

Observing with Argus



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Version 2017.12



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Where to find observer information

- Argus Observer's Web page:

www.gb.nrao.edu/argus

- Example Argus observing scripts are located at:

[/home/astro-util/projects/Argus/OBS](#)

- Example Argus GBTIDL reduction scripts are located at:

[/home/astro-util/projects/Argus/PRO](#)

- Links for GBT observing and data reduction

www.gb.nrao.edu/CDE2017

Argus Block Diagram

- 16 element
- single linear polarization
- Uses I-Q mixing scheme for side-band separation

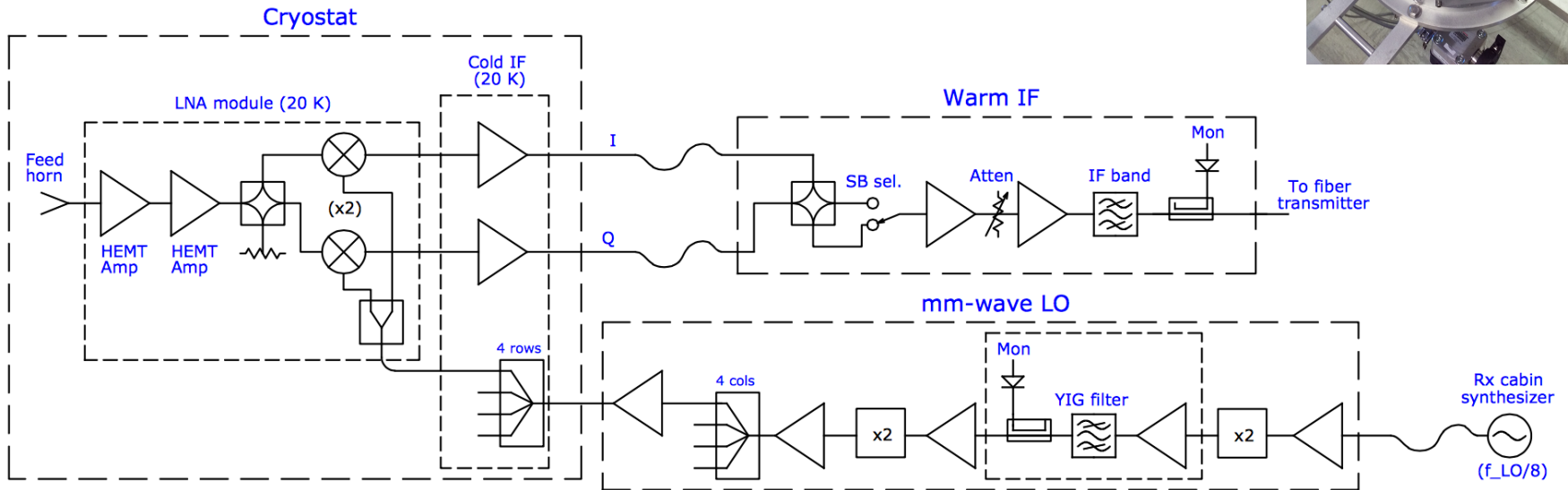
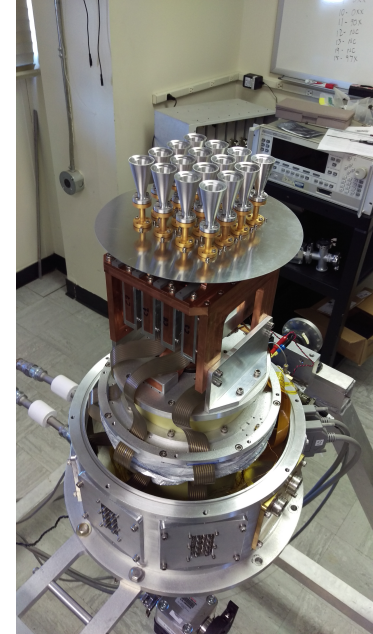


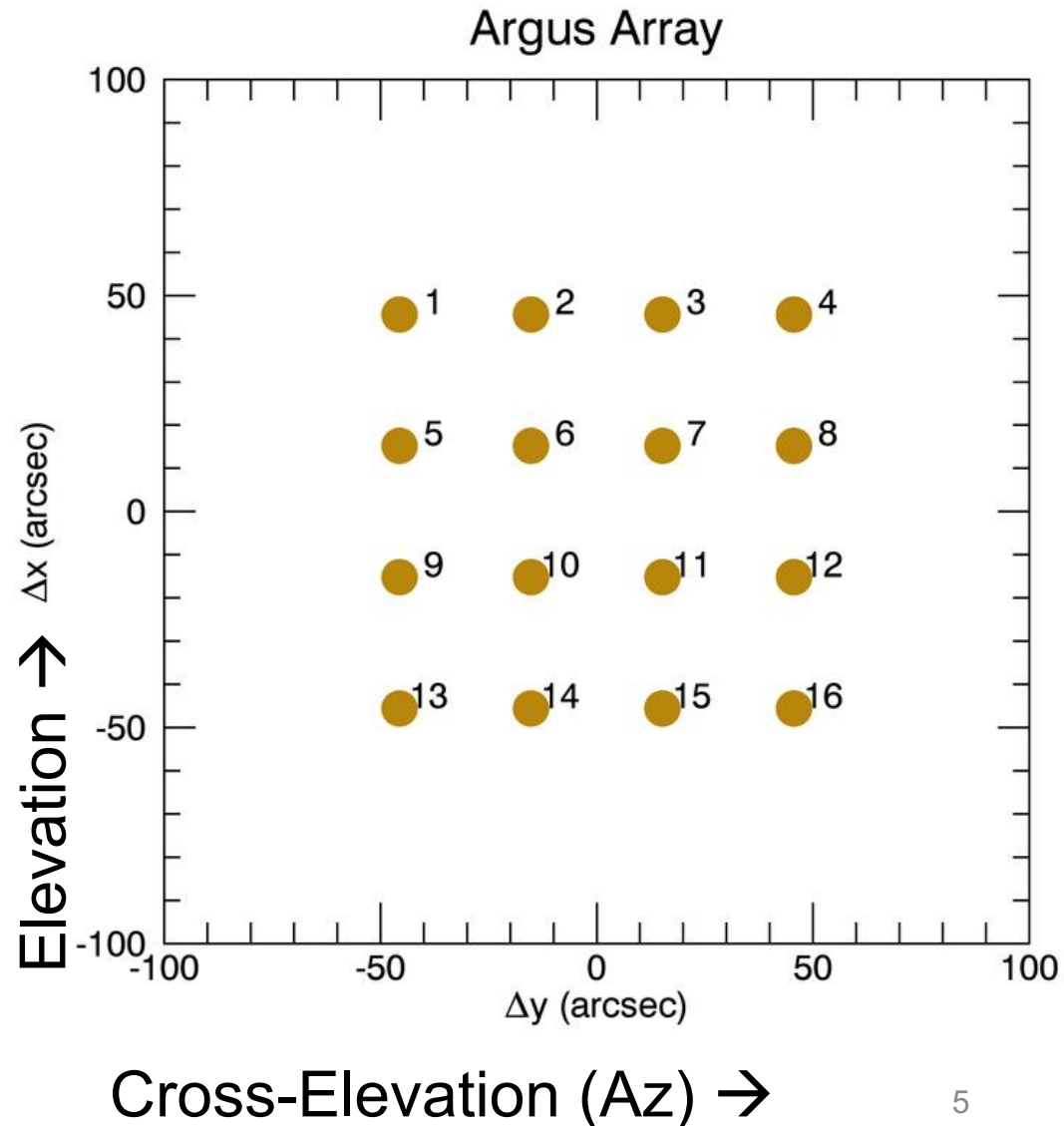
Figure 1: Schematic block diagram of Argus' signal path for a single receiver.

**YIG-filter 50MHz wide needed
for clean LO input**

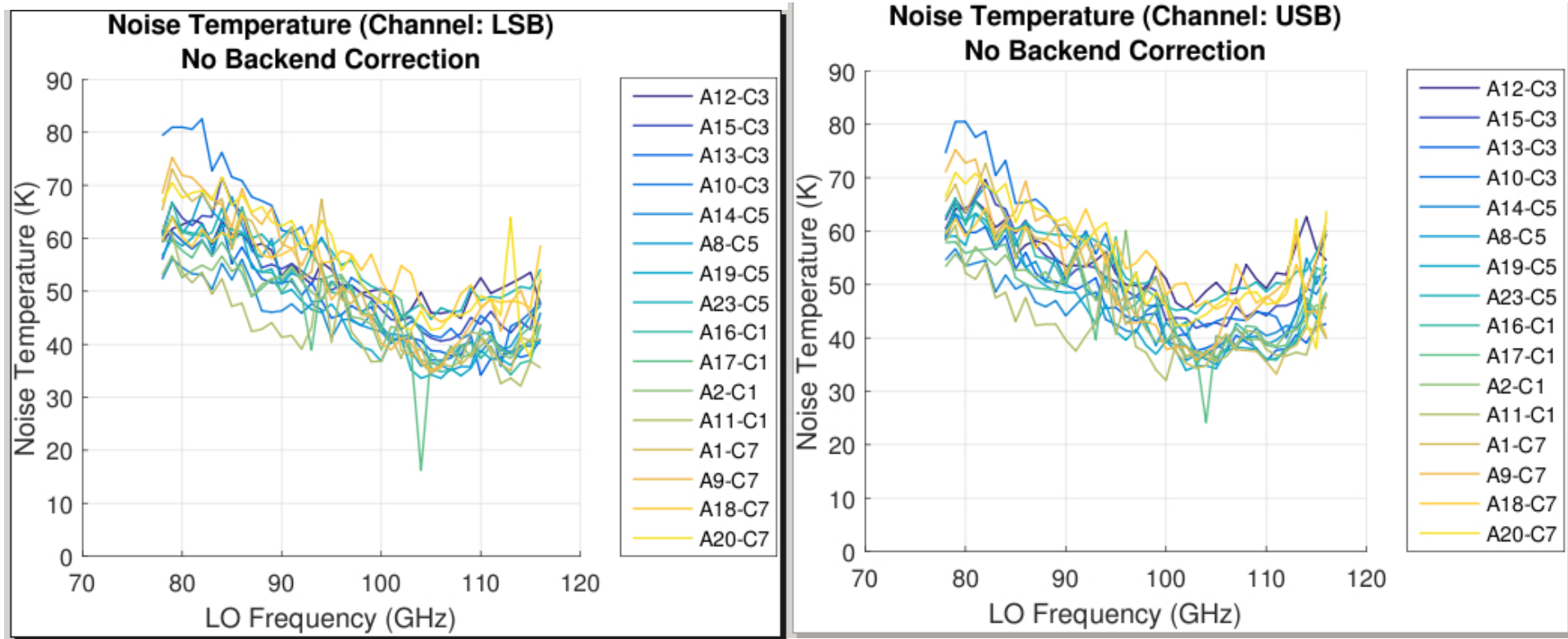
Argus Footprint on the Sky

4x4 array with each beam separated by 30.4" on sky in EI and xEI directions

- Only Beams 9-16 can be used with the DCR.
- Beam-10 is the default pointing/focus beam.
- All 16 beams can be used with VEGAS.
- Beams 1 and 12 tend to show higher noise than the other beams, depending on frequency
- Beam-8 has no side-band rejection.



Argus lab performance



Receiver temperature measurements of the LSB (left) and USB (right) as function of observing frequency for each of the 16 Argus channels.

Argus Performance on Sky

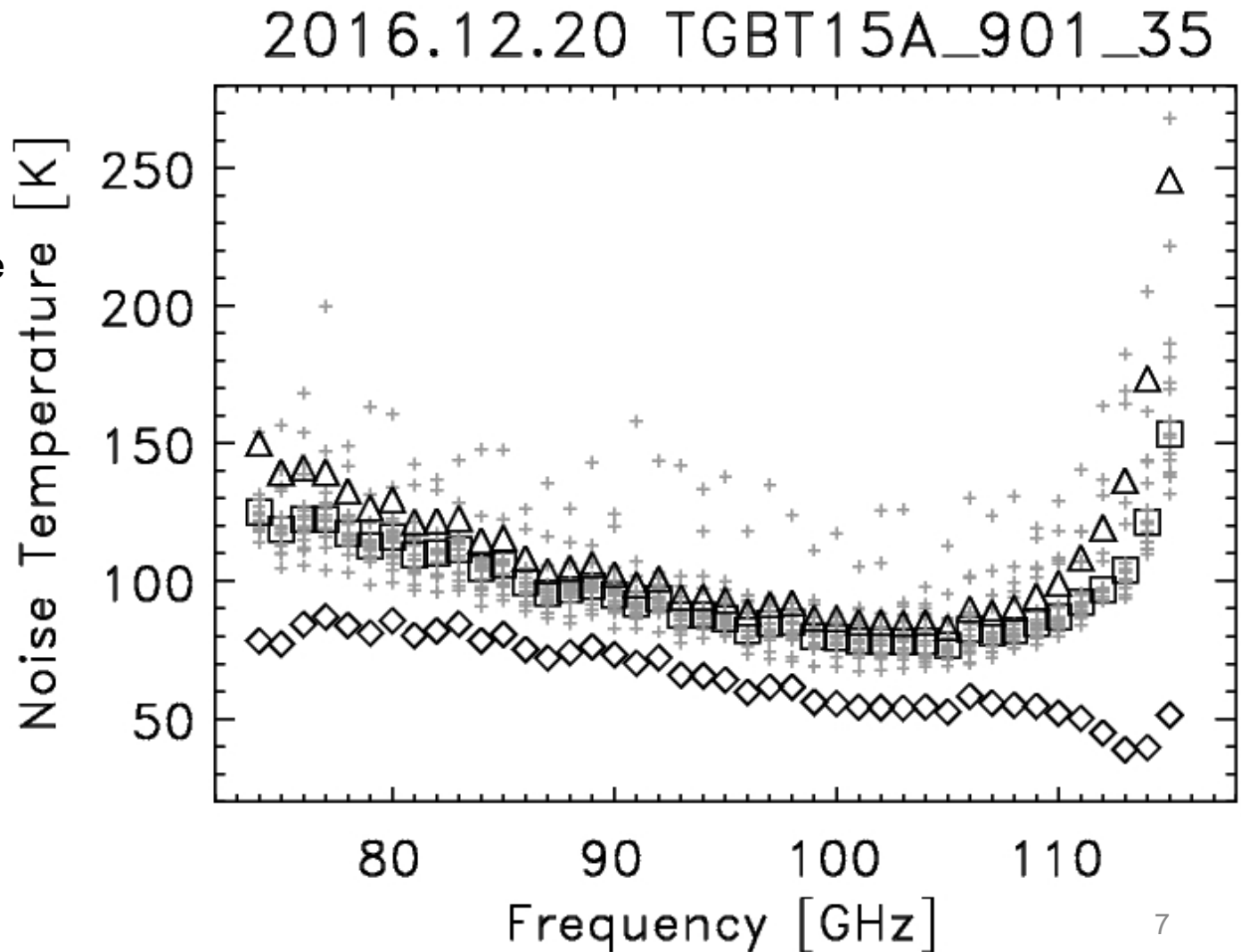
Measured noise on sky for Argus (zenith $\tau_{90\text{GHz}}=0.06$)

Grey '+'s are the individual T_{sys} measurements for each beam associated with T_a .

