

Proposing for the GBT



David Frayer (NRAO)



Green Bank, WV is original the NRAO site

Started 1958
Completed 1959



Completed 1965



Completed 1995



GBT: Completed 2000, surface improved for high-frequency in 2009



Completed 1994

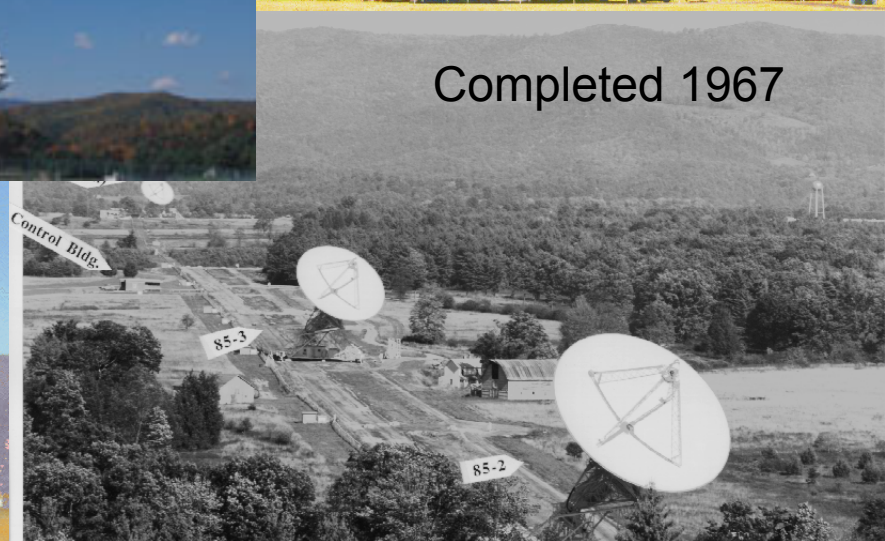
Completed 1962



Completed 1962, collapsed 1988



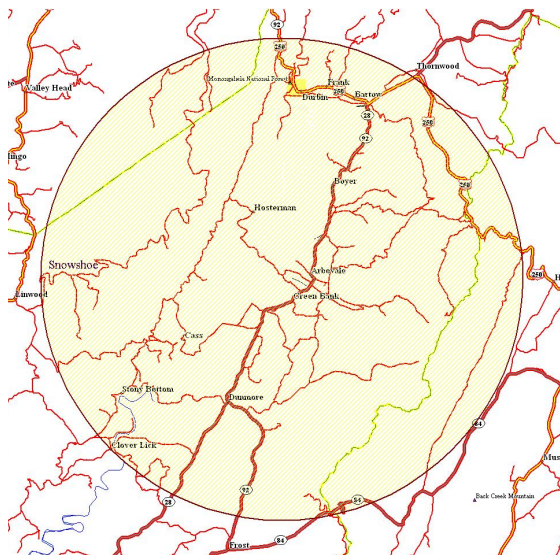
Completed 1967



Site protected from Radio interference

WV Radio Astronomy Zone

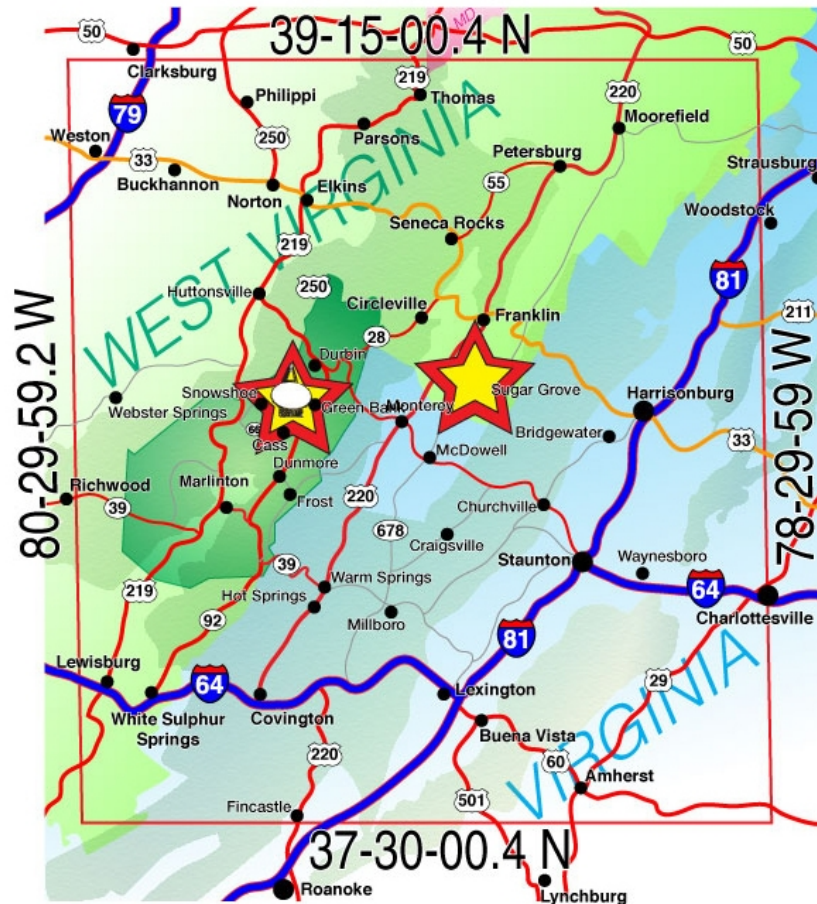
Established by the West Virginia Legislature (1956)



