Do current X-ray observations capture most of the black-hole accretion at high redshifts?

arXiv: 2109.00078

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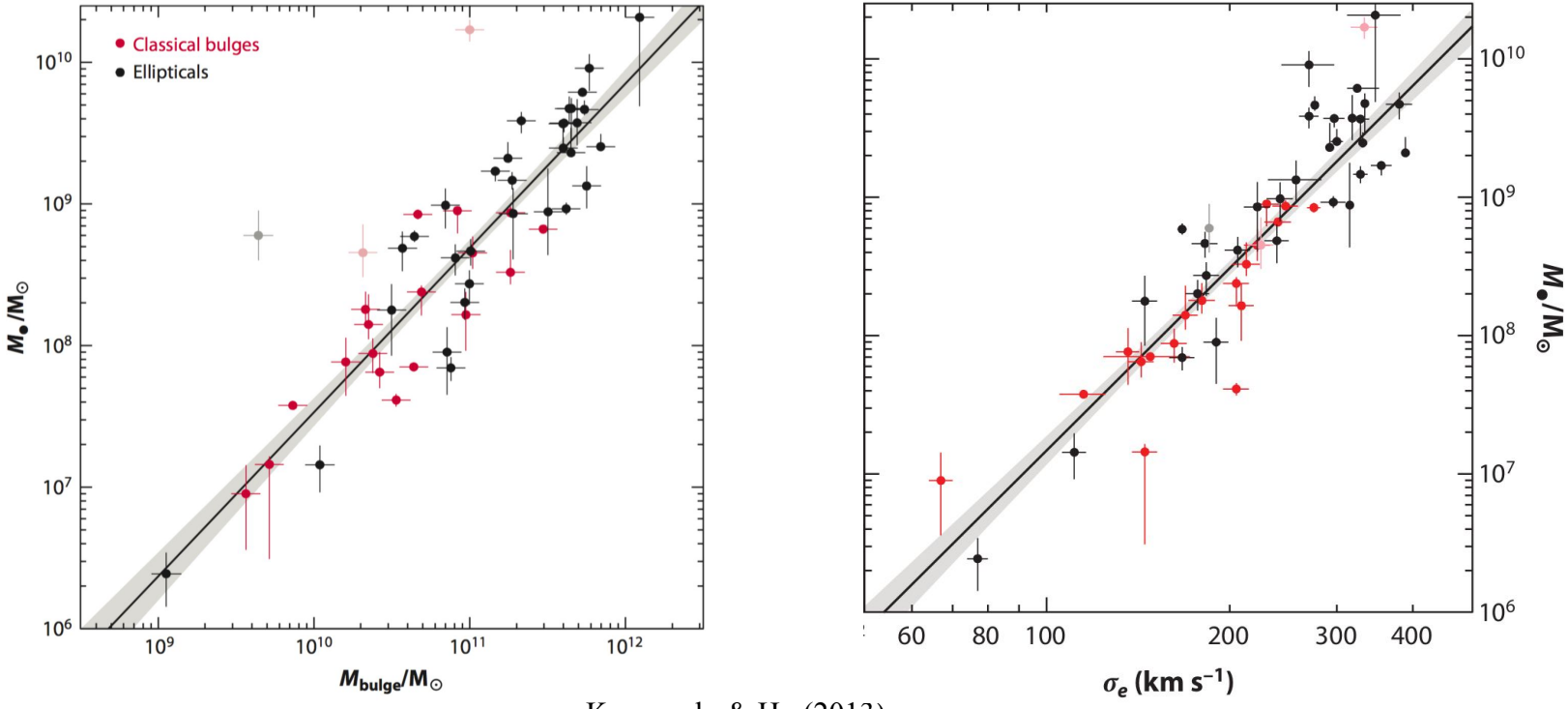
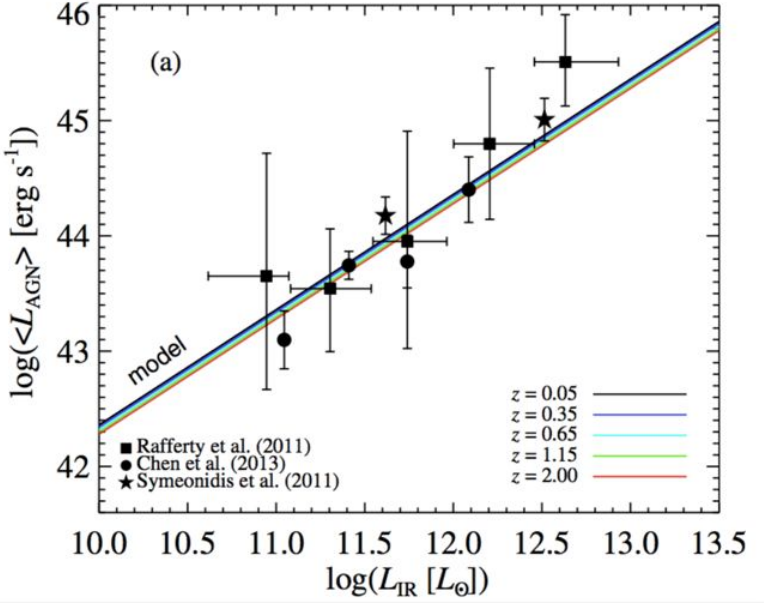
Sept. 16, 2021@exgal meeting

$M_{\rm BH}$ is related to host galaxy, but why?

