Mock Surveys of the Sub-millimetre Sky

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DEX-X: Thurs 9th Jan 2014

Institute for Computational Cosmology

Outline

- Sub-millimetre Galaxies
- Observational Motivation
  - Angular resolution
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- Theoretical Model
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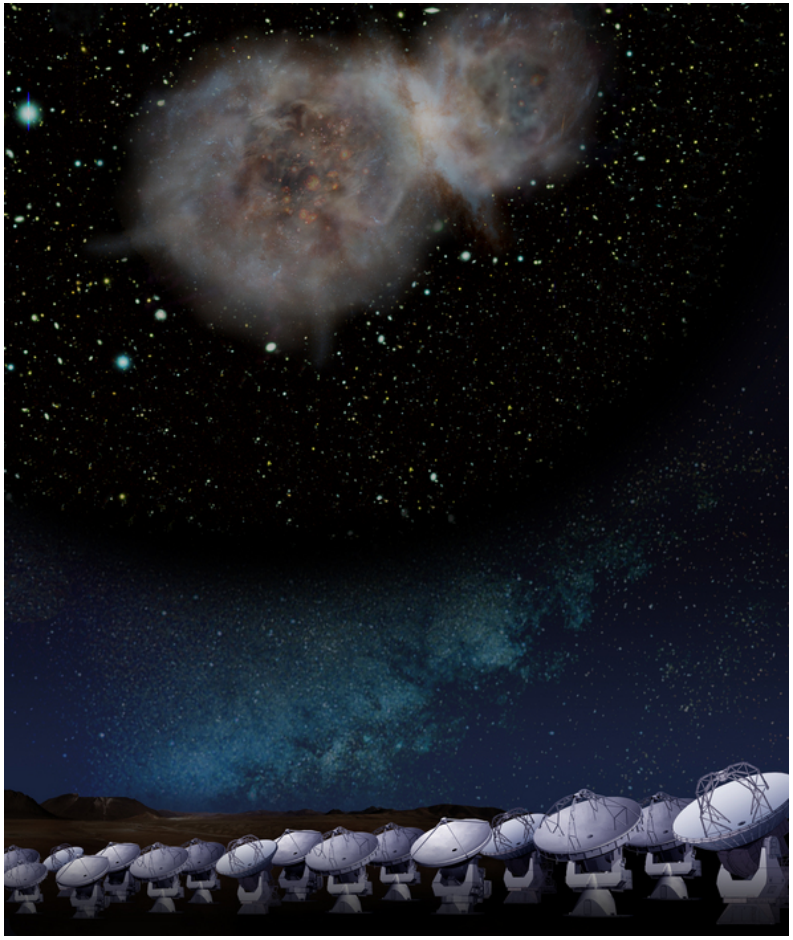
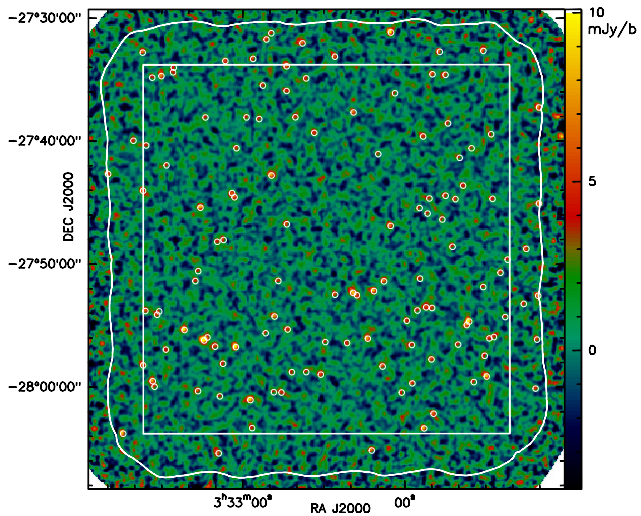
  - Dust model
  - Creating lightcones
- Results and Future Work



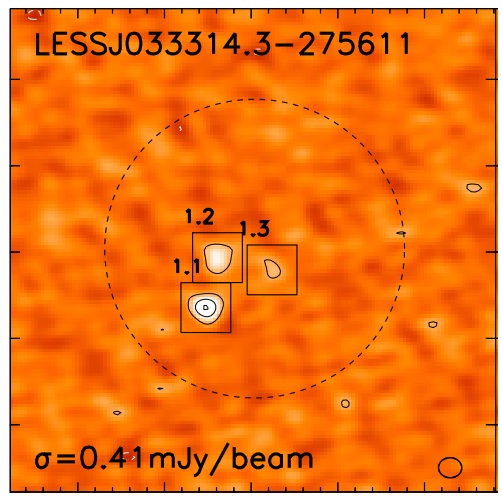
ALMA observing sub-mm galaxy LESS J0332
credit:NAOJ

Sub-millimetre Galaxies (SMGs)

- First detected by SCUBA/JCMT in late '90s
- Luminous, high redshift ($z \sim 1-4$), dusty galaxies
- $L_{\rm IR} \gtrsim 10^{12} L_\odot \implies$ SFR $\sim 10^2$-10^3 $M_\odot yr^{-1}$
- Single-dish sub-mm surveys:
  - Coarse angular resolution ($\sim$ 20" FWHM)
  - Pencil-beam areas ($\lesssim 0.7$ deg^2)



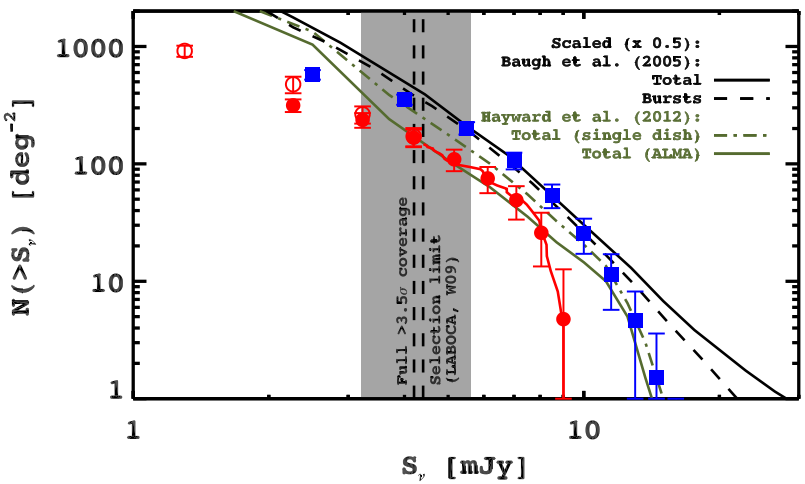
870μm LESS (20" FWHM, 0.25 deg^2) map
Weiss *et al* 2009



ALMA (1.5" FWHM) observation of
LABOCA (20" FWHM) source
Karim *et al* 2013

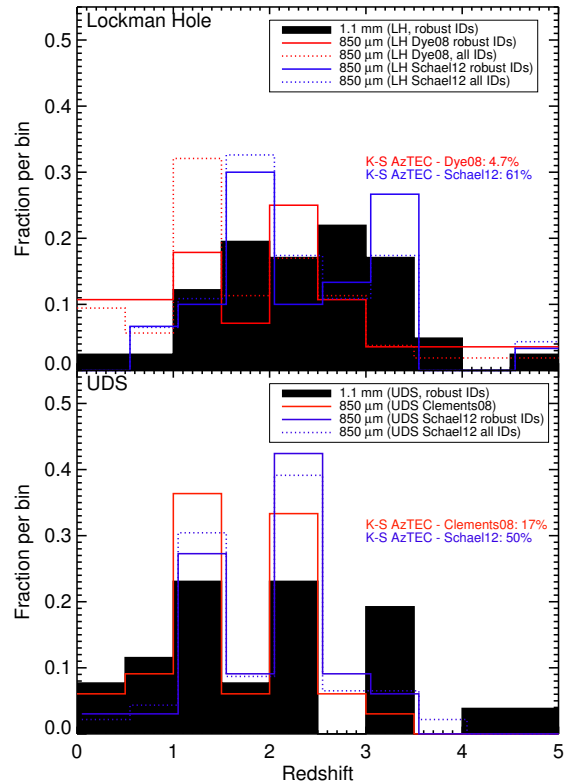
Observational Motivation

- Angular resolution:
  Some 20" 'blended' sources break up into multiple fainter 1.5" sources, affecting observed number counts



Karim *et al* 2013

- Field-to-field variations:
  2% prob of LH and UDS samples being drawn from same population

