



NATIONAL  
RADIO  
ASTRONOMY  
OBSERVATORY

OPPORTUNITIES  
FOR  
STUDENTS  
AND  
VISITORS

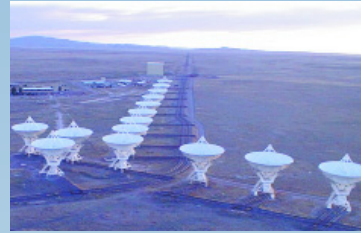
## OPPORTUNITIES FOR STUDENTS AND VISITORS AT THE NATIONAL RADIO ASTRONOMY OBSERVATORY

The National Radio Astronomy Observatory designs, builds, and operates the world's largest and most advanced radio telescopes. Scientists from the United States and around the world use these powerful telescopes to study the Sun, planets, and other solar system objects, as well as distant stars, black holes, galaxies, quasars, and other mysterious objects many millions, even billions, of light years away.

### NRAO TELESCOPES

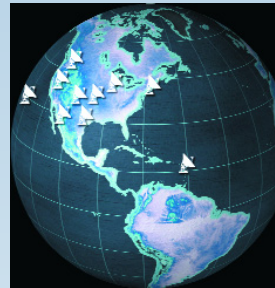
#### *The Very Large Array (VLA)*

The VLA is an imaging array composed of 27 radio antennas distributed in a Y-shaped configuration on the plains of San Augustin fifty miles west of Socorro, New Mexico. Each antenna is 25 m in diameter. The data from the antennas are combined electronically to give the angular resolution of an effective antenna as large as 36 km across, and the sensitivity of a single antenna that is 130 m in diameter. The VLA operates at wavelengths of 7 mm up to 4 m. A major upgrade of the VLA is currently underway that will increase its power tenfold.



#### *The Very Long Baseline Array (VLBA)*

The VLBA is also an imaging array that operates at wavelengths similar to those of the VLA. The VLBA is composed of ten antennas spread across the United States and its territories from St. Croix, the Virgin Islands, to Mauna Kea, Hawaii. Astronomical observations are recorded at each 25 m antenna and combined electronically at a central processing facility located at the Array Operations Center in Socorro, New Mexico. Acting like a giant eye 8,600 km wide, the VLBA can produce the sharpest images of any telescope on Earth or in space.



#### *The Green Bank Telescope (GBT)*

Completed in 2000, the GBT is the world's largest fully steerable radio telescope. The GBT is of an unusual design. Unlike conven-



tional radio telescopes that support a subreflector over the main reflector, the GBT employs an unblocked aperture using off-axis optics. The GBT is 100 x 110 m in size and is located in Green Bank, West Virginia.

#### *The Atacama Large Millimeter Array (ALMA)*

ALMA will be an imaging array composed of sixty-four high precision antennas located on the Chajnantor plain in the Chilean Andes at a height of 5000 m above sea level. ALMA will operate a millimeter and submillimeter wavelengths in order to observe the enigmatic cold regions of the Universe with unprecedented sensitivity and clarity. ALMA, a new facility under construction, is a partnership among Europe, North America, and possibly Japan, in cooperation with the Republic of Chile. ALMA construction and operations are led on behalf of North America by the NRAO.



