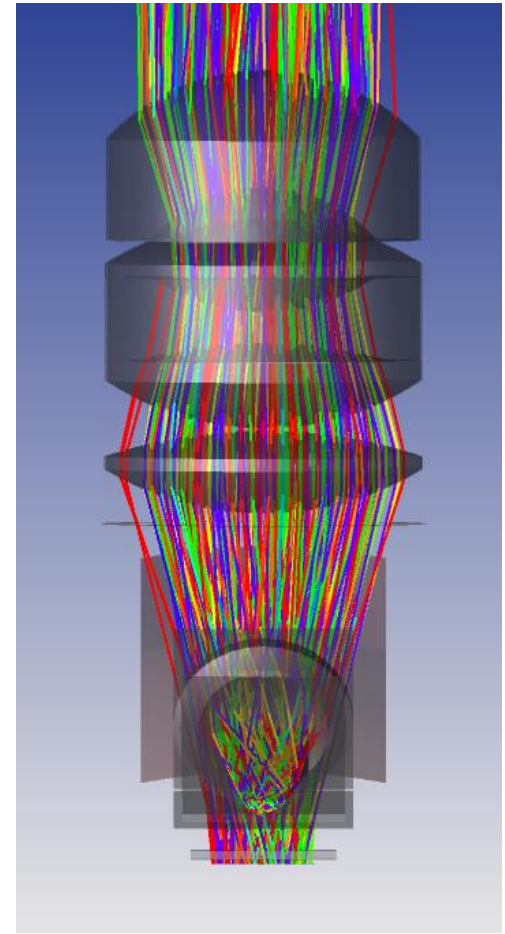
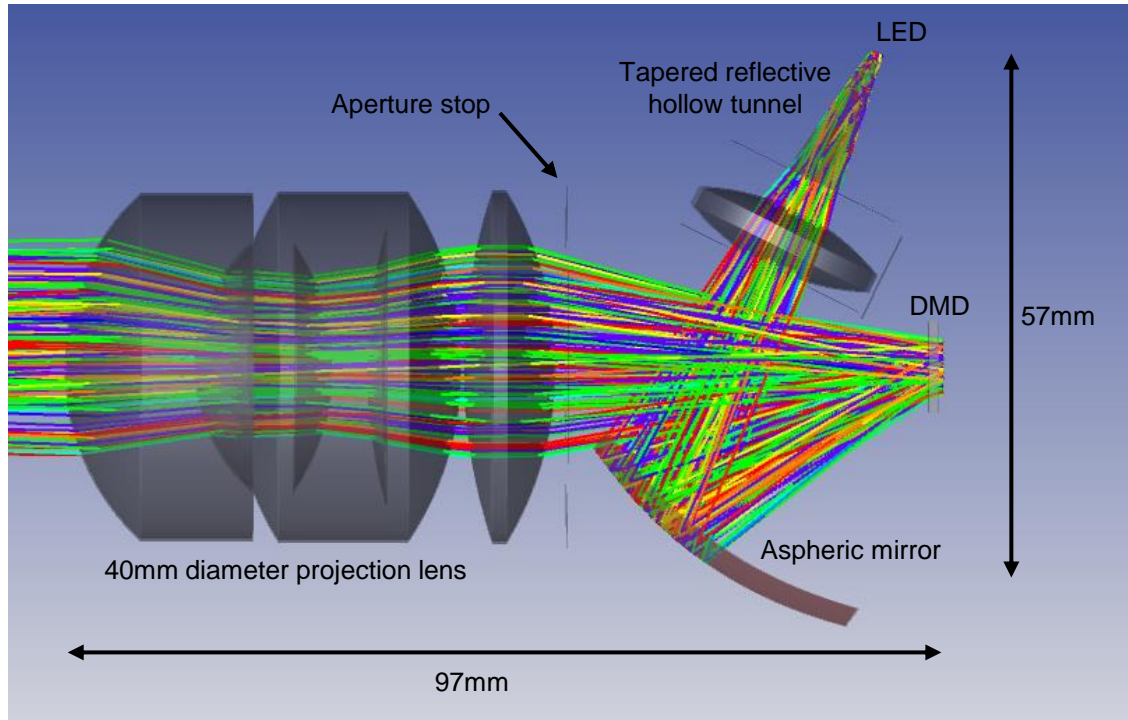


