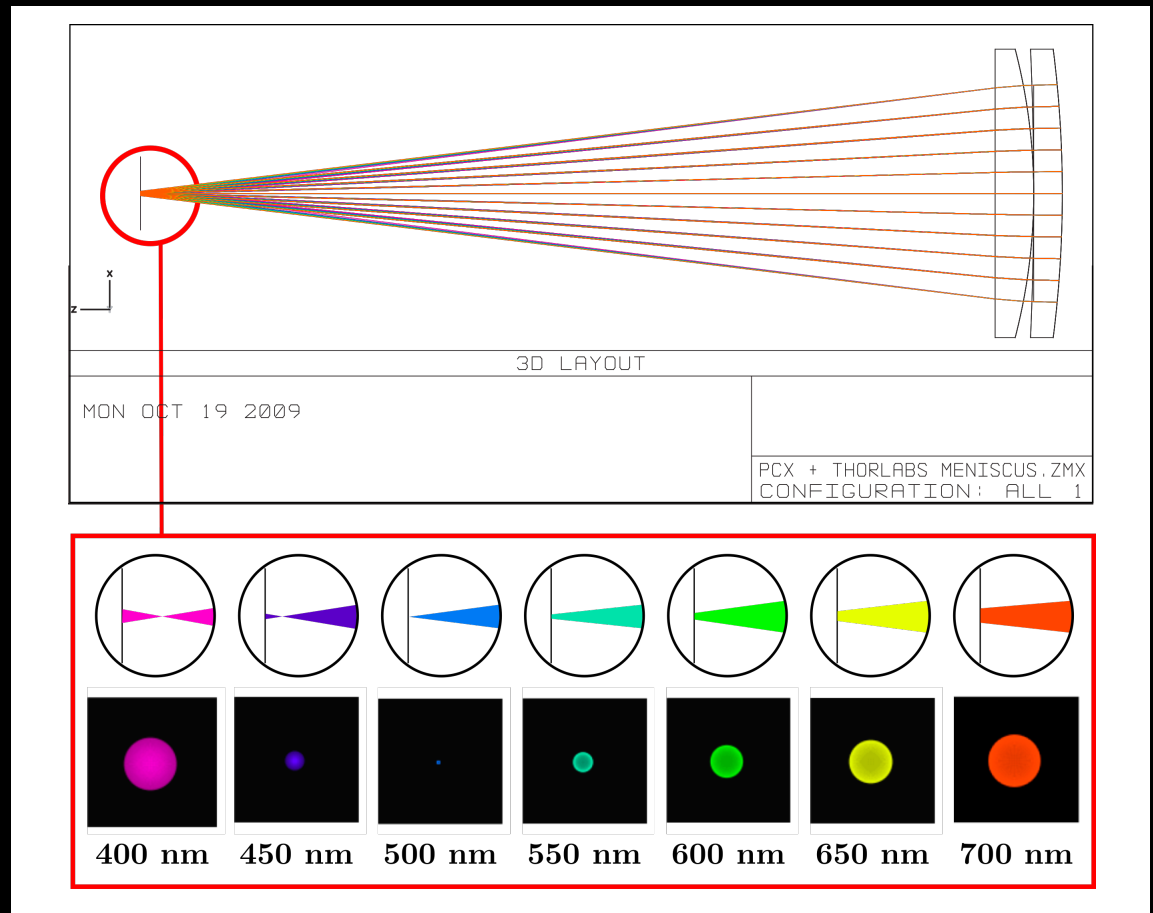


Spectral Focal Sweep (SFS): Extended Depth of Field from Chromatic Aberrations

Supplementary Material

Doublet SFS Design

- 75mm EFL F/4 Doublet
- Strong axial chromatic aberrations
- Maximum defocus diameter 100 μ m at 400nm and 700nm



