WIYN OBSERVATORY

WISCONSIN INDIANA YALE & NOAO

Newsletter

October 2007

Director's News

Summer at the observatory is always the busiest period. That's the best time to tackle all those nagging problems that have accumulated over the year. This summer, though, had some special twists that you will see summarized in these pages. For example, the new infrared camera, WHIRC, made it to the telescope and took its first pictures of the sky. During a 3-week shutdown, the entire mirror chain of the telescope was re-aluminized after 3 years. But so much more was accomplished during the shutdown that I simply refer you to the article by Charles Corson.

I mentioned in the last *Newsletter* that the WIYN Consortium would be undergoing its second "5-year" review, as required by the WIYN agreement. The review was held on August 27 and 28. The panel's report is now complete and a summary is included in this edition of the *Newsletter*. Preparing for the review was a major effort for all of WIYN. The process of doing that work provided an excellent opportunity for the WIYN partners to reflect on what WIYN was, what it is, and most importantly, what it can become as we begin the partnership renewal process.

Finally, in this last *Newsletter* of FY07, we offer Steve Howell and Dave Sawyer best wishes as they transition from WIYN to NOAO. On behalf of WIYN and personally, I thank them for their dedication, creativity, hard work, and unquestioning (well, most of the time) support. They made science and education happen, and they will continue to do so from the NOAO component of WIYN.

~ George Jacoby

Science News

Steve Howell

WIYN Imaging Probes the Formation and Structure of Giant Galaxies. More than 80 years have passed since Edwin Hubble first proved the existence of galaxies beyond the Milky Way. Still, the question of how and when galaxies formed remains a fundamental problem in astrophysics and cosmology. Using the WIYN 3.5-meter telescope, Katherine Rhode (Indiana University) and colleague Steve Zepf (Michigan State) have been carrying out a survey of giant galaxies to address this question.

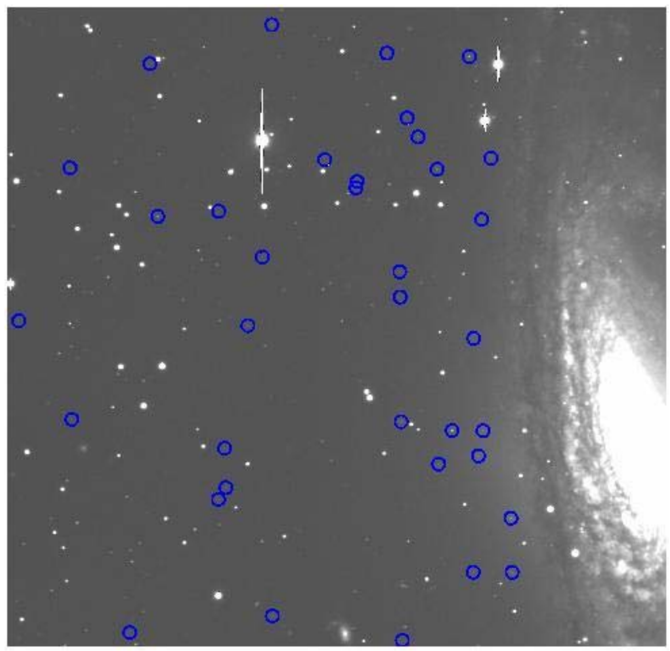

Figure 1: Image of the spiral galaxy NGC 7331 taken at the WIYN 3.5-meter telescope with S2KB. The discovered globular cluster candidates are marked.

Galaxies of all types harbor globular clusters (GCs). With typical ages of 12 billion years, GCs are thought to have been among the first bound stellar systems formed in the Universe. Thus, studying the entire system of GCs around a galaxy provides important clues about the formation and early history of the galaxy.

To date, imagers on the WIYN 3.5-meter and the Mayall 4-meter have studied in detail the GC systems of 10 spiral, lenticular, and elliptical galaxies located at distances of 10-20 Megaparsecs (see figures 1 and 2). Archival imaging data from the Hubble Space Telescope has been added to supplement the ground-based observations.

Rhode's measurements of the total numbers and specific frequencies of the GC systems, their spatial distributions, and their colors, directly test the predictions of galaxy formation models.

