The MASSIVE SURVEY

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Ma et al (2014) arXiv 1407.1054

The MASSIVE Survey

An integral field spectroscopic survey
of the ~100 most massive early-type galaxies within ~108 Mpc

Volume-limited, selected based on stellar mass (K-band mag)

Also a multi-wavelength, photometric survey

Use spatially-resolved 2-d stellar kinematics
to study the formation history of
early-type galaxies and their central black holes
in the nearby universe

The MASSIVE Survey

Why study the most massive ETGs? They are potential

- Hosts of the most massive black holes
- Quiescent counterparts of high-z luminous quasars
- Descendants of z~2 massive SF galaxies & compact red nuggets
- Sites of varying IMFs

Why another galaxy survey?

- Only ~65% of MASSIVE galaxies have SDSS photometry
- Only ~25% have SDSS spectra (single 3" fiber)
- Only 6 are in Sauron/ATLAS^{3D} survey (260 galaxies)
- Only 2 are in SLUGGS survey (25 galaxies)
- Only ~75% live in identifiable group/cluster environments

Sample Selection

Stellar-mass selected

K < - 25.3 (2MASS XSC)

$M^* > 10^{11.5}\ M_{sun}$

ATLAS: K < -21.5

Volume limited

D < 108 Mpc (2MASS Redshift Survey)

Include Virgo & Coma Clusters

ATLAS: D < 42 Mpc

Morphology

~100 Early-type galaxies (Hyperleda)

Mostly ellipticals

A handful S0s

ATLAS: many fast rotators, S0s

Additional criteria

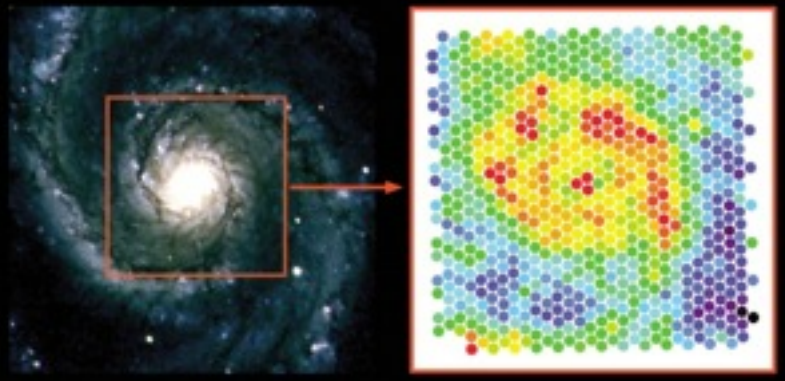
Dec > -6 Av < 0.6

No overlapping neighbors

The MASSIVE Survey

Combine wide-field and high-resolution (AO) IFUs

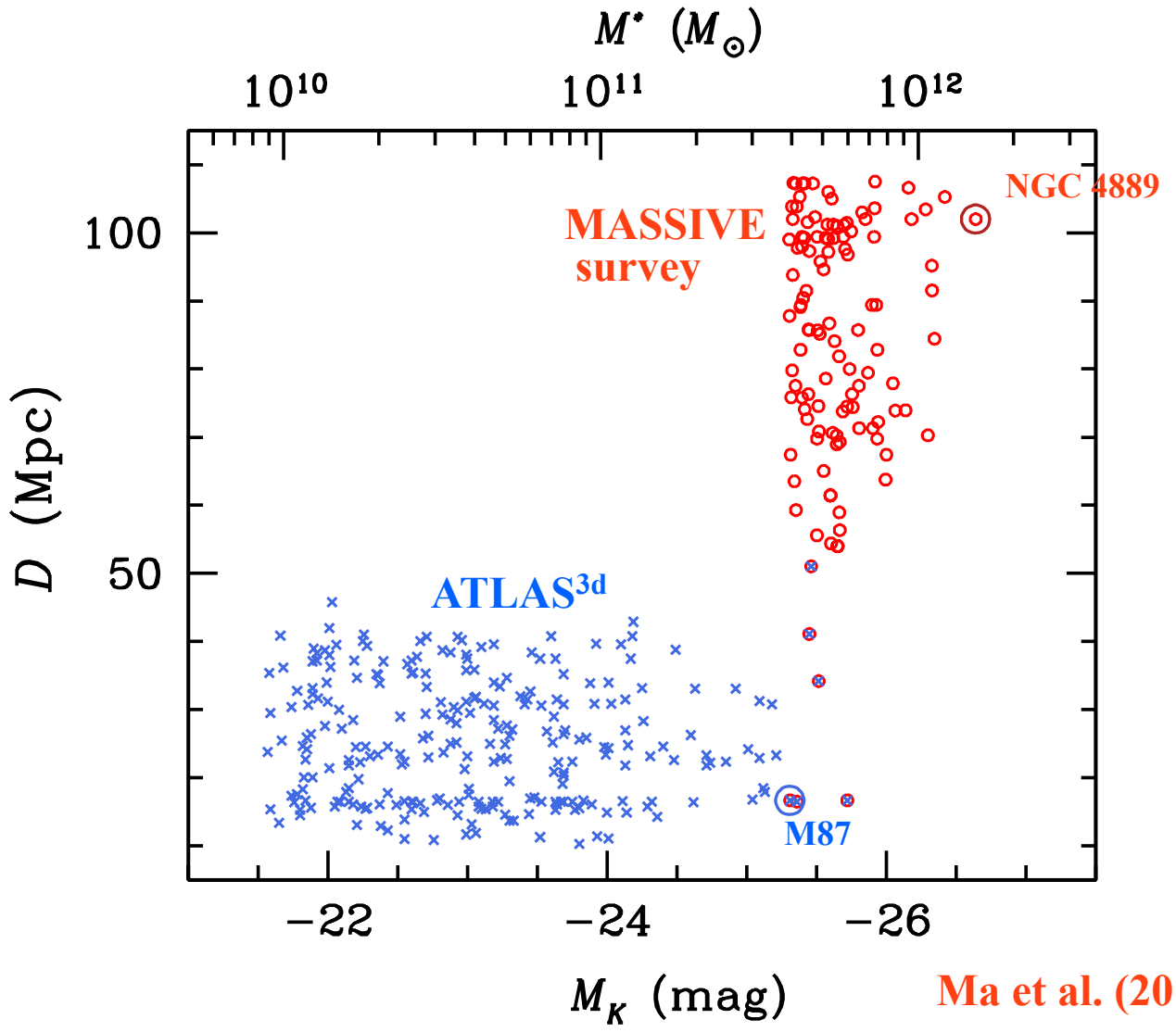
Wide-field (107”x107”)
- Mitchell IFU McDonald 2.7m
- 246 fibers each 4”
- 3600-5800 å
- Out to ~2 Re for >50% galaxies