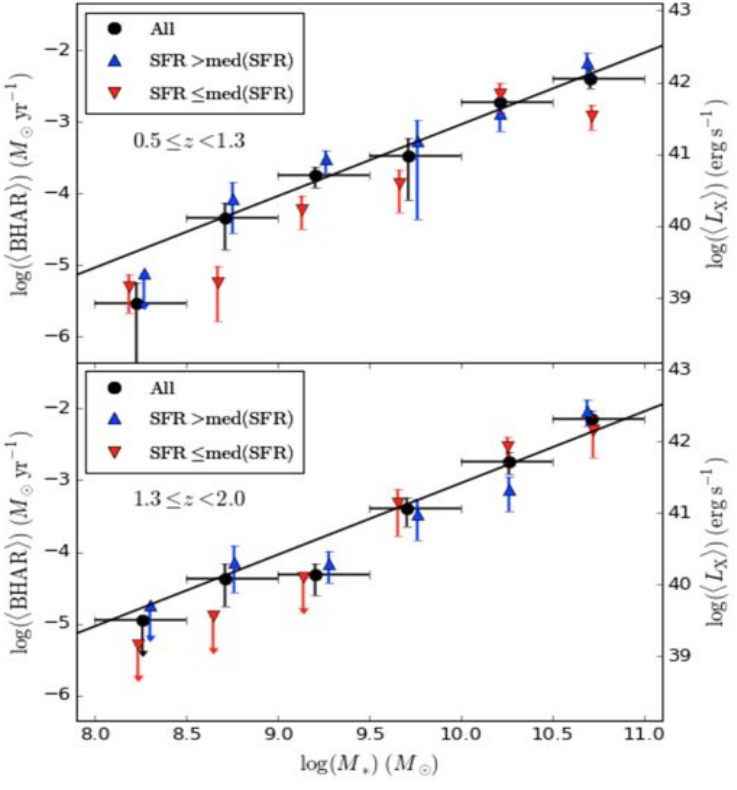


Kormendy & Ho (2013)

Previous works are controversial. Many studies tried to prove links between black hole accretion rate (BHAR) and SFR. But it turns out the BHAR-SFR links are largely a bias due to BHAR-M_* relation and the M_*-SFR main sequence



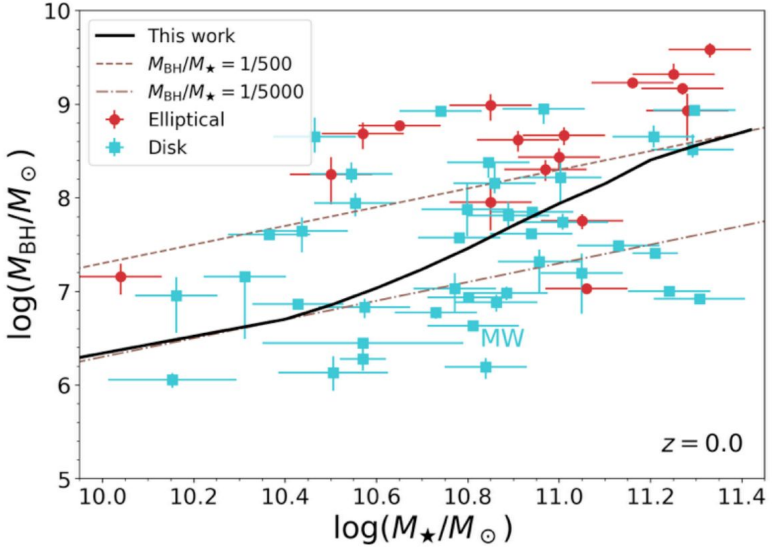
Hickox et al. (2014)



Yang et al. 2017

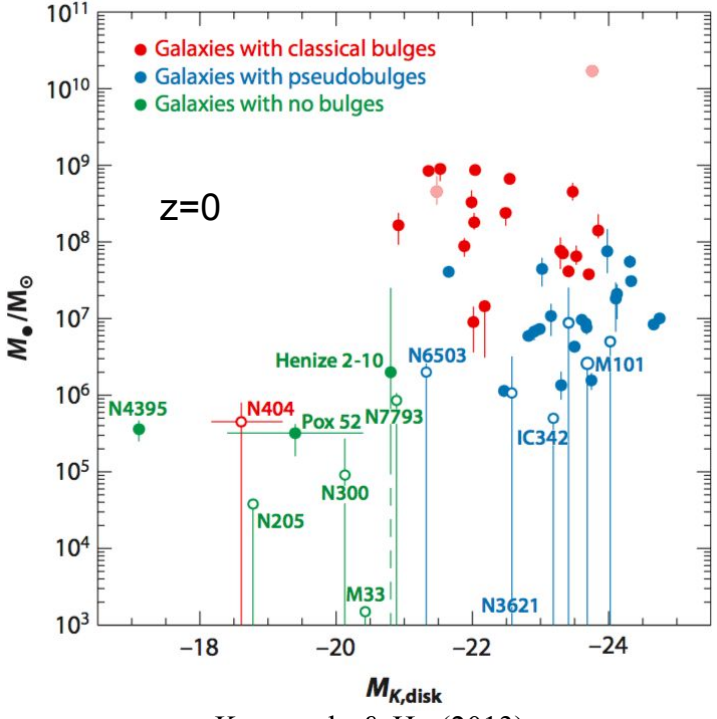
Morphology might be the key, but is mostly neglected by previous studies due to technical difficulties

