

# High resolution ALMA imaging of SMGs

Bitten Gullberg

with Ian Smail, Mark Swinbank  
and the ALESS collaboration.



Durham  
University

# Sub-millimetre galaxies

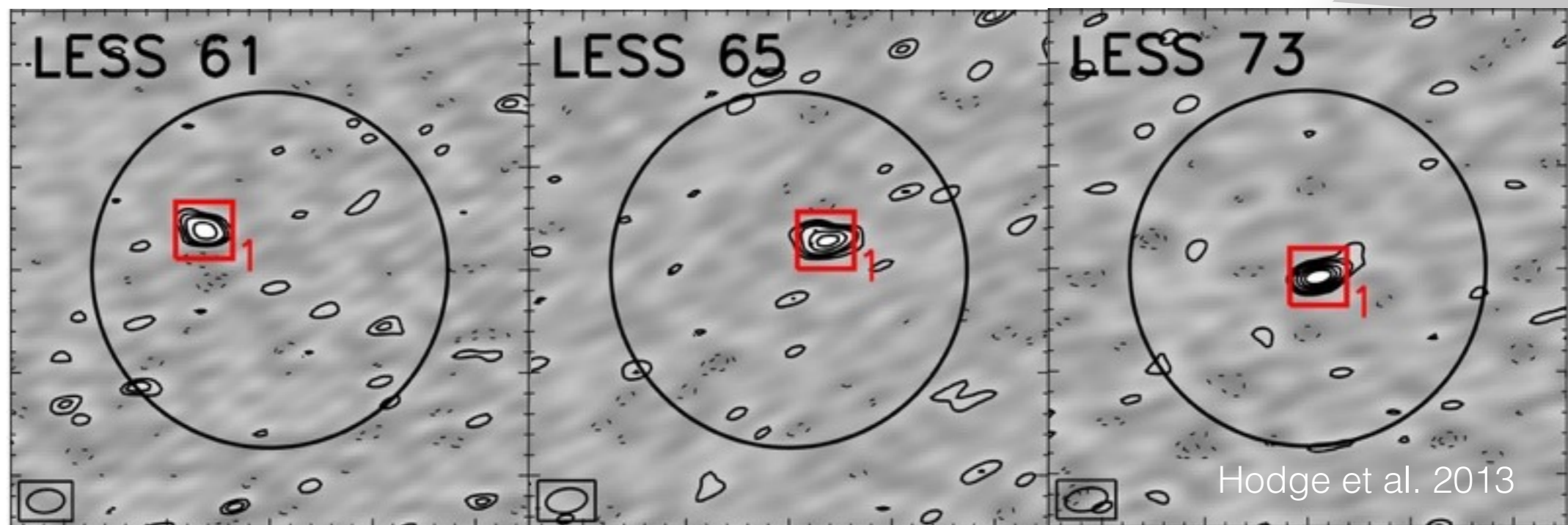
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- Bright ( $L_{\text{FIR}} > 10^{12} L_{\odot}$ ) galaxies detected in the sub-millimetre range.
- Star-burst dominated ( $\text{SFR} \sim 1000 M_{\odot}/\text{yr}$ ).
- High redshift
  - lensed
    - + makes them easier to detect (i.e. demands less observing time).
    - makes it difficult to achieve the initial conditions and morphology (lensing models).
  - non-lensed
    - makes them more difficult to detect (i.e. demands more observing time).
    - + have the initial conditions and morphology available (no need for lensing models).

# Samples: ALESS

ALMA LABOCA ECDFS Sub-millimetre Survey  
where ECDFS is: Extended Chandra Deep Field South

- 126 SMGs discovered with LABOCA/APEX at 850 $\mu$ m, with angular resolution of  $\sim 19''$  FWHM (Weiss et al 2009).
- Followed up at 850 $\mu$ m with ALMA in cycle-0 with angular resolution of  $\sim 1.5''$  (Hodge et al. 13).

