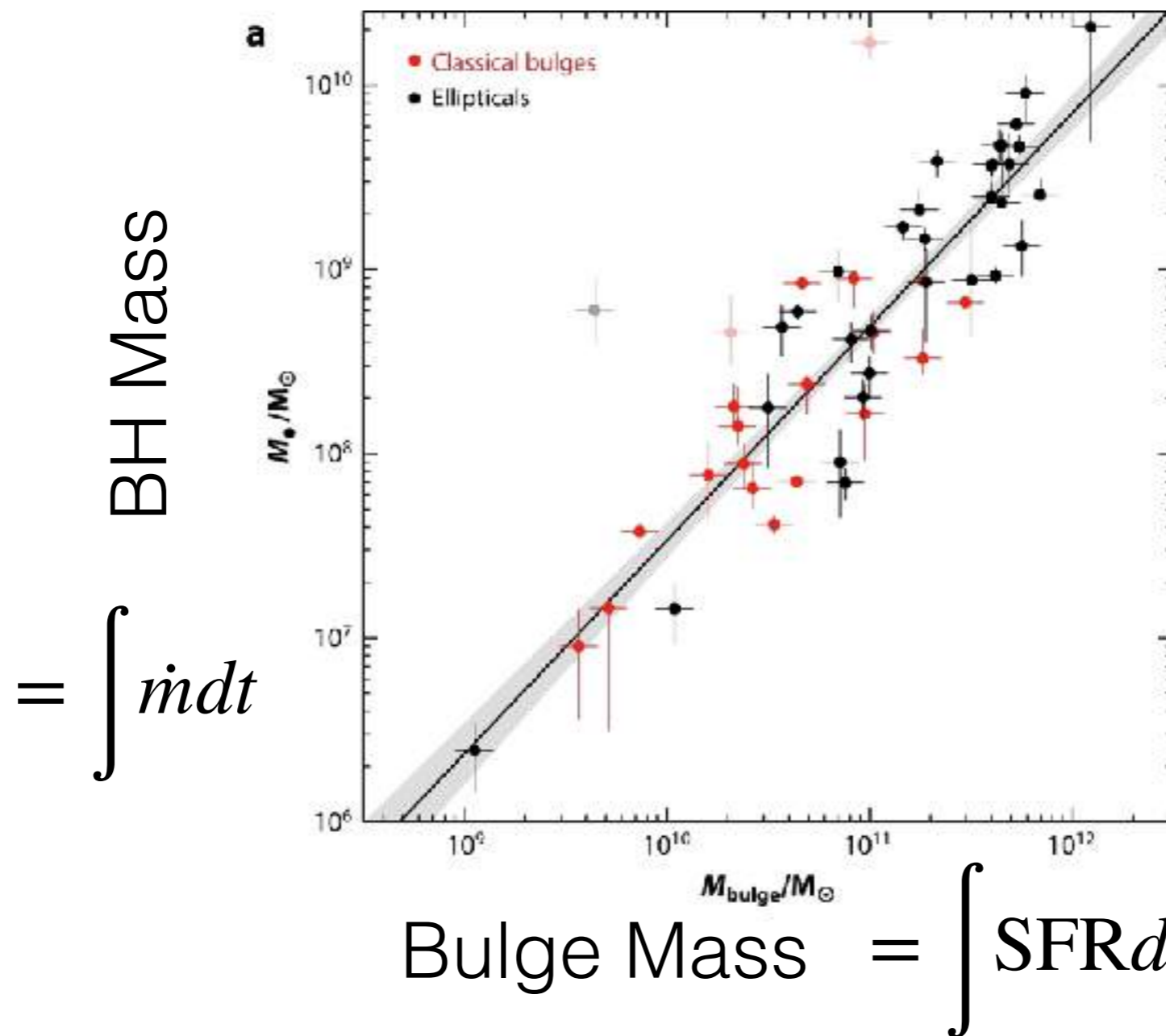
SMBH-Host connection

- Low SF efficiency (AGN feedback)

