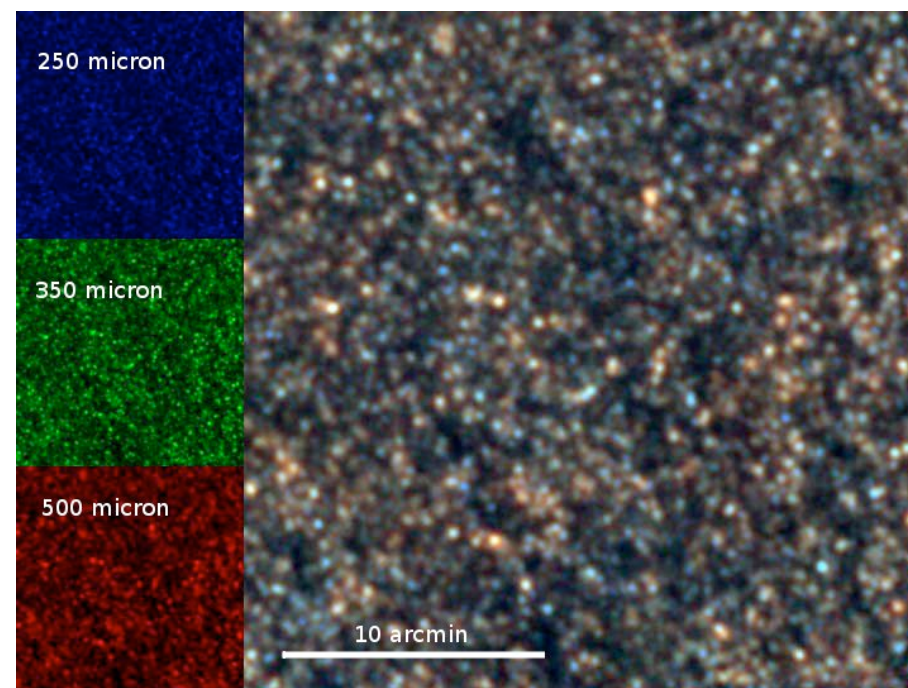


Lensing & Herschel unveils extreme star-formation at $z \gtrsim 2$

Julie Wardlow

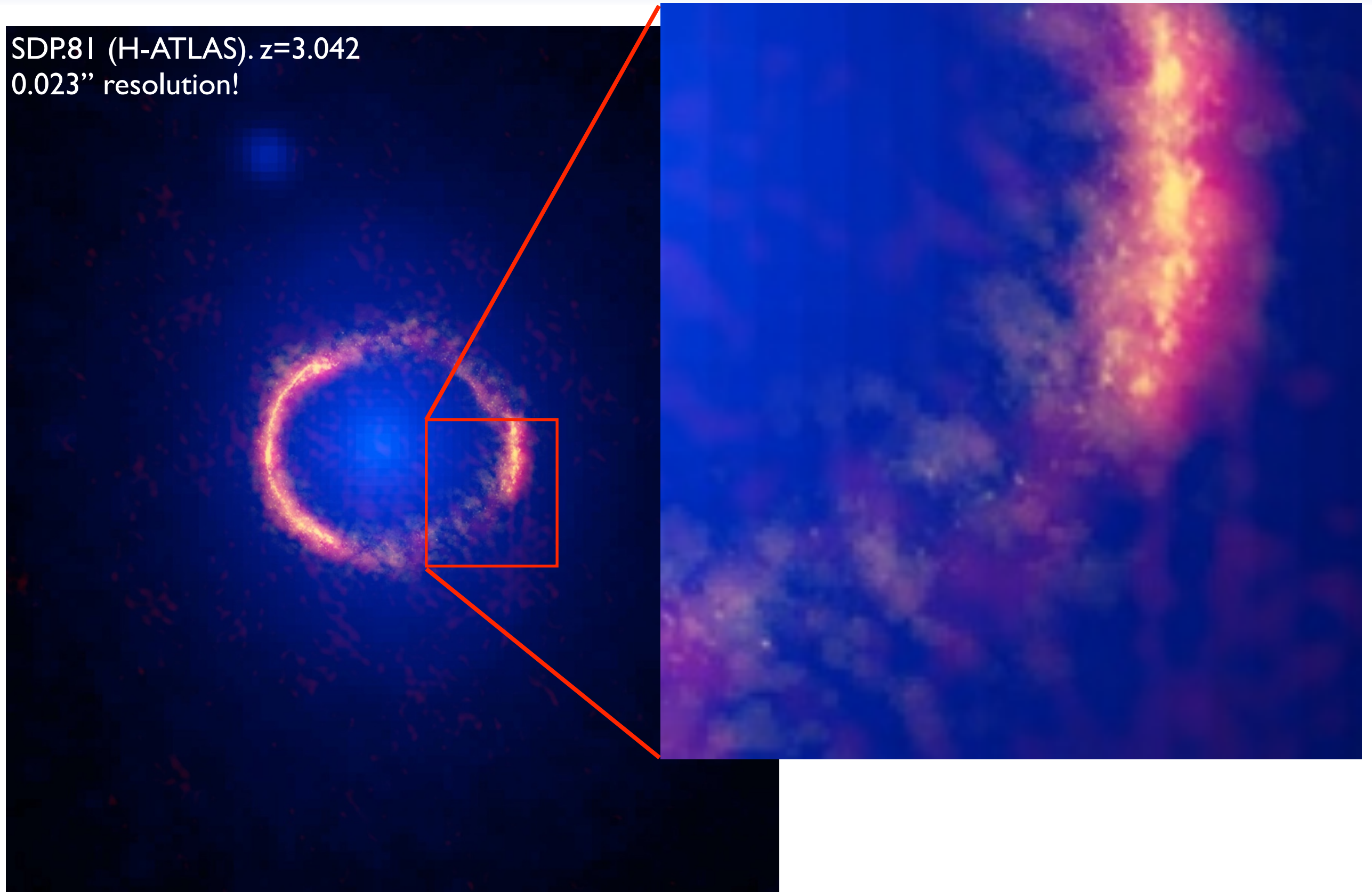


with Shane Bussmann, Jae Calanog, Alex Conley, Asantha Cooray, Francesco De Bernardis, Rui Marques Chaves, Paloma Martínez Navajas, Ismael Perez Fournon, Dominik Riechers & HerMES

What?

Example: SDP.81 discovered by Herschel, imaged by ALMA

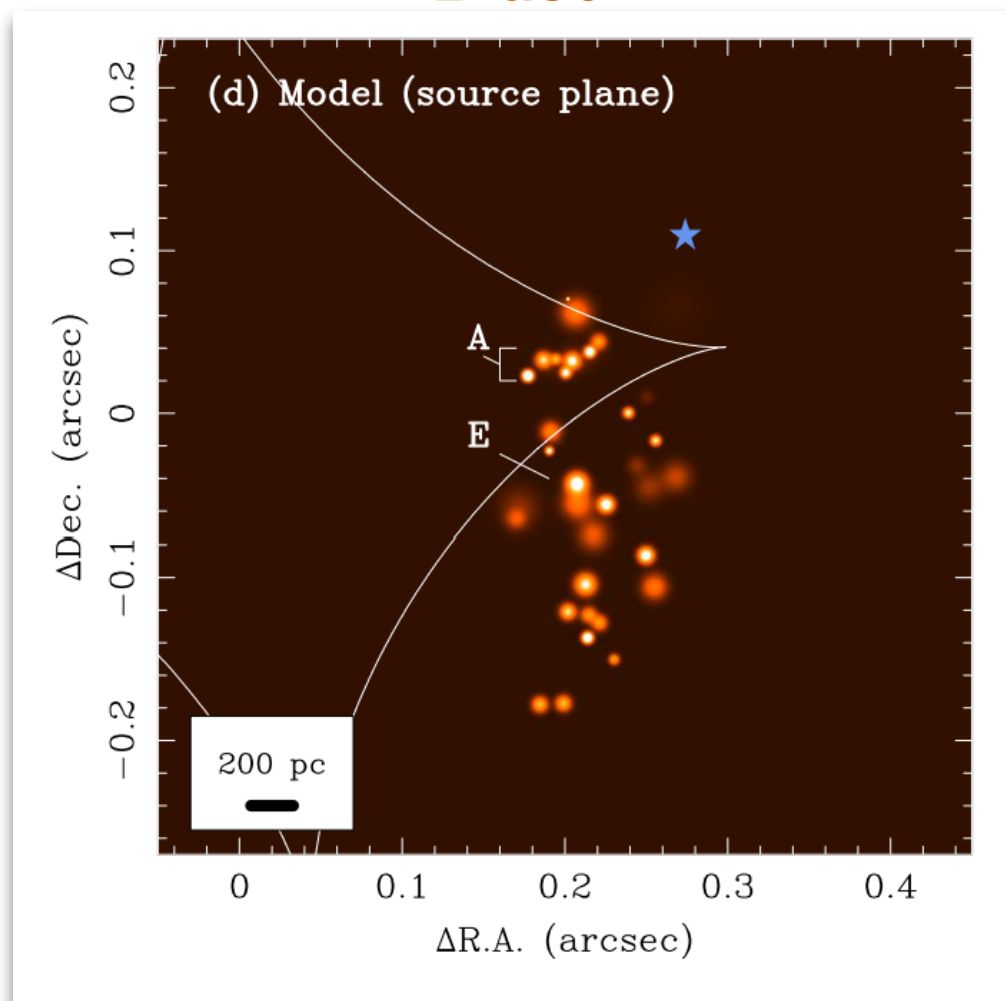
SDP.81 (H-ATLAS). $z=3.042$
0.023" resolution!



