The Submillimeter Array
Update on activities

Ray Blundell

Mauna Kea Directors' Meeting

25th 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

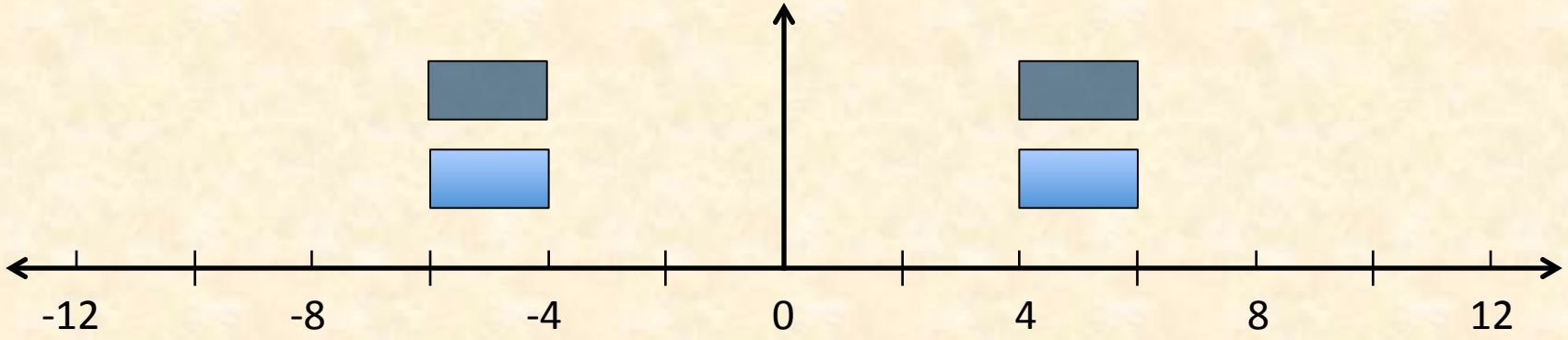
Simultaneous operation of two receivers

- 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 corrrelator 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)



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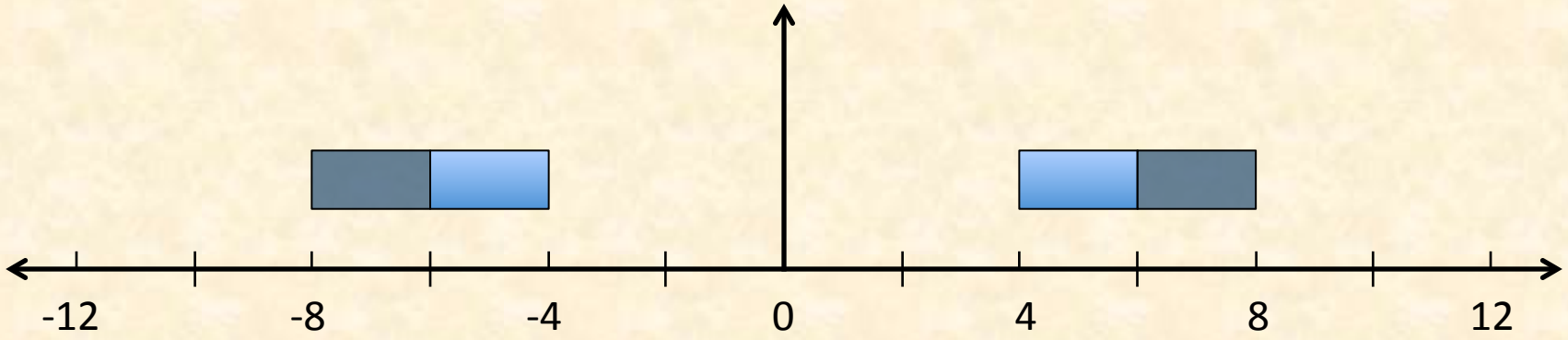
Double the Bandwidth for Single Receiver Operation (January 2010)



