SMA Science Opportunities

Science with the wideband Submillimeter Array:
A Strategy for the Decade 2016–2026

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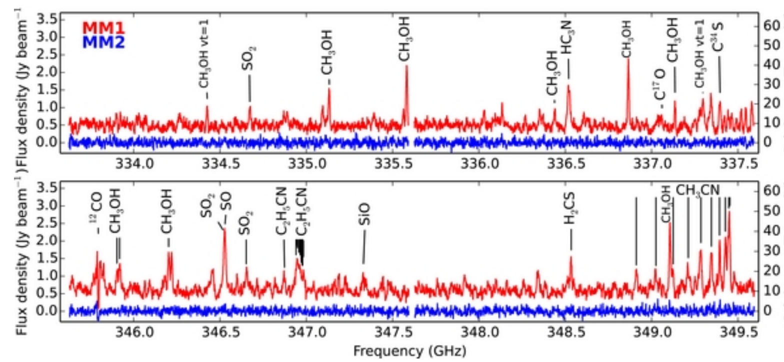
Figure 1: *The eight movable 6-meter antennas of the Submillimeter Array on Mauna Kea, Hawaii.*



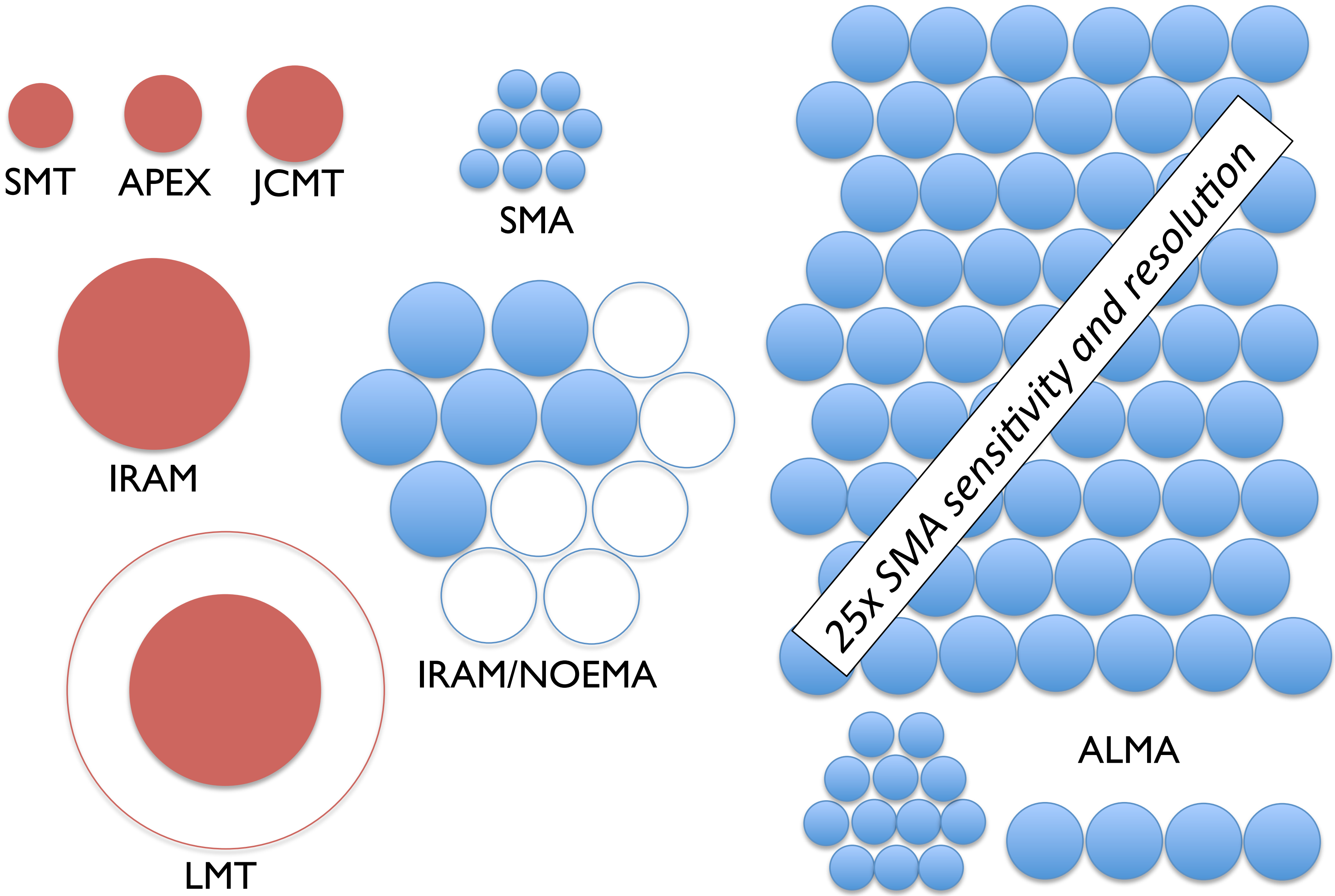
David J. Wilner

Submm Astronomy: Major Science Drivers

High resolution imaging and spectroscopy at mm/submm wavelengths are essential to address a broad range of key questions in astronomy (e.g. Astro2010 Science Frontier Panels)

- star formation history of the universe, z=0 to 10
