The highest redshift quasars $7<z<9$ from Euclid + LSST

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Euclid preparation: V. Predicted yield of redshift $7 < z < 9$ quasars from the wide survey

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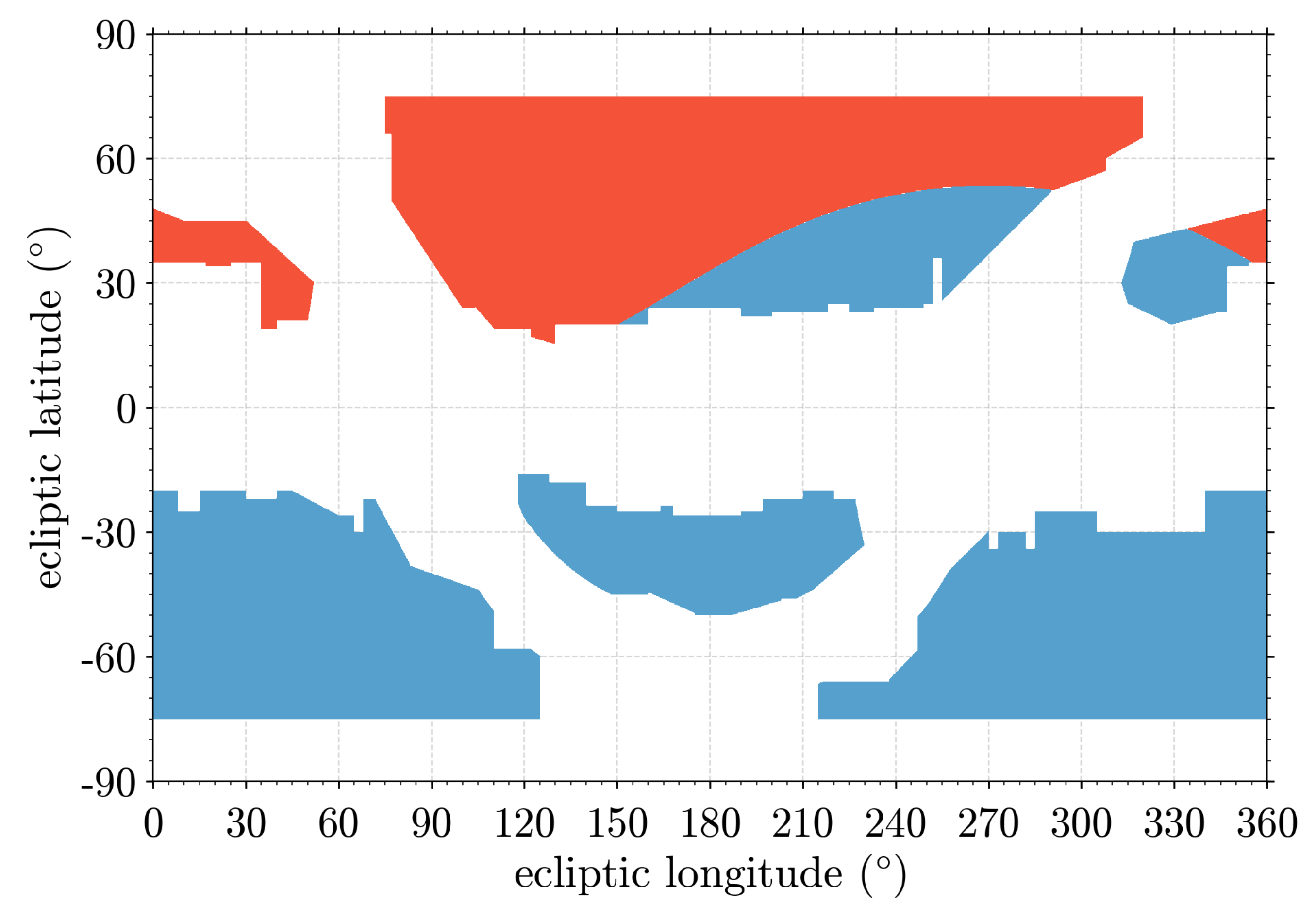
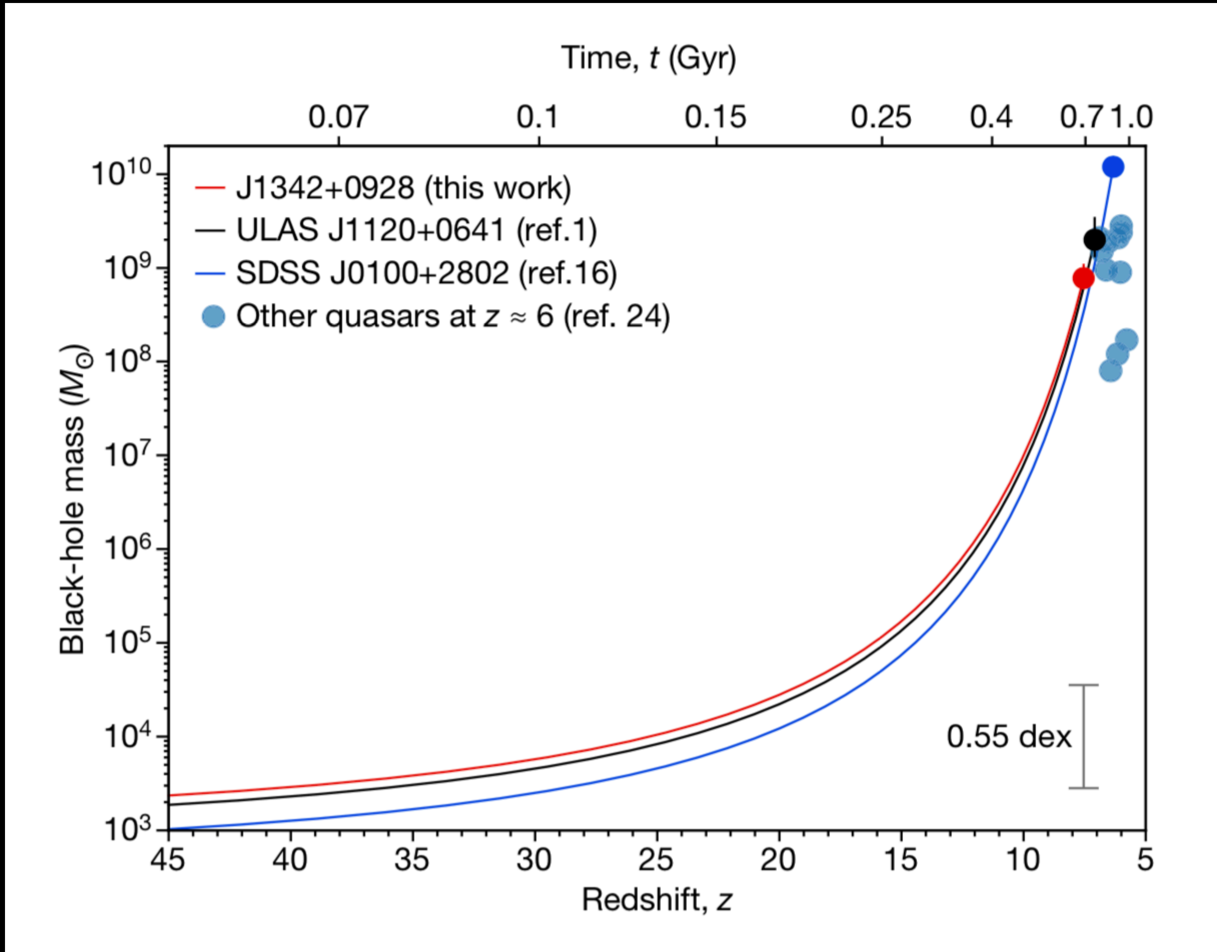
LSST 10000 deg^2 (and PanStarrs 5000 deg^2)
1yr depth z(AB)=24.9 5sig