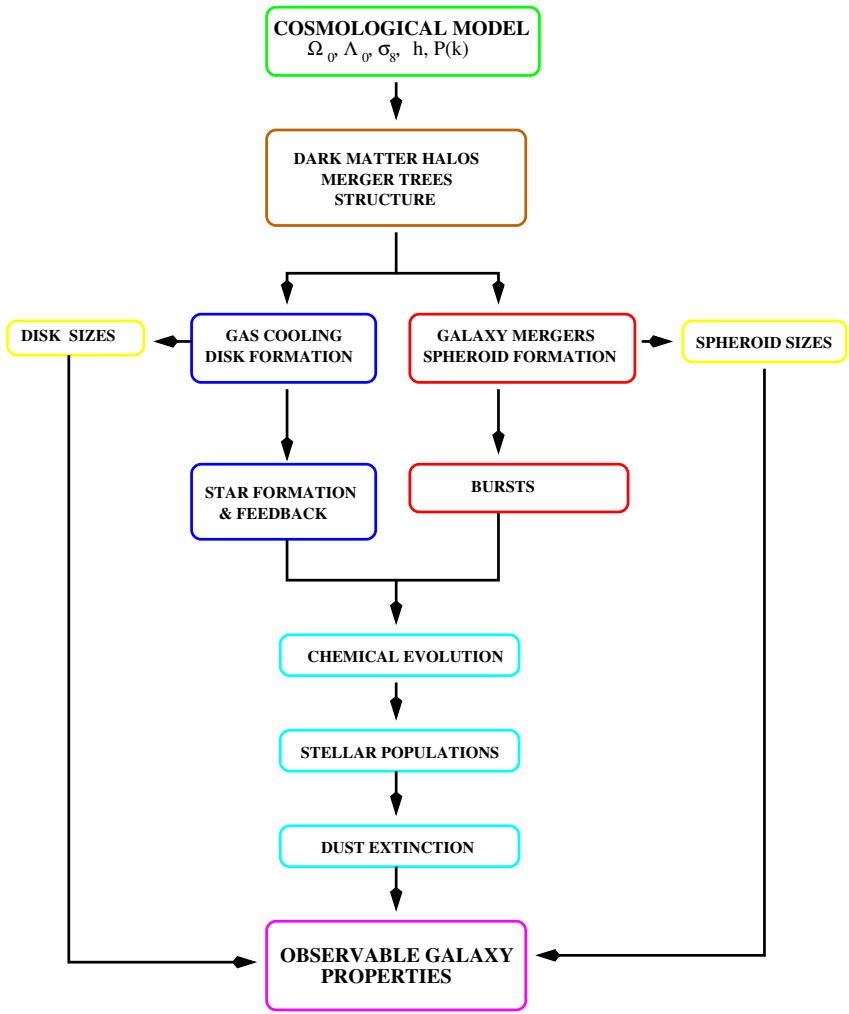


Michalowski *et al* 2012

GALFORM

Durham Semi-Analytic Galaxy Formation Model

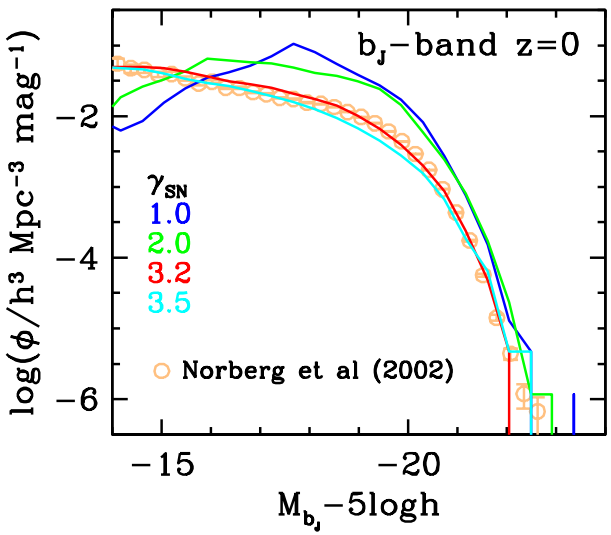
- Galaxy formation and evolution *is* complex
- Semi-Analytic Models (SAMs) use simplified descriptions of physical processes
- *Ab initio*, physically motivated method to populate N-body simulations with galaxies, with minimal computational expense
- Parameters constrained by requiring local galaxy population to be reproduced

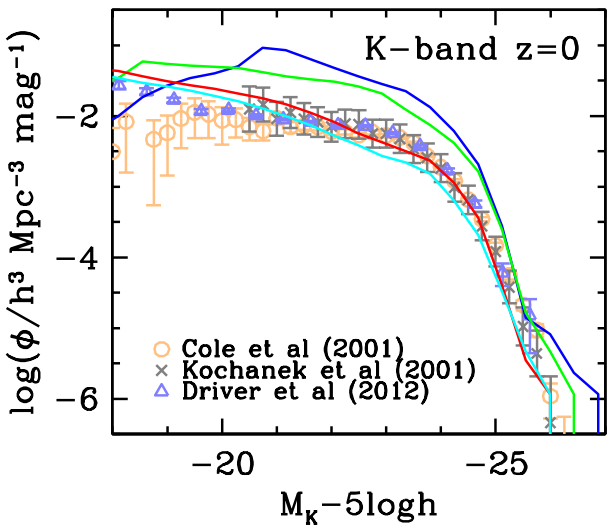


Adpated from Cole *et al* (2000)

Lacey `14 Model

Features of the Model





Lacey *et. al.* 2014 *in prep*

- Millennium N-body simulation (WMAP-7 cosmology)
- AGN feedback
- Improved star formation treatment
- Successfully predict sub-mm observations and present day ($z = 0$) luminosity function
- Top-heavy IMF ($x = 1$) in starburst galaxies
- Bursts triggered by disk instabilities and galaxy mergers
- Multi-wavelength predictions
  - K-band luminosity function
  - Lyman-break luminosity function

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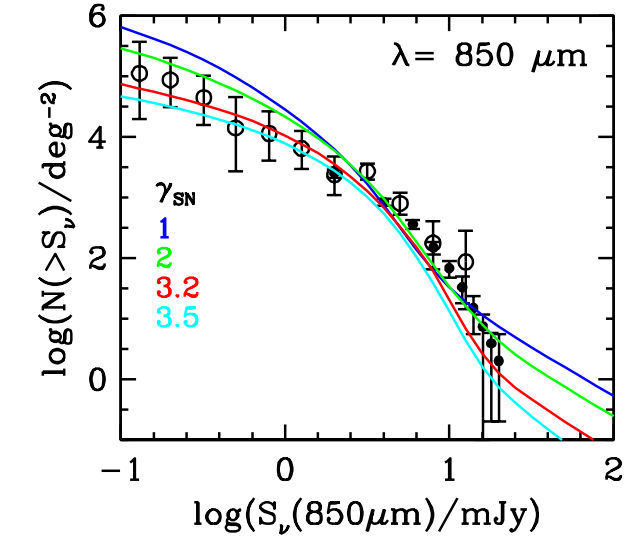

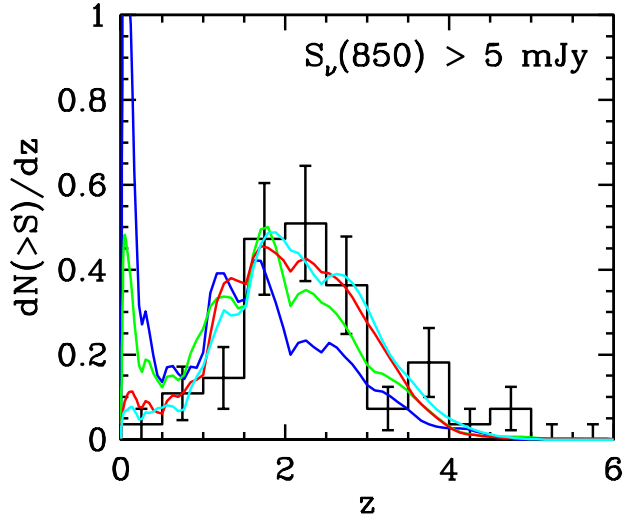

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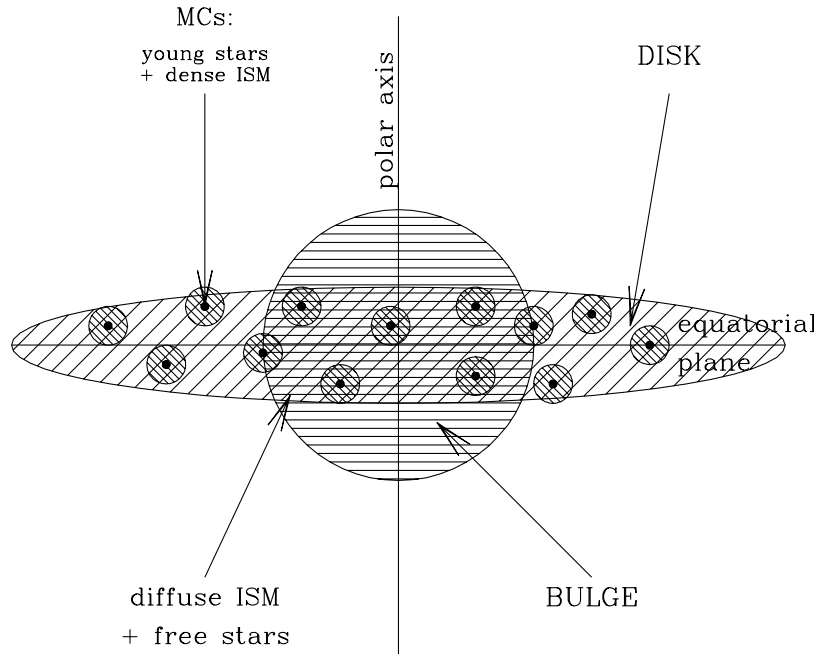
Galform Dust Model

- Two component dust medium: Molecular clouds (in which stars form) + Diffuse ISM
- Dust in thermal equilibrium with stellar radiation emits as modified blackbody:

$$L_\lambda^{\text{dust}} = 4\pi\kappa_d B_\lambda(T_d) M_d$$

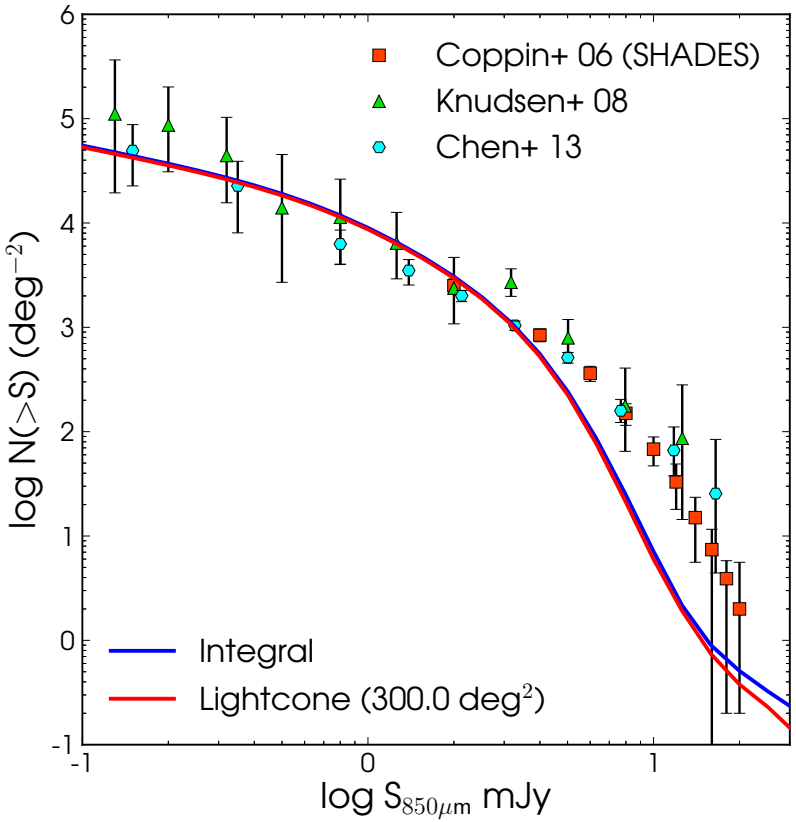
- Dust temperature calculated self consistently



