AGN13
BEAUTY and the BEAST

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The prodigious history of the first SMBHs and their host galaxies: Gargantua and Pantagruel at cosmic dawn

Raffaella Schneider
Sapienza Università di Roma

collaborators

Rosa Valiante
INAF/Osservatorio Astronomico di Roma

Edwige Pezzulli
INAF/Osservatorio Astronomico di Roma

Michele Ginolfi
Observatoire Astronomique - UNIGE

Marta Volonteri – Institut d'Astrophysique de Paris

Kazuyuki Omukai – Tohoku University

Simona Gallerani – Scuola Normale Superiore di Pisa

Luca Graziani – Scuola Normale Superiore di Pisa

Maria Carmela Orofino – Scuola Normale Superiore di Pisa

Tullia Sbarrato – Università di Milano Bicocca

Luca Zappacosta – INAF/Osservatorio Astronomico di Roma

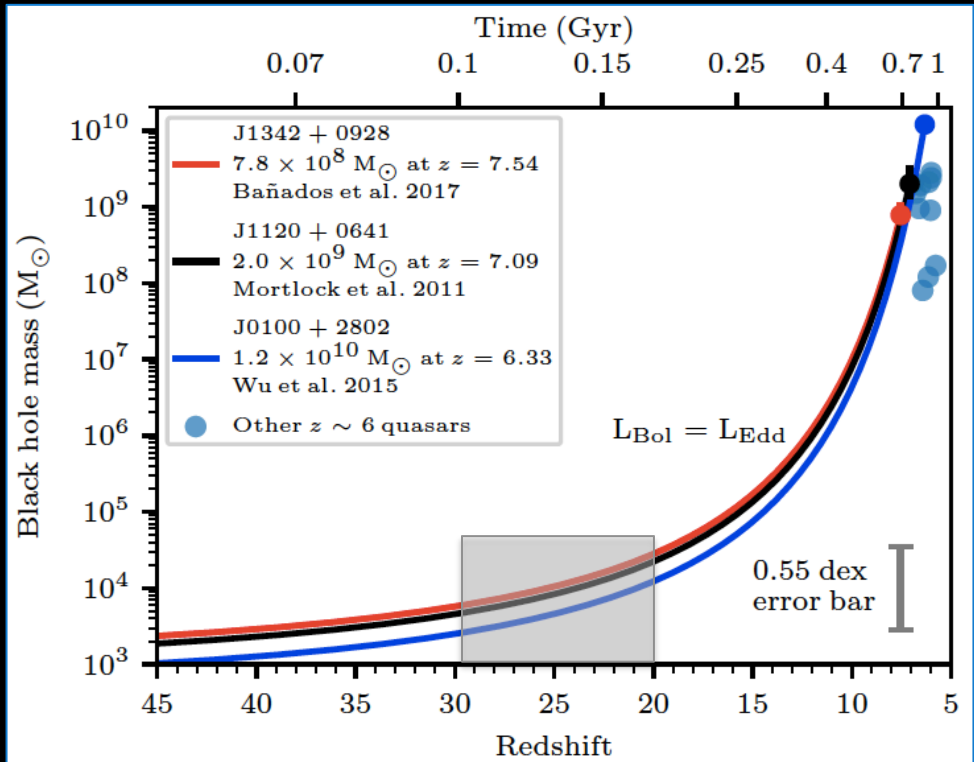
outline

- the history of Gargantua: BH seeds and their growth
- the history of Pantagruel: the assembly of the host galaxy
- Gargantua and Pantagruel: coevolution at cosmic dawn

the most distant quasars: theoretical challenge

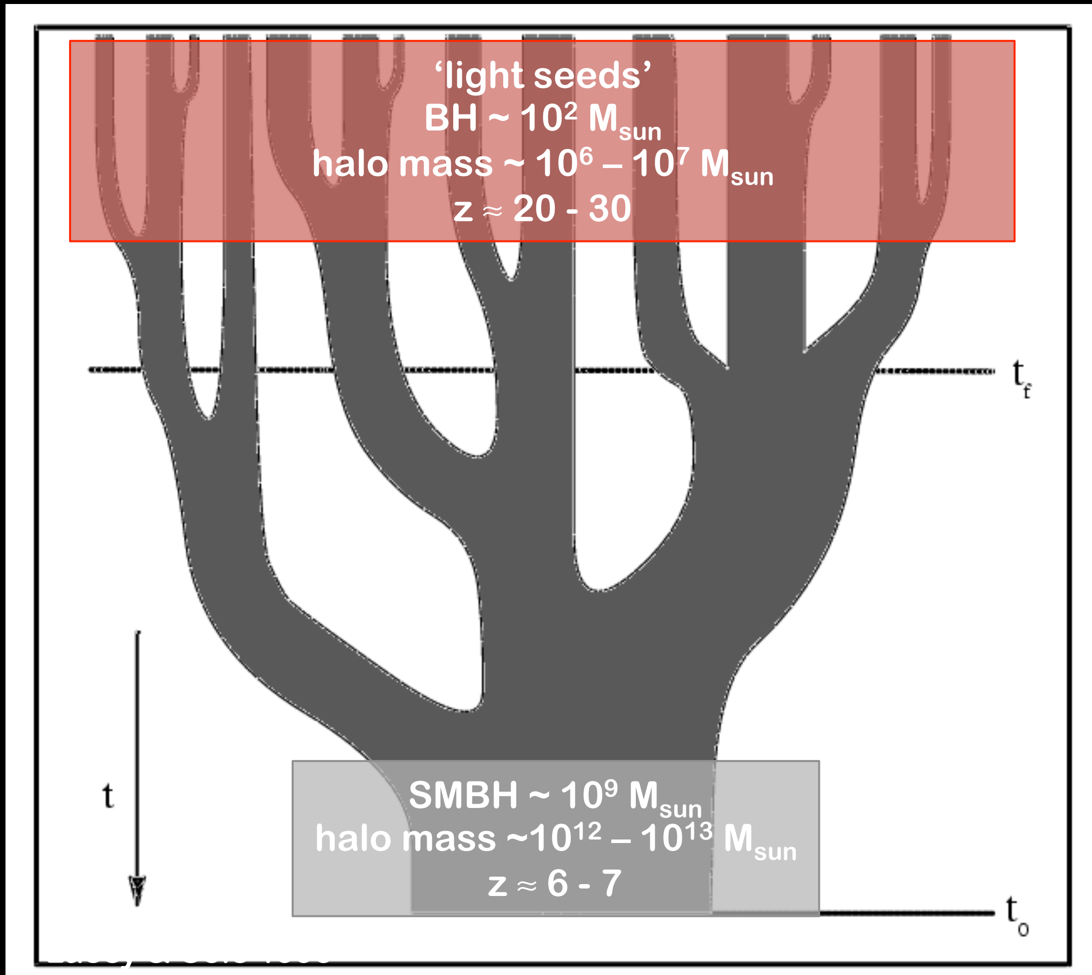
How do these SMBHs grow in less than 1 Gyr?

