

Ultra Dusty Milky Way/LIRG Galaxies Behind Massive Lensing Clusters

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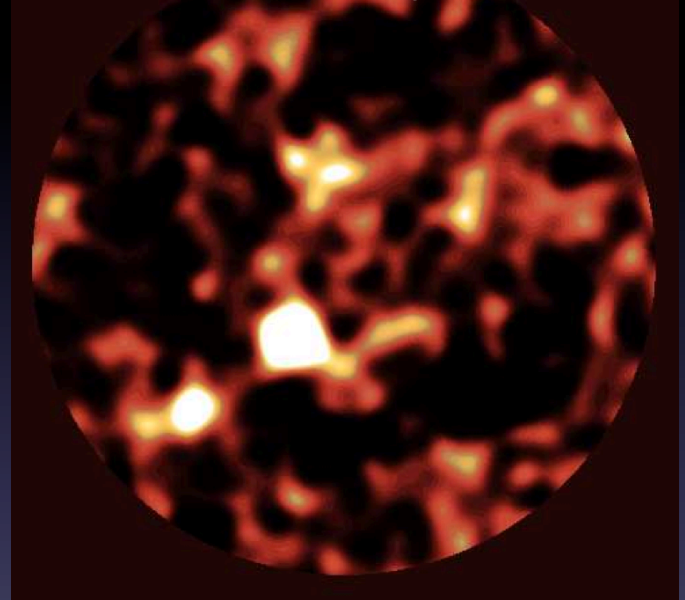
Lennox Cowie (UH), Amy Barger (UW-Madison, UH), Wei-Hao Wang (ASIAA)

Chian-Chou Chen (Durham), Jonathan Williams (UH)

Submillimeter Galaxies

SMGs are dusty, star-bursting galaxies that cannot be easily picked out in the rest-frame optical/UV samples.

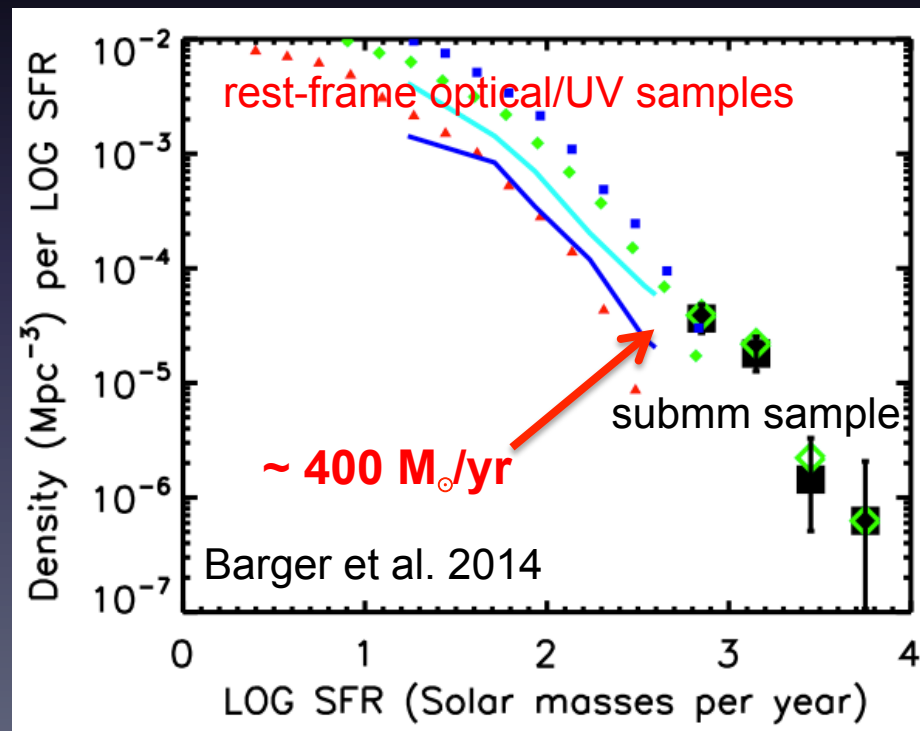
Hubble Deep Field (Hughes et al. 1998)



Observations at 850 μm with single-dish telescopes cannot detect faint SMGs below the confusion limit (~ 2 mJy), corresponding to an IR luminosity of $10^{12} L_{\odot}$ (ULIRG).

