**Report From the NOAO Blanco Instrumentation Partnership Review Panel**

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The panel met 2004 August 12th and 13th to review the proposal for the Dark Energy Survey, submitted in response to the NOAO Announcement of Opportunity of October, 2003. The proposal was submitted by the Dark Energy Consortium: the University of Illinois at Urbana-Champaign, University of Chicago, University of California Berkeley, Lawrence Berkeley National Laboratory and Fermilab, who led the proposal. The panel was charged to advise the NOAO director whether the proposal should be accepted and whether it merits 30% of the Blanco time for the five years of the project.

The committee was impressed by the thorough scientific and technical description of the project presented in the proposal, and appreciated the effort put into the presentations and subsequent discussions on behalf of the proposal during the review.

We feel that the instrument as described will be an asset to the National Observing system, and that it and the Dark Energy Survey archive will enable an enormous amount of science over a broad spectrum of interests in the NOAO user community.

In summary, we recommend that NOAO and the DEC move forward with this partnership provided that the following conditions are met:

1 That the Dark Energy Consortium deliver, as a package, the complete Dark Energy Survey as proposed: the camera, the data reduction pipelines and the data archive of the Dark Energy Survey.

2 That there be an external oversight committee for this project that reports to AURA and URA.

3 That requirements be imposed on the DECam and secondary cage design to include the f/8 secondary on an integrated mechanical structure to enable efficient changes

from prime-focus to cassegrain operations.

4 That the DEC filter mechanism be designed and implemented to accommodate daytime changes of the filter complement under normal CTIO operations.

5 That NOAO supplement the DEC filter complement in addition to the griz set that the Consortium will deliver.

6 That there be an E/PO plan integrated into the project.

7 That adequate NOAO resources be committed to enable community science with this instrument.

8 That NOAO and the Dark Energy Consortium develop a formal set of written acceptance testing plans and performance metrics.

We feel that these conditions are necessary to ensure that the project succeed to the benefit of both members of the partnership, and we elaborate on them below in our response to the detailed elements of the panel's charge.

## Response to Charge

**1) "The science plan should be compelling and also feasible. In addition, it should outline anticipated astronomy community use of the instrument through merit based proposals."**

We considered the science goals of the survey, steady tightening of the constraints on the dark energy equation of state and its possible evolution, to be exciting and timely. The science plan as outlined appeared to be feasible. We felt that the Dark Energy Camera (DECam) and Survey would be a good use of the Blanco 4m telescope and that partnering in the production of the survey data was an appropriate role for NOAO. The committee also felt that the other uses of the camera, survey data and associated database were at least as exciting as the plan detailed by the collaboration.

The committee was concerned about the relevance of the science goals of the survey and the degree of motivation of the science team should the project schedule slip. In this respect we felt that the major competition for this survey was not LSST or JDEM/ SNAP, as emphasized by the collaboration, but rather the more immediate projects Pan-Starrs and OmegaCam on VST.

The DES collaboration proposed 4 major science programs: optical (galaxy) cluster finding, weak gravitational lensing, galaxy angular clustering and supernovae. The committee felt that the case for the supernova science was the weakest of the four. This part of the survey would be considerably strengthened if the collaboration could articulate a coherent plan for spectroscopy of a significant fraction of the expected supernova yield to ensure proper typing and accurate velocities.

The prospects for the weak lensing projects were felt to be poor given the anticipated image quality. While we agree with the collaboration that weak lensing was a science goal that could be pursued with little extra cost to the collaboration, we recommend that weak lensing not be allowed to drive either the observing strategy or the hardware optimization decisions.

There is also a very strong reliance on a tie-in with spectroscopic redshifts, not only from the SDSS southern strip but also from deep redshift surveys, in particular to calibrate the photometric redshifts in the range 0.5-1 and above. We are not as confident as the Consortium that the data from DEEP2 and the VVDS will be sufficient for their task and were concerned about the lack of commitment from partners who would dedicate spectroscopic time to this, particularly since the calibration of the photometric redshifts is such a fundamental component of the project.

The community use of the instrument needs significantly more attention. Narrow-band imaging is one of the clear scientific uses for this camera outside the Dark Energy Survey, and the panel felt that the optimization of the optical design of the corrector should include consideration of ghosting from narrow band filters. Also, the design presented for the DECam allowed for the filter set to be changed during the day – we strongly recommend that easy daytime filter changes be made a requirement in order to increase the camera's future scientific usefulness for the community.

**2) "The technical plan should present a conceptual design of the instrument in sufficient depth for peer reviewers to assess the feasibility of the project with the resources to be committed."**

The panel felt that the reference design for the DECam as presented in the proposal demonstrated that the consortium had the technical wherewithal to deliver an instrument that met their requirements.

We strongly recommend that the consortium be required to mount the the Blanco f/8 secondary with the DECam on the telescope. Mounting and removing the secondary mirror would impose a significant burden on CTIO operations and greatly increase the risk to the mirror.

The Dark Energy Survey does not need ultraviolet imaging, and the DEC as proposed is a red-optimized imager. We do not feel that good ultraviolet performance is a requirement, but the committee did think it incumbent on the consortium to report on the expected ultraviolet image quality and throughput in their final corrector and camera design.

