Observing Report
MAESTRO run April 3-7, 2008
Jill Bechtold

1. Before the run.

The following issues were addressed after the November 2007 run.

a. Plate scale of the slit viewer.

The plate scale of the slit viewer was initially chosen so that we could see the maximum field of view. However, at this scale, the slits were not easily visible, and it was not possible to acquire objects. Moreover, the guider software only centroids to ½ a guider ccd pixel, and this is not adequate for guiding. We purchased a replacement focusing lens which cut the field of view by about a factor of 2, and Michelle designed and fabricated a new mount, and installed it. Michelle Reed also redesigned the bracket that attaches the slit viewer camera to the focus stage, so it is much easier to mount and dismount the camera, and adjust its tilt. We adjusted the camera so that the best focus was in the range of travel of the stepper motor.

b. Finish mounting slits plates in slit holders.

We fabricated new slit mounts and anodized them, so that we could mount at least one of every slit. The slits are custom disks which have been optically polished and aluminized. These slits are glued into custom made black rings which are then screwed into the slit holder. The alignment in the ring and the alignment of the ring in the slit holder requires careful alignment via a microscope. Michelle identified a much cheaper source for the magnets which hold the slit mounts in the spectrograph, and we used those. However these proved to be inadequate and on the telescope, we "lost" the slit holder whenever we tried the slits with these magnets – resulting in an hour of work to remove the covers and recover the slit. We therefore have to use the stronger, more expensive magnets. We'll have to drill out the slit holders we have to accommodate the better magnets.

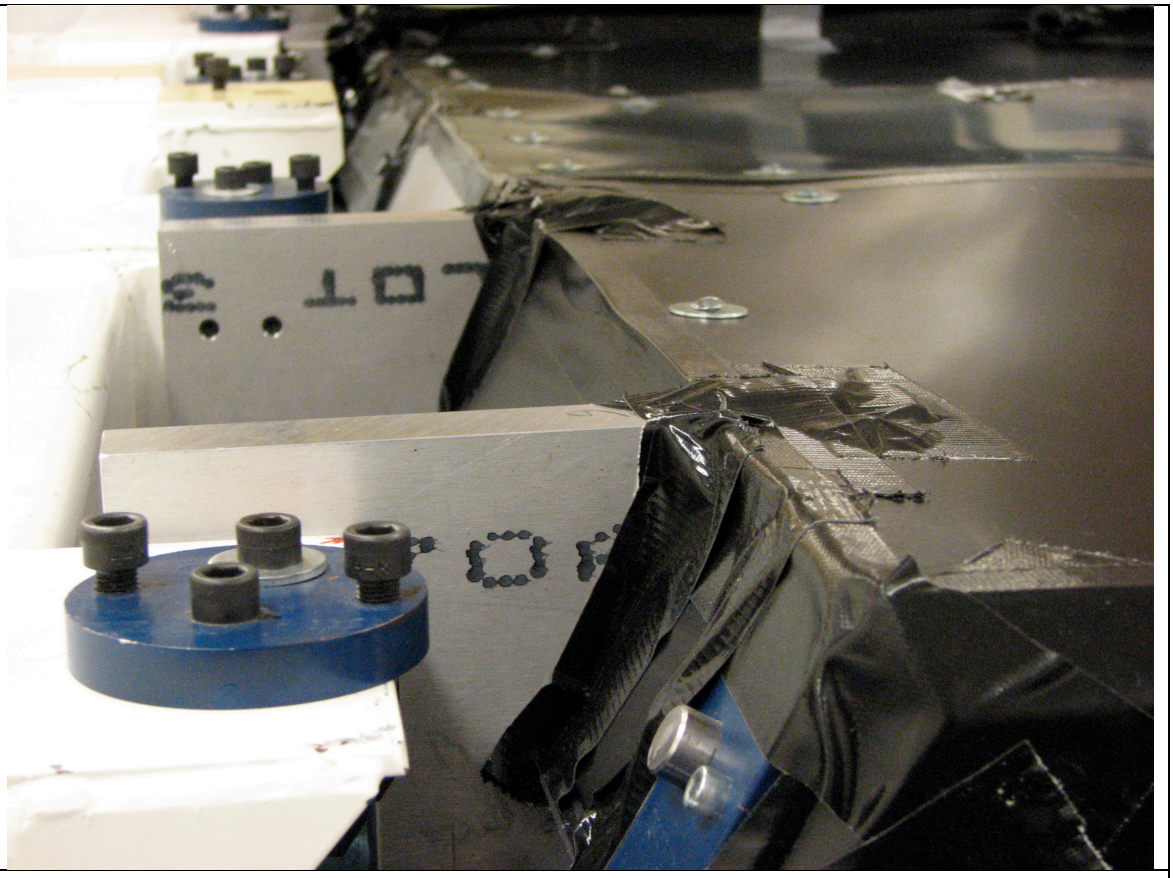
c. Isolate the shutter to eliminate fixed pattern noise.

In November, Dave Baxter and Roy Tucker determined that the significant noise we see on the science CCD on the mountain, particularly with the building drives on, was pickup due to the shutter. Jeff Rill built an isolator box, and it was installed. On the mountain, the read noise was measurably better. However, there are a number of other CCD grounding problems, described below, and the shutter remains under suspicion.

