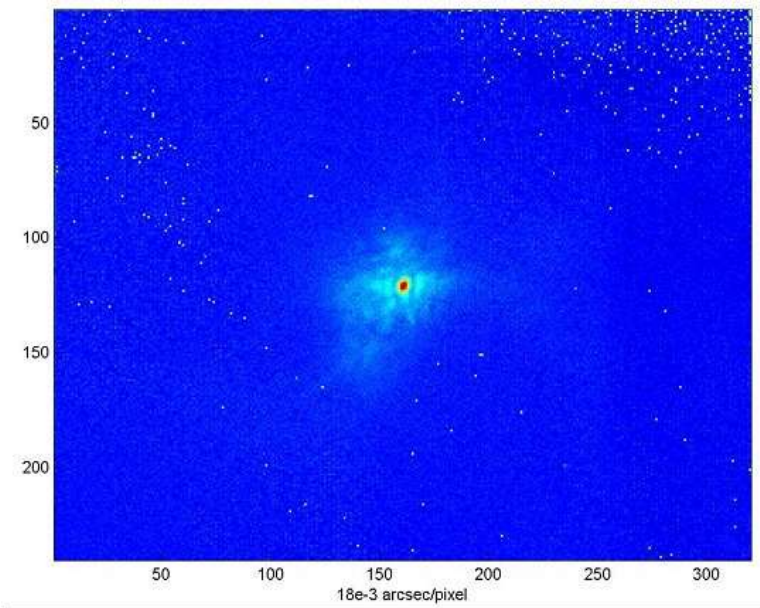
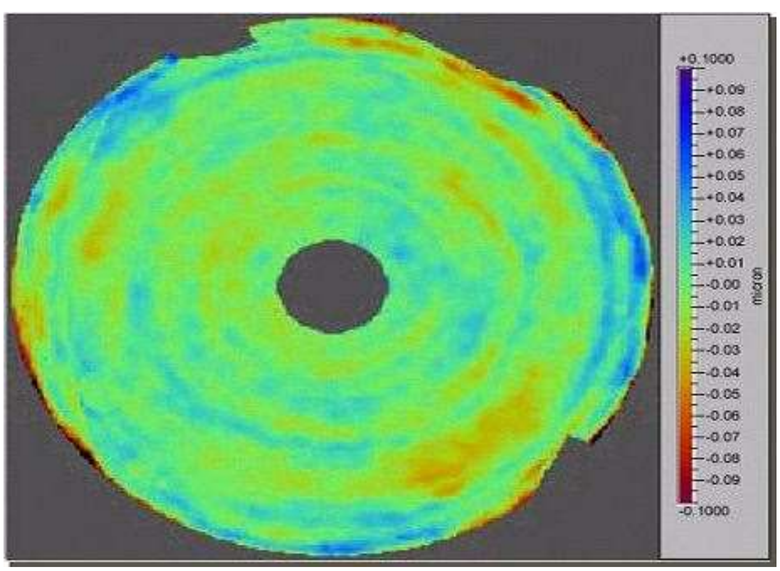
# BIMONTHLY SUMMARY

## November - December 2002

It was such an exciting two months at the MMT that we had to include two images:




*H-band image taken with the f/15 secondary. Adaptive loop not closed.*




*Map of the surface errors of the completed f/5 secondary – rms error =17 nm.*

## Important Notice

The MMTO web site has moved to URL *http://www.mmto.org*. Please update your links. The old URL on sculptor redirects to the new location.

## Personnel

In November Dan Blanco returned to MMTO after a 12-year hiatus. He will take on the duties of Associate Director for Operations at the MMT site.

P. Spencer and C. O'Neal transferred to the mountain staff effective January 1.

Steve Nichols (SAO) finished his temporary assignment and has left to resume teaching physics for the spring semester back east. We wish him well and hope to see him here again.

Andy Szentgyorgyi (SAO) returned to Boston for the holidays; we expect to see him back here in the spring.

## Development

### Adaptive Optics First Light

November included a very successful run of the adaptive optics secondary mirror. Though there is still much work to do to bring this into regular use, the first results were very impressive, reducing ~3/4 arcsecond seeing limited images to just over 1/8 arcsecond.

The following is courtesy of F. Wildi (CAAO, Steward Observatory):

At the end of November 2002, the CAAO was allocated a significant slice of MMT time to test and commission the MMT AO system. Deployment and pre-integration started about three days prior to the telescope's being available to us. Note that the secondary endured the packing, transport, and unpacking without being contaminated by dust.

