Recent Activities of K-GMT Science Program & Coevolution of Supermassive Black Holes and Galaxies

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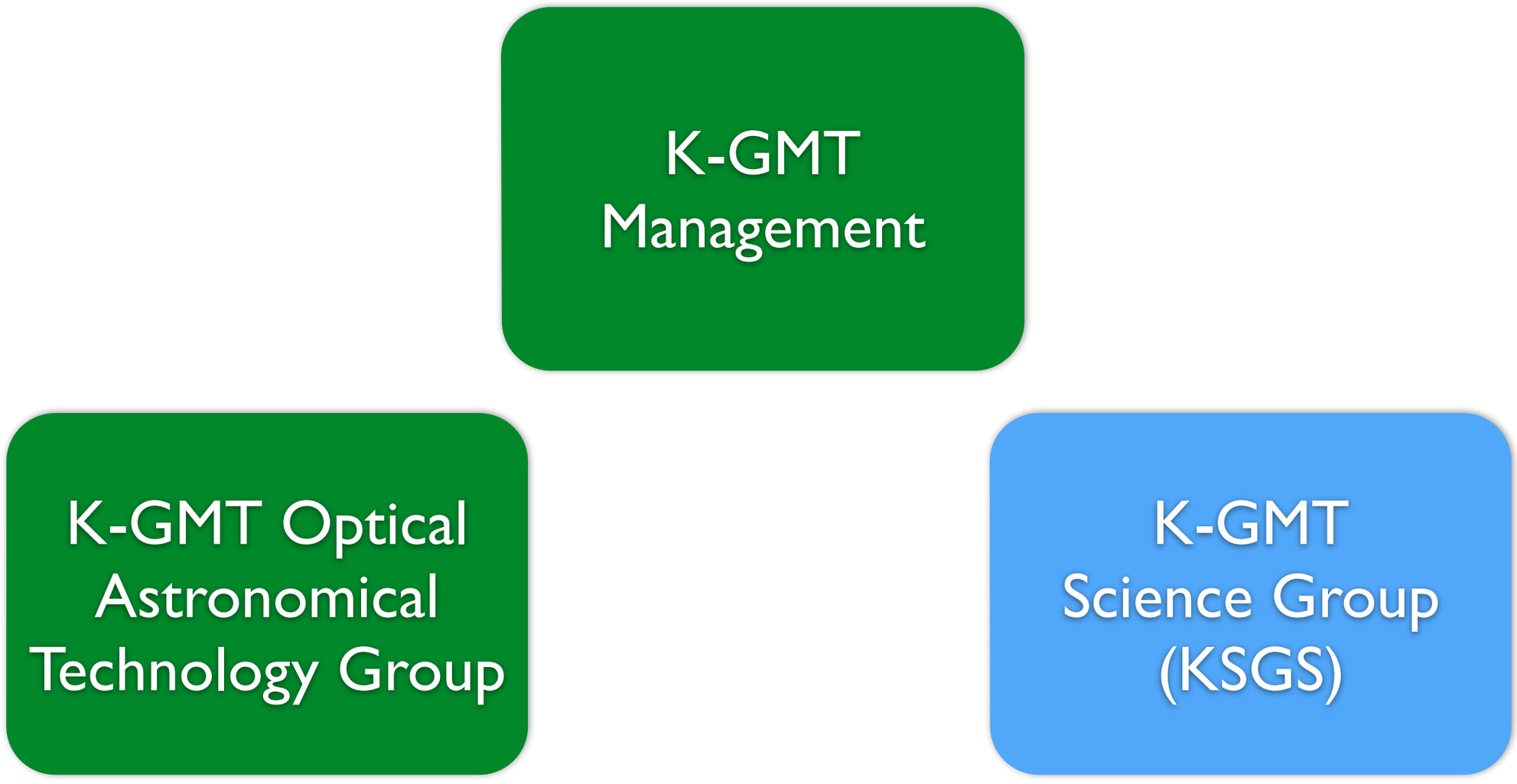
Contents

Center for Large Telescopes
(K-GMT Project Office)

- An official interface between KASI and GMTO
  (K-GMT PM : Byeong-Gon Park)



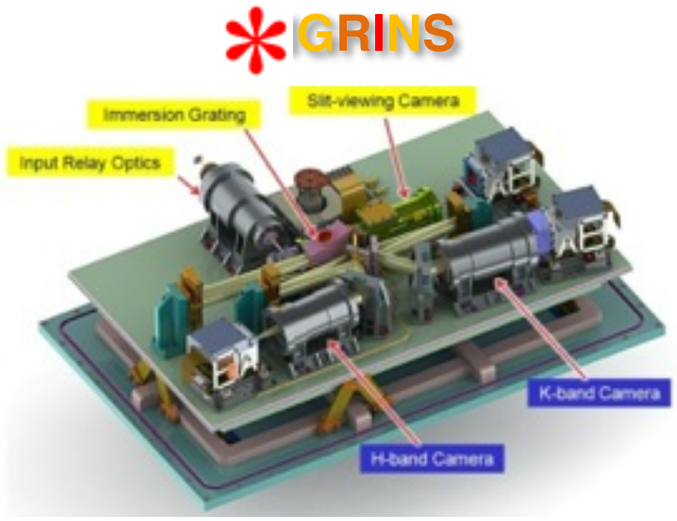
K-GMT Science Group

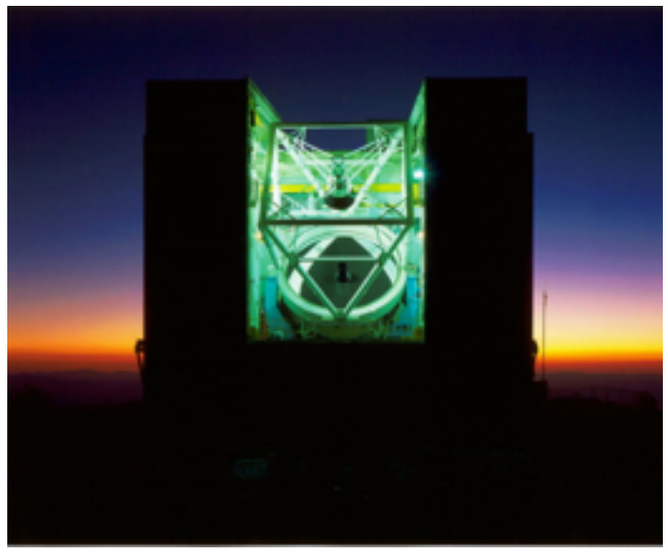
- Main mission
  - To Lead and Support the Development of Research Capability of the Community in preparation of GMT era

- KGSG Operations include:
  - GMT SAC participation
  - Joint Fellowship Program
  - **K-GMT Science Program**
  - K-GMT Science White Paper
  - K-GMT Summer/Winter School
  - International collaboration on scientific activities

K-GMT Science Program

- Provides Korean community with access to large telescope/ observing facilities
  - Phase I: 2009~2013 (CFHT, AAT, UKIRT)
  - Phase II: 2014~
    - ✓ Open time to Korean community
    - ✓ MMT: 2014~
    - ✓ Gemini: 2015~
    - ✓ IGRINS@McD/DCT: 2014~





K-GMT Science Program

- Currently, acting as an interface bet. Korea and Observatories - “virtual observatory”
- Aim to expand the program to include GMT, and to establish “K-GMT Observatory” system

Korean Astronomy Society

GMT

McDonald Observatory
The University of Texas at Austin

The MMT Observatory
A joint facility of The Smithsonian Institution and The University of Arizona

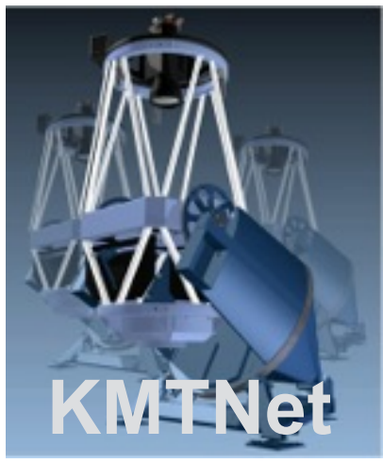
GEMINI OBSERVATORY
Exploring the Universe, Sharing its Wonders

K-GMT Science Program

- 2.5-3 oversubscription until 2017A
- 1st K-GMT SP user meeting
  - one day meeting in KASI (March 2017)
  - 90 participants

