



# The Host Galaxies of High Redshift Quasars

ASTRO3D



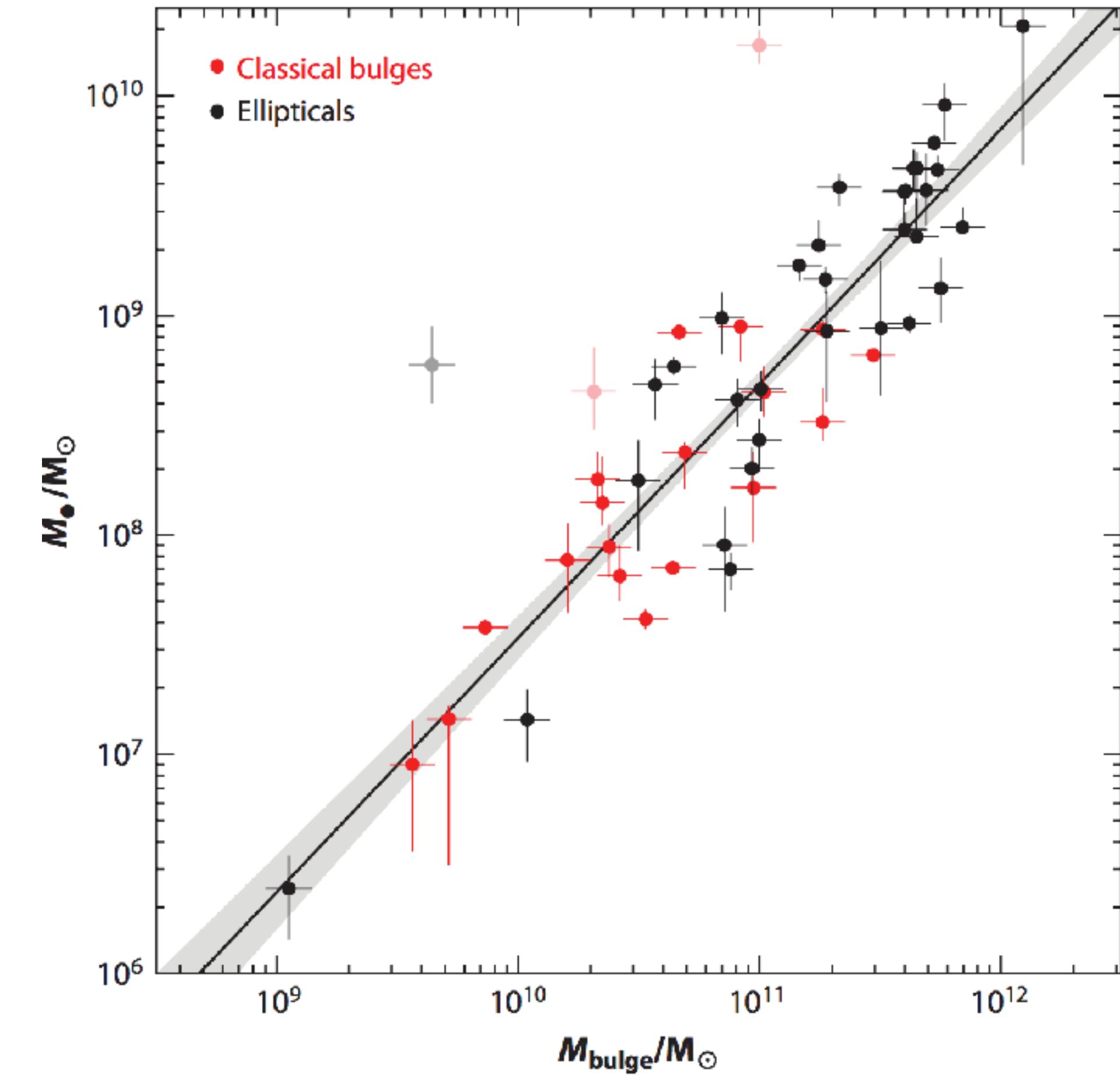
THE UNIVERSITY OF  
MELBOURNE

Madeline Marshall

with Stuart Wyithe (University of Melbourne),  
Simon Mutch (University of Melbourne) &  
Tiziana Di Matteo (Carnegie Mellon University)

# High Redshift Quasars

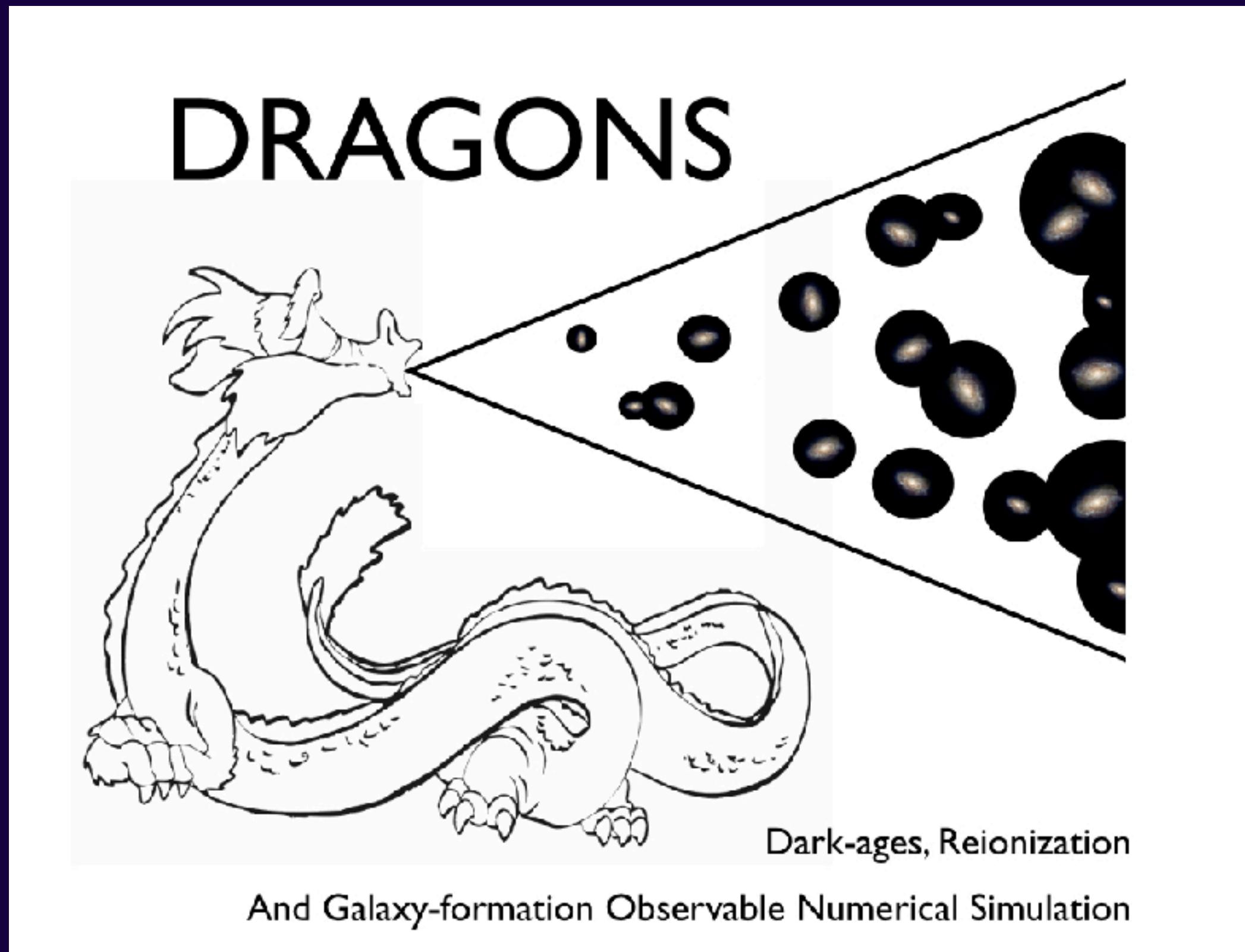
- Formed remarkably fast (<1 Gyr)
- Extremely luminous
- Do low-z black hole-host relations still apply?
- z~6 quasar hosts currently undetectable in rest-frame UV or optical
- We're observing two z~6 quasars with JWST
- Theoretically, what do we expect?



