

## From the Director's Office

*Steve Keil*

The NSO 2008 Program Plan is now available on the NSO Web site at [www.nso.edu/general/docs/](http://www.nso.edu/general/docs/). Highlights include preparations for a final baseline review of the Advanced Technology Solar Telescope (ATST) in anticipation of a construction start in 2009. The concentration of this review is on defining work packets that will support requests for proposals for major sub-systems (e.g., primary mirror, telescope structure, enclosure) and completion of the Environmental Impact Statement.

Major elements of the program at Sunspot are instrumentation for the Dunn Solar Telescope (DST), critical hardware replacement, and storage-area network upgrades required to meet the increased data rates generated by instruments such as the Arcetri Interferometric Bidimensional Imaging Spectrometer (IBIS) and the Queens University, Belfast, Rapid Oscillation in the Solar Atmosphere (ROSA) cameras. In Tucson, the focus is on completing the Synoptic Optical Long-term Investigations of the Sun (SOLIS) instrumentation and data analysis pipeline, and data acquisition with the NSO Array Camera in the region of 1–5 microns at the McMath-Pierce telescope, as well as improved guiding and upgrading of the Adaptive Optics (AO) system. The NSO GONG++ staff will continue the development of new magnetic and helioseismology products and now are using their data handling experience to help with the SOLIS data pipeline.

In addition to its traditional uses for probing the secrets of the Sun's interior, the GONG high-resolution upgrade, GONG++, has added several new features to this very productive network. These include maps to probe the inhomogeneous and intermittent structure below the surface. These maps are serving as guidance for modelers of magneto-convection, an early warning of active region formation, and helping us understand the connectivity between the deep layers where magnetic field is generated and the atmospheric layers where the field dominates the solar plasma.

Another new GONG product is one-minute cadence line-of-sight magnetograms and intensity images in the 6768 Å Ni line. These magnetograms are obtained every minute around the clock and provide a unique and unprecedented record of the solar magnetic field. They are providing support for STEREO and are being used to generate source-surface extrapolations of the magnetic field in the corona. Finally, GONG is now providing active region maps of the farside of the Sun.

As many of you are aware, the NSF Senior Review recommended that NSO seek to obtain the majority of the network operating funds from external (non-NSF) sources, otherwise they recommended that

the network be closed one year after the Solar Dynamics Observatory (SDO) begins returning helioseismology data; SDO is currently scheduled for launch in January 2009. For those who have not seen GONG products recently, please visit our Web site at [gong.nso.edu](http://gong.nso.edu). We seek your help in identifying potential funding partners.

As ATST advances through the approval process for a construction start, NSO is considering how it will handle the data stream that the ATST will generate. Questions such as the level at which the data should be stored—raw, partially processed (e.g., flat fielded and polarization calibrated), or fully processed (e.g., intensity, velocity, magnetic-field maps)—are being discussed. Data will be stored as part of the NSO digital library and made available to the Virtual Solar Observatory.

NSO plans to make all ATST data open. Thus, another important issue is the length of time Principal Investigator (PI) and thesis data should be proprietary. Note that we are considering several modes of operation: queue observing, in which a proposal accepted by the Telescope Allocation Committee is conducted at a time when the conditions are optimal for the science; campaign modes in conjunction with other ground and space assets; and a PI mode, in which the scientist comes to the telescope for specialized observations. Your inputs on any aspects of data handling are welcome.

NSO/Sacramento Peak will host three visitors this spring. Gianna Cauzzi and Kevin Reardon from the Arcetri Observatory in Florence, Italy, will be here for approximately six months beginning in February along with their two children. They will be working and consulting with the staff on IBIS data. In addition, they will participate in ATST planning and discuss possible contributions from Italy. Kevin will also be working on ATST data handling. Rob Rutten, now emeritus from the University of Utrecht in the Netherlands, will arrive in late February accompanied by his wife Rietje. Rob will be working on a book as well as participating in IBIS data analysis. We extend our welcome and hope all have a productive stay at the Peak.