- galactic structure and kinematics
- energetics of molecular clouds
- star formation
  - super star clusters
  - high mass and Sun-like star formation
- planet formation and circumstellar disks
- late stages of stellar evolution
- astrochemistry
- Solar System bodies
- black holes (including Galactic Center)

Landscape of mm/submm Telescopes



The ALMA era is well underway

- early science observations started in September 2011
- time allocation NA:EU:EA:CL = 34:34:22:10
- overwhelming worldwide community interest

  Cycle 0: 919 proposals, 16 antennas, 800 hours

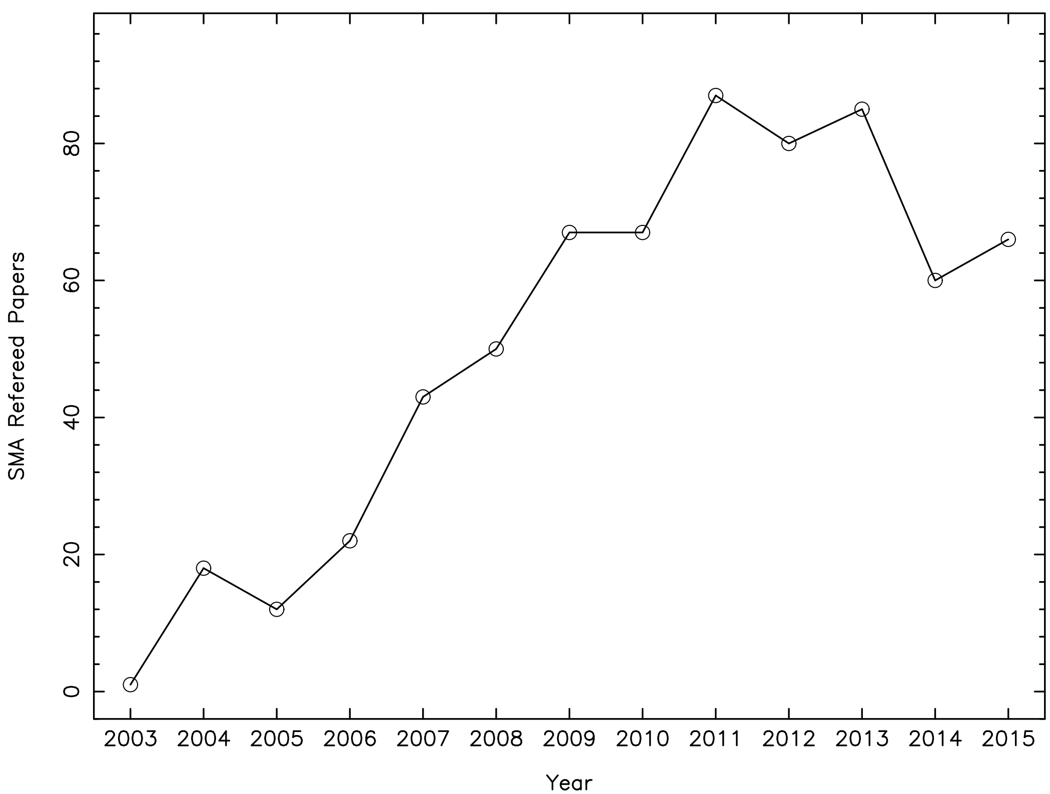
  Cycle 1: 1133 proposals, 32 antennas, 800 hours

