Design of a Scanning MEMS Based Lidar

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Overview

The goal of this proposal is to design a scanning MEMS based lidar operating at 905nm.

This is a common wavelength for most commercially available Lidars in the automotive industry.

It is important to mention that the system designed in this work is the transmitting optics.

The receiving optics which is also important is not discussed in this treatise. Its design will be similar, but different in some ways since we must address the detector array.

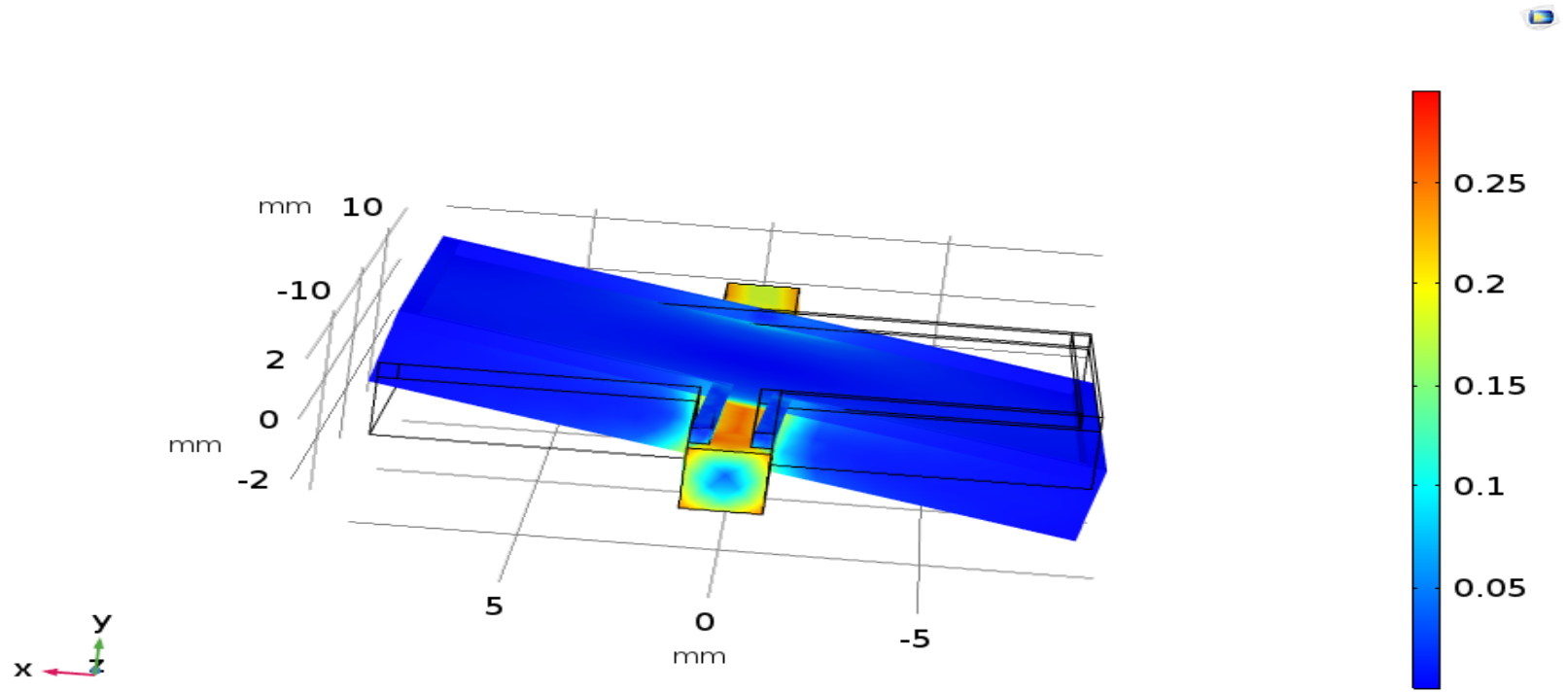
Electromechanical Fundamentals of Mirror rotation

There are several techniques which have been used to actuate the mirrors including electrostatic methods, piezoelectric effects, and electromagnetic technique. Using the electromagnetic Lorentz force will require lower power. An electric current is introduced in a coil which sits on the micromirror, in the presence of a magnetic field. This condition creates a Lorentz force which will rotate the mirror about an axis.

