On the validity of the M_{BH}-σ relation

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Based on:

Beifiori et al. 2009, ApJ, 692, 856
Beifiori et al. in preparation

Introduction

- The mass M_{BH} of supermassive black holes has been measured in the center of about 50 nearby galaxies (Gultekin et al. 2009).

- Different scaling relations have been found between M_{BH} and the properties of the host galaxies, but their slope and scatter are still uncertain (e.g., Thomas, Gadotti, Gebhardt).

- There is a pressing need to acquire better M_{BH} statistics both in term of the number and of broadening the range of host galaxies.

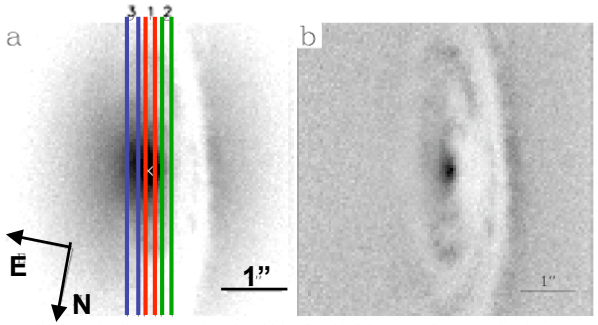
- This will allow to constrain the mass-accretion history of black holes which drives their coevolution with the host galaxies (e.g. BHFP, Hopkins et al. 2007).

Upper limits on M_{BH} from nebular lines

- AIM: Derive M_{BH} upper limits for the largest possible number of galaxies by measuring their gas kinematics in HST archival data.
- SELECTION CRITERIA:
  - nearby galaxies (D<100 Mpc).
  - STIS/G750M nuclear spectra (slit width 0.1”).
  - Hα, [NII]6548,6583Å, [SII]6716,6731Å.
  - available stellar velocity dispersion.
- SAMPLE:
  - 105 galaxies (out of 177).
  - 26% E, 20% S0, 54% Sa-Sc.
  - $60 < \sigma < 420$ km/s (18% $\sigma < 100$ km/s)
  - homogeneous measurements of the central emission-line width

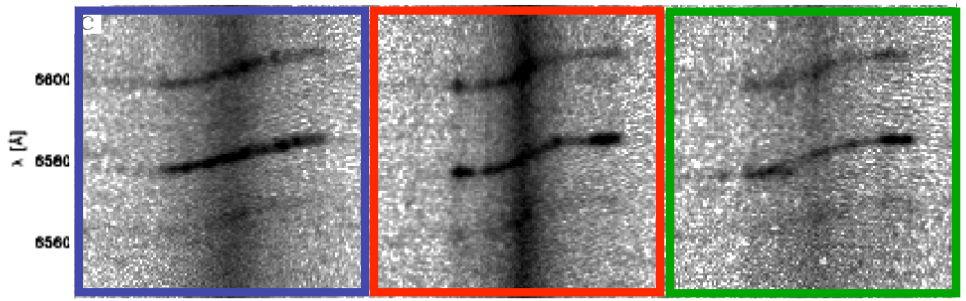
Ionized-gas kinematics in galactic nuclei

