


Welcome to Green Bank!
(virtually)



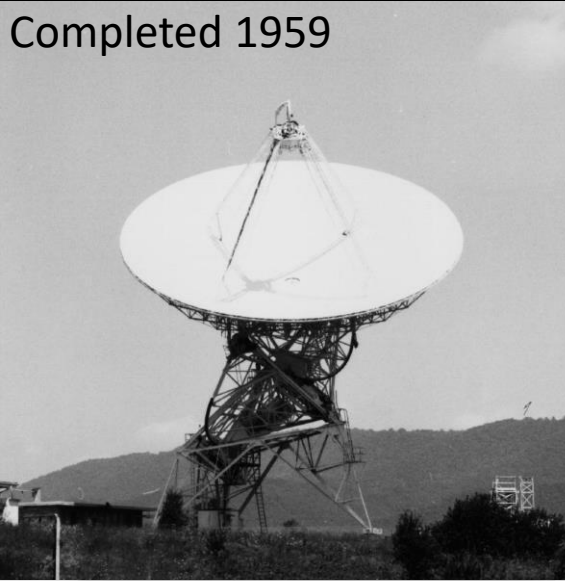
Welcome to Green Bank!



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.

Original National Radio Astronomy Observatory, with world class telescopes for 60 years

Completed 1959



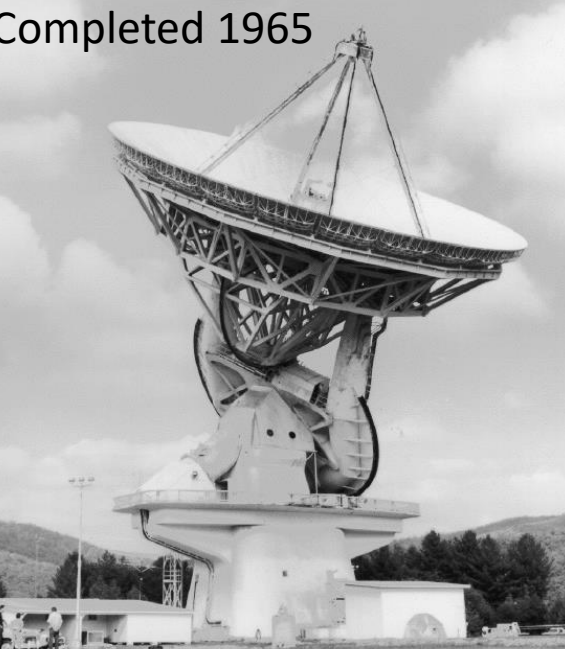
Completed 1995



Completed
1962



Completed 1965



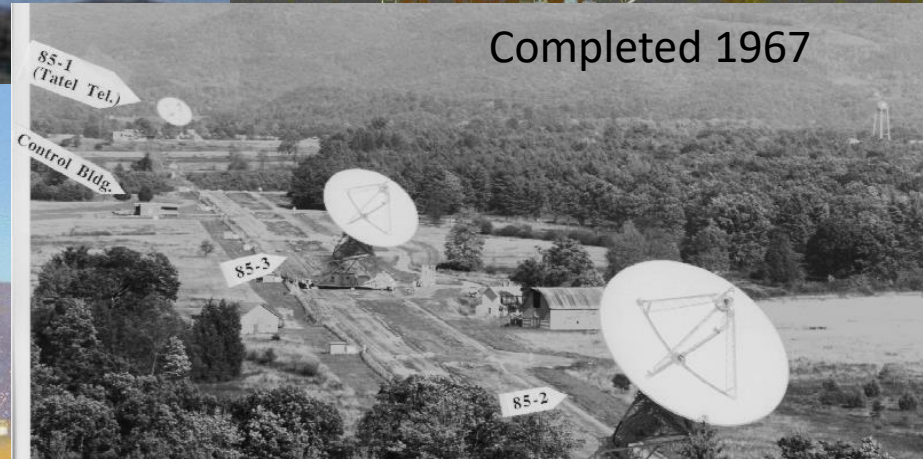
Completed
2000



Completed 1962



Completed 1967



Completed
1994



The GBT

A World Class Facility for Science Research



- 85% sky coverage
- 0.2 – 116 GHz range
- Unblocked aperture
- Phenomenal sensitivity (μJy)
- 30% aperture eff. at 100 GHz
- 6800 hours available annually

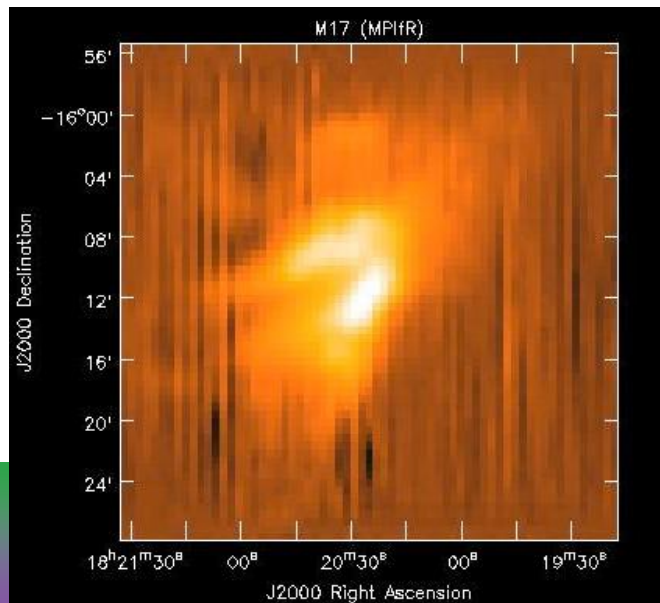
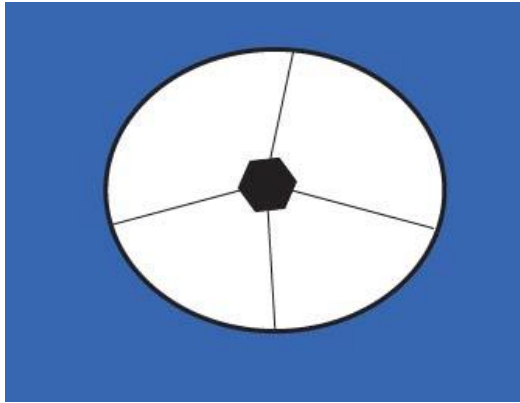
User Community :