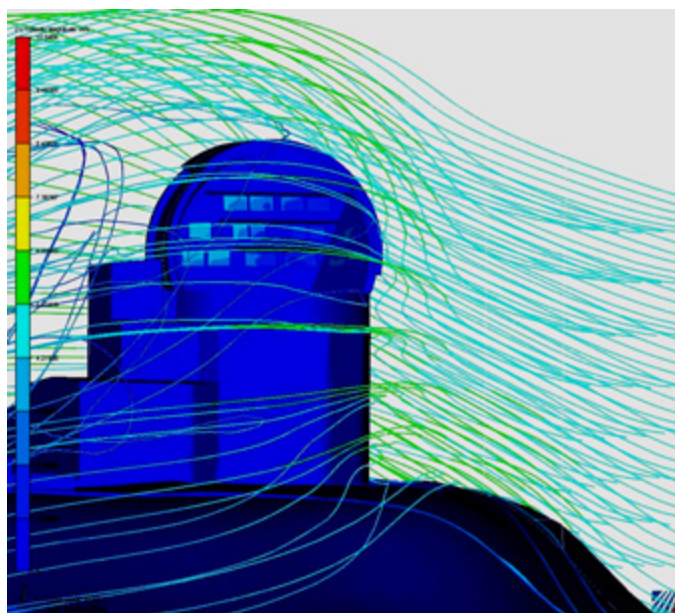
NSO is also pleased to welcome John Britanik, who will be helping to develop instrument control software and data processing algorithms for advanced solar instrumentation projects at the McMath-Pierce facility on Kitt Peak. John comes to us from Sandia National Laboratories, where he was a principal member of the technical staff. Prior to their move to Albuquerque in 2001, Tucson was home to John and his wife, Lana, a former GONGster who has accepted a software engineer position with NOAO. We're delighted to have John and Lana back with us.

# Protecting ATST from the Sun

*LeEllen Phelps & the ATST Team*

A paradoxical challenge in designing the world's largest solar telescope is protecting it from the Sun so that it can produce the world's best solar science data. Minimizing atmospheric seeing effects—turbulent fluctuations of the index of refraction within the atmosphere along the optical path—will be a key factor in the ultimate success of the ATST.

To address this challenge, the ATST design incorporates active thermal controls throughout the observatory. Our various studies and experiments have shown that if the temperatures of these components can be maintained close to or slightly below the ambient air temperature, self-induced seeing can be controlled within the error-budget allocations.



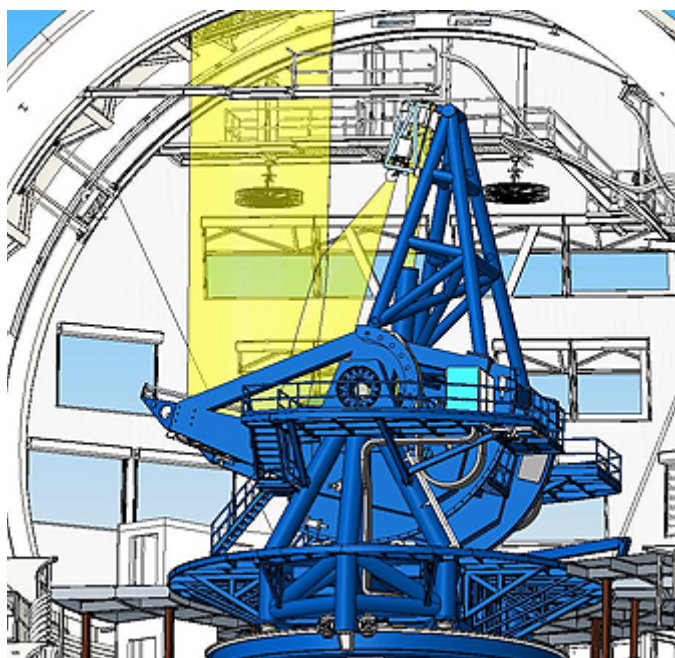
Computational fluid dynamics models depict the prevailing southwesterly wind flow around and over the ATST enclosure, and the resulting air stagnation on the enclosure's leeward side. (Credit: LeEllen Phelps and NSO/AURA/NSF)

Thermal control for the enclosure starts with a shape that minimizes the surface area normal or near-normal to the Sun. In combination with a white concrete apron surrounding the base of the enclosure, this reduces the thermal load that must be removed from the carousel (the rotating part of the enclosure) by more than 50 percent from the baseline configuration. The carousel surface temperature is actively controlled by covering all surfaces that receive insulation with plate coil heat exchangers. Chilled heat-transfer solution is circulated through the plates to maintain the surface temperature at, or slightly below, ambient temperature.