Future Plan

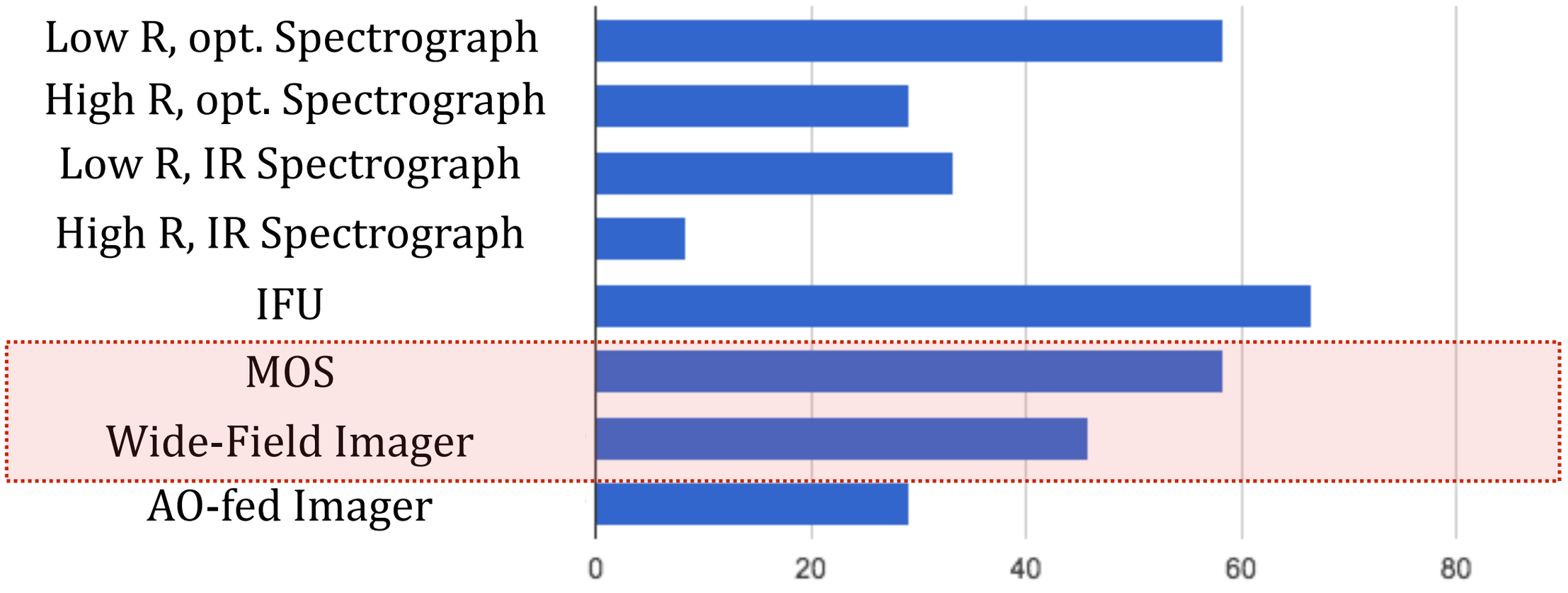
- **Gemini**
  - Confirmed until 2018
  - Plan to use in combination with ALMA, KMTNet, LSST, GMT
  - Will be a major component of future ‘K-GMT Observatory’



- **MMT**
  - Confirmed until 2018 based on collaborations w/ U of Arizona
  - Expand to initiate KASI-Arizona Joint Postdoctoral Fellowship

Possible collaboration with Subaru?

Q. What type of instrument do you need to pursuit your research?



2016 K-GMT SP User survey

K-GMT Science Program

K-GMT
Observatory

GMT

Korean Astronomy Society

SUBARU TELESCOPE

McDonald Observatory
The University of Texas at Austin

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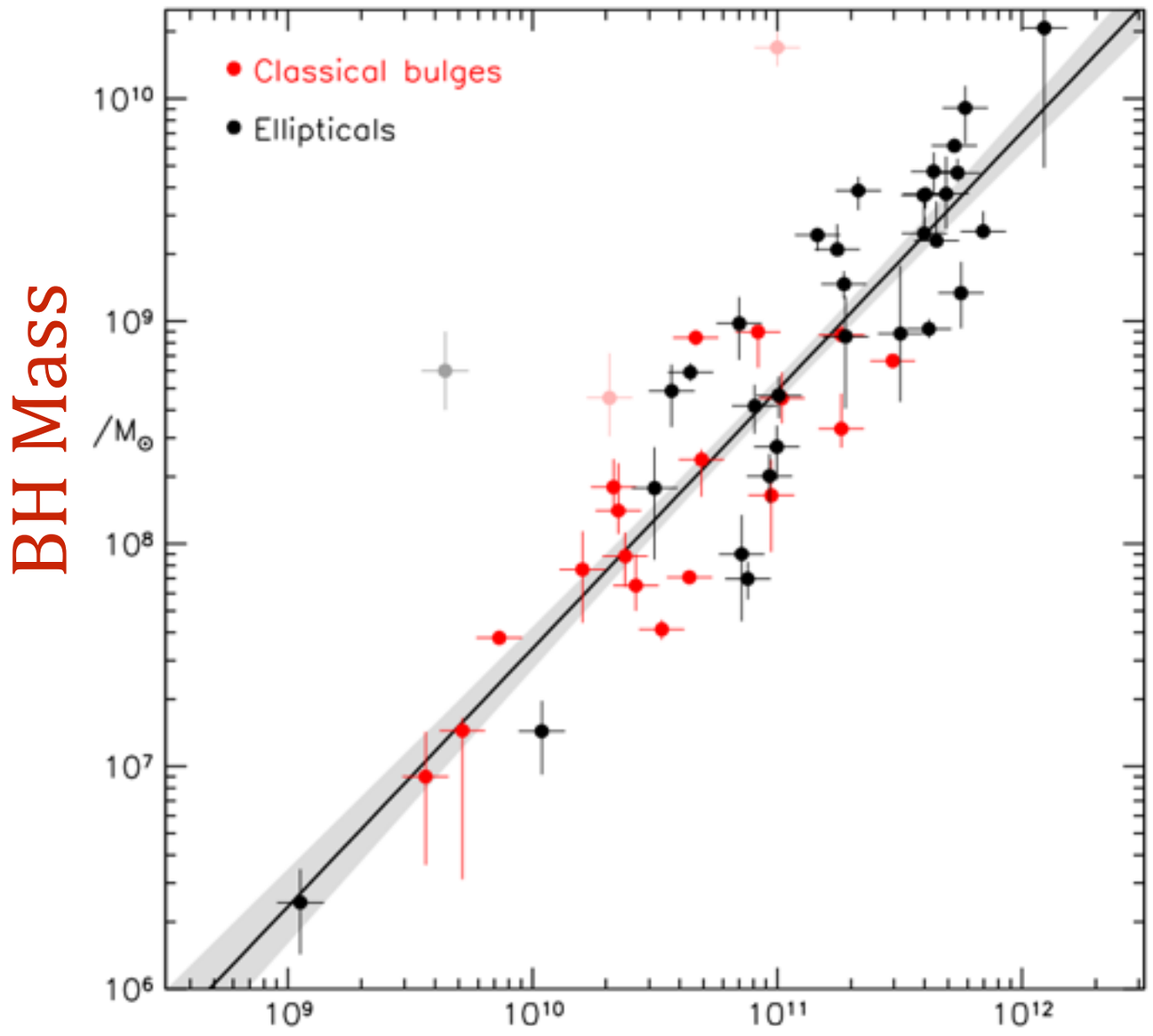
BH-Host relation for normal galaxies

Normal Galaxy



Kormendy & Ho 2013

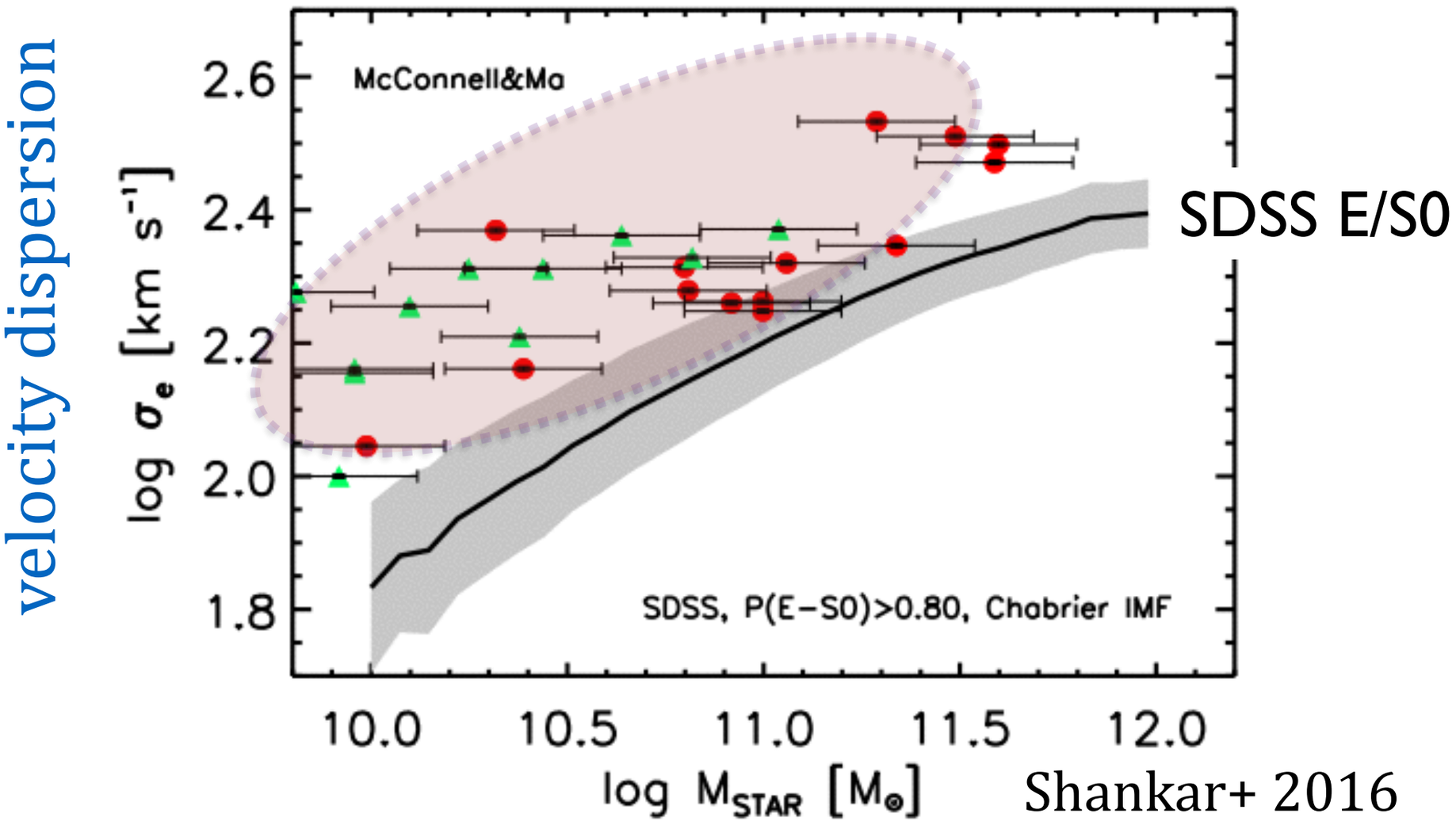
Bias for normal galaxy

- Bias in BH-host scaling relation?
- Selection Bias (Sample bias)
- Mass (Morphology) dependency

