MAGELLAN PROJECT

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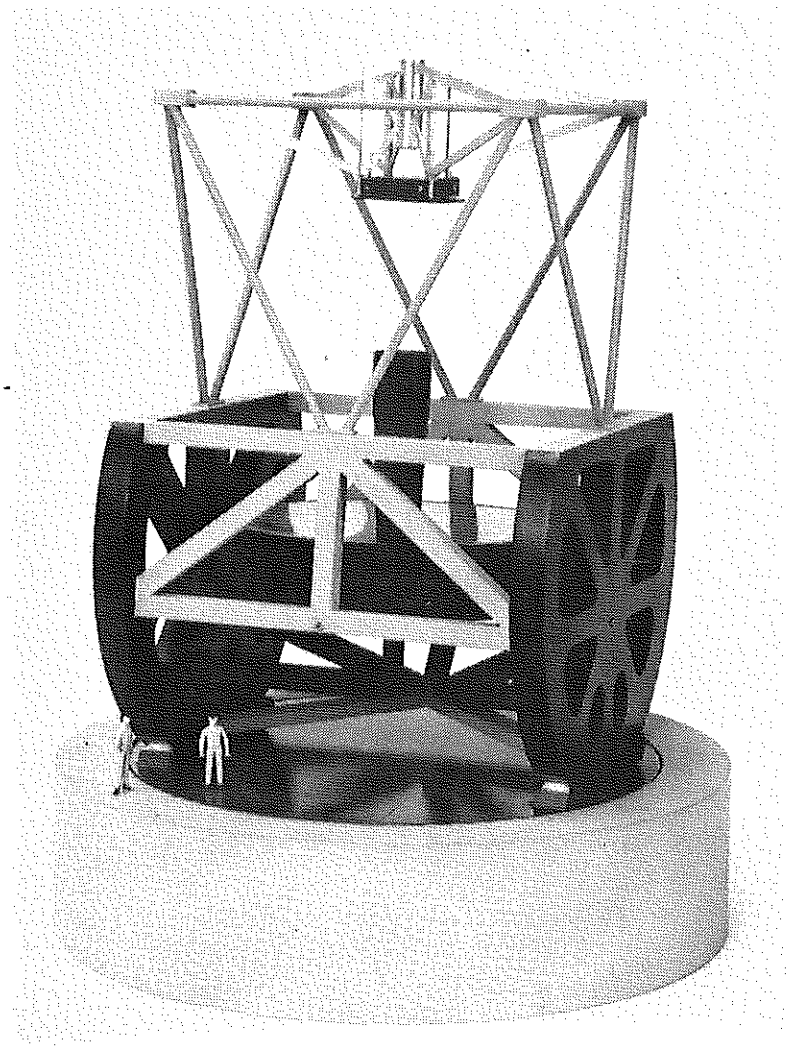

More All-Spherical Wide-Field Corrector Alternatives for the Columbus and Magellan Telescopes

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May 2, 1989
No. 9

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1. Introduction

At the present time the baseline optical geometries for the Magellan and Columbus telescopes are similar but not identical. The purpose of this report is to present additional all-spherical broad-passband wide-field correctors whose f/ratios, maximum nontelecentric angles and fields of view further explore the parameter space which separates the respective telescope concepts at this time.

The present Magellan configuration calls for a 315-inch f/1.20 parabolic primary with an hyperbolic optical secondary which combines with a 3-element all-spherical field corrector with (ADC), to yield a 40-arcmin mildly curved field which is fully corrected over the (0.33 to 1.10)-micron chromatic range without refocus. The corrected f/6.50 focus lies approximately 80 inches behind the primary-mirror vertex.

The present Columbus configuration (UA-88-12, July 8, 1988) calls for a 315-inch f/1.20 hyperbolic primary (A_2=-1.00126, Ritchey-Chrêtien at f/15) with an hyperbolic optical secondary which combines with an unspecified field corrector to provide a 45-arcmin field corrected over an unspecified chromatic range. The corrected f/5.40 focus location is doubly specified as being located 69.8 inches and 80.0 inches behind the primary-mirror vertex. Interest has been expressed in an even larger field of view.

Both Projects have voiced concern that maximum nontelecentric angles larger than perhaps 1.5 degrees could compromise efficient coupling to fiber optic fed spectrometers. Both groups agree however that this potential problem could be handled mechanically if it cannot be dealt with optically in a reasonable manner.

In another report, (Epps, May 6, 1989) it will be argued again on fully quantitative grounds that there is no need to deviate from a strictly parabolic primary mirror in order to achieve fully diffraction limited performance at the f/15 infrared focus for wavelengths of 2 microns and beyond. Therefore a 315-inch diameter f/1.20 parabolic primary mirror will be adopted in all of the corrector designs to be presented in this report.

2. Old 40-Arcmin f/5.40 and f/6.50 Baseline Corrector Designs

In a previous report (Epps, January 1989) 3-element all-spherical (0.33 to 1.10)-micron field correctors with (ADC) and mildly curved 40-arcmin diameter fields of view were presented. These f/5.40 and f/6.50 baseline correctors were nearly equivalent in optical performance, thus establishing the fact that the final Cassegrain f/ratio choice has little impact on field corrector designs with the possible exception of the nontelecentricity problem.

Run No. 5933 (01/18/89) shown in Table 1 is the baseline all-spherical corrector with (ADC) which uses a 315-inch f/1.20 parabolic primary mirror corrected to f/5.40. It contains 3 fused silica lens elements and the (ADC) is made of FK5 and LLF2 in the usual manner. It has rms image diameters averaged over all field angles and colors of 0.18 +/- 0.07 arcsec with 0.12 arcsec of maximum rms lateral color. The 40-arcmin field of view is

concave toward the sky with a radius of -232.7 inches, somewhat less curved than the f/6.50 model. If the corrector is removed and the secondary mirror is moved toward the primary mirror some 0.1647 inches, the resulting naked Cassegrain operates at f/5.20. The naked focal surface is located some 73.0 inches behind the primary-mirror vertex. The maximum nontelecentric angle for this f/5.40 corrector is 0.62 degrees which is quite acceptable.

Run No. 7708 (01/18/89) shown in Table 2 is the analogous f/6.50 baseline model. Its rms image diameters averaged over all field angles all colors are 0.16 +/- 0.06 arcsec with 0.11 arcsec of maximum rms lateral color. The concave field of view has a -161.1-inch radius. Removing the corrector and moving the secondary mirror some 0.0965 inches toward the primary mirror produces a naked f/6.24 Cassegrain whose focal surface lies some 79.3 inches behind the primary-mirror vertex. The maximum nontelecentric angle for this f/6.50 corrector is an alarming 2.16 degrees.

3. New 40-Arcmin f/6.50 Corrector with Reduced Nontelecentricity

Run No. 749 (04/30/89) is the best in a sequence of 40-arcmin f/6.50 correctors with reduced nontelecentricity. Its rms image diameter averaged over all field angles and all colors is an acceptable 0.20 +/- 0.07 arcsec with 0.13 arcsec of maximum lateral color. This corrector shows 0.10 arcsec of uncorrected equivalent longitudinal chromatic aberration (axial color) which was not present in the baseline f/6.50 corrector but is (just) acceptable. There is a tendency for correction to falter on axis in the infrared and in the ultraviolet at full field. Worst-case images have rms diameters of about 0.32 arcsec.

