NOAO OBSERVATORY PLANS

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Abstract: *The National Optical Astronomical Observatory (NOAO) has an ambitious long-range plan to support US astronomical research efforts. This plan includes large-scale new facilities such as LSST, GSMT, and NVO, as well as instrumentation development programs, and continuing efforts in detector research and development. This paper serves to provide a brief overview of the NOAO observatory plans.*

Key words: *Charge-Coupled Device (CCD), Infrared (IR), Focal Plane Assembly (FPA), mosaic, data acquisition, imager, MONSOON, Large Synoptic Survey Telescope (LSST), One Degree Imager (ODI), NOAO Extremely Wide-Field Infrared Imager (NEWFIRM), ORION, observatory.*

1. INTRODUCTION

The stated mission of NOAO is "to enable research and discovery in U.S. ground-based astronomy and promote public education, understanding, and support of astronomy and related sciences."[1] The current long-range plan states that NOAO will: 1) support the use of state-of-the-art facilities, such as Gemini; 2) undertake the next generation of forefront facilities; 3) develop an integrated national observing system and work with the community to achieve a robust instrumentation capability; and 4) foster an environment in which the integration of astronomical research with public outreach and education is a routine part of daily activities and staff responsibilities. NOAO is strongly influenced by the recent Astronomy and Astrophysics Survey Committee (AASC) report [2], often referred to as the Decadal Survey. In the Decadal Survey are detailed a range of new initiatives such as the LSST, GSMT, TSIP, NVO and other efforts. NOAO is to play a key role in all these efforts.

2. DETECTOR RESEARCH AND DEVELOPMENT

NOAO is continuing its long-standing role as a center for detector research and development. One of the ongoing efforts is the development of a next-generation 2K×2K×1-5 μm InSb focal plane assembly (FPA) known as ORION (see Fig. 1). ORION is an extension of the successful Aladdin 1K×1K program with Raytheon Infrared Operations (RIO) in Santa Barbara, formerly known as SBRC (Santa Barbara Research Center). ORION is a collaborative effort amongst NOAO, the U.S. Naval Observatory, and NASA Ames Research Center.

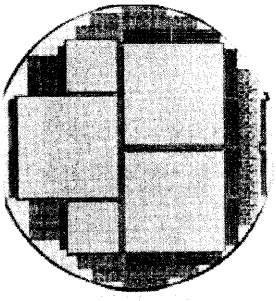

Figure 1. The ORION focal plane assembly.

Efforts are also on going in the OUV where NOAO is collaborating with the Lawrence Berkeley National Laboratories (LBNL) and Lick Observatory in the evaluation of high-resistivity deep depletion CCDs.

NOAO, in collaboration with Steward Observatory and Lucent Tecnologies/Bell Labs, is in the process of specifying and evaluating optical detector technologies for the LSST [3,4] project detailed later in this paper. These include high-resistivity back-illuminated CCDs, orthogonal transfer CCDs, silicon PIN diodes on CMOS multiplexor readouts, and monolithic CMOS devices.

All of these detector technologies and research efforts are discussed in more detail in other papers in these proceedings.

The MONSOON Image Acquisition System is a scalable, high-performance, multi-channel data acquisition system designed to provide "detector-limited" performance for all imaging devices needed for the next-generation of systems under development at NOAO and the astronomical community. It is being developed in collaboration with a number of external institutions and is a full "open-source" development effort for the astronomical community. MONSOON is designed to support all imaging system needs: single OUV or IR detector to large-scale mosaics, technical as well as scientific applications. For more information, MONSOON is detailed in a paper in these proceedings [5], or visit www.noao.edu/ets/monsoon/.

3. U.S. GEMINI PROGRAM

NOAO is tasked with acting as the interface of the U.S. astronomical research community to the twin 8-m telescopes of the International Gemini Project. To this end NOAO has created the NOAO Gemini Science Center, which provides remote operations from Tucson to both Mauna Kea and Cerro Pachon (see Fig. 2). In addition, NOAO will continue to develop and support OUV and IR instrumentation and detector technology for Gemini [6].

