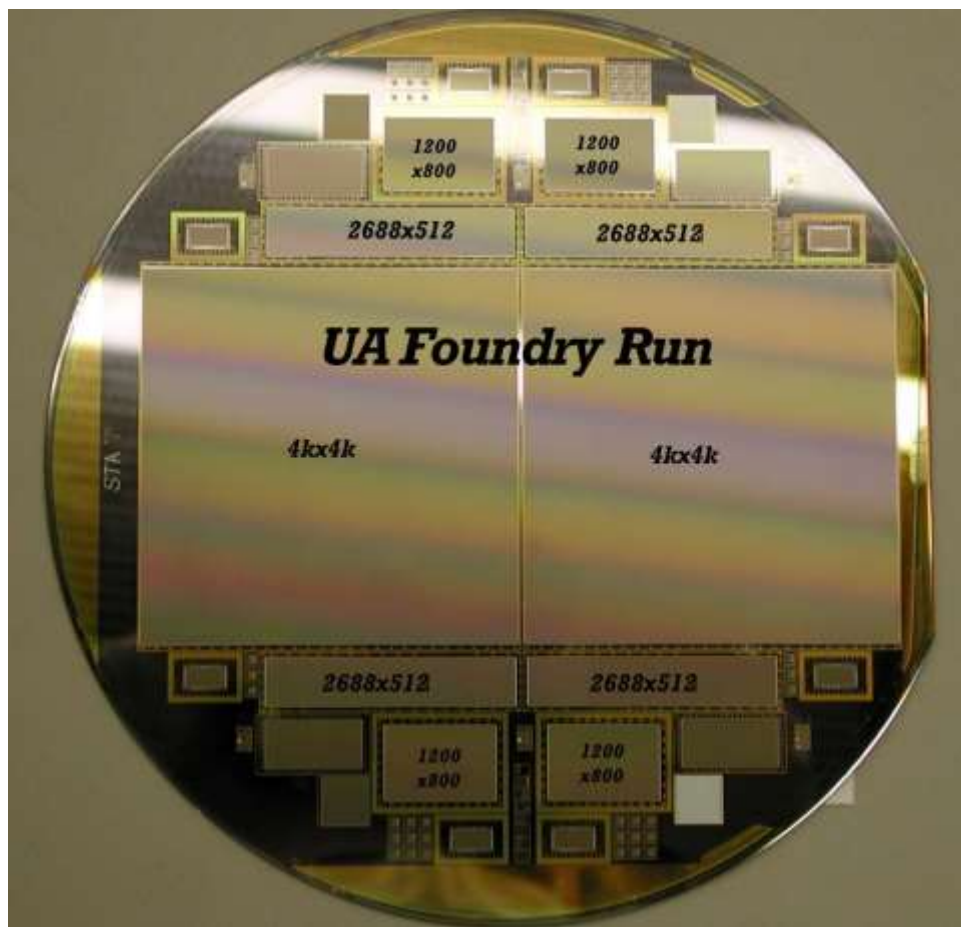


BIMONTHLY SUMMARY

January - February 2002



*An image of a completed wafer containing the new Red and Blue Channel CCD detectors.
Image by Mike Lesser, ITL.*

Personnel

Mike Alegria is now serving as our third telescope operator. Mike replaces Carol Heller who retired last year.

On February 15, the “Committee on Origin and Evolution of Life” of the National Academy of Sciences toured the MMT. They were hosted by Jonathan Lunine (LPL) and Dan Brocius.

Craig Foltz, Dan Fabricant (SAO), and Gary Schmidt (SO) participated in the final Pre-Ship review for the DEIMOS spectrograph on January 4.

Craig Foltz presented a Lecture entitled “The Big Bang for Beginners” as part of the annual FLWO Green Valley lecture series on February 20.