Due to technical problems (telescope and AO), the AO was not on the sky until night #4. On the fourth night of the run, the system was finally on the sky and it was possible to confirm that it focused at the correct location. Three nights later, the adaptive optics loop was closed at 20 Hz using the "slow" computer and correcting 22 modes. Two nights later, full speed adaptive optics correction was achieved for the first time. After closer inspection, it turned out that the IR image exhibited a fair amount of astigmatism that was traced down to curvature in the visible light pick-off mirror (dichroic) induced by excessive clamping in the mount. Once this was solved, the image became immediately much more symmetrical as the image below testifies. The night was spent characterizing the system, in particular the reconstructors and the loop gain. Guide stars of faint magnitude were also tried but with modest success due to significant noise in the wavefront sensor camera.

The last three nights of the run were dedicated to the integration of the AO with BLINC/MIRAC, the glorious infrared nulling instrument. Using MIRAC in K-band, we could clearly observe that some astigmatism was present in the images. The spots had roughly a 3-to-1 elongation with a least square circular fit of 0.4 arcsec FWHM.

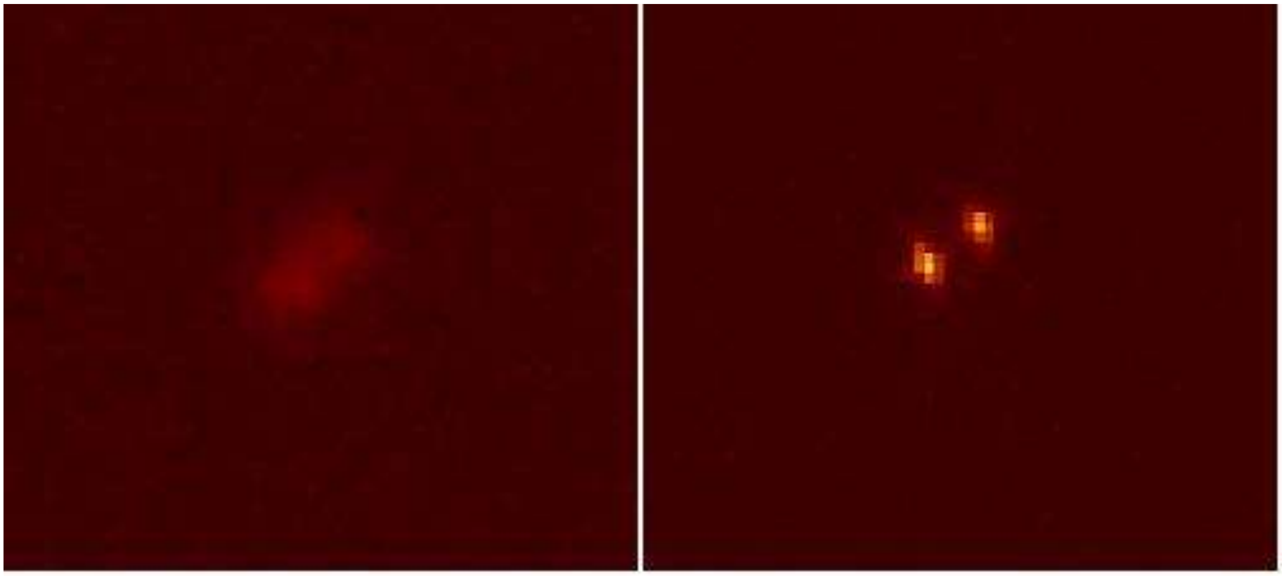


*Figure 1: Here are two 300s duration exposures of the same objects taken in K-band (2.2 micron) with MIRAC. This is the same 0.5 arcsec binary as pictured above, as seen without AO (left) and with AO. Strehl ratio is approximately 10%.*

### ***Lessons Learned***

The AO displays the expected characteristics of a young system with a few technical issues to be addressed and progress to be made on the user-friendliness side. Worries about the sensitivity to contamination by dust are not as acute as they were after the deformable mirror had worked uninterrupted for seven nights, although there are plans to improve the dust protection in the future. Here are the principal lessons we can draw:

- The deformable mirror has run without problems seven nights in a row.
- Closed loop was maintained at times for over an hour.
- Convenience of the system needs to be improved so that the system appears less complicated to the user and requires less personnel for operation.

## **MMT Spectrograph**

C. Foltz and D. Smith installed new detectors in the Red Channel of the MMT Spectrograph, extending the service life of this long-lived and productive instrument. The new detector is denoted ccd34. It is a 1200x800 device processed by Mike Lesser's team at the UA Imaging Technology Lab. The new device is cosmetically clean and has a read noise of 3 e-, nearly a factor of two better than the previous device. The chip position is nearly optimal; very little astigmatism is seen with high angle of use gratings. The operation of the cross-dispersed mode was checked and the instrument was used in this configuration for scientific observations.

