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University of Wisconsin • Indiana University • Yale University • National Optical Astronomy Observatory

January 30, 2012

## To: NSF Portfolio Review Committee

Dear Colleagues:

The three member universities of the WIYN consortium strongly recommend continuing NSF investment in WIYN through the US OIR national observatory, NOAO. The WIYN partnership among state and private universities and NSF/NOAO has produced a state-of-the-art facility with highly productive yet cost-effective operations. Our most recent external review accurately summarizes the state of the Observatory. The review found that:

- WIYN delivers the best images over a wide field-of-view of any continental US facility.
- Operations have achieved an outstanding level of reliability and efficiency.
- WIYN has had a major impact on the research opportunities available to member universities, involving a broad base of faculty and providing important career development paths for younger faculty and postdocs.
- The number of Ph.D. dissertations making important use of the facility is especially impressive. For the astronomy departments of the university partners, WIYN is the largest source of experimental data for doctoral theses.
- WIYN has served national interests by 1) providing a proving ground for technological innovations; 2) enabling access to wide-field multi-object spectroscopy for the US astronomical community; and 3) providing substantial aperture very cost-effectively.

**We believe that few, if any, of the successes of the WIYN Observatory would have been possible without the major contributions of NOAO to our partnership.** This letter attempts to document the current and future importance of NOAO as a partner in the WIYN collaboration.

### **Importance of our relationship with NOAO**

The WIYN Board views an active partnership with NOAO to be essential for maintaining the current quality of operation. NOAO plays the lead role in operations and technical support by providing a pool of expertise for telescope operation, instrument development, and maintenance. Access to multiple individuals with diverse skills has been critical in delivering the high level of reliability and productivity that characterizes WIYN operations. Of course, the university partners provide funds to NOAO for this access; we contribute fairly to our share of the costs. However, it would be nearly impossible for the university partners on their own to support the extensive range of skill sets necessary to operate and maintain a facility as complex as WIYN. The collaborative nature of our relationship with NOAO, and the fact that we can freely share the expertise present at NOAO – both in Tucson and on Kitt

Peak – is what allows us to operate WIYN in such a cost effective way. **The future of WIYN is directly tied to the future of NOAO.**

### **WIYN and the System Model**

The two most recent decadal surveys have both stressed the importance of the development of a shared “system” of optical and near-IR ground-based telescopes and the establishment of public-private partnerships to carry out major new initiatives. WIYN has served as the pathfinder for the creation of such agreements. We support the System concept, and are proud of our role in helping to make it a reality. Without a strong NOAO, however, the System concept cannot survive. **NOAO must be the backbone of any US OIR System concept.** We view the WIYN partnership as a shining example of what can be achieved when state and private funds are used in conjunction with resources available through the national observatory. In a fully-developed OIR System, the integrated telescope facilities truly are more than the sum of the parts.

### **New Instruments, New Opportunities**

WIYN has continued to invest in new, cutting-edge instrumentation. Examples include the popular new NIR imager WHIRC (available since 2009, provides high-resolution (0.1 arcsec/pixel) imaging) and a soon-to-be delivered HexPak optical IFU developed at the University of Wisconsin. When combined with our other core instruments like the Hydra multi-fiber positioner, the recently upgraded and improved Bench Spectrograph, and the high-resolution Mini-Mosaic optical imager, these new instruments deliver a diverse and comprehensive set of capabilities to the WIYN and national communities. If one further considers the powerful new instruments available on the Mayall telescope (NEWFIRM, KOSMOS, upgraded Mosaic, FLAMINGOS), the combination of the two 4-m class telescopes on Kitt Peak offer truly amazing opportunities.

