Queen Mary
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Optical system sensitivity analysis - updated

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LhARA
Laser-hybrid Accelerator for Radiobiological Applications

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Redoing optical simulations for the LION beamline experimental conditions

What is the sensitivity of the liquid scintillator imaging system to realistic lens and assembly tolerances?

Using Ansys ZEMAX OpticStudio (premium) 2024R1.00

Lens tolerances and lens tube thread details

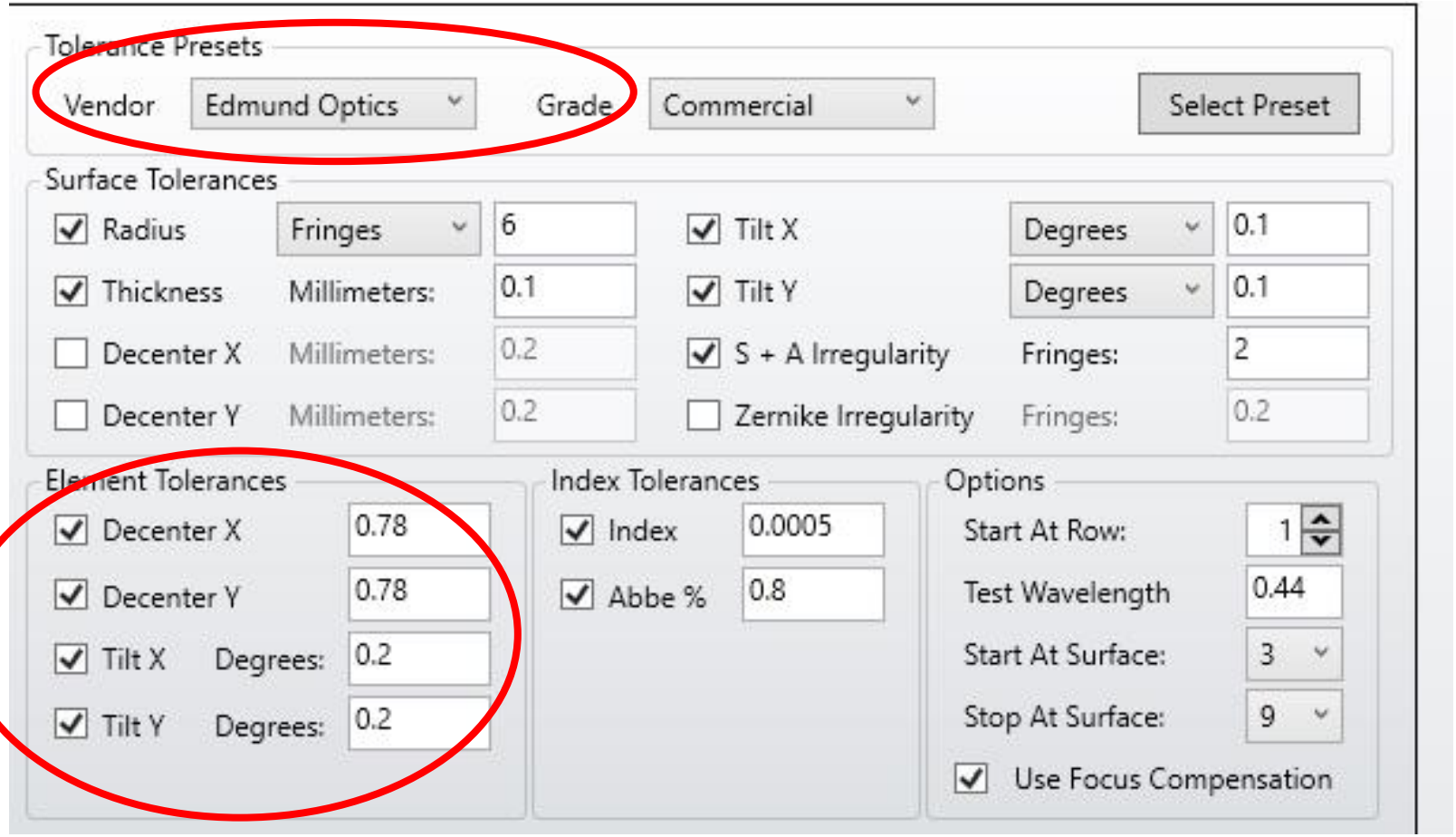
Physical & Mechanical Properties

Diameter (mm):	25.00 +0.0/−0.025	**Clear Aperture CA (mm):**	24.00
Centering (arcmin):	<1	**Center Thickness CT (mm):**	11.40 ±0.20
Center Thickness CT 1 (mm):	9.00 ±0.10	**Center Thickness CT 2 (mm):**	2.40 ±0.10
Edge Thickness ET (mm):	8.78	**Bevel:**	Protective bevel as needed

