Keck I Cassegrain ADC: Detailed Design Review

UCO/Lick Observatory

21 May 2004

Overview & Changes from PDR

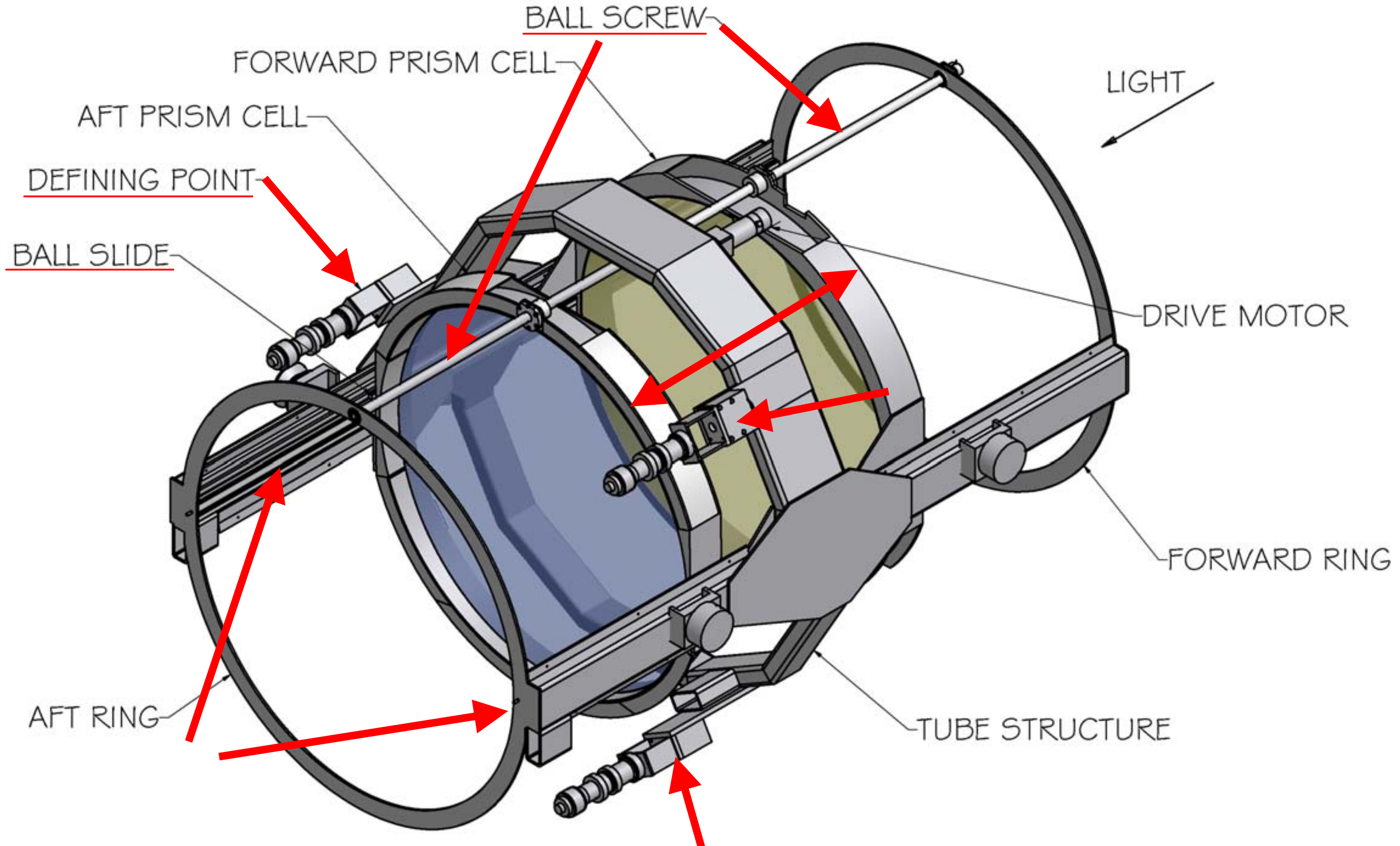
- Introduction

- Optics
- Mechanical
- Electrical
- Software

Optical Design Parameters

Prism opening angle	2.5°
Prism central thickness	45 mm
Prism clear aperture ★	1019.2 mm (min.) + 10 mm for safety
First prism offset	-22.1 mm (below center)
Minimum prism edge thickness	22 mm
First prism angle at outer surface	1.67°
First prism angle at inner surface	-0.83°
Minimum prism separation	20 mm
Maximum prism separation	1700 mm
Location in front of telescope focal surface ★	1575 mm – center of ADC 680 mm – min. distance (wrt 2^{nd} prism)
Zenith distance for full correction	0 -- 60°
Prism Material	Fused Silica (Grade D purchased)
Coatings	MgF_2 + Sol-Gel
Expected Transmission ★	> 92%; ≥ 94% average

Mechanical Design: Overview



ADC WITHOUT CLADDING OR COVERS

(PDR Version)

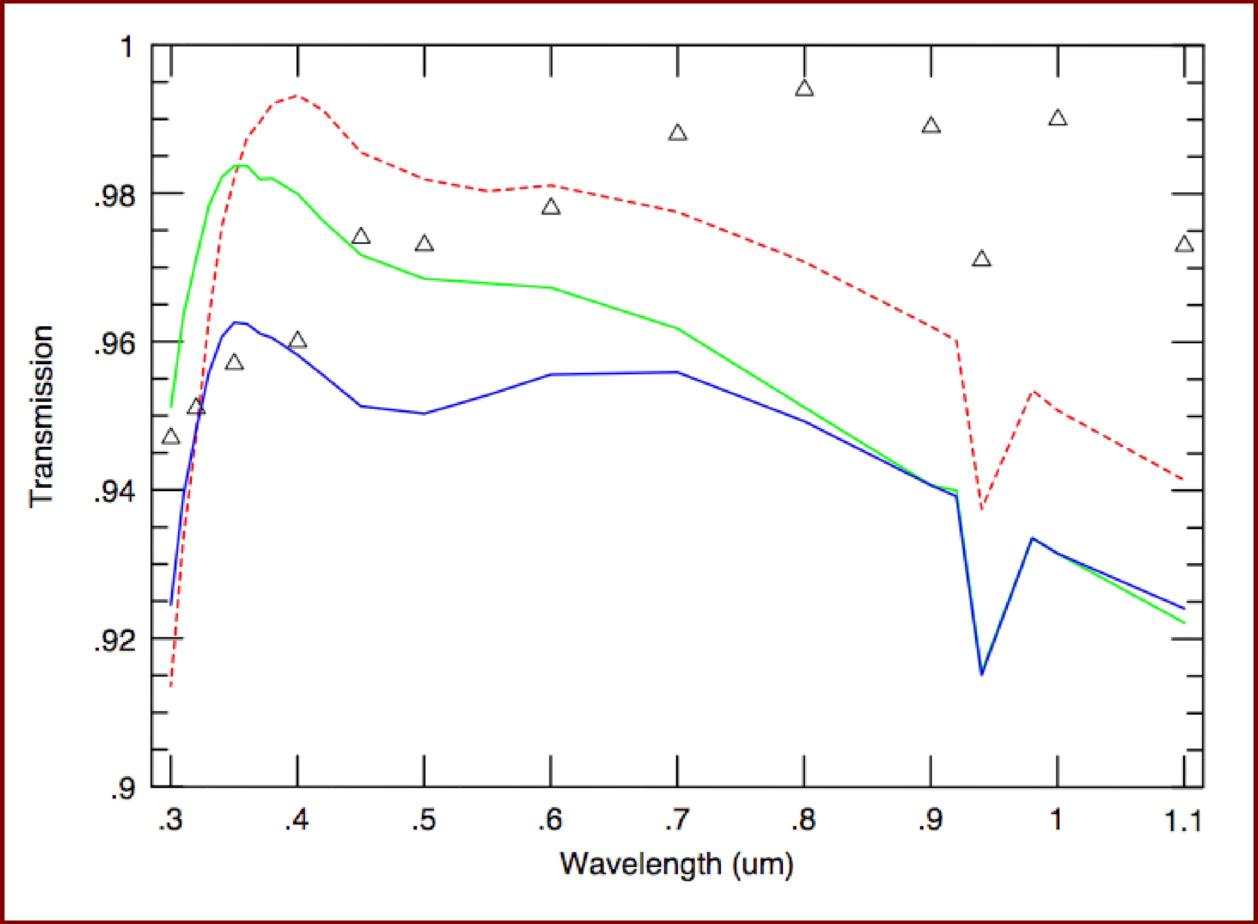
Overview & Changes from PDR

- Introduction

- Optics
  - Coatings & Expected Transmission (4.1.2)
  - Pointing and Focus Adjustment Models (4.1.3)
  - Prism separation vs. Elevation (4.1.4)

- Mechanical
- Electrical
- Software

Expected ADC Transmission



- 90 mm quartz with 4 surfaces as measured (green, blue = measured; red = model)

Pointing & Focus Adjustments

- Pointing changes in elevation only ($\Delta\theta$) and depends purely on prism separation (Δd):

$$\Delta\theta = 2.807 \times 10^{-2} \cdot \Delta d + 1.15$$

- 2ndry Piston (focus) depends on prism separation and instrument rotation (ϕ):

