# Optical Design and specifications for the 90-in Prime Focus Corrector
# Part 1: specifications and tolerances

# Revision E-2

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October 26, 2000

This memo summarizes the optical design for the 90-in Prime Focus Corrector. The final specifications and tolerances for the individual lenses and for the mounting are given. Part 2 of this memo gives the analysis of the performance of the optical system.

Design revisions:

Rev. A Sept. 1, 1999 – original memo

Rev. B Sept. 9, 1999
Filter moved 28 mm towards the CCD
(spacing from filter to lens 4 changed from 44 to 16 mm
spacing from lens 3 to filter changed from 172 to 200 mm)
Drawing and tables modified to reflect this change
This does not affect performance

Rev. C Oct. 25, 1999
Incorporated measurements of the primary mirror from Sarlot et al.
Some lens spacings were changed
The figure on the aspheric surface was changed (Lens 2, concave surface)
The overall performance and the tolerances are not affected

Rev D April 20, 2000
Accommodated radius change for L2 for available test plate
Incorporated as-built dimensions for L3, L4 (they were within spec)
Slight re-spacing of elements to re-optimize

Rev E October 26, 2000
Changed field of view to accommodate 69 x 69 mm focal plane
Changed Lens 4 to 254 mm diameter, 22.5 mm center thick (19 mm edge thick).
Filter – L4 spacing set at 19 mm
Respaced, using only PM-L1 and L3-L4 to optimize performance

**System specifications**

Primary mirror (from Sarlot et al.)

| | |
|---|---|
| Radius of curvature R | 12281 ± 4 mm |
| Conic constant K | -1.0646 ± 0.001 |
| Clear aperture D | 90” ± 0.06” |
| Central obscuration | 33.5 ± 0.1” |

Spacings (in mm)

| | Rev. E | Rev. E change | Rev. D | Rev. C | Rev B |
|---|---|---|---|---|---|
| Primary mirror – Lens1 spacing | 5010.9 ± 1 | ✓ | 5010.4 ± 1 | 5009.4 ± 1 | 4958.2 ± 1 |
| Lens1 thickness | 45 ± 0.1 | | 45 ± 0.1 | 45 ± 0.1 | 45 ± 0.1 |
| Lens1 – Lens2 spacing | 429.9 ± 0.3 | | 429.9 ± 0.3 | 430.5 ± 0.3 | 434.8 ± 0.3 |
| Lens2 thickness | 14 ± 0.1 | | 14 ± 0.1 | 14 ± 0.1 | 14 ± 0.1 |
| Lens2 – Lens3 spacing | 441.6 ± 0.3 | | 441.6 ± 0.3 | 442.3 ± 0.3 | 450.8 ± 0.3 |
| Lens3 thickness | 30.21 ± 0.005 | | 30.21 ± 0.005 | 30 ± 0.3 | 30 ± 0.3 |
| Lens3 – filter spacing (focus adjust for system) | 197.5 ± 5 | ✓ | 204.4 ± 5 | 204.9 ± 5 | 200.± 5 |
| Filter thickness | 8 ± 4 | | 8 ± 4 | 8 ± 4 | 8 ± 4 |
| Filter – Lens4 spacing | 19 ± 3 | ✓ | 16 ± 3 | 16 ± 3 | 16 ± 3 |
| Lens4 thickness | 22.5 ± 0.5 | ✓ | 17.75 ± 0.005 | 17.3 ± 0.5 | 17.3 ± 0.5 |
| Lens4 – focal plane spacing | 5 ± 1 | | 5 ± 1 | 5 ± 1 | 5 ± 1 |
| Overall length Lens 1 to FP | 1213 | ✓ | 1212 | 1213 | 1221 |

