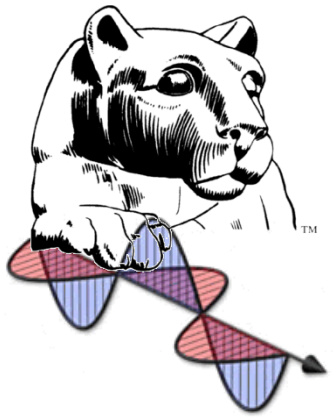
The New Arecibo HF Facility Dual Array Cassegrain Antenna

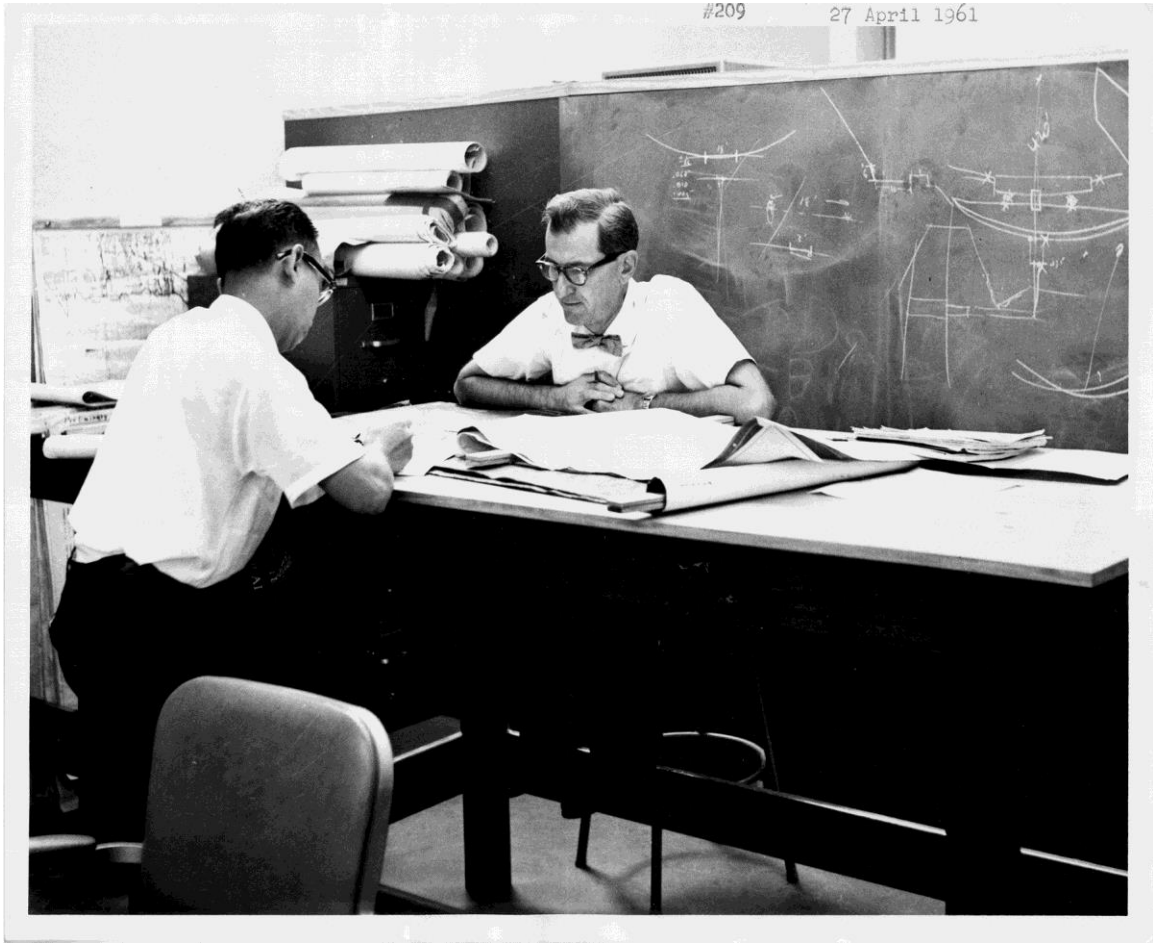
Prof. James K. Breakall
Señor "Rompe Todo"
Electrical Engineering Department
Penn State University



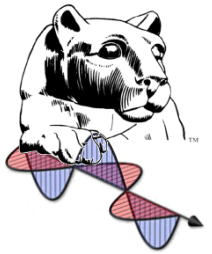
Arecibo Observatory 50th Anniversary
Arecibo, Puerto Rico
October-November, 2013

PENNSTATE

Dr. William Gordon in 1961



Previous HF Heating Facilities at Arecibo



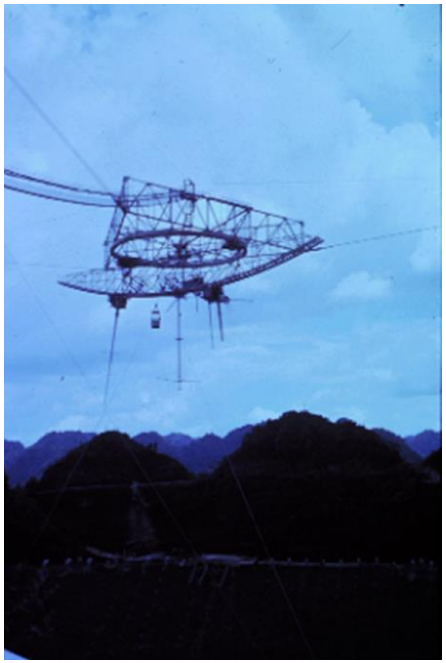
- Crossed log-periodic antenna located on-site at the observatory
- Islote - Log-periodic array located off-site

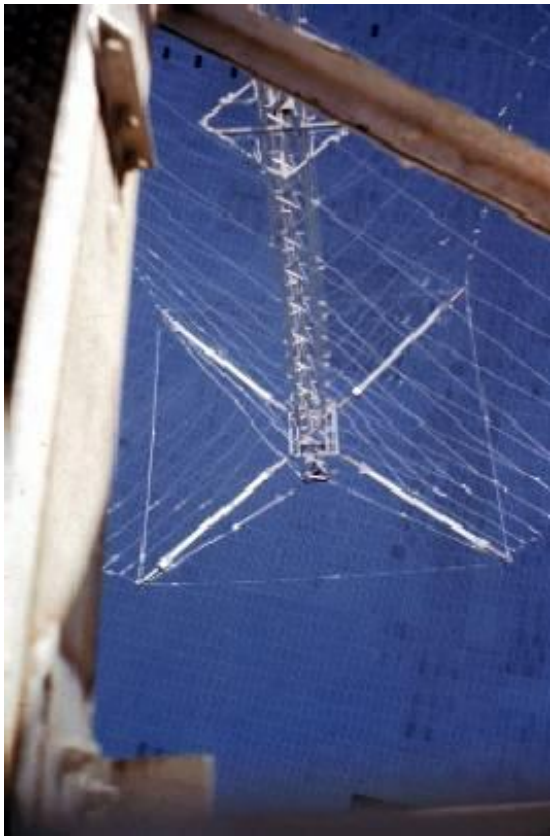
First HF Heating Facility

- Log-periodic antenna was located over the main dish, pointing downward
- Use was discontinued when the antenna developed arcing and corona problems

- Bandwidth from 3 – 10 MHz
- Fed with 100 kW source
- Gain Estimated 40% of Aperture