Thermal modeling of the ATST enclosure to correctly size equipment and estimate performance has been based on covering all of the external surfaces with a white coating having a solar reflectivity of

84 percent and a thermal emissivity of 93 percent. These are typical values for white titanium-oxide or zinc-oxide paints. The properties of traditional white coatings and paints are known to degrade with time as they are exposed to the elements. The thermal coating system for the ATST is based on test results of samples weathered on the Haleakalā High Altitude Observatories site.

Two coatings have been identified for ATST: one for the areas that receive the most direct insulation and are nearest the light path, and a second for the bulk of the surface area. It is cost prohibitive to use the higher-performance coating over the whole facility.



A computer model of the ATST illustrates the large cross-section available for air flow to ensure that the carousel and Telescope Mount Assembly stay close to ambient temperature. (Credit: LeEllen Phelps and NSO/AURA/NSF)

The coating system for the most critical areas is AZJ-4020 white epoxy thermal-control coating manufactured by AZ Technology. Initial test results indicate a solar reflectance of just over 86 percent and near-normal emittance of 97 percent after one year of weathering. The bulk of the enclosure surface will use Energy Seal Acu-Shield, a white acrylic elastomeric coating manufactured by Advanced Coating Systems, Inc. Three-year test results reported by the Energy Star® Roof Products Program indicate an initial solar reflectance of 86 percent, and then 84 percent after three years of weathering. Emittance is not reported in the program, but ATST test results indicate an initial near-normal emittance of 94 percent and verify an initial solar reflectance of 86 percent.

In addition to rejecting any incident heat load, the enclosure must protect the telescope while allowing the wind to flush the optical

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*Protecting ATST from the Sun continued*

surfaces. Toward this end, the enclosure is designed to be highly ventilated. Passive flushing is provided by 32 independently controllable vent gates, along with the carousel rear access door and the carousel entrance aperture. This provides an area of just over 200 square meters for ventilation. The active ventilation system for the carousel interior has two parts that work in tandem: fans mounted on the interior of the carousel, and exhaust fans that pull air through the floor at the base of the Telescope Mount Assembly. The fans selected for the baseline design provide 22,377 cubic feet per minute of free-air displacement using four airfoil fans. They provide an estimated one-meter-per-second breeze throughout the carousel when not competing with wind. The fan motors will be encased in a water jacket to remove waste heat.

Most recently, modeling efforts have centered on optimization of the cooling system for the lower enclosure, looking for an approach that would allow us to avoid building the utility tunnels to the nearby utility buildings, and otherwise reducing the costs and complexity of the baseline active cooling system. Thermal-mass concepts were

considered for maintaining the lower enclosure surface temperatures near ambient. Two cases were developed in the RadTherm thermal modeling program to establish surface temperatures of a number of different thicknesses of concrete in different seasonal circumstances.

Winter is considered the worst case, since the Sun is lower in the sky and illuminates the walls of the lower enclosure more directly. The other case considered was intended to be representative of the most common conditions during excellent seeing at the site: Sun at 15 degrees from the horizon, wind from the northeast at 5–6 meters per second, and ambient temperature of 13 degrees Centigrade. Using site-survey data for both cases revealed that significant sub-cooling occurs through the night. Computational fluid dynamic analyses including the effects of surface temperatures were performed to examine how this might affect the ATST optical path. The results show that any affects of lower enclosure sub-cooling do not extend to the optical path, and that the concept is quite effective in keeping the surface temperatures within range in the high end. ●

# SOLIS

*Aimee Norton, Kim Streander, Carl Henney, & the SOLIS Team*

The SOLIS team was excited to capture the first sunspots of Solar Cycle 24 on 4 January 2008, when a small sunspot group of the new cycle polarity appeared in the Sun's northern hemisphere. (The GONG++ data from this day were used by the National Oceanic and Atmospheric Administration (NOAA) to announce the new solar cycle, see the accompanying GONG++ article.) Since the SOLIS instruments were specifically designed to study the long-term changes wrought by the 11-year sunspot cycle, we are eager to document in scientific detail the onset of the new cycle.