Kormendy & Ho (2013)

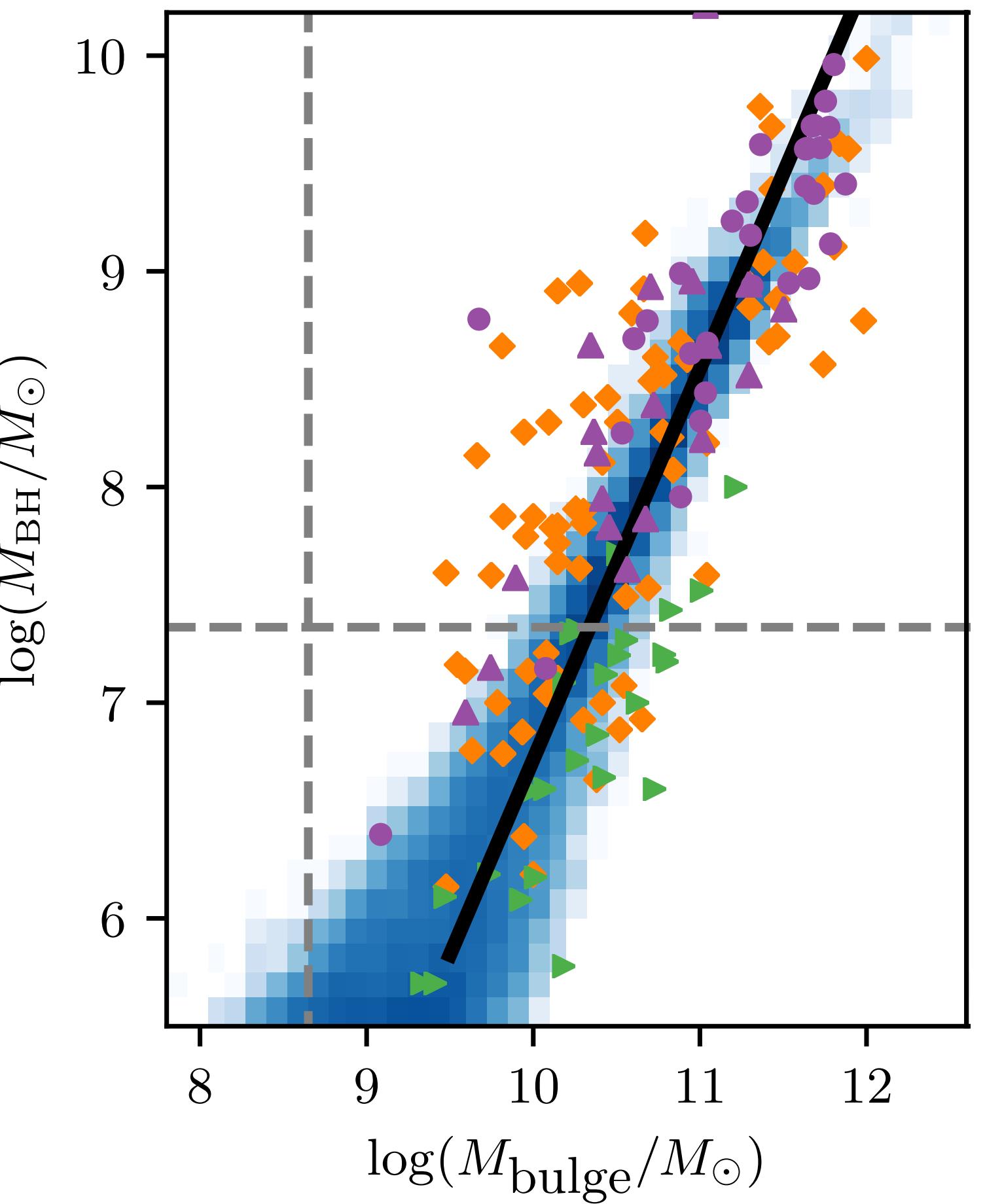
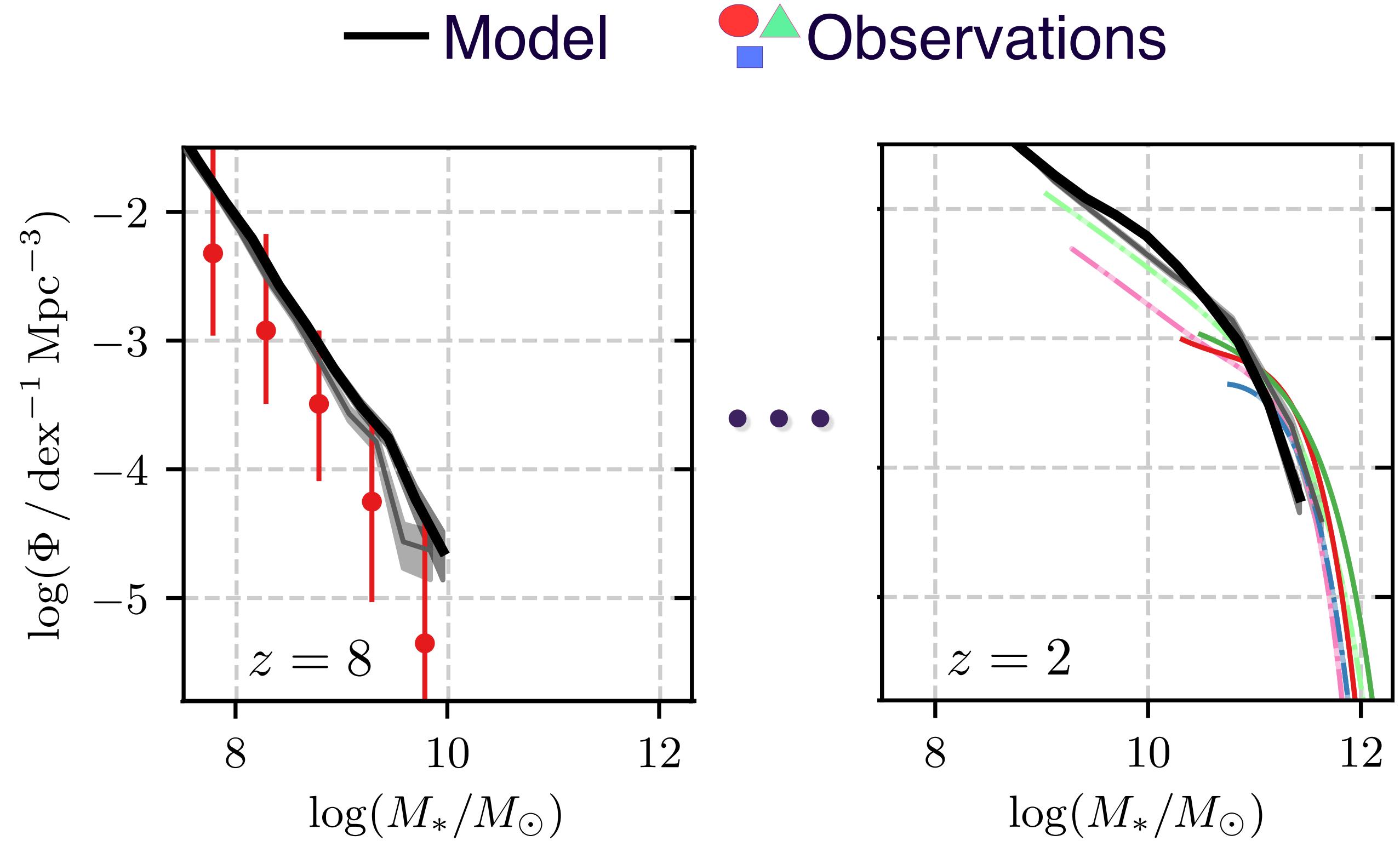
# Semi-Analytic Model: MERAXES

