A GNIRS Near-IR Spectroscopic Survey of z>5.7 Quasars

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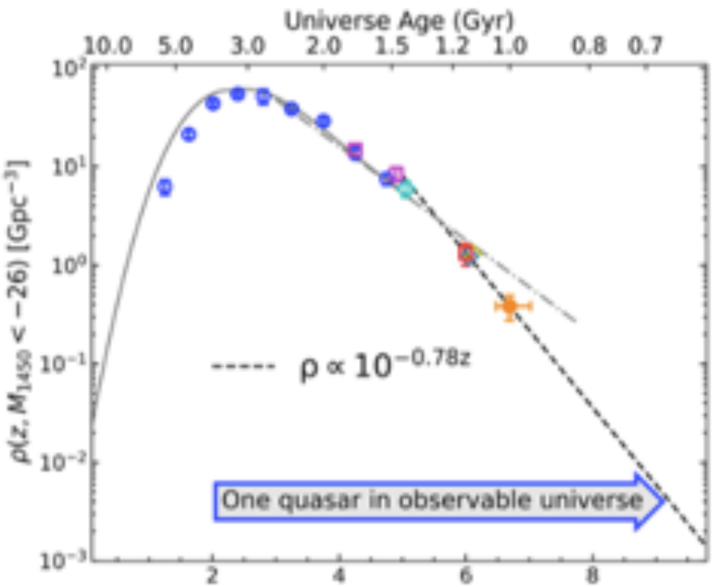
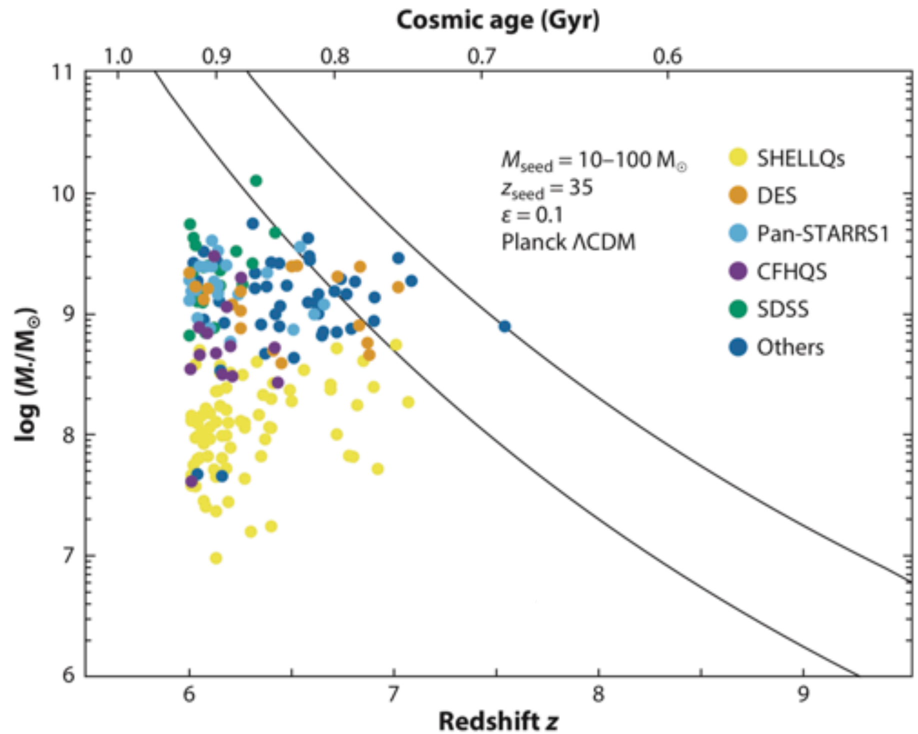
The emergence of earliest SMBHs

Thanks to SDSS, CFHT, PanSTARRS, DECam, Subaru, etc. (wide, deep, multi-band)

Lbol~10⁴⁷ erg/s



Wang et al. (2019)



