The "**missing seed**" problem for massive black holes at high redshift

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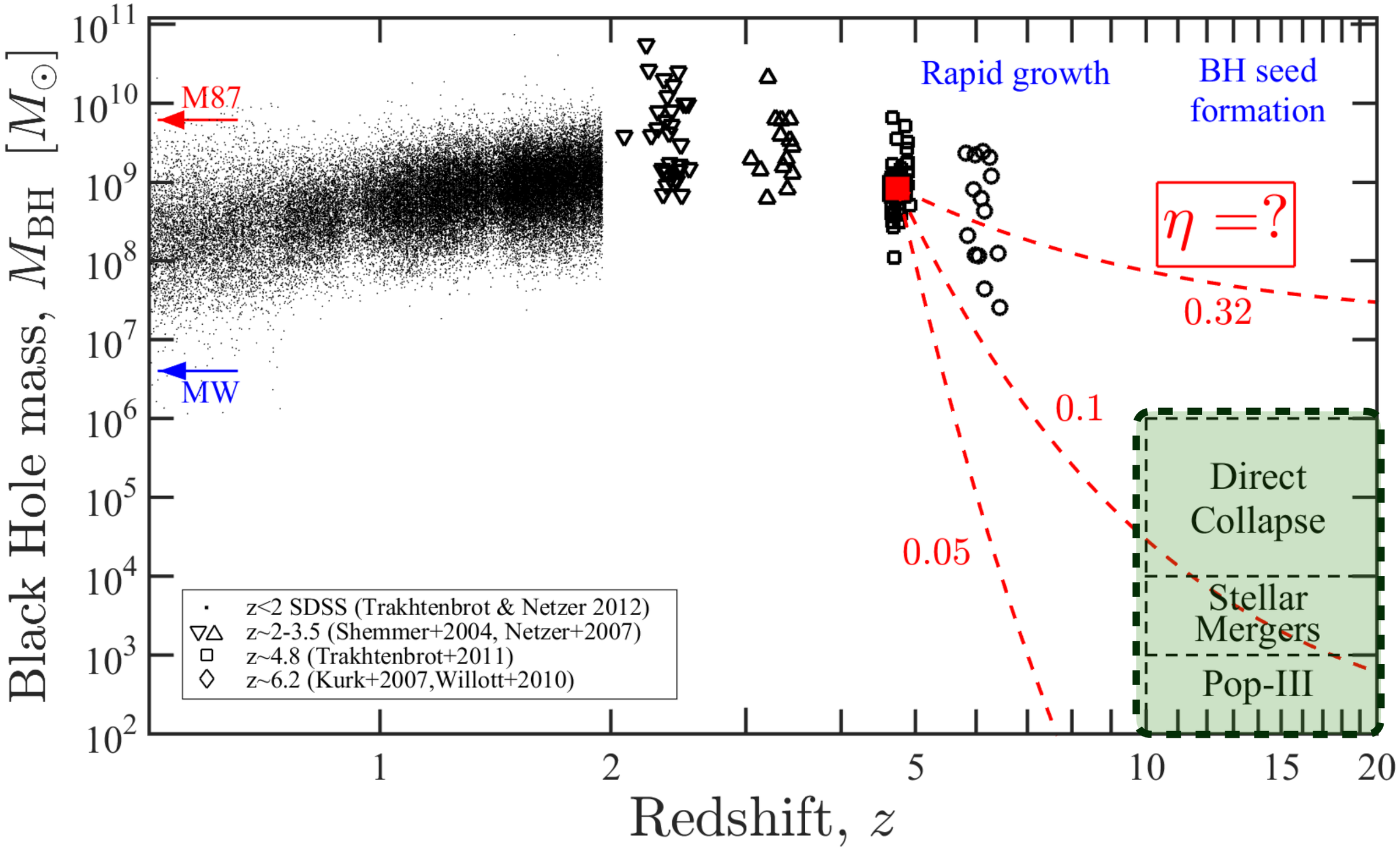
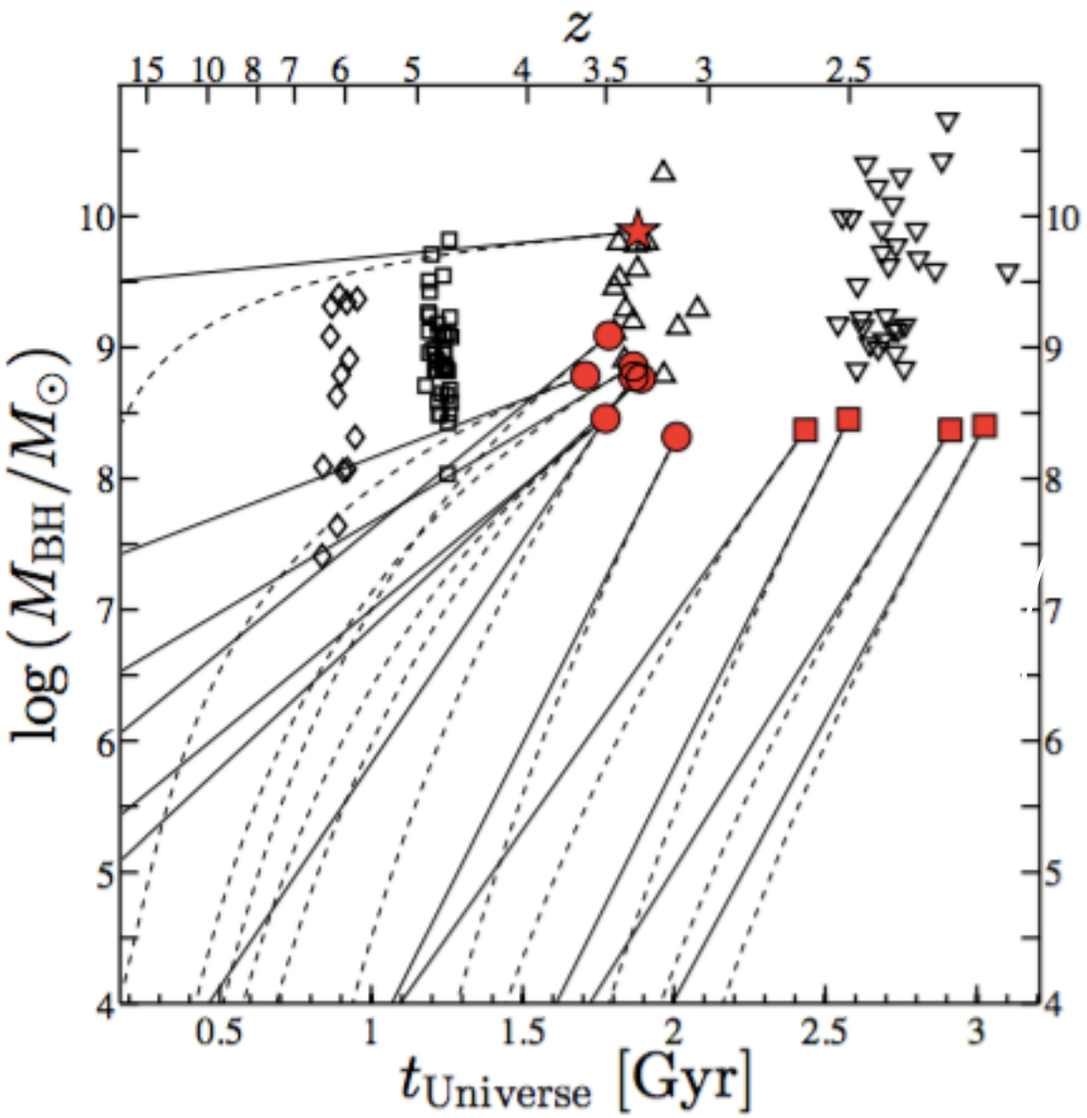
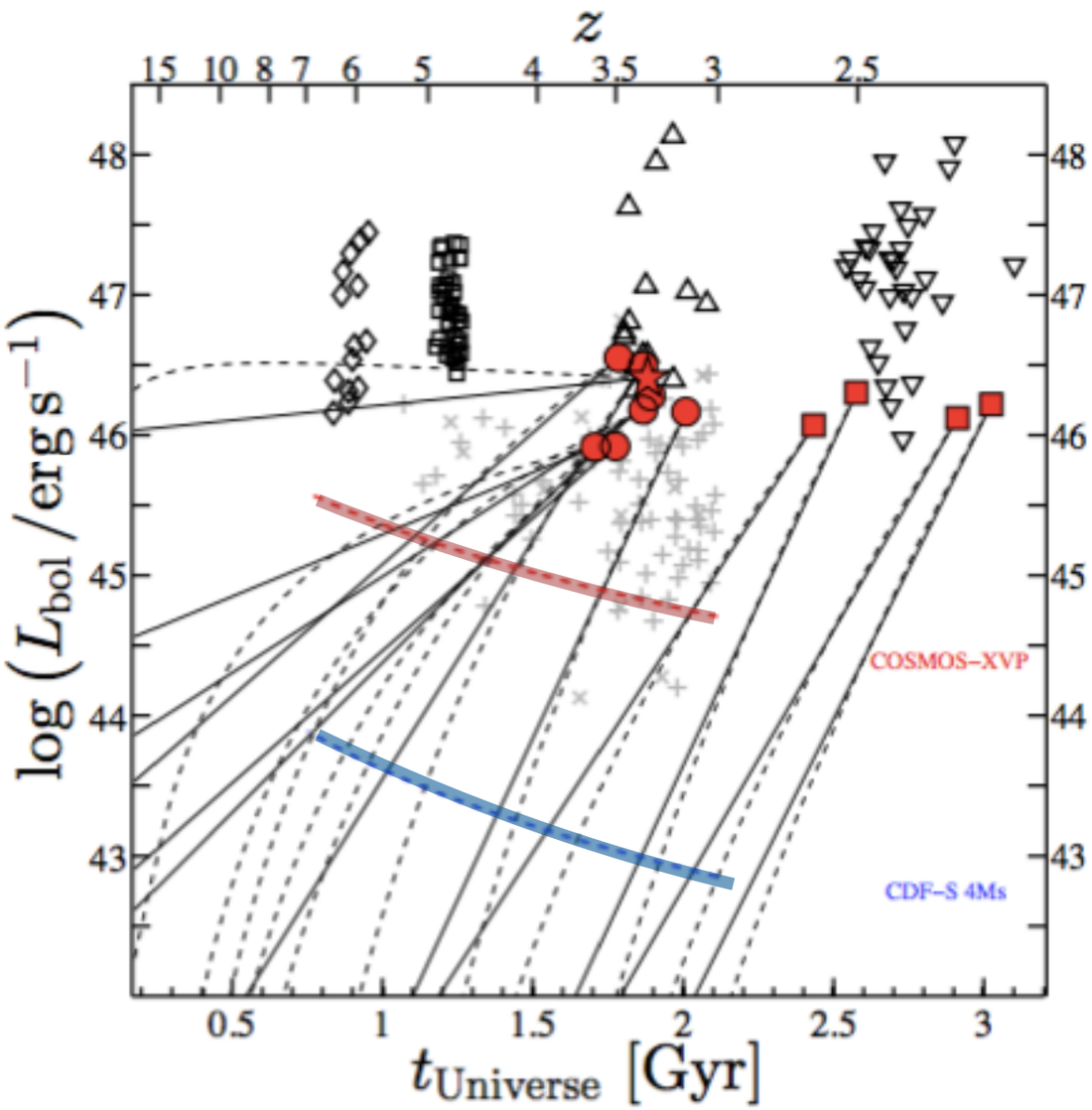
ETH black hole group
Grüp Bœgg Negar Politecnic da Zürig



