

Advances in Residential Lighting Technologies

CABEC conference – San Diego, CA
October 21, 2011

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Lighting Education & Design

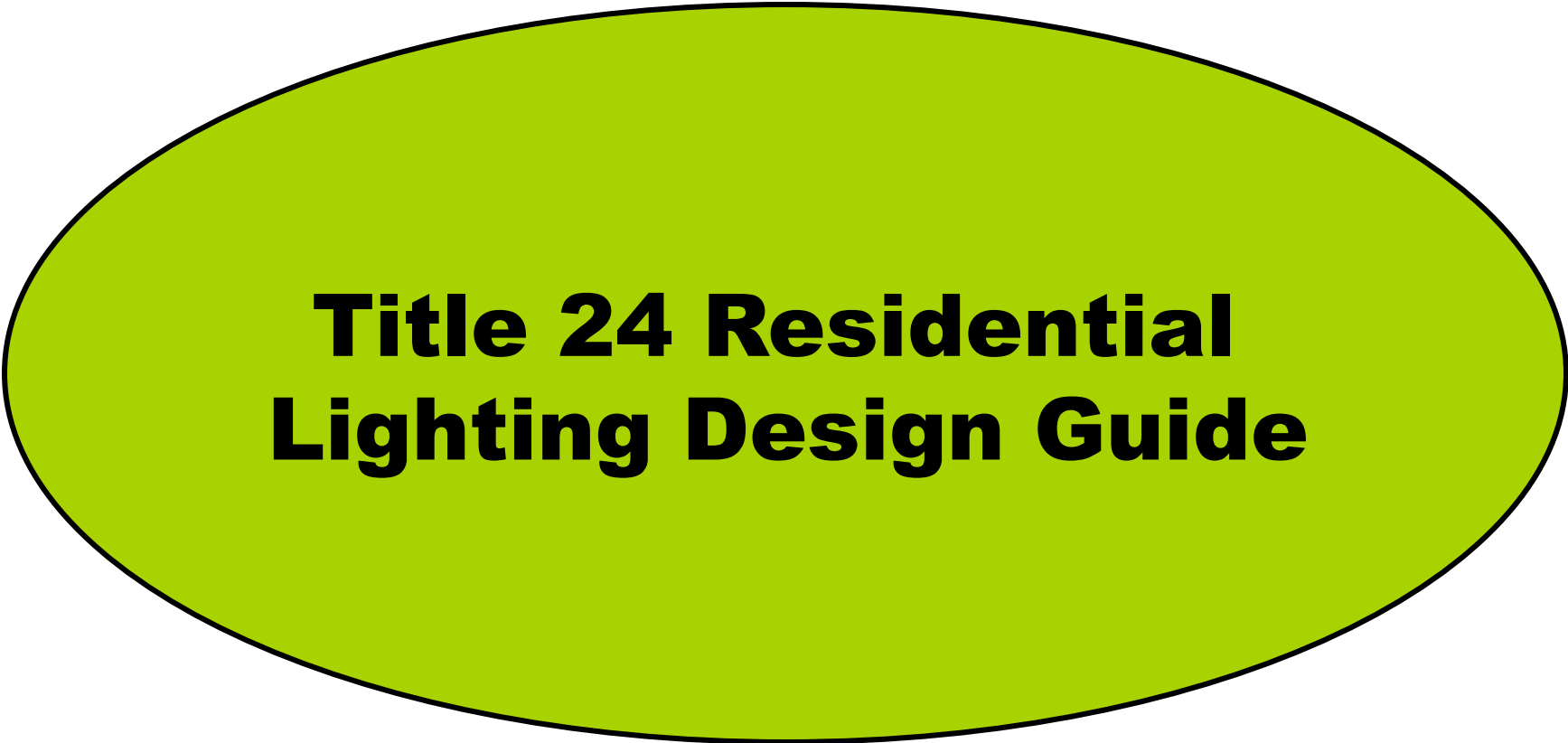
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San Francisco, CA 94131

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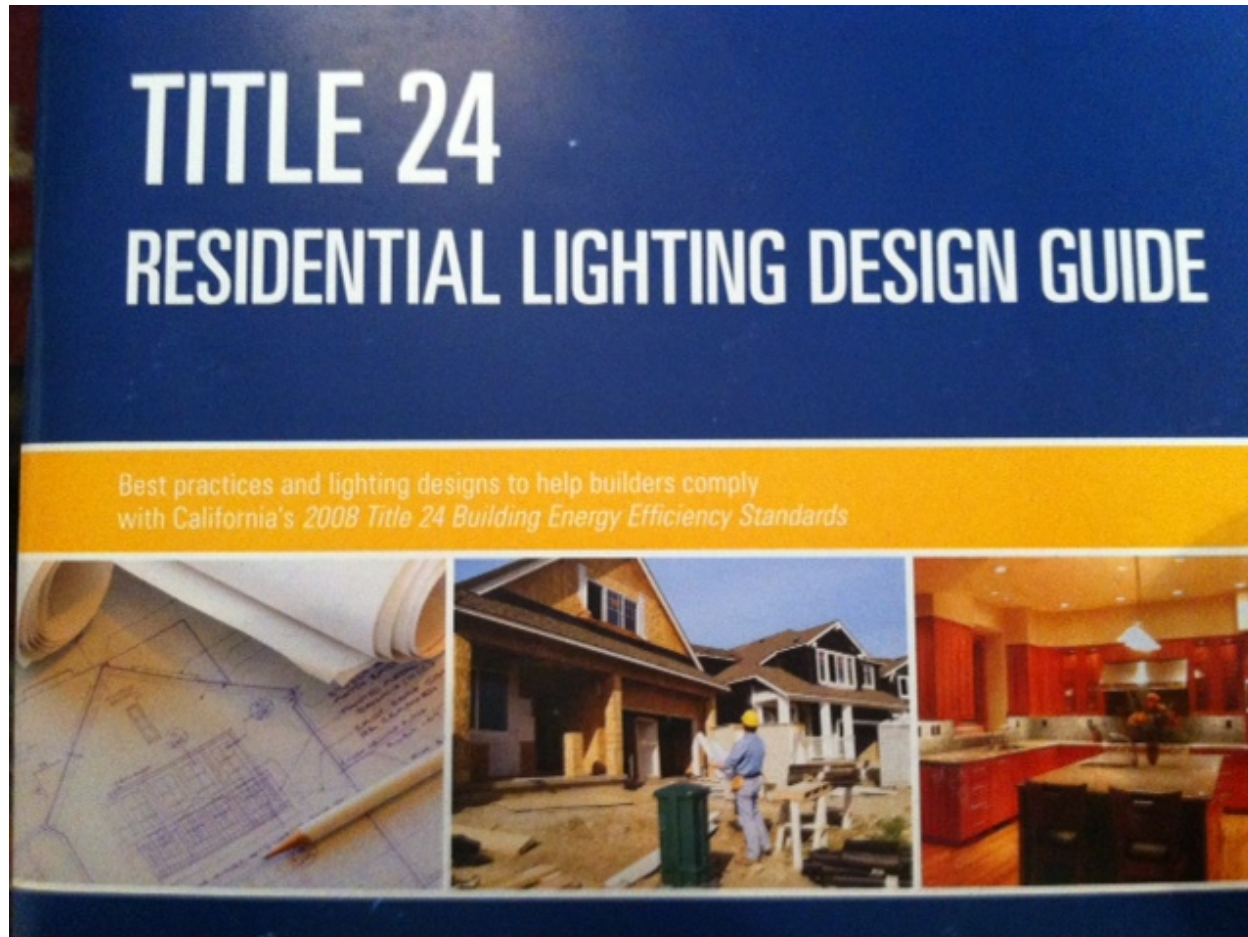
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Title 24 Residential Lighting Design Guide