Looking ahead into the future, a key component of the WIYN instrumentation is the One-Degree Imager (ODI). This state-of-the-art camera will deliver both wide field coverage and excellent image quality via its use of orthogonal transfer arrays (OTAs). ODI complements other planned wide-field cameras in uniquely supporting narrow-band filters. The WIYN partners have already invested roughly \$11M in the development of this camera, supplemented by a \$1.6 million award of NSF TSIP funding in 2006. The delays in completing ODI are well documented and center almost exclusively on unexpected problems with detector development. With a new NOAO-led management team in place since late 2010, the project has been re-scoped and refocused and is now on track for delivering a camera featuring a partially-filled focal plane (with 14-16 OTAs rather than the 64 required for the completed instrument) to the telescope in the second half of 2012. This version of the camera (dubbed pODI) will allow the instrument team to test all aspects of the final fully-populated version of ODI, work out unforeseen problems by commissioning a less complicated version of the camera, and to provide proof-of-concept for the overall design. In addition, pODI will provide a highly useful science instrument on an interim basis, delivering a filled field-of-view of either 24 or 30 arcmin on a side, depending on the final configuration of the available OTAs. The WIYN consortium is continuing to pursue additional (non-NSF) funding to complete the full ODI camera in the next two to four years. In the short term, however, the availability of pODI will further enhance the ability of both the WIYN partners and the national community to do cutting-edge science by providing a high-resolution imager with a substantially wider field than is currently available on WIYN.

## Importance for Students

Access to WIYN is a central component of the graduate student training for each of the three university partners. The majority of graduate students who go through our programs observe on the telescope at some point during their studies, and for a large fraction (more than 30 in the past dozen years) WIYN data represents a significant part of their thesis research. The ability to get observations with WIYN also enhances the viability of proposals written by our students for time on non-optical facilities (e.g., NRAO, Spitzer, Chandra). Furthermore, the hands-on experiences that our students receive by working at WIYN are highly valuable throughout their subsequent careers.

Each of the three WIYN university partners also emphasizes research opportunities for their undergraduate students. It is very common to find undergraduates at the telescope running an instrument under the supervision of a faculty member. At Indiana University, for example, we typically take between four and eight undergraduates to WIYN each year; the numbers at Yale and Wisconsin are comparable.

Finally, a large number of graduate students from the general US community benefit from access to WIYN. Examination of the scheduled observing programs assigned through the NOAO telescope allocation process reveals that a large fraction are supporting thesis projects. **Whether being used by undergraduates or graduate students, WIYN students or students from Georgia Tech or Vanderbilt, a key core constituency of WIYN users are students.** Educational opportunities are an important aspect of what WIYN provides.

## Importance of General Access

While WIYN is a critically important component of the research programs at the three partner universities, it should also be stressed that WIYN provides a substantial fraction of the 4-meter class nights available to the US community in the northern hemisphere. That is, the scientific impact of the facility is enhanced by having 40% of the telescope time allocated through a competitive national proposal process. The admixture of programs from a large national pool diversifies the scientific output and enriches the reputation of the observatory. A dramatic reduction in funding to NOAO would jeopardize this essential aspect of US astronomy. The ability to obtain telescope access via a peer reviewed proposal process regardless of the home institution of the astronomer is a core tenet of the national observatory system.

## WIYN Science – Addressing Frontier Science Questions

In its request for community input to the Portfolio Review Committee, the NSF stressed the need for all contributions to directly speak to how a given facility could be used to address the key science questions highlighted in the Astro2010 Decadal Survey document *New Worlds, New Horizons in Astronomy & Astrophysics* (NWNH). In the case of WIYN, this is simple! Science currently being carried out with WIYN is already addressing a number of problems given special attention in NWNH. This includes areas such as time-domain astronomy, astrometry, cosmic origins (e.g., galaxies, large-scale structure, fossil record of galaxy assembly, stars), chemical evolution of stars and galaxies, nature of exoplanets, etc. The superb image quality of WIYN, together with the excellent suite of instruments currently available and anticipated, brings a wide range of important science questions within reach. Here we briefly mention just a few specific examples:

### **Exoplanets at WIYN**

The WIYN telescope plays an important and critical role in exoplanet validation for the NASA Kepler mission. The extremely good native seeing, combined with speckle imaging, allows Kepler exoplanet candidates to be vetted at a high reliability level. No other telescope plus instrument combination currently in existence can provide the diagnostic level of high resolution imaging that WIYN provides. This capability will **continue to be important** for future exoplanet missions such as TESS and WFIRST.

