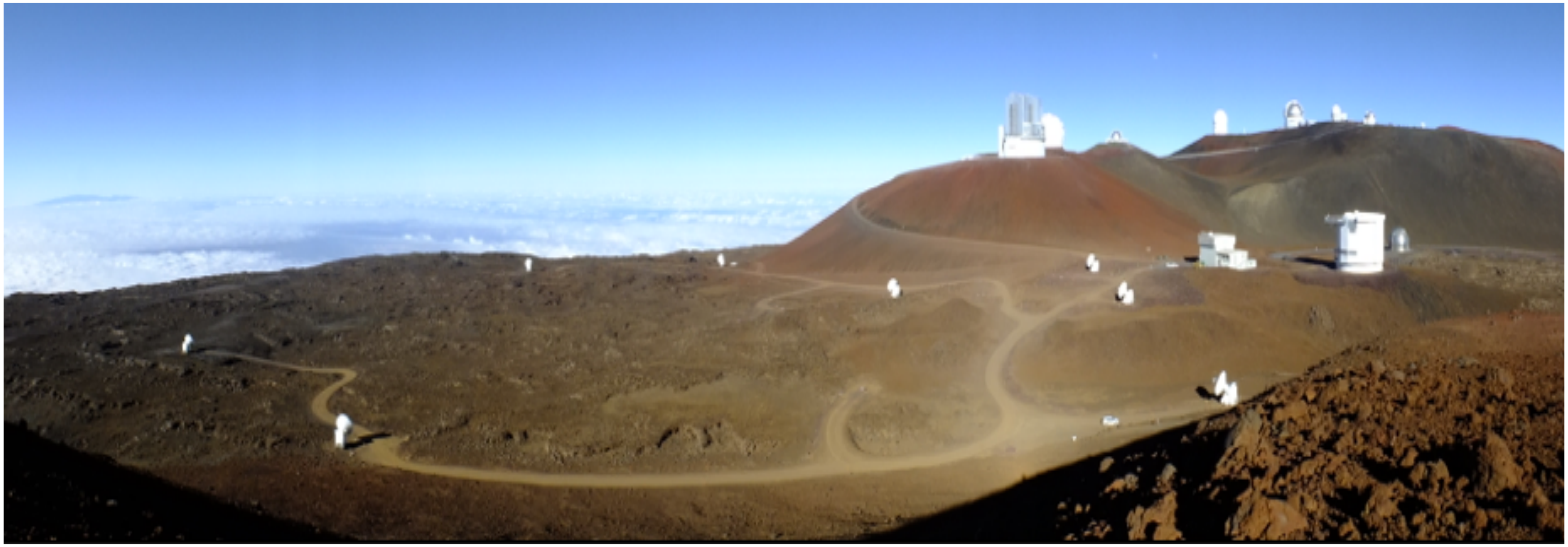
SMA in the mm/submm Landscape

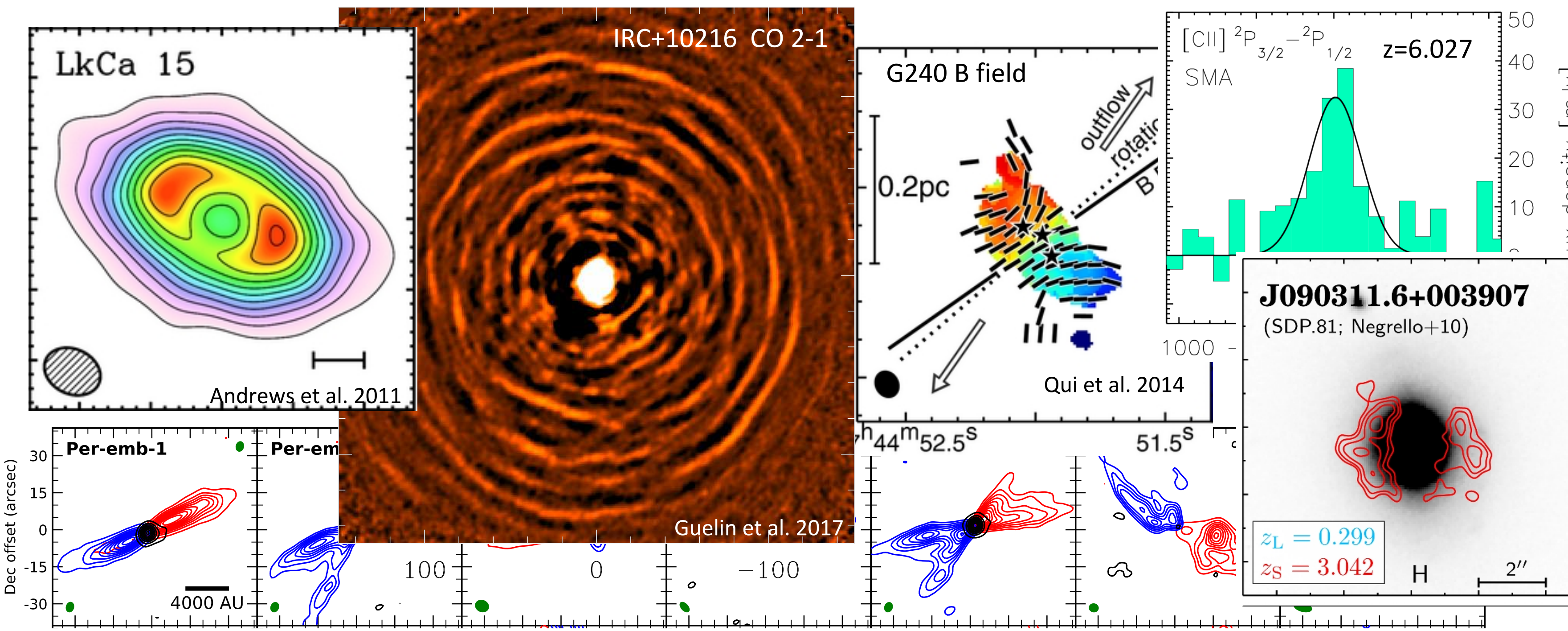
David J. Wilner



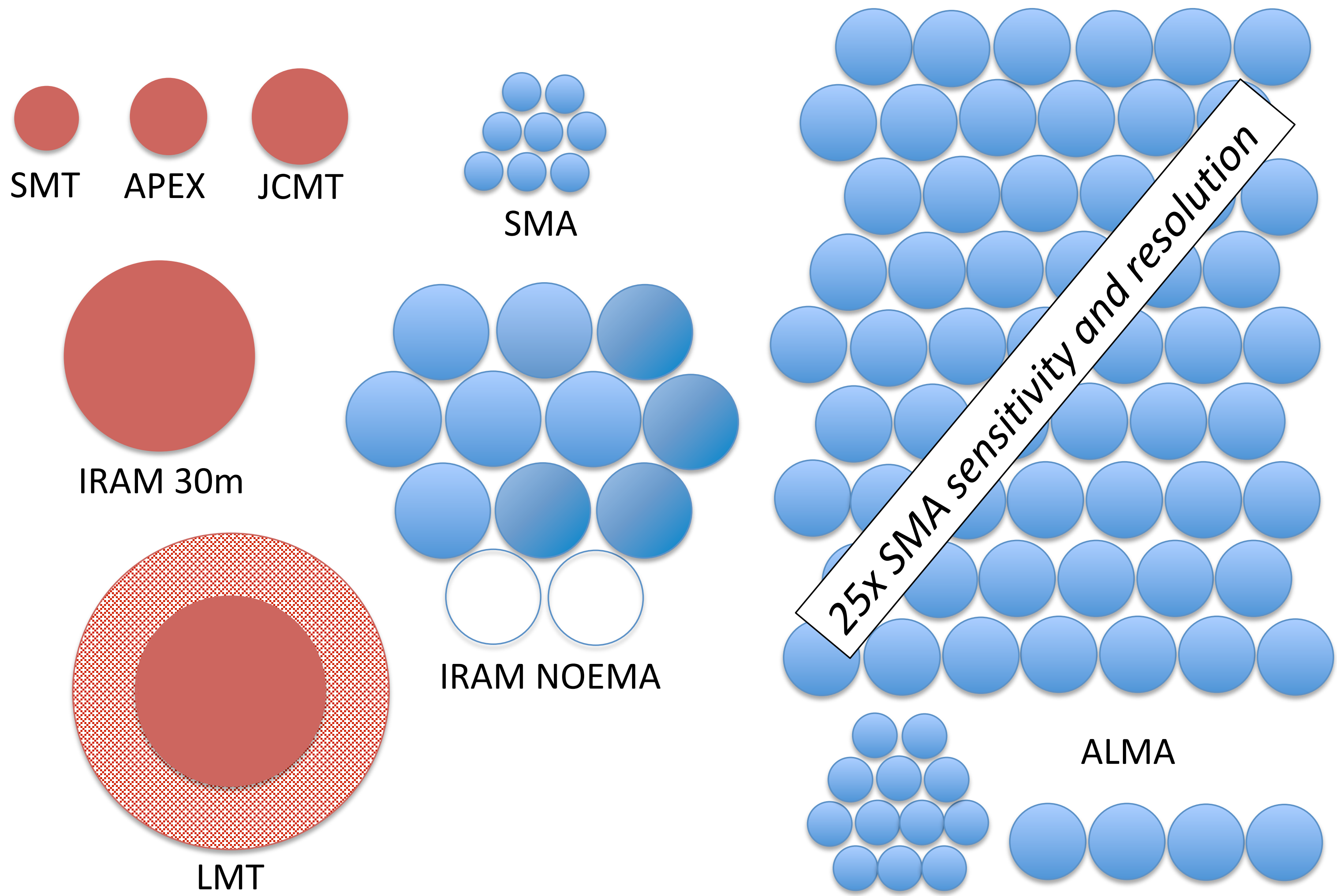
SMA Science

- High resolution imaging and spectroscopy at millimeter and submillimeter wavelengths are essential tools to advance understanding of a broad range of astrophysical phenomena
- SMA has transformed fields from planet formation to high-z

800+ refereed science papers (>1/week); 28000+ citations (~5/day)



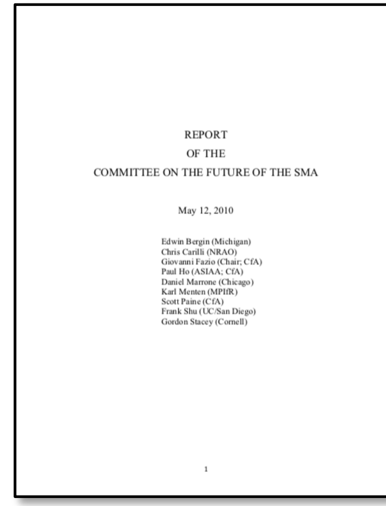
mm/submm Telescopes



SMA Development Vision

Committee on Future of SMA (2010)

- **increase bandwidth**
  - priority: 345 GHz band
- initiate multi-beam program
- add 2 more antennas


REPORT
OF THE
COMMITTEE ON THE FUTURE OF THE SMA

May 12, 2010

Edwin Bergin (Michigan)
