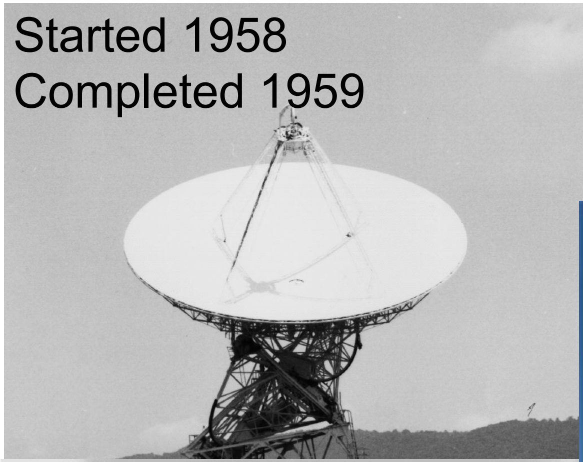
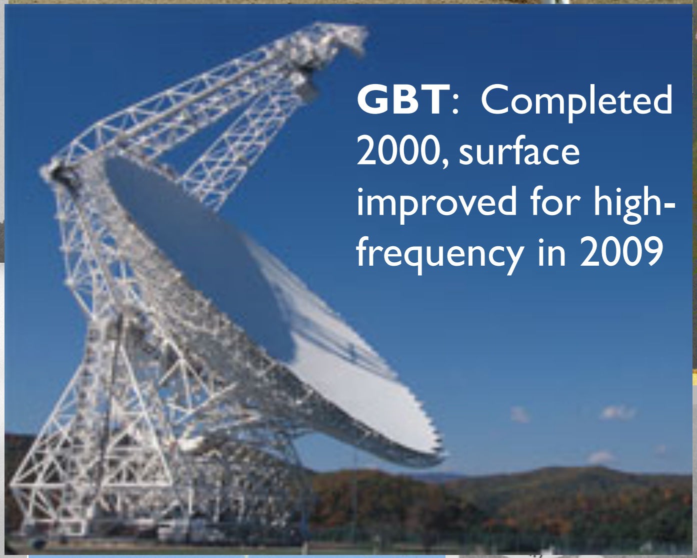
Proposing for the GBT

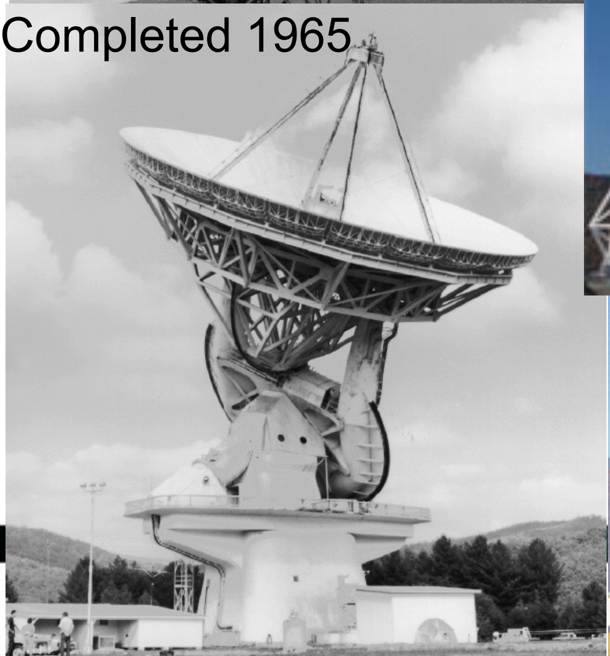
David Frayer (NRAO)

Green Bank, WV is original the NRAO site



Completed 1962

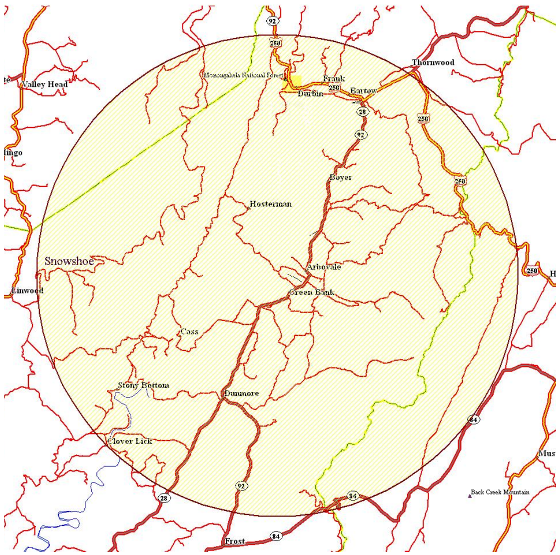




Site protected from Radio interference

WV Radio Astronomy Zone

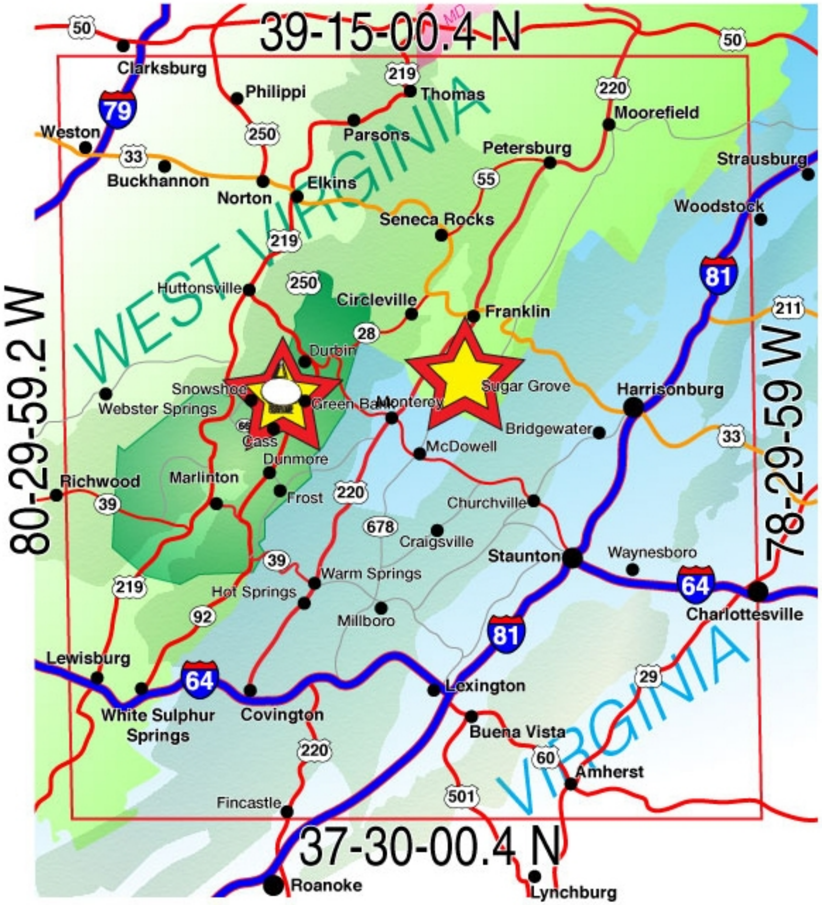
Established by the West Virginia Legislature (1956)



Protection within ten miles of the Observatory

National Radio Quiet Zone

Established by the FCC and NTIA (1957)