acquisition image
slits



unsharp masking
dust (and gas) disk

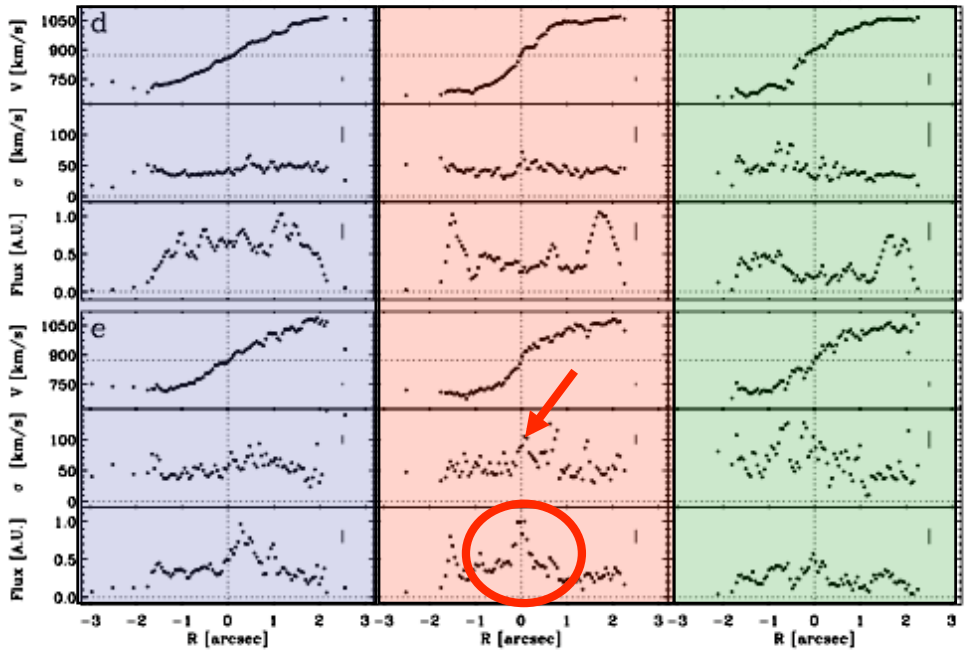
NGC 4435



[NII] λ6583Å
Hα λ6563Å
[NII] λ6548Å

Coccato et al. (2006)

