# Super-Massive Black Holes in Compact Galaxies

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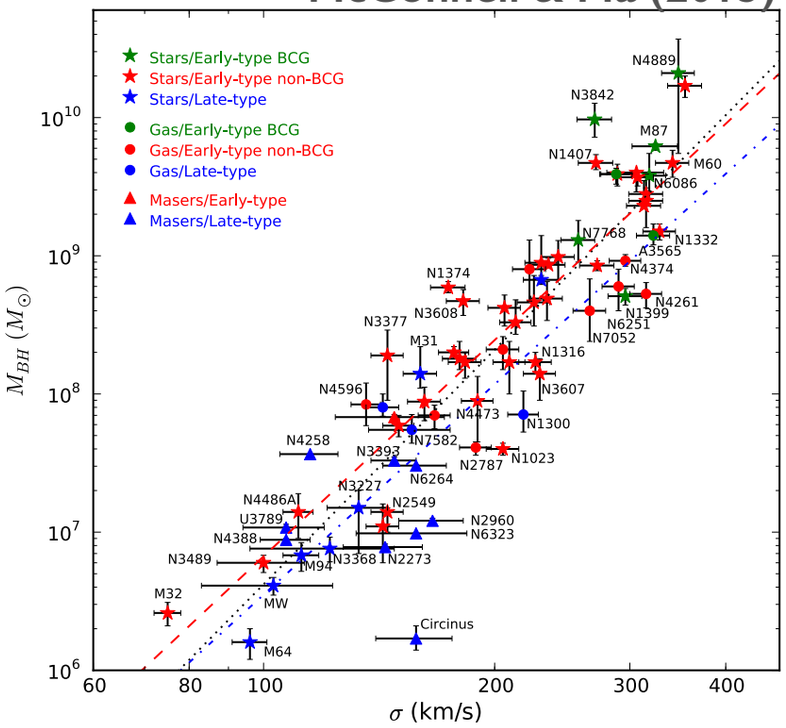
# DIRECT BLACK HOLE MASSES

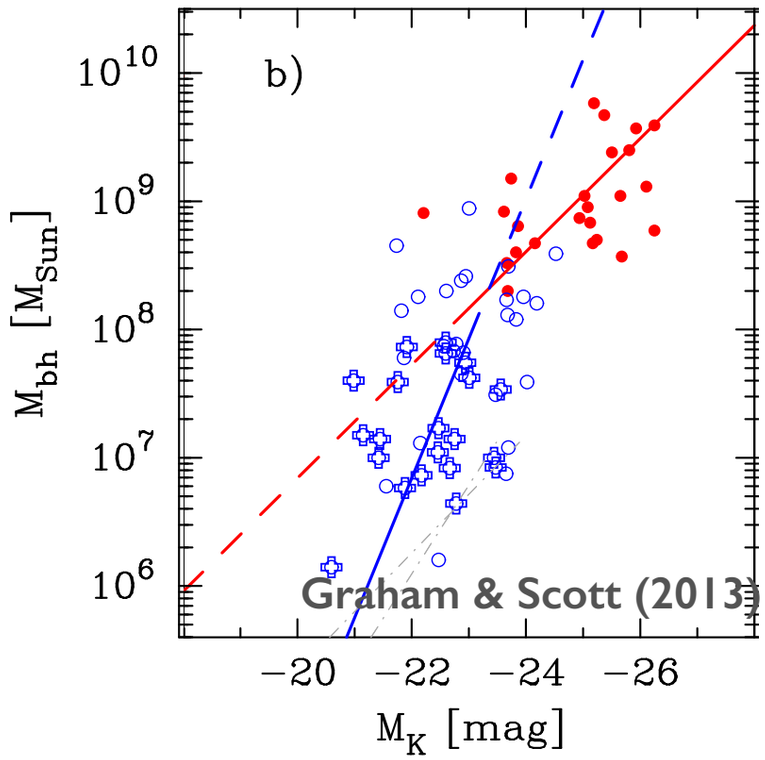
- The direct black hole masses in nearby galaxies are the basis for all BH mass estimates.

- Only ~80 have been measured to date.

- Requires high spatial resolution spectroscopy (ELT; Do+2014)

McConnell & Ma (2013)



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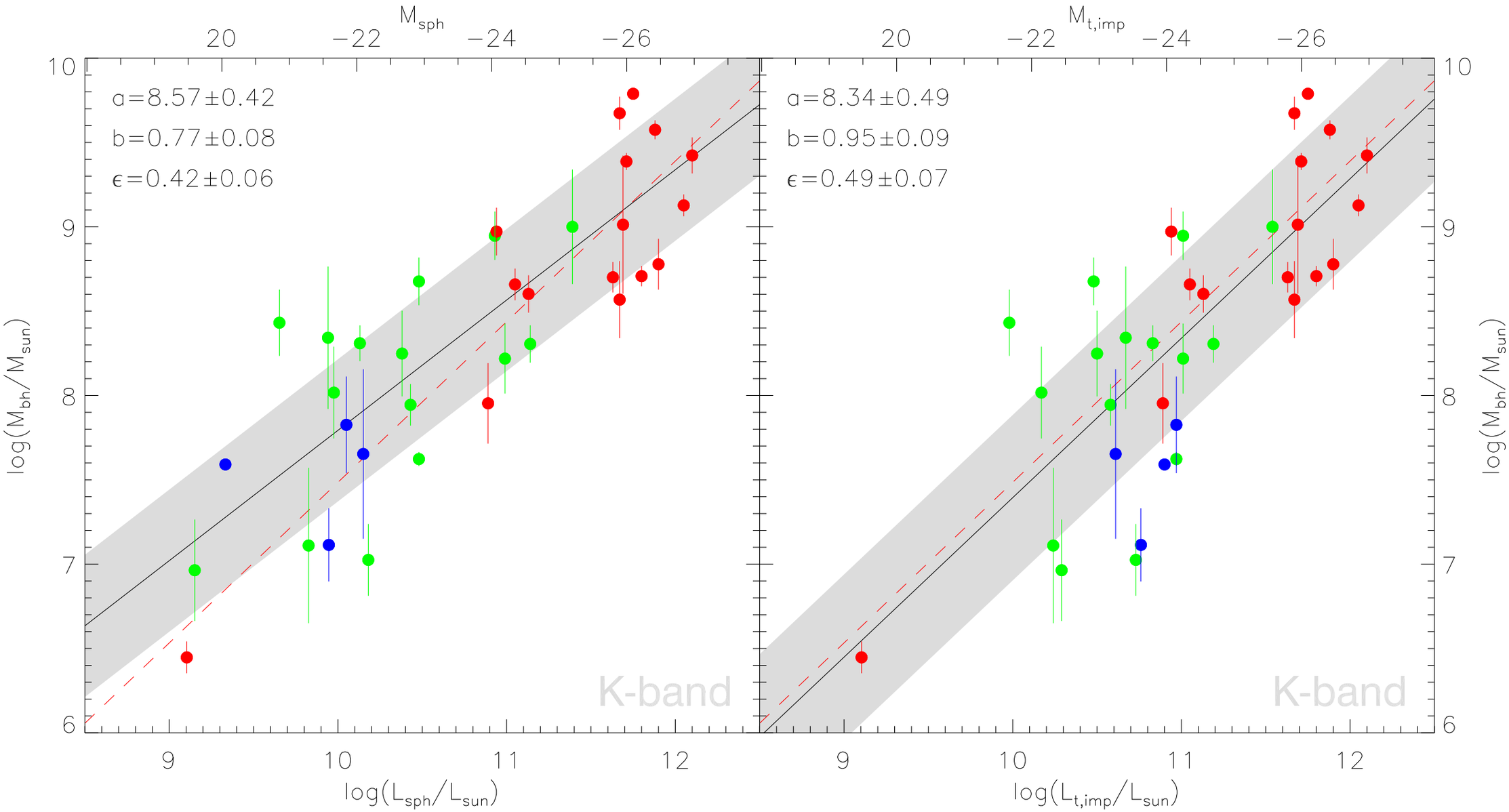


**Läsker et al 2014**

See poster 48 by Ronald Läsker

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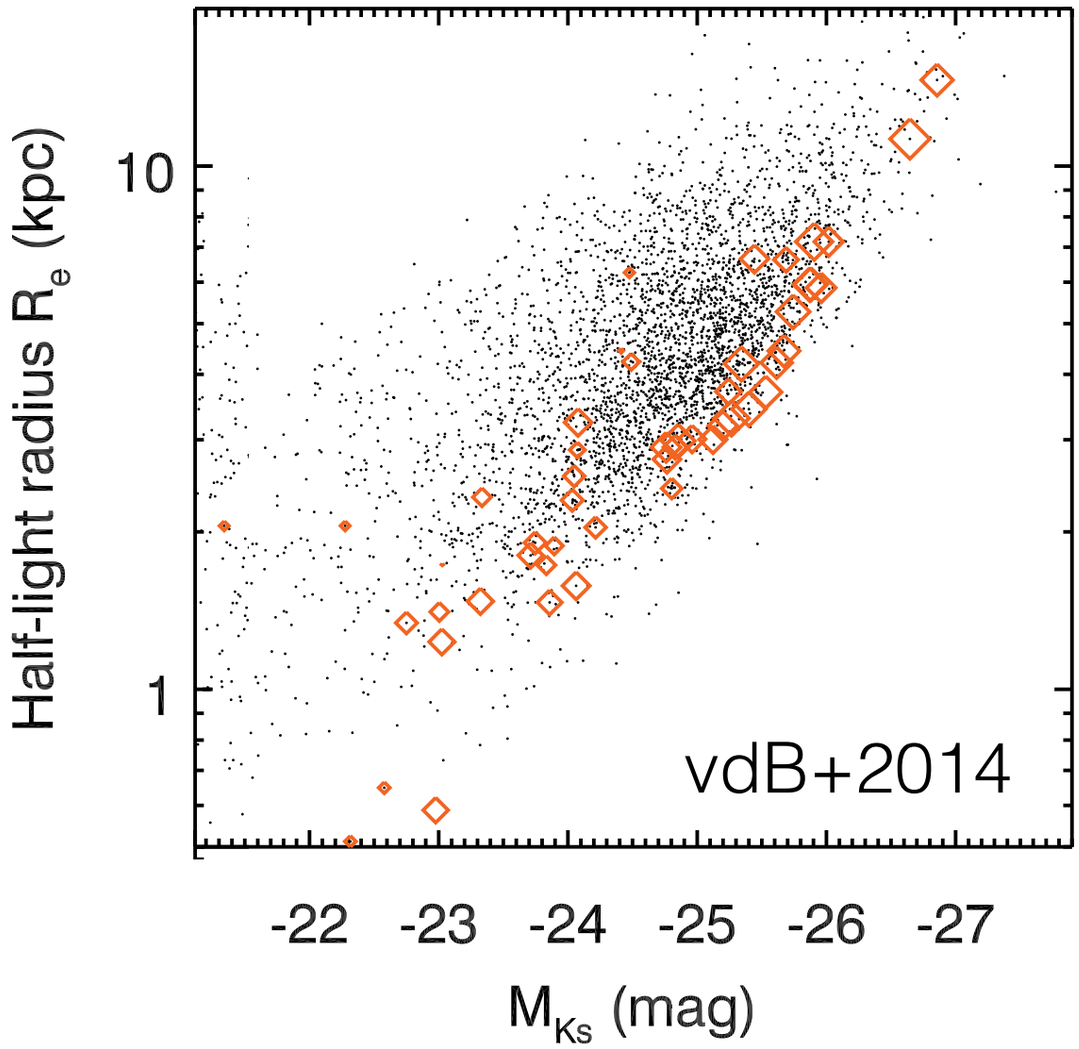

