CTIO – Modernization and New Capabilities Ahead

Alistair Walker

In response to the report of the NSF Senior Review, NOAO is strongly reaffirming its commitment to keeping the telescopes and instruments at Kitt Peak National Observatory (KPNO) and Cerro Tololo Inter-American Observatory (CTIO) performing optimally, and to providing state-of-the-art facilities for the user community. In this article, I summarize telescope-related activities planned for the near future at CTIO. Activities can be broadly divided between New Capabilities, and Modernization & Infrastructure improvements, so I will deal with these two topics in turn. Regular progress reports will appear in future editions of this *Newsletter*, and on our Web site.

New Capabilities

The evolution of the System of telescopes and instruments available to the US astronomical community via NOAO will be guided by the report of the Renewing Small Telescopes for Astronomical Research (ReSTAR) committee, due at year-end. This report will also specifically help us plan the instrumentation future for the NOAO-operated telescopes, and can be expected to influence the developments presented below.

Regular readers of this *Newsletter* will be familiar with two major instruments that will transform the imaging capability of the Blanco 4-meter telescope: NEWFIRM and the Dark Energy Camera (DECam).

NEWFIRM is a wide-field near-infrared (IR) imager that is beginning science operations at the Mayall telescope on Kitt Peak. After 2.5 years (i.e., early 2010) we plan to move NEWFIRM to the Blanco telescope, likely for a similar period of time. Our plans are described in detail in *www.noao.edu/ets/newfirm/NEWFIRM_info.pdf*. NEWFIRM will be mounted at the *f*/7.5 RC focus of the Blanco telescope, and will alternate with Hydra at that focus.

DECam is a very wide field CCD imager that will replace the Mosaic imager at prime focus of the Blanco telescope in late 2010. As a facility instrument, it will be available for all users; however, 30 percent of the time between September and February will be devoted for five years to the Dark Energy Survey (DES), a project to be carried out by the Fermilab-led consortium that is building the instrument.

Both NEWFIRM and DECam will come with data-reduction pipelines that will deliver flat-fielded frames, together with astrometric and photometric information, to the NOAO Science Archive (NSA). Additionally, after a 12-month proprietary period, the similarly processed data frames from the DES will be available from the NSA. Following the completion of the DES in 2015, high-level science products such as object catalogs will also be made generally available from the NSA.

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Credit: T. Abbott

CTIO - Modernization and New Capabilities Ahead continued

The Southern Astrophysical Research (SOAR) 4.1-meter telescope has an exciting instrument program as well (see *www.soartelescope.org/release/06observing/eng_observing/instruments/main_instruments.html*). Toward the end of 2008, we expect both the Goodman Spectrograph and the Spartan IR imager to become available, with the IFU spectrograph to follow in 2009. Depending on arrangements made with Gemini, the high-resolution IR spectrograph Phoenix will be either moved to or shared with SOAR, likely in late 2008.

These instruments will be followed to the telescope by the SOAR Adaptive Module (SAM), which is now in construction (see the related article in this *Newsletter*). Finally, the SOAR TELescope Echelle Spectrograph (STELES), a high-resolution optical spectrograph being built in Brazil, is estimated to be available for users in 2010-2011. SOAR can mount all these instruments simultaneously at its Nasmyth and folded-Cassegrain ports, together with the present instruments, the SOAR Optical Imager (SOI) and the Ohio State InfraRed Imager/Spectrometer (OSIRIS).

The small telescopes at CTIO continue to be operated by the Small and Moderate Aperture Research Telescope System (SMARTS) consortium. The focus of instrumentation activities in the near-term is at the 1.5-meter telescope where, led by Andrei Tokovinin, we are planning to install a high-resolution optical spectroscopic capability during 2008. This initially will be a fiber feed to the Blanco Echelle spectrograph, which would sit on the floor of the 1.5-meter coudé room, but a definitive instrument could be a updated version of the Bench Mounted Echelle (BME) we offered some years ago. Other instrument possibilities for this telescope include replacing the RC spectrograph with a high-throughput multi-object optical spectrograph. Initial discussions among consortium members on this subject are underway.

We are also attending to a number of items that can best be classified as "instrumentation infrastructure." Apart from trying in the short term to improve the reliability of our present instruments by attending mostly to computer and controller issues, we intend to phase out the Arcon controllers on all instruments (except Mosaic) and replace them with MONSOON controllers.

