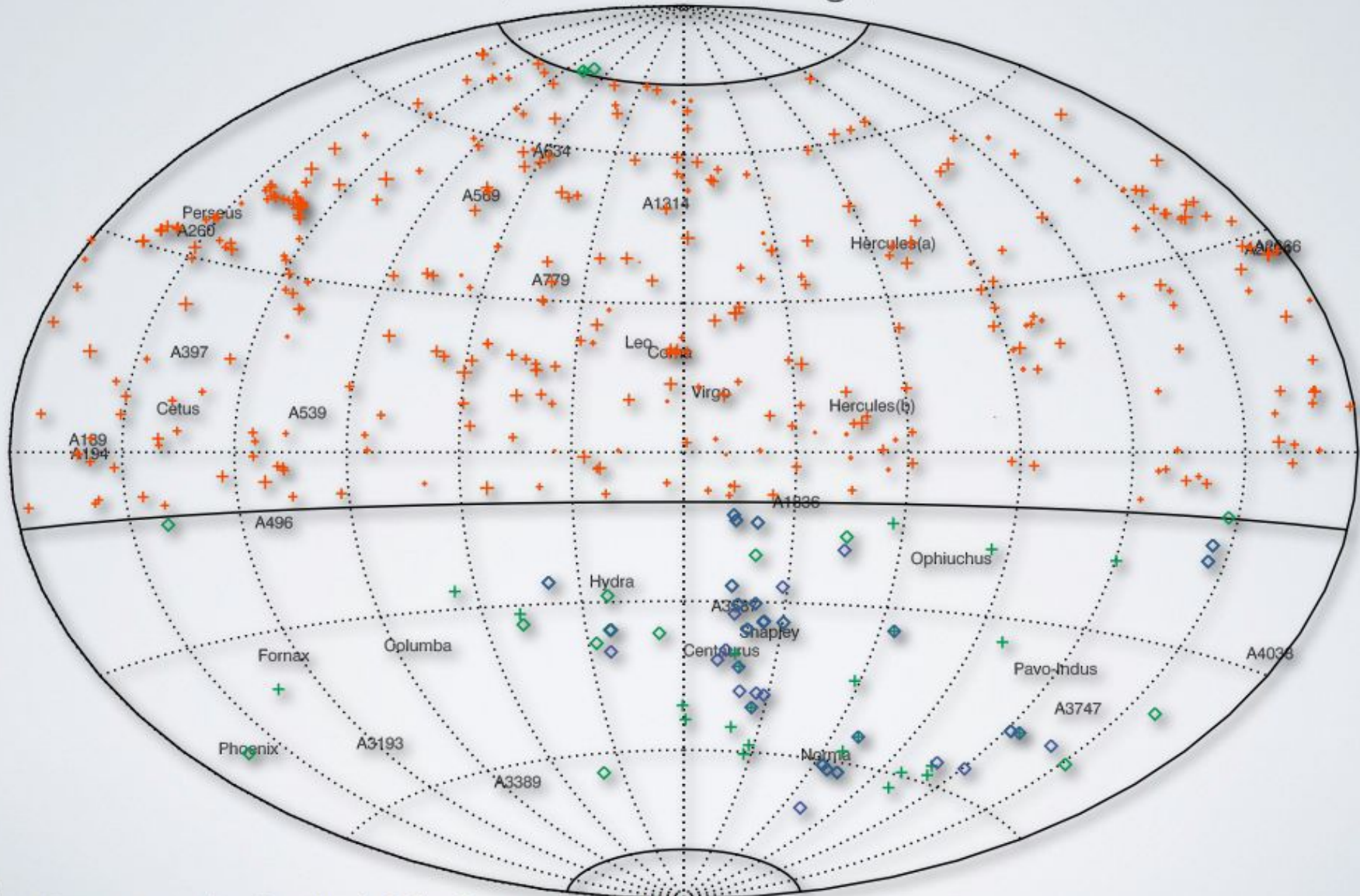


HET NEARBY MASSIVE GALAXIES SURVEY

Remco van den Bosch, MPIA, Fornax, Virgo, Coma et al. 2011

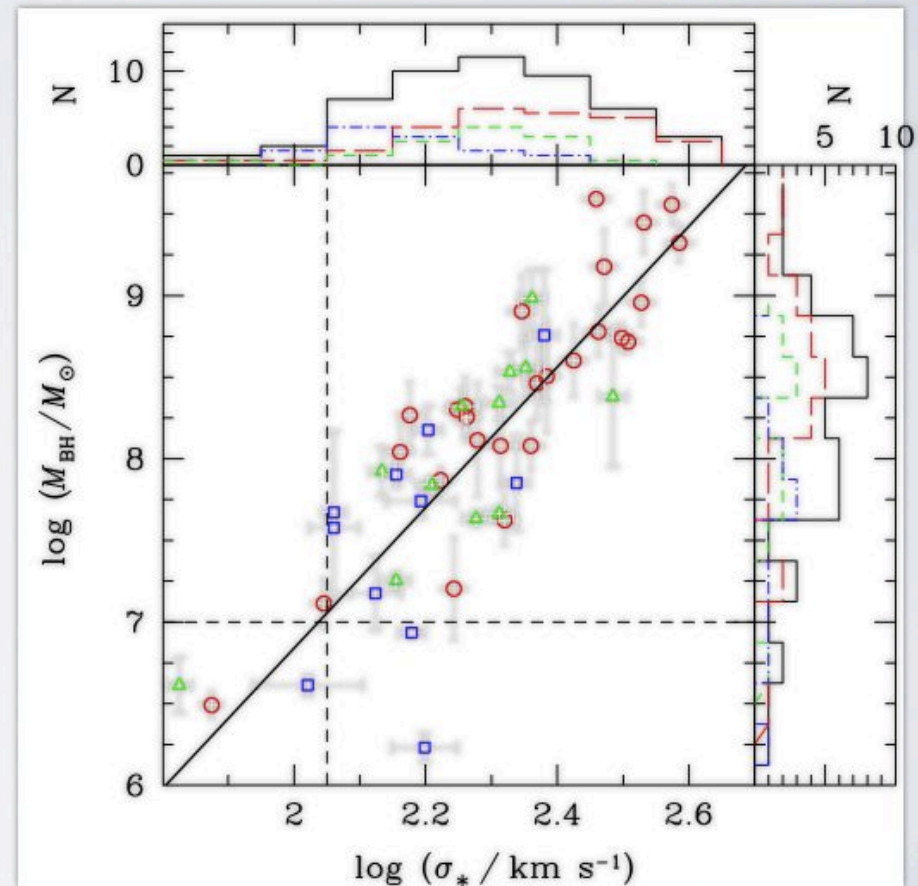


NEARBY MASSIVE GALAXIES AND THEIR BLACK HOLES

Greene et al 2010

- **WHY ANOTHER GALAXY SURVEY?**

- Black hole mass and galaxy properties shown strong correlations (e.g. M-sigma)
- However few (~60) direct measurements exist.
- Few Low and High mass black holes
- Only 6 above $10^9 M_{\text{sun}}$
- Dominated by intrinsic measurement errors (Bender's talk)



WHY ARE THERE FEW BLACK HOLE MASS MEASUREMENTS?