$M_{SMBH}(t) = M_{seed}(t_{form})\, e^{[(1-\varepsilon)/\varepsilon]\,\Delta t/t_{Edd}}$ $\varepsilon = 0.1$ $t_{Edd} = 0.45$ Gyr



models of SMBH growth require massive seeds (> $10^4\ M_{sun}$) and/or episodes of super-Eddington accretion

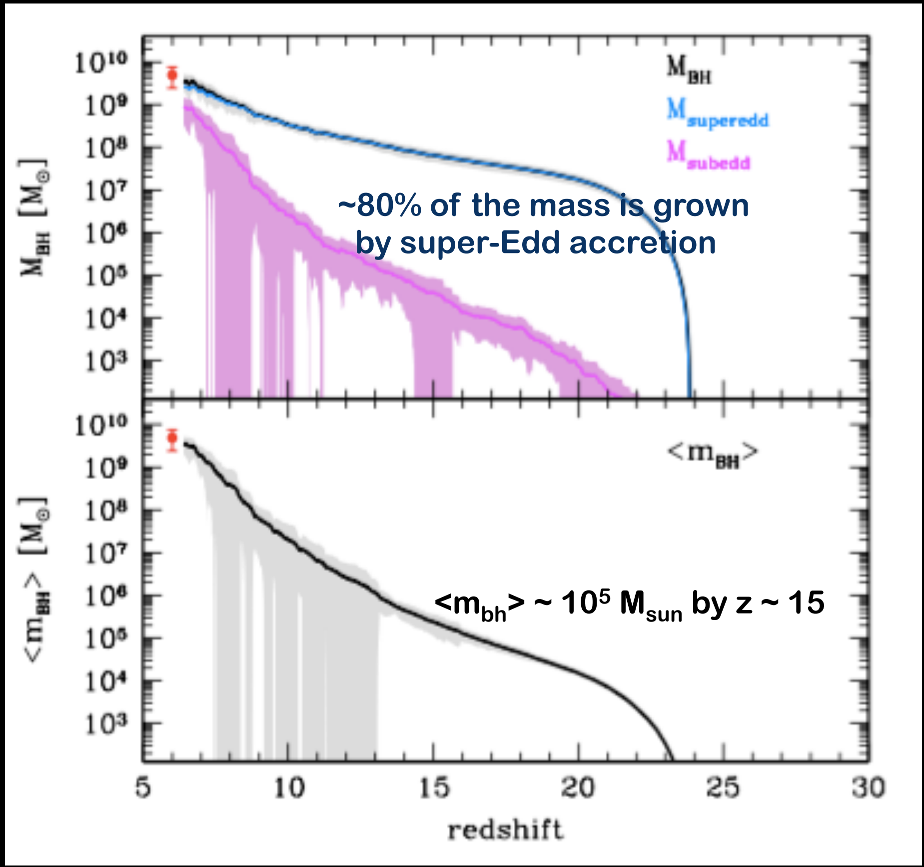
the formation of the first SMBHs: planting and growing seeds in a highly biased region



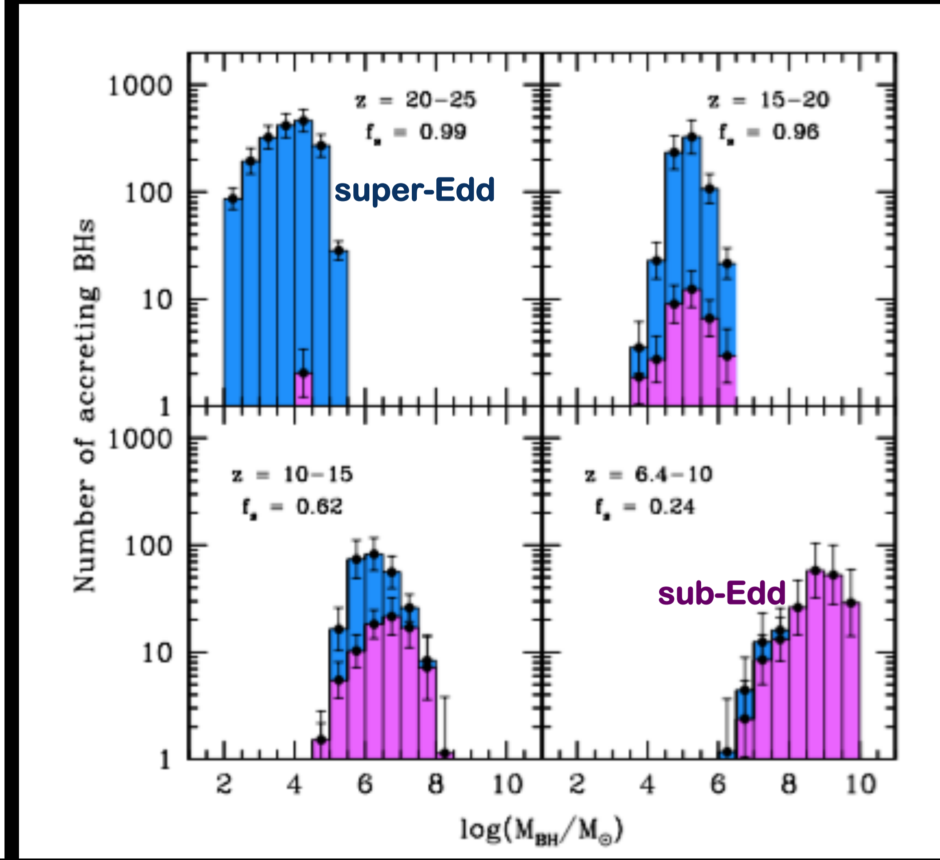
Haiman & Loeb 2001, Volonteri et al. 2003, Wyithe & Loeb 2003, Haiman 2004, Menci et al. 2004, 2008, Shapiro 2005, Yoo & Miralda-Escude' 2004, Bromley et al. 2004, Volonteri & Rees 2005, Li et al. 2007, Pelupessy et al. 2007, Sijacki et al. 2009, Tanaka & Haiman 2009, Lamastra et al. 2010, Valiante et al. 2011, Petri et al. 2012; Valiante et al. 2015; 2016, 2017, 2018; Pezzulli et al. 2016, 2017