d. Flexure

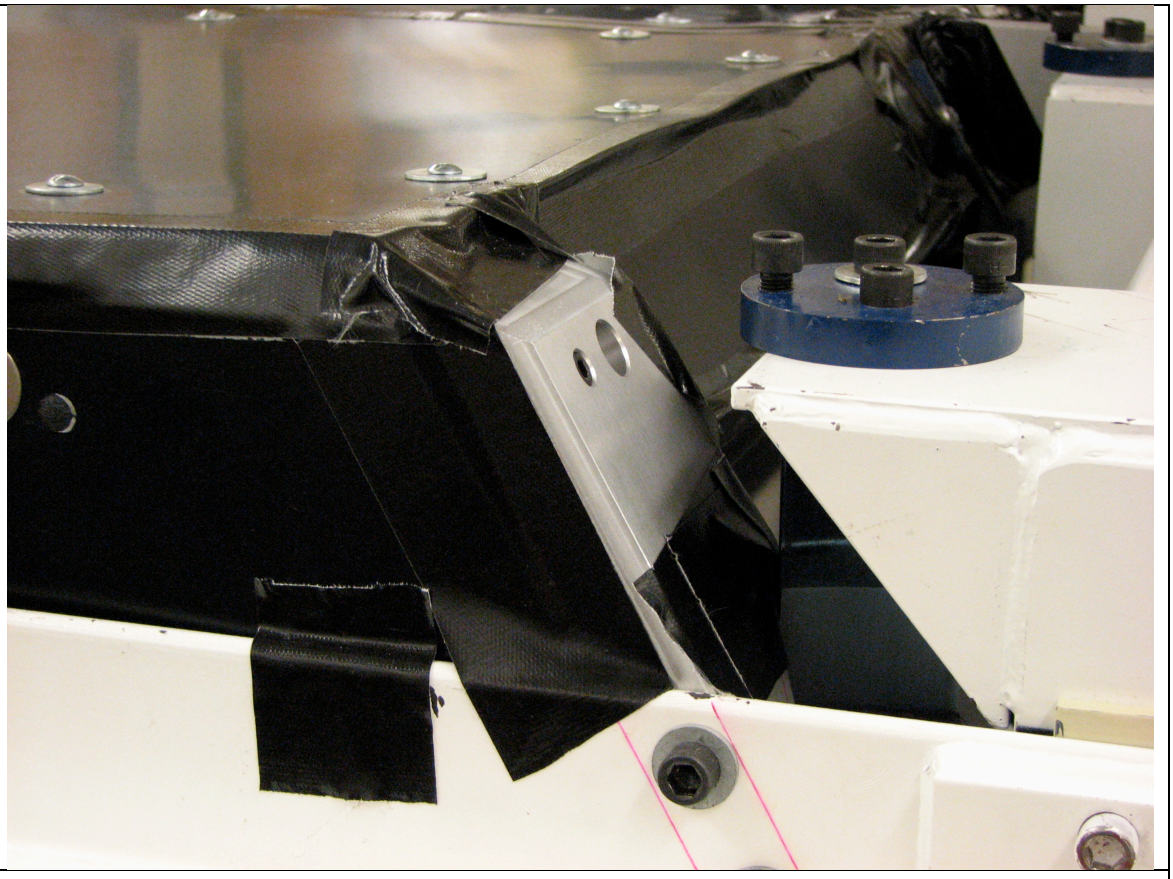
Flexure tests in November showed that the flexure is better behaved with the new grating angle adjustment mount, but that there is an unacceptable amount of flexure in the cross-disperser direction (with the spectrograph rotation at 0 degrees). Shawn Callahan analyzed the problem, and came up with a number of solutions, which he then designed and installed, with Mike Orr of the machine shop.

- Aluminum brackets were installed at 8 places, to secure the connection between the space frame and the steel weldment, since the poor design of the blue flexures which attach the apex fittings to the weldment is probably the main source of flexure. The brackets are designed so that the space frame may be lowered from the weldment easily, should that be come necessary. Since the space frame is at a slight tilt with respect to the weldment, the parts were match drilled on the spectrograph. Modifications to the covers were necessary at all points where the new brackets are mounted. Unfortunately, the design of the grating platform made it impossible to mount a support bracket behind it.



Aluminum brackets to decrease flexure.

- To help support the grating platform, holes were drilled in the white end piece which is screwed into the two forks of the weldment, and it was attached to a piece which replaced the flexure at that apex fitting.



- The grating motor was found to be inadequately holding the grating in place. Creighton Chang and John Dimiceli of the MMTO replaced it with a single shaft of aluminum, and improved the design of the mount and bracket to bolt the grating in place.
- The grating platform mounting hardware had been kludged together in order to position the grating in the spectrograph where it needed to be optically. Stiffer brackets were designed, fabricated and installed.
- Even with the above modifications, the grating cell could easily be tilted a large, measurable amount by pressing on it. Shawn made shims and other brackets and we installed them with jbweld to hold the grating cell in place.
- We tested in the lab that the modifications did not move the spectrum on the ccd significantly.

As described below, the modifications were successful in reducing the flexure. We are extremely grateful for Shawn's work on this problem, and for Mike Orr's careful installation of the parts.

I. Comparison lamp flip mirror.

The light from the comparison lamp box is directed towards the slit by a mirror which is moved in and out of the beam by a remotedly controlled stepper motor. The original mechanical designed involved a rotational motion which swung the mirror on a bearing. Despite a lot of adustment and redesign of some parts, this mechanism never worked well, and the mirror was not always at the commanded position because of mechanical play in the bearings.

A new stage was purchased to allow the mirror to simply be moved in a linear motion in and out of the beam. It turned out that the line of stepper motor+ precision stages has been discontinued, but we bought one of the last existing stages which is identical to the other stages in MAESTRO, so no electronic or software modifications were necessary. The old comparison flip mirror stage will be used as a spare for the guide camera focus stage.

John Dimiceli of the MMTO designed, fabricated and installed a new bracket for the flip mirror so that it was attached to the new stage. The old bracket consisted of 3 pairs of push-pull screws which were not positioned to allow adequate adjustment of the mirror tilt and position. The new bracket allows easy adjustment of the mirror.