The concave field of view has a -187.9-inch radius, somewhat flatter than the baseline f/6.50 model. Removing the corrector and moving the secondary mirror some 0.0883 inches toward the primary mirror produces a naked f/6.18 Cassegrain whose focal surface lies some 79.0 inches behind the primary-mirror vertex. The maximum nontelecentric angle for this f/6.50 corrector is an acceptable 1.28 degrees.

No attempt was made to design an f/6.50 corrector with a field of view larger than 40-arcmin as it was felt that excessive lens-element diameters and nontelecentricity would have been encountered.

4. New 50-Arcmin f/5.40 Corrector

Run No. 8342 (04/29/89) is the best in a sequence of 50-arcmin f/5.40 correctors which explores the question of whether a larger field of view is practical. Its rms image diameters averaged over all field angles all colors are 0.25 +/- 0.08 arcsec with 0.16 arcsec of maximum lateral color. The concave field of view has a -199.1-inch radius. Removing of the corrector and moving the secondary mirror some 0.2411 inches toward the primary mirror produces a naked f/5.26 Cassegrain whose focal surface lies some 77.9 inches behind the primary-mirror vertex. The maximum nontelecentric angle for this f/5.40 corrector is 1.56 degrees.

In order to complete this design it proved necessary to extend the front surface vertex of the first lens element some 11.1 inches above the primary-mirror vertex which may be undesirable. It was also necessary to extend its focal surface an additional 6.0 inches beyond the focal surface location in the baseline f/5.40 corrector.

Axial color is well corrected but tendencies toward poorer images on axis in the infrared and in the ultraviolet at full field appear. The average image softness relative to the baseline corrector makes this corrector obviously less desirable for imaging at all field locations.

5. New 50-Arcmin f/5.40 Corrector with Reduced Nontelecentricity

Run No. 448 (04/30/89) is the best in a sequence of 50-arcmin f/5.40 correctors with reduced nontelecentricity. Its rms image diameters averaged over all field angles all colors are 0.37 +/- 0.13 arcsec with 0.18 arcsec of maximum rms lateral color. The concave field of view has a -252.8-inch radius. Removing the corrector and moving the secondary mirror some 0.2020 inches toward the primary mirror produces a naked f/5.16 Cassegrain whose focal surface lies some 75.0 inches behind the primary-mirror vertex. The maximum nontelecentric angle for this f/5.40 corrector is just 0.46 degrees.

There is a residual 0.09 arcsec of uncorrected axial color and the tendency toward image breakup on axis in the infrared and in the ultraviolet at full field is pronounced. Worst-case rms image diameters approaching 0.6 arcsec are seen! It would be fair to say that this corrector is unacceptable for direct imaging.

6. New 40-Arcmin f/6.00 Baseline Corrector

Run No. 6572 (05/01/89) is the best in a sequence of 40-arcmin f/6.00 correctors. Its rms image diameters averaged over all field angles all colors are 0.18 +/- 0.06 arcsec with 0.10 arcsec of maximum lateral color. The concave field of view has a -183.6-inch radius. Removing of the corrector and moving the secondary mirror some 0.1254 inches toward the primary mirror produces a naked f/5.77 Cassegrain whose focal surface lies some 79.9 inches behind the primary-mirror vertex. The maximum nontelecentric angle for this f/6.00 corrector is 1.51 degrees.

Axial color is perfectly corrected and the image quality is uniform and superb over all field angles and colors. The worst-case images are just 0.27 arcsec in rms diameter at the edge of the 40-arcmin field of view.

The 70.18-inch diameter secondary mirror has a maximum aspheric deviation of 691 waves and is physically intermediate between the larger, more aspheric f/5.40 baseline secondary and the smaller, less aspheric f/6.50 baseline secondary.

7. Installation of a Window into the 40-Arcmin f/6.00 Baseline Corrector

A 0.50-inch thick flat fused silica window was installed into Run No. 6572 (05/01/89) approximately 2.06 inches ahead of the final focus. A focal adjustment of 0.1617 inches was required which is very nearly what would have been expected from Gaussian theory. No other change was made to the design. The new rms image diameter averaged over all field angles all colors was 0.18 +/- 0.06 arcsec with 0.11 arcsec of maximum rms lateral color. These values are nearly identical to those reported in section 6 for the optimum (windowless) design.

Approximately 0.08 arcsec of uncorrected residual axial color appears when the window is installed as would have been expected due to the variation of the refractive index of fused silica over the large (0.33 to 1.10)-micron wavelength interval. This small amount of axial color is probably acceptable because windows (and filters) will be used primarily for direct imaging over scientifically limited passbands and refocus is allowed between passbands. As an alternative the corrector could easily be reoptimized for zero axial color with the window in place. In this case 0.08 arcsec of axial color would appear in the opposite sense when the window was removed.

8. New 50-Arcmin f/6.00 Corrector

Run No. 7874 (05/01/89) is the best in a sequence of 50-arcmin f/6.00 correctors. Its rms image diameters averaged over all field angles all colors are 0.23 +/- 0.08 arcsec with 0.16 arcsec of maximum lateral color. The concave field of view has a -166.9-inch radius. Removing of the corrector and moving the secondary mirror some 0.1758 inches toward the primary mirror produces a naked f/5.83 Cassegrain whose focal surface lies some 81.8 inches behind the primary-mirror vertex. The maximum nontelecentric angle for this f/6.00 corrector is 2.52 degrees. In order to complete this design it became necessary to allow the first lens element's leading surface vertex to be located 9.94 inches above the primary-mirror vertex which may be undesirable.

Axial color is well corrected, however there is a slight tendency for the images to degrade on axis in the infrared and in the ultraviolet at full field. Worst-case images have rms diameters of about 0.36 arcsec.

9. New 50-Arcmin f/6.00 Corrector with Reduced Nontelecentricity

Run No. 8225 (05/01/89) is the best in a sequence of 50-arcmin f/6.00 correctors with reduced nontelecentricity. Its rms image diameters averaged over all field angles all colors are 0.33 +/- 0.11 arcsec with 0.17 arcsec of maximum lateral color. The concave field of view has a -186.0-inch radius. Removing of the corrector and moving the secondary mirror some 0.1364 inches toward the primary mirror produces a naked f/5.77 Cassegrain whose focal surface lies some 79.1 inches behind the primary-mirror vertex. The maximum nontelecentric angle for this f/6.00 corrector is 1.86 degrees.

There remains about 0.09 arcsec of residual axial color in this design. Individual on-axis rms image diameters increase toward the infrared, reaching 0.40 arcsec at a wavelength of 1.10 microns. Images are uniformly soft at full field, exhibiting typical 0.49 arcsec rms diameters over the full (0.33 to 1.10)-micron wavelength interval.

10. Discussion and Conclusions

A summary of corrected Cassegrain geometric parameters is shown in Table 9. The follow observations can be made:

1. The maximum nontelecentric angle(s) in the baseline system(s) is smaller at faster f/ratio.

2. The maximum nontelecentric angle increases sharply as the field of view is increased.

3. Curvature of field in the baseline model(s) is less at faster f/ratio.

4. Curvature of field increases mildly as the field of view is increased.

5. Reduction of the maximum nontelecentric angle also reduces field curvature mildly.

6. Secondary mirror diameter is larger at faster f/ratio.

7. Maximum aspheric deviation on the secondary mirror increases sharply at faster f/ratio and at larger field of view.

8. No 50-arcmin f/6.50 data is shown because such a corrector would have unacceptably large lens elements and maximum nontelecentricity.