  Cycle 2: 1381 proposals, 34 antennas, 1700 hours (+470 hours Cycle 1)

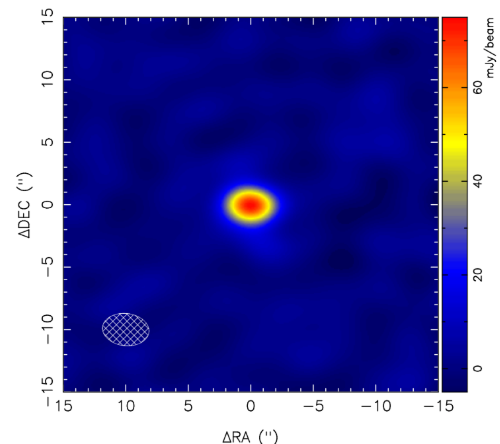
  Cycle 3: 1578 proposals, 36 antennas, 2133 hours

SMA is in Demand and Highly Productive

- > 80 proposals per semester
- oversubscription 3:1
- > 60 refereed papers per year

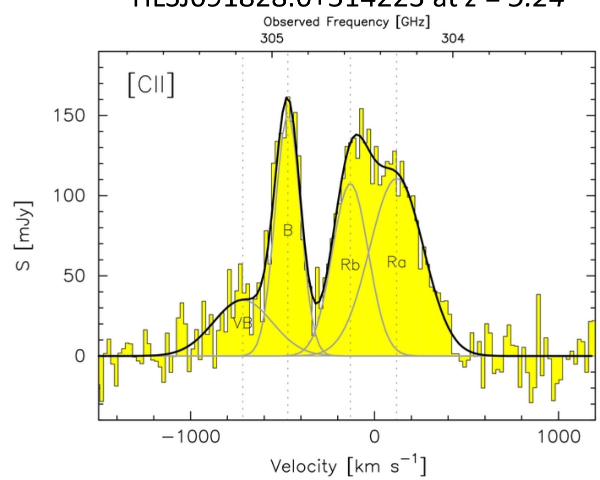


NEA 205 YU_{55} at 0.85 lunar distances



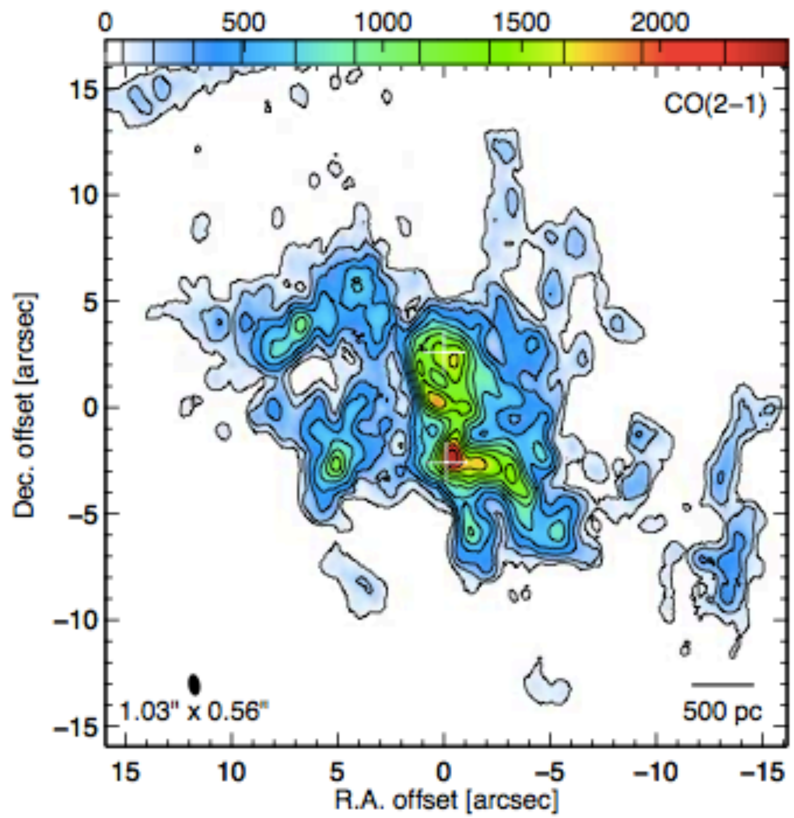
Muller et al. 2013

HLSJ091828.6+514223 at $z = 5.24$



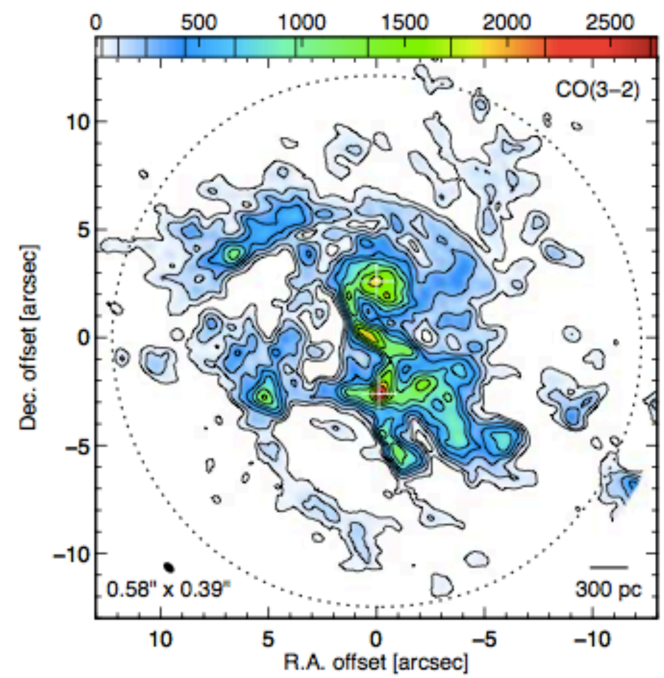
Rawle et al. 2014

NGC 3256 IR-Luminous Merger (dec -44)