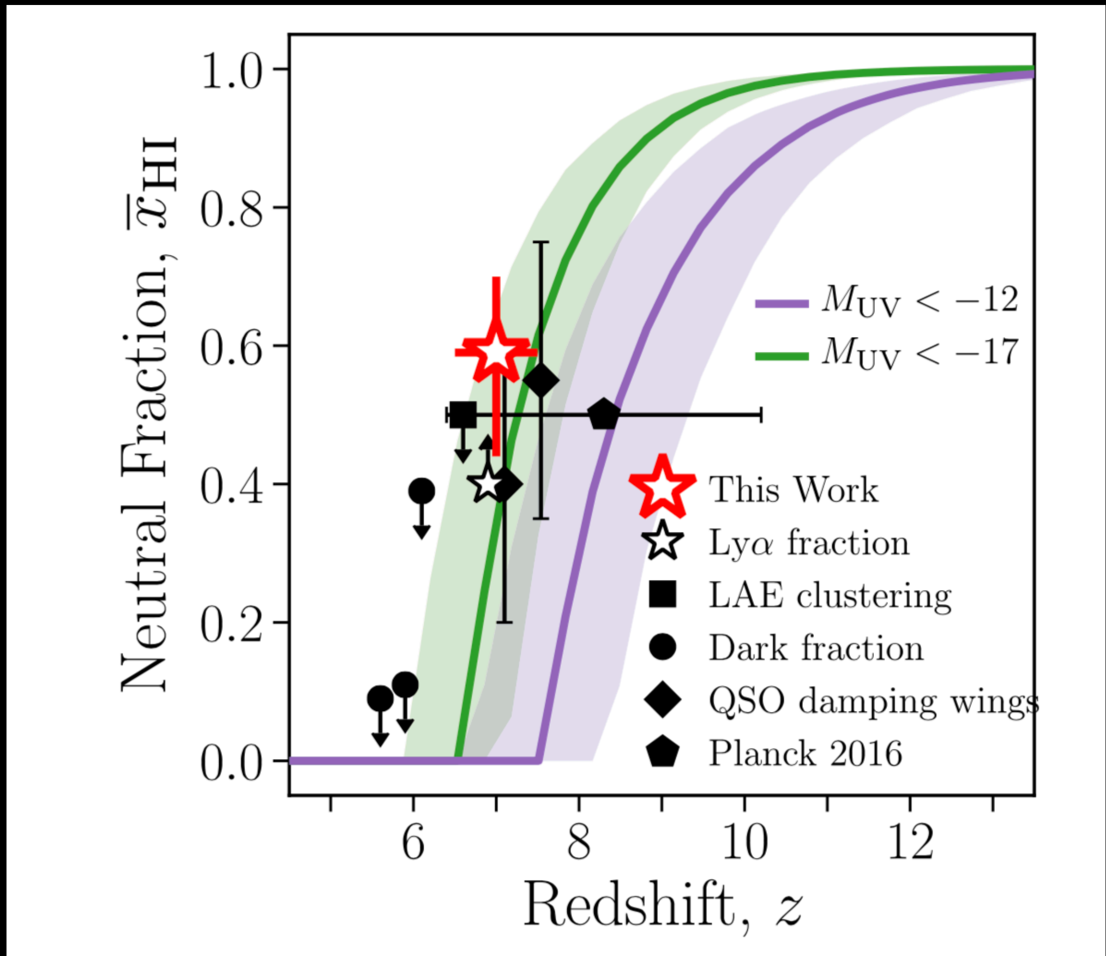
Motivation

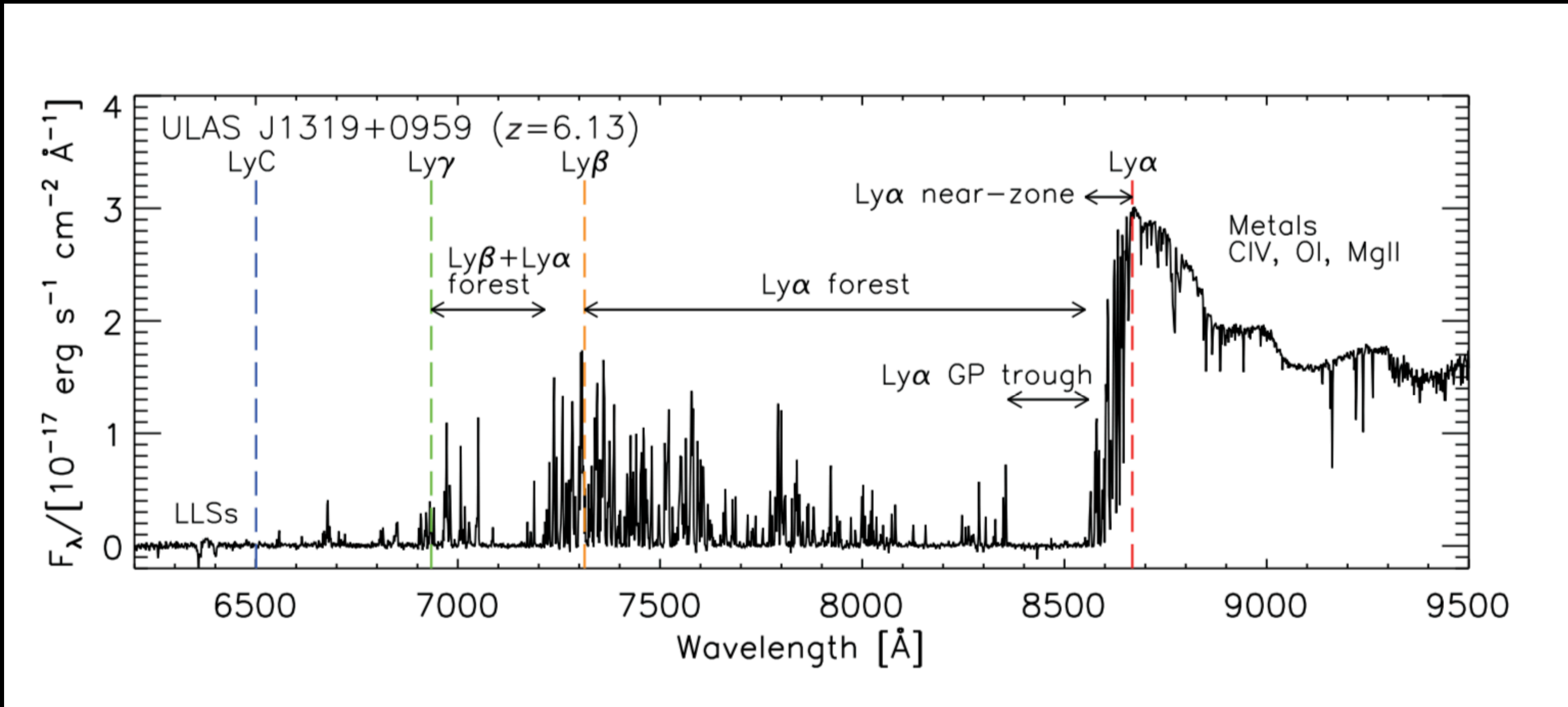
- The problem of supermassive black holes 10^9 M_{sol} at high redshift $z>7$
- The epoch of reionisation: charting the Universal neutral fraction of hydrogen x_{HI} over $7<z<9$
- The quasar luminosity function $7<z<9$