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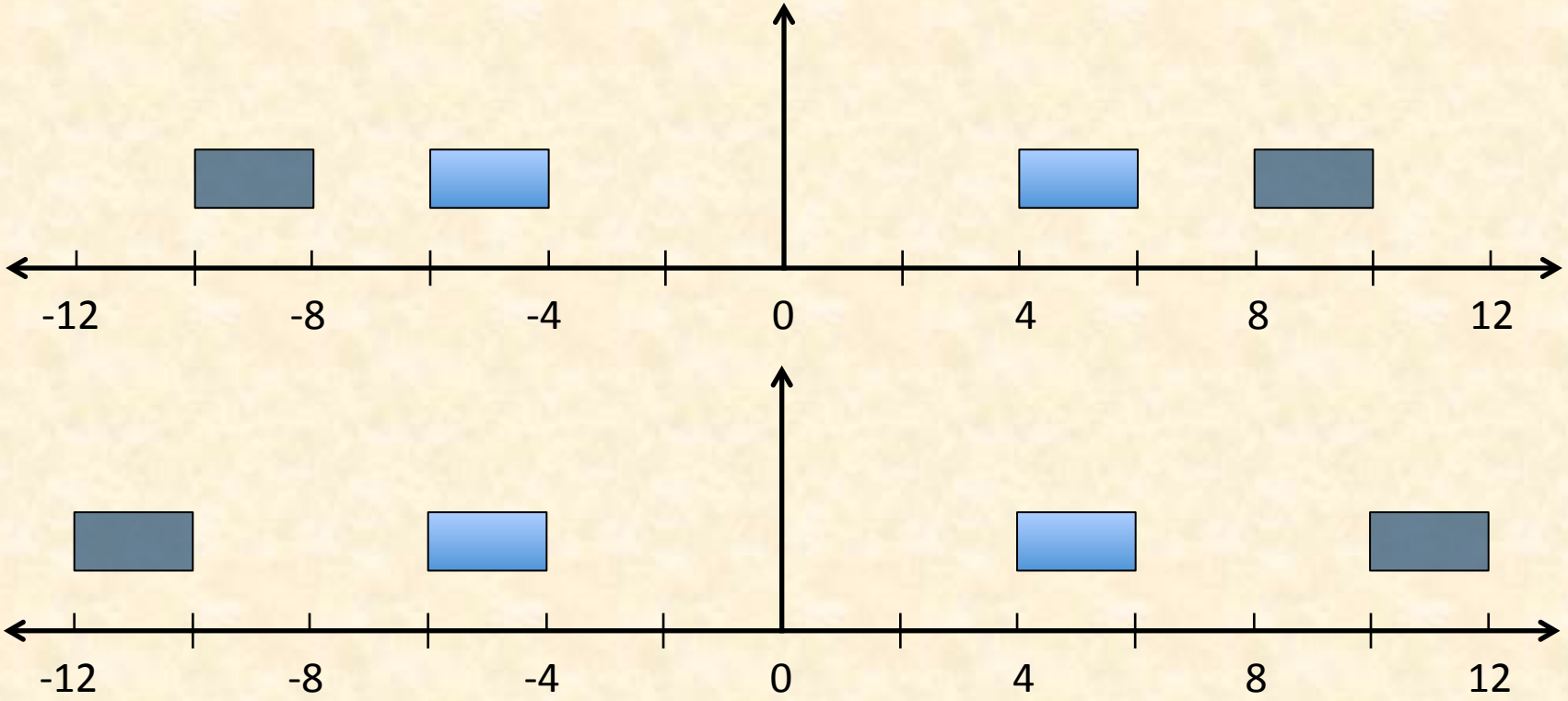
Much of the time only half the correlator capacity used due to weather

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

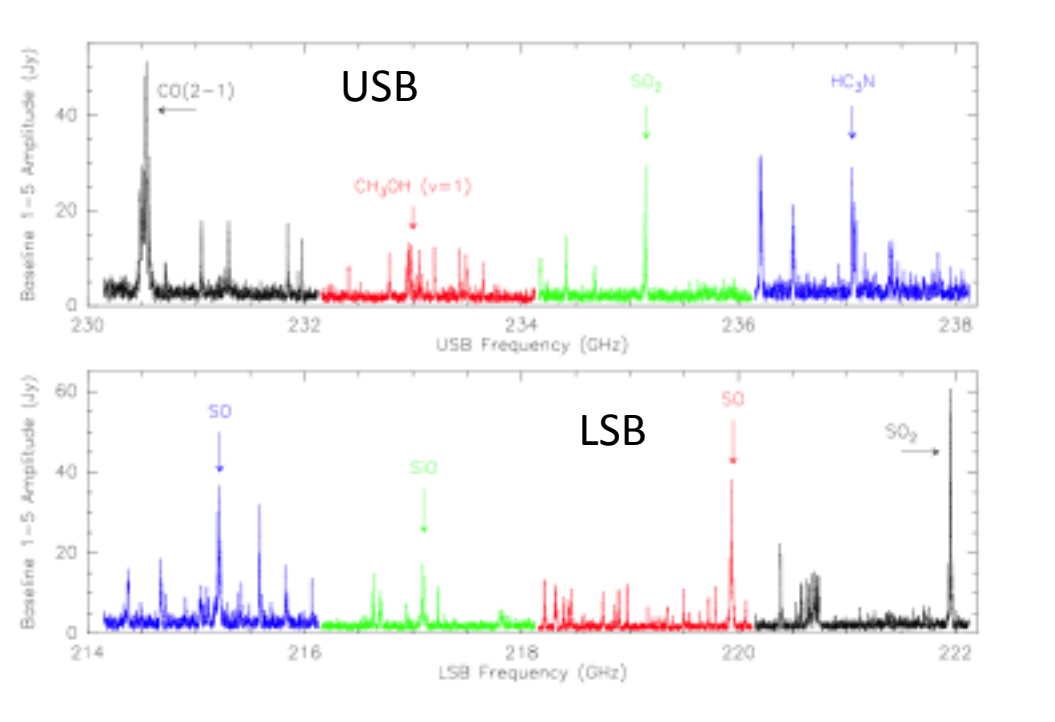
Double the Bandwidth for Single Receiver Operation (August 2012)