Chris Carilli (NRAO)
Giovanni Fazio (Chair; CfA)
Paul Ho (ASIAA; CfA)
Daniel Marrone (Chicago)
Karl Menten (MPIfR)
Scott Paine (CfA)
Frank Shu (UC/San Diego)
Gordon Stacey (Cornell)

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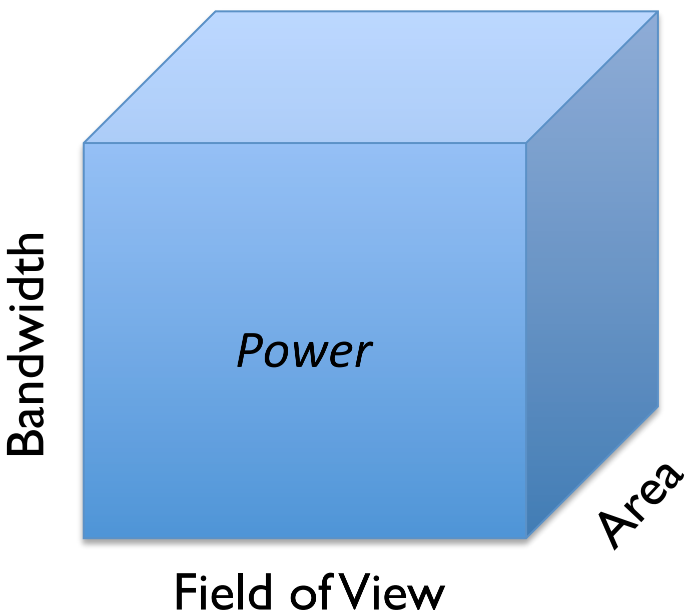

Maximize SMA power for a diversity of science drivers, capitalizing on Maunkea site, affordable advances in technology, rapid upgrade timescale, and expertise.

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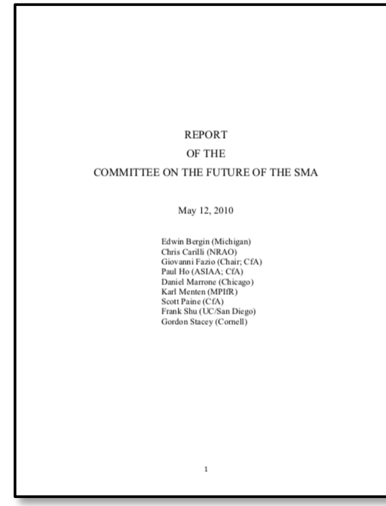
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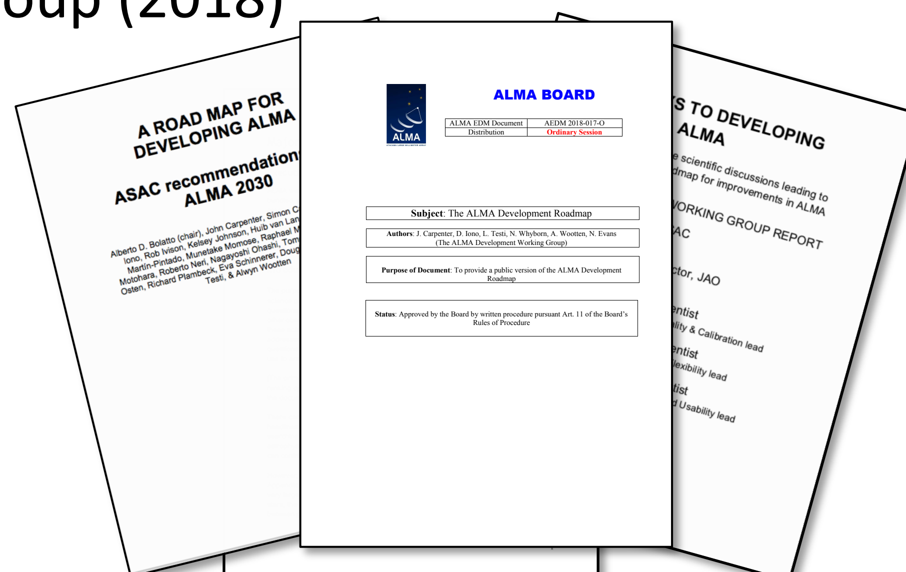
ALMA Development Working Group (2018)

- **increase bandwidth**
  - priority: Bands 6 and 7
- longer baselines
- focal plane arrays
- add 12m antennas
- large single dish antenna



