



# **The Advanced Green Bank Telescope: Planning for the Next Decade**

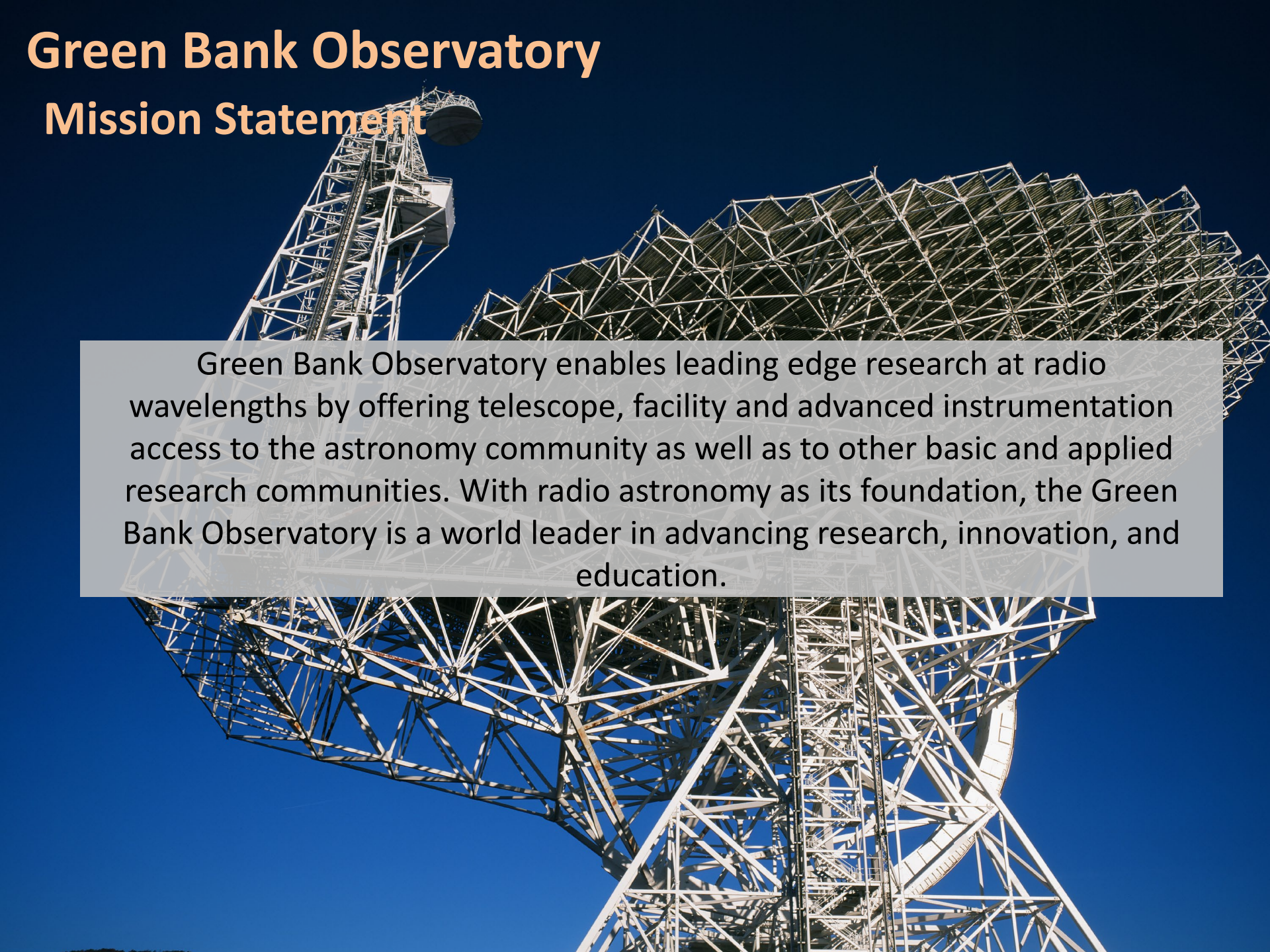
## **Welcome and Overview**





# Green Bank Observatory

## Mission Statement



Green Bank Observatory enables leading edge research at radio wavelengths by offering telescope, facility and advanced instrumentation access to the astronomy community as well as to other basic and applied research communities. With radio astronomy as its foundation, the Green Bank Observatory is a world leader in advancing research, innovation, and education.



