

S2COSMOS

An EAO survey of sub-mm sources in the COSMOS field

Wei-Hao Wang (ASIAA) on behalf of the S2COSMOS consortium



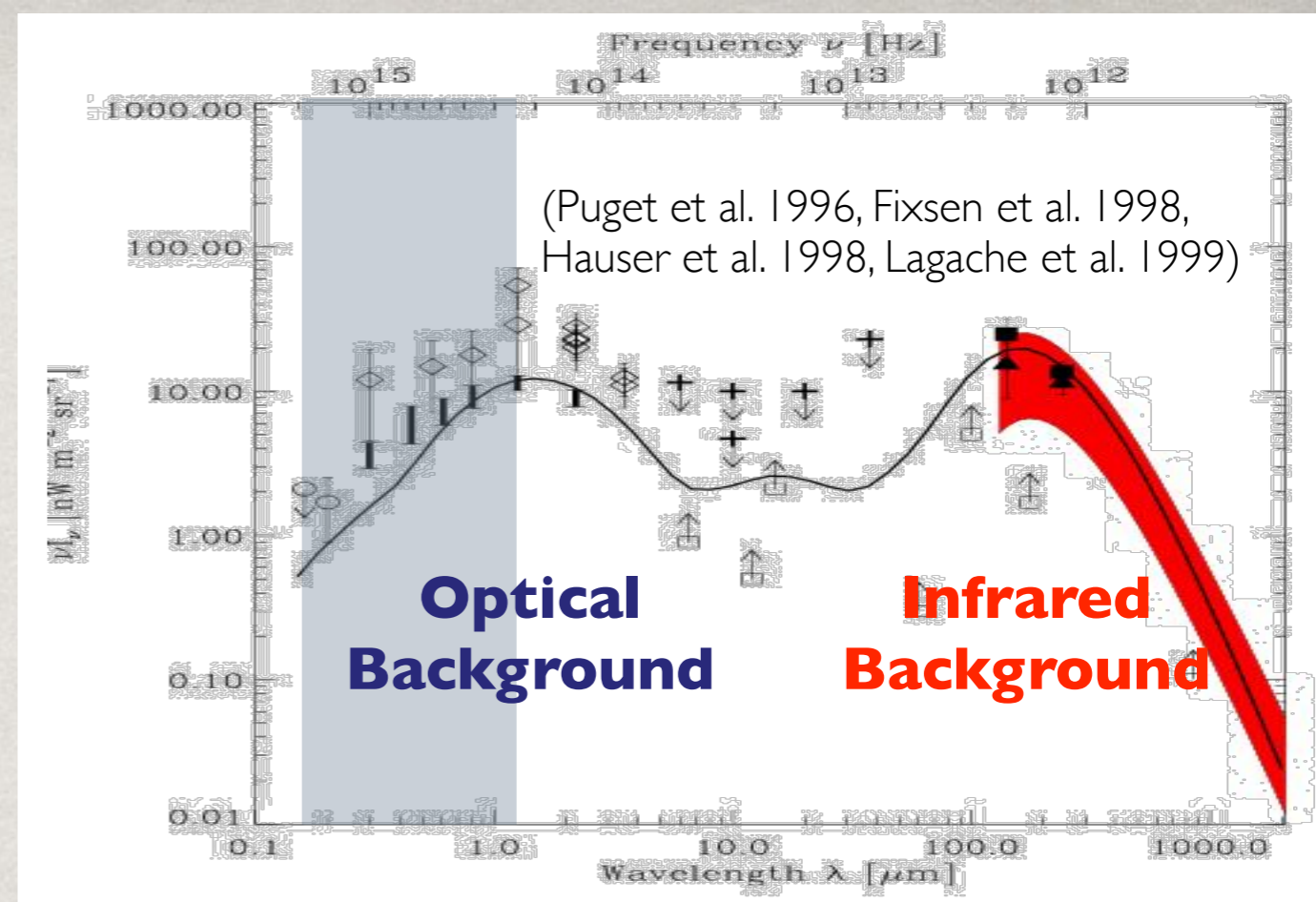
viewgraphs provided by James Simpson (ASIAA, EACOA Fellow)

OUTLINE

- Science background
- Survey goal
- Current status
- Papers and proposals

Background

- COBE showed that $\sim 50\%$ of the light produced by extra-galactic objects has been reprocessed by dust and re-emitted in the far infrared and sub-mm.
- Far Infrared background = opt/UV \rightarrow half of the energy production (from SF or AGN) over history of the Universe arises in highly obscured regions



