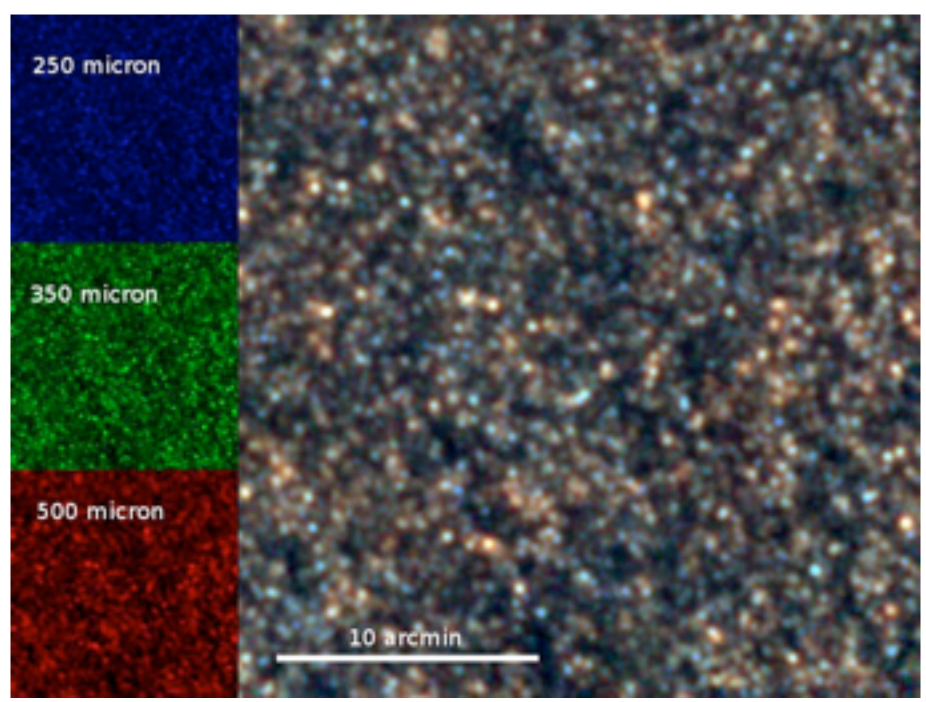
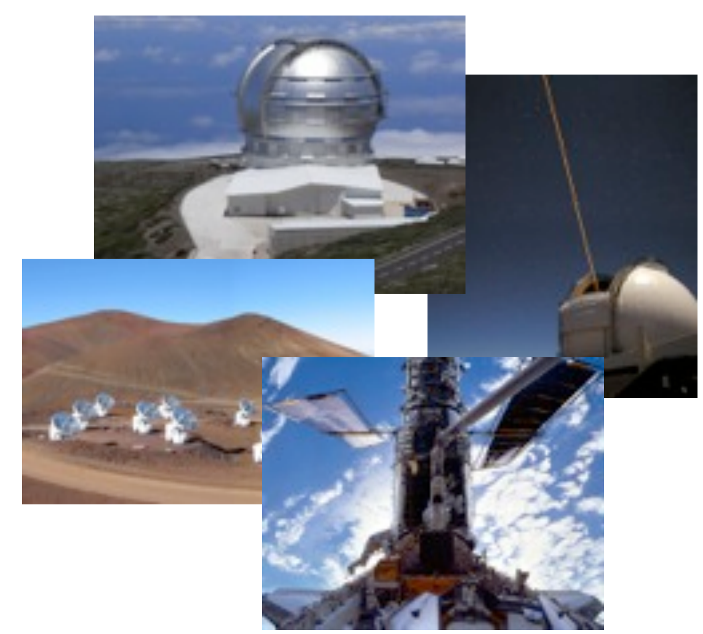
Dark Cosmology Centre