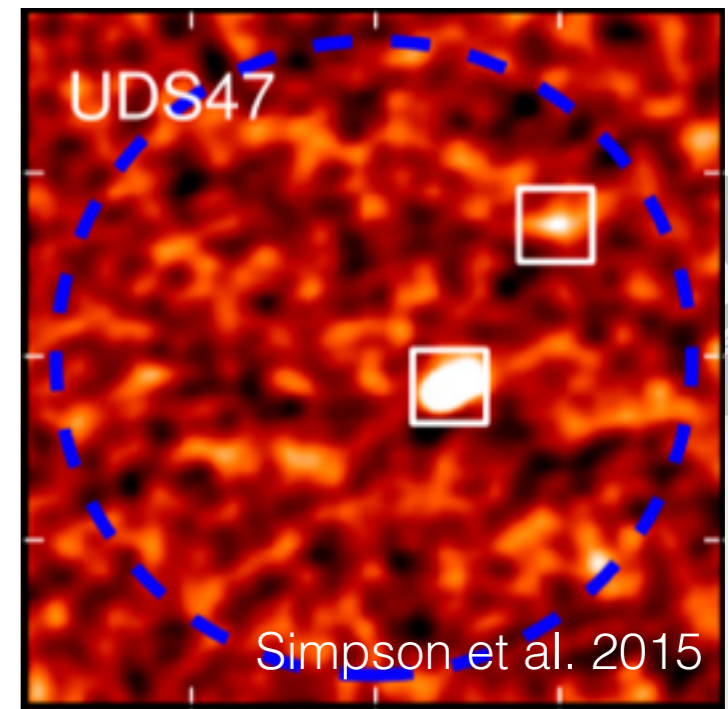


# Sample: AS2CLS

ALMA SCUBA-2 Cosmology Legacy Survey

where SCUBA-2 is: Sub-millimetre Common-User Bolometer Array 2

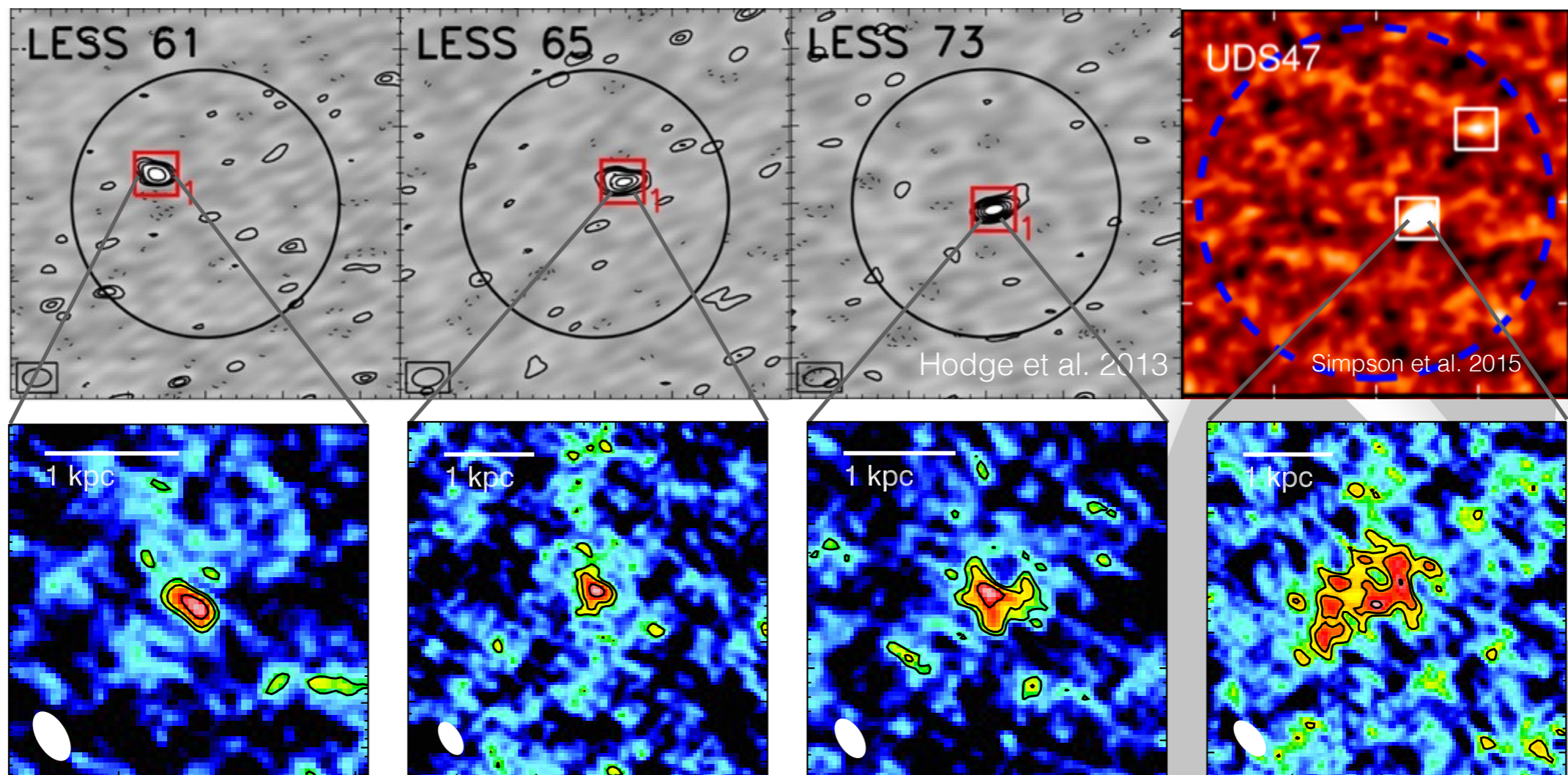
- 30 bright submm sources detected in the UDS by SCUBA-2 at an angular resolution of 20.5".
- Followed up at 850 $\mu$ m with ALMA in cycle 1 at an angular resolution of 0.3", detecting 52 SMGs (Simpson et al. 2015).



