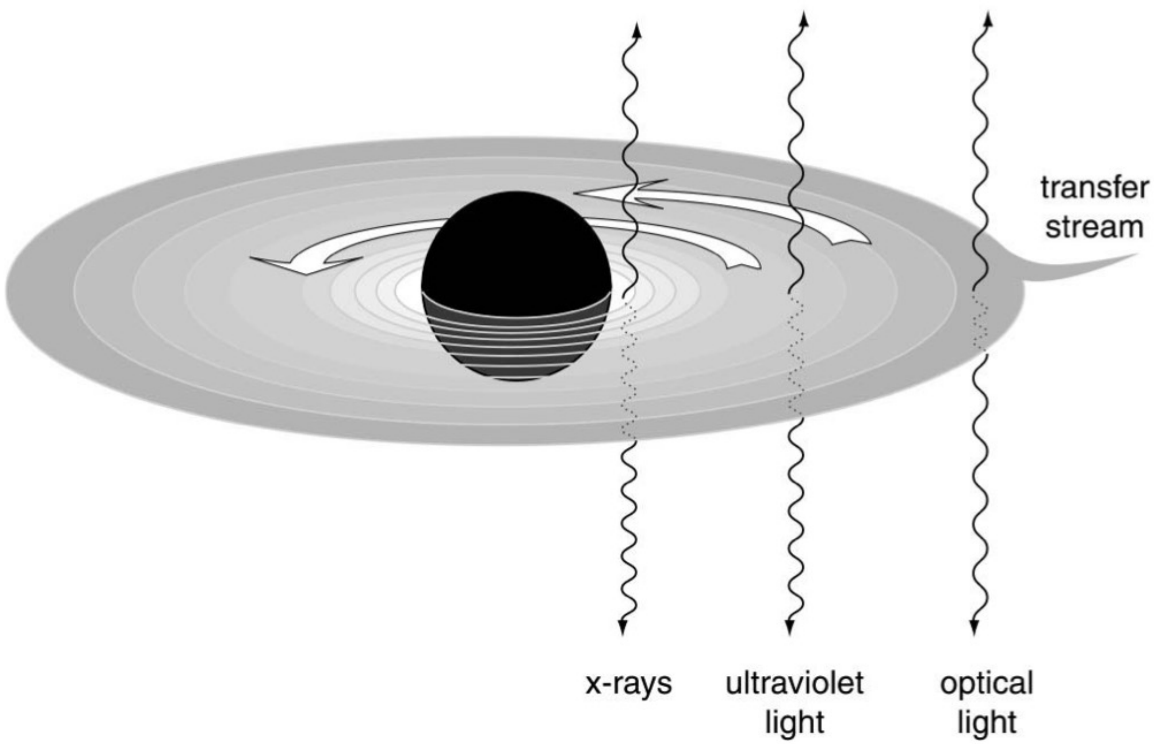
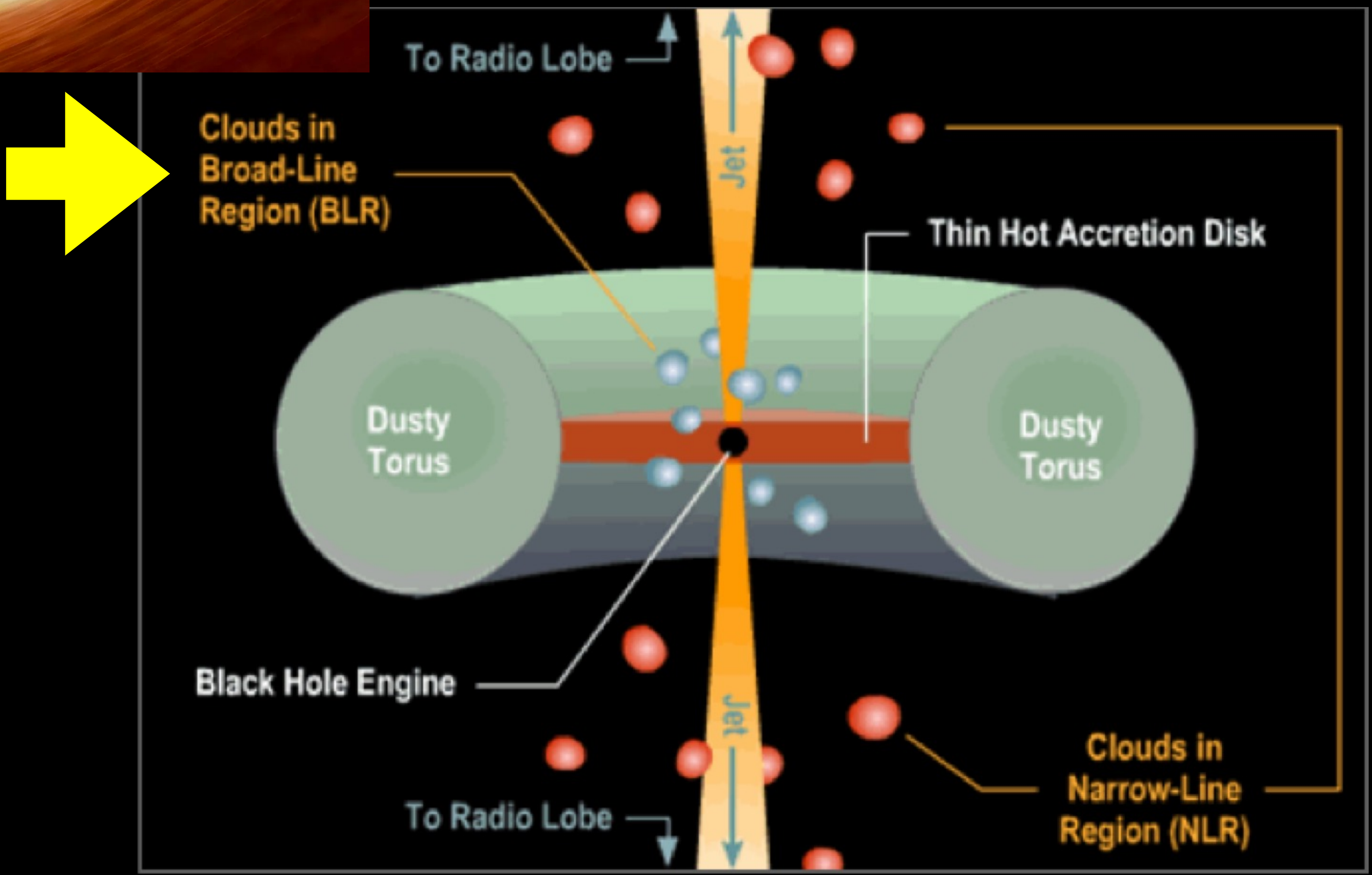
Black Holes Masses

