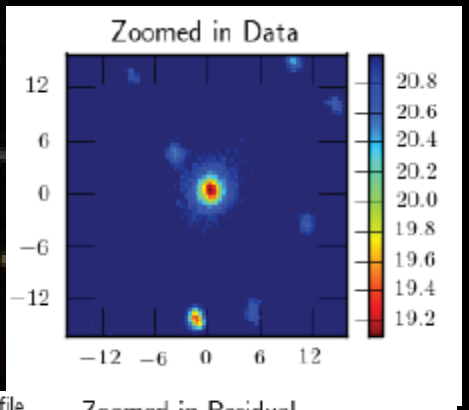
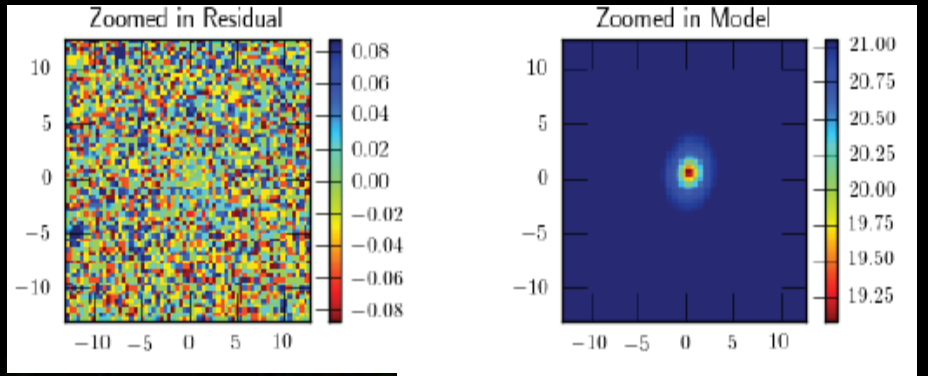
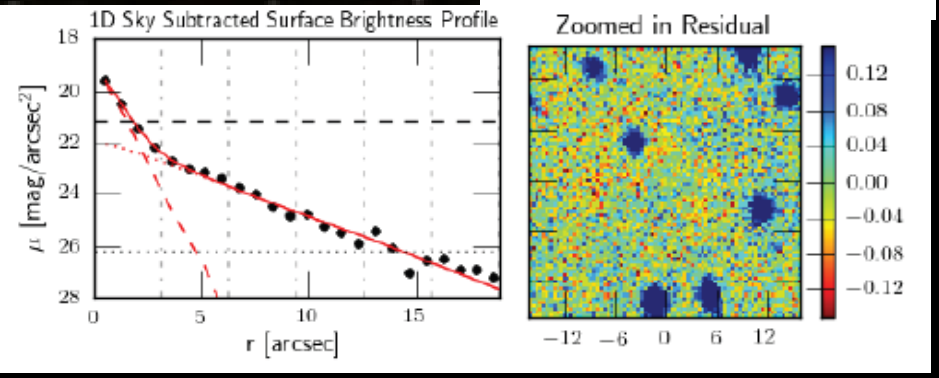
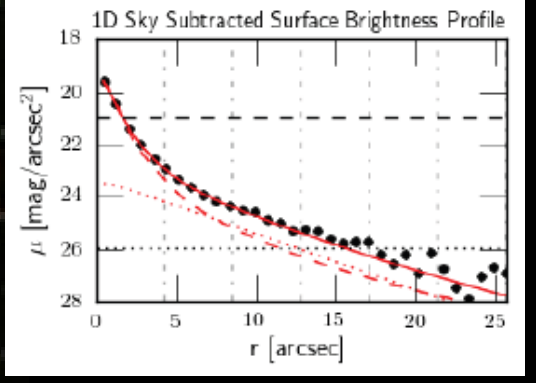
Massive galaxies: improved photometry and consequences

M. Bernardi
UPenn







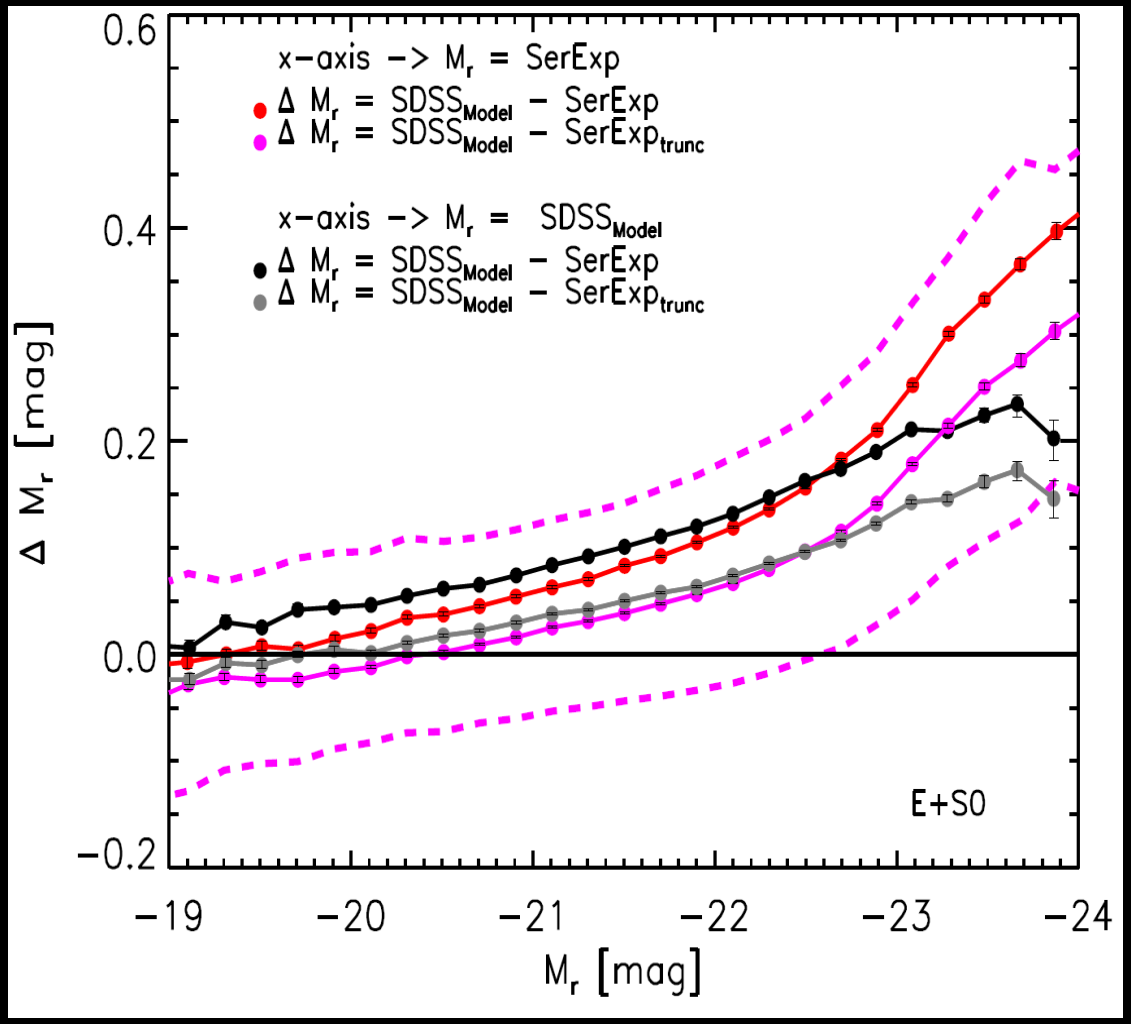


Outline

- Better photometry of SDSS massive galaxies
  - Stellar Mass Function/Variable IMF
  - Dark matter fraction

- Selection bias in SMBH samples having dynamically measured masses

Better photometry of the brightest SDSS galaxies .....



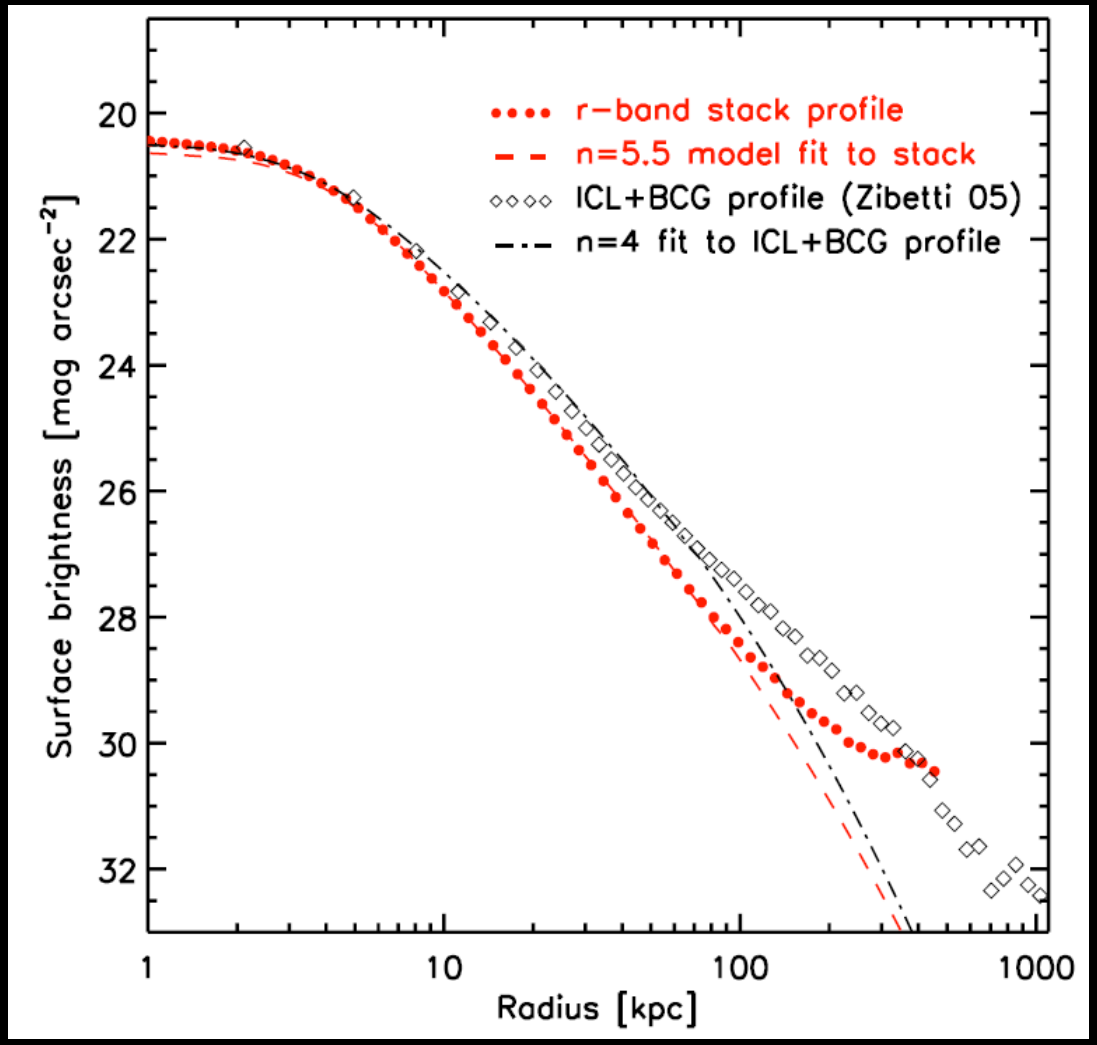
- Dependence on sky
- Dependence on fitted model/truncation
- Dependence on ICL

Bernardi et al. 2013 -- 2017

It is more than semantics .....

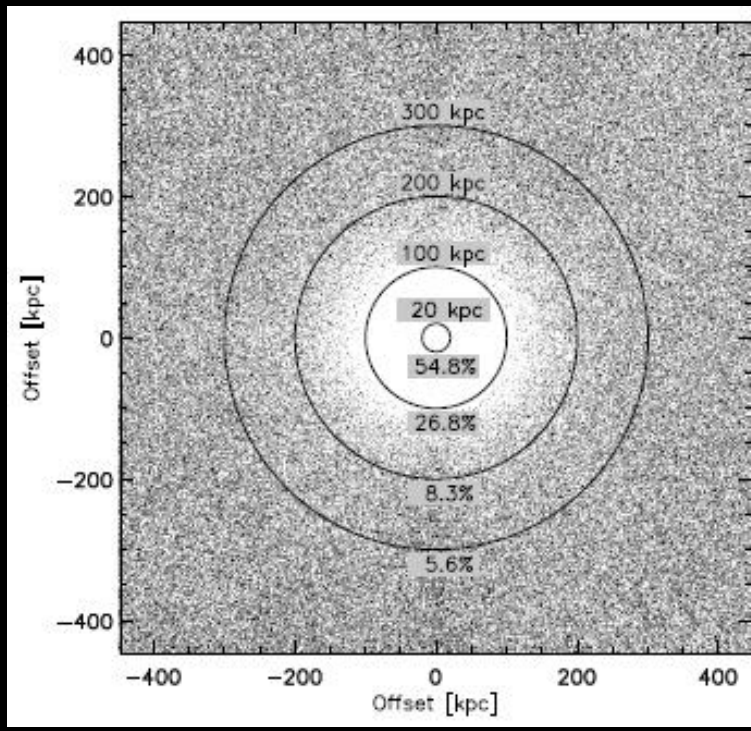
1) SDSS 1% of sky level is ~ 26 mag/arcsec^2

Individual SDSS galaxy profiles CANNOT be dominated by ICL



Tal & van Dokkum 2011

Stacking analysis of LRGs and BCGs



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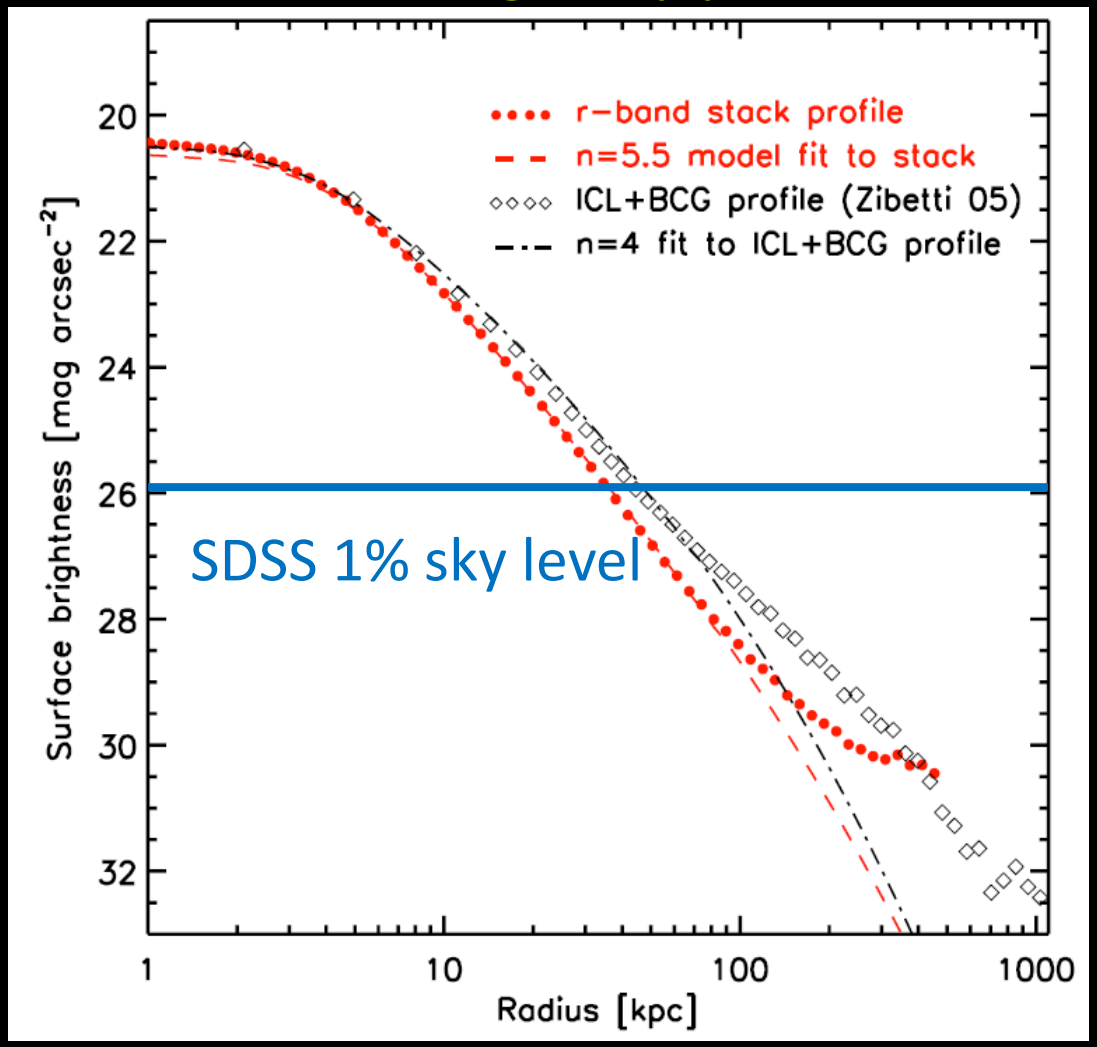