Development

Mirror Support

During this time period cell crate modification and repair was initiated. The primary task was to find a possible wiring error or discontinuity that might have caused the false reading of the main hardpoint air monitor in the cell GUI. A discontinuity was traced through the cell wiring back to the Greenspring’s IP carrier card in the cell VME crate. One repair attempt exchanged the IP carrier card with a spare Greenspring #VIP616 card. The spare card eliminated the hardpoint reading error, but caused an error in reading the first 15 channels of the cell force monitor. That is, the computer was not seeing force monitor multiplier chip 0 channels. This shows up as a force error on cell actuators 1-16, and a mirror panic results. After several conversations with K. Van Horn, D. Clark, and K. Duffek, it was decided to exchange the VIP616 carrier card again – this time with the carrier card used in the actuator teststand. This fixed the problem. On close inspection of the two IP carrier cards it was found that the spare card is a later version of the cards used in the teststand and the original cell crate. Theoretically (according to the manufacturer) the two versions are interchangeable, but at this time it is not known how to do this. Presently the carrier card that was originally used in the cell VME crate is now being used in the actuator teststand, and the carrier card that was used in the actuator teststand is being used in the cell VME crate. Both systems are now in operation.

A key switch has been added to the cell power supply chassis that allows the cell computer to be powered for hardpoint testing without powering up the primary mirror actuators.

Hexapod and Thermal System

A considerable amount of time was spent analyzing issues that arose with the hexapod (including focusing and collimation) and thermal systems after the telescope came back on-line in January. Many of these issues, such as persistent alarms with the Carrier cooling unit, freezing of the Neslab cooling unit, and erroneous LVDT readings from the hexapod, are still being addressed. A purchase order is in progress to repair and upgrade the Carrier so that it can operate at sub-freezing temperatures. This will reduce the cooling load on the Neslab. Software and operator procedures

were modified to reduce icing and overloading problems for the Neslab. Hardware modifications were made to the LVDT for actuator 1 of the hexapod.

Telescope Tracking

After a significant amount of investigation, it was determined that the tracking performance at the MMT is compromised significantly by two effects: 1) compliance in the elevation drive system that limits stiffness, and 2) an occasional discontinuity in the apparent az-el coordinates as measured from the absolute encoder.

Continued testing during this reporting period was aimed at determining the source of the low-frequency resonance of the elevation drive train. Using the LBT DSP tools with D. McKenna's help, we measured the open-loop response of the elevation axis with the feedback from the incremental encoders converted to analog signals via the DSP board. Using the DSA to measure the Bode response of the telescope in open-loop configuration, we detected a low-Q resonance at ~ 1.85 Hz. Further investigation revealed that the elevation motor mounts are under-constrained in rotation about the motor axis. The total lost motion due to this windup is of order 2 arcseconds on the sky under full torque. In addition, the motor is fairly unconstrained along the drive arc axis. More careful measurements of the magnitude and direction of the motor case motion remain to be done. It is clear from these early results that we must correct the motor mount resonance before we can hope to achieve better elevation tracking.

Until this reporting period, it was not clear whether the coordinate discontinuity was just a display artifact or a physical problem with the drive/encoder system. We have determined that it is the latter. While slewing the telescope in elevation, the hardpoint forces were being monitored at 111 Hz. Figure 1 shows a plot of the hardpoint forces vs. elevation for a complete slew cycle between 90 and 20 degrees. The ringing in the hardpoint forces was suspicious, and upon further examination we found that elevation discontinuities impulse the telescope structure (as shown in the lower two figures).

