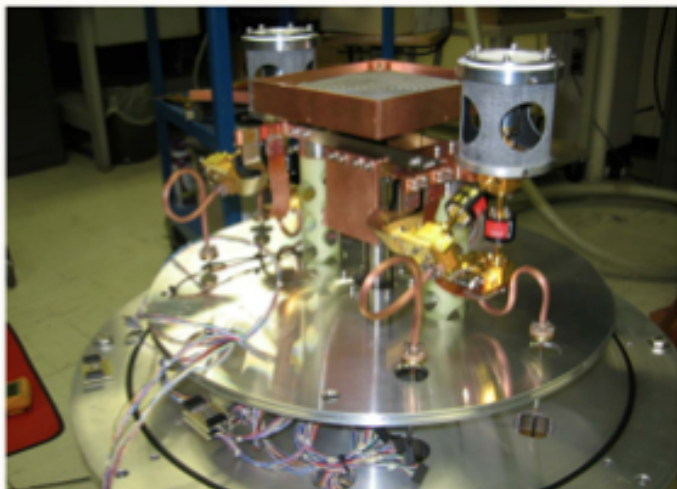
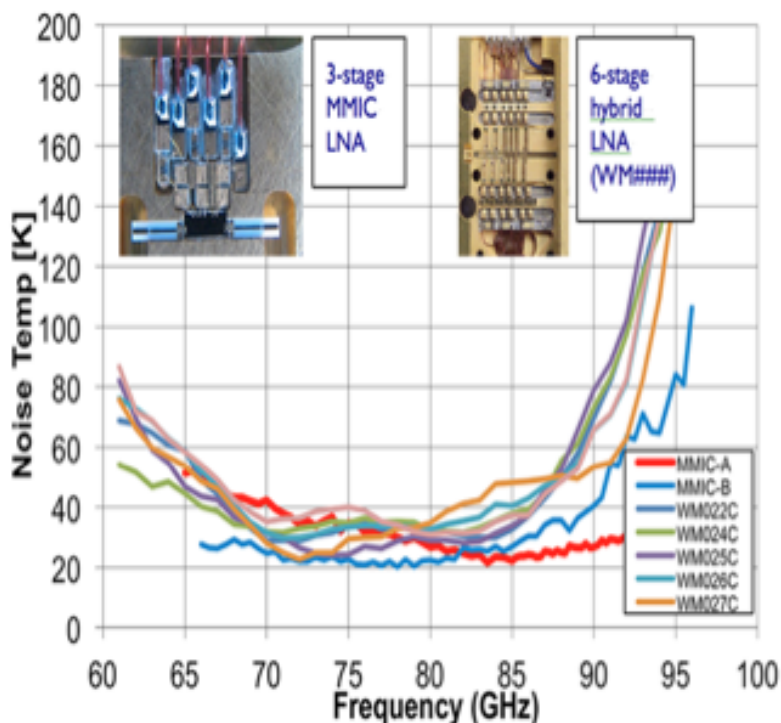


# Observing with the 4mm Rx



- **Commission in 2012**
- **Operates from 67—93 GHz**
- **Dual feed, dual linear polarization**
- **Has  $\frac{1}{4}$  wave-plate that provides circular polarization for VLBI**
- **Only instrument in the world that can currently observe the key (1-0) deuterated transitions in the cold proto-stellar cores**

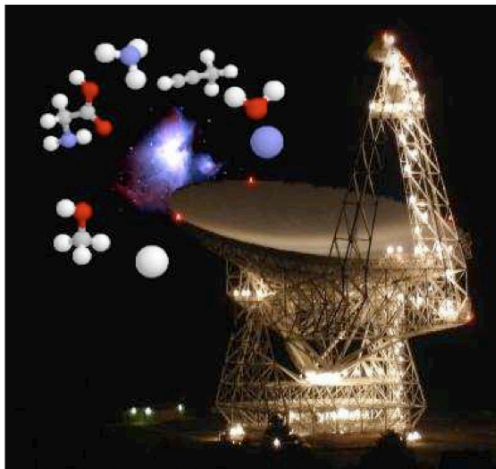
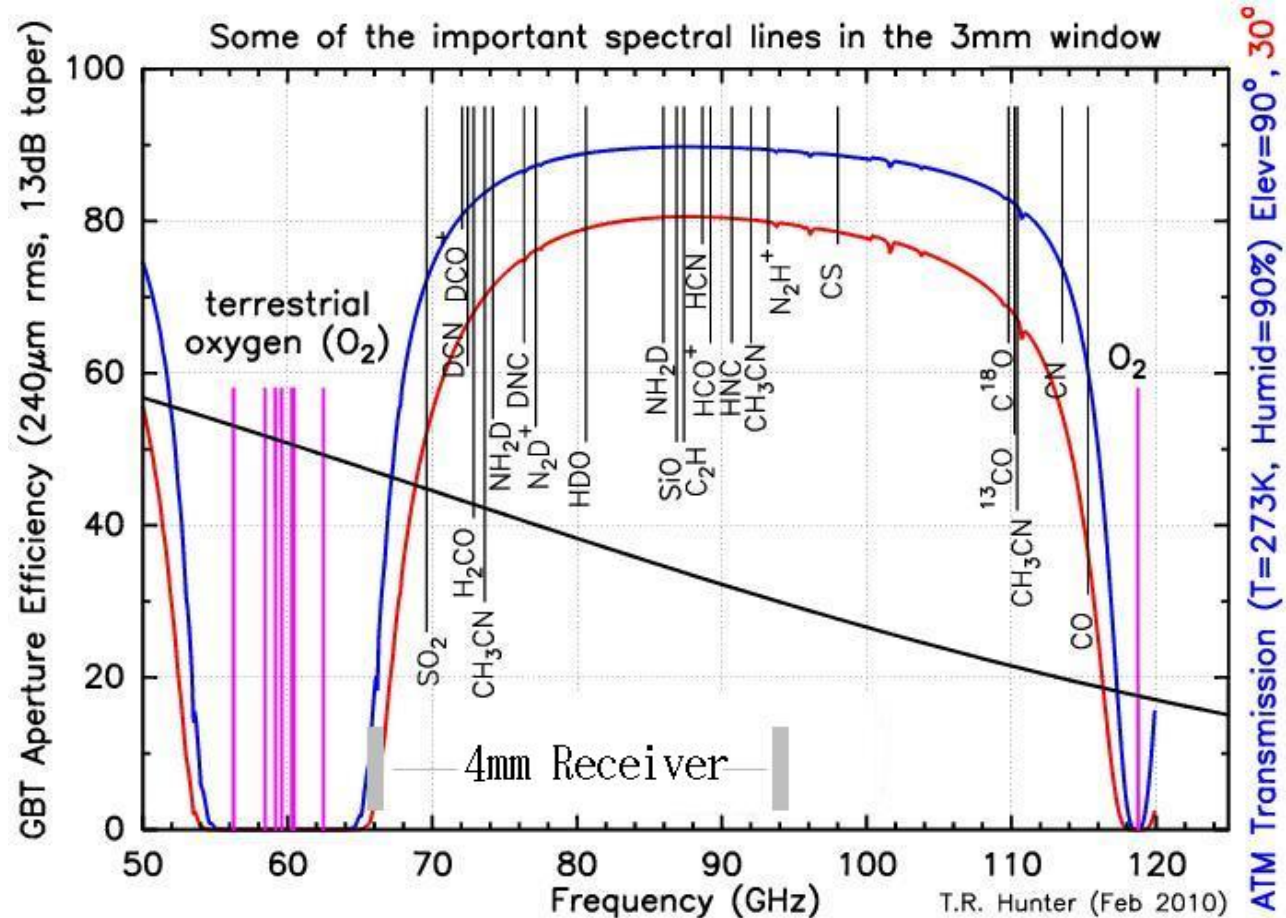
**(Left) The performance of different cold amplifier designs measured in the lab. The GBT 4mm system has better receiver temperatures than ALMA Band-3.**



# Science with 4 mm Rx, Lines:



- Dense gas tracers in star-forming regions and nearby galaxies (HCN, HNC, HCO+ all at ~90GHz)
- D-species in cold cloud cores (~70-80GHz)
- Astro/bio-chemistry (throughout the band)



# Web Links...



## 4mm Web Page:

<http://www.gb.nrao.edu/4mm/>

**4mm Wiki:** <https://safe.nrao.edu/wiki/bin/view/GB/Gbt4mmRx>

→ 4mm Commissioning Wiki (latest status and information on performance):

<https://safe.nrao.edu/wiki/bin/view/GB/Gbt4mmRxCommissioning>





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## Green Bank Telescope 4mm Receiver

### Introduction

NRAO has built a 4mm dual-beam receiver to cover the low-frequency end of the 3mm atmospheric window from 67-93 GHz. The amplifiers were updated in fall of 2012 which has provided better performance.