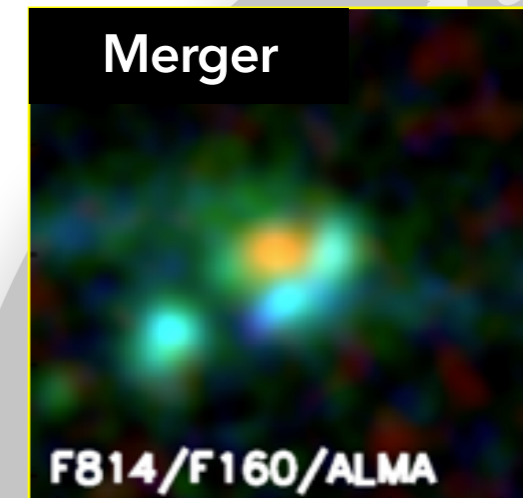
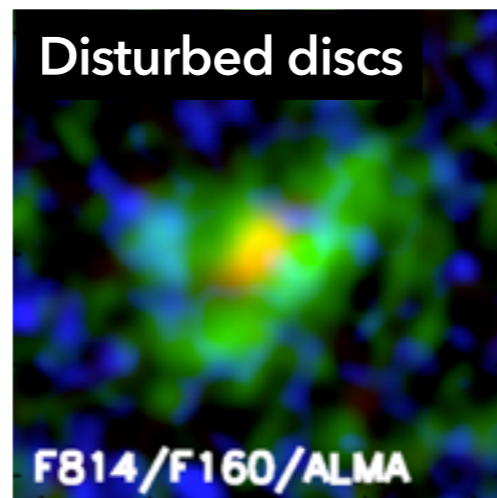
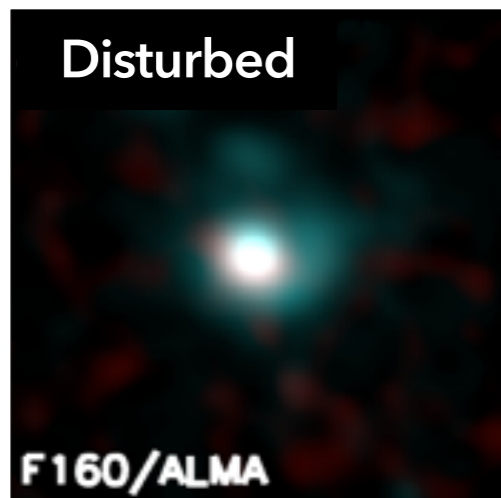
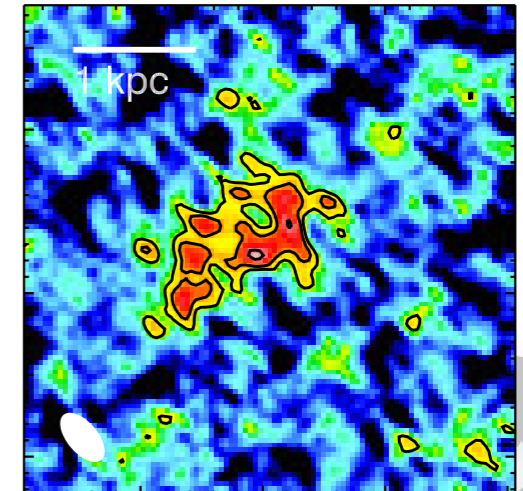
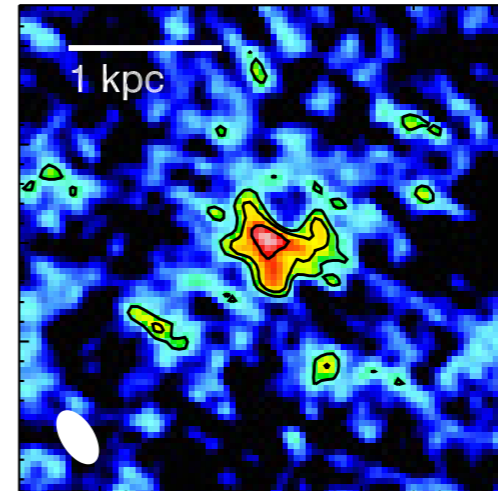
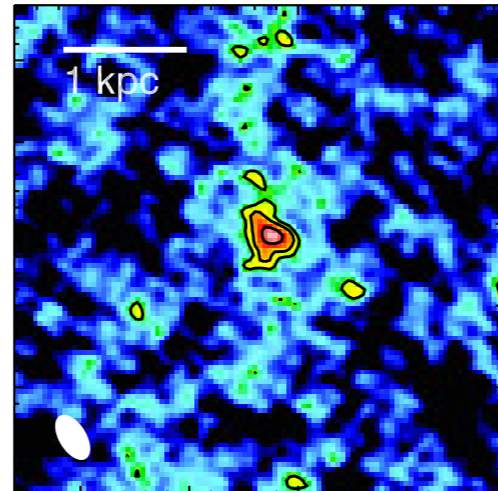
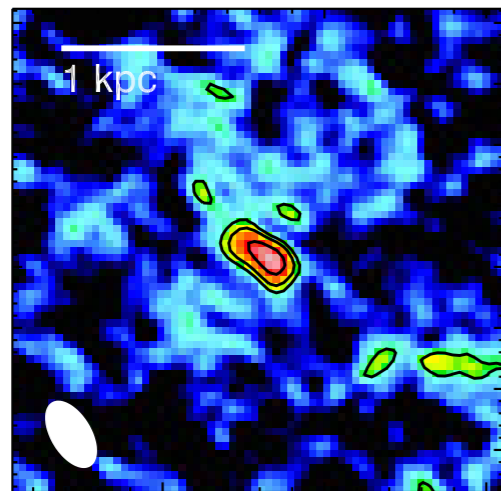


# High resolution

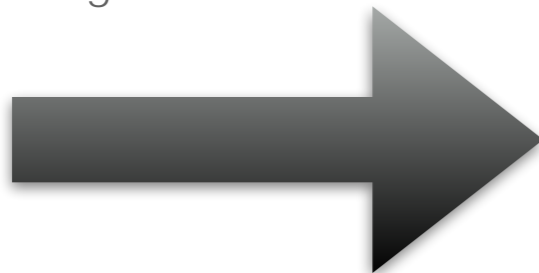
- Follow-up with ALMA of four SMGs
- High redshift:  $z \sim 4.4 - 4.8$
- Longest-baseline  $\sim 16\text{km} \Rightarrow$  angular resolution of **0.03''**.