Granato *et. al.* 2000

Creating Lightcones

Merson *et al* 2013

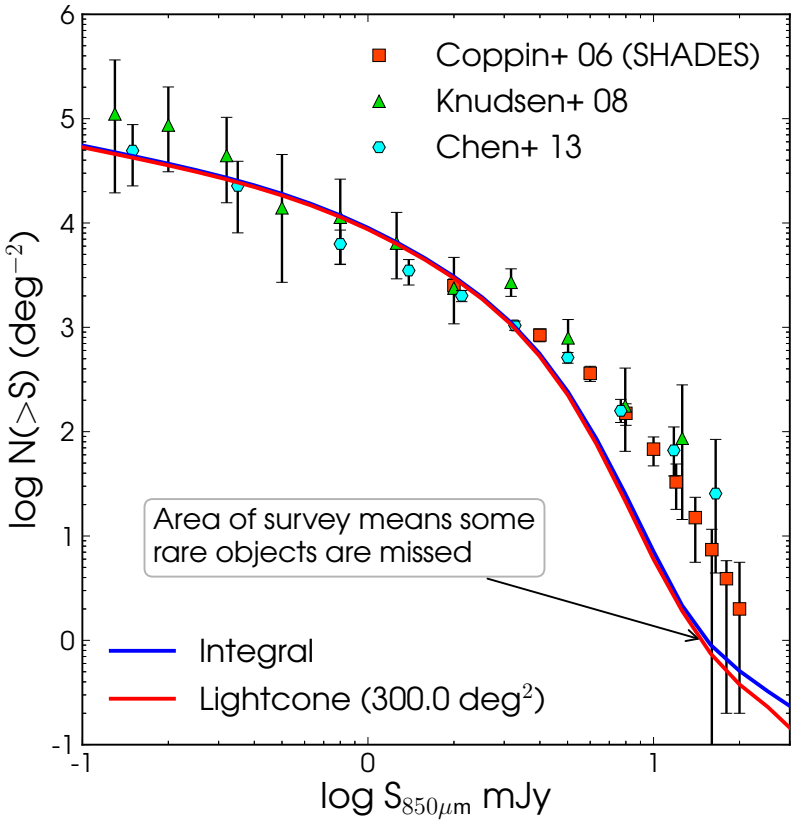


- N-body simulation volume tiled to fill lightcone volume
- Cone geometry assigned
- Galaxy positions interpolated
  - Preserves correlation function
- *K*-correction interpolated
- C.f. integral method of calculating number counts/redshift distribution

$$\int \frac{d^2N}{d\ln S_\nu\, dz} = \int \left\langle \frac{dn}{d\ln L_\nu} \right\rangle \frac{dV}{dz}$$

Creating Lightcones

Merson *et al* 2013



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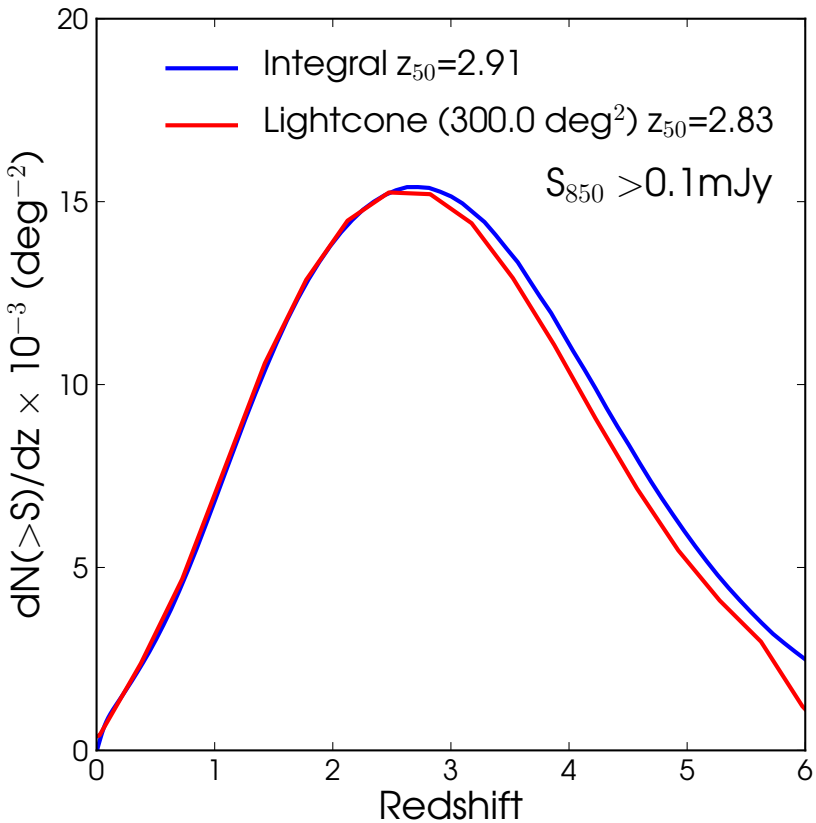

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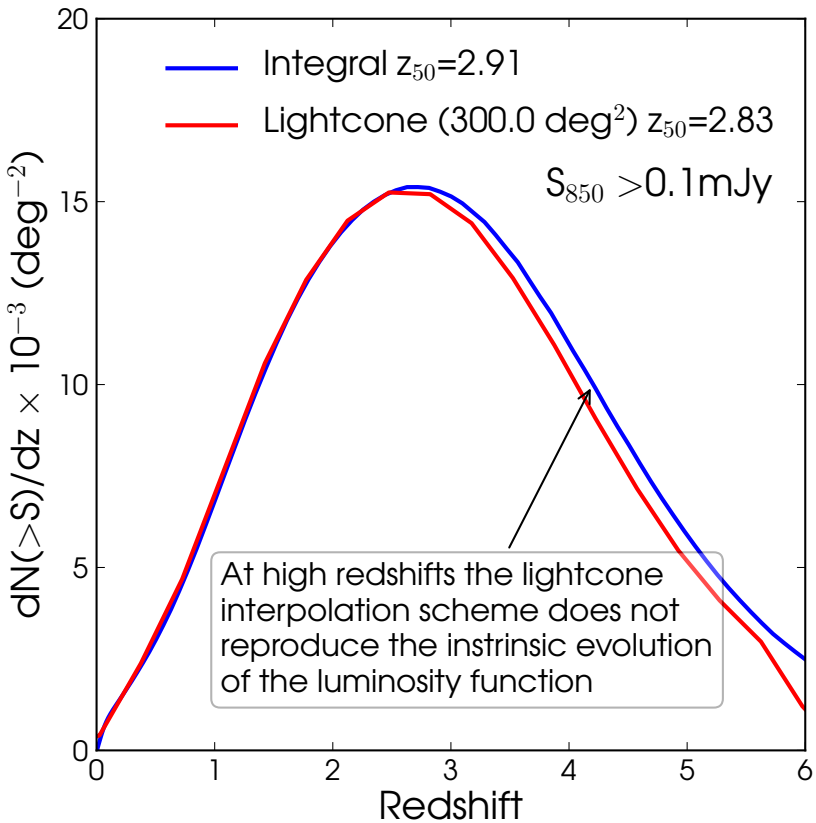