The ISM in Dusty Star Forming Galaxies at z=1–3

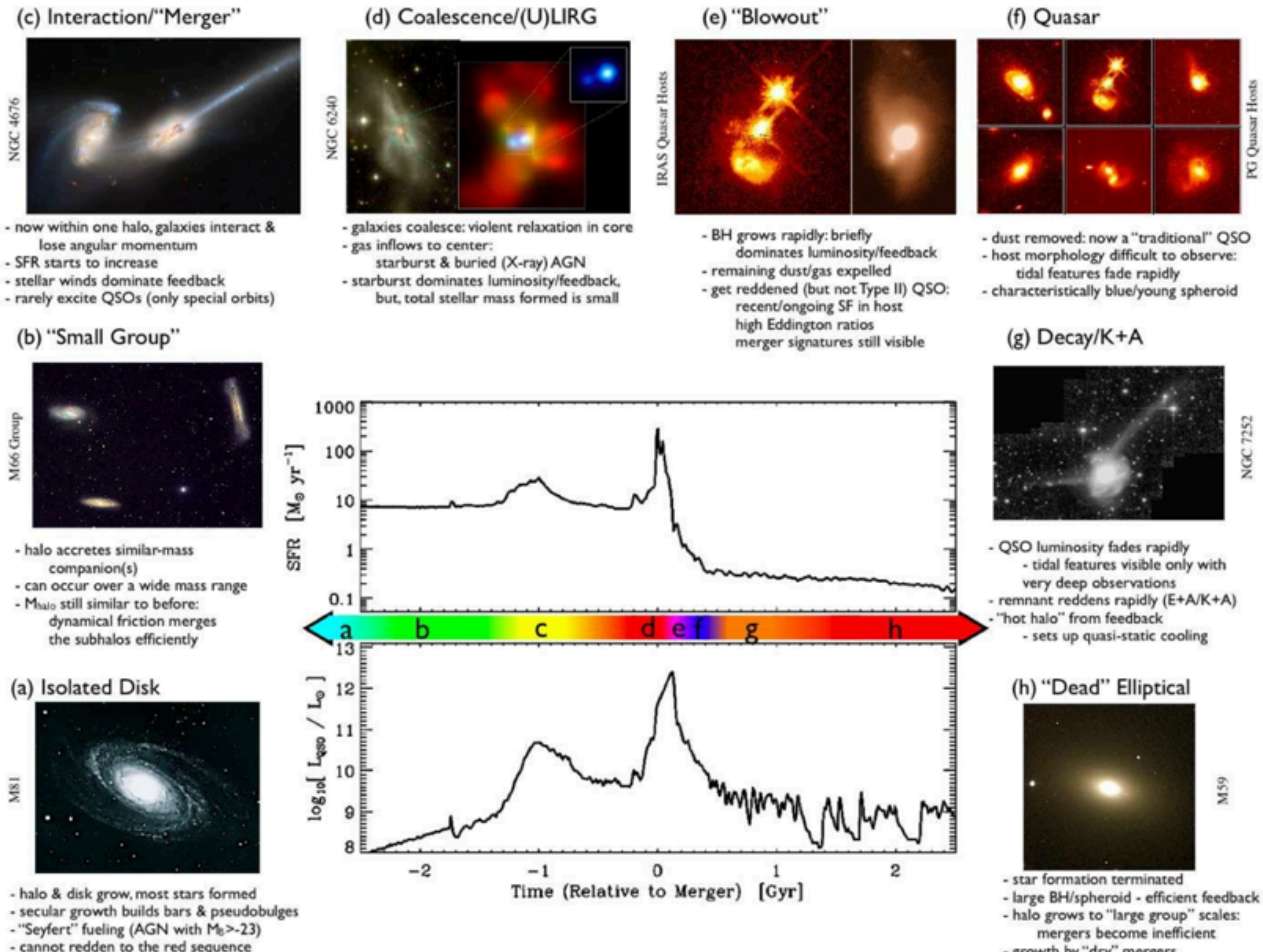
Julie Wardlow

Dark Cosmology Centre, University of Copenhagen



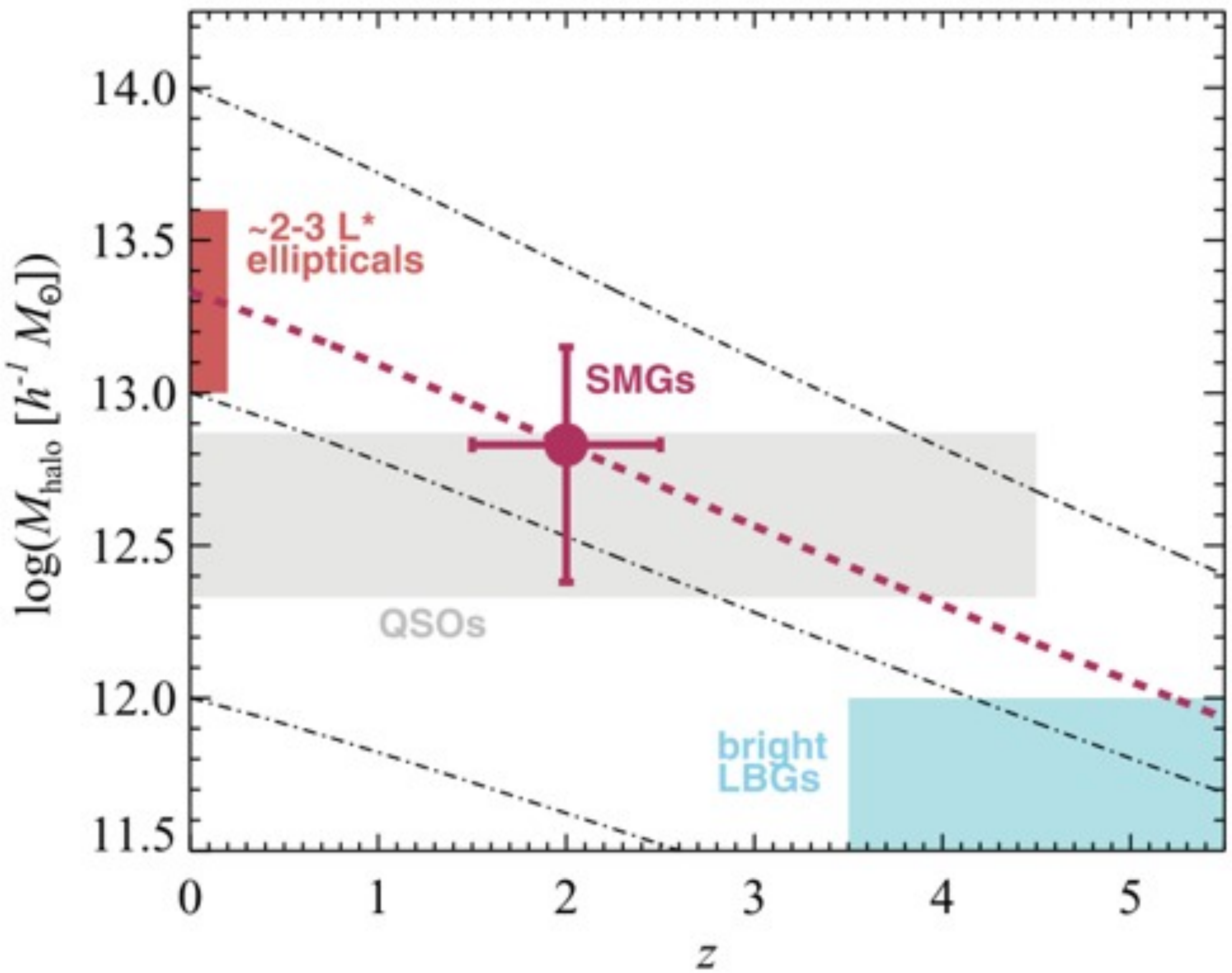


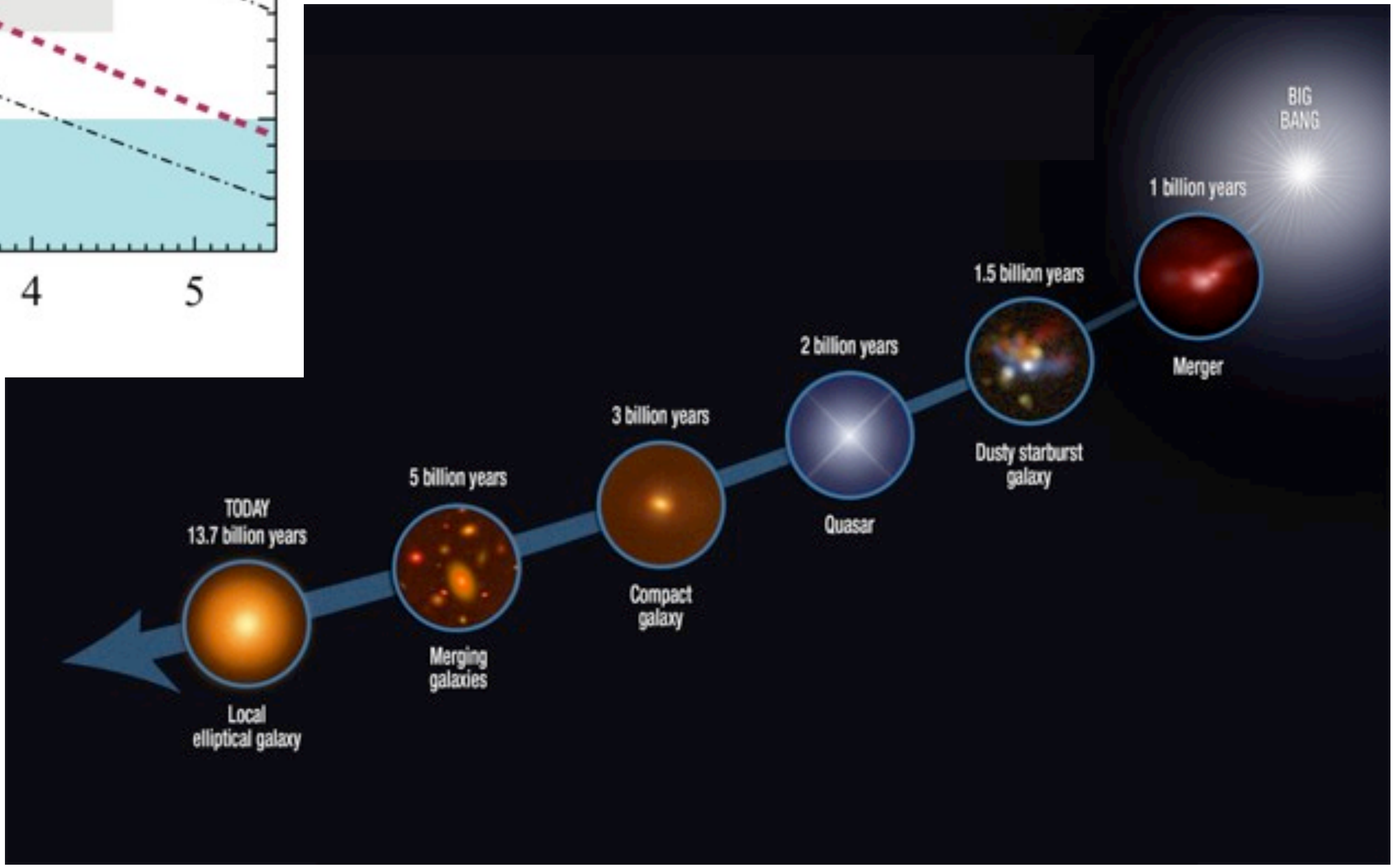
Dusty star formation as a crucial phase of galaxy evolution



Hopkins et al. 2008

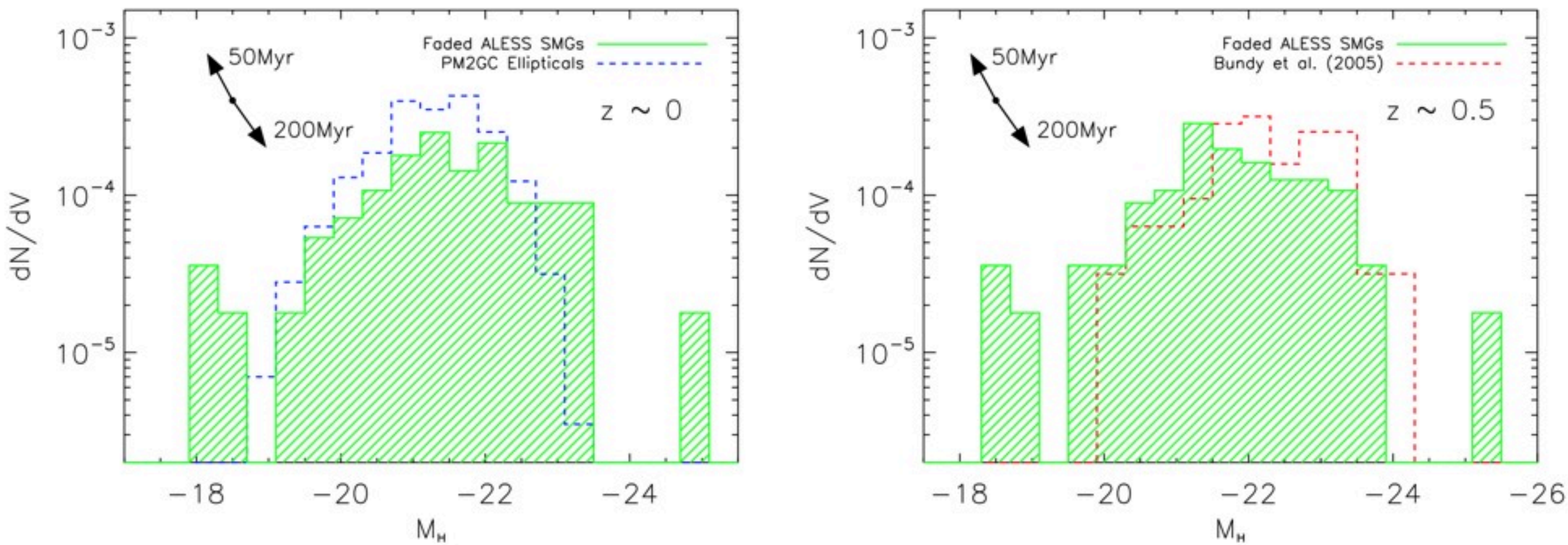
Massive ellipticals formed early in the Universe





Hickox, JW et al. 2012
Toft et al. 2014

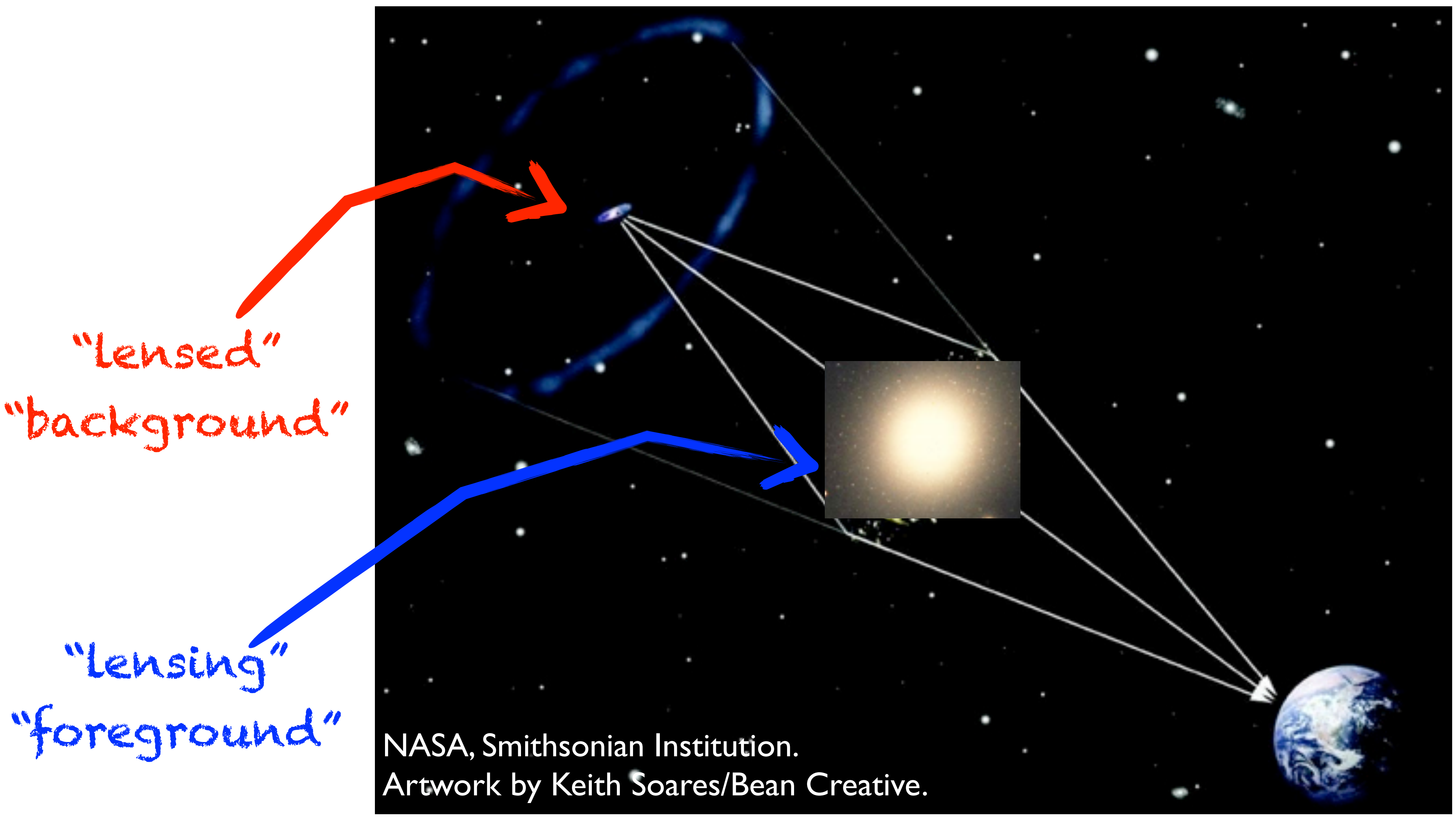
Faded DSFGs have brightness distributions consistent with nearby ellipticals