Protection within ten miles of the Observatory

National Radio Quiet Zone

Established by the FCC and NTIA (1957)

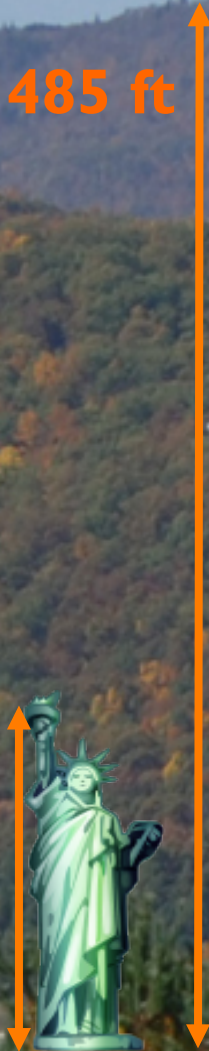


13,000 Square Miles

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 $\delta \geq -46^\circ$
- ◆ Pointing to 1"-2" accuracy
- ◆ Surface good for 3mm work

2.3 acre collecting area



151 ft

The Active Surface 2209 actuators

Currently rms $\sim 240\mu\text{m}$ at night, the goal is $\sim 200\mu\text{m}$

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

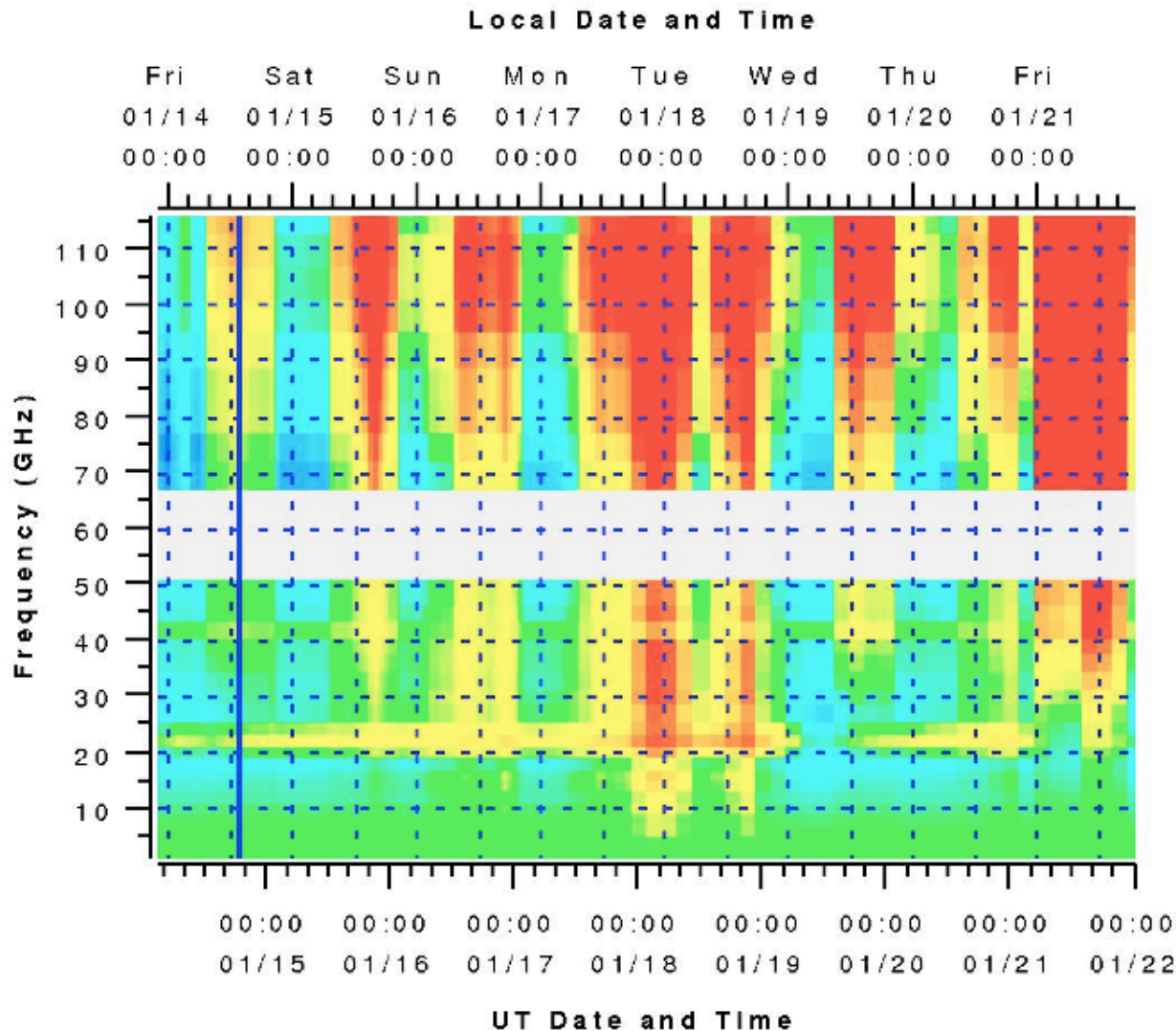


Some Key GBT Science Areas:

- **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-chemistry**
- **Masers:** black hole masses, distances via proper motions and independent measurement of H_0
- **Star Formation:** NH_3 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

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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Search all of NRAO Go

Home About NRAO Science **Facilities** Observing Opportunities

ALMA/NAASC VLA **GBT** VLBA CDI

Facilities > GBT > Practical Information For Astronomers

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.

The Green Bank Site

In the News

GBT Science

GBT Development Program

Broader Impact/General Public

Help Desk

Practical Information for Astronomers

People

Publications

Other Green Bank Telescopes

Weather Forecast

Interference



GBT Proposal Guide (updated with each proposal call)

The Proposer's Guide for the Green Bank Telescope

GBT Support Staff

December 19, 2013

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)



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 I4B

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

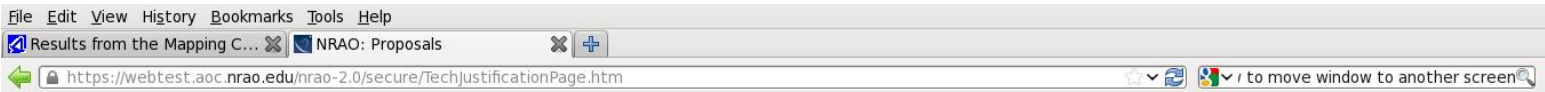


Available GBT Backends for I4B

Table 2: GBT Backends

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