$$\Delta z = (a \cdot \cos\phi + b) \cdot \Delta d + c$$

$$a = -2.6726 \times 10^{-5}; b = 7.353 \times 10^{-6}; c = -1.3492$$

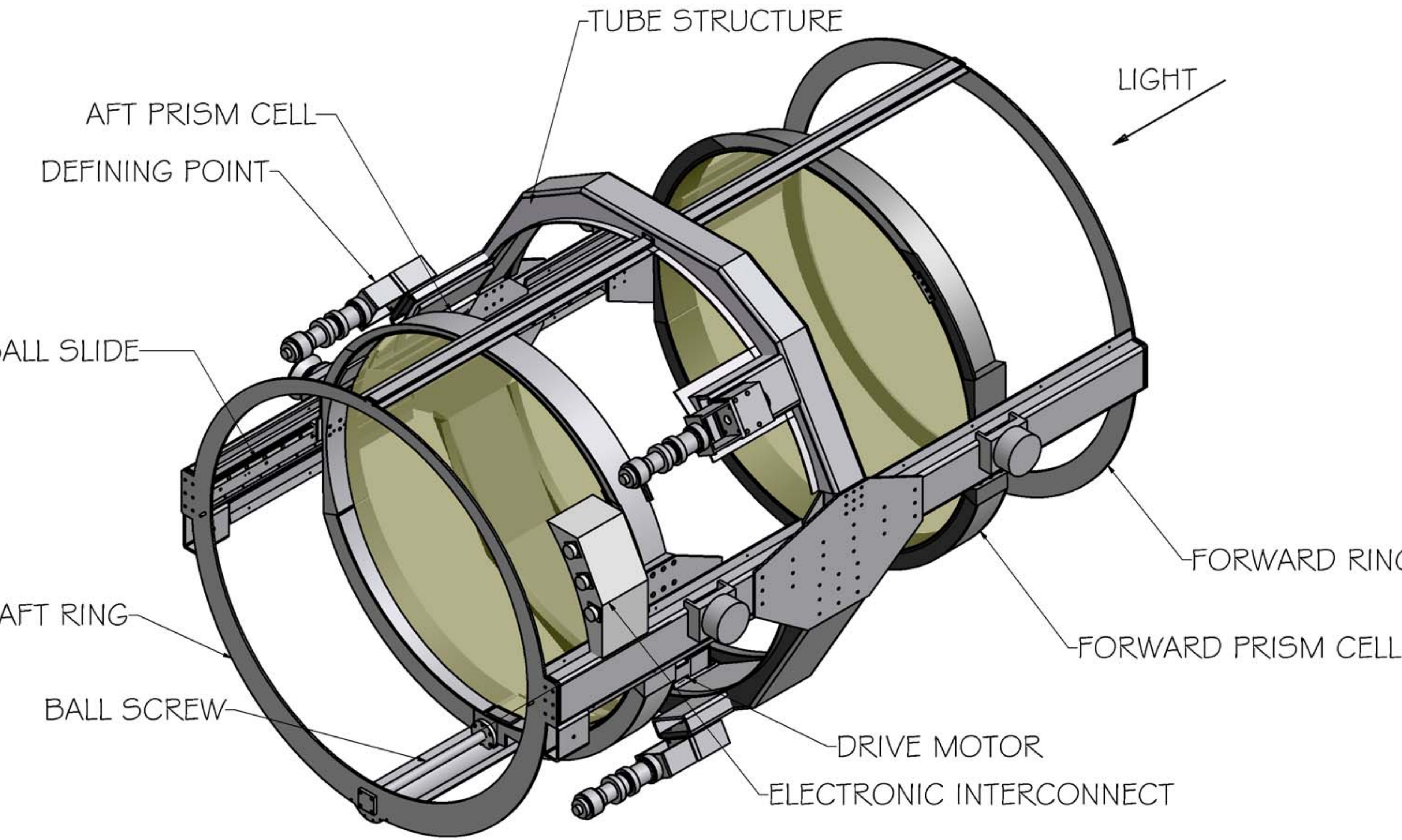
Prism Separation vs. Elevation

Lookup table or values for an interpolation function.

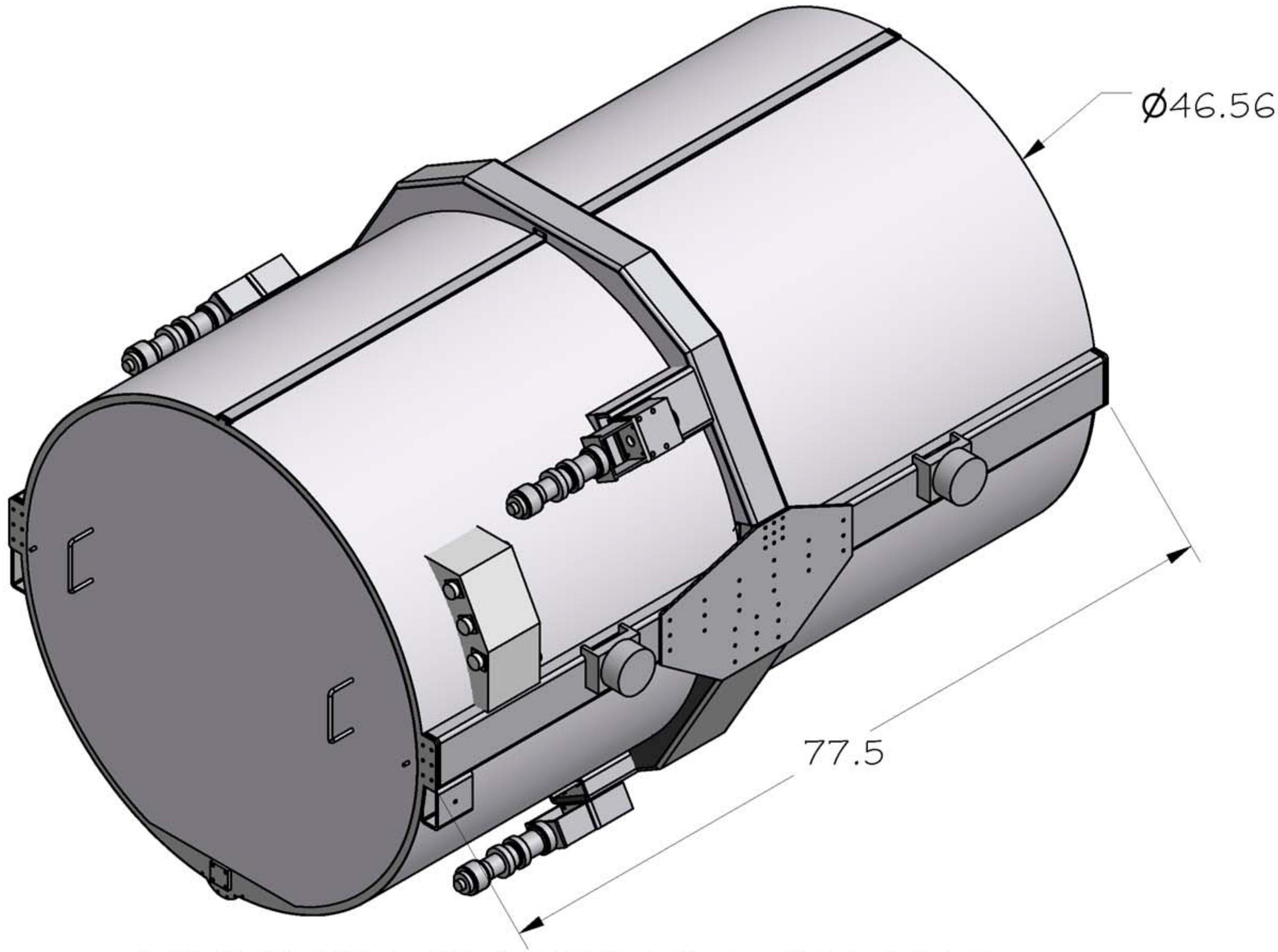
Z (deg)	Full Separation (mm)		**Z (deg)**	Full Separation (mm)
3	12.58		**50**	580.43
4	21.32		**52.5**	635.81
8	56.56		**54**	672.13
12	92.50		**55**	697.82
16	129.54		**56**	724.80
20	168.07		**57**	753.20
24	206.61		**58**	783.16
28	251.75		**59**	814.81
32	298.20		**60**	848.34
36	348.88		**61**	883.93
40	404.97			
42.5	443.43			
45	485.08			
47.5	530.50			

Overview & Changes from PDR

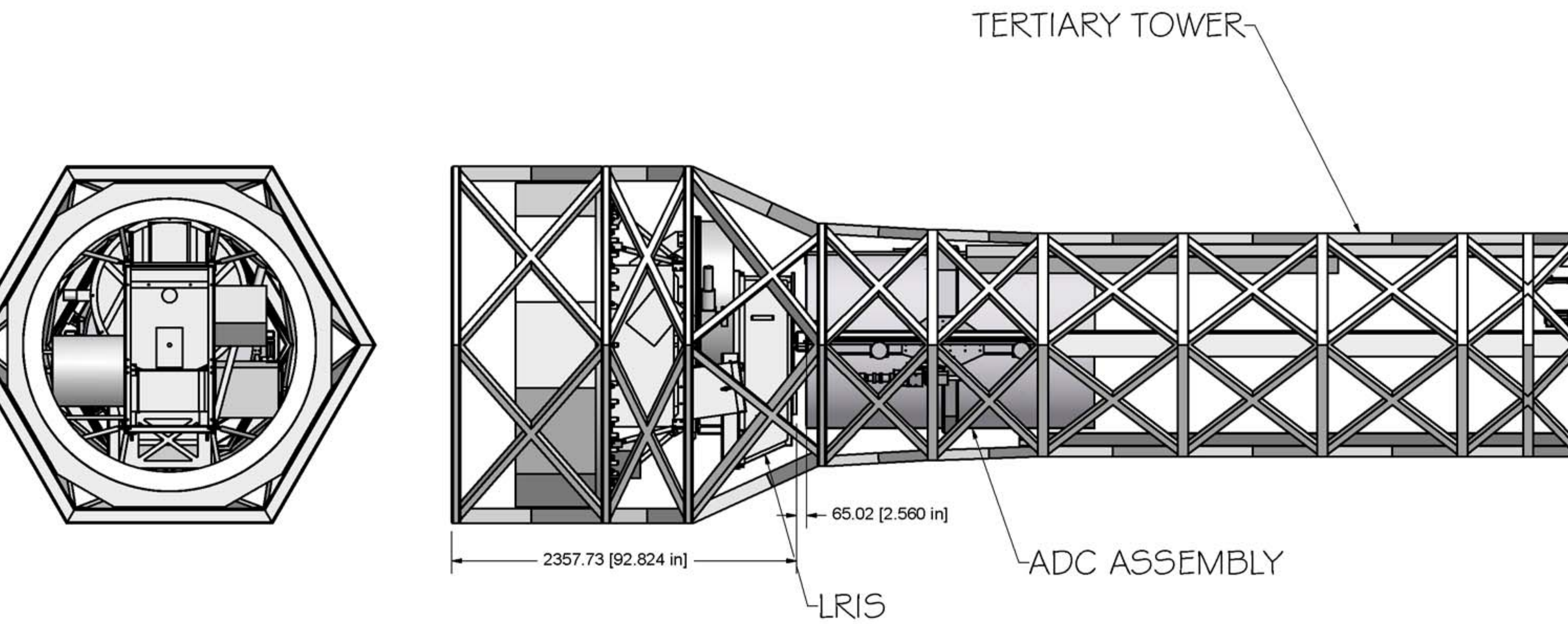
- Optics
- Mechanical (Vern Wallace)
  - Final Detailed Design
  - Structural Analysis
  - Assembly and Alignment
- Electrical
- Software