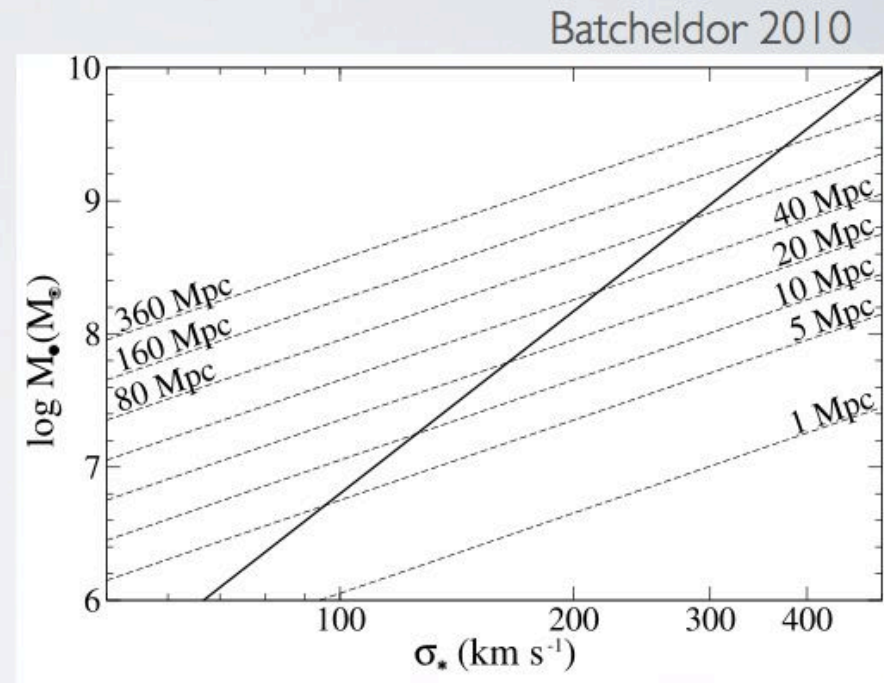
- **MANY REQUIREMENTS FOR DYNAMICAL ESTIMATES:**

- Resolve the Sphere-of-influence

$$R_{soi} = \frac{GM_{\bullet}}{D\sigma^2} \propto \frac{\sigma^{2.2}}{D}$$

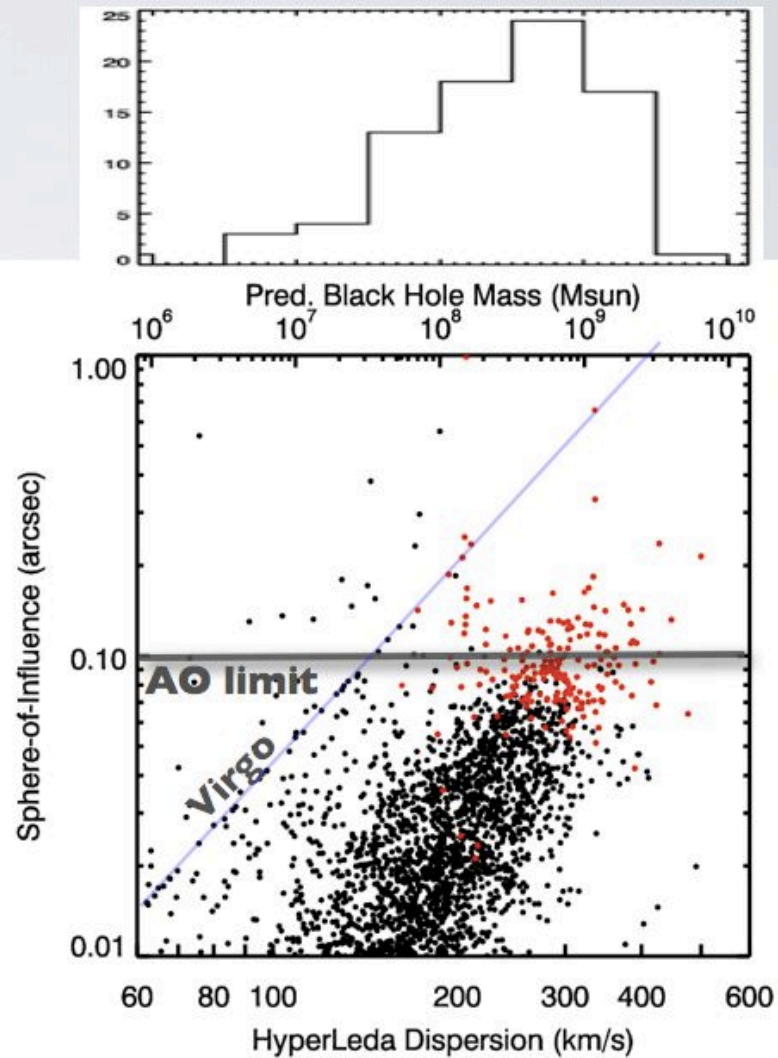
Thus HST/STIS or AO. And few available targets

- Plus large scale kinematics and high resolution photometry and large scale photometry for stellar mass model
- Complications due to dark matter, geometry, etc



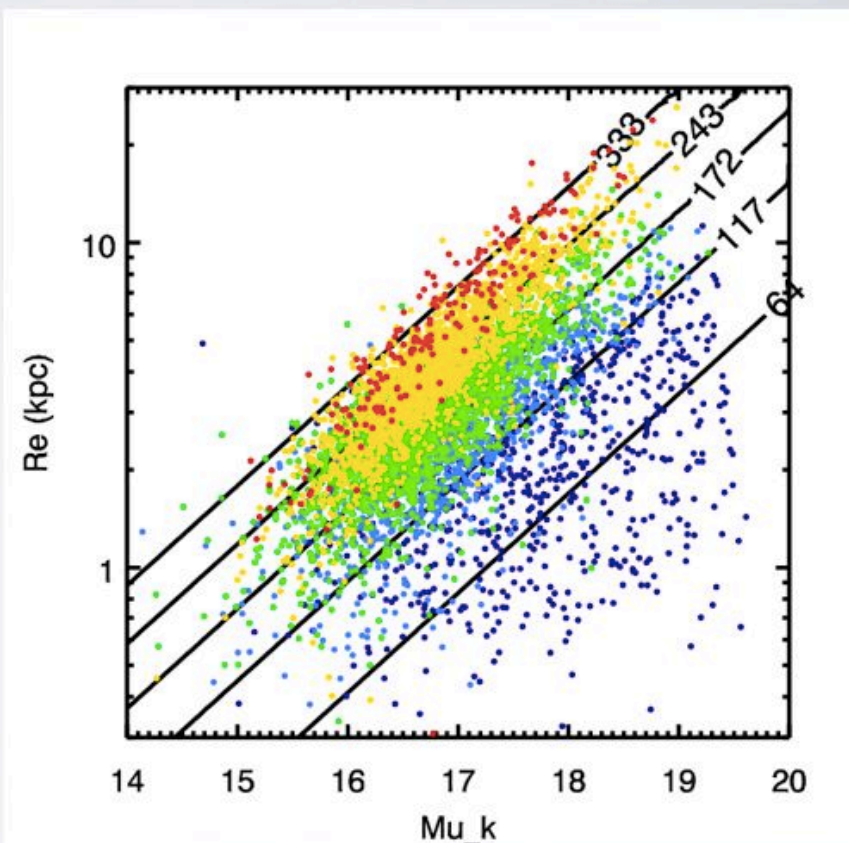
HET NEARBY MASSIVE GALAXIES SURVEY

- **Select candidate galaxies with Hyperleda**
- Guestimate black hole mass using M-sigma
- 18 targets with with black holes bigger than $10^9 M_{\text{sun}}$ and $\text{SOI} > 0.1''$
- No selection on galaxy type
- 201 galaxies observed
- (Most nearby galaxies are not in SDSS)