High-resolution (~0.1” to 3”)
- OSIRIS + AO Keck
- NIFS + AO Gemini
- GMOS N+S Gemini

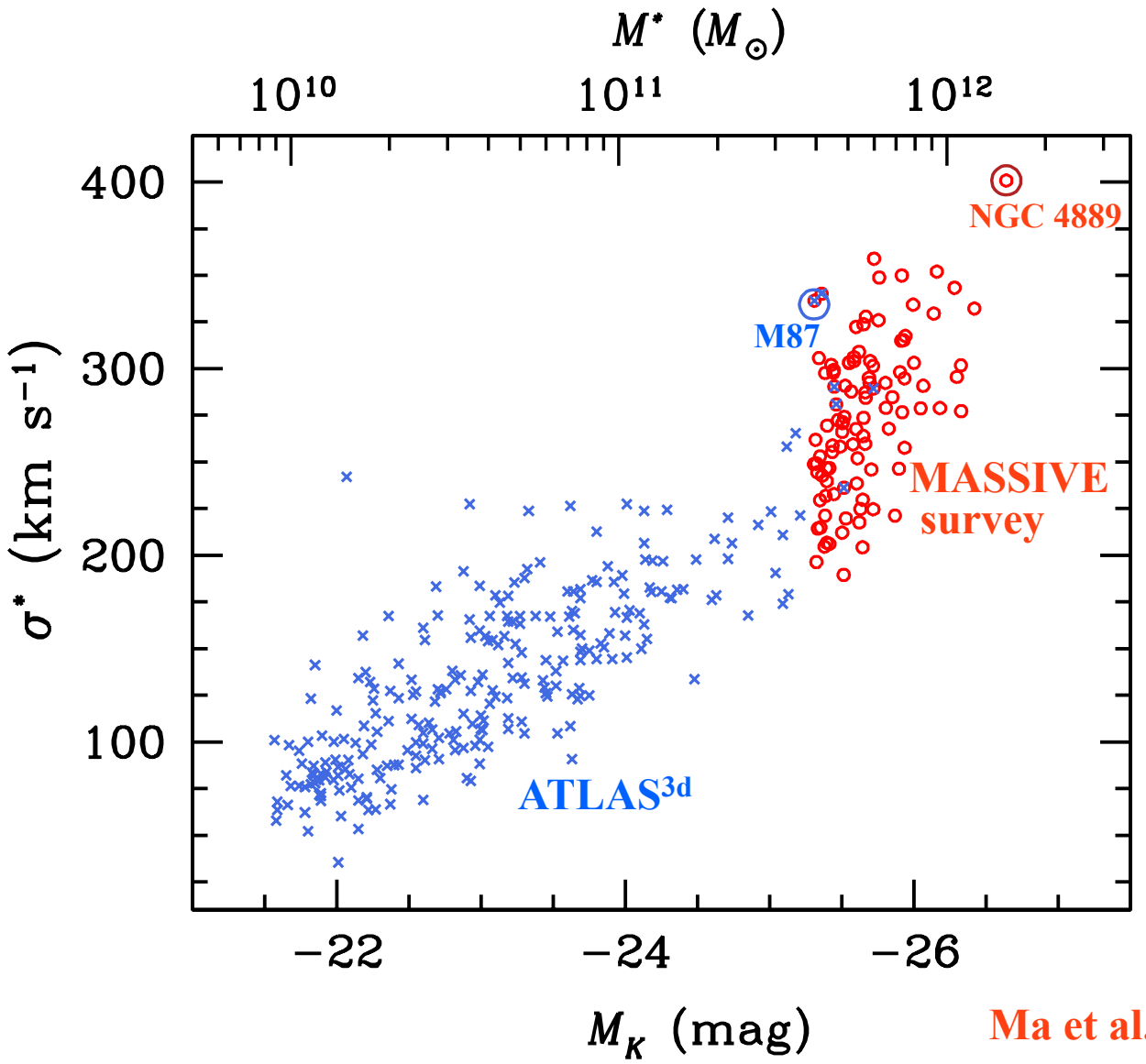
Photometry
- CFHT, UKIRT, HST, PanSTARRS

New parameter space: stellar mass and distance



Ma et al. (2014)

