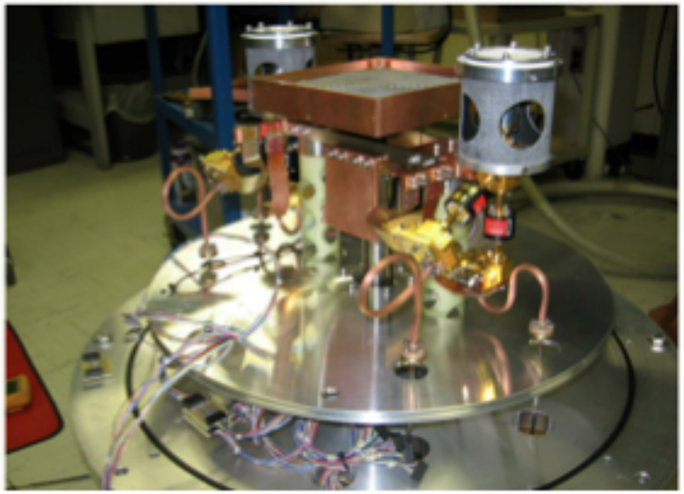
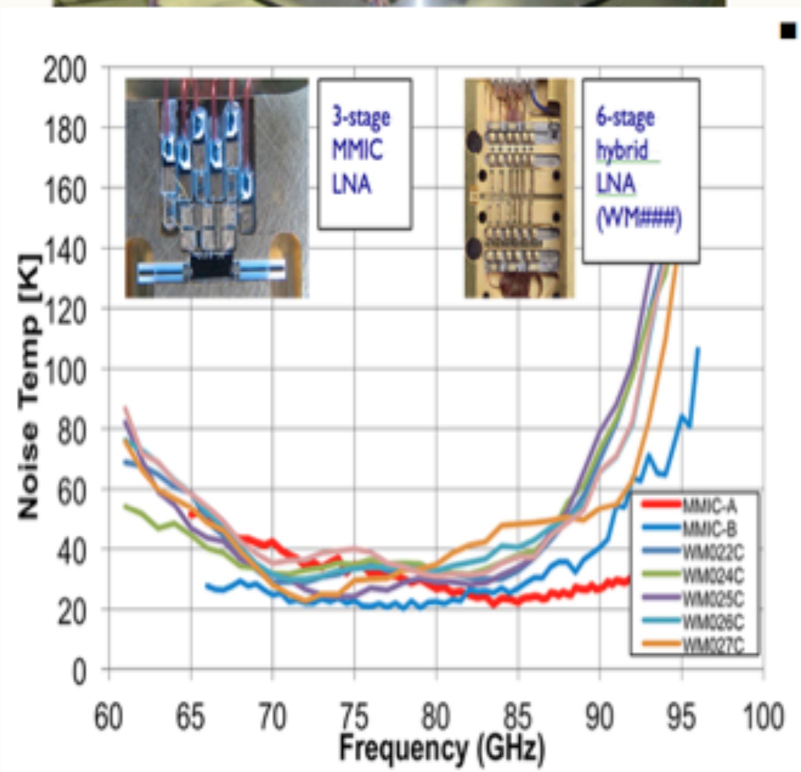
Observing with the 4mm Rx





- **Commission in 2012**
- **Operates from 67—93 GHz**
- **Dual feed, dual linear polarization**
- **Has ¼ 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.

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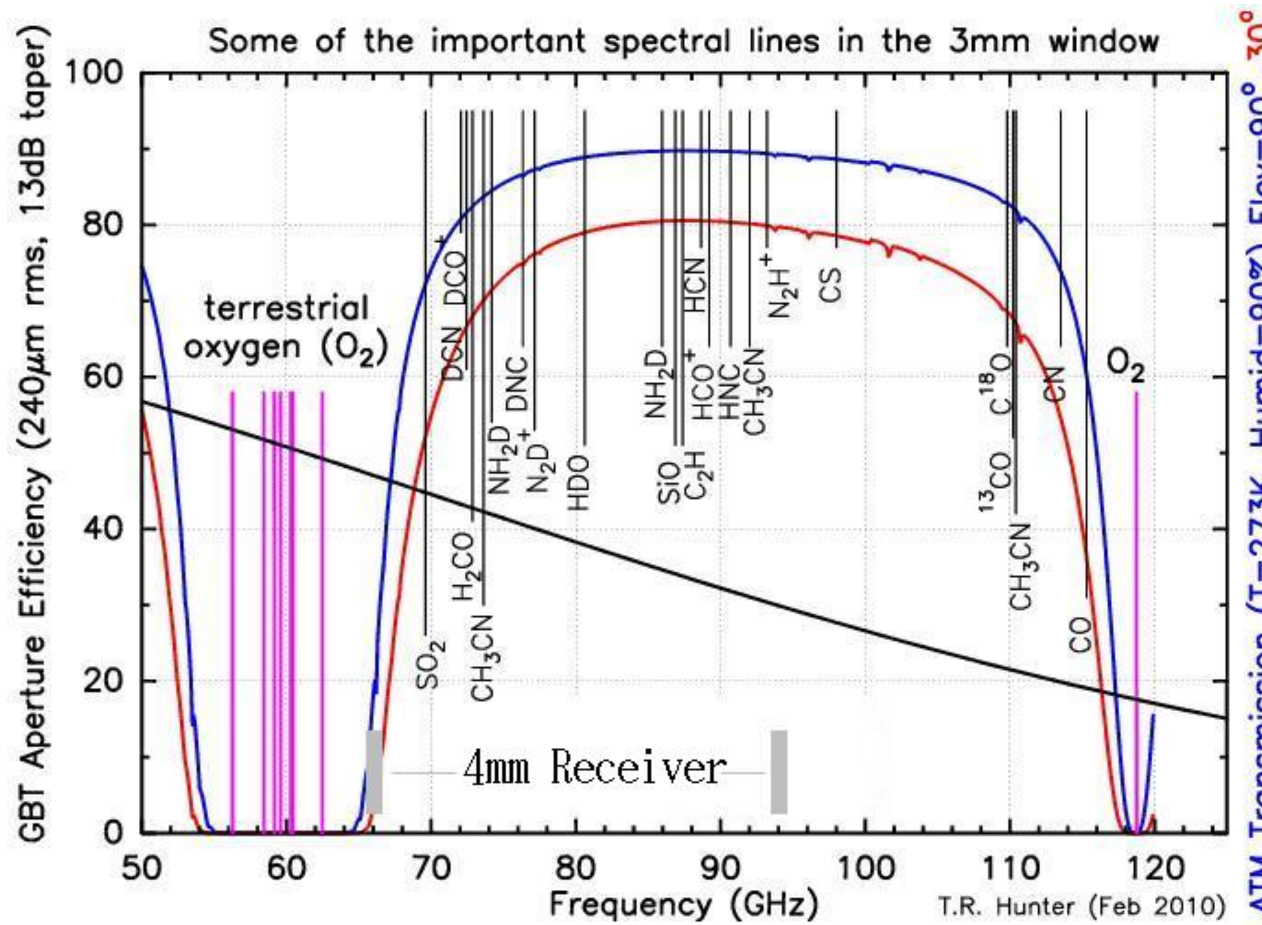
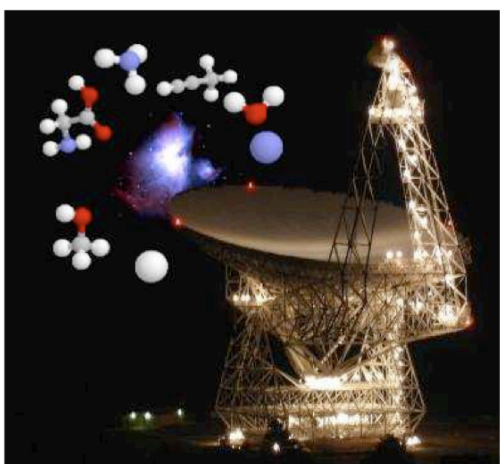
Science with 4 mm Rx, Lines:

- 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

GBT 4mm Receiver Page

www.gb.nrao.edu/4mm/

NRAO National Radio Astronomy Observatory

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

Thursday 23 October 2014

NRAO Sites | Home - Scientists | Home - Public | Charlottesville | Green Bank | Socorro | Tucson | Santiago | Telescopes | ALMA | EVLA | GBT | VL

