AN OPTICAL SOLUTION FOR THE VST WITH REMOVABLE ADC AND ONE FIXED LENS CORRECTOR

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1 Introduction

In this document, another possible optical solution for the VST, is reported. Respect to the one presented in the VST_180798_optic1.doc document, there is one fixed lens, when changing from the configuration in which ADC is inserted to that in which it is removed. All Kick-off meeting requirements are satisfied, although the optical quality is lower than for the design in which all corrector elements are removed when changing configuration. The first surface of the first lens, and the first and last surface of ADC were normalized to DIN table 58166. The other radius of curvature values were rounded, because a normalization produces a decrease of the optical quality.

2 One fixed lens and removable ADC

In this solution, respect to the previous one, one lens is fixed when inserting or removing ADC. So, only one lens has to be inserted or removed. For this design one lens less would be manufactured. The optical quality is below that of the previous solution, but still satisfies requirements. Respect to the previous design, the dewar window has an higher curvature. The distance between the mirrors is still fixed when changing the corrector for use in the different bands. All lenses and ADC surfaces are spherical 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 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 inserted (B, V, R, I band) and removed (U ÷ I), are reported for all fields of view, at zenith angle z=0° 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.

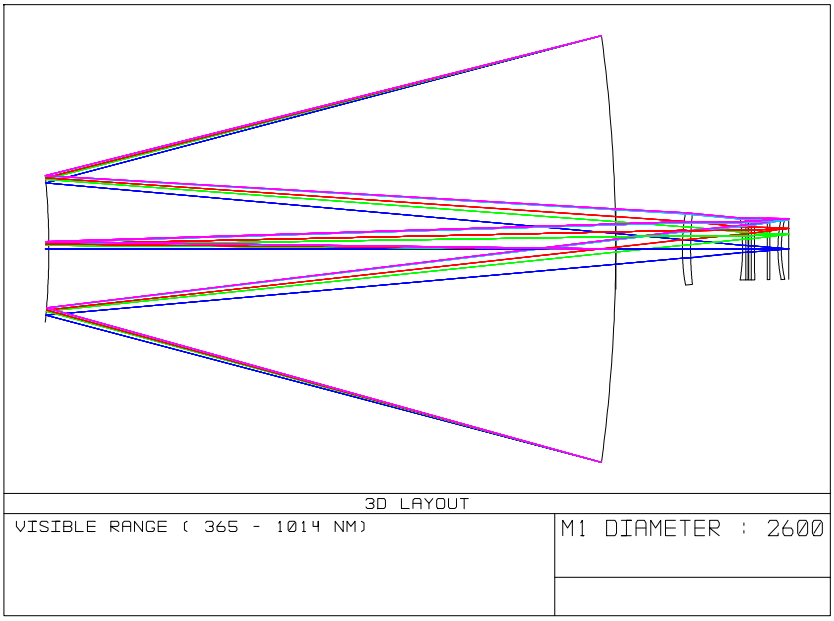

Figure 2-1 VST complete optical layout of telescope with one fixed lens, the ADC and a curve dewar window