SMA wideband upgrade concept

year	receiver bandwidth	bands × pols	total bandwidth	continuum rms (μJy) 230 GHz	345 GHz
2004	2 GHz × 2 sb	2	8 GHz	600	1250
2017	8 GHz × 2 sb	2	32 GHz	230	520
2019	12 GHz × 2 sb	2	48 GHz	190	425
2022	16 GHz × 2 sb	4	128 GHz	140	330

- Science: unique combination of wide bandwidth for spectral coverage and uniform high resolution, $\lambda/\Delta\lambda \approx 2.5\text{x}10^6$
  - core 230 and 345 GHz bands (matched to Maunakea site)
  - Continuum: 16x faster or 4x deeper, and + higher fidelity imaging
  - Spectral lines: 16x grasp = more spectrum simultaneously
- Practical: better calibration, homogeneous data archive
- Dedicated open space to exploit new opportunities

Astronomer's view of wSMA spectral coverage

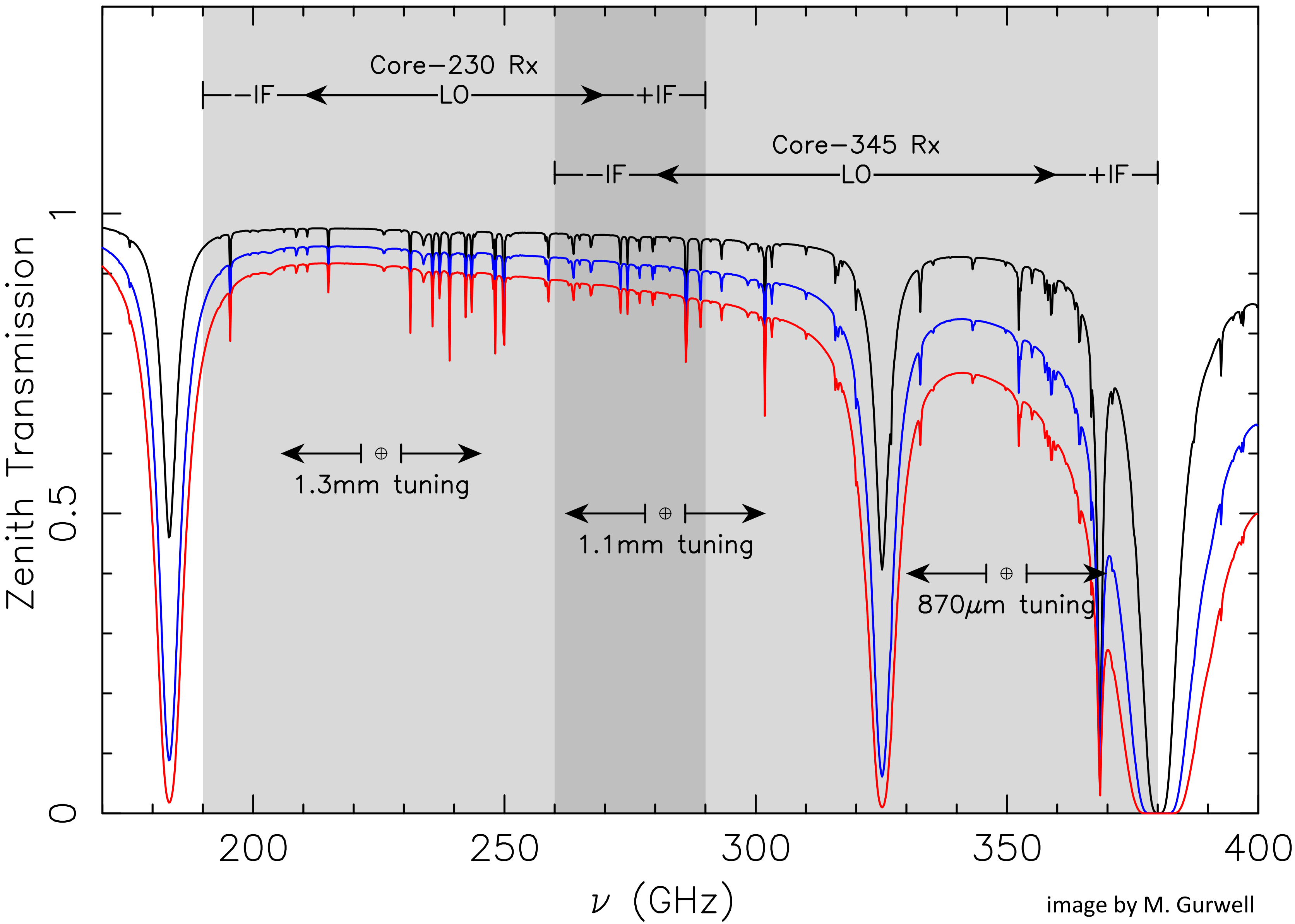


image by M. Gurwell

SMA Science Workshop

→ wSMA Science White Paper

wSMA Science White Paper

SMA Memo #165

Science with the wideband Submillimeter Array:
A Strategy for the Decade 2017–2027

ed. D. Wilner *contributing authors:* E. Keto, G. Bower, T.C. Ching, M. Gurwell, N. Hirano, G. Keating, S.P. Lai, N. Patel, G. Petitpas, C. Qi, TK Sridharan, Y. Urata, K. Young, Q. Zhang, J.-H. Zhao

Version 2.0, January 27, 2017

Figure 1: *The eight 6-meter antennas of the Submillimeter Array on Maunakea, Hawaii (photo by N. Patel).*

Contents

wSMA Science Opportunities

Spectral line surveys

in effect, every observation is an imaging spectral line survey

Solar System, star-forming regions, evolved stars, galaxies

Time Domain / Transients

Increased instantaneous sensitivity and/or wide spectral coverage very advantageous for time variable phenomena

comets, AGN activity, gamma-ray bursts

Everything the SMA does now, better and faster

including efficient wide-field mapping observations

Spectral Line Surveys

Galactic Star Forming Regions

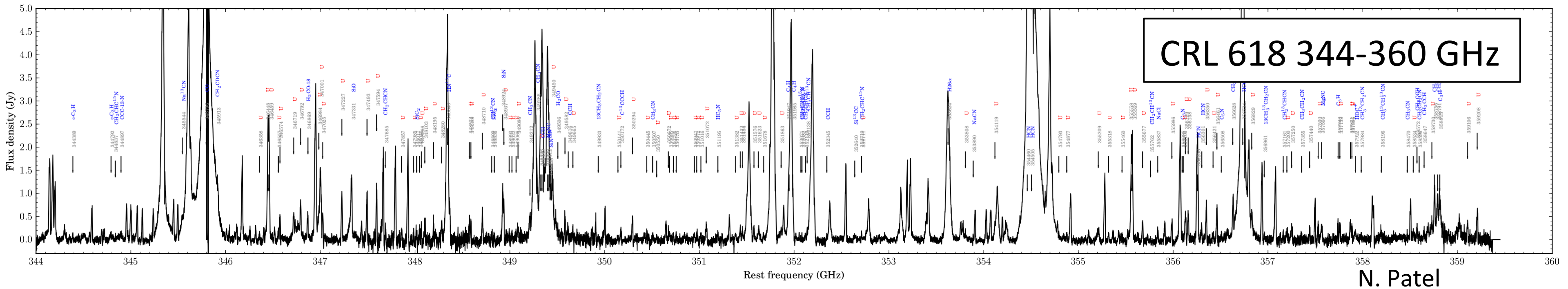
Comprehensive multi-line studies that exploit chemical complexity and gas motions to probe the early evolution of young stellar objects

Galaxies Near and Far

Cold gas inventories for star formation physics, chemical fingerprints of starburst and nuclear activity, high-z [CII] intensity mapping