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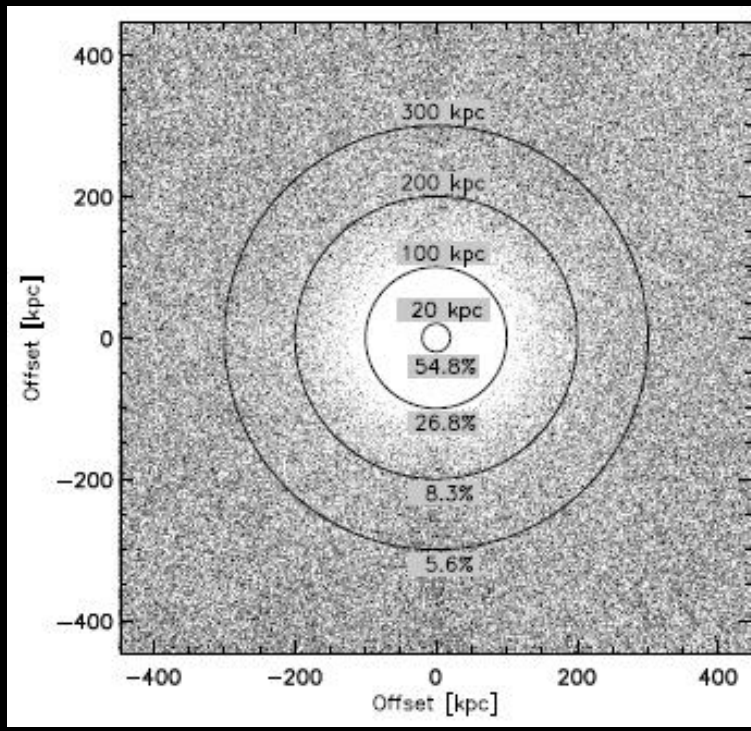
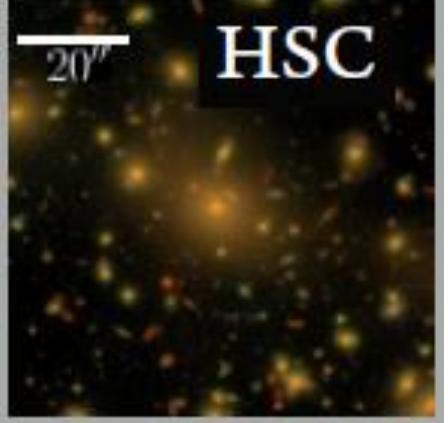




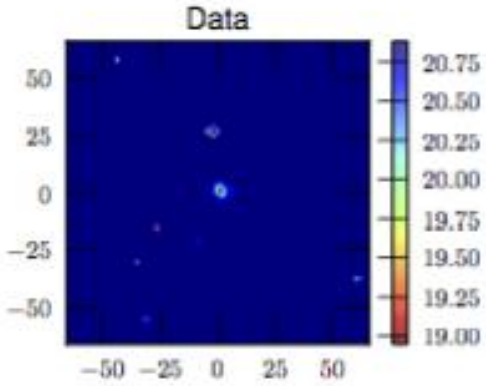
M_{serexp} = -23.649
m_{serexp} = 15.919
B/T_{serexp} = 0.71
n_{serexp} = 4.60
$r_{hl,cir,serexp}$ = 4.29
$r_{bulge,serexp}$ = 3.60
$r_{disk,serexp}$ = 4.42
$pa_{bulge,serexp}$ = 35.58
$pa_{disk,serexp}$ = -0.67
$ba_{bulge,serexp}$ = 0.69
$ba_{disk,serexp}$ = 0.89

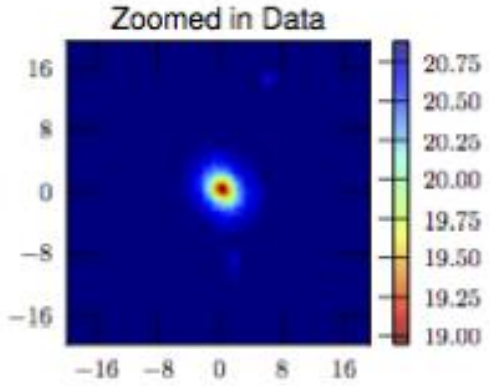
FLAGS

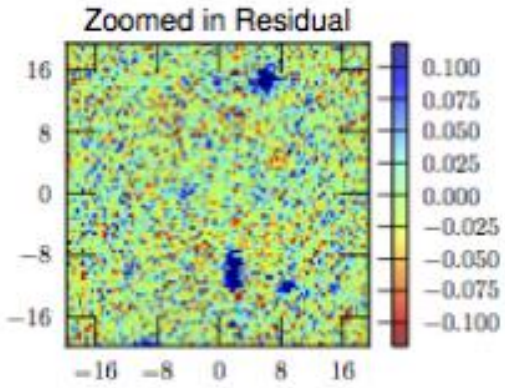
Good Total Magnitudes and Sizes

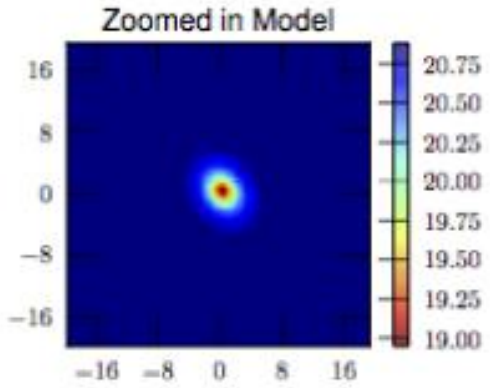
Two-Component Galaxies

No Flags

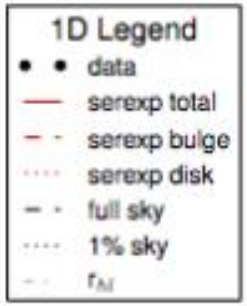


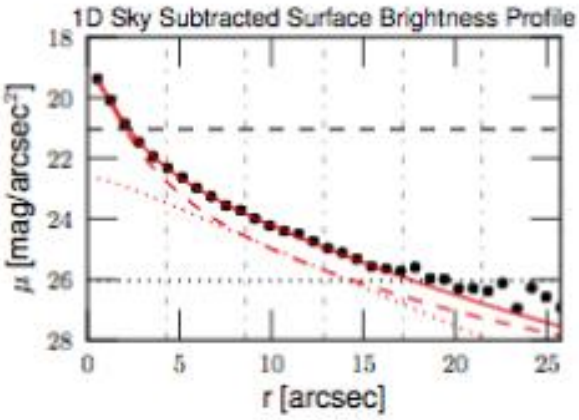


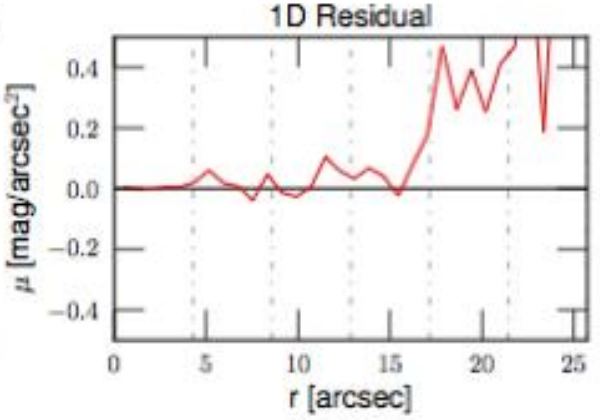




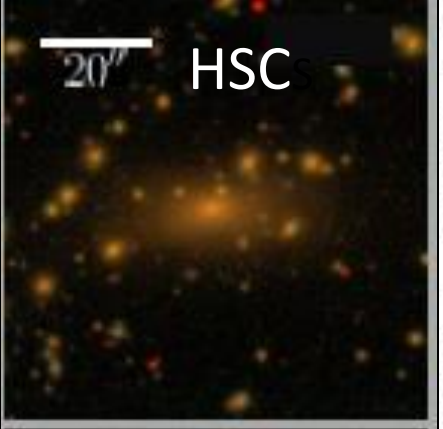
Z ~ 0.19
M_r ~ -23.6
R_{hl} ~ 13 kpc
$n_{Ser(Bulge)}$ ~ 5
n_{Ser} ~ 5.5







Bernardi et al. 2017b



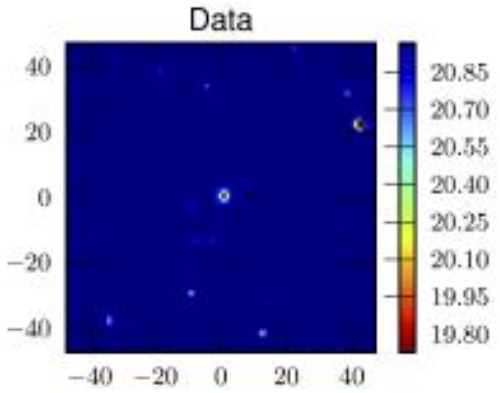
M_{serexp} = -23.439
m_{serexp} = 17.429
B/T_{serexp} = 0.68
n_{serexp} = 5.03
$r_{hl,cir,serexp}$ = 3.48
$r_{bulge,serexp}$ = 1.82
$r_{disk,serexp}$ = 7.01
$pa_{bulge,serexp}$ = -58.75
$pa_{disk,serexp}$ = -34.32
$ba_{bulge,serexp}$ = 0.91
$ba_{disk,serexp}$ = 0.55

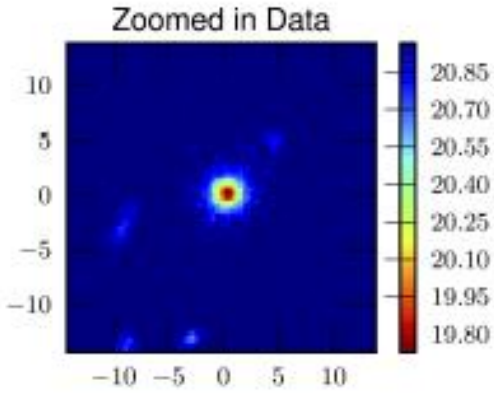
FLAGS

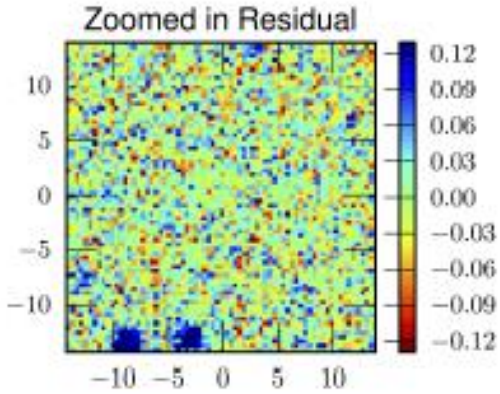
Good Total Magnitudes and Sizes

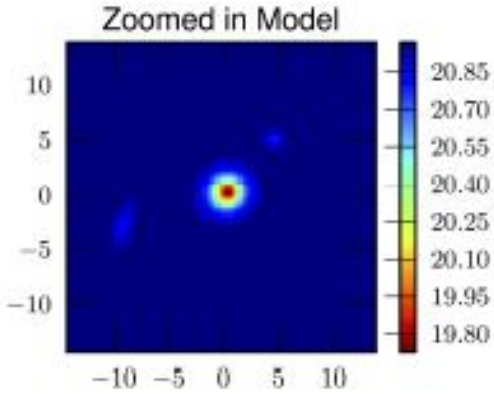
Two-Component Galaxies

No Flags

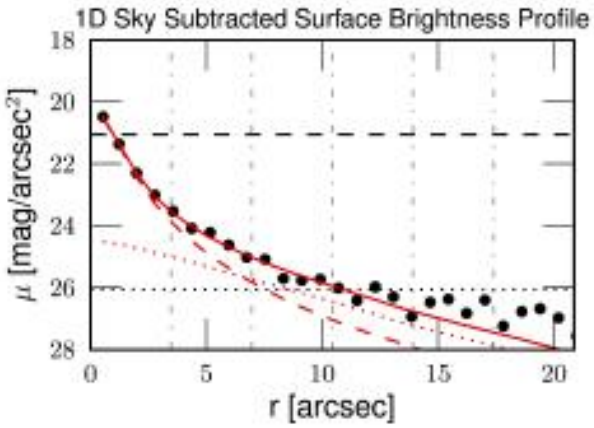


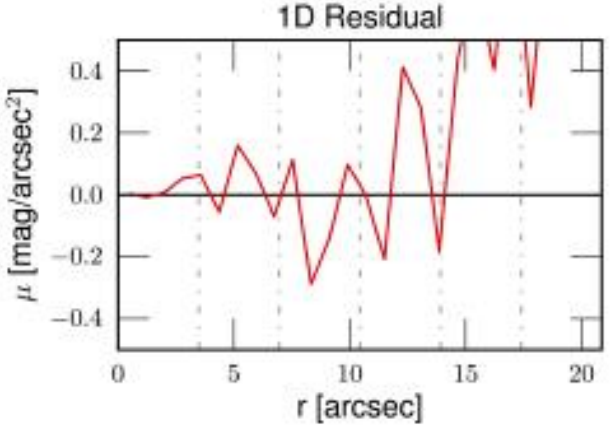






Z ~ 0.3
M_r ~ -23.5
R_{hl} ~ 18 kpc
$n_{Ser(Bulge)}$ ~ 5
n_{Ser} ~ 7

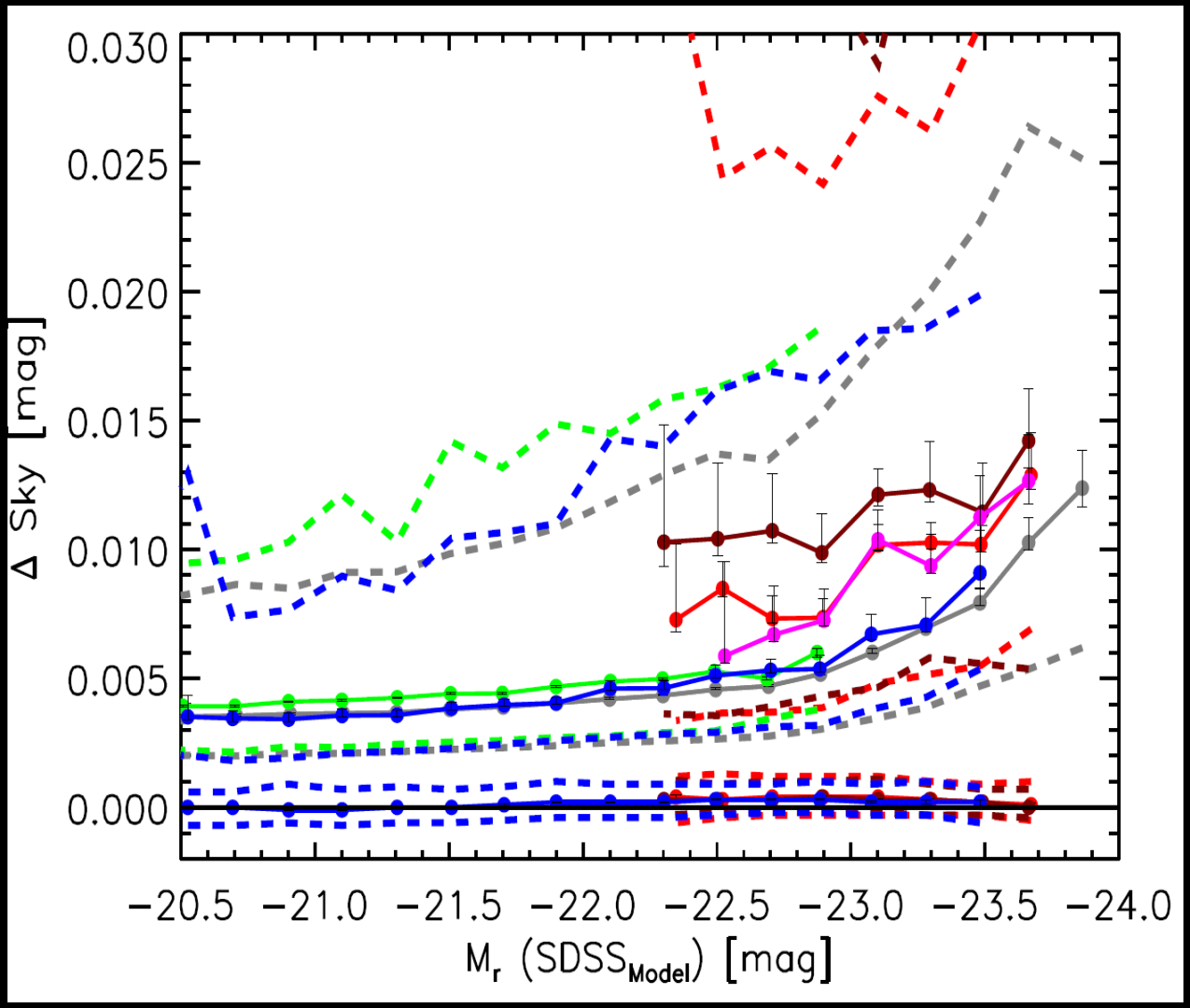




Bernardi et al. 2017b

It is more than semantics .....