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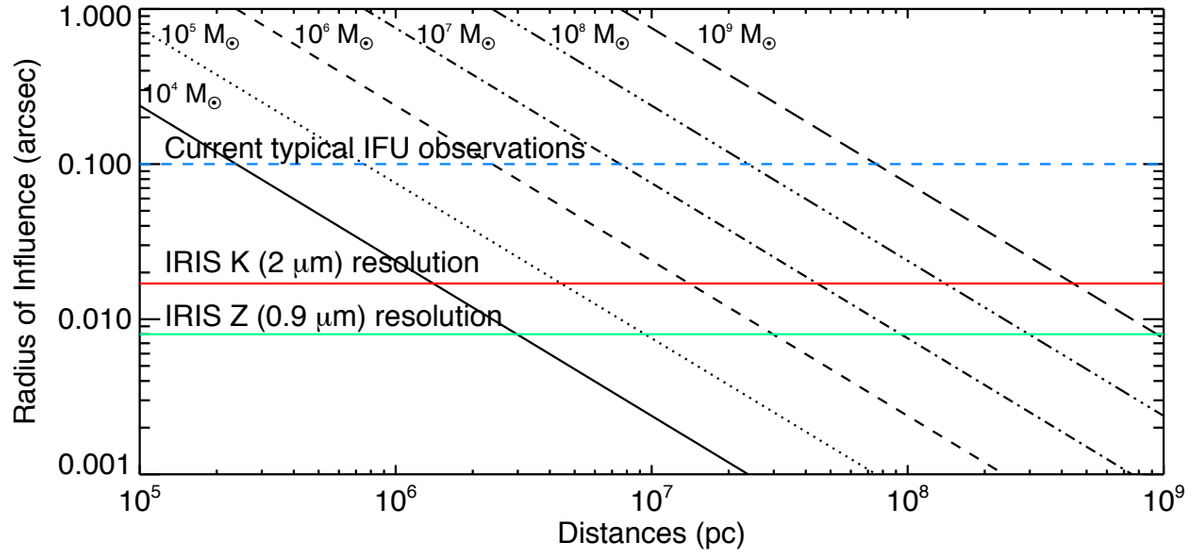


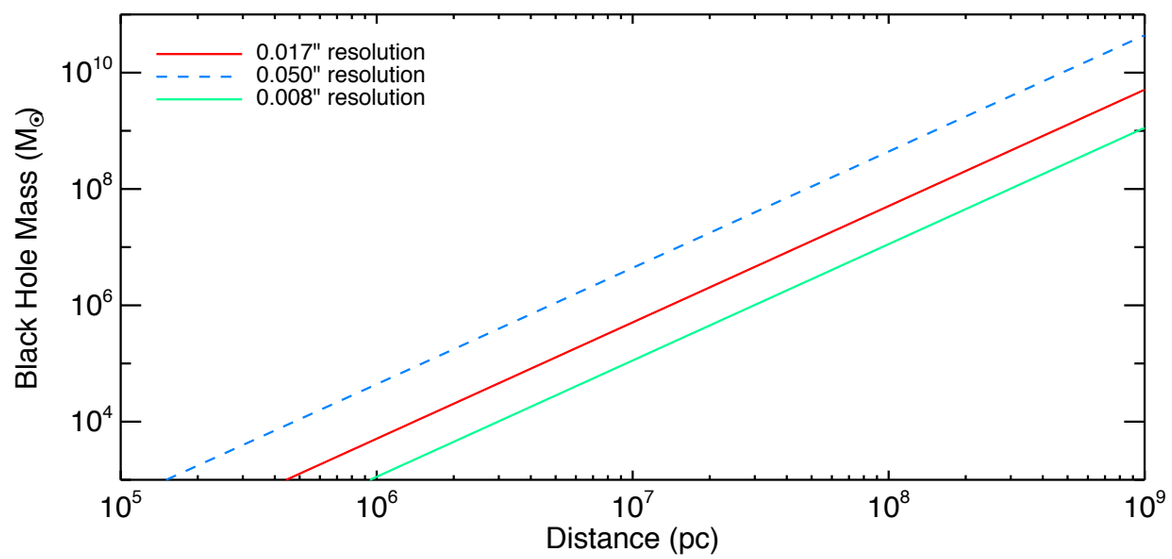


Do+2014

# HET SURVEY

- Long slit spectra with the Marcario Low Resolution Spectrograph
- 4200-7400 AA, 106 km/s resolution, 1”x2.5’ slit
- 1006 galaxies
- Distances less then ~140 Mpc
- Targeting the galaxies with the largest sphere of influences.
- Effectively probing the massive nearby galaxies

vdB+2014

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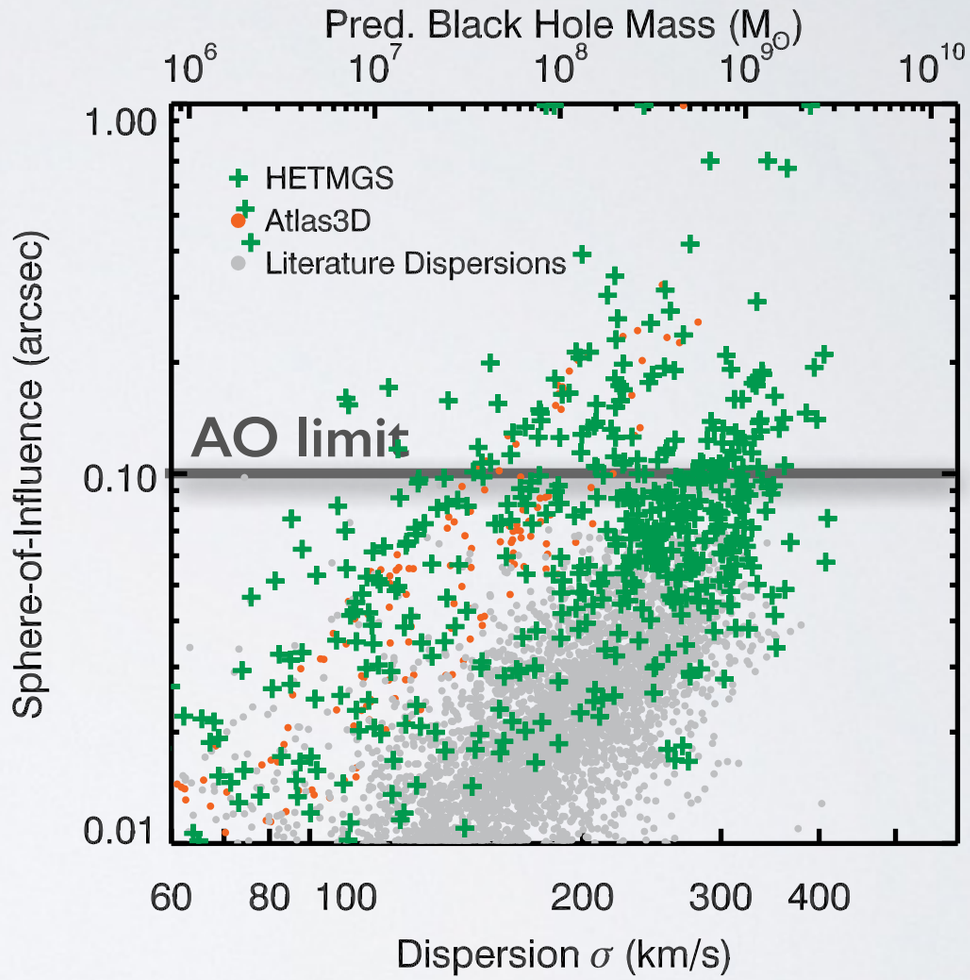
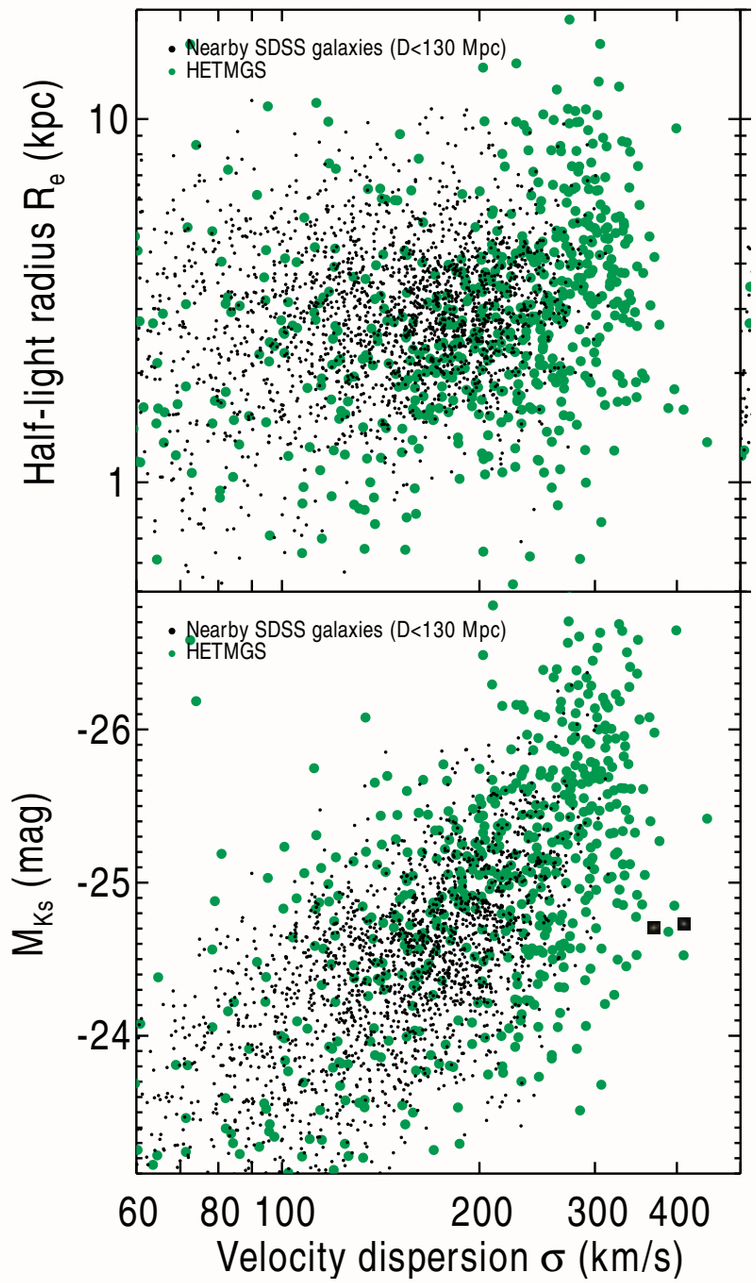