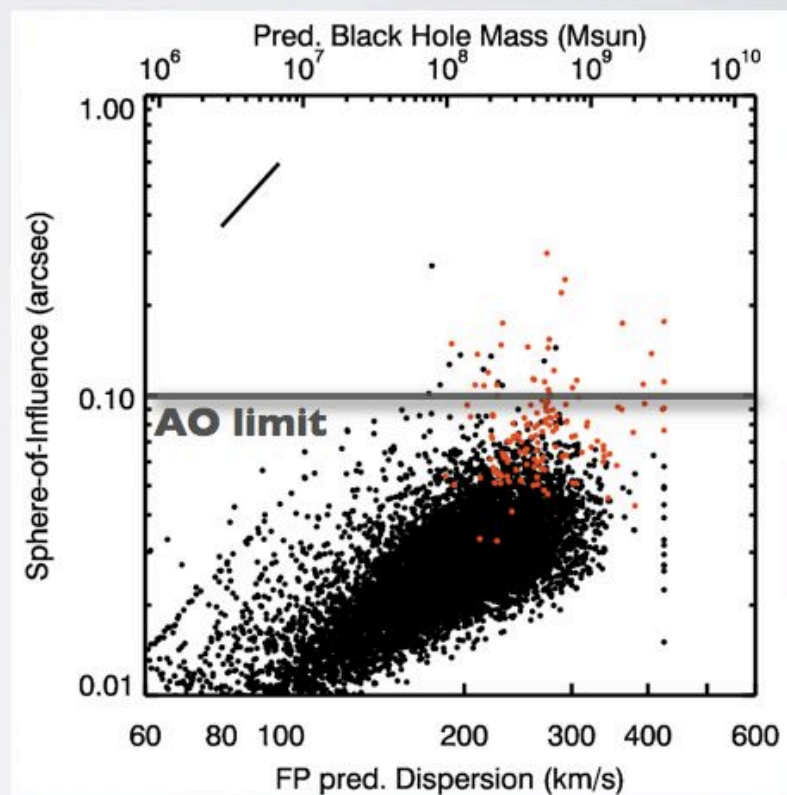
2MASS FUNDAMENTAL PLANE

- **Not all nearby galaxies have dispersions**
- Predict dispersion:
 - 2Mass XSC (Jarret et al. 2000)
 - 2MRS Redshifts (Huchra et al.)
 - Fundamental Plane (Pahre et al, 1998)
 - No selection on galaxy type
- Dispersion estimate standard deviation 31 km/s



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- **166 targets observed**





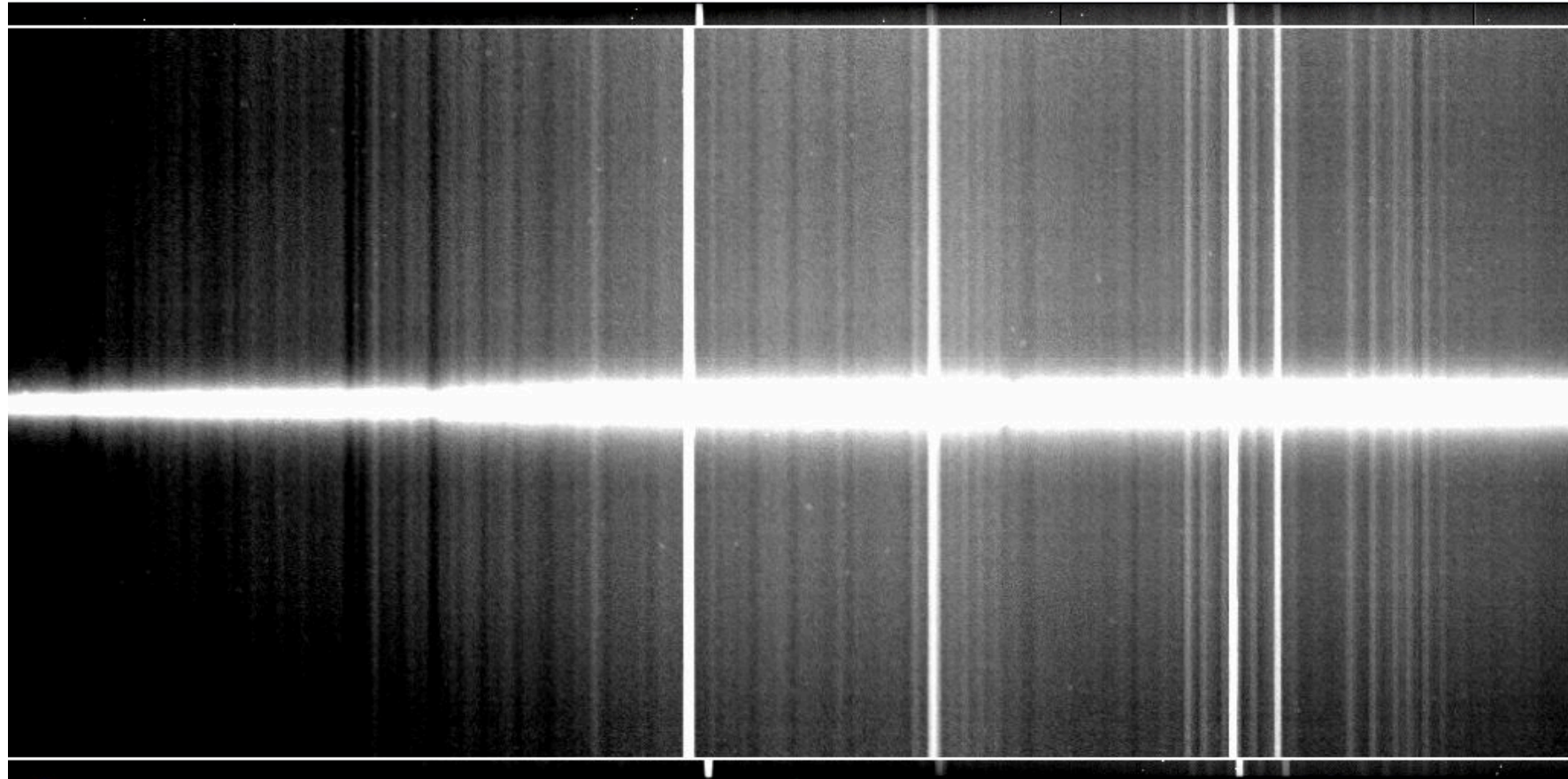
HET OBSERVATIONS

- Long slit spectra with the Marcario Low Resolution Spectrograph
- 4200-7400 AA, 180km/s resolution, 2"x2.5' slit
- 367 galaxies observed
- Distances are 40~140 Mpc
- Effectively probing the most massive nearby galaxies
- ~100 more queued