Additional IF hardware, coupled with wider band receivers enables more flexibility
Better enable simultaneous observations of multiple spectral lines

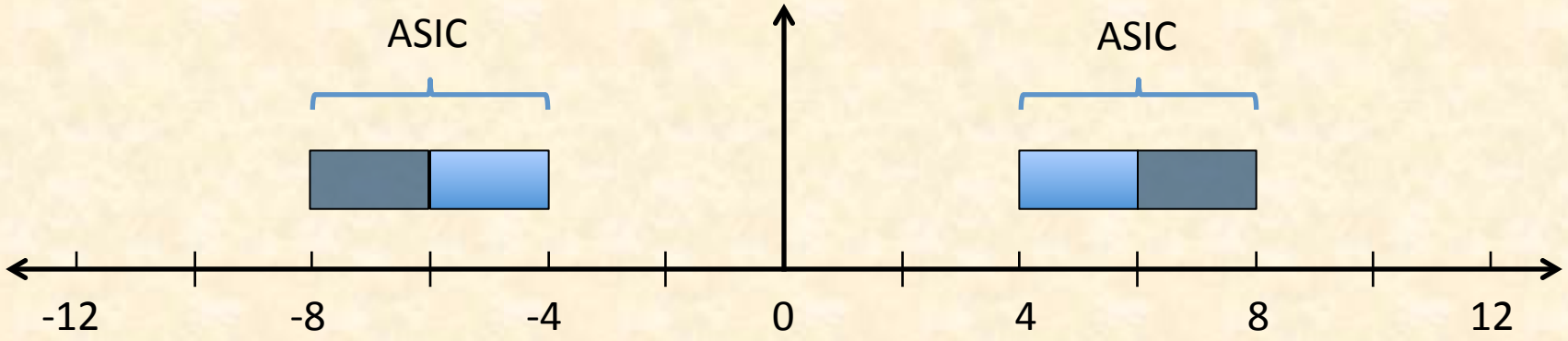
SMA Throughput – Double Bandwidth Mode

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

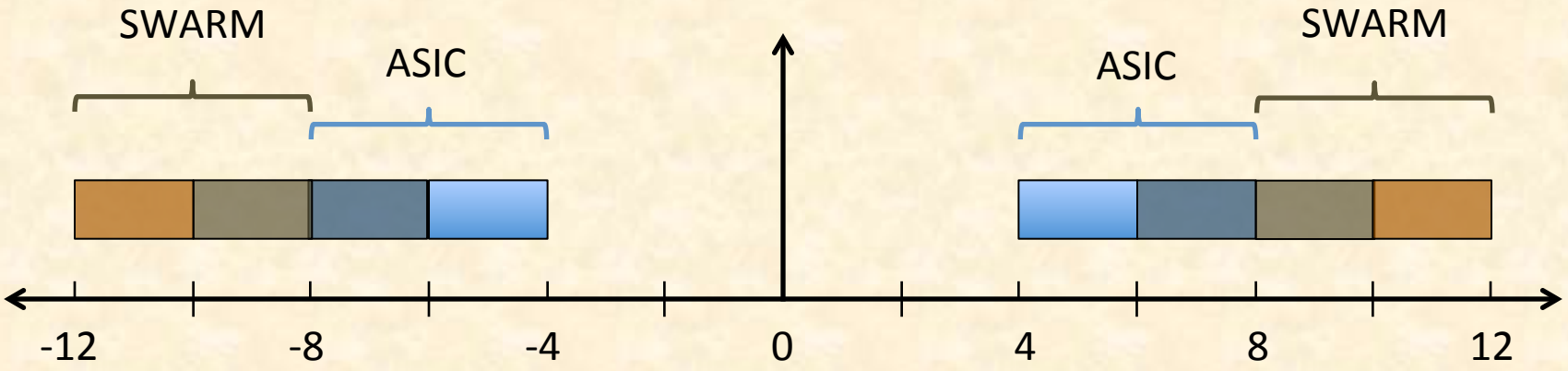
Augment frequency coverage with additional, modular correlator

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



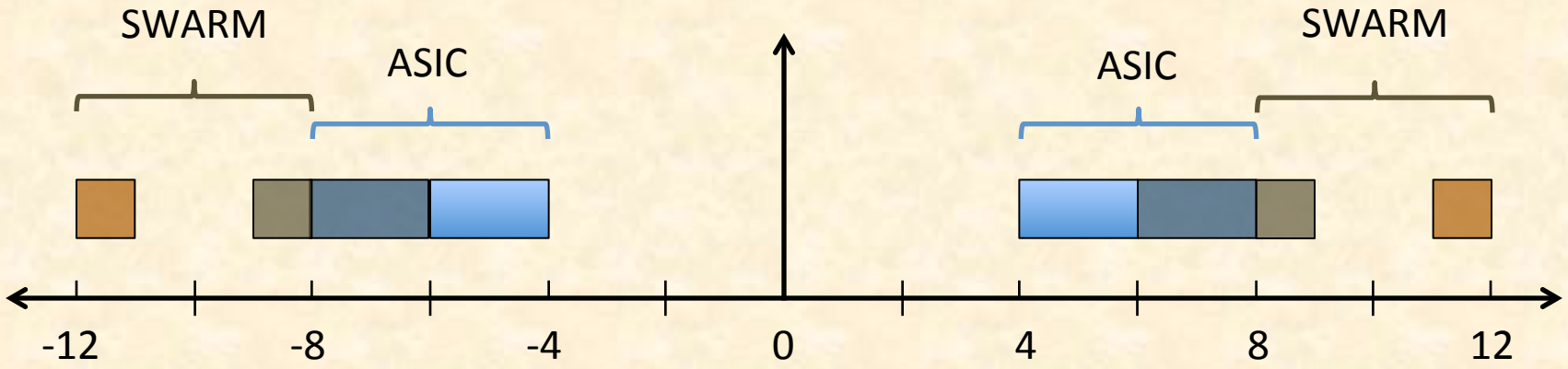
Use original ASIC correlator to cover the 4-8 GHz IF