vdB+2014

# COMPACT GALAXIES



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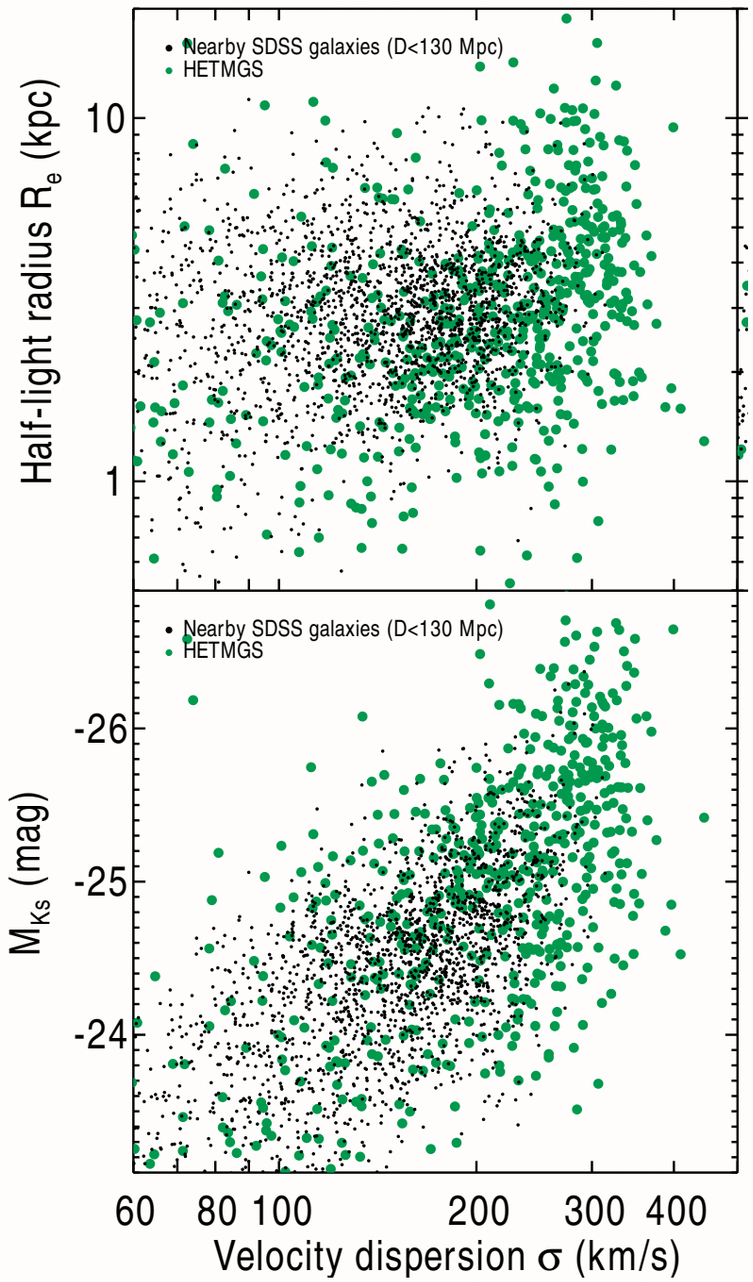
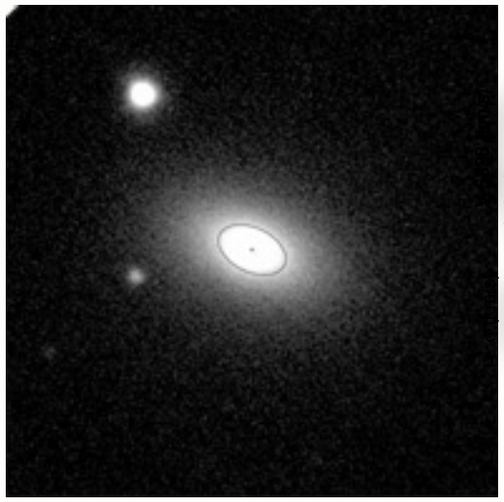
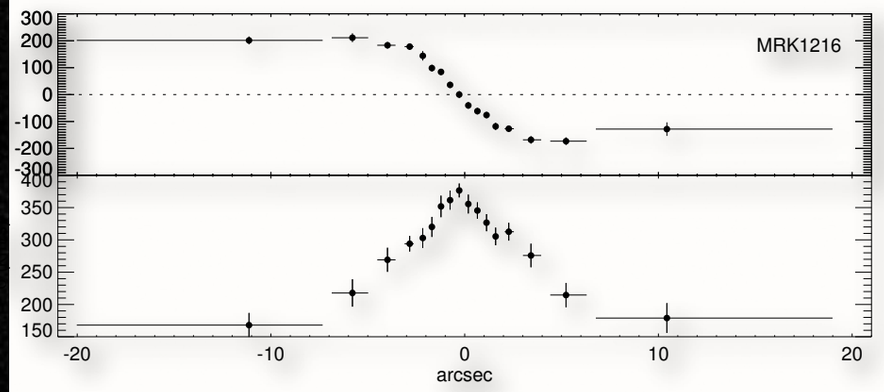
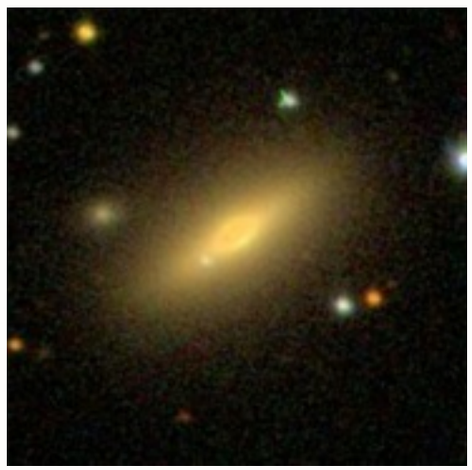
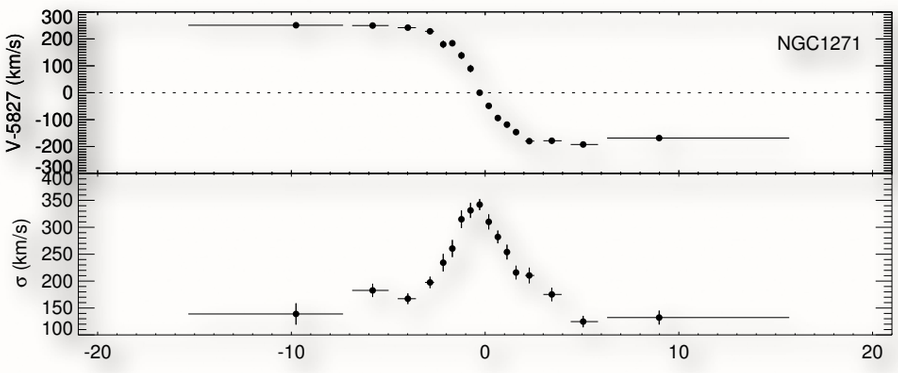
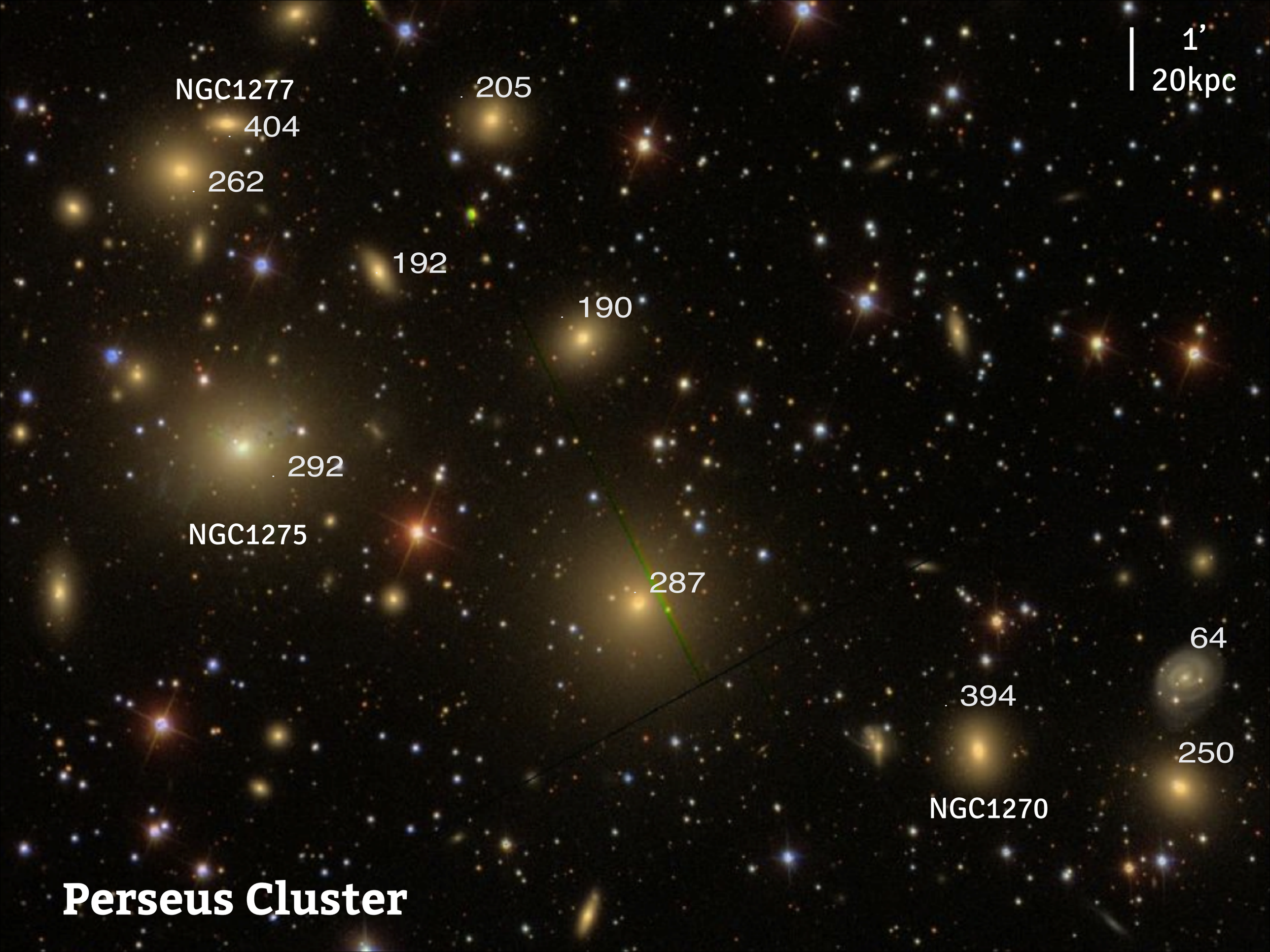