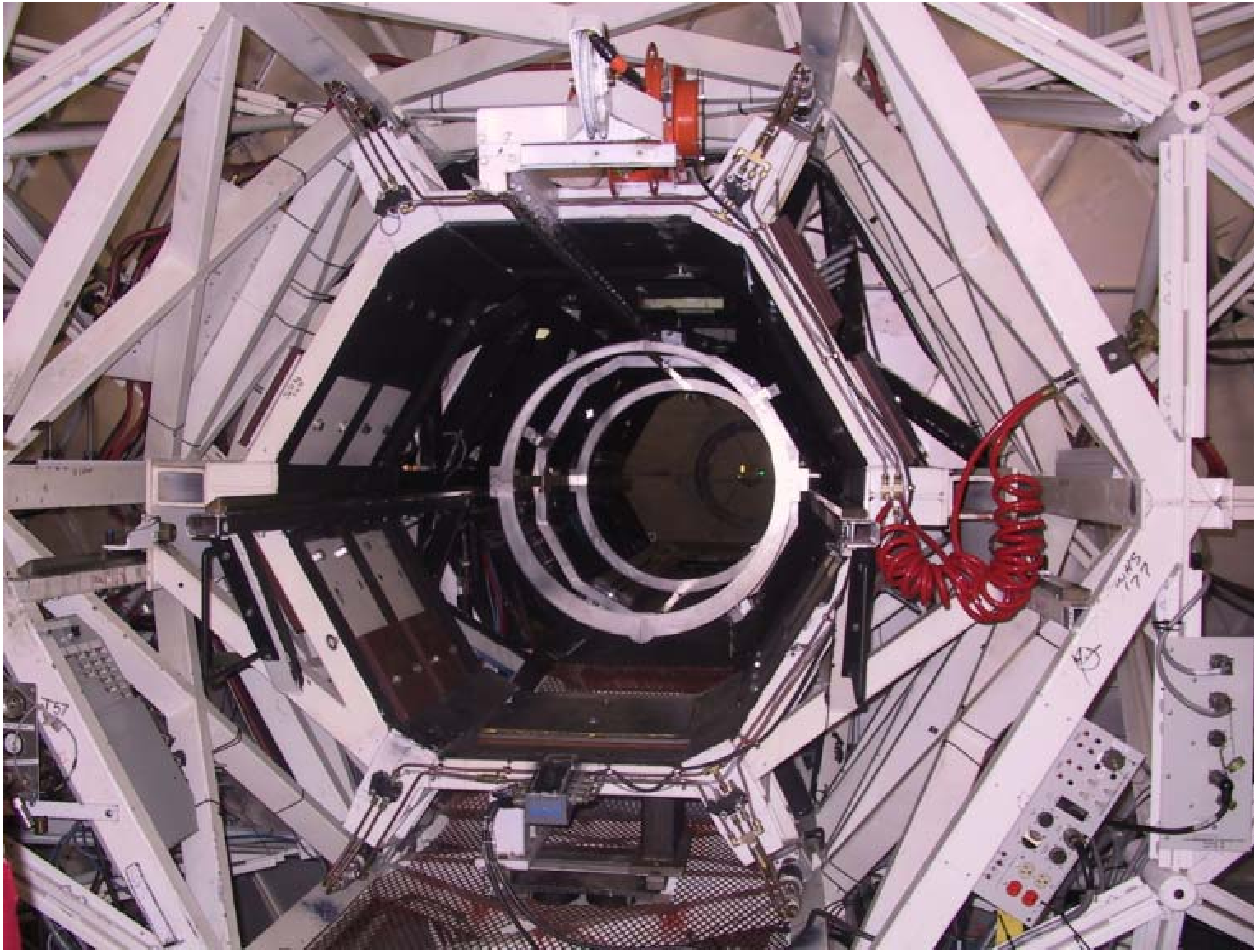
ADC WITHOUT CLADDING OR COVERS

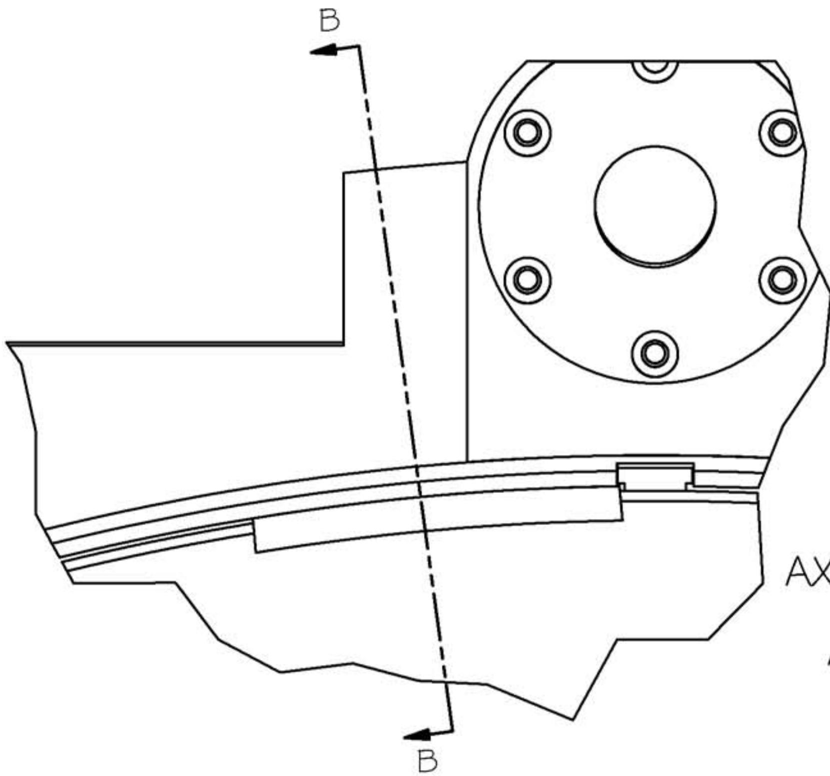


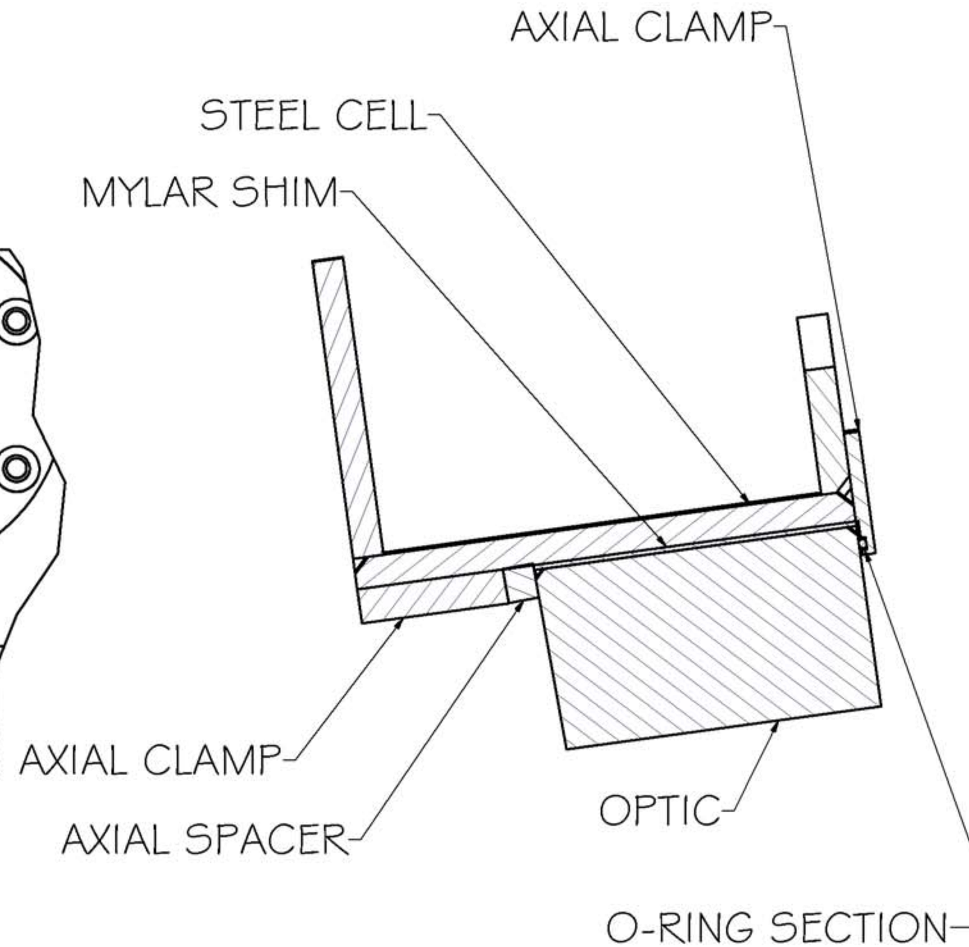
ADC WITH CLADDING & COVERS



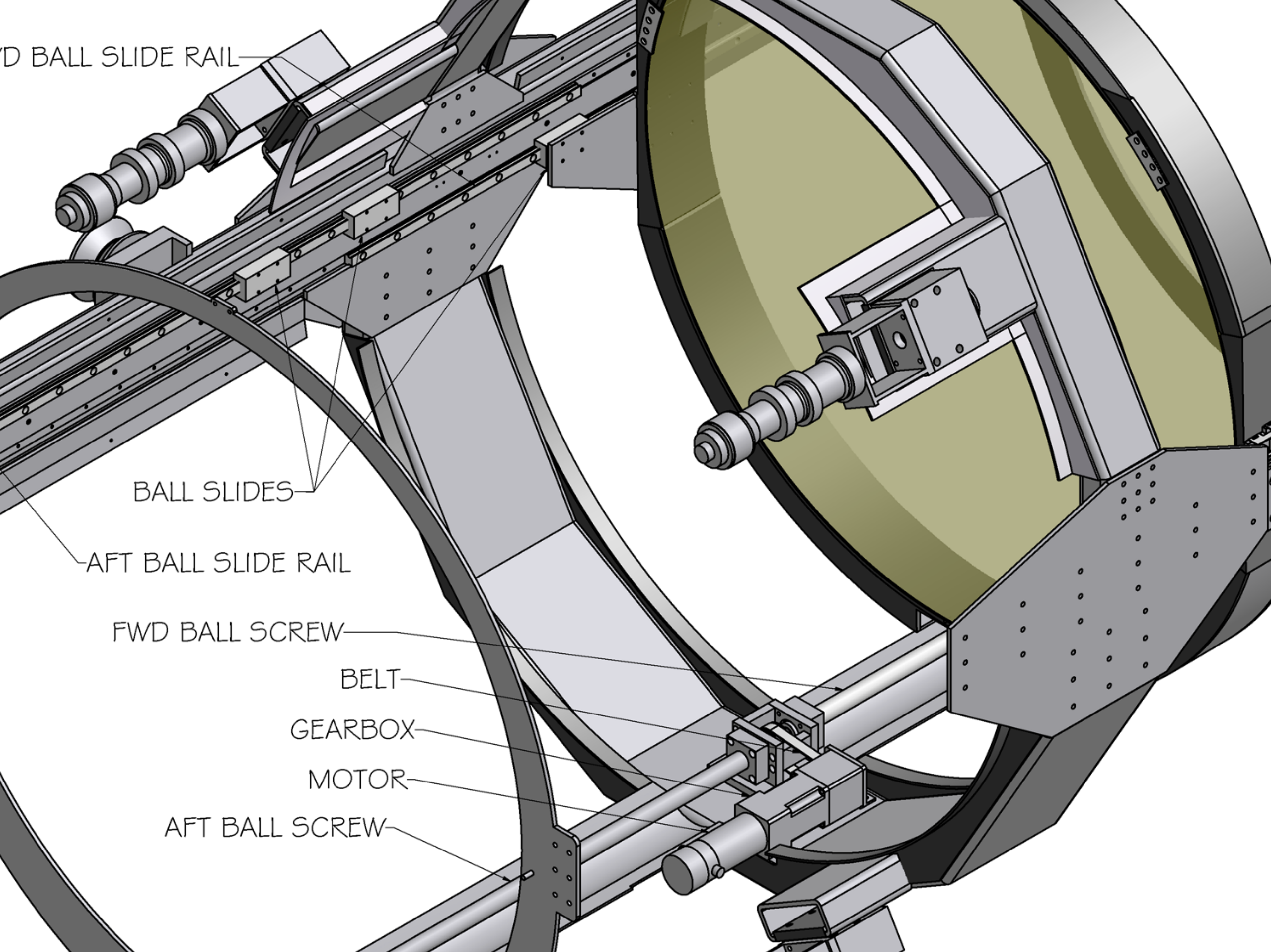
LRIS & ADC IN TERTIARY TOWER

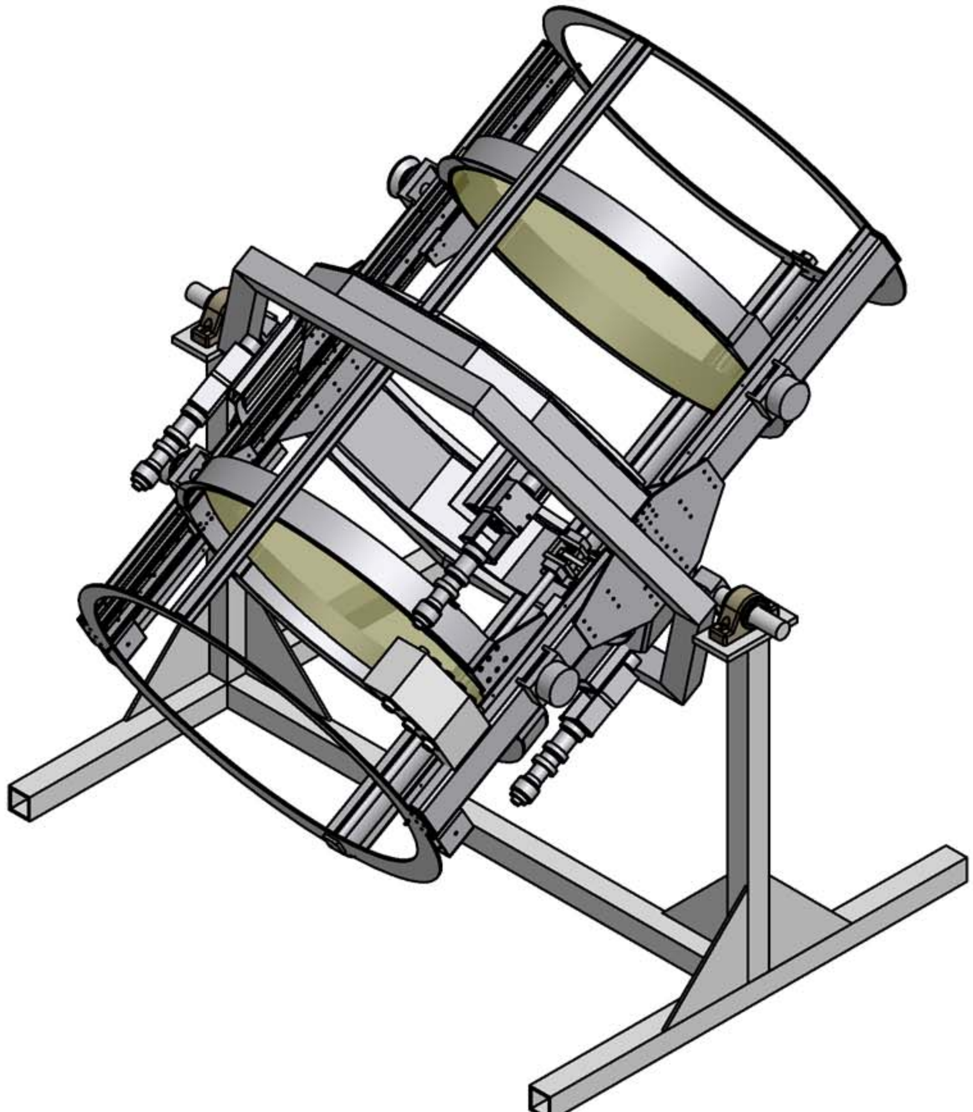



B
B

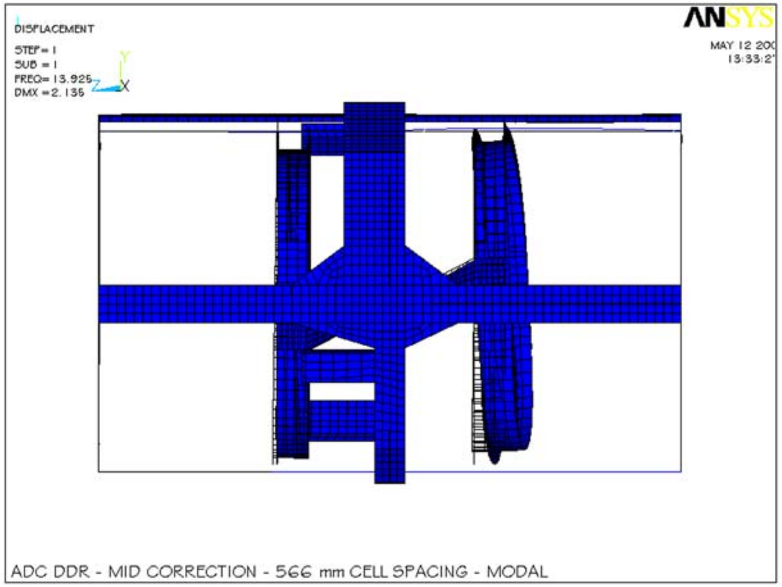

AXIAL CLAMP
STEEL CELL
MYLAR SHIM
AXIAL CLAMP
AXIAL SPACER
OPTIC
O-RING SECTION