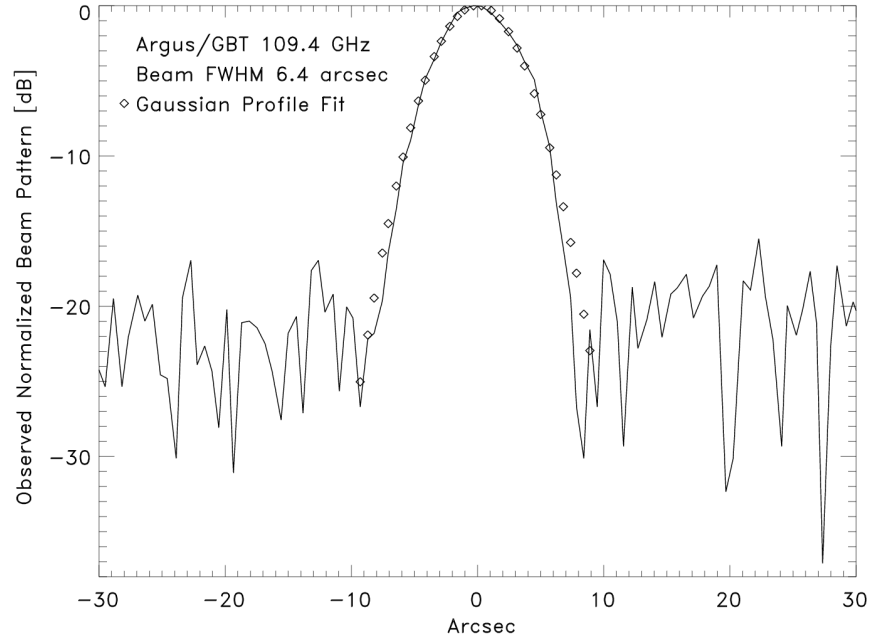
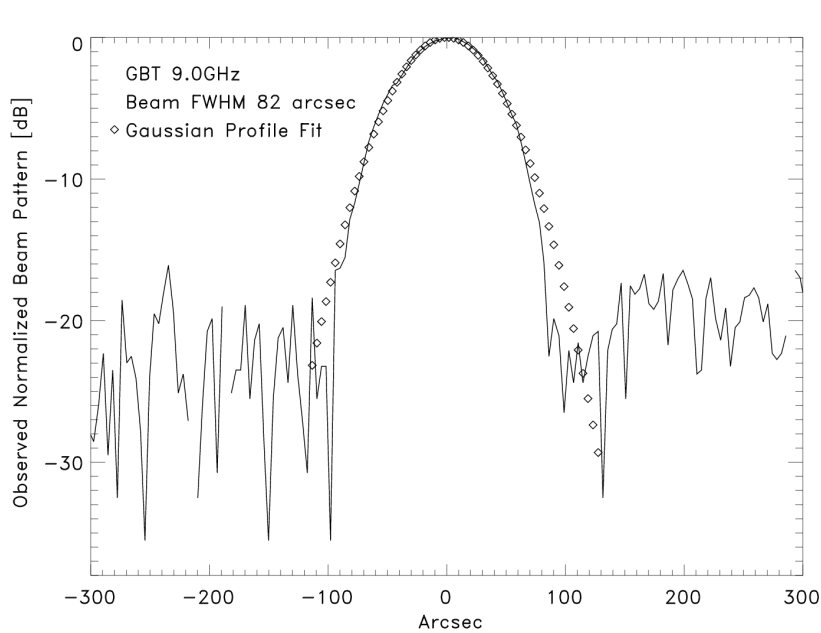
Boxes are median value of the T_a T_{sys} for Argus.

Triangles are median value for T_{sys}^* which is the noise temperature associated with T_a^* .

Diamonds are the inferred receiver noise after subtraction of the sky and estimated spillover.



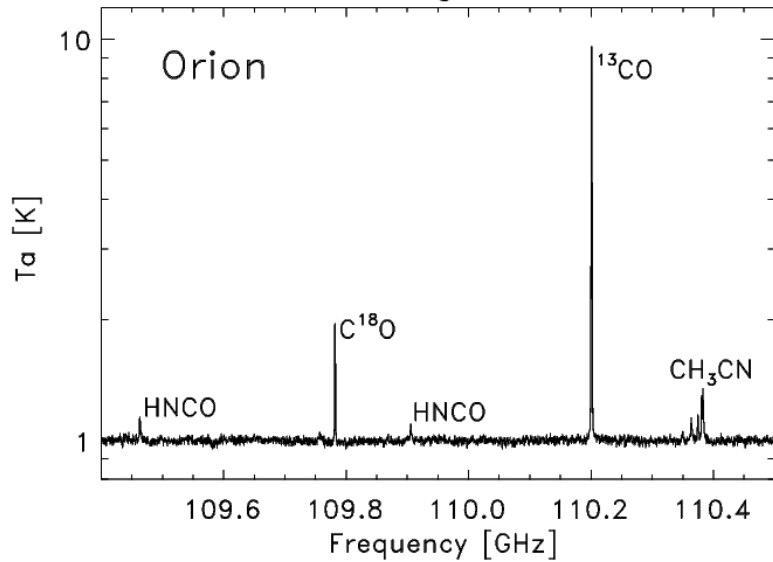
GBT Achieves Theoretical Beam with Argus at 109 GHz – GBT memo#296



Left is the GBT beam at 9.0 GHz and **Right** GBT at 109.4 GHz. With Argus, the GBT can achieve beam sizes of ~ 1.15 -- 1.2 λ/D (in good conditions after OOF).

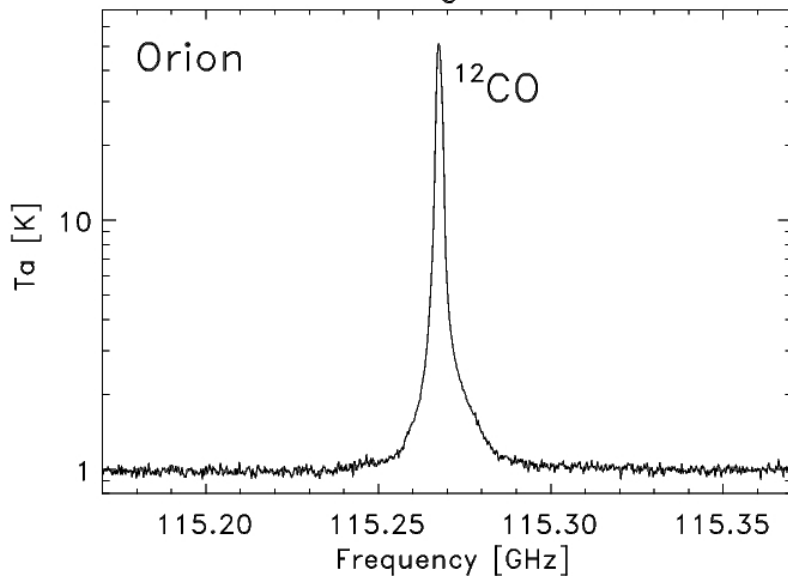
Argus early test observations:

ARGUS First Light 2016.03.30

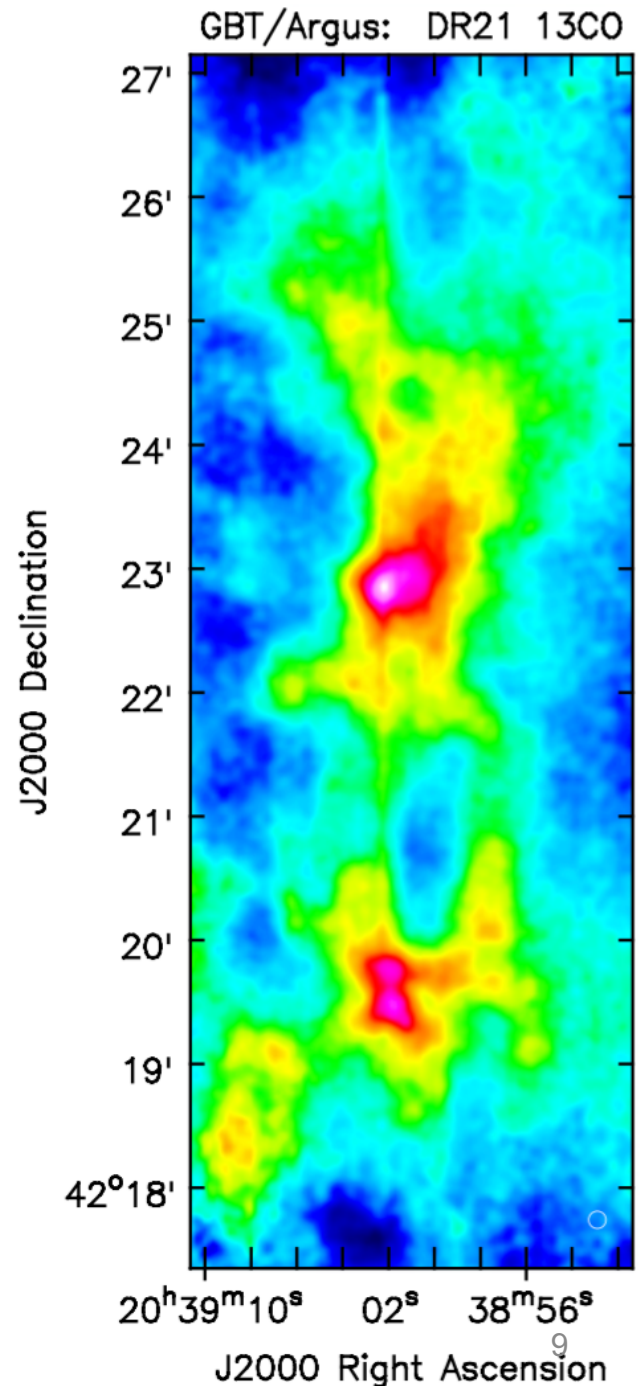


(left) 1st and 2nd light spectra taken of Orion.

ARGUS 2nd Light 2016.04.06



(right) ¹³CO 10'x3' map of DR21 using all 16 beams taken in 40 min under marginal conditions $\tau=0.42$



Argus-Specific Observing Information

- There are no noise diodes with Argus. Any data that you want to be calibrated requires vanecal observations after any new configuration or balance.
- It is best to observe similar frequencies together in time since it can take a few minutes for the YIG system to adjust to large frequency jumps. Frequency shifts of order a 1-2 GHz or less between observations are ok, but if you need to switch by a large amount (e.g., 4-10+ GHz), configure, wait a couple of minutes, and re-configure and balance again.
- For Astrid/GFM processing of the pointing and focus scans to work, the data processing needs to be done in "Raw" mode and you should relax Heuristics. Use the .sparrow file to avoid to set "RAW" processing in advance when starting astrid. Also, watch for the Astrid pop-ups. Generally do not abort the peak procedure just because astrid says the Az fit(s) "fail", continue with EI scans. Manually send corrections to the telescope and repeat peak as needed. Focus after getting good pointing solutions.
- Argus is able to observe from 74 -- 116 GHz.
- Only beams 9-16 that go through the IFRack can be configured with the DCR. All 16 beams can be configured with VEGAS using 8 dedicated optical-fibers for Argus beams 1-8.
- Beam 8 has no sideband rejection so signal from opposite sideband is seen.
- The continuum "Auto" procedures will run vanecal observations by default. To save time during the initial pointings/focus that do not need to be calibrated, use the calSeq=False keyword in your observing scripts, e.g., AutoPeak(source,frequency=90000.,calSeq=False). If your frequency is not set, the default frequency for the Auto procedures for Argus is 86000 MHz (units are MHz, not GHz).
- Run AutoOOF with with the vanecal (default) since this will use calibrated data from both beams for fitting the surface model.