SMA CO 2-1

3 configurations (6-8 ants)
13h on-source



ALMA CO 3-2

2 configurations (20+ ants)
1.5h on source

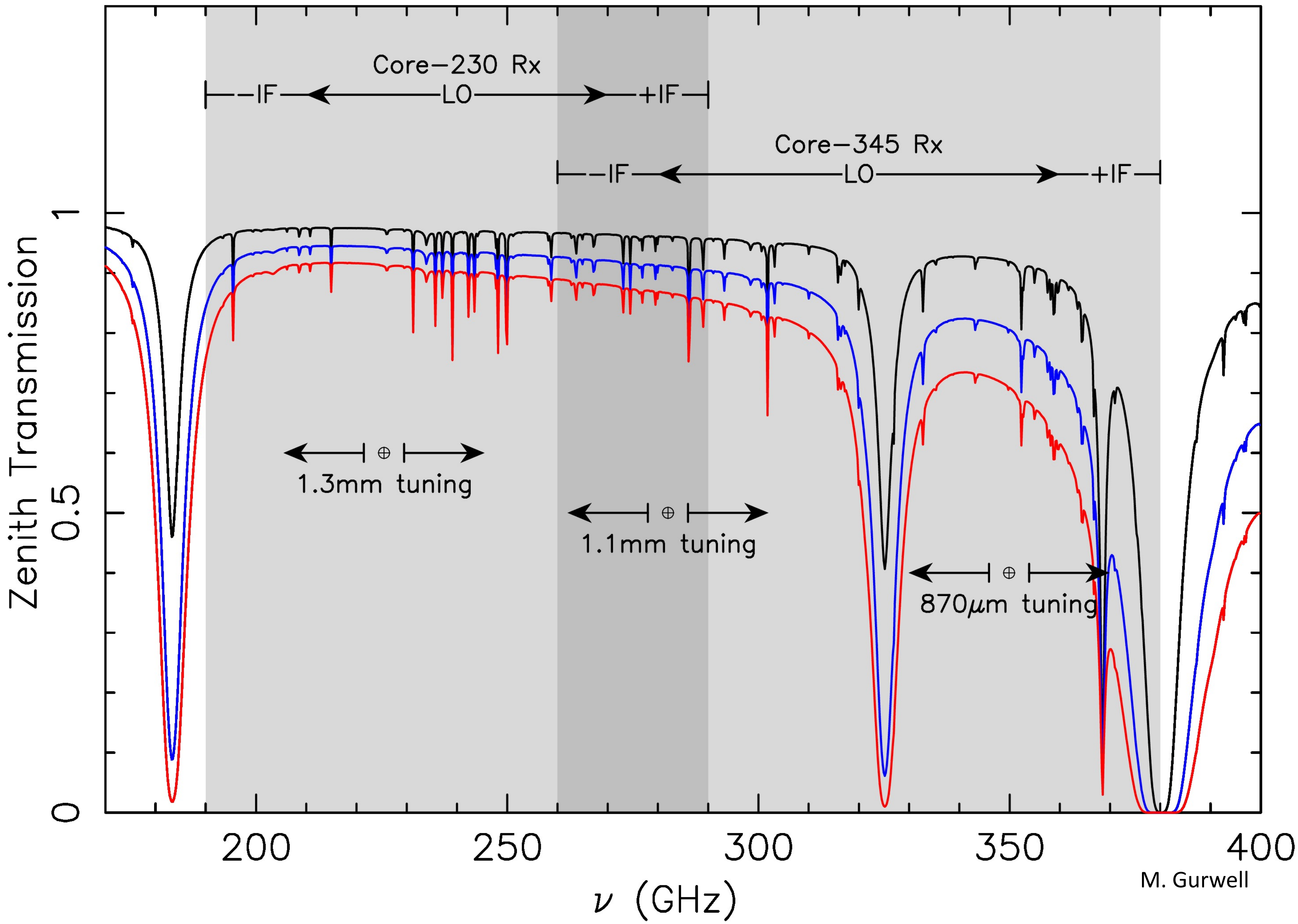
Sakamoto et al. 2014

SMA ultra-wideband upgrade

	year	receiver bandwidth	bands × polarizations	total bandwidth	continuum rms (mJy) 230 GHz	345 GHz
stage 0	2004	2 GHz × 2 sidebands	2	8 GHz	0.60	1.25
stage 1	2016	8 GHz × 2 sidebands	2	32 GHz	0.23	0.52
stage 2	2020	16 GHz × 2 sidebands	4	128 GHz	0.14	0.33

- unique combination of wide bandwidth for spectral coverage and uniform high spectral resolution, $\lambda/\Delta\lambda \approx 2.5\text{x}10^6$
- two atmospheric windows typically wide open from Maunakea
- continuum
  - 16x more obs to same sensitivity in given time (or 4x more sensitivity)
- spectral lines
  - 16x more spectrum simultaneously for faster coverage
- improved calibration, simplified ops, homogeneous archive