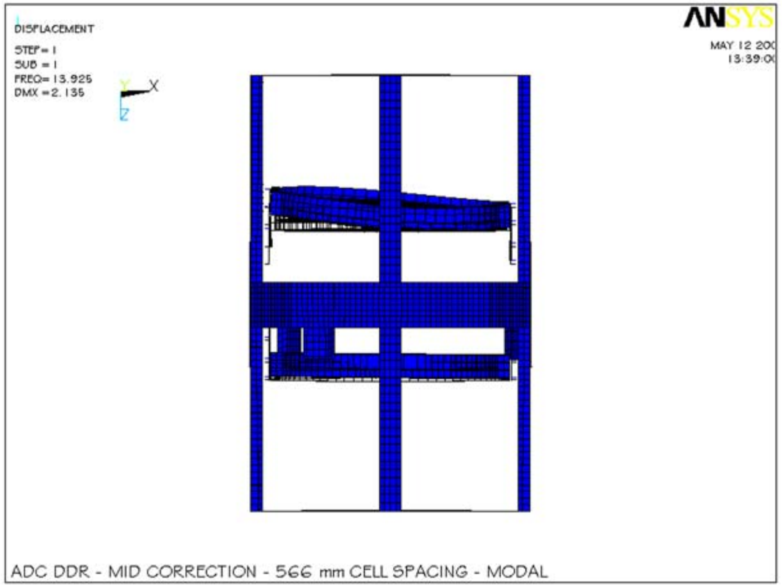
SECTION B-B


FWD BALL SLIDE RAIL
BALL SLIDES
AFT BALL SLIDE RAIL
FWD BALL SCREW
BELT
GEARBOX
MOTOR
AFT BALL SCREW



ADC ON TEST STAND


DISPLACEMENT
STEP=1
SUB =1
FREQ=13.925
DMX =2.135
ANSYS
MAY 12 200
13:33:27
ADC DDR - MID CORRECTION - 566 mm CELL SPACING - MODAL


DISPLACEMENT
STEP=1
SUB =1
FREQ=13.925
DMX =2.135
ANSYS
MAY 12 200
13:39:00
ADC DDR - MID CORRECTION - 566 mm CELL SPACING - MODAL