NRAO Home > Green Bank > GBT 4mm Receiver

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

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

Technical Information for Proposals

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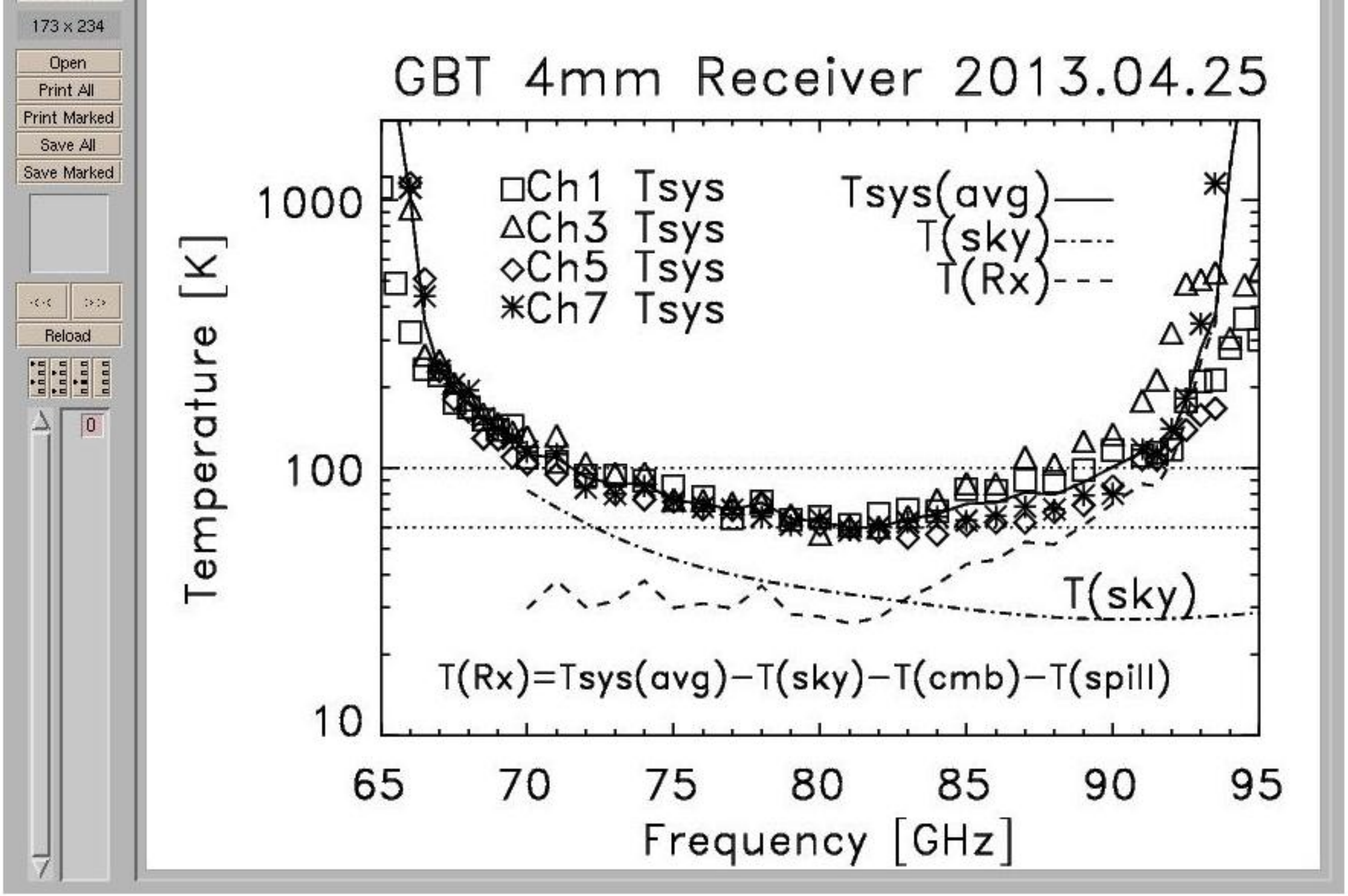
GBT 4mm Receiver Call for Proposals

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.



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 obseravations. The dashed line is the inferred receiver temperature (T(rx) = Tsys - 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_2 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.

Get Latest Info from the Wiki Status Page

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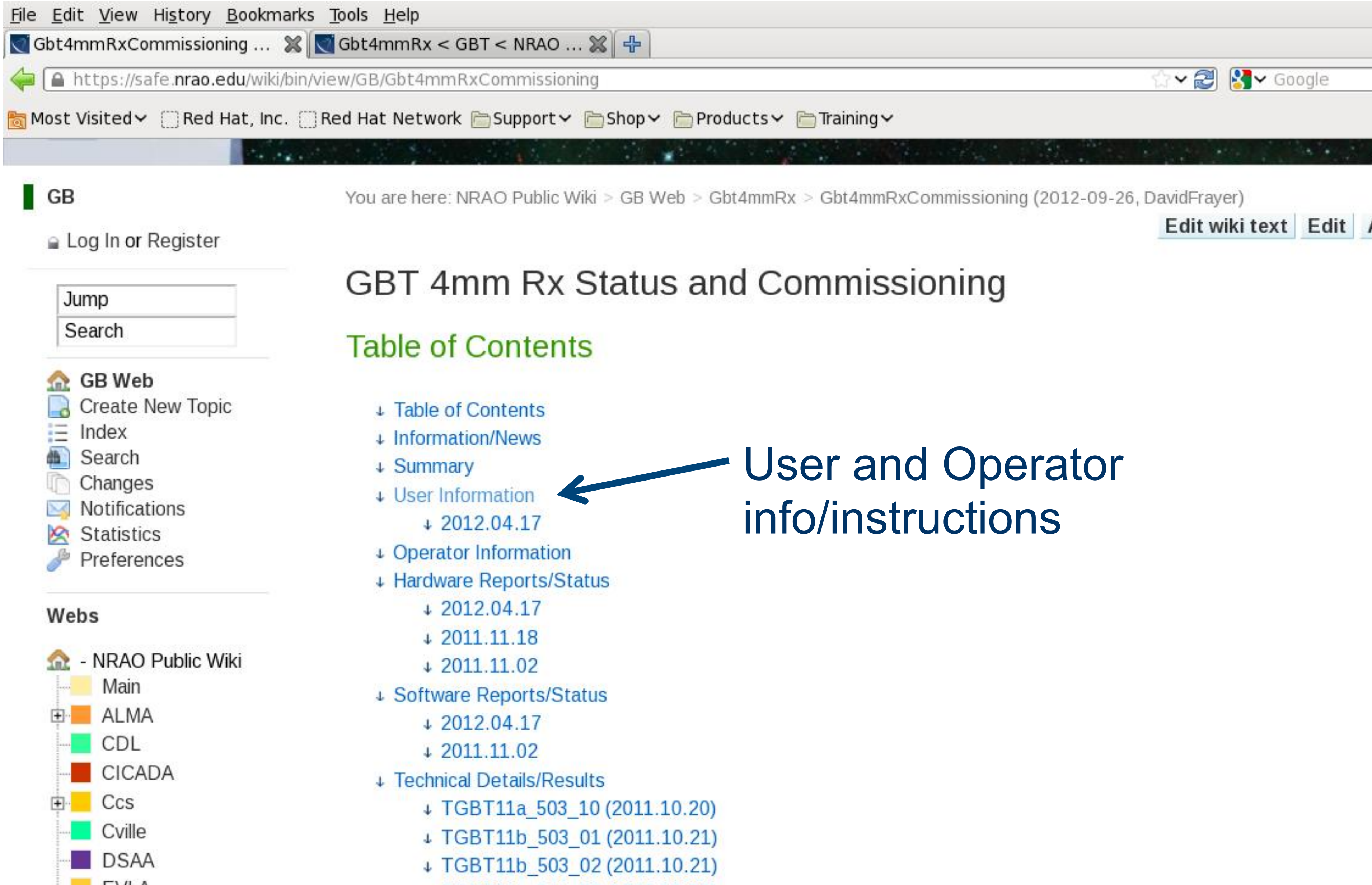
File Edit View History Bookmarks Tools Help