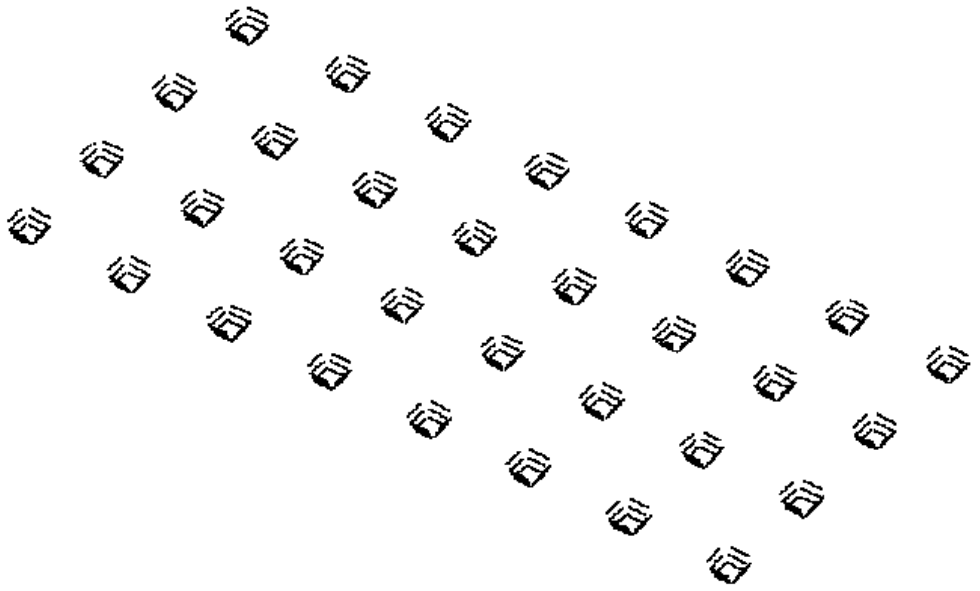
Past Log-Periodic Dish Feed





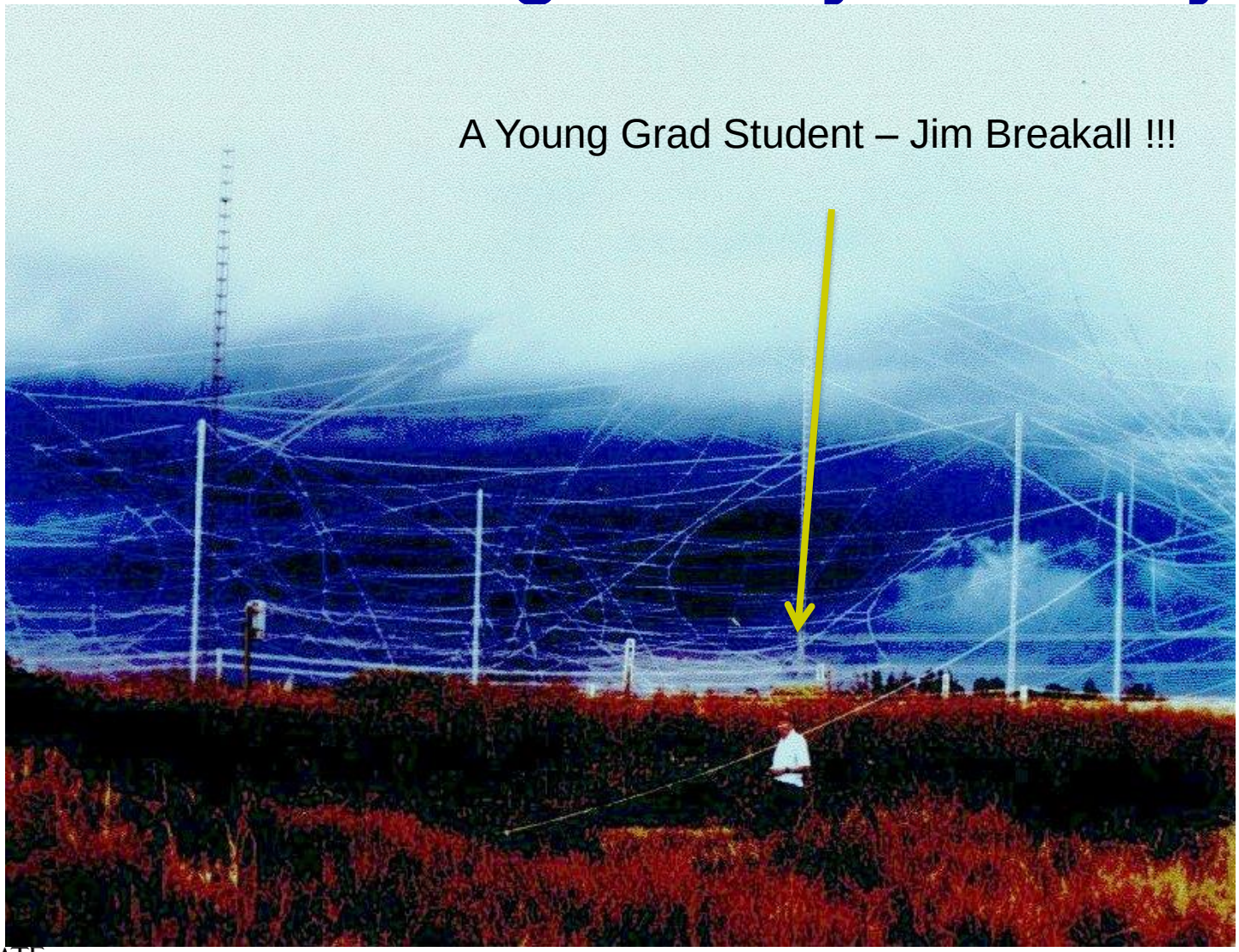
Second HF Heating Facility

- Consisted of a pyramidal log-periodic array with 32 elements
- Was destroyed in Sept. 1998 in Hurricane Georges

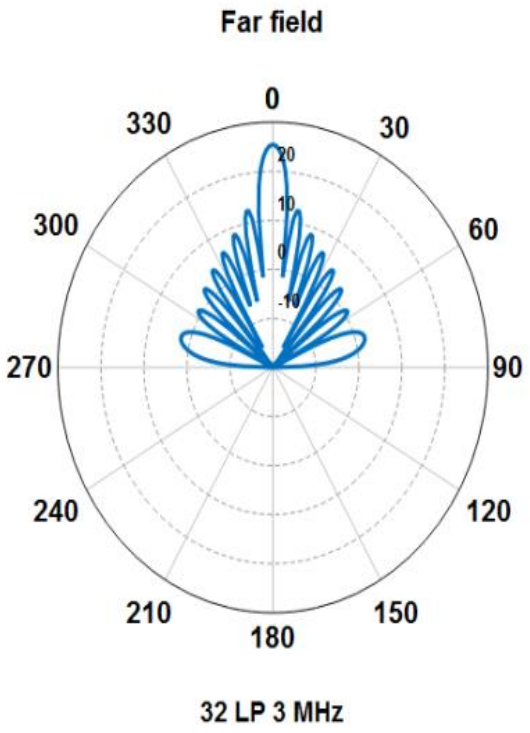


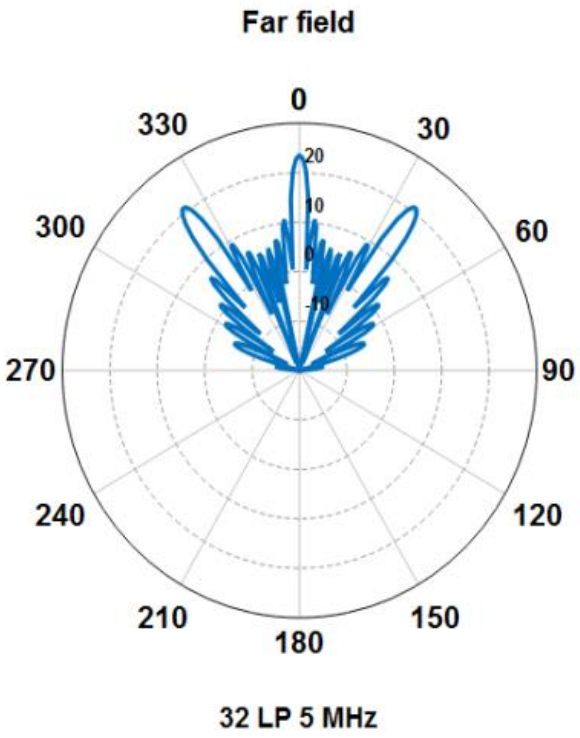
- Constant Gain: 23 dBi
- Bandwidth: 3 - 8 MHz
  BUT Grating Lobes!
- Radiated Power: 600 kW

