



NRAO and Spectrum Management

Chris De Pree, Deputy Spectrum Manager

CORF Meeting, November 20-21, 2024



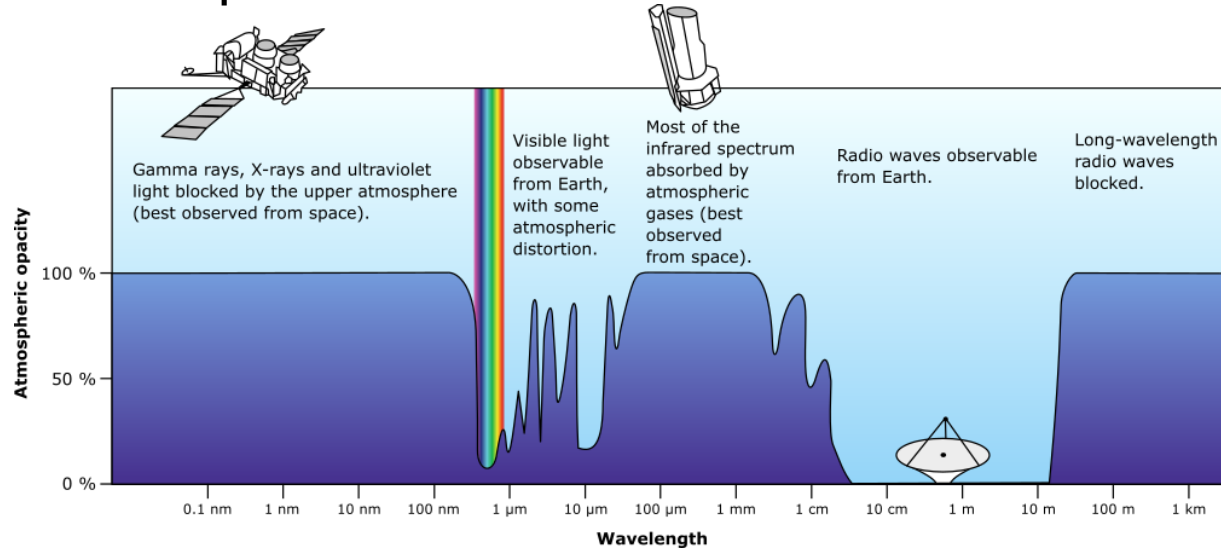
Mission Statement

The National Radio Astronomy Observatory enables forefront research into the Universe at radio wavelengths. In partnership with the scientific community, we:

- *provide world leading telescopes, instrumentation, data and expertise;*
- *train the next generation of scientists and engineers;*
- *advance broader, equitable, inclusive participation in science and engineering;*
- *and promote astronomy to foster a more scientifically literate society.*

NRAO is a facility of the NSF... national science infrastructure

The Universe at RF: Spectral Windows and Limitations



Green Bank Telescope



Very Large Array



Atacama Large Millimeter Array



Very Long Baseline Array





Jansky Very Large Array



Very Long Baseline Array

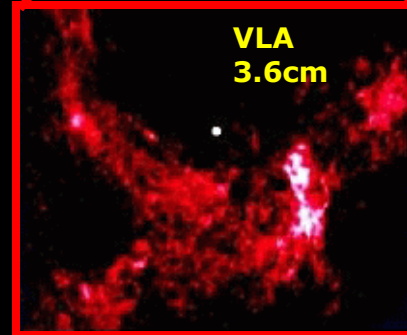
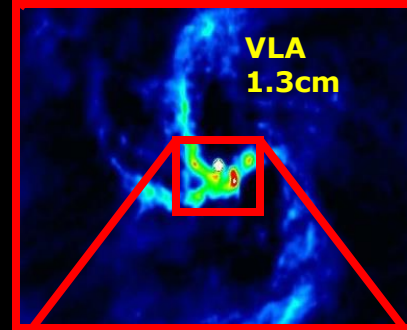
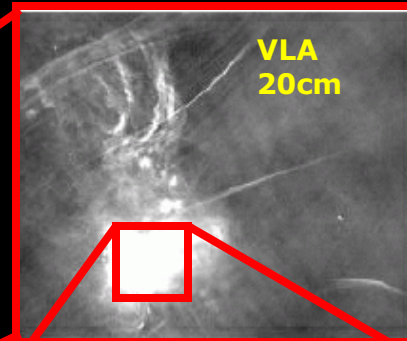
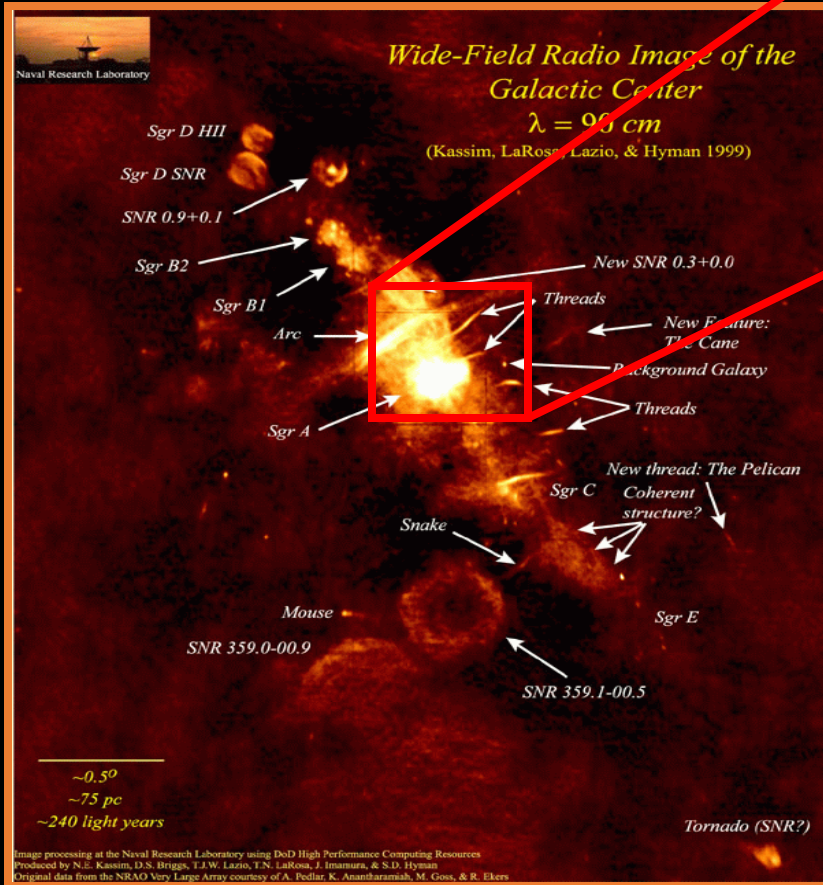
Atacama Large Millimeter/submm Array - ALMA



Robert C. Byrd Green Bank Telescope

+ major labs/HQs...