Augment frequency coverage with additional, modular correlator

Take advantage of CASPER collaboration using ROACH 2 technology

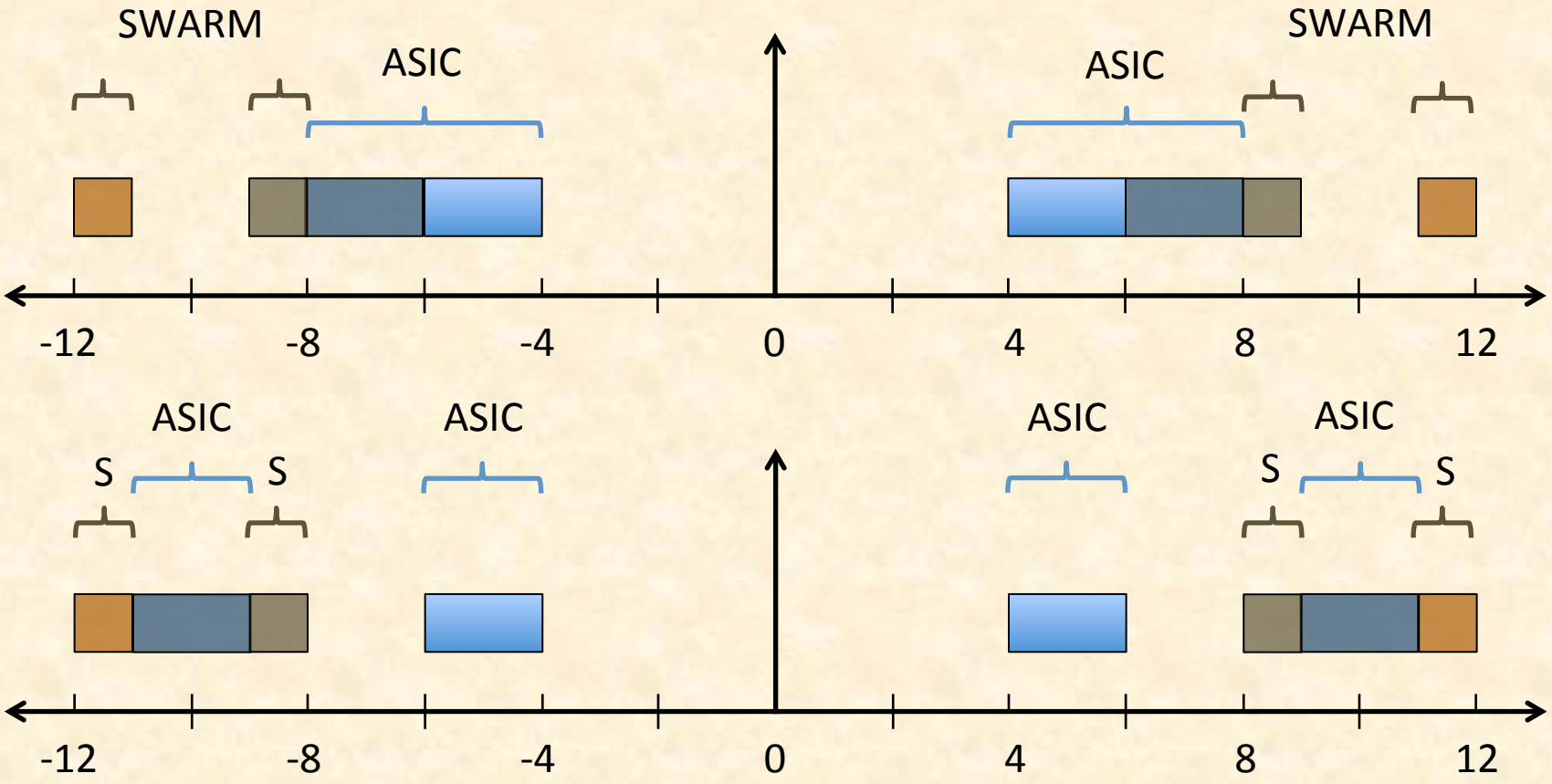
- Add 2x2 GHz wide chunks to further double processed bandwidth
- SWARM correlator (SMA Wideband Astronomical Roach 2 Machine)
- Modular approach will allow for additional correlator sections to be added later
- And enable ASIC correlator to be retired

