

LSST Telescope – Revised Sensitivity Analysis

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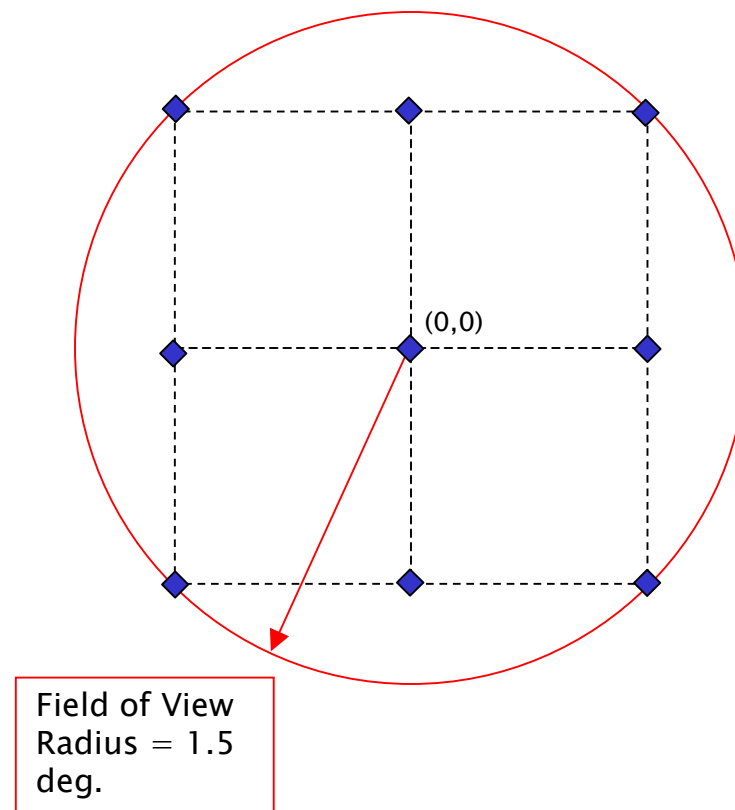
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LSST Telescope – Revised Sensitivity Analysis

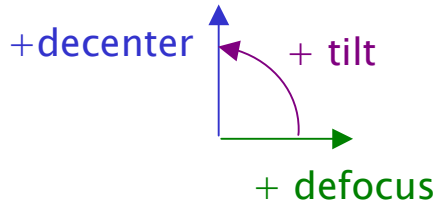
- Not a tolerance analysis!
 - addresses the question of how accurately position must be maintained during a measurement cycle
 - assumes ‘ideal’ image quality has been achieved at the outset
- Free parameters:
 - decenter (radially from the optical axis)
 - tilt (about the element vertex or front surface)
 - defocus (motion along the optical axis)
- Considered only the instrument assembly, primary, secondary, and tertiary mirrors
 - each has been positioned relative to a global origin → element motion is independent
- Calculate sensitivity coefficients
 - quadratic for encircled energy spot size growth
 - linear for boresight error and plate scale variation

Details...

