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SELECTING, SCHEDULING AND CARRYING OUT OBSERVING PROGRAMMES AT THE LARGE BINOCULAR TELESCOPE

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Abstract. The diverse LBT partnership allocates time through various partner-based mechanisms. Each of the four major partner groups receives blocks of observing time, with the fraction of the total proportional to its share of investment in the Observatory. The allocation is currently about one week per lunation per partner, but the week centered on full moon is for technical time devoted to commissioning of telescope and new instrumentation. The partners typically observe their own programs in queue fashion, with strong support from LBTO astronomers.

1. The Telescope and Its Instruments

The Large Binocular Telescope (LBT) is unique among telescopes in providing two optical trains with 8.4m diameter primary mirrors on a common mount. There will be three pairs of facility instruments for observing the same field of view on each side. They can be used as like pairs with identical configurations, as like pairs with different configurations, or as mixed pairs. The other main mode of observation is coherent combination of the beams from the two sides in one of two Fizeau interferometers, in mid-infrared and near infrared. The f/15 secondary mirrors are adaptive, providing compensation for atmospheric turbulence for the pair of near-IR facility imager/spectrographs and the interferometers. The Italian team integrating the system has demonstrated very high Strehl ratios on sky with their system.

The facility instrument complement consists of optical wide-field imagers, optical imaging multi-object spectrographs, and near-IR imaging multi-object spectrographs. The Large Binocular Camera (LBC) imagers produced by the Italian partners are at prime focus. Each is a 36-megapixel CCD mosaic. One is optimized for performance in the UV through green, the other in yellow through deep red. The optical spectrographs from Ohio State, MODS 1 and 2, are mounted at the direct Gregorian foci. Each is dual-beam, providing the option for full optical band coverage, or blue or red only. A cassette can be loaded daily with laser cut multi-object masks that are robotically inserted into the focal plane. LUCI 1 and 2 from the German partners can take near-IR images and spectra at seeing-limited and diffraction-limited scales. They are mounted at bent Gregorian focal stations. A cassette of custom-cut multi-object masks is inserted cold into the instrument, with masks robotically selected for observation. One cassette with 23 masks is loaded per lunation, covering three partner observing runs, as discussed below.

As of this writing, observers may choose from the pair of LBCs, MODS 1 and LUCI 1. MODS 2 and LUCI 2 are on track for lab acceptance in the last quarter of 2012. When they are fully commissioned, observers will have the option of choosing any combination of instruments, one from the left side and one from the right. The most straightforward observational mode will be 12-meter mode, where the same object(s) is observed with the same instrument and configuration on both sides. Any dithering will be done with the mount, and the exposure times will be identical for the instrument pair. The other extreme is using one instrument on one side and another on the other, with different MOS masks set at different position angles. The two sides can be run asynchronously, with small dither motions performed independently by each optics train, until the parallel sequences complete. All facility instruments are available all the time on "hot standby". The focal stations can be addressed by establishing the desired optical train. The prime focus cameras, AO secondaries, and tertiaries are all on swing arms to take them into and out of the telescope beams. The telescope can be dynamically rebalanced by pumping fluid among various storage tanks on the mount structure. The longest change takes about 20 minutes; rotation of the tertiary to address a different bent Gregorian port is a matter of minutes.

Two instruments are being developed to combine the beams coherently in Fizeau mode. The LBT Interferometer (LBTI) covers 2 – 11 microns with two cameras, and has a nulling mode at longer wavelengths. It has recorded first fringes with both AO loops closed, and achieved fringe contrast very close to theoretical predictions. The plan is for science data collection for circumstellar environments by spring of 2013. LINC-NIRVANA will cover 1-2.5 microns, with both ground-layer and high-layer AO correction prior to the fringe tracker and science camera. The team will exercise one ground-