Extragalactic Supernovae - VLBA

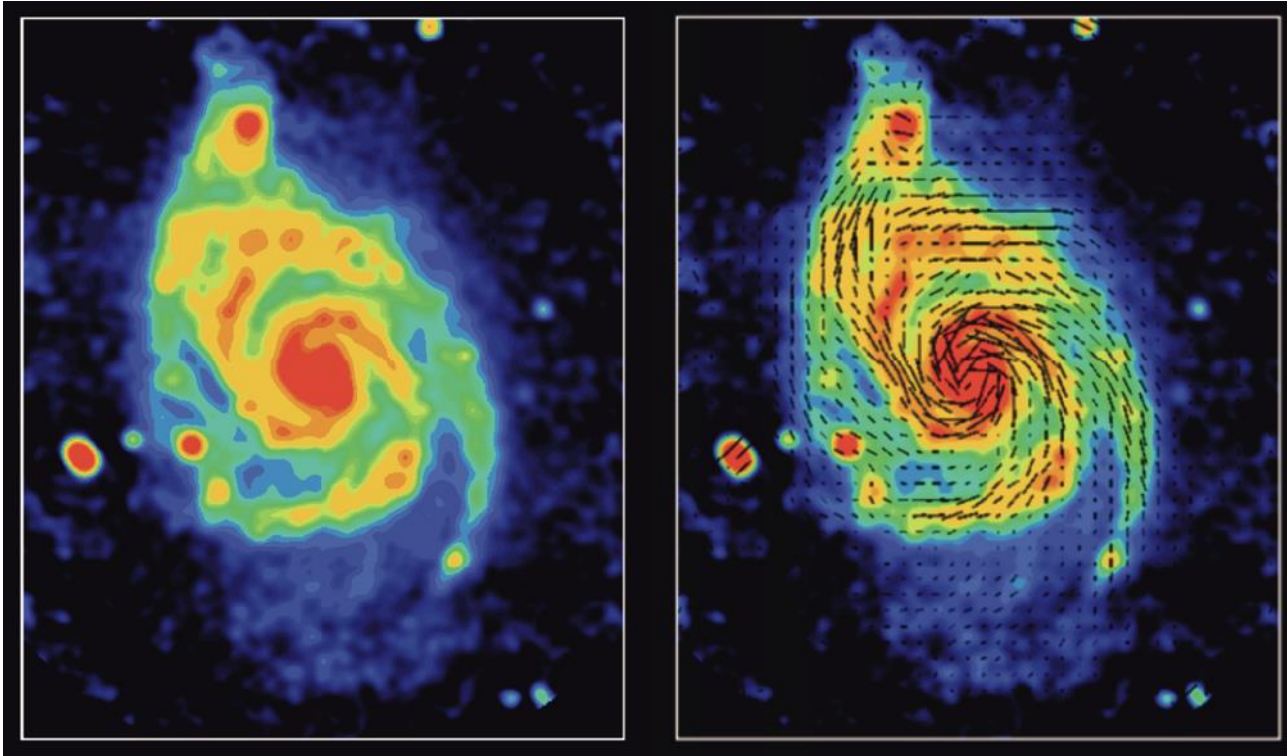


SN 1993J in M81

VLBA Observation from
May 17, 1993 – Feb 25 2000



Magnetic Field Orientation in Galaxies



Radio Continuum

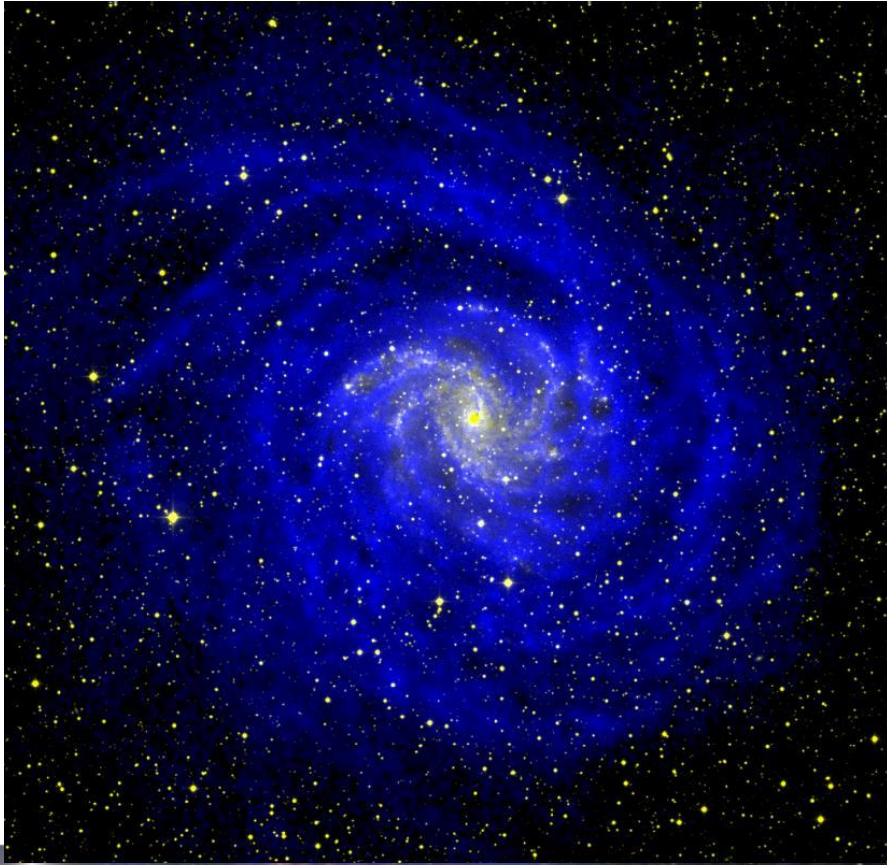
Lines=Magnetic Field Orientation

Beck, Horellou, Neininger

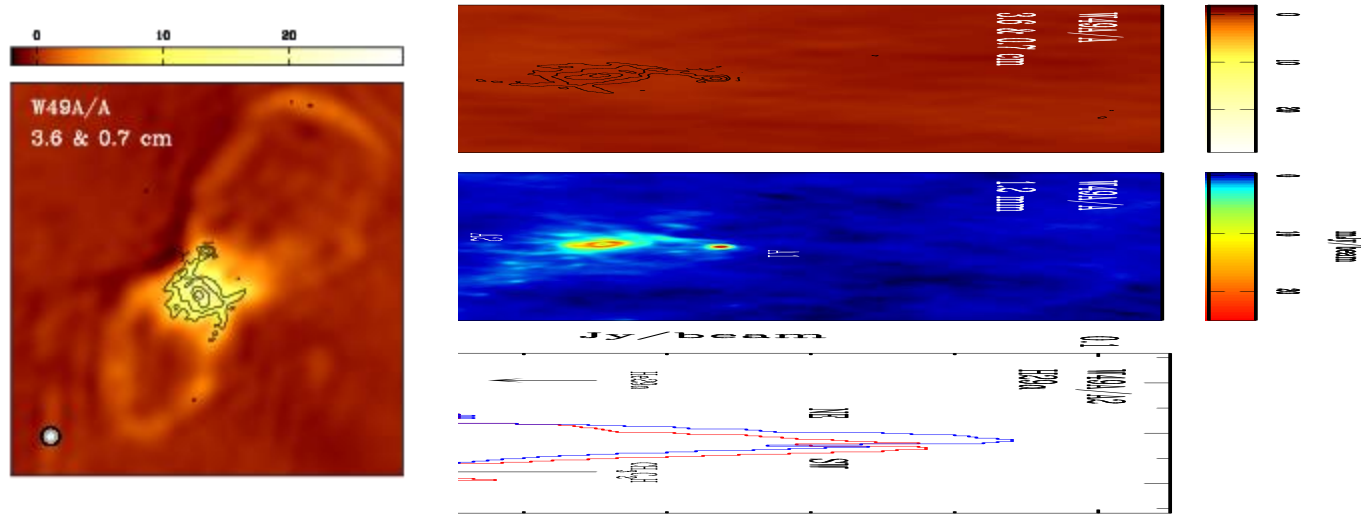
www.nrao.edu/imagegallery

Neutral Hydrogen in Galaxies

- B/W=optical image of NGC 6946 from Digital Sky Survey
- Blue=Westerbork Synthesis Radio Telescope 21 cm image of Neutral Hydrogen
- Neutral Hydrogen is the raw fuel for all star formation