Energy Release From Central Engines

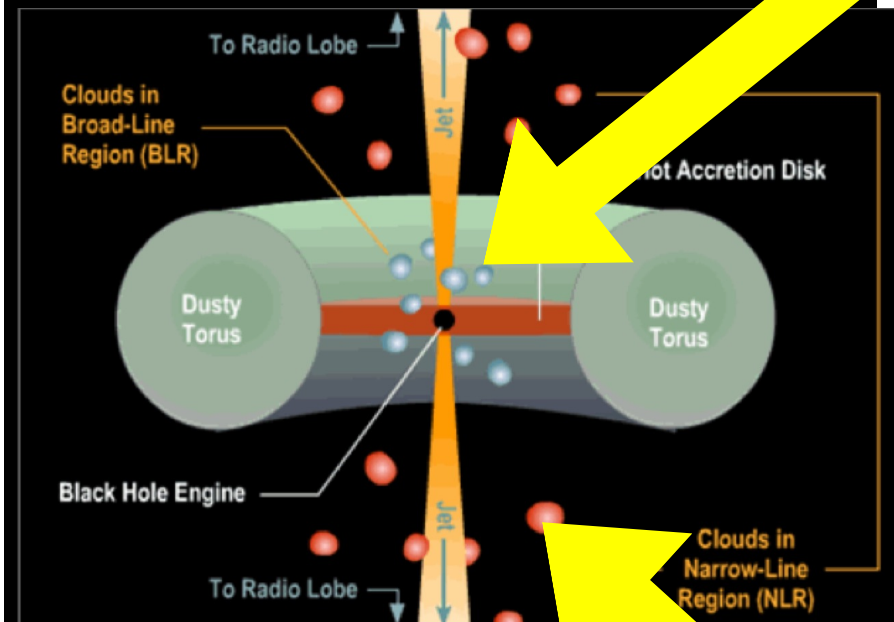
Some of it will emerge as a mix of ***thermal emission*** from various parts of the accretion disk; some emerges as a ***non-thermal synchrotron emission*** from particles accelerated by the magnetic fields embedded in the accretion disk or the BH itself



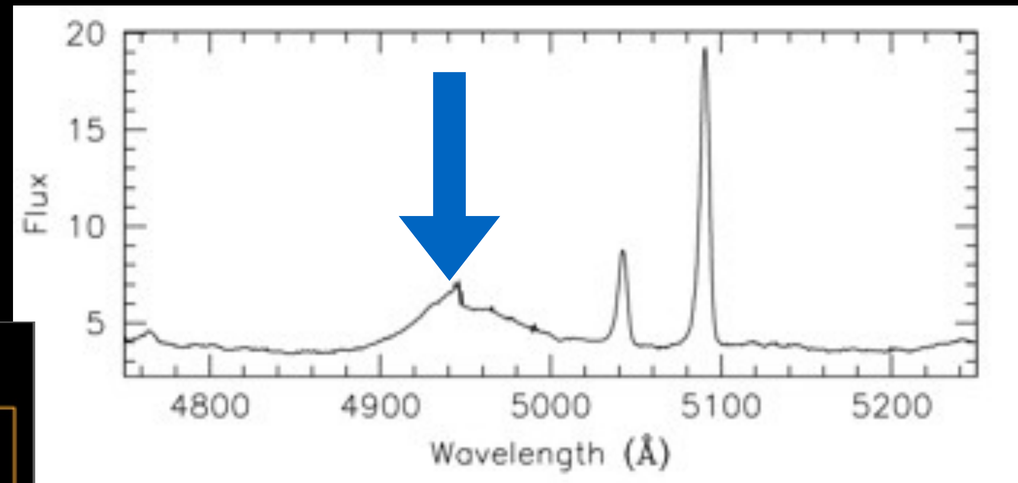
Unified Model for an actively accreting SMBH (Active Galactic Nucleus – AGN)



Brooks/Cole Thomson Learning

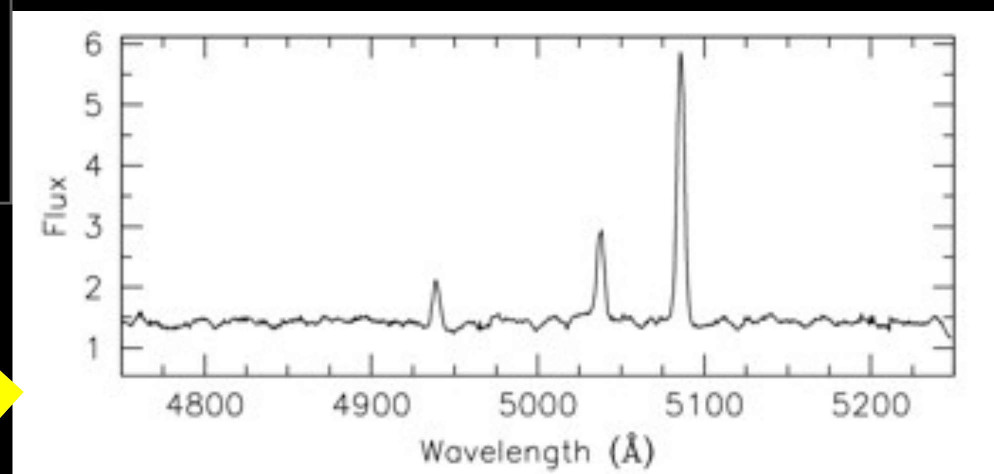


Brooks/Cole Thomson Learning



BLR ~ 0.02 – 0.1 pc

V ~ few 10^3 km/s



NLR 10 pc – 1 kpc

V ~ few x 100 km/s

Then, assuming the gas clouds in the BLR are in virial equilibrium, the width of the emission line tells you the circular speed.