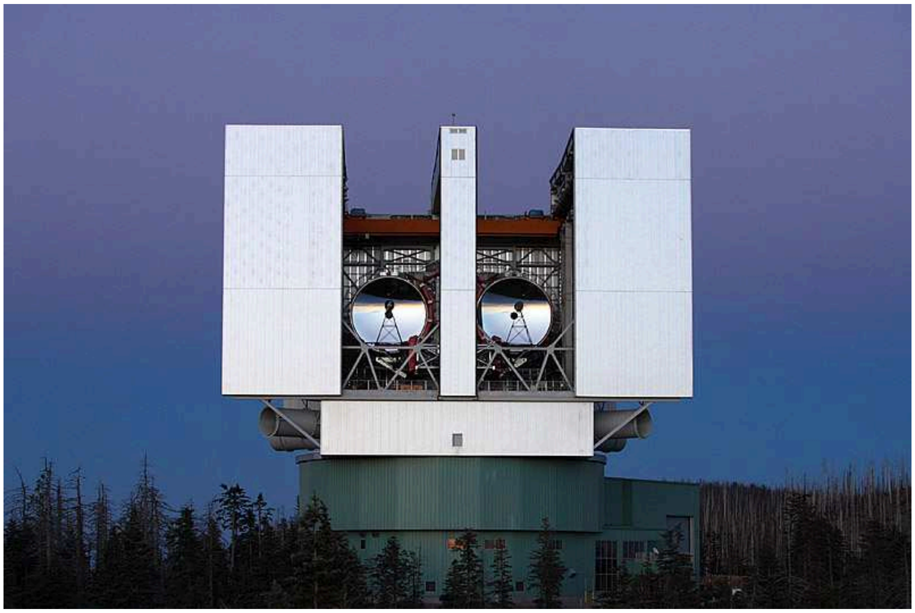

Figure 1. A view of the Large Binocular Telescope on Mt. Graham through the open enclosure. Image courtesy of LBTO.

layer wavefront sensor in early 2013, with the goal of deployment of the full instrument in 2014.

There will also be a PI instrument PEPSI planned for commissioning in 2013 from the AIP in Potsdam that is a fiber-fed, bench-mounted echelle spectrograph with high dispersion and high stability. Its science goal is long-term synoptic monitoring of stellar activity, but the PI also intends to make time available to other observing partners for their programs.

2. Organization of the Observatory

The Large Binocular Telescope Observatory (LBTO) is a collaboration among institutions in Arizona, Italy, Germany, and the US. The fractional share of observing time for each partner institution is equal to the share it provided for construction plus the initial instrument complement. That fraction is also equal to the fraction of the annual operations budget supported by each institution.

The partners are as follows. The concept for the LBT was initially developed by the University of Arizona and the Arcetri Observatory in Florence, Italy, starting in the 1980s. Today, the University of Arizona is the interface for the 25% share belonging to the entire state university system, including Arizona State University and Northern Arizona University. Arcetri is one participant among the whole group of Italian astronomical research institutes with 25% share supported by INAF, the Istituto Nazionale di Astrofisica. The German 25% share is represented by the LBT Beteiligungsgesellschaft, which is composed of the Max-Planck-Institut für Astronomie (MPIA) in Heidelberg, the Zentrum für Astronomie der Universität Heidelberg, the Max-Planck-Institut für Radioastronomie in Bonn, the Max-Planck-Institut für Extraterrestrische Physik in Munich and the Leibniz Institut für Astrophysik Potsdam. The Ohio State University (OSU) has a 1/8 share. Research Corporation for Science Advancement (RCSA) supports the final 1/8 share on behalf of the University of Minnesota, the University of Notre Dame, the University of Virginia (UVa), the University of Arizona, and the Ohio State University.

3. Observing Time Allocation

At the time of this writing, the observatory is in transition from completion and commissioning to science operations. Observations are carried out for ten months of the year. Of that time, 60% is allocated to partner science and 40% to commissioning of the telescope and newly provided instruments. That split will be trending toward a higher fraction for partner science in coming semesters. Two months of the year are the summer monsoons in July and August. These typically have less than 30% workable hours, and are used for major upgrades and maintenance projects with daytime efforts that do not leave the telescope usable for nighttime operations.

