

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

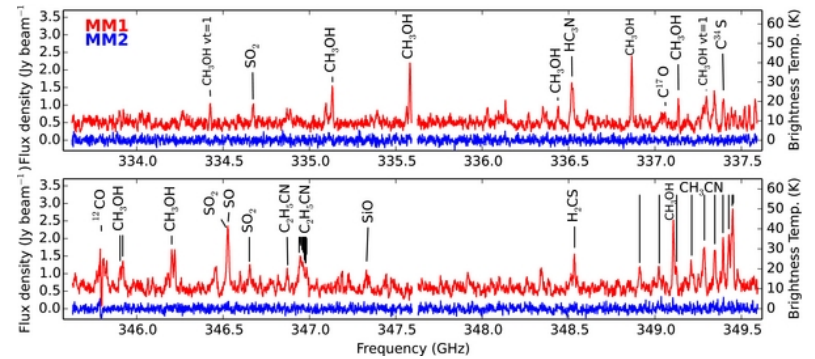
ed. D. Wilner; contributing authors: E. Keto, M. Gurwell, N. Patel,
G. Petitpas, C. Qi, TK Sridharan, K. Young, Q. Zhang, J.-H. Zhao, ...

DRAFT: December 2, 2015



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

SMA Science Opportunities



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)

**THE SUBMILLIMETER ARRAY:
FIRST DECADE OF DISCOVERY**
Cambridge, MA, USA June 9 & 10, 2014
Marriott Courtyard Boston-Cambridge
<http://www.cfa.harvard.edu/sma/events/smaConf/>

Celebrating 10 years of research with the SMA and looking forward to the future, this conference focuses on submillimeter-wavelength science at high angular resolution. Topics to be covered include star formation, protoplanetary disks, nearby and distant galaxies, magnetic fields in the interstellar medium, high-energy and time-variable phenomena, our galactic center, the solar system, and submillimeter instrumentation.