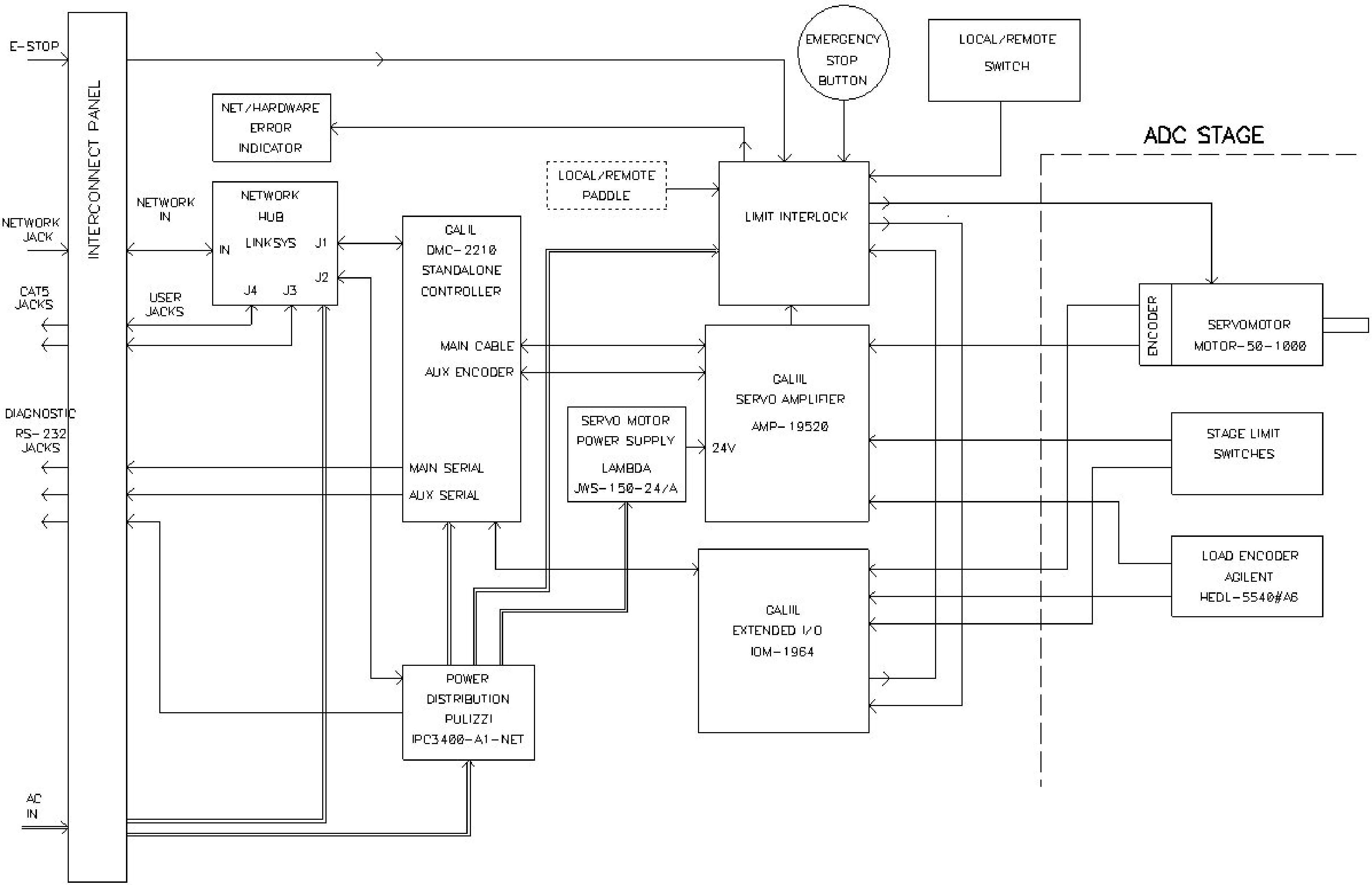
Overview & Changes from PDR

- Optics
- Mechanical

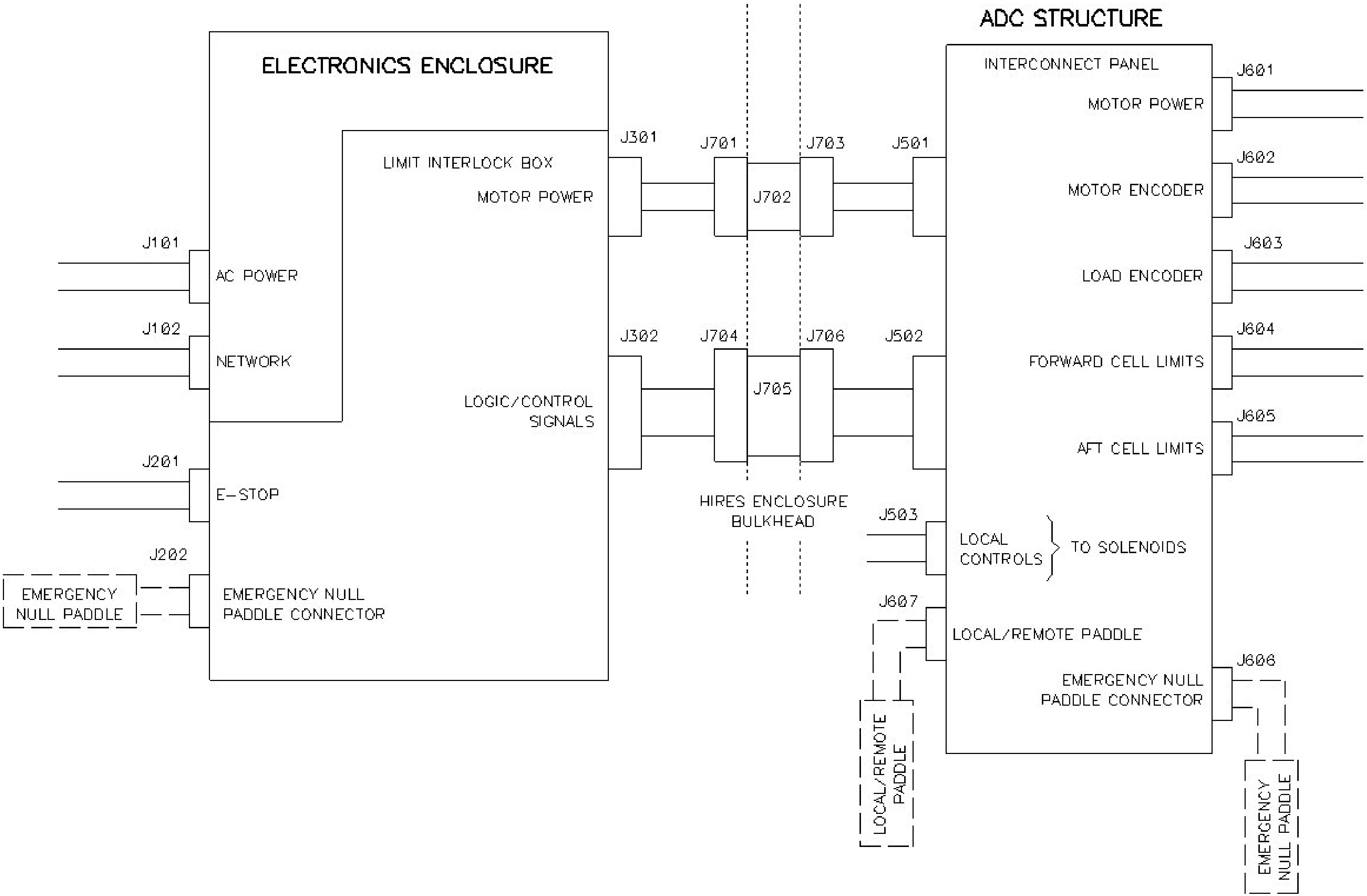
- Electrical (Barry Alcott)
  - Block Diagram
  - Interconnects
  - Enclosure

