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End of Quarter Summary

October - December 2015

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

The annual staff meeting and photo took place at the summit on November 18. Lunch was provided, followed by the "State of the MMTO" address by Director G. Williams, and the staff photo.

Staffing

Site visits were conducted with three Electrical Engineer candidates on October 20, 23, and 26. However, due to several staffing changes and re-evaluation of the staff organization chart, the decision was made in December to not hire an Electrical Engineer at this time.

B. Kunk started as a Telescope Operator on December 7, following S. Gottilla's last day as Telescope Operator on December 2.

D. Clark made the decision in November to leave the MMTO, while continuing to work from home as needed through the end of the year. His departure will be official in spring 2016.

D. Blanco announced in December that he would be retiring from the MMTO. He will continue on staff until his retirement is official in spring 2016.

Reports and Publications

There were 32 peer-reviewed publications and five non MMT-related publications during this reporting period. No technical memoranda or reports were generated. See the listing of publications in Appendix I, p. 21.

An abstract entitled "Automation and control of the MMT thermal system" was submitted by D. Gibson, D. Porter, and W. Goble for the SPIE 2016 conference in Edinburgh, Scotland.

Presentations and Conferences

J. Hinz gave a talk entitled "MMT Future Instruments & Science Projects" at the KASI-Arizona Collaboration Meeting on December 7. G. Williams and R. Cool also attended the meeting.

Safety

The F. L. Whipple Observatory (FLWO) mountain driving policy was updated this period. All MMTO employees who might use FLWO vehicles to drive to the observatory were required to read and sign the updated policy.

Monthly inspection of emergency lights at the MMT was started and is being conducted by a volunteer group. Several of the lights were serviced at the beginning of December.

After thorough sorting and cleaning out of stored flammable liquids, a small storage locker for flammable liquids was purchased to replace the larger locker that had been in use in the campus electronic shop. The larger locker was transported to the MMT to replace the locker in the summit electronic shop.

Automatic-closing gates were purchased for the two 4th floor lofts at the MMT. They replaced older gates that did not automatically close.

Meeting highlights of the FLWO safety committee quarterly meeting included: review of the updated mountain driving policy, discussion of the MMT summit road construction, discrepancies in the METR report and the assigning of individuals to address them, and organizing monthly trainings by the safety committee.

The Steward Observatory safety committee meeting was held on December 3. G. Williams, R. Ortiz, and J. DiMiceli attended the meeting. Topics included addressing workplace violence and a new online Safety Data Sheet (SDS) system being implemented by the University of Arizona.

A second telescope imbalance runaway event occurred on October 8. There was no damage, just as there was also no damage from an incident in May. However, procedures will be re-addressed.

Training

CPR/AED training provided by Desert Fire and CPR was held on October 1 at Steward Observatory for MMTO personnel. Ten staff members attended.

Safety Inspections

A safety inspection of the telescope site was conducted by Steward Observatory safety personnel on October 20.

Primary Mirror

The primary mirror support system continues to exhibit intermittent problems. The logs show bad raises, excessive Z-moments, and occasional panics on Oct 2, Oct 9, and Oct 15. Each time, the system recovered without any significant loss of observing time.

Mirror Support

Construction started on a new cell crate power supply. This power supply will be a combination of the original and the most recent designs. It will incorporate the known good power supply units from the old supply, along with voltage sensing circuits from the new supply, into an enclosure that will also incorporate the 48V switch.

Coating & Aluminization

Although progress has been made over the past three months, due to limited resources, full-scale testing of the M1 aluminization system at basecamp has been delayed until late March. The tasks to be completed before attempting a full scale testing include: component level testing of the turbo pump system, high vacuum testing of the bell jar assembly, and filament control system testing using the load resistors.

The backing pump (Varian SD-1400) for the bell jar turbomolecular pump was received in December and is scheduled to be vacuum tested in early February. Once the baseline pressure of the backing pump has been determined, the turbo pump will be tested in a blanked-off condition while backed with the new pump. Once the turbo pump checkout and characterization has been completed, the turbo/backing pump assembly will be installed on the bell jar to start high vacuum testing.

In order to run the high vacuum pumps and support equipment required for a full scale test of the aluminization system at base camp, the electrical power feed to the bell jar was reconfigured to supply the appropriate power to these subsystems. A 480V to 208Y/120V transformer (and the necessary disconnect) has been physically installed, as well as the breaker panel for the 208Y/120V electrical loads. These components are anticipated to be wired into the system in early February.

To determine the necessity of removing primary mirror support actuators from the mirror cell during realuminization, the process of vacuum testing a limited number of single axis mirror actuators has begun. The design work has been completed for a mount that will support a single axis mirror actuator in the small Sunnyside coating chamber, and the mirror actuator test stand has been reconfigured to test single axis actuators. The initial plan for testing the actuators is: the actuator will be tested on the test stand, then the actuator without the electronics card will be vacuum cycled, and finally the actuator will be tested again on the test stand. This test plan was developed not only to test for obvious actuator failures but to also determine if vacuum cycling may possibly contribute to performance degradation. Testing is expected to be completed in February.

The welder interface cables were upgraded to a thicker gauge conductor. Twelve cables were constructed (ten main cables, two spare) out of 20 gauge twisted shielded pair wire. They are ready for use during the aluminization test shot planned for March.

A new test procedure was written for the welder interface box. This new procedure incorporates changes due to the installation of new power supplies and modifications to the electronics card. All welder interface units were tested and verified to be operational.

Ventilation and Thermal Systems

New fiber was run from the communications room to the MGE room, and from the MGE room to the Carrier2 chiller. This fiber will be used for the BACnet system. The communications room consisted of six pair of fiber, the MGE room consisted of nine pair, and three fiber pair for the Carrier. All terminations were completed and tested.

Due to a motor insulation failure, the M1 thermal system blower motor was replaced on October 7 and 8. The new variable frequency drives installed as part of the HVAC system upgrade detected the issue with the motor, and an electrical contractor (Sabino Electric) was able to quickly diagnose the issue. Fortunately, an identical spare motor was in storage and the thermal system was only off-line for one night. The motor removed from service has been rebuilt and is currently stored in the MMTO area of the upper warehouse at base camp.

Much progress was made on upgrading the HVAC (heating, ventilation, and air conditioning) and primary mirror (M1) ventilation systems at the MMT during this reporting period. Work focused on implementing telemetry, logging, and system control, much of which is based upon "BACnet", an industry-standard data communication protocol for building automation and control networks (http://www.bacnet.org/). A summary of this progress is presented below. Work on this upgrade continues, with additional work planned into 2016.

Two new Contemporary Controls "BACcontrol" 20-point BACnet (a.k.a. "BAS20") controllers (http://www.ccontrols.com/basautomation/bascontrol.php) were implemented: one for the shop heat exchanger and one for the pit heat exchanger. These controllers regulate three-way glycol valves for the two heat exchangers as well as acquisition of temperature data (*e.g.,* heat exchanger intake and discharge air temperatures). Unused points are available on both BAS20 controllers for additional device control and environmental monitoring. The shop BACnet controller also provides on/off control of two new 10-hp glycol pumps that replaced smaller 5-hp pumps. These pumps will be brought on-line in January 2016. Increased glycol flow by the pumps is expected to impact overall M1 ventilation system performance and will be factored into revised control software. The extensive new glycol plumbing, also part of the HVAC upgrade, will also impact M1 ventilation system performance. A discussion of the graphical user interface (GUI) for controlling the new glycol pumps is presented below.

Four new Contemporary Controls "BASrouter" BACnet MS/TP-to-IP network routers (http://www.ccontrols.com/basautomation/basrouter.php) were deployed. These routers act as communication bridges between BACnet MS/TP (master slave/token passing) and IP (internet protocol) physical layers. The routers allow network communication with: 1) the currently used Carrier chiller (Carrier1) via a new OpenUPC BACnet module, 2) the newer Carrier chiller (Carrier2), also via an OpenUPC BACnet module, 3) the two native BACnet blower motor variable frequency drives (VFDs), both on a single router, and 4) the four new HVAC fan coil units distributed throughout the MMT enclosure, all on a single BACnet router. Configuration of these routers was optimized to allow periodic logging on secondary BACnet ports, allowing the standard default BACnet port 47808 (hexadecimal 0xBAC0) to be used exclusively for standard BACnet communication. Details of router configuration will be discussed in future documents. Work on BACnet communication with the Carrier1 and Carrier2 chillers, in particular, is ongoing.