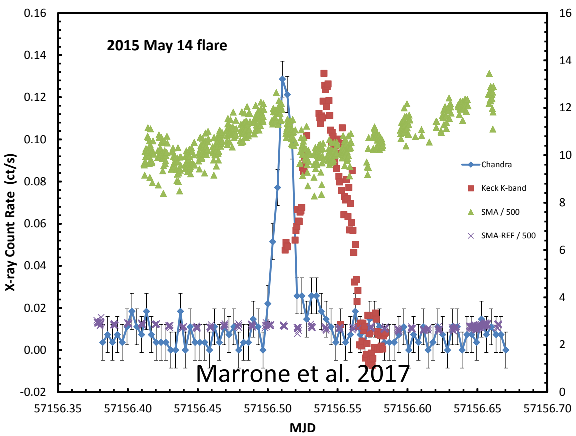
Evolved Stars

Large samples of systems for unbiased views of chemical processes, mass-loss and wind physics, ISM enrichment



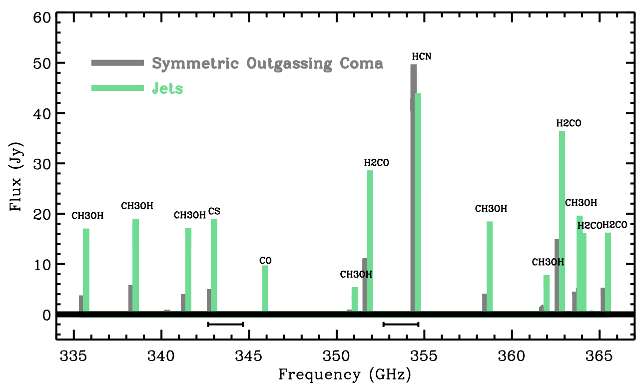
N. Patel

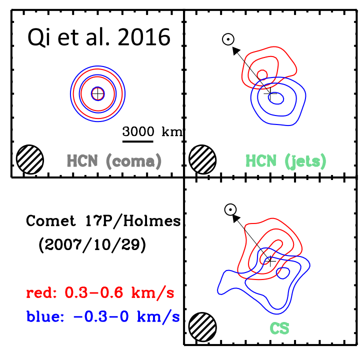
Time Doman / Transients



SgrA*

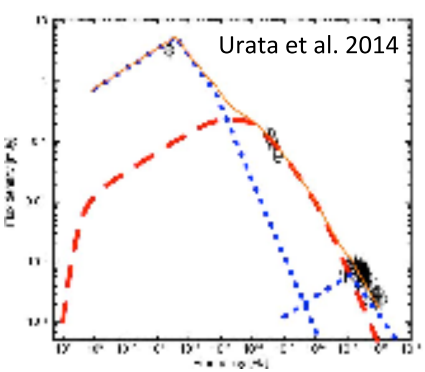
Simultaneous multi-freq Faraday rotation measures for time variability of black hole accretion rate (context for EHT)





Comets

Separate time variable coma and jet, spatially and spectrally, in many species



GRB afterglows

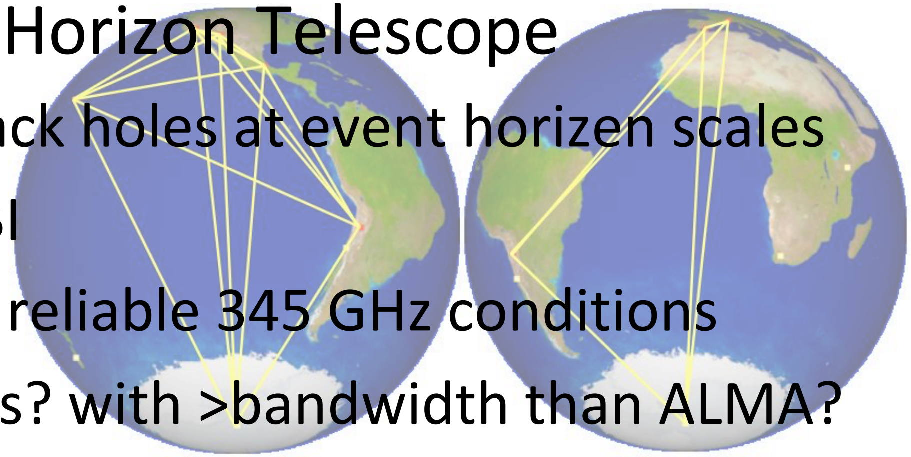
Reverse shock synchrotron properties: B-field, Γ

Requires rapid ToO response (minutes)

Potentially detectable to z=10 or higher

More Science Modes

Key station in global Event Horizon Telescope



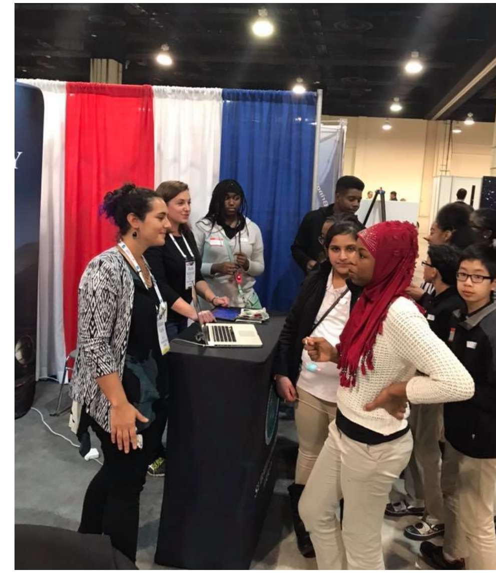
- Imaging supermassive black holes at event horizen scales
- SWARM designed for VLBI
- One of the few sites with reliable 345 GHz conditions
- Non-imaging observations? with >bandwidth than ALMA?

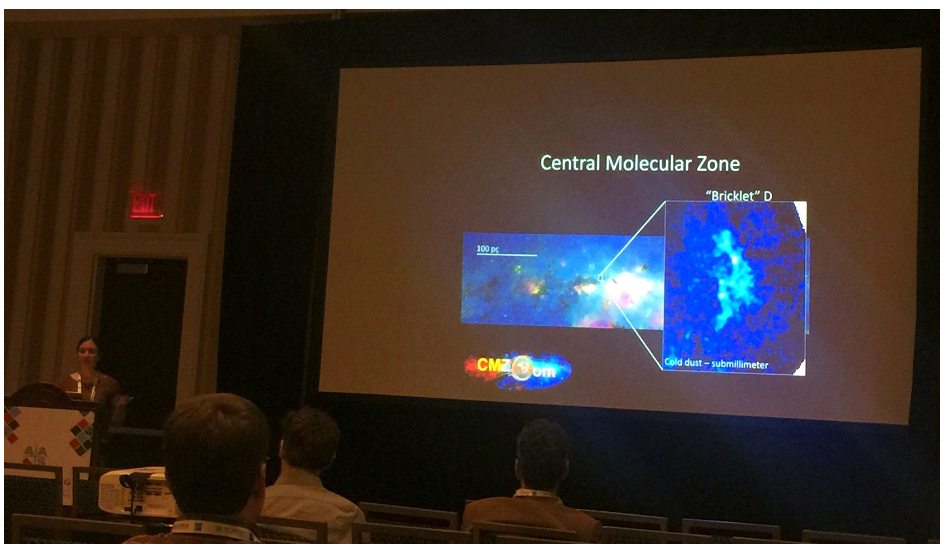
Opportunities for new instrumentation

- upgrade concept explicitly incorporates open space
- modest scale allows SMA to drive/adapt to innovation
- potential path for new collaborations
- examples: multi-beam? higher freq band? lower freq band?

