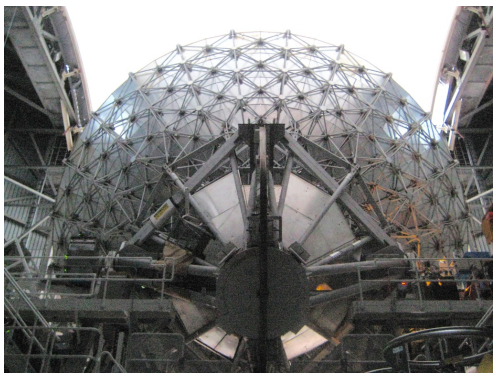
JCMT Status and Sciences

2024 Survey Science Workshop, High 1, 2024 March 29-31

Woojin Kwon (Seoul National University) **2024 January 30**

JCMT

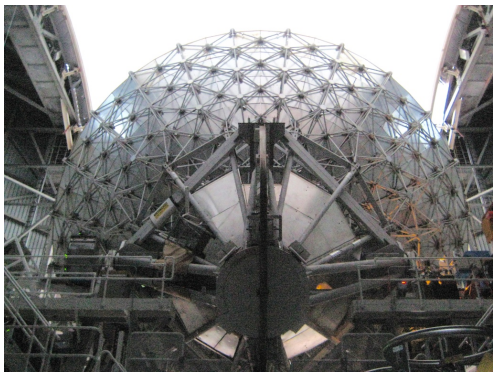




- James Clerk Maxwell Telescope
- Mauna Kea, Hawaii
- Operated by East Asian Observatory since 2015:
  KASI, NAOC, ASIAA, NAOJ, NARIT, UK, Canada
- 15 m single dish
  HARP: Heterodyne Array Receiver Program, 16 pixels, 325—375 GHz
  SCUBA-2 (+ POL-2): Submillimeter Common-User Bolometer Array 2, 10000 pixels, 450/850 μm
  Namakanui ("Big-Eyes", from 2019B): heterodyne receivers at 86, 230, 345 GHz
- CADC: Canadian Astronomy Data Centre
- Starlink: Reduction tool

