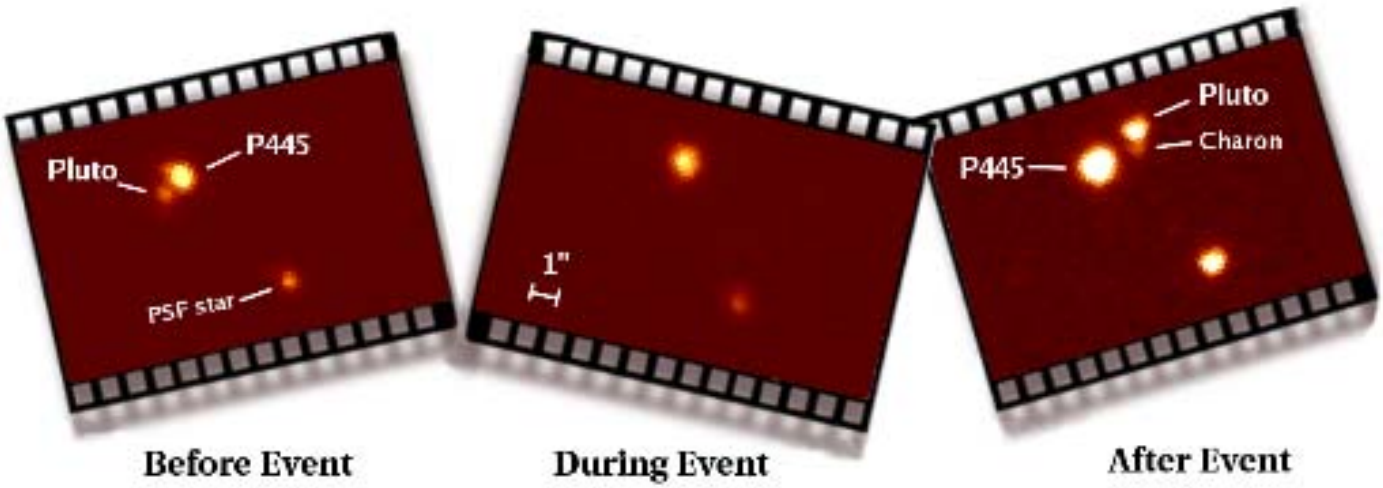
MMT Observatory
Smithsonian Institution &
The University of Arizona

BIMONTHLY SUMMARY

March - April 2007



On March 18, the MMT recorded the occultation of the bright star P445.3 by Pluto. The above three frames, out of a sequence of 20,000, illustrate that sequence of events as recorded by the PISCES camera operating at 2.5 Hz in the H-band (1.6 microns). The observations were obtained at low elevation angle (20-35 deg., 3 airmasses) and illustrate the excellent atmospheric seeing characteristic of the MMT site. Individual frames easily resolve Pluto and its moon Charon with an angular separation of 0.7 arcsec. These exceptionally high signal-to-noise images revealed numerous unexpected scintillations as the starlight traversed Pluto's atmospheric layers. This work was part of a dual wavelength (H, V) experiment conducted by Arizona (Hubbard, Kulesa, McCarthy) and MIT (Elliot, Kern, Person). Shawn Callahan and the entire MMT staff provided extensive logistical support to make these observations successful. Image courtesy of Dr. Craig Kulesa, Steward Observatory.

Personnel

Morag Hastie assumed the position of MMTO's new Firestone Fellow on March 5. She comes to us following completion of her Ph.D. in astronomy with an interest and background in astronomical instrumentation.

Student programmer Clay Barnes left the MMTO in March.

On April 10, Dondi Gerber passed her first year mark.

On April 23, electrical engineering undergrad Creighton Chang was hired to work with the electronic group. Initially he is helping to transfer paper data to digital format to be added to the SiteScape database.

Meetings, Conferences, and Seminars

Betty Stobie participated in the definition of the 2007 program for the Astronomical Data Analysis Software and Systems Conference (ADASS), including the selection of special topics, guest speakers, and tutorials. She continued to review multiple iterations of and suggest revisions for the Definition of the Flexible Image Transport System document as a member of the IAU FITS Working Group Technical Panel.

Faith Vilas gave the following seminars:

> "Hayabusa: The Mission to Asteroid 25143 Itokawa" on March at Wellesley College, Wellesley, Massachusetts.
>
> "Probing Near-Earth Asteroid Characteristics: The Japanese Hayabusa Mission to Asteroid 25143 Itokawa" on March 8 at the Harvard-Smithsonian Center for Astrophysics, Cambridge, Massachusetts.

Faith also attended the XXXVIII Lunar and Planetary Conference, March 12-16, Houston, Texas, where the following paper was presented:

> "In-flight Calibration of the Hayabusa Near Infrared Spectrometer (NIRS)"
> M. Abe, F. Vilas, K. Kitazato, P. A. Abell, Y. Takagi, S. Abe, T. Hiroi, and B. E. Clark

On March 12-14, engineers from MMT, Magellan, and LBT met to discuss recent hardpoint testing, issues concerning the primary mirror cell crate and supporting hardware, and aluminization developments. Various presentations were given and are available in SiteScape.

The MMT Council met twice during March-April: A 1-hour meeting/telecon was held on March 2, attended by Faith Vilas and Grant Williams. A full-day meeting was held in Tucson on April 26, attended by Faith Vilas and J. T. Williams. The new Firestone Fellow, Morag Hastie, also met the council members in April.

Primary Mirror Systems

M1 Thermal System Performance

We used Betty Stobie's batch_temp tool to analyze snapshots of M1 thermal data that are captured during the course of acquiring WFS data. The motivation was to see if different approaches to controlling the thermal system yielded measurable differences in thermal system performance. The nights of March 6-7, 2007, and March 11-12, 2007, provide a good case study for comparison. Both nights used the f/5 secondary plus Hectochelle configuration and had fairly stable conditions. For March 6-7, a constant offset of approximately -6.5C from chamber ambient temperature was used for the Carrier chiller's setpoint. For March 11-12, the offset from chamber ambient was changed every 1-2 hours.

The batch_temp tool analyzes the mirror temperature state by fitting a set of Zernike polynomials to the E-series thermocouple data. The results of finite element modeling are used to generate predicted mirror surface distortions from the temperature fits. For the purposes of the current comparison, the surface distortion modes that correspond to wavefront defocus and spherical aberration are the most salient. They provide a measure of symmetric, radially-dependent temperature variations. The predicted focus error term actually has two components. One is a bulk term that correlates with the mean temperature so that a completely isothermal mirror would have a predicted focus error of -21*T(mean) microns. The batch_temp results for the two nights are shown below:

March 6-7, 2007

#Time-GMT	Focus	Spherical Aberration	Mean Temp	RMS(Temp)
03:16:16	-135.024	243.6	9.58	0.119
05:55:47	-117.291	166.1	9.78	0.081
05:56:42	-117.759	144.3	9.77	0.080
08:38:04	-97.779	31.7	9.54	0.067
08:38:59	-99.483	59.4	9.53	0.068
10:12:08	-101.960	46.5	9.32	0.089
10:13:03	-102.280	7.9	9.34	0.089
11:36:58	-118.631	60.8	9.40	0.098
11:39:44	-120.594	58.3	9.42	0.100
11:41:35	-120.008	44.9	9.42	0.100
11:42:30	-117.844	30.6	9.42	0.097

March 11-12, 2007

#Time-GMT	Focus	Spherical Aberration	Mean Temp	RMS(Temp)
02:20:28	-104.798	214.6	6.74	0.155
02:21:24	-105.161	198.8	6.74	0.153
04:06:34	-109.369	131.2	6.67	0.101
04:07:29	-110.089	128.7	6.68	0.100
06:34:16	-92.271	60.5	6.97	0.053
06:35:11	-92.878	74.5	6.96	0.053
10:34:07	7.804	-86.5	6.12	0.149
10:35:57	7.092	-114.6	6.12	0.148

The first thing to note is that the mirror is well within its isothermality spec in each of these cases. At worst, the temperature RMS is 0.16 C and at best it's 0.05 C, which is very, very good! The second thing to note is that the performance with the Carrier setpoint automatically kept at -6.5 C below chamber ambient produces results that are at least as good, if not better than manual control by the operator. Based on these results, a new "carrier_auto" script was written that sets the Carrier temperature to a constant offset from a selected ambient temperature, usually from the chamber. Further evaluation of M1 thermal behavior during use of this script needs to be done, but the initial results are very promising. If the script is implemented for normal operations, it would eliminate the need for operator input for M1 thermal control except in abnormal observing conditions, such as high humidity or dewpoint.