- Hydrogen usually much more extended than stars



Ionized Gas in Massive Star Forming Regions

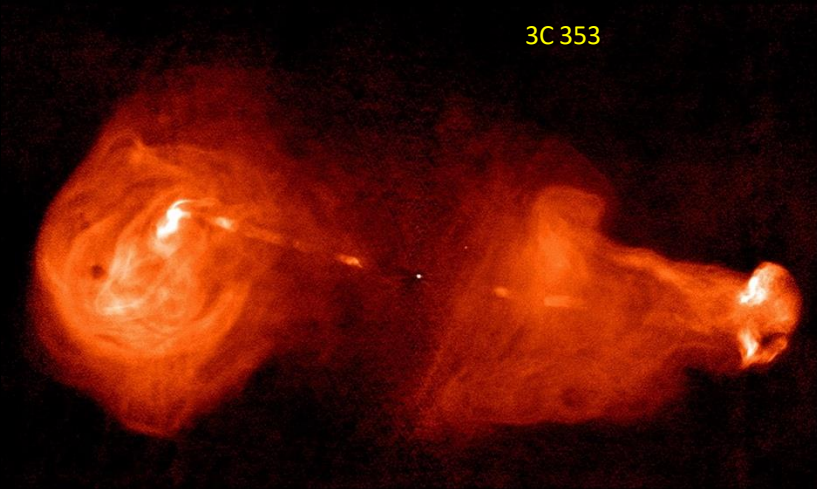


- VLA 3 cm $\rightarrow$ ionized, asymmetric, bipolar lobes ~ 0.1 pc
- VLA 7 mm $\rightarrow$ central, flattened ~ 2000 au structure; A1 companion
- ALMA 1.2 mm, H29 α $\rightarrow$ ionized ring w/expansion and sub-Keplerian rotation; remnant accretion disk? (cf. Miyawaki+2023)

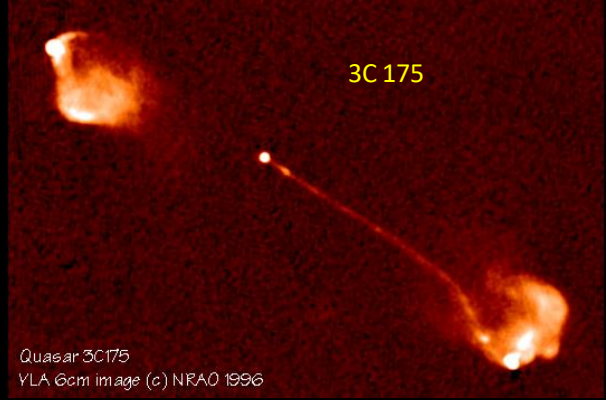


The Radio Sky
1 GHz @ 300'

3C 353

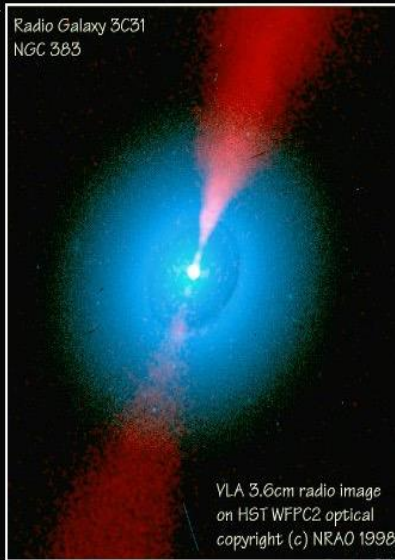
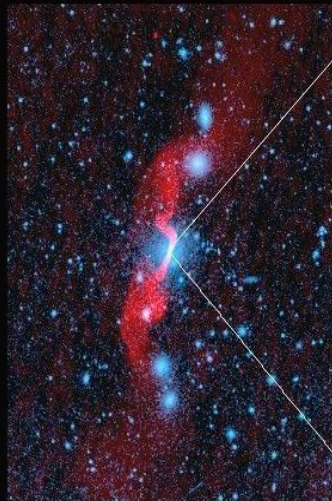