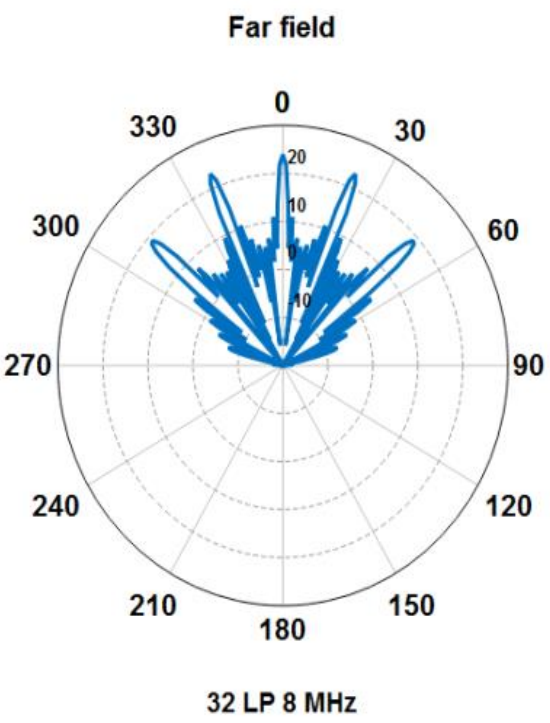
Islote Heating Facility LP Array



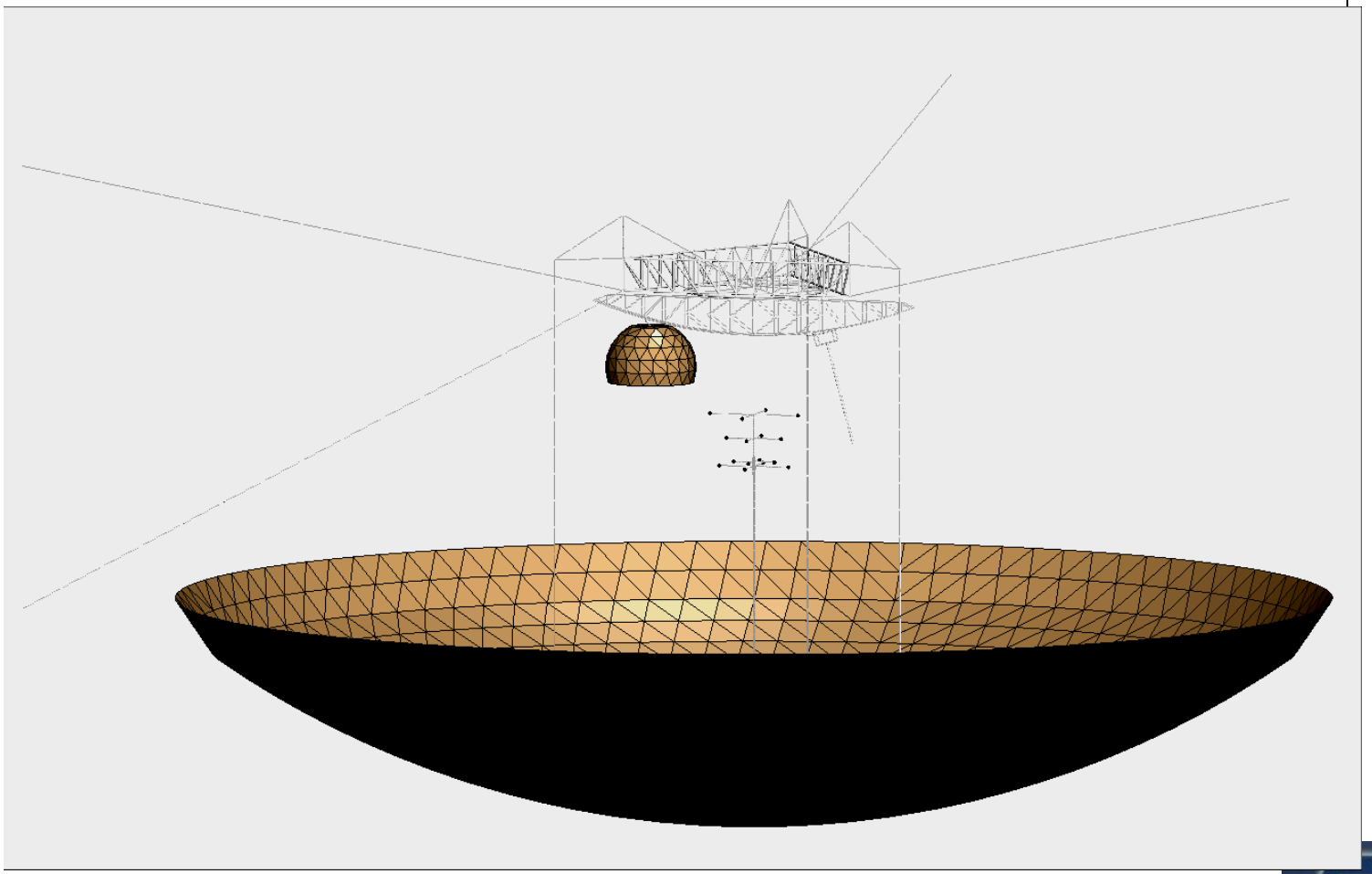
Radiation Patterns of Islote 32 Log Periodic Array – Grating Lobes







First Design of Full HF Interactions Facility Simulation Model



Full Crossed-Dipole Yagi Feed Simulation Model

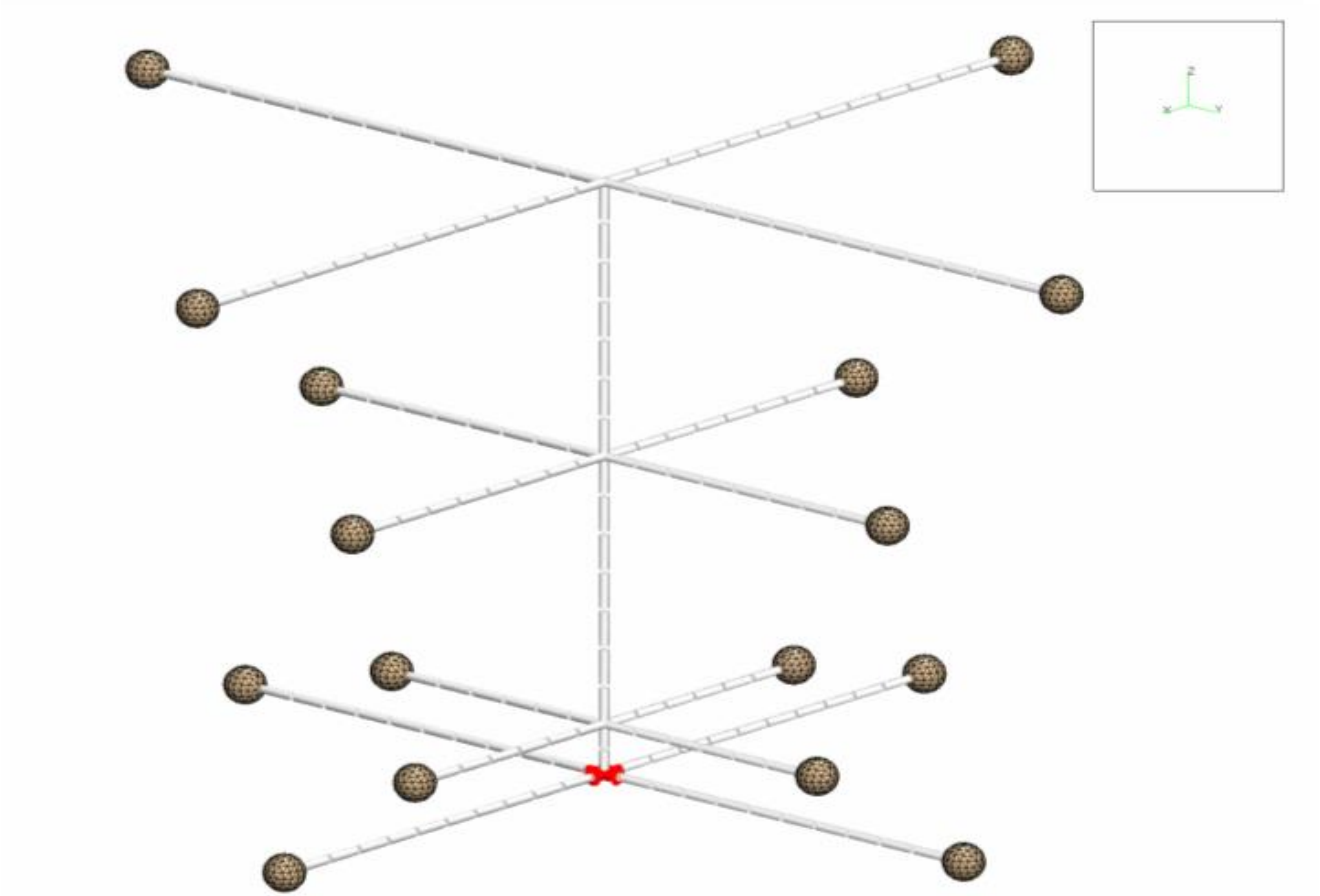
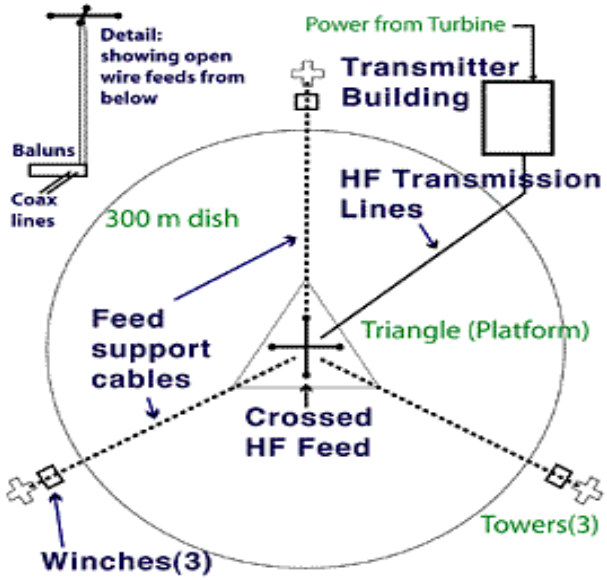
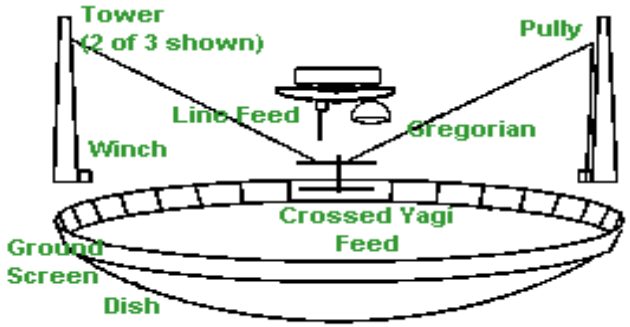