T24 Residential Lighting Design Guide



cltc.ucdavis.edu/title24

T24 Residential Lighting Design Guide

- Technology overview
- Lighting Design Guide:
 - ✓ Title 24, Part 6 changes
 - ✓ Kitchens
 - ✓ Bathrooms, Garages, Closets, Laundry Rooms & Utility Rooms
 - ✓ Other Rooms
 - ✓ Multi-family Common Areas
 - ✓ Parking Lots & Garages
- Compliance checklist
- Glossary
- Resources & information

LED recessed fixtures

THREE LED

3" APERTURE LED LUMINAIRES WITH THE POWER OF MR16'S



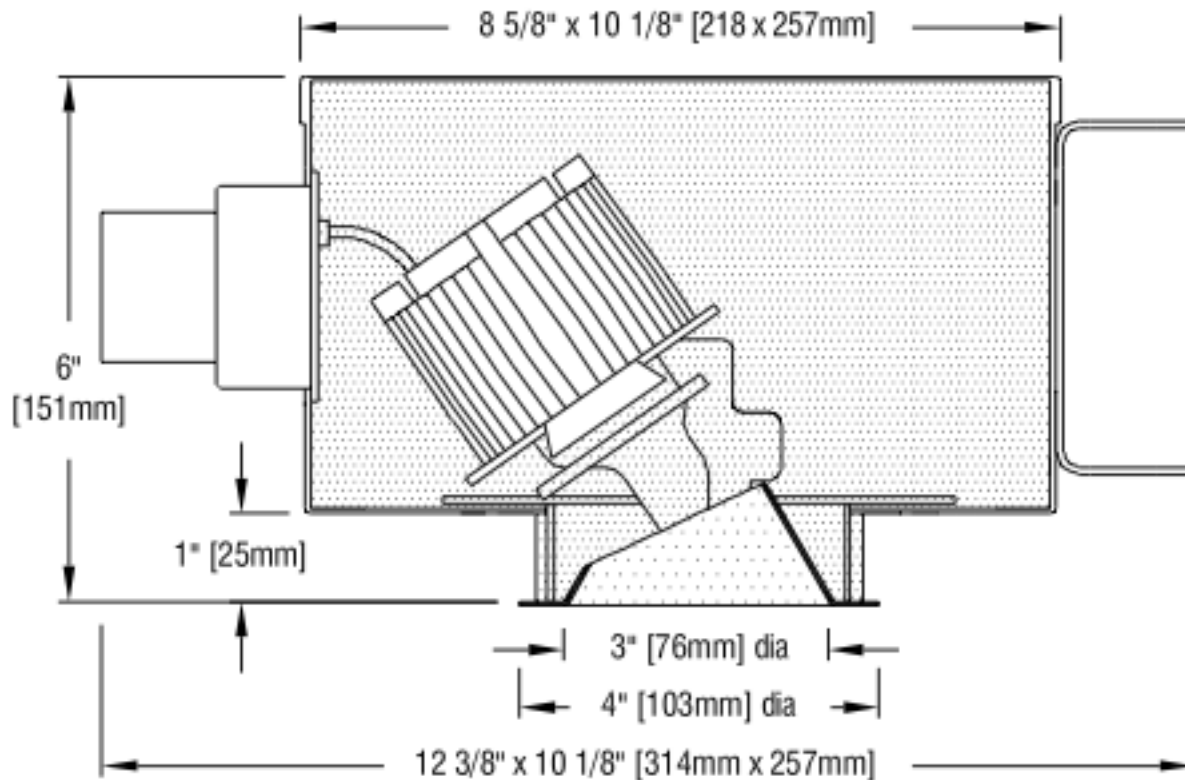
accent

downlight

wallwasher

details

LED recessed fixtures



Requires ceiling opening of 3 3/4" (95mm) for Overlap or Flush Detail.
Requires ceiling opening of 4" (102mm) for Trim Flush Detail.