Information on the new detector can be found by clicking on the link for ccd34 at the ITL detector page:

*http://www.itl.arizona.edu/UAO/FacilityCCDs.htm*

D. Smith and D. Blanco located and fixed a problem in Blue that was causing erratic indexing of the aperture plate. The limit switch was broken and the drive chain was out of adjustment. Since this repair the unit has worked well. This was always a problem related to temperature. We had to realign the wheel once repairs were completed.

M. Wagner (LBTO) and NASA Space Grant student E. Little have begun a project that will result in exposure time calculators. This will eventually be used for LBT instruments but they will start the project by constructing calculators for the MMT Spectrograph.

**Primary Mirror Support**

There were several primary mirror panics in which the primary mirror was automatically lowered onto its safety supports, interrupting observing. Historically, this was caused by low line voltage. K. Van Horn, T. Trebisky, and P. Spencer first tried to solve this problem by putting the crate on a UPS power source. The problem reoccurred and the +15V supply was temporarily replaced with an external supply. This seems to have solved the problem, and a spare internal supply has been ordered. During this investigation the voltage monitoring circuit was found to be less than desirable and needs to be addressed.

**Primary Mirror Ventilation System**

Evaluation and modification of the ventilation system has been ongoing. This includes performance monitoring and data reduction using Excel spreadsheets.

Computer control of the blower has been achieved and it is now controlled and monitored from the GUI. The Vaisala dewpoint sensor has finally been successfully interfaced to the Cyclades RS232 interface and now is being used by the thermal control software.

Work began on a thermal system technical report. It is envisioned that this report may ultimately be three separate reports: one on the thermal system hardware, one on thermal system software, and one on the thermal system performance as compared to design specifications.

**Servos**

We continue to investigate the servo behavior of the MMT. D. McKenna (LBTO) has been an invaluable resource for analyzing, modeling, and helping to understand the system. We expect to collect more data in the next reporting period for his next go at identifying the system for later use in servo development. In addition, Peter Cheimets (SAO) has come on board as an additional resource for understanding and improving our servos.

## Encoders

The source of the 1024-cycle error on the absolute encoders continues to be elusive, with some analysis and testing done during the reporting period by D. Clark, T. Trebisky, and T. Pickering. The Electronics Group technicians are now building some test tools for doing an independent measurement of the sine and cosine Inductosyn signal. We will be doing some more testing and evaluation (and hopefully, fixing) in January once the test tools are ready for use.

## Tracking and Encoder Performance Profiling

More tests were performed to help track down the cause of the low frequency oscillations in the elevation and azimuth absolute encoders. The first was to take a close look at the indexer output to make sure there are no subtle digital artifacts such as stuck low-order bits. The 16-bit indexer should smoothly ramp from 0 to 65535 and do so 512 times per 360 degrees of rotation (the indexer output is meshed with a 16-bit resolver to give a full 25-bit per 360 degree encoder output). Indexer ramps were run through the IRAF task "bitstat" to check the statistics of the output bits. In every case all of the bits behaved normally with equal numbers of 1's and 0's. The smoothness of the oscillations made it somewhat improbable that the problem was digital, but this was a worthwhile sanity check.

The 1024 cycle/rev oscillation is clearly visible in the detrended elevation indexer ramp output shown in Figure 2. The lower amplitude azimuth oscillation likely is swamped by mechanical signal due to only the inner loop's being closed for this test. D. Clark has been using the clues provided by the phasing of the oscillation with the indexer ramp frequency to track down the problem in the electronics. In the meantime, T. Trebisky added some code to the mount crate to try to compensate for the oscillation. Figure 3 shows the oscillation as a function of elevation angle. At first glance, after a few tests, it appeared to have a constant phase with some position-dependent variation in amplitude. However, several attempts at fiddling with amplitude and phase parameters in the compensation code resulted in little or no improvement in the on-sky tracking performance.

To help further monitor tracking, the Minicam guider code was modified to use higher resolution timestamps, the permissions on the guider log files were modified so that the guider account can write to them, and a cron script was written to compress and rotate the log files nightly. Eventually the Minicam guider logs on *packrat* will be copied over to *hacksaw* and archived with the rest of the guider logs, but there are ssh compatibility issues that need to be resolved first.