Recent results from the telescope include those from Raouafi, Harvey, and Henney (2008), who used magnetograms from the Vector Spectromagnetograph (VSM) to study the latitudinal distribution of magnetic-flux elements as a function of latitude in the solar polar caps. They find that the density distribution of the magnetic flux, normalized by the surface of the polar cap and averaged over months, decreases close to the solar poles. This trend is more pronounced when considering only flux elements with relatively large size. This research has implications for the latitudinal extent and strength of the meridional flows that bring the magnetic flux from lower to higher solar

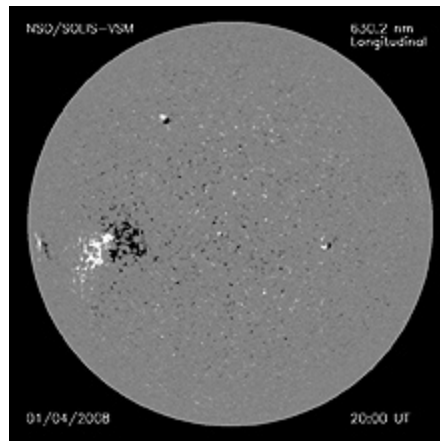


Figure 1: A full-disk solar image with gray-scale indicating the line-of-sight magnetic flux as observed in the photosphere with the 630 nm Fe I lines on 4 January 2008. White/black indicate positive/negative polarity of magnetic fields. It is interesting to note that the hemispheres are slightly out of sync with one another. Remnants of the old Solar Cycle 23 magnetism are still appearing in the southern hemisphere near the equator as the new Solar Cycle 24 magnetism appears at higher latitudes in the northern hemisphere.

latitudes, resulting in the solar-cycle reversal. The results are also of importance in studying polar structures contributing to the fast solar wind, such as polar plumes.

Several improvements have occurred in the calibration of VSM polarization data. For quite some time, the VSM calibration waveplate and polarizer rotation mechanisms have been experiencing position repeatability problems. During a thorough investigation, we discovered that the motors were under-powered due to a wiring problem. Correction of the error has ensured proper positioning of calibration motors, which, in turn, simplifies observing procedures as manual intervention to correct for random positional errors is no longer required.

In addition, algorithms have been developed to remove unwanted fringing in the Stokes polarization data. Due to imperfect modulation of the polarized states and small spatial offsets in the optics, fringes often appear and cause problems in the data interpretation. Once the fringe pattern, both its amplitude and phase, is fitted, the fringes can be effectively removed in order to supply a clean spectrum to the community.

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*SOLIS continued*

The recently purchased Sarnoff cameras have passed qualification testing and new camera mounting hardware has been fabricated. Software interfaces are now being modified to incorporate this data acquisition system (DAS) into the current operating system, with a goal of replacing the cameras within the next few months.

The Kitt Peak SOLIS Tower (KPST) storage area network (SAN), which supports the SOLIS real-time data acquisition and processing, was purchased eight years ago and was supported up until recently. Recent disk failures had become more frequent, and rebuilding the current system had limited observations. Work was recently completed on upgrading the KPST SAN to a RAID-1 in order to avoid data loss when one SAN disk fails and to have parts that are serviceable. 📀

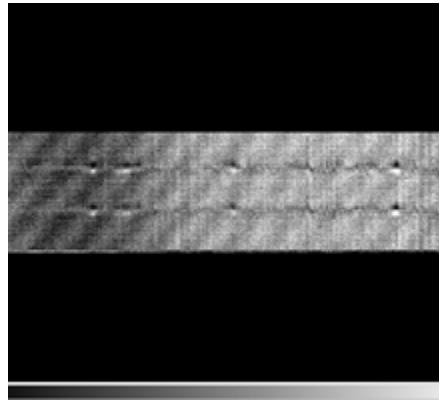


Figure 2: Diagonal fringing in Stokes V polarization can be seen simultaneously with the real Zeeman-splitting magnetic signal of the Fe I spectral lines at 630.1 and 630.2 nm.

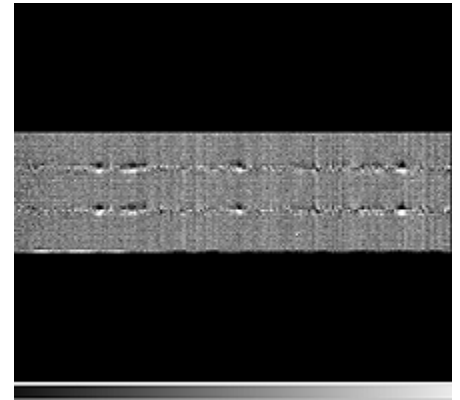


Figure 3: Once the amplitude and phase of the fringe pattern is fit, the fringes can be effectively removed so that a "clean" spectra is analyzed.