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The WIYN Observatory is owned and operated by the WIYN Consortium, which consists of the University of Wisconsin, Indiana University, Yale University, and the National Optical Astronomy Observatory (NOAO).

Science News, *continued*

The results from the GC system survey point toward a picture of hierarchical galaxy formation; in this type of scenario, galaxies are assembled over time from smaller protogalactic fragments (a "bottom-up" model). The first generation of GCs forms in the early universe (before redshifts of 10-15) within protogalaxies, and additional populations of GCs are formed as protogalaxies collide and merge together to form the massive galaxies we see today.

Besides serving as probes of galaxy origins, globular clusters are also extremely useful as tracers of the structure of galaxies and their dark matter halos. GCs can be detected as point-like objects out to 10-15 galactic radii from the center of their host galaxy. Follow-up spectroscopy for the GCs detected in the WIYN and Mayall imaging data will allow Rhode to study the GC kinematics, as well as to infer the mass distributions of the host galaxies.

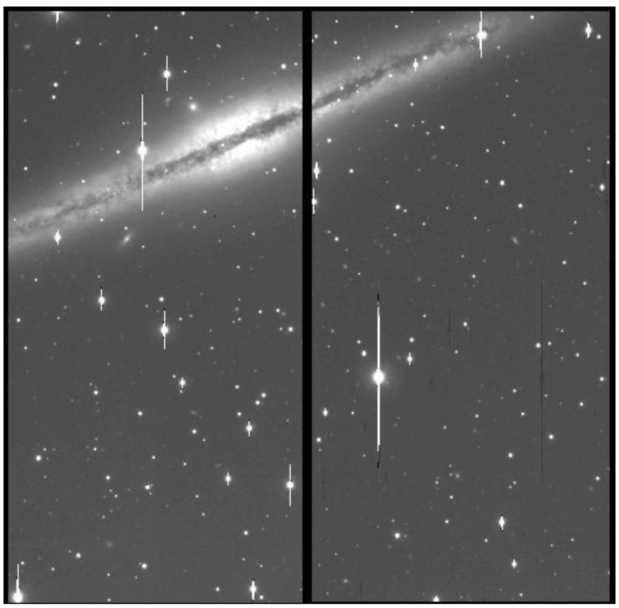

Figure 2: The spiral galaxy NGC 891 imaged at WIYN with Mini-Mo. Globular cluster candidates are being selected and will be used to further Rhode's study.

Rhode plans to use the future WIYN One Degree Imager (ODI) to initiate the "Next Generation" GC System Survey. She will study the global properties of the GC systems of many more galaxies, over a larger range of masses, and located in a wider range of galaxy environments. The technical requirements for such a survey are a large field of view (because GC systems are typically more extended than the host galaxy light), excellent resolution (to distinguish point-source GCs from background galaxies), and deep, multi-color imaging (so that accurate magnitudes and colors of the objects can be used to further distinguish real GCs from foreground stars and background galaxies). ODI will satisfy all of these requirements and therefore is ideally matched to the science goals of the survey.

WIYN WOCS across the Galactic Disk. The kinematics and chemical abundances of open star clusters have long served as probes of the dynamical and chemical evolution of the Galactic disk. The distribution of chemical elements, namely Fe, in the disk is traditionally characterized as a linear gradient of decreasing [Fe/H] with increasing distance from the Galactic center (Rgc). However, recent literature results argue for a "step function" distribution with all clusters interior to Rgc=10 kpc having an average [Fe/H]=0 and all clusters exterior having an average [Fe/H]=-0.3. This finding is supported by recent studies of open clusters, field stars, and Cepheids in the outer disk that show a sudden drop in both [Fe/H] and [α/Fe] around Rgc ~10-12 kpc (see figure 3).

The WIYN Open Cluster Study (WOCS) project plays a major role in the study of open clusters.