3C 175



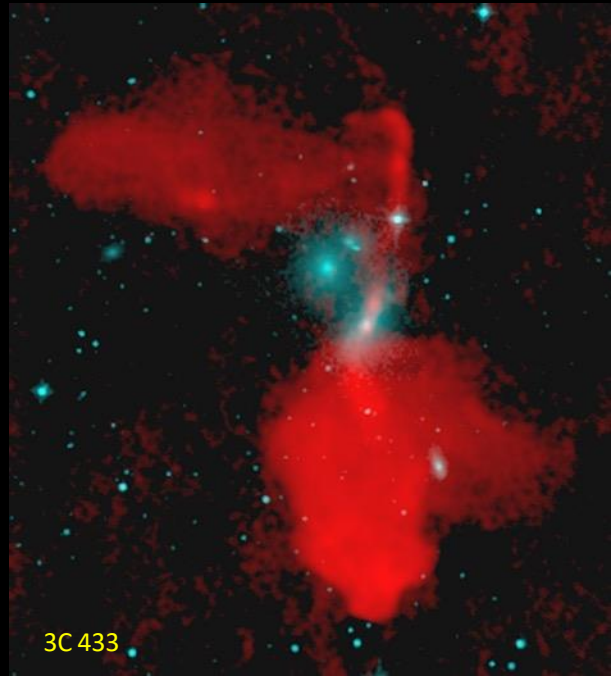
Quasar 3C175
VLA 6cm image (c) NRAO 1996

Radio Galaxy 3C31
NGC 383



VLA 3.6cm radio image
on HST WFPC2 optical
copyright (c) NRAO 1998

3C 433



Why do astronomy?

- Find our place in the Universe
- Cosmic laboratory
- Technology development
- Grow STEAM interests





Just for Fun! Infrared Art

The panel to the left is a type of infrared (heat) detector. It is made of a special type of liquid crystal, and you can "draw" on it with anything that gives off heat.

What to do...

Place your hand on the liquid crystal film. When it gets warm, it turns a white, then a light blue, then a dark blue, and finally a black. You can "draw" on the film with your hands. See how the colors change as you move your hands. You can also "draw" a picture with the warmth of your hands. See how the colors change as you move your hands. You can also "draw" a picture with the warmth of your hands.

What it means...

When you touch a film of liquid crystal, it changes color. The color change is caused by the warmth of your hands. The liquid crystal film is a type of infrared detector. It can detect heat from anything that gives off heat.



FLIR



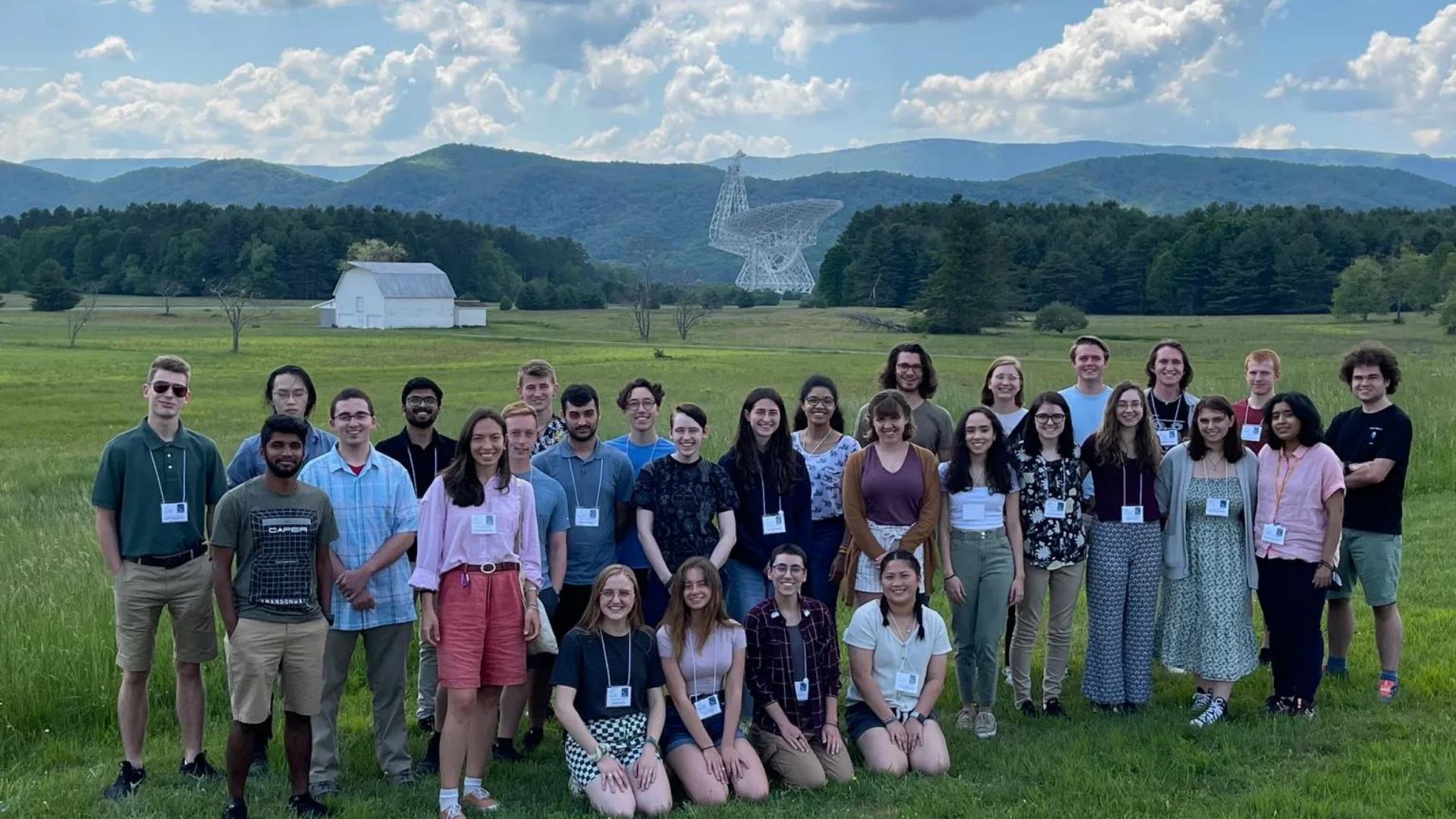
See Yourself in the Infrared

Mounted to the top of this display is an infrared camera. The camera is the infrared spectrum. Using it, you can see the "false color image" where they're not. Cameras like this are used for night-time surveillance.

