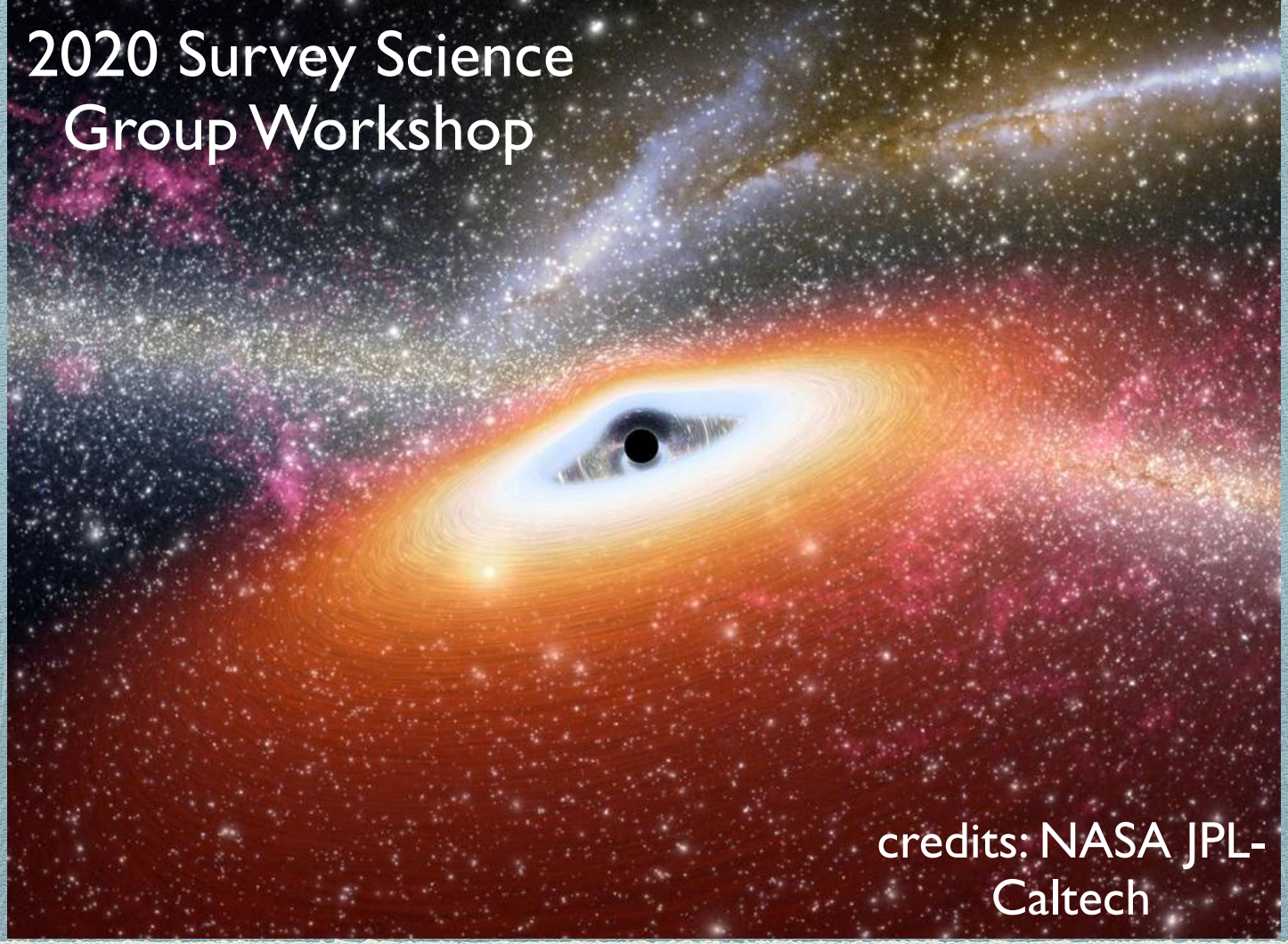
2020 Survey Science Group Workshop

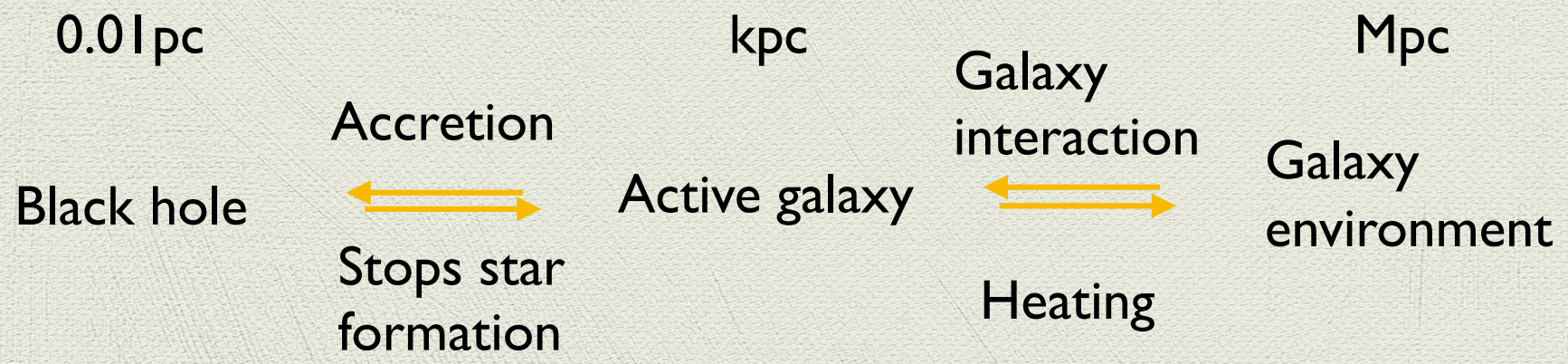


Constraints on the Black Hole Growth for High Redshift Quasars

Hyunsung Jun (KIAS)

High Redshift Quasars (Astro2020 white paper)

- How massive/rapidly growing are the black hole seeds?
- Are they rare objects at z>6?
- Is the black hole growth linked to galaxy formation?
- Is the intergalactic medium neutral by z=8?



Growth of black hole seeds

- How massive/rapidly growing are the black hole seeds?