Other work on the M1 thermal control system involved revising the Carrier control web interface, and adding additional possible reference temperatures, such as the Yankee thermohygrometer.

Primary Mirror Support

Work continues on producing RTV tests using the actuator test stand. Although we have the base and catalyst mix (borrowed from the Steward Mirror Lab), we are still in the process of acquiring the vacuum pump necessary to de-gas the mixture before bonding. We will generate a force onto the RTV to study the effects of tearing and shearing. This will give us a better understanding of how the RTV acts while attached to the mirror, and its behavior as it nears the end of its predicted life expectancy.

Mounts to hold the new Heidenhain length gauges were designed and fabricated for the hardpoint test stand. The mounts position the length gauges at a repeatable distance from the axis of the hardpoint. They will also expedite the mounting and adjustment of individual gauges. Testing with the new mounts has not been completed.

Optics

In March, reflectance and scattering measurements were obtained before and after a CO_2 cleaning of the primary mirror. The results are waiting calibration against standards.

Secondary Mirror Systems

f/5 Support Secondary Support

The f/5 secondary mirror support system continues to be problematic and, despite our efforts, is still only operating at minimal specifications. After reports of an unstable image in late February, Creighton Chute and Brian Comisso attempted to align the hardpoints again. After the adjustments were made, testing of the system was limited to about 20 percent of the normal elevation change. Until a method is developed to test the f/5 off the telescope at all elevation angles, any support system adjustments can only be tested when the secondary is mounted. (NOAO has a very large test fixture that is capable of duplicating the "iron maiden," a large test fixture used in the original testing of the f/5 mirror support system. Usage of this facility would require permission from and coordination with NOAO. Additionally, the f/5 would have to be transported to campus and mechanically adapted to do the testing.)

On April 10, engineers from Magellan (Alan Uomoto and Charlie Hull), MMT, and SAO (Andy Szentgyorgyi and Tim Norton) met to discuss the current performance of both f/5 secondary mirror support systems. The following presentations were given by MMT and Magellan staff, and may be viewed in SiteScape.

- Introduction (Callahan and Uomoto)
- Review of design requirements (Callahan)
- MMT servo system (Clark)
- MMT hardware overview (Chute)
- MMT puck bond failures (Chute)
- Current performance of the MMT system (Comisso)
- Image quality measurements (Tim Pickering)
- Magellan system status (Charlie Hull)

f/9-f/15 Hexapod

The motor servos for the f/9-f/15 hexapod were tested and tuned to reduce the following error, just as was done previously with the f/5 hexapod. A similar increase in performance was observed and it is now possible to make smooth focus adjustments during exposures that do not significantly degrade image quality.

f/5 Secondary Baffle

Safety straps were added to the attachment points of the upper baffle. A safety mechanism will be built into the next generation of baffle support arms.

Telescope Tracking and Pointing

Servos and Encoders

During the reporting period, we collected open-loop data on the elevation servo, with the AO deformable mirror (DM) and laser optics installed, to complete the bestiary of f/9, f/5 and f/15 telescope configurations.

Below is the open-loop elevation response, scaled to degrees of motion per volt of input excitation in decibels using band-limited noise as the input signal. This method limited the motion and acceleration of the telescope during the test to be safe with the delicate DM optic.

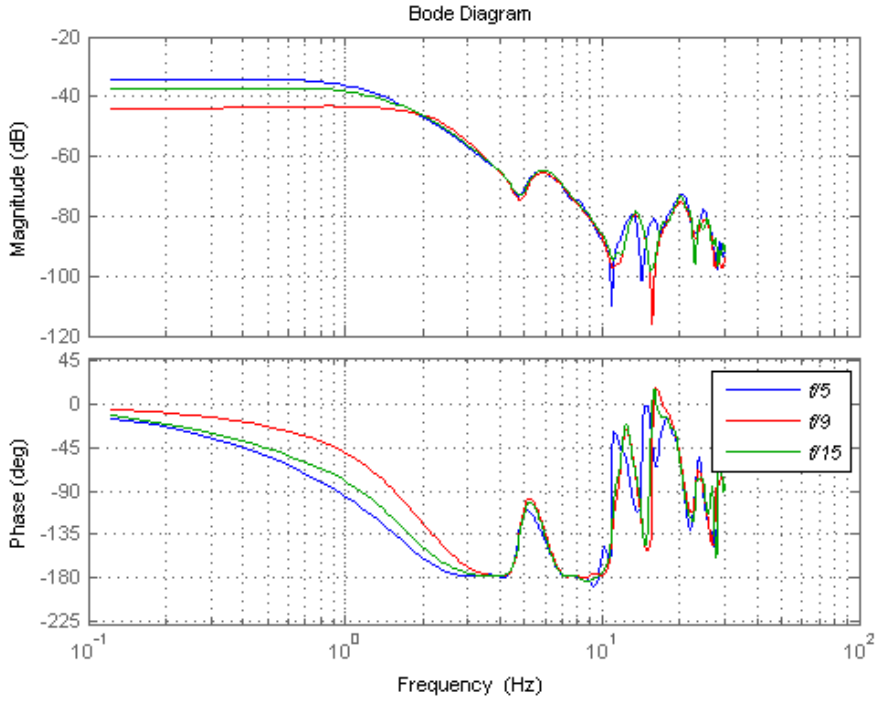


Figure 1: open-loop elevation response.

The primary structural modes on the telescope do not change by much depending on the telescope configuration, though the low-frequency response varies due to the change in inertia. This can be accommodated by proper servo design to produce a robust and stable controller for all the possible configurations. Optimization of the controller may need to take into account the configuration, but this can be left as a future effort.

Dusty Clark has also been working on using this (and open-loop time data) to refine the elevation model to improve the overall design of the controller and determine optimal closed-loop gains. Included in this work is simulation of wind shake on the controller to try to predict actual on-sky performance.

During the engineering night of April 11, Tom Trebisky and Dusty Clark tested the VxWorks controller implementation, with mixed results. The tracking results in high winds during the night were disappointing (Figure 2 below).

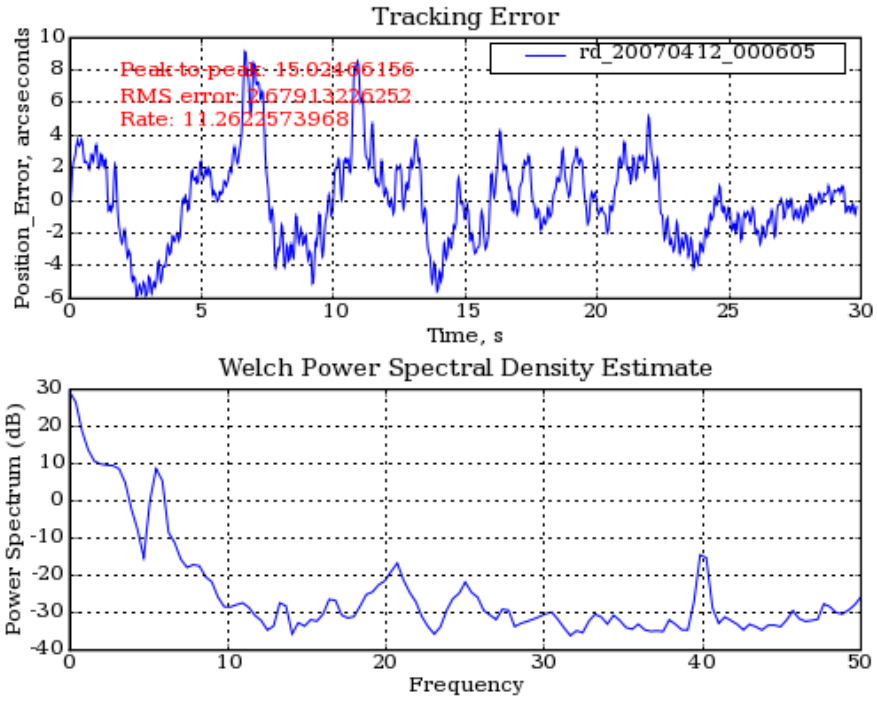


Figure 2: April 11, 2007 VxWorks controller implementation tracking results.

