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Example 0.45'' WXGA Optical Reference Design

Note: This design is not representative of the optics found in the DLP® LightCrafter™ 4500

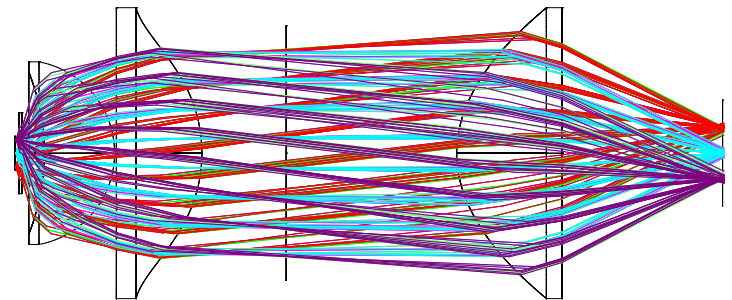
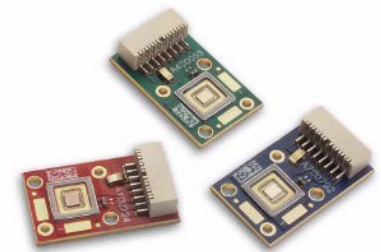
Objective

- Design the illumination system for a 0.45" WXGA DMD using a Luminus PT54 LED Die
 - Design using a light tunnel
 - Anamorphic F/#
- Goal: Achieve >400lm on the screen w/ LED overlap

Note: Only illumination system will be designed

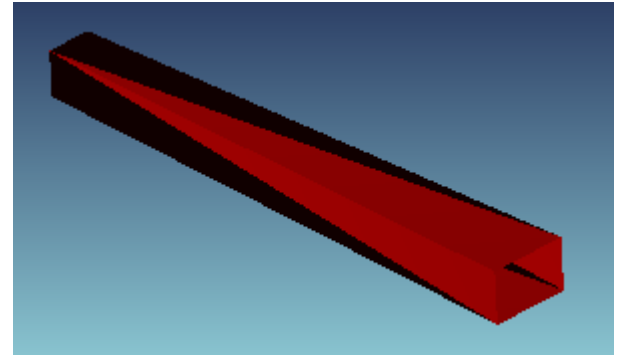
LED to Tunnel

- LED
 - Luminus PT54 (2.7mm x 2mm = 5.4mm²)
 - Lambertian Emitter: $\pm 90^\circ$
 - Wavelengths: 464nm, 526nm, 623nm
- Optical Design
 - Designed for $\pm 80^\circ$
 - Pre-Collimator: S-LAH53 glass (n=1.806)
 - Collimator & Condenser: Polycarbonate
 - Curved surfaces are aspheric
- Collection Angle = 60°



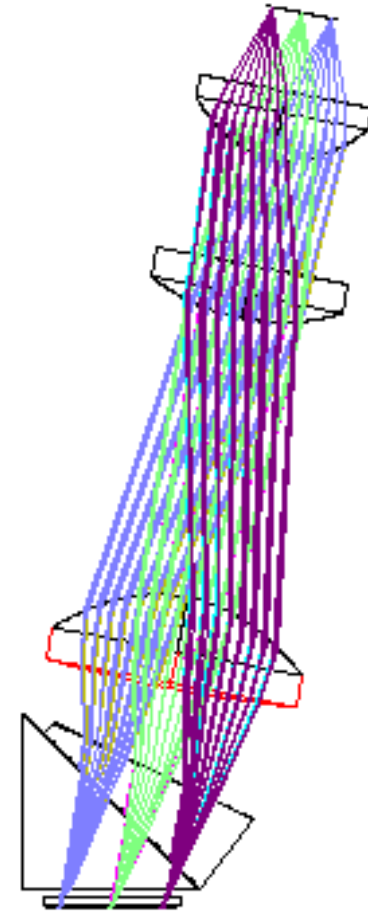
Tunnel Design

- Input: $\sim F/1.1$
 - Corresponds to a collection angle of $\sim 60^\circ$ from LED
 - Dimensions: 4mm x 4mm
 - $\sim 24\%$ overfill due to etendue mismatch b/w LED and DMD
 - May require physical aperture to block unnecessary light
- Output: $\sim F_x/1.8 \times F_y/1.2$
 - Dimensions: 6.165mm x 4.11mm
- Length: 35mm



