NRAO eNews

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Upcoming Events

NRAO Users Committee Meeting
(http://www.nrao.edu/admin/do/external_committees.shtml#USERS)
May 11 - 12, 2011 | Green Bank, WV

ALMA Early Science Proposal Preparation Tutorial at the AAS
(http://science.nrao.edu/facilities/alma/training/boston)
May 23 & May 24, 2011 | Boston, MA

SKA 2011 (http://www.ska2011.org/)
Jul 4 - 8, 2011 | Banff, Alberta Canada

Sixth NAIC/NRAO School on Single Dish Radio Astronomy
(http://www.nrao.edu/meetings/sds6/)
Jul 10 - 16, 2011 | Green Bank, WV

2011 NRAO Postdoc Symposium

Brian Kent, Huib Intema, and Jessica Utley

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The 7th annual NRAO Postdoctoral Science Symposium was held April 11-13, 2011 in Charlottesville. The event brings together postdoctoral researchers actively engaged in cutting-edge science.

Seven Jansky Fellows, eight NRAO Postdoctoral Fellows, and six University of Virginia postdoctoral researchers delivered talks on a wide variety of science topics including nearby and high redshift galaxies, star formation in the Milky Way, dwarf galaxies, AGN, pulsars and instrumentation, dynamics theory, and planetary science.

In addition, the symposium hosted a guest keynote speaker and former NRAO postdoc, Tracy Clarke of the Naval Research Laboratory. Discussions and special sessions featuring NRAO facilities were held in

conjunction with the NRAO and University of Virginia faculty and staff. Participants also toured the NRAO Technology Center (NTC) in Charlottesville, where they were able to see first hand the exciting developments for ALMA front and back end technology.

The symposium's science program is at: **http://www.nrao.edu/meetings/pdsym2011/ (http://www.nrao.edu/meetings/pdsym2011/)**

This Month @ the NAASC

Spotlight on NAASC Services: ALMA Training

During the month of April, the North American ALMA Science Center **(NAASC) (https://science.nrao.edu/facilities/alma/intro-naasc)** continued to provide training to interested members of the community via a series of ALMA Community Events in Baltimore, Toronto, Boston and Charlottesville, Virginia.

The NAASC will also be on the road for much of May and early June, providing training in:

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Figure 1: Hands-on tutorial session at the April 18-19 ALMA Training in Toronto

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- **Gainesville, Florida (May 2-3)**
- **Victoria, British Columbia (May 4-5)**
- **Iowa City, Iowa (May 9-10)**
- **Charlottesville, Virginia (May 9)**
- **Quebec City, Quebec (May 10)**
- **University of Arizona (May 12-13)**
- **Calgary (May 12-13)**
- **Two Splinter Sessions at the AAS meeting in Boston (May 23 & May 24)**
- **Amherst, MA (May 25)**
- **Columbia University (May 27) and**
- **London, Ontario (June 3).**

We hope to see you at one of these ALMA training sessions. Information about these upcoming ALMA events can be found on the **ALMA Community Day Events (https://science.nrao.edu/facilities/alma/community1)** page.

NAASC Research Activities: Jim Braatz

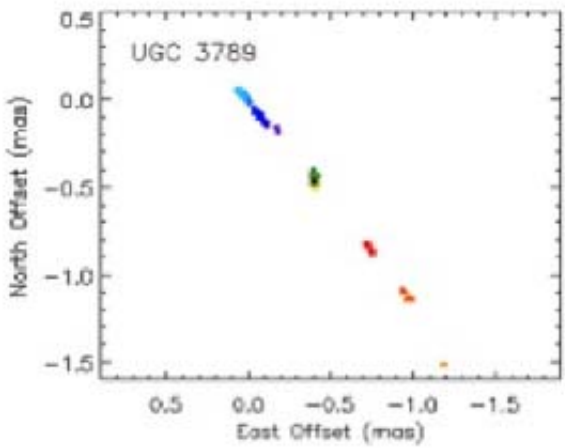

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Figure 3: Water maser spots imaged in the edge-on accretion disk in the galaxy UGC 3789. Color represents the direction of motion: blue spots are moving toward the observer as they orbit the black hole, red spots are moving away, and green spots fall just in front of the black hole. Note the scale in milliarcseconds. Figure adapted from M. Reid et al, 2009, ApJ, 695, 287.