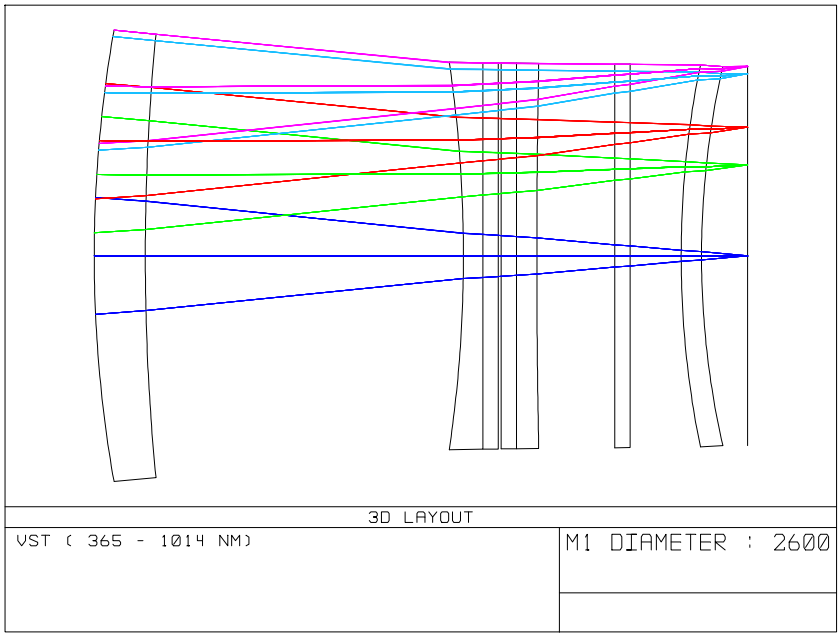

Figure 2-2 VST zoom of the optical layout of the corrector with one fixed lens, the ADC and a curve dewar window

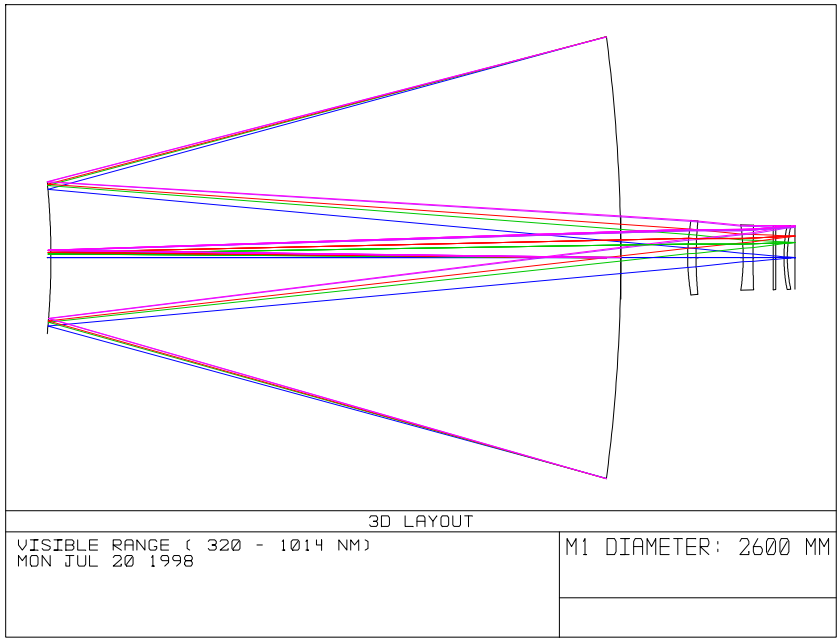

Figure 2-3 VST optical layout of telescope with two lenses (U ÷ I bands)

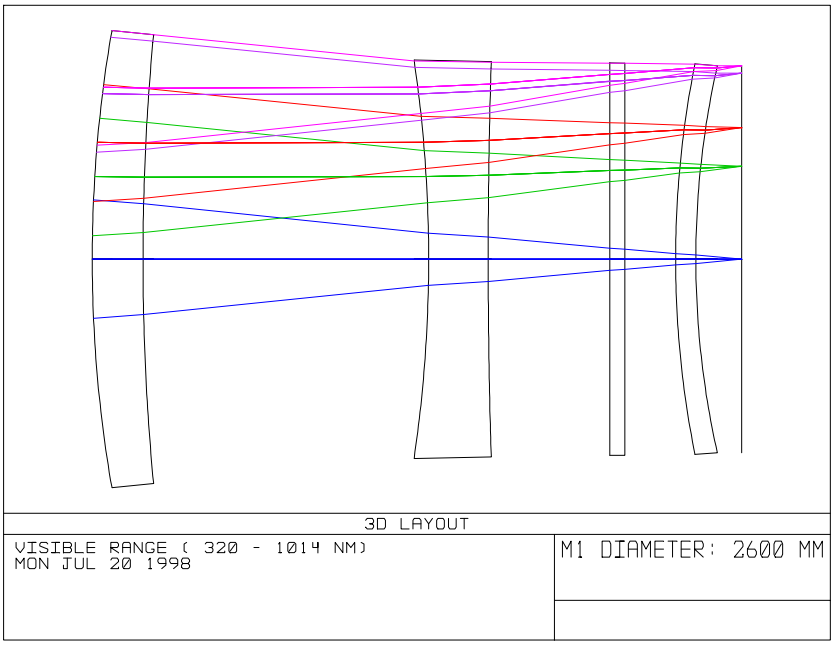

Figure 2-4 VST zoom of the optical layout of the two lenses (U ÷ I bands)