Doublet SFS Implementation

- 75mm EFL F/4 Doublet
- Design fitted to off-the-shelf elements

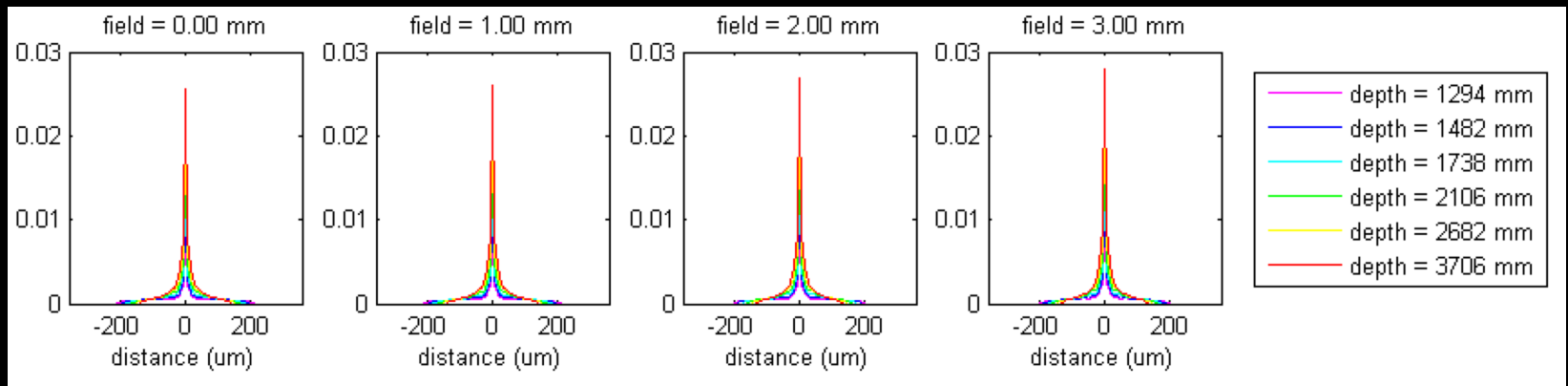


Edmund Optics #48184
1" Dia. 100mm FL
Plano-convex asphere

Thorlabs #LE1929
1" Dia. 300mm FL
positive meniscus

Simulated SFS PSFs

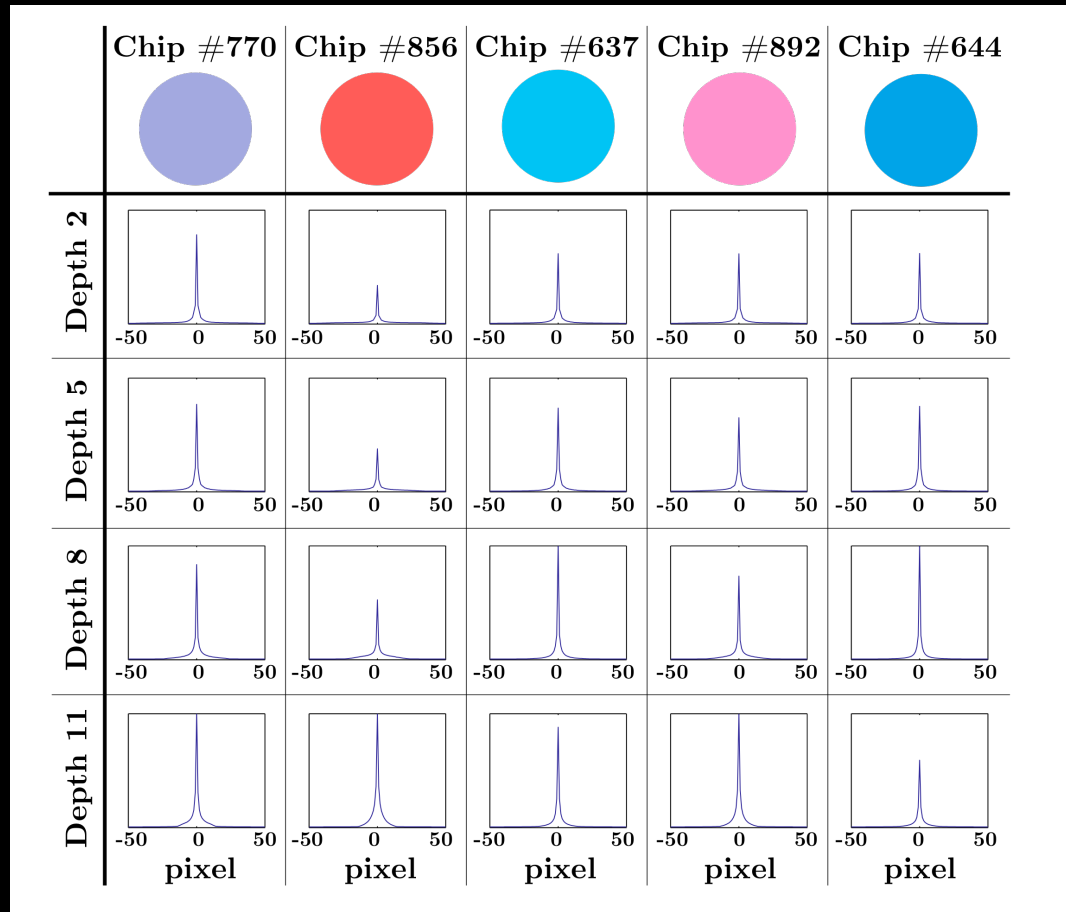
Simulated PSFs using Zemax Optical Design Software for a white spectrum and a 1/3" black and white sensor with 10um pixel size.