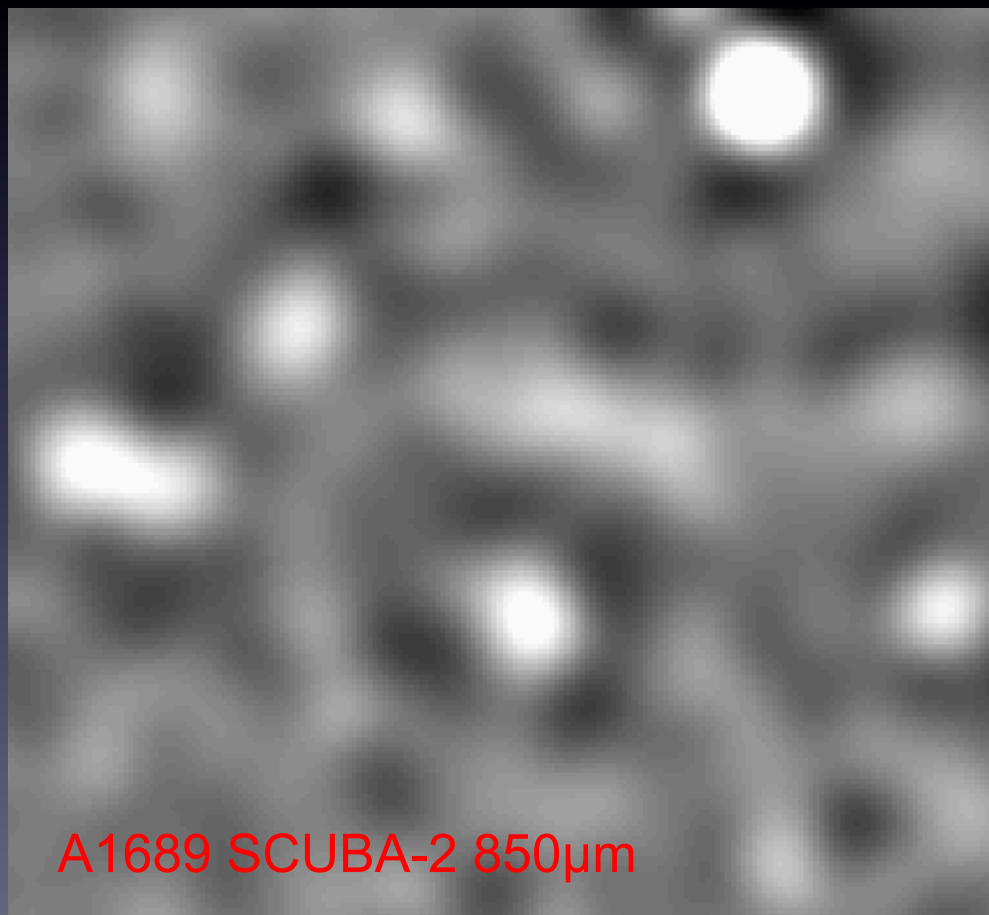
Faint SMGs

Are faint SMGs less dusty star-forming galaxies that correspond to optical/UV selected galaxies?



Observations of Massive Clusters

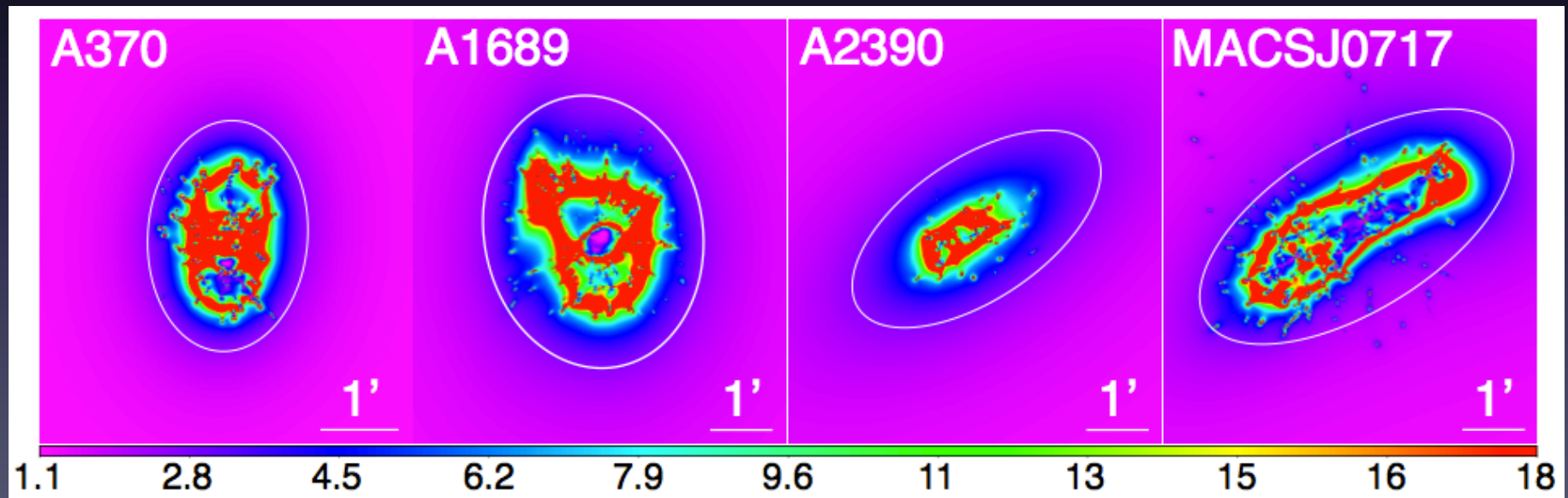
Observations of massive lensing clusters can probe lensed galaxies with IR luminosity $< 10^{12} L_{\odot}$ (LIRG) or even $< 10^{11} L_{\odot}$ (Milky Way)