A unique opportunity arose later in the night to collect data with the existing LM628 controller and the xPC Target test controller as well, under the same windy conditions, which gave the results shown in Figures 3 and 4 below.

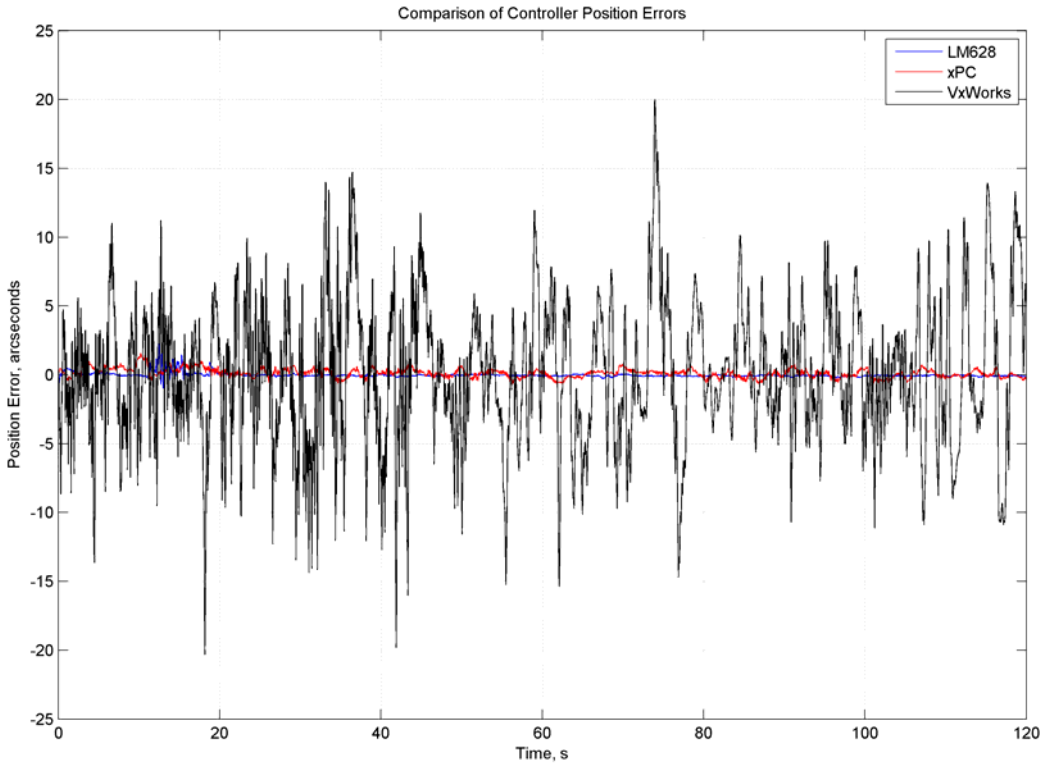


Figure 3: April 11, 2007, LM628 controller, xPC Target test controller, and new VxWorks controller tracking results.

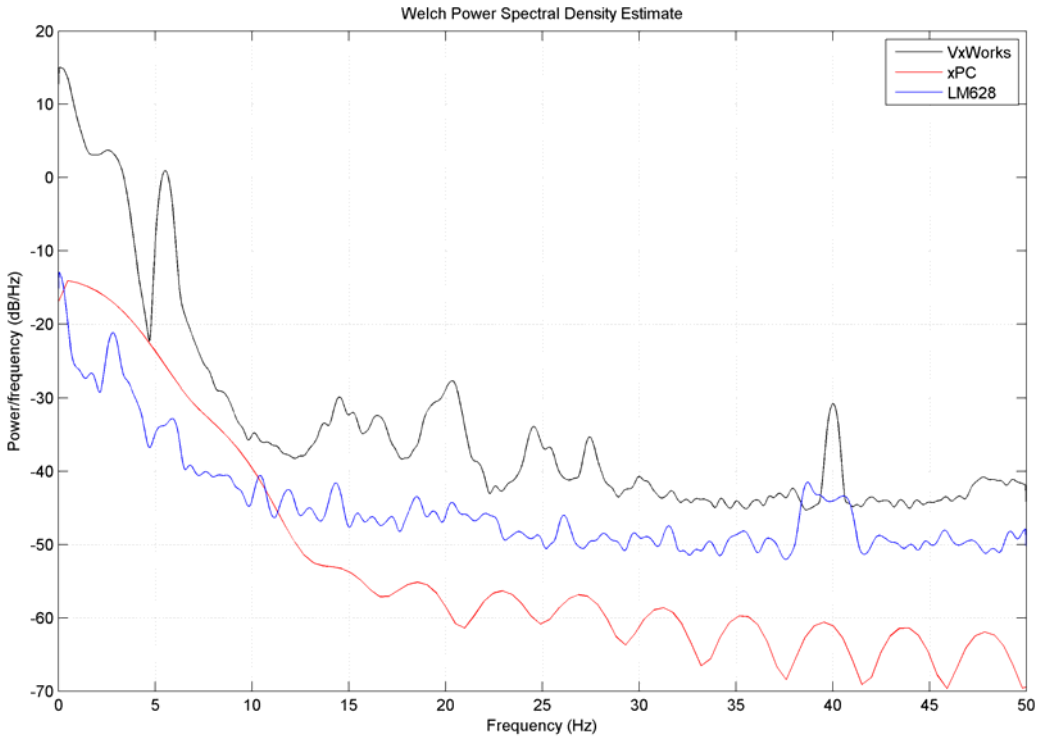


Figure 4: Controller position error power spectral density for the LM628, xPC Target, and new VxWorks controllers.

Clearly the VxWorks implementation has some problem that makes the control loop not yet equivalent to the xPC Target test controller. Several other plots of the relevant tracking data from this engineering night are available at *http://www.mmto.org/~dclark/Reports/Tracking%20Figures/*. Work is ongoing to solve this problem.

For interested readers, other work related to safely starting the telescope servo and discussion on the state of the servo modeling can be found here:

http://www.mmto.org/~dclark/Reports/Servo%20Project%20Progress%20Report8.pdf

Tom Gerl made a minor modification to one of the servo amplifiers, being used by Dusty Clark for elevation servo testing, to properly locate the decimal point in the current display. He also calibrated this unit and updated the schematic.

Mount Alignment Telescope (MAT)

Fabrication drawings for the mount alignment telescope (MAT) have been completed. A formal prefabrication final design review is scheduled for May 3. All MAT drawings and documentation can be found in SiteScape.

MMT Pointing Performance

On the night of March 12-13, 2007, we performed a pointing run to try and verify the systematic azimuth-dependent pointing errors we have been observing. We used one of the Hecto fiber positioner robot cameras and observed a set of 59 stars. Open loop hexapod corrections were applied before each observation. The results were analyzed with TPOINT using the standard set of terms for an Alt/Az telescope. The best fit solution is:

	coeff	change	value	sigma
1	IA	-0.042	+1193.56	2.352
2	IE	-0.237	+0.59	0.534
3	NPAE	-0.072	-1.90	3.327
4	CA	+0.076	+11.23	3.875
5	AN	+0.011	-2.55	0.182
6	AW	-0.002	-12.26	0.176
7	TF	+3.785	+9.21	1.956
8	TX	-1.129	-3.95	0.869

Sky RMS = 1.22
Popn SD = 1.31

For reference, the model that we had been using was derived from pointing data obtained in January 2004. The best fit terms from it are:

	coeff	change	value	sigma
1	IA	+0.001	+1193.31	1.895
2	IE	-0.001	-1.54	0.498
3	NPAE	-0.001	-4.57	2.235
4	CA	+0.000	+8.81	2.664
5	AN	+0.001	-3.33	0.226
6	AW	+0.001	-16.03	0.224
7	TF	+0.010	+13.55	1.246
8	TX	-0.008	-5.59	0.319

Sky RMS = 1.59
Popn SD = 1.70

There are slight variations between the 2004 and 2007 models, but nothing significant enough to explain the errors we have observed. In fact, in the course of doing the pointing run it was obvious, from where the stars appeared on the camera as we went around in azimuth, that there is a significant harmonic error not accounted for by the Alt/Az model alone. This can be seen in the plots shown in Figure 5 below.

