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BiSON Birmingham Solar-Oscillations Network

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Abstract

Details of the trip to Narrabri in 2010 February are presented.

Contents

1 Introduction

The Narrabri station was last visited by Brek Miller in 2007 March [1]. Since that trip one of the hard disks in the computer had failed. It was decided that since the station had not been visited for some time a trip should be organized to replace the hard disk and install the latest version of temperature controllers that have been successfully installed at other sites. Steven Hale and Ian Barnes visited Narrabri from January 25 to February 21.

The full list of jobs that were scheduled to be completed is given below.

- Fix autoguider.
- Install new Temperature Controllers.
- Install Mains Controller.
- Replace failed HDD in computer.
- Upgrade the Zoo software to the latest version.
- Replace shaft couplers.
- Replace the cloud detector for a “fast change” version.
- Reconfigure the temperature monitor.
- Measure the dome.

2 Computer Repairs & Upgrades

On the Narrabri computer one of the hard disks had failed. Fortunately we use raid arrays at all of the stations within BiSON and so a single disk failure is not really a major problem. The failed disk was replaced and the computer was configured so that it could boot from either disk should the station suffer another hard disk failure in the future.

It was also necessary to update the Zoo software. The temperature controllers require the Iguana program which was not included in the version of the Zoo installed at Narrabri.

Whilst on site the packages for Fedora 5 were also updated.

3 Mains Controller

The station at Narrabri did not have a Mains Controller [2] prior to this visit. Due to the success and obvious usefulness of these units at other stations it was decided that Narrabri should also have a Mains Controller installed.

3.1 Mains Controller Channel Configuration

The channel configuration of the mains controllers used within BiSON is different for each station. The channel configuration for the Mains Controller in Narrabri is given in Table 1.

Table 1: Channel Allocation of the Narrabri Mains Controller

Mains Controller Channel	*DIO Port*	*System*	*Connection Type*
0	3B0	Main Electronics Crate	IEC 2m
1	3B1	Pockels Cell Driver	IEC 3m
2	3B2	Temperature Controllers	IEC 2m
3	3B3	Temperature Monitor	IEC 2m
4	3B4	Network Camera, Modem and Picstart	Plug 4-way 3m
5	3B5	GPS	IEC 2m
6	3B6	Not Used	
7	3B7	Not Used	

3.2 Mains Controller Scripts

There are a number of scripts that are associated with the Mains Controller. These scripts are located in the */home/zoo/bin/* directory.

There are scripts to turn individual channels of the Mains Controller on and off. These are named *mainsX_on* and *mainsX_off*, where X is the channel number which is in the range 0–7.

As well as the scripts mentioned above there are also links to more useful names for the scripts. For example the GPS is connected to the mains controller and the scripts to turn it on and off are *gps_on* and *gps_off* respectively. All of the script names that are used in Narrabri are summarized in Table 2.

Table 2: Narrabri Mains Controller — Script names

System	*Script Base Name*
Main Electronics Crate	main_crate
Pockels Cell Driver	pockels
Temperature Controllers	tempcont
Temperature Monitor	temp_monitor
Modem, camera and Picstart	aux
GPS	gps

3.3 Mains Controller Cable

The Mains Controller Cable connects the Mains Controller to the DIO Splitter Card. Figure 1 shows the cable that is used in Narrabri.

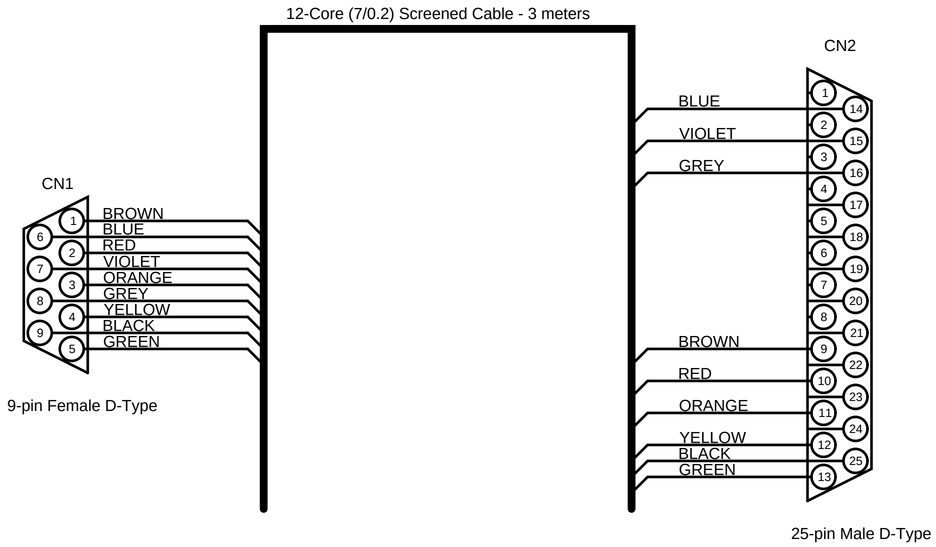

Figure 1: The Mains Controller Cable.

4 Temperature Controllers

One of the main tasks to be completed on this trip was to replace the Temperature Controllers. The temperature controller unit is described in BTR-321. The configuration of the temperature controllers is described in BTR-333.

In Narrabri the spectrometer components that require temperature control are as follows:

- Starboard Detector.
- Port Detector.
- Interference Filter.
- Oven.

During the installation of the Mains Controller it was discovered that the switch on the existing temperature controllers was broken. If the old temperature controllers are to be used again then the main power switch will have to either be replaced or bypassed.

With the installation of the new temperature controllers there would also be changes necessary to the temperature monitor. The new temperature controller system is shown in Figure 2.