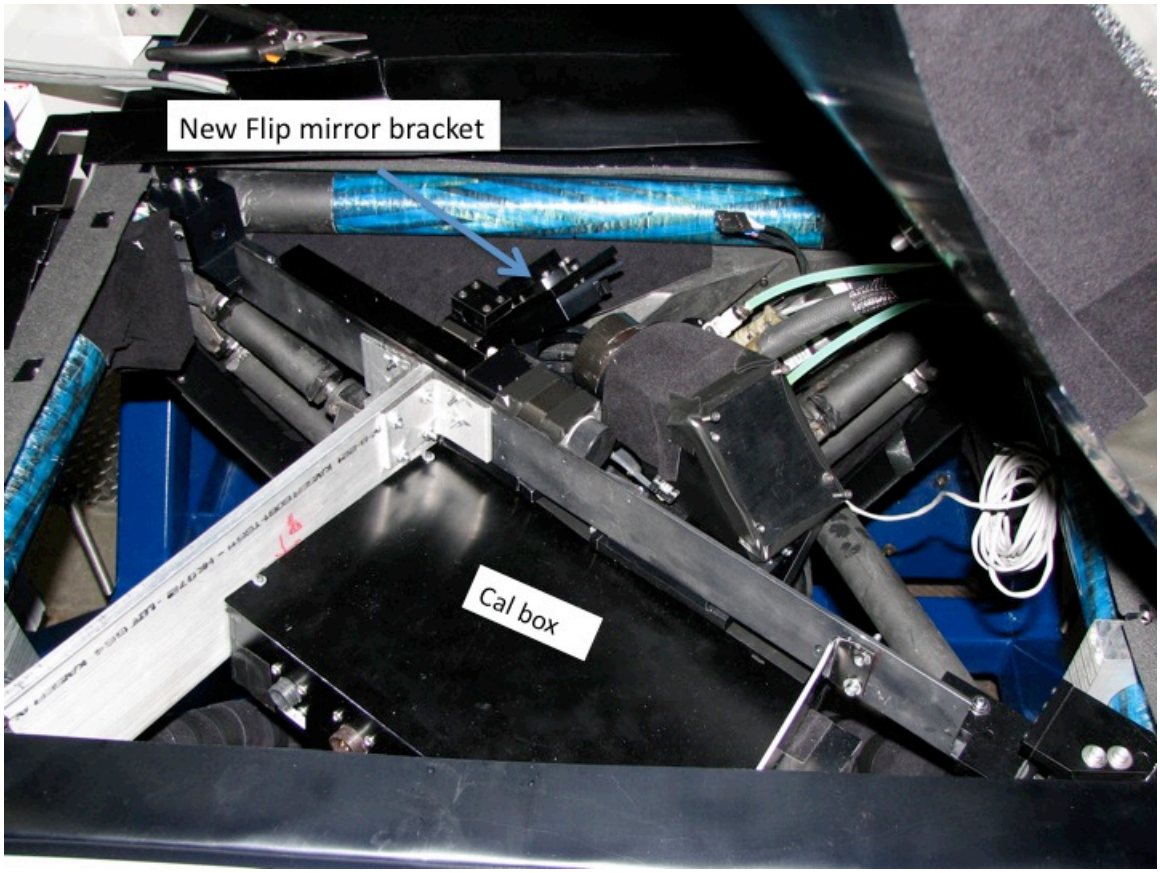
One calamity occurred when the shop attempted to drill a hole in the mirror cell. As they clamped down the mirror cell, the mirror popped out. On the one hand, this was a good thing since we had used special epoxy for mounting the mirror and the epoxy gave before the mirror broke, which was exactly what it was supposed to do. On the other hand, Michelle Reed had to move out of her office the week before the run, and we just had thrown out a bunch of the epoxies we had used in the course of the project, figuring that by the time we would use them again, they would be expired and we'd have to get new epoxy anyway. Fortunately we still had some of the epoxy we had used to glue small optics like the flip mirror, and Michelle kindly came in on her vacation time to glue it back on.

In summary, the flip mirror now works great, and in the future most observers will use the lamps in the comparison box for calibration during the night. Previously, we were stuck using the f/5 lamps. However, these produce some unfortunate optical artifacts and so in the future we won't use them unless the internal lamps burn out during the run.

II. Cal Box Focus.

Although the focus looked great with the f/5 comp lamps, there was noticeable astigmatism and defocus in the blue with the internal MAESTRO lamps. The cal box bean initially consisted of the following: the lamps in the cal box are reflected off mirrors to a UV-transmissive diffuser. The diffuser

light it relayed via 2 flat mirrors through a lens which produces an f/5 beam and then is reflected off of the flip mirror through the injection optics, and onto the slit.
First, we purchases a small stage so that we could move the diffuser, which is mounted on a heavy cell. The stage proved flimsy and the attachment design for the diffuser was unstable. We redesigned the mount of the diffuser and put it on rails so that it could be adjusted better. We also made new baffles for the relay mirrors, and more sturdy brackets to hold the cal box in place.



In the lab we spent a lot of time trying to adjust the focus of the cal light, using the adjustments of the mirrors and the adjustment of the diffuser. We decided that the lens was causing the optical problems, and replaced it with a brass tube. The optical problems went away, since now the light illuminating the slit is a diffuse bean.

Access to the cal box remains awkward. Changing a lamp is not possible once the instrument is mounted on the telescope. Although we have ideas on how to solve this, we chose to keep the current configuration for the time-being.

Analysis of the flexure data taken in November showed that there is no measurable difference between the flexure measured with the internal cal box lamps, and that of

the f/5 lamps. That is, the cal box motions we had before the new brackets did not cause the flexure measured.

For the observations of redshifted molecular hydrogen to measure changes in the ratio of the mass of the proton to the mass of the electron, we require very well understood wavelength calibration. We purchased 3 hollow cathode lamps to install, to compare to the Th-Ar lamp used by all other echelle spectrographs: Fe, Cs (which is in the same column of the periodic table as thorium) and Pt, which is used in the echelles on HST. The Pt spectrum is far sparser than Th-Ar, but has a good list of lab wavelengths for the strong lines, so we left the Pt lamp in for the run.

III. Grating Motor and PZTs.

We had intended to mount the grating motor, set the limits, and experiment with using it to tilt the spectrum. Also, we wanted to experiment with using the PZTs to tilt the spectrum small amounts. In the end, we decided that flexure mitigation was more important, and will return to working on these at a future date.

IV. Covers.

We did a lot of work on the spectrograph covers, although the spectrograph structure was fluid until we left for the mountain. We widened the ccd dewar fill cover, and designed, made and installed several other panels. The last panel on the grating end was installed on the mountain. At this point, there are covers on all parts of the space frame, and all covers are anodized. Our experience during the run however showed that there are modifications to the covers on the dewar end which will be necessary before the next run.

V. Storage

Russ Warner got us a surplus cabinet for storing parts on the mountain. We bought plastic containers for important items like the grating cover. We also got surplus metal ammo boxes to store hardware, and painted them blue with clear labeling.

We had been preparing to store MAESTRO in the pit. This would have required building a protective tent and filtering oil spray. Although initially I thought that we would remove MAESTRO from the pit whenever we worked on it, the general feeling was that we should build a structure like the AO group did and work on it in the pit. Since access to the pit is via a ladder, and lugging tools in and out of the pit was awkward, we didn't look forward to this possibility.

Instead, the MMTO installed an instrument lift at the common building labs, so that we can transport MAESTRO in the truck to the common building and store it there. THIS IS TERRIFIC, and we are extremely grateful that we will have a clean area to store the spectrograph and a good place to work on it off the telescope. The area in the common building labs where MAESTRO is to be stored will require some clean up, but it is WAY better than the pit. **THANK YOU**.

VI. Writeups and analysis.

As usual, after a flurry of writing up proceedures and looking at the data after the November run, progress slowed and we spent more time on hardware. I solved the identification of the thorium-argon spectrum, and was gratified to see that the plate scale and resolution was exactly what I predicted from analytical formulae for the optical design.