A1689 SCUBA-2 850 μ m

SCUBA-2 Lensing Cluster Surveys

- Observing at 450 and 850 μm simultaneously
- Eight massive clusters, including four HST frontier fields



magnification maps assuming source planes at $z = 3$

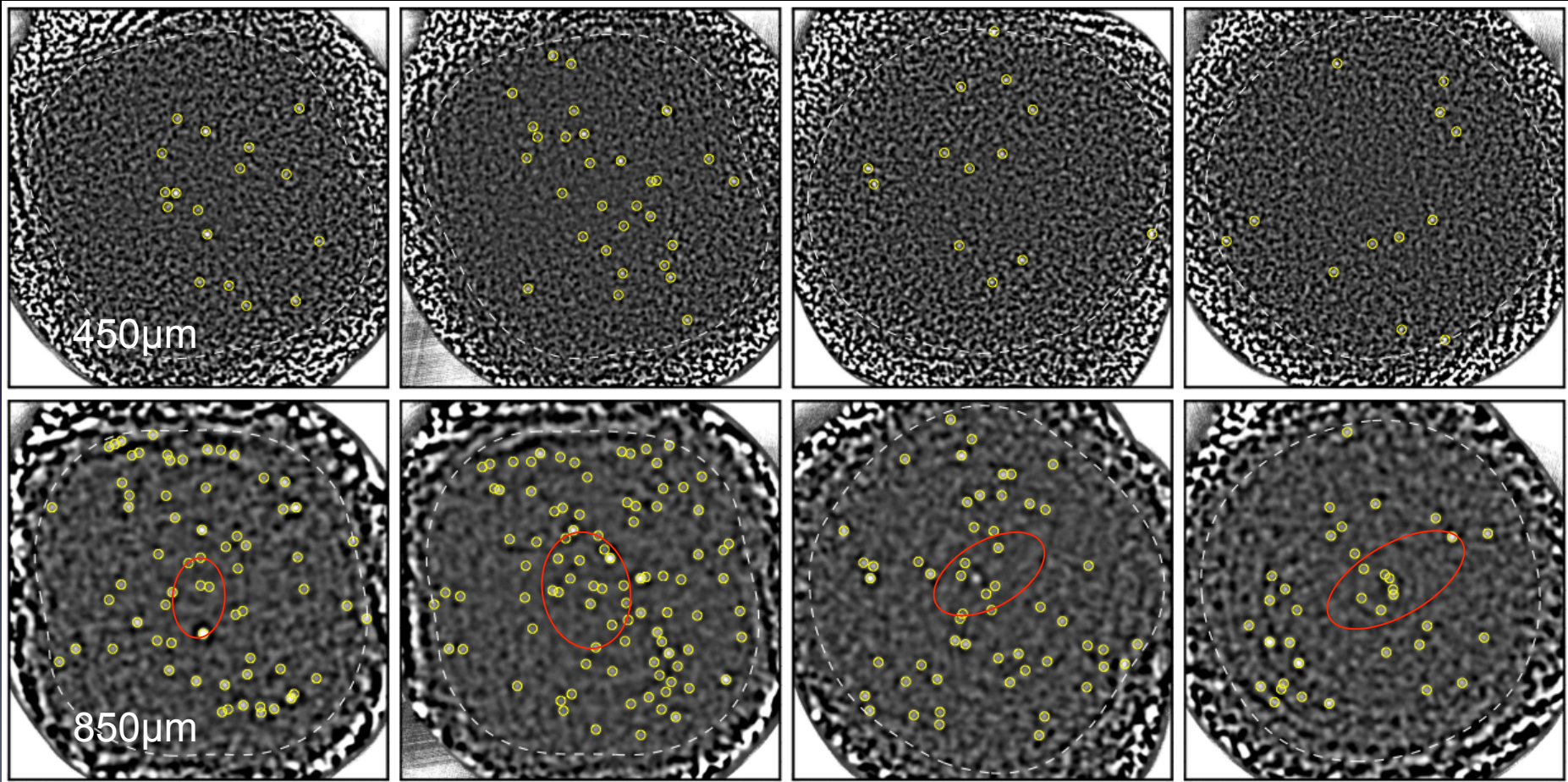