(1) Selection bias

r_h: Sphere of influence of the black hole $\quad r_h = \frac{G \times M_{\rm BH}}{\sigma^2}$

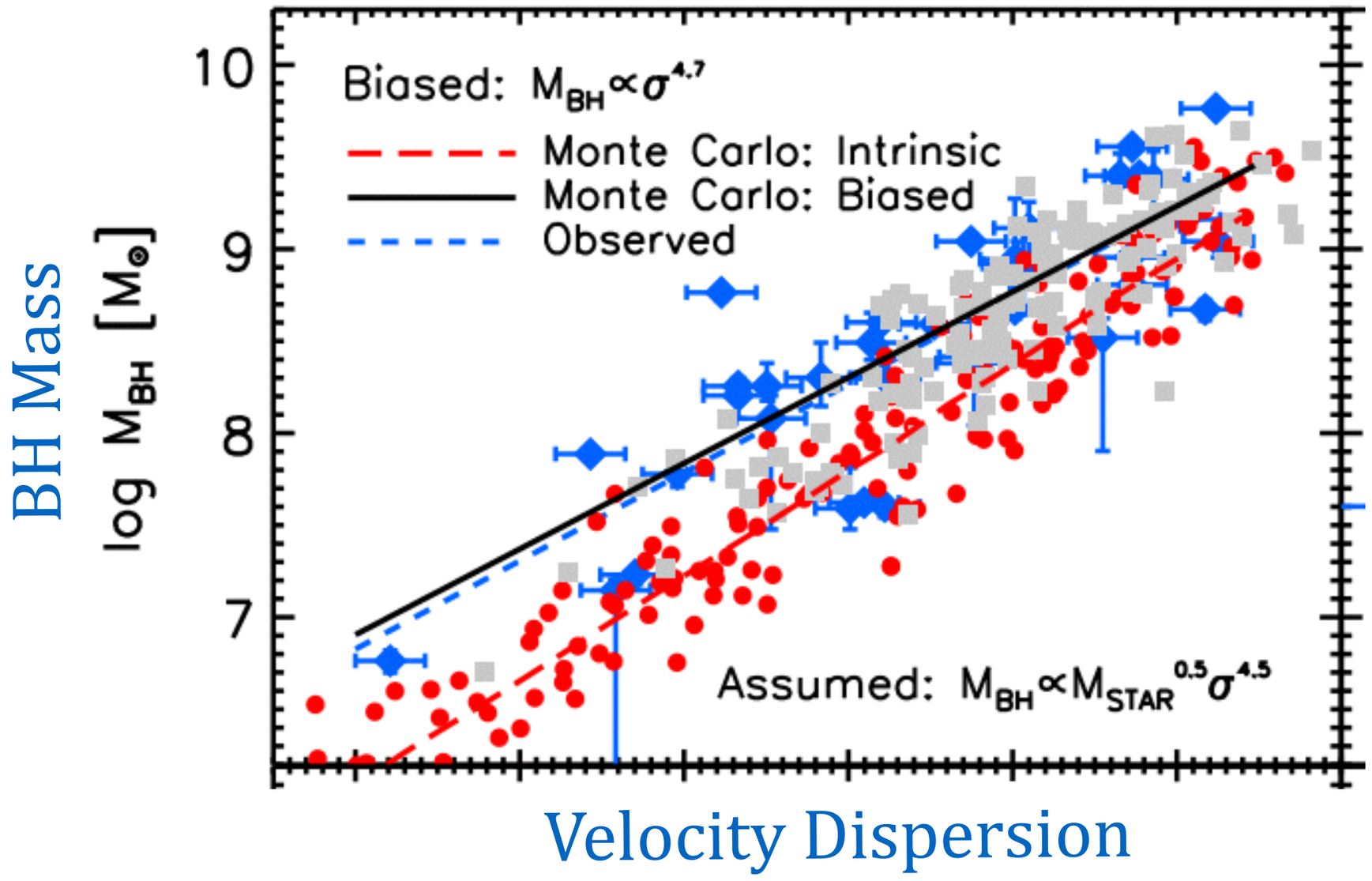
Galaxies with M(BH) measurements



Shankar+ 2016

(1) Selection bias

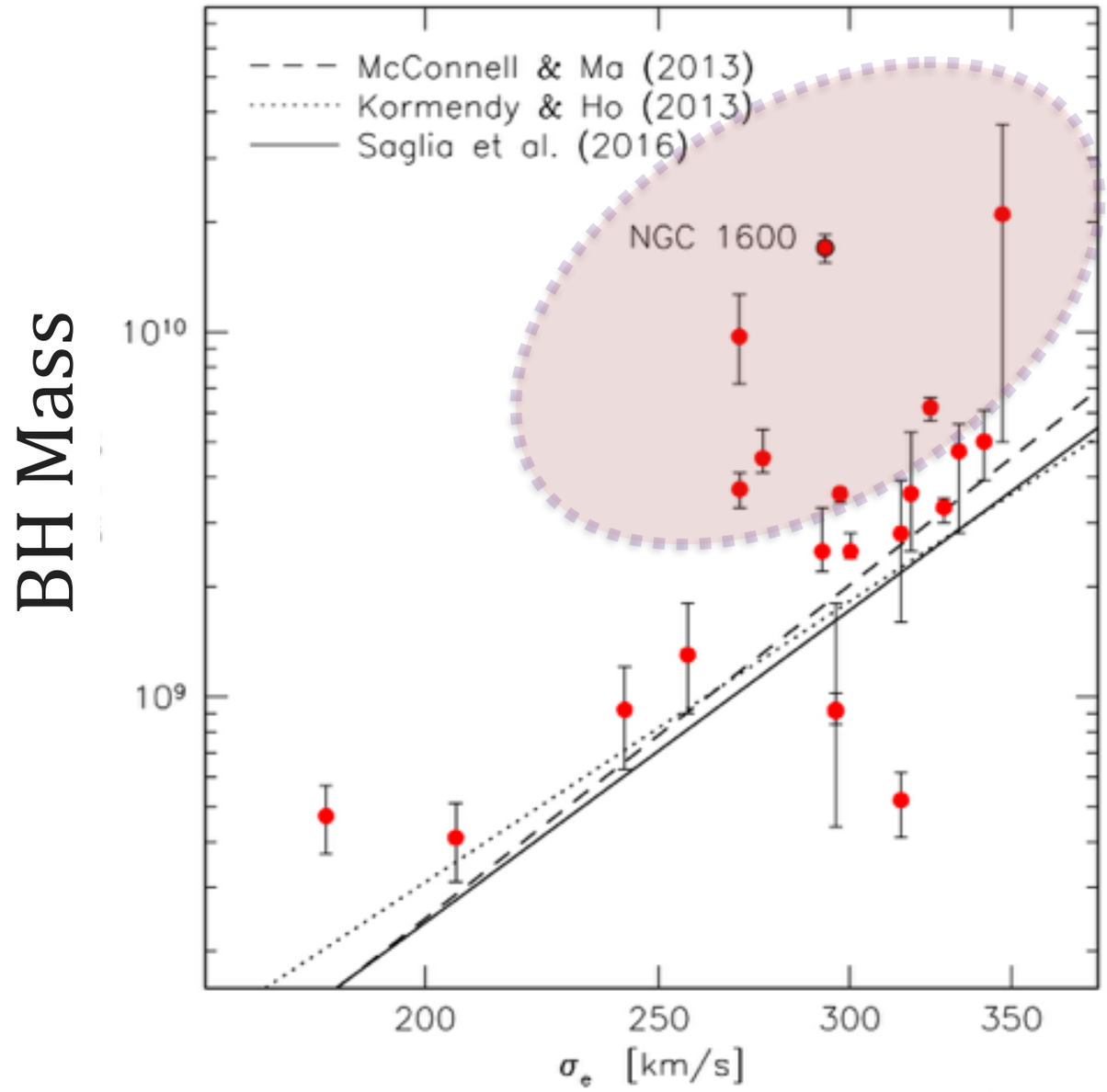
Zero-point of BH-host relation can be overestimated!