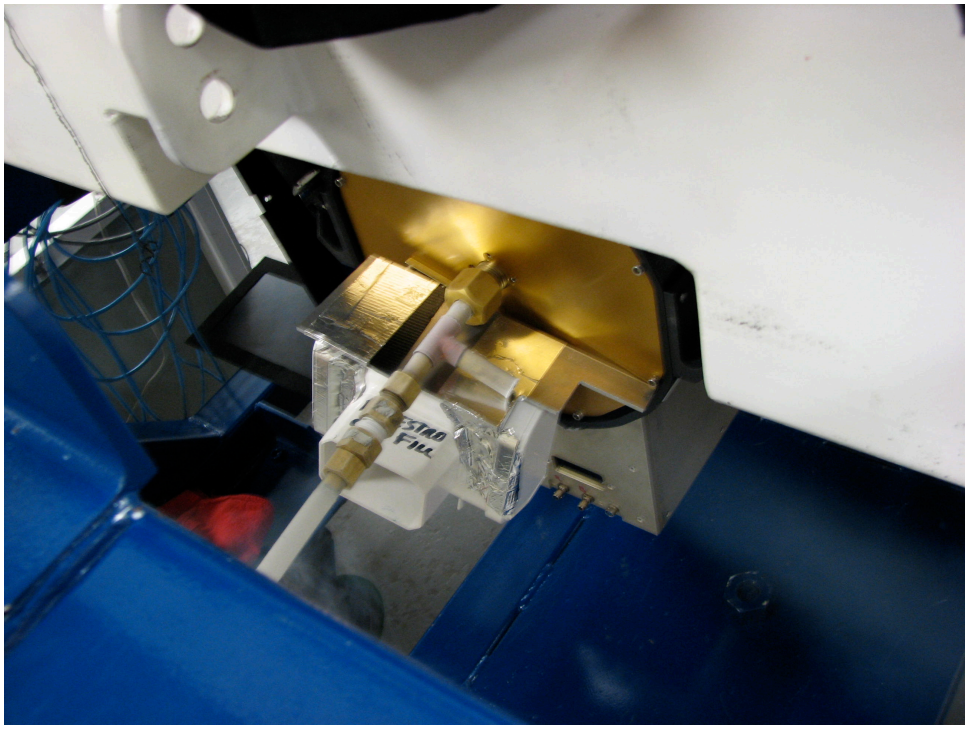
Two of the nights of the April run were for observations by Christy Tremonti, and she kindly worked on iraf scripting for bias subtraction, so now we have a version which can automatically bias subtract any image, with any binning.

VII. CCD contamination.

In the course of lab testing, we ran out of liquid nitrogen at one point, and the CCD warmed up. We returned the dewar to ITL, so it could be pumped down. Baxter and Lesser noticed that the CCD had accumulated contaminants on its surface. This would most likely be caused by a leak in vacuum, but the dewar was tested and no leak was found. Therefore we think that perhaps the vacuum pump hook up hardware leaked for some reason. The hardware is located below the dewar fill tube unfortunately, so it gets frozen by spilled liquid nitrogen whenever the dewar is filled.

The CCD was cleaned by the ITL staff and the dewar pumped down and cooled. This is a process that potentially harms the AR coating on the CCD and is dangerous.

To avoid future CCD contamination, we put together a protective cover for the vacuum pump valve – see below.



VIII. Spectrograph gui problems.

The Galil and Pullizi are controlled by a gui which was written in ruby, by Jeff Rill. It runs on any computer with ruby, and sends signals to the Galil board and pullizi over the internet. The code had many problems both in the lab and on the mountain in July and November. Some of which might have been the result of heat in the electronics box in the lab. The problems included hanging, moving a motor but not updating the step count reported on the gui, and not reporting when the motor was stopped for a limit. Jeff has made several changes to the code. The latest version, which we only got working on the mountain, appears much better than previous versions. We will test it more extensively in the lab. Ultimately, we hope that Skip Schaller and Tim Pickering can help us write a user interface that has the look and feel more similar to the MMT spectrograph interfaces, and which has the server-client architecture that will allow spectrograph parameters to be put into data headers automatically. We are just now getting to the point where the hardware is stable enough to allow this. We note that during the run Christy and grad student Aleks Diamond-Stanic used the engineering gui with no problems, so what we have is adequate for the time-being.

2. Transport to the Mountain.

Morag Hastie arranged for MAESTRO to be transported in the air ride truck by MMT personnel – Shawn Callahan, John Dimicelli, Dennis Smith and Bill Stangert on Wednesday, April 2. We were grateful that the spectrograph was packed up and moved entirely by the MMTO, especially since we worked late on Tuesday and had left the spectrograph in a state with much to be buttoned down before moving.

At our request, it was put in the loading bay so we could work on it on Wednesday afternoon and evening. Modifications were made to the flip mirror and cal box on Monday and we didn't have time to align the mirrors and get light on the slit.

On Wednesday we worked on the spectrograph, hooking up the CCD and electronics in the loading bay. This worked reasonably well although we had to take data through the computer in the downtown lab, since f/9 was on and we couldn't use alewife, even remotely. Ruby is also not installed with the gui add-ons on every computer on the mountain, and it would be great to be able to run the gui on any of the computers. Morag helped a lot.

Tom Stalcup checked in on us several times and proved invaluable. In the end, he was the one who got the flip mirror aligned correctly. He also gave John Dimicelli suggestions on how to design a better mirror adjustment mechanism in the future! The one John made for us was so much better than

what we had before, it is hard to imagine that there could be any room for improvement. We are extremely grateful for Tom's help.

3. Mounting the spectrograph on the telescope.

Mounting the spectrograph on the telescope went relatively smoothly, but I learned several important lessons for the future.

- Put the spectrograph in the loading bay with the dewar end facing the control room. That means that the spectrograph should be loaded in the truck with the dewar end facing out, or the grating end facing into the truck. The dewar end is the one with the rigging for the crane. The grating end is the one where John's red wheels are attached. This time we had the spectrograph rotated by 180 degrees.

  Once the spectrograph is in the loading dock, we can't turn it around. We were able to pull it through the hatch to the chamber floor but it was hard and not safe for the doors to the control room.

- Mounting really requires a "foreperson" whose sole focus is to direct everything with the checklist and documentation for the mounting procedures in hand. I printed out the procedure and distributed copies but we were missing some key details that required looking up pictures on the web site. I took a lot of notes this time and new pictures which will need to be incorporated in the procedure documentation. Unfortunately I was trying to solve some other problems at the same time the spectrograph was being mounted and did not direct the mounting effort in the chamber.