The problem of supermassive black holes at z>7
Banados et al. 2018

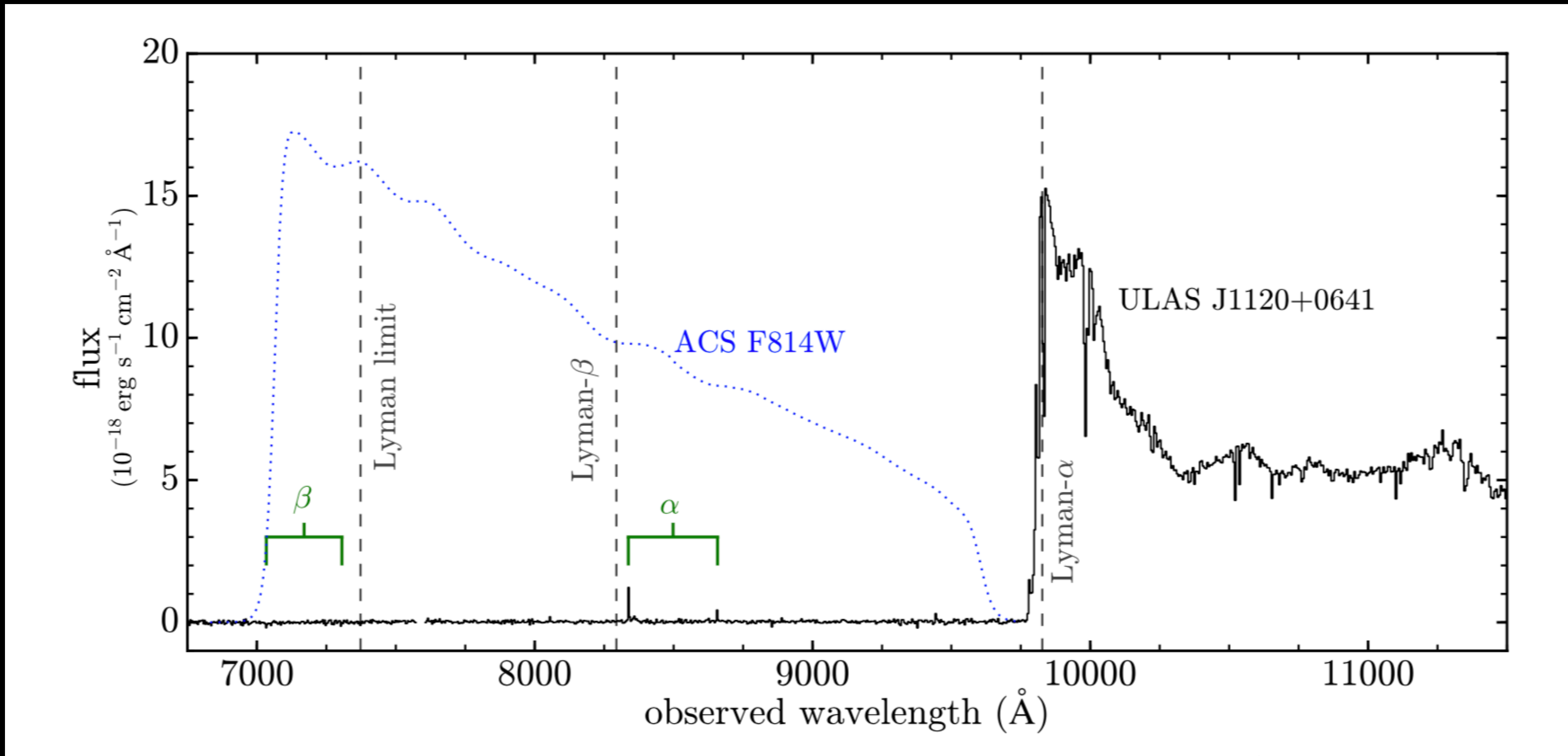


Measuring the neutral fraction x_{HI} 7<z<9
Mason et al. 2018

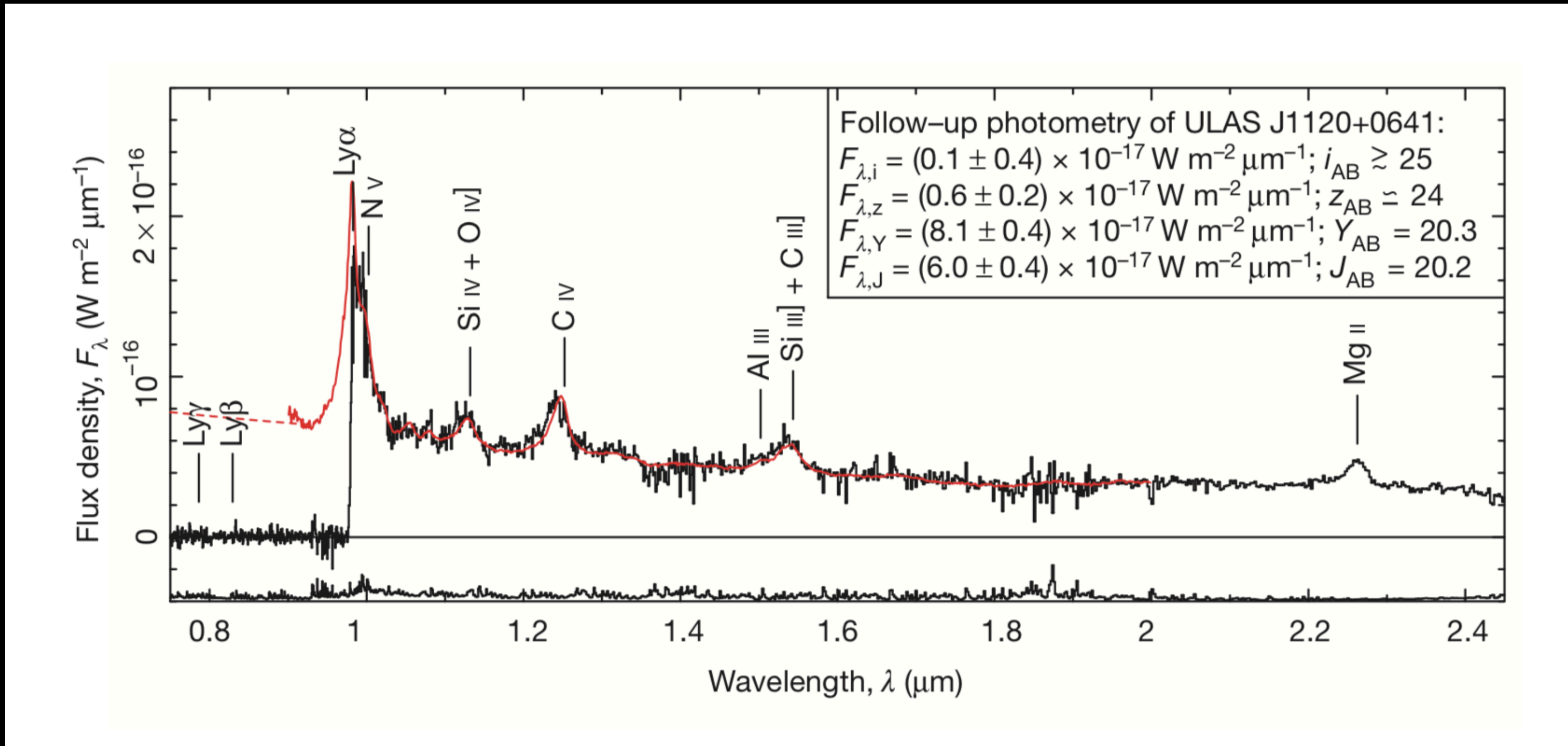



ULAS J1319+0959 (z=6.13)
LyC
Lyγ
Lyβ
Lyα
Lyα near−zone
Metals
CIV, OI, MgII
Lyβ+Lyα
forest
Lyα forest
Lyα GP trough
LLSs
Fλ/[10−17 erg s−1 cm−2 Å−1]
Wavelength [Å]
0
1
2
3
4
6500
7000
7500
8000
8500
9000
9500