### Observing Information

- [\(GBT Observer's Guide for 4mm Rx, March 2013 \[pdf\]\)](#)
- [\(How to Observe at 4mm, Oct. 2014 \[pdf\]\)](#)
- [\(Instrument Status -- latest user information and technical performance details\)](#)

### Proposal Information

- [Technical Information for Proposals](#)

### Specification Summary

- Tunable frequency range: 67-93GHz
- Polarization: Dual linear with selection of circular using a 1/4 wave plate for VLB observations
- Number of beams: Two beams with dual polarization.
- Beam separation: 4.7 arc-minutes in the Az direction.

### Related Links

[GBT 4mm Receiver Project Book](#) Reference material for the project --- provides technical information and science case

[GBT 4mm Rx Wiki Page](#) Development status/summary with ongoing discussion notes and meetings

[GBT W-FPA Web Page](#) Web page for the GBT W-FPA program

[GBT W-band FPA Wiki Page](#) Provides status and links to the W-FPA program including overlapping science cases for the 4mm band.

### Background Info

[Precursor Project](#)

#### General

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## GBT 4mm Receiver Call for Proposals

The GBT 4mm system is a traditional dual-beam feed horn receiver designed to cover the low-frequency end of the 3mm atmospheric window from 67-93 GHz ([GBT 4mm Receiver](#)).

### System Performance

- The frequency range of the system is currently 67--93 GHz.
- The receiver temperatures are 30-100 K from 67-93 GHz, with the best performance below 85 GHz. See the Figure below for the performance as a function of frequency.
- The IF system for the 4mm system is broken into four separate filter bands:
  - FL1: 67-74 GHz
  - FL2: 73-80 GHz
  - FL3: 79-86 GHz
  - FL4: 85-93 GHz,



You can only use one of these bands at a time (i.e., you cannot simultaneously observe lines in more than one band).

- The millimeter down-converter filters of the system limits the instantaneous bandwidth to 4 GHz for 73-93 GHz (filters FL2, FL3,FL4), while 6 GHz of bandwidth is available for 67-74 GHz (filter FL1). ([IF-system](#)).
- The FWHM beam size is about 9 arcsec at 90 GHz.
- The separation of the two beams is 286 arcsec (4.77') along the cross-elevation (azimuth) direction.
- The aperture efficiency for night-time observations is expected to be about 32% at 90 GHz. The surface performance is better at lower frequencies.
- In general, continuum observations should be done with Mustang.



#### General

- [General Public](#)
- [Teachers and Students](#)
- [GBT Astronomers](#)
- [Green Bank Staff Resources](#)
- [Green Bank Weather](#)
- [National Radio Quiet Zone](#)

#### GB Telescopes

- [Green Bank Telescope](#)
- [43 Meter](#)
- [GBI](#)
- [40 Foot](#)
- [45 Foot](#)
- [20 meter](#)
- [Historical GB Telescopes](#)



173 x 234

Open

Print All

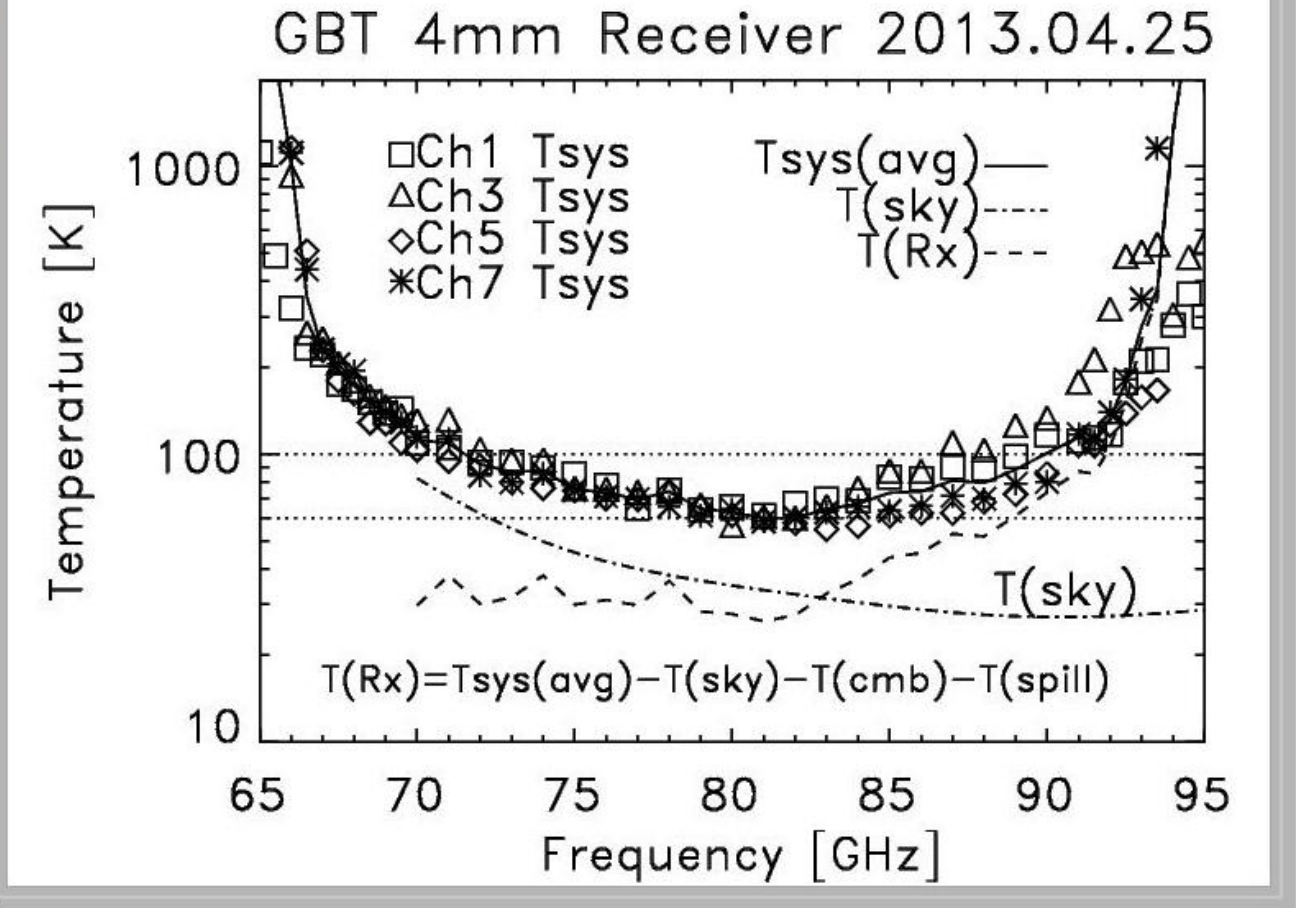
Print Marked

Save All

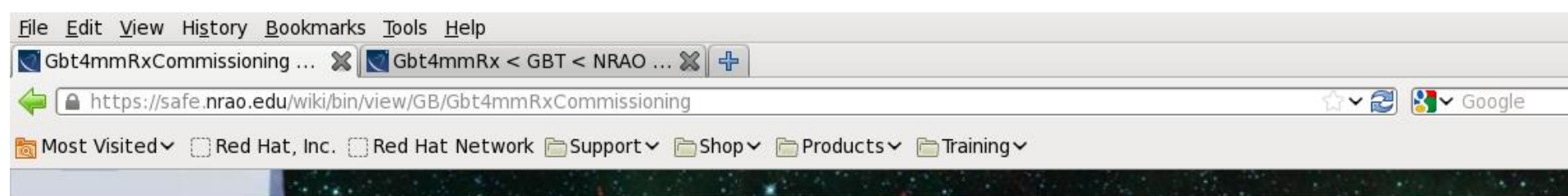
Save Marked

Reload

0



Above shows the measured system temperatures for the 4 channels (2 beams and 2 polarizations) as symbols. The solid line is the average(median) Tsys for 4 channels as a function of frequency. The dashed-dotted line shows the contribution of the atmosphere at the time of the observations. The dashed line is the inferred receiver temperature  $T(rx) = T_{sys} - T(sky) - T(cmb) - T(spill)$ , where T(cmb) is the 2.7 K cosmic background and T(spill)=2.8 K is the estimated contribution to the system temperature from spill-over. The dotted-lines (100K and 60K) are reference lines to show the performance over the middle of the band. The Tsys goes up at low frequency due to the Atmospheric O<sub>2</sub> line, while the high-end of the band is limited by the receiver. Beam-2 (ch5 and ch7) has better performance within the 85-90 GHz frequency range.



