BIMONTHLY SUMMARY

May – June 2005

An all-sky camera image of a laser beam during the June 14-18 Laser Guide Star observing run at the MMT.

Personnel

On May 6 Dan Blanco left the MMTO to become acting Optics Group manager for NOAO, with the thirty meter telescope (TMT) project. Before becoming MMTO Assistant Director for Operations in November 2002, Dan had worked at EOS Technologies, the WIYN project on Kitt Peak, and was MMTO mechanical engineer 1983-1990. Dan brought a wealth of experience in telescope design and optimization to the MMTO, where he made many significant contributions to the telescope performance. We wish him the best in his new endeavors.

On May 17, Ricardo Ortiz returned from his adventures in Washington, D.C., to resume his engineer position at MMTO. We missed him terribly while he was gone. Welcome back!

In mid May, Nima Forghani left the MMTO to pursue a summer internship at Honeywell in Phoenix. He will resume his MMTO student engineer position when the fall semester begins.

On May 23, principal engineer Thomas Stalcup Jr. transferred from the Steward CAAO group to MMTO. As MMTO's adaptive optics (AO) staff scientist, Thomas's principal duties will relate to the commissioning of the unique AO system that is designed to make wavefront corrections with the MMT deformable *f*/15 secondary mirror. Tom will defend his PhD thesis in Optical Sciences at OSC this winter.

Student engineer Kristy Pearson graduated in May and was subsequently hired as a temporary Engineer Associate May 16-June 30. At the end of her temporary assignment she left the MMTO to attend graduate school at the University of Washington in Seattle this fall.

Grant Williams traveled to Cambridge, Massachusetts, to participate in the Critical Design Review (CDR) of the MMT and Magellan Infrared Spectrograph (MMIRS), which was held on May 17-18.

Dusty Clark attended the IEEE annual American Controls Conference in Portland, Oregon, June 8-10, as one of the speakers in the tutorial session, "Pointing and Tracking Challenges of Antennas and Telescopes." The original paper this session was based on can be found at http://www.mmto.org/MMTpapers/pdfs/ACCpaper2b_final3.pdf. Other speakers were from JPL, TMT, MAN Technologie, and Vertex Antennentechnik (ALMA project).

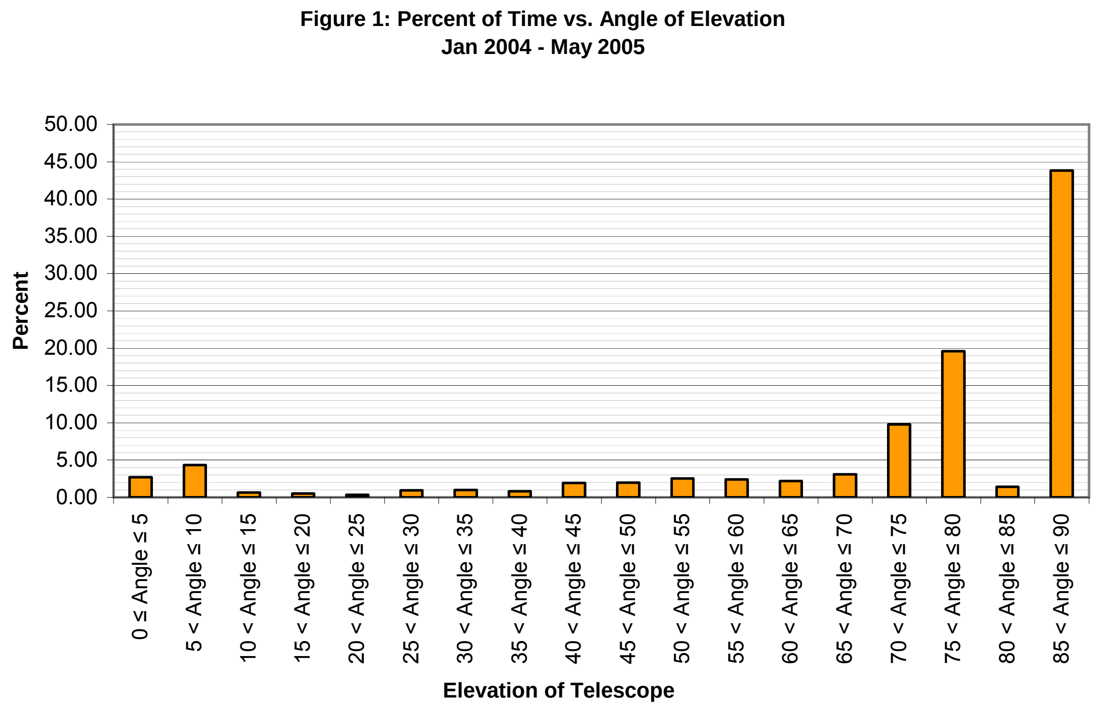
In early June, Bill Kindred (BK to most) announced his medical retirement starting with medical leave July 1. Bill will be available to consult with MMTO engineers through a transition period.