super-Eddington growth of light BH seeds

BH mass evolution



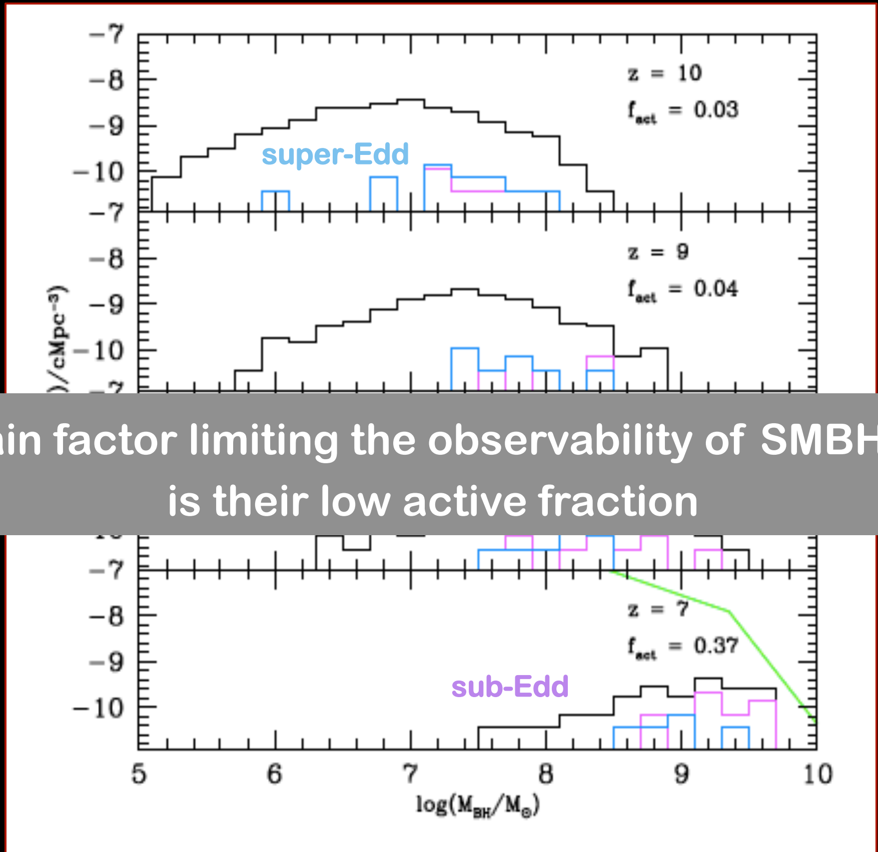
mass/redshift distribution of accreting SMBH progenitors



Pezzulli et al. (2016, 2017a)

first SMBHs can grow from Pop III BH remnants via short episodes of super-Edd accretion

episodic super-Edd accretion limits the observability of SMBH seeds



the main factor limiting the observability of SMBH seed is their low active fraction