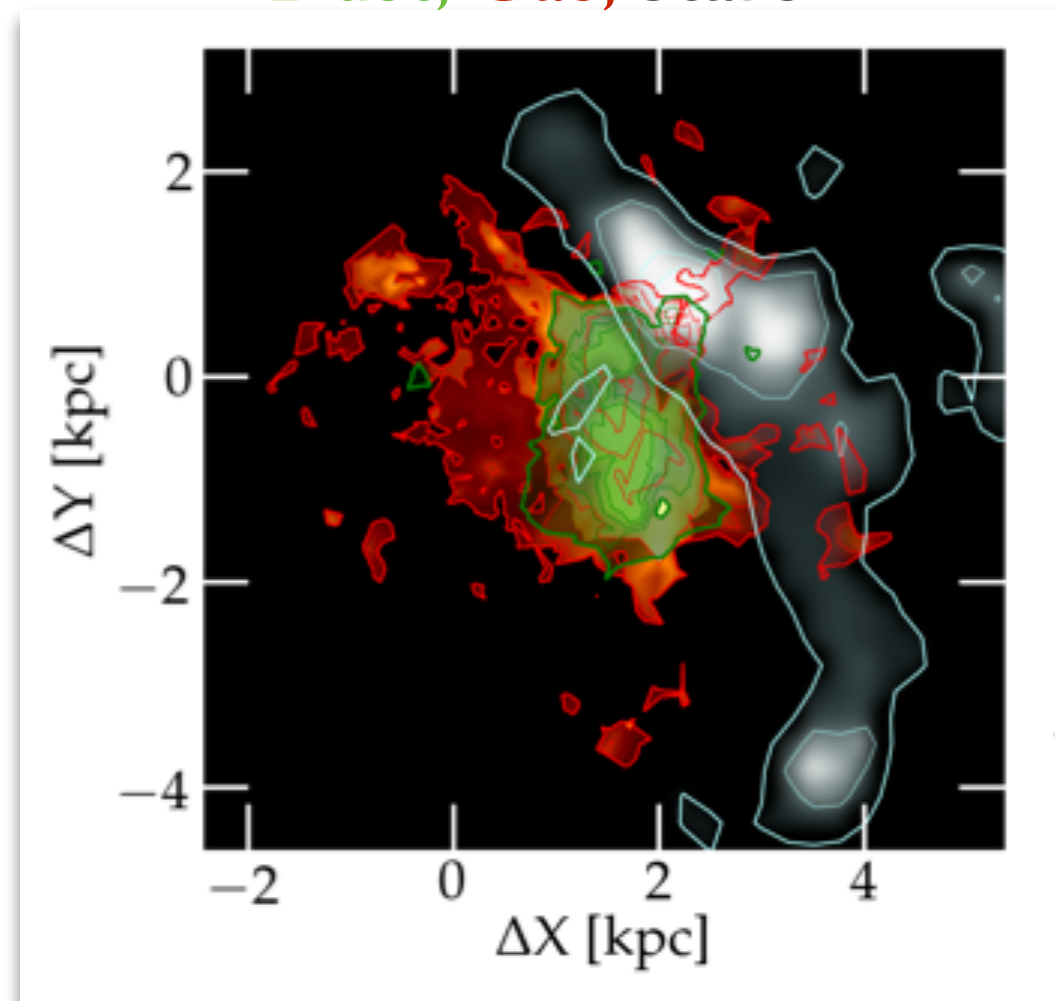
What?

Example: SDP.81 discovered by Herschel, imaged by ALMA

Dust



Dust, Gas, Stars



Since March:

Vlahakis et al. 2015

Swinbank et al. 2015

Rybak et al. 2015a,b

Hatsukade et al. 2015

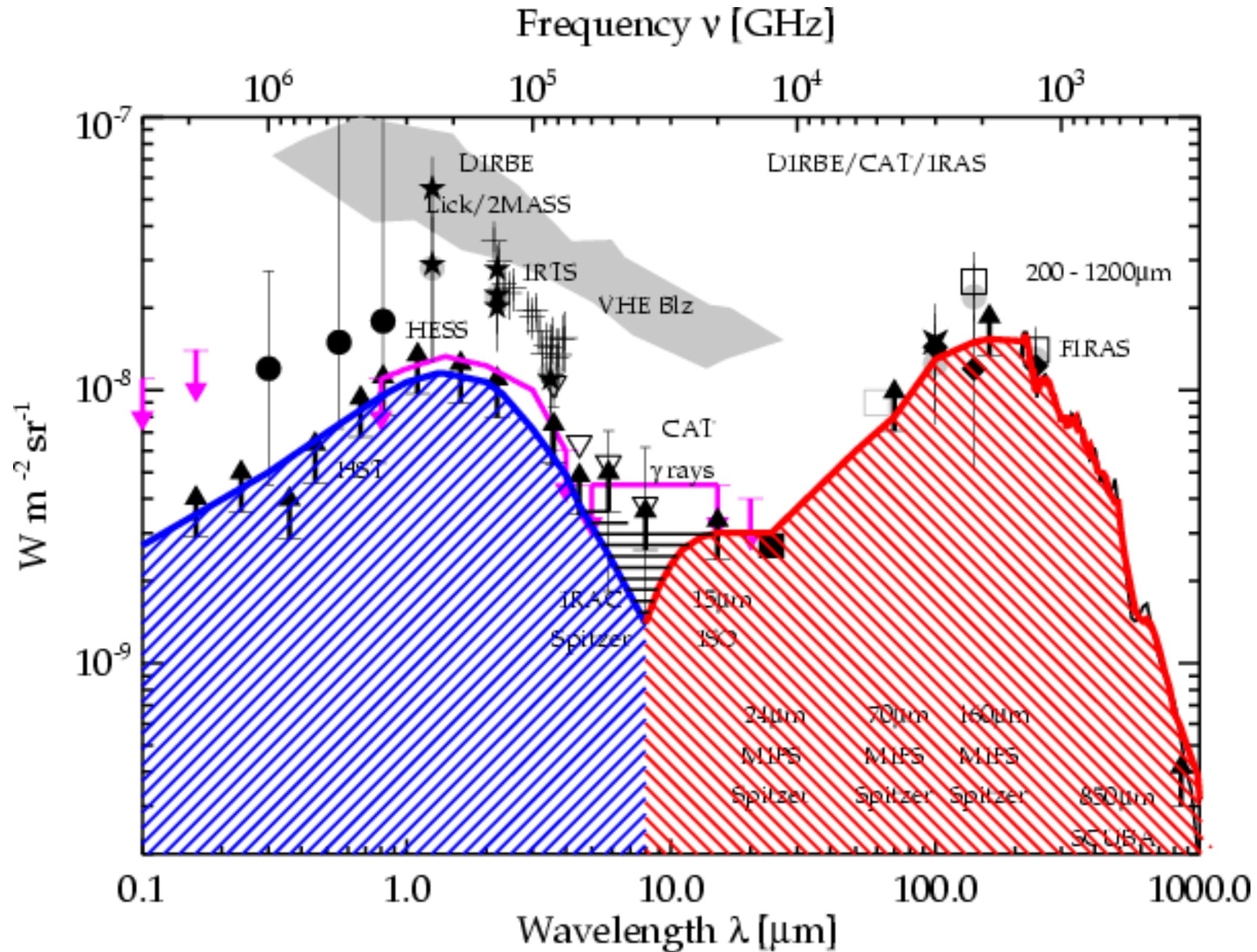
Dye et al. 2015

Tamura, et al. 2015

Wong et al. 2015

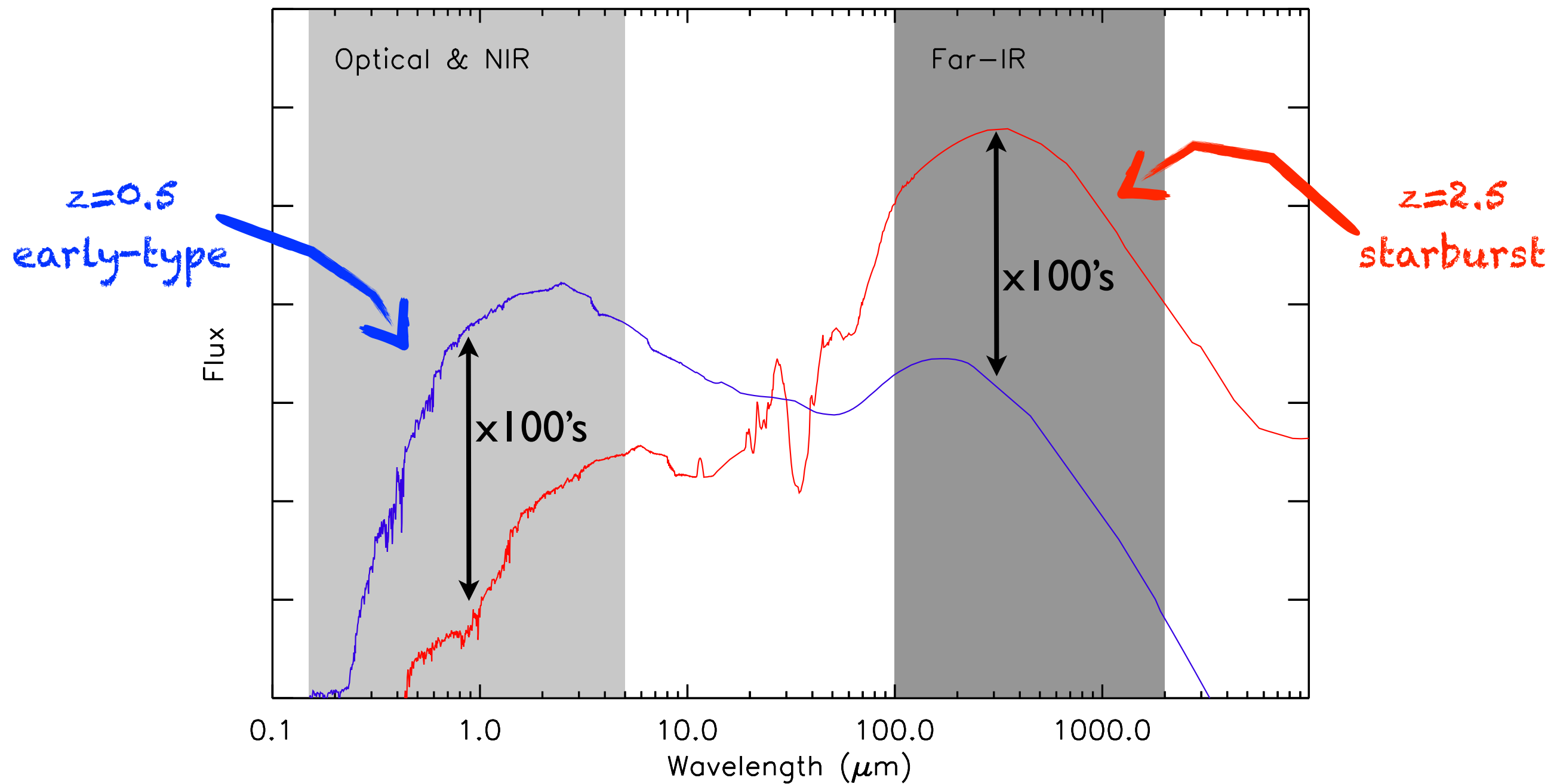
Why?