2) SDSS sky is biased more for Centrals than for Satellites



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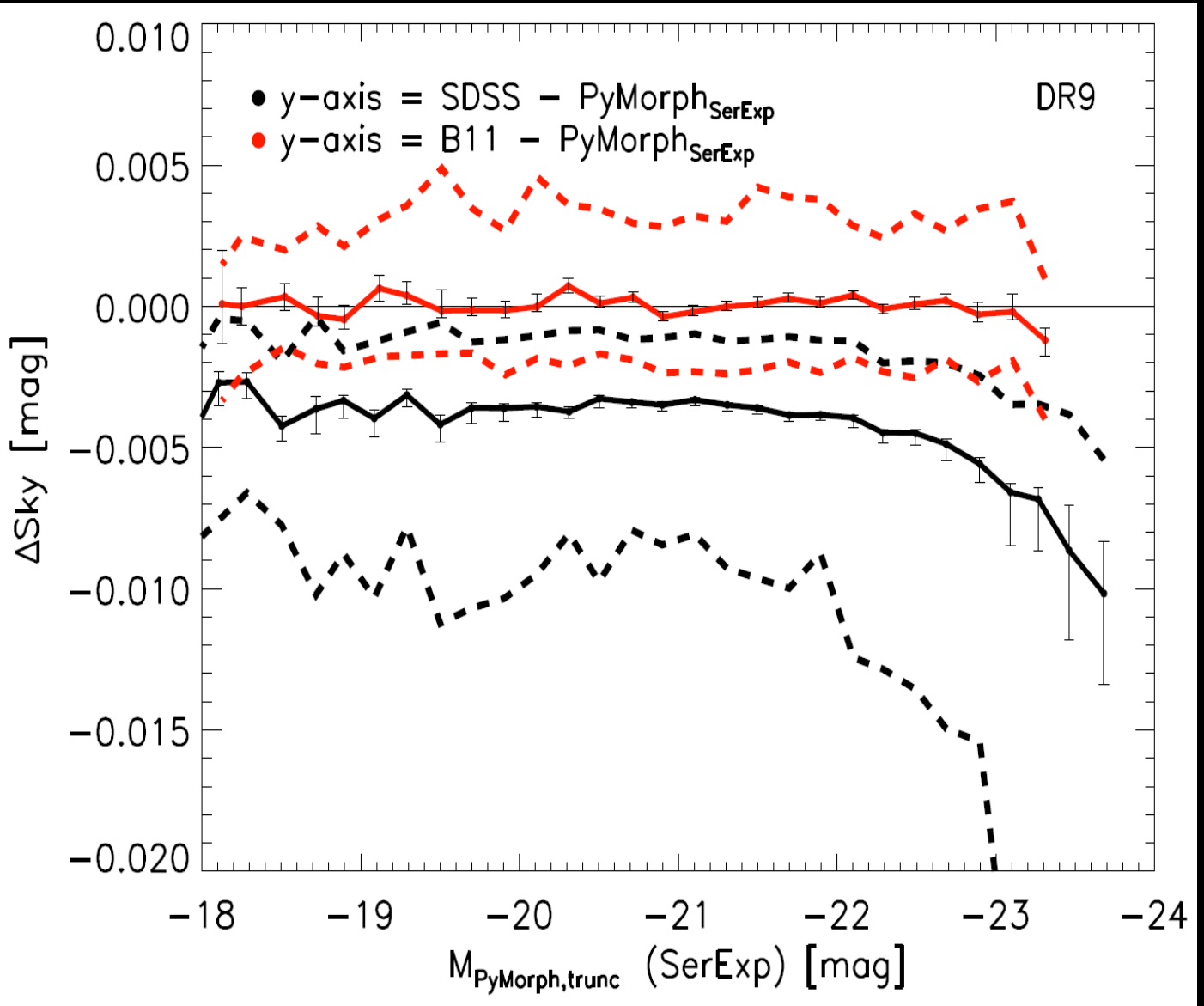
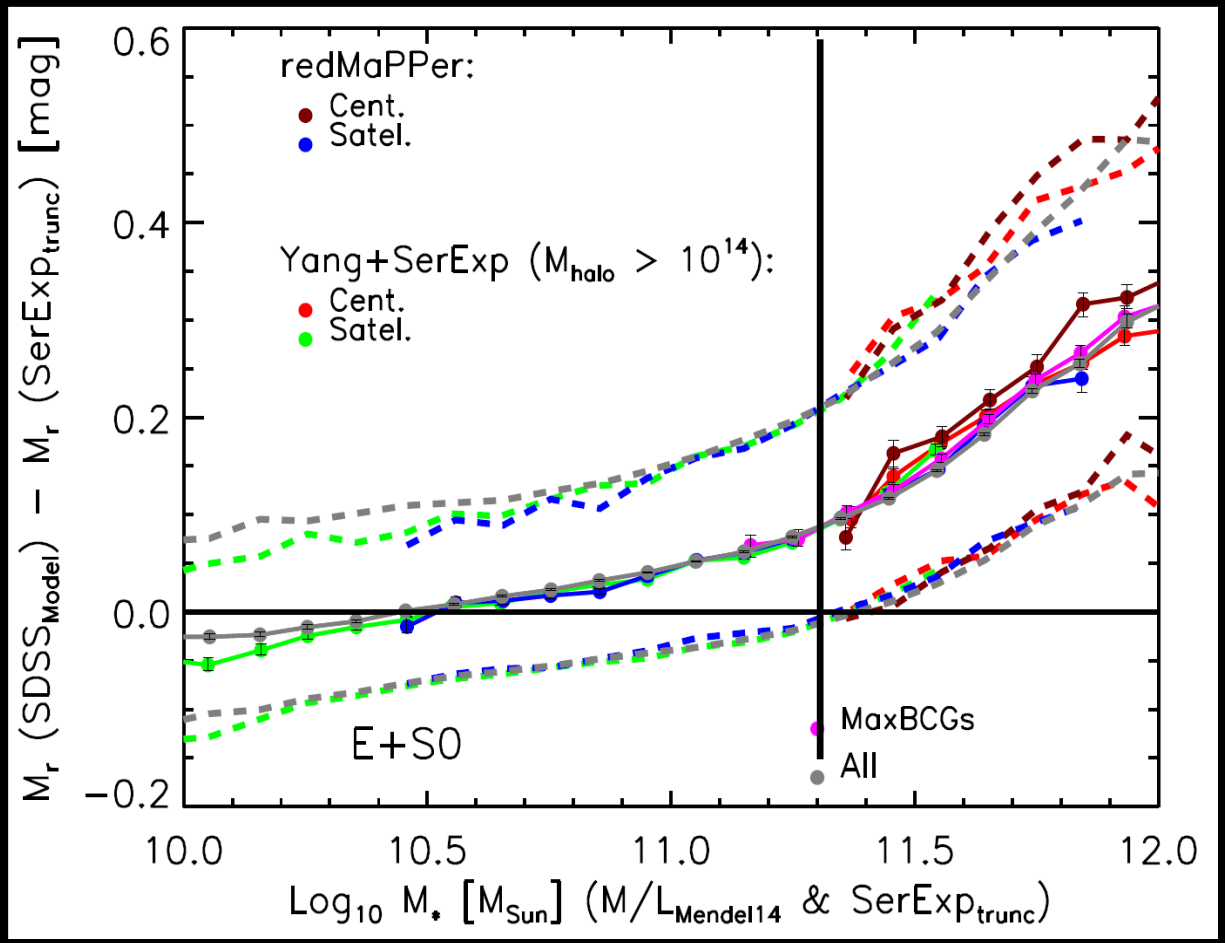


PyMorph sky in excellent agreement with Blanton et al. (2011)

Fischer et al. 2017

It is more than semantics .....

3) Centrals and Satellites are similar when (the correct!) PyMorph SerExp luminosities are used



Departure from deV related more to mass (accretion) than environment

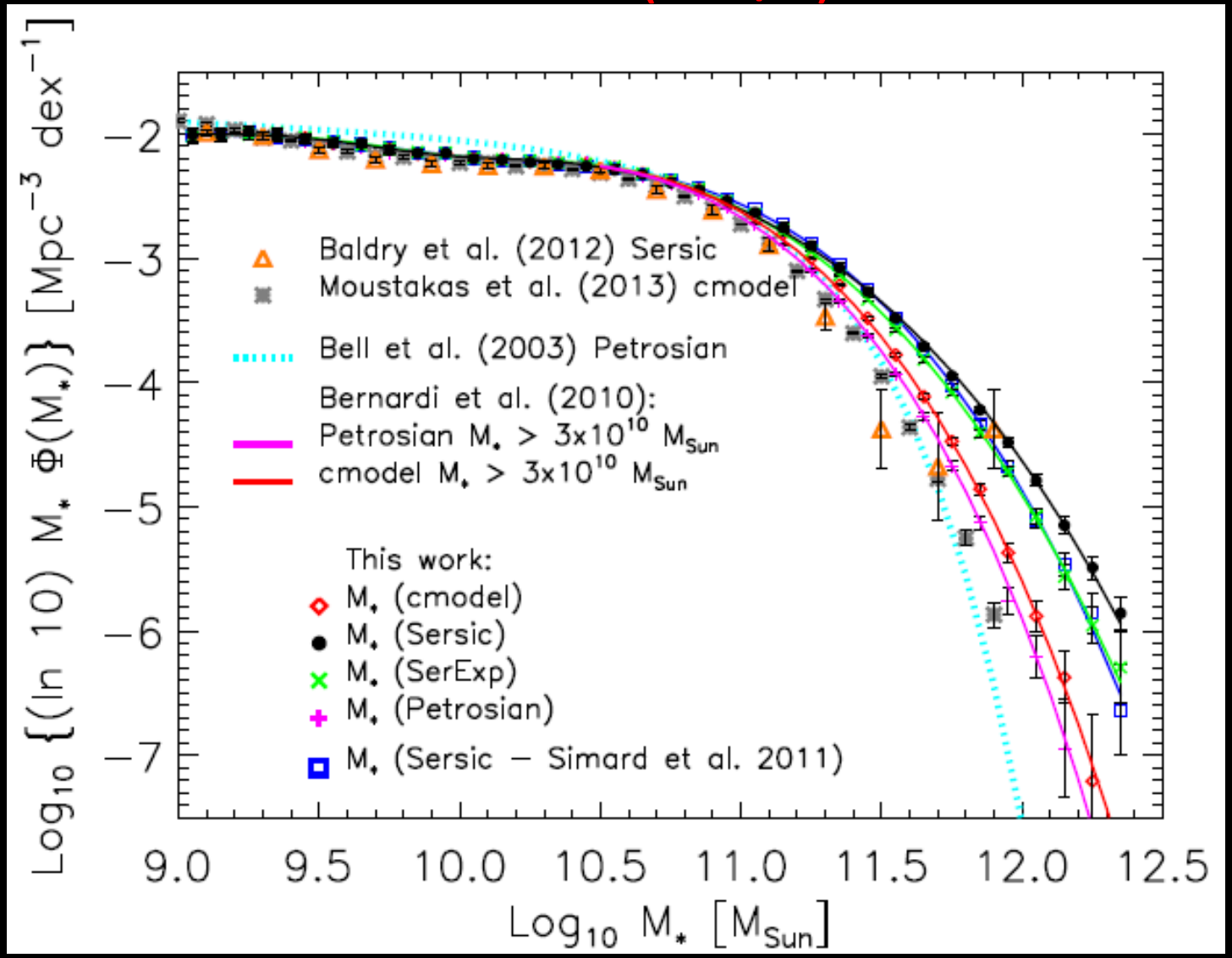
Mass scale 2×10^{11} M_{sun} is where other scaling relations change (Bernardi et al. 2011)

Bernardi et al. 2017

NOTE: x-axis uses PyMorph SerExp mag

M* Function

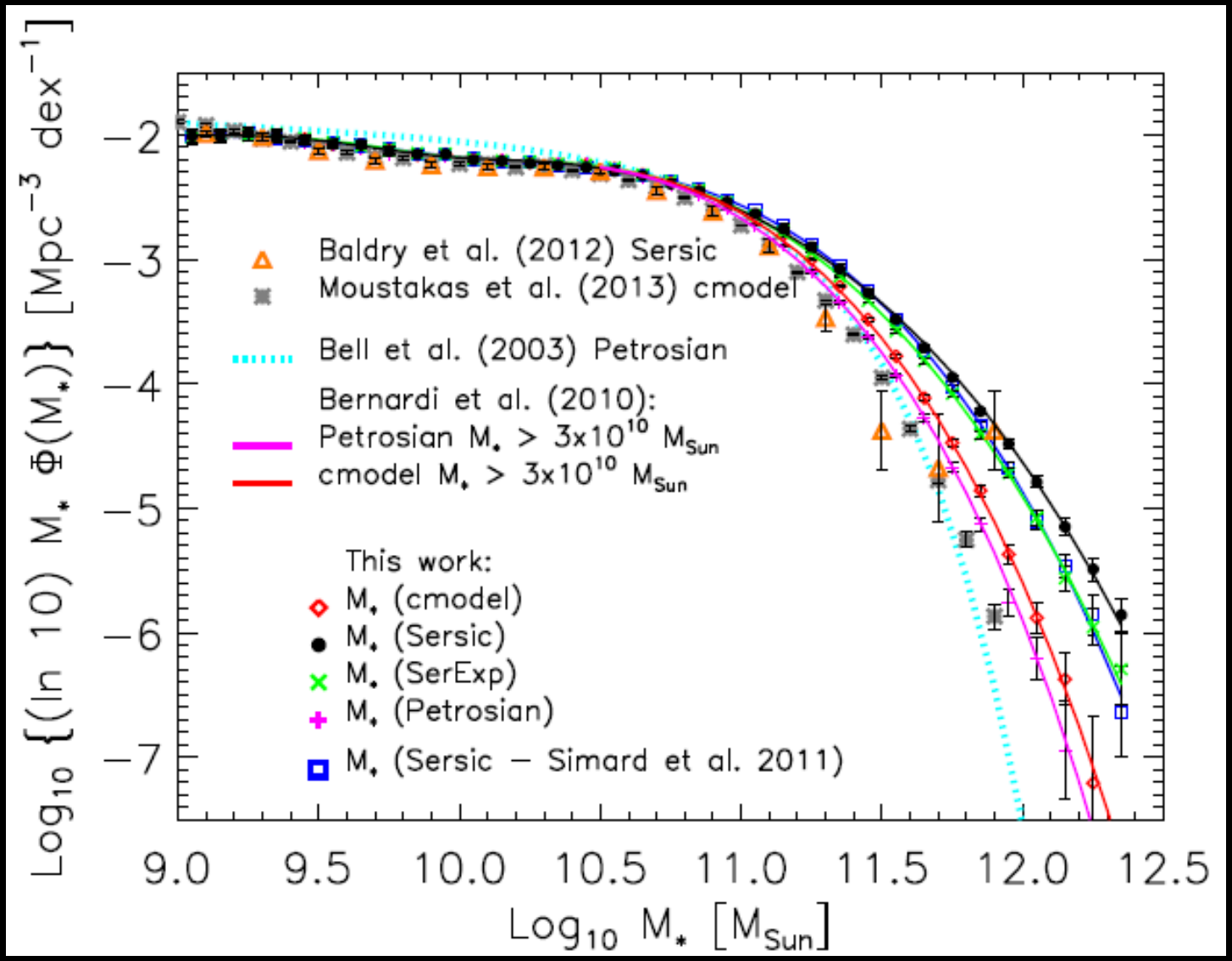
M* = L x (M*/L)