adapted from Trakhtenbrot & Netzer 2012





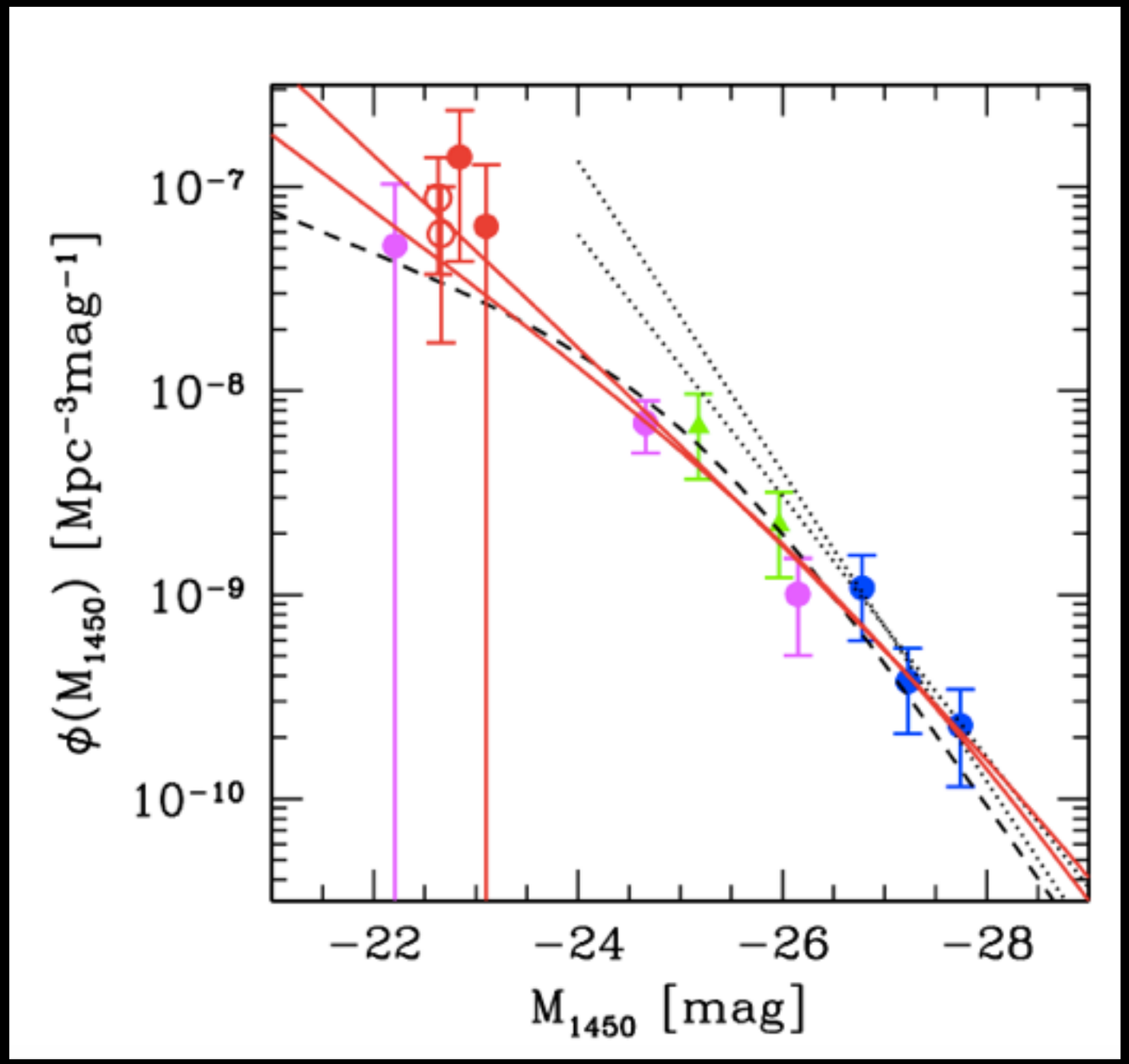
Trakhtenbrot+16

Current **observational** constraints on high-z AGN

I. Wide-area quasar surveys
   - SDSS/deep Jiang+09
   - CFHQS Willott+10
   - SuprimeCam Kashikawa+15

II. Deep fields
   - CDFS stacking Treister+11,13
   - CDFS individual sources Weigel+15

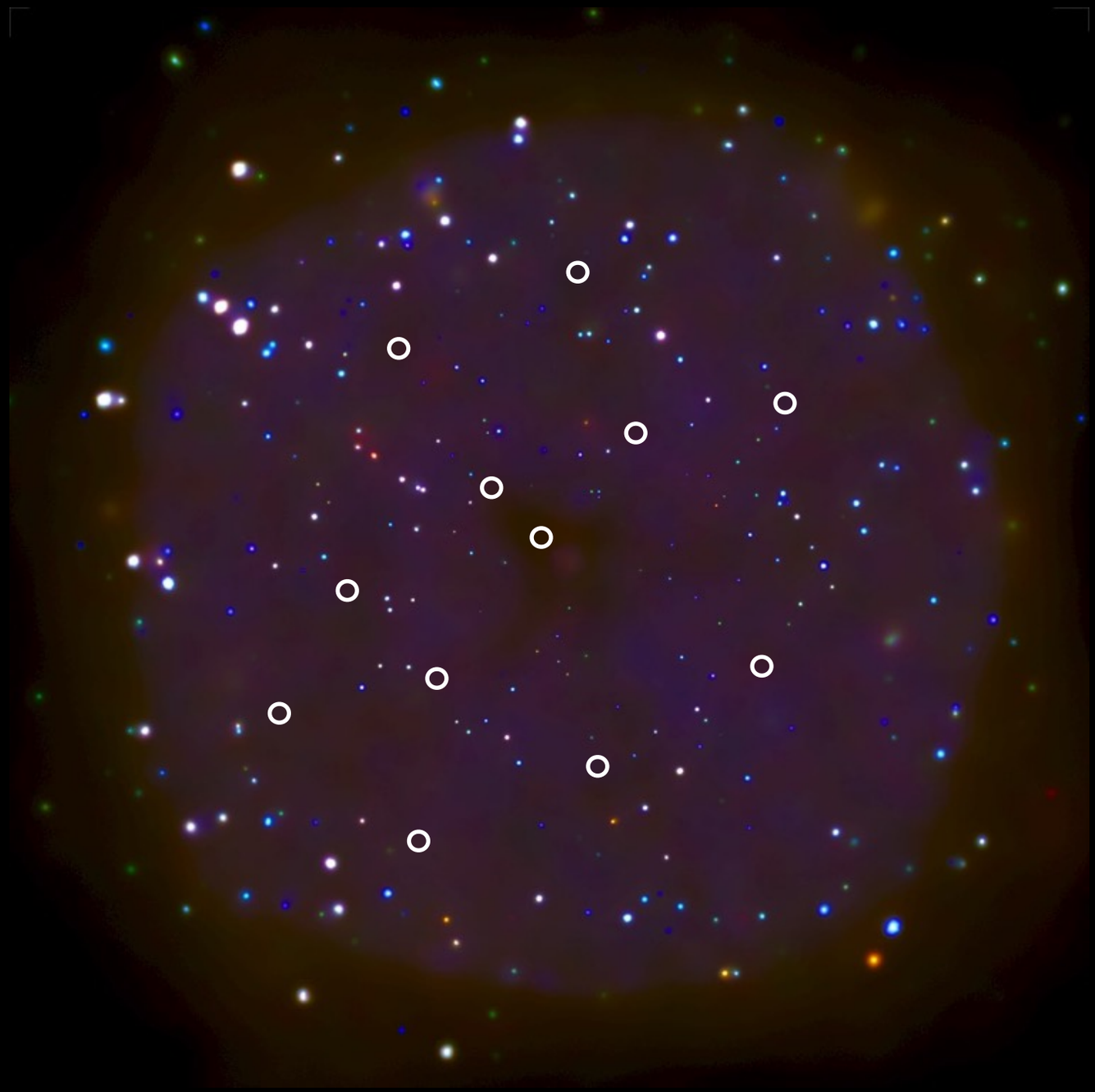
I. Wide area quasar surveys



Kashikawa+15 (latest compilation)

II. Deep fields

Chandra X-ray stacking of z=[6,7,8] dropout galaxies



Treister+13

II. Deep fields

Chandra X-ray stacking of z=[6,7,8] dropout galaxies