# Combined HST and ALMA imaging

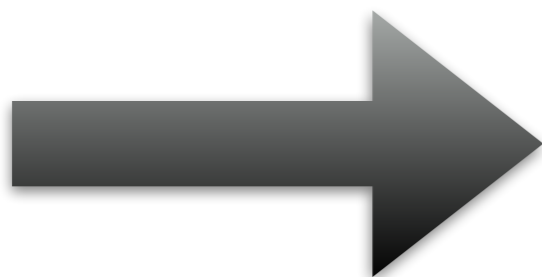
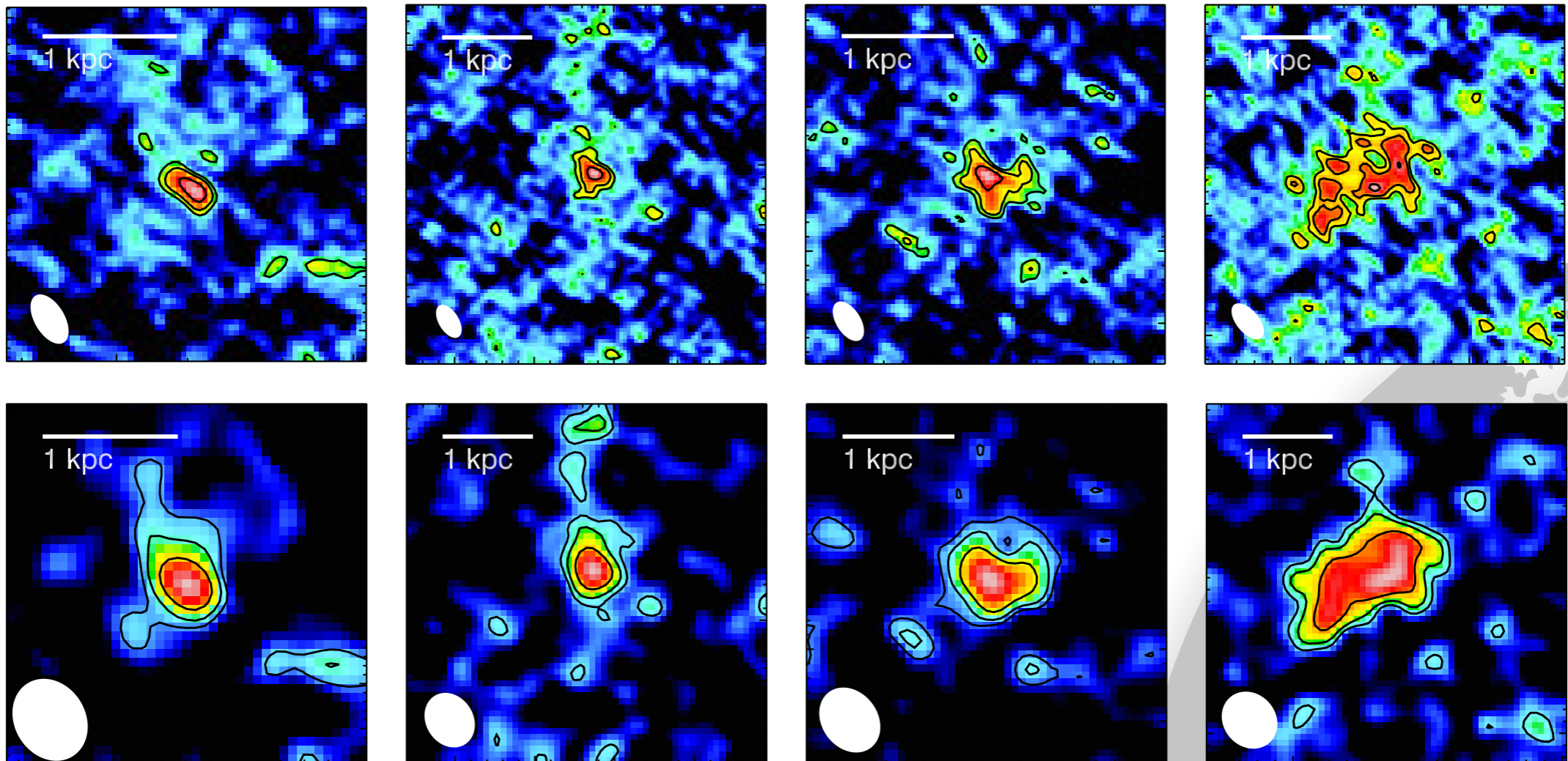


Hodge et al. 2016



Apparent morphology: smooth and compact or extended and 'clumpy'