SCUBA-2 Lensing Cluster Surveys

A370

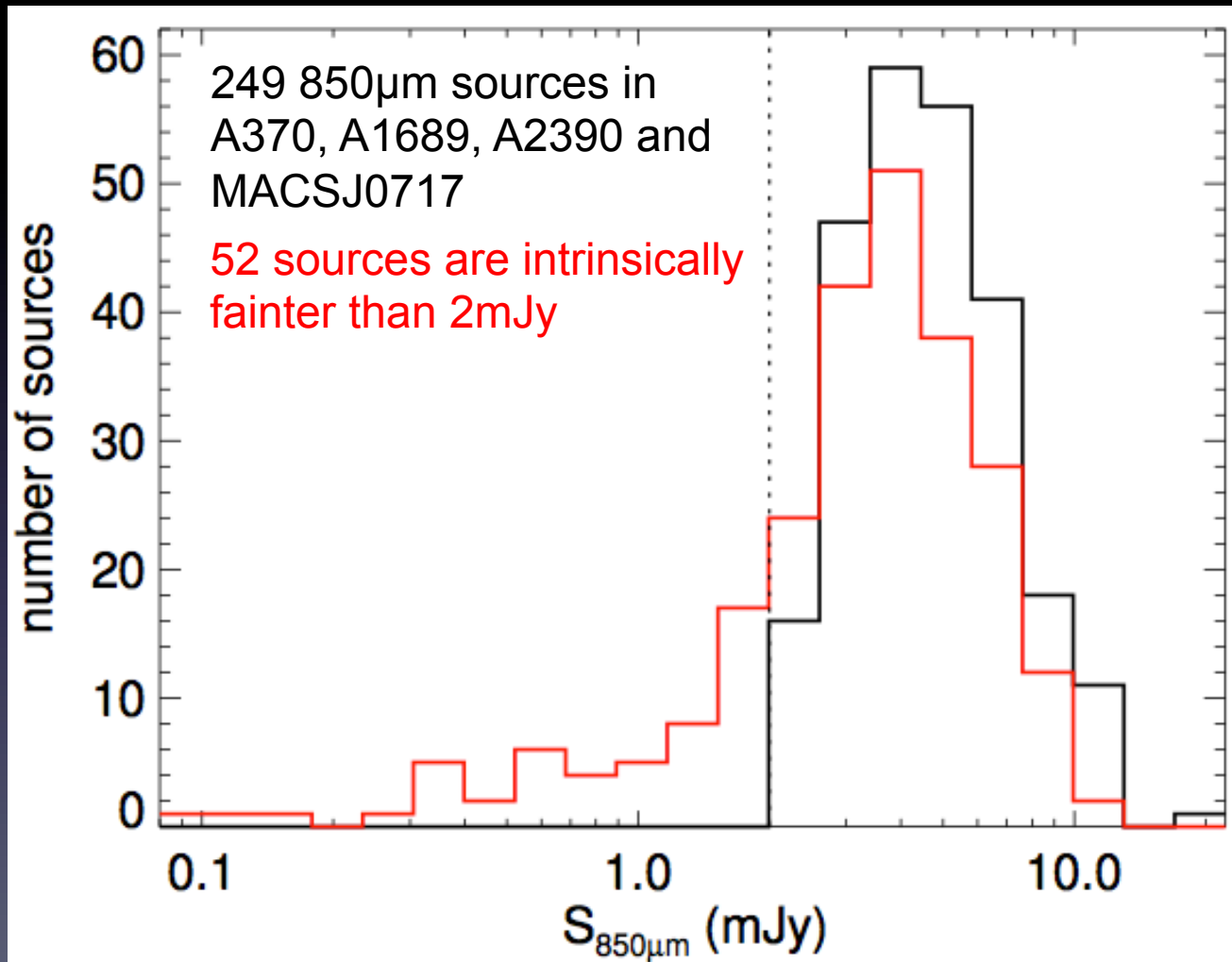
A1689

A2390

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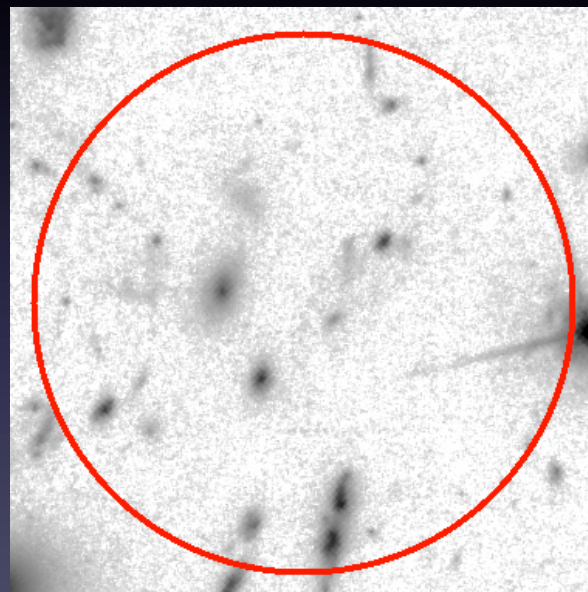
SCUBA-2 Lensing Cluster Surveys



