A PUBLICLY ACCESSIBLE REPOSITORY FOR ARECIBO PLANETARY RADAR OBSERVATIONS OF NEAR-EARTH ASTEROIDS. B. Aponte-Hernández[1], P. A. Taylor[1] , E. G. Rivera-Valentín[1], and M. O'Dell[1], [1]Lunar and Planetary Institute, USRA, Houston, TX.

Introduction: The Arecibo Observatory in Puerto Rico was the world's most sensitive and powerful planetary radar system. Observations with this system provided astrometric measurements and physical characterization of over 850 near-Earth asteroids (NEAs), confirmed the existence of binary and triple NEAs, verified the existence of the Yarkovsky effect and contributed to the verification of the YORP effect. Additionally, it obtained the first non-spacecraft images of cometary nuclei and imaged a number of main-belt asteroids, among other discoveries. Its 1 MW transmitter, nearly 20-acre collecting area, and gain of 2×10^6 made the Arecibo planetary radar an invaluable tool for post-discovery characterization and orbital refinement of NEAs.

In order to broaden the scientific impact of Arecibo, the Lunar and Planetary Institute (LPI) in collaboration with the observatory are developing a portal for access to public-friendly radar data products. A full data repository is beyond the scope of this project and is being managed by a separate institution. Here, we describe the data products available on the web portal.

Data Description: The Arecibo Observatory planetary radar project conducted observations of known asteroids as well as a rapid-response program to study NEAs shortly after their discovery. A typical observing run, which could last up to 2.5 hours due to Arecibo's field of view, would begin with a continuous-wave (CW) experiment. Using the S-band (12.6 cm; 2380 MHz) planetary radar system, a monochromatic, unmodulated circularly polarized light was transmitted and echoes in the same circular (SC) and opposite circular (OC) polarization as transmitted were received and processed as power spectra (e.g., Fig. 1). This experiment reveals velocity offsets with respect to the object's predicted ephemeris, disk-integrated measurements of an objects radar cross section and polarization ratio (SC/OC or CPR), as well as constraints on rotation rate, spin-axis direction, size, and surface properties.

With sufficient radar signal strength, which depends on an object's size and distance from Earth, delay-Doppler experiments were possible (e.g., Fig. 2), which produced detailed "imaging" of an NEA. In such experiments, a modulated, circularly polarized signal is transmitted. Modulation occurs by flipping the phase of the emitted signal in a pseudo-random, repeated pattern every baud (i.e., time step) over a given code length. By correlating the received echo with the transmitted signal, a range resolution equivalent to the baud can be achieved. Delay-Doppler images are then produced by mapping the received signal in both range (delay) and frequency (Doppler). Such experiments allowed for direct measurement of an NEA's size within the illuminated area and line-of-sight distance offsets with respect to the object's predicted ephemeris. Additionally, delay-Doppler imaging can be used to characterize an asteroid's near-surface geology, even revealing craters and boulders, as well as constrain an NEA's regolith properties. Importantly, radar imaging can be used along with inversion techniques to model the NEA's 3-D shape and spin state. Arecibo was able to achieve a range resolution as fine as 7.5 m per pixel. Thus, these images were able to provide spacecraft-flyby level data, but over a much larger sample of the NEA population.

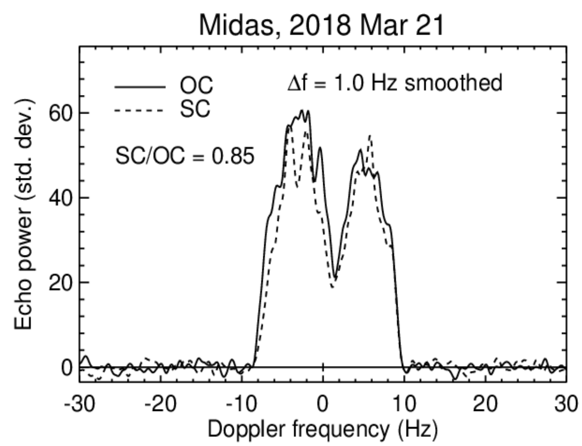

Figure 1: CW spectrum, smoothed to 1.0 Hz, of NEA 1981 Midas observed on 2018 March 21 with SC/OC of 0.85.

Figure 2: Delay-Doppler image of NEA 1981 Midas observed on 2018 March 24. The Doppler frequency is plotted on the horizontal axis and the delay is on the vertical axis with resolution of 0.954 Hz and 0.5 us (75 m), respectively.

Archive Content: The database consists of CW and radar imaging data products of NEAs observed at Arecibo, alongside other known properties. CW data are provided as power spectra with the measured CPR. These data products will be available for download as images in png format and the raw data as comma separated values (CSV). For those objects where imaging was possible, delay-Doppler images will be included in png and FITS file formats. Additionally, if sufficient rotation coverage was possible, an animation of a sequence of radar images in gif format is also provided. Radar images are z-score normalized such that the mean of the background is equal to 0 and the standard deviation is equal to 1. In addition to the observation data, the archive will also include characteristics of the studied body, such as orbital elements and physical parameters. An example entry is shown in Figure 3.

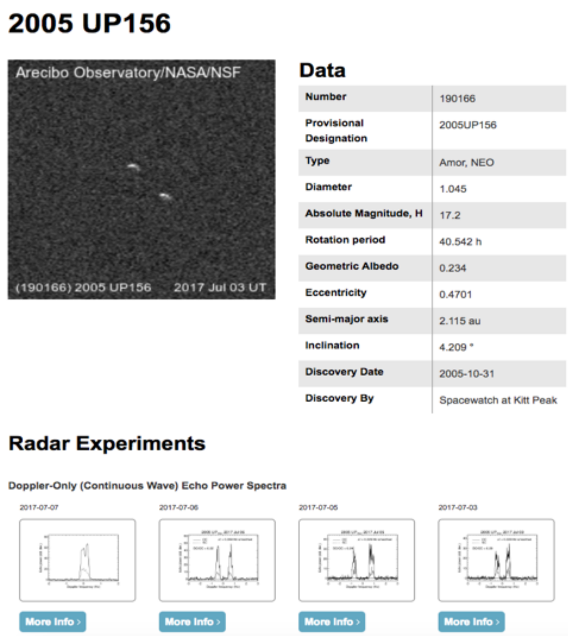

Figure 3: Data view for binary NEA 2005 UP156. showing asteroid information, delay-Doppler image, and CW spectra from different observation dates.

Availability: This resource will be made available to the public by the LPI by LPSC in March 2021. A full archive of data, rather than data products, is being developed for the scientific community by the University of Arizona's Lunar and Planetary Laboratory.

Conclusion: The Arecibo Observatory in Puerto Rico was the world's most sensitive and most powerful planetary radar system. To broaden the scientific impact of Arecibo, the LPI along with the observatory are developing this accessible and public-friendly portal of Arecibo radar data products. A full data repository is currently under development and will be managed by a separate institution for the scientific community.

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