JCMT Large Programs Status

(James Clerk Maxwell Telescope)

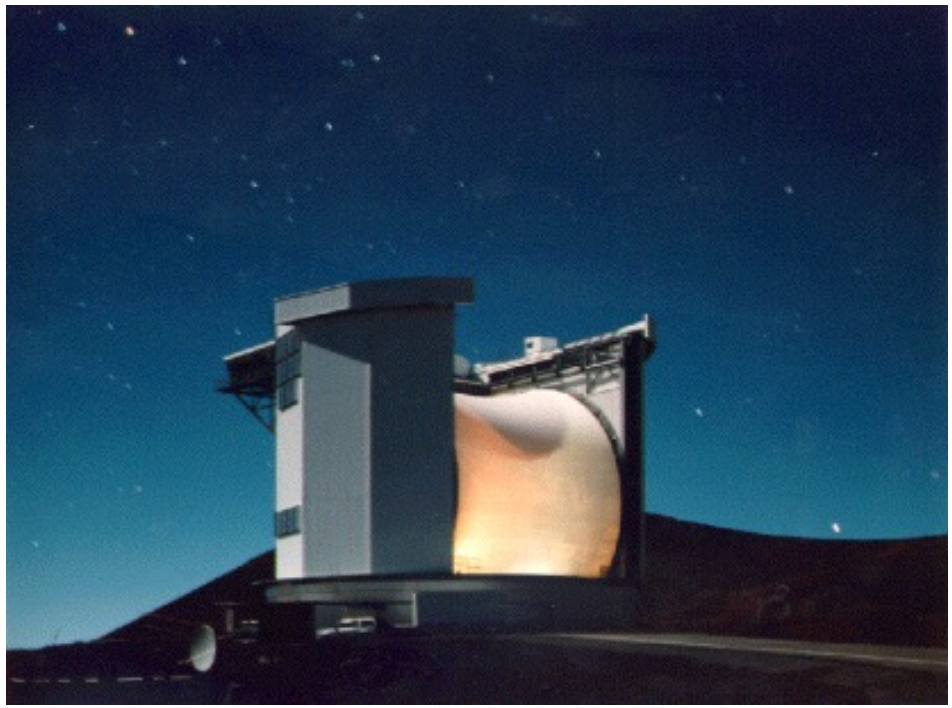
2023년 1월 17일

여아란

동아시아 천문대는 2015년 3월부터 JCMT 운영 시작

15m JCMT (1987 운영 시작)

East Asia Observatory (China, Japan, Taiwan, South Korea) + UK & Ireland + Thailand
+ Observers: Indonesia, Malaysia, Vietnam