(Mutch et al. 2016)



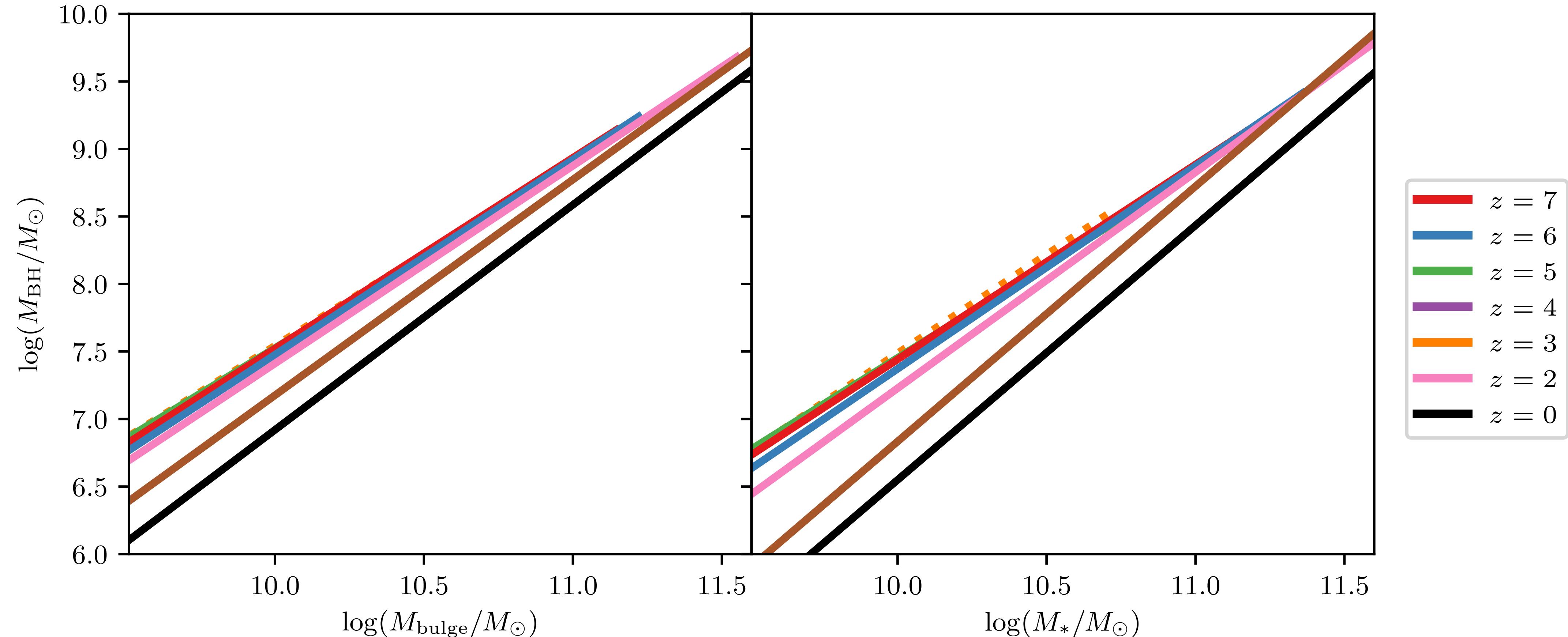
- Designed for studying galaxy formation during EoR
- Analytically models galaxy formation & evolution physics on Tiamat N-body simulation
- Typical black hole growth model (Qin et al. 2017):
  - “Quasar-mode” cold gas accretion triggered by mergers and disc instabilities
  - “Radio-mode” hot gas accretion

# Calibration



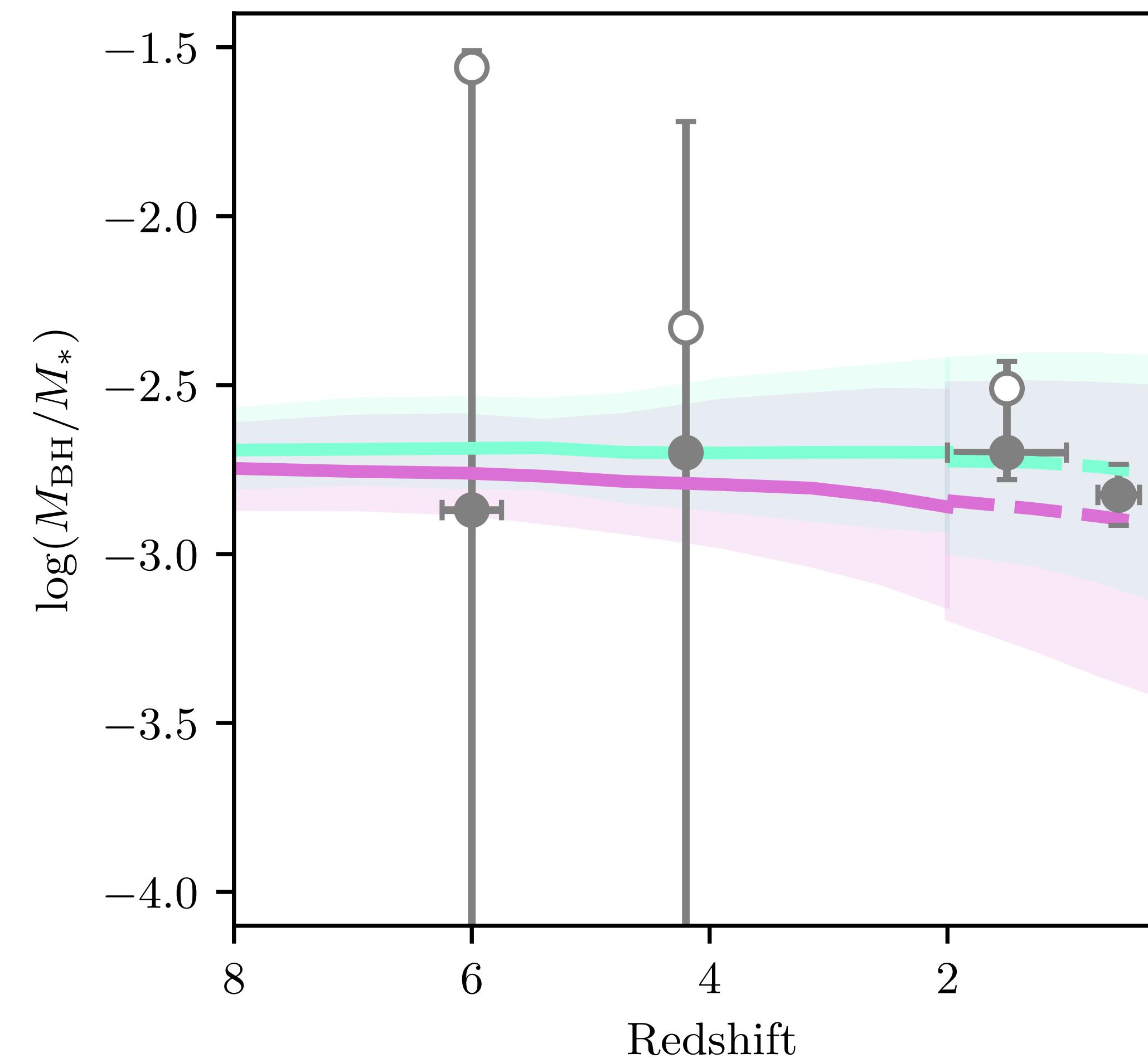
- Calibrated to the  $z=8-2$  stellar mass functions, and the  $z=0$  black hole—bulge mass relation (Marshall et al. 2019)