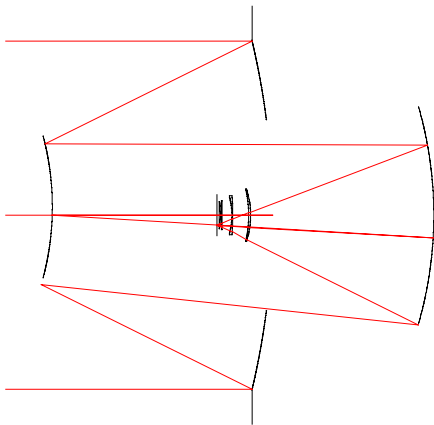
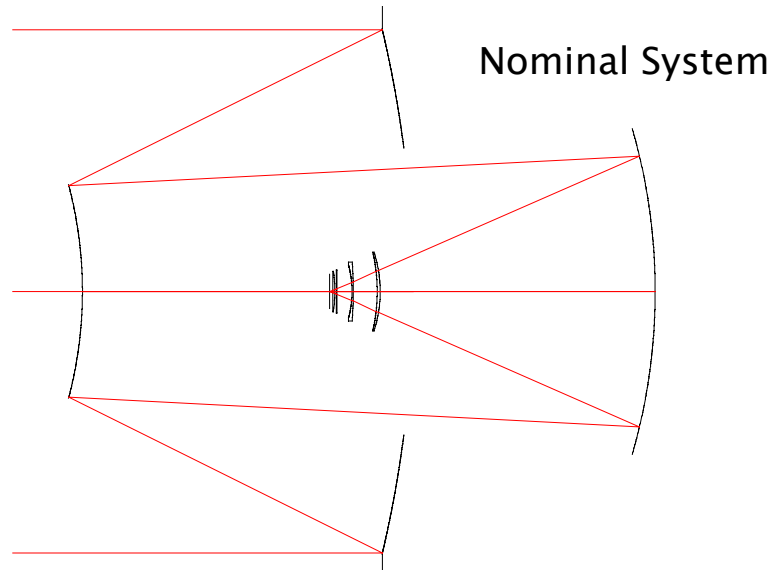
- Specified 9 object points over the full field of view
- Encircled energy in each band is averaged over all 9 field points in each at after each element perturbation
 - encircled energy spot diameter is 10 microns (0.2 arc sec)
- Boresight error is assessed as the shift of the on-axis image center divided by the focal length (decenter and tilt only)
- Change in system focal length is used to assess plate scale errors (defocus only)



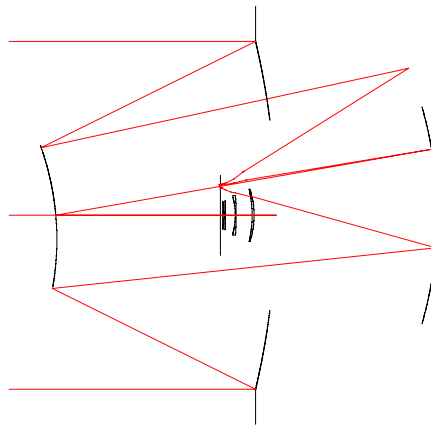
Sign Conventions



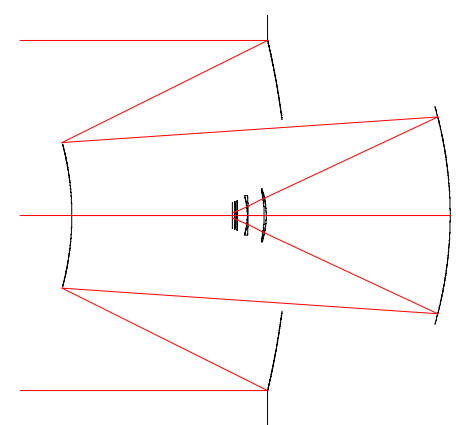
Positive Field Angles
map to Positive
Image Height!



+decenter
(secondary)



+ tilt
(secondary)



+ defocus
(secondary)

