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Plans for a Restored HF Heating Facility at the Arecibo Observatory

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The collapse of the 900-ton instrument platform of the Arecibo Observatory (AO) on December 1, 2020, resulted in the loss of the transmitting antenna of the Arecibo high-power high-frequency (HF) ionospheric heating facility, as well as most of the other AO radio and radar systems. The Arecibo heating facility, also known as the ionospheric modification facility, was the only such facility located at mid to low latitudes. It was used for experiments in atmospheric and plasma physics, and in the development of innovative atmospheric remote sensing techniques.

Beginning in 1970, Arecibo has had several implementations of high-power HF facilities. The most recent made use of the 305-meter dish as the primary component of the HF transmitting antenna, with a suspended wire net shaped to serve as a secondary Cassegrain reflector, and a triangular array of crossed dipoles at the center of the dish, with each of the six single dipoles transmitting up to 100 kW of power.

The transmitters of the HF facility are located a short distance north of the dish, and were not damaged in the collapse. This means that, with an appropriate antenna, the HF facility could be restored to full operation.

Options for a new antenna include restoring the 305-meter dish, perhaps with a new mesh surface sufficient for use at low frequencies, similar to the original "chicken wire" surface that covered the dish in the 1960s. This option is also of interest for radio astronomy, which, with a 1-cm mesh, could conduct transit observations at frequencies between 20 MHz and 1.6 GHz. Fixed-pointing 430-MHz incoherent scatter observations might also be considered, as the 430-MHz transmitter also survived the platform collapse.

Another alternative might be to construct a new HF array at a suitable location near the transmitters. A separate array might be designed with flexibility in pointing. For example, $\pm$50-degree zenith angle pointing would allow transmissions as far as parallel and perpendicular to the geomagnetic field, matching the pointing envisioned in plans currently under discussion for a rebuilt main Arecibo radar and radio system (see *Isham et al.*, session G06, this meeting). This option could be much more costly, and would have the difficulty that only relatively small sites are currently available where an array might be built, although there are larger sites that might be used within 2 kilometers of the current transmitters.

As of early February 2021 (the time of submission of this abstract) it appears that enough of the major HF antenna components may be salvageable from the wreckage of the collapse to aid in putting together a 5-MHz system of the original design, at modest cost. The use of wider-bandwidth radiating elements and baluns and an alternative arrangement of dipoles, which would enhance possibilities for new science, are also being considered, but would add to the cost (see also *Bernhardt et al.*, this session).

Available diagnostics include the passive and active optical, radio, and magnetometer instrumentation operating at sites including the main Arecibo Observatory, the Arecibo Remote Optical Facility on Culebra Island (150 km east), the USGS San Juan Observatory in Cayey (110 km east), and at field sites typically arranged during heating campaign periods. In addition, there are efforts towards installing a new HF radar near the main Arecibo Observatory, and an HF imaging array in Aguadilla (40 km west) (see *Isham et al., session GH3, this meeting*).

In addition to providing opportunities to work on new and continued science goals, a restored Arecibo heating facility would be able to make indirect contributions to science. For example, a collaboration with the ESA Jupiter Icy moons Explorer (JUICE) mission to Jupiter, planned for launch in June 2022, could use the Arecibo heating facility to assist in calibrating the 3-axis Radio Wave Instrument (RWI) of the Radio and Plasma Waves Investigation (RPWI), which operates from 80 kHz to 45 MHz, before its final departure to Jupiter in November 2026 — there is currently no transmitter suitable for this purpose. Interesting ionospheric and radio propagation science might also be done, taking advantage of the vector polarization measurements of the JUICE radio instrument.