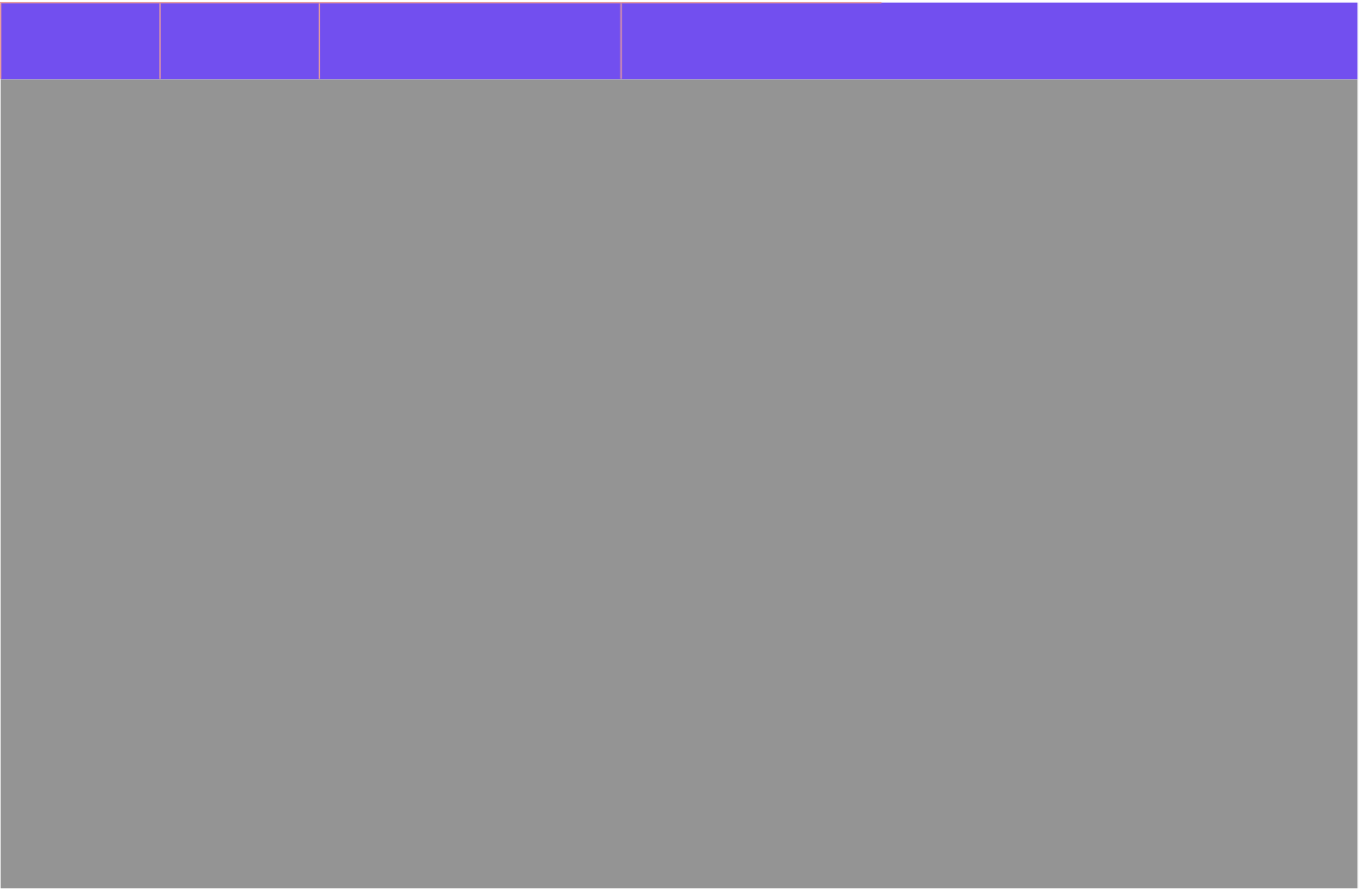




Introduction

Two Traditional Approaches to Tolerancing

Wavefront Differential Tolerancing



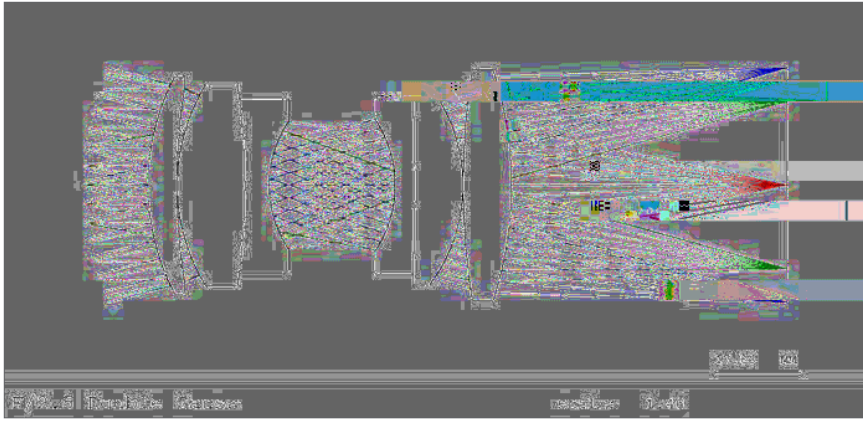
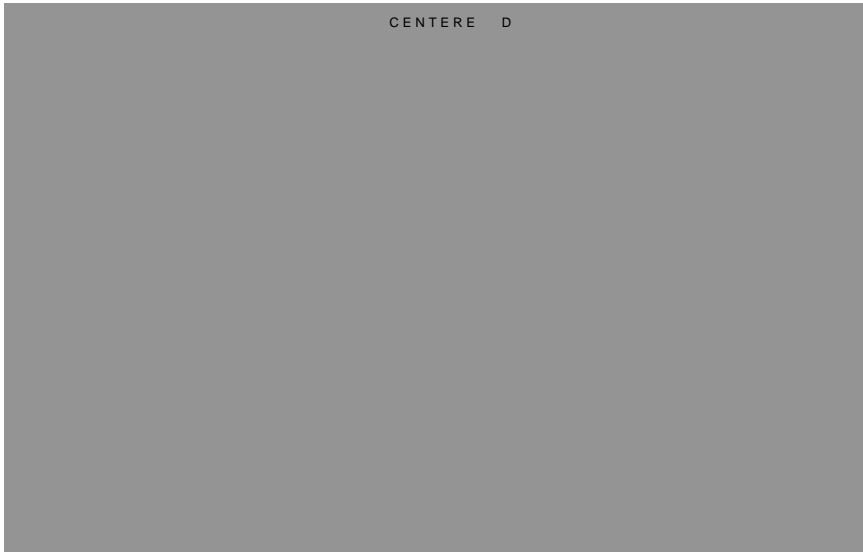


Figure 1: F/2.5 Double Gauss Lens



Tolerancing Method	Computation Time for an Intel® Core™ i7 2.7GHz CPU
Wavefront Differential (TOR)	2 seconds
Finite Difference (TOLFDIF)	46 seconds (23x TOR)
Monte Carlo—1000 trials (TOLMONTE)	17 minutes, 37 seconds (494x TOR)

Table 3: Speed comparison of tolerancing methods