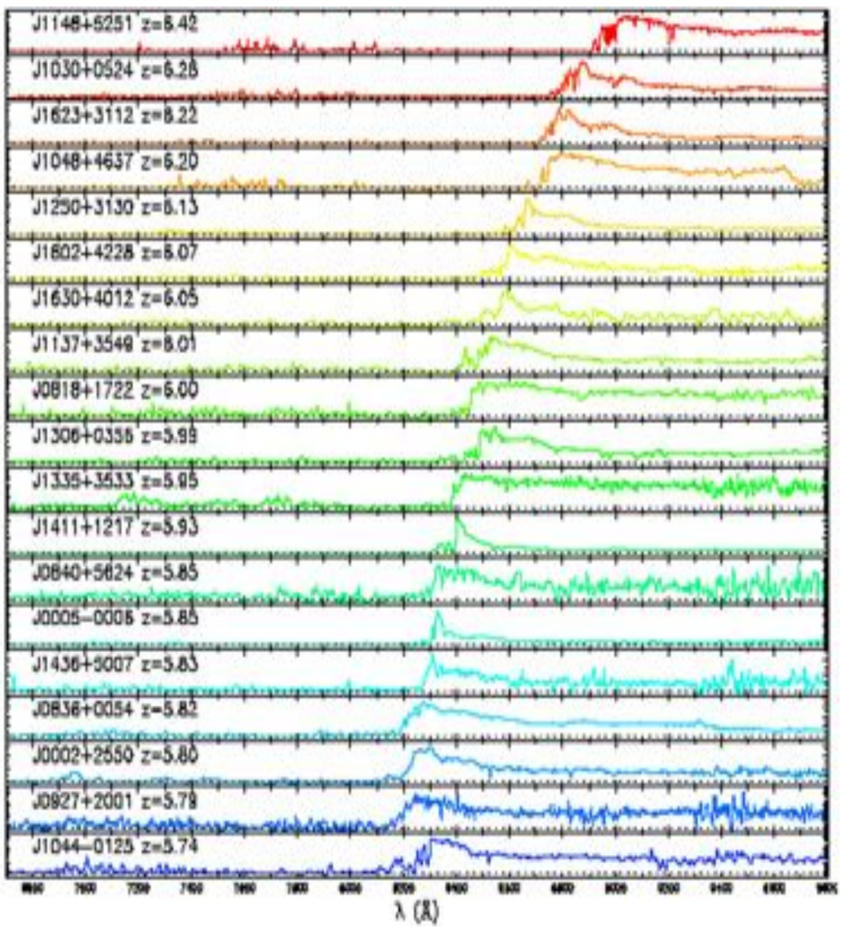
Inayoshi et al. (2020, ARA&A)