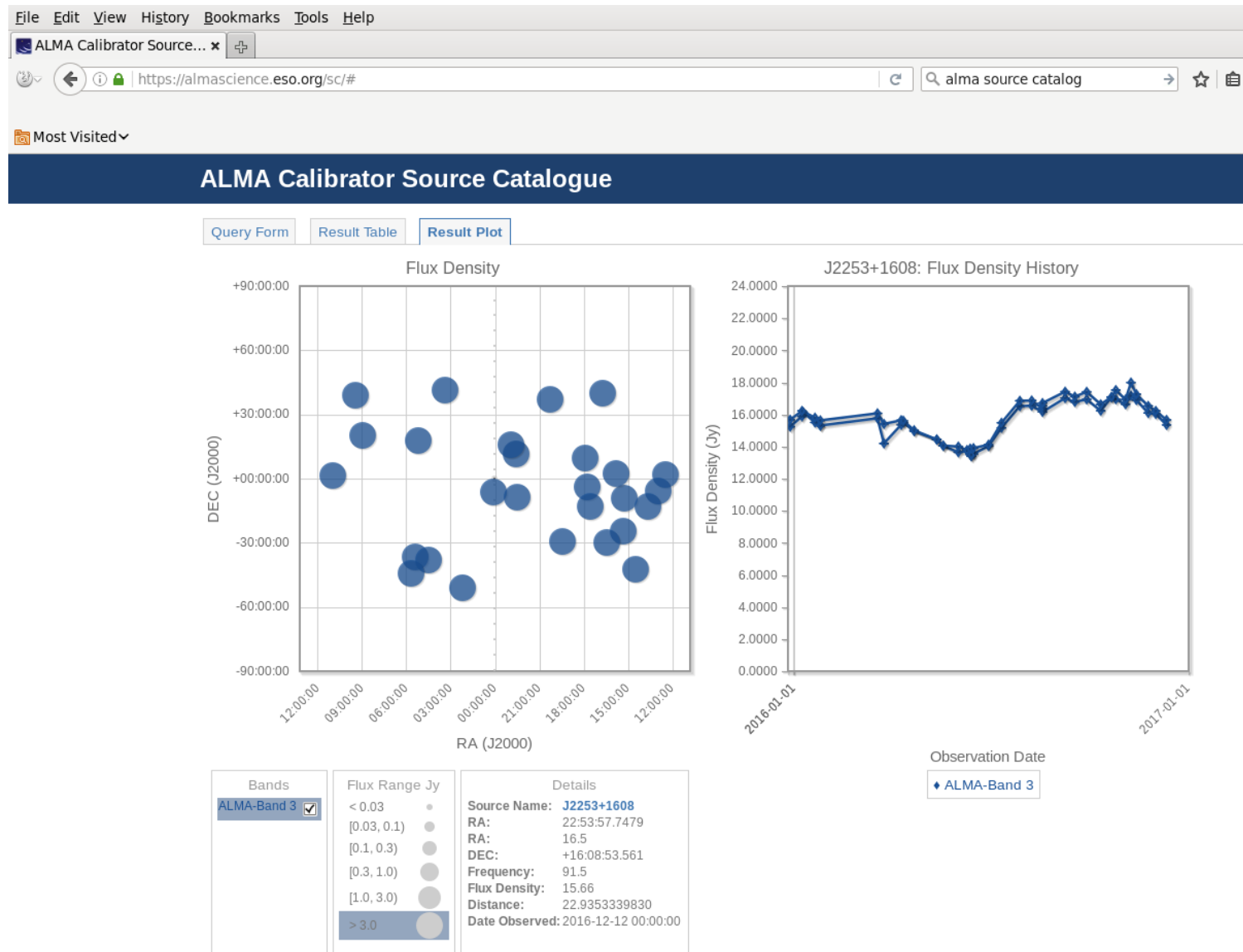
Recommended Argus Observing Procedures

- 1) Copy w.sparrow file into `~/sparrow` before starting astrid. This tells astrid to process data in Raw mode to avoid errors/delays in GFM processing.
- 2) Startup **astrid** and relax heuristics for pointing and focus tab.
- 3) Go **online** with control in Astrid and run the **argus_startup** script (when given permission by operator).
- 4) Run **autooof** (where source is the brightest available quasar with $el > \sim 25\text{deg}$ and $el < 80$). This step is needed if you want to correct the surface for thermal corrections which is important for sources sizes $\sim <$ beam size. If you do not need an AutoOOF, then the initial point should be done at a lower frequency receiver in order to find the initial pointing offsets for Argus. If Ka+CCB is available use this for AutoOOF.
- 5) Run **autopeak_focus** with Argus (where source is >1 Jy source within $\sim 30\text{deg}$ of target region; brighter sources are better than closer sources since the GBT pointing model is accurate, and choose a frequency that is the approximate frequency of your science frequency). For best results, **autopeak_focus** should be run every 30-50 minutes depending on conditions (point more often during the day and after sunrise and sunset). Avoid pointing in the "key-hole" ($el > 80.0$).
- 6) Carry out target observations. Run the **argus_vanecal** script after configuration and balance. Check the LOpower for the YIG. Check that the vane is in the obs position (seeing the sky) before collecting target data. Observers can use device explore to check instrument parameters.
- 7) Check instrument performance by reducing the vanecal observations within gbtidl, e.g., **GBTIDL -> vanecal,25,ifnum=3**. Note that the T_{sys}^* is the effective T_{sys} which is applicable for T_a^* and includes the atmospheric correction, $T_{\text{sys}}^* = T_{\text{sys}} \times \exp(\tau_o \times \text{Airmass}) / \eta_l$.
- 8) For absolute calibration carryout **autopeak_calibrate** scans after applying good pointing and focus corrections for a source of known flux density (e.g., ALMA source catalog (<https://almascience.eso.org/sc/>)). The ALMA calibrator catalog can also be used to check the strength of your pointing/focus source.

Preparing for Observations

- Configuration file – frequency(ies), spectral resolution, observing mode (see GBTog and presentations on GBO web pages)
- Source catalog (RA, DEC, Velocity)
- Observing scripts (see GBTog)
- Picking OOF, pointing, focus, and calibration sources (use online ALMA Calibration Catalog for absolute flux calibration)

Use the **ALMA Calibrator Source Catalogue** to find pointing source and for absolute calibration



Configuration Parameters for Argus

- receiver = 'RcvrArray75_115'
 - beam = 'all' (for all 16 beams with Vegas)
 - swmode = 'tp_nocal' (or 'sp_nocal')
 - sideband = 'LSB' (or 'USB')
 - pol = 'Linear'
- Argus is single linear polarization (X) for all 16 beams and has **no noise-diodes** ("nocal"). Argus allows choice of LSB vs USB. Sideband separation is 3.05 GHz. Above 110GHz use USB for slightly better performance, and use LSB at ~110 GHz and below for slightly better performance.

Edit

Run

Project:

TGBT15A_901

Scheduling Blocks:

aArgus_VEGAS_LOOP_tsy

aArgus_VEGAS_quick_LO

argus_config_example

argus_config_example_fs

argus_monitor

argus_quickfix

argus_reboot

argus_shutdown

argus_startup

argus_tip

argus_vanecal

autofocus

autooof

autopeakfocus

Balance

config_110

config_110_fsw

config_110_halfsec

config_12co

config_13co_map

config_70000

config_74000

config_75000

config_80000

config_86000

config_88900

Editor: You are currently editing argus_config_example

```

1 #
2 #Configure VEGAS mode-2 with ARGUS 16 beams
3 #HCN and HCO+
4 #dfrayer 2016.12.09
5 #
6 Configure("""
7 receiver = 'RcvrArray75_115'
8 beam     = 'all'
9 obstype  = 'Spectroscopy'
10 backend  = 'VEGAS'
11 restfreq = 89000.
12 bandwidth = 1500
13 swmode   = 'tp_nocal'
14 swtype   = 'none'
15 swper    = 2.0
16 swfreq   = 0.0, 0.0
17 tint     = 2.0
18 vlow     = 0
19 vhigh    = 0
20 vframe   = 'lsrk'
21 vdef     = 'Radio'
22 pol      = 'Linear'
23 nchan    = 'high'
24 sideband = 'LSB'
25 vegas.subband=1
26 """)
27 #
28 Balance()
29 # Check the YIG status after configuration
30 yigvolt, sampleTime = GetSample("RcvrArray75_115", "YIGData,lo_power")
31 print "Yig voltage: ", yigvolt, ", Sample time:", sampleTime

```

Enter target frequencies

tp_nocal (no noise diodes)

swper >=0.4 for fsw

tint <~1sec for mapping

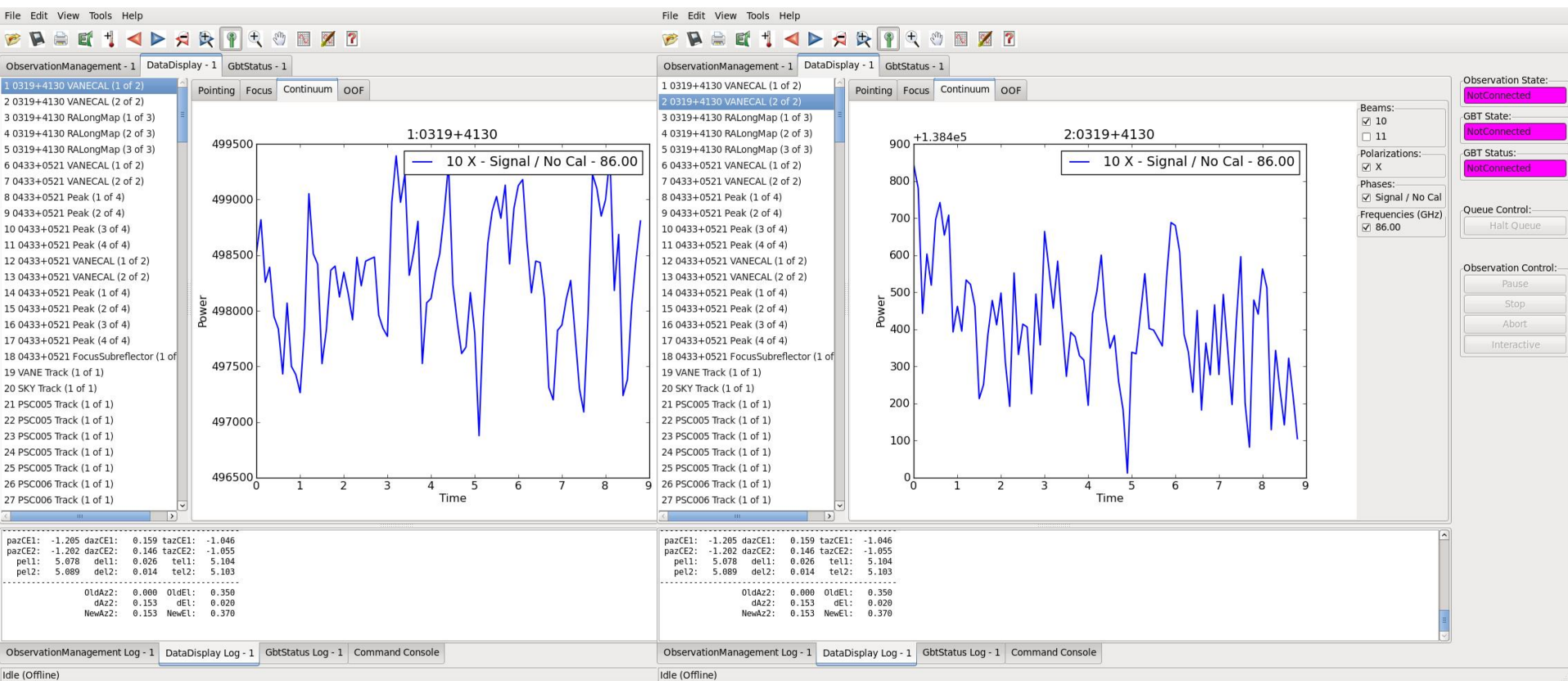
pick sideband

Check YIG-LO_power after configuration

Observing: Antenna Optimization

- Should point+focus (AutoPeakFocus) every 30min-50min depending on conditions (point+focus takes ~5min)
- AutoOOF (which takes ~20min) is used to correct the surface for thermal effects at night.
- Daytime surface changes <1hr time scales and the AutoOOF solutions can cause more harm than good during rapidly changing conditions from the AutoOOF (so it is typically not useful to use the “thermal” corrections during the day).

Example Argus AutoOOF data: (scans 1+2) Vanecal-scans with the DCR



Vanecal scans with the DCR – first scan is with VANE (4.985e5 counts) and second scan is on SKY (1.354e5+500 counts).
 $T_{\text{syst}} \sim T_{\text{warm}} (\text{SKY} / (\text{VANE} - \text{SKY})) = 104 \text{ K}$ for $T_{\text{warm}} \sim 270$.
Should have VANE/SKY > ~3 in good conditions.

(scan 3) Argus OOF map-1 data

File Edit View Tools Help

ObservationManagement - 1 DataDisplay - 1 GbtStatus - 1

1 0319+4130 VANECA (1 of 2)
2 0319+4130 VANECA (2 of 2)
3 0319+4130 RALongMap (1 of 3)
4 0319+4130 RALongMap (2 of 3)
5 0319+4130 RALongMap (3 of 3)
6 0433+0521 VANECA (1 of 2)
7 0433+0521 VANECA (2 of 2)
8 0433+0521 Peak (1 of 4)
9 0433+0521 Peak (2 of 4)
10 0433+0521 Peak (3 of 4)
11 0433+0521 Peak (4 of 4)
12 0433+0521 VANECA (1 of 2)
13 0433+0521 VANECA (2 of 2)
14 0433+0521 Peak (1 of 4)
15 0433+0521 Peak (2 of 4)
16 0433+0521 Peak (3 of 4)
17 0433+0521 Peak (4 of 4)
18 0433+0521 FocusSubreflector (1 of 1)
19 VANE Track (1 of 1)
20 SKY Track (1 of 1)
21 PSC005 Track (1 of 1)
22 PSC005 Track (1 of 1)
23 PSC005 Track (1 of 1)
24 PSC005 Track (1 of 1)
25 PSC005 Track (1 of 1)
26 PSC006 Track (1 of 1)
27 PSC006 Track (1 of 1)

Pointing Focus Continuum OOF

3:0319+4130

10 X - Signal / No Cal - 86.00

Beams:
 10
 11

Polarizations:
 X

Phases:
 Signal / No Cal

Frequencies (GHz)
 86.00

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

pazCE1:	-1.203	dazCE1:	0.159	tazCE1:	-1.040
pazCE2:	-1.202	dazCE2:	0.146	tazCE2:	-1.055
pel1:	5.078	del1:	0.026	tel1:	5.104
pel2:	5.089	del2:	0.014	tel2:	5.103

OldAz2:	0.000	OldEL:	0.350		
dAz2:	0.153	dEL:	0.020		
NewAz2:	0.153	NewEL:	0.370		

OOFMAP 1.0

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

Idle (Offline)

First map at default focus and should see source at good S/N. Here, the source is offset from the center of the time stream/map which implies a significant +el LPC.

(scan 4) Argus OOF map-2 data

File Edit View Tools Help

ObservationManagement - 1 DataDisplay - 1 GbtStatus - 1

1 0319+4130 VANECA1 (1 of 2)
2 0319+4130 VANECA1 (2 of 2)
3 0319+4130 RALongMap (1 of 3)
4 0319+4130 RALongMap (2 of 3)
5 0319+4130 RALongMap (3 of 3)
6 0433+0521 VANECA1 (1 of 2)
7 0433+0521 VANECA1 (2 of 2)
8 0433+0521 Peak (1 of 4)
9 0433+0521 Peak (2 of 4)
10 0433+0521 Peak (3 of 4)
11 0433+0521 Peak (4 of 4)
12 0433+0521 VANECA1 (1 of 2)
13 0433+0521 VANECA1 (2 of 2)
14 0433+0521 Peak (1 of 4)
15 0433+0521 Peak (2 of 4)
16 0433+0521 Peak (3 of 4)
17 0433+0521 Peak (4 of 4)
18 0433+0521 FocusSubreflector (1 of 1)
19 VANE Track (1 of 1)
20 SKY Track (1 of 1)
21 PSC005 Track (1 of 1)
22 PSC005 Track (1 of 1)
23 PSC005 Track (1 of 1)
24 PSC005 Track (1 of 1)
25 PSC005 Track (1 of 1)
26 PSC006 Track (1 of 1)
27 PSC006 Track (1 of 1)

Pointing Focus Continuum OOF

4:0319+4130

10 X - Signal / No Cal - 86.00

Beams:
 10
 11

Polarizations:
 X

Phases:
 Signal / No Cal

Frequencies (GHz)
 86.00

Observation State:
NotConnected

GBT State:
NotConnected

GBT Status:
NotConnected

Queue Control:
Halt Queue

Observation Control:
Pause
Stop
Abort
Interactive

paZCEL2: -1.202	daZCEL2: 0.140	taZCEL2: -1.055
pe11: 5.078	de11: 0.026	te11: 5.104
pe12: 5.089	de12: 0.014	te12: 5.103

OldAz2: 0.000	OldEl: 0.350	
dAz2: 0.153	dEl: 0.020	
NewAz2: 0.153	NewEl: 0.370	

OOFMAP 1.0
OOFMAP 2.0

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

Idle (Offline)

Counts lower since map made out of focus (+12mm)

(scan 5) Argus OOF map-2 data

File Edit View Tools Help

ObservationManagement - 1 DataDisplay - 1 GbtStatus - 1

1 0319+4130 VANECA1 (1 of 2)
2 0319+4130 VANECA1 (2 of 2)
3 0319+4130 RALongMap (1 of 3)
4 0319+4130 RALongMap (2 of 3)
5 0319+4130 RALongMap (3 of 3)
6 0433+0521 VANECA1 (1 of 2)
7 0433+0521 VANECA1 (2 of 2)
8 0433+0521 Peak (1 of 4)
9 0433+0521 Peak (2 of 4)
10 0433+0521 Peak (3 of 4)
11 0433+0521 Peak (4 of 4)
12 0433+0521 VANECA1 (1 of 2)
13 0433+0521 VANECA1 (2 of 2)
14 0433+0521 Peak (1 of 4)
15 0433+0521 Peak (2 of 4)
16 0433+0521 Peak (3 of 4)
17 0433+0521 Peak (4 of 4)
18 0433+0521 FocusSubreflector (1 of 1)
19 VANE Track (1 of 1)
20 SKY Track (1 of 1)
21 PSC005 Track (1 of 1)
22 PSC005 Track (1 of 1)
23 PSC005 Track (1 of 1)
24 PSC005 Track (1 of 1)
25 PSC005 Track (1 of 1)
26 PSC006 Track (1 of 1)
27 PSC006 Track (1 of 1)

Pointing Focus Continuum OOF

5:0319+4130

10 X - Signal / No Cal - 86.00

Beams:
 10
 11

Polarizations:
 X

Phases:
 Signal / No Cal

Frequencies (GHz)
 86.00

Observation State: NotConnected
GBT State: NotConnected
GBT Status: NotConnected

Queue Control: Halt Queue

Observation Control: Pause Stop Abort Interactive

OldAz2: 0.000 OldEL: 0.350
dAz2: 0.153 dEL: 0.020
NewAz2: 0.153 NewEL: 0.370

OOFMAP 1.0
OOFMAP 2.0
Started search for data products for AGBT17B_044_02 scan 3
Searching for files in /home/gbtdata/AGBT17B_044_02/OOF/s3-1-db-000.