- >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

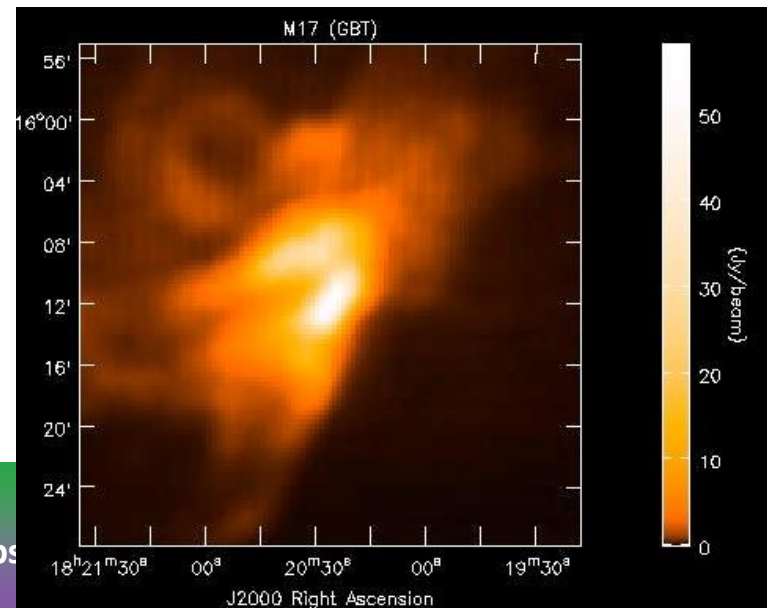
*Based on number of individual email addresses

The GBT:

Unblocked Optics, High Dynamic Range

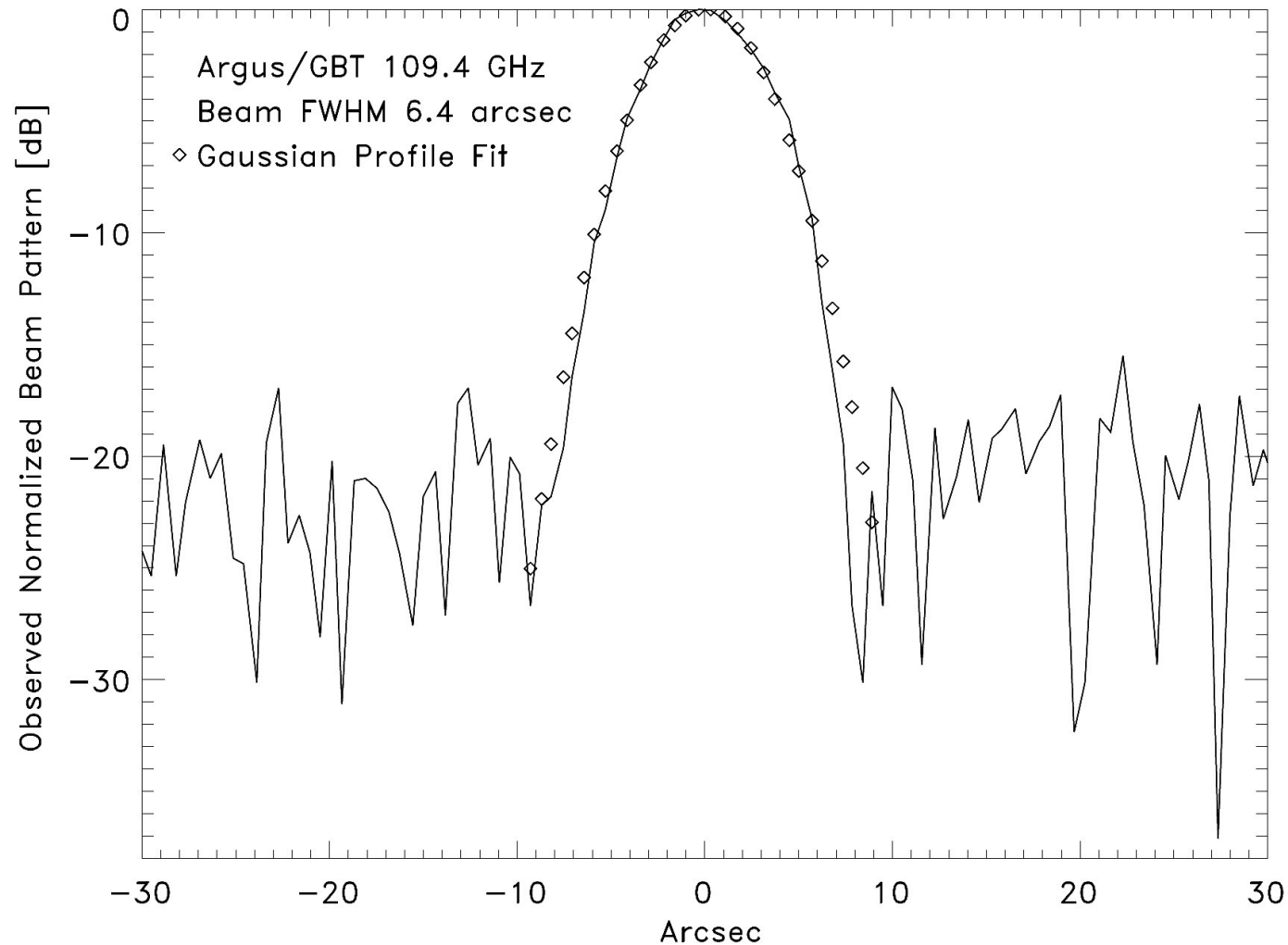


Green Bank Obs



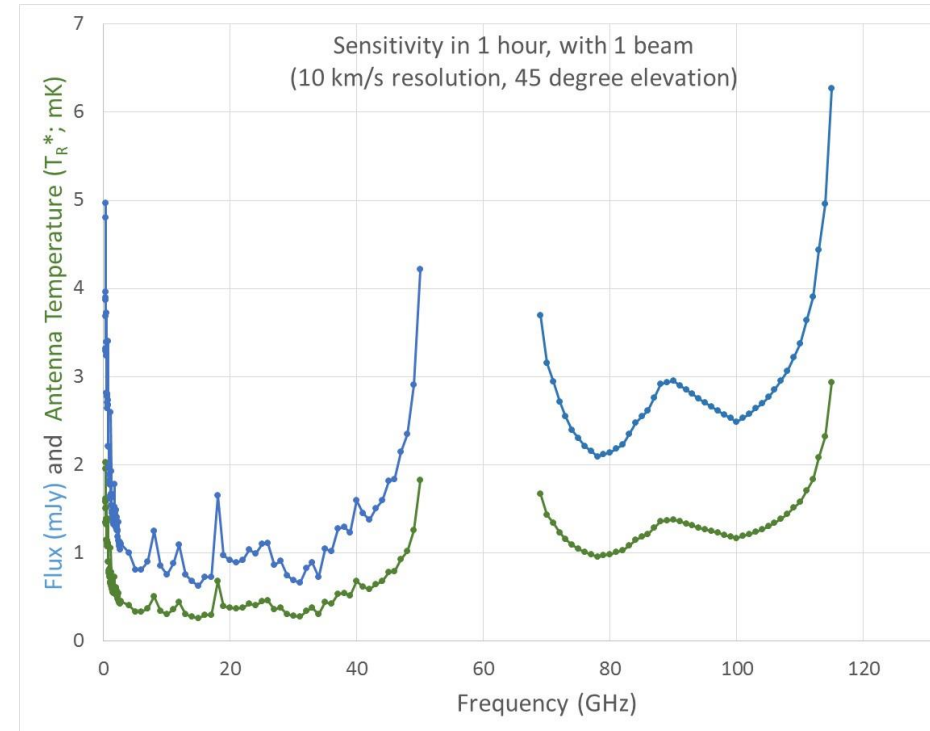
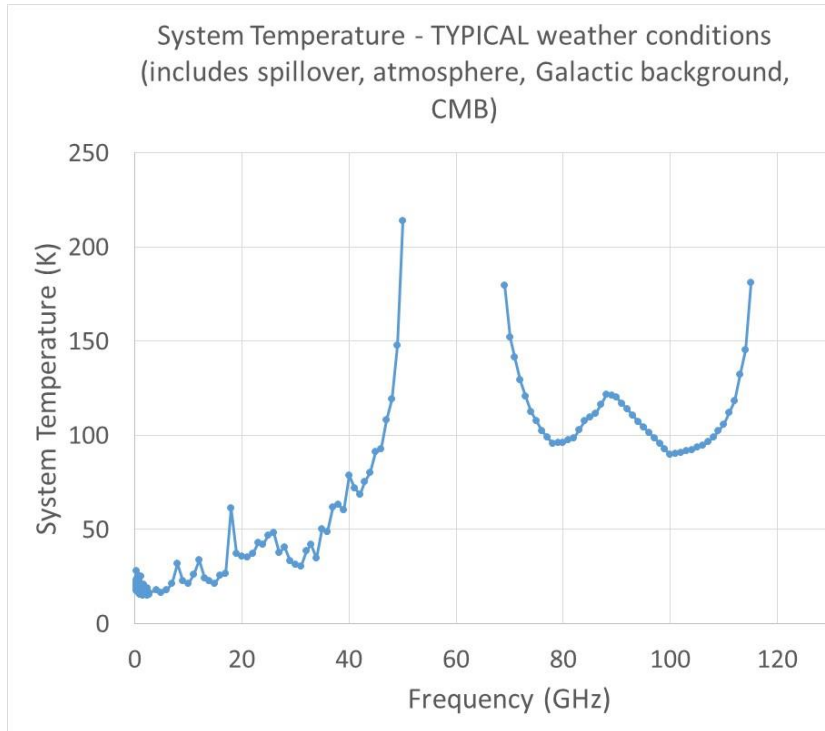
The GBT:

GBT Beam at 109 GHz; 6.4''



The GBT:

Frequency Coverage from 0.2-116 GHz



- Most receivers are single/dual pixel, however...
 - Three multi-pixel ‘cameras’ now available on the GBT
- Primary backend is FPGA/GPU system

The Future

Meeting the scientific needs of the next decade:

The Advanced GBT

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

New Capabilities

ngVLA: Antenna site; More?

GBT Radar System

Radio Cameras

Phased Array Feed Technology

FLAG -> KPAF, FLAG2

Traditional Feedhorn Arrays

KFPA -> ARGUS -> ARGUS+

Bolometer Arrays

MUSTANG -> MUSTANG 1.5 -> MUSTANG2

Optimized Feeds

Wide-band Feeds

UWB (0.8 – 4.0 GHz) -> Increase across all bands

Optimized Feed technology

L-band -> ??