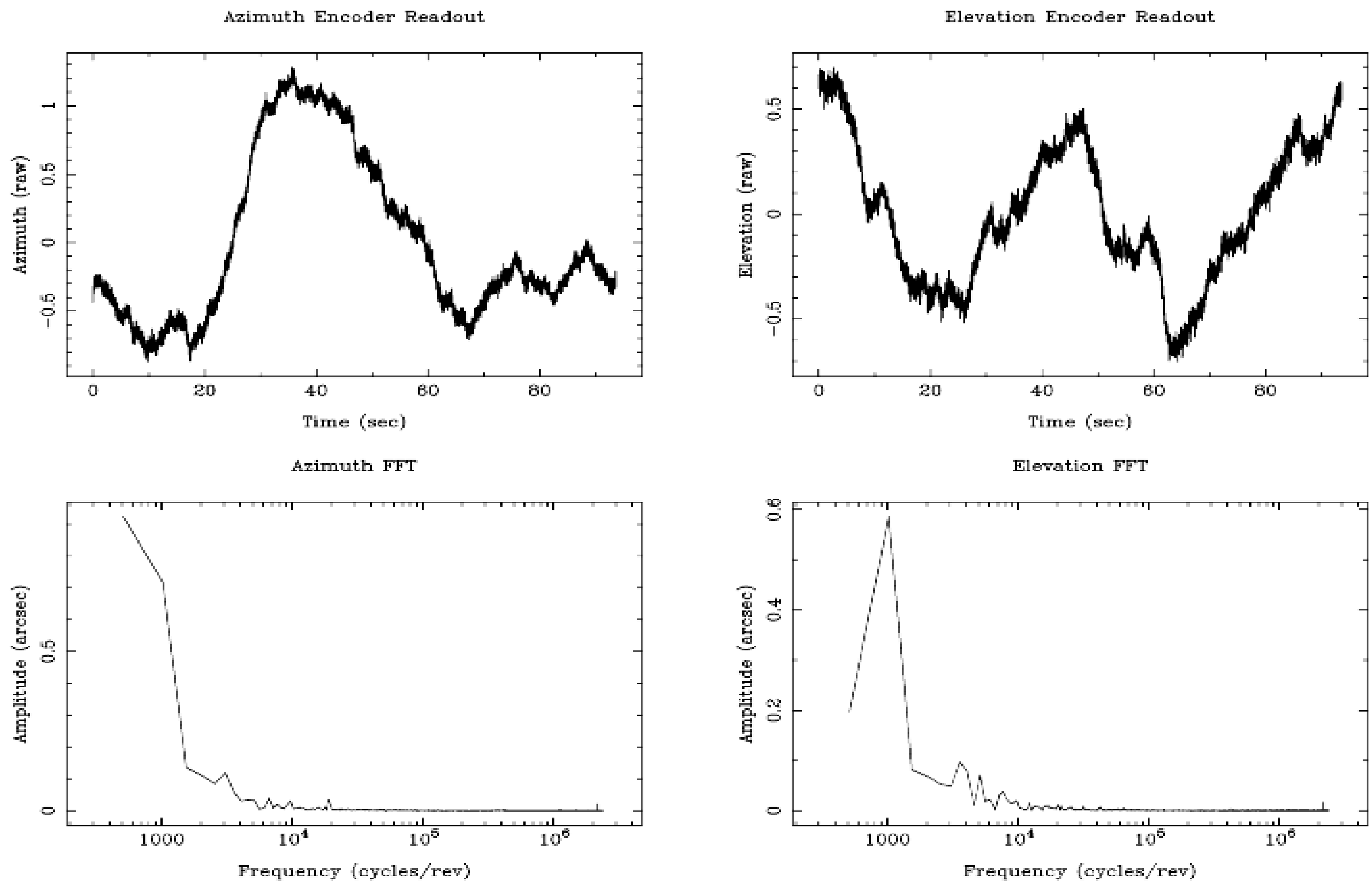



*Figure 2: Plot of detrended indexer readout over a single 0 to 65535 count cycle. The indexer cycles 512 times per 360 degrees of revolution, so the 1024 cycles/rev oscillation cycles twice per indexer cycle. This is clearly seen on the elevation readout. The outer loop was open for this test, which results in the significant mechanical noise that is likely washing out the 1024 cycles/rev signal in the azimuth output.*

