MMT Observatory
Smithsonian Institution &
The University of Arizona®

Quarterly Summary

April - June 2017

MMT Observatory Activities

Our Quarterly Summary Reports are organized using the same work breakdown structure (WBS) as used in the annual Program Plan. This WBS includes a major category with several subcategories listed under it. In general, many specific activities might fall a tier or two below that. The WBS will be modified as needed in future reports.

Administrative

Program Management

Engineering meetings were held in April and June. An MMT Council meeting was held April 14.

Staffing

Connor Oswald, UA undergraduate, began work in May as a student technical assistant with the software group. He will work on migrating the current MMTO website from a deprecated version of Drupal to the current version of Wordpress.

Alan Williams, UA undergraduate, started in June as a student documentation assistant. He will work on digitizing and organizing the numerous photos of the former and present-day MMTO for accessibility and archival purposes. He will also help with digitizing and organizing engineering drawings.

K. Duffek continued his involvement with the TAO (Tokyo Atacama Observatory) group, as requested by group leader T. Connors of Steward Observatory. The formal review of their mirror safety design was extended, with the additional review time prompted by changes to the TAO support electronics.

Reports and Publications

There were 16 publications this quarter. See the listing in Appendix I, p. 27.

Presentations and Conferences

B. Weiner attended the workshop "Building Infrastructure for Time-Domain Alert Science in the LSST Era" held May 22-25 at NOAO in Tucson. He participated in discussions of queue schedule management, protocols/APIs for observation requests, and spectroscopic data reduction.

Safety

C. Knop presented talks on "Home Safety" and "Heat Stress" to the Steward Observatory Safety Committee at the Tri-annual Safety Meeting held on April 17. The committee will meet on a bi-annual basis in the future due to scheduling conflicts of committee members.

Training

J. Di Miceli attended a Wilderness First Responder (WFR) re-certification course held May 18-22. The course was given through the Flagstaff Field Institute in Flagstaff, AZ. He was re-certified in the following skill sets: conducting a thorough physical exam, obtaining a patient history, assessing vital signs, providing extended emergency care in the wilderness, and making crucial evacuation decisions. The re-certification is good for 2 years.

Figure 1. Five WFR attendees selected to be "patients with broken arms" for a training scenario. J. Di Miceli is pictured second from left.

Safety Inspections

A METR inspection was conducted at the MMT on May 16-17.

Primary Mirror

As the primary mirror support system continues to age, a review of sub-system upgrades continues. One system identified for upgrading is the cell air monitoring system. It has been determined that the pressure transducers currently in use in the cell are obsolete. The electronics group has identified suitable replacement transducers and has procured 10 units. All 10 units have been assembled and connectorized for planned installation during the upcoming summer shutdown. This upgrade allows for minimal possible down time if a failure of a transducer occurs, as well as provides sufficient spares and reduces the possibility of obsolescence in the future.

Actuators

Several inoperative single/special/dual actuator circuit cards were sent to the MMTO campus electronic shop for repair. Repair of circuit cards involved inspection, testing, troubleshooting, and parts replacement. All but two of the cards were repaired. An inventory of spare cards on hand was taken with the result being: 6 dual, 2 single, and 3 special. Cards installed in spare actuators are not included in these numbers.

During the repair of the cards, a chip in the tester failed, requiring repair. The failed chip was ordered and received, and awaits installation. While the tester was open, several issues occurred causing more chips to fail. All were replaced with parts already on hand. A lot of knowledge was gained during the troubleshooting of the tester.

Servos

As part of an in-house electronics training program, J. Wood (mountain support staff) worked in the campus electronic shop one day per week for two weeks. The training consisted of instruction/familiarization on soldering basics, techniques, and hands-on practice. Both standard thru-hole and surface mount components were addressed. Additionally, the building drive servo cards (A, B, and C) were inspected by J. Wood for proper component values. This inspection identified several discrepancies on the cards. All cards were returned to values identified in the schematics.

Cell Crate

During operation of the cell crate power supply, it was determined that the -12V and +12V power sense LED cards were not adjusted to operate within the prescribed limits. A recalculation of resistor values was performed, and the cards were reconfigured to operate within the prescribed limits. The modification of these cards will give staff a visual indication that the power supply is operating within specifications.

The spare cell crate power supply located on the mountain was brought to the campus electronic shop and was repackaged into new and modern packaging. This will allow power supplies to be swapped out without reconfiguration of cabling.

The telescope has systems requiring different keys to shut down or reboot for daily operations. Two of the most used systems are the cell crate power supply and the f/5 hexapod controller. The key switches for these systems were standardized to allow the use of a signal key to operate both of the systems.

Secondary Mirrors

Nothing to report.

Hexapods

f/9 and f/15 hexapod

A new radio repeater system was installed during this quarter. With the new installation, it was hoped that the radio frequency (RF) energy would no longer impact the f/9 hexapod electronics. Testing took place on July 10 utilizing the same setup from August 6, 2015: the spare actuator was powered up on the loading dock and the radio system was keyed. Initial testing was very promising. With the radio keyed and loading dock doors open, minimal signal degradation was seen on the actuator transducer signal. Additional testing will be performed on the f/9 hexapod after it is installed in July.

Optics Support Structure

Nothing to report.

Pointing and Tracking

Nothing to report.

Science Instruments

f/9 Instrumentation

The f/9 instruments were on the telescope for 23% of the available nights from April 1 – June 30. Approximately 71% of those nights were scheduled with the Blue Channel Spectrograph, 10% with Red Channel, and 19% with SPOL. 162.5 hours were allocated for f/9 observations. 31% of these hours were lost due to weather. Instrument, facility and telescope problems account for less than 1% of lost time. Blue lost 25% of its time to bad weather, with Red Channel losing 0%, and SPOL losing 71%.

f/5 Instrumentation

There were 66 nights scheduled for observing with f/5 SAO instruments this quarter. MMIRS was scheduled for 28 nights, Hectospec for 27 nights, and 11 nights for Hectochelle. The weather was better than average, and only 18% of the scheduled time was lost to clouds. A half dozen nights had weather bad enough where no science observations could be taken. While MMIRS lost no entire nights, 4 nights of Spec and 2 nights of Chelle were completely lost to bad weather.

A service mission took place in April to replace the gimbal actuators in the Hecto positioner and to adjust the associated electronics. The annual cleanup and inspection was also performed. During the inspection, a screw for clamping a connector was found on the edge shelf of the positioner inside the covers. The source connector was located and re-secured.

Time was lost in April due to a power outage caused by a failure of the generator transfer switch and its fuel pump. Also, a transformer change at the summit in June took 16 hours rather than the expected 8-hour day, costing most of that night. Problems with system restart and the secondary hexapod system prevented observations in the couple of hours remaining after the transformer work was completed. Issues with user-supplied guide stars and a mirror panic also contributed to some lost time.

The MMIRS instrument obtained 3,663 image exposures and 1,304 spectral exposures for scientific targets. In addition, 4,826 calibration exposures were taken consisting of darks, alignment, telluric, flat, comp, and test images. MMIRS was on the telescope April 4-16, May 11-16, and June 9-19, with observations run exclusively in queue mode.

The April run consisted of 8 programs, including one Target of Opportunity program, using 16 different custom slit masks and 68 submitted targets. A mask change was conducted on April 10 to accommodate all of the requested masks. Of the 121.5 hours allocated, 5.5 were lost to weather, 1.5 hours were lost to unresponsive GUIs on the MMIRS interface, and 0.25 hours were lost to a primary mirror panic. Approximately 48 of the submitted fields were observed.

Due to the short duration of the May run, the May and June runs were conducted in a single joint queue. This was the first time two separate runs were treated as a single queue. The runs consisted of 8 programs, with 13 individual slit masks and 132 submitted targets. A mask change was done between the two runs in order to accommodate all of the requested masks. Of the 118.3 hours allocated, 15.7 hours were lost to weather, and half an hour was lost due to an actuator fault. Approximately 80 observing blocks were observed.

Although MMIRS operated with few issues, a couple of masks were difficult to align due to the selection of fainter than average alignment stars. At the end of one run, the gate valve that isolates the MOS (slit/slit mask) section from the camera section would not close. The instrument was removed from the telescope with the gate valve open. When the system was restarted after the power cycle related to coming off the telescope, everything worked fine and the gate valve closed normally. We exercised it a couple more times and did not see any issues.