PSF is approximately invariant to depth and field position

Simulated Color SFS PSFs I

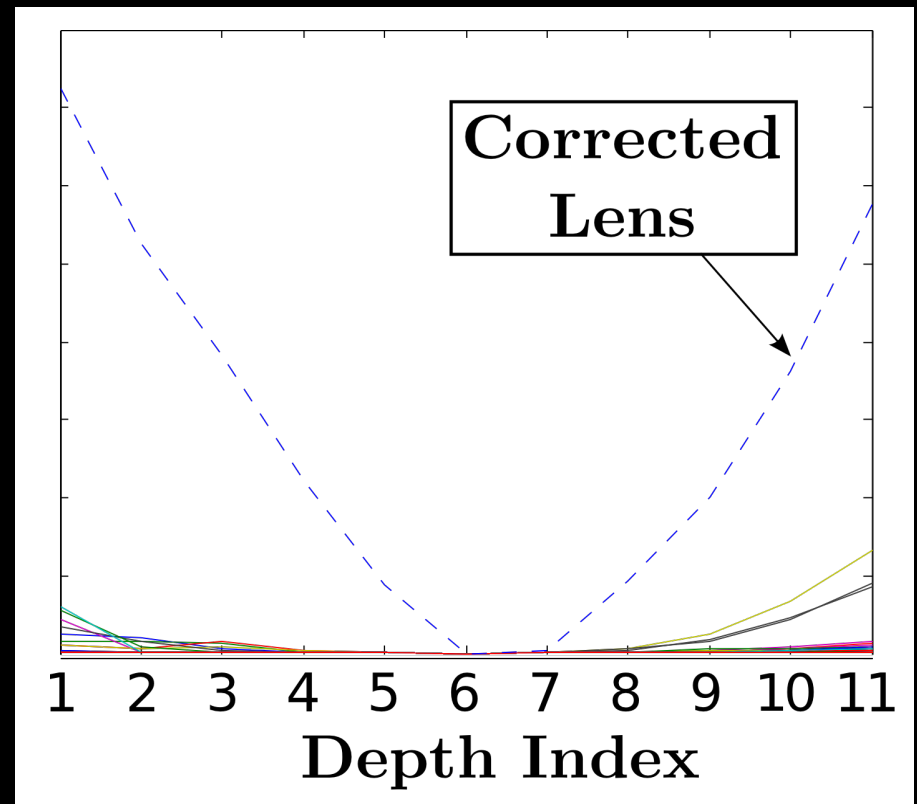
- PSFs simulation using Zemax
- PSF simulated for Munsell database: 1250 spectra
- Randomly selected Munsell colors
- PSF is approximately invariant to depth for each color*