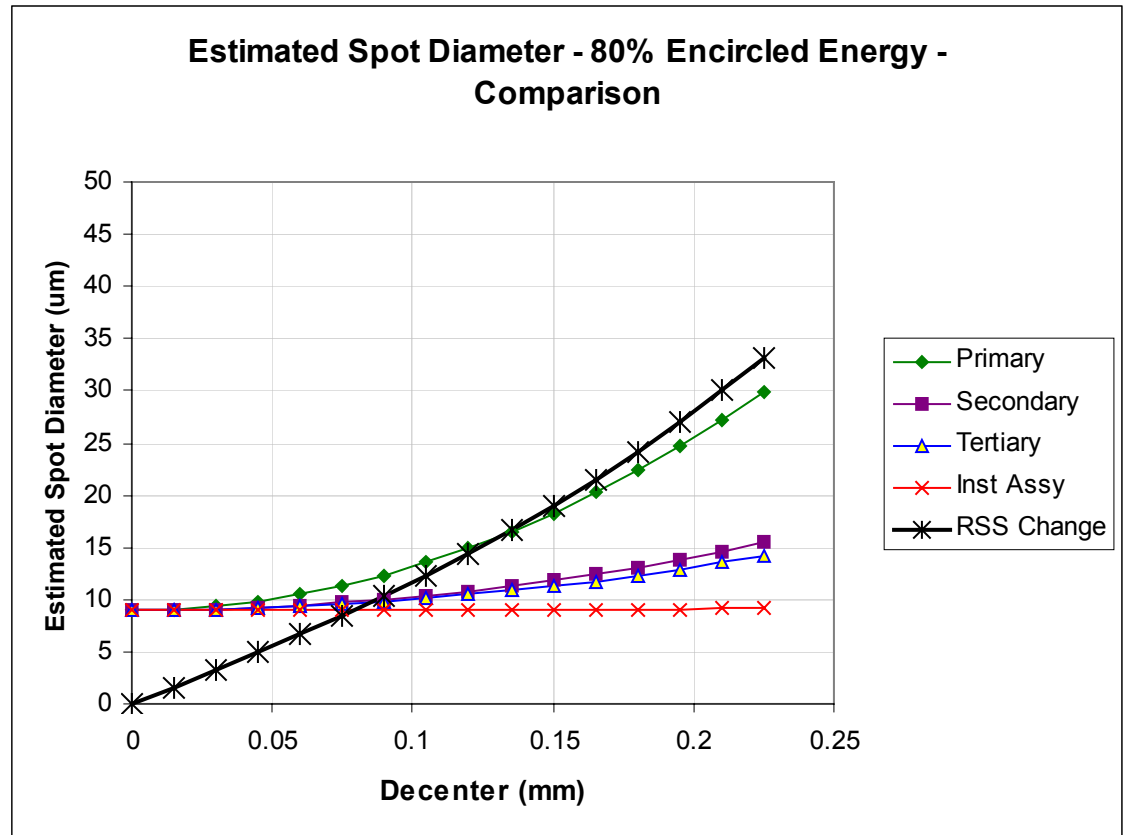
Encircled Energy Sensitivity – Decenter

Element	Quadratic Coefficient	Linear Coefficient	Constant
Primary Mirror	414.58	0.000	8.96
Secondary Mirror	128.01	0.000	8.96
Tertiary Mirror	103.20	0.000	8.96
Inst Assy	3.53	0.000	8.96

Quadratic Approximation Valid Over:

Primary Mirror	0.2500	mm (+/-)
Secondary Mirror	0.5000	mm (+/-)
Tertiary Mirror	0.5000	mm (+/-)
Inst Assy	1.0000	mm (+/-)