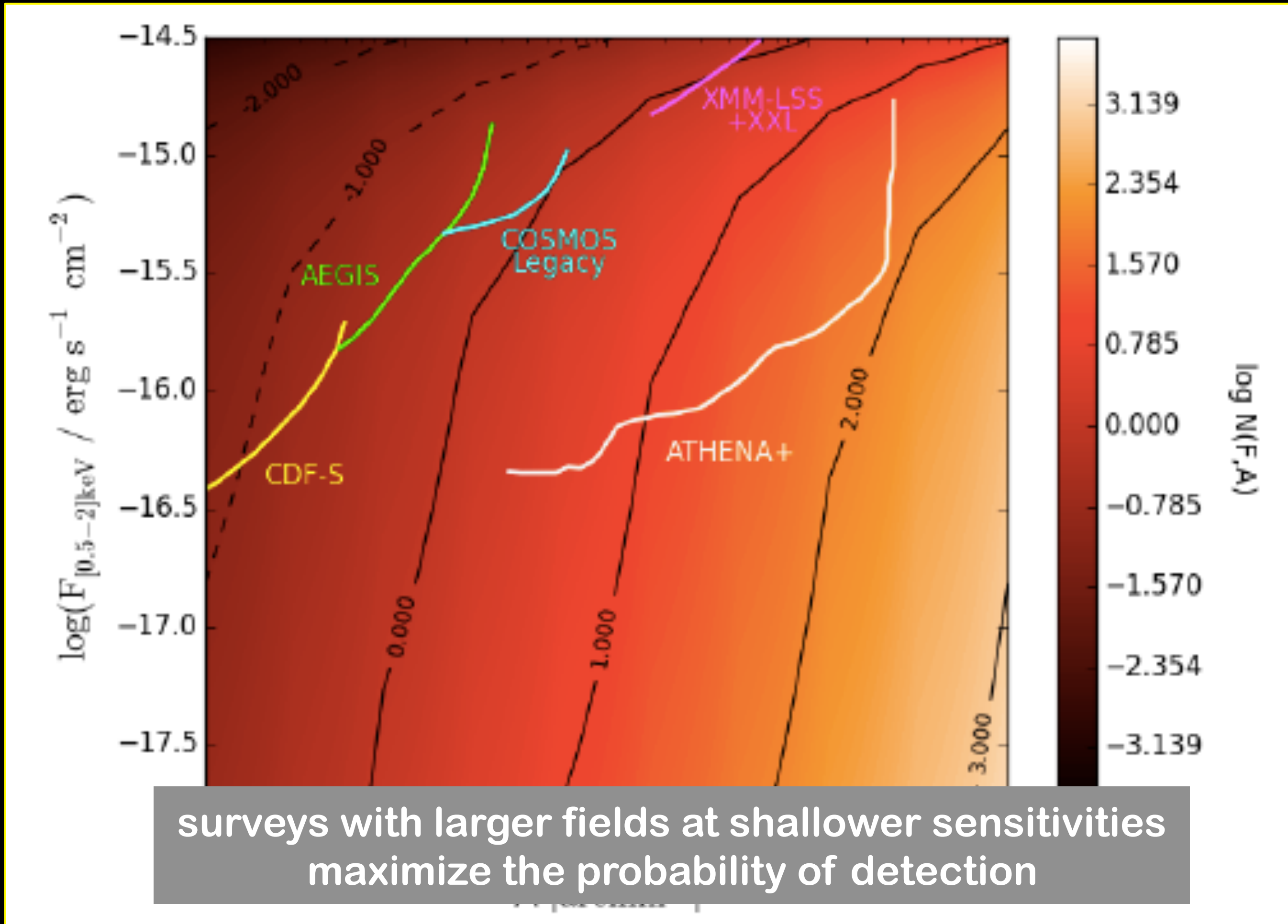
Pezzulli et al. 2017b

f_{act} = fraction of active BHs

$\lambda_{Edd} > 5\ 10^{-3}$

$\langle f_{act} \rangle \sim 1\%$

the observability of z ~ 6 SMBH light BH progenitors

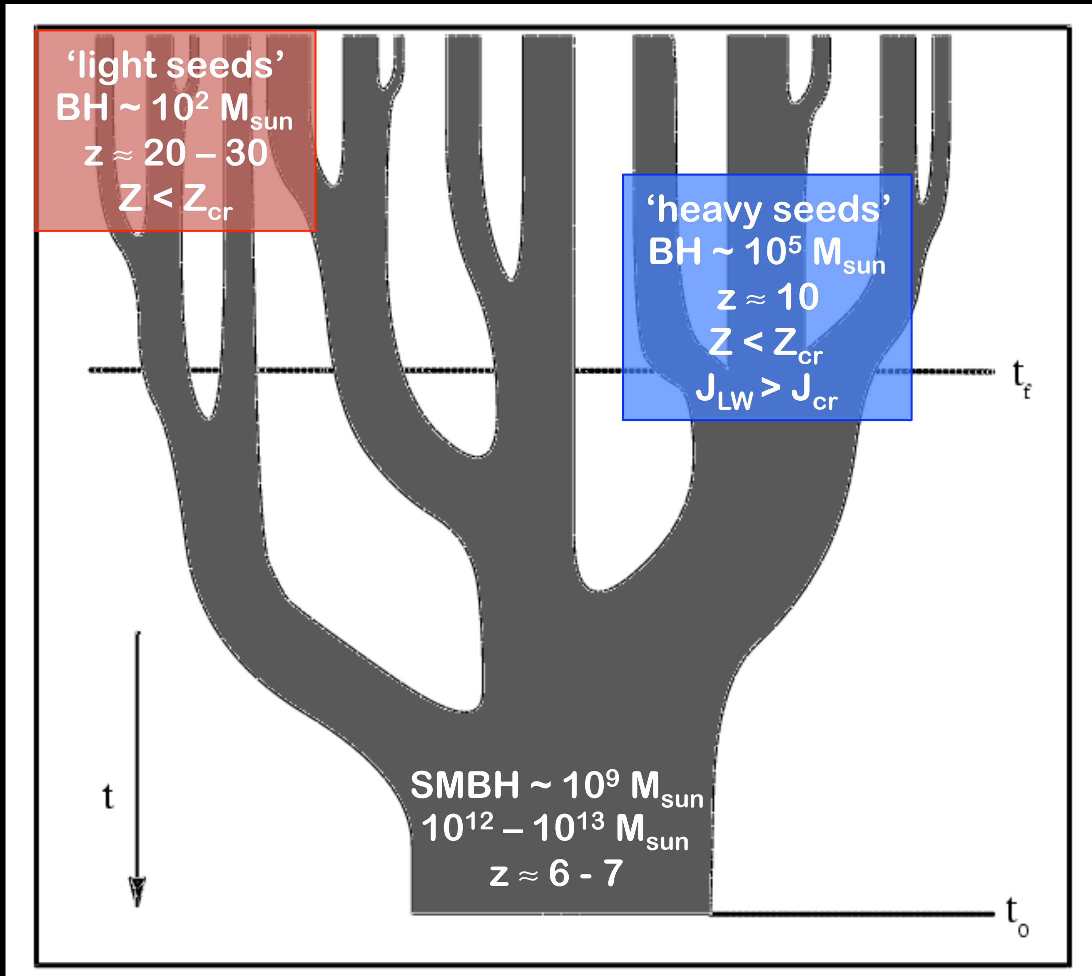


surveys with larger fields at shallower sensitivities maximize the probability of detection

Pezzulli et al. 2017b

alternative route: a "head start" from direct collapse black holes

Omukai 2001; Bromm & Loeb 2003; Wise+2008; Regan & Haehnelt 2009; Hosokawa+2012; Latif+2013,2014, 2016; Prieto+2013; Regan+2014; Inayoshi+2014; Choi +2015; Becerra +2015, 2018



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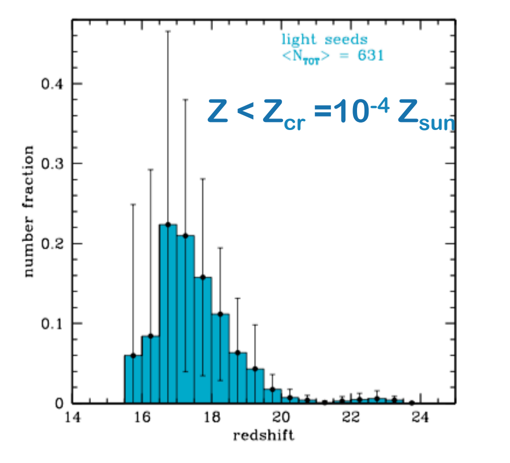
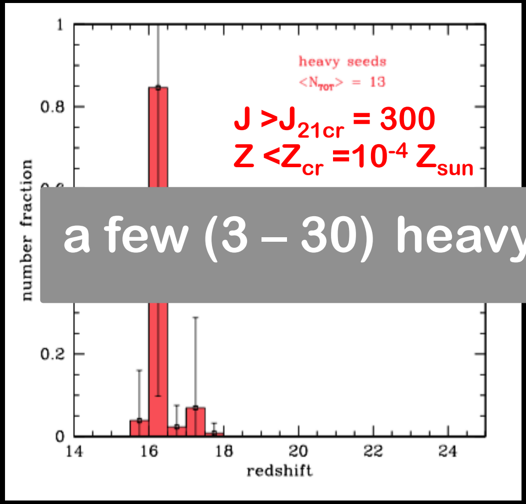
growing the first SMBHs

Light seeds as Pop III remnants

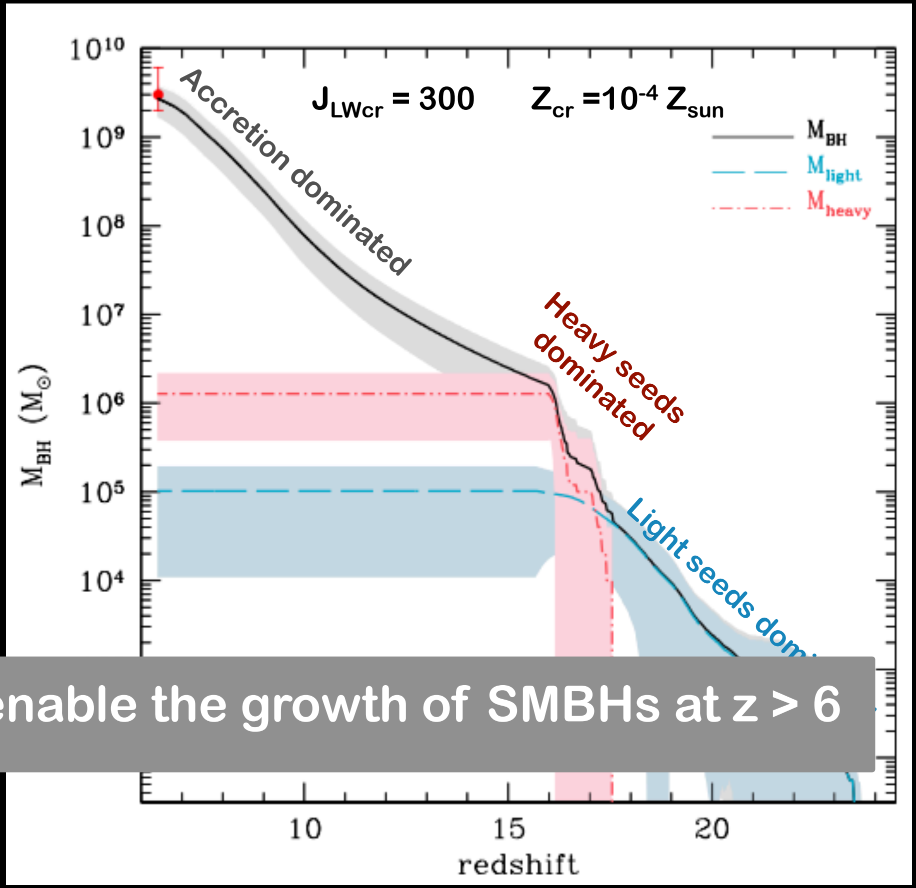
Heavy seeds with $M_{bh} = 10^5\ M_{sun}$ in Lyman-α cooling halos where star formation is suppressed