wSMA Special Session at 2018 January AAS meeting

125. Science with the Wideband Submillimeter Array
Organizer(s): David Wilner (Smithsonian Astrophysical Observatory)
2:00 PM - 3:30 PM; National Harbor 3 (Gaylord at National Harbor)





wSMA in the ALMA Era

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  - Flexible scheduling, rapid response, quick turnaround, large programs
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- Key station in EHT
  - Correlating directly with ALMA
- Expert education and training
  - Millimeter/submillimeter astronomy and radio interferometry
- Test bed for new technologies and techniques
  - Engine for innovation

Expert Education and Training

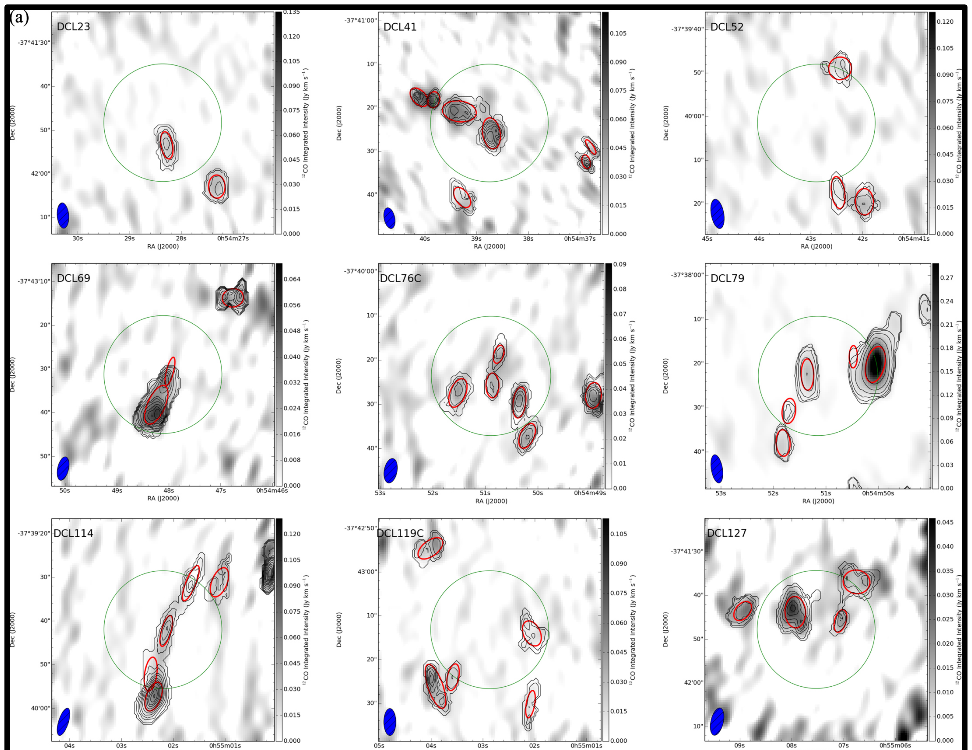
- hands-on, all aspects, in the CfA and Maunakea environments
- former SMA postdocs and students →

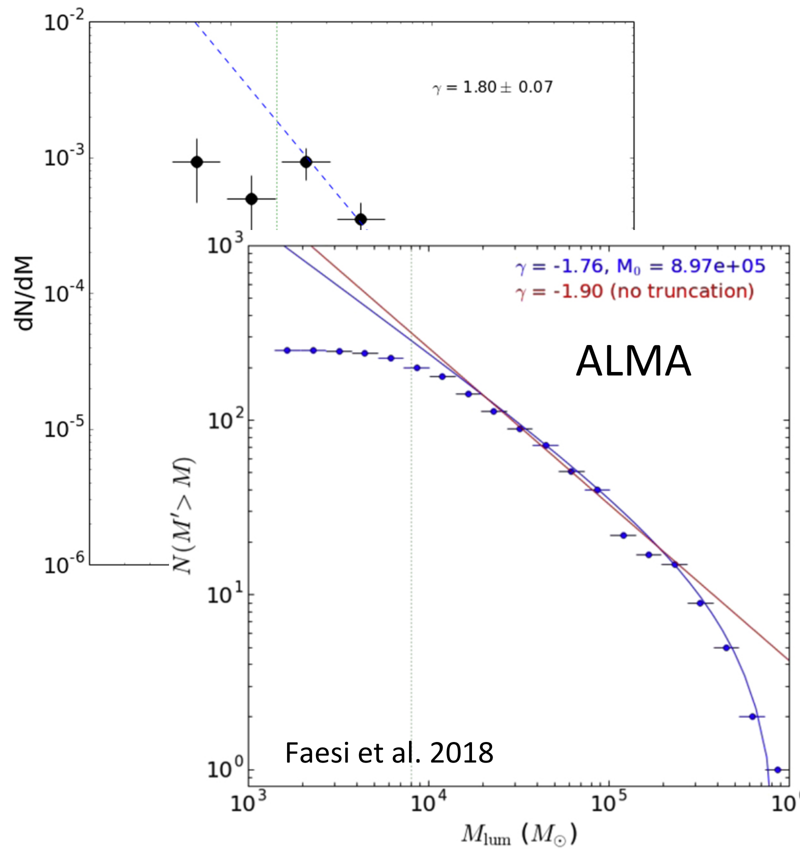
not complete!

THE ASTROPHYSICAL JOURNAL, 821:125 (16pp), 2016 April 20
doi:10.3847/0004-637X/821/2/125

RESOLVING GIANT MOLECULAR CLOUDS IN NGC 300: A FIRST LOOK WITH THE SUBMILLIMETER ARRAY

CHRISTOPHER M. FAESI[1,3], CHARLES J. LADA[1], AND JAN FORBRICH[1,2]
[1] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA
[2] University of Vienna, Austria
Received 2015 October 23; accepted 2016 February 15; published 2016 April 21