# 850 $\mu\text{m}$ continuum emission

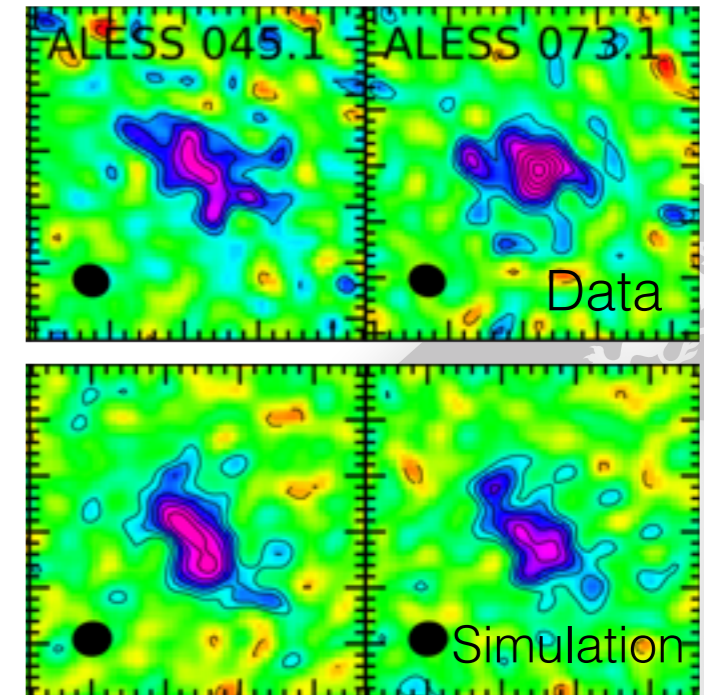
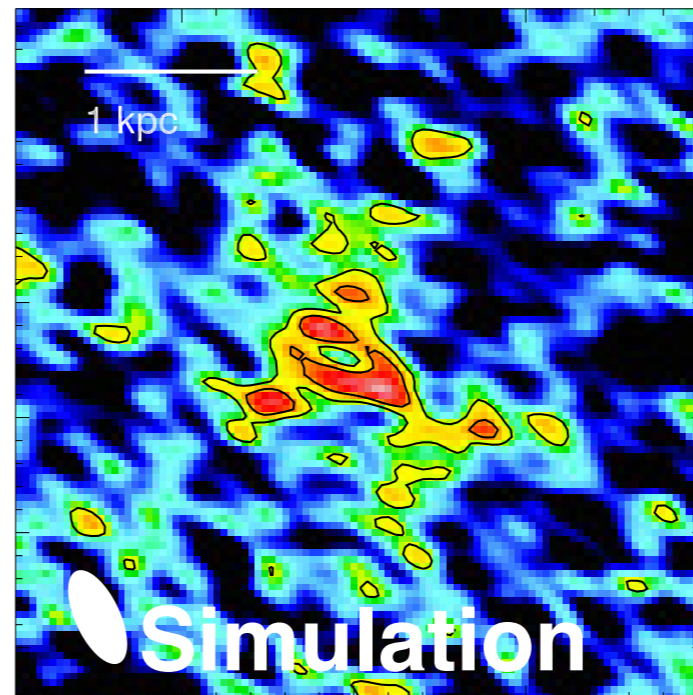
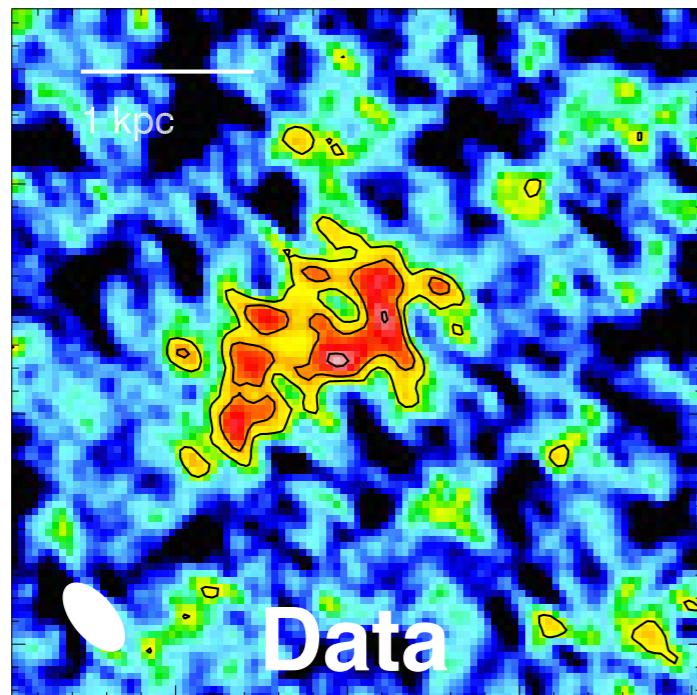


Tapering to from 0.03'' to 0.05''  
makes the 'clumps' less significant  
→ more similar to smooth discs.



# Data vs simulations

Simulation: how a disc with similar size and brightness as the low resolution observations will portray in 0.03" observations.