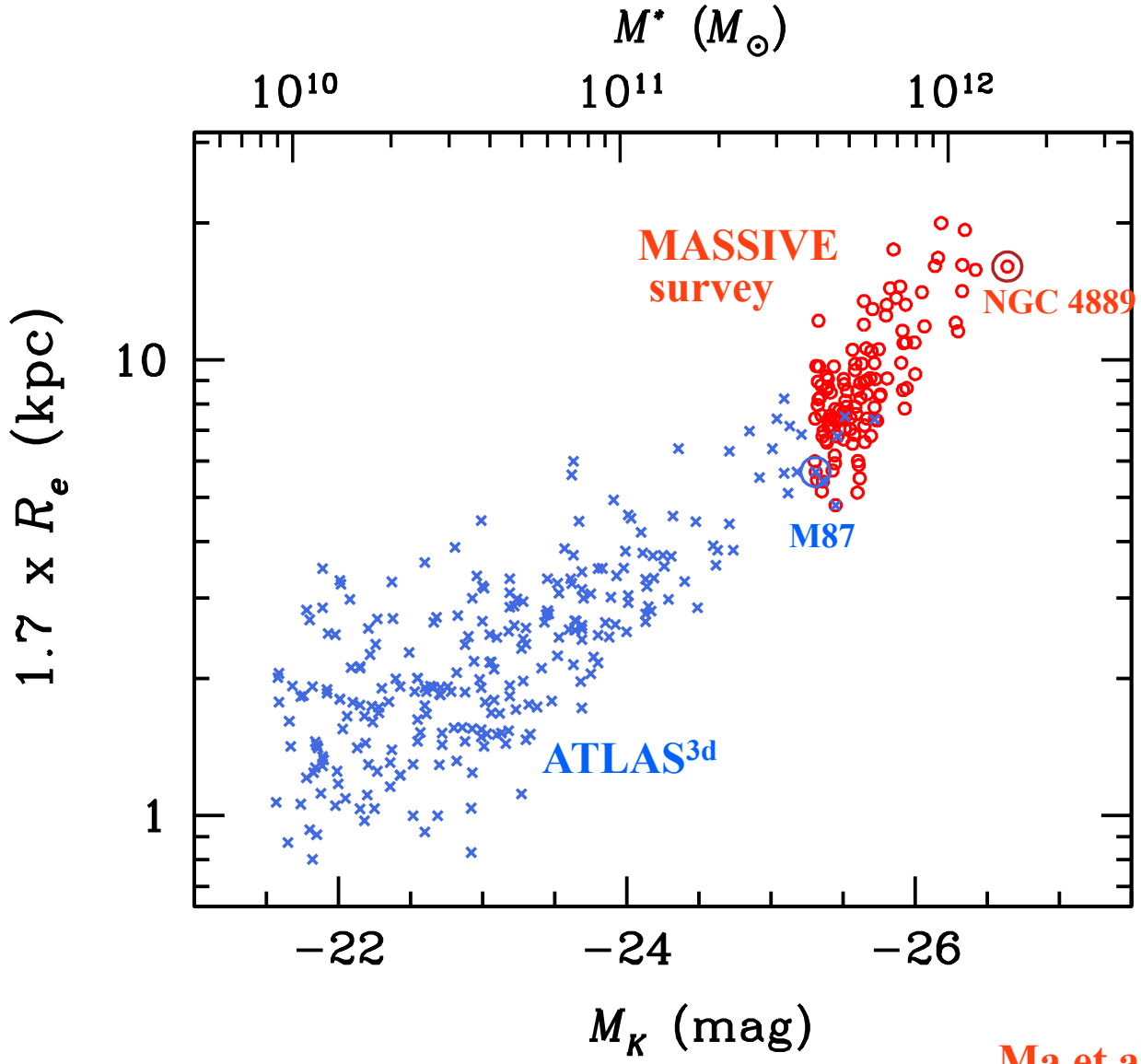
L - σ Relation



No cuts on velocity dispersions

Ma et al. (2014)