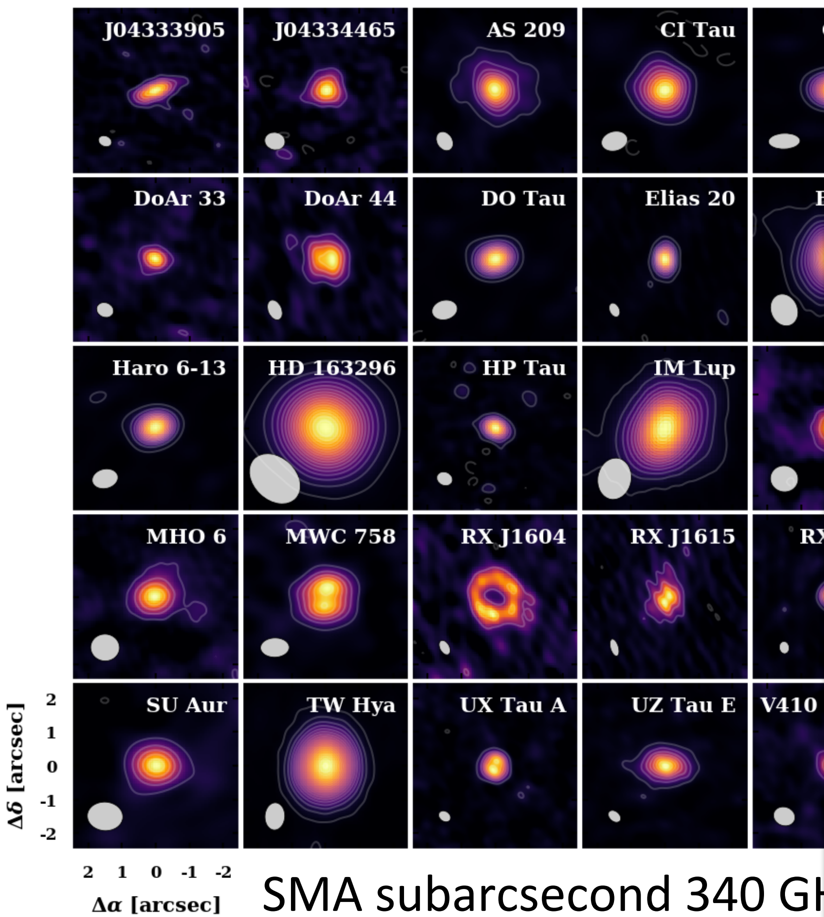




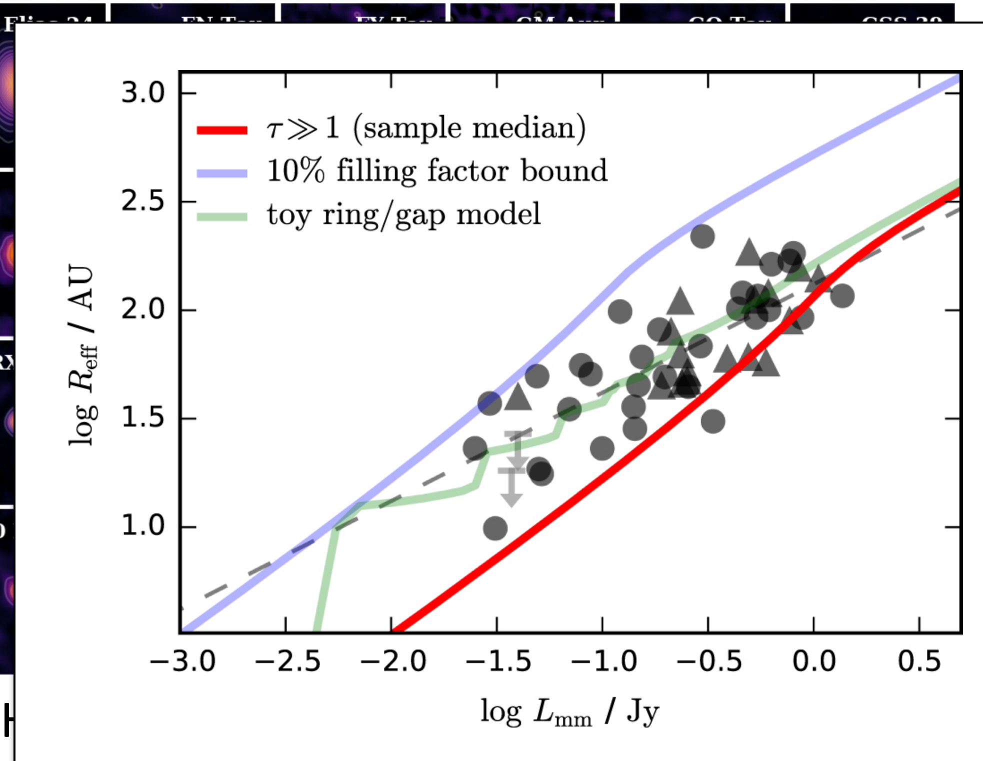
THE ASTROPHYSICAL JOURNAL, 845:44 (16pp), 2017 August 10 https://doi.org/10.3847/1538-4357/aa7c62

A millimeter Continuum Size–Luminosity Relationship for Protoplanetary Disks

Anjali Tripathi[1], Sean M. Andrews[1], Tilman Birnstiel[2], and David J. Wilner[1]
[1] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA; atripathi@cfa.harvard.edu, sandrews@cfa.harvard.edu
[2] University Observatory, Faculty of Physics, Ludwig-Maximilians-Universität München, Scheinerstr. 1, D-81679 Munich, Germany
Received 2017 February 2; revised 2017 June 21; accepted 2017 June 26; published 2017 August 10



SMA subarcsecond 340 G



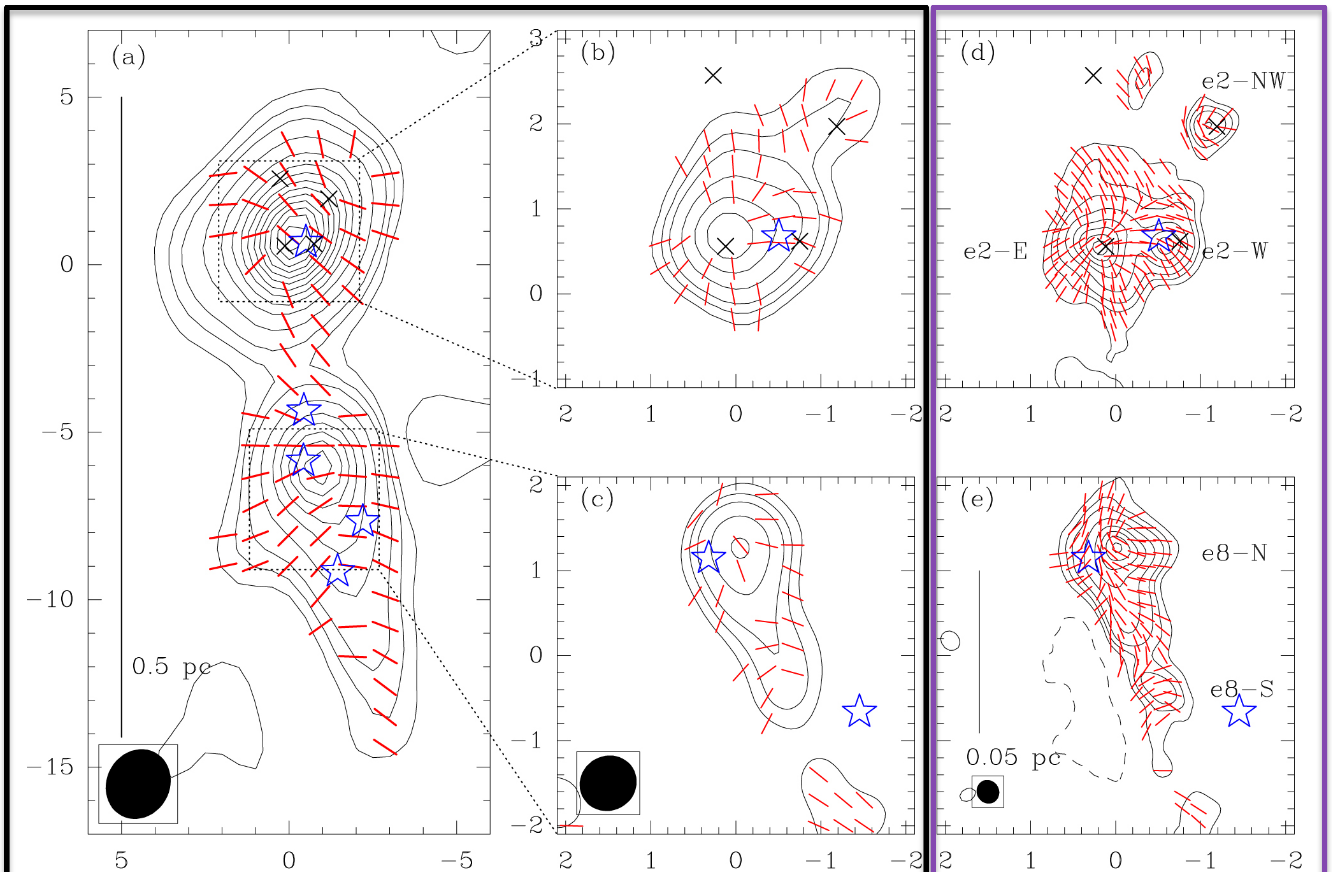
The Astrophysical Journal, 855:39 (19pp), 2018 March 1 https://doi.org/10.3847/1538-4357/aaa4c1

CrossMark

Polarization Properties and Magnetic Field Structures in the High-mass Star-forming Region W51 Observed with ALMA