Table 1. Stacking Results

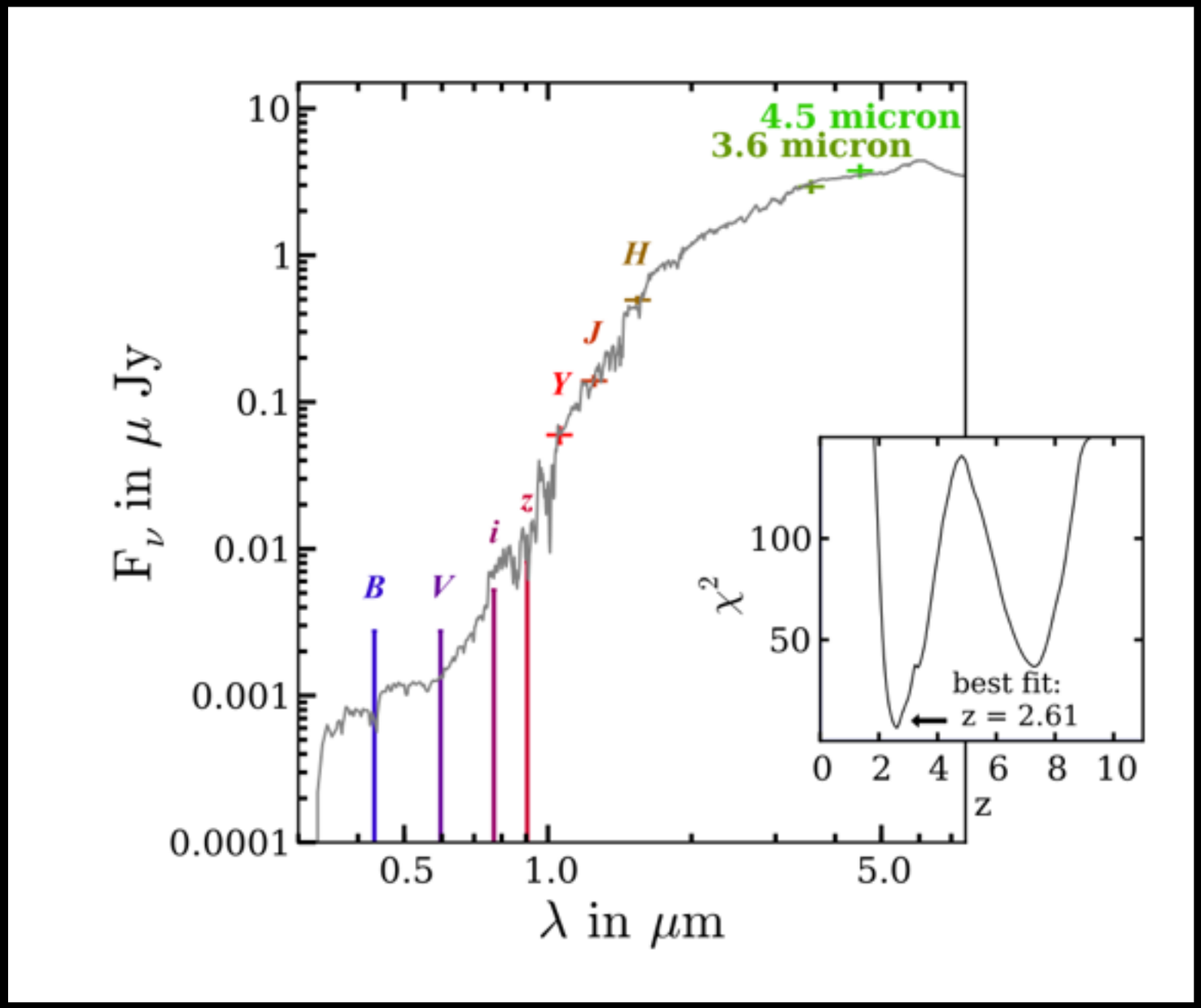
Redshift	Sample				X-ray Lum[a]	BH Mass[a]
	B06	B11	F12	Combined	[erg s^{-1}]	[$M_\odot Mpc^{-3}$]
			Soft Band (0.5-2 keV)			
$z\sim6$	-3.4±6.2	—	-3.6±4.7	-4.0±6.5	$<3.1\times10^{41}$	<996
$z\sim7$	—	0.7±1.4	-0.6±2.5	-0.4±2.6	$<6.8\times10^{41}$	<623
$z\sim8$	—	1.6±1.7	0.7±1.9	1.9±2.1	$<1.5\times10^{42}$	<628
			Hard Band (2-8 keV)			
$z\sim6$	-6.3±9.1	—	-3.3±6.7	-9.1±9.4	$<1.6\times10^{42}$	<4750
$z\sim7$	—	0.2±2.4	1.8±4.1	1.5±4.1	$<5.3\times10^{42}$	<4704
$z\sim8$	—	-4.7±2.1	-0.4±2.6	-1.8±2.8	$<9.8\times10^{42}$	<4346