Fill in Technical Justification Boxes



National Radio Astronomy Observatory

- Dashboard
- Proposals
- Reviews
- Data Processi
- Obs Prep
- Helpdesk
- Profile

Hi, David | Sign Out

- My Proposals
- Available Authors
- Available Organizations

Tuesday 31 December 2013

- Validate
- Print
- Submit

Save Help

TECHNICAL JUSTIFICATION

« Technical Justification »

- Options
 - My Proposals
 - GBT/2013-04-007
 - General
 - Authors
 - Science Justification
 - Technical Justification
 - Sources
 - Resources
 - Sessions
 - Print Preview

GBT Technical Justification

Use this page to specify how the technical set-up requested for your proposal enables the scientific goals to be met. Input is required for all fields. If a field is not relevant for your proposal then enter "NA" into the textbox. The links within each box provide information concerning these technical questions.

For each resource briefly justify the observing mode and all values used in determining the required observing time (e.g. frequency switching or position switching, bandwidth, spectral resolution, polarization, etc.). Include all inputs and results for the GBT sensitivity calculator. IF the sensitivity calculator is not used then provide all equations, with each term defined, along with the values used. If a specific documented instrument sensitivity is used then provide the reference for the value used.

https://dss.gb.nrao.edu/calculator-ui/war/Calculator_ui.html

For any session that uses mapping present all inputs and results from GBT mapping planner. If the mapping planner is not used then provide all equations, with each term defined, along with the values used. The sensitivity calculator observing time results are for a sensitivity per beam. To calculate time per pixel simply divide the time per beam by the number of pixels per beam.