The system effective focal length is 6830.0 mm

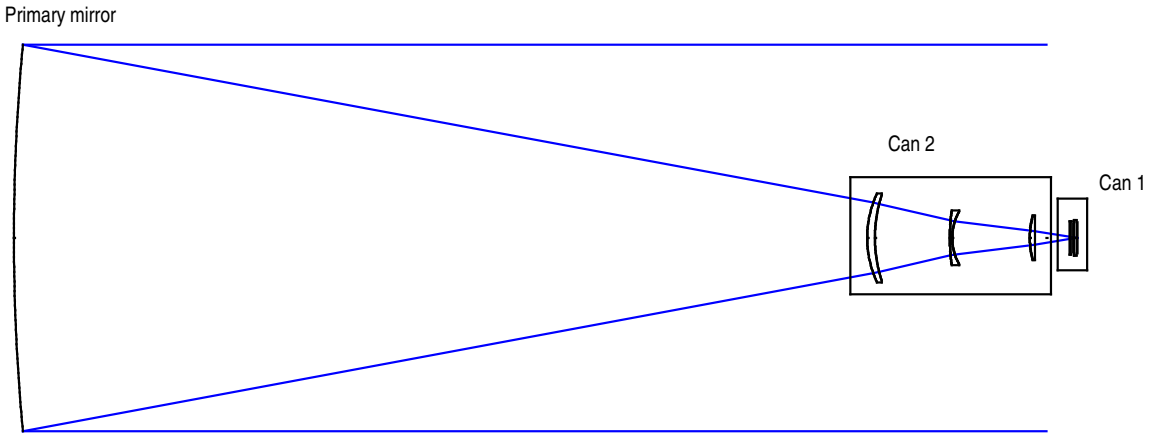
The overall design is shown below. We have divided the system into two parts – Can 1 and Can 2. Can 1 which holds the filter mechanism, Lens 4 (which is the dewar window) and the focal plane array. Can 2 holds Lens1, Lens 2, and Lens 3. The entire unit is supported by a spider, which is bolted to the telescope.

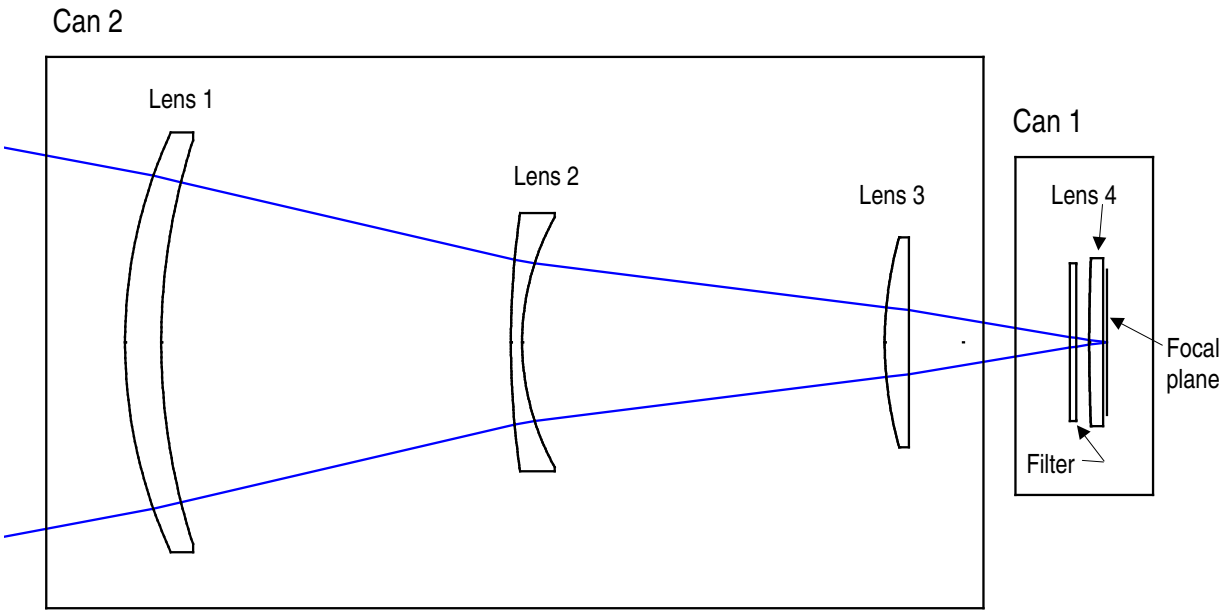
The requirements for the systems are

Overall system, supported by spider
Held with Lens1 – PM distance of 5010 ± 5. (Must maintain this to ±1 mm.)
Centered to telescope axis to 0.1 mm
Aligned in rotation to 0.05 mrad (about middle of system)

