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A NEW POSSIBLE OPTICAL SOLUTION FOR THE VST

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1 Introduction

In this document, a new optical solution for the VST is reported. This solution comes out from the Kick-off meeting held in Garching on 24 - 25 June 1998, and the telephone discussion with ESO of 15/07/98. It has a removable ADC and a curve dewar window. It is provided with a corrector made of two lenses from U to I bands ($0.320 \div 1.014 \mu\text{m}$). From V to I bands ($0.365 \div 1.014 \mu\text{m}$), this corrector can be replaced by another one with one different lens and an ADC with curve entrance and exit surfaces. The aspherical surface was removed from the second lens of the corrector and the curvature of the exit surface of the ADC was increased and normalized to DIN tables. All Kick-off meeting requirements are satisfied and the rays of curvatures were normalized to DIN table 58166.

The ADC type chosen is constituted of two identical couples of prisms, made of UBK7 and LLF6, which must be suitably counter rotated, to correct the atmospherical dispersion at the different observation angles, respect to zenith. The study of optical quality was done at zenith angle and at the z angle corresponding to the maximum dispersion of ADC.

2 Optical layout and encircled energy values

This configuration has a curve dewar window and the optical quality meets requirements. The field corrector is made of one lens and an ADC with curved entrance and exit surfaces. The aspherical surface was eliminated from the second lens as requested. In Figures 2-1 and in 2-2, the complete optical layout of the telescope with one lens and the ADC and the zoom of the corrector are respectively shown. In Figures 2-3, 2-4 the complete optical layout of the telescope with the two lenses and the zoom of the corrector are reported. In Tables 2-1 and 2-2 the diffraction encircled energy values for the two configurations in which ADC is respectively inserted (B, V, R, I band) and removed (U ÷ I), are reported for all fields of view, at zenith angle $z=0^\circ$ and at the zenith angle corresponding to the maximum dispersion of ADC. In Figure 2-5 the fraction of polichromatic diffraction encircled energy values curves are shown.

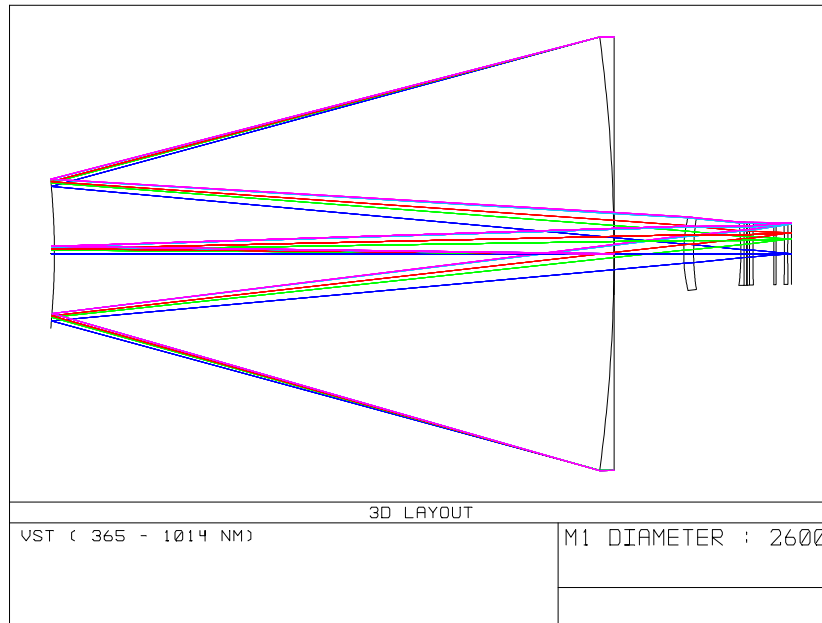


Figure 2-1 VST complete optical layout of telescope with one lens and the, with a cuve dewar window

