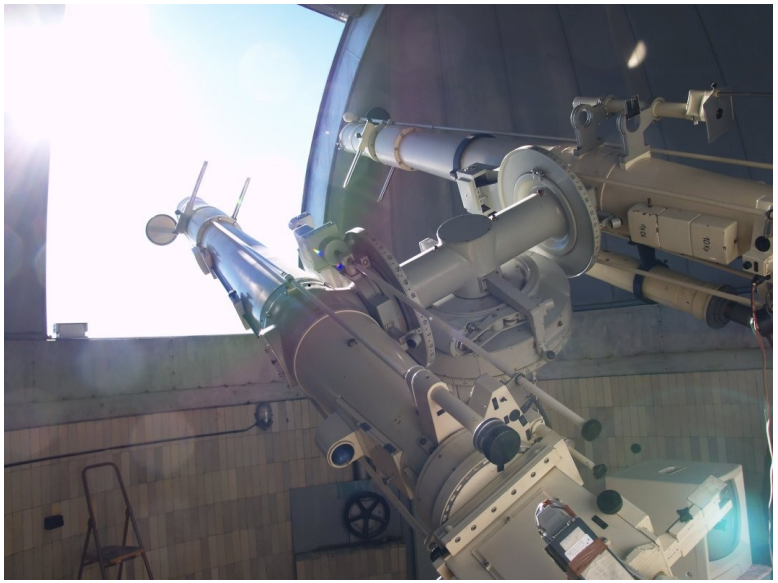
Zeiss Lens Replacement Analysis for Coronagraphs at the Lomnicky Stit Observatory

Phil Oakley

2/27/2014



Analysis Summary

- Original coronagraph lenses are several decades old and have small imperfections from use and cleaning
- Zeiss is able to replace the lenses, but can only manufacture lenses with small differences to existing lenses
- How will this effect the performance of the instruments?

Summary of Lens Differences

Lens	Material	Front Radius of Curvature [mm]	Rear Radius of Curvature [mm]	Calculated Focal Length [mm at 1083 nm]
Original Objective Lens	BK7	1710.0	-17000.0	3068.217
Replacement Objective Lens	N-BK7	1709.9	-17013.0	3068.269
Original Field Lens	BK7	199.49	-390.00	260.630
Replacement Field Lens	N-BK7	199.53	-389.90	260.642

The focal length shifts are on order 10s of microns while the ***estimated*** depth of focus is 100s of microns.

Summary of Lens Differences (Zemax Lens Data Editor)

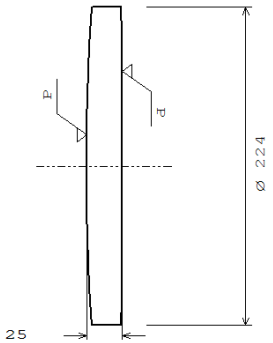
	Surf:Type	Comment	Radius	Thickness	Glass	Semi-Diameter		Conic
*	Standard		Infinity	Infinity		Infinity		0.0000000
*	Standard	Objective	1710.000000	25.0000000	BK7	112.0000000	U	0.0000000
2*	Standard		-17000.0000	2974.454469		112.0000000	U	0.0000000
3*	Standard	Focus	Infinity	5.8500000		22.8241385		0.0000000
4*	Standard	Field Lens	199.4900000	10.7200000	BK7	29.5000000	U	0.0000000
5*	Standard		-390.000000	167.7000000		29.5000000	U	0.0000000

New Replacement Lenses

	Surf:Type	Comment	Radius	Thickness	Glass	Semi-Diameter		Conic
*	Standard		Infinity	Infinity		Infinity		0.0000000
*	Standard	Objective	1709.900000	25.0000000	N-BK7	112.0000000	U	0.0000000
2*	Standard		-17013.0000	2974.454469		112.0000000	U	0.0000000
3*	Standard	Focus	Infinity	5.8500000		22.8225352		0.0000000
4*	Standard	Field Lens	199.5300000	10.7200000	N-BK7	29.5000000	U	0.0000000
5*	Standard		-389.900000	167.7000000		29.5000000	U	0.0000000