Can 1, Focal plane assembly
Driven axially for focus adjustment
10 µm resolution and stability for axial motion
0.2 mrad rotation about interface to Can 2
0.5 mm centration

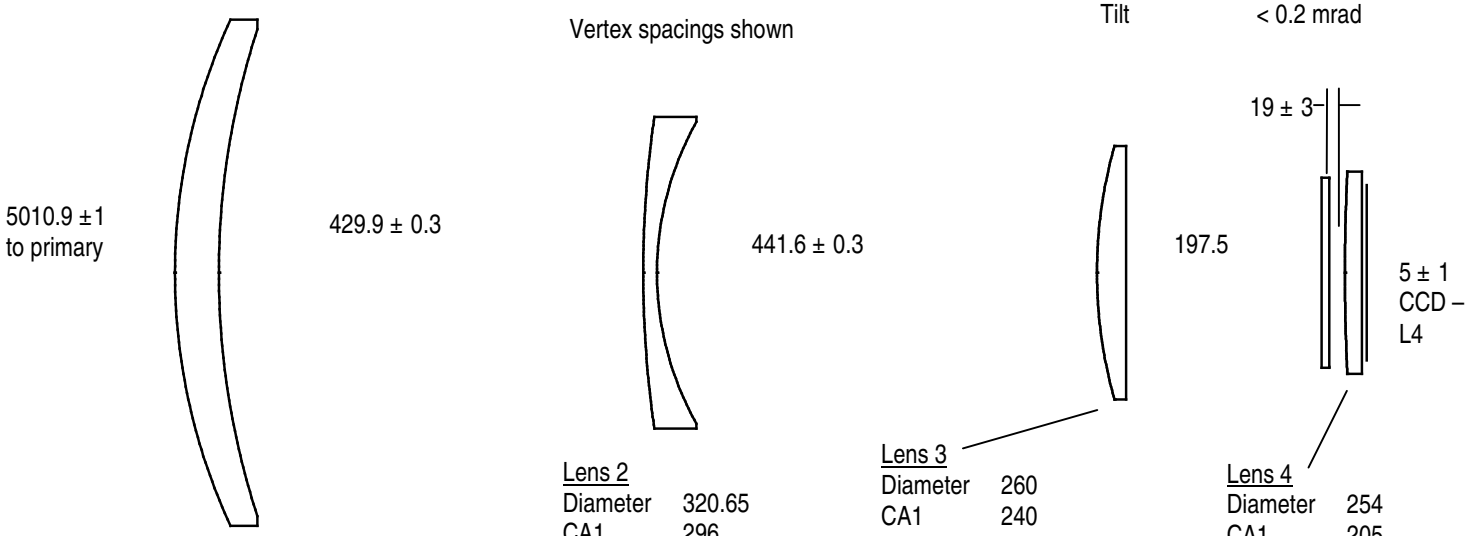
Can 2, Lens housing
50 µm stability for axial motion
0.1 mrad rotation about interface to Can 1
0.1 mm centration






Lens mounting specifications

Vertex spacings shown




Focal plane

| | |
|---|---|
| decenter | ? |
| Tilt | < 0.2 mrad |

Lens 1

| | |
|---|---|
| Diameter | 520 |
| CA1 | 495 |
| CA2 | 480 |
| CT | 45.0 ± 0.1 |
| (ET | 27.4 ) |
| Wedge | < 0.05 mm |
| decenter | < 0.1 mm |
| Tilt | < 0.05 mm (0.1 mrad) |