# Black Hole–Host Mass Relations

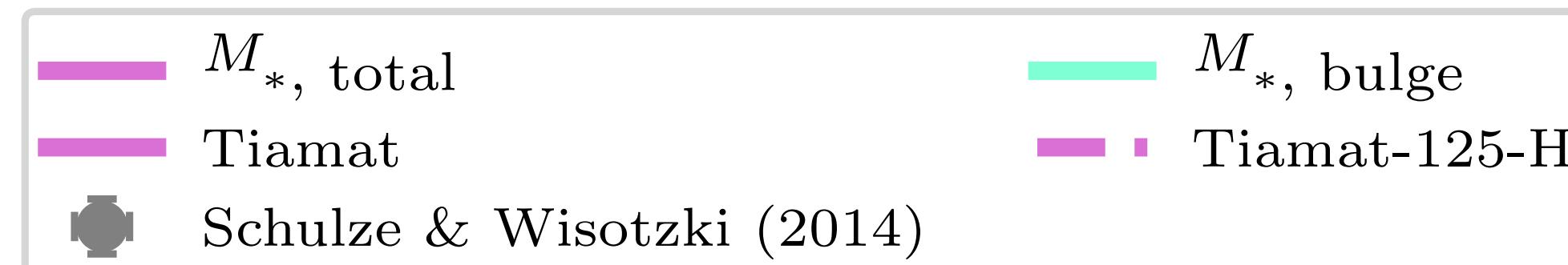


- Meraxes predicts very little evolution in the black hole–bulge and black hole–total stellar mass relations

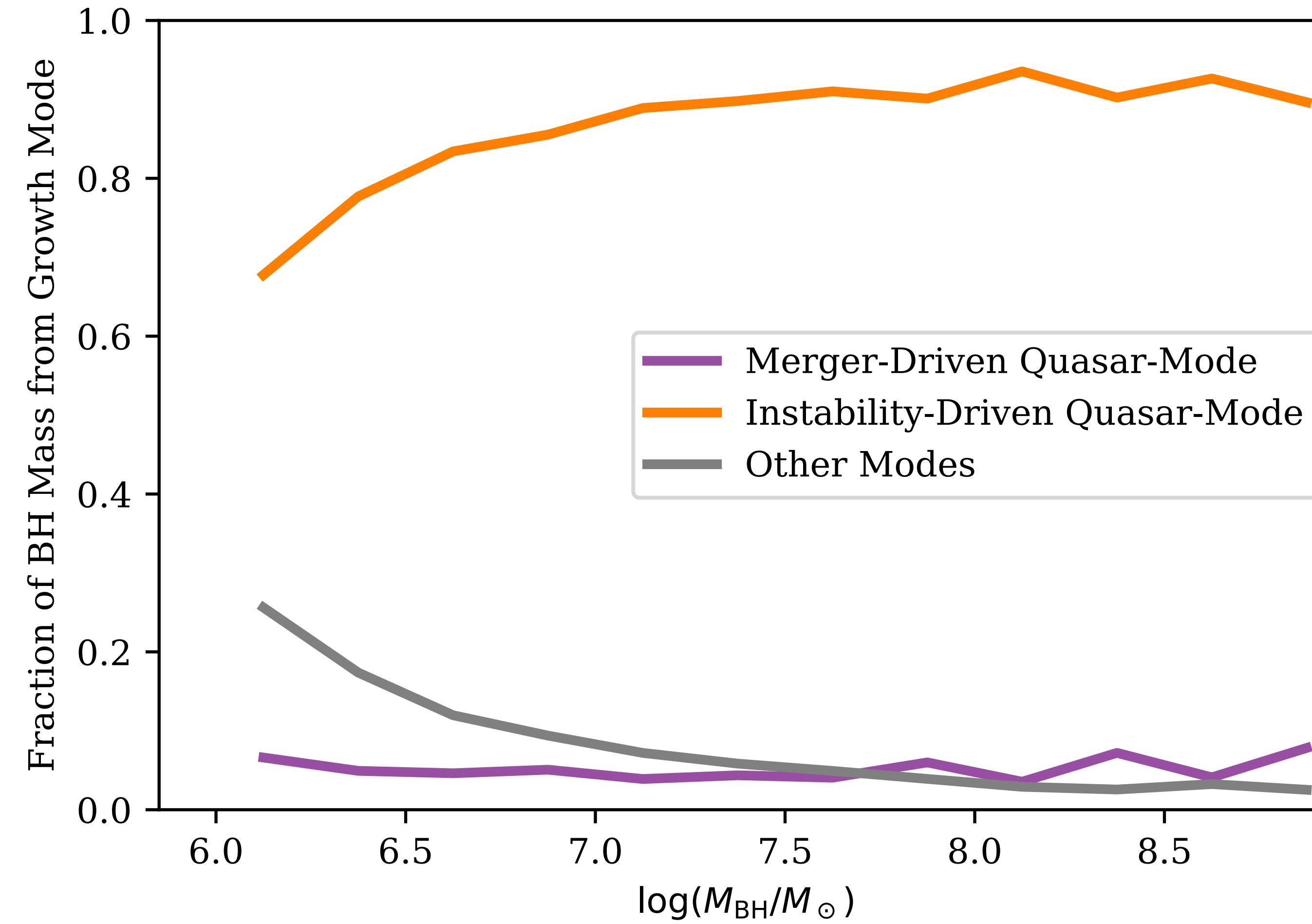
# Black Hole–Host Mass Relations



- Meraxes predicts no evolution in the ratio between black hole–bulge and black hole–total stellar mass