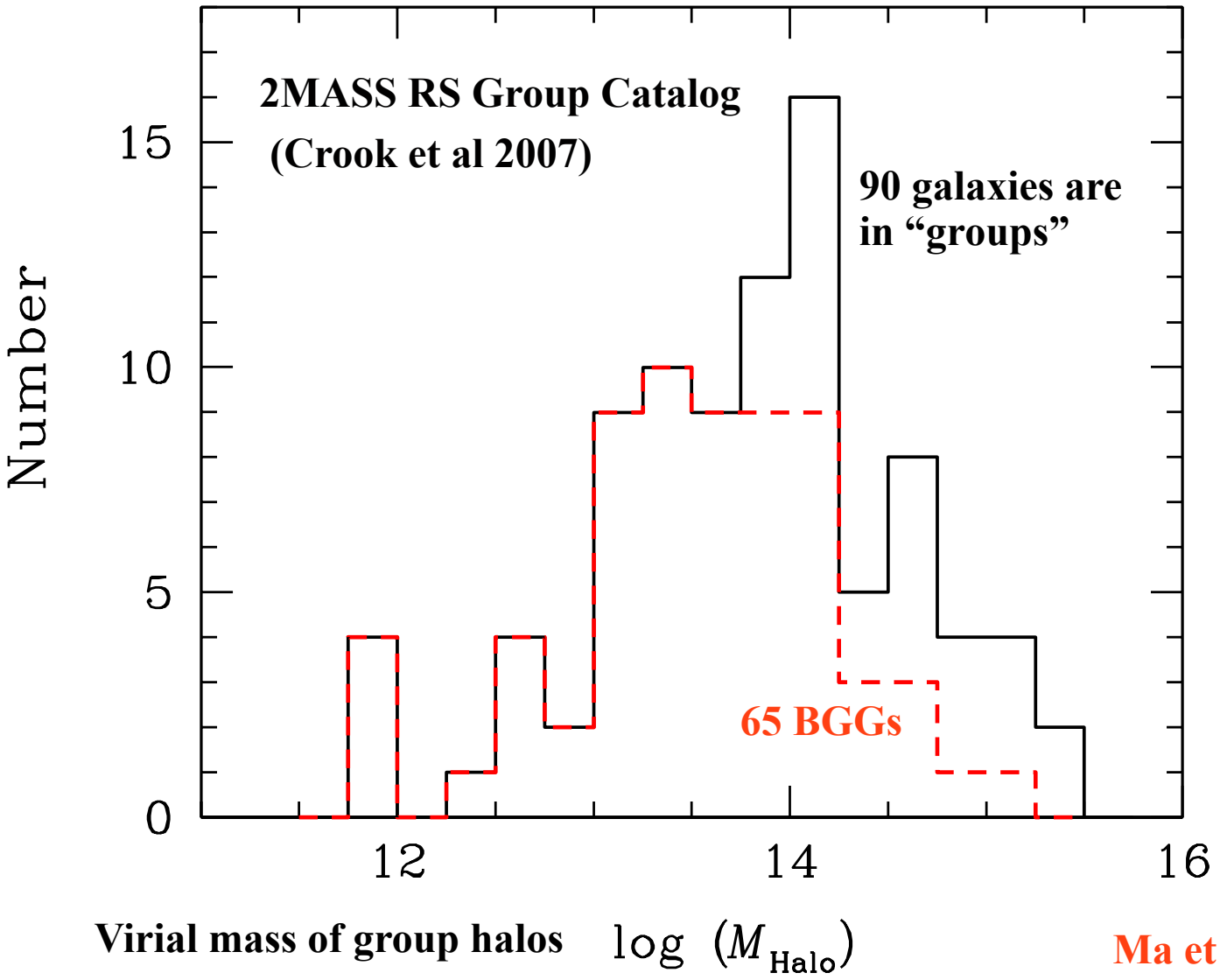
Size - Mass Relation



No cuts on size

Ma et al. (2014)

Diverse Environment

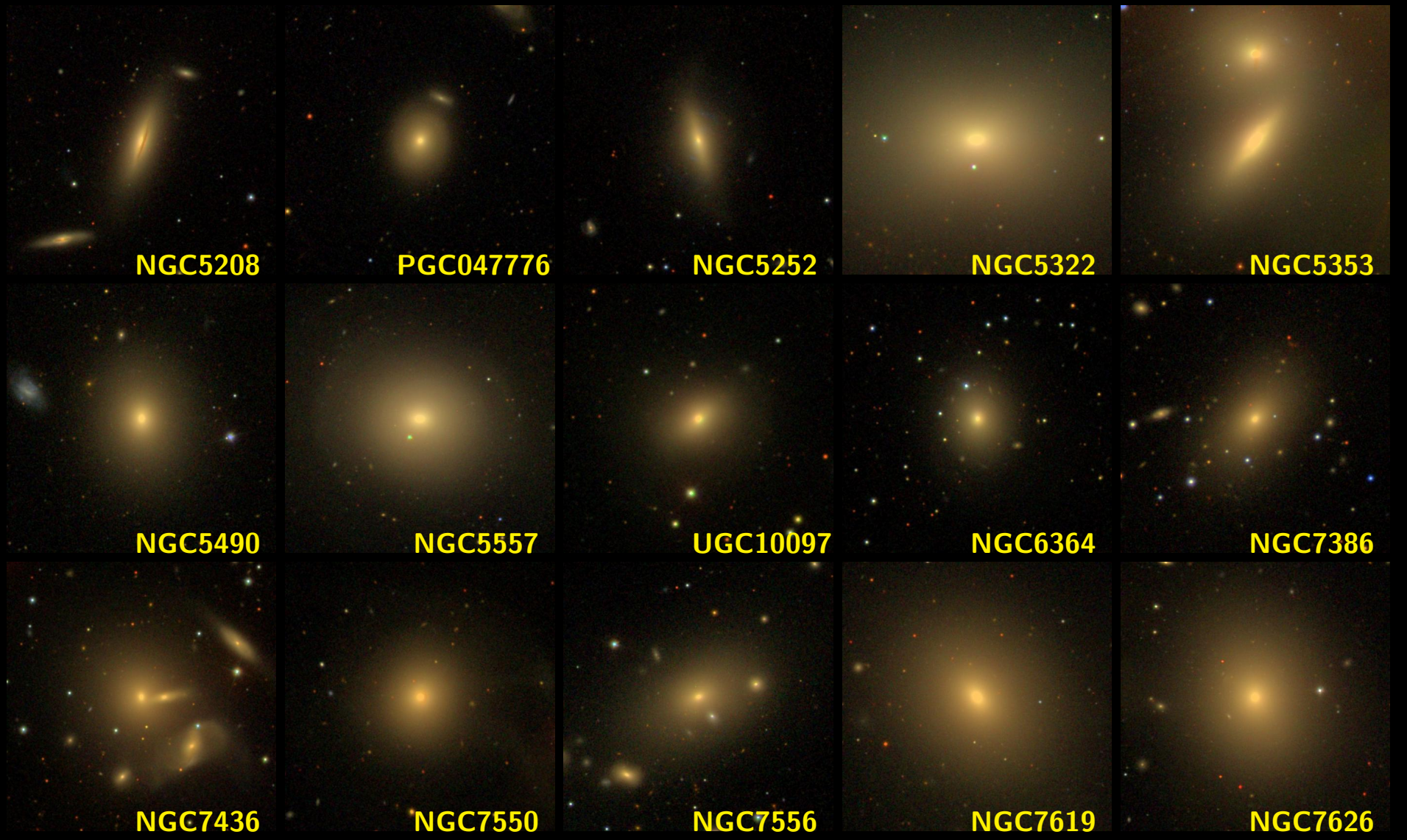


26 are group less

~50% of galaxies in groups with $M_{halo} > 10^{13.7} M_{sun}$ are not Brightest Group Galaxies

Ma et al. (2014)