# Green Bank Observatory

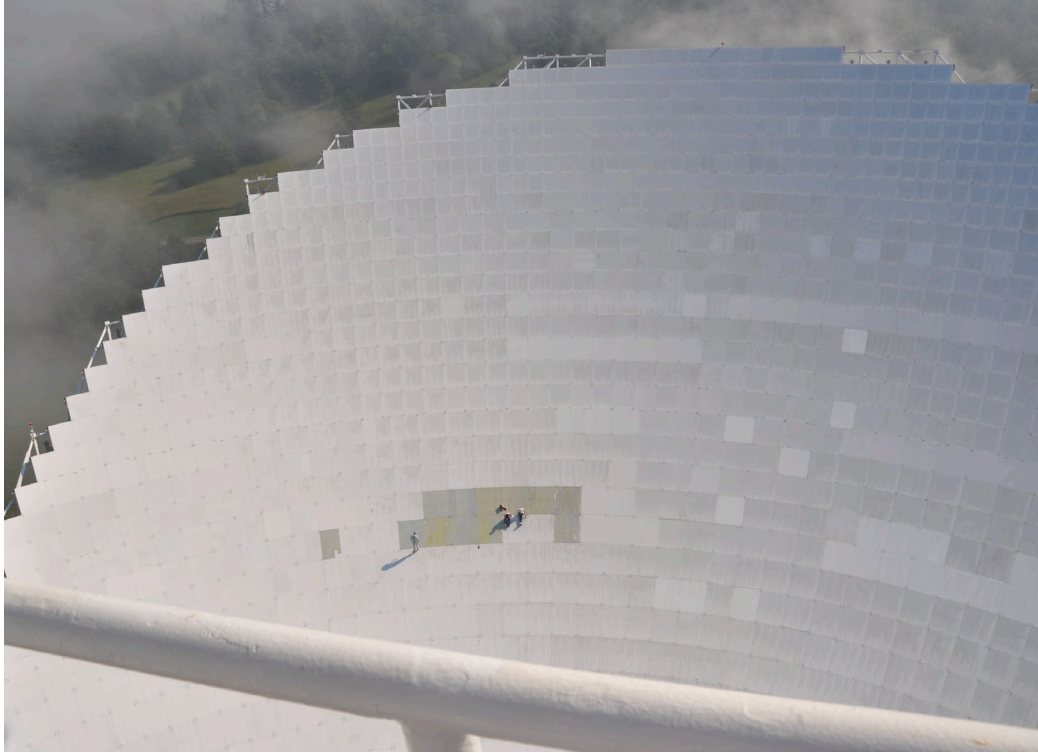
## Briefly

- Located in Green Bank, WV
- Original site of the National Radio Astronomy Observatory
- Split from NRAO to become Green Bank Observatory in 2016
- Home of 7 large telescopes, including the 100-m GBT
- Managed by Associated Universities, Inc since inception

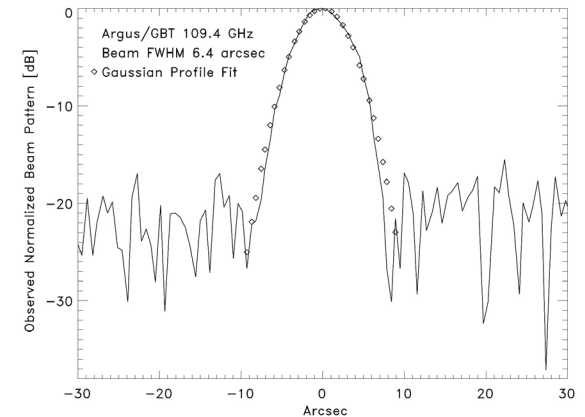


# The GBT

## A World Class Facility for Science Research



- 100m Diameter
- 85% sky coverage
- 0.2 – 116 GHz range
- Unblocked aperture
- Phenomenal sensitivity ( $\mu\text{Jy}$ )
- 30% aperture eff. at 100 GHz
- 6800 hours available annually



# The GBT

## A World Class Facility for Science Research



- 100m Diameter
- 85% sky coverage
- 0.2 – 116 GHz range
- Unblocked aperture
- Phenomenal sensitivity ( $\mu\text{Jy}$ )
- 30% aperture eff. at 100 GHz
- 6800 hours available annually