Zoom (images/2_3.png)

In active galaxies, as gas in the nucleus is pulled toward its fate by the central, supermassive black hole, it forms into a disk. The gas swirls around at millions of miles per hour, gets heated to temperatures hotter than the sun, and shines intensely at X-ray and UV wavelengths. Yet in this hostile environment, delicate water molecules can exist and even thrive, buffered from the intense heat and the hard radiation field by dust in the disk. Energized by relatively gentle collisions with other particles in the disk, the water molecules shine brightly with beamed megamaser radiation. Masers are the radio frequency equivalent of lasers, and megamasers are the particularly powerful variety of masers associated with active galaxies. Observations of these megamasers, it turns out, make a powerful tool that can be used to explore a host of interesting problems in astrophysics, including the black hole themselves, galaxy evolution, and the mysterious dark energy that causes the expansion of the universe to accelerate.

Jim Braatz leads the Megamaser Cosmology Project, a team that includes collaborators Mark Reid, Jim Condon, Christian Henkel, Fred K.Y. Lo, Cheng-Yu Kuo, and Violetta Impellizzeri. We hunt for new masers with the Green Bank Telescope, and image interesting maser systems in high resolution using the Very Long Baseline Array, which we combine with the Green Bank Telescope and the Max-Planck Institute's Effelsberg radio telescope to form a global VLBI array. Using these telescopes, we can pinpoint the relative locations of

individual maser clouds to a precision of about 10 micro-arcseconds, or about 1000 times better than the resolution of the Hubble Space Telescope. By mapping the positions of maser clouds, we get a direct image of the gas in the AGN accretion disk, the only technique capable of imaging such disks directly. Combining these precise positions with line-of-sight Doppler velocities, we then have a valuable tool for probing the dynamics of the disk.

We can apply this tool to demonstrate that the object in the center of the active galaxy must be a black hole, and we can precisely measure the mass of the black hole. Masers provide this information uniquely because they measure gas very close to the black hole, within about a light-year, so the masses we determine are accurate to about 10%, whereas other techniques can only get within a factor of two or so.

With precise black hole masses, we can investigate important relationships between the black hole and its host galaxy, such as how the black hole mass compares to that of stars in the galactic bulge, or to the velocity dispersion of stars in the bulge. It is comparisons like these that lead to a better understanding of how galaxies evolve. So far, our initial findings have been surprising. We have found that not all black holes follow the tight correlations previously seen between the black hole mass and the bulge properties suspected from optical studies of big elliptical galaxies.

A second problem that we can address with studies of water megamasers is a notoriously difficult one: measuring distances to galaxies. By analyzing the internal dynamics of a water maser system, we can calculate the accretion disk radius. Comparing this radius with the angular size of the disk measured from VLBI maps, we can (conceptually) triangulate to get a geometric distance to the galaxy. Because this method is geometric, it is a promising alternative to “standard candle” techniques that historically have been troubled with systematic uncertainties. While the maser technique is elegant and valuable for its simplicity, it can be difficult to apply in general because the most interesting masers are faint. The Megamaser Cosmology Project has measured a few galaxies this way, and more are on the way. Having measured distances to galaxies, we can then determine the expansion rate of the Universe, the famous “Hubble Constant.” When combined with studies of the cosmic microwave background, a precise Hubble constant holds the key to understanding of the dark energy, which seems to pervade the universe and causes its expansion to accelerate.