~50% of stellar & AGN emission is dust reprocessed

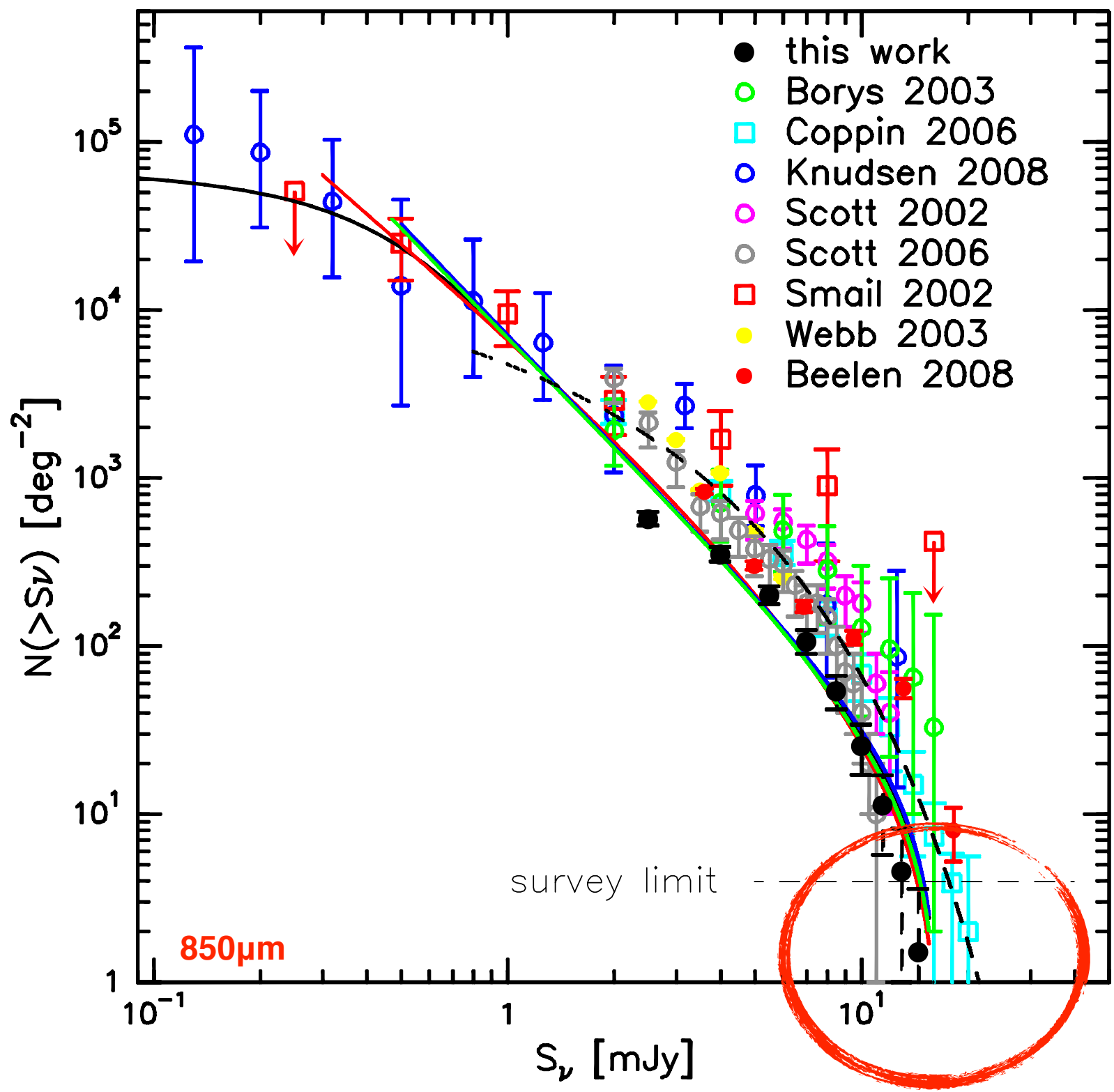


Dole et al. 2006

Lensed SMGs are easily distinguished from lenses



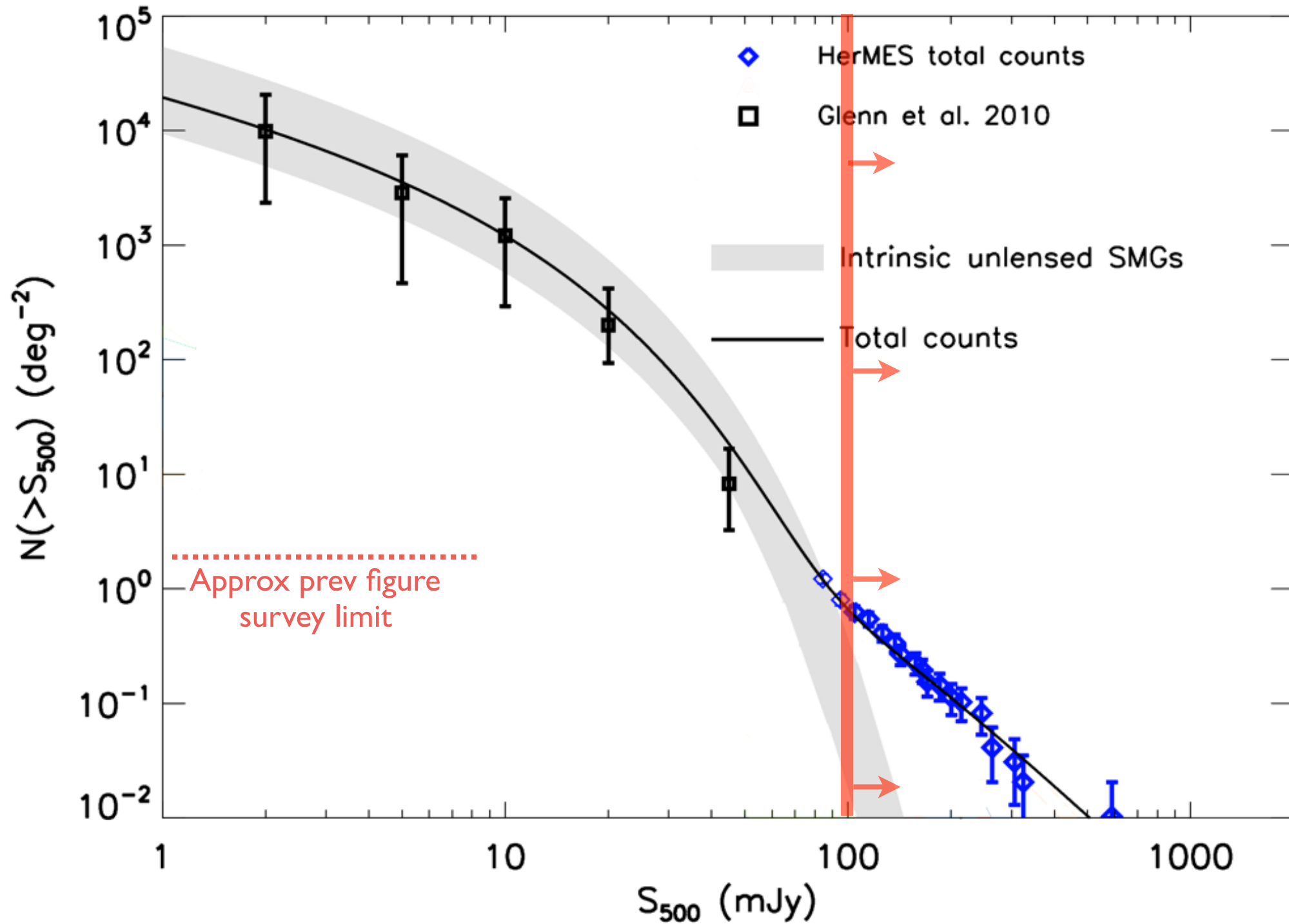
Lensed galaxies are readily identifiable in wide far-IR data