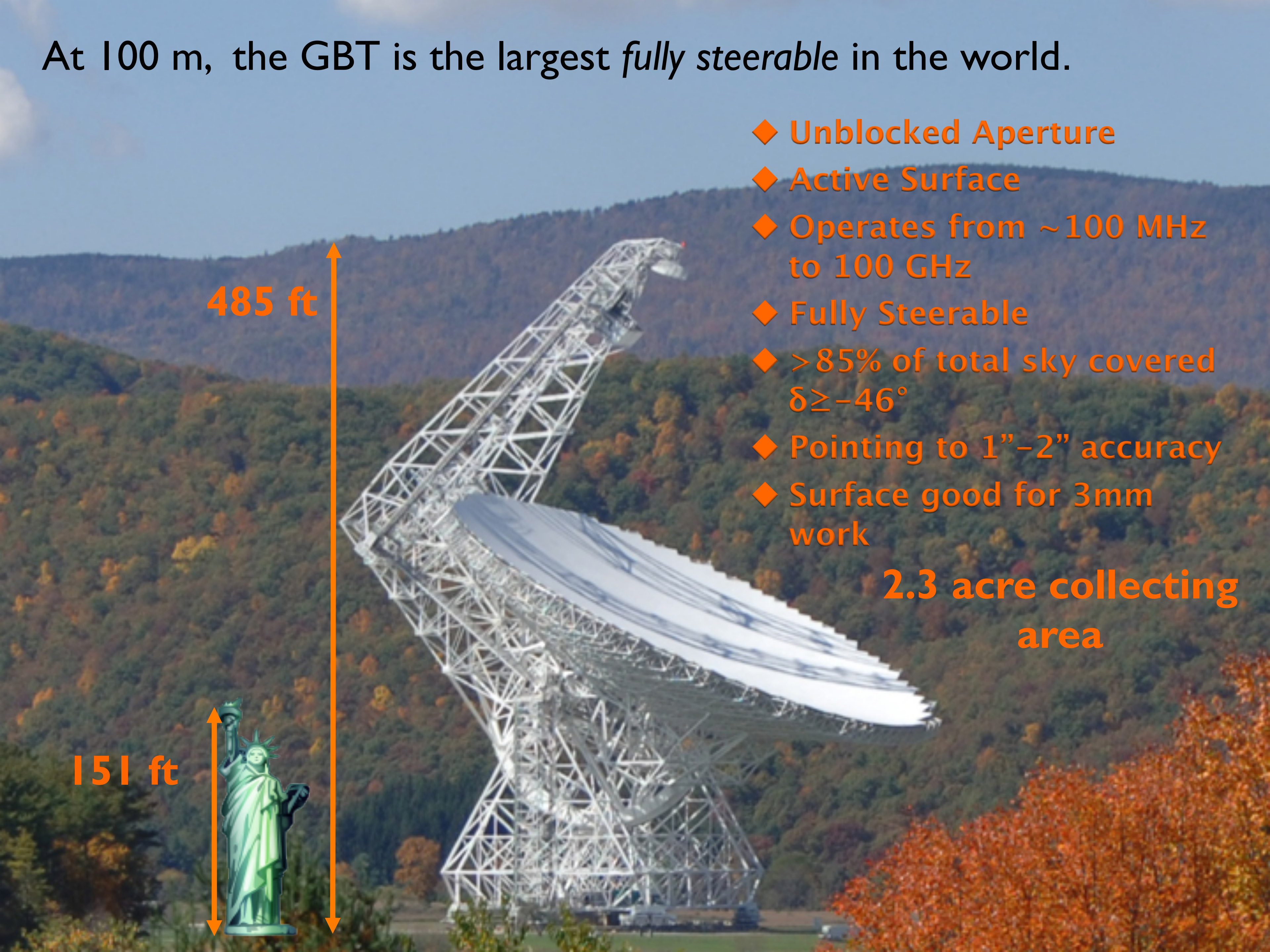


13,000 Square Miles

At 100 m, the GBT is the largest *fully steerable* in the world.

- Unblocked Aperture
- Active Surface
- Operates from ~100 MHz to 100 GHz
- Fully Steerable
- >85% of total sky covered $\delta \geq -46°$
- Pointing to 1"–2" accuracy
- Surface good for 3mm work

2.3 acre collecting area



The Active Surface 2209 actuators

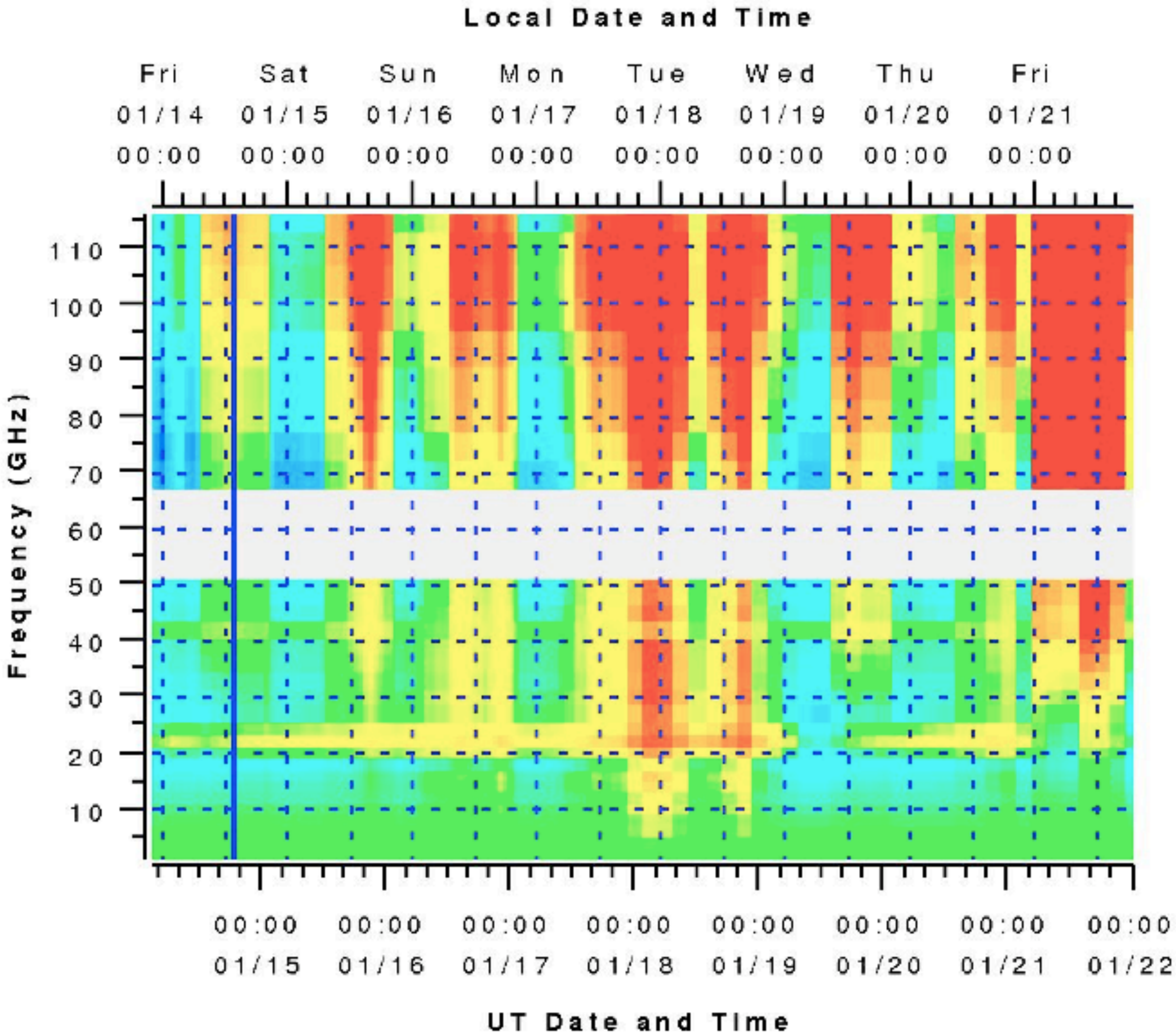
Currently rms ~240μm at night, the goal is ~200μm

Makes the GBT the largest single-dish operating efficiently at 3mm in the world

Some Key GBT Science Areas:

- Pulsars: Discovery of new pulsars, the most massive pulsar, gravity waves via pulsar timing
- Neutral Hydrogen HI: Masses of local galaxies, Kinematics of galaxy and local group/dark matter
- High-redshift/Cosmology: Galaxy clusters, CO in the early universe, HI intensity mapping at high-redshift
- Interstellar Organic Molecules/Astro-chemisty
- Masers: black hole masses, distances via proper motions and independent measurement of Ho
- Star Formation: NH3 mapping, cold and dense gas tracers at 4mm
- Basic Physics: The search for Gravitational Radiation, Limits on Fundamental "constants"
- Solar system astronomy -- planetary radar

Dynamical Scheduling System allows efficient use of telescope at high frequency – based on weather model predictions that are updated every 6 hrs.