## GONG++

*Frank Hill & the GONG++ Team*

The last quarter has seen continued increase in the use of the GONG++ magnetograms by the scientific community. The data are now being used in the Air Force Research Laboratory Wang-Sheeley-Arge solar wind model, by the STEREO and Hinode research teams, and in the Center for Integrated Space Weather Modeling program. Individual non-GONG++ user research programs have also begun to utilize the near-real-time, Web-accessible magnetograms, with the main focus being naturally on observations of rapid variations in the magnetic field.

The enthusiastic acceptance of the GONG++ magnetograms from outside the helioseismology research community has been welcomed and should increase the prospects that GONG++ will succeed in identifying outside operational funding as recommended by the NSF Senior Review. On the research-funding front, we have had some good news with the recent award of a three-year continuation of our NASA SOHO Guest Investigator program.

**Science Highlights**

On 4 January 2008, the National Oceanic and Atmospheric Administration (NOAA) announced that the first sunspot of the new Solar Cycle 24 had been observed. The data they used for this announcement was a GONG++ magnetogram obtained at the Mauna Loa Observatory; this image can be seen in figure 1. Magnetic fields associated with Cycle 24 had been spotted previously, notably with NSO's SOLIS instrument (see the December 2006 *Newsletter*), but those fields failed to create a sunspot. The onset of Cycle 24 had been predicted to occur in March 2008 with an error of  $\pm 6$  months, so this sunspot is right on time! The outgoing Cycle 23 was one of the longer cycles (13 years), and it will be interesting to watch Cycle 24 unfold to test the prediction of its strength.

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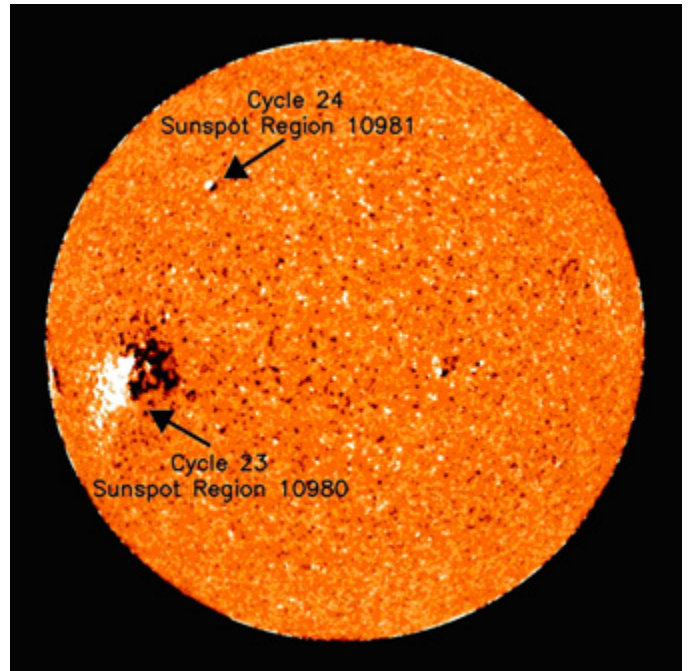


Figure 1: This GONG++ magnetogram, obtained at Mauna Loa on 4 January 2008, shows the first appearance of a sunspot associated with the new activity Cycle 24. The sunspot, labeled with its official NOAA number of 10981, can be seen near the top of the image. The high-latitude location ( $27^\circ$  north), and the negative polarity leading to the right in the northern hemisphere, indicate that this spot is from the new solar cycle. A spot from Cycle 23, number 10980, is also evident on the disk. The image annotations are courtesy NOAA/NWS/SWPC.

GONG++ *continued*

Irene González Hernández has been investigating the meridional flow below the solar surface. This flow is in the north–south direction, and is thought to be a key component of the solar dynamo mechanism that maintains the solar activity cycle. There are some localized “bumps” in the meridional flow velocity as a function of latitude, as seen in figure 2. The latitude of these bumps is the same as the latitude where the sunspots emerge and evolve, so it is plausible that the bumps and the sunspots are related.