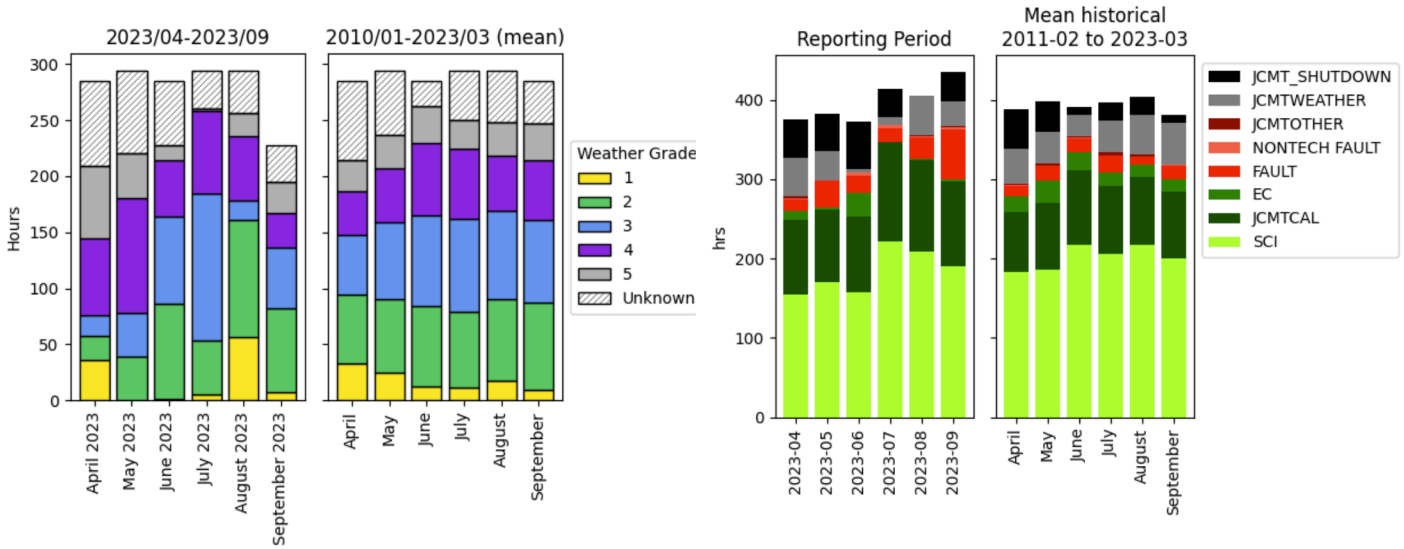
JCMT Status





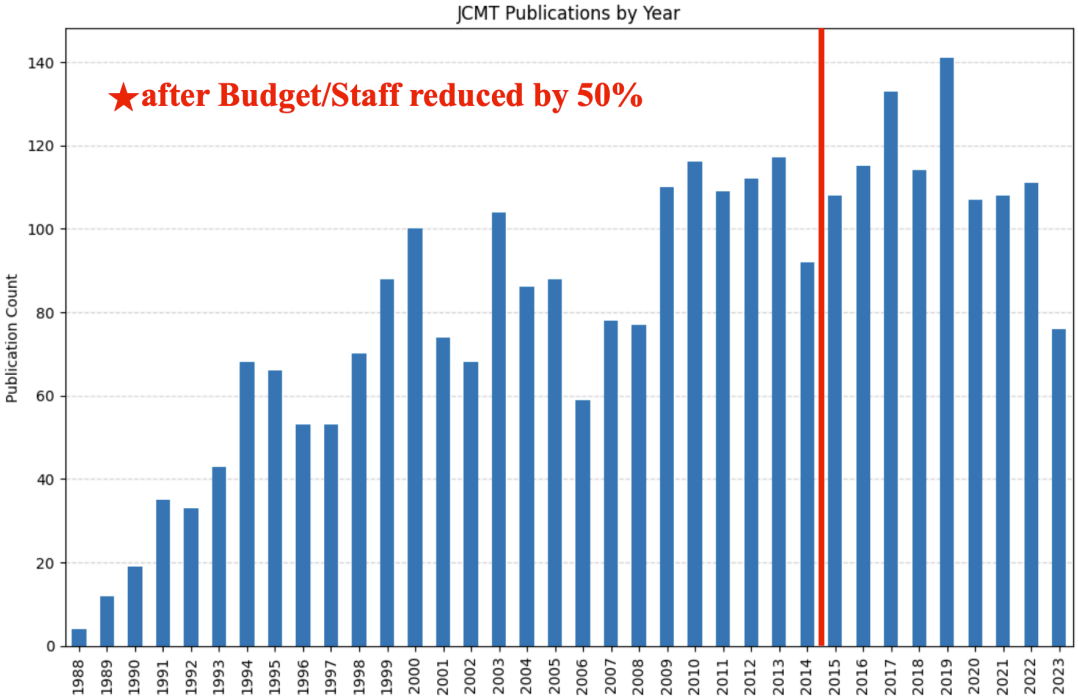
- 50% for large programs, 50% for PI proposals
- Oversubscription rate ~3-4
- Additional potential partners
  Observer Status : Vietnam, Malaysia, Indonesia
  Special “Potential Partner Programs”: India, Argentina, Brazil
- Expanded VLBI programs (EHT, GMVA, EAVN-hi, ngEHT)
- Staffing level at ~17 FTE (critical level)
- Completely remote operations from Hilo

Weather conditions improved in August: closed 15 nights, but cyberattack started in September



From P. Ho’s slides

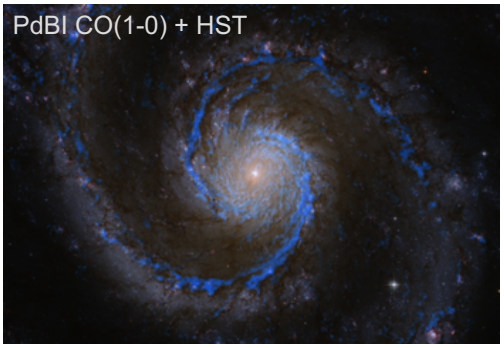
Publication Statistics Stable



From P. Ho's slides

Why (sub)mm?