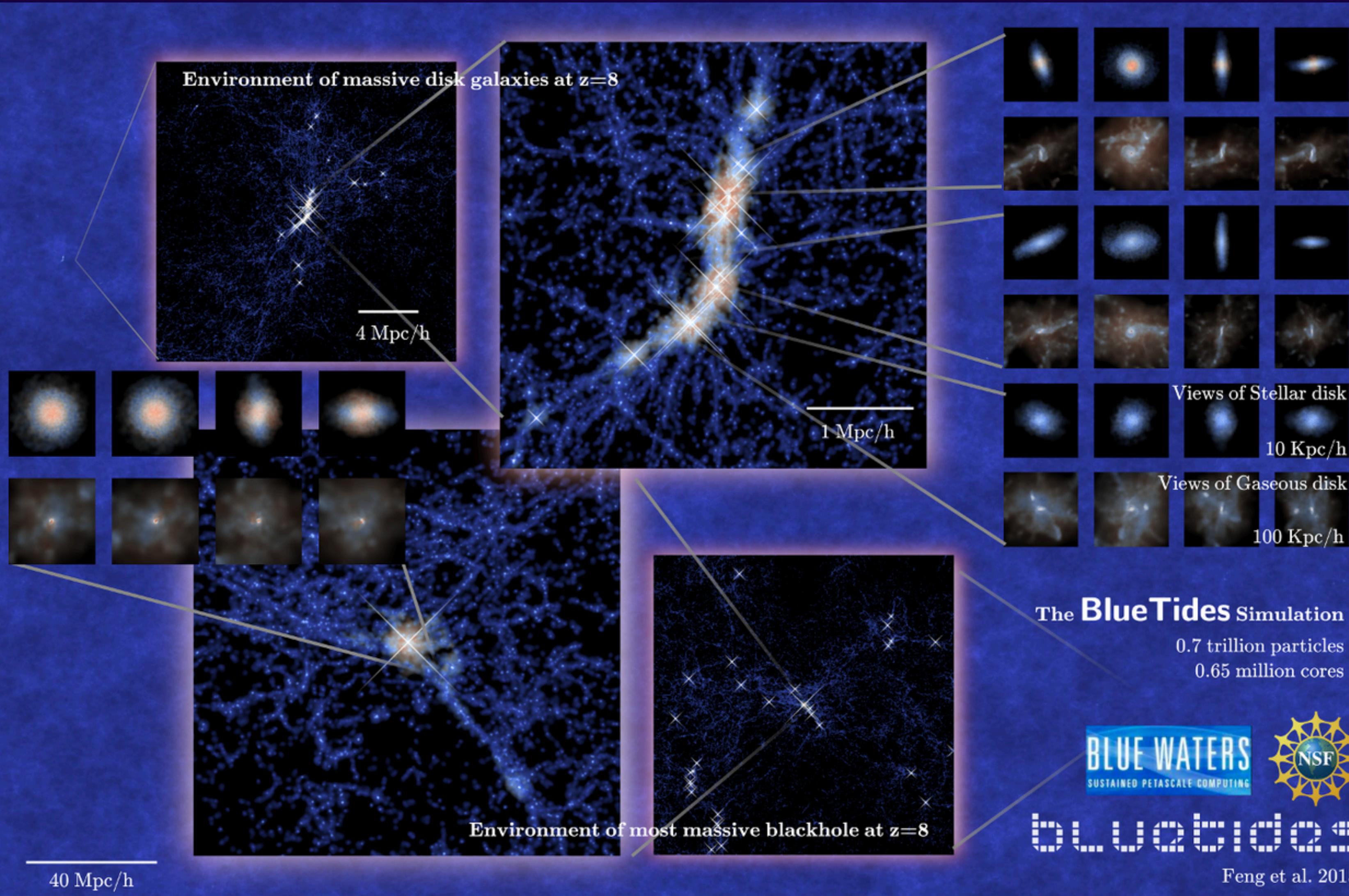
# How Do Black Holes Grow?



- Most black hole growth is from the instability-driven mode (at all redshifts)

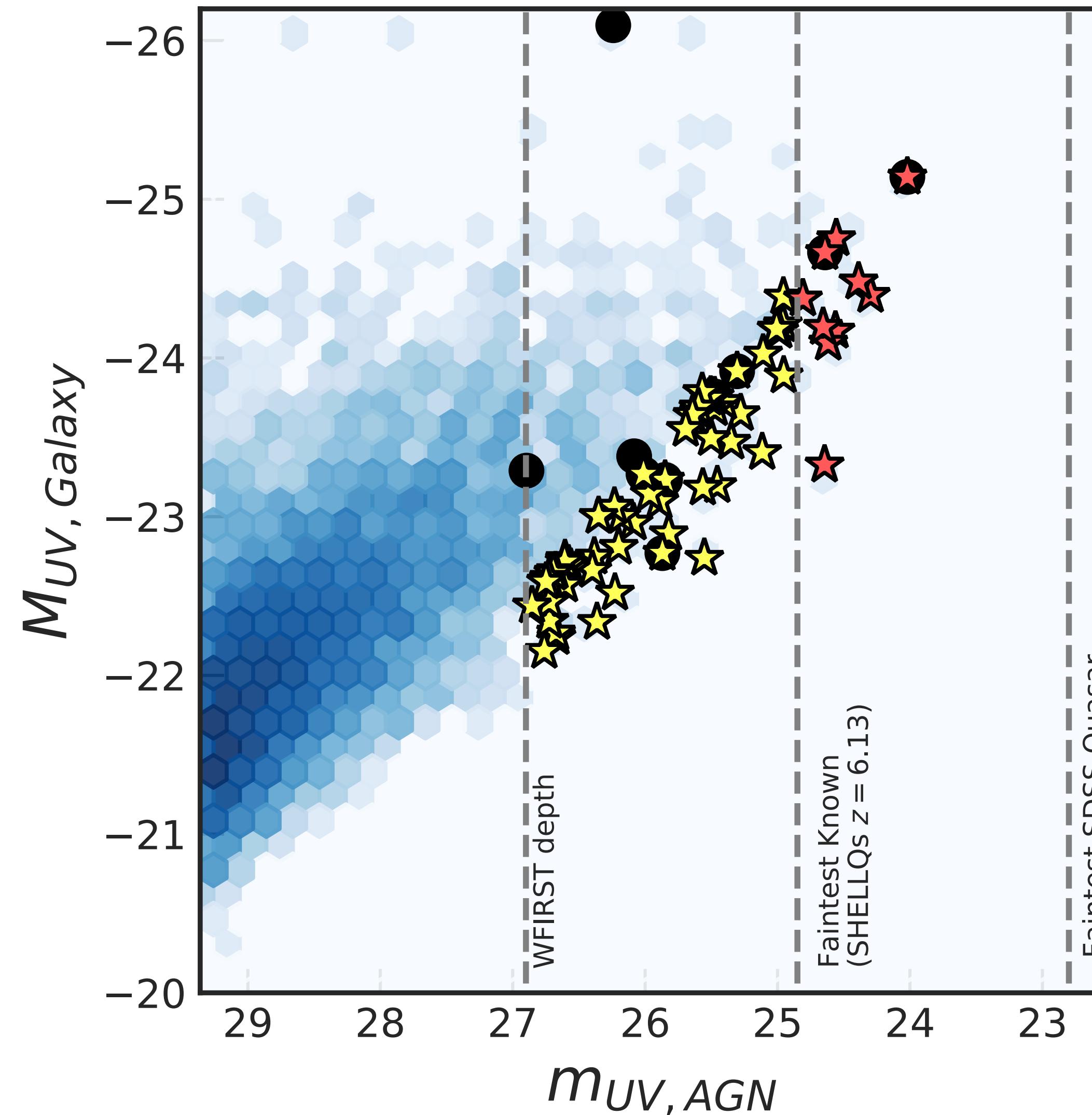
# Hydrodynamical Simulation: BLUETIDES

(Feng et al. 2015)



