The Future of the James Clerk Maxwell Telescope

Observing the Present and the Past

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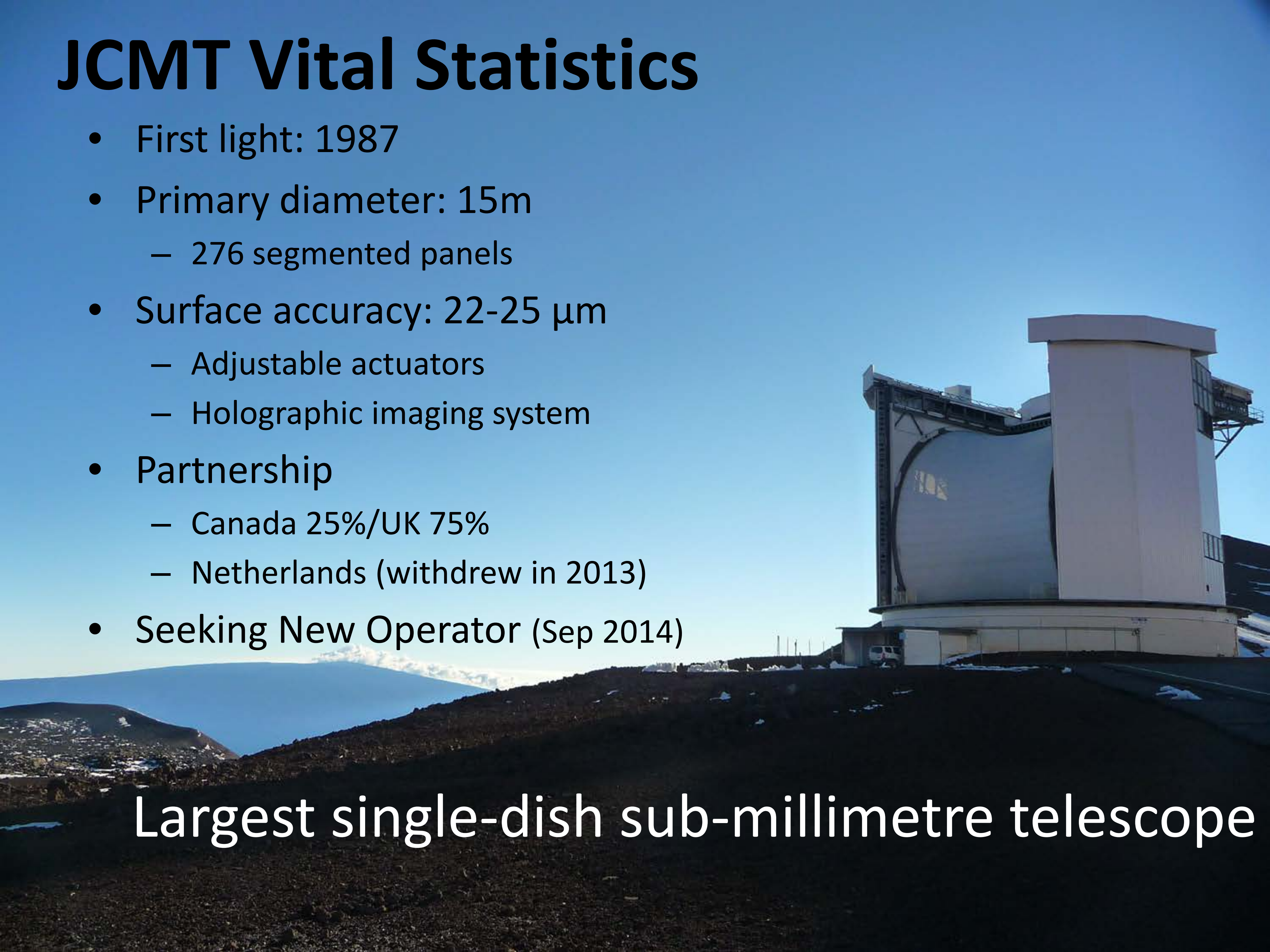
Marcel Clemens



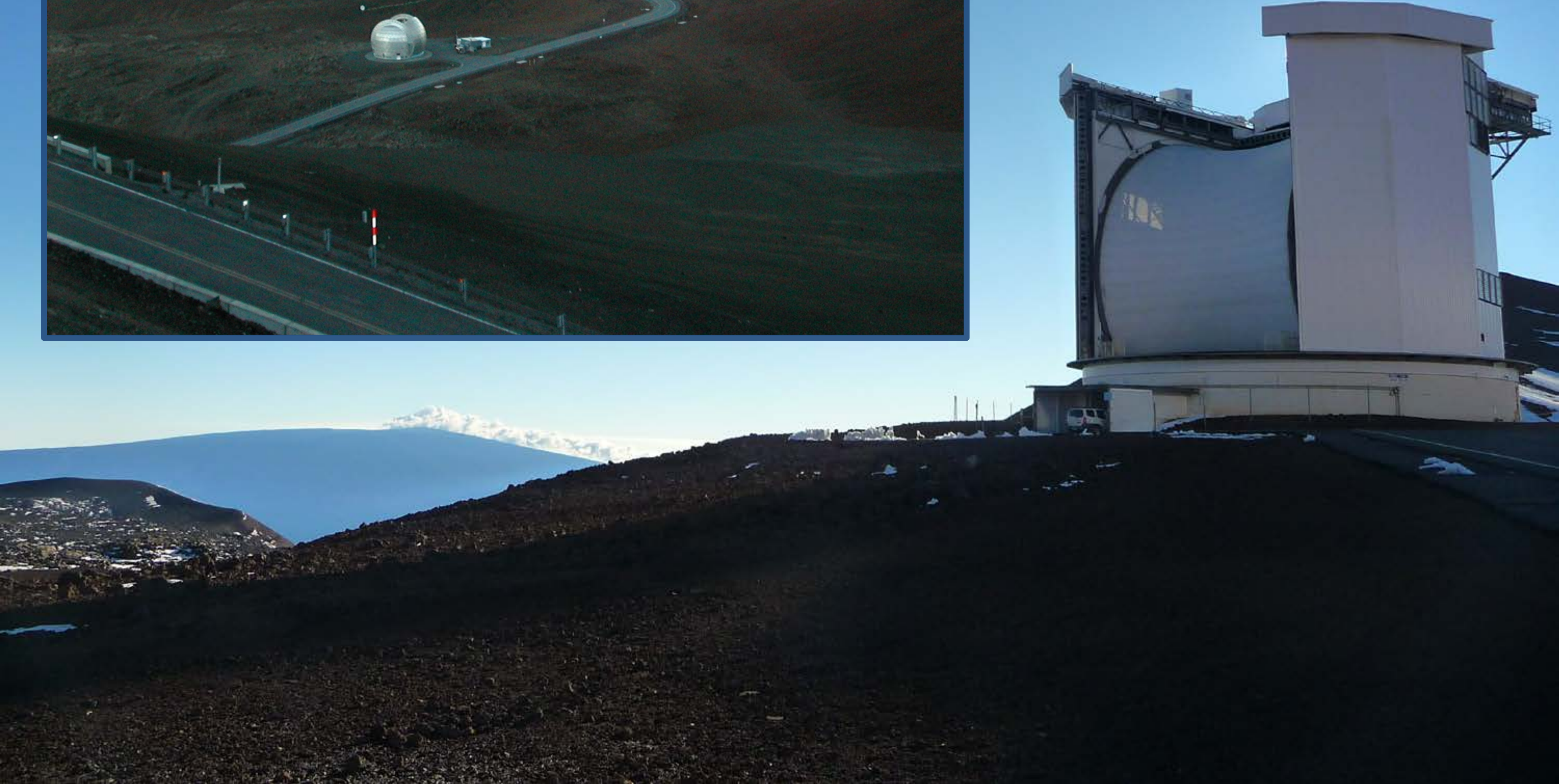
JCMT Vital Statistics

- First light: 1987
- Primary diameter: 15m
  - 276 segmented panels
- Surface accuracy: 22-25 µm
  - Adjustable actuators
  - Holographic imaging system
- Partnership
  - Canada 25%/UK 75%
  - Netherlands (withdrew in 2013)
- Seeking New Operator (Sep 2014)

Largest single-dish sub-millimetre telescope

Summit of Mauna Kea

- 4092 m elevation
- routine operations at 450 and 850 microns
- protected by Gore Tex Membrane



