Keck 1 Cassegrain ADC, Preliminary Design Study

June 20, 2003

This is the first monthly report for this project, which officially started on June 2, 2003. The format of this report will probably change after discussion with Sean Adkins, CARA's Instrument Program Manager. No financial information other that what was in the Work Plan (Cassegrain ADC web site: http://adc.ucolick.org/) is available for this report.

Optical Design

Drew Phillips has been working on the optical design, exploring parameter space for optimal parameters. These include:

1. Building a working ZEMAX model, and identifying the optimum field positions to study.

2. Prism angle vs. spacing: smaller angles with long reach is ever-so-slightly preferred optically, but mechanical and weight issues should clearly be the main driver here.

3. Optimal angle for first face of prism: 1.7-deg (vs. Mast's 2.5-deg) gives slightly improved performance over the full focal area sampled by LRIS. This makes the prism cells slightly more difficult to fabricate, but it shouldn't be too bad.

3a. Better performance can be had by tilting the prisms actively, as a function of field position, i.e., LRIS orientation (helps to counter some of the telescope aberrations) but adds significantly to the mechanical complexity and probably is not worth it (to be discussed Wednesday).

3b. At any rate, image quality will be better in the lower half of the focal plane than the upper, due largely to the fact that the lower half will be looking at a field that is less off-axis.

4. The displacement of the curved focal surface (or alternatively, the tilt to the focal plane) as the prisms separate has been confirmed using ZEMAX. I have not found a way to counteract this by secondary tilt/decenter, as the aberrations introduced rapidly become too large. This is a feature of the linear ADC that has not been appreciated in the literature.

5. Prism diameters can be minimized by allowing the front prism (closest to the secondary) to slip downward relative to the optical axis as the prisms are separated, to follow the field offset -- the total displacement is about 34 mm. (The prism closest to the focal plane should always be on-axis.) Alternatively, the forward prism can be

oversized, but it only needs to be oversized in one direction, so the trick is to oversize by 1/2 the needed amount and offset it so the top edges of both prisms coincide when closed.

6. Looked into optical issue of sag of the prisms under their own weight. I did this by tilting the second prism relative to the first. Thin prisms are insensitive to small tilt deviations to first order, so I assumed that any section of the prisms could be approximated by a thin prism, and that varying the angle of the entire second prism relative to the first provides an envelope of the effects to be seen by tilting any smaller section of the prisms (i.e., sag). Optically, there is very little effect on image quality, but there is a change in plate-scale (i.e., distortion). The envelope for realistic sag values shows that this is a non-issue, but the level of distortion will probably require us to up our tolerance on maintaining the prism angles to perhaps 3 times tighter than what Mast had given us for CoDR. However, as the current mechanical design exceeds Mast's tolerance by a factor of 10-20x, this is again not a problem.

Still remaining to be done (coming up in next 2-3 weeks):

-- Distortion studies (in particular, what is the change in plate scale between ADC and no-ADC; and does the plate scale change as the prisms are separated?)

-- Determine residual [chromatic] dispersion

At that point we should be ready to set up performance specs and make the optical design decisions; then I can start tolerancing and work on adding the LRIS optical model.

The Lick Optical Lab made a scale model of the Cassegrain ADC wedge plates to use as concept review (Lick Observatory overhead). The disks are 6.625" in diameter with a 2.5 degree wedge between the two optical surfaces. The thick edge is 0.432" thick and the thin edge s 0.143" thick.

David Hilyard asked Corning to quote on supplying us with the fused silica material sawn from a thick blank at the specified wedge angle to investigate the cost effectiveness vs. two parallel face blanks which would then need to be generated to the wedge angle. This approach appears to be cost effective. I have estimated the finishing costs, and expect a savings of around $18,000. but I am now pursuing hard numbers from a sub-contractor for finishing costs.

David Hilyard has sent out RFQ's to Zygo for the grinding and polishing of the Corning supplied wedges. Having the blanks shaped to the wedge angle will cost less for the finish processing. All though he has not ruled out doing the final processing at Lick on a conventional polishing machine, what he has learned from polishing the scale model prisms makes him believe that a planetary polisher at Zygo is the best tool for controlling flatness and wedge, and would be cost effective.

Mechanical Design

Vern Wallace worked on developing a parametric Inventor model of the ADC system and establishing the documentation format for the mechanical portion of the project.

He has begun exploring cell designs to mount the optics. He has also begun to study spacing from LRIS and vignetting issues.

Electronic Design

Ken Dietsch mocked up a proposed limit switch circuit and we have a configuration that looks promising for use on the ADC. Ken is continuing testing.

Software

No report this month.