Credit : R. Somerville

SMBH vs. Galaxy (Bulge) mass

$M_{BH} \sim 0.2\%$ of M_{bulge} or $M_{bulge} \sim 500\ M_{BH}$

$$= \int \dot{m}dt$$
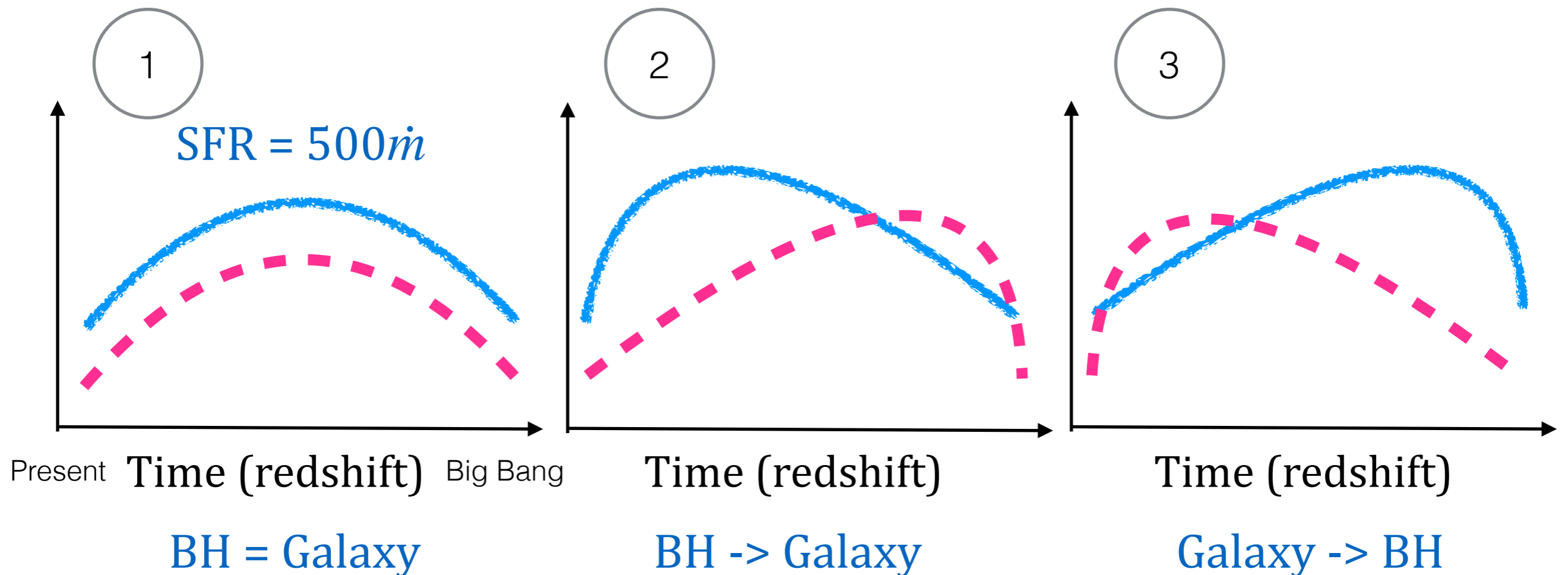
BH Mass

Bulge Mass $= \int SFR dt$

Kormendy and Ho 2013

BH growth vs. SFR

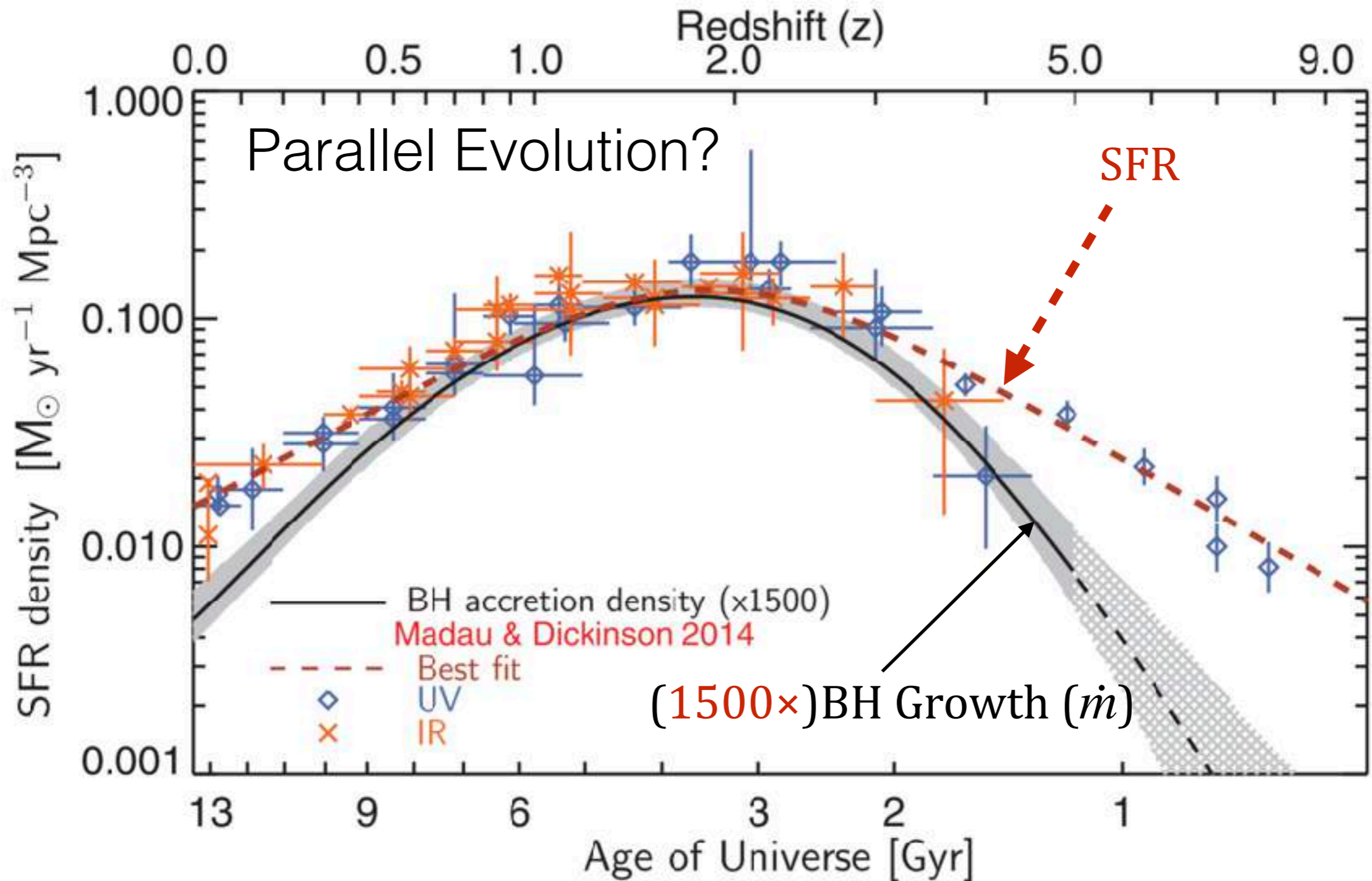Direct Method : measurements of SFR and BH Growth rate in AGNs!

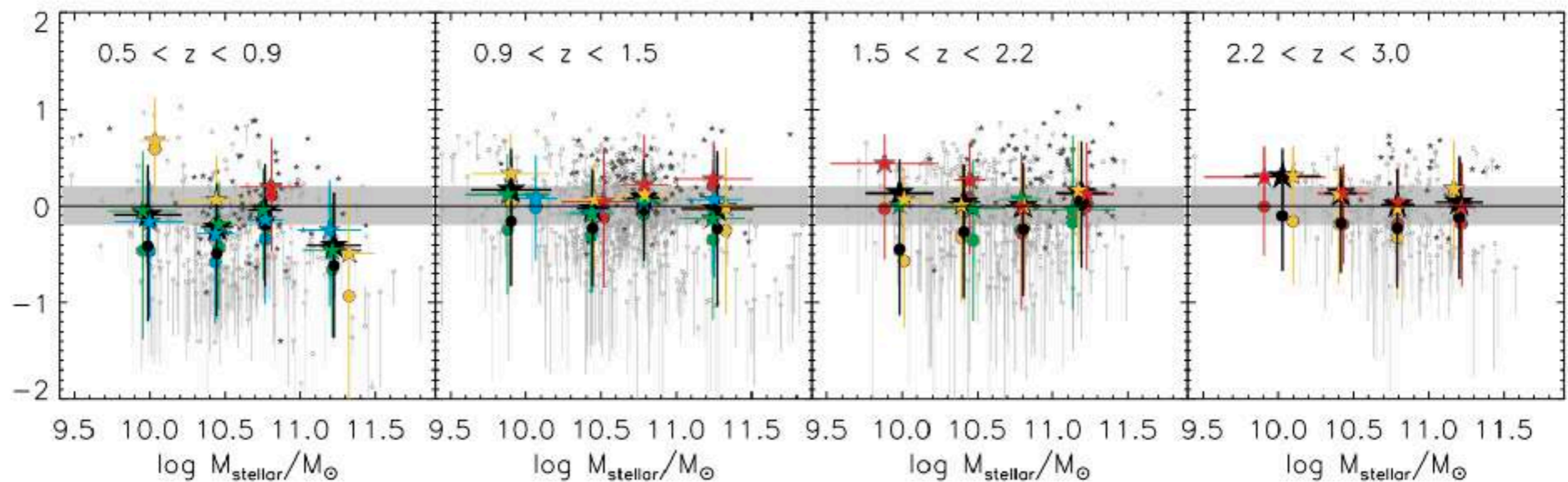— SF (Galaxy Growth)

- - - BH Growth ($\dot{m}$)

① SFR = $500\dot{m}$

②

③

Present Time (redshift) Big Bang

Time (redshift)

Time (redshift)

BH = Galaxy

BH -> Galaxy

Galaxy -> BH

BH growth vs. SF (Global Trends)