DLP Headlight EVM

3/11/2020

System Layout



Illumination Source

- **Nichia NV3W470A** (LED alone) / **NLSW03A04A** (LED on PCB module)
 - Emission area: 3.5mm x 1.4mm
 - Output flux: 3900 lumens
 - For further details contact Nichia directly
 - <https://www.nichia.co.jp/en/contact/contact.html>
 - <https://www.nichia.co.jp/en/contact/inquiries.html>
- Alternative light source: **Luminus PT-50X-W**
 - Emission area: 3.33mm x 1.54mm
 - Output flux: 3900 lumens
 - EVM will require mechanical mounting changes to accommodate this LED
 - For further details contact Luminus directly
 - sbellosguardo@luminus.com

Illumination Profile at DMD

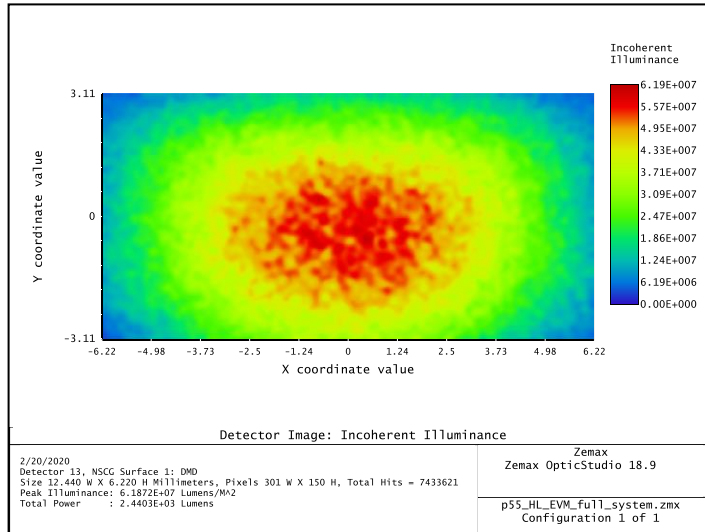
Nichia NV3W470A rayset Source Analysis

Refer to file: p55_HL_EVM_full_system_FINAL.zar

Note: LED rayset not included in file. Must request from Nichia directly and insert into model.

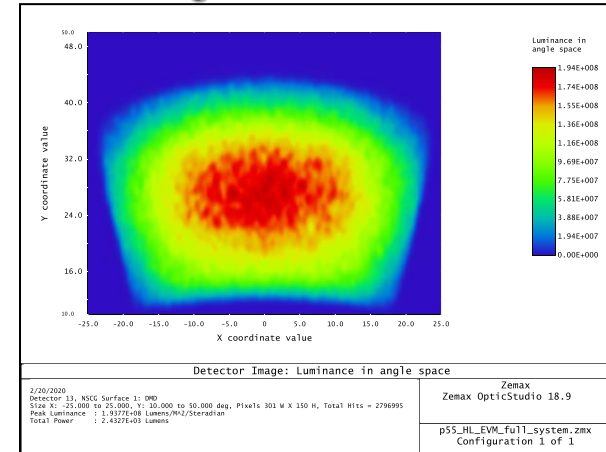
Optics Coatings Applied:
Lenses = Zemax AR coating
Tunnel = 97%R
Curved Mirror = 97%R
DMD Window Coating

Spatial Distribution



- LED size: 3.5mm x 1.4mm
- LED output flux: 3900lm

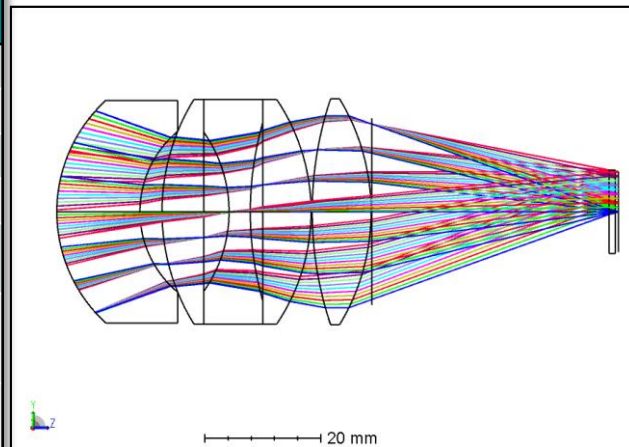
Angular Distribution



- 28° central ray angle of incidence
- Full angular cone size:
 - $\pm 22.5^\circ$ horizontal & $\pm 16^\circ$ vertical
- Illumination F/#:
 - F/1.3 horizontal x F/1.8 vertical