During the setup of the temperature controllers it was spotted that the power required to keep the port and starboard detectors at the required set-point of 20°C was very different. By switching off the temperature control and allowing the detection to settle at the ambient temperature, it was found that there was a 1.5°C offset between the two temperature sensors in the detectors. To match the powers required by both detectors, the set point of the port detector was increased to 21.5°C to compensate for the offset.

The power to maintain these setpoints was putting the Peltiers on maximum cool and so the detector temperatures were increased again to 23°C for starboard and 24.5°C for port.

It would be better to apply an offset to the temperature reading for the port detector to make it match the starboard detector, assuming that they are both actually at the same temperature. Unfortunately it is not simple since the temperature controller offset option is applied directly the ADC counts, and not after they have been scaled to temperature.

It seems more natural to multiply by the scale first. However, in the original temperature monitor, the ADC did not output a signed integer ADC count. Instead, `0x0000` was for -10 V, `0x8000` was for 0 V, and `0xffff` was for $+10$ V. So you can find:

```
Lizard.AllChannels.Offset:  -0x8000
```

in the *zoo.conf* file. Now if the scale were applied before the offset, then the offset would depend on the scale. That is, we would need different offsets for different types of input. But that doesn't really make sense. The offset is an ADC offset and is the same for all channels.

Now, the ADS1210s output signed integers and there is no ADC offset. So it would now make sense to do things the other way around. Especially since there is a temperature offset on the AD590s. Instead of saying -273.15, we need:

```
Iguana.adcChannel0.offset:  -4535495
```

We should really have an `adcOffset` *and* an `offset`. Then we could do:

$$V = (A + adcOffset) * scale + offset.$$

But since we only have the ADC offset available, we need to work out the number of ADC counts that corresponds to a change of 1.5°C.

Let T be the temperature of the LM35 in degrees Celsius. Its output voltage V_s is

$$V_s = 0.01\,T.$$

Now consider the INA114. Let R be the resistance of the gain resistor in Ohms. The datasheet says that the gain G is given by:

$$G = 1 + \frac{50,000}{R}.$$

The voltage V_a at the input to the ADC is then $V_a = GV_s$.

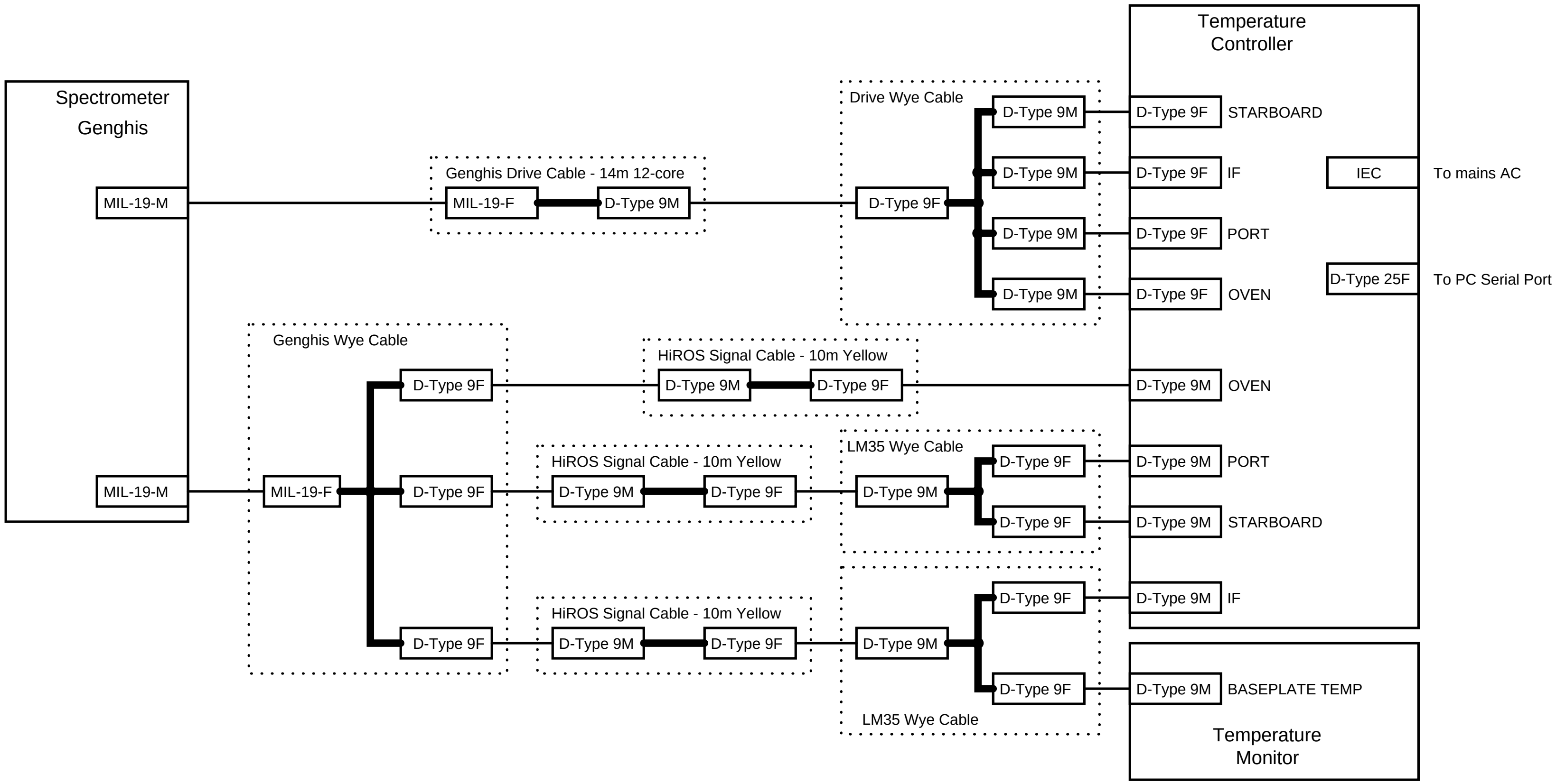

Figure 2: The Narrabri temperature controller system.