SDSS Composite Images



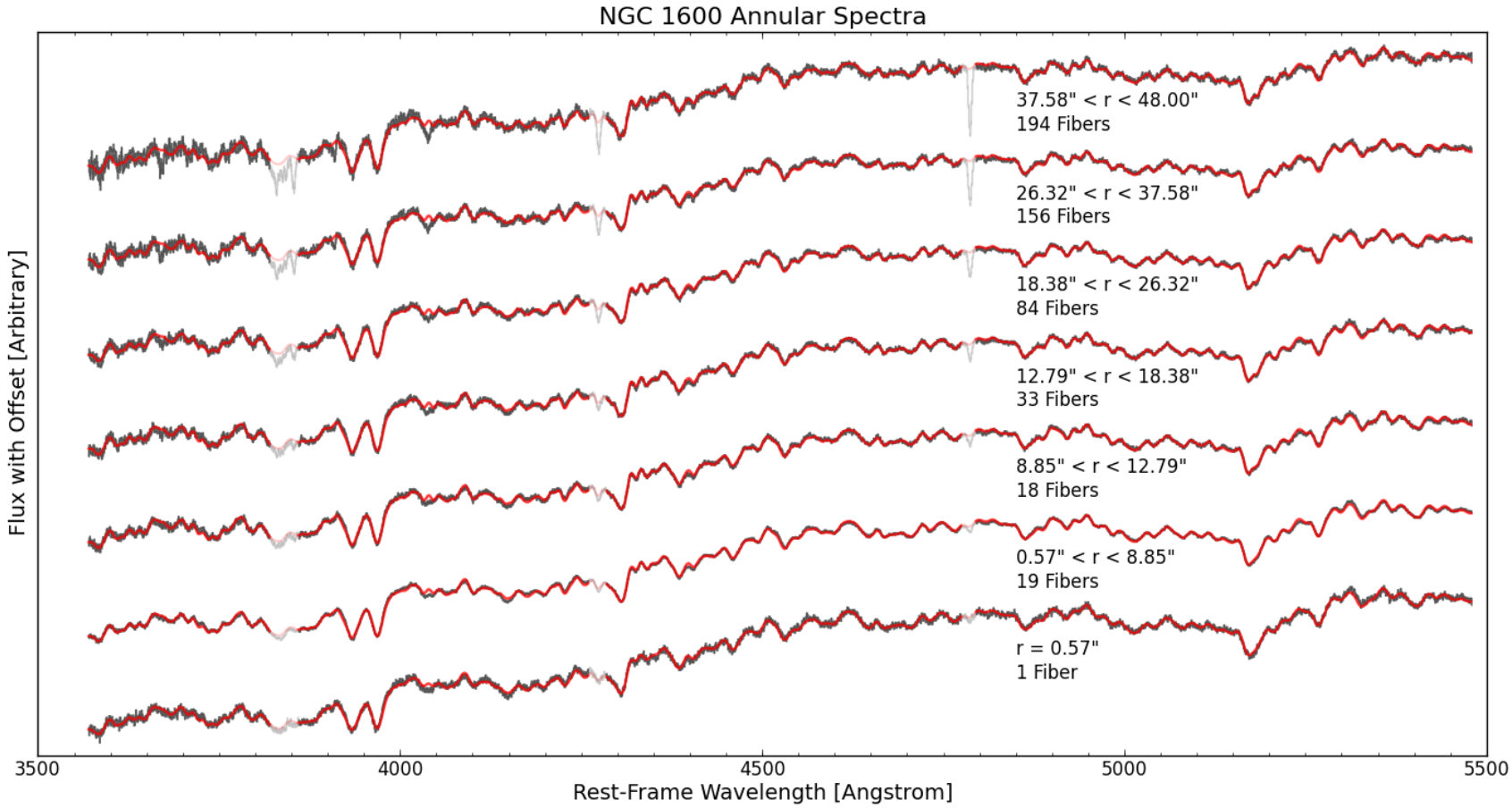
Survey Status

Entire Sample (K < -25.3, D<108 Mpc)
116 candidate galaxies
High Priority Targets (K < -25.5, D<105 Mpc)
71 candidate galaxies

McDonald Mitchell IFU (~4 to 107 arcsec)
In hand: **IFU data** for 50+ galaxies
Data mostly reduced
Extracting stellar kinematics
Running mock tests & orbit models
Stellar population gradients

Gemini/Keck IFU + AO (~0.1 to 3 arcsec)
20+ candidates for M_{bh}
Among these, 7 have published M_{bh}
In hand: 5+ others