$$M_{BH} = M_{BH,0}\, exp(\frac{1-\eta}{\eta}\frac{t}{t_0})$$

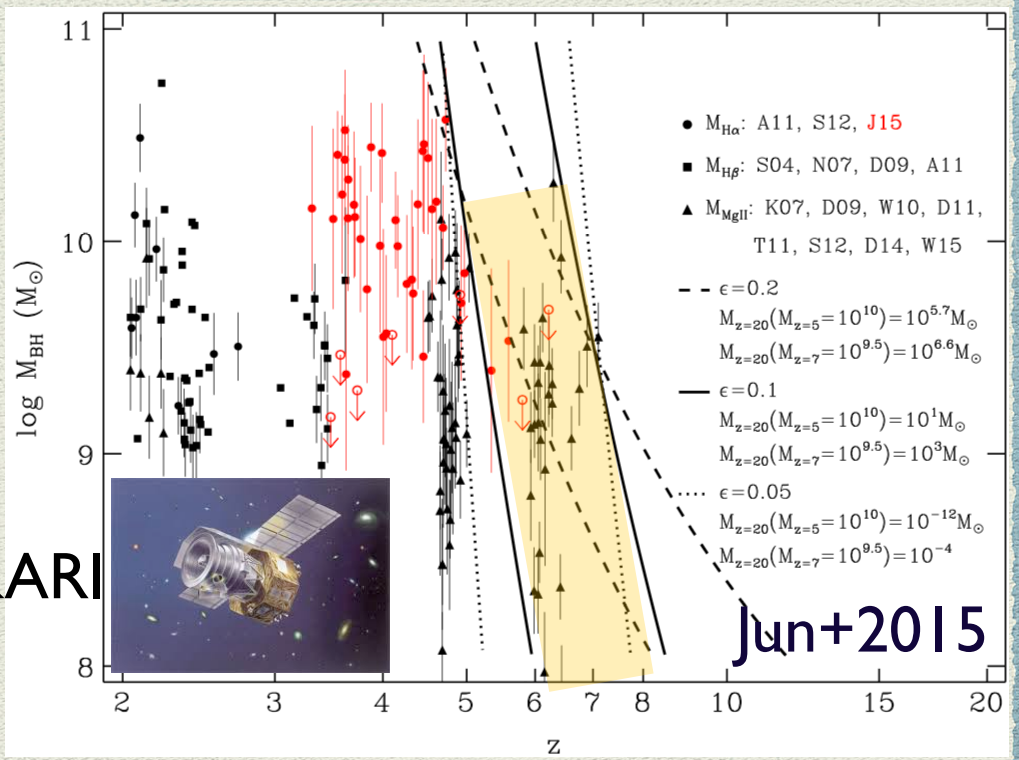
$\eta =$ Radiative efficiency

$$t_0 = 0.45 Gyr/f_{Edd}, f_{Edd} = L/L_{Edd}$$