Aird et al. 2015

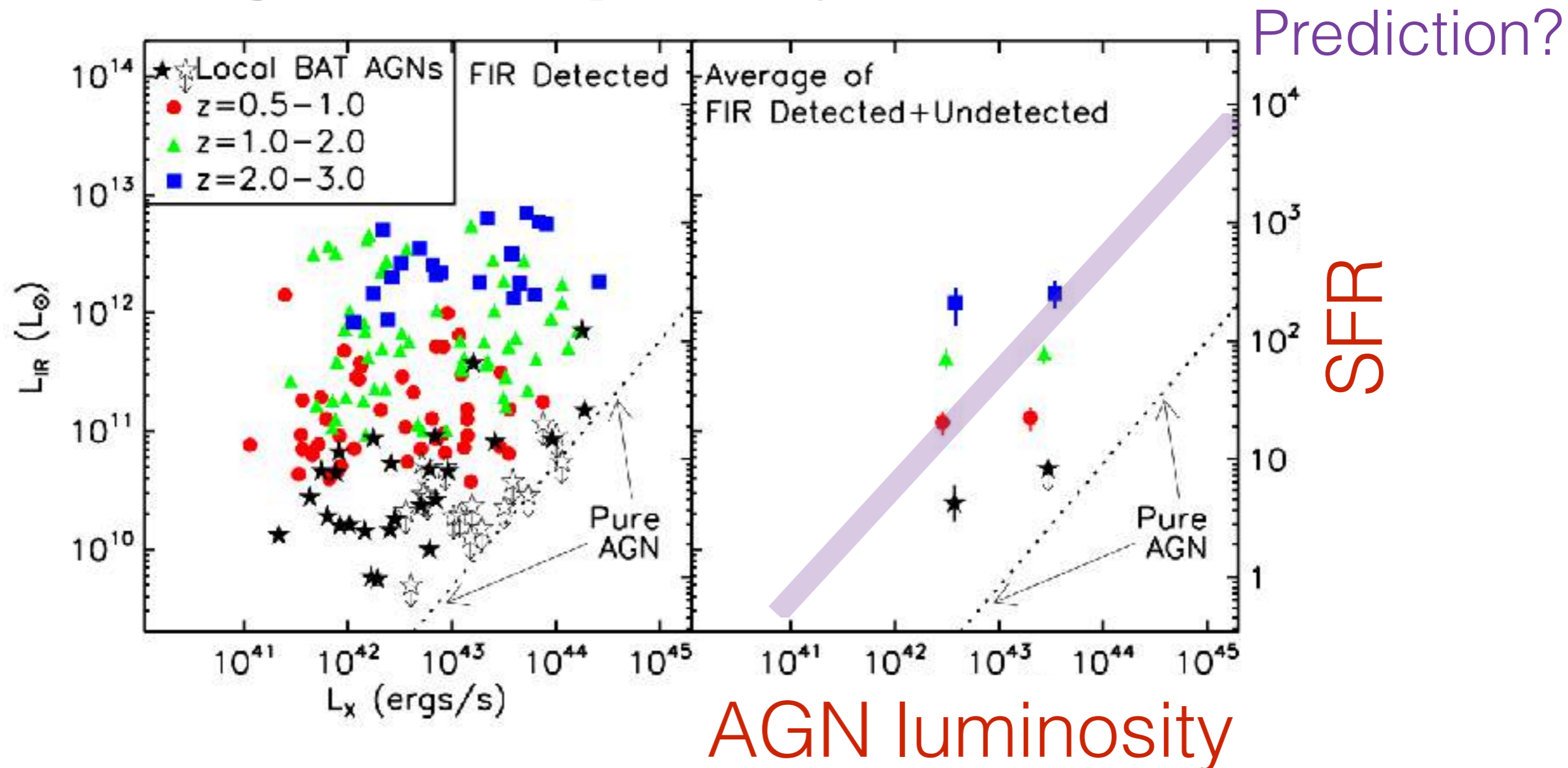# SF in AGNs at z~2

AGN host galaxies are SF Main Sequence

No AGN Feedback?

Suh et al. 2017; 2019

BH Growth vs. SFR for AGNs @ ~z<2

- No Link between BH growth and SFR???
- Strong Redshift dependency

Prediction?

SFR

AGN luminosity

Mullaney et al. 2012

BH Growth vs. SFR for AGNs @ ~z<2

Flat features (no connection between SFR and BH Growth?)
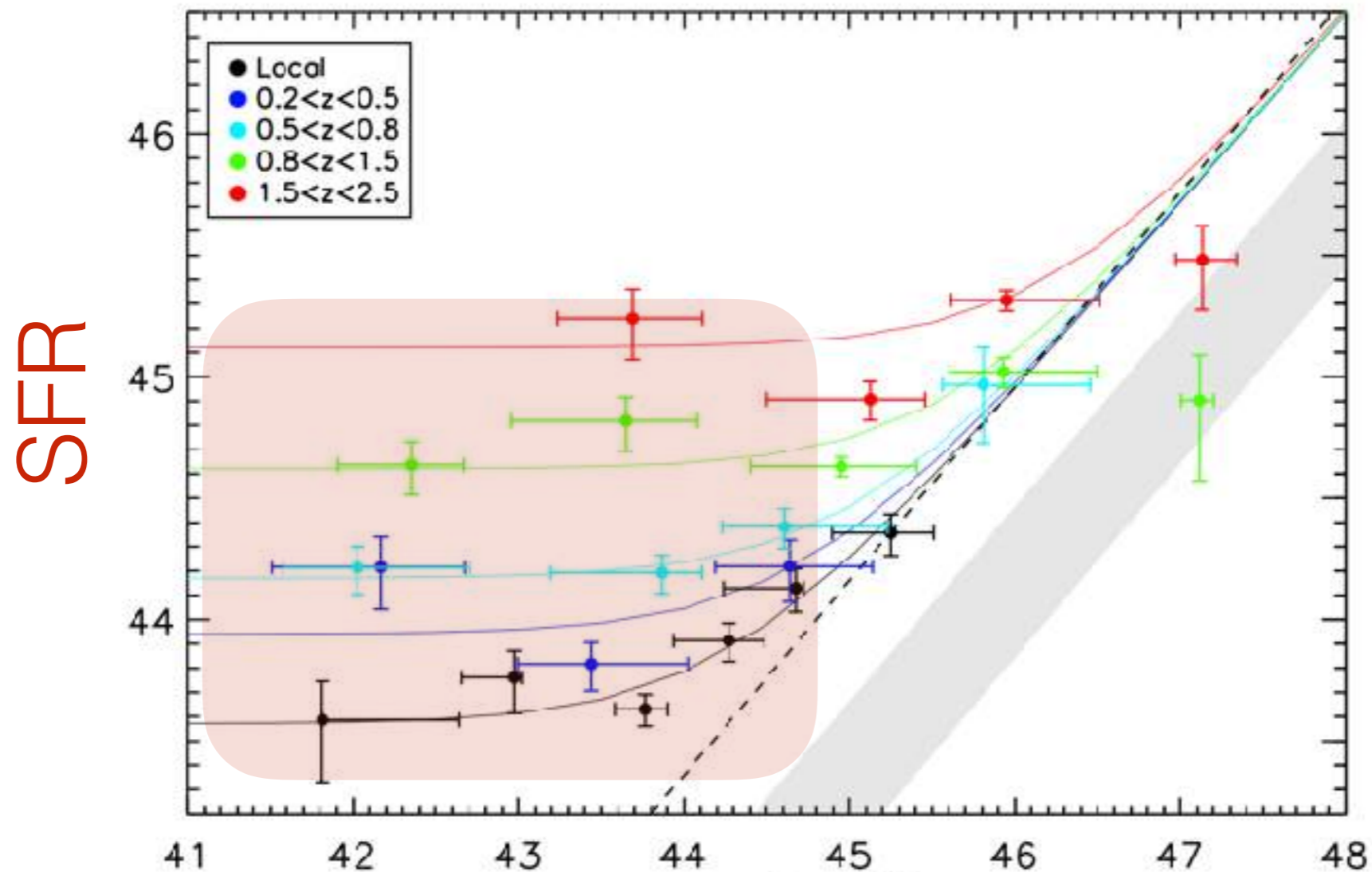
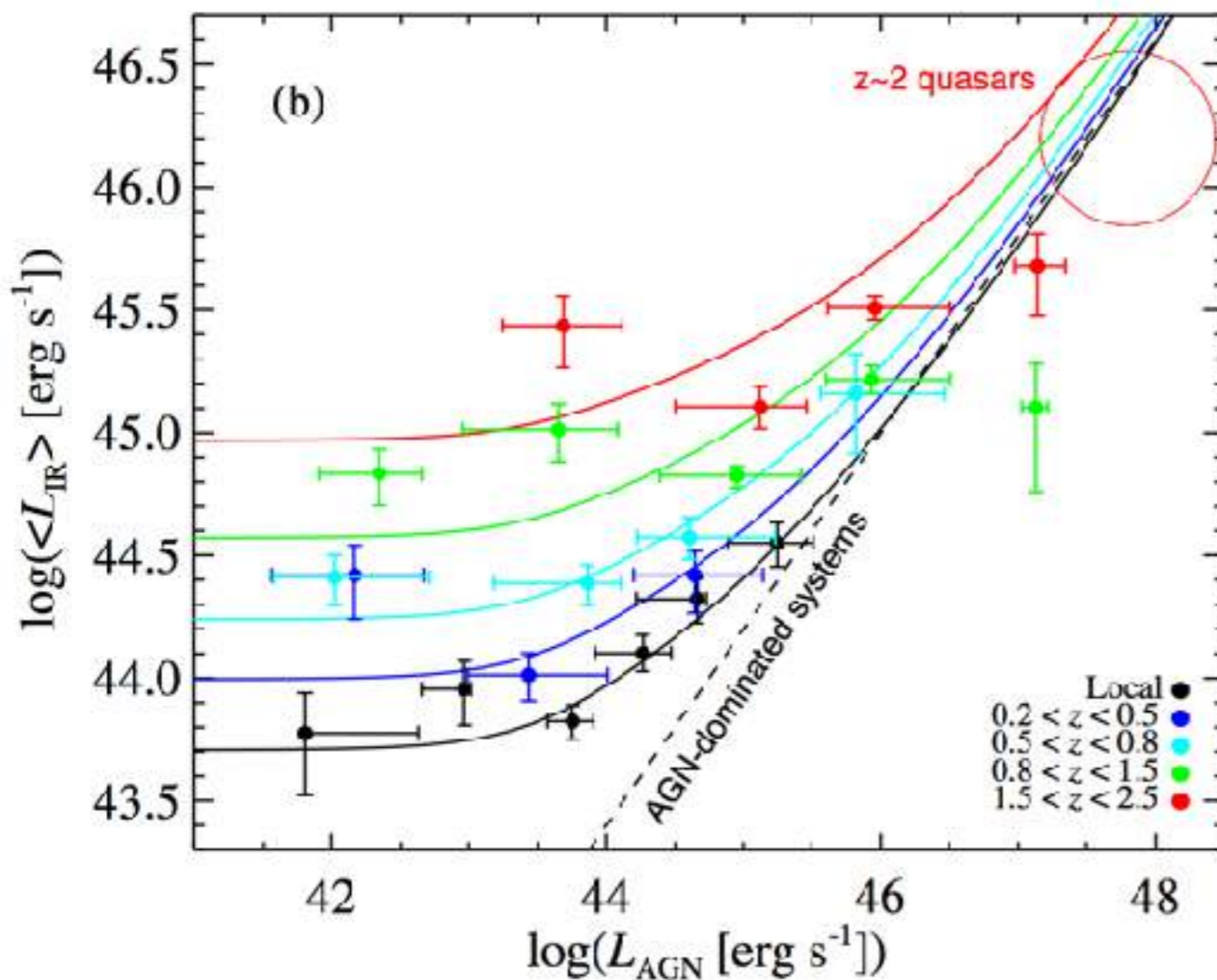