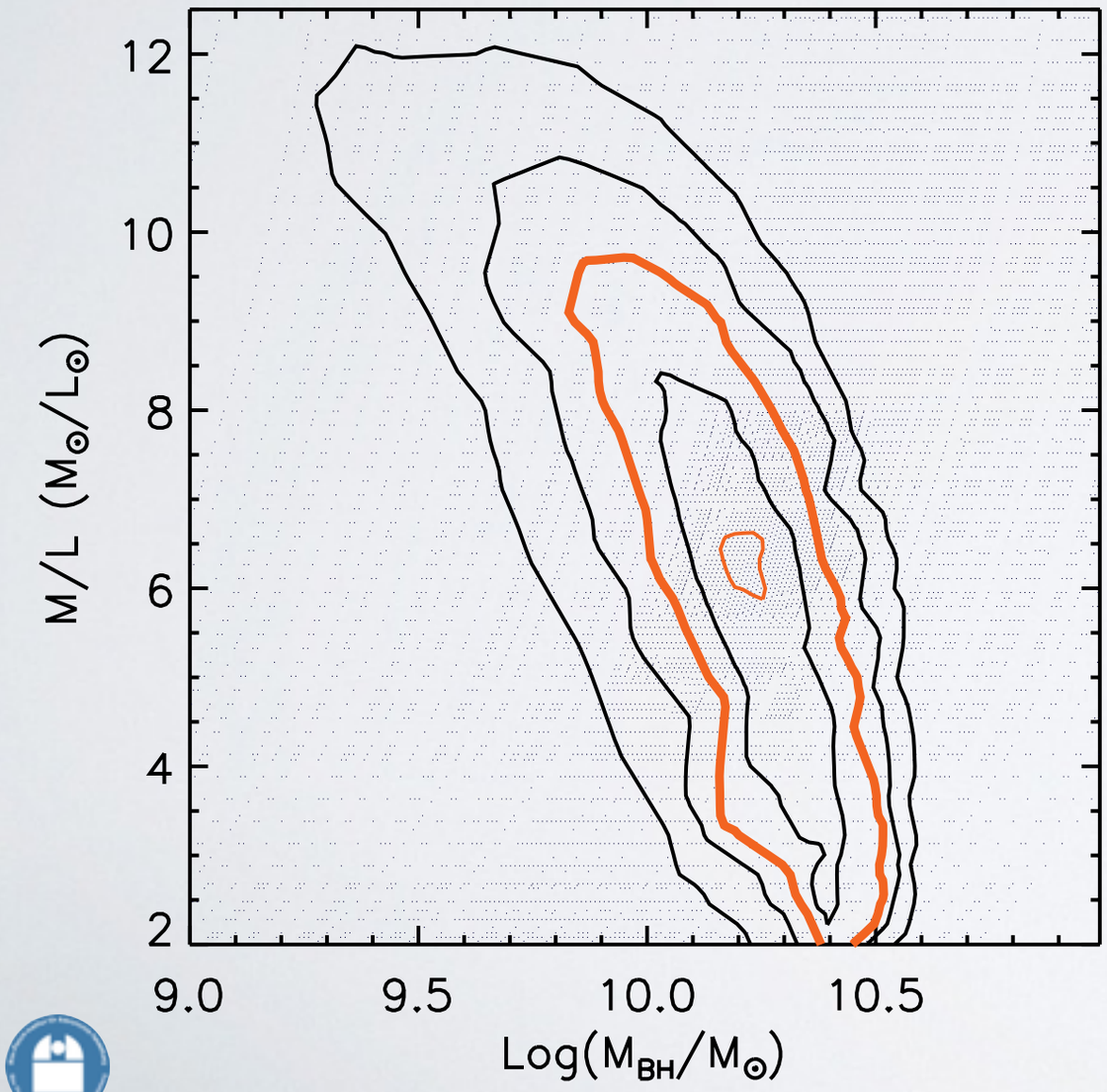



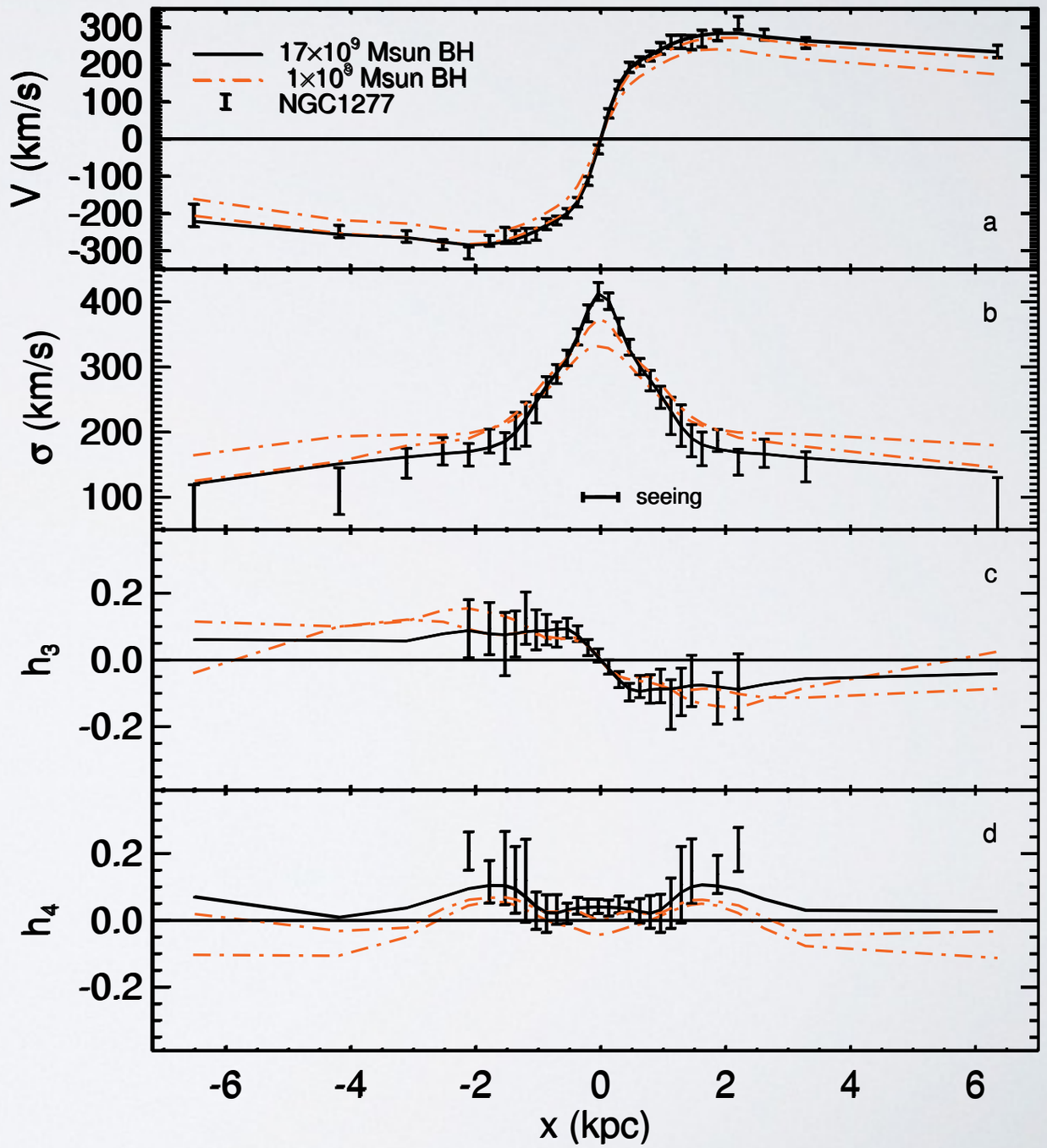


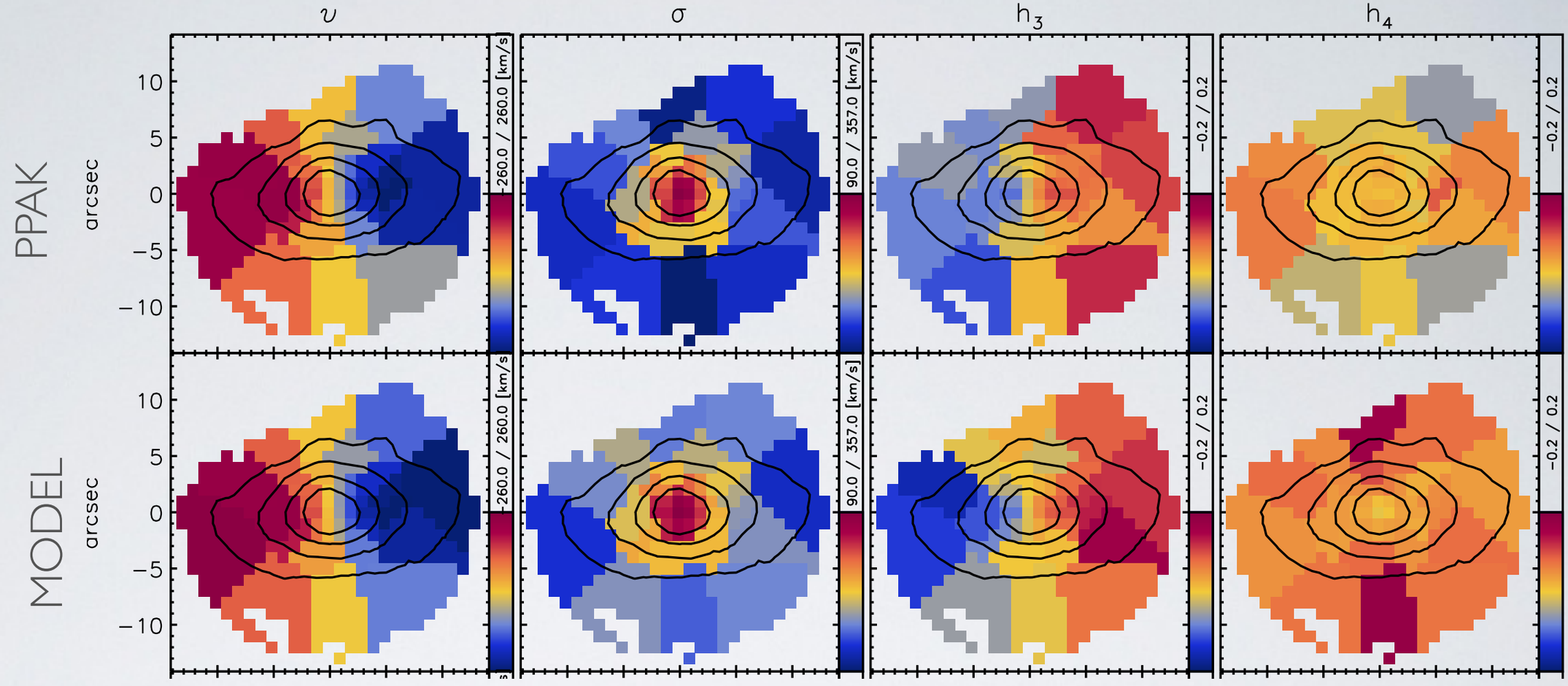

1’
20kpc
NGC1277
205
404
262
192
190
292
NGC1275
287
64
394
250
NGC1270
Perseus Cluster

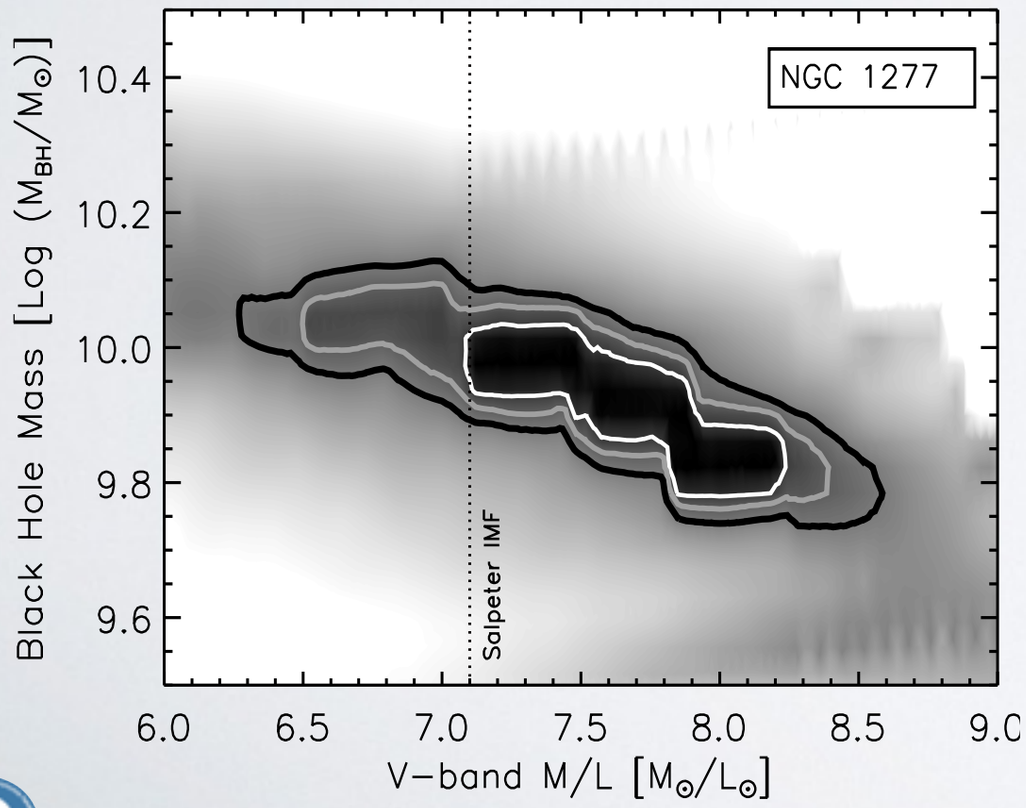
# NGC 1277: A BIG BLACK HOLE IN A SMALL GALAXY