Shankar+ 2016

(2) Mass (Morphology) dependency

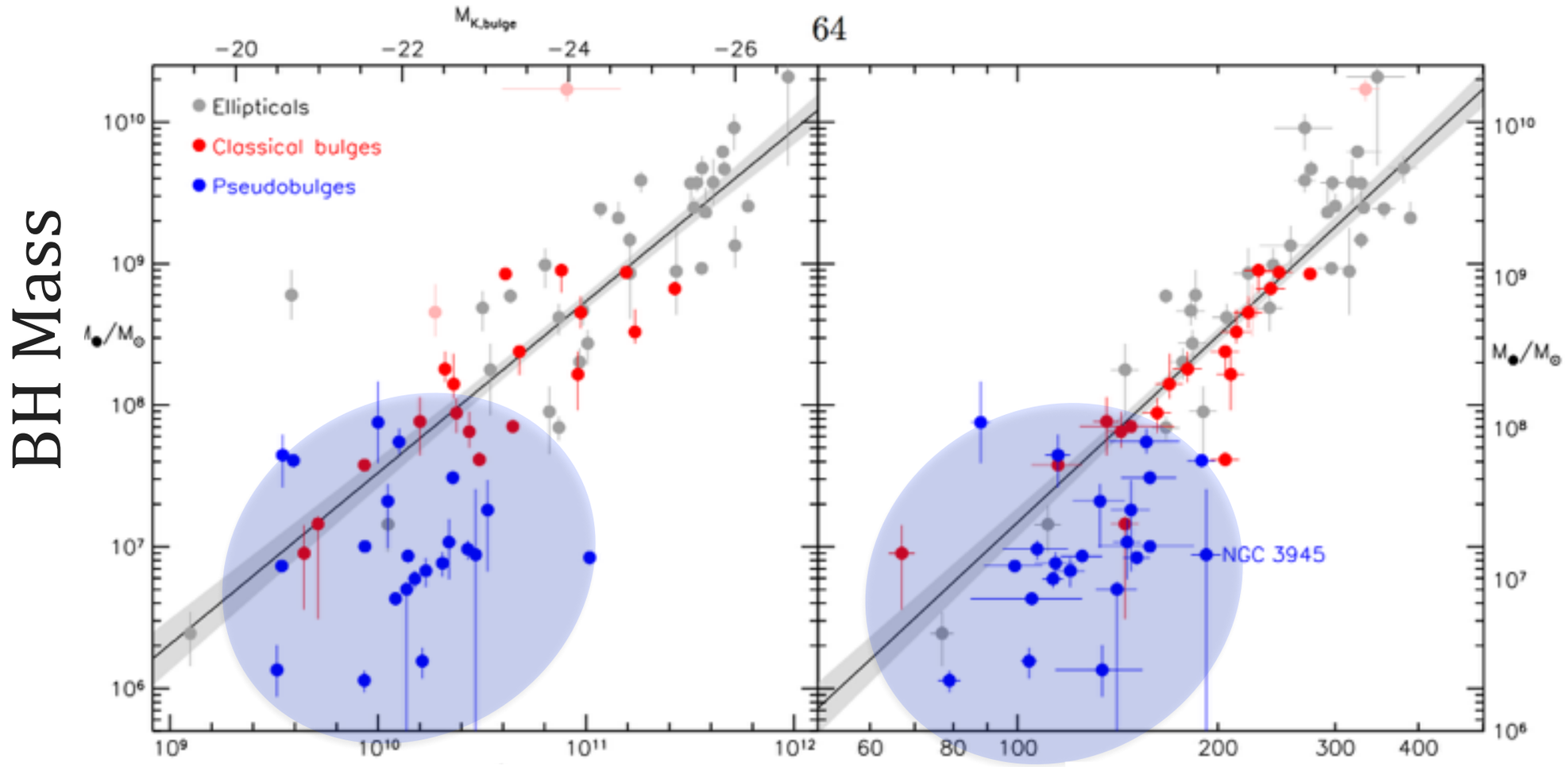
Abnormality in high-end mass?



Van den Bosch+12, Thomas+16

(2) Mass (Morphology) dependency

Classical bulge vs. Pseudobulge

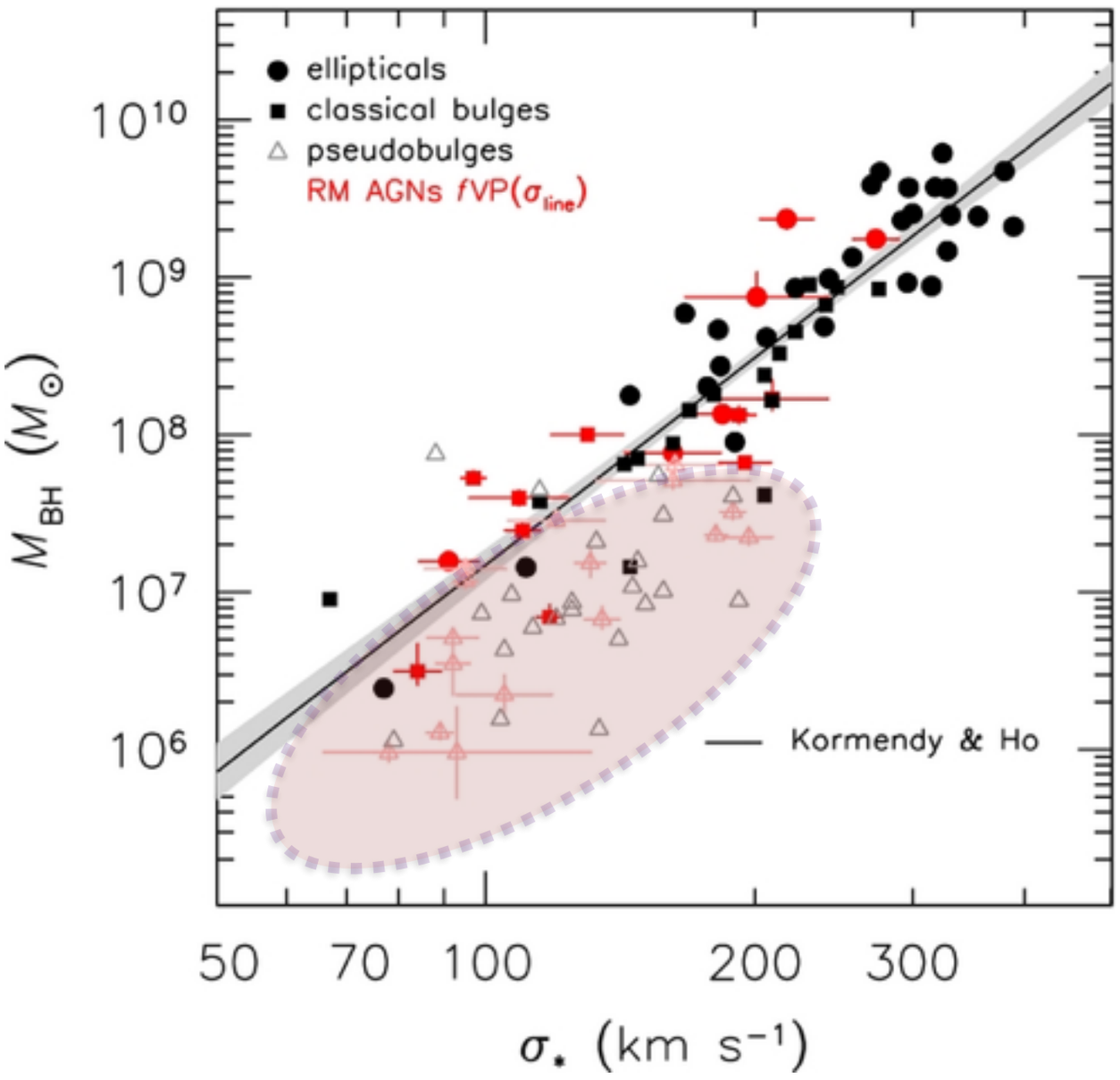


Kormendy & Ho 2013

BH-host relation in Active Galaxies?

- Relative Ease of BH mass measurement
  - Virial method : $M_{\mathrm{BH}} \sim f \times \mathrm{RV}^2$
- Relatively free from Selection Bias (Sample bias)
- Question? :
  Mass (Morphology) dependency?
  Any unexpected bias?

(1) Morphology dependency in AGN



AGN with pseudobulges

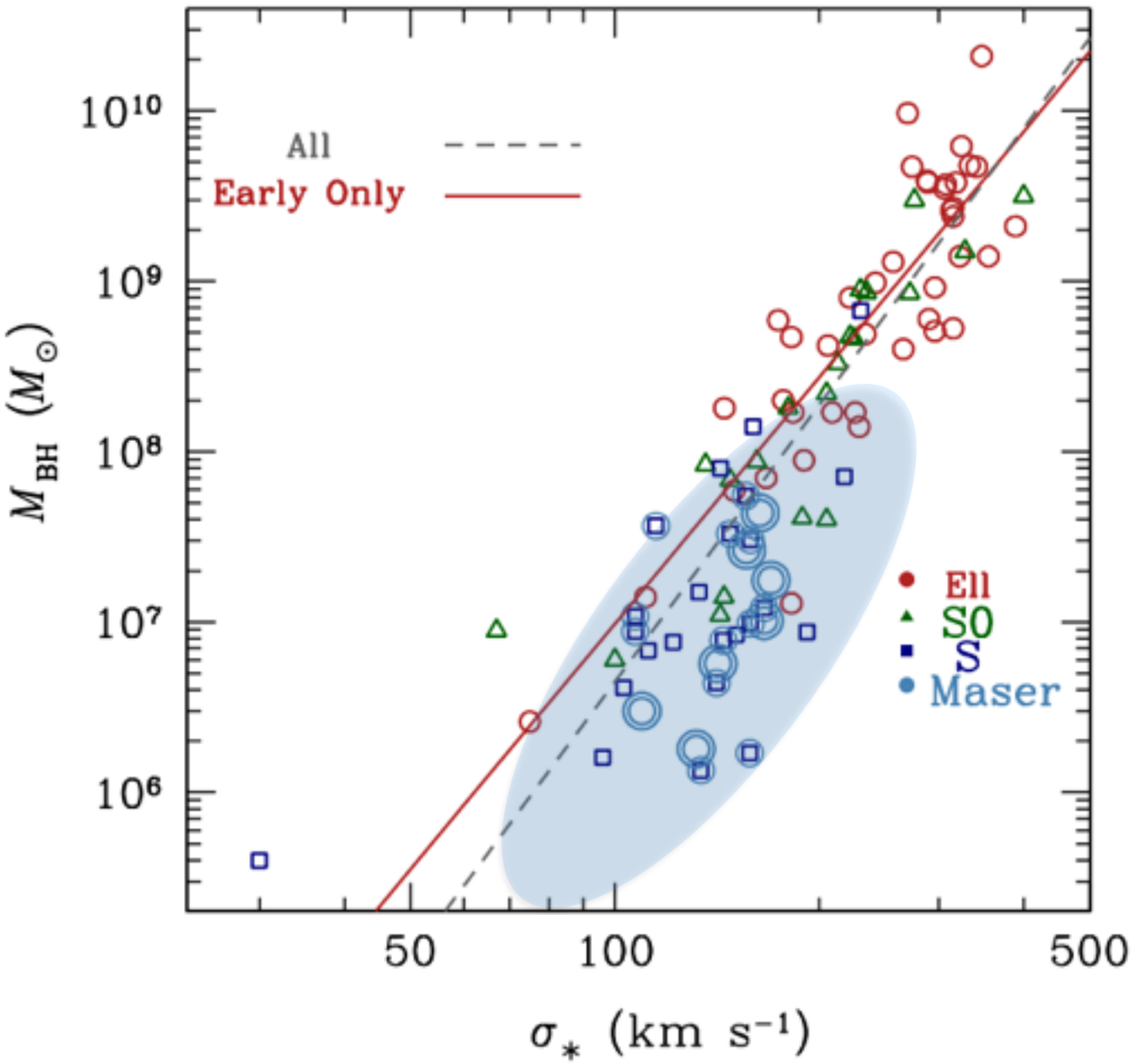
(1) BH is less massive

(2) *f*-factor (~3.2) is smaller

(f~6.3 for classical bulges)

Ho & Kim 2014; 2015

BH-host relation from Megamaser AGNs



(1) Large scatter

(2) Light-weight BH

(~0.6 dex)

Greene, Seth, Kim+16

(2) Any unexpected bias in AGN?