Infrared detectors are also used in telescopes and in space telescopes throughout the universe.









Radio Astronomy is a Diverse Community

2005-2024 Domestic

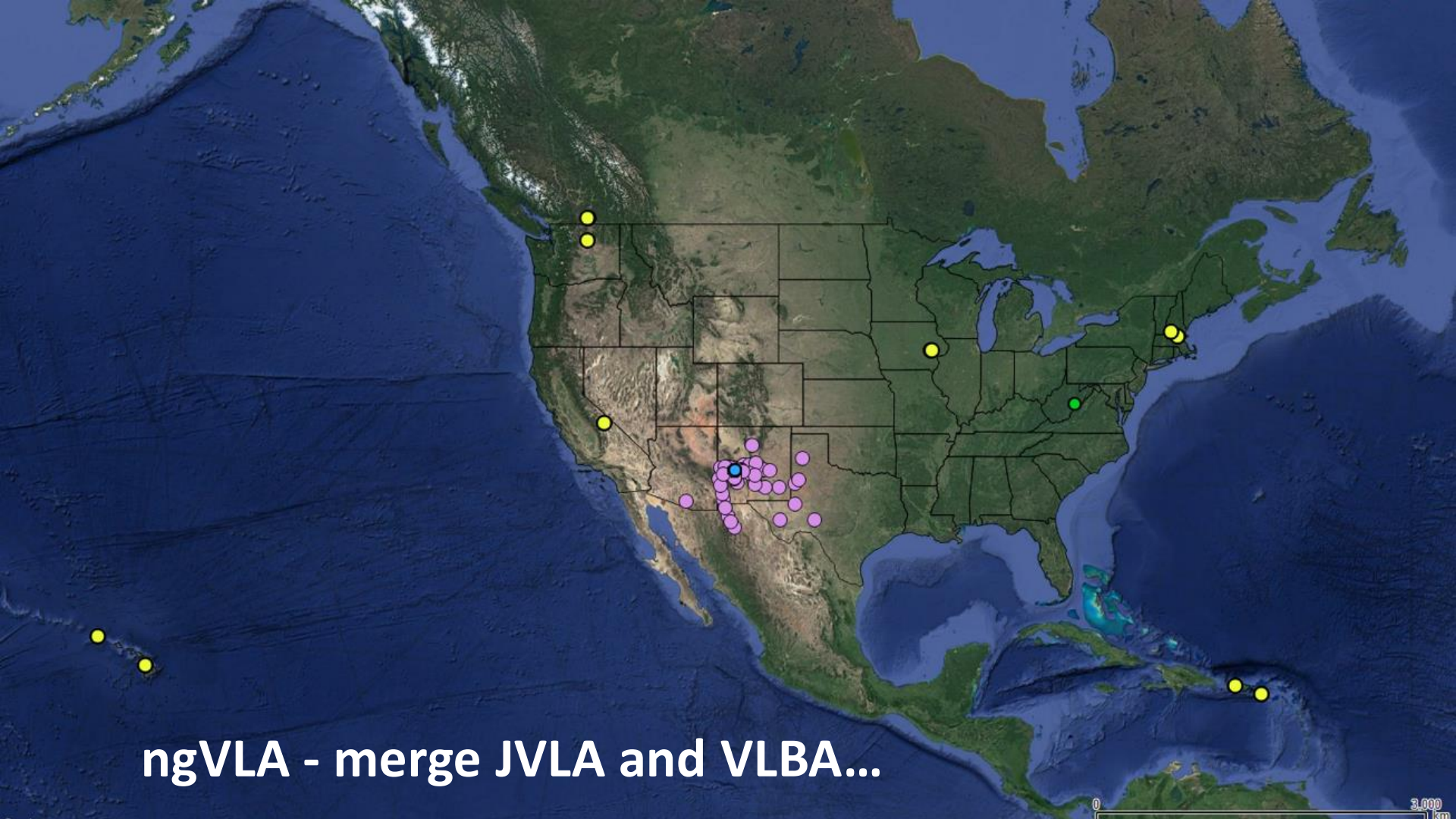
- 49 states + DC, PR, VI
- **4,173** researchers

No: SD

2005-2024 NRAO International

- 74 countries
- **7,925** researchers
- VLA, VLBA, GBT, ALMA
- DE: 11% (2005:13%)
- PRC: 5% (2005:2%)

NSF user Facilities provide leading-edge science opportunities to everyone/everywhere in the U.S....



ngVLA - merge JVLA and VLBA...