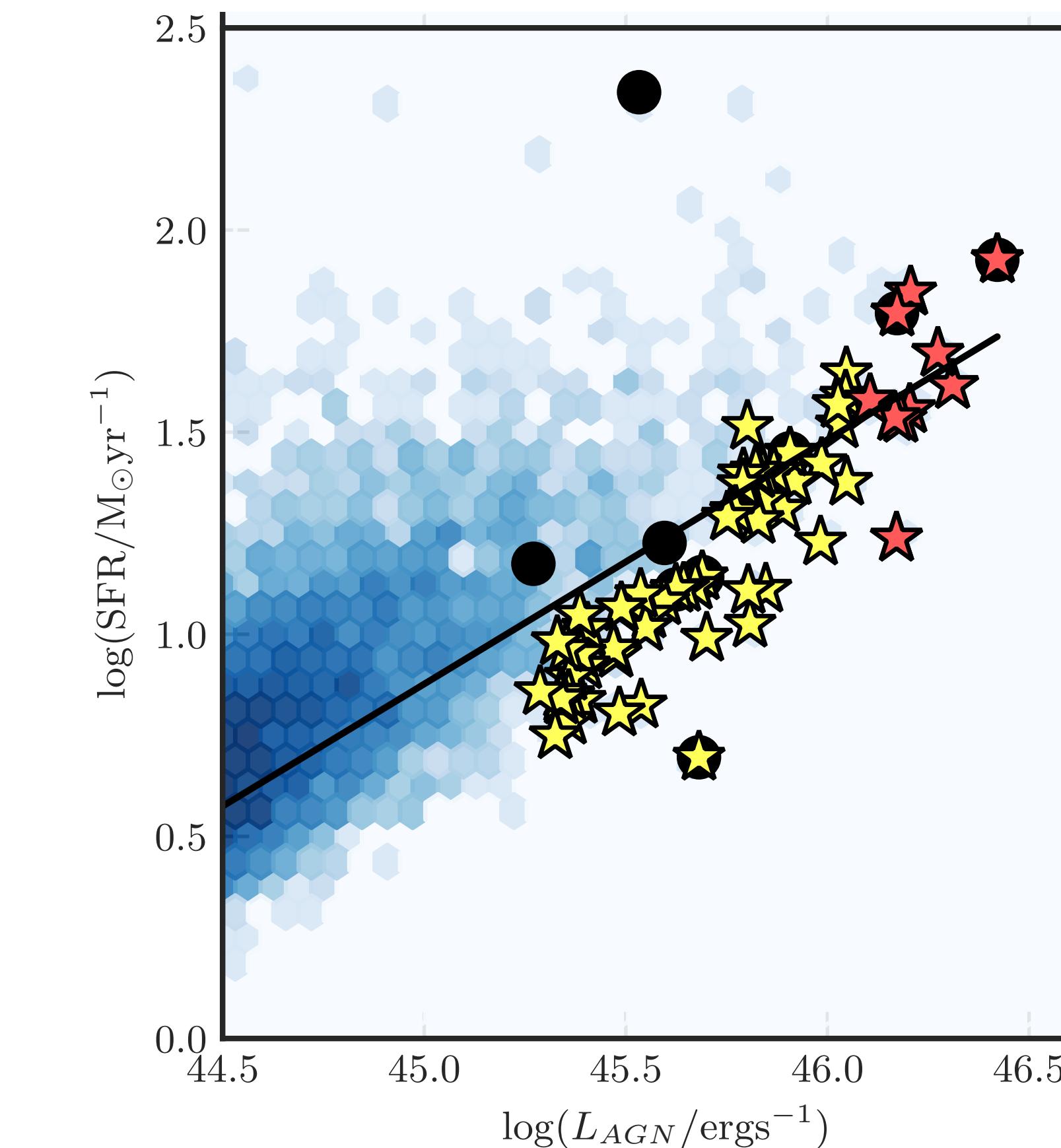
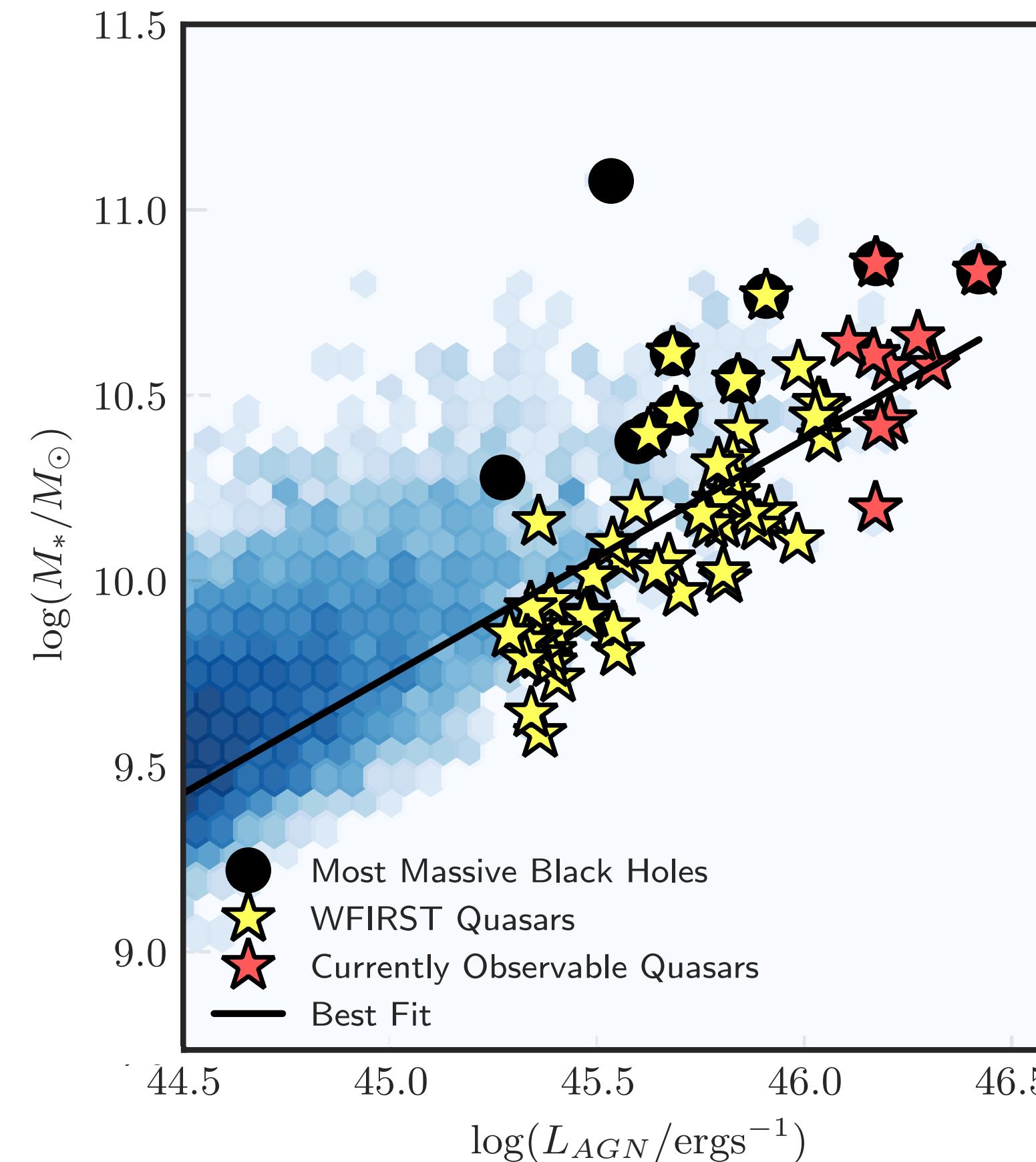
- Smoothed particle hydrodynamics (SPH)
- Box with volume  $(400/h \text{ Mpc})^3$
- Run for  $z \geq 7.3$