Now for the ADC. The ADC has two (differential) input terminals, each of which must be between 0 V and 5 V. So the voltage difference between the two inputs can vary between -5 V and $+5$ V. That is a 10-V swing. It is a 24-bit ADC, so the ADC output A is related to its input by:

$$A = V_a \frac{2^{24}}{10}.$$

Put that all together and we get:

$$A = \frac{2^{24}}{10}\left(1 + \frac{50,000}{R}\right) 0.01\,T.$$

For an LM35, we use $R = 6,800\,\Omega$. Put $T = 1.5$°C into that formula and you get $A = 210208$.

An offset of -210208 counts was applied to the port detector in *zoo.conf*, and the setpoint of both detectors reset to 23°C. The power required to maintain this temperature was now the same in both detectors.

5 Temperature Monitor Reconfiguration

Following the installation of the new temperature controllers the temperature monitor needed reconfiguring. This was because the old temperature controllers passed the temperature voltages for the various spectrometer components to the temperature monitor. The Iguana now handles the control and logging of temperatures and so they do not need passing to the temperature monitor.

The temperature monitor needed to be reconfigured for the following parameters:

- Room Temperature.
- Dome Temperature.
- Spectrometer Baseplate Temperature.
- Cloud Detector Voltage.

The room and dome temperatures are measured using LM35 temperature sensor ICs on long cables. The spectrometer baseplate temperature comes from within the spectrometer down one of the cables going to the temperature controllers. The system diagram for the re-configured temperature monitor in Narrabri is shown in Figure 3.

Usually the output from the LM35 sensors is fed into an amplifier stage contained on an LM35 board within the temperature monitor main unit. Unfortunately the Narrabri unit does not have an LM35 board inside it and so the LM35s had to be connected directly to the ADC. This meant a loss of resolution but at least the temperatures could still be measured.

Also the existing wiring for the LM35 temperature probes was found to be incorrect and used non-standard cable. The probes were re-wired and the wiring is shown in Figure 4.

The loss of the amplifier stage meant that the LM35 scale had to be changed. This is simpler than with the temperature controller because the internal gain was chosen in a very nice way.