In looking through the TPOINT software installation on *hacksaw*, it was found that there exists a procedure called "MMT" that implements an Alt/Az model plus several harmonic terms as functions of Alt and Az. This was likely leftover from when TPOINT's author, Pat Wallace, did some consulting for the pre-upgrade MMT. Since we're still using the same mount and rotary encoders, it seemed likely that this model is still relevant. Modeling the March 2007 pointing data with this procedure produced the following results:

	coeff	change	value	sigma
1	IE	+0.000	+17.06	2.543
2	IA	-0.000	+1194.12	1.567
3	& HACA2	-0.000	-0.10	0.285
4	& HACA4	+0.000	+0.09	0.261
5	& HZCZ	+0.000	+16.45	2.183
6	& TF	-0.000	+9.87	1.559
7	NPAE	+0.026	-1.03	2.297
8	CA	+0.000	+10.25	2.644
9	& HZSA	-0.000	+0.87	0.238
10	& HZSA2	-0.000	+0.47	0.152
11	& HZSA3	-0.000	+1.23	0.173
12	AW	-0.000	-11.76	0.187
13	AN	-0.000	-2.38	0.121

Sky RMS = 0.80
Popn SD = 0.90

A very significant improvement in the sky RMS and population standard deviation to better than an arcsecond RMS! Note the size of term #8, specifically, which is an Az error that is proportional to cos(Az). Experimenting with different mixes of harmonic terms yielded slightly better results, but not significantly so. A larger pointing run with better sky coverage would help determine which harmonic terms we really need. Also, when the new servo system is implemented we may need to do different tweaks to the TPOINT model to reflect the changes due to using the tape vs. rotary encoders for position information. It will require some effort to implement a more sophisticated TPOINT model into our mount software, but the payoff will likely be RMS pointing errors less than 2/3 what they are now, and overall pointing performance that would be the envy of most other large telescopes.

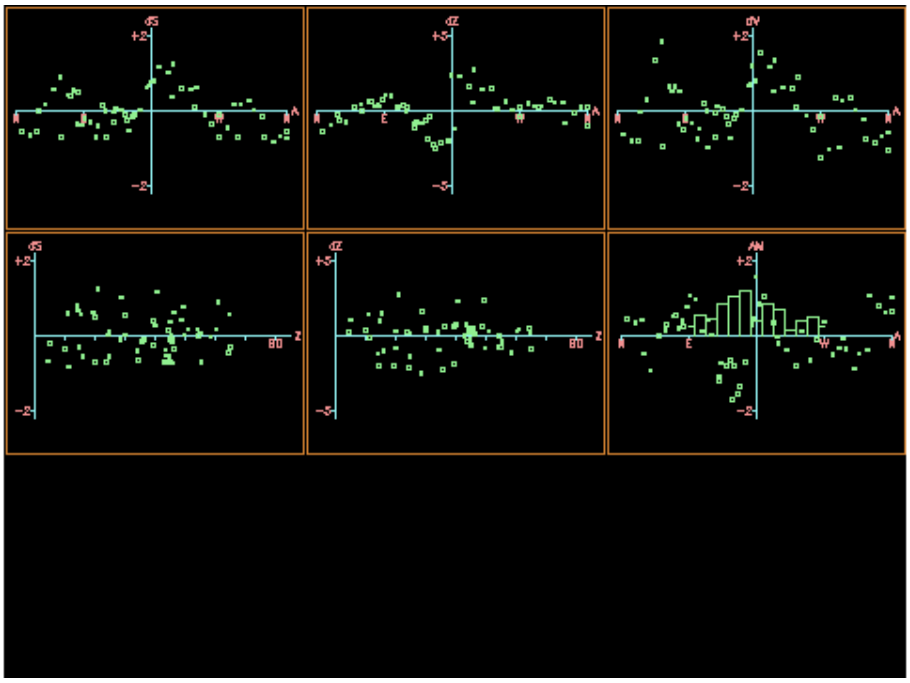


Figure 5: TPOINT residual plots for the Alt/Az fit to pointing data from March 12-13, 2007.

Computers and Software

Observer Catalog Tool

The MMT Observer's Catalog Tool has been significantly enhanced. Some of its key features include:

- Observers catalog entries are displayed on top of All Sky Camera as colored dots and updated in real-time.
- Air mass and elevation are plotted over a 12-hour period for all catalog entries.
- Wind direction and speed are continuously updated.
- Azimuth and DEC skycam overlay can be toggled on and off.
- Every observer who submits a catalog via the MMT Catalog Submission website automatically receives a link to view their catalog using this new tool.
- Runs in a web browser and compatible with Windows, Mac, and Linux.
- It takes advantage of the capabilities provided by the Flash 9 plug-in from Adobe.

Figure 6 shows a screenshot of the tool. MMTO staff can view and use this tool via the URL *http://hacksaw.mmto.org/catalogs/skycam/admin.php from within the MMTO network*

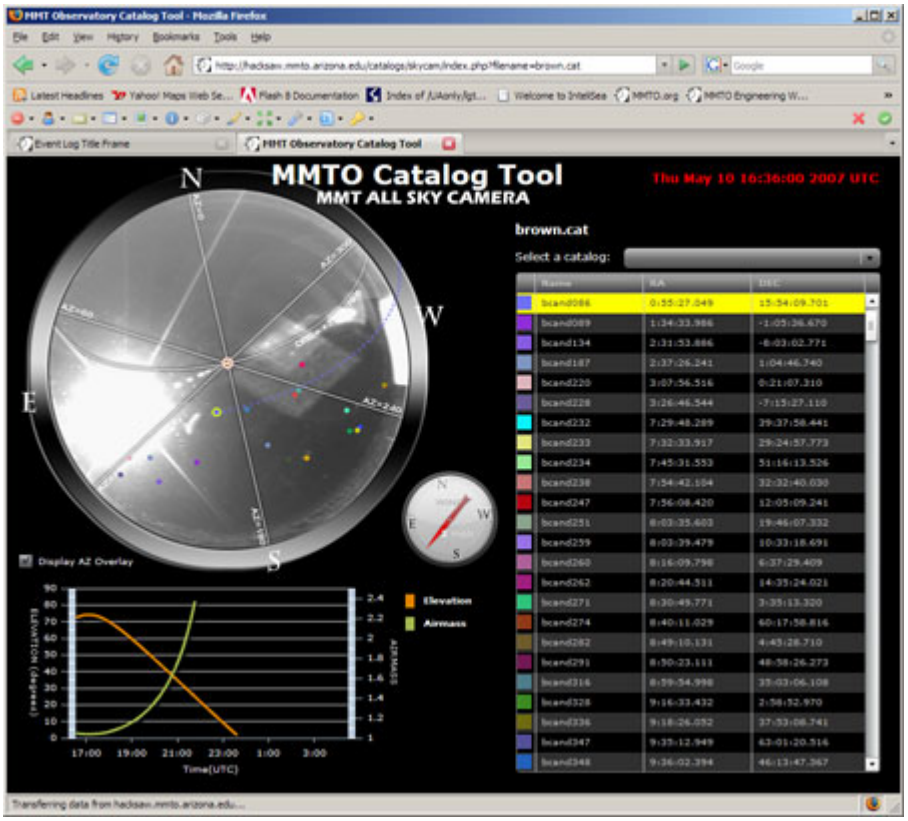


Figure 6: Screenshot of the new web-based MMTO Observer Catalog Tool.