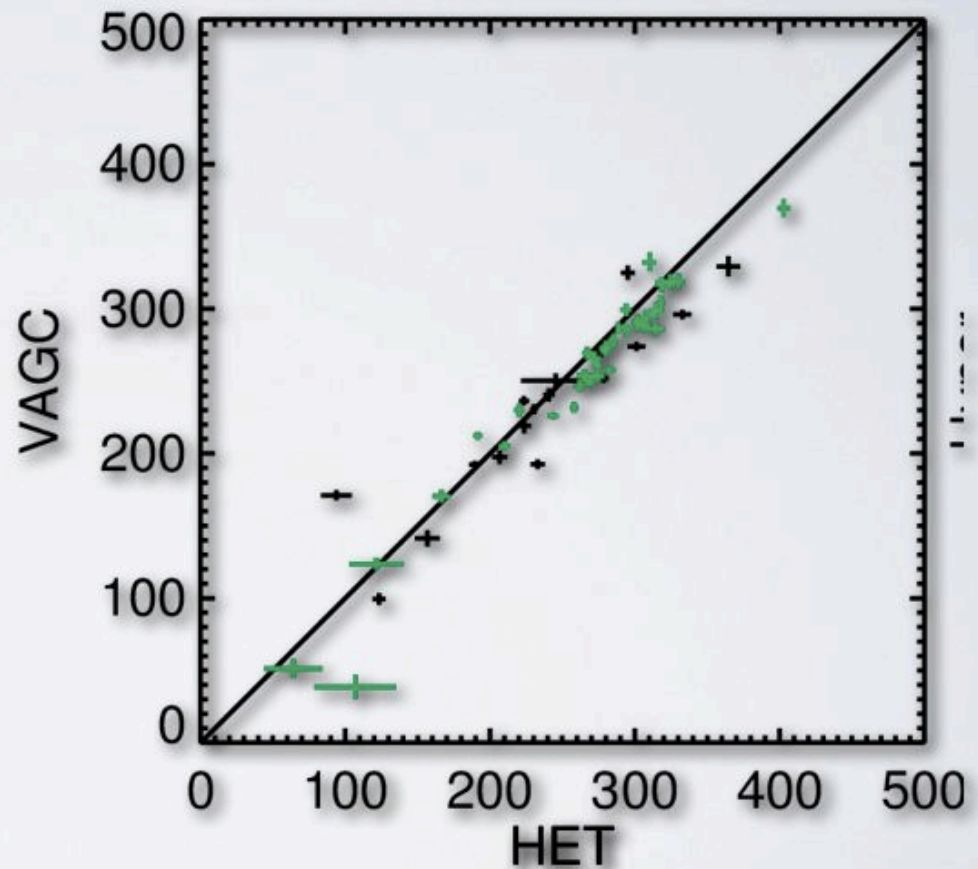


LONG SLIT SPECTRA



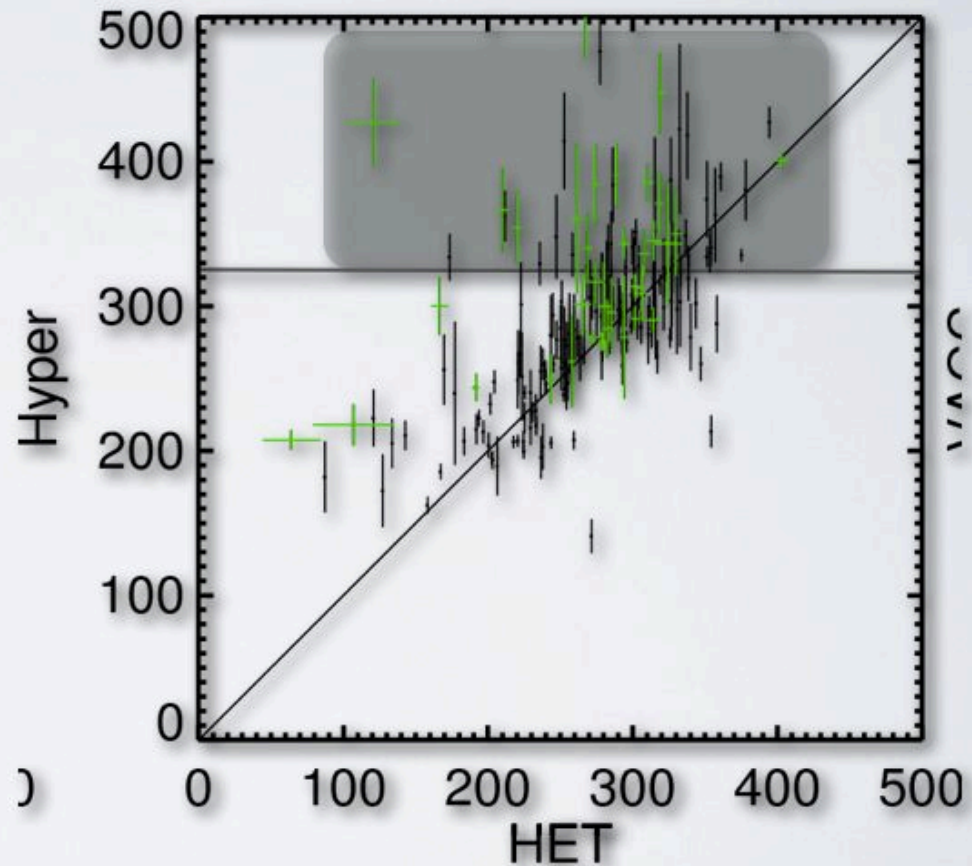
DISPERSION COMPARISON

- Good agreement between SDSS and HET
- Not so for Hyperleda
- Large (SOI) galaxies in Hyperleda often overestimated



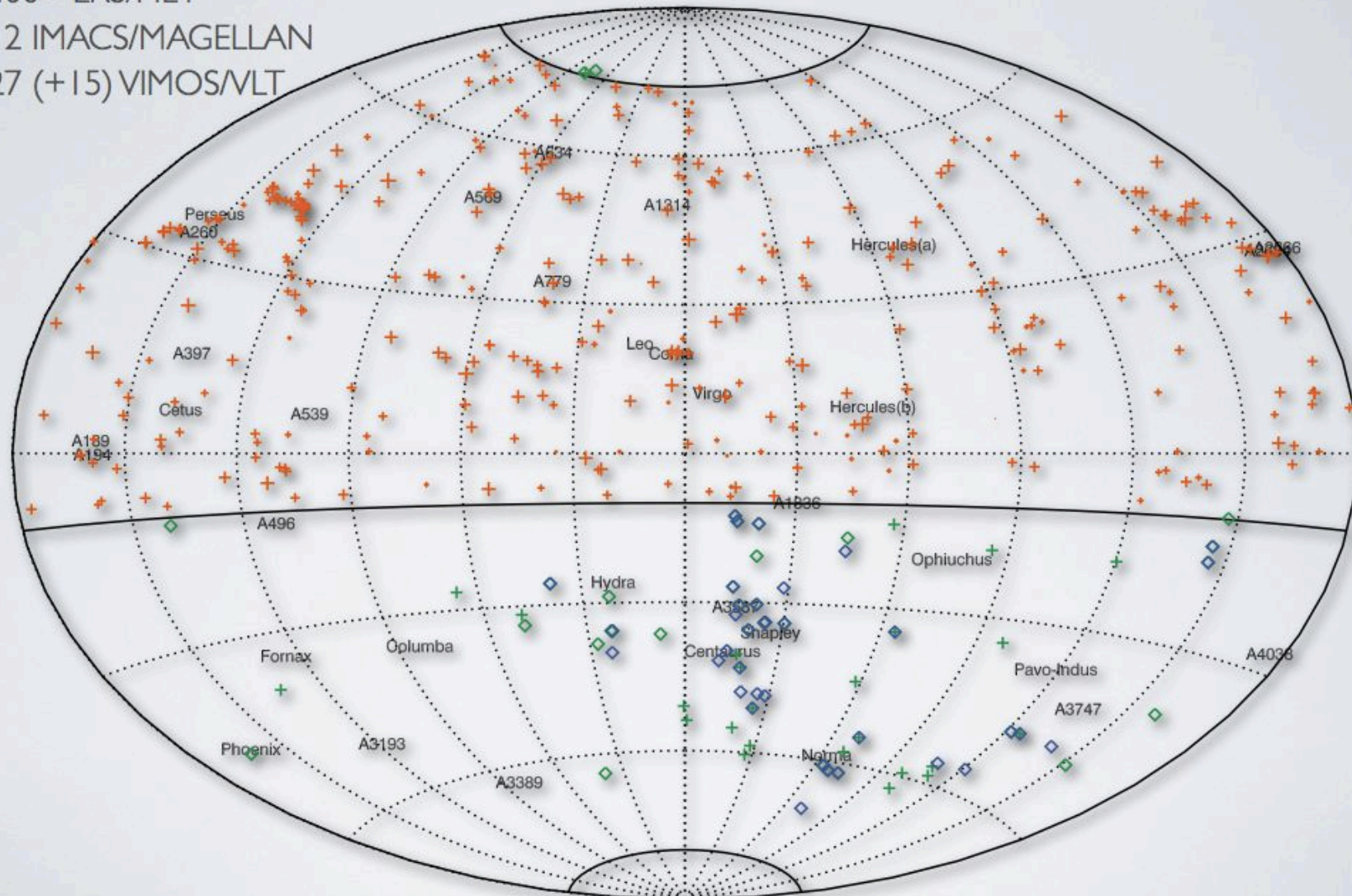
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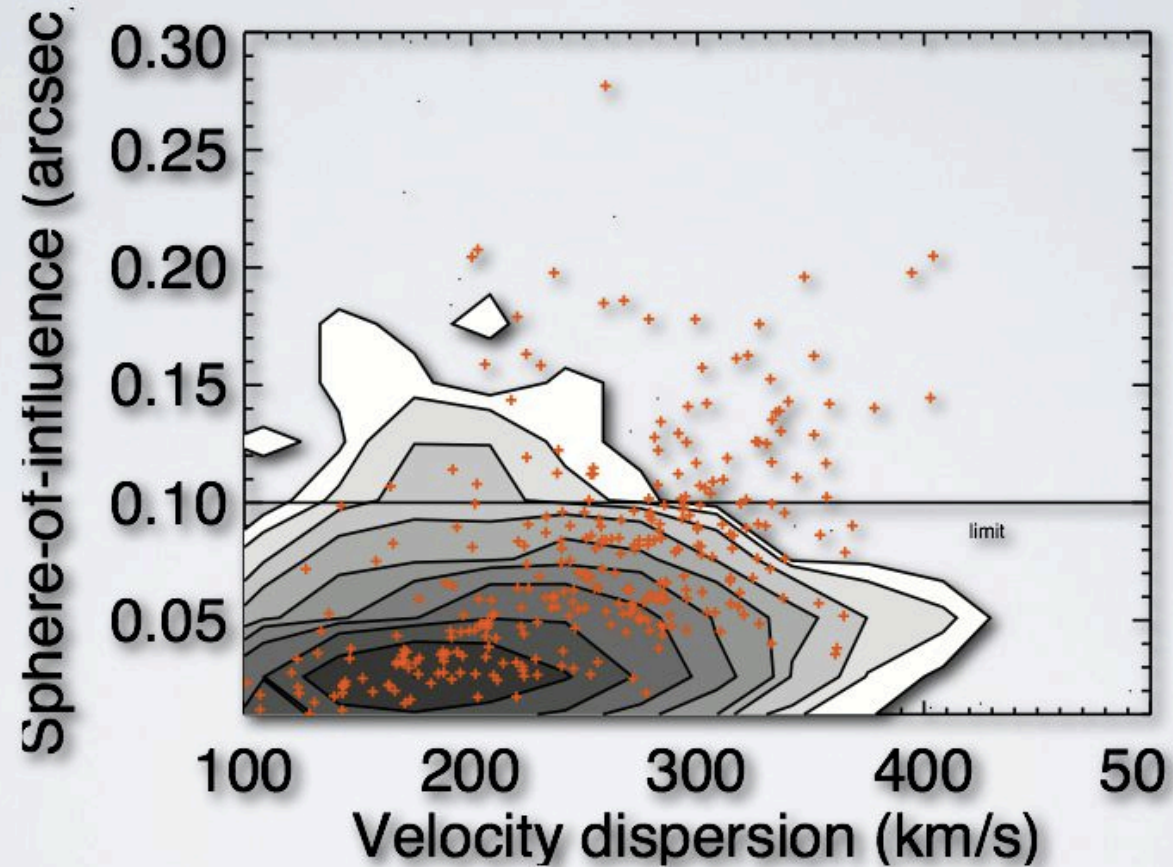