AGN luminosity

Rosario et al. 2012

Timescale issue

- SF timescale : up to ~ a few Gyr
- AGN duty cycle : up to ~ 100 Myr
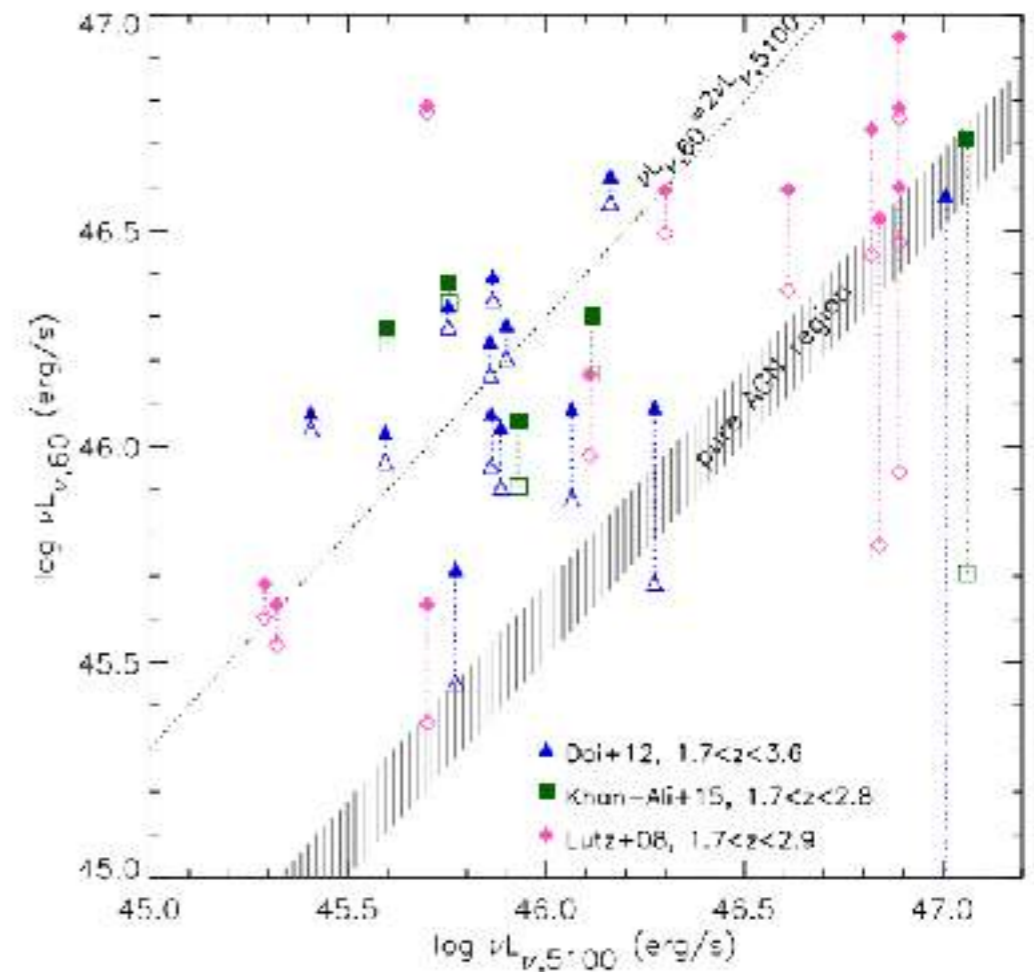
Toy model successfully reproduced the observational trend!