Astronomer's View of "wSMA" Spectral Coverage

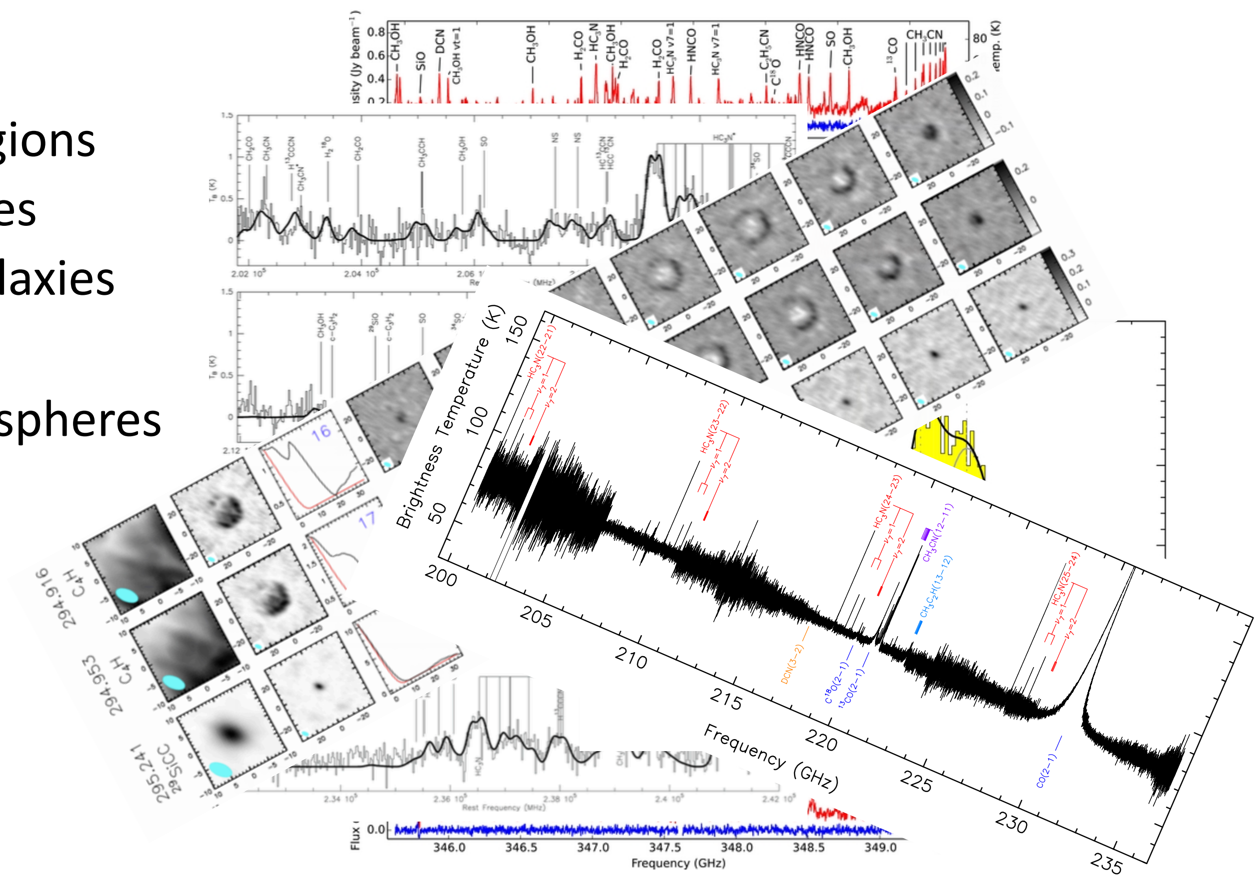


M. Gurwell

wideband SMA Science

- in effect, every observation is an imaging spectral line survey

- examples
  - star forming regions
  - starburst galaxies
  - high redshift galaxies
  - evolved stars
  - planetary atmospheres
  - …