There was a mid-run mask exchange this quarter as we had many clear nights. Several MMIRS masks have been fabricated using the SAO laser mask cutter. Diverter tubes are being set up to control the liquid nitrogen overflow from the two MMIRS dewars, and to also prevent the liquid from spraying on the f/5 secondary or the Binospec instrument. The MMIRS camera section was warmed after the January run and cooled prior to the April run. The MOS (upper) section is allowed to warm between runs so new masks can be swapped in.

M. Lacasse had discussions with B. McLeod regarding the lowering of the loft Neslab chiller in the daytime during MMIRS' runs. The lower temperature seems to risk forming condensation in the heat exchanger fins if outside or chamber air is allowed into the rack boxes. Also, when the telescope and instrument go into lightning shutdown, the chiller sometimes continues to operate although the rack electronics and heat exchanger fans are powered off – again creating a chance of condensation forming in the rack heat exchangers. The lightning shutdown procedure was written for SAO systems computers. The procedure will change in the fall with the installation of a smart module in a second UPS to allow automated proper power-down of all the f/5 computer equipment in 3 East.

Mask designs for the upcoming July MMIRS run were due on May 16. Two were ordered from Photomachining, Inc., and six were cut with the Binospec laser-cutting machine.

The Hectospec and Hectochelle instruments gathered 458 science exposures on 132 fields over the 32 nights of those runs. There were 1,446 additional calibration frames consisting of bias, flat, comp, dark, and sky exposures. On the second day of the April Hecto run, there was a jump in the home encoder position for the X Follower axis home location. After suggestions from D. Fabricant, a second home was performed and cables were inspected, but no reason was found for the change in the encoder. A new policy was established to do a second home of the positioner axes at the end of each night. No additional issues with the encoder readings occurred. A few days later the Z down motion of Robot 2 for a certain fiber generated an error that repeated a couple of times. We put that fiber in the dead-fiber list so it would not be used, and there were no additional issues with the Z axis. We believe something may have contaminated the magnet on the base of the fiber button. A week or so later, there was an issue with a third axis: the Y1 axis of Robot 1 had a couple of following-errors. We went through the recovery procedure each time. One error was later in the night, and observations were done with MMTCam afterwards while plans were set up to replace the motor amplifier. When the motor amplifier was examined, M. Lacasse found a connector had not been properly secured after work done in the amplifier crate over a year ago. The cable was reseated and properly secured. The axis did not give any further problems. At the next instrument mounting, one of the Hecto cables was hanging a bit lower than usual and was caught beneath the instrument lift as it was lowered, which damaged the cable clamp. Continuity checks revealed that one or two conductors had also been damaged. The spare 25' cable was retrieved and used for that run. The cable was draped external to the instrument, and the mounting supports were frequently inspected to verify that the cable was not being stressed. When B. Fata, K. Bennet, and J.Barbaris were on the summit for the corrector packing in June, the damaged cable was removed from the instrument and the spare cable put in its place. A modification to the instrument mounting procedure now has the cable ends carried in and protected by a bucket whenever they are not attached to the drive arc.

The WaveFront Sensor -MMTCam system continues to operate well. Some tests were done to look at the low level light contamination introduced by the MMTCam communication electronics in the Hectospec observations. MMTCam took 435 science exposures on 34 targets with 778 calibration frames consisting of bias, flat, dark, and a few engineering frames to look for evidence of mount/mirror oscillation. MMTCam images were taken on 24 nights during the Hecto observation runs with 8 of those nights used just for calibration data.

Work continues with plans and preparations for the arrival of Binospec and the laser mask cutter in the fall. The Instrument Repair Facility (IRF) floor has been resurfaced. Associated equipment being planned for includes a large clean tent, a flow bench, the telescope simulator, air compressors, and chillers. Electrical supply and outlet distribution issues have been discussed. The Common Building basement has been nearly cleared, with the SWIRC instrument still needing to be relocated. The WideField Corrector was packed and shipped to Cambridge in June for a thorough cleaning prior to Binospec's arrival. B. Fata, K. Bennet, and J. Barberis traveled here to direct that process as well as to check on the status of Binospec preparations.

f/15 Instrumentation

The f/15 secondary mirror was packaged and driven from the summit to base camp on May 29. The journey continued the next day, and the mirror arrived in Tucson at the Steward Observatory adaptive optics lab on campus just before noon on May 30. The f/15 was brought to campus to undergo upgrades associated with the MAPS project. For the entire trip, the f/15 was transported in the MMTO box truck with the mirror facing up in the deformable mirror (DM) Jockey as shown in Figure 2. A Slam Stick X accelerometer, programmed to start recording when 0.8g's of acceleration was exceeded in any direction, was installed on the mirror cell. The accelerometer did not record a single event during the trip from the summit to Tucson. All of the f/15 equipment stored in the common building basement and at the summit has also been delivered to Steward Observatory, with the exception of the two top boxes that were relocated to the upper warehouse at the base camp.

Figure 2. The f/15 mirror being secured for transport in the MMTO box truck to Tucson.

The working simulation was completed for the MAPS voice coil actuators. Simulation results were compared with MMT test data and matched quite well. Work continues with updating parameters, performance optimization tools, and other aspects to create better simulations.

Work was also done on a PID controller design.

A finalized plan was developed to complete three f/15 actuator prototypes: A single actuator, a 4 actuator, and a 19 actuator prototype. Work has started on the single axis actuator prototype. The single axis actuator is expected to provide some insight into the manner in which the signal for the capacitive sensor is read, the rate at which the actuator can be operated, and the effectiveness of the pulse width modulated control scheme.

The original f/15 test stand was resurrected in the adaptive optics lab. Work related to operating the f/15 in its original configuration on the test stand was started.

Topboxes and Wavefront Sensors (WFS)

f/9 Topbox

The camera for the f/9 wavefront sensor was replaced in April, and commissioned on-sky in May. Details on the camera and its new host computer implementation are given in the report for the previous quarter. The new camera is well-aligned with the optical axis of the system, though slightly rotated with respect to the lenslet array as seen in Figure 3. This rotation calibrates out and does not affect the analysis of the WFS images.

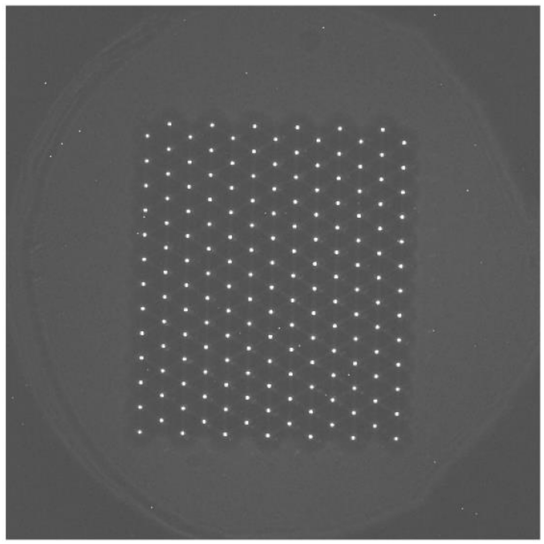

Figure 3. LED reference image for the f/9 WFS with the new SBIG ST-8300 camera.

The new camera has a significantly different pixel scale than the old one - 5.4 microns/pixel vs 20. Therefore, the camera is configured to use 3x3 binning for normal WFS operations to provide improved sensitivity and reduced readout time while still providing more than sufficient resolution of the spot images.

An attempt was made to use the new camera with the old WFS software. In principle, it should be possible if the relevant configuration parameters (e.g. pixel scale, pixel size, image size) are changed, but in practice, the old system's algorithms for finding spots and associating them with lenslet apertures are too fragile to deal with the new WFS image format. The new, fully refactored WFS software works fine with this data, however. A preliminary version of a web interface to the new WFS software was deployed and was successfully used during the May and June f/9 campaigns.

Wavefront Sensor Software

Development of the new WFS software continued over the course of the quarter. Deploying a version of it on-sky to support the new f/9 WFS camera provided some useful new test cases. These data helped in the testing and development of improved methods for background subtraction and aperture alignment, which has made the core code much more robust. These have been further validated against archived WFS data. The new core routines can now reliably handle a much wider range of aberrations than the old system, and can reliably centroid spots with seeing as bad as 2.5".

There remains some work to be done to fully validate on-sky the corrections used to re-center the WFS image using the hexapod. However, the rest of the corrections (e.g. focus, coma, and primary mirror forces) have been validated and successfully used with the f/9 configuration. Given that, they should also work as well for the other WFS modes.