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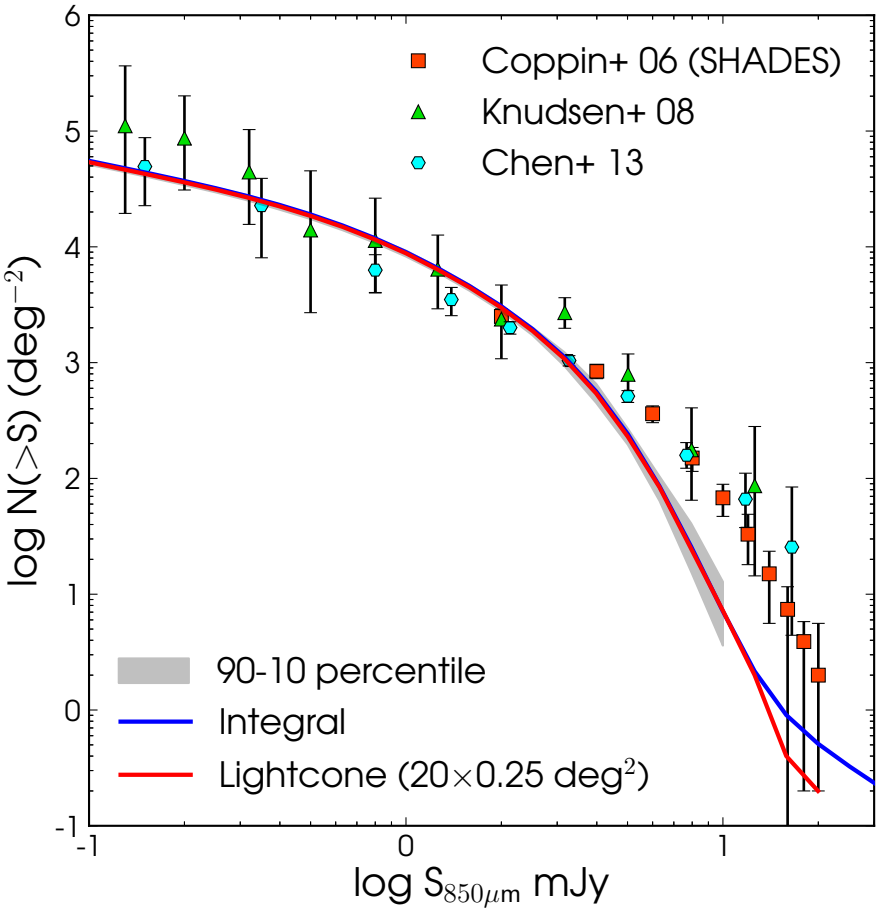
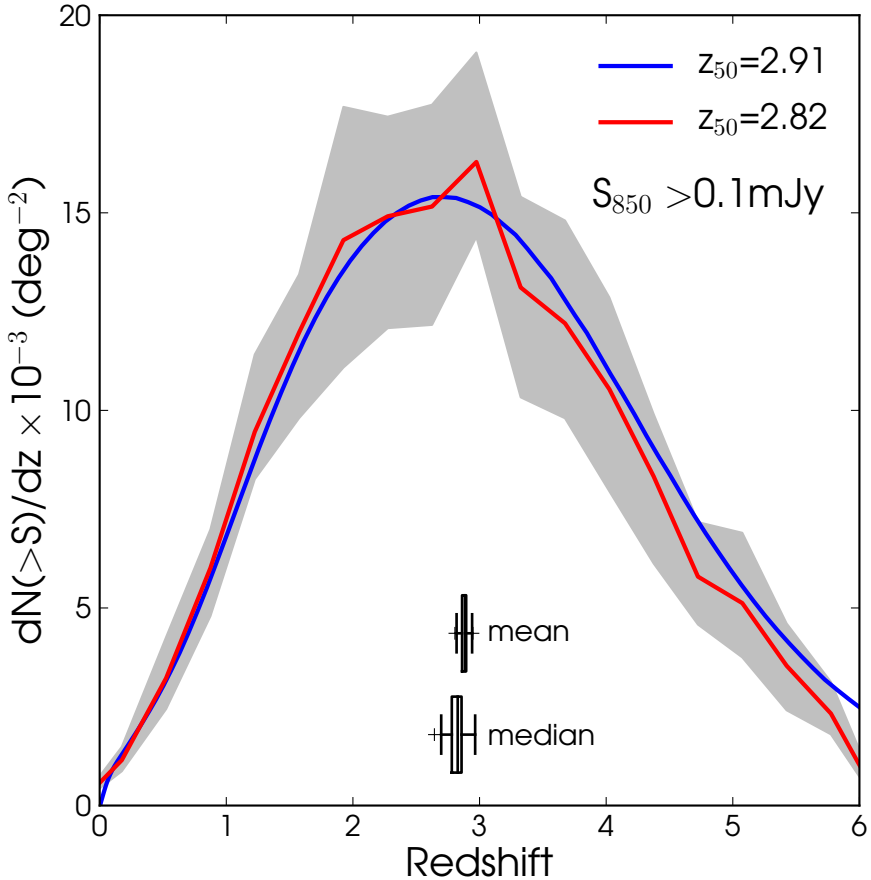
Mock Surveys: Field-to-field Variance

20×0.25 deg^2 surveys





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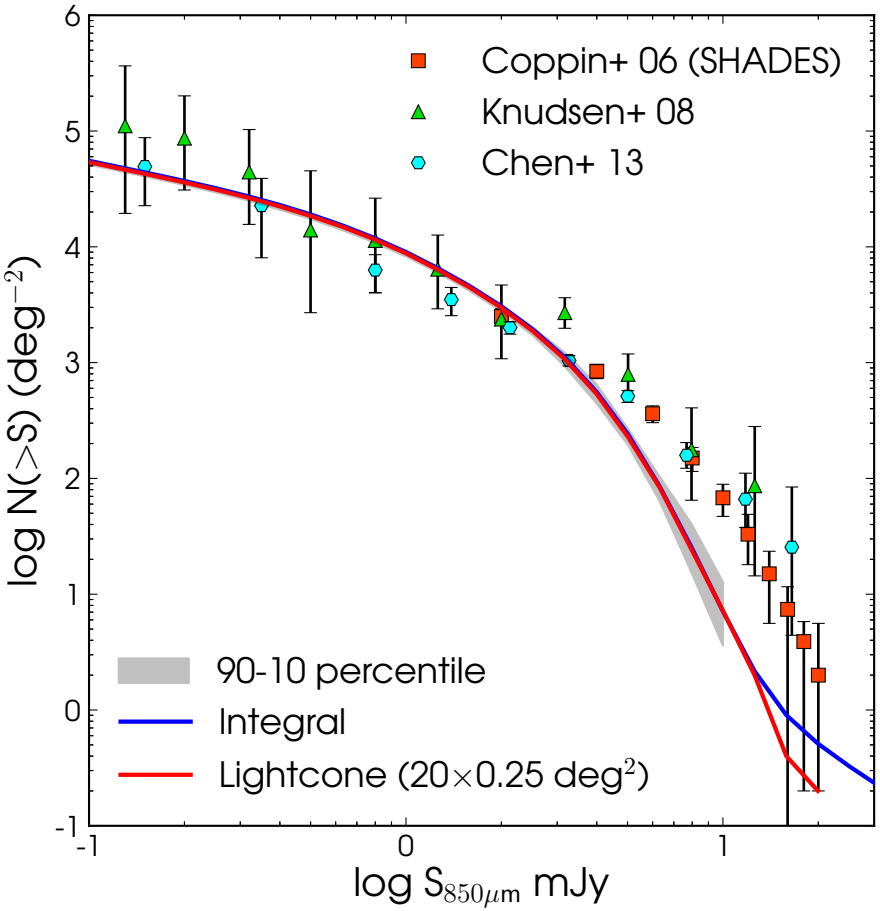