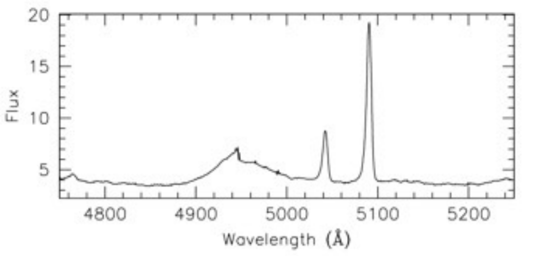
$$2K = -U \qquad V^2 = \frac{GM_{BH}}{fR} \qquad M_{BH} = fRV^2/G$$

Fudge factor for geometry of BLR

$$f = \sqrt{3/2}$$

Radius of BLR (reverberation mapping for Local sources)

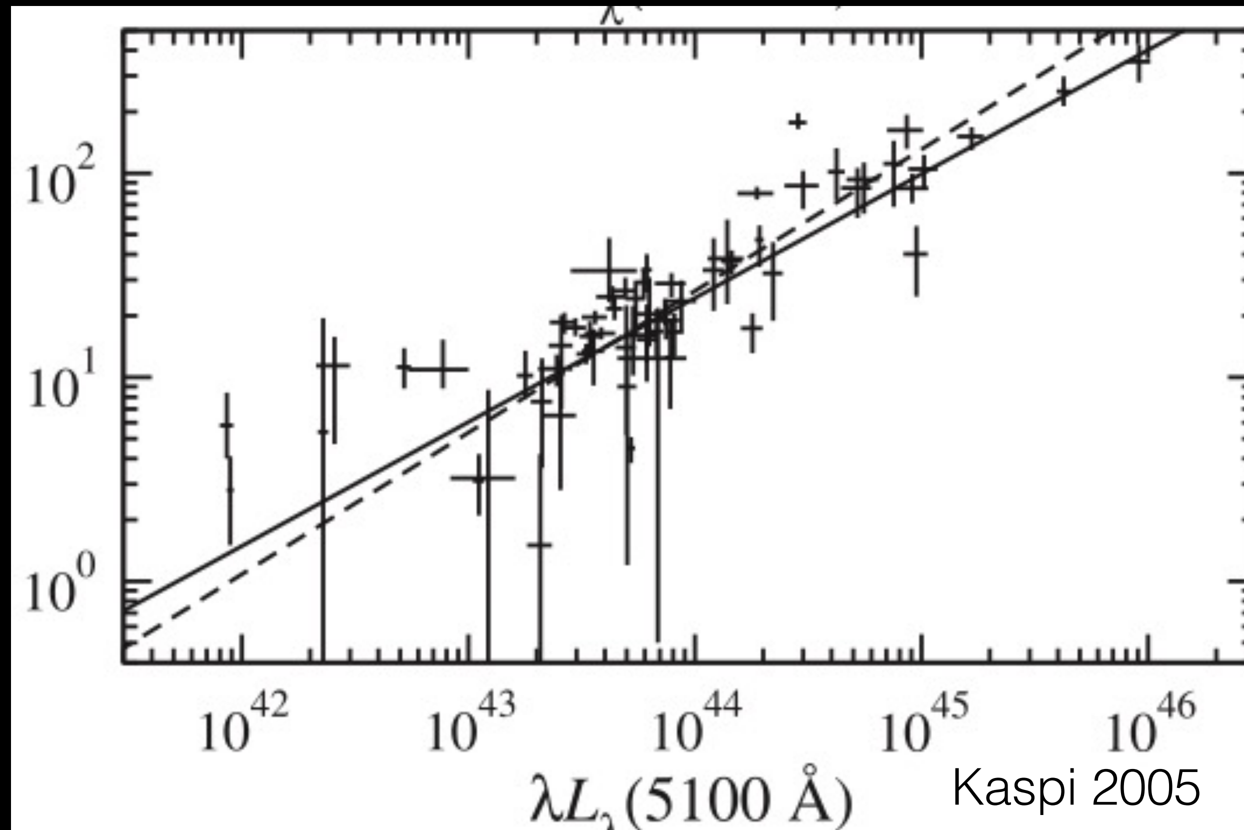
V from FWHM of emission lines (Hbeta, Mg II)



Correlation between BLR size (R_{BLR}) and luminosity of continuum

$R_{BLR} \propto L^{0.5}$

BLR Size



$$\log\left(\frac{M_{\mathrm{BH,vir}}}{M_\odot}\right) = a + b\log\left(\frac{L_{5100}}{10^{44}\,\mathrm{erg\,s^{-1}}}\right) + c\log\left(\frac{\mathrm{FWHM}}{\mathrm{km\,s^{-1}}}\right)$$

a =0.91, b = 0.5, c = 2

Vestergaard & Peterson 2006, Feng + 2014, Shen + 2015

Folks also use Hbeta, MgII

$$M_{\rm BH} = 2.4 \times 10^{6} \left(\frac{L_{\rm H\beta}}{10^{42}\ {\rm erg\ s^{-1}}} \right)^{0.59} \left(\frac{\rm FWHM_{H\beta}}{10^{3}\ {\rm km\ s^{-1}}} \right)^{2} M_{\odot}. \quad (5)$$

JWST!