Schinnerer et al. (2013)

galaxy = dark matter + stars + **ISM**

ISM = gas (H I, H II, H_2, He, C, N, O; atoms + **molecules**)
+ dust (PAH, **grains**)

submm: extinction-free probe for ~1000 spectral lines from inter- & circum-stellar medium and dust

From Y. Yang's slides

Galaxy Spectral Energy Distribution

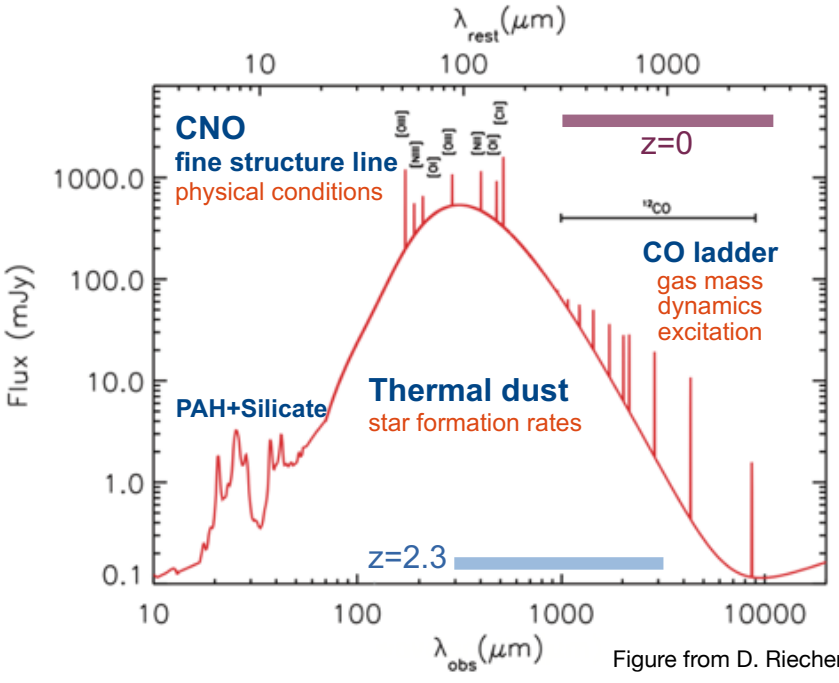


Figure from D. Riechers

From Y. Yang's slides

JCMT Large Programs

- November 2015: 7 programs for topics related to
  Star Formation, Nearby Galaxies and Cosmological studies
- 2017: additional 9 programs (some of which were extension programs) were awarded time
- 2019: 13 further programs (again, some as extension requests) were awarded time
- 2021: 4 new programs were awarded time.

https://www.eaobservatory.org/jcmt/science/large-programs/

- 50% time allocated to large programs
- You can join any of the large programs. There is a co-PI or coordinator representing the Korea community for each of the programs.