### User Community :

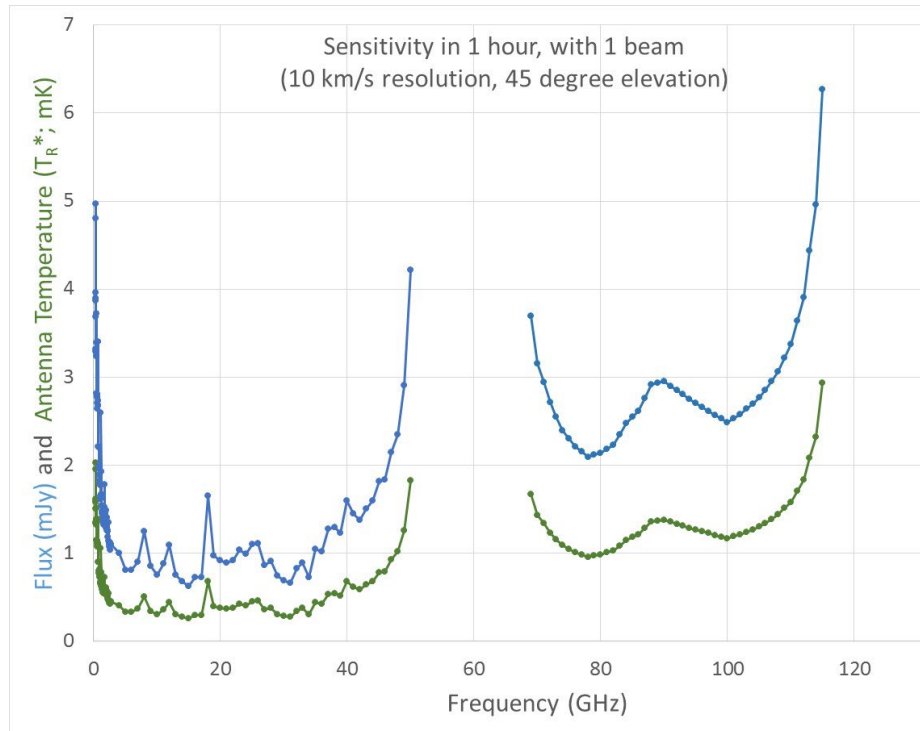
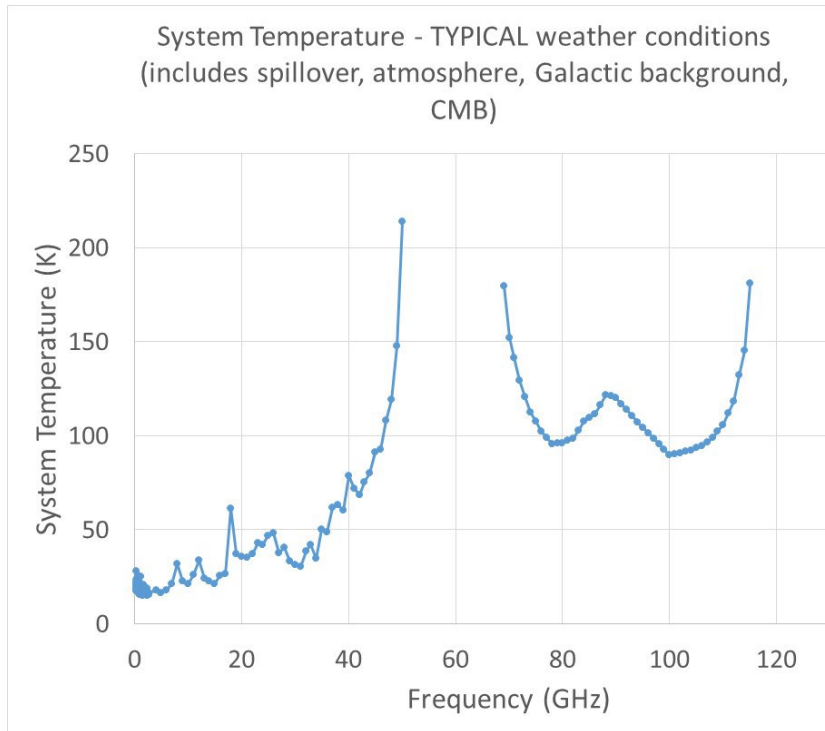
- >3000 individual scientists proposed to use the GBT in past 5 years\*
- Span range of disciplines from planetary science to chemistry and physics
- Roughly 20% of proposers are new each semester