HST - optical

Herschel 250-500um



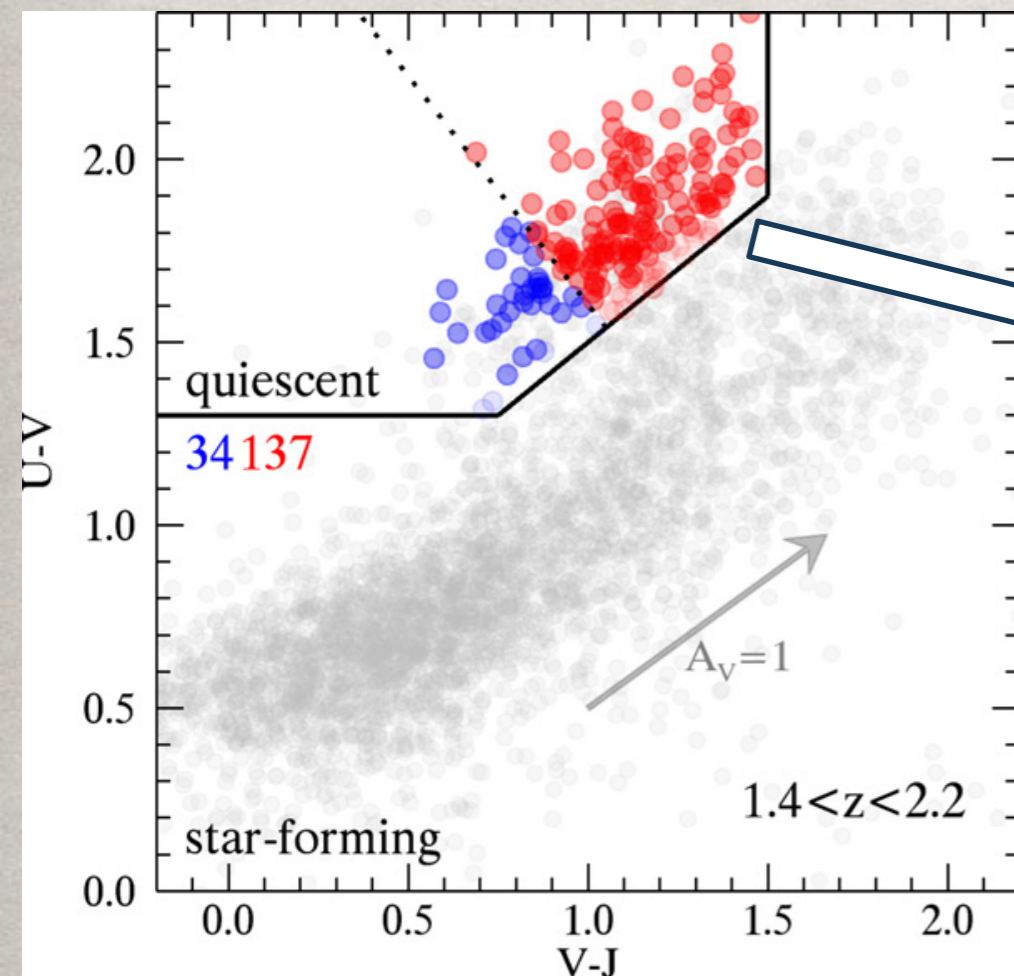
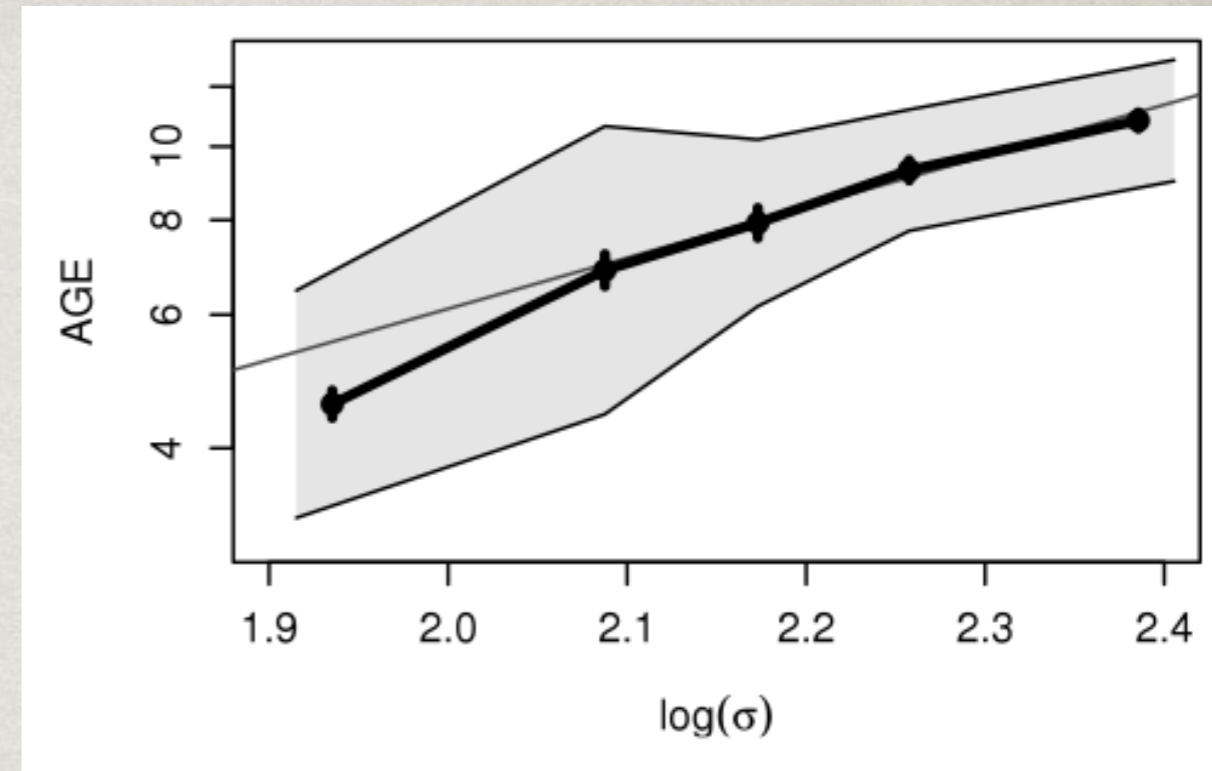
- Most luminous far-infrared galaxies at $z \sim 0$ are UltraLuminous InfraRed Galaxies (ULIRGs)
- $L_{\text{FIR}} > 10^{12} L_{\odot}$, inferred star formation rates of > 100 's M_{\odot}/yr
- Host $< 1\%$ of star formation at $z=0$ but are now known to be more important at high redshift

Ages of Massive Galaxies

(Nelan et al. 2005)

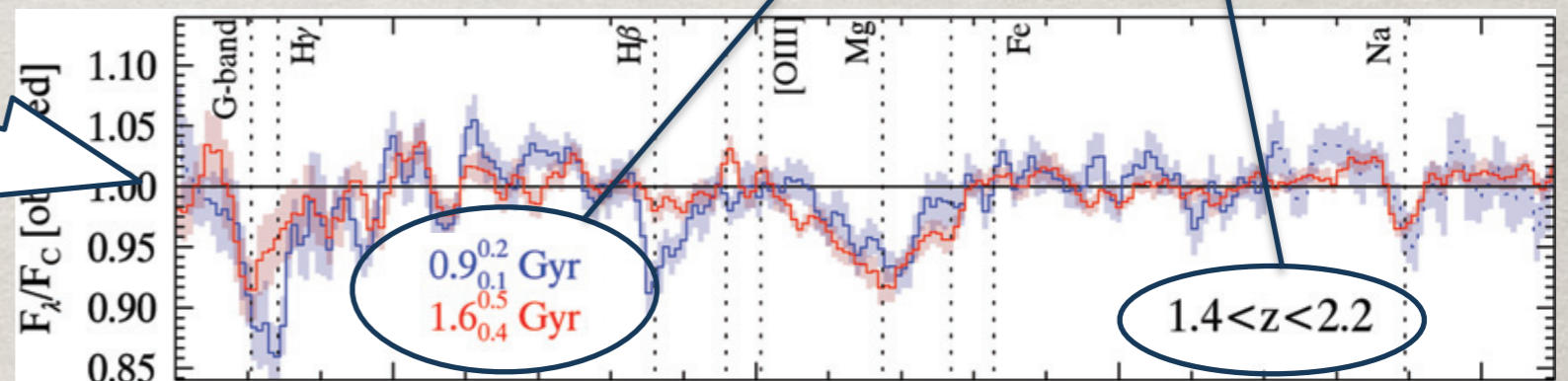
Low Redshift

- Most massive Ellipticals appear to have old stellar populations that formed at $z > 2$.
- Stellar archaeology indicates that a large fraction of these stars formed in a single, rapid burst. We should look for $z > 2$ starbursts to find proto-Ellipticals SMGs!