Intrinsically
VERY bright
sources are rare

Weiss et al. 2009
See also Blain et al. 1996

HerMES lens candidates: $S_{500} > 100 \text{ mJy}$

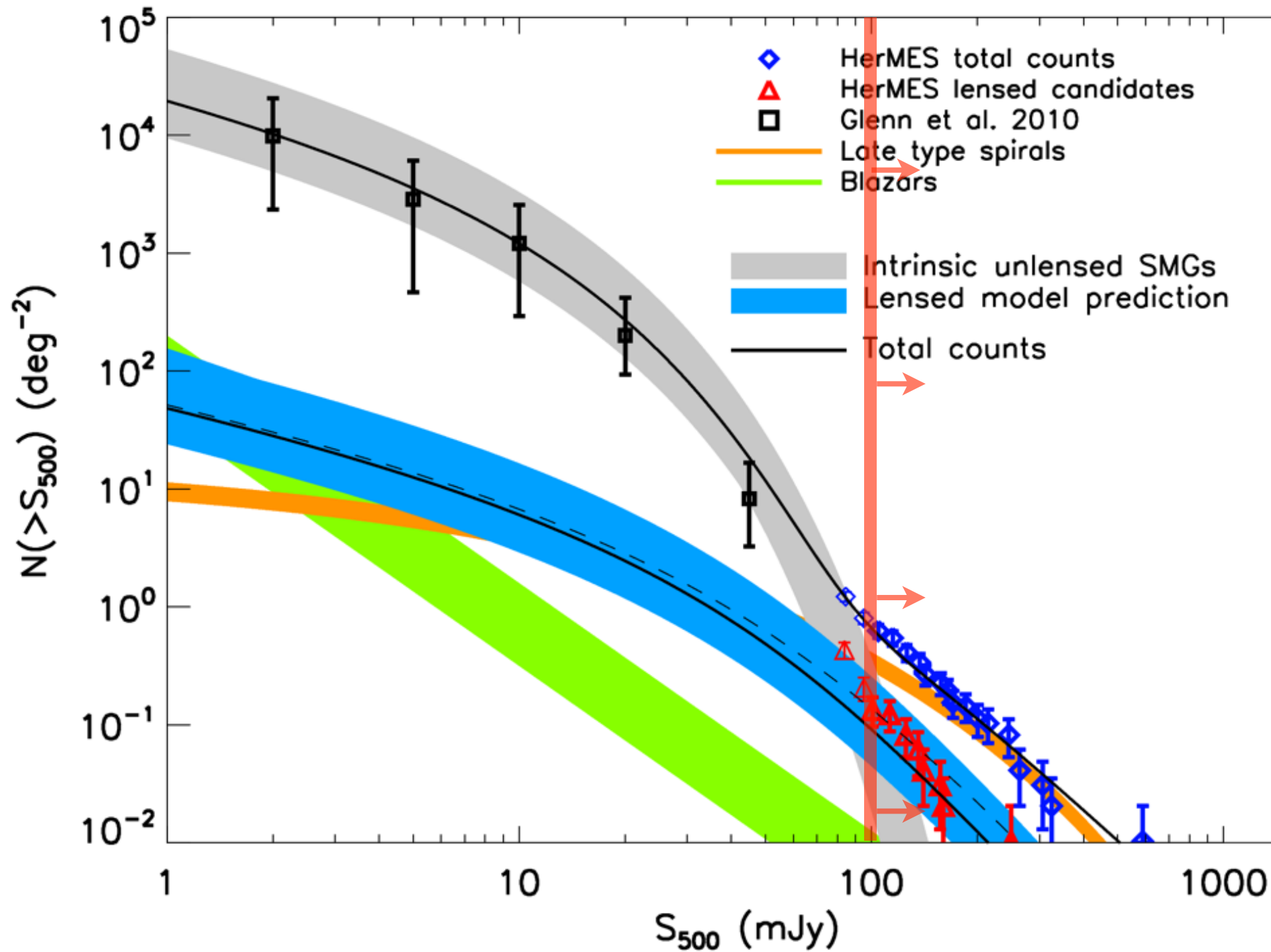


Candidates: $\sim 0.15 \text{ deg}^{-2}$

Wardlow et al. 2013

HerMES lens candidates

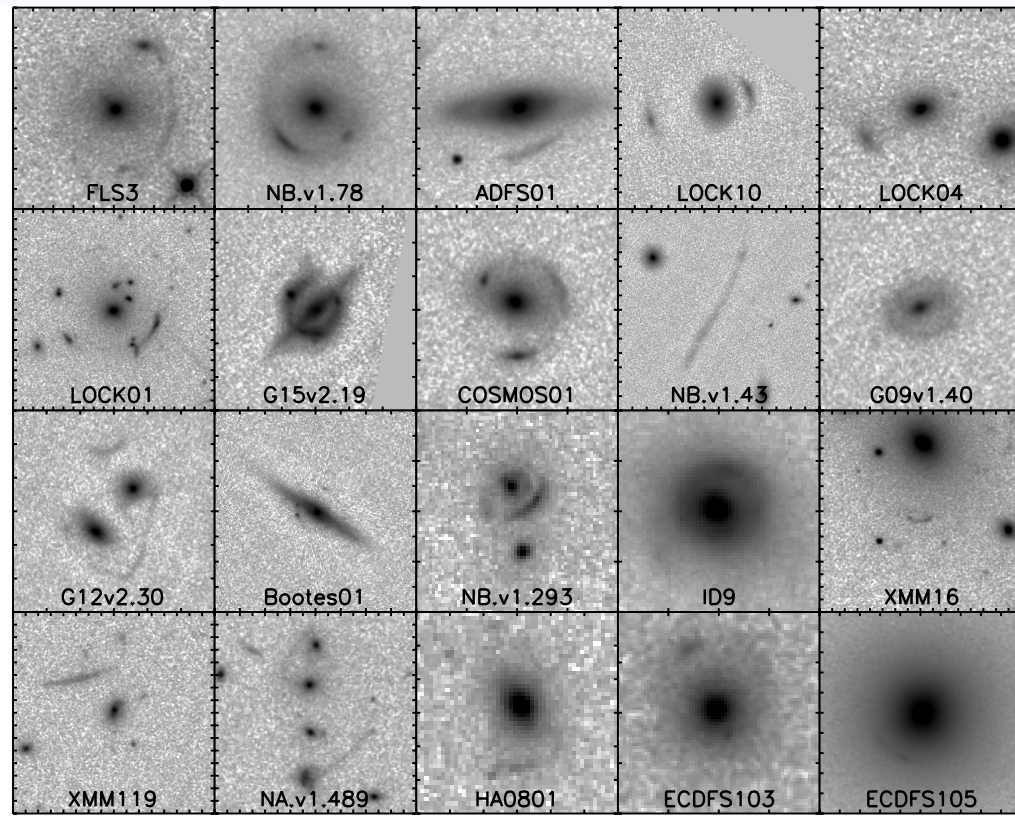
$S_{500} > 100 \text{ mJy}$ & no blazars or local spirals \rightarrow



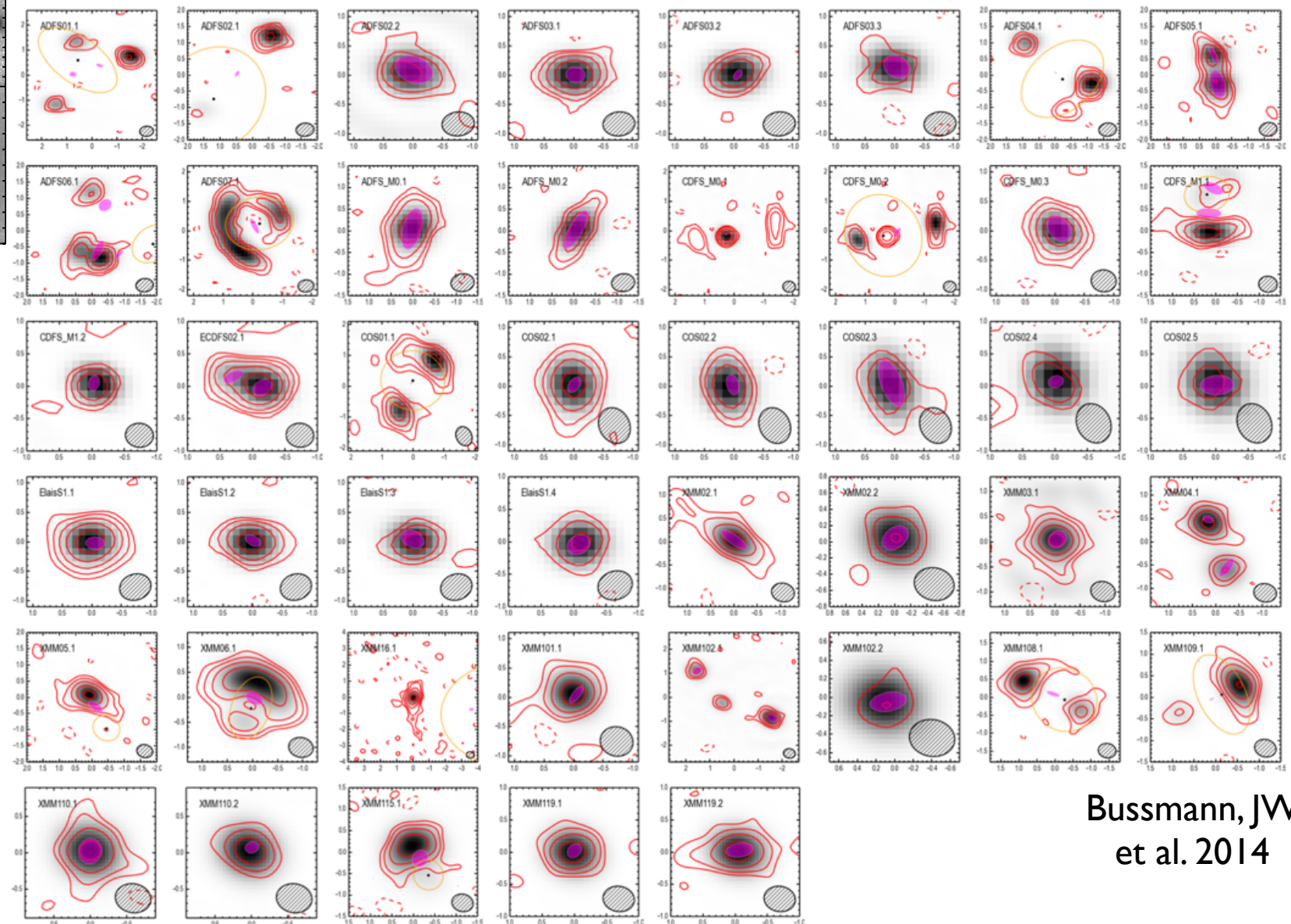
Candidates: $\sim 0.15 \text{ deg}^{-2}$