The number of studied clusters in and beyond this transition region in the disk is relatively few. Not only are a great many more clusters desired to characterize the nature of this transition, it is paramount that they are studied homogeneously, as any systematics will alter the true abundance trends. To this end, Heather Jacobson (Indiana University) and collaborators have surveyed a sample of ~25 open clusters with Rgc greater than or equal to 9 kpc. The bulk of the data has been obtained with the Hydra spectrograph on WIYN, with supplementary data coming from the CTIO and NOAO 4-meter telescopes and the MMT.

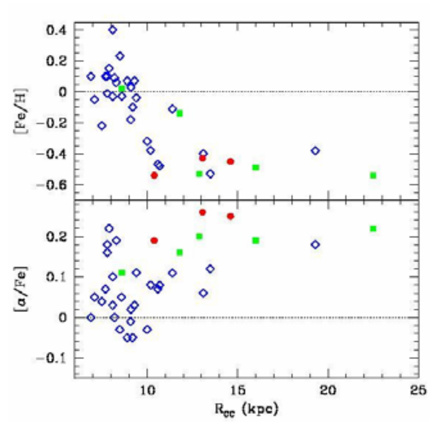

Figure 3: [Fe/H] and [α/Fe] values as a function of Galacto-centric distance for old open clusters available from the literature (open blue diamonds); old open clusters from Yong et al. (2005, AJ, 130, 597; filled green squares); and three distant K giants (filled red circles). Figure from Carney et al. (2005, AJ, 130, 1111).

In addition to Fe, Jacobson *et al*. are determining abundances for O, Na, Mg, Si, Ca, Ti, and Ni. [O/Fe] and [α/Fe] serve as indicators of star formation history, and characterizing the metallicity trend through the transition zone is very important. Jacobson aims to provide a clearer picture of the open cluster transition region and use this to formulate a better understanding of the formation and evolution of the Galactic disk.~

WHIRC

Margaret Meixner (STScI, PI) & Patricia Knezek (WIYN, Co-I)

WHIRC was delivered to WIYN in July 2007 and has been undergoing telescope integration and testing. Figure 1 shows WHIRC mounted on the WIYN Tip-Tilt Module (WTTM) port. Commissioning activities will continue this fall. Once complete, WHIRC is scheduled to become a facility near-IR (NIR) camera for the WIYN 3.5-meter telescope residing on the WTTM port.

During 2008A, WHIRC will be provided in direct imaging mode only, i.e. without the WTTM operating. In this capacity, WHIRC will have seeing limited performance, which is typically ~0.5-0.6" in the near-infrared (0.9-2.5 micron) spectral range of the camera, and can be ~0.3" on very good nights.

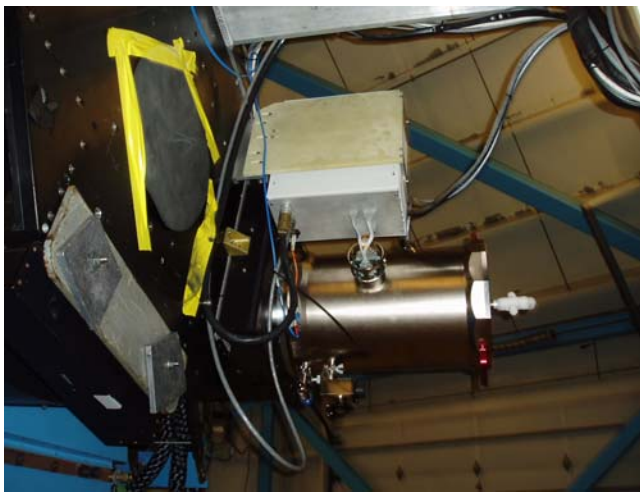

Figure 1: WHIRC mounted on the WIYN Tip-Tilt Module port.

Once WHIRC is available with the tip-tilt first-order AO corrections of WTTM, it is expected that it will be able to deliver 0.3-0.4" images on average, and near-diffraction-limited images (0.15") in K_s on exceptional nights. The optical design uses a 2048x2048 HgCdTe VIRGO array, made by Raytheon, with one plate scale, ~0.1" per 20 mm pixel, resulting in a field of view of 3.3'x3.3' that covers most of the WTTM corrected field. WHIRC has two filter wheels that provide three broadband filters (J, H, K_s), and an assortment of 10 narrow band filters (see the table at right).