3rd OOF map with focus at -12mm (peaks higher than +12mm map so focus LFC will be negative)

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

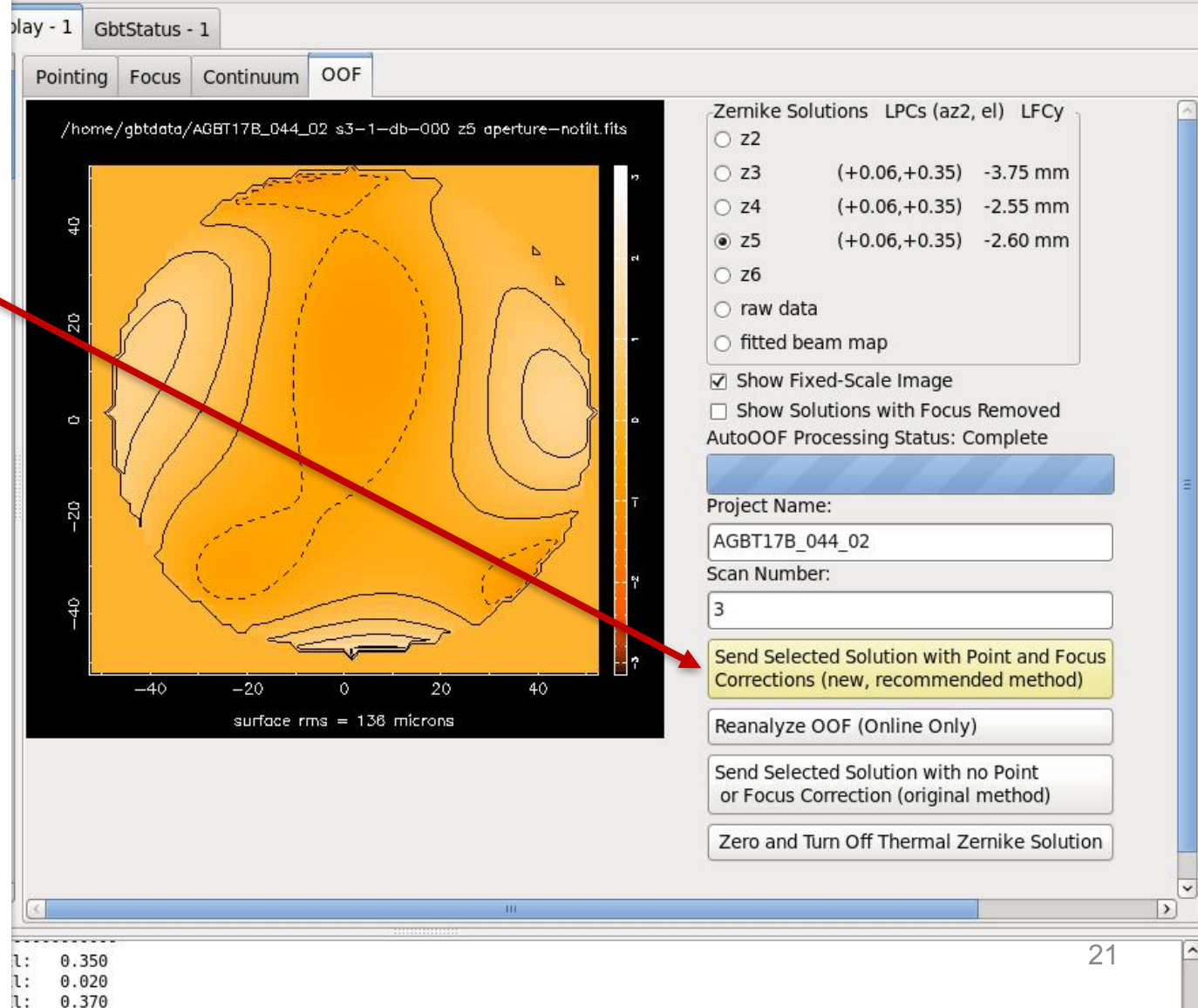
Idle (Offline)

AutoOOF Solutions

Click yellow button after OOF processing to send corrections to GBT and turn on the thermal zernike's.

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

Be weary of "rms" >300 microns (which happens in windy conditions)



The screenshot displays the AutoOOF software interface. The main window shows a contour plot of surface residuals with a color scale from -3 to 3 microns. The plot is titled `/home/gbtdata/AGBT17B_044_02 s3-1-db-000 z5 aperture-nofilt.fits`. Below the plot, it indicates `surface rms = 136 microns`. The interface includes tabs for `Pointing`, `Focus`, `Continuum`, and `OOF`. On the right, the `Zernike Solutions` panel lists several options:

Zernike Solution	LPCs (az2, el)	LFCy
<input type="radio"/> z2		
<input type="radio"/> z3	(+0.06,+0.35)	-3.75 mm
<input type="radio"/> z4	(+0.06,+0.35)	-2.55 mm
<input checked="" type="radio"/> z5	(+0.06,+0.35)	-2.60 mm
<input type="radio"/> z6		
<input type="radio"/> raw data		
<input type="radio"/> fitted beam map		

Additional options include Show Fixed-Scale Image, Show Solutions with Focus Removed, and AutoOOF Processing Status: Complete. The Project Name is `AGBT17B_044_02` and the Scan Number is `3`. A yellow button labeled `Send Selected Solution with Point and Focus Corrections (new, recommended method)` is highlighted with a red arrow. Other buttons include `Reanalyze OOF (Online Only)`, `Send Selected Solution with no Point or Focus Correction (original method)`, and `Zero and Turn Off Thermal Zernike Solution`.

At the bottom left, the following parameters are listed:

```
l: 0.350  
l: 0.020  
l: 0.370
```

AutoOOF "Raw data"

File Edit View Tools Help

ObservationManagement - 1 | DataDisplay - 1 | GbtStatus - 1

1 0319+4130 VANECA (1 of 2)
 2 0319+4130 VANECA (2 of 2)
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 23 PSC005 Track (1 of 1)
 24 PSC005 Track (1 of 1)
 25 PSC005 Track (1 of 1)
 26 PSC006 Track (1 of 1)
 27 PSC006 Track (1 of 1)

Pointing | Focus | Continuum | **OOF**

Zernike Solutions LPCs (az2, el) LFCy
 z2
 z3 (+0.06,+0.35) -3.75 mm
 z4 (+0.06,+0.35) -2.55 mm
 z5 (+0.06,+0.35) -2.60 mm
 z6
 raw data
 fitted beam map

Show Fixed-Scale Image
 Show Solutions with Focus Removed
 AutoOOF Processing Status: Complete

Project Name: AGBT17B_044_02
 Scan Number: 3

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

```
OldAz2: 0.000 OldEl: 0.350
dAz2: 0.153 dEl: 0.020
NewAz2: 0.153 NewEl: 0.370

OOFMAP 1.0
OOFMAP 2.0
Started search for data products for AGBT17B_044_02 scan 3
Searching for files in /home/gbtdata/AGBT17B_044_02/OOF/s3-1-db-000.
```

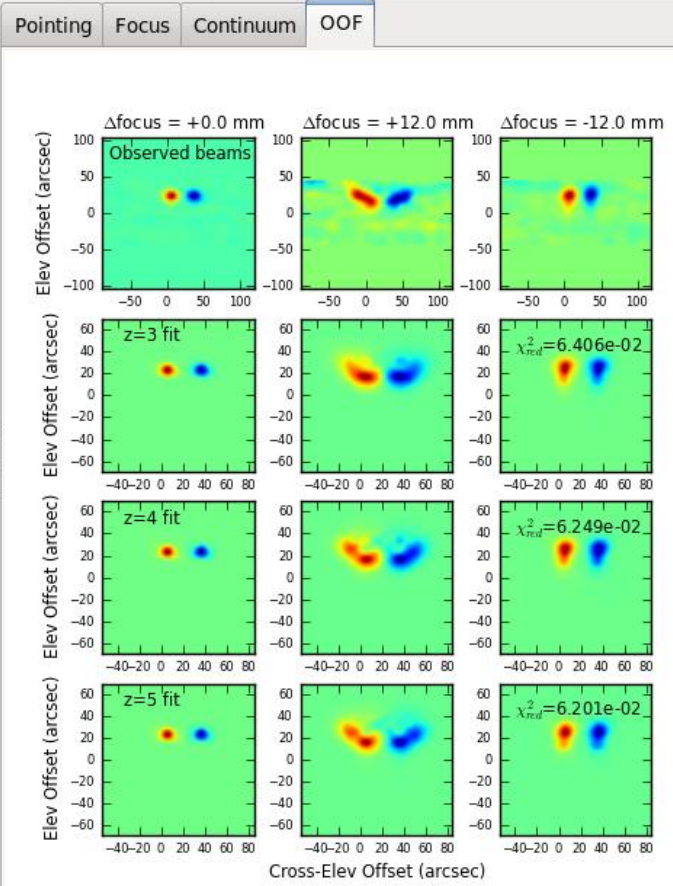
AutoOOF Beam Fits

File Edit View Tools Help



ObservationManagement - 1 DataDisplay - 1 GbtStatus - 1

- 1 0319+4130 VANECA (1 of 2)
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- 3 0319+4130 RALongMap (1 of 3)
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- 5 0319+4130 RALongMap (3 of 3)
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- 15 0433+0521 Peak (2 of 4)
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- 22 PSC005 Track (1 of 1)
- 23 PSC005 Track (1 of 1)
- 24 PSC005 Track (1 of 1)
- 25 PSC005 Track (1 of 1)
- 26 PSC006 Track (1 of 1)
- 27 PSC006 Track (1 of 1)



- Zernike Solutions LPCs (az2, el) LFCy
- z2
 - z3 (+0.06,+0.35) -3.75 mm
 - z4 (+0.06,+0.35) -2.55 mm
 - z5 (+0.06,+0.35) -2.60 mm
 - z6
 - raw data
 - fitted beam map

Show Fixed-Scale Image
 Show Solutions with Focus Removed
 AutoOOF Processing Status: Complete

Project Name:

 Scan Number:

- 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:

GBT State:

GBT Status:

Queue Control:

Observation Control:

```

01dAz2: 0.000 01dEL: 0.350
dAz2: 0.153 dEL: 0.020
NewAz2: 0.153 NewEL: 0.370
  
```

```

OOFMAP 1.0
OOFMAP 2.0
Started search for data products for AGBT17B_044_02 scan 3
Searching for files in /home/gbtdata/AGBT17B_044_02/OOF/s3-1-db-000.
  
```


Example of a Bad OOF

In this case observations were done in the keyhole at $>85\text{deg}$ and OOF “rms” $438\mu\text{m}$ with a large implied focus and EL pointing offset.

Solution with large rms $>400\mu\text{m}$ should not be used.

Check the raw data and fitted beam maps.

The screenshot displays a software interface for observing a target. The main window is titled "GbtStatus - 1" and has tabs for "Pointing", "Focus", "Continuum", and "OOF". The "OOF" tab is active, showing a beam map of a circular target with a color scale from 0 to 40. The map is labeled "surface rms = 438 microns". To the right of the map is a list of Zernike Solutions (LPCs) with their corresponding LFCy values:

Zernike Solution	LPCs (az2, el)	LFCy
<input type="radio"/> z2		
<input type="radio"/> z3	(+0.25, +0.81)	-6.56 mm
<input type="radio"/> z4	(+0.25, +0.82)	-11.54 mm
<input checked="" type="radio"/> z5	(+0.24, +0.83)	-13.19 mm
<input type="radio"/> z6		
<input type="radio"/> raw data		
<input type="radio"/> fitted beam map		

Below the list, there are checkboxes for "Show Fixed-Scale Image" (checked) and "Show Solutions with Focus Removed" (unchecked). The "AutoOOF Processing Status" is "Complete". A blue progress bar is visible. Below the progress bar, there are input fields for "Project Name" (AGBT17B_044_01) and "Scan Number" (3). There are several 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)", and "Zero and Turn Off Thermal Zernike Solution".

On the right side of the interface, there are status indicators for "Observation State: NotConnected", "GBT State: NotConnected", and "GBT Status: NotConnected". There is also a "Queue Control" section with a "Halt Queue" button and an "Observation Control" section with "Pause", "Stop", "Abort", and "Interactive" buttons.

At the bottom of the window, there is a command console with the following text:

```
7B_044_02 scan 3  
7B_044_02/OOF/s3-1-db-000.  
plugin.  
7B_044_03 scan 3  
7B_044_03/OOF/s3-1-db-000.  
7B_044_01 scan 3  
7B_044_01/OOF/s3-1-db-000.
```

Beam Maps of Example Bad OOF

File Edit View Tools Help

The “observed” beams should not be streaks or very elongated. This can happen in windy conditions.

In this case data were taken in the keyhole causing the apparent focus correction to be very large and a large EL LPC.

Do not apply OOF corrections if you cannot trust the results.

The screenshot displays the GbtStatus software interface. At the top, there are tabs for 'Pointing', 'Focus', 'Continuum', and 'OOF'. The 'OOF' tab is active, showing a grid of beam maps. The first row shows 'Observed beams' for three different focus offsets: $\Delta\text{focus} = +0.0$ mm, $+12.0$ mm, and -12.0 mm. The subsequent rows show 'z=3 fit', 'z=4 fit', and 'z=5 fit' for the same focus offsets. Each map plots 'Elev Offset (arcsec)' on the y-axis and 'Cross-Elev Offset (arcsec)' on the x-axis. To the right of the maps, there are 'Zernike Solutions' and 'LPCs (az2, el) LFCy' listed for various Zernike modes (z2, z3, z4, z5, z6) and a 'raw data' option. Below this, there are checkboxes for 'Show Fixed-Scale Image' and 'Show Solutions with Focus Removed', and a status bar indicating 'AutoOOF Processing Status: Complete'. On the far right, there are control panels for 'Observation State' (NotConnected), 'GBT State' (NotConnected), 'GBT Status' (NotConnected), 'Queue Control' (Halt Queue), and 'Observation Control' (Pause, Stop, Abort, Interactive). At the bottom, there is a 'Project Name' field (AGBT17B_044_01), a 'Scan Number' field (3), and several buttons for sending solutions and reanalyzing OOF. A command console at the bottom shows log entries for scans 02, 03, and 01.