Telescope dynamically scheduled daily based on weather conditions and receiver and observer availability. Dynamic Scheduling matches the project to the weather

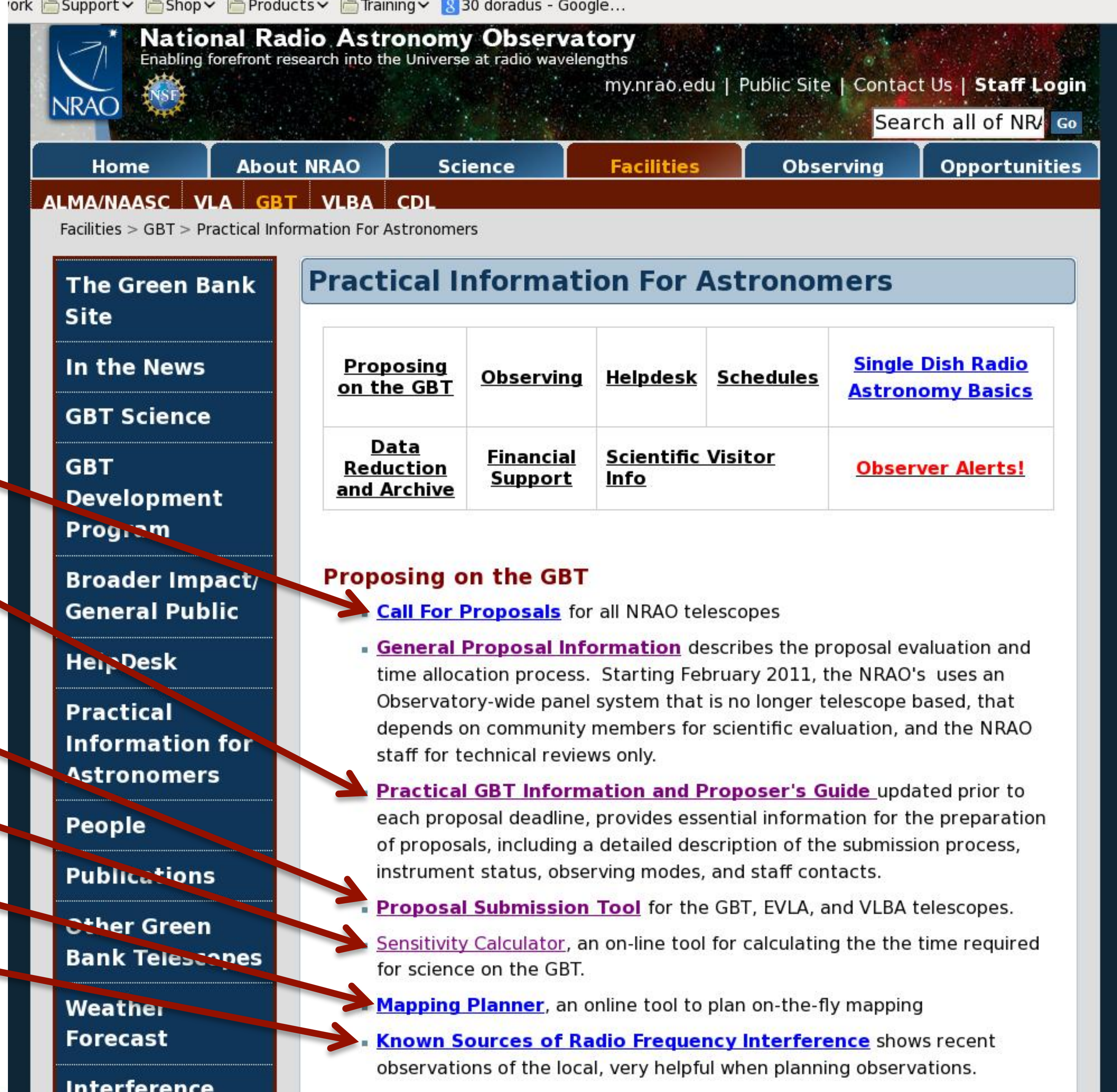
6500+ hours a year scheduled for astronomy

In 2010 there were 1776 hours used at frequencies above 18 GHz

NRAO

GBT Astronomer's Web-page ("Practical Information for Astronomers")

- Call for Proposals
- GBT proposal Guide
- Proposal Submission Tool (PST)
- Sensitivity calculator
- Mapping Planner
- Known RFI



National Radio Astronomy Observatory
Enabling forefront research into the Universe at radio wavelengths

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Home | About NRAO | Science | Facilities | Observing | Opportunities

ALMA/NAASC | VLA | GBT | VLBA | CDL

Facilities > GBT > Practical Information For Astronomers

The Green Bank Site
In the News
GBT Science
GBT Development Program
Broader Impact/ General Public
HelpDesk
Practical Information for Astronomers
People
Publications
Other Green Bank Telescopes
Weather Forecast
Interference

Practical Information For Astronomers

Proposing on the GBT	Observing	Helpdesk	Schedules	Single Dish Radio Astronomy Basics
Data Reduction and Archive	Financial Support	Scientific Visitor Info		Observer Alerts!

Proposing on the GBT

- Call For Proposals for all NRAO telescopes
- General Proposal Information describes the proposal evaluation and time allocation process. Starting February 2011, the NRAO's uses an Observatory-wide panel system that is no longer telescope based, that depends on community members for scientific evaluation, and the NRAO staff for technical reviews only.
- Practical GBT Information and Proposer's Guide updated prior to each proposal deadline, provides essential information for the preparation of proposals, including a detailed description of the submission process, instrument status, observing modes, and staff contacts.
- Proposal Submission Tool for the GBT, EVLA, and VLBA telescopes.
- Sensitivity Calculator, an on-line tool for calculating the the time required for science on the GBT.
- Mapping Planner, an online tool to plan on-the-fly mapping
- Known Sources of Radio Frequency Interference shows recent observations of the local, very helpful when planning observations.

GBT Proposal Guide (updated with each proposal call)

News for 14B:

- **VEGAS replaces the GBT spectrometer and spectral processor**
- C-band upgrade to cover 3.95-8 GHz frequency range (shared-risk)
- Mustang 1.5 will be upgraded (shared-risk)

The Proposer's Guide for the Green Bank Telescope

GBT Support Staff

December 19, 2013

This guide provides essential information for the preparation of observing proposals on the Green Bank Telescope (GBT). The information covers the facilities that will be offered in Semester 14B.

Available GBT receivers for 14B

Table 1: GBT Receivers

Receiver	Frequency Range
PF1	290-920 MHz
PF2	910-1230 MHz
L	1.15-1.73 GHz
S	1.73-2.60 GHz
C (shared risk)	3.8-8.0 GHz
X	8.0-12.0
Ku	12.0-15.4 GHz
KFPA - seven pixel array	18.0-26.0 GHz
Ka	26.0-39.5 GHz
Q	38.2-49.8 GHz
W	67-93.3 GHz
MBA1.5 - Bolometer Array(shared risk)	80-100 GHz