HET NEARBY MASSIVE GALAXIES SURVEY

- 400+ LRS/HET
- 12 IMACS/MAGELLAN
- 27 (+15) VIMOS/VLT



GATEWAY TO MORE BLACK HOLE MASSES

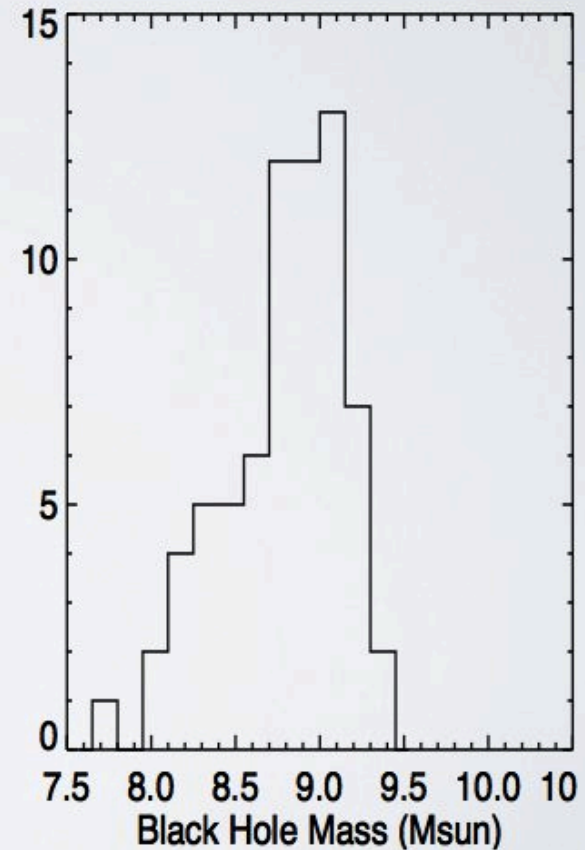
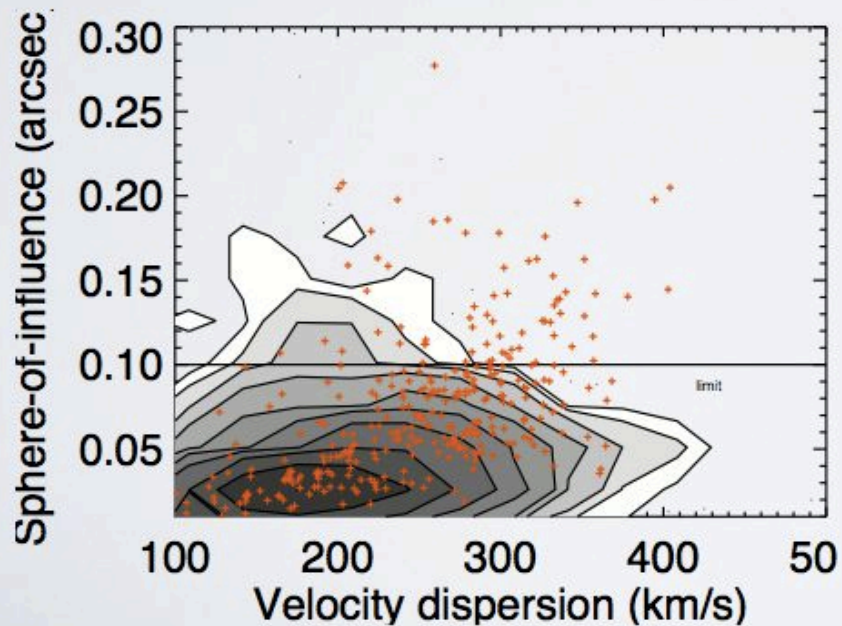


- Survey has probed nearly all likely candidates.