<http://www.gb.nrao.edu/GBT/setups/mapplan.html>

For each resource, briefly discuss the potential impact of RFI and how it would be handled during the observations and during data reduction:

For each session, discuss the amount of overhead time needed and how that value was derived (e.g. receiver change time, slew time, time for pointing and focusing, time for AutoOOF, calibration observations, etc.):

<https://science.nrao.edu/facilities/gbt/proposing/GBTpg.pdf> (Section 6)

If your proposal contains novel observing or data reduction techniques please provide details on the techniques to be used:

Pulsar proposals should list the information such as the spin period, dispersions measure, binary period, average flux, etc. for any known pulsar:

➤ 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

General Information

Derive: Observing Time from Desired Sensitivity
 Sensitivity from Observing Time

Sensitivity Units: Flux Density (mJy)
 Antenna Temp., Ta (mK)
 Main Beam Temp., Tmb (mK)
 Radiation Temp., Tr (mK)

Desired Sensitivity (1-sigma):

Hardware Information

Answer questions from top to bottom. If you change a question that was answered previously, check all answers that follow. Some answers will dictate the answer for other questions.

Backend:
Mode:
Receiver:
Beams:
Polarization:
BandWidth (MHz):
Number of Spectral Windows:
Switching Mode:

Source Information

Frequency Specified in Topocentric Frame
the: Rest Frame

Rest Frequency (MHz):
Doppler Correction:
Source Velocity (km/s):

Controls

Results

Results	
Derived Total Observing Time:	00:34:24.6 HH:MM:SS.S
Time at Signal Position or Frequency:	00:17:12.3 s
Time at Reference Position or Frequency:	00:17:12.3 s
Effective Integration Time:	00:08:36.1 s
Obs. Mode Time Mult. Factor:	4
FWHM Beamwidth:	0.14 '
Aperture Efficiency:	0.31
Extended Source Efficiency:	0.31
Confusion Limit:	0.00 S (mJy)
# Hrs Above Min Elevation:	6.71 hours
Topocentric Frequency:	88631.000 MHz
Min. Topocentric Channel Width:	88.000 kHz
Desired Freq. or Vel. Resolution:	50.000000 MHz or km/s
Typical Air Mass:	1.6
Typical Atmospheric Attenuation:	1.221
Typical System Temperature:	123.8 K
Backend Sampling Efficiency (K1):	1.0000
Backend Channel Weighting (K2):	1.0000
Other Results	
Maximum Elevation:	51.6 d



GBT Mapping Calculator



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:

- 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)

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 Rectangle

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)

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](#)



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

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 occupancy seen by the GBT receivers themselves, and (eventually) from the [GBT RFI Monitor](#) (pictured right).

The second, still under construction, will be a RFI Database which provides details of persistent, identified RFI sources including coordination information where applicable. Now, we have a [Table of Known RFI Sources](#) and a number of [Older Surveys and Summaries](#) linked below.