$$EE(\%) = Const + QC * perturbation^2$$



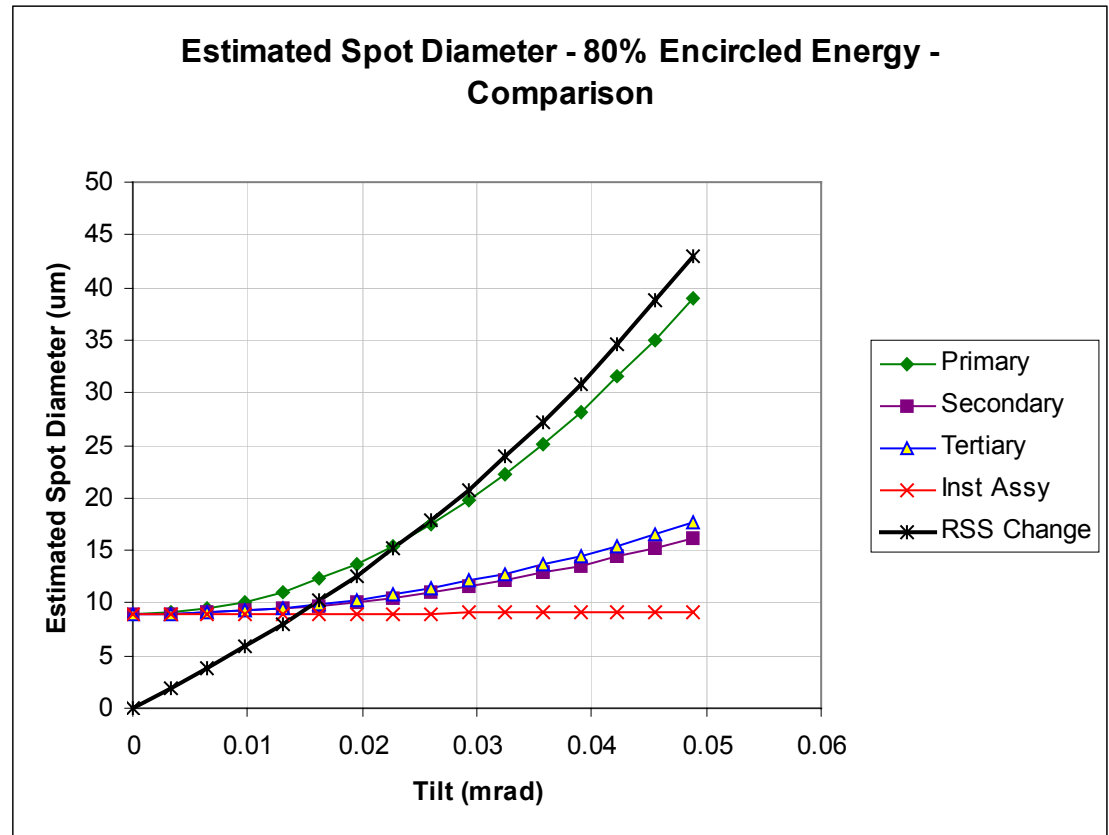
Encircled Energy Sensitivity – Tilt

Element	Quadratic Coefficient	Linear Coefficient	Constant
Primary Mirror	12609.75	0.000	8.96
Secondary Mirror	3031.98	0.000	8.96
Tertiary Mirror	3648.90	0.000	8.96
Inst Assy	96.01	0.000	8.96

Quadratic Approximation Valid Over:

Primary Mirror	0.0500	mrad (+/-)
Secondary Mirror	0.0500	mrad (+/-)
Tertiary Mirror	0.0500	mrad (+/-)
Inst Assy	0.5000	mrad (+/-)

$$EE(\%) = Const + QC * perturbation^2$$



Max Departure @ edge due to Tilt:

Primary: 0.21 mm, Secondary: 0.085 mm, Tertiary: 0.13 mm

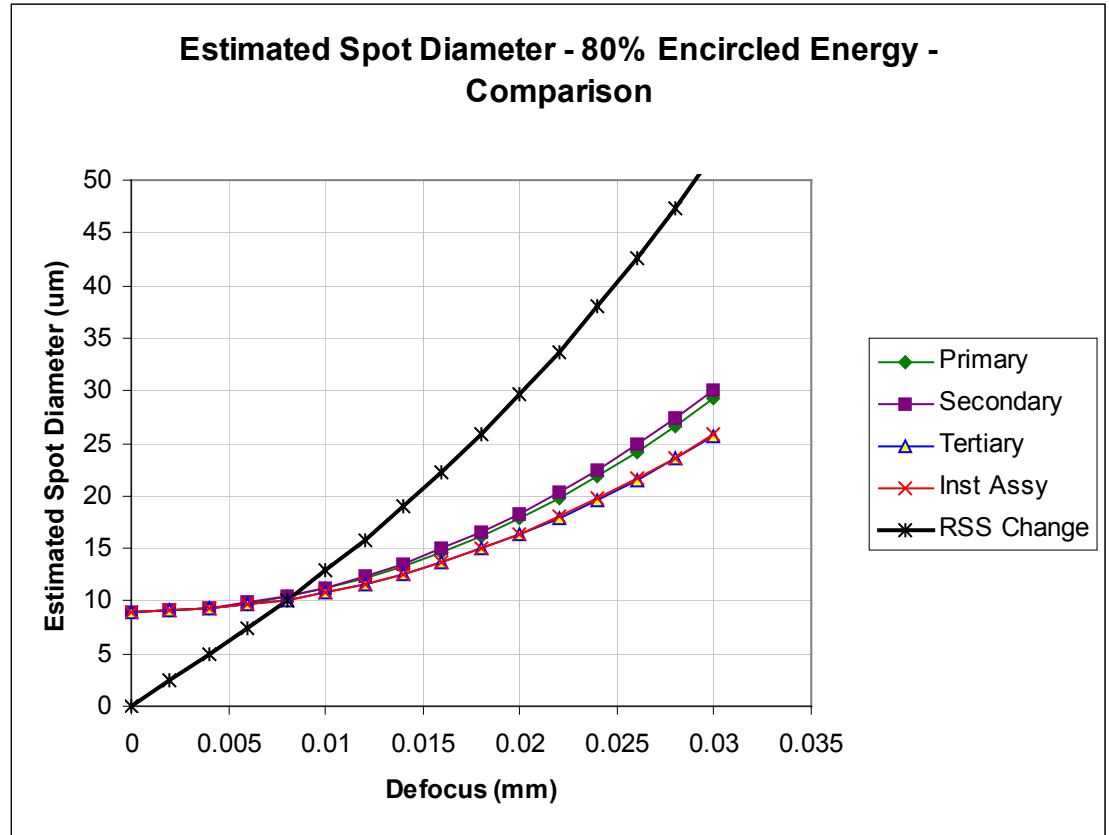
Encircled Energy Sensitivity – Defocus

Element	Quadratic Coefficient	Linear Coefficient	Constant
Primary Mirror	22489.15	0.000	8.96
Secondary Mirror	23452.89	0.000	8.96
Tertiary Mirror	18555.24	0.000	8.96
Inst Assy	18691.18	0.000	8.96

Quadratic Approximation Valid Over:

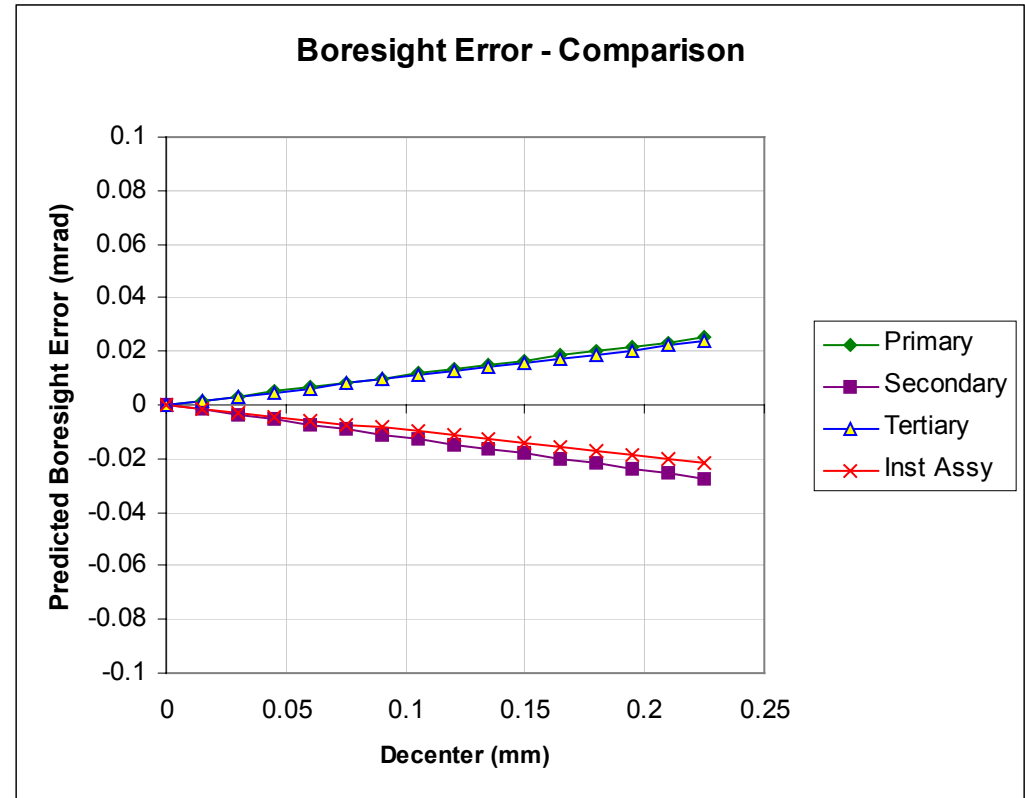
Primary Mirror	0.0300	mm (+/-)
Secondary Mirror	0.0300	mm (+/-)
Tertiary Mirror	0.0300	mm (+/-)
Inst Assy	0.0300	mm (+/-)