High Redshift

Formation epoch: $z \sim 3$

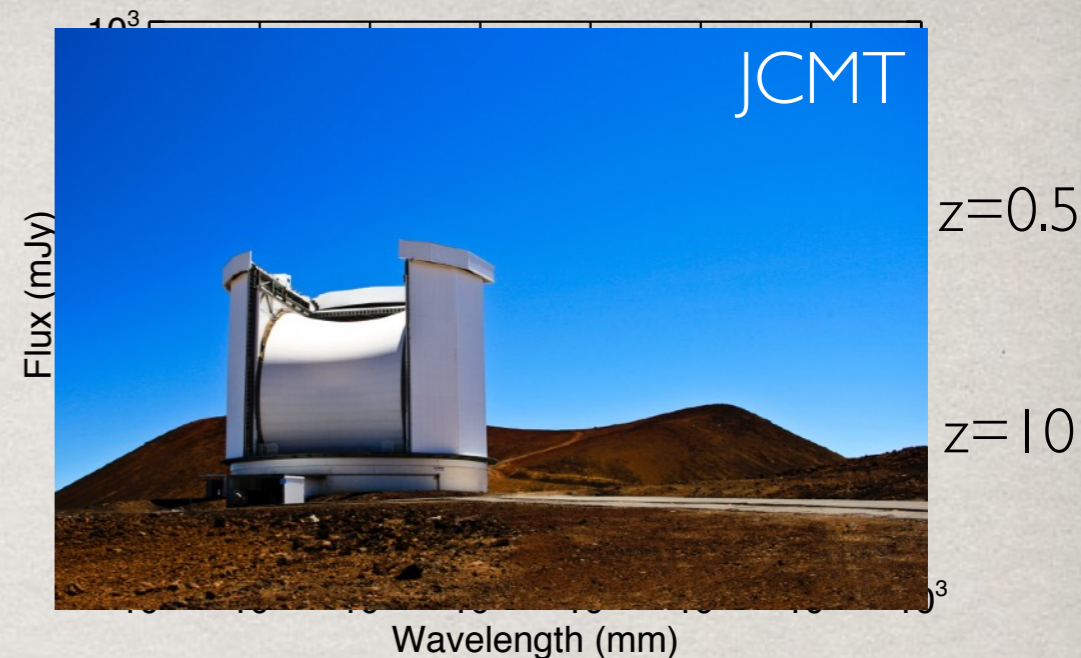


- At high redshift quiescent galaxies appear to have old stellar populations. Consistent with formation at $z > 2$.
- To understand these populations we need to find their progenitors at high- z .

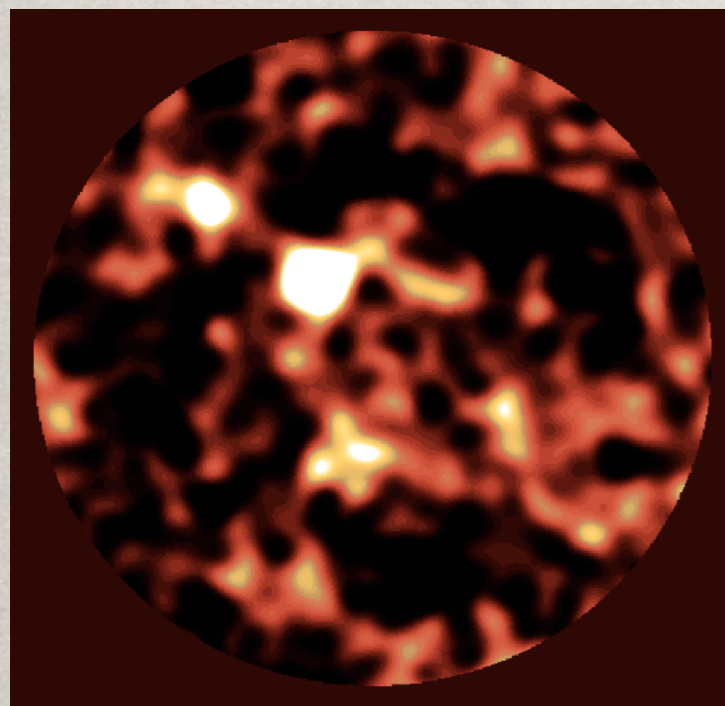
(Whitaker et al. 2013)

Finding SMGs

- The negative k-correction at sub-mm wavelengths means that surveys at $\sim 850\mu\text{m}$ have a near uniform selection in obscured star-formation ($\sim >300\text{Mo/yr}$) out to $z\sim 7$.
- JCMT has led the way with deep surveys at $850\mu\text{m}$, initially with SCUBA and now SCUBA2

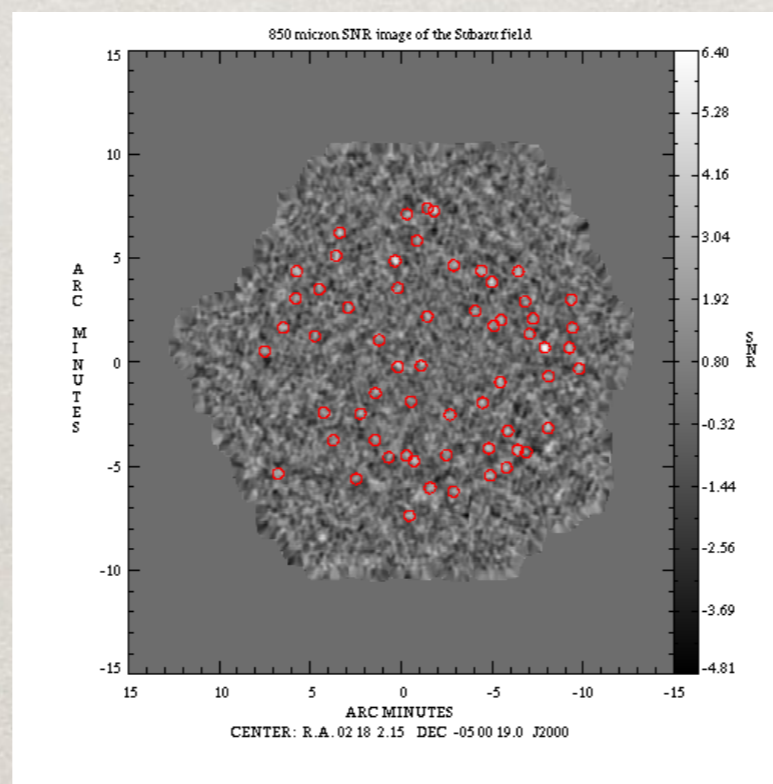


HDF (Hughes et al. 1998)