JCMT Large Programs

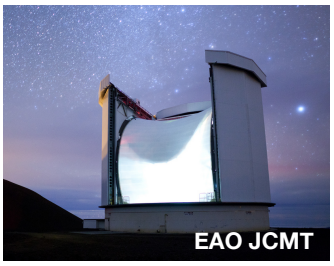
- **Star formation and evolution within the Milky Way**
  - A Transient Search for Variable Protostars (이정은, 서울대)
  - SCOPE: SCUBA-2 Continuum Observations of Pre-protostellar Evolution (김기태, 천문연)
  - SPACE: Submilimeter Polarization and Astro-Chemistry in Earliest star formation (김기태, 천문연)
  - ALOHA IRDCs: A Lei Of the Habitat and Assembly of Infrared Dark Clouds (김기태, 천문연)
  - BISTRO: B-fields In STar forming RegiOns (권우진, 서울대)
  - CHIMPS2: Resolving Star Formation in the Galactic Plane with HARP (김기태, 천문연)
  - NESS: The Nearby Evolved Star Survey (김효선, 천문연)
  - MAJORS: Massive, Active, JCMT-Observed Regions of Star formation (김기태, 천문연)
  - CLOGS: CO Large Outer-Galaxy Survey (김기태, 천문연)
  - SURFING: SURveying Filaments in Nearby Gas Clouds (이창원, 천문연)
- **Solar System**
  - JCMT-Venus: monitoring phosphine and other molecules in Venus's atmosphere (권우진, 서울대)

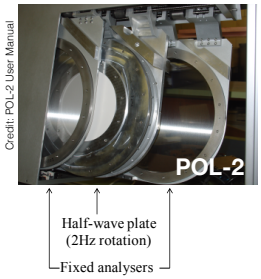
JCMT Large Programs

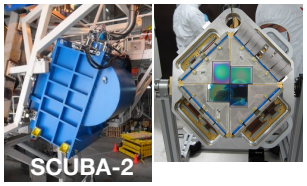
- **Nearby Galaxy Studies**
  - MALATANG: Mapping the Dense Molecular Gas in the Strongest Star-forming Galaxies (정애리, 연세대)
  - JINGLE: the JCMT dust and gas In Nearby Galaxies Legacy Exploration & JINGLE II (황호성, 서울대)
  - HASHTAG: HARP and SCUBA-2 High-Resolution Terahertz Andromeda Galaxy Survey (정애리, 연세대)
  - DOWSING: Dust Observations Using Scuba-2 In Nearby Galaxies (정은정, 충남대)
- **Sub-mm Galaxy Studies**
  - RAGERS: The RAdio Galaxy Environment Reference Survey (심현진, 경북대)
  - S2-COSMOS: An EAO SCUBA-2 survey of 1,000 SMGs in the COSMOS field & eS2COSMOS (양유진, 천문연)
  - STUDIES: SCUBA-2 Ultra Deep Imaging EAO Survey & STUDIES SXDS (심현진, 경북대)
  - NEP2: Extragalactic JCMT Survey of the North Ecliptic Pole (심현진, 경북대)
  - S2LXS: SCUBA-2 Large eXtragalactic Survey (우종학, 서울대)
  - AWESOME – A Well-Deep EAO Survey Observing Most Of The EBL (정웅섭, 천문연)
- **Black Holes**
  - PITCH-BLACK: Sub-Millimetre Polarimetry and Timing of Relativistic Jets with JCMT SCUBA-2/POL-2

BISTRO

- **B**-fields **I**n **ST**ar-forming **R**egin **O**bservations
- JCMT (15 m sub-mm telescope) POL-2 project
- Aims to map Gould Belt star-forming regions in dust polarization at 850 μm **for studying magnetic field structures on intermediate scales (1000—10000 au scales)**
- **PIs**
  Derek Ward-Thompson (UK)
  Pierre Bastien (Canada), Ray Furuya (Japan),
  Woojin Kwon (Korea), Shih-Ping Lai (Taiwan), Keping Qiu (China),
- Members >140 (26 in BISTRO-Korea)
- 224 hours (16 fields x 14 hours/field) awarded: 2016—2018
  All data obtained as of Jan. 2019, all 1G papers published
- **BISTRO-2** (2018—2020): 224 hours, farther/massive star forming regions
  Data ~ 100% as of Jan. 2021
- **BISTRO-3** (2020—present): 224 hours,
  larger evolutionary and environmental space
  Data ~ 79% (as of Jan. 2024)