V
σ
Flux
V
σ
Flux



Hα λ6563Å
kinematics

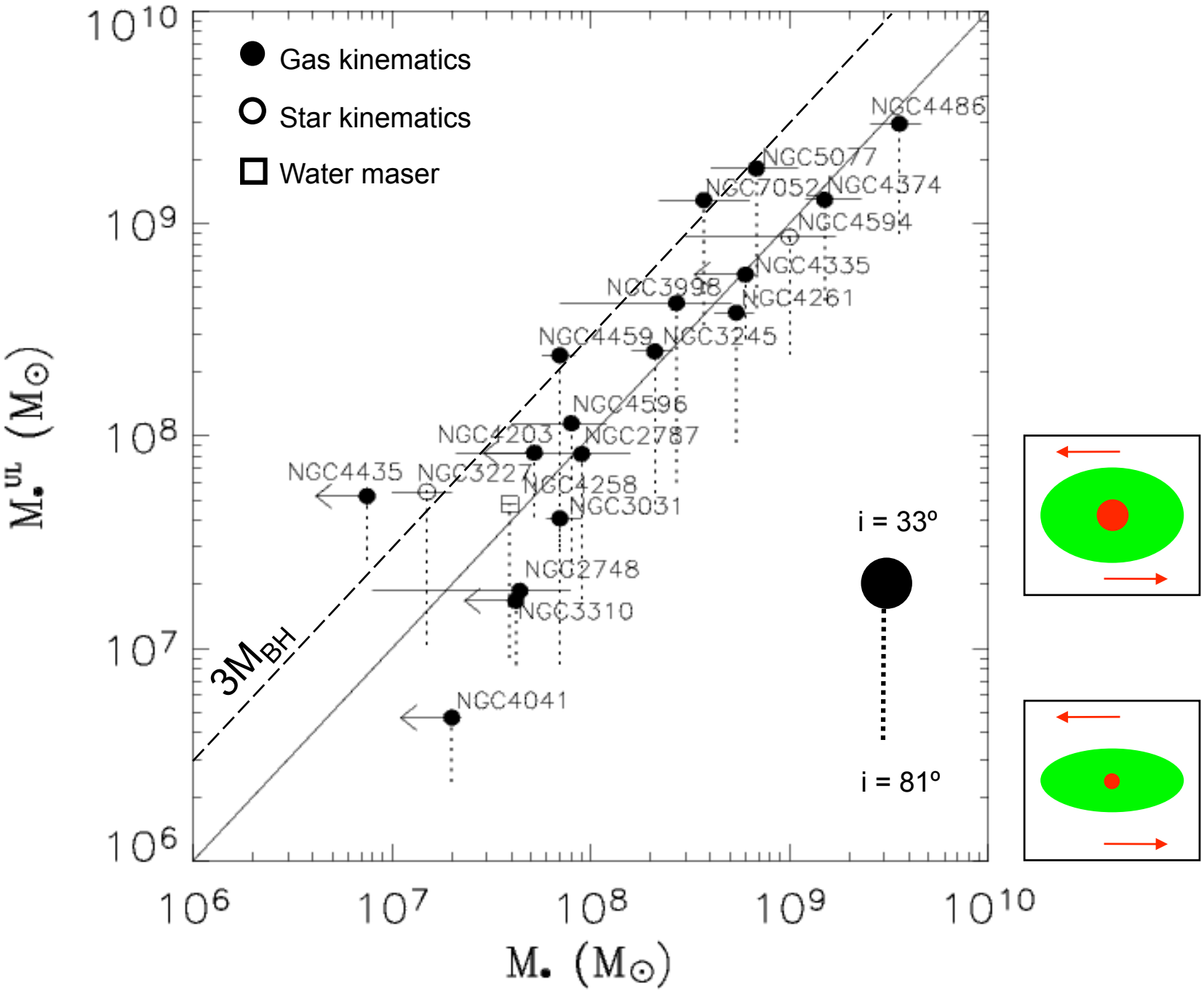
[NII] λ6583Å
kinematics

Modeling the width of the nebular lines

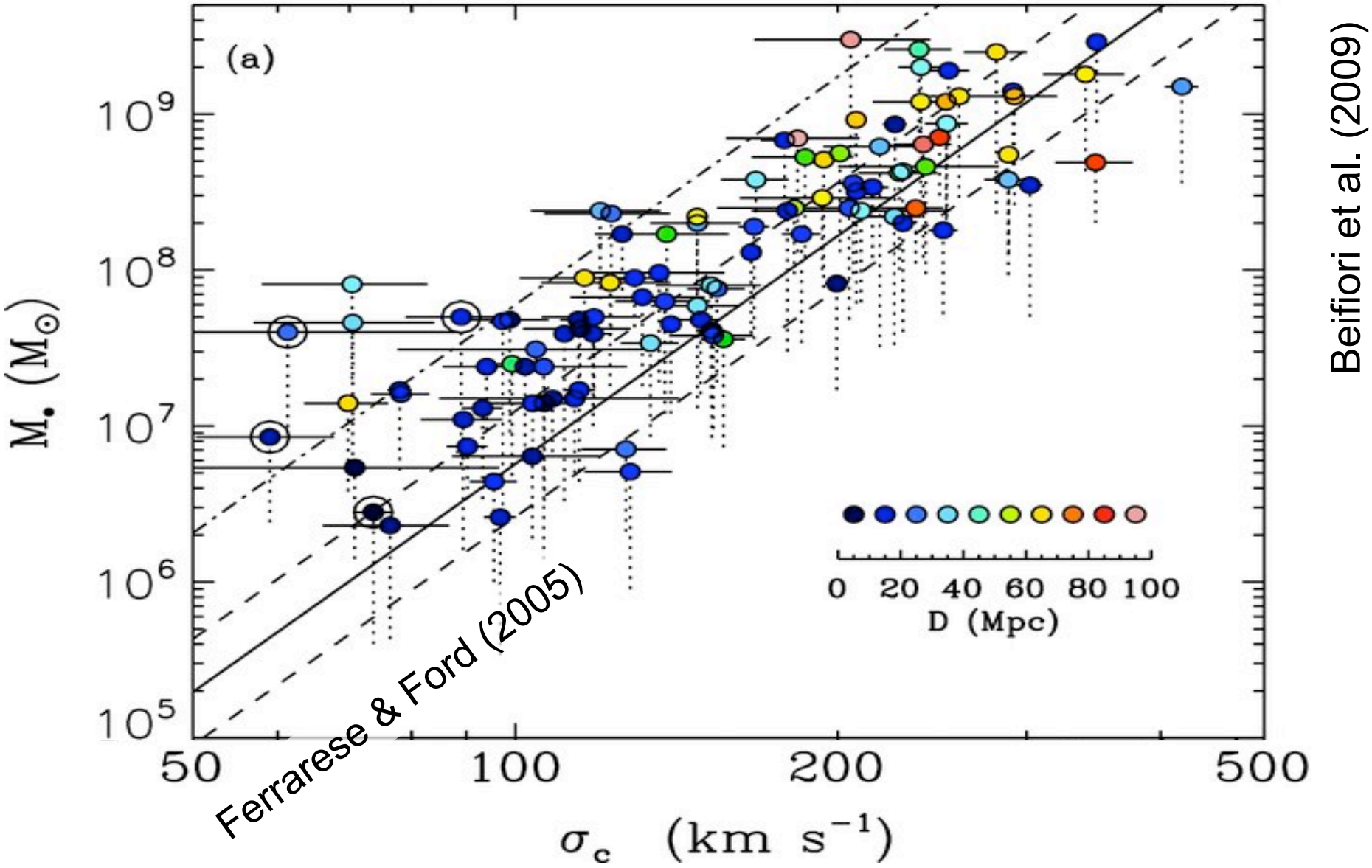
- Line broadening from gas in Keplerian motion onto circular obits in a thin disk with
  - unknown inclination (i = 33º, 81º)
  - unknown position angle (squared apertures)
  - intrinsic emissivity with a Gaussian radial profile (conservative)