Infrastructure

Shared spectrum

Digitized IF -> Improved RFI Resilience

Data Archive

Archive tool -> facility -> clouds + hard storage

Improved data processing tools

Port of existing tools to pipeline

Increased hours: high frequency science

LASSI -> LASSI2

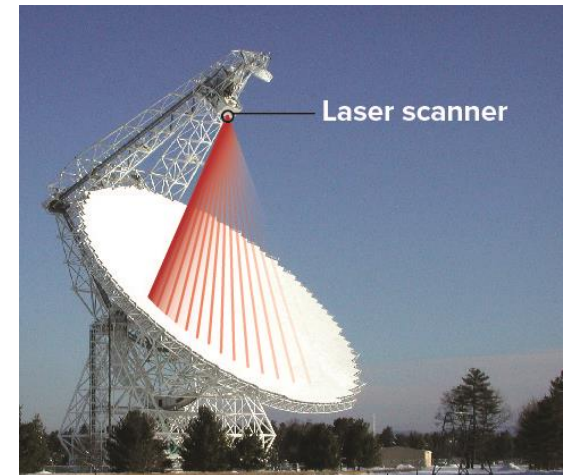
GREEN BANK
OBSERVATORY

The Future

LASSI: Laser Active Surface Scanning Instrument

\$1.3M grant from NSF MSIP

- Place Terrestrial Laser Scanner on GBT to provide real time surface corrections
- Allows for high frequency observing during the day
- Minimize time needed for OOF Holography
- **Increase high frequency hours available to GBT**
- Will ease scheduling issues, benefit all science
- **Commissioning for instrument underway!**
- PI: Lockman



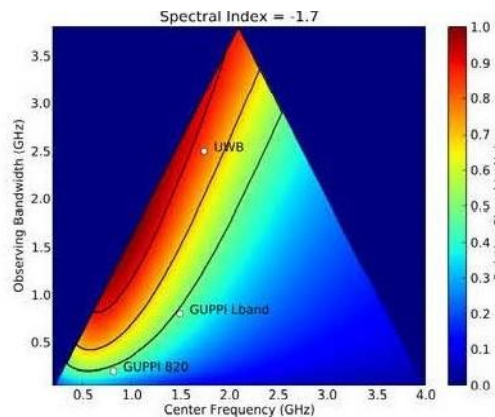
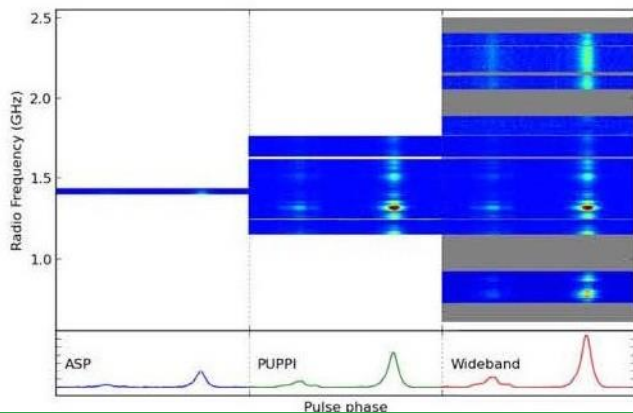
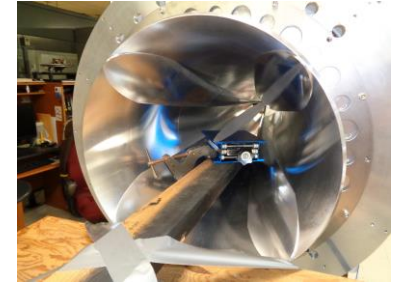
The Future

Ultra Wideband Feed



Moore Foundation award (PI: Ransom – NRAO/NANOGrav)

- 0.7 – 4.0 GHz feed optimized for pulsar work
- Aim is $T_{\text{sys}} \sim 30$ K
- Doubles the sensitivity for most pulsar timing observations
- Under construction;



Left: Pulse profile versus frequency for J2214+ 3000 as observed by ASP, PUPPI, planned UWB

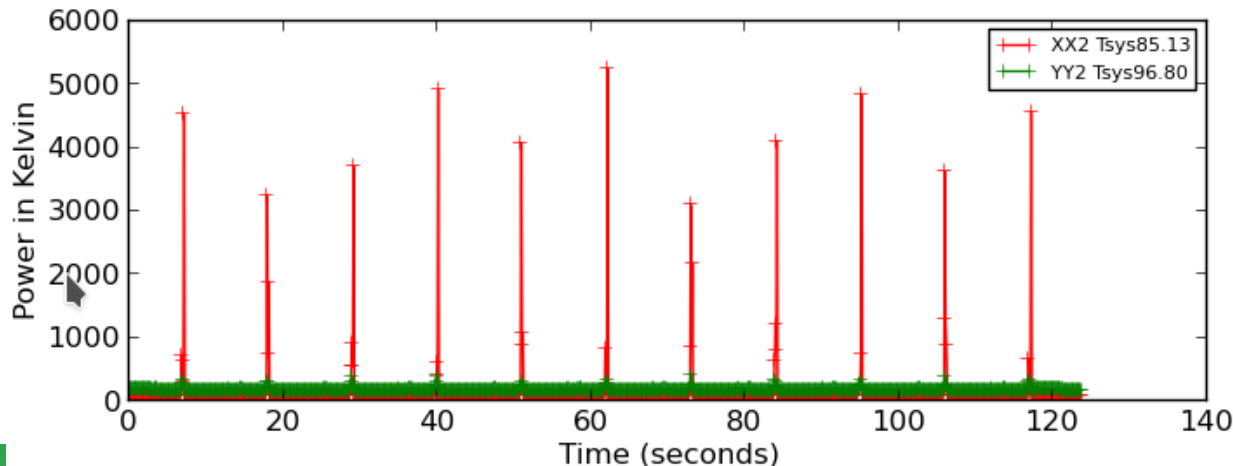
Right: Relative SNR as a function of observing bandwidth and center frequency for uniformly-weighted data and a typical pulsar spectral index of -1.7