$$t_e\,(\eta = 0.1, f_{Edd} = 1) = 50 Myr$$

$$\Delta t\,(z = 20 > 6) = 760 Myr \sim 15 t_e$$

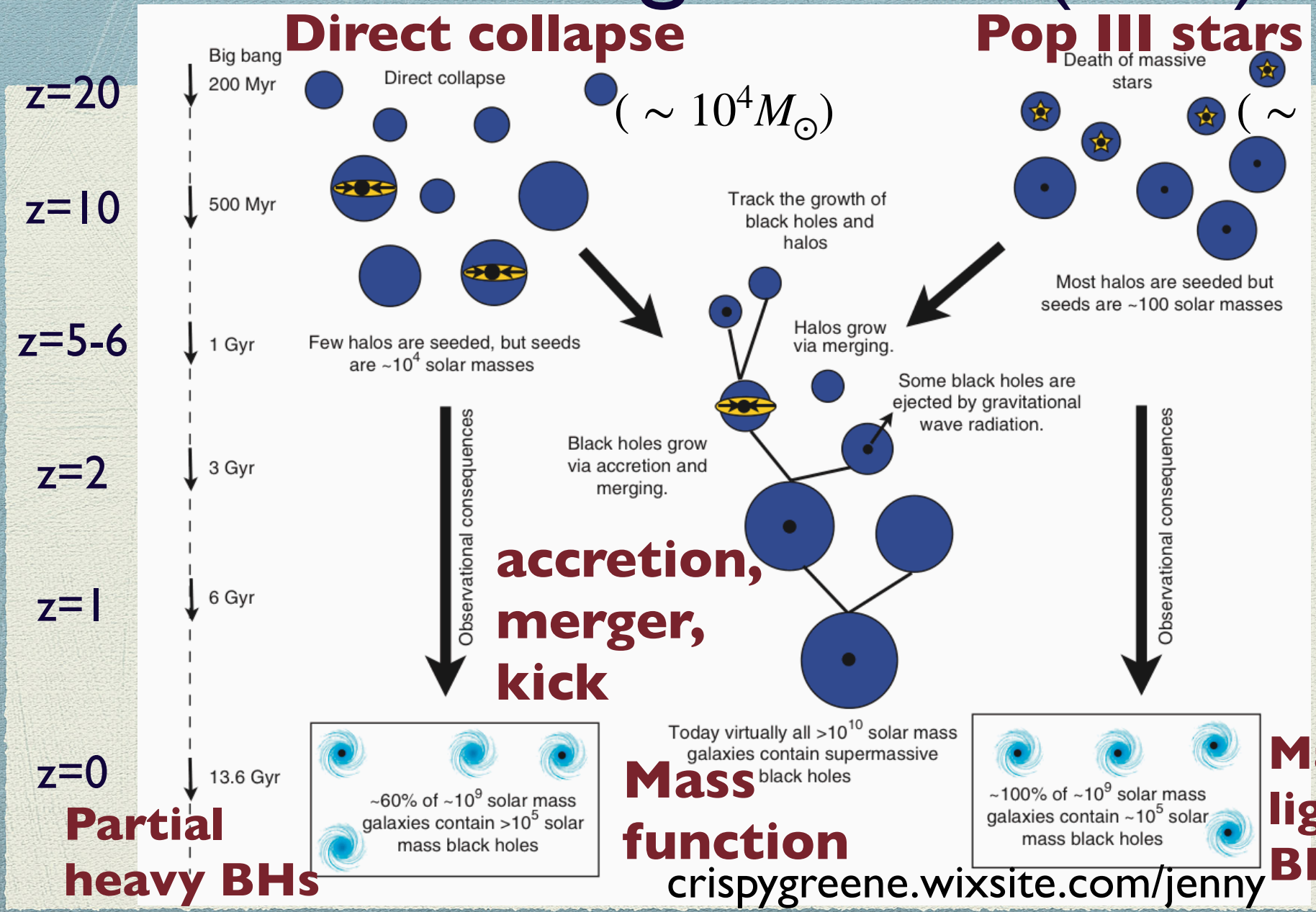