Finally, we would like to install a laser calibration system and new high-tech flat field screen at the Blanco telescope. These developments are led by Chris Stubbs (Harvard University), and a similar system is expected to be first implemented on Pan-STARRS. To guide our activities in this area, we have formed a Calibration Working Group, with representation from CTIO, SOAR, DES and the community. This group will also consider the suite of auxiliary instruments needed on Cerro Tololo and Cerro Pachón that are indispensable for the operation of a modern observatory, and which provide essential metadata for the archived data, such as DIMMS, all-sky cameras, instruments to measure ground-layer turbulence, and weather stations.

Blanco Telescope Modernization

Our CTIO modernization activities mostly involve the Blanco telescope. We have begun a project to replace the Telescope Control System (TCS) and encoders with a modern implementation based on the system at SOAR. This project can be considered a milestone for the TCS being developed for the Large Synoptic Survey Telescope (LSST). An expert team, involved in both the SOAR and LSST projects, is engaged in this effort, which is mostly software. Development and installation can proceed in parallel with present operations, with full switchover to the new system in early 2010.

To aid in installation and maintenance of new large instruments such as DECam and NEWFIRM, we will build a clean room in the ex-coudé room of the Blanco dome. A number of projects can be classed as repairs and maintenance. Chief among these is redesigning and replacing components of the primary mirror radial supports, which have been delaminating from the primary mirror since the telescope was built. This task requires a major shutdown to re-glue. Other more facility-oriented activities include a new control system for the elevator, new telescope and instrument UPS, and attending to a multitude of maintenance issues that has been set aside for the last few years due to lack of funds. We will also accelerate replacement of computers and peripherals.

Attending to hardware and software issues as outlined above requires considerable staff time and energy, which will be obtained both from existing CTIO staff and via outsourcing. However we are also very aware that our Telescope Operations staff, in particular, has suffered attrition over the last several years, and to operate our facility properly we need to hire into all the critical engineering skills—electronics, electrical, optics and software. We have made four new technical hires in the past few months. We also need to increase the scientific staff devoted to telescope operations and instrument development, and advertisements have been placed.

With this increased commitment to operating the NOAO telescopes as a critical part of the US system of facilities, we are confident that there are exciting times ahead for both our users and our staff. NL

CTIO Observing Modes

Alistair Walker

The scientific productivity of an astronomical facility is a function of several factors: the telescope size and performance, the instrumentation, the quality of the observing site, and how the scientific programs are matched to all of the above.

We have been considering how to enhance the observing mode options at the Blanco 4-meter and SOAR 4.1-meter telescopes to allow execution of science programs that are currently run rather inefficiently, or are not possible at all. We present what we plan to offer for Semester 2008B —your input over the next few months prior to the proposal announcement on 1 March 2008 will guide our thinking and be very much appreciated.

I will also discuss how we will go about investigating whether we can offer options that would provide time or cost advantages to those scientists who might not presently propose due to the geographical remoteness of CTIO.

Some definitions - At the present time, our users are offered only *classical observing* (astronomer at telescope) on the Blanco and SOAR telescopes. Other possible modes include *service observing*, here defined as a program carried out at a pre-scheduled time by a local staff member, and *queue observing*, where the program can specify observing conditions and it is executed, also by local staff, only in those conditions or better. Additionally, for *remote observing,* the astronomer operates the instrument and some of the telescope functions from an off-mountain site, perhaps their home institution, instead of being at the telescope. It is useful to differentiate between *active* and *passive remote observing*. The latter, also called *eavesdropping* or *over-the-shoulder observing*, would be the situation when the astronomer participates over a video link, communicating with an operator/service observer (or graduate student!), but does not directly control the telescope or instrument.

More details, and what others do - Classical observing at Blanco and SOAR will surely remain the choice for many programs, for example for programs that are complex, or where real-time control by the astronomer is a priority, or where student training is an important part of the project. We intend to continue to schedule the Hydra spectrograph on the Blanco in classical mode only, because of the complexity of the instrument and its operation. Classical mode discriminates against small programs or non-conformist programs such as time domain and target-of-opportunity astronomy; however, the alternate modes have staffing and cost implications as more people are required to handle both the actual observing and the increased observing infrastructure.

Large telescopes and their instrumentation are generally complex. The staff levels required to support queue operation at the Very Large Telescope and Gemini are very high, and sophistication is needed all the way from the proposal to the image archive.