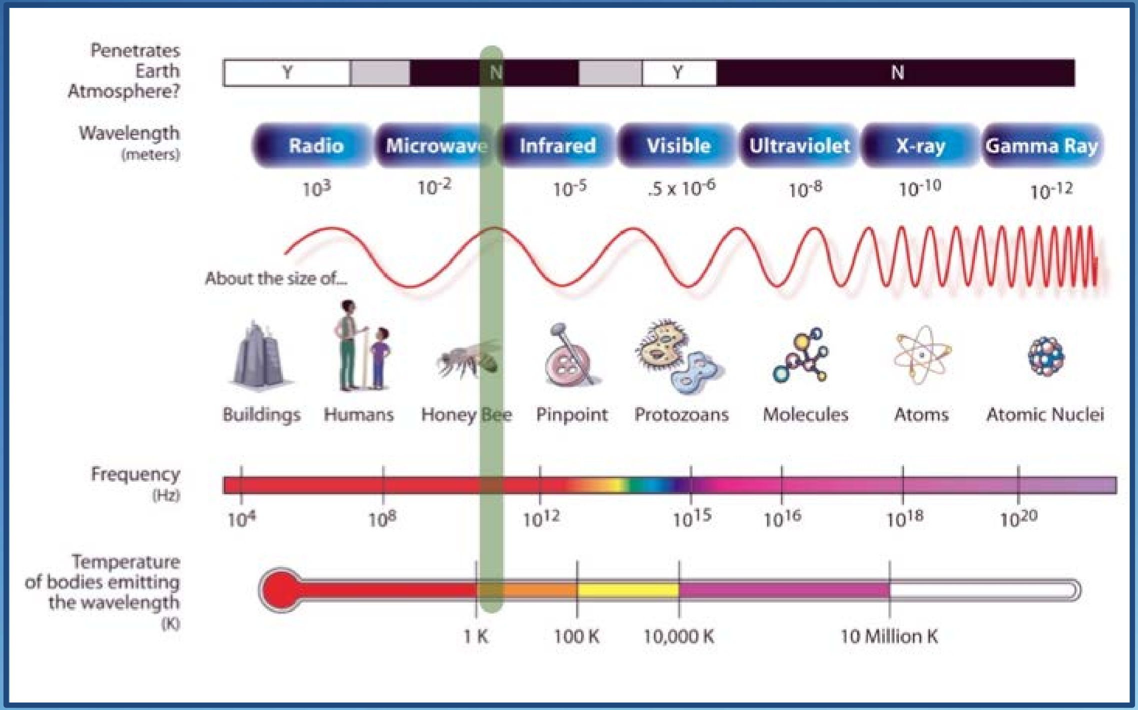
Sub-Millimetre Waves

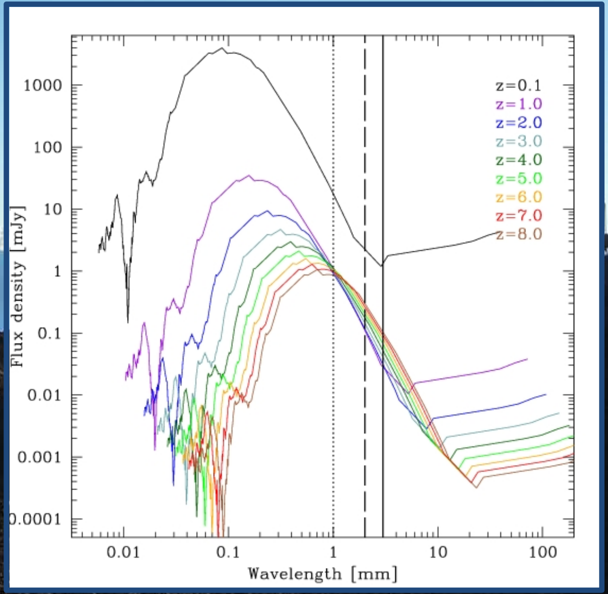
Continuum photons

- Explore Cold, Old, & Dirty

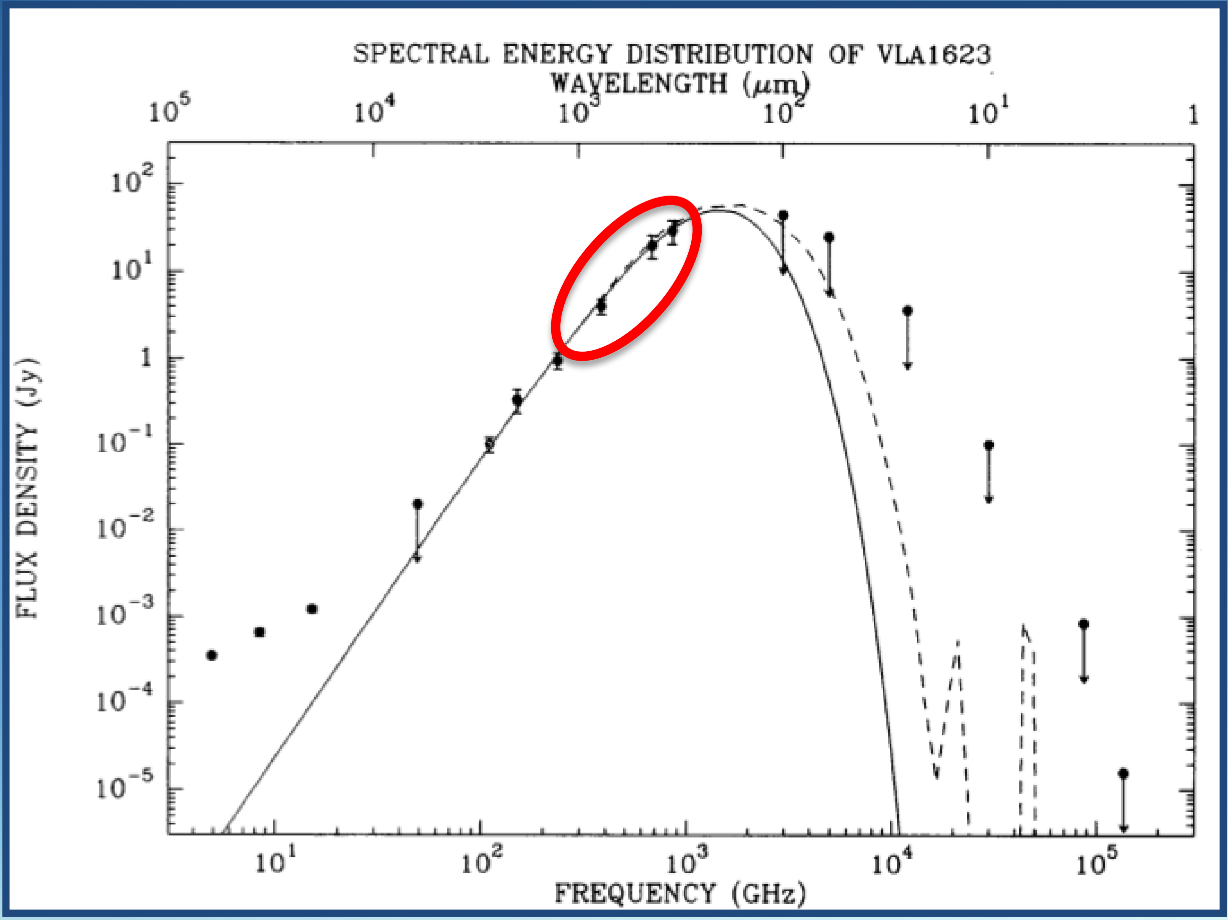
Molecular lines

- Explore Astro-chemistry
- Trace physical conditions



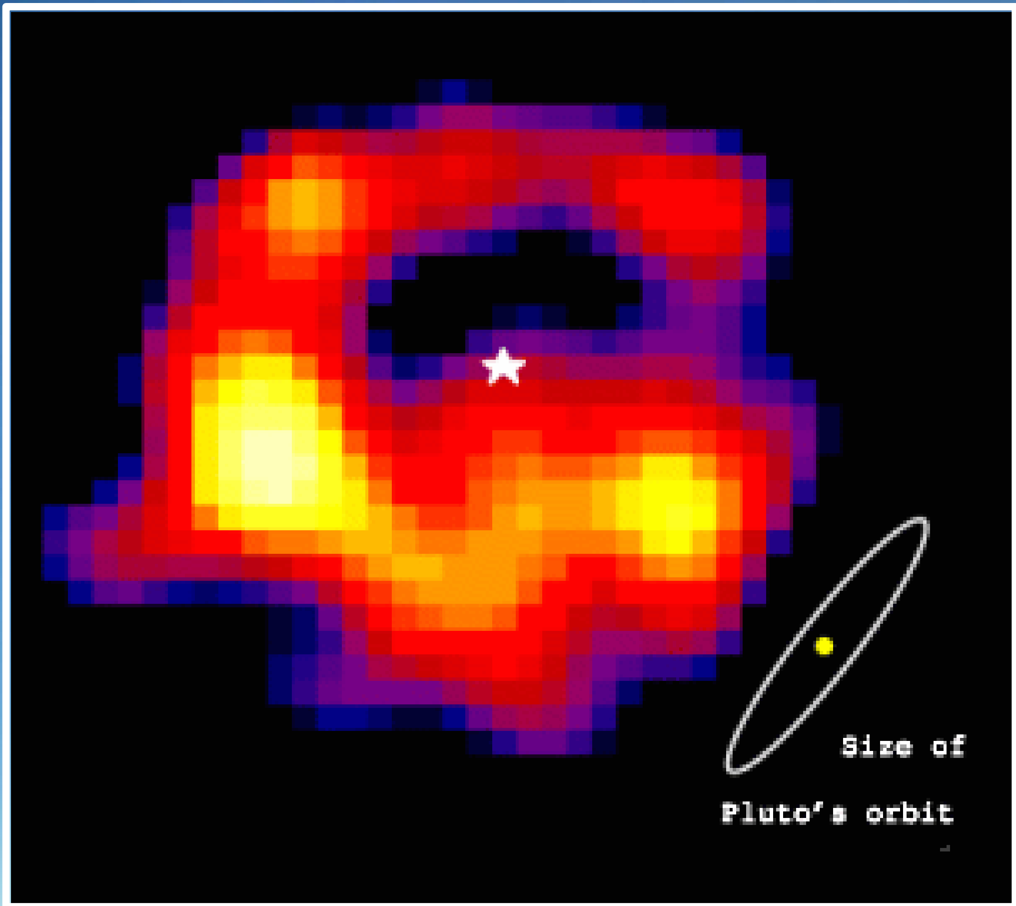


Early Scientific Success



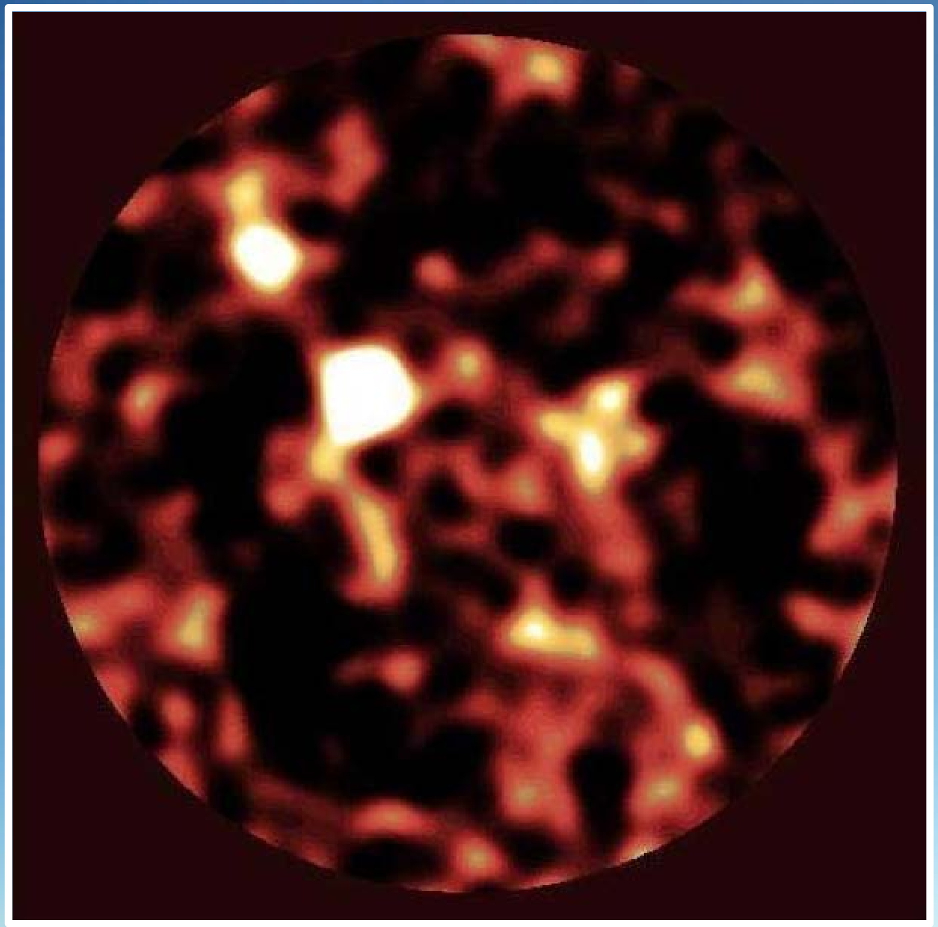
VLA 1623 SED by
Andre et al. 1993
- UKT14 (single bolometer)

Deeply Embedded Protostars:
The earliest stage (Class 0) of star formation