For even more throughput add additional Correlator Hardware



SWARM correlator currently running at half speed – half bandwidth

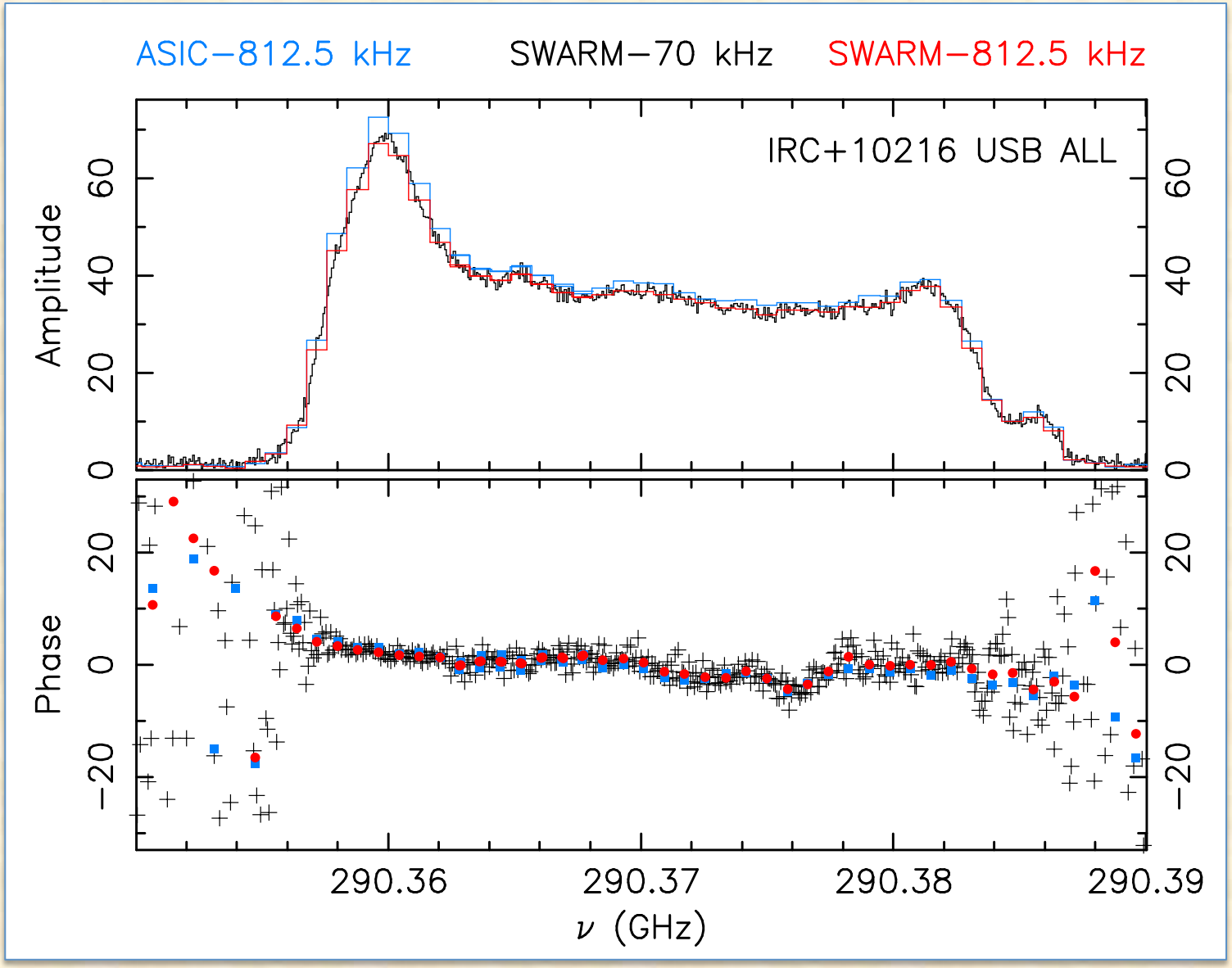
For even more throughput add additional Correlator Hardware



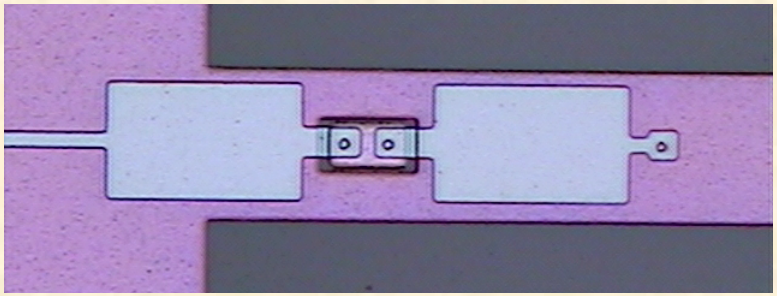
SWARM correlator currently running at half speed – half bandwidth