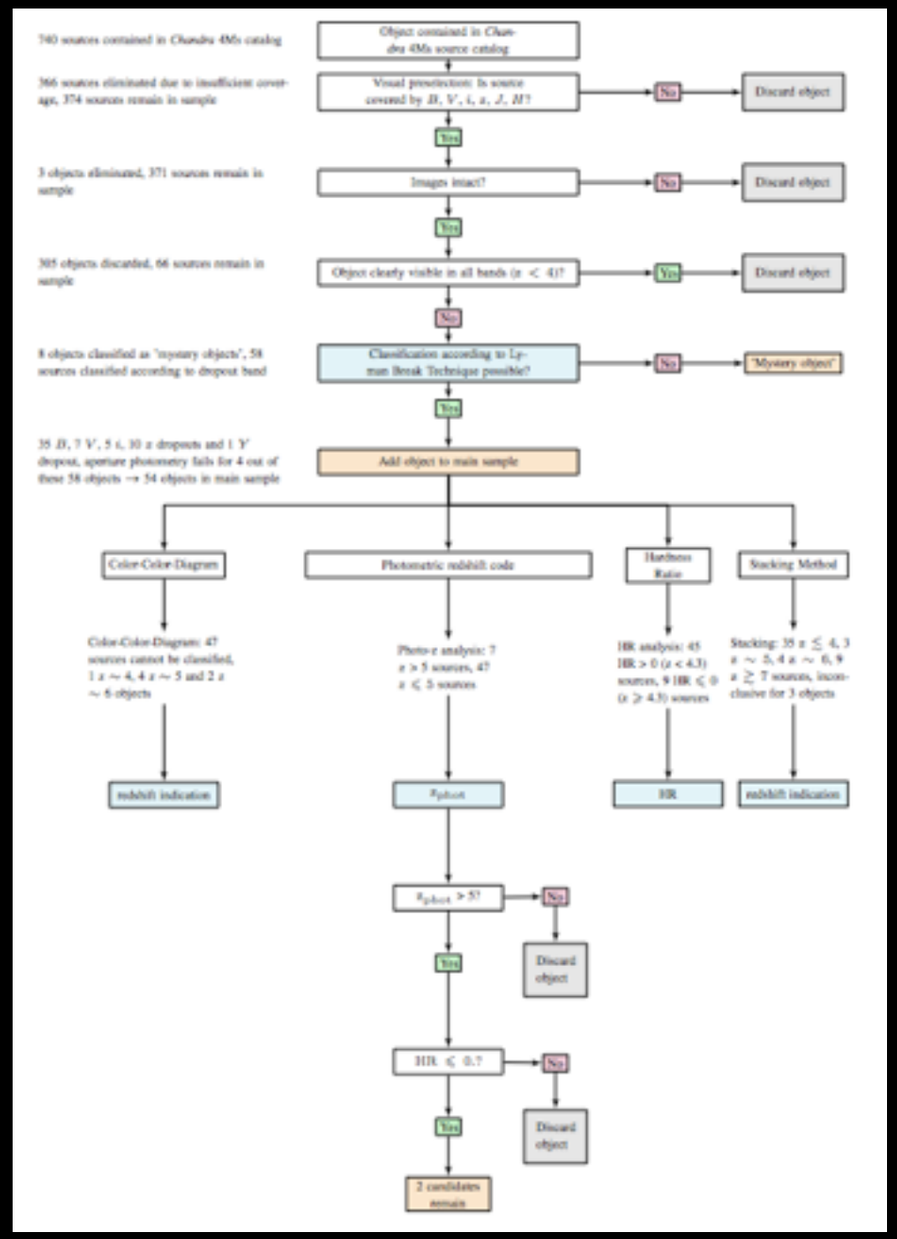
[a]For the combined sample

Treister+13

II. Deep fields

Counterparts of Chandra sources: *no* z>5 candidates in 4 Msec data



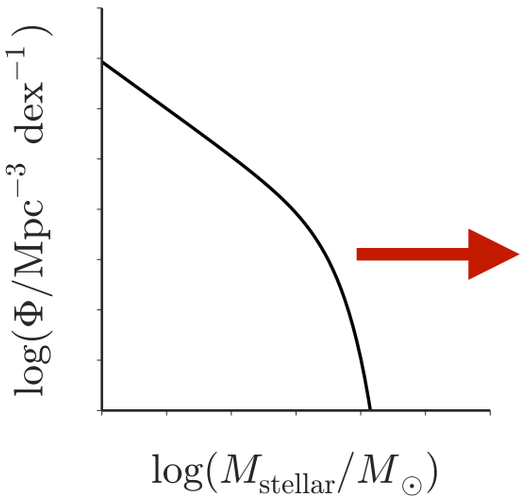


Weigel+15, c.f. Giallongo+15

is there a contradiction between
quasar surveys and **deep fields**?