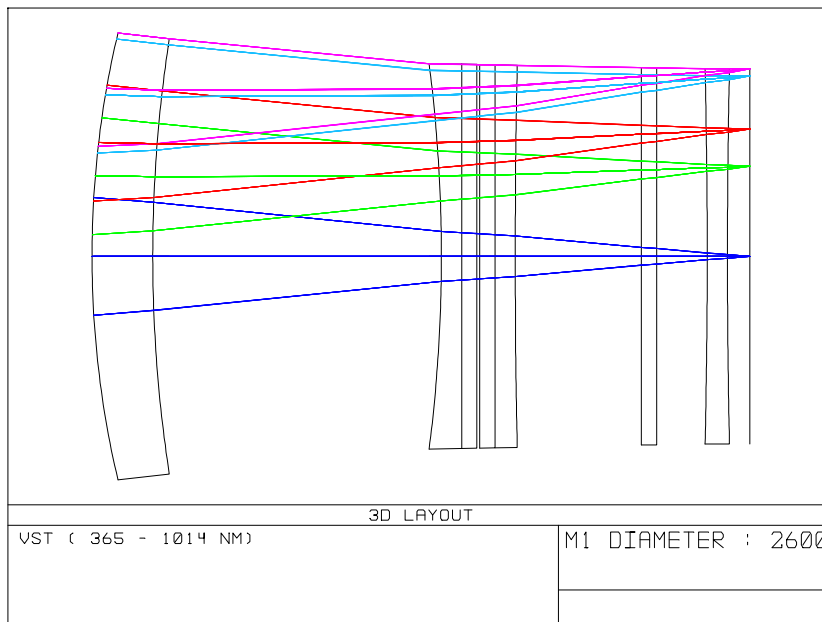


Figure 2-2 VST zoom of the optical layout of the corrector with one lens and the ADC and a curve dewar window

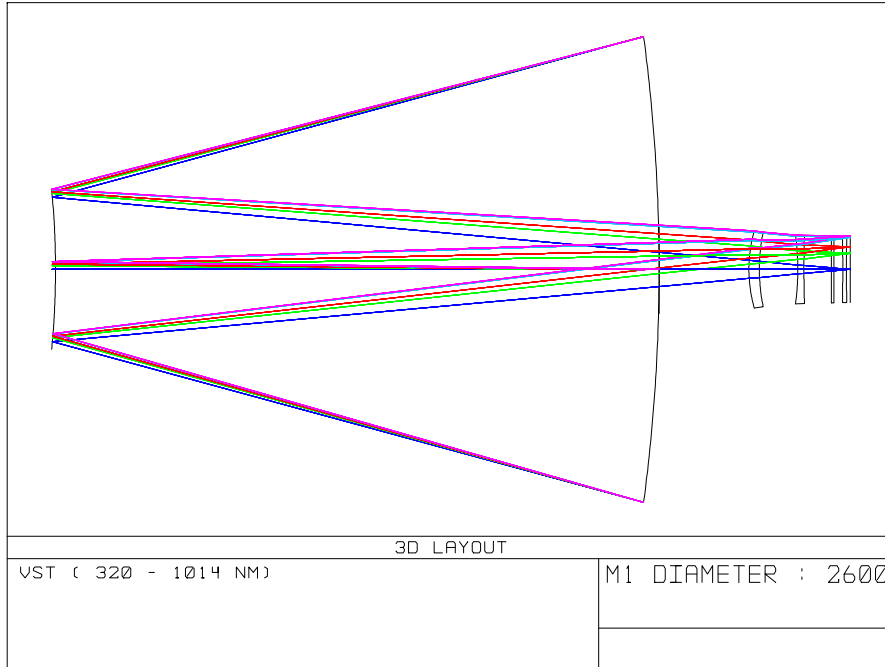


Figure 2-3 VST optical layout of telescope with two lenses (U ÷ I bands)