ALMA will be a remarkable telescope for observing molecular gas in active galactic nuclei. There are numerous water maser transitions available in the millimeter and submillimeter wavelengths, but ALMA’s contributions will not be limited to observing those. It will also image emission from other molecules as well, masers or not. ALMA will open the door to obtaining a more complete picture of molecular gas in active galaxies and will reveal, directly, how the nuclear gas begins to interface with the host galaxy.

Meet the NAASC: Jim Braatz

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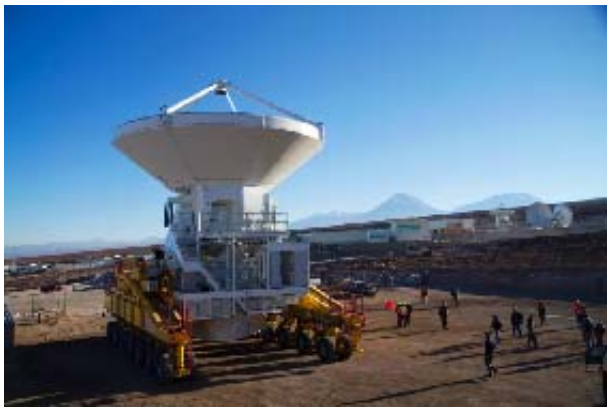
Jim Braatz is an astronomer at the NRAO in Charlottesville, Virginia. A native Marylander, Jim received his B.A. in Physics from the Johns Hopkins University and Ph.D. in astronomy from the University of Maryland. He then held a postdoc at the Harvard-Smithsonian Center for Astrophysics and was a Jansky Fellow in Green Bank. Jim then joined the NRAO scientific staff. He currently works with the North American ALMA Science Center, helping to prepare the astronomical community to use ALMA. Jim's research is centered on observations of radio emission from active galaxies. Jim is the PI of the Megamaser Cosmology Project, a multi-year effort that aims to use observations of water megamasers to measure distances to galaxies and black hole masses in AGNs.

ALMA Construction Progress

Al Wootten



(images/3_1.png)

Figure 1: The first production antenna from the AEM Consortium (Thales Alenia Space, European Industrial Engineering, and MT-Mechatronics) was delivered to the Joint ALMA Observatory after acceptance on 21 April 2011. Credit: NRAO/AUI/NSF, Carlos Padilla. Acknowledgment: General Dynamics C4 Systems.

Zoom (images/3_1.png)

(images/3_2.png)

Figure 2: With every available antenna foundation hosting an antenna, there was a 'Full House' at the ALMA OSF on 2 May 2011. There are 10 antennas in this image -- one on each of the OSF foundations -- in various stages of Assembly, Integration, and Verification and preventive maintenance. Each of the four major ALMA antenna designs is represented. In the foreground stand three of the NAOJ 7m antennas, with Vertex 12m antennas DV11, DV05 and DV13 behind them. On the far left, in front of the OSF Technical Building, stands the European 12m antenna DA41, To its right are NAOJ 12m antenna PM04, followed by DV12 and DV02. Image courtesy P. Carrillo for ALMA (ESO/NAOJ/NRAO).

Zoom (images/3_2.png)

As is clear from the image in Figure 1, the weather at the ALMA site in northern Chile has improved to autumnal clarity. During April, the upgraded central signal distribution system and the doubled-capacity correlator were put to use as science verification continued. Power and signal distribution to additional antenna foundations in the central cluster was completed. The array, with eleven antennas positioned at the 16500 foot Array Operations Site (AOS) by April's end, has outgrown the station complement of the Atacama Compact Array. Antennas will be moved to new positions in the northeast sector of the central cluster during May.

ALMA will employ four major antenna designs when complete. Two of these designs -- the 12m diameter antenna designs from the North American and Japanese partners -- have been in use at the AOS. During April the final two antenna designs were accepted from their contractors and began testing at the Operations Support Facility (OSF). On 21 April, the first of the European 12m antennas made the short journey from the Site Erection Facility where it had been assembled and tested by contractors and ALMA scientists, to the OSF, where further tests will be made. On 25 April, the first of the 7m antennas from Japan was accepted, and it will join the other antennas at the OSF at the beginning of May. All four major antenna designs are now undergoing testing within ALMA, and the total number of accepted antennas is now eighteen.