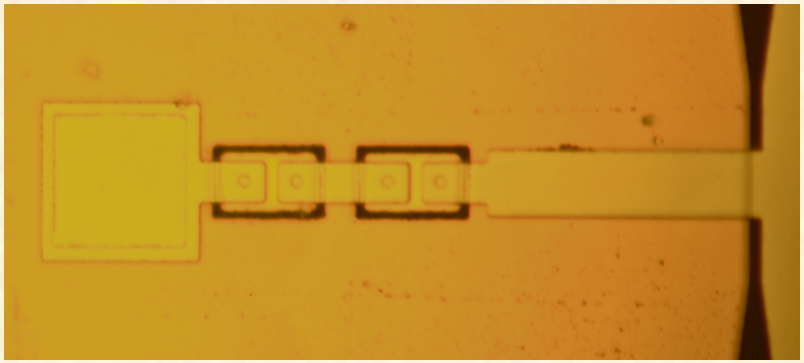
Can move ASIC correlator blocks to change IF coverage

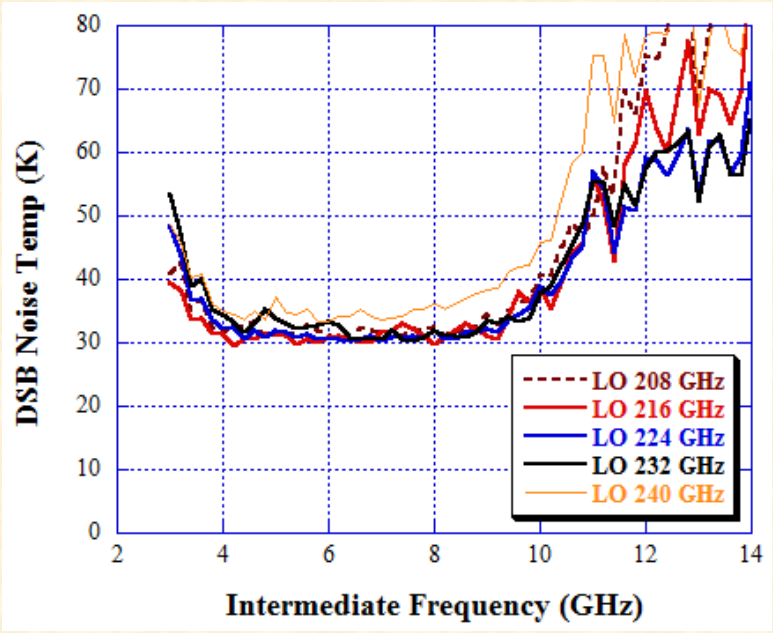
Comparison between ASIC and SWARM Correlator Outputs