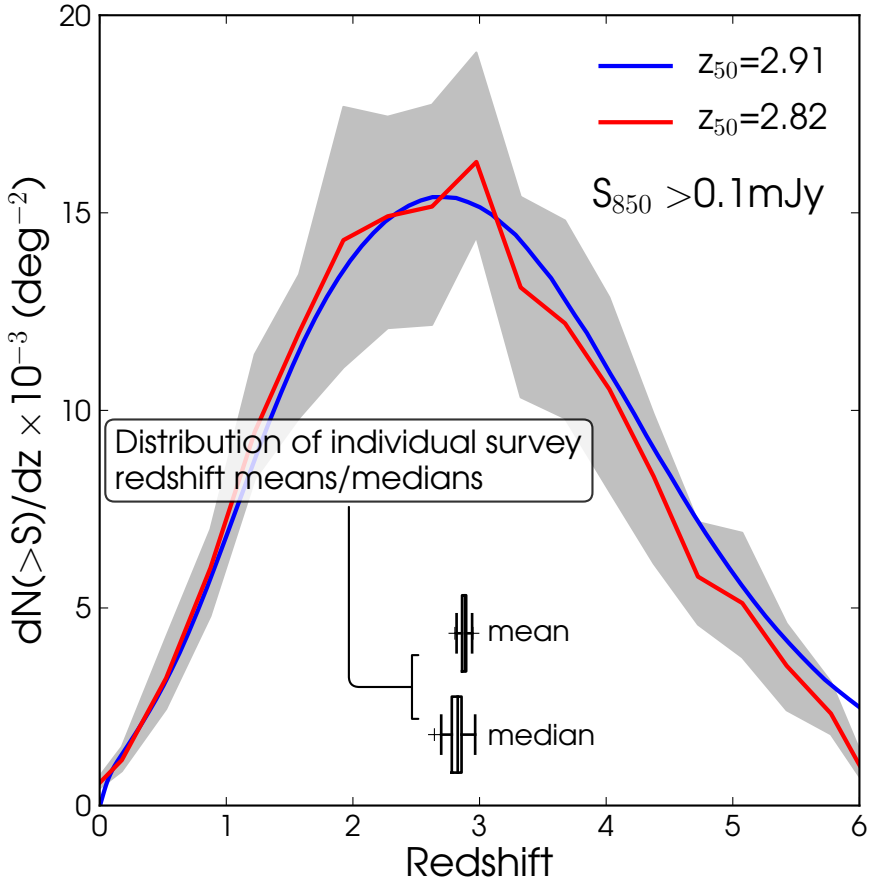

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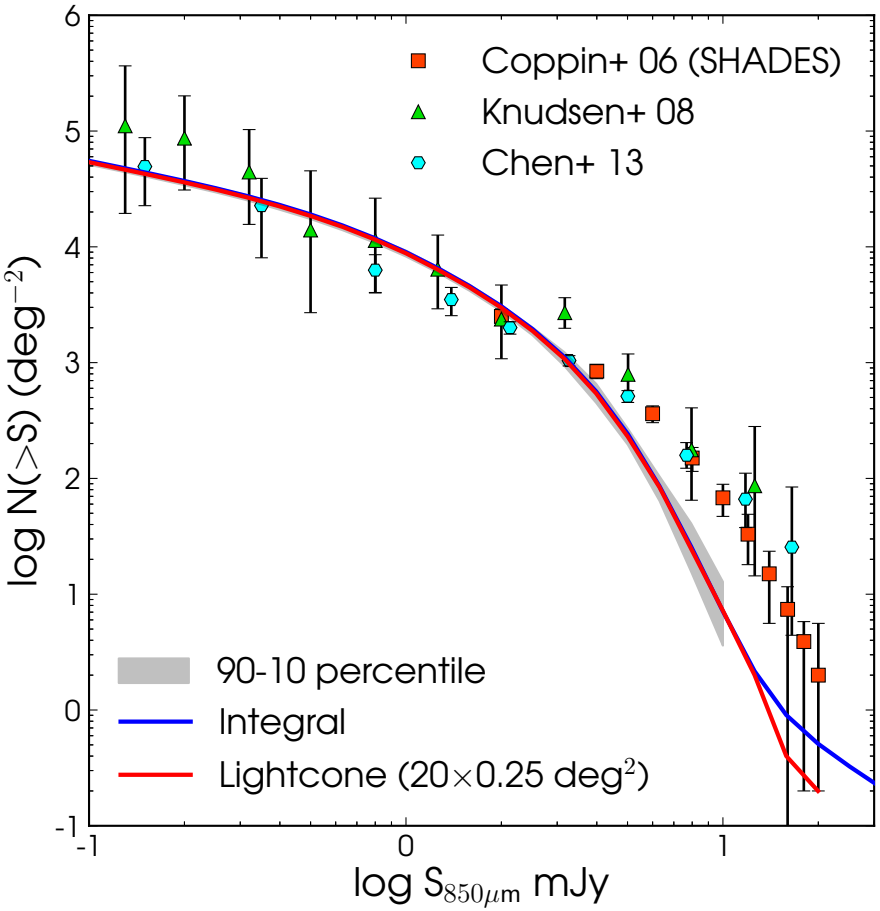
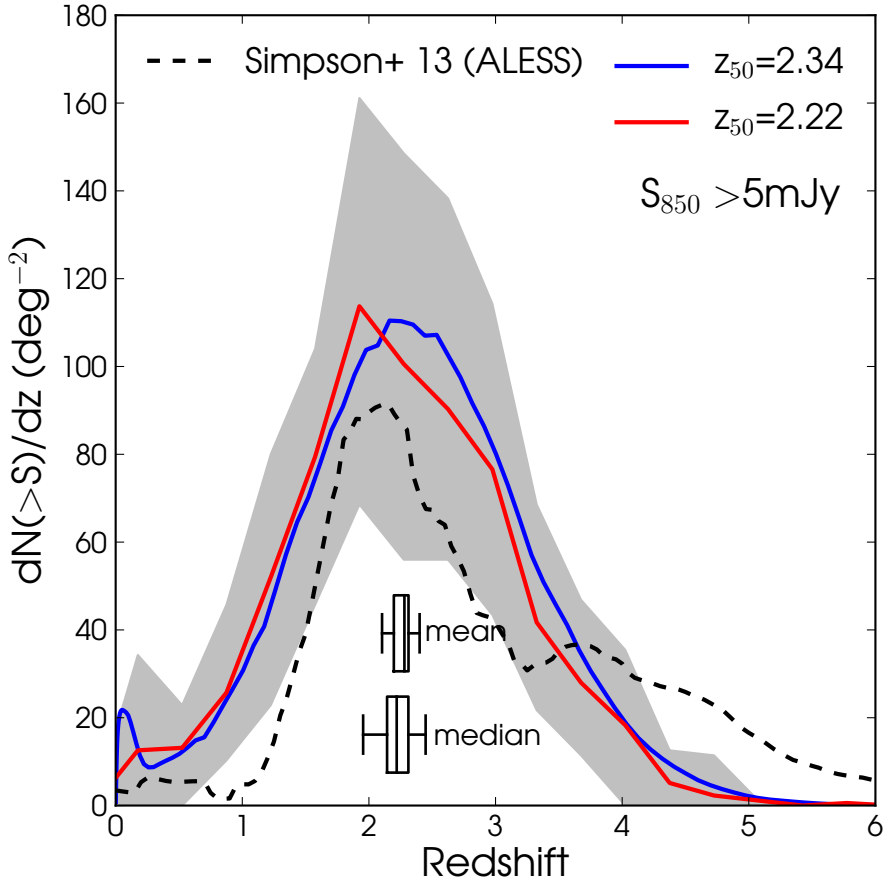
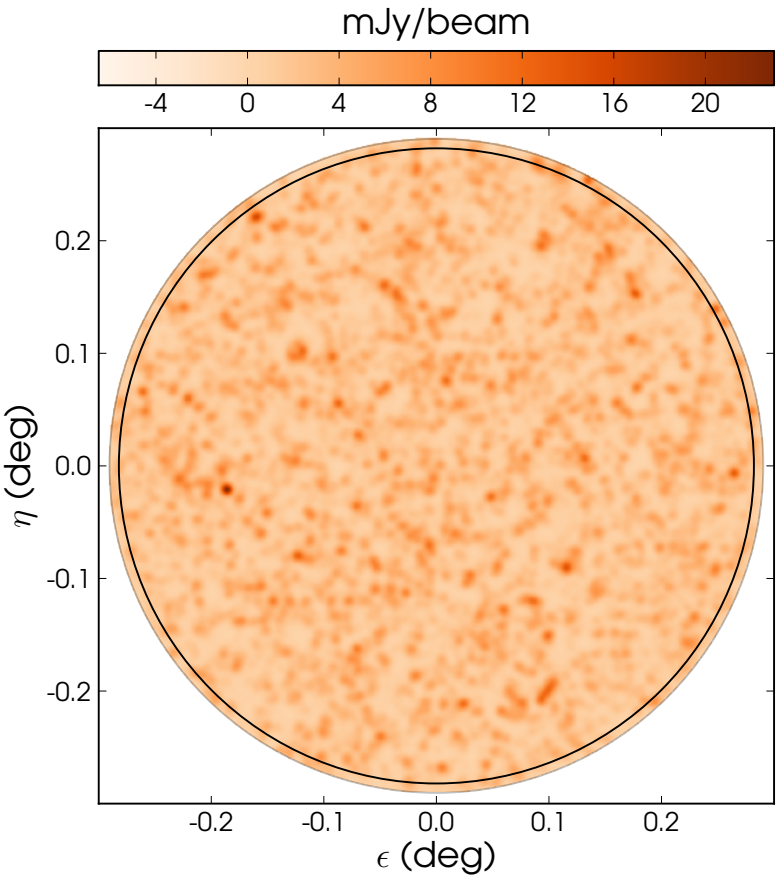




Mock Surveys: Angular Resolution I

Creating Mock Catalogues



- Lightcone: RA, DEC and $S_{850\mu m} > 0.1$mJy
- Pixelate (0.2"$\times$0.2" pixels)
- Convolve 15" FWHM $\approx$ SCUBA2
- Re-pixelate (2"$\times$2" pixels)
- Add white noise ($\approx$1mJy)
- Zero mean
- Convolve with matched filter

$$g(q) = \frac{s^*(q)/J(q)}{\int |s(q)|^2/J(q) d^2q}$$

e.g. Laurent *et al* 2005

- Source Extraction:
  Search for hottest pixel in map and subtract off PSF

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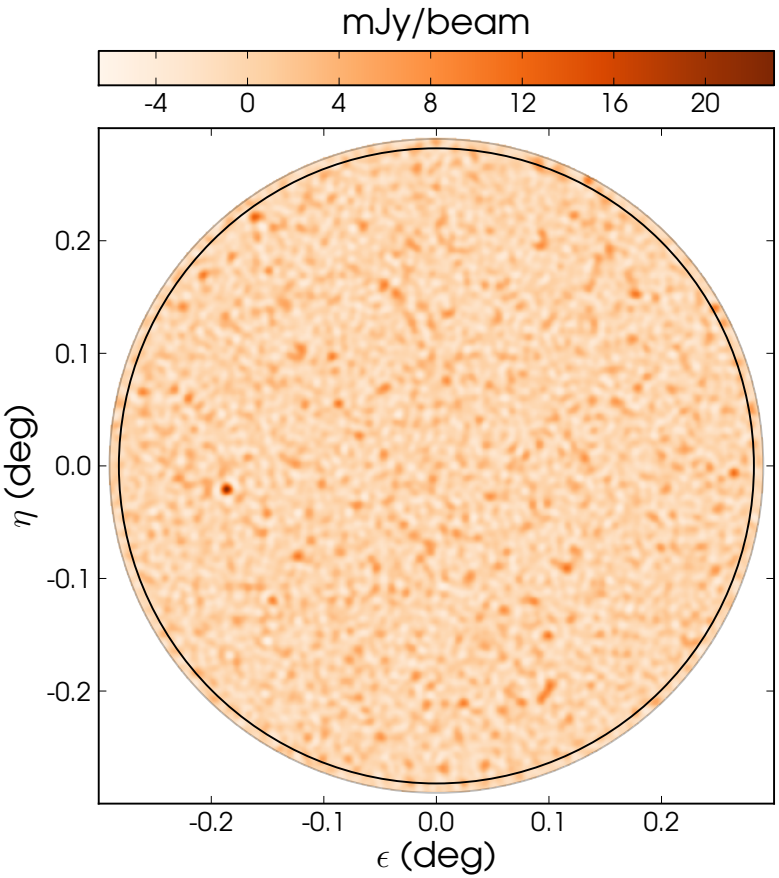

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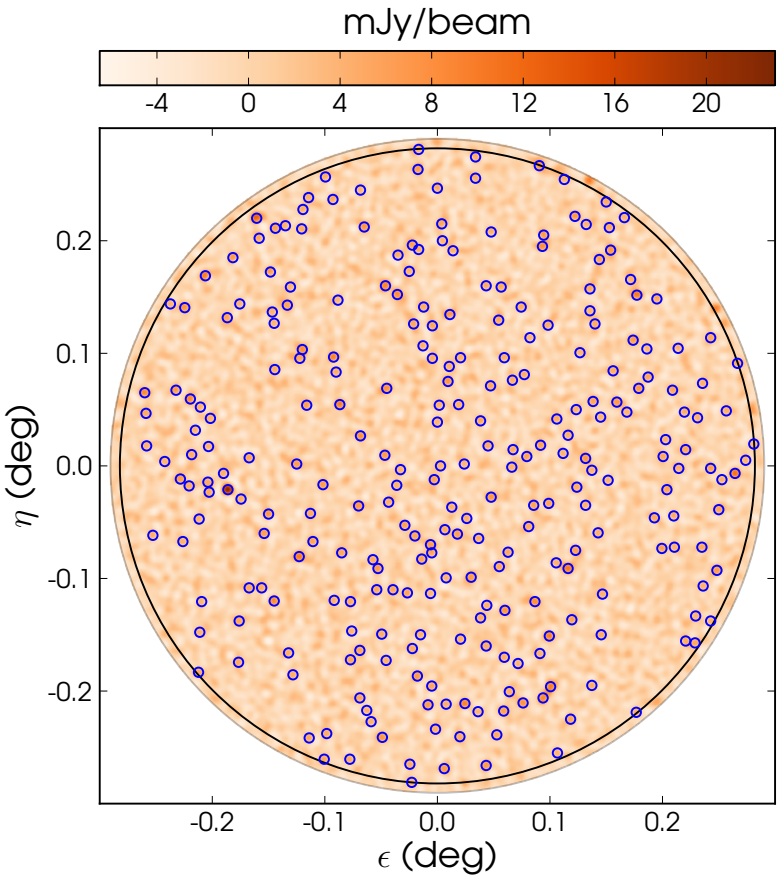