Mitchell IFU Spectra



Black: data

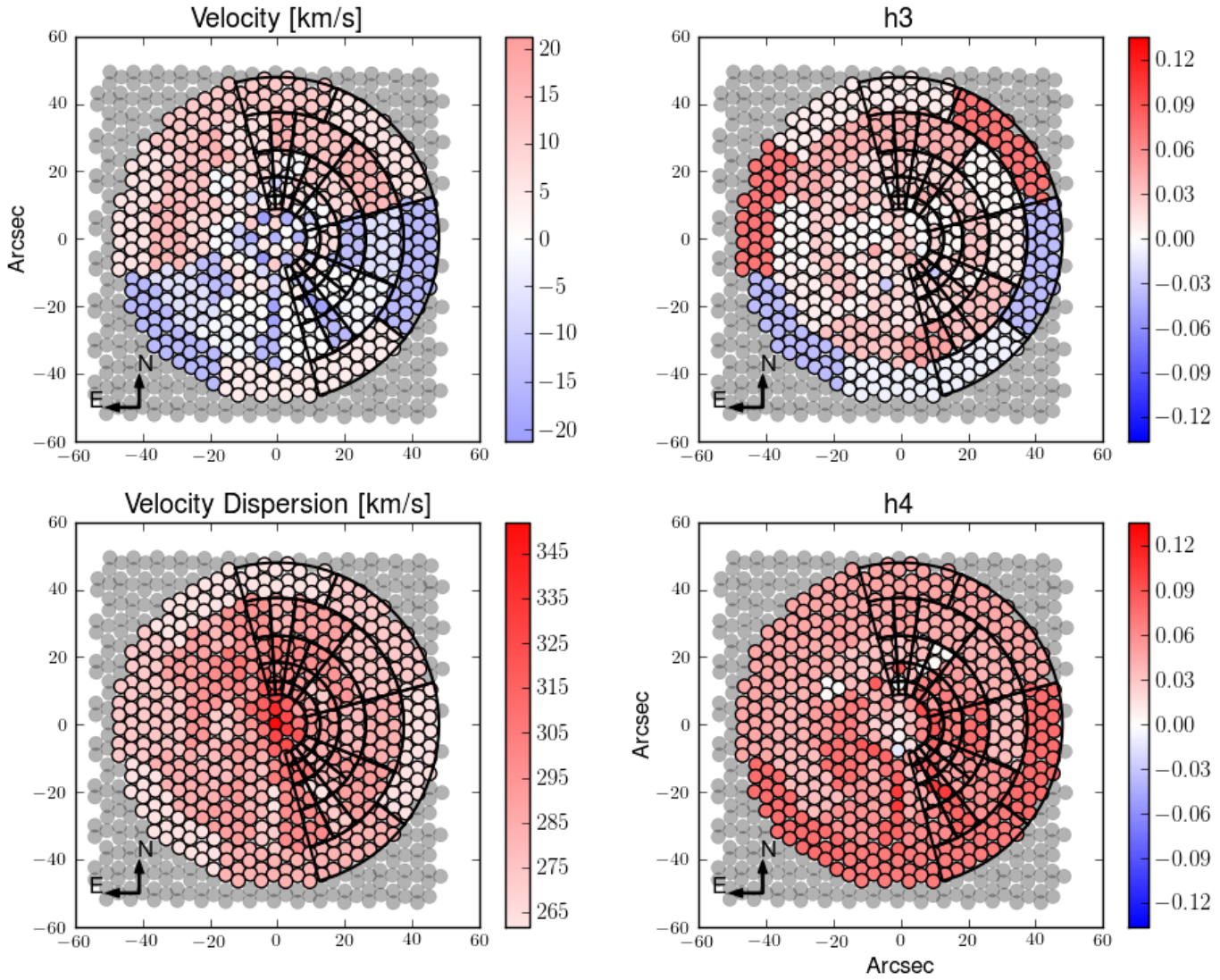
Red: pPXF fits

NGC 1600: Kinematic Maps

Janish et al (2014 in prep)
Thomas et al (2014 in prep)