$$\boldsymbol{F} = I\boldsymbol{L} \times \boldsymbol{B}$$

$$\nabla . \mathrm{S} + \boldsymbol{F} . \boldsymbol{v} = 0$$

Finite element simulation of Mechanical Deflection



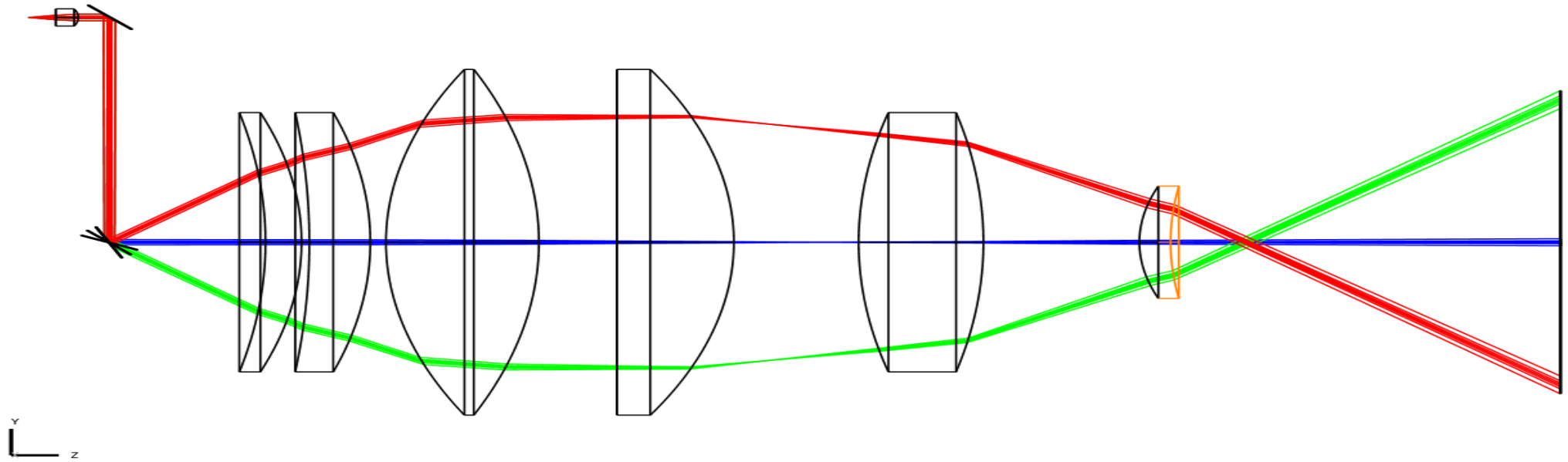
Optical System Performance

This work majors on the Optical design of a lens system that will use a scanning MEMS Micromirror. The table below provides a typical optical system performance.