$$EE(\%) = Const + QC * perturbation^2$$



Boresight Error – Decenter

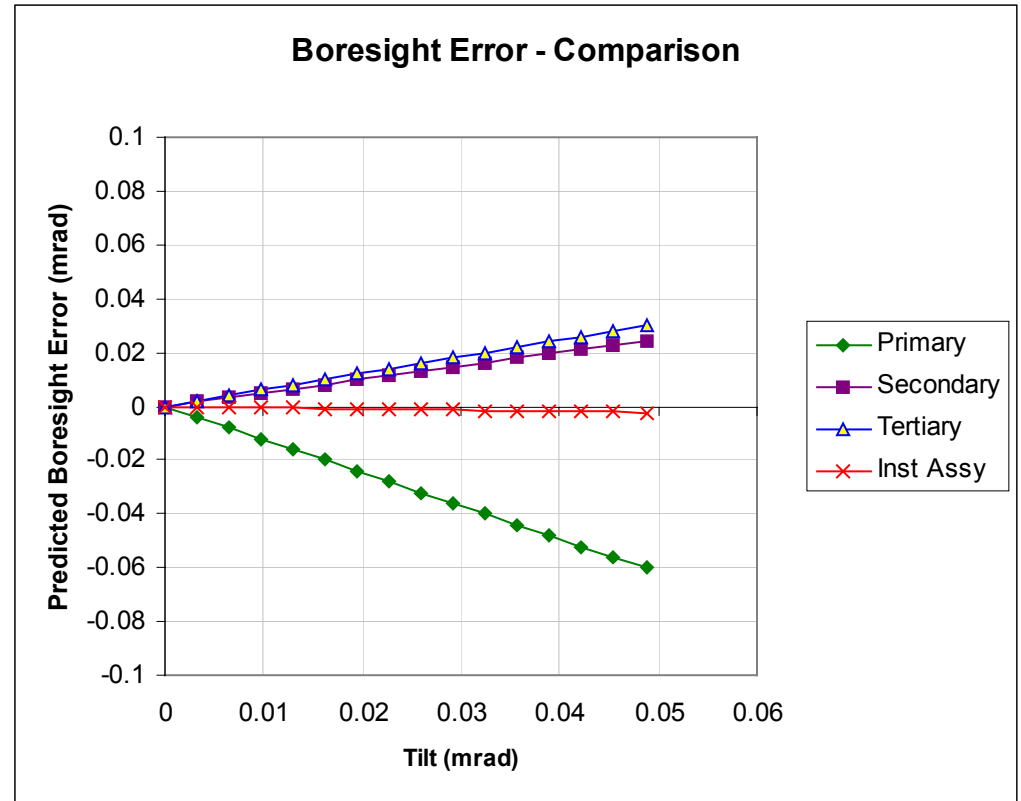
Element	Maximum Perturbation (mm)	Boresight Error (mrad)	Slope (mrad/mm)
Primary Mirror	0.25	0.027938	0.111752
Secondary Mirror	0.5	-0.0607475	-0.121495
Tertiary Mirror	0.5	0.0524204	0.1048408
Inst Assy	1	-0.095098	-0.095098
Max Limits:			
Primary Mirror	0.2500	mm (+/-)	
Secondary Mirror	0.5000	mm (+/-)	
Tertiary Mirror	0.5000	mm (+/-)	
Inst Assy	1.0000	mm (+/-)	



BORESIGHT ERROR == image surface deviation of on-axis chief ray / telescope focal length

