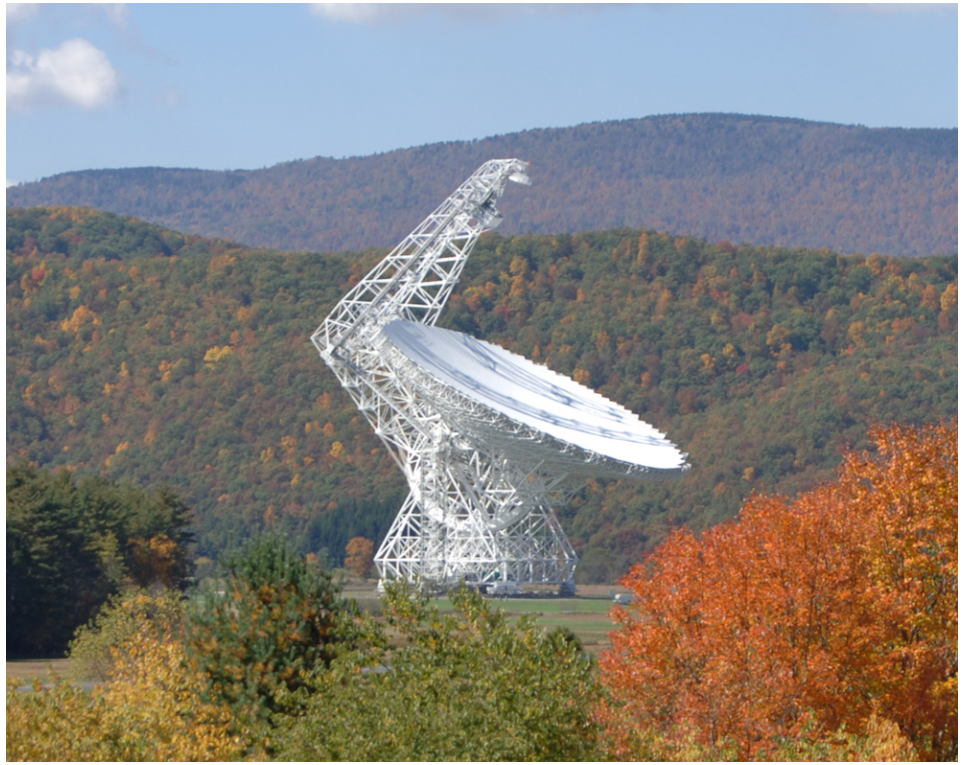
The GBT-VLBA Planetary Radar Program



Walter Brisken, Patrick Taylor, Flora Paganelli, Tony Beasley, Stephen Wilkinson, Bishara Shamee, & Aaron Wallace

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GBT as a radar receiving station: Venus