Simulated Color SFS PSFs II

PSF Variation

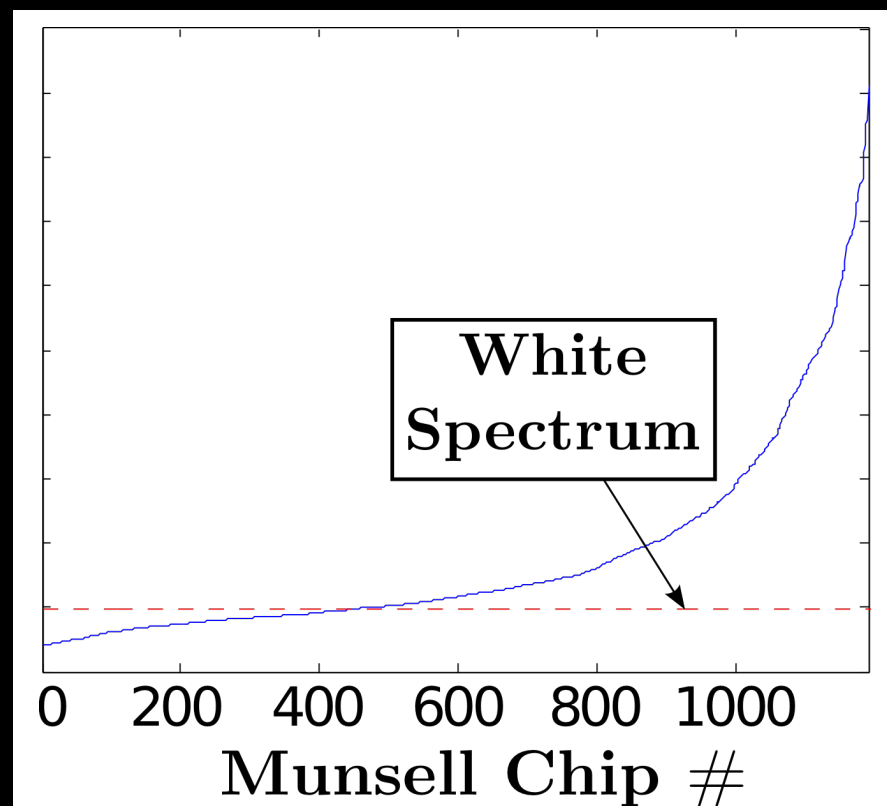
- PSF distance calculated as L2 norm of Weiner reconstruction error
- PSF variation measured as PSF distance relative to center PSF for all Munsell colors
- PSF variation significantly less than a corrected lens for all Munsell colors at all depths*



Simulated Color SFS PSFs III

- PSF variation averaged over all depths for each Munsell color
- Average PSF variation for a corrected lens almost 1000x greater than for a white spectrum
- %95 of all Munsell colors have less than 10x average variation of white spectra, %80 have less than 3x.*

Average PSF Variation



Experimental Setup

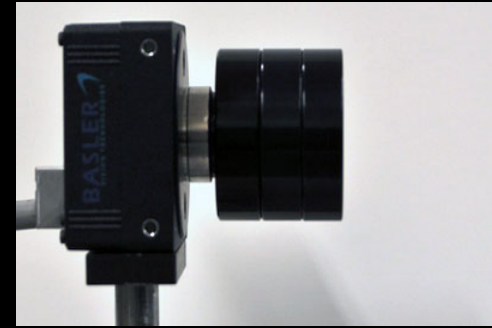
B&W Examples
(Basler 1/3" sensor)

Corrected Lens



F/1.4 75mm
EFL Cosmicar

SFS Doublet Lens



F/4 SFS 75mm
EFL Doublet

Color Examples
(Canon 450D sensor)



F/2.8 100mm
EFL Cannon



F/4 SFS 75mm
EFL Doublet

Deblurring

- B&W (exact method)
 - Wiener deconvolution
- Color (approximate method)
 - Transform from RGB to YUV space
 - Wiener deconvolution of Y image
 - Transform back from YUV to RGB space