A summary of corrector image quality parameters is shown in Table 10. The following observations can be made:

1. Image quality in all of the 40-arcmin baseline correctors is superb over the entire (0.33 to 1.10)-micron chromatic internal without refocus. Image quality is essentially independent of Cassegrain f/ratio in all of the baseline designs.

2. Image quality including maximum rms lateral color degrades mildly with increased field of view. Axial color is not affected.

3. Reduction of the maximum nontelecentric angle tends to degrade image quality including a tendency toward residual axial color in the sense that the bluer passbands tend to focus ahead of the redder ones.

It was shown in section 7 that a 0.50-inch thick fused silica window can be introduced into the baseline f/6.00 corrector near focus with little penalty. This will most likely be true also at f/5.40 and certainly at f/6.50. A modest refocus amounting to roughly 0.16 inches is required which is mildly color dependent (axial color). This is in the sense that redder passbands tend to focus ahead of the bluer ones, which is opposite from the axial color that results when the maximum nontelecentric angle is reduced in the design. Thus, a reduced nontelecentric design (without a window) might show axial color that would be acceptable for spectroscopy. This would be compensated to some extent when a filter and/or detector window was introduced for direct imaging.

It is difficult to arrive at a final f/ratio recommendation for the Magellan and Columbus Projects that is fully objective. To some extent the decision will be based on subjective perceptions of the relative difficulties associated with nontelecentricity, large aspheric secondary mirror fabrication and accommodation in the telescope structure, the importance of superb image quality, of larger field of view and the like.

The data summaries in Table 9 and Table 10 will at least provide a quantitative framework within which thorough discussions can develop and hopefully, within which a sound decision can be reached.

Respectfully submitted,

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Consultant in Optical Design

APPENDIX

A. Referenced Tables

1. System Prescription: Run No. 5933 (01/18/89) 40-Arcmin f/5.40 Baseline Corrector
2. System Prescription: Run No. 7708 (01/18/89) 40-Arcmin f/6.50 Baseline Corrector
3. System Prescription: Run No. 749 (04/30/89) 40-Arcmin f/6.50 Corrector with Reduced Telecentricity
4. System Prescription: Run No. 8342 (04/29/89) 50-Arcmin f/5.40 Corrector
5. System Prescription: Run No. 448 (04/30/89) 50-Arcmin f/5.40 Corrector with Reduced Nontelecentricity
6. System Prescription: Run No. 6572 (05/01/89) 40-Arcmin f/6.00 Baseline Corrector
7. System Prescription: Run No. 7874 (05/01/89) 50-Arcmin f/6.00 Corrector
8. System Prescription: Run No. 8225 (05/01/89) 50-Arcmin f/6.00 Corrector with Reduced Nontelecentricity
9. Summary of Corrected Cassegrain Geometric Parameters
10. Summary of Corrector Image Quality Parameters

OPTICAL OPTIMIZATION RUN----PROGRAM OARSA(01/11/89 VERSION)----EPPS/ASTRONOMY/UCLA

Table 1

RN* 3 315-INCH F/1.2 PARABOLA CORRECTED TO F/5.4 AT (F/5.2?) CASS FOC RUN NO. 5933 (01/18/89)

FINAL SYSTEM: SCALED TO DABS(GAUSSIAN FOCAL LENGTH)= 1701.000 INCHES
OBJECT DISTANCE= INFINITY
APERTURE RADIUS= 157.50 INCHES FIELD RADIUS= 20.00 ARC MIN

RMS IMAGE(S) TYP DIAM= 37.9 +/- 14.0 MICRONS
0.18 +/- 0.07 ARC SEC
MAX RMS LATERAL COLOR= 25.5 MICRONS (0.12 ARC SEC)

CLR DIA	SAG	ASPH	NS	NNE,CRV, 5ASC,NNA NSE,X,4RN,2ICR,NSA	WAVLEN(MI)	PASBN(F-C)	WAV2ND(MI)	PA2BN(F-C)	WGHT(%)			NS
			C	0	0.35666	1.69840	0.61978	2.02314	76.42		0	C
315.000	0.0	0.0	1	0 0.0	0.10000000D+01	0.0	0.10000000D+01	0.0		0	0	2 1
			2	3 -0.13227513D-02	-0.10000000D+01	0.0	0.0	0.0	0.0			0 2
316.718	-16.586	0.0457	2	8 -0.29359527D+03	-0.10000000D+01	0.0	-0.10000000D+01	0.0		0	0	0 2
			3	3 -0.45477492D-02	-0.25603180D+01	0.0	0.0	0.0	0.0			0 3
75.005	-3.163	0.0144	3	9 0.29610235D+03	0.10000000D+01	0.0	0.10000000D+01	0.0		0	0	0 3
			4	3 0.40379949D-01	0.0	0.0	0.0	0.0	0.0			0 4
28.835	4.629	0.0	4	1 0.29999993D+01	0.14758040D+01	0.39590000D-02	0.14574120D+01	0.50660000D-02		21	-239	0 4
			5	3 0.35122365D-01	0.0	0.0	0.0	0.0	0.0			0 5
27.782	3.618	0.0	5	1 0.62897985D+01	0.10000000D+01	0.0	0.10000000D+01	0.0		0	0	0 5
			6	3 0.23472172D-01	0.0	0.0	0.0	0.0	0.0			0 6
26.464	2.107	0.0	6	1 0.13378958D+01	0.14758040D+01	0.39590000D-02	0.14574120D+01	0.50660000D-02		21	-239	0 6
			7	3 0.43374393D-01	0.0	0.0	0.0	0.0	0.0			0 7
25.316	3.786	0.0	7	9 0.60000002D+01	0.10000000D+01	0.0	0.10000000D+01	0.0		0	0	0 7
			8	3 0.0	0.0	0.0	0.0	0.0	0.0			0 8
25.317	0.0	0.0	8	1 0.11999994D+01	0.15053180D+01	0.40100000D-02	0.14864080D+01	0.50660000D-02		31	-189	0 8
			9	3 0.0	0.0	0.0	0.0	0.0	0.0			0 9
25.317	0.0	0.0	9	1 0.13999995D+01	0.15729500D+01	0.76290000D-02	0.15389730D+01	0.75140000D-02		28	21	0 9
			10	3 0.0	0.0	0.0	0.0	0.0	0.0			0 10
25.318	0.0	0.0	10	1 0.11999994D+01	0.15053180D+01	0.40100000D-02	0.14864080D+01	0.50660000D-02		31	-189	0 10
			11	3 0.0	0.0	0.0	0.0	0.0	0.0			0 11
25.318	0.0	0.0	11	1 0.12577623D+01	0.10000000D+01	0.0	0.10000000D+01	0.0		0	0	0 11
			12	3 -0.32075273D-03	0.0	0.0	0.0	0.0	0.0			0 12
25.318	-0.026	0.0	12	9 0.17874211D+01	0.14758040D+01	0.39590000D-02	0.14574120D+01	0.50660000D-02		21	-239	0 12
			13	3 -0.94556988D-02	0.0	0.0	0.0	0.0	0.0			0 13
25.321	-0.761	0.0	13	1 0.44193929D+02	0.10000000D+01	0.0	0.10000000D+01	0.0		0	0	0 13
			14	3 0.0	0.0	0.0	0.0	0.0	0.0			0 14
20.615	0.0	0.0	14	1 0.50000044D+00	0.10000000D+01	0.0	0.10000000D+01	0.0		0	0	0 14
			15	3 0.0	0.0	0.0	0.0	0.0	0.0			0 15
20.563	0.0	0.0	15	1 0.20569441D+01	0.10000000D+01	0.0	0.10000000D+01	0.0		0	0	0 15
			16320	-0.42970432D-02	0.0	0.12050741D-01	0.57388160D-01	0.14122085D+00	0.0			1 16
20.073	-0.217	0.0	16	2 -0.14783643D-03	0.10000000D+01	0.0	0.10000000D+01	0.0		0	0	0 16
			16	*2 -0.30708221D-03	*SYSTEM WAS REFOCUSED FOR SECONDARY MEAN WAVELENGTH ANALYSIS							

NOTICE: END OF COMPUTATIONS FOR THIS SYSTEM. TERMINATION WAS NORMAL.