1 GbtStatus - 1

Pointing Focus Continuum OOF

Zernike Solutions LPCs (az2, el) LFCy

- z2
- z3 (+0.25,+0.81) -6.56 mm
- z4 (+0.25,+0.82) -11.54 mm
- z5 (+0.24,+0.83) -13.19 mm
- z6
- raw data
- fitted beam map

Show Fixed-Scale Image
 Show Solutions with Focus Removed
AutoOOF Processing Status: Complete

Project Name:
AGBT17B_044_01

Scan Number:
3

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

plugin.
7B_044_02 scan 3
7B_044_02/OOF/s3-1-db-000.
7B_044_03 scan 3
7B_044_03/OOF/s3-1-db-000.
7B_044_01 scan 3
7B_044_01/OOF/s3-1-db-000.

lay Log - 1 GbtStatus Log - 1 Command Console

Brightest OOF Sources 2016/2017

Source	Snu (91.5 GHz) [Jy]
0319+4130	24.3
0854+2006	6.7
1058+0133	6.6
1229+0203	9.9
1256-0547	10.6
2253+1608	15.7

Pointing & Focus

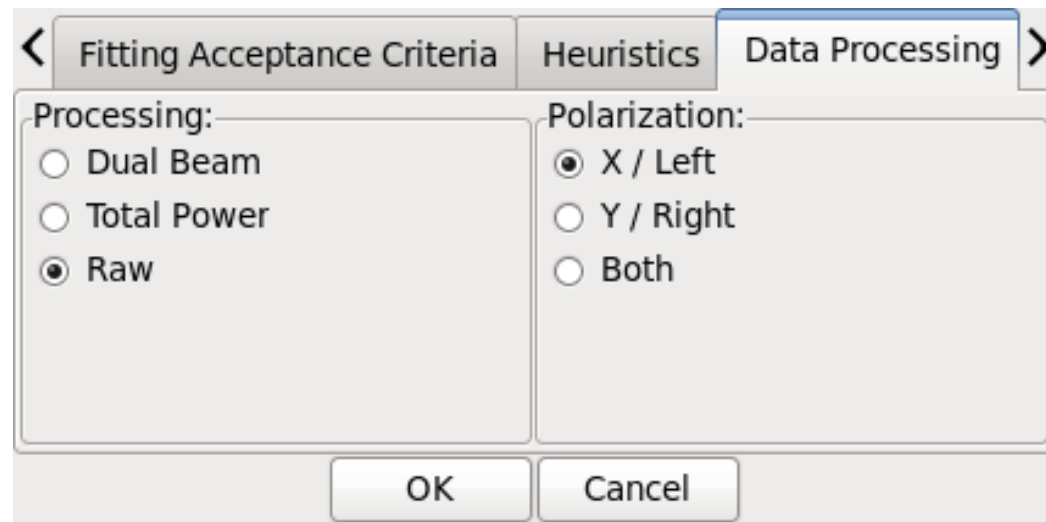
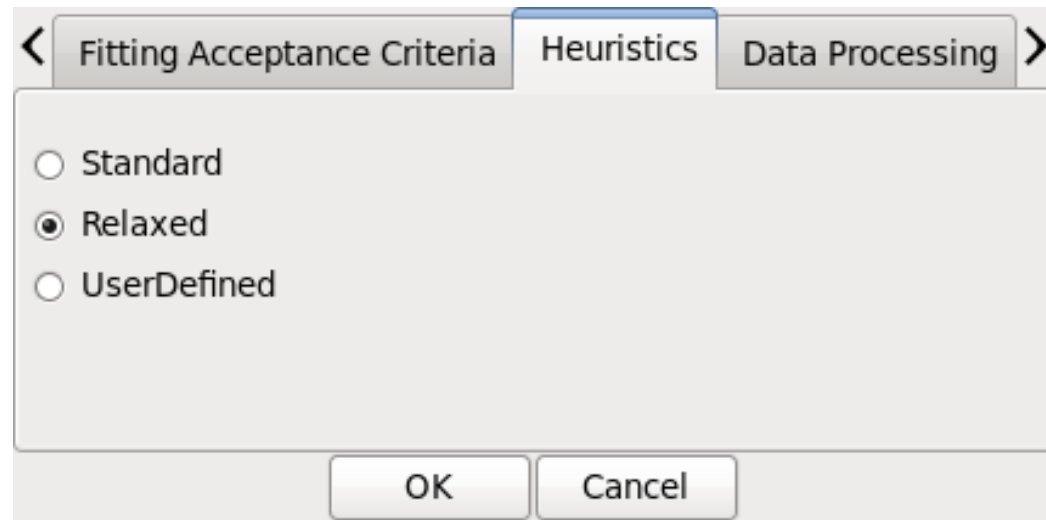
- Peak and focus on sources within 30deg and brighter than 1 Jy. Brighter sources are better than closer sources since the GBT pointing model is very good.
- The point/focus frequency should be the approximate frequency of your science frequency with VEGAS.
- For best results, **autopeak_focus should be run every 30-50 minutes** depending on varying conditions.
- Astrid/GFM requires processing data in "Raw mode" and using relaxed Heuristics
- It is very important to get good pointing (and focus) solutions if you want to observe your target position. **You should monitor every set of pointing+focus scans in real-time**, and not assume that the automatic astrid-defaults will produce the good solutions.

Astrid/GFM

For Argus:

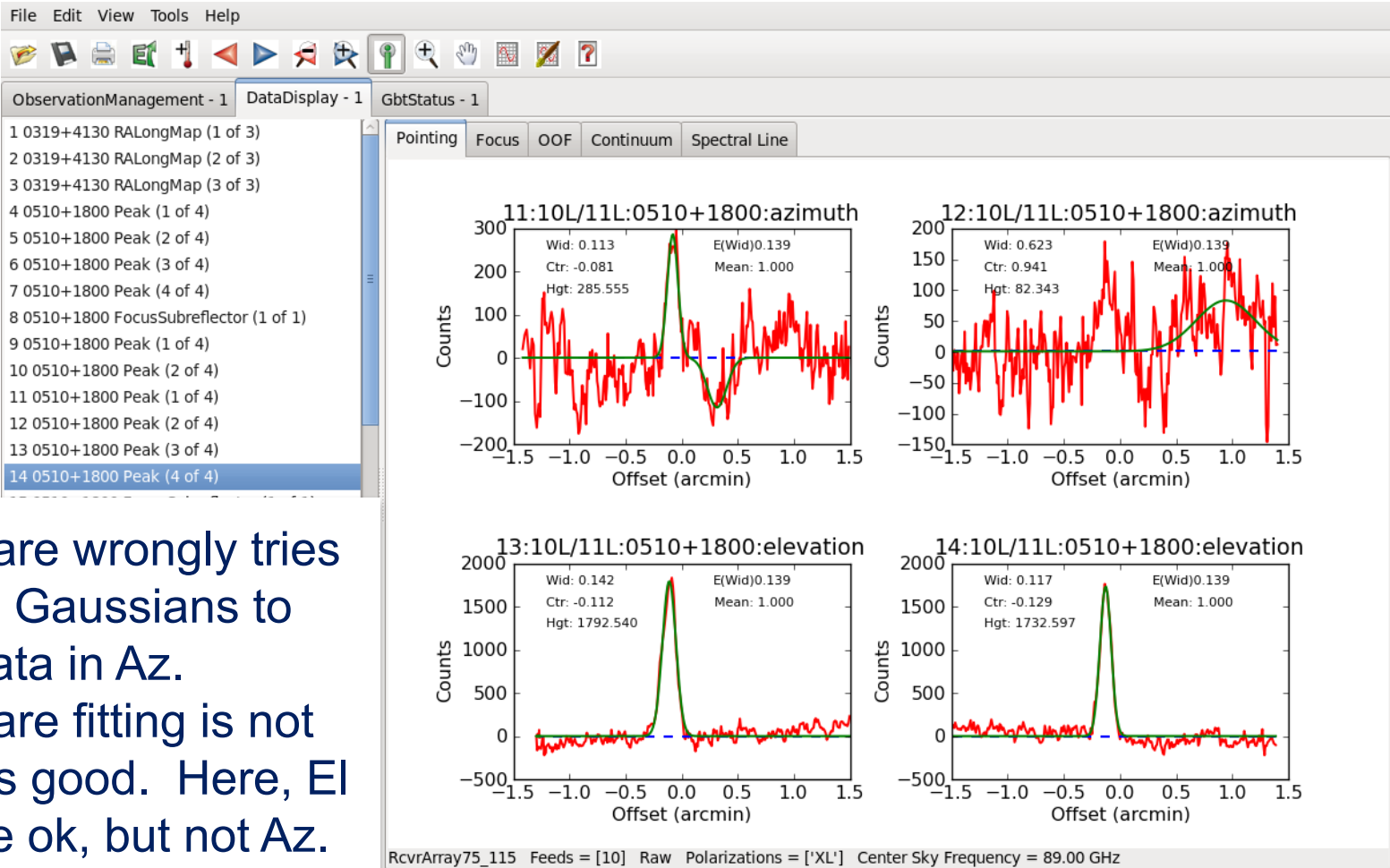
- Select Heuristics = “Relaxed”
- Select Data Processing = “Raw”

If Raw not selected, you will get an error as shown (avoid this by using the “.sparrow” file.



```
TrackBeam = 10 , SkyBeam = 11
Reducing data with 'Standard' Heuristics, DualBeam Mode, Polarizations = XL
Acceptance Criteria: Automatically accept good fits, automatically reject bad fits
*** Error: Cannot retrieve calibration information. Try reprocessing this scan in Raw mode.
Encountered the following exception while analyzing Peak: unsupported operand type(s) for *: 'NoneType' and 'float'
*** Error: Cannot retrieve calibration information. Try reprocessing this scan in Raw mode.
Error processing scan 20 : <type 'exceptions.TypeError'> , unsupported operand type(s) for *: 'NoneType' and 'float'
```


Example Pointing: El offset by 7-8" so source weak in Az scans



Observation State:
 NotConnected

GBT State:
 NotConnected

GBT Status:
 NotConnected

Queue Control:
 Halt Queue

Observation Control:
 Pause
 Stop
 Abort
 Interactive

Software wrongly tries to fit 2 Gaussians to raw data in Az. Software fitting is not always good. Here, El fits are ok, but not Az.

```

Proj: AGB116B_119_02, Scan: 14, Sub: 4, EWidth: 0.139, Width: 0.117, Center: -0.129, Height: 1732.597, lsys: 1.000

Scans: 11 - 14 0510+1800 (Az,El) = (200.002,68.565)

-----
pazCE1: -1.305 dazCE1: -0.081 tazCE1: -1.386
pazCE2: -1.306 dazCE2: 0.941 tazCE2: -0.365 *** heuristics failed ***
pel1: 2.999 del1: -0.112 tel1: 2.887
pel2: 3.020 del2: -0.129 tel2: 2.891

-----
OldAz2: 0.010 OldEl: 0.050
dAz2: 0.430 dEl: -0.120
NewAz2: 0.440 NewEl: -0.070 *** Az heuristics failed
    
```

After applying EI corrections (previous point), this point was successful in both Az and El

File Edit View Tools Help

ObservationManagement - 1 DataDisplay - 1 GbtStatus - 1

1 0319+4130 RALongMap (1 of 3)
 2 0319+4130 RALongMap (2 of 3)
 3 0319+4130 RALongMap (3 of 3)
 4 0510+1800 Peak (1 of 4)
 5 0510+1800 Peak (2 of 4)
 6 0510+1800 Peak (3 of 4)
 7 0510+1800 Peak (4 of 4)
 8 0510+1800 FocusSubreflector (1 of 1)
 9 0510+1800 Peak (1 of 4)
 10 0510+1800 Peak (2 of 4)
 11 0510+1800 Peak (1 of 4)
 12 0510+1800 Peak (2 of 4)
 13 0510+1800 Peak (3 of 4)
 14 0510+1800 Peak (4 of 4)
 15 0510+1800 FocusSubreflector (1 of 1)
 16 0510+1800 Peak (1 of 4)
 17 0510+1800 Peak (2 of 4)
 18 0510+1800 Peak (3 of 4)
 19 0510+1800 Peak (4 of 4)
 20 0510+1800 FocusSubreflector (1 of 1)
 21 0510+1800 Track (1 of 1)
 22 0510+1800 Track (1 of 1)
 23 0510+1800 Track (1 of 1)
 24 0510+1800 Track (1 of 1)
 25 CORE01 Track (1 of 1)
 26 CORE01 Track (1 of 1)
 27 CORE01 Track (1 of 1)
 28 CORE01 Track (1 of 1)

Pointing Focus OOF Continuum Spectral Line

16:10L/11L:0510+1800:azimuth
 Counts
 Wid: 0.153 E(Wid)0.139
 Ctr: -0.032 Mean: 1.000
 Hgt: 10166.736
 Offset (arcmin)

17:10L/11L:0510+1800:azimuth
 Counts
 Wid: 0.154 E(Wid)0.139
 Ctr: -0.050 Mean: 1.000
 Hgt: 9125.832
 Offset (arcmin)

18:10L/11L:0510+1800:elevation
 Counts
 Wid: 0.108 E(Wid)0.139
 Ctr: 0.004 Mean: 1.000
 Hgt: 9129.649
 Offset (arcmin)

19:10L/11L:0510+1800:elevation
 Counts
 Wid: 0.121 E(Wid)0.139
 Ctr: 0.009 Mean: 1.000
 Hgt: 10694.789
 Offset (arcmin)

RcvrArray75_115 Feeds = [10] Raw Polarizations = ['XL'] Center Sky Frequency = 89.00 GHz

Proj: AGBT16B_119_02, Scan: 19, Sub: 4, EWidth: 0.139, Width: 0.121, Center: 0.009, Height: 10694.789, Tsys: 1.000

Scans: 16 - 19 0510+1800 (Az,El) = (202.486,68.279)

pazCE1: -1.307	dazCE1: -0.032	tazCE1: -1.339
pazCE2: -1.303	dazCE2: -0.050	tazCE2: -1.353
pel1: 2.918	del1: 0.004	tel1: 2.922
pel2: 2.937	del2: 0.009	tel2: 2.946

OldAz2: 0.010	OldEl: -0.070
dAz2: -0.041	dEl: 0.007
NewAz2: -0.031	NewEl: -0.064

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

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

Idle (Offline)

You should get good pointing solutions before doing the focus. There is a break between the pointing scans and focus for this purpose (within autopeak_focus).