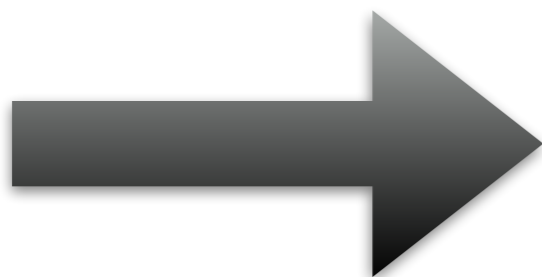
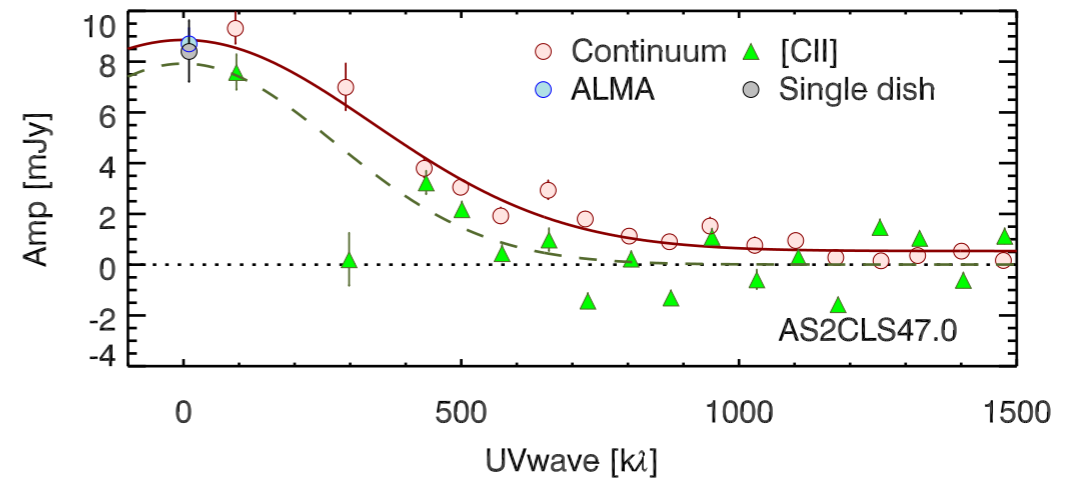
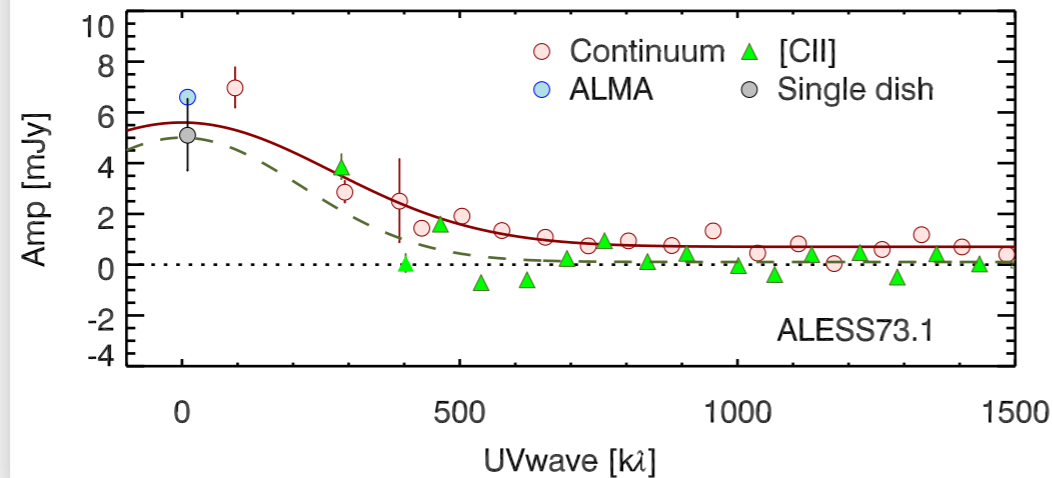
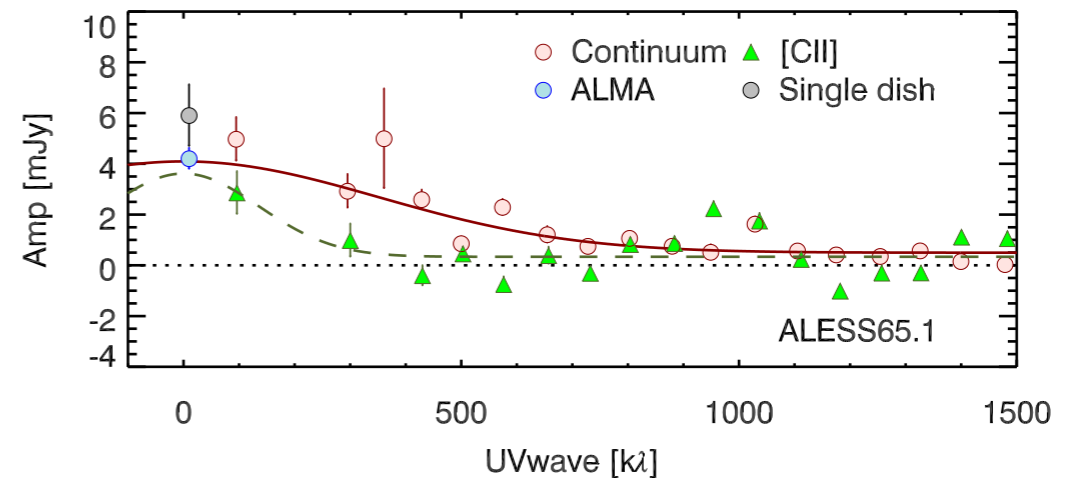
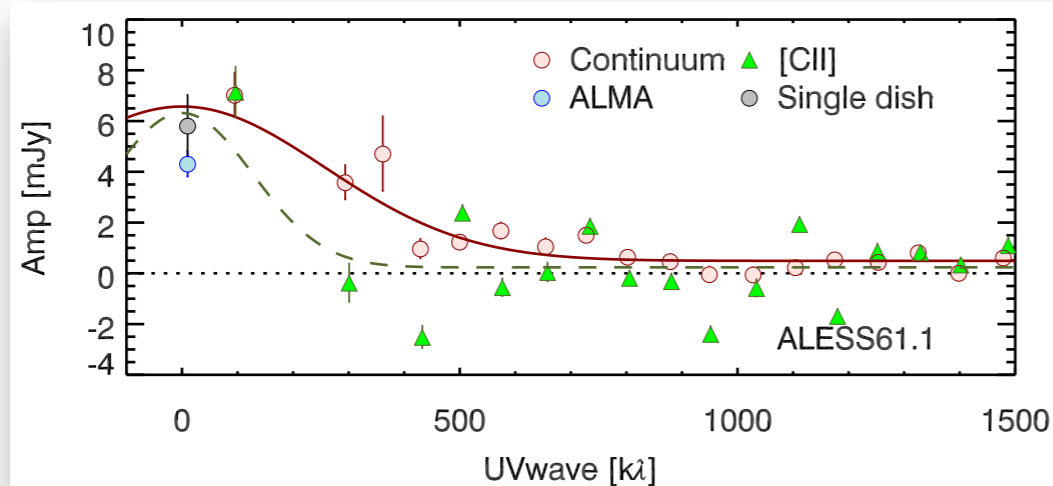