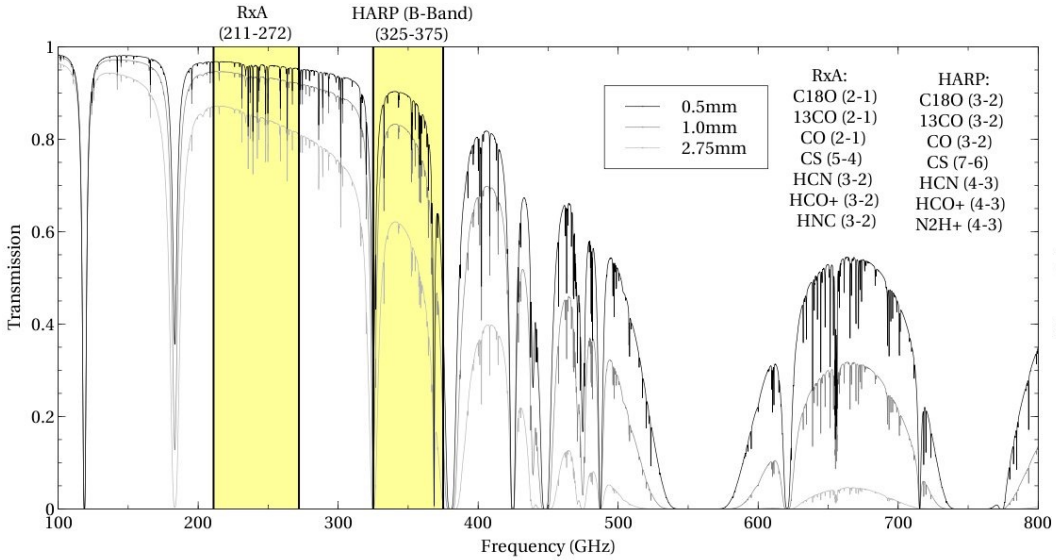
Instrumentation

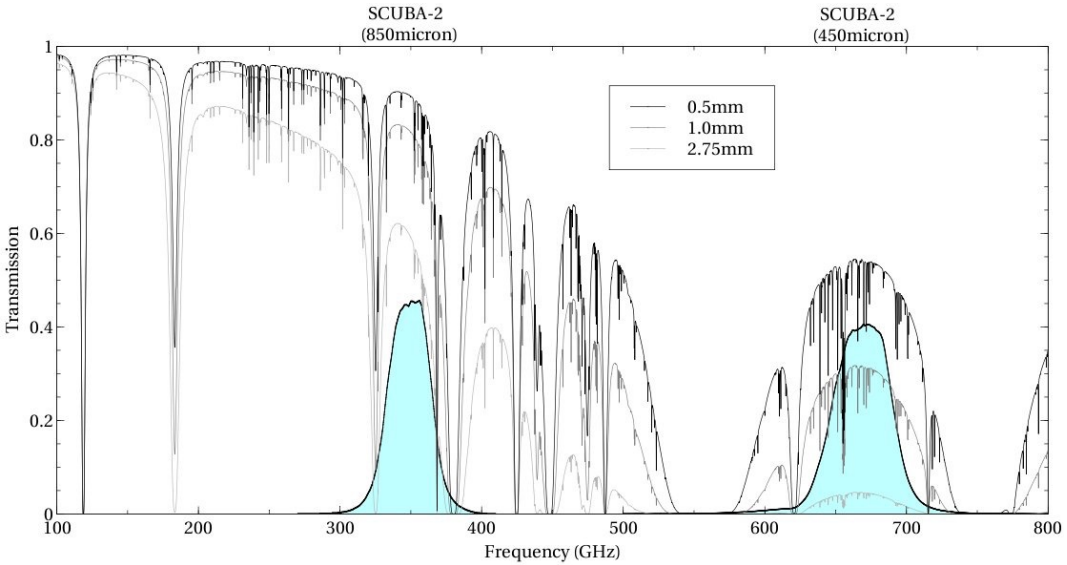
Heterodyne Instrumentation

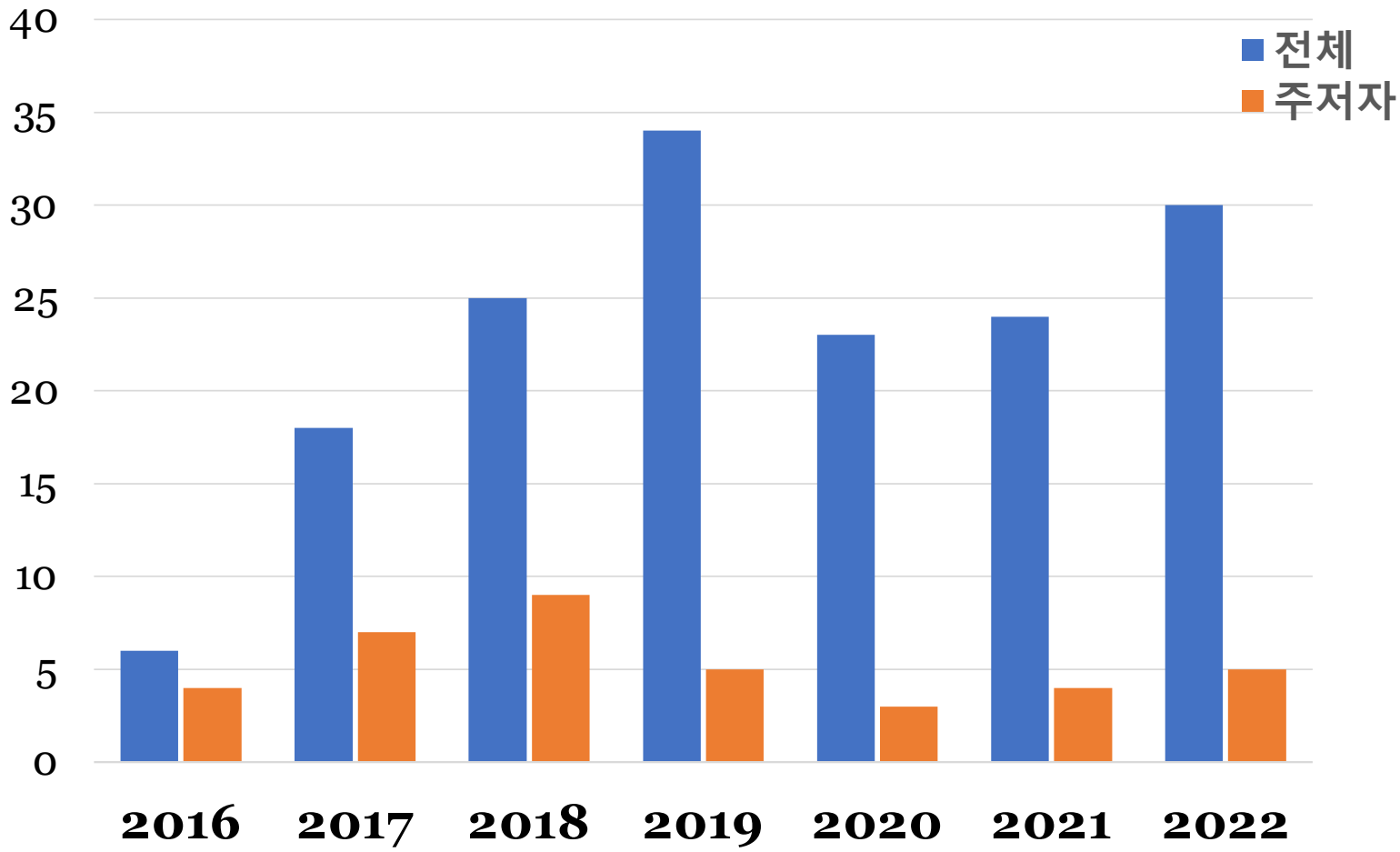
HARP, 16-pixel array receiver working at 345 GHz;
U-u, single-pixel insert on Namakanui working at 230 GHz;
Aweoweo, single-pixel insert on Namakanui working at 345 GHz.

Continuum Instrumentation

SCUBA-2 is the JCMT's continuum camera.
four 32×40 detector arrays at 850 and 450 micron, in total 10240 detectors.