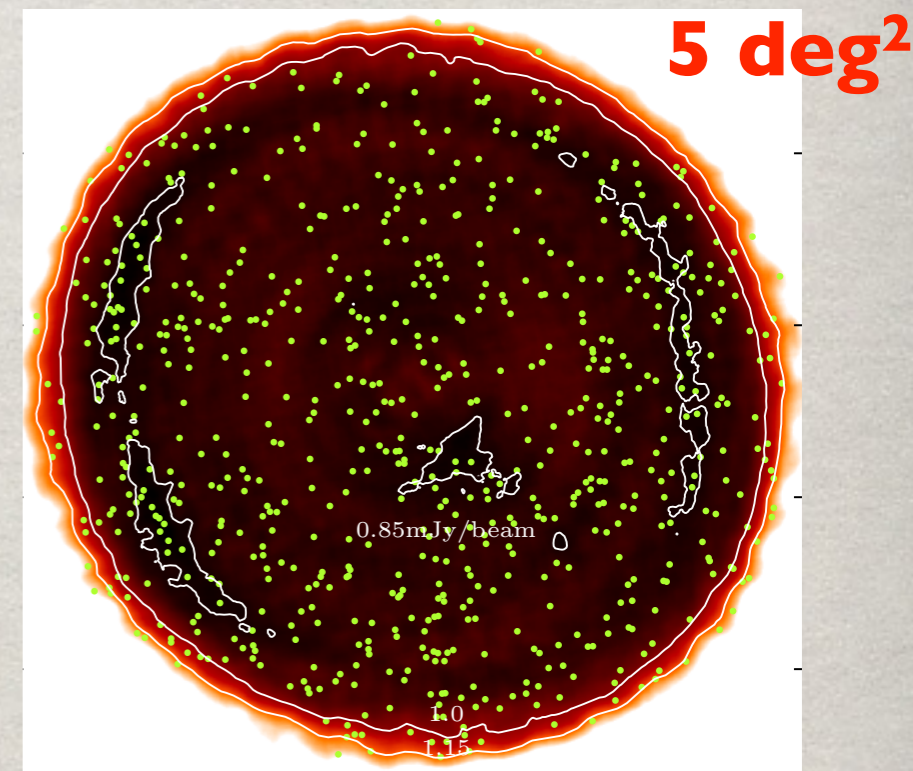
FoV: 3 arcmin

SHADES (Coppin et al. 2006)



FoV: 20 arcmin

S2CLS/UDS: 717 sources with $S_{850} > 3.6\text{mJy}$ (Geach et al. 2016)