Prototype Antenna Contract Awarded - mtex

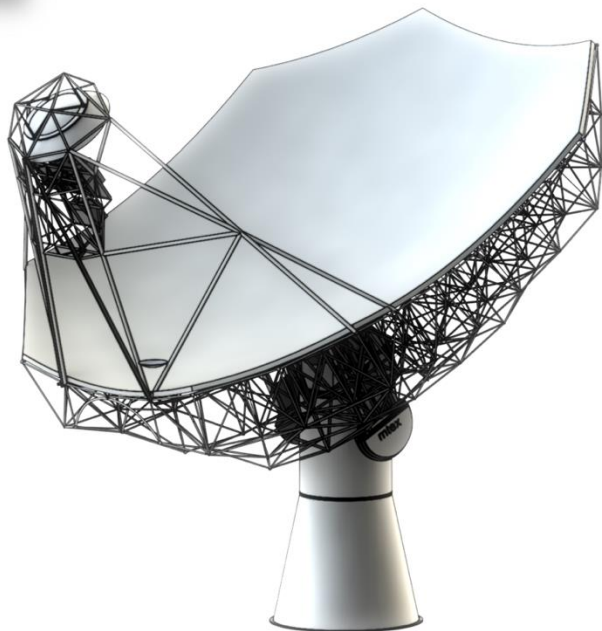


ngVLA Concept

88deg



mtex | antenna technology



Confidential - Copyright mtex antenna technology gmbh

8





2024-08-29 07:35:13

Tycho crater: ~85 km



Resolution: ~9 meters/px

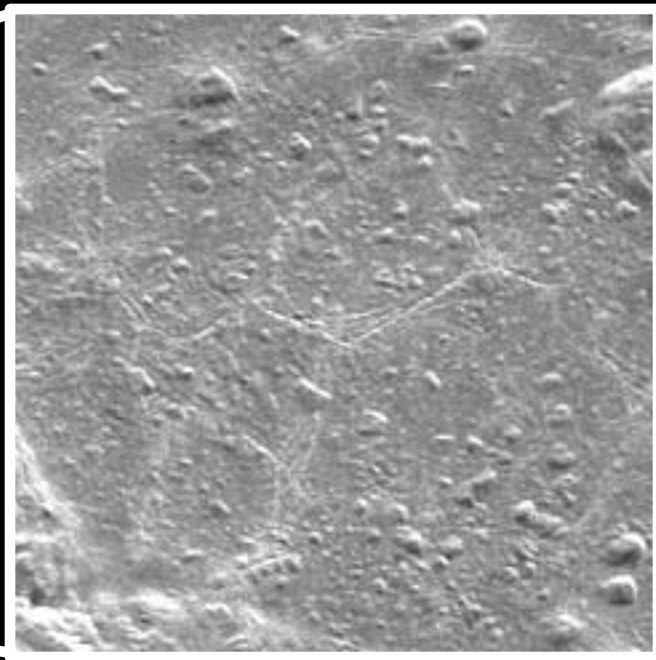
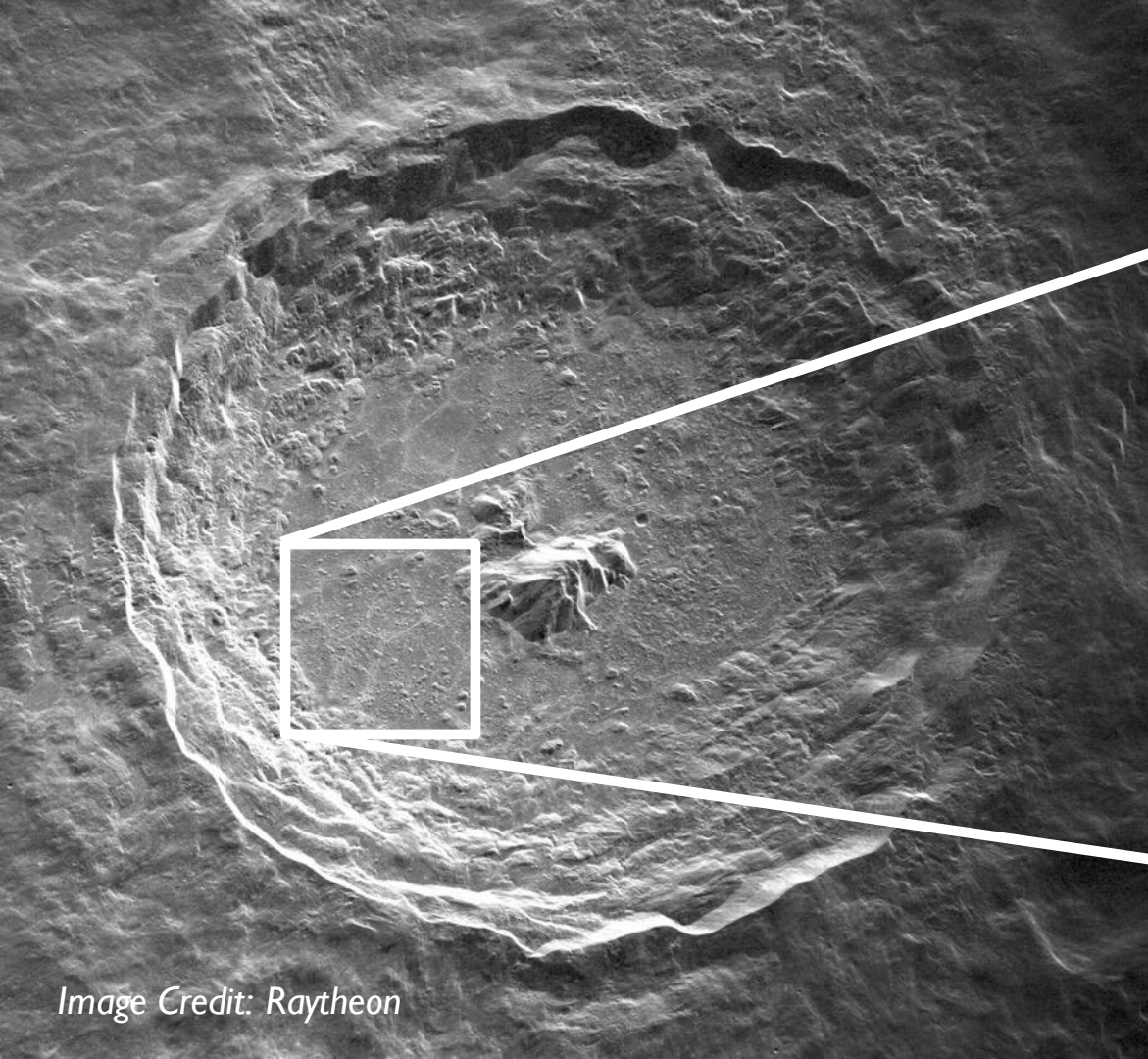