한국 연구 기관에 근무하는 연구자가 저자로 포함된 JCMT 논문 개 수의 추이

Large Program

50% of it's available science time, in total 6,167 hours

2015: 7 programs
2017: 9 programs (some of them are the extension programs)
2019: 13 programs
2021: 4 programs

Star formation and evolution within the Milky Way

- A **Transient** Search for Variable Protostars
- **SCOPE**: SCUBA-2 Continuum Observations of Pre-protostellar Evolution
- **SPACE**: Submilimeter Polarization and Astro-Chemistry in Earliest star formation
- **ALOHA** IRDCs: A Lei Of the Habitat and Assembly of Infrared Dark Clouds
- **BISTRO**: B-fields In STar forming RegiOns
- **CHIMPS2**: Resolving Star Formation in the Galactic Plane with HARP
- **NESS**: The Nearby Evolved Star Survey
- **MAJORS**: Massive, Active, JCMT-Observed Regions of Star formation*
- **CLOGS**: CO Large Outer-Galaxy Survey*
- **SURFING**: SURveying Filaments in Nearby Gas Clouds*

Nearby Galaxy Studies

- **MALATANG**: Mapping the Dense Molecular Gas in the Strongest Star-forming Galaxies
- **JINGLE**: the JCMT dust and gas In Nearby Galaxies Legacy Exploration & JINGLE II
- **HASHTAG**: HARP and SCUBA-2 High-Resolution Terahertz Andromeda Galaxy Survey
- **DOWSING**: Dust Observations Using Scuba-2 In Nearby Galaxies

Sub-mm Galaxy Studies

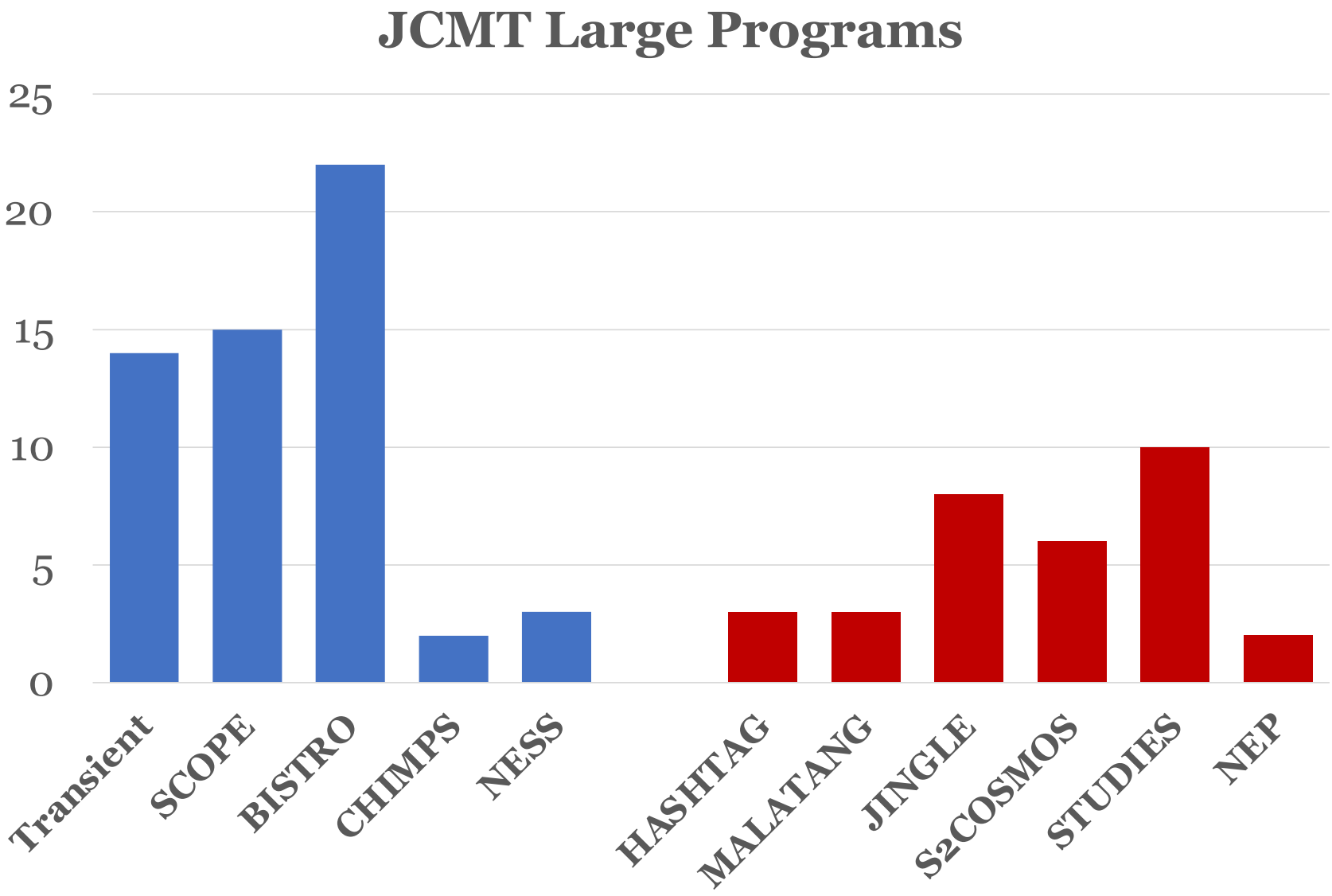
- **RAGERS**: The RAdio Galaxy Environment Reference Survey
- **S2-COSMOS**: An EAO SCUBA-2 survey of 1,000 SMGs in the COSMOS field & eS2COSMOS #
- **STUDIES**: SCUBA-2 Ultra Deep Imaging EAO Survey & STUDIES SXDS
- **NEP**: Extragalactic JCMT Survey of the North Ecliptic Pole
- **S2LXS**: SCUBA-2 Large eXtragalactic Survey
- **AWESOME** – A Well-Deep EAO Survey Observing Most Of The EBL