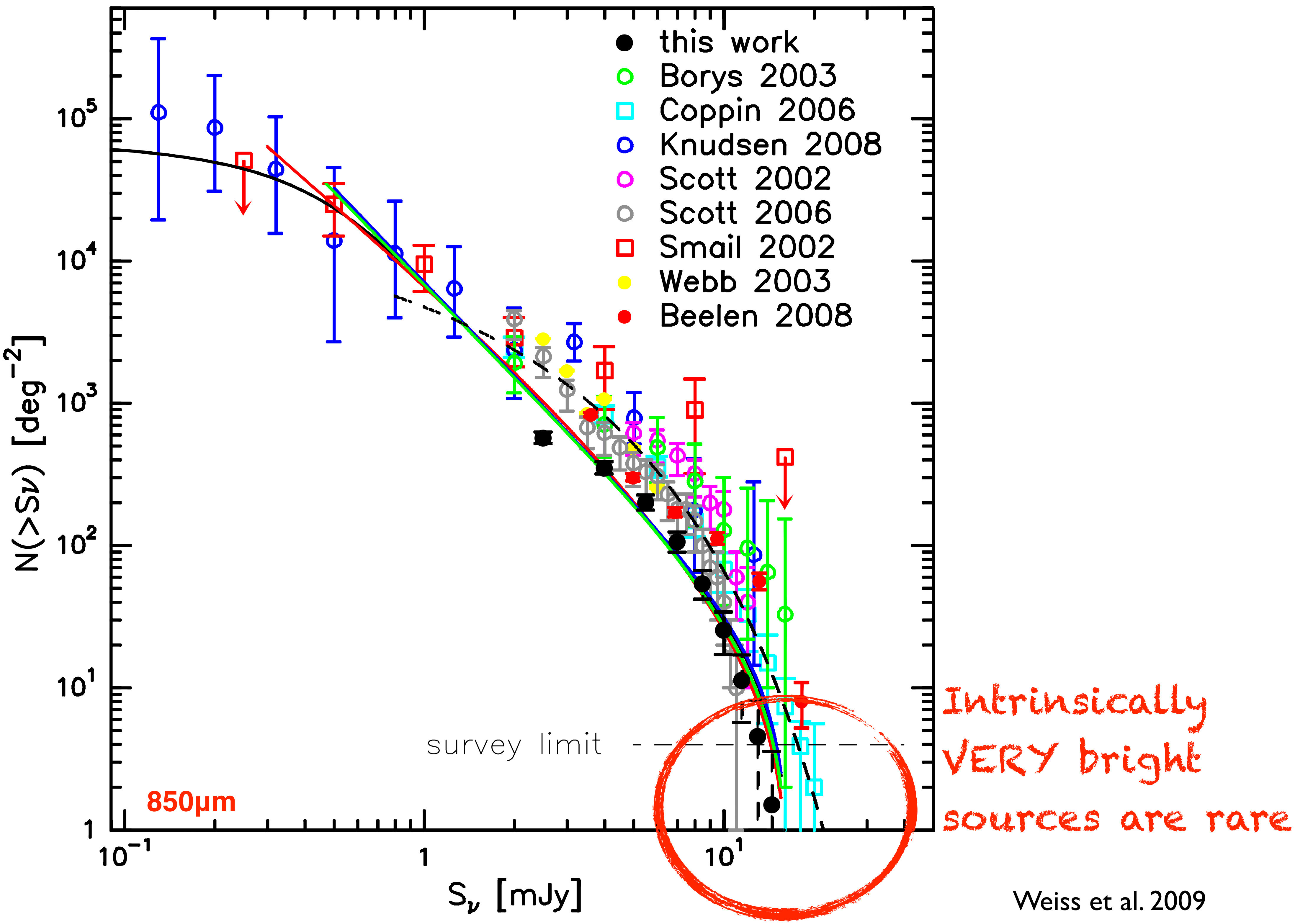
Simpson, JW et al. 2014

Gravitational Lensing

- **Background galaxy: flux boost**
- **Background galaxy: spatial resolution boost**
- Foreground galaxy: mass profile
- Cosmology: numbers and distribution of lensing



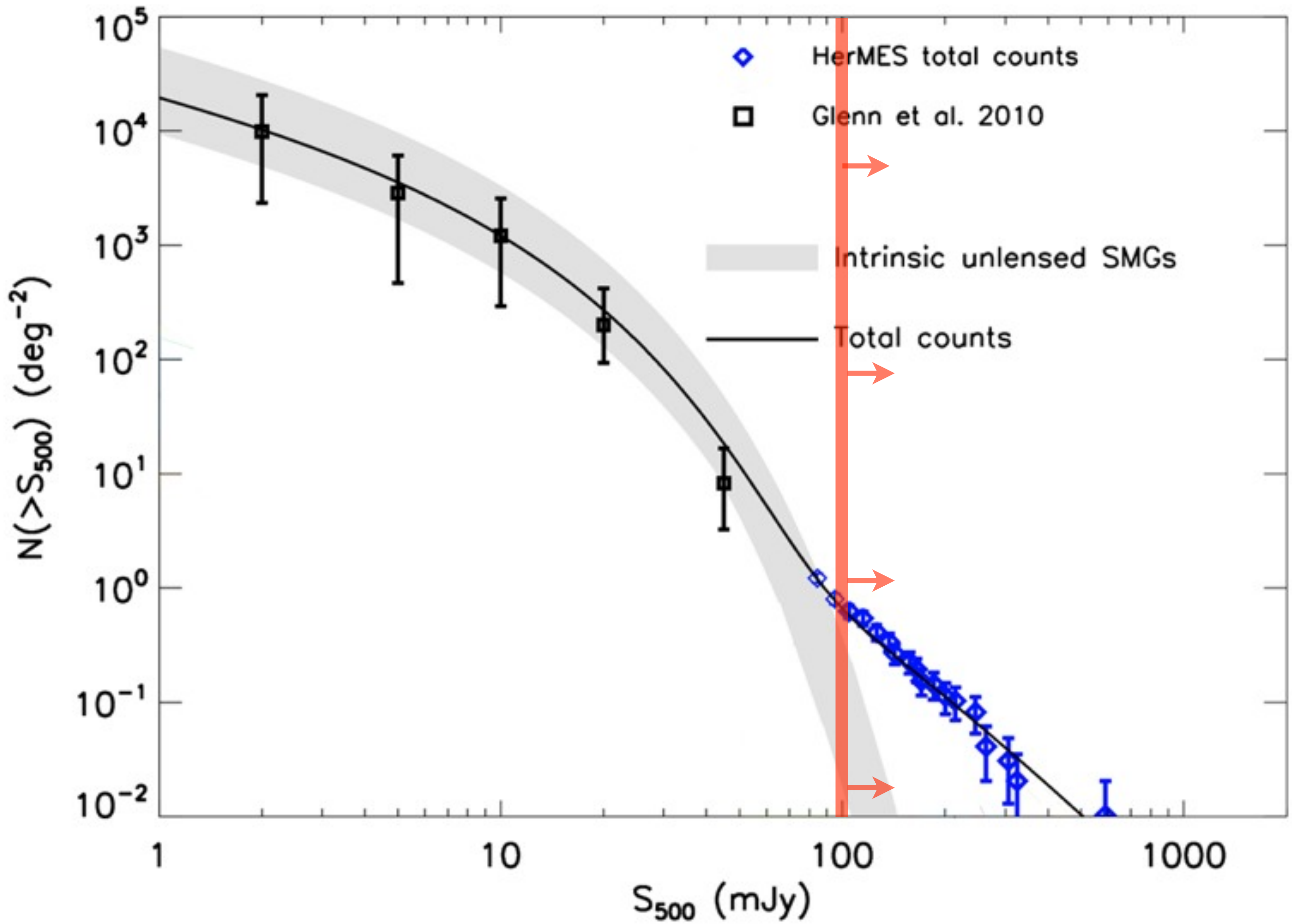
Lensed galaxies are readily identifiable in wide far-IR data