JWST CEERS

Green & Ho 2005
Larson 2023

Kormendy & Ho 2013 Equations 6 and 7

Magorrian Relation

$$\frac{M_\bullet}{10^9\ M_\odot} = \left(0.542^{+0.069}_{-0.061}\right)\left(\frac{L_{K,\mathrm{bulge}}}{10^{11}\ L_{K\odot}}\right)^{1.21\pm0.09}$$

M_{bh}-σ Relation

$$\frac{M_\bullet}{10^9\ M_\odot} = \left(0.309^{+0.037}_{-0.033}\right)\left(\frac{\sigma}{200\ \mathrm{km\ s^{-1}}}\right)^{4.38\pm0.29}$$

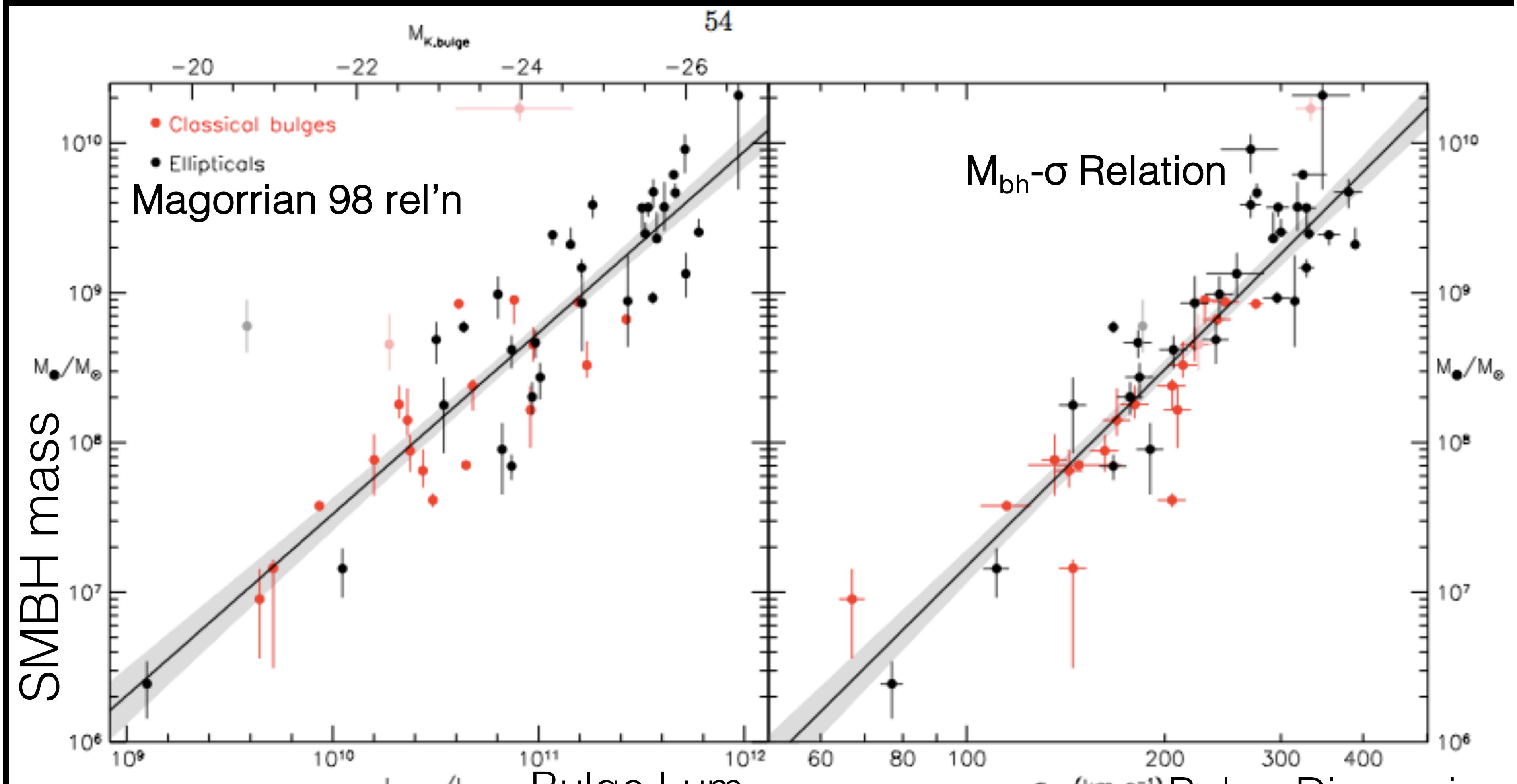
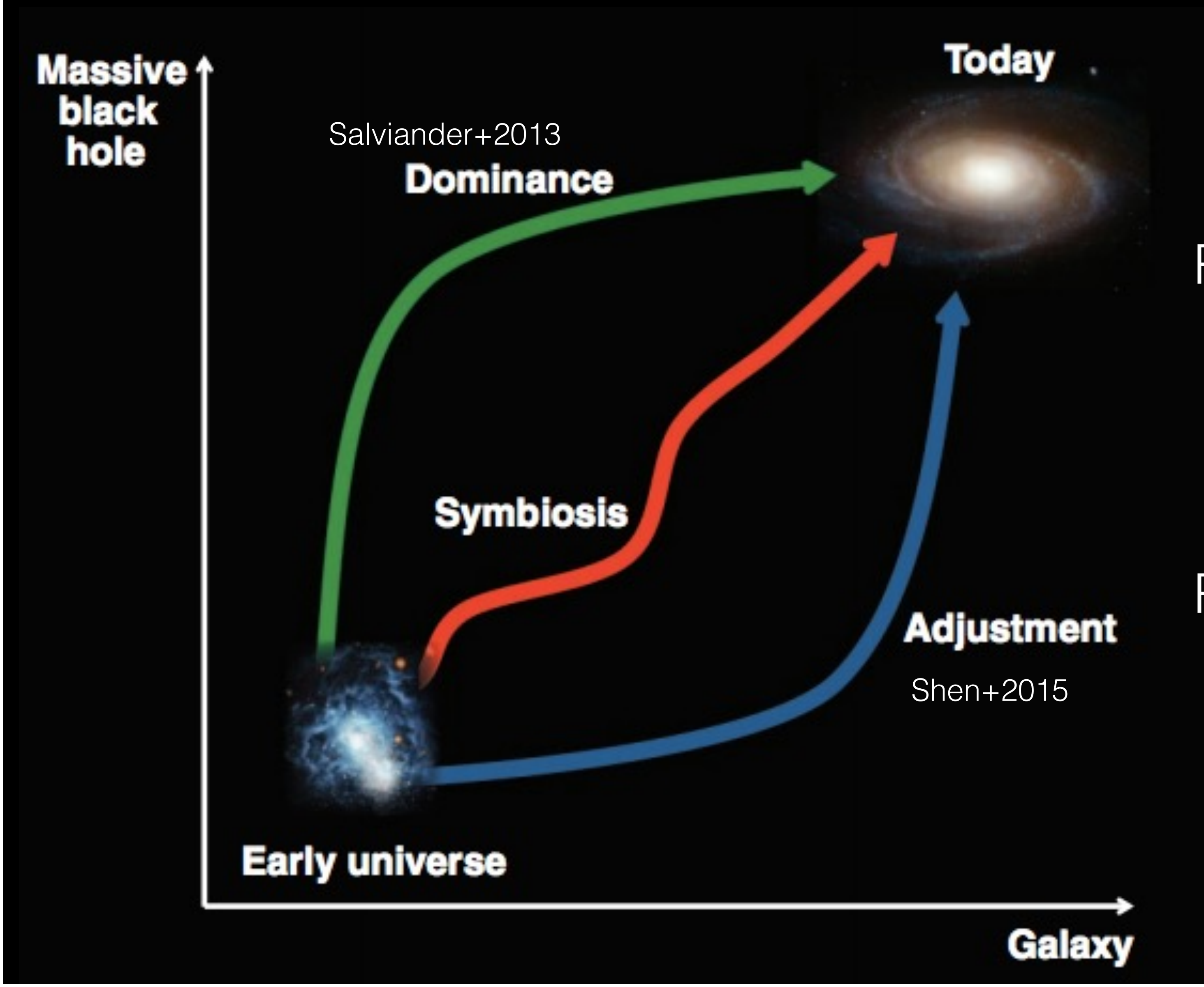