Counterpart Identification

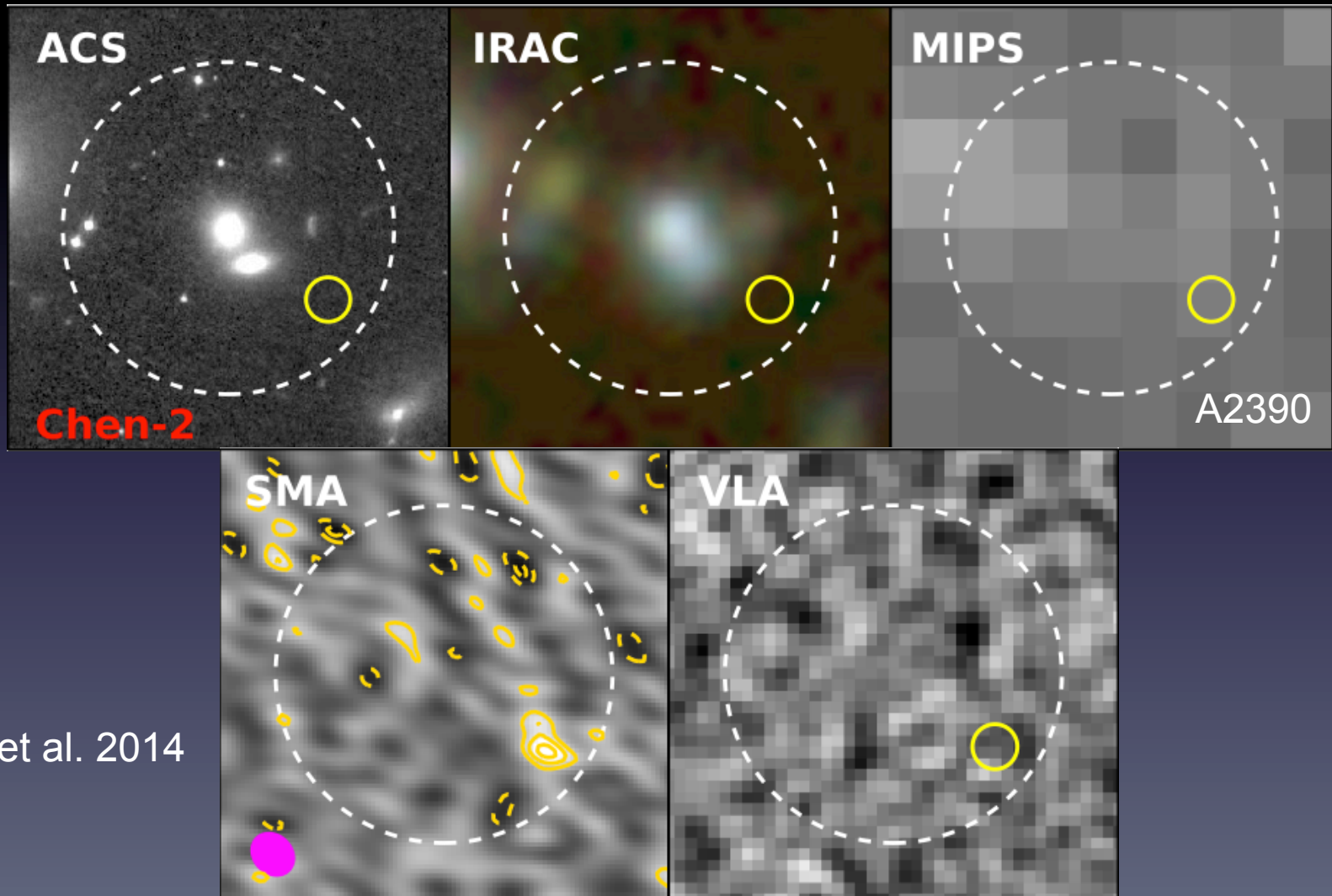
- JCMT(15m) beam sizes (FWHM) :
7.5" at 450 μ m 14.5" at 850 μ m
- Radio interferometry (biased against high-z galaxies)
- Submm interferometry

A1689 (HST F814W)