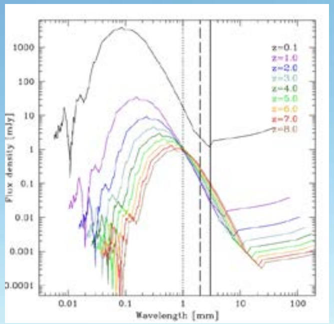
Epsilon Eridani by
Greaves et al. 1998
- SCUBA (128 bolometers, 450/850µm)

Dusty Debris Disks:
The connection between disks and planets



Hubble Deep Field by
Hughes et al. 1999

- SCUBA (128 bolometers, 450/850μm)
- Over 1000 citations!



Sub-Millimeter Galaxies (SMGs):
The Source of the Cosmic Infrared Background

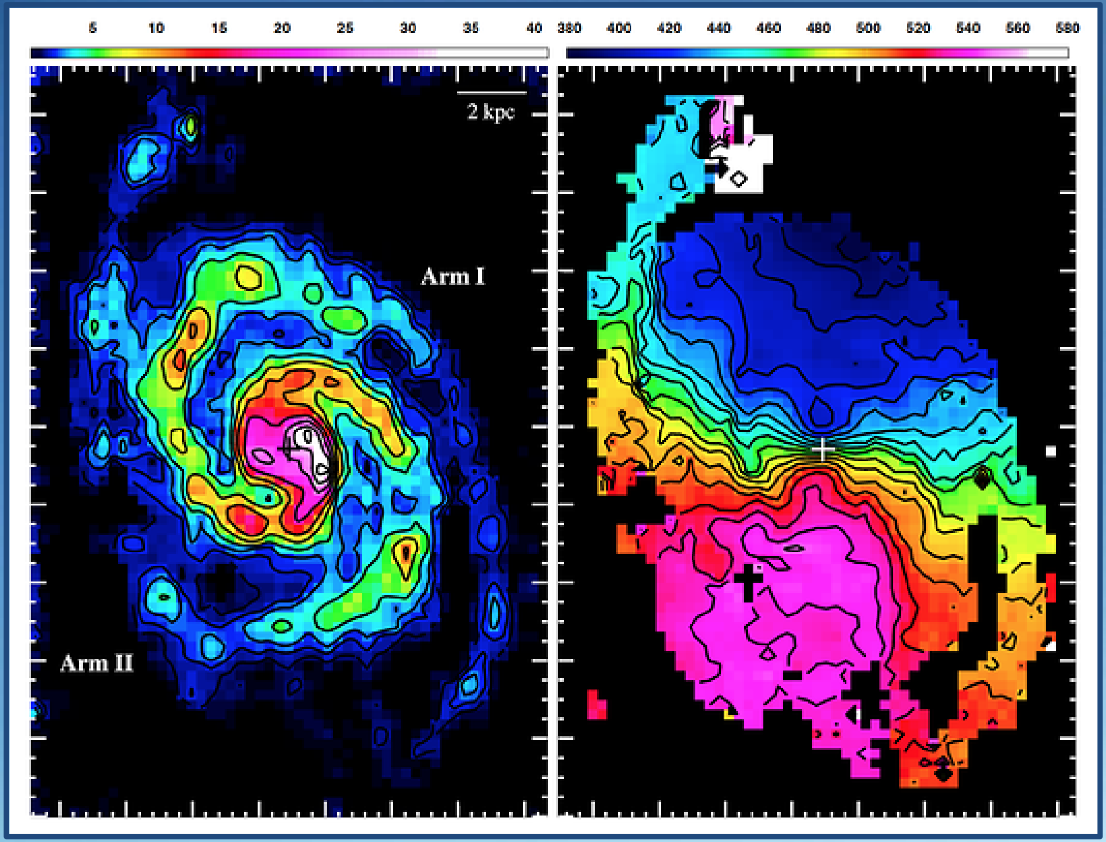
Orion A: OMC 1,2,3, and 4 by
Johnstone & Bally 1999
- SCUBA (128 bolometers, 450/850μm)