Figure 17

M-sigma / Magorrian relations indicate that the growth of SMBHs and their galaxy hosts are related

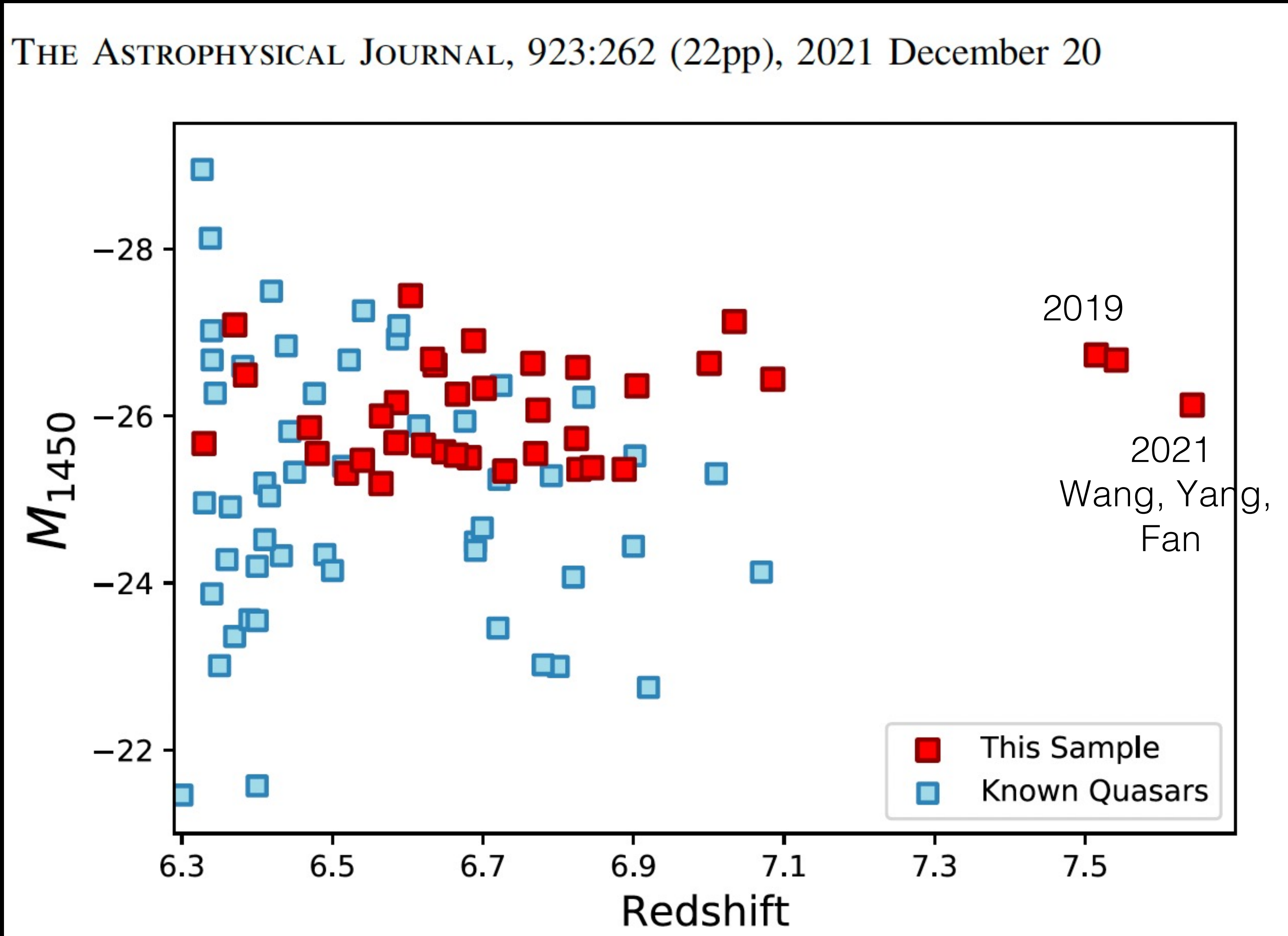


Halo Regulated?

And/Or

Black Hole Regulated?