JCMT 850 μ m beam

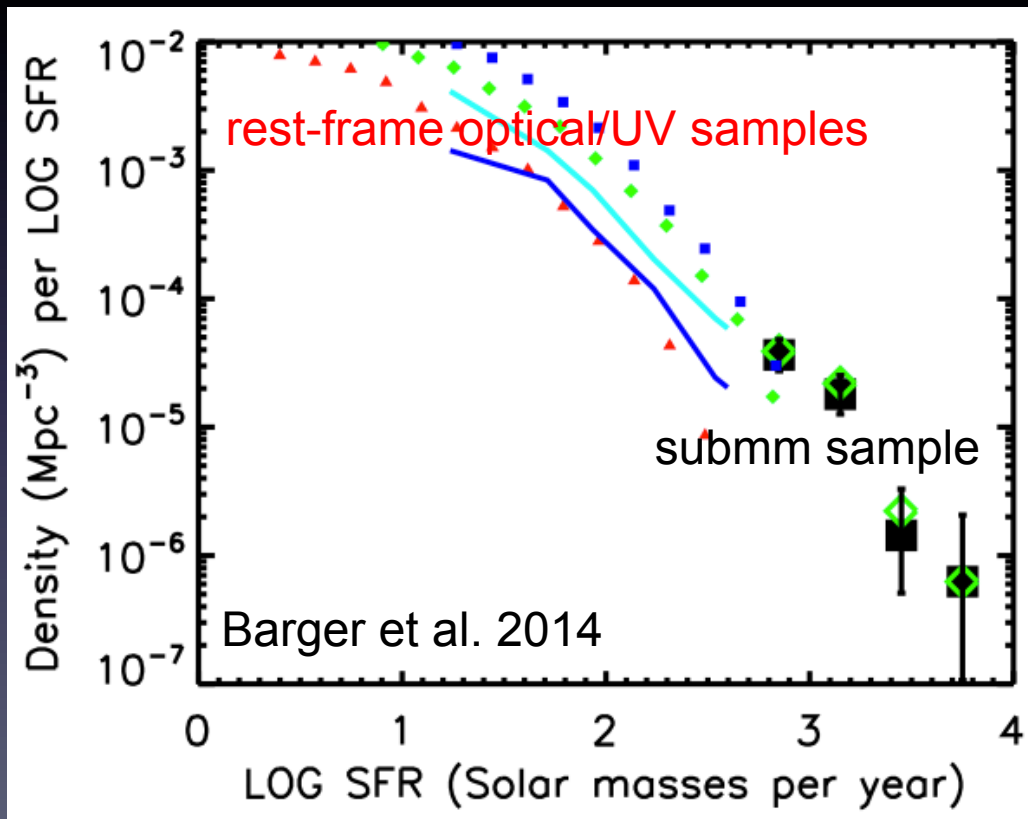
SMA Follow-up at 345GHz



Chen et al. 2014

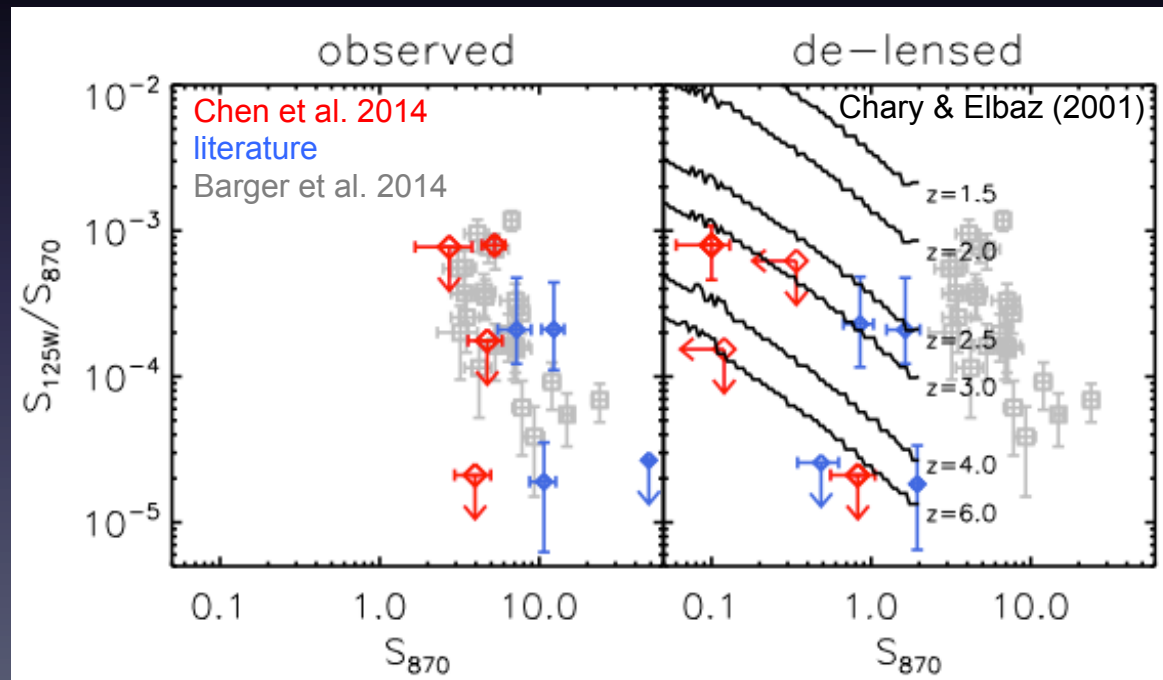
Results

- All the five sources detected in Chen et al. (2014) have intrinsic fluxes of ~ 0.1 - 0.8 mJy, the critical flux range for $\text{SFR} \sim 100 M_{\odot}/\text{yr}$



Results

- Only two out of five have optical/NIR counterparts
- Low NIR/submillimeter flux ratios



We need a larger sample of faint SMGs !