  The foreperson will need to be aggressive in directing everybody. Initially, we did not follow the part of the procedure where raising the spectrograph to the rotator is done so that the last inch is done with jacks so that it is level. Even though I suggested that we switch to jacks at one point I didn't insist on it, and as a result, stress was put on the rotator I think.

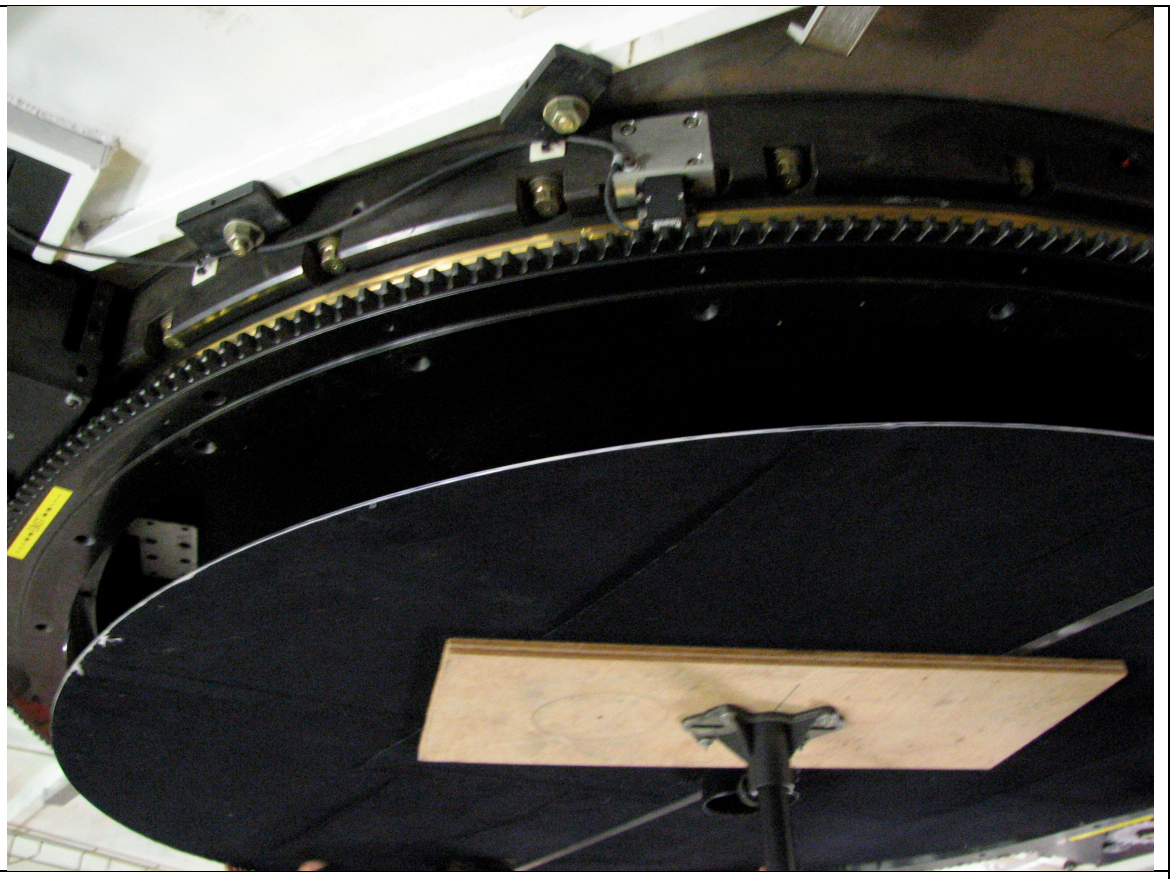
- We were missing key hardware – the screws for mounting the derotator baffle, and the large guide pins that we put in the rotator to align the spectrograph with. It turns out that this hardware was left behind in the lab. We had to scrounge new hardware, which took a little time. The counterweight hardware was mixed in with the spectrograph mount hardware and it took time to sort it all out. We need to find the necessary hardware in advance and know where it is. The blue ammo boxes should help a lot.
- The instrument change this time included a secondary change from f/9. The crew started early changing the secondary and installing the f/5 corrector and top box, testing the WFS and installing the f/5 lamps in the secondary hub. I estimate that it took 5 hours to pull the spectrograph through the hatch and mount it. We can cut maybe an hour of this if we have the spectrograph in the chamber the night before, and if we are more organized with the proceedures and hardware. However, we were cabling up the

spectrograph at dusk and focused it after dark. In the winter, it will be very difficult to change secondaries and mount the instrument in one day without spending some of the dark time that night for set up. Also I was completely worn out by the beginning of the observing that night, so whoever oversees the instrument mount cannot be expected to stay up all night and observe.

- Filling the dewar was not straight-forward. MAESTRO has a tube inserted in the dewar which keeps the liquid nitrogen from spilling but means that filling the dewar requires a small bore tube. In July we didn't have this dewar insert and spilled a lot of liquid nitrogen. In November, I brought along the fill tube from the lab because I was worried that the MMT tubes wouldn't be small enough. We were told that the MMT Spectrographs had similar dewar inserts now and so their fill tubes were small enough to fill the MAESTRO dewar. In fact, we used the MMTO fill tube to fill the MAESTRO dewar in November. So this time, the dewar fill tube was left behind in the lab.

  This time, for some reason, the available tubes on the mountain were all too thick to use to fill the MAESTRO dewar. The solution was to unscrew the dewar insert every time we had to fill the dewar. Ultimately we'll want to avoid wear and tear on the dewar insert and so we'll bring our own fill tube and leave it with the spectrograph. We appreciate Morag's help in keeping the dewar filled.

1. Startup on alewife was not straightforward. We asked Grant and Morag to "reset" the account to maestro, and they did, but we didn't reboot. Thus the bash environment variables were not set up for AZCAMTOOL and we required an awkward workaround to run IRAF/ICE. Figuring this out took precious time, and it wasn't until the 2nd or 3rd night that I figured out what the problem was.
2. Grant kludged together a version of the SOGUIDER software that runs on hoseclamp, and we are grateful for that. Recall that the software worked fine in July 2007 and didn't work at all in November because hoseclamp had been replaced. It helped a lot to be able to run SOGUIDER on hoseclamp directly rather than through vncviewer, but there is a kludge in the sense that files are written to a forbidden area and error messages are produced. When trying to debug the various hardware and software problems we encountered, this was one more suspicious item to worry about. However we gained valuable experience using the SOGUIDER software this run.
3. We had trouble firing up the f/5 comparison lamp gui and ADC. Luckily, Marc Lacasse was on the mountain, and kindly came by to show us the ropes. Morag wrote up instructions on the MAESTRO wiki page.