Wardlow et al. 2013

A sample of Herschel lens systems

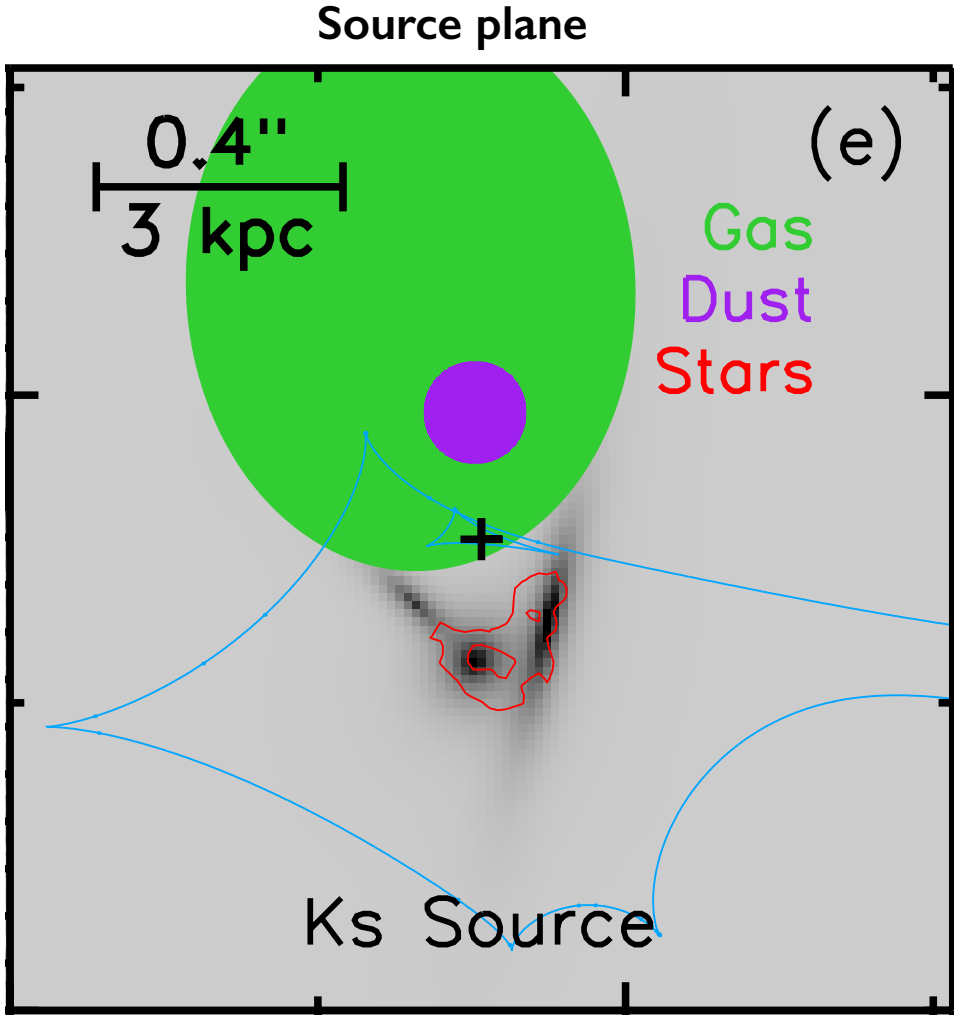
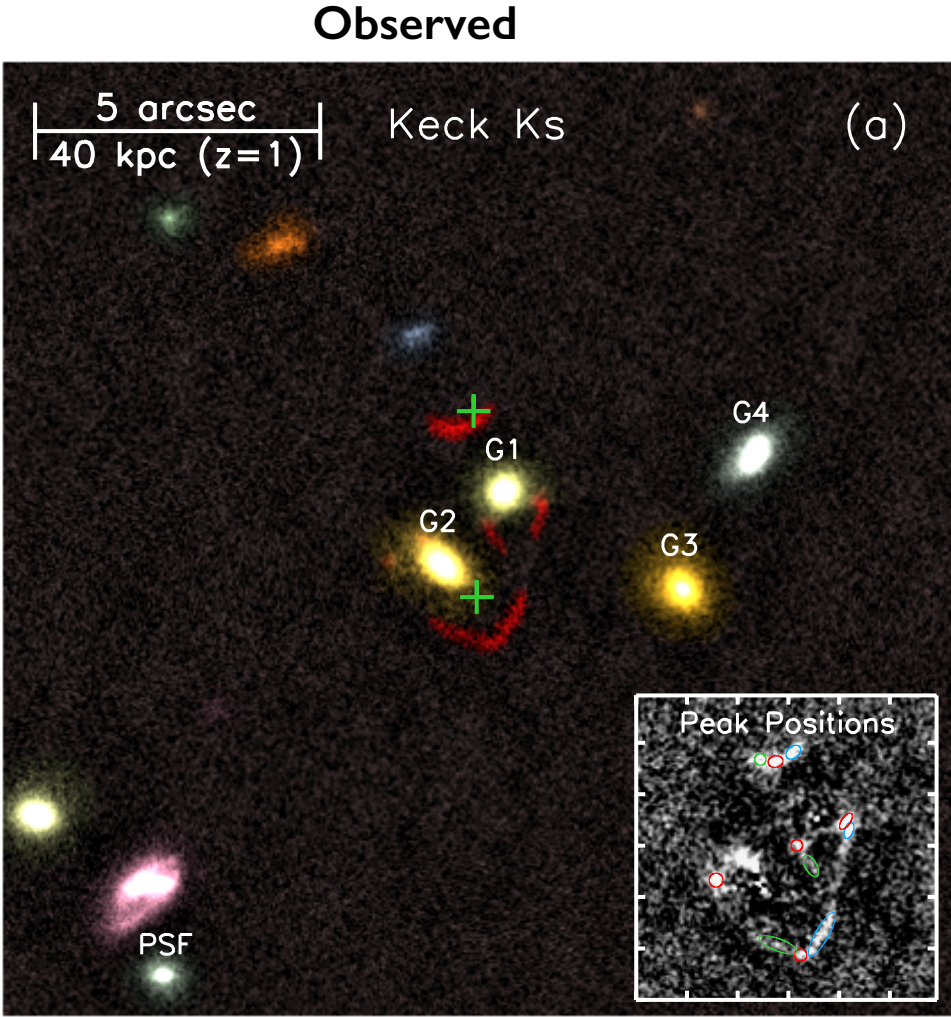


Calanog, JW et al. 2014

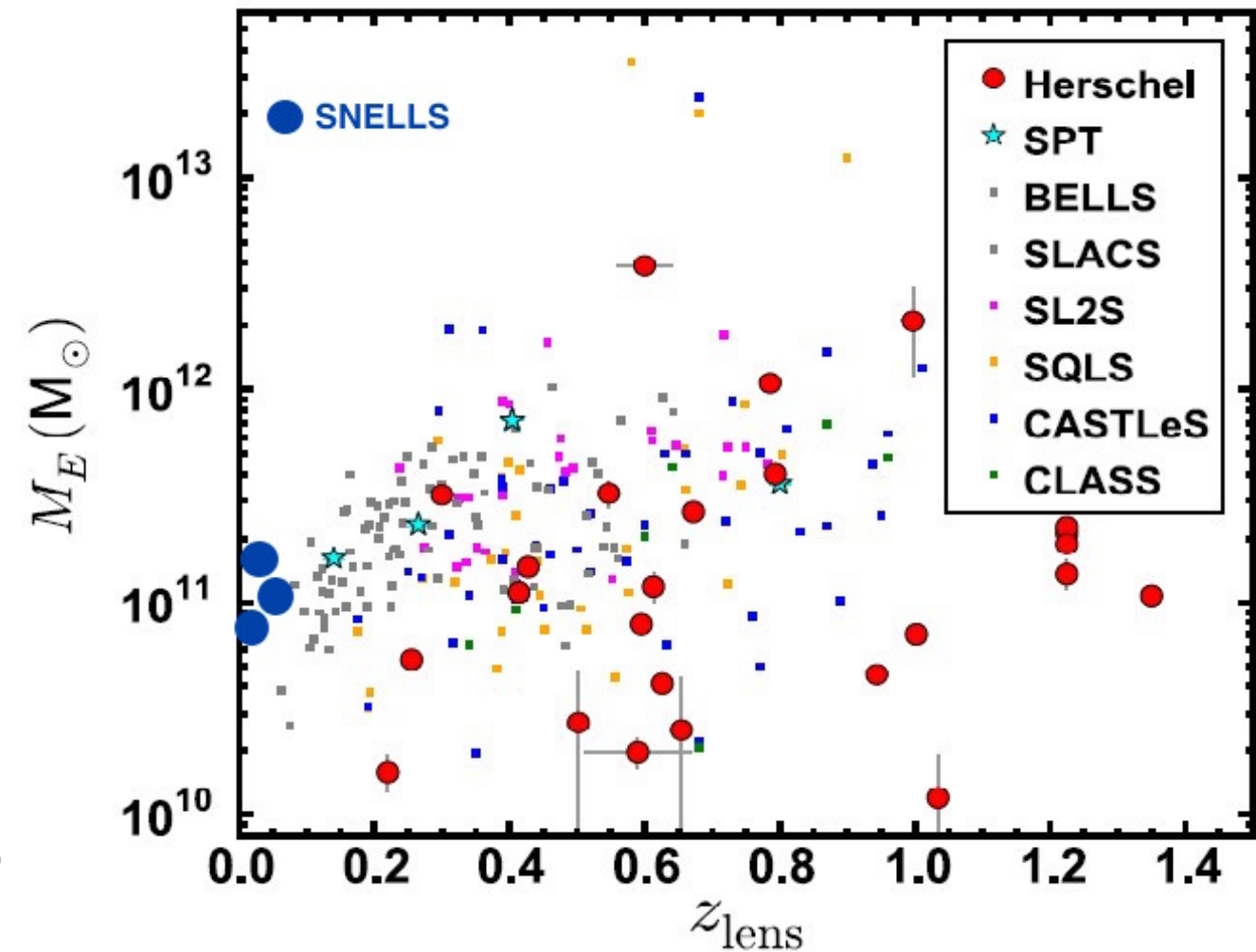
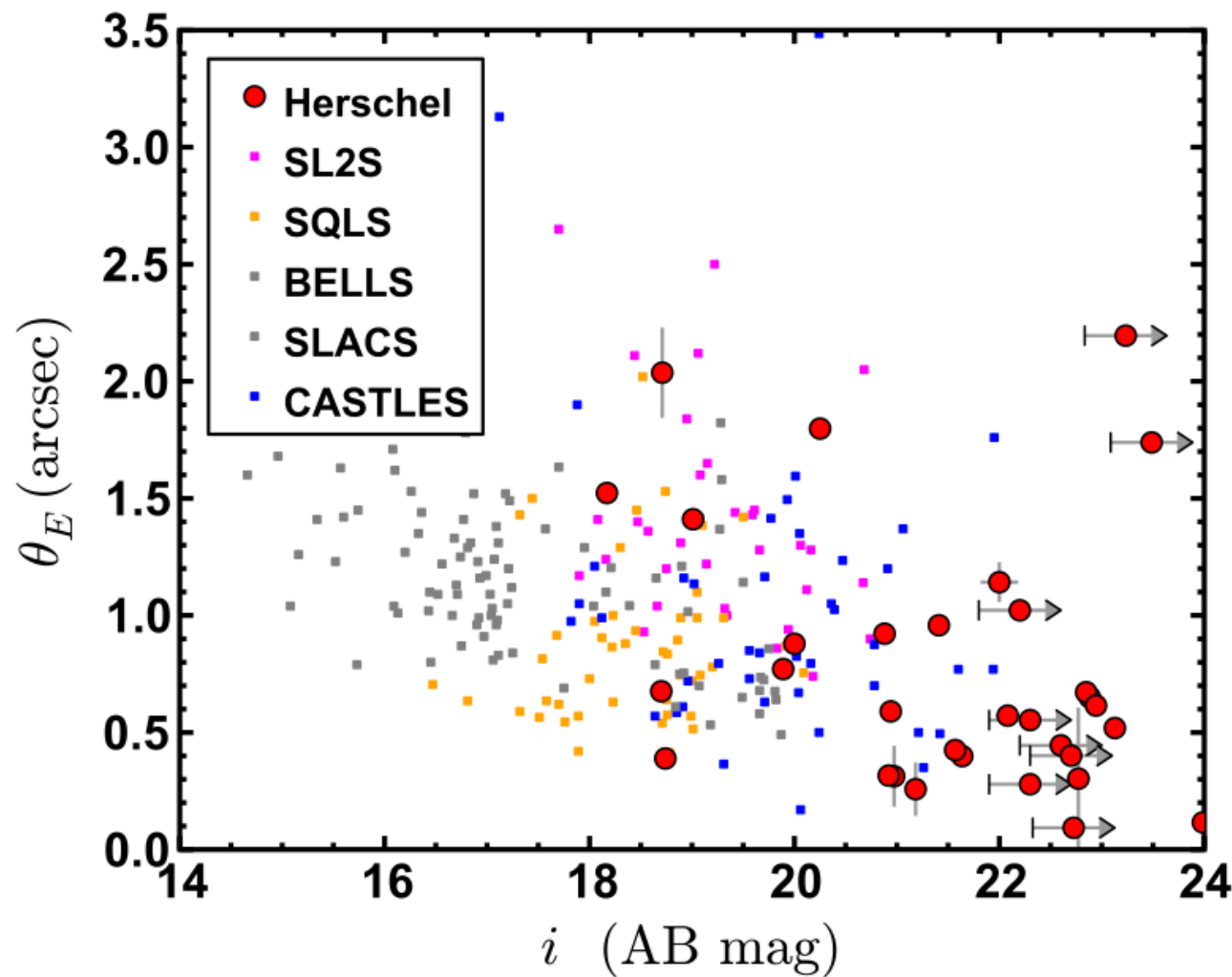


