The Submillimeter Array Update on activities

Ray Blundell
Mauna Kea Directors’ Meeting
25<sup>th</sup> September 2014
Presentation Outline

• Upgrades to Instrumentation
  – Receiver Upgrades
  – Correlator (spectrometer) Upgrades

• Special Events
  – SMA 10-year – First Decade of Discovery
  – SMA Advisory Committee Meeting (SAO)

• Metrics
  – Proposal Statistics
Upgrades to Instrumentation

- Receiver Upgrades
- Correlator Upgrades
- Even Wider Bandwidths are Possible
SMA Throughput - IF and Correlator

The SMA was originally designed to operate from 200 – 850 GHz

Simultaneous operation of two receivers

- One low frequency < 350 GHz and one high frequency > 350 GHz
- (Possibly use the low frequency receiver for phase transfer to high frequency unit)
- And dual polarization capability in the 300 – 350 GHz atmospheric window
- Each receiver was designed with a 2 GHz – wide IF centered at 5 GHz
- SMA was designed to process 2 receivers 4-6 GHz IF, DSB
- Total throughput = 2x2x2 = 8 GHz
- Purpose-built correlator using ASIC from MIT-Goddard collaboration

Mauna Kea is an excellent site for the millimeter, OK for the submillimeter

- ~ 50% of the time using 200 GHz receiver, and 50% using 300 GHz receiver
- Small amount of time allocated to frequencies above 400 GHz
SMA Throughput - IF and Correlator (Original Design)

Simultaneous operation of two receivers

- One low frequency < 350 GHz and one high frequency > 350 GHz
  (Possibly use the low frequency receiver for phase transfer to high frequency unit)
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Double the Bandwidth for Single Receiver Operation (January 2010)

Mauna Kea is an excellent site for the millimeter, OK for the submillimeter
~ 50% of the time using 200 GHz receiver, and 50% using 300 GHz receiver
Small amount of time allocated to frequencies above 400 GHz

Much of the time only half the correlator capacity used due to weather
Introduce wider bandwidth receivers and make use of unused correlator capacity
Only minor modifications required to IF to double the bandwidth for single receiver operation
Double the Bandwidth for Single Receiver Operation
(August 2012)

Additional IF hardware, coupled with wider band receivers enables more flexibility
Better enable simultaneous observations of multiple spectral lines
SMA Throughput – Double Bandwidth Mode

Test observations towards Orion BN/KL: LO at 226 GHz

For single receiver use 4-6 GHz IF processed as usual
Additional IF hardware enables any 2 GHz-wide band
between 6 and 14 GHz to be processed simultaneously
For even more throughput add additional Correlator Hardware

Use original ASIC correlator to cover the 4-8 GHz IF
Augment frequency coverage with additional, modular correlator
Take advantage of CASPER collaboration using ROACH 2 technology

CASPER – Collaboration for Astronomy Signal Processing and Electronics Research
ROACH – Reconfigurable Open Architecture Computing Hardware
For even more throughput add additional Correlator Hardware

Use original ASIC correlator to cover the 4-8 GHz IF
Augment frequency coverage with additional, modular correlator
Take advantage of CASPER collaboration using ROACH 2 technology
Add 2x2 GHz wide chunks to further double processed bandwidth
SWARM correlator (SMA Wideband Astronomical Roach 2 Machine)
Modular approach will allow for additional correlator sections to be added later
And enable ASIC correlator to be retired
For even more throughput add additional Correlator Hardware

SWARM correlator currently running at half speed – half bandwidth
For even more throughput add additional Correlator Hardware

SWARM correlator currently running at half speed – half bandwidth
Can move ASIC correlator blocks to change IF coverage
Comparison between ASIC and SWARM Correlator Outputs

![Graph showing comparison between ASIC and SWARM correlator outputs.](image-url)
Ongoing 200 GHz Receiver Upgrades

The previous 3-junction design (upper left) shows a drop in sensitivity above 11 GHz IF. The 4-junction design (upper right) and new IF amplifier show good Trx to 15 GHz. We expect upgraded mixers to be in service on all SMA antennas by the end of 2014.
Ongoing 300 GHz Receiver Upgrades

Two designs show good performance. Both use 3 junction designs (Tong).