New antennas continue to arrive at the OSF: the 19th Vertex antenna will arrive at the site in early May and four more 7m antennas have arrived from Japan and will travel to the OSF early in May. Eight additional antennas from the AEM consortium are at the ALMA site. By mid-May ALMA will host a total of 41 antennas in all stages of construction.

Click **here (http://almaobservatory.org/en/outreach/newsletter/268-newsletter-no-8)** to view the latest newsletter from the Joint ALMA Observatory.

Expanded Very Large Array Status

Chris Langley & Joseph McMullin

The final hardware design upgrades needed to have a fully compliant EVLA are the 3-bit 4-Gs/sec sampler boards. Testing of prototype units in the system last fall uncovered a non-linearity when comparing output to input power at the chip level, along with an excess amount of noise in the 3-bit path. Lab tests have corroborated the non-linearity findings. The assemblies were re-designed to allow for differential input clocking and data signals to the chip, as opposed to the single input scheme adopted in the previously tested 3-bit sampler board design. Also, the global and track-and-hold clocks to the chip may be now be phase shifted so that the affect on output data may be observed. Four new prototypes were installed on the array in April 2011 and testing is ongoing. As previously reported, the delay in the implementation of 3-bit samplers does not constitute an overall delay in the delivery of the EVLA by the end of 2012.

The production and installation of the EVLA-compliant C-band (4-8 GHz), K-band (18-26.5 GHz), Ka-band (26-40 GHz), and Q-band (40-50 GHz) receiver sets are complete. L-Band (1-2 GHz), S-Band (2-4 GHz), X-band (8-12 GHz), and Ku-band (12-15 GHz) receiver production is continuing at the predicted rate. At this time, the number of available, completed EVLA receivers is: 12 L-band (16 interim with 1 GHz bandwidth), 15 S-band, 8 X-band (21 interim), and 11 Ku-band.

Acceptance of the WIDAR correlator has been separated into two activities: basic hardware checkout and on-the-sky testing. Hardware testing is on going and will be completed this summer. This testing will verify the successful integration and quality of all correlator components. The complete WIDAR acceptance plan, which will verify the functionality of advanced software and firmware, is being drafted. This will incorporate significant amounts of information from already-completed commissioning work.

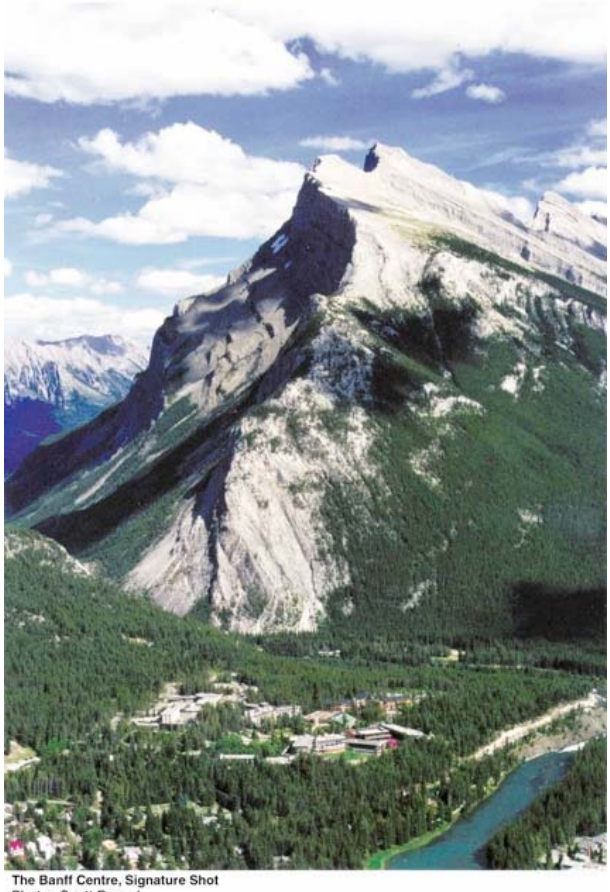
EVLA Commissioning activities continue in parallel with the construction and science operations. About half of all time from C-configuration through B-configuration has been spent on science observing commitments (up from 30% in the initial D-configuration); the other half of the time is dedicated to expanding the capabilities to meet the original goals of the EVLA construction. In the Seattle AAS in January 2011, a special session was held on Early Science results from the EVLA (see **presentations (https://science.nrao.edu/facilities/evla/publications/AAS_217)**) and a special Astrophysical Journal Letters issue will be published this year containing approximately 35 articles describing EVLA Early Science results.