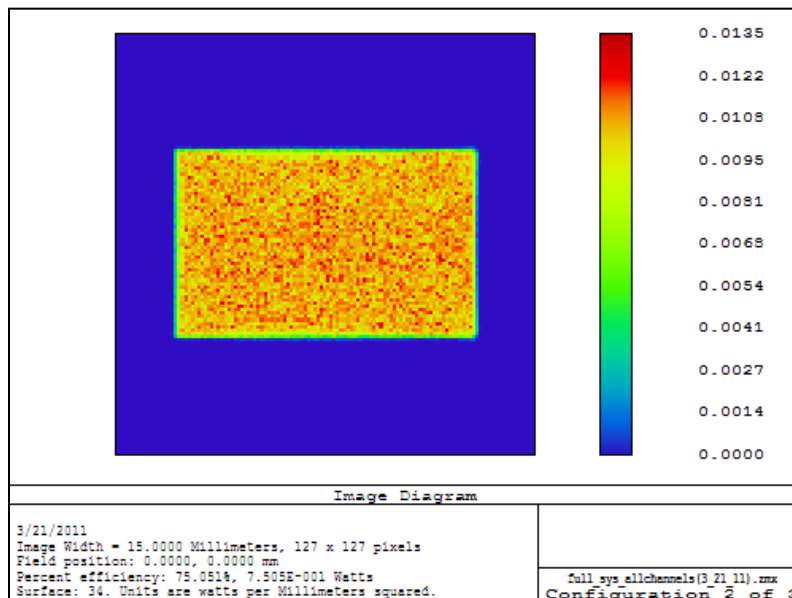
Tunnel to DMD

- Tunnel Output
 - 6.165mm ($F_x/1.8$) x 4.11mm ($F_y/1.2$)
 - X-dimension slightly decreased due to anamorphism
- 3 Lens Relay
 - Magnification: $\sim 1.6x$
 - All PMMA plastic lenses
 - Curved surfaces have only conics (no aspheric coefficients)
- RTIR w/ wedge
 - N-SK5 glass
 - Airgap: 0.1mm
 - Prism to DMD Coverglass: 0.83mm
 - Can be increased if necessary
- Pupil Offset: 3°

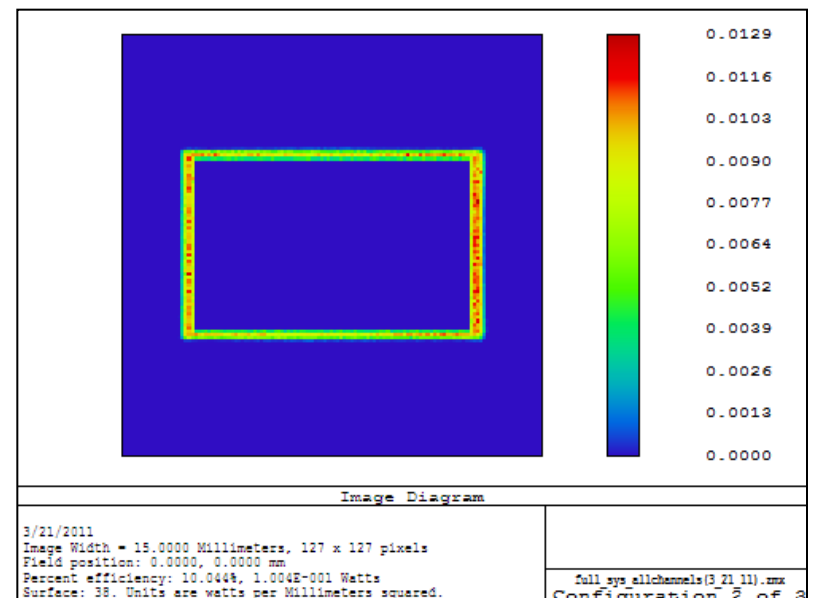


Performance- LED to DMD

- Illumination on plane of DMD
 - Red=71.5% ; Green= 75.1%; Blue=77.8%
- Illumination on active array of DMD
 - Red=61.8% ; Green= 65.0%; Blue=67.5%