Diagram of Proposed Antenna

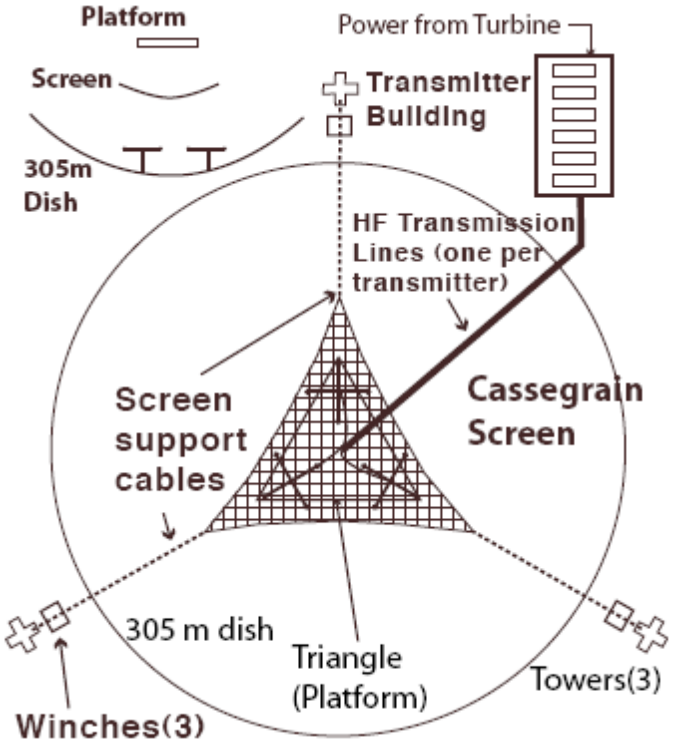




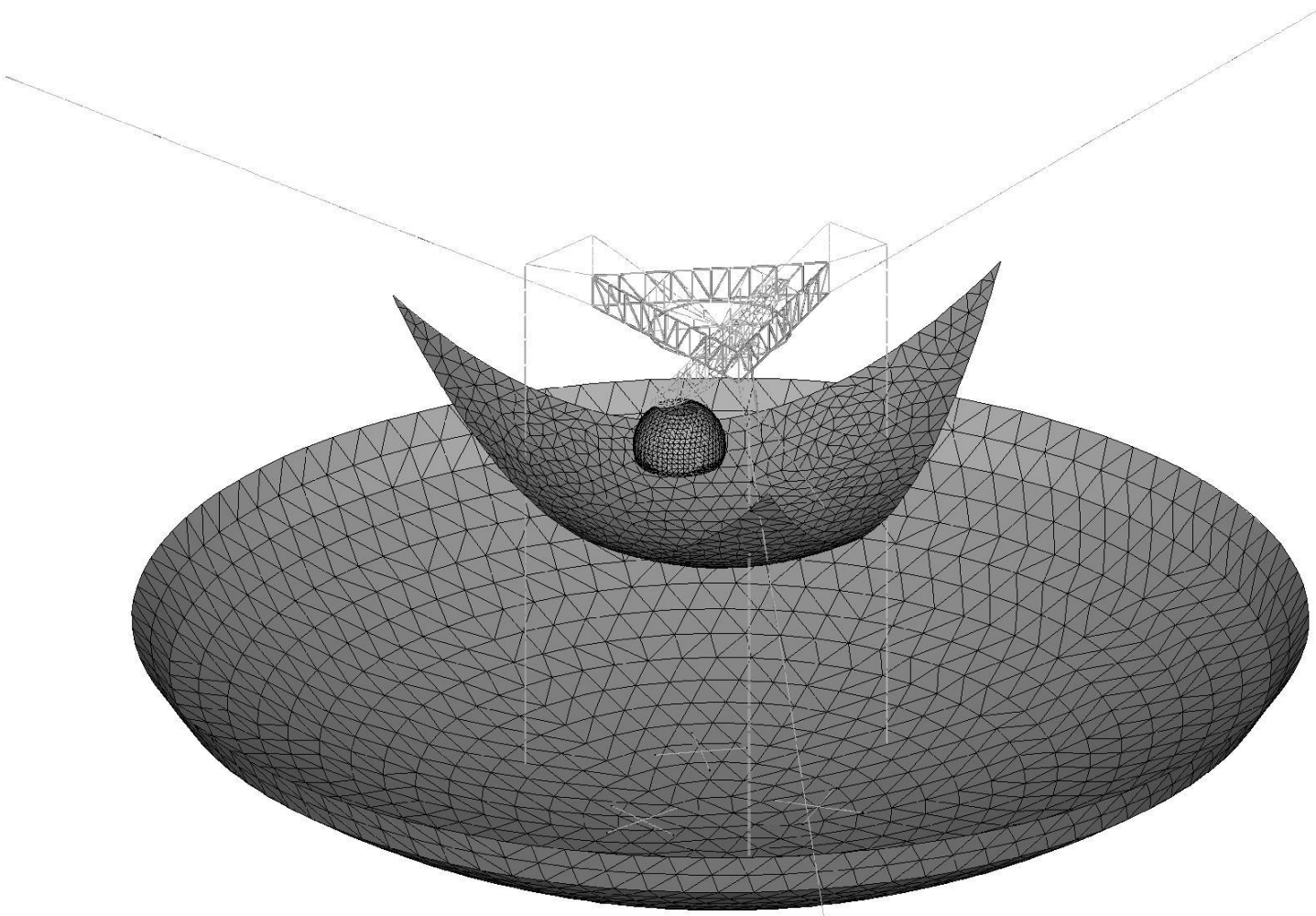
Near Electric Field Measurements
Construction of Full Size Prototype Dipole

Proposed New HF Heating Facility

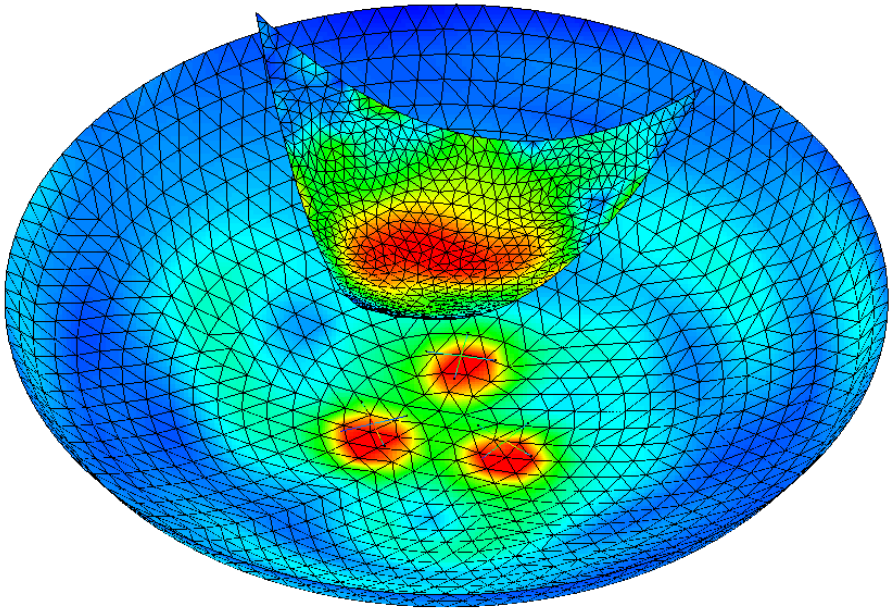
- Located on-site at the observatory
- New antenna design uses a cassegrain system with a subreflector suspended from the upper platform
- Cassegrain will be fed with a phased array of crossed dipoles located close to the main dish
- Operating frequencies centered at 5.1 and 8.175 MHz



