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To: Nat Butler
From: The RATIR CoDR Review Committee - Andrew Szentgyorgyi (Chair), Christopher Bebek, Rebecca Bernstein, Bruce Bigelow, Harland Epps, Jochen Greiner
Cc: Josh Bloom
Date: 30 Apr 2009 – Draft II
References: RATIR Preliminary Design Report, Version 3, 13 Apr 2009.

Summary: The RATIR CoDR Review Committee

Preliminary Design Review Report: On 17 Apr 2009, a review panel was convened at University of California, Santa Cruz for a Concept Design Review (CoDR) of the Reionization and Transients Infrared/optical Projects (RATIR). The committee was composed of:

- Christopher Bebek – LBL, Berkeley
- Rebecca Bernstein – UCSC, Santa Cruz
- Bruce Bigelow – UCSC, Santa Cruz
- Harland Epps – UCSC, Santa Cruz
- Jochen Greiner – MPE, Munich
- Andrew Szentgyorgyi (Chair) – CfA, Cambridge

In attendance were:

- Nat Butler – UCB, Berkeley (RATIR PI)
- Josh Bloom – UCB, Berkeley
- Michael Bolte – UCSC, Santa Cruz
- Alejandro Farah – IA/UNAM, Mexico City
- Julien Girard – IA/UNAM, Mexico City
- Jesus Gonzales – IA/UNAM, Mexico City
- Alexander Kutyrev – GSFC, Green Belt
- William Lee – IA/UNAM, Mexico City
- Xavier Prochaska – UCSC, Santa Cruz
- Enrico Ramairez-Ruiz – UCSC, Santa Cruz
- Michael Richer – IA/UNAM, Mexico City
- Alan Watson – IA/UNAM, Mexico City

The review committee congratulates the instrument team for developing a concept for an instrument that is capable of opening up exciting new astrophysical discovery space, potentially measuring the redshift of gamma ray burst sources with z >> 8.0. The RATIR concept is both powerful and economical. A description of the RATIR science mission as well as all technical details can be found in the design review briefing book (RATIR Preliminary Design Report, Version 3, 13 Apr 2009, see - http://astro.berkeley.edu/~nat/RATIR/ucsc_design_review/). We note that the review committee feels that the material presented in this document and at the review is at a level of maturity consistent with that of a Conceptual Design Review (CoDR) rather than a Preliminary Design Review (PDR), hence we refer to this review as a CoDR throughout this document.

Furthermore, RATIR turns a new page in Mexican astronomy in several ways. It will provide a significant new instrumental capability at San Pedro de Martir Observatory (SPM). SPM enjoys good seeing statistics and is one of the darkest Northern hemisphere astronomical sites, yet it is, to date, somewhat under-utilized. The broadband photometry RATIR will deliver exploits the virtues of SPM and will rejuvenate the SPM 1.5m telescope, offering new capability to the Mexican observer community. The robotic operation of the 1.5m will make observations extremely efficient. RATIR will also serve as an important pathfinder for the vastly more ambitious Synoptic All Sky InfraRed (SASIR) Survey Telescope, also to be sited at SPM.

The RATIR team, at the time of the CoDR was considering several very different concepts:

- A "warm" design, consisting almost entirely of dichroic splitting filters and filters which define optical and infrared photometric bands. This is ostensibly a simpler design that accepts the existing, f/13 telescope focal ratio. The 1.5m focal ratio results in a relatively small field of view. This design has no cold pupil.
- A "cold" design with focal reduction that optimizes the system focal ratio and has a cold pupil, which significantly reduces thermal background in the IR channels.
- Either a warm or cold instrument operated with a new telescope secondary mirror that delivers an f/10 beam and a wider field of view.

