Southern African Large Telescope
High-Resolution Spectrograph

SALT HRS

3210AA0007 Optical tolerancing, testing and ghost analysis

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Issue History

Number and file name	Person	Issue	Created	Status
3210AA0007	SIB	1.0	15 Mar 2005	Cover sheet for DJ's document.

Table of contents

1 Scope

This document contain the report complied by Damien Jones of Prime Optics “Camera Tests and Mechanical Tolerances” dated February 23, 2005, Version 1.0.

2 Preamble

This report summarizes the mounting tolerances for the “blue” and “red” cameras (v1.09) and demonstrates an acceptance test for each. Ghost analysis findings are summarised.

3 Camera Mechanical Tolerances

A tolerance and sensitivity analysis has been carried out for both cameras. The following two tables list the respective camera mechanical tolerances, specifically component tilt, decenter and axial placement. It can be seen that close attention will need to be given to centration and perpendicularity of the mounts, particularly with the blue camera. It is assumed that the 2nd pupil mirror will be used for fine-focussing after the final assembly.

Table 1: Blue Camera Component Alignment & Mounting Tolerances

Component	TIR, mount (mm)	Decenter (mm)	Axial (mm)
BCM1	±0.05	±0.05	“Collimated”
BCM2	±0.025	±0.025	±0.1
BCM3	<±0.025	±0.025	±0.1
BCM4	±0.03	±0.05	±0.1
BCM5	±0.025	±0.03	±0.1
BCM6	±0.03	±0.04	±0.1
BCM7	±0.04	±0.04	±0.1
D	±0.025	-	±0.05

Table 2: Red Camera Component Alignment & Mounting Tolerances

Component	TIR, mount (mm)	Decenter (mm)	Axial (mm)
RCM1	±0.04	±0.03	“Collimated”
RCM2	±0.04	±0.03	±0.1
RCM3	±0.05	±0.05	±0.1
RCM4	±0.05	±0.05	±0.1
RCM5	±0.05	±0.05	±0.1
D	±0.025	-	±0.05

4 White Pupil Mirror Mechanical Tolerances

The following 3 sections repeat some material in the first optical design report of June 2004.

"The dimensional and quality tolerances for these components is described in a separate document. The alignment and mounting tolerances are summarized in the following table. M1 is the first collimating mirror, M2 and M3 are the respective "blue" and "red" pupil relays. Each mirror has its plane of symmetry in the y-z plane."

Table 3: White Pupil Relay Mirrors' Alignment & Mounting Tolerances

Component	x-Tilt (pitch) (deg)	y-Tilt (roll) (deg)	x-Disp (mm)	y-Disp (mm)
M1	±0.025	±0.025	±1.0	±1.0
M2	±0.025	±0.05	±1.0	±1.0
M3	±0.025	±0.05	±1.0	±1.0

"The tilt tolerances are quite tight. However, there is huge leverage to be had in auto-collimation so I see no reason why this level of accuracy should not be achieved. I do not imagine for a moment that the 1.0 mm tolerance in lateral displacement tolerance will ever be exploited!"

5 Echelle Pitch, Roll and Yaw

"Pitch, roll and yaw are rotations around the local x, y and z local axes of the echelle respectively. The local origin is located at the centre of the grating and the plane of the grating defines the local x-y plane. Thus the local x-axis is parallel with the groove direction whilst the local y-axis is perpendicular to this. The local z-axis is parallel with the surface normal."

The tolerances are:

Pitch : ±0.1 deg ; **Roll** : ±0.1 deg ; **Yaw** : ±0.05 deg

"Pitch and roll are mainly mounting tolerances. Yaw relates to the perpendicularity of the rulings with the mechanical edge of the grating. An optimum grating mounting can be found by aligning calibration wavelengths at the "white slit" the locations of which can be modelled."

6 VPH X-Disperser Pitch, Roll and Yaw

"The cameras' performance is loosely tied to the X-Disperser pitch and roll but tightly bound to yaw. This is because there is significant defocus in the pseudo-collimated beam and yaw changes the balance of intrinsic astigmatism picked up because of this. Thus the tolerances are:"

Pitch : ±0.5 deg ; **Roll** : ±0.5 deg ; **Yaw** : ±0.1 deg

7 Camera Acceptance Tests

The first step, for both cameras, is to fabricate a plano-cylindrical "negative" for the last, cylindrical, surface of each of the field flatteners. These are mounted as closely as possible to their positive counterparts. There does not have to be a contact; indeed, if there were the two surfaces would probably stick themselves together because of the "interference fit". A small separation can be achieved with, for example, brass shim material. These extra elements endow the cameras with essentially axial symmetry, for all intents and purposes, so that they can be tested in single ("star test") or double pass (auto-collimation).