Black Holes

- **PITCH-BLACK**: Sub-Millimetre Polarimetry and Timing of Relativistic Jets with JCMT SCUBA-2/POL-2

Solar System

- **JCMT-Venus**: monitoring phosphine and other molecules in Venus's atmosphere*


JCMT Large Programs
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Transient
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MALATANG

MApping the dense moLecular gAs in the sTrongest stAr-formiNg Galaxies

Mapping the HCN and HCO^+ J = 4 – 3 line emission in 23 of the nearest, IR-brightest galaxies beyond the Local Group.

The MALATANG survey: dense gas and star formation from high-transition HCN and HCO^+ maps of NGC253 *(Jiang et al. 2020, MNRAS, 494, 1276)*

: HCN and HCO^+ emission features tend to be centrally concentrated, which is contrast to the shallower distribution of CO 1-0 and the stellar component.

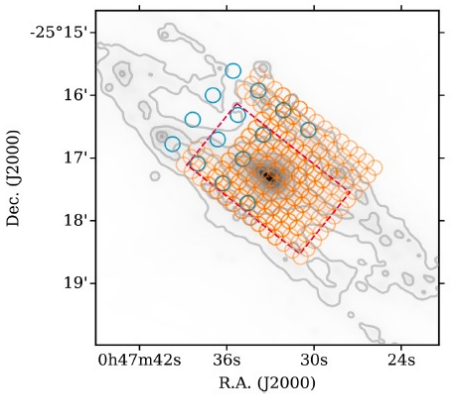
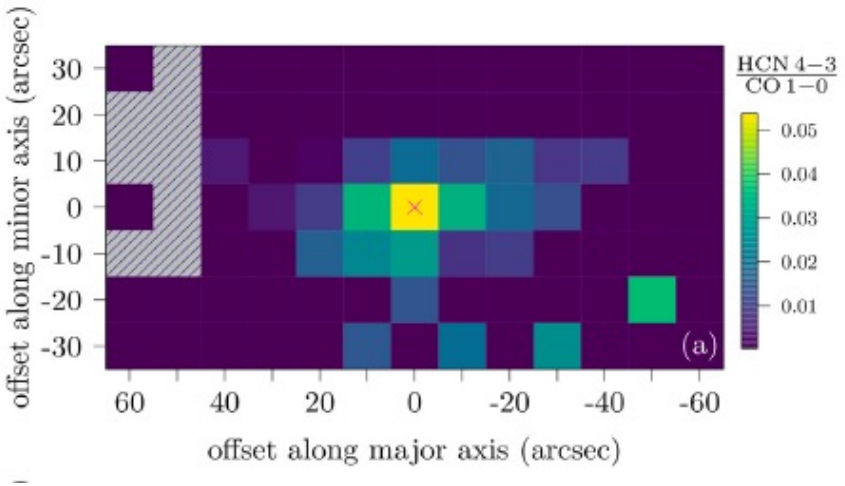
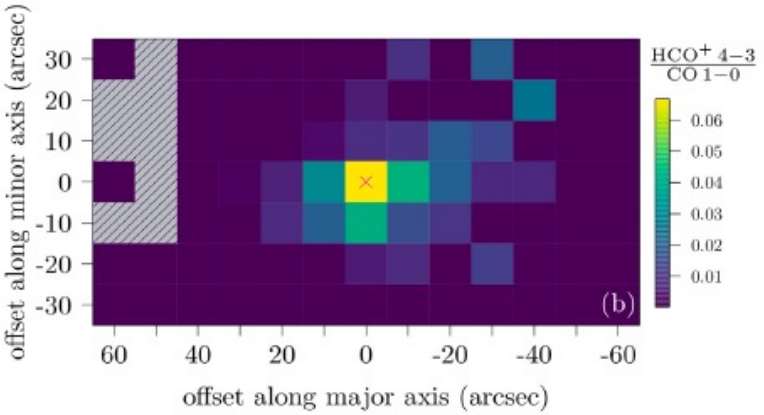


Figure 1. JCMT observing positions for NGC 253 overlaid on *Herschel* PACS 70 μm emission on a logarithmic stretch. Orange circles denote positions observed in jiggle mode, and blue circles denote positions observed in stare mode. Diameters of the circles are 14 arcsec representing the HPBW of JCMT at this frequency. The central 13 × 7 positions (red box) outline those data points used for analysis in subsequent figures.