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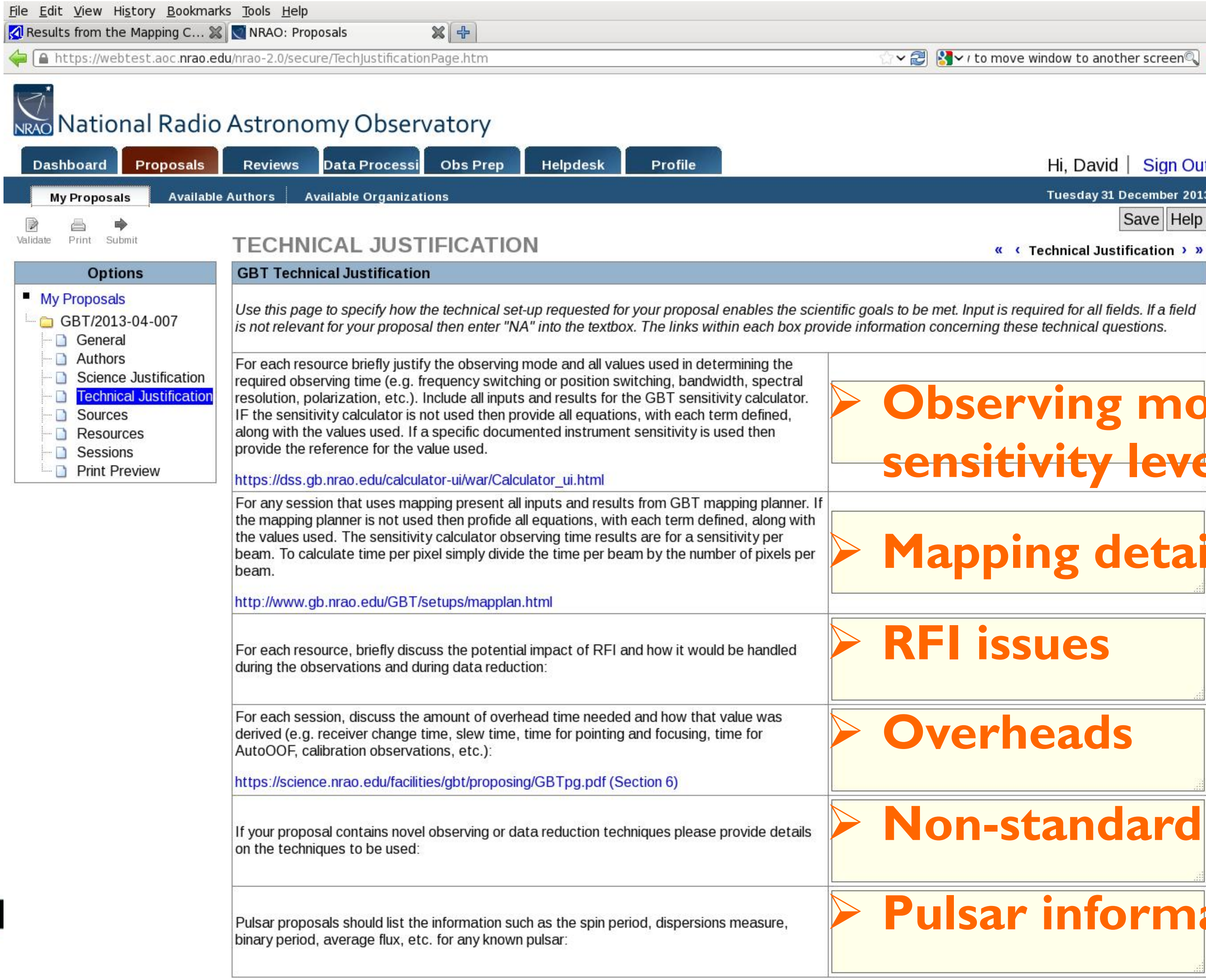
Available GBT Backends for 14B

Table 2: GBT Backends

Backend	Observing Modes
VEGAS	Continuum, pulsar, spectral line
DCR	Continuum
Guppi	Pulsar
Mark Vc	VLBI
CCB	Continuum (Ka-band)
Zpectrometer	Private PI instrument – contact the NRAO helpdesk for further information (Ka-band)
Radar	Private PI instrument – contact the NRAO helpdesk for further information

NRAO

Fill in Technical Justification Boxes



- Observing modes and sensitivity level
- Mapping details
- RFI issues
- Overheads
- Non-standard techniques
- Pulsar information

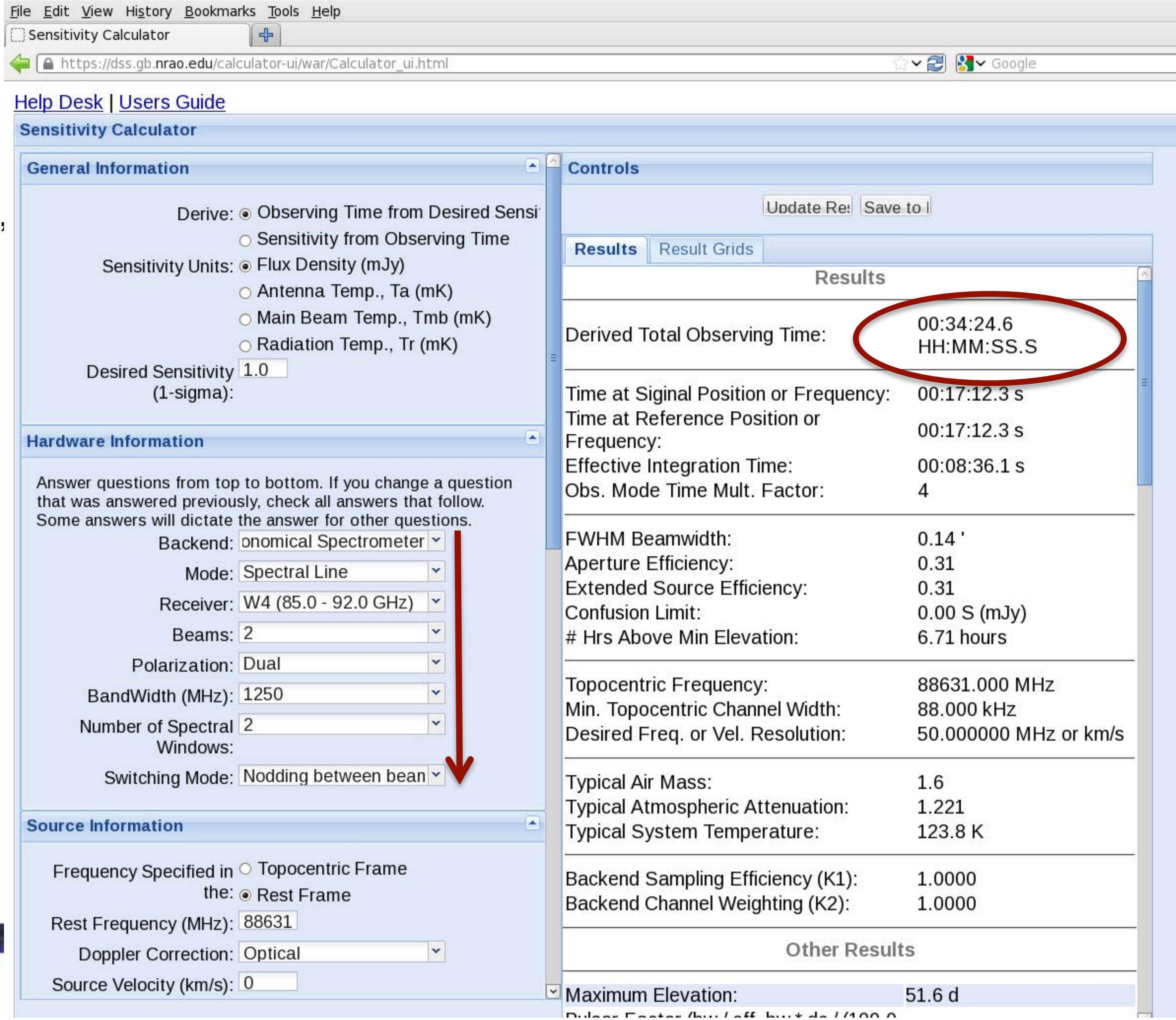
Where to find information needed for "Technical Justification Boxes":

1) **Observing modes and sensitivity level:** inputs and results of sensitivity calculator
2) **Mapping details:** Mapping Calculator web page
3) **RFI issues:** RFI web pages, if needed
4) **Overheads:** Section 6 of GBT proposers guide
5) **Non-standard techniques:** staff/experts, if needed
6) **Pulsar information:** pulsar experts, if needed

GBT Sensitivity Calculator/Time Estimator

GBT Sensitivity Calculator also useful for verifying available modes (number of beams, polarization, spectral windows)

Input sensitivity needed, results of observing time required, setup and observing mode(s) in the Technical Justification boxes of the PST



GBT Mapping Calculator

Input:

- Backend
- Map Type (OTF, point)
- Frequency
- Integration time per beam
- Map Size (or radius)
- Sampling (with respect to Nyquist)

Output:

- Observing time (including overheads)
- Astrid command to carry out observation
- Any warnings (e.g., too many accelerations per minute)

www.gb.nrao.edu/~rmaddale/GBT/GBTMappingCalculator.html

GBT Mapping Calculator

Last Modified: December 6, 2013
Ronald J Maddalena

Calculates the time needed to map,an area including overhead, based on the integration time per beam area (e.g., the results from the Sensitivity Calculator) and the area to be mapped. Provides example ASTRID commands as well as other mapping parameters. Supports the typical mapping commands for on-the-fly (OTF) rectangular maps, OTF Daisy maps, and point rectangular maps.