average redshift distribution





average evolution of the total nuclear BH mass



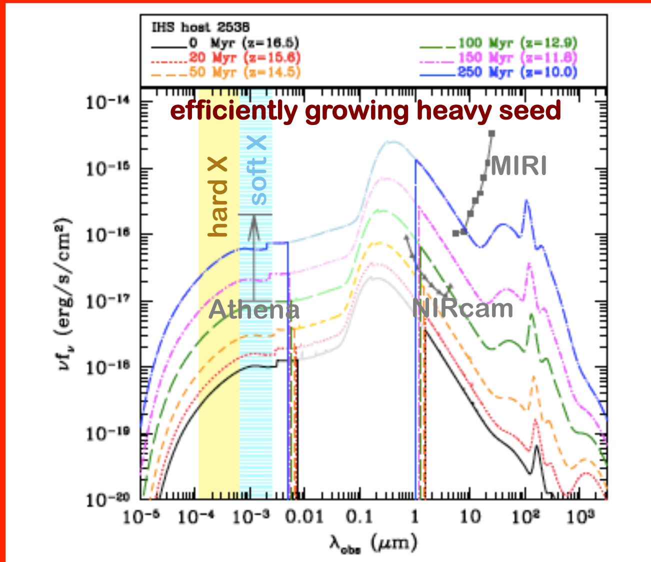
a few (3 – 30) heavy seeds enable the growth of SMBHs at z > 6

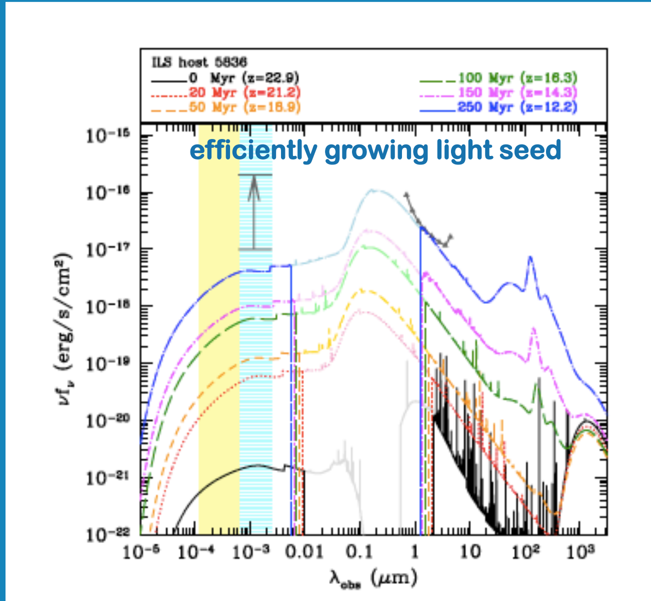
Valiante, RS, Volonteri, Omukai 2016

see also Ferrara+2014;Agarwal+2015; Habouzit+2016

chasing the nature of BH seeds: candidate observability

SED of efficiently growing seeds (Valiante et al. 2018b)