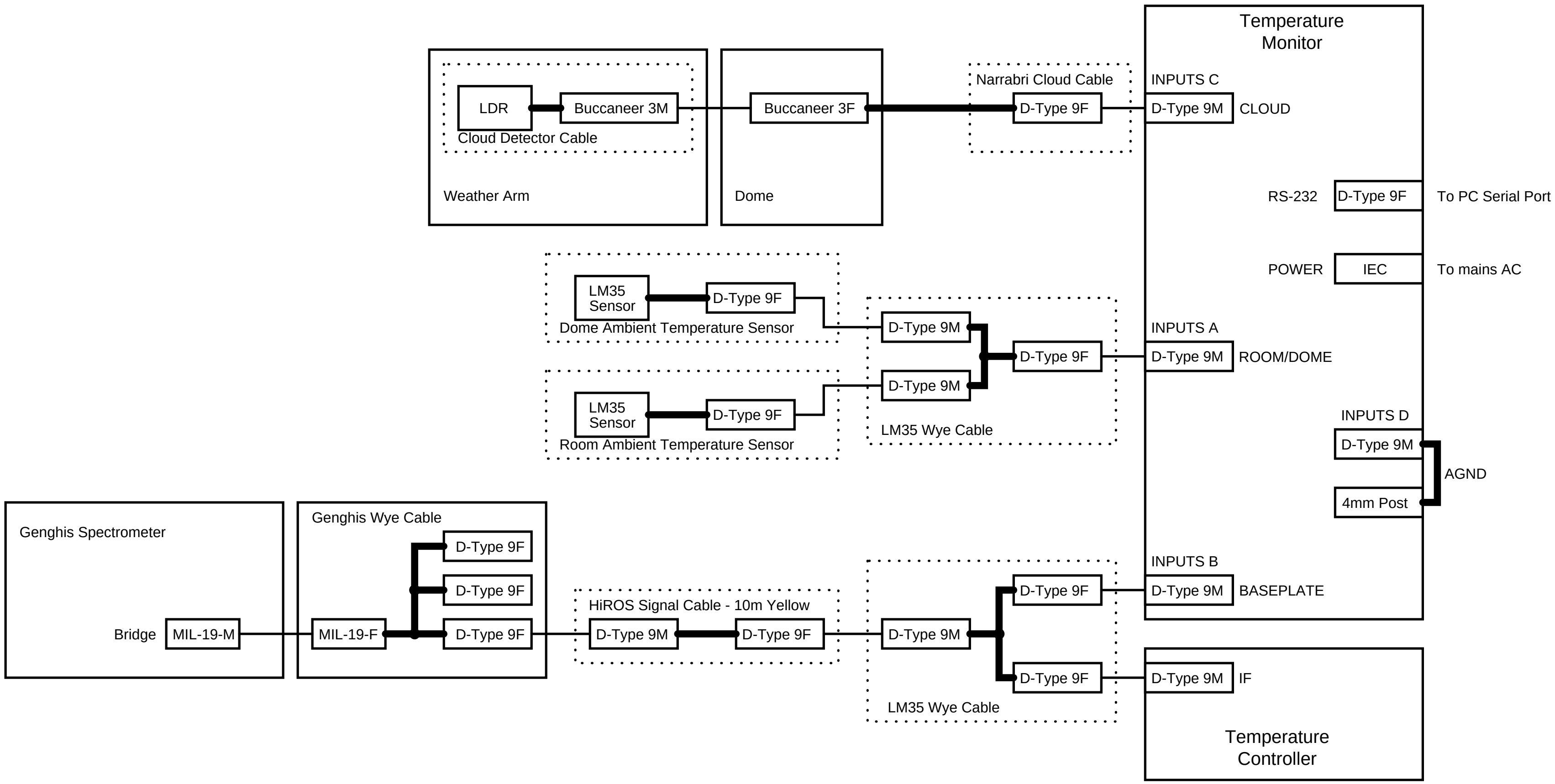

Figure 3: The Narrabri temperature monitor system.

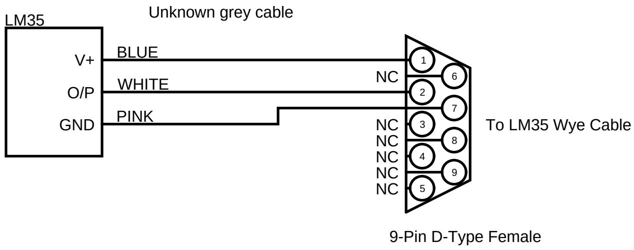

Figure 4: The Narrabri temperature probes.

The temperature monitor has differential inputs. Each half of each input can swing between $-10\,\mathrm{V}$ and $+10\,\mathrm{V}$. That means the differential voltage swings between $-20\,\mathrm{V}$ and $+20\,\mathrm{V}$. The monitor contains a 16-bit ADC. So the relationship is

$$A = V\frac{2^{16}}{40}.$$

The LM35 outputs from the old temperature controllers were

$$V = 0.110\,T,$$

which results in

$$A = 0.110\,\frac{2^{16}}{40}\,T.$$

The correct scale factor for *zoo.conf* is:

$$\frac{T}{A} = \frac{1}{0.110}\,\frac{40}{2^{16}} = 0.0055487.$$

But when you connect the LM35s directly, you get:

$$V = 0.010\,T,$$

which results in

$$A = 0.010\,\frac{2^{16}}{40}\,T.$$

The correct scale factor for *zoo.conf* is:

$$\frac{T}{A} = \frac{1}{0.010}\,\frac{40}{2^{16}} = 0.061035.$$

In order to combine the room and dome temperatures to use a single connector on the rear of the temperature monitor an LM35-Wye cable was used. The LM35-Wye cable is shown in Figure 5.

The temperature monitor hardware has undergone several hardware revisions since the Narrabri unit was built. Given the lack of the LM35 board and the fact that the cloud detector interface is on veroboard it is strongly recommended that the temperature monitor here gets replaced on the next visit.

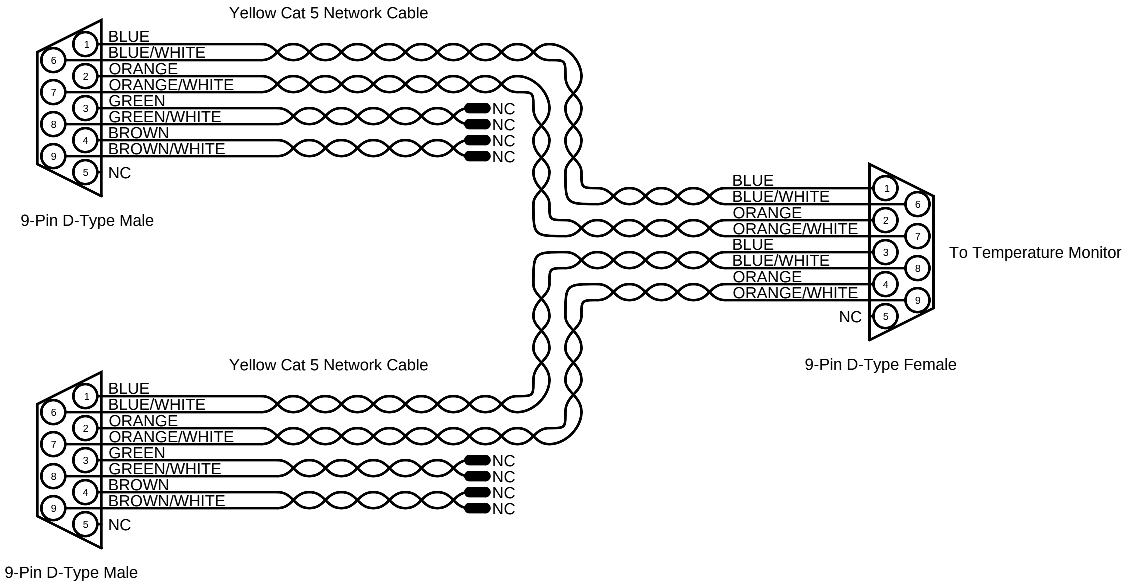

Figure 5: The LM35 wye cable.

6 Narrabri V-to-F Problem

For a while now there has been a strange problem in Narrabri with the V-to-F converters. Every so often for no apparent reason the counts on the starboard detector increase by a factor of three. This has normally been cleared by cycling the V-to-F power.

On arrival on site the counts were normal and various attempts were made to get the starboard counts into this strange state so that the cause could be investigated. Eventually turning the V-to-F power off and back on again got the starboard counts into the bad state. This time however cycling the power did not reset the counts back to the normal levels.