$$M_{BH,0} \gtrsim 10^{1-3} M_\odot$$



AKARI

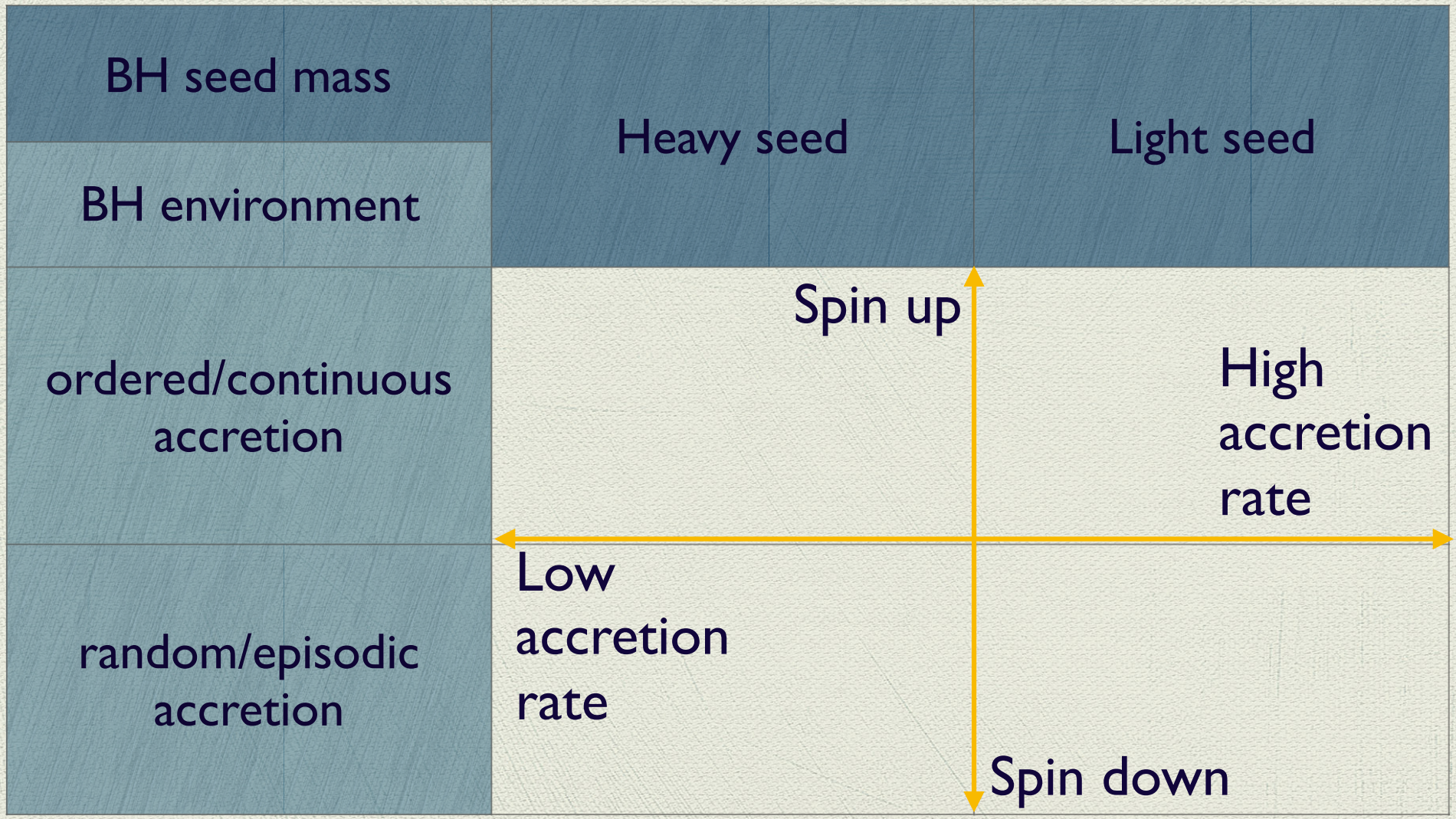
i) continuous accretion from PopIII stars, or
ii) slower accretion from heavier seeds