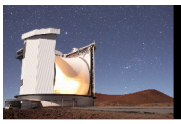






Proposal calls & TAC

- Proposal calls: twice per year
  A semester running from Feb. 1st to Jul. 31st
  Typical call deadline: mid September
  B semester running from Aug. 1st to Jan. 31st
  Typical call deadline: mid March
- Supplement calls
  e.g., 23B for UK & Ireland
  24A for Korea (due on Jan. 10th)
- TAC
  10 members
  ~50 proposals per semester



SCUBA-2 High Redshift Bright Quasar Survey. II. The Environment of z~6 Quasars at Submillimeter Band

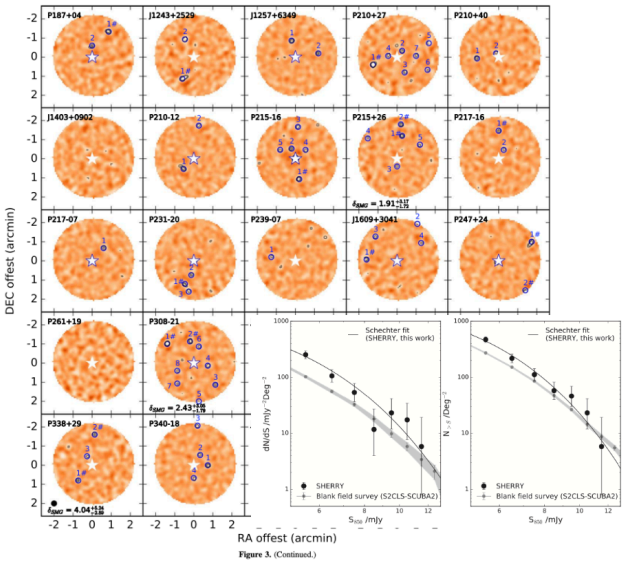


Figure 3. (Continued.)

Combined differential and cumulative number counts at 850 μm. The filled black circles and black lines indicate the data and Schechter fitting, respectively. The gray line shows the blank-field number counts of SMGs in the S2CLS field in Geach et al. (2017).

Li et al. 2023 ApJ, 954, 174L

Presents the **first systematic study** of the environment of quasars at **z~6**.
They carried out a **survey** of **54** quasars using **SCUBA-2** to study the environments around quasars.

Identified **170 submillimeter galaxies** (SMGs) with above 3.5σ detections in 450 or 850 μm maps.

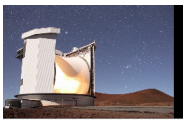
Their far-IR luminosities are (2.2-6.4)×10^{12} $L_{\odot}$, and their star formation rates are ~400-1200 $M_{\odot}$ yr^{-1}.

Submillimiter Galaxies' **overdensity** exceede the blank-field source counts by a factor of 1.68.

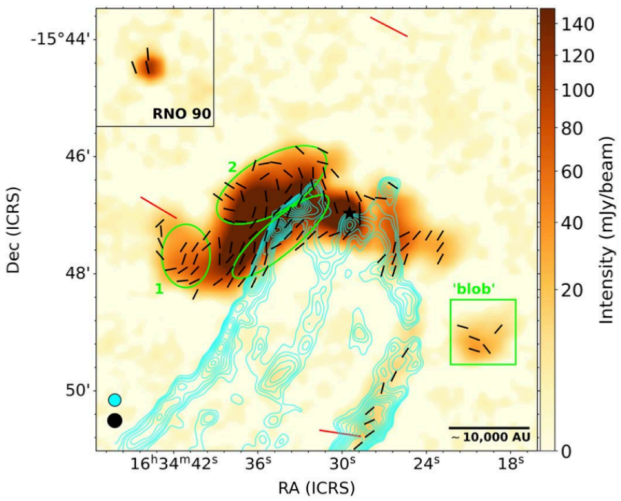
Authors find that 13/54~**24%** quasars show overdensities (at ~5.5 mJy) of δ_{SMG} ~ 1.5-5.4.