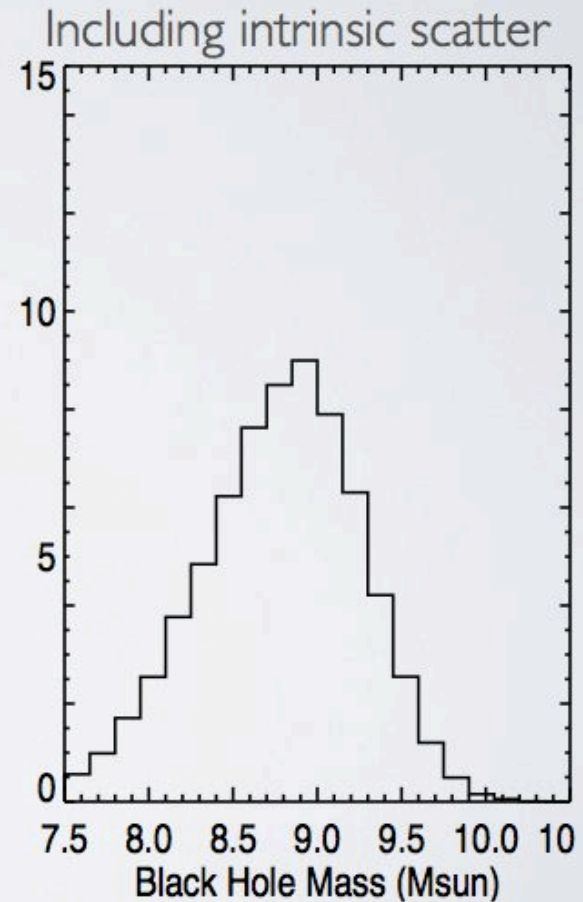
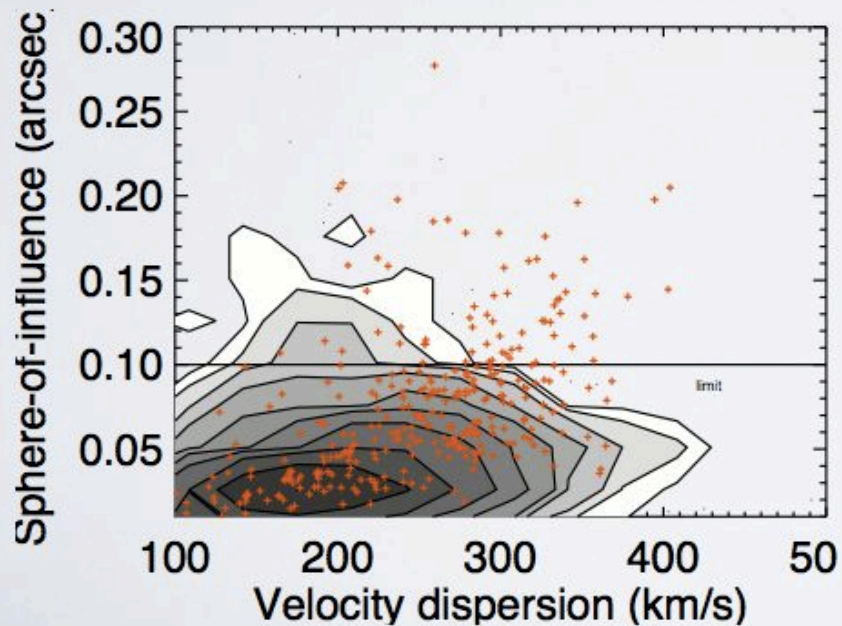
GATEWAY TO MORE BLACK HOLE MASSES

- Survey has probed nearly all likely candidates.
- 69 new targets of which 22 with black holes bigger than $10^9 M_{\text{sun}}$



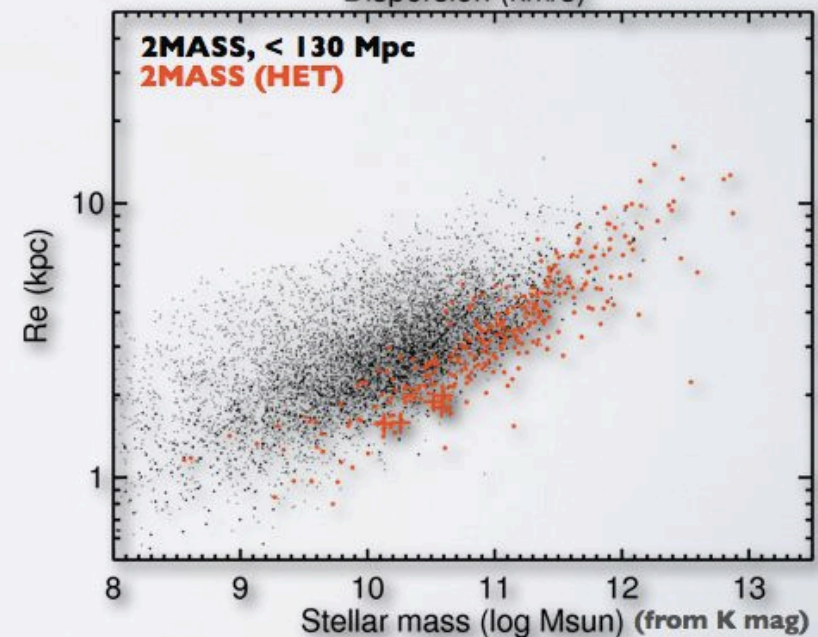
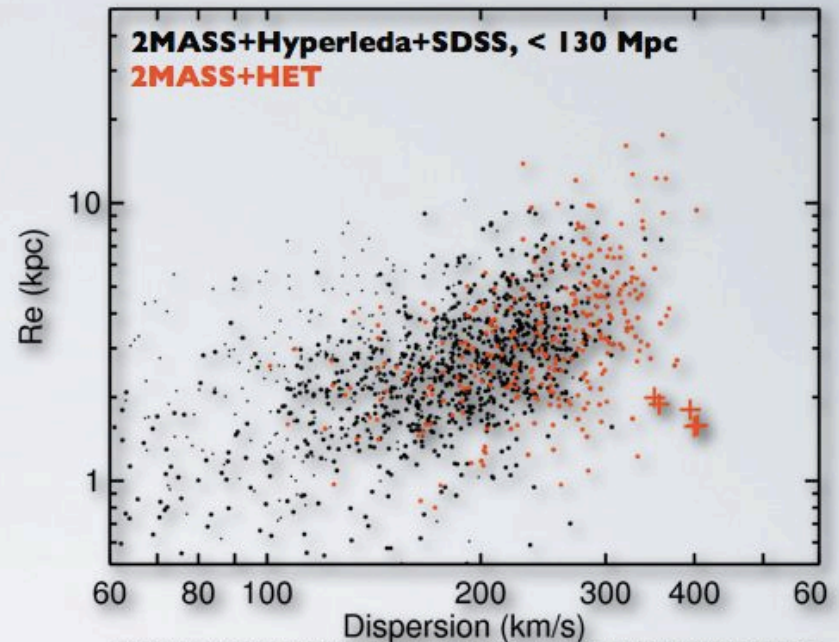
GATEWAY TO MORE BLACK HOLE MASSES

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SAMPLE OVERVIEW

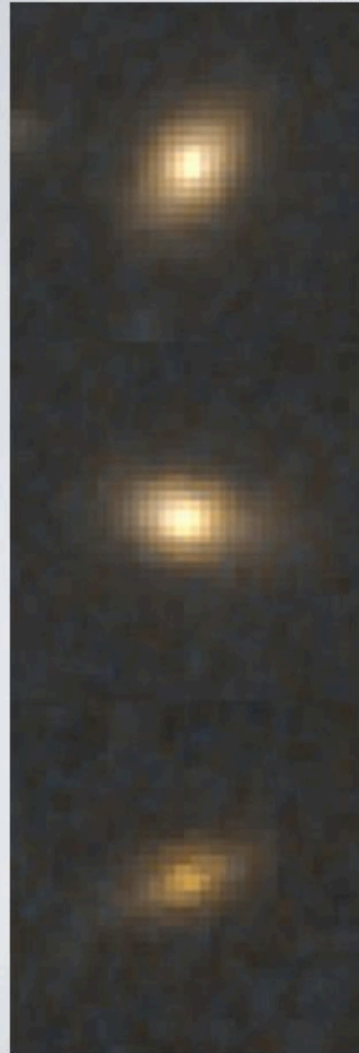
- Probing the largest dispersions and the largest masses.
- Mostly early-type galaxies
- Some galaxies have high dispersion and are very compact.



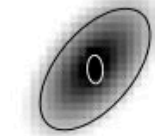
THEY ARE DISCS

van der Wel et al. 2011

Possible scenario: Size evolution happens and but these galaxies have not undergone minor merging because they are small and live in a dense cluster. Alternatively, AGN feedback is prevented because their gas reservoir got striped when they entered the cluster: Or size evolution doesn't happen.