The two new blower VFDs are now controlled remotely through the BACnet protocol. Only one VFD is used at a time. The active VFD will alternate on a monthly basis to distribute the workload between the two units. GUI control of the VFDs is discussed below.

HVAC fan coil units were brought on-line for: 1) the first-floor loading dock/drive room, 2) the second floor west (2W) instrumentation room, 3) the third floor east (3E) computer server room, and 4) control room, located on the first floor. The occupancy setpoints for the HVAC fan coil units were modified from those set by the HVAC contractor to better cool instrumentation and computer server areas of the MMT enclosure. Further ductwork may be necessary to improve air distribution from these fan coil units. Thermal analysis of the fan coil units has begun. The glycol temperature requirements of these fan coil units will be incorporated into revised M1 ventilation system control software. Each of the fan coil units has its own BACnet controller. Configuration parameters for these controllers can be modified via the BACnet protocol.

Extensive testing of BACnet commands through a command-line interface was completed to become familiar with the protocol and the numerous BACnet objects available on the new hardware. This testing has aided in both the approach to logging of BACnet objects as well as controlling the new HVAC hardware. This work allowed individual hardware devices, controllers, routers, and the associated network communication to be systematically tested.

New Linux system services were created to log data from the various BACnet devices. Several approaches were evaluated to provide the best logging approach. The current approach uses a custom compiled C executable, based upon the BACnet protocol stack (http://bacnet.sourceforge.net) software, created by Steve Karg. The C executable is run from a Perl script as a subprocess with two-directional pipes for data exchange. The Perl script performs the higher-level database inserts, appends CSV log files, and performs other administrative tasks while the C executable handles the low level BACnet communication. This approach was found to be more efficient and robust than other approaches, such as the Python-based "BACpypes" BACnet software. Details of the system service software and logging will be presented elsewhere.

A "BACnet" MySQL configuration database was created for the over 850 new BACnet objects that have been added because of the HVAC upgrade. This database contains all relevant BACnet objects, parameters, and attributes for data telemetry, logging, and device control. A "measurements" MySQL database was implemented with separate tables for each of the BACnet parameters. Data are also logged to comma-separated-value (CVS) text files as a backup for the database. Periodic logging of data began in November. Intervals between logged database entries vary from five seconds to two minutes, depending on the parameter and hardware. Some parameters are marked as inactive and are not logged. Further work may allow additional parameters to no longer be logged or may require currently inactive parameters to be active. In general, BACnet objects provide extensive monitoring and control of hardware, commonly more than is typical for MMT equipment.
Thermal characterization of the new HVAC and M1 ventilation system has begun, although not all aspects of the new system are in place as discussed elsewhere. This characterization will form a basis for a revised version of the automated M1 ventilation control ("vent_auto") system, for which the current version has been in place since 2009. The revised version will use BACnet communication and separate control three-way glycol valves at the shop and pit heat exchangers. The new "vent_auto 2.0" software will use newly characterized thermal behavior of the M1 ventilation system after the HVAC upgrade.

In addition to the “back-end” BACnet software development previously described for the new HVAC system, a new GUI (Figure 1) was created to easily interface with all of the new components. The new GUI provides on-and-off and variable control for the VFD blower controllers, the Carrier1 and Carrier2 chillers, the two new glycol pumps, the shop and pit glycol flow valves, the four fan-coil units, and the MMT enclosure perimeter heaters. The setpoints can be manually input as well. Depending on the state of the entire system, the GUI updates the glycol flow colors, the pump icons, valve arrow positions, and the airflow temperature colors from the blower to the mirror cell. The goal of this GUI is to give the operators a visual representation of how the complete system works as a whole in addition to controlling the equipment individually.

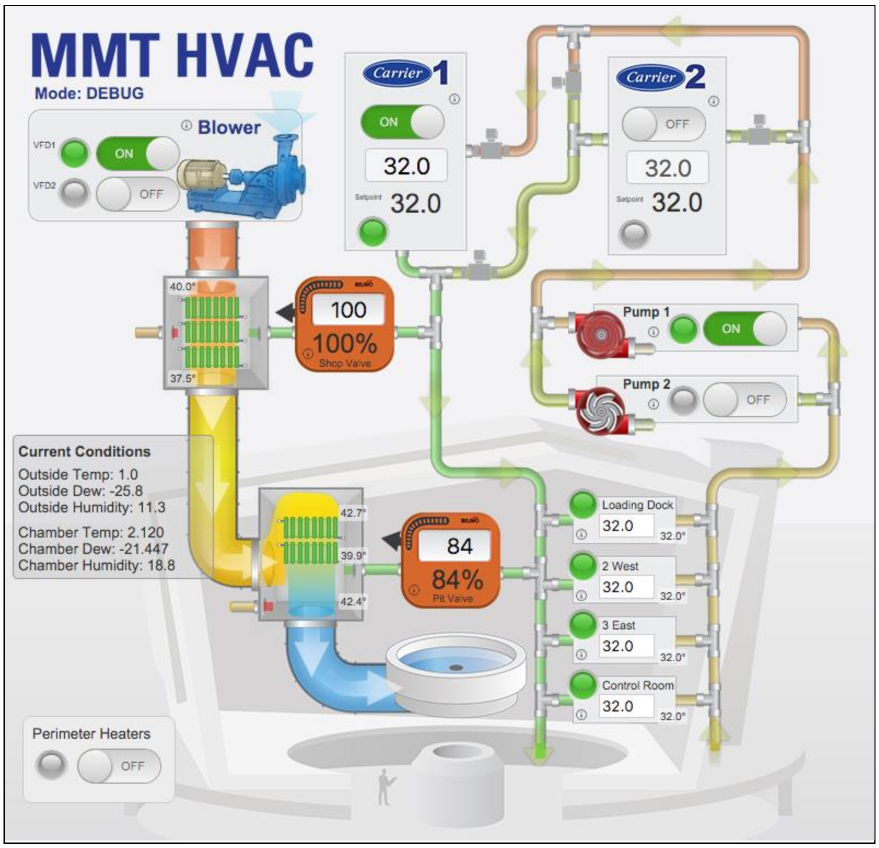

Figure 1. Graphical User Interface (GUI) for manual control of the upgraded HVAC/M1 Ventilation system. This GUI will provide control of: 1) the two Carrier chillers (Carrier1 and Carrier2), the ventilation system blower via two variable-frequency drives (VFDs), 3) two 10-hp glycol pumps, 4) two three-way glycol mixing valves, one at the shop heat exchanger and one at the pit heat exchanger, 5) occupancy setpoints for the four new HVAC fan-coil units, 6) temperature information at various points, and 7) control of the MMT enclosure perimeter heaters.

Actuators

Cell crate actuator card DC-DC power converters were tentatively sourced. The converter for the single actuators is available from Mouser electronics. The converter for the dual is obsolete and unavailable at this time. Currently, one spare is on hand for each type. A surplus company has been found as a source for the dual converters. However, once these are depleted, there are no more known dual converters available. We are in the process of looking for a new converter or supplier.

Secondary Mirrors

f/5

The f/5 secondary mirror support system failed, causing bad positioning of the mirror. The mirror support card was swapped out with the spare, and the system was returned to an operational status. The faulty card was tested on the bench with no faults being noted. The card was subsequently tested on the f/5 and failed again. An inspection of the card revealed a corroded contact on the card connector. All pins were cleaned and the card tested successfully. The card was left in the system, and the other card returned to the spares locker.

f/15

Programming of the adaptive optics (AO) smart card enclosure was started. All cards inside the unit were tested and basic code for the Arduino Yun was written. All LED indicator lights tested good. More code will be written to include all safety checks.

Hexapods

Nothing to report.

Optics Support Structure

Nothing to report.