Distance to Quasars



Yang, Wang, Fan + 2021

Most Distant QSO

The Astrophysical Journal Letters, 907:L1 (7pp), 2021 January 20 https://doi.org/10.3847/2041-8213/abd8

CrossMa

A Luminous Quasar at Redshift 7.642

Feige Wang[1,15], Jinyi Yang[1,16], Xiaohui Fan[1], Joseph F. Hennawi[2,3], Aaron J. Barth[4], Eduardo Banados[3], Fuyan Bian[5], Konstantina Boutsia[6], Thomas Connor[7], Frederick B. Davies[3,8], Roberto Decarli[9], Anna-Christina Eilers[10,15], Emanuele Paolo Farina[11], Richard Green[1], Linhua Jiang[12], Jiang-Tao Li[13], Chiara Mazzucchelli[5], Riccardo Nanni[2], Jan-Torge Schindler[3], Bram Venemans[3], Fabian Walter[3], Xue-Bing Wu[12,14], and Minghao Yue[1]

Mass = 1.6e9 Msun

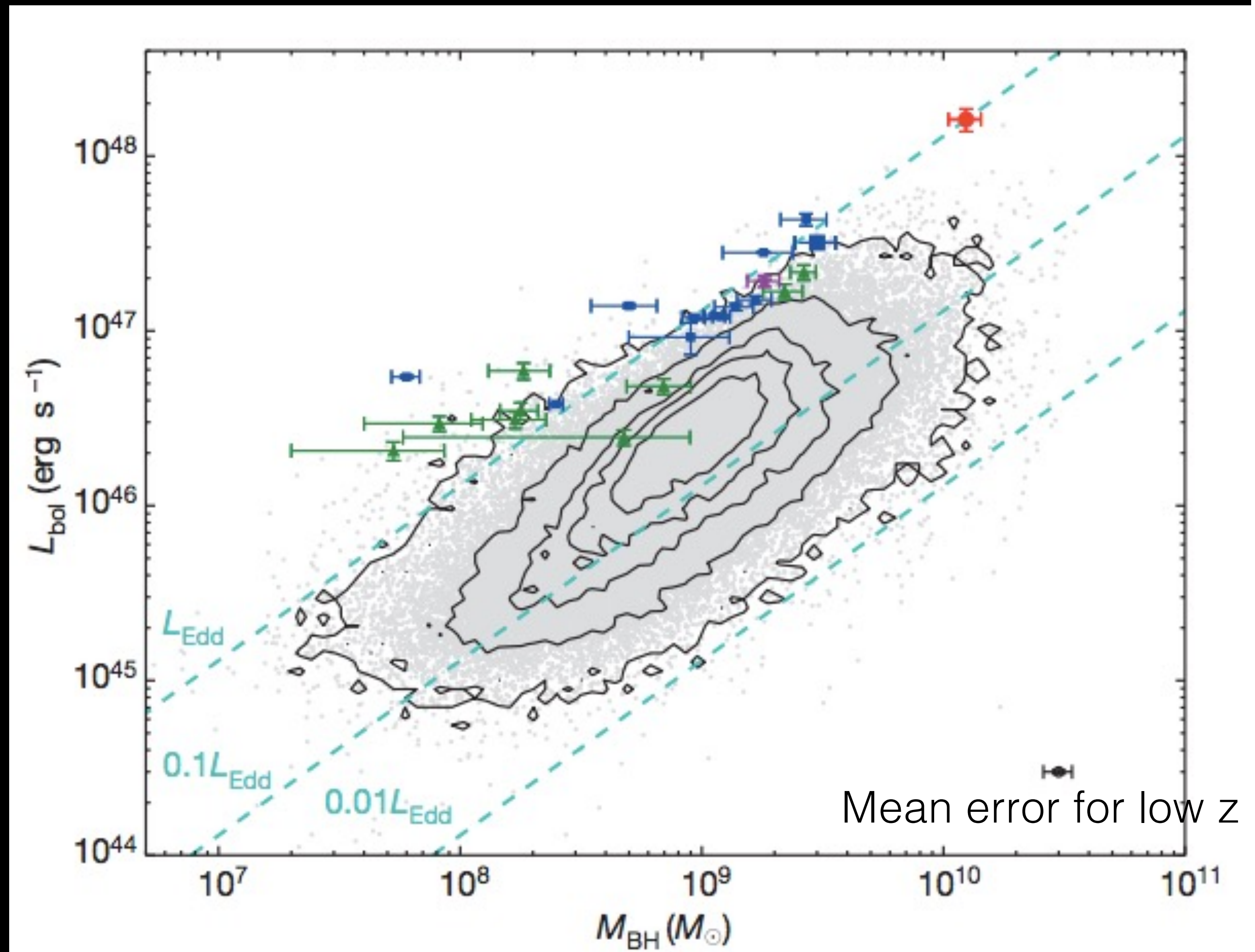
Wang+2021

Most massive SMBH at z ~ 6.3

M_{bh} = (1.24 +/- 0.19) x 10^{10} M⊙ Wu + 2015

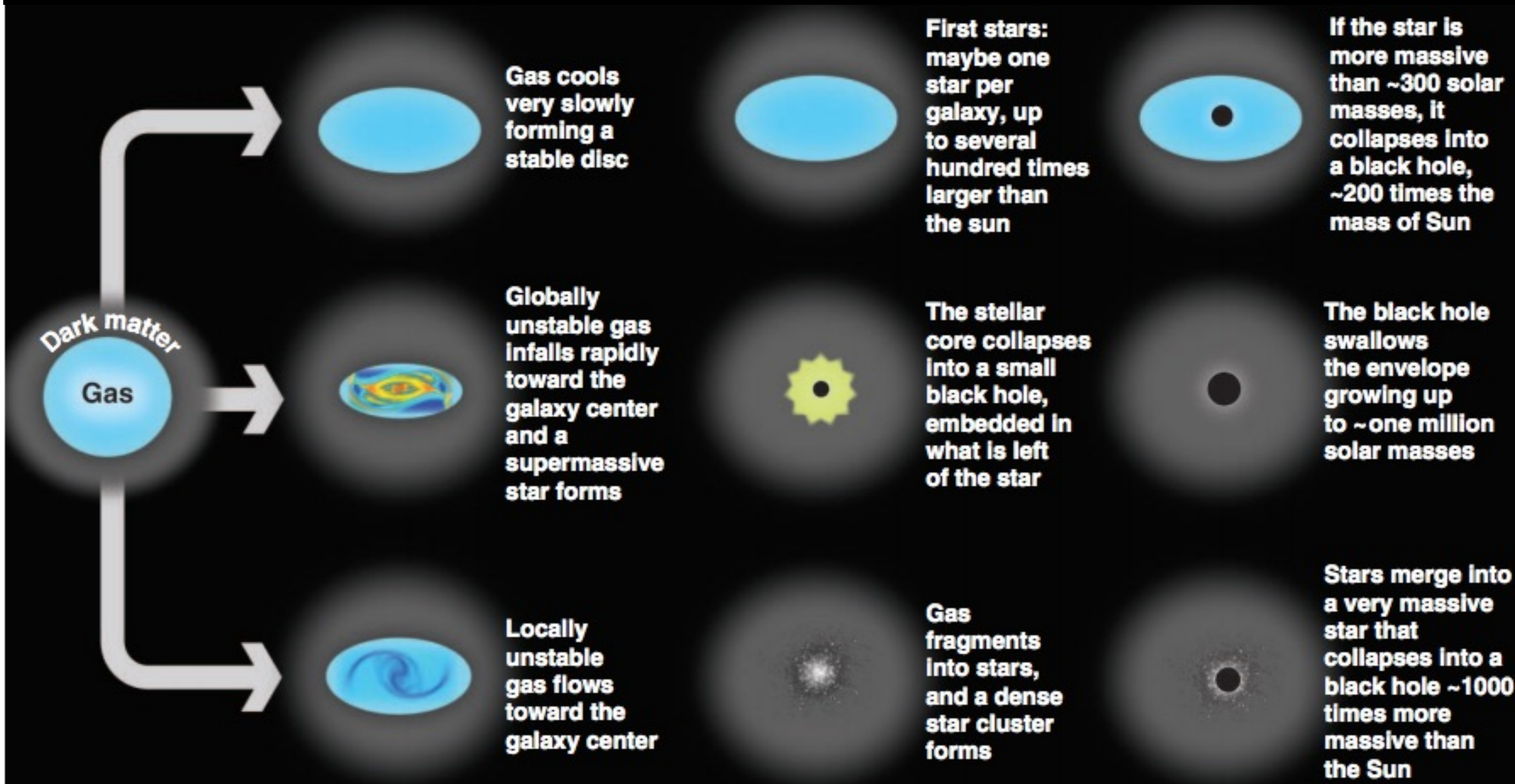
Isn't super high z, but *much more massive* than other high z SMBHs.

Most massive SMBH we know of at any redshift is ~ 7e10 Msun



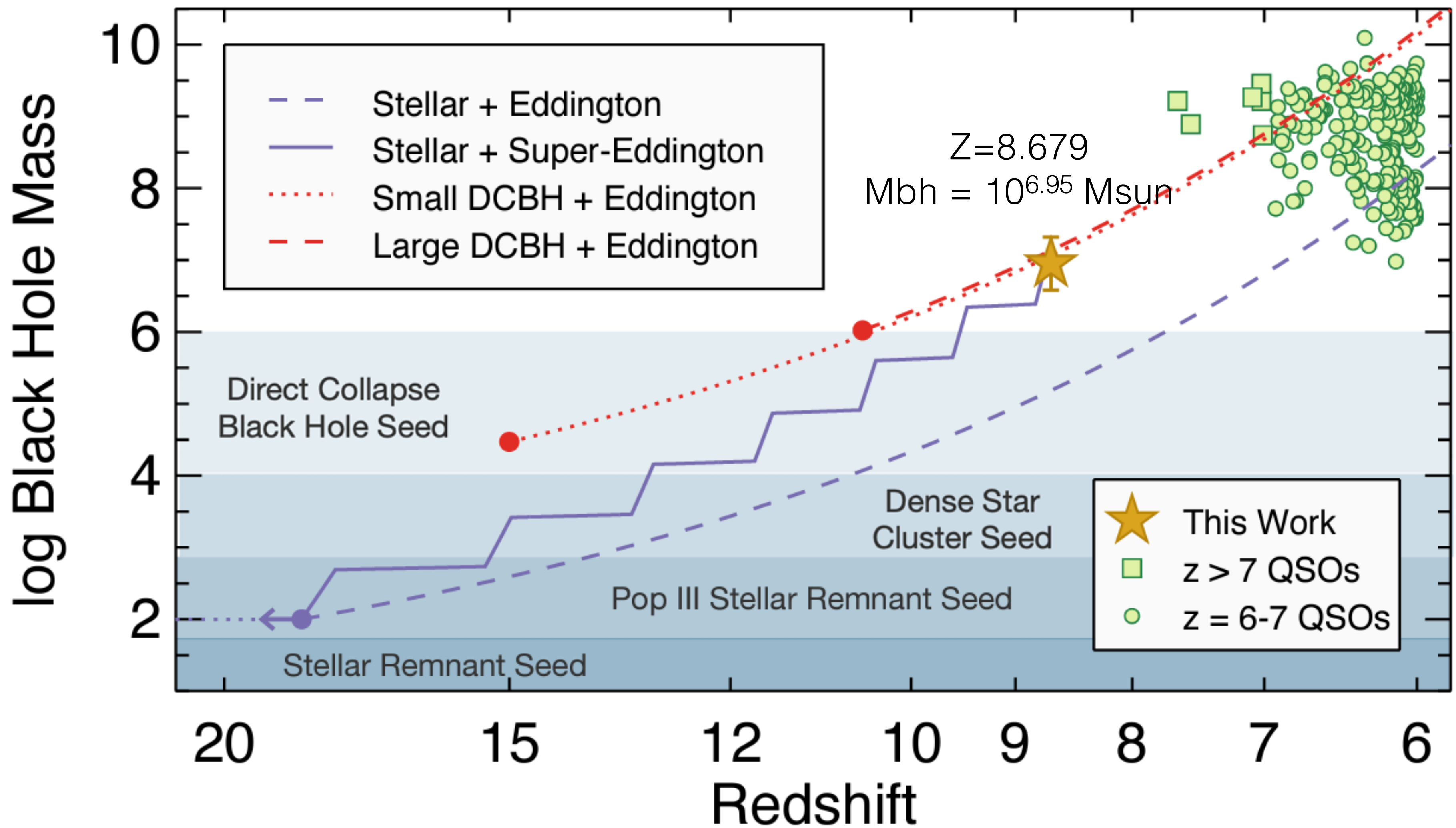
Dominance?