Patrick M. Koch[1], Ya-Wen Tang[1], Paul T. P. Ho[1,2], Hsi-Wei Yen[3], Yu-Nung Su[1], and Shigehisa Takakuwa[4,1]
[1] Academia Sinica, Institute of Astronomy and Astrophysics, Taipei, Taiwan; pmkoch@asiaa.sinica.edu.tw
[2] East Asian Observatory (EAO), 660 N. Aohoku Place, University Park, Hilo, HI 96720, USA
[3] European Southern Observatory (ESO), Karl-Schwarzschild-Str. 2, D-85748 Garching, Germany
[4] Department of Physics and Astronomy, Graduate School of Science and Engineering, Kagoshima University, 1-21-35 Korimoto, Kagoshima, Kagoshima 890-0065, Japan
Received 2017 April 7; revised 2017 November 27; accepted 2017 December 24; published 2018 March 5

SMA

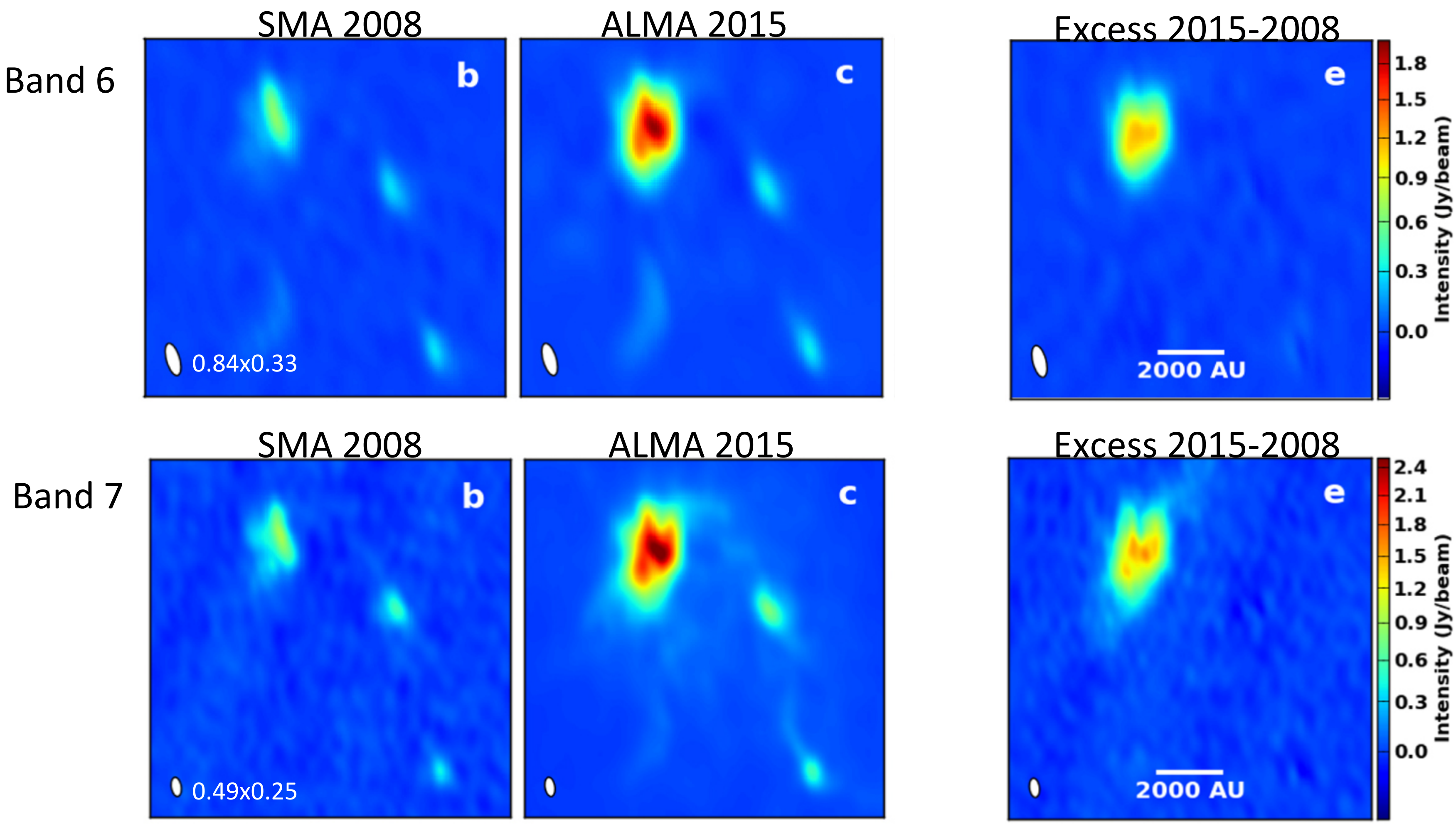


ALMA

The Astrophysical Journal Letters, 837:L29 (6pp), 2017 March 10 https://doi.org/10.3847/2041-8213/aa5d0e

An Extraordinary Outburst in the Massive Protostellar System NGC 6334I-MM1: Quadrupling of the Millimeter Continuum

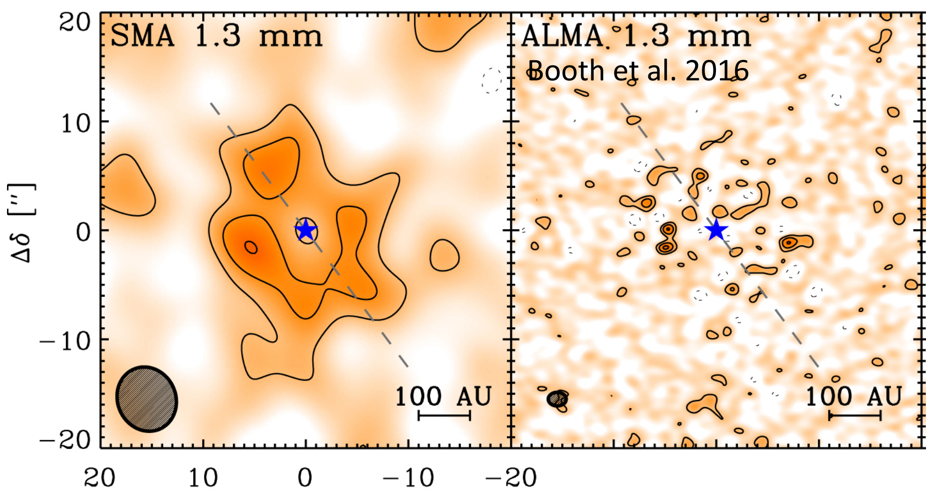
T. R. Hunter[1], C. L. Brogan[1], G. MacLeod[2], C. J. Cyganowski[3], C. J. Chandler[4], J. O. Chibueze[5,6,7], R. Friesen[8], R. Indebetouw[1,9], C. Thesner[7], and K. H. Young[10]



The Astrophysical Journal, 855:56 (10pp), 2018 March 1 https://doi.org/10.3847/1538-4357/aaacd7

Resolved Millimeter Observations of the HR 8799 Debris Disk

David J. Wilner[1], Meredith A. MacGregor[1,2,6], Sean M. Andrews[1], A. Meredith Hughes[3], Brenda Matthews[4], and Kate Su[5]
[1] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA; dwilner@cfa.harvard.edu
[2] Department of Terrestrial Magnetism, Carnegie Institution for Science, 5241 Broad Branch Road, Washington, DC 20015, USA
[3] Department of Astronomy, Van Vleck Observatory, Wesleyan University, 96 Foss Hill Drive, Middletown, CT 06459, USA
[4] National Research Council of Canada, Herzberg Astronomy and Astrophysics Programs, 5071 West Saanich Road, Victoria, BC, V9E 2E7, Canada
[5] Steward Observatory, University of Arizona, Tucson, AZ 85721, USA
Received 2017 December 21; revised 2018 January 30; accepted 2018 January 31; published 2018 March 7