Pointing and Tracking

Rotator

Two spare encoder tape heads were received from Heidenhain. One unit had been repaired, but the second unit was beyond economical repair. The serviceable unit was returned to the spares locker at the summit.

Science Instruments

f/9 Instrumentation

The f/9 instruments were on the MMT for 44% of the available nights from October 1 through December 31. Approximately 75% of those nights were scheduled with the Blue Channel

Spectrograph, 15% with Red Channel, and 10% with SPOL. Of the 452.1 total hours allocated for f/9 observations, 174.6 hours (39%) were lost to weather conditions. Instrument, facility, and telescope problems accounted for 14.15 hours of lost time. Much of this was due to the failure of the shutter on the Blue Channel. Blue Channel lost 36% of its time to poor weather, with Red Channel losing 40%, and SPOL losing 59%.

f/5 Instrumentation

The process for astronomers to submit masks for MMIRS observations was refined during this reporting period. Near the beginning of each observing trimester, observers are contacted and given a link to the current mask design software and given a deadline of ~6 weeks in advance of the scheduled observing block. This allows for delivery of masks in advance of the system cooling to alleviate one mask swap. Iteration with SAO staff was performed to keep all code up to date.

A number of scripts were added to *pixel* to help make communications with the MMIRS computer, *fields*, more efficient for observers. A number of "setup" tasks were also included to the mmtobs reset script for MMIRS (such as restoring ssh keys) to minimize the number of steps needed when getting the system ready for observing with MMIRS.

There were 39 nights scheduled for f/5 observing. The weather was too poor to allow opening of the chamber on 16 of these nights. Twenty nights were Hecto, 17 nights (starting and ending the quarter) were MMIRS, and the other two nights were devoted to MMTCam.

Due to the persistent poor weather conditions, 47% of the 458 scheduled observing hours was lost. Nearly one night was also lost to instrument issues, and slightly more than one hour to telescope issues.

Instrumental issues included a reboot for unknown reasons of the computer *fields* (which runs most of the MMIRS servers) on December 30. Similar restarts had occurred in June and September. We believe these to be related to the quality of the power from the MGE and monitoring circuitry in the computer's power supply, but the exact parameters leading to the restarts have not yet been isolated. The computer had operated reliably for more than two months when this restart occurred. We plan to obtain and install a different type of UPS to attempt to correct the problem. The computer restart required all of the software to be started from scratch. One of the temperature monitoring servers was missed that night but was restarted the next day.

The staff is still learning about the MMIRS instrument, which returned to the MMT this past June. Efficiency of operation during the December MMIRS run was lessened by the failure of an actuator for one of the two wavefront sensor (WFS)/guider camera stages. All the actuators had checked out properly the preceding week when the instrument was prepped and tested, but the Y axis of the WFS 2 system would not work after the instrument was mounted on the telescope. The software reported the condition as "motor axis open loop," which could have been related to several different items. Early testing included swapping the axis drive card with the matching unit for WFS 1, but this did not correct the problem. After the run, the failure remained when the instrument was started in the lab for additional testing. In working on this issue, we learned that the spare MMIRS PMAC cards had not been packed with the instrument when it was shipped from Chile in June. We borrowed a card from the BINOSPEC project to verify the point of failure and then found that the original card was working again when it was reinstalled to verify its condition. We also learned that the #1 camera was not correcting the wavefront as expected. It seemed to make things worse, either because the #2 unit had been calibrated for wavefront sensing or because the seeing was generally poor on the days weather allowed us to open.

There were other issues with the MMIRS WFS/guider software that caused the system to become unresponsive at times, or to lose stars as the telescope was dithered. In part, this might have been due to the staff learning how much dither is allowed, especially for a star near the edge of the pickoff mirror. R. Cool was diligent in pursuing the causes of these software issues and he corrected several of them.

There were multiple issues on the third night of the December MMIRS run. The rotator limits were not totally clear to users and operators, and the catalog software had failed to include the required position angle. This made it look like the required rotator position was out of range. (About a quarter hour of telescope time was lost while people puzzled over that.) The second issue that night was with the grism wheel, which got "lost" and could not find its home position. That may have been due to a roller switch in the cryogenic dewar that was sticking and not registering properly, or a problem with the ability of the motor to rotate the unbalanced wheel containing the grisms when pointing far from zenith. It is possible that additional "exercising" of the wheel at the start of the night might be of aid with both of these issues. The wheel homed properly the next day at zenith, and performed properly the rest of the run.

Upon mounting the Hecto instrument on the telescope in November, we discovered that a pellicle had split. This resulted in being unable to center on stars in the normal way. We adapted, as in the past, by centering the star in the aperture formed by the gripper jaws – a bit less precise, but workable. An issue with a gimbal axis also appeared from time to time as the robots were being moved to the stow position from the acquire/guide state. One axis would oscillate and cause the move to fail. The problem would disappear when the command was re-issued or a small manual move was introduced, making minimal impact on observations. We tried varying a few servo parameters to no avail. After the instrument had been on the telescope for about a week, there was a sequence configuration failure when the gripper reported that it had not closed properly on a button. After recovering from that condition, the fibers were parked and a new configuration was begun. That configuration also had a "gripper not closed" error that caused the sequence to fail. At that point, D. Fabricant suggested a service mission was needed to look at the three issues: gripper, pellicle, and T1 axis oscillation. MMTCam observations were done when weather allowed for the remaining few nights of the run before the instrument was taken off the telescope. The service mission crew from Cambridge spent about a week at the MMT looking at the issues. The pellicle was repaired. The gripper failure error did recur at least once in the lab. After verifying that the mechanism looked good and that all of the cables passed continuity tests, we changed out the stepper motor amplifier/controller. The gripper problem has not recurred. The T1 problem was not occurring frequently and was not causing sequence failures, so it was decided to monitor it but not change anything at this time.

The computer controlling the Hecto acquisition camera, that was troublesome in the previous quarter, did not give us any additional problems this quarter after we pulled the computer out of the rack and reseated the cards and connectors.

The Hecto instruments observed 68 fields and gathered 260 object exposures. There were an associated 717 calibration files consisting of bias, flat, comp, dark, and sky exposures.

In spite of all of the weather and instrument problems reported earlier, the MMIRS instrument gathered data on 70 fields, obtaining 2388 object exposures. There were also 1164 calibration files obtained consisting of dark, alignment, "test," flat, and comp exposures. Slightly less than half of the object fields were stars used to extract the telluric features of the night sky to properly correct the object spectra.

MMTCam observations were performed on nine nights, taking 72 images of 14 objects. There were an associated 242 engineering images taken consisting of bias, dark, and flat images.

f/15 Instrumentation

There was one adaptive optics (AO) run from 21 October through 1 November. The run consisted of one M&E night and eleven science nights. In general, the adaptive optics system ran well when on-sky and good science data were obtained despite bad weather on several nights. In particular, a significant amount of useful data were collected for the SAO exoplanet atmospheric characterization program.

There were a number of computer and network issues that affected the run, including periods of extremely slow computer response time. This can seriously affect the ability of the AO operators to close the loop and/or keep it closed. These issues often seem to appear and disappear randomly, and there is currently no known cause. In addition, there was another crash of the server *hacksaw*, resulting in the need to restart the AO system, causing a significant loss of time on-sky. This problem has occurred before, and there is currently no known cause.

On the second night, the deformable mirror (DM) power supply failed due to an under-voltage condition. The VCCA power supply voltage was re-adjusted to an acceptable range and caused no further problems throughout the run. There was also significant contamination found in the gap between the DM shell and the reference body. Small metallic flakes were removed from the gap edge. There were also indications of water contamination from a water leak coming from the roof on a previous run. The contamination was never completely cleared despite exercising the DM on several nights. This resulted in the gain, and therefore the correction of the AO loop, to be reduced for the final three nights of the run.

Additional AO software tests were performed to improve the response and reliability of the system. These tests mainly focused on the WFS camera, but also included enhancements to the controller algorithms to increase closed loop performance.

Topboxes and Wavefront Sensors (WFS)

The plotted output generated by the WFS centroid routines has been overhauled to provide the telescope operators with more detailed information on the robustness of the WFS corrections.