Data Mining All-Sky Camera Data for Transient Events

All sky camera data can now be processed with one IDL program, ntransient_search. Difference images are now computed on-the-fly in the program, eliminating the need to store difference frames on disk. The sky camera image acquisition software now stores data with North up and East to the left. The data archived on *hacksaw* has been modified to match this, which eliminates the need to flip images for display purposes. The program now checks the phase of the moon and its elevation, as well as the sun's elevation, in order to determine what images to exclude from processing. Tables are produced containing moving objects tracked frame to frame (aircraft), stationary objects of one - two frames (meteors), and stationary objects over multiple frames (usually bogus detections). Clouds still present an issue. Although photometry on the raw frames may indicate the level of cloudiness in areas of bright sources, in many cases it may vary substantially across the frame.

Although IDL is a perfect environment for prototyping the transient search program, a batch program implemented in C will better serve in a production environment because it will execute faster and no IDL license will be required. We have acquired the Slalib, a collection of C routines for positional astronomy from Patrick Wallace, RAL. Routines in this library will replace the IDL routines from the Astron library for computing the sun and moon position and the moon phase as well as providing many useful astronomical routines for other applications. Betty Stobie is investigating two open source implementations of the Hough Transform, one in the Gandalf package and the XHoughtool. If one of these routines is viable for our needs, it would be preferable to developing a new Hough transform from scratch.

Telescope Balance Calculator

The "balancer" web page was updated to include a new MySQL database and associated web pages. The new MySQL database was created on *hacksaw* with tables for:

- moments for different secondaries, instruments and other telescope attachments,
- observed telescope configurations as well as the associated counterweight settings and elevation motor drive currents,
- calculated configurations for hypothetical telescope configurations.

Four new web pages have been created including the telescope balance calculator and tabular views of the moments, observed configurations, and calculated configurations database tables.

Mirror Coating Performance

Duane Gibson continued work with Ricardo Ortiz on a new MySQL database and web pages for aluminum reflectance and scattering data from the MMT primary, secondaries, and aluminized reference standards. Separate tables were created for raw, corrected, and averaged data for the primary mirror, f/5 and f/9 secondary mirrors, and the MMT-SS1 reference standard. (SS1 is a 4"x7" second-surface aluminum coating, glass protected from the atmosphere for long term stability.) These tables contain reflectance and scattering data for wavelengths from 400 to 700 nanometers, in 10 nanometer intervals, collected over the past few years. These data are currently being reviewed for quality assurance. Web pages were created for charting of reflectance and scattering data versus wavelength, time, and mirror cleaning status.

Other Software-Related Tasks

The "rerr" web page viewer was revised (again) to limit the number of displayed lines and to prevent performance issues for large log files. Changes were made to the cell crate code to reduce the size of logs.

MySQL logging of newly published cell variables for the X, Y, Z, TX, TY, and TZ platform parameters (in millimeters) was added. Additional cell status parameters for bump status, bump warnings, and bump errors were added to the cell crate and to the MySQL background logging for the cell.

Additional work was done on the MMT system status web page. Rather than using the code as a web page, we are currently considering creating a new "service" from this code that would automatically send emails to the appropriate people when problems arise.

Thermal data were supplied to Gabor Furesz (SAO) for evaluation with f/5 data with Hectochelle.

A MySQL database table was set up for the cell, hexapod, and mount crate event logs. Dallan Porter is working on a new "logger" socket server, inputting data into this event_log database table, and web interfaces to these logs.

TempTrax digital thermometer probes were installed in the drive room at the MMT and in the MMTO web server room on campus.

Connie Walker, an astronomer with the NOAO Education and Public Outreach Office, sought Betty Stobie's help in debugging their TLRBSE Solar Spectra Data Analysis Package developed in IDL. There were two logistical problems with the reading of the raw data and the processing of extracted spectra. The problems were easy to diagnose, and workarounds were provided for both.

Instruments

f/15 Instrumentation

Several MMT staff members met with the UAO Telescope Instrumentation Committee on April 19 to discuss current plans and schedules for support and deployment of both the Natural Guide Star (NGS) and Laser Guide Star (LGS) f/15 instrumentation. All these instruments are PI instruments that, like all PI instruments, require some support from the MMT staff. The f/15 instrument suite includes CLIO, MIRAC-4, ARIES (imaging and spectroscopic channels), LAIRS, and IRIS.

Natural Guide Star

AO operator training has commenced, even though the system has not officially been transferred to MMTO. Creighton Chute and Morag Hastie both spent a few nights learning how to operate the system at the end of April. They will be joined in the future by Tim Pickering and Ricardo Ortiz.

The new PC-Reconstructor system was used for both AO runs during this reporting period. There are still some bugs that are being worked out, but it should be finished sometime around summer shutdown. There will likely be more refinements planned afterward, but the basic system should be stable at that point.

Laser Guide Star (LGS)

The attempt to close the loop during the LGS run at the end of March was again unsuccessful. Examination of the data saved during the run points to a combination of several problems that result in large biases in the spot positions. This resulted in the spots moving out to the edge of the subapertures and beginning to leak over into neighboring subaps. Procedures and new software are being developed to fix this problem for the next run. During the run, however, a lot of useful data were collected about the relative orientation of the deformable mirror (DM) and the three cameras in the LGS topbox. The NGS tip/tilt loop was also closed, which is a vital part of the LGS closed loop system.

Motion of the projected laser beams on the sky, due to natural harmonic rotation about the Z axis of the secondary fixed hub, is a major problem with the LGS beam projector. This motion is due primarily to a rotational mode of the hub, so it is not seen by the science instrument. But since the lasers enter into the side of the hub, it strongly affects them. In the past we have seen several arcseconds of motion at 14 Hz. Attempts during the past year to correct this, based on a servo loop closed around the spot position on the CCD, were unsuccessful due to the delays incurred during CCD integration and readout. In December 2006 and during the late March 2007 LGS run, additional bracing wires were installed on the hub to dampen this mode. For the March run, Ricardo Ortiz redesigned the setup from December to be stiffer and easier to install. He was helped in fabrication and installation by Bill Stangret, Dennis Smith, and others from the MMT day crew. Unfortunately, it seems that while the wires helped, they did not provide nearly enough damping.

During the NGS run at the end of April, correction of the laser up-beam jitter was attempted using accelerometers mounted on the hub. This has the advantage of being completely independent of the camera, so is not subject to the integration and readout delay. The lasers were not fired for this test, but instead a camera was mounted in the laser box using the laser projection optics as a telescope. The accelerometer signal was fed directly to a fast steering mirror in the laser pupil box, and a weak control loop was closed around the image position on the camera to stabilize the spot position and correct any residual from the accelerometers. Figure 7 shows a one-second integration with the correction on and off. During the test period, the uncorrected motion was as large as 5 arcseconds peak-to-peak, with a residual error of 0.7 arcseconds or less. This was in moderate wind conditions of 10-15 mph.