Lens 2

| | |
|---|---|
| Diameter | 320.65 |
| CA1 | 296 |
| CA2 | 276 |
| CT | 14.0 ± 0.1 |
| (ET | 43 ) |
| Wedge | < 0.05 mm |
| decenter | < 0.1 mm |
| Tilt | < 0.05 mm (0.16 mrad) |

Lens 3

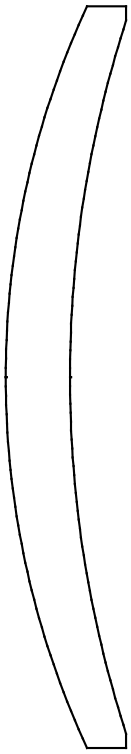
| | |
|---|---|
| Diameter | 260 |
| CA1 | 240 |
| CA2 | 240 |
| CT | 30.21± 0.005 |
| (ET | 12.2 ) |
| Wedge | < 0.05 mm |
| decenter | < 0.1 mm |
| Tilt | < 0.05 mm (0.2 mrad) |

Lens 4

| | |
|---|---|
| Diameter | 254 |
| CA1 | 205 |
| CA2 | 205 |
| CT | 22.5 ± 0.5 |
| (ET | 19.1 ) |
| Wedge | < 0.05 mm |
| decenter | < 0.2 mm |
| Tilt | < 0.2 mm (1 mrad) |

## Lens 1 Rev E. (No change from Rev A)

| | |
|---|---|
| Outside diameter | 520 |
| Center thickness | 45.0 ± 0.1 mm |
| (Edge thickness | 27.4 mm) |
| Wedge | < 0.05 mm |



Surface 1

| | |
|---|---|
| CA1 | 495 |
| R1 | 622.0 ± 0.15 (cvx) |
| Figure | Measured by custom 250 mm test plate<br>0.5 fringes power<br>0.25 fringes irregularity |

Surface 2

| | |
|---|---|
| Diam | 500 |
| CA2 | 480 |
| R2 | 813 ± 0.3 (ccv) |
| Figure | Measured by PSI<br>Rms slopes < 0.025 waves/cm |

Material

Fused silica (equivalent with Amersil Grade 4000 or Hereaus Herasil 3)
Refractive index inhomogeneity < 1e-5 P-V
Birefringence < 10 nm/cm
Total inclusion cross section < 1 mm/100 cc
Maximum inclusion 1 mm

## Lens 2 – Rev. E. (No change from Rev D)

| | |
|---|---|
| Outside diameter | 320.65 *as built* |
| Center thickness | 14.0 ± 0.1 mm |
| (Edge thickness | 43 mm) |
| Wedge | < 0.05 mm |

Surface 2, asphere

| | |
|---|---|
| Diam | 310 |
| CA2 | 276 |
| R2 | 312.58 |
| K2 | -0.249 |
| Figure | Measured by PSI<br>Using ellipse test<br>0.2 waves/cm |

Surface 1

| | |
|---|---|
| CA1 | 296 |
| R1 | 1128.1 ± 1 (cvx) |
| Figure | Measured by Kreisher<br>150 mm test plate<br>0.5 fringes power<br>0.25 fringes irregularity |

Material
Fused silica (equivalent with Amersil Grade 4000 or Hereaus Herasil 3)
Refractive index inhomogeneity < 1e-5 P-V
Birefringence < 10 nm/cm
Total inclusion cross section < 1 mm/100 cc
Maximum inclusion 0.76 mm