vdB+12



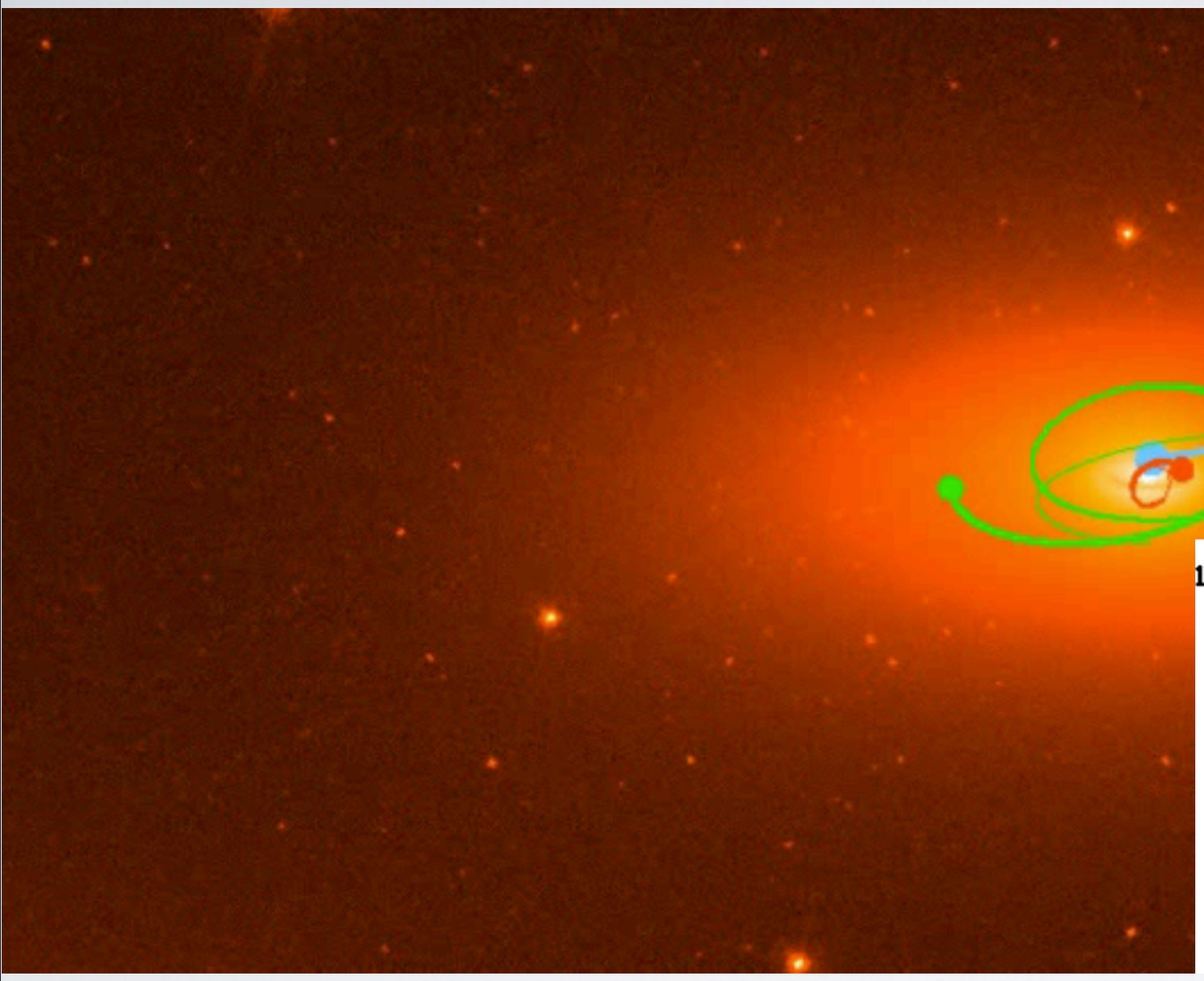


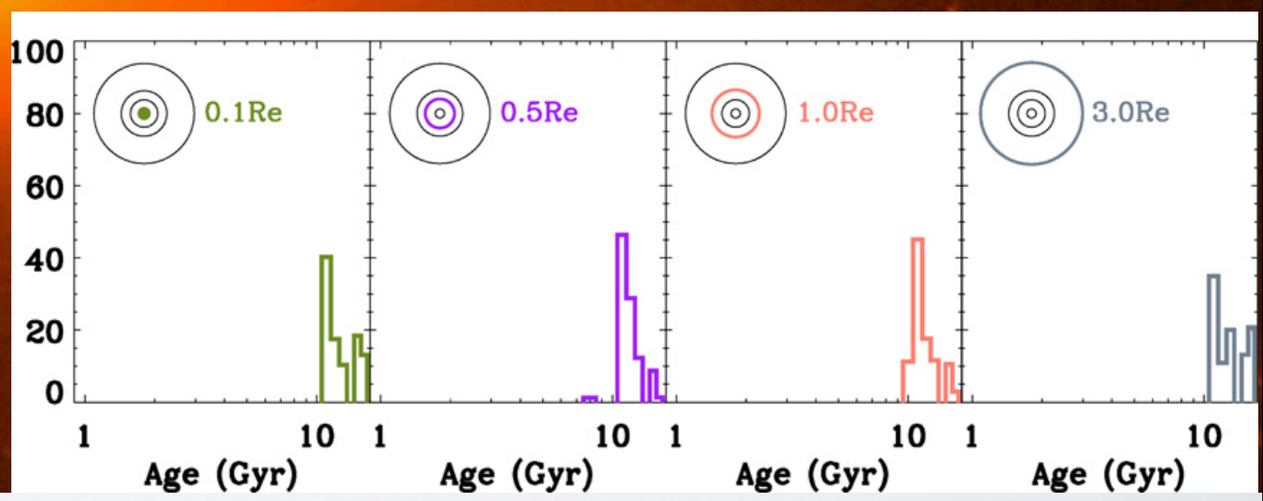




- PPAK IFU observations constrains the dynamical mode
- Higher mass-to-light ratio and smaller black hole

**Yildirim+14**

# NGC1277 IS AN OLD DISK GALAXY






- No Classical Bulge, which implies no coevolution.
- Bottom heavy stellar populations (Emsellem 2013)
- stellar ages >10 Gyr. (Trujillo+2014)
- Chandra X-ray luminosity of 1e40 (Fabian et al. 2013), implies low accretion rate.
- That still leaves a lot of options: Cold streams (Di Matteo), Unstable disks (Bournaud), merger (Bonoli), direct collapse (Agarwal), Feedback (Fabian), Run-aways (Shields)

# COMPACT GALAXIES

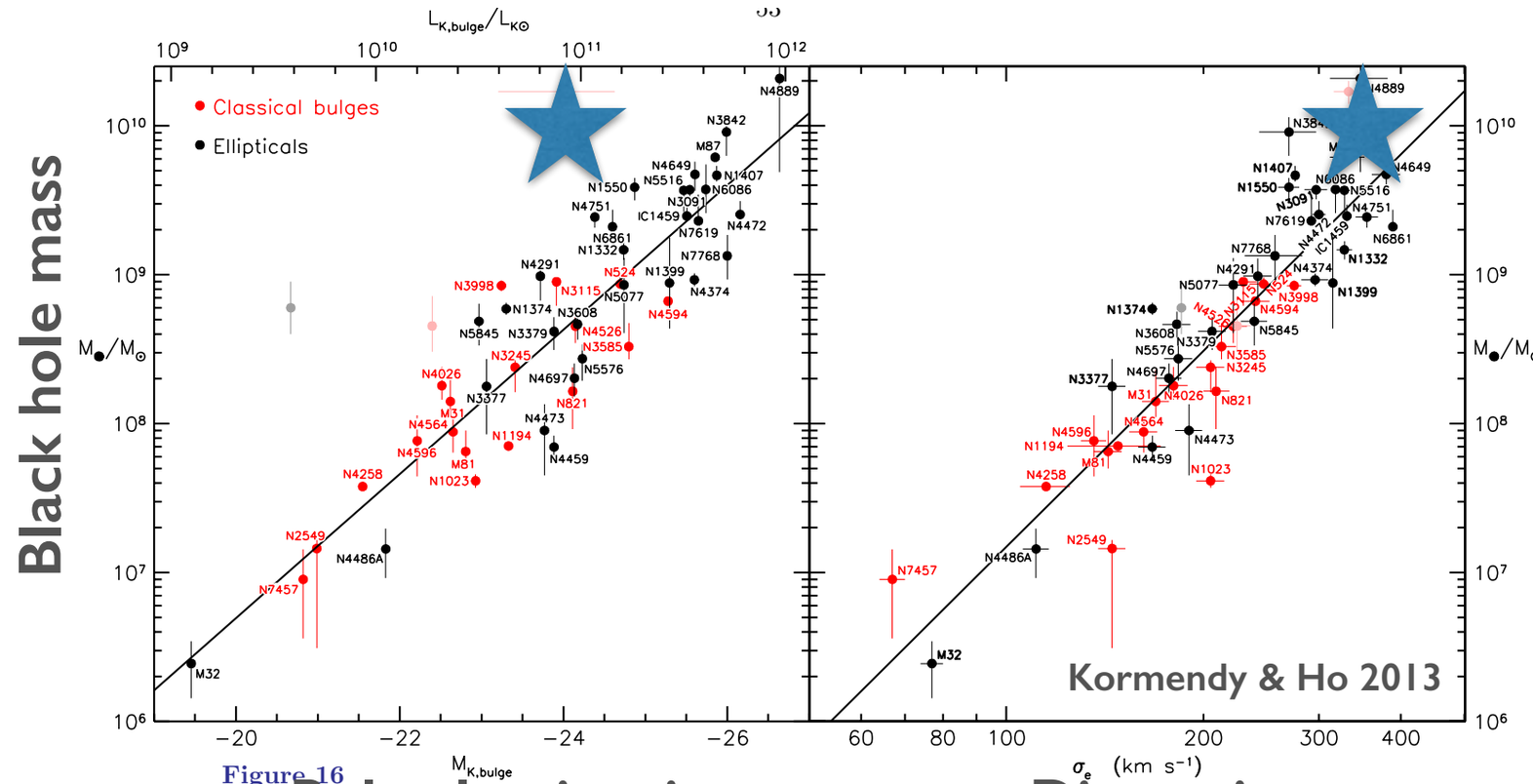
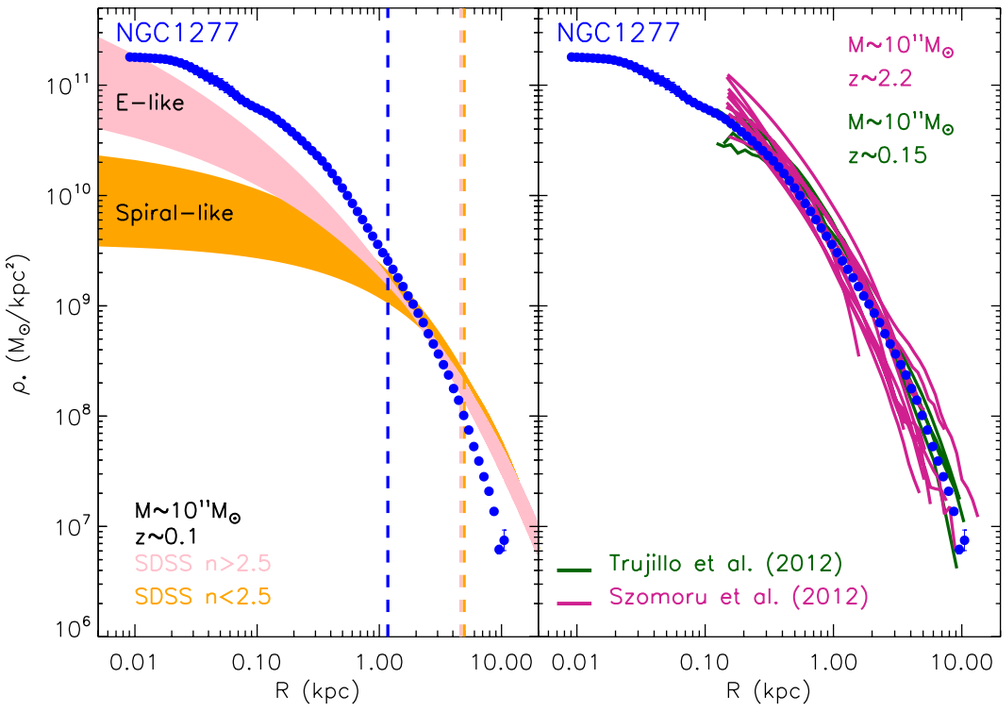



Figure 16

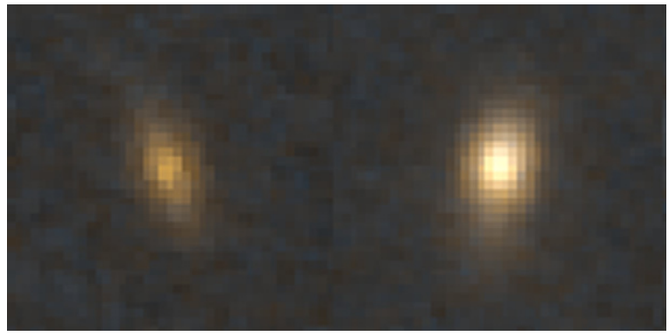
- large lever on BH co-evolution
- appear similar to z~2 passive galaxies (Red Nuggets)
- implies large mass-to-light ratios and bottom heavy IMF