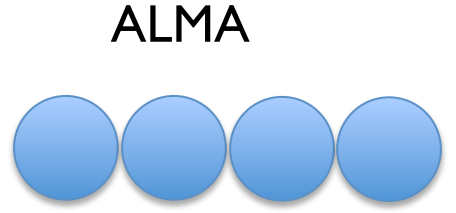
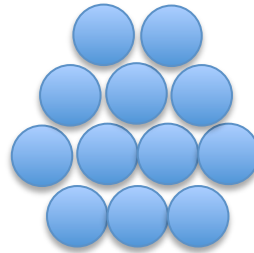
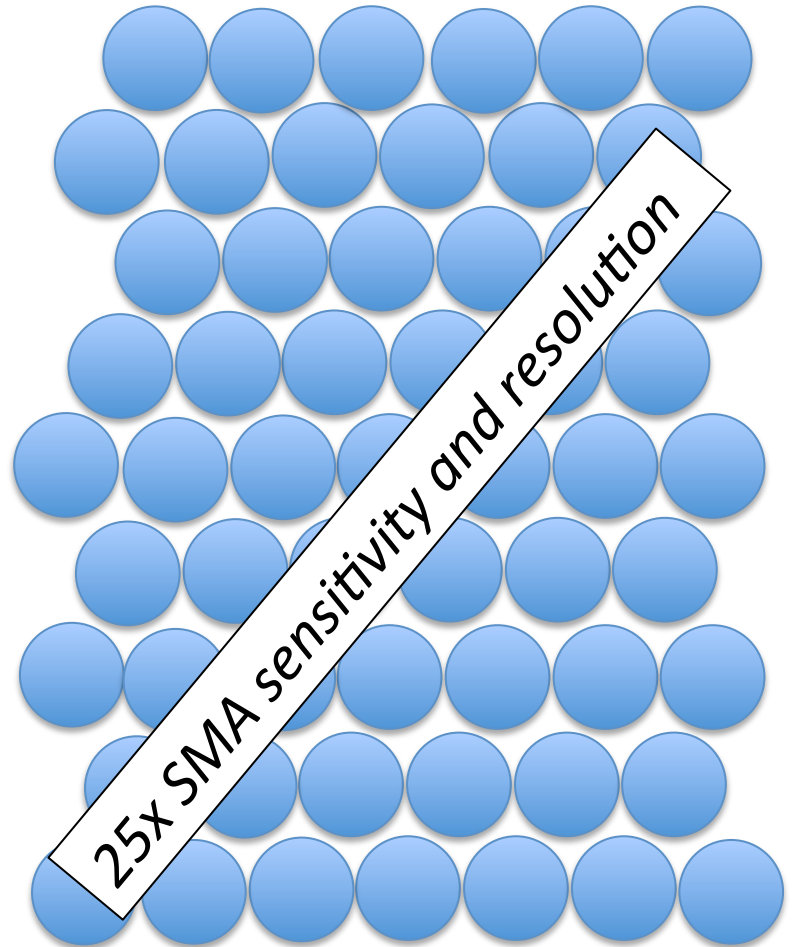
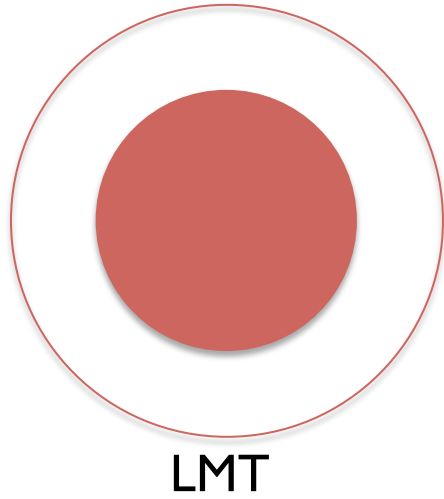
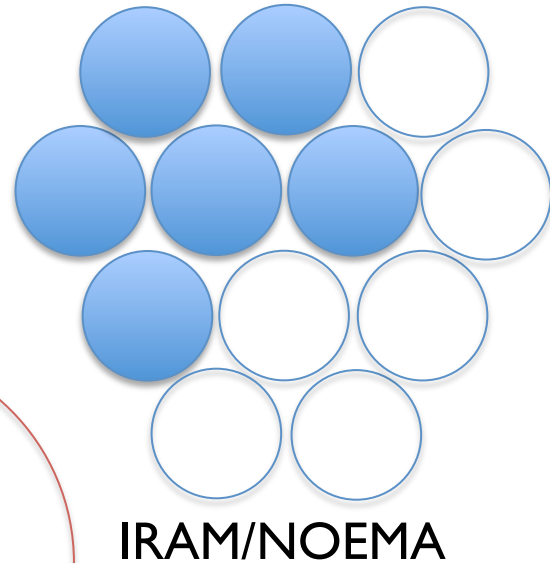
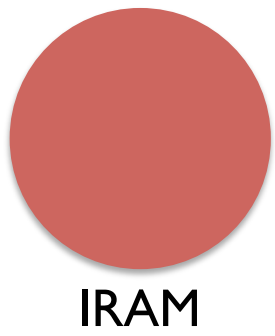
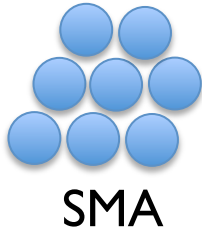
CONFIRMED INVITED SPEAKERS

 LOC Candace Barrett Arjun Dey Sheila Houlter Jensie Kambler Patricia Mainhol James Moran (chair) Margaret Simonson	 CONFIRMED INVITED SPEAKERS Sean Andrews (CU) Shepherd Doekema (CSA/MT Haystack) Izaskun Jimenez-Serra (ESO) Tomasz Kaminski (MPIR) Daniel Marrone (University of Arizona) Anastie Maury (IRFU) Karl Menten (MPIR) Arielle Mennill (NRAO) Karin Oberg (CSA) Kazuaki Sakamoto (ASIAA) Wei-Hao Wang (ASIAA) Ann Wehrle (SSI)	 SOC Raymond Blundell Pierre Cox Arjun Dey Mark Gorenfeld Paul Ho Eric Keto Karl Menten James Moran (chair) Frits van Dishoeck Jonathan Williams David Wilner Qibin Zhang
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MEETING SPONSORS