7.1 Collimation or "Star Test"

Both cameras show residual spherical aberration when imaging a perfectly collimated source. This is to be expected because they are optimised to balance severe astigmatism and spherical aberration from their second, spherical, pupil mirrors. A "pre-aberrated collimated source is required and the most economical way of delivering this is to use one of the pupil mirrors, as fabricated. The mirror and either camera are set up with a common optical axis and a source is placed on this axis at a predetermined position near the mirror's focus. The source can be the end of an optical fibre or a similarly sized pinhole fed from the side so as to minimize central obscuration and diffraction effects. The final image is demagnified approximately 6.7 times so that it is small enough to be examined by a low-power travelling microscope set up on the common axis. The image will not be perfect but the blur can be quantified and decentrations picked up using standard defocusing techniques. Typical layouts and optical performance are shown in Figures 1 and 2.

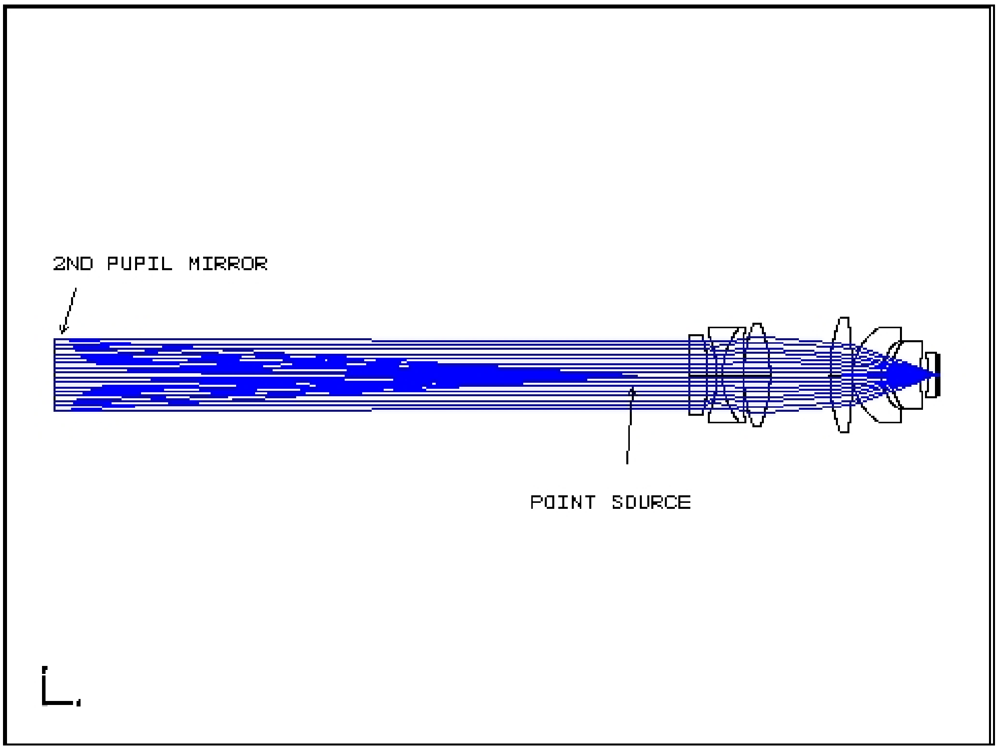

Figure 1a : Blue camera acceptance test layout

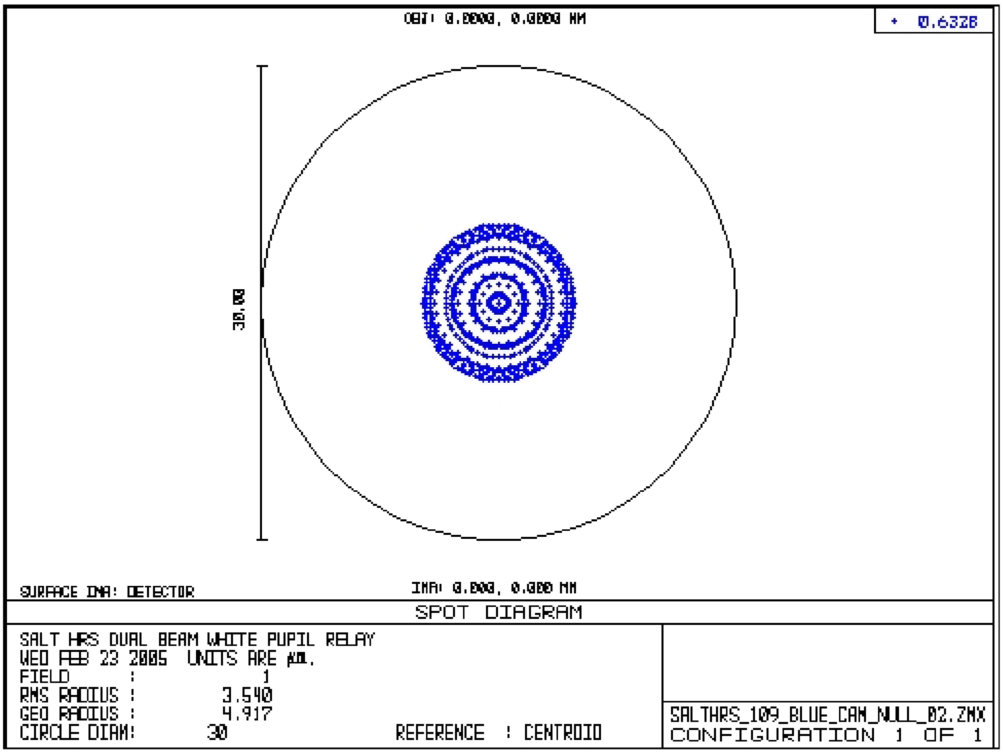

Figure 1b : Blue camera acceptance test performance

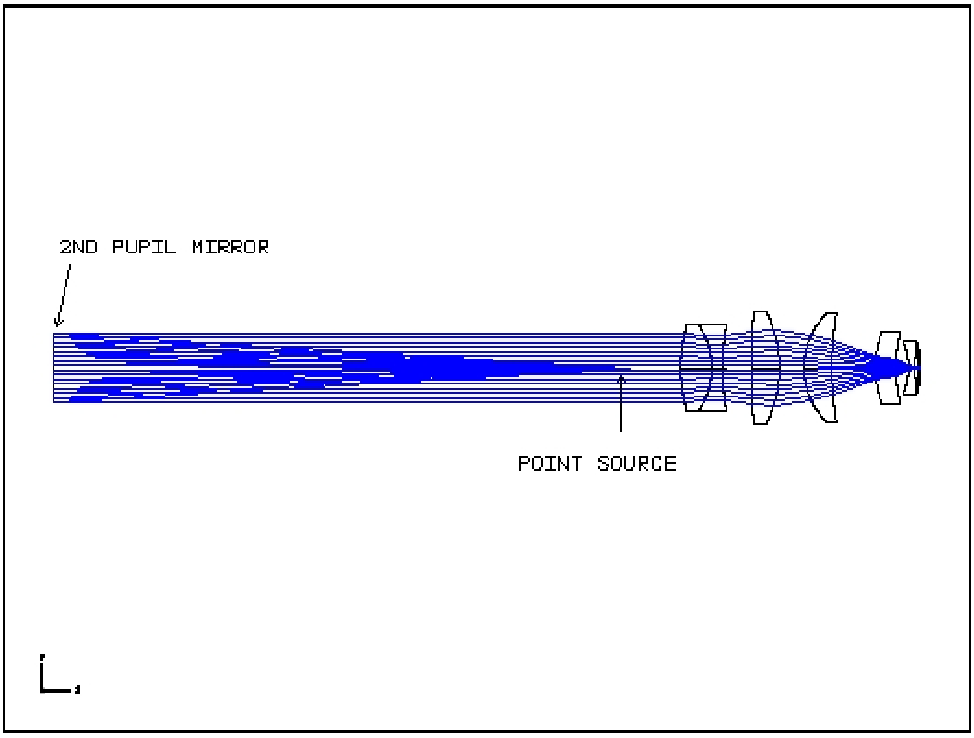

Figure 2a : Red camera acceptance test layout

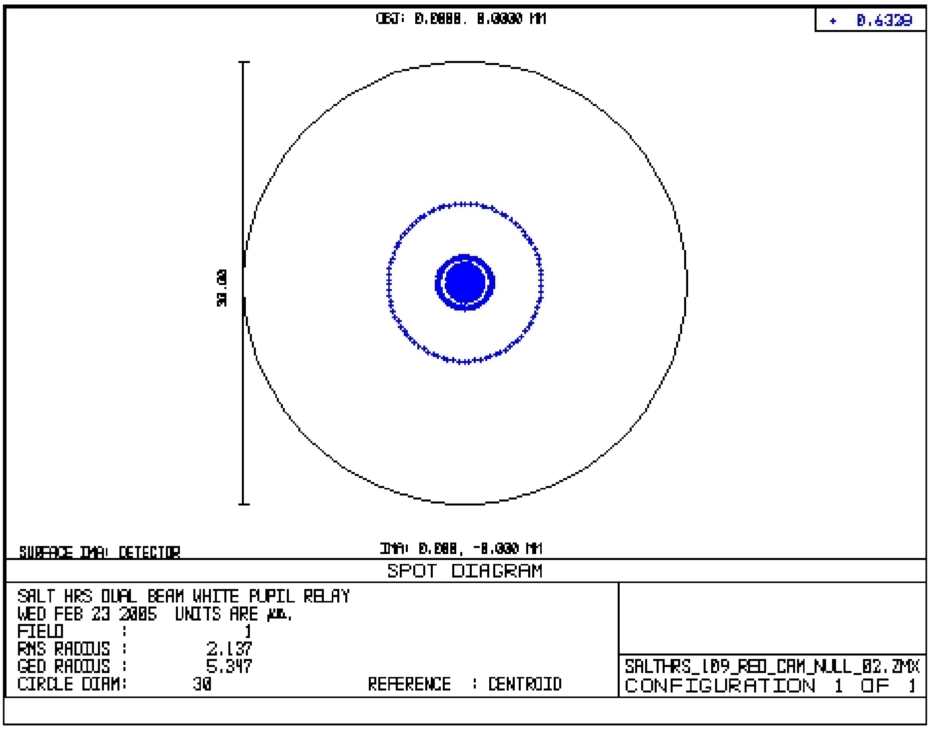

Figure 2b : Red camera acceptance test performance

7.2 Auto-collimation Tests

The auto-collimation tests also require a cylindrical "negative" of the trailing surface of the field flattener with similar mounting conditions.

The actual test for either camera has a point source placed near the camera's focus. Collimated light emerges from the front of the camera and is retro-reflected from a plane mirror. A doublet corrector is interposed between this mirror and the camera to correct the camera's intrinsic spherical aberration. This test can achieve diffraction-limited performance in the red camera, even in double-pass. However, the cost-effectiveness of adding another layer of complexity to an already complex system would be questionable. The optical and mechanical tolerances of the doublet corrector are on a par with the rest of the system so that, in the end, the achievable performance would probably be on par with the "star test" described above.

Layouts and performance plots of the auto-collimation tests are shown in Figures 3 and 4 below.