Objective Lens

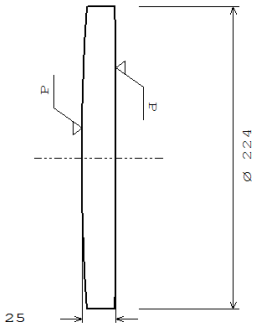
Original Objective Lens



Dimensions in Millimeters

Left Surface	Material	Right Surface
R 1710 CX	GLASS: BK7	R 17000 CX
$Ø_E$ 224	N_d= 1.516800	$Ø_E$ 224
Ⓐ	V_d= 64.17	Ⓐ
3/	0/ –	3/
4/ –	1/ –	4/ –
5/ –	2/ –	5/ –
6/ –		6/ –

Replacement Objective Lens

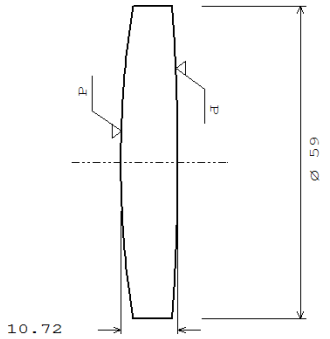


Dimensions in Millimeters

Left Surface	Material	Right Surface
R 1709.9 CX	GLASS: N-BK7	R 17013 CX
$Ø_E$ 224	N_d= 1.516800	$Ø_E$ 224
Ⓐ	V_d= 64.17	Ⓐ
3/	0/ –	3/
4/ –	1/ –	4/ –
5/ –	2/ –	5/ –
6/ –		6/ –

Field Lens

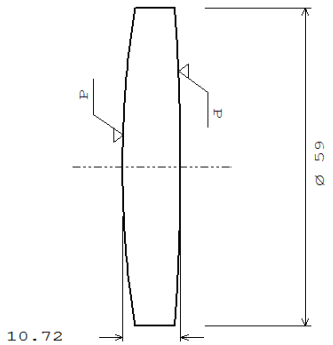
Original Field Lens



Dimensions in Millimeters

Left Surface	Material	Right Surface
R 199.49 CX	GLASS: BK7	R 390 CX
$Ø_E$ 59	N_d= 1.516800	$Ø_E$ 59
Ⓚ	V_d= 64.17	Ⓚ
3/	0/ -	3/
4/ -	1/ -	4/ -
5/ -	2/ -	5/ -
6/ -		6/ -

Replacement Field Lens



Dimensions in Millimeters

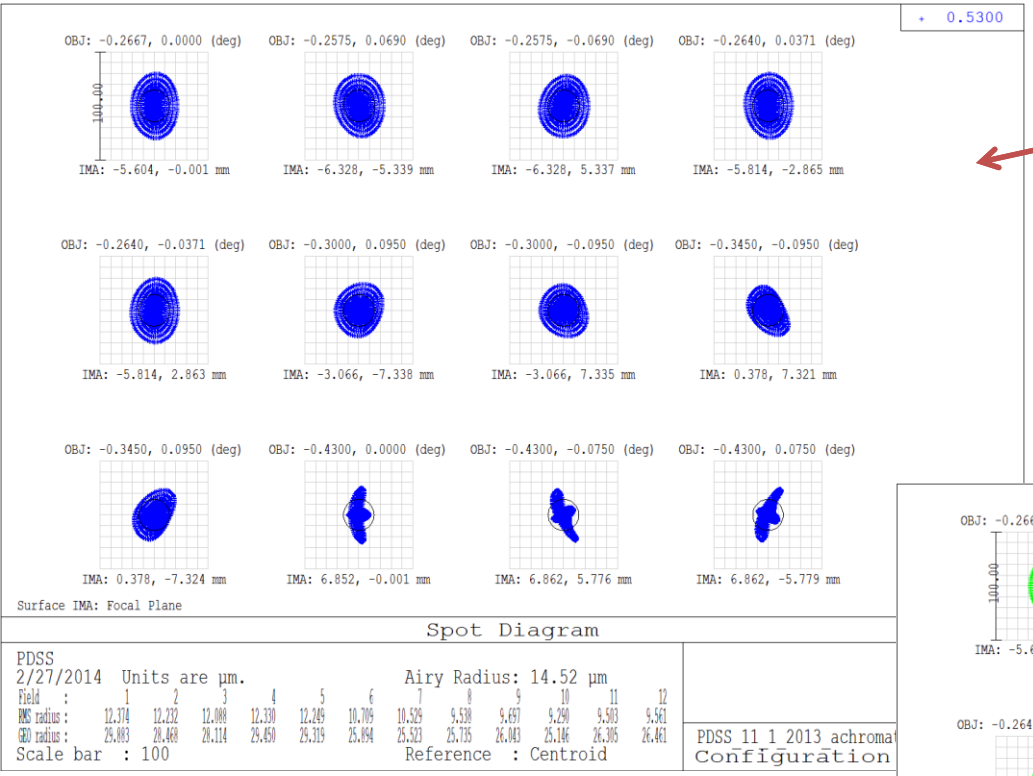
Left Surface	Material	Right Surface
R 199.53 CX	GLASS: N-BK7	R 389.9 CX
$Ø_E$ 59	N_d= 1.516800	$Ø_E$ 59
Ⓚ	V_d= 64.17	Ⓚ
3/	0/ -	3/
4/ -	1/ -	4/ -
5/ -	2/ -	5/ -
6/ -		6/ -