Single Tolerance Comparison		
(Delta Radius of surface 7, ± 0.02 0mm)		
Wavefront Differential Results		
Field	Change in MTF at 15 cycles/mm	
	+ Tolerance	- Tolerance
1 (On - axis)	+0.01 6	- 0.01 8
2 (+10 deg , tan)	+0.0 24	- 0.0 27
3 (+14 deg , tan)	- 0.0 14	+0.0 07
4 (- 10 deg , rad)	+0.0 03	- 0.0 05
5 (- 14 deg , rad)	- 0.015	+0.0 13
Compensator (refocus) Motion	for best 0. 9T 5.9243 0 4 418.	

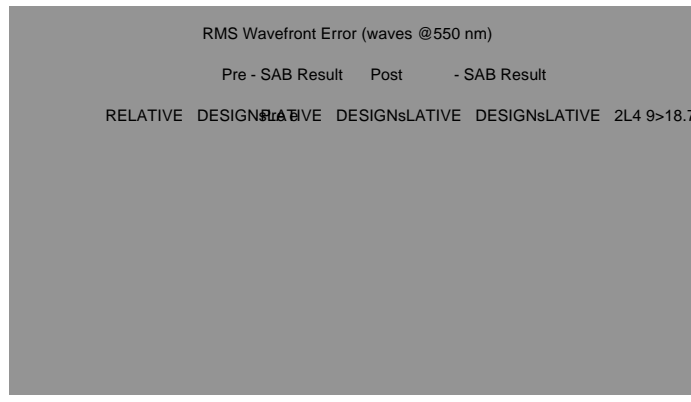
%P\vb` cXafTgbe` bgba'elTaZX'YbeT`_dp_XeTaVXf`VbeX_Igf`i Xel j X_`Ybej`X'g b` Xg`bWf`fj`_g`'a`*`±@f!G[X'ceXWgkWcXelbe` TaVX`