Hodge et al. 2016



A smooth disks can portray as clumpy at high resolution

# Sizes: continuum vs [CII]



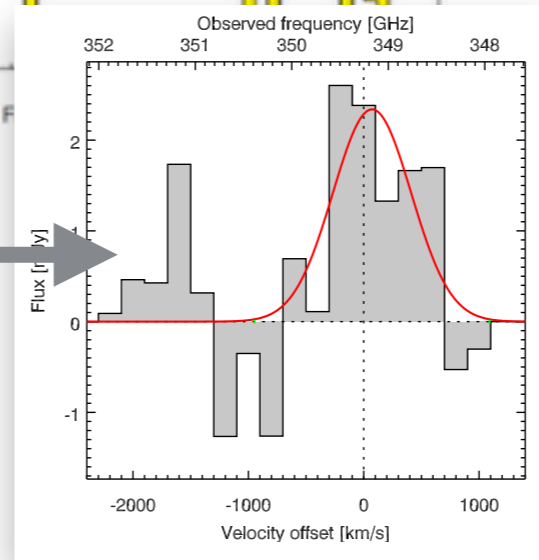
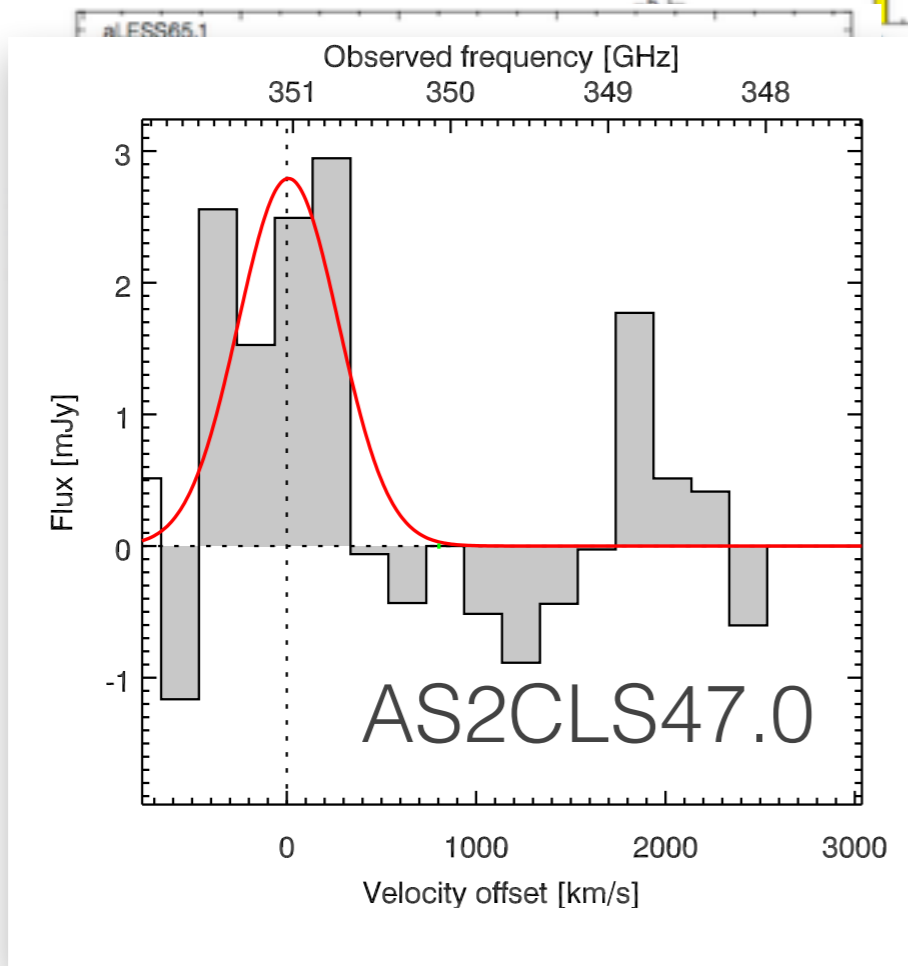
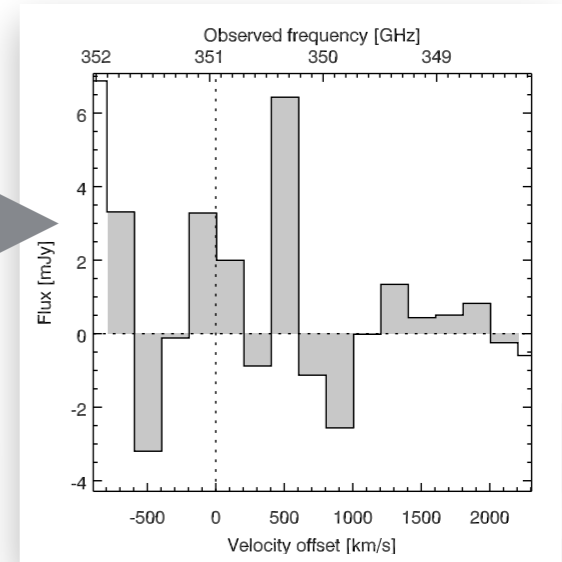
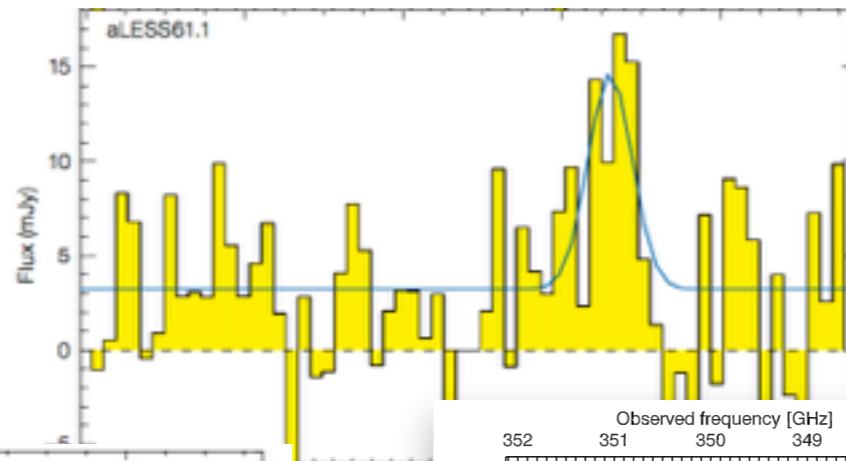
[CII] emission is more extended than dust continuum emission