Observable signatures (z=0)



crispygreene.wixsite.com/jenny

Observable signatures (z=5-6)

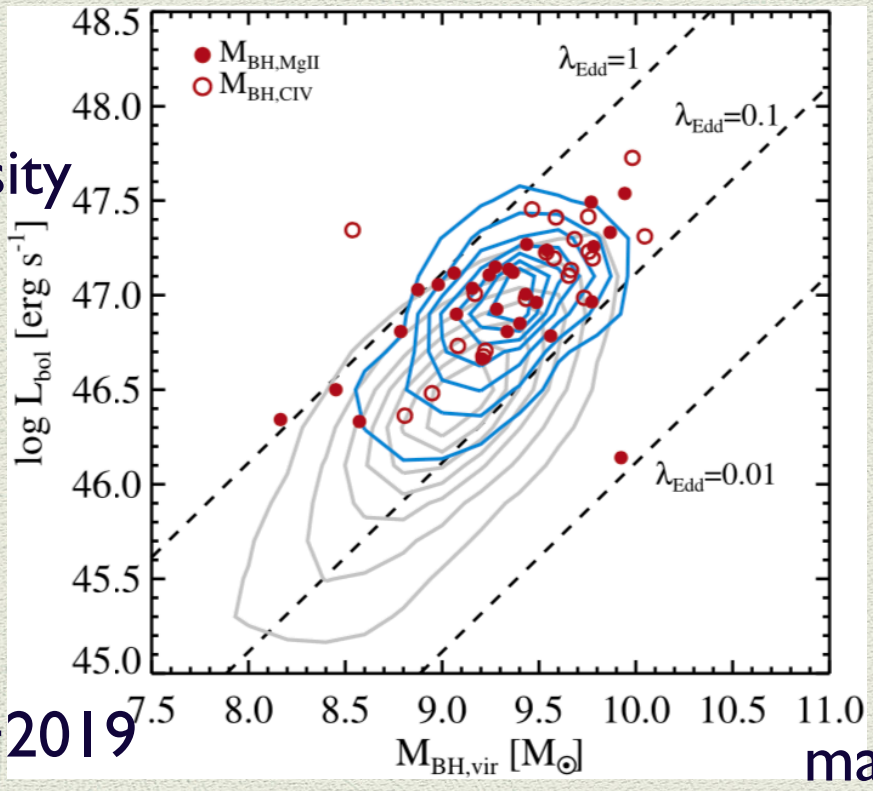


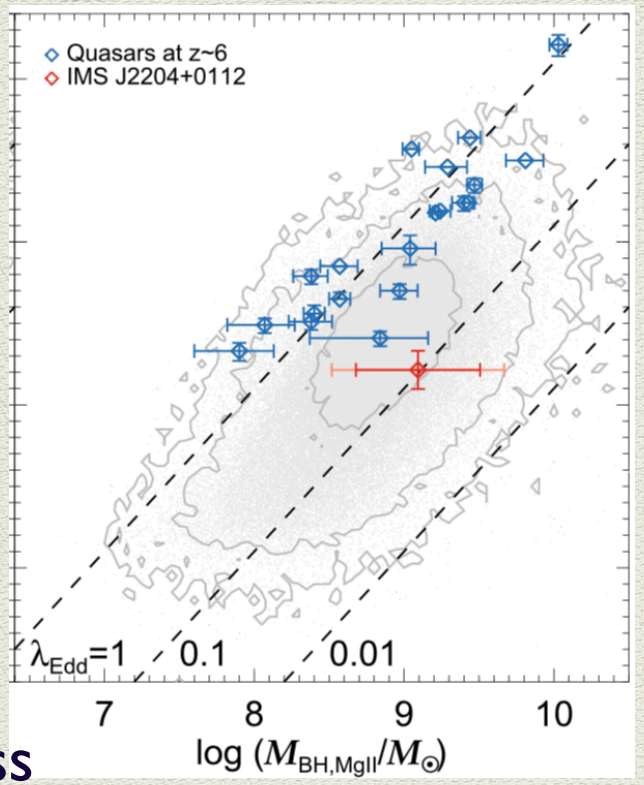
Volonteri+2005

Accretion rate

Light seed

luminosity





Heavy seed

Shen+2019

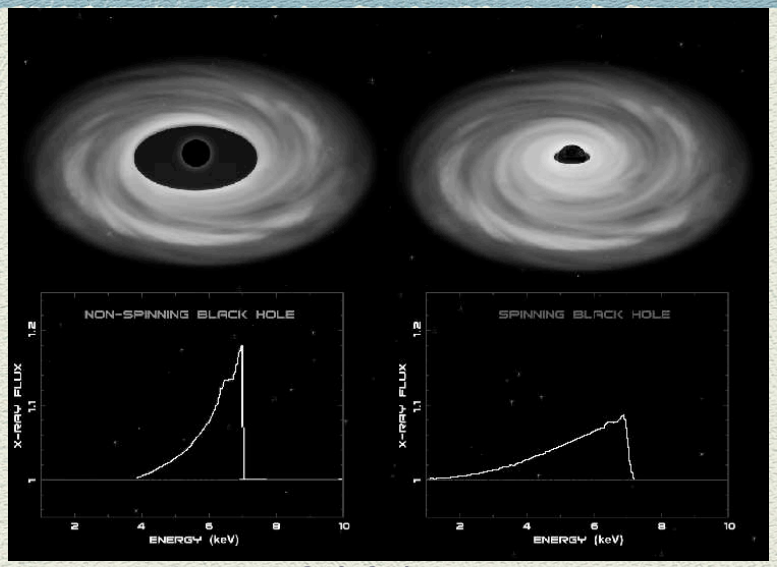
mass

Kim+2018

- z~6 quasars have $f_{Edd} \sim 0.1 - 1$, similar to luminosity-matched SDSS quasars (z~2)
- Luminosity selection effect against faint AGN at z~6

