Abstract

Installation of 16 antenna temperature sensors was completed by the end of July 2003. Approximately 10 hours of telescope time was used overnight on 2/3 August 2003 EDT to perform repeat pointing and focus measurements on 2344+8226, a source near the North Celestial Pole, with a view to start characterizing these quantities as a function of structural temperature. This note summarizes the experiment, and presents a first “quick-look” at the data obtained.

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History


21.2 7 September 2003. Update focus results with corrected fits (Richard Prestage)
1 Introduction

Telescope time from 11:20pm EDT on Saturday 02 August 2003 through 9:30am EDT Sunday 03 August 2003 was used to perform repeat pointing and focus measurements on 2344+8226, a source near the North Celestial Pole, while acquiring structural temperature data using the 16 temperature sensors installed during July 2003. This note describes the experimental setup and summarizes the results of the pointing and focus measurements. A “quick-look” of these quantities as a function of temperature is also presented.

2 Experimental Method

The weather was poor but stable, with uniform, thick cloud cover throughout the night, and in fact light rain at the start of the observations. Winds were light. The forecast was for potential thunderstorms. Accordingly the observations were all performed at C-band. In the following, the two polarizations of the C-band receiver are referred to as “receiver 1” and “receiver 2”.

The receiver/ IF/ backend system was configured for C-band observations at 5.0GHz using the DCR, in the standard PTCS manner. Configuration was performed by the new glish script:

```
/home/groups/ptcs/obs/setup/setup_pointing.g
```

Which in turn uses the “configurator” and pntC.cfg (Appendix A) to set up the system. The Archivist was configured using the ArchOn.g script (Appendix B).

The antenna was configured for with the standard (what is this called) pointing model in effect at the time of the observations. The standard Ys (radial) focus-tracking coefficients were replaced with those recommended by PTCS/PN/18.2, i.e. \( a = -7.289, b = 8.339, c = 2.168 \) for the duration of the experiment (apart from scans 591 to 596, performed at the end of the run to confirm these had been removed).

Since the new (az,el) peak analysis procedures were still under development, (ra,dec) peaks were performed. An initial \( \pm 120\text{mm} \) “iards” focus was performed, so that the iards real-time display could update the focus offset. Subsequent focus measurements were performed using the full \( \pm 240\text{mm} \) range suggested by Condon.

After performing initial “peak” and “focus” measurements, automatic updates of pointing and focus corrections were turned off. Although the intent was to set the Y focus offset to 0, the offset fitted by IARDS to scan 6 of 5.33mm appeared to get “stuck” in the system, and so was used for all subsequent peak observations.

Details of the specific observations are provided in Table 1.

<table>
<thead>
<tr>
<th>Scan</th>
<th>Source</th>
<th>Procedure</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-4</td>
<td>2344+8226</td>
<td>peak</td>
<td>ra/dec peak; LPCs (0.075, 0.167)</td>
</tr>
<tr>
<td>5</td>
<td>&quot;</td>
<td>focus</td>
<td>iards focus (+/− 120mm) good fit; 8.28mm</td>
</tr>
<tr>
<td>6</td>
<td>&quot;</td>
<td>focus</td>
<td>Condon focus (+/− 240mm) poor fit; 5.33mm</td>
</tr>
<tr>
<td>7-10</td>
<td>&quot;</td>
<td>peak</td>
<td>ra/dec peak; LPCs (0.158, 0.183)</td>
</tr>
<tr>
<td>11</td>
<td>&quot;</td>
<td>focus</td>
<td>Condon focus (+/− 240mm)</td>
</tr>
<tr>
<td>12, 17, and every 5th scan to 587, ra/dec peak with initial LPCs (0.158, 0.183), focus offset 5.33mm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16, 21, and every 5th scan to 591, Condon focus (+/− 240mm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>592-595</td>
<td>&quot;</td>
<td>peak</td>
<td>ra/dec peak; LPCs (0.010, 0.117)</td>
</tr>
<tr>
<td>596</td>
<td>&quot;</td>
<td>focus</td>
<td>Condon focus (+/− 240mm), peak around 15mm</td>
</tr>
</tbody>
</table>