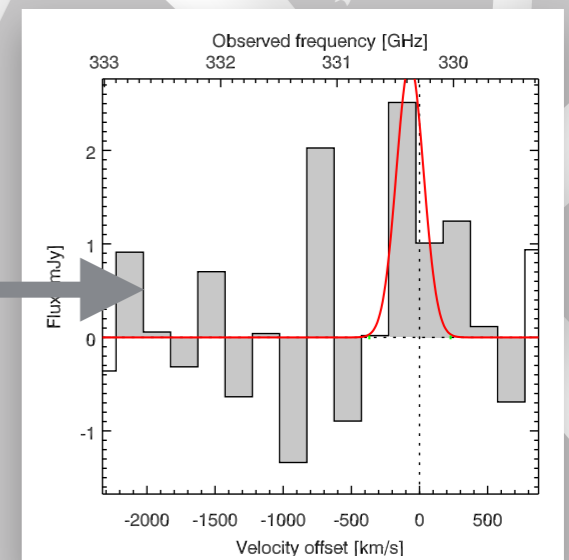
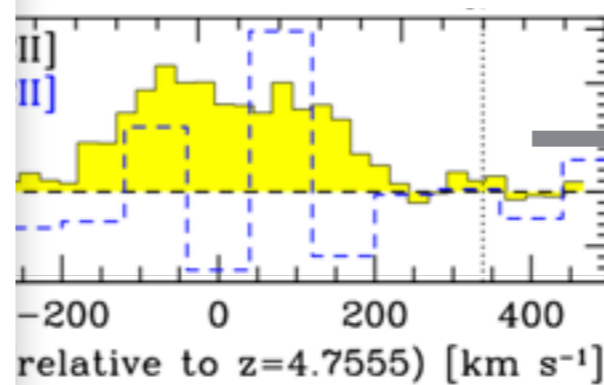
# [CII] emission

ALESS61.1

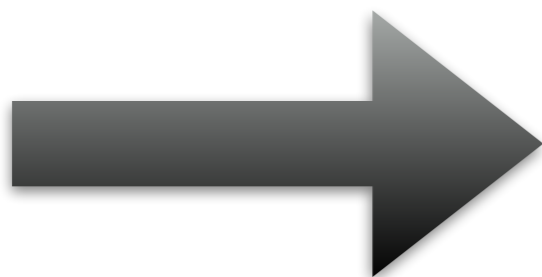
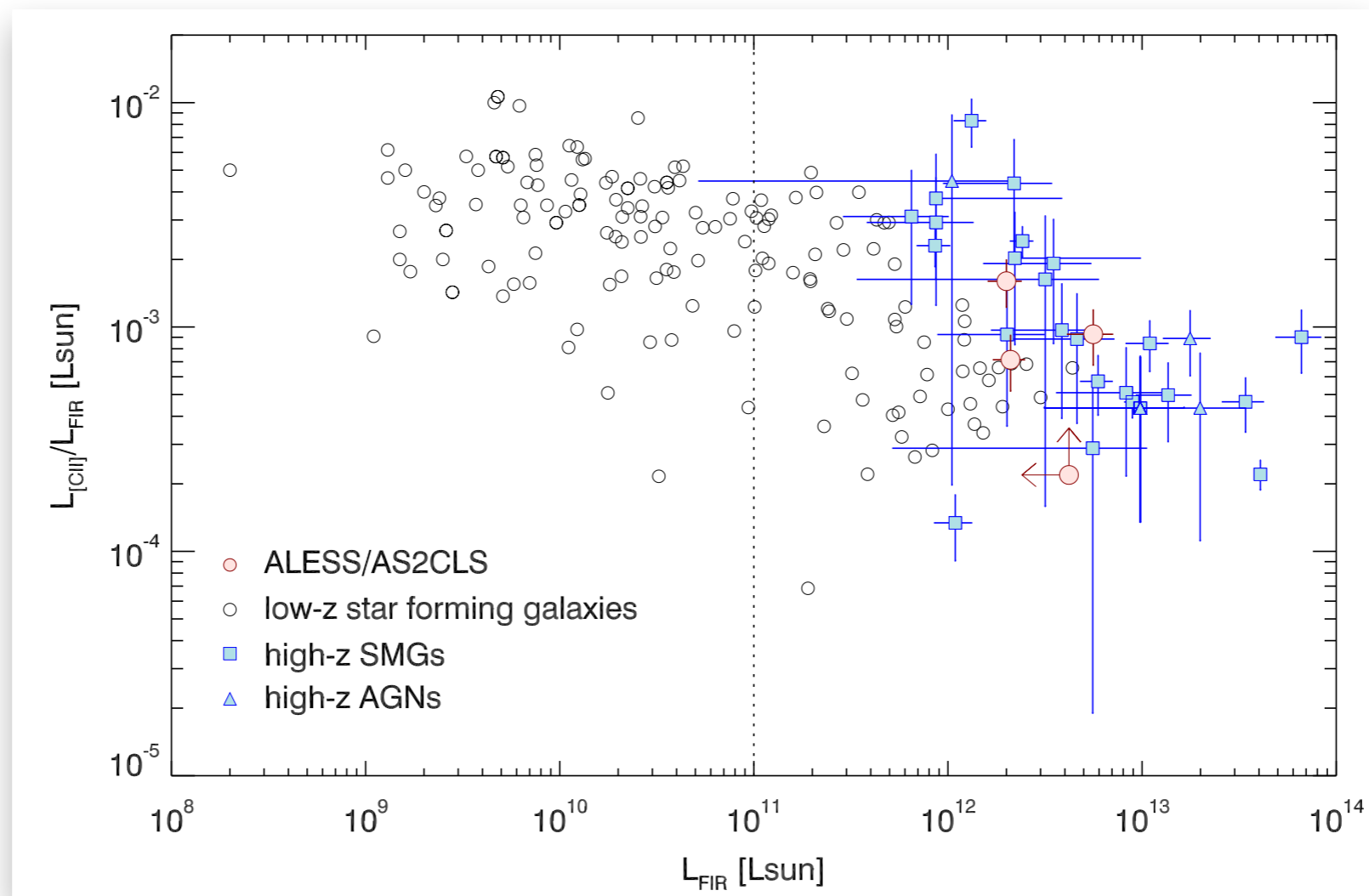
Swinbank et al. 2014



ALESS65.1



# [CII] 'deficit'



Follow the 'normal' [CII] line  
'deficit' compared to FIR luminosity

# Summary

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High resolution is good, but one has to be careful not to resolve out emission...

Smooth discs can portray as 'clumpy' at high resolutions.

The dust is more compact than [CII] emission.

# Thank you for your attention



Durham  
University

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