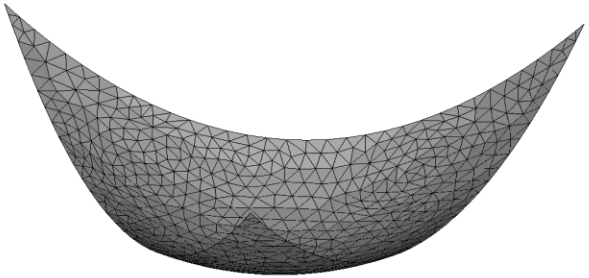
Full FEKO Original Subreflector Model

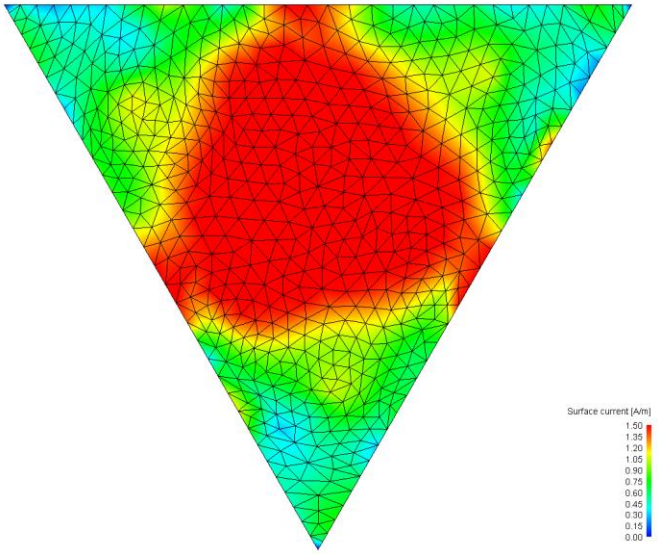


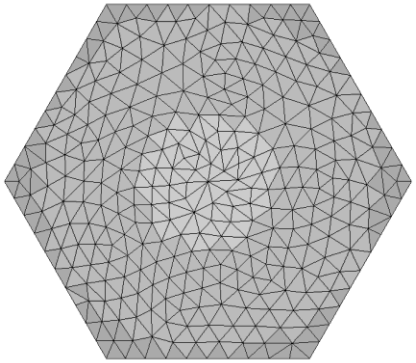
Surface Current Animation

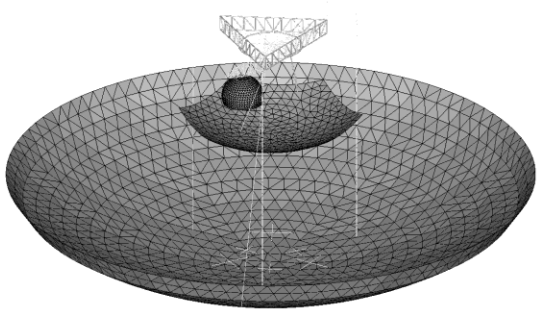


Re-design of Subreflector



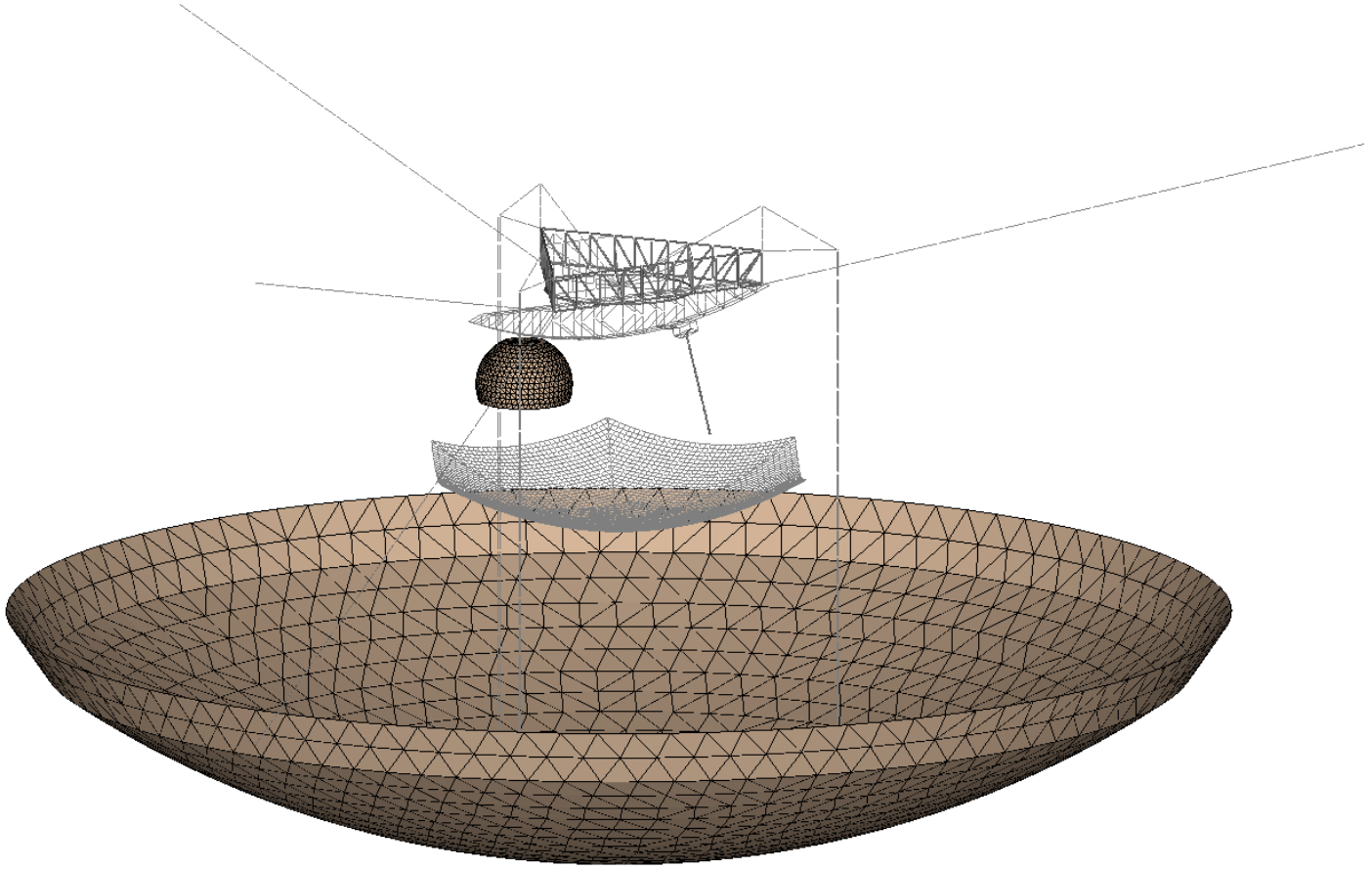




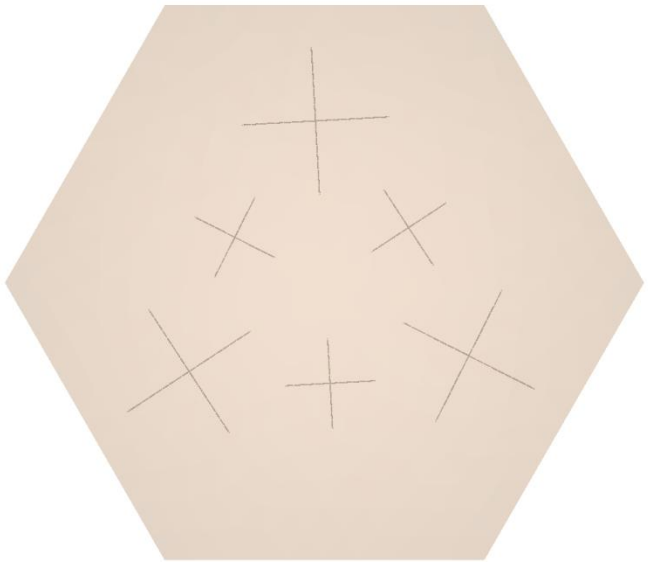


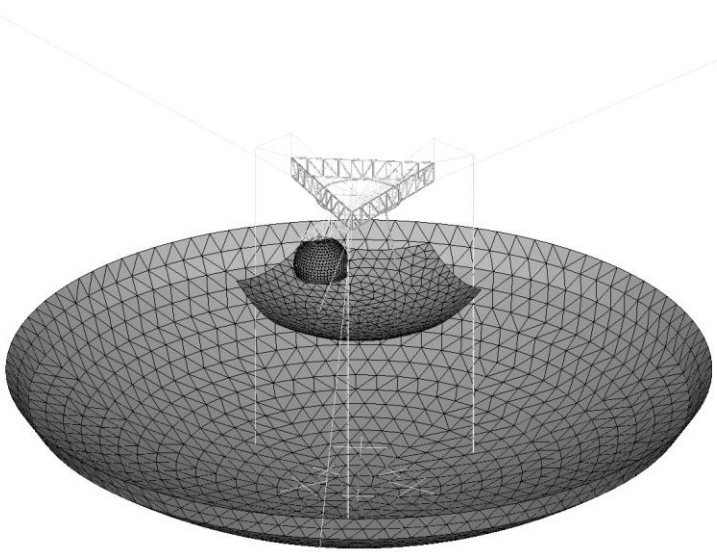
PI

FEKO Model with Wire Subreflector



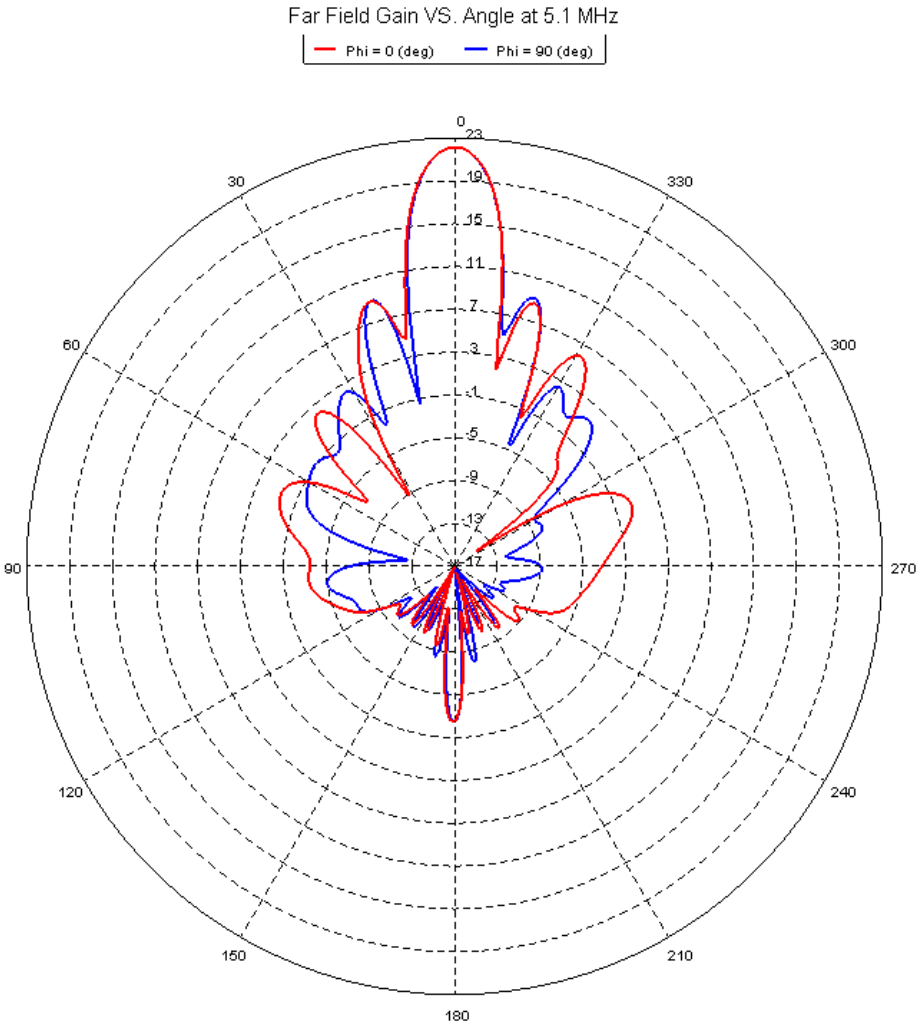
Final Design





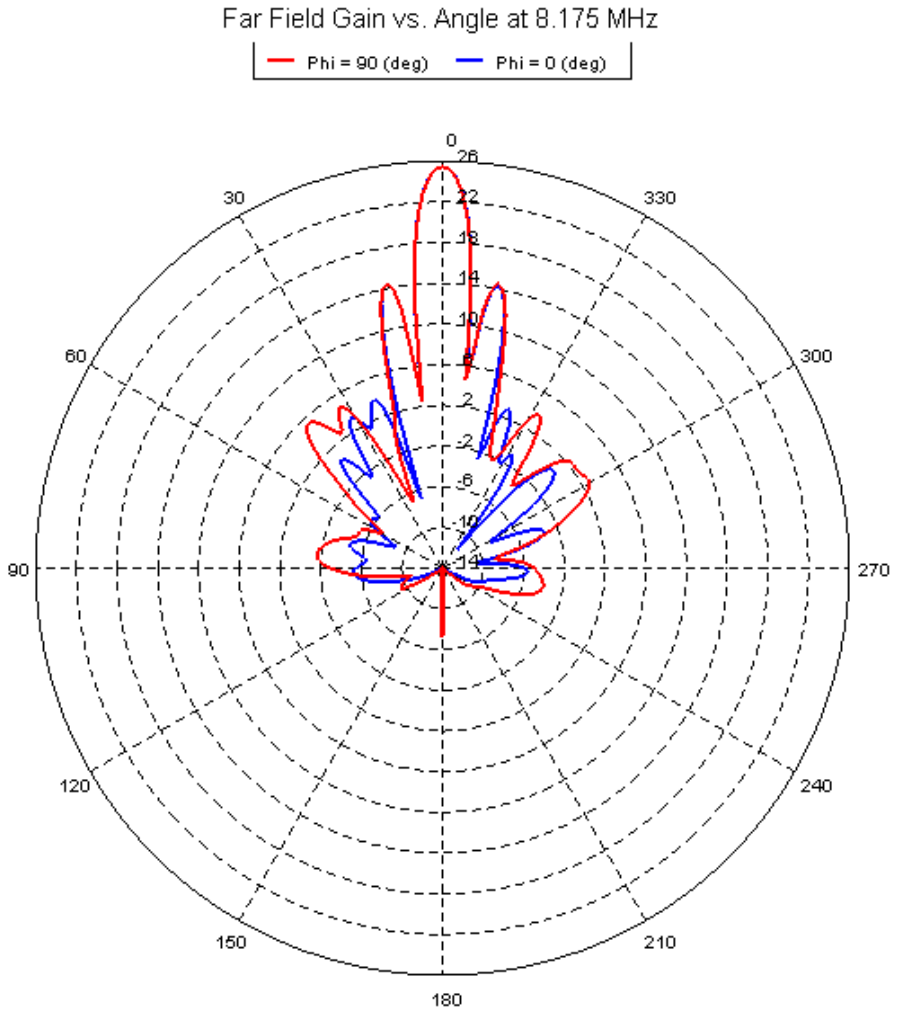
Final Design Gain 5.1 MHz

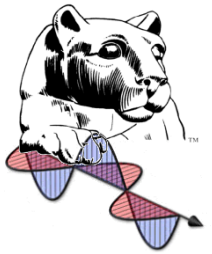
- **Main beam gain 22.16 dBi**



Final Design Gain 8.175 MHz