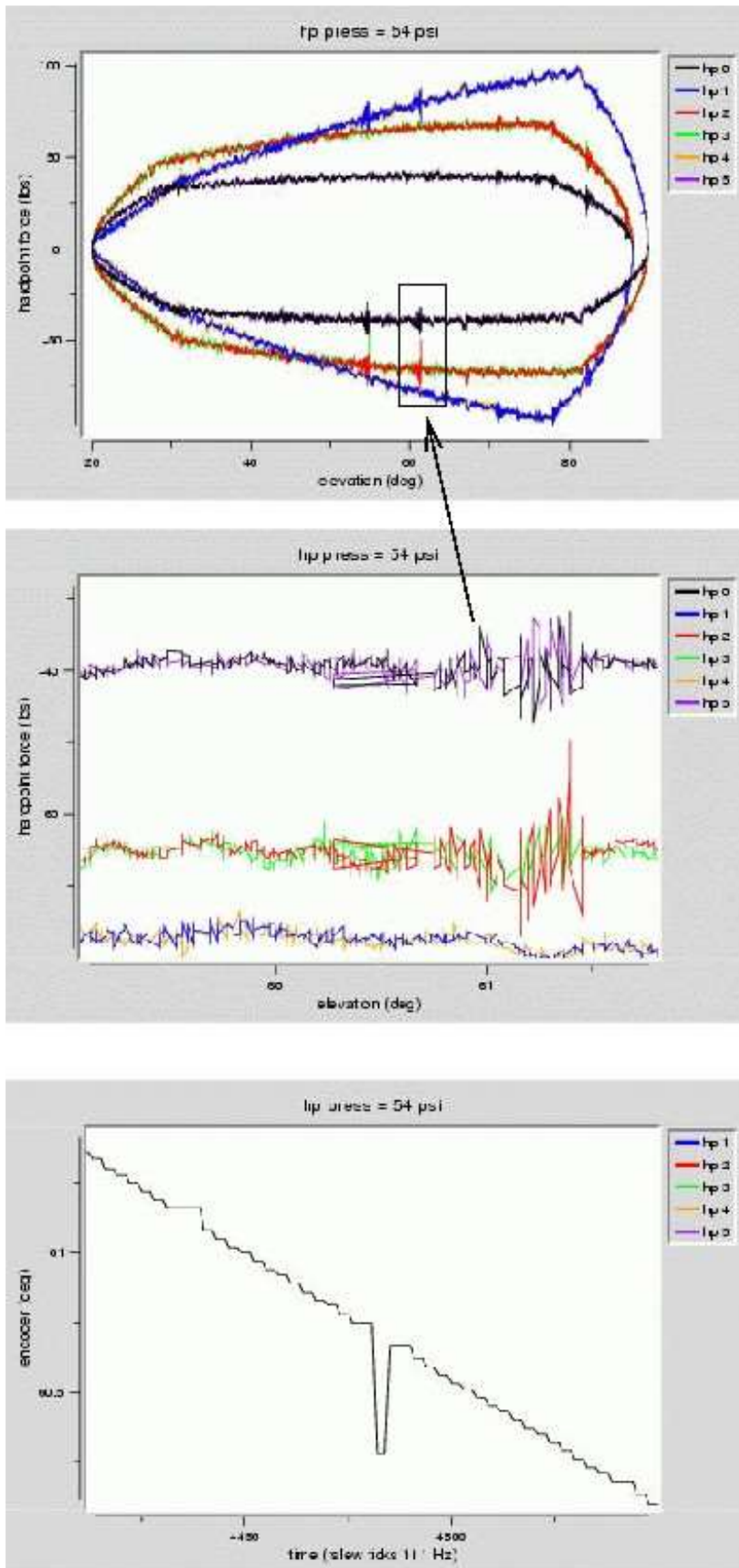


Figure 1: Hardpoint force (y) vs. elevation during slewing (top). Middle shows zoom of hardpoint force during a ringing event. Zoom of elevation encoder (y) vs. time showing that an elevation discontinuity causes the structural ringing in the hardpoint platform (bottom).

The elevation servo amplifier has also been checked and found to be within acceptable limits of its calibration.

Wavefront Sensing

High Resolution Interferometric Hartmann

The interferometric Hartmann was attached to the top box during January 7-8 to assess the passive performance of collimation and primary mirror thermal control. Only a single observation could be made prior to cloudy weather conditions. Figure 2 shows the diffraction image calculated from the first 19 Zernike modes (excluding tilts and defocus). The collimation was untouched from the previous night, the primary mirror thermal control was working normally, and no figure correction was applied. The box is 0.25-arcsec on a side.