Input Values	**Instructions**
Backend and Mode: Default Spectral Line	Used by the calculator to provide values for the minimum time resolution and minimum sampling time. If you don't know what to select here, try '*DCR*' for continuum observations and '*Default Spectral Line*' for spectral line observations.
Map Type: ◉ OTF Rectangle ○ OTF Daisy ○ Point Rectangule	The type of map. Either: *OTF Rectangle*: On-the-fly mapping of a rectangular area. The OTF motion is either along rows of the map (i.e., *RALongMap*) or along columns

Radio Frequency Interference (RFI)

National Radio Astronomy Observatory

NRAO Green Bank > RFI Protection Group > GBT RFI Archives

GBT Radio Frequency Interference

- Introduction
- GBT Receiver Plots by Band
- GBT RFI Monitoring Station Plots by Band
- Older Surveys and Band Summaries
- Known Sources Database

Introduction

The Green Bank Radio Frequency Interference (RFI) Protection Group would like to offer two primary tools to observers for the purposes of RFI avoidance and mitigation. One of these tools is an archive of RFI scans which will give the observer an idea of spectral oc seen by the GBT receivers themselves, and (eventually) from the GBT RFI Monito (pictured right).

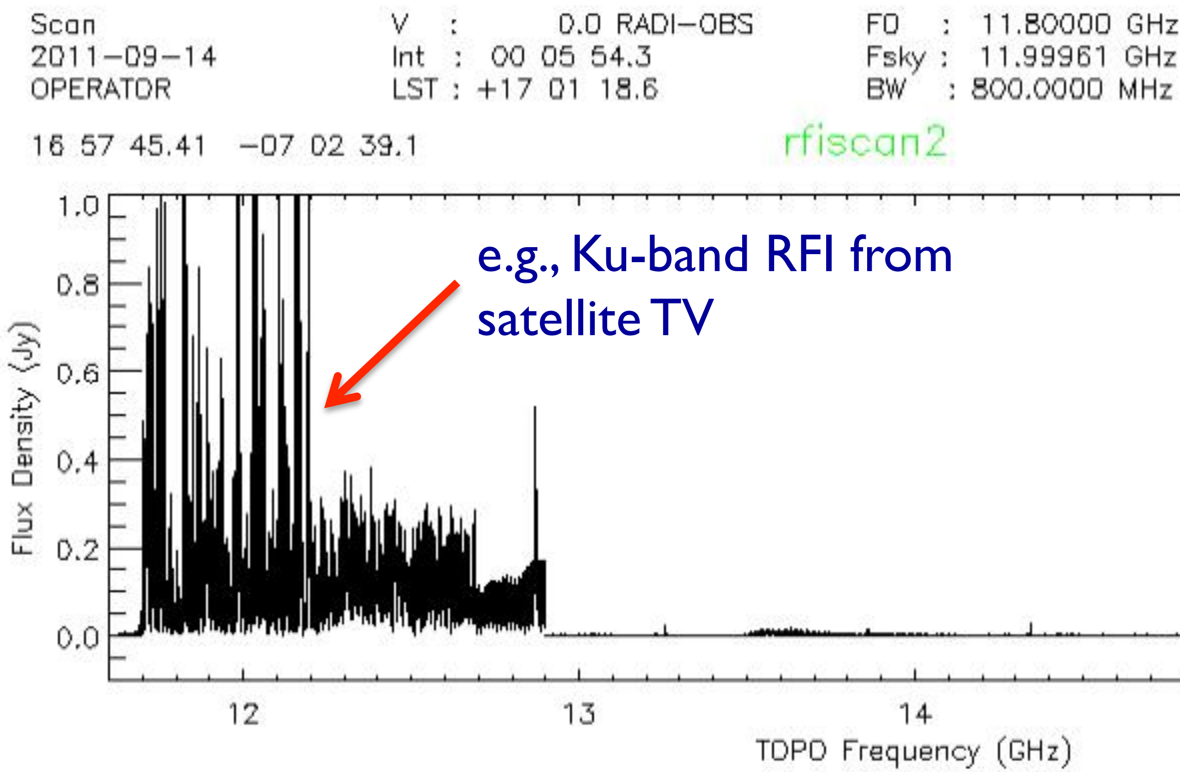
The second, still under construction, will be a RFI Database which provides details persistent, identified RFI sources including coordination information where applica now, we have a Table of Known RFI Sources and a number of Older Surveys and Summaries linked below.

To maximize your chances of RFI avoidance, we advise the following:
1) Consult the latest GBT RFI plots to determine whether the spectrum you wish t typically clear, or occupied by RFI.
2) Consult the Table of Known RFI Sources and/or the Surveys and Band Summa determine whether the source of the RFI is well known and/or likely to be somethi coordinate with (broadcast television, for instance, isn't going to coordinate with us
3) Contact a member of the Green Bank RFI Group to determine whether coordin possible. If it is, you will need to obtain a fixed window from the dynamic schedulin your observation, and the RFI group can then arrange coordination.

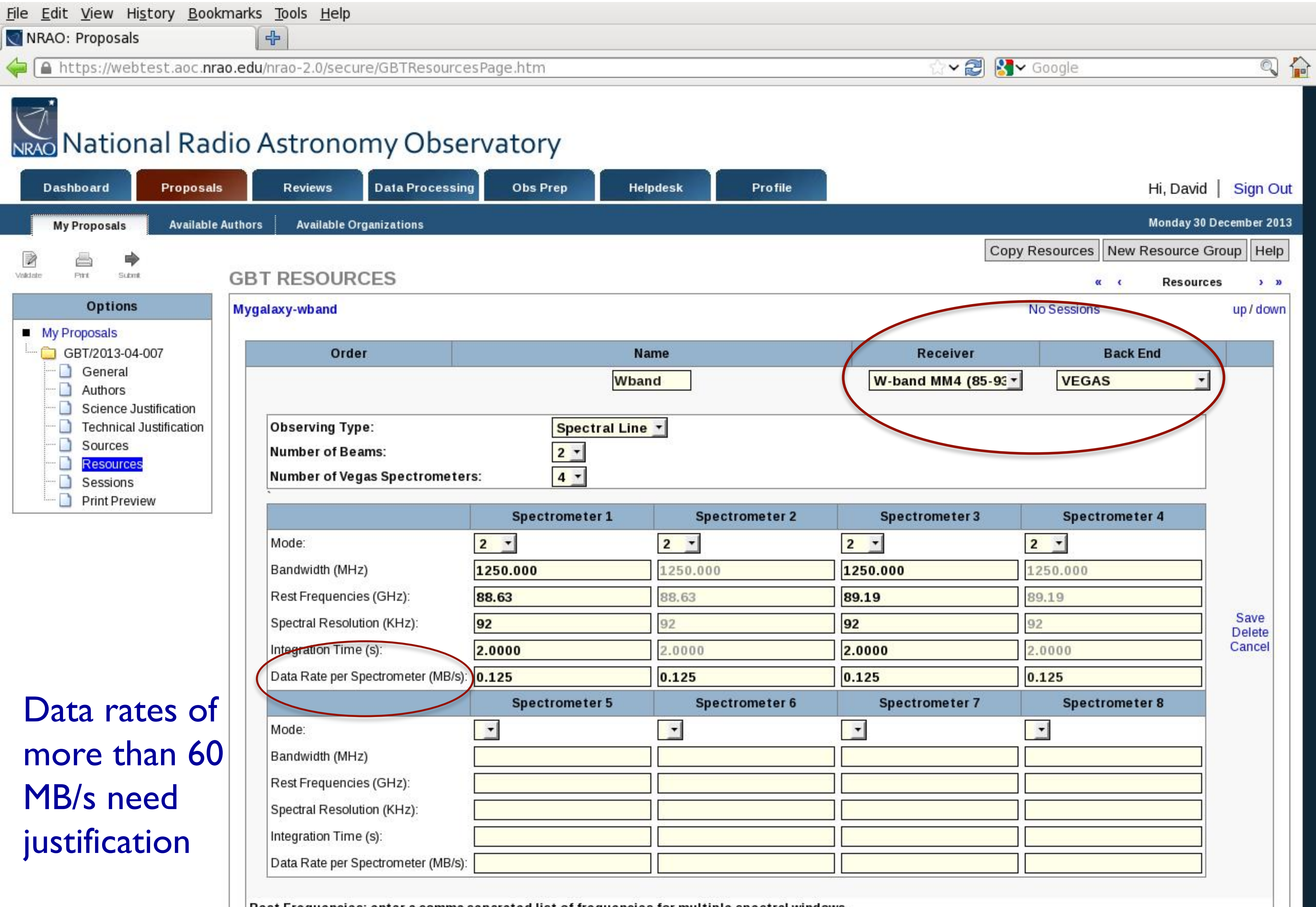
Usually, by the time RFI is experienced during observation, it is too late to do anyt it, but it is still worth reporting, in case it can be mitigated in advance of future obse

For additional information email interference@nrao.edu.