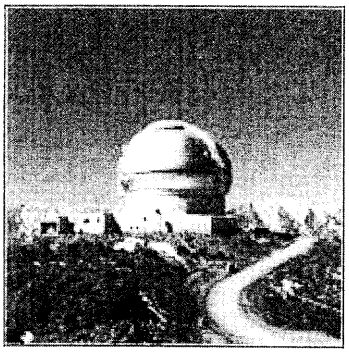

Figure 2. "Gemini South"- The Gemini Observatory's telescope in Cerro Pachon, Chile

Currently, Phoenix, a high-resolution 1K×1K 1-5 μm imaging spectrometer, and ABU, a 1K×1K IR Imager are operating at Gemini South with GNIRS, a 1-5 μm Near Infrared Long-Slit Spectrometer to be in commissioning later this year. The Gemini Array Controller at Gemini North is part of the NIRI instrument developed at UH. NOAO has collaborated on the GMOS and bHROS optical instrumentation efforts as well. NOAO has just completed a design study for the GSAOI 4K×4K 1-2.5 μm NIR Imager for the Gemini MCAO system. The NOAO Data Products Program is working to strengthen data reduction, pipelining and analysis tasks for the Gemini data products.

4. KPNO AND CTIO

NEWFIRM (see Fig. 3) [7] is a 4K×4K 1-2.5 μm IR wide-field imager currently under design for both the Mayall and Blanco 4-m telescopes at Kitt Peak and Cerro Tololo, respectively. NEWFIRM will have an array of four 2K×2K buttable focal plane array (FPAs). These FPAs are the ORION 2K×2K InSb described in the Detector Research and Development section of this paper. Goddard Space Flight Center and the Space Telescope Science

Institute are developing an NGST prototype multi-object NIR spectrograph called IRMOS for use at KPNO.

Ricardo Schmidt describes the instrumentation efforts at CTIO in a paper also in these proceedings [8].

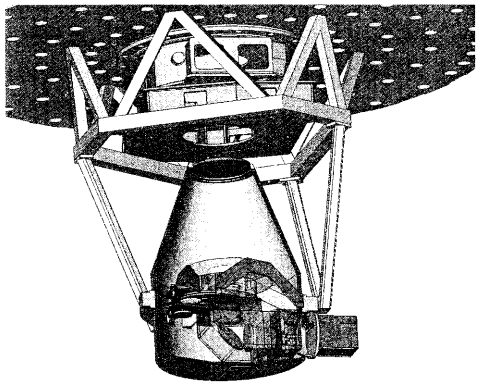

Figure 3. The NEWFIRM imager.

QUOTA is an 8K×8K optical imager based on a mosaic of four 4K×4K orthogonal transfer arrays (OTAs) designed for the WIYN 3.5-m telescope. QUOTA, which stands for "QUad OTA," is intended as a scalable design component for the follow-on One Degree Imager (ODI) project, which is a 32K ×32K mosaic imager. ODI will effectively be 16 QUOTAs in a single focal plane [9].

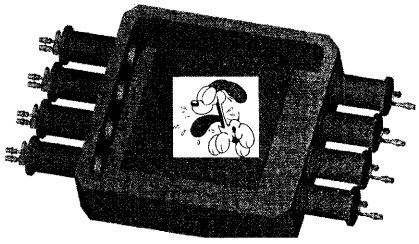

Figure 4. The QUOTA optical imager.

5. NVO

The National Virtual Observatory (NVO) is a development effort to establish a federated system of astronomical databases spanning the electromagnetic spectrum. NVO is a project of national scale requiring partnerships of many institutions and organizations spanning the range of national centers, universities, and the private sector. NOAO's role will be to function as a focal point for assembling the core scientific, technical, and

management skills for development of the NVO, to serve as an Optical/IR node, and lead the development of the data management system. For more information visit http://www.us-vo.org/.

6. LSST

The Large-aperture Synoptic Survey Telescope (LSST) (see Fig. 5) is an 8.4-m telescope with a 3-degree field and better than 0.2″ pixel sampling. The telescope is a 3-mirror design with an f-ratio of 1.25, designed to "go faint, fast."