The EVLA technical capabilities continue to expand. The February 2011 Call for Proposals offered capabilities to the community previously only available to resident scientists supporting EVLA commissioning. These capabilities provide significant improvements in number of spectral points, number of independently tunable sub-bands, and overall bandwidth (all 8 times that previously offered). The S (2-4 GHz) and Ku (12-18.5 GHz) receiver bands have been opened and used for science observing; the wideband X-band receivers (8-12 GHz) will also be available starting in the 2011 D-configuration (previously accepted proposals for X-band observing will use these receivers as they come online). In April 2011, the 74 MHz dipoles will be deployed on the array allowing the first science observing at these frequencies since the EVLA transition. Finally, updates and expansion of the existing documentation for observers is being developed with improvements to calibrator catalogs, sensitivity calculators and observing strategies. Please consult the following links for additional information:

EVLA general information for observers (http://science.nrao.edu/evla/observing/)

EVLA science/technical capabilities (http://evlaguides.nrao.edu/index.php?title=Category:Status)

Registration Open for SKA 2011



The Banff Centre, Signature Shot
Photo: Scott Rowed

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Zoom (images/5_1.jpg)

On-line registration is now open for SKA 2011: the international Square Kilometre Array (SKA) Forum, Science, and Engineering Meetings, which will be held 4-8 July 2011 in Banff, Canada and will feature three related meetings. The Canadian and United States SKA Consortia, and the international Square Kilometre Array Program Development Office (SPDO) are the co-hosts. Participants may register for any or all of the SKA 2011 events via the "Registration" tab at **http://www.ska2011.org (http://www.ska2011.org)**

The theme for the SKA2011 Science Meeting on 4-5 July is "SKA Science and Frontiers of Astronomy in the Era of Massive Datasets: The Promise and Challenges". Advancing our understanding of the Universe from star and planet formation to galaxy evolution across cosmic time to the cosmological implications of fundamental physics will depend upon scientists' abilities to effectively deal with data product volumes and processing rates approaching the Exa-scale. This two-day meeting we will showcase current, upcoming, and planned astronomy facilities, programs, projects, techniques, and research that will need or produce such large data volumes and rates. These are from all parts of the electromagnetic and particle/field energy spectrum, but will focus on those relevant to SKA science goals or that will benefit from SKA science data products or results.

The “International SKA Forum” on 6 July 2011 will be a day of public presentations and events, bringing

together scientists, industrialists, policy makers, government representatives and funding agencies who are working together to advance the SKA implementation plan.

The "Engineering and Industry Opportunities in the SKA" meeting on 7-8 July 2011 will include a cross-section of industrial organizations discuss the status, technical challenges, and opportunities of the SKA. The theme of the meeting is "A Walk Through the SKA System", with a strong emphasis on illustrating where industrial involvement is needed to successfully develop the SKA.