GB

You are here: NRAO Public Wiki > GB Web > Gbt4mmRx > Gbt4mmRxCommissioning (2012-09-26, DavidFrayer)

[Edit wiki text](#) [Edit](#)

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## Webs

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## GBT 4mm Rx Status and Commissioning

### Table of Contents

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  - ↓ TGBT11b\_503\_02 (2011.10.21)

← User and Operator info/instructions



# User Info from Wiki Status Page



- Since there are no noise diodes in the 4mm Rx, users should take a calibration sequence whenever changing their configuration or taking a balance for any data that they want to be calibrated. Users should use the astrid script called [CalSeq](#) for carrying out the calibration. Documentation on this command is in the Observers's Guide. Since the deployment of software release 14.4 (2014.09.30), users are now encourage to use the "auto" option for [CalSeq](#), e.g., [CalSeq](#) ("auto",30.,fixedOffset=Offset("J2000","00:00:00","00:02:00")). The fixedOffset parameter is optional. It provides a measurement of Tsys on blank-sky, if observing a very bright source, but does not affect the calibration based on the warm and cold loads.
- The special 4mm ".sparrow" file is no longer required for 4mm pointing and focus (please remove this from your home area if one exists).
- Example setup files and observing scripts are shown in /home/astro-util/projects/4mm/.
- Start project with [AutoOOF](#) -- sets surface as well as getting initial pointing and focus value. If your source is extended and the beam details are not crucial to your science, you could potentially skip [AutoOOF](#) (contact your support scientist if you have questions).
- During a calibration sequence, if the wheel does not move when expected and/or goes into a fault mode, unlock cleo page and try to move wheel manually. If the wheel does not move manually, then this is a major problem and should be reported.
- Standard GBTIDL scripts (getps, getnod, getfs) do not work since these assume a noise diode for calibration. Preliminary w-band scripts exist at /home/astro-util/projects/4mm/PRO, e.g., wonoff\_gain.pro for reduction. For DCR reduction, there are some specialized scripts that exist. See David Frayer for details.
- [SubBeamNod](#) does not put the source in the middle of the beams. Check with your support scientist about updates with [SubBeamNod](#) if needed. NOD observations with 1 minute scans could be taken in good weather conditions instead, but significant data editing for baselines issues may be needed for broad, weak lines using NOD observations.



# How to configure Rx



System uses standard config-tool. GBT support staff see MR3Q211 for details.

- Example setup files and observing scripts are shown in `/home/astro-util/projects/4mm/`.
- After configuration check the RF power levels in the `IFrack` to see if saturated ( $<9$ ) for each channel (need to be at  $<\sim 4$  on the sky to avoid possible saturation on warm load). Although reasonable data may be detected downstream, observers should worry about non-linear effects with IF power near saturation and special care should be taken in calibration of such data.

# Example 4mm Configuration



ay - 1 GbtStatus - 1

Editor: You are currently editing config\_line\_FL4

```

1  # -----
2  # 4mm line setup FL4 89GHz
3  # -----
4
5  Configure( ""
6  receiver = 'Rcvr68_92'
7  beam     = 'B12'
8  obstype  = 'Spectroscopy'
9  backend  = 'Spectrometer'
10 nwin     = 1
11 restfreq = 89000.
12 deltafreq = 0
13 bandwidth = 800
14 swmode   = "tp_nocal"
15 swtype   = "none"
16 swper    = 0.2
17 swfreq   = 0, 0
18 tint     = 5.0
19 vlow     = 0.
20 vhigh    = 0.
21 vframe   = "lsrk"
22 vdef     = "Radio"
23 pol      = "Linear"
24 nchan    = "high"
25 spect.levels = 3
26 "")
27
28 Balance()
29

```

← **Two Beams**

← **No noise-diodes**

← **Default linear polarization;  
Circular puts 1/4wave plate  
in front of one of the beams  
(e.g. for VLBI circular pol  
observations)**

Validation Output:

```

*** Begin Validation - 2012-09-27 11:21:08.79
Using the perfect GBT cabling file
Default values are
if3freq = [0]
noisecal = lo-ext
WARNING: Using a simulated telescope device
Using the perfect GBT cabling file
Default values are
if3freq = [0]
noisecal = lo-ext
WARNING: Using a simulated telescope device
Using the perfect GBT cabling file
Default values are
if3freq = [0]
noisecal = lo-ext
WARNING: Using a simulated telescope device
Using the perfect GBT cabling file
Default values are
if3freq = [0]
noisecal = lo-ext
WARNING: Using a simulated telescope device
Your observing script is syntactically correct!

*** End Validation - 2012-09-27 11:21:21.55 ***

*** Begin Validation - 2012-09-27 11:29:23.15
Your observing script is syntactically correct!

*** End Validation - 2012-09-27 11:29:23.16 ***

```

# IFRack CLEO Page



Target RF Power at 1.5. If saturated with warm-load ~10, need to worry about non-linearity with calibration.

Rx uses channel's 1&3 for beam1 and 5&7 for beam2

The screenshot displays the IFRack CLEO control interface. At the top, there are tabs for channel groups: S1&2 - OD1&2 (selected), S3&4 - OD3&4, S5&6 - OD5&6, S7&8 - OD7&8, and General. The main area shows a signal flow diagram where two input channels, S1 (containing R1\_2XL:1) and S2 (containing R4\_6XL:1), are combined at a central junction S9. The signal then splits into two paths, each passing through an attenuator (25 dB and 19 dB) and a filter (2360-3640 MHz and All Pass). These paths lead to Optical Driver 1 and Optical Driver 2. Optical Driver 1 has an RF Power of 0.94 and is connected to DCR:A\_1 and OpticalReceiver1. Optical Driver 2 has an RF Power of 0.04 and is connected to DCR:A\_2 and OpticalReceiver2. Both drivers have control panels with checkboxes for Auto Lvl Ctrl, Laser Pwr (On), System Select, and Bal Enabled, and a State indicator (Running). At the bottom, there are control buttons for Locked, AutoPrepare, Prepare, Turn All Lasers On, Balance, and Quit. The status bar shows 'Status clear', 'State Running', and a timestamp of 13:47:16.



# MM-converter CLEO Page



File Managers SamplerRates Help

Power Supplies

+15V	15.176	-15V	-15.195
+5V	5.020	+28V	28.081

Temperatures

1	-6.626	2	-7.031
---	--------	---	--------

Channel Status

A	0	B	0
C	0	D	0

Converter1 Converter2 Converter3 Converter4

State Ready Ready Standby Ready

Subsystem Select

Status Warning State Standby 13:47:50 Locked Auto Prepare Prepare Quit

LO voltage (LO1B) should be near 5V and appropriate filter will be chosen based on observed frequency. There is 6 GHz of bandwidth for FL1 (2-8 GHz) and 4GHz of bandwidth for FL2, FL3, and FL4 due to the 4-8GHz filter after LO1B.

# How to Calibrate



- Since there are no noise diodes, users must take calseq scans to calibrate their data, e.g.,

**CalSeq(“auto”,30.0)**

This takes a 30sec scan that includes calibration observations of the sky, the cold load, and the ambient load for both beams.