Check for possible RFI issues from RFI group's web pages and posted RFI scans from the GBT



GBT "Resources" (Receiver and Backend configuration)



Data rates of more than 60 MB/s need justification

VEGAS: the new GBT backend

Eight separate spectrometers that can be divided between beams and different frequencies as needed and can support up to 8 spectral windows per spectrometer.

Could configure with very large data rates, but most projects at <1MB/s (~30MB/s for pulsars), >60MB/s need to justify.

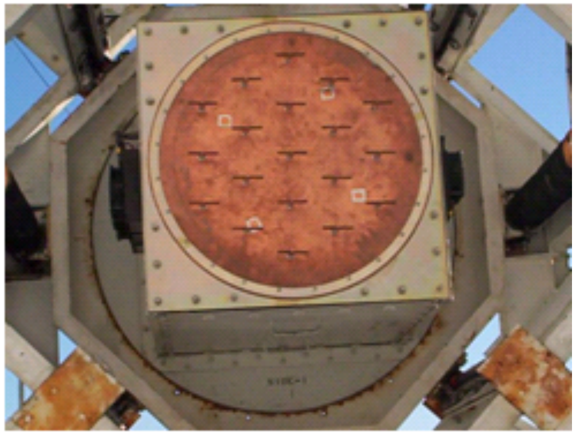
Mode	Oberving Type	Spectral Windows per Spectrometer	Bandwidth per Spectrometer (MHz)	Number of Channels per Spectrometer	Approximate Spectral Resolution (kHz)
1	Continuum	1	1250	1024	1465
1	Pulsar	1	1250	1024	1465
1	Spectral Line	1	1250	1024	1465
2	Spectral Line	1	1250	16384	92
3	Spectral Line	1	850	16384	61
4	Spectral Line	1	187.5	32768	5.7
5	Spectral Line	1	187.5	65536	2.9
6	Spectral Line	1	187.5	131072	1.4
7	Spectral Line	1	100	32768	3.1
8	Spectral Line	1	100	65536	1.5
9	Spectral Line	1	100	131072	0.8
10	Spectral Line	1	23.44	32768	0.7
11	Spectral Line	1	23.44	65536	0.4
12	Spectral Line	1	23.44	131072	0.2
13	Spectral Line	1	23.44	262144	0.1
14	Spectral Line	1	23.44	524288	0.05
15	Spectral Line	1	11.72	32768	0.4
16	Spectral Line	1	11.72	65536	0.2
17	Spectral Line	1	11.72	131072	0.1
18	Spectral Line	1	11.72	262144	0.05
19	Spectral Line	1	11.72	524288	0.02
20	Spectral Line	8	23.44	4096	5.7
21	Spectral Line	8	23.44	8192	2.9
22	Spectral Line	8	23.44	16384	1.4
23	Spectral Line	8	23.44	32768	0.7
24	Spectral Line	8	23.44	65536	0.4
25	Spectral Line	8	15.625	4096	3.8
26	Spectral Line	8	15.625	8192	1.9
27	Spectral Line	8	15.625	16384	0.95
28	Spectral Line	8	15.625	32768	0.48
29	Spectral Line	8	15.625	65536	0.24

Instruments in Development

FLAG

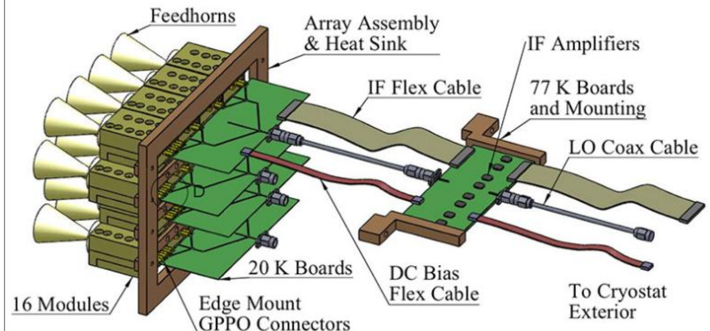
19-element phased-array feed [PAF] (7beams) at 21cm (2014/2015)

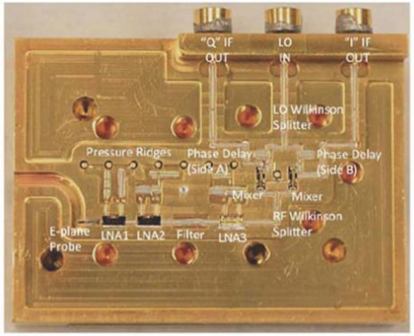
BYU/NRAO. Planned future 37element PAF (20beams).



Argus

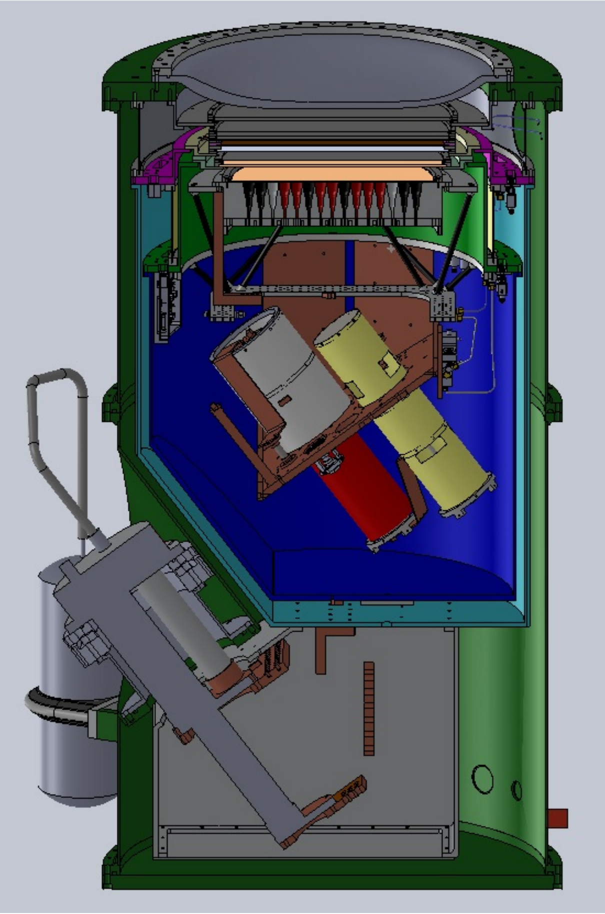
16 element scalable 75-115 GHz FPA (2014) Stanford/CIT-JPL/UMd/Miami/ NRAO (similar mapping speeds to ALMA)





Mustang-1.5 (2013) & Mustang-2 (2015) [Upenn/ NRAO] (10x mapping speed of ALMA)

3mm bolometer camera



New 3mm instruments will map faster than ALMA

Proposing with the GBT: Summary

- VEGAS is a new backend that replaces the current spectrometer for 14B
- The GBT is a powerful instrument – single-dish flexibility, large collecting area, wide-frequency coverage
- Development ongoing to enhance the capabilities of the GBT well into the future (higher frequency coverage, multi-pixel receivers, flexible spectrometers – the NSF is funding 5 instrumentation programs for the GBT involving many universities while planning for the telescope's "divestment")
- The GBT can provide key short-spacing data for several VLA and ALMA programs