WHIRC was built in Baltimore by the Space Telescope Science Institute (STScI) and the Johns Hopkins University Instrument Development Group (JHU/IDG). The WHIRC instrument team includes Margaret Meixner (principal investigator, STScI), Ed Churchwell (project scientist, University of Wisconsin), Patricia Knezek (co-investigator, WIYN/NOAO liaison), Todd Miller (software lead, STScI), Steve Smee (lead engineer, mechanical/thermal designer, JHU/IDG), Robert Barkhouser (optics lead, JHU/IDG), Ryan Doering (PhD student, University of Illinois/STScI), Joe Orndorff (electrical lead, JHU/IDG), Gregg Scharfstein (mechanical engineer, JHU/IDG), Jeff Percival (software scientist, University of Wisconsin), Dave Mills (software engineer, NOAO), and Mark Hunten (MONSOON project manager, NOAO).

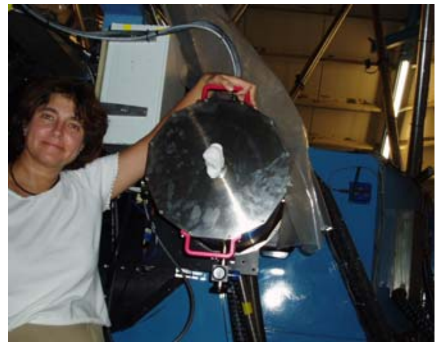

Figure 2: Margaret Meixner (WHIRC Principal Investigator, STScI) and WHIRC during the July testing and integration phase on the WIYN 3.5-meter telescope.

Figure 3: STScI/JHU WHIRC team members, (back row l-r) Robert Barkhouser, Todd Miller, Steve Smee; (front row l-r) Gregg Scharfstein, Margaret Meixner, and Joe Orndorff.

The WHIRC team is grateful for the technical support provided by NOAO, Kitt Peak, and WIYN staff during the design, building, telescope integration and test phases. The WHIRC project was funded largely by STScI and the National Science Foundation ATI program on grant 0504085, with additional support from the WIYN Consortium, NOAO/Kitt Peak, and the University of Wisconsin.~

Table: WHIRC filter complement.

Filter	λ_0 (μ m)	$\Delta\lambda/\lambda$
J	1.25	0.128
H	1.635	0.177
K_s	2.15	0.149
HeI	1.083	0.01
Pa β	1.28395	0.01
[FeII]	1.64629	0.01
H_2	2.12	0.01
Br γ	2.16	0.01
CO	2.295	0.01
Pa β (~4500 km/s)	1.30321	0.01
[FeII] (~4500 km/s)	1.67098	0.01
Br γ (~4500 km/s)	2.1924	0.01
Low Airglow	1.061	0.013

Report on the WIYN External Review

George Jacoby

The WIYN External Review panel met in Tucson with WIYN representatives from all four partners on August 27 and 28. The panel included Richard Kron (University of Chicago), Suzanne Hawley (University of Washington) and Bruce Carney (University of North Carolina). Each of the panel members has had direct and relevant experience with observatory operations – Sloan, ARC, and SOAR, respectively.

The panel's report on WIYN's scientific and educational effectiveness represents a critical first step toward the 2010 renewal. The key points from their report are summarized below with no further comment or interpretation. A written report will be available at the October Board meeting.