- **Main beam gain 25.46 dBi**





In Terms of ERP

- Old Log-periodic dish feed(est. 40% of Aperture)
- ERP(3 MHz) = 3.7MW (100kW transmitter power)
- ERP(5.1 MHz) = 10.6MW (100kW transmitter power)
- ERP(8.175 MHz) = 27.3MW (100kW transmitter power)

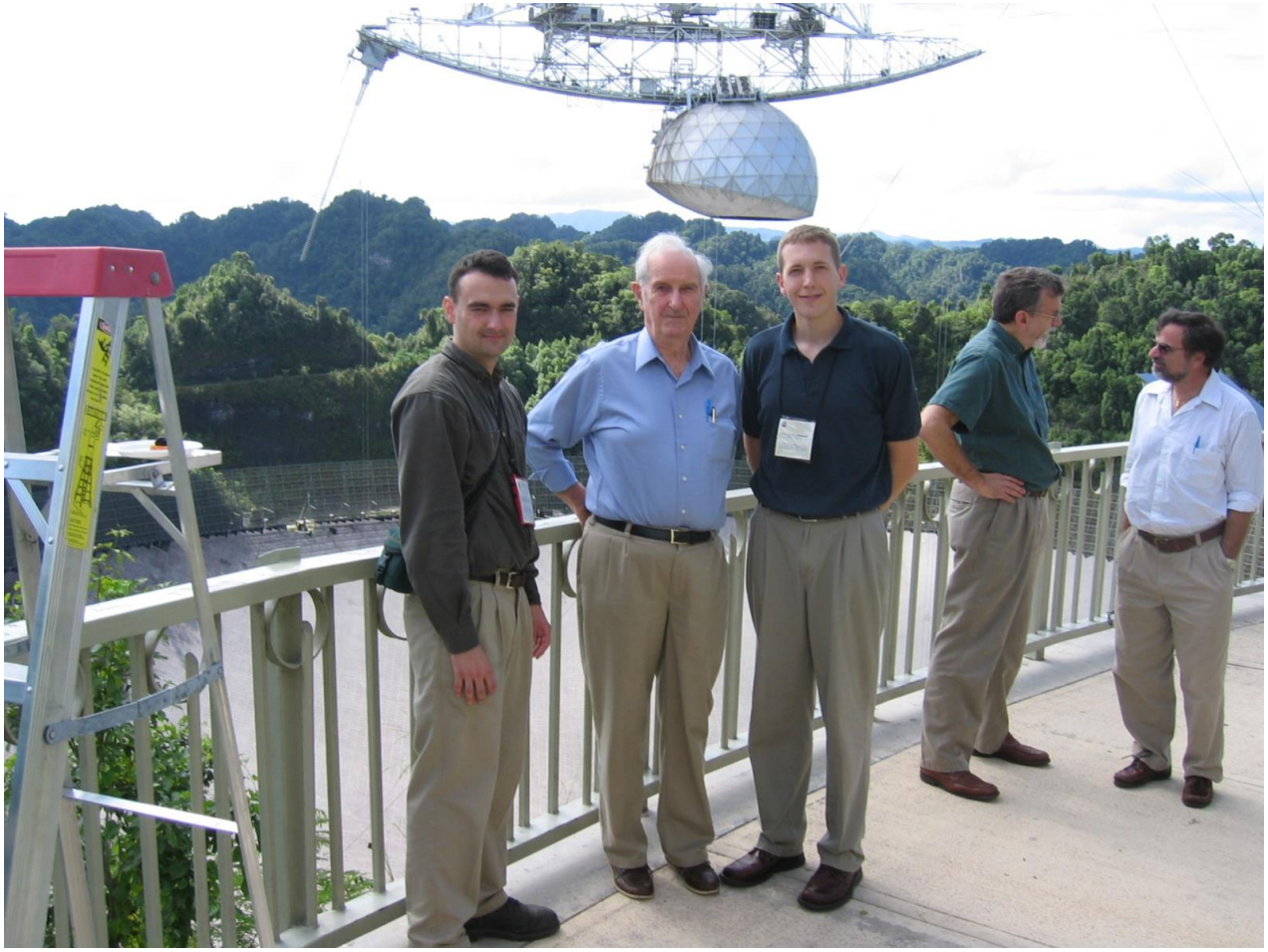
- Islote 32 Log-periodic array
- ERP(3 to 8 MHz) = 79.8MW (400kW transmitter power)

- New HF Design
- ERP(5.1 MHz) = 99.6 MW (600kW transmitter power)
- ERP(8.175 MHz) = 212.9 MW (600kW transmitter power)

New HF Array at Bottom of Dish (Still Under Construction)

Dr. Bill Gordon, Rey Velez, and me (21 years old!) working on original HF Heating Design