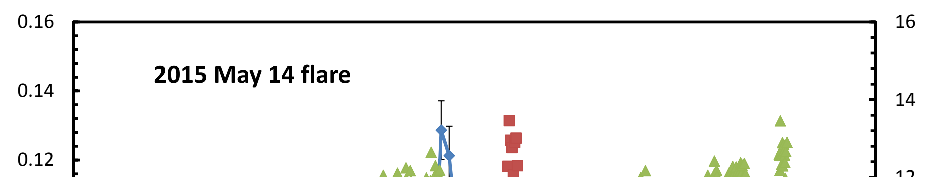


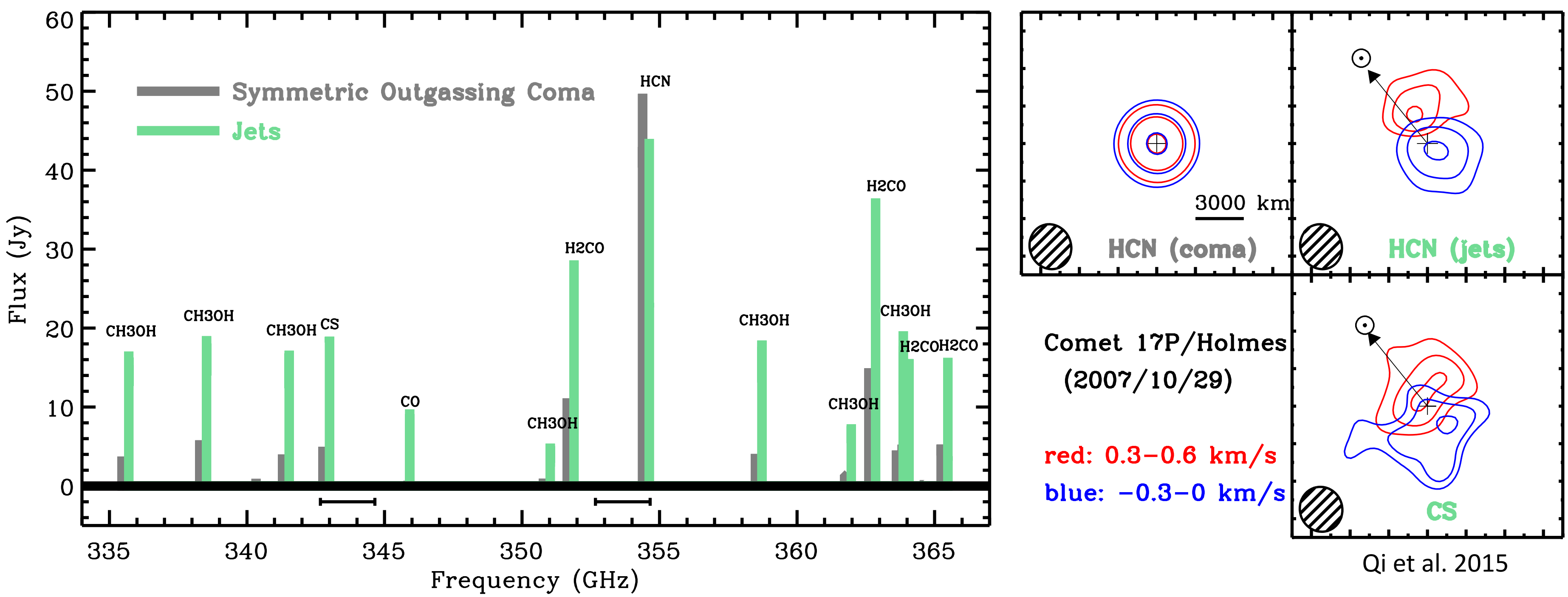
- n.b. ALMA is not efficient in this mode
  - wSMA gives 8x bandwidth and 4x spectral resolution, 4x field of view

wideband SMA Science

- very advantageous for time variable phenomena

- examples
  - SgrA* (+ polarization)
  - comets

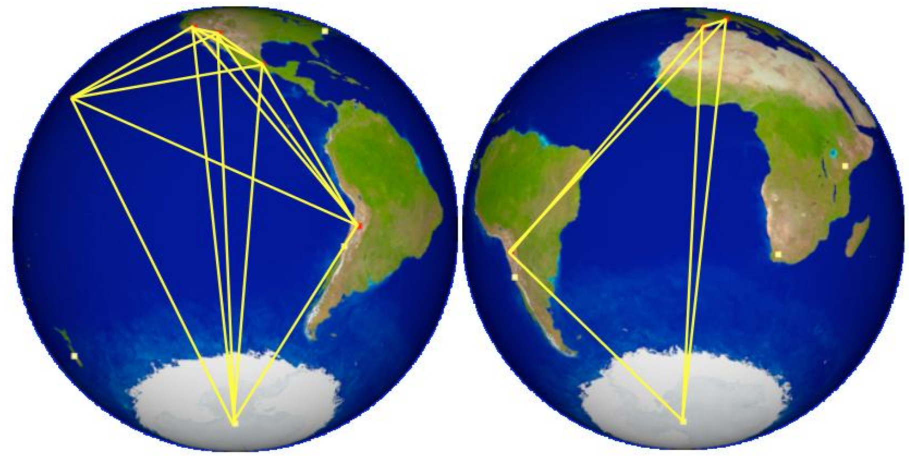




Qi et al. 2015

Additional Science Modes

- key station in global Event Horizon Telescope
  - SWARM designed for VLBI
  - reliable 345 GHz weather
  - simultaneous 230/345 GHz?
  - non-imaging observations with more bandwidth than ALMA provides?



- opportunities for additional instrumentation
  - upgrade concept explicitly incorporates open "guest" space
  - modest scale allows SMA to drive/adapt to innovation
  - potential path for new collaborations
  - examples: 690 GHz band, CI line at 492 GHz, 345 GHz mulit-beam rx

SMA Science in the ALMA Era

1. programs that don't require full ALMA sensitivity/resolution
   - spectral surveys and time domain
   - flexibility and rapid response
2. focused large scale programs
   - build samples to probe correlations, evolution, etc.
3. seed studies designed for ALMA follow-up
   - select targets, refine methods, optimize return, take risks
4. access to northern sky
   - known (and unknown) important sources
5. key station in global Event Horizon Telescope
   - correlating directly with ALMA
6. testbed for technologies and techniques
7. expert education and training