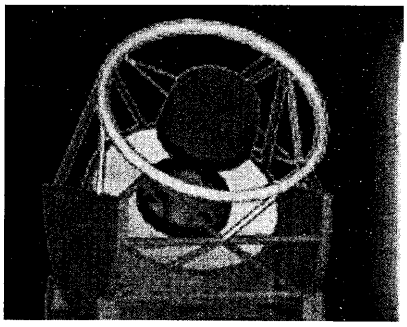

Figure 5. The LSST telescope.

LSST is estimated to provide a digital survey of the entire visible sky every few weeks to a deep limiting magnitude (~24 magnitude), LSST will fulfill a broad range of science goals such as: detection of near-earth objects, supernovae research, study of variable objects, gravitational lending, etc. The LSST will have a single optical instrument (0.3 to 1 μm) which will be a 55 cm focal plane fully-filled with a close-butted mosaic of 10 μm pixel devices. The current design employs 568 2K×2K devices, over 2.2 Gigapixels (see Fig. 6), and would translate in size to a 47K×47K square focal plane. The typical integration time of LSST is anticipated to be 10 sec with a maximum 2 sec read time and better than 5 e^- readnoise. The MONSOON Image Acquisition System has been designed to address the needs of the LSST camera.

NOAO plans to facilitate the community-based effort to construct the LSST with the project proceeding in four phases: 1) generate fully-coasted proposal for construction, 2) during proposal evaluation, continue to develop the plan especially in the areas of evaluating detector design, data acquisition, and data management, 3) construction, 4) operation and distribution of data. The nucleus of the project will be Steward Observatory, Lucent Technologies/Bell Labs, LBNL, NOAO, as well as other institutions. For more information visit http://www.noao.edu/lsst/.

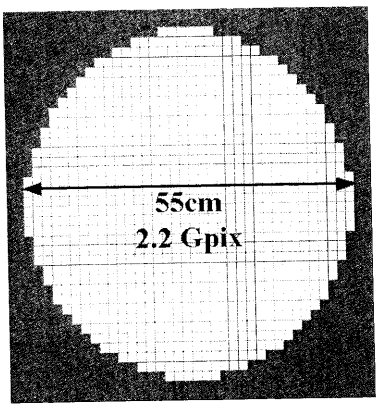

Figure 6. The LSST 47K×47K square focal plane.

7. GSMT

The Giant Segmented Mirror Telescope (see Fig. 7) is a proposed 30-m optical/infrared ground-based telescope.

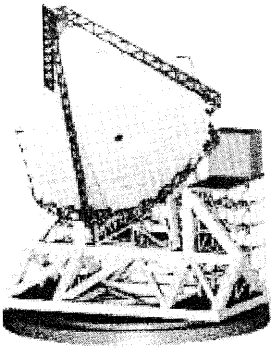

Figure 7. The GSMT telescope.

NOAO was charged with the essential roles of involving and representing the U.S. community in all phases of GSMT development and operation. The AURA (Association of Universities for Research in Astronomy) New Initiatives Office is leading this effort. Near-term goals are a summary of key design issues, initial trade studies of key technologies, development of cost and performance models, and a proposal for a preliminary GSMT design study. For more information visit http://www.aura-nio.noao.edu/.

8. TSIP

The Telescope System Instrumentation Program (TSIP) is a 5 million dollar per year program to fund the development of instruments for the independent observatories and provide time on these telescopes to the community. NOAO role will largely be management and administrative support. For more information visit http://www.noao.edu/system/tsip/.

9. CONCLUSION

NOAO has a wide-ranging plan for a mixture of science support, next-generation observatory facilities design, OUV and IR instrumentation and detector research and development, as well as educational outreach. The LSST effort and GSMT efforts are of an impressive scale and will obviously be accomplished through collaborative efforts with many institutions. The instrumentation development efforts focus primarily on large mosaics of both IR FPAs and CCDs, with a defined focus to push new limits in performance both in data rates and quality.

10. REFERENCES

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