- ODI will be a major "stamp" of WIYN's identity in the community. It is a major project that sets WIYN apart from other 4-meter facilities, and the consortium is commended for taking it on. The project has energized the WIYN staff to look to an exciting future.
- Scientific output appears to be good. The thesis production record is excellent.
- WIYN must streamline its operations, or enhance its level of personnel.
    - The current level of operations support is not adequate or sustainable.
    - In looking to the future, the bent Cass port may be a better solution to the supporting multiple instruments than operating Hydra in campaign mode.
    - The Bench spectrograph is a complex system that takes too much effort to re-configure frequently.
    - Offer more remote operations with more live instruments (e.g., via the bent Cass port) and less classical observing. NOAO users should be allowed to observe remotely, and nights can be split to use dark time more effectively.
- Instrumentation funding appears to be well considered.
    - WHIRC is a very good example of a low [WIYN] resource project.
    - ODI appears to be a very powerful use of WIYN resources.
    - The Bench upgrade must be completed soon, even at the expense of other projects.
- The 0.9-meter consortium seems to be doing well with few resources.
- Major barriers exist to keep partner scientists from being involved in operations. WIYN needs to recognize that scientific staff is an up-front operations expense.
- With WHIRC and ODI, WIYN is well-prepared for the next decade. The instrument suite places WIYN in an excellent position to barter for time trades instead of building a "next big thing." WIYN is better informed about "the System" than most other groups, and should be thinking in those terms when planning for future instruments.
- The 2010 renewal process is in place, but details need to be worked out. WIYN should include language for new partners in the next agreement.
- The ODI pipeline, as agreed upon among the partners, will not be scientifically effective. The Board must recognize the gap between what will be delivered by the ODI project and what is needed for science. This is a consortium-wide issue.

On behalf of WIYN, I thank the panel members for their sage and insightful advice, and their patience in reviewing volumes of background material.~

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The *WIYN Newsletter,* contacts list, and miscellaneous information about WIYN Observatory may be viewed on our Website at *www.noao.edu/wiyn/*.

Bench Upgrade Project

Matt Bershady (U. Wisconsin), Project Scientist & Patricia Knezek (WIYN), Project Manager

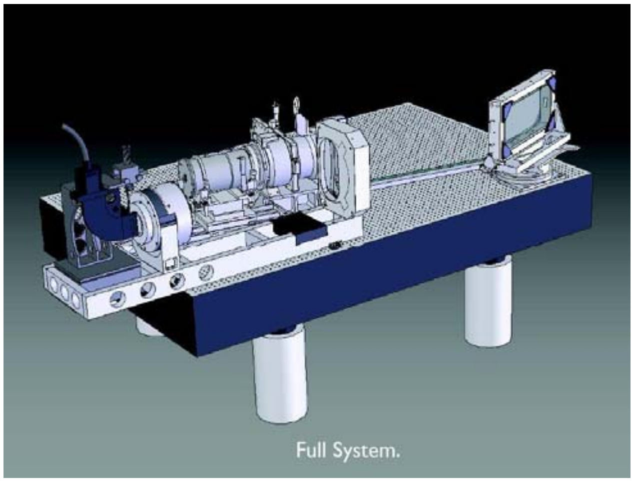


Figure 1: Solid model (Joe Keyes) of all-refractive collimator for the Bench shown in an echelle setup. Cantilevered frame avoids need for additional fold and provides room for direct VPH grating configurations down to incidence angles of 35°.

All-refractive Collimator: Progress on the baseline all-refractive collimator has continued, with recent focus on bringing the mechanical design to CDR-level. We are moving forward with bid-packages for the glass. An internal review of the optical design was carried out in July. A second internal review, this one of the mechanical design, occurred in September. These reviews will culminate in a formal CDR of the collimator in October.

VPH Gratings: Progress has been made on identifying a high-performance AR coating for the large, high line-density VPH grating. This 3300 l/mm grating manufactured by CSL is designed for use at incidence angles in the range of 45-70 degrees (central wavelengths between 428 and 569 nm), with peak diffraction efficiency between 55-65 degrees incidence (496-551 nm central wavelength) at spectral resolutions up to 25,000. At these high incidence angles, there are significant reflection losses (e.g., 11% per surface at 65 degrees, uncoated).

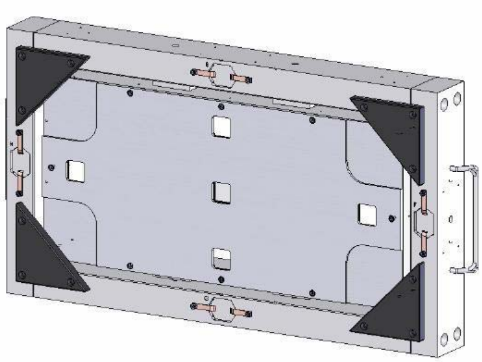


Figure 2: Coating cell and witness-sample test jig (Joe Keyes) for the large 3300 l/mm VPH grating. Pictured is the insert which will hold an array of witness samples (four at edges held with clips; five interior in cells), to verify coating performance and uniformity.