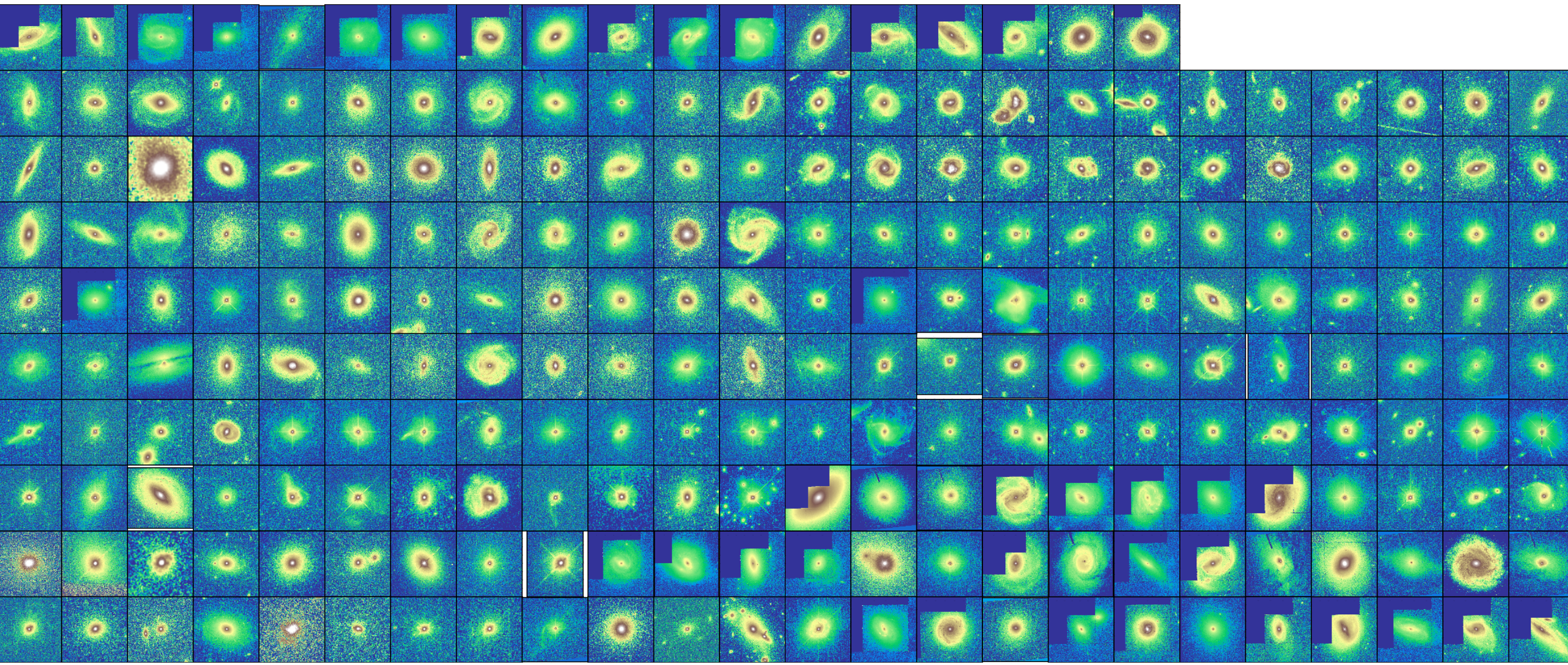
- Motivation : BH-Host relation of AGN depends on any properties of AGNs/host galaxies?

- Challenge : Difficulty to investigate host properties for Type I AGNs

- Solution : high resolution images (e.g., HST) to decompose the stellar light of host galaxies from the nucleus.

(2) Any unexpected bias in AGN?

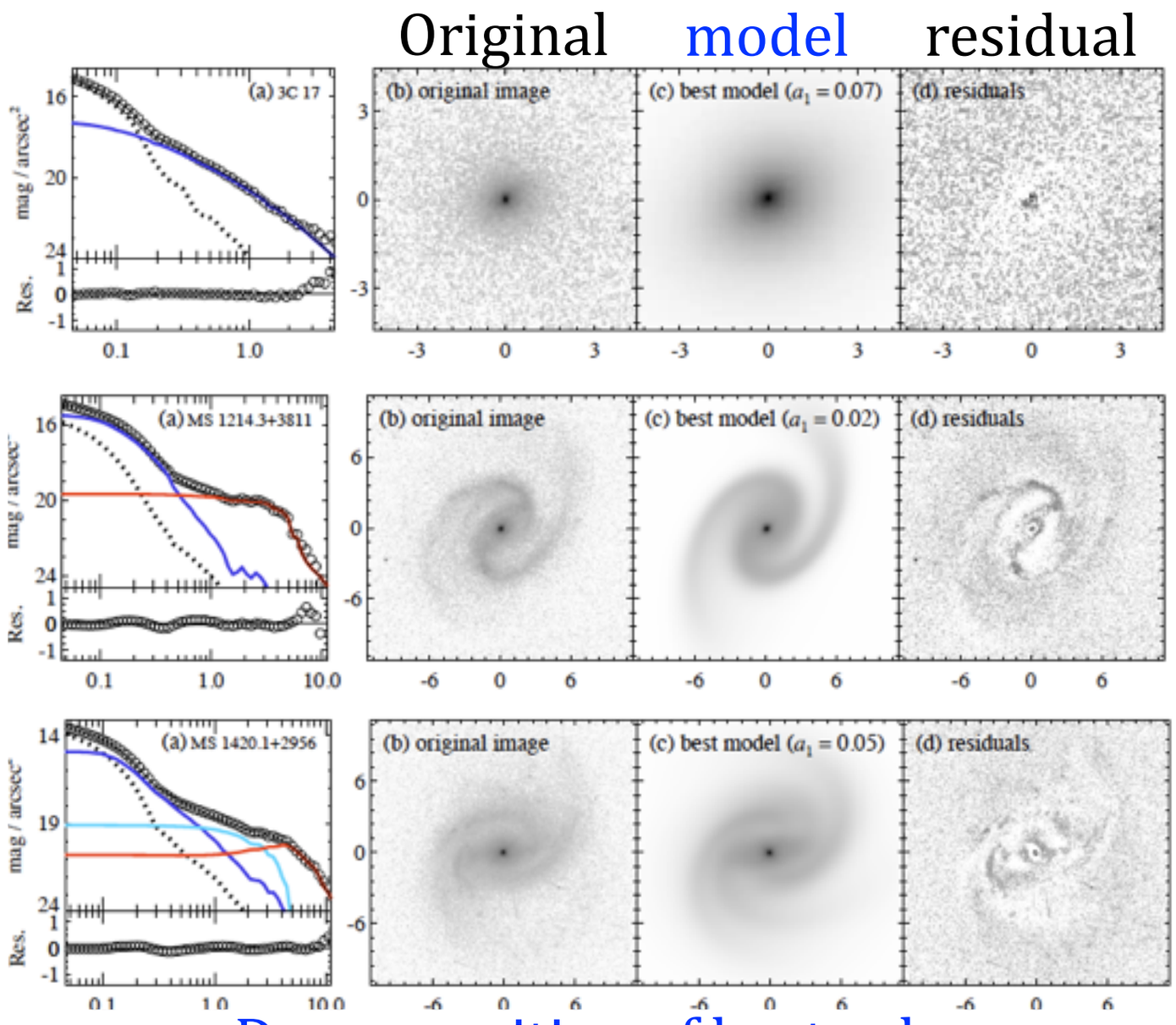
- Sample
  - HST archival images of 235 (nearby) type I AGNs



Kim et al. in preparation

(2) Any unexpected bias in AGN?