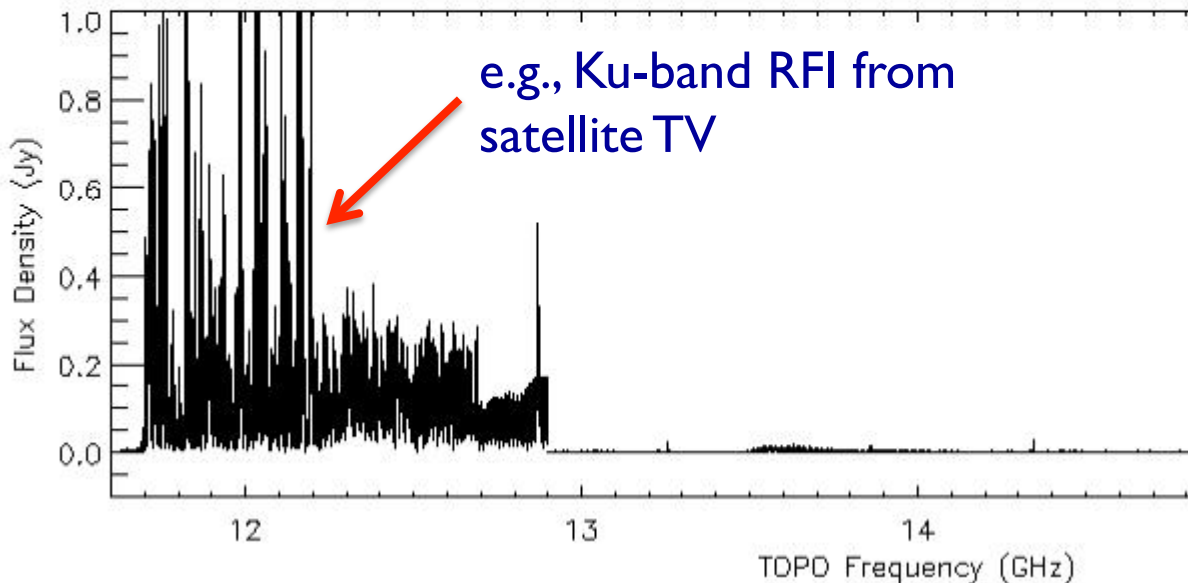
- To maximize your chances of RFI avoidance, we advise the following:
- 1) Consult the latest GBT RFI plots to determine whether the spectrum you wish to observe is typically clear, or occupied by RFI.
 - 2) Consult the [Table of Known RFI Sources](#) and/or the [Surveys and Band Summaries](#) to determine whether the source of the RFI is well known and/or likely to be something you can 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 coordination is possible. If it is, you will need to obtain a fixed window from the dynamic scheduling system for 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 anything about it, but it is still worth reporting, in case it can be mitigated in advance of future observations.

For additional information email interference@nrao.edu.

```
Scan          V :      0.0 RADI-OBS      FO : 11.80000 GHz
2011-09-14   Int : 00 05 54.3      Fsky : 11.99961 GHz
OPERATOR      LST : +17 01 18.6      BW : 800.0000 MHz
18 57 45.41  -07 02 39.1
```

rfiscan2



GBT "Resources" (Receiver and Backend configuration)

Options

- My Proposals
 - GBT/2013-04-007
 - General
 - Authors
 - Science Justification
 - Technical Justification
 - Sources
 - Resources
 - Sessions
 - Print Preview

GBT RESOURCES

Mygalaxy-wband

No Sessions up / down

Order	Name	Receiver	Back End
	Wband	W-band MM4 (85-93)	VEGAS

Observing Type: Spectral Line
Number of Beams: 2
Number of Vegas Spectrometers: 4

	Spectrometer 1	Spectrometer 2	Spectrometer 3	Spectrometer 4
Mode:	2	2	2	2
Bandwidth (MHz):	1250.000	1250.000	1250.000	1250.000
Rest Frequencies (GHz):	88.63	88.63	89.19	89.19
Spectral Resolution (KHz):	92	92	92	92
Integration Time (s):	2.0000	2.0000	2.0000	2.0000
Data Rate per Spectrometer (MB/s):	0.125	0.125	0.125	0.125
	Spectrometer 5	Spectrometer 6	Spectrometer 7	Spectrometer 8
Mode:				
Bandwidth (MHz):				
Rest Frequencies (GHz):				
Spectral Resolution (KHz):				
Integration Time (s):				
Data Rate per Spectrometer (MB/s):				

Save
Delete
Cancel

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

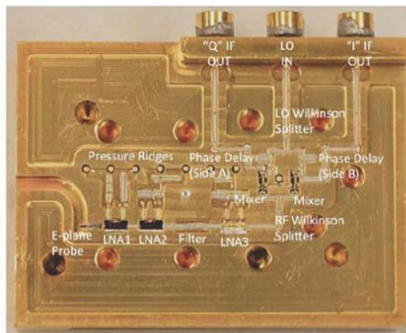
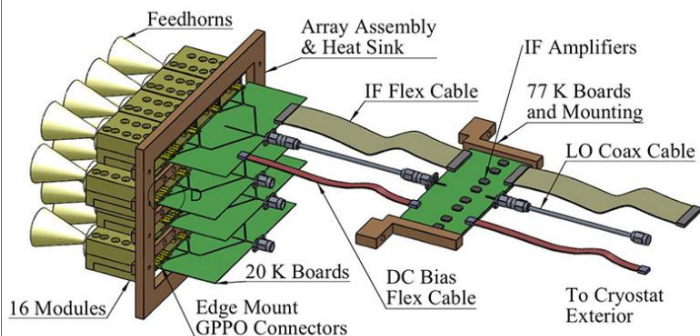
Instruments in Development

FLAG

19-element phased-array feed [PAF] (7beams) at 21cm (2014/2015) BYU/NRAO. Planned future 37element PAF (20beams).