The CCDs represent the most significant schedule risk to the project schedule. We recommend that the consortium consider a second vendor for the CCDs and that the design of the focal plane be kept open to a second vendor as far as possible.

We are also concerned that the project's incomplete funding is a considerable risk to the schedule. The project is optimistic that the NSF will provide $4M on their schedule when huge demands are already being made for high priority, highly capable facilities (GSMT, LSST, TSIP, AODP) as recommended by the Decadal Survey.

**3) "The management plan should outline the proposed sharing of responsibilities for optomechanical, focal plane, data acquisition, and data management work packages between the proposer and NOAO. A general management structure along with a schedule of project reviews (PDR, CDR) and acceptance testing should be included."**

A useful draft management plan has been presented by the proposers, to which the review panel recommends the following additions be made.

- We strongly recommend that an external Oversight Panel be formed, in order to regularly review the progress of the project and represent the interests of both the DEC partners and the NOAO user community. This panel would report to the URA and AURA. It would act to review the progress of the project and the on-schedule provision of deliverables. In particular, it would be responsible for receiving the reports of external and independent review panels such as those for PDR and CDR. It would also review any proposed changes to the scope of the project, and project progress once survey operations begin.
- A schedule of project reviews (PDR, CDR) and acceptance testing must be added. The acceptance criteria for all deliverables must be agreed in advance as part of MOU negotiations, and NOAO needs to involve its user community in this process so that the final delivered instrument is most useful for the entire community. NOAO should also take a lead in informing and engaging the community in this project and the scientific opportunities it offers, perhaps as early as the next AAS meeting.
- We recommend that the NOAO Director regularly communicate on project progress with the NOAO User Committee.

- We recommend that as a prelude to MOU negotiations, the DES survey team provide to NOAO a prioritized list of their infrastructure requirements both before and during the anticipated 5-year duration of the survey. MOU negotiations will then enable all parties to have a clear understanding of the deliverables from both sides, and will allow the NOAO Director to plan for necessary resource allocation. In particular, NOAO will need to identify the resources it will need to allocate (and the assistance the DES team can supply) in the provision, considered by the Panel to be essential and critical, of a pipeline and archive for NOAO user community programs with the DECam.

- The data management plan was not developed to a level equivalent to the level of the instrument plan, and as a result it was difficult for us to evaluate against our charge. We are not confident in the work estimates, the ability to deliver to the stated schedule nor the synchronization with the instrument build phase. This part of the management plan needs to be refined and reviewed again no later than the PDR.

- The panel strongly felt that the survey archive is one of the deliverables of this project (see below). It is therefore felt that the funding of operations is just as critical as the funding of the build phase, and that this needs to be addressed and clarified early in the project. Similarly, a mechanism for NCSA commitment to the operations phase needs to be identified early in the project.

**4) "The management plane should include a plan for public and educational outreach and explain the broader impacts of the project."**

The proposal did not include ideas that specifically target dark energy education and the broader impact, despite the enormous curiosity about this new area of science, both public and scientific. People are excited, skeptical, fascinated and confused by dark energy, and they are eager for more and clearer explanations. Dark energy has the capacity to captivate our curiosity just as black holes can engage people with physics. We are living in a moment when there is a knowledge gap that will be filled, and at a moment when there is an education gap that must be filled. Both can be accomplished easily and effectively by the proposed DES partnership.

As we learn more about how dark energy integrates into our universe as a natural physical component, that knowledge must propagate into the formal education process, perhaps through a module in NOAO's Teacher Leaders program, and into the informal audience through passive (web sites) and active (media) pathways. Dark energy is today's obvious and easy E/PO science topic.

Unfortunately, the presenters indicated that DOE's mission is not E/PO oriented. Consequently, funding from DOE for E/PO will be difficult or impossible to obtain. On the other hand, funding for the project is inadequate without support from other agencies, such as NSF, where E/PO components are required.

In order to support the quest for NSF funding, and to ensure an E/PO presence in the DES project, we strongly recommend appointing an Outreach project manager at the same structure level as the instrument and data management leaders (Brenna Flaugher and Joe Mohr), and having representation on the Management Committee. Responsibilities for this person include advocating for E/PO funding, both within DOE and outside, and working with his/her counterparts at the partner institutions for writing proposals (or their education components) to private and public agencies, developing education modules, and managing scientific and technical press releases.

All of the partners have strengths in E/PO, and they serve a diverse audience. Thus, the project has a unique opportunity to build an E/PO collaboration across the physics and astronomy communities that is well aligned with national directions and can be incorporated into a national dark energy roadmap.

**"The panel is also asked to comment on what NOAO should contribute to such a partnership."**

The Consortium has designed the Dark Energy Survey around the current performance of the Blanco but has stated several areas where improvements at CTIO would directly benefit their project. The panel felt this was a sensible way to proceed and that it seemed the DES relied most on infrastructure improvements that were likely to happen, like the telescope control system and network upgrades. We discussed above our concern that this set of expectations and requirements must be better defined as part of the MOU between the partners.