Gbt4mmRxCommissioning … | Gbt4mmRx < GBT < NRAO …

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

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  - CDL
  - CICADA
  - Ccs
  - Cville
  - DSAA

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

Edit wiki text | Edit

GBT 4mm Rx Status and Commissioning

Table of Contents

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 <~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

```
# -=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-
# 4mm line setup FL4 89GHz
# -=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-

Configure( """
receiver  = 'Rcvr68_92'
beam      = 'B12'
obstype   = 'Spectroscopy'
backend   = 'Spectrometer'
nwin      = 1
restfreq  = 89000.
deltafreq = 0
bandwidth = 800
swmode    = "tp_nocal"
swtype    = "none"
swper     = 0.2
swfreq    = 0, 0
tint      = 5.0
vlow      = 0.
vhigh     = 0.
vframe    = "lsrk"
vdef      = "Radio"
pol       = "Linear"
nchan  =  "high"
spect.levels = 3
""")

Balance()
```

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)

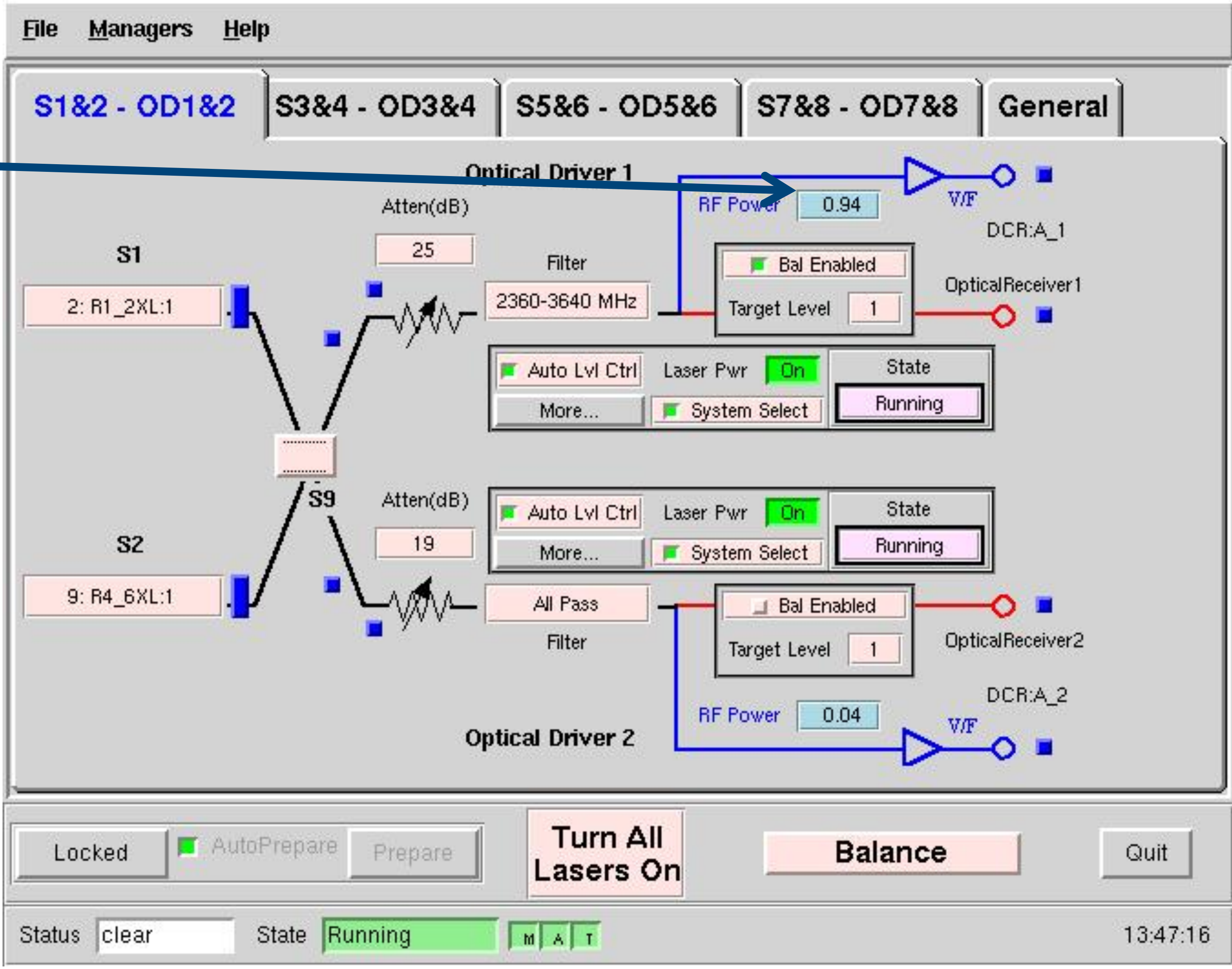
Validation Output:

```
*** 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 **
```

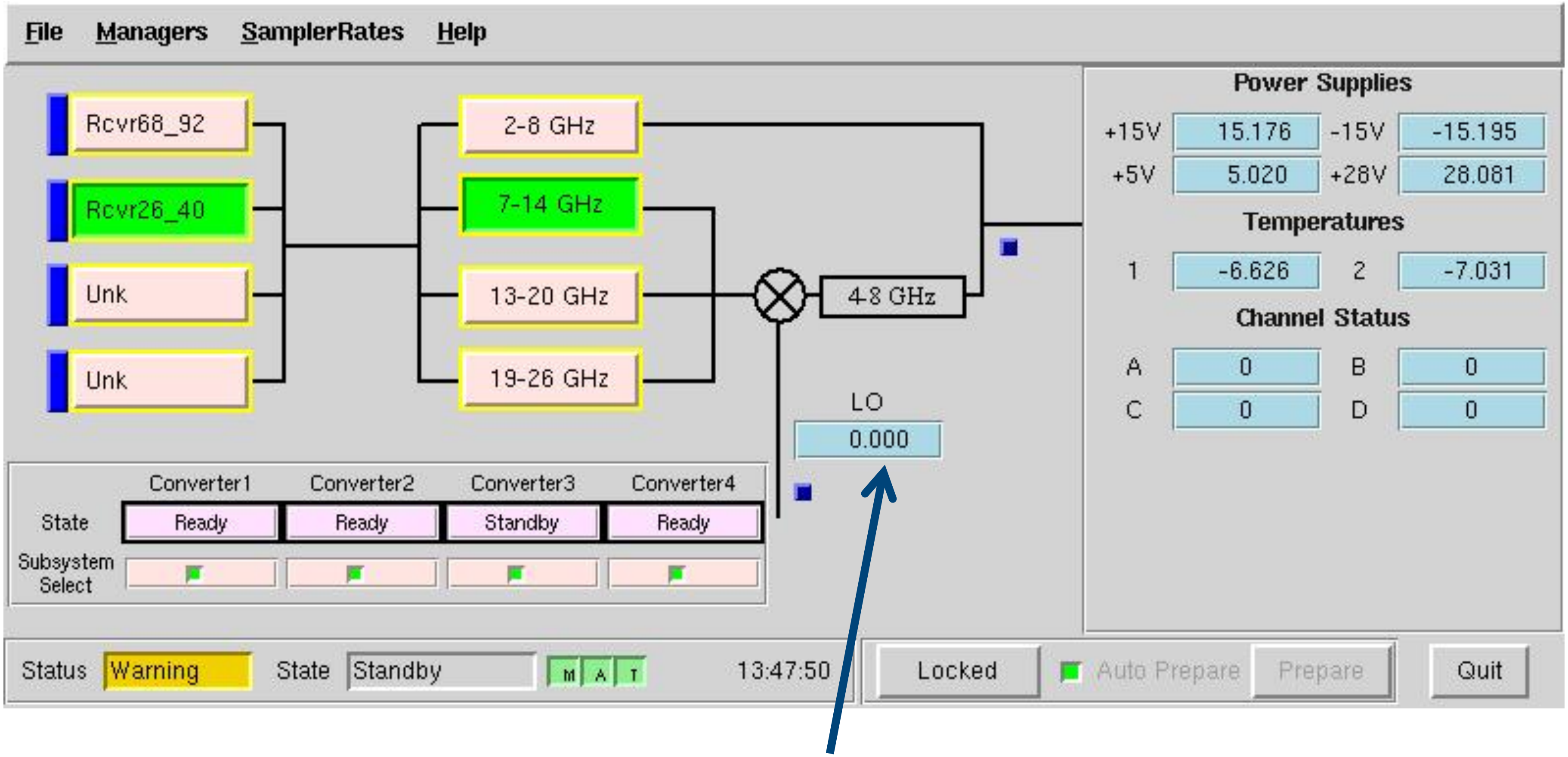
IFRack CLEO Page

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



MM-converter CLEO Page



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.