### STUDENT PROGRAMS AT THE NRAO

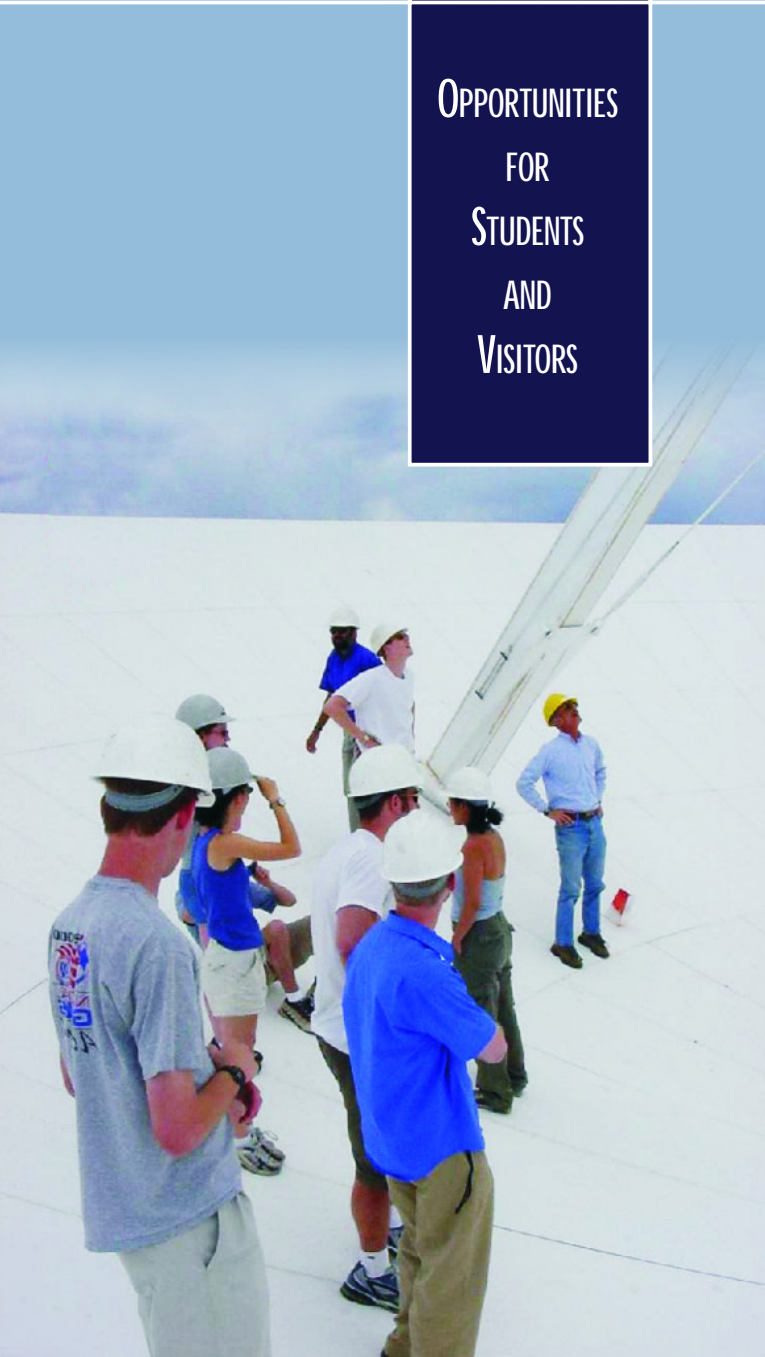
The NRAO has programs for undergraduate, graduating seniors, and graduate students. These involve students in astronomical research, astronomical computing, or engineering. Programs run from three months for the summer programs to two or more years for the co-op and pre-doctoral programs. The individual programs are briefly described below; more complete information on each NRAO student program may be found on-line at <http://www.nrao.edu/students/>.

#### *Summer Student Programs*

NRAO summer students conduct research under the supervision of an NRAO staff member at one of three NRAO sites (Socorro, New Mexico; Green Bank, West Virginia; Charlottesville, Virginia). The project may involve any aspect of astronomy, including original research, instrumentation,



telescope design, or astronomical software development. Often, these projects result in publications in scientific journals. Students also collaborate on their own observational projects using NRAO telescopes. Students receive relocation support and a monthly stipend. Partial financial support may be available for students to





present their summer research at a meeting of the American Astronomical Society.

Besides their research, students take part in other activities, including a number of social events and excursions as well as an extensive lecture series.

The NRAO Summer student programs are available to both undergraduate and graduate students:

- Undergraduate students that are U.S. citizens or permanent residents are eligible for the *NRAO Research Experience for Undergraduates (REU)* program, which is funded by the National Science Foundation. Students who do not meet REU guidelines, such as graduating seniors, some foreign undergraduate students, or students who are interested in projects involving pure engineering or computer programming, are eligible to apply for the *NRAO Undergraduate Summer Student Assistantship Program*.
- Graduate students affiliated with a U.S. institution that are in their first or second year are eligible for the *NRAO Graduate Summer Student Research Assistantship Program*. Promising graduate students are also encouraged to consider longer term visits at any of the NRAO sites. (*see below*)

Applications are due at the end of January of each year. More information on the NRAO summer student programs is available at <http://www.nrao.edu/students/summer-students.shtml>.