FRACTION (%) OF DIFFRACTION ENCIRCLED ENERGY										
	1 FIXED LENS +ADC CORRECTOR									
Field radius (deg)	**B ÷I bands** (0.365 ÷ 1.014 μm)		**B band** (420 ÷ 520 nm)		**V band** (560 ÷ 650 nm)		**R band** (650 ÷ 740 nm)		**I band** (775 ÷ 900 nm)	
	Zenith (z=0°)	**z = 63°**	**z=0°**	**z=63°**	**z=0°**	**z=63°**	**z=0°**	**z=63°**	**z=0°**	**z=63°**
	2.07 pxl (32 μm)	**2.66 pxl** (40 μm)	**1.4 pxl** (20μm)	**1.06 pxl** (16μm)	**1.46 pxl** (22μm)	**1.4 pxl** (20 μm)	**1.6 pxl** (24 μm)	**1.53 pxl** (23 μm)	**1.73 pxl** (26μm)	**1.73 pxl** (26μm)
0	96	97	**97**	**93**	**99**	**98**	**99.9**	**98**	**98**	**97**
0.3535	92	91	**88**	**87**	**90**	**93**	**93**	**95**	**95**	**96**
0.5	85	84	**80**	**80**	**80**	**81**	**83**	**85**	**86**	**88**
0.707	82	82	**93**	**86**	**81**	**84**	**80**	**80.5**	**80**	**81**
0.735	80	80	**91**	**81**	**84**	**87**	**82**	**83.4**	**82**	**84**

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

FRACTION (%) OF DIFFRACTION ENCIRCLED ENERGY	
TWO LENSES CORRECTOR	
Field radius (deg)	**U ÷I bands (0.320 ÷ 1.014 μm)**
	2 pxl (30 μm)
0	83.7
0.3535	96.5
0.5	85.8
0.707	81
0.735	81.4

Table 2-2 Diffraction encircled energy values for the configuration with two lenses corrector from U to I bands

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 for the two configurations, 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. Respect to the solution of VST_180798_optic1.doc document, the maximum distortion is reduced from 0.19% to 0.15%, when ADC is inserted, and from 0.18% to 0.12% when ADC is removed. The maximum field curvature values are comparable.

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 lenght	14500mm (two lenses) 14379.4 mm (one fixed lens +ADC)
Image scale	0.21 arcsec/pixel
Overall lenght	4445.78 mm (fixed)
Distance between M1 and M2	3405.78 mm (fixed)
Spectral Range	U ÷ I bands
Distance M1 vertex to first corrector lens in B ÷ I bands	400 mm (min. req)
Distance M1 vertex to first corrector lens in U÷ I bands	400 mm (min. req)
Distance M1 vertex to CCD plane	1040 mm (< max.req)
Footprint diameter of light beams in M1 centre hole	490 mm (< max. req)
Distance between last corrector element and the image plane	206.37 mm for one lens +ADC (> min. req) 249.75 mm for two lenses (> min. req)
Image plane corrector in B, V, R, I bands	One fixed lens +ADC
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	-9829 mm
Conic constant K1	-1.145442
f/number	1.89
Secondary Mirror parameters	
Diameter	894 mm
Ray of curvature	-4571.06 mm
Conic constant K2	-5.782526