M_{BH} not related to $M_\star$



Yang et al. (2018b)

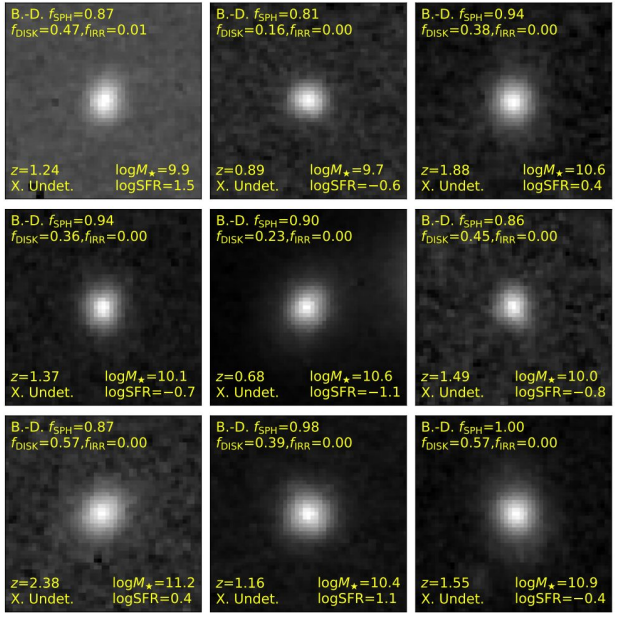
M_{BH} not related to disk



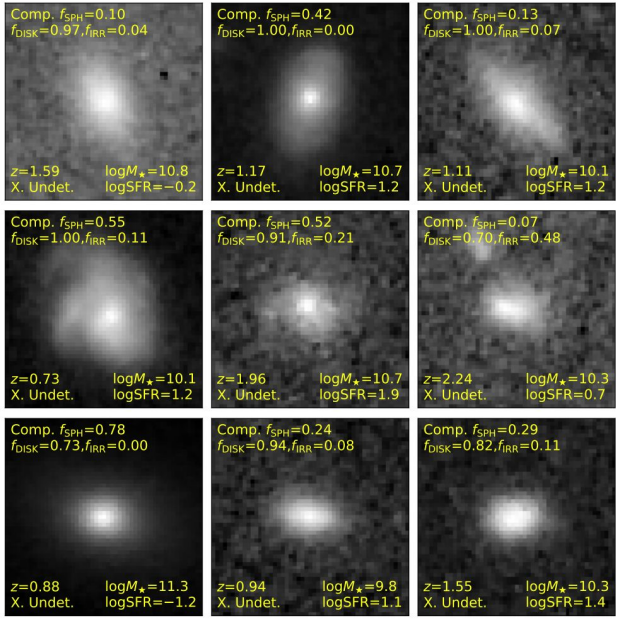
Kormendy & Ho (2013)

***HST* F160W imaging** can do the job of bulge vs. non-bulge classification up to z~3

Bulge-dominated (~25%)



Comparison (~75%)