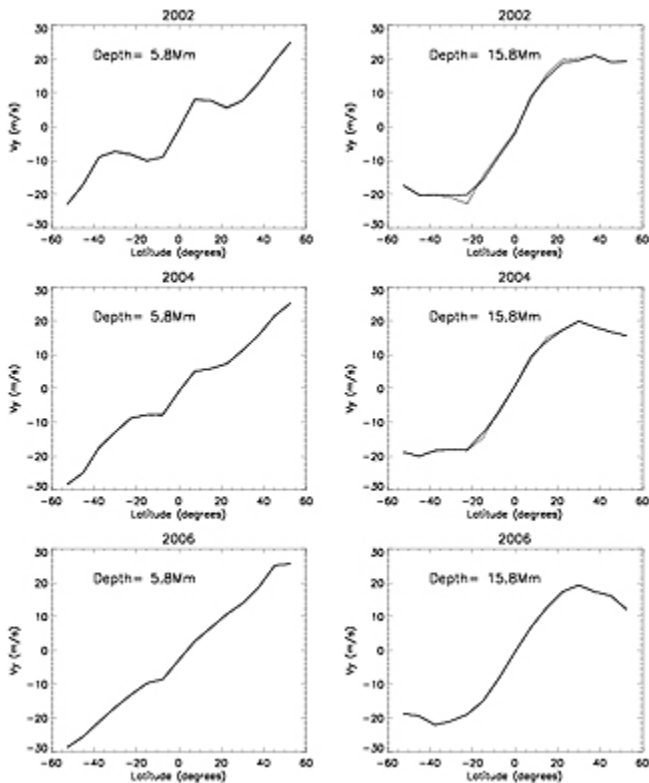


Figure 2: The north–south meridional flow averaged for three different years (2002 top, 2004 middle, and 2006 bottom) and two depths (5.8 Mm left, 15.8 Mm right) obtained by applying ring-diagram analysis to GONG++ continuous data. The flows were calculated: a) using all data available (solid thick line) and b) excluding the areas of concentrated magnetic activity such as active regions (faint thin line). Close to the surface, the flows show localized “bumps” at the latitudes corresponding to the active belts that move toward the equator as the solar cycle progresses toward minimum. The characteristics of the bumps are not affected by the removal of areas of high activity, so the bumps are not caused by organized flows around the active regions or artifacts from the magnetic field, but arise from a global pattern of circulation in the active latitudes. The graphs also show that the amplitude of the meridional increases toward solar minimum, particularly close to the surface. Preliminary analysis of a subset of the data using another local helioseismology technique (time-distance) seems to confirm these results.

However, there has been a question as to whether the meridional flow bumps are local active-region flows, or even artifacts of the surface activity, with the magnetic field contaminating the velocity signal. Recently, González Hernández completed an analysis in which she masked out the surface active regions and determined the meridional

flow from regions where no activity was present. She found that the bumps were still present and unchanged in the flow, thus suggesting that these features are real global features of the solar internal velocity field, and are neither local flows nor artifacts. We think that the meridional flow bumps are related to the east–west zonal flow known as the torsional oscillation.

**Network Operations & Engineering**

In the last quarter of 2007, preventive maintenance (PM) teams visited Udaipur and Mauna Loa. In addition to the usual tasks, a problem with the waveplate synchronization circuit was found in the new waveplate hardware while it was being installed at Udaipur. A considerable reduction in the circuit noise was seen when an apparently extraneous ground cable was removed. This change will be made at the remaining five sites. An additional improvement will be to install a differential receiver into the circuit to further reduce noise pickup. A new circuit card has been designed, built, and tested, and all new waveplate hardware will be updated with the new design.

The Mauna Loa PM was more routine and allowed for upgrades to numerous system components. In particular, a CCD camera with improved temperature control and a Lyot filter (which was rebuilt with a more stable optical coupling compound) were installed. Subsequent to the Udaipur PM, problems with the uninterruptible power supply (UPS) began following installation of new, higher-capacity air conditioners. The higher load now causes the input voltage to drop to the point that the UPS switches to battery power, and although the switch-over is brief, it occurs frequently enough that the batteries eventually lose their charge, and the UPS shuts down completely. Some interim actions have been taken to prevent further unexpected shutdowns, and additional adjustments to the UPS control parameters are being tried in order to determine a long-term solution.