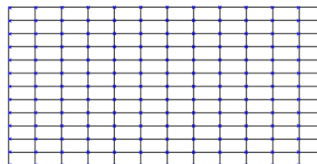
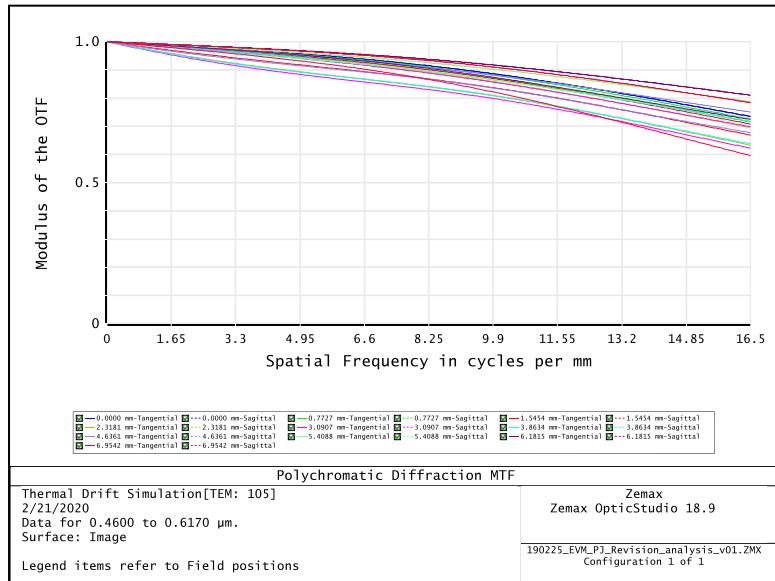
Projection Lens Design

	Optical Specification Requirement	Projection Lens design	Meets Spec?	Comment
Physical Requirements	DMD Size: 0.55"	0.55"	✓	
	Projection Lens Diameter: ≤40mm	40mm	✓	
	Back Working Distance: ≥40mm	41mm	✓	Space for illumination
	F/#: Largest possible w/o exceeding size	F/1.3	✓	
	No Doublets	None	✓	Glued doublets may not withstand automotive temps
	No Aspheres	None	✓	Meant for cost reduction
	Lens Count: ≤5	5	✓	
Performance Requirements	Outer Lens Shape: Convex	Convex	✓	Desired shape from most customers
	Projection Distance: 25m	25m	✓	Can be refocused
	Field Of View: 14°x7°	14°x7°	✓	
	MTF: ≥0.3 @16.5lp/mm for all fields	>0.6 for all fields	✓	16.5lp/mm = 4x4 pixel block
	Lateral Color: ≤30μm	16μm	✓	≤ 4x4 pixel block
	Distortion: ≤8%	<1%	✓	



Refer to file:
p55_HL_EVM_projection_lens_FINAL.zar

Projection Lens Performance

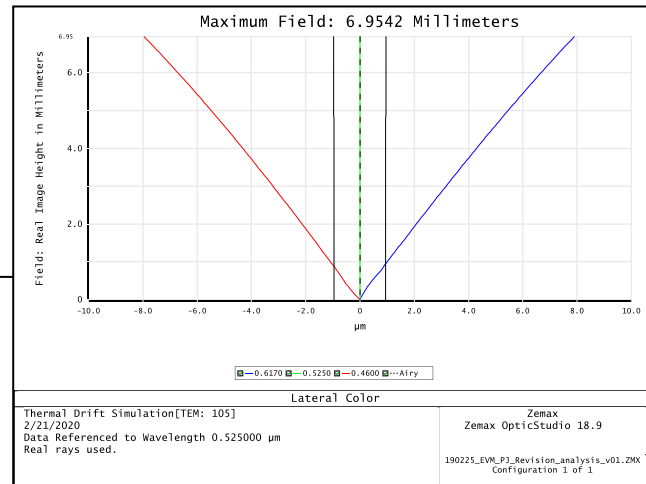


Field units changed to field angle

Thermal Drift Simulation[TEM: 105]
2/21/2020
Field: 14.0000 w 7.0000 h Degrees
Image: 12.61 w 6.31 h Millimeters
Maximum distortion: -0.7993% SMIA TV distortion: -0.6644%
Scale: 1.000X, Wavelength: 0.5250 μm

Zemax
Zemax OpticStudio 18.9

190225_EVM_PJ_Revision_analysis_v01.ZMX
Configuration 1 of 1



Projected Image Performance (at 25m)

Nichia NV3W470A rayset Source Analysis

Refer to file: p55_HL_EVM_full_system_FINAL.zar

Note: LED rayset not included in file. Must request from Nichia directly and insert into model.