HASHTAG

HARP and SCUBA-2 High Resolution Terahertz Andromeda Galaxy Survey

Survey the entirety of Andromeda with SCUBA-2 at 450 and 850μm, and we will also observe selected regions in CO(3-2) with HARP

The HASHTAG Project: The First Submillimeter Images of the Andromeda Galaxy from the Ground *(Smith et al. 2021, APJS, 257, 52)*

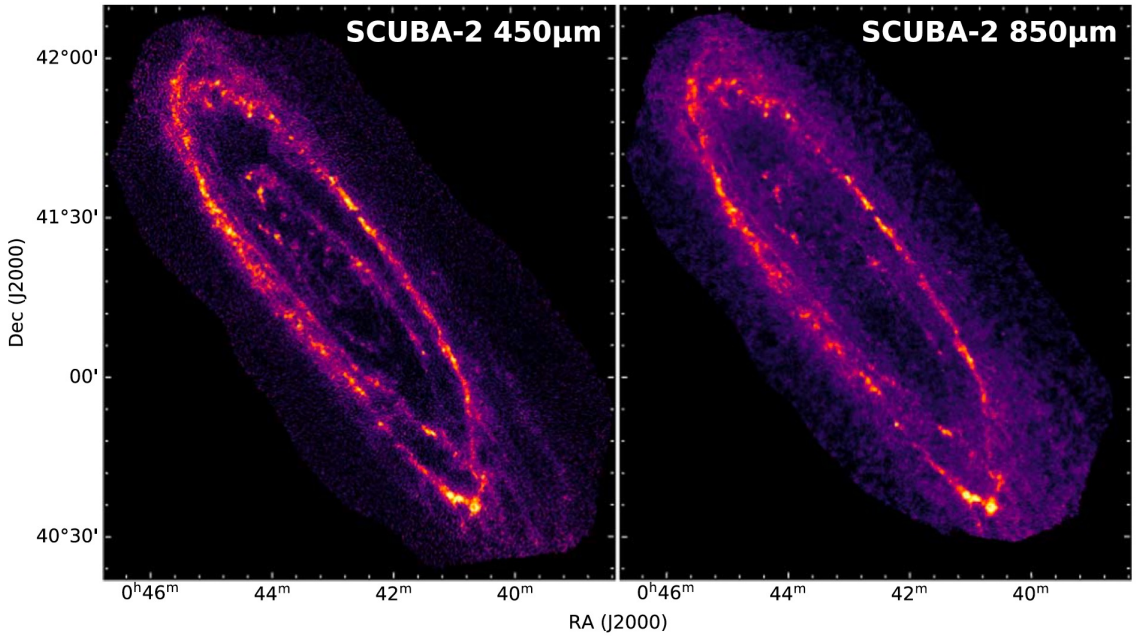


Figure 1. The HASHTAG images created from the first ∼70% of the final SCUBA-2 data set. The 450 and 850 μm images have been smoothed with 7.″9 and 13″ FWHM Gaussians, respectively. For the raw-resolution images see Figure 16.

JINGLE

The JCMT dust and gas In Nearby Galaxies Legacy Exploration

Phase I: 850μm continuum of 193 Herschel-selected galaxies + CO(2-1) of 75 of these galaxies
Phase II: extends JINGLE to galaxy populations, starburst and green-valley galaxies

JINGLE – IV. Dust, HI gas, and metal scaling laws in the local Universe

(De Looze* et al. 2020, *MNRAS 496, 3668)

: Study how the dust and metal content varies with specific gas mass (M_{HI}) across a diverse sample of 423 nearby galaxies.

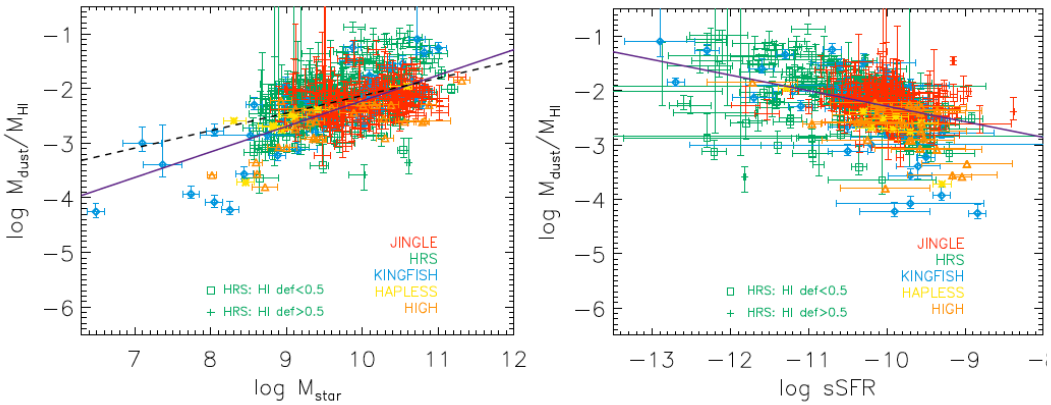


Figure 4. The scaling of the dust-to-H I mass ratio (i.e. $M_{dust}/M_{H\,I}$) with stellar mass ($M_\star$, left-hand panel) and specific star formation rate (sSFR with sSFR $= SFR/M_\star$, right-hand panel). See the caption of Fig. 2 for more details on the symbols and plotted curves.