The Director assigns nights in blocks to each major partner on a semester basis, with the semesters running from August 1 – January 31 and February 1 – July 31. (OSU and the RCSA partners are assigned time together in a single block.) There are three partner science blocks per lunation plus one commissioning block centered on full moon. A partner science block therefore averages six – seven nights in length, alternating among grey time with moon at the end of the night, dark time, and grey time with moon at the beginning.

The partnership has diverse scientific goals, and the partners put varying procedures in place to select and forward observing programs. They each select their own programs, and there is no consortium-level TAC. For INAF, the telescope is a national facility, so they issue national calls for proposals on a semester basis, which are read and ranked by a nationally constituted time allocation committee. The University of Arizona solicits proposals within the Arizona system (formerly by trimester but now by semester) and has a multi-institutional TAC for proposal selection. Their time allocation has a complexity, in that they have accelerated the commissioning of LBTI by allocating some technical nights within their science time blocks. That

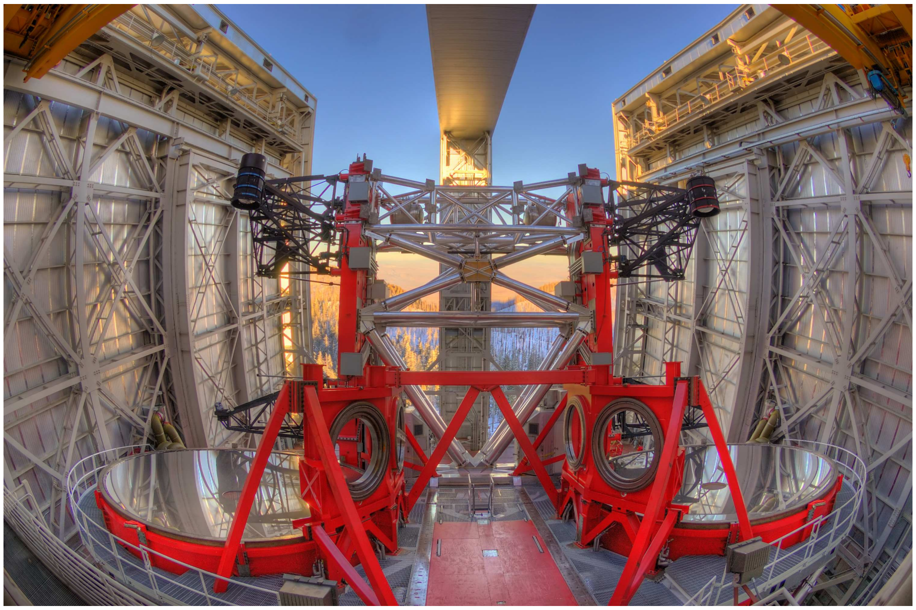

Figure 2. Interior of the Large Binocular Telescope (prior to installation of the main instrument complement) looking out at sunset. Image courtesy of Wiphu Rujopakarn and LBTO.

approach was required because of the higher priority claims on off-the-top commissioning time by facility instruments and telescope performance upgrades. The competition in these TAC processes heavily oversubscribes the time available.

At OSU, they have a call for proposals every semester, once the LBT schedule of partner science blocks is known. They have a TAC of four people evaluating the proposals and then issuing rankings (basically, Band 1, 2 or 3). Since they received some support for the building of MODS from the US National Science Foundation, a certain number of their nights will be made available to the US astronomy community through proposals to the NOAO TAC.

The RCSA partners have diverse approaches to time assignment. At UVa they have a TAC that consists of two faculty members. They solicit proposals once per semester, after the initial schedule is released. They make sure people are aware of the time and equipment constraints, so that proposals are realistic. Then they assign time in order of rank. They make small adjustments to assignments during a semester according to the priority ranking and completion statistics.

Notre Dame operates differently. To date, they've mostly had two groups using their time, so they've essentially divided the time, with some consideration for who had some time pressures for observations. Largely they reevaluate the needs before each OSU/RC run. That gives them a great deal of flexibility, especially for transient studies. Programs are approved by the individual PIs. The priority is set by consensus, based on who has a more pressing need, who has gotten more time recently, and what grad student projects need to make headway. The matching to the time available is done on a very rough basis, because we work within the OSU/RC merged queue. They therefore do not receive a set fraction of time being set aside per run, since that gets assessed on an annual basis, roughly. Notre Dame astronomers submit requests for a bit more time than they would nominally get on a given run, and they accept what actually gets observed. It is then up to the PIs to decide if they want to resubmit unobserved objects for the next OSU/RC run.