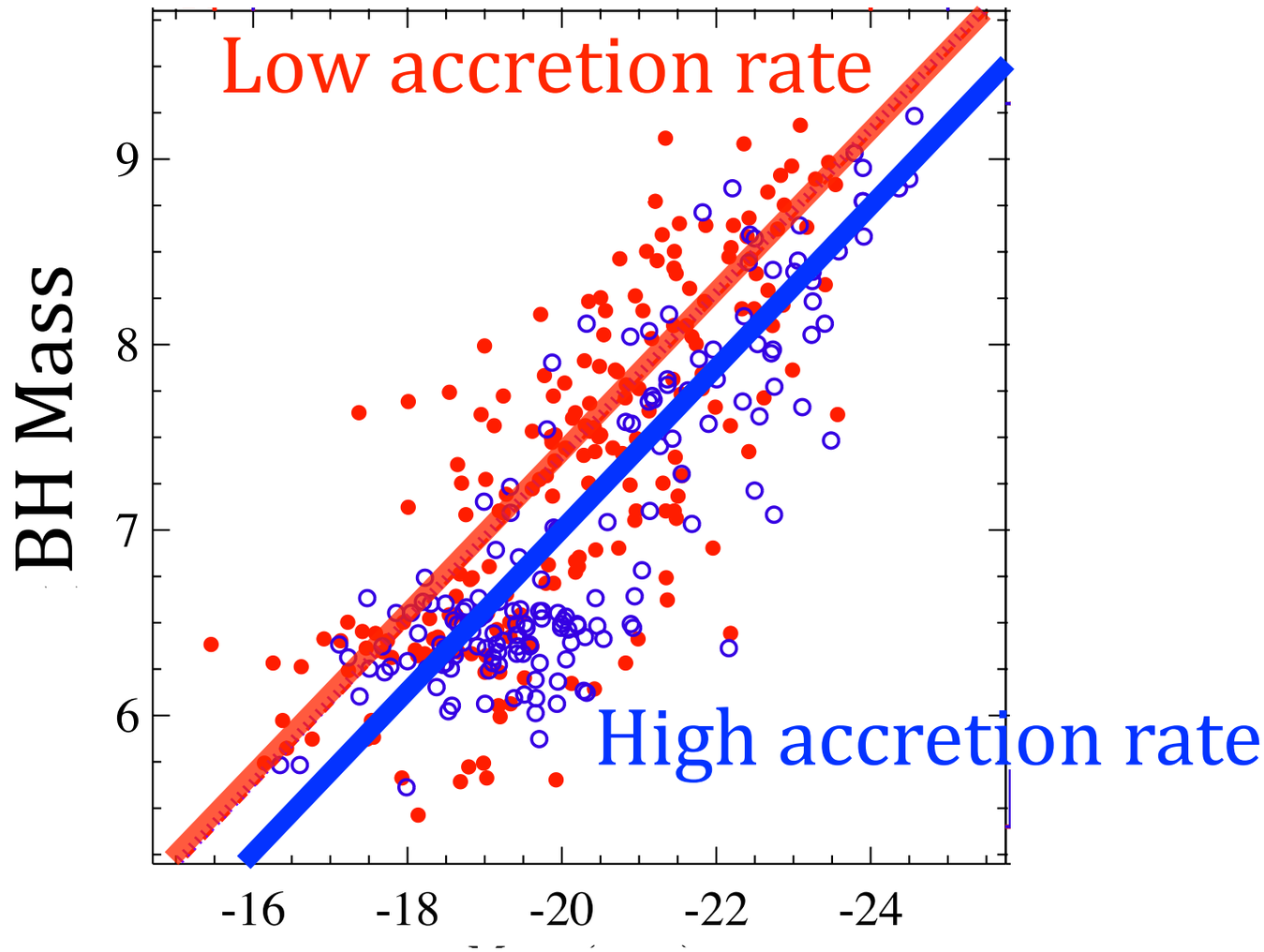
- Rigorous measurements of bulge brightness using GALFIT



Decomposition of host galaxy

(2) Any unexpected bias in AGN?

- Dependency on the accretion rate
  bias in BH mass measurement? (scaling factor)
  or young stellar population?



What Subaru can contribute?

- What we know for 235 HST sources (valuable dataset!)

  - AGN properties : BH Mass, accretion rate, radio loudness

  - Host properties : bulge luminosity, structural properties (size, effective brightness, B/T, lopsidedness, etc.)

- What is missing?

  Stellar velocity dispersion of host galaxies

  -> Dynamical mass of host galaxies (M-sigma, M-M relation)

  -> less affected by the stellar population than luminosity

  -> Fundamental plane of host bulges

- Required Instruments :

  AO-fed IR spectrograph (e.g., IRCS/AO)

  - F(Nuc.)/F(Host) becomes minimum at NIR.

Possible Subaru Observation

- Stellar velocity dispersion of AGN hosts with HST images
  - IRCS with AO guiding
  - 5 nights for ~20 sources
  - In close collaboration with astronomers in China and Korea,
  (happy to extend the collaboration with other countries in EA)

- AGN feedback in young luminous quasars in cosmic noon

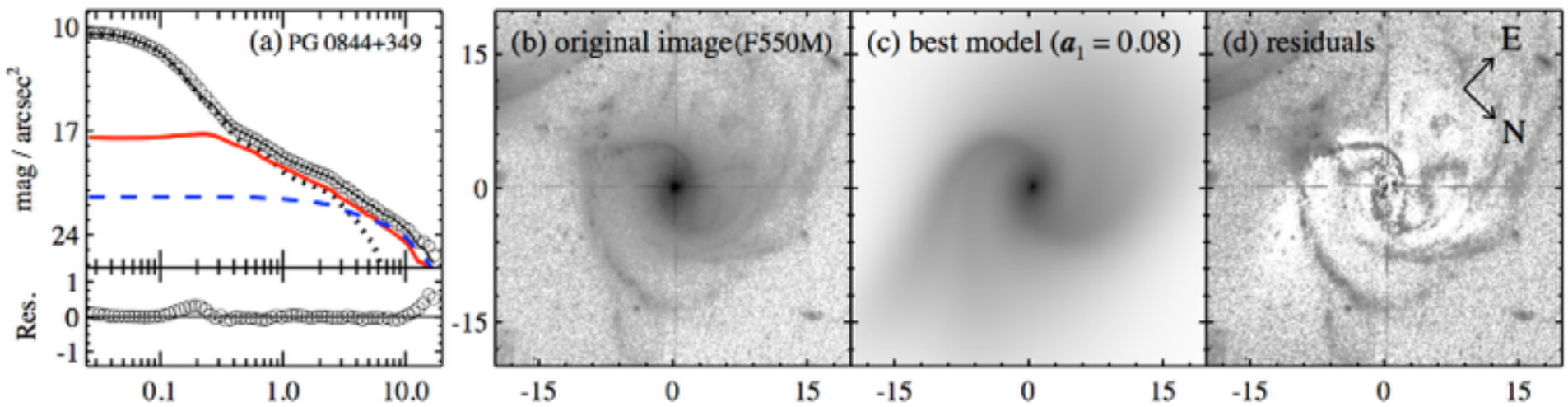
- Follow-up observation of an Intermediate Mass Black Hole

Thank you!

Previous observation

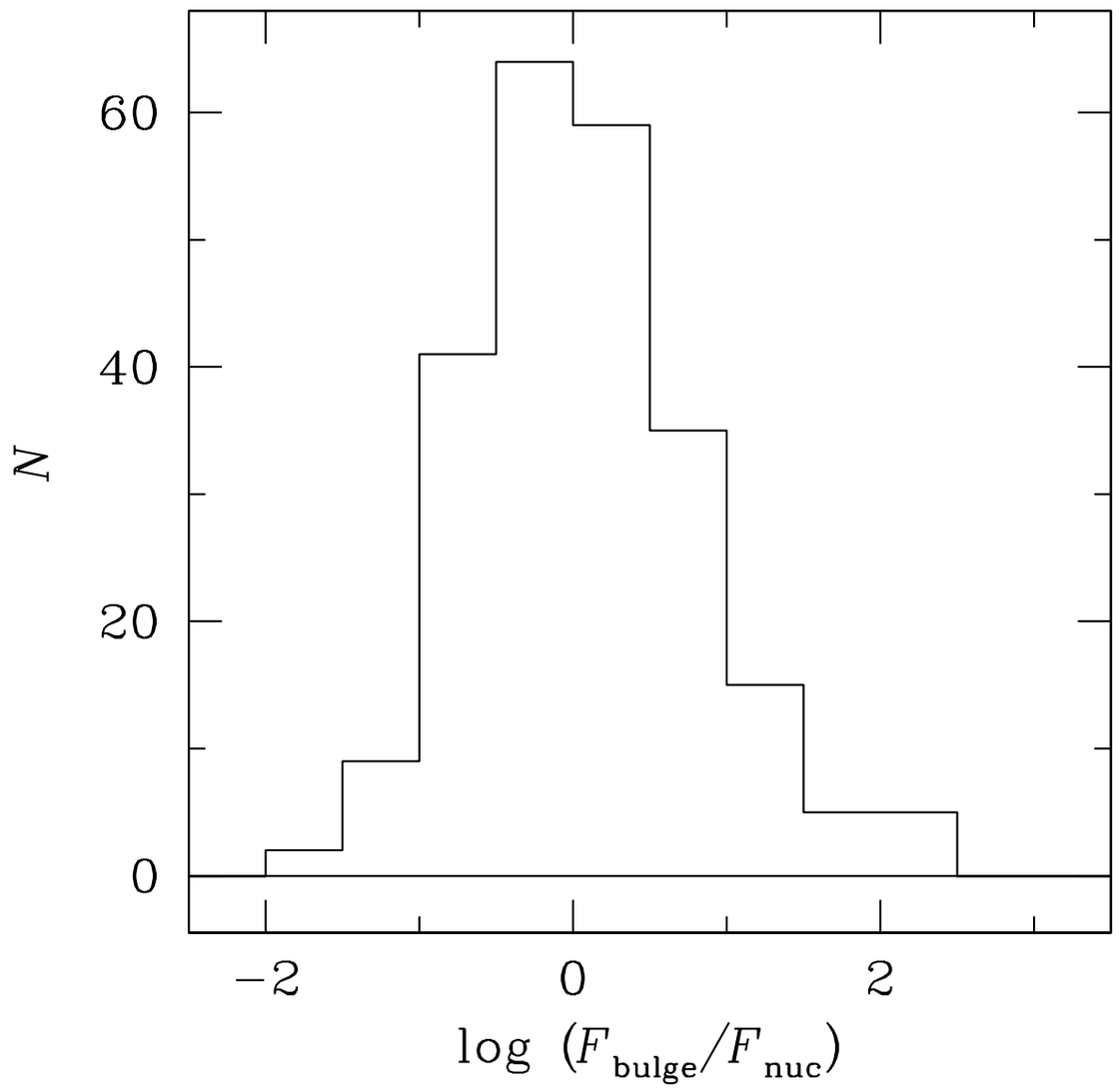
- We did try similar experiment 15 years ago with Subaru/IRCS! (Proposal # : 02B-127)

  - failed to detect stellar signal in IRCS spectrum of PG 0844+349.
  - without knowing host properties (the nucleus is 6 times brighter than the bulge)



Previous observation

- Now, photometric parameters of 235 sources are known.
  -> can improve the success rate by choosing the proper sample
  [e.g., F(bulge) > F(nuc)]