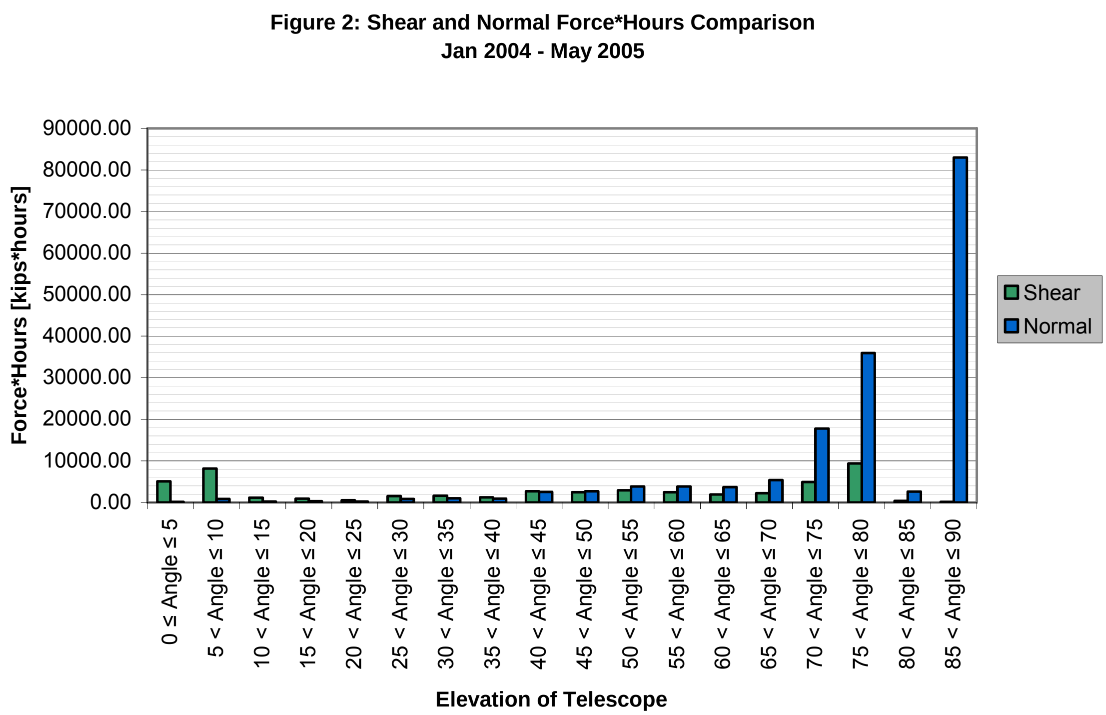
Primary Mirror Systems

RTV Puck Bonds

Work continues on determining when failure of the adhesive bonds (Dow Corning RTV, Q3-6093) that attach the support pucks to the back of the primary mirror might occur. Kristy Pearson generated several graphs that summarize the telescope elevation angle versus time. These graphs are based on the past 1.5 year's telescope elevation and temperature data versus time. These data were mined from the telescope background logs. Figure 1 shows the percentage of time versus telescope elevation. Figure 2 compares both the shear and normal force multiplied by time at various angles.