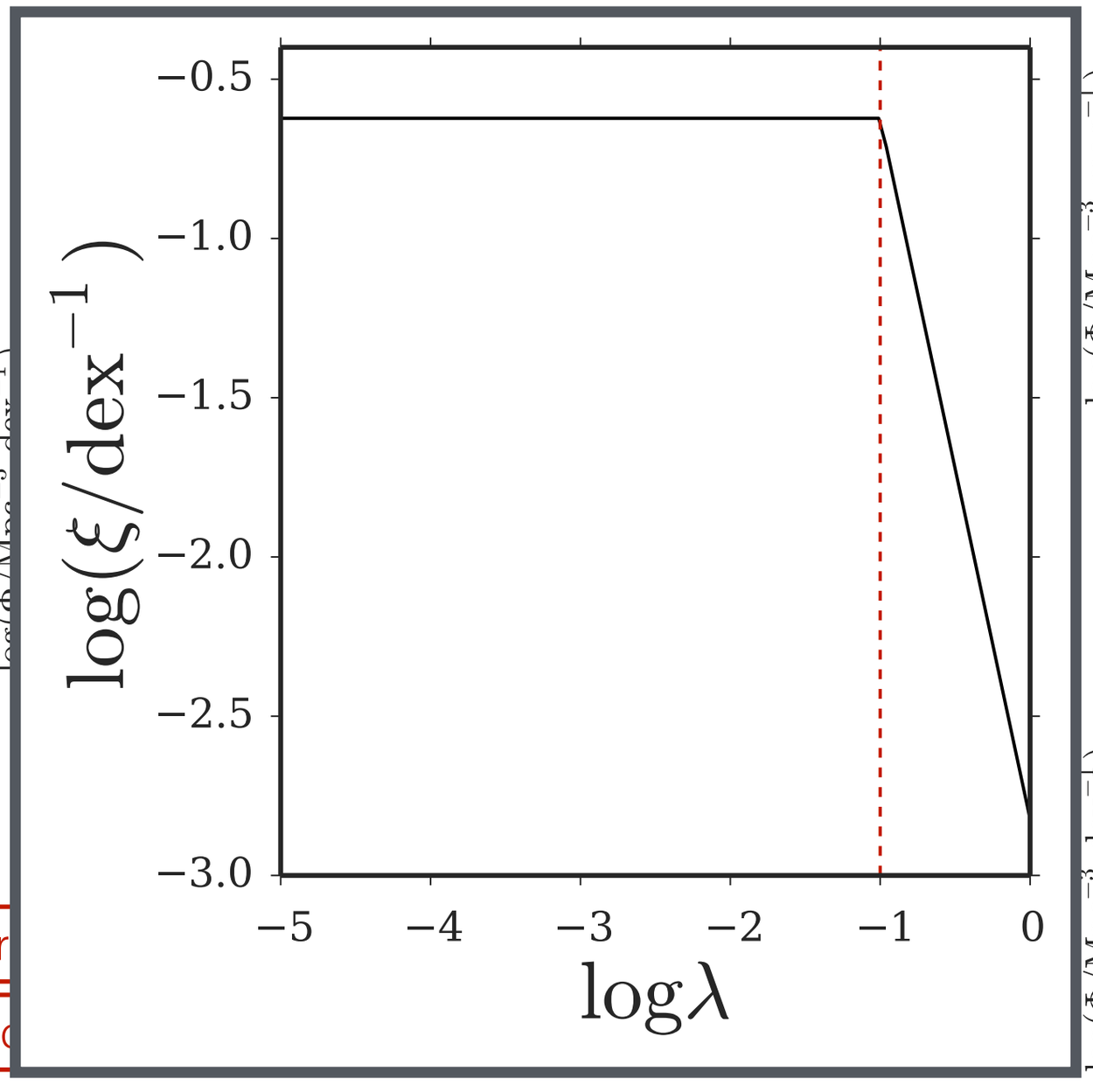
Phenomenological modeling of black hole growth at z~6

stellar mass function



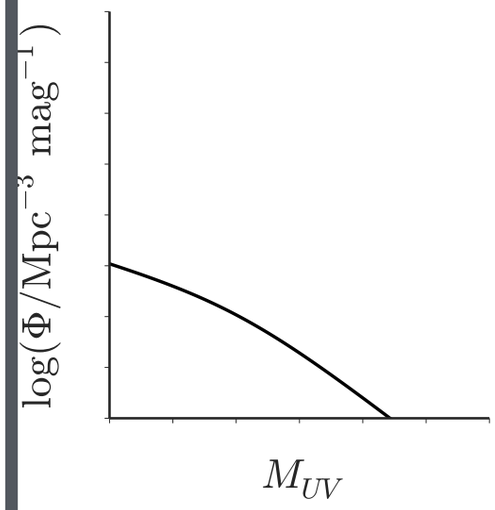
MBH-Mstellar r

occupation frac

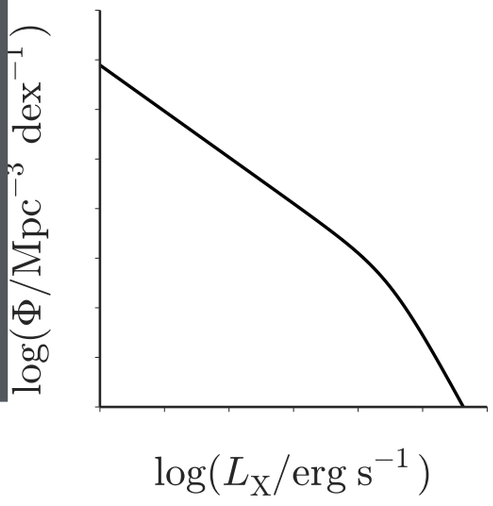


obscured fraction: 50%

AGN UV luminosity function



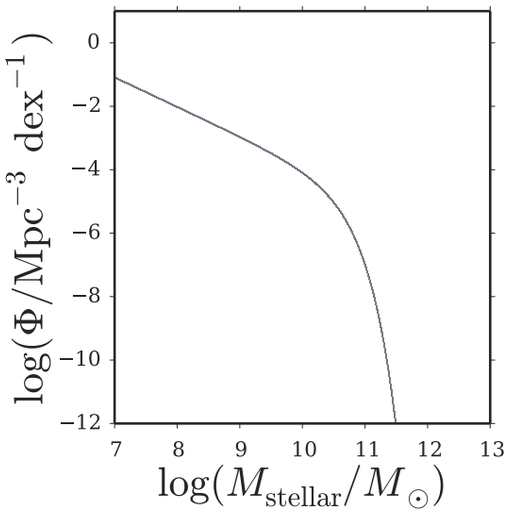
AGN X-ray luminosity function



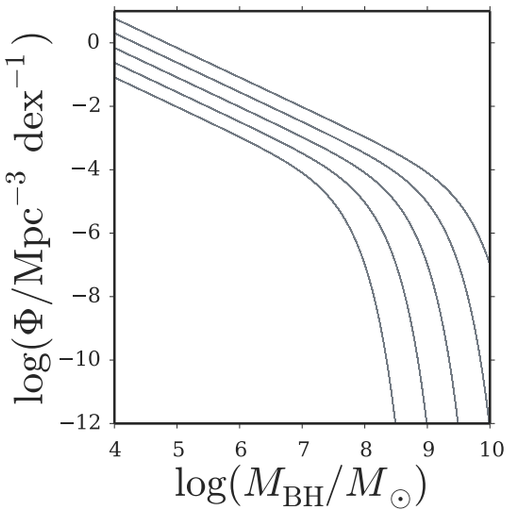
Schawinski+ (in prep)