SM1 Threading: Ø1" Lens Tubes, 30 mm Cage Systems			
External Thread, 1.035"-40.0 UNS-2A		Internal Thread, 1.035"-40.0 UNS-2B	
Max Major Diameter	1.0339"	Min Major Diameter	1.0350"
Min Major Diameter	1.0288"	Min Pitch Diameter	1.0188"
Max Pitch Diameter	1.0177"	Max Pitch Diameter	1.0234"
Min Pitch Diameter	1.0142"	Min Minor Diameter (and 83.3% of Thread)	1.008"
Max Minor Diameter	1.0068"	Max Minor Diameter (and 64.9% of Thread)	1.014"

Worst case tolerance of lateral fit of lens to tube = 0.78 mm

Zemax lens tolerances



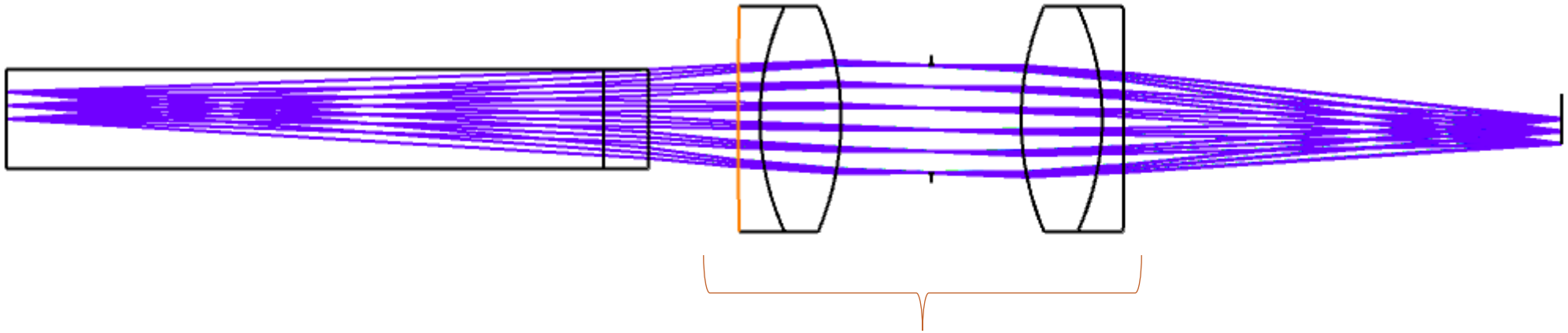
Worst case tolerance of lateral fit of lens to tube = 0.78 mm

Zemax tolerance analysis setup

Wavelength = 440 nm

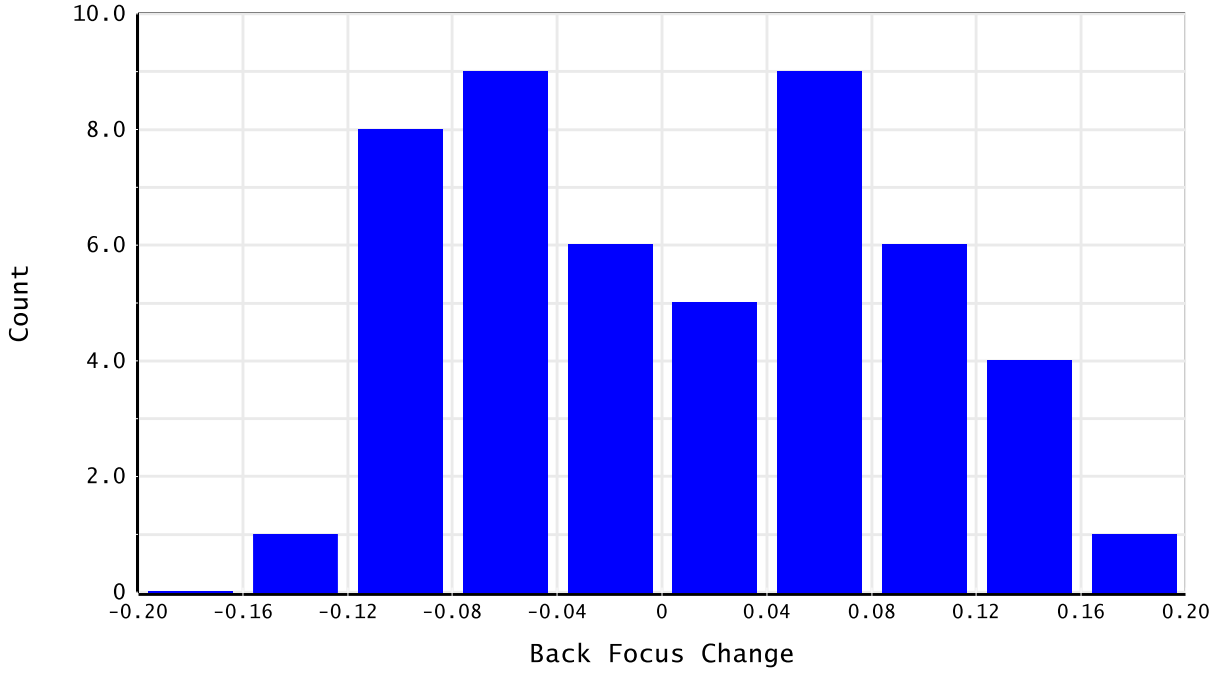
Minimise rms spot radius, use paraxial focus as compensator;