Previously, the final output of the WFS code, alongside the Zernike coefficients, was a plot of the simulated point spread function (PSF) (only including Zernike terms selected for correction) and an image of the wavefront error on the telescope pupil (again, only including the Zernike terms marked for correction), as shown in the figure below.

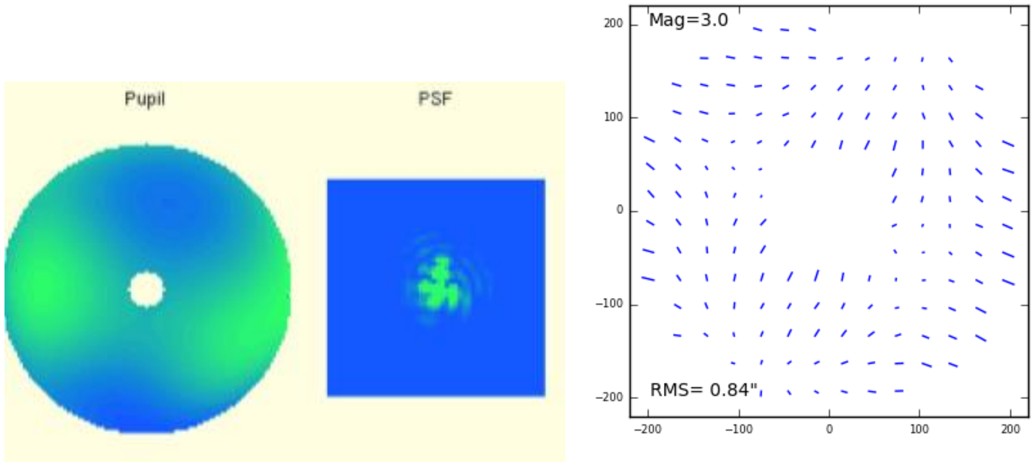

Figure 2.

Left: Previous output visualizations from the f/5 and f/9 WFS correction software. The two panels show the wavefront error as a function of position in the system pupil on the left and the simulated PSF based on the selected Zernike modes set for correction. Since the PSF is generated using only the term selected for correction, a very well formed PSF in this plot doesn't give much information about the quality of the system.

Right: New addition to the WFS visualization (used in place of the PSF plot on the left). Displacement vectors show the distance between the reference spot and WFS image spot, including the RMS variation in the distances. A robust correction should result in randomly oriented vectors and small residuals.

We have replaced the image of the pupil with a plot showing the displacement between each identified WFS spot and the associated reference spot location. Rather than a simulated image of the pupil, this plot gives an empirical measurement of the remaining distortion in the WFS spot pattern. To make the trends easier to see, we've multiplied the length of each displacement vector by a factor of Mag (default=3.0). A well-corrected image will have mostly randomly distributed vectors. In addition, we have added an estimation of the RMS in the displacement between spots and reference (in arcseconds) to this display. If the RMS measured in the spot pattern is smaller than the seeing (measured from the size of each spot in the pattern), further correction will have diminishing impact on delivered image quality, giving the operators a quantitative measure of when "enough" correction has been applied.

f/5 WFS

Prior to December, all MMIRS WFS work had been completed with MMIRS guide camera 2. During this run, however, we were unable to move the stage for WFS camera 2. In order to properly WFS with camera 1, we utilized the MMIRS LEDs to create a well-formed set of reference spots for camera 1. WFS with camera 1 still produced astigmatic images; the cause of this is still being investigated. It's possible the astigmatic images resulted from ignoring the fact that the MMIRS WFS cameras are observing stars off-axis and thus with some amount of well-known wavefront error, versus on-axis where there is no intrinsic wavefront error. This simplification can result in the addition of extra wavefront error for on-axis images.

In the final week of December, we began to implement a routine that will calculate the off-axis aberration and subtract that from the Zernike coefficients determined from off-axis stars to better correct on-axis images. The figure below shows that these terms can be quite large, especially near the location of the WFS guide probes.

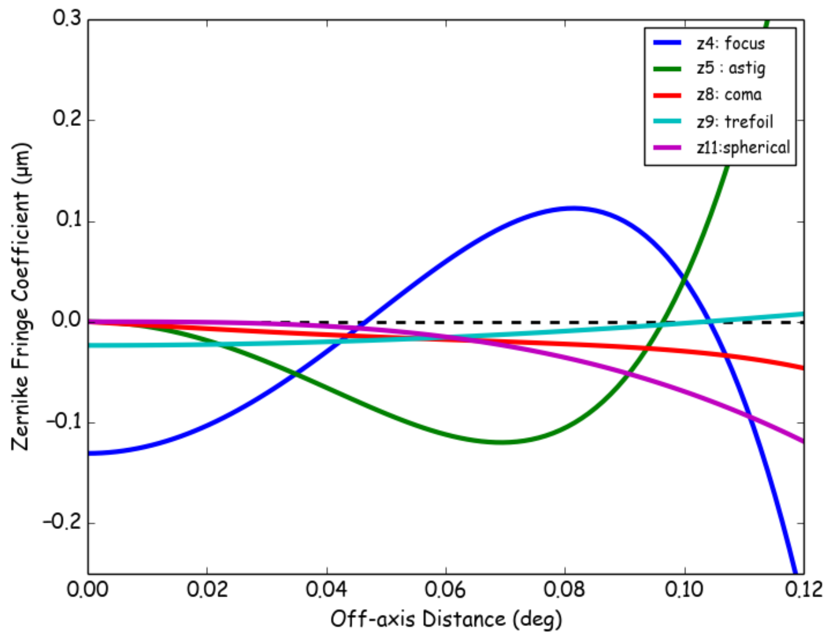

Figure 3. Zernike fringe coefficients as a function of off-axis distance for the MMIRS configuration. The MMIRS guide cameras (also used for wavefront sensing) are located off-axis, but correct WFS images as if they were observed on-axis, resulting in introducing systematic wavefront error to the system. Instead, we must predict the off-axis aberrations at the location of the WFS camera and correct the system to that known off-axis aberration rather than to the on-axis non-aberrated value.

Further code is required to rotate the terms above to a given off-axis angle and interface with the current WFS routines to provide the off-axis correction. We will test these correction factors during the March 2016 MMIRS M&E night.

Facilities

Main Enclosure

The building drive experienced random dropouts. An investigation showed that the field voltage resistors were getting hotter than normal. The temperature of the resistors, measured during operation, rose to 185°F within fifteen minutes. Further inspection revealed that the THHN wire within the box was discolored and brittle, evidence that it had been exposed to a great amount of heat. In fact, one of the wires fell off the terminal strip when touched. This could certainly cause intermittent failures in the major fault detection circuit. A new heatsink assembly for the two sets of resistor banks was mounted to a DIN rail to allow for more air flow and cooling. After an hour of operation the maximum temperature reading was 90°F, fine for continuous operation. The electronics will be repackaged into a cleaner and more reliable design that will include a fan to cool the resistors at all times.

General Infrastructure

<u>MMT Roof</u>

Construction started in mid-October with the delivery of the roof heating panels and the low-emissivity standing seam panels. Installation of the new safety features will be added in spring 2016. Reports are available in the Documentation database under Administration/SI Projects/1383801 MMT Heated Roof.

Computers and Information Technology

Computers and Storage

Hodir has been updated to OS X 10.11 (El Capitan) as a testbed for a future upgrade for *pixel* and other mountain Macs. A number of issues have become clear during this upgrade, so upgrading the mountain computers has been put on hold until as many issues as possible have been corrected to make the transition as smooth as possible.

A number of software systems (*shwfs* and *mmtlogger* primarily) have been fully integrated into the MMTO git repository to allow for a detailed version control and the ability to revert changes quickly should the need arise, due to bugs in an update.

Network

During this quarter the MMT software group addressed various system problems. The most serious one was repeated crashes of *hacksaw*, the main server at the summit. After much investigation, this appears to have been caused by a latent bug in VirtualBox, the software that runs *hacksaw* as a virtual machine. There have been no further crashes since upgrading VirtualBox.