\*Based on number of individual email addresses



# The GBT

## Current Instrumentation

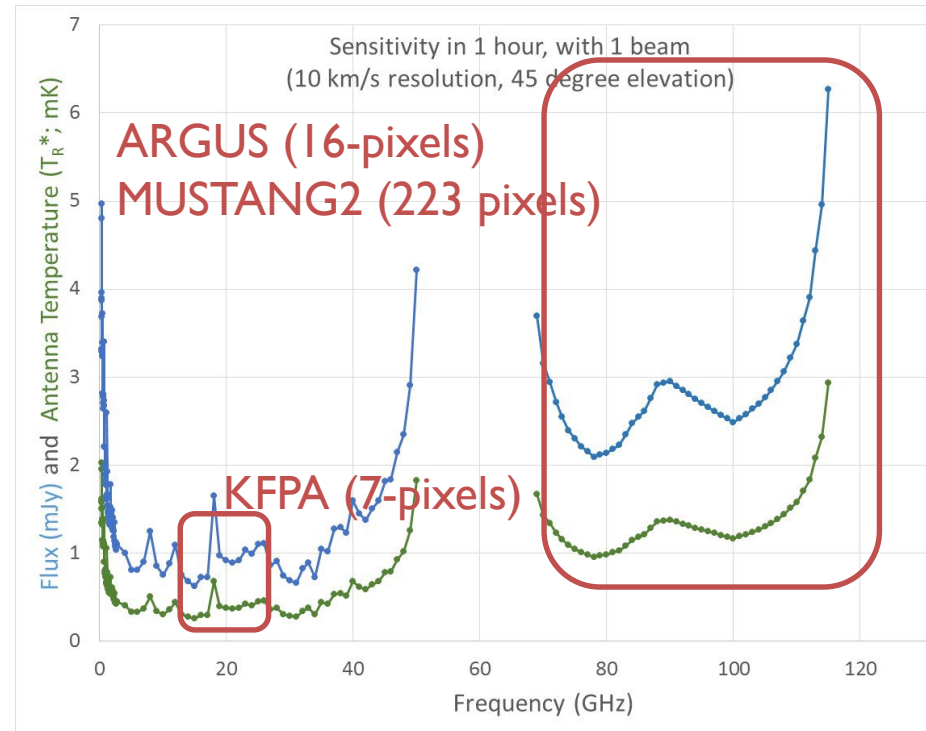
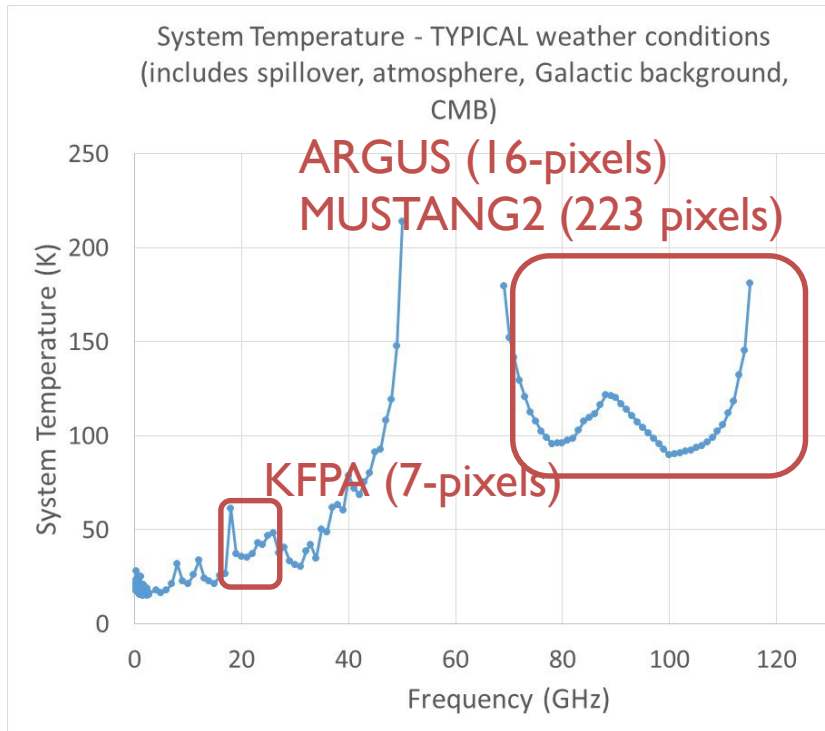