The Future

Digitizing the RF

NSF ATI award (R.Lynch, PI)

- Designed for wide-band digital systems
- Increase the range of frequencies detected at any instant
- Allows for active RFI mitigation;
- Improves dynamic range, baselines
- Development underway; Goal is to deploy on UWBR



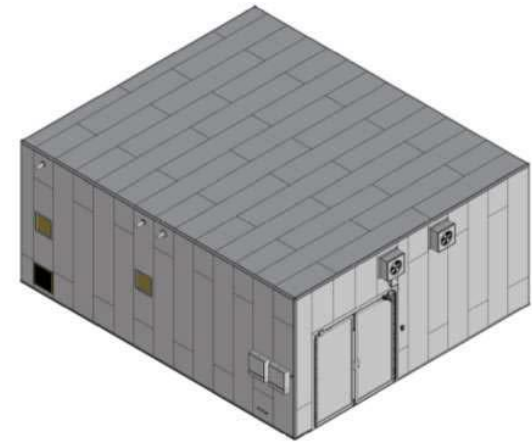
Data from the GBO 20-m telescope demonstrating our new, real-time robust recursive power estimation excision technique.

The Future

Data Archive Center

NSF WoU award

- Allow for onsite archiving of **all** GBT open skies data
- Data will be accessed through the NRAO AAT
- Cost effective means for data storage

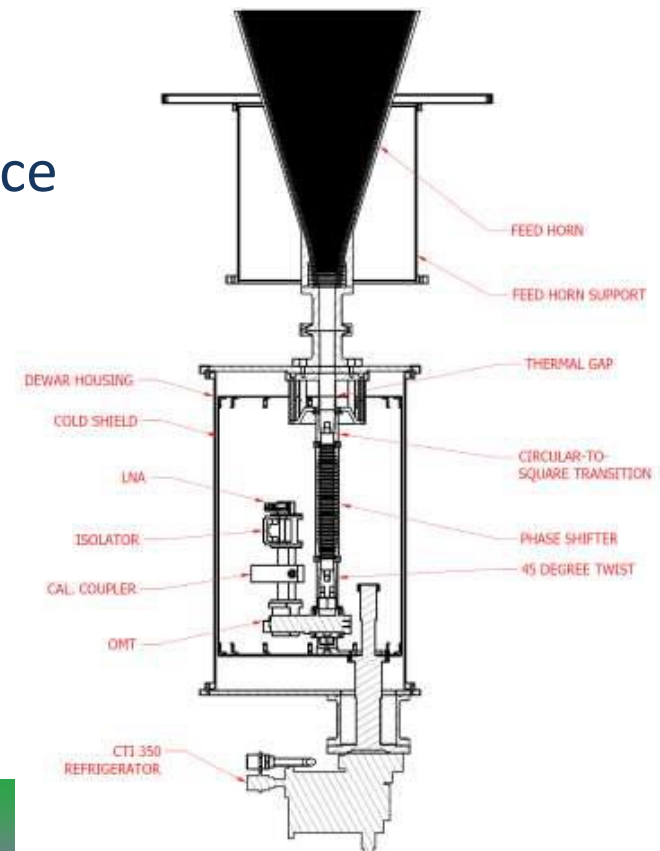


The Future

X-band Receiver Replacement

Internally funded

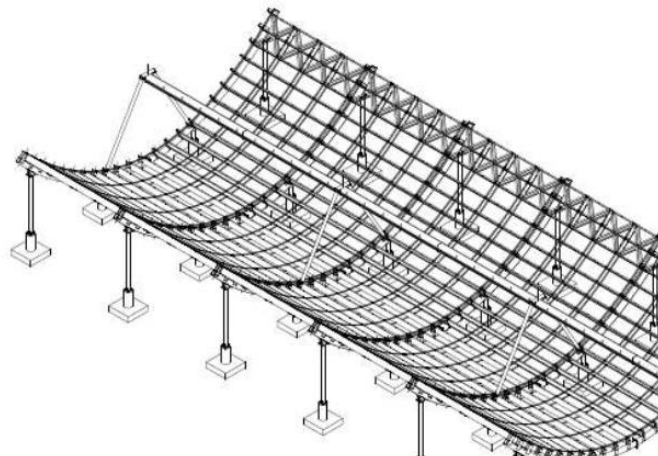
- Replaces the current GBT X-band receiver at the Gregorian focus
- Increased frequency range
 - 8-12 GHz instead of 8-10.1 GHz
- Higher cooling capacity = less maintenance
- Improved baseline stability
- Commissioning planned for 2021



The GBT – Looking Ahead

CHIME Outrigger

- Proposed CHIME outrigger antenna on site
- Planned construction to start as soon as weather allows