The Role of Filaments:
From Clouds to Pre/Proto-stellar cores

Transformation: Instrument Advances

Upgrades to both continuum and heterodyne instruments

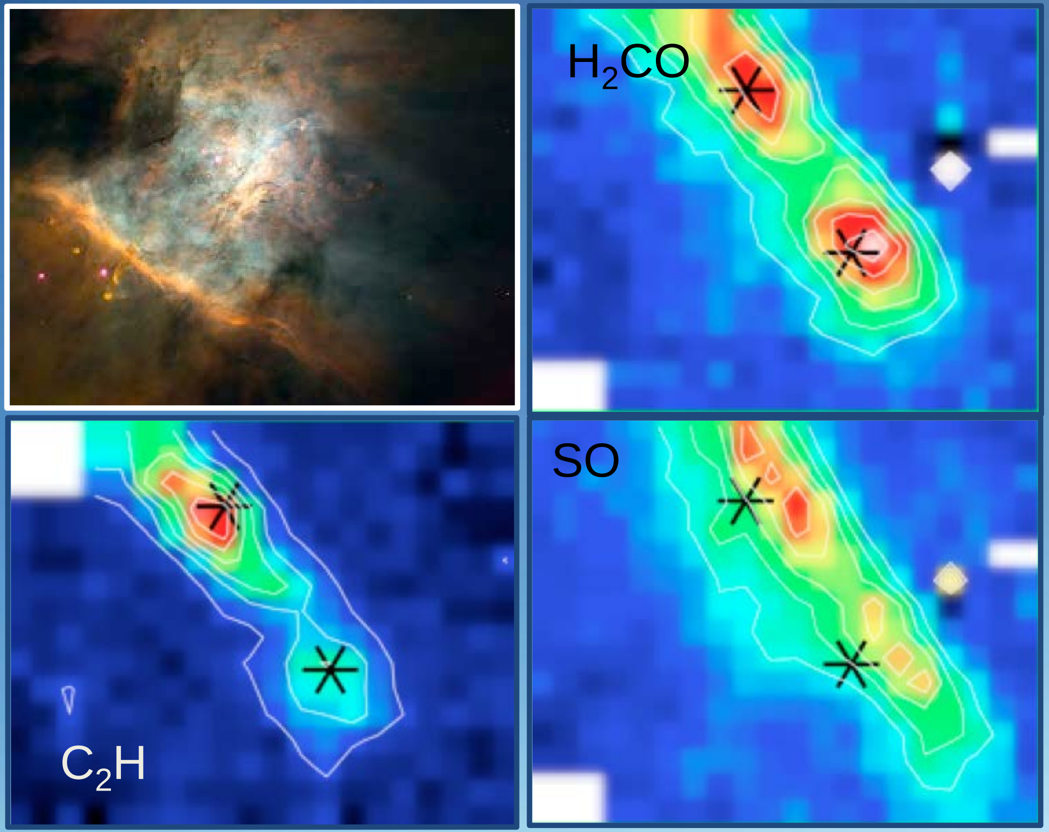
- SCUBA-2 (850 and 450 microns)
  - Larger arrays
  - increased field of view
  - greater sensitivity
- HARP (325-375 GHz Receiver)
  - Many more spectral channels
  - 16 receptors (4x4 grid)



M51 – CO 3-2 map by
Vlahakis et al 2013

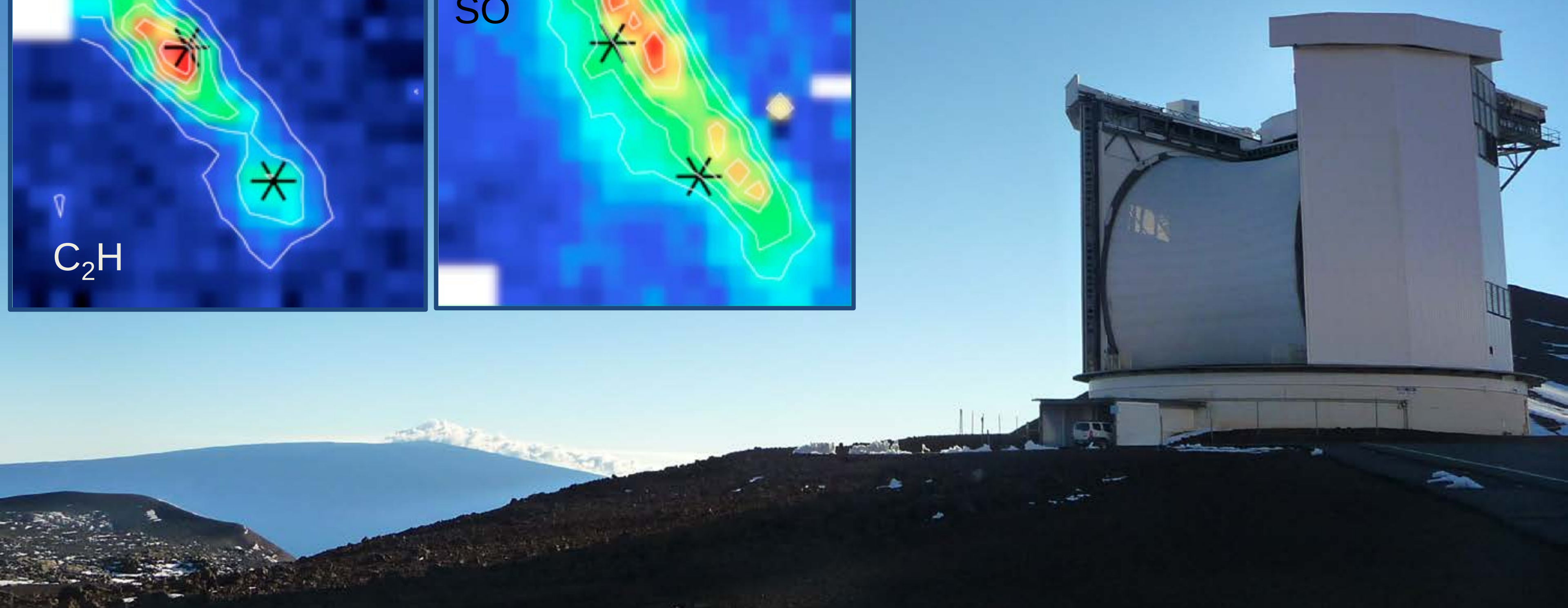
- HARP (16-receptors)