Dr. Bill Gordon with Penn State Graduate Students at 40th Anniversary



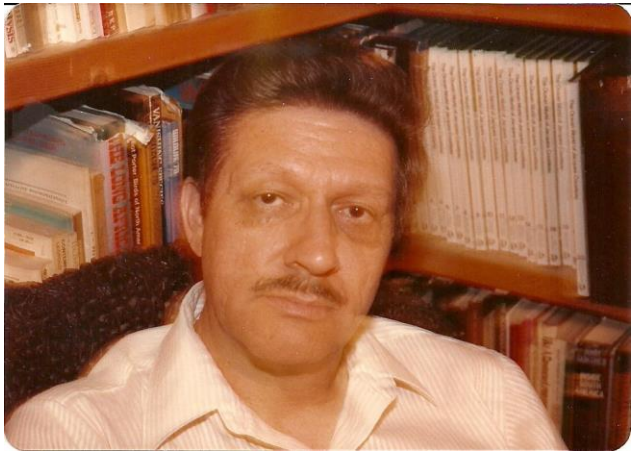
Señor Rompe Todo with PR Mafia

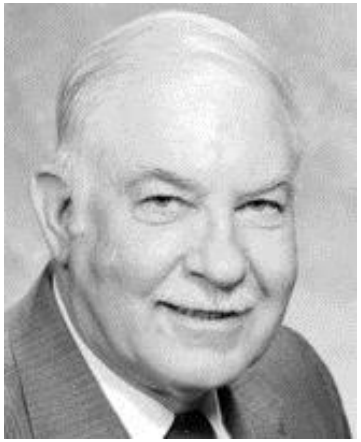
PR Godfather

Here I am on New England Public TV about Ham Radio from 100 ft Dish

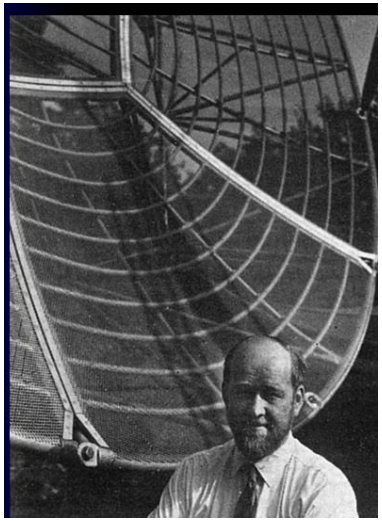
John Denver look in 1977

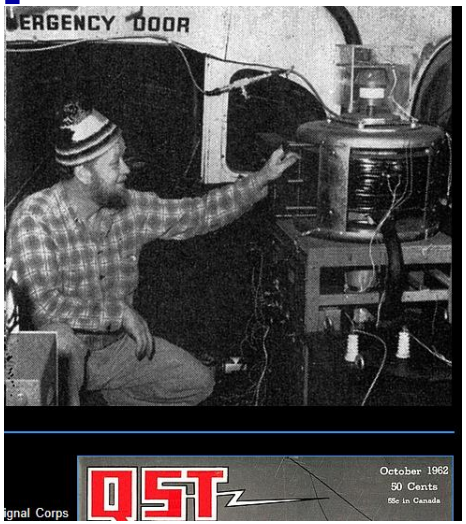
I Owe a Lot to These People!!!

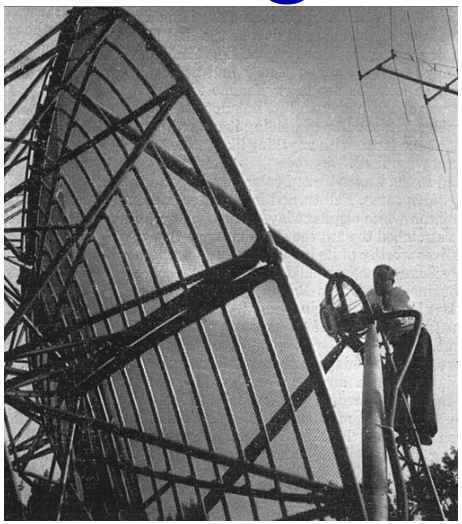


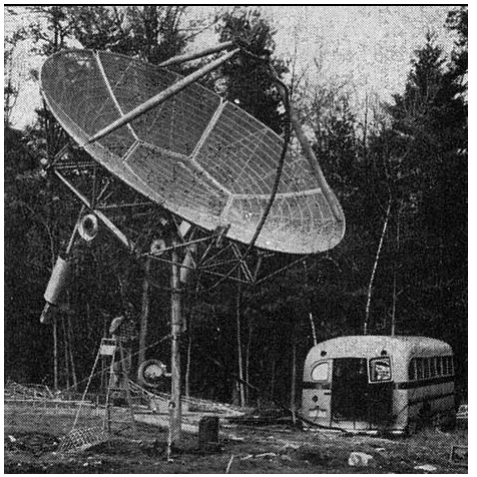


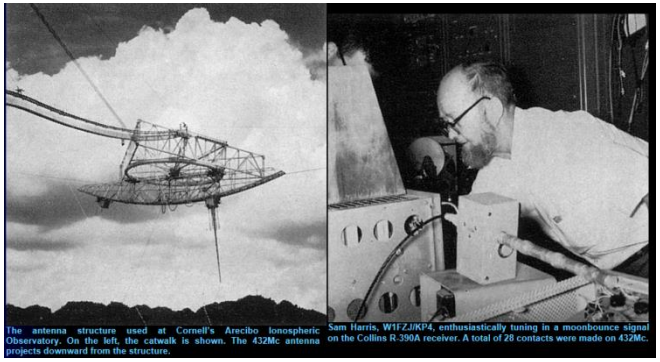
Sam Harris – A Real Inspiration and Legend