# Installation, calibration wheel and external cover



File Edit View History Bookmarks Tools Help

PhotoArchive < GBT < NRAO ...

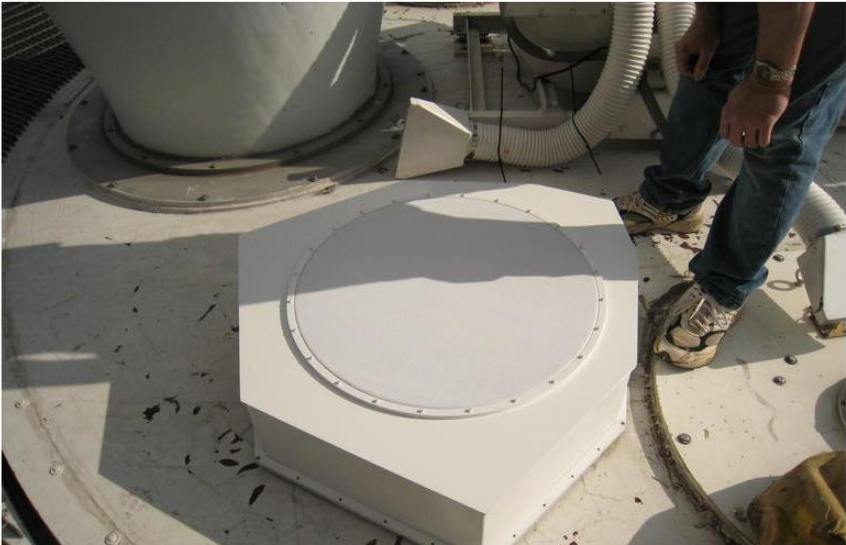
[https://safe.nrao.edu/wiki/bin/view/GBT/PhotoArchive?validation\\_key=5d8d2120a2b1501ec51149d7bab59553](https://safe.nrao.edu/wiki/bin/view/GBT/PhotoArchive?validation_key=5d8d2120a2b1501ec51149d7bab59553) Google

Most Visited Red Hat, Inc. Red Hat Network Support Shop Products Training



A photograph showing several people working on a large, circular, metallic calibration wheel assembly. The wheel is mounted on a white, octagonal base. The assembly is complex, with various components and wires visible. The people are wearing work clothes and are focused on the task.

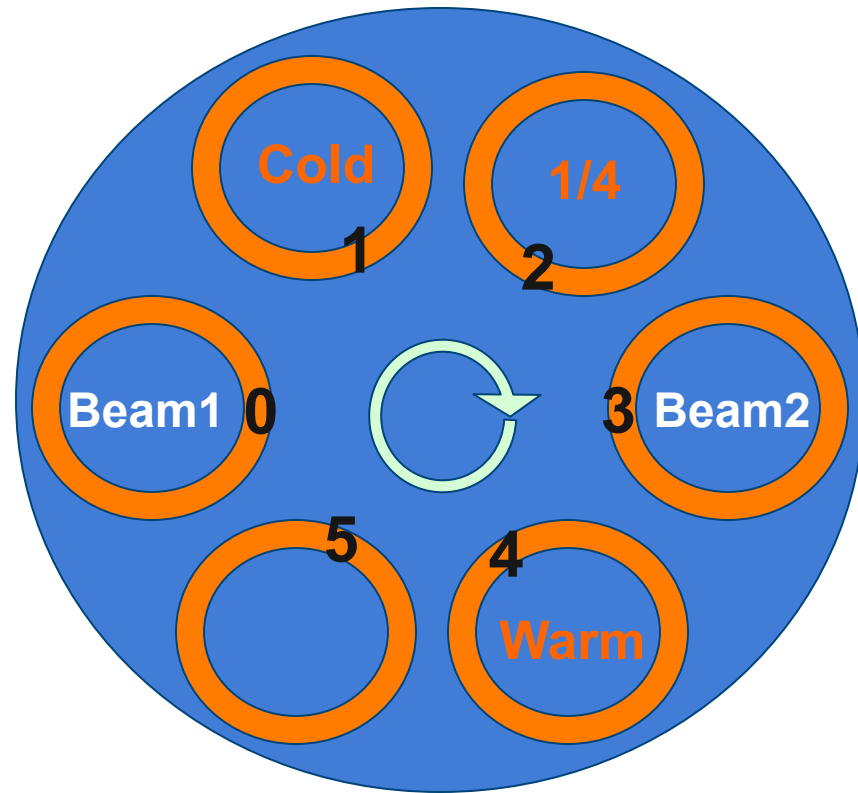
- Cover installed:



A photograph showing the white, octagonal external cover installed on the base of the calibration wheel. The cover is a simple, flat, white plate with a circular opening in the center. The base is mounted on a concrete surface. A person's legs and feet are visible in the background, indicating the cover is in place.



# 4mm Calibration Wheel



	Wheel Position (defined wrt Beam1)	Beam 1	Beam 2
0	Observing	Sky	Sky
1	Cold1	Cold	Warm
2	Position2	1/4wave circ	Sky
3	Position3	Sky	Sky
4	Cold2	Warm	Cold
5	Position5	Sky	1/4wave Circ