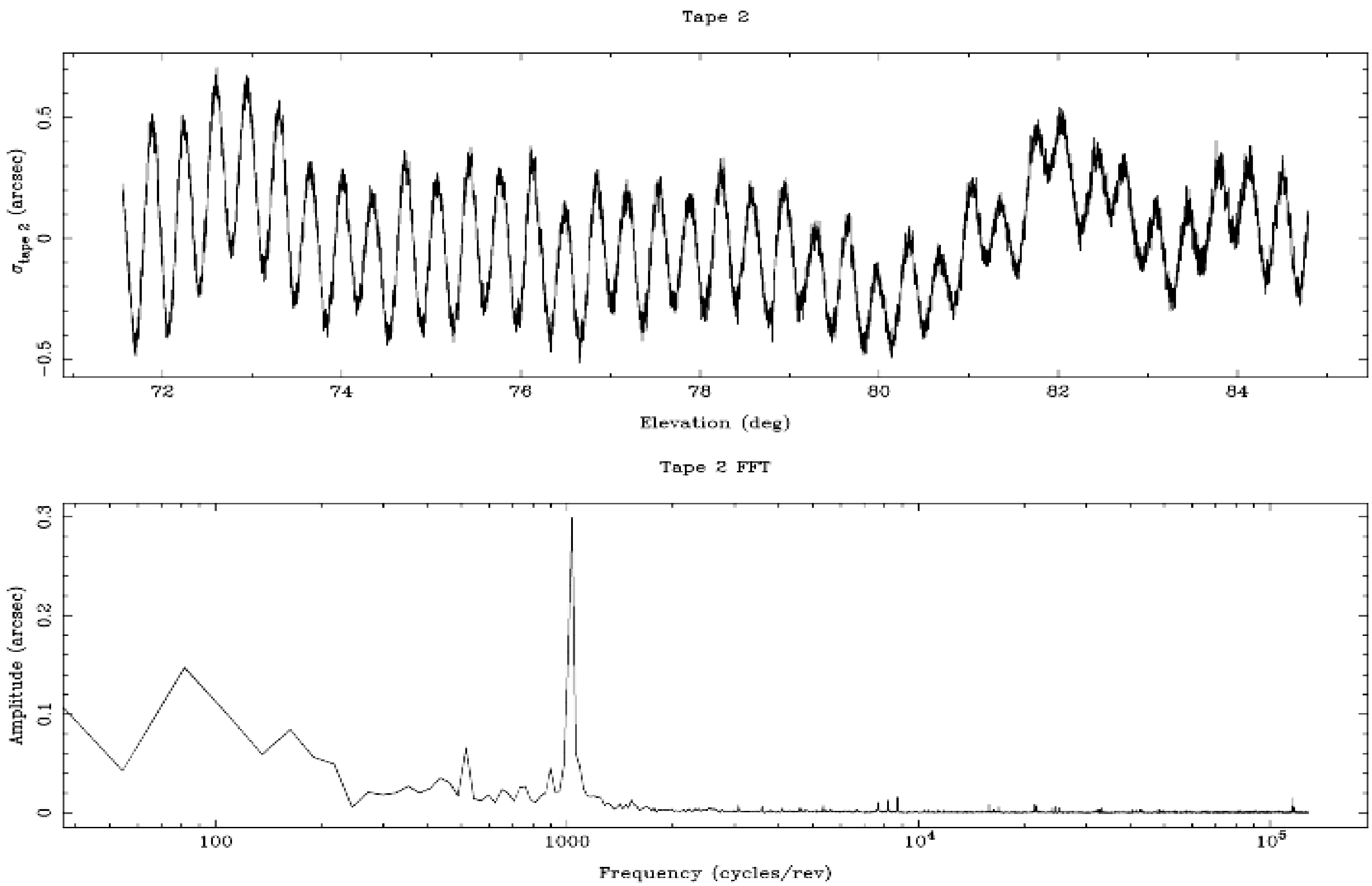



*Figure 3: Plot of elevation tape readout with outer loop closed. Note the prominent peak at 1024 cycles/rev with a smaller, but still significant, peak at 512 cycles/rev.*

## F/5 Secondary Polishing and Testing

During early November the f/5 secondary polishing was completed at SOML and the mirror was subsequently accepted by MMTO, SO, and SAO. This is a major milestone. To the best of our knowledge, this is the largest astronomical secondary mirror ever produced. After correcting for some low-order aberrations, the surface error of the secondary is 17 nm. Buddy Martin is preparing a final report on the polishing; it will be issued as a technical memo. An image of the acceptance interferogram is given on the cover page.

Immediately after the acceptance of the secondary, S. Callahan and the mechanical team installed the f/5 mirror into the telescope cell that had been moved from the MMTO shop to SOML. After careful testing of the support system, the mirror and cell were moved onto the secondary test tower to measure the figure. By the end of December we were successfully supporting the mirror and producing interferograms that were nearly identical to the interferograms taken on the polishing cell. In early January, S. Callahan and B. Smith (SOML) will write a report on a direct comparison of the two mirror support systems.

The f/5 secondary lifting fixture components were collected, assembled, modified in some cases, and cleaned in preparation for aluminizing the secondary in early January. B. Kindred is spear-heading this effort.

## F/5 Mirror Support

The f/5 mirror support electronics design was finalized and turned over to C. Knop for layout and subsequent fabrication by Advanced Circuits. We expect to have results for test of the new printed-circuit board in the next reporting period.

We have lifted the mirror with both the wire-wrap card and now with the PC version. Enough problems were discovered with the quality of the PC board that K. Van Horn feels we will be justified in doing a new layout and acquiring a new board from a different source. The existing board should be developed through the rest of the process, and then all the fixes will be incorporated into a new board. This effort will be ongoing.

