Identifying the brightest 110 S2-CLS sources with the SMA (and brightest SMGs in wider field)

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Sample is the S2-CLS
Brightest (>10mJy) SMGs context

• clustering
• beacons for structure; regions of rapid evolution
• Laboratories for extreme/maximal SFRs
• Multiplicity - how many really bright (S850>10mJy, >15mJy, >20mJy) SMGs are there?
SMA program (PI: Chapman)

• Aim to observe all 110 S2-CLS sources with S850_{observed}>10mJy (some >8mJy) -- complements AS2-UDS (20 sources bright enough to be included here)
• SMA compact config (~2") 860um observations obtained over 5 proposals and 2.5 years; 31 tracks/ nights
• 2014A-2016A (July 26, 2014 to Nov 29, 2016)
• Growing SWARM correlator through this time meant changing strategy (# sources per track).
• Aimed for ~uniform sensitivity, but practicality/weather meant range of RMS: 0.5 to 2mJy – ave 1.2mJy
• Major commitment from SMA

Examples in AEGIS
Multiwave properties
S2-CLS counts, SMA identified
(Hill, Chapman, Scott et al. 2017)

- Field by field ... story is consistent with bright sources not typically breaking up
S2-CLS counts, SMA identified
(Hill, Chapman, Scott et al. 2017)

• Counts show more bright single sources than Simpson+15 A-UDS
  – But consistent within Poisson errors
  – A-LESS (Hodge/Karim2013) just doesn’t have bright single sources.
• 2.4” SMA beam means the expected blending of close doubles (~10% of Simpson +15)
• ~10% signs of being lensed (TBD)
Extreme SMGs: Brightest (unlensed) sources in S2-CLS $\sim5\text{deg}^2$

- COS1 (as verified by s2cosmos); $S_{\text{(SCUBA2)}}=21\text{mJy}$
- single SMA ID S870=19mJy
- SMA (green) and VLA (red); IRAC image
- Mild Multiplicity ($19 + 3\text{ mJy}$)
- Keck LRIS shows $z=2.5$ (single line Ly$\alpha$)

Previous brightest $\sim20\text{mJy SCUBA(2)}$ sources:
- GN20 looks like single massive disk
- H1700-Harriet looks like close major merger

These were found at 850um in 100 arcmin$^2$ surveys!
Brightest unlensed SMGs from *Herschel*

Herschel SPIRE ~300 deg$^2$ search

- $z=2.4$ Ivison+13: ~45mJy (2 major components 25+12mJy)
- $z=4.4$ Oteo+16: ~32mJy (2 major components 20+10mJy)
The South Pole Telescope survey

The South Pole Telescope  
PI: John Carlstrom

Goal: Cosmological survey to study CMB fine structure and Sunyaev–Zel'dovich signal from Galaxy clusters

Area: 2500 deg²

Wavelengths: 3, 2 and 1.4 mm (typical rms at 1 mm ~3.5 mJy)

Bonus: Large sample of rare ultra bright sources  
Vieira+08

Funded by NSF

2500 deg²  
DEC. -55 deg  
Carlstrom et al. 2011
Brightest 3 SPT unlensed SMGs

- SPT2349 (S850=100mJy >12 components)
- SPT0348 (56mJy 2 cmpts)
- SPT2052 (40mJy 2 cmpts)

(Hill, Chapman, Scott et al. 2017)

Individual galaxy SFR vs halo mass issues

0.001

3/2500 deg$^{-2}$
Unlensed SPT0348

$z=5.7$  S850=56mJy LABOCA

Lacaille+2017: 50mJy resolved by ALMA

cy4 C+,N+,CO4-3 highres

cy3 b7 imaging 0.3”

cy3 CO5-4 lowres

ATCA  CO2-1

SPT0348 $z=5.7$

massive merger system

b7 cy3
0.3”

b7 C+
0.6”
Unlensed SPT2052

SPT2052 z=4.3
3 widely separated massive starbursts

— SPT2052 and 0348 are/ or amongst most luminous starbursts known,
— comparable to Ivison et al. 2013: most luminous starburst known from Herschel surveys

GN20 clone (20mJy) (Daddi+2008,Hodge+2014)
Both of these (GN20,Harriet) found from 100arcmin2 surveys!

Harriet clone (20mJy) (Chapman+2015, Perry+2017)

outflowing gas?
• Unique source in 2500 deg$^2$ SPT-SZ survey; All others are lensed DSFGs or weaker.

SPT 1.4mm ; 4 deg$^2$

• SPT2349-56 not even detected with Planck.

Resolved by LABOCA (18'')
and even marginally by SPT (1')

(a S2-CLS footprint)
SPT2349 Extended Emission – tip of the iceberg (ALMA Cy5), and wider field (MUSE,Gemini)

- Bright mm source splits up into >12 components in ALMA 1.3mm map with SFR~10,000\(M_\odot\)/yr.
- LABOCA 870um contours, IRAC ~100mJy ‘source’
- ~20,000 \(M_\odot\)/yr of SFR still unaccounted for
Unlensed SPT-SMGs
SPT2349 — massive $z=4.3$ proto-cluster

12 galaxies confirmed in 13\" radius using [CII] and CO(4-3) lines.
• $100 < \text{SFR} < 2000$, tot: $10000 \ M_\odot/\text{yr}$, up to 22000 accounting for full 850\micron flux.
• Velocity dispersion 500 km/s implies a viral cluster mass $\sim 2 \times 10^{13} \ M_\odot$.
• Extreme SFR density with $<1'$ compared to other proto-clusters!

Brightest source is huge turbulent disk
Conclusions

• SMA resolved ~110 brightest S2CLS sources
  – Detailed study and followup will provide insights into ...
• What factors drive the highest resolved (galactic scale) 870um fluxes?
  – Major HyLIRG Mergers seem very important!
  – Wider environment (clusters)?
  – Giant turbulent disks (GN20, SPT2349-A, SPT2052-A)
  – Redshift? More at higher-z? Expect lower-z (High noon)
• Real (resolved) ~20mJy sources relatively rare: CLS ~1/5deg²
  – 2/deg² at >14mJy
• Statistics not very good; could actually be higher?
  – 20mJy GN20 & Harriet/H1700 found in 100arcmin² surveys
• S2XLS Legacy survey under way at JCMT ... ~10deg²
  – Not a huge leap, but enough to probe these issues well
Fun SMG20 fact

• March’98, an unnamed author of SIB1997: “there’s no point publishing yet another counts paper, the field is already saturated”

... thus successfully delaying the canadian SCUBA cluster paper to 2002.