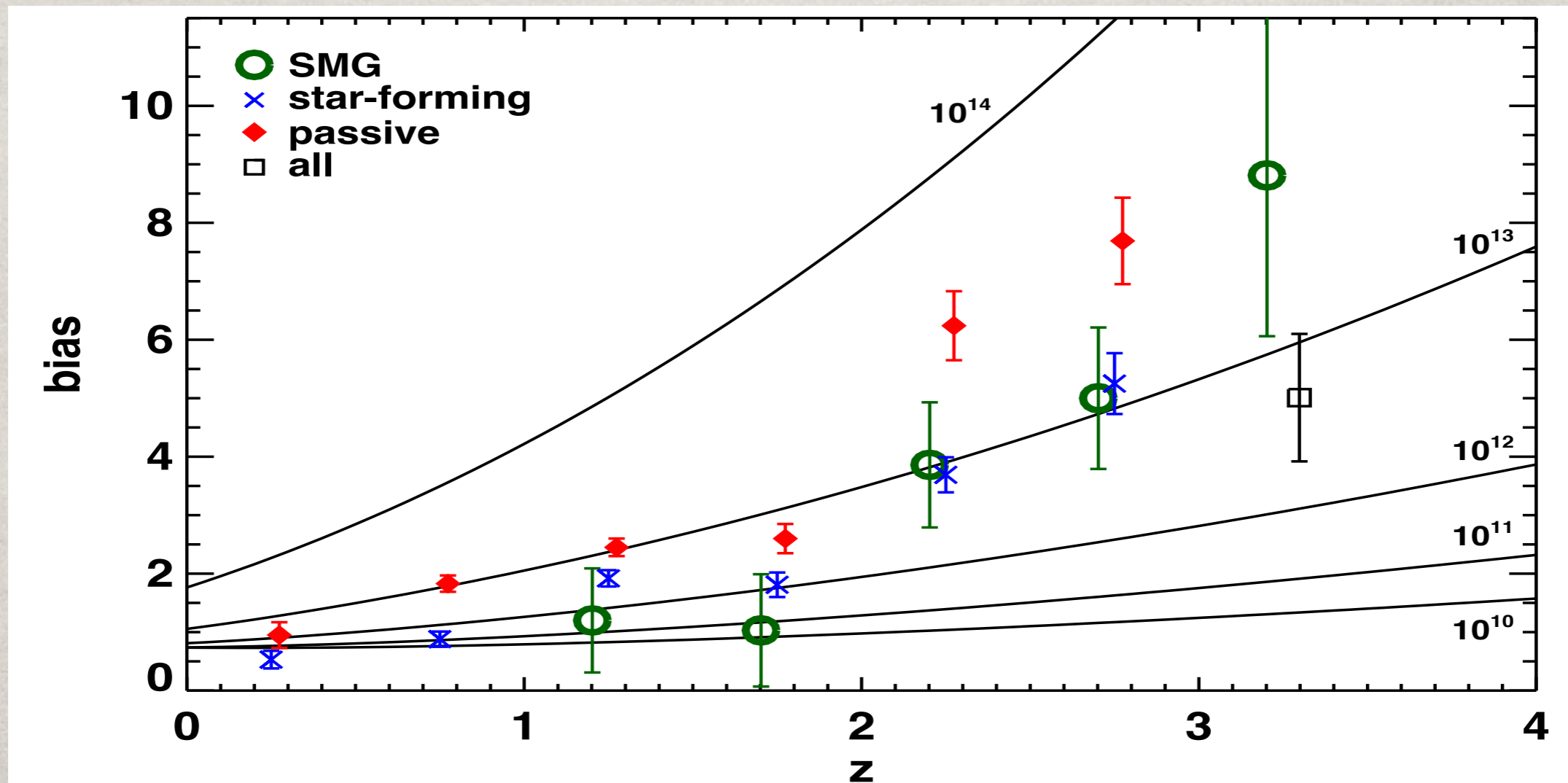


- Wide-field surveys with culminated with the SCUBA2 Cosmology Legacy Survey. The deepest, wide, observations were taken in the UDS, reaching $\sim 0.9\text{mJy/beam}$ over 1 sq. deg

Linking SMGs to Ellipticals and Dark Matter Halos

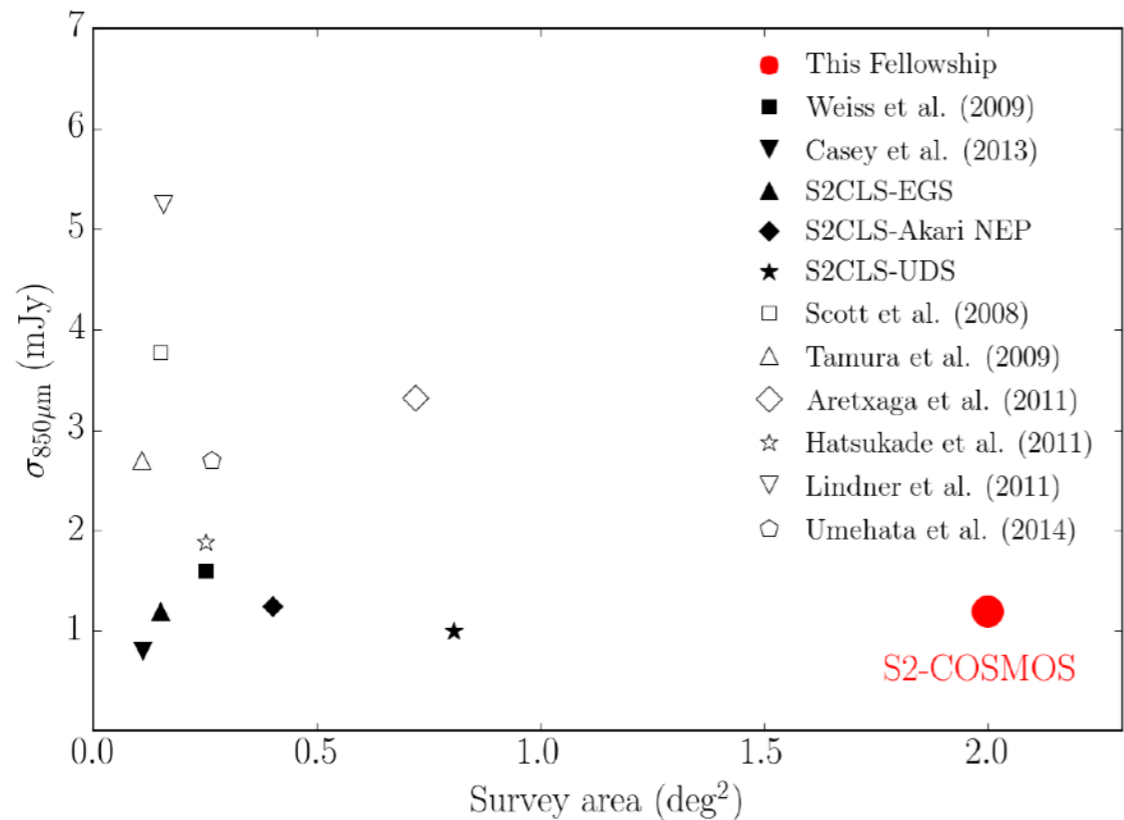
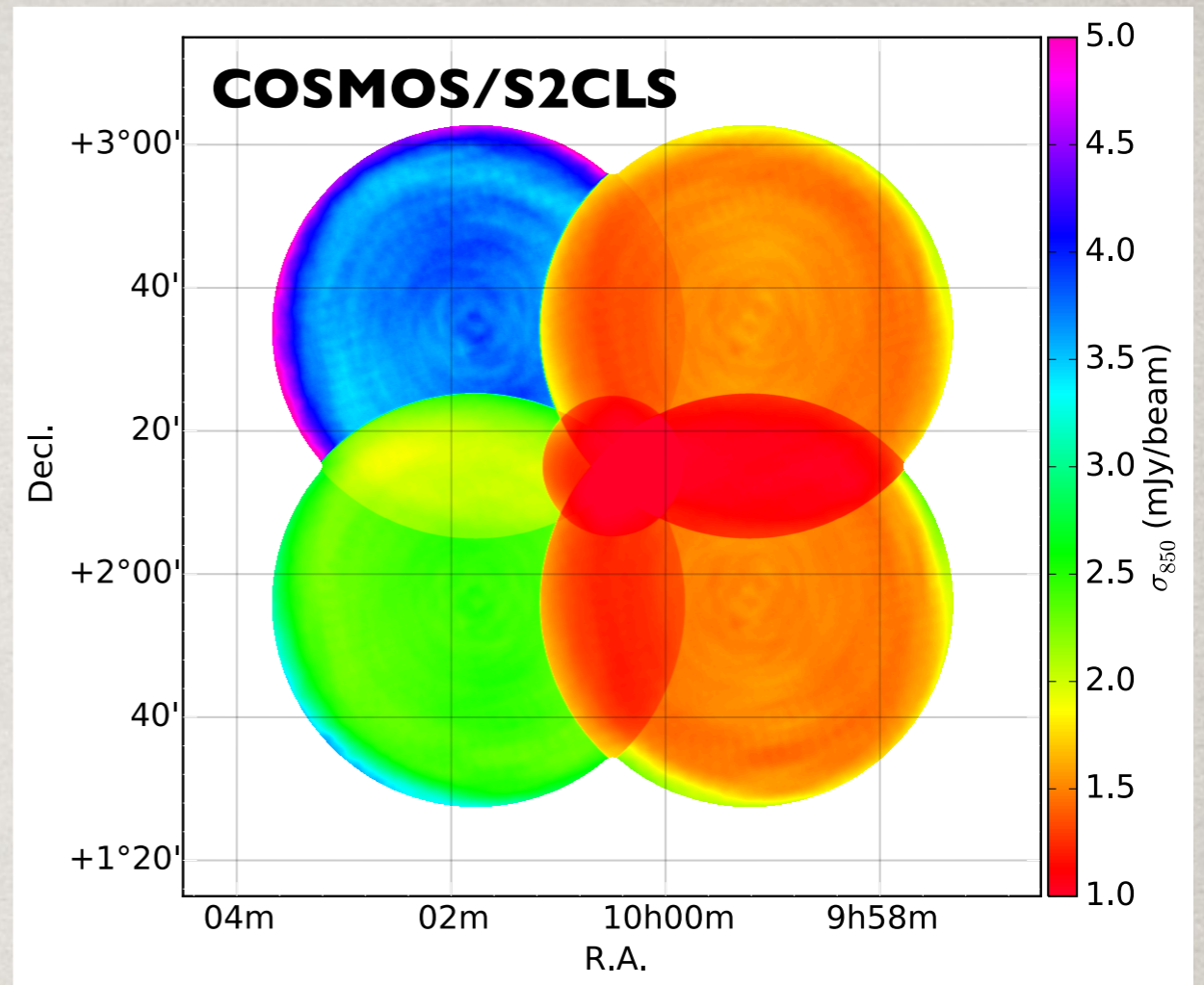
- Measuring the clustering strength of SMGs is arguably the most powerful way to understand the connection between these sources and other galaxy populations.
- Clustering can be used to measure the typical halo mass of SMGs, and hence provide a mass estimate free from the systematics that plague stellar and dynamical mass estimates for these sources.
- Wilkinson et al. 2016 used the 850um imaging of the UDS to a galaxy bias of 2.18 ± 0.97 for SMGs, indicating that these sources are consistent with other star-forming galaxies at high-redshift. However, need more sources/wider area to make a robust measurement