Molecular line strength and Galaxy Kinematics

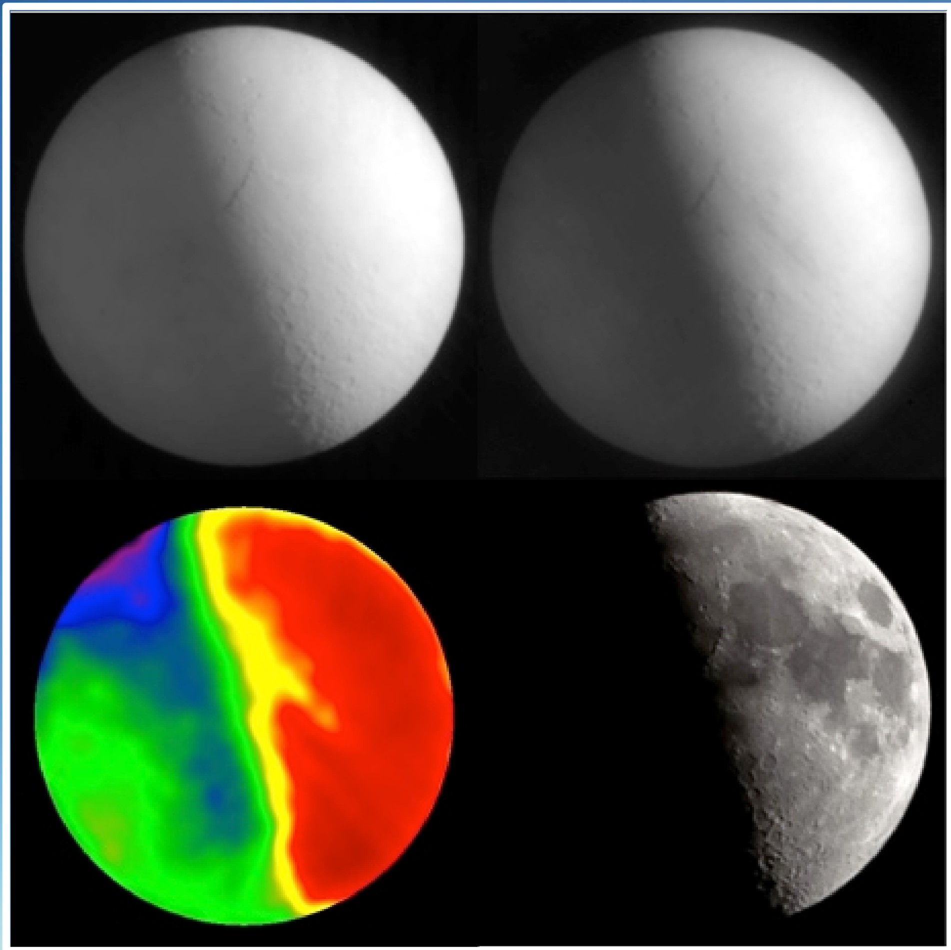


Orion Bar as part of the Spectral Line Survey

- HARP



Probing Astrochemistry and Physical Conditions



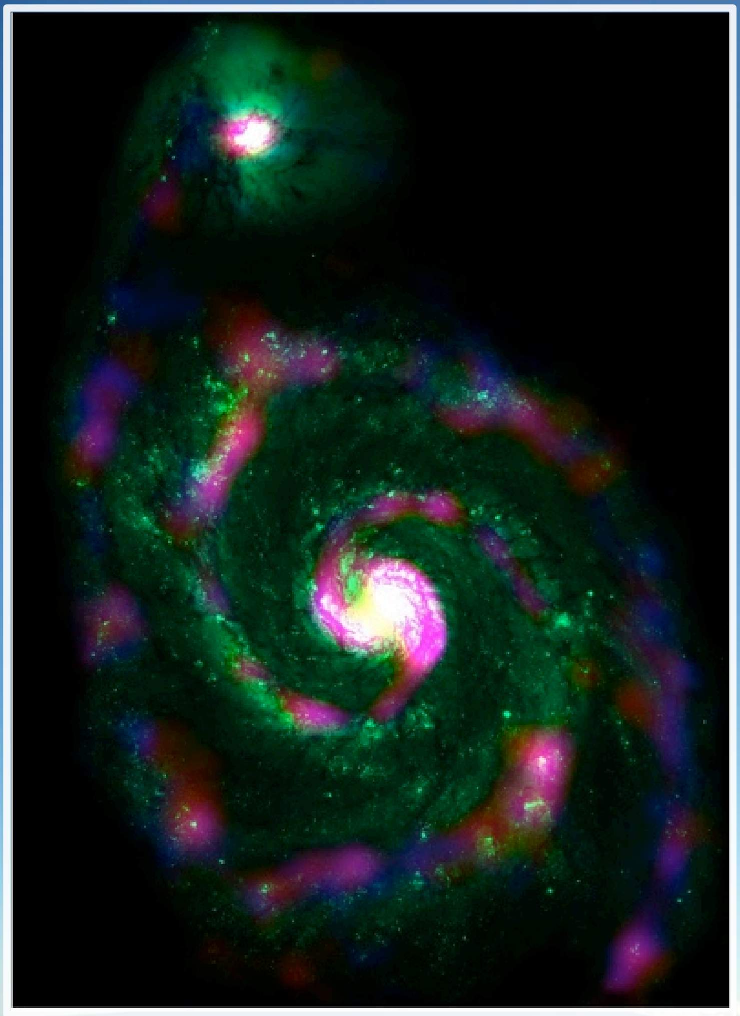
Temperature of Lunar Surface

Top: Left 450μm; Right 850μm

Bottom: Left Temp map; Visible Image

- SCUBA-2 (10,000 pixels, 450/850μm)

SCUBA-2 Test Observations



Nearby Galaxies Survey – M51

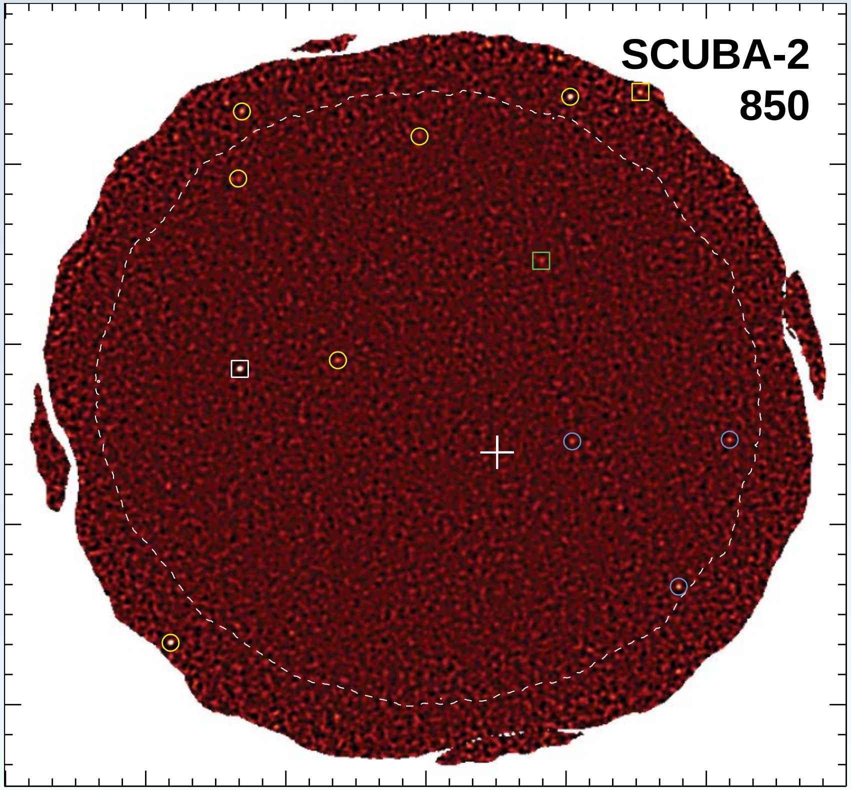
Wilson, Israel, and the NGLS 2012

- SCUBA-2 (red: 850μm, blue: 450μm)
- HST (green)

Dust temperature and location

Recent Scientific Success

SCUBA-2: σ Orionis Star Cluster Deep Imaging



σ Orionis estimated age 0.5 Myr.

0.5^{o} field contains 297 young stars.

8 proto-planetary disks detected.
- masses 5-16 M_{jup}

3 non-stellar sources, likely SMGs.