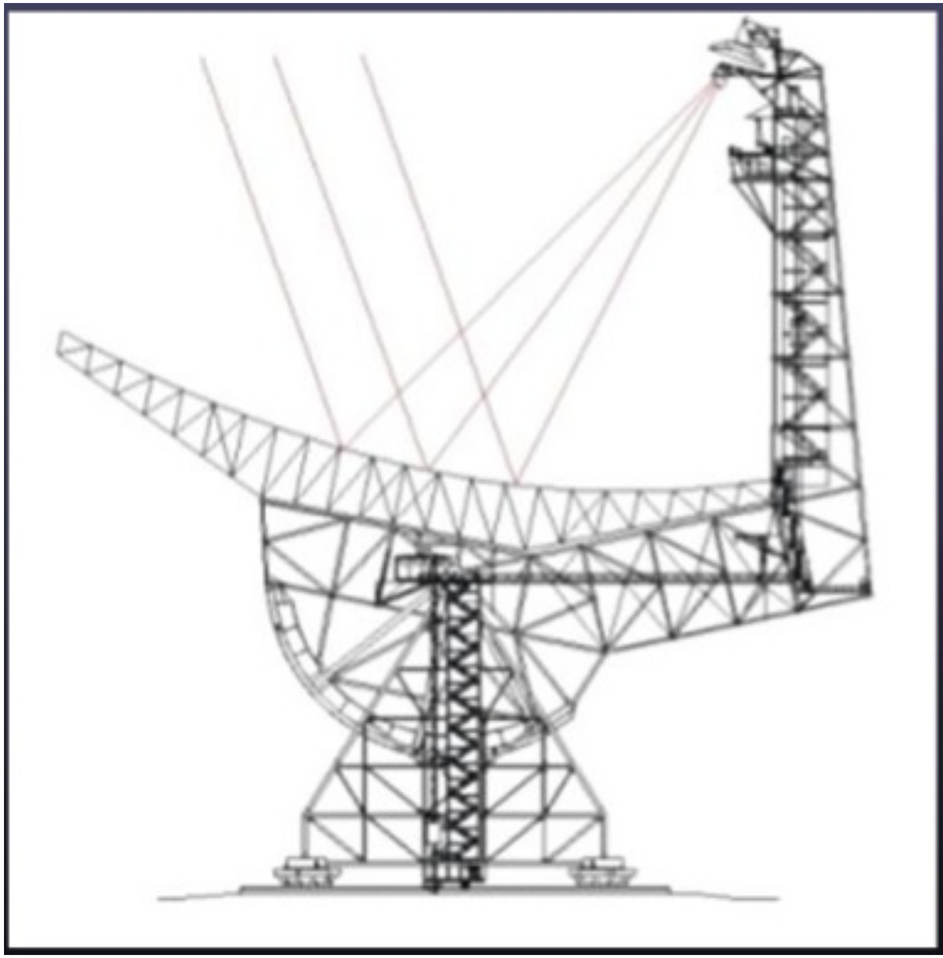
Additional Slides

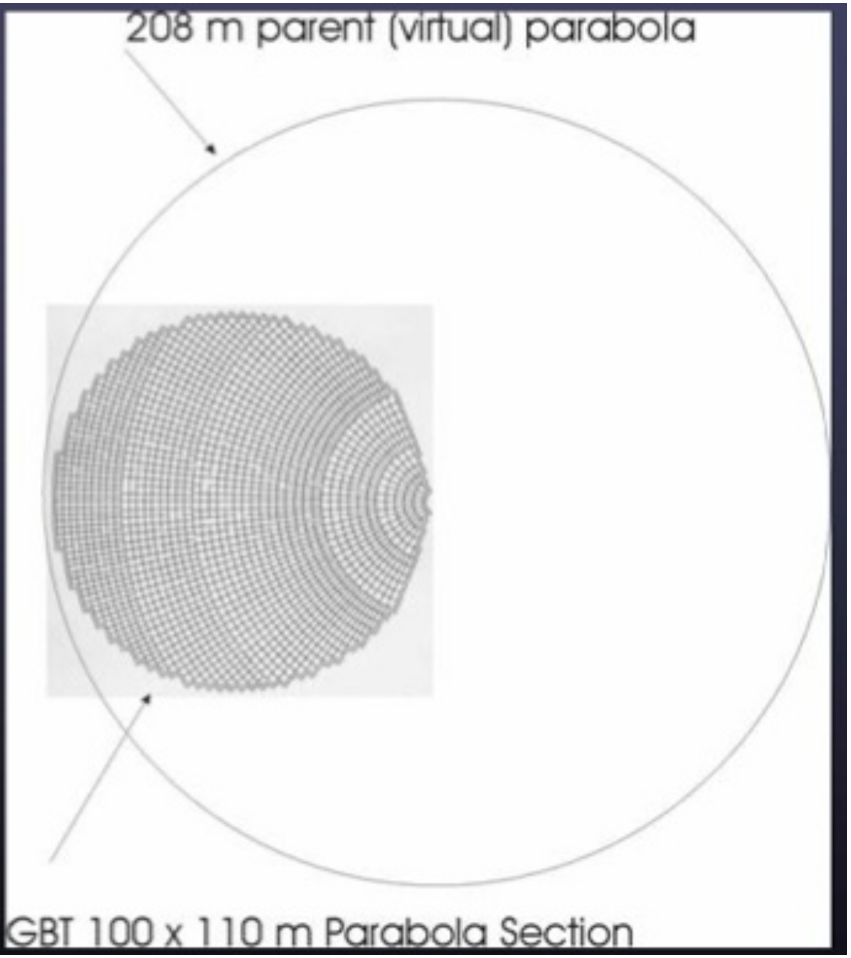
GBT Specs:

Location	Green Bank, West Virginia, USA
Coordinates	Longitude: 79°50′23.406″ West (NAD83) Latitude: 38°25′59.236″ North (NAD83) Track Elevation: 807.43 m (NAVD88)
Optics	110 m x 100 m unblocked section of a 208 m parent paraboloid Offaxis feed arm
Telescope Diameter	100 m (effective)
Available Foci	Prime and Gregorian f/D (prime) = 0.29 (referred to 208 m parent parabola) f/D (prime) = 0.6 (referred to 100 m effective parabola) f/D (Gregorian) = 1.9 (referred to 100 m effective aperture)
Receiver mounts	Prime: Retractable boom with Focus-Rotation Mount Gregorian: Rotating turret with 8 receiver bays
Subreflector	8-m reflector with Stewart Platform (6 degrees of freedom)
Main reflector	2004 actuated panels (2209 actuators) Average intra-panel RMS 68 μm
FWHM Beamwidth	Gregorian Feed: $\sim 12.60/f_{GHz}$ arcmin Prime Focus: $\sim 13.01/f_{GHz}$ arcmin (see Section 3.1.1)
Elevation Limits	Lower limit: 5 degrees Upper limit: $\sim$ 90 degrees
Declination Range	Lower limit: ~ -46 degrees Upper limit: 90 degrees
Slew Rates	Azimuth: 35.2 degrees/min Elevation: 17.6 degrees/min
Surface RMS	Passive surface: 450 μm at 45° elevation, worse elsewhere Active surface: $\sim$ 250 μm, under benign night-time conditions
Pointing accuracy	1σ values from 2-D data 5″ blind 2.7″ offset