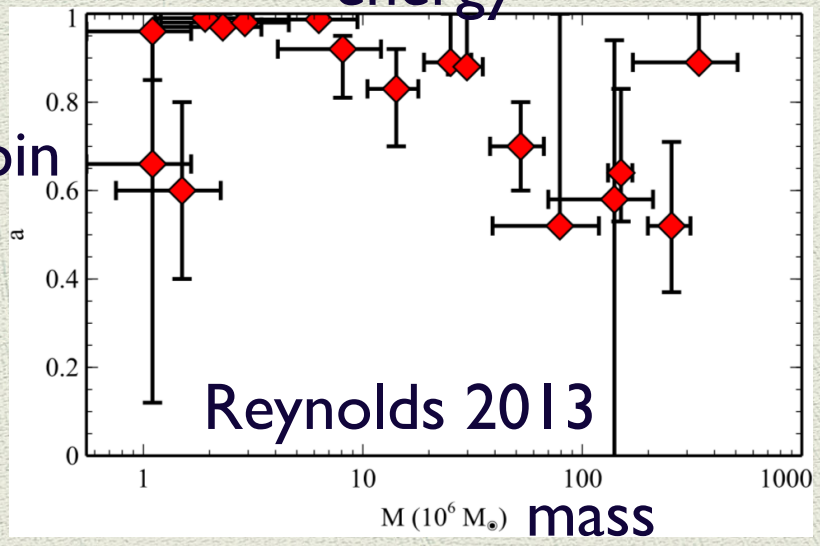
Spin

non-spinning spinning

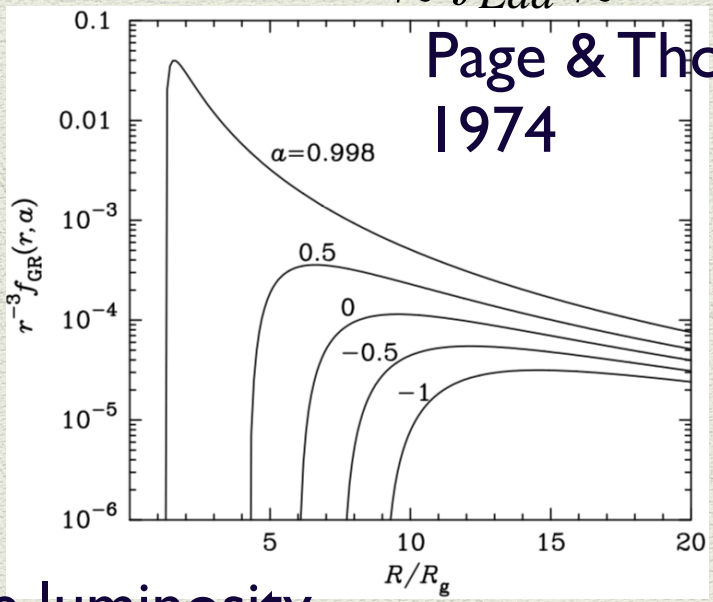


flux

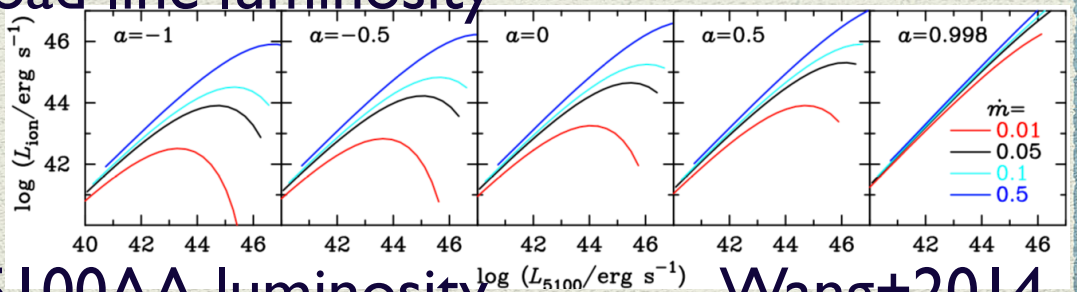
energy



- Spin-dependent ISCO (AGN, thin disks $0.01 \lesssim f_{Edd} \lesssim 0.3$)