4. April 3, 2008

   We hastily focused and opened in high winds and variable, mediocre seeing (1”-2”). We tried to determine the offset in focus steps from the best focus returned from the wavefront sensor, by observing an SAO star spectrum. We attempted to obtain observe a standard star for throughput measurements, but wind buffeting and poor seeing made it difficult to keep the star in the slit.
   We used the SOGUIDER to guide for the first time, and it communicated with the telescope mount fine, to my relief. However, the default parameters were not ideal and it took some experimentation to guide well. John McAffee drew on his experience with guiders to find and adjust the guider parameters.
   We stopped early because we were exhausted and because the seeing was poor. John Dimiceli joined us for the first part of the night, and gained insight into how people observed, which is great.

5. April 4 and 5, 2008

Morag arranged for flexure tests to be carried out by John Dimiceli during the day. A careful focus series was taken with the f/5 Thorium Argon and the 0.3"x0.3" slit.
Flexure tests were done with the rotator at zero degrees, using both f/5 and internal lamps. Quick look at the results showed a significant improvement compared to November 2007. Details are given in the Appendix.
At sunset, John Macaffe tried to raise the primary and it wouldn't start up, with one of the actuators indicating a serious hardware condition. We phoned everybody we could, but could not reach key personnel – it was Friday night of course. Skip Schaller logged on in the wee hours and had some useful advice for John to help figure out what was wrong.
While waiting for help, we did another flexure run at rotation=0 degrees, and then at 45 degrees. At that point, Ale suggested that we shouldn't be tipping the primary while we had a problem with the primary that we didn't understand, and we stowed the telescope.
At stow, we tried the Milky Flat aperture, and found that it gave a very nice flatfield.
On Saturday morning, Grant Williams organized a rescue team consisting of Dennis Smith and Dusty Clark. They worked all day and into the night tracking down the problem and fixing it. We are enormously grateful to them for going way beyond the call of duty to fix the problem.
Putting on my MMT Council hat for a minute, it is unfortunate that the problem with the primary cost two nights of observing. While I'm the obvious beneficiary of MMTO staff help with MAESTRO, it seems that the mountain staff is very thin. It's not clear to me how many people besides Dusty could have tracked down and solved this problem – which was a tricky combination of software and hardware failure, in a part of the telescope that is apparently poorly documented. Dusty is "old school" in the sense he can dive into a system he hasn't seen before and has enough general knowledge to fix it. He spent literally 14 hours on a ladder on a Saturday with his head stuck in the primary cell, until the problem was solved.
We're grateful that Dennis was able to come up to the mountain so quickly, but it is a burden on him to be on call for problems like this.
Someone with a better overall view of how similar problems have been dealt with should check that this is not another area of "single point failure". It's probably of higher priority to have people on the MMT staff who can fix telescope problems than to have people who can run the instruments. That being said, I am very grateful for the time and energy of Shawn and John DiMicelli, as well as of course Morag Hastie, Tom Stalcup, and Marc Lacasse who have helped solve Maestro problems large and small. It is obviously of benefit to the staff to work on the instruments, but that is only one need of the observatory.

Back to MAESTRO: After the first night it was clear that we were still having problems seeing stars on the slit with the slit viewer camera. The problem is that the camera looks at the slit plate at a significant tilt. We had experimented with tilting the slit plate in the lab, but only by a few degrees. John Dimiceli designed and fabricated in the MMT shop a modified slit holder which allowed us to tilt the slit plate by about 30 degrees.
On April 5 we finally opened at about 2am. The primary was way out of thermal equilibrium, and you could see in the Shack-Hartman images exactly where Dusty had been standing all day.
The tilted slit enabled us to see stars as faint as 17th, which is still unacceptable, but a vast improvement over the first night, when we couldn't see 6th magnitude stars. We had a lot of trouble guiding on spilt light, however, and the star sometimes wandered out of the slit.
We tried again to observe a standard star, and the results were disappointing. I calculated that we could be losing as much as 95% of the light due to slit losses, given the poor image quality and the size of the slit. We had installed a 1" wide slit but because of the tilt, it was effectively a 0.7" slit.
This night we began to see problems with the CCD which plagued the rest of the run:

- Images would read out normally but have the lower 1/3 – 2/3 of the format overwhelmed by charge. The previous and subsequent images would be fine. By the end of the run, I concluded the problem occurs most often while the instrument is rotating. At Christy's suggestion we left a long stream of zeros running when we went to bed one morning and did not see the problem in any of them. While rotating, the light baffle brushes on the dewar end of the spectrograph scrape against the derotator baffle which is covered in flocking material. Although we have taken standard precautions to isolate the dewar electrically, it's possible that charge is being transferred to the CCD, especially at high elevation where the rotation rate is fast.

  Other artifacts that are similar but not identical were seen during flexure tests, at low elevations. These might be due to stress on the cables, although we took much care to hook the cables with adequate stress relief. Tests are underway in the lab to try to reproduce the problem.
  Tests in the lab when we got back, suggested by Mike Lesser, showed that the origin of these problems is not within the dewar. We took hundreds of zeros with the dewar cover on and never saw images with excess charge.

- If the observer uses the pause/resume feature during an exposure, the exposure counts down normally, but then hangs when reading out, and the exposure is lost. Sometimes the exposure count-down stopped and the exposure was lost, even if we didn't pause/resume. We had tested the pause/resume feature in the lab, running IRAF/ICE from optics2, and it worked fine. Pause/resume is not something you do while focusing or flexure testing, but we needed to do it when we had problems with the guider – e.g. the star wandering out of the slit.