(Wilkinson et al. 2016)



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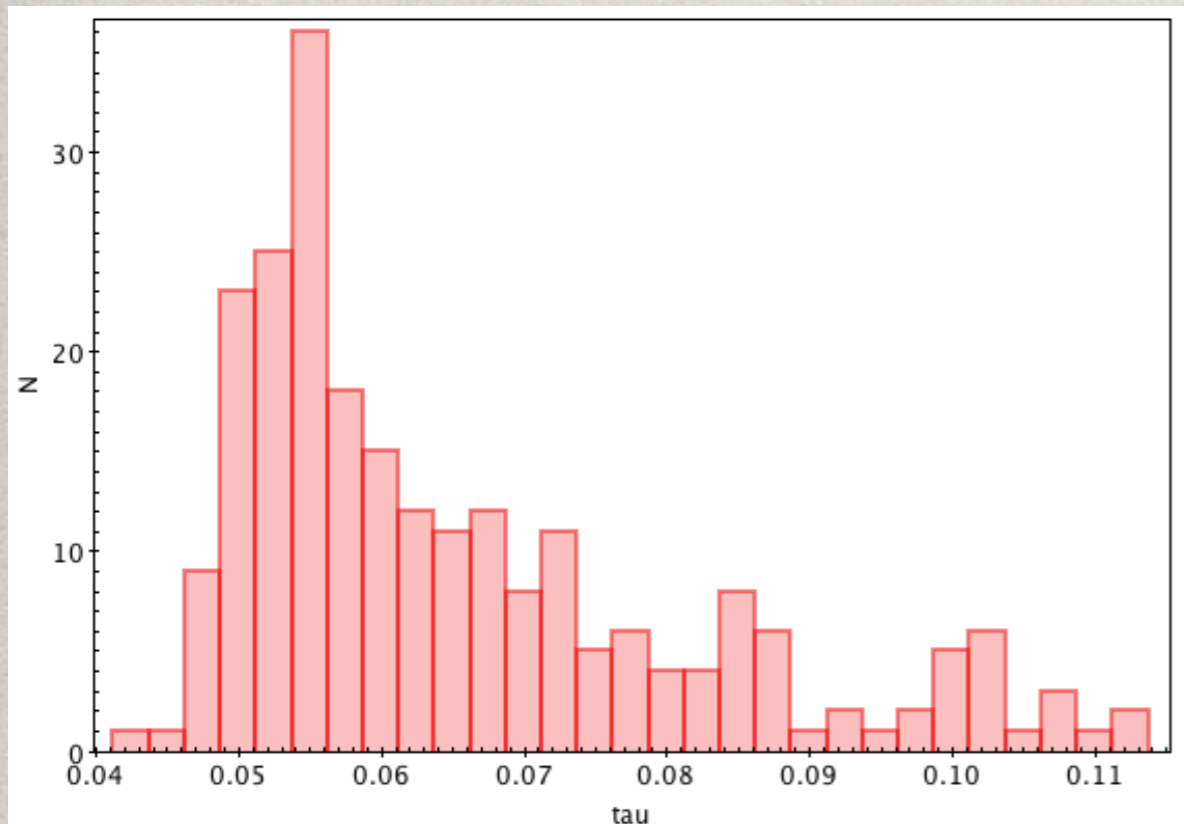
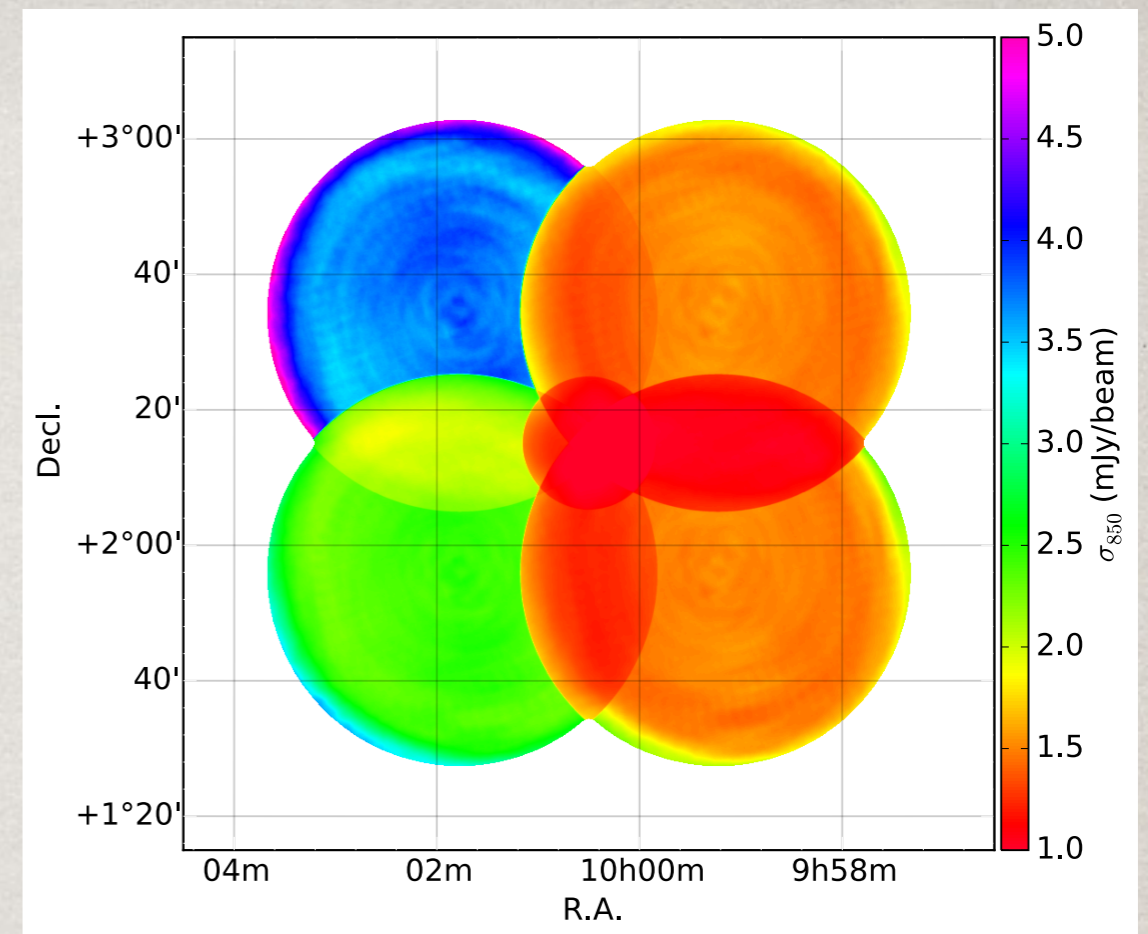
- COSMOS is the pre-eminent ALMA-visible extragalactic survey field, with a wealth of deep archival imaging across Xray to Radio wavelengths.
- Field was observed as part of S2CLS but the observations were not completed with the rms in the "final" map varying from ~ 1 to ~ 4 mJy across the field