less massive galaxies are currently in the process of vigorously forming stars

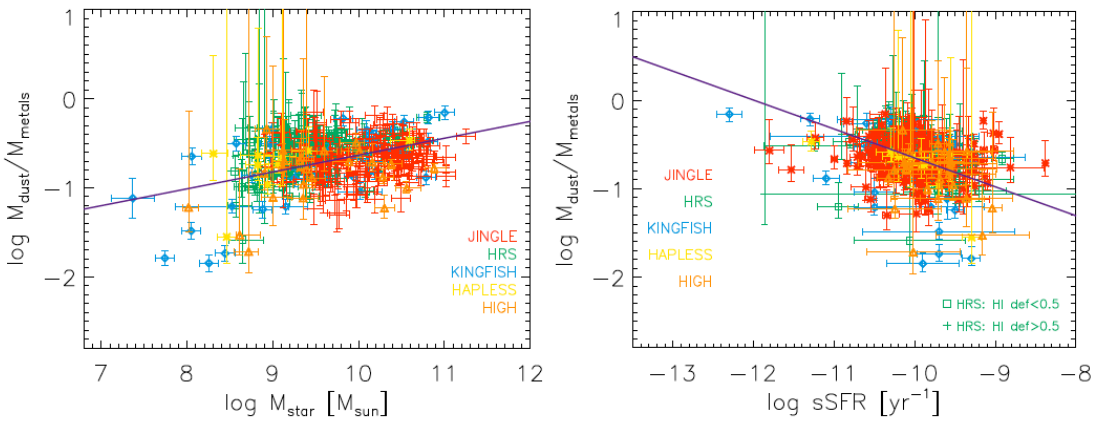


Figure 6. The scaling of the dust-to-metal mass ratio (i.e. M_{dust}/M_{metals}) with stellar mass ($M_\star$, left-hand panel) and specific star formation rate (sSFR with sSFR $= SFR/M_\star$, right-hand panel). See the caption of Fig. 2 for more details on the symbols and plotted curves.

dust-to-metal ratios increases as a galaxy evolves

S2COSMOS/eS2COSMOS

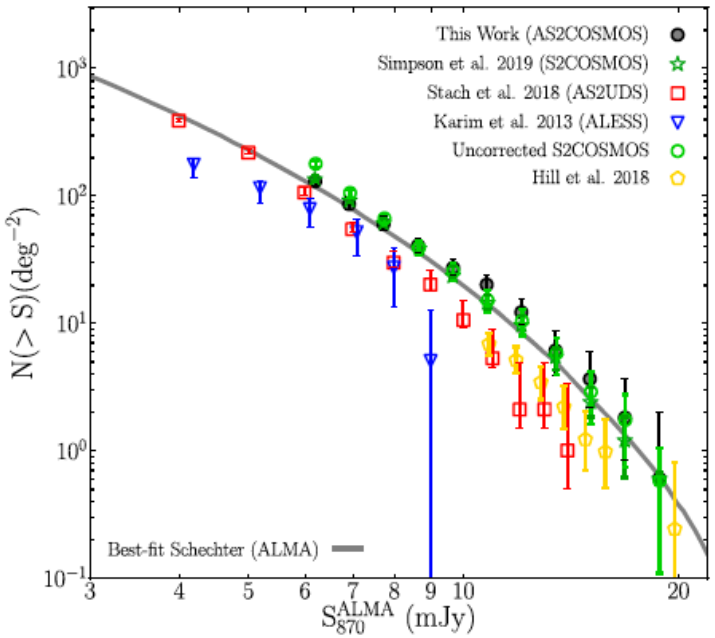
A SCUBA-2 survey of SMGs in the COSMOS field

deep 850μm map of the extragalactic sky – in the 2 square degree COSMOS field.

An ALMA survey of the brightest sub-millimetre sources in the SCUBA-2–COSMOS field

(Simpson et al. 2020, MNRAS, 495, 3409)

:We present an ALMA study of the ~180 brightest sources in the SCUBA-2 850-μm map of the COSMOS field from the S2COSMOS survey, as a pilot study for AS2COSMOS – a full survey of the ~1000 sources in this field.



the corrected counts from the single dish survey are in good agreement with those determined from our ALMA observations.

STUDIES

SCUBA-2 Ultra Deep Imaging EAO Survey

:**ultra deep, confusion limited 450 μm image in the COSMOS-CANDELS region**

SCUBA-2 Ultra Deep Imaging EAO Survey (STUDIES). IV. Spatial Clustering and Halo Masses of Submillimeter Galaxies (Lim et al. 2020, ApJ, 895, 104)