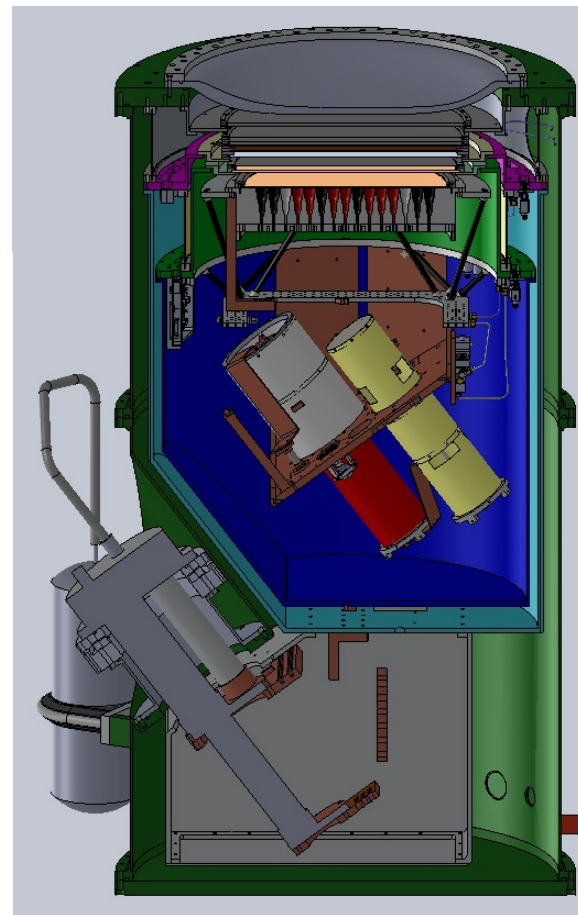


16 element scalable 75-115 GHz FPA (2014) Stanford/CIT-JPL/UMd/Miami/NRAO (similar mapping speeds to ALMA)



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

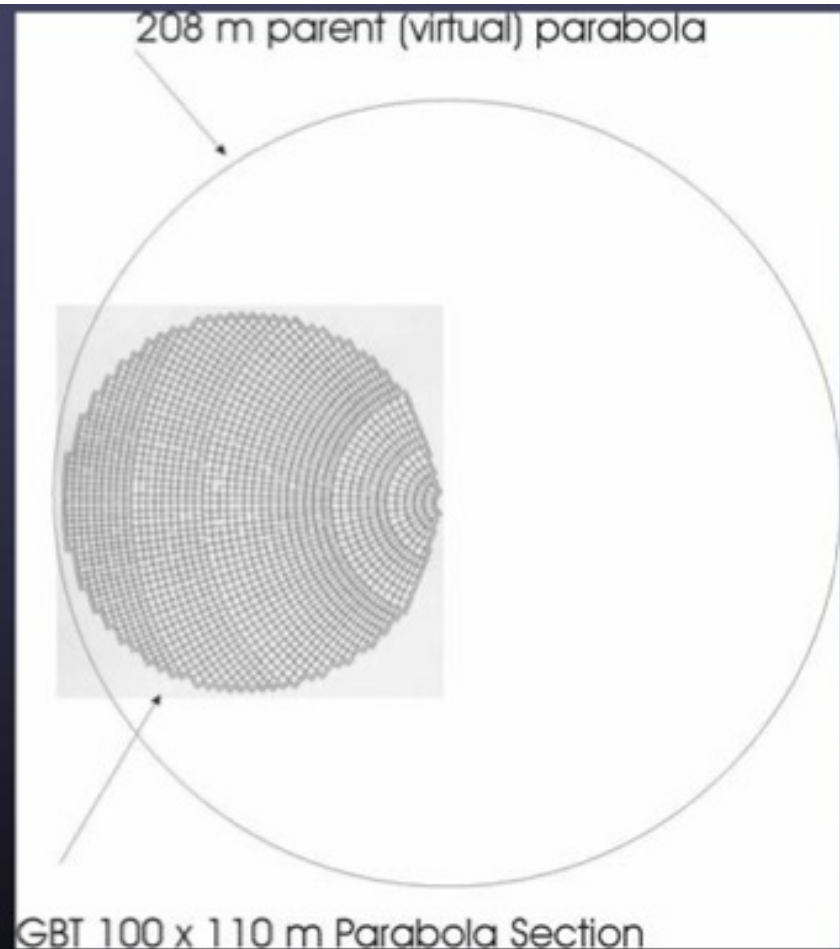


GBT Specs:

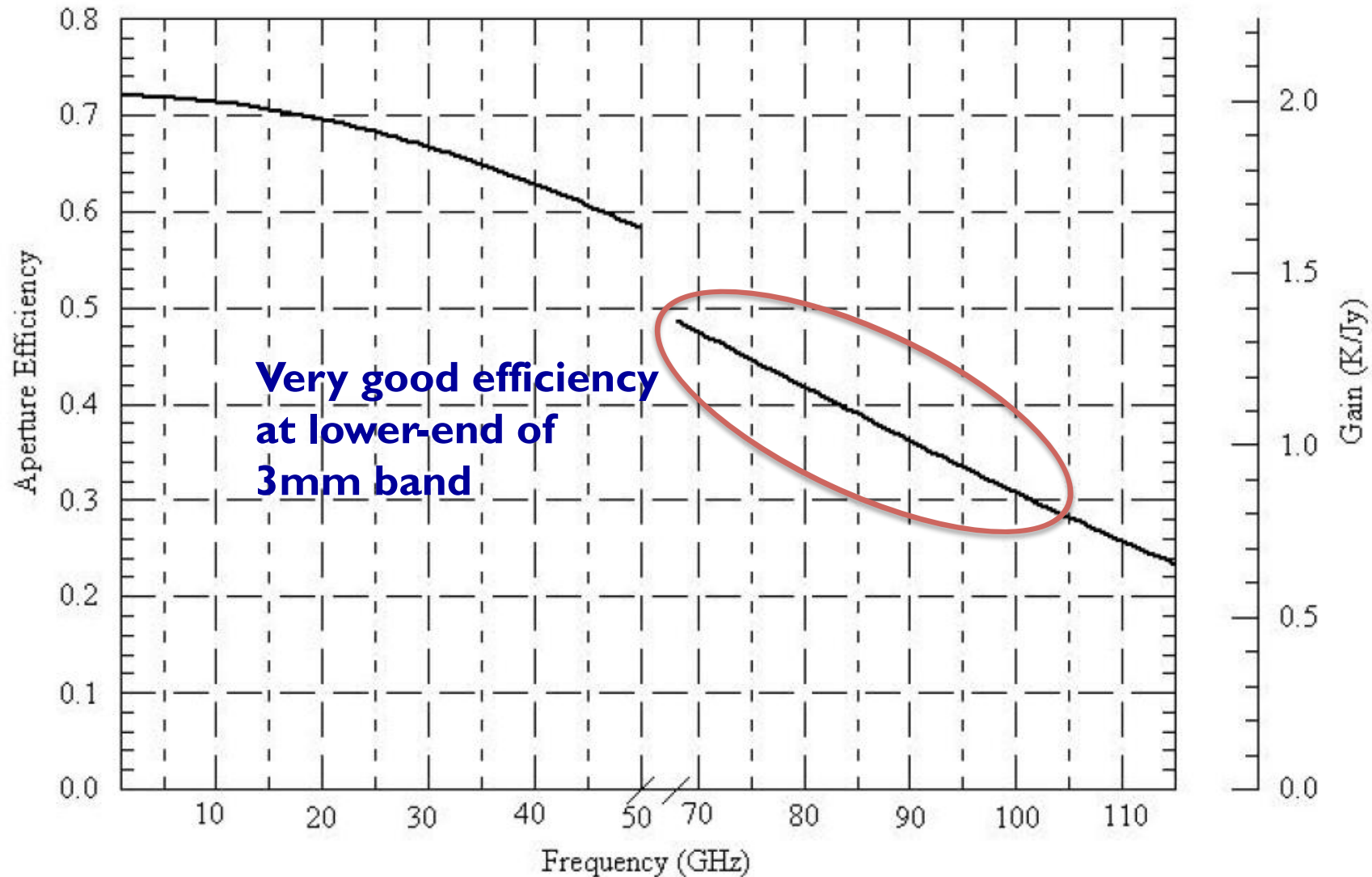
Location	Green Bank, West Virginia, USA
Coordinates	Longitude: 79°50'23.406" West (NAD83) Latitude: 38°25'59.236" North (NAD83) Track Elevation: 807.43 m (NAVD88)
Optics	110 m x 100 m unblocked section of a 208 m parent paraboloid Offaxis feed arm
Telescope Diameter	100 m (effective)
Available Foci	Prime 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: $\sim 12.60/f_{\text{GHz}}$ arcmin Prime Focus: $\sim 13.01/f_{\text{GHz}}$ arcmin (see Section 3.1.1)
Elevation Limits	Lower limit: 5 degrees Upper limit: ~ 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: ~ 250 μm , under benign night-time conditions
Pointing accuracy	1 σ values from 2-D data 5" blind 2.7" offset