## F/5 Hexapod

The updated design of the hexapod control system proceeded during the reporting period with only a few of the usual last-minute glitches. The power amplifier cards were laid out by C. Knop and populated by B. Comisso. They were checked electrically and installed onto their heatsink assembly. The new wire-wrap control cards were built, and we expect to have good progress on having fully debugged firmware by the middle of January. The electronics was repackaged into a single double-height Eurocard chassis, and some "pre-owned" power supplies were pulled from storage to serve as the high-power linear supplies for the motor amplifiers. The new chassis, power supplies, and cabling are expected to be complete in early January, and we will subsequently turn the hardware over to the Software Group for development.

Preliminary tests of repeatability of position commands for the new f/5 hexapod were performed.

**F/5 Instrumentation**

Visits from Frank Licata and Mike Honsa (December 9-13), Dan Fabricant and Bob Fata (December 11-13), and Roger Eng, Jack Barberis, and Mark Ordway (December 16-20) advanced the ongoing installation of the fiber runs, bench spectrographs, and helped us plan for other modifications in support of the f/5 instrumentation.

The Hectospec alignment, led by N. Caldwell, is currently as good as it was in the lab at Cambridge. Preliminary test images show that the fiber images have a 98% encircled energy radius of approximately four pixels. This should be compared with the Zemax model estimate of approximately three pixels. Additional measurements using 50-micron fibers are planned to determine if this is the characteristic image size for the instrument.

The test images also revealed both internal scattered light as well as ambient room light. One source of scattered light was tracked to the inner wall of the corrector cell and the ground edge of the corrector lens. A temporary baffle was installed while a permanent solution is being designed. More tests are planned to identify additional sources of scattered light. The Andy Cam instrument is being used to track down sources of the ambient room light. R. Eng (SAO) completed measurements and designed a tent to enclose both Hectospec and Hectochelle.

The Hectochelle gratings were installed in early November. Alignment of the instrument, led by A. Szentgyorgyi, is now complete through the grating. The corrector and camera will be installed and aligned by early February.

S. Nichols (SAO) provided on-site support for the full two months.

A meeting was held on December 12 to formulate plans for the March and April f/5 commissioning runs. Participants included J. T. Williams, D. Blanco, D. Fabricant, B. Fata, N. Caldwell, B. McLeod, and G. Williams. The primary goal for the March run will be to commission the f/5 secondary and the f/5 wavefront sensor and to assess the performance of the bare Cassegrain optics. The primary goal for the April run is to commission the f/5 corrector and baffles and to assess the performance of the wide-field optics.

G. Williams traveled to Cambridge on December 19 to meet with SAO scientists and engineers regarding implementation of the iodine vapor cell into the Hectochelle instrument. The iodine cell should be ready for use shortly following first light.

**Miscellaneous**

Components for the new topbox alignment laser are fabricated and assembled. As feared, the beam splitting optic does have considerable wedge, rendering it unsuitable. It will be replaced with a pellicle.

## Computers and Software

### Hexapod Software Modifications

Work has begun on an effort to reorganize the software used to control the hexapod used to position the telescope secondary. The software currently in use with the f/9 secondary has served us well for a number of years now, but we have become aware of a number of limitations in the software, and want to make changes that will make telescope operation simpler as well as make observing more efficient.

Currently the hexapod is controlled by software running under VxWorks on a VME bus computer, as well as scripts running on the operator console computer. The changes in progress are moving much of the control code from the scripts into the real-time computer, making us much less dependent on network performance for proper functioning of the hexapod. One goal of the changes is to allow smooth platform motions, such as focus changes, by moving all of the pods in a synchronized manner. Our scripts will then become true "user interface" scripts, and it will be possible to run multiple instances of them to monitor status of the hexapod.

The hexapod software now supports the f/9 and f/15 secondaries (which have different geometries), and will soon need to support the f/5 secondary with a significantly different complement of interface electronics. We intend to present a uniform interface to all of these secondaries using network sockets. Commands such as focus changes will now be directed to the appropriate sockets on the hexapod computer using a consistent protocol in all cases.

We are also developing and testing an improved set of network protocols on the new hexapod, which will someday be used on the mount computer and the primary mirror cell.

### Miscellaneous

A prototype msg server in Ruby was completed, and is compatible with the existing Tcl msg socket protocol. The server allows multiple msg clients to register that they wish to be informed when a variable in the server changes. Clients can also execute registered commands within the server as is done in Tcl msg servers.

Hexapod errors in reading the LVDTs were addressed. Maintaining a set of cached values for the LVDT readings in the hexapod crate, rather than directly querying the small-board computer for LVDT values, has removed the source of these errors.