Note: maximum shear forces on the puck-RTV-glass bond is at 0 degrees elevation angle (horizon pointing). Maximum normal forces on the bond is at 90 degrees elevation (zenith pointing).





Primary Mirror Support

The Actuator Test Stand has been modified physically to make it more stable and maintainable. The adjustable bench power supply has been replaced with a fixed supply, and both supplies mounted appropriately. Draft code was added to the test stand VxWorks code for actuator testing. The new code commands each actuator to progressively larger positive and negative forces. These tests will be used during summer shutdown to measure how closely the applied force of an actuator follows the commanded force.

Aluminizing

Construction of the aluminizing hardware continued during the reporting period. New welder interface boards were laid out, populated, and mounted in boxes for placement at each welder unit. Front end I/O boards for data acquisition were laid out, assembled, and wired into the 19" rack-mount chassis. A portable 19" rack now holds a PC with analog to digital inputs boards, the data interface and control enclosure, and power supplies for controlling and monitoring all the welder circuits. Brian Comisso and Cory Knop also built all the cables necessary to connect the system components together.

We now have in hand portable weatherproof cases to hold all the electronic hardware when in storage. All spares, electronic boxes, and documentation will remain in the cases for use when needed for future coating.

We still need to build the Softwire data acquisition application, and we also plan to test the complete 10-circuit system at the summit prior to the aluminizing run in August.

Bill Kindred's aluminization control rack has undergone some modifications to replace the LCD displays with LEDs and provide additional monitoring capabilities. Mechanical completion of the rack is near.

In June Ricardo Ortiz traveled to Oxford Instruments (Austin Scientific) in Austin, Texas, to participate in and document disassembly and repair of the #1 cryopump, which had been shipped to the manufacturer for repair of a cracked liquid nitrogen line. In addition, he assisted with performing a running purge of two helium compressors that had been returned for helium adsorber replacement and retrofit of stainless steel flex hoses.

Later in the month Ricardo made a second trip to Austin to assist with re-assembly and testing of the cryopump and compressors. The equipment performed flawlessly, achieving an ultimate pressure of 1.6×10^{-8} Torr, which is the limit for this particular pump. It then was shipped to the FLWO basecamp for a final check before transport to the MMT.

Figure 3: Ultimate pressure testing of #1 cryopump at Austin Scientific.

Ryan Odegard and Kristy Pearson replaced the seals on the vacuum chamber aft covers. They also designed and fabricated lifting fixtures to flip the covers over without damaging the seals.

Due to lack of time, the plan to fabricate and test a bridge to aid in the mirror washing process has been put on hold for future evaluation.

Miscellaneous

Work continues on fabricating a new mirror cover. Plans are to install the new cover shortly after aluminization of the primary mirror.

Secondary Mirror Systems

Hexapod Control Matrices

New platform-to-pod and pod-to-platform matrices were obtained from Dan Blanco, now at NOAO, for the *f*/9 and *f*/15 hexapods. The previous versions of these matrices used an inverted geometry for the hexapod and were erroneously introducing image movement on center-of-curvature moves of the secondary mirror. Scripts were written to temporarily load these new matrices into the hexapod crate. On-sky testing of the new matrices for the *f*/9 secondary will be attempted during July M&E time.

No time was available for on-sky testing of the new *f*/15 matrices during the June *f*/15 run. This testing will need to be done at a later time.