These SMGs are candidates for follow-up spectroscopic observations.

From H. Pena's slides



The JCMT BISTRO Survey: Studying the Complex Magnetic Field of L43



Magnetic field half-vectors are plotted in black over the 850 μm dust emission map. Planck vectors are the larger red vectors. The CO outflow continuum in blue contours. The BIMA and JCMT beam sizes are shown in the lower left in blue and black, respectively.

Karoly et al. 2023 ApJ, 952, 29K

Observations of **polarized** dust emission at 850 μm from the **L43** molecular cloud. Data from **POL-2** as a part of the BISTRO large program.

Also used CO J=1-0 HARP **archival** observations.

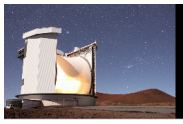
Authors found values of H_2 column densities typical of dense starless cores (~10^{22}–10^{23} cm^{-2}).

They found **indications of a possible decrease** in **grain alignment efficiency**, within the molecular cloud based on power-law index −0.85 in polarization percentage as a function of total 850 μm intensity.

The magnetic field orientation in L43 was found to be complicated and multiple-component magnetic field. Divided the magnetic field into three regions.

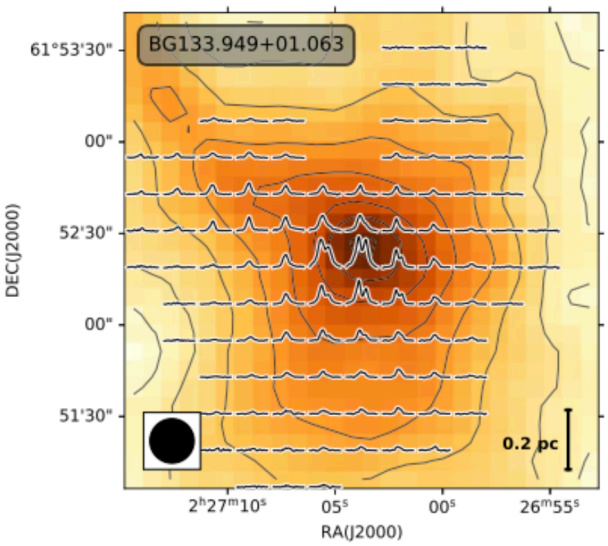
They found alignment between the magnetic field and the outflow cavity walls that is distinctly different from the magnetic field in the rest of the cloud.

From H. Pena's slides



Clump-scale Gas Infall in High-mass Star Formation: A Multitransition View with James Clerk Maxwell Telescope HCN (4-3) Mapping





Grids (2 × 2 pix2) of HCN (4–3) line profiles overlaid on a continuum map SCUBA-2. The beam size of the HARP receiver at 350 GHz is shown in the bottom left. The scale bar of 0.2 pc is shown in the bottom right.

Xu et al. 2023, ApJS, 269, 38X

Survey of HCN(4–3) on **38 massive clumps** with blue profiles in HCO^+ (3–2.

They found a **diversity** of line **profiles**, indicating that blue-profile HCO+ (3–2) does not guarantee the same in HCN (4–3).

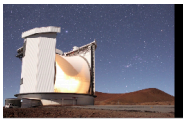
Only 14 out 38 have blue profiles in HCN(4–3)lines.

Interpreted the the low detection rate of high-J blue profiles to a combination of **insufficient HCN (4–3) opacity** and the intricate gas motion across different density layers.

They selected **11 infall candidates** estimating a median mass infall rates of 4.5×10^{-3} $M_\odot$ yr^{-1} and 7.6×10^{-3} $M_\odot$ yr^{-1}.