A summary of functionality and ASCII commands that could be migrated from the hexapod GUI into the hexapod crate was prepared. C code was written for LVDT voltage-to-micron conversion for use in the hexapod crate. In addition, polynomial equations were determined for these voltage-to-micron conversions for use in place of the existing lookup tables. New transformation matrices were created for the f/15 hexapod and were incorporated into a f/15 hexapod GUI.

Modifications were made to the "scope" GUI so that catalogs can be opened directly from the file menu. In addition, slew and scratch catalogs are now created and can be opened directly by the operator. The coordinates for any telescope slew made by the operator are automatically appended to a slew catalog for the night. The operator can append coordinates to a daily scratch catalog that can be used at a later time.

The Vaisala weather station, which includes temperature, relative humidity, and dewpoint data, is now accessible over the network. Software was written so that the dataserver queries the Vaisala at regular intervals. Vaisala data are being logged by the dataserver and are incorporated into thermal GUIs for the operators.

Decision trees were prepared for warming, cooling, and idle modes for the thermal system. These decision trees were presented to MMT staff. Code changes were made to the thermal software that implement a simple auto mode. The operator specifies an offset, for both the Carrier and Neslab, from the ambient temperature as measured by the Vaisala.

Modifications were made to the dataserver to fix file user permission problems. All output from the dataserver is now redirected to a log file. The Perl script that automatically generates Excel spreadsheets from the dataserver log was migrated from *hacksaw* to *mmt*.

Documentation was written in HTML format for the various Ruby classes in the dataserver. This documentation describes all Ruby classes in the dataserver and the methods for each class.

## Optics

No activity to report.

## General Facility

The secondary hoist parked switch is installed and functioning, although it can still be pushed past the limits. This will cause a violation of the elevation safety chain if the hoist is not carefully parked. Mechanical stops need to be installed to prevent this problem.

## Maintenance and Repair

### Building Drive

A cold front (with first snow) and a warm building resulted in differential thermal expansion between the building and the radial track in the pit, causing the building drive to fail on Saturday December 8. J.T. Williams, K. Van Horn, and D. Smith responded and were able to cool the pit. This helped restore the building drive's functionality. On December 9, D. Blanco, R. Ortiz, and P. Ritz removed a shim from one building azimuth roller. This alleviated the problem; however, several building crashes have occurred since. It appears that tuning the building servo may increase the effective operating margin. P. Spencer and K. Van Horn are monitoring the building servo signals in preparation for servo tuning during the next reporting period.

In December, an Agilent Technologies DAU was configured to monitor the building drive Copley motor amplifiers. The DAU was connected to the current and voltage monitor outputs of the two drive amplifiers and placed in the scan mode reading at 0.1 sec intervals. On December 20 the DAU captured a building shutdown during a slew. The graph below shows the building drive voltages during the slew. The monitored voltages are scaled at 40V/V, and each data point is read at 0.1 sec intervals. The graph clearly shows a large voltage spike ~ -280V on motor #2 at reading #4427. This voltage spike exceeded the amplifier bus voltage of 270V, which should activate the building drive "dumper." If the dumper circuitry is not properly adjusted or is inoperable, the Copley amplifiers internal protection should engage and shut down the drives. Another observation derived from the motor current building shutdown data was what appears to be an under-damped resonance and a suspicious current offset.