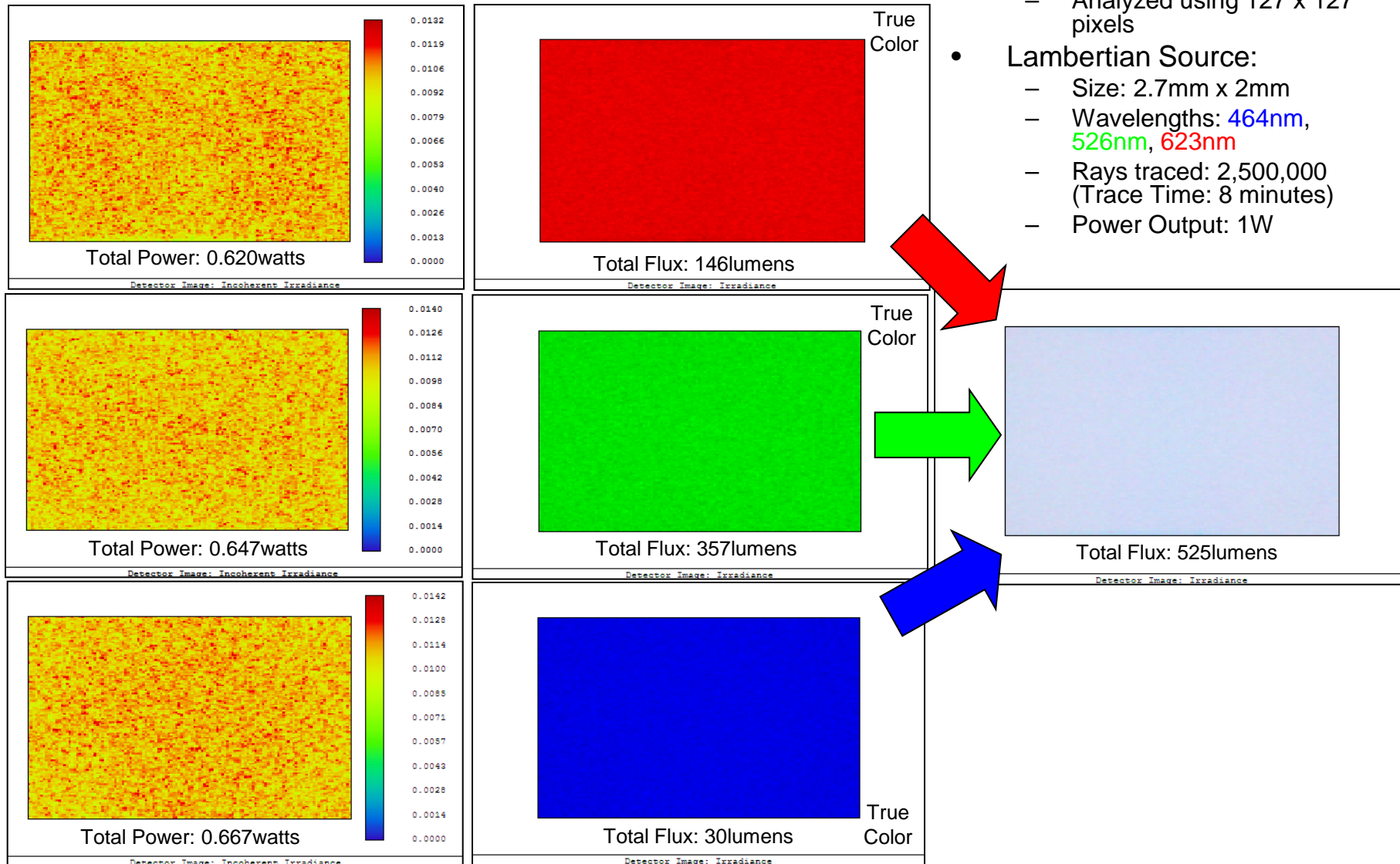


Illumination on DMD Plane (Green)



13.5% Overfill on DMD active array (Green)

Non-Sequential Analysis

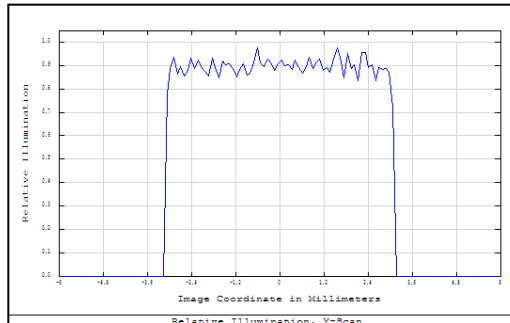
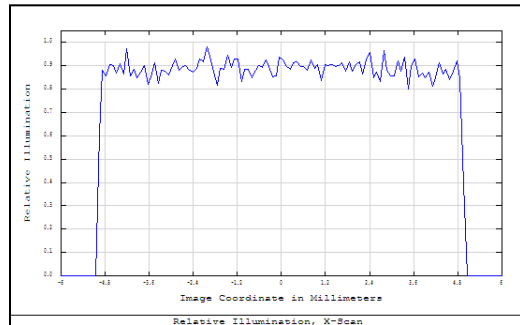