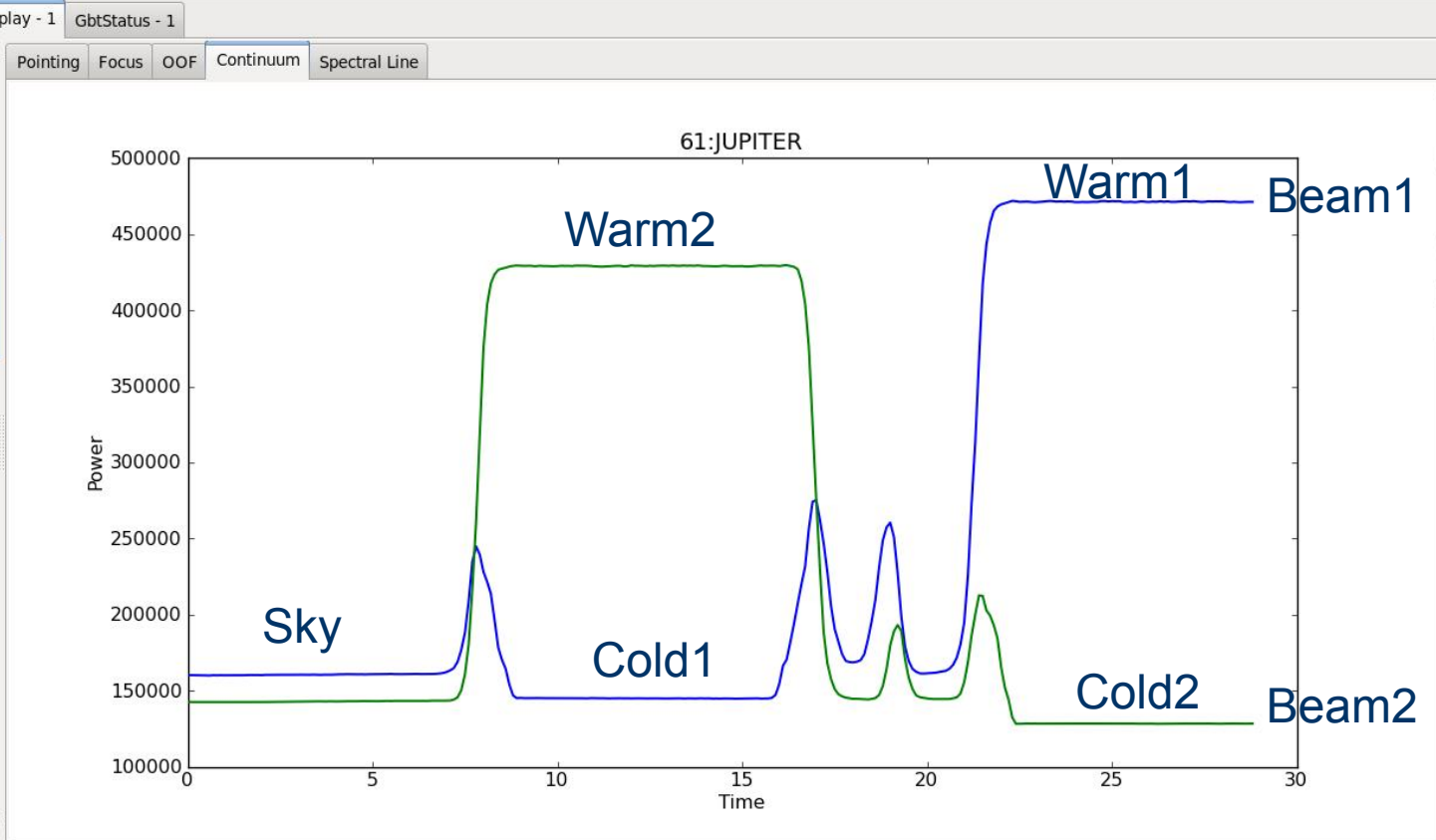
# CalSeq-auto Scan



File Edit View Tools Help



- 52 B0212+735 OnOff (1 of 2)
- 53 B0212+735 OnOff (2 of 2)
- 54 J1012+5307 Track (1 of 1)
- 55 J1012+5307 Track (1 of 1)
- 56 J1012+5307 Track (1 of 1)
- 57 J1012+5307 Track (1 of 1)
- 58 J1012+5307 Track (1 of 1)
- 59 J1012+5307 Track (1 of 1)
- 60 J1012+5307 Track (1 of 1)
- 61 JUPITER CALSEQ (1 of 1)
- 62 JUPITER Peak (1 of 4)
- 63 JUPITER Peak (2 of 4)
- 64 JUPITER Peak (3 of 4)
- 65 JUPITER Peak (4 of 4)
- 66 JUPITER FocusSubreflector (1 of 1)
- 67 JUPITER CALSEQ (1 of 1)
- 68 JUPITER Peak (1 of 4)
- 69 JUPITER Peak (2 of 4)
- 70 JUPITER Peak (3 of 4)
- 71 JUPITER Peak (4 of 4)
- 72 JUPITER FocusSubreflector (1 of 1)
- 100 2255+4202 Peak (1 of 4)
- 101 2255+4202 Peak (2 of 4)
- 102 2255+4202 Peak (3 of 4)
- 103 2255+4202 Peak (4 of 4)
- 104 2255+4202 FocusSubreflector (1 of 1)
- 105 2322+4445 Peak (1 of 4)
- 106 2322+4445 Peak (2 of 4)
- 107 2322+4445 Peak (3 of 4)



Beams:

- 1
- 2

Polarizations:

- X
- Y

Phases:

- Signal / No Cal

Frequencies (GHz)

- 77.00

Pyro Client Initialized. Using Pyro V3.4

```

Proj: TREG_140917, Scan: 10, Sub: 1, EWidth: 8.810, Width: 9.108, Center: -0.026, Height: 11.658, Tsys: 16.716
Scan numbers in calibration sequence: [61]
Calibration results:
TWARM 281.0
TCOLD 50.0
gain(beam-1, pol-Y) = 7.61e-04 K/counts
gain(beam-1, pol-X) = 7.08e-04 K/counts
gain(beam-2, pol-X) = 7.68e-04 K/counts
gain(beam-2, pol-Y) = 6.67e-04 K/counts
Tsys(beam-1, pol-X, Observing) = 113.6 K
Tsys(beam-1, pol-Y, Observing) = 111.5 K
Tsys(beam-2, pol-Y, Observing) = 111.0 K
Tsys(beam-2, pol-X, Observing) = 109.7 K
    
```



When you click on a calseq scan, GFM reports the gains and Tsys in the console window

ObservationManagement Log - 1 DataDisplay Log - 1 GbtStatus Log - 1 Command Console

Idle (Offline)

# Rcvr68\_92 Cleo Page



Used to control the wheel manually and to verify that receiver is working

File Managers SamplerRates Help

**Power Supplies**

+5V	0.00
+28V	0.00
+15V	0.00
-15V	0.00

**Cryo Monitor**

15K	0.00
50K	0.00
Ambient	0.00
Dewar Vac (V)	0.00
Pump Vac (V)	0.00
Dewar Heat Mon	0
Vac Solenoid Mon	0
Pump Req Mon	0
Cryo Control	0
Cryo Status	0
Cal Man/MCB Ctl Mon	0
Refrig Man/MCB Ctl Mon	0

**Cryogenics State**

Cooling

**Calibration Sequence**

Manual (highlighted)      Desired Position: Observing

Auto

Locked     AutoPrepare    Prepare    Quit

Status: Warning    State: Standby    M A T    13:49:29

	YR1	Y2	XL1	X2
LED	-99.00	-99.00	-99.00	-99.00
Gate 5,6	-99.00	-99.00	-99.00	-99.00
Gate 2,3,4	-99.00	-99.00	-99.00	-99.00
Gate 1	-99.00	-99.00	-99.00	-99.00



# How to set surface with AutoOOF



- Start observations with AutoOOF, if science source of interest  $\lesssim$  beam size and/or to produce the smallest primary beam size. AutoOOF also provides initial pointing offsets which can be large enough to be missed by the Peak procedure with blind pointing offsets at the start of an observing session.
- AutoOOF takes 30minutes to carry out and needs to be done every 2-4 hours to maximize the aperture efficiency
- Need to use bright  $>\sim 4$ Jy source for good AutoOOF solutions.

# Brightest 3mm/4mm Quasars



S(90GHz) [Jy]

>~4Jy for AutoOOF

>~1Jy for point/focus  
(depending on sky  
conditions)

There are not a lot of bright  
4mm sources in the sky –  
use planets as needed, e.g.,  
Uranus is ~10Jy and ~3")

Leverage ALMA, CARMA,  
IRAM-30m, PdBI, SMA  
calibration efforts.

1256-0547	12:56:11.1665	-05:47:21.524	J2000	16.10
0319+4130	03:19:48.1601	+41:30:42.103	J2000	13.20
1924-2914	19:24:51.0559	-29:14:30.121	J2000	9.50
1229+0203	12:29:06.6997	+02:03:08.598	J2000	8.20
2253+1608	22:53:57.7479	+16:08:53.560	J2000	6.20
0927+3902	09:27:03.0139	+39:02:20.851	J2000	4.80
0854+2006	08:54:48.8749	+20:06:30.640	J2000	4.40
2202+4216	22:02:43.2913	+42:16:39.979	J2000	4.35
1058+0133	10:58:29.6052	+01:33:58.823	J2000	4.00
1733-1304	17:33:02.7057	-13:04:49.548	J2000	3.90
0423-0120	04:23:15.8007	-01:20:33.065	J2000	3.80
1743-0350	17:43:58.8561	-03:50:04.616	J2000	3.80
1337-1257	13:37:39.7827	-12:57:24.693	J2000	3.58
2258-2758	22:58:05.9628	-27:58:21.256	J2000	3.44
1642+3948	16:42:58.8099	+39:48:36.993	J2000	3.37
0359+5057	03:59:29.7472	+50:57:50.161	J2000	3.32
0102+5824	01:02:45.7623	+58:24:11.136	J2000	2.94
2015+3710	20:15:28.7333	+37:10:59.505	J2000	2.80
2229-0832	22:29:40.0843	-08:32:54.435	J2000	2.80
0339-0146	03:39:30.9377	-01:46:35.803	J2000	2.72
0237+2848	02:37:52.4056	+28:48:08.990	J2000	2.70
0530+1331	05:30:56.4167	+13:31:55.149	J2000	2.60
2225-0457	22:25:47.2592	-04:57:01.390	J2000	2.41
0418+3801	04:18:21.2772	+38:01:35.800	J2000	2.30
1153+4931	11:53:24.4666	+49:31:08.830	J2000	2.30
2136+0041	21:36:38.5863	+00:41:54.213	J2000	2.23
0136+4751	01:36:58.5948	+47:51:29.100	J2000	2.20
0730-1141	07:30:19.1124	-11:41:12.600	J2000	2.20
1512-0905	15:12:50.5329	-09:05:59.829	J2000	2.16
1927+7358	19:27:48.4951	+73:58:01.569	J2000	2.12
1751+0939	17:51:32.8185	+09:39:00.728	J2000	2.10
1800+7828	18:00:45.6839	+78:28:04.018	J2000	2.10
0108+0135	01:08:38.7710	+01:35:00.317	J2000	2.00
-----	-----	-----	-----	---

# GFM OOF



Click yellow button after AutoOOF processing to send solutions to GBT and turn on the thermal model zernike's.