  under the influence of the putative BH disregarding
  - stellar contribution (~15% for i = 33º at 21.4 Mpc)
  - non-gravitational forces

- These are upper limits on the BH mass because
  - velocity gradient is not resolved within the aperture
  - stellar contribution and non-gravitational forces are neglected

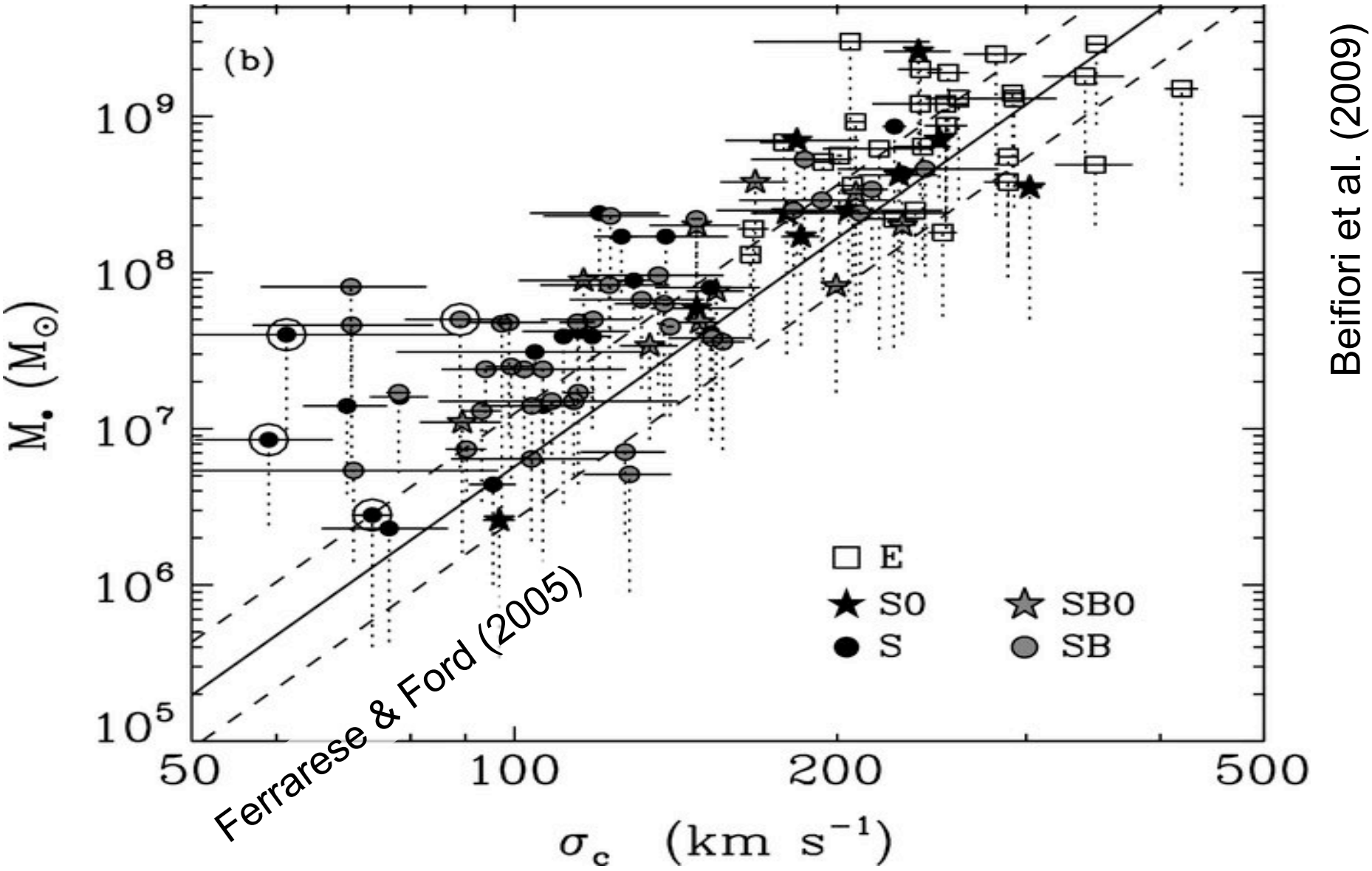

Gas kinematics
Star kinematics
Water maser
NGC4486
NGC5077
NGC7052
NGC4374
NGC4594
NGC4335
NGC3998
NGC4261
NGC4459
NGC3245
NGC4596
NGC4203
NGC2787
NGC4435
NGC3227
NGC4258
NGC3031
NGC2748
NGC3310
NGC4041
3M_BH
i = 33°
i = 81°
M•^UL (M⊙)
M• (M⊙)
10^10
10^9
10^8
10^7
10^6

The M_{BH}-σ relation: distance



Beifiori et al. (2009)