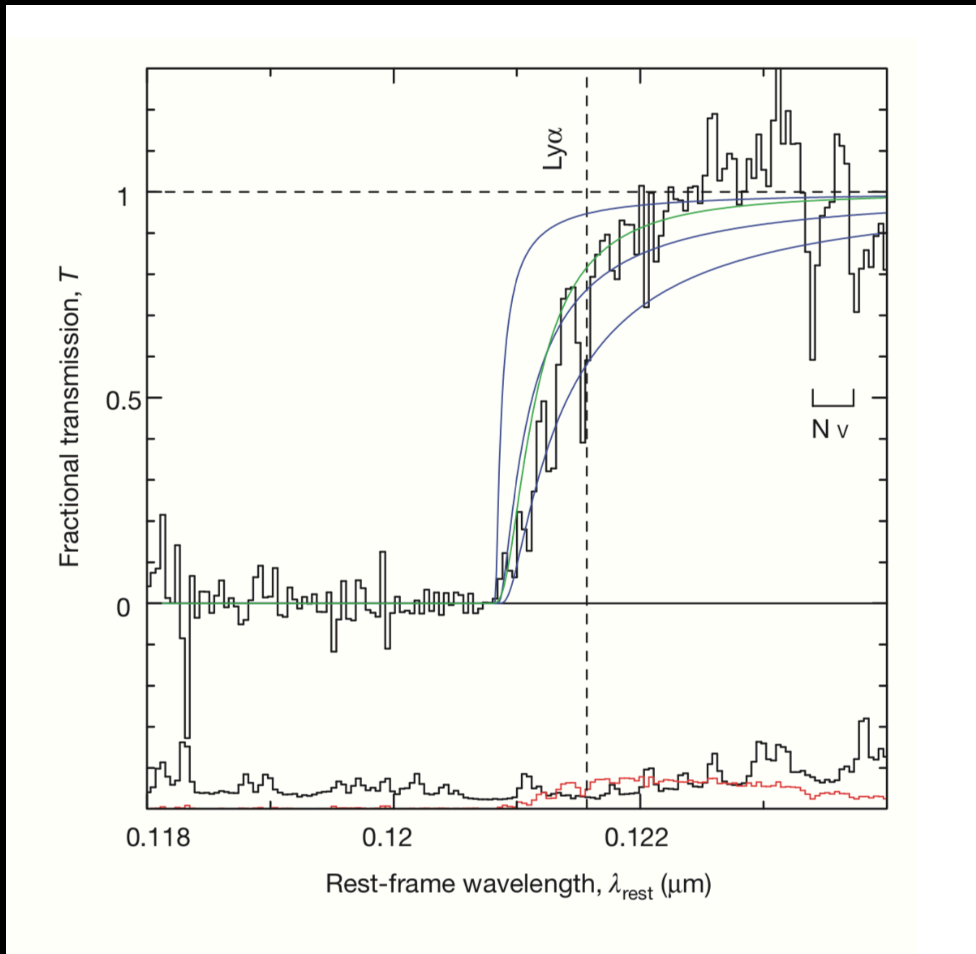
Barnett et al. 2015



Mortlock et al. 2011



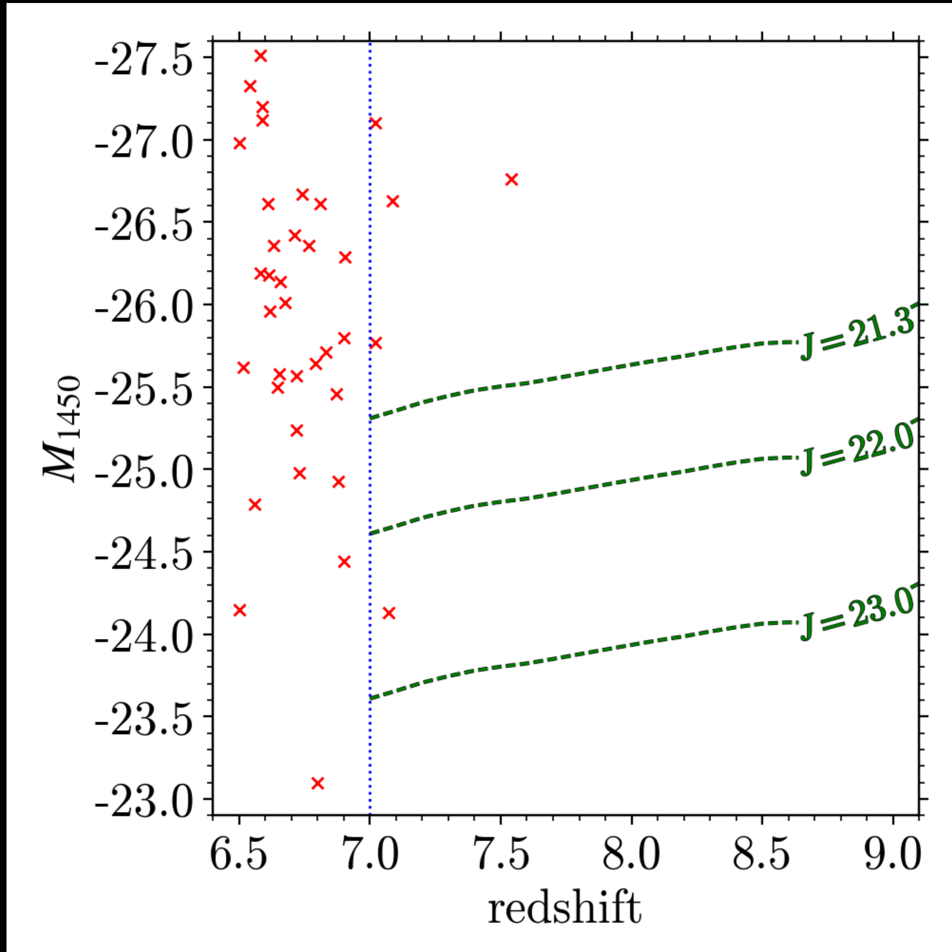
Mortlock et al. 2011



Current status z>6.5 (all since 2011)

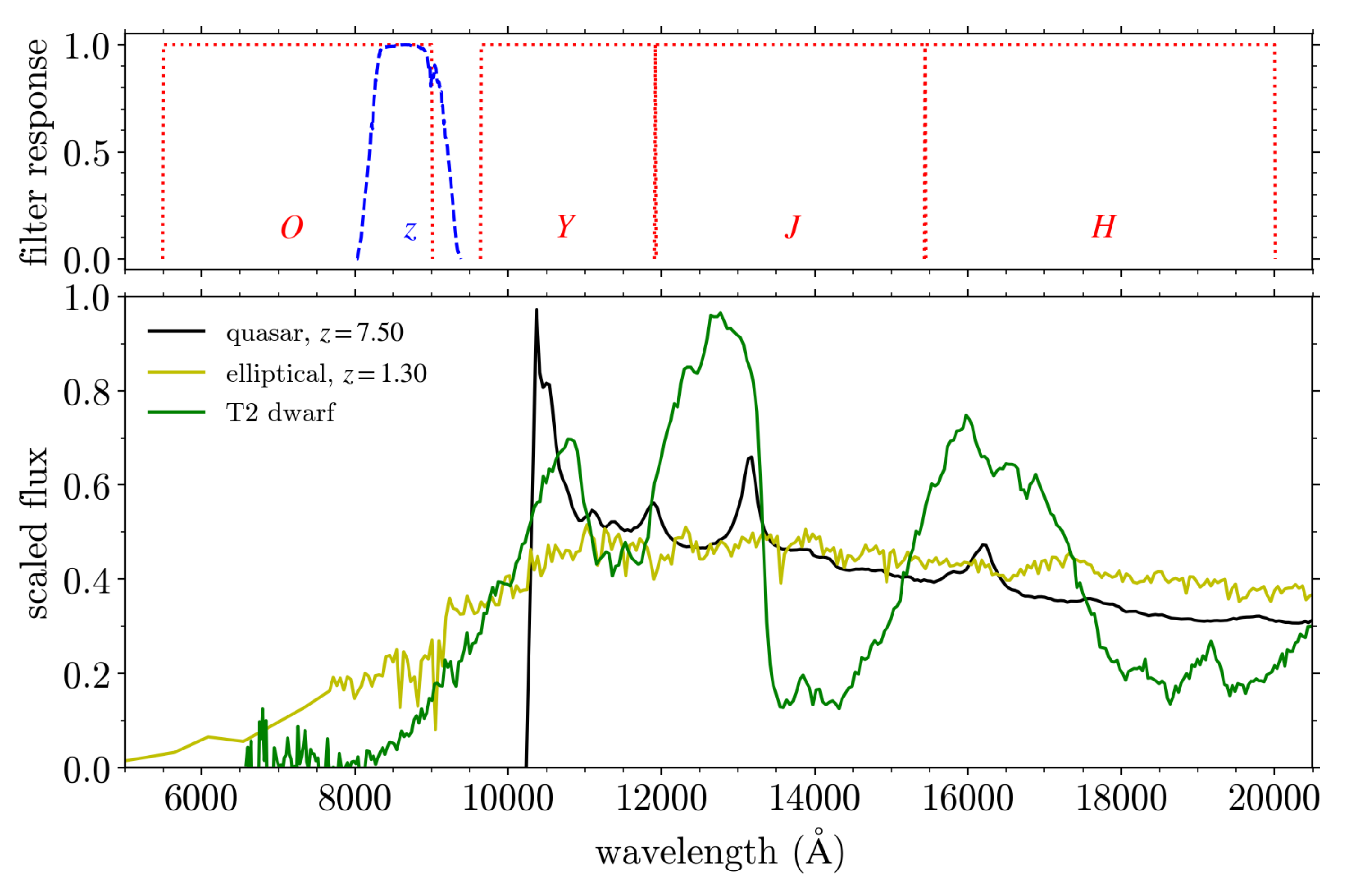
Euclid is 1-2mag deeper than UKIDSS/VHS/VIKING

15000 deg^2 and sensitive at z>7.5



Search method

Bayesian model comparison Mortlock et al. 2012



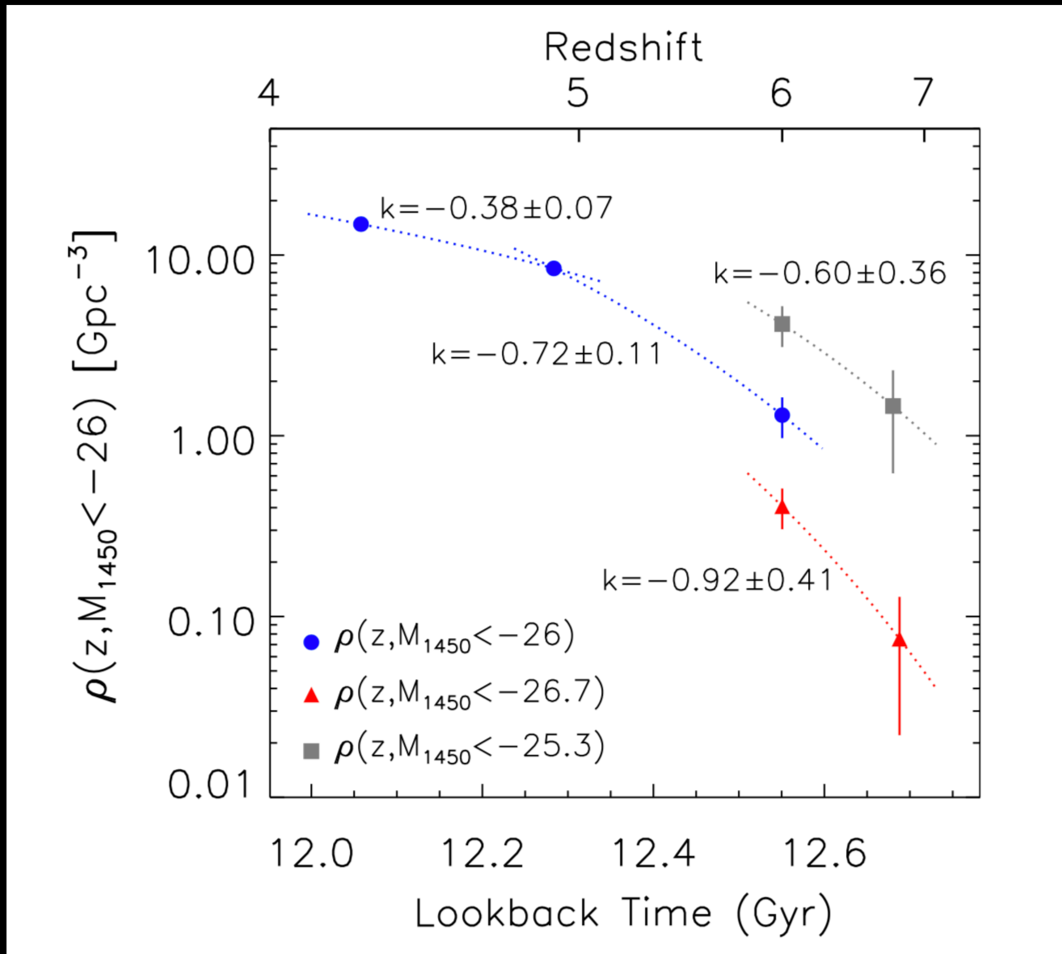
Assumed depths

Table 1: Summary of survey combinations explored in simulations in this paper.