### **Gravitational Lensing Studies of Galaxies and Galaxy Clusters with WIYN**

Measurements of the growth of massive structures over the redshift range  $0 < z < 1.5$  constrain the dark energy and can provide fundamental tests of the validity of General Relativity on large scales. Measurements of the mass function for clusters, particularly the abundant clusters with  $M_{\text{vir}} < 2 \times 10^{14} M_{\text{sun}}$ , requires the ability to resolve large numbers of galaxies behind clusters of galaxies that can span up to a degree on the sky. Because faint galaxies are small, achieving a source density of 60 resolved galaxies per square arcminute means measuring shapes for galaxies whose half-light radii are only  $\sim 0.15''$ . This can only be reliably done with deep exposures in seeing of  $0.5''$  or better. WIYN's excellent seeing and the field of view and orthogonal transfer capability of ODI are unique in offering the possibility of measuring masses for clusters at  $z < 0.5$ , where the field of view required makes mapping with HST prohibitively expensive. By measuring the intrinsic shape distribution as a function of size and magnitude over tens of square degrees, WIYN and ODI will also provide the best data to calibrate the systematic uncertainties to the shear correlation function due to objects at the resolution limit of LSST.

### **Time Domain Astronomy: SN 2011fe in M101**

Studying time-variable phenomena has been a focus for several scientists in the WIYN consortium. Flexible scheduling options and quick switches between instruments make WIYN particularly effective for target-of-opportunity observations of rare and/or fleeting events. Here we give one very recent but high-impact example. The nearby Type Ia supernova 2011fe was discovered on August 24, 2011. Its importance for calibrating the absolute luminosity of all Type Ia supernovae, and hence the distance scale of the universe, was immediately recognized. By the end of the afternoon on the following day, WIYN and NOAO scientists had developed a target-of-opportunity observing plan that would yield a high-quality NIR light curve for this once-in-a-lifetime event. This plan was approved by the WIYN President and went to the telescope that same day. Data were obtained nightly in a manner that was minimally obtrusive to the scheduled observers until the source was no longer observable in the west in evening twilight. The collaborative and cooperative nature of the WIYN consortium allowed for this type of immediate access to the telescope, and has resulted in a significant science result that will have lasting impact on the field.

### **Galactic Archeology – Spectroscopy of Stellar Streams**

Understanding the formation and accretion history of the Milky Way is a key area of research currently receiving much attention. The stunning discoveries made in recent years of coherent tidal streams of stars in the halo of the Milky Way has opened up an entirely new area of study. The clear need for doing wide-field, multi-object spectroscopy of the stars in these candidate streams is a key capability that WIYN currently provides. These spectra provide both kinematic information that help to constrain the locations of the streams in velocity-position phase space, as well as metal abundances that can provide clues about the nature of the accreted galaxy that was the progenitor of the stream. The combination of

Hydra (one degree field-of-view) and the upgraded bench spectrograph (higher throughput) on WIYN are the perfect combination for helping to disentangle the complicated picture of the Milky Way's accretion history. Until the completion of BigBOSS, WIYN will continue to be the premiere northern-hemisphere facility available to US astronomers for this type of work.

**In summary**, the university astronomers in the WIYN partnership continue to strongly support the WIYN Observatory because it provides a key component of the system of telescopes available to them for research. In particular, the WIYN telescope serves as an essential platform for

- long-term observational studies, including survey projects
- graduate and undergraduate student research projects & undergraduate education, and
- new PI instruments.

Significant access to WIYN elevates the national standing of the astronomy programs of the WIYN universities. Just as importantly, the healthy oversubscription rate on the public side testifies to its comparable role in the broader community. Our collaboration with NOAO to run the WIYN Observatory has been a successful, cost-effective way to provide telescope access to multiple constituencies. **The loss of NOAO as a partner would severely damage and likely place at risk our ability to operate WIYN.** We urge the NSF Portfolio Review Committee to place considerable weight on the value of this high performance wide-field telescope and of its enabling of scientific productivity for a broad constituency as you struggle to achieve the proper balance in the distribution of national funding for astronomy.

Sincerely yours,



John J. Salzer, President  
On behalf of the Board of Directors, WIYN Inc.

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