

CTIO/CERRO TOLOLO

INTER - AMERICAN OBSERVATORY

SOAR Mirror Delivered to Cerro Pachón

Steve Heathcote & Victor Krabbendam

To the great happiness of all concerned, the SOAR Active Optical System (AOS), including the 4.1-meter clear-aperture primary mirror, was safely delivered to the SOAR site on 9 January 2004.



The convoy carrying the SOAR AOS passes through the city of Coquimbo, just south of La Serena, during the early hours of January 9. The first wide load is the primary mirror cell, the second is the mirror itself, while the container holds the control electronics, smaller optics, and ancillary systems.

The AOS began its 10,000-kilometer odyssey on December 10, when it was trucked from the Danbury, Connecticut, plant of contractor Goodrich Aerospace to the port of New York. There it was loaded onto a freighter, SS Sea Tiger, which carried it via the Panama Canal to the Port of San Antonio, Chile, arriving on the evening of January 5. The shipment was quickly disembarked, cleared through customs, and carried by truck on the final 560-kilometer leg of its journey to Cerro Pachón.

The SOAR team is currently hard at work integrating the AOS with the telescope and its control system, with the help of expert on-site support provided by Goodrich staff. The SOAR primary mirror was successfully aluminized in the Gemini South coating plant on January 28. Following months of preparation, the coating process itself took only 40 minutes. Subsequent measurements confirm that a good-quality coating was achieved with reflectivity at 470 nanometers, in excess of 91 percent over the majority of the clear aperture. At the same time, the 120-actuator support system for the primary mirror, the active mount for the secondary mirror, and the tip-tilt tertiary assembly are being put through their paces in the laboratory prior to installation on the telescope. Integration will be followed by an intensive period of optomechanical alignment, calibration, and testing, culminating in first light, which we anticipate will occur in late March. This will be just in time for the SOAR dedication ceremony symbolically scheduled for 17 April 2004, six years to the day after the groundbreaking ceremony!



The convoy winds its way up Cerro Pachón toward SOAR and Gemini South.



At long last, the SOAR primary mirror arrives on the summit of Cerro Pachón.



The primary mirror is carefully washed in preparation for aluminization in the Gemini South coating plant.



SOAR Telescope Time—Coming Soon!

Steve Heathcote & Alistair Walker

Through NOAO, the US community has access to 30 percent of the time on the SOAR telescope (Brazil receives 30.8 percent, the University of North Carolina at Chapel Hill 16.7 percent, Michigan State University 12.5 percent, and Chile 10 percent). With first light now only a few months away, it is time to begin thinking

seriously about proposals to use SOAR. It is currently expected that time will first become available through the regular NOAO Time Allocation Committee (TAC) process in the 2005A semester. However, it is likely that some time will be available in the 2004B semester. We expect that both the SOAR Optical Imager and OSIRIS will be available during the second part of

that semester, and both the Goodman High Throughput Spectrograph and Spartan infrared camera may come on line during this period. Be on the lookout for a special call for proposals shortly after first light.

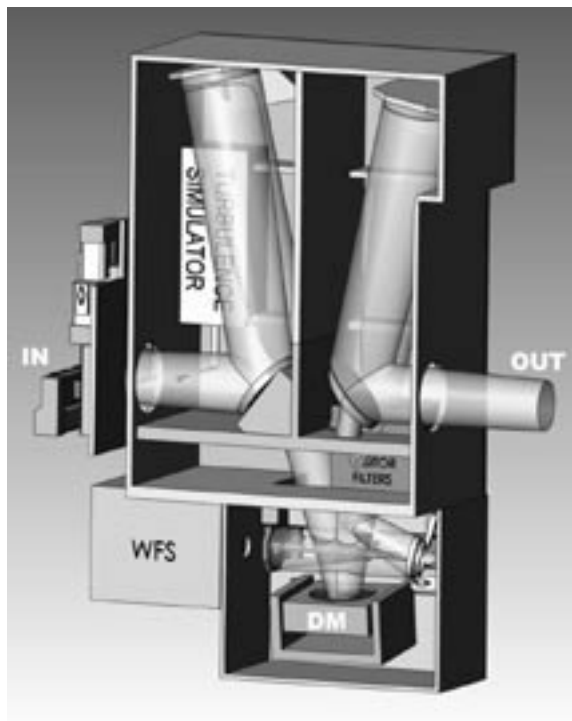
See www.soartelescope.org for more information about SOAR and its instruments.