Prime Focus Quality Comparison

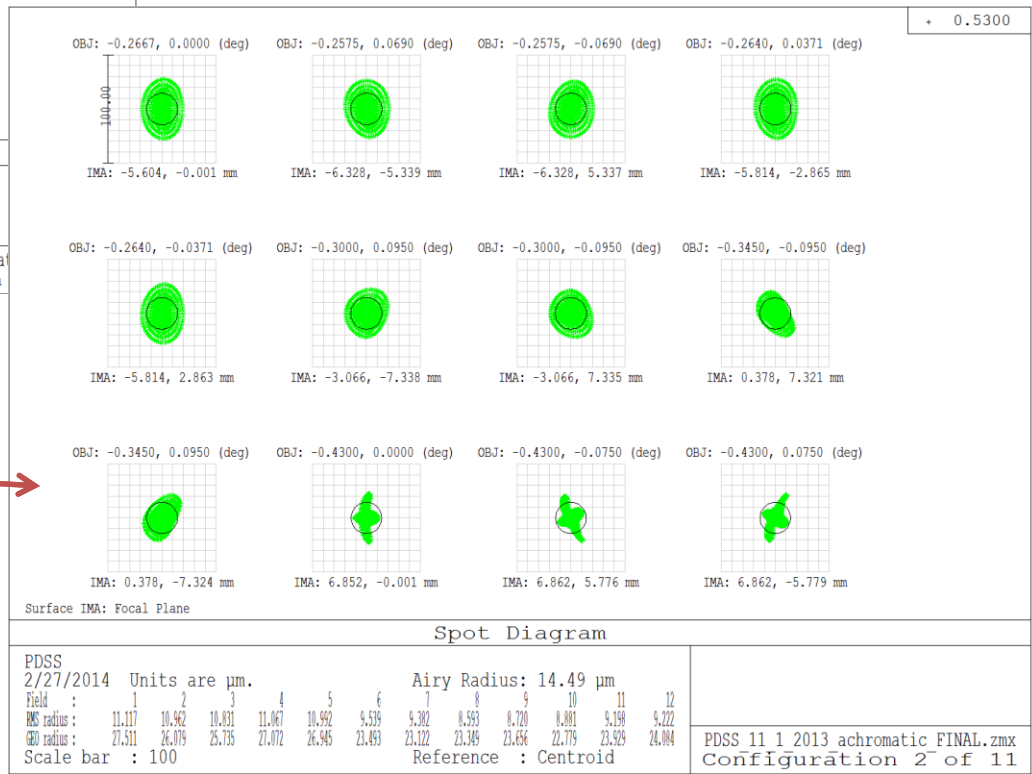
- Blue = Original Objective Lens
- Green = Replacement Objective Lens
- Summary = no significant loss of quality