Examples from paper

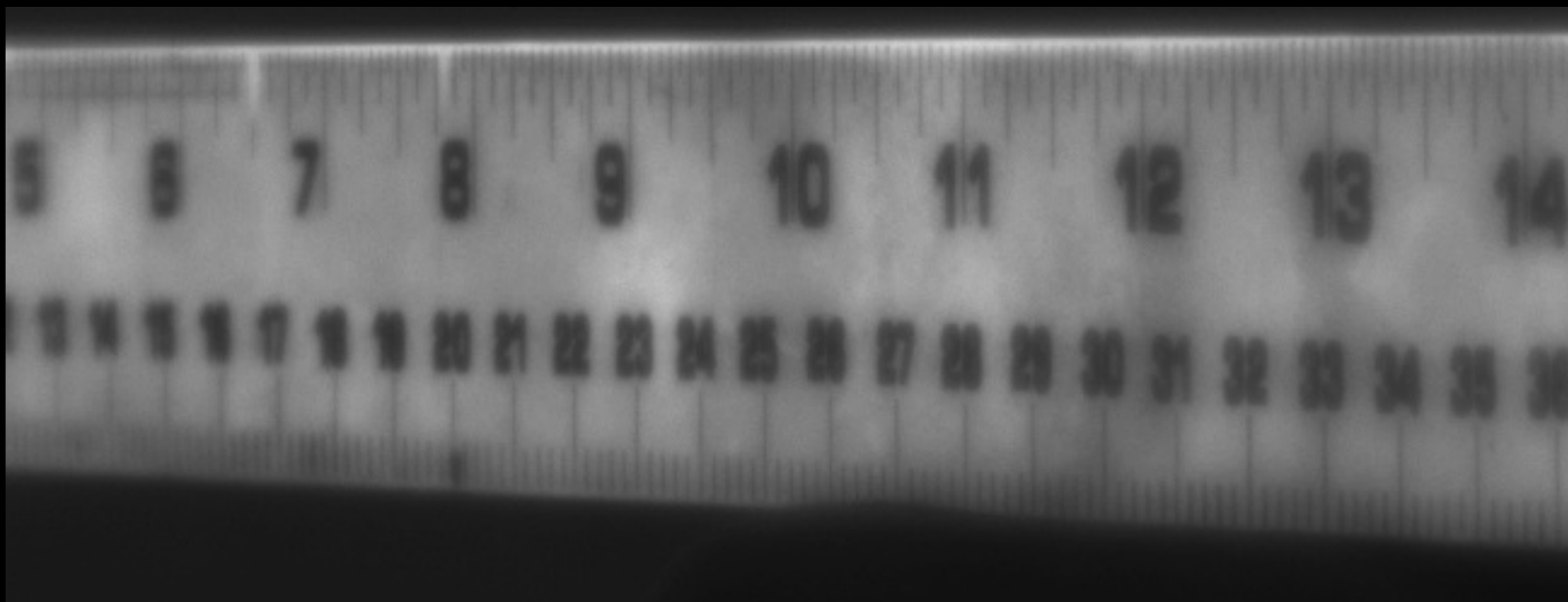


F/4 Corrected Lens





F/4 SFS Lens





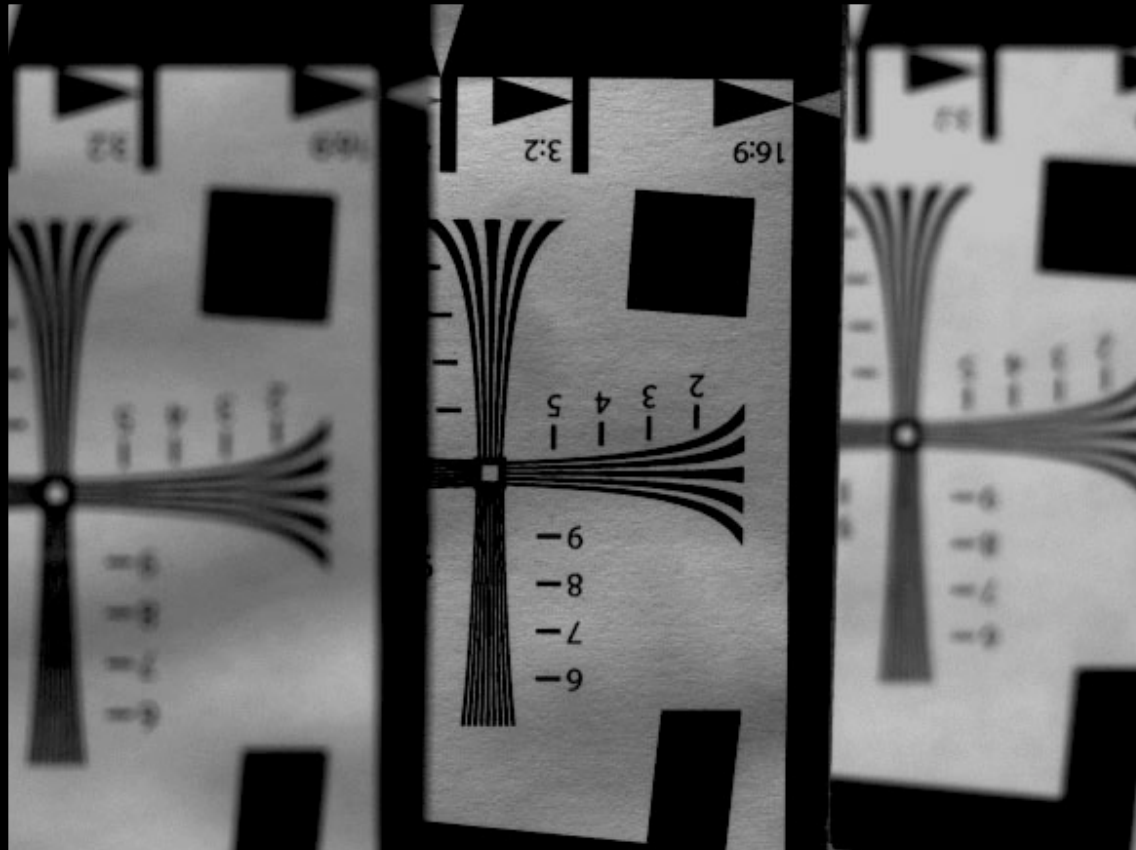
F/4 SFS Lens

(Deblurred)