 National Science Foundation  European Space Agency	 Academia Sinica Institute of Astronomy and Astrophysics	 Drexel University Drexel Institute of Astrophysics sma10@cfa.harvard.edu
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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

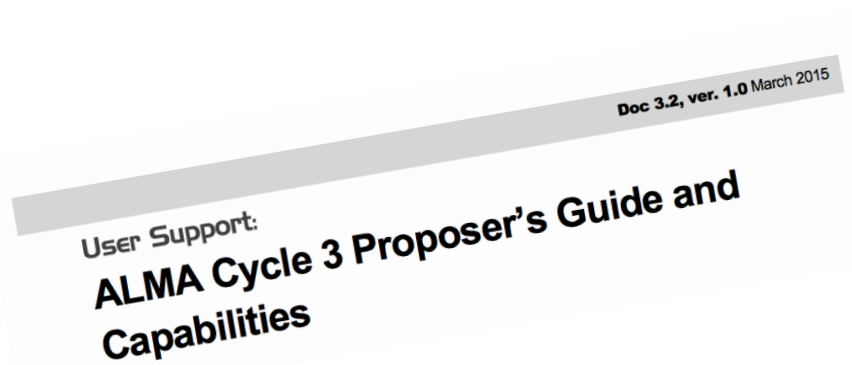


Cycle 0: 919 proposals, 16 antennas, 800 hours

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



ALMA Observing Tool (OT)
(32)

What do I do if I can't get the OT to work?