Phenomenological modeling of black hole growth at z~6

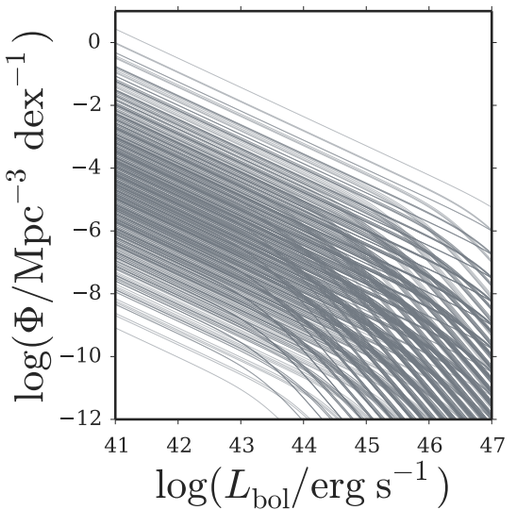
stellar mass function



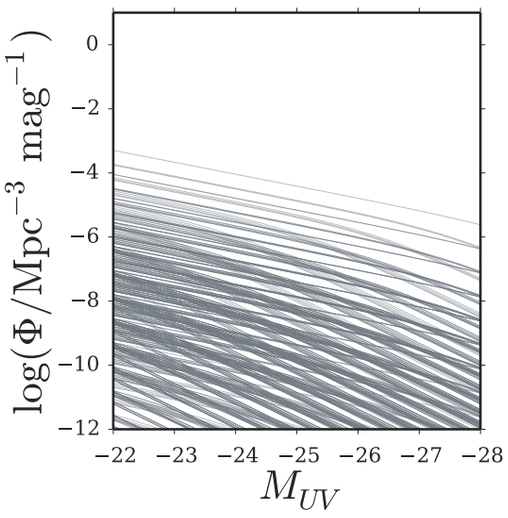
Black Hole mass function



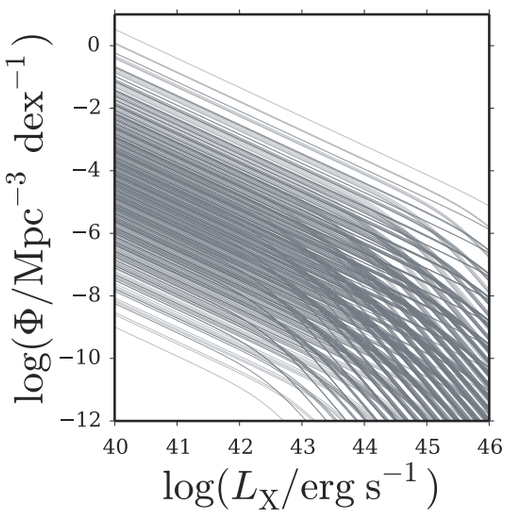
AGN bol. luminosity function



AGN UV luminosity function



AGN X-ray luminosity function



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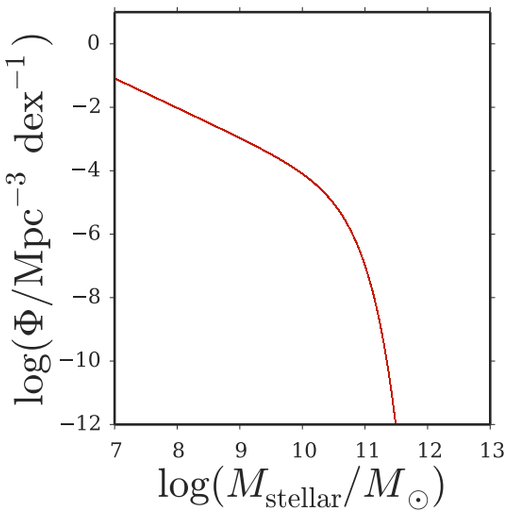
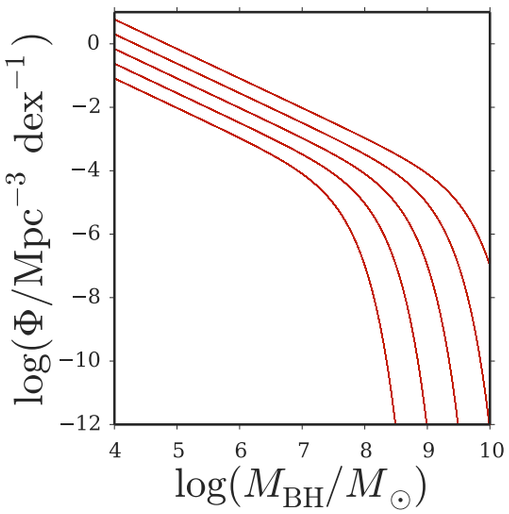
Phenomenological modeling of black hole growth at z~6