# COMPACT GALAXIES

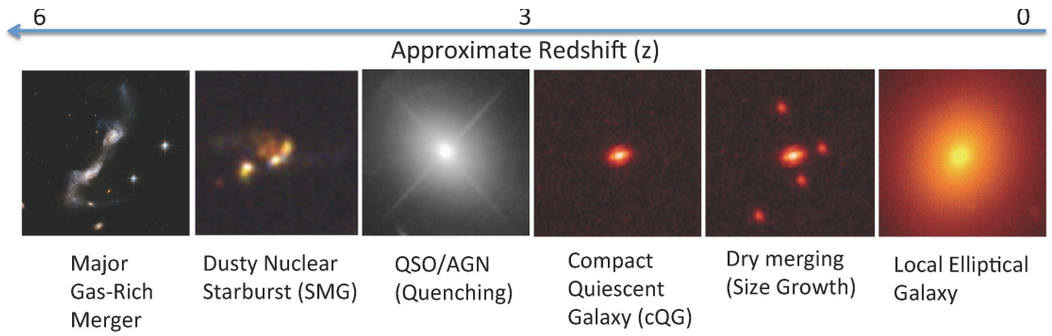
Trujillo+14




van der Wel+11




Toft+14

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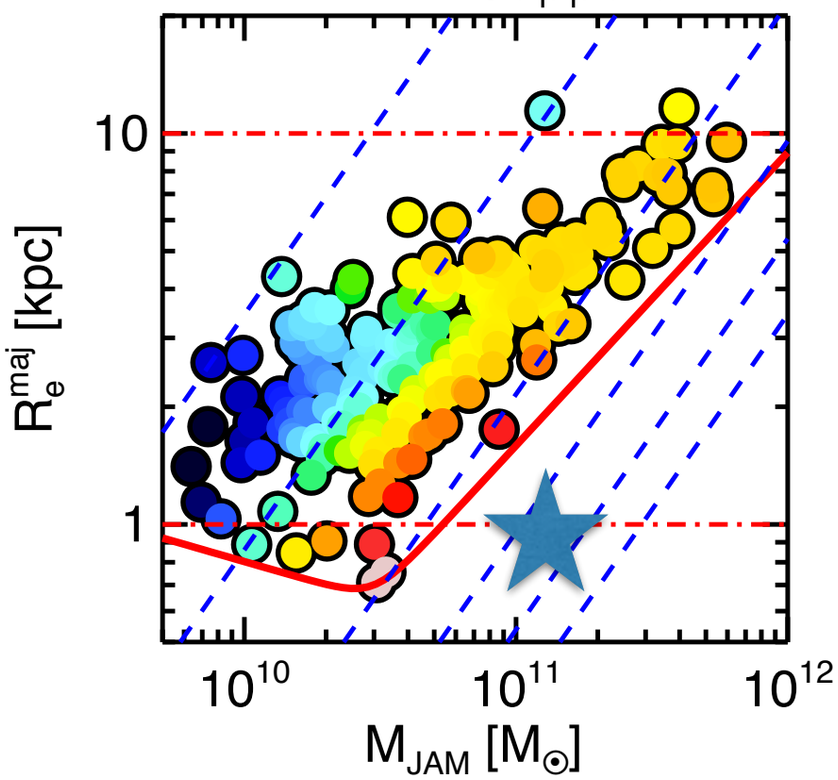
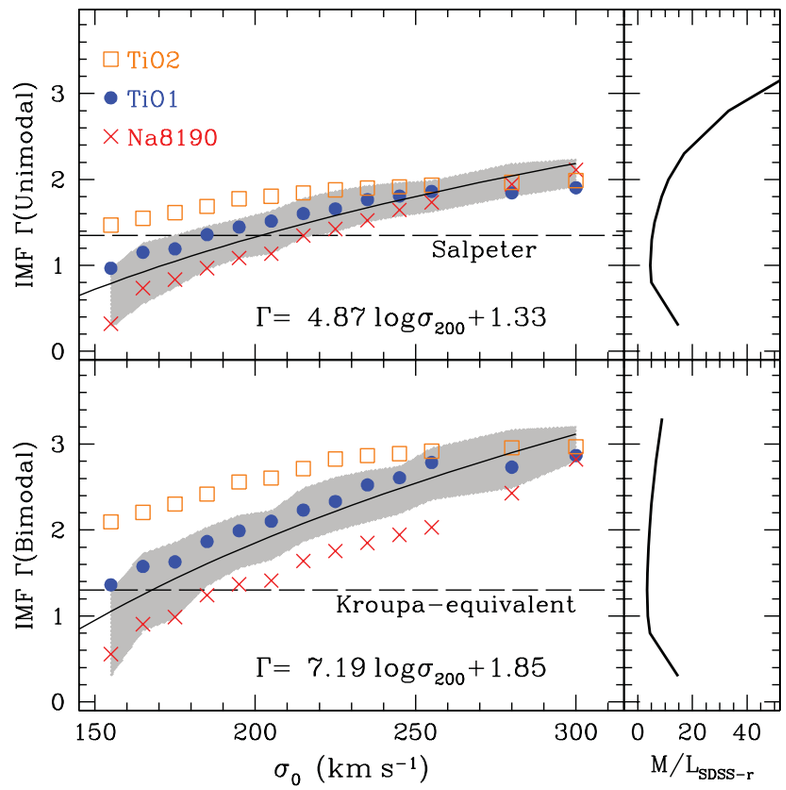
# COMPACT GALAXIES

Cappellari+13




Ferreras+13

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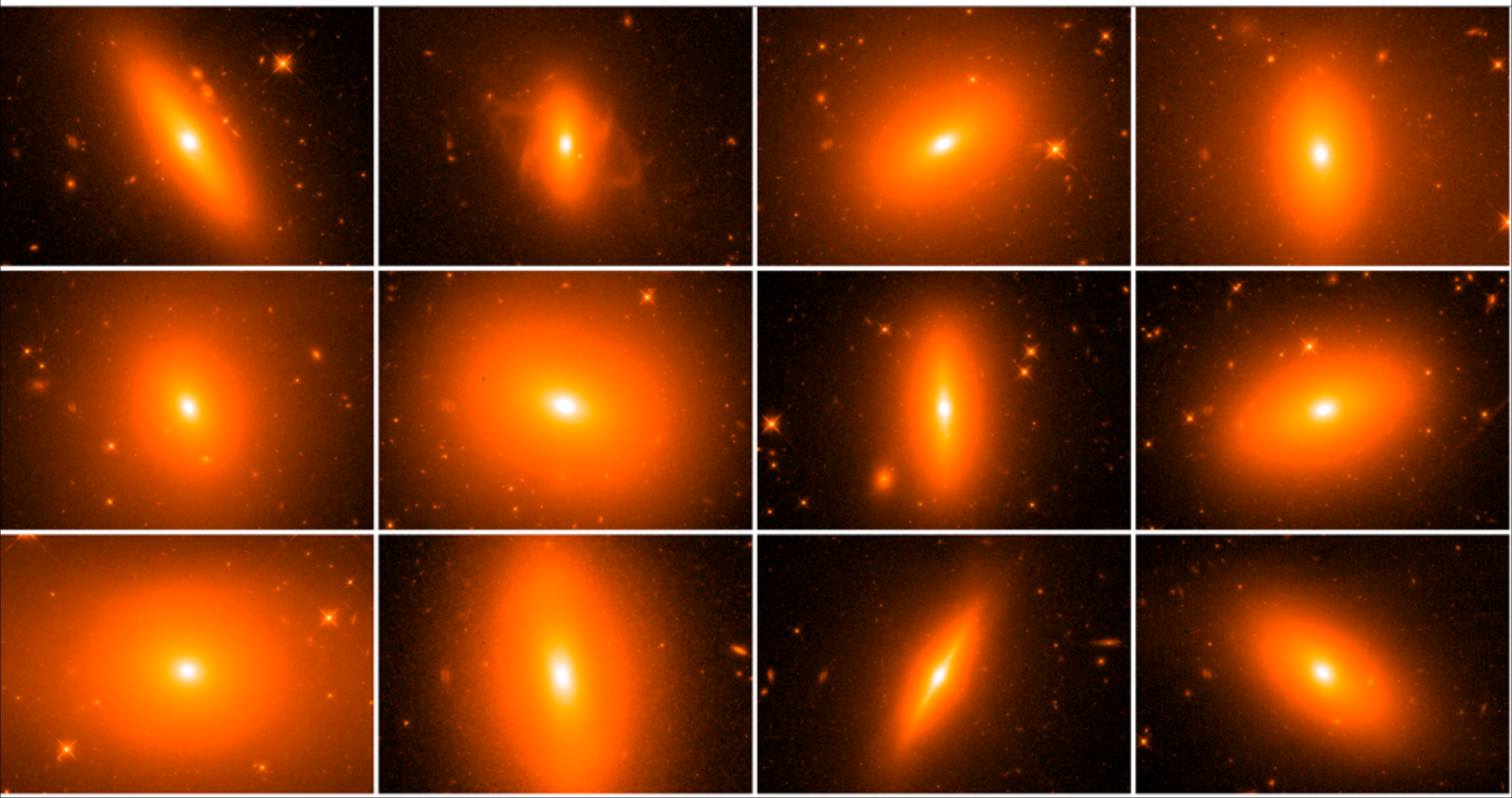
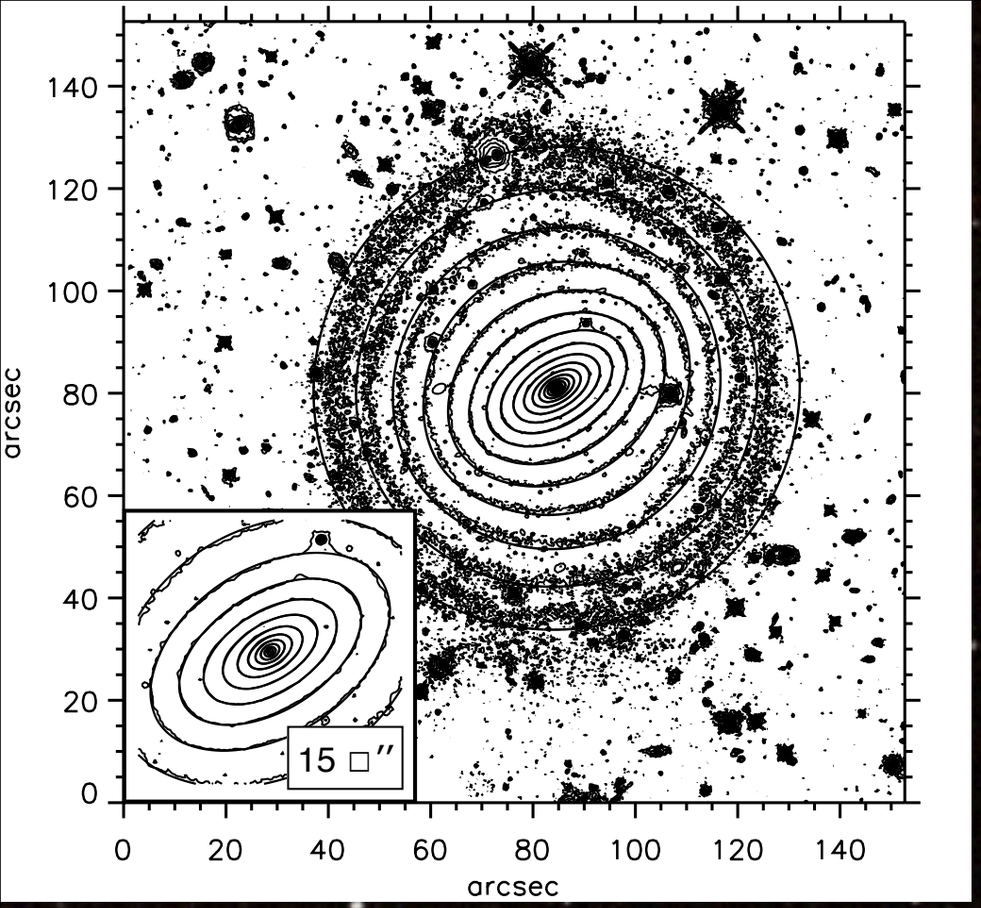
# FOLLOW UP OF 17 COMPACTS WITH HST AND PPAK IFU