ALMA Science Archive Query

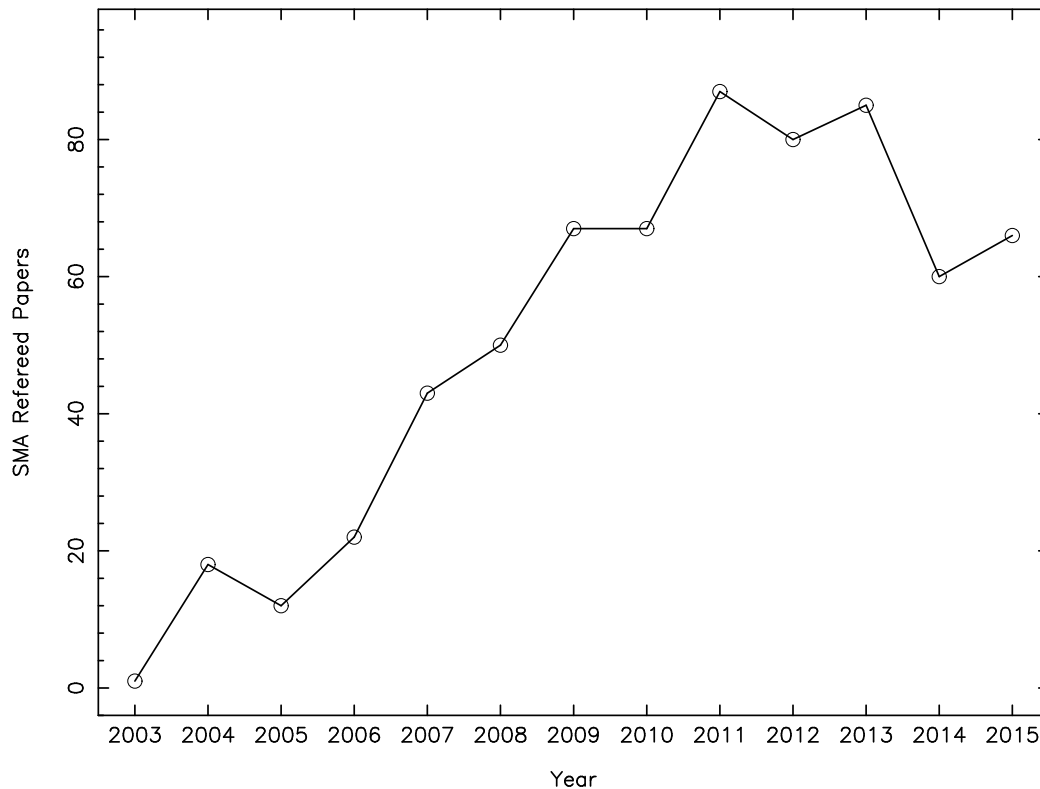
Query Form

Results Table

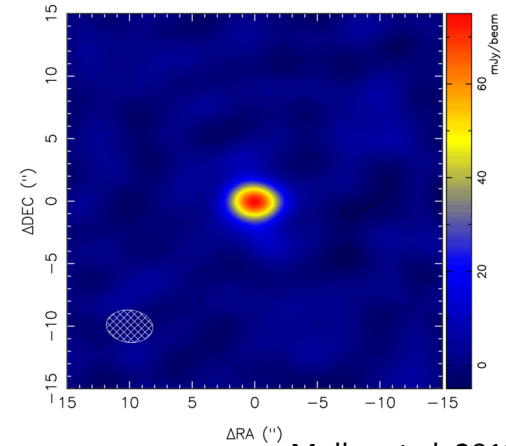


SMA is in Demand and Highly Productive

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