Two somewhat more modest examples are worth presenting. The first example is the Small and Moderate Aperture Research Telescope System consortium operating the small telescopes on Cerro Tololo with a mixture of classical, service and simple queue (photometric or non-photometric) for both NOAO users and consortium partners. Here the service/queue observer also operates the telescope, with pre- and post-observing astronomer support off-site.

The second example is of a 4-meter class telescope, the Telescopio Nazionale Galileo (TNG), which is perhaps closer to what might be achievable for the Blanco and SOAR telescopes. The TNG is a 3.5-meter telescope on La Palma, and is operated 50 percent classical and 50 percent non-classical. The non-classical observing is mostly queue observing, with multiple "hot" instruments, very similar to the situation that SOAR will be in by late 2008 or early 2009. Eight support astronomers spend almost all their work hours supporting telescope operations at the TNG. While CTIO is ramping up its scientific staff support level, and we have 30 percent of SOAR time rather than 100 percent, this level of support will not be easily available.

Remote observing experiments - Remote Observing is the observing mode of choice on the SOAR telescope for the university partners Michigan State University and University of North Carolina. Both have constructed remote observing rooms on campus, and once astronomers are familiar with the telescope and equipment, observing proceeds very efficiently from the point of view of both observers and observatory.

A telescope operator is still present at the telescope for safety reasons, with communication between operator and observer by video or computer. Generalizing this concept to the NOAO community clearly involves issues of training. For example, one could stipulate that an observer must have previously observed classically at SOAR before observing remotely would be permitted. Also, from experience with SOAR, solving network and firewall problems is time-consuming. Given the additional requirement of good bandwidth and preferably video equipment to allow face-face communication, the best solution may be setting up a small number of remote observing centers that are geographically dispersed. Over the next few months we will gain experience by connecting up remote observing center at NOAO North in Tucson and go from there. We have ordered a multi-user Polycom to upgrade the present single-user system in the Blanco control room, plus a better television monitor.

Service observing for 2008B? - We propose to offer service observing on both Blanco and SOAR beginning in semester 2008B. Instruments offered would be restricted to Mosaic and the Infrared Side Port Imager on the Blanco, and the SOAR Optical Imager and Ohio State Infrared Imager/Spectrometer on SOAR. The service observing would be scheduled in advance on fixed nights, and the number of nights available will depend on user demand and availability of staff, both those doing pre- and post-observing tasks and carrying out the observing itself. Data frames are expected to be able to be accessed post-run by the Principal Investigator (PI) from the NOAO Science Archive. PI's and Co-Investigators will be able to participate via our upgraded video link.

We wish to particularly encourage short scientific programs of length from an hour to 1-2 days. Initially, we anticipate not offering longer programs in service mode, unless they were time domain in nature, such as one night per month over a semester.

We would like to hear from people who would plan to write proposals for short or time-domain programs. More general comments on any of the above will be of great value to aid our planning. Send your comments to me at *awalker@noao.edu*.

Laser Guide Star System for SAM Passes PDR

Nicole van der Bliek & SAM team

The SOAR Adaptive Module (SAM) project successfully passed the Preliminary Design Review (PDR) for its Laser Guide Star System. SAM will be an adaptive optics instrument for SOAR, working at visible wavelengths. It will primarily be a ground-layer adaptive optics (GLAO) instrument, using a low-altitude, Rayleigh laser guide star (LGS).

SAM will deliver improved-seeing images with a typical FWHM of 0.3 instead of 0.7 arcsec, over a fairly large field of view (3x3 $arcmin^{2}$). Two sensitive natural guide star probes for tip-tilt sensing assure complete sky coverage. The laser itself operates at ultraviolet wavelengths, and because the resulting power density encountered in the sky it is not hazardous to the eyes or skin, it should not require spotters for aircraft avoidance.

The PDR review panel consisted of Gabriel Perez and Maxime Boccas (Gemini Observatory), Steve Heathcote (SOAR), Michael Lloyd-Hart (University of Arizona) and Thomas Stalcup (MMT), chair. Francois Rigaut (Gemini Observatory) participated in the review as observer, and Bob Fugate (formerly of the Starfire Optical Range), who unfortunately could not be present at the September 28 review, read the presentations and provided written comments.

The panel was pleased with the documentation and presentations provided by the team, and in general approved the design of the LGS system. Their immediate feedback was very constructive and to the point, particularly as all committee members (except for the "customer" Steve Heathcote) have extensive experience with the design and operation of existing LGS systems. The committee will provide the team with a written report containing more detailed comments.