Arecibo transmit, 2.4 GHz, 2001

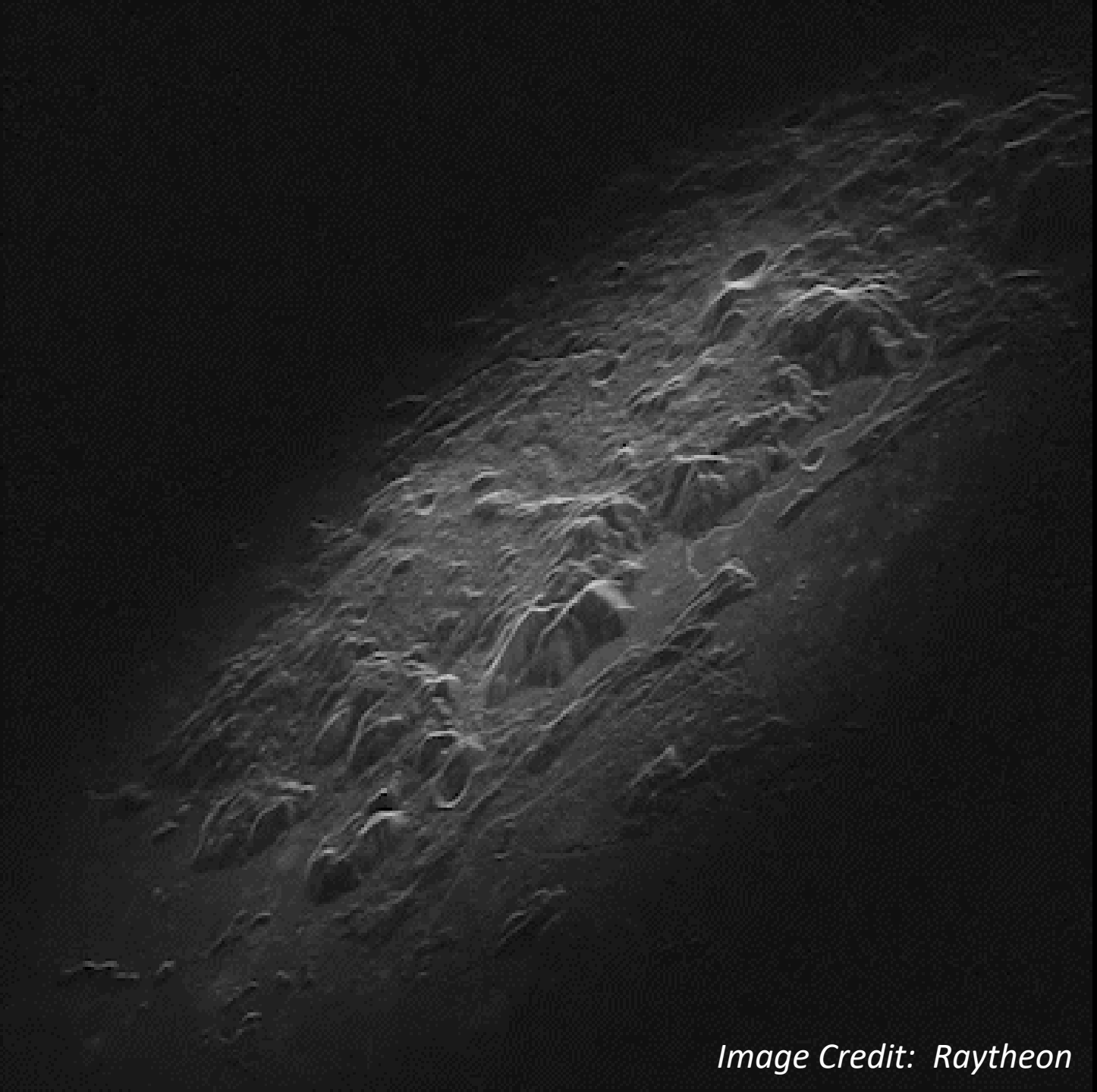


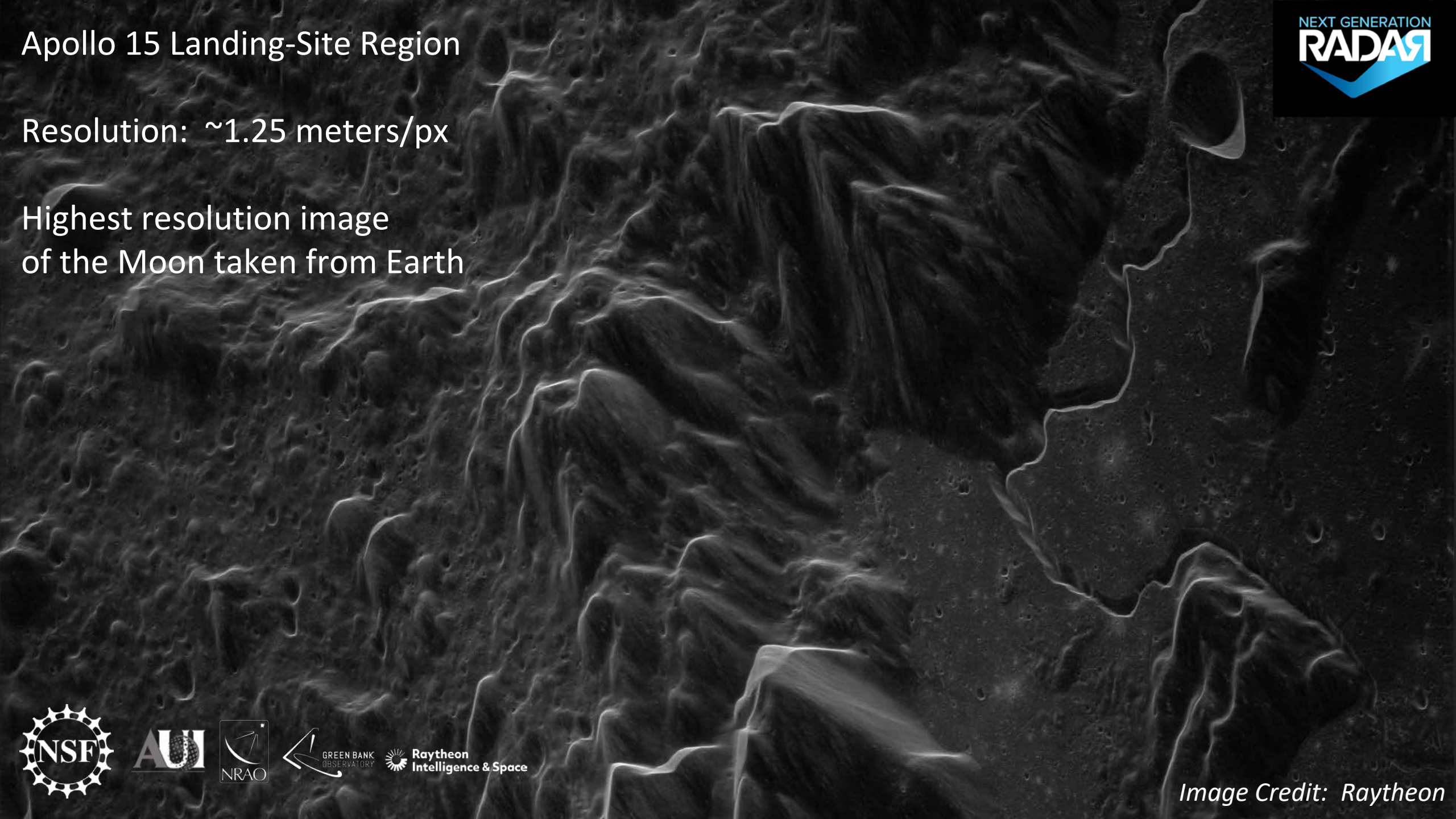
Image Credit: Raytheon

Pilot Observations

- Transmitter designed and built by Raytheon
- Mounted at prime focus on the GBT
- Ten 25-m VLBA antennas received echoes
- Solid-state amplifier technology
- Transmitter Frequency: 13.9 GHz (Ku band)
- Output Power: up to 700 W (continuous)
- Waveform Bandwidth: up to 200 MHz (~1 m)

- Observations completed in 2020/2021
  - Moon, space debris, and asteroid

- Left: "Spotlight" radar images of the Apollo 15 landing-site region


Apollo 15 Landing-Site Region
Resolution: ~1.25 meters/px
Highest resolution image
of the Moon taken from Earth
NEXT GENERATION
RADAR
NSF
AUI
NRAO
GREEN BANK OBSERVATORY
Raytheon Intelligence & Space
Image Credit: Raytheon