Currently the astronomers at Minnesota are in the Institute for Astrophysics within the School of Physics and Astronomy. They arrange time allocation by a semi-annual consensus activity whereby they match science needs and requirements based on deliverables necessary to meet externally funded program activities and support commitments. They have a similar issue to that of Notre Dame in that they cannot count on specific program completion in any given run, because of their inclusion in the larger OSU/RC queue.

The German LBTB partners also have a diverse set of time allocation procedures, depending on the individual institute. MPIA has an internal proposal process. The Center at the University of Heidelberg received some state and national grant money for construction of the LUCI instruments, so may ultimately need to make some limited time available to the broader university community. The programs for each observing block are prioritized and merged in advance by the LBTB Partner Coordinator, who is currently on the staff at the MPIA.

4. Program Execution

Partners tend to manage each of their blocks as a mini-queue. Partner observers come to the Observatory on Mt. Graham in southeastern Arizona, since there is not (yet) support for fully remote observing. At least one partner, LBTB, is experimenting with eavesdropping, where the PI of a proposal is online during its execution, so that s/he can interact with the observers and perform near real-time quality assurance on the data. The goal is, of course, to achieve the scientific objective, which can require some expert judgment, particularly when the data are being acquired under non-optimal conditions. The three facility instruments are always available, and it is routine to use two of them on a given night, depending on lunar phase and distribution of high priority programs in right ascension.

The advantage of the current arrangement is that each partner has control over the execution of their programs, and can manage completion of the highest priorities. Often one of the observers will be the PI on a major high priority program to be executed, adding to the probability of successful completion. The disadvantages arise from the limited scope of one partner's program for any given month. There can be uneven distribution of targets over the night and single high-priority programs calling for an instrument otherwise not used. Calibration overheads can be somewhat higher for the multiple configurations required with a variety of small programs. Although the Board that sets policy and the Science and Technical Committee have both discussed the option of a single merged queue, that has not been the chosen direction to date. Partners are free to combine or otherwise share their time, but they do so on a limited and case-by-case basis, primarily for time-critical targets.

A more challenging problem for all partners is having enough backup programs for non-optimal conditions. The excitement of access to the world's largest telescope prompts proposals that exploit its limiting capabilities in light-gathering power and angular resolution. Mt. Graham can have workable nights with bad seeing or reduced transparency that push long exposures under ideal conditions beyond the limit. The partners are beginning to develop the culture of soliciting proposals that can be successfully executed under less than ideal conditions, which should enhance the ultimate scientific productivity.

Partners are urged to send at least one expert and experienced observer for each of their blocks. Nevertheless, the instruments are relatively new and the telescope performance is being continually upgraded, with consequent changes to interfaces and new techniques to learn for efficiency and error recovery. Therefore, one of the three support astronomers spends the full partner block at the telescope assisting the visiting observers. In addition, they check the observing scripts in advance of the block, and provide feedback to the PIs for improvements in approach that make the program more likely to achieve the stated scientific goals. Formal manuals and performance updates are accessed by partner observers through an instrumentation website in the first instance, and a less formal wiki page in the second. A near term priority is to improve the online documentation, particularly to facilitate observing preparation. In parallel, the LBTO science support group will initiate the definition and production of a comprehensive observing planning tool. It will incorporate the best of the features provided by the instrument teams, and is intended to make observing script production more straightforward and observing sequences more robust (as guide stars follow dither patterns around the patrol field).

5. Conclusion

The LBT is just coming to life as a scientifically productive facility. The ongoing challenge is creating the interfaces that will allow efficient exploitation of its unique capabilities: use of two facility instruments on 8-meter telescopes simultaneously, seamless integration of adaptive optics modes, and ultimately routine interferometric observations covering the Fizeau field of view.