Of course, we are only seeing the tip of the iceberg

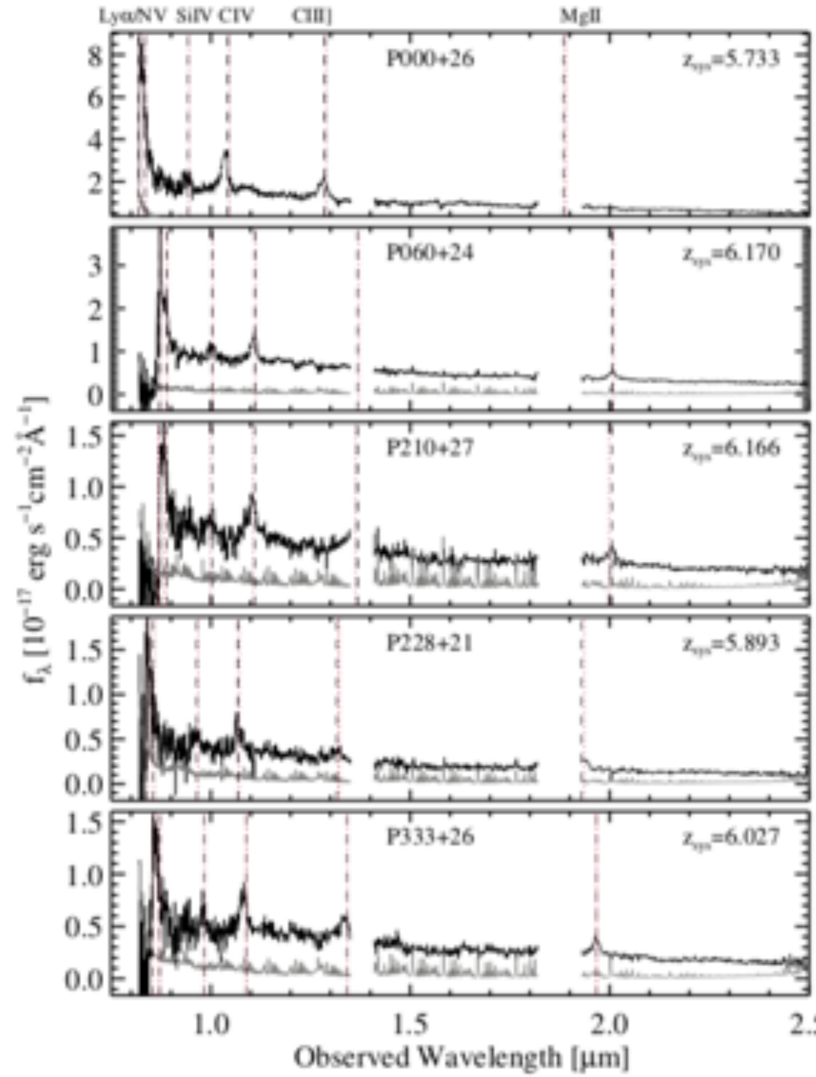
>200 known at z>6 as of late 2019

~~Record holder is a z=7.54 quasar (Bañados et al. 2018)~~
New record: z=7.642 (Wang et al. 2020)

Infrared spectroscopy necessary to cover the rest-frame UV lines to constrain the physical properties (e.g., BH mass) of z>5.7 quasars.



Optical spectra of z~6 quasars



GNIRS spectra of z~6 quasars

Project Synopsis

GNIRS spectroscopy for 50 quasars at z>5.7 to understand the physical properties and growth history of the first SMBHs.

A large sample is necessary to draw statistical conclusions on the population.

Main Goals:

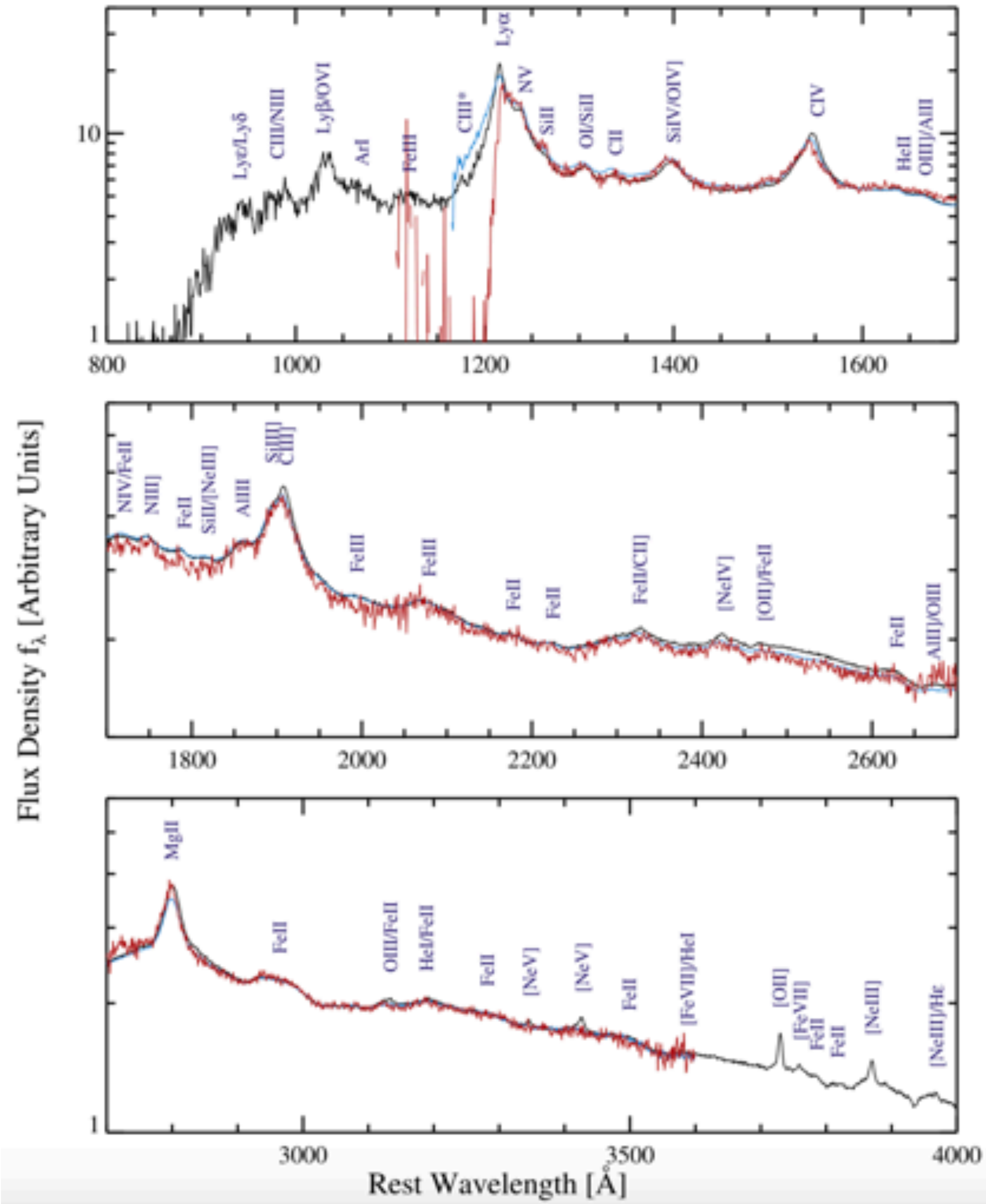
- To study the physical properties of these earliest SMBHs at cosmic dawn
- To quantify their abundance and constrain SMBH growth models
- To study high-z metal absorption lines

Status

- 15B-17A
- usable data ~ 100%
- Spectral analysis complete

Image Credit: STScI

Do they look different ?