Tycho crater: ~85 km

Resolution: ~5 meters

NEXT GENERATION RADAR

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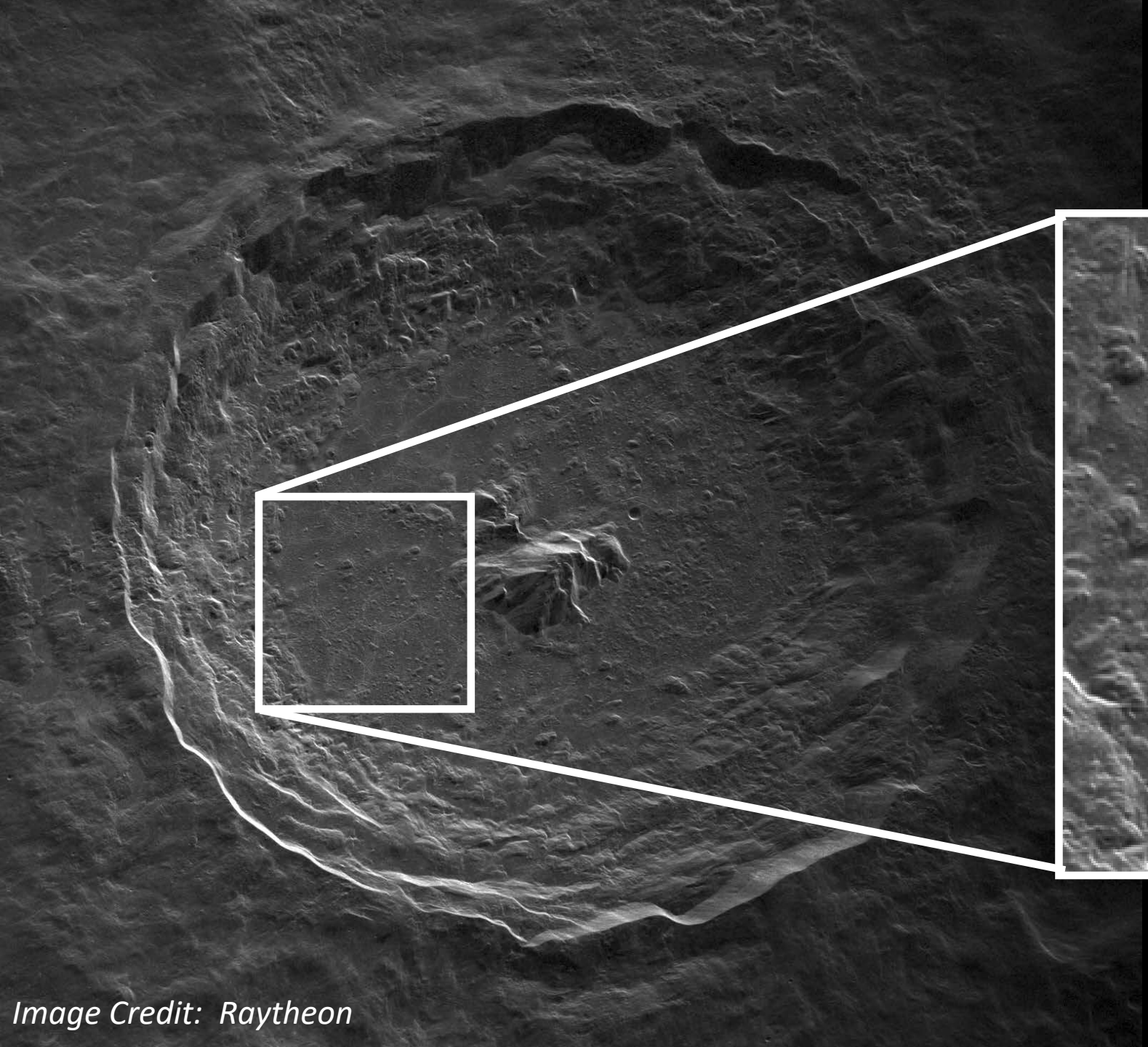
Image Credit: Raytheon