SOAR-AO Passes Delta CoDR and Receives a Name

David Sprayberry & the CTIO AO Team

NOAO's Major Instrumentation Program is designing a ground-layer adaptive optics (AO) system for the SOAR telescope to provide enhanced image quality over a field of view of several arcmin at visible and near-infrared wavelengths. The project had its original Conceptual Design Review (CoDR) in April 2003, but the design has changed somewhat since then. The changes were needed for three reasons: a) the SOAR telescope optics were completed but at a slightly different primary mirror size from the original design; b) the new electrostatic deformable mirror technology proved not suitable for the needs of the project after extensive testing; and c) meeting the primary science goal (partial correction over a wide field) without compromise for the secondary goal (full correction over a narrow field) allowed for a much simpler and more robust design.

The design changes were presented to a reconvened review panel on January 26, and the review panel strongly supported all the changes. The project team is working hard toward preparing a more detailed design, along with a realistic budget and schedule, all to be presented at a Preliminary Design Review in a few months. In addition, the team came up with a final name for the project: SAM, the SOAR Adaptive Module. Congratulations, SAM.



Beam path inside the SOAR Adaptive Module. The optical design is essentially an OAP 1:1, with folds preserving the optical axes.



New Instruments to See the “Seeing”

Andrei Tokovinin

Ground-based astronomy is seriously affected by “seeing,” that is, image degradation in the terrestrial atmosphere. Recognizing this, major observatories are equipped with seeing monitors (Differential Image Motion Monitors or DIMMs). Site surveys for new telescopes (e.g., the Thirty Meter Telescope) consider seeing to be one of the major selection criteria. Still, knowing just the seeing is not enough. We have to know where it comes from as well. In other words, we have to measure the vertical distribution of turbulence in the atmosphere and its speed. This information is vital for designing adaptive optics systems and for understanding the mechanisms of the seeing itself.

That is where the Multi-Aperture Scintillation Sensor (MASS) comes in. MASS is a small instrument that measures the vertical turbulence profile. Unlike previous techniques, it is simple, inexpensive, and designed to work continuously as a turbulence monitor at existing and new sites. It is based on a statistical analysis of stellar scintillations in four concentric-ring

apertures. This novel approach was proposed in 1998 and tested the same year at Mt. Maidanak in Uzbekistan. The first MASS instrument came into operation in 2002 at Cerro Tololo (see figure 1). It was built by a team at the Sternberg Astronomical Institute (Moscow) led by Victor Kornilov under an AURA contract. The control software provides on-line data reduction, so one can watch the turbulence evolution on a computer screen in real time.

What do we learn from MASS?

MASS subdivides the whole atmosphere into six thick “slabs,” and measures the turbulence intensity in each layer. The vertical resolution of MASS is low, only about half of the slab’s altitude. Yet, this information is a significant addition to plain seeing data and it provides new insights.

During even the first year of MASS operation at Cerro Tololo we learned a few new things about seeing. It is true that, typically, the first kilometer above the summit suffers most from turbulence. However, the turbulence in this layer cannot be very strong. When the seeing is really bad (say, above

1.5 arcsec), it is caused by turbulence in higher layers as one would suspect, and hence seeing is equally bad on all neighboring mountains. On the other hand, there are periods when the whole upper atmosphere is very calm with a seeing of only 0.2 to 0.3 arcsec. During these (fairly common) periods, the seeing is entirely dominated by ground-layer turbulence. Hence, subtle differences between mountains, locations on the same mountain, and even the height of the telescope dome become very important. When all layers are calm, images as small as 0.3 arcsec (in the visible) can be obtained, as has been demonstrated at Magellan and the Very Large Telescope (VLT).