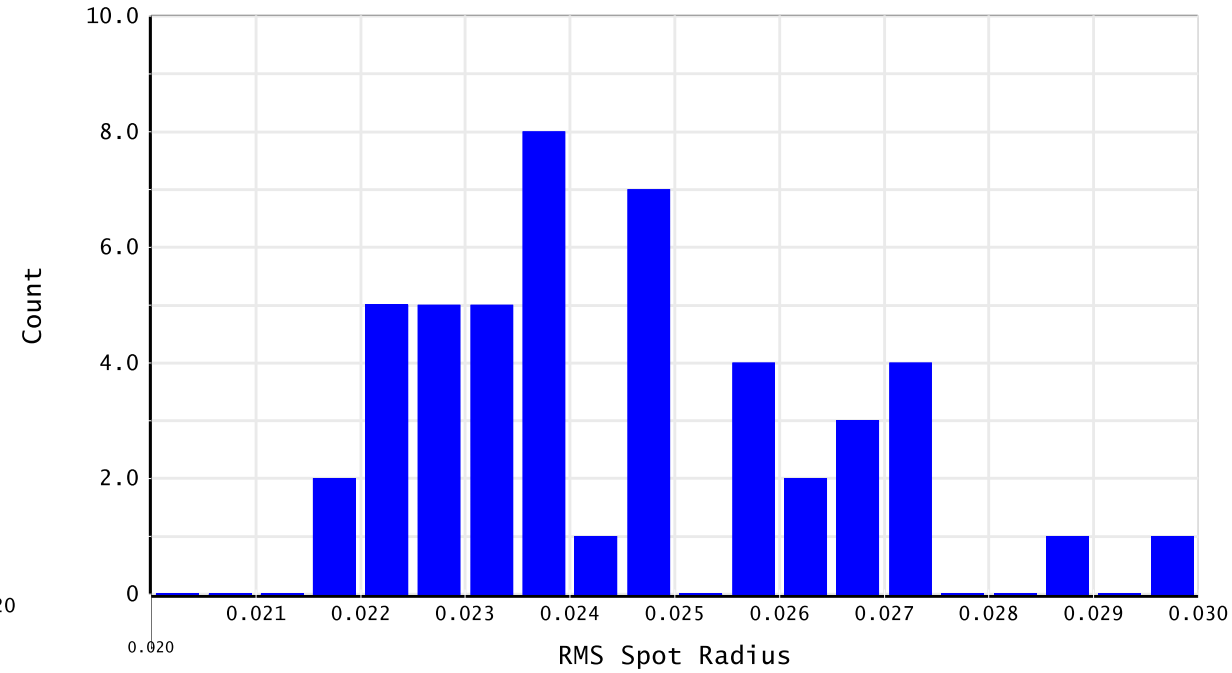
Made **50 MC runs** and assumed a normal distribution of deviations.