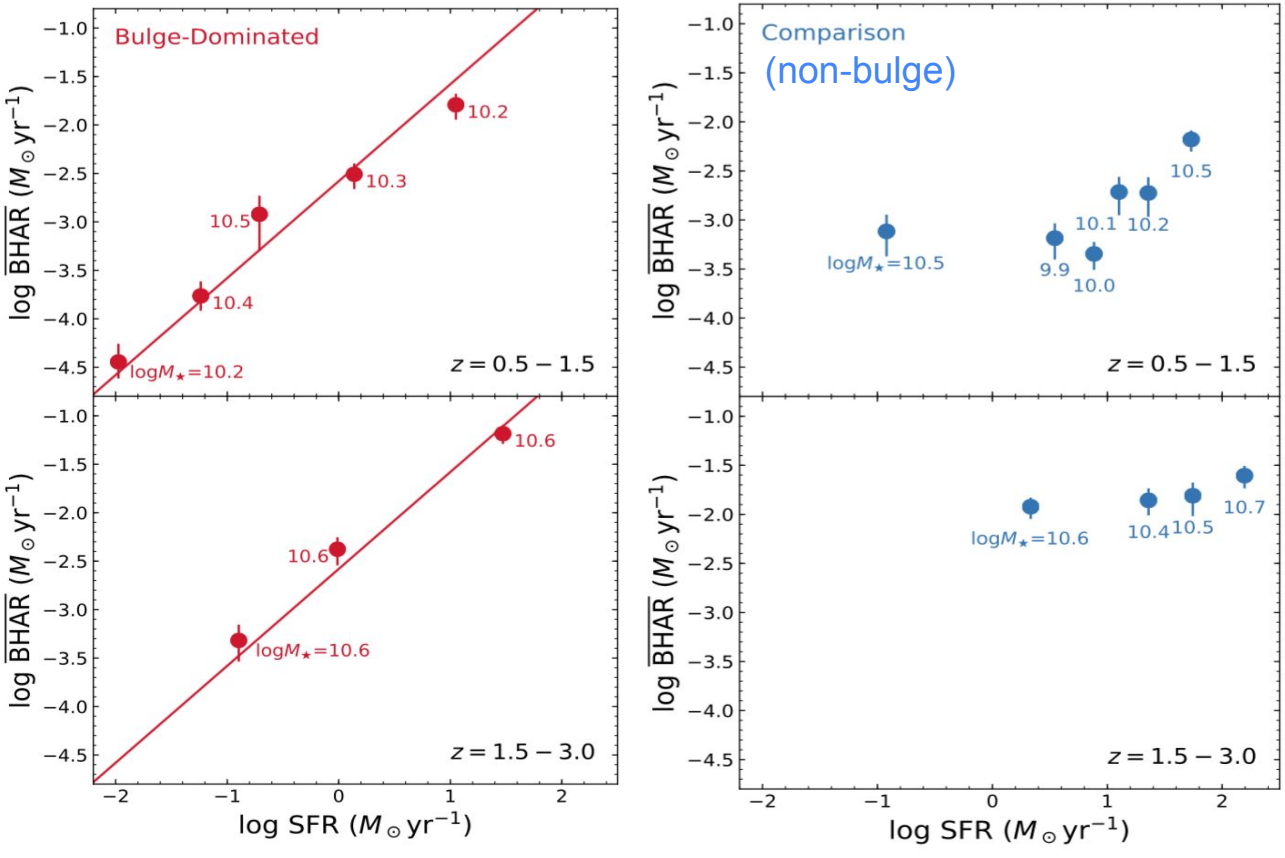


Machine-learning based classification (Huertas-Company+2015)

Bulge vs. non-bulge samples are totally different!

Bulge-dominated: BHAR is indeed correlated with SFR (10σ)

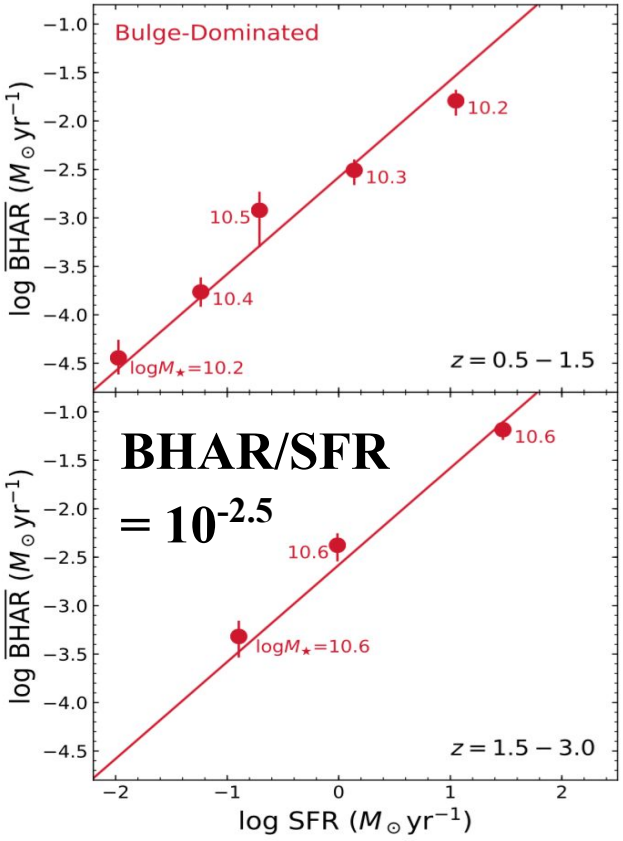
Non-bulge: BHAR is not significantly related to SFR (<2σ)



Yang et al. (2019)

Lockstep BH-bulge growth

(also confirmed by Ni+2020 with COSMOS sample)



Yang et al. (2019)