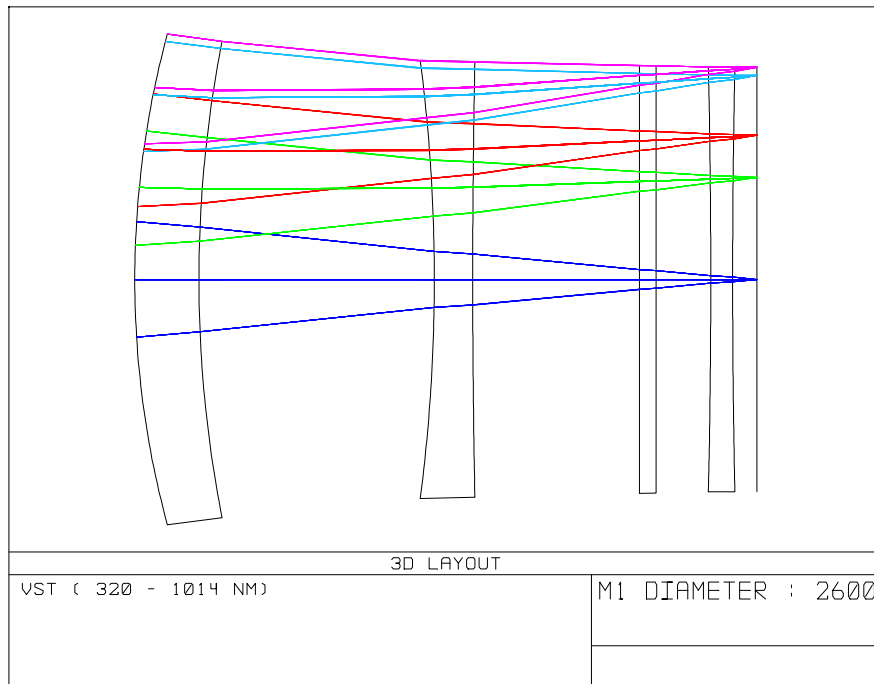




Figure 2-4 VST zoom of the optical layout of the two lenses (U ÷ I bands)

FRACTION (%) OF DIFFRACTION ENCIRCLED ENERGY VALUES FOR THE DIFFERENT FIELDS OF VIEW, AT Z=0° AND AT Z=66°										
1 LENS +ADC CORRECTOR										
Field radius (deg)	B ÷ I bands (365 ÷ 1014 nm)		B band (420 ÷ 520 nm)		V band (560 ÷ 650 nm)		R band (650 ÷ 740 nm)		I band (775 ÷ 900 nm)	
	Zenith (z=0°)	z = 66°	z=0°	z=66°	z=0°	z=66°	z=0°	z=66°	z=0°	z=66°
	1.76 pxl (26.4µm)	2.6 pxl (39µm)	1pxl (15µm)	1pxl (15µm)	1.16 pxl (17.4µm)	1.25 pxl (18.8µm)	1.46 pxl (22µm)	1.5 pxl (22.5µm)	1.76 pxl (26.4µm)	1.76 pxl (26.4µm)
0	94	98	96	95	89	91	81.4	80	93	91
0.3535	95	97	89	93	96	98	96	96	98	98
0.5	92	91	80	87	89	91	95	95	95	95
0.707	81	81	86	85	80	81	86	85	82	80
0.735	80.4	80.6	88	85	82.5	83	87	85	81	80

Table 2-1 Percentage diffraction encircled energy values, from B to I bands and for each band, for the configuration of one lens and ADC

FRACTION (%) OF DIFFRACTION ENCIRCLED ENERGY	
TWO LENSES	
Field radius (deg)	U ÷ I bands (0.320 ÷ 1.014 µm)
	1.5 pxl (22.5µm)
0	86
0.3535	93
0.5	93
0.707	83
0.735	80

Table 2-2 Diffraction encircled energy values for the configuration with two lenses

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3 VST optical data and performance

In Table 3-1 VST main optical data are reported. In Tables 3-2 and 3-3 the optical data, with the ADC inserted and with the ADC removed are respectively shown. In Tables 3-4, 3-5 the optical performance for the two configurations are reported.

VST MAIN OPTICAL CHARACTERISTICS	
Main optical data for the full system	
Optical configuration	Modified Ritchey Chretien
Pupil diameter	2600 mm
Angular field of view	1.47°
F#	5.5
Equivalent focal length	14381.04 mm (two lenses) 14484.9 mm (one lens +ADC)
Image scale	0.21 arcsec/pixel
Overall length	4447.11 mm (fixed)
Distance between M1 and M2	3377.11mm (fixed)
Spectral Range	U ÷ I bands
Distance M1 vertex to first corrector lens in B, V, R, I bands	420. 3 mm (>min. req)
Distance M1 vertex to first corrector lens in U÷ I bands	502.8 mm (>min. req)
Distance M1 vertex to CCD plane	1070mm (<max.req)
Footprint diameter of light beams in M1 centre hole	493 mm (< max. req)
Distance between last corrector element and the image plane	231.63 mm for one lens +ADC (> min. req) 259.1mm for two lenses (> min. req)
Image plane corrector in B, V, R, I bands	One lens +ADC with curved entrance and exit surfaces.
Atmospheric Dispersion Corrector (ADC)	Two double prisms made of UBK7 and LLF6
Image plane corrector in U÷ I bands	Two lenses
Focal Plane CCD mosaic	16 k x 16 k
Ccd pixel size	15µm x 15µm
Primary Mirror parameters	
Outer Diameter	2600 mm
Inner Diameter	720
Ray of curvature	-9746.3mm
Conic constant K1	-1.151891
f/number	1.87
Secondary Mirror parameters	
Diameter	893.4 mm
Ray of curvature	-4511.32 mm
Conic constant K2	-5.778442