Weiss et al. 2009

See also Blain et al. 1996

HerMES lens candidates:
S_{500}>100mJy

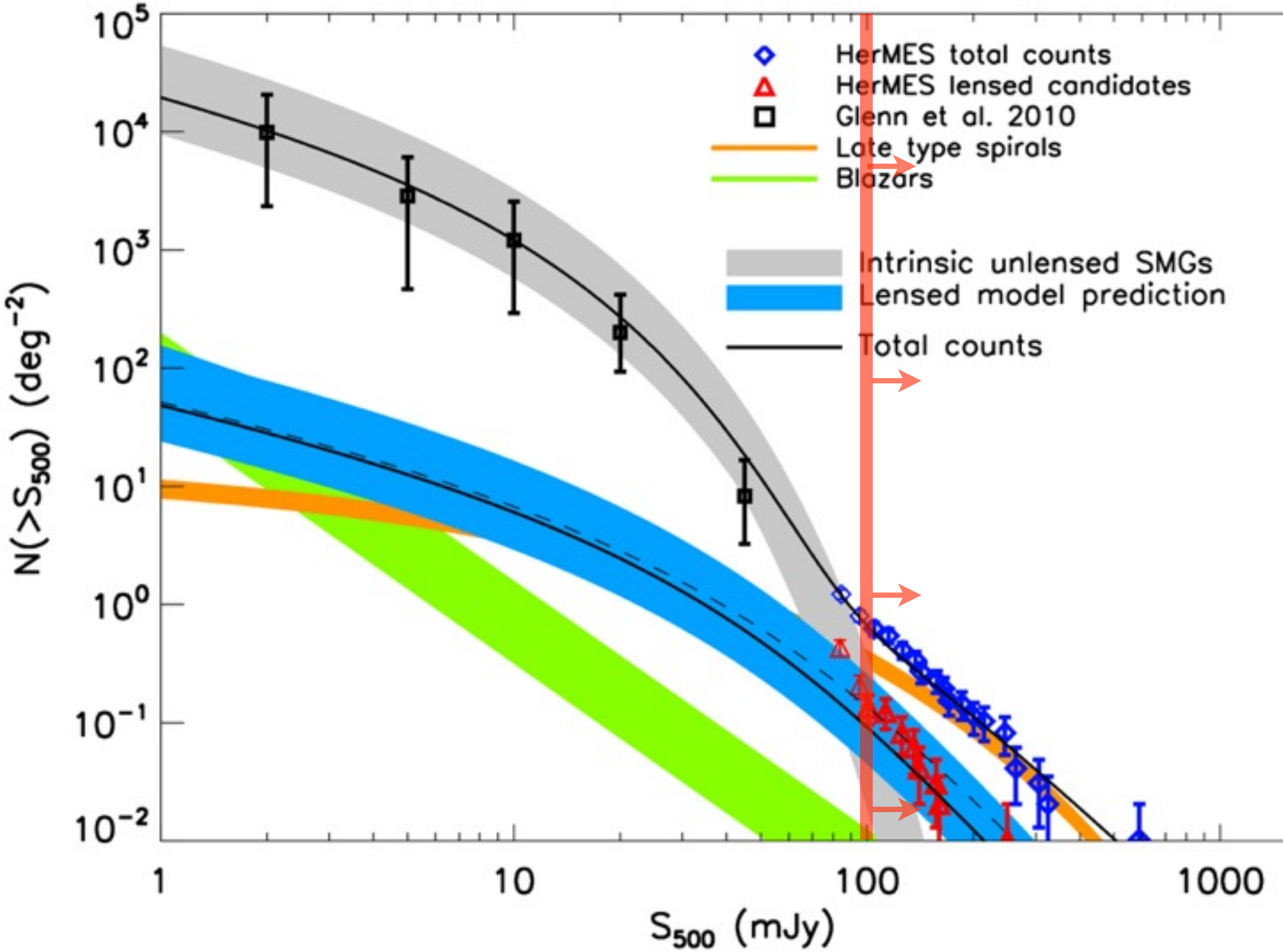


Candidates: ~0.15 deg^{-2}

Wardlow et al. 2013

HerMES lens candidates

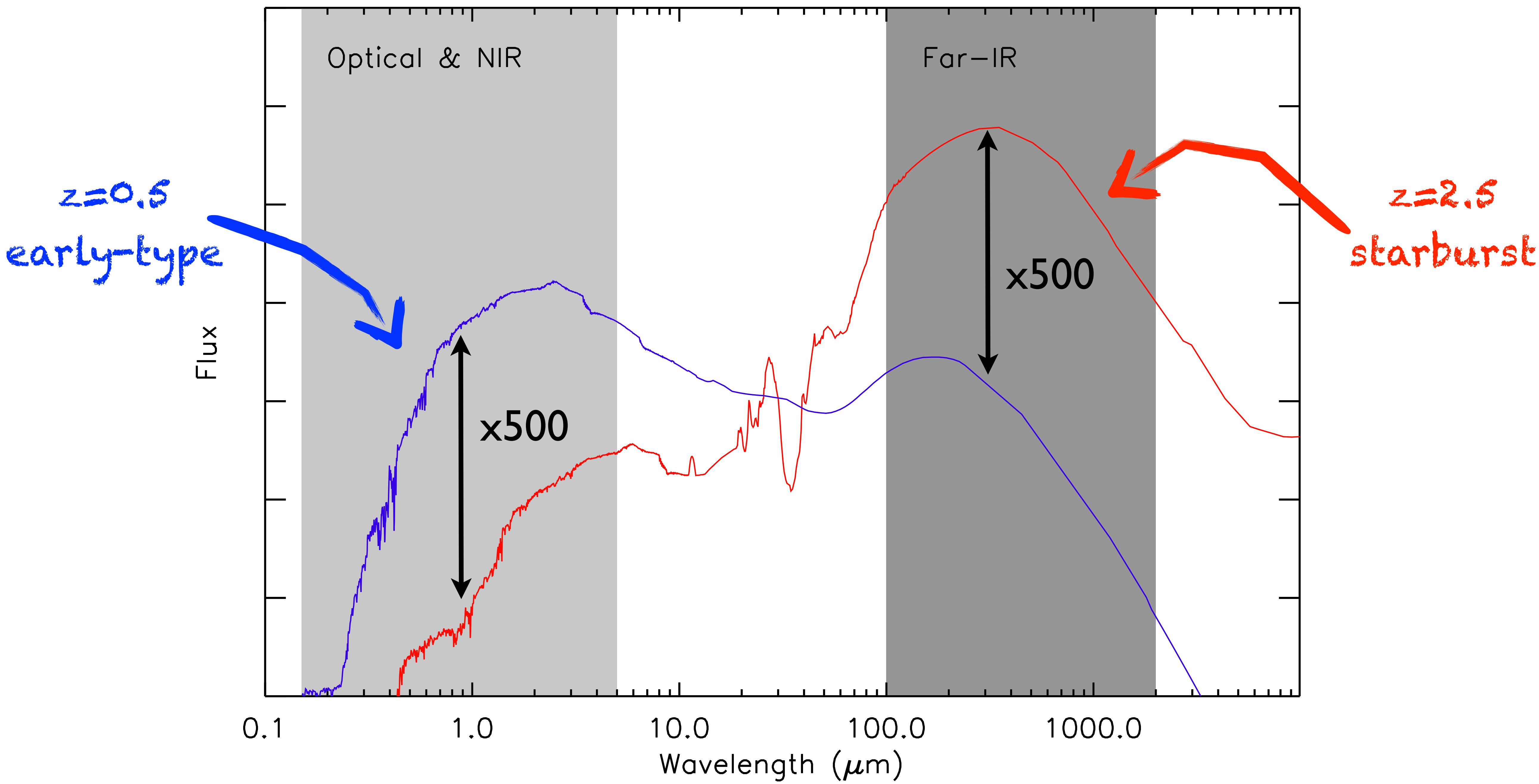
S_{500}>100mJy & no blazars or local spirals