OPTICAL OPTIMIZATION RUN----PROGRAM OARSA(01/11/89 VERSION)----EPPS/ASTRONOMY/UCLA

Table 2

RN* 3 315-INCH F/1.2 PARABOLA CORRECTED TO F/6.5 AT (F/6.3?) CASS FOC RUN NO. 7708 (01/18/89)

FINAL SYSTEM: SCALED TO DABS(GAUSSIAN FOCAL LENGTH)= 2047.500 INCHES
OBJECT DISTANCE= INFINITY
APERTURE RADIUS= 157.50 INCHES FIELD RADIUS= 20.00 ARC MIN

RMS IMAGE(S) TYP DIAM= 40.4 +/- 16.1 MICRONS
0.16 +/- 0.06 ARC SEC
MAX RMS LATERAL COLOR= 28.3 MICRONS (0.11 ARC SEC)

CLR DIA	SAG	ASPH	NS	NNE,CRV, 5ASC,NNA NSE,X,4RN,2ICR,NSA	WAVLEN(MI)	PASBN(F-C)	WAV2ND(MI)	PA2BN(F-C)	WGHT(%)			NS
			C	0	0.35666	1.69840	0.61978	2.02314	76.42			0 C
315.000	0.0	0.0	1	0 0.0	0.10000000D+01	0.0	0.10000000D+01	0.0		0	0	2 1
			2	3 -0.13227513D-02	-0.10000000D+01	0.0	0.0	0.0	0.0			0 2
316.718	-16.586	0.0457	2	8 -0.30435260D+03	-0.10000000D+01	0.0	-0.10000000D+01	0.0		0	0	0 2
			3	3 -0.54767486D-02	-0.21785866D+01	0.0	0.0	0.0	0.0			0 3
65.933	-2.948	0.0129	3	9 0.30719866D+03	0.10000000D+01	0.0	0.10000000D+01	0.0		0	0	0 3
			4	3 0.38849651D-01	0.0	0.0	0.0	0.0	0.0			0 4
30.777	5.106	0.0	4	1 0.35000006D+01	0.14758040D+01	0.39590000D-02	0.14574120D+01	0.50660000D-02		21	-239	0 4
			5	3 0.33240927D-01	0.0	0.0	0.0	0.0	0.0			0 5
29.594	3.891	0.0	5	1 0.40683783D+01	0.10000000D+01	0.0	0.10000000D+01	0.0		0	0	0 5
			6	3 0.22913295D-01	0.0	0.0	0.0	0.0	0.0			0 6
28.918	2.465	0.0	6	1 0.11091545D+01	0.14758040D+01	0.39590000D-02	0.14574120D+01	0.50660000D-02		21	-239	0 6
			7	3 0.40870968D-01	0.0	0.0	0.0	0.0	0.0			0 7
27.792	4.329	0.0	7	9 0.60000001D+01	0.10000000D+01	0.0	0.10000000D+01	0.0		0	0	0 7
			8	3 0.0	0.0	0.0	0.0	0.0	0.0			0 8
27.845	0.0	0.0	8	1 0.12000008D+01	0.15053180D+01	0.40100000D-02	0.14864080D+01	0.50660000D-02		31	-189	0 8
			9	3 0.0	0.0	0.0	0.0	0.0	0.0			0 9
27.868	0.0	0.0	9	1 0.13999986D+01	0.15729500D+01	0.76290000D-02	0.15389730D+01	0.75140000D-02		28	21	0 9
			10	3 0.0	0.0	0.0	0.0	0.0	0.0			0 10
27.895	0.0	0.0	10	1 0.12000008D+01	0.15053180D+01	0.40100000D-02	0.14864080D+01	0.50660000D-02		31	-189	0 10
			11	3 0.0	0.0	0.0	0.0	0.0	0.0			0 11
27.919	0.0	0.0	11	1 0.16766050D+01	0.10000000D+01	0.0	0.10000000D+01	0.0		0	0	0 11
			12	3 -0.27998178D-02	0.0	0.0	0.0	0.0	0.0			0 12
27.960	-0.274	0.0	12	9 0.17840315D+01	0.14758040D+01	0.39590000D-02	0.14574120D+01	0.50660000D-02		21	-239	0 12
			13	3 -0.99615764D-02	0.0	0.0	0.0	0.0	0.0			0 13
28.008	-0.982	0.0	13	1 0.52611804D+02	0.10000000D+01	0.0	0.10000000D+01	0.0		0	0	0 13
			14	3 0.0	0.0	0.0	0.0	0.0	0.0			0 14
24.674	0.0	0.0	14	1 0.49999950D+00	0.10000000D+01	0.0	0.10000000D+01	0.0		0	0	0 14
			15	3 0.0	0.0	0.0	0.0	0.0	0.0			0 15
24.643	0.0	0.0	15	1 0.21035364D+01	0.10000000D+01	0.0	0.10000000D+01	0.0		0	0	0 15
			16	320 -0.62069709D-02	0.0	0.15332903D-01	0.73043914D-01	0.18036663D+00	0.0			1 16
24.183	-0.454	0.0	16	2 -0.39106709D-02	0.10000000D+01	0.0	0.10000000D+01	0.0		0	0	0 16
			16	*2 -0.40785580D-02	*SYSTEM WAS REFOCUSED FOR SECONDARY MEAN WAVELENGTH ANALYSIS							

NOTICE: END OF COMPUTATIONS FOR THIS SYSTEM. TERMINATION WAS NORMAL.

OPTICAL OPTIMIZATION RUN----PROGRAM OARSA(01/11/89 VERSION)----EPPS/ASTRONOMY/UCLA

Table 3

RN* 4 315-INCH F/1.2 PARABOLA CORRECTED TO F/6.5 AT (F/6.2?) CASS FOC RUN NO. 749 (04/30/89)

FINAL SYSTEM: SCALED TO DABS(GAUSSIAN FOCAL LENGTH)= 2047.500 INCHES RMS IMAGE(S) TYP DIAM= 49.4 +/- 18.2 MICRONS
OBJECT DISTANCE= INFINITY 0.20 +/- 0.07 ARC SEC
APERTURE RADIUS= 157.50 INCHES FIELD RADIUS= 20.00 ARC MIN MAX RMS LATERAL COLOR= 32.3 MICRONS (0.13 ARC SEC)