Image Credit: Raytheon

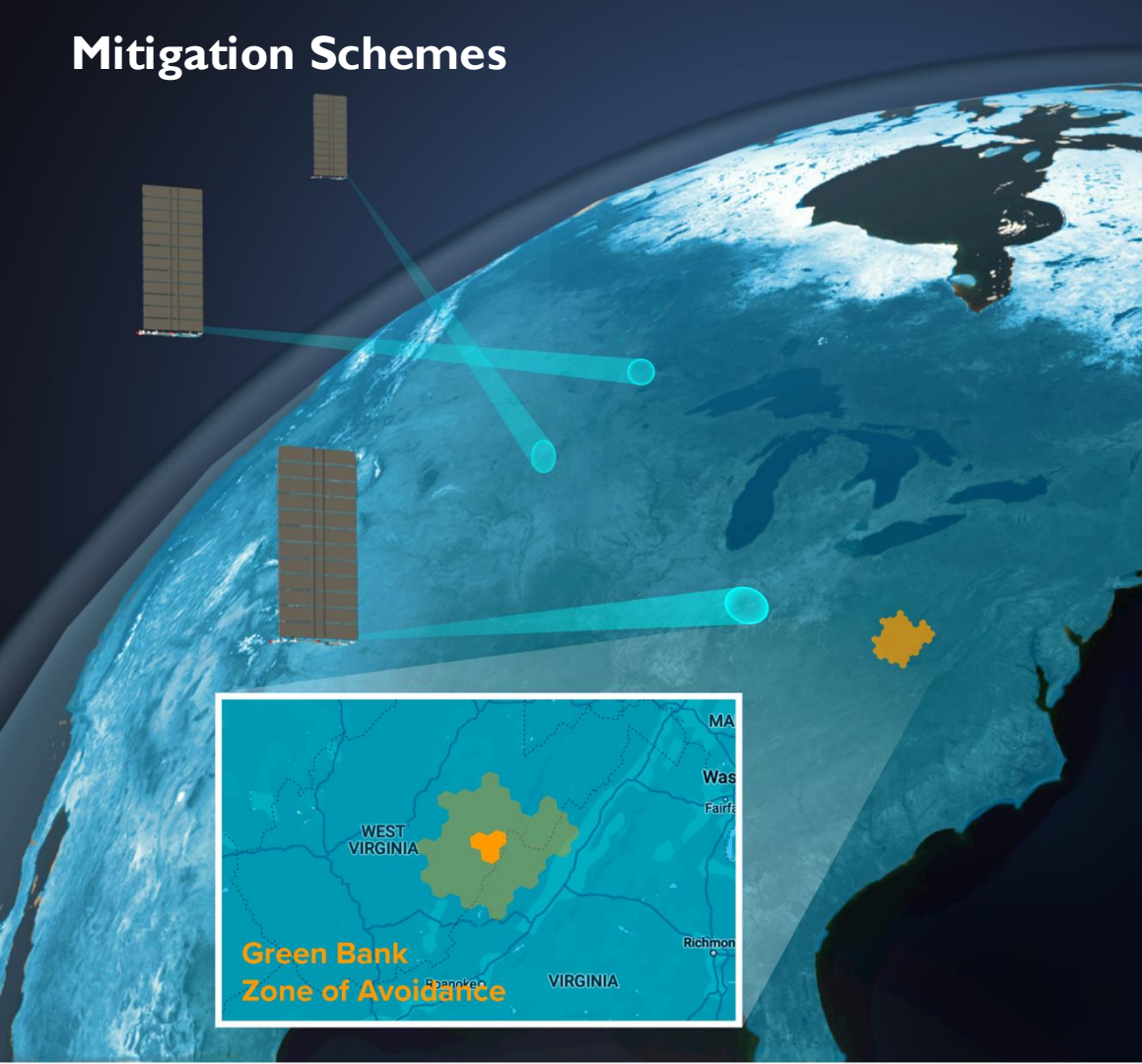




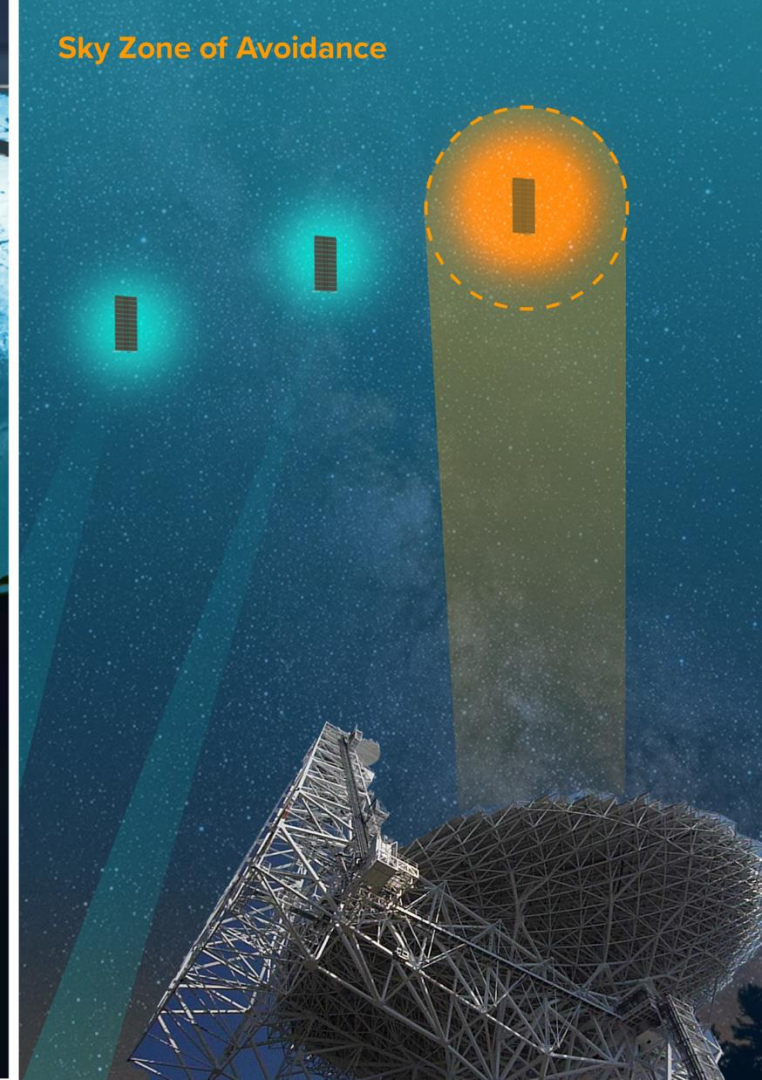
**GREEN BANK
OBSERVATORY**

greenbankobservatory.org

Mitigation Schemes



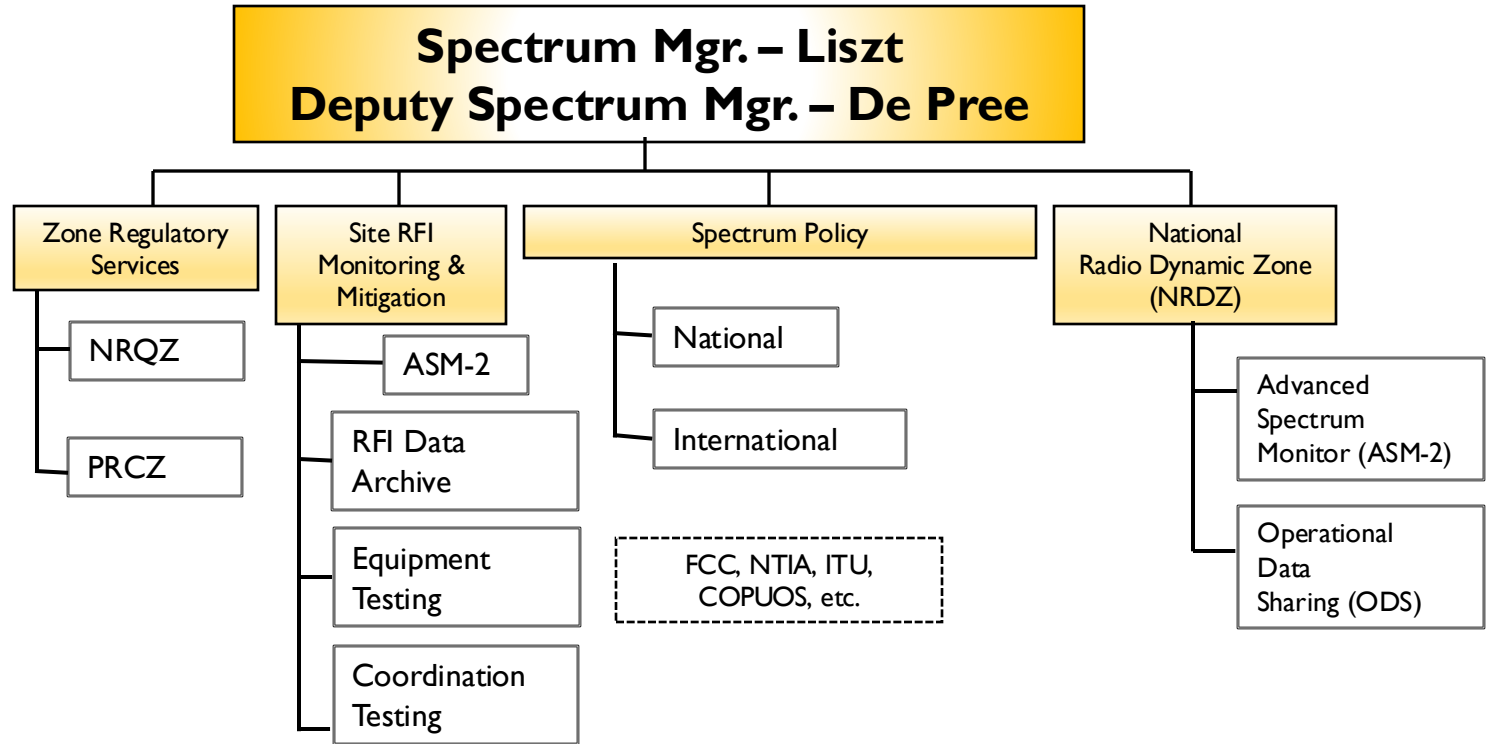
Sky Zone of Avoidance





BETTYMAYA FOOTT - 2022

Spectrum Management at NRAO



Spectrum Management Areas of Effort (What we do)

- **National Radio Dynamic Zone (NRDZ)**
 - Operational Data Sharing (ODS)
 - Collaborative Experiments (e.g. SpaceX)
 - Advanced Spectrum Monitor (ASM-2)
 - Curriculum Initiatives in Spectrum Policy and Engineering (Broader Impacts)
- **Radio Frequency Interference (RFI) Monitoring and Mitigation**
 - Site RFI Scans
 - RFI GUI Development
- **Zone Regulatory Services (ZRS)**
 - National Radio Quiet Zone (NRQZ)
 - Puerto Rico Coordination Zone (PRCZ)
- **National and International Spectrum Policy (NISP)**
 - FCC Comments, participation in ITU (US delegation)
 - Discussions with Federal agencies
 - World Radio Congress (WRC) Input and Attendance

Spectrum Management Staff (Who we are)

Spectrum Manager: Harvey Liszt (NISP, RFI)

Deputy Spectrum Manager: Chris De Pree (NISP, NRDZ, NRQZ, RFI)

RFI Scientist: Bang Nhan (NRDZ, RFI)

Zone Regulatory Services (ZRS) Coordinator: Sheldon Wasik (ZRS, RFI)

Puerto Rico Coordination Zone (PRCZ) Administrator: Angel Vasquez (ZRS-PRCZ)

RFI Data Analyst (VLA/VLBA): Aaron Lawson (NRDZ, RFI)