Zemax tolerance analysis

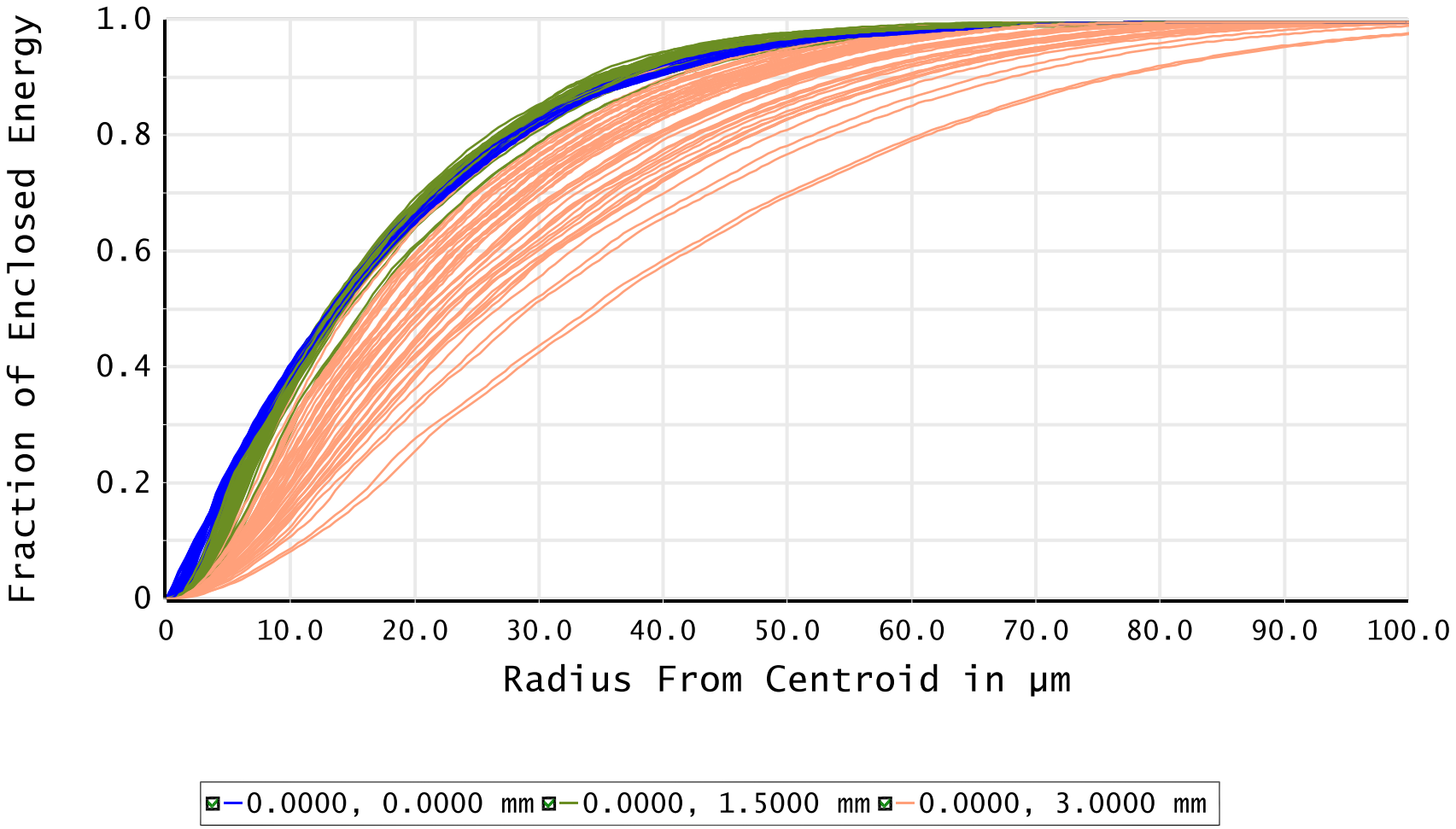
Wavelength = 440 nm, on-axis field, dimensions in [mm]