- S2COSMOS: awarded 223hrs in Band2/3. Aims to first complete the coverage of the full field to the depth of the deepest existing S2CLS maps and then increasing the depth ~ 1.2 mJy rms.
- S2COSMOS aims to provide a resource of > 1000 SMGs to the EAO community and determine the nature of SMGs (e.g. clustering)

S2COSMOS - Survey status

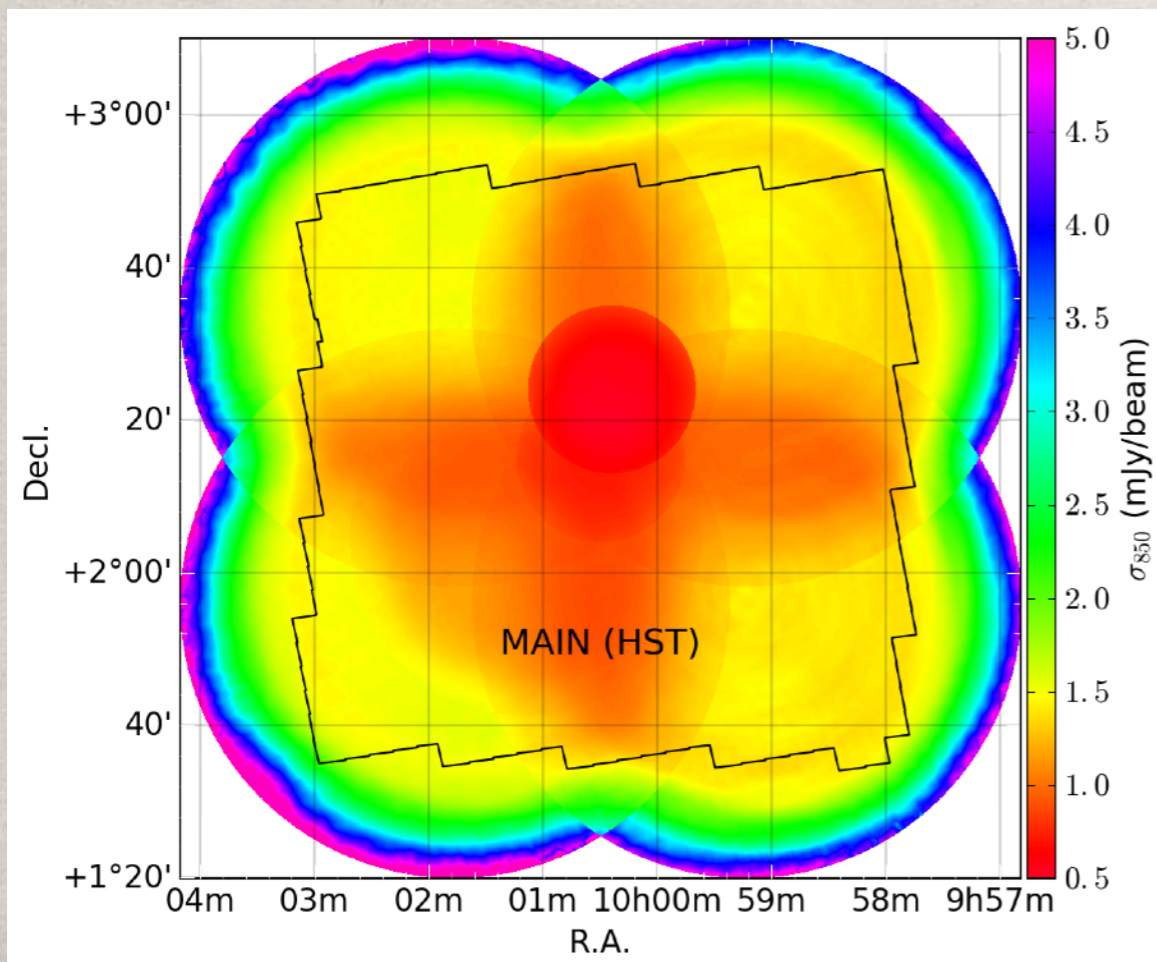
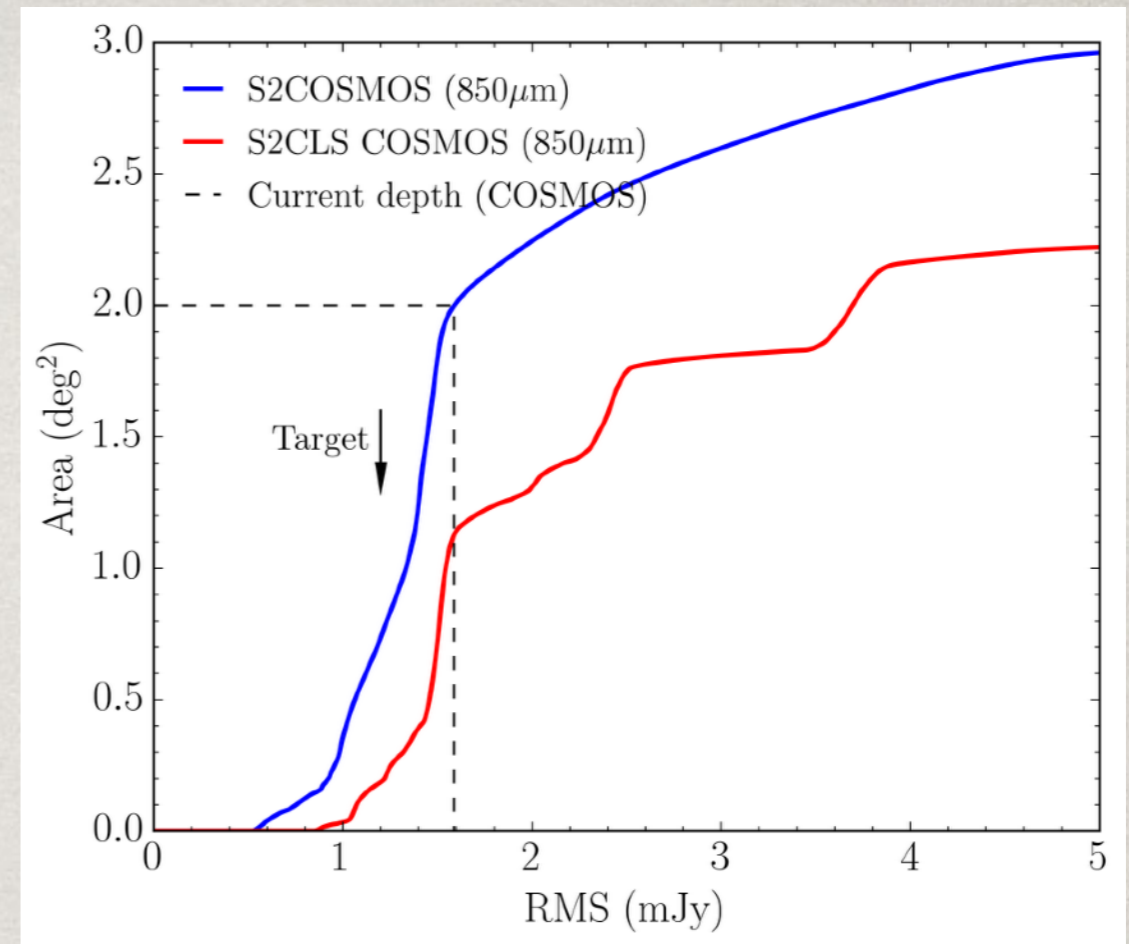
- JCMT Large Program, awarded 223hrs (Band 2/3) to observe the COSMOS field.
- S2CLS strategy consisted of four wide PONG2700 and a single central PONG900.
- S2COSMOS employ the same observing strategy. However, focus first on the two Eastern PONG2700, with the aim of achieving a uniform rms across the field.



- Highly successful first “year” of data acquisition, with 168hrs of data taken between Jan-May 2016 while COSMOS is visible (~74% complete). COSMOS now visible again but combination of weather and maintenance of SCUBA2 means the survey is still 79% complete - although we hope to finish by summer 2017.
- Overall the observations have been taken in good conditions, median tau of ~0.06. Although we note that the achieved rms per 40min PONG is typically ~20% poorer than expected.

S2COSMOS - Survey status

- Made extremely good progress at creating a uniform image of the COSMOS field. Current S2COSMOS image contains all archival SCUBA2 data in the COSMOS field and achieves an rms of <1.5 mJy in each of the four quadrants.
- Custom built source extraction package written in Python. Identify sources at >3.75 sig in the S/N image and fit emission with model PSF



- Identify 1180 SMGs in “MAIN” catalog (HST coverage) and a further 258 SUPP SMG (IRAC coverage) with 850um fluxes of $\sim 2-21$ mJy
- Expect final map to contain $\sim >1500$ SMGs
- Deboosting and completeness is estimated by injecting fake sources into jackknife maps and measuring the properties of the recovered sources.

Projects underway

- Projects and proposals are co-ordinated through a consortium website, with involvement from EA and UK collaborators

Papers:

- Survey paper including counts and cluster. (Simpson et al.; ASIAA)
- Multiwavelength identifications and properties paper. (An et al.)
- Selection of ultra-red sources ($z > 4$) and 850 μ m dropouts (Oteo et al.)
- Stacking SCUBA-2 images in different environment for Lyman-break galaxies and photo-z selected galaxies at $z \sim 1-4$ (Chang et al.)
- Dust mass and SFR as a function of stellar mass from 850 μ m+Herschel (Bourne et al.)
- Sub-mm measurements of radio vs. X-ray vs. IR vs. optically selected AGNs (Alexander et al.)

Follow-up

Proposals:

- ALMA imaging of 150 bright SMGs in S2-COSMOS. PI: Y. Matsuda
- SMA imaging of "red" 850 μ m sources at $z > 4$. PI: I. Oteo