The next most serious problem was the failure of the ethernet driver on *chisel* and *pipewrench,* the telescope operator computer and its backup. After much correspondence with kernel maintainers and testing of patches for a possible fix, this is still unresolved. We are currently running *chisel* and *pipewrench* with a much older kernel. Work was also done on trying to understand and improve a new, unusual behavior of the audit daemon. There has been no resolution, but this does not appear to be a serious problem.

The computer server room on the third floor of Steward Observatory is being converted to office space. As a first step in migrating the MMT campus servers to a new location, these computers were located temporarily into the Electronics lab within the MMT department area on the fourth floor of Steward Observatory. Pascal Fortin of Whipple Observatory has graciously offered to let the MMT use the Veritas server room, which is adjacent to the MMT department area, as a new permanent location for our servers. The network and power requirements for moving MMT equipment into this location were evaluated. Eight new University Information Technology Services (UITS) network ports on the campus MMT subnet and a separate circuit breaker were installed for MMT use. MMT servers and associated equipment will be moved into the Veritas server room in January 2016.

In the continued effort to move "non-critical" activities from *hacksaw*, logging from miniservers was stopped onto *hacksaw*. This logging is now running on the *ops* computer. Logging will also be added to a new *ops2* computer in January 2016. The *ops2* computer is a clone of the *ops* computer and will act as a backup. Both computers are located at the summit. In particular, the new HVAC controls software is running on the *ops*/*ops2* computers.

Defective hard drives were replaced in *nas1* and *nas2*. The RAID arrays on these network-attached storage devices were rebuilt without incident.

Telemetry, Logging, and Database Management

Data telemetry and logging were added for the final two quadrants of T-series thermocouples on the M1 mirror. Data from these thermocouples are now being logged into the "mmtlogs" MySQL relational database.

Telstat

Although feedback has been overwhelmingly positive for the new telstat (telescope status) displays, one common comment is the difficulty for users to determine which direction the wind is blowing, based upon the direction arrows within the displays (see Figure 4 below). The confusion is whether the arrows point either *into* or *with* the wind direction. Several attempts to make this distinction clearer have resulted in even more confusion.

A simple label was added below the arrows that told the viewer that the wind blows *into* the arrow. Unfortunately, this label is often unnoticed by the viewer. To make it more visually intuitive and to quickly determine the wind direction at a glance, a new browser-based, fluid simulation model that uses real-time wind values from the wind sensors was overlaid onto the summit top-view diagram (see Figure 4). The simulation places evenly spaced particles into the wind flow, and the particles are animated over the summit image. The simulation takes into account the building and the support building shapes, resulting in a highly informative display. Although the simulation is only two-dimensional and relatively low-resolution, it does a great job of visualizing the general wind direction trends in real-time. It also demonstrates some recent innovative developments in JavaScript programming and web-based visualization.

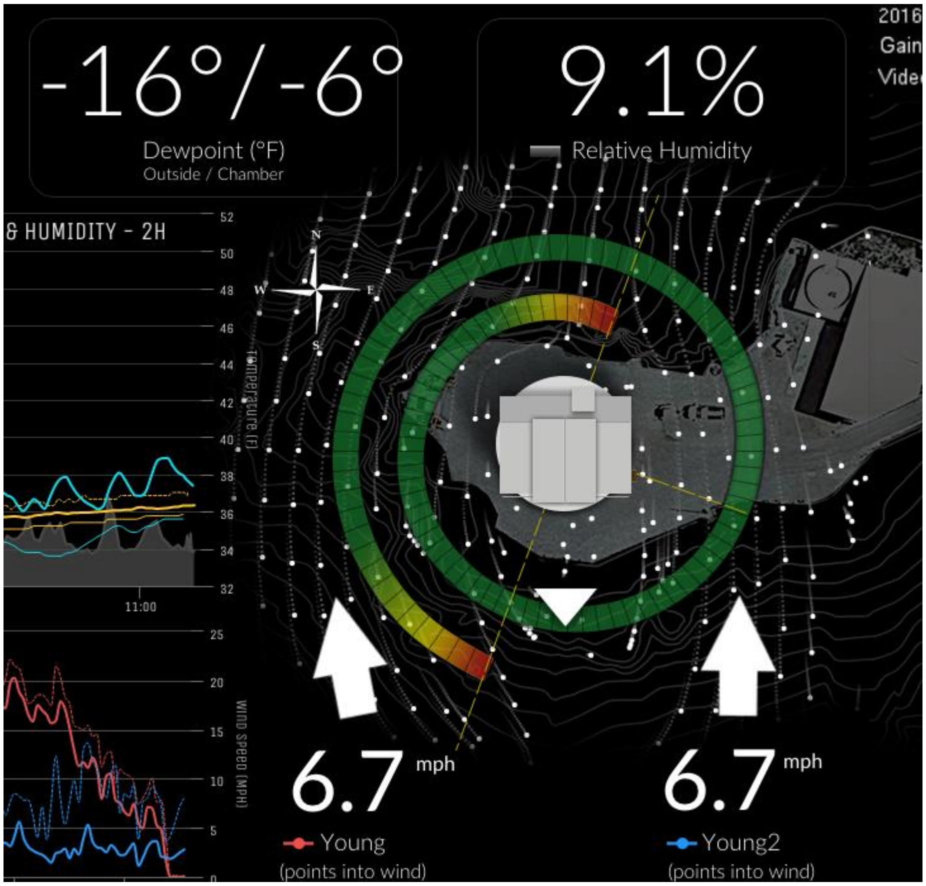

Figure 4. Details of the wind portion of the weather telstat display. Particle animation is used to simulate real-time wind flow around the MMT enclosure and the Support building. Although the simulation is only two-dimensional, it provides a highly intuitive visualization of the current wind patterns around the MMT enclosure and the relationship of wind arrow direction and wind flow.

Weather and Environmental Monitoring

Weather Stations

A new dual port Lantronix unit was installed and tested. Additionally, isolation units were installed in the RS-232 lines to further reduce the potential damage caused by lightning. The system works well but has an erroneous spike of excessive wind speed from time to time. Troubleshooting has identified the serial to data unit as the likely cause. A new serial to RS-232 unit was ordered from R.M. Young and is awaiting installation.

All Sky Camera and Web Cameras

A final assembly for the Beefcake relay control system was made for use on the All Sky Camera. The system is up and fully operational.

Seeing

As discussed in previous Quarterly reports, the MMT and Magellan Infrared Spectrograph (MMIRS), a wide-field near-IR imager and multi-object spectrograph, generates WFS-related seeing values much more quickly than other f/5 or f/9 instruments. This instrument was on the telescope for a few days during early October 2015 and late December 2015. Of the 2130 total f/5 samples for the period of October 1 - January 1, 1387 are from MMIRS. There are 743 f/5 seeing values that are not from MMIRS (e.g., Hecto) and 791 seeing measurements from f/9 instruments.

Figures 5 and 6 present apparent seeing values, corrected to zenith, at the MMTO during this reporting period. These values are derived from measurements made by the f/5 (MMIRS and non-MMIRS) and f/9 WFSs. Figure 5 presents the seeing values as a histogram with 0.1 arcsec bins while Figure 6 presents the same data as a time-series chart. f/5 WFS values are divided into MMIRS and non-MMIRS categories. In Figure 5, f/5 (MMIRS) seeing data are shown in blue, f/5 (non-MMIRS) data are in green, f/9 data are in red, and the combination of all three WFS values is in cyan. In Figure 6, seeing measurements for the f/5 are similarly shown as blue (MMIRS) and green (non-MMIRS) diamonds while f/9 WFS seeing measurements are represented by red squares.

The median f/5 seeing value for MMIRS data of 1.07 arcsec is much higher than for other instruments. However, these data were obtained during only a few days of observation. The median non-MMIRS f/5 seeing is 0.80 arcsec while the median f/9 seeing value is 0.76 arcsec. The combined median seeing for all data WFS systems is 0.96 arcsec. As previously stated, the data are highly biased towards the few nights that MMIRS was used for observing and are not representative of overall seeing trends at the MMTO.