System Performance Table

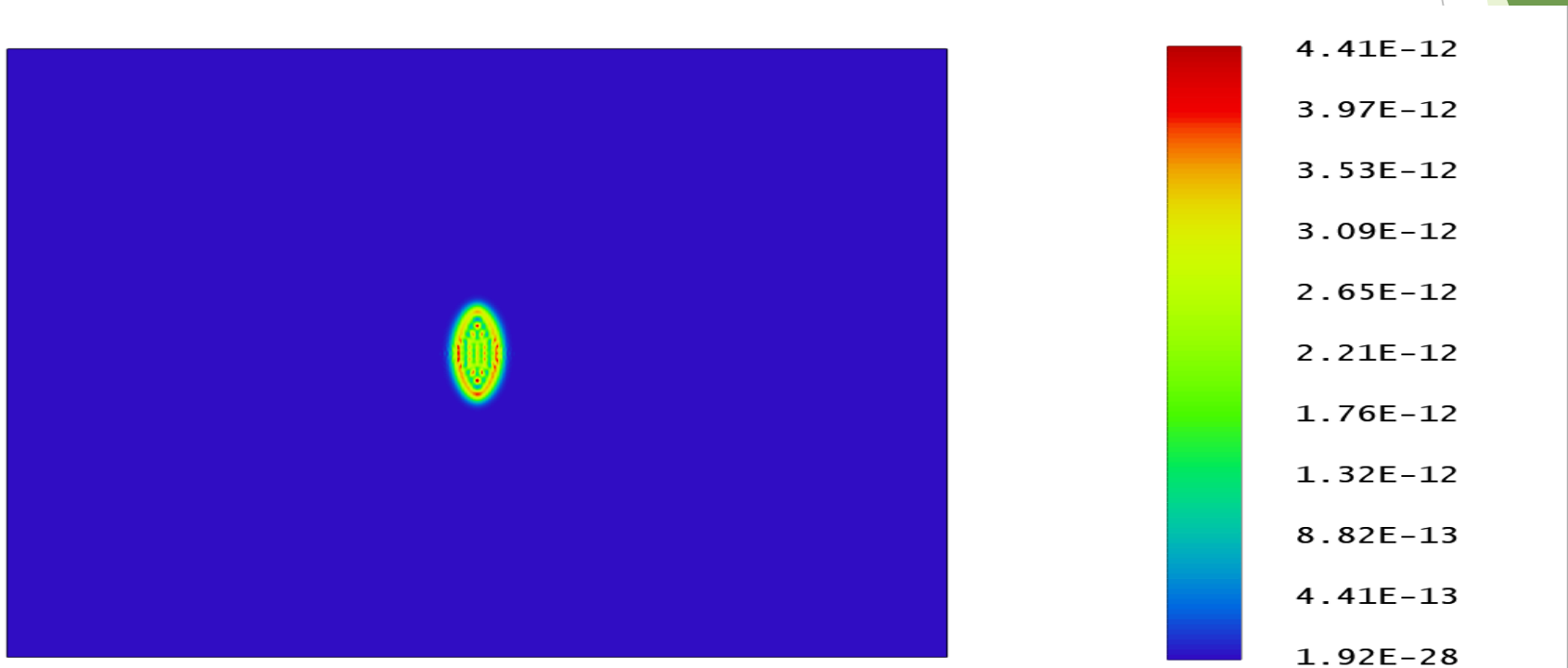
	Specification Minimum	Specification Maximum	Design_M1	Design_M2	Design_M3
Scan field	40^0	120^0	80.42^0	110.4^0	40^0
Spot radius (100m away) **x-radius** **y-radius**	1cm	20cm	53.25cm 148.1cm	171.5cm 211.7cm	171cm 289cm

Design 1 , with Zemax



3D Layout	
2/24/2020	Zemax Zemax OpticStudio 18.4.1
	Design_M1.zmx Configuration: All 3