The main thrust now is to complete building the new interface. An initial version has been deployed to support the f/9 WFS which can also be used for the other modes, if desired. However, it currently only supports manual interaction. Work is ongoing to integrate and automate image acquisition so that the new system can support automated and continuous operation. The plan is to commission and deploy the new WFS software for all modes after the end of summer shutdown.

The development of this project is hosted at https://github.com/MMTObservatory/mmtwfs/.

Some screenshots of the current web interface are shown in the following figures:

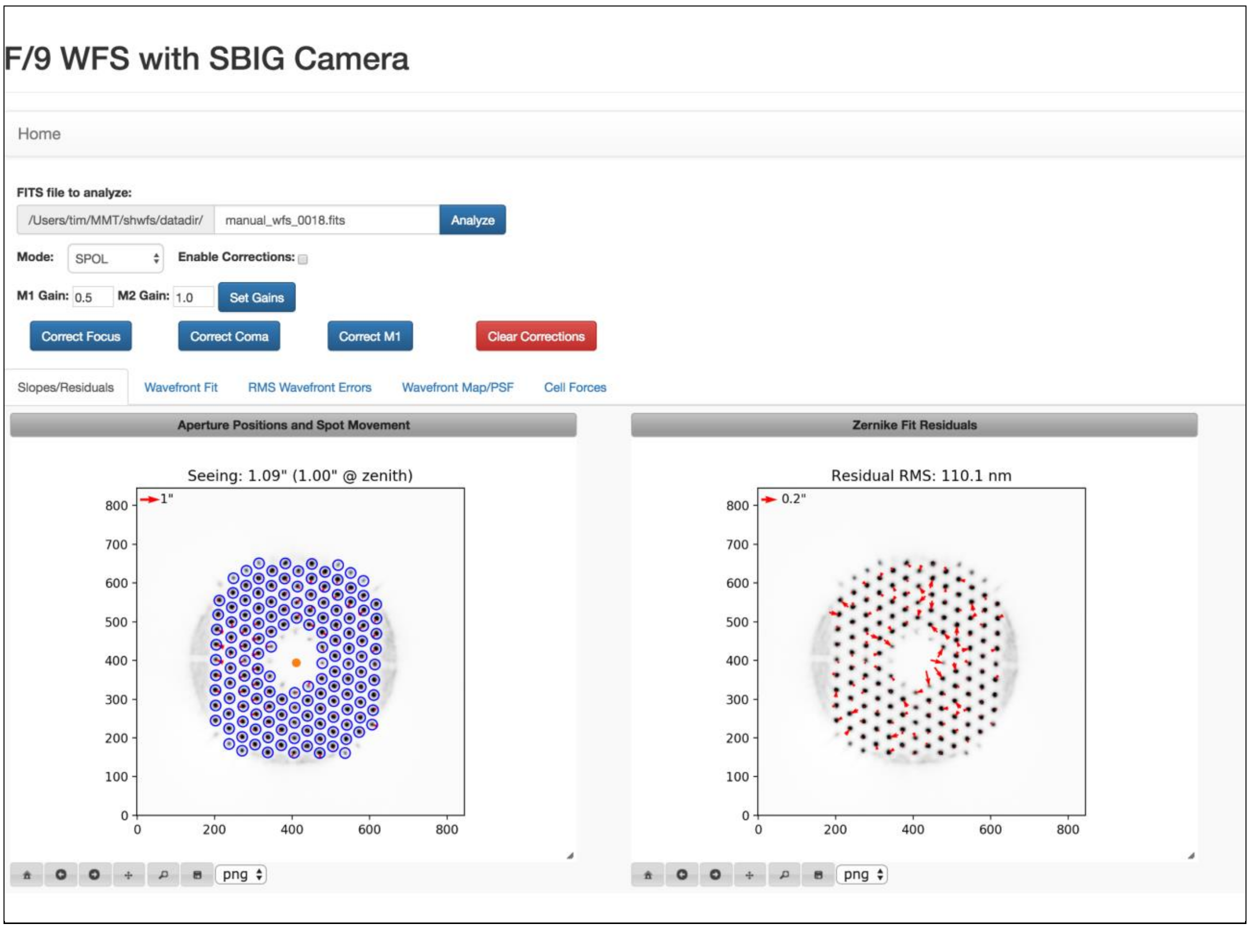

Figure 4. Default WFS page showing the spot positions and motions on the left, and the residuals of the wavefront fit on the right. The residuals are the difference between the measured spot motion and the motion predicted by the wavefront fit. The residual RMS provides a measure of the "goodness" of the wavefront fit, i.e., how well the fit describes the overall motion of the spot images.

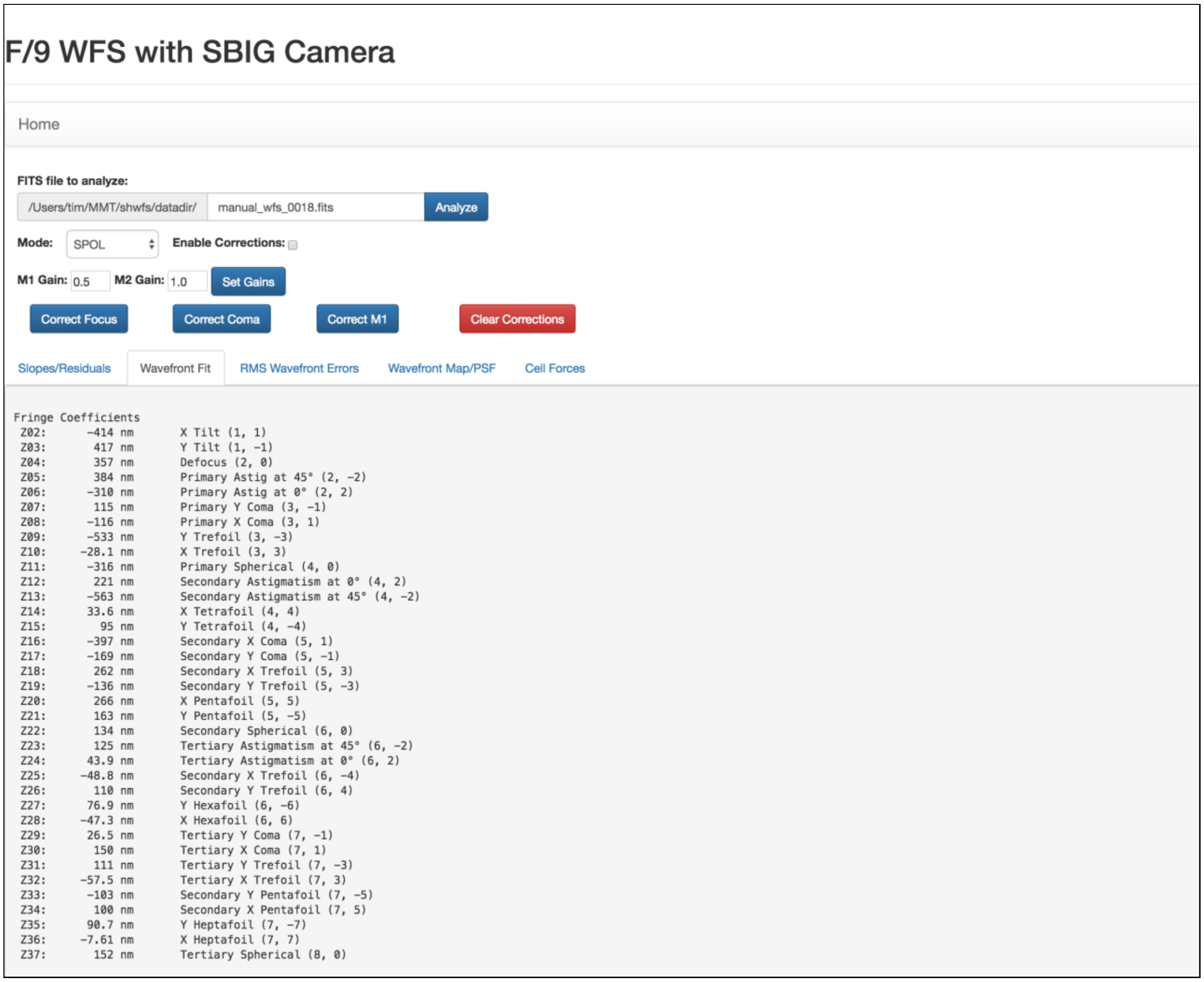

Figure 5. The new system uses 36 Zernike modes in its fits so that the first three spherically-symmetric terms are included. The ordering has been changed from the old system, and now conforms to the Noll standard used elsewhere in the optical sciences. The "fringe coefficient" amplitudes match the units and scaling used in the old system.