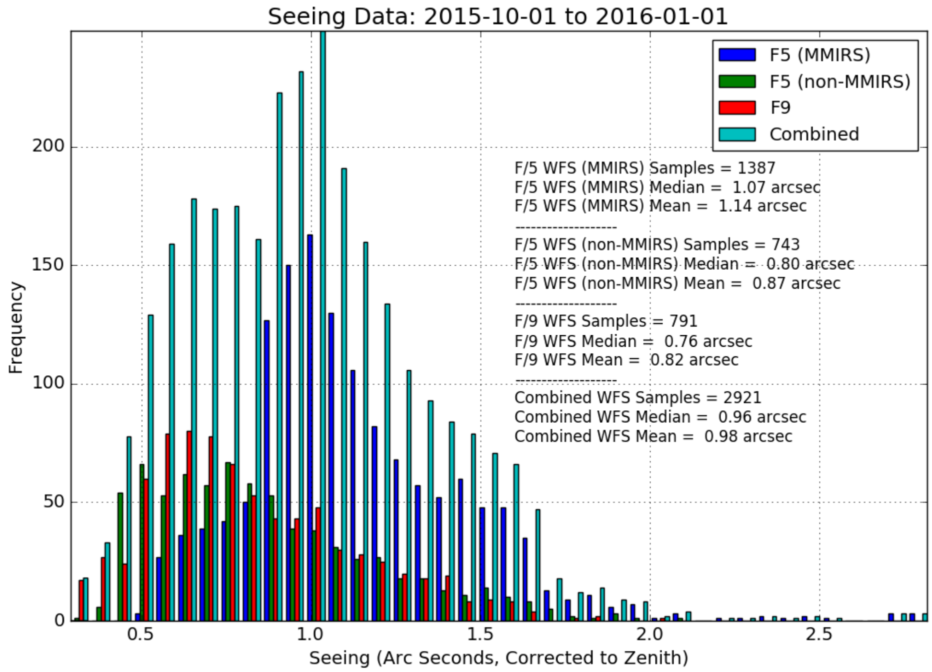

Figure 5. Histogram (with 0.1 arcsec bins) of derived seeing values for the f/5 (MMIRS and non-MMIRS) and f/9 WFSs from October-December. Seeing values are corrected to zenith. The median f/5 MMIRS seeing is 1.07 arcsec and f/5 non-MMIRS seeing is 0.80 arcsec while the median f/9 seeing is 0.76 arcsec. A combined median seeing value of 0.96 arcsec is found for the 2921 WFS measurements made during this period.

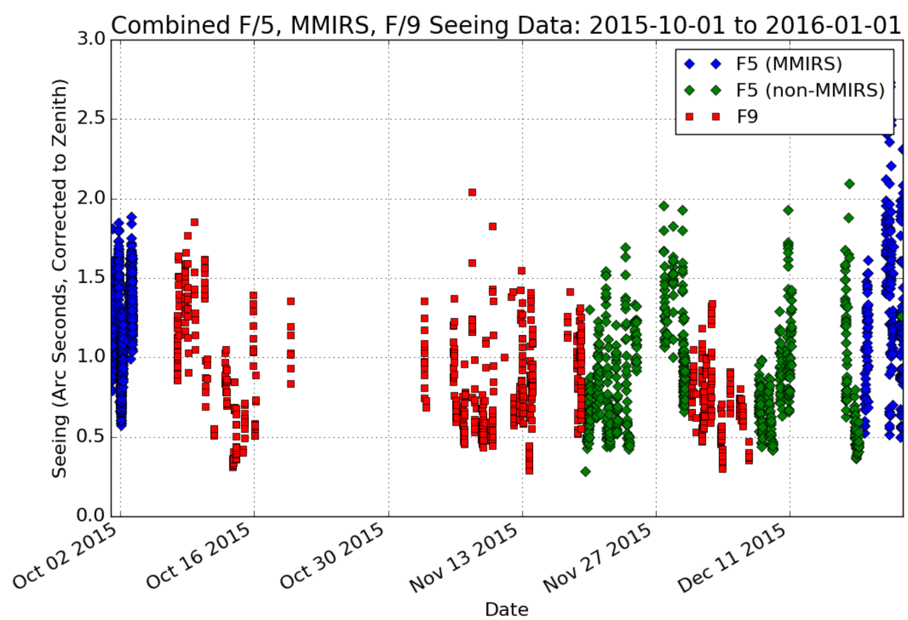

Figure 6. Derived seeing for the f/5 (MMIRS and non-MMIRS) and f/9 WFSs from October-December. Seeing values are corrected to zenith. f/5 seeing values are shown in blue (MMIRS) and green (non-MMIRS) while f/9 values are in red. Data from MMIRS are typically sampled more frequently than for other instruments.

User Support

Remote Observing

This quarter a total of 16.5 nights of remote observing were supported by the MMTO. CfA used 6.5 nights, while 10 nights were used by the UA. We had our first successful remote observations from Korea in November.

Documentation

Nothing to report.

Public Relations and Outreach

Visitors and Tours

10/3/15 – D. Blanco and E. Martin escorted a group of educators from the NSF-funded program, EPSCoR (Experimental Program to Stimulate Competitive Research) who were given a tour of the Mt. Hopkins Ridge telescopes including MINERVA. They originally wanted to tour the MMTO, but there was not enough time.

11/18-19 – Four Chinese astronomers, accompanied by R. Green of Steward Obs., visited the MMTO and were given a tour by G. Williams. They stayed overnight on 11/18 to watch observations by the X. Fan group from Steward Obs.

12/15/15 - Two undergraduate students from UC Santa Cruz visited the MMTO with their advisor, D. Williams. They were given a tour by G. Williams and also watched some nighttime operations.

MMTO in the Media

The discovery, by K. Evans and P. Massey, of a "runaway" massive star in M31 using MMT data was featured in the AAS Nova story "A Star on the Run" by S. Kohler on October 26.

Site Protection

The MMTO sent a letter to the International Dark-Sky Association Board of Directors in support of the designation of Kartchner Caverns State Park as an International Dark Sky Park.

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)

15-59 Comparison of Observed and Predicted Lyα and Ultraviolet Lines in Galaxy Spectra at Redshifts z<3.7, Adopting Photoionization+Shock Composite Models
M. Contini
MNRAS, **452**, 3795

15-60 The Extreme Ultraviolet Spectrum of the Kinetically Dominated Quasar 3C 270.1
B. Punsly and P. Marziani
MNRAS Lett, **453**, L16

15-61 Quasar Classification Using Color and Variability
C.M. Peters, G.T. Richards, A.D. Myers, et al.
ApJ, **811**, 95

15-62 A Rise in the Ionizing Photons in Star-forming Galaxies over the Past 8 Billion Years
L.J. Kewley, H.J. Zahid, M.J. Geller, et al.
ApJ, **812**, 20

15-63 The Next Generation Virgo Cluster Survey. X. Properties of Ultra-compact Dwarfs in the M87, M49, and M60 Regions
C. Liu, E.W. Peng, P. Cote, et al.
ApJ, **812**, 34

15-64 The ELM Survey. VI. Eleven New Double Degenerates
A. Gianninas, M. Kilic, W.R. Brown, et al.
ApJ, **812**, 167

15-65 The O- and B-Type Stellar Population in W3: Beyond the High-Density Layer
M.M. Kiminki, J.S. Kim, M.B. Bagley, et al.
ApJ, **813**, 42

15-66 Stellar Velocity Dispersion and Anisotropy of the Milky Way Inner Halo
C. King III, W.R. Brown, M.J. Geller, S.J. Kenyon
ApJ, **813**, 89

15-67 The Origin of Double-peaked Narrow Lines in Active Galactic Nuclei. I. Very Large Array Detection of Dual AGNs and AGN Outflows
F. Müller-Sánchez, J.M. Comerford, R. Nevin, et al.
ApJ, **813**, 103

15-68 *Kepler* Monitoring of an L Dwarf. II. Clouds with Multi-year Lifetimes
J.E. Gizis, K.G. Dettman, A.J. Burgasser, et al.
ApJ, **813**, 104