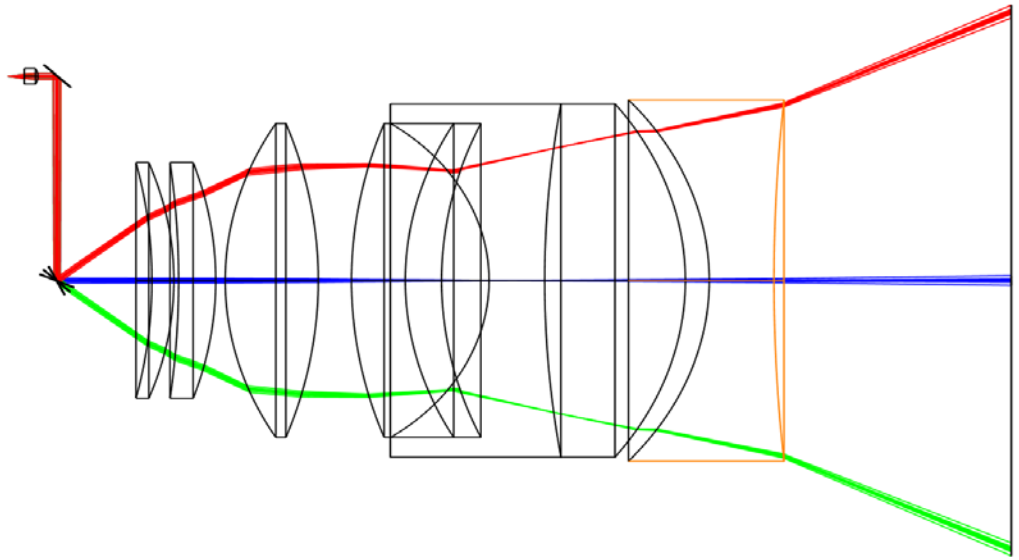
Beam Profile



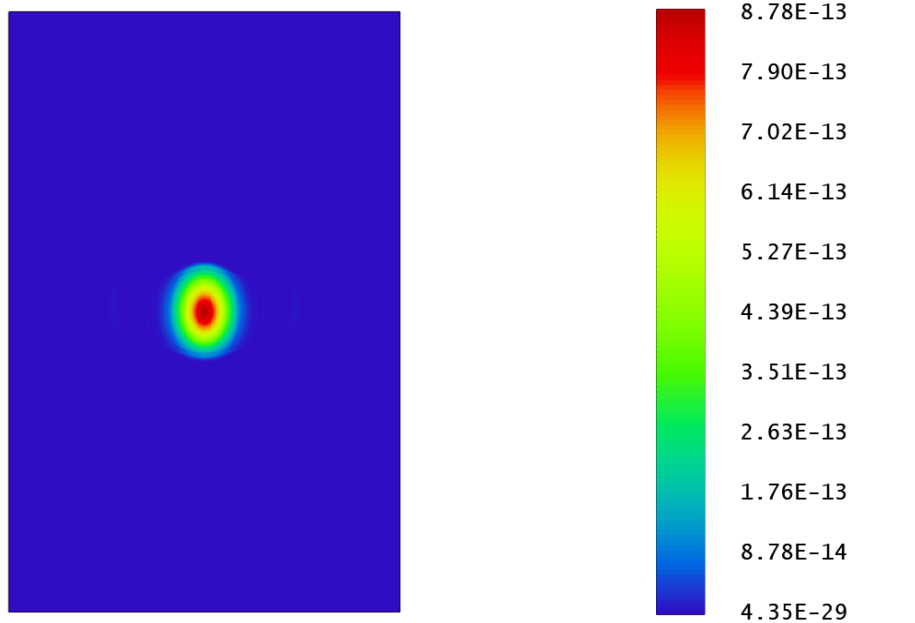
Total Irradiance surface 25

2/24/2020
Beam wavelength is 0.90500 µm in the media with index 1.00000 at 0.0000 (deg)
Display X Width = 1.7932E+04, Y Height = 1.8225E+04 Millimeters
Peak Irradiance = 4.4108E-12 Watts/Millimeters^2, Total Power = 5.7905E-06 Watts
Pilot: Size= 1.5043E+03, Waist= 2.4774E-02, Pos= 1.2937E+05, Rayleigh= 2.1305E+00
Beam Width X = 5.32532E+02, Y = 1.48106E+03 Millimeters

Design 2



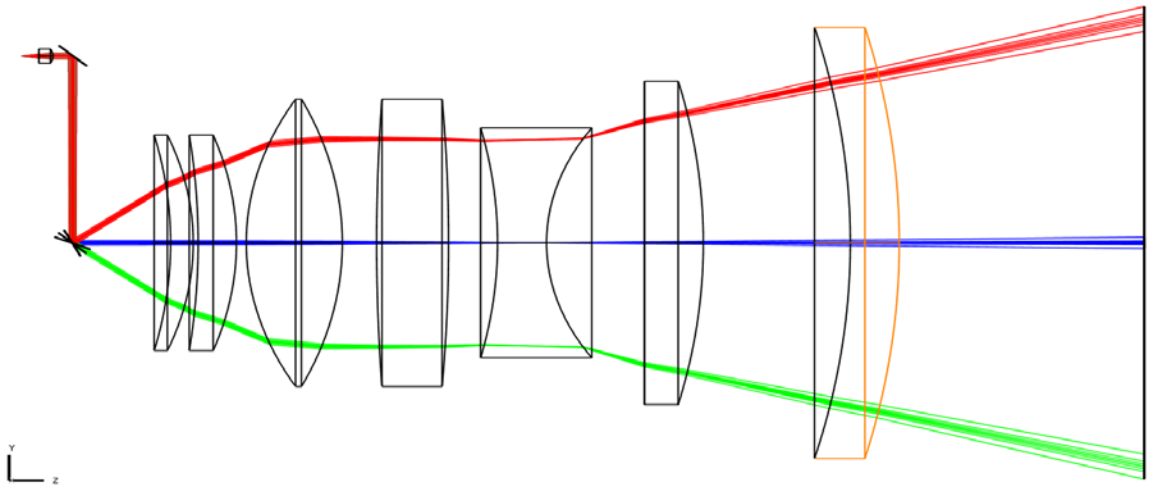
3D Layout	
2/24/2020	Zemax Zemax OpticStudio 18.4.1 Design_M2.zmx Configuration: All 3