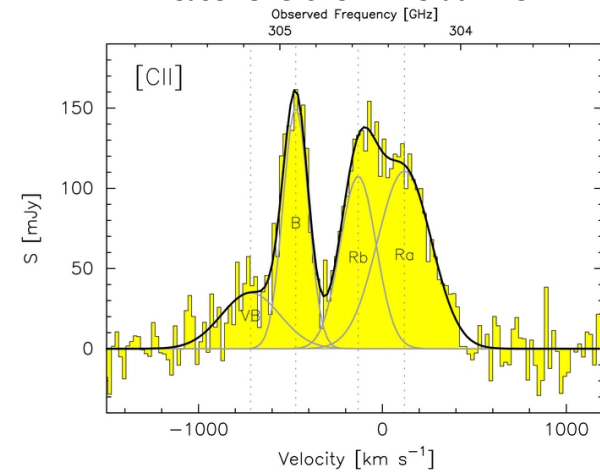


NEA 205 YU₅₅ at 0.85 lunar distances



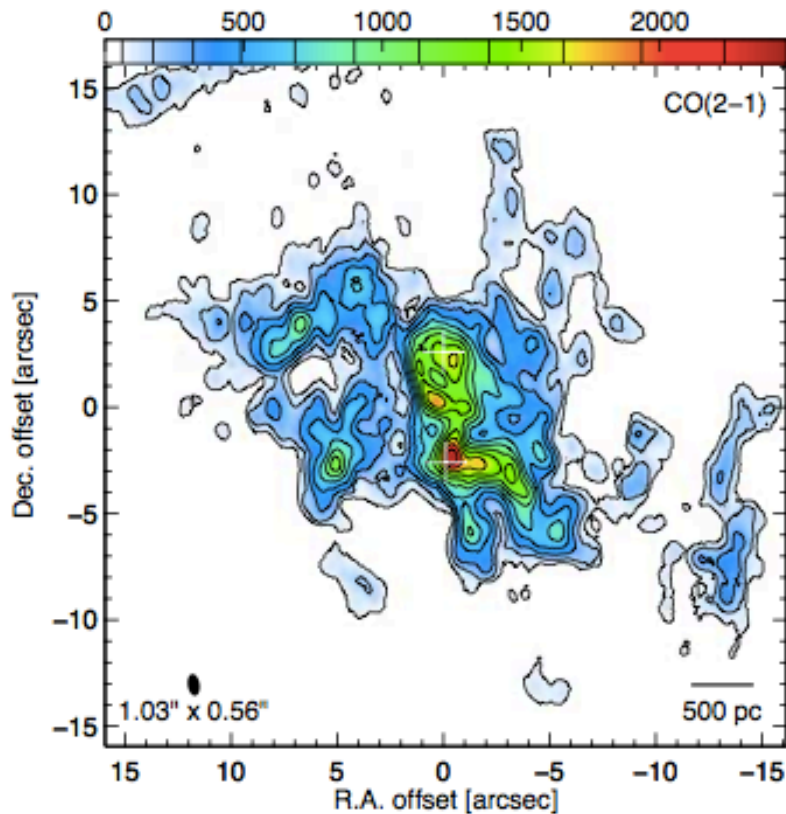
Muller et al. 2013

HLSJ091828.6+514223 at $z = 5.24$



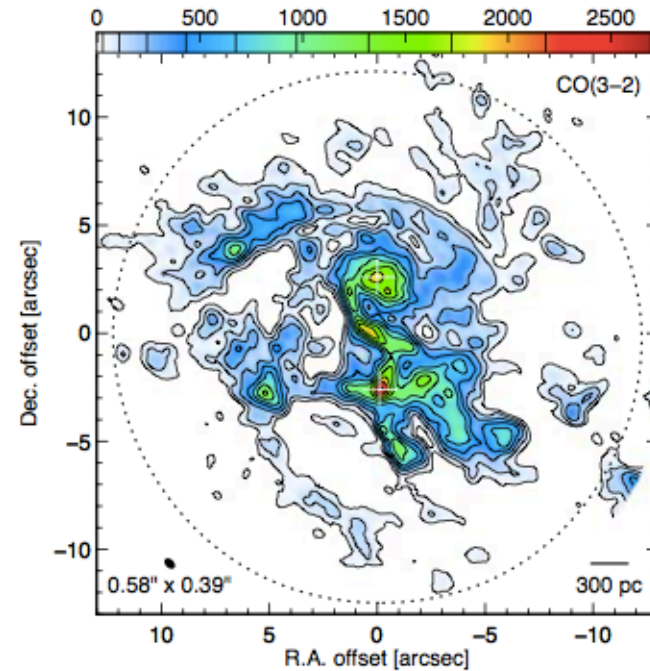
Rawle et al. 2014 5