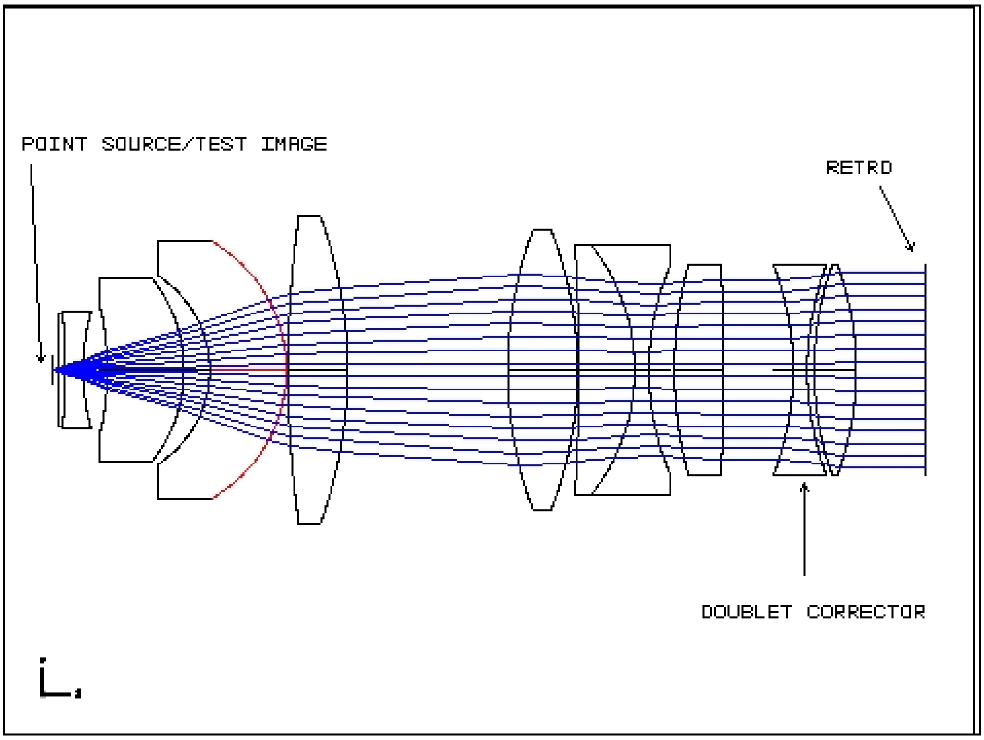

Figure 3a : Blue camera double-pass acceptance test layout

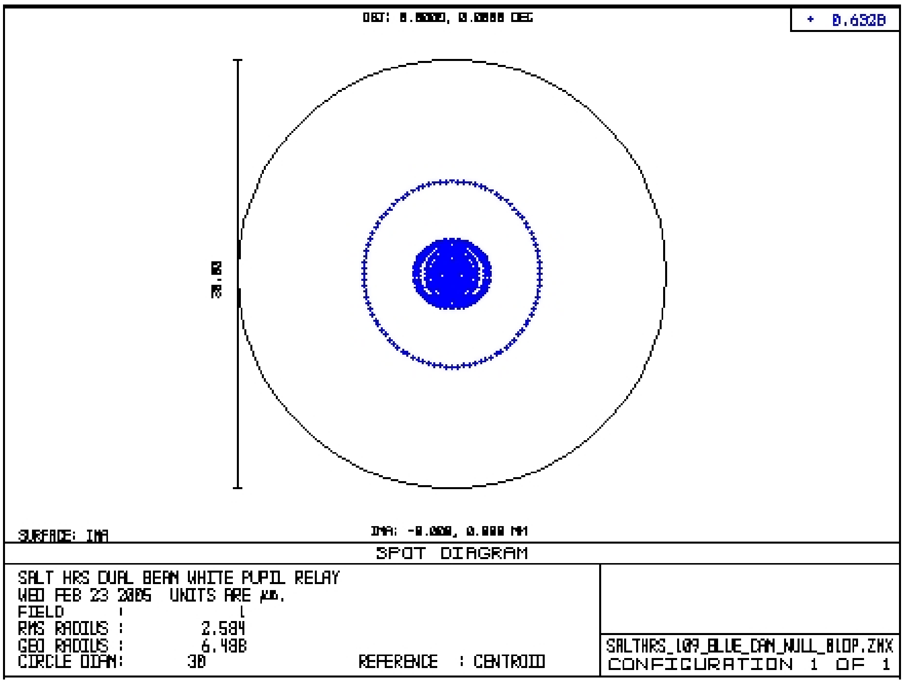

Figure 3b : Blue camera double-pass acceptance test performance

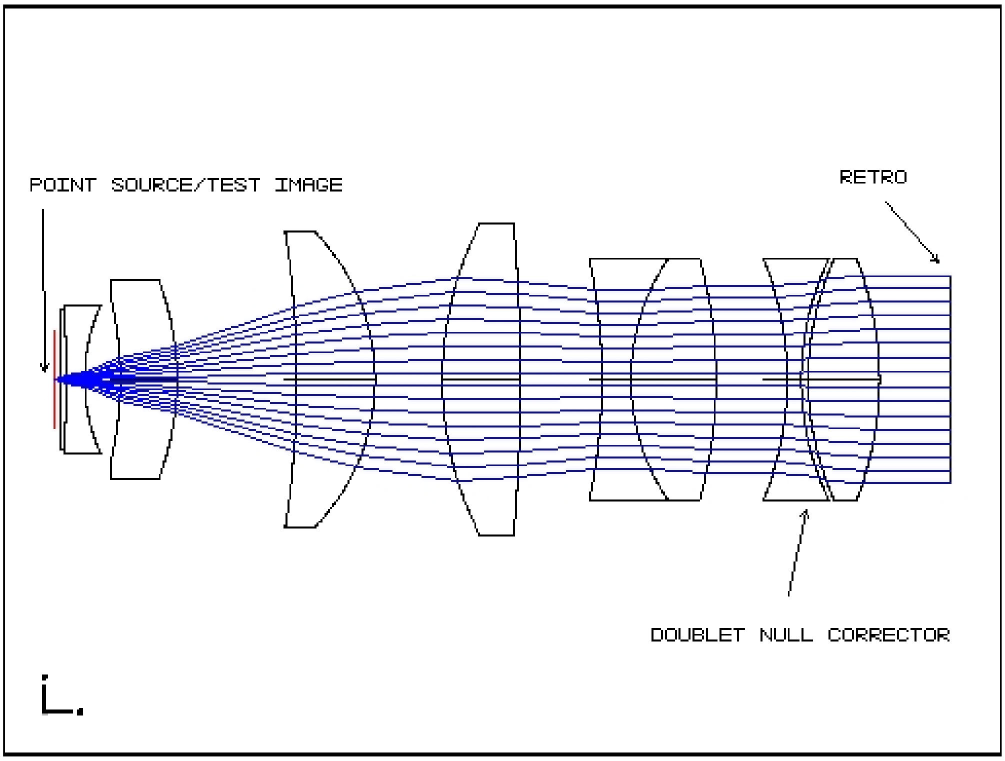

Figure 4a : Red camera double-pass acceptance test layout

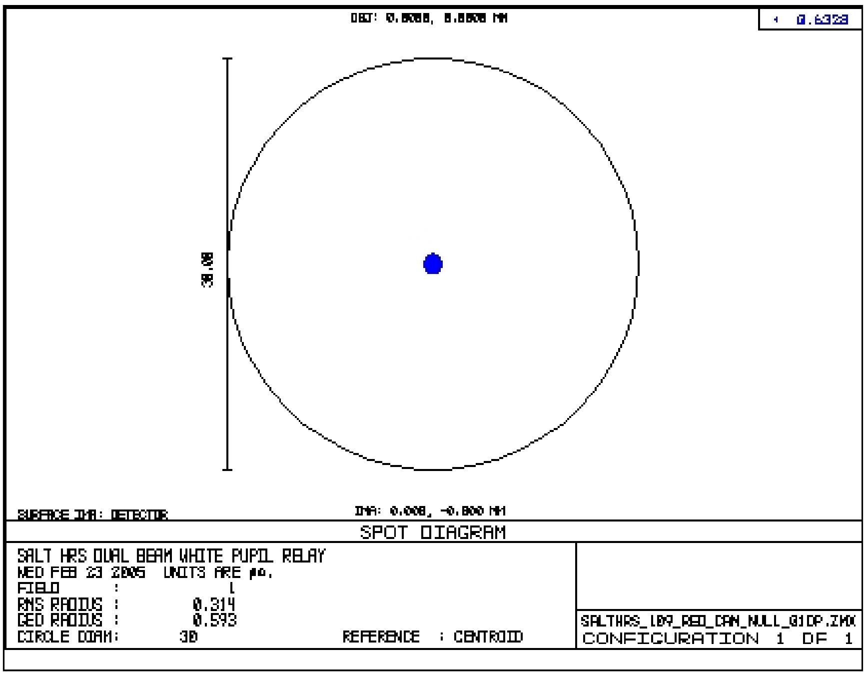

Figure 4b : Red camera double-pass acceptance test performance

7. Ghost Analysis

7.1. Blue Camera

All detector ghosts are significantly defocused to blur circles greater than 1 mm in diameter.

A fainter ghost around 0.5 mm in diameter is caused by reflections from the first surface of element 4.1 and the second surface of element 2.1 and is designated 4.1/1//2.1/2. This ghost rapidly becomes less important away from the central wavelength. It is therefore not expected to cause problems as the A-R coating efficiencies will no doubt peak near this wavelength.

7.2. Red Camera

As for the blue camera, all detector ghosts are significantly defocused to blur circles greater than 1 mm in diameter.

A very faint ghost is caused by the reflection 7.1/1//1.1/1 and is around 3.0 mm in diameter. It is visible, but displaced, at the central wavelength of each order. Again, it is not expected to be troublesome.