Bussmann, JW et al. 2014

Lensed HATLAS12-00 @z=3.3: gas, stars & dust are offset

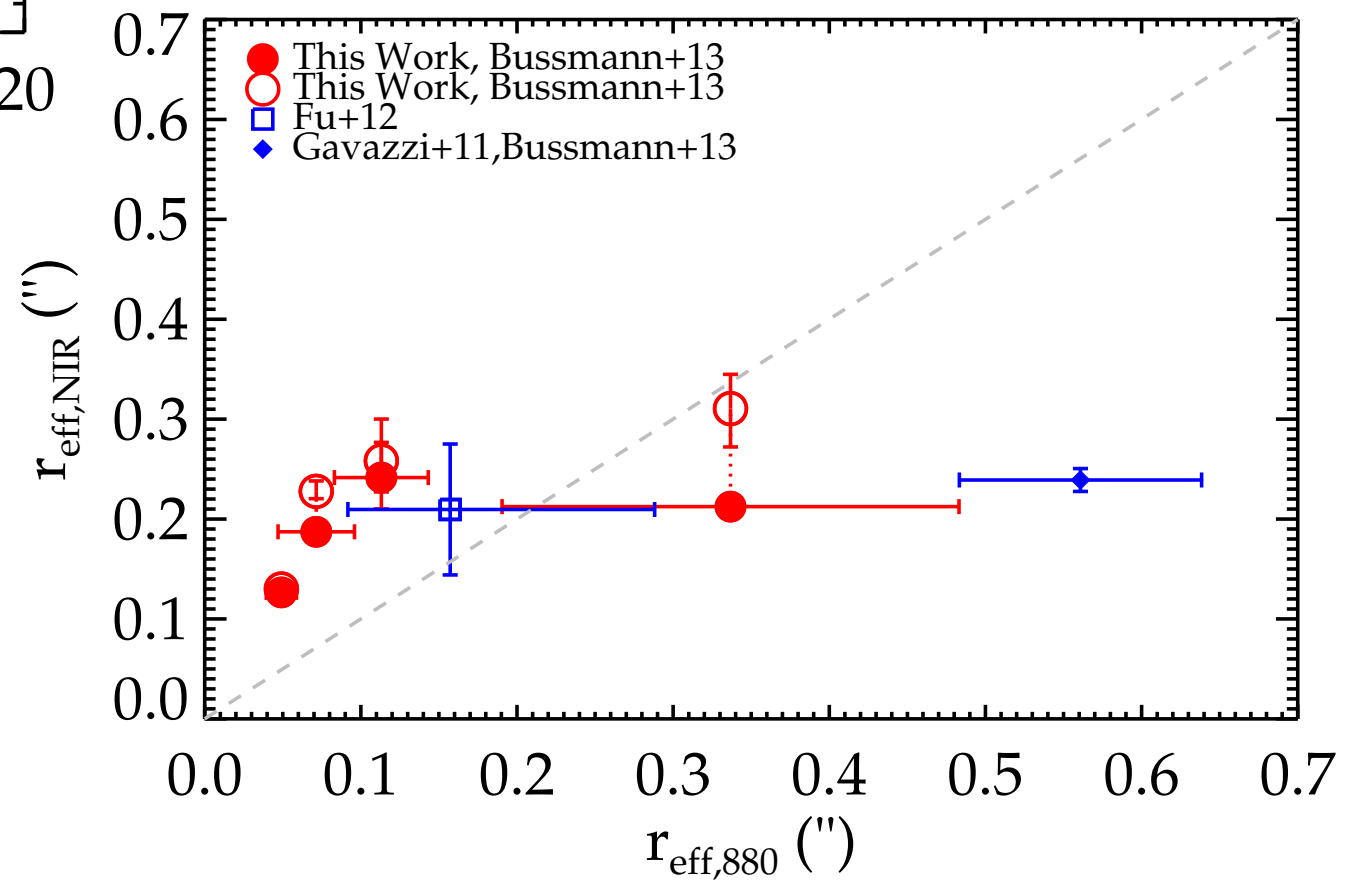
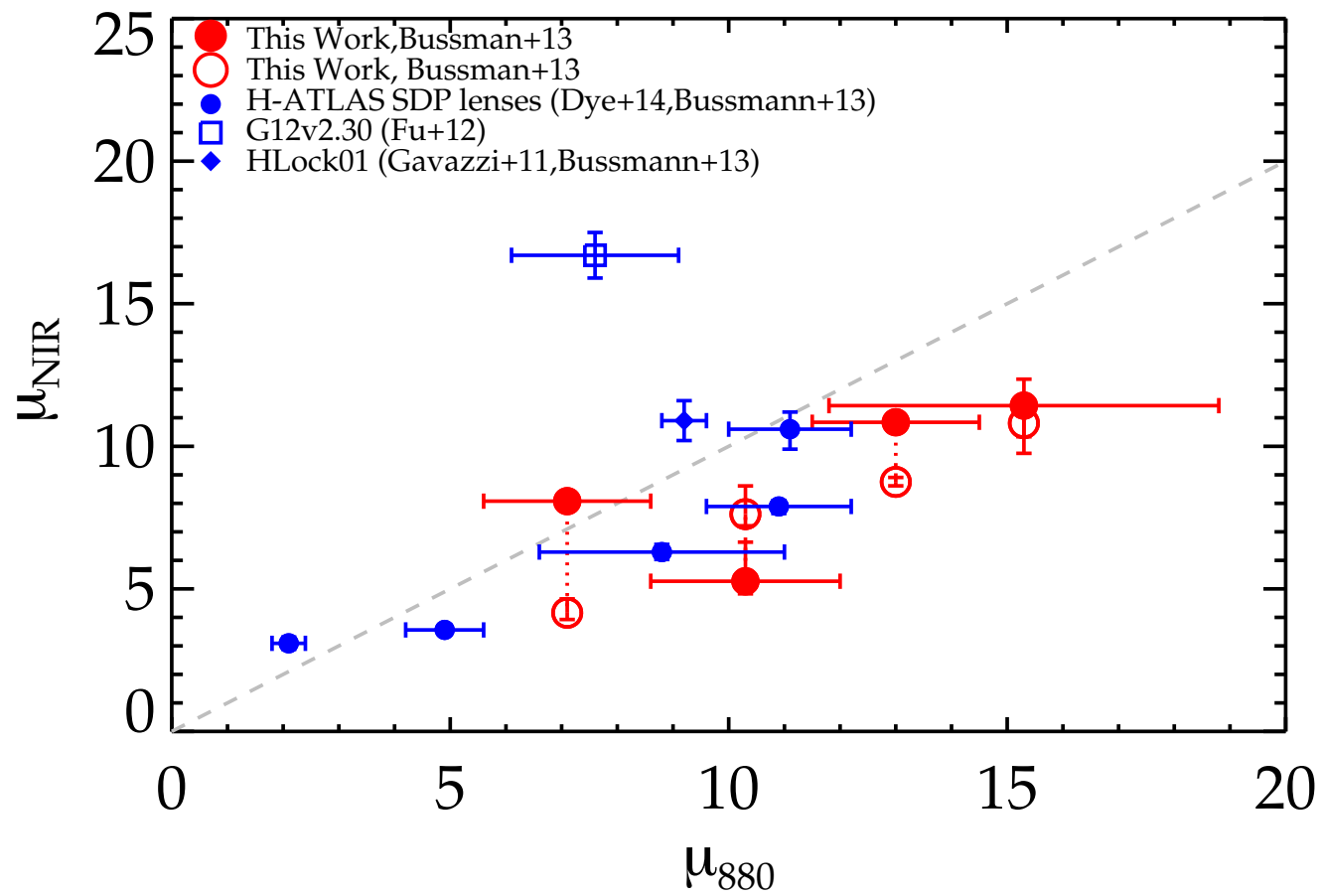