Bernardi et al. 2013

M* Function

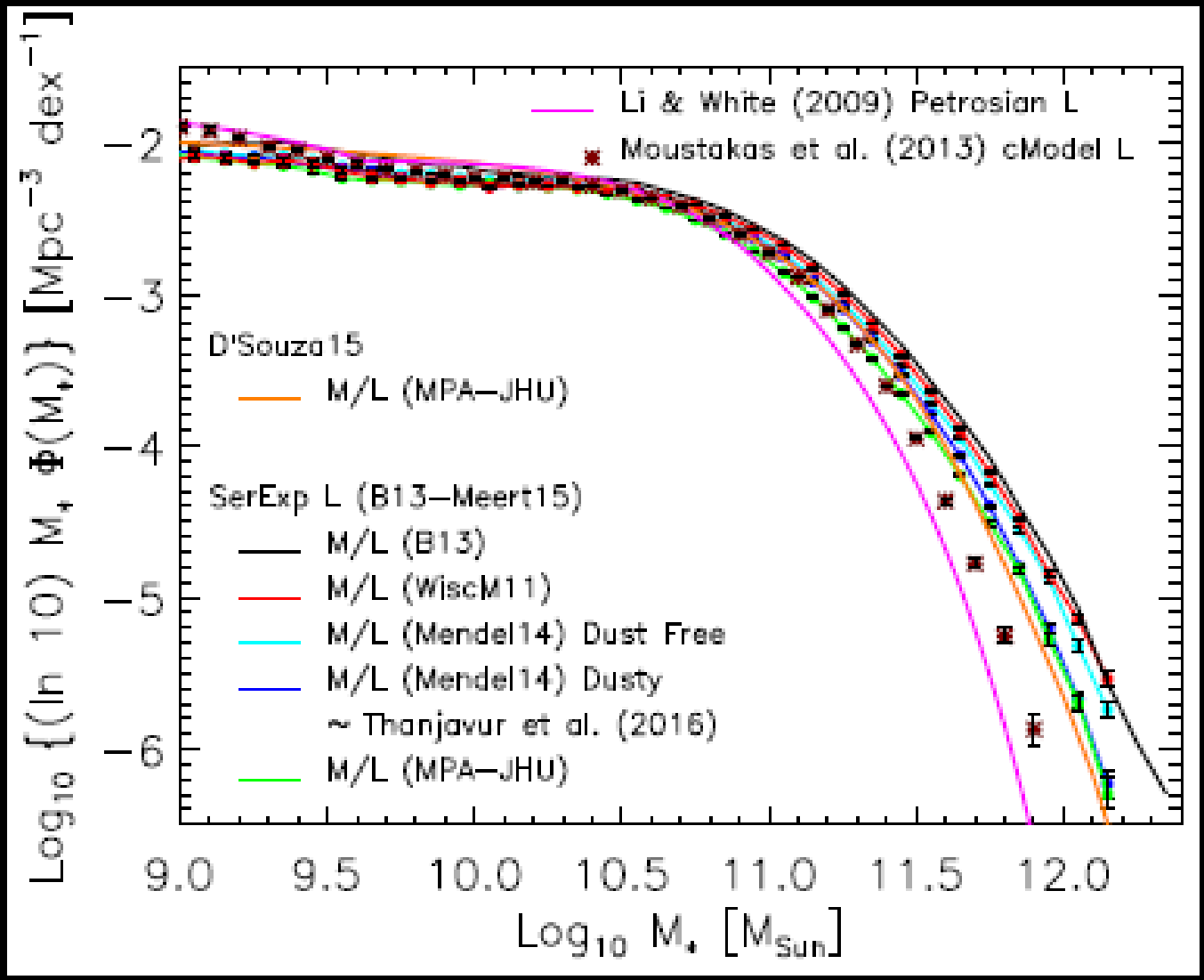
Dependence on L (same M*/L)



Bernardi et al. 2013

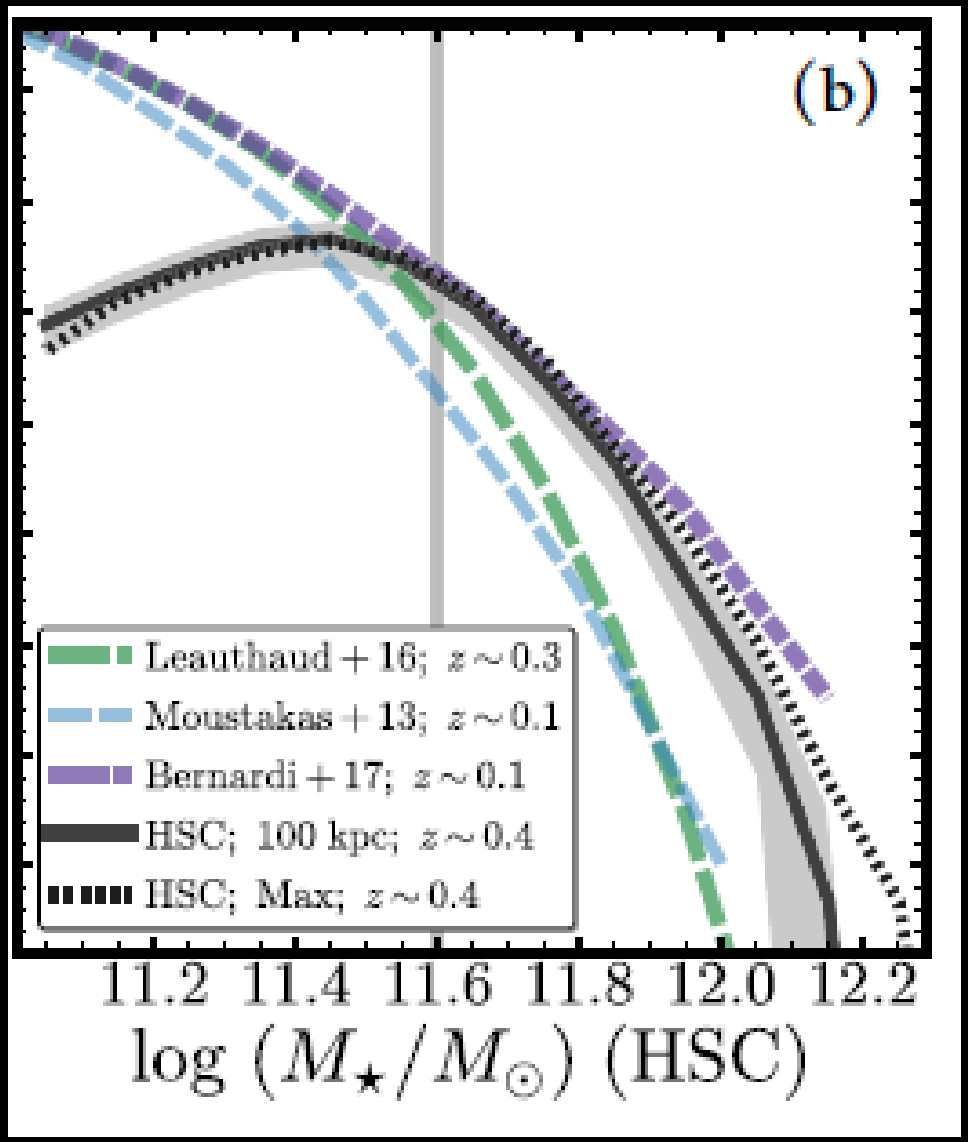
M* Function

Dependence on M*/L (same L)



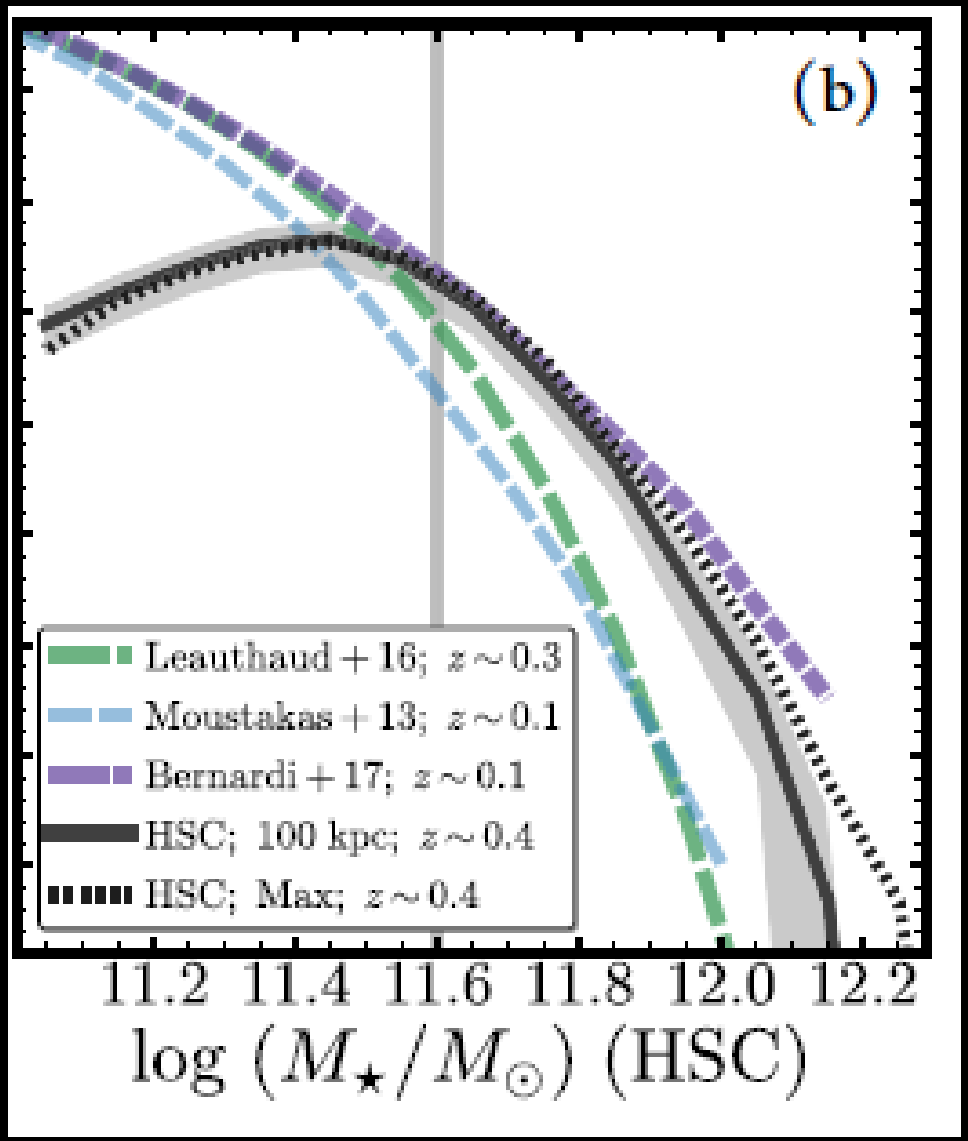
Bernardi et al. 2017a

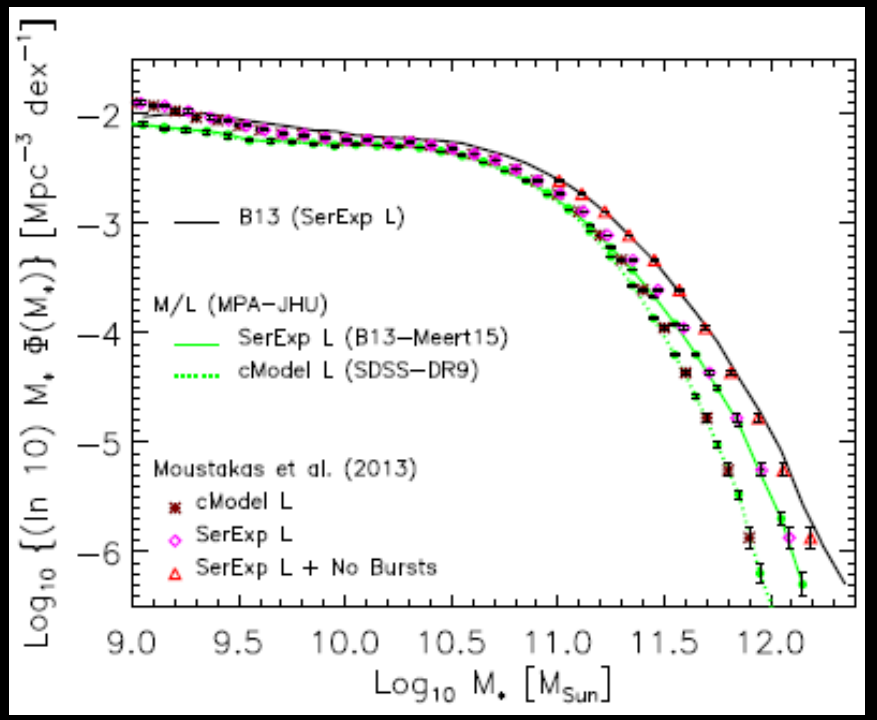
Confirmed by other groups



Huang et al. 2017
(see also Thanjavur et al. 2016
D'Souza et al. 2015)

Confirmed by other groups





Bernardi et al. 2017a

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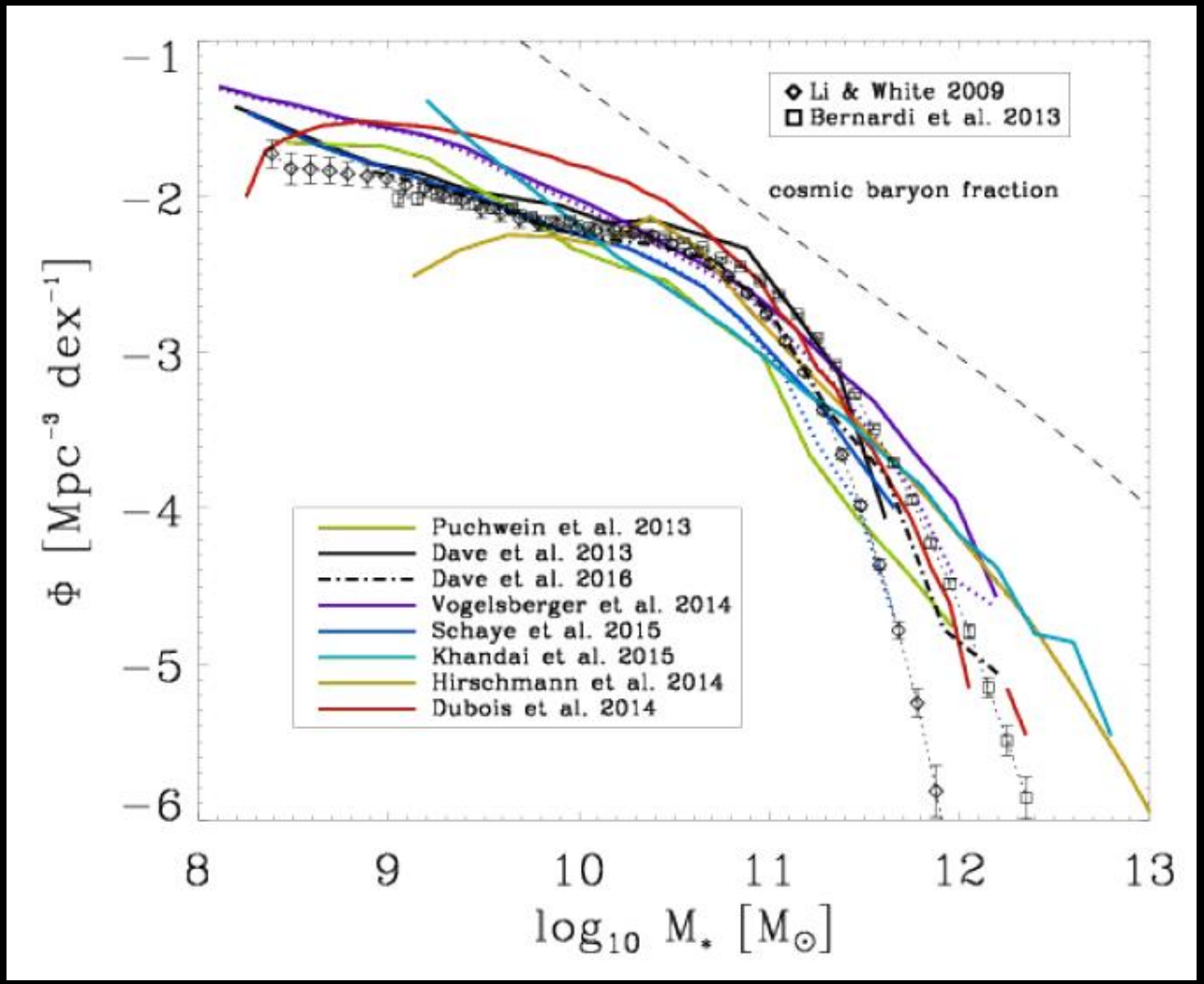
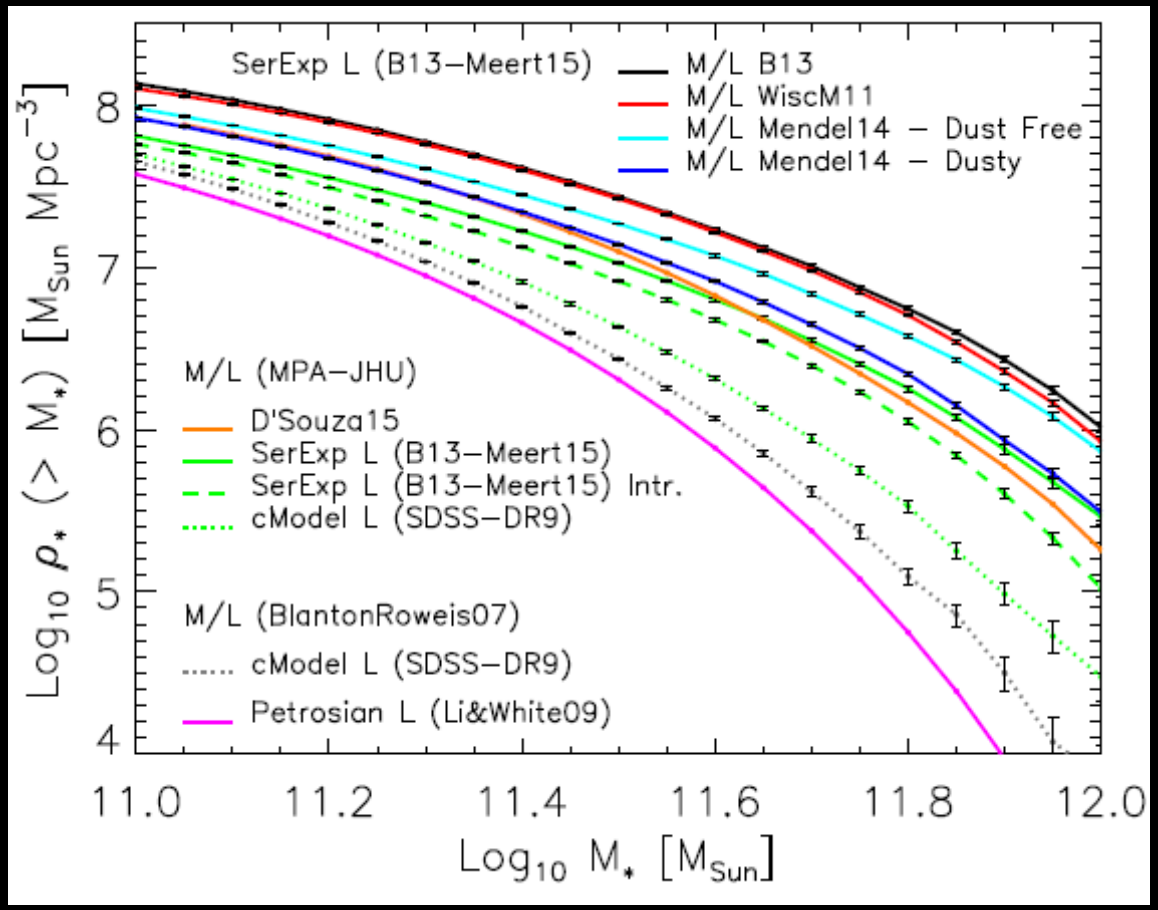