Table 3-1 VST main optical data

OPTICAL DATA FOR ONE LENS AND ADC CORRECTOR, FILTER AND DEWAR WINDOW							
Element	Prism angle	R1	R2	Material	Diameter	Thickness	Air thickness
L1	0°	957.75 mm	1412.5mm	Silica	441 mm 429.5 mm	60mm	285.05mm
ADC S1 (First prism)	0°	-1496.2		UBK7	380.6mm	20 mm	0 mm
ADC S2 (First prism)	2.8°	Infinity		LLF6	380.5mm	15 mm	3 mm
ADC S3 (Second prism)	0°	Infinity		UBK7	377.1mm	15 mm	0 mm
ADC S4 (Second prism)	2.8°	8912.5		LLF6	377.1mm	20 mm	121.63mm
Filter (B band)		Infinity	Infinity	Silica	369 mm 369 mm	15 mm	50 mm
Filter (V band)		Infinity	Infinity	Silica	369 mm 369 mm	14.95 mm	50 mm
Filter (R band)		Infinity	Infinity	Silica	372 mm 372 mm	14.92 mm	50 mm
Filter (I band)		Infinity	Infinity	Silica	369 mm 369 mm	14.98 mm	50 mm
Dewar window		-7943.3	8912.5	Silica	367.6mm 367.4 mm	20 mm	25 mm (req.)

Table 3-2 VST optical data for camera, ADC, filter and dewar window in, B, V, R, I bands

OPTICAL DATA FOR TWO LENSES CONFIGURATION						
Element	R1	R2	Material	Diameter	Thickness	Air thickness
L1	794.33 mm	1044.1 mm	Silica	430.3 mm 417.6mm	58.45mm	214.65mm
L2	-1453.8	8912.5mm	Silica	384.1 mm 381.9 mm	35 mm	149.1 mm
Filter	Infinity	Infinity	Silica	375.4 mm 375 mm	15 mm	50 mm
Dewar window	Infinity	Infinity	Silica	372.8 mm 372.5 mm	20 mm	25 mm

Table 3-3 VST optical data for corrector filter and dewar window in U ÷ I bands

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VST OPTICAL PERFORMANCE (WORST CASE) FOR THE CONFIGURATION WITH 1 LENS +ADC	
B BAND	
Diffraction encircled energy	Z=0°: 80 % in 1 pixel Z=66°: 85% in 1 pixel
Tangential maximum field of curvature Sagittal maximum field of curvature	z=66°: 0.19 mm at $\lambda = 0.52 \mu\text{m}$ z=66°: 0.16 mm at $\lambda = 0.52 \mu\text{m}$
Maximum distortion	z=66°: 0.19% (< 0.3% goal), at $\lambda = 0.42 \mu\text{m}$ at the edge of the field
Glass transmission	95% at $\lambda = 0.365 \mu\text{m}$
V BAND	
Diffraction encircled energy	Z=0°: 80 % in 1.16 pixel Z=66°: 81% in 1.25 pixel
Tangential maximum field of curvature Sagittal maximum field of curvature	z=66°: 0.27 mm at $\lambda = 0.65 \mu\text{m}$ on axis z=66°: 0.25 mm at $\lambda = 0.65 \mu\text{m}$ on axis
Maximum distortion	z=66°: 0.19% (< 0.3% goal) at $\lambda = 0.56 \mu\text{m}$ at the edge of the field
Glass transmission	99% at $\lambda = 0.580 \mu\text{m}$
R BAND	
Diffraction encircled energy	Z=0°: 81.4 % in 1.46 pixel Z=66°: 80% in 1.5 pixel
Tangential maximum field of curvature Sagittal maximum field of curvature	z=66°: 0.29 mm at $\lambda = 0.74 \mu\text{m}$ on axis z=66°: 0.32 mm at $\lambda = 0.74 \mu\text{m}$ on axis
Maximum distortion	z=66°: 0.19% (< 0.3% goal) at $\lambda = 0.65 \mu\text{m}$ at the edge of the field
Glass transmission	99% at $\lambda = 0.660 \mu\text{m}$
I BAND	
Diffraction encircled energy	Z=0°: 81 % in 1.76 pixel Z=66°: 80% in 1.76 pixel
Tangential maximum field of curvature Sagittal maximum field of curvature	z=66°: 0.35 mm at $\lambda = 1.014 \mu\text{m}$ on axis z=66°: 0.33 mm at $\lambda = 1.014 \mu\text{m}$ on axis
Maximum distortion	z=66°: 0.19% (< 0.3% goal) at $\lambda = 0.775 \mu\text{m}$ at the edge of the field
Glass transmission	99 % at $\lambda = 0.810 \mu\text{m}$