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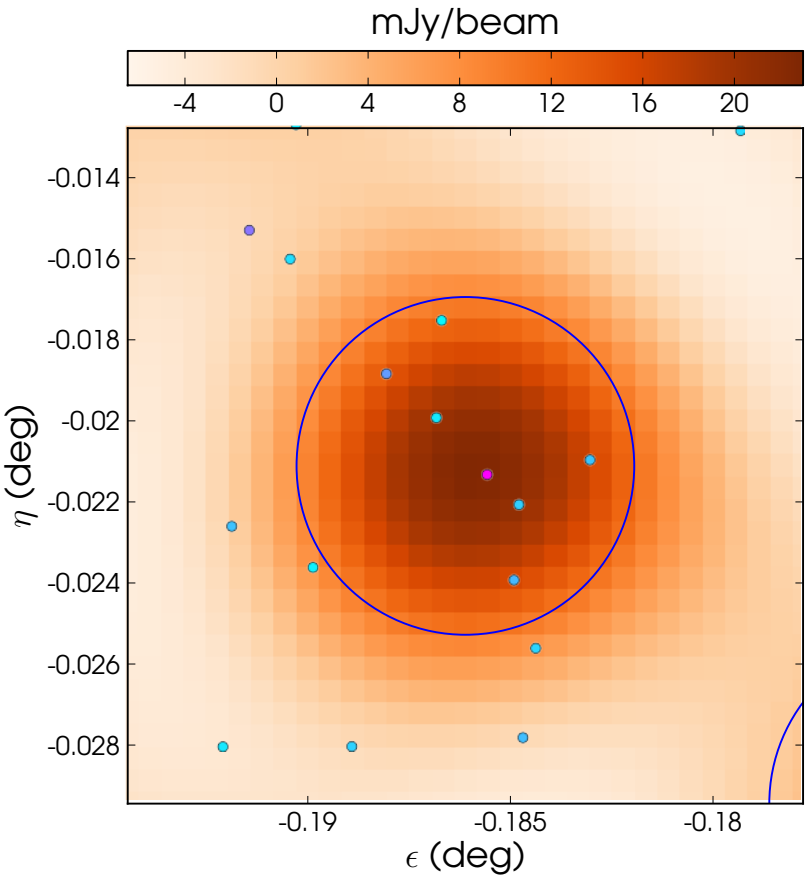

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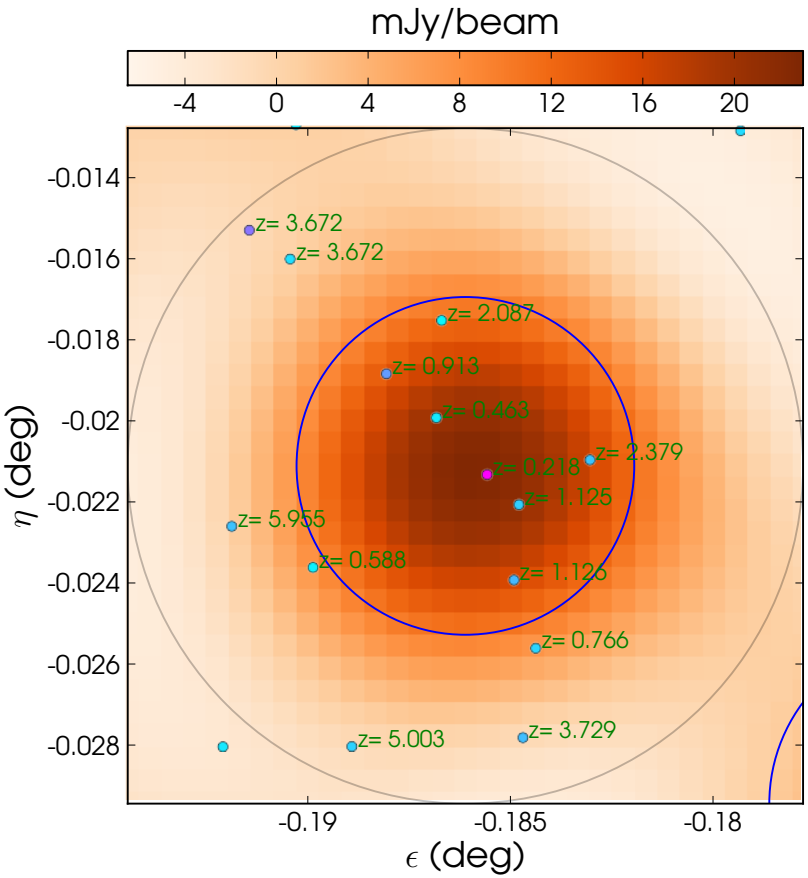

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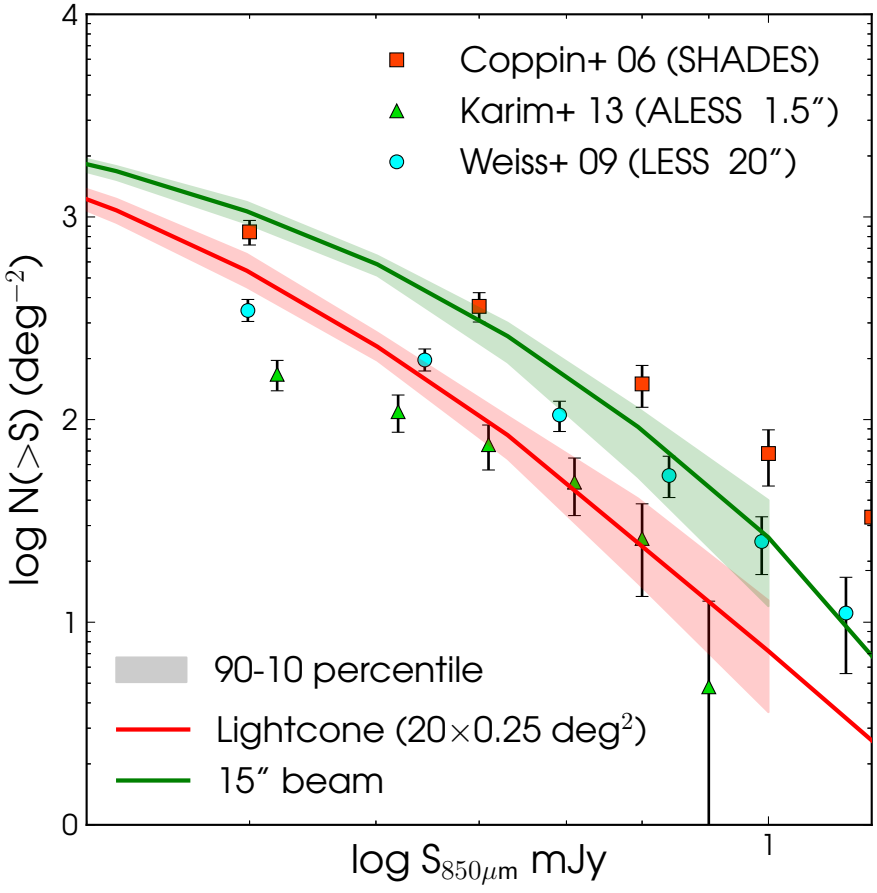
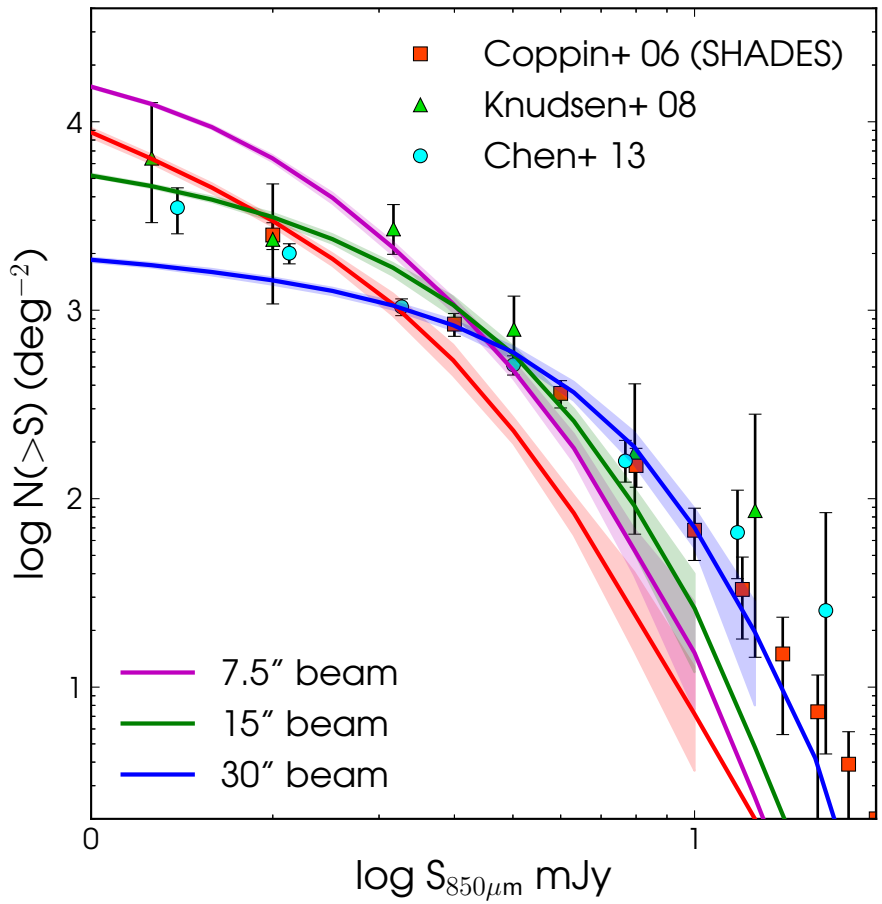
Mock Surveys: Angular Resolution II