- Frequency coverage from 0.2 through 116 GHz (non-contiguous)
- Most receivers are single/dual pixel, however...
  - Four multi-pixel ‘cameras’ now available on the GBT



# The GBT

## Current Instrumentation



- Frequency coverage from 0.2 through 116 GHz (non-contiguous)
- Most receivers are single/dual pixel, however...
  - Three multi-pixel ‘cameras’ now available on the GBT

# The GBT

## Current Instrumentation

- Signal travels ~1 mile from telescope to control room
- Primary backend - VEGAS
  - FPGA+GPU system; 100-1500 MHz bandwidth x8
  - Spectral Line + Pulsar modes
- Other available backends:
  - Digital Continuum Receiver
  - VLBI Mark VI recorder
  - Radar
  - Breakthrough Listen
  - Caltech Continuum Backend (CCB)
  - Ready ability to add additional system to telescope





# The GBT

## Upcoming Instrumentation

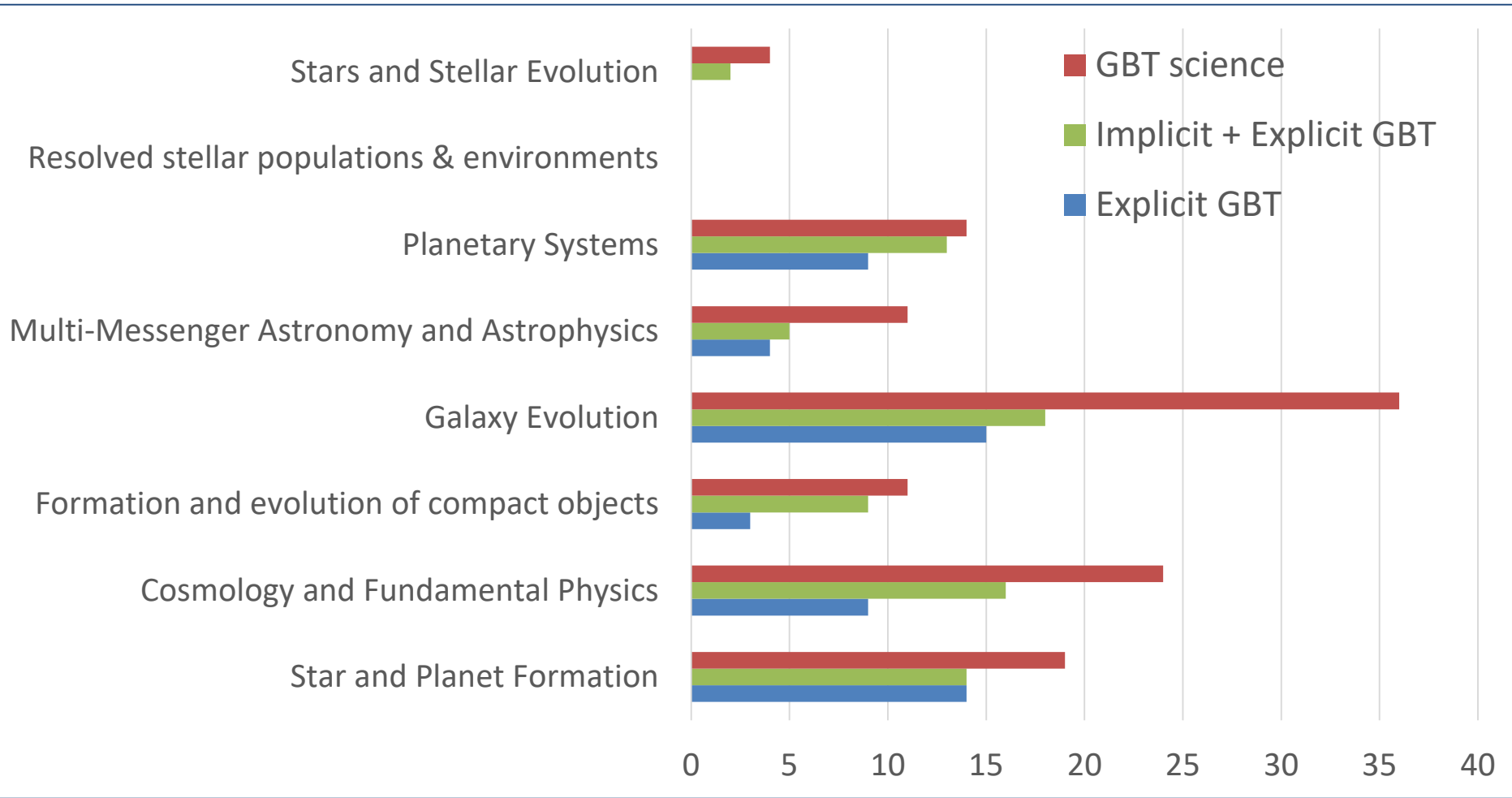
- **LASSI** (Laser Active Surface Scanning Instrument – NSF-MSIP; 175.175):
  - Real time surface corrections using laser scanner
    - Increase high frequency hours  $\sim 1,000/\text{year}$  + during the day
    - Will ease scheduling issues, benefit all science
- **Ultra Wideband Feed** (Gordan & Betty Moore Foundation; 175.17, 175.18):
  - 0.6 – 2.8 GHz feed optimized for pulsar work ;  $T_{\text{sys}} \sim 30 \text{ K}$
  - Doubles the sensitivity of the GBT for most pulsar timing
- **Digital Interference Excision** (NSF-ATI; 109.30):
  - Research proposal for automatic detection and incision of RFI
  - Build next-generation DSP board for UWB receiver