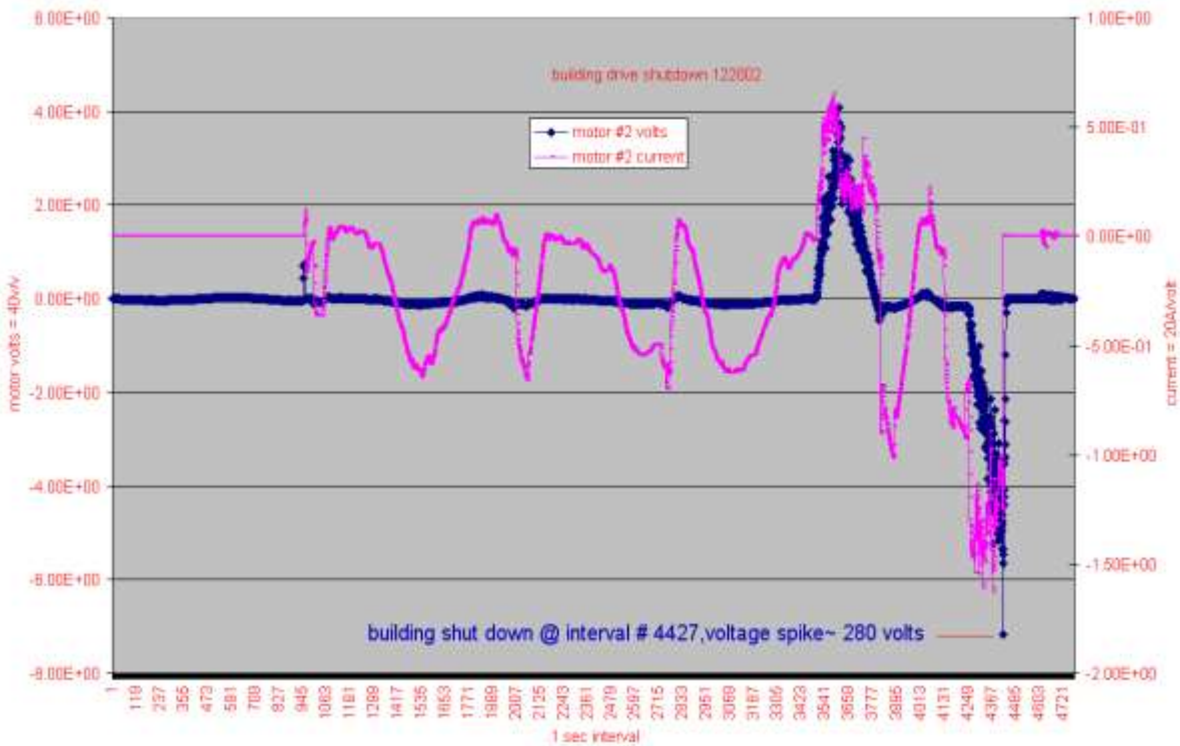



*Figure 4: Building drive motor voltage monitored during a shutdown.*

**RUPS**

RUPS crashed due to an aged relay. Locating and repairing this took some time. The part was bent back into shape and is now operating. During this process the DC motor brushes were found to be bad but no spares were available. Spares were ordered, the brushes were replaced, and the commutator was trued. After the batteries were recharged, the unit came up with little problem although the frequency adjustment is still problematical. It might be useful to investigate an alternate method for controlling this frequency.

RUPS was off-line during most of the holidays, and fortunately Citizen's power was reasonably dependable with only minor glitches during this period. RUPS continues to be a maintenance challenge as the manufacturer is no longer in business. K. Van Horn, D. Clark, and P. Spencer are considering installing UPS's at key points as an alternative to RUPS.

## Visitors

November 7: Ken Steele from Kaman Aerospace accompanied by Kurt Kenagy and Ken Ramey (Steward Technical Group) and T. Trebisky. Ken Steele will be writing the software for the LOTIS collimator. He was shown the user interfaces for the MMT to give him an idea of what he'll need to provide for LOTIS.

November 8: Prof. Tushar Prubhu (Indian Institute of Astrophysics, Bangalore) and one colleague, accompanied by P. Wehinger (SO).

November 14: Michel Chevalet (French TV science journalist) and Bruno Caron (cameraman), accompanied by Dr. Hevre Dole (Steward), his wife Caroline Barban, and C. Foltz. The title of the broadcast is "La Science en Question," a monthly 26-minute science magazine, and is on a cable/satellite channel under the Canal Satellite consortium. It will be broadcast in late November. Courtesy of H. Dole, images are available at the following URL:

*http://lully.as.arizona.edu/~hdole/observatories/20021114MMTChevalet/*

## Publications

### MMTO Internal Technical Memoranda

02-2 MMT Mount Control System Operation and Performance
D. Clark

### MMTO Technical Memoranda

None

### MMTO Technical Reports

None

### Scientific Publications

02-16 The Frequency and Radio Properties of Broad Absorption Line Quasars
Hewett, P. C., Foltz, C. B.
To appear in the April 2003 *AJ*

### Observing Reports

M. Lloyd-Hart: November 13-21, Adaptive System

Copies of these publications are available from the MMTO office. We remind MMT observers to submit observers' reports, as well as preprints of publications based on MMT research, to the MMTO office. Such publications should have the standard MMTO credit line: "Observations reported here were obtained at the MMT Observatory, a facility operated jointly by the University of Arizona and the Smithsonian Institution."

Submit publication preprints to *bruss@mmto.org* or to the following address:

MMT Observatory
P.O. Box 210065
University of Arizona
Tucson, AZ 85721-0065

**MMTO in the Media**

No activity to report.

**MMTO Home Page**

*Important Note: The MMTO web site has moved to http://www.mmto.org. Please update your links.*

The MMTO maintains a World Wide Web site (the MMT Home Page) which includes a diverse set of information about the MMT and its use. Documents that are linked to include:

1. General information about the MMT and Mt. Hopkins.
2. Telescope schedule.
3. User documentation, including instrument manuals, detector specifications, and observer's almanac.
4. A photo gallery of the Conversion Project as well as specifications and mechanical drawings related to the Conversion.
5. Information for visiting astronomers, including maps to the site and observing time request forms.
6. The MMTO staff directory.

The page can be accessed via URL *http://www.mmto.org*.