The cables for port and starboard were swapped over on the counters and sure enough the counts switched sides. The cables were also swapped on the die-cast metal box inside Genghis that houses the V-to-F electronics and again the counts swapped over so it was concluded that the cables were fine. Switching the detector input to the V-to-F caused the problem to remain on the same channel, which ruled out a problem with the detectors. At this point it was suspected that the problem was probably a failure on the V-to-F IC itself.

A small voltage from a power supply was injected directly into each V-to-F channel and the number of counts on the starboard channel was three times the number on the port channel.

The power to and from the voltage regulators was checked and found to be correct, so to determine if it was a broken IC the two Soclair V-to-F chips were swapped over. Sure enough the triple counts switched from the starboard side to port. So it seemed that the chip that was originally in starboard had become faulty. The chips were returned to their original positions.

The Soclair V-to-F chips are obsolete now but there were some spare ones left back in Birmingham. Replacement chips were hurriedly sent out to Narrabri and the suspect device was changed. Now the counts on starboard are reading as they should be.

7 Cloud Detector

The cloud detector units are damaged by the UV radiation from the sun. As a consequence they have to be changed when the plastic dome covering the LDR has become opaque. To make this change as quickly as possible a “fast change” cloud detector has been designed and one was sent out to Narrabri for fitting.

The old cloud detector was removed from the dome and the new unit fitted to the weather arm. Following the change over to the new unit it was found to be faulty. So the original unit was reinstalled. A new cloud detector should be sent and fitted on the next visit to Narrabri.

8 Slew Motor & Shaft Couplers

Narrabri had got some really old style shaft couplers that relied on a set screw to attach the coupler to the motor shaft. Very often these slipped and wore a groove into the motor shaft. Instead a new type of coupler is now used which clamps around the whole shaft. This type of coupler does not damage the motor shaft and has been found to be less prone to slipping. For this reason the couplers were replaced on all the shafts in Narrabri.

The slew motor in Narrabri has been broken for some time now. As it was necessary to replace the shaft couplers on the slew motor anyway the whole assembly was looked at to see if it could be repaired.

Power was not making it up to the slew motor at all. The relays were checked and found to be working properly. There is a power resistor located in the relay box that had obviously got very hot as it had melted some of the plastic conduit near it. The resistor was destroyed. There wasn't a spare one in the dome but luckily Mike managed to find a similar one that could be used.

The resistor specified in the Relay Box Network manual was 6.8-R 10-W. We had a 10-R 10-W available to us. This is okay, it just means that the slew motor runs slightly slower. The resistor in the Relay Box was replaced, and power now made it all the way up to the MIL-connector on the tracking/slew motor assembly in the dome. But there was still no power on the slew motor itself.

Further inspection found a microswitch that is pressed when the clutch is disengaged that allows power to go to the motor. The microswitch was destroyed. The terminals from the microswitch had fallen out of the switch housing and shorted out, which is what caused the resistor to melt in the relay box. The winding on the solenoid that pulls the clutch apart was also loose and about to break.

Mike ordered some new microswitches (RS 159-4427) and a new solenoid (RS 349-715) from RS. The new parts were fitted to the slew motor assembly and the slew motor started to work. The next day it was noticed that the new microswitch was smashed! When the mount is in the sunset position, the RA gearbox fouls on the microswitch. The original microswitch must have been broken in the same way and yet carried on working for the past 19 years! Another new microswitch was installed, and this time the terminals bent clear of the mount.

However there was still a problem. When the dogs on the clutch mesh completely, the solenoid doesn't have enough power to pull them apart. At some other sites a mechanical stop has been installed in order to prevent the clutch from fully engaging. A similar stop was installed in Narrabri to only allow the dogs to mesh half way. This is more than enough for the clutch to work, and still allows the solenoid to pull the clutch apart. The slew motor now works as intended.

9 Tilted Front Red Filter Mount and Autoguider

The front red filter mount on the front of Genghis was replaced.

On a previous trip the red filter was tilted in order to remove the footprint [1]. The front optical mount had a mistake that caused the first lens to be considerably further forward than it should have been. The position of the second lens was adjusted to compensate for this.

The new red filter mount had the lens in the correct position. So after installing it, the changes from the previous trip had to be undone. The lens holder for L2 had been turned around to move it more forward. The lens holder was returned to the original direction, and the lens itself rotated to keep the orientation the same. To check the focus, every component between the second and third lenses was removed so that the beam could be observed. The position of L2 was adjusted so that the beam size was roughly constant between L2 and L3.

The focus of the autoguider was also inspected. The occulting disc in front of the quadrant photodiode is only slightly smaller than the photodiode itself. If the image of the sun is too small it is completely blocked by the occulting disc, and a dead zone is created. If the image is too large it spills over the diode and again a dead zone is created. The eyepiece was set to ensure the image was very slightly larger than the occulting disc. This appears to have improved the autoguider performance. The autoguider gain is set to 2 on both RA and Dec, so this can also be increased if further problems are experienced.

Since many changes had been made to the internal optics of both the instrument and the autoguider it was necessary to do some guider scans. The autoguider micrometers were found to be set to RA = 8.00 mm and Dec = 8.25 mm on arrival.