# The GBT

## Science Impact

## Astro2020 Science Papers



# Green Bank Observatory

## The Future of EPO: Expanding STEM Engagement across STEM Pathways

2025  
2024  
2023  
2022  
2021  
2020

### Milestones:

Innovative  
REU/RET  
Program

Updated  
Exhibits

GBT Data  
Program

20 M Telescope  
Improvement

Teacher PD Plan

Marketing/  
Dissemination  
Plan

### Teachers & Faculty

- RET Program
- Teacher Workshops
- Curriculum Repository

### Undergraduates

- Immersion: Expanding multi-disciplinary research opportunities for first generation UG;
- Leadership: Expanding UG outreach

### K-12 Students

- Immersion: Doubling PING residential research program
- Outreach: Increasing high impact outreach to WV Schools through WV SPOT
- Engagement: expanding access to radio astronomy and radio astronomy data

### Families and the Public

- Improving Science Center Exhibits
- Sustained Engagement: Deploy programmatic resources online, develop podcasts, increase online events
- Increasing opportunities for families to experience STEM



# Green Bank Observatory

## Current Status

- Environmental impact/historical assessment process complete
- AUI awarded 5-yr cooperative agreement (FY20-FY24)
- Total contract is approximately 62% of operating costs
  - 80% of funding from NSF; 20% of funding from NRL
- Open skies time on GBT approx.  $\leq 62\%$  of total time available
- Other partners include:
  - Breakthrough Listen ( $\sim 20\%$ )
  - NANOGrav ( $\sim 5\%$ )
  - West Virginia University ( $\sim 2.5\%$ ) (FY20)
  - Other groups/contracts (remaining 10.5%)



# Green Bank Observatory

## Current Status – Reduced Open Skies Time

- Total open skies time on GBT equals fraction of operational costs covered by NSF for open skies
- Many contracts required fixed and/or windowed observations
  - Reduction in open skies time has significantly greater effect on fixed, windowed, and excellent weather observations
- Contracts can also place requirements on receiver availability