30

Sending Pointing (and focus) corrections to the telescope

5.1.3.4 Send Corrections

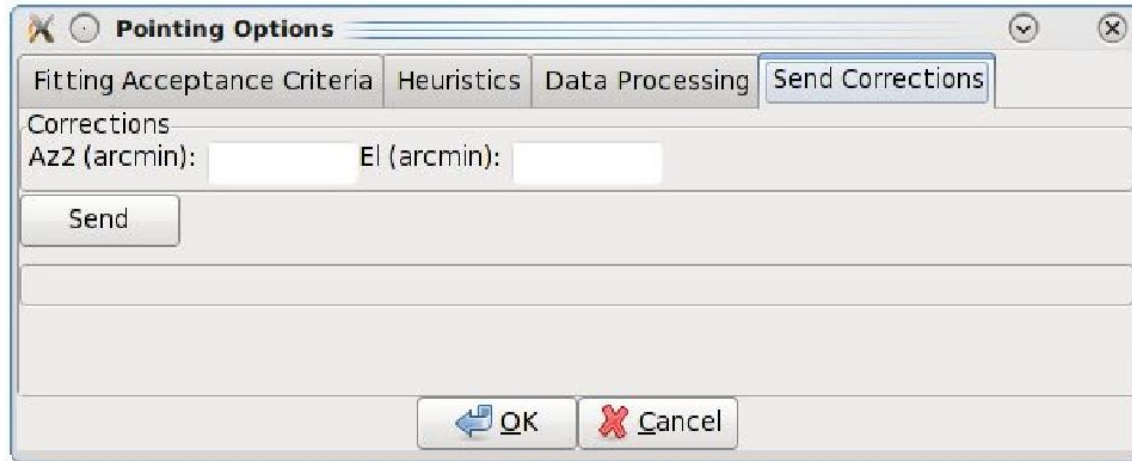


Figure 5.6: The pop-up menu to manually send pointing corrections to the telescope.

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 scan after good pointing corrections applied (LFC typically within +/- 4 mm for Argus)

File Edit View Tools Help

ObservationManagement - 1 DataDisplay - 1 GbtStatus - 1

1 0319+4130 RALongMap (1 of 3)
2 0319+4130 RALongMap (2 of 3)
3 0319+4130 RALongMap (3 of 3)
4 0510+1800 Peak (1 of 4)
5 0510+1800 Peak (2 of 4)
6 0510+1800 Peak (3 of 4)
7 0510+1800 Peak (4 of 4)
8 0510+1800 FocusSubreflector (1 of 1)
9 0510+1800 Peak (1 of 4)
10 0510+1800 Peak (2 of 4)
11 0510+1800 Peak (1 of 4)
12 0510+1800 Peak (2 of 4)
13 0510+1800 Peak (3 of 4)
14 0510+1800 Peak (4 of 4)
15 0510+1800 FocusSubreflector (1 of 1)
16 0510+1800 Peak (1 of 4)
17 0510+1800 Peak (2 of 4)
18 0510+1800 Peak (3 of 4)
19 0510+1800 Peak (4 of 4)
20 0510+1800 FocusSubreflector (1 of 1)
21 0510+1800 Track (1 of 1)
22 0510+1800 Track (1 of 1)
23 0510+1800 Track (1 of 1)
24 0510+1800 Track (1 of 1)
25 CORE01 Track (1 of 1)
26 CORE01 Track (1 of 1)
27 CORE01 Track (1 of 1)
28 CORE01 Track (1 of 1)

Pointing Focus OOF Continuum Spectral Line

20:10L/11L:0510+1800:focus

Counts

Offset (mm)

Wid: 14.131
Ctr: -13.570
Hgt: 10848.010
E(Wid)12.126
Mean: 1.000

RcvrArray75_115 Feeds = [10] Raw Polarizations = ['XL'] Center Sky Frequency = 89.00 GHz

Acceptance Criteria: Automatically accept good fits, automatically reject bad fits
*** Error: Cannot retrieve calibration information. Try reprocessing this scan in Raw mode.
Encountered the following exception while analyzing Peak: unsupported operand type(s) for *: 'NoneType' and 'float'
*** Error: Cannot retrieve calibration information. Try reprocessing this scan in Raw mode.
Error processing scan 20 : <type 'exceptions.TypeError'>, unsupported operand type(s) for *: 'NoneType' and 'float'

TrackBeam = 10 , SkyBeam = 11
Reducing data with 'Relaxed' Heuristics, Raw Mode, Polarizations = XL
Acceptance Criteria: Automatically accept good fits, automatically reject bad fits
Proj: AGBT16B_119_02, Scan: 20, Sub: 1, EWidth: 12.126, Width: 14.131, Center: -13.570, Height: 10848.010, Tsys: 1.000
Offset = -13.570mm. Old DFC = -15.039mm. New LFC = 1.469mm.

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

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

Idle (Offline)

Another Good Pointing Example

The screenshot displays a software interface with a menu bar (File, Edit, View, Tools, Help) and a toolbar. The main window is titled 'DataDisplay - 1' and contains four plots under the 'Pointing' tab. Each plot shows 'Counts' vs 'Offset (arcmin)' for a specific observation. The plots are:

- 14:10L/11L:0433+0521:azimuth (Counts: 0 to 2000, Offset: -1.5 to 1.5). Parameters: Wid: 0.114, Ctr: 0.159, Hgt: 1530.061, E(Wid)0.139, Mean: 1.000.
- 15:10L/11L:0433+0521:azimuth (Counts: -500 to 2000, Offset: -1.5 to 1.5). Parameters: Wid: 0.124, Ctr: 0.146, Hgt: 1677.110, E(Wid)0.139, Mean: 1.000.
- 16:10L/11L:0433+0521:elevation (Counts: -500 to 1500, Offset: -1.5 to 1.5). Parameters: Wid: 0.136, Ctr: 0.026, Hgt: 1488.376, E(Wid)0.139, Mean: 1.000.
- 17:10L/11L:0433+0521:elevation (Counts: -500 to 2000, Offset: -1.5 to 1.5). Parameters: Wid: 0.165, Ctr: 0.014, Hgt: 1551.263, E(Wid)0.139, Mean: 1.000.

On the right side, there are control panels for 'Observation State' (NotConnected), 'GBT State' (NotConnected), 'GBT Status' (NotConnected), 'Queue Control' (Halt Queue), and 'Observation Control' (Pause, Stop, Abort, Interactive).

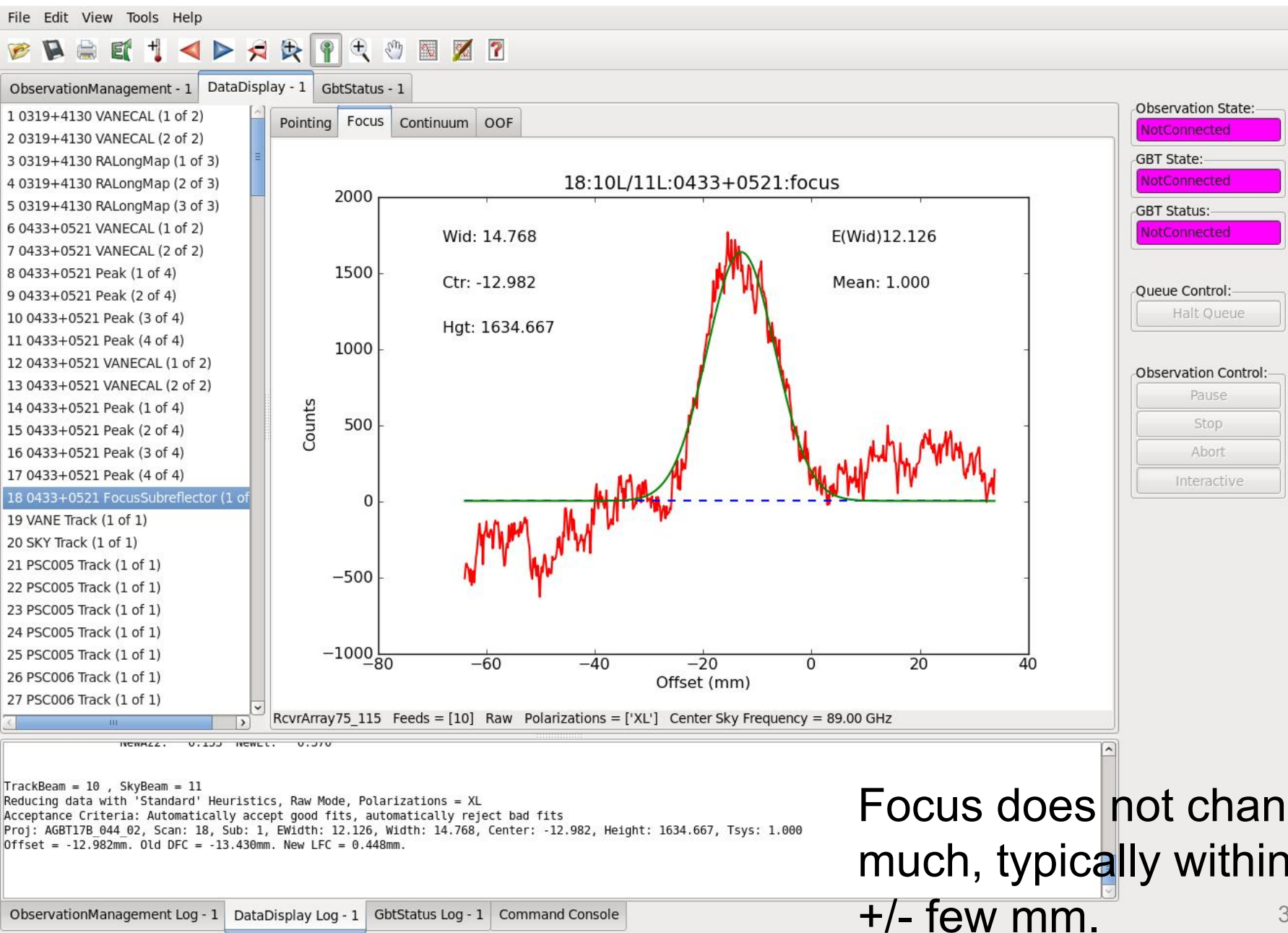
At the bottom, there are logs for 'ObservationManagement Log - 1', 'DataDisplay Log - 1', 'GbtStatus Log - 1', and 'Command Console'. The Command Console shows the following data:

pazCE1: -1.205	dazCE1: 0.159	tazCE1: -1.046
pazCE2: -1.202	dazCE2: 0.146	tazCE2: -1.055
pel1: 5.078	del1: 0.026	tel1: 5.104
pel2: 5.089	del2: 0.014	tel2: 5.103
OldAz2: 0.000	OldEL: 0.350	
dAz2: 0.153	dEL: 0.020	
NewAz2: 0.153	NewEL: 0.370	

At the bottom left, it says 'Idle (Offline)'. At the bottom right, the page number '33' is visible.

If you do not see your source try a large EL LPC, e.g., 0.2-0.4 (pointing model needs updating as of fall 2017). In this case Az LPC=0.153' and El LPC=0.370'. It is easy to miss your source with a 6-8" beam so point often to minimize the effects of pointing drifts.

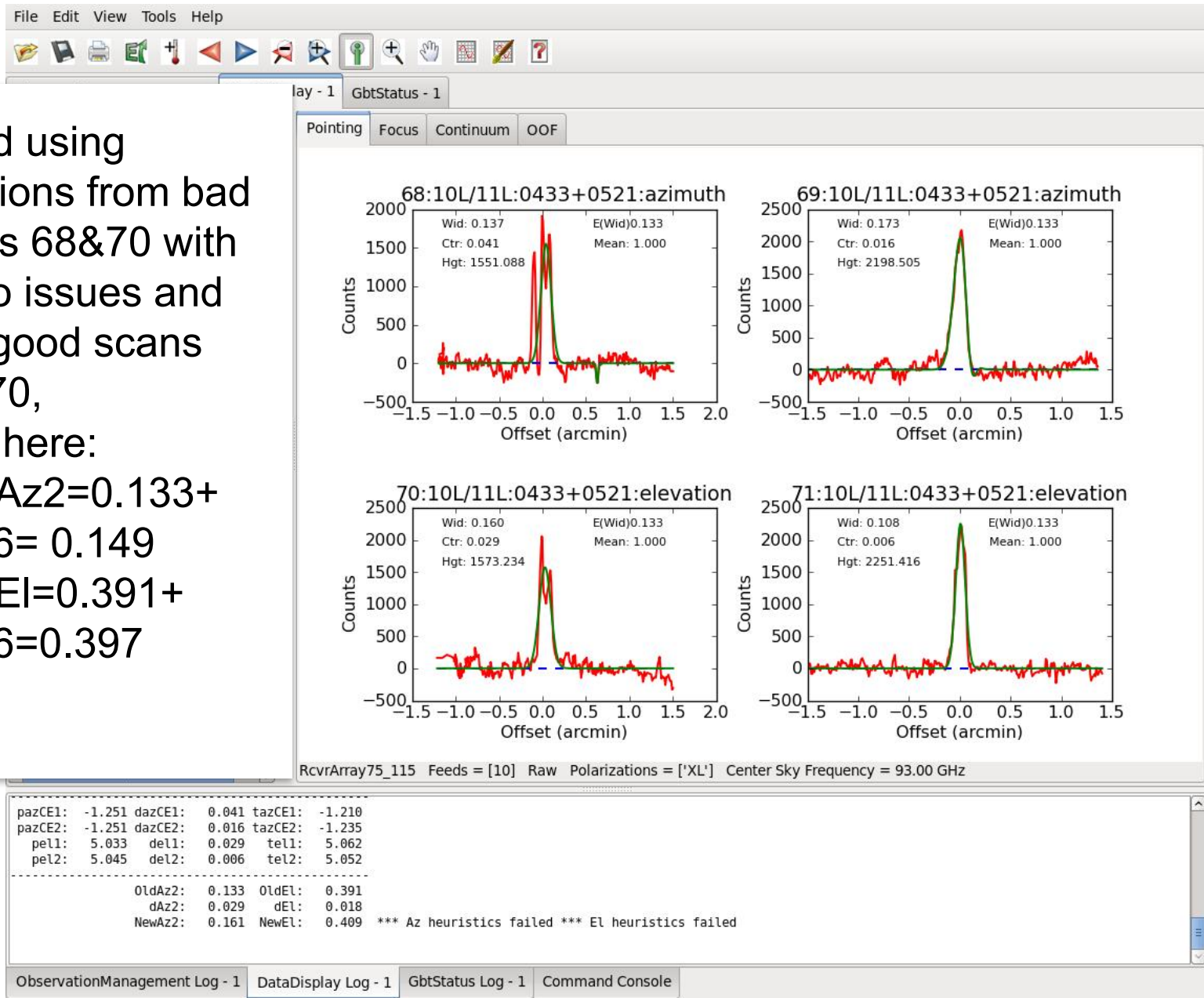
Another Good Focus Scan



Focus does not change much, typically within +/- few mm.