heavy seeds

10 < z < 13

detectable JWST & Athena

similar BH-dominated

SED at t > 100 Myr

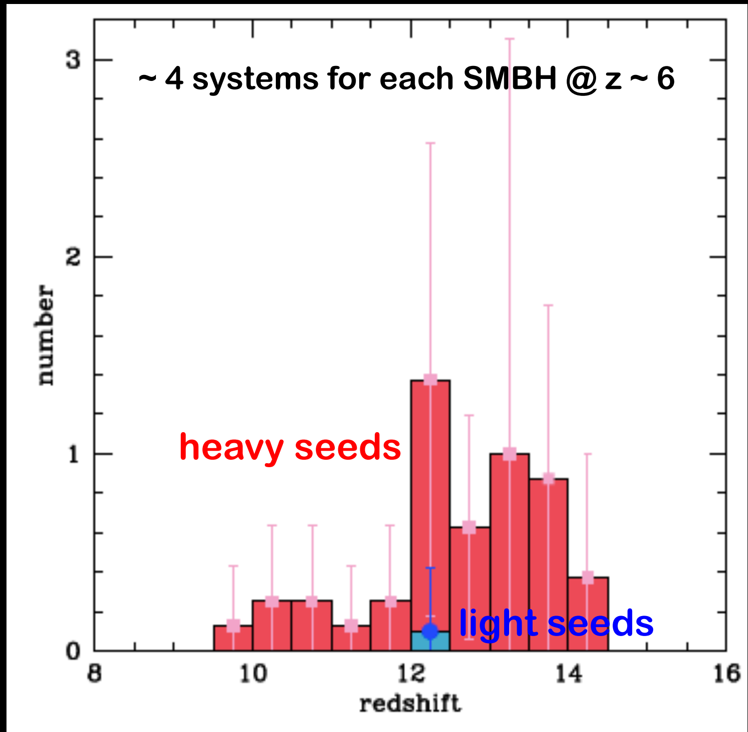
light seeds

12 < z < 16

not detectable

chasing the nature of BH seeds: candidate observability

redshift distribution of detectable BH seeds



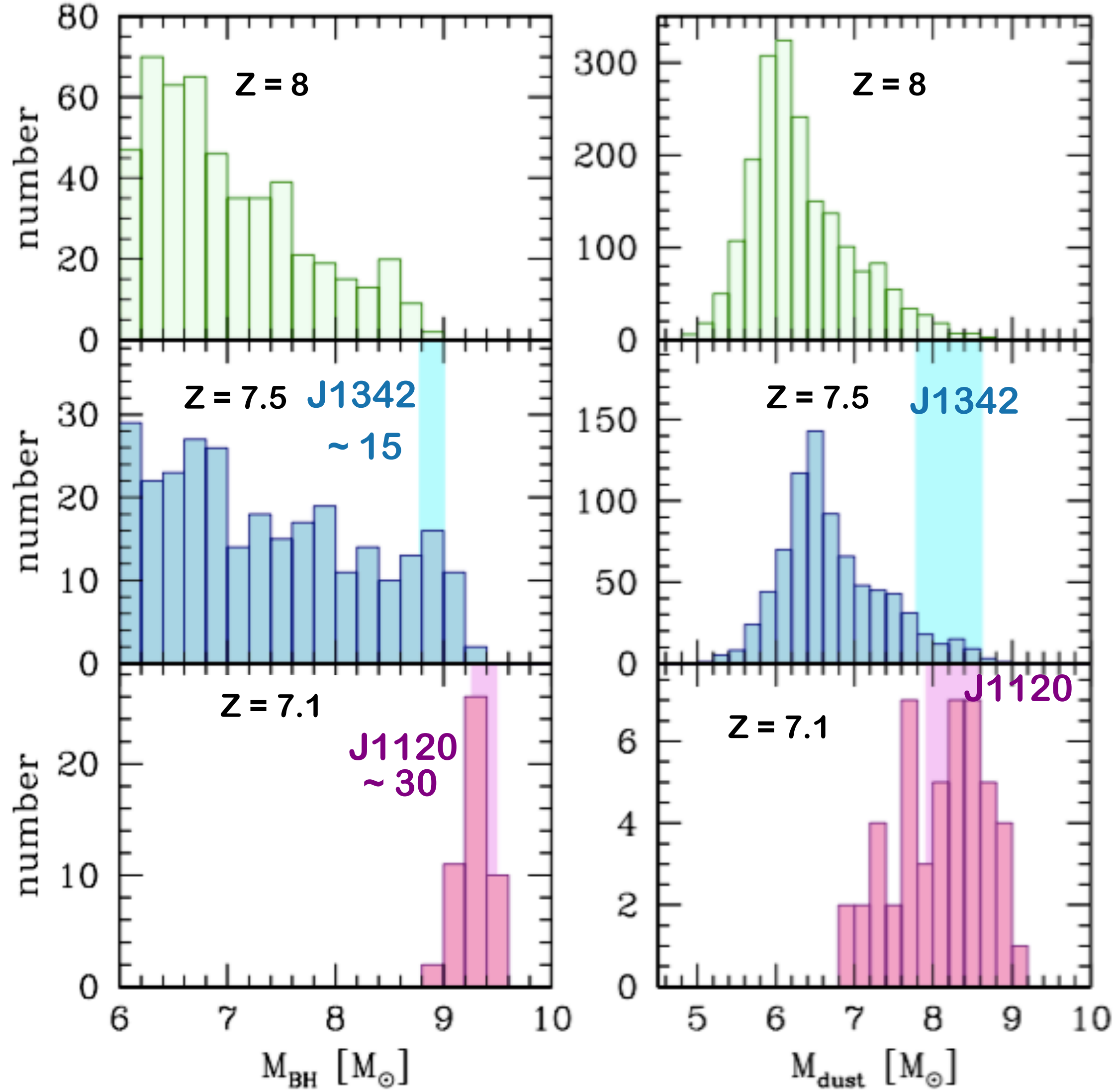
Valiante et al. 2018b

the more luminous (more likely to be detected) systems have a larger probability to be powered by growing heavy seeds

Pacucci et al. 2015, 2016; Natarajan et al. 2017; Volonteri et al. 2017

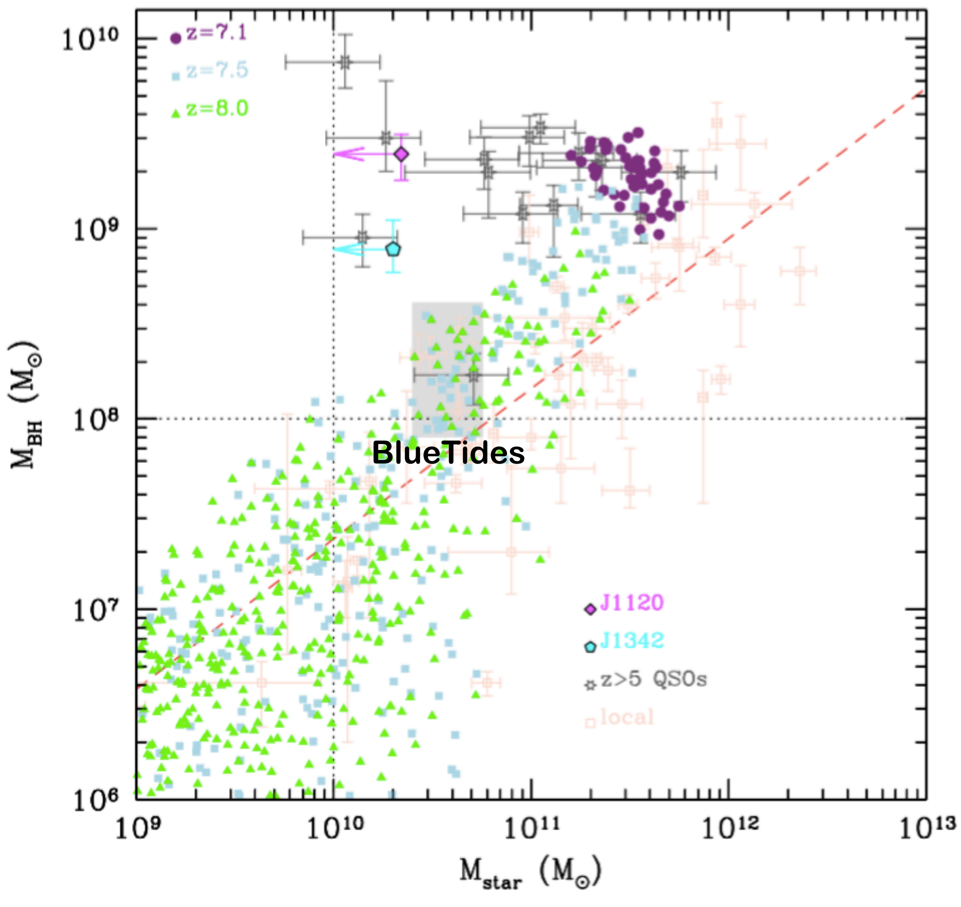
the assembly of the host galaxy: from J1342 @ z = 7.5 to J1120 @ z = 7.1