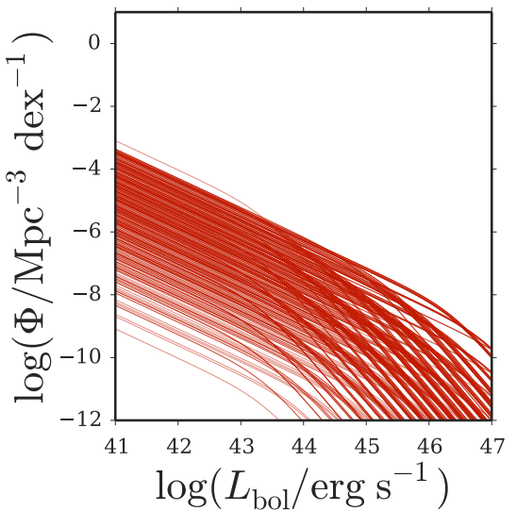
stellar mass function



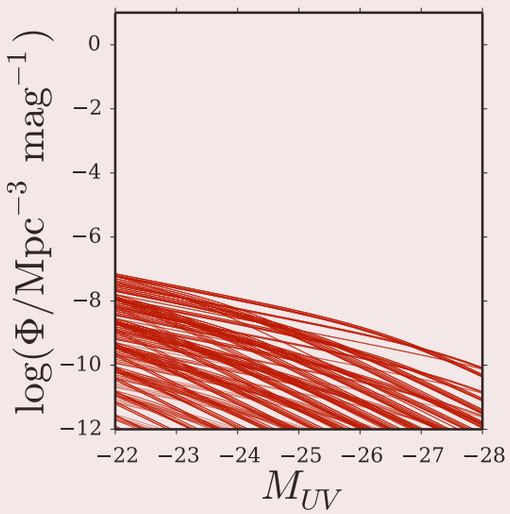
Black Hole mass function



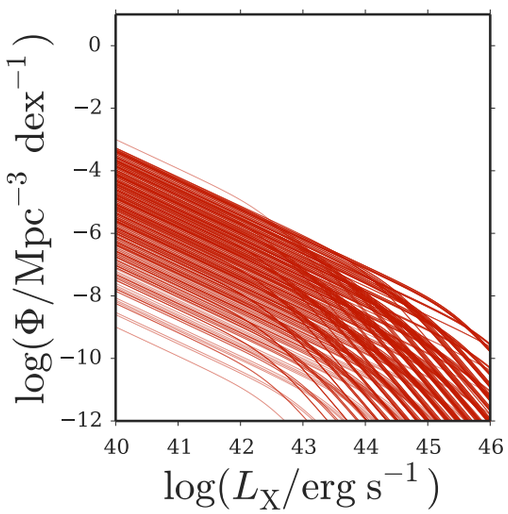
AGN bol. luminosity function



AGN UV luminosity function

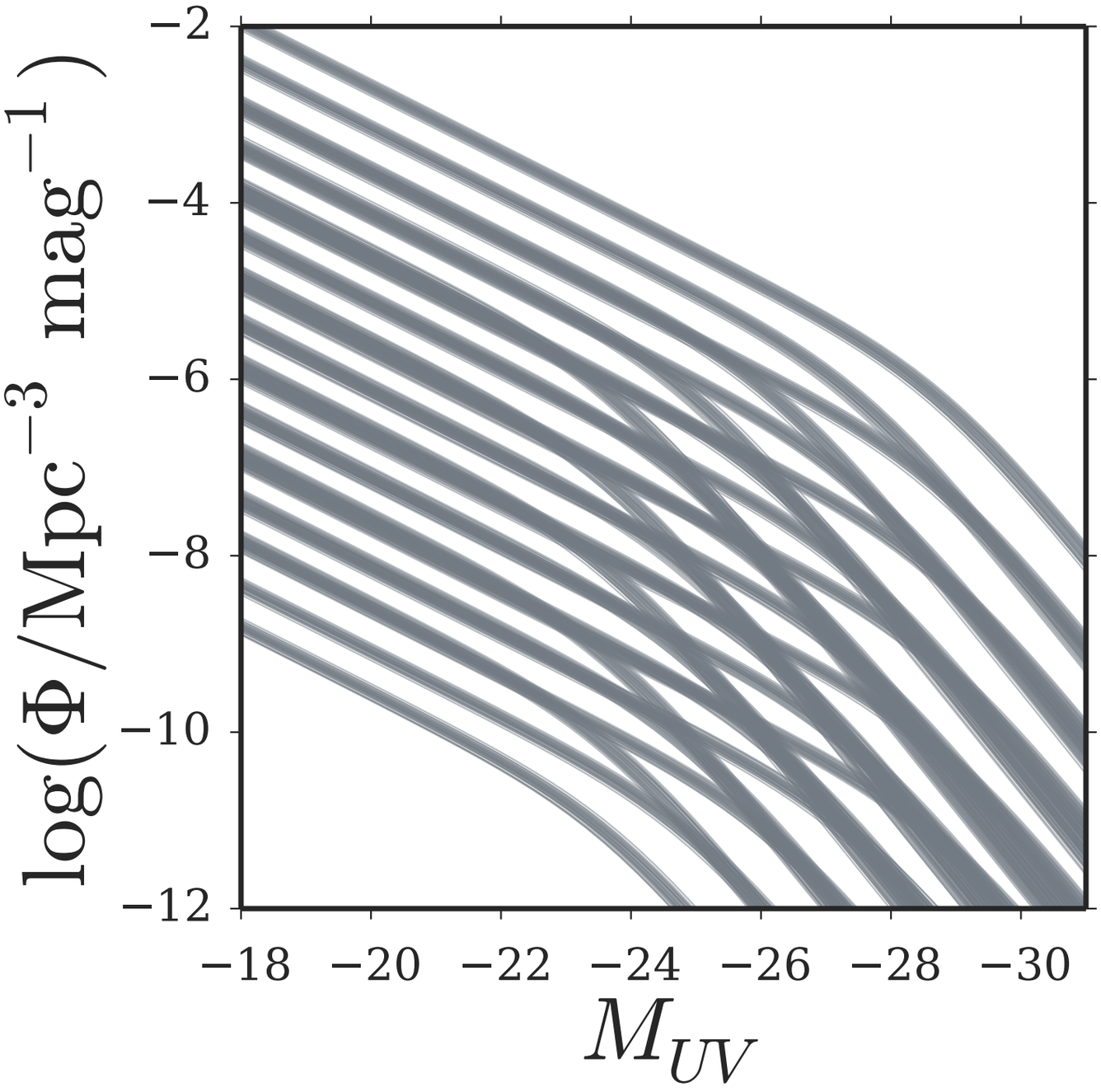


AGN X-ray luminosity function



Schawinski+ (in prep)

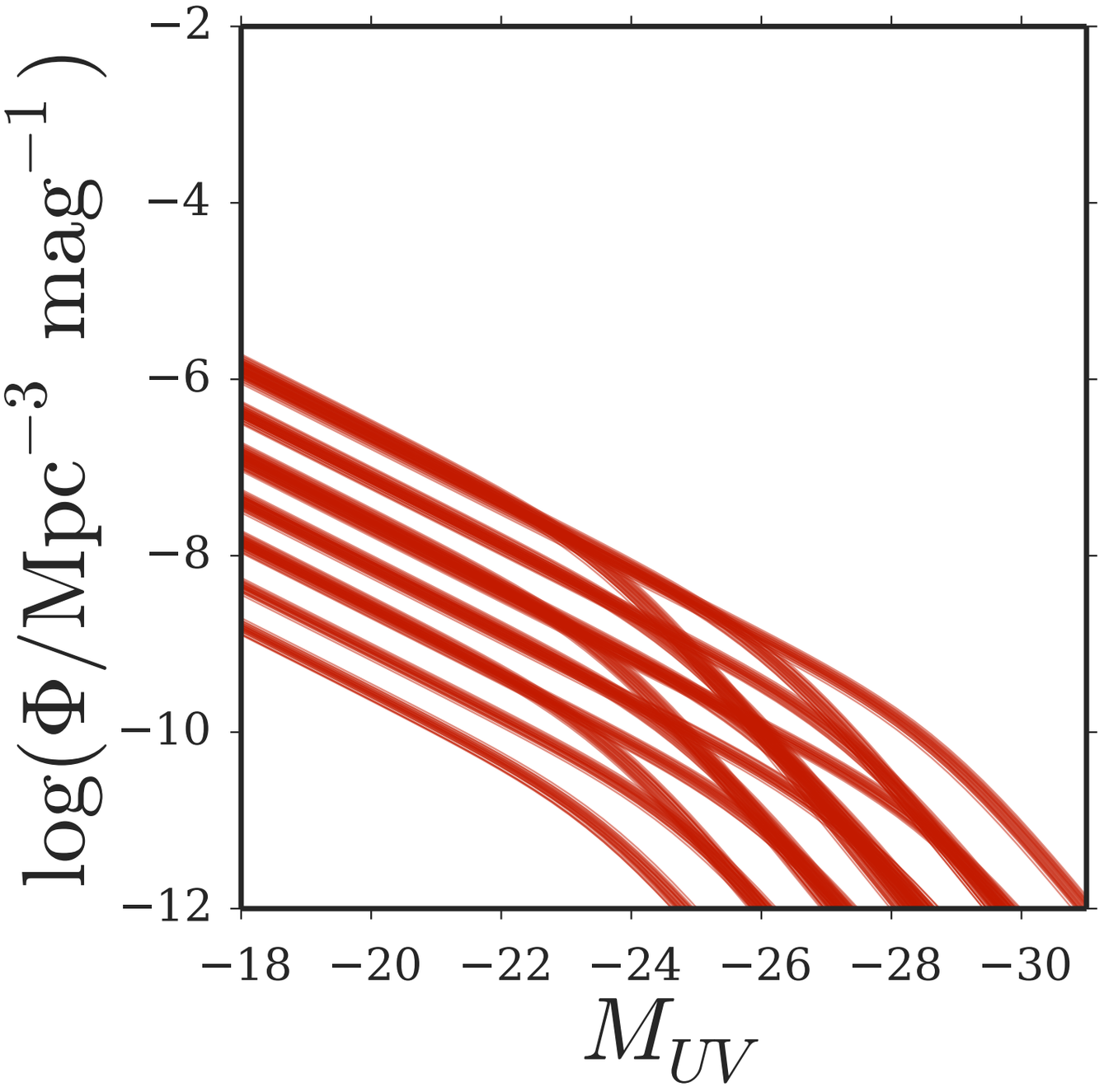
Phenomenological modeling of black hole growth at z~6



Schawinski+ (in prep)