Design and fabrication of the SAM main module have been underway since the end of 2005, following the PDR of the main module on 2 December 2005. Integration and alignment of the main module will start in 2008, and commissioning, operating initially in Natural Guide Star (NGS) mode, is expected to take place mid-2009.

In parallel to the integration and alignment of the main module, the team will proceed with design and fabrication of the LGS system. This includes the Laser Launch Telescope, Beam Transfer Optics and a Laser Box, containing the laser and a beam expander. It is anticipated that following the commissioning of the NGS mode of SAM, the team will proceed with the integration and alignment of the LGS system. Commissioning of the LGS mode will take place in 2010.

Five Years of ISPI

Nicole van der Bliek

September 2007 marked five years since the Infrared Side Port Imager (ISPI) saw first light at the Blanco 4-meter telescope at Cerro Tololo. ISPI is a near-infrared (IR), wide-field imager with a 10.25x10.25$arcmin^2$ field of view and 0.3-arcsec pixels. ISPI is equipped with the broadband $YJHK_s$ filters and a set of narrowband filters. A full description of ISPI can be found on the ISPI Web pages at *www.ctio.noao.edu/instruments/ir_instruments/ispi*.

During these five years, ISPI has been used for 287 nights to conduct more than 100 observing programs. These included several programs to observe star-formation regions, like the search for young, Jupiter-mass objects by Allers et al., 2006 (*ApJ* 644, 364), observations of the Galactic bulge and Galactic Center, and observations of red-clump stars to determine the distances to clusters in the Magellanic Clouds (Grocholski et al., 2007, *AJ* 134, 680). ISPI was also used for various high-redshift programs like the Multiwavelength Survey by Yale-Chile (MUSYC; see more below), as well as for target-of-opportunity observations such as a program by Rhoads, Fruchter et al., to observe afterglows of gamma-ray bursts.

ISPI has been used to go as deep as J=22.5, H=21.5, and K_s=21 (cf. Quadri et al., 2007, *AJ* 134, 1103). The efficiency of the instrument is about 70 percent for observations in bands with a low sky background, the J band and the narrow bands. For background limited observations in the K band, when several co-adds are being used, the overhead goes up to 50 percent, and in case of extended objects, when sky frames have to be taken outside the ISPI field of view, the overhead can be as large as 100 percent.

Some highlights of results obtained with ISPI are:

MUSYC: deep near-infrared imaging and the selection of distant galaxies (Paulina Lira & Ryan Quadri)
MUSYC has imaged 1.2 square degrees spread over four fields in UBVRIzK down to R~25 and K~22 (AB). MUSYC is unique among the current generation of wide-deep surveys in having been optimized for the study of the high-red shift Universe at z~2-4 (Gawiser et al. 2006, ApJS 162, 1). Information at near-IR wavelengths is essential as these bands provide very useful information for photometric redshifts and traces the rest-frame optical light. Each 30x30 $arcmin^2$ field was imaged using ISPI to a magnitude limit of K_s~22 and additionally the central 10x10 $arcmin^2$ regions were observed in JHK to a limit ~22 (Blanc et al., 2007 in prep.; Quadri et al., 2007, *AJ* 134, 1103). The IR sources were used to construct a mass-selected sample of 294 galaxies

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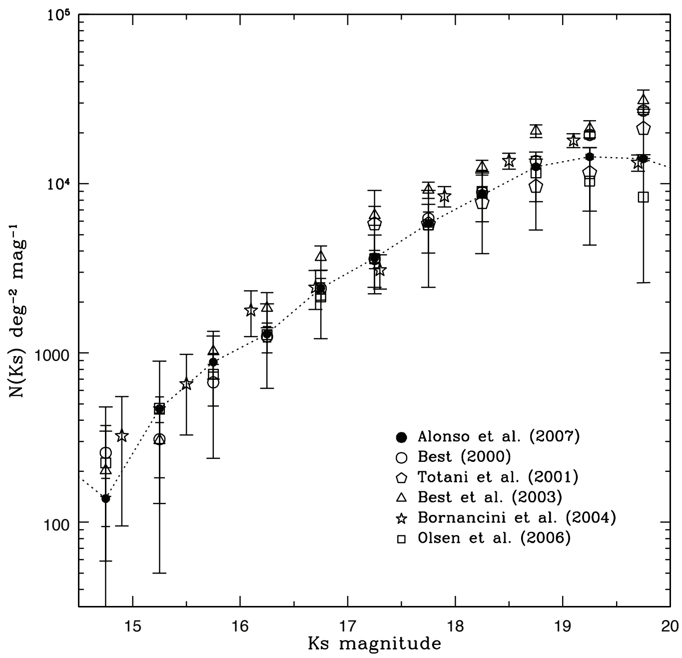
Five Years of ISPI continued