IRAM fabrication (above left) Incorporates 1.1 μm² junctions

ASIAA fabrication (Wang, above right) Incorporates 1.3 μm² junctions
Ongoing 400 GHz Receiver Upgrades

Developing mixer with 2-junction array (Tong)
Initial batches (Min-Jye Wang) show improved performance in the lab (Tong)
Junction size larger than design – mixer tuned low in frequency
Pending supply of good devices, SMA could be equipped by the end of 2014
Even wider bandwidths are possible

Latest amplifier technology offers potential for 24 GHz IF bandwidth
Dual polarization DSB receivers would yield 2x2x24 GHz = 96 GHz BW
This is 24x original SMA single receiver output, 8x current upgrade,
and 8x ALMA bandwidth
Special Events

• SMA 10-year – First Decade of Discovery
  – June 9 – 11 Cambridge, MA
  Organized chiefly by Jim Moran

• SMA Advisory Committee Meeting (SAO)
  – June 12 – 13 Cambridge, MA
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
Sean Andrews (CfA)
Sheperd Doeleman (CfA/MIT-Haystack)
Izaskun Jimenez-Serra (ESO)
Tomasz Kaminski (MPIfR)
Daniel Marrone (University of Arizona)
Anaelle Maury (IRFU)
Karl Menten (MPIfR)
Arielle Moullot (NRAO)
Karin Öberg (CFA)
Kazushi Sakamoto (ASIAA)
Wei-Hao Wang (ASIAA)
Ann Wehrle (SSI)

LOC
Carolann Barrett
Arjun Dey
Shelli Hostler
Jenine Humber
Patricia Mailhot
James Moran (chair)
Margaret Simonini

MEETING SPONSORS
Smithsonian Astrophysical Observatory
Academia Sinica Institute of Astronomy and Astrophysics

Direct inquiries to:
sma10@cfa.harvard.edu
The Submillimeter Array: 
First Decade of Discovery

Complete presentation: Oral session l-invited

Sean Andrews (CfA)

Protoplanetary Disk Structures with the SMA
http://www.cfa.harvard.edu/sma/events/smaConf/posters/

Cara Battersby (CfA)

*The SMA Legacy Survey of the Central Molecular Zone*

View: [Poster](#) and [Poster Blast](#)

Geoffrey Bower (ASIAA), Ramprasad Rao, Dick Plambeck, Dan Marrone

*Probing the Subparsec Accretion Disk of Perseus A with Millimeter Polarimetry*

Complete presentation: [Oral Session VII-invited](#)

David Clements (Imperial College)

*The SMA, Herschel, and the High-Redshift Universe*

Complete presentation: [Oral Session VII-invited](#)

Sheperd Doeleman (CfA/MIT-Haystack)

*Building an Event Horizon Telescope: Imaging and Time-Resolving Black Holes*
Rita Mann (National Research Council Canada)
*The Potential to Form Planets in the Orion Nebula*

James Moran (CfA), Mark Gurwell, and Dan Marrone
*Waiting for G2*

Arielle Moullet (NRAO)
*From Venus to Pluto: The SMA at the Forefront of Thermal Mapping in the Solar System*

Kazushi Sakamoto (ASIAA)
*SMA Discoveries in Nearby Galaxies*
Submillimeter Array Advisory Committee Report

July 19, 2014

Summary

The 2014 meeting of the Submillimeter Array Advisory Committee was preceded by The First Decade of Discovery scientific meeting, an impressive showcase of SMA and related science. The SMA continues to attract excellent scientists who use the array to advance studies of a wide range of topics. SMA data are playing an increasing role in ALMA proposals, showing that the utility of the SMA in the ALMA era is strong. The Committee sees a very healthy collaboration between the CfA and ASIAA in operating and supporting the observatory.

Many of the Committee’s comments relate to increasing the SMA’s visibility and impact. A mix of individual and collaborative large observing projects is healthy and needed. The Committee suggests that approximately 20%, but no more than 40%, of time go to large projects; approximately 20% of the time go to short programs refereed on a timescale much shorter than a semester; and the balance be assessed and scheduled in the customary way. Whatever the exact divisions in time, the TAC should keep a high priority on assigning time to complete projects in good time even if this limits the total number of projects in any one semester. Improving the archive’s usability will help capitalize on the SMA’s results, inside and outside the CfA.

Overall, the instrument’s performance, reliability, technical development, and operation are very good. Proper maintenance of the telescopes is important, especially as the instrument ages. Erosion in observatory staffing is having an impact on science productivity and observatory operation; replacing site technical staff and bringing the Observatory up to its usual complement of postdoctoral scientists must be high priorities. In looking to the future, the Committee strongly suggests building the Observatory’s capabilities in digital signal processing (DSP).
## Proposal Statistics

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<th>Science category</th>
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Star formation and observation of galaxies, near and far, continue to dominate observing programs.
Proposal Statistics

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<td>16</td>
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<td>101</td>
<td>1846</td>
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SAO began a large, multi-semester project during 2014 A
Consequently fewer proposals submitted through SAO in 2014B
Time requests are higher in 2014 B for both institutions

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With ~ 600 hours on source observing time per semester (excluding UH) the SMA remains oversubscribed by more than a factor of three