Ming Liang completed a performance comparison of simple MgF_2 and 3-layer coatings. The latter reduce losses by a factor of two, and match typical vendor performance quotes. This means our worst-case expectations are for ~10% reflection losses, and hence small amounts of polarization. However, discussion with several vendors indicates that ion-assisted deposition processes are available that will produce coatings with losses lower still by an additional factor of two.

At least one vendor can handle our large grating, and perform the coating within the constraints of a cold process. Accordingly, a bid-package is nearing completion, as is a simultaneous effort to fabricate a jig for verification and witness samples. At this time, we remain optimistic that we can obtain a superior AR coating to significantly enhance the 3300 l/mm which already appears to be two times more efficient than the echelle in on-order configurations. Pending vendor schedule, we are aiming to commission the final, coated grating in semester 2008A.

New CCD System and Controller: Progress continues to develop a low-noise optimization of the MONSOON controller for use with the STA detectors. These were produced as part of the ODI effort. A final set of four 4000x2600 (12 micron) pixel devices have now been packaged. Their noise properties will undergo testing this fall and into early winter. We remain optimistic that ~3e- read-noise will be achievable. Lab tests indicate red response was not as good as initially thought, but the devices overall are significantly enhanced relative to the T2KC/T2KA devices below 800 nm. We anticipate some early engineering tests on the telescope in early 2008.

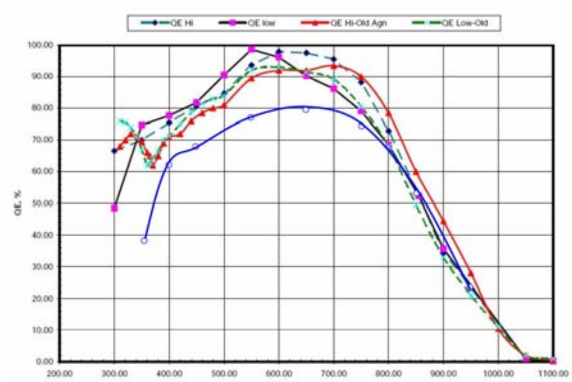


Figure 3: Comparison of QE curves for new STA CCDs compared to the old Bench CCD T2KC (bottom, blue curve; similar to the current T2KA).

Testing Plan: The Bench team has drafted a series of tests to baseline throughput and image quality performance of the current system, and to carefully monitor improvements at each stage of the upgrade. These tests are designed for minimum impact on scheduling, and require little on-sky time. They will serve to control and document the phased changes during the final stages of the Bench Upgrade. ~

WIYN Summer Shutdown Report

Charles Corson

Summary of Main Tasks Completed

- Primary, secondary, and tertiary mirrors (M1, M2, and M3) were re-aluminized
- Elevation drive surface was reground to ~1 ten-thousandth of an inch flatness and installed into nominal operation
- Elevation motor modules were re-built and installed
- Telescope center section: Added enhanced flocking for scattered light reduction and replaced weather seals
- Secondary vacuum seal was replaced, and now exceeds performance expectations
- Tertiary air bag was replaced, and now exceeds performance expectations
- Secondary mirror cell metrology provided: this aids in the installation of the mirror in the cell

Mirror Aluminizing: The mirrors were last recoated in the summer of 2004. All coatings were in serviceable condition, but their scatter was peaking well above 3% after hand washing. Previous photometric data from Abi Saha had correlated a system throughput loss of ~30% for scatter values of the range 3-4%. The primary now has a reflectivity of 92.5%, and scatter is reduced to 0.2%.

M1 Stress Fracture: A significant stress fracture was found in the M1 cassegrain hole wall, bridging two deep bubbles within the glass. Following evaluation, the fracture was drilled, ground, and acid etched to remove residual stresses and halt the fracture's propagation. Another fracture was found, but it was deemed to be in a stress-free state.

Figure 1: Primary mirror post-aluminization.