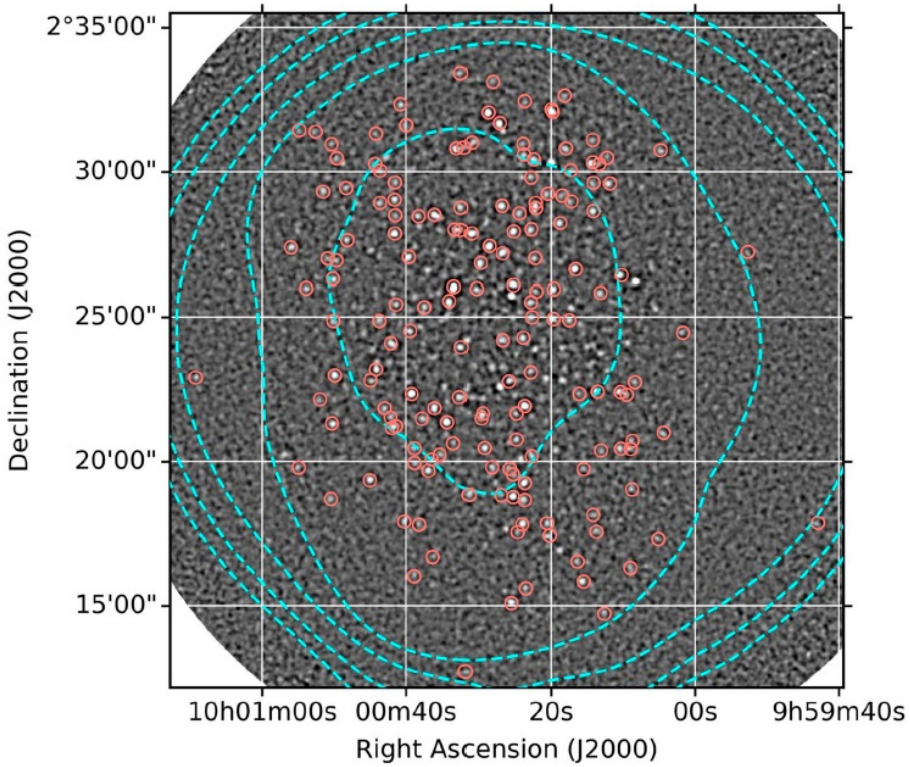


Figure 1. JCMT SCUBA-2 450 μm S/N image, showing the positions of the 164 S/N $\geqslant$ 4 and $S_{450\ \mu m} \geqslant 4$ mJy sources with K-band counterparts based on the VLA and MIPS identifications (red circles). The cyan contours show the instrumental noise levels with contours at 1, 5, 9, 13, and 17 mJy.

221 SMGs from this image; too small to meaningfully study the redshift evolution of the clustering of the population.

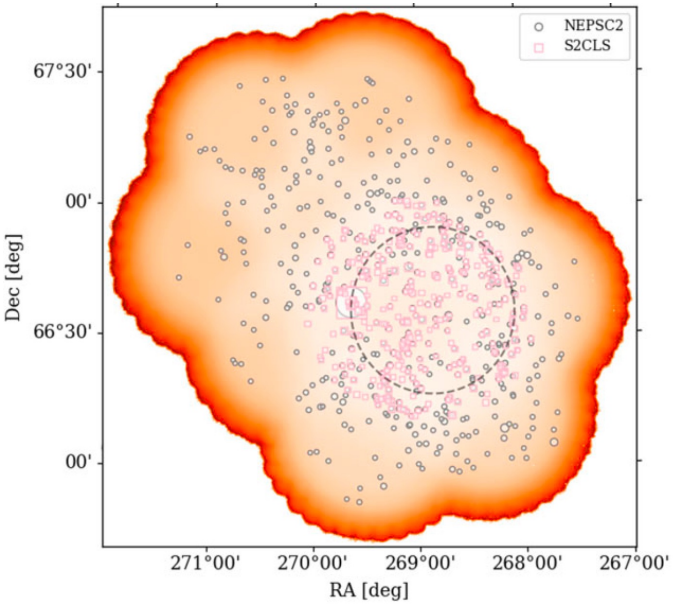
Ultilizing this SMG sample and the 4705 K-band-selected non-SMGs lying within the <1mJy beam^{-1} noise level region of the 450 μm image as a training set, we develop a machine-learning classifier to identify SMG candidates in the full COSMOS field.

***SMG candidates may have more recent star formation** and, consequently, have a higher proportion of young stars.*

North Ecliptic Pole (NEP) Survey

The SCUBA-2 850um Survey in the North Ecliptic

Multiwavelength properties of 850-μm selected sources from the North Ecliptic Pole SCUBA-2 survey *(Shim et al. 2022, MNRAS, 514, 2915)*



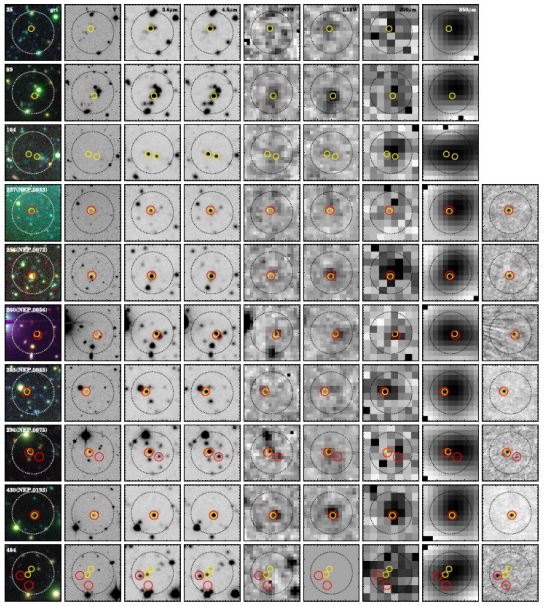


Figure 6. Examples of multiwavelength cut-out images of the 850-μm sources and their counterpart identifications. All images have a size of 40 arcsec × 40 arcsec. Images listed are (from left to right): (1) an optical colour composite image (based on the Subaru/HSC *g*-, *r*-, and *i*-band images as blue, green, and red, respectively); (2) Subaru/HSC *y*-band image; (3) *Spitzer*/IRAC 3.6-μm image; (4) *Spitzer*/IRAC 4.5 μm image; (5) *AKARI*/IRC 9 -μm image; (6) *AKARI*/IRC 18-μm image; (7) *Herschel*/SPIRE 250-μm image; (8) *JCMT*/SCUBA-2 850-μm image; and (9) VLA 20-cm image. The large dotted circles represent 15 arcsec radius circles, which is twice the SCUBA-2 beam size. The small circles indicate the positions of counterparts identified in different wavebands, coloured red (3 arcsec radius) in the radio, and yellow (2 arcsec radius) at 4.5 μm. There exist cases that the counterparts are not detected at wavelength shorter than 3.6 μm (e.g. 227 and 260), and cases where radio objects within the matching radius are different from the most likely optical–NIR counterparts (e.g. 484).