- Software

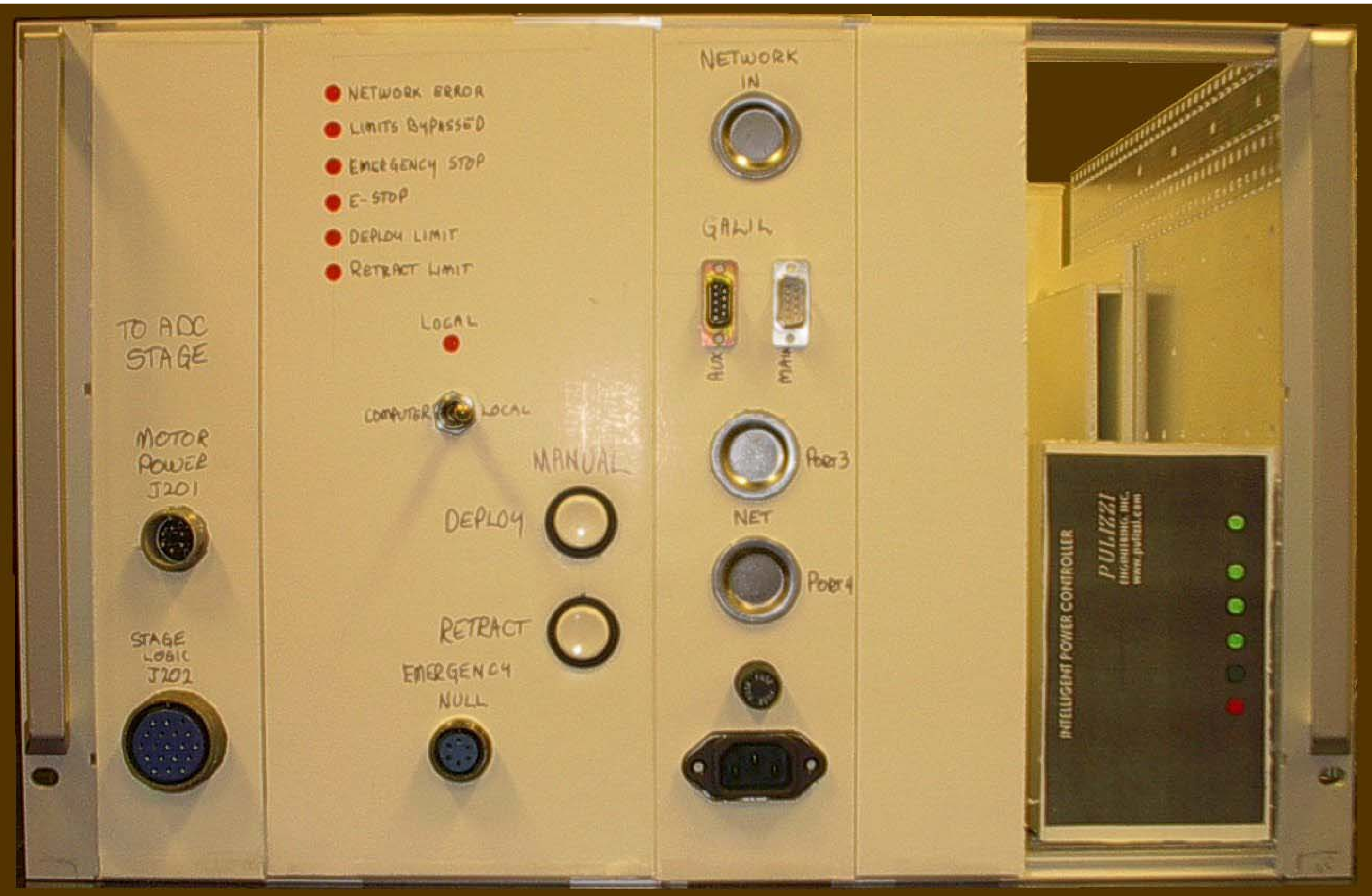
ADC Block Diagram



ADC Interconnection Diagram



ADC Rack Mounted Box

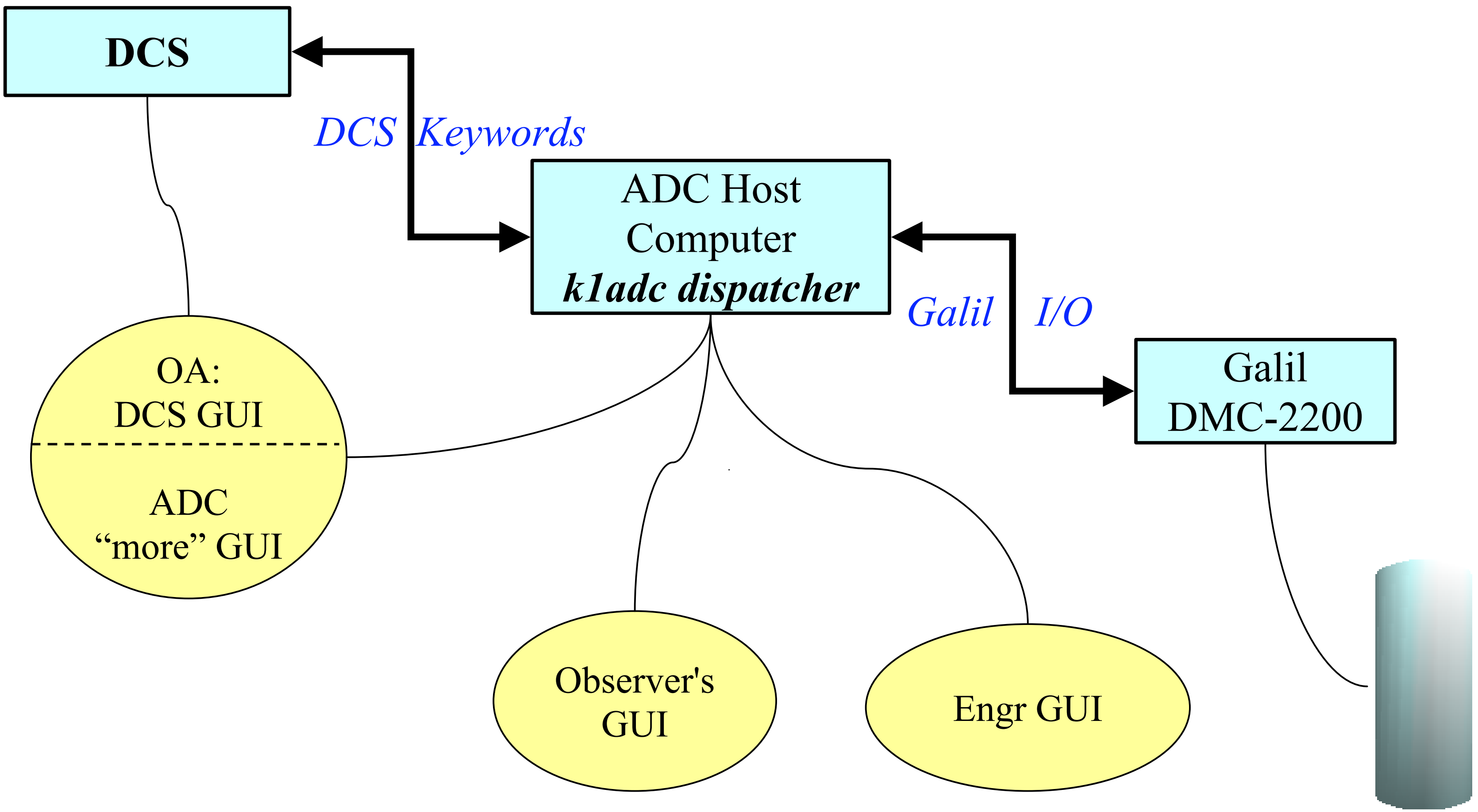


Overview & Changes from PDR

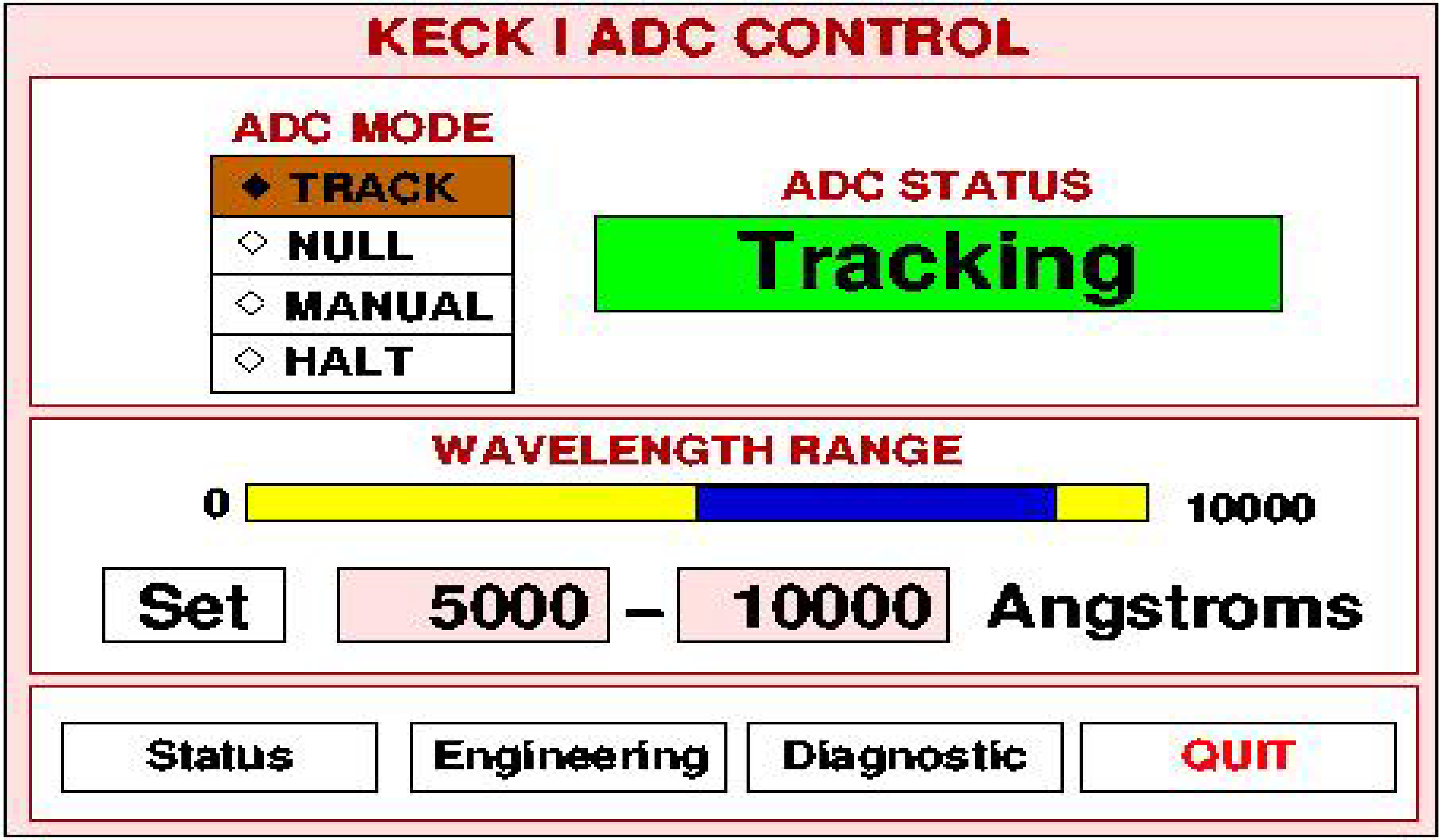
- Optics
- Mechanical
- Electrical

- Software (Will Deich)
  - Schematics
  - GUIs

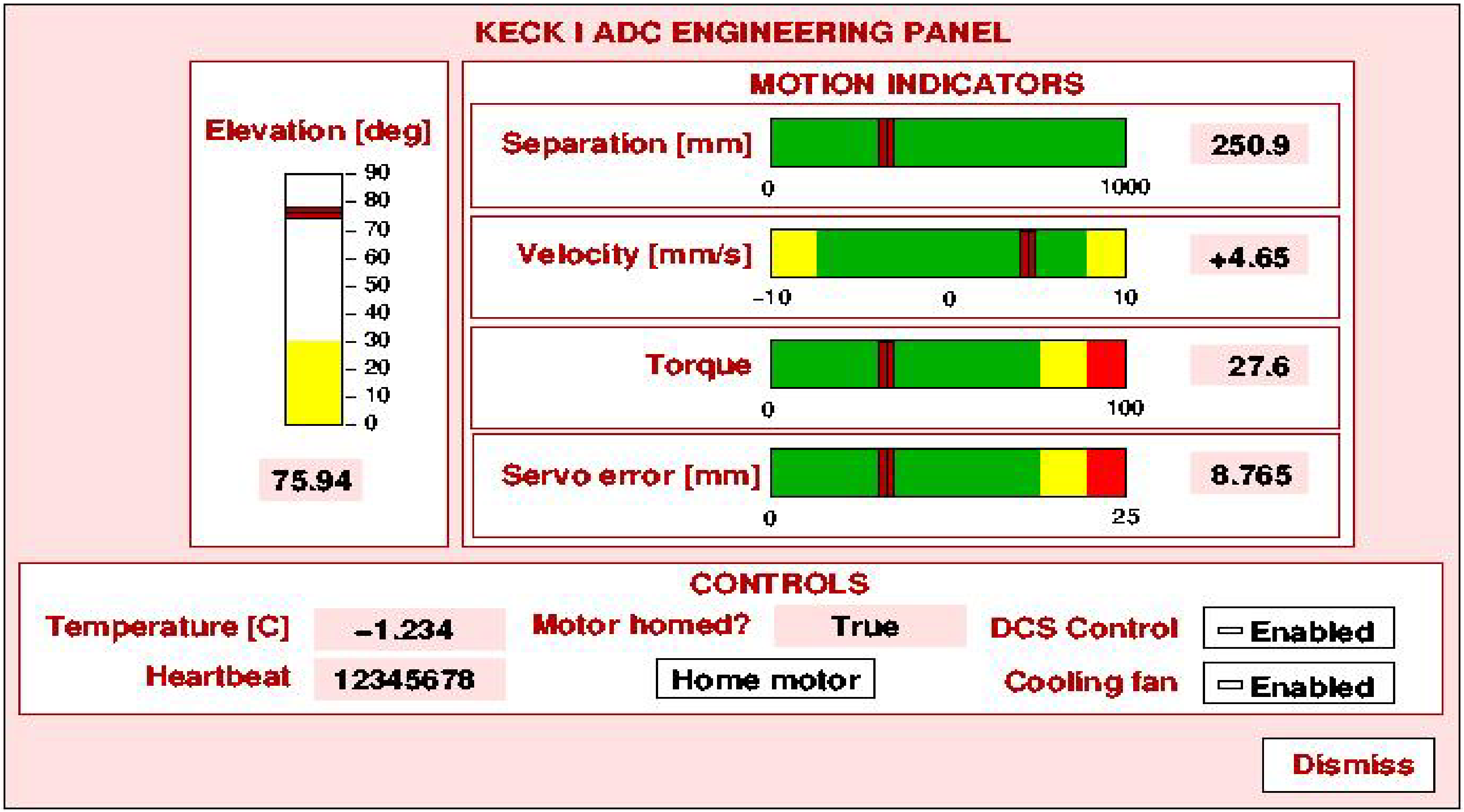
ADC Architecture



Sample GUI - 1


KECK I ADC CONTROL
ADC MODE
TRACK
NULL
MANUAL
HALT
ADC STATUS
Tracking
WAVELENGTH RANGE
0
10000
Set
5000
–
10000
Angstroms
Status
Engineering
Diagnostic
QUIT

Sample GUI - 2


KECK I ADC ENGINEERING PANEL
Elevation [deg]
90
80
70
60
50
40
30
20
10
0
75.94
MOTION INDICATORS
Separation [mm]
0
1000
250.9
Velocity [mm/s]
-10
0
10
+4.65
Torque
0
100
27.6
Servo error [mm]
0
25
8.765
CONTROLS
Temperature [C]
-1.234
Heartbeat
12345678
Motor homed?
True
Home motor
DCS Control
Enabled
Cooling fan
Enabled
Dismiss