CLR DIA	SAG	ASPH	NS	NNE,CRV, 5ASC,NNA NSE,X,4RN,2ICR,NSA	WAVLEN(MI)	PASBN(F-C)	WAV2ND(MI)	PA2BN(F-C)	WGHT(%)			NS
			C	0	0.35666	1.69840	0.61978	2.02314	76.42		0	C
315.000	0.0	0.0	1	0 0.0	0.10000000D+01	0.0	0.10000000D+01	0.0		0	2	1
			2	3 -0.13227513D-02	-0.10000000D+01	0.0	0.0	0.0	0.0		0	2
316.718	-16.586	0.0457	2	8 -0.30376997D+03	-0.10000000D+01	0.0	-0.10000000D+01	0.0	0	0	0	2
			3	3 -0.54213692D-02	-0.21962144D+01	0.0	0.0	0.0	0.0		0	3
66.422	-2.961	0.0129	3	9 0.31067854D+03	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	3
			4	3 0.41572935D-01	0.0	0.0	0.0	0.0	0.0		0	4
30.209	5.334	0.0	4	1 0.35000006D+01	0.14758040D+01	0.39590000D-02	0.14574120D+01	0.50660000D-02	21	-239	0	4
			5	3 0.34166613D-01	0.0	0.0	0.0	0.0	0.0		0	5
29.081	3.867	0.0	5	1 0.31533491D+01	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	5
			6	3 0.21656155D-01	0.0	0.0	0.0	0.0	0.0		0	6
28.612	2.272	0.0	6	1 0.23630491D+01	0.14758040D+01	0.39590000D-02	0.14574120D+01	0.50660000D-02	21	-239	0	6
			7	3 0.44538612D-01	0.0	0.0	0.0	0.0	0.0		0	7
26.826	4.447	0.0	7	9 0.60000001D+01	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	7
			8	3 0.0	0.0	0.0	0.0	0.0	0.0		0	8
26.919	0.0	0.0	8	1 0.12000008D+01	0.15053180D+01	0.40100000D-02	0.14864080D+01	0.50660000D-02	31	-189	0	8
			9	3 0.0	0.0	0.0	0.0	0.0	0.0		0	9
26.963	0.0	0.0	9	1 0.13999986D+01	0.15729500D+01	0.76290000D-02	0.15389730D+01	0.75140000D-02	28	21	0	9
			10	3 0.0	0.0	0.0	0.0	0.0	0.0		0	10
27.013	0.0	0.0	10	1 0.12000008D+01	0.15053180D+01	0.40100000D-02	0.14864080D+01	0.50660000D-02	31	-189	0	10
			11	3 0.0	0.0	0.0	0.0	0.0	0.0		0	11
27.057	0.0	0.0	11	1 0.70308825D+00	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	11
			12	3 -0.12488289D-02	0.0	0.0	0.0	0.0	0.0		0	12
27.089	-0.115	0.0	12	9 0.18966095D+01	0.14758040D+01	0.39590000D-02	0.14574120D+01	0.50660000D-02	21	-239	0	12
			13	3 -0.96134393D-02	0.0	0.0	0.0	0.0	0.0		0	13
27.145	-0.889	0.0	13	1 0.49223051D+02	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	13
			14	3 0.0	0.0	0.0	0.0	0.0	0.0		0	14
24.722	0.0	0.0	14	1 0.49999950D+00	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	14
			15	3 0.0	0.0	0.0	0.0	0.0	0.0		0	15
24.698	0.0	0.0	15	1 0.19477887D+01	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	15
			16320	-0.53226918D-02	0.0	0.18506806D-01	0.88743449D-01	0.22065596D+00	0.0		1	16
24.263	-0.392	0.0	16	2 -0.14593402D-02	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	16
			16	*2 0.51895769D-02	*SYSTEM WAS REFOCUSED FOR SECONDARY MEAN WAVELENGTH ANALYSIS							

NOTICE: END OF COMPUTATIONS FOR THIS SYSTEM. TERMINATION WAS NORMAL.

OPTICAL OPTIMIZATION RUN----PROGRAM OARSA(01/11/89 VERSION)----EPPS/ASTRONOMY/UCLA

Table 4

RN* 6 315-INCH F/1.2 PARABOLA CORRECTED TO F/5.4 AT (F/5.2?) CASS FOC RUN NO. 8342 (04/29/89)

FINAL SYSTEM: SCALED TO DABS(GAUSSIAN FOCAL LENGTH)= 1701.000 INCHES
OBJECT DISTANCE= INFINITY
APERTURE RADIUS= 157.50 INCHES FIELD RADIUS= 25.00 ARC MIN

RMS IMAGE(S) TYP DIAM= 52.2 +/- 16.5 MICRONS
0.25 +/- 0.08 ARC SEC
MAX RMS LATERAL COLOR= 33.5 MICRONS (0.16 ARC SEC)

CLR DIA	SAG	ASPH	NS	NNE,CRV, 5ASC,NNA NSE,X,4RN,2ICR,NSA	WAVLEN(MI)	PASBN(F-C)	WAV2ND(MI)	PA2BN(F-C)	WGHT(%)			NS
			C	0	0.35666	1.69840	0.61978	2.02314	76.42		0	C
315.000	0.0	0.0	1	0 0.0	0.10000000D+01	0.0	0.10000000D+01	0.0		0	2	1
			2	3 -0.13227513D-02	-0.10000000D+01	0.0	0.0	0.0	0.0		0	2
316.765	-16.591	0.0457	2	8 -0.29361433D+03	-0.10000000D+01	0.0	-0.10000000D+01	0.0	0	0	0	2
			3	3 -0.45616253D-02	-0.25294806D+01	0.0	0.0	0.0	0.0		0	3
75.884	-3.247	0.0150	3	9 0.28255136D+03	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	3
			4	3 0.33144494D-01	0.0	0.0	0.0	0.0	0.0		0	4
35.281	5.694	0.0	4	1 0.29999993D+01	0.14758040D+01	0.39590000D-02	0.14574120D+01	0.50660000D-02	21	-239	0	4
			5	3 0.28682663D-01	0.0	0.0	0.0	0.0	0.0		0	5
34.323	4.516	0.0	5	1 0.67092598D+01	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	5
			6	3 0.19691963D-01	0.0	0.0	0.0	0.0	0.0		0	6
33.025	2.760	0.0	6	1 0.13496814D+01	0.14758040D+01	0.39590000D-02	0.14574120D+01	0.50660000D-02	21	-239	0	6
			7	3 0.34542031D-01	0.0	0.0	0.0	0.0	0.0		0	7
31.757	4.743	0.0	7	9 0.60000002D+01	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	7
			8	3 0.0	0.0	0.0	0.0	0.0	0.0		0	8
31.755	0.0	0.0	8	1 0.11999994D+01	0.15053180D+01	0.40100000D-02	0.14864080D+01	0.50660000D-02	31	-189	0	8
			9	3 0.0	0.0	0.0	0.0	0.0	0.0		0	9
31.754	0.0	0.0	9	1 0.13999995D+01	0.15729500D+01	0.76290000D-02	0.15389730D+01	0.75140000D-02	28	21	0	9
			10	3 0.0	0.0	0.0	0.0	0.0	0.0		0	10
31.753	0.0	0.0	10	1 0.11999994D+01	0.15053180D+01	0.40100000D-02	0.14864080D+01	0.50660000D-02	31	-189	0	10
			11	3 0.0	0.0	0.0	0.0	0.0	0.0		0	11
31.752	0.0	0.0	11	1 0.14699753D+01	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	11
			12	3 -0.18549871D-02	0.0	0.0	0.0	0.0	0.0		0	12
31.751	-0.234	0.0	12	9 0.19374490D+01	0.14758040D+01	0.39590000D-02	0.14574120D+01	0.50660000D-02	21	-239	0	12
			13	3 -0.86649657D-02	0.0	0.0	0.0	0.0	0.0		0	13
31.770	-1.098	0.0	13	1 0.60145360D+02	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	13
			14	3 0.0	0.0	0.0	0.0	0.0	0.0		0	14
25.657	0.0	0.0	14	1 0.50000044D+00	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	14
			15	3 0.0	0.0	0.0	0.0	0.0	0.0		0	15
25.608	0.0	0.0	15	1 0.22351208D+01	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	15
			16	320 -0.50231307D-02	0.0	0.13548029D-01	0.64348678D-01	0.15786140D+00	0.0		1	16
25.055	-0.395	0.0	16	2 -0.15794803D-02	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	16
			16	*2 -0.11667490D-02	*SYSTEM WAS REFOCUSED FOR SECONDARY MEAN WAVELENGTH ANALYSIS							

NOTICE: END OF COMPUTATIONS FOR THIS SYSTEM. TERMINATION WAS NORMAL.