Tycho crater: ~85 km

Resolution: ~5 meters



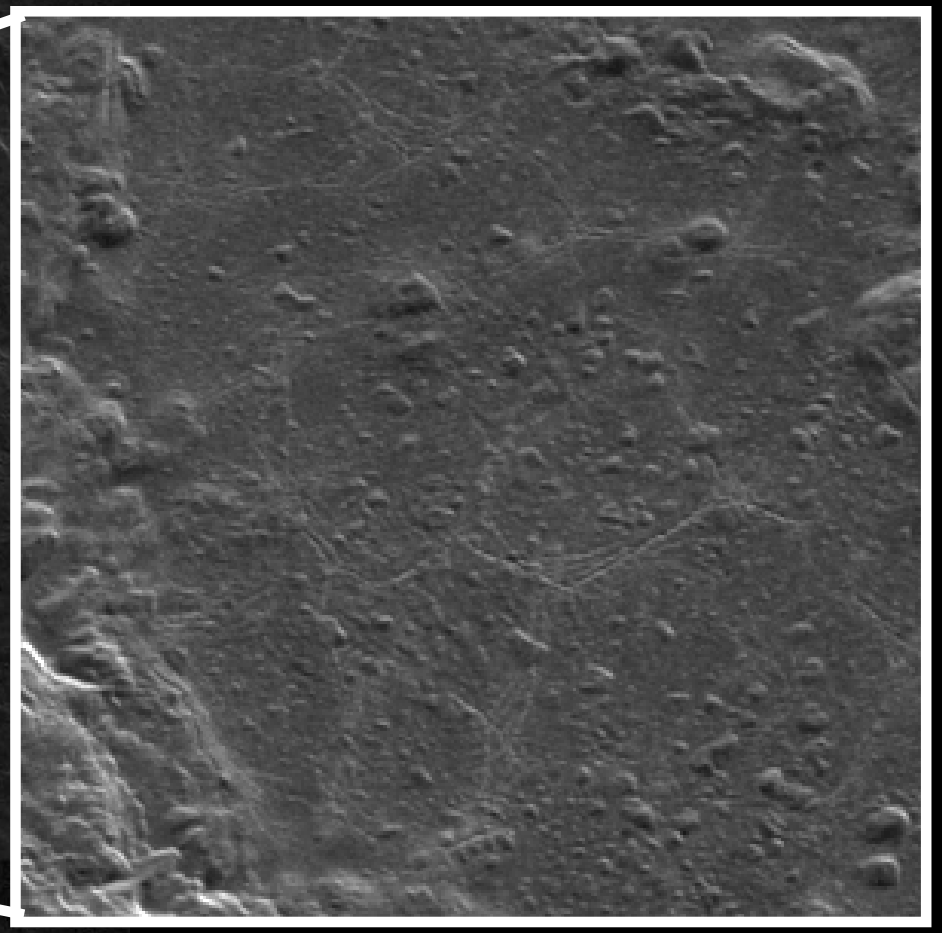