Table 3-1 VST main optical data

OPTICAL DATA FOR ONE LENS AND ADC CORRECTOR, FILTER AND DEWAR							
Element	Prism angle	R1	R2	Material	Diameter	Thickness	Air thickness
L1	0°	1258.9 mm	2238.7 mm	Silica	440.4 mm 432.6mm	50 mm	311.63 mm
ADC S1 (First prism)	0°	-1294.81		UBK7	378.05 mm	19 mm	0 mm
ADC S2 (First prism)	3°	Infinity		LLF6	377.9 mm	15 mm	3 mm
ADC S3 (Second prism)	0°	Infinity		UBK7	375.3 mm	15 mm	0 mm
ADC S4 (Second prism)	3°	10000		LLF6	375.6 mm	20 mm	76.37 mm
Filter (B band)		Infinity	Infinity	Silica	370.7 mm 370.6 mm	15 mm	50 mm
Filter (V band)		Infinity	Infinity	Silica	370.7 mm 370.5 mm	15 mm	50 mm
Filter (R band)		Infinity	Infinity	Silica	373.8 mm 373.2 mm	15 mm	50 mm
Filter (I band)		Infinity	Infinity	Silica	370.8 mm 370.6 mm	15 mm	50 mm
Dewar window		930.57 mm	829.63 mm	Silica	370 mm 367 mm	20 mm	45 mm

Table 3-2 VST optical data for one fixed lens, 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	1258.9 mm	2238.7 mm	Silica	440.4 mm 432.6 mm	50 mm	281.53 mm
L2	-1295.7	5997.4 mm	Silica	383.4 mm 380.6 mm	58.72 mm	119.75 mm
Filter	Infinity	Infinity	Silica	377.7 mm 377.5 mm	15 mm	50 mm
Dewar window	930.57 mm	829.63 mm	Silica	375.8 mm 372.6 mm	20 mm	45 mm

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

VST OPTICAL PERFORMANCE (WORST CASE) FOR THE CONFIGURATION WITH 1 FIXED LENS +ADC	
B BAND	
Diffraction encircled energy	Z=0°: 80% in 1.4 pixel Z=63°: 85% in 1.06 pixel
Tangential maximum field of curvature Sagittal maximum field of curvature	z=63°: 0.22 mm at λ =0.52 μm z=63°: 0.20 mm at λ =0.52 μm
Maximum distortion	z=63°: 0.15% (< 0.3% goal), at λ =0.42 μm at the edge of the field
Glass transmission	95% at λ =0.365 μm
V BAND	
Diffraction encircled energy	Z=0°: 80% in 1.46 pixel Z=63°: 81% in 1.4 pixel
Tangential maximum field of curvature Sagittal maximum field of curvature	z=63°: 0.23 mm at λ =0.65 μm on axis z=63°: 0.25 mm at λ =0.65 μm on axis
Maximum distortion	z=63°: 0.14% (< 0.3% goal) at λ =0.56 μm at the edge of the field
Glass transmission	99% at λ=0.580 μm
R BAND	
Diffraction encircled energy	Z=0°: 80% in 1.6 pixel Z=63°: 80% in 1.5 pixel
Tangential maximum field of curvature Sagittal maximum field of curvature	z=63°: 0.27 mm at λ =0.74 μm on axis z=63°: 0.25 mm at λ =0.74 μm on axis
Maximum distortion	z=63°: 0.15% (< 0.3% goal) at λ =0.65 μm at the edge of the field
Glass transmission	99% at λ=0.660 μm
I BAND	
Diffraction encircled energy	Z=0°: 80% in 1.73 pixel Z=63°: 81% in 1.73 pixel
Tangential maximum field of curvature Sagittal maximum field of curvature	z=63°: 0.32 mm at λ =1.014 μm on axis z=63°: 0.33 mm at λ =1.014 μm on axis
Maximum distortion	z=63°: 0.14% (< 0.3% goal) at λ =0.775 μm at the edge of the field
Glass transmission	99 % at λ=0.810 μm