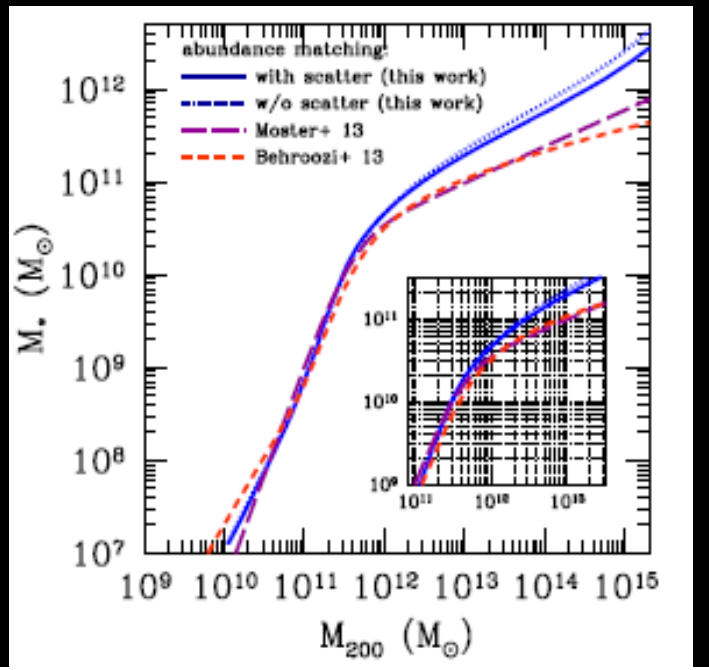
Required feedback at large M* is reduced, in better agreement with models

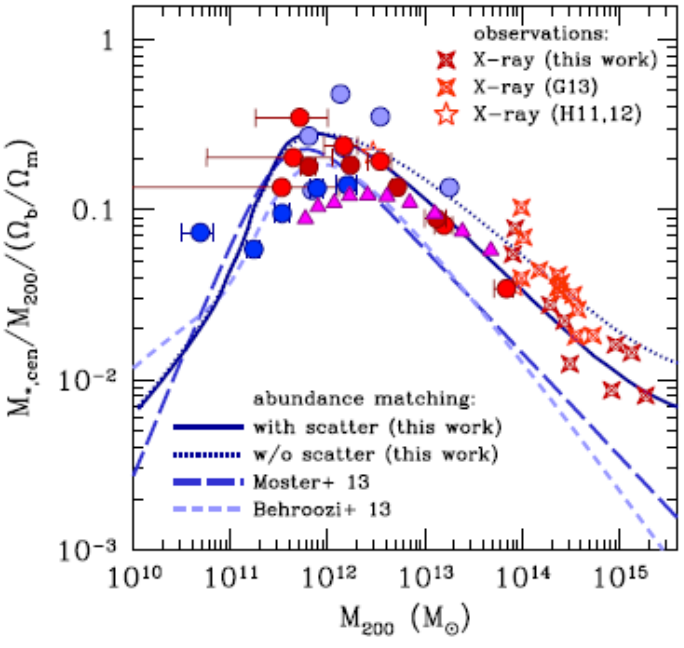
Naab & Ostriker 2017 (see also Cattaneo et al. 2017)

Bernardi et et al. (2017a)



Kravtsov et al. (2014)

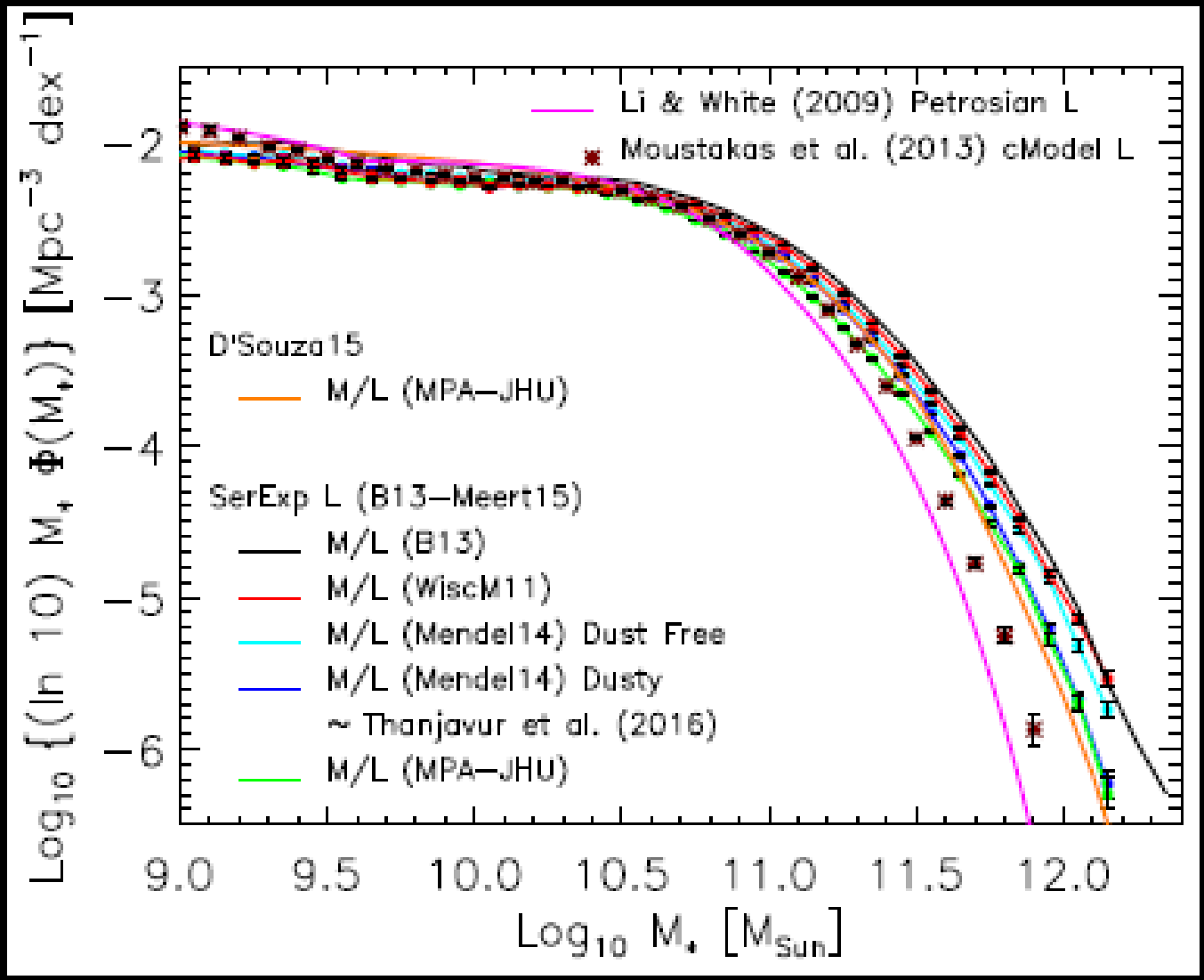




- impacts HOD/SHAM M*-M_{halo} relations (Shankar et al. 2014)
- reduces required feedback at high M

M* Function

Dependence on M*/L (same L)



Bernardi et al. 2017a

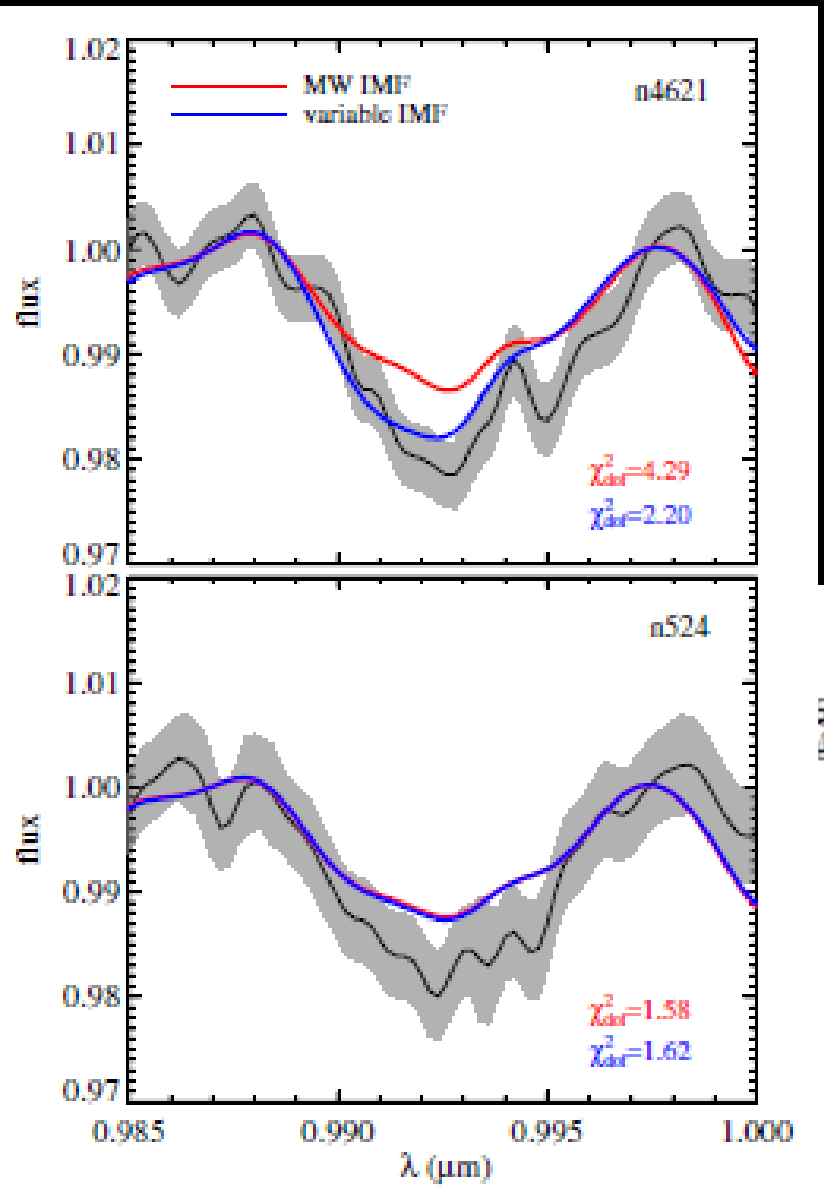
M* Function

Dependence on M*/L (same L)

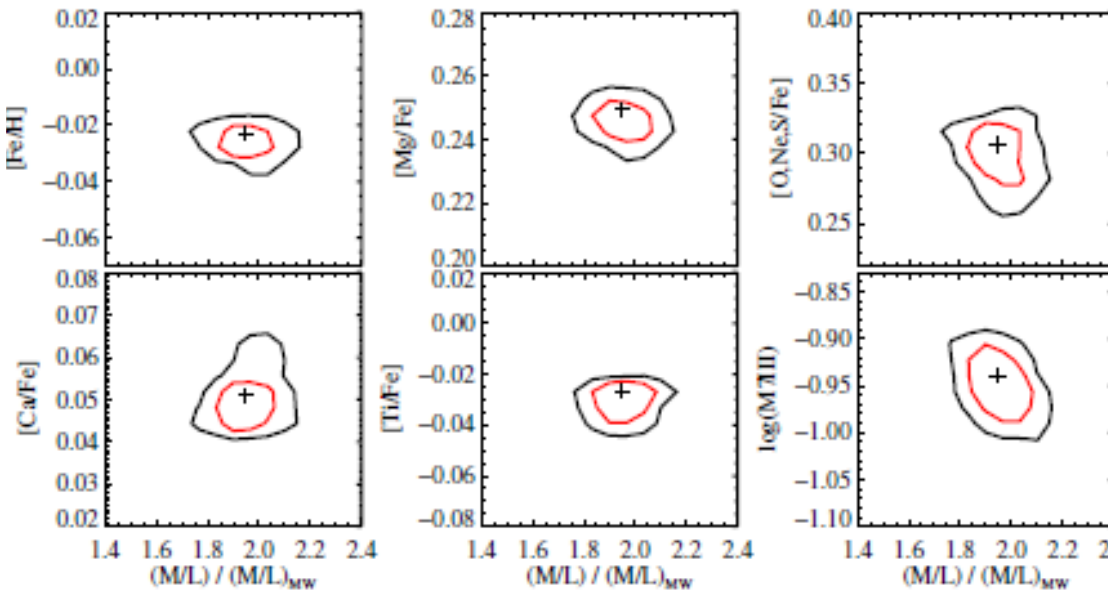
M*/L depends on SFHistory, Dust, and IMF