The M_{BH}-σ relation: morphology

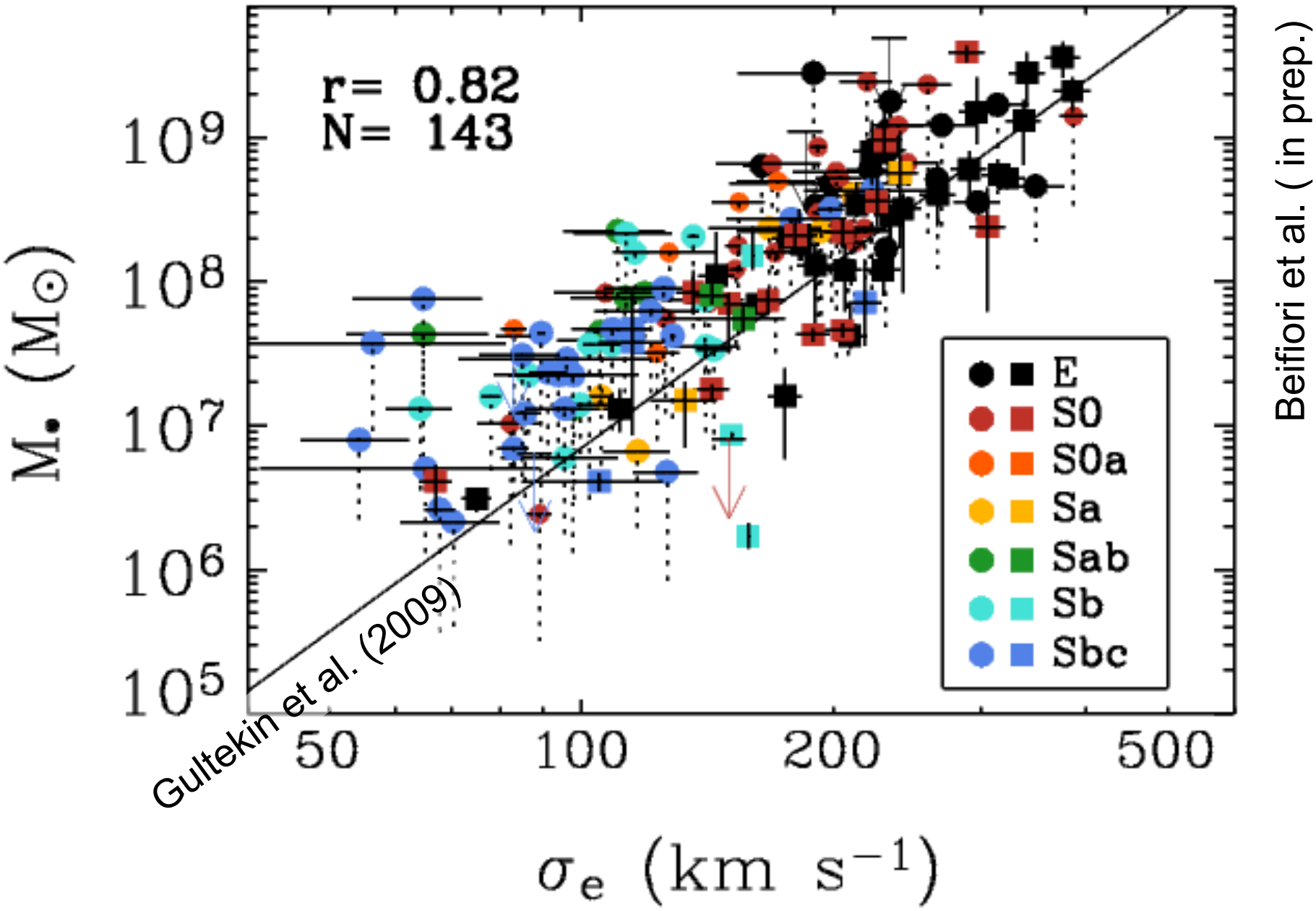


Beifiori et al. (2009)