PDSS Image Comparison (530 nm)

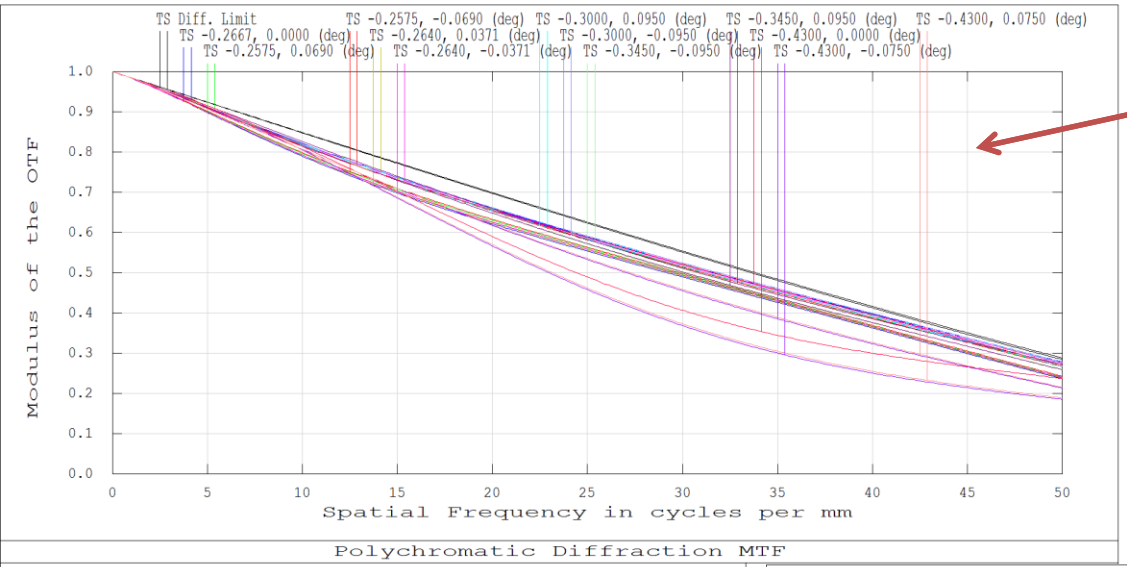
Original Lenses



Replacement Lenses

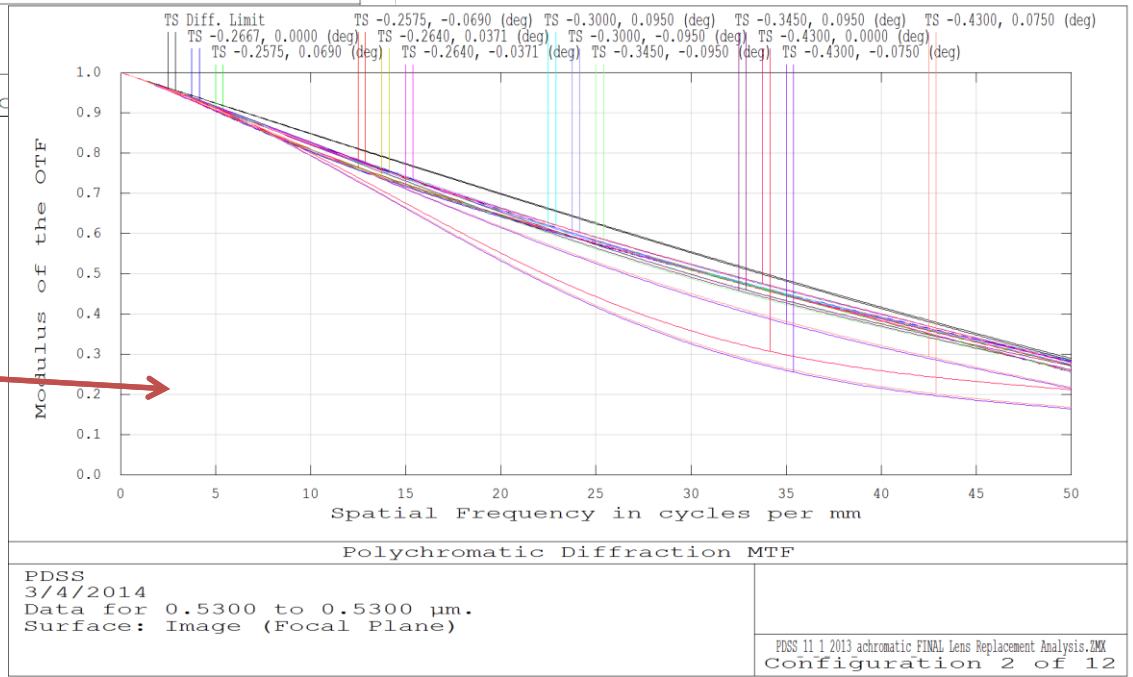


PDSS Image Comparison (530 nm)