Good seeing is rare and fragile because it only occurs by a coincidence of several independent conditions. However, we can make it more frequent by compensating the ground-layer turbulence with a special kind of adaptive optics. Such an instrument is being designed for the SOAR telescope: the SOAR Adaptive Module. Data obtained with MASS at Cerro Pachón in 2003 were very useful for statistical prediction of the gain in resolution

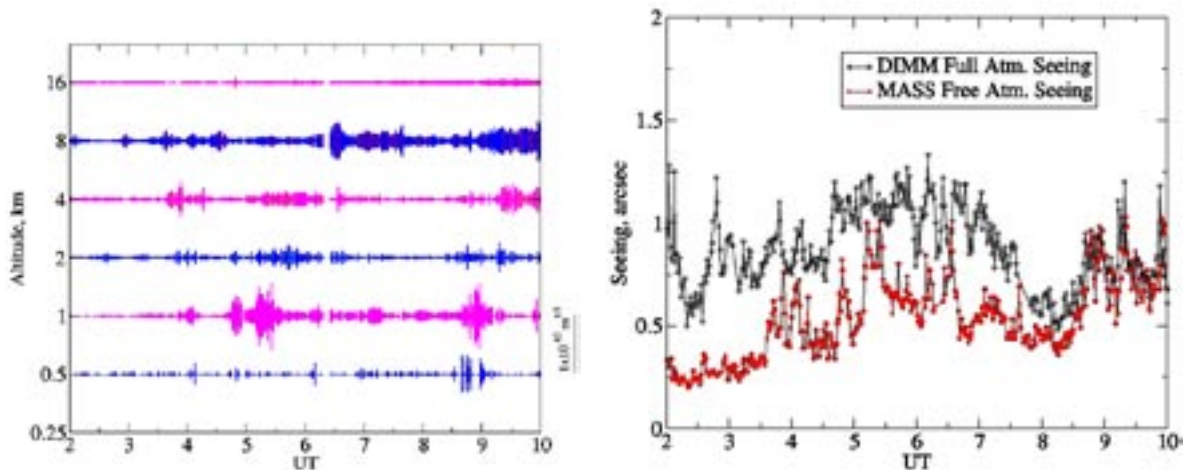


Figure 1. Evolution of seeing (left) and turbulence profile (right) on the night of 14–15 July 2002 at Cerro Tololo.

continued



New Instruments to See continued

expected from this instrument. It turns out that the gain is indeed significant (of the order of two) most of the time.

Combining MASS with DIMM

As ground-layer turbulence does not produce any scintillation, it is not sensed by MASS. On the other hand, DIMM senses the whole atmosphere. Thus, the intensity of the turbulence in the ground layer can be measured by combining MASS and DIMM data; indeed, the two instruments should always work together!

Yet another reason for this “marriage” is that DIMM is wasteful, using only two portions of its telescope mirror and throwing away the rest. Happily, the same telescope can (and should) feed both instruments. Facing this challenge, we developed a combined MASS-DIMM instrument. In its interior, an image of the telescope pupil is formed and segmented: two apertures are sent to the DIMM channel, whereas four concentric apertures are cut out to feed the MASS detectors.

MASS-DIMM is designed to work with small portable telescopes, such as the Meade LX-200 (see figure 2). Hence,

the instrument itself is very compact and weighs only 1.2 kilograms. The optics are also tiny: the diameters of the four MASS mirrors range from 1 to 5.5 millimeters. In addition, the instrument is meant to work in harsh environments. It is sealed from dust, and there are no moving parts inside (apart from the manually activated viewer mirror). The MASS electronics are a real masterpiece: four miniature Hamamatsu photomultipliers are packaged together with high-voltage supply, photon counters, and microprocessors in a single modular unit. A four-wire RS-485 cable connects to a PC computer and only 12 volts are needed to make it all work. Despite this small size, the electronics designed by Kornilov does not compromise performance. The dead time of the photon counters is among the fastest in the world at only 12 nanoseconds.

Nine MASS-DIMM instruments were fabricated in October 2003. The electronics, optics, and software were prepared by Kornilov’s team in Moscow, while mechanical fabrication, integration, and testing were done in La Serena.

Are we ready to get data?

The MASS-DIMMs are intended to replace the regular DIMMs as site monitors at Cerro Tololo, Cerro Pachón and Las Campanas. Other units will be used in the TMT site testing campaign: the first one is already installed in Chile, others will go to potentially interesting sites like Mauna Kea or San Pedro Martir in Mexico. Finally, one unit was sent to an Antarctic site, Dome C, in collaboration with a team from the New South Wales University in Sydney.