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

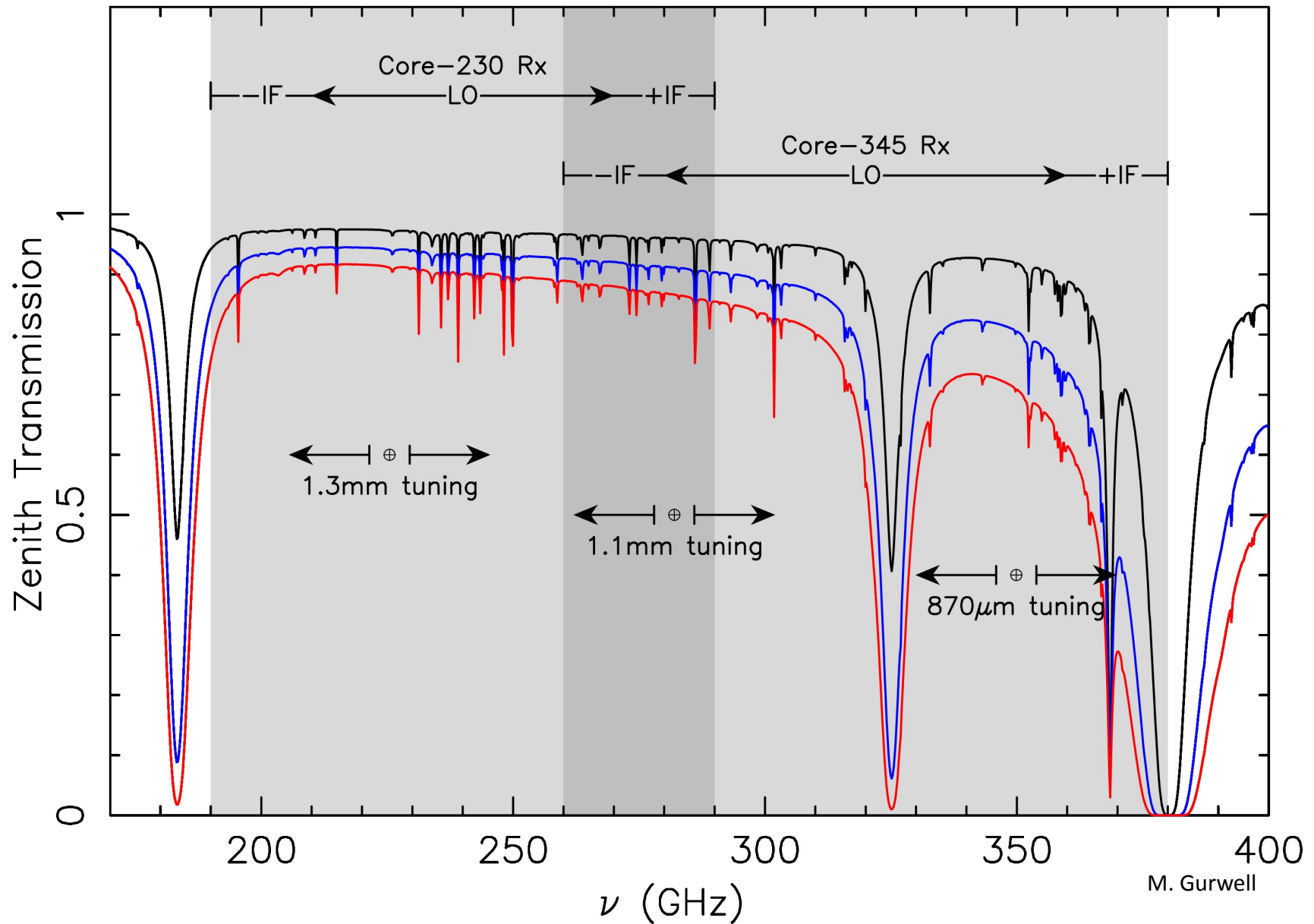
Sakamoto et al. 2014

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, $\lambda/\Delta\lambda \approx 2.5 \times 10^6$
- 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