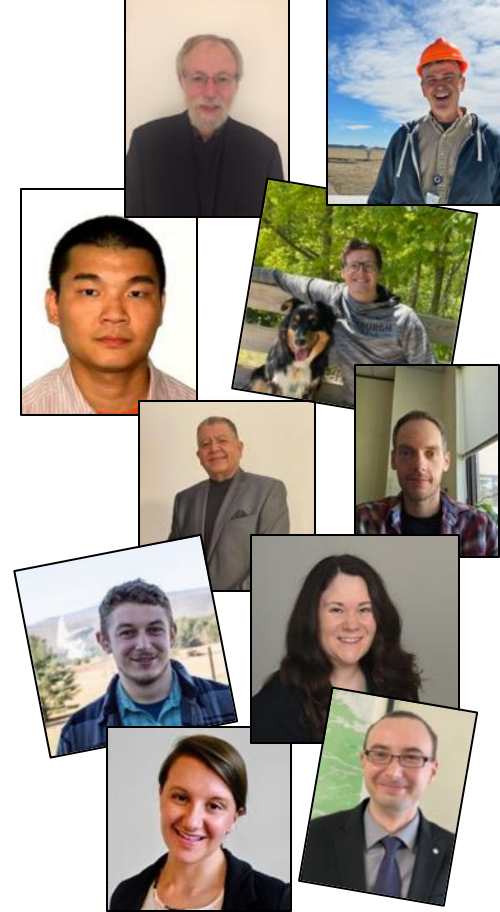
RFI Data Analyst (GBT): Daniel Bautista (NRDZ, RFI)

Curriculum Specialist: Valarie Bogan (NRDZ-Broader Impacts)

Spectrum Software Engineer: Dawn Pattison (NRDZ, RFI)

Project Manager: Randy Arnold (NRDZ)

Many other contributors not officially part of Spectrum Management (e.g. Paul Demorest, Brenne Gregory, Karen O'Neil, Kacey Purcell, ...)



Summary

The National Radio Astronomy Observatory enables forefront research into the Universe at radio wavelengths.

In partnership with the scientific community, we provide world leading telescopes, instrumentation, data and expertise; train the next generation of scientists and engineers; advance broader, equitable, inclusive participation in science and engineering; and promote astronomy to foster a more scientifically literate society.

- Spectrum Management is...
 - Supporting the NRAO mission statement by working to ensure that radio wavelengths will remain available to passive users in the coming decades
 - Developing a unified approach to spectrum-related issues across AUI observatories and increasing internal communication
 - Building a strong team delivering hardware, software and policy initiatives
 - Developing a productive relationship with satellite constellation operators
 - Increasing funding for special efforts, and working to build spectrum management considerations into regular NRAO structures