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

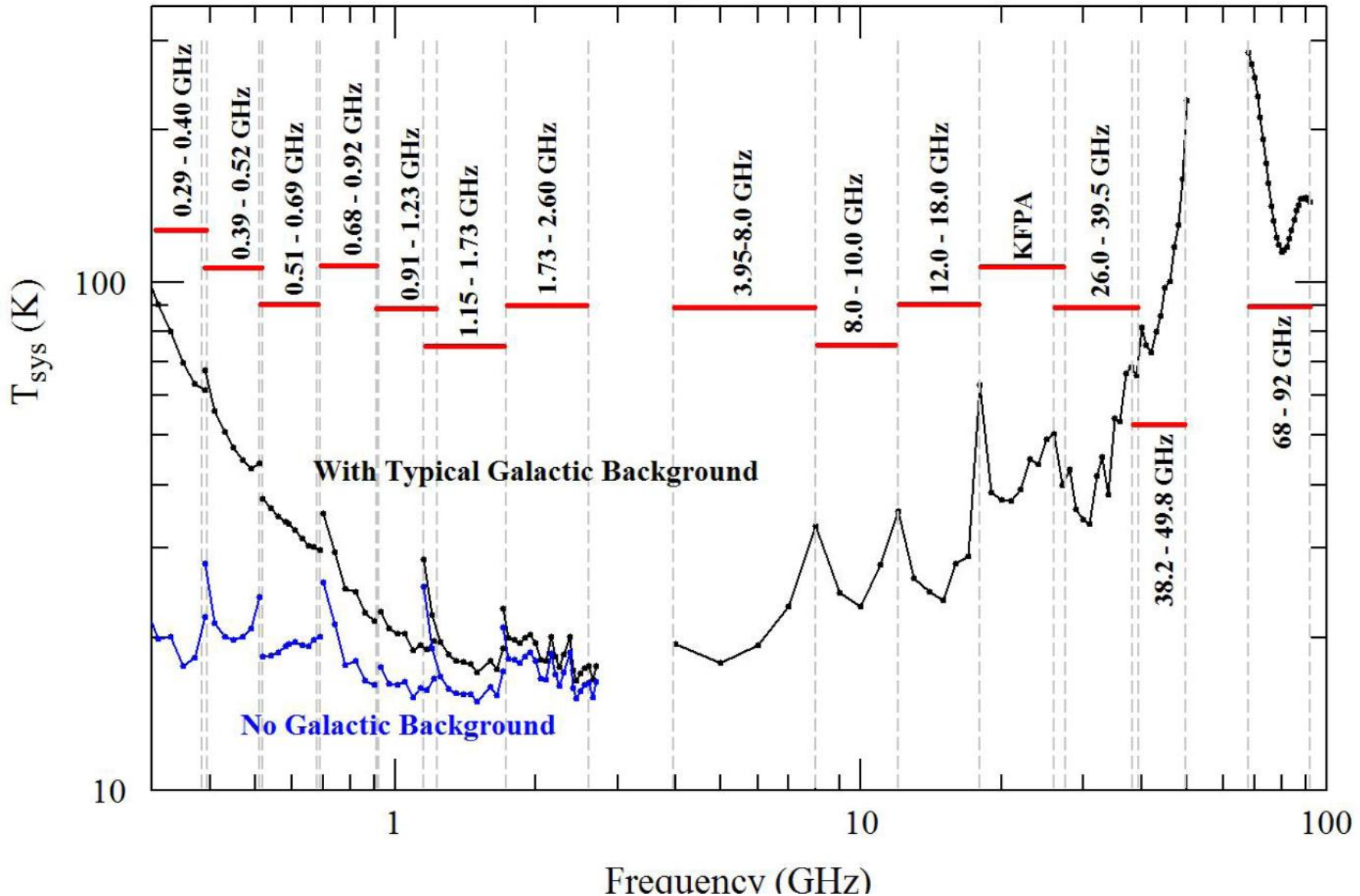


GBT Aperture Efficiency and Gain (K/Jy)



Noise Levels (T_{sys}) for Typical Weather

Log-Log Plot of Expected T_{sys} for Typical Weather Conditions



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	286''	10''	1.0	35-47%
	MM-F2	73-80	Greg.	Circ	2	2				
	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