Any contribution NOAO makes to operational efficiency and robustness at CTIO in support of the Dark Energy Survey will be of benefit to all concerned, as it will help create the DES archive as well as increase the effectiveness of community observing time. The decision as to whether any particular project will be a worthwhile expenditure of NOAO resources should be based on a careful analysis of its expense, likely success and benefit to the proposed project.

The panel concluded that NOAO must provide additional filters for the DECam beyond the griz set that the Consortium will use for the Dark Energy Survey. This is necessary to expand the scientific range of the DECam as a facility instrument at CTIO.

The committee feels very strongly that this proposed instrumentation partnership will not

be of practical benefit to the NOAO user community unless NOAO commits the resources necessary to provide the pipelines and infrastructure to process and calibrate data from general user programs on the DECam, and an archive by which the data from those programs can be accessed by the rest of the community. Given the investment that the DES will make in software, the panel recommends that the most straightforward way to achieve this will be for NOAO to work with the survey team to provide a version of the Dark Energy Survey pipelines for other users of the DECam. Since the committee regards the pipelines as one of the Dark Energy Survey project deliverables, this collaborative effort should be a natural part of the partnership.

The Committee notes that NOAO and the CTIO Director must accept long term commitment to the DES program and the community use of the opportunity provided by this initiative. Budget wedges, personnel, and infrastructure (especially in the Data Products Program) that exceed those mentioned in the Announcement of Opportunity may be necessary to successfully complete the program.

**"The panel may wish to quantify the provision of an instrument in return for up to 30% of the Blanco time for 5 years."**

The committee does not feel that the DEC instrument alone is sufficient to justify granting 30% of the Blanco time over five years to the DES Consortium through this partnership. However, we do see the combined package of instrument, reduction pipelines and the Dark Energy Survey itself, available to the community in an archive, as providing a sufficiently productive return to the community in exchange for this large allocation of national observatory telescope time.

In order to ensure that all these components of the Dark Energy Survey keep pace with one another, the committee feels that it is necessary for the Data Management part of the project to pass the project's proposed Data Challenge milestones on schedule. The Oversight Panel (see above) should commission reviews of the project at these points just as it will the PDR and CDR of the instrument. In order to monitor progress toward the final data archive, the committee recommends that a serious review of the Dark Energy Survey be focused on the proposed release of the Survey's Level 2 (co-added) data products at the end of the second year. This will allow the Oversight Panel to ensure that the Survey, Dark Energy Consortium science and community use of the data and instrument are proceeding to the benefit of all partners. Allocation of subsequent Blanco time should be contingent on the outcome of this review.

**Appendix: Technical Suggestions to the DES Team**

While a technical review was not within the scope of our charge, the panel accumulated a variety of design and implementation suggestions for the DES team during the course of the presentations and subsequent discussion. That list is included below.

Roller shutter - could have 'slots' for guide CCDs on just one of the 'dark' sides of the roller shutter directions. This would allow the guide CCDs to retain guide lock and do acquisition, while keeping the detector dark or reading out AND also allow true 'dark' frames to be obtained, simply by directing the shutter to close in one each of the two possible directions.

Dedicated guide CCDs are included to do on-line focusing of the telescope. However, as these seem to be planned for read-out and re-focus on the timescale of a data CCD readout, there is the possibility that the telescope focus will always be 'chasing its own tail'.

There are in fact telescopes of the Blanco's vintage that have working, robust and reliable hardware focus compensation systems. The system installed and used at the Anglo-Australian Telescope, in particular, should be examined to see if something similar can be retro-fitted to the Blanco. This system means that the AAT can stay focused regardless of temperature or orientation over several NIGHTS, and such a system on the Blanco would mean that having the Blanco 'chase its focus tail' while observing would be essentially unnecessary, and would contribute to long-term robustness of image quality. In a survey like this, data quality is all, and its better to engineer the system right, then try to correct it with lash-up systems.

It is recommended that the DES team plan on concentrating their best quality CCDs in a contiguous central region of the camera field, where they will be available for optimum science by programs not requiring the full field of the DEC.

Narrow-band science will clearly be a strength of this camera for the NOAO user community. Given this, the camera should be able to be used in a read mode delivering slower read-times (possibly considerably slower) but with read-noise pushed down to 3e-.

Strongly consider more expensive AR-coatings for the critical surfaces which are concave toward the detector to minimise ghosting.

Consider an ion pump rather than zeolite or other passive gettering mechanism. The volume of the vacuum enclosure is large, there will be a lot electronics and mechanical structure inside, and experience has shown that the surface chemistry of CCDs is

sensitive to vacuum quality. A large quantity of zeolite can perform unreliably, and is a significant maintenance burden in the long term. An ion pump is a much more reliable way to maintain a good, stable vacuum over time in such a large instrument.

Consider how to guide with narrow-band or undersized filters.

Review the telescope baffling in the scattered light analysis.

Consider whether the existing flat-fielding screen is adequate

NOAO may wish to organize technical workshops among the many wide-field imager projects currently being designed in order to share technology solutions. Areas include filters, shutters, detectors, electronics, software, cooling and corrector designs.