Model Assumptions:

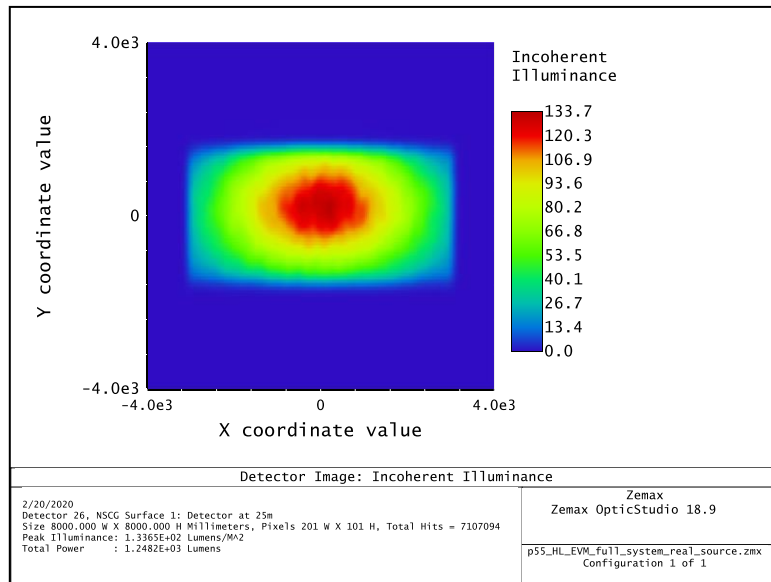
Lenses = Zemax AR coating

Tunnel = 97%R

Curved Mirror = 97%R

DMD Window Coating

Duty Cycle = 99/1



Field Of View: 14°x7°

Simulated Performance

LED Output	Peak Lux	Total Lumens	Efficiency
3900 lumens	134	1248	32%

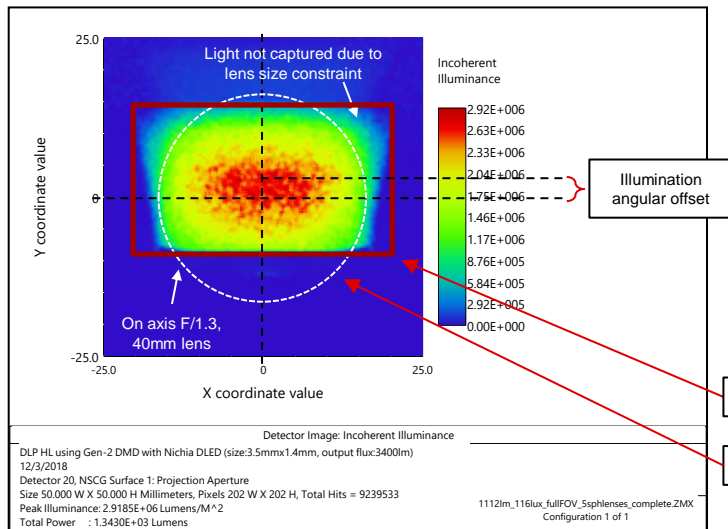
- Low efficiency is a result of system size and contrast constraints
 - Larger projection lens could enable >40% efficiency

Measured Performance

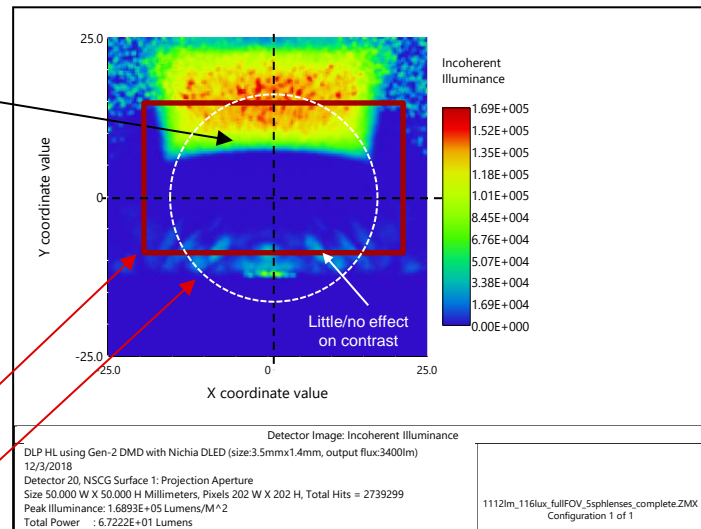
Peak Lux	Total Lumens	Contrast
129	1280	325:1

F/# = Brightness/Efficiency & Contrast tradeoff

On-State Light at Projection Pupil



Flat-State Light at Projection Pupil



- 40mm lens limits the F/# of the system – F/1.3
- Higher peak illumination hotspot results in faster F/#. Light cannot be collected by F/1.3 lens
- Illumination is angularly offset because of the higher incidence angle onto DMD. Requires faster F/# lens to collect light
- Smaller F/# or higher illumination offset results in less flat-state overlap improving contrast