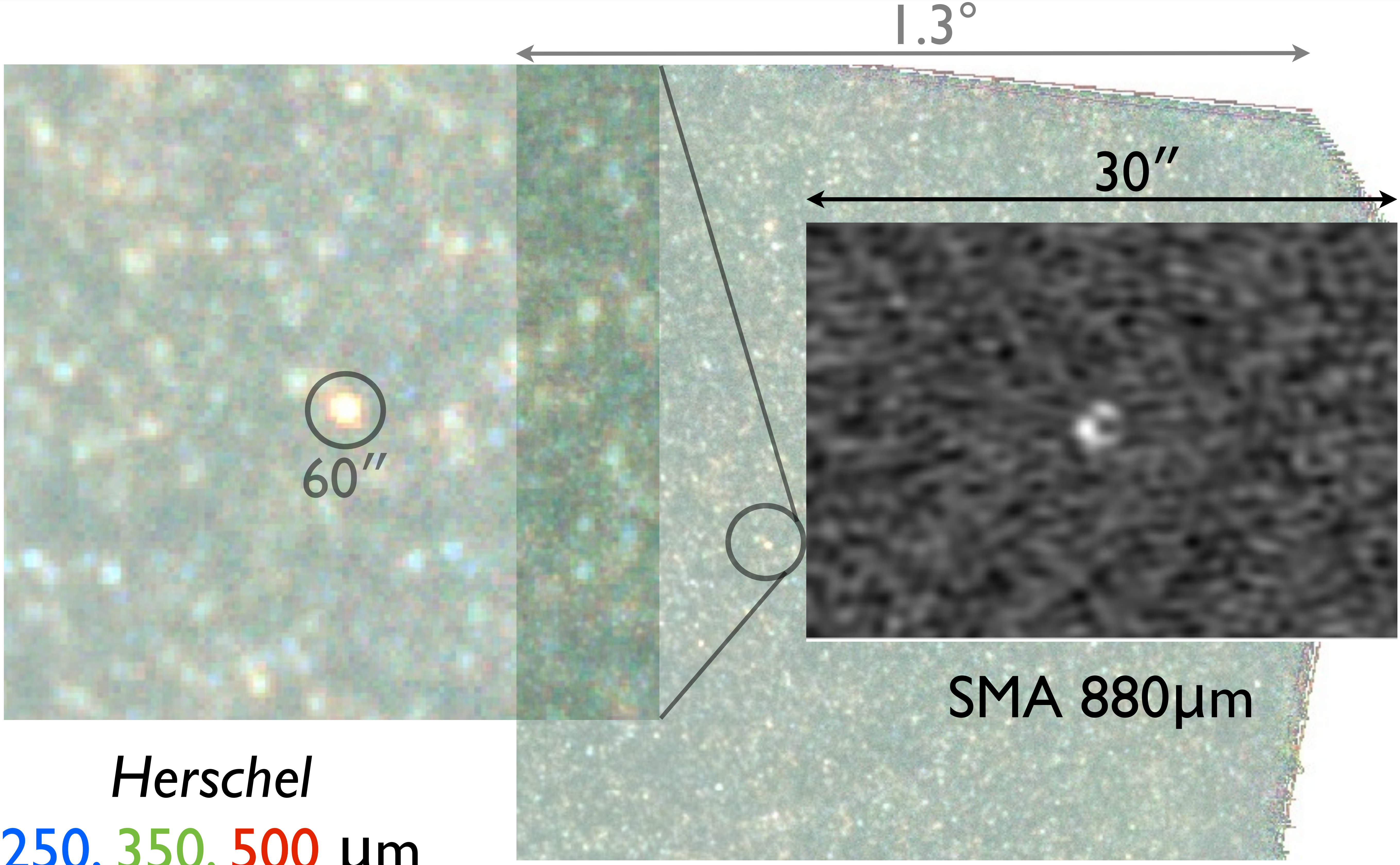
Candidates: ~0.15 deg^{-2}

Wardlow et al. 2013

Lensed SMGs are easily distinguished from lenses

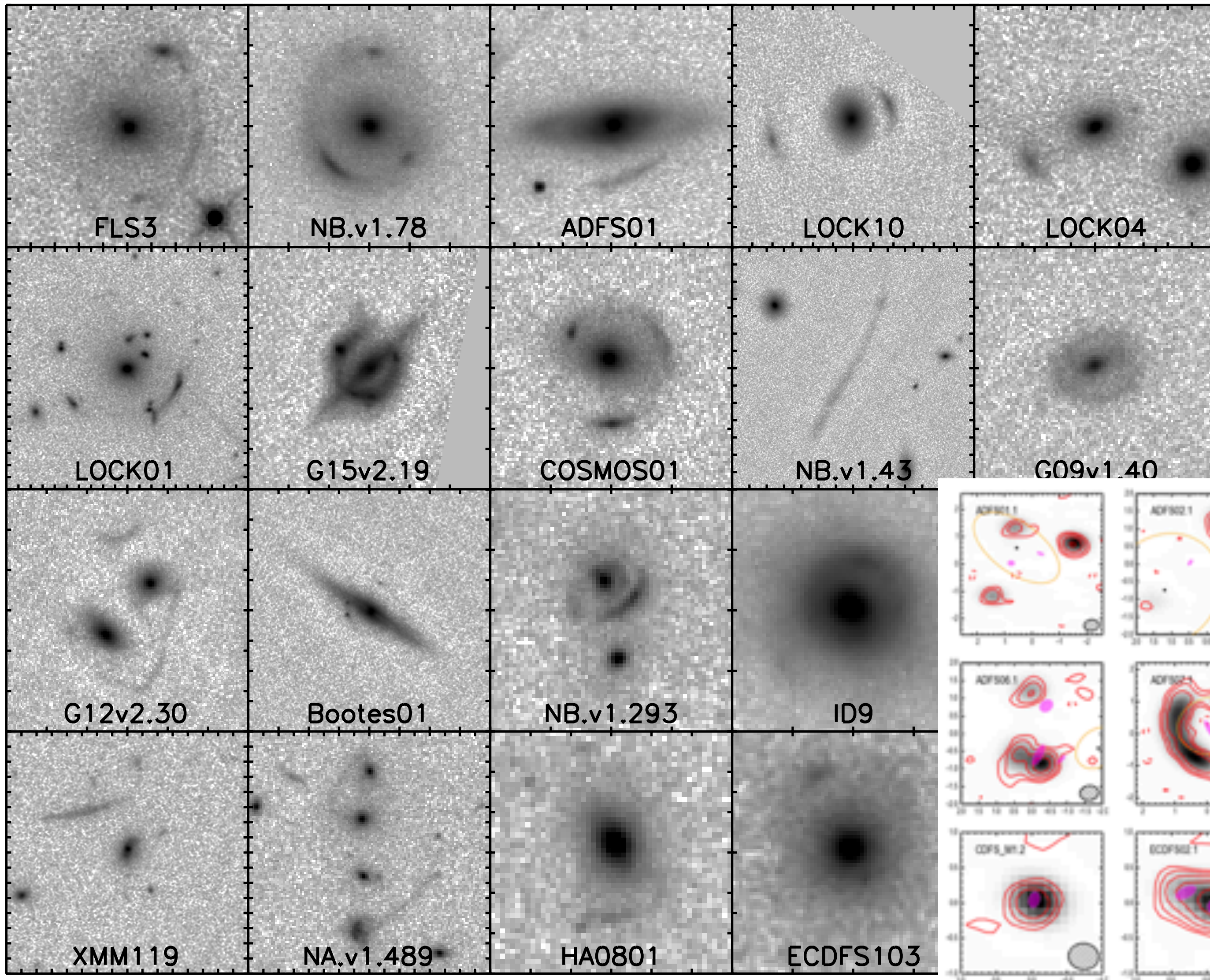


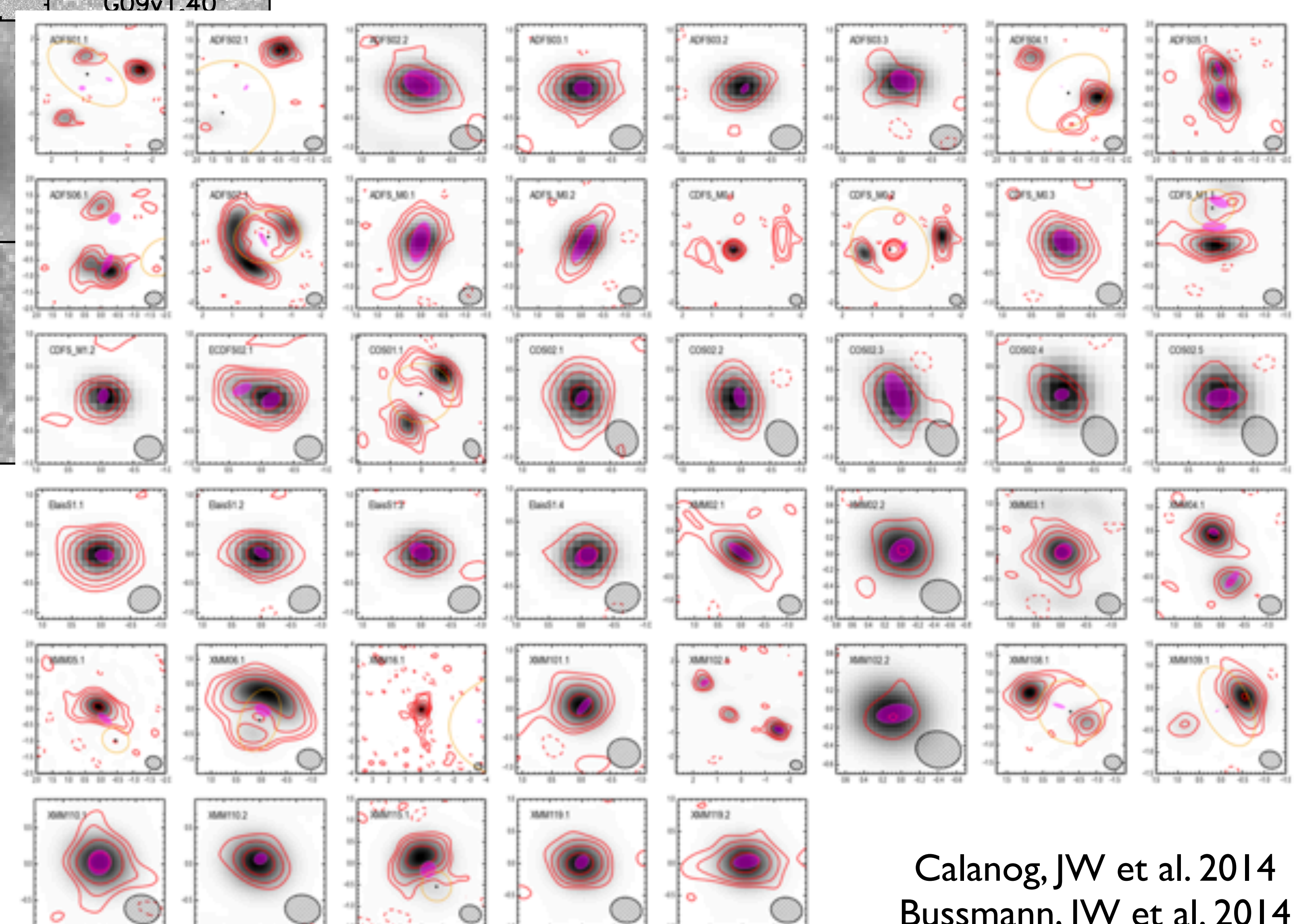
HerMES Boötes image



Herschel
250, 350, 500 µm

A sample of Herschel lens systems in submm & NIR

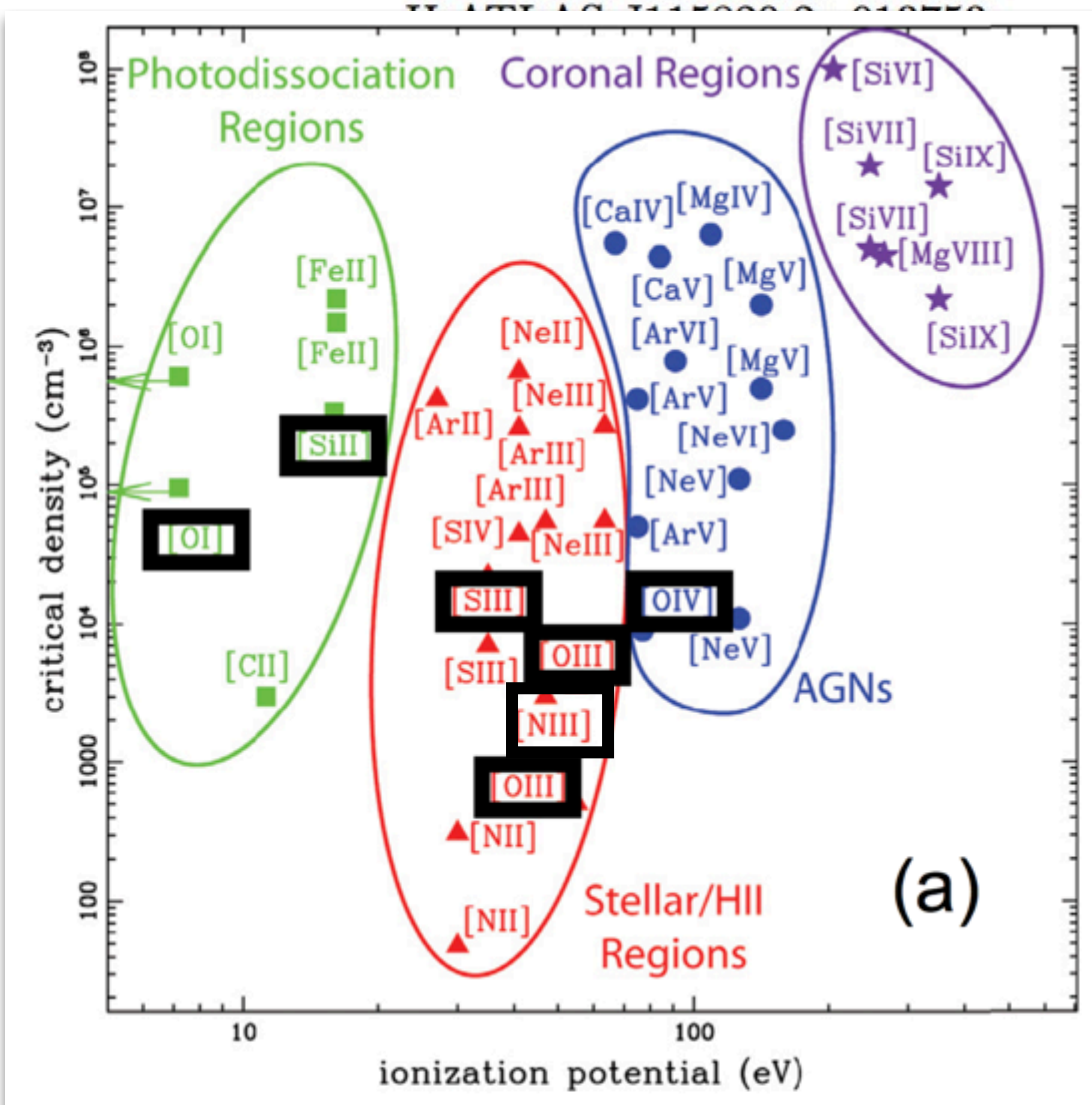




Calanog, JW et al. 2014
Bussmann, JW et al. 2014

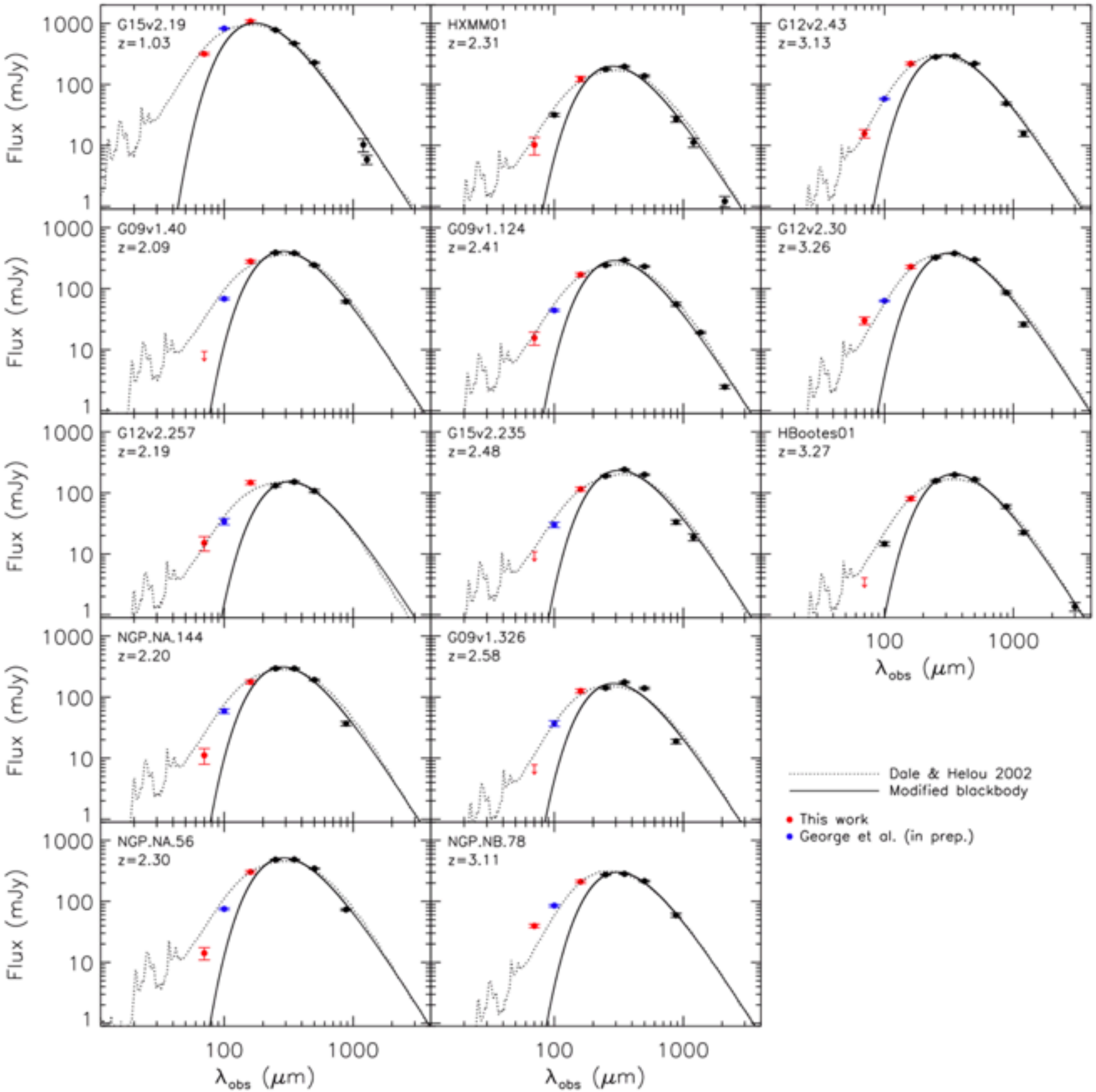
Herschel PACS OT2 survey of 13 lenses: targets

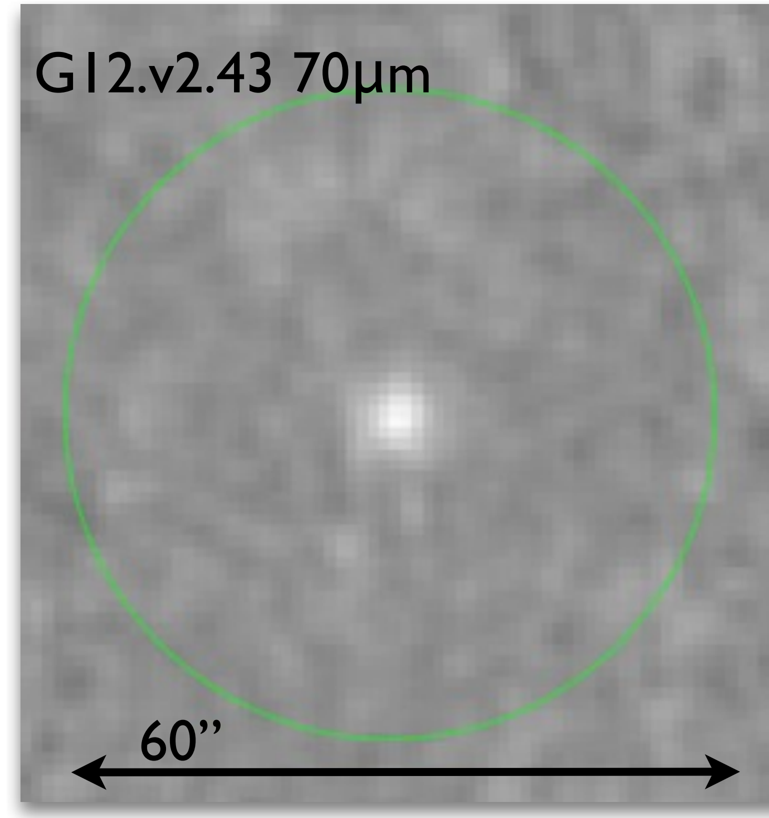
Target	Short Name	z_{source}	z_{lens}	Magnification
H-ATLAS J142935.3−002836	G15v2.19	1.027	0.218	9.7 ± 0.7^a
H-ATLAS J085358.9+015537	G09v1.40	2.091	...	15.3 ± 3.5
	G12v2.257	2.191	...	13.0 ± 7.0
	NGP.NA.144	2.202	...	4.4 ± 0.8
	NGP.NA.56	2.302	0.672	11.7 ± 0.9
	HXMM01	2.307	0.654	1.5 ± 0.3
	G09v1.124	2.410	0.348	2.8 ± 0.2
	G15v2.235	2.479	...	1.8 ± 0.3
	G09v1.326	2.581	...	1
	NGP.NB.78	3.111	0.428	13.0 ± 1.5
	G12v2.43	3.128	...	2.8 ± 0.4
	G12v2.30	3.259	1.225	9.5 ± 0.6
	HBootes01	3.274	0.590	4.5 ± 0.4