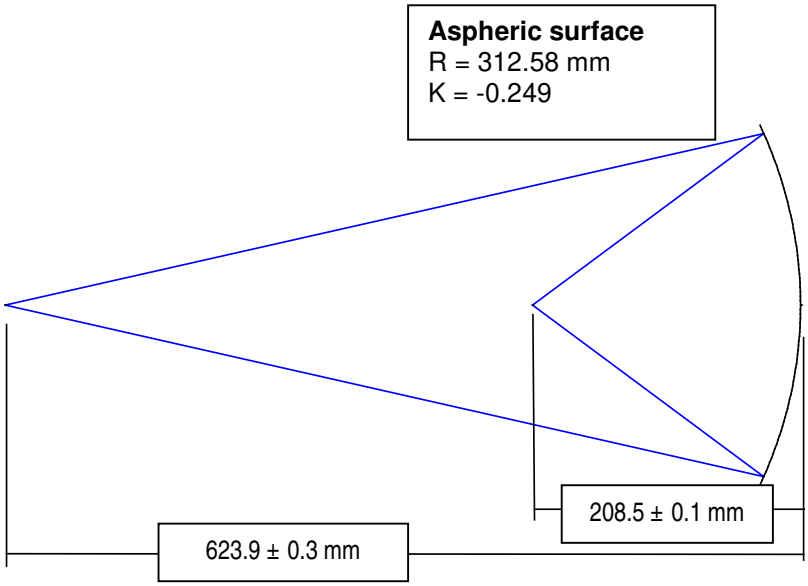
Ellipse test – Rev. D

Measure interferometrically using natural conjugate points for the ellipse

The radius of curvature and conic constant tolerances follow from the tolerances defined for the test conjugates.

C1 = 623.9 ± 0.3 mm
C2 = 208.5 ± 0.1 mm

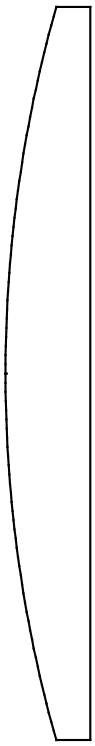
Rms surface slopes < 0.2 waves/cm



## Lens 3 Rev E (no change from Rev D)

### *All dimensions shown AS_BUILT*

| | |
|---|---|
| Outside diameter | 259.99 ± 0.025 |
| Center thickness | 30.21 |
| (Edge thickness | 12.2 mm) |
| Wedge | < 0.02 mm |



Surface 1

| | |
|---|---|
| CA1 | 240 |
| R1 | 478.59 |
| Figure | Measured by Kreisher<br>100 mm test plate<br><0.5 fringes power<br>0.1 fringes irregularity |

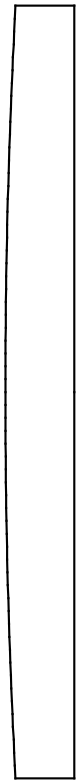
Surface 2

| | |
|---|---|
| CA2 | 240 |
| R2 | Flat (1 fringe convex/25cm TP) |
| Figure | Measured with 25 cm test plate<br>0.1 fringes irregularity |

Material
Fused silica (equivalent with Amersil Grade 4000 or Hereaus Herasil 3)
Refractive index inhomogeneity < 1e-5 P-V
Birefringence < 10 nm/cm
Total inclusion cross section < 1 mm/100 cc
Maximum inclusion 0.76 mm

## Lens 4 Rev E (Replaces Rev D)

| | |
|---|---|
| Outside diameter | 254 |
| Center thickness | 22.5 ± 0.5 mm |
| (Edge thickness | 19.1 mm) |
| Wedge | < 0.05 mm |



Surface 1

| | |
|---|---|
| CA1 | 205 |
| R1 | 2370.5 ± 20 mm |
| Figure | Measured by Kreisher<br>100 mm test plate<br>4 fringes power<br>2 fringes irregularity |

Surface 2

| | |
|---|---|
| CA2 | 205 |
| R2 | Flat (1 fringe concave over full aperture)) |
| Power | < 10 fringes / 100 mm |
| Figure | Measured with 100 mm test plate<br>4 fringes power<br>2 fringes irregularity |

Material
Fused silica (Amersil Grade 4100 or Hereaus Herasil 2)
Refractive index inhomogeneity < 6e-6 P-V
Birefringence < 10 nm/cm
Total inclusion cross section < .1 mm/100 cc
Maximum inclusion 0.3 mm