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

OPTICAL OPERFORMANCE FOR THE CONFIGURATION WITH TWO LENSES (WORST CASE)	
U ÷ I bands (0.320 ÷ 1.014 μm)	
Diffraction encircled energy	80% in 2 pixel
Maximum tangential field of curvature Maximum sagittal field of curvature	0.41 mm at λ = 1.014 μm on axis 0.41 mm at λ = 1.014 μm on axis
Maximum distortion	0.12 % 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 fixed lens and ADC and with two lenses are reported

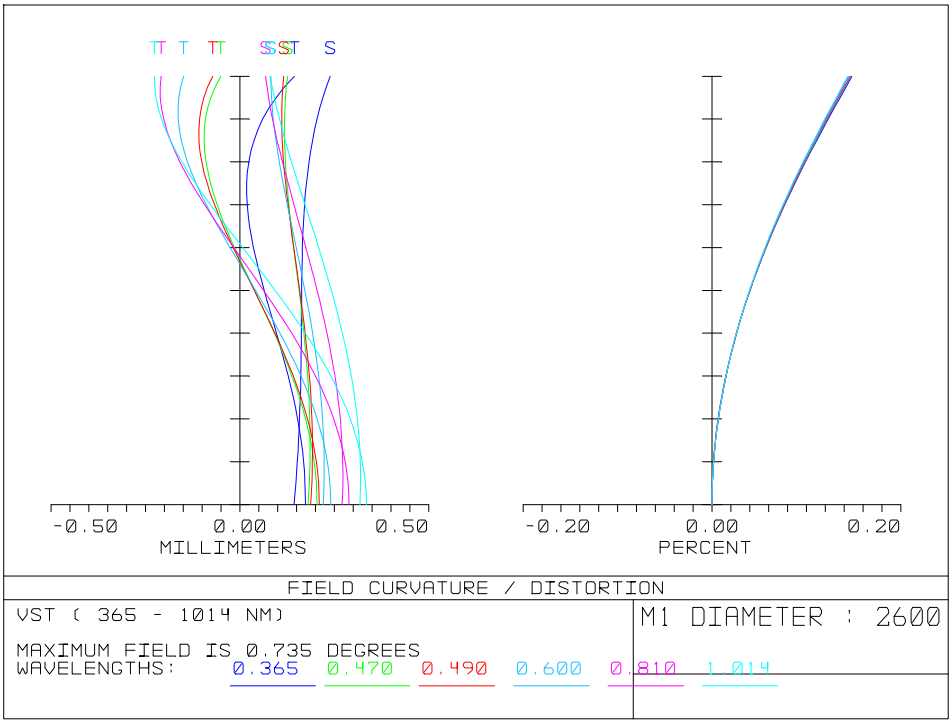

Figure 4-1 Field curvature and distortion curves for the configuration with one lens and ADC