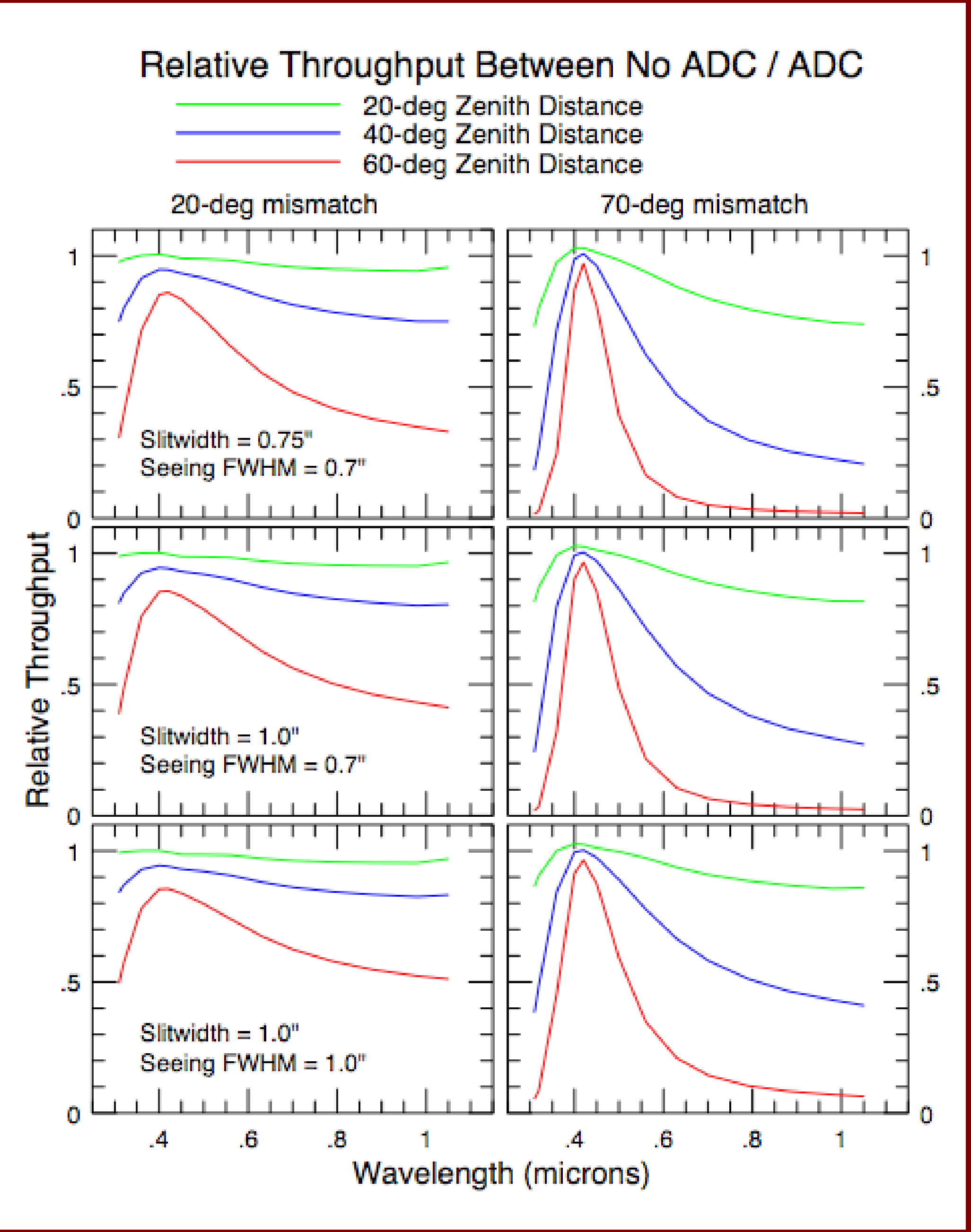
Responses to Specific PDR Questions & Concerns

1. *The ADC science gains should be quantified in "typical" configurations detailing the performance of LRIS without the ADC; with a perfect ADC; and LRIS with the predicted performance of the ADC as designed.*

ADC Merit

- Relative throughput without ADC for well-aligned and poorly-aligned slitlets (*l-r*), for a variety of conditions (*top-to-bottom*) and elevations (*colors*).

- Report to the SSC included as Appendix 1.



Responses to Specific PDR Questions & Concerns

2. A detailed assembly and alignment procedure for the ADC should be developed during the Detailed Design phase.

Ans: This has been done and summarized in Sect. 4.2.3

Responses to Specific PDR Questions & Concerns

Gravity acting on the prism cells as the telescope elevation changes will cause the prism cells to place a moment on the lead screw via the nut. The deflection produced is minimal as the lead screws are 25 mm in diameter. Cyclic loading due to the deflection is well below the endurance limit and the estimated life of the nut and bearing is not impacted. The end of each lead screw is turned down to a shaft, which passes through two bearings, so eccentric motion of the shaft end is not expected, but this will be reviewed in the detail design phase.

Ans: See discussion in Introduction and Sect. 4.2.1.5. We believe there are no concerns regarding this.

Responses to Specific PDR Questions & Concerns

3. The performance of the ADC at commissioning should include representative spectra taken with and without the ADC that can then be used to further quantify the scientific benefit of the ADC.

Ans: We agree, and this is part of the com-missioning test suite now being developed with CARA personnel.

Responses to Specific PDR Questions & Concerns

4. Additional attention should be given to characterizing the coatings and confirming the transmission that will be achieved. In particular test coatings should be done to confirm the transmission and to evaluate compatibility with various cleaning procedures.

… and …

Responses to Specific PDR Questions & Concerns

5. *The field flattener from the original HIRES dewar should be removed after the upgrade is complete and sent to Livermore for measurement of transmission. The original and new transmission curves can then be compared to look for aging effects. Other groups should also be contacted for information about coating durability and aging effects.*

Response to Q. 4 and 5

- HIRES dewar window has not yet been removed
- Both PFCam and DEIMOS Sol-Gel coatings look fine after 2-to-many years
- We have discussed Sol-Gel extensively with Jim Stilburn at DAO:
  - ages well -- if hydrophobic agent is applied
  - cleans with alcohol wash or gentle swabbing
  - withstands soft rubbing if hardened … but …
  - adheres poorly to [some] MgF_2

(more ...)

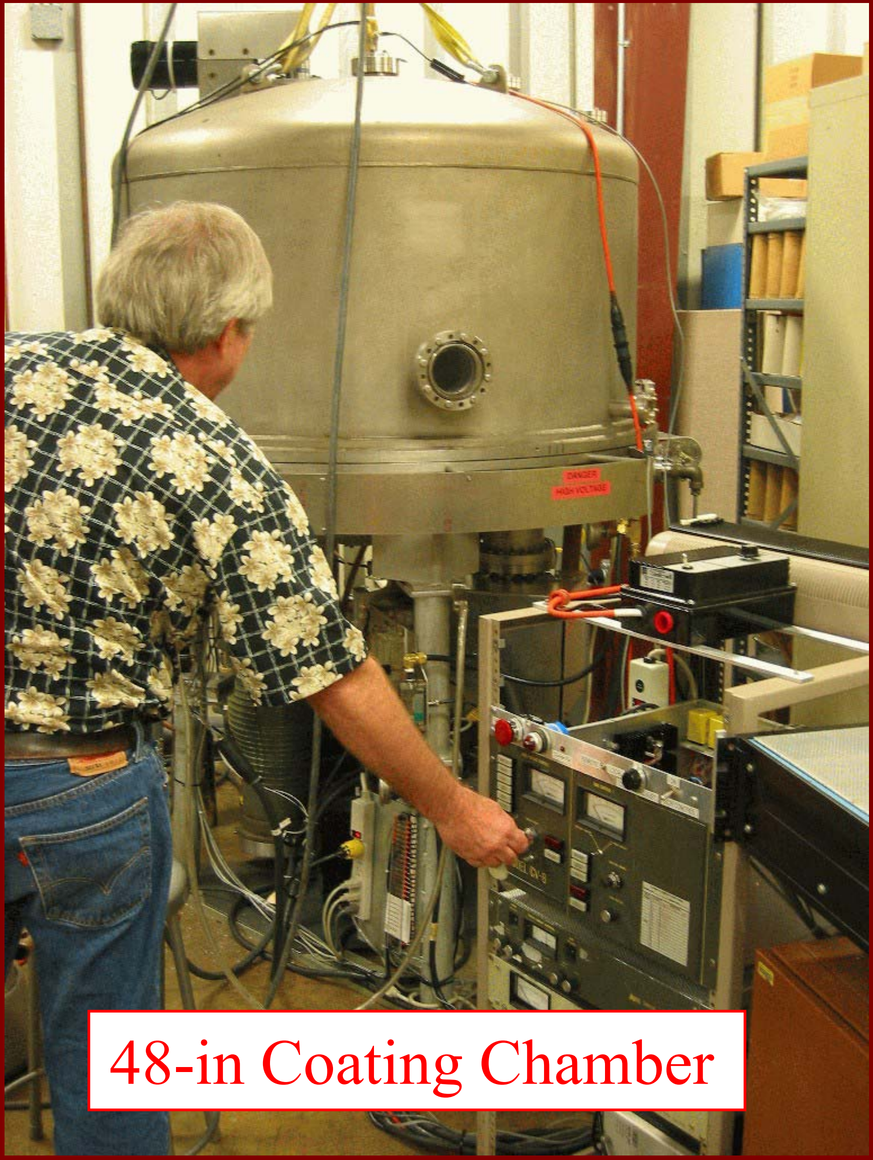
Response to Q. 4 and 5, cont'd.

- Poor adhesion of Sol-Gel to MgF_2 remains serious problem!
- Possible solution: *deposit a very thin bond layer of silica (or … ?) over MgF_2*

Sol-Gel + MgF_2: Adhesion Tests

- Deposited MgF_2 on 2"× 1/8" quartz samples
- Overcoated with thin "bond" layer
- Jim Stilburn (DAO) spin-coated w/ Sol-Gel
- Results of abrasion/adhesion tests:
  - Bare MgF_2: Poor ("comes right off")
  - ~40 Å of SiO_2 or SiO_x: Adheres as well as to bare glass
  - ~40 Å of Al_2O_3: "tough as nails"