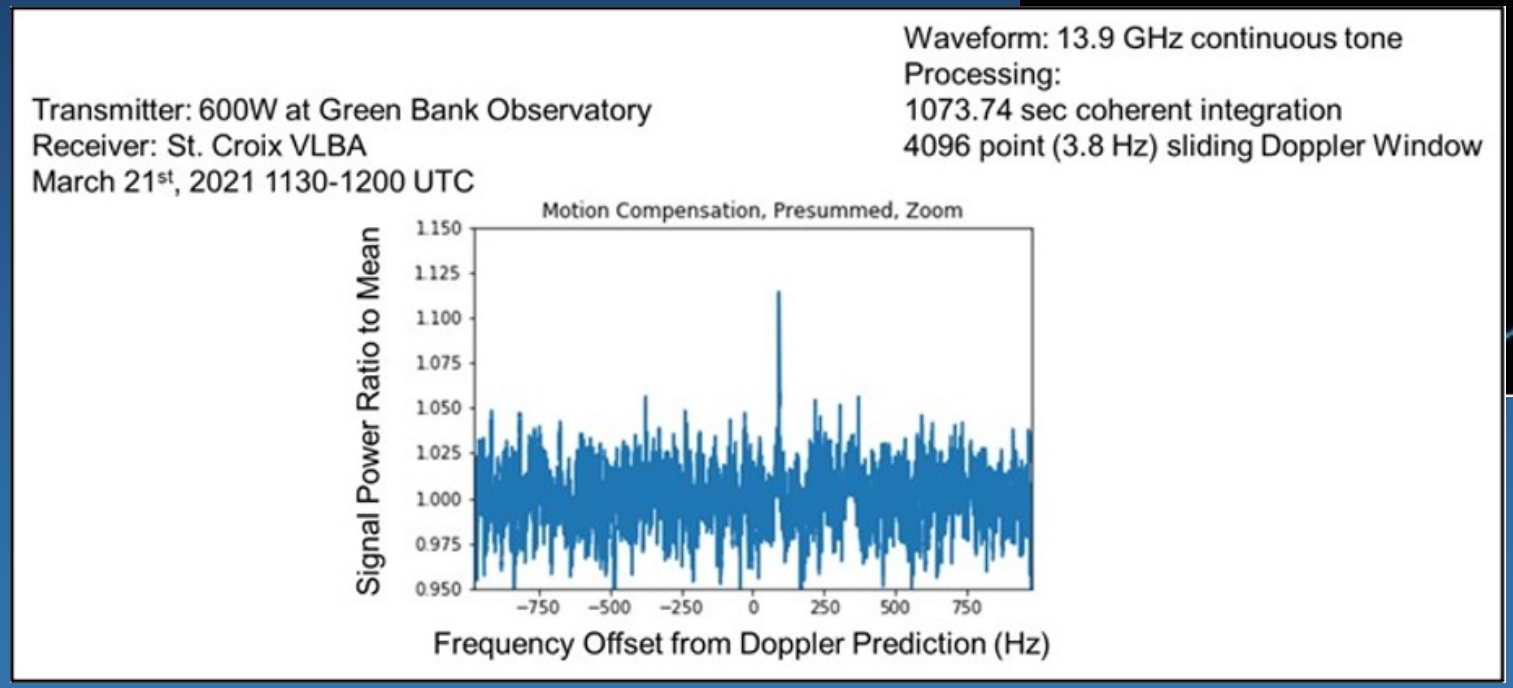
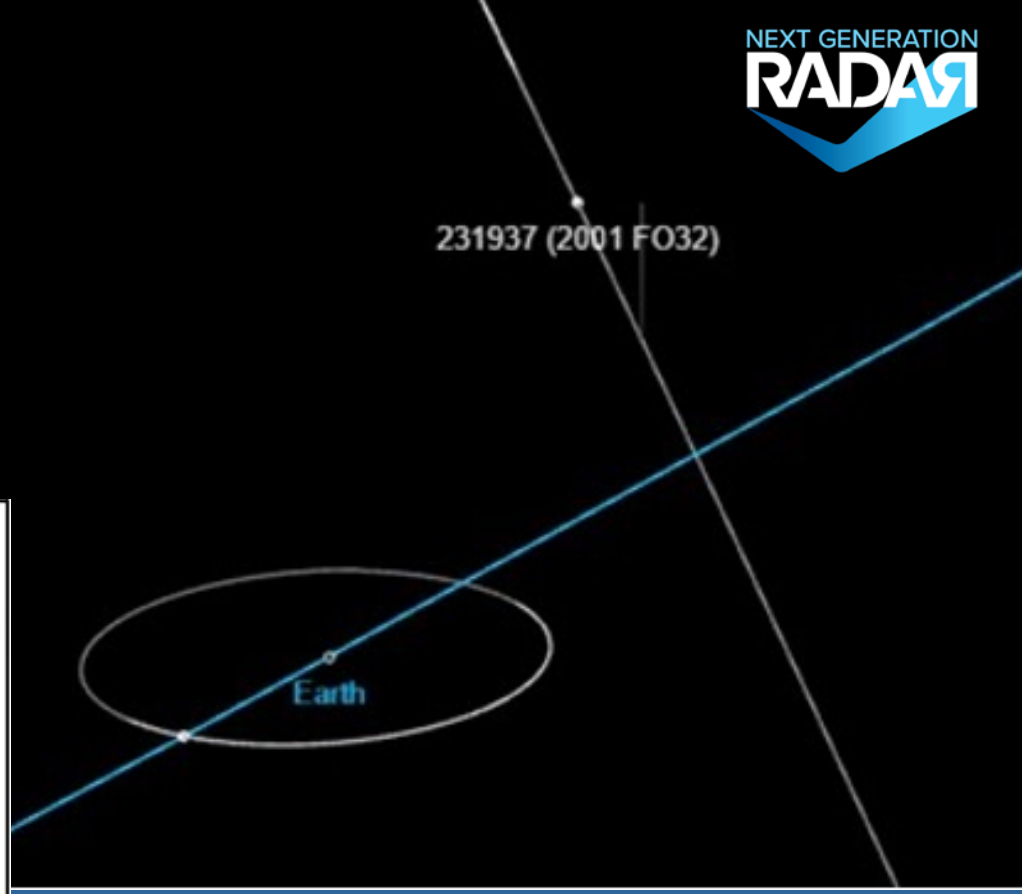