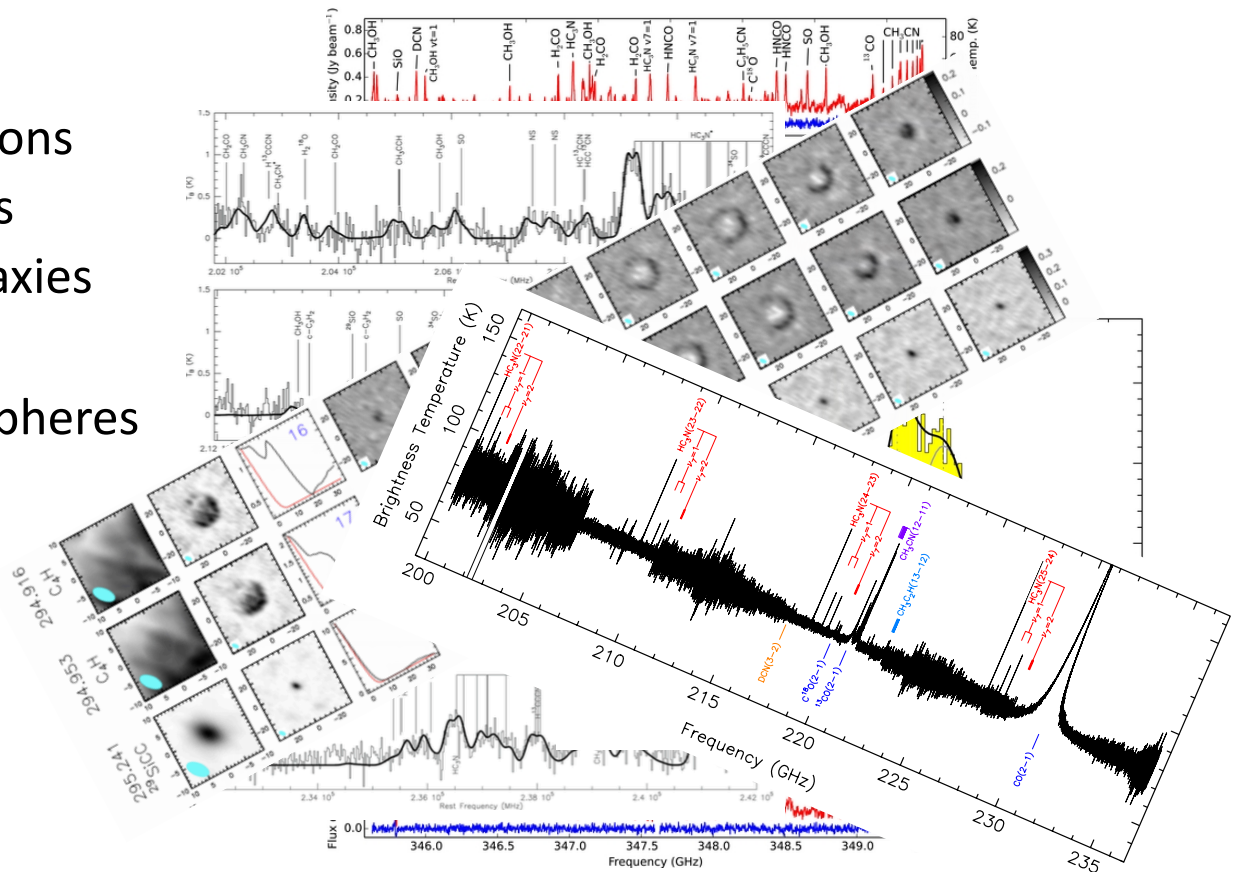


wideband SMA Science

- 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

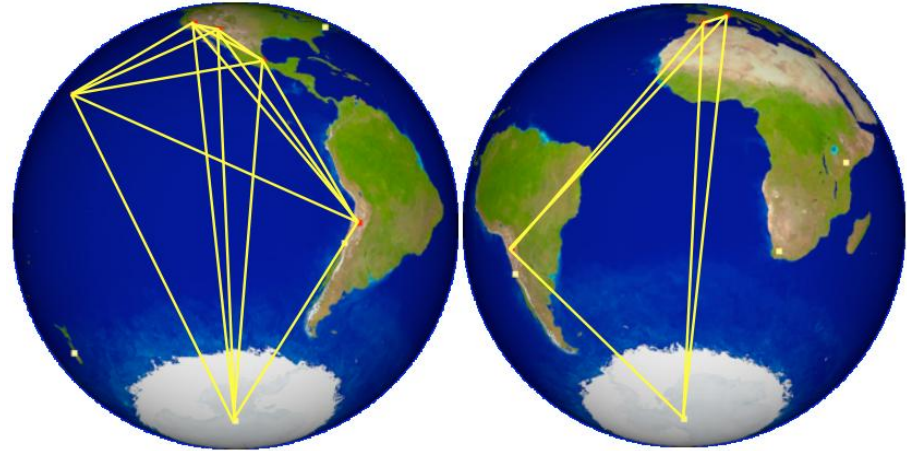
- very advantageous for time variable phenomena
- examples
 - SgrA* (+ polarization)
 - comets



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 multi-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