URSI GASS 2021, Rome, Italy, 28 August - 4 September 2021

Towards a New Arecibo Radar Telescope for Incoherent Scatter and All Radar Science

Brett Isham*(1), Christiano Brum(2), Francisco Córdova(2), Juha Vierinen(3), Anne Virkki(2), and Marco Milla(4)
(1) Interamerican University of Puerto Rico, Bayamón, Puerto Rico, USA
(2) Arecibo Observatory, Puerto Rico, USA
(3) University of Tromsø, Tromsø, Norway
(4) Jicamarca Radio Observatory, Jicamarca, Peru

The collapse of the 900-ton instrument platform of the Arecibo Observatory (AO) on December 1, 2020, resulted in the loss of the world's most sensitive incoherent scatter radar (ISR), and the world's only mid/low-latitude ISR. However, work is already underway on a proposal for a new Arecibo radar and radio system, and a white paper proposal for a New Generation Arecibo Telescope, or AO2, was publicly released on February 2, 2021 (*http://-www.naic.edu/NGAT/NGAT_WhitePaper_v2_01022021.pdf*).

The Arecibo radar telescope has always been multidisciplinary and unique, and the guiding principles for AO2 are that it should also be multidisciplinary and unique, and, in addition, better, and revolutionary. Revolutionary means not the same and better, but better and with new capabilities to enable exciting new and discovery science.

The primary instrument of the AO2 system, as proposed in the white paper, is a planar, rigidly-steerable array of parabolic dishes, equal in overall size to, but with a far different structure than, the previous 305-meter dish and instrument platform. The proposed planar array could accommodate frequencies from Ka band (30 GHz) down to the high VHF band (200 MHz). The lower VHF and HF capabilities of the previous AO telescope (AO1) are not included in the AO2 white paper proposal (see also *Bernhardt et al.* and *Breakall et al.*, session HG1).

Given that as a starting point, many capabilities may be considered that can contribute to atmospheric science with AO2 — in the neutral atmosphere, the ionosphere, and the plasmasphere. That science includes not only current science and our best guess at near-future science, but also future science that is impossible to predict. That is the scientific future towards which we can aim the technical capabilities desired for AO2.

Of the three major AO science areas — space and atmospheric science (SAS), planetary science, and radio astronomy — SAS has the largest number of potential telescope options and parameters that can contribute to science goals. Further, while incoherent scatter radar is an extremely powerful remote sensing technique in the ionosphere, coherent radar is important throughout the atmosphere, and over a much broader frequency range. Finally, all proposed AO2 radars could be productively used for both atmospheric and planetary science, if they are designed with that goal in mind.

(1) Capabilities specified for the proposed AO2 radars include:
— Increased radar transmitter power for greater sensitivity and greater range.
— Pulsed radar from 200 to 500 MHz.
— Continuous wave (CW) (100% maximum duty cycle) radar somewhere between 2 and 6 GHz.
— Maximum zenith angle of 48 degrees (versus 20 degrees for AO1).

(2) Capabilities not specified for the proposed AO2 radars include:
— Selectable radar frequencies from 200 MHz to 6 GHz.
— CW and pulsed operation at all radar frequencies.
— Wide instantaneous bandwidth for high range resolution and multi-frequency measurements.
— Simultaneous operation at multiple frequencies within each transmitter tuning band.
— Simultaneous collinear operation of all transmitter feeds.
— Multiple radar beams for local area and mesoscale measurements.
— Variable beam width (beam widening and shaping).

(3) Capabilities not included for the proposed AO2 radar systems:
— Transmitter and radar frequencies between 2 and 200 MHz.
— Bistatic receiving sites for improved resolution, vector velocities, interferometry, and CW radar.

The capabilities in (2) above would allow the proposed AO2 radars to be optimally used for any science purpose. The capabilities in (3) would go farther, but would require significant additions to what is currently proposed in the white paper. Flexibility of use has been a traditional strength of Arecibo Observatory, and it is also important for education. Making it even stronger for AO2 will help to achieve the stated goals that the new AO be multidisciplinary, unique, better, and revolutionary. The best path to transition to AO2 — making good use of the remaining assets and capabilities of AO1 while restoring previous capabilities and adding new ones — will also be discussed.