Zemax tolerance analysis – encircled energy

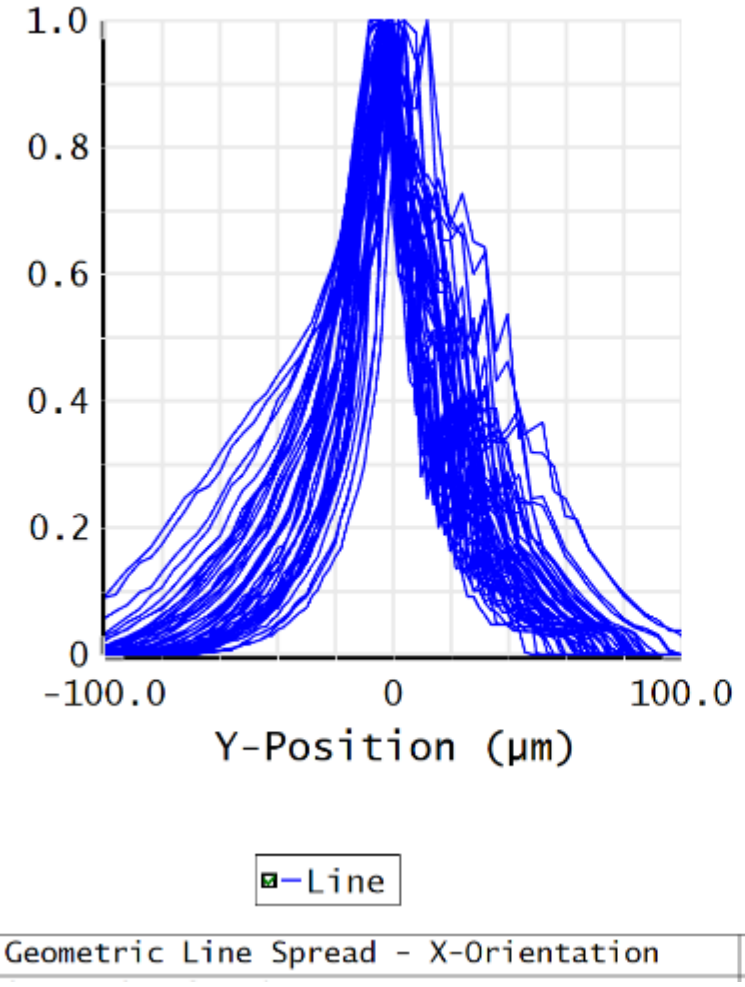
Wavelength = 440 nm

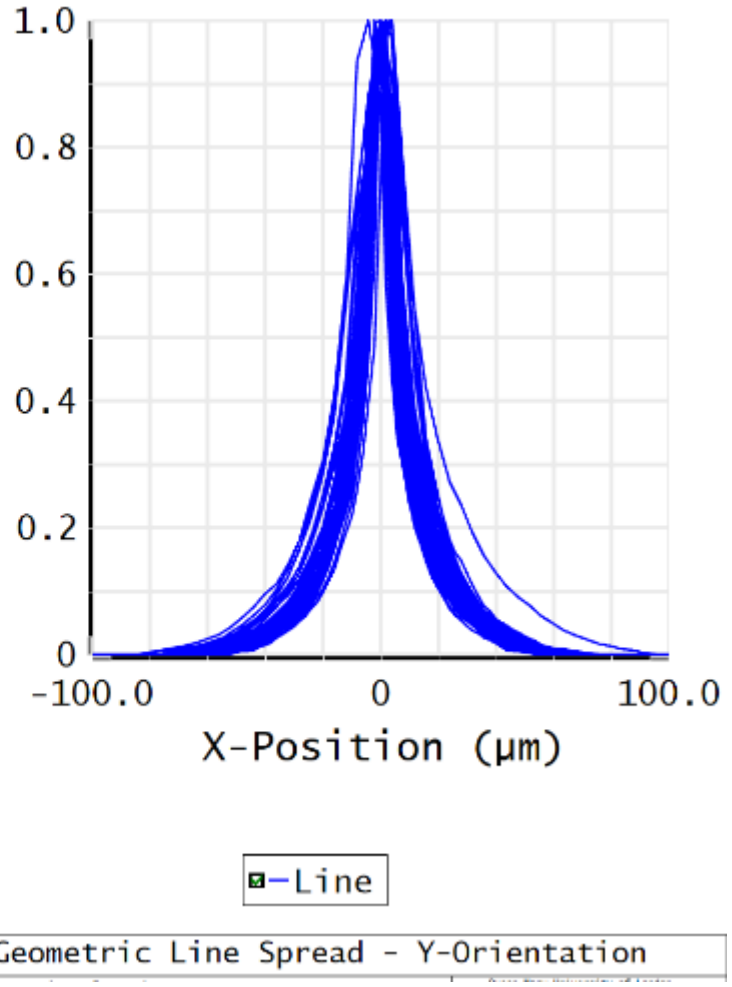


Zemax tolerance analysis – line spread

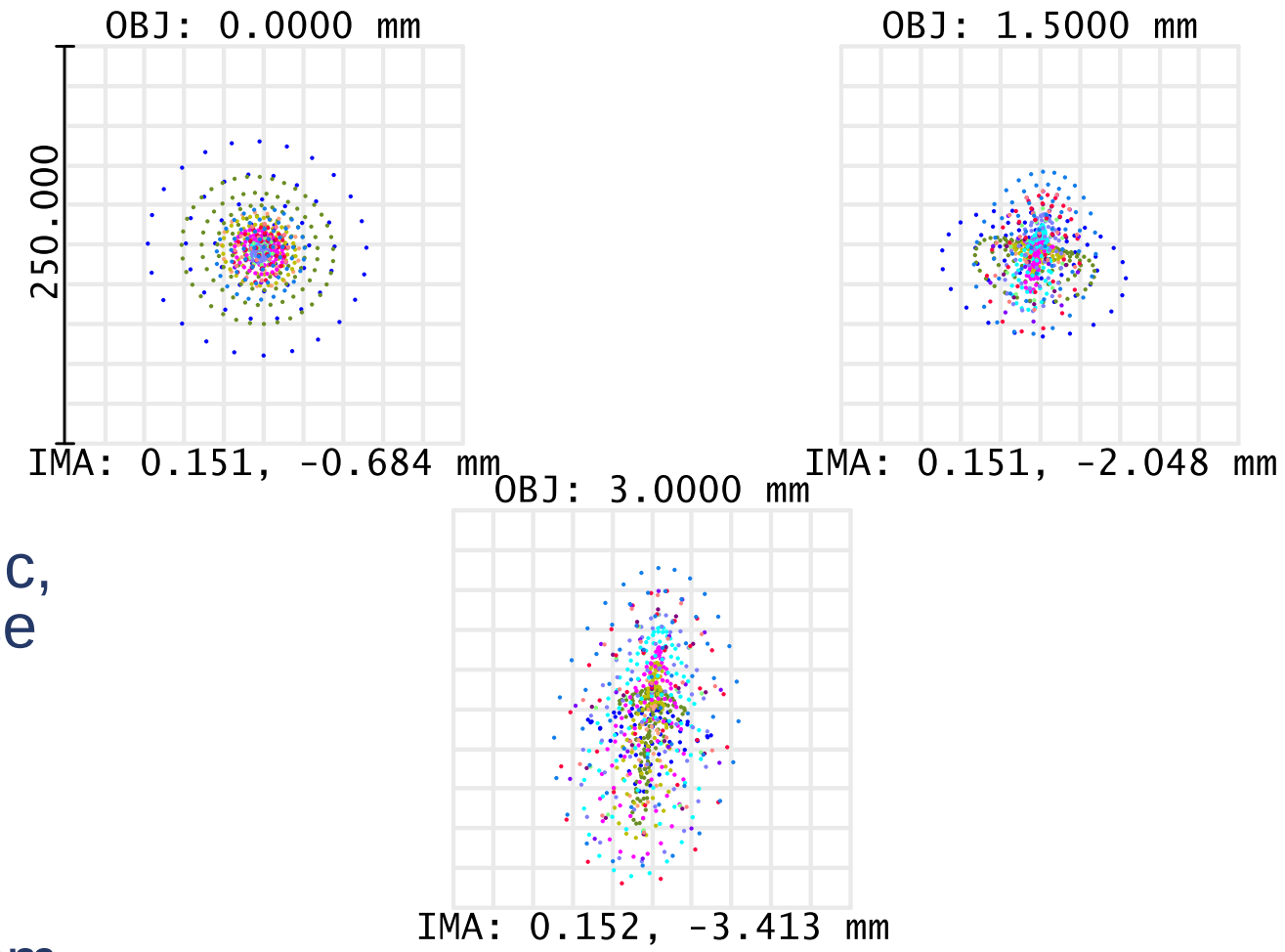
Wavelength = 440 nm

Field = 3.0 mm off-axis





Zemax tolerance analysis – spot diagrams



Wavelength = polychromatic, only 20 MC runs, worst case shown.

Scale bar = 250 μm

Fields at 0.0, 1.0 and 3.0 mm

Further work

I think we have a good idea already what the effects of realistic tolerances are on some aspects of image quality from this study.

In the previous worst case (1 run from 20) the image centre from a point source can be more than 0.5 mm away from the assumed optical (camera) centre.

Understand the effect of ideal but laterally shifted optics on the imaging of a uniform cylindrical light source using full Non-sequential raytracing.

As above but with worst MC data from sequential tolerancing.

More work needed to check these initial conclusions/trends.