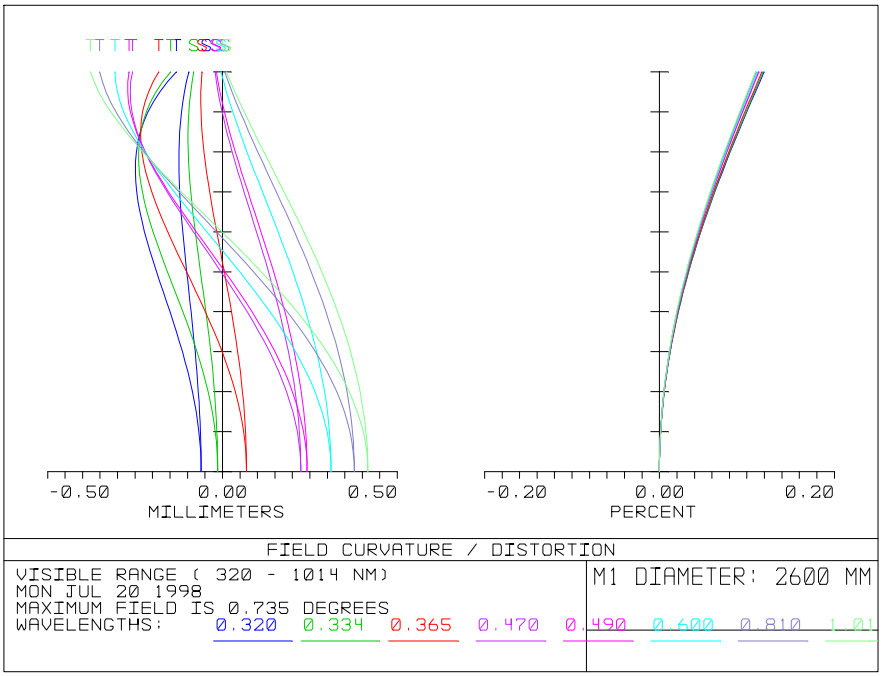

Figure 4-2 Field curvature and distortion curves for the configuration with two lenses

5 Spot diagrams

In figures 5-1, 5-2 the spot diagrams for one fixed lens and ADC configuration at zenith and at 63° are reported from B to I bands, and in Figure 5-3 the spot diagrams for two lenses configuration are shown.