I turned out that linux on alewife had been updated about a month before our run, and drivers on maestroccd had not been updated, so there were problems any time the CCD dewar temperature was queried, sometimes resulting in a hang. Mike Lesser and Skip Schaller figured out the problem quickly, and Mike installed a quick fix. However, it turned out that the fix messed resulted in images that looked like this:
Delacing was not being done correctly. The "real" fix involved significant surgery on the code, and we all agreed that it was too risky to do such a major change during a run.
At one point while tracking down these CCD problems, I decided to reboot all computers involved, including alewife. Unfortunately no one had rebooted alewife since the Linux upgrade and it came up in a mode where it could ping other computers successfully, but no one could ping it. We couldn't take images. Fortunately Tim Pickering was in the office and able to track down the problem and fix it. We were scolded for rebooting alewife in the first place, which observers are not supposed to do, apparently!
The bottom line is that we have been stung again by changes in the computers on the mountain, and encountered problems which didn't exist during previous runs. This time the problem was a show-stopper. The alternative would be to haul up my own computer from the lab to the mountain and use it, but I'd rather use the mountain computers.
I suggest the following:

- When any changes are made on the computers in the control room, I assume these are logged somewhere. It would be helpful to send an email alert to PIs bringing instruments, or have the log be accessible to PIs. This way we when we encounter a new problem we know there have been changes, because even if they seem irrelevant, they may cause problems. It takes time and energy to figure out these problems when the hardware is also changing, and it would help to know what has been changed and what has not.
- Please make a separate account on alewife for maestro, so we don't use mmtobs. This would allow us to take test data while observers are using the MMT Spectrograph. We can easily run through a set of tests to identify problems such as the ones we encountered here, in advance, so we could deal with them before the run starts.

April 6-7, 2008

During the day on April 6, we installed two of the 4 temptrax sensors: one near the grating, and one on the lens can. One already reads the electronics box temperature.
We were joined by Christy Tremonti late on April 5, and on the 7th, Aleks Diamond-Stanek came up. They were both extremely helpful and patient. It was gratifying to see how easily they were able to learn how to run MAESTRO, and it was very helpful to have other sets of eyes looking at the data.

After our experience with the very tilted slit, we tried tilting another slit with a larger width, to mitigate slit losses. We had trouble seeing bright SAO stars in this slit however, indicating that the exact angle to the guider is critical. Moreover, the throughput was very low with the tilted slit. I despaired that we had made some major blunder, like putting in the grating backwards. However, I then realized that the tilted slit was off-center from the optical axis by about 8" (since mounting was a bit of a kludge) and perhaps that was far enough off-axis that the light was missing the small turn mirror below the slit. We observed a standard star with the tilted slit, and then immediately with a slit which wasn't tilted. The spectrum with the non-tilted slit had about a factor of 10 more counts.

The other problem we encountered was that it was not possible to guide on spilled light with the SOGuider. Gary Schmidt said he had no problems with spilled light guiding, but his objects must be much brighter. We were unable to see spilled light unless the exposure times of the guide camera were much longer than 1 second – sometimes 60 seconds or more were required. This means that updates are too slow, and the target is spending up to 50% of the time not in the slit.

We also noticed significant degradation in the alignment and focus over periods as short as 30 minutes, under thermally stable conditions. This shows that significant gains will be made if we can use the f/5 WFS during exposures for tweaking the telescope.

The solution to the guider and WFS problems is the following.

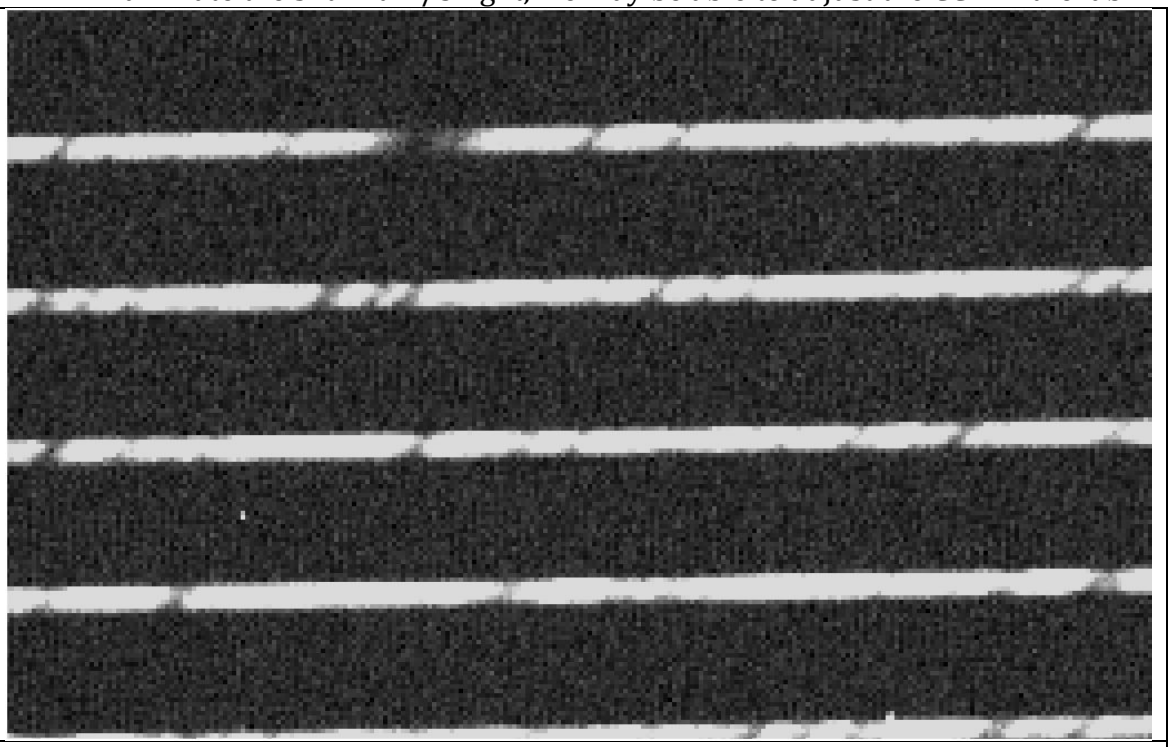
Redesign the slit-viewer geometry, perhaps like Blue Channel's, with the slit tilted at a modest angle, facing a mirror that directs the image to the slit viewer. This would require mechanical modifications, a new place to put the stage and slit viewer camera, and slightly modified slit holders. John Dimiceli could easily accomplish this before the engineering run in July. The same slit viewer camera can see as faint as m=21 with blue channel and there's no reason we should be any less sensitive.

Use the SOguider for target acquisition, but use the f/5 WFS for guiding. This requires new software. The f/5 WFS guiding could be stopped every so often to update alignment and focus, then guiding resumed, while the exposure is underway.