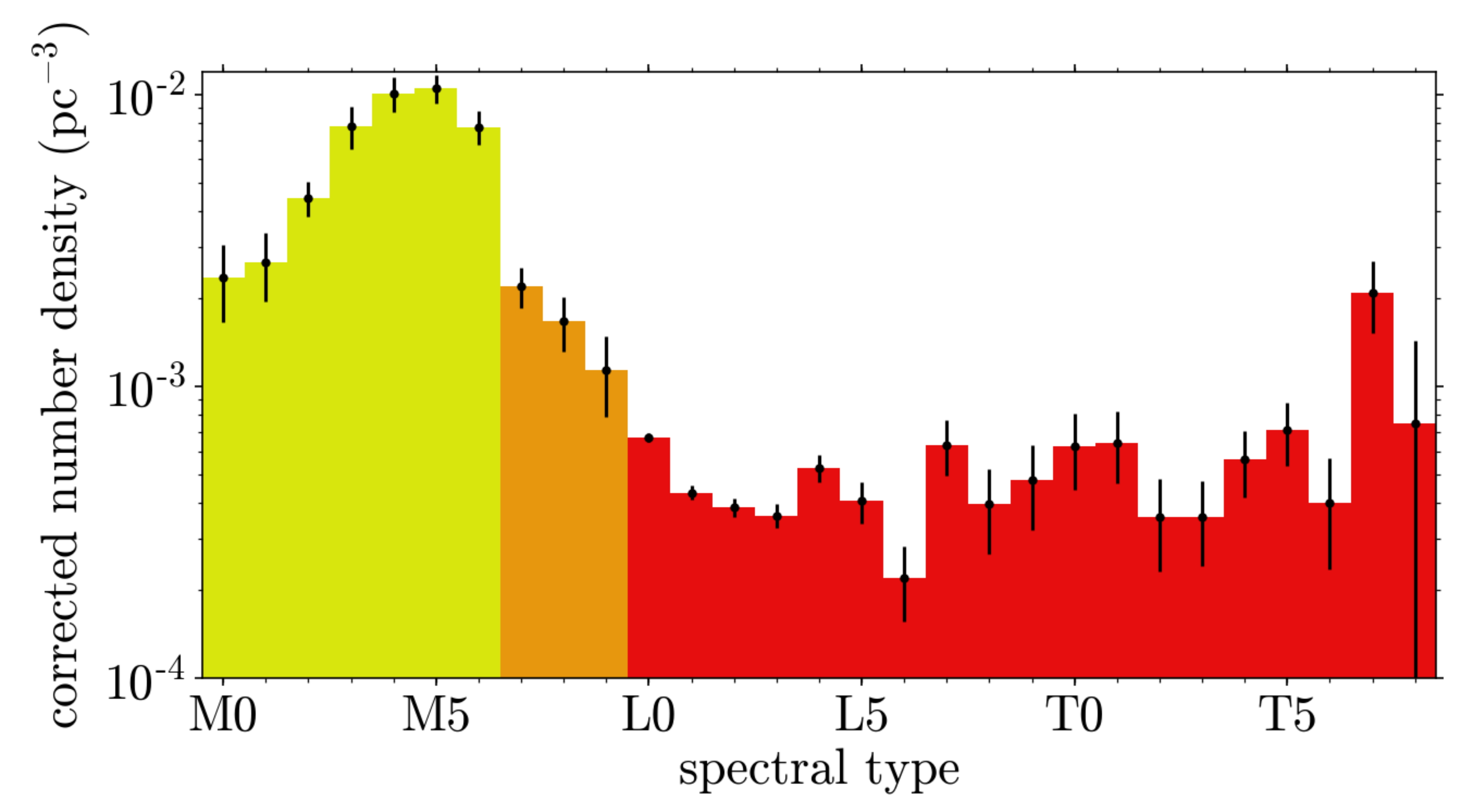
Survey(s)	Depth in near-infrared	Depth in optical	Positional constraints	Fiducial area
Euclid	YJH 24.0 ($5\,\sigma$)	O 24.5 ($10\,\sigma$)	ERS coverage (Fig. 2)	$15\,000\,\mathrm{deg}^2$
Euclid + PS (DR3)	YJH 24.0 ($5\,\sigma$)	z 24.5 ($5\,\sigma$)	as *Euclid* only, and $\delta > 30°$	$5\,000\,\mathrm{deg}^2$
Euclid + LSST (1 yr)	YJH 24.0 ($5\,\sigma$)	z 24.9 ($5\,\sigma$)	as *Euclid* only, and $\delta < 30°$	$10\,000\,\mathrm{deg}^2$