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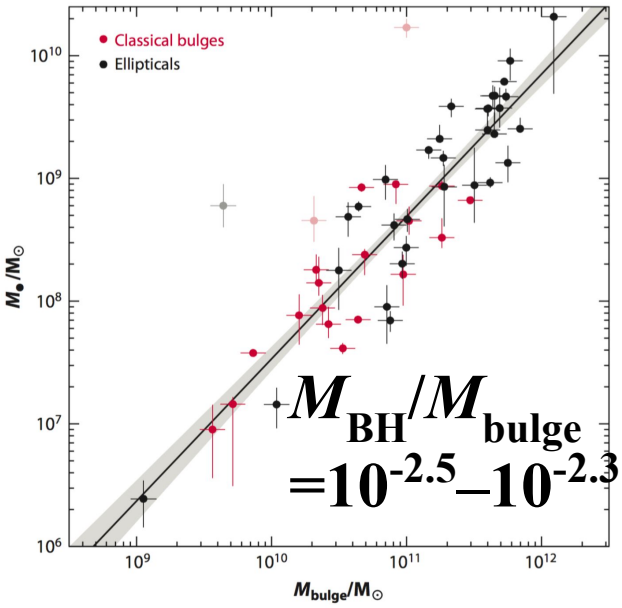


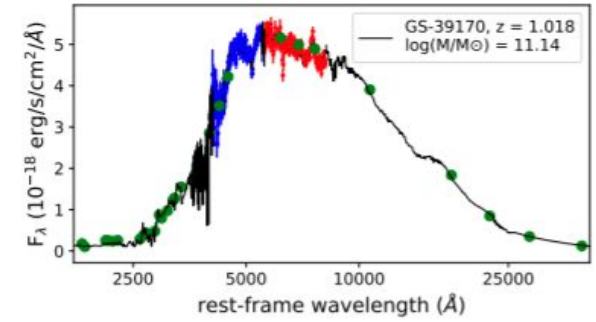
Kormendy & Ho (2013)

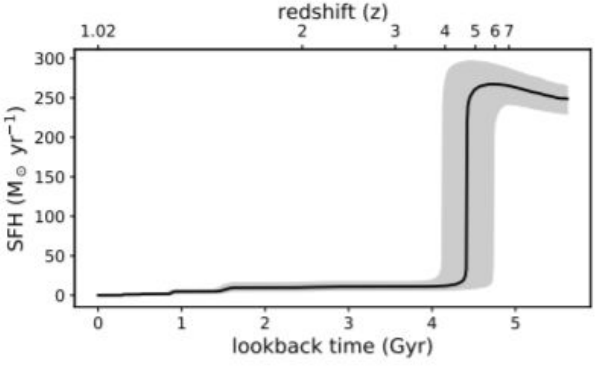
BHAR-SFR relation allows you to **playback BH accretion history**

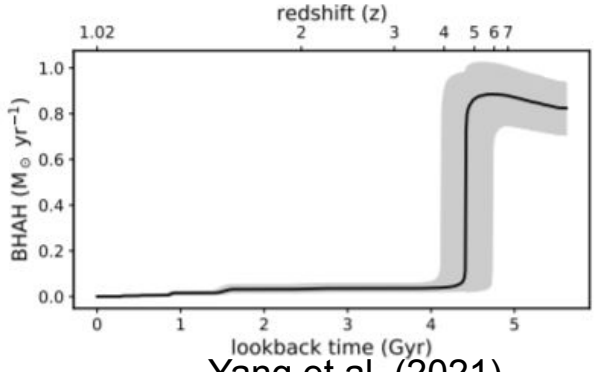
HST spectroscopy (CLEAR survey) + broad-band photometry ⇒ **star formation history (SFH)** for each bugle-dominated galaxy (thank Vince)

The BHAR-SFR relation can convert the SFH to **black hole accretion history (BHAH)**

Add up all the BHAH and divide by the comoving volume ⇒ **black hole accretion density (BHAD)** from bulge-dominated galaxies

