ARECIBO OBSERVATORY
PLANEARTY RADAR UPDATES

Flaviane Venditti
Small Bodies Assessment Group meeting
June 7, 2021
Arecibo Observatory site status

• Debris removal from reflector area completed

• Finalizing debris removal from site

• Ongoing work on towers’ structure for safety

• Re-budget request for Hurricane repair funds to be used on projects not impacted by the collapse are under evaluation
Arecibo Observatory instruments

Current:
• Arecibo Lidar Facility
• Remote Optical Facility (Culebra site)
• Arecibo Optical Facility

Under development:
• Culebra Aerosol Research Lidar (Culebra site)
• 12-m Steerable Antenna, S and X bands receivers
• AO-CALLISTO spectrometer for monitoring solar activity and space weather research
• Meteor radar (Culebra site)

http://www.naic.edu/ao/scientist-user-portal/#sciencenow
The Arecibo planetary radar program continues to be funded by the NASA NEOO grant awarded to the University of Central Florida (2019-2023)

Sub-awards to other institutions continue to be funded by the NASA grant awarded to UCF to support the Arecibo planetary radar program

Budget has been restructured to focus more on science/data analysis since the telescope is no longer operational

PI change: Anne Virkki → Flaviane Venditti
Arecibo Planetary Radar Group - Present

• Data archiving (PDS)

• Data analysis: backlog of data to be analyzed. Ongoing physical and dynamical studies

• Shape reconstruction of NEAs with high resolution images. Can support future small bodies missions

• NEA radar astrometry: reporting new uncertainties for NEAs from the past 5 years that didn’t require delay/Doppler correction

• Publications
Manuscripts in preparation (Arecibo Staff)

• 3200 Phaethon shape model/characterization (led by Sean Marshall)

• 1981 Midas shape model/characterization (led by former Arecibo REU student Riley McGlasson; mentor Sean Marshall)

• Radar data report for 156 NEAs observed between 2017-2019 (led by Anne Virkki)

• 2019 OK characterization (led by Luisa Zambrano-Marin)

• 52768 (1998 OR2) shape model/characterization (led by Maxime Devogèle)

• More to come...
955 NEA detections (multiple apparitions)  
> 850 individual NEAs  
+  
Main belt asteroids, comets, inner and outer planets
Arecibo recently discovered NEA detection history

RDs greatly benefit from radar astrometry. **Rapid response is crucial!**
The AO Planetary Radar system was the most powerful and sensitive in the world. **No existing facilities can replace the lost capabilities.**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
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<tbody>
<tr>
<td>Diameter</td>
<td>305 meters, Fixed dish</td>
</tr>
<tr>
<td>S-band (frequency)</td>
<td>12.6 cm, 2.38 GHz</td>
</tr>
<tr>
<td>Power</td>
<td>1 MW</td>
</tr>
<tr>
<td>Range resolution</td>
<td>as fine as 7.5 m</td>
</tr>
<tr>
<td>Radial velocity</td>
<td>precision as fine as mm/s</td>
</tr>
<tr>
<td>Declination</td>
<td>-1 to +38 degrees</td>
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</tbody>
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The importance of legacy Arecibo’s planetary radar for Planetary Defense:

- Schedule flexibility to observe recently discovered asteroids even within 24 hours of discovery by optical surveys
- Radar astrometry:
  - could rule out impact false alarms in minutes
  - increase orbit predictability window from a few years to centuries
  - Detect orbit perturbation
- Physical characterization of NEAs (important for asteroid deflection missions)
Science Outreach

• STAR Academy:
  • Supported by NASA’s Planetary Radar program
  • Opportunity for 9th-12th grade PR students to learn about planetary science research
  • Happens two semesters per year (spring and fall)

• Arecibo Planetary Radar outreach website: https://www.lpi.usra.edu/resources/asteroids/
### Planetary Defense and Solar System Exploration

| Post-discovery characterization and orbit determination of up to 90% of possible asteroid impactors | Study the surface and sub-surface of ocean worlds around Jupiter, Saturn and other Solar System objects | Observe asteroids in the outer regions of the main-belt and beyond |
| Space Situational Awareness (SSA) to categorize space debris down to mm-size in LEO, and smaller than one meter in GEO and cislunar space | Support NASA Human Exploration program by characterizing spacecraft landing sites and identifying potential hazards at low cost | Support and extend the science return of missions including NASA’s DART, Janus, Europa Clipper, and Dragonfly missions; and ESA’s JUICE mission |
An array of 1,112 dishes of 9 m in diameter within a ~314 m
An array of 400 dishes of 15 m in diameter within a ~331 m
Next Generation Arecibo Telescope:
- 5 GHz
- 5 MW power
- Zenith angle range of 48 degrees

Parameters considered for detectability plot:
- SNR of 6
- 1 hour of observation
- 140-m asteroid
- spin rate of 2.1 hours
- Radar albedo of 0.1

NGAT white paper:
http://www.naic.edu/ao/ngat

(Credit: Sean Marshall)
• Support from PR government: $8 million has been allocated (not available yet) for feasibility and engineering studies for the NGAT concept

• NSF Arecibo Options Workshop: June 2, 4, 10, 14, 16, 18, 28 (https://arecibo.hub.ki/)

• Short, mid, and long term ideas for Arecibo to be discussed for Planetary radar, Radio astronomy, Space and Atmospheric Sciences