27 July 2005

To: Dr. W. Van Citters, NSF Cc: Dr. Stephen Keil, NSO

From: NSO User's Committee

Re: NSF Senior Review of Portfolio Facilities

Dear Dr. van Citters,

As the committee that represents the users of the National Solar Observatory, its facilities and its data, we would like to communicate our evaluation of the scientific capabilities of the NSO facilities at this juncture. The committee has as its charge to represent the scientific community which uses data from the NSO facilities, both data provided by NSO from its systematic daily ('synoptic') observations and those data obtained by a Principle Investigator (PI) using an NSO user-dedicated telescope. The members of the committee thus draw upon their own expertise and consult with other members of the solar physics community to formulate such reports. Below we present our evaluation of the NSO facilities in the two subgroups.

SYNOPTIC FACILITIES:

SOLIS:

While full deployment is not yet complete for the Synoptic Optical Long-term Investigation of the Sun (SOLIS) facility, daily maps of the line of sight component of the solar magnetic field (replacing the long-running Kitt Peak Spectromagnetograph) have been available for two years and are enjoying wide-spread use. The Kitt Peak magnetograms were one of the most widely used data products of the NSO and the transfer to SOLIS line-of-sight data has been smooth, especially as the latter have proved to be of higher resolution and higher sensitivity (as was advertised). The vector capability is enthusiastically anticipated by the user community, for it will provide the first full-disk synoptic vector magnetic field data available, anywhere. The vector capability is crucial for determining the heliographic components of the magnetic field, *i.e.* the most physical representation of the magnetic field at the photospheric boundary.

The community strongly supports a plan to clone the SOLIS instrument suite for deployment at complementary terrestrial longitudes in order to obtain more complete observations of the evolving Sun. Temporal coverage is crucial for understanding solar active region evolution, especially for those quickly-evolving active regions that are responsible for the majority of space weather effects. As the GONG program has repeatedly demonstrated in concert with the SOHO/MDI mission, the planned upcoming space-based missions which include full-disk vector field data in no way diminish the need for multiple-SOLIS-like capability, and in fact enhance the need for such capability. Complementary ground-based and space-based data provide the redundancy required to track data quality, and the multiple data sets force algorithm consistency checks that are especially crucial to obtain consistent, believable, quantitative results. Additionally, the community encourages NSO to invest in bringing SOLIS to full vector capability for chromospheric data, as interest is growing in routine vector magnetic field measurements at this force-free layer of the solar atmosphere. The lower boundary (photosphere and chromosphere) of the solar magnetic field provides our most direct window into the energy source that drives the space weather and its myriad terrestrial impacts. The community finds it imperative to bring this NSO capability to full fruition in order to provide the data with which key questions about understanding and predicting solar storms can be answered.

GONG:

The Global Oscillations Network Group (GONG) program has undergone a recent revitalization including instrumental upgrades to larger detectors, polarizing optics, and more continuous data acquisition. The resulting "GONG++" network provides data for global, far-side, and local helioseismology as well as maps of the surface magnetic field concentration. The data are being fully exploited by both the helioseismic and synoptic community. As an example, the new line-of-sight magnetic field data product from GONG ++ is included in Big Bear Solar Observatory's Active Region Monitor project. The GONG program also continues to provide checks on complementary space-based helioseismic instruments (e.g., the Michelson Doppler Imager aboard SOHO), and near real-time data acquisition. For a physical understanding of the Sun and the drivers of its magnetic activity, the User's committee strongly supports the recommendation of the AURA Solar Observatory Council that GONG continue for a full 22-year solar cycle.

HILLTOP FACILITY [SPO]

The Hilltop facility now occupies a very low priority for maintenance and support by NSO. The instruments are used daily by NCAR/HAO for coronal magnetic and velocity scans for which NCAR also provides an observer. Thus, Hilltop is active in an on-going scientific program while having minimal impact on NSO resources.