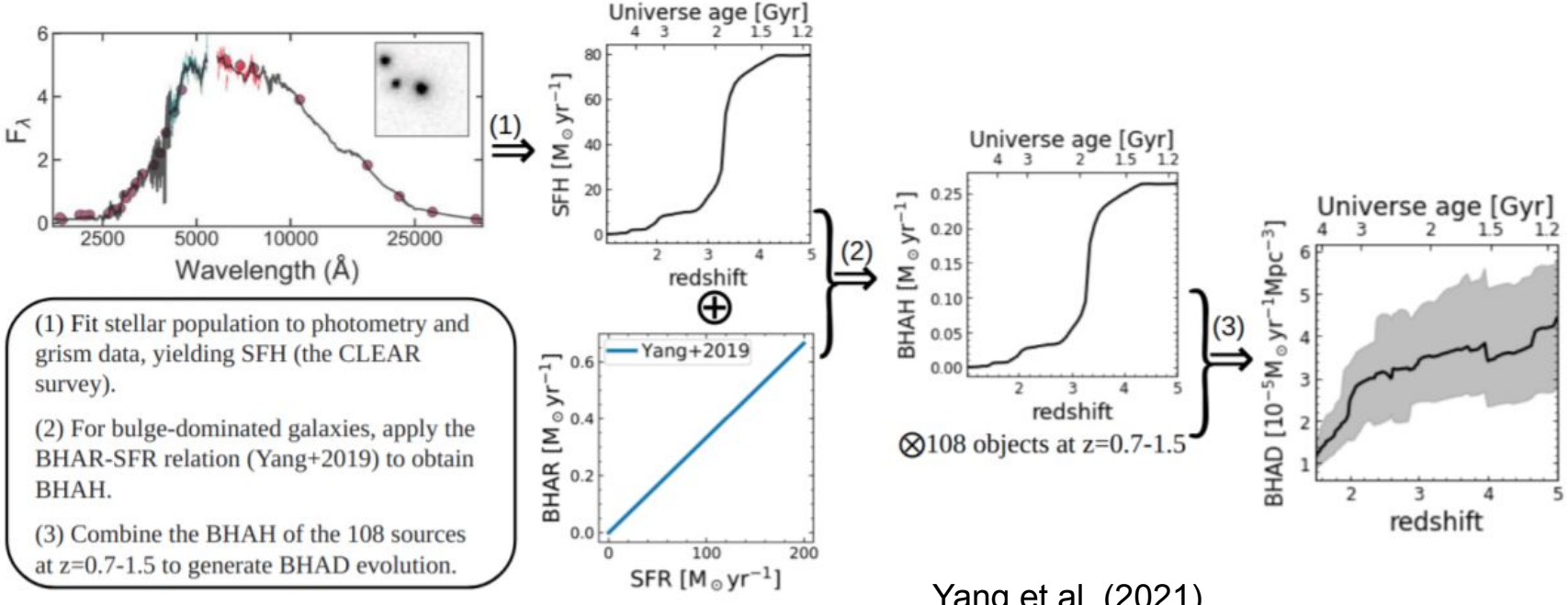






Yang et al. (2021)

Summary of our approach



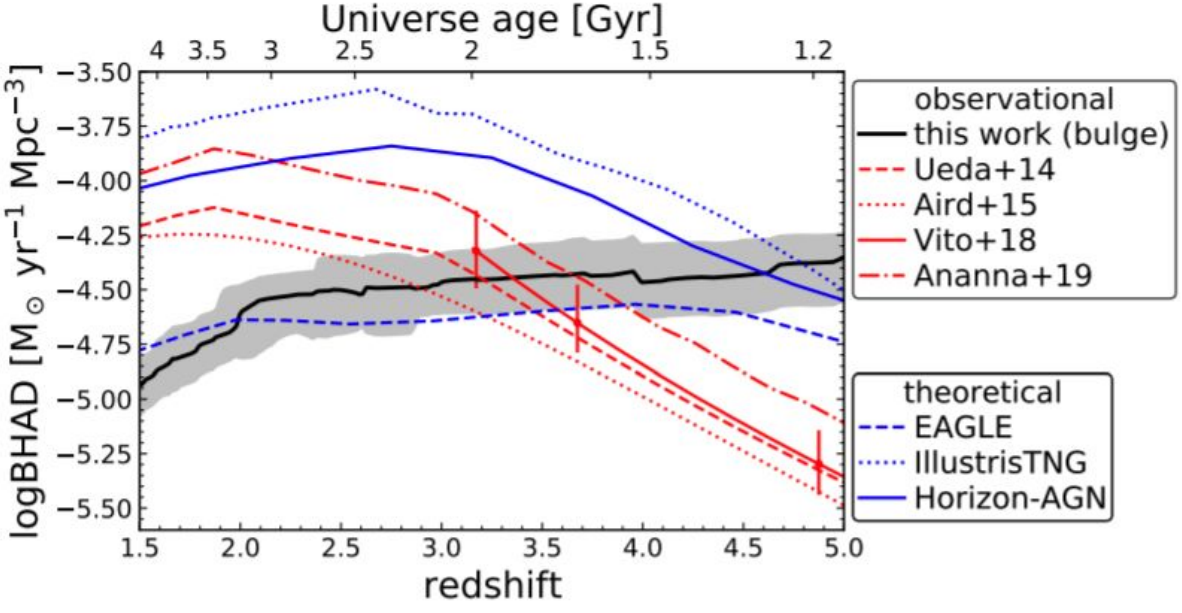
Yang et al. (2021)

Result: At z=4-5, our BHAD >> X-ray observed BHADs

At z≲3, our bulge BHAD is consistent with (lower than) both theoretical and observational (X-ray) results

At z=4-5, our BHAD is still similar to theoretical BHADs but **much higher than the X-ray BHADs**

X-ray BHADs have been **corrected for systematics** due to radiation efficiency and bolometric correction