Standard to assume IMF is same for all galaxies

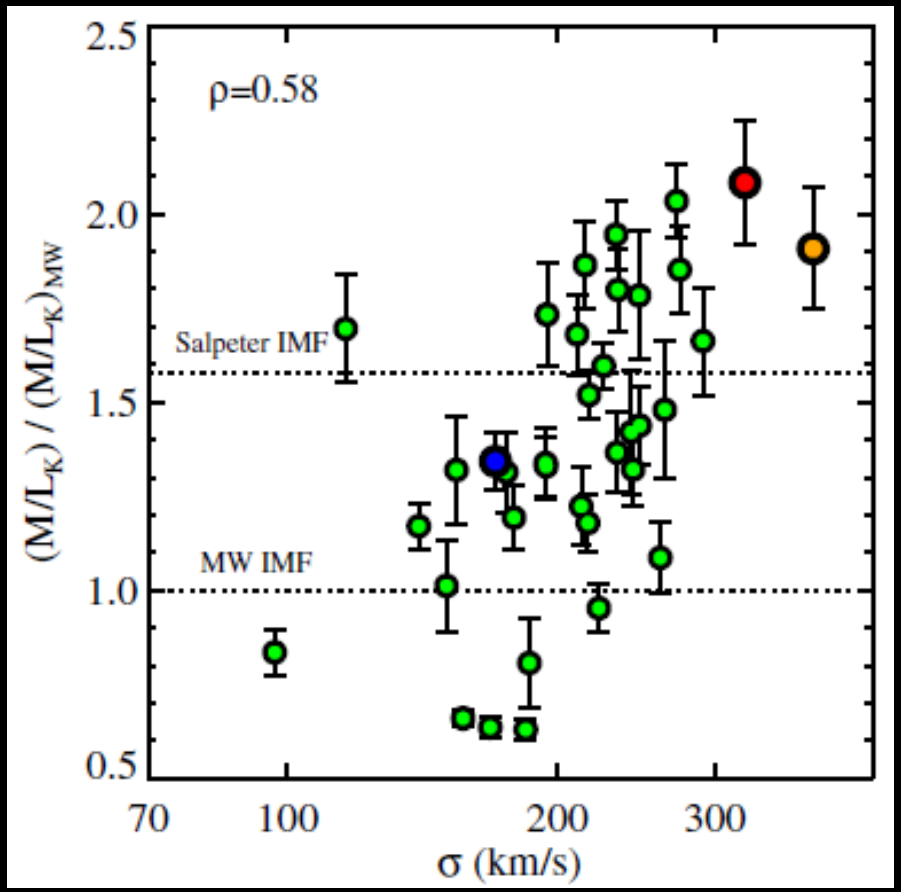
Evidence for variable IMF

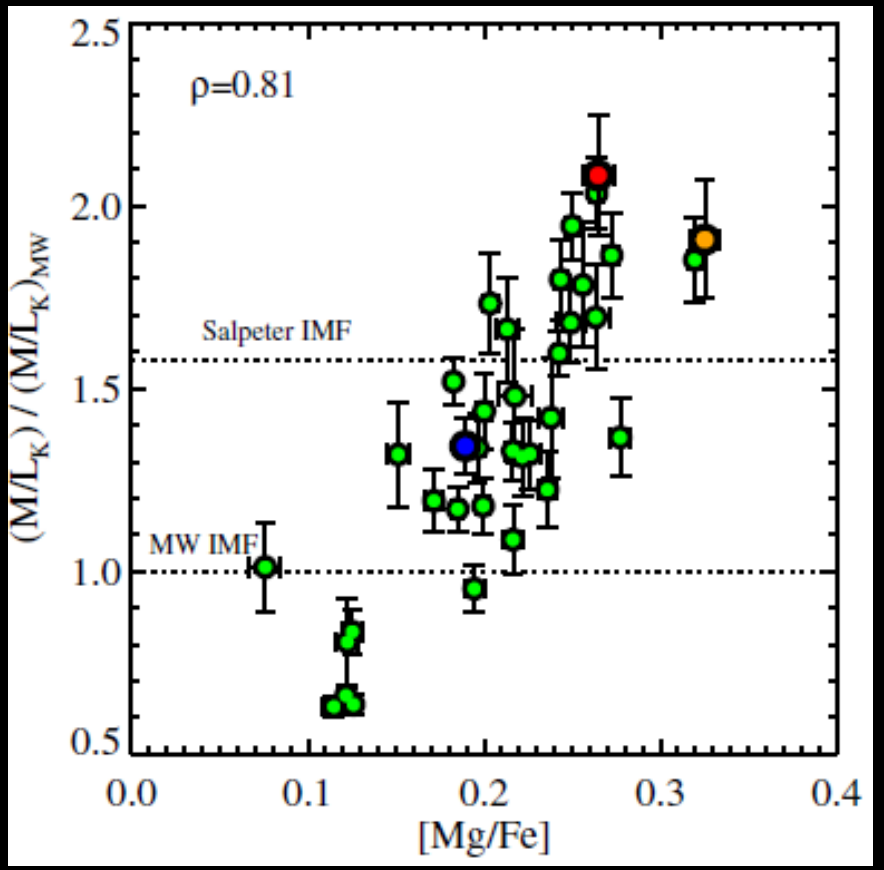


Conroy & van Dokkum 2012



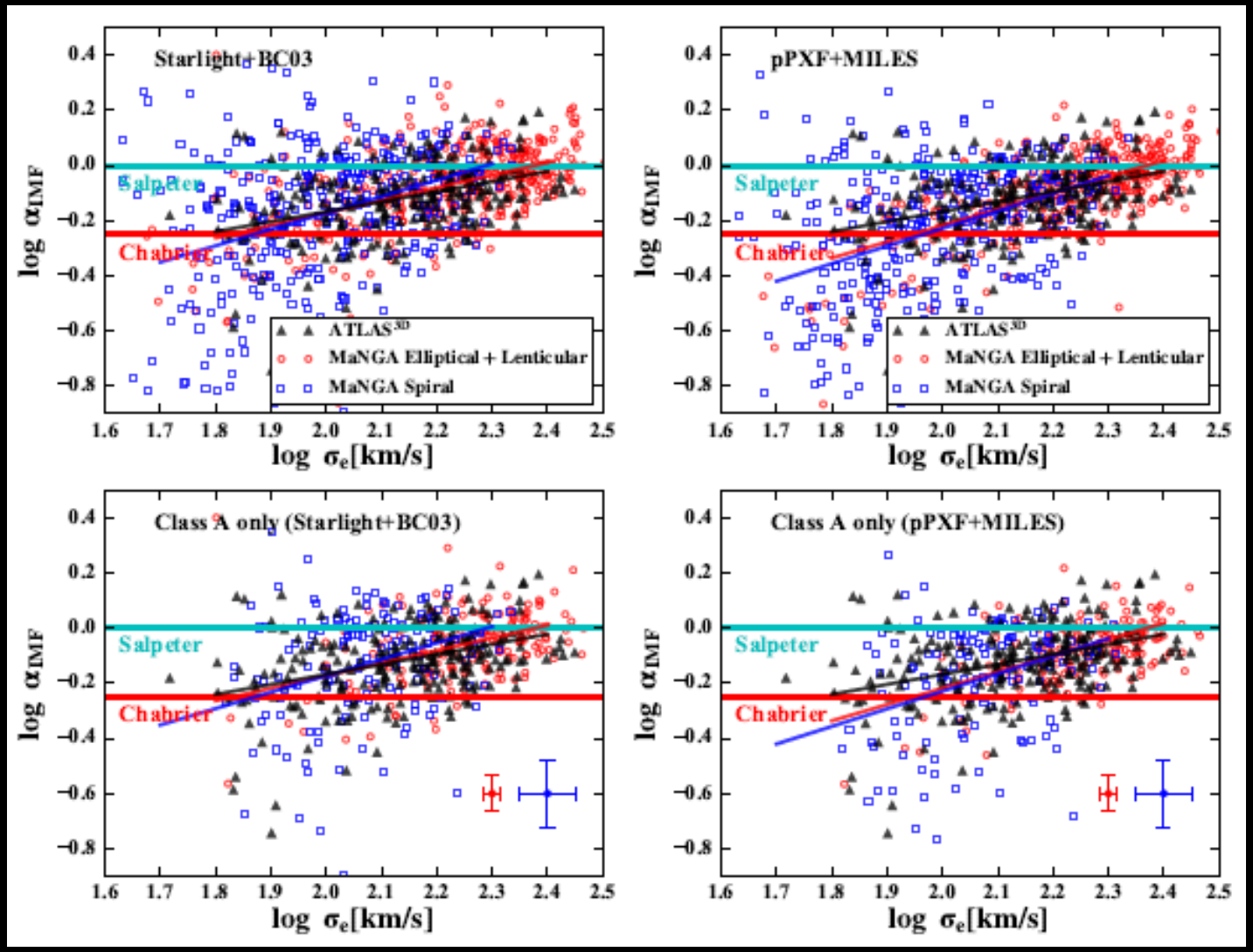
IMF correlates with other properties





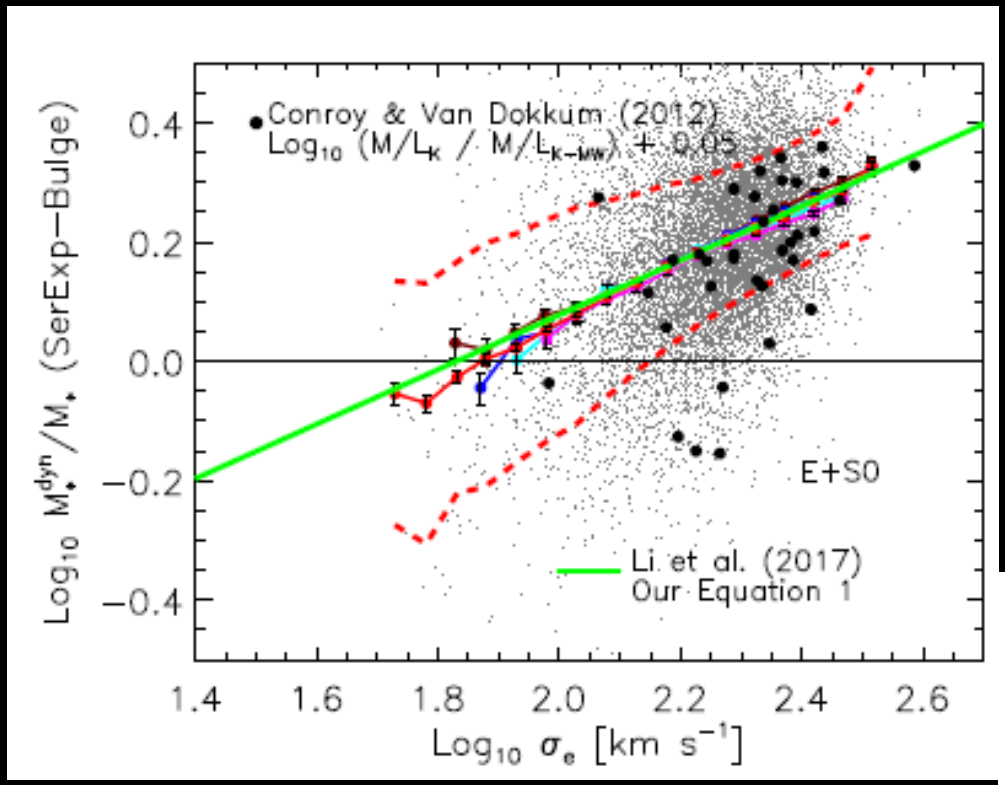
Conroy & van Dokkum 2012

Variable IMF using ~800 MaNGA galaxies



Li et al. 2017

M* after accounting for variable IMF ~ $M^*_{dynamical}$

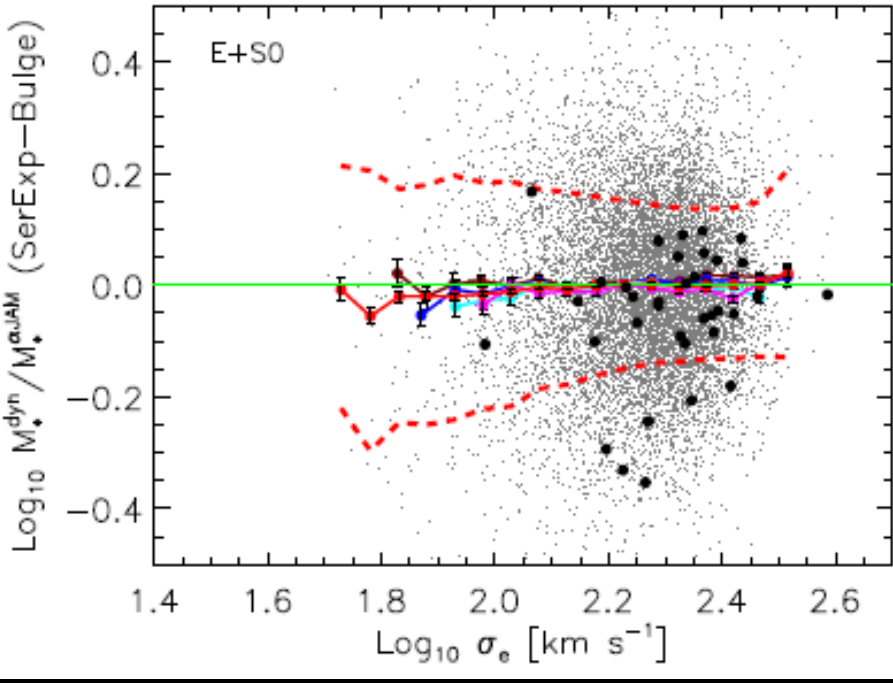


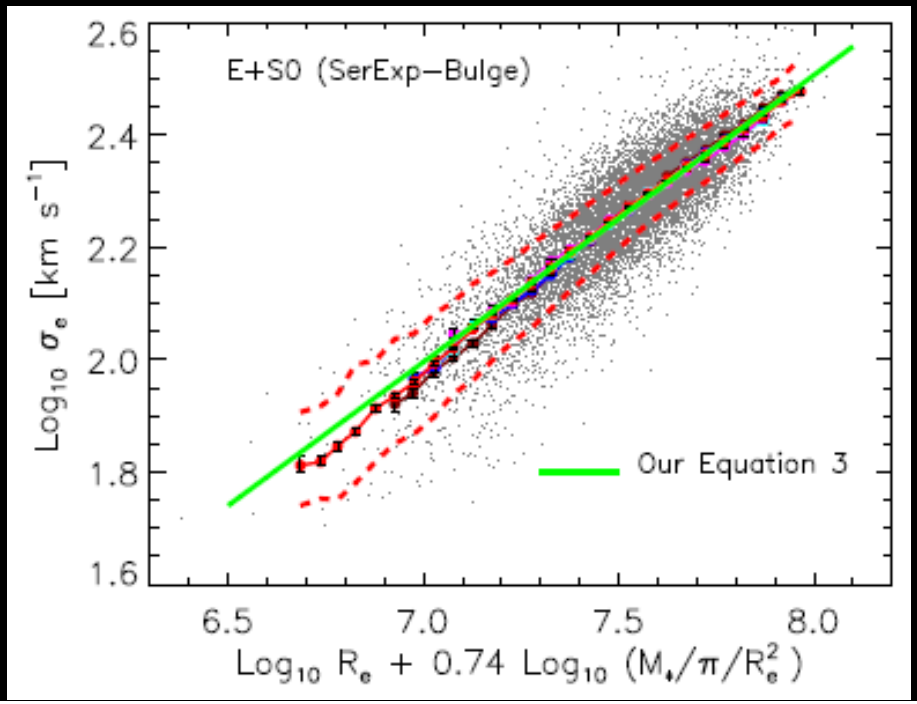
$$M^{\rm dyn}_{\star+{\rm gas}} = k(n, t_a)\,\frac{R_e\sigma_a^2}{G}, \quad \text{where} \quad t_a \equiv \frac{\theta_a}{\theta_e}$$

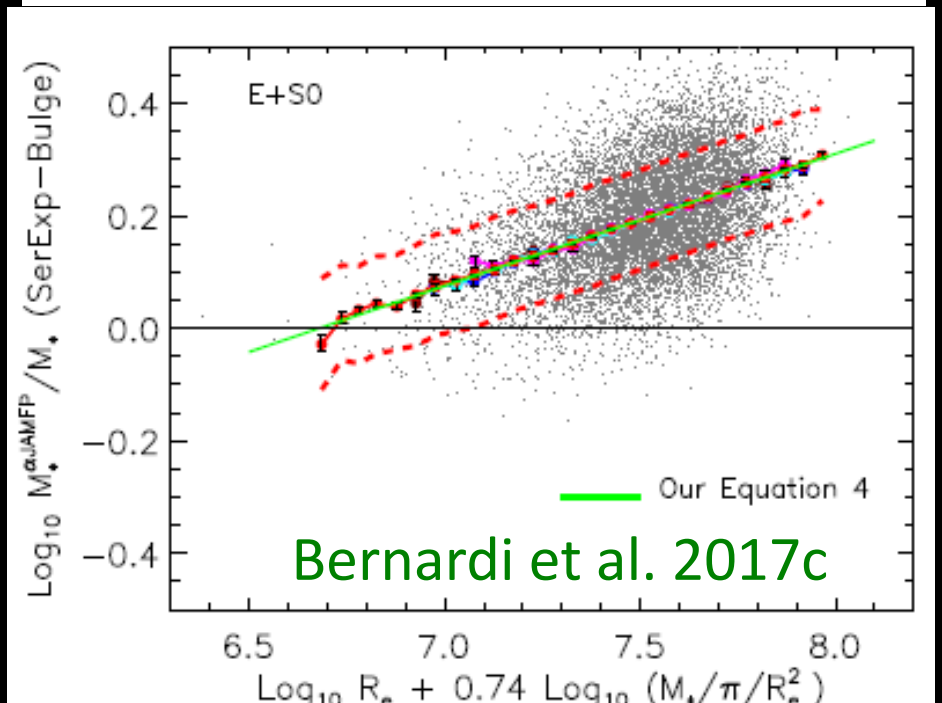
Bernardi et al. 2017c

$$\left\langle \log_{10}\frac{M_\star^{\alpha\rm JAM}}{M_\star}\,\middle|\,\log_{10}\sigma_e\right\rangle = a + b\,\log_{10}\frac{\sigma_e}{\rm km\ s^{-1}} + 0.25$$