F/4 Corrected Lens

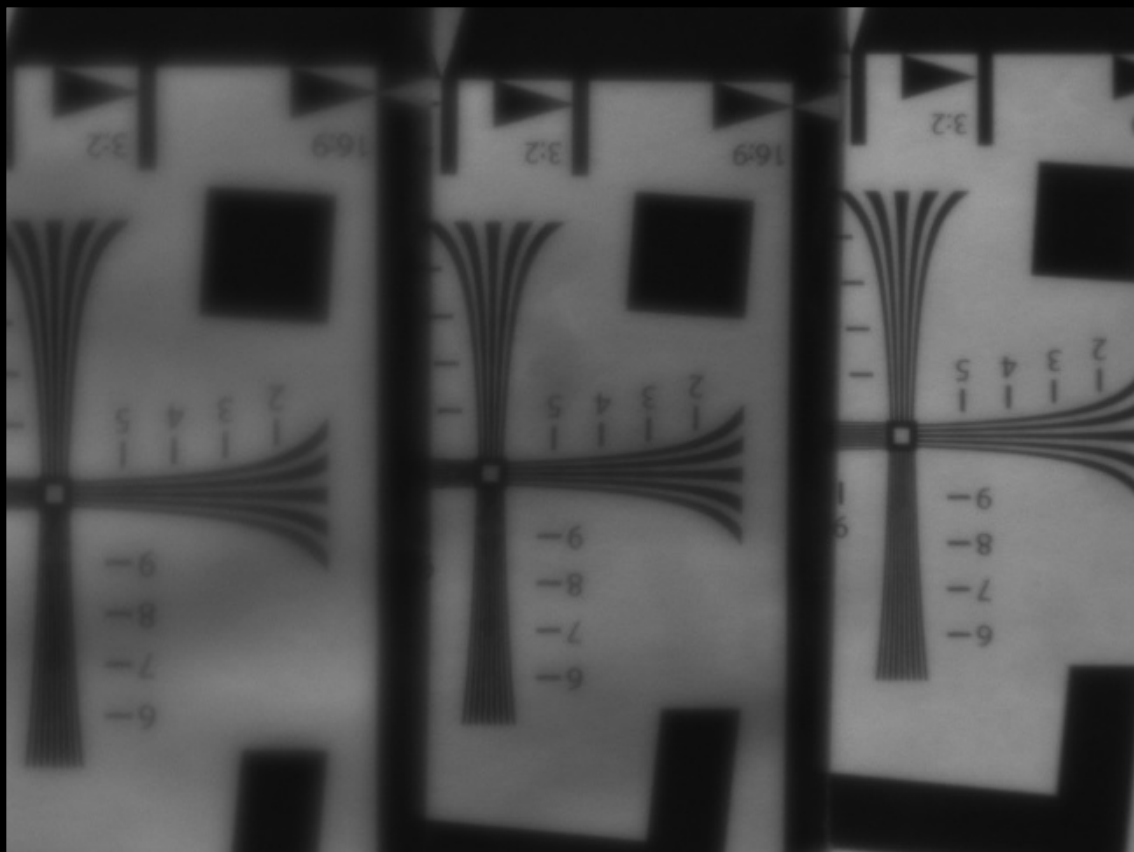


ICCP 10 Submission #19

8ms exposure

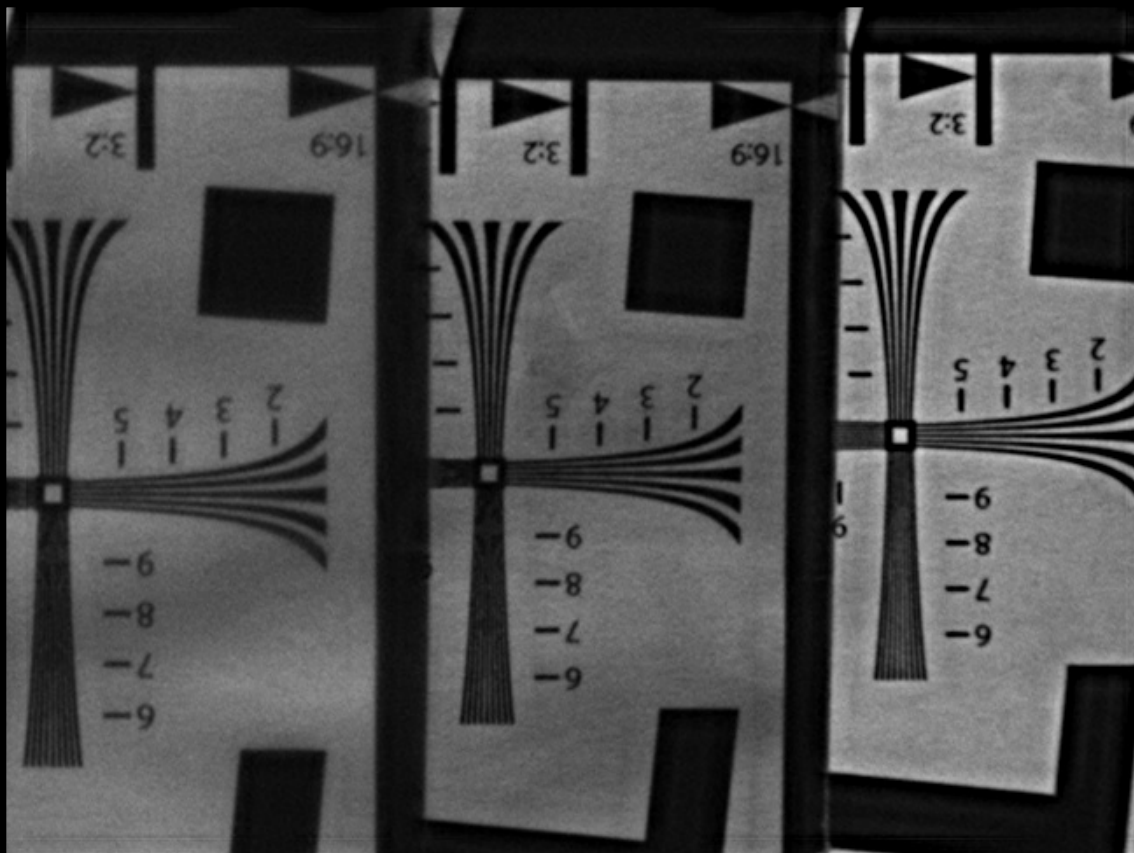


F/4 SFS Lens





F/4 SFS Lens (Deblurred)





F/4 Corrected Lens



ICCP 10 Submission #19

8ms exposure



F/4 SFS Lens



ICCP 10 Submission #19

8ms exposure



F/4 SFS Lens

(Deblurred)





F/4 Corrected Lens



ICCP 10 Submission #19

16ms exposure



F/4 SFS Lens



ICCP 10 Submission #19

16ms exposure



F/4 SFS Lens

(Deblurred)





F/4 Corrected Lens





F/4 SFS Lens





F/4 SFS Lens

(Deblurred)



Additional Examples



F/4 Corrected Lens



ICCP 10 Submission #19

16ms exposure



F/4 SFS Lens



ICCP 10 Submission #19

16ms exposure



F/4 SFS Lens

(Deblurred)



ICCP 10 Submission #19

16ms exposure



F/4 Corrected Lens



ICCP 10 Submission #19

16ms exposure



F/4 SFS Lens



ICCP 10 Submission #19

16ms exposure



F/4 SFS Lens

(Deblurred)



ICCP 10 Submission #19

16ms exposure



F/4 Corrected Lens



ICCP 10 Submission #19

16ms exposure



F/4 SFS Lens



ICCP 10 Submission #19

16ms exposure



F/4 SFS Lens

(Deblurred)





F/4 Corrected Lens





F/4 SFS Lens





F/4 SFS Lens

(Deblurred)





F/4 Corrected Lens





F/4 SFS Lens





F/4 SFS Lens

(Deblurred)