Figure 6. Bar chart showing the RMS wavefront error due to each mode of the wavefront fit along with the total and residual RMS.

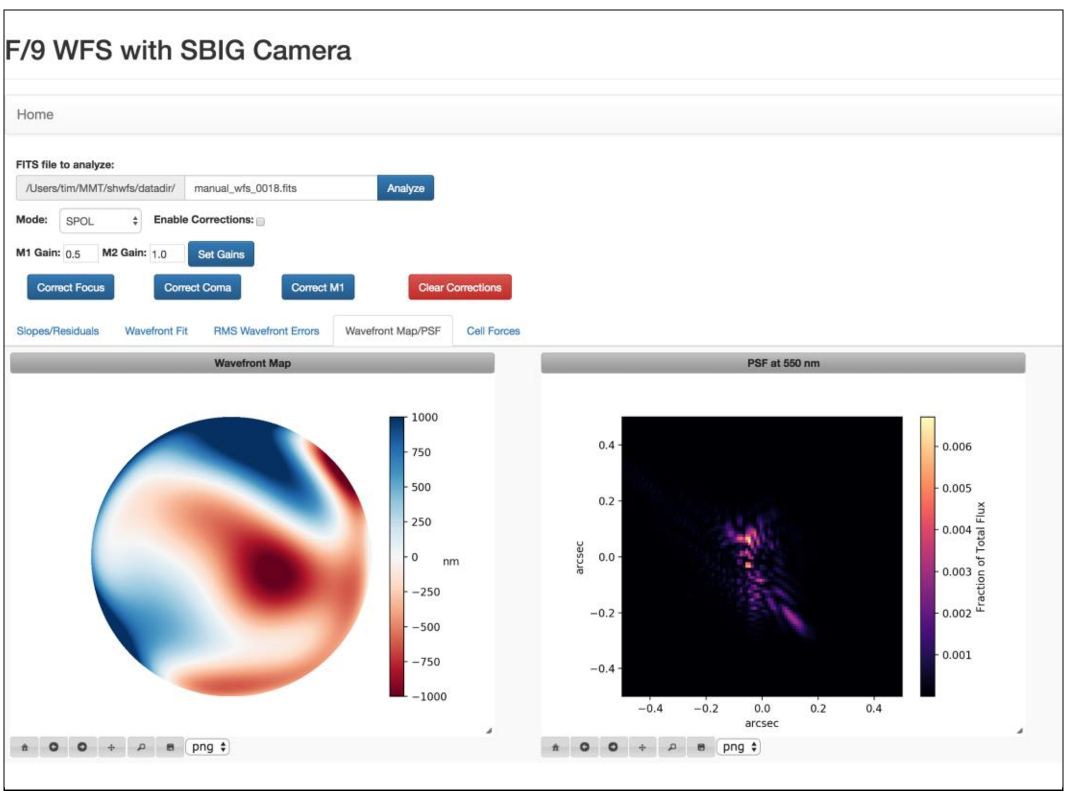

Figure 7. 2D map of the wavefront aberrations and resulting diffraction-limited PSF.

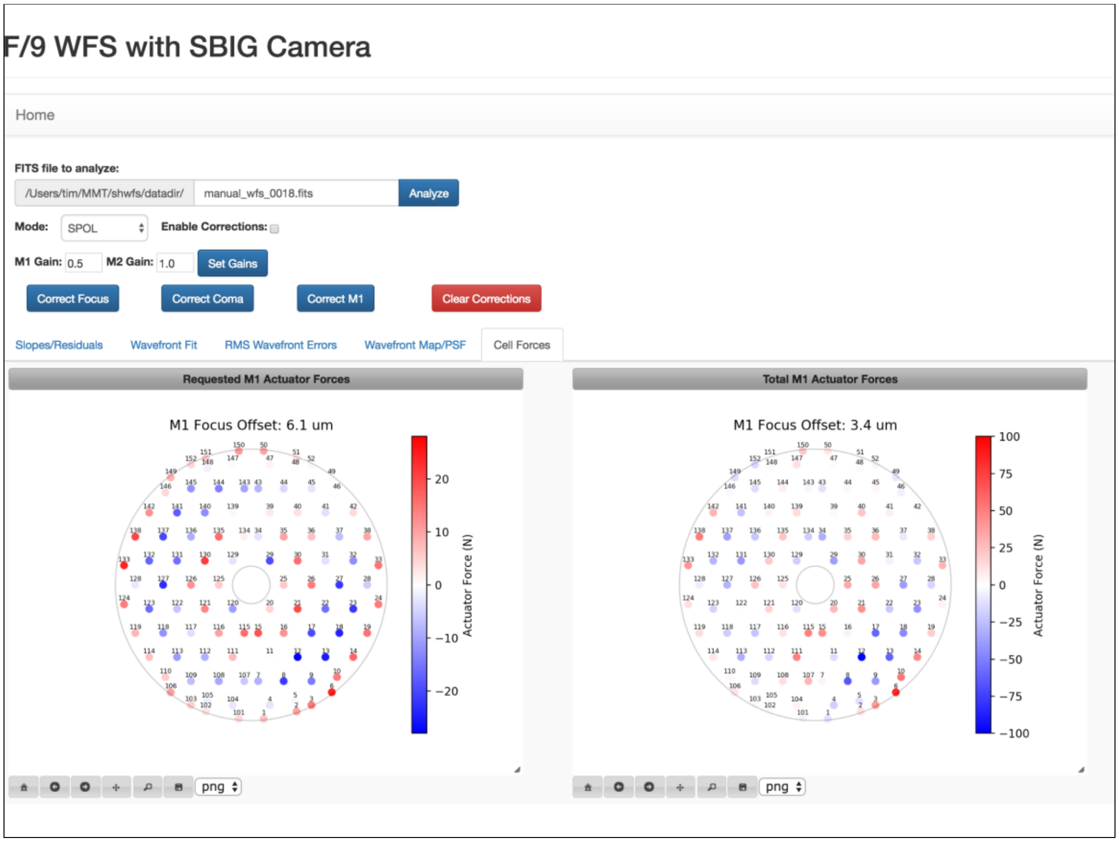

Figure 8. Plots showing forces required for requested corrections and total forces that have been applied by the WFS.

Facilities

Main Enclosure

A new power feed for the roof heaters was completed. This will provide the extra power needed to provide heater traces on the fall-protection anchors located on the shutter.

The building drive continued to function without any dropouts since the LVDT (Linear Variable Differential Transformer) mount was serviced.

During this reporting period the electronics group took inventory on the building drive servo card spares. Two cards were located, and time was allocated to test cards B & C. Each card was substituted into the building drive electronics rack, and building slews were performed. It was determined that both cards were unusable.

The servo cards were brought back to the campus electronics shop for troubleshooting. Each card was inspected for incorrect component values as well as verifying that the schematic for the building drive servo card was current and up to date. Discrepancies were found and corrected, and the cards were returned to the mountain.

Again, time was allocated for testing of the repaired servo card spares. J. Wood substituted each card into the building drive rack and performed numerous building slews. Both cards and all tests worked without fail. All spares have now been returned to the spares locker with serviced stickers indicating current card status.

Instrument Repair Facility (IRF)

The holes for the telescope simulator anchors were located and drilled by subcontractor KappCon using the templates provided by SAO. Under the supervision of B. Fata, the anchors were located with the templates, and epoxied into place.

After the anchor epoxy was completely cured and the templates could be removed, the floor in the IRF was recoated.

The concrete pathway between the main enclosure and the IRF was completed to facilitate the movement of instruments between the two buildings. To reduce the possibility that the new pathway would degrade the seeing at the telescope due to the release of thermal energy during the night, the pathway was coated with Increte Renovate coating (in white) to reduce solar heat gain during the day. After completing the pathway, subcontractor SM&R brought up additional gravel and graded the parking lot.

Figure 9. Completed concrete pathway for moving instruments between the telescope enclosure and the IRF.

Common Building

All items that were stored in the Common Building basement were relocated in order to begin the process of cleaning up the area and securing the basement from rodents. Once this is completed, the basement will be reconfigured to provide an environmentally-controlled room for the Binospec mask cutter.