black hole and dust mass distributions for 50 simulations

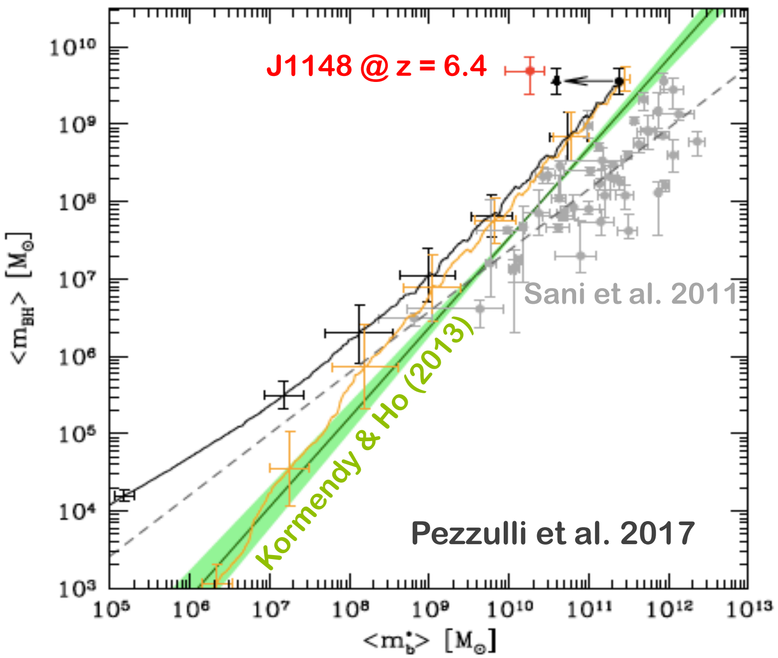


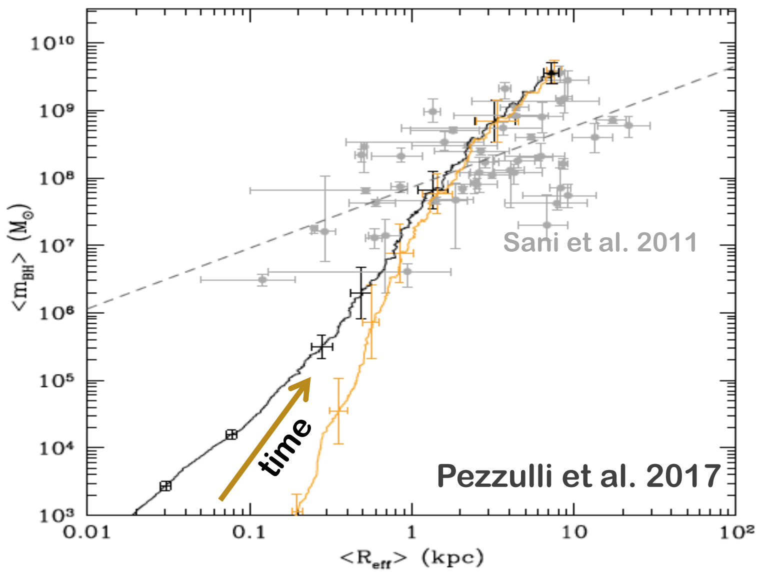
Valiante et al. in prep

coevolution at cosmic dawn



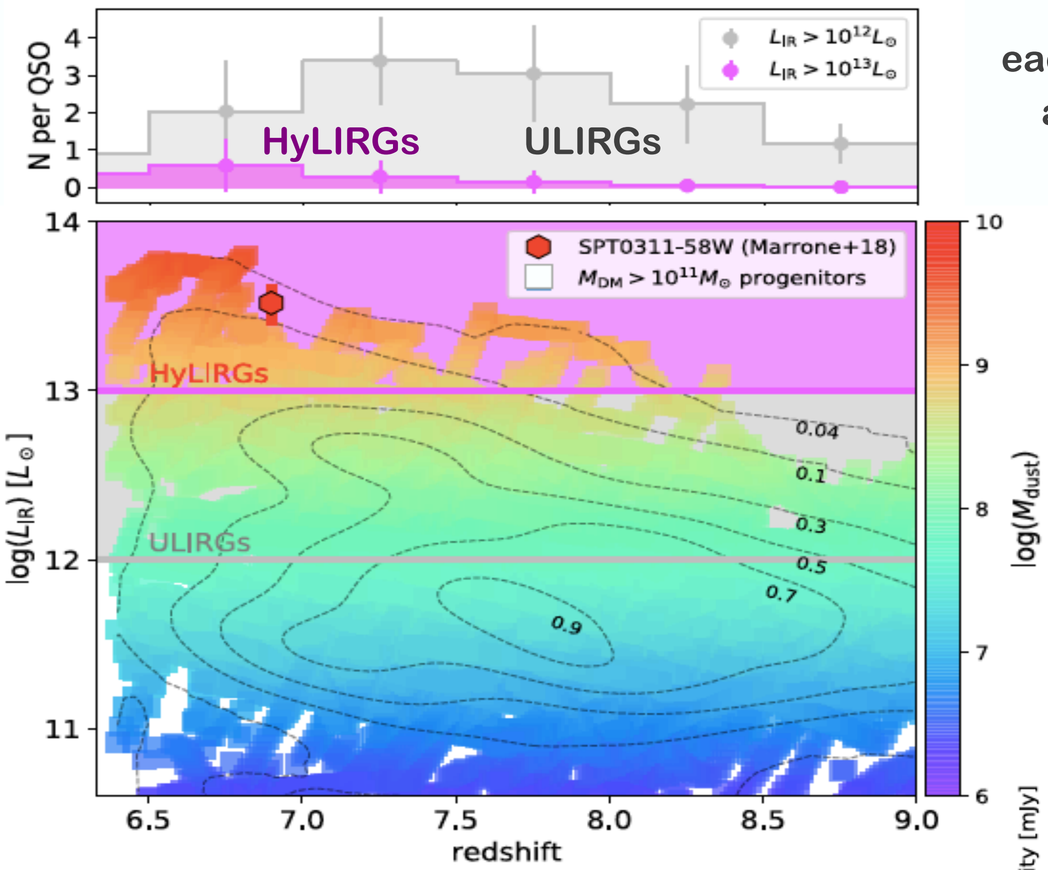
Valiante et al. in prep





the IR luminous progenitors of z ~ 6 quasars

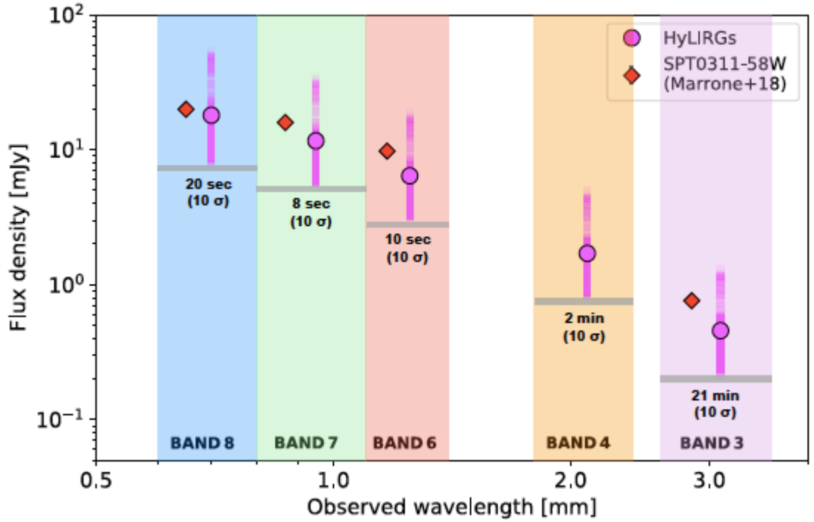
Ginolfi et al. submitted



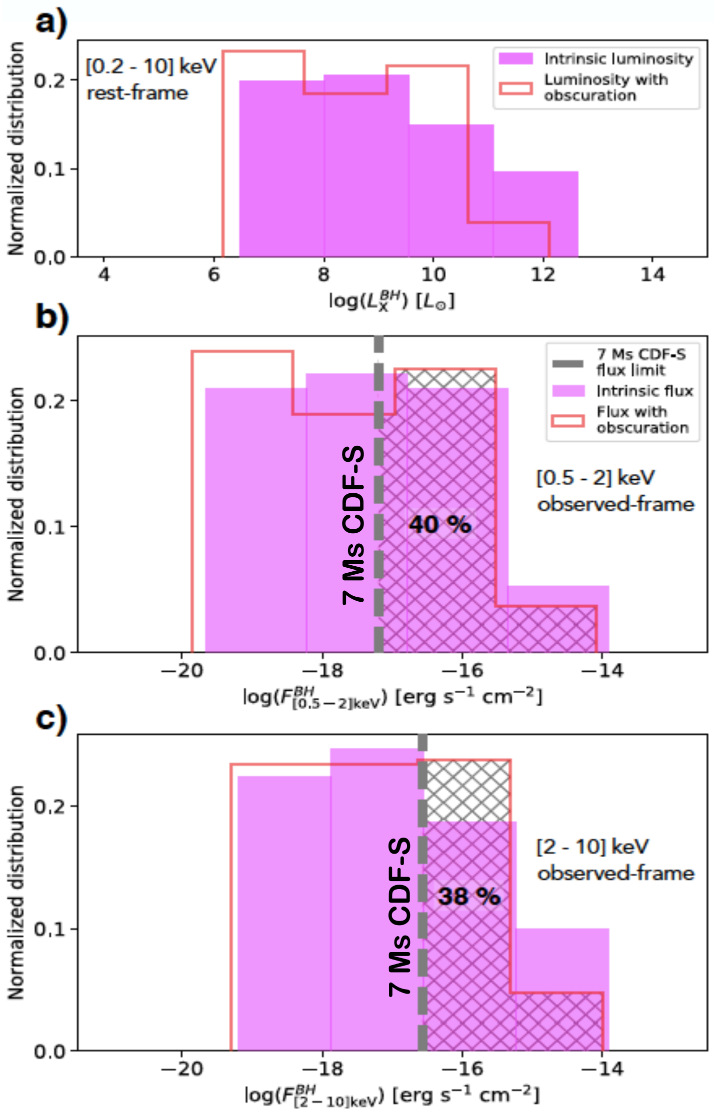
each z ~ 6 quasar has, on average, ~ 2.8 ULIRGs and ~ 0.4 HyLIRGs progenitors at 6.5 < z < 8

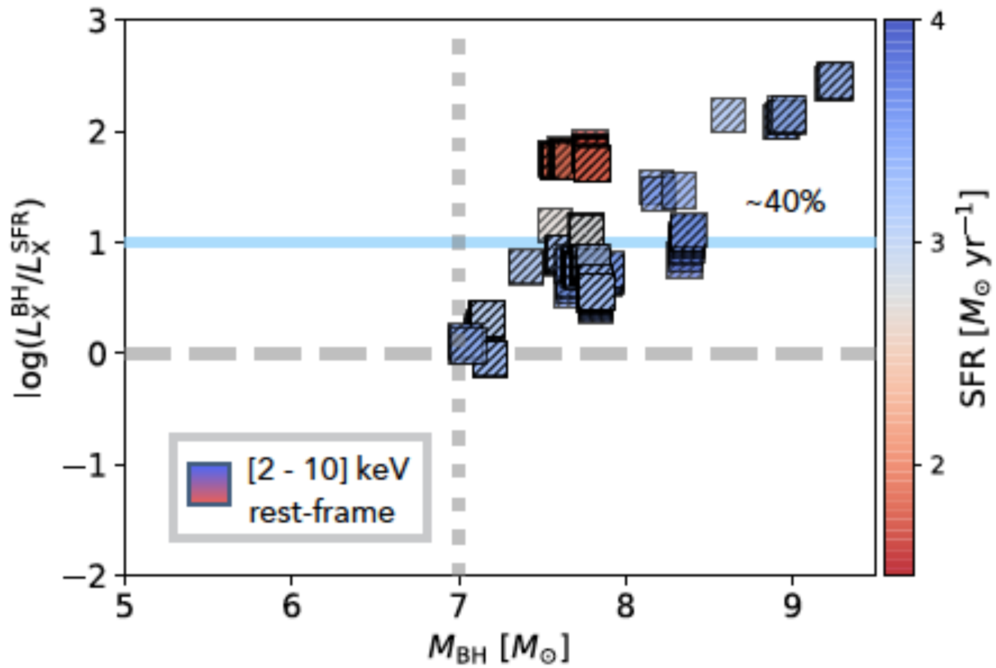
~ 180 quasars @ z > 6 → ~ 70 HyLIRGs

all these systems can be observed with ALMA



X-ray properties of HyLIRGs at z > 6





Ginolfi et al. submitted

Summary

- the history of Gargantua can either start from ~ 100 M_{sun} seed and grow at episodic super-Eddington rates or from ~ 10^4 - 10^5 M_{sun} with Eddington limited accretion

- for each z ~ 6 SMBH we expect ~ 4 BH seeds at z > 10 detectable with JWST and Athena BUT discriminating their nature is hard

- the history of Pantagruel is that of a massive chemically evolved galaxies with HyLIRGs progenitors at 6.5 < z < 8 similar to SPT0311 that could be easily detectable with ALMA

- Gargantua and Pantagruel grow hand-in-hand in the M_{BH} vs M_{star} plane extended stellar bulges (~ 8 kpc) that may be missed in current dynamical mass estimates?