Fifty Years of Chile-USA Collaboration

Sergio Cabezon

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Figure 1: [Left to right] Eduardo Hardy, AUI/NRAO Representative in Chile and NRAO Director in Chile; R. Chris Smith, Director of AURA and Cerro Tololo Interamerican Observatory in Chile; Alejandro Wolff, US Ambassador to Chile; Alfredo Moreno, Chilean Minister of Foreign Affairs; Gabriel Rodríguez, Director of Energy, Science and Technology and Innovation from Ministry of Foreign Affairs; Miguel Roth, Director of Las Campanas Observatory and Representative for Carnegie and GMT; and Mónica Rubio, Director of CONICYT Astronomy Program.

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The NRAO participated in a major exhibition in Santiago 11-13 April 2011 to commemorate the 50th anniversary of American astronomy in Chile. On-going and planned astronomical facilities in Chile – including ALMA, the Large Synoptic Survey Telescope (LSST), and the Giant Magellan Telescope (GMT) – were described via videos, posters, and models. This exhibition was inaugurated by Chilean Minister of Foreign Affairs, Alfredo Moreno, and featured the US Ambassador to Chile, the Honorable Alejandro D. Wolff. The institutions participating in this event included the Ministry of Foreign Affairs in Chile; Associated Universities Inc. (AUI); NRAO; the Association of Universities for Research in Astronomy (AURA); NOAO; Carnegie Institution for Science; and the National Commission for Scientific and Technological Investigation in Chile (CONICYT).

The importance of Chile and the United States to world-class science was highlighted during President Barack Obama's recent visit to Chile. A joint statement by President Obama and Chilean President Sebastián Piñera noted that "… both Heads of State highlighted the effective collaboration in the fields of astronomy and astro-

engineering which will allow the operation of the LSST and ALMA telescopes in the northern Chile, involving an investment of 1.5 billion dollars, with a close collaboration between public and private academic and research institutions in both countries."

Alfredo Moreno, Minister of Foreign Affairs in Chile further noted: "By 2018, Chile will host 70% of the global infrastructure for major astronomical telescopes. We are aware of the extraordinary opportunities these developments represent and the significant challenges they also entail. It is an honor for the Chilean Government to support and develop such world-class astronomical facilities and research capabilities."

CONICYT representatives recognized that these astronomical projects benefit Chile in multiple ways: Chilean scientists have access to 10% of the available observing time, enabling the in-country astronomical community to conduct transformative research and positioning Chile among the global scientific elite. Additionally, Chilean industry can engage in opportunities to develop the sophisticated technology required by these projects, promoting local astro-engineering and state-of-the-art technology transfer. Astronomy is also being integrated into the Chilean culture, enriching it.

"Beginning in 2011, ALMA will open new windows on our cosmic origins and reinforce Chile's status as the 'global capital' for astronomy," said Eduardo Hardy, AUI/NRAO Representative in Chile and NRAO Director in Chile.

From the Archives

Ellen Bouton

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About this month's photograph: Students participating in NRAO summer student programs arrive at their respective NRAO sites in late May. Since its inception in 1959, the summer student program has engaged close to 1,000 young people in scientific research, and many NRAO summer students have gone on to distinguished careers in astronomy and other physical sciences. The list of former NRAO summer students now includes women and men who represent a wide range of career stages, research interests, geographic locations, and ethnic backgrounds. This image of the Charlottesville and Green Bank summer students was taken in 1975 at a late June picnic in Green Bank. [Standing, left to right]: Michael Carter, Kevin Baines, Judith Soukup, John Brasunas, Jeffrey Waldhuter, Richard Glassco, Alan Marscher, David Berg, Kenneth Cosner, Jack Burns, Walter Gorman. [Seated left to right]: Edward Teyssier, Alice Kust.

From the Archives is an ongoing series illustrating NRAO and U.S. radio astronomy history via images selected from our collections of individuals' and institutional papers. If readers have images they believe would be of interest to the Archives, please contact Ellen Bouton, **ebouton@nrao.edu (mailto:ebouton@nrao.edu)** .

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