B/T = 0.26



Rd = 1.4 kpc
Rb, eff = 0.34 kpc

B/T = 0.43



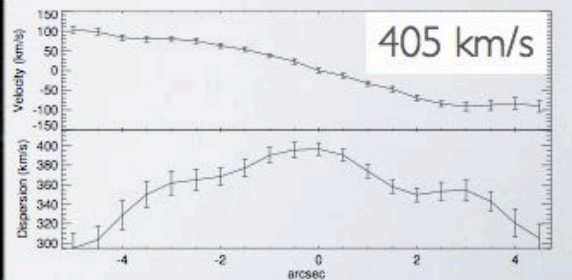
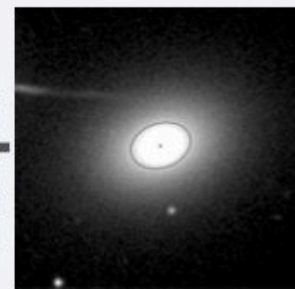
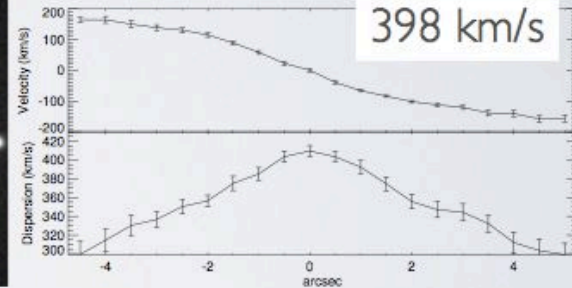
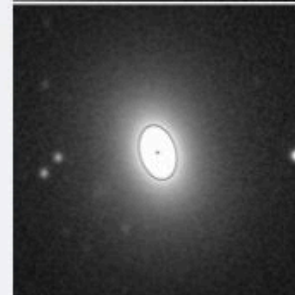
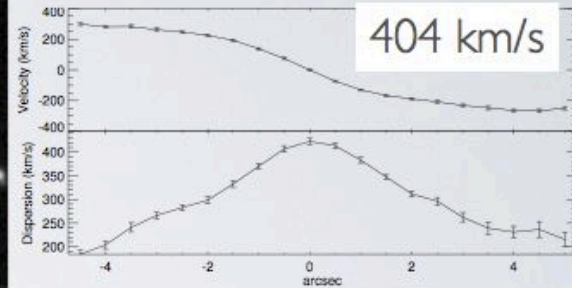
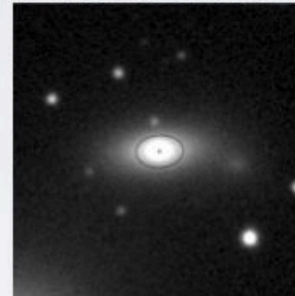
Rd = 1.9 kpc
Rb, eff = 0.58 kpc