# $z=7.3$ Quasar Sample



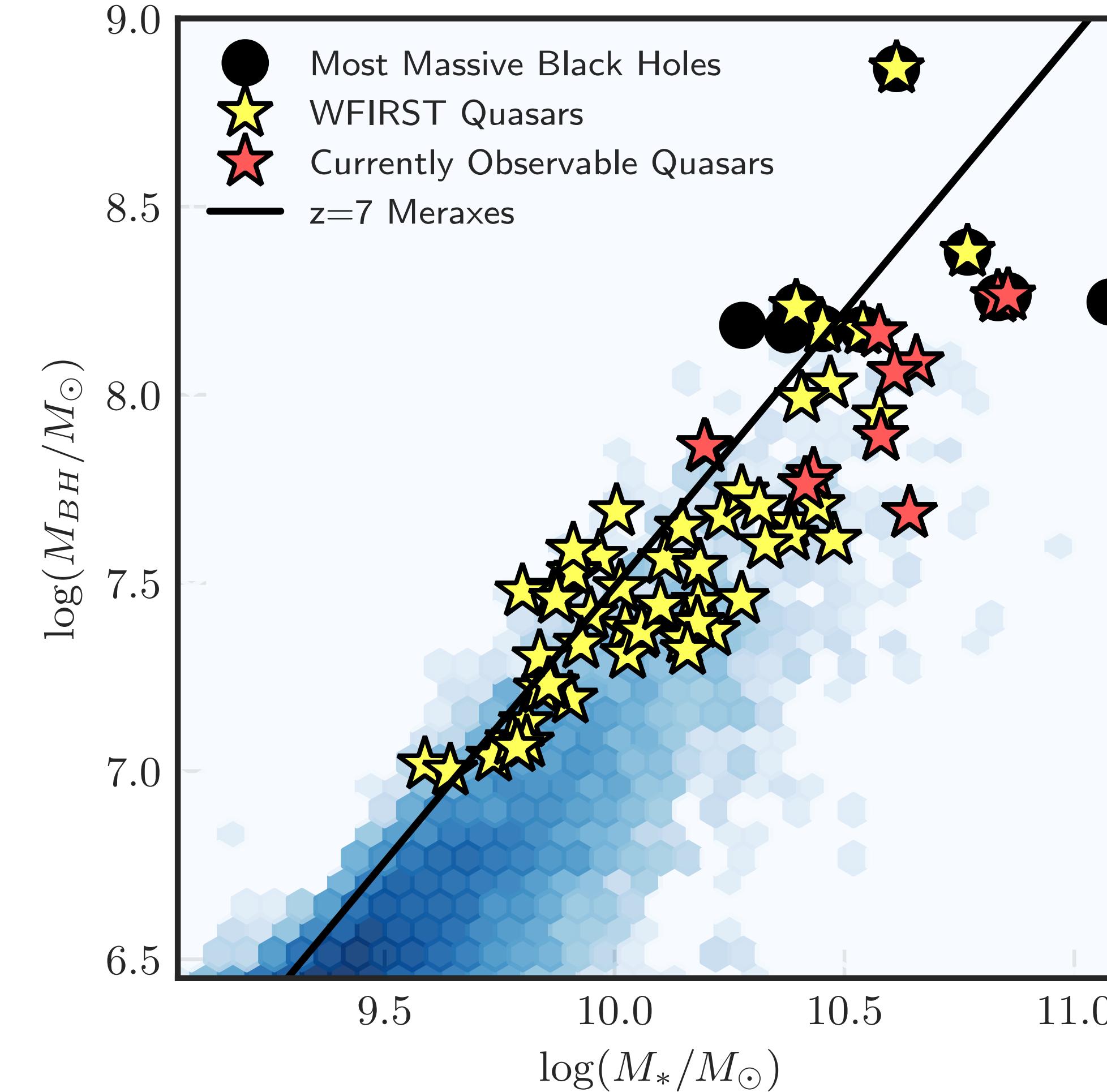
- Select 3 samples:
- 10 most massive black holes
- ★ AGN brighter than host, brighter than faintest known high-z quasar
- ★ AGN brighter than host, brighter than WFIRST depth

# Host Masses & Star Formation Rates



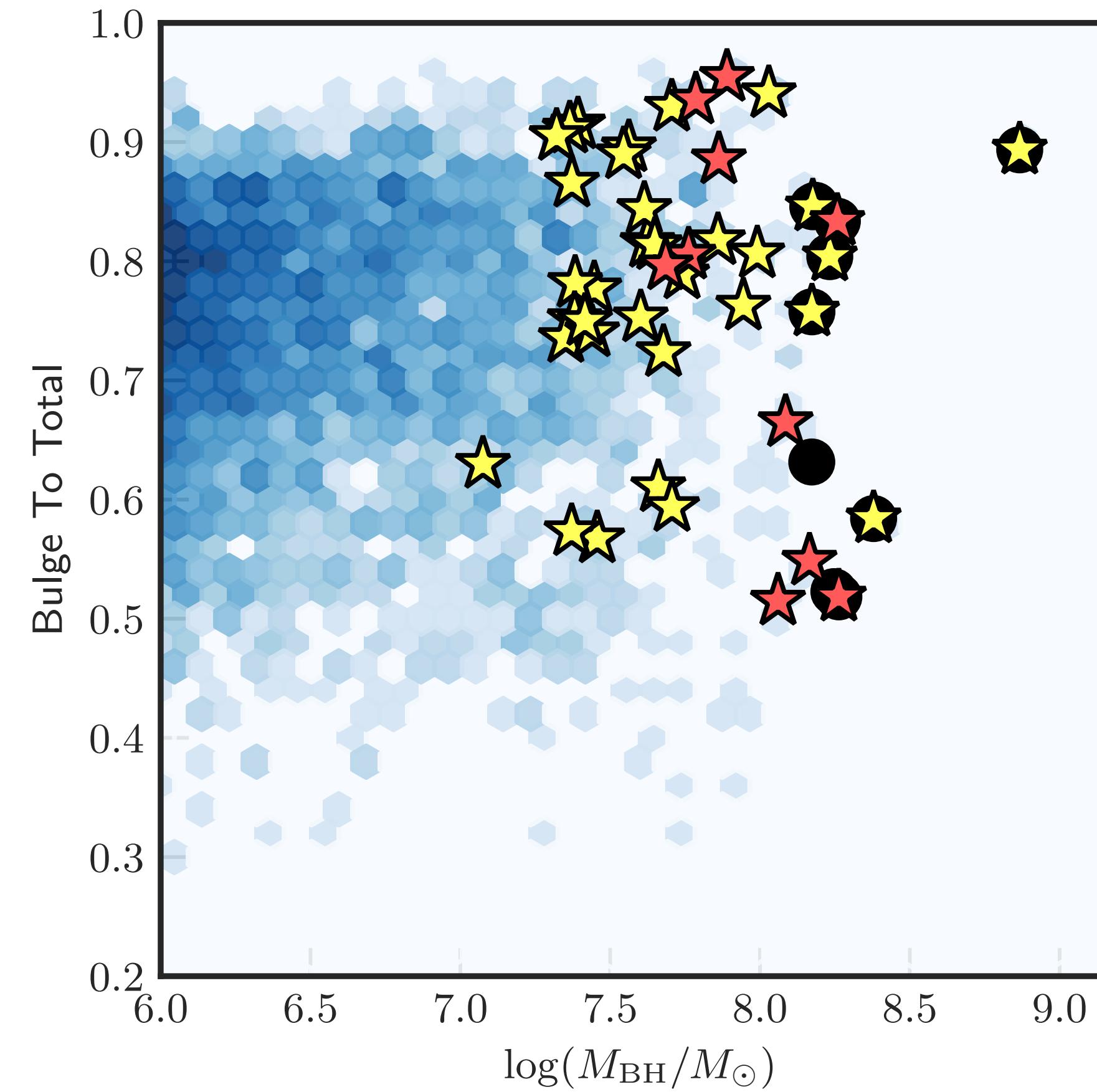
- Hosts have low star formation rates, but more ‘normal’ stellar masses