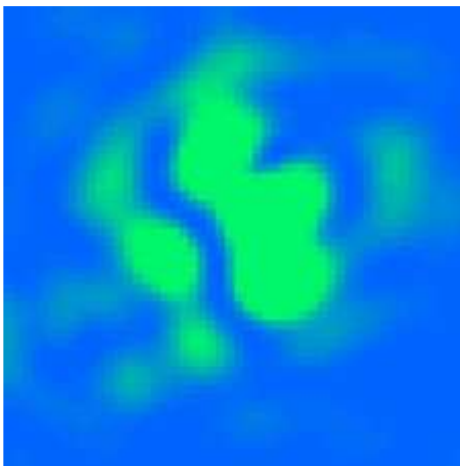


Figure 2: The passive on-axis diffraction image of the MMT on January 7, 2002. No figure or collimation corrections were applied prior to measuring the wavefront. The box is 0.25×0.25 arcsec. This image shows that the passive performance of the telescope is becoming quite good.

Top Box f/9 Shack-Hartmann Wavefront Sensor

Working from an optical design by S. West, S. Callahan and Ron James designed the optical support hardware and completed the package of fabrication drawings. R. Ortiz worked with P. Spencer to modify a 2-axis stage for the wavefront sensor and to set up the limit switches and electronic controls. R. Ortiz completed the fabrication drawings for the limit switch assembly. A schematic is shown in Figure 3, and the device just prior to the installation of the optics is shown in Figure 4.

P. Spencer initiated a stepper motor driver card electrical design for the wavefront sensor. The stepper motor will allow the sensor to be remotely switched between direct imaging and interferometric mode.

S. Callahan worked with B. McLeod and others from SAO to work out a means to mount the f/9 top box wavefront sensor onto the Minicam shutter plate.

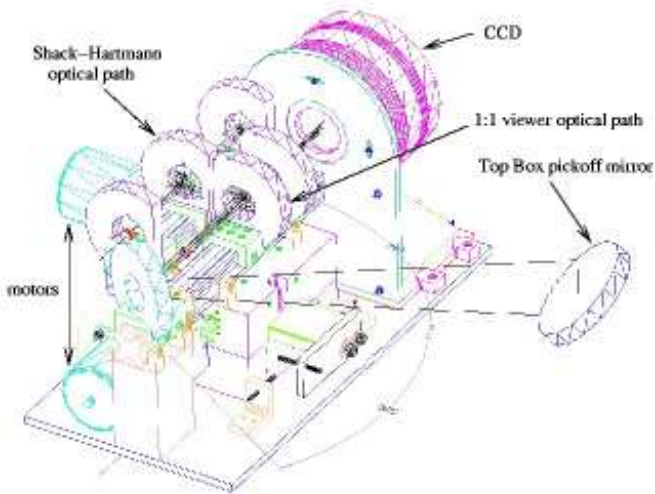


Figure 3: Schematic of the $f/9$ top box Shack-Hartmann wavefront sensor. One of two optical rails can be inserted into the beam.

Figure 4: Photo of the $f/9$ top box wavefront sensor prior to inserting the optics.



F/9 Collimation

In the past, elevation-dependent collimation problems have arisen from the secondary support system and from the primary mirror hardpoints. Since the modifications to the secondary mirror support system last December, it has remained stable and problem-free. We have implemented computer monitoring of the secondary load cell forces so we can see the beginnings of potential problems with the support system, should they arise.

However, the primary mirror hardpoints have continued to cause intermittent collimation problems. Two more hardpoints required removal and correction of soft breakaway mechanisms. Modifications consisted of re-gapping and changing the number of springs in the breakaway mechanisms of the problematic hardpoints.

Although reducing the frequency of hardpoint-related collimation problems, these modifications did not eliminate them. Rather than simply looking for soft breakaway mechanisms under slew conditions, we devised a new test where the hardpoints were reacted against the mirror and scanned

through the region from tension breakaway to compression breakaway. The results are shown in Figure 5. The hardpoint profile behaves as generally expected. As the hardpoint length is changed while in the tension breakaway (left side of graph), the force changes very little. The stiffness becomes large when the hardpoints finally “lock-up,” and then the compression breakaway is characterized by two levels corresponding to the spring forces and then the air pressure (hardpoint #4 [gold] shows no air pressure breakaway because it has an exceptionally large spring gap). Two hardpoints show a discontinuity in their “lock-up” profiles that appear to be some type of stick-slip behavior for small negative forces. The worst case (hardpoint #3: green) will be replaced during the next engineering run.