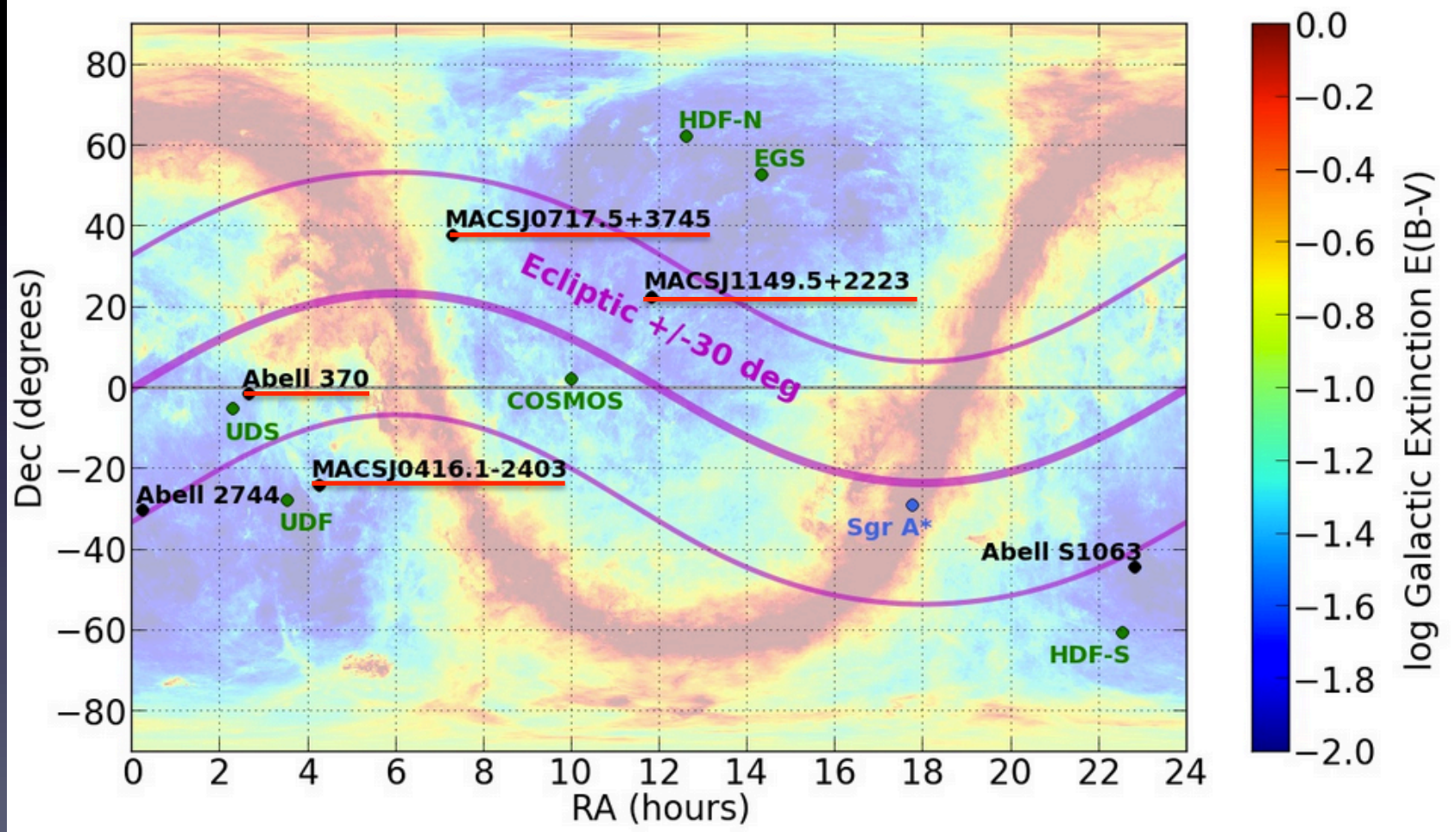
Current&Future Work

- Image over 30 faint SMGs in our cluster fields with SMA and the new SWARM correlator
 - better estimates of lensing magnifications
 - multi-wavelength studies
 - redshift distribution
 - NIR morphology and spectroscopy of the optically bright sources
 - future ALMA CO or [CII] line surveys on optically faint objects

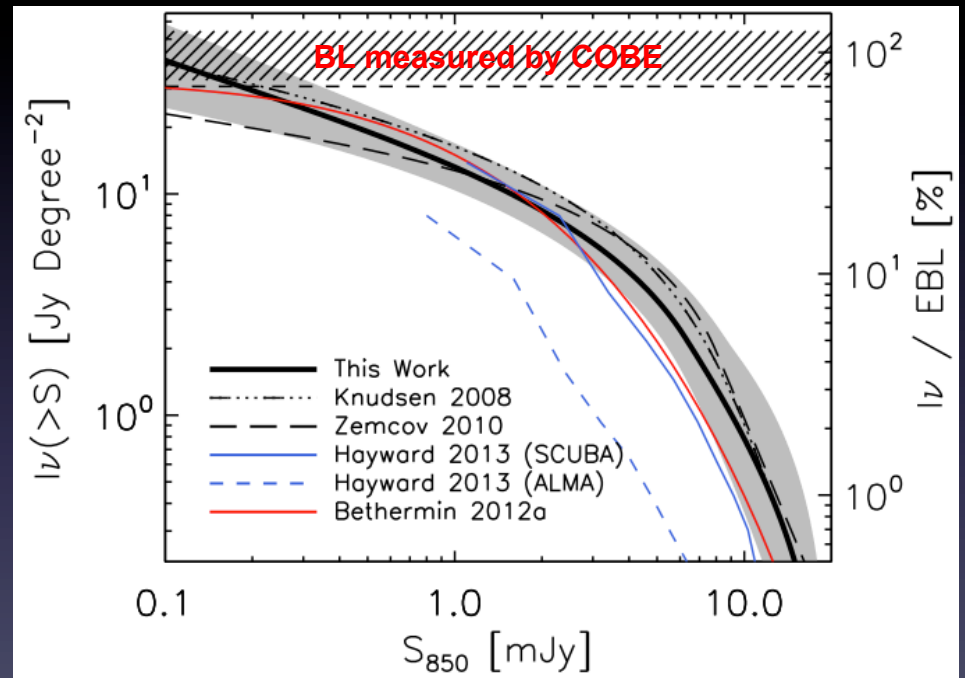
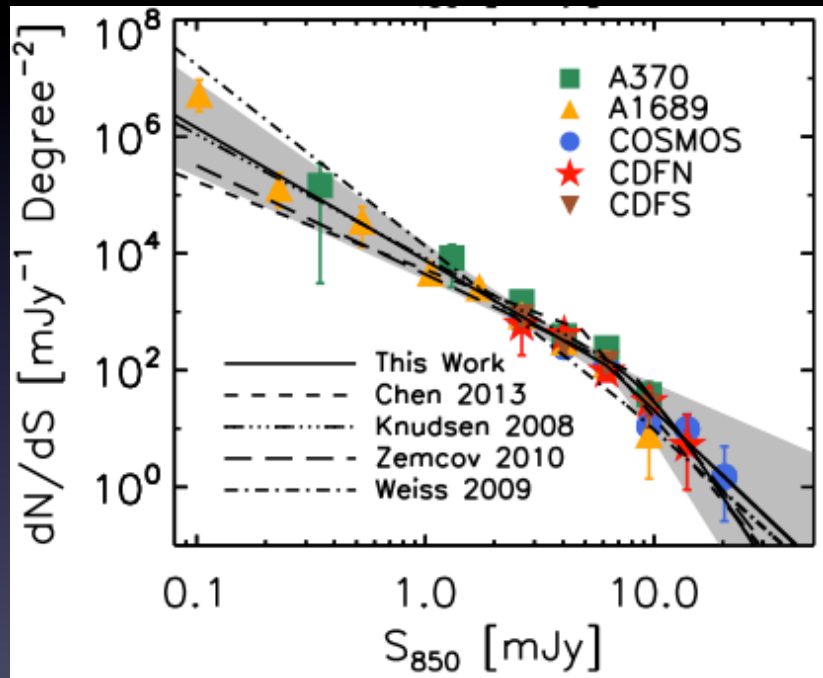
Many low-luminosity, dust-obscured star forming galaxies at high redshifts might not be included in the optical/UV star formation history