Meanwhile, upgrades to cameras, Lyot filters, electronics, clean-air systems, and turrets have been underway in preparation for the next round of PM trips scheduled to begin in March 2008. Long-term testing (now at eight-plus months) of the prototype, clean-air system upgrade continues at Tucson’s engineering site. We hope to get at least one year of use out of the pump before it needs to be rebuilt, which would allow pump servicing to be done by our staff during the annual maintenance trips.

The replacement candidate for the GONG++ camera has been set up in the lab and is collecting preliminary images. A replacement candidate for the GONG workstation has been received and configuration and testing is progressing as time permits.

**Data Processing, Software Development, & Analysis**

Two new Linux servers have been ordered. These servers will support routine pipeline operations and facilitate the eventual retirement of GONGXX and Tarat. Additional disk space is being added to the archive to support the increasing demand for online data products.

Recent detailed analysis of the GONG synoptic maps shows an apparent motion of the polar field with a one-year periodicity. This is an artifact arising from a problem in our data processing pipeline. We are currently reviewing the software to identify and correct the problem.

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## GONG++ *continued*


Work continues on the pipeline to process fully calibrated, full-resolution, merged magnetograms. The pipeline will also include modifications to process SOLIS magnetograms. The programming team continues to port GONG's production software to Linux. The calibration pipeline is the latest module to be approved for routine processing on the Linux platform.

Processing to date includes time series, frequencies, merged velocity, and rings for GONG Month 123 (centered at 6 July 2007), with a fill factor of 0.90. Last quarter, 750 GB of data were distributed through the FTP site.

### Program

In addition to the successful NASA SOHO Guest Investigator award mentioned earlier, we have submitted a joint SOLIS/GONG++ proposal to NASA to develop new synchronic maps of the global solar magnetic field. These new data products would be constructed with a background/quiet-Sun field from the GONG++ high-cadence magnetograms and the radial field inside active regions derived from the SOLIS vector magnetograms.

The proceedings from the 24th NSO/Sacramento Peak Summer Workshop, "Subsurface and Atmospheric Influences on Solar Activity," are in press and should be distributed shortly. Congratulations to Rachel Howe and her co-editors Rudi Komm, Gordon Petrie, and K.S. Balasubramaniam for completing the job! NSO/GONG++ hosted a NASA Target Research and Technology team meeting on emerging active regions on January 28, followed by a two-day Local Helioseismology Comparison Group (LoHCo) workshop on January 29–30, the 11th meeting of this group.

We are now inviting speakers for the GONG 2008/SOHO 21 meeting to be held in Boulder, CO, 11–15 August 2008 ([www.hao.ucar.edu/gong-soho/](http://www.hao.ucar.edu/gong-soho/)). We are also gearing up for the second International Research Experience for Students program this summer. Funded by the NSF Office for International Science and Engineering, this program will send four US graduate students, studying any field of astronomy, to work with scientists at the India Institute for Astrophysics in Bangalore, India, for eight weeks this summer. Last year's program was extremely successful, and we are happy to report that we have substantial oversubscription for the student slots this year. 

## Third Quarter Deadline for NSO Observing Proposals

The current deadline for submitting observing proposals to the National Solar Observatory for the third quarter of 2008 is **15 May 2008**. Information is available from the NSO Telescope Allocation Committee at P.O. Box 62, Sunspot, NM 88349, for Sacramento Peak facilities ([sp@nso.edu](mailto:sp@nso.edu)) or P.O. Box 26732, Tucson, AZ 85726, for Kitt Peak facilities ([nsokp@nso.edu](mailto:nsokp@nso.edu)). Instructions may be found at [www.nso.edu/general/observe/](http://www.nso.edu/general/observe/).

A Web-based observing-request form is at [www2.nso.edu/cgi-bin/nsoforms/obsreq/obsreq.cgi](http://www2.nso.edu/cgi-bin/nsoforms/obsreq/obsreq.cgi). Users Manuals are available at [nsosp.nso.edu/dst/](http://nsosp.nso.edu/dst/) for the Sac Peak facilities and at [nsokp.nso.edu/](http://nsokp.nso.edu/) for the Kitt Peak facilities. An observing-run evaluation form can be obtained at [ftp://ftp.nso.edu/observing\\_templates/evaluation.form.txt](http://ftp://ftp.nso.edu/observing_templates/evaluation.form.txt).