The Future

Radar Systems

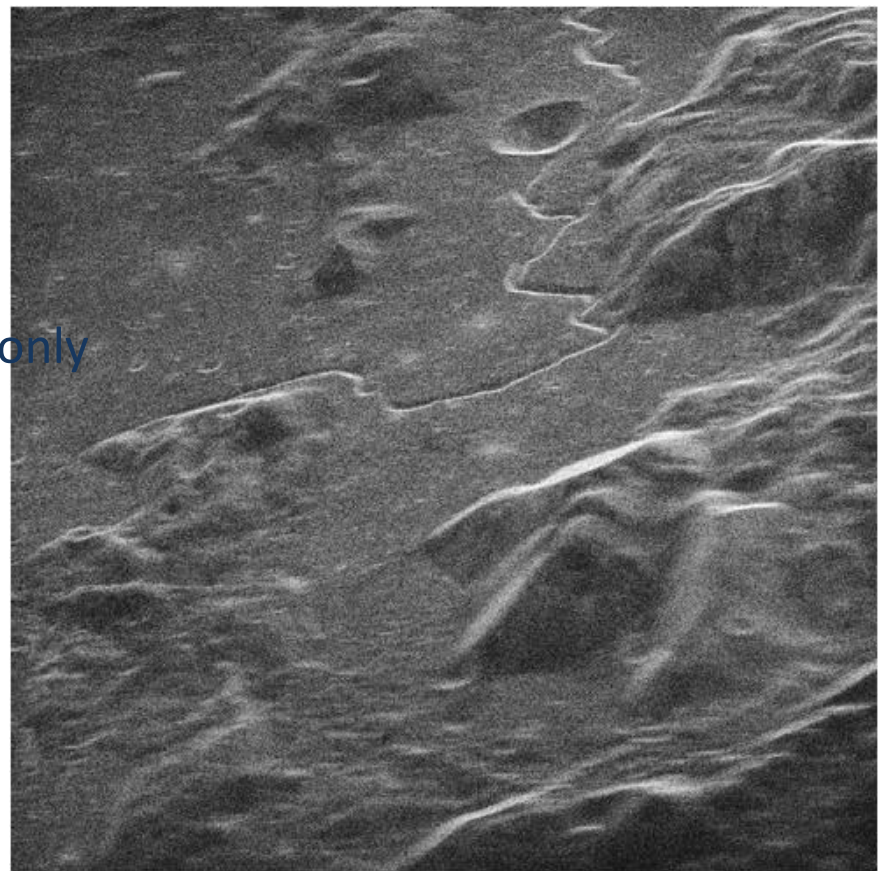
Planning for new high power radar system on GBT

Phase I: low power demonstration

- Test system: 700W, 14 GHz
- Images Apollo 15 landing site
- Image show receive with Hancock VLBA only

Phase II: high power system

- 50-100s kW transmit on GBT
- VLBA then ngVLA as receive
- Project planning underway
- Not yet funded

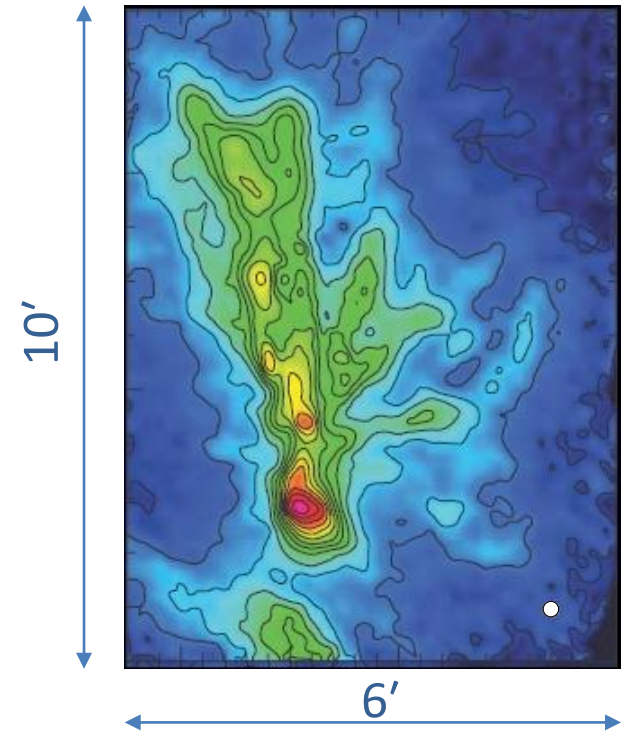


The Future

The GBT – Radio Cameras

ARGUS 144

- Planned instrument
- 10 x 10 pixels; 85-116 GHz
- Pixel spacing 26.7" ; Footprint: 4'x4'
- T_{sys} : 50-60K
- FWHM: 8" at 89 GHz; 6.5" at 110 GHz
- ≥ 1 GHz instantaneous bandwidth
- ≥ 2 spectral windows of 100 MHz each
 - Frequency resolution ~ 60 kHz (0.2 km/s)
- Project not yet funded
- Have applied to NSF MSIP program



Part of OMC-1 mapped by Argus in HNC(1-0). This map took 4.5 hours, including pointing, surface setting and calibration. The white circle (lower right) shows the Argus beam. With Argus+ and the planned GBT metrology improvements spectral lines images with identical sensitivity over a somewhat larger area will be acquired in <30 min.

(Figure courtesy of Alvaro Hacar).

The Future

Meeting the scientific needs of the next decade:

The Advanced GBT

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

New Capabilities

ngVLA: Antenna site; More?

GBT Radar System

Radio Cameras

Phased Array Feed Technology
FLAG -> KPAF, FLAG2

Traditional Feedhorn Arrays
KFPA -> ARGUS -> ARGUS+

Bolometer Arrays
MUSTANG -> MUSTANG 1.5 -> MUSTANG2

Optimized Feeds

Wide-band Feeds
UWB (0.8 – 4.0 GHz) -> Increase across all bands

Optimized Feed technology
L-band -> ??