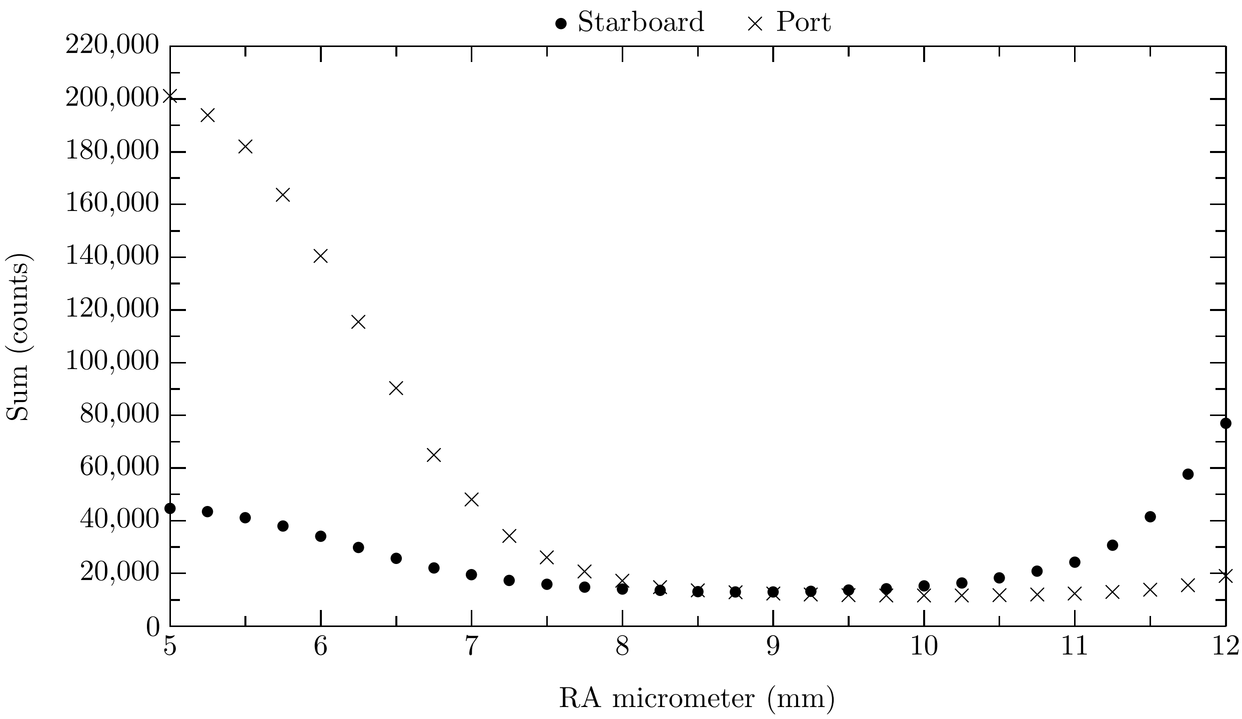

Figure 6: Cold RA scan (2010 February 10).

The first scan was done with the oven cold (see Figures 6 and 7). There appears to be some misalignment in RA of the two detectors, since the scan did not suggest the same position for both. A setting of RA = 9.5 mm and Dec = 8.75 mm seemed the most appropriate to minimize the cold scattering.

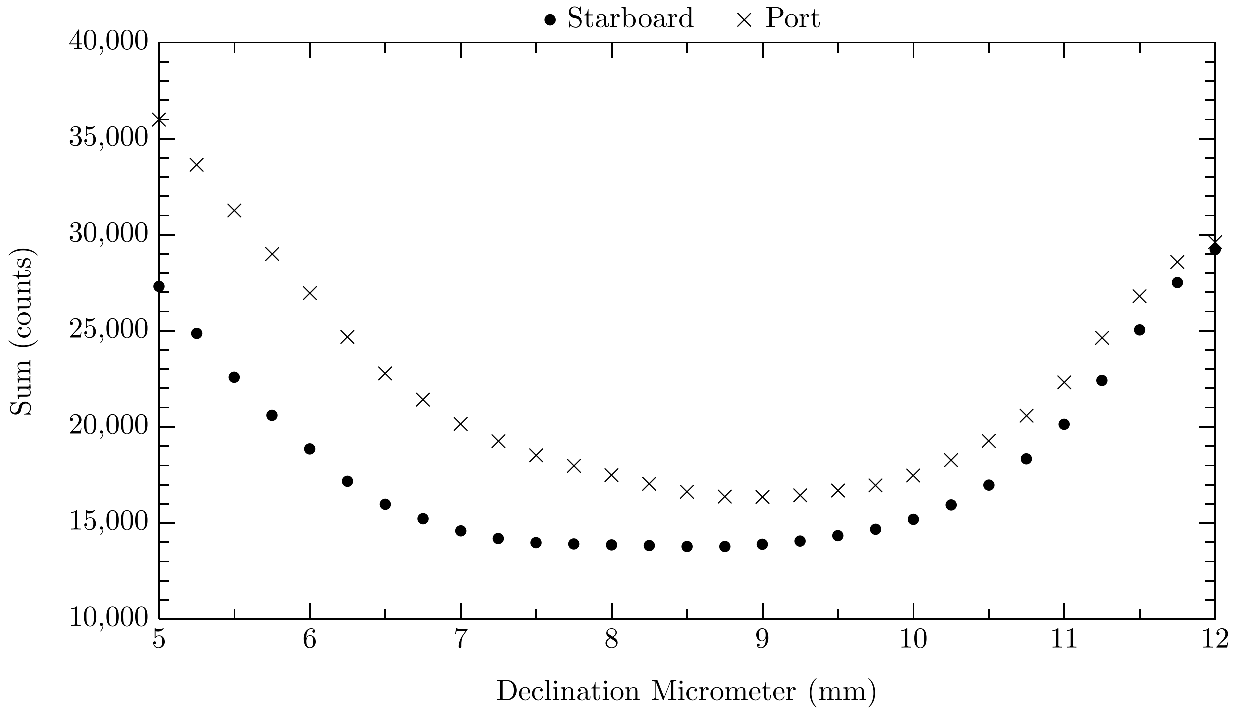

Figure 7: Cold declination scan (2010 February 10).