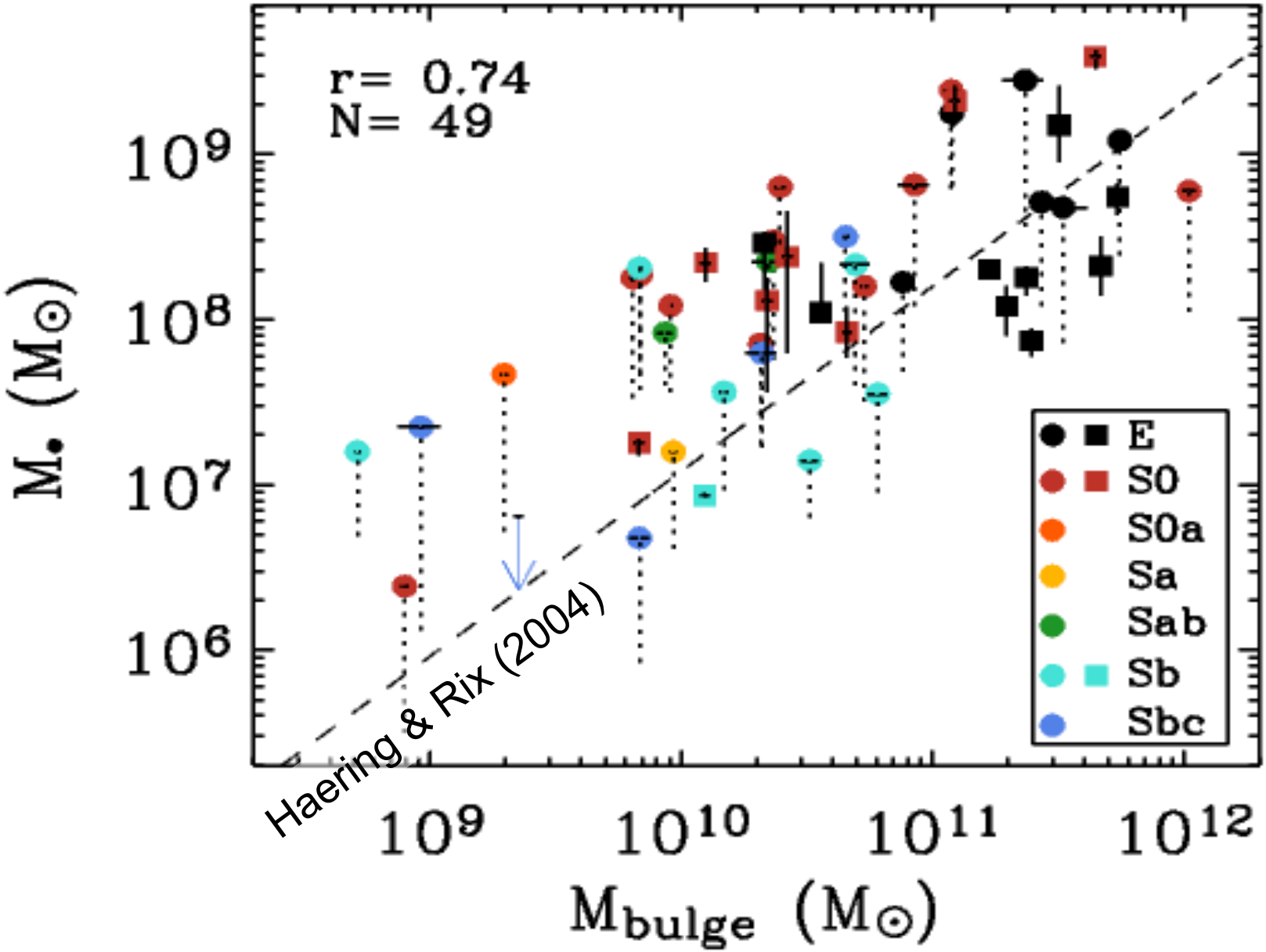
Relationships between M_{BH} and host galaxy properties

- AIM: Search for fundamental correlation between M_{BH} and bulge (σ, $L_{i,bulge}$, M_{bulge}, n) or galaxy parameters (V_c, $L_{i,gal}$, $M_{*,gal}$, M_{gal})
- SAMPLE:
  - 105 M_{BH} upper limits from Beifiori et al. (2009)
  - 49 secure M_{BH} + 5 M_{BH} upper limits from Gultekin et al. (2009)
- BULGE AND GALAXY PROPERTIES:
  - SDSS g- and i-band images
    - aperture photometry to derive $L_{i,\,gal}$, $r_{e,\,gal}$, $r_{24.5}$, $C_{28,}$ g-i
    - 2D photometric decomposition to derive $L_{i,\,bulge}$, $r_{e,\,bulge}$, n,$\langle I_e \rangle$
  - V_c and σ from literature