OPTICAL OPTIMIZATION RUN----PROGRAM OARSA(01/11/89 VERSION)----EPPS/ASTRONOMY/UCLA

Table 5

RN* 7 315-INCH F/1.2 PARABOLA CORRECTED TO F/5.4 AT (F/5.2?) CASS FOC RUN NO. 448 (04/30/89)

FINAL SYSTEM: SCALED TO DABS(GAUSSIAN FOCAL LENGTH)= 1701.000 INCHES
OBJECT DISTANCE= INFINITY
APERTURE RADIUS= 157.50 INCHES FIELD RADIUS= 25.00 ARC MIN

RMS IMAGE(S) TYP DIAM= 76.6 +/- 28.1 MICRONS
0.37 +/- 0.13 ARC SEC
MAX RMS LATERAL COLOR= 37.6 MICRONS (0.18 ARC SEC)

CLR DIA	SAG	ASPH	NS	NNE,CRV, 5ASC,NNA NSE,X,4RN,2ICR,NSA	WAVLEN(MI)	PASBN(F-C)	WAV2ND(MI)	PA2BN(F-C)	WGHT(%)			NS
			C	0	0.35666	1.69840	0.61978	2.02314	76.42		0	C
315.000	0.0	0.0	1	0 0.0	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	2	1
			2	3 -0.13227513D-02	-0.10000000D+01	0.0	0.0	0.0	0.0		0	2
316.765	-16.591	0.0457	2	8 -0.29273595D+03	-0.10000000D+01	0.0	-0.10000000D+01	0.0	0	0	0	2
			3	3 -0.44898487D-02	-0.25792382D+01	0.0	0.0	0.0	0.0		0	3
76.627	-3.258	0.0152	3	9 0.28980525D+03	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	3
			4	3 0.40443215D-01	0.0	0.0	0.0	0.0	0.0		0	4
33.600	6.584	0.0	4	1 0.29999993D+01	0.14758040D+01	0.39590000D-02	0.14574120D+01	0.50660000D-02	21	-239	0	4
			5	3 0.31556566D-01	0.0	0.0	0.0	0.0	0.0		0	5
32.918	4.610	0.0	5	1 0.34158401D+01	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	5
			6	3 0.20684898D-01	0.0	0.0	0.0	0.0	0.0		0	6
32.302	2.778	0.0	6	1 0.22391397D+01	0.14758040D+01	0.39590000D-02	0.14574120D+01	0.50660000D-02	21	-239	0	6
			7	3 0.43235178D-01	0.0	0.0	0.0	0.0	0.0		0	7
29.986	5.517	0.0	7	9 0.60000002D+01	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	7
			8	3 0.0	0.0	0.0	0.0	0.0	0.0		0	8
30.001	0.0	0.0	8	1 0.11999994D+01	0.15053180D+01	0.40100000D-02	0.14864080D+01	0.50660000D-02	31	-189	0	8
			9	3 0.0	0.0	0.0	0.0	0.0	0.0		0	9
30.019	0.0	0.0	9	1 0.13999995D+01	0.15729500D+01	0.76290000D-02	0.15389730D+01	0.75140000D-02	28	21	0	9
			10	3 0.0	0.0	0.0	0.0	0.0	0.0		0	10
30.040	0.0	0.0	10	1 0.11999994D+01	0.15053180D+01	0.40100000D-02	0.14864080D+01	0.50660000D-02	31	-189	0	10
			11	3 0.0	0.0	0.0	0.0	0.0	0.0		0	11
30.058	0.0	0.0	11	1 0.14179635D+01	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	11
			12	3 -0.20035815D-02	0.0	0.0	0.0	0.0	0.0		0	12
30.085	-0.227	0.0	12	9 0.19546561D+01	0.14758040D+01	0.39590000D-02	0.14574120D+01	0.50660000D-02	21	-239	0	12
			13	3 -0.95455744D-02	0.0	0.0	0.0	0.0	0.0		0	13
30.123	-1.088	0.0	13	1 0.53122867D+02	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	13
			14	3 0.0	0.0	0.0	0.0	0.0	0.0		0	14
25.726	0.0	0.0	14	1 0.50000044D+00	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	14
			15	3 0.0	0.0	0.0	0.0	0.0	0.0		0	15
25.686	0.0	0.0	15	1 0.20903605D+01	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	15
			16	320 -0.39552618D-02	0.0	0.18109915D-01	0.86962957D-01	0.21652523D+00	0.0		1	16
25.172	-0.313	0.0	16	2 -0.52647385D-02	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	16
			16	*2 -0.12191690D-02	*SYSTEM WAS REFOCUSED FOR SECONDARY MEAN WAVELENGTH ANALYSIS							

NOTICE: END OF COMPUTATIONS FOR THIS SYSTEM. TERMINATION WAS NORMAL.

OPTICAL OPTIMIZATION RUN----PROGRAM OARSA(01/11/89 VERSION)----EPPS/ASTRONOMY/UCLA

Table 6

RN* 2 315-INCH F/1.2 PARABOLA CORRECTED TO F/6.0 AT (F/5.8?) CASS FOC RUN NO. 6572 (05/01/89)

FINAL SYSTEM: SCALED TO DABS(GAUSSIAN FOCAL LENGTH)= 1890.000 INCHES RMS IMAGE(S) TYP DIAM= 41.4 +/- 13.6 MICRONS
OBJECT DISTANCE= INFINITY 0.18 +/- 0.06 ARC SEC
APERTURE RADIUS= 157.50 INCHES FIELD RADIUS= 20.00 ARC MIN MAX RMS LATERAL COLOR= 24.1 MICRONS (0.10 ARC SEC)