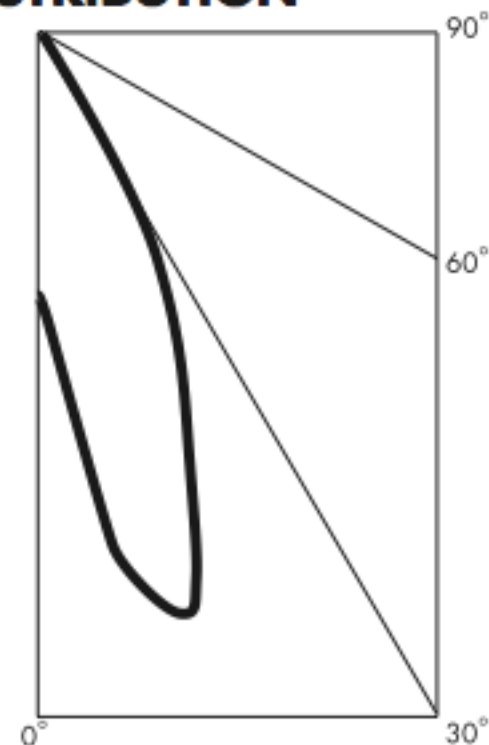
LED recessed fixtures



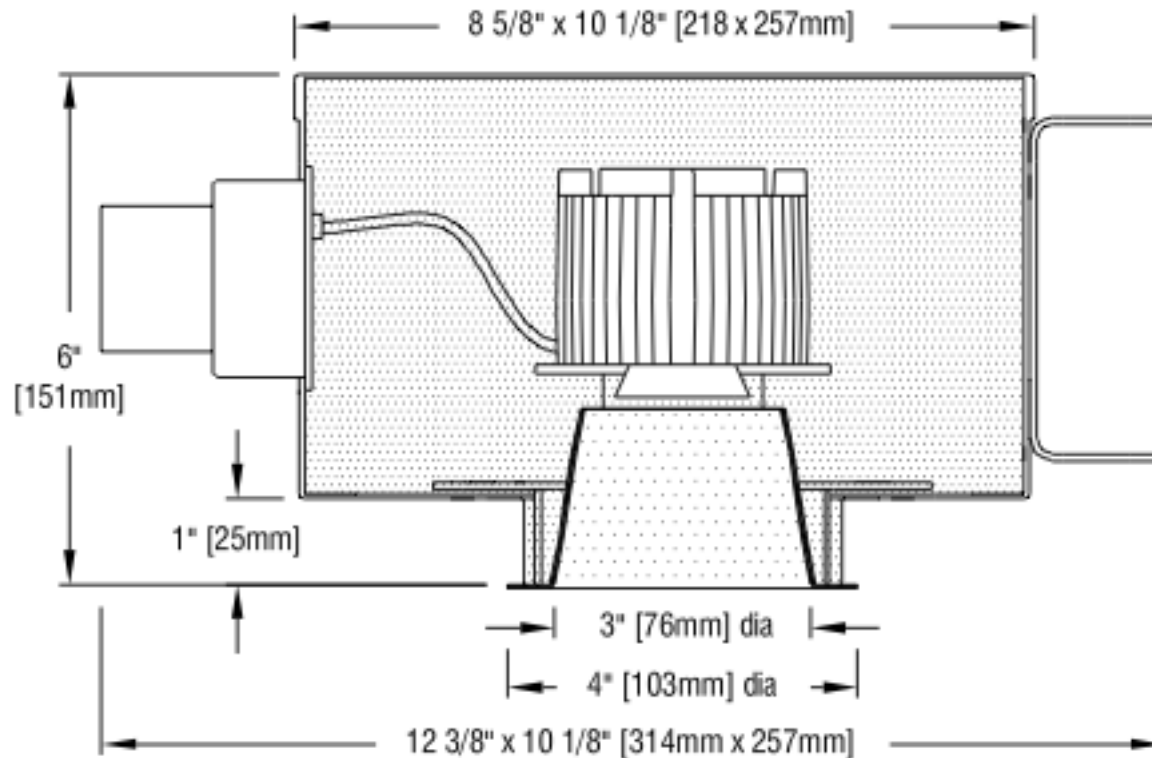
LED recessed fixtures

LUMINAIRE STANDARD CANDLEPOWER DISTRIBUTION

Vertical Angle	Horizontal Angle				
	0	45	90	135	180
0	1042	1042	1042	1042	1042
5	1459	1269	956	714	582
15	2415	1260	390	83	8
25	1379	488	6	0	0
35	237	29	0	2	2
45	0	14	0	0	0
55	0	0	0	0	0
65	0	0	0	0	0
75	0	0	0	0	0
85	0	0	0	0	0
95	0	0	0	0	0