Hexapod Control Software

Minor changes were made to the hexapod GUI, hexgui, to provide more obvious correlation between the secondary that is chosen by the user and the secondary value currently present in the hexapod crate. Math errors in hexgui were also corrected for on-sky tilts in zero-coma mode. A new version of this GUI, hexgui2, was written and tested. This new version differs primarily in reduced lines of code and fewer required supporting files. All widget creation is directly in the code, not in separate Glade files. hexgui2 also presents a more realistic geometry of allowed transport limits for the hexapod. Testing of both hexgui and hexgui2 will continue under new versions of the Ruby-Gnome software, with the eventual retirement of hexgui.

f/5 Secondary Baffle

On June 28 it was noted that about 30 percent of the spot welds on the *f*/5 upper baffle were separated. Brian Love, Creighton Chute, and Court Wainwright riveted L-brackets to the entire circumference of the baffle. This restored the structural integrity of the baffle but not the positional tolerance. The tolerance of this edge of the frustum is stated to be within ±.060", but it is now ±.472". Options are being investigated to address this issue.

f/9 Secondary Support

On May 16 Brian Comisso installed an air pressure sensor on the inlet side of the *f*/9 support system. This sensor will prevent the electronics from ramping up the force signal when there is no air pressure. When air pressure is detected, the support system electronics will be activated and gently lift the mirror. Brian also discovered that the transducer seals were made of Buna-N (likely to crack in our high ozone environment). All four transducers have been sent back to the manufacturer and rebuilt with Viton seals.

Telescope Tracking and Pointing

Mount Servos

We successfully tested the mount controller tracking Polaris with the hybrid setup of the "new" controller running the telescope under setpoint commands from the existing mount VME computer using a hardware link. While there were some issues with data integrity across the link, tracking in 10-15 mph winds at Polaris was acceptable, and did not exhibit the heretofore problematic 5.6 Hz resonant oscillation. We decided to adopt this model and continue development with this servo, optimizing the gains for subsequent deployment.

Keith Powell and Dusty Clark continued development on the elevation controller, focusing on optimizing the controller gains and disturbance rejection properties. After our last run on the mountain working with the prototype, we froze the controller design and released it to Tom Trebisky for software implementation. We await further developments on this front as we migrate the controller to the new PC running Simulink-generated code.

A trip to the mountain with Ed Bell to work with his controller was unsuccessful. Detailed examination of his controller revealed fundamental flaws in its construction, notably unstable real poles in the right-hand side of the pole-zero map for the controller transfer function. This means that it has uncontrollable oscillations, and cannot be used to drive the telescope. Further work on this controller was discontinued. We thank Ed for his contributions, which include a detailed mechanical model of the MMT elevation axis, which allows great insight into the resonant modes of the structure. This model will be documented in a subsequent MMT Internal Technical Memorandum.

Computers and Software

Non-Sidereal Code Development

"mmt_xephem," which is based upon XEphem (see www.clearskyinstitute.com), was upgraded to be based upon XEphem 3.6, the current version. An attempt was made to make as few changes to the XEphem code as possible in creating the new version of mmt_xephem. New mount remote protocol commands are being used to improve tracking. On-sky testing showed that XEphem always produces coordinates in the J2000 epoch rather than the current epoch. Code was also changed to check whether the operator had selected a new target for tracking rather than forcing the operator to manually stop tracking one object before tracking a new object.

mmt_xephem tracking is sufficient for many non-sidereal objects. However, tracking is poor for fast moving objects such as near-earth orbiting satellites. Ultimately it is our goal to perform tracking calculations for all non-sidereal objects within the mount crate where they can be updated at the full loop speed. Work has begun on this task by investigating the migration of the NORAD SGP4/SDP4 orbital models for earth orbiting satellites into the mount crate code.

We are organizing our local modifications to XEphem as a unix "patch" so we will be able to quickly and reliably utilize new versions of XEphem as they are released.

Hexapod Code Migration

The VxWorks/VME computer that now controls the hexapod no longer has any interface hardware and few, if any, real time requirements. We are exploring the possibility of eliminating it altogether and replacing its functionality with a server running on one of our Linux computers. We are most enthusiastic about using POSIX threads (i.e. "pthreads") to migrate the existing VxWorks code (in C), and believe this can be done in a way that will allow at least 80 percent of the code to simply be recompiled.

We now have a good set of spares for the UMAC system and can use these as a second system for development of new code and experimentation, including the development of coordinated and continuous motion code for the hexapod.