CLR DIA	SAG	ASPH	NS	NNE,CRV, 5ASC,NNA NSE,X,4RN,2ICR,NSA	WAVLEN(MI)	PASBN(F-C)	WAV2ND(MI)	PA2BN(F-C)	WGHT(%)			NS
			C	0	0.35666	1.69840	0.61978	2.02314	76.42		0	C
315.000	0.0	0.0	1	0 0.0	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	2	1
			2	3 -0.13227513D-02	-0.10000000D+01	0.0	0.0	0.0	0.0		0	2
316.718	-16.586	0.0457	2	8 -0.29930565D+03	-0.10000000D+01	0.0	-0.10000000D+01	0.0	0	0	0	2
			3	3 -0.50247586D-02	-0.23254235D+01	0.0	0.0	0.0	0.0		0	3
70.178	-3.062	0.0136	3	9 0.30213114D+03	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	3
			4	3 0.38648447D-01	0.0	0.0	0.0	0.0	0.0		0	4
30.304	4.901	0.0	4	1 0.32307698D+01	0.14758040D+01	0.39590000D-02	0.14574120D+01	0.50660000D-02	21	-239	0	4
			5	3 0.32637027D-01	0.0	0.0	0.0	0.0	0.0		0	5
29.244	3.714	0.0	5	1 0.44727954D+01	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	5
			6	3 0.22403587D-01	0.0	0.0	0.0	0.0	0.0		0	6
28.408	2.320	0.0	6	1 0.11755618D+01	0.14758040D+01	0.39590000D-02	0.14574120D+01	0.50660000D-02	21	-239	0	6
			7	3 0.40700062D-01	0.0	0.0	0.0	0.0	0.0		0	7
27.270	4.130	0.0	7	9 0.60000000D+01	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	7
			8	3 0.0	0.0	0.0	0.0	0.0	0.0		0	8
27.283	0.0	0.0	8	1 0.11999999D+01	0.15053180D+01	0.40100000D-02	0.14864080D+01	0.50660000D-02	31	-189	0	8
			9	3 0.0	0.0	0.0	0.0	0.0	0.0		0	9
27.288	0.0	0.0	9	1 0.13999999D+01	0.15729500D+01	0.76290000D-02	0.15389730D+01	0.75140000D-02	28	21	0	9
			10	3 0.0	0.0	0.0	0.0	0.0	0.0		0	10
27.294	0.0	0.0	10	1 0.11999999D+01	0.15053180D+01	0.40100000D-02	0.14864080D+01	0.50660000D-02	31	-189	0	10
			11	3 0.0	0.0	0.0	0.0	0.0	0.0		0	11
27.299	0.0	0.0	11	1 0.15136852D+01	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	11
			12	3 -0.23395814D-02	0.0	0.0	0.0	0.0	0.0		0	12
27.308	-0.218	0.0	12	9 0.16830044D+01	0.14758040D+01	0.39590000D-02	0.14574120D+01	0.50660000D-02	21	-239	0	12
			13	3 -0.96412294D-02	0.0	0.0	0.0	0.0	0.0		0	13
27.332	-0.904	0.0	13	1 0.53085282D+02	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	13
			14	3 0.0	0.0	0.0	0.0	0.0	0.0		0	14
22.775	0.0	0.0	14	1 0.50000007D+00	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	14
			15	3 0.0	0.0	0.0	0.0	0.0	0.0		0	15
22.733	0.0	0.0	15	1 0.18957984D+01	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	15
			16	320 -0.54454287D-02	0.0	0.12305689D-01	0.58017043D-01	0.14216476D+00	0.0		1	16
22.276	-0.338	0.0	16	2 -0.12451157D-01	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	16
			16	*2 -0.12397042D-01	*SYSTEM WAS REFOCUSED FOR SECONDARY MEAN WAVELENGTH ANALYSIS							

NOTICE: END OF COMPUTATIONS FOR THIS SYSTEM. TERMINATION WAS NORMAL.

OPTICAL OPTIMIZATION RUN----PROGRAM OARSA(01/11/89 VERSION)----EPPS/ASTRONOMY/UCLA

Table 7

RN* 3 315-INCH F/1.2 PARABOLA CORRECTED TO F/6.0 AT (F/5.8?) CASS FOC RUN NO. 7874 (05/01/89)

FINAL SYSTEM: SCALED TO DABS(GAUSSIAN FOCAL LENGTH)= 1890.000 INCHES RMS IMAGE(S) TYP DIAM= 54.1 +/- 19.6 MICRONS
OBJECT DISTANCE= INFINITY 0.23 +/- 0.08 ARC SEC
APERTURE RADIUS= 157.50 INCHES FIELD RADIUS= 25.00 ARC MIN MAX RMS LATERAL COLOR= 36.2 MICRONS (0.16 ARC SEC)

CLR DIA	SAG	ASPH	NS	NNE,CRV, 5ASC,NNA NSE,X,4RN,2ICR,NSA	WAVLEN(MI)	PASBN(F-C)	WAV2ND(MI)	PA2BN(F-C)	WGHT(%)			NS
			C	0	0.35666	1.69840	0.61978	2.02314	76.42		0	C
315.000	0.0	0.0	1	0 0.0	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	2	1
			2	3 -0.13227513D-02	-0.10000000D+01	0.0	0.0	0.0	0.0		0	2
316.765	-16.591	0.0457	2	8 -0.29973579D+03	-0.10000000D+01	0.0	-0.10000000D+01	0.0	0	0	0	2
			3	3 -0.50633228D-02	-0.23038092D+01	0.0	0.0	0.0	0.0		0	3
70.735	-3.134	0.0142	3	9 0.28979358D+03	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	3
			4	3 0.33142759D-01	0.0	0.0	0.0	0.0	0.0		0	4
36.312	6.074	0.0	4	1 0.32307698D+01	0.14758040D+01	0.39590000D-02	0.14574120D+01	0.50660000D-02	21	-239	0	4
			5	3 0.28219309D-01	0.0	0.0	0.0	0.0	0.0		0	5
35.323	4.715	0.0	5	1 0.47087029D+01	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	5
			6	3 0.19752712D-01	0.0	0.0	0.0	0.0	0.0		0	6
34.544	3.037	0.0	6	1 0.13851571D+01	0.14758040D+01	0.39590000D-02	0.14574120D+01	0.50660000D-02	21	-239	0	6
			7	3 0.34257102D-01	0.0	0.0	0.0	0.0	0.0		0	7
33.182	5.173	0.0	7	9 0.59999997D+01	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	7
			8	3 0.0	0.0	0.0	0.0	0.0	0.0		0	8
33.200	0.0	0.0	8	1 0.12000007D+01	0.15053180D+01	0.40100000D-02	0.14864080D+01	0.50660000D-02	31	-189	0	8
			9	3 0.0	0.0	0.0	0.0	0.0	0.0		0	9
33.214	0.0	0.0	9	1 0.14000005D+01	0.15729500D+01	0.76290000D-02	0.15389730D+01	0.75140000D-02	28	21	0	9
			10	3 0.0	0.0	0.0	0.0	0.0	0.0		0	10
33.230	0.0	0.0	10	1 0.12000007D+01	0.15053180D+01	0.40100000D-02	0.14864080D+01	0.50660000D-02	31	-189	0	10
			11	3 0.0	0.0	0.0	0.0	0.0	0.0		0	11
33.245	0.0	0.0	11	1 0.15477100D+01	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	11
			12	3 -0.31773879D-02	0.0	0.0	0.0	0.0	0.0		0	12
33.264	-0.440	0.0	12	9 0.17929886D+01	0.14758040D+01	0.39590000D-02	0.14574120D+01	0.50660000D-02	21	-239	0	12
			13	3 -0.91333722D-02	0.0	0.0	0.0	0.0	0.0		0	13
33.309	-1.274	0.0	13	1 0.65566693D+02	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	13
			14	3 0.0	0.0	0.0	0.0	0.0	0.0		0	14
28.418	0.0	0.0	14	1 0.49999950D+00	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	14
			15	3 0.0	0.0	0.0	0.0	0.0	0.0		0	15
28.382	0.0	0.0	15	1 0.21424428D+01	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	15
			16320	-0.59923027D-02	0.0	0.15772996D-01	0.75051304D-01	0.18471463D+00	0.0		1	16
27.857	-0.582	0.0	16	2 -0.29911250D-02	0.10000000D+01	0.0	0.10000000D+01	0.0	0	0	0	16
			16	*2 -0.26293501D-02	*SYSTEM WAS REFOCUSED FOR SECONDARY MEAN WAVELENGTH ANALYSIS							

NOTICE: END OF COMPUTATIONS FOR THIS SYSTEM. TERMINATION WAS NORMAL.