Table 1: TPTCSRMP030802 C-band Observations on 2344+8226
3 Analysis

The peak scans from 7 to 587 inclusive correspond to 117 separate peak observations, while the focus scans from 11 to 591 inclusive correspond to 117 focus observations. These were reduced separately to provide residuals from the pointing model and axial focus tracking model respectively. All of the processed data from this commissioning run is available in the directory:

/home/groups/ptcs/analysis/TPTCSRMP030802

In five ascii text files, with content as follows:

**TPTCSRMP030802.txt** Output of Glen Langston’s “summary” program.

**scanInfo.txt** Scan info extracted from the Antenna FITS file using the “getInfo.py” python script. Columns are: SCAN; DATE-OBS; SDMJD; SOBSCAZ, SOBSEC; SMNTCAZ, SMNTCEL; LPCAZ2 (arcsec) LPCEL (Arcsec)

**tempInfo.txt** temperature sensor information extracted from the TemperatureMonitor FITS files using the “getInfo.py” script. Columns are: SCAN; SDMJD; [1,1],[2,1]; [2,2]; [2,4]; [3,1]; [3,2]; [3,3]; [4,2]; [4,3]; [4,4]; [4,5]; [4,6]; [5,1]; [5,2]; [5,3]; [5,4] where the temperatures are averaged over the scan, and [N,M] refers to concentrator gbttsN, sensor 200M.

**pointing.txt** Results from pointing fits using the DCR tool described in more detail below. Columns are: scan; receiver 1 az residual; receiver 1 el residual; receiver 2 az residual; receiver 2 el residual

**focus.txt** Focus fits determined by Dana Balser. Columns are: scan, elevation; focus-tracking model; receiver 1 fit; receiver 1 residual; receiver 2 fit; receiver 2 residual

3.1 Az/El Coverage

Observations commenced with the source at [az,el] (9.3, 41.0) at the start of the run, transitting during scan 276 at (0,46.0), and ended with scan 596 at (350.4, 39.6). Thus, a data-set symmetric about transit could be created if desired, to average out (az,el) related effects either side of transit. This [az,el] coverage is shown in Figure 1.

3.2 Temperature Data

A few TemperatureMonitor FITS files were selected at random, and inspected manually using fdump. The sensor values appeared to change by at most a few hundredths of degrees C throughout a scan, so each scan is simply represented by the average value of each sensor for that scan. (Ideally a median would be taken, but FQL provides an extremely simple automatic way to create an average; since the variations are so small, the difference is negligible. If necessary, the individual scan values could be median filtered). Results for the sixteen sensors as a function of scan number are shown in Figure 2.

Upon producing the plots, it appears that for three scans, 101, 169 and 192, temperature sensor gbtts2_2004 is corrupted. This is as a result of two readings of 1.00C in each scan.

3.3 Pointing Data

The peak scans were processed using the “gbt” version (AIPS++ Version 1.8 Build 667) of the aips++ DCR tool. This appears to have lost the ability to create a pointing archive file. Accordingly, a simple script was written (Appendix C) to process the data using the DCR “point1” procedure. Four successive scans are processed, and the azimuth and elevation pointing residuals are then given by avg(1,2) + avg(3,4) in each of azimuth and elevation.
Since “auto-update” of LPCs was turned off, in each case, this is the residual LPC correction from the initial accepted value of (9.48”, 10.98”). Each individual peak scan was not inspected individually.

The peak observation corresponding to scans 82-85 has the largest pointing residual, with an elevation residual of 11.54”. This is dominated by the single RA scan 83, which has a somewhat poorer baseline, and individual (az,el) residuals of (~9.24”, 11.88”). However, this scan does not appear pathologically bad, and is initially included in the continuing reduction.

The results for the peak scans are shown in figures 3 through 8 respectively, which show az residual for each of receiver 1 and 2, el residual for each of receiver 1 and 2, and the difference in az and el residuals between the two receivers. The mean and standard deviations for each of these are summarised in table 2.