Observing Catalogs

We have made changes that liberalize our observing catalog format while retaining complete compatibility with our previous format. It is now possible to prepare catalogs that include the rotator position angle for extended objects. Also, catalogs can be prepared that are almost free-format and, if desired, can omit fields such as magnitude and spectral type. These new features are supported by the "scope" GUI (which parses the catalogs). These new formats are flagged by an optional set of header lines in catalogs. For details, see the MMT web page at http://www.mmto.org/obscats where further changes and options will be described.

MMT Engineering Web Pages

Various additions and modifications were made to the following MMT engineering web pages:

- Additional web pages were added for the new TempTrax4 digital thermometer (see http://www.mmto.org/engineering/#temptrax4). This 4-probe unit samples temperatures from the roof and eastern side of the MMT building.

- Additional web pages were added to provide 5-minute data for telescope chamber conditions (see http://mmt.mmto.arizona.edu/engineering/chamber.php).

- The thermal transect web page was expanded to include probes within the ventilation ducts, the pit, and the yoke room (see http://www.mmto.org/engineering/thermal_transect_w_ducts.php). Automatic archiving is also done of these thermal transects (see http://www.mmto.org/engineering/archives/thermal_transect_w_ducts/).

- Additional links were added to the MMT engineering home page (http://www.mmto.org/engineering/), for example, to images from the MMT All-Sky Camera.

Miscellaneous Software

Fedora Core 4 was released and migration of Linux machines has begun. This is now much easier than with previous releases, since the upgrade can now be done remotely and it integrates the upgrading of updated and external packages such as the ones we maintain for IRAF. The main improvements include better DVD burning support, more reliable support for removable USB storage devices, and improved performance. The updated IRAF package now includes the long-awaited enhanced CL interface, which provides full command-line editing to the IRAF environment, a feature requested by observers many times over the years.

A drive failure in the computer controlling the all-sky camera required a new drive and a fresh OS install. The new version of the video encoder used to create the archived movies broke compatibility with Windows and Mac-based viewers. Only a few nights' worth of data were affected, though, before the problem was discovered and fixed. The camera itself continues to work very well and has proven very popular with the operators and observers.

The Steward guider (in the *f*/9 topbox) software was updated on June 6. The new software was tested during the Megacam to Blue Channel instrument change on June 8.

Instruments

f/5 Observing Run

A wiring problem in the hecto fiber positioner forced the nights of May 14-18 to be used (without an instrument) for *f*/5 engineering. A crew from SAO traveled to the MMT to diagnose and repair the fiber positioner. The positioner was dismounted and the two units were separated and inspected carefully. After extensive inspection and debugging of all mechanical and electrical parts, a broken wire to the gripper-closed optical sensor was found. The broken wire was fixed and 650 pick and place operations, using a dummy button, were run without a failure. The fiber positioner was reassembled, tested, and mounted back on the telescope on May 19. During summer shutdown the gripper wiring on both robots will be replaced with rated flex cable in the region that flexes with Z-axis motion.

The encoder on the east atmospheric dispersion corrector (ADC) motor was damaged during removal of the *f*/5 corrector on May 26. The cart for the corrector collided with a corner of the encoder while the instrument lift was being raised. The damaged encoder was removed and successfully replaced on June 21. The ADC was tested in the lab and found to work properly.

Natural Guide Star (NGS) Adaptive Optics

The June run of the natural guide star adaptive optics (NGS-AO) system went well, with only 44 percent of the time lost to bad weather. The five micron camera, CLIO, had a very successful engineering run over two nights, which included sensitivity tests that confirmed its theoretical sensitivity limits. The rest of the AO run used the BLINC/MIRAC camera, and poor weather conditions seriously limited the science and engineering observations.

Despite these setbacks, two projects successfully obtained good science data and many engineering tasks were completed. A live seeing monitor now provides feedback for both the AO group and the observers during AO operations, allowing assessment of the current conditions at the telescope and the first measurements that allow us to assess the performance of the closed loop.