Operating multiple instruments in robotic mode is a new challenge. To complicate things, at least three different telescope systems are being used with MASS-DIMMs, with three different versions of the control software. Furthermore, the DIMM CCD detectors are operated under Windows OS, whereas other components, including MASS, are Linux-driven. Consequently, the effort of setting up and operating MASS-DIMMs is split between different teams, with CTIO being responsible only for the Meade-based version.

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Figure 2. MASS-DIMM installed on a Meade LX200 telescope (left) and its electronics module (right) containing four tiny photomultipliers (one shown apart), photon-counting circuits, and microprocessors.



New Instruments to See continued

With MASS-DIMM instruments coming into operation one by one, managing the data flow becomes a task in itself. As a first step, the MASS data from 2002 have been made accessible on the Web at mass.ctio.noao. Going

forward, we have to develop a full-fledged database that will facilitate the control of data quality and will make the data available for both immediate use and in-depth analysis.

For more information visit the MASS Web site at www.ctio.noao.edu/atokovin/profiler or www.ctio.noao.edu/sitetests for AURA site-testing.

The Hexapod Telescope

Hugo E. Schwarz

As approved during the Council of Directors meeting on August 13 last year, the Hexapod telescope will definitely be coming to Cerro Tololo. All that remains to set the move into motion is the impending signing of the memorandum of understanding.

The Hexapod telescope is a super-lightweight, 1.5-meter telescope built as a showcase for German industry at a cost of about \$5 million. The telescope is 7 meters tall, and mounts on a base ring of 3 meters in diameter. It ships in two standard 40-foot containers, and can be assembled in one day. It weighs only 2.2 tons, which is about 1.2 tons per square meter (as compared to the 5 tons per square meter typical for alt-az telescopes), has a hexapod mount, carbon-fiber construction (including the mirror cell), Zeiss active optics that put 80 percent energy into 0.3 arcsec, a hexapod-controlled M2, Ritchie-Chretien, and an *f*/8 Cass single focus. The active optics has 36 actuators, of the push-pull type, controlled by a Shack-Hartmann wavefront sensor with closed loop, and a CCD guider. The pointing limit is 30 degrees altitude, and there is no singularity at zenith. Finally, the telescope comes with a lightweight building, "the pyramid." The two halves open fully so that the Hexapod telescope operates in free air, avoiding deterioration of the local site seeing.

The Hexapod telescope has been tested in Bochum, Germany, and was a project at the European EXPO2000, but it has yet to be used on any mountaintop with good seeing. To accomplish this, the telescope will be installed on a site near the 2-MASS telescope. During 2004, a service building will be constructed next to and downwind from the pyramid.

Possible instruments are a fiber-fed spectrograph in the style of FEROS (see www.ls.eso.org/lasilla/sciops/feros) or an infrared camera.

The Hexapod telescope is fully funded from the University of Bochum, which plans to operate it about six months per year. The use of the remaining observing time and a detailed operations model are still to be decided. The SMARTS consortium has expressed interest in the Hexapod telescope.

For details and pictures of the Hexapod telescope see www.astro.ruhr-uni-bochum.de/astro/hpt. For local info contact hschwarz@ctio.noao.edu.

Changes in Computing Staffing and Structure at CTIO

Chris Smith

We welcome two new staff members to the computer-related staff in La Serena—Petri Garagorri and Nelson Saavedra. Petri, a recent graduate of the Universidad Técnica Santa María, will be working in computer systems support, concentrating in the area of databases and Web support. Nelson is actually an old CTIO hand, coming back after working several years at Gemini South. He will be leading infrastructure development and operations for the Data Products program in La Serena.

These new additions have been accompanied by a reorganization in the computer staff in La Serena, breaking the groups up into three focused areas: instrument and telescope programming (the "Computer Applications Group," or "CAG"), computer and network support (the "Computer Infrastructure Support Services," or "CISS"), and support for the NOAO Data Products Program in Chile (DPP). Ron Lambert has been named to lead the CISS group in its new role of supporting not only CTIO observatory functions, but all of NOAO's wider activities in Chile, including collaborations with and support of observatories and consortia (Gemini, SOAR, and SMARTS).