Image Credit: Raytheon

(231937) 2001 FO32

- "Potentially hazardous" asteroid
- Detected at >2 million km with 600 W
- First with a transmitter on the GBT!





Radar provides information valuable to calculate, monitor, and mitigate Earth-impact risk

NEXT GENERATION RADAR

Next Generation Planetary Radar with the Green Bank Telescope

Science ngRADAR website:

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A Next Generation Planetary Radar on the GBT

- ***ngRADAR***: A multi-static, high-power, solid-state, deep-space radar (500 kW at 13.7 GHz) for planetary science, defense, and space situational awareness
- Demonstrated compelling radar results with a pilot system with potential for:
  - Meter-scale imaging of the Moon from the ground
    - *Geology and dynamics*
  - Detecting, tracking, and characterizing space debris in cislunar space
    - *Safety and security*
  - Detecting, tracking, and characterizing NEOs for planetary defense
    - *Impact hazard assessment and mitigation planning*
  - Studying solid bodies across the Solar System for planetary science
    - *Physical and dynamical characterization*

Scientific capabilities of ngRADAR + VLBA

- Lunar imaging
  - Resolution as good as 0.5 meters; can we see signs of human activity?
- Asteroids
  - Characterize near-earth objects as small as 20 meters at 10x lunar distance
  - Image main-belt asteroids -> surface properties, binarity, dynamics
- Planets and moons
  - Inner planets, Jovian and Saturnian moons

Status of the ngRADAR Project

- Concept design funded by an NSF Mid-Scale Research Infrastructure award
- Concept design review expected in Spring 2023
- Seeking construction funding for 2024 and beyond

- ngRADAR will be a significant infrastructure project on the GBT

- Soliciting input from the community, *e.g.*, science desirables, data products, science/technical advisory roles
  - Public ngRADAR website: public.nrao.edu/next-generation-radar
  - Science ngRADAR website: ngradar.nrao.edu
  - Join our mailing list on the science site above!