Elevation Drive Surfaces: Each of the elevation drive surfaces were removed from the telescope and re-ground to be truly flat. The goal was to remove the concave and irregular surfaces that were delivered with the original mount; these irregularities adversely impacted performance. We still have some tuning issues to tackle so that pointing and tracking is realized, but this is not unexpected for such a major change.

Elevation Motor Modules: The original modules did not provide the proper constraint of the motor bearings, nor did they properly seal the lubricants for the bearings. This was corrected. The modules will need to be monitored in the coming months, but all indications are that they will provide high reliability.

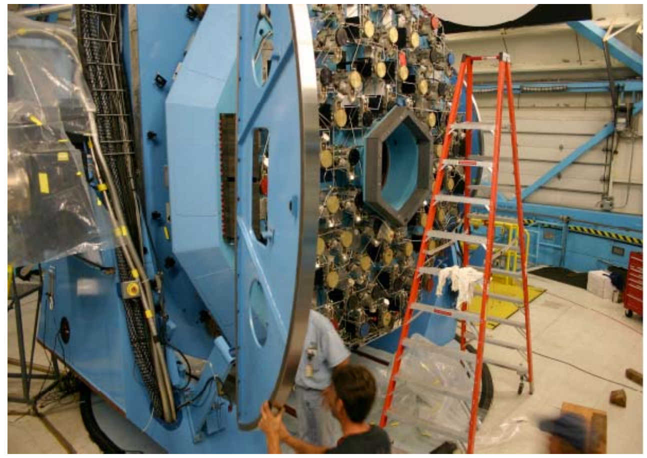


Figure 2: Installation of WIYN port drive segment.

Telescope Center Section: WIYN followed a pathway provided by the MMT to install effective flocking to the telescope center section by first applying the flocking to magnetic sheeting, and then applying it to the section walls. The expected result is that a large source of scattered light will be removed. Age and wear maintenance issues (such as weather seals) were also addressed to reduce sources of stray/scattered light.

Secondary Vacuum Support Replacement: The WIYN secondary is supported only on three hard points, which are inadequate to support a 1.2-meter diameter mirror. A vacuum must be applied to support the full 269 lbs of glass. The circumference seal that provides the bulk of the plenum barrier was 14 years old and it leaked. A new implementation of the seal was executed, and the vacuum now holds exceedingly well.

Tertiary Air Bag Support: The tertiary must also be supported by an air bag or bladder to remove mechanical print through. The original bag was replaced and has performed very well in testing. Variability in support force is down by a factor of eight.

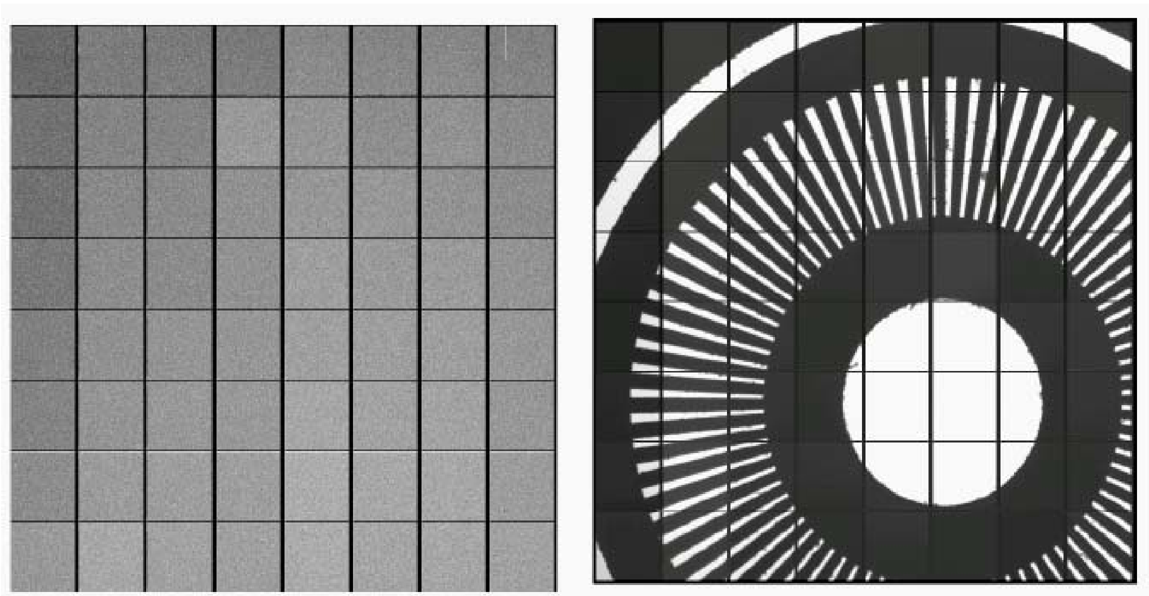
Summary of Minor Maintenance Tasks Performed