Boresight Error – Tilt

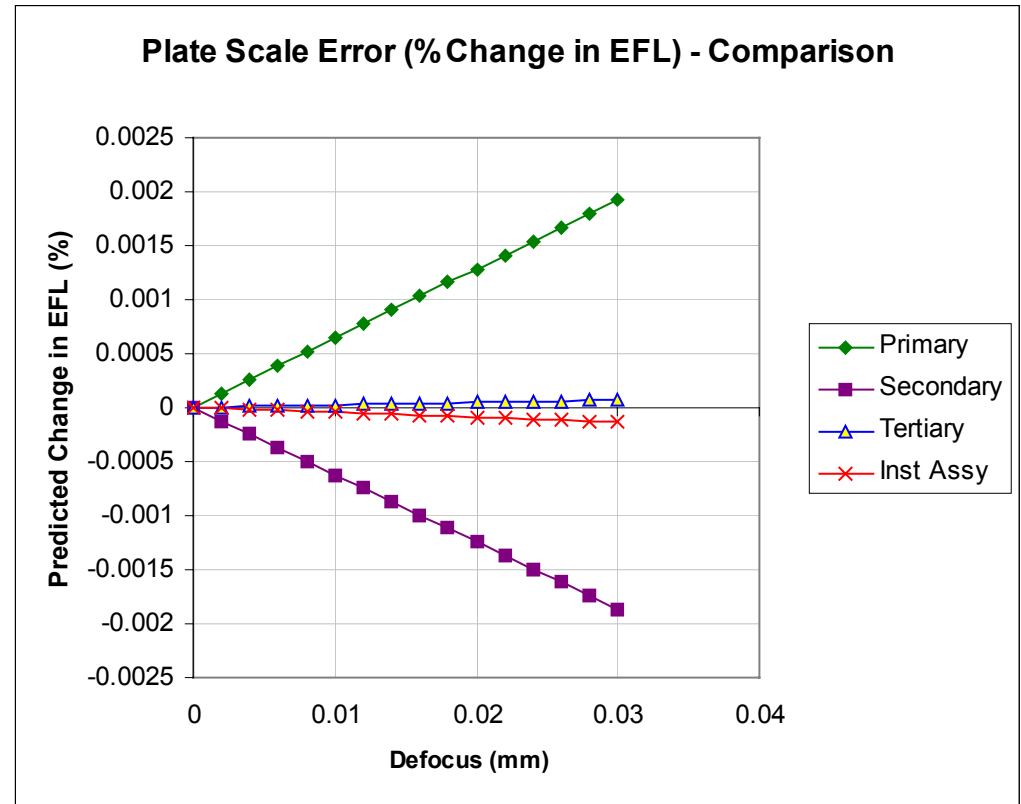
Element	Maximum Perturbation (mrad)	Boresight Error (mrad)	Slope (mrad/mrad)
Primary Mirror	0.05	-0.0616858	-1.233716
Secondary Mirror	0.05	0.0250801	0.501602
Tertiary Mirror	0.05	-0.0306088	-0.612176
Inst Assy	0.5	0.0235028	0.0470056
Max Limits:			
Primary Mirror	0.0500	mm (+/-)	
Secondary Mirror	0.0500	mm (+/-)	
Tertiary Mirror	0.0500	mm (+/-)	
Inst Assy	0.5000	mm (+/-)	



BORESIGHT ERROR == image surface deviation of on-axis chief ray / telescope focal length

Plate Scale Change (%Change in EFL) – Defocus

Element	Maximum Pertubation (mm)	Change in EFL (%)	Slope (%/mm)
Primary Mirror	0.03	0.0019293	0.06431
Secondary Mirror	0.03	-0.00186573	-0.062191
Tertiary Mirror	0.03	0.000074	0.002466667
Inst Assy	0.03	-0.000137819	-0.004593967
Max Limits:			
Primary Mirror	0.0300	mm (+/-)	
Secondary Mirror	0.0300	mm (+/-)	
Tertiary Mirror	0.0300	mm (+/-)	
Inst Assy	0.0300	mm (+/-)	



0.002% change in focal length → image shift of .0055 mm at the edge of the field of view

Concluding Remarks

- Axial position sensitivity (defocus) for all mirrors and the instrument assembly is very high
- Primary mirror is has the highest sensitivities
- Plate scale error is negligible over range of perturbations analyzed