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 moveable 6-meter antennas of the Submillimeter Array on Mauna Kea, Hawaii.

SMA Science Opportunities

David J. Wilner

SMA Governing Board, December 3, 2015
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

- SMT
- APEX
- JCMT
- SMA
- IRAM
- IRAM/NOEMA
- LMT
- ALMA

25x SMA sensitivity and resolution
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
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
SMA ultra-wideband upgrade

- unique combination of wide bandwidth for spectral coverage and uniform high spectral resolution, $\frac{\lambda}{\Delta \lambda} \approx 2.5 \times 10^6$
- 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

<table>
<thead>
<tr>
<th></th>
<th>year</th>
<th>receiver bandwidth</th>
<th>bands × polarizations</th>
<th>total bandwidth</th>
<th>continuum rms (mJy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>stage 0</td>
<td>2004</td>
<td>2 GHz × 2 sidebands</td>
<td>2</td>
<td>8 GHz</td>
<td>0.60</td>
</tr>
<tr>
<td>stage 1</td>
<td>2016</td>
<td>8 GHz × 2 sidebands</td>
<td>2</td>
<td>32 GHz</td>
<td>0.23</td>
</tr>
<tr>
<td>stage 2</td>
<td>2020</td>
<td>16 GHz × 2 sidebands</td>
<td>4</td>
<td>128 GHz</td>
<td>0.14</td>
</tr>
</tbody>
</table>
Astronomer’s View of “wSMA” Spectral Coverage
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 mult-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