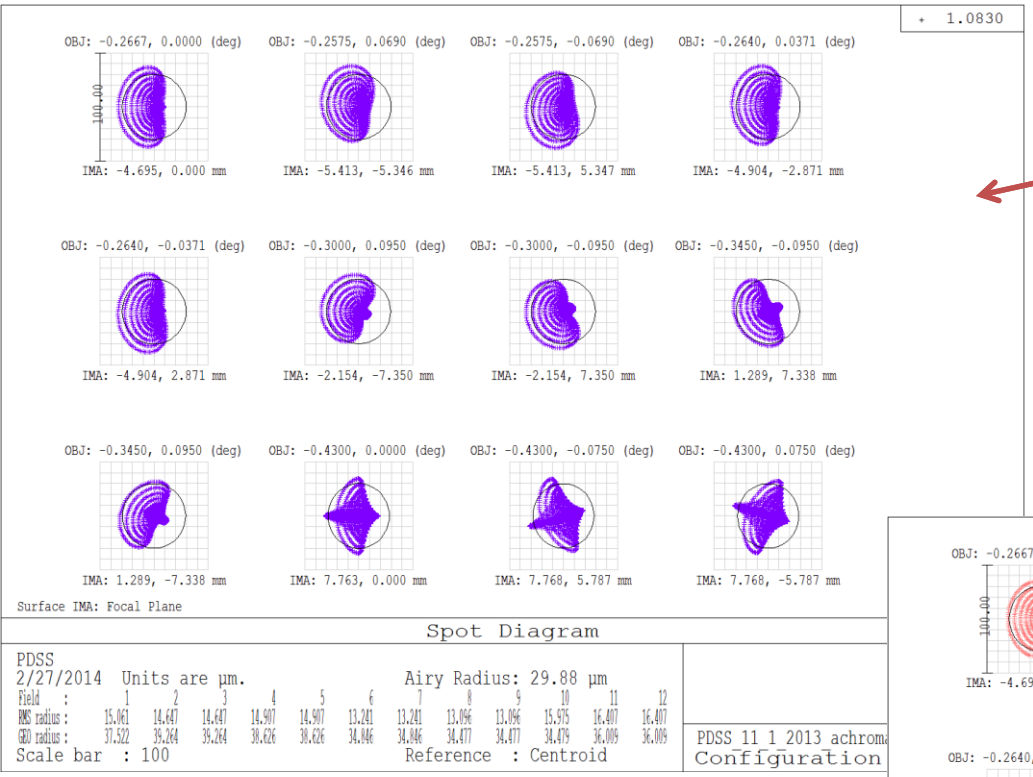
Original Lenses

Replacement Lenses

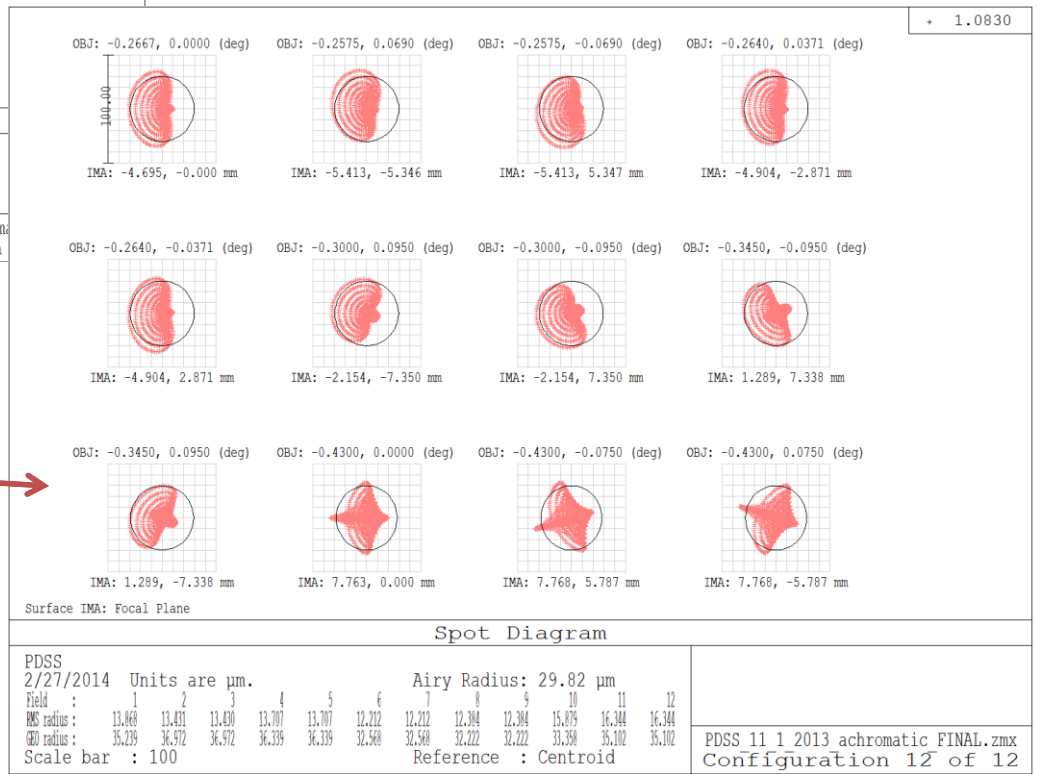


PDSS Image Comparison (1083 nm)