- Detector Parameters:
 - Size: 9.855mm x 6.1614mm (.45" WXGA Array)
 - Analyzed using 127 x 127 pixels
- Lambertian Source:
 - Size: 2.7mm x 2mm
 - Wavelengths: 464nm, 526nm, 623nm
 - Rays traced: 2,500,000 (Trace Time: 8 minutes)
 - Power Output: 1W

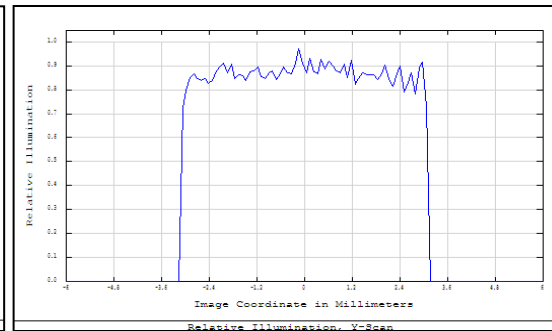
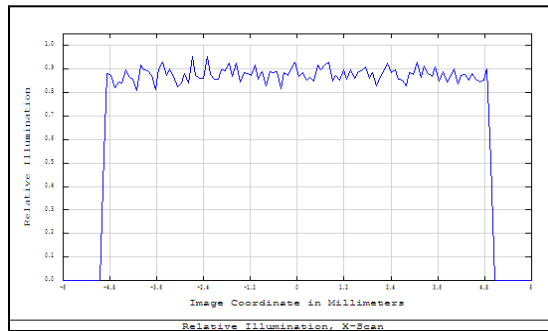
Color Uniformity

- Plots were generated using the “illumination XY scan” function in Zemax

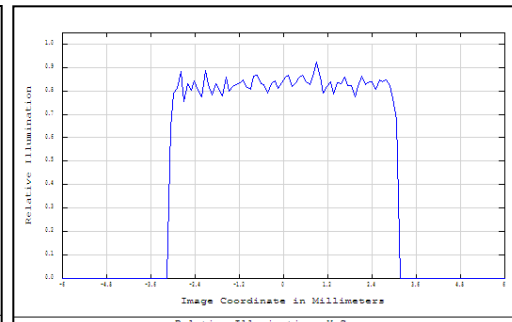
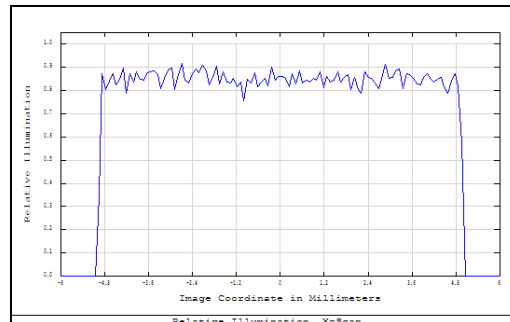
462
nm