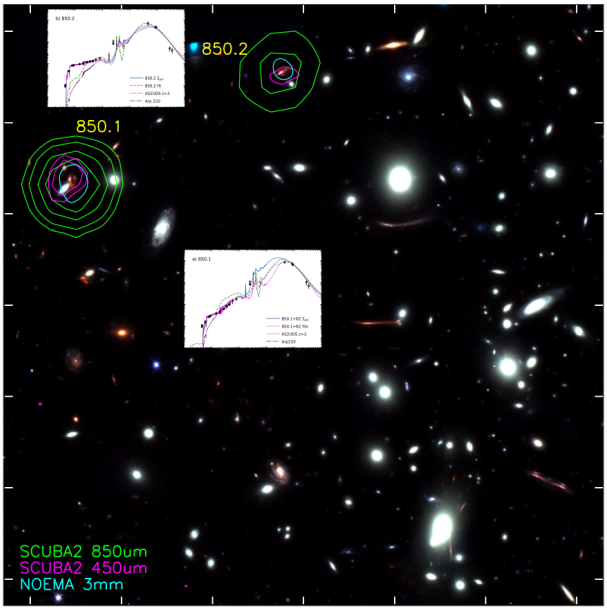
They suggest a steady accretion process from the clump gas envelope to the inner region based on consistency in mass infall rates derived from HCO+ (3–2) and HCN (4–3).

From H. Pena's slides



Hidden Giants in JWST's PEARLS: An Ultramassive z = 4.26 Submillimeter Galaxy that Is Invisible to HST





Smail et al. 2023 ApJ 958, 36S

Multiwavelength analysis of two dusty star-forming galaxies, **850.1** and **850.2** at **z = 4.26**, lensed by massive cluster A 1489.

Data from **JCMT**, SMA, NOEMA, JWST, the Hubble Space Telescope (HST), and the Spitzer Space Telescope.

Source 850.1 is one of the **most** massive and highly **obscured** galaxies known at z>4 with $\mathbf{M_\bullet \sim 10^{11.8} M_\odot}$ and A_V~5.

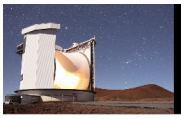
Source 850.2 is one of the least massive and least obscured dusty star-forming galaxies z>4 with A_V~1.

Authors argue that the **diversity** of these two galaxies illustrates the **incompleteness** of galaxies at z>3–4 **in Optical and NIR photometric surveys.**

Suggest that 850.1 is the **central galaxy** of a group in which 850.2 is a **satellite** that will likely merge in the near future.

The morphology of 850.1 shows **arms** and a linear **bar** feature related to the active dynamical environment it resides within.

From H. Pena's slides



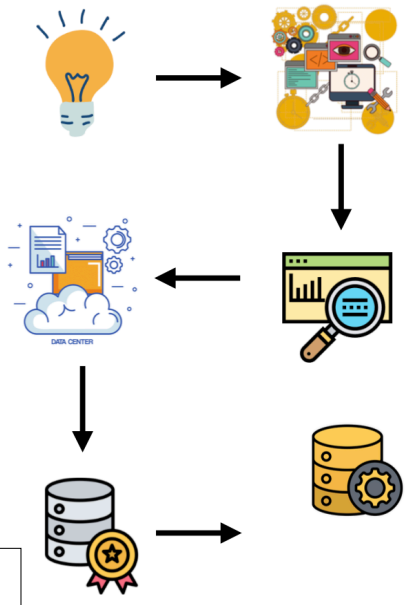
User support

JCMT has a cradle to grave approach:

- We support from proposal ideas and use of instruments,
- MSB creation,
- Monitoring and Following up programs,
- Data archive access,
- Data quality,
- Help data with processing,
- And we organize workshops (e.g., LLAMA workshops)

The help-desk email:

Sarah Graves (Scientific Programmer): Archive, data processing, and Starlink.
Graham Bell (Scientific Programmer): Hedwig, OMP, Starlink, data processing. And FoPs.



From H. Pena's slides

Take home messages

JCMT Status and Sciences

- **JCMT**
  15 m
  Continuum (+ pol) at 450/850 μm
  Lines around 86, 230, 345 GHz
- **Many large programs** waiting for you
- **Various interesting studies** you can do

- **Proposal call (24B)**
  March/April 2024