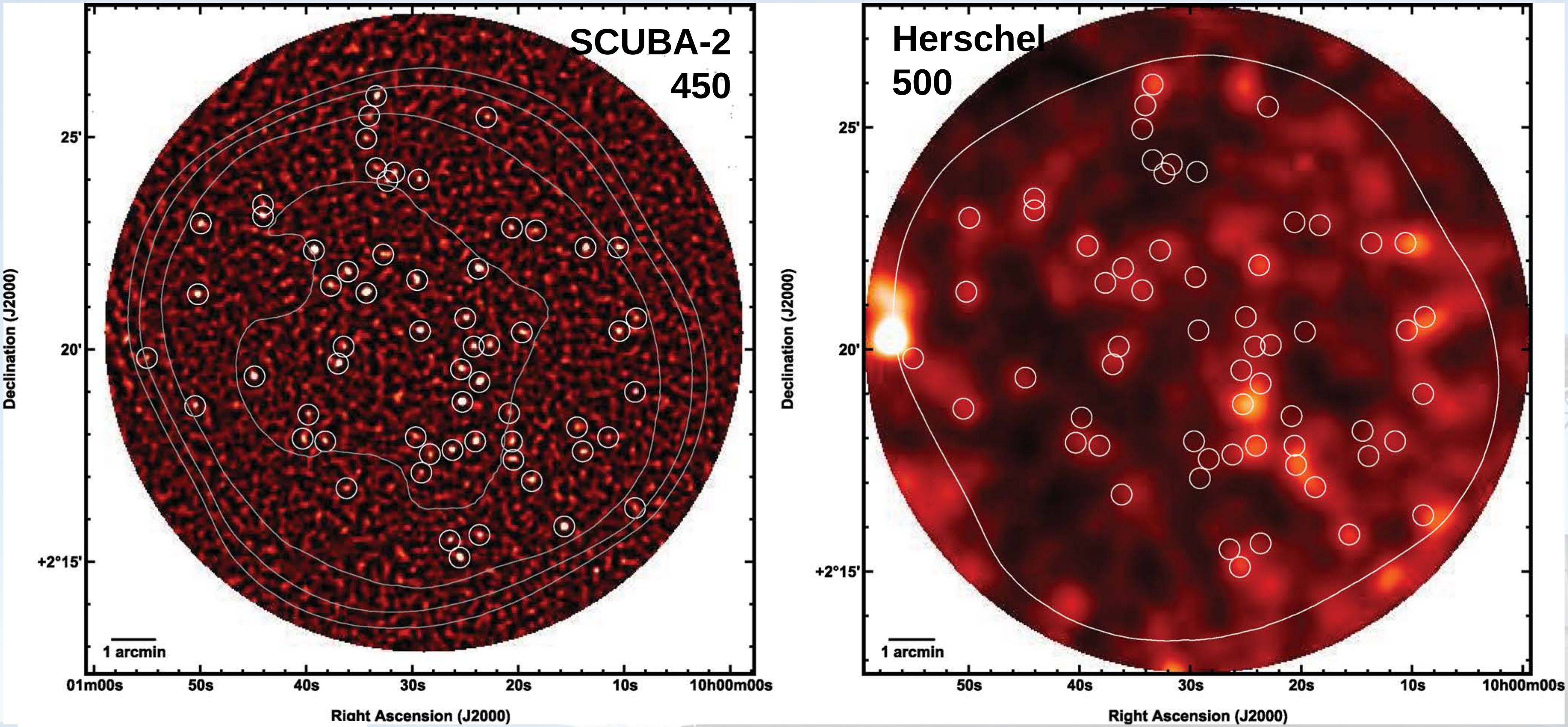
Stacking up all non-detections reveals excess emission.
- mean mass ~ 0.5 M_{jup}

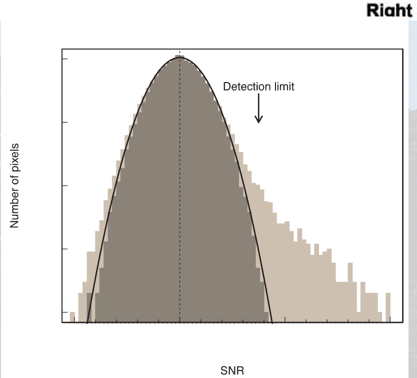
31hrs –> 2.9 mJy/bm

Comparison with much younger Taurus star cluster indicates significant disk mass evolution.

Williams et al. 2013, ApJ.

SCUBA-2: Cosmology Legacy Survey Blank Field





140 arcmin² HST-Candles Blank Field, observed to 1.3 mJy at 450 μm.

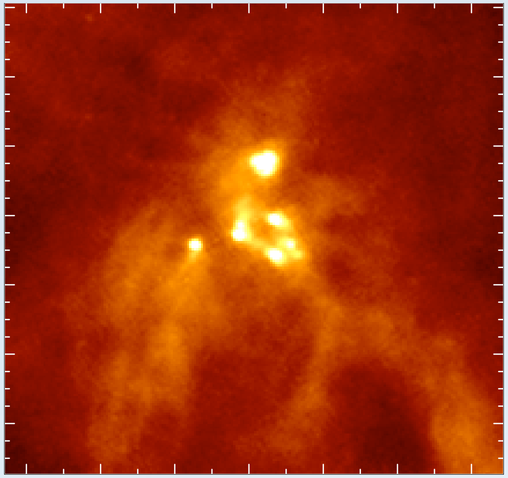
60 SMGs identified with > 3.75σ -> directly resolve 16±7 percent of CIB.

Statistical stacking of 24μm emitters recovers an additional ~40 percent.

Average redshift of emitters is estimated to be <z> = 1.3.

Geach et al. 2013, MNRAS.

SCUBA-2: Mapping in the Perseus Molecular Cloud (B1)



Part of the Gould Belt JCMT Legacy Survey.

Images reveal importance of spatial resolution.

Disentangling dust properties (T_d, κ_d) requires both JCMT and Herschel observations.

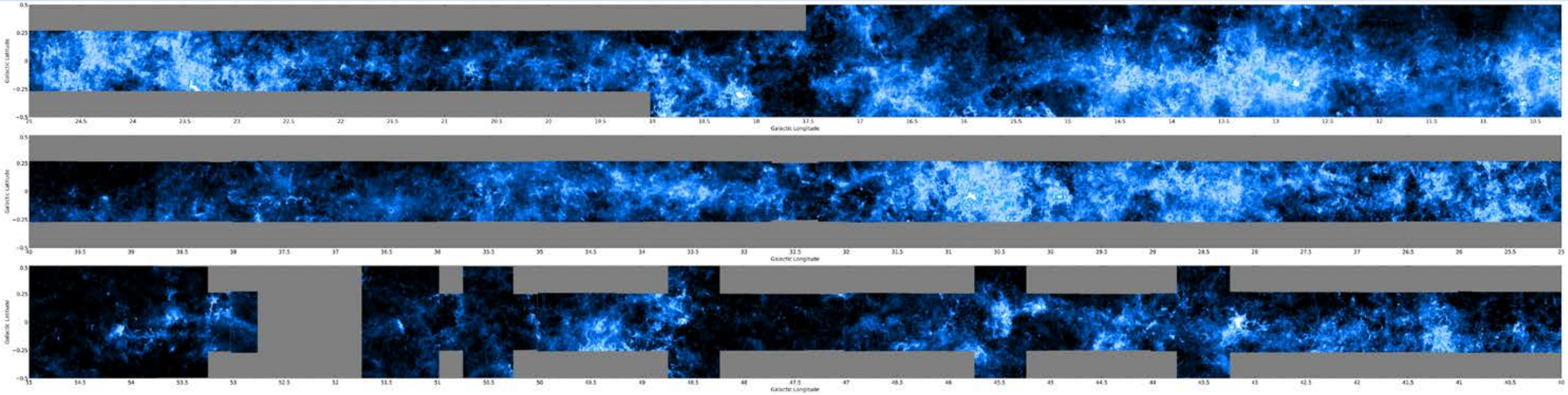
Emissivity power-law, β, found to vary with density in region.
- β~2, moderate density
- β ~ 1.6, high density

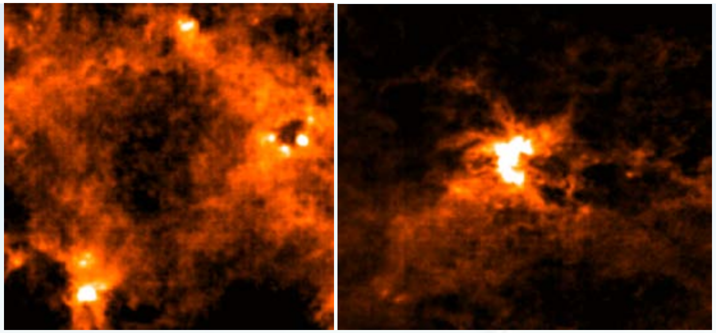
Herschel: 160 , 500 μm.