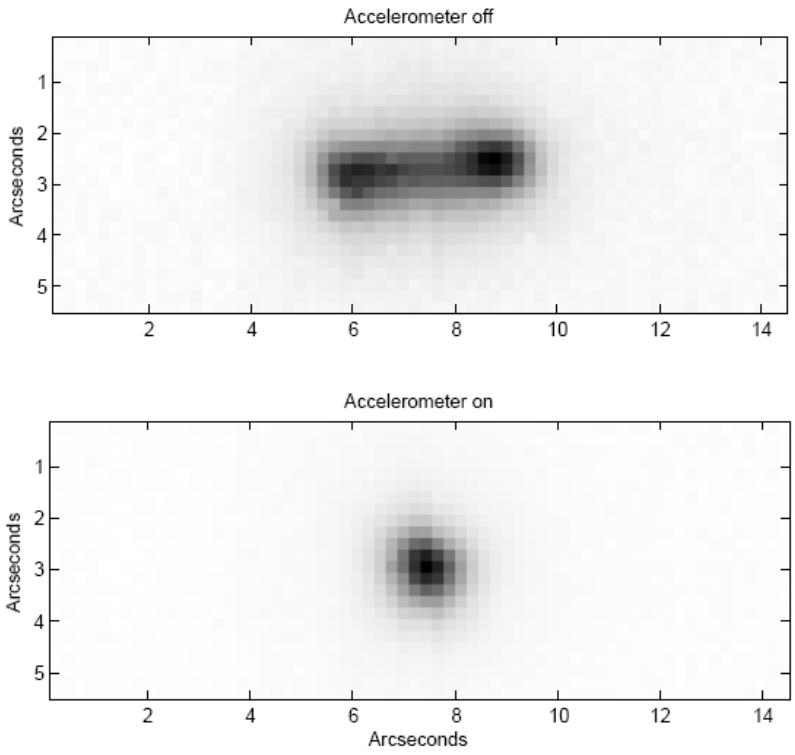


Figure 7: AO accelerometer correction off (top) and on (bottom).

f/5 Instrumentation

f/5 Wavefront Sensor

Part of the engineering night of April 11 was used to test off-axis wavefront sensing with the f/5 wavefront sensor. The MAESTRO instrument may use this mode to perform continuous wavefront sensing. When the wavefront sensor is operated off-axis with the corrector in the spectroscopic mode, the first internal fold mirror, M1, must be tilted to keep the image centered. This is necessary because the chief ray angle with respect to the optical axis increases with field angle, reaching 2.8 degrees at the edge of the field-of-view. In addition, because the chief ray off-axis passes through the pickoff plane at an angle, the focus correction for the wavefront sensor is different from the sag of the focal surface and must be adjusted accordingly. The manuals for the f/5 wavefront sensor and corrector detail the necessary focus and tilt adjustments as a function of field angle.

The off-axis wavefront sensor adjustments have been incorporated into the SAO "WAVESERV Motion Control" GUI (wavedisplay) such that the tilt of M1 and the wavefront sensor focus are automatically changed when a non-zero field angle is supplied. The telescope was pointed at bright catalog stars, which were imaged with the StellaCam acquisition camera. Telescope offsets were then applied and the resulting field angle was input into the wavedisplay GUI. This method was successful in that the off-axis targets were acquired with the StellaCam for several field angles; however, poor seeing (~3.5 arcsec) inhibited the acquisition of any wavefront data. More testing may

be done on the engineering night of May 30 when the corrector is in the imaging configuration for Megacam.

Hecto

The Hectospec and Hectochelle instruments had successful runs late February into March and in mid to late April. The atmospheric dispersion compensator (ADC) failed early in the run, and the instrument was operated without compensation. The pin that connects the ADC motor shaft to the gear, which had been replaced recently, had worked loose again. A new gearbox/shaft/pin/gear unit was replaced by Bob Fata, Jack Barberis, and Marc Lacasse (SAO) on March 20. The new unit is working well.

While the SAO engineering crew was in Arizona, a new grating changer rail was installed on the Hectospec bench so that the robot operators no longer must hold up the heavy (~35 lbs), delicate optics free-hand. The unit was designed and installed by Joe Zajac with assistance from Bob Fata, Jack Barberis, and Marc Lacasse.

Guider #3 on the hecto positioner failed to position correctly on April 14. A quick trip by Mark Mueller and Tim Rodrigues (SAO) in early May, with assistance from MMT staff, determined that the brake was not releasing fully and that the drag was causing the error. The software was modified so that the brake solenoid would not heat up as much, and a pneumatic replacement is being considered by the engineering staff.

Binospec

The week of March 19, Bob Fata and Jack Barberis (SAO) presented the current design of Binospec at the MMT Common Building. Most of the MMT engineering and operations staff were present. The presentation is available in SiteScape.

f/9 Instrumentation

Red Channel Spectrograph

A set of circular plastic shims was manufactured for use as spacers between the Red Channel dewar and the instrument. These shims allow the position of the collimator to be fixed at the zero astigmatism position while focusing by moving the detector (albeit manually). The required shim thickness was determined during earlier measurements. During the day of March 26, a 0.0125-inch thick shim was installed. The plot below shows the output from IRAF's "specfocus" routine indicating the position of the collimator, which yields the best focus is 3.74 volts.

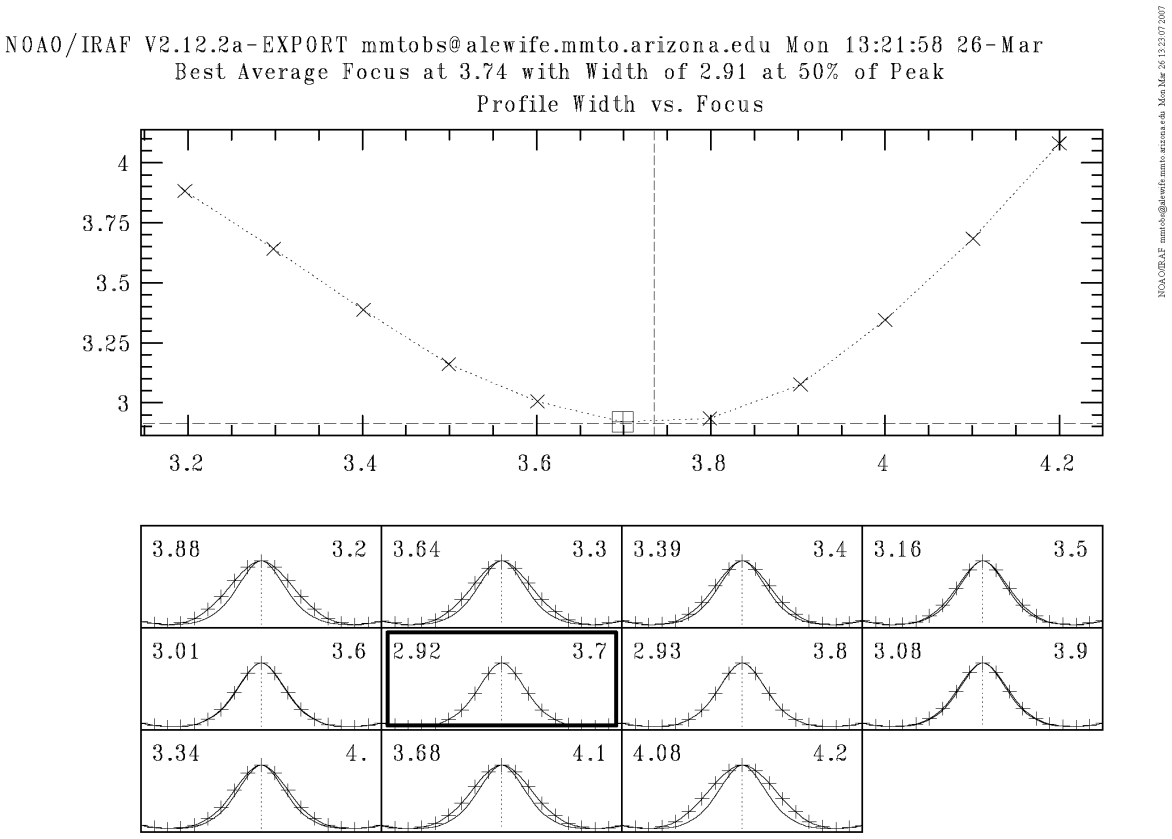


Figure 8: Output from IRAF's "specfocus" routine.

Part of the engineering night of March 28 was used to obtain Red Channel throughput data. This is the first set of throughput data obtained since the instrument was upgraded to use the LBL deep depletion CCD. Conditions were mostly clear and the seeing varied between approximately 1.0 and 2.0 arcsec. The 5 x 180 arcsec slit was used to obtain data from various spectrophotometric standards. The following table lists the standard stars that were observed and the spectrograph configurations used:

Grating/Blaze	Central Wavelength	Filter	Spect. Standard
270/7300	7509	LP495	Feige 67
600/6310	6309	L42	Feige 67
150/4800	5539	L495	BD+332642

Reduction and analysis of the data has not yet been performed.