$$(a, b, \Delta_{int}) = (-1.086, 0.457, 0.082)$$



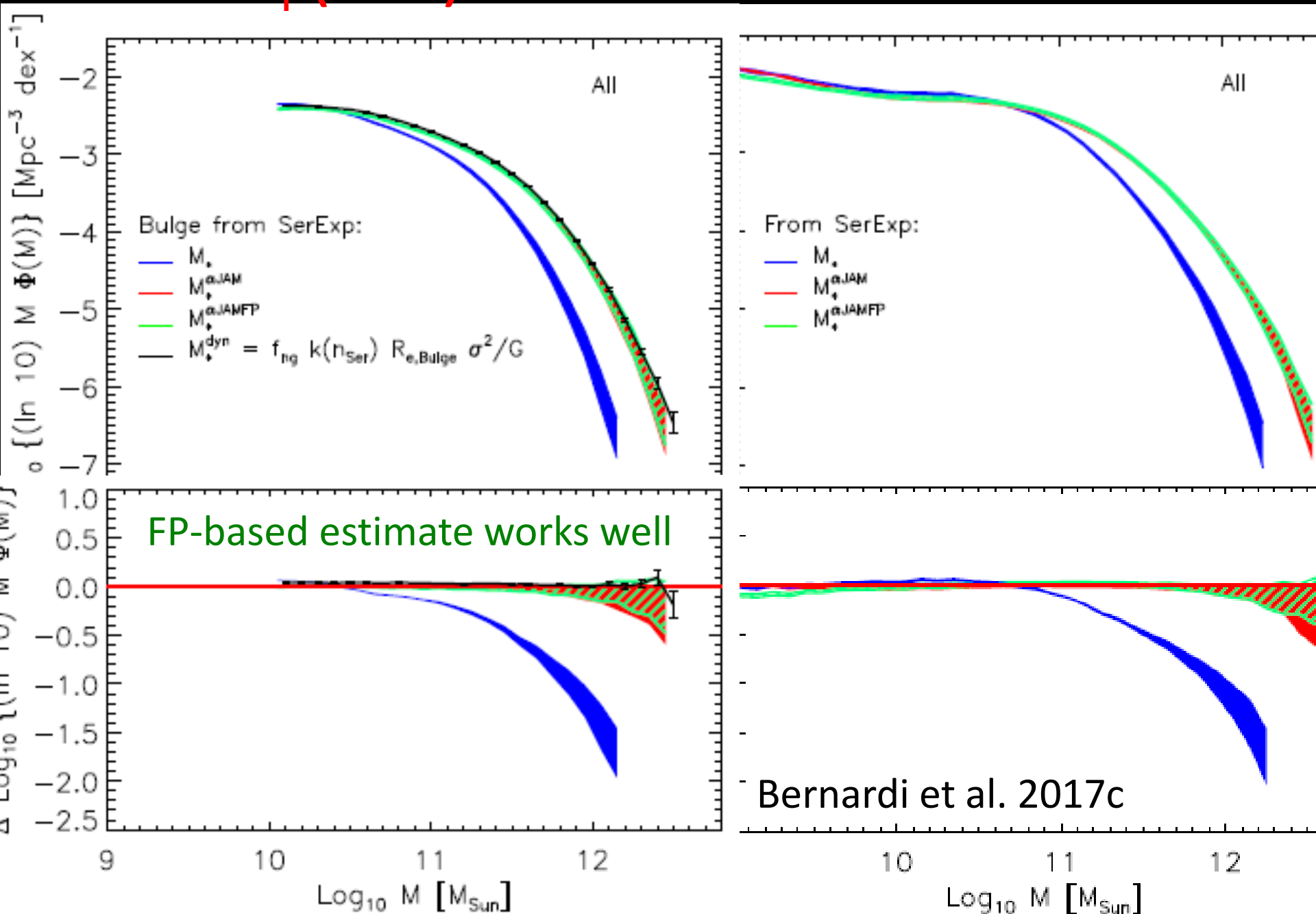


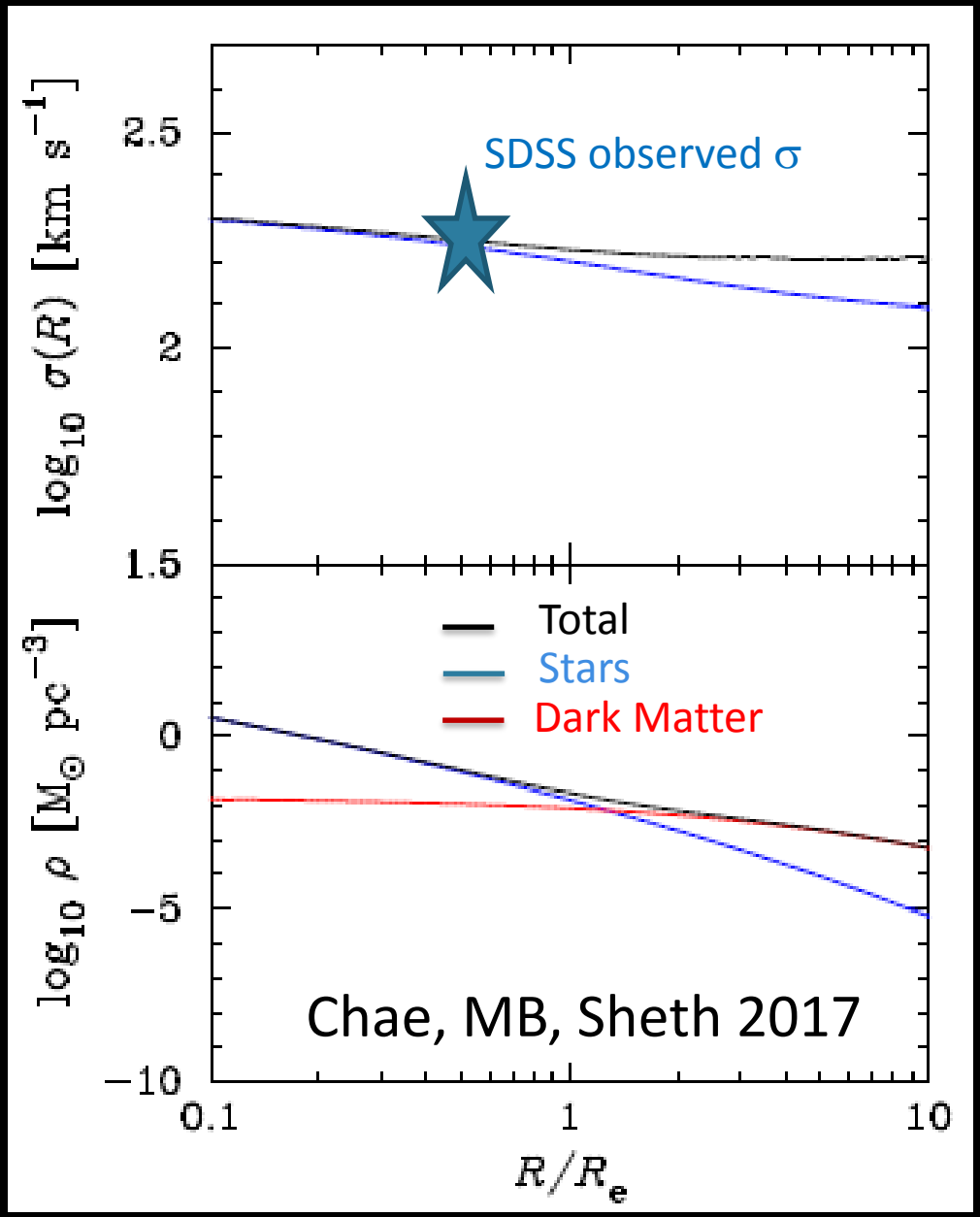


Measuring σ at z>0.5 is expensive:

To estimate Mdyn/M*(IMF-corr) without σ, use the FP (combination of effective radius R_e and surface M* density) as proxy σ

ϕ(M*) with variable IMF



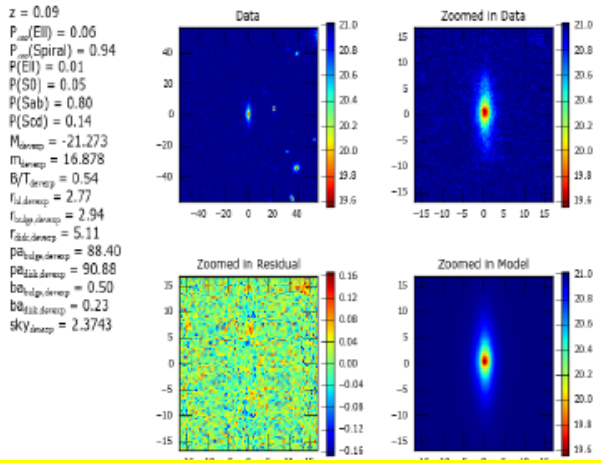


Strictly speaking, M_{dyn} assumes σ inside SDSS fiber dominated by stars

Expected if Halo Model estimates of DM-M* relation are OK

(Implications for MOND …)

Welcome to the UPenn SDSS PhotDec Catalog!



Meert, Vikram & Bernardi (2015, 2016)

!! THIS IS A PAID COMMERCIAL ANNOUNCEMENT !!
STELLAR MASSES HAVE BEEN ADDED TO THE CATALOG

The UPenn SDSS PhotDec Catalog provides 2-d galaxy profile fits in several visible bands using SDSS data. Additional data collected from other sources is provided to facilitate analysis. The catalog is constructed and maintained by Mariangela Bernardi, Alan Meert and Vinu Vikram. To learn more about the catalog visit the other sections.

Explore the Catalog

About the Catalog
PLOTS!!! Radius vs. Magnitude | Sersic vs. Radius | Sersic vs. Magnitude
View the Galaxies
Classify the Galaxies
Download the Catalog Data

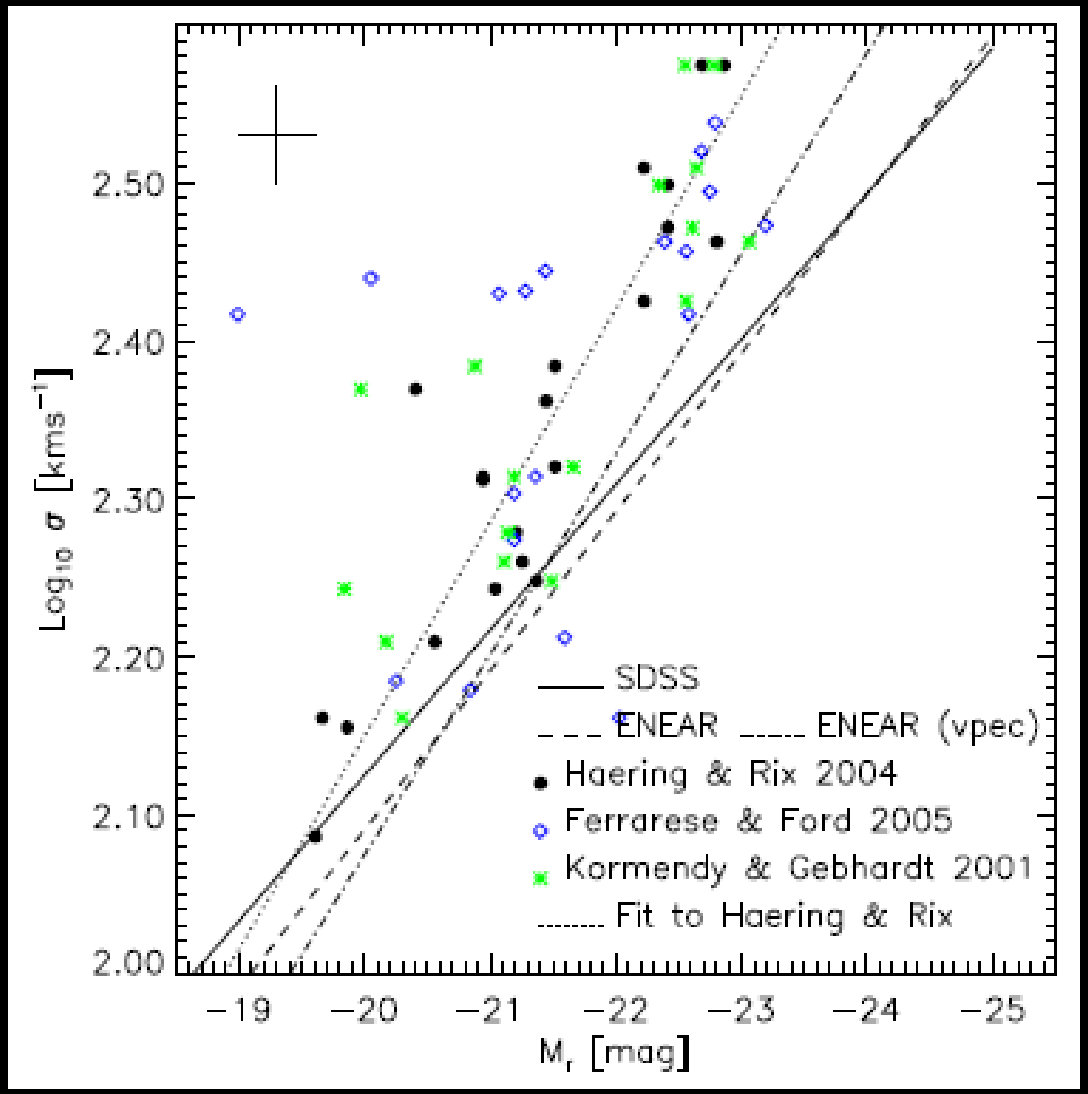
http://shalaowai.physics.upenn.edu/~ameert/fit_catalog/

Outline

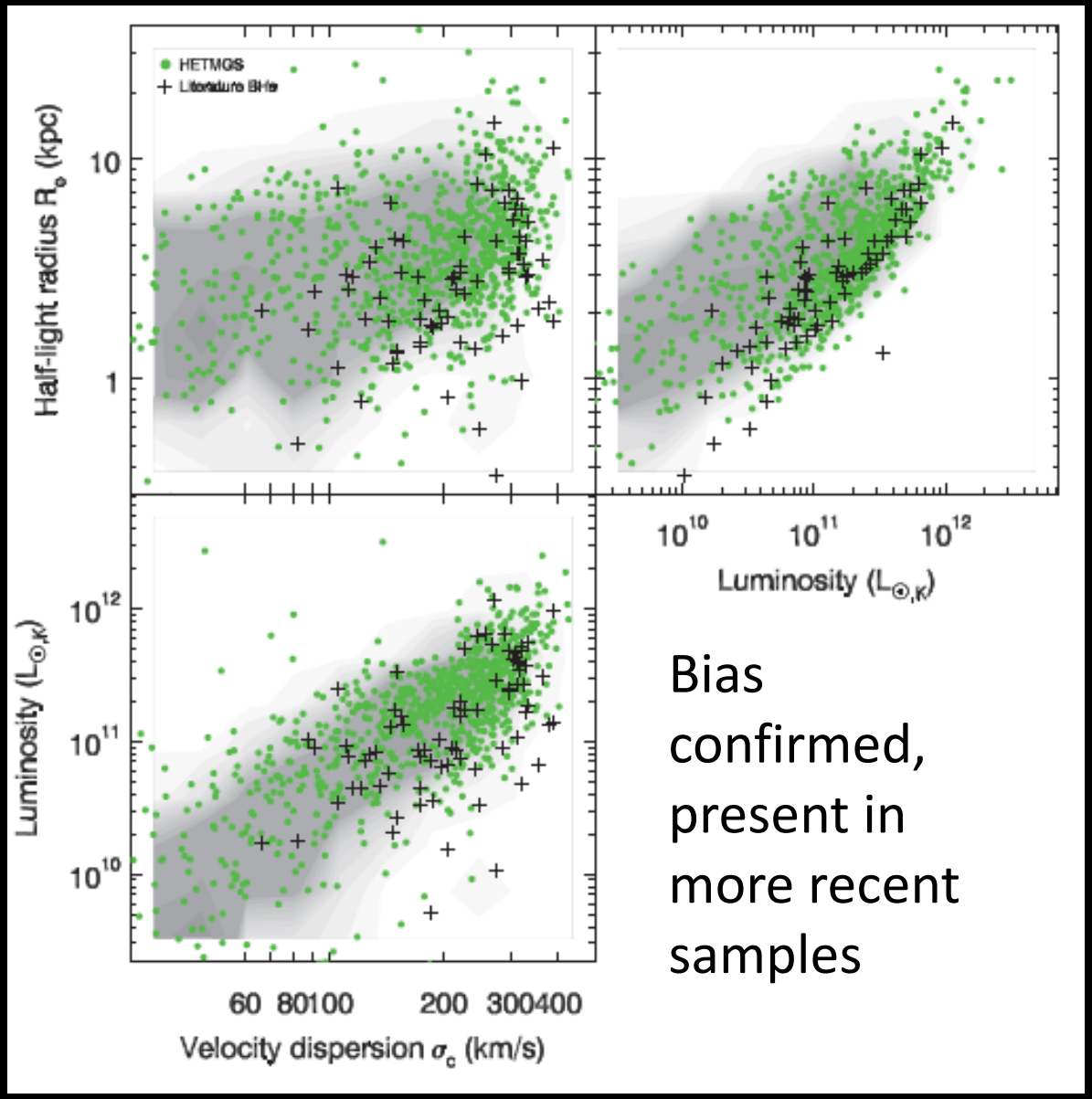
- Better photometry of SDSS massive galaxies
  - Stellar Mass Function/Variable IMF
  - Dark matter fraction