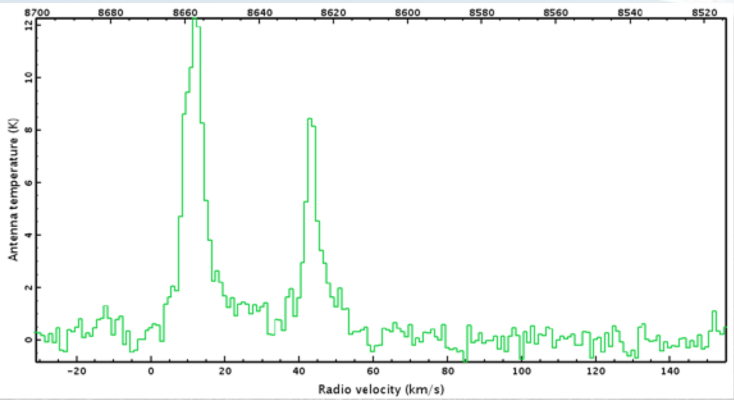
SCUBA-2: 450 ,850 μm.

Sadavoy et al. 2013, ApJ

HARP: CO High Resolution Survey of Galactic Plane (COHRS)





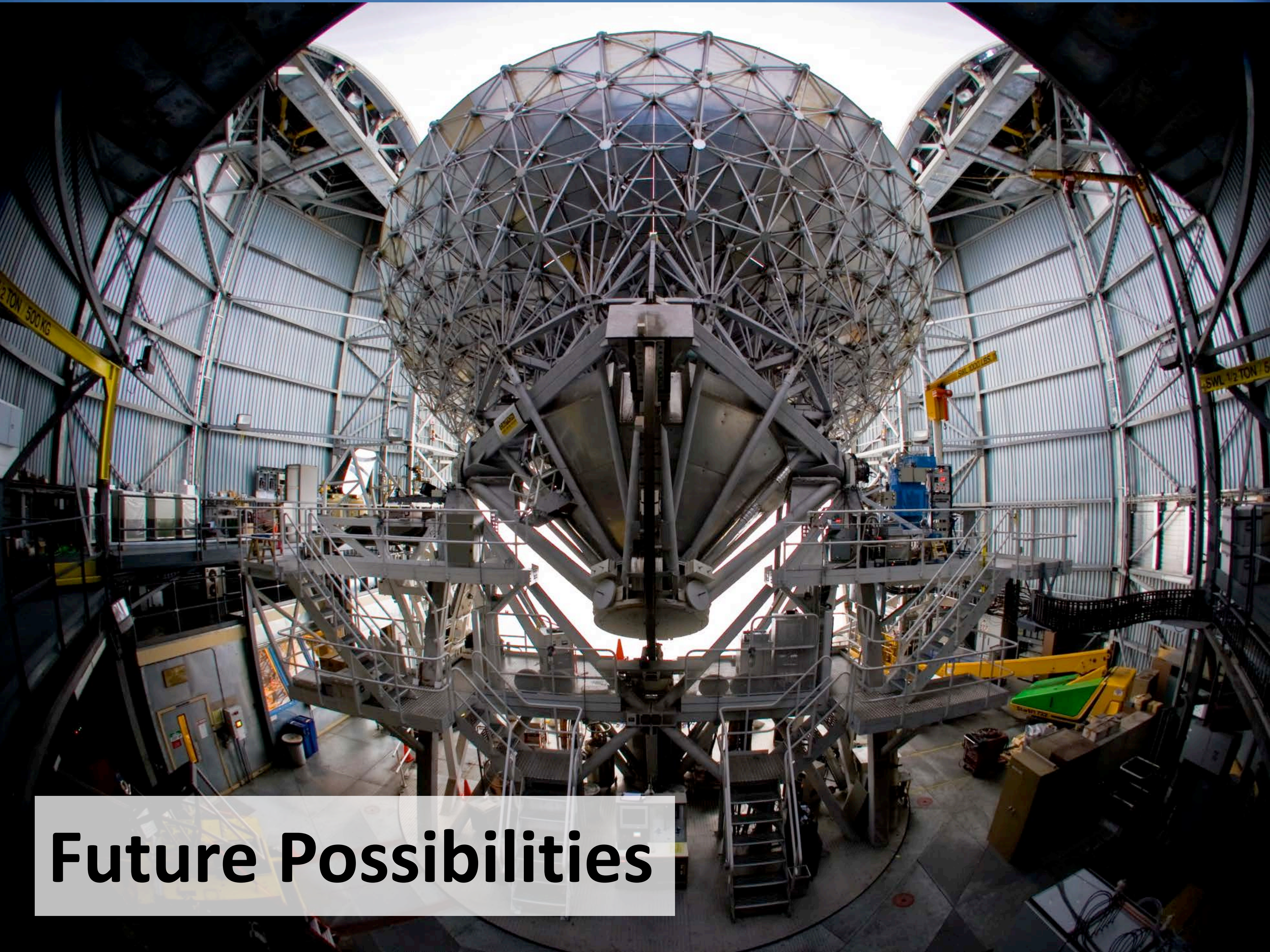


Map of ^{12}CO (3-2) covering over 25 square degrees of the Galactic Plane ($10^o < l < 55^o$).

Reduced data products are publicly available through VO-Space at CADC as 0.5^o tiles :

- PPV data cubes smoothed to 1km/s resolution
- Integrated intensity maps, clipped at 3σ
- L-V maps (cubes collapsed over latitude)