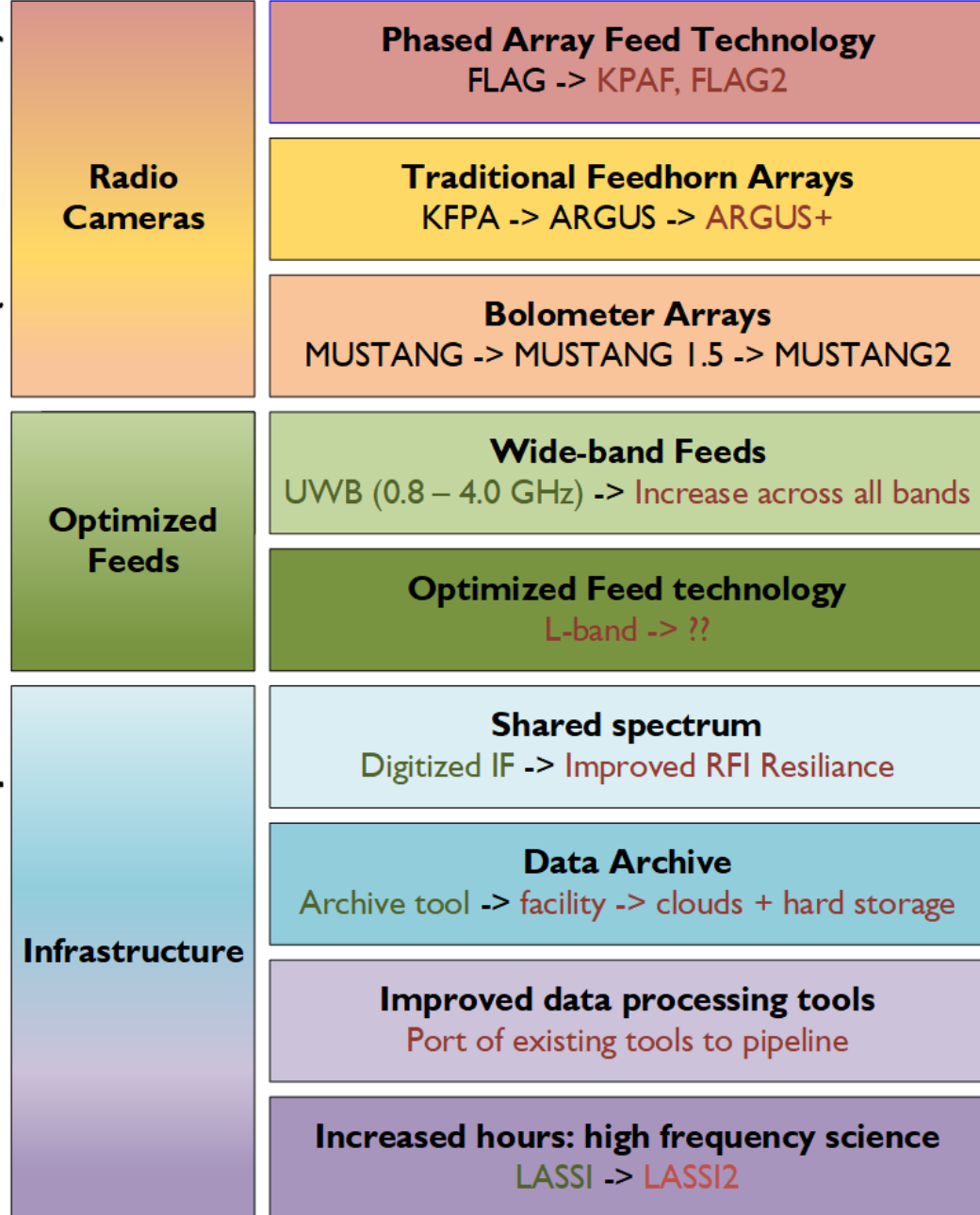
Need to ensure that we can maximize science from the available open skies time on the GBT



# The Advanced GBT

- Numerous internal and external workshops held to understand community needs for the next decade
- Need to finalize plan in light of community/astro2020 desires

Green Bank Telescope in the Next Decade (2020 – 2030)





# The Advanced GBT

## Session Goals

- Numerous internal and external workshops held to understand community needs for the next decade
- Need to finalize plan in light of community/astro2020 desires
- Solicit interest and ideas from the community on plans
- Solicit volunteers for focused working groups interested in collaborating on instrumentation projects

Green Bank Telescope in the Next Decade (2020 – 2030)

Radio Cameras	<b>Phased Array Feed Technology</b> FLAG -> KPAF, FLAG2
	<b>Traditional Feedhorn Arrays</b> KFPA -> ARGUS -> ARGUS+
	<b>Bolometer Arrays</b> MUSTANG -> MUSTANG 1.5 -> MUSTANG2
Optimized Feeds	<b>Wide-band Feeds</b> UWB (0.8 – 4.0 GHz) -> Increase across all bands
	<b>Optimized Feed technology</b> L-band -> ??
Infrastructure	<b>Shared spectrum</b> Digitized IF -> Improved RFI Resilience
	<b>Data Archive</b> Archive tool -> facility -> clouds + hard storage
	<b>Improved data processing tools</b> Port of existing tools to pipeline
	<b>Increased hours: high frequency science</b> LASSI -> LASSI2





# GREEN BANK OBSERVATORY

[greenbankobservatory.org](http://greenbankobservatory.org)

*The Green Bank Observatory is a facility of the National Science Foundation  
operated under cooperative agreement by Associated Universities, Inc.*