CENTERED TOLERANCES										
F/3.55 Inverted Telephoto										
SUR	RADIUS	TOL	RADIUS POW/IRR	FRINGES THICKNESS	THICKNESS TOL	GLASS	INDEX V TOL (%)	- NO		
1	82.52700	0.0417	1.0/	0.25	3.62536	0.05000	627.586	0.00050	0.50	
2	552.75182	2.0127	1.0/ 0.25	0.10000	0.05000					
3	70.28017	0.0412	1.0/ 0.25	4.24208	0.05000	669.523	0.00050	0.50		
4	14.03202	0.0036	1.	0/ 0.25	20.96646	0.05000				
5	25.18458	0.0262	1.0/ 0.25	4.32311	0.05000	680.339	0.00050	0.50		
6	-92.32481	0.4040	1.0/ 0.25	2.91221	0.05000					
7			0.67259				0.05000			
8	53.77045	0.2177	1.0/ 0.25	2.39888	0.05000	646.556	0.00050	0.50		
9	-23.74002	0.0446	1.0/ 0.25	0.89584	0.05000					
10	-15.73622	0.0212	1.0/ 0.25	3.03014	0.05000	755.275	0		.00050	0.50
11	28.32816	0.0670	1.0/ 0.25	0.78824	0.05000					
12	-67.78803	0.3832	1.0/ 0.25	2.57758	0.05000	692.496	0.00050	0.50		
13	-13.97934	0.0133	1.0/ 0.25	37.99347						
14					-0.49333					

DECENTERED TOLERANCES										
F/3.55 Inverted Telephoto										
ELEMENT NO.	FRONT RADIUS	BACK RADIUS	ELEMENT TIR	WEDGE ARC MIN	ELEMENT TIR	TILT ARC MIN	EL. DEC/ROLL(R)	TIR mm.		
1	82.52700	552.75182	0.0130	1.1	0.0040	0.3	0.0107	0.0250		
2	70.28017	14.03202	0.0130	1.9	0.0024	0.3	0.0299	0.0250		
3	25.18458	-92.32481	0.0130	3.0	0.0015	0.3	0.0198	0.0250		
4	53.77045	-23.74002	0.0130	3.9	0.0011	0.3	0.0175	0.0250		
5	-15.73622	28.32816	0.0130	4.1	0.0011	0.3			0.0274	0.0250
6	-67.78803	-13.97934	0.0130	4.0	0.0011	0.3	0.0180	0.0250		

Table 6: "Select [5] Tolerance set

TK\ h\ \ cbi X XagTa\ g\ Tg\ XTccbtV[j be'f UXfg G[X'xfhg f[bj a'a GTUX* Ybeg X'` XTa'f %P TfzUh\gE@F j Ti X\bag



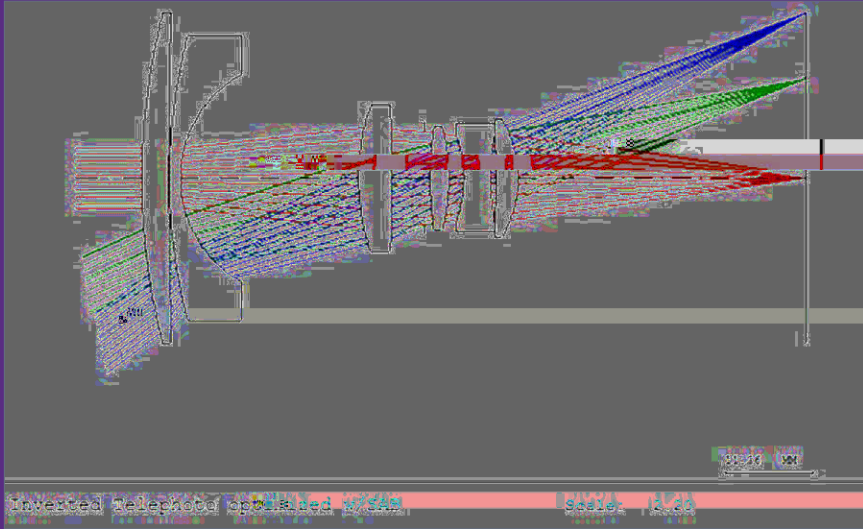


Figure 5: F/3.5 inverted telephoto after tolerance desensitization optimization