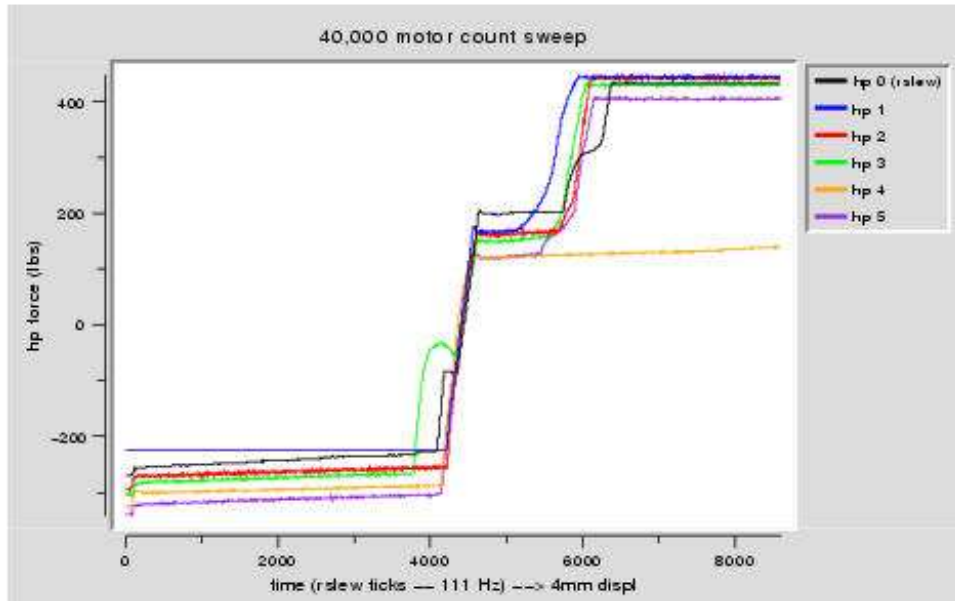


Figure 5: Primary mirror hardpoint breakaway profiles. Hardpoint force (Y) is plotted against time for a constant velocity scan of the hardpoint length corresponding to 4 mm.

Videoscope Camera

B. Kindred and R. Ortiz designed the hardware to mount the Videoscope camera into the f/9 top box. S. Callahan and R. James, with support from J. Ludeke and S. Bauman, quickly completed the drawings for fabrication at the University Research Instrumentation Center.

F/9 Mirror Support

A Microchip PIC16C773 processor-based digitizing board was added to the mirror cell electronics for reporting the support loadcell forces over an RS-232 link. D. Clark and S. West verified its operation with a small Tcl script. The force data can be sampled continuously, or one “snapshot” can be taken by sending a simple command character over the link. The system remains to be integrated into the operators’ GUI system by the software group.

F/9-F/15 Hexapod

The f/9 hexapod single board computer (SBC) battery (#2032) was replaced. The battery configuration was also modified to accommodate faster and simpler battery replacement. The original installation directly soldered the battery to the PCB board, which makes for difficult repair and maintenance. Battery replacement required that the SBC be removed from the f/9 secondary and then all power to the SBC removed. This action could possibly wipe out the SBC's programming. To ensure that the SBC does not lose programming during this procedure, two parallel battery sockets were added. When replacing with a fresh battery, the new battery is installed in the empty socket and then the old battery is removed from its socket, thereby allowing battery power to be maintained during battery replacement. The battery should be replaced every two years. P. Spencer completed this modification with B. Comisso and K. Van Horn.

The brass bushings for the LVDT connecting rods were removed. The tight core alignment requirements imposed by these bushings would sometimes result in sticking LVDT cores and bent connecting rods. P. Spencer and R. James carried out this modification.

After these modifications, the f/9 hexapod control electronics and power supply were installed in racks in B. Kindred's lab. This required moving secondary cabling from the west side of the telescope OSS to the east side. This task was completed by C. Knop and B. Comisso.

We attempted open-loop corrections of the telescope focus for temperature variations with mixed success. The corrections were based on both ambient and OSS steel temperatures. Rather than refine this correction further, the effort was put into the new top box wavefront sensor, which will make closed-loop corrections of the focus.