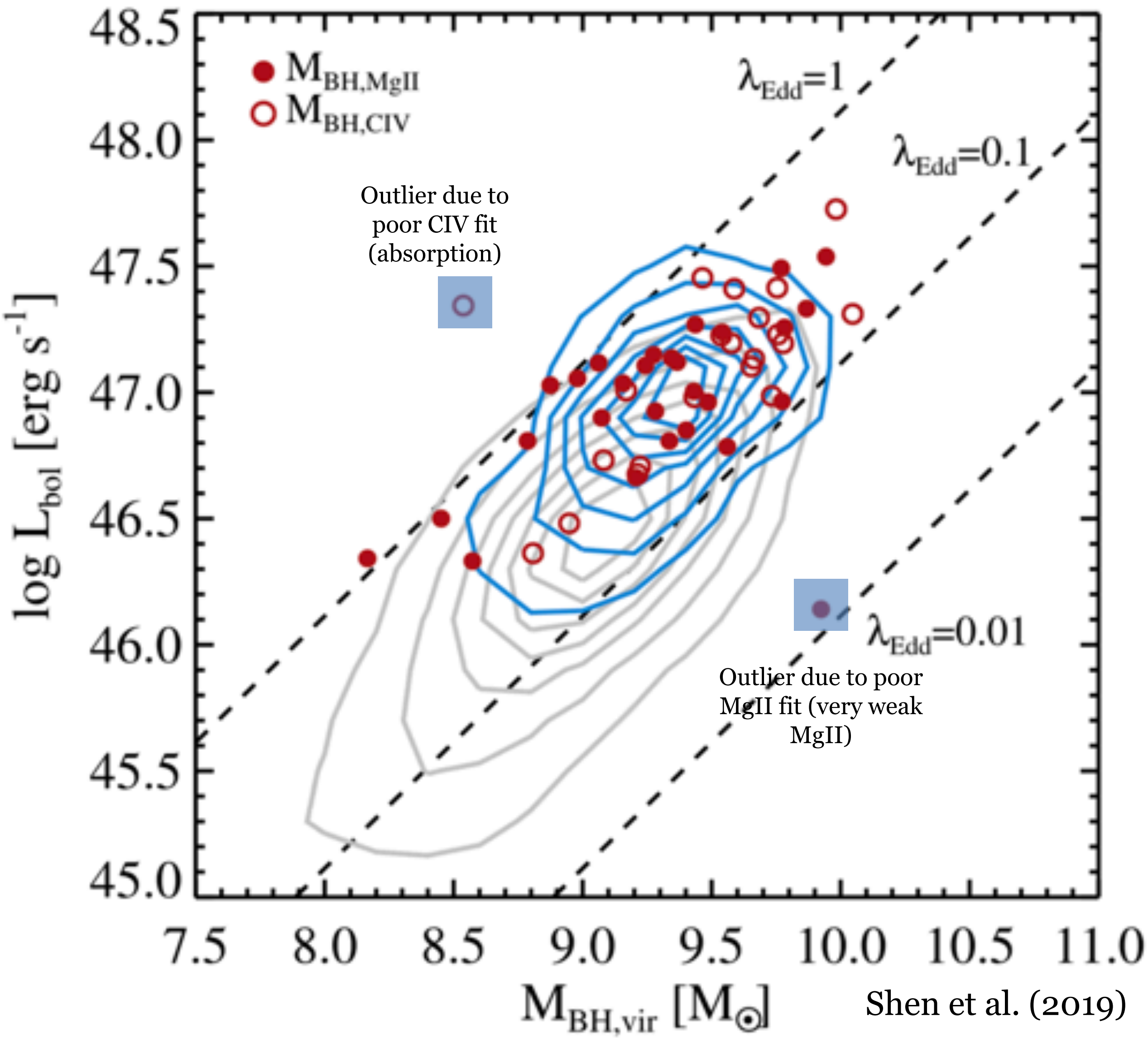
Red: composite spectrum from **this program**

Cyan: composite spectrum from a control SDSS quasar sample at z~2 matched in luminosity

Black: Vanden Berk et al. (2001) SDSS quasar composite

This similarity extends to other wavelengths (e.g., X-rays; Nanni et al. 2017)