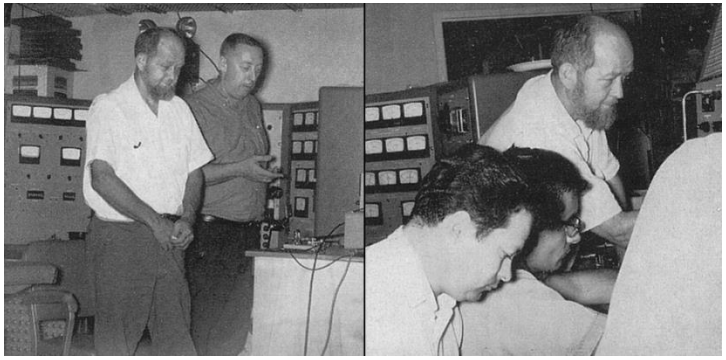










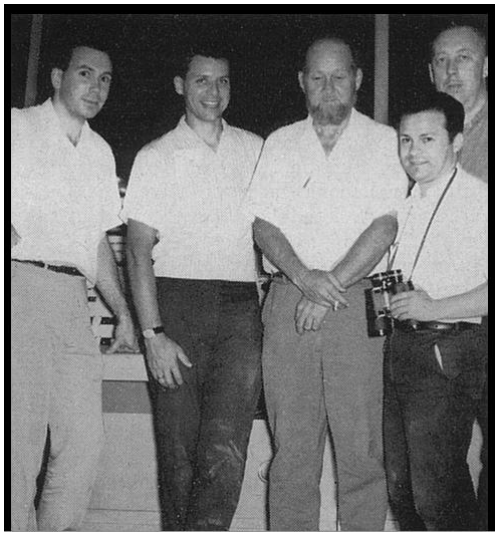


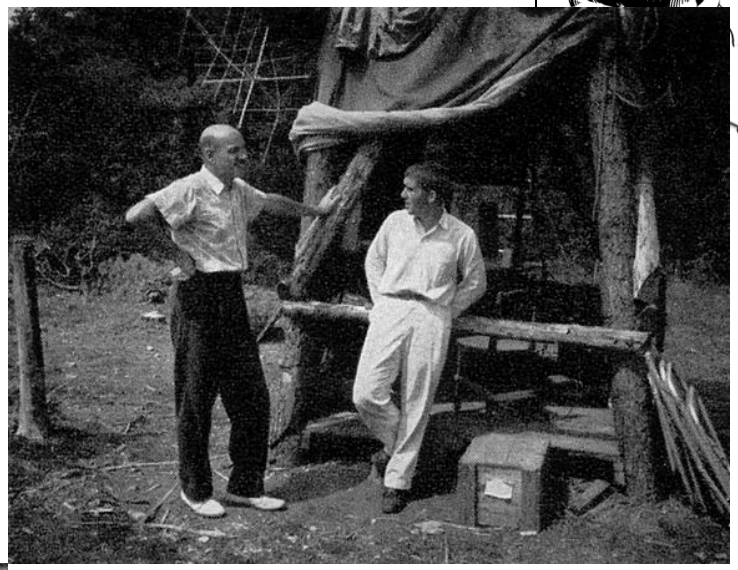
PENNSTATE

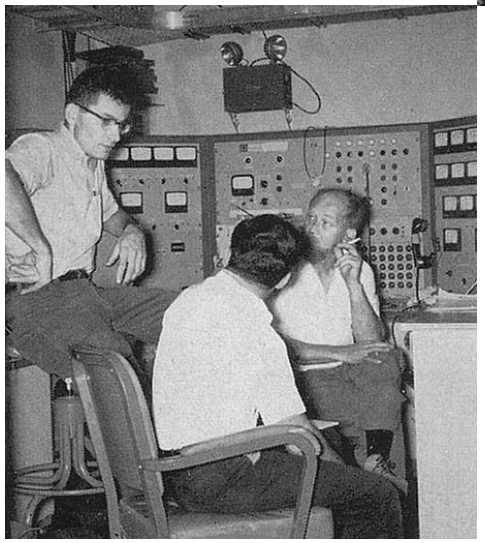
1855

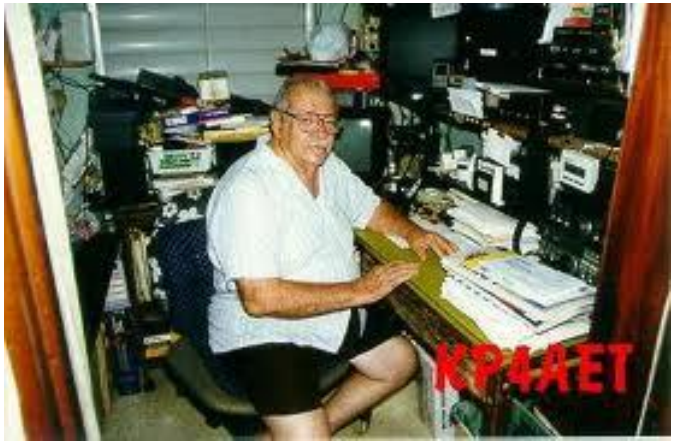
50th ANNIVERSARY

More Arecibo Hams

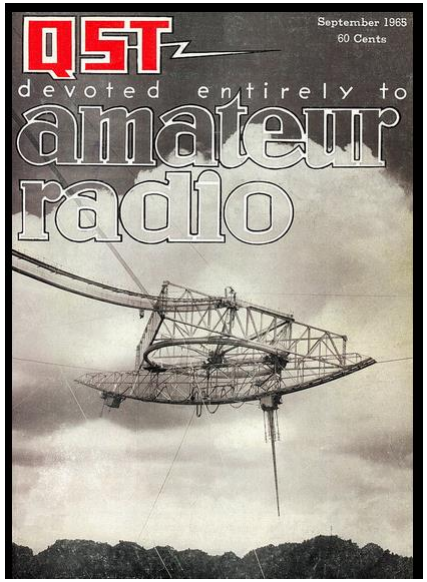








Moonbounce at Arecibo



Arecibo 10th Anniversary

Arecibo Observatory Celebrates Tenth Birthday

The discovery of mountains on Venus, thick dust on the moon, Mercury's spin, a new superdense form of matter, a number of pulsars and the nature of the ionosphere were some of the candles on the cake for the radio telescope at the Arecibo Observatory as scientists celebrated the instrument's tenth birthday Nov. 1.

Rising stark white and 565 feet in the air out of a blue-green jungle in the mountains of Puerto Rico, the concrete and steel structure has been a mecca for radio astronomers from all over the world, interested tourists and scores of graduate students, 28 of whom earned their doctoral degrees with the aid of data gathered in observations at Arecibo.

The observatory is part of the National Astronomy and Ionosphere Center (NAIC), a national research center operated by Cornell University under contract with the National Science Foundation (NSF). The NAIC has a staff of 166 members in Ithaca and Arecibo. Harold D. Craft Jr. was recently named director of operations at the observatory.

The telescope itself, the largest of its kind, is indeed getting better and not older. Ten years of constant adjustments, improvements, additions and innovations have increased the instrument's sensitivity a thousandfold. *(See photo feature on Pages 4-5.)*

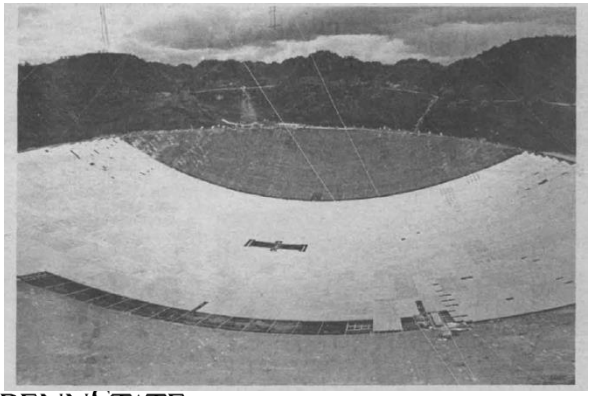
"We can now map distances on Venus with accuracies better than the length of a city block," said Frank D. Drake, NAIC director and professor of astronomy at Cornell. "There are areas of the earth we don't know as well as that."

Described in the press as "the world's biggest eye," "the world's largest ear," "a spidery mechanism on a web of steel," the radio telescope at Arecibo can reach farther into deep space than any other instrument built by man. Its 1,000-foot reflector bowl has collected radio signals emitted by quasars — mysterious star-like objects which appear to exist at the edge of the universe.

Radio signals, like light, are emitted by stars and galaxies, and can be bounced off the surfaces of planets in radar experiments. Unlike light, they can be observed right through clouds or dust with equal strength in daytime and nighttime. Radio energy from some sources requires more than 10 billion years to reach the earth. Celestial radio signals are so faint that all the energy collected in the 40-year history of radio astronomy is about equal to that released when a few

(Continued on Page 6)

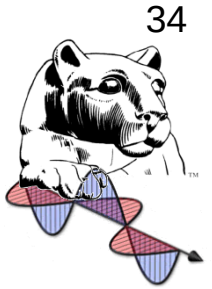
2 Cornell Reports November, 1973



The rugged terrain of the area makes overland trucking of large objects difficult, so the aluminum panels are assembled in a factory right at the telescope site.

Vegetation growing wild under the dish figures significantly in holding down the topsoil in which the cement cable anchors are rooted. The new surface will let in considerably less sunlight — about as much as reaches the surface of the planet Mars.

Arecibo Triple Moonbounce



26 Nashua Telegraph, Thursday, May 11, 1972

Scientists Discover New Game Of Interspace Handball

Bounce Radar Beams Between Earth and the Moon

By WARREN E. LEARY

CAMBRIDGE, Mass. (AP) — Astronomers playing a kind of interspace handball game have succeeded in triple-bouncing radar beams between the earth and the moon.

This unprecedented triple bounce allows earth-based scientists to make radar studies of the earth as if from a radar telescope on the moon a quarter of a million miles out in space.

In Puerto Rico

The experiments were performed at the world's largest radar telescope in Arecibo, Puerto Rico, which is operated by Cornell University for the National Science Foundation.

Professor Gordon H. Pettengill, of the Massachusetts Institute of Technology, was the principal investigator on the experiment team, which included Donald Campbell and Rolf Dyce, both of the National Astronomy and Ionosphere Center at the Observatory.

Pettengill said that the experiment failed on previous occasions, but in January, a more powerful transmitting and receiving system was used.

Radar studies of the moon and other planets have given much data on the surface characteristics, and in the case of Venus, have allowed man to "see" through the continuous cloud cover to chart mountain ranges.

A Fixed Bowl

The Arecibo Observatory's huge radar reflector is a fixed bowl of wire mesh 1,000 feet in diameter. Because it can't be moved, it can only collect signals from areas in the Caribbean and the Atlantic Ocean areas.

Future facilities with greater flexibility should be able to scan much wider areas of earth.

Scanning ocean areas is fine for now because water reflects radar beams much better than land and the relatively weak

The Arecibo facility is being upgraded and by 1974, the radar telescope should have another hundred-fold increase in sensitivity. Pettengill predicts that this will lead to further refinements in studying the earth from the moon, including studies of dry land.

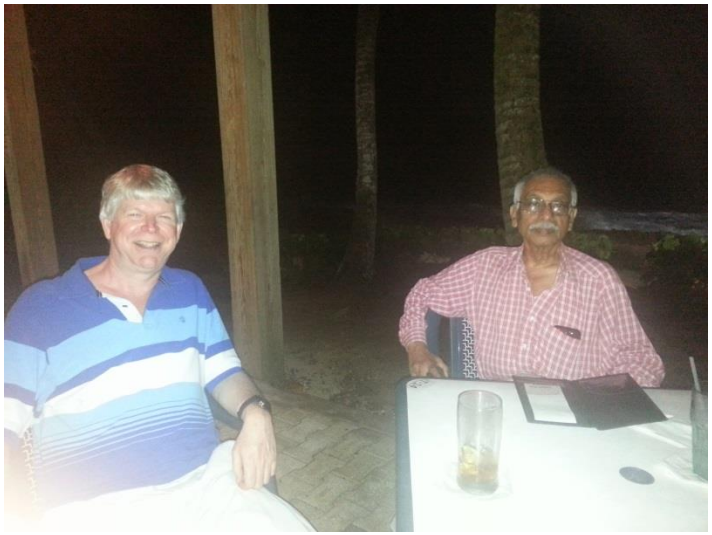
"We have just crossed the threshold of such studies," Pettengill said.

"When the Sky Lab (manned space station) is orbited in 1973, radar studies of earth from the moon should amplify and supplement data taken by its orbiting telescope," Pettengill said.

DON'T EVER FORGET

Some Old Arecibo Hangouts!!

- El Farol – The place to eat in those days!!
- The Peking Restaurant – Chinese in Town
- Grand Café – Great Carne Mechada
- Buen Café – Not Grand, Just Good
- Greens – Mexican
- The Scorpion



Mi Hermano