Typically pick between z4,z5,z6 based on residual rms and beam fits.

The screenshot shows the 'OOF' (Out-of-Focus) processing window in the GBT software. The main plot displays a Zernike solution for Z6, with a surface rms of 132 microns. The plot shows a cross-section of the beam with a central peak and surrounding lobes. A blue arrow points from the text on the left to the yellow button labeled 'Send Selected Solution with Point and Focus Corrections (new, recommended method)'. The right panel shows the Zernike Solutions list with Z6 selected.

Zernike Solution	LPCs (az2, el)	LCy
<input type="radio"/> z2		
<input type="radio"/> z3	(-0.12, -0.00)	+1.26 mm
<input type="radio"/> z4	(-0.13, -0.00)	+0.45 mm
<input type="radio"/> z5	(-0.13, -0.01)	+0.41 mm
<input checked="" type="radio"/> z6	(-0.12, -0.00)	-1.42 mm
<input type="radio"/> z7	(-0.12, -0.01)	-0.76 mm
<input type="radio"/> raw data		
<input type="radio"/> fitted beam map		

Project Name: AGBT12A\_436\_03  
 Scan Number: 19

Buttons:  
 Send Selected Solution with Point and Focus Corrections (new, recommended method)  
 Reanalyze OOF (Online Only)  
 Send Selected Solution with no Point or Focus Correction (original method)  
 Zero and Turn Off Thermal Zernike Solution

Plot-Color	Scan	Int	Beam	Pol	IF	Phase	Sampler	Source	Procedure	Major	Minor	Epoch	El (deg)	TSys (K)	Ctrfq (MHz)
green	3	0	1	XX	0	0	A13	Cold2	Track (1/1)	10:28:41	-9:41:20	2000.0	41.916	1.000	8.853e+04
blue	3	0	2	XX	0	0	B25	Cold2	Track (1/1)	10:28:41	-9:41:20	2000.0	41.916	1.000	8.853e+04
orange	3	0	2	YY	0	0	B29	Cold2	Track (1/1)	10:28:41	-9:41:20	2000.0	41.916	1.000	8.853e+04



# Scans through source during AutoOOF



File Edit View Tools Help

ObservationManagement - 1 DataDisplay - 1 GbtStatus - 1

4 Sky Track (1 of 1)  
 5 Cold1 Track (1 of 1)  
 6 Cold2 Track (1 of 1)  
 7 Sky Track (1 of 1)  
 8 Cold1 Track (1 of 1)  
 9 Cold2 Track (1 of 1)  
 10 Sky Track (1 of 1)  
 11 Cold1 Track (1 of 1)  
 12 Cold2 Track (1 of 1)  
 13 Sky Track (1 of 1)  
 14 Cold1 Track (1 of 1)  
 15 Cold2 Track (1 of 1)  
 16 Sky Track (1 of 1)  
 17 Cold1 Track (1 of 1)  
 18 Cold2 Track (1 of 1)  
 19 1256-0547 RALongMap (1 of 1)  
 20 1256-0547 RALongMap (2 of 1)  
 21 1256-0547 RALongMap (3 of 1)  
 22 MARS Peak (1 of 4)  
 23 MARS Peak (2 of 4)  
 24 MARS Peak (3 of 4)  
 25 MARS Peak (4 of 4)  
 26 MARS FocusSubreflector (1 of 1)  
 27 Sky Track (1 of 1)  
 28 Cold1 Track (1 of 1)  
 29 Cold2 Track (1 of 1)  
 30 MARS Nod (1 of 2)

Pointing Focus Continuum OOF Spectral Line Beta

21:1256-0547

1 X - Signal / No Cal - 89.00

Beams:  
 1  
 2

Polarizations:  
 X  
 Y

Phases:  
 Signal / No Cal

Frequencies (GHz):  
 89.00

Observation State: NotConnected  
 GBT State: NotConnected  
 GBT Status: NotConnected  
 Queue Control: Halt Queue  
 Observation Control: Pause, Stop, Abort, Interactive

Plot-Color	Scan	Int	Beam	Pot	IF	Phase	Sampler	Source	Procedure	Major	Minor	Epoch	El(deg)	ISys(K)	Ctrfq(MHz)
red	4	0	1	XX	0	0	A9	Sky	Track (1/1)	10:31:31	-21:34:41	2000.0	30.034	1.000	8.853e+04
green	4	0	1	YY	0	0	A13	Sky	Track (1/1)	10:31:31	-21:34:41	2000.0	30.034	1.000	8.853e+04
blue	4	0	2	XX	0	0	B25	Sky	Track (1/1)	10:31:31	-21:34:41	2000.0	30.034	1.000	8.853e+04
orange	4	0	2	YY	0	0	B29	Sky	Track (1/1)	10:31:31	-21:34:41	2000.0	30.034	1.000	8.853e+04

Started search for data products for AGBT12A\_436\_03 scan 19  
 Searching for files in /home/archive/science-data/12A/AGBT12A\_436\_03/OOF/s19-1-db-000.



# AutoOOF takes map on both sides of focus and near focus to derive model solutions (30 minutes of telescope time)



Beams as function of fits and focus:

File Edit View Tools Help

ObservationManagement - 1 DataDisplay - 1 GbtStatus - 1

4 Sky Track (1 of 1)  
5 Cold1 Track (1 of 1)  
6 Cold2 Track (1 of 1)  
7 Sky Track (1 of 1)  
8 Cold1 Track (1 of 1)  
9 Cold2 Track (1 of 1)  
10 Sky Track (1 of 1)  
11 Cold1 Track (1 of 1)  
12 Cold2 Track (1 of 1)  
13 Sky Track (1 of 1)  
14 Cold1 Track (1 of 1)  
15 Cold2 Track (1 of 1)  
16 Sky Track (1 of 1)  
17 Cold1 Track (1 of 1)  
18 Cold2 Track (1 of 1)  
19 1256-0547 RALongMap (1 of 4)  
20 1256-0547 RALongMap (2 of 4)  
21 1256-0547 RALongMap (3 of 4)  
22 MARS Peak (1 of 4)  
23 MARS Peak (2 of 4)  
24 MARS Peak (3 of 4)  
25 MARS Peak (4 of 4)  
26 MARS FocusSubreflector (1 of 4)  
27 Sky Track (1 of 1)  
28 Cold1 Track (1 of 1)  
29 Cold2 Track (1 of 1)  
30 MARS Nod (1 of 2)  
31 MARS Nod (2 of 2)  
32 1229+0203 Peak (1 of 4)  
33 1229+0203 Peak (2 of 4)  
34 1229+0203 Peak (3 of 4)  
35 1229+0203 Peak (4 of 4)

Pointing Focus Continuum **OOF** Spectral Line Beta

$\Delta\text{focus} = +0.0 \text{ mm}$   $\Delta\text{focus} = +18.0 \text{ mm}$   $\Delta\text{focus} = -18.0 \text{ mm}$

Observed beams

$z=5 \text{ fit}$   $\chi^2_{\text{red}} = 1.120e+05$

$z=6 \text{ fit}$   $\chi^2_{\text{red}} = 1.094e+05$

$z=7 \text{ fit}$   $\chi^2_{\text{red}} = 1.088e+05$

Elev Offset (arcsec)

Cross-Elev Offset (arcsec)

Zernike Solutions LPCs (az2, el) LFCy

- z2
- z3 (-0.12, -0.00) +1.26 mm
- z4 (-0.13, -0.00) +0.45 mm
- z5 (-0.13, -0.01) +0.41 mm
- z6 (-0.12, -0.00) -1.42 mm
- z7 (-0.12, -0.01) -0.76 mm

raw data

fitted beam map

Show Fixed-Scale Image

Show Solutions with Focus Removed

AutoOOF Processing Status: Complete

Project Name: AGBT12A\_436\_03

Scan Number: 19

Send Selected Solution with Point and Focus Corrections (new, recommended method)