# Black Hole–Stellar Mass Relation



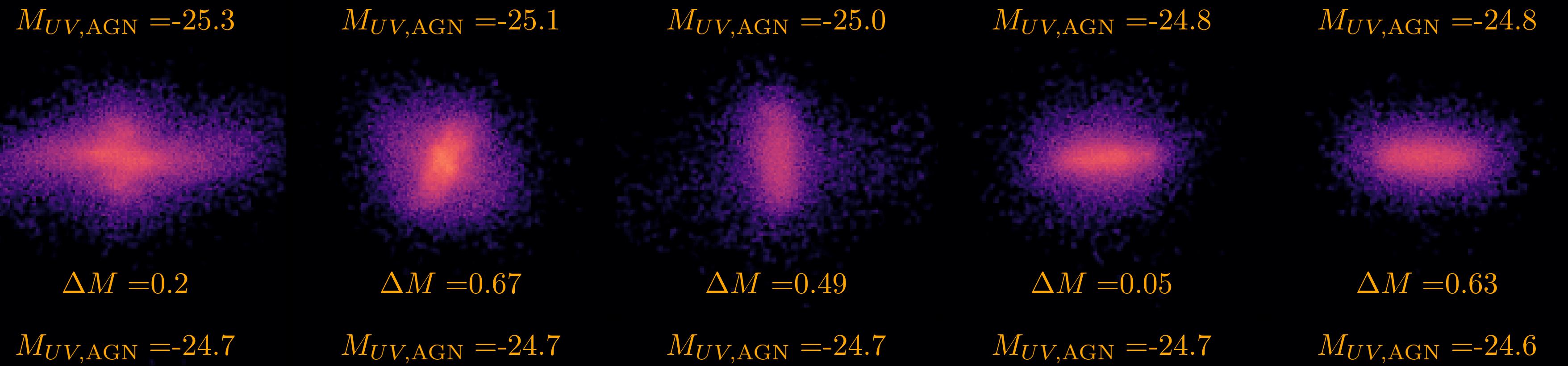
- See a bias towards high black hole masses for a given stellar mass

# Host Morphologies

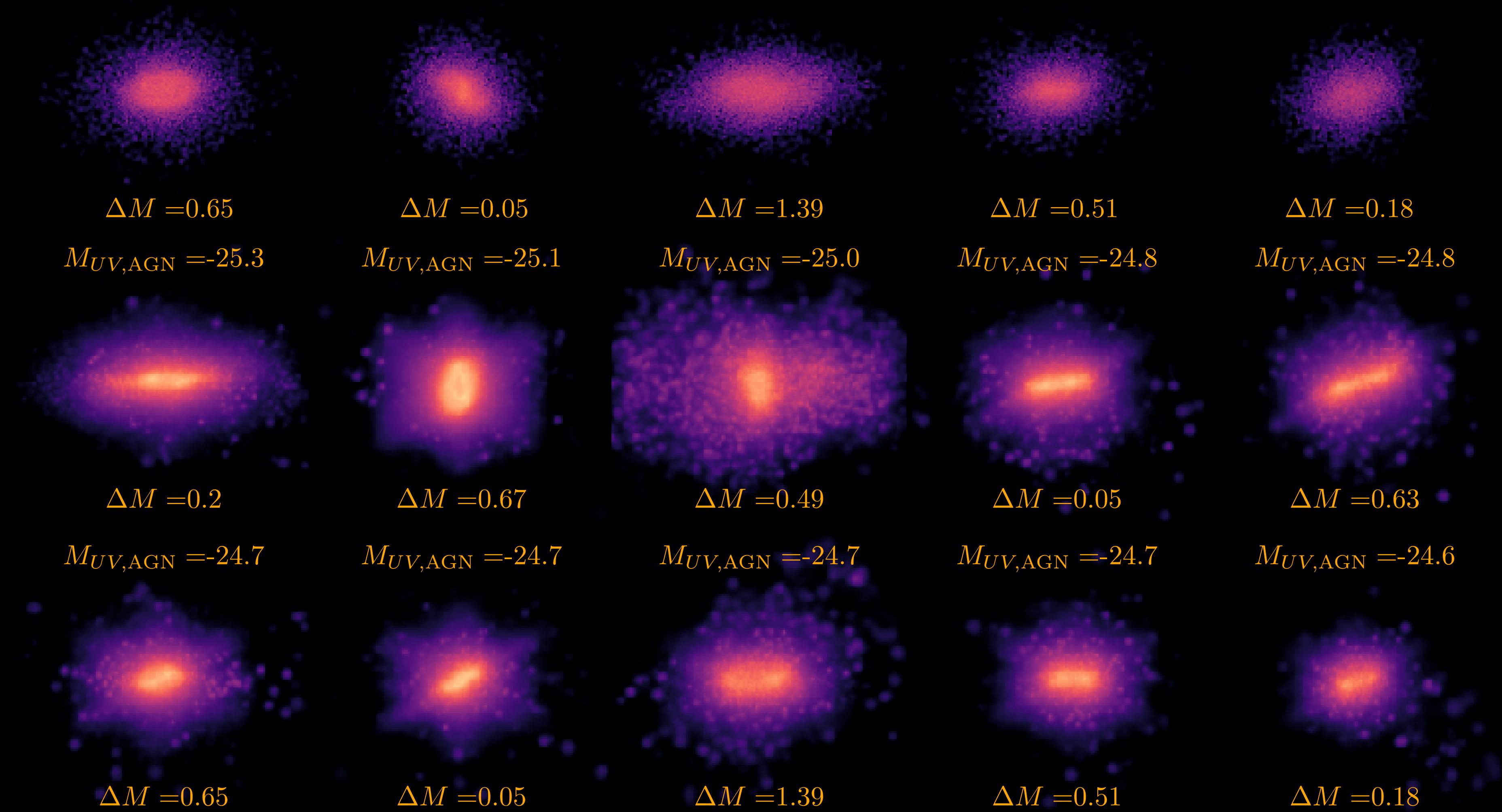


- Hosts have a range of morphologies

# MASS



# JWST (F115W)



# CONCLUSIONS

## MERAXES Semi-Analytic Model

- very little evolution in the black hole—bulge and black hole—total stellar mass relations
- No evolution in the ratio between black hole—bulge and black hole—total stellar mass

## BLUETIDES Hydrodynamical Simulation

- Quasar hosts have low star formation rates, but more ‘normal’ stellar masses
- Observe a bias towards high black hole masses for a given stellar mass
- Hosts have a range of morphologies