Quasar numbers $10^{k(z-z0)}$

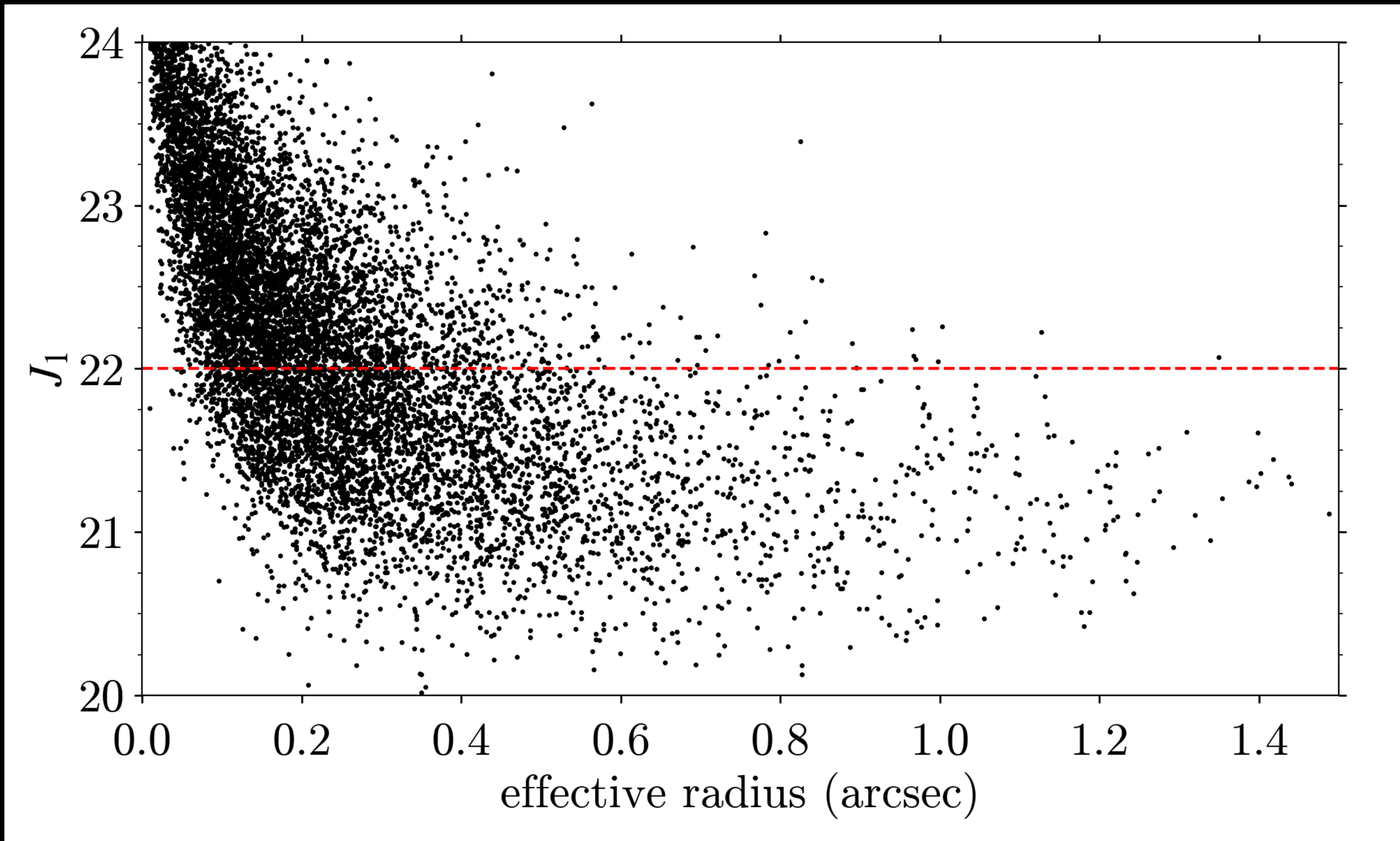
k=-0.72, -0.92



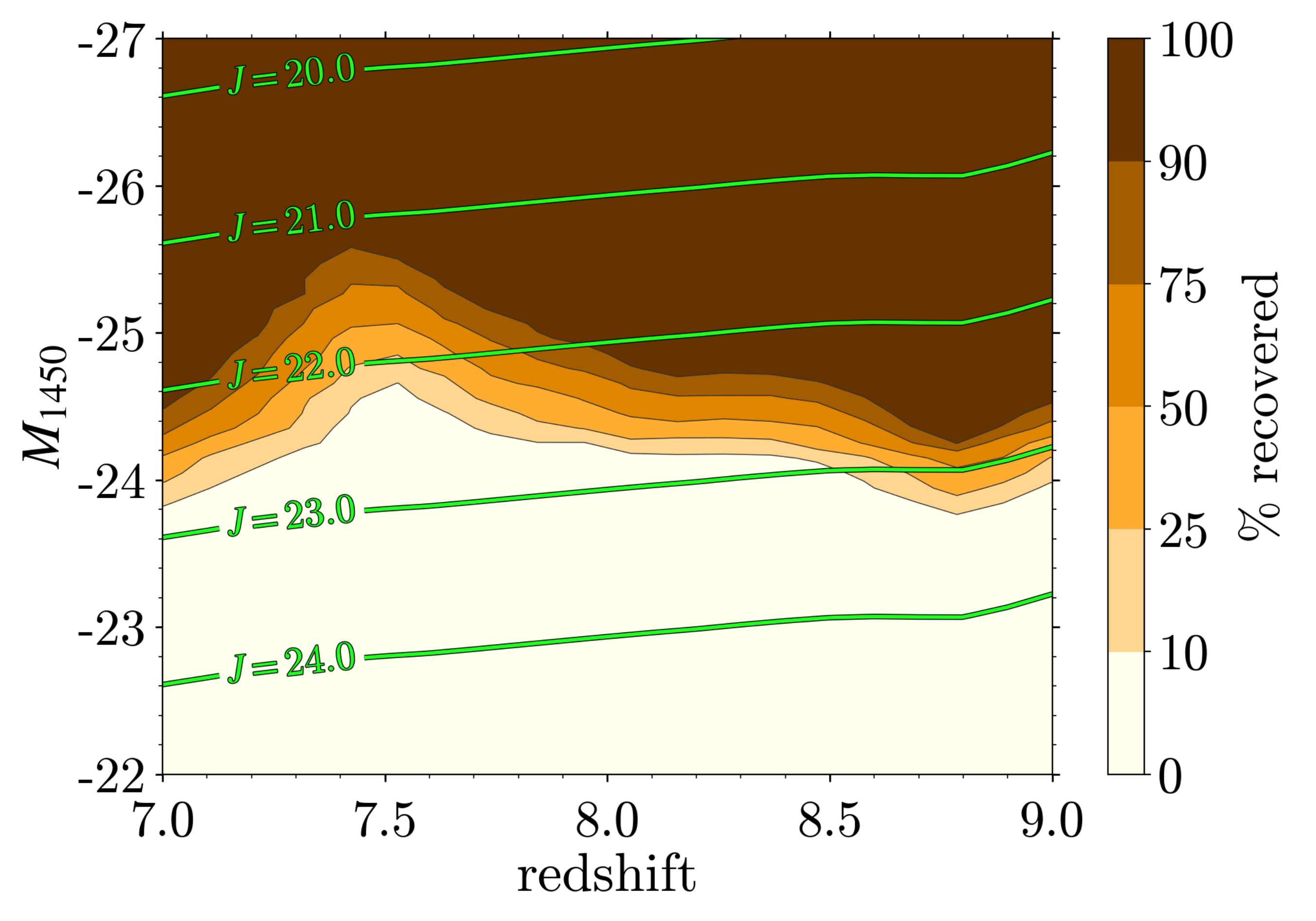
Ultracool dwarf numbers
Skrzypek et al. 2016