Table 3-4 Optical performance for the configuration with ADC inserted

OPTICAL PERFORMANCE FOR THE CONFIGURATION WITH TWO LENSES (WORST CASE)	
U ÷I bands (0.320 ÷ 1.014 μm)	
Diffraction encircled energy	80 % in 1.5 pixel
Maximum tangential field of curvature	0.34 mm at λ = 1.014 μm on axis
Maximum sagittal field of curvature	0.34 mm at λ = 1.014 μm on axis
Maximum distortion	0.18 % at the edge of the field at λ = 0.32μm
Glass transmission	99 %

Table 3-5 Optical performance for the configuration with two lenses

4 Field curvature and distortion curves

In Figures 4-1, 4-2 the field curvature and distortion curves for the configurations with one lens and ADC and with two lenses are respectively reported.

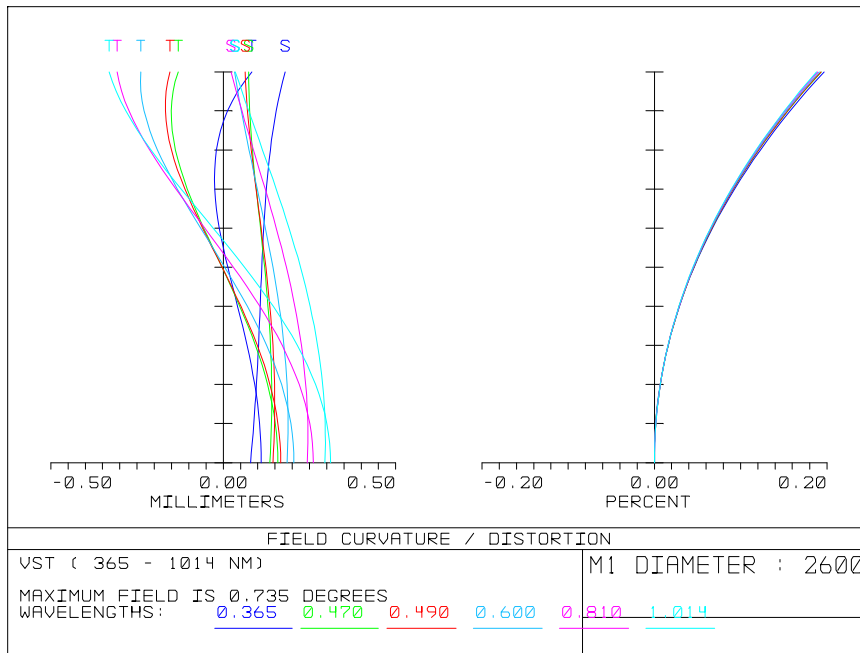


Figure 4-1 Field curvature and distortion curves for the configuration with one lens and ADC at z angle of 63°