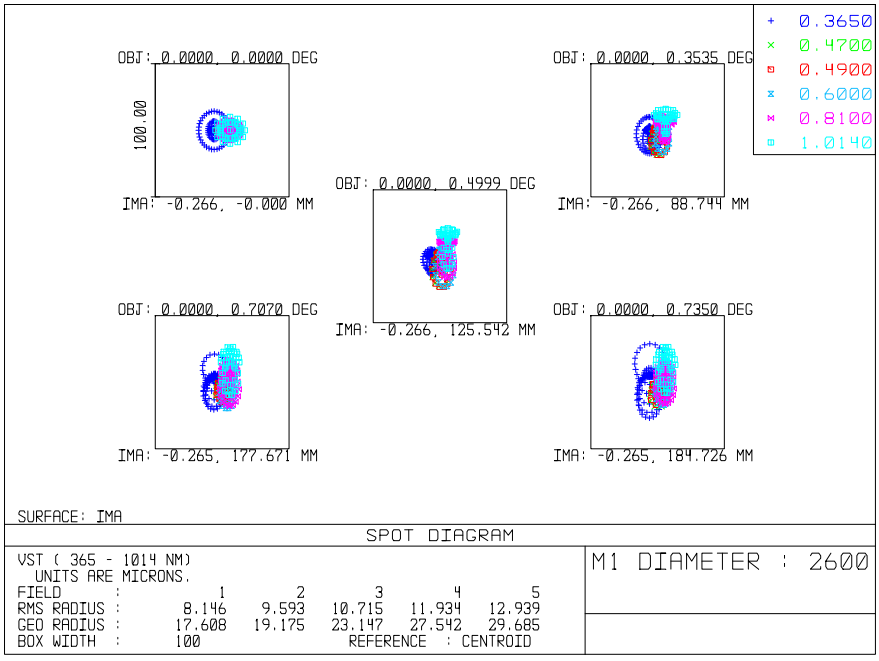

Figure 5-1 Spot diagram for one fixed lens and ADC at zenith from B to I

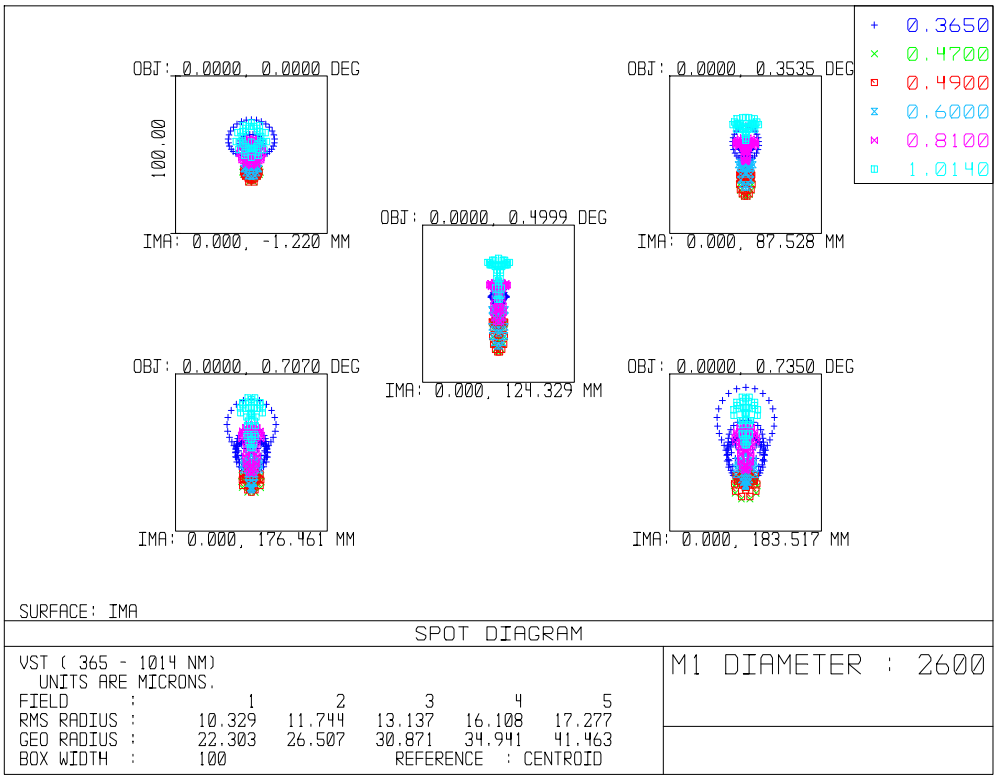

Figure 5-2 Spot diagrams for one fixed lens and ADC at z=63°

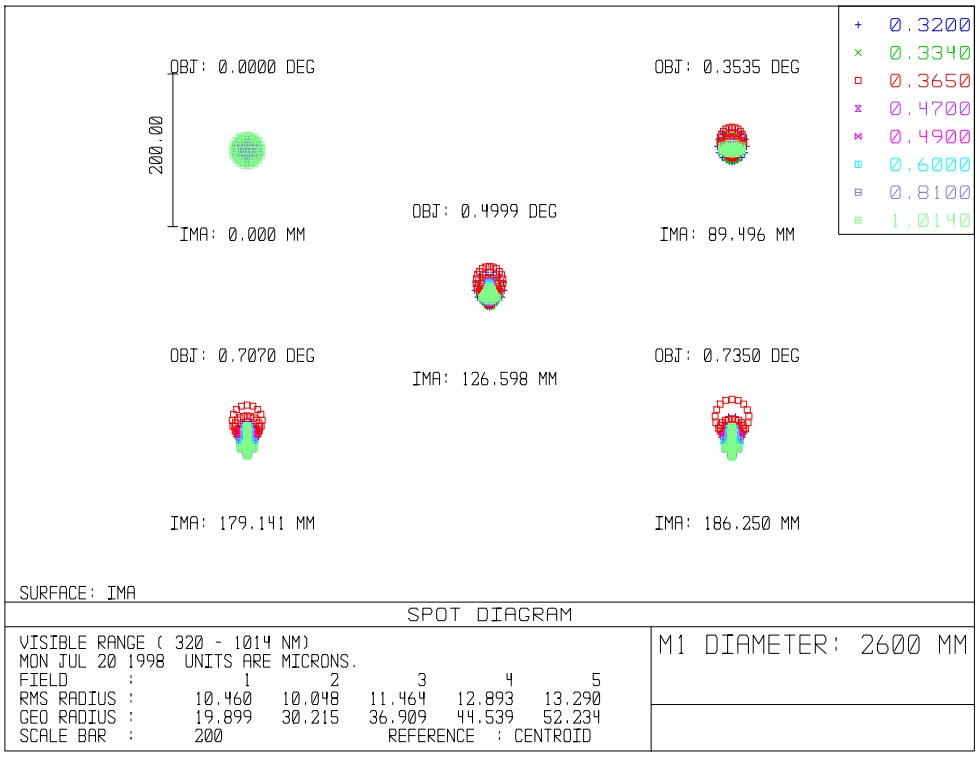

Figure 5-3 Spot diagram for two lenses from U to I bands