The review team recommends the RATIR collaboration immediately adopt the cold design operated with the existing 1.5m telescope secondary. We make this recommendation for the following reasons:

1. A design that permits incorporation of a cold pupil is significantly more robust - vastly reducing stray and scattered out-of-band light at the focal plane and reducing the risk of an unanticipated light leak.
2. Focal reduction will enlarge the field of view and offer a more sensible pixel sampling.
3. It would be possible to deliver a wider field of view and better sampling by building a new, faster secondary. However, the committee feels this is an expensive alternative and will take considerably more time than the project schedule allows.

4. The RATIR team proposes a rapid schedule. This is only possible if they reduce the decision space and focus on refining one design that satisfies the scientific requirements of all involved partners.

We recognize the cold design is more complicated, hence more costly and requires somewhat more time to build. In the committee's opinion however, the benefits and risk mitigation it provides outweigh the negatives of additional cost and time required.

RATIR is an ambitious project on a short timeline. The information presented at the CoDR indicates the RATIR project is still at the conceptual phase. External imperatives (e.g. phasing of the NASA SWIFT program) make it necessary for the project to move rapidly to a more advanced phase. It is essential that the team move intelligently and deliberately, and perhaps most urgently, reassess the requirements and schedule so that they are more closely aligned with pragmatic considerations – i.e. the time required to bring designs to maturity and have vendors fabricate and deliver system components. We regard adoption of single design concept (i.e. the cold design discussed above) as the most critical next step for the RATIR team.

We note that the RATIR team is relatively young and energetic, so we believe they can meet their success-oriented schedule fast enough to execute their core, gamma ray burst program. We note the involvement of Goddard Space Flight Center brings critical experience and resources to this program. The Goddard team has built similar instrumentation for ground-based telescopes on a rapid time scale and has considerable in-house resources that effectively provide a cost and schedule margin for the project.

We also note that Co-Investigator Bloom has previously rehabilitated the 2MASS telescope (renamed PAIRITEL) so that it operated robotically. This roboticization program has performed flawlessly since first light. The heritage of this program and Bloom's experience are huge assets to the RATIR project and build considerable confidence that the RATIR team can succeed at making the 1.5m telescope robotic. The committee notes that the 1.5m is an old telescope that does not perform well optically or mechanically. Getting this telescope to meet the RATIR performance requirements will not be trivial. The rehabilitation of the 1.5m is a parallel program to be undertaken by UNAM, the operators of SPM, and is outside the purview of this review committee. The committee has been assured the upgrades to the 1.5m will transpire on a schedule that will allow the RATIR team to meet their scientific objectives.

The review committee has several specific comments and presents them in three categories: recommendations, missing items and concerns. These are:

Recommendations (in approximate rank order):

1. As soon as possible, choose a single design concept, either a warm or cold design and decide whether or not to build a new secondary. As we mentioned earlier in this document, the review committee strongly recommends a cold design utilizing the existing secondary.
2. Reassess the program schedule. Re-visit performance requirements and where possible defer instrument subsystems that fulfill secondary requirements. As an example, the

review committee suggests postponing the deployment of the second optical camera and the associated dichroic. The RATIR team could start operations using a single camera for all optical observations at first light. The mechanical interfaces for the second camera should be implemented so it can be easily added when funds become available to purchase the necessary parts.