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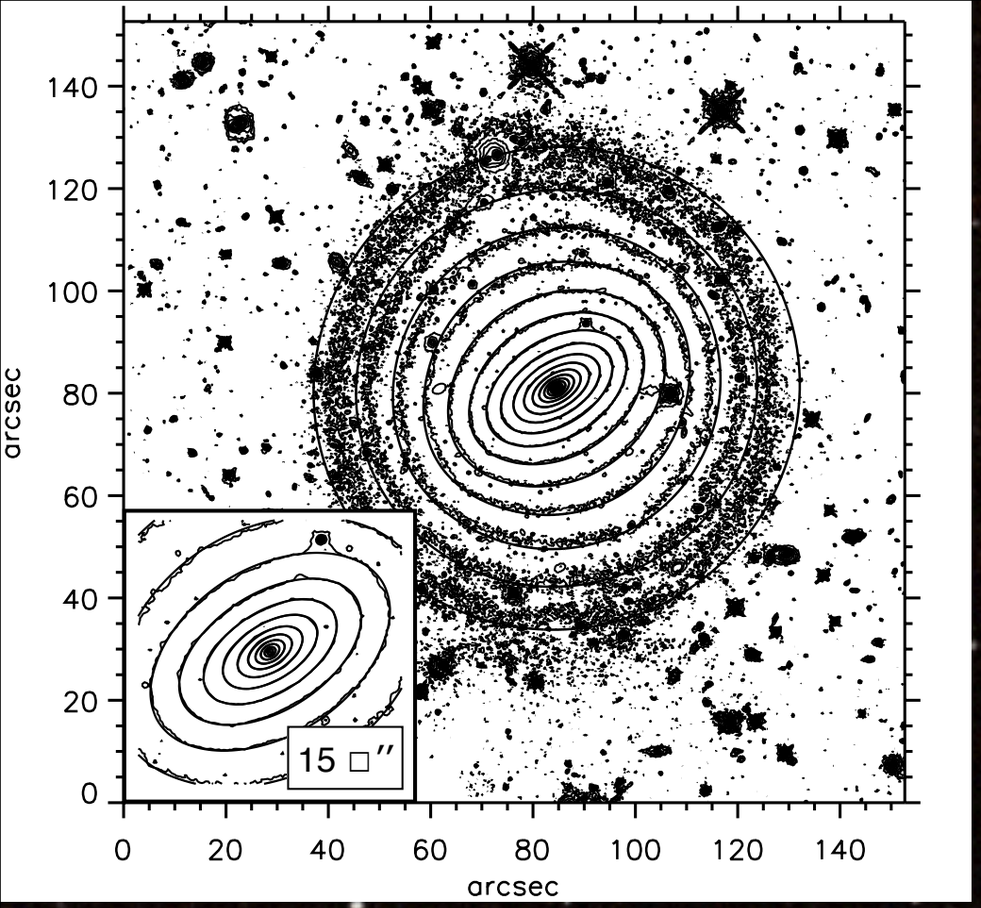
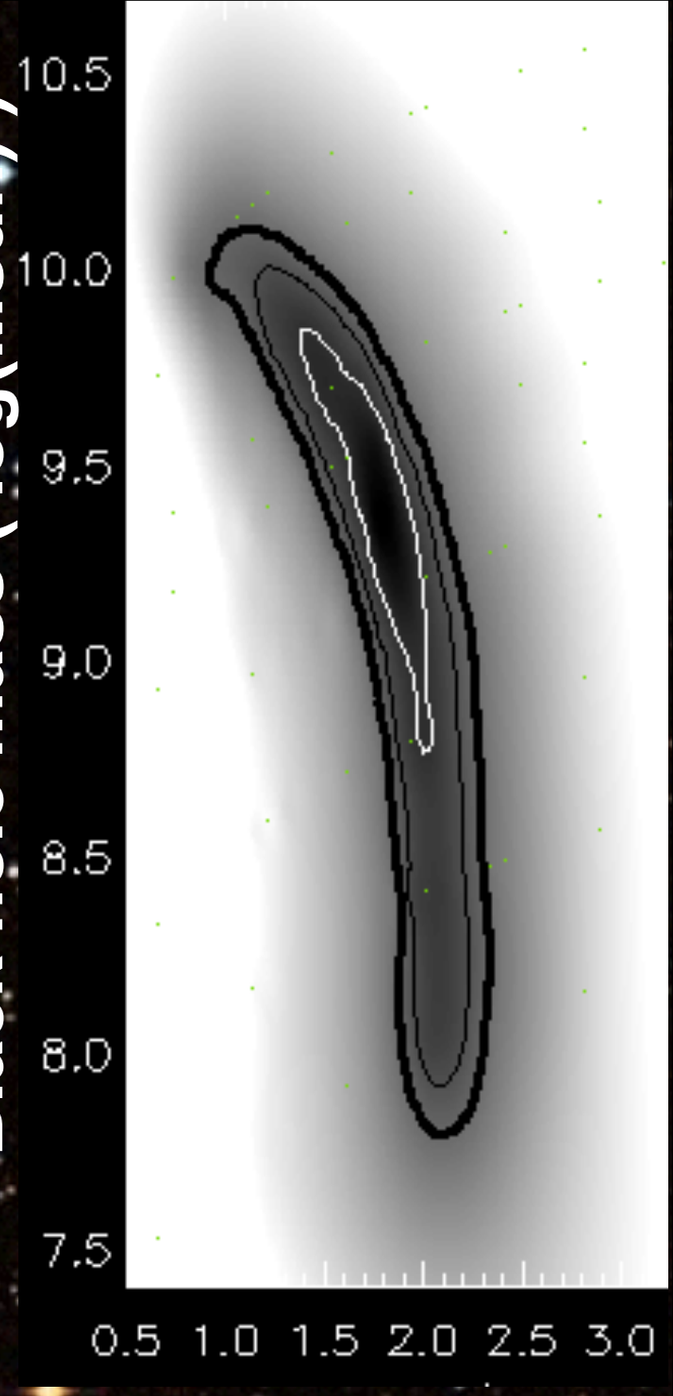
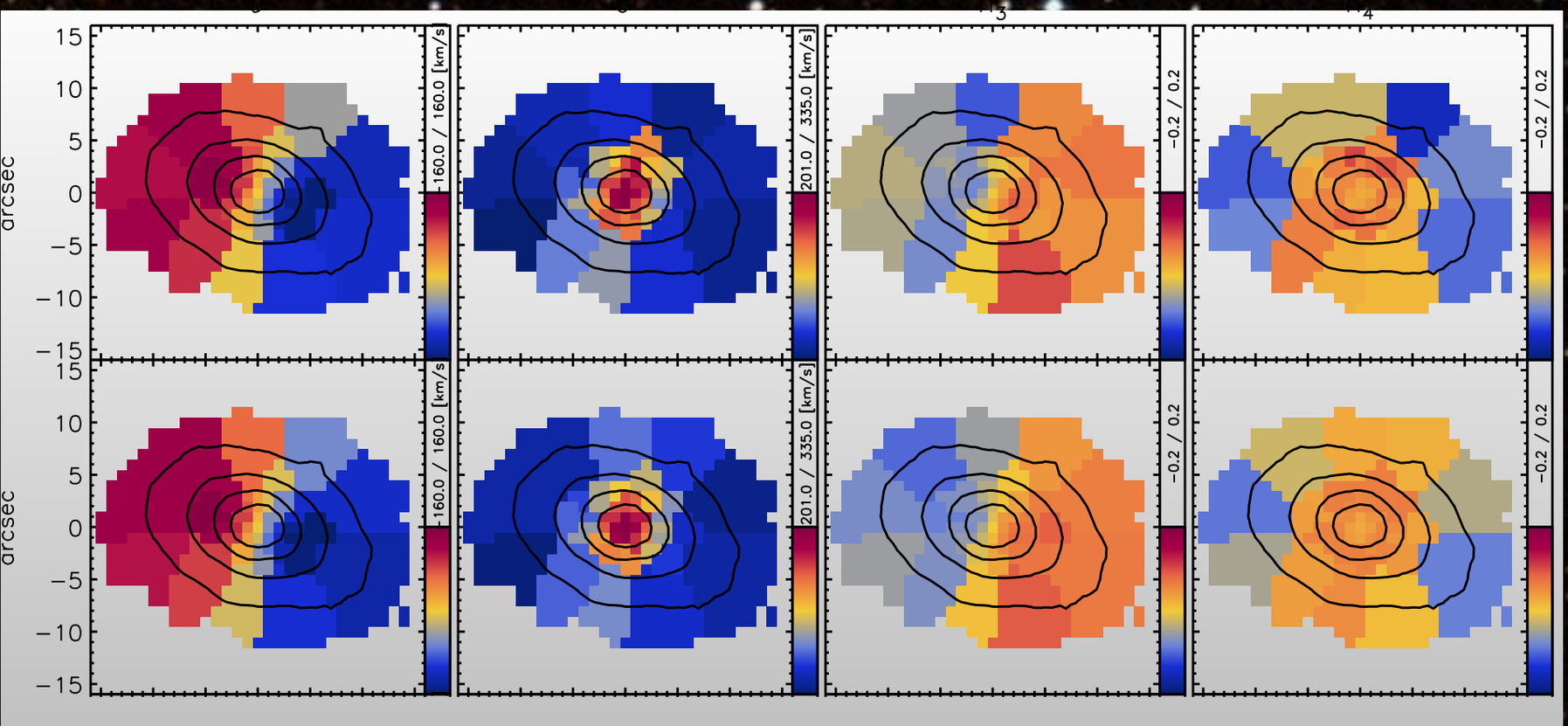