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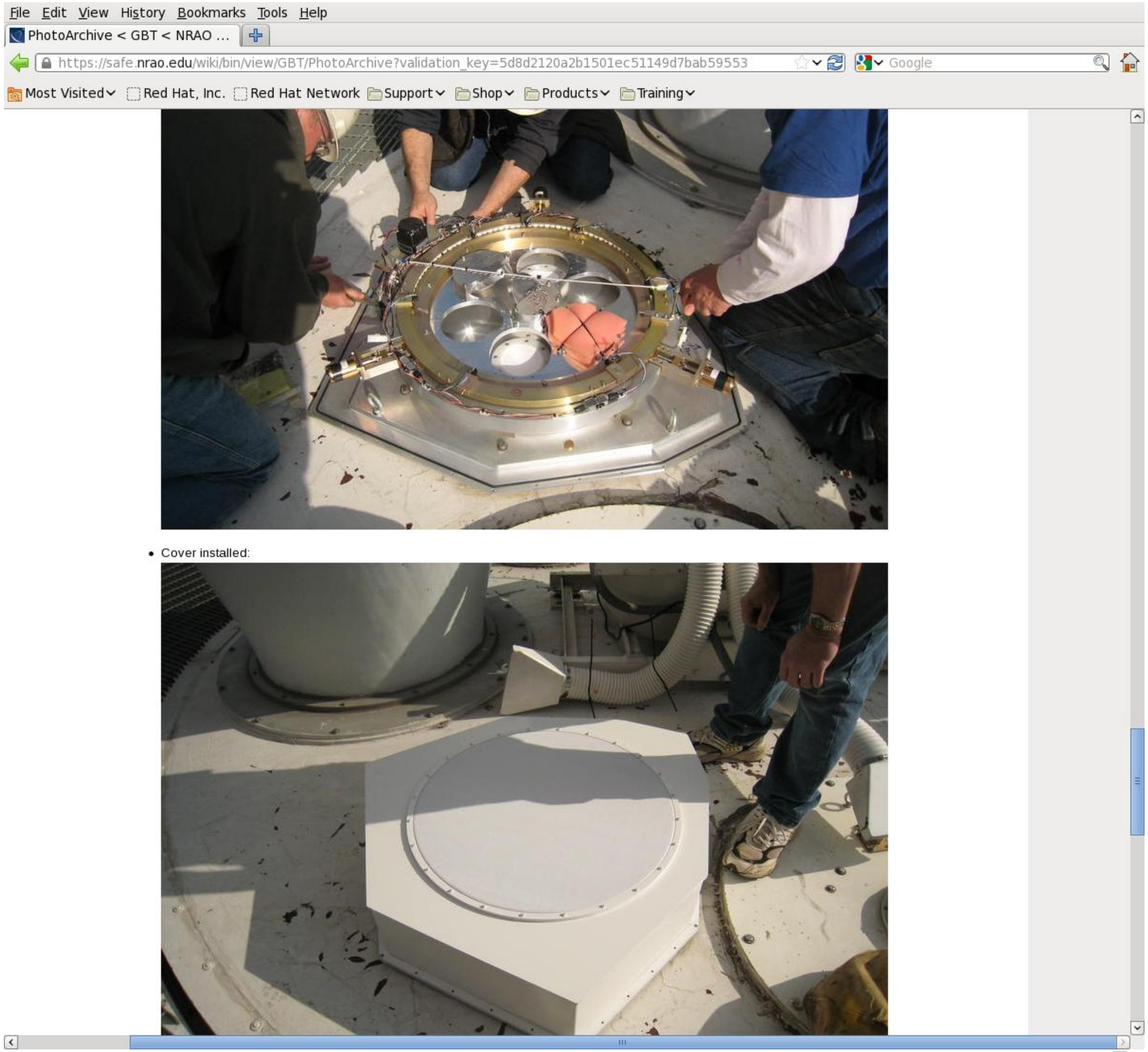
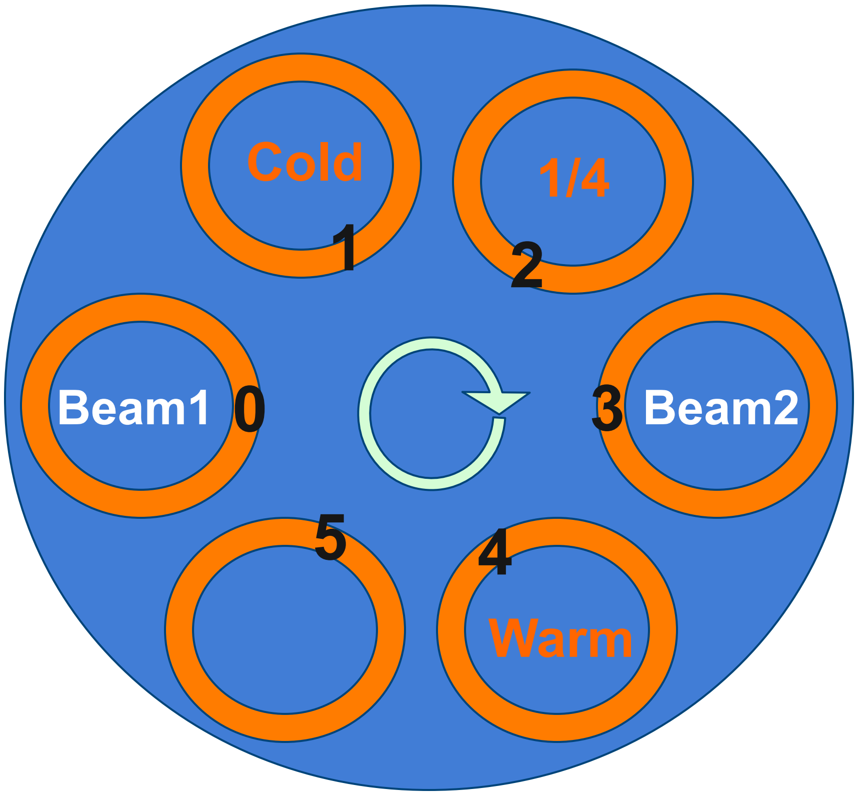
Installation, calibration wheel and external cover