with $M>10^{11}\ M_{sun}$ at $2<z<3$ (van Dokkum et al., 2006 *ApJL* 638, L59). Seventy percent of these galaxies classify as Distant Red Galaxies (DRGs), which represent a mix of passive galaxies with low star-formation rates and dusty active galaxies (Kriek et al., 2006, *ApJL* 649, L71). The survey team determined the rest-frame optical luminosity function of K-selected galaxies at $2<z<3.5$ and found them to be 1.2 magnitudes brighter than in the local universe, but with a space density five times smaller (Marchesini et al., 2007, *ApJ* 656 42). A clustering analysis found that they reside in massive dark matter halos of 5e12 M_{sun} while the subset of DRGs reside in ever more massive halos of 3e13 M_{sun} (Quadri et al., 2007, *ApJ* 654, 138).

The XMM-Newton Distant Cluster Project's Southern Cluster Survey (SCS) with Mosaic-2 and ISPI
(René Fassbender, Joe Mohr, J. Song, W. Barkhouse, and H. Boehringer)

We successfully used the ISPI camera in September 2006 to complement Mosaic-2 follow-up observations of X-ray selected galaxy cluster candidates in the South Pole Telescope (SPT) survey region. We obtained ISPI H-band images of a total of 25 high-redshift galaxy cluster candidates with no or only a weak optical counterpart in the shallower Mosaic bands. A preliminary photometric analysis confirmed about 18 systems at redshifts z>~0.8, of which 6-10 candidates are expected to be at redshifts beyond unity. The ISPI observations have been invaluable for pinning down the high-redshift tail of the cluster population for which we have submitted spectroscopic follow-up proposals to Gemini South and the Very Large Telescope. The successful start of the project will be continued this fall toward the final goal of compiling a large sample of high-redshift clusters for detailed structure formation studies.

Target-of-Opportunity observations of GRBs
(David Bersier)
GRB 050401 was observed with ISPI as part of a multi-observatory campaign (European Southern Observatory, CTIO, United Kingdom Infra-Red Telescope (UKIRT), Nordic Optical Telescope and Telescopio Nazionale Galileo on La Palma). This burst, at a red shift z=2.9, has a very high column density (inferred from X-ray data and from the Lyman-alpha line seen in the optical spectrum) but low extinction. The infrared data (obtained at CTIO with ISPI and at UKIRT) provide strong constraints on the level of extinction in this burst. Fitting the optical/near-IR energy distribution yields a value of the visual extinction A_V that is much lower than what is inferred from the X-ray spectrum. One strong conclusion based on the spectral energy distribution is that the dust-to-metals ratio has to be very low. The high metal column density and little extinction may be interpreted as possible evidence of dust depletion.



Number of galaxies as function of magnitudes per unit area in the neighborhoods of triplets of quasars.

Multicolor photometry of the neighbors of high-redshift triplets of quasars
(Maria Victoria Alonso)
In 2006, a team formed by Maria Victoria Alonso (Observatorio Astronomico, Universidad Nacional de Cordoba (OAC), Argentina), Ilona Söchting (Gemini), Georgina Coldwell (OAC), Malcolm Smith (NOAO/AURA), Diego Garcia Lambas and Carlos Bornancini (OAC) obtained multicolor photometry of the neighborhoods of high-redshift triplets of quasars using ISPI and Mosaic. The existing studies of quasar environments suggest their association with forming structures, marking merging clusters and filaments. Consequently, groupings of quasars can be expected to trace regions of extraordinary activity. Preliminary results of the number of galaxies as a function of the magnitudes per unit area in the neighborhoods of the studied triplets of quasars are shown in the figure (from Alonso et al., 2007, *MNRAS*, in prep.). These results allow us to check the characteristics of our catalog in both homogeneity and depth. These counts were compared with the results of Best (2000, *MNRAS* 317, 720), Totani et al., (2001, *ApJ* 559, 592), Best et al., (2003, *MNRAS* 343, 1), Bornancini et al., (2004, *AJ* 127, 679), and Olsen (2006, *A&A* 456, 881), and showed excellent agreement. Our catalog is complete until $K_s \approx 19$, and it will allow us to analyze the over-densities and the galaxy population in the neighbors of the triplets of quasars.