Pointing Scans showing Servo-System Jitters

Avoid using solutions from bad scans 68&70 with servo issues and use good scans 69&70, e.g., here:
 $NewAz2 = 0.133 + 0.016 = 0.149$
 $NewEl = 0.391 + 0.006 = 0.397$



```

pazCE1: -1.251 dazCE1: 0.041 tazCE1: -1.210
pazCE2: -1.251 dazCE2: 0.016 tazCE2: -1.235
pel1: 5.033 del1: 0.029 tel1: 5.062
pel2: 5.045 del2: 0.006 tel2: 5.052

OldAz2: 0.133 OldEl: 0.391
dAz2: 0.029 dEl: 0.018
NewAz2: 0.161 NewEl: 0.409 *** Az heuristics failed *** El heuristics failed
    
```

Example pointing scans affected by changing sky

The screenshot displays a software interface for radio astronomy data analysis. The main window is titled "DataDisplay - 1" and contains four plots showing pointing scans for different observations. Each plot shows "Counts" on the y-axis and "Offset (arcmin)" on the x-axis. The plots are:

- 161:10L/11L:0433+0521:azimuth**: Shows a peak at 0.0 arcmin. Parameters: Wid: 0.298, Ctr: -0.107, Hgt: 2329.345, E(Wid)0.139, Mean: 1.000.
- 162:10L/11L:0433+0521:azimuth**: Shows a peak at 0.0 arcmin. Parameters: Wid: 0.390, Ctr: -0.050, Hgt: 2394.938, E(Wid)0.139, Mean: 1.000.
- 163:10L/11L:0433+0521:elevation**: Shows a peak at 0.0 arcmin. Parameters: Wid: 0.146, Ctr: -0.028, Hgt: 1485.043, E(Wid)0.139, Mean: 1.000.
- 164:10L/11L:0433+0521:elevation**: Shows a peak at 0.0 arcmin. Parameters: Wid: 0.136, Ctr: 0.057, Hgt: 1214.427, E(Wid)0.139, Mean: 1.000.

The interface also includes a list of observations on the left, a control panel on the right, and a log window at the bottom. The log window shows the following data:

```
pazCE1: -1.264 dazCE1: -0.107 tazCE1: -1.371 *** heuristics failed ***
pazCE2: -1.267 dazCE2: -0.050 tazCE2: -1.317 *** heuristics failed ***
pel1: 4.343 del1: -0.028 tel1: 4.315
pel2: 4.369 del2: 0.057 tel2: 4.426

OldAz2: 0.050 OldEl: 0.258
dAz2: -0.079 dEl: 0.015
NewAz2: -0.029 NewEl: 0.272 *** Az heuristics failed *** El heuristics failed
```


Another example of variable sky during pointing scans

File Edit View Tools Help

ObservationManagement - 1 DataDisplay - 1 GbtStatus - 1

161 0433+0521 Peak (1 of 4)

162 0433+0521 Peak (2 of 4)

163 0433+0521 Peak (3 of 4)

164 0433+0521 Peak (4 of 4)

165 0433+0521 VANECA (1 of 2)

166 0433+0521 VANECA (2 of 2)

167 0433+0521 Peak (1 of 4)

168 0433+0521 Peak (2 of 4)

169 0433+0521 VANECA (1 of 2)

170 0433+0521 VANECA (2 of 2)

171 0433+0521 Peak (1 of 4)

172 0433+0521 Peak (2 of 4)

173 0433+0521 Peak (3 of 4)

174 0433+0521 Peak (4 of 4)

175 0433+0521 FocusSubreflector (1 of 1)

176 0433+0521 VANECA (1 of 2)

177 0433+0521 VANECA (2 of 2)

178 0433+0521 Peak (1 of 4)

179 0433+0521 Peak (2 of 4)

180 0433+0521 FocusSubreflector (1 of 1)

181 0433+0521 VANECA (1 of 2)

182 0433+0521 VANECA (2 of 2)

183 0433+0521 Peak (1 of 4)

184 0433+0521 Peak (2 of 4)

185 0433+0521 Peak (3 of 4)

186 0433+0521 Peak (4 of 4)

187 0433+0521 VANECA (1 of 2)

188 0433+0521 VANECA (2 of 2)

Pointing Focus Continuum OOF

183:10L/11L:0433+0521:azimuth

184:10L/11L:0433+0521:azimuth

185:10L/11L:0433+0521:elevation

186:10L/11L:0433+0521:elevation

RcvrArray75_115 Feeds = [10] Raw Polarizations = ['XL'] Center Sky Frequency = 89.00 GHz

Observation State:

NotConnected

GBT State:

NotConnected

GBT Status:

NotConnected

Queue Control:

Halt Queue

Observation Control:

Pause

Stop

Abort

Interactive

```

pazCE1: -1.275 dazCE1: -0.796 tazCE1: -2.070 *** heuristics failed ***
pazCE2: -1.270 dazCE2: -0.037 tazCE2: -1.308 *** heuristics failed ***
pel1: 4.432 del1: -0.008 tel1: 4.424
pel2: 4.447 del2: 0.044 tel2: 4.491 *** heuristics failed ***

OldAz2: 0.029 OldEl: 0.252
dAz2: -0.417 dEl: 0.018
NewAz2: -0.387 NewEl: 0.270 *** Az heuristics failed *** El heuristics failed
    
```

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

Idle (Offline)

Monitoring Argus and Logs

- Cleo status: LPC's, YFC, active surface
- Balancing: VEGAS levels -20.0, IFRack 1.5 V
- Cleo Device-Explorer: YIG LO_power ~0.1-0.6;
vane_status: obs/cal
- Sampler Log files at:
/home/gbtlogs/RcvrArray75_115*
- Argus Manager Log at:
/home/gbt/etc/log/fire/RcvrArray75_115*
- Astrid Log can be generated via: getastridlog
ProjectID

Cleo Status Window

File Launch Help

Status **Error** State **Running** LST **07:09:19** UTC **07:18:45**

Device	Status	State
Antenna	Info	Running
LO1	clear	Running
IFRack	clear	Running
ConverterRack	clear	Running
SwitchingSignalSelector	clear	Running
Measurements	clear	Running
ActiveSurface	clear	Running
QuadrantDetector	Error	Running
VEGAS	clear	Running
RcvrArray75_115	clear	Running
IFManager	clear	Running

Source: CORE06 Scan #: 65
 Project: AGBT16B_119_02 SS Master: VEGAS
 Start: 07:17:02 Length: 120.0
 Countdown: ---:-- Remaining: 00:00:18
 Observer: Youngmin Seo
 Obs. Type: LINE Switching: FSW12NOCAL
 Proc Name: Track Sequence: 1 / 1
 Rest Freq: 89188.5247 Velocity: 7
 Frame: KinematicalLSR Vel Def: Radio

Time to Set: 04:19:29 Encoder

Indicated Azimuth: 266.84786 Elevation: 53.43131
 Commanded Azimuth: 266.84780 Elevation: 53.43125
 Rate (/min): 10.9 -11.4
 Difference: -0.00006 -0.00006
 Servo Err ("): -0.3 -0.1

On Source Axis Fault/E-Stop
 Az LPC: -0.0801 EI LPC: 0.0047
 X FC: 0.0 Y FC: 0.6 Z FC: 0.0 Xt FC: 0.00 Yt FC: 0.00 Zt FC: 0.00 LFC: FOC
 Config Model: Guiding
 Model 5r - Latest Coord Mode: J2000
 Temp: -5.9
 Wind: 2 Temp: 2a V(m/s) T(C)

Dynamic Corrections
 DC Pointing DC Focus Az1: 0.00 Az2: 0.05 EI: 0.07 Focus: -13.91

Devices IF Manager Messages

ActiveSurface VEGAS

Num Disabled	Cmd RMS	Peak Resid	Cmd IQ RMS	Cmd Resid	OOF Zernike Mode	Zero Offsets	FEM Model	Zernike Coeff	Z Thermal Coeff	Random Offsets	Sim Mode	Ctrl Mode
37	33.693	34625	37.065	160	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	real	Enabled

J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14	J15	J16
-19.33	-19.73	-19.84	-20.29	-18.76	-19.63	-19.12	-19.63	-19.81	-19.97	-19.58	-19.76	-19.48	-19.95	-19.53	-19.46

Auto Scroll Off 10 Phase Table... Other Devices Retrace IF

Az, EI LPCs
Focus YFC

Active
Surface ON
with Thermal
corrections
from OOF

VEGAS
balance
values on sky:
~-20(+/-3)

Device Explorer: Monitor the LO_power into the Yig after configuration and the Vane_state obs/cal when calibrating

The screenshot shows the Device Explorer interface with the following configuration:

- Manager:** RcvrArray75_115 is selected (highlighted in green).
- Parameters:** vane_state is selected.
- Parameter Fields:** vane_state is selected, with the value 'obs' highlighted in blue.
- Samplers:** YIGData is selected.
- Sampler Fields:** lo_power is selected, with the value 0.407 highlighted in blue.

Additional details from the interface:

- Attributes for vane_state:** Type: enum, Units: none, Values: obs cal, ArrayCount: 0, Description: State of calibration vane.
- Attributes for lo_power:** Type: float, Units: Volts, Values: (empty), ArrayCount: 0, Description: LO power detector voltage.
- Status:** clear
- State:** Ready
- Buttons:** Auto Prepare, Prepare, Quit

Select RcvrArray75_115 (far left) to show Argus parameters.

Select vane_state parameter to show whether the vane is in the “obs” vs “cal” position

Select YigData under Samplers and lo_power in Sampler Fields to see Yig LO power

Yig LO_power vs Frequency

Frequency [GHz]	Yig LO_power [V]
75	0.06
80	0.15
85	0.3
90	0.4
100	0.5
105	0.6
115	0.3

Argus Trouble-Shooting

- (1) Make sure cif and lan are both on (run startup script).
- (2) Make sure vane is in desired position (e.g., obs for looking at the sky; cal for looking at the vane).
- (3) Make sure there is LO power going to the YIG after configuration.
- (4) The status of the instrument is checked before each scan and the scan will be aborted if there is not enough yig power. If low yig power, reconfigure and try again (it takes a few minutes for the yig to have sufficient power if changing frequency by a large amount [$>5\text{GHz}$]).
- (5) If Argus remains in a fault state after configuration and multiple attempts to collect data, then
 - (a) Turn manager off and back on again and reconfigure.
 - (b) If (a) does not work, then have operator restart turtle, and reconfigure.
 - (c) If still having problems, then call an Argus instrument expert.

If RcvrArray75_115 (Argus) reports an error that puts the instrument in a “Fault” state, then turn the manager “Off” then back “On” within Device Explorer (select RcvrArray75_115 at far-left first)

The screenshot shows the Device Explorer application window. The 'Managers' menu is open, with 'On' selected. The interface is divided into several panes:

- Parameters:** A list of parameters including 'asap', 'cif_power', 'debugLevel', 'input_string', 'Ina_control', 'Ina_power', 'Ina_voltages', 'nextScanNumber', 'output_string', 'projectId', 'recipientNumber', 'requestedStartTime', 'requestedStopTime', 'sampleRate', 'scanLength', 'scanlog', 'scanNumber', 'source', 'startTime', 'state', 'status', 'vane_state', and 'wif_settings'.
- Parameter Fields:** Contains the 'asap' parameter. Below it, the 'Attributes' section shows: Type: Bool, Units: none, Values: ArrayCount: 0, Description: controls whether the manager starts as soon as possible. A text box below contains the value '0'.
- Samplers:** A list of samplers including 'CheckData', 'CIFData', 'CryoData', 'LNADData', 'PowerData', 'SetsData', 'VaneData', 'WIFData', and 'YIGData'.
- Sampler Fields:** Contains the 'lo_power' sampler. Below it, the 'Attributes' section shows: Type: float, Units: Volts, Values: ArrayCount: 0, Description: LO power detector voltage. A text box below contains the value '0.005'.

At the bottom of the window, the 'RcvrArray75_115' manager is selected. The 'Status' is 'clear' and the 'State' is 'Ready'. There are buttons for 'Auto Prepare', 'Prepare', and 'Quit'.

Balancing Notes for Argus+Vegas

- After the commissioning work, all Argus channels balanced across the full frequency range of the instrument. Optical-driver 4 runs out of attenuation, but is still within range at the ends of the band (75 GHz and 115 GHz).
- Vegas should balance for all banks and all frequencies near the nominal -20 value. When the vane is covering the array, VEGAS will show values of about -15 if previously balanced on the sky (i.e., the vane is ~ 5 dB (factor of ~ 3) brighter than the sky).
- A few converter modules associated with the dedicated fibers can sometimes show low power which could impact the data and result in failed balancing. Report cases of this to your project friend. We have fixed this in the past by un-connecting and re-connecting the optical fibers.
- The target levels for the IFRack are 1.5 V.

Mapping Argus Beams to VEGAS and IF Channels

VEGAS Bank	VEGAS (J)	Argus Beam	Converter Module CM	IFrack Optical Driver OD	Dedicated Fibers
A1	1	9	1	1	-
A2	2	11	5	3	-
B1	3	10	2	2	-
B2	4	12	6	4	-
C1	5	1	3	-	1
C2	6	3	7	-	3
D1	7	2	4	-	2
D2	8	4	8	-	4
E1	9	13	9	5	-
E2	10	15	13	7	-
F1	11	14	10	6	-
F2	12	16	14	8	-
G1	13	5	11	-	5
G2	14	7	15	-	7
H1	15	6	12	-	6
H2	16	8	16	-	8

Calibration with One Load, T_A^*

With a chopper wheel/vane and a simple temperature sensor, one can calibrate to the approximate T_a^* scale without any knowledge of the sky (e.g., Kutner & Ulich 1981).

$$T_a^* = T_{cal} [ON - OFF] / [V_{amb} - V_{sky}]$$

$$T_{cal} = [T_{amb} - T_{sky}] / \eta_l * \exp(\tau_o A)$$

but with some algebra η_l and τ_o drops out to first order (where T_{amb} = temperature of vane) and

$$T_{cal} = (T_{atm} - T_{bg}) + (T_{amb} - T_{atm}) \exp(\tau_o A)$$

The values T_{atm} and τ_o are derived from GBO weather database and the above expression is used for detailed calibration, but within about 5% **$T_{cal} \approx T_{amb}$** for most observations.