Laser Guide Star (LGS) Adaptive Optics

The laser guide star (LGS) run of June 14-18 produced some good data. Prior to our first night, we spent several days in the basement of the common building assembling and testing our instrument to make sure that it survived the trip to the telescope. The first couple of days were spent solving problems and recording calibrations. The night of June 17 started very promising, with lots of good work finishing the calibration of our instrument in preparation for collecting the science data. Unfortunately about midnight we received a call from Space Command instructing us to shut down for the rest of the night. The following night, however, we were recording data almost the entire night. We had all three of our cameras running and recording simultaneous wavefront data from the laser constellation, wavefront data from a natural star, and during a portion of the night a wide field view with three other natural stars for sensing low order modes. There was a break of about 1.5 hours while Thomas Stalcup removed the remains of a moth that decided to commit suicide—a moth doesn't have much of a chance versus the focused laser beam (see Figure 5).

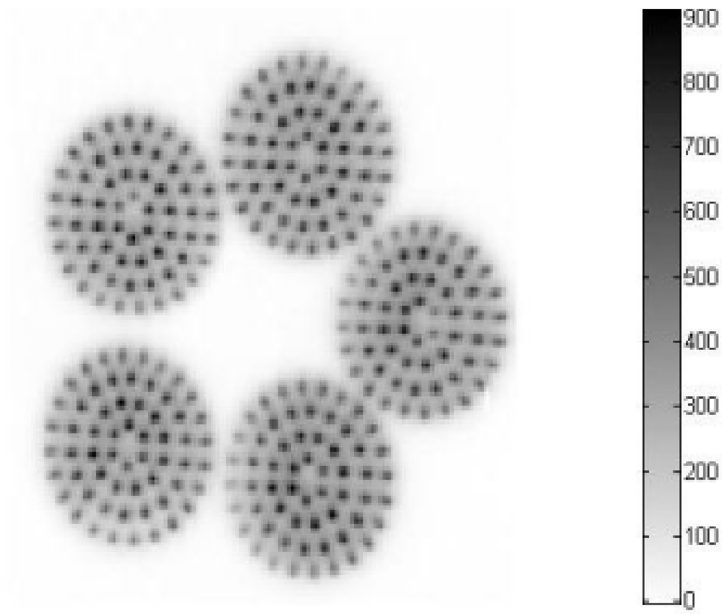


Figure 4: Shack-Hartmann pattern from five dynamically refocused laser beacons.

Figure 5: An unfortunate moth flew into the laser beam at the steering prism, bonding to the glass surface.

Blue Channel Spectrograph

The first half of the engineering night on June 8 was used to obtain additional throughput data with the Blue Channel spectrograph. The data were taken for the following grating configurations: 300 gpm @ λ_c = 5300, 500 gpm @ λ_c = 5300, 800 gpm @ λ_c = 4300.

General Facility

TeleVue Eyepiece

The MMT now owns a TeleVue 41 mm Panoptic eyepiece, an Astro-Physics Maxbrite 2 diagonal mirror, and a JMI DX-2 focuser. Brian Love built a mount for the focuser, which attaches to the rotator alignment tool (RAT). The engineering night of June 28 provided an opportunity to test the eyepiece. The telescope was configured with the *f*/5 secondary, the *f*/5 corrector/ADC, the *f*/5 wavefront sensor (WFS), and the RAT. The position of the eyepiece in its new mount was perfect; the nominal focus position for the WFS corresponded to the center-of-travel of the eyepiece focuser.

Several targets were observed through the eyepiece including Comet 9P/Tempel 1, Jupiter, the Ring Nebula, and Campbell's hydrogen star. The engineering time was also used to test non-sidereal tracking in anticipation of observations of the deep impact of Comet 9P/Tempel 1. The views through the MMT eyepiece are nothing short of spectacular. The eyepiece will be used during high profile tours of the facility.

Absolute Encoders

Intermittent problems with the azimuth absolute encoder continued to plague us. We therefore accelerated the design of the next-generation electronics in hopes of a) alleviating the situation, and b) improving the performance. Performance goals for this upgrade are threefold: 1) improve the low-level analog signal integrity by doing the conversion to digital angles inside the encoder housing; 2) improve the digital transmission data integrity by enhancements to the digital data path to the mount computer; 3) add web-browser capability to the encoder electronics to make troubleshooting access easier. Parts have been ordered and board layout will begin during the next reporting period.