F/5 Mirror Support System

After a number of minor setbacks, the prototype mirror support board was completed during the reporting period. The initial harness wiring was begun in the cell, with every part (loadcell, valve, etc.) connected to the harness via an intermediate connector. This will make it simple to replace the part if necessary in the field; simply unsnap the connector, remove the part, replace, and reconnect the wire. As soon as the dummy mirror assembly is complete, we will begin installation and checkout of the electronics.

J. Ludeke and S. Callahan designed a cart for handling the mirror. This cart will be used for installing the mirror into the cell. It will also store the mirror when not on the telescope.

S. Bauman designed hardware to mount three LVDTs parallel to the f/5 tangent rods. With the three axial LVDTs already in the cell, we will be able to measure the position of the mirror with respect to the cell. These LVDTs will also determine the stiffness of the support system.

The SAO team of Mark Ordway, Jack Barberis, Frank Licata, and Larry Knowles were at MMTO February 12-14 working on a variety of f/5 instrumentation issues, including layout and tests for elevation axis cable carriers, à la energy chains.

F/5 Hexapod

The hexapod amplifier and controller have been tested extensively on the spare actuator in the lab. R. James and B. Comisso began initial wiring and checkout of the hexapod itself. It was discovered in the process that as the hexapod struts change length, the roller nut/cardan joint twists slightly. This leads the proximity switches used for travel limits to either have the detector tab out of detection range (0.8 mm) or to run into the proximity switch body. We have determined a replacement scheme using mechanical limit switches and a new mounting tab to correct this problem. Most firmware updates to the controller have been completed, with a few minor changes needed prior to turning it over to the software engineer. Firmware changes have been made quite simple with the replacement of the PIC16773 unit (a UV-EPROM type) with a PIC16F873, a unit with twice the memory space that is Flash-reprogrammable. When the complete cable harness that we will use at the telescope is built, it will be ready for testing and software development.

Miscellaneous

S. Callahan and J. Ludeke modified the powered instrument mover to accept standard trailer hitch hardware.

Computers and Software

Instrument Rotator Software

A significant amount of effort was expended during this time period to improve the instrument rotator software. We have made rotator limits persistent so that the operators do not have to reenter them after every software boot. A number of features have been added to avoid the need for the operators to make calculations involving position angles by hand. A feature has been added to support a mode, referred to as “Track at Zero,” see Figure 6, where it is desired to maintain the instrument slit nearly normal to the horizon, yet to have the rotator actively tracking so that the autoguider can be used.

Dismiss	Recal	Tracking Off	Tracking On	Track at Zero
Rotator Slew	0	Go	Home	
Rotator Jog	0	-	+	
CCW Limit	-180	Set	-140.00000000	
CW Limit	180	Set	120.00000000	
Instrument offset	0	Set	0:00:00.00	
Parallactic angle			-359:59:60.00	
Position angle Jog	0	-	+	
Position angle	0	Set	TFH	0:00:00.00
Position angle offset	-90 90.00	+0 0.00	+90 -90.00	+180 -180.00
demand position				0:00:00.00
current position		Synch		0:00:00.00
Rotator Tape (NE Head)	999.00000000	Uncal		
Rotator Tape (SW Head)	999.00000000	Uncal		

Figure 6: The new rotator GUI.

During the end of this time period, we experienced a catastrophic failure of the incremental encoders on the four motors driving the rotator. This necessitated reorganizing the servo code to allow the rotator to be run using only the tape encoder. This has turned out to work very well, and the tape encoder has been entirely reliable and robust.

GPS Clock and NTP Time

A key step in the process of improving telescope pointing is the definition of an accurate time base. The first step in this process was to configure the computers on the summit to use NTP (network time protocol). Without NTP, the system clocks of our computers could drift as much as minutes per week. With NTP running and utilizing the campus timeservers, along with a sample of public servers spread around the Internet, excellent stability was obtained with hoseclamp and alewife with RMS offsets of <10 ms over timescales of weeks. Hacksaw, however, does not appear to have a stable system clock and can drift off by 100 ms or more on timescales faster than NTP can handle. NTP corrects the offsets eventually, but not smoothly, so hacksaw's clock is not terribly trustworthy.