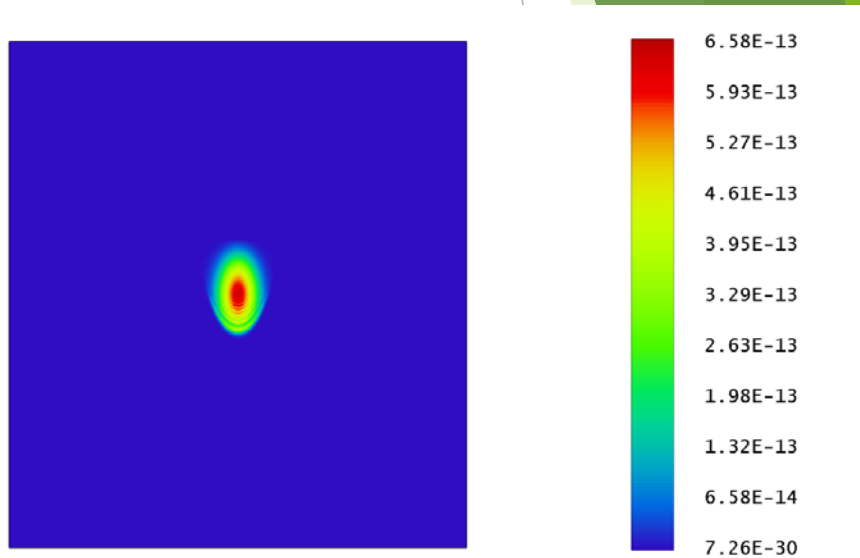
Total Irradiance surface 26

2/24/2020
Beam wavelength is 0.90500 µm in the media with index 1.00000 at 0.0000 (deg)
Display X Width = 1.9976E+04, Y Height = 3.1954E+04 Millimeters
Peak Irradiance = 8.7782E-13 Watts/Millimeters^2, Total Power = 5.7905E-06 Watts
Pilot: Size= 2.0997E+03, Waist= 1.5314E-02, Pos= 1.1162E+05, Rayleigh= 8.1409E-01
Beam Width X = 1.71524E+03, Y = 2.11687E+03 Millimeters

Design 3



3D Layout	
2/24/2020	Zemax Zemax OpticStudio 18.4.1
	Design_M3.zmx Configuration: All 3



Total Irradiance surface 27

2/24/2020
Beam wavelength is 0.90500 µm in the media with index 1.00000 at 0.0000 (deg)
Display X Width = 3.1321E+04, Y Height = 3.7295E+04 Millimeters
Peak Irradiance = 6.5845E-13 Watts/Millimeters^2, Total Power = 5.7905E-06 Watts
Pilot: Size= 2.8522E+03, Waist= 1.0504E-02, Pos= 1.0400E+05, Rayleigh= 3.8299E-01
Beam Width X = 1.70914E+03, Y = 2.89321E+03 Millimeters

Conclusion

I found a 100-degree wide-angle lens in Zemax library rescaled it for a focal length of about 40mm, the used and combined half of with the optimized Telecentric Ftheta lens.

So far Design 2, has a good performance, since it has a large scan field of 110 degrees. Design 1 is also performs good in terms of the spot radius. Design 3 needs more work.

We will continue to explore more optical designs and efficient ways to adapt optoelectromechanics for next generation efficient Lidar systems

Reference

[1] Nkorni Katte “Multiphysics Analysis of a Micromirror System” COMSOL Multiphysics Conference, BOSTON, October 2019.

Acknowledgments

We are very grateful for the continuous support of Ohio Space grant Consortium and for our College of Professional studies who have always supported us to push for quality research and