Reanalyze OOF (Online Only)

Send Selected Solution with no Point or Focus Correction (original method)

Zero and Turn Off Thermal Zernike Solution

Observation State: NotConnected

GBT State: NotConnected

GBT Status: NotConnected

Queue Control: Halt Queue

Observation Control: Pause Stop Abort Interactive

Color	Scan	Int	Beam	Pol	IF	Phase	Sampler	Source	Procedure	Major	Minor	Epoch	El(deg)	TSys(K)	Ctrfq(MHz)
red	3	0	1	XX	0	0	A9	Cold2	Track (1/1)	10:28:41	-9:41:20	2000.0	41.916	1.000	8.853e+04
green	3	0	1	YY	0	0	A13	Cold2	Track (1/1)	10:28:41	-9:41:20	2000.0	41.916	1.000	8.853e+04
blue	3	0	2	XX	0	0	B25	Cold2	Track (1/1)	10:28:41	-9:41:20	2000.0	41.916	1.000	8.853e+04
orange	3	0	2	YY	0	0	B29	Cold2	Track (1/1)	10:28:41	-9:41:20	2000.0	41.916	1.000	8.853e+04

Plot-Color	Scan	Int	Beam	Pol	IF	Phase	Sampler	Source	Procedure	Major	Minor	Epoch	El(deg)	TSys(K)	Ctrfq(MHz)
red	4	0	1	XX	0	0	A9	Sky	Track (1/1)	10:31:31	-21:34:41	2000.0	30.034	1.000	8.853e+04
green	4	0	1	YY	0	0	A13	Sky	Track (1/1)	10:31:31	-21:34:41	2000.0	30.034	1.000	8.853e+04
blue	4	0	2	XX	0	0	B25	Sky	Track (1/1)	10:31:31	-21:34:41	2000.0	30.034	1.000	8.853e+04

ObservationManagement Log - 1 DataDisplay Log - 1 GbtStatus Log - 1 Command Console

# Example Pointing with GFM



The default is to use a calseq scan within the peak/focus procedure to calibrate the data and derive Tsys.

The screenshot shows the GBT software interface with the following components:

- Observation Management List:**
  - 1 0319+4130 CALSEQ (1 of 1)
  - 2 0319+4130 RALongMap (1 of 3)
  - 3 0319+4130 RALongMap (2 of 3)
  - 4 0319+4130 RALongMap (3 of 3)
  - 5 0319+4130 CALSEQ (1 of 1)
  - 6 0319+4130 Peak (1 of 4)
  - 7 0319+4130 Peak (2 of 4)
  - 8 0319+4130 Peak (3 of 4)
  - 9 0319+4130 Peak (4 of 4)
  - 10 0319+4130 FocusSubreflector (1 of 1)
  - 11 0319+4130 CALSEQ (1 of 1)
  - 12 0319+4130 Peak (1 of 4)
  - 13 0319+4130 Peak (2 of 4)
  - 14 0319+4130 Peak (3 of 4)
  - 15 0319+4130 Peak (4 of 4)
  - 16 0319+4130 CALSEQ (1 of 1)
  - 17 0319+4130 FocusSubreflector (1 of 1)
  - 18 0319+4130 CALSEQ (1 of 1)
  - 19 0319+4130 FocusSubreflector (1 of 1)
  - 20 0319+4130 CALSEQ (1 of 1)
  - 21 0319+4130 CALSEQ (1 of 1)
  - 22 0319+4130 RALongMap (1 of 3)
  - 23 0319+4130 RALongMap (2 of 3)
  - 24 0319+4130 RALongMap (3 of 3)
- Pointing Plots:** Four plots showing  $T_A$  (K) vs Offset (arcmin) for azimuth and elevation.
  - 6:1L/2L:0319+4130:azimuth: Wid: 0.163, Ctr: 0.043, Hgt: 12.651, E(Wid)0.160, Tsys: 149.707
  - 7:1L/2L:0319+4130:azimuth: Wid: 0.157, Ctr: 0.048, Hgt: 13.163, E(Wid)0.160, Tsys: 149.707
  - 8:1L/2L:0319+4130:elevation: Wid: 0.150, Ctr: -0.027, Hgt: 13.224, E(Wid)0.160, Tsys: 149.707
  - 9:1L/2L:0319+4130:elevation: Wid: 0.188, Ctr: -0.032, Hgt: 13.299, E(Wid)0.160, Tsys: 149.707
- Project Information:**
  - Proj: TGBT13A\_501\_07, Scan: 9, Sub: 4, EWidth: 0.160, Width: 0.188, Center: -0.032, Height: 13.299, Tsys: 149.707
  - Scans: 6 - 9 0319+4130 (Az,El) = (70.913,58.276)
  - paZCE1: -3.649 dazCE1: 0.043 tazCE1: -3.606
  - paZCE2: -3.641 dazCE2: 0.048 tazCE2: -3.593
  - peL1: 4.198 del1: -0.027 tel1: 4.172
  - peL2: 4.195 del2: -0.032 tel2: 4.163
  - OldAz2: -0.162 OldEl: 0.135
  - dAz2: 0.046 dEl: -0.029
  - NewAz2: -0.117 NewEl: 0.105
- System Status:** Rcvr68\_92 Feeds = [1, 2] DualBeam Polarizations = ['XL'] Center Sky Frequency = 77.00 GHz

# Sending Pointing (and focus) corrections to the telescope manually



## 5.1.3.4 Send Corrections

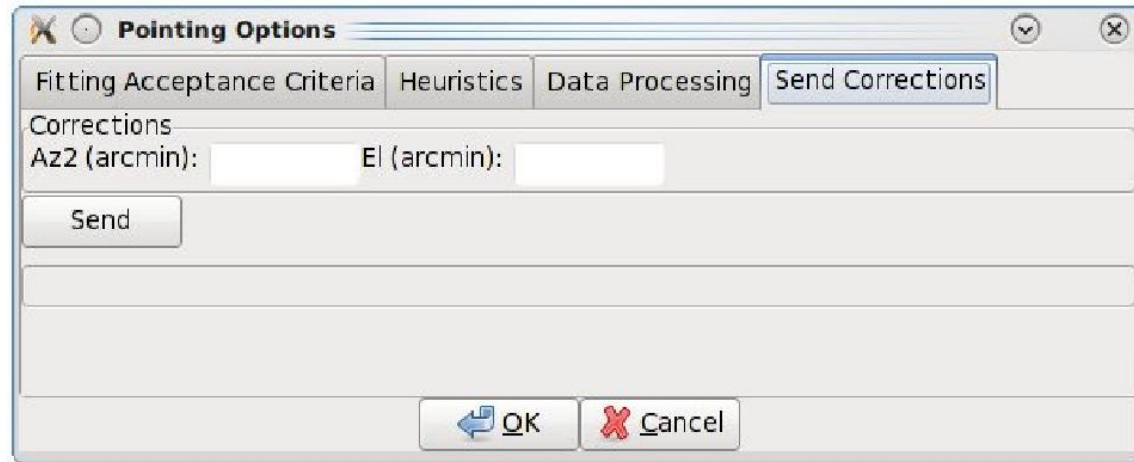


Figure 5.6: The pop-up menu to manually send pointing corrections to the telescope.