General Infrastructure

- An all-hands FLWO cleaning of the upper warehouse took place in May. Soon after, the scrap metal that had been gathered in front of the bell jar was removed by a metal recycler.
- A new transformer for the mountain was installed in June at the Ridge area.
- An Arc Flash Survey was conducted throughout the entire FLWO facility (including MMT). A report with recommendations for deficiencies is expected soon.
- Carrier 1 was removed in preparation of installing Carrier 3 in its place. Due to the amount of slope inherent in the concrete slab under Carrier 1, a steel frame is being designed to support Carrier 3 above the slab.
- A new asphalt surface was applied to Mount Hopkins Road between the concrete section of the summit road and the Common Building. This work eliminated the abrupt transition between the existing road surface and the new concrete road.
- The Brifen cable guardrail just below the concrete section of the summit road was repaired after stopping a contractor operating a forklift that had been driven off of its transportation trailer while being loaded. Fortunately, no one was injured from this incident.
- Fire alarm communications were upgraded at the base camp.

Computers and Information Technology

Work began on upgrading the existing MMTO website, http://www.mmto.org. Drupal 6, used since 2012 for this site, has become deprecated, and updating content on the site has become increasingly difficult. Migration to the current versions of Drupal and Wordpress, both popular open-source content management systems, was investigated. However, the software-based migration of the existing website to either of these choices was not robust. As much work would be required to clean up the migrated site as to create a new site from scratch. The decision was made to use Wordpress rather than Drupal because of its popularity and simplicity relative to Drupal while still meeting the needs of the MMT Observatory.

As part of this migration, website content will be updated and a more modern theme will be adopted that is more suitable for both desktop and mobile devices.

A statement of work (SOW) was written to upgrade the existing website to use current web technologies, while maintaining its current appearance. It was realized that substantially more work would be involved in upgrading the website to modern standards. The SOW was distributed to potential commercial website developers. Although there was some response, no commercial vendors met the criteria needed by the MMTO.

A student position was advertised targeting English, journalism, and similar media arts students at the University of Arizona, and Connor Oswald was hired. He migrated the content from the current website to draft a new Wordpress site. It soon became evident that the site could be significantly improved by redesign, so weekly meetings were started to facilitate this work. A commercial Wordpress template, Caldera, was purchased to form the framework for the new site. Substantial progress was made during this quarter, but much work remains. Connor will spend the fall semester abroad, returning in January 2018 to continue work on the new website. In the interim, the mmto.org website using Drupal 6 will continue to be used.

Computers and Storage

B. Weiner, D. Gibson, D. Porter, and S. Moran (SAO) worked on the specification and ordering of a server to be the user-facing side of Binospec operations. This will include mask design, data hosting and reduction, queue operations, and database interaction between the queue and Binospec. Some aspects of serving quicklook and reduced data to users will also be included.

Network

The following network tasks were done by S. Schaller:

- Monthly backups of *mmto* and *hacksaw*
- Reboots to pick up new kernels and virtualbox drivers
- Upgraded *hacksaw* to Fedora 25
- Set up the HP477 printer in the control room
- Upgraded phpMyAdmin on *hacksaw,* restoring functionality
- Cleaned up DNS tables, fixed mistakes and resolved many inconsistencies
- Worked on troubleshooting a failing AXIS video encoder used for guiding
- Identified the cause of one of our hosts that was overloading the name server on MMTO
- Restricted httpd access to our fedora mirror to MMT networks only (our web server was being overloaded by web crawlers copying our fedora mirror)
- Restricted all access to our vmhosts to MMT networks only, as a safety measure
- Worked on a problem with the IDL license manager on *ao-server*
- Investigated a Blue Channel grating wheel problem that turned out to be mechanical
- Worked on a new web page to document our MMT mailing lists, using the new Google API
- Worked on improvements to the annunciator, with the goal of providing more information in the alert messages
- Removed the temptrax4 related checks from the annunciator

Hardware/Software Interfaces

Binospec Software

Weekly meetings started between MMTO and SAO software staff for the Binospec instrument, which is expected to arrive at the MMTO in early fall. A virtual machine (VM), "dbshare," is being configured to run joint MMT/SAO software.

A dedicated IDL license has been obtained for this VM. The VM will be used to host graphical user interfaces (GUIs), databases, and data reduction software related to the Binospec instrument by both MMTO and SAO staff. The VM is expected to host data for at least the first few years of Binospec work. Data will also be hosted at SAO in Cambridge, MA. Procurement of a vSphere host server for this VM is underway by the MMTO. Existing SAO vSphere servers at the summit can be used as backups for this new server. Initial work on the dbshare VM is being done on one of these SAO servers.

Discussions have included the organization of a shared database, including relational database software. PostgreSQL was chosen over other options such as MySQL and MariaDB because of its stability and because of its advanced features such as spherical coordinates and the ability to use various procedural languages within PostgreSQL.

Binospec GUIs will be written in both PHP and Node.js. Much of the queue scheduling software framework being used for the MMIRS instrument, written by D. Porter and D. Gibson, will also be used for Binospec. Some software modifications will be required because of the differences between the MMIRS and Binospec instruments. A new mask submission system is being developed by S. Moran at SAO. Data reduction software, written in part in IDL by I. Chilingarian of SAO, will include "quick look" tools for the queue observers and for astronomers. Work on wavefront sensor software for Binospec is being done by T. Pickering. Work on Binospec software will continue through summer shutdown.

<u>MMIRS Queue Software</u>

Further refinements were made to the MMIRS queue scheduling software, especially on the GUI. Four separate MMIRS queue runs occurred during this quarter. These runs provided an excellent opportunity to test the queue software under a wide variety of conditions and to improve the robustness of the code. Various new features were added to the scheduling code during this period including: 1) more documentation, 2) use of a "stats" data structure to communicate between the "front-end" GUI and "back-end" queue scheduling software, 3) a modified TimeAllocationConstraint so that the value never completely reaches zero, allowing objects to be scheduled even after all time for the program has been used, 4) a "sunset" mode for high priority targets that will set just after sunset, and 5) modified observing block names so that each name is guaranteed to be unique.

Weather and Environmental Monitoring

Seeing

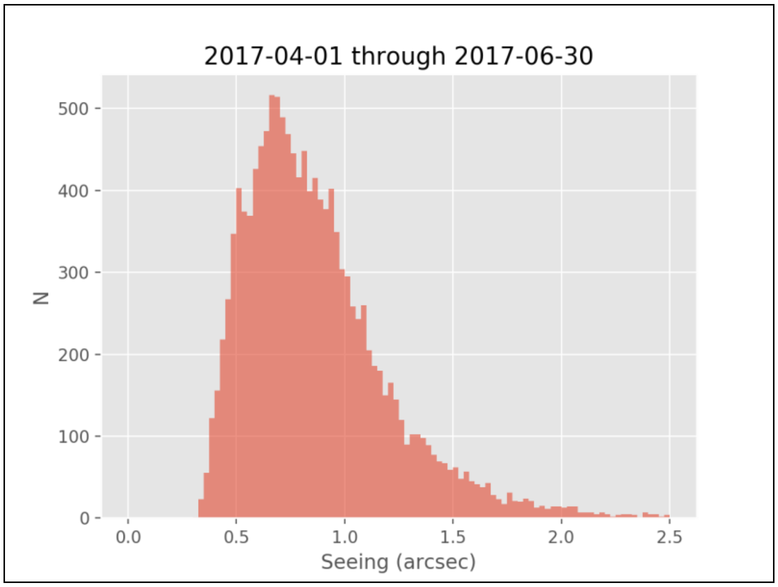

Figure 10. Histogram of seeing measurements taken with the MMTO wavefront sensors during this quarter.

A total of 13,329 valid seeing measurements were collected by the MMTO wavefront sensor (WFS) systems over this quarter (Figure 10). The overall statistics are well-described by a log-normal probability distribution. Figure 11 shows a normalized histogram and a best-fit log-normal probability density function (PDF). The best-fit PDF gives a median seeing of 0.80" and a mode (i.e., the most probable value) of 0.67." The best-fit median agrees well with the value of 0.81" calculated directly from the data. These numbers are fairly consistent with the long-term statistics for the site.