The lenses are fainter and higher z than other surveys



Bussmann, JW et al. 2013
& adapted by R. Smith

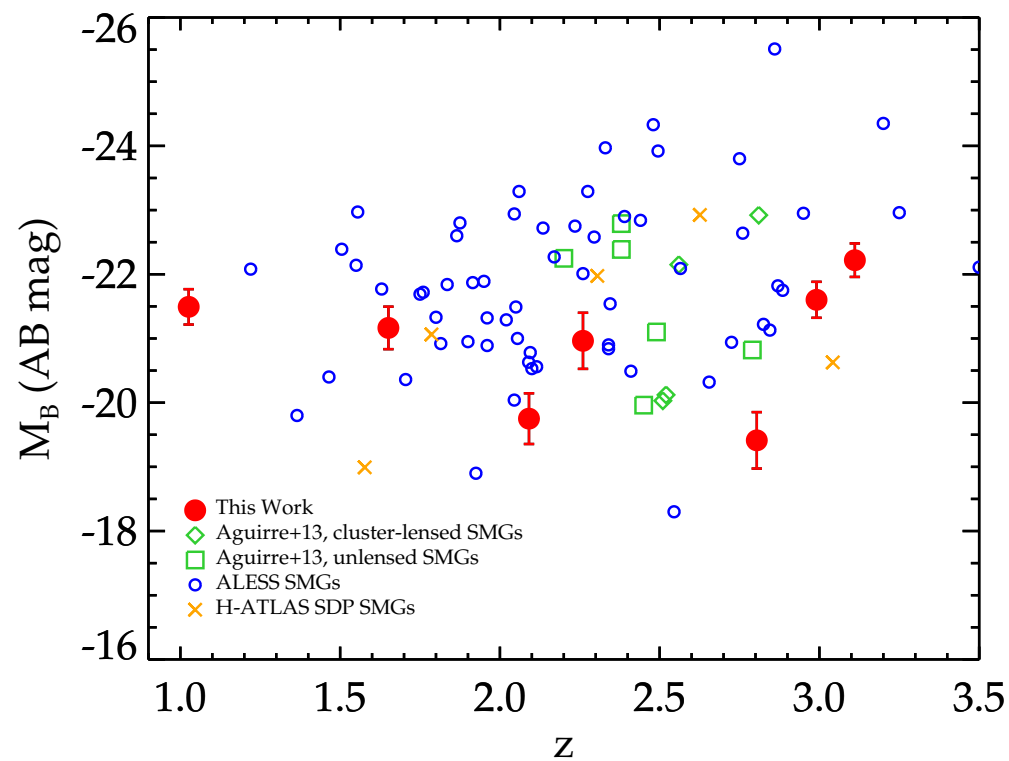
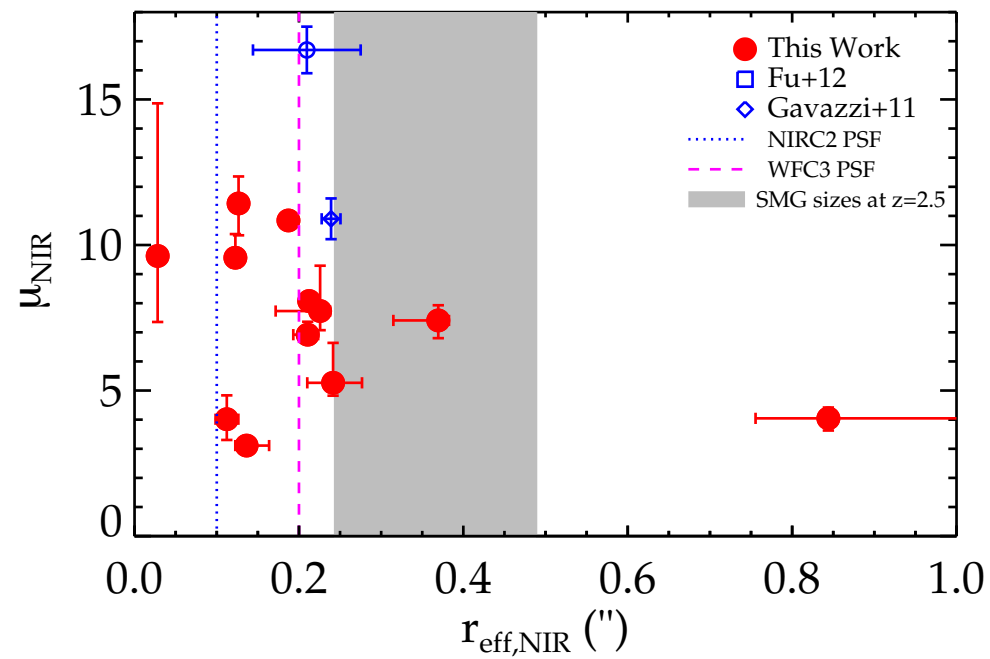
The submm emission is typically more magnified & smaller than the NIR



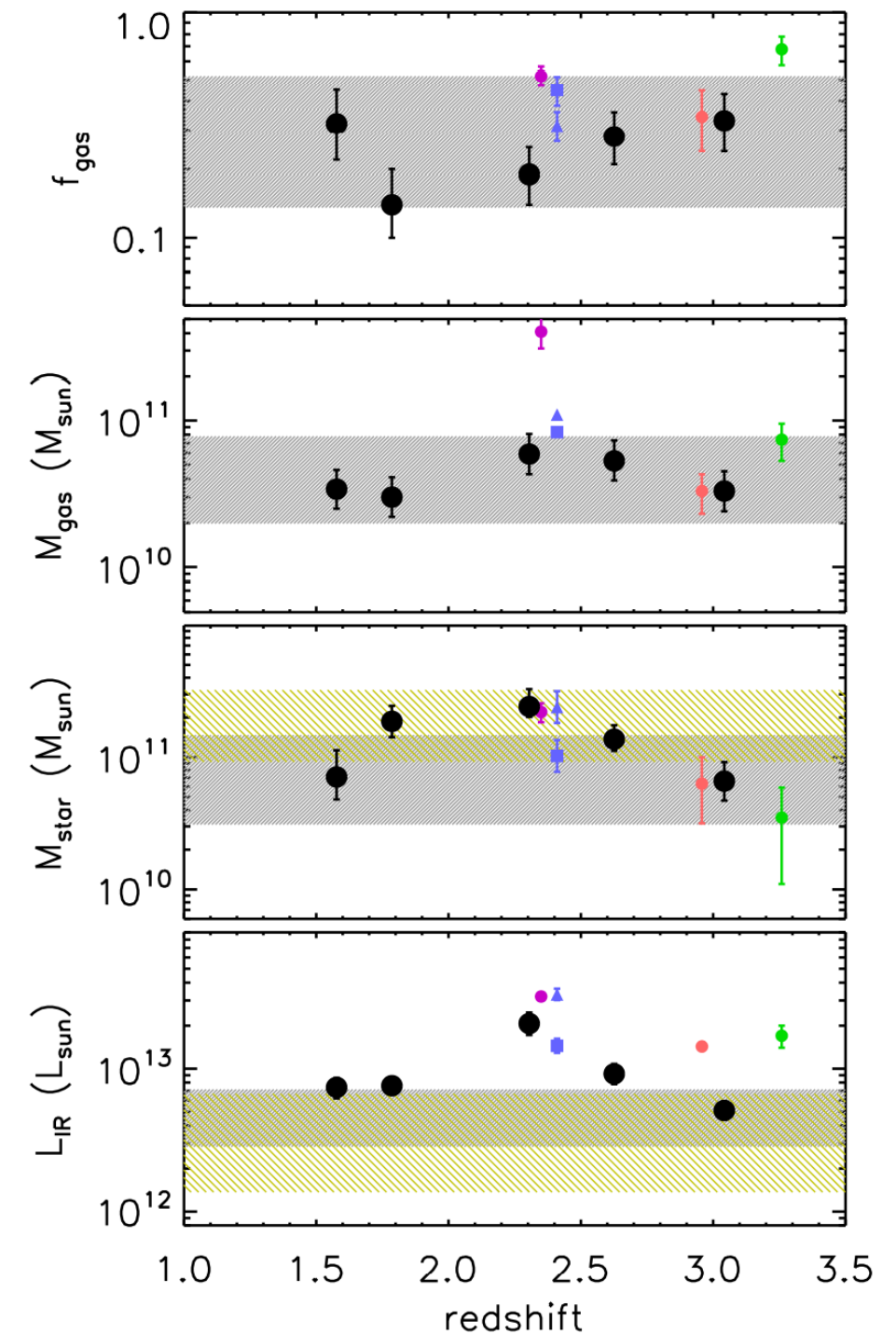
Calanog, JW et al. 2014

Lensing probes smaller structures but similar systems to classical SMGs

HerMES+H-ATLAS (red)



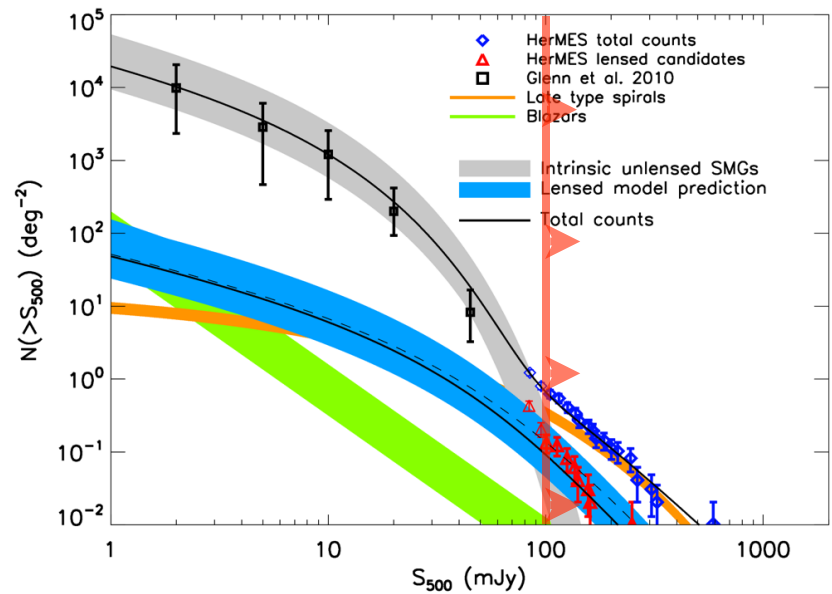
H-ATLAS original (black)