Dempsey et al. 2013, ApJS

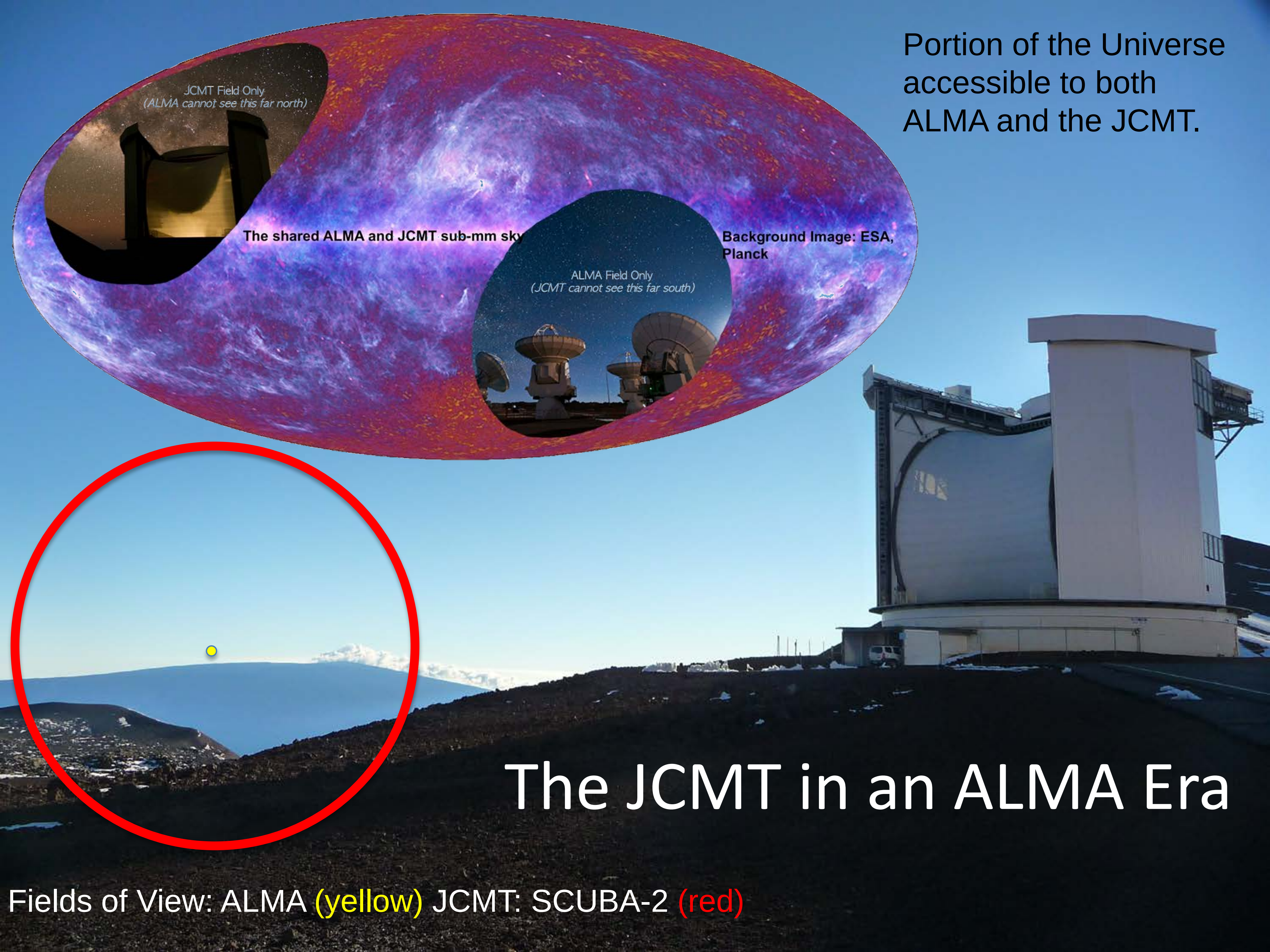


Future Possibilities

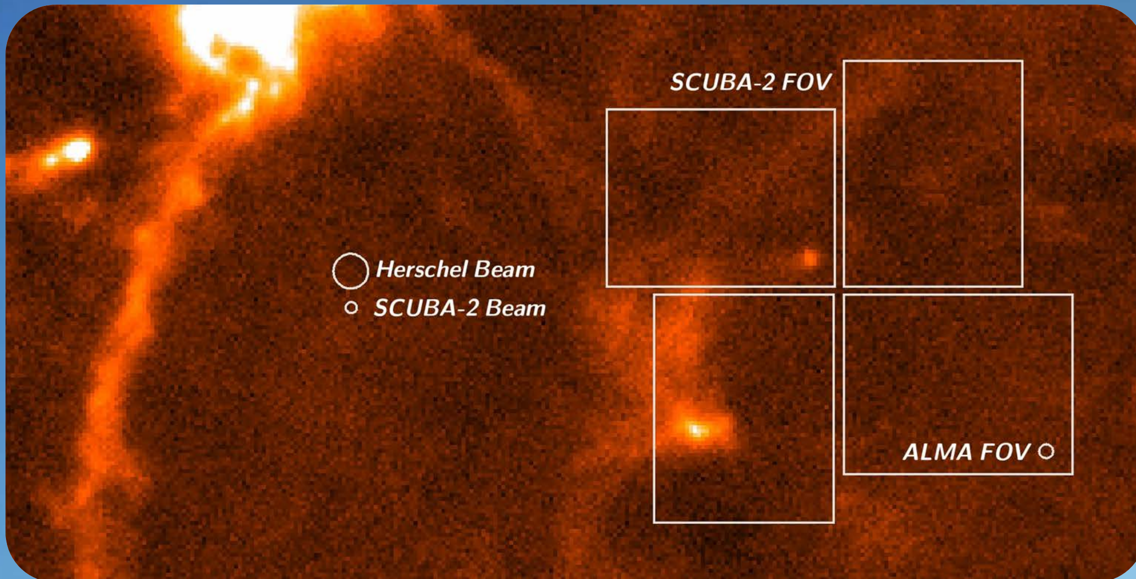
Continually Improving Efficiency

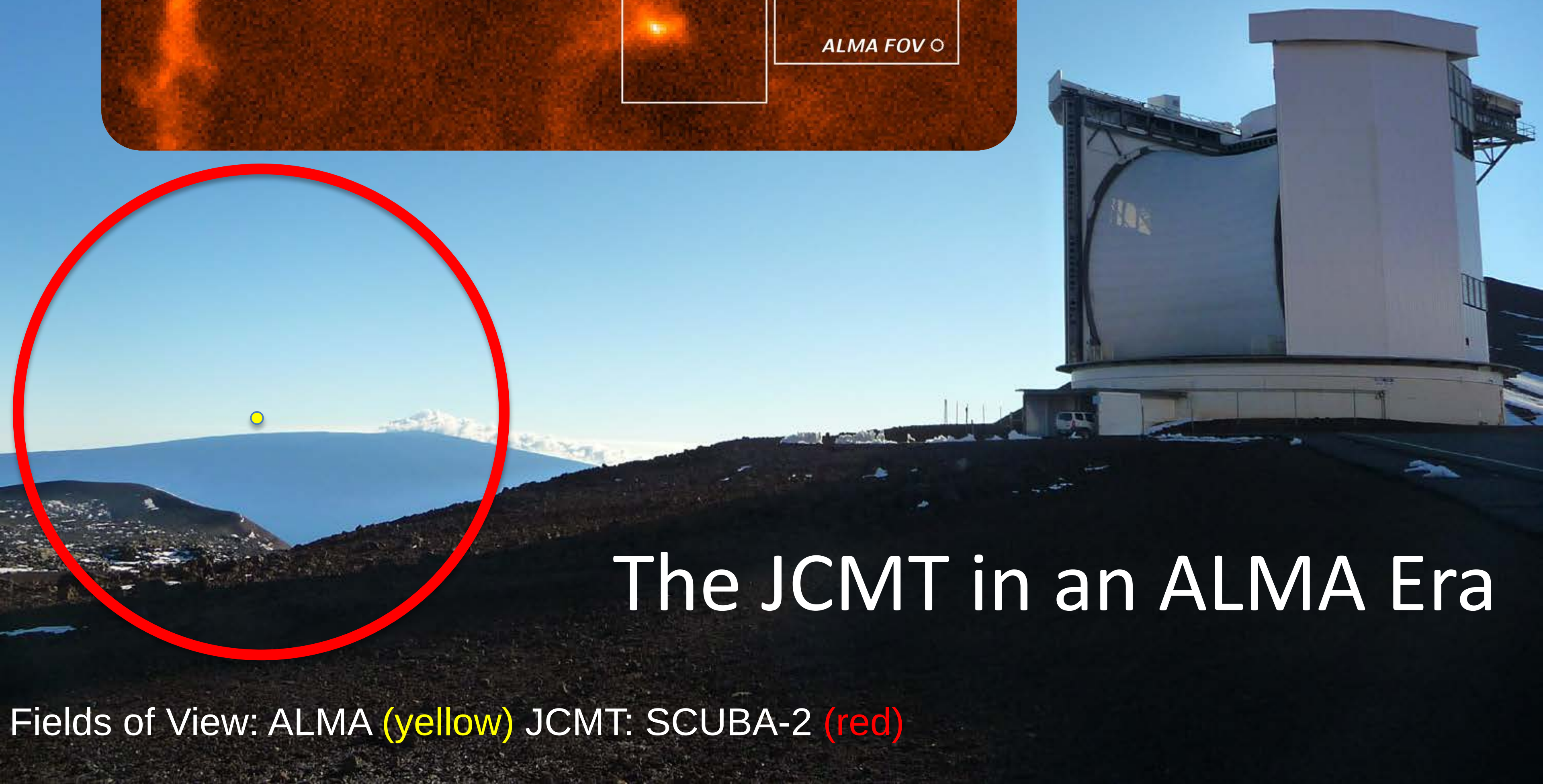
- Monitoring technical faults dramatically reduces time lost…
  - Routinely less then 5% time lost to faults, despite complex instrumentation
- Monitoring calibrations and overheads yields efficiencies…
  - Have added over 30 minutes of science observing each night
- Extended Observing hours via Remote Ops.
  - JCMT can operate during the day
    - Somewhat poorer performance as dish warms
    - Somewhat poorer weather conditions during daytime
  - Initial tests with remote operations in morning
    - Adding ~2hrs of observations per day

Publication record in 2012:
Over 100 publications (many archival SCUBA data)


Portion of the Universe accessible to both ALMA and the JCMT.
JCMT Field Only
(ALMA cannot see this far north)
The shared ALMA and JCMT sub-mm sky
ALMA Field Only
(JCMT cannot see this far south)
Background Image: ESA, Planck
The JCMT in an ALMA Era
Fields of View: ALMA (yellow) JCMT: SCUBA-2 (red)

Beam size and Field of View for JCMT:SCUBA-2 and Herschel 500 micron





The JCMT in an ALMA Era

Fields of View: ALMA (yellow) JCMT: SCUBA-2 (red)

JCMT Enhancement Possibilities

- A new surface (to ~18μm from 22-25μm)
  - ~3M$ for panels
- A new surface and backing structure (to ~13μm)
  - ~7.5M$ in total
  - Would allow removal of wind-blind (polarimetry)
- Even Larger array cameras
  - Super-HARP (100 element heterodyne array)
    - ~15M$ in total
  - Redesign the Nasmyth focus (continuum)
- Low spectral resolution imaging pixels
  - z-machine …

Not to mention enhanced polarimetry …

Location, Location, Location

- *one careful owner!*
- *only driven at night, in benign conditions!*
- *owner leaving town, must sell!*
  - *deadline Sep 2014*
- *bargain price!*
  - *ask for details …*

Marcel Clemens