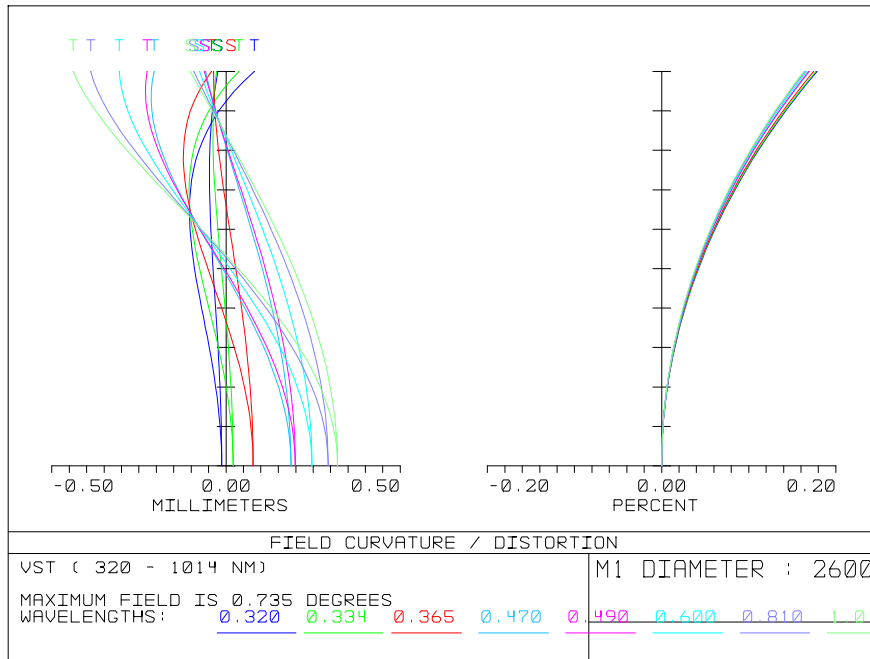


Figure 4-2 Field curvature and distortion curves for the configuration with two lenses

5 Spot diagram

In Figures 5-1, 5-2 the spot diagrams for one lens and ADC configuration at zenith and 66° are reported from B to I bands and in Figure 5-3 the spot diagrams for two lenses configuration are shown.