15-69 Influence of Stellar Multiplicity on Planet Formation. IV. Adaptive Optics Imaging of *Kepler* Stars with Multiple Transiting Planet Candidates
J. Wang, D.A. Fischer, J.-W. Xie, D.R. Ciardi
ApJ, **813**, 130

15-70 Photometric Study on Stellar Magnetic Activity. I. Flare Variability of Red Dwarf Stars in the Open Cluster M37
S.-W. Chang, Y.-I. Byun, J.D. Hartman
ApJ, **814**, 35

15-71 Mid-infrared Luminosity Function of Local Star-forming Galaxies in the North Ecliptic Pole-Wide Survey Field of AKARI
S.J. Kim, H.M. Lee, W.-S. Jeong, et al.
MNRAS, **454**, 1573

15-72 A Runaway Red Supergiant in M31
K.A. Evans, P. Massey
AJ, **150**, 149

15-73 HAT-P-57b: A Short-period giant Planet Transiting a Bright Rapidly Rotating A8V Star Confirmed via Doppler Tomography
J.D. Hartman, G.A. Bakos, L.A. Buchhave, et al.
AJ, **150**, 197

15-74 Dissecting the Power Sources of Low-luminosity Emission-line Galaxy Nuclei via Comparison of HST-STIS and Ground-based Spectra
A. Constantin, J.C. Shields, L.H. Ho, et al.
ApJ, **814**, 149

15-75 A Decade of Short-duration Gamma-ray Burst Broadband Afterglows: Energetics, Circumburst Densities, and Jet Opening Angles
W. Fong, E. Berger, R. Margutti, B.A. Zauderer
ApJ, **815**, 102

15-76 The Environment of Massive Quiescent Compact Galaxies at $0.1<z<0.4$ in the COSMOS Field
I. Damjanov, H.J. Zahid, M.J. Geller, H.S. Hwang
ApJ, **815**, 104

15-77 Metamorphosis of SN 2014C: Delayed Interaction between a Hydrogen Poor Core-collapse Supernova and a Nearby Circumstellar Shell
D. Milisavljevic, R. Margutti, A. Kamble, et al.
ApJ, **815**, 120

15-78 Late-time Spectral Line Formation in Type IIb Supernovae, with Application to SN 1993J, SN 2008ax, and SN 2011dh
A. Jerkstrand, M. Ergon, S.J. Smartt, et al.
A&A, **573**, 12

15-79 The Sloan Digital Sky Survey Reverberation Mapping Project: Technical Overview
Y. Shen, W.N. Brandt, K.S. Dawson, et al.
ApJS, **216**, 4

15-80 Sloan Digital Sky Survey III Photometric Quasar Clustering: Probing the Initial Conditions of the Universe
S. Ho, N. Agarwal, A.D. Myers, et al.
JCAP, **5**, 40

15-81 Merger-driven Fueling of Active Galactic Nuclei: Six Dual and Offset AGNs Discovered with *Chandra* and *Hubble Space Telescope* Observations
J.M. Comerford, D. Pooley, R.S. Barrows, et al.
ApJ, **806**, 219

15-82 Hiding in Plain Sight: Record-Breaking Compact Stellar Systems in the Sloan Digital Sky Survey
M.A. Sandoval, R.P. Vo, A.J. Romanowsky, et al.
ApJ Lett, **808**, L32

15-83 A *Herschel* Study of 24 μm-Selected AGNs and Their Host Galaxies
L. Xu, G.H. Rieke, E. Egami, et al.
ApJS, **219**, 18

15-84 A Spectroscopic Survey of the Fields of 28 Strong Gravitational Lenses
Momcheva, I.G., Williams, K.A., Cool, R.J., et al.
ApJS, **219**, 29

15-85 Bayesian High-Redshift Quasar Classification from Optical and Mid-IR Photometry
G.T. Richards, A.D. Myers, C.M. Peters, et al.
ApJS, **219**, 39

15-86 Linking Stellar Coronal Activity and Rotation at 500 Myr: A Deep *Chandra* Observation of M37
A. Núñez, M.A. Agüeros, K.R. Covey, et al.
ApJ, **809**, 161

15-87 The Gas Phase Mass Metallicity Relation for Dwarf-Galaxies: Dependence on Star Formation Rate and HI Gas Mass
J. K.-V. Tran, A. Saintonge, G. Accurso, et al.
ApJ, **812**, 98

15-88 PS1-10jh Continues to Follow the Fallback Accretion Rate of a Tidally Disrupted Star
S. Gezari, R. Chornock, A. Lawrence, et al.
ApJ Lett, **815**, L5

15-89 The UV/Blue Effects of Space Weathering Manifested in S-Complex Asteroids II: Probing for Less-Weathered Objects in the Solar System
F. Vilas, A.R. Hendrix, and E.A. Jensen
P&SS, **118**, 273

15-90 Making the Observational Parsimonious Richness a Working Mass Proxy
S. Andreon
A&A, **582**, 100

MMT Technical Memoranda / Reports

None

Non-MMT Related Staff Publications

PRIMUS: The Effect of Physical Scale on the Luminosity Dependence of Galaxy Clustering via Cross-correlations
Bray, A.D., Eisenstein, D.J., Skibba, R.A., et al. (Cool, R.J.)
ApJ, **811**, 90

Dark Matter Halo Models of Stellar Mass-dependent Galaxy Clustering in PRIMUS+DEEP2 at 0.2>z>1.2
Skibba, R.A., Coil, A.L., Mendez, A.J., et al. (Cool, R.J.)
ApJ, **807**, 152

PRIMUS: The Relationship between Star Formation and AGN Accretion
Azadi, M., Aird, J., Coil, A.L., et al. (Cool, R.J.)
ApJ, **806**, 187

PRIMUS: Effects of Galaxy Evironment on the Quiescent Fraction Evolution at z<0.8
Hahn, CH, Blanton, M.R., Moustakas, J., et al. (Cool, R.J.)
ApJ, **806**, 162

RCS2 J232727.6-020437: An Efficient Cosmic Telescope at z=0.6986
Hoag, A., Bradac, M., Huang, K. H., et al. (Hinz, J.)
ApJ, **813**, 37

Appendix II - Service Request (SR) and Response Summary: October – December 2015

The 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 9 presents the distribution of SR responses by priority during the period of October through December 2015. As seen in the figure, the highest percentage (30%) of responses was "Low" priority, followed by 21% "Near-Critical" and 20% "Information Only." In addition, 15% are "Important" and 14% "Critical" priority.

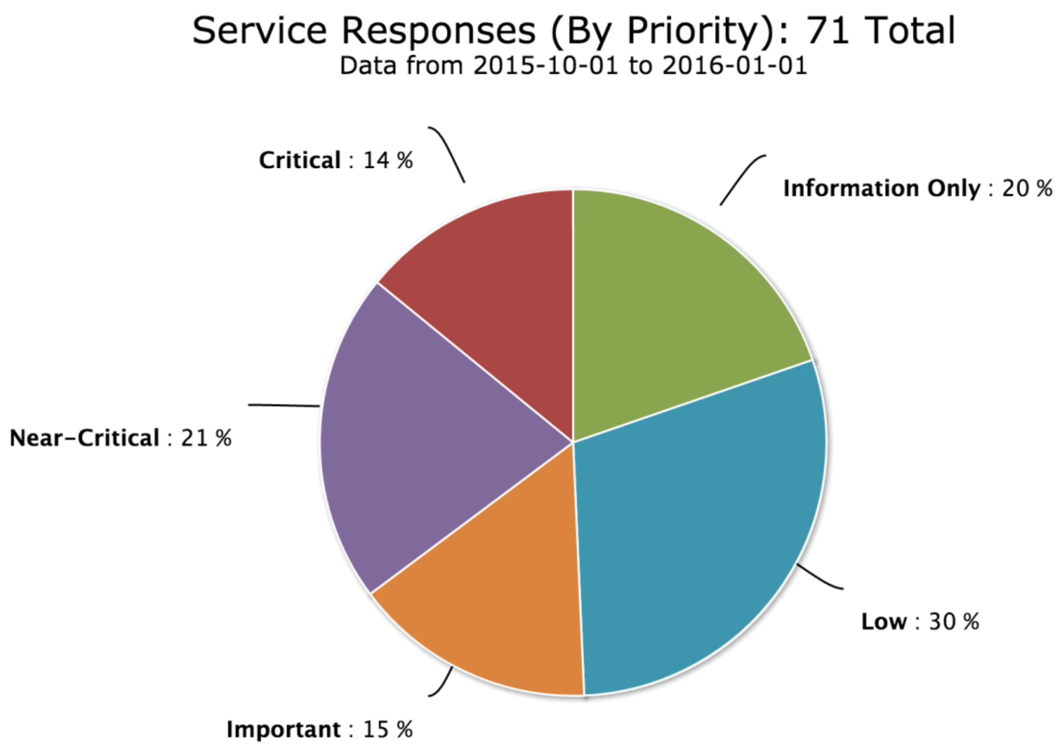

Figure 9. Service Request responses by priority during October through December 2015. 14% were "Critical" responses, 21% "Near-Critical," 15% "Important," 30% "Low," and 20% "Information Only."