The mass-luminosity plane of z~6 quasars

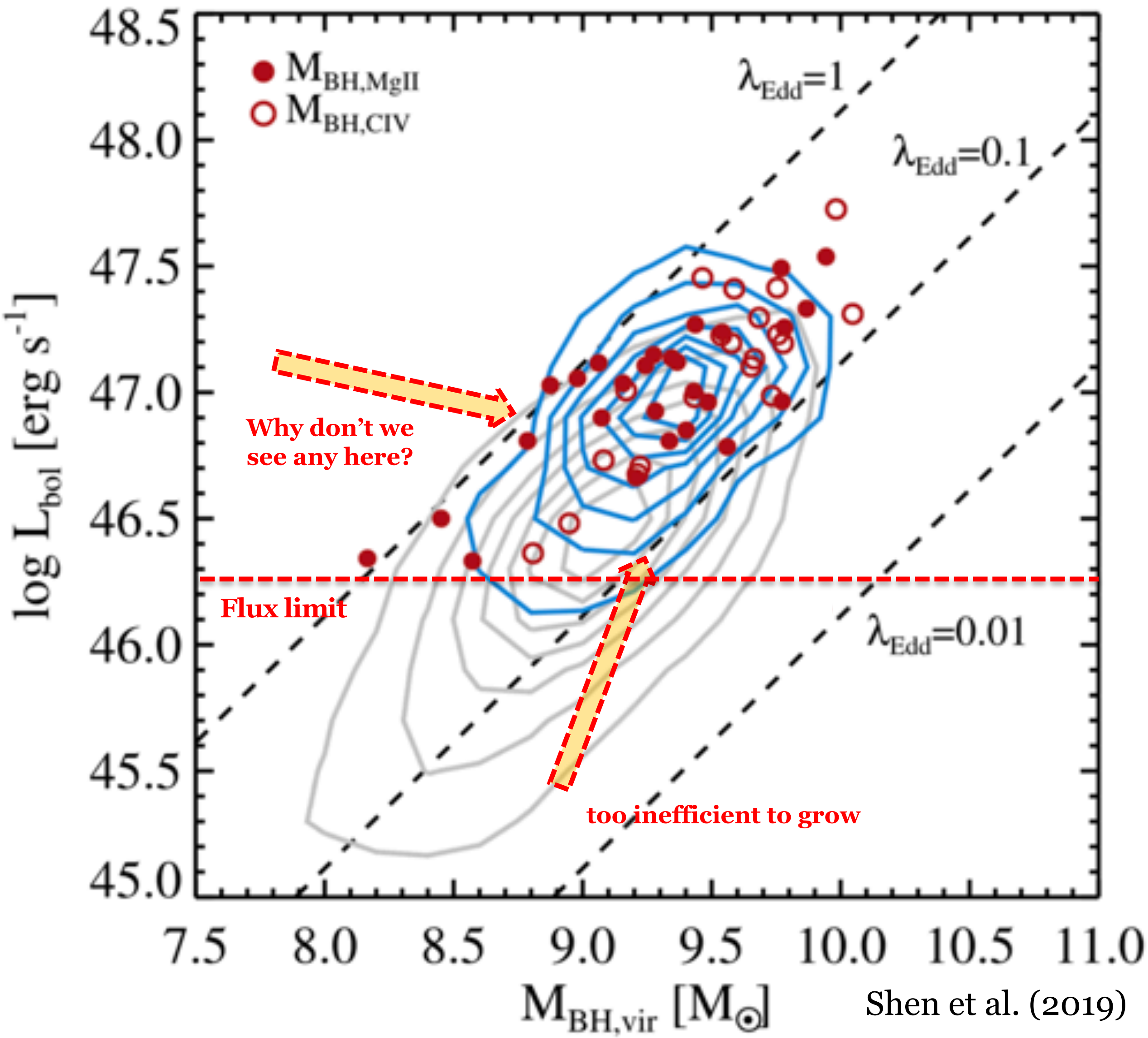


Shen et al. (2019)

Ignore the two problematic objects, the remaining z~6 quasars have a similar distribution in the M-L plane as the z~2 control sample matched in luminosity

They are well bounded between 10% and 100% Eddington in luminosity

The mass-luminosity plane of z~6 quasars



Shen et al. (2019)