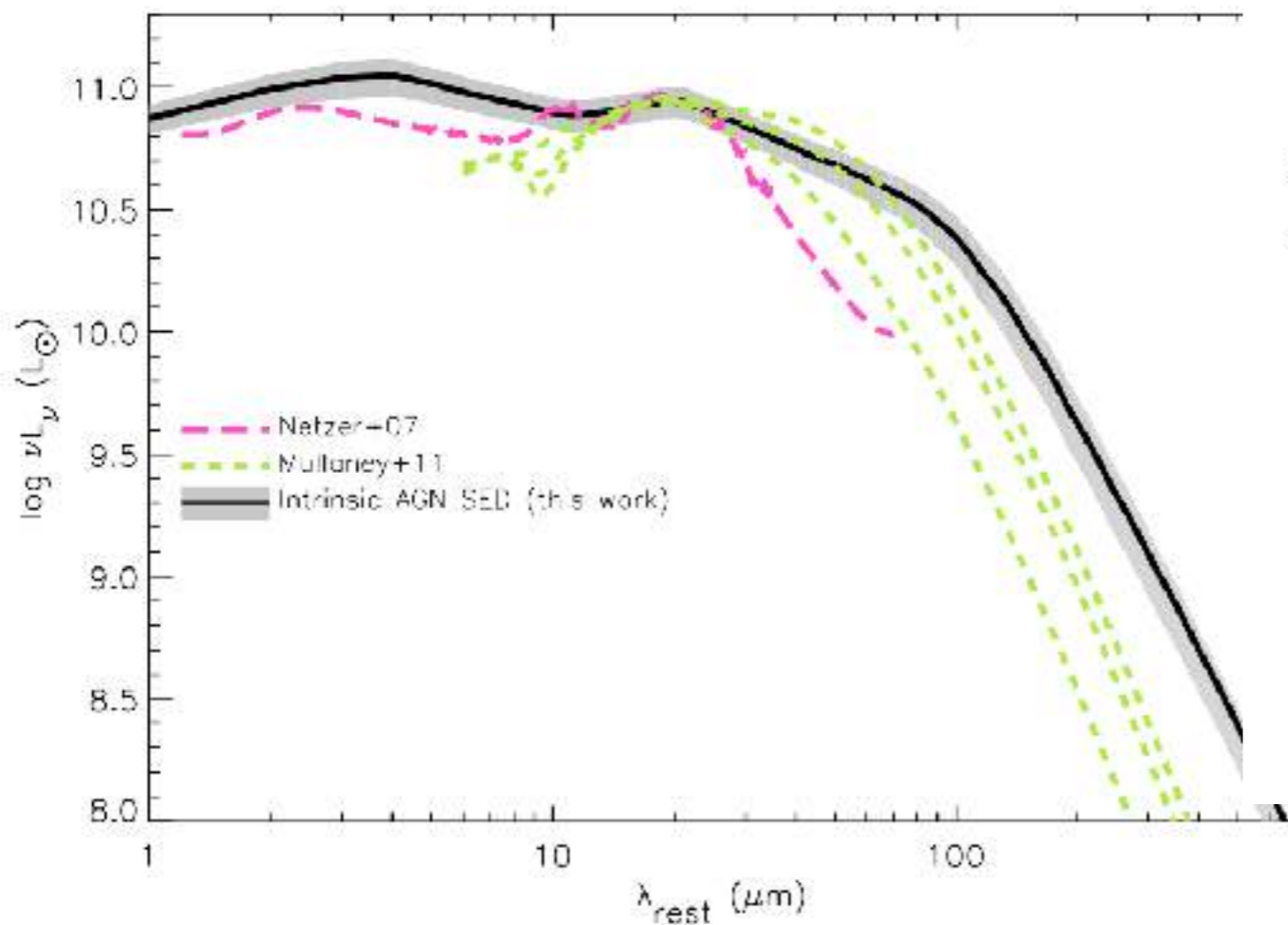(1) SFR ~ $\alpha\dot{m}$ on average

(2) time scale of SFR > $\dot{m}_{BH}$

(3) FIR LF for z~0-2

Hickox et al. 2014

Technical issue

AGN are cooler than you think (Symeonidis+2016)

With FIR one may overestimate SFR in AGNs!

open symbols : pure SF

Limitation of Previous Studies

- Different Studies reached different conclusions (possibly due to the biased sample and method).

- Mostly relied on FIR luminosity, which can be somewhat biased.

- Intriguing caveat : Time scales of SF and AGN are significantly different at least by an order of magnitude.

- Our goal : **Time averaged** relative stellar growth rate (specific SF) using **independent methods** (not FIR)!

Sample and Analysis

- Sample : 235 type I AGNs with deep HST images

- BH mass : Viral method (Single-epoch + multi-epoch)

- Bulge Luminosity : Imaging decomposition
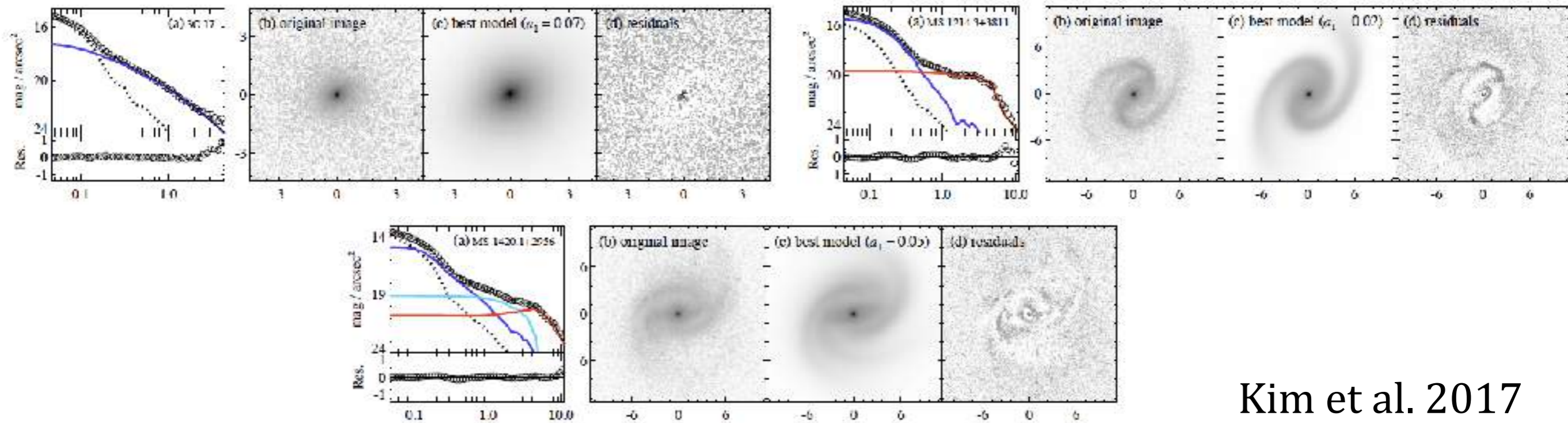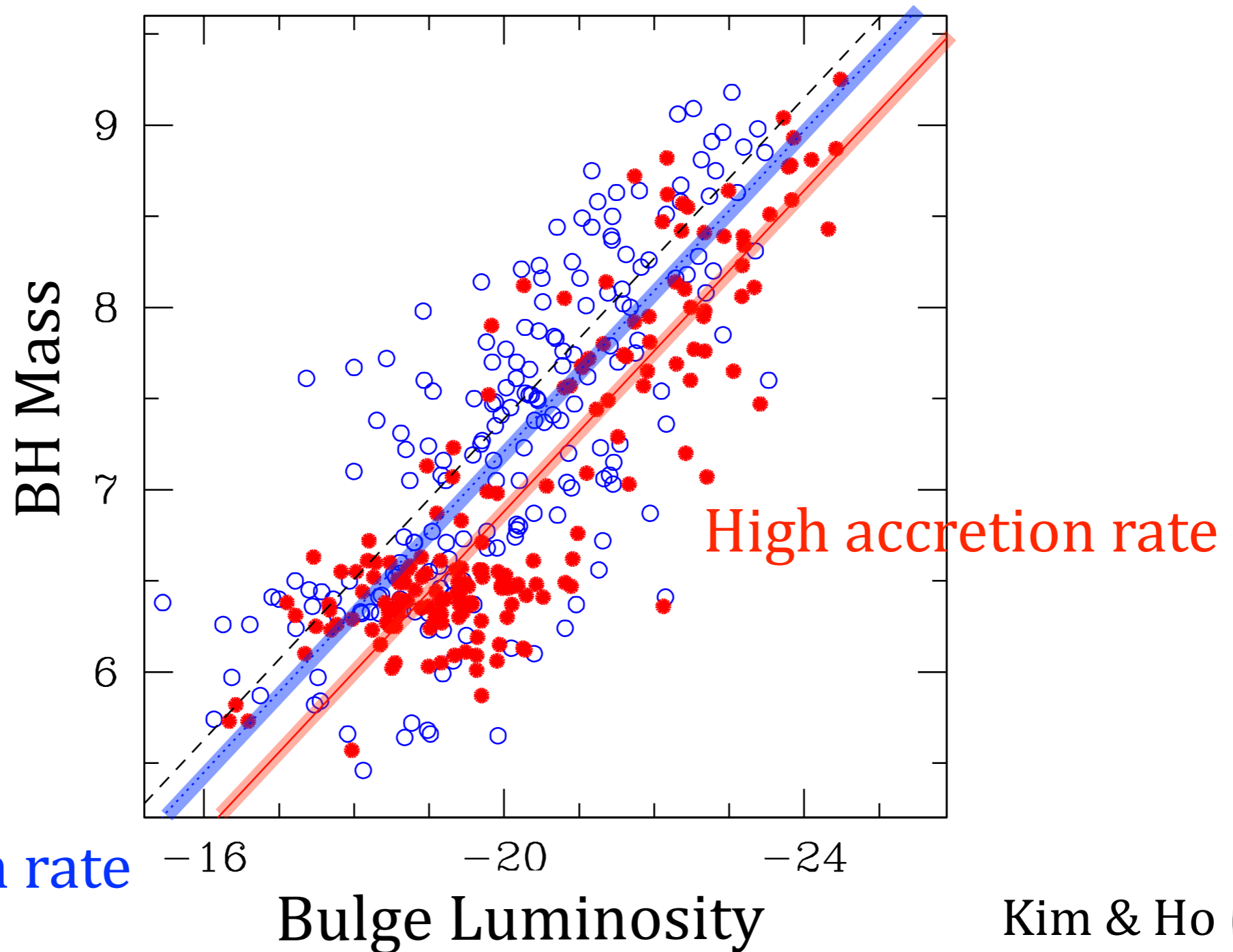