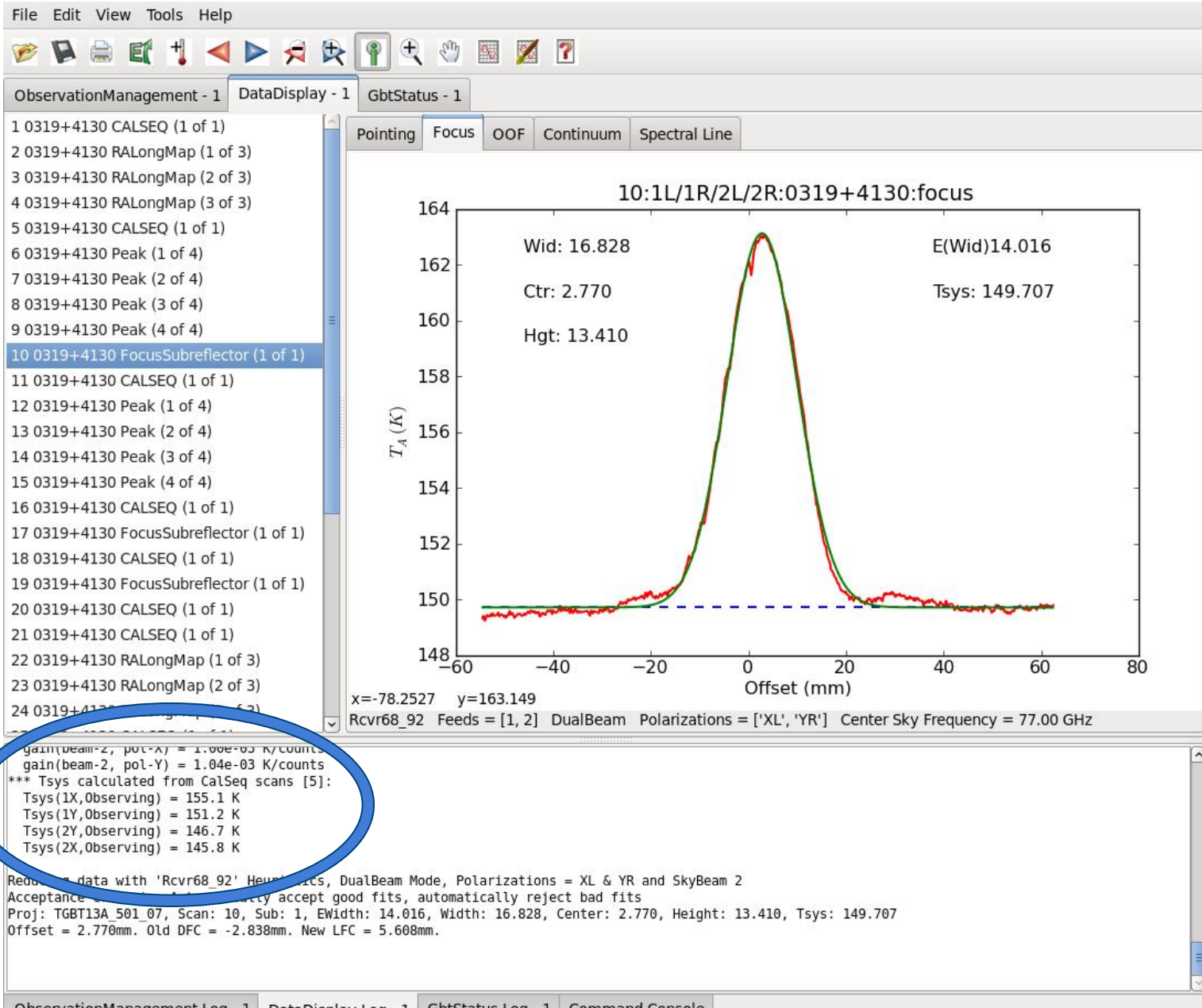
Users can send corrections manually to the telescope within GFM using Tools-> Options-> Send Corrections Tab. One can move the cursor over the plot windows and GFM will display “X” position (arcmin for pointing window) in lower left. If needed, one can manually move the cursor over the peak and derive a solution by eye, e.g.,  $\text{New\_LPC} = \text{Old\_LPC} + X$ .



# Example Focus Observation



Tsys and gains derived from preceding calseq scan. If no calseq scan is taken (e.g., calseq=False keyword), the gains are assumed to be 1.0 by the software)





# GBT Status – Overview of things to check while observing



File Display Launch Help

Status **Warning** State **Running** **M** LST **16:09:55** UTC **20:33:34**

Device	Status	State
Antenna	Info	Running
LO1	Warning	Running
Rcvr6_10	clear	Running
IFRack	clear	Running
ConverterRack	clear	Running
AnalogFilterRack	clear	Running
SwitchingSignalSelector	clear	Running
Spectrometer	Warning	Running
Measurements	clear	Running
ActiveSurface	clear	Committed

Source: LA407+ Scan #: 110  
 Project: AGBT12B\_129\_02 SS Master: Spectrometer  
 Start: 20:33:33 Length: 360.0  
 Countdown: ---:-- Remaining: 00:05:59

Observer: Loren Anderson  
 Obs. Type: LINE Switching: TPWONE  
 Proc Name: OffOn Sequence: 1/12  
 Rest Freq: 9183 Velocity: 42.5  
 Frame: Kinematical SW Vel Dr: Radio

Time to Set: 07:02:05 Encoder: [ ]

Indicated	Commanded	Rate (/min)	Difference	Servo Err (")
Azimuth: 142.43991	142.44286	-16.4	0.00295	10.6
Elevation: 30.52425	30.52520	-45.1	0.00095	3.3

Az LPC: -0.2370 El LPC: -0.2986  
 X FC: 0.0 Y FC: 2.4 Z FC: 0.0 Xt FC: 0.00 Yt FC: 0.00 Zt FC: 0.00  
 Config Model: Guiding Model5e Coord Mode: J2000

Dynamic Corrections: DC Pointing DC Focus Az1: 0.00 Az2: 0.03 Pt: 0.07 Focus: 4.00

On Source: [ ] Axis Fault/E-Stop: [ ]

FOC: [ ]

V(m/s): [ ] Temp: 20.7

Devices IF Manager Messages

LO1: IF Center (MHz): 2746.392 Tolerance (Hz): 10.000 LO1A (Hz): 11927656683  
 15 K: 13.67 Ext. Cal: [ ]  
 50 K: 44.43 Noise L: [ ]  
 Vac (V): -0.09 Noise R: [ ]  
 LO Pwr: 5.60

Rcvr6\_10

IFRack: OD2: 3.31 OD4: 3.20 OD6: 3.25 OD8: 3.35

Spectrometer: J9: 1.39 J10: 1.35 J11: 1.45 J12: 1.31 J13: 1.31 J14: 0.92 J17: 1.45 J18: 1.29 J21: 1.43 J22: 1.31 J25: 1.40 J26: 1.51 J29: 1.46 J30: 1.48 J33: 1.30 J34: 1.35 J37: 1.33 J38: 1.37

ActiveSurface: Num Disabled: 17 ODF Zernike Mode: [ ] Sim Mode: real  
 Cmd RMS: 36.865 Zero Offsets: [ ] Ctrl Mode: Enabled  
 Peak Resid: 32564 FEM Model: [ ]  
 Cmd IQ RMS: 42.995 Zernike Coeff: [ ]  
 Cmd Resid: 506 Z Thermal Coeff: [ ]  
 Random Offsets: [ ]

Auto Scroll: Off 10 Phase Table... Other Devices: [ ] Retrace IF

pointing+&focus corrections

pointing model

IF rack power

Spectrometer power

Active surface

# How to check-out Rx (for GBT support scientists)



- Run `4mm_TRCO` from `TRCO` – the script is self-documented
- Run `calseq_4ch.pro` within `gbitd1` to return the `tsys` and gains for each of the the 4 channels
- Run `wnod.pro` with input gains to reduce nod scan

# How to reduce data



- gbtidl data reduction scripts in /home/astro-util/projects/4mm/PRO
- Run calseq.pro to derive gains
- Run wnod.pro for Nod data, wfsw.pro for frequency-switched data, wonoff\_gain.pro for position-switched data, and wsnod.pro for SubBeamNod
- Use getatmos.pro to get the opacity at the time of observations

# Applying calibration



1. Cal-sequence measures gains of the system [K/counts]
2.  $g = (T_{\text{warm}} - T_{\text{cold}}) / (V_{\text{warm}} - V_{\text{cold}})$ 
  - $V_{\text{warm}}$  and  $V_{\text{cold}}$  observed
  - $T_{\text{cold}}$  from lab measurements
  - $T_{\text{warm}}$  from Rx temperature sensor
3.  $T_{\text{sys}} = g * T_{\text{off}}$
4.  $T_a = T_{\text{sys}} (T_{\text{on}} - T_{\text{off}}) / T_{\text{off}}$
5. Recommend scalar  $T_{\text{sys}}$  (median/avg across bandpass) for broad-bandwidths to give better baselines or vector  $T_{\text{sys}}$  (as function of frequency) for higher accuracy