SCCS/ICE Modifications and Updates

Further work was done to upgrade the Red and Blue Channel spectrograph control software. More functionality was moved from the client to the server. For the sake of comparison, two different browser-based GUI clients were built. The first was built using Java's native GUI toolkits and runs in a web browser as an applet. The second was also built in Java, but used the Google Web Toolkit

(GWT; *http://code.google.com/webtoolkit/*) to create an HTML+javascript interface from the Java code. The applet method works well, but requires that the java plugin, which is not included in the base OS, be installed and maintained on mountain machines. It is also not as easily integrated into our OS updating/installing scheme as other third-party plugins such as Adobe's Flash. However, these issues have been worked around in the past to support applet-based satellite image viewers and the new applet-based cell GUIs. The GWT method generates HTML+javascript code that can support almost any modern browser with no need for any extra plugins. The resulting interface loads quickly and works fairly well. However, this is done at the expense of functionality in the provided interface widgets (e.g., the lack of a spinner widget for entering floating point values) and greater complexity in back-end implementation). For example, the java applet can communicate directly with the spectrograph server using the SOAP protocol, whereas the GWT interface must communicate via its own RPC protocol to java code running on a server, which then relays the request to the spectrograph server. This has been implemented using the Tomcat5 to run the server-side java code on hacksaw. Tomcat5 is well-supported by the OS that we use and was not difficult to configure to run the GWT server-side code, but seems to be an overly complicated solution to the problem at hand. Further testing is ongoing and the new SCCS server/client software should be deployed by this summer.

Mike Lesser (ITL) fixed some bugs in the AzCam server software that is used by the Blue and Red Channel CCDs. These changes required some modifications to our ICE interface. These were implemented and tested so that pausing and resuming exposures should now work reliably for both the Red and Blue Channel CCDs.

Steward Observatory Guider

A new ITL/Magellan guider controller was successfully tested on the Steward 90-inch SO Guider on the nights of March 18 - 20. Since the new controller appears to be functioning nominally, ITL will soon implement the controller for use with the MMT SO Guider.

LOTIS Aluminizing Project

The Heraeus-Engelhard "Roots" vacuum blower suffered a drive motor failure at the Steward Mirror Lab (SOML), and we had to scramble to replace it. Thanks to J.T. Williams, we were able to find a new and improved replacement, with minimal delays.

Leak testing continued thanks to the generosity of Phil Hinz (SO), who loaned his spare pumping station to back the residual gas analyzer (RGA) being used in Helium leak testing. No discrete leaks have been found, but we may leak test one more time after reclosing the belljar flanges.

The new power distribution cables for the belljar feed-throughs have been tested. We are in the process of testing the welders and trying to bake-out the chamber using the old filaments. Wonderful pictures and video were collected for every welder filament section, plus a movie of all welders running simultaneously. The system is now ready for a new set of filaments to coat test slides and measure uniformity.

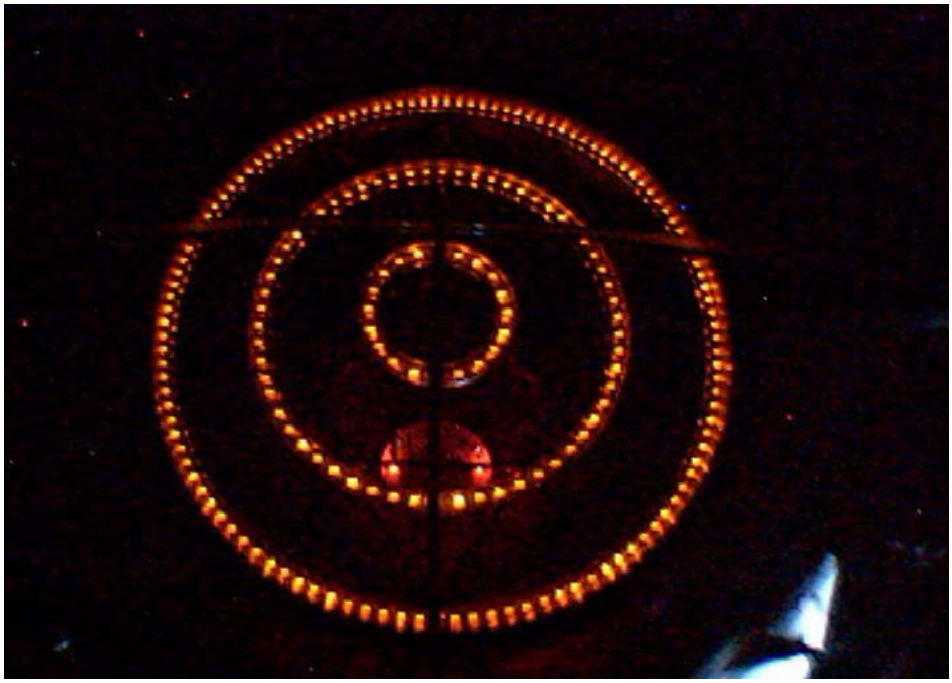


Figure 9: The view through a window into the new LOTIS belljar. Pictured are 200 filaments glowing under vacuum, with all 10 welders working under one controller at 10 x 360 amps. In the image is seen what appear to be missing filaments. They are blocked from view by a new "T" frame, with the same curvature as the mirror, to mount witness slides.

Dondi Gerber is observing progress of the LOTIS project in order to understand the entire aluminization process. She spent time at SOML setting up the vacuum system, leak testing with Helium gas, and testing welder cables, currents, and voltages.

In preparation for a full power servo test, Cory Knop worked with J.T. Williams and Ricardo Ortiz to perform low resistance checks of the new cable and connector assemblies, and performed connectivity checks between each welder and the belljar. He also built a water flow gauge indication box to give the operator a visual indication of cooling water flow. The box was used during a pump-down of the belljar.

General Facility

Chamber Floor

On March 9, M3 Engineering released a concept report for the MMT chamber floor replacement. The proposed flooring system in this report was recommended by the MMTO staff and consists of a 1/8-inch steel plate over a 1-1/2-inch fiberglass grating with insulation in-fill.

Removal of the light lock must be completed before the new floor is installed. Shawn Callahan and Bill Stangret inspected the light lock wall and determined that these can be easily removed by MMT staff. M3 is now analyzing what is required to allow removal of a column at the southwest corner of

the light lock. Preliminary analysis shows that the 10-inch floor joist will need reinforcement. A report on removal of this post is expected in early May.

It is our goal to rapidly progress on the floor design in order to provide contractors enough time to install the floor during this year's summer shutdown.

Roof Repair

On March 12, M3 Engineering released a concept report for the repair of leaks in the MMT enclosure roof. This report presents three options: repairing the existing roof, adding a new thermoplastic seamless membrane over the entire roof, or replacing the metal roof deck with a new metal roof system without exposed connections.

Shawn Callahan and Steve Criswell met with contractors from Rain-Tite Roofing to review thermoplastic membrane roofing options for the MMT enclosure.

The fabricators would pre-weld the membrane off-site before unrolling and fastening it to the existing roof. They estimate that the installation should take only a few days, and saw no reason why the telescope could not remain operational at night during installation.

Rain-Tite sent Shawn three color samples: beige, grey, and white. Laying the samples on the roof in the afternoon sun quickly demonstrated that white had the highest reflectivity. A similar test exposing the samples to the nighttime sky indicated that the emissivity of the three samples was indistinguishable. The uniformity of the sample was within the 0.1C resolution of a hand-held digital thermometer.

Rain-Tite is currently preparing an estimate of the cost of fabrication and installation of a white PVC membrane roof. They will provide estimates with and without roof heaters. It is likely that we will be able to use our existing roof heaters with an improved control system to prevent melting of the membrane.

Instrument Repair facility

M3 will resume work on the instrument repair facility after completion of the flooring design, which has highest priority.