OPTICAL OPTIMIZATION RUN----PROGRAM OARSA(01/11/89 VERSION)----EPPS/ASTRONOMY/UCLA

Table 8

RN* 3 315-INCH F/1.2 PARABOLA CORRECTED TO F/6.0 AT (F/5.8?) CASS FOC RUN NO. 8225 (05/01/89)

FINAL SYSTEM: SCALED TO DABS(GAUSSIAN FOCAL LENGTH)= 1890.000 INCHES RMS IMAGE(S) TYP DIAM= 75.8 +/- 26.1 MICRONS
OBJECT DISTANCE= INFINITY 0.33 +/- 0.11 ARC SEC
APERTURE RADIUS= 157.50 INCHES FIELD RADIUS= 25.00 ARC MIN MAX RMS LATERAL COLOR= 39.9 MICRONS (0.17 ARC SEC)

CLR DIA	SAG	ASPH	NS	NNE,CRV, 5ASC,NNA NSE,X,4RN,2ICR,NSA	WAVLEN(MI)	PASBN(F-C)	WAV2ND(MI)	PA2BN(F-C)	WGHT(%)			NS
			C	0	0.35666	1.69840	0.61978	2.02314	76.42		0	C
315.000	0.0	0.0	1	0 0.0	0.10000000D+01	0.0	0.10000000D+01	0.0		0	2	1
			2	3 -0.13227513D-02	-0.10000000D+01	0.0	0.0	0.0	0.0		0	2
316.765	-16.591	0.0457	2	8 -0.29945140D+03	-0.10000000D+01	0.0	-0.10000000D+01	0.0		0	0	2
			3	3 -0.50331667D-02	-0.23257208D+01	0.0	0.0	0.0	0.0		0	3
70.976	-3.137	0.0143	3	9 0.29599913D+03	0.10000000D+01	0.0	0.10000000D+01	0.0		0	0	3
			4	3 0.37649193D-01	0.0	0.0	0.0	0.0	0.0		0	4
35.191	6.664	0.0	4	1 0.32307698D+01	0.14758040D+01	0.39590000D-02	0.14574120D+01	0.50660000D-02		21 -239	0	4
			5	3 0.29903384D-01	0.0	0.0	0.0	0.0	0.0		0	5
34.380	4.756	0.0	5	1 0.39051902D+01	0.10000000D+01	0.0	0.10000000D+01	0.0		0	0	5
			6	3 0.20223799D-01	0.0	0.0	0.0	0.0	0.0		0	6
33.671	2.954	0.0	6	1 0.13500367D+01	0.14758040D+01	0.39590000D-02	0.14574120D+01	0.50660000D-02		21 -239	0	6
			7	3 0.39688761D-01	0.0	0.0	0.0	0.0	0.0		0	7
31.890	5.687	0.0	7	9 0.59999997D+01	0.10000000D+01	0.0	0.10000000D+01	0.0		0	0	7
			8	3 0.0	0.0	0.0	0.0	0.0	0.0		0	8
31.910	0.0	0.0	8	1 0.12000007D+01	0.15053180D+01	0.40100000D-02	0.14864080D+01	0.50660000D-02		31 -189	0	8
			9	3 0.0	0.0	0.0	0.0	0.0	0.0		0	9
31.942	0.0	0.0	9	1 0.14000005D+01	0.15729500D+01	0.76290000D-02	0.15389730D+01	0.75140000D-02		28 21	0	9
			10	3 0.0	0.0	0.0	0.0	0.0	0.0		0	10
31.978	0.0	0.0	10	1 0.12000007D+01	0.15053180D+01	0.40100000D-02	0.14864080D+01	0.50660000D-02		31 -189	0	10
			11	3 0.0	0.0	0.0	0.0	0.0	0.0		0	11
32.010	0.0	0.0	11	1 0.15567953D+01	0.10000000D+01	0.0	0.10000000D+01	0.0		0	0	11
			12	3 -0.22556803D-02	0.0	0.0	0.0	0.0	0.0		0	12
32.061	-0.290	0.0	12	9 0.19141895D+01	0.14758040D+01	0.39590000D-02	0.14574120D+01	0.50660000D-02		21 -239	0	12
			13	3 -0.91075589D-02	0.0	0.0	0.0	0.0	0.0		0	13
32.113	-1.180	0.0	13	1 0.58428085D+02	0.10000000D+01	0.0	0.10000000D+01	0.0		0	0	13
			14	3 0.0	0.0	0.0	0.0	0.0	0.0		0	14
28.500	0.0	0.0	14	1 0.49999950D+00	0.10000000D+01	0.0	0.10000000D+01	0.0		0	0	14
			15	3 0.0	0.0	0.0	0.0	0.0	0.0		0	15
28.470	0.0	0.0	15	1 0.19575806D+01	0.10000000D+01	0.0	0.10000000D+01	0.0		0	0	15
			16	320 -0.53752496D-02	0.0	0.20500300D-01	0.97788350D-01	0.24321321D+00	0.0		1	16
27.976	-0.527	0.0	16	2 -0.17148868D-01	0.10000000D+01	0.0	0.10000000D+01	0.0		0	0	16
			16	*2 -0.12056440D-01	*SYSTEM WAS REFOCUSED FOR SECONDARY MEAN WAVELENGTH ANALYSIS							

NOTICE: END OF COMPUTATIONS FOR THIS SYSTEM. TERMINATION WAS NORMAL.

Table 9. Summary of Corrected Cassegrain Geometric Parameters

Run No.	f.o.v. (arcmin)	f/ratio (corrected)	max. nontelec. (degrees)	R.C. field (inches)	secondary diam. (inches)	max. asph. dev. (waves)	f/ratio (naked)
5933 (01/18/89)	40	f/5.40	0.62	-232.72	75.01	732	f/5.20
8342 (04/29/89)	50	f/5.40	1.56	-199.08	75.88	762	f/5.26
448 (04/30/89)	50	f/5.40	0.46	-252.83	76.63	772	f/5.16
6572 (05/01/89)	40	f/6.00	1.51	-183.64	70.18	691	f/5.77
7874 (05/01/89)	50	f/6.00	2.52	-166.88	70.34	721	f/5.83
8225 (05/01/89)	50	f/6.00	1.86	-186.04	70.98	726	f/5.77
7708 (01/18/89)	40	f/6.50	2.16	-161.11	65.93	655	f/6.24
749 (04/30/89)	40	f/6.50	1.28	-187.87	66.42	655	f/6.18

Table 10. Summary of Corrector Image Quality Parameters

Run No.	f.o.v. (arcmin)	f/ratio (corrected)	average rms image diam. (arcsec)	max. rms lateral color (arcsec)	axial color (arcsec)	worse-case rms image diam. (arcsec)
5933 (01/18/89)	40	f/5.40	0.18 +/- 0.07	0.12	0.00	0.29
8342 (04/29/89)	50	f/5.40	0.25 +/- 0.08	0.16	0.01	0.37
448 (04/30/89)	50	f/5.40	0.37 +/- 0.13	0.18	0.09	0.58
6572 (05/01/89)	40	f/6.00	0.18 +/- 0.06	0.10	0.00	0.27
7874 (05/01/89)	50	f/6.00	0.23 +/- 0.08	0.16	0.01	0.36
8225 (05/01/89)	50	f/6.00	0.33 +/- 0.11	0.17	0.09	0.50
7708 (01/18/89)	40	f/6.50	0.16 +/- 0.06	0.11	0.00	0.26
749 (04/30/89)	40	f/6.50	0.20 +/- 0.07	0.13	0.10	0.32