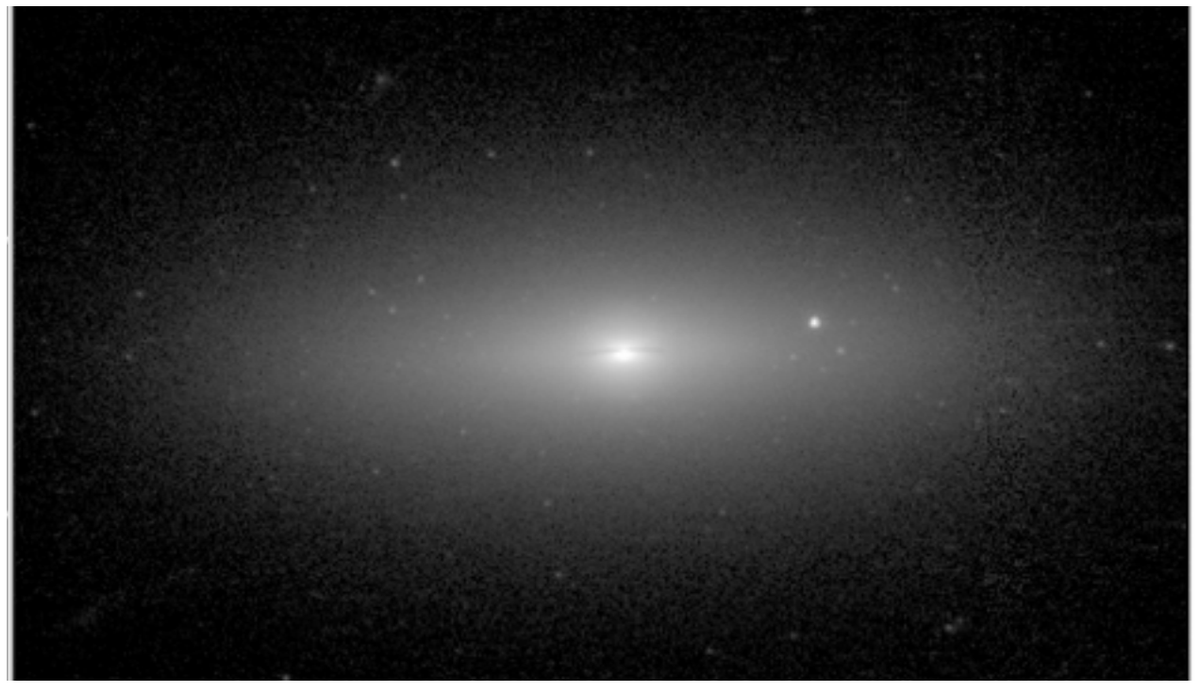

MRK1216

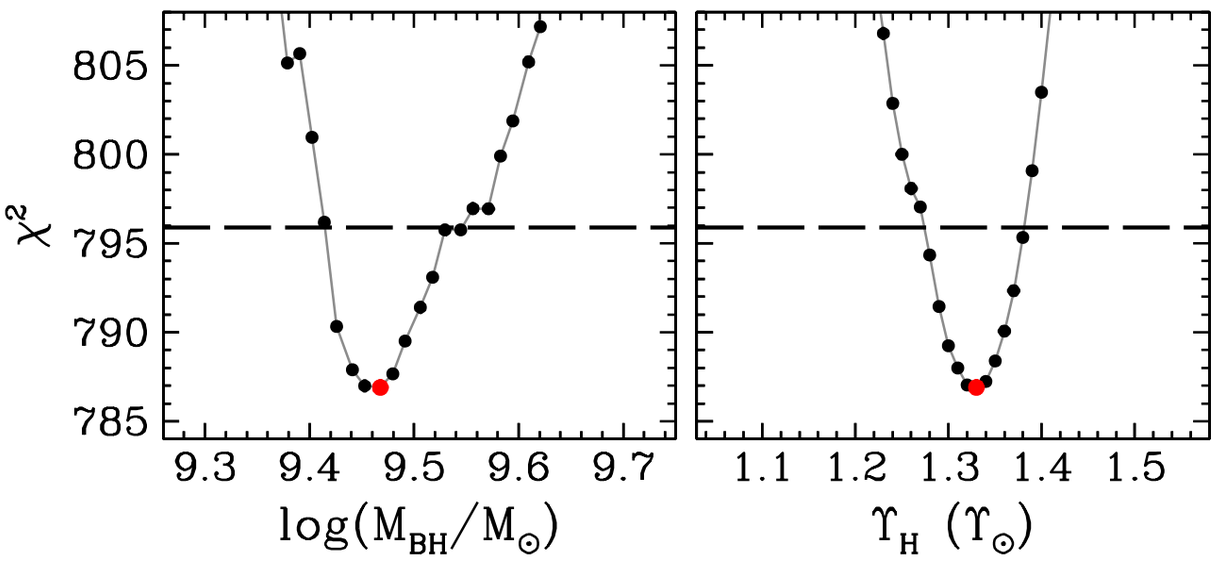


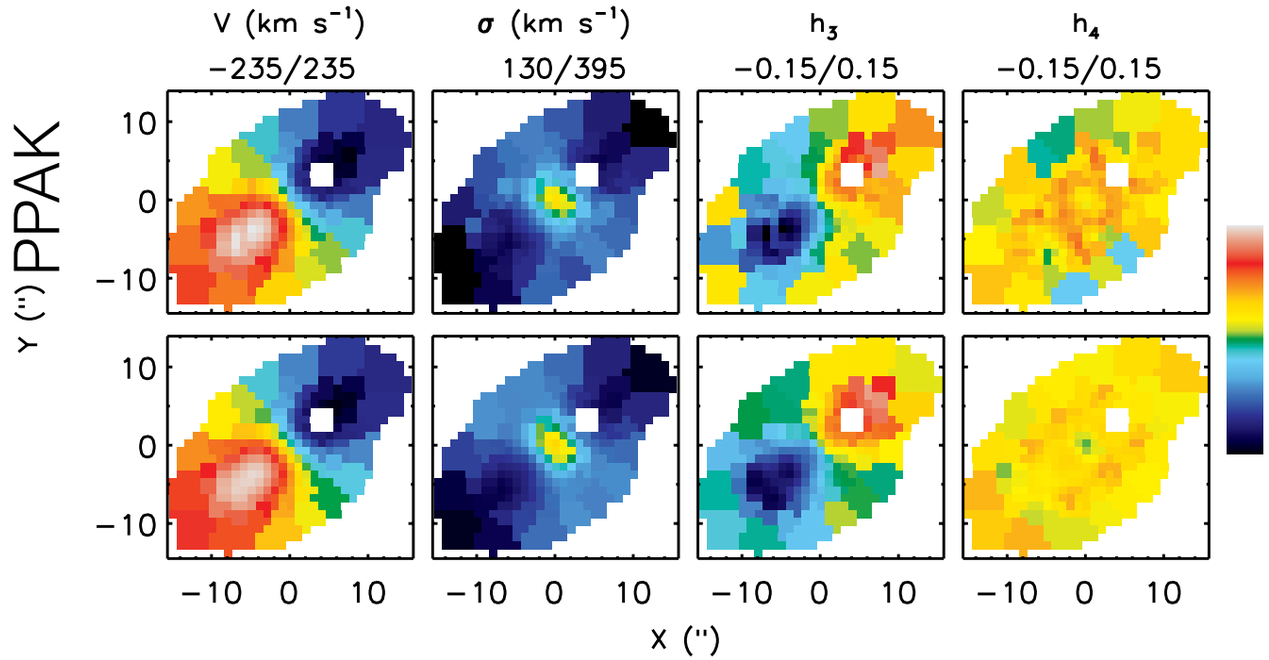



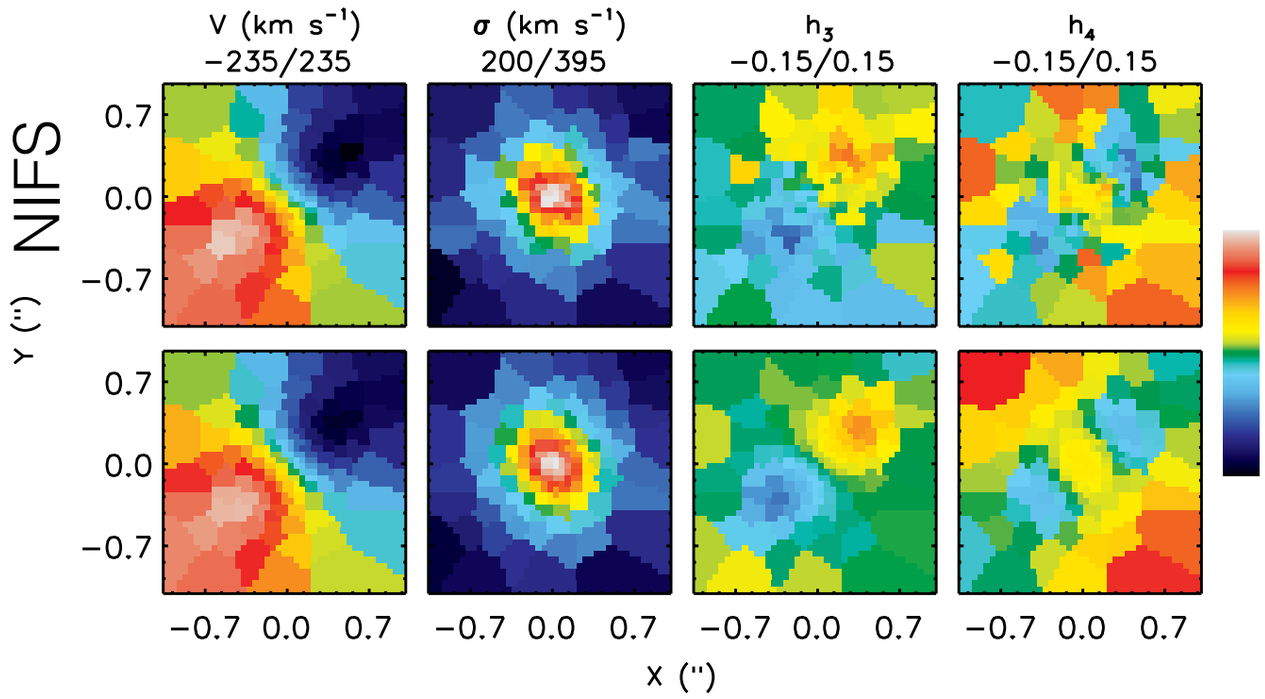

Yildirim+14

# NGC1271 WITH PPAK AND NIFS





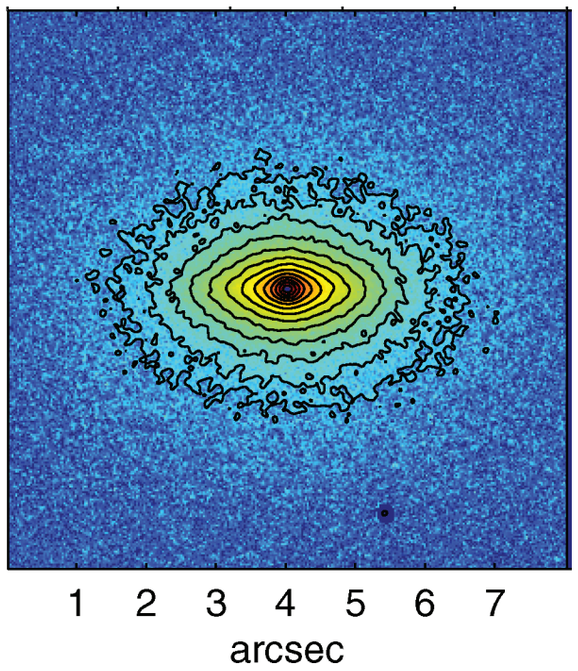



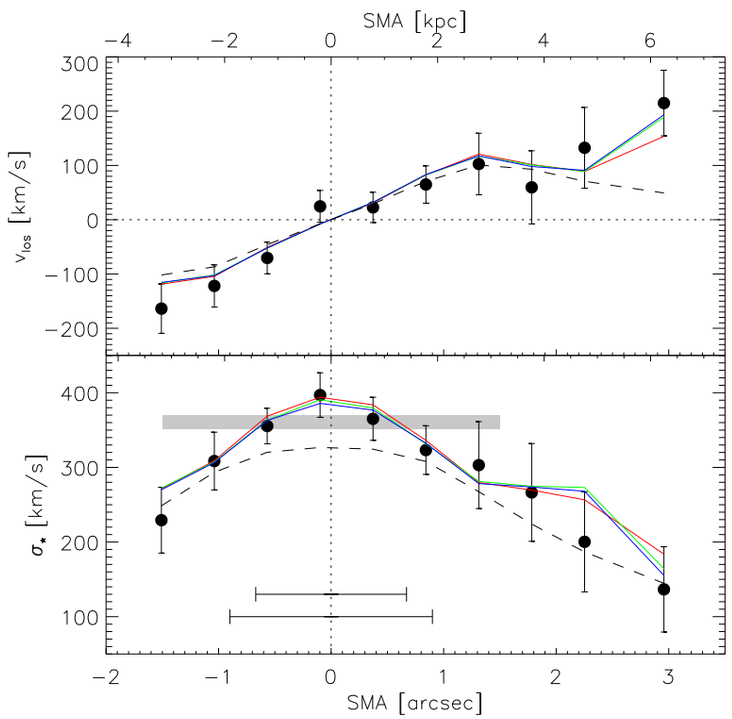



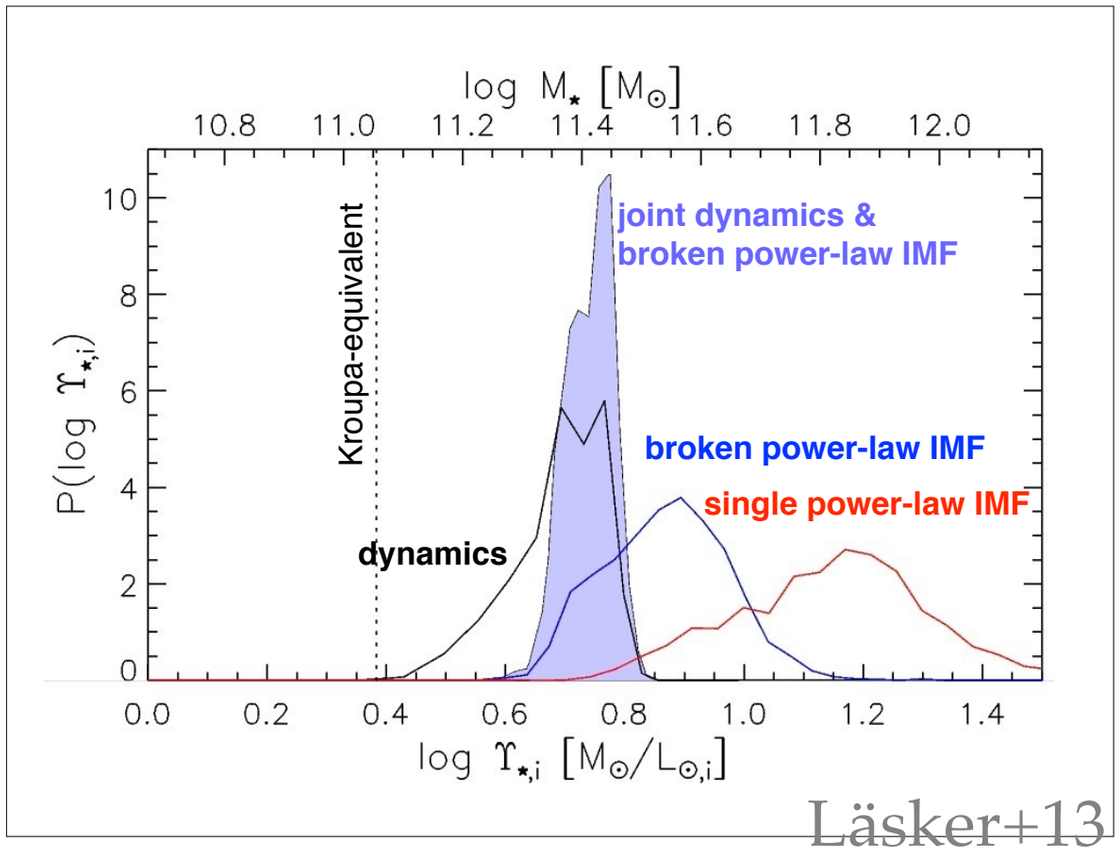

**Walsh+14**

# THESE GALAXIES EXIST IN SDSS TOO

BERNARDI+2007




Läsker+13

See poster 48 by Ronald Läsker

# CONCLUSIONS

- 3D observations are the way forward for black hole mass measurements, in either continuum or emission.

- Compact Galaxies
  - differentiate between different BH scaling relations
  - appear very similar to z~2 passive galaxies
  - have large stellar mass-to-light ratio, which implies bottom heavy IMFs.