Kim et al. 2017

Decomposition of host galaxy

Methods

- Light excess(ΔL) in the bulges of AGN hosts compared to the normal galaxies, measured from

    1. M_{BH} - L_{bulge} relation

    2. Kormendy relation (size-surface brightness)

- ΔL -> Fraction of young stars -> Stellar growth rate

- L_{AGN} and M_{BH} -> BH Growth rate

Smaller M/L in bulges of AGNs

High accretion rate

Low accretion rate

Bulge Luminosity

BH Mass

Kim & Ho (2019)

Smaller M/L in bulges of AGNs

- Dependency on the accretion rate

(1) BH is actively growing? ✖

(2) M(BH) is underestimated? ✓

ΔL : the light excess of the bulge

(3) host galaxy is overluminous
    due to young stars? ✔
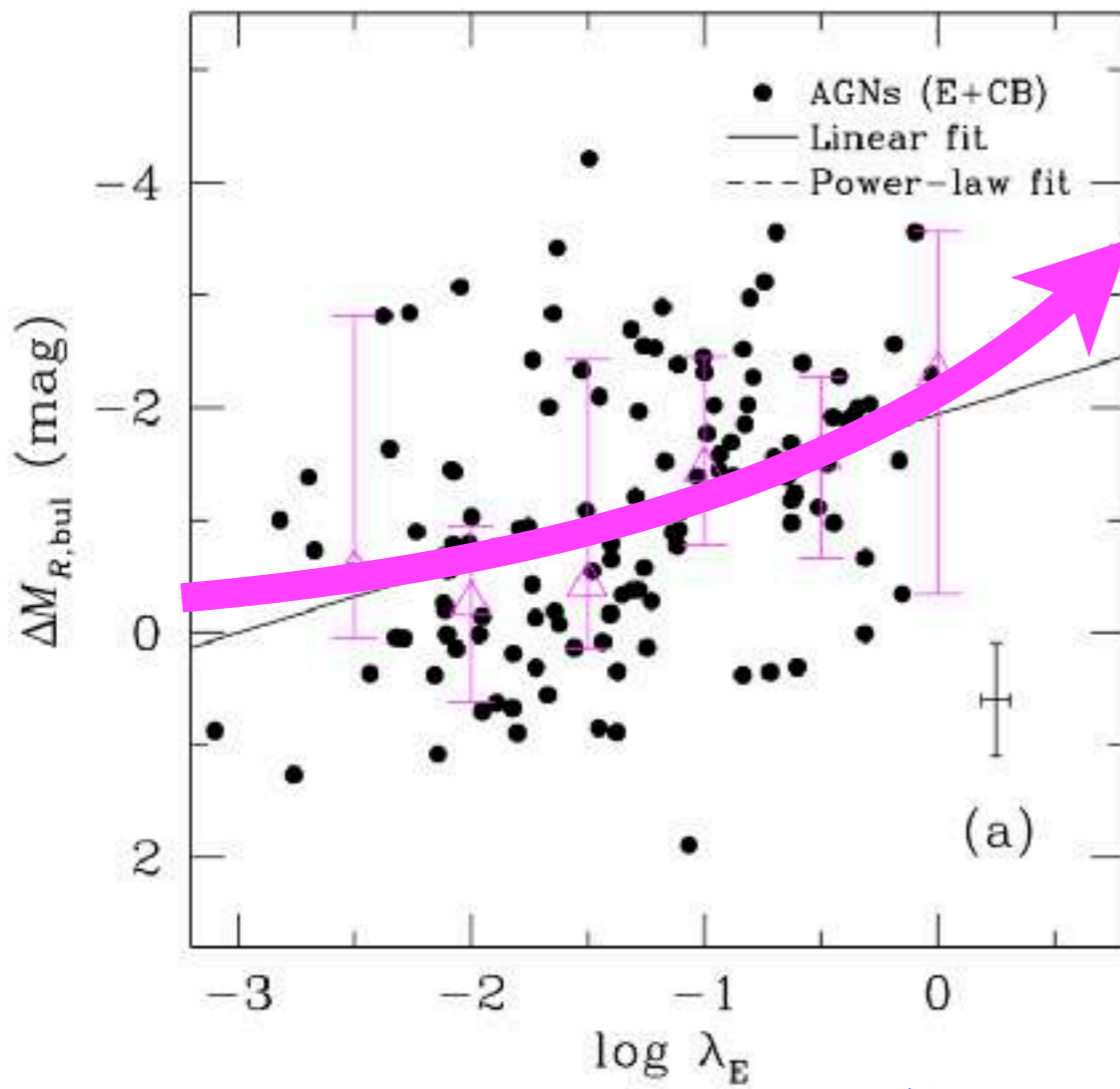
Kim & Ho (2019)
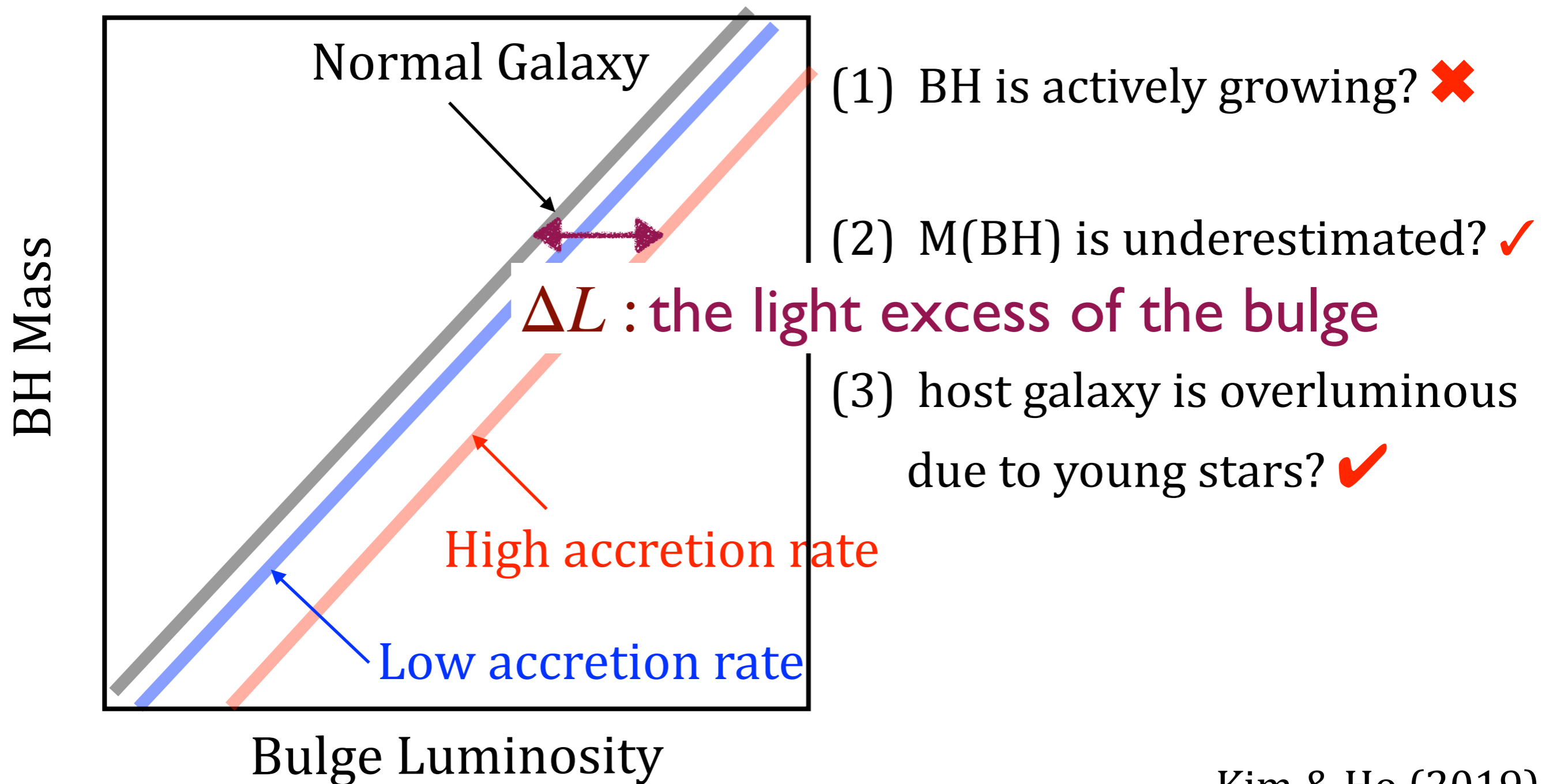
Smaller M/L in bulges of AGNs
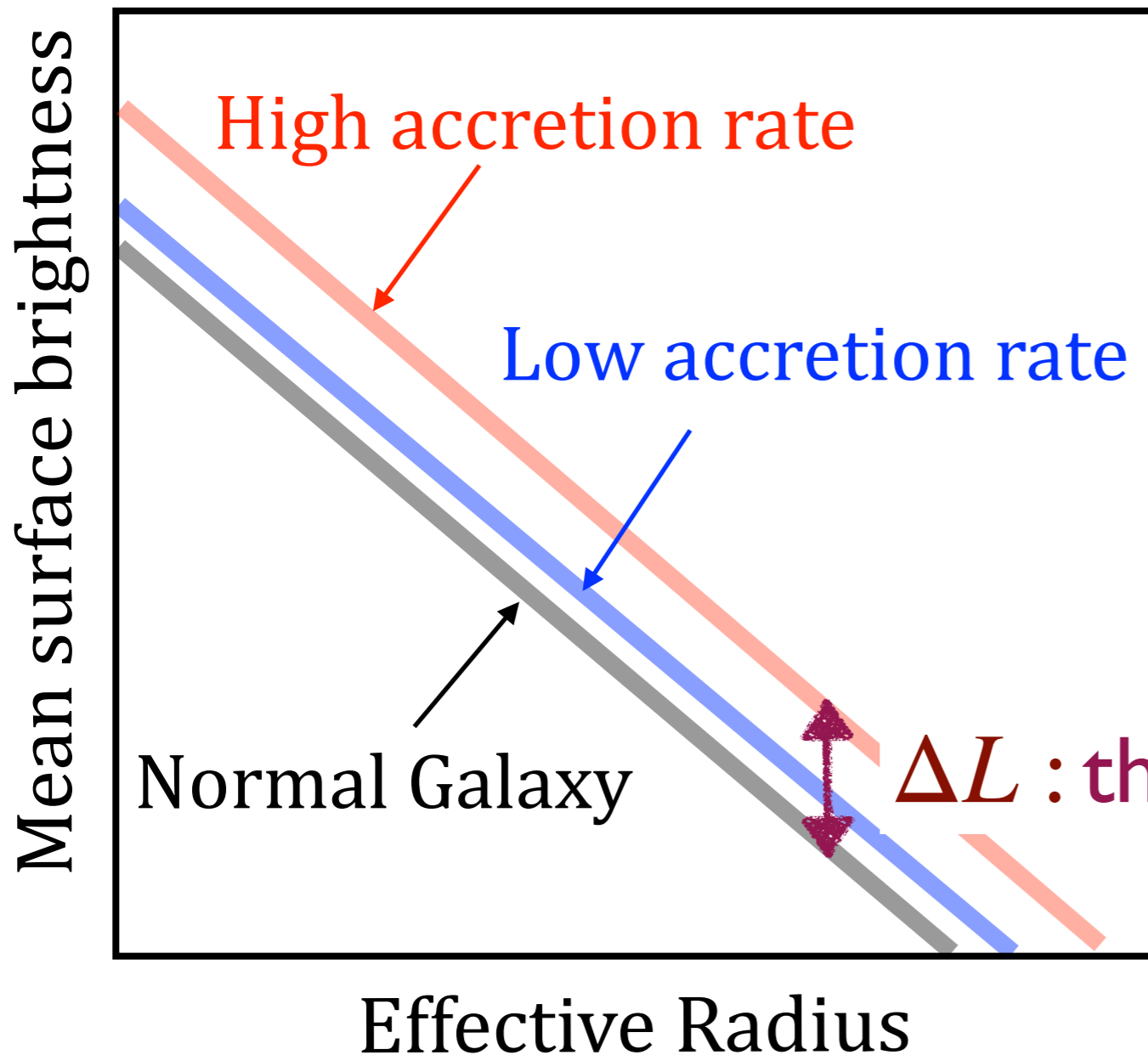
- Kormendy Relation