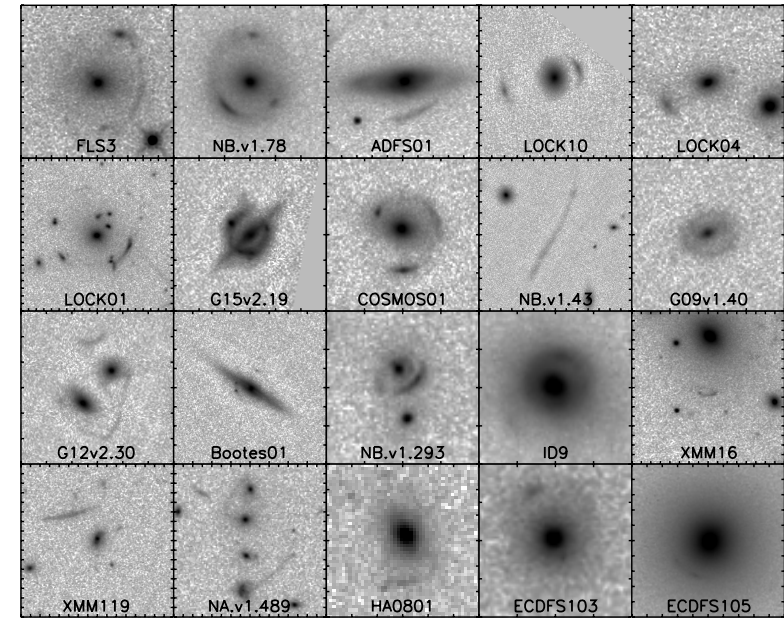
Calanog, JW et al. 2014
Negrello, JW et al. 2014

Summary

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

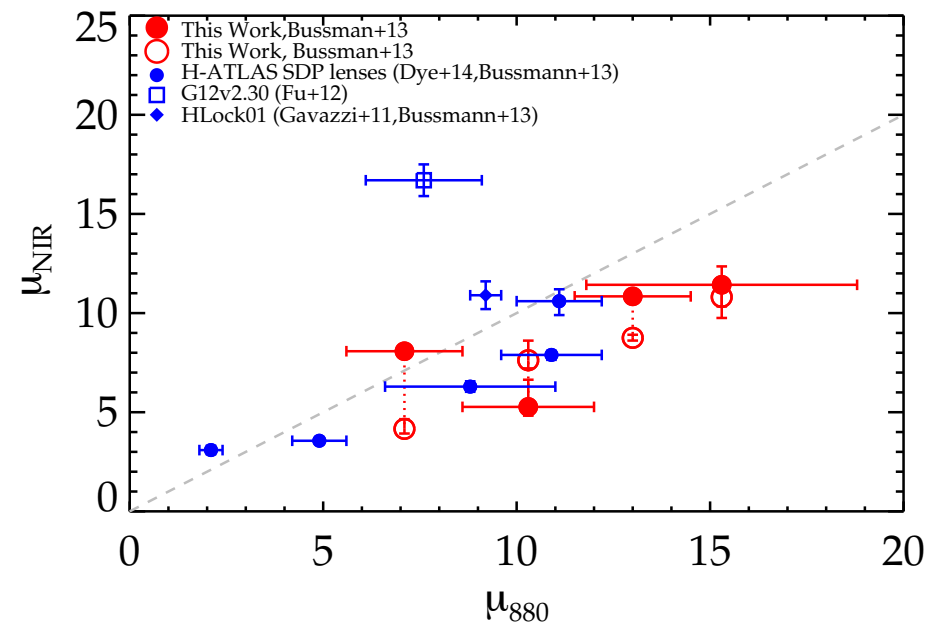
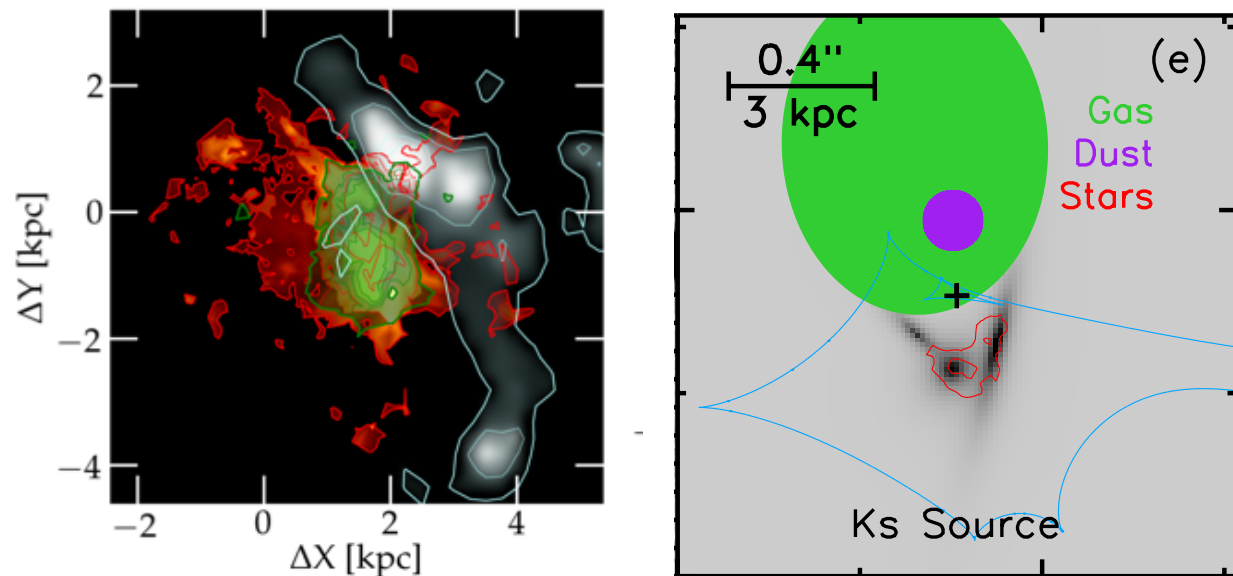


... and they are very efficient at finding lensed galaxies.



Lensing is revealing the complicated structures & conditions in $z > 2$ galaxies.

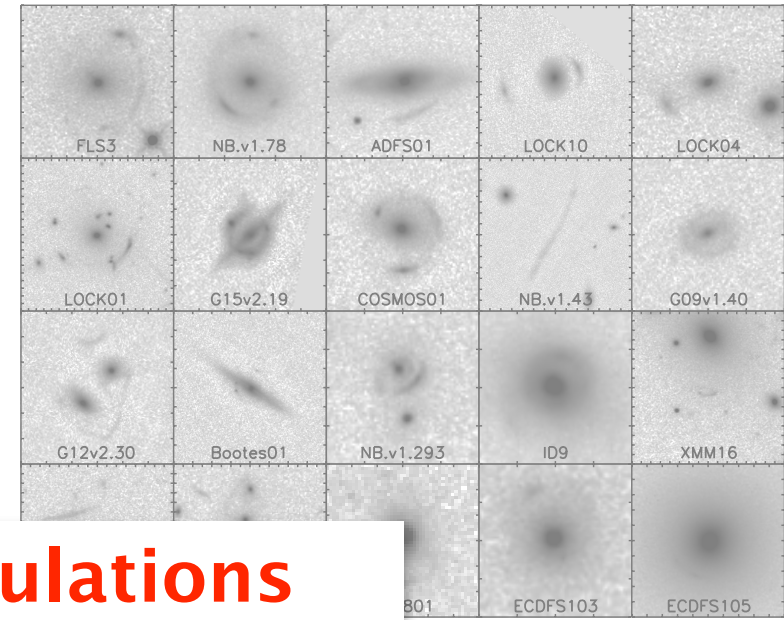
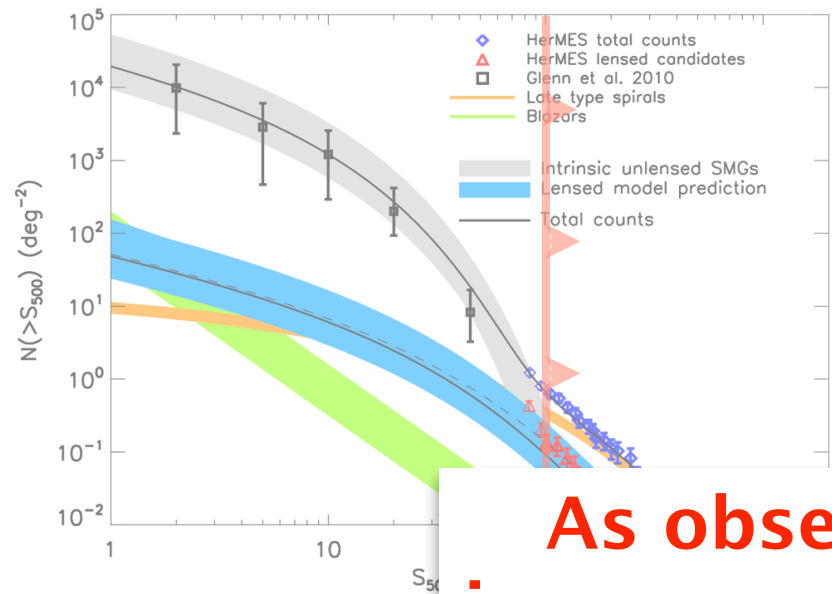
Typical magnifications are factors of $\sim 5-10$ and are often higher in the FIR than NIR.



Summary

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

... and they are very efficient at finding lensed galaxies.



As observations and simulations improve, are SMGs still a thorn in the side of simulations?

Lensing is revealing the conditions in $z > 2$ galaxies.

factors of $\sim 5-10$ and are often higher in the FIR than NIR.