Infrastructure

Shared spectrum
Digitized IF -> Improved RFI Resilience

Data Archive
Archive tool -> facility -> clouds + hard storage

Improved data processing tools
Port of existing tools to pipeline

Increased hours: high frequency science
LASSI -> LASSI2

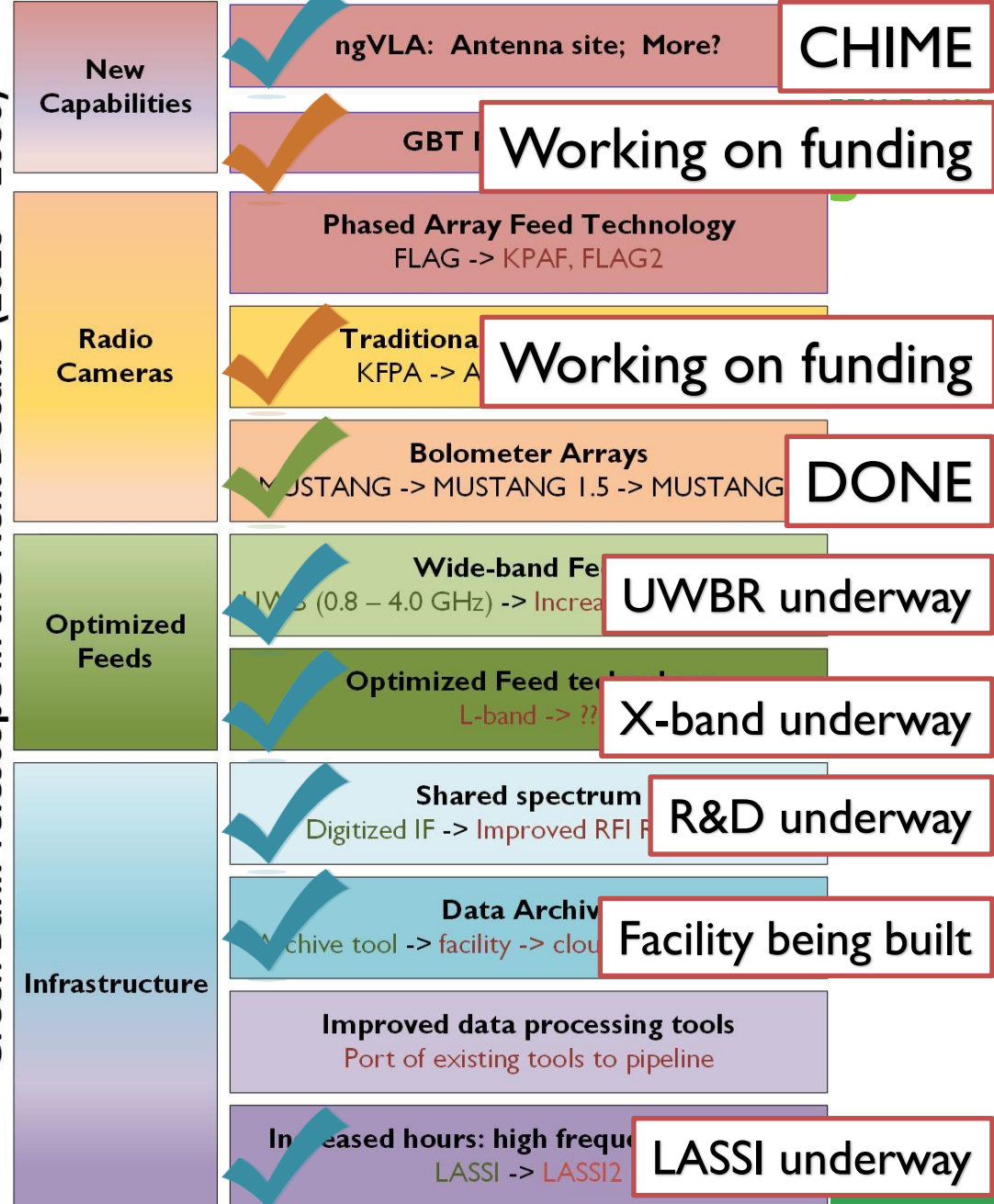
GREEN BANK
OBSERVATORY

The Future

Meeting the scientific needs of the next decade:

The Advanced GBT

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



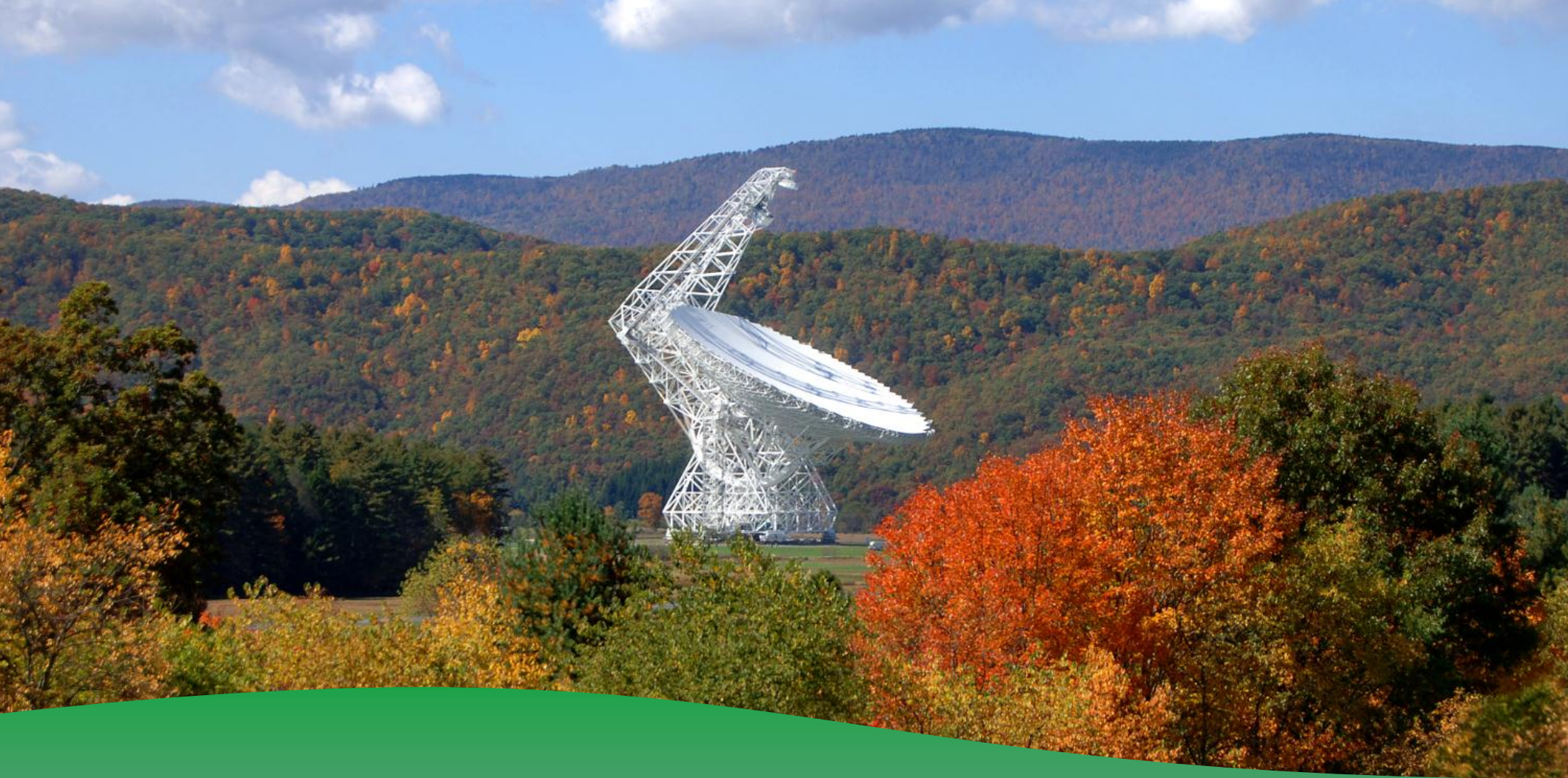
The Future

What is next?



- Numerous new instruments and capabilities under development
- GBT will see many new capabilities within the decade
- After that?
 - Working to define GBT/GBO's role in the era of the ngVLA
 - ngVLA antenna site; Role for GBT with zero spacing, high sensitivity?
 - Operational plans for radar system may also play into GBT+ngVLA plans
- But the long term GBT future is also up to you!
 - The GBT was built for the astronomy community
 - Community input is **the** basis for our long term goals and instrumentation





GBT Remote Observing Workshop

Virtual Workshop

May 24, 26, 28, 2021



- Welcome to the Green Bank Observatory! *(kind of)*
- Located in the “National Radio Quiet Zone”, protected from radio interference.
- Come visit and explore the grounds
 - Trail maps available upon request
 - No electronic devices near the telescopes (past the gate)
 - Be aware of wildlife
- Gift shop/science center open online
 - 10% off coupon in Informational email



Goals for the Workshop

- Become familiar with GBT observing modes and user interfaces
- Practice standard data reduction techniques
- Learn how to observe remotely
 - ...*But come visit in person some day!*

Schedule

- 9 am – 4:30 pm EDT on Monday & Wednesday
 - Lectures and Observation Prep
 - We'll be on this Zoom for all of these
- 5:30 pm – 8 am : Monday Group Observations
- 5:30 pm – 8 am : Wednesday Group Observations
 - Each group has their own Zoom for overnight observations.

Friday Activities:

9 am – 10:30 am : Data Reduction Session

11 am – 12:30 pm : Project Presentations (Each Group)

	Monday May 24		May 25	Wednesday May 26		May 27	Friday May 28
9:00	Welcome <i>(Karen O'Neil & Will Armentrout)</i>			Continue Data Reduction & Observing Preparation w/ Project Friends VLBI Discussion (Optional) 10:00-10:30 <i>(Tapasi Ghosh)</i>			Data Reduction w/ Project Friends
9:30	The Green Bank Telescope <i>(David Frayer)</i>						
10:00							
10:30				Break	Break		
11:00	Introduction to Astrid and Cleo <i>(Brenne Gregory & Amber Bonsall)</i>			Observing Recap & GBT Public Relations <i>(Will Armentrout & Jill Malusky)</i>			Project Presentations <i>(Participants)</i>
11:30				Review of High Freq. GBT Corrections <i>(Natalie Butterfield)</i>			
12:00			Break (Speakers will be available)			GBT Dynamic Scheduling System <i>(Toney Minter - Recorded)</i>	
12:30	Remote Observing / Connection Workshop <i>(Andrew Seymour)</i>						
13:00	Green Bank Computing Environment - Linux, IDL, etc. <i>(Larry Morgan)</i>		"Office Hour" w/ Project Friends	Break (GBT Community Zoom - Natalie Butterfield)		"Office Hour" w/ Project Friends	All times are EDT <i>(UTC - 4)</i>
13:30	Spectral Line & Continuum Reduction (Pedro)	Pulsar Data Reduction (Andrew)		How to Prepare and Submit a GBT Proposal <i>(Will Armentrout)</i>			
14:00							
14:30	Group Observing Preparation w/ Project Friends			Frequently Asked Questions <i>(Amber & Jesse)</i>			
15:00	Break			Break (Speakers will be available)			
15:30	Group Observing Preparation w/ Project Friends			Group Observing Preparation w/ Project Friends			
16:00							
	Night One Observing Begins at 5:30 pm			Night Two Observing begins at 5:30 pm			

Observing Accounts

- If we have a new account for you, I'll send you a message over Zoom with your account information.
- Otherwise, your project friend will be able to open up a remote session for you.
- Two Options to Log In
 - (1) Login using “ssh [username]@ssh.gb.nrao.edu”
 - (2) Use “FastX” -- Link included in welcome email.
- Change password with “passwd” command.