Thank you !

HST Frontier Fields

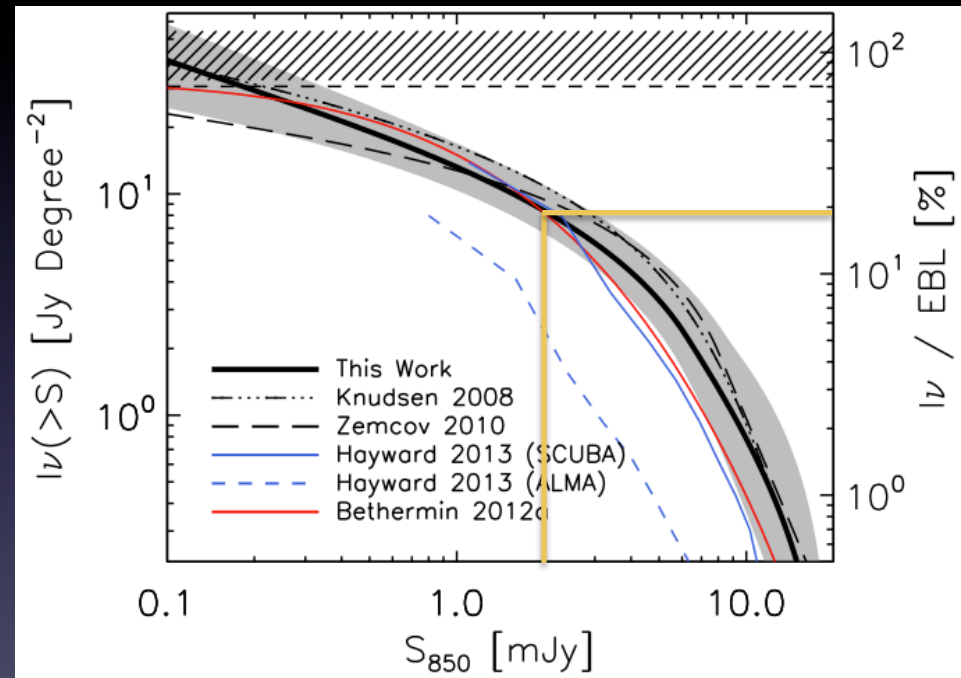
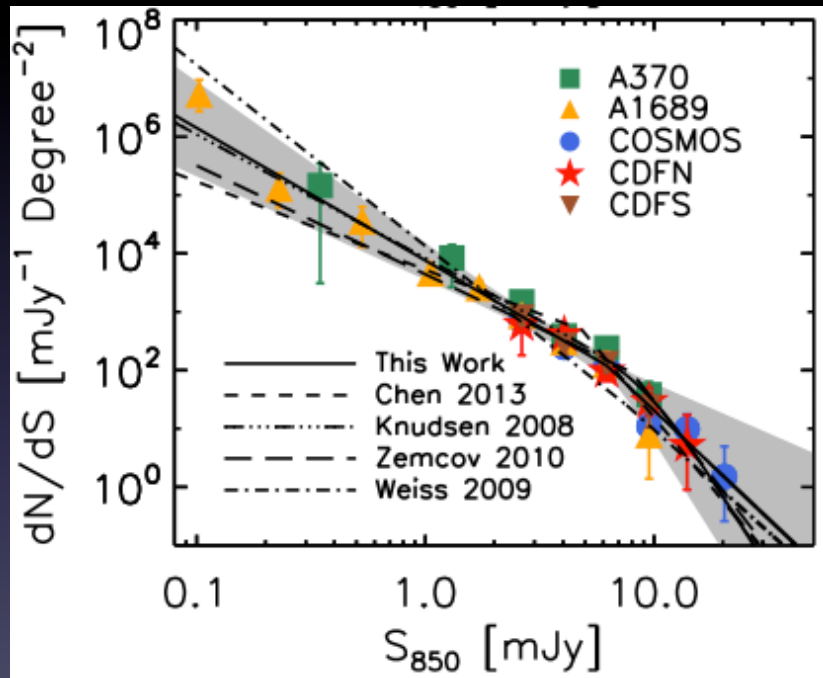


The majority of submm background can be measured with cluster lensing



Chen et al. 2013

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Chen et al. 2013