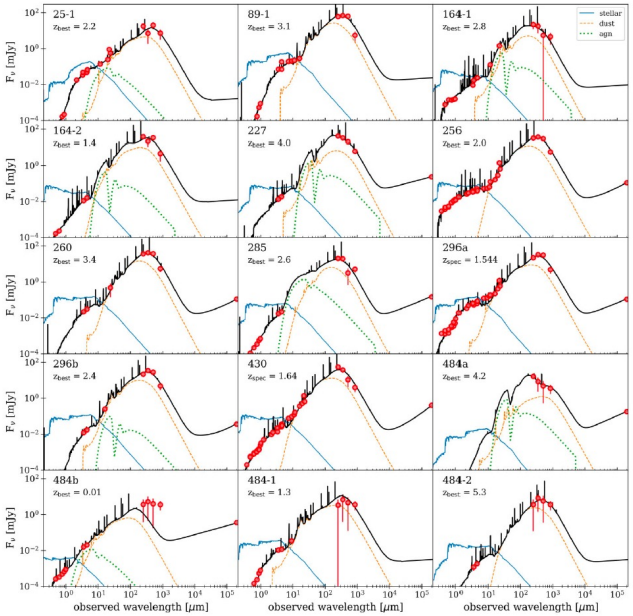


Figure 7. Examples of the best-fitting SEDs for the 850-μm source counterparts from CIGALE. Each plot shows the best-fitting SED for each object identified in Fig. 6. Black solid lines are model SEDs, which consist of the stellar component (blue lines, before attenuation for clarity), dust emission component (orange dashed lines), AGN component (green dotted lines), and non-thermal radio emission at the longest wavelengths. The number of photometric points used in the SED fitting is different for different objects, with the maximum number being 36. For objects with available spectroscopic redshifts (cases 296a and 430), the redshift is fixed during the SED fitting.

*at least 40 per cent of the **SMGs** are classified as **bursty systems whose SFRs are more than three times larger** than the star-forming main-sequence galaxies at those redshifts.*

SCUBA-2 + POL2

Submillimetre observations of the two-component magnetic field in M82

(Pattle et al. 2021, MNRAS, 505, 684)

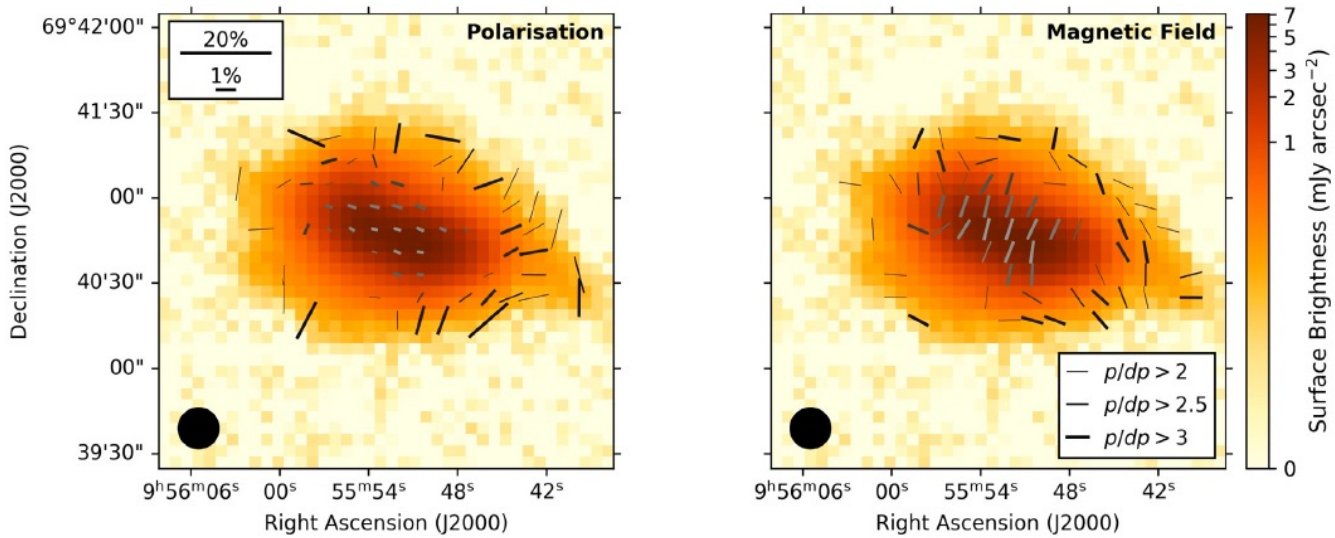


Figure 1. 850 μm POL-2 observations of M82. Left-hand panel: POL-2 polarization vectors, with length shown in square-root scaling for clarity. Right-hand panel: POL-2 *B*-field vectors (polarization vectors rotated by 90°), shown with uniform length. In both panels, the vectors are overlaid on 850 μm Stokes *I* emission. Vector thickness depends on signal-to-noise ratio in polarization fraction. Vector colour scaling is arbitrary and chosen for contrast against the background image.

***two-component magnetic field**: a **poloidal** component aligned with the galactic 'superwind', extending to a height ~350 pc above and below the central bar; and a spiral-arm-aligned, or possibly **toroidal**, component in the plane of the galaxy, which dominates the 850 μm polarized light distribution at galactocentric radii 2 kpc.*