Meteorological Equipment

In early April, Tom Gerl and Brian Comisso moved the Yankee MET-2010 thermohygrometer from the telescope chamber to the elevator shaft on the roof outside of the building. This move allows the Yankee unit to be used as an accurate indicator for outside dewpoint prior to opening the chamber. The location also allows easy access to service the unit when required. Immediately following the move, systematic oscillations in dewpoint and temperature values were observed. After several discussions with the manufacturer, the unit was returned for servicing and calibration. The repair is estimated to take up to two months.

Instrument Lift

Tom Gerl installed a down limit switch to the west side of the instrument lift. This will allow the west side of the lift to continue down after the east side has reached its lower limit. He also updated the documentation for the instrument lift platform.

Thermal Activity

In March, Dondi Gerber spent several days at the MMT testing for thermal activity using an infrared camera. Every room was scanned, including the chamber. We are currently in search of "hot zones" and what may be causing them within the MMT. The infrared camera showed various results. In mid April, more thermal images were acquired during a nighttime visit to the MMT. A presentation of thermal images is planned.

Other Facility Improvements and Repairs

Bill Stangret and Dennis Smith lubricated the counterweight and cleaned the Thomson linear bearing rods, which guide the weights as they are adjusted. Bill cleaned and recoated the building track, and also did preventive maintenance on the trench fan.

Tom Gerl found a source for phones identical to those currently installed at the MMT, and purchased four units. We now have spares with which we should be able to keep the present system running until a new system can be installed.

One of the lathes in the shop quit functioning and we traced the problem to a pair of blown fuses in the three-phase disconnect box. This may have been caused by lightning, but no other problems have been discovered. The lathe has functioned well since replacing the fuses.

The StellaCam was reinstalled in the f5 WFS with its own power supply, which operates off the same relay that had been used to supply power from the computer power supply. This relay had a spare contact through which we could supply AC to a wall module power supply. This modification seems to be working fine.

Comfort Control visited the MMT to survey for the quotation they will submit to continue the rebuild of the building's Freon chiller system.

The blower starting power-on reset module has been built and partially tested, and should be finished and installed soon. The software changes have been discussed with Tom Trebisky.

John Glaspey, Bill Stangret, and Dennis Smith cleaned and attempted to organize the storage area under the Common Building.

Dennis Smith relabeled all the Blue and Red Channel cables and attachment points.

Tom Gerl replaced some of the chamber incandescent lamp switches that were failing.

Ceiling tiles were replaced on the second and third floors.

Cory Knop developed a safety orientation check-sheet for new employees. Steward Observatory is very interested in adopting this form for observatory-wide use.

The majority of the documentation H-Files have been transferred to digital format and installed in SiteScape.

Top: Arizona Game and Fish recently re-introduced wild turkeys into the Santa Ritas. Photos by Perry Berlind, FLWO.

Left: A ringtail cat saunters across the summit parking lot “like he owns the place.” Photo by AO plane spotter Bryan Cardwell. Several ringtail cats were finally trapped and removed from the MMT building and released down the road a ways, where it is hoped they will remain.

Visitors

March 9: Kristian Finlator of Steward accompanied several prospective grad students to the MMT.

April 2: Frank Eisenhauer and Sebastian Rabien (Max Planck Institute for Extraterrestrial Physics in Garching, Germany) and Olivier Guyon (Subaru Telescope in Hilo, HI) were accompanied by Michael Lloyd-Hart and Roger Angel (Steward).

April 5: Dan Brocious (FLWO) accompanied reporter Michelle Nijhuis from the bi-weekly news magazine High County News. Michelle is doing a story on observatory site protection in the West. High County News covers 11 western states, and reports on the West's natural resources, public lands, and changing communities.

Publications

MMTO Internal Technical Memoranda

None

MMTO Technical Memoranda

None

MMTO Technical Reports

None

Scientific Publications

07-4 G515, Revisited. I. Stellar Populations and Evidence of Nuclear Activity in a Luminous "E+A" Galaxy
C. T. Liu, E. J. Hooper, K. O'Neil, D. Thompson, M. Wolf, T. Lisker
ApJ, **658**, 249

07-5 The Rapidly Pulsating Subdwarf B Star PG 1325+101. II. Structural Parameters from Asteroseismology
S. Charpinet et al.
A&A, **459**, 565

07-6 Observations of Herbig Ae Disks with Nulling Interferometry
W. M. Liu, P. M. Hinz, M. R. Meyer, E. E. Mamajek, W. F. Hoffmann, G. Brusa, D. Miller, M. A. Kenworthy
ApJ, **658**, 1164

07-7 Physical Orbit for λ Virginis and a Test of Stellar Evolution Models
M. Zhao, J. D. Monnier, G. Torres, A. F. Boden, A. Claret, R. Millian-Gabet, E. Pedretti, J.-P. Berger, W. A. Traub, F. P. Schloerb, N. P. Carleton, P. Kern, M. G. Lacasse, F. Malbet, K. Perraut
ApJ, **659**, 626

Non MMT Scientific Publications by MMT Staff

Rapid Multiwaveband Polarization Variability in the Quasar PKS 0420–014: Optical Emission from the Compact Radio Jet
F. D. D'Arcangelo, A. P. Marscher, S. G. Jorstad, P. S. Smith, V. M. Larionov, V. A. Hagen-Thorn, E. N. Kopatskaya, G. G. Williams, W. K. Gear
ApJ, **659**, L107

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 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

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:

- What's New at MMTO.
- General information about the MMT and Mt. Hopkins.
- Telescope schedule.
- User documentation, including instrument manuals, detector specifications, and observer's almanac.
- Scientific and technical publications
- A photo gallery of the Conversion Project as well as specifications related to the Conversion.

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

March 2007

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	10.00	100.20	54.00	0.00	1.25	0.00	0.00	55.25
PI Instr	19.00	198.10	31.20	1.50	0.00	0.00	0.00	32.70
Engr	2.00	20.20	0.00	0.00	0.00	0.00	0.00	0.00
Sec Change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**31.00**	**318.50**	**85.20**	**1.50**	**1.25**	**0.00**	**0.00**	**87.95**

Time Summary Exclusive of Summer Shutdown

Percentage of time scheduled for observing	93.7
Percentage of time scheduled for engineering	6.3
Percentage of time scheduled for sec/instr change	0.0
Percentage of time lost to weather	26.8
Percentage of time lost to instrument	0.5
Percentage of time lost to telescope	0.4
Percentage of time lost to general facility	0.0
Percentage of time lost to environment (non-weather)	0.0
Percentage of time lost	27.6

* Breakdown of hours lost to telescope
cell crate 1.25

April 2007

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	267.30	74.95	4.25	2.75	0.00	0.00	81.95
Engr	1.00	9.30	0.00	0.00	0.00	0.00	0.00	0.00
Sec Change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**30.00**	**276.60**	**74.95**	**4.25**	**2.75**	**0.00**	**0.00**	**81.95**

Time Summary Exclusive of Summer Shutdown

Percentage of time scheduled for observing	96.6
Percentage of time scheduled for engineering	3.4
Percentage of time scheduled for sec/instr change	0.0
Percentage of time lost to weather	27.1
Percentage of time lost to instrument	1.5
Percentage of time lost to telescope	1.0
Percentage of time lost to general facility	0.0
Percentage of time lost to environment (non-weather)	0.0
Percentage of time lost	29.6

* Breakdown of hours lost to telescope
wavefront sensor 2.75

Year to Date April 2007

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	24.00	262.20	128.15	0.00	3.25	0.00	0.00	131.40
PI Instr	89.00	933.85	337.60	9.50	2.75	2.00	0.00	351.85
Engr	7.00	76.25	25.45	0.00	0.00	0.00	0.00	25.45
Sec Change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**120.00**	**1272.30**	**491.20**	**9.50**	**6.00**	**2.00**	**0.00**	**508.70**

Time Summary Exclusive of Summer Shutdown

Percentage of time scheduled for observing	94.0
Percentage of time scheduled for engineering	6.0
Percentage of time scheduled for sec/instr change	0.0
Percentage of time lost to weather	38.6
Percentage of time lost to instrument	0.7
Percentage of time lost to telescope	0.5
Percentage of time lost to general facility	0.2
Percentage of time lost to environment (non-weather)	0.0
Percentage of time lost	40.0