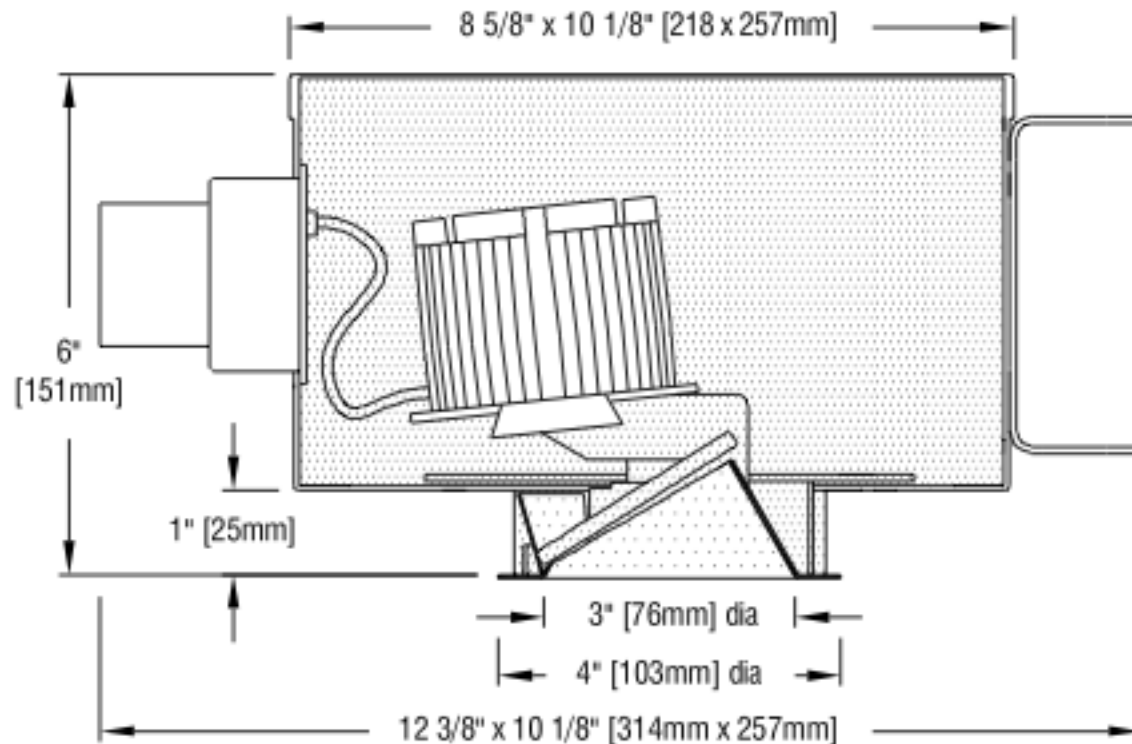


LED recessed fixtures



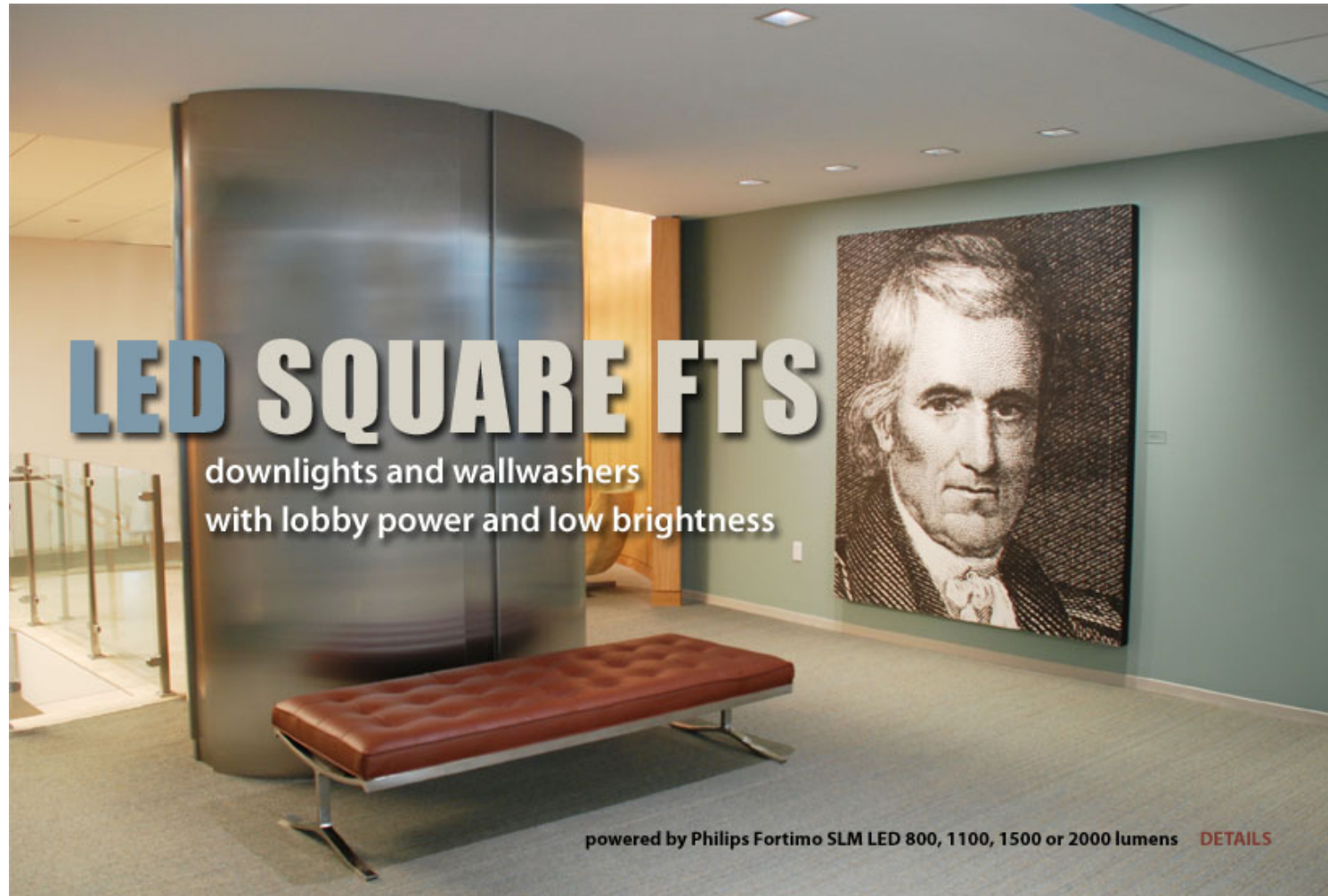
Requires ceiling opening of $3 \frac{3}{4}"$ (95mm) for Overlap or Flush Detail.
Requires ceiling opening of 4" (102mm) for Trim Flush Detail.