In the meantime, we continue to monitor (and try to locate and repair) the intermittent problem with the AZ on-axis encoder.

Building Drive

Ken Van Horn and Court Wainwright replaced the telescope-to-building LVDT. The measured range of telescope rotation at the LVDT tested to be ±1.63 inches, which is well within the new LVDT's ±2-inch range of travel. The new LVDT appears to work so well it was left in place with no recalibration of the building drive. A spare for this new device has been received, as well as the spare fans for the building drive power cabinet.

Thermal Control System

The ongoing upgrade to the tempprobe system continues with the identification of more termination issues and the necessary modifications for aluminization. The issues identified so far have made significant improvements to the reliability of this system. One more TempTrax probe needs to be ordered.

Other Facility Improvements and Repairs

Heat extraction ducting has been installed in the cell cone above the instrument rotator and at the secondary hub. This vacuum heat scavenging system pulls warm air into the pit where it is ducted outside.

Ryan Odegard repaired the back shutter cable tensioning device. Apparently a bolt was loaded primarily in bending, causing it to fatigue over time. This bolt, as well as a clevis, was replaced and correctly installed.

Preventive maintenance was performed on both the Mattei and Gardner Denver telescope air compressors.

Visitors

May 5: A group of Optical Sciences graduate students, accompanied by Jim Burge (Steward) and Grant Williams.

Publications

MMTO Internal Technical Memoranda

05-02 Hazardous Chemical Procedures at MMT Observatory – Initial Release
W. Kindred

MMTO Technical Memoranda

None

MMTO Technical Reports

None

Scientific Publications

05-16 Galaxy Cluster Assembly at $z = 0.37$
Gonzalez, A. H., Tran, K.-V. H., Conbere, M. N., Zaritsky, D.
ApJ, **624**, L73

05-17 Comoving Space Density of X-Ray–Selected Active Galactic Nuclei
Silverman, J. D., Green, P. J., Barkhouse, W. A., Cameron, R. A., Foltz, C., Jannuzi, B. T., Kim D.-W., Kim, M., Mossman, A., Tananbaum, H., Wilkes, B. J., Smith, M. G., Smith, R. C., Smith, P. S.
ApJ, **624**, 630

05-18 Deep Photometry of GRB 041006 Afterglow: Hypernova Bump at Redshift $z = 0.716$
Stanek, K. Z., Garnavich, P. M., Nutzman, P. A., Hartman, J. D., Garg, A., Adelberger, K., Berlind, P., Bonanos, A. Z., Calkins, M. L., Challis, P., Gaudi, B. S., Holman, M. J., Kirshner, R. P., McLeod, B. A., Osip, D., Pimenova, T., Reiprich, T. H., Romanishin, W., Spahr, T., Tegler, S. C., Zhao, X.
ApJ, **626**, L5

05-19 Cepheus OB2: Disk Evolution and Accretion at 3–10 Myr
Sicilia-Aguilar, A., Hartmann, L. W., Hernández, J. Briceño, C., Calvet, N.
AJ, **130**, 188

05-20 Structural Parameters of the Hot Pulsating B Subdwarf PG 1219+534 from Asteroseismology
Charpinet, S., Fontaine, G., Brassard, P., Green, E. M., Chayer, P.
A&A, **437**, 575

Observing Reports

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 Smithsonian Institution and the University of Arizona."

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

The MMTO maintains a web site (*http://www.mmto.org*) that 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 related to the Conversion.

5. Information for visiting astronomers, including maps to the site.

6. The MMTO staff directory.

Observing Database

The MMTO maintains a database containing relevant information pertaining to the operation of the telescope, facility instruments, and the weather. Details are given in the June 1985 monthly summary. The data attached to the back of this report are taken from that database.