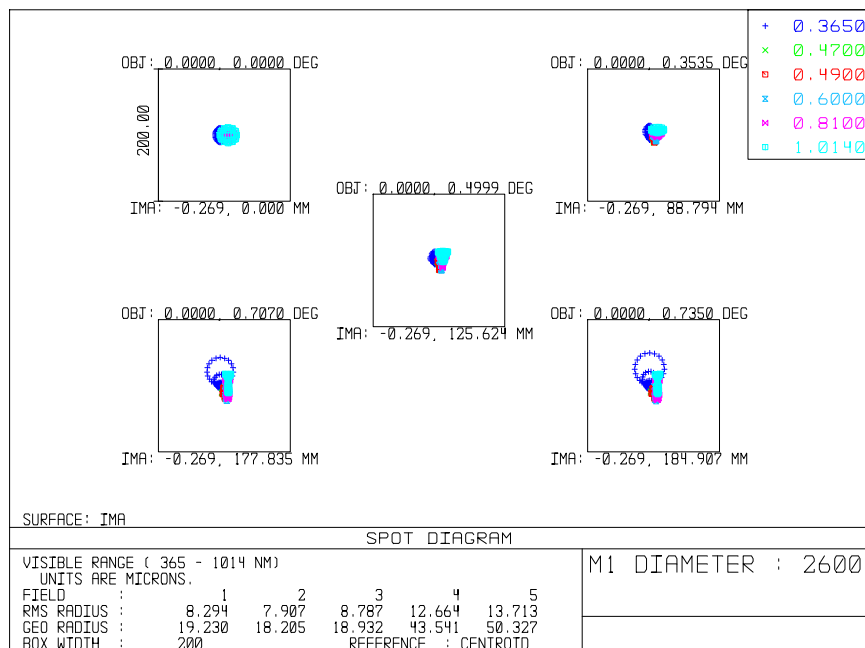


Figure 5-1 Spot diagram for one lens and ADC at zenith from B to I

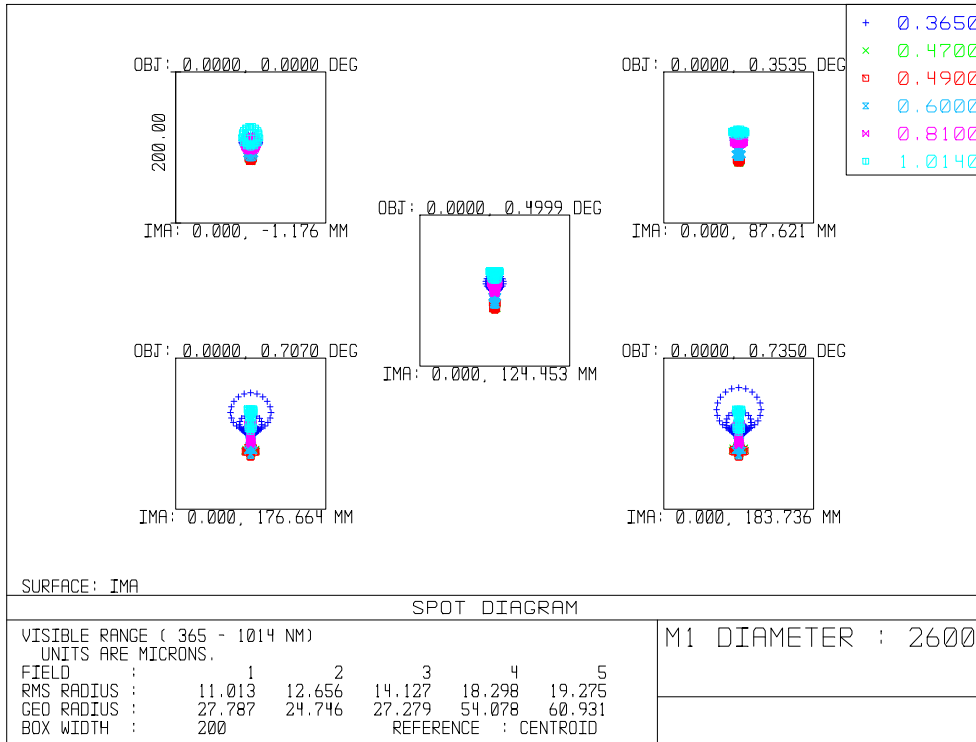


Figure 5-2 Spot diagrams for one lens and ADC at $z=66^\circ$

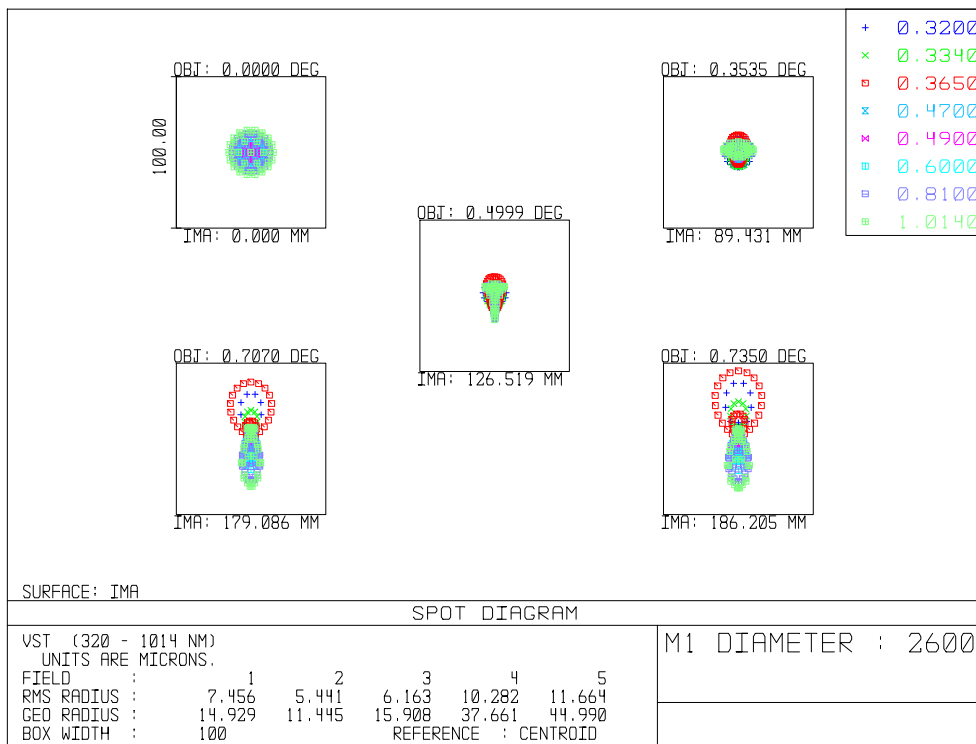


Figure 5-3 Spot diagram for two lenses from U to I bands