"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 71 SRs during this three-month period, up from 41 during the previous three-month reporting period. However, the previous period included summer shutdown during which there were no SRs.

Figure 10 presents the same 71 SR responses grouped by category. These categories are further divided into subcategories for more detailed tracking of issues. The majority of the responses from October through December were related to the "Building," "Thermal Systems," and "Computers/Network" categories with 21, 12, and 10 responses, respectively. Responses also occurred in the "Cell," "Electronics," "Instruments," "Software," "Support Building," and "Weather Systems" categories.

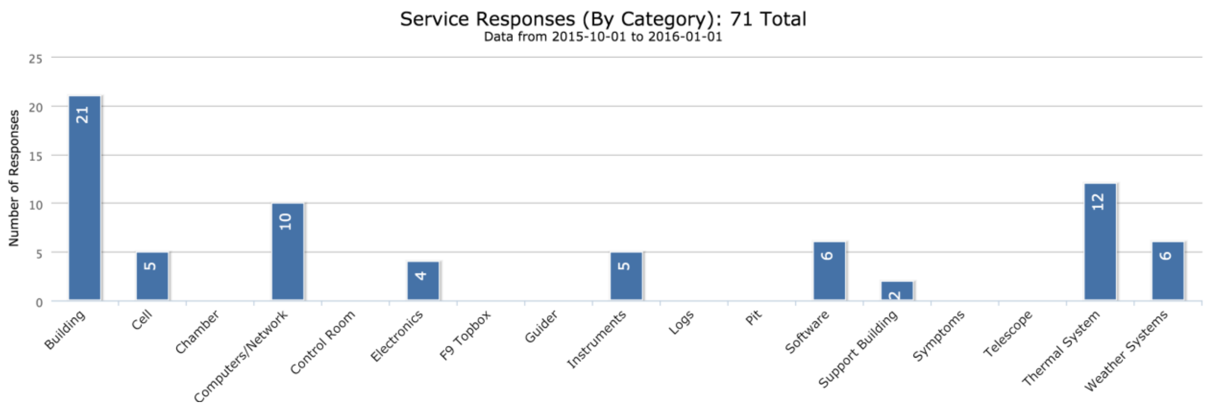

Figure 10. Service Request responses by category during October through December 2015. The majority of responses were within the "Building," "Thermal System," and "Computers/Network" categories.

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

October 2015

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	12.00	130.10	74.70	0.00	0.40	0.00	0.00	75.10
PI Instr	18.00	195.30	123.10	0.30	2.80	0.00	0.00	126.20
Engr	1.00	11.00	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	**31.00**	**336.40**	**197.80**	**0.30**	**3.20**	**0.00**	**0.00**	**201.30**

Time Summary

Percentage of time scheduled for observing	96.7
Percentage of time scheduled for engineering	3.3
Percentage of time scheduled for sec/instr change	0.0
Percentage of time lost to weather	58.8
Percentage of time lost to instrument	0.1
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	59.8

* Breakdown of hours lost to instrument
- 0.30 Issue with MMIRS

** Breakdown of hours lost to telescope
- 0.30 Runaway due to imbalance
- 1.00 Guider issues
- 0.15 M1 panic
- 0.25 East elephant hose broke
- 1.50 DM contamination

November 2015

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	16.00	184.50	50.75	0.00	1.00	10.60	0.00	62.35
PI Instr	12.00	140.60	34.80	15.40	0.20	0.00	0.00	50.40
Engr	2.00	23.50	11.60	11.90	0.00	0.00	0.00	23.50
Sec Change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**30.00**	**348.60**	**97.15**	**27.30**	**1.20**	**10.60**	**0.00**	**136.25**

Time Summary

Percentage of time scheduled for observing	93.3
Percentage of time scheduled for engineering	6.7
Percentage of time scheduled for sec/instr change	0.0
Percentage of time lost to weather	27.9
Percentage of time lost to instrument	7.8
Percentage of time lost to telescope	0.3
Percentage of time lost to general facility	3.0
Percentage of time lost to environment (non-weather)	0.0
Percentage of time lost	39.1

* Breakdown of hours lost to instrument
- 27.30 Hecto robot gripper jaw problems

** Breakdown of hours lost to telescope
- 1.00 Failure of actuator 141 / burnt electronics smell
- 0.20 Annunciator not receiving values / timestamps

*** Breakdown of hours lost to facility
- 0.25 Hacksaw server crash
- 5.85 Damage to new roof from wind
- 4.50 2'x4' section of new roof blew off due to wind

Year to Date November 2015

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	101.00	1043.60	488.10	11.50	3.15	11.10	0.00	513.85
PI Instr	181.00	1750.40	816.60	22.80	16.00	7.00	0.00	862.40
Engr	17.00	169.70	68.10	11.90	0.00	0.00	0.00	80.00
Sec Change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**299.00**	**2963.70**	**1372.80**	**46.20**	**19.15**	**18.10**	**0.00**	**1456.25**

Time Summary Exclusive of Shutdown

Percentage of time scheduled for observing	94.3
Percentage of time scheduled for engineering	5.7
Percentage of time scheduled for sec/instr change	0.0
Percentage of time lost to weather	46.3
Percentage of time lost to instrument	1.6
Percentage of time lost to telescope	0.6
Percentage of time lost to general facility	0.6
Percentage of time lost to environment (non-weather)	0.0
Percentage of time lost	49.1

December 2015

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	83.30	17.50	8.00	0.00	0.00	0.00	25.50
PI Instr	23.00	276.00	149.30	7.80	1.00	0.00	0.00	158.10
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**	**359.30**	**166.80**	**15.80**	**1.00**	**0.00**	**0.00**	**183.60**

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	46.4
Percentage of time lost to instrument	4.4
Percentage of time lost to telescope	0.3
Percentage of time lost to general facility	0.0
Percentage of time lost to environment	0.0
Percentage of time lost	51.1

* Breakdown of hours lost to instrument

8.00 Blue Channel shutter
1.00 MMIRS GUI & guider problems
4.30 MMIRS wfs problems, grism not homing
1.00 MMIRS guider, server, dither patterns
1.50 MMIRS computer issues

** Breakdown of hours lost to telescope

0.75 M1 not raised
0.25 Rotator problems

Year to Date December 2015

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	108.00	1126.90	505.60	19.50	3.15	11.10	0.00	539.35
PI Instr	204.00	2026.40	965.90	30.60	17.00	7.00	0.00	1020.50
Engr	17.00	169.70	68.10	11.90	0.00	0.00	0.00	80.00
Sec Change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**329.00**	**3323.00**	**1539.60**	**62.00**	**20.15**	**18.10**	**0.00**	**1639.85**

Time Summary Exclusive of Shutdown

Percentage of time scheduled for observing	94.9
Percentage of time scheduled for engineering	5.1
Percentage of time scheduled for secondary change	0.0
Percentage of time lost to weather	46.3
Percentage of time lost to instrument	1.9
Percentage of time lost to telescope	0.6
Percentage of time lost to general facility	0.5
Percentage of time lost to environment	0.0
Percentage of time lost	49.3