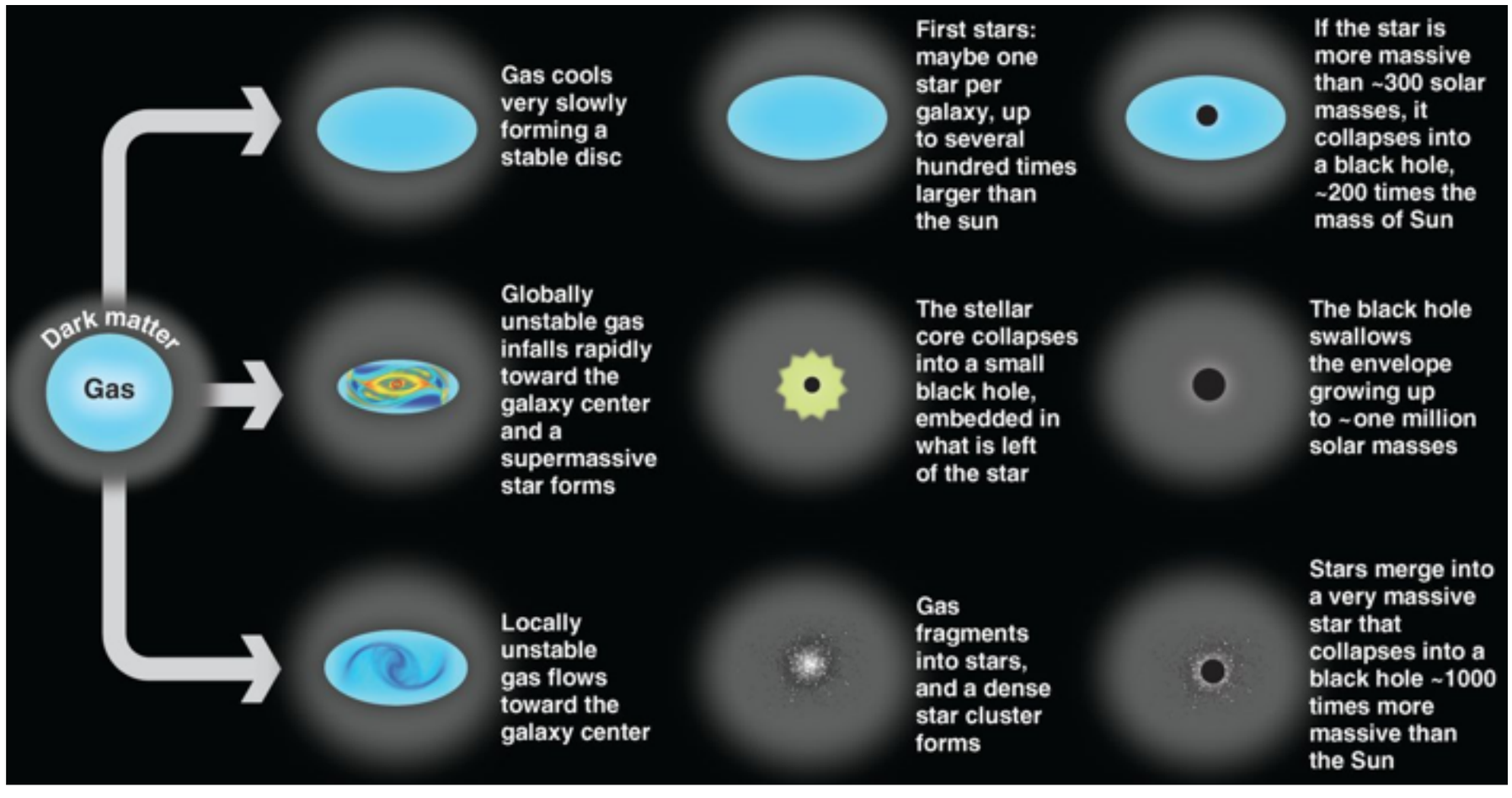
Off-nucleus

2. An Intermediate-mass Black Hole in the Seyfert Galaxy NGC 5252

Minjin Kim, Luis Ho, Junfeng Wang, Guiseppina Fabbiano,
Myungshin Im and Chandra team

Intermediate-mass Black Holes (IMBH)

- 10^2 - $10^5 M_\odot$ BH
- Missing link between stellar mass BH and supermassive BH
- Extremely rare in the present-day universe



Volonteri 2012

IMBH

- Where are they?

  - Low-mass active galaxies (Greene & Ho, Reines, Ho & Kim, etc.)

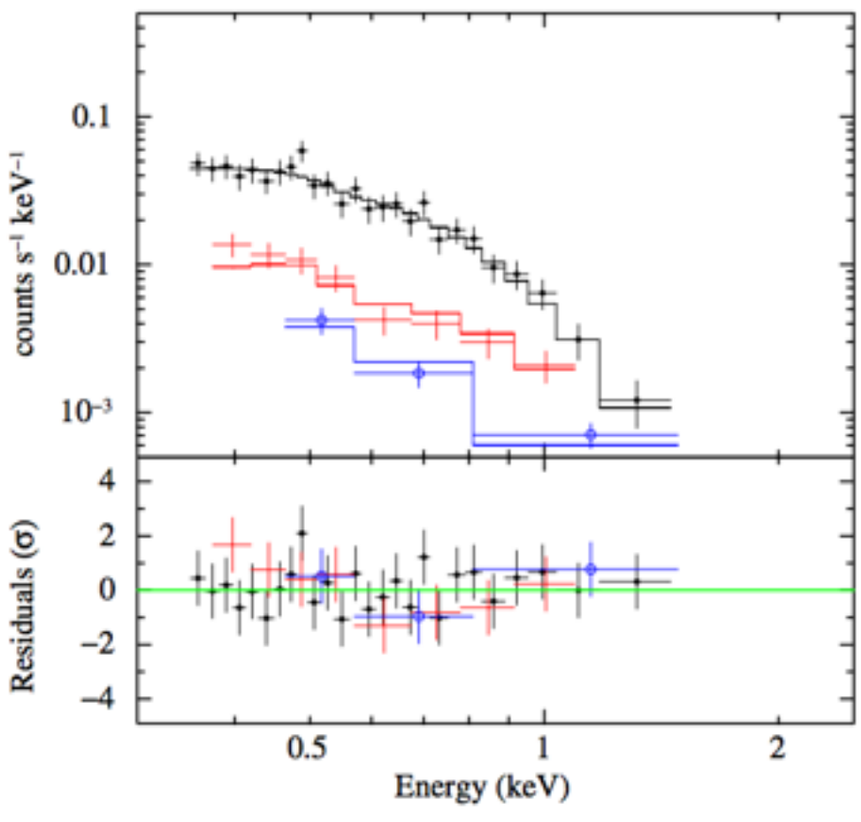
  - Massive star clusters (G1, *w* Cen, M54)

  - Ultraluminous X-ray sources (ULXs)

IMBH

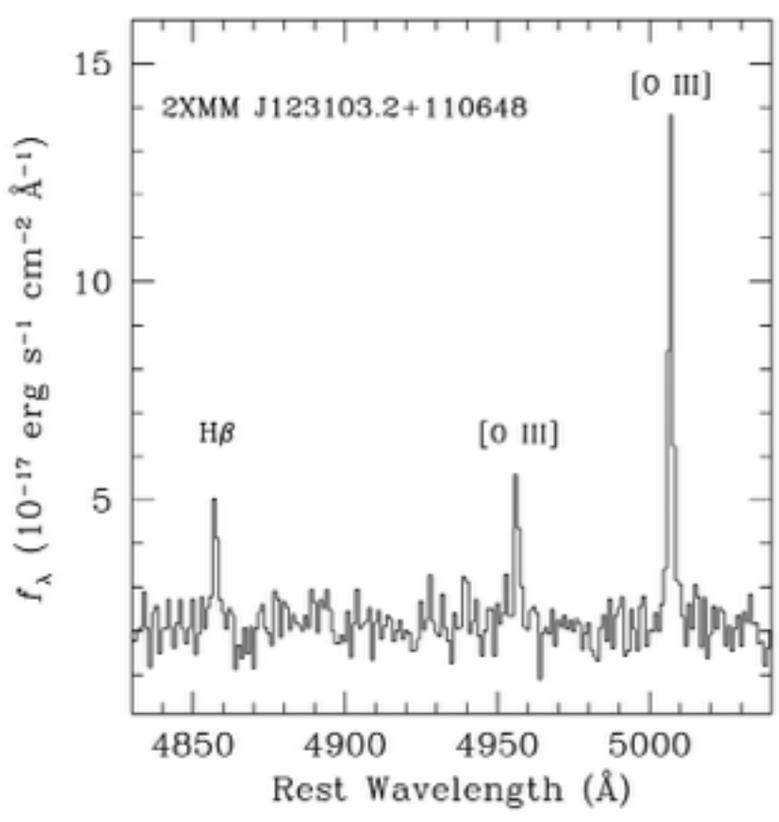
- Where are they? (Variability in X-ray)
  - J1231+1106 : $M_{\rm BH} \sim 3\text{-}7 \times 10^4\ M_\odot$

X-ray spectrum



Terashima et al. 2012; Kamizasa et al. 2012

Magellan/IMACS spectrum



Ho, Kim, Terashima 2012; Ho & Kim 2016

IMBH

- Where are they?

  - Low-mass active galaxies (Greene & Ho, Reines, Ho & Kim, etc.)