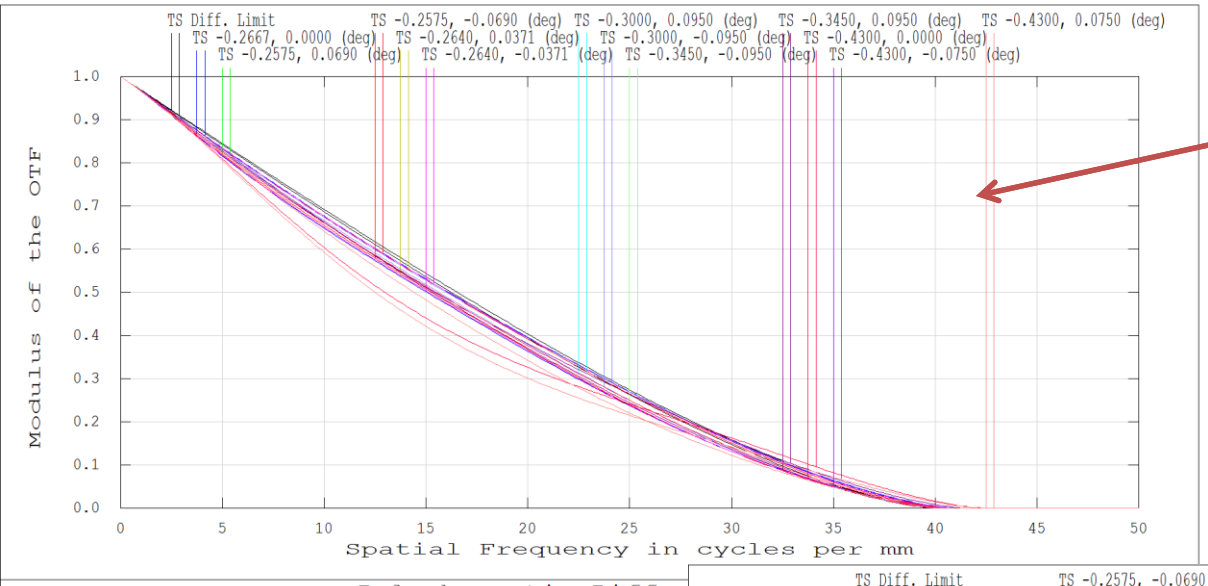
Original Lenses



Replacement Lenses



PDSS Image Comparison (1083 nm)

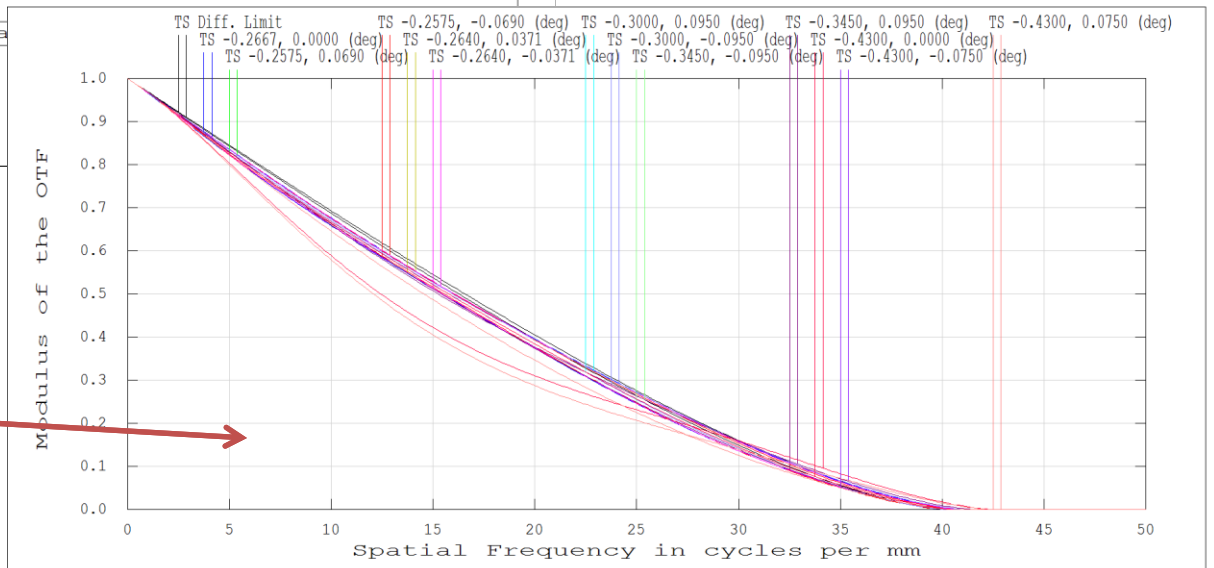


Original Lenses

Polychromatic Diffra

PDSS
3/4/2014
Data for 1.0830 to 1.0830 µm.
Surface: Image (Focal Plane)

Replacement Lenses



Polychromatic Diffraction MTF

PDSS
3/4/2014
Data for 1.0830 to 1.0830 µm.
Surface: Image (Focal Plane)

PDSS 11 1 2013 achromatic FINAL Lens Replacement Analysis.ZMX
Configuration 12 of 12

Unknowns?

- AR Coatings
- Clear Aperture
- Surface Runout (wedge)
- Surface irregularity
- Index uncertainty
- Radii uncertainty
- If these tolerances are worse than the original lenses then performance loss might become more significant

Summary

- The new replacement lens cause changes in focal lengths of 10s of microns
- The PDSS optical design can tolerate 10s of microns of defocus.
- PDSS Instrument maintains image quality without any adjustments given new lenses (assuming optimal lenses)
- New lens unknowns listed on previous slide could effect performance if delivered lens differs from optimal (example – if new lenses have very loose tolerances on parameters). PDSS optical design is generally forgiving, so this is unlikely.