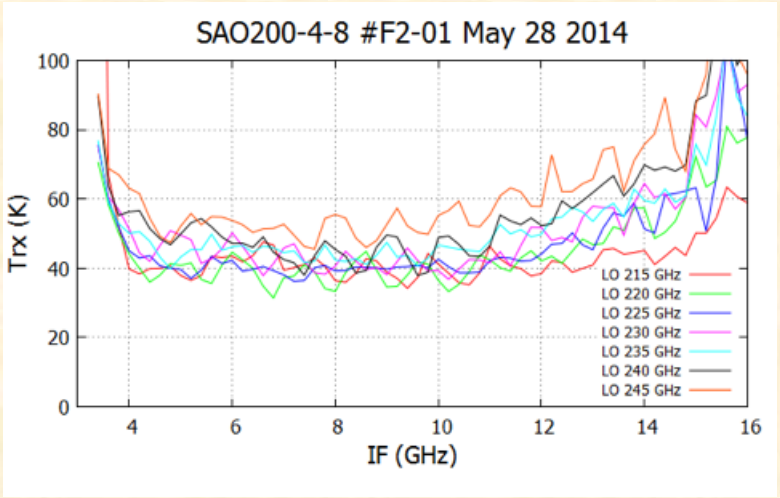


Ongoing 200 GHz Receiver Upgrades



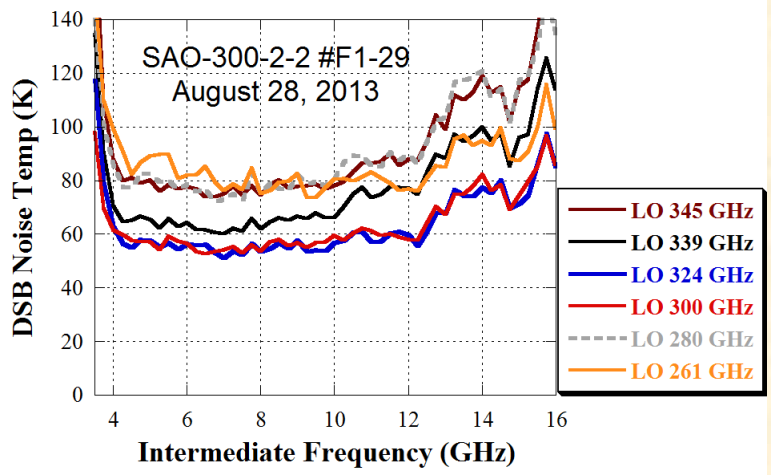


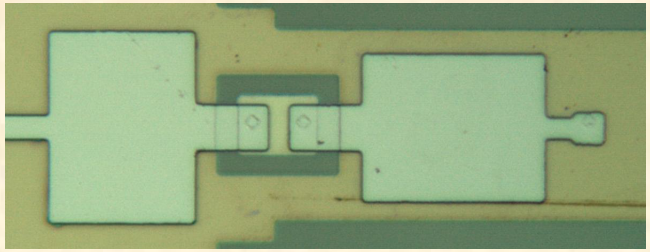


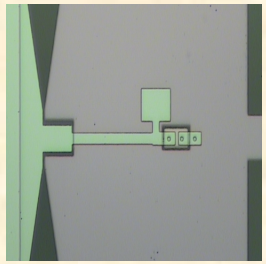


The previous 3-junction design (upper left) shows a drop in sensitivity above 11 GHz IF
The 4-junction design (upper right) and new IF amplifier show good Trx to 15 GHz
We expect upgraded mixers to be in service on all SMA antennas by the end of 2014

Ongoing 300 GHz Receiver Upgrades





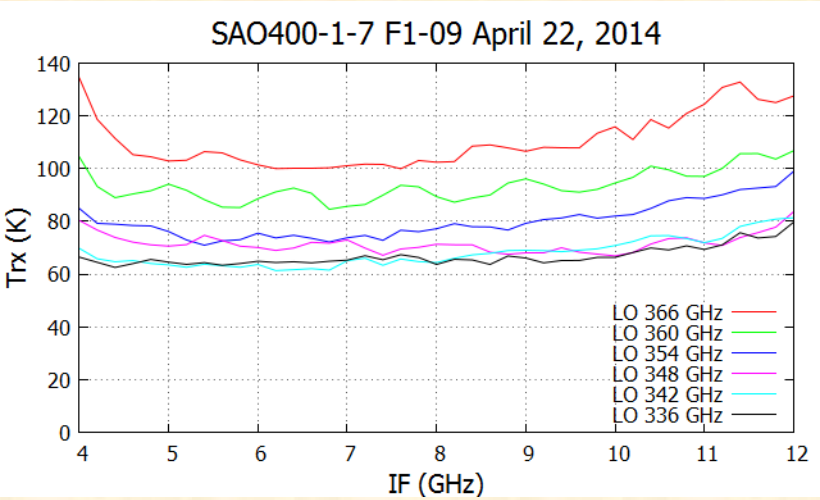


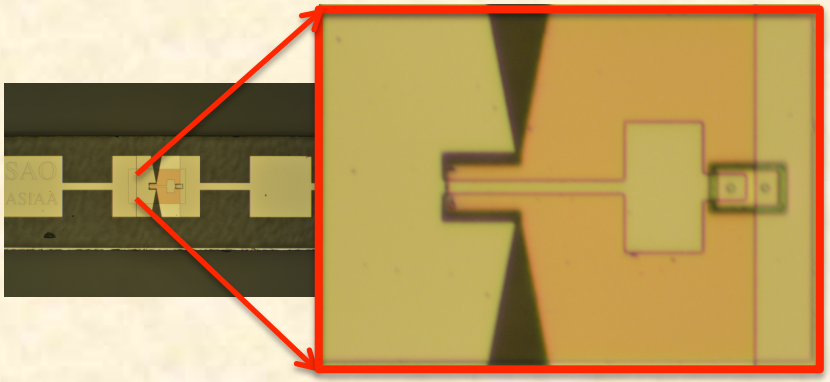
Two designs show good performance
Both use 3 junction designs (Tong)