V

σ

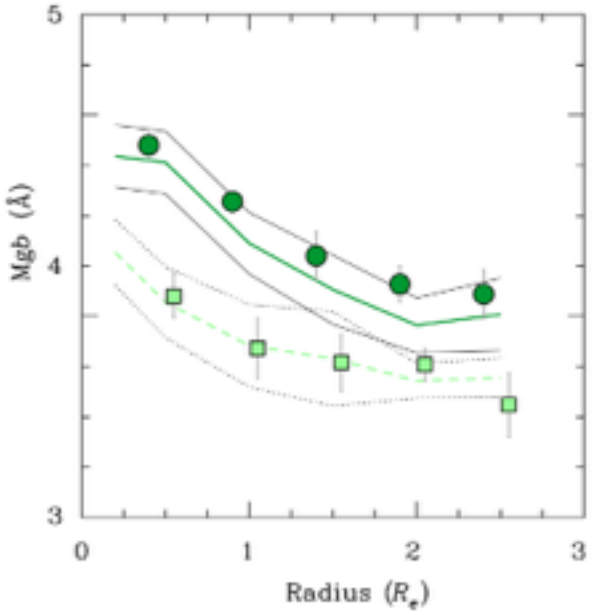


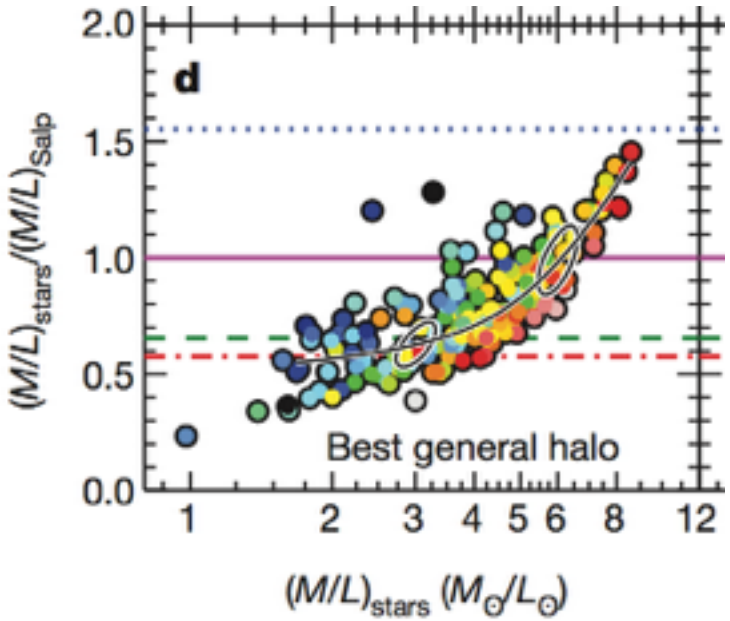
h_3

h_4

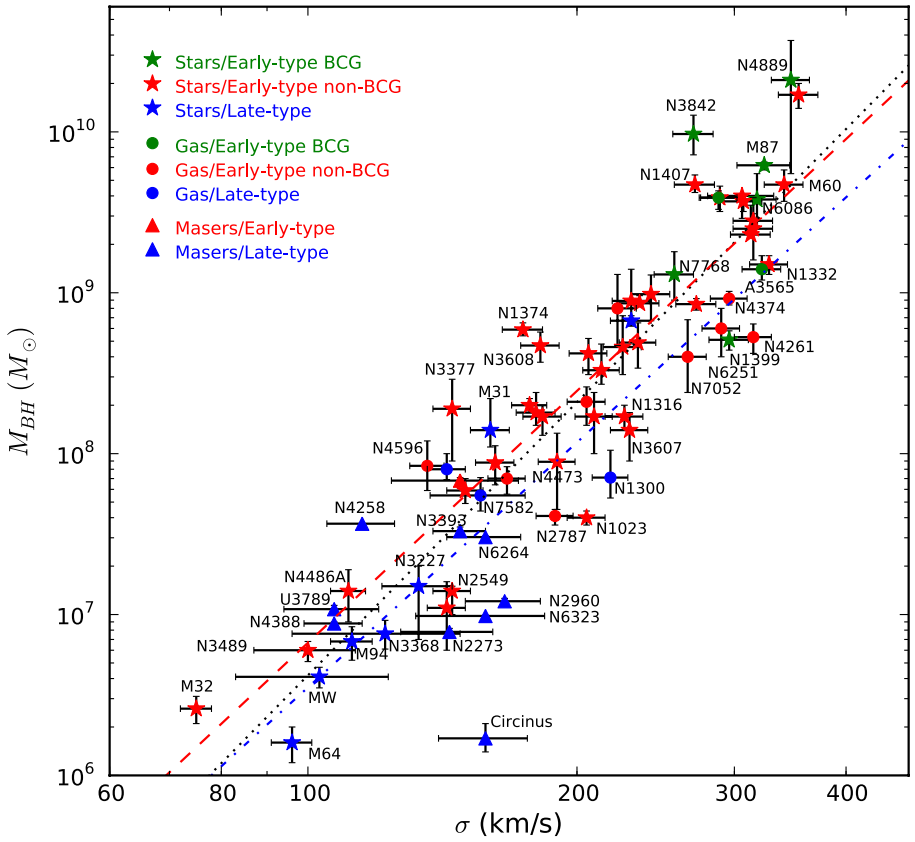
Examples of Survey Science

Chemical abundance gradients
Greene et al (2013)



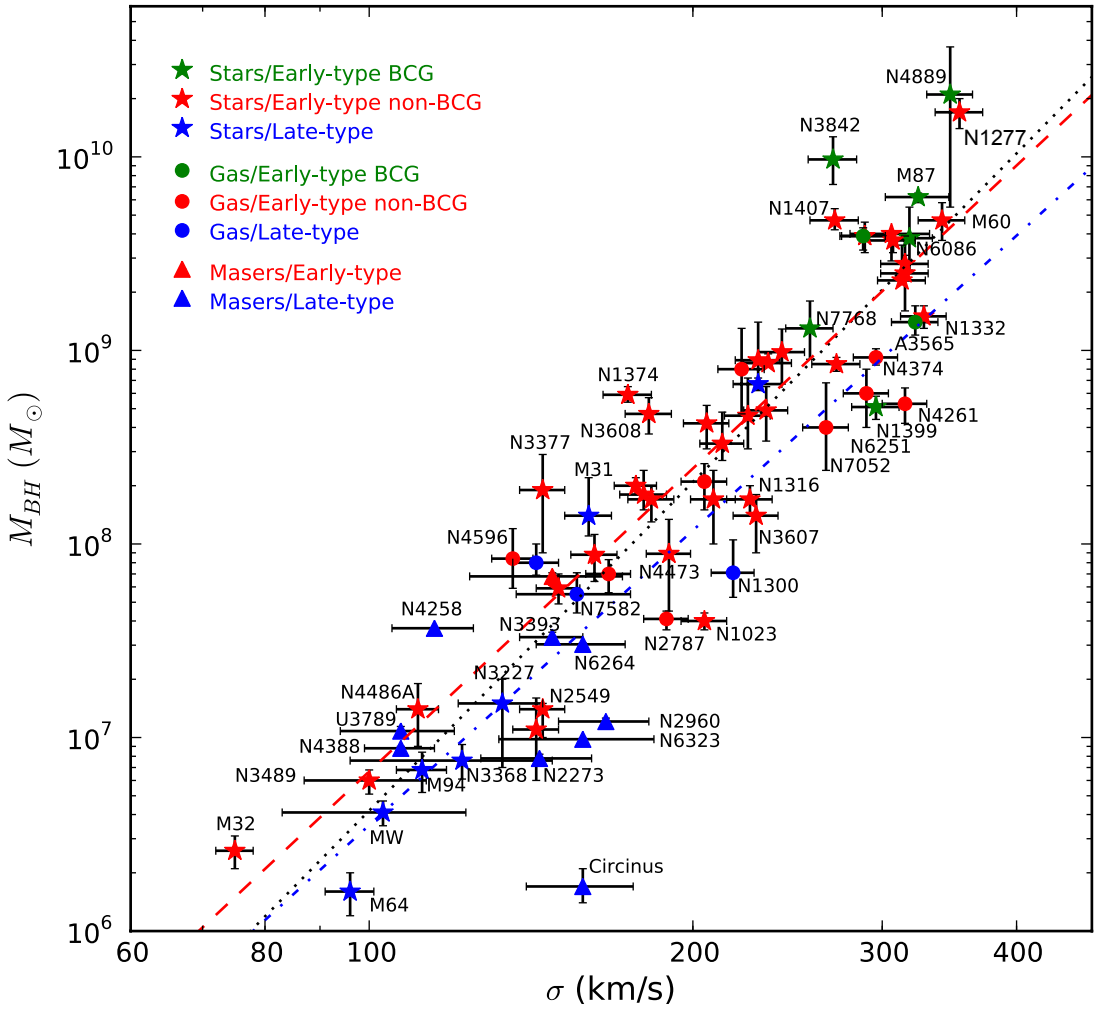


Black hole-galaxy correlations
McConnell & Ma (2013)



Dynamical M*/L
IMF variations
Cappellari et al (2012)