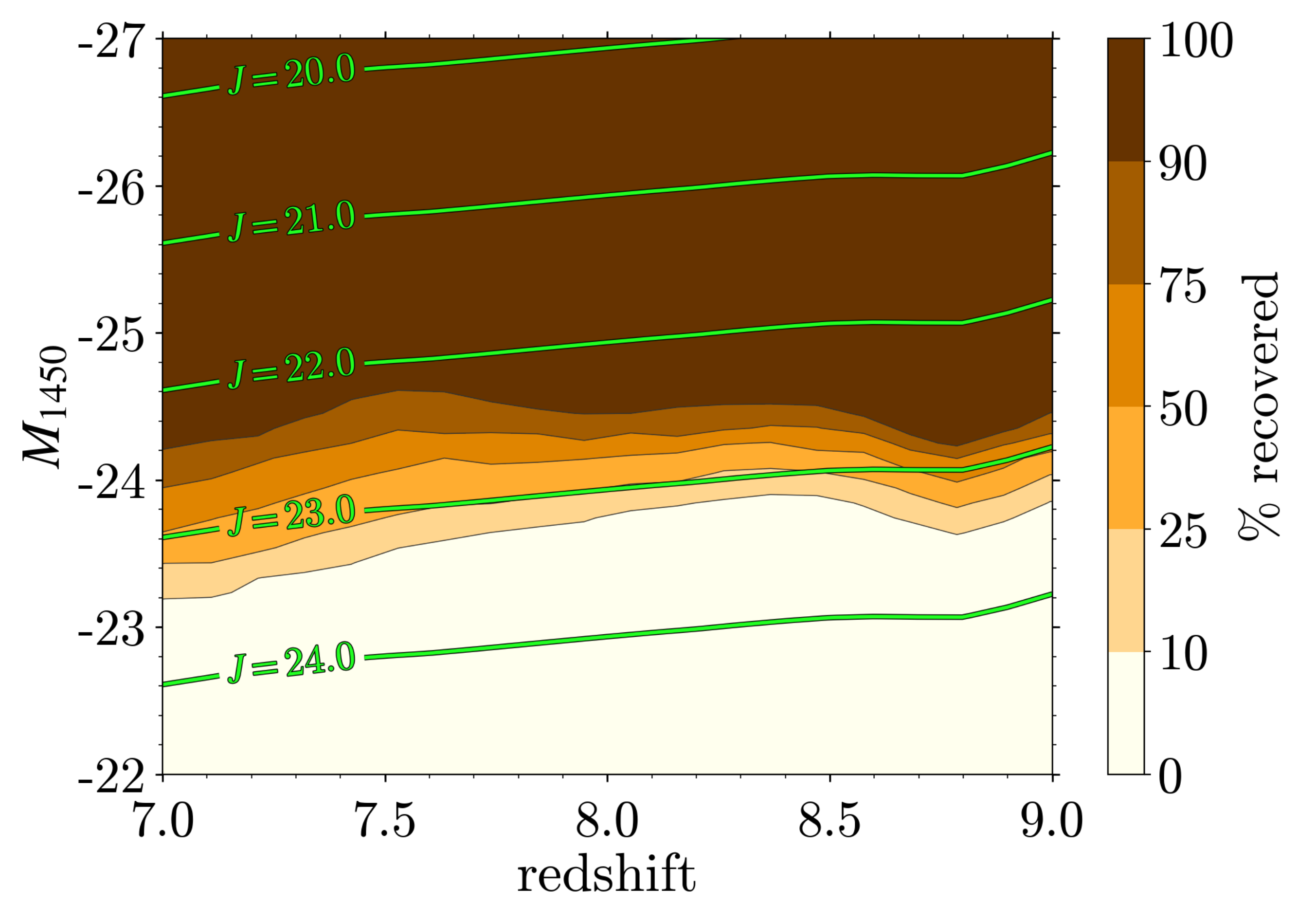
Early-type galaxy numbers CDFS

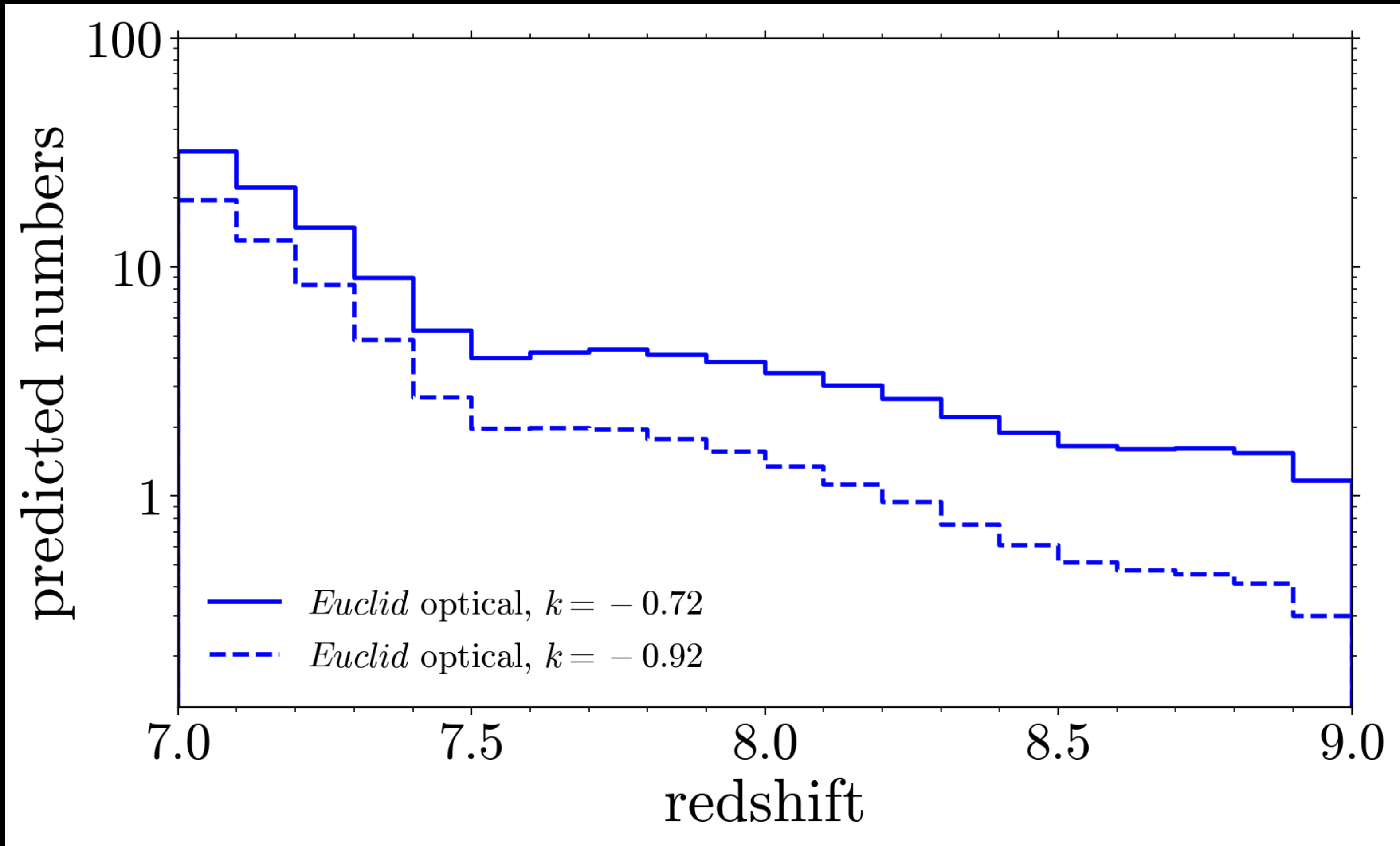


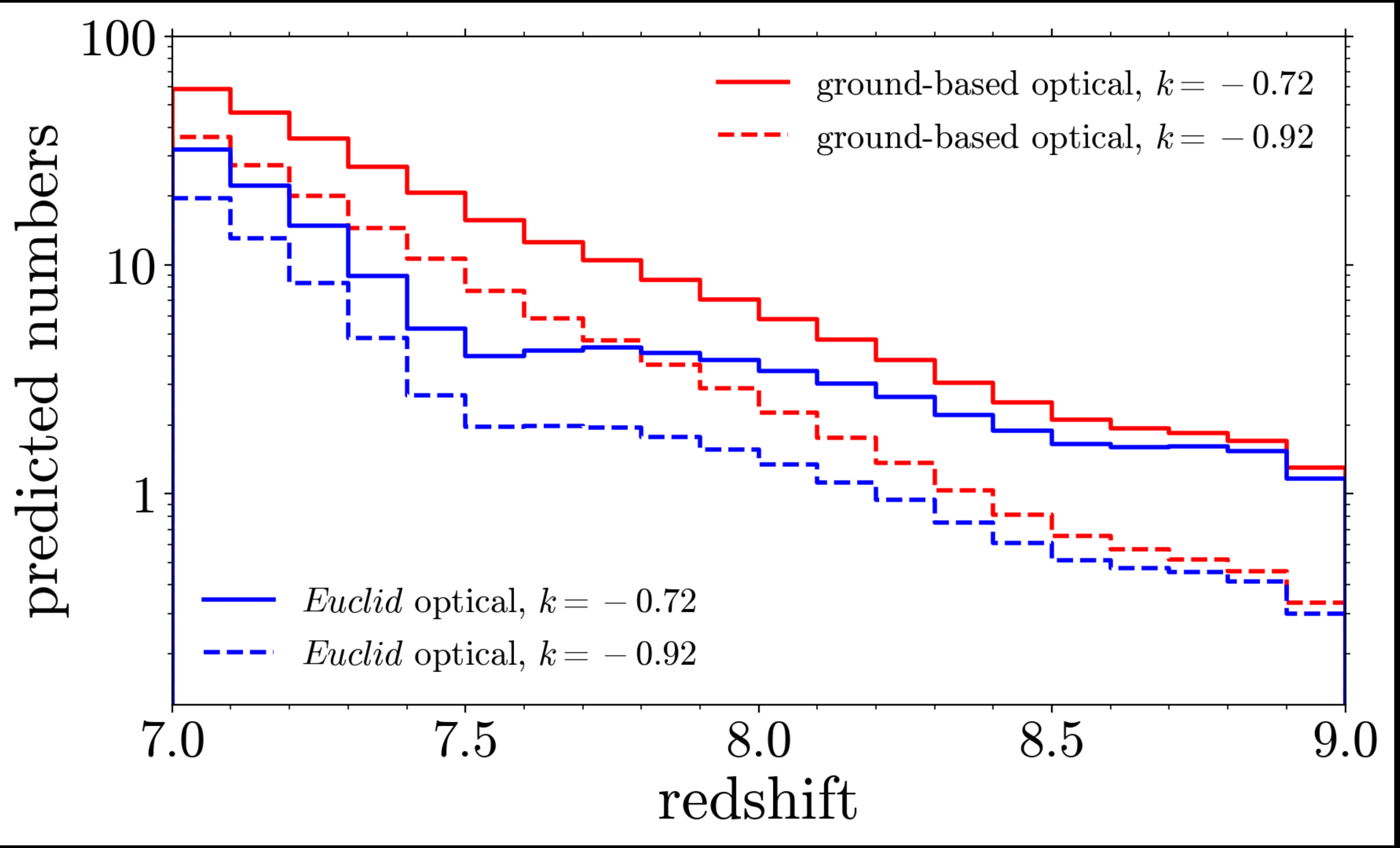
Results: selection functions
Euclid O



Results: selection functions
LSST z

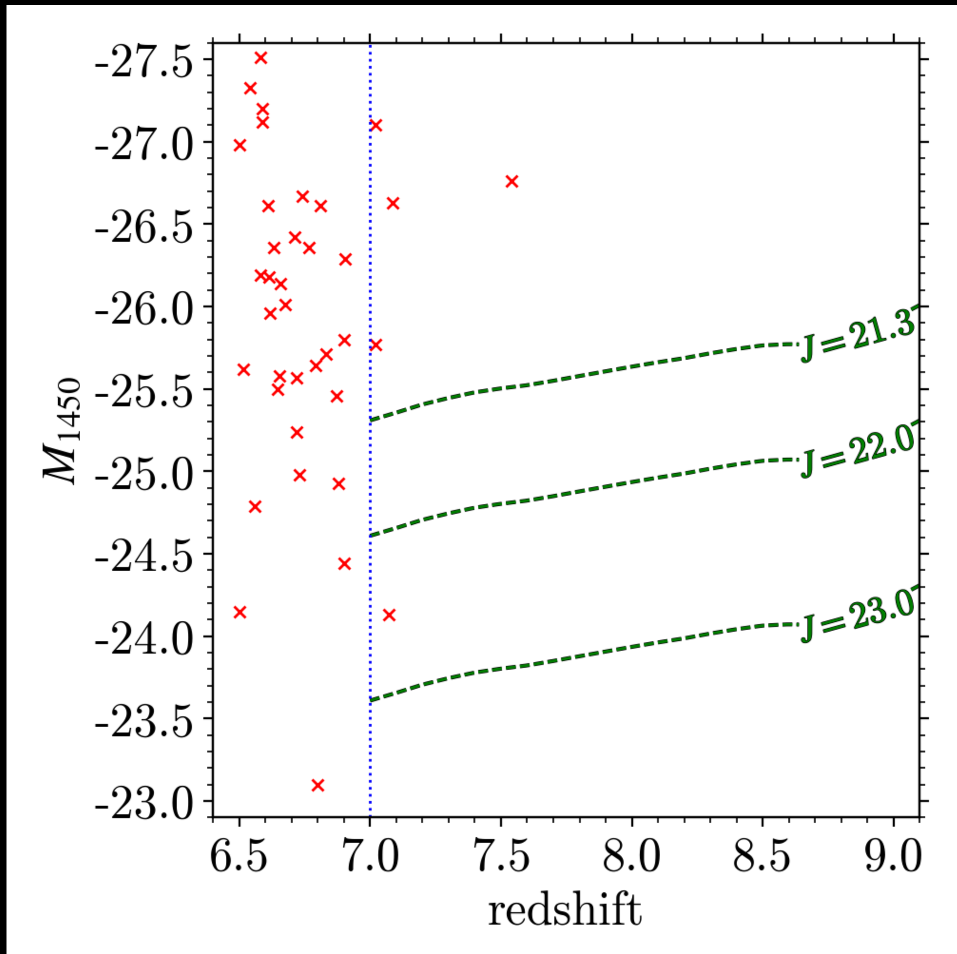



100
10
1
predicted numbers
7.0
7.5
8.0
8.5
9.0
redshift
Euclid optical, k = −0.72
Euclid optical, k = −0.92

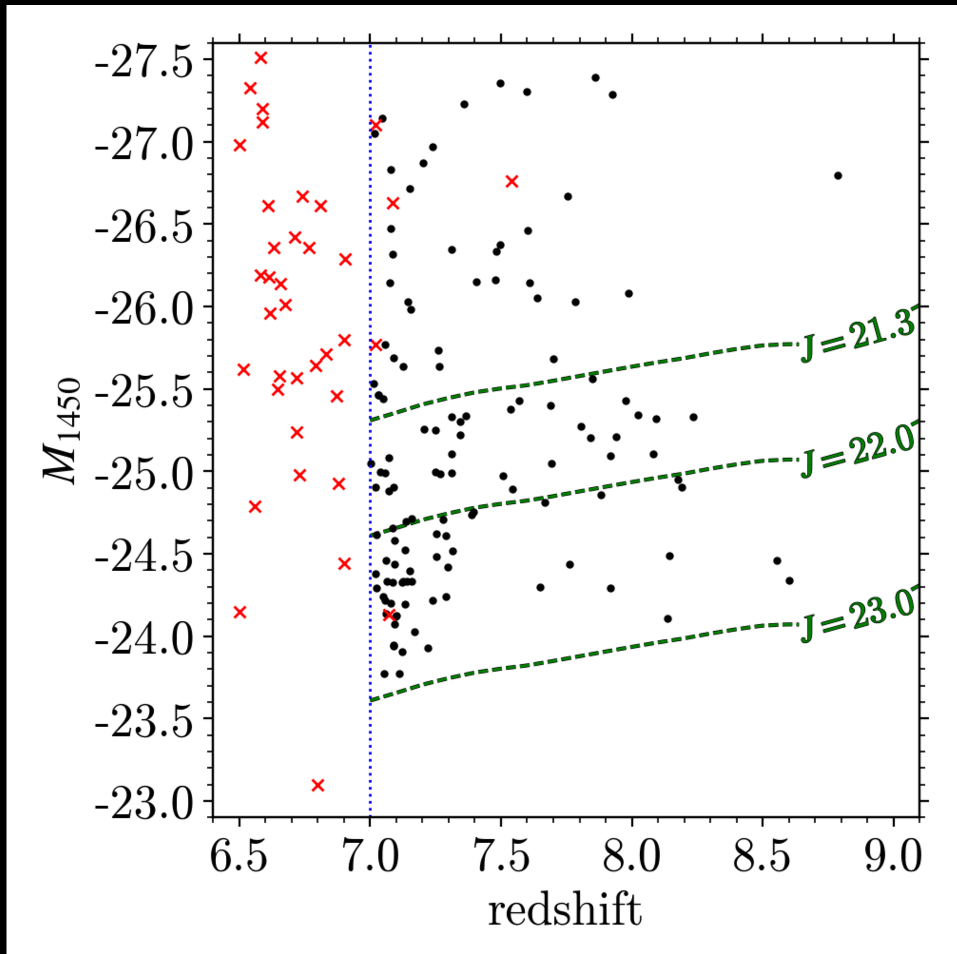


100
10
1
predicted numbers
7.0
7.5
8.0
8.5
9.0
redshift
ground-based optical, $k = -0.72$
ground-based optical, $k = -0.92$
Euclid optical, $k = -0.72$
Euclid optical, $k = -0.92$

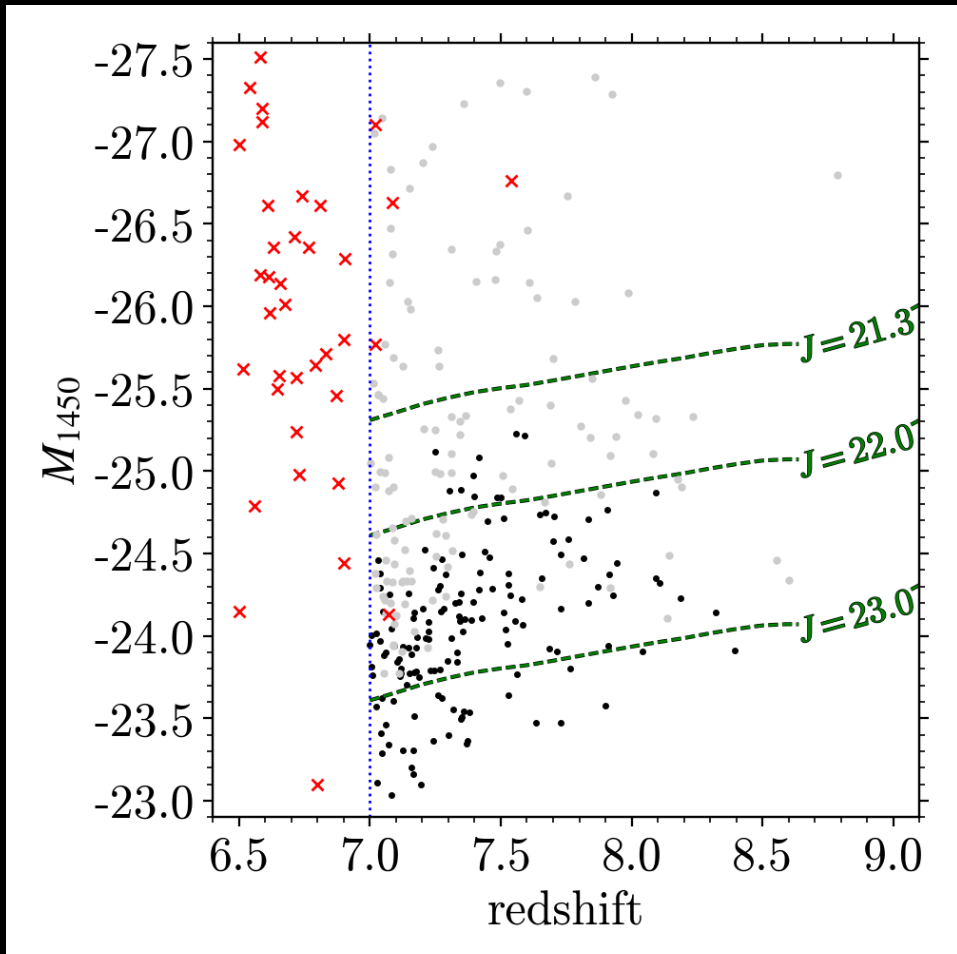
Current status z>6.5 (all since 2011)



Euclid YJH + Euclid O



Euclid YJH + LSST z (1yr)



Quasar numbers

Redshift range	*Euclid* optical		Ground-based optical	
	$k = -0.72$	$k = -0.92$	$k = -0.72$	$k = -0.92$
$7.0 < z < 7.5$	87 (41)	51 (24)	204 (91)	117 (52)
$7.5 < z < 8.0$	20 (13)	9 (6)	45 (26)	19 (11)
$8.0 < z < 8.5$	11 (11)	4 (4)	16 (14)	6 (5)
$8.5 < z < 9.0$	6 (6)	2 (2)	7 (7)	2 (2)

Summary

- Euclid will transform epoch of reionisation studies using quasars $7<z<9$
- LSST + PanStarrs optical data will more than double quasar numbers
- Particularly crucial if the decline in space density of quasars accelerates beyond $z=6.5$ (e.g. $k=-0.92$).
- List driven photometry of Euclid sources is required.