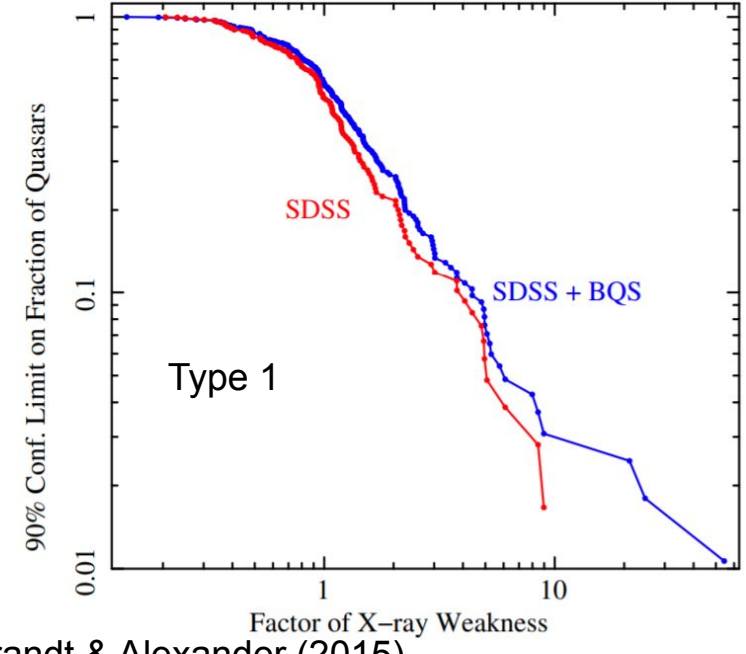


Yang et al. (2021)

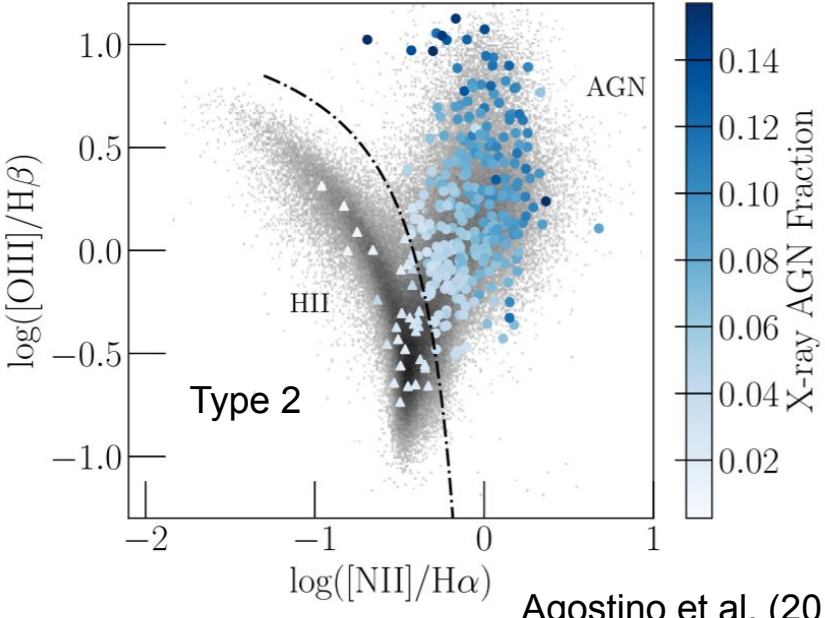
Scenario 1: X-ray surveys are incomplete

Most type-1 AGNs are also strong X-ray emitters. But many BPT-selected **type-2 AGNs are missed by X-ray**.

The reason is likely **obscuration**. When **$N_H > 10^{24}$ cm^{-2} (Compton-thick)**, even high-energy X-rays are suppressed.



Brandt & Alexander (2015)



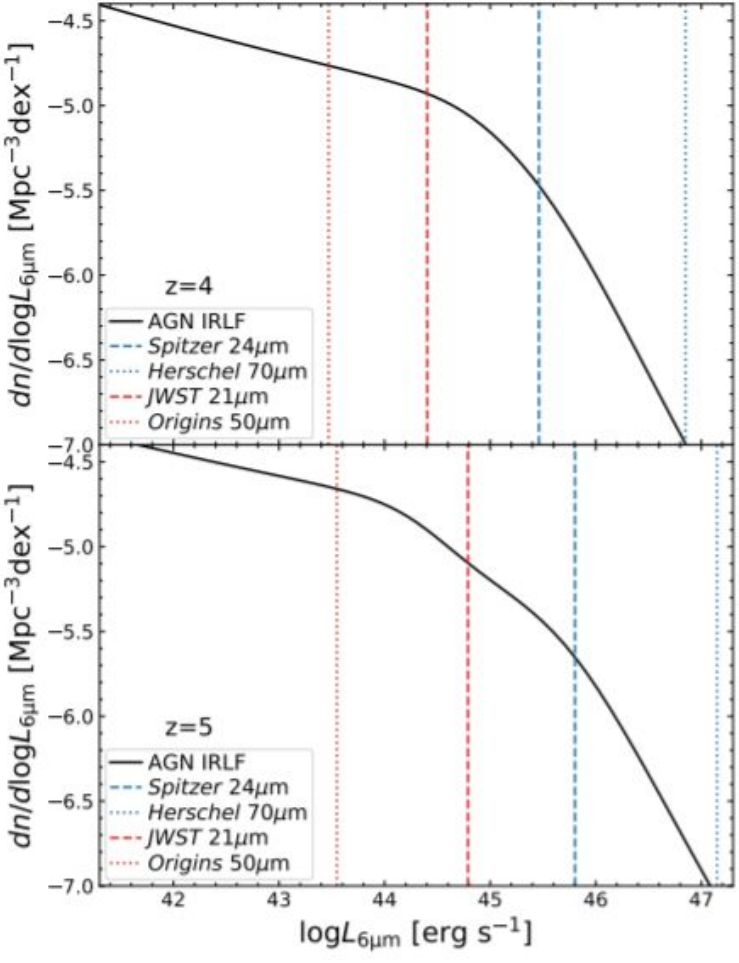
Agostino et al. (2019)

Predictions for AGN IR luminosity function

The X-ray missed Compton-thick AGNs likely have strong **IR dust re-emission**.