### **Co-op Program**

The National Radio Astronomy Observatory has developed relationships with many U.S. universities with strong Engineering and Computer Science departments. Each semester, the NRAO sponsors one or more paid undergraduate students at our research facilities in New Mexico, Virginia, and West Virginia. Co-op students, normally



ALMA Prototype VertexRSI Antenna

juniors and seniors, spend three alternating semesters with an NRAO mentor in progressively more technical duties. Typical co-op assignments focus on engineering tasks related to the design, prototyping, testing, or production of radio astronomical instrumentation or programming tasks related to the monitor and control of radio telescopes. Our goal is to assist future professionals



to develop practical work and leadership skills that reinforce their academic experience. Further information on this program may be found at <http://www.nrao.edu/students/co-op.shtml>.

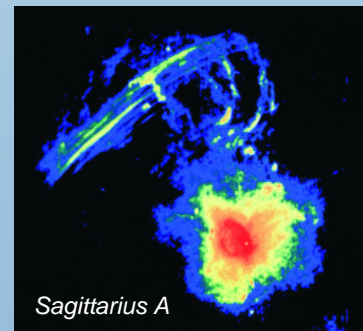
### **Graduate Student Research Assistantships**

The Graduate Student Research Assistantships program is for graduate

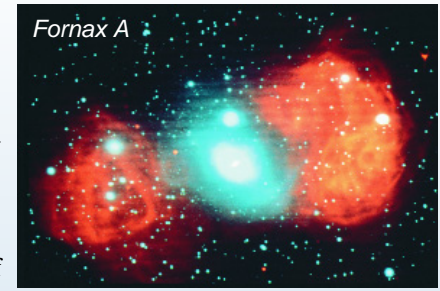
students who have not yet become doctoral candidates — typically in their first or second year — but have a serious interest in pursuing research in radio astronomy, instrumentation and hardware development, electrical engineering, or computer science. Opportunities may be available at all the NRAO sites. Students receive a monthly stipend. Travel support and housing assistance may also be available. Appointments to this program may be made for a duration of from three to six months. Working under the supervision of an NRAO staff member, the successful candidate participates in one or more of: radio-astronomical research; instrument design, development, fabrication, and testing; scientific programming. Graduate students at all levels in engineering, physics, astronomy, mathematics, and computer science are eligible for the program. Further information on this program may be found at <http://www.nrao.edu/students/grad-prog-in-id.shtml>.

### **Pre-Doctoral Research Program**

The NRAO pre-doctoral program supports upper-level graduate students who have completed all the requirements of their academic institution for becoming doctoral candidates. Students in astronomy, engineering, and computer science are encouraged to participate. Under the joint supervision of an NRAO staff member and the student's academic advisor, the student is free to pursue research full time in order to work toward completion of the doctoral thesis. Students are typically nominated for the program by an NRAO scientist and/or by their academic advisor. Students may be supported for periods of six months to two years, or longer, and work at one of the NRAO sites. Participants in the program have full access to the resources available to



NRAO staff members, including computing resources and travel support. Applications are accepted throughout the year. However, candidates are strongly encouraged to seek the support of an NRAO scientist before applying for the program. More information is available at <http://www.nrao.edu/students/pre-docs-research.shtml>.



### **GBT Student Support Program**

The GBT Student Support program provides monetary support for graduate and undergraduate students at U.S. universities to conduct research with the Green Bank Telescope, the world's largest fully steerable single aperture telescope. Applications to this program are sent in with GBT observing proposals. More information is available at <http://www.gb.nrao.edu/gbtprops/gbtstudentsupport.shtml>.

### **VISITORS PROGRAM AT THE NRAO**

The NRAO encourages Ph.D. scientists and engineers in radio astronomy and related fields to visit any of its sites. We particularly encourage visits by young scientists who are faculty members at colleges and universities, scientists affiliated with NASA missions, foreign scientists, and senior scientists. The terms of a visit are negotiable, ranging in duration from weeks to months. The purpose of the visit can be for interaction with one or more NRAO staff members, summer visits for research, or sabbatical visits. Further details can be found at <http://www.nrao.edu/visitors.shtml>.



[www.nrao.edu](http://www.nrao.edu)