$M_{BH} - \sigma$ Relation



All 72 galaxies

$$M_{BH} \propto \sigma^{5.64 \pm 0.32}$$

$$(\epsilon_0 = 0.38)$$

53 early-type galaxies

$$M_{BH} \propto \sigma^{5.20 \pm 0.36}$$

$$(\epsilon_0 = 0.34)$$

19 late-type galaxies

$$M_{BH} \propto \sigma^{5.06 \pm 1.16}$$

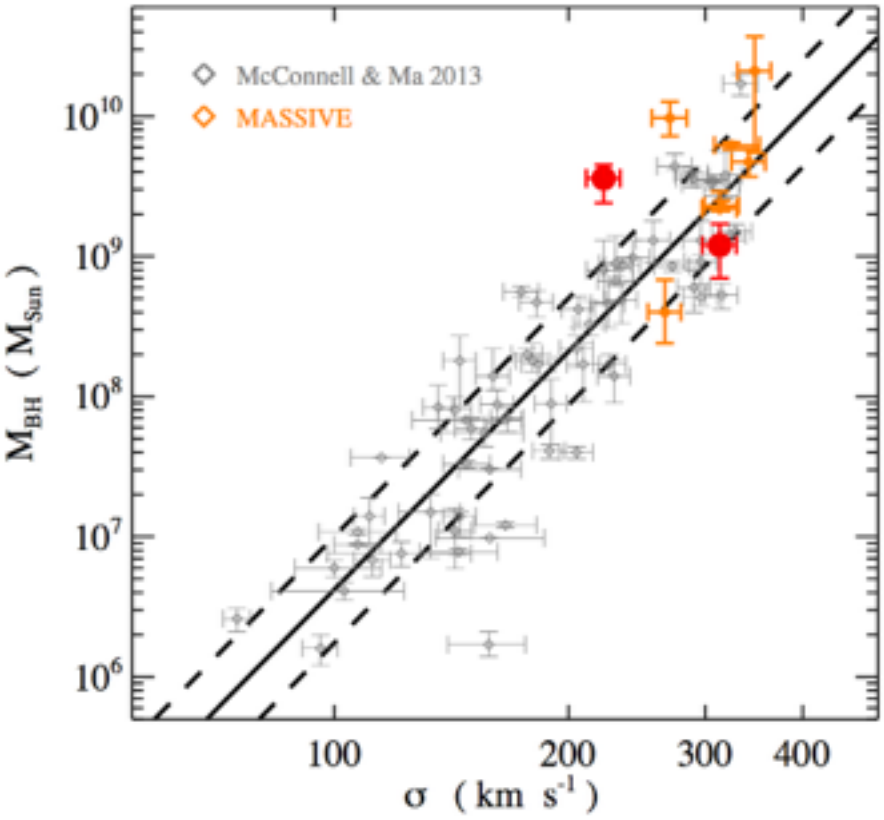
$$(\epsilon_0 = 0.46)$$

McConnell & Ma (2013)

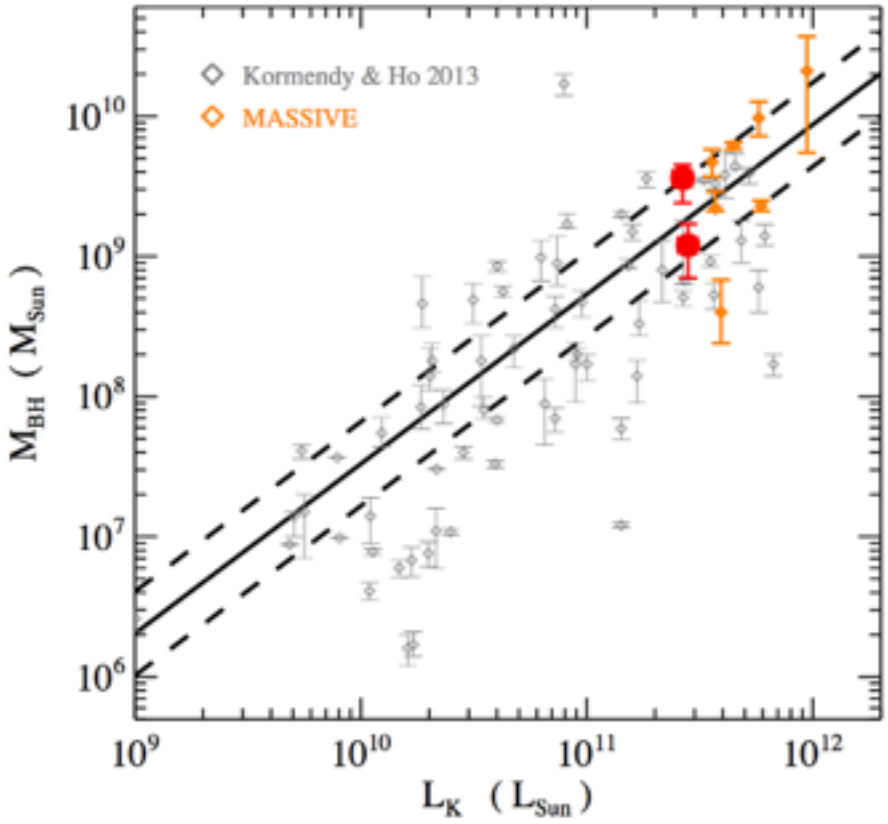
Black Hole - Galaxy Correlations

McConnell et al (2014 in prep)

$M_{BH} - \sigma$ Relation



$M_{BH} - L_v$ Relation



The MASSIVE Survey

Summary

Survey in progress, targeting new parameter space

$M^* > 10^{11.5}\ M_{sun}$ D < 108 Mpc

Deep K-band imaging on CFHT and UKIRT

~1/3 have HST and Chandra/XMM archival data

HI or CO gas?

Welcome input, collaboration, theoretical interpretation

MASSIVE = ?

the **M**itchell spectrograph **A**ssembly of **S**tars and **S**tuff
with **I**ntegral-field spectroscopy in the **V**isible,
oh, and we're looking at **E**arly-type galaxies

OR simply **MASSIVE!**