3. Re-examine the angles at which the dichroics are operated, with the goal of reducing the angles of incidence to near 30°. At present, all dichroics are operated at ~45°, which is very close to the Brewster angle, a choice that is likely to produce unwanted polarization effects. The current concept design has two filters operated at crossed angle, a situation that exacerbates polarization effects. The next generation of designs should eliminate crossed fold angles.
4. A study of the polarization effects in the final design should be done before proceeding to final design or fabrication.
5. Develop a clean set of interfaces that clearly define the responsibility of collaboration teams. We feel strongly that the Goddard team should be given full responsibility for the design and fabrication of the RATIR infrared module.
6. Add an ion pump to the dewar and run the pump continuously to guarantee a good vacuum (~ 1 microtorr) at all times to prevent contamination of the infrared focal planes.
7. Investigate the possibility of using extrafocal image information to continuously update the telescope focus.
8. Further investigate the possibility of including a Shack-Hartmann sensor in the optical system to continuously or frequently update telescope collimation.
9. Every effort should be made to exploit existing designs and parts. As an example, the design of an athermal, cryogenic, kinematic IR array holder can present significant challenges. However, many designs are already in existence that probably can be adapted to RATIR, saving considerable non-recurring engineering.
10. Dome seeing appears to be a big contributor to the bad seeing at the 1.5m. It would seem that a modest effort to improve dome seeing could be undertaken for modest cost, yielding much better telescope optical performance.
11. The baseline design calls for air-cooled CCD cameras, which can only hurt dome seeing. The review team suggests using water-cooled cameras (an off-the–shelf option), which would make it possible to exhaust heat in a way that did not affect the dome seeing.

Items "Missing" from the Design Report or Presentation (in approximate order of urgency)**:**

1. At present there are no formal interface control documents (ICDs) and the roles of the RATIR teams do not seem fully defined. Before proceeding to specific design tasks, the team needs to articulate who is going to do what. The interfaces should be as clean as possible.
2. A detailed (3-4 level) work breakdown structure (WBS) should be written, and used to guide further development of the project budget and schedule.
3. Neither an optical nor a mechanical model of the cold design exists. While it seems likely that a good, workable design can be developed, it is time to move on and develop such a design.

4. A finite-element thermal model of RATIR needs to be constructed before proceeding to final design or fabrication.
5. An optical scattering model that incorporates realistic surface finish and cleanliness levels should be developed so that a quantitative calculation of stray light contamination can be performed. Photon Engineering or Breault Optical Research could be engaged to help with this task.
6. An electrical design does not exist at this time and needs to be completed.

Concerns:

1. While UNAM intends to rehabilitate the 1.5m telescope, there is residual concern among committee members that it may not perform well enough post-rehab to accomplish the RATIR science mission. Alternatively, the scope of the required rehabilitation may exceed the resources of UNAM or take too long for timely execution of the RATIR gamma ray burst program, which is tied to several NASA missions with finite operational lifetimes.
2. The RATIR Project management should hold at least one more design review prior to starting full-scale construction of the instrument, i.e. a true PDR, perhaps 4-6 months from now. Such a review would not necessarily preclude ordering long lead-time items such as optical materials and components. Nevertheless, there are significant areas of the design, planning and documentation efforts that are not mature at this point in time. The project will benefit by completing that work and reviewing it before the construction phase of the project.
3. As a critical component of the hardware development for this project, it is important to include the telescope rehabilitation planning and progress in future reviews.
4. The review committee feels the costing for the filters, based on quotes from a single, small vendor are too low. The RATIR budget should adjusted to allocate enough funding to procure the filters from vendors with better heritage.
5. While the use of wedged filters for aberration compensation is clever, some reviewers were worried that it would be hard for vendors to meet specification. Wedged filters will be significantly more expensive and add risk (e.g.. substrate breakage). The GROND experience has been that wedged filters take 18-24 months to actually produce.
6. The window at the entrance to the instrument and the window that divides the optical and infrared sections should be thick enough to mitigate ghost images. Sapphire is not an optimal material for windows, since it is birefringent. Other materials are available which are equally transmissive in the wavebands of interest and do not suffer from this problem, e.g., Heraeus Infrasil 302 or Ohara's new anhydrous synthetic fused silica SK-1310.

The committee concludes by noting the recent discovery of a z=8.2 gamma ray burst GRB 090423 (see, e.g. http://www.eso.org/public/outreach/press-rel/pr-2009/pr-17-09.html) is a reminder that RATIR will be an extremely timely instrument. The committee consensus is that the schedule is aggressive and there are challenges the RATIR team must confront, but the team has a good mix of skills and resources; they can succeed in achieving their science goals if they are organized and deliberate.