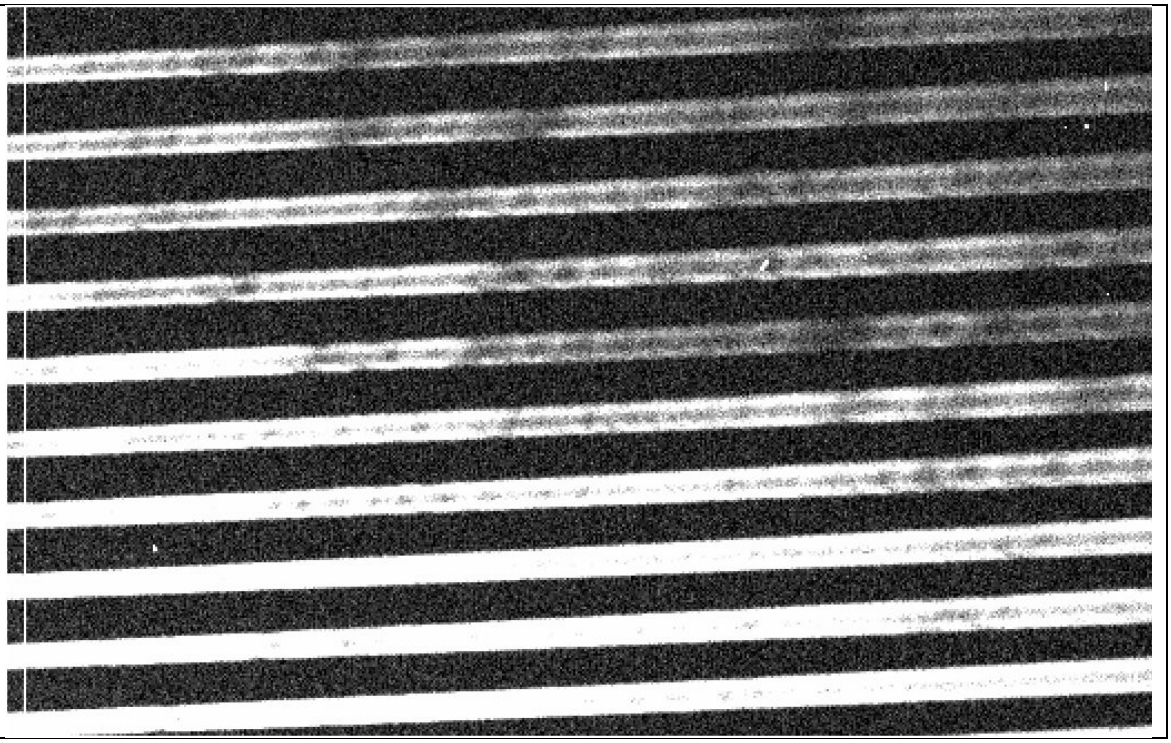
I hope these changes can be made, since the guiding and target acquisition issues are the biggest remaining show-stoppers to using MAESTRO for science.

We observed a star which is known to have vsini<1 km/sec, through the 0.3"x0.3" hole, to test optical performance. The results were very interesting. First off, the lines are very narrow, and the optical performance is excellent. However, we have detectable astigmatism in the blue, and defocus in one corner. Analysis with Zemax after we got back indicated that these effects may be caused by the CCD which may be off-center. Also we may be able to tilt the CCD to improve the focus on one corner. These results were similar to what we were seeing with the internal comparison box and the focusing lens, and are not evident in any lamps because the lamps are

delivering a diffuse beam to fill the slit. Since we have the optics to instead illuminate the slit with f/3 light, we may be able to adjust the CCD in the lab.



Close up of the spectrum of a star with vsini < 1 km/s, through 0.3”x0.3” slit, showing astigmatism.



Enlargement of bluest corner of spectrum of narrow lined star, showing defocus with the 0.3"x0.3" slit.

While we were not able to observe the high redshift H2 absorption which was the subject of our proposal, we did take long exposures with the f/5 Th-Ar and Pt lamps. This will allow us to have an independent check on the Th-Ar wavelength calibrations which are used to argue for a "rolling" proton-to-electron mass ratio.

We obtained a short "art-shot" of a z=3 quasar with a damped Lyman alpha system. This observation will be used to test our scattered light corrections and sky subtraction scheme, since the bottom of the Lyman alpha line should be very black. There can be light that is scattered by the grating within orders which is not seen between orders, and that can be difficult to correct for.

Since we need to modify the guider mount and since the common building was not cleaned up yet, we decided to bring back MAESTRO to Steward. There some confusion at first when I woke up the next day about where exactly MAESTRO was; this continues to be a source of amusement to my children (You lost your spectrograph! How can you lose something that weighs thousands of pounds!). However, Morag and Shawn orchestrated the move with perfect care, and we are grateful to them for their help.

Tasks for the next run

1. Fix the slit-viewer/slit plate tilt problem so that we can acquire faint objects. This means purchasing a mirror, and designing and fabricating a new mount for it and for the guide camera. Also, the slit mounts will need modification.
2. Finish modifying the f/5 WFS software so we can do WFS off-axis during exposures.
3. Modify the f/5 WFS software so we can use it to guide.
4. Track down the origin of the excessive charge on some CCD images.
5. Modify the top of the dewar end baffle to eliminate contact with the derotator baffle. This will probably be necessary anyway to accomplish #1.
6. Update the software on maestroccd so that it works from alewife. Set into place a system for routine testing of software and computer interfaces before the run.
7. Analyze the flexure data and discuss where to go from here. Decide what to do about the grating motor and PZTs.
8. Organize the mounting hardware and documentation so that no time is wasted during instrument changes. Finish new modifications early

enough so that the spectrograph can spend the night before the run in the chamber.

9. Analyze the optical quality measurements and adjust the position of the CCD accordingly.
10. Fix the UV LEDs to make them brighter, and align them so we can use them.
11. Shave off 0.1 inch from the derotator baffles so the fit is not so tight.
12. Modify the side panels of the dewar area covers so they can easily be removed and replaced. Use captive screws, and a stiff frame, like the grating area cover. Finish odds and ends with the covers.
13. Make a dust cover for the spectrograph. After the trip up or down the mountain in the truck, the spectrograph had a layer of fine dust all over it.
14. Clean up the common building because this time MAESTRO will stay on the mountain.
15. Update the web page and advertise the availability of MAESTRO to observers.
16. Use the throughput measurements to create an ETC.
17. Work on data reduction pipeline.
18. Complete the procedure document pages and organize them.
19. Rewrite the spectrograph control gui to be more user friendly.
20. Finish installing the temptrax temperature sensors.