Temperature Scales

- $T_a = T_{\text{sys}} (\text{ON-OFF}) / \text{OFF}$ (GBT typically uses uncorrected antenna temperature)
- $T_a' = T_a \exp(\tau_o A)$ (corrected for atmosphere)
- $T_{\text{mb}} = T_a' / \eta_{\text{mb}}$ ($\eta_{\text{mb}} \sim 1.3 \eta_a$)
- $T_a^* = T_a' / \eta_l$ (Argus uses T_a^* , $\eta_l \sim 0.99$ for the GBT)
- $T_a' / S_v = 2.84 \eta_a$ (for the GBT)

Calibration:

Flux Density vs Antenna Temp vs Main-Beam Temp

$$P_{\text{rec}} = \frac{1}{2} A_e S_v \Delta\nu = k T_a' \Delta\nu$$

$$A_e = \eta_a (\pi/4) D^2$$

$$S_v = 3520 T_a' / (\eta_a [D/m]^2)$$

➔ $T_a' / S_v = 2.84 \eta_a$ for the GBT ($\eta_a = 0.71$ at low ν)

- Know S_v (use ALMA calibration database available online) and derive η_a from measured T_a'
- Measure FWHM from good pointing scans or within your image to derived η_{mb} and T_{mb} ; **$T_{\text{mb}} = T_a' / \eta_{\text{mb}}$**
- **$\eta_{\text{mb}} = 0.8899 \eta_a (\theta_{\text{FWHM}} 100\text{m} / \lambda)^2$** (assumes Gaussian beam, where beam FWHM is in radians)

Example Calibration

86 GHz:

Aperture efficiency: 36% (230um effective rms)

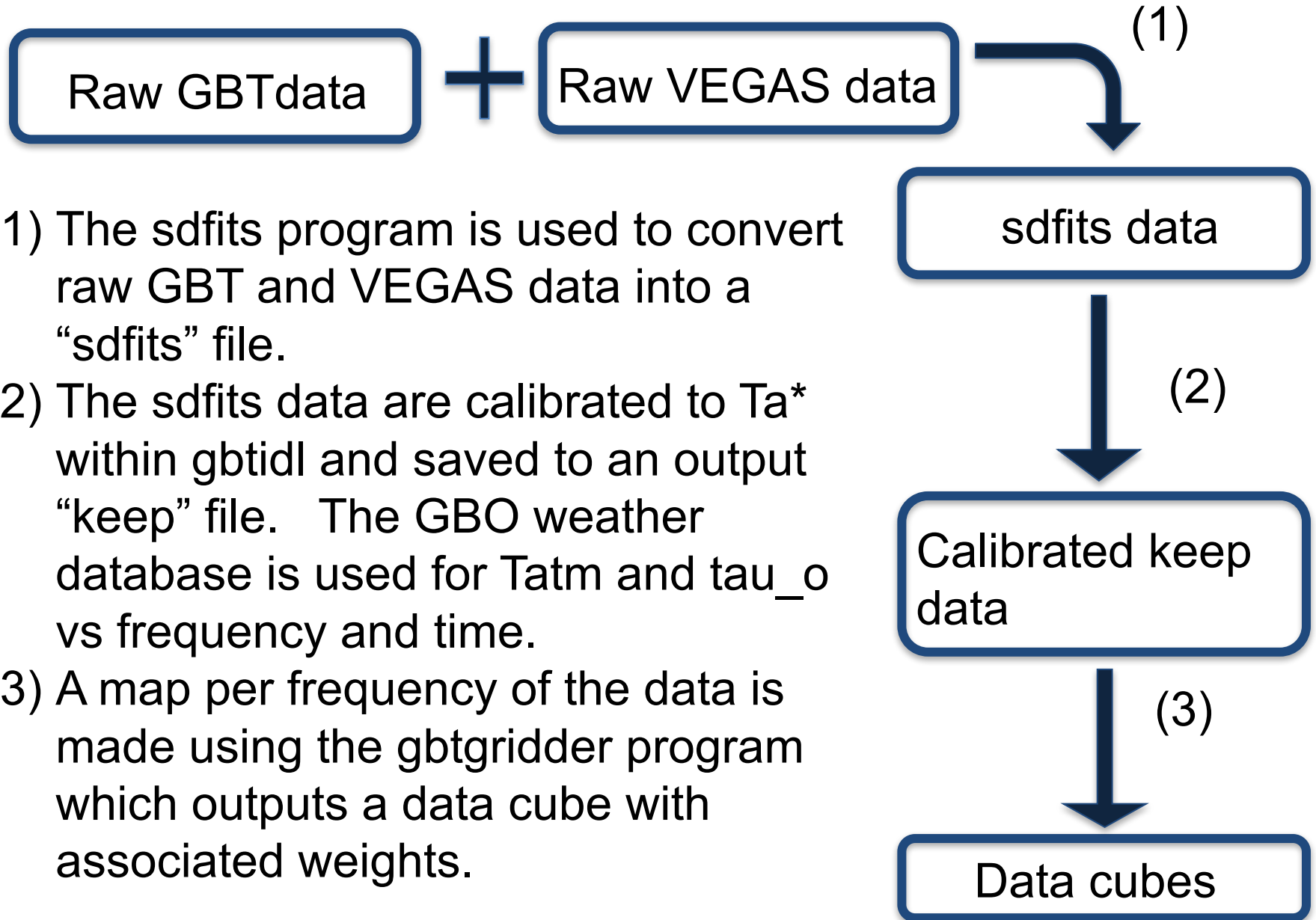
Beam efficiency: ~46% (beam = 1.2 λ/D)

Moon efficiency: ~89%

Forward efficiency: ~99%

So at ~86 GHz, ~46% of the power is in beam, ~43% is in near side-lobes, ~10% is scattered in the forward direction, and ~1% is in rear-spillover.

Argus Data “Flow” Chart



(1) The sdfits program is used to convert raw GBT and VEGAS data into a “sdfits” file.

(2) The sdfits data are calibrated to T_a^* within gbtidl and saved to an output “keep” file. The GBO weather database is used for T_{atm} and τ_{o} vs frequency and time.

(3) A map per frequency of the data is made using the gbtgridder program which outputs a data cube with associated weights.

GBO Data Directories

- Home area: `/users/user_name`
- Scratch data area: **`/home/scratch/user_name`**
- Raw gbtdata by project (e.g.,
AGBT16B_037_04):
`/home/gbtdata/AGBT16B_037_04`
- Raw Vegas data by project:
`/lustre/gbtdata/AGBT16B_037_04/VEGAS`
- sdfits data by project:
`/home/sdfits/AGBT16B_037/04`

Public Data Processing Machines with lustre access:

- newton, planck, fourier (192GB ram)
- arcturus (132GB ram)
- Working data area:
- /home/scratch/user_name
- Extra temporary disk space on lustre (if needed):
/lustre/pipeline/scratch/user_name

GBTIDL

- Data access (connecting to sdfits file)
 - gbtidl> online
 - gbtidl> offline,'AGBT16B_037_04'
 - gbtidl> filein,'mysdfitsfile.fits'
 - gbtidl> summary

- User "pro" directory used by gbtidl:
/users/user_name/gbtidlpro

Argus GBTIDL scripts

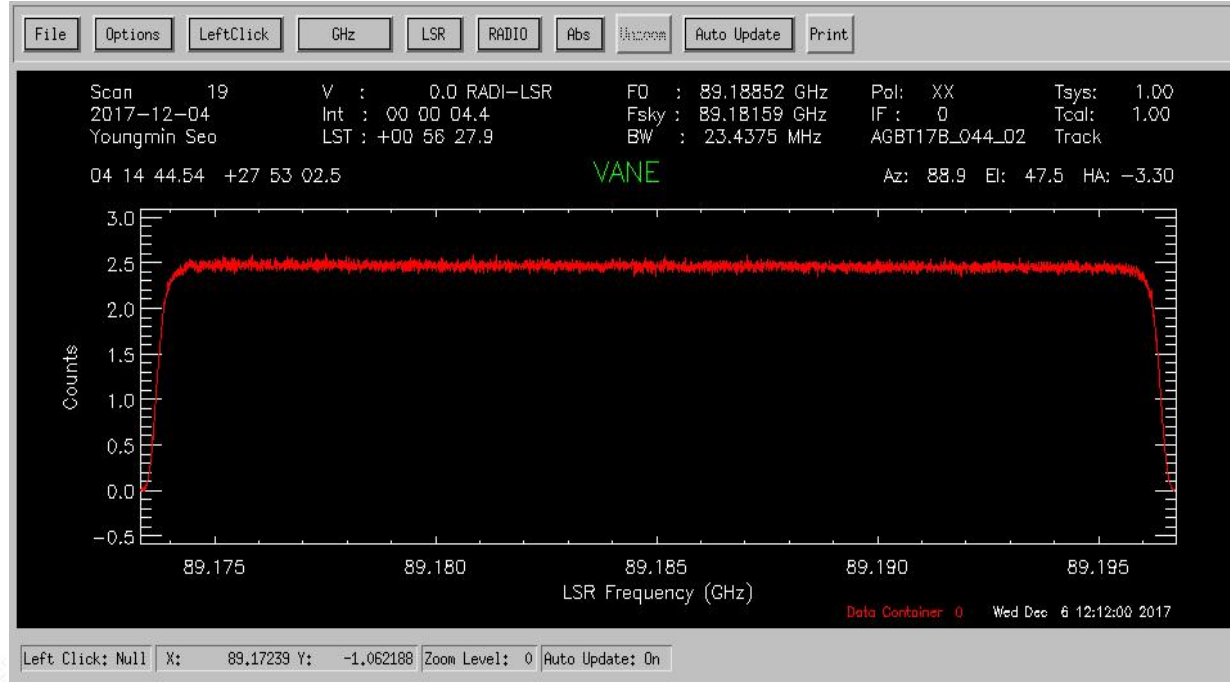
/home/astro-util/projects/Argus/PRO:

- vanecal.pro – reduces vanecal observations and provides Tsys for all the beams
- getatmos.pro – returns opacity and ATM temperature for an input MJD and frequency
- argus_fsw.pro -- reduces frequency-switched scan
- argus_onoff.pro – reduces total-power ON-OFF scan

Checking Tsys in all 16 Beams

Run “vanecal”
script in gbtidl.
The VANE scan
is 19 here.

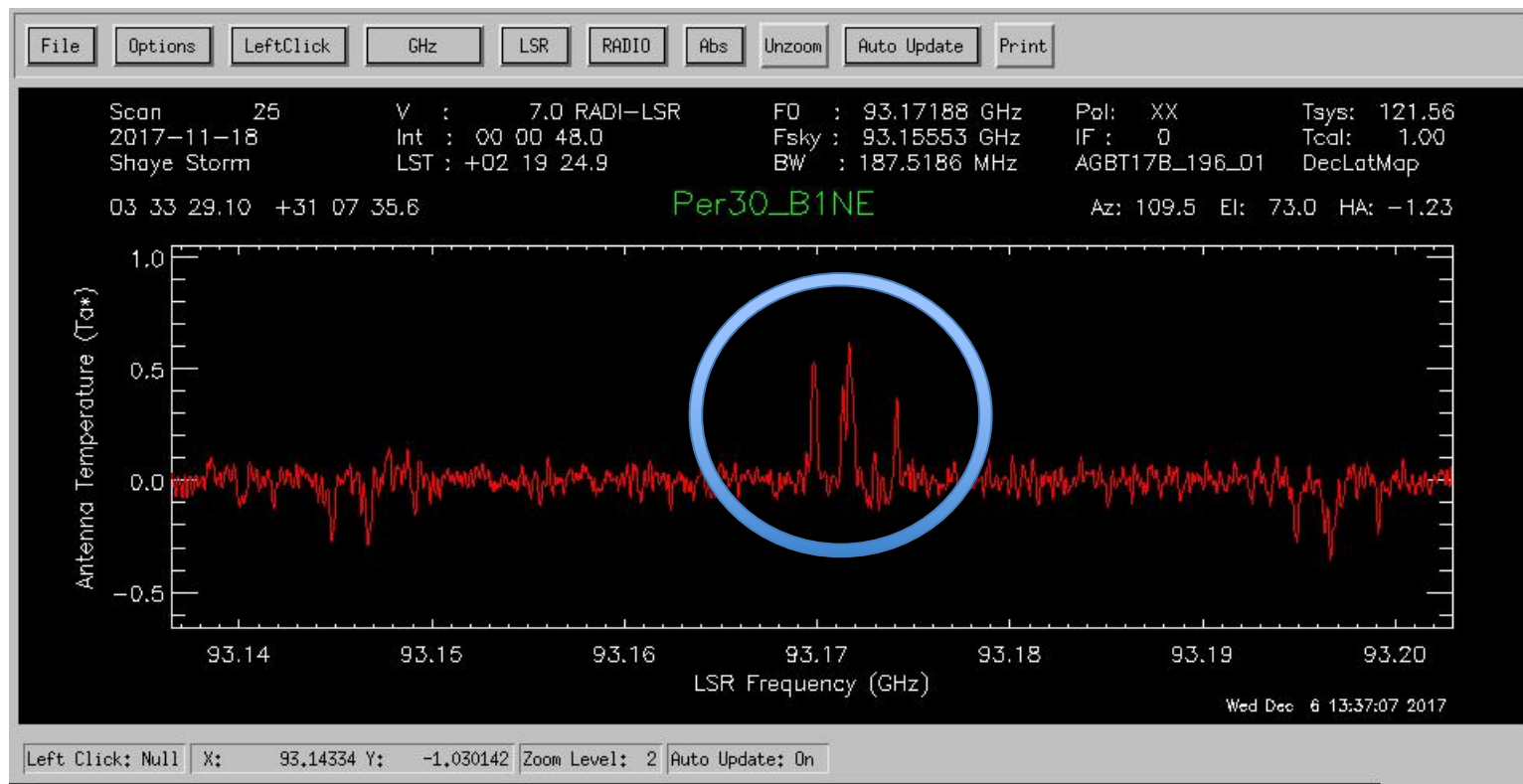
```
GBTIDL ->
GBTIDL -> vanecal,19
% Compiled module: VANECAI.
Scan: 19 (IF:0 FD:10 PL:0) Tsys: 1.00
% Compiled module: GETATMOS.
(zenith) Opacity(89.181592,58091.058) = 0.0754
AtmTsys(89.181592,58091.058) = 25.8880
Tatm(89.181592,58091.058) = 266.4082
beam, Tsys*[K]: 1 111.44295
beam, Tsys*[K]: 2 106.53290
beam, Tsys*[K]: 3 108.46513
beam, Tsys*[K]: 4 123.56812
beam, Tsys*[K]: 5 109.14355
beam, Tsys*[K]: 6 108.45131
beam, Tsys*[K]: 7 114.54882
beam, Tsys*[K]: 8 114.63135
beam, Tsys*[K]: 9 114.34038
beam, Tsys*[K]: 10 107.05890
beam, Tsys*[K]: 11 108.75631
beam, Tsys*[K]: 12 143.17644
beam, Tsys*[K]: 13 121.82879
beam, Tsys*[K]: 14 111.47134
beam, Tsys*[K]: 15 114.85225
beam, Tsys*[K]: 16 112.29262
Tcal, Twarm, tatm: 276.02470 277.54999 266.408
GBTIDL -> []
```



Returns weather information, e.g., zenith opacity (0.0754) and Tatm and computes $T_{\text{sys}}^* = T_{\text{cal}} \times \text{SKY} / (\text{VANE} - \text{SKY})$ for each beam. Note that $T_{\text{cal}} \sim T_{\text{warm}}$ which is generally true.

Quick-Look of Data, example frequency switching

N₂H⁺
transitions



```
GBTIDL>argus_fsw,25,18,fdnum=9
```

Reduces FSW scan 25 using VANE scan 18 for fdnum=9 (beam-10)

Mapping

- After calibration within gbtidl, users can make a data cube using the “gbtgridder” (eg.):

```
gbtgridder -c 11000:11251 -a 7 --noline --nocont -o myout mysave.fits
```

(grids channels 11000:11251, averaging over 7 channels) to make output cube and weight map.

➔ myout_cube.fits, myout_weight.fits