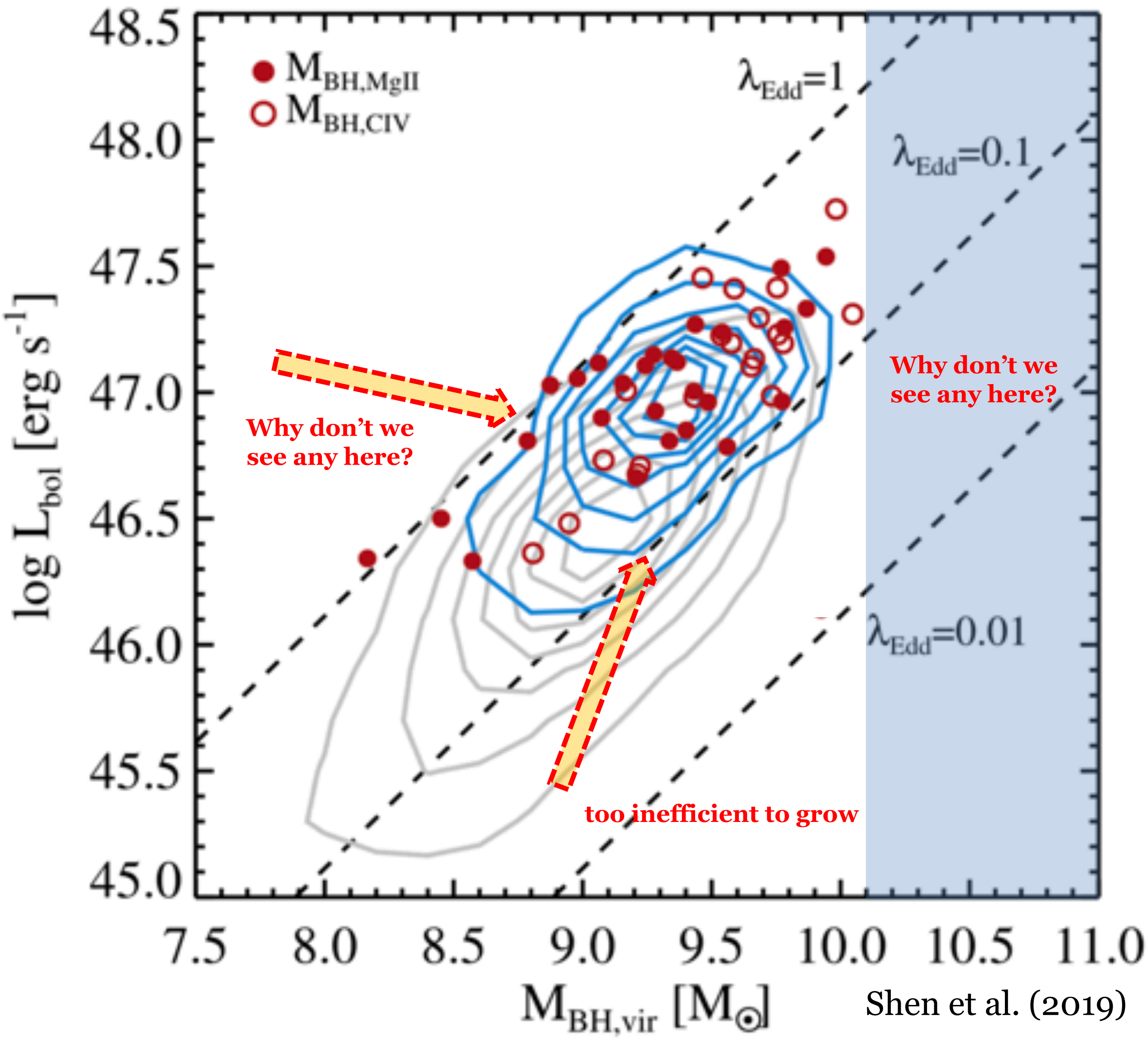
Immediate implications

1. No evidence for super-Eddington luminosity

Possibilities:

- They are obscured and missing from optical surveys (but why do they become unobscured near Eddington limit?)
- They never go well above Eddington in luminosity (e.g., high accretion rate with low radiative efficiency)

The mass-luminosity plane of z~6 quasars



Shen et al. (2019)

Immediate implications

2. No evidence for >10^{10} Msun SMBHs

Possibilities:

- They become inactive once reaching that mass regime: Not enough fuel or feedback kicks in, e.g., physics limits growth (e.g., Natarajan & Treister 2009; King 2016)
- There is not enough time to grow such massive BHs at z>6 (but both the super-Eddington accretion and heavy seeds scenarios can overcome)
- They are just too rare

Project Synopsis

GNIRS spectroscopy for 50 quasars at z>5.7 to understand the physical properties and growth history of the first SMBHs.

Future direction

IR spectroscopy for fainter z~6 quasars to catch their early growth phase (e.g., w/ JWST and GSMTs).

Summary of Project

- Basic spectral analysis complete; statistical analysis ongoing.
- Current publications
  - Physical properties of z>5.7 quasars (Shen et al. 2019, ApJ, 873, 35)
  - Metal absorbers up to z~6 (Zou et al. 2021, ApJ, 906, 32)
  - Black Hole Demographics (Wu et al., in prep)

Image Credit: STScI