UCO/Lick Coatings Facility

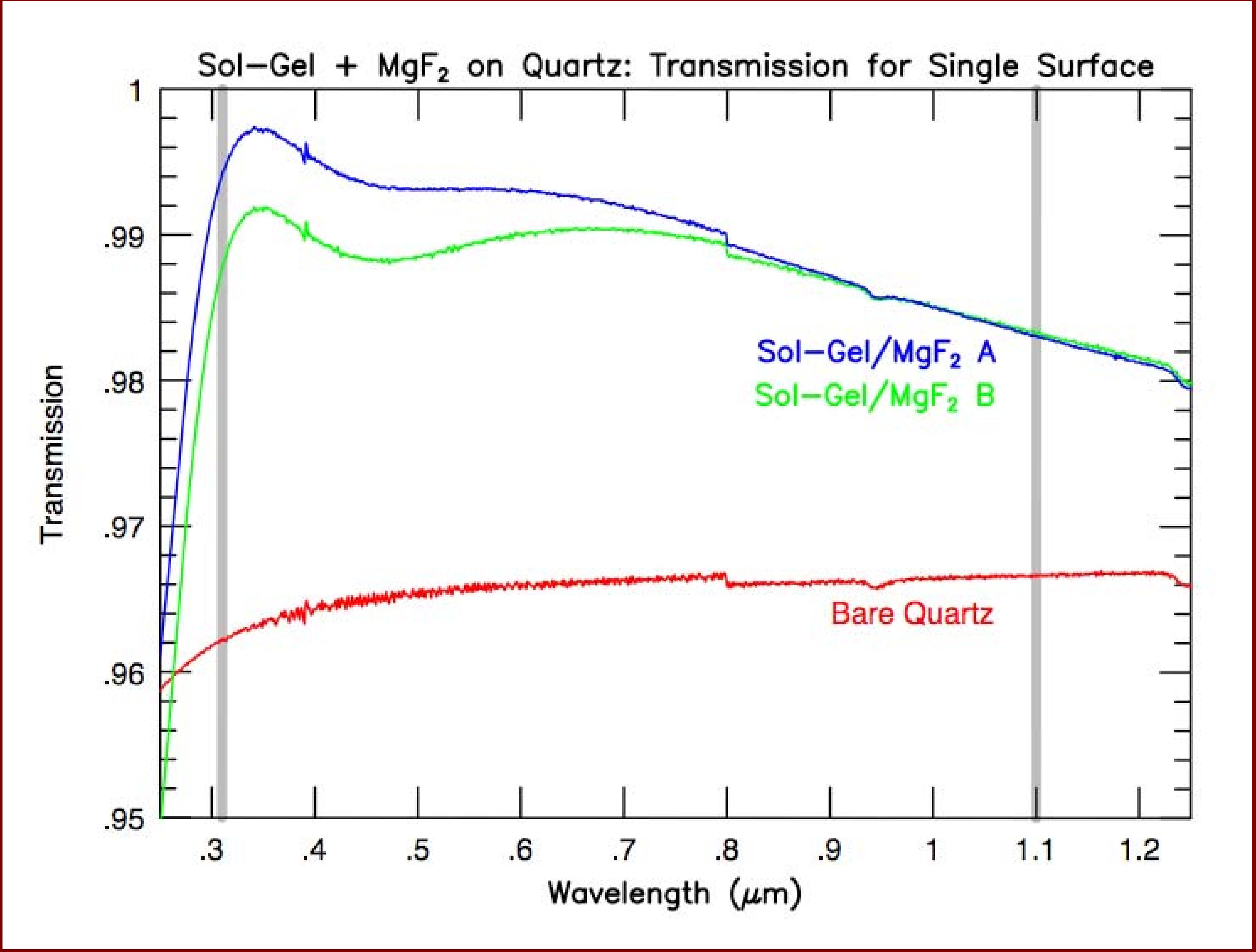


48-in Coating Chamber

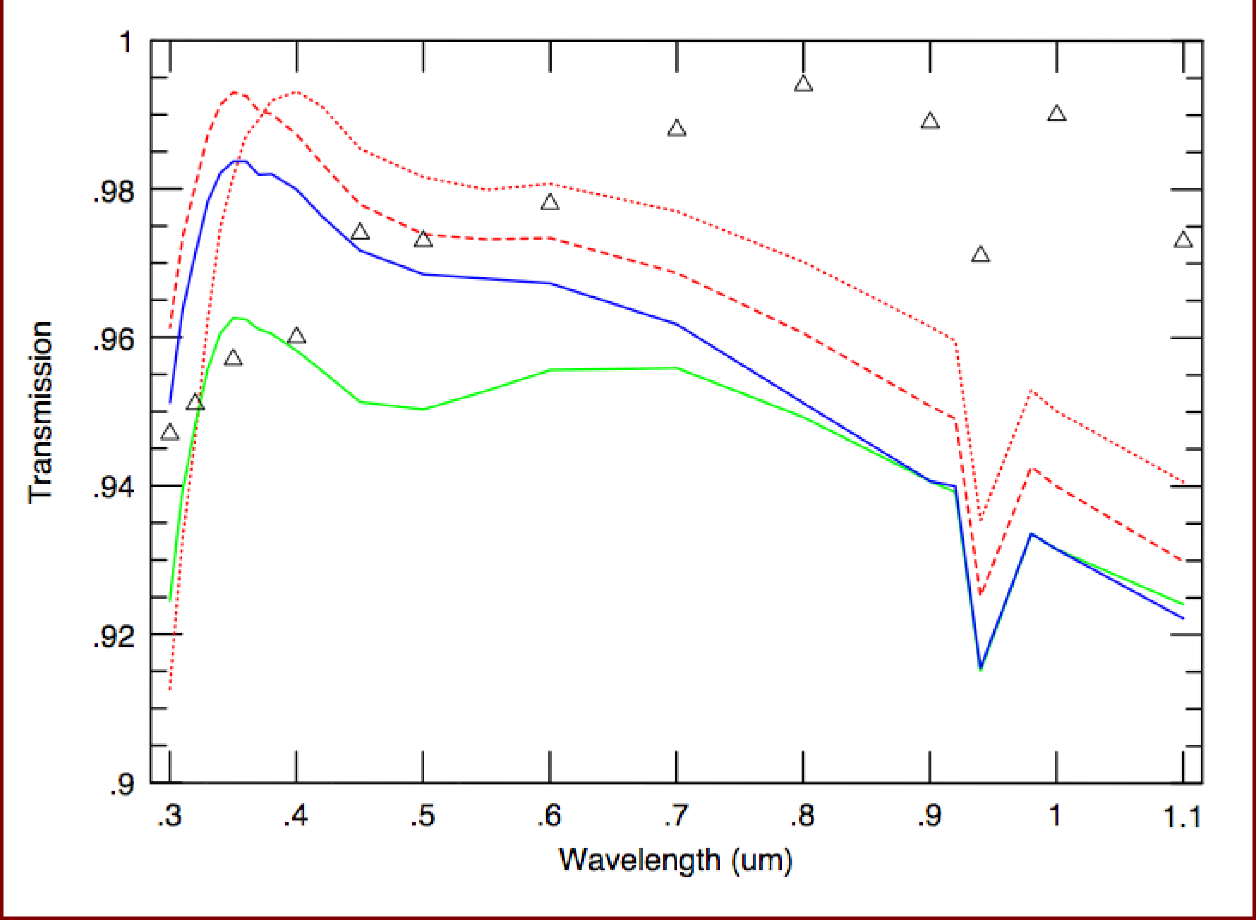
Cary 5000 Spectrophotometer

2” Samples

Single-Surface Transmission



Expected ADC Transmission



- 90 mm quartz with 4 surfaces as measured (green, blue = measured; red = models)

Project Concern/Risk Area

- We feel that coatings remain a technical challenge and that additional development work needs to be done in the next few months. In particular:
  - Need to investigate CO_2 or alt. cleaning
  - Concern about "one-shot" LLNL Sol-Gel dip
  - Concern about applying hydrophobic agent

Responses to Specific PDR Questions & Concerns

6. The effect of the ADC should be evaluated in terms of the acceptable tolerances for pointing and focusing accuracy.

Ans: Pointing and focus adjustments have been quantified. Interpolation formulas represent the data to within ~0.5″ for the pointing and ±3-µm for the 2ndry piston.

CARA has accepted responsibility for applying these pointing and focus effects.

Responses to Specific PDR Questions & Concerns

7. *Any software GUI designs required by the ADC should be defined in the detail design phase.*

Ans. GUI designs are being developed with CARA input, and acceptable designs exist (Sect. 4.4.4)

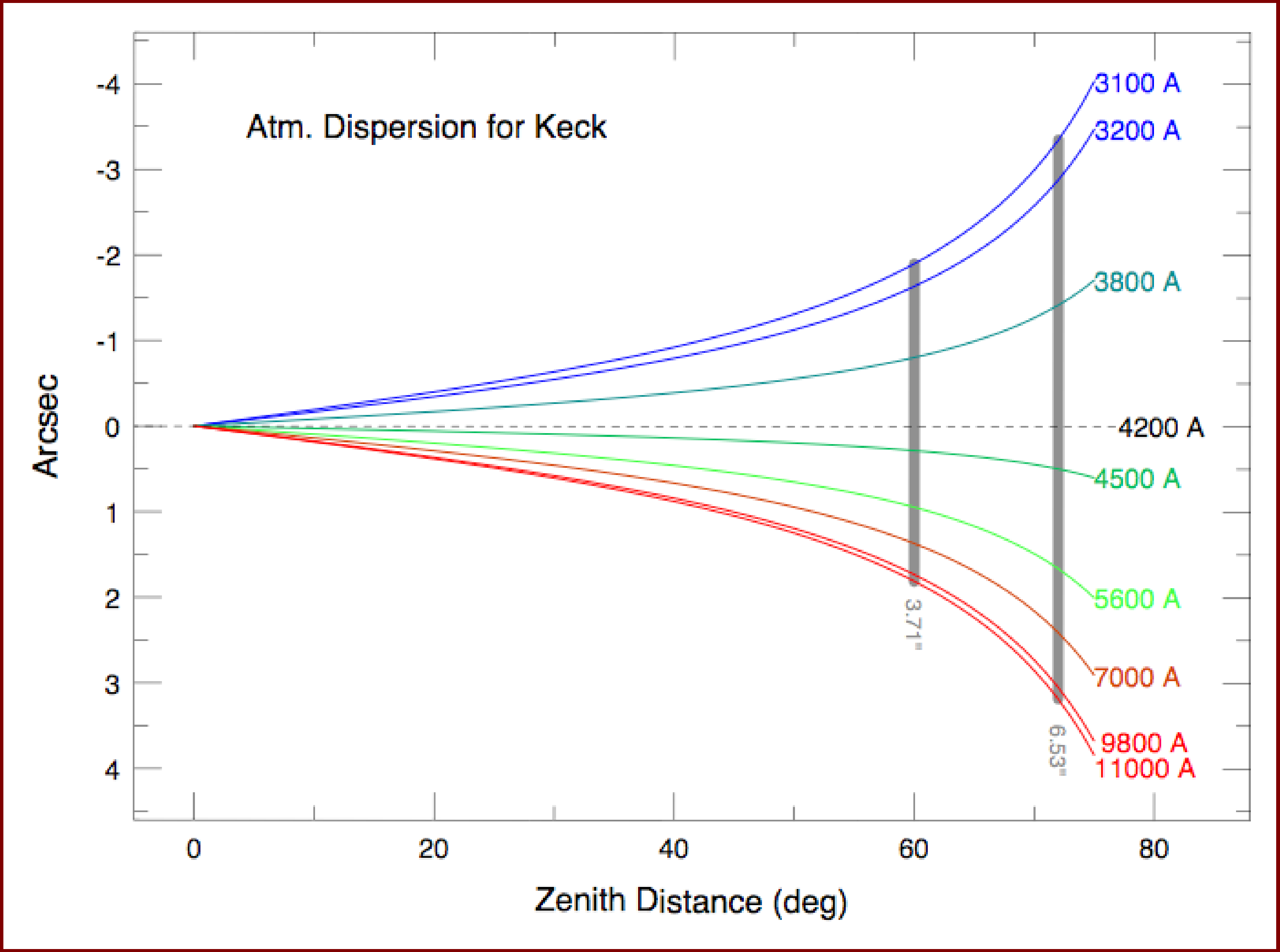
Responses to Specific PDR Questions & Concerns

Stress induced birefringence may have an impact on precision polarimetry, Jacques Beckers recommends that the ADC design team contact Keller at the National Solar Observatory for comments on this issue. Christoph Keller is evaluating these effects for the LADC design for the LBT. In lieu of other information the best recommendation is that the ADC not be used when precision polarimetric observations are done with LRIS.

Ans. No action taken so far, as this has no impact on design or decision to build. This will be done before PSR so that observers can be properly advised.

(end of presentation)

The Problem



Atm. Dispersion for Keck
Arcsec
-4
-3
-2
-1
0
1
2
3
4
0
20
40
60
80
Zenith Distance (deg)
3100 A
3200 A
3800 A
4200 A
4500 A
5600 A
7000 A
9800 A
11000 A
3.71"
6.53"

Corrected with ADC