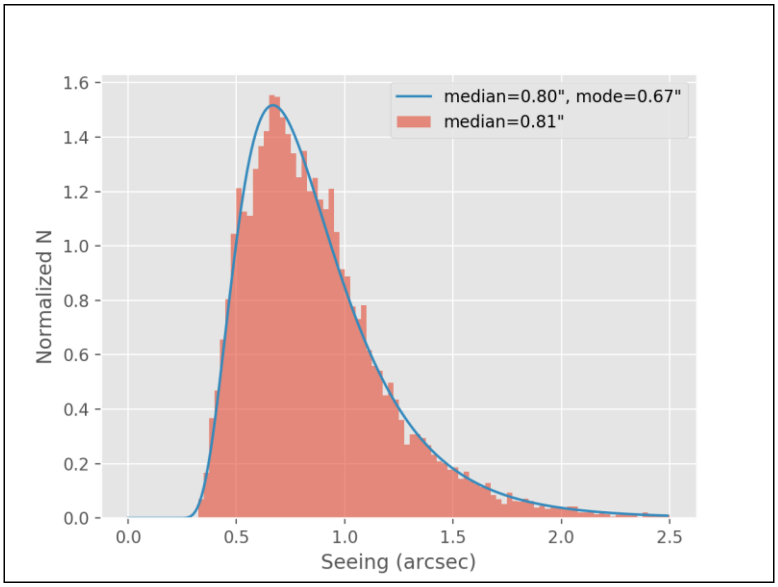

Figure 11. Normalized histogram of seeing measurements and best-fit log-normal probability distribution function. The plot legend shows the best-fit median and mode as well as the median calculated directly from the data.

However, the statistics are somewhat skewed by the large amount of WFS data taken during the April MMIRS campaign, which had some stretches of excellent weather. That campaign alone accounted for almost half (6,541) of the total number of seeing measurements. Figure 12 bears this out by showing histograms of the data broken down per month. April had a median seeing of 0.71" while it was significantly worse in May and June (0.93" and 0.92", respectively). This isn't just due to MMIRS vs. the other WFS systems, since the May and June MMIRS campaigns contributed 4,603 of the 6,125 seeing measurements during that time.

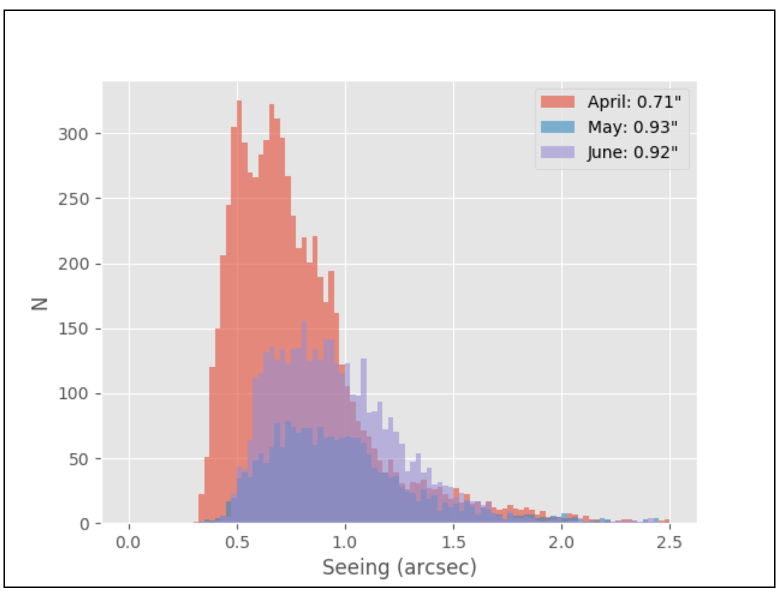

Figure 12. Seeing data broken down by month. The plot legend lists the median seeing for each month.

To help show this trend a bit better, Figure 13 shows the minimum, maximum, and median seeing for each night that had valid data. The nearly two straight weeks of sub-arcsecond median seeing in April is clearly visible. After that there are no clear trends, but a lot of night-to-night as well as intra-night variability is evident.

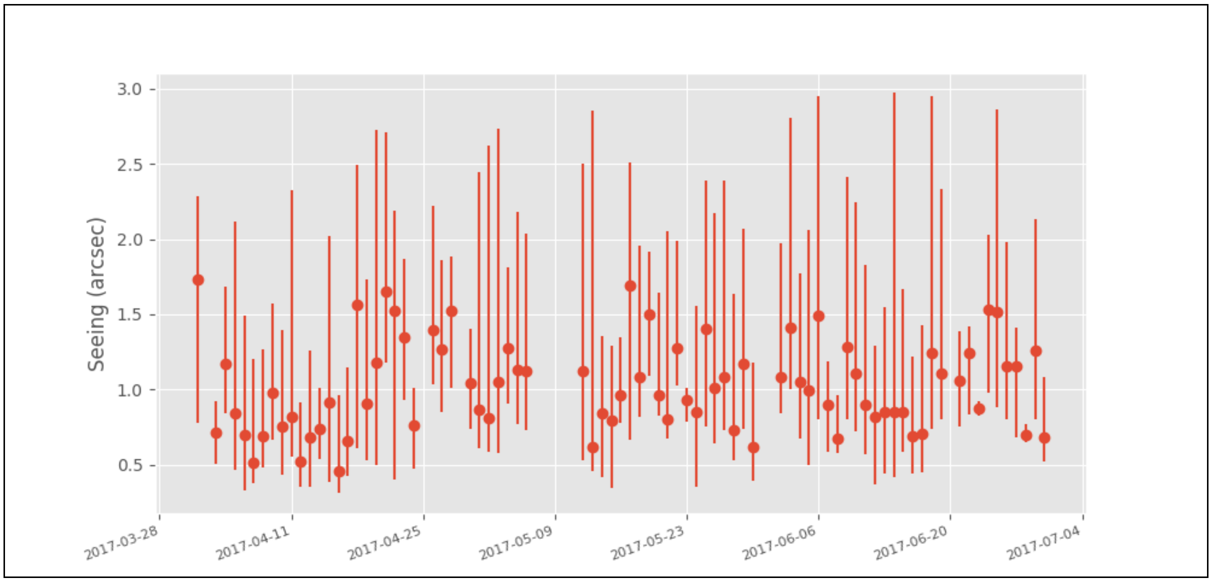

Figure 13. Seeing data broken down by night showing the median, minimum, and maximum for each night.

One interesting trend that was uncovered is a significant difference between the statistics of the seeing data taken before and after midnight (Figure 14). The median seeing for the first half of the night is 0.86," but it drops to 0.73" for the second half. This doesn't appear to be an issue of sampling bias. The amount of data is split 55%/45% between the first and second halves and the ratio of MMIRS data to other WFS data is 82% in the first half and 86% in the second. There could be a meteorological component to this (e.g., inversion layer dropping below the summit as the night progresses), but this could also be an indication of dome seeing that subsides as temperatures equilibrate. It may be possible to analyze the WFS spot shapes in greater detail to get some indication of dome seeing (e.g., changes in width/shape as a function of pupil location). However, truly discriminating between site seeing and dome seeing requires an external seeing monitor, and we are assessing options for setting one up.

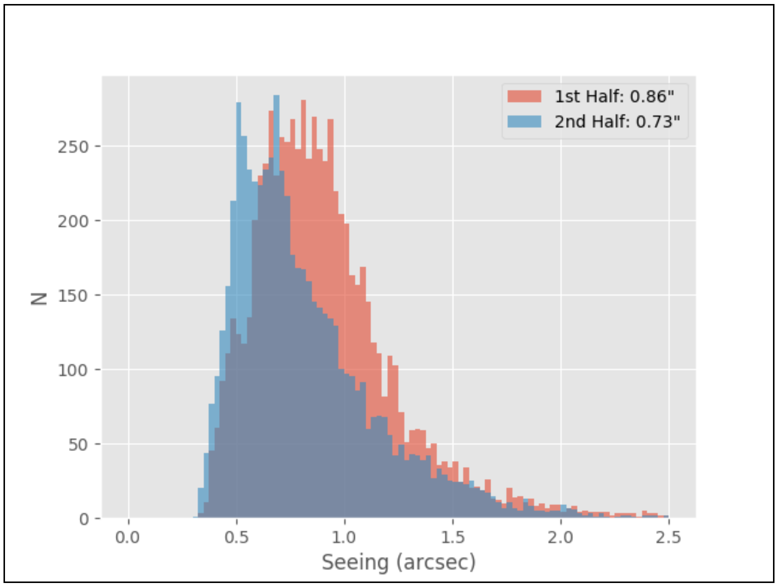

Figure 14. Histograms of seeing measurements taken during the first and second halves of the night.

The data and Jupyter notebook used in this analysis are hosted at https://github.com/MMTObservatory/seeing_analysis.

User Support

Web Pages

B. Weiner prepared a web page hosting preliminary information for Binospec proposers/users in anticipation of forthcoming proposal calls, and also updated a web page for Hectospec users detailing common data reduction problems.

Remote Observing

The MMTO supported 15.5 nights of remote observing this quarter. Seven and a half nights were for UA observers, with 8 nights for CfA observers.