Phenomenological modeling of black hole growth at z~6

limits from deep fields:
Treister+13
Weigel+15

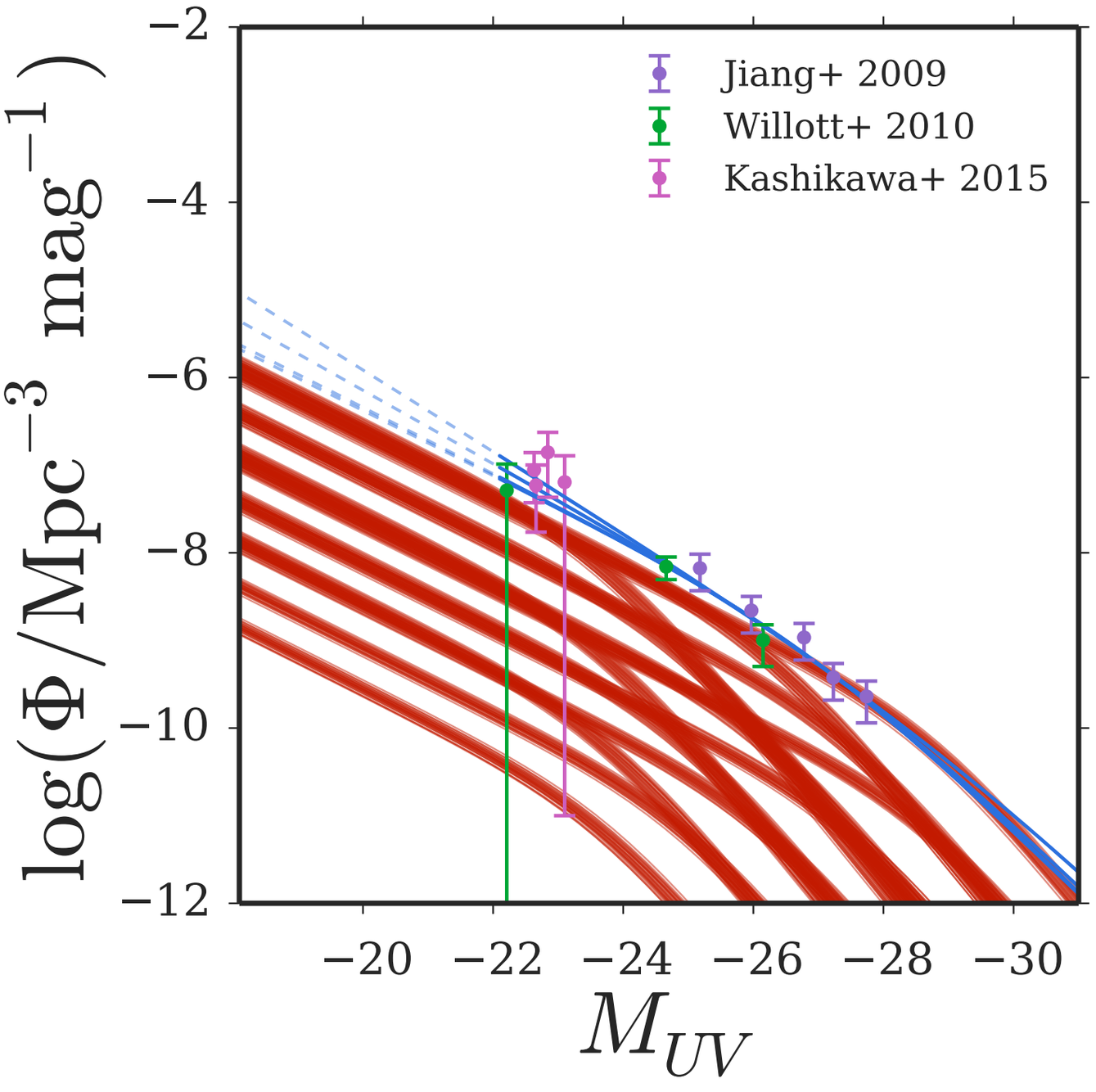


Schawinski+ (in prep)

Phenomenological modeling of black hole growth at z~6

limits from deep fields:
Treister+13
Weigel+15

comparison to quasar surveys:
Jiang+09
Willott+10
Kashikawa+15



Schawinski+ (in prep)

Phenomenological modeling of black hole growth at z~6

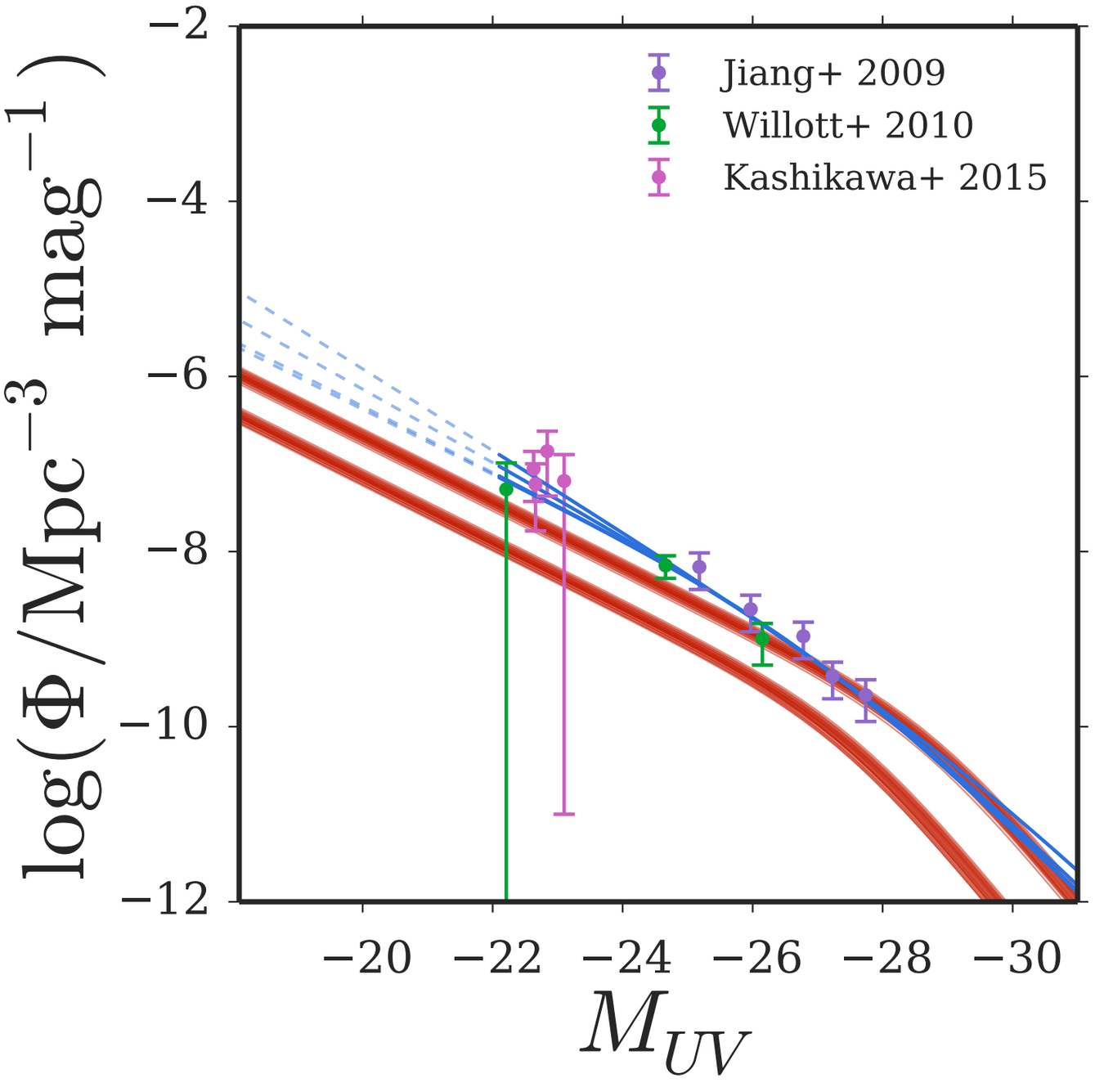
$\log \lambda^* = \log(0.7)$ to $\log(0.9)$

duty cycle = 80% to 100%

occupation fraction = 0.01%

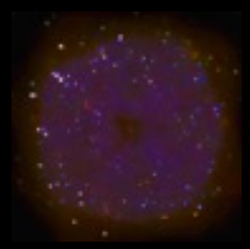
$M_{\rm BH}/M_{\rm stellar} = 0.03$ and 0.1

obscured fraction = 50%



Schawinski+ (in prep)

the Chandra-COSMOS “X-ray Visionary Project”



CDFS

~Msec depth

15 arcmin

N

E

Take away messages: what *Chandra* can do in the Next Decade

apparent tension between quasar surveys and deep fields **can be resolved** if seed formation is *highly* inefficient

exploring the AGN LF at 4<z<10 is **difficult, but possible** with *Chandra* — provided the right survey strategy is used.

reading material: Treister+13, Weigel+15, Trakhtenbrot+16
stay tuned for: Schawinski+16