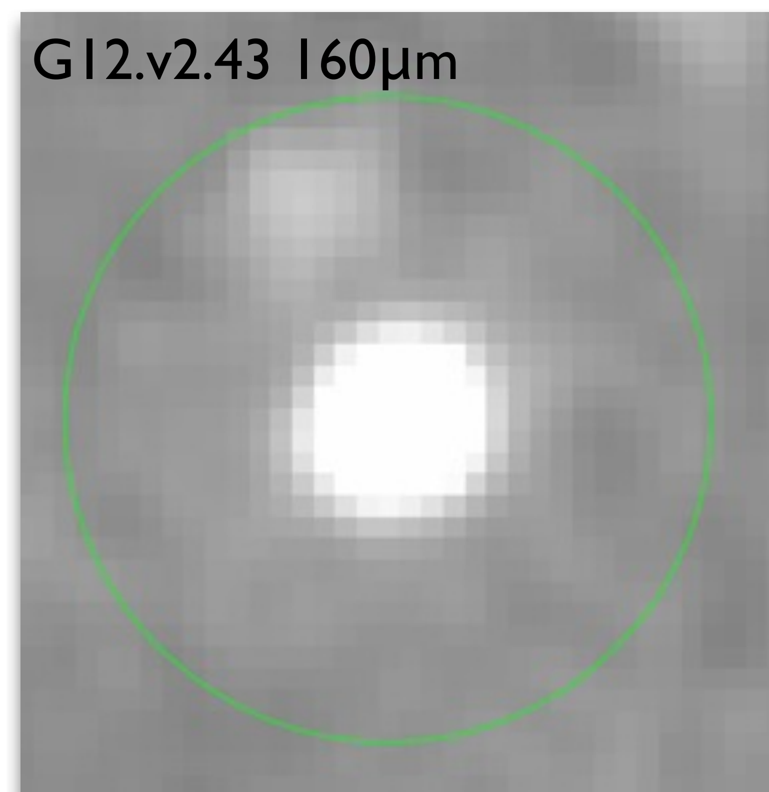


Spinoglio et al. 2009

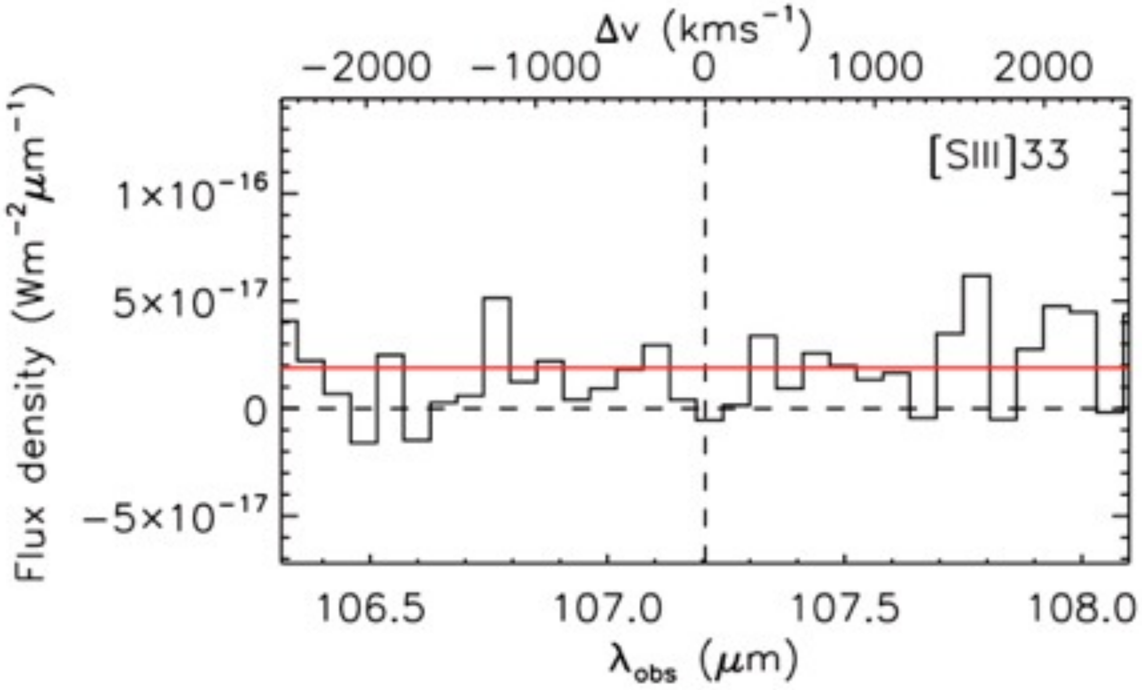
All targets have apparent $L_{FIR} > 10^{13} L_\odot$