The next step was the acquisition of a dedicated NTP server with a built-in GPS-based clock and temperature compensated crystal oscillator. The unit purchased was the Praecis Gntp from EndRun Technologies. Its key features include:

- The use of Linux as its operating system, which allows it to be accessed and configured much like any other Linux machine using standard tools like ssh, scp, and the bourne shell.
- 1 Hz (PPS) and 1 kHz pulse outputs. Both are TTL and synced on the leading edge of the pulse. The PPS pulses are 1 ms in duration while the 1 kHz output has a 50% duty cycle.
- Ability to maintain accurate time lock without constant GPS satellite lock. The local oscillator allows the unit to freewheel for several hours without any GPS lock and with very little degradation in time accuracy.

Once the unit knows its spatial position accurately, it only requires one visible satellite to maintain a time lock. This makes it practical to keep the GPS antenna indoors near a window where it is protected from lightning and the elements. An attempt was made to use the existing GPS antenna attached to the building near the loading dock, but it is not fully compatible with the Praecis and thus not reliable. When the Praecis is running and fully locked, the internal time accuracy is 10 microseconds or better.

The most crucial step was getting the NTP time into the mount control VME computer. Since the mount software runs under VxWorks, which does not routinely support NTP, it was necessary to expend substantial effort to adapt and test publicly available source for the ntpdate program. This is important because the rdate protocol that VxWorks uses by default rounds time to the nearest second. Ntpdate, as we have now adapted it, runs well under VxWorks and polls a list of timeservers to obtain a 64-bits time value. From this list, a single server is selected based on a number of criteria, including the network delay to that server, and the advertised stratum of the server. The Praecis GPS clock is on the local network and is a stratum 1 server (the highest level). So if it is running, the GPS clock will be the server used. If the GPS clock is not available for any reason, however, this scheme offers a smooth and transparent failover to another server. This

scheme is now in use, and the mount currently synchronizes time both on software boot and again when slew to a new object is requested. A time offset of 1 or 2 milliseconds is typically obtained.

We also have modified the mount software to allow the operators to introduce the current DUT (DUT=UT1-UTC) correction.

Cyclades Terminal Server

For months, the deployment of our 32-port Cyclades terminal server was delayed due to a mysterious data buffering “feature.” If one connected to a network port on the Cyclades via telnet, data went through to the matching serial port with no delay. However, if one connected using a raw network socket, the data would get buffered by some seemingly arbitrary amount before anything got through to the serial port. The problem turned out to be a combination of old firmware and poor documentation. The old documentation only listed two possible port modes: socket (i.e., telnet) and ssh. The manual for the new firmware listed a new mode: raw_data. Installing the new firmware and configuring the ports to use the raw_data mode cleared up all of the data buffering issues. Work is underway to optically isolate the things we wish to interface using the Cyclades.

SAO Autoguider

During the first week of January, B. McLeod and T. Pickering worked extensively on the SAO guider to fix outstanding issues, make it more robust, and make it easier to use. This was very successful and the guider has been used extensively in the weeks since with very few problems. Starting up the guider is now just a matter of selecting the appropriate instrument entry from the desktop menu. Another key usability feature is the ability to easily customize the guider for different instrument configurations. Generally, if there is RS170 video available, then all that is required is the orientation of the camera and its pixel scale, which are then plugged into a new configuration file. This was done easily for Flamingos, for example. Flamingos also required the ability to move the guide boxes along with the telescope when doing offsets. This feature was added by B. McLeod and has worked quite well.

New Web-Based Catalog Submittal Form

A new web page was created using HTML and PHP for MMT observers to submit, verify, and view catalogs. The submitted catalogs reside on an MMT server. Options are available on the web page for updating and deleting previously submitted catalogs. Individual catalogs can be viewed in a spreadsheet-format on the web page and sorted by any of the following data fields: object name, right ascension, declination, magnitude, or spectral type. Small portions of the catalog can also be viewed. This web page is currently being incorporated into a set of web pages for each observer to obtain and submit information related to their upcoming MMT projects. The catalog submittal form will be available by logging on to a mountain machine.