IRAM fabrication (above left)
Incorporates 1.1 μm^2 junctions

ASIAA fabrication (Wang, above right)
Incorporates 1.3 μm^2 junctions

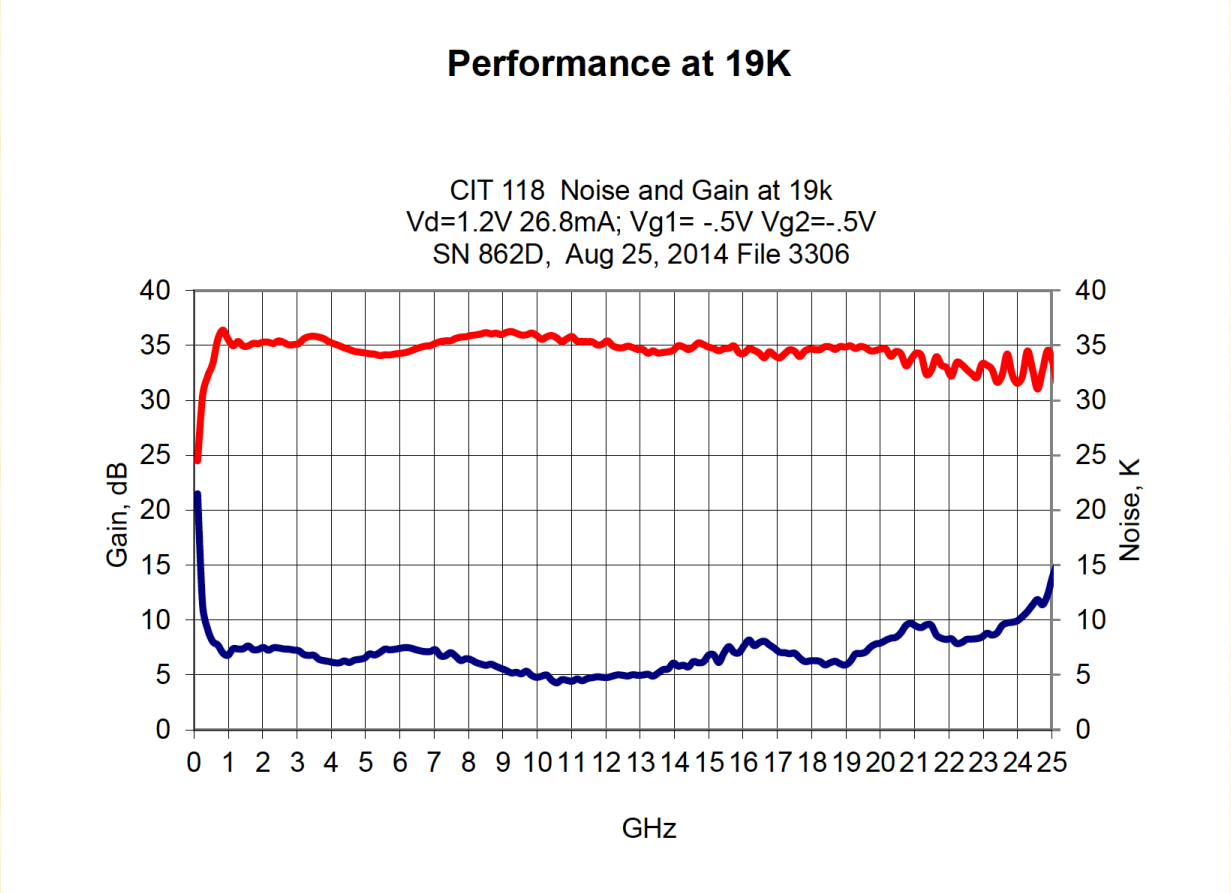
Ongoing 400 GHz Receiver Upgrades





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)
Anaëlle Maury (IRFU)
Karl Menten (MPIfR)
Arielle Moullet (NRAO)
Karin Öberg (CfA)
Kazushi Sakamoto (ASIAA)
Wei-Hao Wang (ASIAA)
Ann Wehrle (SSI)

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

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The Submillimeter Array:
First Decade of Discovery

- Home Page
- Conference Poster
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- Presenters & Posters
- Registration CLOSED
- Lodging
- Other Logistics
- Confirmed Attendees
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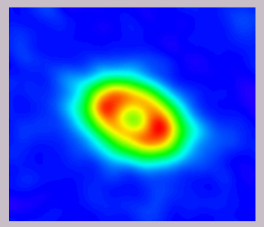

Complete presentation: **Oral session I-invited**

Sean Andrews (CfA)

Protoplanetary Disk Structures with the SMA

http://www.cfa.harvard.edu/sma/events/smaConf/posters/

View: Poster and Poster Blast

Cara Battersby (CfA)

The SMA Legacy Survey of the Central Molecular Zone

Complete presentation: Oral Session VII-invited

Geoffrey Bower (ASIAA),

Ramprasad Rao, Dick Plambeck, Dan Marrone

Probing the Subparsec Accretion Disk of Perseus A with Millimeter Polarimetry

Complete presentation: Oral Session IV-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

http://www.cfa.harvard.edu/sma/events/smaConf/posters/

Complete presentation: Oral Session I

Rita Mann (National Research Council Canada)

The Potential to Form Planets in the Orion Nebula

View: Poster

James Moran (CfA), Mark Gurwell, and Dan Marrone

Waiting for G2

Complete presentation: Oral Session V-invited

Arielle Moullet (NRAO)

From Venus to Pluto: The SMA at the Forefront of Thermal Mapping in the Solar System

Complete presentation: Oral Session II-invited

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

Semester	2014 A	2014 A	2014 B	2014 B
Science category	Number	Hours	Number	Hours
submm / high z galaxies	12	265	13	326
Local galaxies, starbursts, AGN	10	180	12	418
Evolved stars, AGB, PPN	9	203	5	71
Galactic center	3	31	0	0
GRB, SN, high energy	2	69	2	69
High mass (OB) star formation, cores	30	356	10	160
Low mass star formation, cores	21	343	25	421
Protoplanetary- transition- debris- disks	11	261	14	371
Solar system	0	0	1	8
Other	3	28	1	3

Star formation and observation of galaxies, near and far, continue to dominate observing programs

Proposal Statistics

Semester	2014 A	2014A	2014 B	2014 B
Institution	Hours	Proposals	Hours	Proposals
SAO	1366	85	1422	67
ASIAA	370	16	424	16
Totals	1736	101	1846	83

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

Semester	2014 A	2014A	2014 B	2014 B
Weather	Hours	%	Hours	%
< 1 mm	113	7	28	2
< 2.5 mm	1013	58	1085	58
< 4 mm	610	35	733	40

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