- Selection bias in SMBH samples having dynamically measured masses

Bias in SMBH samples



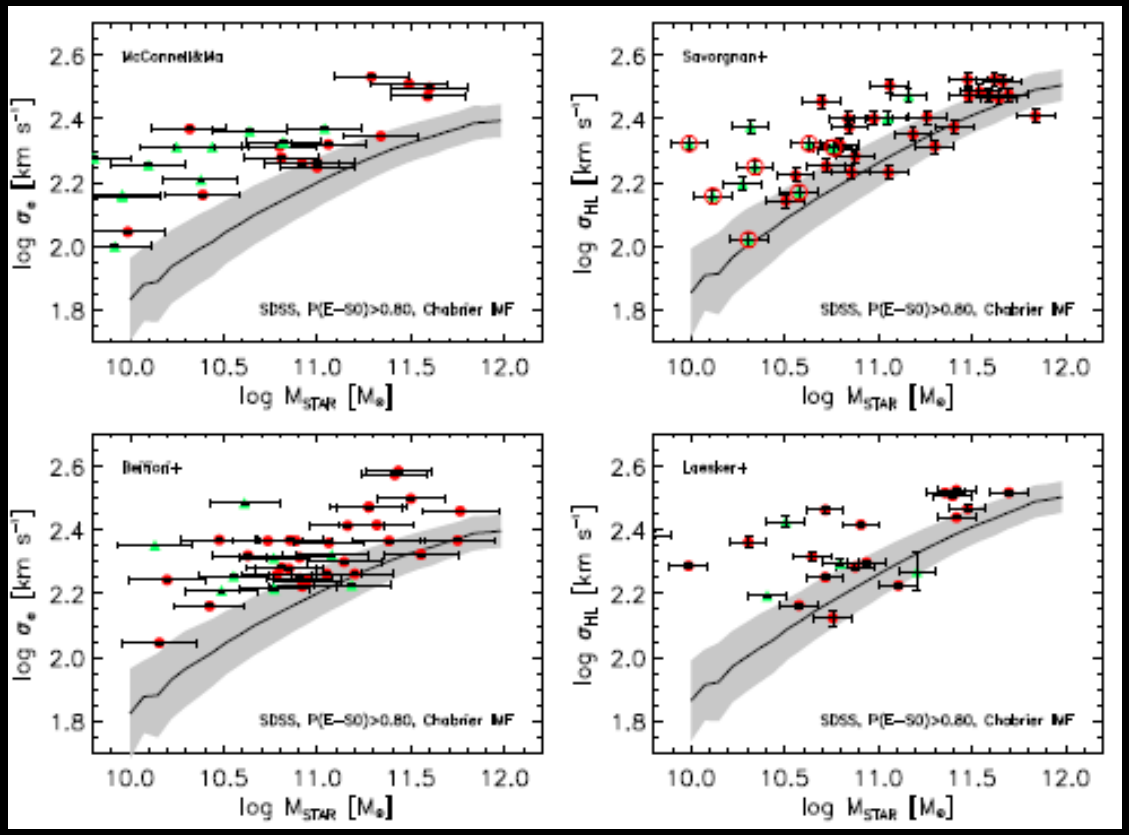
Bernardi et al. 2007



Bias confirmed, present in more recent samples

Van den Bosch et al. 2015

Data + Simulations

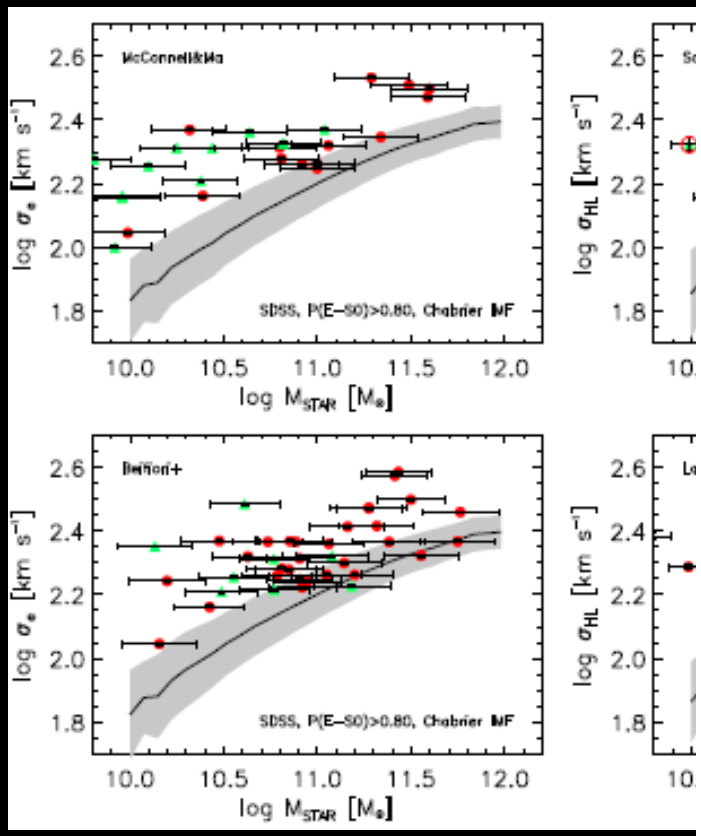


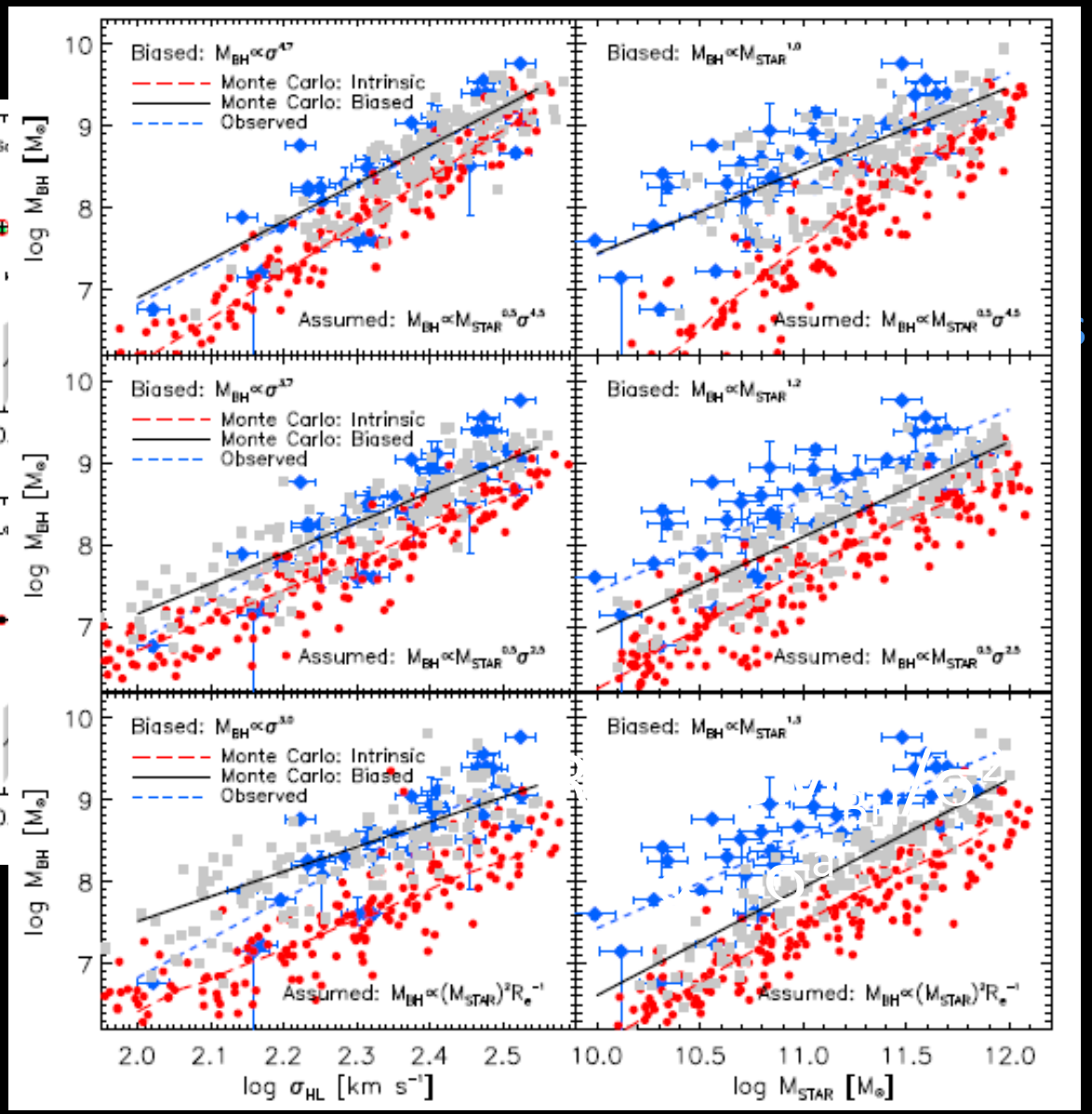
There is a well-known selection effect but often ignored: black hole dynamical mass estimates are only possible if (some multiple of) the black hole's sphere of influence is resolved

$$R_{inf} = GM_{BH}/\sigma^2$$
$$\propto \sigma^a$$

Shankar, MB et al. 2016

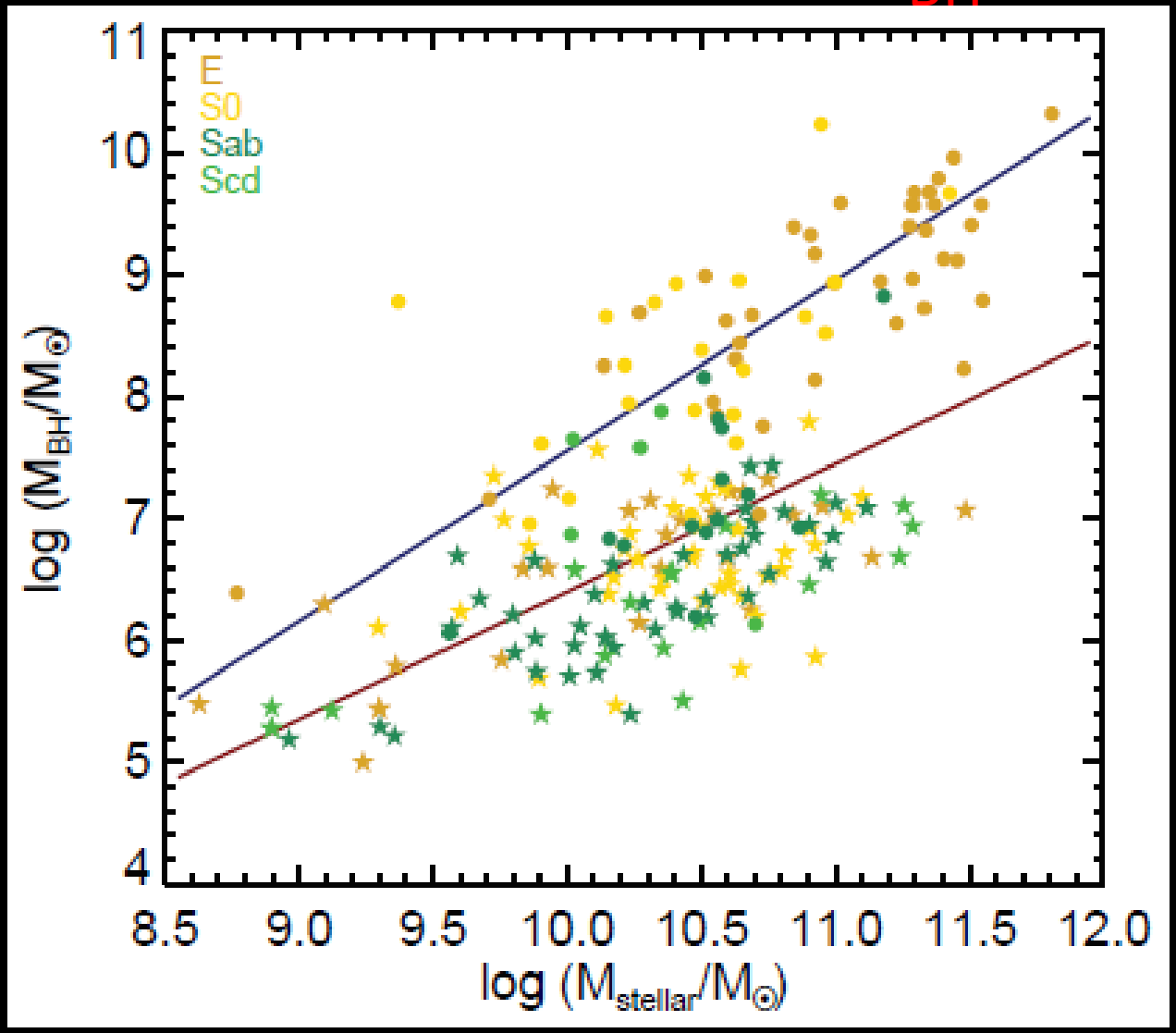
Data + Simulations





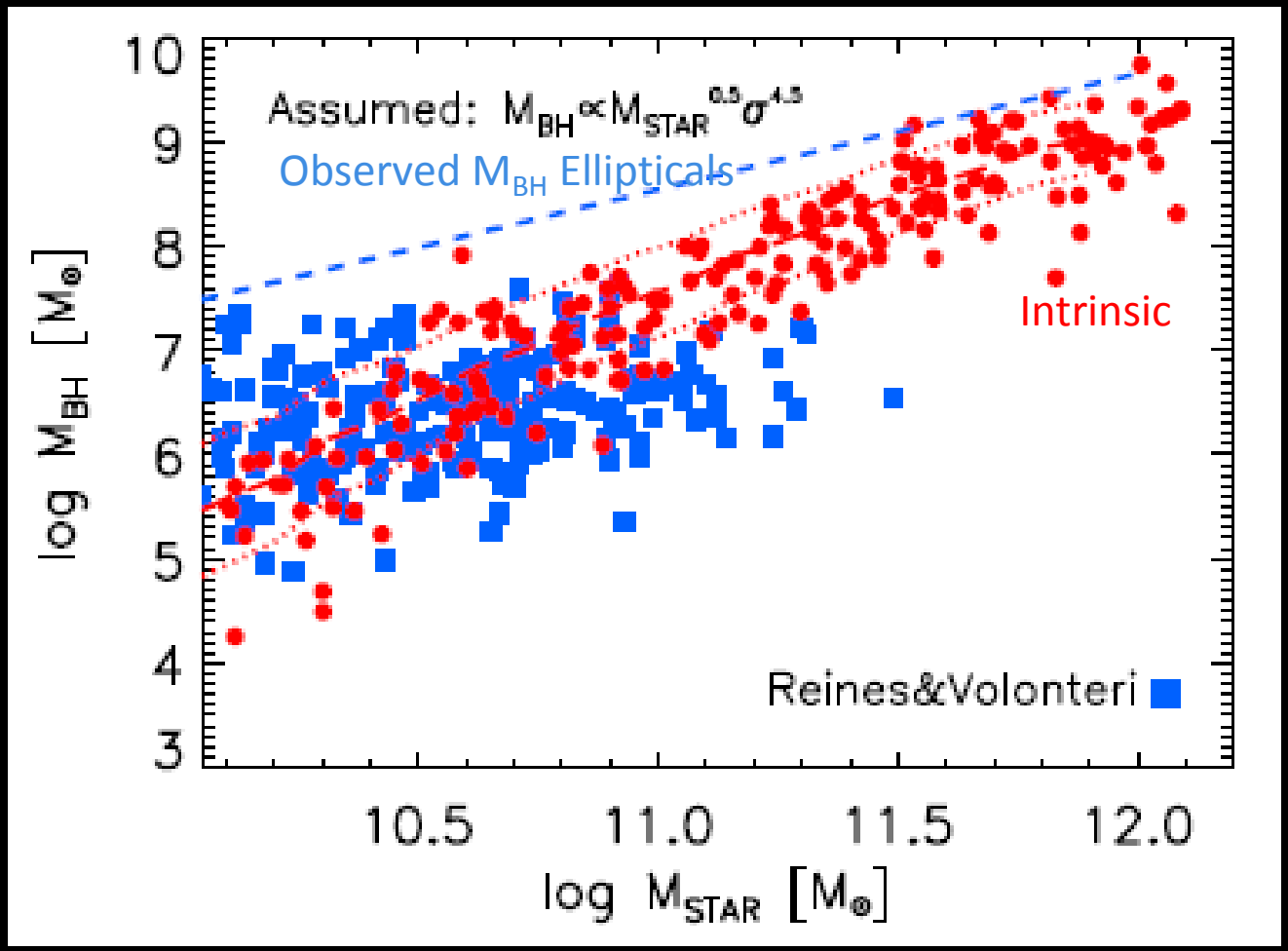
Shankar, MB et al. 2016

Discrepancy between dynamical and AGN measured M_{BH}



Reines & Volonteri 2015

Due to selection bias!



Shankar, MB et al. 2016

Implications

- Black hole masses, abundances have been overestimated
- Accounting for this brings BH scaling relations into better agreement with those for AGN
- Smaller MBH → smaller AGN feedback → consistent with higher M*?
- Predicted PTA gravity wave signal 3x smaller

Conclusions

- Sky-subtraction + Sersic/SerExp fits suggest more objects at $M_{*}>10^{11}$ M_{sun} than previous work:
  - impacts HOD/SHAM M*-Mhalo relations
  - reduces required feedback at high M*

- Bias in SMBH samples having dynamically measured masses