New Scope/Catalog GUI

Work was initiated on a new scope/catalog GUI for the operators. Development of this GUI proceeded using C/Gtk+ because of the need for fast computation for large astronomical catalogs, and for access to the more sophisticated widgets available in Gtk+. A prototype was developed to the extent of loading large catalogs into a spreadsheet-like GUI, sorting catalogs on selected

columns, and implementing drag-and-drop between catalogs. This work led to investigation of the open-source Xephem software available from Clear Sky Institute, Inc. Modifications were made to Xephem to allow the telescope operator to point-and-click on a displayed object and either: 1) add that object to a MMT-format catalog, or 2) move the telescope to the selected object.

Miscellaneous

The problems accessing the town Windows computers seem to have stabilized. Certain procedures do work, but it is nowhere near as easy and friendly as it used to be.

Optics

No activity to report.

General Facility

A MatLab GUI has been developed by D. Clark for getting data from a single digital dial gauge (Sylvac Ultra Digit Mark V). This utility allows realtime display of the measurement value, plus the ability to save the measurements to a file selected by the user. At this point it is useable running under MatLab, but will be built into a fully standalone application for any Windows user at a later date.

As noted above, the cell computer has been moved from the roll-around rack to the new SAO-supplied tall rack, which will be known as rack #4. Rack #3 should arrive this month and will have the Minicam electronics installed after three six-inch holes are drilled in the floor for its cables.

Maintenance and Repair

The Carrier problems continue. A quote has been received from them to: a) replace the expansion valves, b) add speed controls for the fan motors, and c) upgrade the software for a brine system. This quote has been submitted to S. Criswell (FLWO) for processing.

The rotator servo amplifier has been tested and found to have a bad Copley amplifier. The spare is also defective and has been sent to the factory for repair. It will replace the bad servo amplifier when it returns. The amp currently in use will then be returned to the factory. The bad amplifier limits the speed of the rotator in one direction only, which has not proved to be a problem.

A new shutter solenoid for the top box has been procured, along with two spares, and has been installed. After installation it was discovered that one shutter card operates one shutter and the other card operates the other shutter. The original card that operated the old I-CCD shutter was left in place and will be repaired as soon as possible. The other card was repaired and is ready to reinstall.

The Stentofon intercom system has been troubleshot and is on the way to recovery. Some schematics had to be redrawn, and the operation is now more understandable. All the subscriber cards we have were tested, and one must be repaired. Several stations must also be repaired, and the motherboard has some problems that are not yet understood.

D. Smith installed a new Para-Flex element, flanges, and drive belt on RUPS. Alignment was verified after the new parts were installed, and RUPS is now back on-line.

Visitors

February 15: The “Committee on Origin and Evolution of Life” of the National Academy of Sciences toured the MMT. They were hosted by Jonathan Lunine (LPL) and Dan Brocius.

Publications

MMTO Internal Technical Memoranda

None

MMTO Technical Memoranda

None

MMTO Technical Reports

None

Scientific Publications

02-1 Kinematics of AWM and MKW Poor Clusters
Koranyi, D. M., Geller, M. J.
AJ, **123**, 100

02-2 Absolute Properties of the Main-Sequence Eclipsing Binary Star WW Camelopardalis
Lacy, C. H. S., Torres, G., Claret, A., Sabby, J. A.
AJ, **123**, 1013

Observing Reports

R. Walterbos: January 19-21, Blue Channel

J. Bechtold: February 5-6 and February 9-10, Blue Channel

Copies of these publications are available from the MMTO office. We remind MMT observers to submit observing 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 Smithsonian Institution and the University of Arizona.”

Submit observing reports and publication preprints to bruss@as.arizona.edu 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

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 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 in two ways. First, it can be loaded via URL <http://mmt.as.arizona.edu>. Second, it can be accessed via a link from the OIR's MMT page at URL <http://cfa-nmm/cfa/oir/MMT/mmt/foltz/mmt.html>. The former should be used by interested parties west of the Continental Divide; the latter is a copy, which is locally mirrored at SAO and is much faster for East Coast access.