NOTE: Beginning January 2005, the formula for accounting lost time on the telescope has been changed. Previously, time lost to weather was deducted from the total observing time before calculating time lost to instrument, telescope, and facility from the remaining balance. From now on, the time lost to each source is computed as a fraction of the total scheduled time.

And beginning June 2005, a new category, environment, was added to account for time lost to natural, uncontrollable, non-weather events such as flying insects melting in laser beams and forest fires.

Use of MMT Scientific Observing Time

May 2005

Instrument	Nights Scheduled	Hours Scheduled	Lost to Weather	Lost to Instrument	* Lost to Telescope	Lost to Gen'l Facility	Lost to Environment	Total Lost
MMT SG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PI Instr	29.00	239.40	36.20	51.85	0.20	0.00	0.00	88.25
Engr	1.50	12.40	0.00	0.00	0.00	0.00	0.00	0.00
Sec Change	0.50	4.30	0.00	0.00	0.00	0.00	0.00	0.00
Total	**31.00**	**256.10**	**36.20**	**51.85**	**0.20**	**0.00**	**0.00**	**88.25**

Time Summary Exclusive of Shutdown

Percentage of time scheduled for observing	93.5
Percentage of time scheduled for engineering	4.8
Percentage of time scheduled for secondary change	1.7
Percentage of time lost to weather	14.1
Percentage of time lost to instrument	20.2
Percentage of time lost to telescope	0.1
Percentage of time lost to general facility	0.0
Percentage of time lost to environment (non-weather)	0.0
Percentage of time lost	34.5

* Breakdown of hours lost to telescope
az oscillation 0.2

June 2005

Instrument	Nights Scheduled	Hours Scheduled	Lost to Weather	Lost to Instrument	* Lost to Telescope	Lost to Gen'l Facility	**Lost to Environment	Total Lost
MMT SG	3.50	27.10	0.50	0.00	0.75	0.00	0.00	1.25
PI Instr	24.00	186.10	42.45	8.10	0.70	0.00	1.50	52.75
Engr	1.50	11.55	0.00	0.00	0.00	0.00	0.00	0.00
Sec Change	1.00	7.75	0.00	0.00	0.00	0.00	0.00	0.00
Total	**30.00**	**232.50**	**42.95**	**8.10**	**1.45**	**0.00**	**1.50**	**54.00**

Time Summary Exclusive of Shutdown

Percentage of time scheduled for observing	91.7
Percentage of time scheduled for engineering	5.0
Percentage of time scheduled for secondary change	3.3
Percentage of time lost to weather	18.5
Percentage of time lost to instrument	3.5
Percentage of time lost to telescope	0.6
Percentage of time lost to general facility	0.0
Percentage of time lost to environment (non-weather)	0.6
Percentage of time lost	23.2

* Breakdown of hours lost to telescope
primary panic, building collision 0.75
az drives 0.7

** Breakdown of hours lost to environment (non-weather)
moth fried in laser beam 1.5

Year to Date June 2005

Instrument	Nights Scheduled	Hours Scheduled	Lost to Weather	Lost to Instrument	Lost to Telescope	Lost to Gen'l Facility	Lost to Environment	Total Lost
MMT SG	23.50	254.40	186.70	0.00	4.75	2.50	0.00	193.95
PI Instr	141.25	1343.60	482.20	92.85	20.90	0.00	1.50	597.45
Engr	5.25	48.25	2.50	0.00	0.00	0.00	0.00	2.50
Sec Change	5.00	49.45	9.00	6.00	0.00	0.00	0.00	15.00
Total	**175.00**	**1695.70**	**680.40**	**98.85**	**25.65**	**2.50**	**1.50**	**808.90**

Time Summary Exclusive of Shutdown

Percentage of time scheduled for observing	94.2
Percentage of time scheduled for engineering	2.8
Percentage of time scheduled for secondary change	2.9
Percentage of time lost to weather	40.1
Percentage of time lost to instrument	5.8
Percentage of time lost to telescope	1.5
Percentage of time lost to general facility	0.1
Percentage of time lost to environment (non-weather)	0.1
Percentage of time lost	47.7