We predict **AGN IR luminosity function** based on our BHAD, assuming the missed AGNs have the same intrinsic L_X distribution and L_X-L_{IR} relation

JWST* and *Origins will sample $\lesssim$ the break luminosity ⇒ dozens of z=4-5 AGNs in a CANDELS-like (~1000 arcmin^2) survey

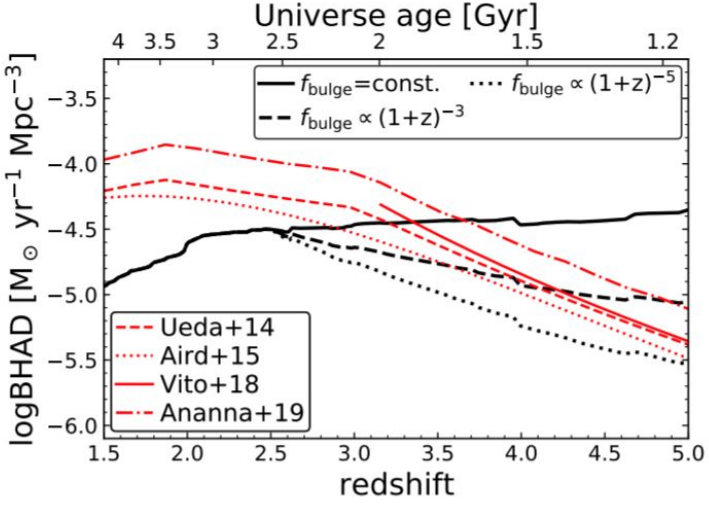


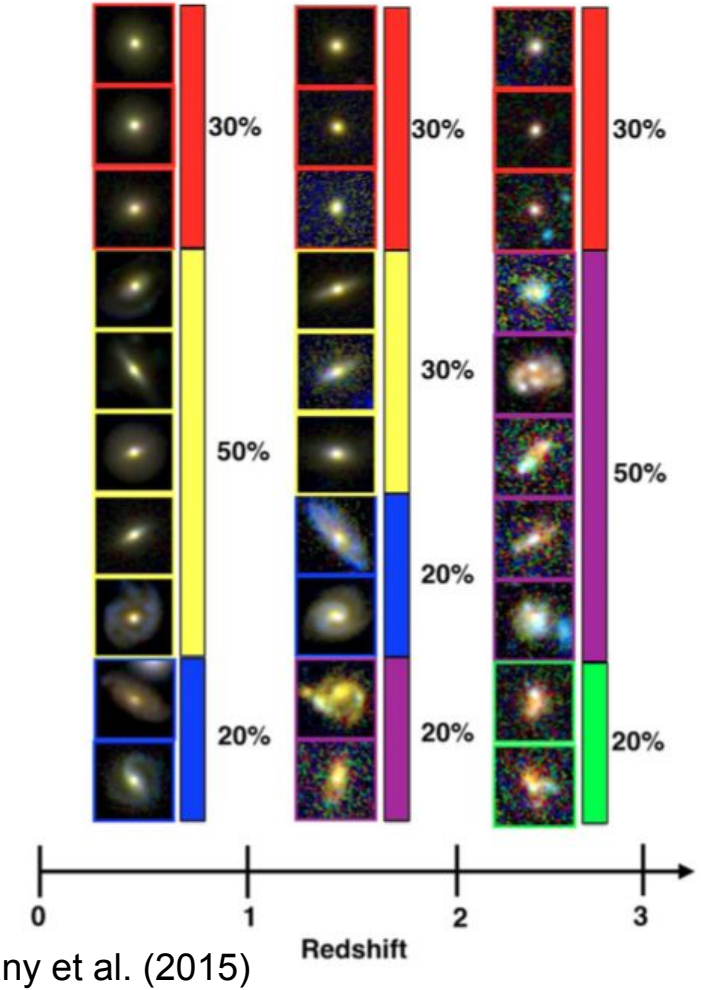
Scenario 2: bulge evolution

Our BHAD estimation assume the **progenitors of our sample are still bulge-dominated**, as BHAR-SFR relation only works for bulge-dominated galaxies.

Current results: **bulge fraction is ~ constant to z~2.5**, supporting our assumption.

But **bulge fraction might drop at z>2.5**. *JWST* will test this scenario.





Huertas-Company et al. (2015)

What's next? Go to even higher redshift

CLEAR results show some **bulge-dominated galaxies form at z>6**.

Simulations cannot reproduce those galaxies.

Bulges and BHs might already be there within the 1st billion year since Big Bang, earlier than theorists' expectation.