Data Quality Assessment

B. Weiner has scripted analyzing a large set of MMTCam images from the spring semester to evaluate image quality and PSF elongation. This has identified that image elongation, when it occurs, is generally along the elevation axis. Further work is continuing to produce more robust image measurement and a more automated analysis.

Reduction Procedures

B. Weiner assisted several Hectospec users with data reduction problems and provided reduced data. He is also investigating a pipeline problem that causes reduction failures for a subset of users / configurations.

Documentation

Nothing to report.

Public Relations and Outreach

Visitors and Tours

4/5/17 - An appreciation event was held for the FLWO volunteer tour guides and docents. J. Hinz, P. Fortin, E. Falco and A. Terry were in attendance. The docents were given a tour of all the telescopes, and dinner was held at the ridge dormitory.

Figure 15. FLWO volunteer tour guides and docents honored at an appreciation event held on April 5. Photo taken at the Administrative Complex with VERITAS in the background.

5/5/17 – The 5th grade class of Sahuarita Intermediate School was given a tour of the MMTO. Helping to show them around were R. Ortiz, J. Di Miceli, and J. Wood.

Figure 16. Fifth grade students from Sahuarita Intermediate School ready for their tour of the MMTO and other Mt. Hopkins facilities.

<u>5/18/17</u> - Five MMTO staff participated in a tour of the Large Binocular Telescope (LBT) on Mt. Graham, along with FLWO staff.

Figure 17. MMTO staff touring the LBT. Shown standing in the back row, starting eighth from the right, are: C. Knop, D. Gibson, J. Wood, S. Kattner, and D. Porter.

5/22/17 – Univ. of Michigan senior astronomy students joined the public tour group on May 22 for a tour of the MMTO and other facilities. Their professor, S. Oey, is a colleague of G. Williams.

5/23/17 – The annual *Smithsonian Journeys* tour of the FLWO facilities and the MMTO took place.

Public Presentations

S. Kattner, MMTO Queue Observer, gave a series of five introductory astronomy lectures for the FLWO tour guides and volunteers. These lectures took place at the basecamp on April 3, 10, 11, 20, and 21.

S. Kattner gave a presentation on the upcoming solar eclipse at the "Night Under the Stars" held at the Historic Hacienda de la Canoa on May 19.

Grant Williams participated in a "Meet a Scientist" family day event held April 29. It was sponsored by the Science and Arts Communication Fellowship, a program with the University of Arizona Museum of Art, that facilitates, to the public, communication by scientists and artists about their work.

Figure 18. G. Williams (center photo) represented the Fellowship program on the flyer for the family day event held April 29.

Site Protection

G. Williams and J. Hinz attended the monthly meeting of the Arizona Astronomy Consortium (AzAC) on April 11.

Appendix I - Publications

MMT Related Scientific Publications
(An online publication list can be found in the MMTO ADS library at http://www.mmto.org/node/244)

17-26 NGC 1980 is not a Foreground Population of Orion: Spectroscopic Survey of Young Stars with Low Extinction in Orion A
M. Fang, J.S. Kim, I. Pascucci, et al.
AJ, **153**, 188

17-27 Photoionization-driven Absorption-line Variability in Balmer Absorption Line Quasar LBQS 1206+1052
L. Sun, H. Zhou, T. Ji, et al.
ApJ, **838**, 88

17-28 Crater 2: An Extremely Cold Dark Matter Halo
N. Caldwell, M.G. Walker, M. Mateo, et al.
ApJ, **839**, 20

17-29 The Physical Nature of Subdwarf A Stars: White Dwarf Impostors
W.R. Brown, M. Kilic, and A. Gianninas
ApJ, **839**, 23

17-30 The Velocity Dispersion Function of Very Massive Galaxy Clusters: Abell 2029 and Coma
J. Sohn, M.J. Geller, H.J. Zahid, et al.
ApJS, **229**, 20

17-31 Endurance of SN 2005ip After a Decade: X-rays, Radio and Hα like SN 1988Z Require Long-lived Pre-Supernova Mass-loss
N. Smith, C.D. Kilpatrick, J.C. Mauerhan, et al.
MNRAS, **466**, 3021

17-32 Rise and Fall of the Dust Shell of the Classical Nova V339 Delphini
A. Evans, D.P.K. Banerjee, R.D. Gehrz, et al.
MNRAS, **466**, 4221

17-33 Growing Evidence that SNe Lax are not a One-parameter Family. The Case of PS1-12bwh
M.R. Magee, R. Kotak, S.A. Sim et al.
A&A, **601**, 62

17-34 HAT-P-67b: An Extremely Low Density Saturn Transiting an F-subgiant Confirmed via Doppler Tomography
G. Zhou, G.A. Bakos, J.D. Hartman, et al.
AJ, **153**, 211

17-35 The Canada-France Ecliptic Plane Survey (CFEPS) – High-latitude Component
J.-M. Petit, J.J. Kavelaars, B.J. Gladman, et al.
AJ, **153**, 236

17-36 The Binary Fraction of Stars in Dwarf Galaxies: The Case of Leo II
M.E. Spencer, M. Mateo, M.G. Walker, et al.
AJ, **153**, 254

17-37 Spectral Analysis of Four 'Hypervariable' AGN: A Micro-needle in the Haystack?
A. Bruce, A. Lawrence, C. MacLeod, et al.
MNRAS, **467**, 1259

17-38 Revisiting the Lick Observatory Supernova Search Volume-limited Sample: Updated Classifications and Revised Stripped-envelope Supernova Fractions
I. Shivvers, M. Modjaz, W. Zheng, et al.
PASP, **129**, 4201

17-39 A Redshift Survey of the Nearby Galaxy Cluster Abell 2199: Comparison of the Spatial and Kinematic Distributions of Galaxies with the Intracluster Medium
H. Song, H.S. Hwang, C. Park, et al.
ApJ, **842**, 88

17-40 Spectroscopic Observation and Analysis of H ii Regions in M33 with MMT: Temperatures and Oxygen Abundances
Z. Lin, N. Hu, X. Kong, et al.
ApJ, **842**, 97

17-41 Photometric and Radial-velocity Time Series of RR Lyrae Stars in M3: Analysis of Single-mode Variables
J. Jurcsik, P. Smitola, G. Hajdu
MNRAS, **468**, 1317

MMT Technical Memoranda / Reports

None

Non-MMT Related Staff Publications

None

Appendix II - Service Request (SR) and Response Summary: April - June, 2017

The MMT Service Request (SR) system is an online tool to track ongoing issues that arise primarily during telescope operations, although the system can be used throughout the day and night by the entire staff. Once an SR has been created, staff members create responses to address and eventually close the SR. These SRs and associated responses are logged into a relational database for later reference.

Figure 19 presents the distribution of SR responses by priority during the period of April through June 2017. As seen in the figure, by far the highest percentage (69%) of responses were of the "Important" priority, followed by 10% as "Near Critical" priority and 8% at "Critical" priority. There were 6% for both the "Low" and "Information Only" priorities.

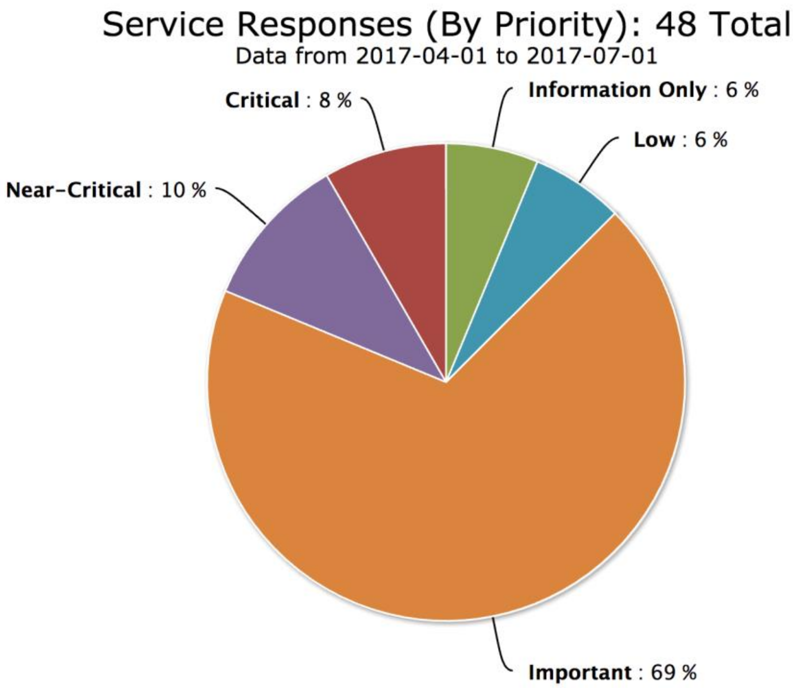

Figure 19. Service Request (SR) responses by priority during April through June 2017. 69% of the SRs were "Important" while 10% were "Near Critical" priority. 8% of the SRs were "Critical" while only 6% were either "Low" or "Information Only" priority.