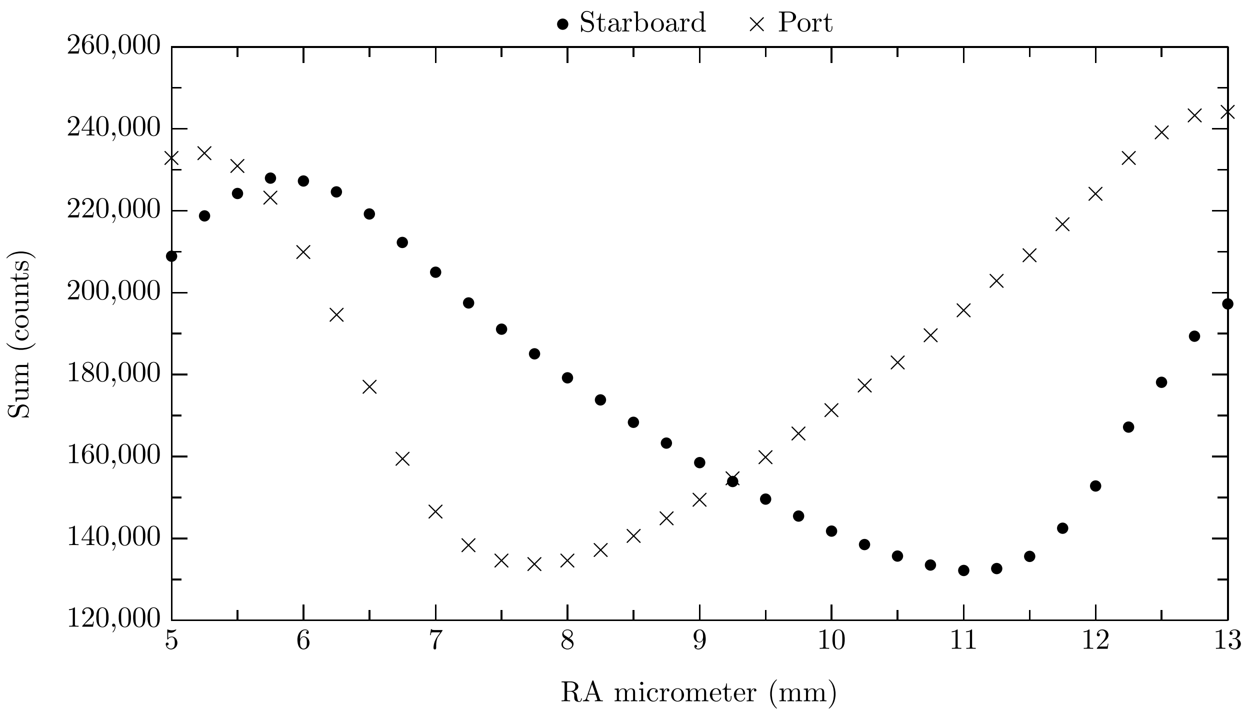

Figure 8: Hot RA scan (2010 February 13).

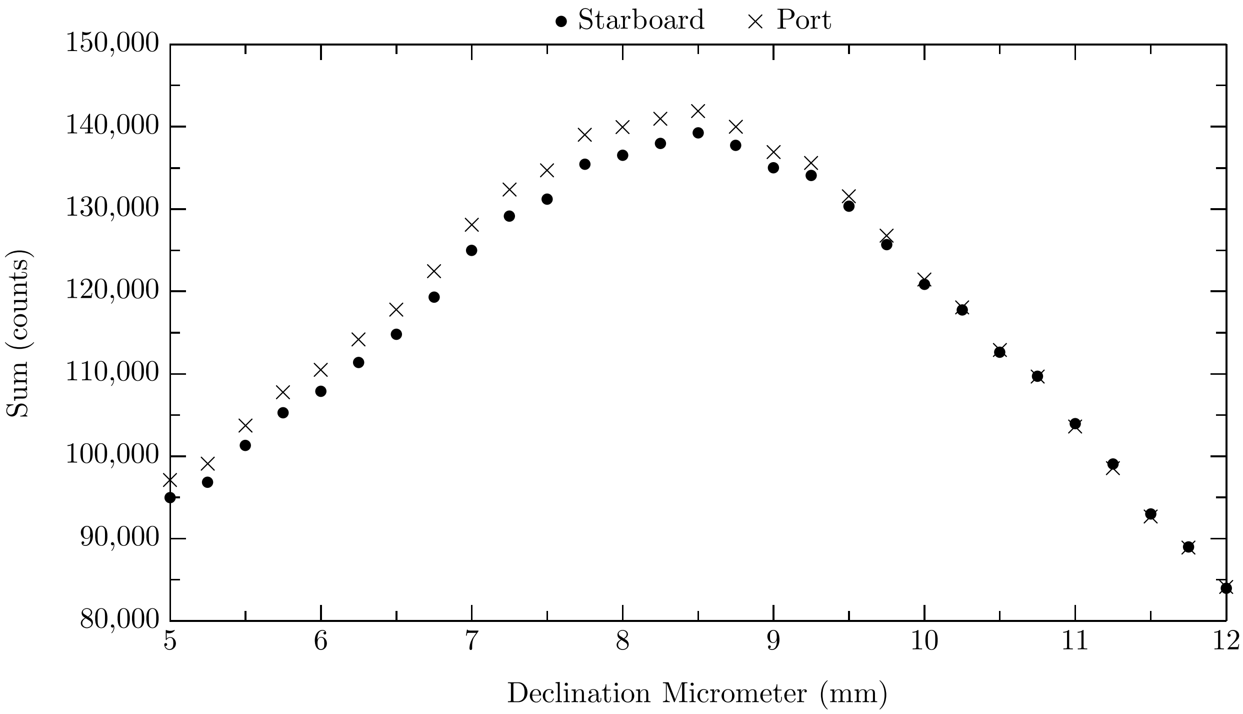

Figure 9: Hot declination scan (2010 February 13).