Number Counts





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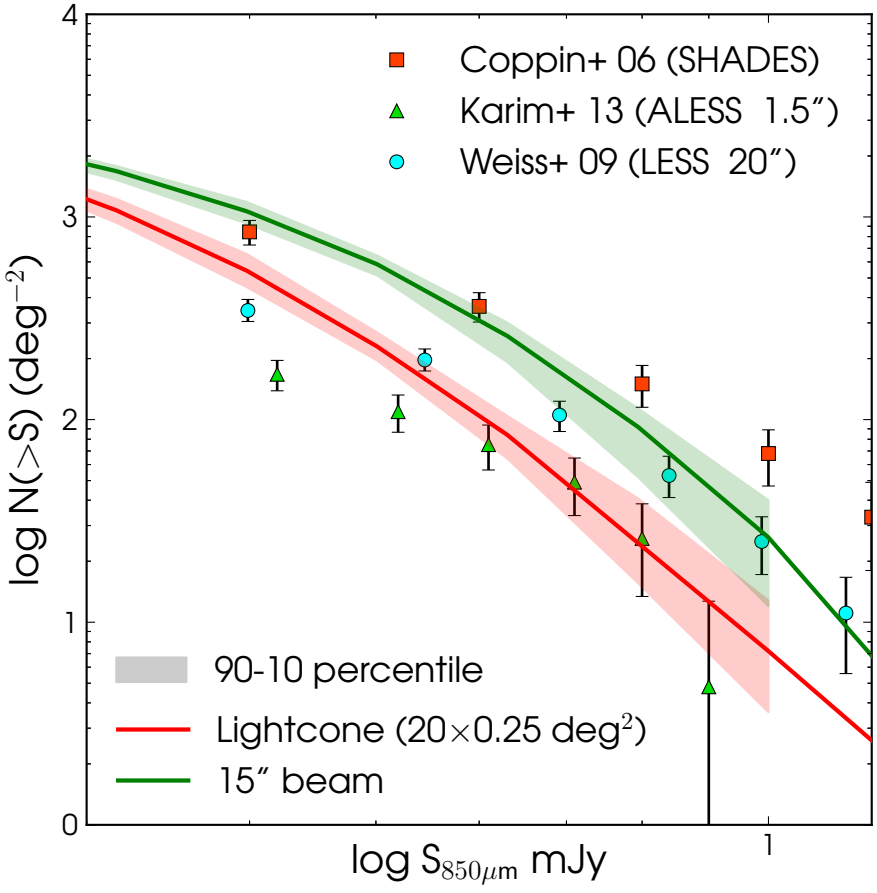

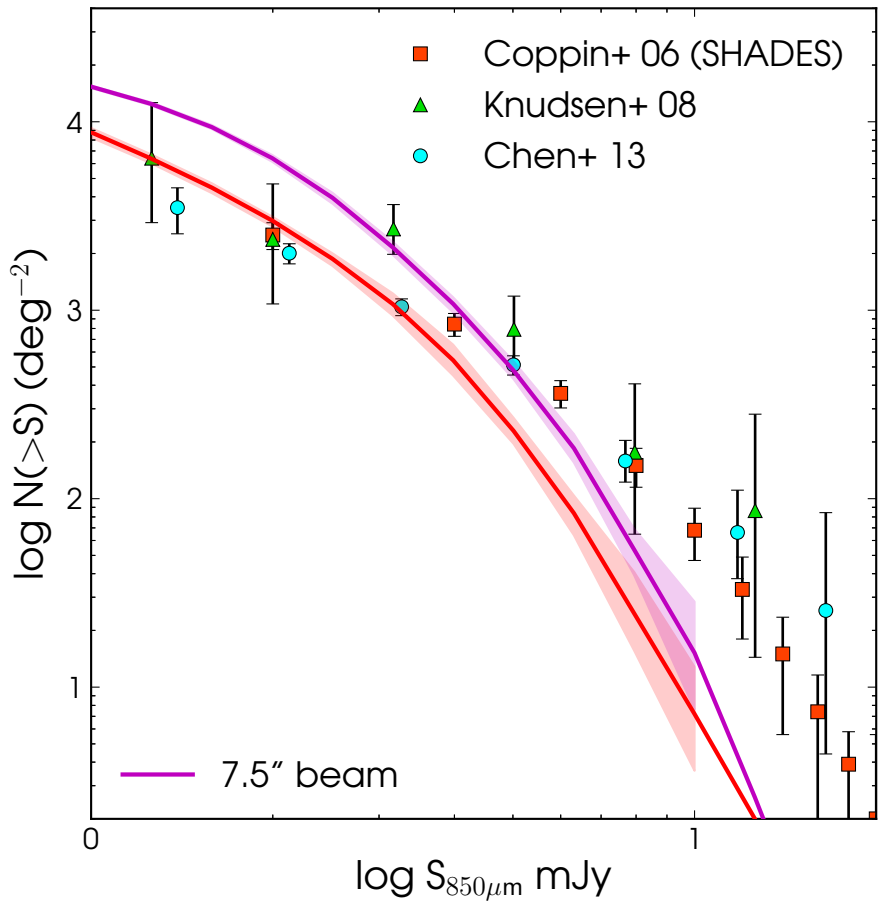

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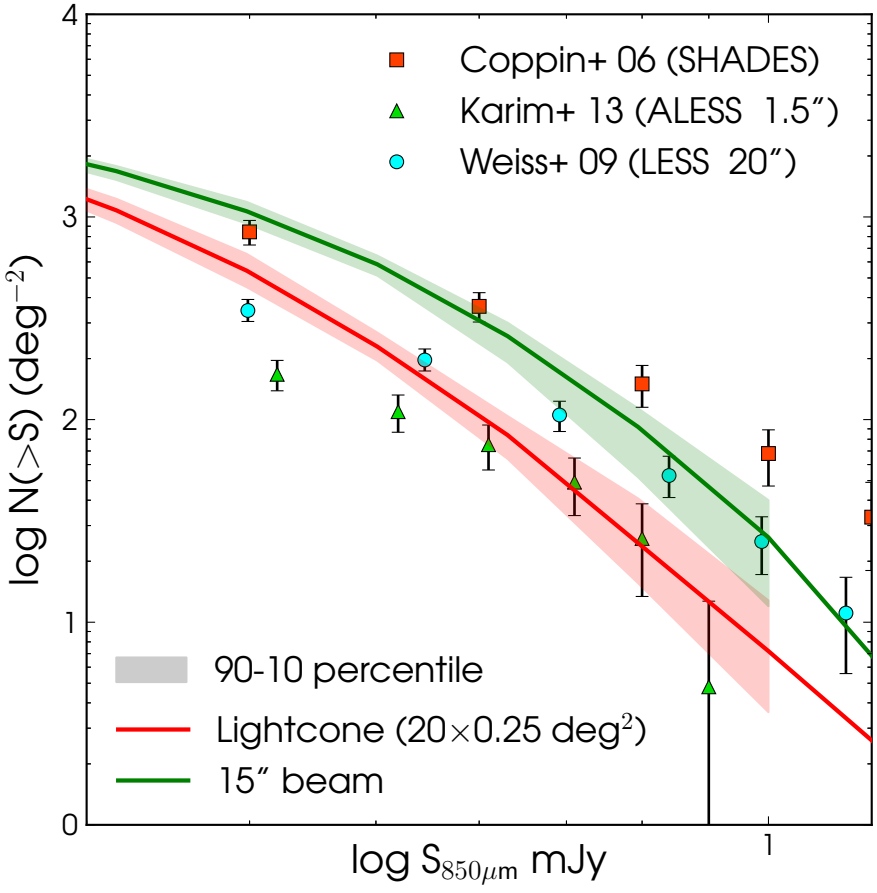