"Critical" SRs address issues that are preventing telescope operation, while "Near-Critical" SRs relate to concerns that pose an imminent threat to continued telescope operation. There were a total of 48 SRs during this three-month period, the same number as the previous three-month reporting period.

Figure 20 presents the same 48 SR responses grouped by category. These categories are further divided into subcategories for more detailed tracking of issues. Seven responses from April through June are related to the "Support Building" category. Six responses were made under the "Thermal System" category while five responses each were within the "Software," "Telescope," and "Weather

Systems" categories. Responses also occurred in the "Building," "Cell," "Chamber," "Computers/ Network," "Control Room," "F9 Topbox," "Instruments," "Logs," and "Pit" categories.

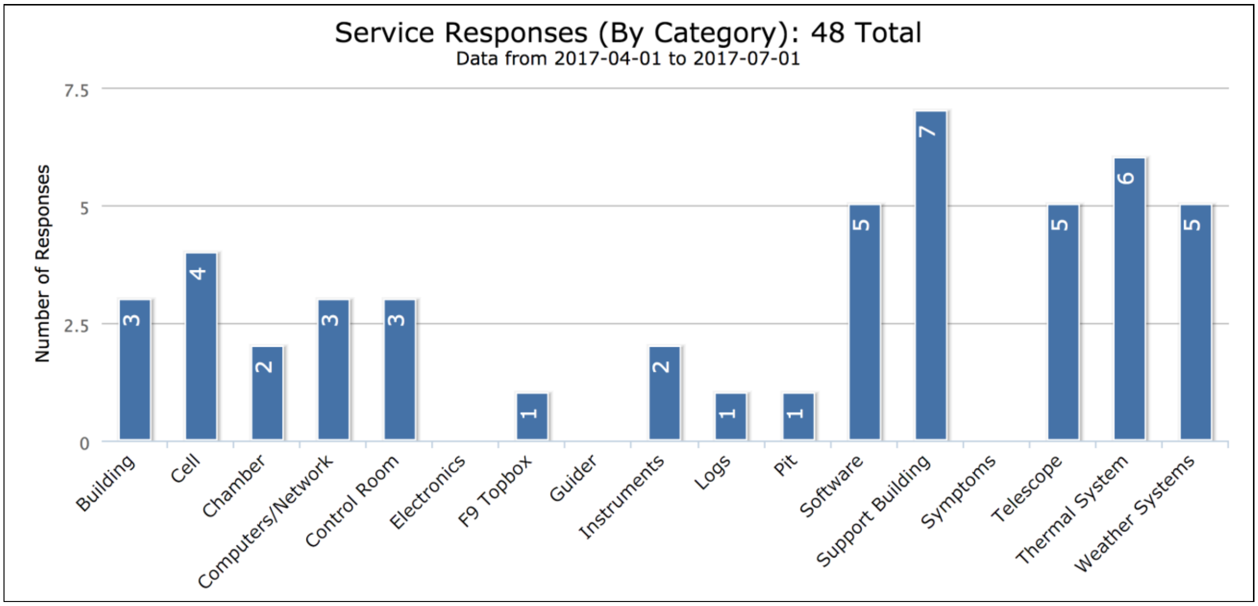

Figure 20. Service Request responses by category during April through June 2017. The majority of responses were within the "Support Building," "Thermal System," "Software," "Telescope," and "Weather Systems" categories. The number of responses for each are listed with the category.

Appendix III - Observing Statistics

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.

Use of MMT Scientific Observing Time

April 2017

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	4.00	38.70	10.45	0.00	0.00	1.00	0.00	11.45
PI Instr	26.00	237.90	35.01	6.08	0.25	7.33	0.00	48.67
Engr	0.00	0.00	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**	**45.46**	**6.08**	**0.25**	**8.33**	**0.00**	**60.12**

Time Summary

Percentage of time scheduled for observing	100.0
Percentage of time scheduled for engineering	0.0
Percentage of time scheduled for sec/instr change	0.0
Percentage of time lost to weather	16.4
Percentage of time lost to instrument	2.2
Percentage of time lost to telescope	0.1
Percentage of time lost to general facility	3.0
Percentage of time lost to environment (non-weather)	0.0
Percentage of time lost	21.7

* Breakdown of hours lost to instrument
- 1.50 MMIRS server crash
- 3.75 Hectospec fiber positioner issues
- 0.83 Hecto error when starting new configuration

** Breakdown of hours lost to telescope
- 0.25 M1 panic

*** Breakdown of hours lost to facility
- 1.00 *Pixel* (observer computer) unresponsive
- 7.33 Power generator failure; Unisource main power feed failure

May 2017

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	6.00	48.80	0.00	0.00	0.00	0.00	0.00	0.00
PI Instr	21.00	173.90	47.80	1.50	0.50	0.00	0.00	49.80
Engr	4.00	33.40	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**	**256.10**	**47.80**	**1.50**	**0.50**	**0.00**	**0.00**	**49.80**

Time Summary

Percentage of time scheduled for observing	87.0
Percentage of time scheduled for engineering	13.0
Percentage of time scheduled for sec/instr change	0.0
Percentage of time lost to weather	18.7
Percentage of time lost to instrument	0.6
Percentage of time lost to telescope	0.2
Percentage of time lost to general facility	0.0
Percentage of time lost to environment (non-weather)	0.0
Percentage of time lost	19.4

* Breakdown of hours lost to instrument
- 1.00 Hecto following error
- 0.50 Problem with hecto robots

** Breakdown of hours lost to telescope
- 0.50 Actuator 102 created unwanted forces

Year to Date May 2017

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	44.00	457.90	174.34	0.00	0.25	1.25	0.00	175.84
PI Instr	96.00	960.70	357.64	11.41	11.25	7.58	0.00	387.88
Engr	11.00	109.80	8.50	0.00	0.00	0.00	0.00	8.50
Sec Change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**151.00**	**1528.40**	**540.48**	**11.41**	**11.50**	**8.83**	**0.00**	**572.22**

Time Summary

Percentage of time scheduled for observing	92.8
Percentage of time scheduled for engineering	7.2
Percentage of time scheduled for sec/instr change	0.0
Percentage of time lost to weather	35.4
Percentage of time lost to instrument	0.7
Percentage of time lost to telescope	0.8
Percentage of time lost to general facility	0.6
Percentage of time lost to environment (non-weather)	0.0
Percentage of time lost	37.4

June 2017

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	7.00	53.90	13.75	5.42	0.00	0.00	0.00	19.17
PI Instr	23.00	178.60	40.38	0.00	0.00	7.00	0.00	47.38
Engr	0.00	0.00	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**	**232.50**	**54.13**	**5.42**	**0.00**	**7.00**	**0.00**	**66.55**

Time Summary

Percentage of time scheduled for observing	100.0
Percentage of time scheduled for engineering	0.0
Percentage of time scheduled for secondary change	0.0
Percentage of time lost to weather	23.3
Percentage of time lost to instrument	2.3
Percentage of time lost to telescope	0.0
Percentage of time lost to general facility	3.0
Percentage of time lost to environment	0.0
Percentage of time lost	28.6

* Breakdown of hours lost to instrument

5.42 Blue Channel grating change problems

*** Breakdown of hours lost to facility

7.00 Transformer swap took longer than expected

Year to Date June 2017

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	51.00	511.80	188.09	5.42	0.25	1.25	0.00	195.01
PI Instr	119.00	1139.30	398.02	11.41	11.25	14.58	0.00	435.26
Engr	11.00	109.80	8.50	0.00	0.00	0.00	0.00	8.50
Sec Change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**181.00**	**1760.90**	**594.61**	**16.83**	**11.50**	**15.83**	**0.00**	**638.77**

Time Summary

Percentage of time scheduled for observing	93.8
Percentage of time scheduled for engineering	6.2
Percentage of time scheduled for secondary change	0.0
Percentage of time lost to weather	33.8
Percentage of time lost to instrument	1.0
Percentage of time lost to telescope	0.7
Percentage of time lost to general facility	0.9
Percentage of time lost to environment	0.0
Percentage of time lost	36.3