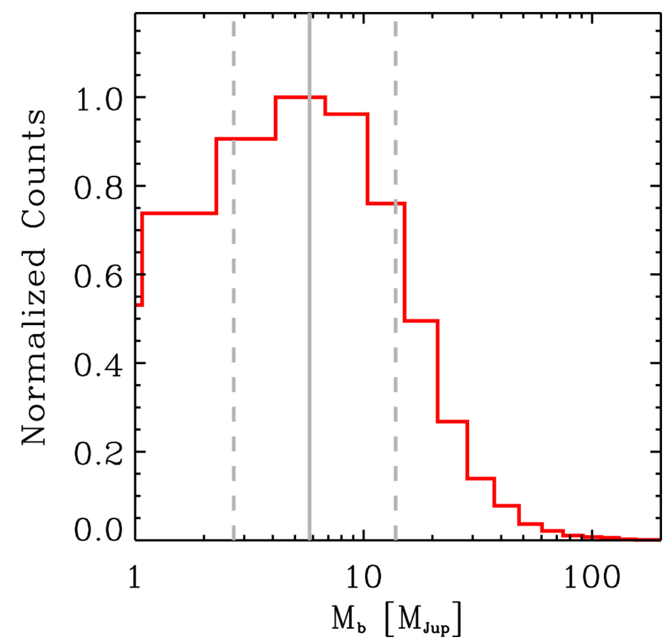


beam 6 arcsec

rms 180 μJy/beam

beam 1.5 arcsec

rms 16 μJy/beam

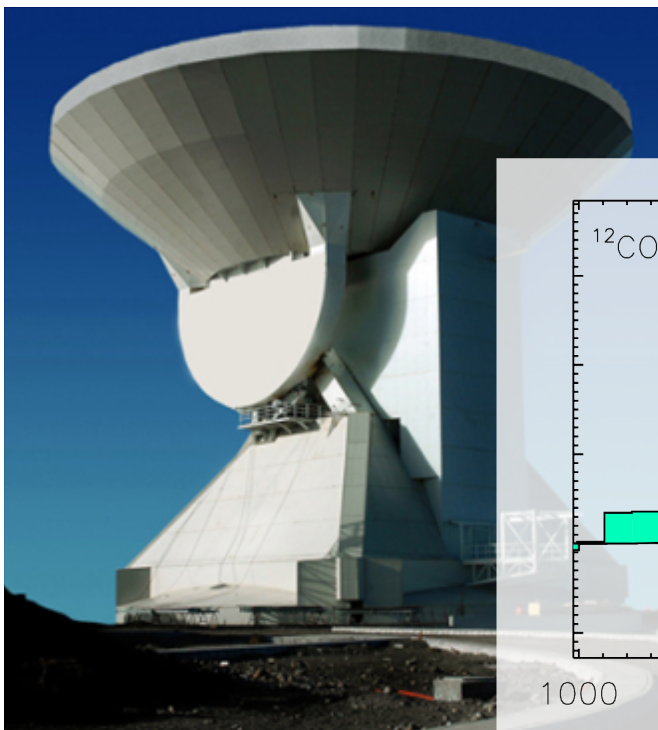


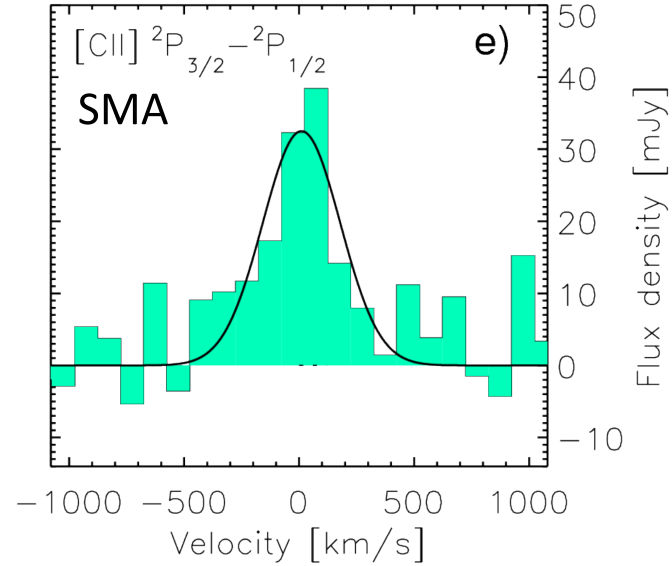
Disk inner edge location puts dynamical constraint on mass of planet b

LETTERS
https://doi.org/10.1038/s41550-017-0297-8
nature astronomy

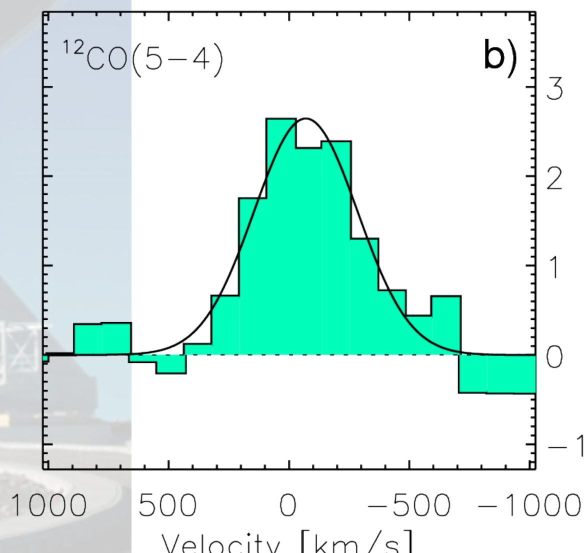
A dusty star-forming galaxy at z = 6 revealed by strong gravitational lensing

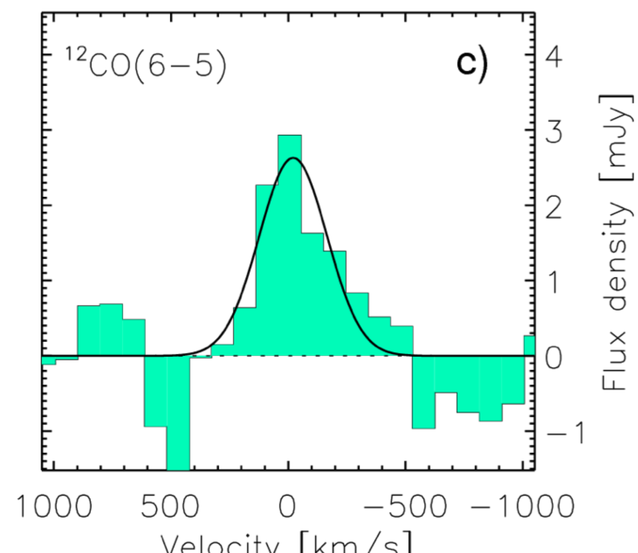
Jorge A. Zavala[1,2*], Alfredo Montaña[3], David H. Hughes[1], Min S. Yun[4], R. J. Ivison[5,6], Elisabetta Valiante[7], David Wilner[8], Justin Spilker[9], Itziar Aretxaga[1], Stephen Eales[7], Vladimir Avila-Reese[10], Miguel Chávez[1], Asantha Cooray[11], Helmut Dannerbauer[12,13], James S. Dunlop[6], Loretta Dunne[6,7], Arturo I. Gómez-Ruiz[3], Michał J. Michałowski[14], Gopal Narayanan[4], Hooshang Nayyeri[11], Ivan Oteo[6,5], Daniel Rosa González[1], David Sánchez-Argüelles[1], F. Peter Schloerb[4], Stephen Serjeant[15], Matthew W. L. Smith[7], Elena Terlevich[1], Olga Vega[1], Alan Villalba[1], Paul van der Werf[16], Grant W. Wilson[4] and Milagros Zeballos[1]





HATLAS J090045.4
Lensed SMG at z=6.027





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End