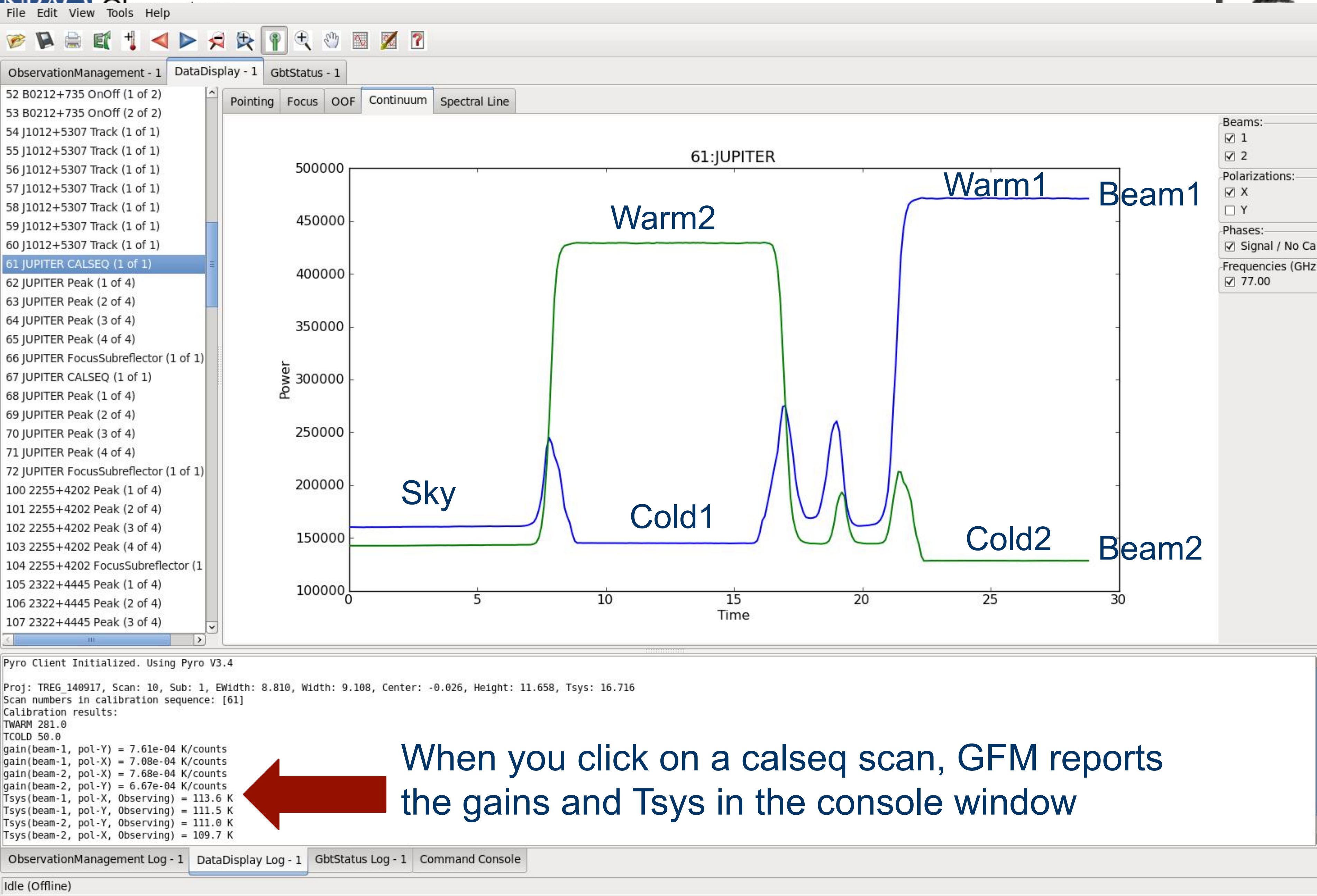


4mm Calibration Wheel



	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

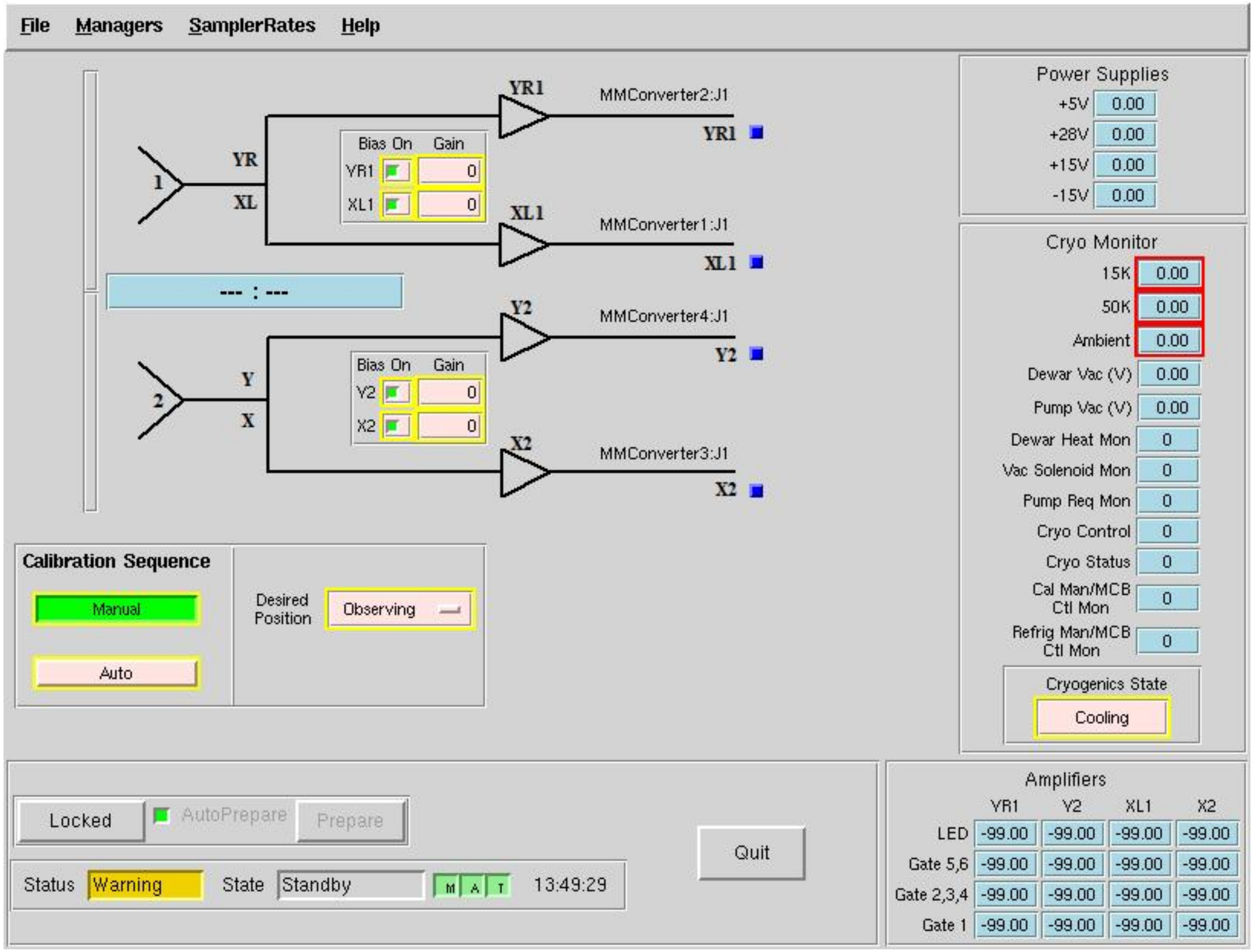
CalSeq-auto Scan



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

Rcvr68_92 Cleo Page

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



How to set surface with AutoOOF

- Start observations with AutoOOF, if science source of interest <~ 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 >~4Jy source for good AutoOOF solutions.