LED recessed fixtures

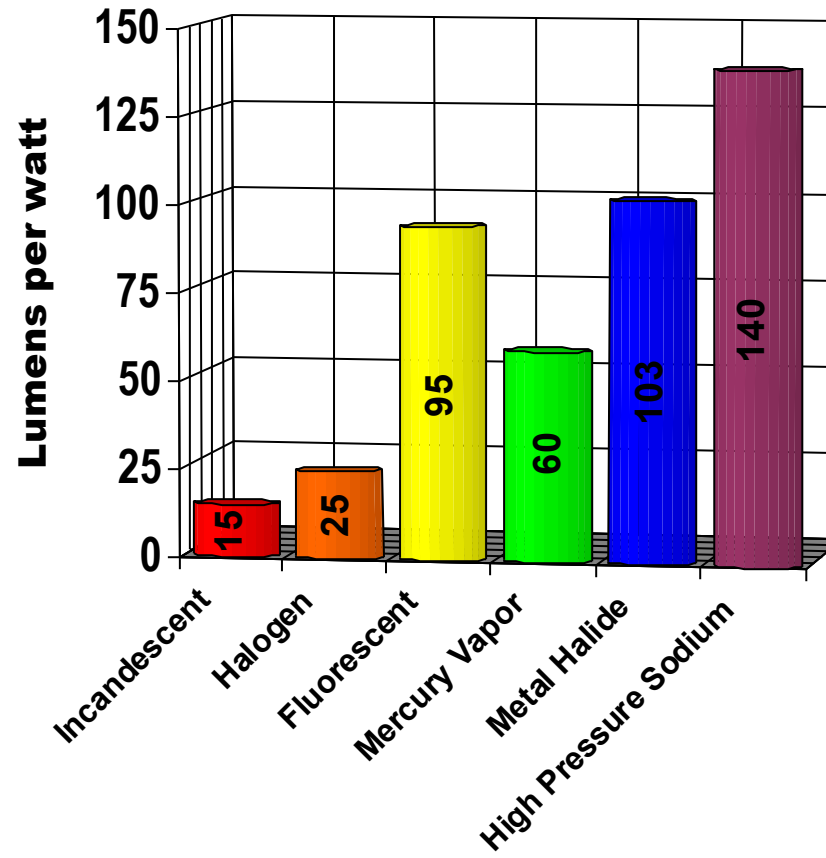


Requires ceiling opening of $3 \frac{3}{4}"$ (95mm) for Overlap or Flush Detail.
Requires ceiling opening of $4"$ (102mm) for Trim Flush Detail.

LED recessed fixtures



Lamp efficacy



Large lamp catalog

Incandescent Lamps

Watts	Bulb	Base	Product Number 046577	Ordering Code	Volts	Flg. Qty.	Description	Class and Filament	LCL (In.)	MOL (In.)	Approximate Hours Life MBCP*	Lumens
75	A-19	Med. A	37472-8	75A	120	48	Frost	C, CC-6		4 1/4	750	1220
			SSS — CONSIDER EARTH LIGHT™ COMPACT FLUORESCENT 20 WATT UNIVERSAL SLS, 18 WATT TABLE LAMP ELT/ OR 18 WATT OUTDOOR EL/O FOR ENERGY SAVINGS									
			27083-5	75A	120	48	Frost	C, CC-6		4 1/4	750	1220
			SSS — CONSIDER EARTH LIGHT COMPACT FLUORESCENT 20 WATT UNIVERSAL SLS, 18 WATT TABLE LAMP ELT/ OR 18 WATT OUTDOOR EL/O FOR ENERGY SAVINGS									
			37473-6	75A	130	48	Frost	C, CC-6		4 1/4	750	1150
			37406-6	75A/99	120-130	48	Frost, Extended Service	C, CC-6		4 1/4	2500	1070
			SSS — CONSIDER EARTH LIGHT COMPACT FLUORESCENT 20 WATT UNIVERSAL SLS, 18 WATT TABLE LAMP ELT/ OR 18 WATT OUTDOOR EL/O FOR ENERGY SAVINGS									
			29689-9	75A/R/S	120	120	Frost, Rough & Vib. Serv.	C, C-17A		3 1/4	1000	830
	A-21	Med. A	24353-5	75A/21	12	120	Frost	C, C-6		9 1/4	1000	1100
	A-19	Med. A	36646-8	75A/CL	12/2	120	24 Clear	C, CC-6	3 1/4	4 1/4	750	1180
			37525-3	75A/CL	130	48	Clear	C, CC-8	3 1/4	4 1/4	750	1195
	A-21	Med. A	31305-6	75A/21	120-130	120	Frost	C, CC-8		5 1/4	1000	1200
			20922-1	75A/RH/TF	12/1	120-130	12 Frost Silicone Coated, Tough Bulb	C, RC-9		5 1/4	1000	
			25668-5	75A/1SBIF	130	120	Frost, Silvered Bowl (43)(64)	C, CC-6		5 1/4	1000	
			20470-1	75A/RH	12/1	120-130	12 Frost, Rough House	C, RC-9		5 1/4	1000	750
	ER-30	Med. A	20572-4	75ER30	120	24	Elliptical Reflector (19)(37)(87)	C, CC-6		6 1/4	2000	
			29636-8	75ER30	130	24	Elliptical Reflector (19)(37)(87)	C, CC-6		6 1/4	2000	
	K-19	Med. A	22487-3	75K19/DL	6/2	120	12 Director®	C, CC-6		4 1/4	1150	1000
	PAR-36	M-P	26278-2	75PAR36/VWSP	12	12	*PAR Compact Very Narrow Spot	C, C-6		2 1/4	2000	
	PAR-38	Med/Skt.	37408-2	75PAR38/2FL	120-130	12	*PAR Cool Beam Flood (52)(82)	C, CC-6		5 1/4	2000	750
		Med/Side Frong	23245-4	75PAR/3FL	120	12	*PAR Compact Flood(32)	C, CC-6		4 1/4	2000	750
			23246-2	75PAR/3SP	120	12	*PAR Compact Spot(32)	C, CC-6		4 1/4	2000	750
	PAR-30S	Med. E	28470-4	75PAR30S/HAL/NSP10	120	15	N. Spot 10 Deg.(86)	C, CC-8		3 1/4	2000	20,000 965
			28489-5	75PAR30S/HAL/NFL30	120	15	N. Flood 30 Deg.(86)	C, CC-8		3 1/4	2000	3900 965
			28491-9	75PAR30S/HAL/FL40	120	15	Flood 40 Deg.(86)	C, CC-8		3 1/4	2000	1900 965
			28492-7	75PAR30S/HAL/FL40	130	15	Flood 40 Deg.(86)	C, CC-8		3 1/4	2000	1900 965
	PAR-30L	Med. E	22930-2	75PAR30L/HAL/NSP9	120	15	N. Spot 9 Deg.(86)	C, CC-8		4 1/4	2000	15,500 940
			22934-4	75PAR30L/HAL/SP16	120	15	Spot 16 Deg.(86)	C, CC-8		4 1/4	2000	6700 940
			22941-9	75PAR30L/HAL/NFL30	120	15	N. Flood 30 Deg.(86)	C, CC-8		4 1/4	2000	3400 940
			22943-5	75PAR30L/HAL/NFL30	130	15	N. Flood 30 Deg.(86)	C, CC-8		4 1/4	2000	3400 940
			22944-3	75PAR30L/HAL/FL40	120	15	Flood 40 Deg.(86)	C, CC-8		4 1/4	2000	2200 940
			22945-0	75PAR30L/HAL/FL40	130	15	Flood 40 Deg.(86)	C, CC-8		4 1/4	2000	2200 940
	PAR-38	Med. E	28782-1	75PAR38/HAL/SP10/WLL	120	12	Spot 10 Deg.(86)	C, CC-8		5 1/4	2500	22,000 1050
		Skt.	28783-9	75PAR38/HAL/SP10/WLL	130	12	Spot 10 Deg.(86)	C, CC-8		5 1/4	2500	22,000 1050
			28784-7	75PAR38/HAL/FL28/WLL	120	12	Flood 28 Deg.(86)	C, CC-8		5 1/4	2500	4800 1050
			28785-4	75PAR38/HAL/FL28/WLL	130	12	Flood 28 Deg.(86)	C, CC-8		5 1/4	2500	4800 1050
	R-20	Med.	35460-5	75R20	120	12	LL Frost, Reflector(87)	C, C-9		3 1/4	2000	800
			SSS — CONSIDER 50BR19/23/SP or 50PAR20/H/NFL 120 VOLT FOR ENERGY SAVINGS									
	BR-30	Med. A	24903-7	75BR30/FL/TF	120	12	Frost Silicone Coated, Reflector	C, CC-6		5 1/4	2000	