The M_{BH}-σ relation

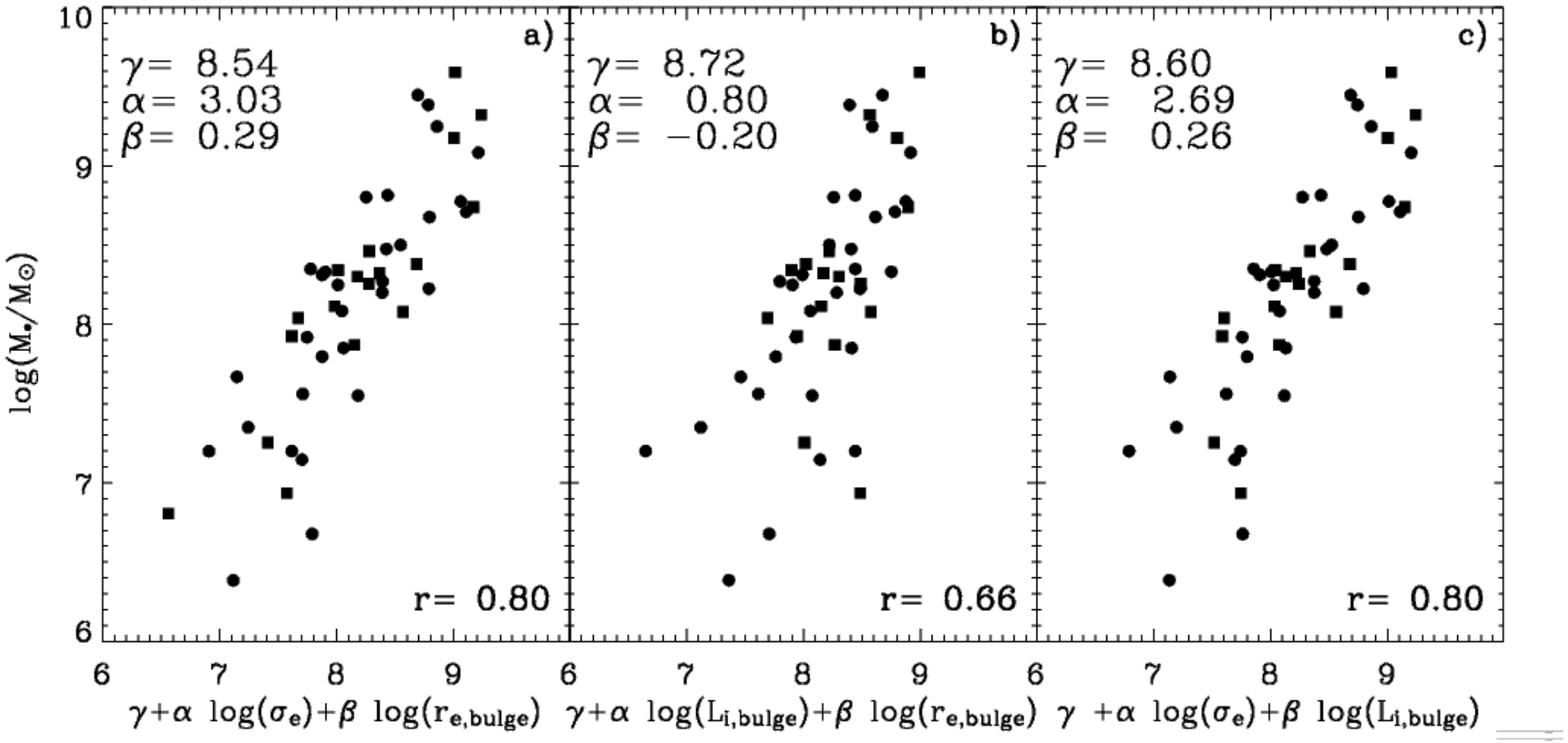


The M_{BH}-M_{bulge} relation



Beifiori et al. (in prep.)

M_{BH} and bulge: linear combinations



Beifiori et al. (in prep.)

Conclusions

- We measured the M_{BH} upper limits in 105 nearby galaxies from the width of nuclear nebular lines in HST/STIS spectra
  - upper limits run parallel and above the M_{BH}-σ relation
  - line widths trace well the nuclear gravitational potential
  - no systematic trend with distance, Hubble type, and bar presence
  - upper limits can be adopted to study M_{BH} scaling relations

- We combined M_{BH} upper limits and secure M_{BH} with kinematical (from literature) and photometric properties (from SDSS images) of the host galaxies to study M_{BH} scaling relations
  - M_{BH} - σ is the tightest relation for all the sampled Hubble types
  - BHFP is fundamentally driven by σ