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Az Rx 1</td>
<td>0.559</td>
<td>1.918</td>
</tr>
<tr>
<td>Ax Rx 2</td>
<td>-0.348</td>
<td>1.900</td>
</tr>
<tr>
<td>El Rx 1</td>
<td>-2.298</td>
<td>2.180</td>
</tr>
<tr>
<td>El Rx 2</td>
<td>-2.611</td>
<td>2.204</td>
</tr>
<tr>
<td>Az diff.</td>
<td>-0.210</td>
<td>0.265</td>
</tr>
<tr>
<td>El diff.</td>
<td>0.313</td>
<td>0.267</td>
</tr>
</tbody>
</table>

Table 2: TPTCSRMP030802 Mean and standard deviations of pointing residuals

3.4 Focus Data

All of the focus observations were visually inspected, and appear of uniform quality, apart from scan 271, which demonstrates a curious effect where the Y-focus value appears to rapidly fluctuate by amounts up to ~ 50mm. In some cases (perhaps most frequently towards the end of the night), the continuum level appeared to change from the start to end of a single scan.

The individual focus scans were analyzed by Dana Balser, who calculated the Ys value corresponding to the peak of each scan, and the residual from the focus tracking curve evaluated for that elevation, for each receiver. The results are plotted in figures 9 through 11. The mean and standard deviation of each of these is summarized in table 3.

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>focus 1</td>
<td>3.386</td>
<td>2.669</td>
</tr>
<tr>
<td>focus 2</td>
<td>3.421</td>
<td>2.721</td>
</tr>
<tr>
<td>focus diff.</td>
<td>0.035</td>
<td>0.664</td>
</tr>
</tbody>
</table>

Table 3: TPTCSRMP030802 Mean and standard deviations of focus residuals

4 Conclusions

From this initial quick look for the data for TPTCSRMP030802, the following conclusions can be drawn:

- each of the azimuth and elevation pointing, and axial focus residuals show long-term trends over the ten hours of the experiment. No attempt has been made to estimate the significance of these; by eye, the correlation appears to be with temperature rather than azimuth or elevation.

- without removing any long-term trends, the rms one-dimensional pointing residual for the project as a whole is 2” in each axis; the rms focus residual is 3mm. These could be significantly improved if an appropriate temperature dependence was identified and removed.
• the rms difference in pointing between the two receivers is 0.27" in each axis. This would imply a typical measurement accuracy for a single peak of around $0.27"/\sqrt(2) = 0.2"$ in each axis.

• using the same argument for focus implies a typical measurement accuracy for a single axial focus measurement of around 0.4mm.

• there appear to be small systematic offsets (-0.2" in az, +0.3" in el) in pointing between the two receivers.
A Setup configuration file

# Backend keyword
# Legal values are : DCR Spectrometer SpectralProcessor
# VLBI BCMP Holography
#
# The configuration tool currently supports the DCR and the Spectrometer backends
backend:= Spectrometer
backend:= DCR

# Receiver keyword
# Legal values are : Rcvr1_2 Rcvr2_3 Rcvr4_6 Rcvr8_10
# Rcvr12_18 Rcvr18_26_A Rcvr18_26_B
# RcvrPF_1_A RcvrPF_1_B RcvrPF2
# The configuration tool currently supports Rcvr1_2, Rcvr2_3, Rcvr4_6 and Rcvr8_10 receivers
rcvr := Rcvr4_6

# Frequency keyword
# Legal values are : 1 to 6 floats
# Frequencies should be input as a comma delimited list of desired frequencies.
# ex1: for 1 frequency ..... freq := 1440
# ex2: for 2 frequencies ... freq := 1440,1600
# The configuration tool currently supports 1 frequency.
freq := 5000

# Velocity keyword
# Legal values are : 1 to 6 floats
# Source velocities should be input as a comma delimited list of desired velocities.
# ex1: for 1 velocity ..... velocity := 144
# ex2: for 2 velocities... velocities := 144,160
velocity := 0

# Bandwidth keyword
# a float
# Spectrometer bandwidths are 12.5 and 50 Mhz for slow samplers
# and 200 and 800 for fast samplers
# bw := 320

# Beam keyword
# Legal values are : SingleBeam BeamSwitching
# DoubleBeamSwitching MultipleBeam
# The configuration tool currently supports SingleBeam
beam := SingleBeam
# Number of frequencies keyword
# Legal values are: 1, 2, or 4
# An artifact for supporting only 1 frequency. This keyword
# will be removed after multiple frequencies are supported
num_freq := 1