□ Exclusive Philips Product

SSS — Energy Saving Product

*Maximum Beam Candlepower

▲ Aluminum Base

† New Since Last Printing

X — Orders will be shipped until inventory is depleted; no longer manufactured

Footnotes located on page 45

(E) Means This Bulb Meets US Federal Minimum Efficiency Standard

*♦ For more information when operated at 120V see pages 43-45

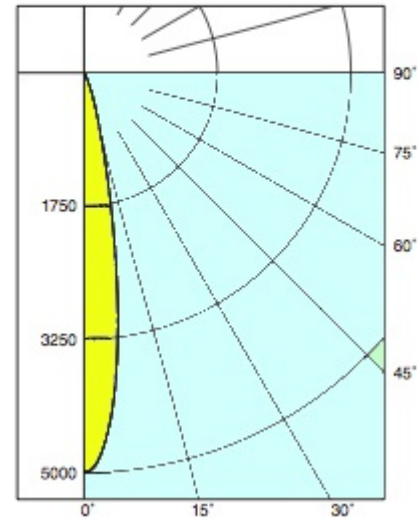
LED vs. MH comparison



Photometry

LRP38A92-20D40

Based on OnSpex 30014165



CREE #LRP-38 12-watt LED “replacement lamp”

LED vs. MH comparison



Lightolier #8111 track fixture with 20-watt metal halide lamp

LED vs. MH comparison

Manufacturer	Product	Light source	Beam		Life	CBCP	CCT	CRI	Lumens	Efficacy (l/w)
			angle	Wattage						
CREE	LRP-38	LED	20	12	50,000 *	4800	2700	94	600	42
Lightolier	24MHT4RNF	20-watt MH	22	26	15,000	5408	3000	84	1800	69
Lightolier	24MHT4RS	20-watt MH	10	26	15,000	17240	3000	84	1800	69