Brightest 3mm/4mm Quasars

>~4Jy for AutoOOF

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

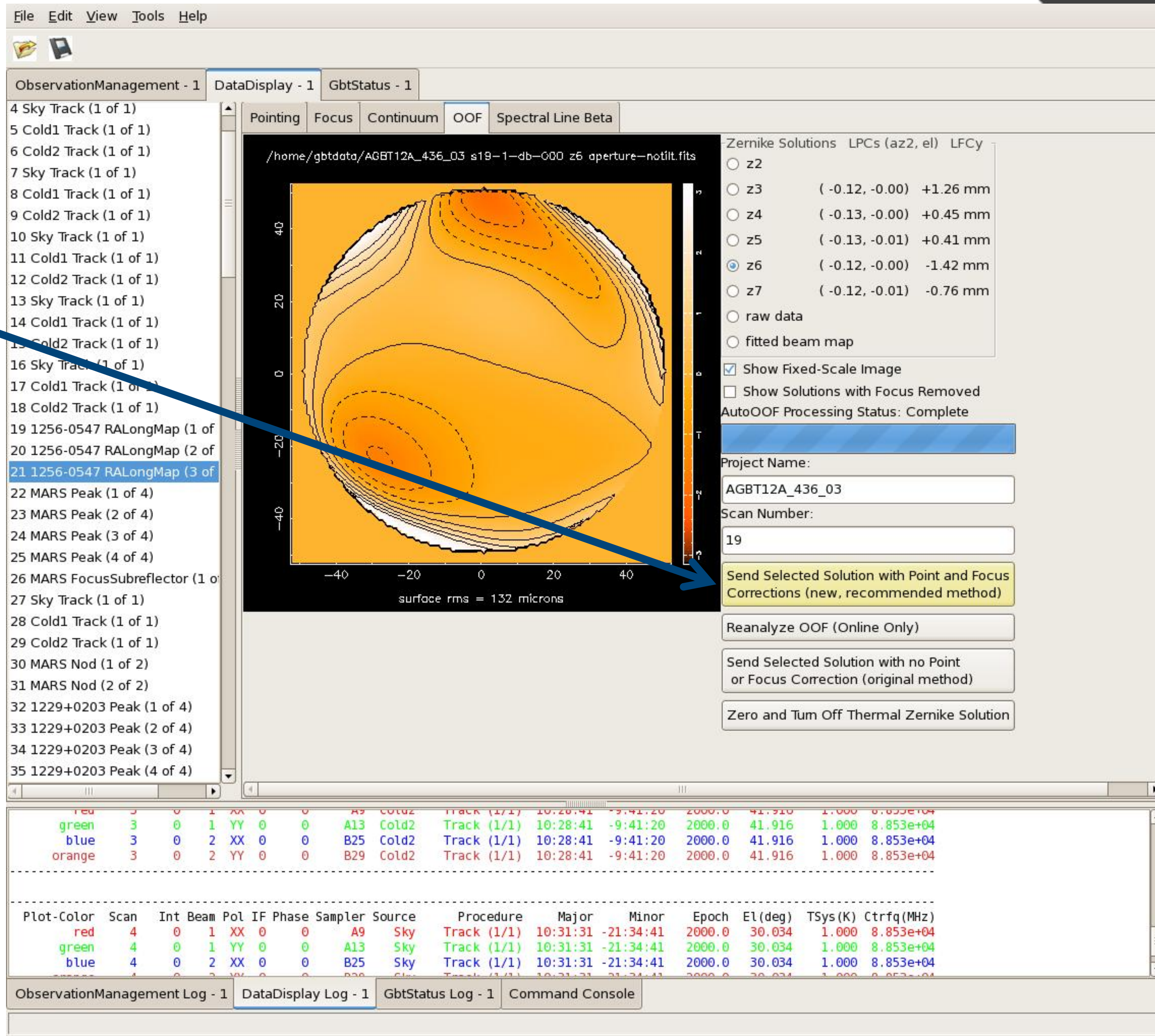
There are not a lot of bright 4mm sources in the sky – use planets as needed, e.g,. Uranus is ~10Jy and ~3")

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

				S(90GHz) [Jy]
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

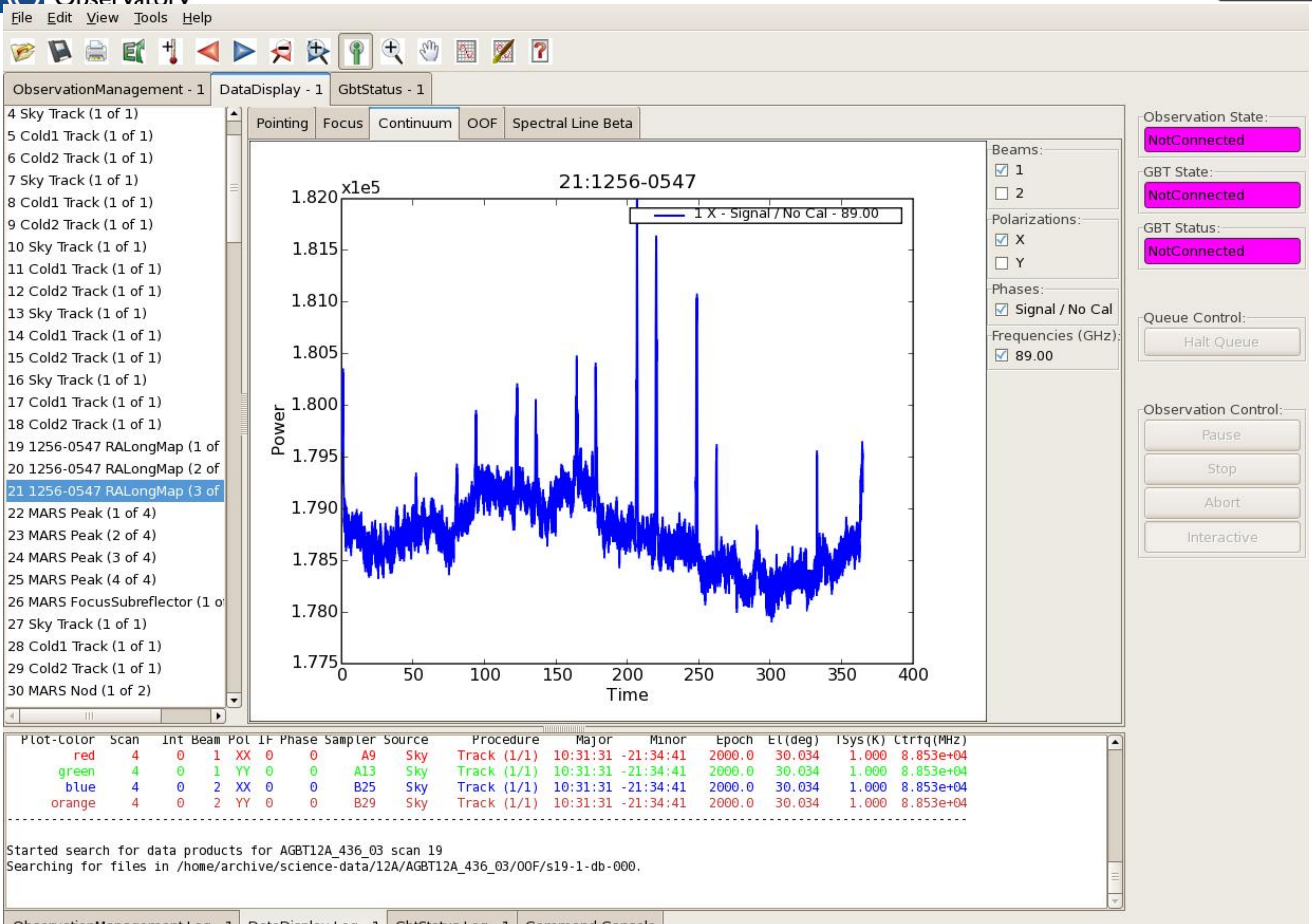
GFM OOF

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.