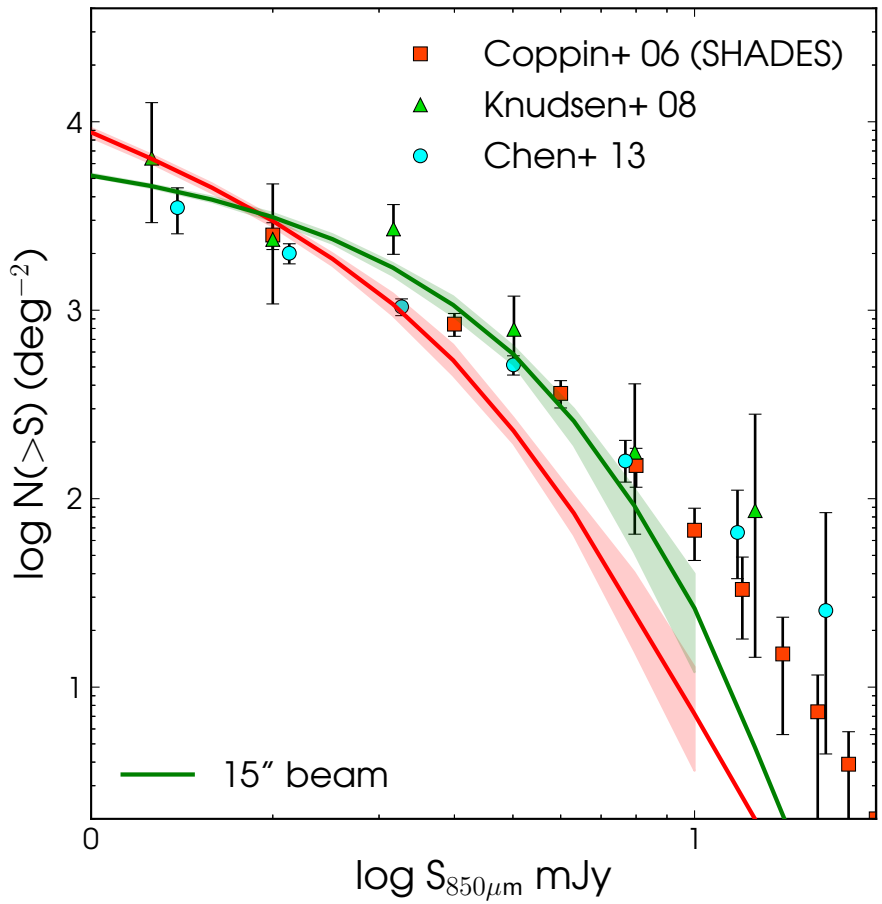

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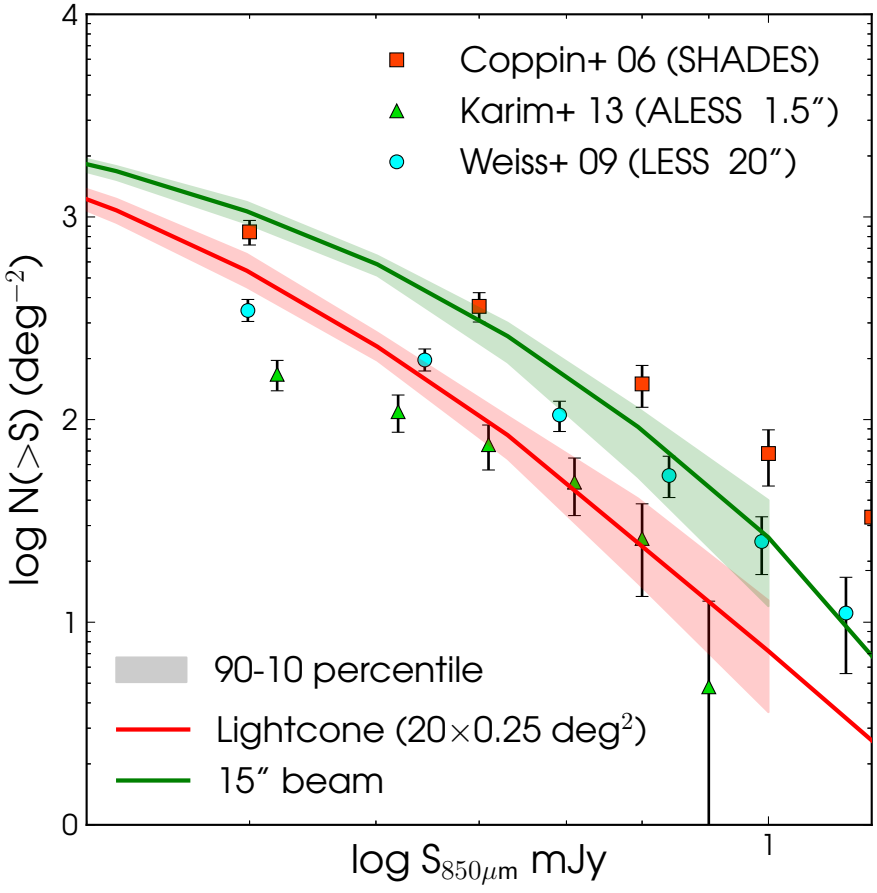

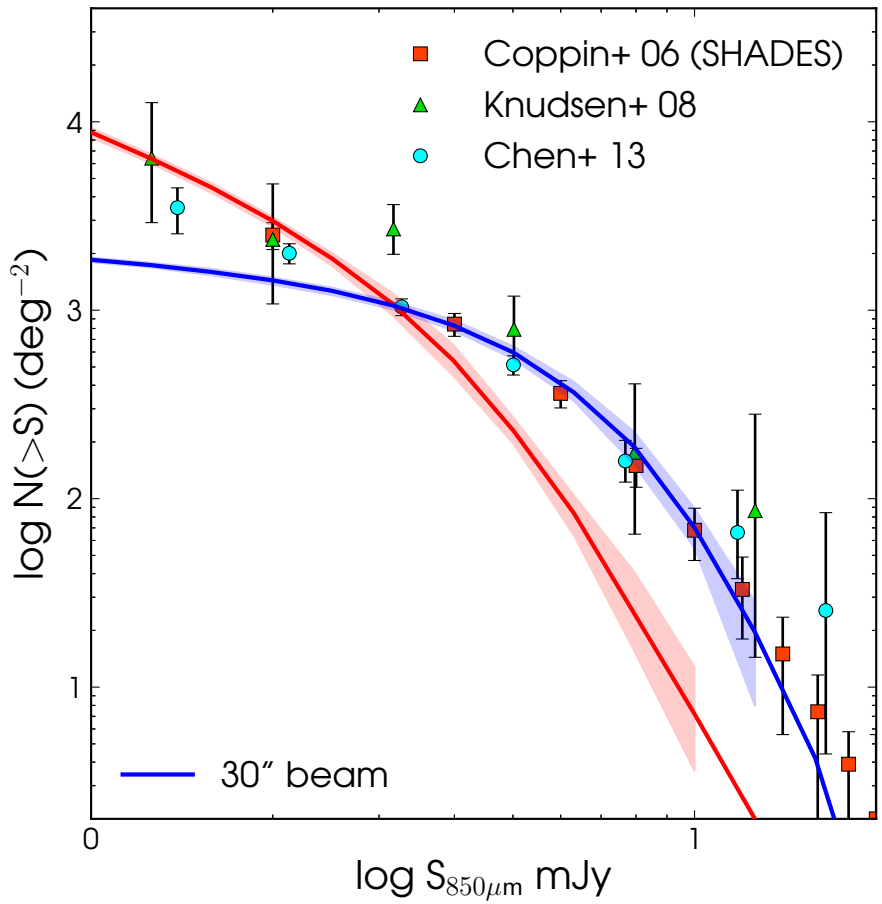

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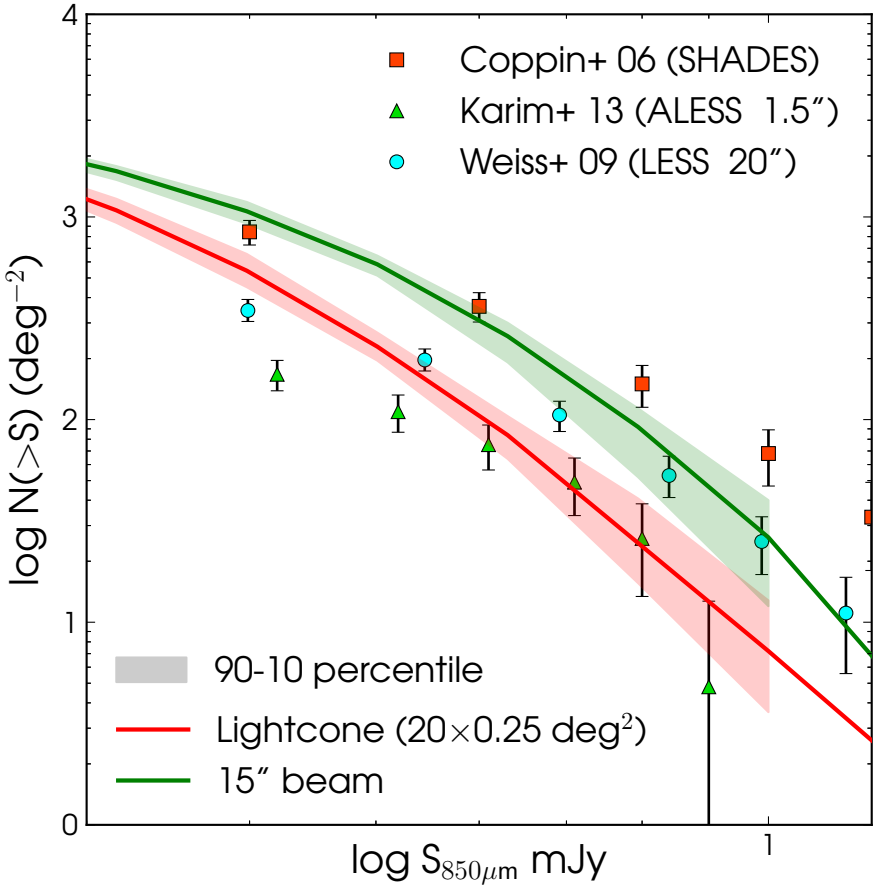

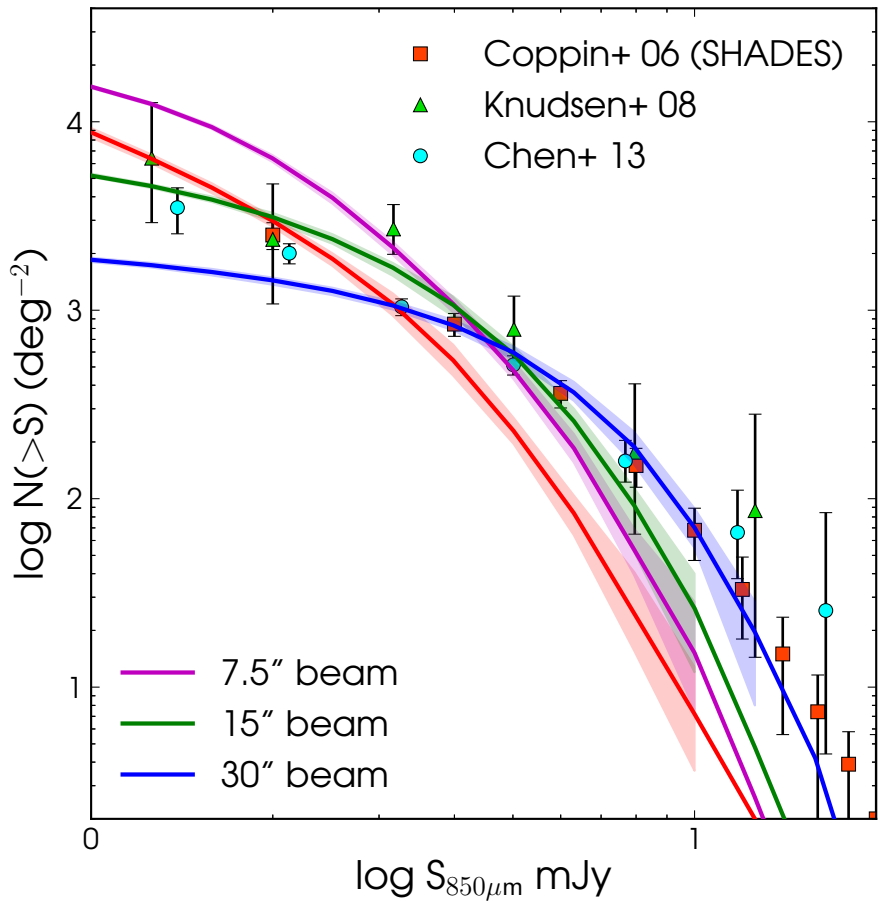

Summary and Future Work

Summary

- SMG observations are sensitive to field-to-field variations
- Angular resolution of single-dish telescopes can skew observed number counts

Future Work

- Properties of the blended SMG population
  - multiple fraction
  - physical (un)associations
- Comparison of multi-wavelength surveys
- Predictions for lensed vs. un-lensed SMG populations