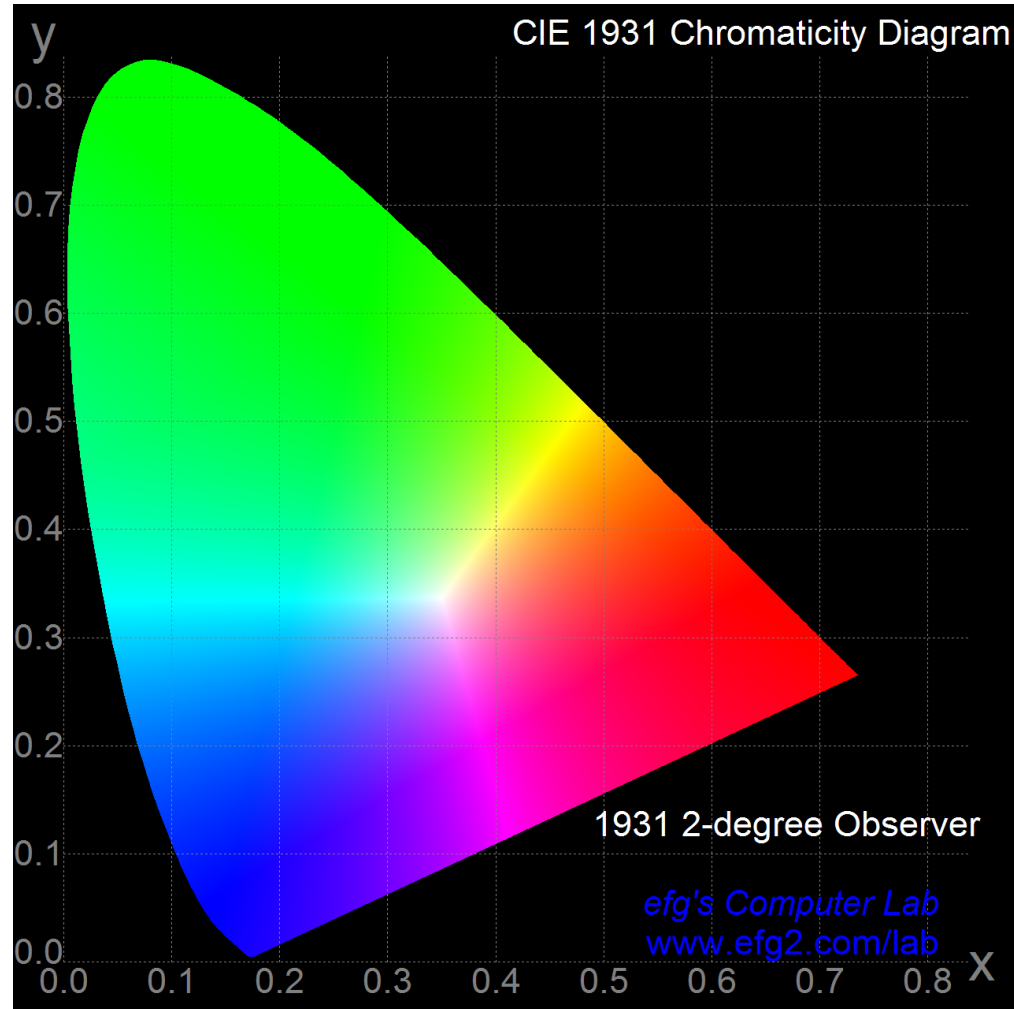
Note for LRP-38:

Energy Star qualified to last at least 25,000 hours

Designed to last 50,000 hours in open fixtures

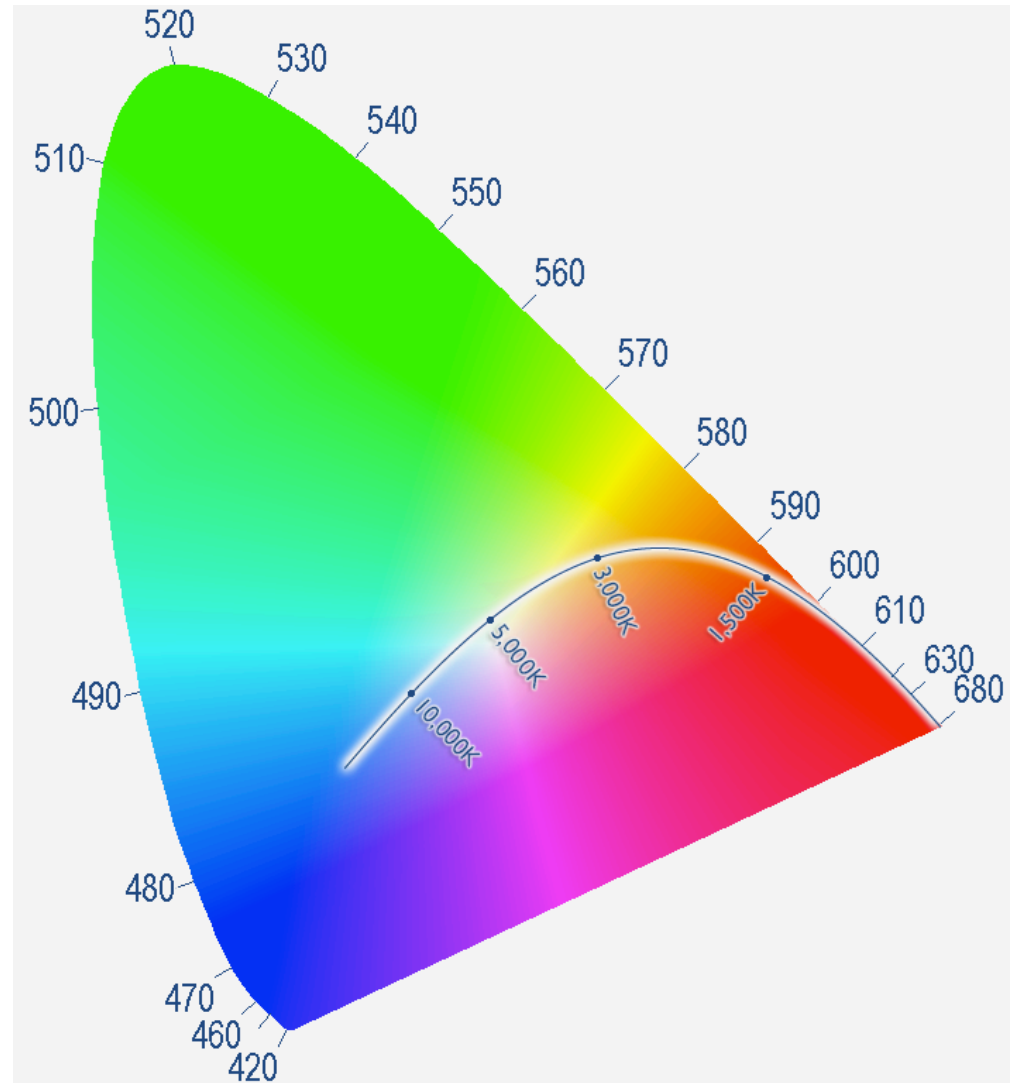
Designed to last 35,000 hours in non-IC recessed fixtures

