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An MF/HF Radio Array for Radar and Radio Imaging of the Ionosphere

Brett Isham*[(1)], Gebrab Zewdie[(2)], Terence Bullett[(3)], Björn Gustavsson[(4)], Emil Polisensky[(5)], Vasyl Belyey[(6)], Jan Bergman[(7)], Leila Norouzi[(8)] Arturs Stramkals[(9)]

(1) Interamerican University of Puerto Rico, Bayamón, PR, USA
(2) Arecibo Observatory, Arecibo, Puerto Rico, USA
(3) University of Colorado, Boulder, Colorado, USA
(4) University of Tromsø, Tromsø, Norway
(5) U.S. Naval Research Laboratory, Washington, DC, USA
(6) Private researcher, Oslo, Norway
(7) Swedish Institute of Space Physics, Uppsala, Sweden
(8) Private researcher, Seattle, Washington, USA
(9) Uppsala University, Uppsala, Sweden

We are developing a 2 to 25 MHz (medium and high frequency or MF/HF) antenna array for radar and radio imaging of the ionosphere. The array will consist of multiple antenna elements, each of which is an active (electrically short and impedance-matched) crossed electric dipole. Elements in the array will be arranged in a partly ordered and partly semi-random pattern providing a good distribution of baseline vectors, with a minimum antenna spacing of 7 meters to eliminate spacial aliasing up to 21 MHz, and a maximum antenna spacing of 400 meters.

Relocatable cable-less antenna elements will be included, in which phase is maintained between elements through the use of GPS-disciplined rubidium clocks, and which may be used independently or together with the main array. For example, five cable-less elements could be located in a ring of about 400-m radius around the central core, providing a roughly three times improvement in imaging resolution.

A primary scientific goal of the array has been to study the mechanisms of ionospheric radio emissions stimulated by the Arecibo Observatory (AO) high-power HF radio transmitter, and their dependence on the geometry of the radiowave pump with respect to the geomagnetic field, through the creation of high resolution radio images of the emission region. The collapse of the observatory's 900-ton instrument platform on December 1, 2020, resulted in the loss of the Arecibo HF transmitting antenna, as well as most of the other AO radio and radar systems. However, plans are being discussed for the restoration of Arecibo HF capabilities, perhaps as early as 2023.

Other important goals of the array include the study of space weather, ionospheric structure and dynamics, plasma physics, and radio propagation, through the use of coherent radar imaging in collaboration with the University of Colorado and NOAA Versatile Interferometric Pulsed Ionospheric Radar (VIPIR) transmitter located at the USGS San Juan Observatory in Cayey, 110 km from Aguadilla.

The array will be an ideal instrument for collaboration with overflights by satellites. For example, the 3-axis Radio Wave Instrument (RWI) of the ESA Jupiter Icy moons Explorer (JUICE), planned for launch in June 2022, could be used for collaborative ionospheric and radio propagation experiments before its final departure to Jupiter in November 2026.