Scans through source during AutoOOF



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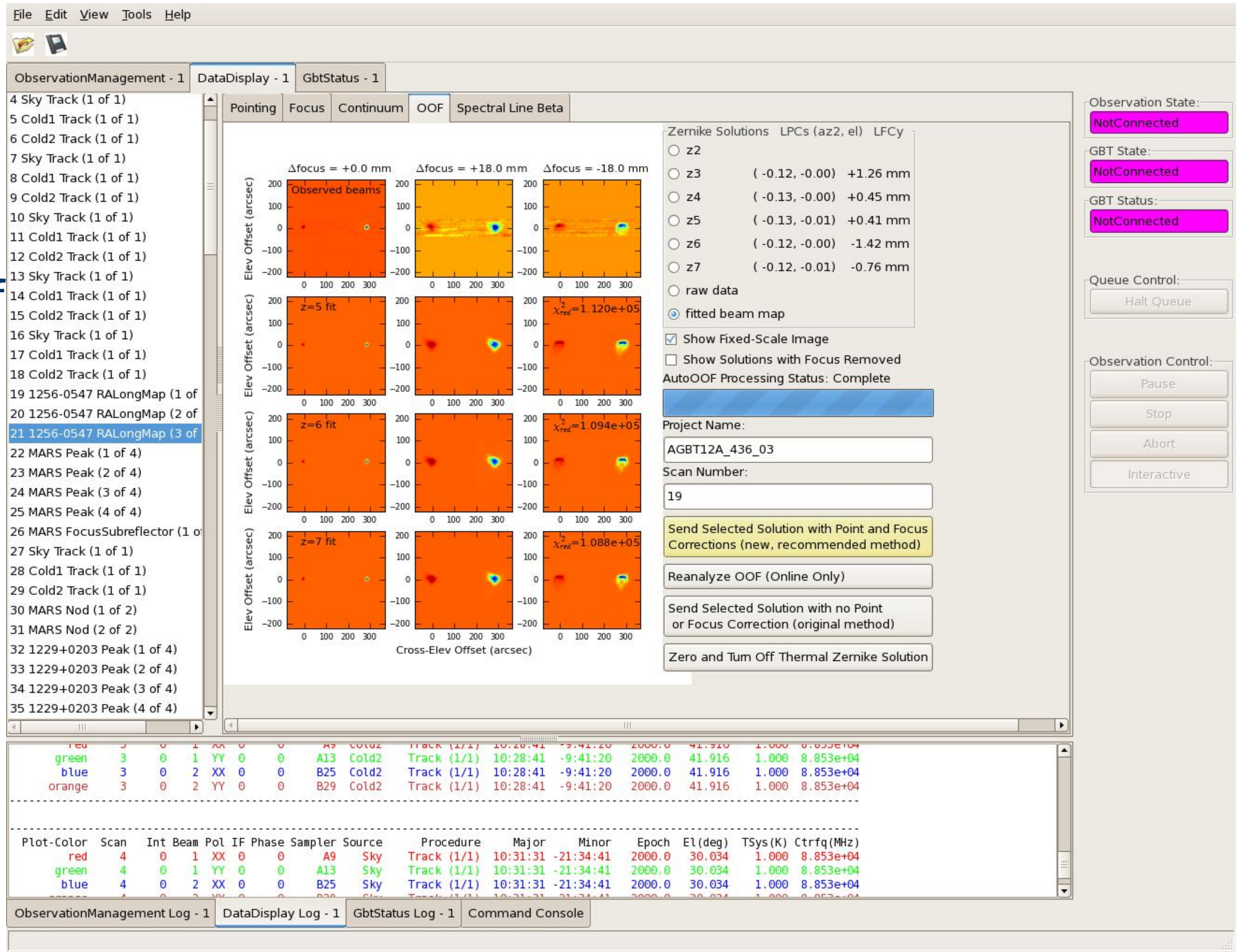
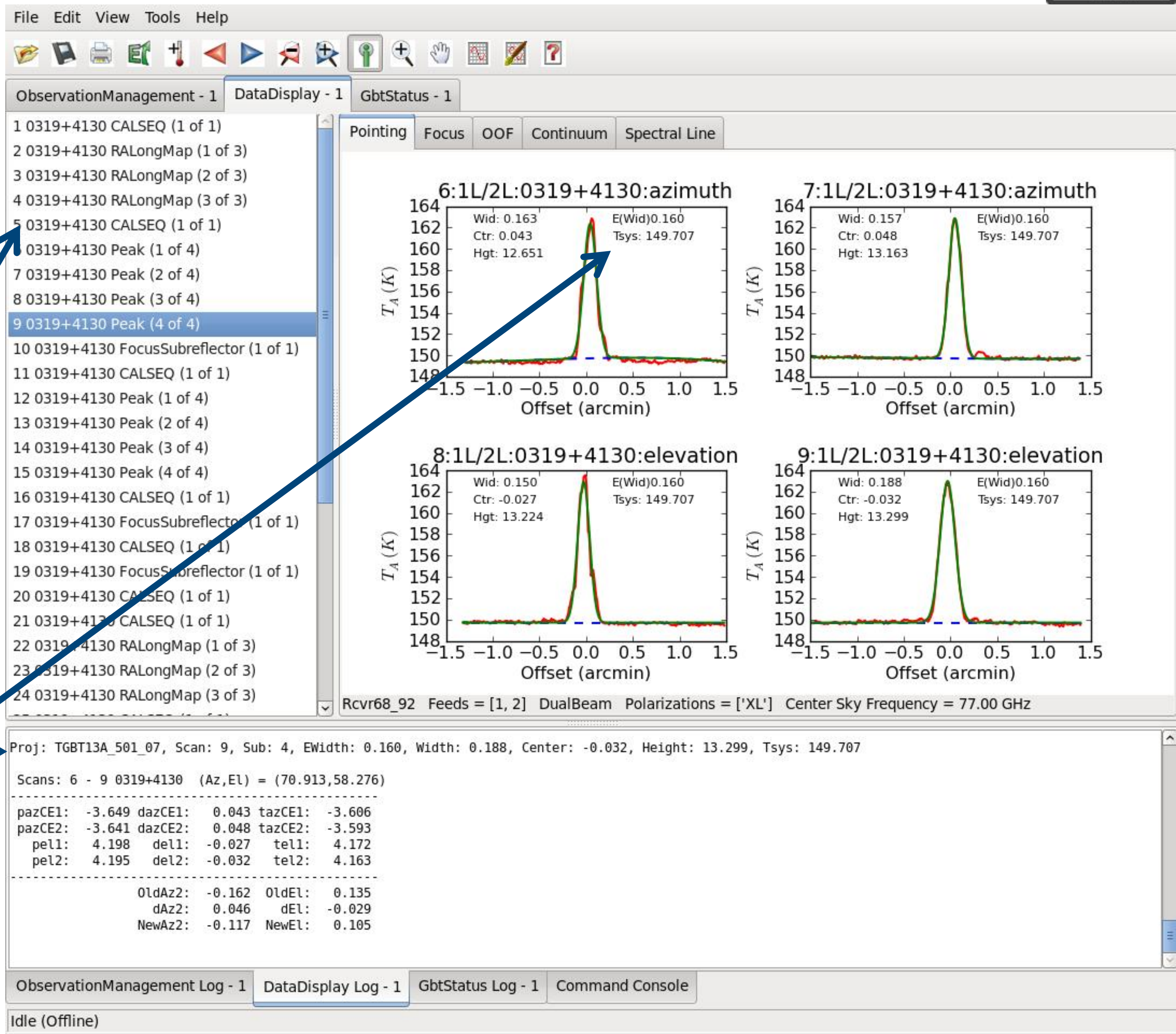
AutoOOF takes map on both sides of focus and near focus to derive model solutions (30minutes of telescope time)

Beams as function of fits and focus:



Example Pointing with GFM

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



Sending Pointing (and focus) corrections to the telescope manually

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5.1.3.4 Send Corrections

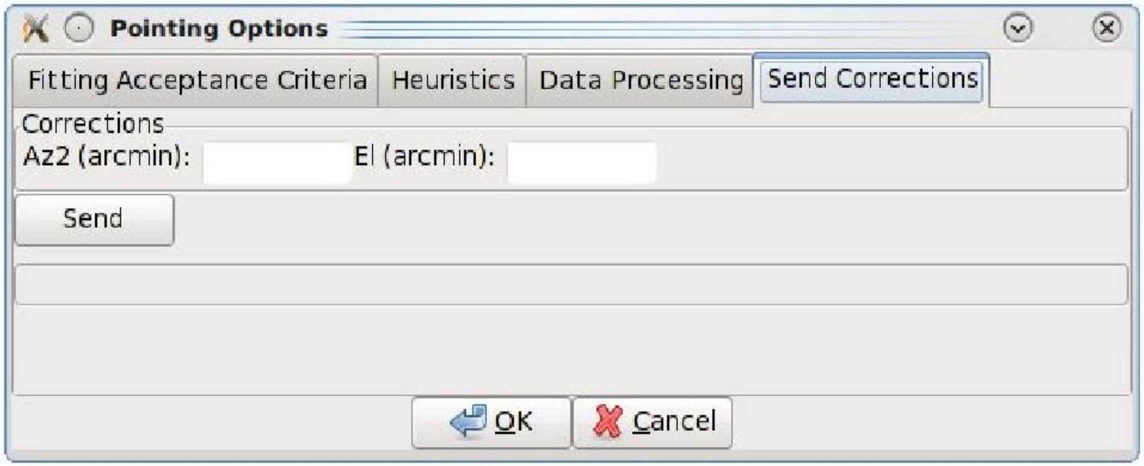


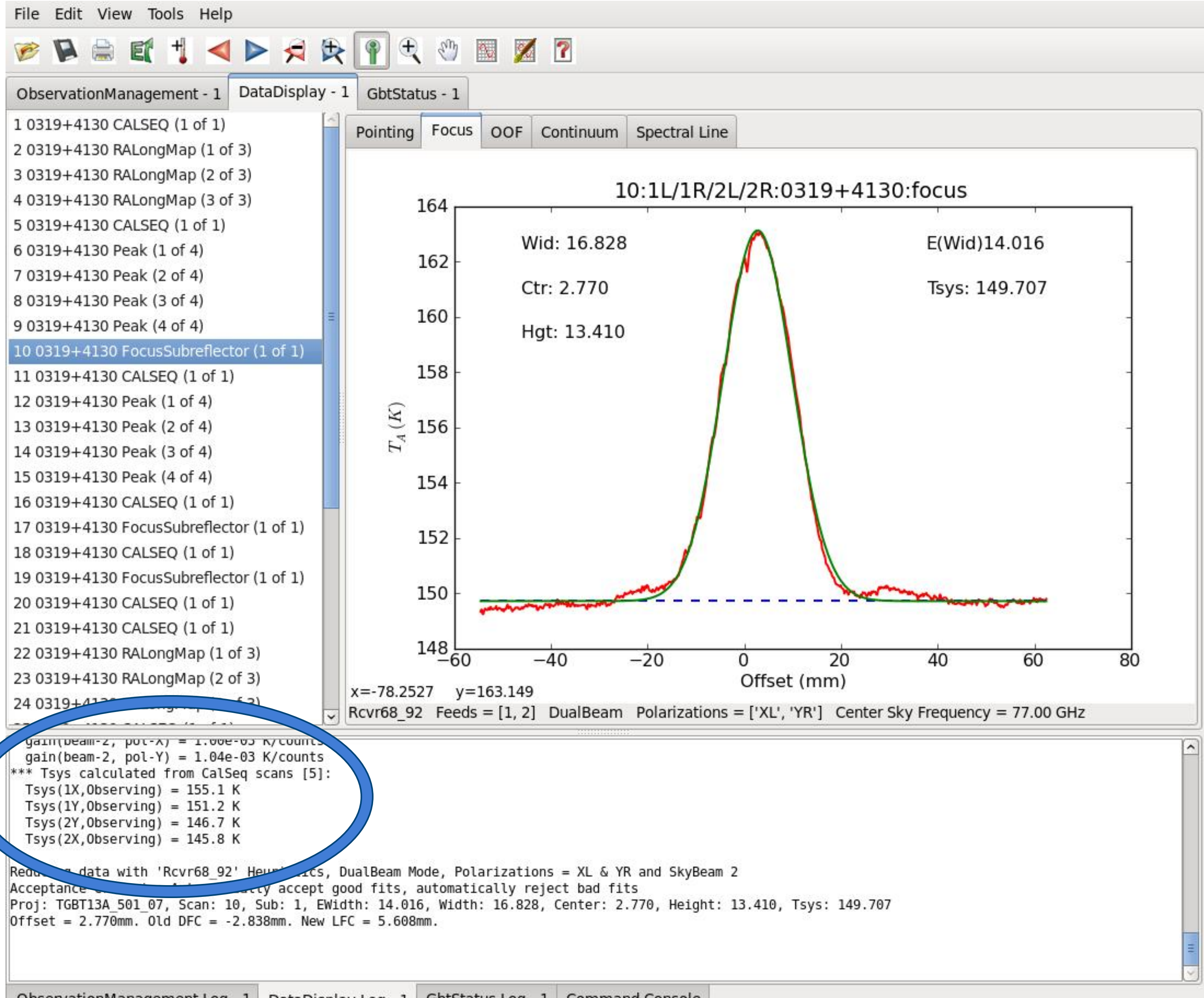
Figure 5.6: The pop–up menu to manually send pointing corrections to the telescope.

Users can send corrections manually to the telescope within GFM using Tools-> Options-> Send Corrections Tab.

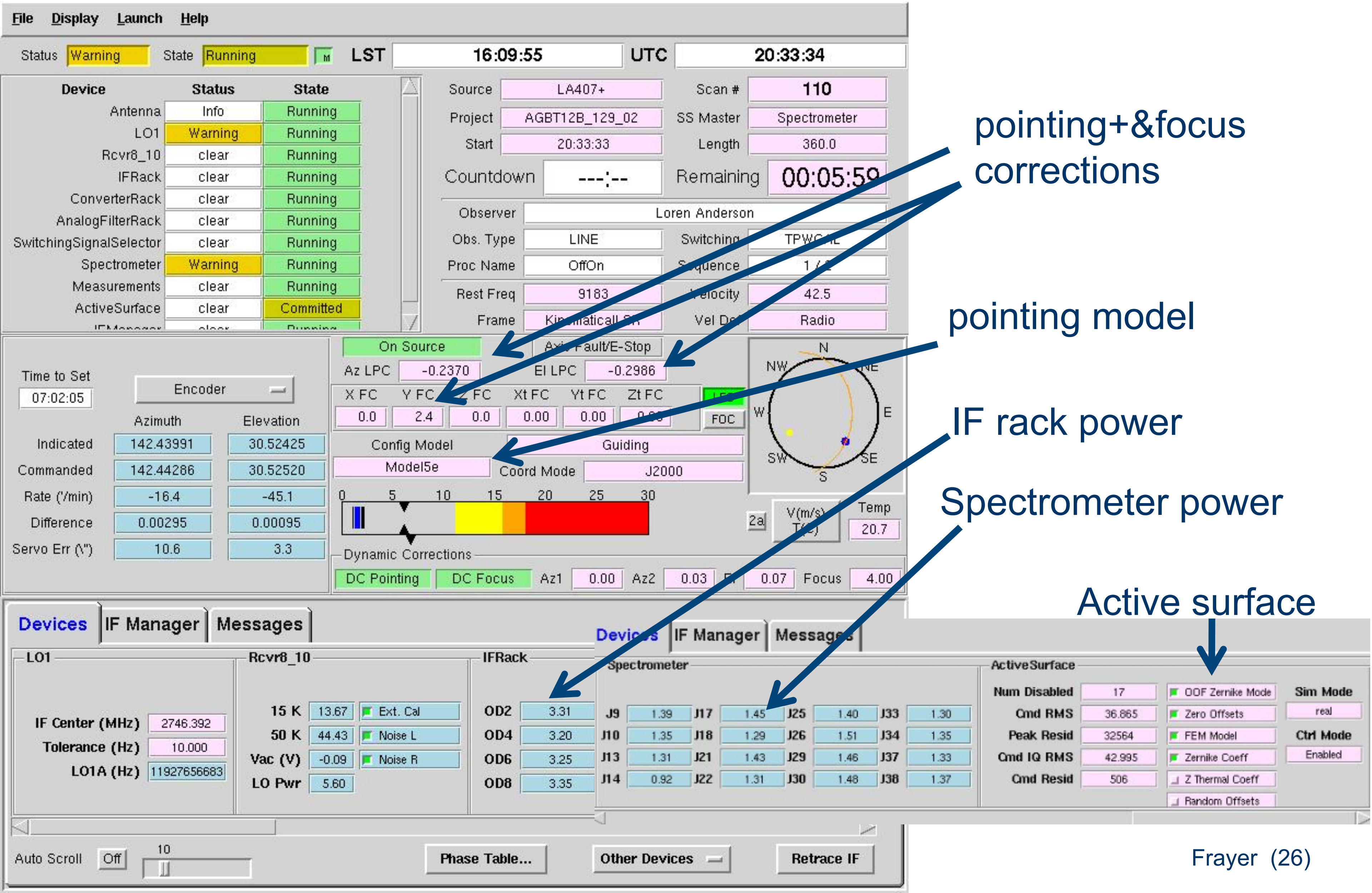
One can move the cursor over the plot windows and GFM will display "X" position (arcmin for pointing window) in lower left. If needed, one can manually move the cursor over the peak and derive a solution by eye, e.g., New_LPC=Old_LPC+X.

Example Focus Observation

Tsys and gains derived from preceeding 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



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

- Run 4mm_TRCO from TRCO – the script is self-documented
- Run calseq_4ch.pro within gbtidl 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 redcution 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=(Twarm-Tcold)/(Vwarm-Vcold)
   - Vwarm and Vcold observed
   - Tcold from lab measurements
   - Twarm from Rx temperature sensor
3. Tsys=g*Toff
4. Ta=Tsys(Ton-Toff)/Toff
5. Recommend scalar Tsys (median/avg across bandpass) for broad-bandwidths to give better baselines or vector Tsys (as function of frequency) for higher accuracy