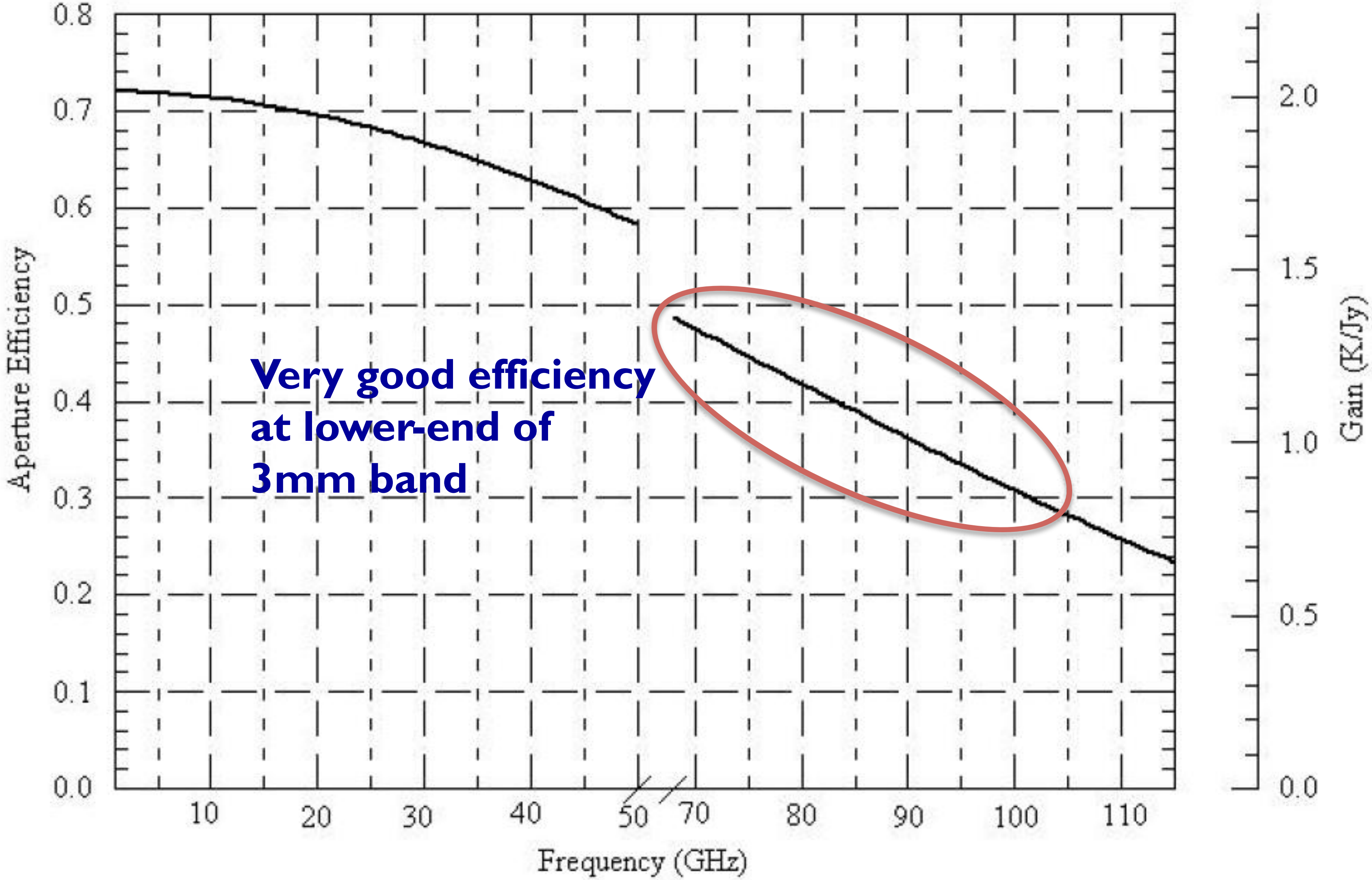
NRAO

The Offset Paraboloid: Clean-beam with very low side-lobes enables high dynamic range and excellent sensitivity to low surface-brightness emission.

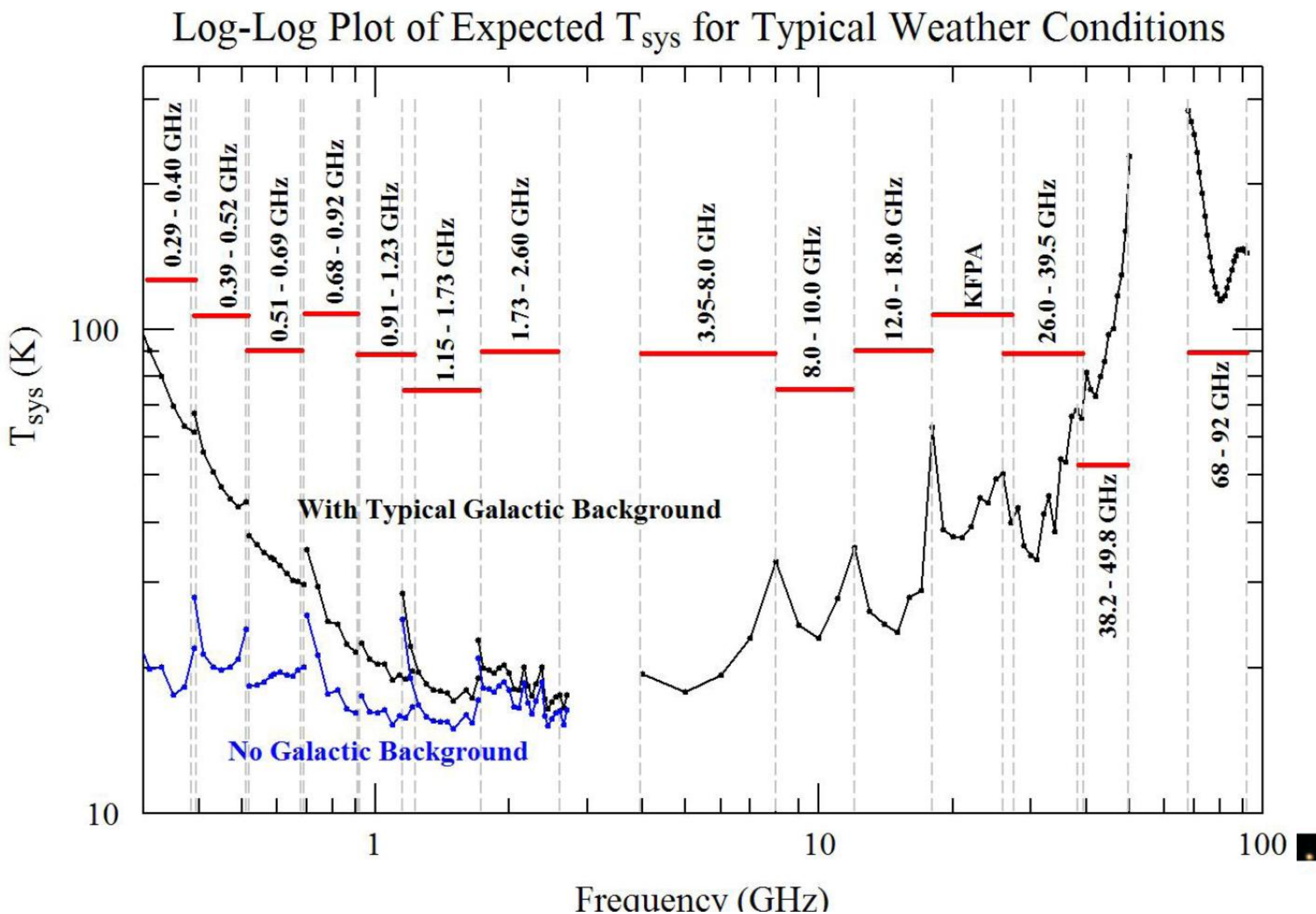




GBT Aperture Efficiency and Gain (K/Jy)



Noise Levels (Tsys) for Typical Weather



GBT Receivers (Observing Bands)

Receiver	Band	Frequency Range (GHz)	Focus	Polarization	Beams	Polarizations per Beam	Beam Separation	FWHM	Gain (K/Jy)	Aperture Efficiency
PF1	342 MHz	.290-.395	Prime	Lin/Circ	1	2	—	36'	2.0	72%
	450 MHz	.385-.520	Prime	Lin/Circ	1	2	—	27'	2.0	72%
	600 MHz	.510-.690	Prime	Lin/Circ	1	2	—	21'	2.0	72%
	800 MHz	.680-.920	Prime	Lin/Circ	1	2	—	15'	2.0	72%
PF2	—	.910-1.23	Prime	Lin/Circ	1	2	—	12'	2.0	72%
L-Band	—	1.15-1.73	Greg.	Lin/Circ	1	2	—	9'	2.0	72%
S-Band	—	1.73-2.60	Greg.	Lin/Circ	1	2	—	5.8'	2.0	72%
C-Band	—	3.95-8.0	Greg.	Lin/Circ	1	2	—	2.5'	2.0	72%
X-Band	—	8.00-10.0	Greg.	Circ	1	2	—	1.4'	2.0	71%
Ku-Band	—	12.0-15.4	Greg.	Circ	2	2	330"	54"	1.9	70%
KFPA	—	18.0-27.5	Greg.	Circ	7	2	96"	32"	1.9	68%
Ka-Band	MM-F1	26.0-31.0	Greg.	Circ	2	1	78"	26.8"	1.8	63-67%
	MM-F2	30.5-37.0						22.6"		
	MM-F3	36.0-39.5						19.5"		
Q-Band	—	38.2-49.8	Greg.	Circ	2	2	58"	16"	1.7	58-64%
W-Band 4mm	MM-F1	67-74	Greg.	Circ	2	2	TBD	10"	1.0	35-47%
	MM-F2	73-80	Greg.	Circ	2	2	286"			
	MM-F3	79-86	Greg.	Circ	2	2				
	MM-F4	85-93.3	Greg.	Circ	2	2				
Mustang	—	80-100	Greg.	—	64	—	—	10"	—	35%

Covers wide range of frequency

Very good aperture efficiency even at 3mm