Broad line luminosity



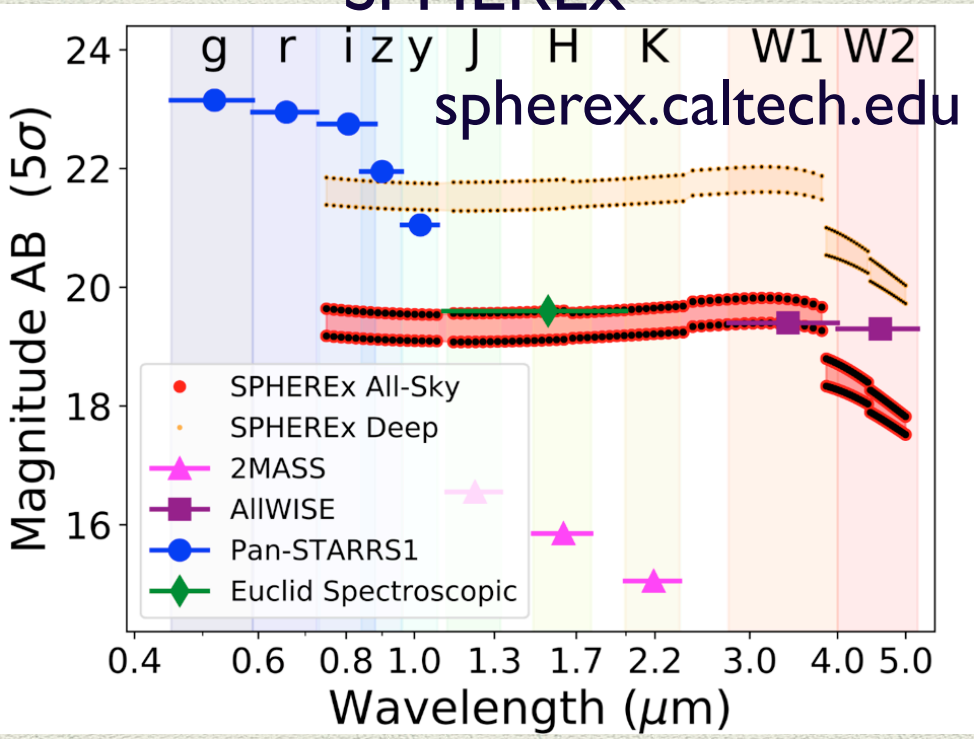
5100AA luminosity

Wang+2014

Upcoming surveys

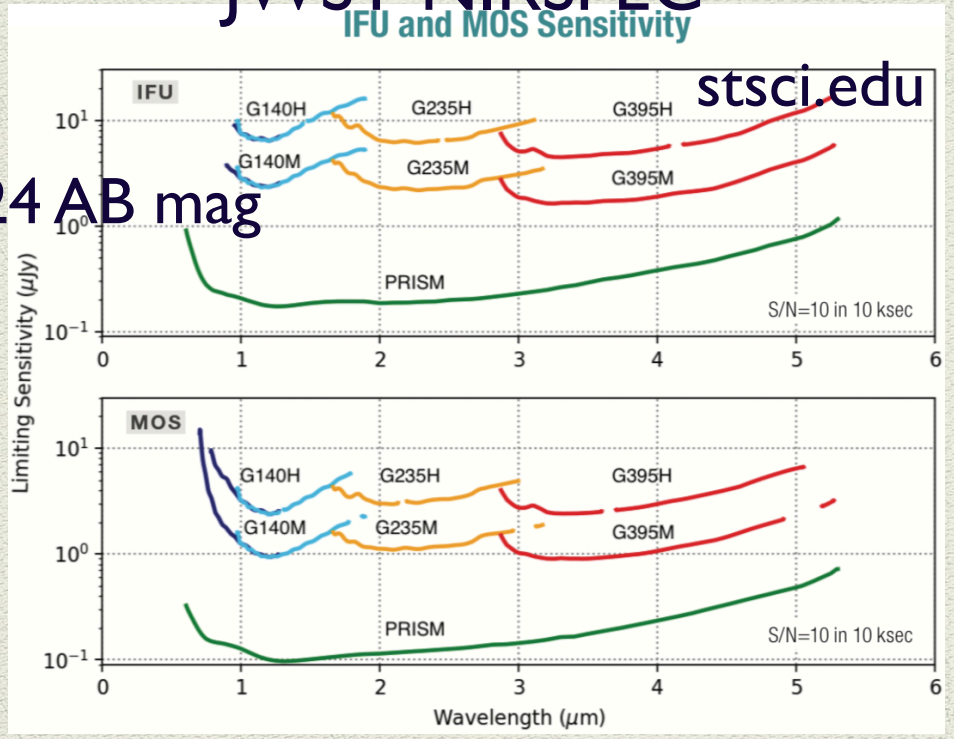
- near-IR: JWST (6.5m, 2021?), Euclid (1.2m, 2022?), SPHEREx (20cm, 2023?), X-ray: eROSITA (1.3x2.6m, 2019-)
- Simulations: Horizon Run 5 - Spin and mass evolution

SPHEREx



JWST NIRSPEC

24 AB mag



Summary

- BH seed mass and spin environment at z>5
- Higher accretion rates constrain lower seed mass, and higher spin ordered/continuous accretion
- We hope to estimate the spin values from observed broad line equivalent width and numerical simulations, before upcoming space-based surveys