Origin of SMBH Seeds



Volonteri+2012

JWST!!!!!



Larson 2023

DCBH = Direct Collapse Black

Most Distant Luminous AGN: JWST!

JADES Survey

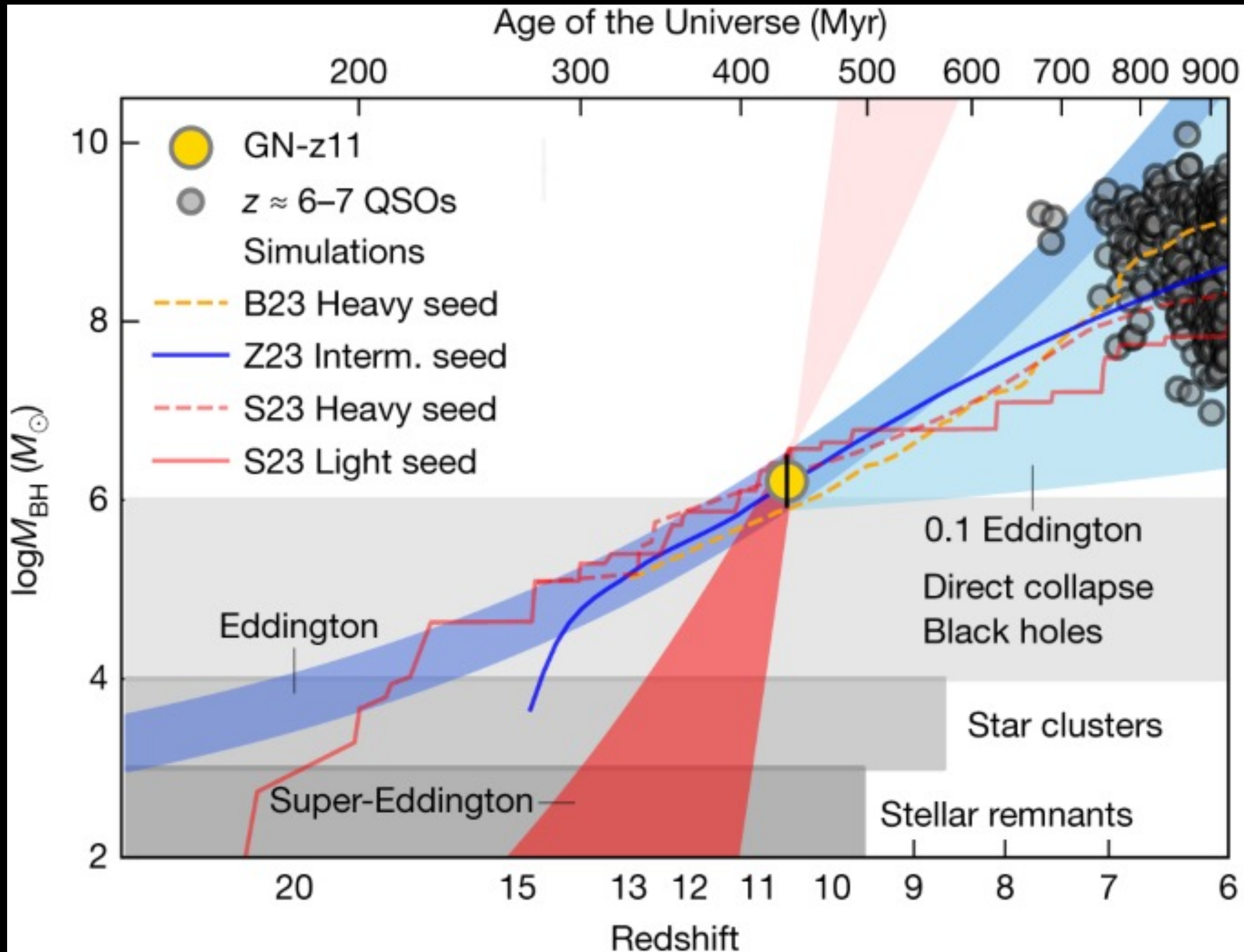
A small and vigorous black hole in the early Universe

Roberto Maiolino, Jan Scholtz, Joris Witstok, Stefano Carniani, Francesco D'Eugenio, Anna de Graaff, Hannah Übler, Sandro Tacchella, Emma Curtis-Lake, Santiago Arribas, Andrew Bunker, Stéphane Charlot, Jacopo Chevallard, Mirko Curti, Tobias J. Looser, Michael V. Maseda, Timothy D. Rawle, Bruno Rodríguez del Pino, Chris J. Willott, Eiichi Egami, Daniel J. Eisenstein, Kevin N. Hainline, Brant Robertson, Christina C. Williams, Christopher N. A. Willmer, William M. Baker, Kristan Boyett, Christa DeCoursey, Andrew C. Fabian, Jakob M. Helton, Zhiyuan Ji, Gareth C. Jones, Nimisha Kumari, Nicolas Laporte, Erica J. Nelson, Michele Perna, Lester Sandles, Irene Shivaei & Fengwu Sun — Show fewer authors

Nature **627**, 59–63 (2024) | Cite this article

- Z=10.6 !

- Assuming local virial relations, we derive a black hole mass of log ($M_{BH}/M_{\odot}$) =6.2 ±0.3 , accreting at about five times the Eddington rate.



Maiolino+2024