-> overluminous bulges

-> another evidence for young stars in luminous AGNs
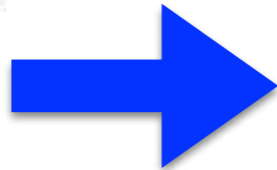
ΔL : the light excess of the bulge

Kim & Ho (2019)

Smaller M/L in bulges of AGNs

From M_{BH}-L_{bulge} relation

From Kormendy relation

ΔL (light excess of bulge)

accretion rate
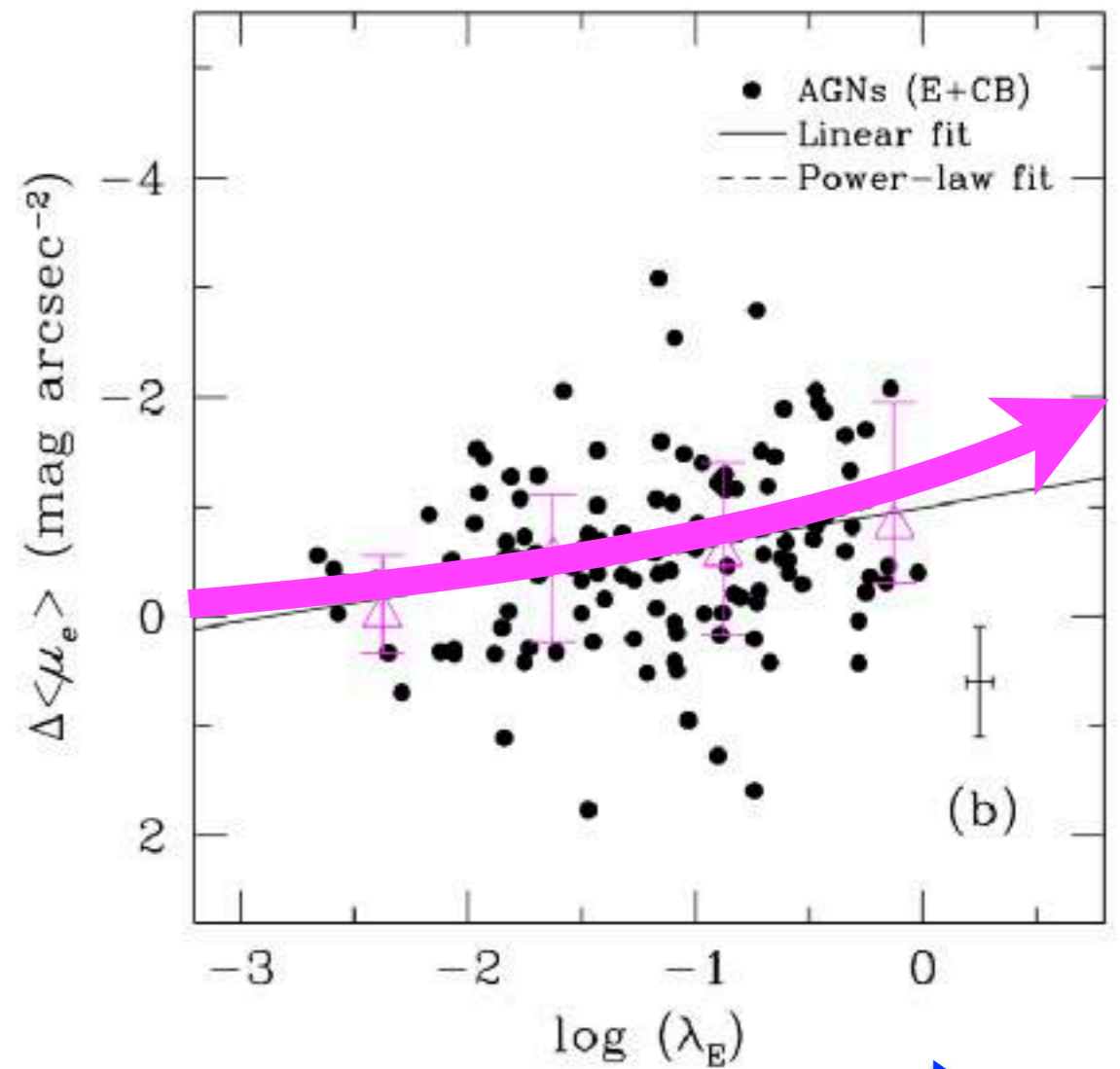
accretion rate
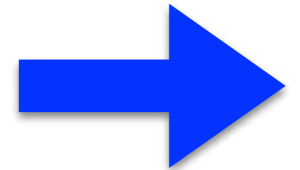
Kim & Ho (2019)

BH growth vs. Stellar Growth in AGNs

$$\frac{M_{*,<500\,\mathrm{Myr}}}{M_{*,10\,\mathrm{Gyr}}} \times 100$$

Stellar Growth (%)

the light excess of bulge
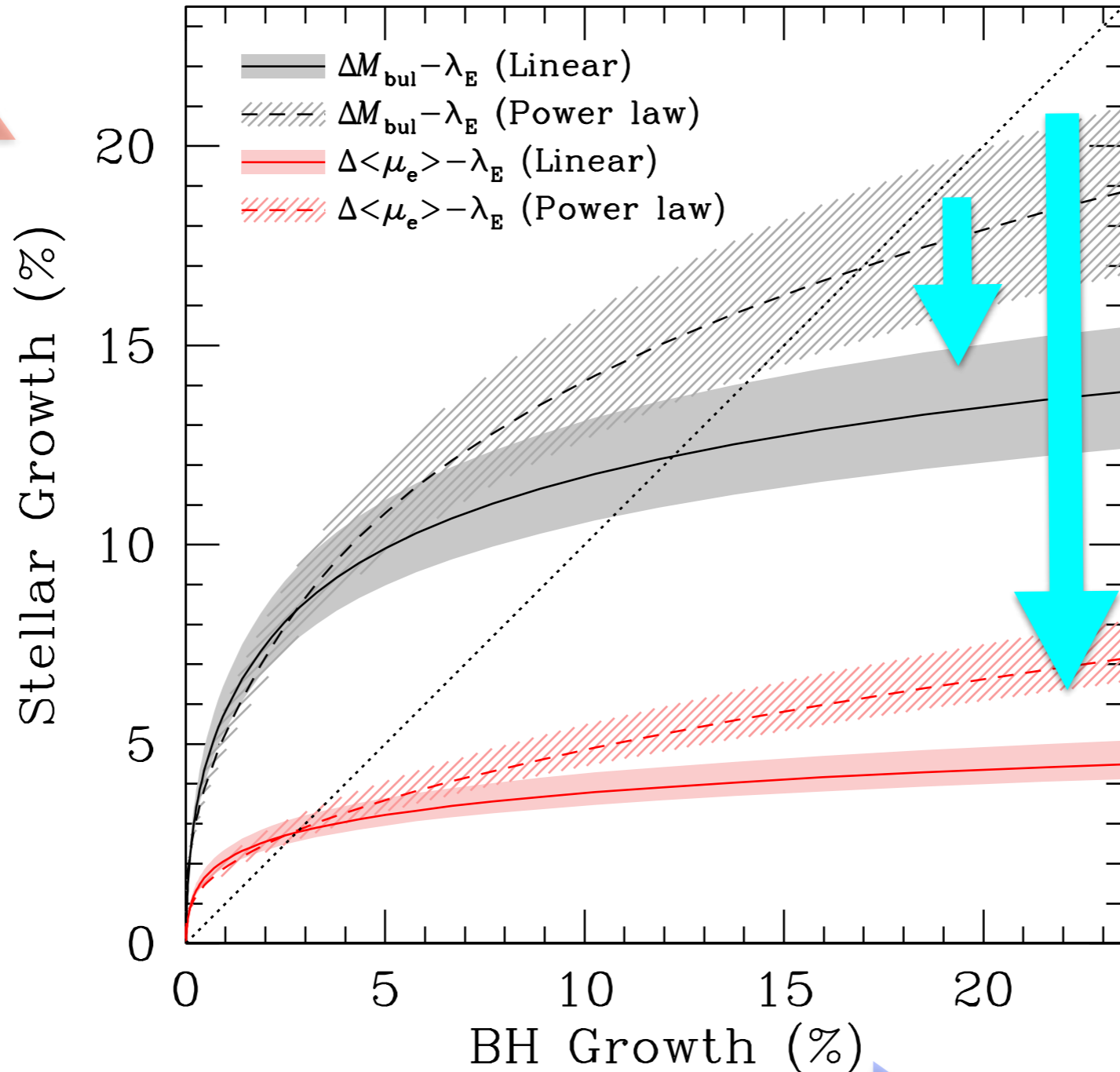
M_{BH}-L_{bul} relation

Kormendy relation

$\Delta M_{\mathrm{bul}}-\lambda_{\mathrm{E}}$ (Linear)
$\Delta M_{\mathrm{bul}}-\lambda_{\mathrm{E}}$ (Power law)
$\Delta <\mu_{\mathrm{e}}>-\lambda_{\mathrm{E}}$ (Linear)
$\Delta <\mu_{\mathrm{e}}>-\lambda_{\mathrm{E}}$ (Power law)

BH Growth (%)

Kim & Ho (2019)
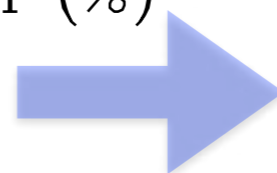
accretion rate $\quad\Longrightarrow\quad \exp\left(\lambda_{\mathrm{E}}\,\frac{1-\epsilon}{\epsilon}\,\frac{t_{\mathrm{AGN}}}{t_{\mathrm{Edd}}}\right)$

Conclusions

- Stellar growth rate and BH growth rate appears to be somewhat correlated. (but not one-to-one relation)

  ➥ SF and BH Growth is NOT perfectly synchronized.

- The correlation becomes flat in high luminous AGNs

  ➥ Indirect signature of AGN feedback?