<u> USER -DEDICATED FACILITIES:</u>

This category of NSO facility centers on the flagship telescopes which are centers for PI-driven investigations with instruments either provided by the user or by other institutions. Each telescope in this category was designed and constructed to provide a unique capability, complementary to the other NSO facilities. Each telescope in the NSO suite is provided to the entire U.S. and foreign user community to provide equal access to first-rate observing facilities which would otherwise be available, if at all, only through private or overseas observatories.

The NSO is anticipating construction funding for the Advanced Technology Solar Telescope (ATST), and the user community has been heavily involved in the planning stages for this new flagship facility. While the solar observational community has agreed to the closure of the present facilities upon the commissioning of the ATST, the following discussion is provided to secure their continued operation and unique capabilities *at least* until that time.

DUNN SOLAR TELESCOPE [SPO]

With its relatively new high-order adaptive optics system, the Dunn Solar Telescope (DST) has reemerged as a user instrument of internationally high acclaim for very high resolution optical imaging and polarimetry. The community has been rapidly developing new instrumentation to both take immediate advantage of the science made available by the AO system, and to prototype instrumentation for the ATST. Recently deployed or in development are the Diffraction-Limited Spectropolarimeter (DLSP), the Italian Bi-dimensional Imaging Spectrograph (IBIS), and the Spectro-Polarimeter for InfraRed and Optical Regions (SPINOR), all developed for the high-resolution multi-height spectropolarimetry required to investigate the 3-D structure of solar magnetic fields, from the tiniest magnetic elements in intergranule lanes to large-scale sunspot and active region evolution. Proposals for observing time have increased in number over recent quarters to the point where there is now routine over-subscription.

Recent results include diagnostics of the magnetic forces in the chromosphere, tracking penumbral waves and feature coherence over extended heights, and the confirmation of strong downflows associated with small magnetic elements. These observations present challenges to theories of magnetoconvection and models of the solar magnetic fields, and are at the cutting-edge of solar

science. Ultimately, observations such as these will be key to understanding the mechanisms responsible for the solar activity cycle.

The DST is currently the only facility in the world which offers the combination of advanced AO, advanced spectropolarimetry, and very high resolution imaging. This will remain the case for at least the next 5 to 10 years. We also foresee an increasing demand from users wishing to coordinate the DST's powerful observational capability with the present TRACE, SOHO and RHESSI missions as well as the upcoming Solar-B, SDO and STEREO missions.

THE EVANS CORONAGRAPH FACILITY [SPO]

The Evans facility is the only coronagraph in the U.S. available for user-defined programs, although with the caveat that users must either operate it or pay for that task. Despite its age, the coronagraph and its Coudé focus still hold great promise for coronal spectroscopy, as demonstrated recently by investigations into coronal magnetography. One of the primary reasons for the recent underutilization of the Evans is the lack of available instrumentation. This issue is being addressed by NCAR which is supporting the development of a new coronal spectro-polarimeter capable of simultaneous data acquisition in the visible and near-infrared. When complete in 2006, this new capability will be available for NSO users. Synoptically, the Evans is still used for daily coronal emission scans by the Air Force operations at SPO, a project which helps ensure the operation of this facility, but does negatively impact outside users requiring the higher-quality observing provided by morning conditions. Still, the Evans facility uniquely provides a testbed for instrumentation, especially for the planned ATST coronal science capability, as well as more immediate developmental research such as the near infrared system tested by Big Bear Solar Observatory. Thus, notwithstanding its small user base, the Evans coronagraph is a definitive component of NSO's observational capability, and a necessary component for instrument development as the community looks forward to ATST.

The Evans telescope supports on-going scientific programs that are key to future NSO capabilities, while having minimal mpact on NSO resources. The User's committee supports the continued support of the Evans facility even at its present nominal level, especially given the interest by NCAR and BBSO to invest in science for which the Evans is presently the sole platform.