  - Massive star clusters (G1, *w* Cen, M54)

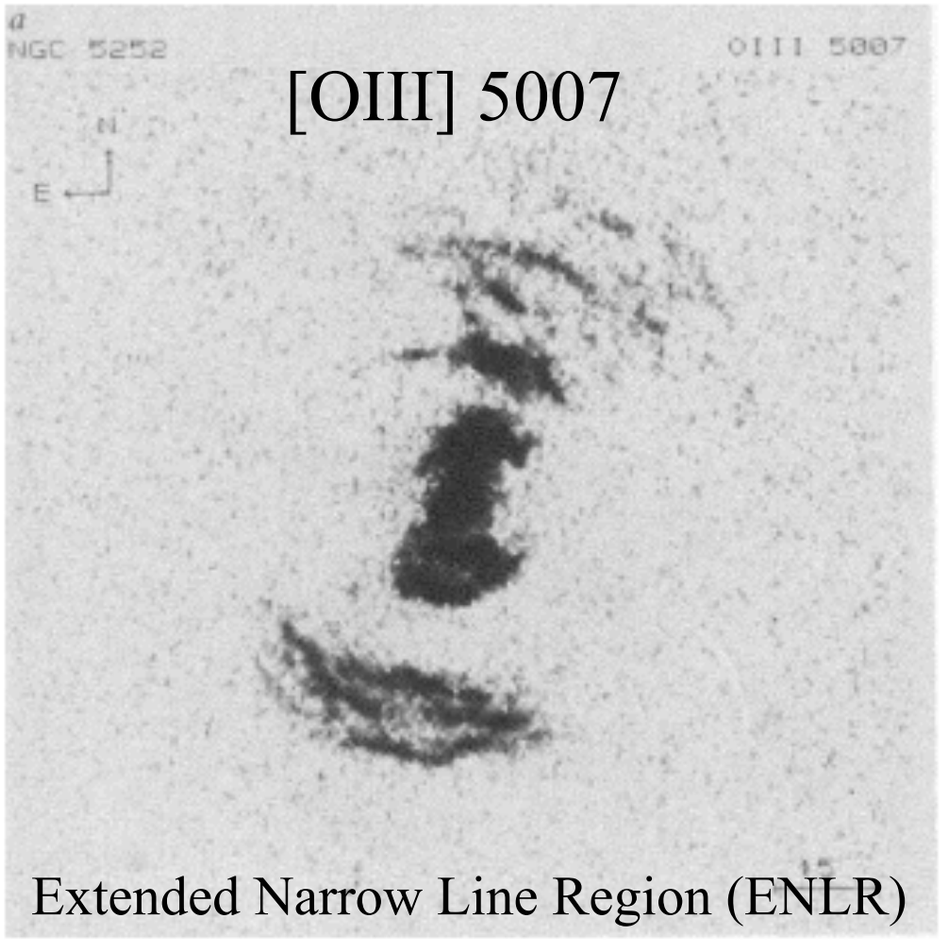
  - Ultraluminous X-ray sources (ULXs)

Ultraluminous X-ray sources (ULXs)

- off-nucleus
- $L_{\text{x-ray}} > 2 \times 10^{39}$ erg s^{-1}
- strong candidates of IMBHs
- very faint optical counterpart
- often associated with low-metallicity HII region

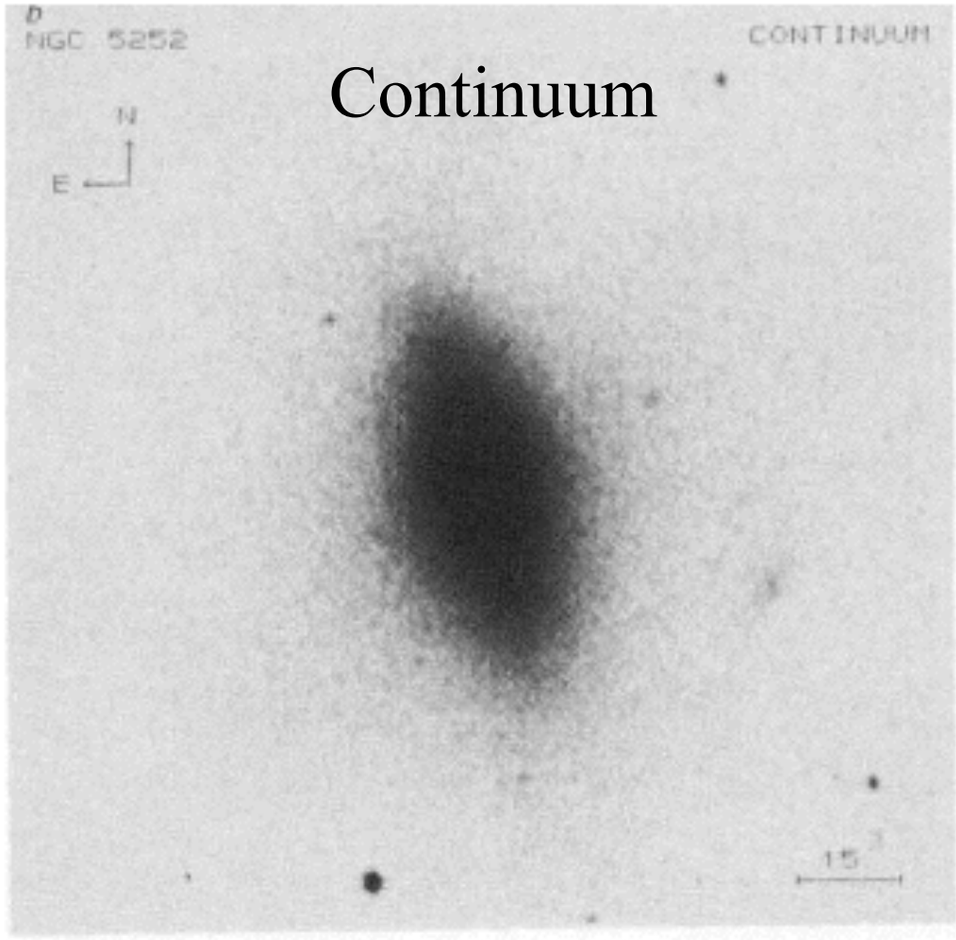
ULX in NGC 5252

NGC 5252 (~100 Mpc)
- type 2 Seyfert S0 galaxy
- extended ionization bicone



[OIII] 5007

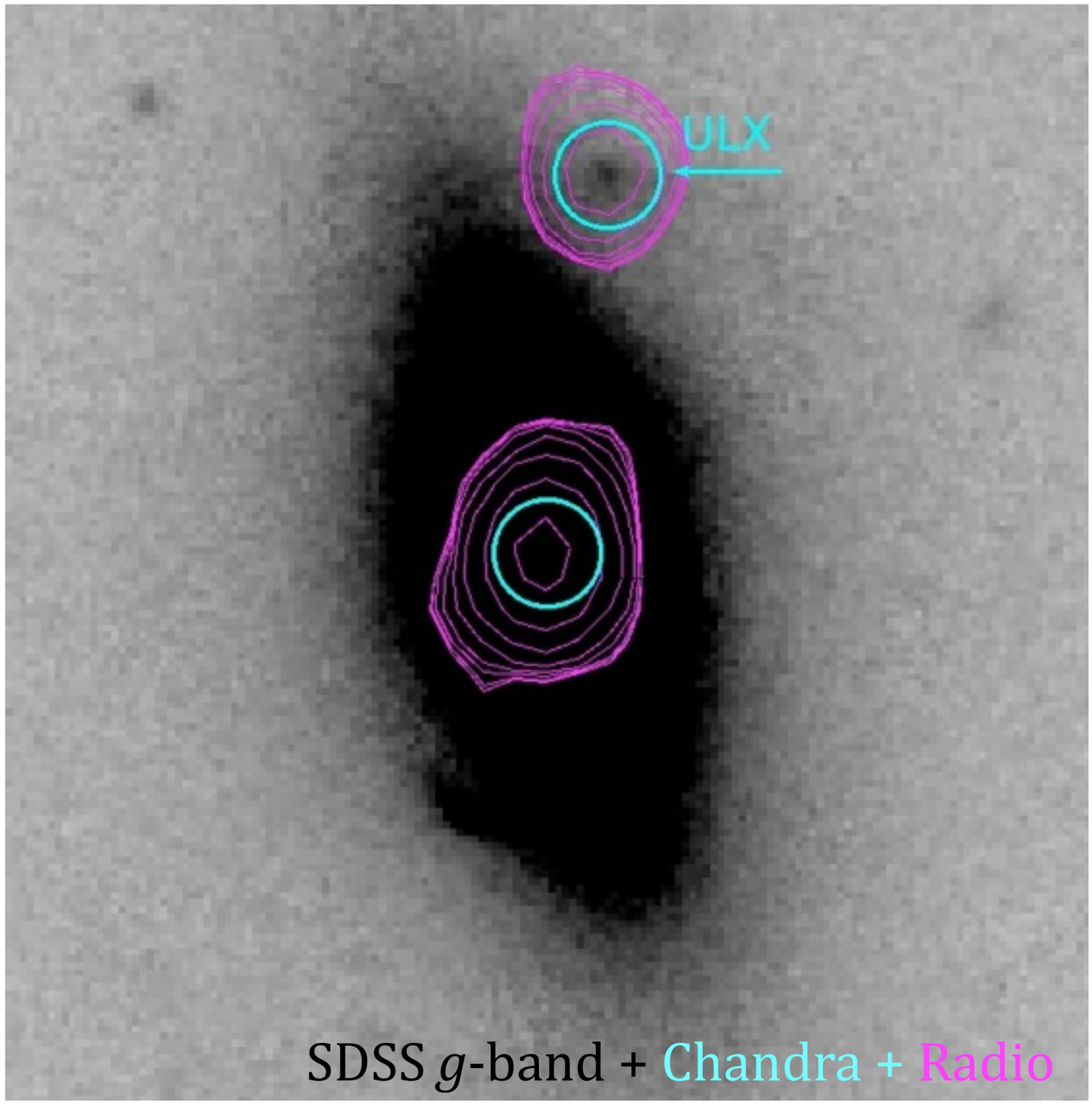
Extended Narrow Line Region (ENLR)



Continuum

Tadhunter+1989

Multi-wavelength Data



- $L_{\text{X-ray}} \sim 10^{40}$ erg s^{-1}
- $N_{\text{H}} << 10^{22}$ cm^{-2}
- $L_{5\text{GHz}} \sim 10^{21}$ W Hz^{-1}

Kim et al. 2015