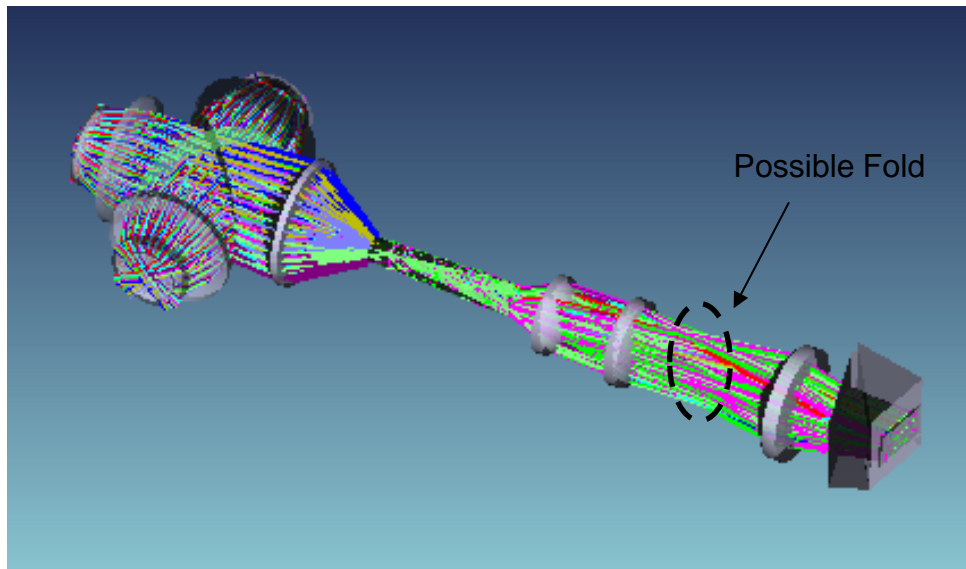
526
nm



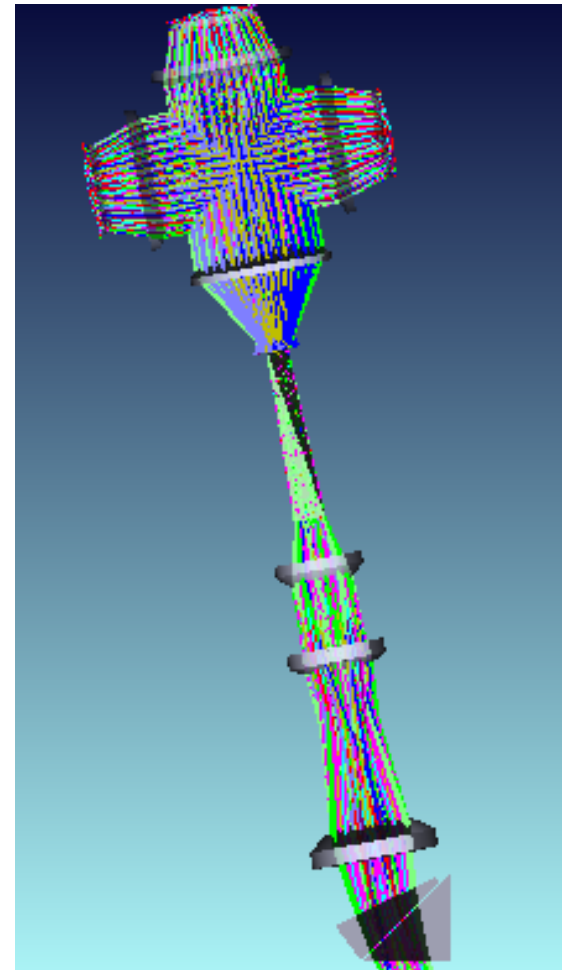
623
nm



LED to DMD



Length: $\sim 200\text{mm} = \sim 7.88\text{in.}$



Efficiency Estimate

Optical Element	Estimated Transmission	Notes:
Collimator Lens Pair	0.960	99% T/surface due to coating
Dichroic	0.950	Typical Estimate
Condenser Lens	0.990	99% T/surface due to coating
Light Tunnel	0.950	99% R/Bounce
Relay Lenses (Qty. 3)	0.940	99% T/surface due to coating
RTIR Prism Assembly	0.920	Estimate
DMD	0.700	Standard Value
Projection Lens	0.900	Typical Estimate

Total Optics Transmission Estimate	0.467
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Geometric Efficiency (from Zemax analysis)	0.650
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Geometric * Transmission	0.304
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Lumen Estimate

No Overlap

	Luminous PT54		
	R	G	B
Luminous Flux	750	1550	325
Current	13.5	13.5	13.5
Duty Cycle	40%	44%	16%
Duty Cycle Flux Available	300	682	52
Total Flux	1034		
Optical Engine Efficiency	30%		
Total RGB White Lumens	310.2		

30%Y Overlap

Duty Cycle	49%	58%	23%
Duty Cycle Flux Available	367.5	899	74.75
Total Flux	1341.25		
Optical Engine Efficiency	30%		
Total RGB White Lumens	402.375		

NOTE: Lumen values in this analysis is estimated by using the lum number from PT54 datasheet. Please measure actual LED lumen under normal operating condition for accurate lumen estimate.

Conclusions

- Color uniformity has been analyzed and shows to be promising
- Efficiency is maxed at the DMD plane
 - Etendue states 76%, efficiency achieved=75%
- Lumen estimate shows ~400lm with lumen numbers as per PT54 datasheet and 30% LED overlap.