# Velocity definition keyword
# Legal values are: Radio Optical Relativistic
velocity_defn := Radio

# Velocity frame keyword
# Legal values are: Local Heliocentric Barycentric
# LocalGroup DynamicLRS Galactocentric
# KinematicalLRS CosmicBackground
#velocity_frame := KinematicalLRS

velocity_frame := Local

# Backend mode
# Legal values are: 0 unsupported
#backend_mode := 0

# Modestring keyword
# Used only when backend = Spectrometer
# All valid single bank modes are supported
modestring := 1N2-2C-12-9

# Polarization keyword
# Legal values are: Linear Circular
# Not all receivers support both modes. Please see gbt specification
# for the receiver of interest
polarization := Circular
#polarization := Linear

# Secondary backend keyword
# Legal values are: none dcr
# This keyword should be set to 'dcr' if the user would like to
# configure the IF path from the Receiver to the DCR
# as well as configuring the IF path to the chosen backend.
sec_backend := none
#sec_backend := DCR
B Archivist setup

Archivist configuration from /home/groups/ptcs/obs/setup/ArchOn.g

```plaintext
v := [ ];
v[1] := [device='ServoMonitor', manager='ServoMonitor', sampler='Az_El_1Hz', delta=0];
v[2] := [device='ServoMonitor', manager='ServoMonitor', sampler='Az_El_50Hz', delta=0];
v[3] := [device='ServoMonitor', manager='ServoMonitor', sampler='azServo1Hz', delta=0];
v[4] := [device='ServoMonitor', manager='ServoMonitor', sampler='azServo50Hz', delta=0];
v[5] := [device='ServoMonitor', manager='ServoMonitor', sampler='elServo1Hz', delta=0];
v[6] := [device='ServoMonitor', manager='ServoMonitor', sampler='elServo50Hz', delta=0];
v[7] := [device='ServoMonitor', manager='ServoMonitor', sampler='Spare1Hz', delta=0];
v[8] := [device='ServoMonitor', manager='ServoMonitor', sampler='Spare50Hz', delta=0];
v[9] := [device='ServoMonitor', manager='ServoMonitor', sampler='summary', delta=0];
v[10] := [device='Weather', manager='Weather1', sampler='weather1', delta=0];
v[11] := [device='Weather', manager='Weather2', sampler='weather2', delta=0];
v[12] := [device='Weather', manager='Weather3', sampler='weather3', delta=0];
v[13] := [device='TemperatureMonitor', manager='TemperatureMonitor', sampler='StructureTemp', delta=0];
v[14] := [device='Antenna', manager='AntennaManager', sampler='azElCommands', delta=0];
```
C  Peak fitting procedure

function doit()
{
    ofile := open(">> fit.txt")
    for (n in 1:117) {
        scan := n*5 + 2
        rec := fit4(scan)
        print scan, rec.daz, rec.del
        fprintf(ofile, '%5d %10.4f %10.4f \n', scan, rec.daz, rec.del)
    }
}

function fit4(scan)
{
    rec := []
    r1 := d.point1(scan,0,plotflag=0)
    r2 := d.point1(scan+1,0,plotflag=0)
    r3 := d.point1(scan+2,0,plotflag=0)
    r4 := d.point1(scan+3,0,plotflag=0)
    rec.daz := 60.0 * ((r1.d_az + r2.d_az)/2.0 + (r3.d_az + r4.d_az)/2.0)
    rec.del := 60.0 * ((r1.d_el + r2.d_el)/2.0 + (r3.d_el + r4.d_el)/2.0)
    return rec
}

D  Figures
Figure 1: Project TPTCSRMP030802: Azimuth/elevation coverage

Figure 2: Project TPTCSRMP030802: The 16 installed temperature sensors plotted as a function of scan number.
Figure 3: Project TPTCSRMP030802: Receiver 1 azimuth pointing residuals

Figure 4: Project TPTCSRMP030802: Receiver 2 azimuth pointing residuals
Figure 5: Project TPTCSRMP030802: Receiver 1 elevation pointing residuals

Figure 6: Project TPTCSRMP030802: Receiver 2 elevation pointing residuals
Figure 7: Project TPTCSRMP030802: azimuth pointing residual differences

Figure 8: Project TPTCSRMP030802: Elevation pointing residual differences
Figure 9: Project TPTCSRMP030802: Focus residual for receiver 1

Figure 10: Project TPTCSRMP030802: Focus residual for receiver 2
Figure 11: Project TPTCSRMP030802: Focus residual differences