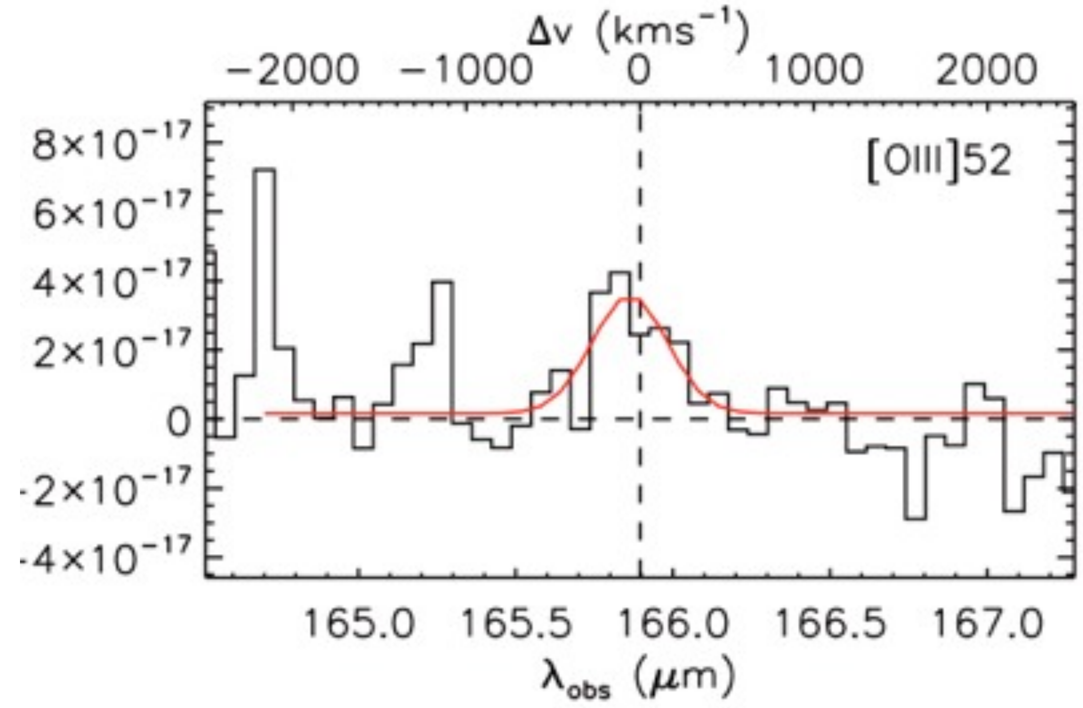


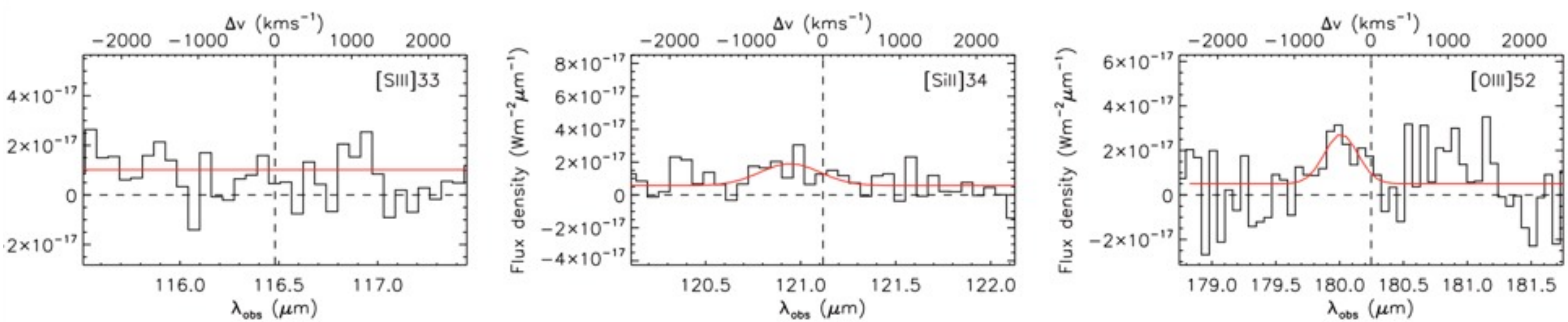




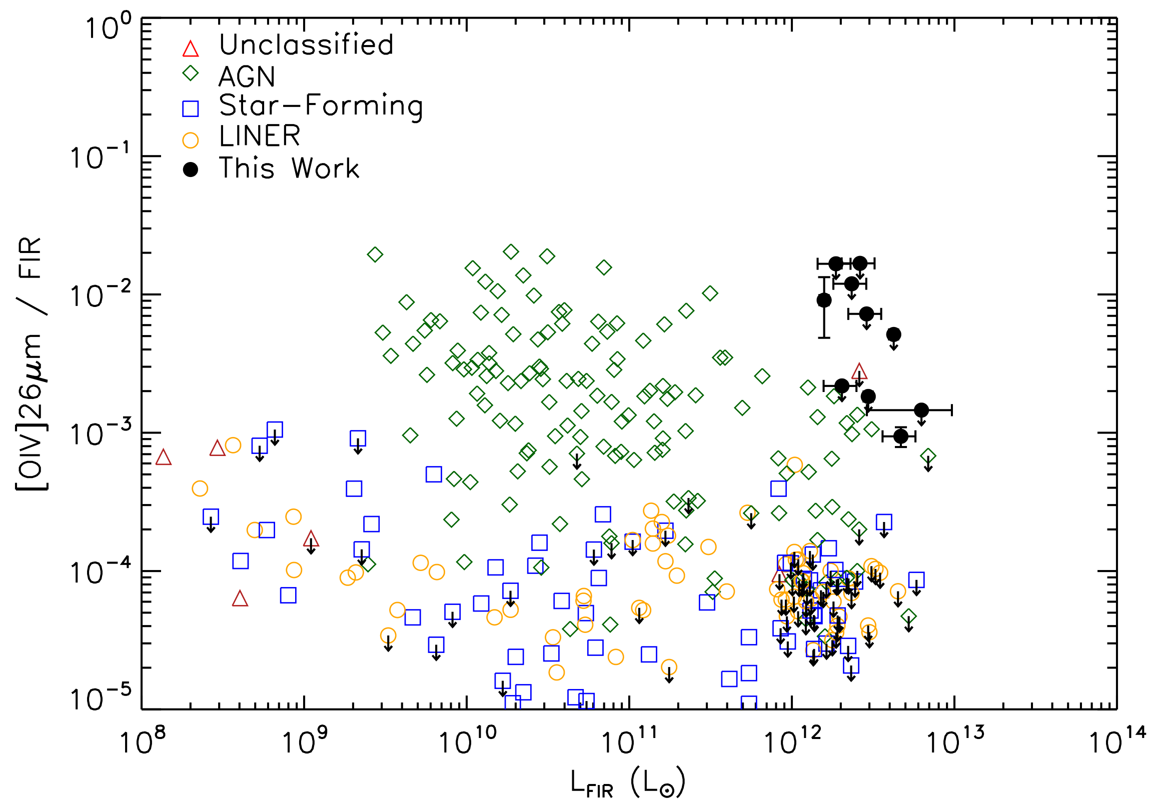
Examples of the spectroscopy

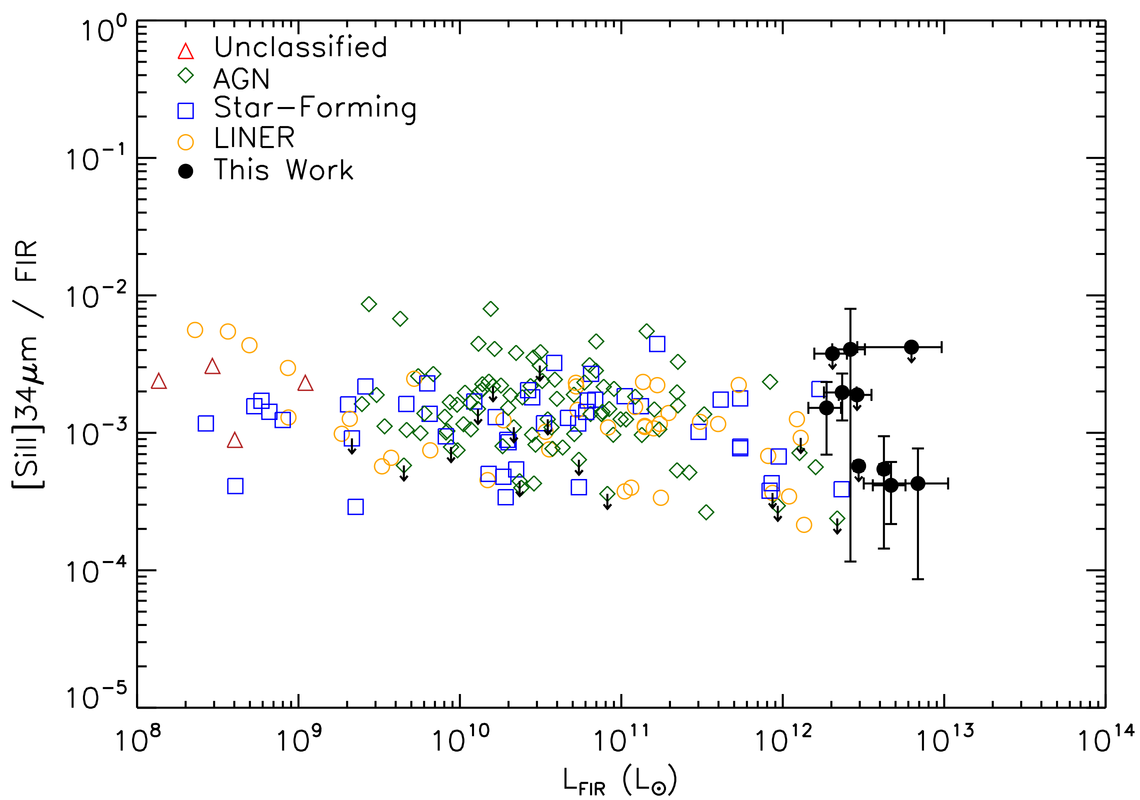


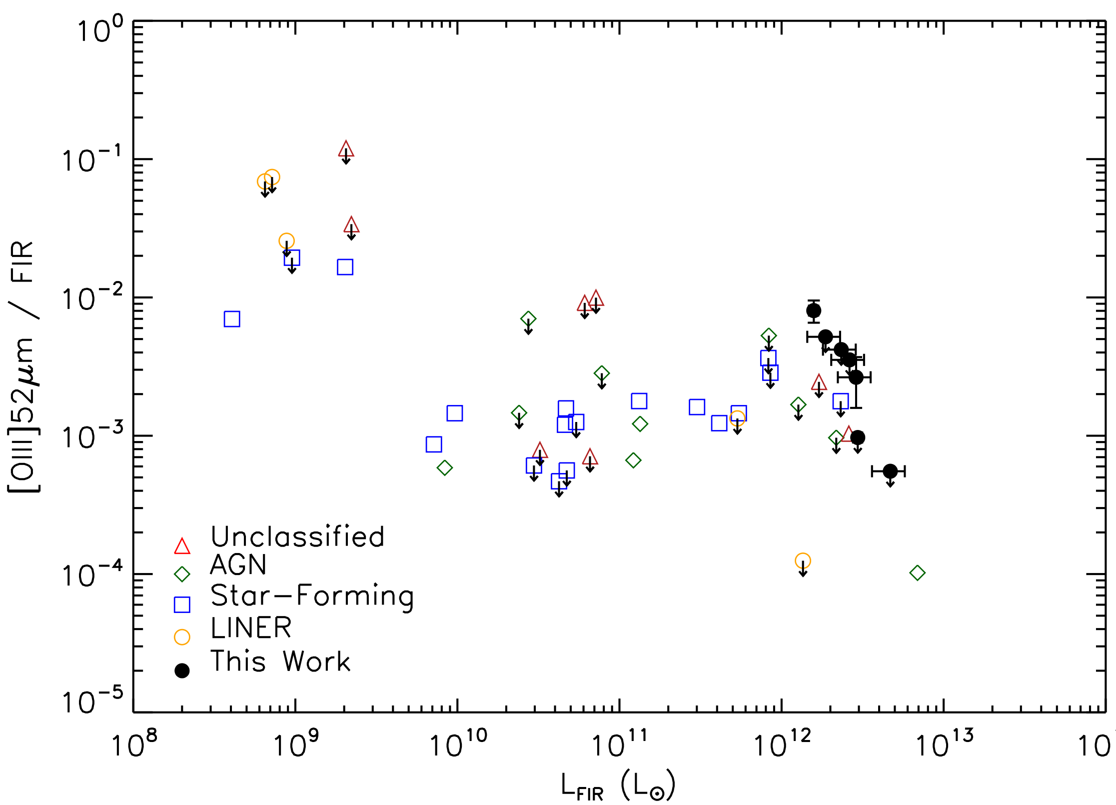




No [OIV]26μm (AGN tracer) in most DSFGs, but evidence of [SiII]34μm (PDRs) & [OIII]52 (HII regions)

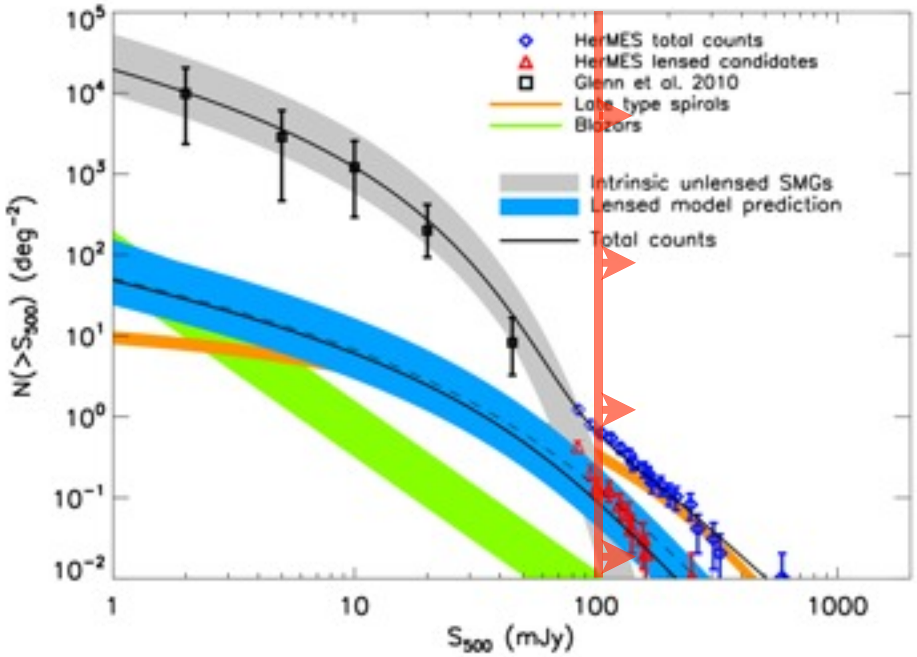




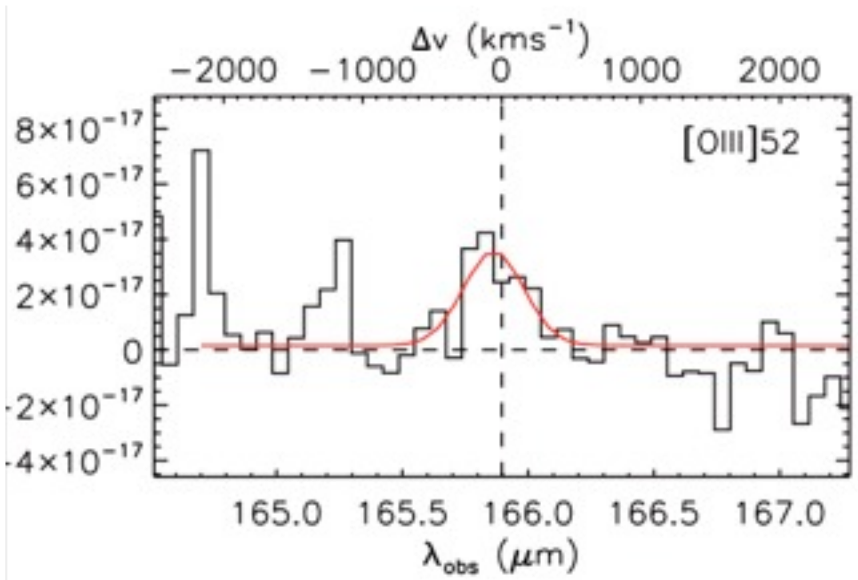


Summary

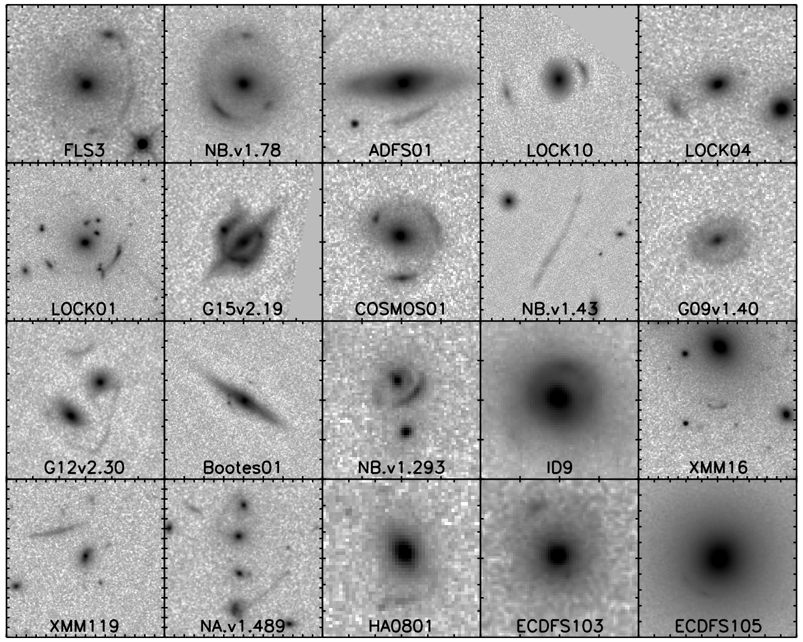
Wide-area, submm surveys can efficiently identify strongly lensed dusty star-forming galaxies by simply selecting the brightest sources.



Our PACS survey is breaking new ground detecting many fine structure lines at z>1.



The lensing amplification makes studies of faint features possible.



The fine structure lines confirm IR emission dominated by HII regions and PDRs (star formation)