The oven was bought back up to temperature and another scan performed (see Figures 8 and 9). With the cell hot, the misalignment between the two detectors was even more obvious. The best position was chosen to be where the two sums crossed over which was RA = 9.25 mm. The best value for Dec was much more obvious with a clear peak at Dec = 8.5 mm.

So which do we believe? Normally we put more weight on the settings suggested by a cold scan since past experience shows this seems to work better. But with the cold scans being so ambiguous, we decided to leave the guider set at the positions given by the hot scan.

The sums from the two detectors are not the same throughout the day due to the misalignment. One gradually increases throughout the day, and the other gradually decreases. These settings put the point at which the two cross over fairly early in the morning, which is unsurprising since that is when we did the scan. The micrometer for RA was reduced slightly down to 9.1 mm to put the cross over point exactly at midday. After collecting a full day of data, this seems to be very good alignment.

Following the scans the guider was left at RA = 9.1 mm and Dec = 8.5 mm.

10 Oven Temperature Scan

On arrival the oven was set to 106°C. After installing the new temperature controllers and optimizing the instrument alignment, a scan was performed on the oven temperature (see Figure 10). The peak was found to be at 113°C and so the oven temperature was increased to this setting.

References

[1] Brek A. Miller. The elimination of the footprint in Narrabri. *BISON Technical Report Series,* Number 290, High-Resolution Optical-Spectroscopy Group, Birmingham, United Kingdom, May 2007.

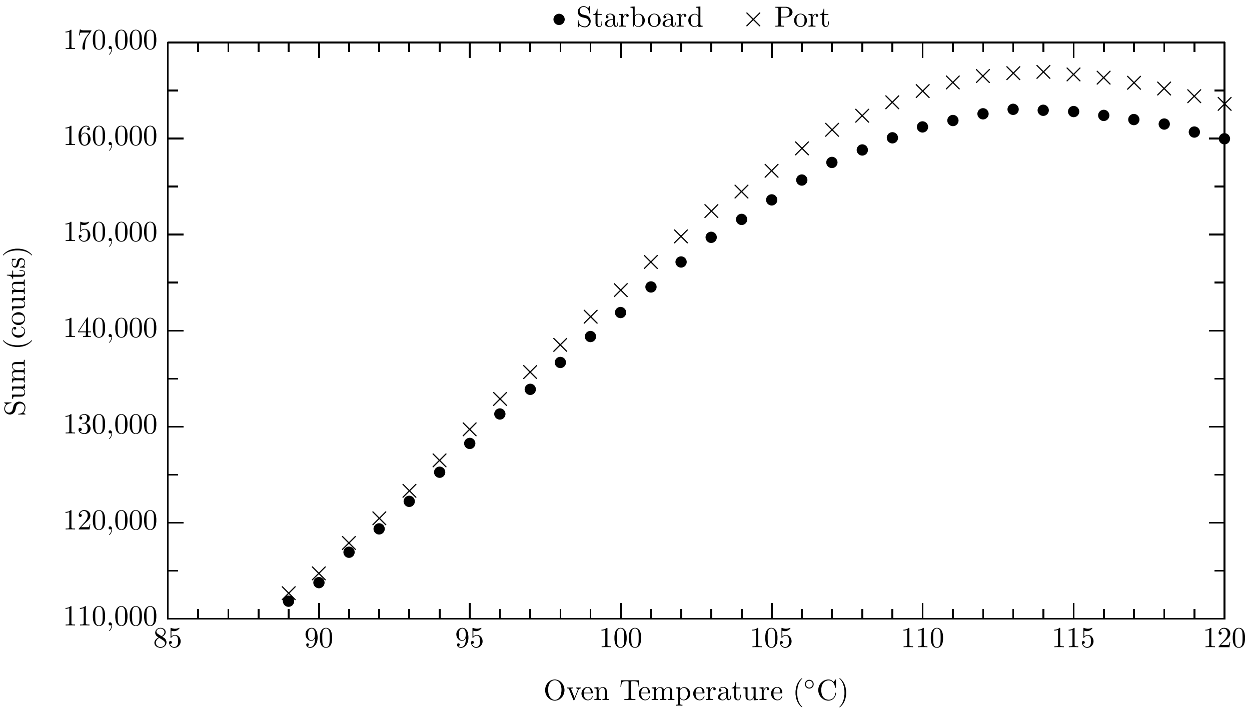

Figure 10: Heating curve (2010 February 16).

[2] Ian Barnes. The Mains Controller. *BISON Technical Report Series,* Number 297, High-Resolution Optical-Spectroscopy Group, Birmingham, United Kingdom, January 2008.

[3] Ian Barnes and Brek A. Miller. A computer-controlled temperature controller. *BISON Technical Report Series,* Number 321, High-Resolution Optical-Spectroscopy Group, Birmingham, United Kingdom, June 2009.

[4] Ian Barnes. The Narrabri temperature controller. *BISON Technical Report Series,* Number 333, High-Resolution Optical-Spectroscopy Group, Birmingham, United Kingdom, November 2010.