- Secondary and Tertiary baffles were re-painted with 'black velvet' and re-flocked
- Elevation encoder was remounted in a more stable fashion and correctly aligned to the drive's surface
- Elevation motor modules alignment was tuned
- Primary Thermal System thermal sensors were calibrated.
- Primary active system supports were inspected
- Drive Servo Amplifiers were lab tested, and settings documented
- Secondary Lead Screw Maintenance and Inspection
- Dome Enclosure was cleaned (dusted, de-greased).
- Verified function of new Primary Mirror Support (PMS) controller cards
- Bad PMS thermal air blower was identified, and replaced with a spare
- Center fiducial etched for tertiary mirror
- Removed DensePak from telescope and from service~

ODI News

Daniel Harbeck

In the last issue of this *Newsletter*, we reported on the completion of the Lot 3 CCD OTA foundry run for the One Degree Imager (ODI). Over the last two months, the new OTA detectors have undergone significant testing. STA packaged three thick devices and we successfully operated them in our lab test dewar. Lot 3 devices show the expected improvements compared to the earlier revision. The readout noise of the MONSOON/OTA system is now below 7 e^- (compared to 12 e^- of Lot 2 devices), and the amplifier glow is virtually gone. The detectors image cleanly without the charge injection at the cell boundaries that was seen in earlier devices.



Figures above show sample images from one of the Lot 3 OTAs: flat-field is on the left, and test target is on the right.

The remaining issue is a "fat zero" problem; i.e., the charge transfer into the serial registers is reduced at background levels below 30-50 e^- leaving a small tail of charge behind for a few pixels. However, in sky-noise limited observations, this background limit will easily be reached. Overall, we consider the Lot 3 design viable and final for ODI. We anticipate having our first thinned versions of these OTAs in February 2008.

Progress was also made in other areas of the ODI project, including fabrication of the corrector optics at SESO. We are moving towards the finalization of the ODI CCD controller design. Virtually all parts of the ODI instrument support package have now been released for fabrication to the NOAO machine shop, and the first parts of ODI have been produced.

Dealing with ODI data will be a special challenge. While all images will undergo a basic data reduction at the telescope site (i.e., data will be bias corrected and flat fielded), a science pipeline to stack images and extract object catalogs is beyond the scope of the ODI instrument project. Nevertheless, it was recognized by the Science Working Group (SWG) and the Science Advisory Committee (SAC) that future ODI users will require support to extract science from the basic images. Thus, an effort was started to coordinate activities towards a common ODI science data pipeline architecture. As a first step, the SWG and SAC members will collect typical use cases for a potential science pipeline.~

PERSONNEL NEWS

Dave Sawyer

Dave Sawyer left WIYN in September to accept a position with NOAO.

Dave first joined the WIYN team as the Site Manager, serving in that position from 1993 to 2000. During that time, he was involved with the construction and commissioning of the new WIYN Observatory, and later with the transition to operations.

In 2003, Dave rejoined WIYN. As the ODI Project Engineer, he has helped to define the scope and requirements for the ODI project. Dave has led the engineering team through several design reviews and also assisted with the development of the OTA detectors and MONSOON controllers.

We thank Dave for his many years of excellent service to WIYN, and wish him well in his new position.

Steve Howell

Steve Howell will transition from WIYN to NOAO/Kitt Peak in October. Fortunately for us, Steve will continue to serve as the WIYN Telescope Scientist.~