McMATH-PIERCE SOLAR TELESCOPE [KPNO]

The McMath-Pierce remains the only large solar telescope in the world suitable for infrared studies beyond 2 μ m. This facility also has the unique capability to combine infrared and polarimetric work, allowing investigations of the thermal and magnetic structure of the solar atmosphere from the deep photosphere into the upper chromosphere. Observations from the McMath-Pierce have recently addressed fundamental issues concerning the physical structure of the solar atmosphere spanning the "magnetic transition zone" and provided data that conflict with other diagnostics in an uncomfortable way (at least for present theories). The answers to questions concerning the solar oxygen abundance and the rare isotopes of C and O, which can be addressed by IR spectroscopy in the 1-5 μ m band, have important implications for areas as diverse as helioseismology and solar-system formation theories. Polarimetry of Mg lines near 12 μ m, which afford the most sensitive known Zeeman diagnostic of solar magnetic fields, cannot be performed anywhere else; this is also the case for the potentially important 3.9 μ m coronal line of Si, which was discovered at this facility.

The power of the McMath-Pierce at all wavelengths (but especially in the infrared) has been significantly enhanced recently with an adaptive optics system. Just at the time of this report, the new Aladdin infrared camera achieved first light, affording an eagerly anticipated extension of the IR-array capabilities pioneered at the McMath-Pierce. For the highest spectral resolution from the ultraviolet to the far infrared, the Fourier Transform Spectrometer (FTS) is a unique resource. Thus the McMath-

Pierce telescope is poised for a renaissance as well, the result of a decade of painstaking work by the NSO staff and their collaborators.

As the only facility where long-wavelength infrared techniques can be developed in preparation for the ATST, the McMath-Pierce telescope returns a high value for its operating budget. Moreover, it is simply not feasible to duplicate the infrared capabilities of the McMath-Pierce from space observatories due to the large apertures necessary to achieve the spatial resolution required by today's scientific inquiries.

DATA ACCESS FACILITY:

The Virtual Solar Observatory (VSO) is a program to provide a single, consistent front-end to locating, gathering, evaluating and acquiring solar physics data from a variety of sources, including NSO as well as a plethora of other sources both ground- and space-based.

Significant improvements have been made in the interface software, and there is broad community support for this tool which promises to mitigate the need for researchers to query multiple websites separately in order to coordinate complementary data products for comprehensive investigations. The VSO promoters and staff have been visible at every widely-attended professional meeting, providing demonstrations and offering assistance. As multi-wavelength, multi-scale, multi-platform coordinated observations become the norm for solar physics investigations, and as the number of those platforms increases, the community sees the VSO transitioning from a novel convenience to an absolute necessity.

SUMMARY:

The User's Committee for the National Solar Observatory, on behalf of the user community of solar physics research, strongly endorses the evolutionary long-range plan of the NSO. The programs presently in place and those under development – for existing facilities and the future ATST, for synoptic and the PI-driven programs – advance both science and technology, continually looking to future capabilities and scientific frontiers. The NSO facilities help build the community of ground-based solar astronomers needed to exploit the ATST and the SOLIS and GONG networks of complementary synoptic programs. Additionally, the NSO capabilities enable solar physicists to take full advantage of both current and planned solar and heliospheric space missions: we believe existing NSO capabilities do and will continue to play pivotal roles in supporting and ensuring the scientific productivity of these space missions.

Despite level funding for many years, the National Solar Observatory continues to provide important facilities and data to the user community. The strategic plan for NSO calls for continued support for the Evans facility through at least five more years, and for the flagship DST and McMath-Pierce telescopes until the ATST is commissioned. We argue and demonstrate here that the solar community is actively using the present facilities in a variety of ways for both near-term scientific endeavors and more far-sighted planning for the new flagship telescope. We hold that premature closure of any of NSO's major facilities would jeopardize the present and future ground-based solar community and negatively impact the wider space-based and theoretical programs of solar physics.

Respectfully submitted,

The NSO User's committee: K. D. Leka (chair), T. Ayres, S. Basu, T. Berger, C. Denker, D. Jennings, P. Judge, J. Mozer, D. Rabin, E. Seykora, S. Tomczyk