B/T = 0.25



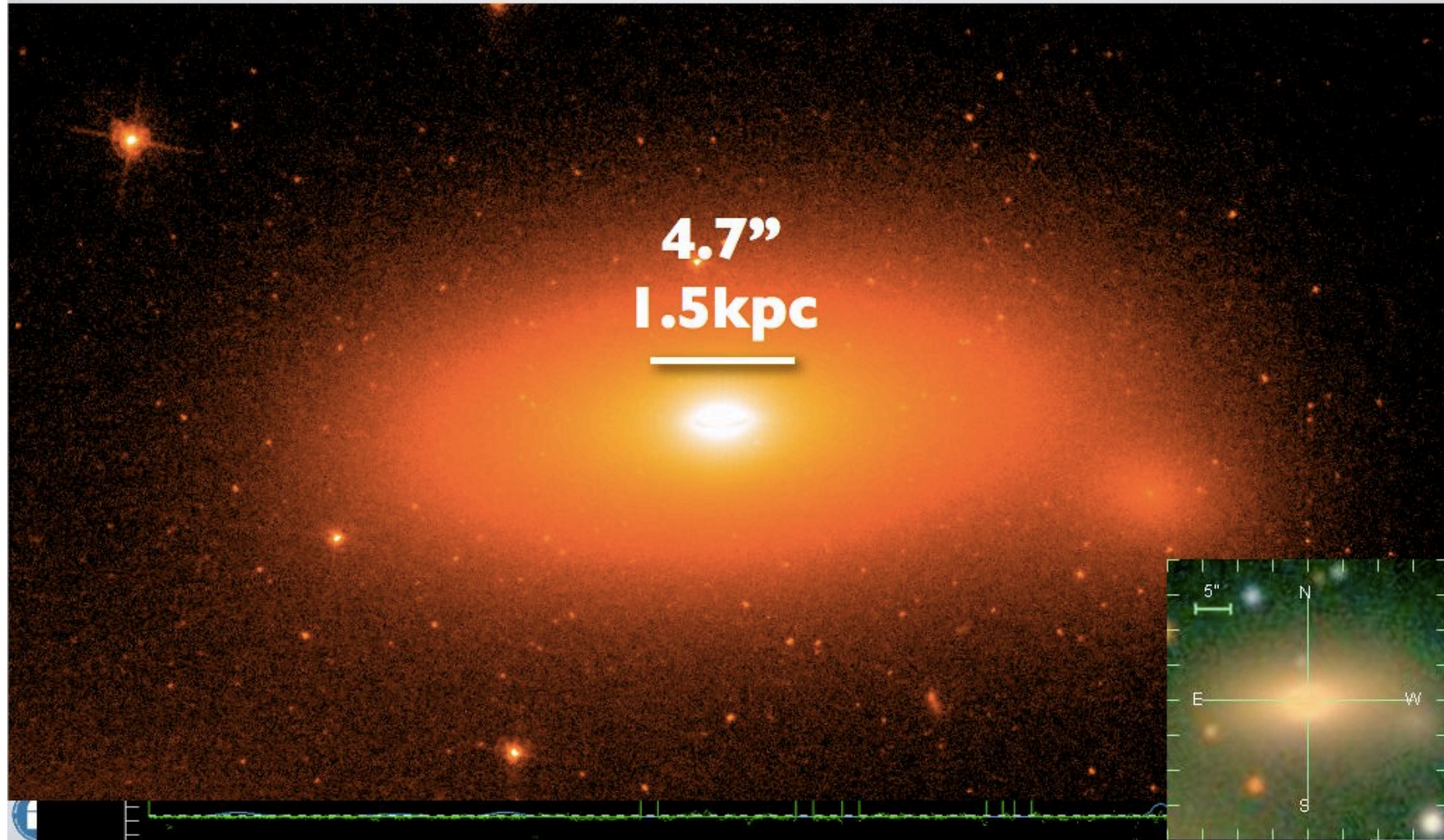
Rd = 1.7 kpc
Rb, eff = 0.33 kpc

1' or
20kpc



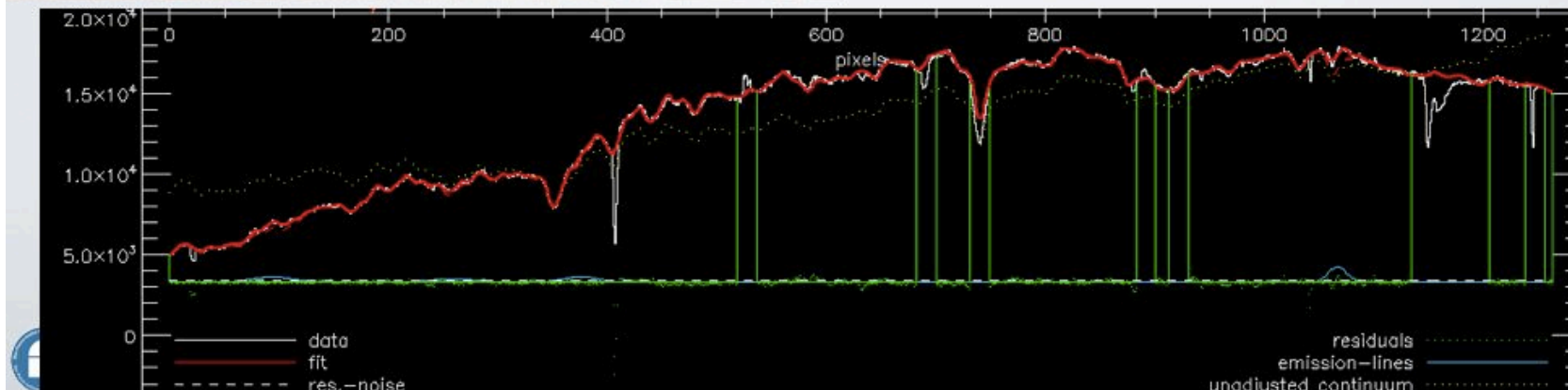
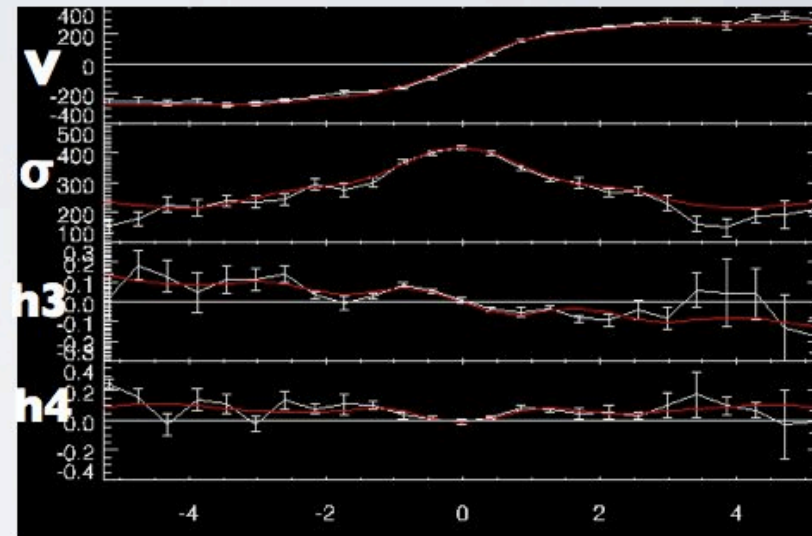
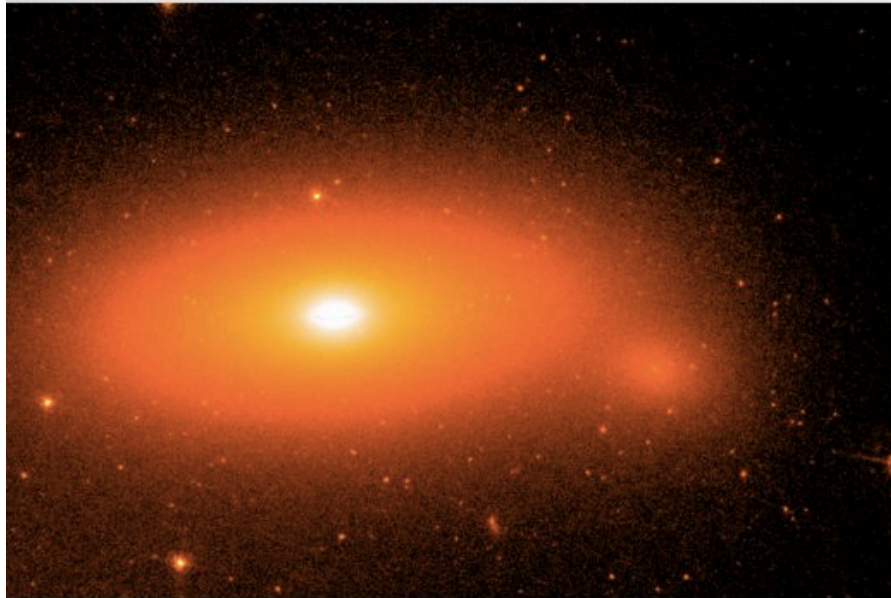
THEY ARE DISCS

Multiple Sersic decomposition shows multiple exponential ($n \sim 1$) components.



THEY ARE DISCS

STELLAR SSP MASS = $10^{10.8}$ MSUN
DYN. MASS = $10^{11.4}$ MSUN



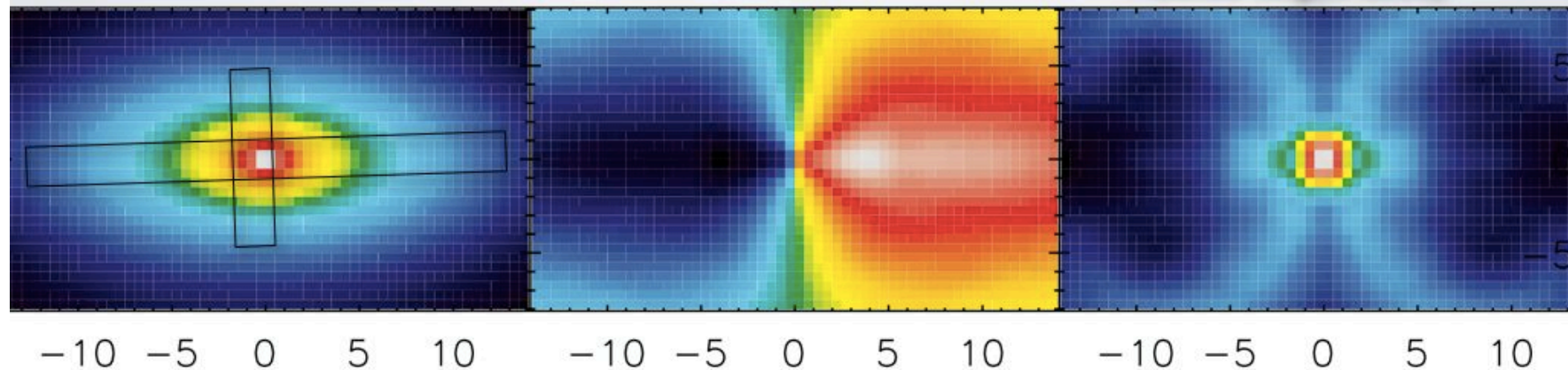
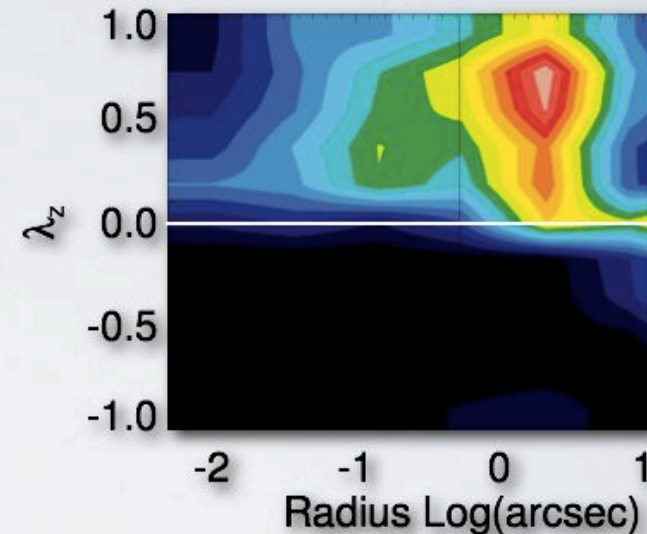
ORBITAL STRUCTURE

Multiple Sersic decomposition shows multiple exponential ($n \sim 1$) components.

Photometric stellar mass = $10^{10.8} M_{\text{sun}}$.

Dyn. mass = $10^{11.3} M_{\text{sun}}$

Based on the two slits and their higher velocity moments we determined that the high dispersion is consistent with a central 'thick disk'



CONCLUSIONS

- Black hole scaling relations are under-sampled at high and low mass end.
- HET massive galaxy survey contains most of the nearby massive galaxies. Large potential for follow-up.
- More than 69 confirmed new targets for black hole mass measurements
- Some high dispersion galaxies are remarkably compact.