CIE chromaticity diagram

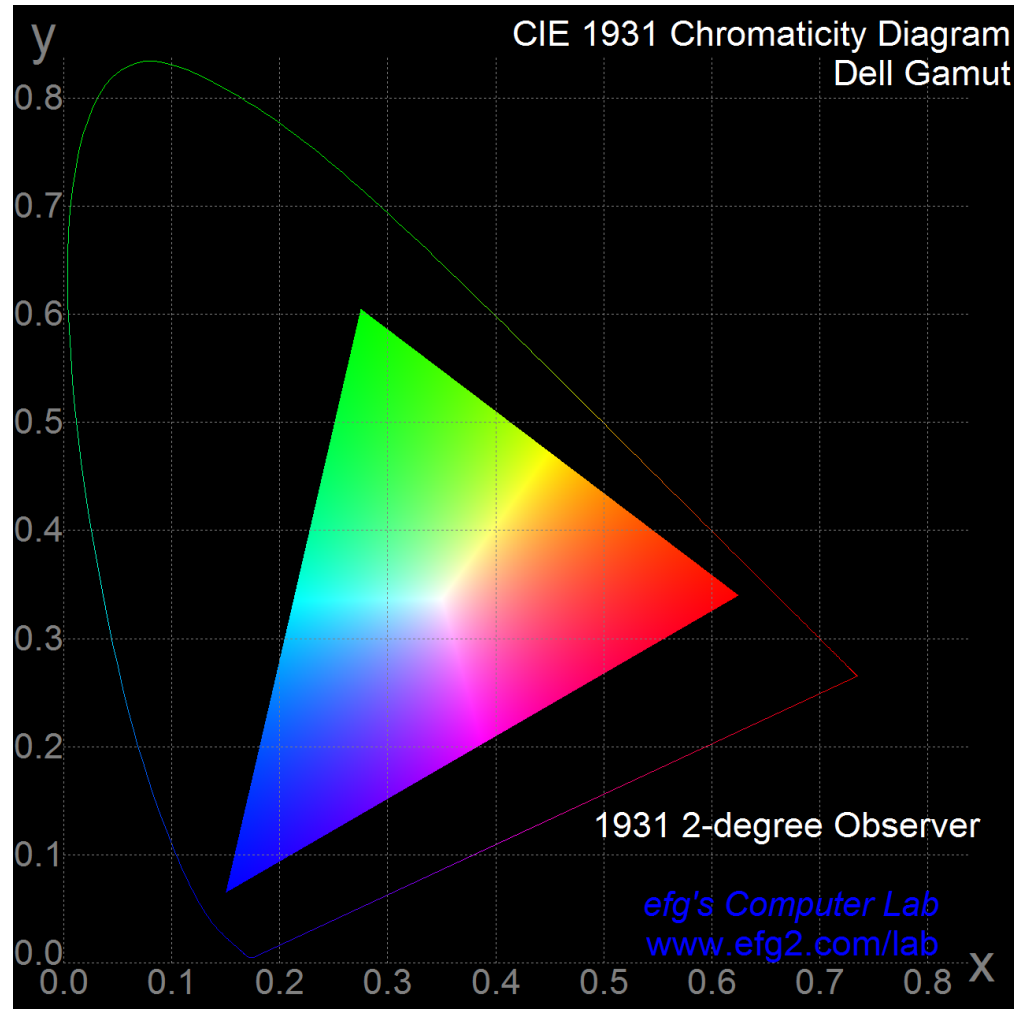


CIE chromaticity diagram

- Can be used to describe the color of a light source
- The curved line is the “blackbody locus”. An incandescent light source will have a coloration somewhere on this line.

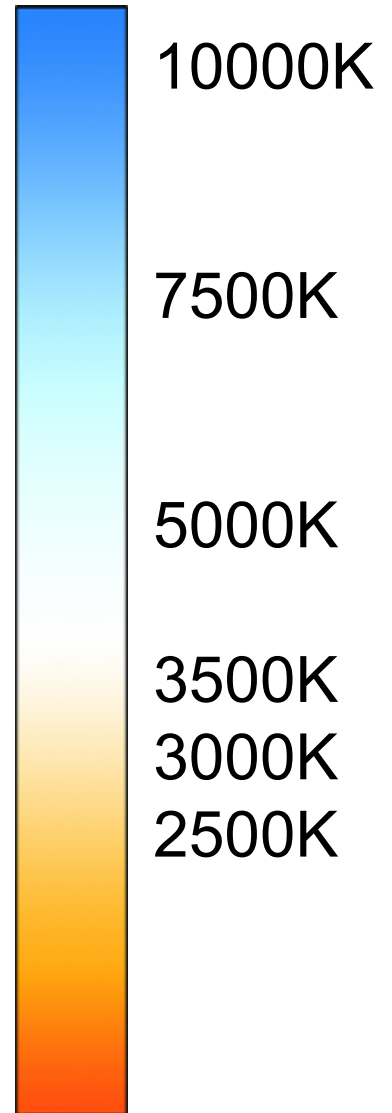


CIE chromaticity diagram



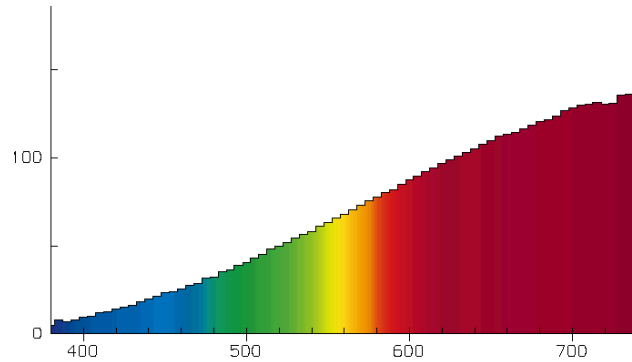
Correlated color temperature (CCT)

- Expression of “coolness” or “warmth” of light source appearance
- Measured in Kelvin (K)
- The higher the temperature, the cooler the color of the source appears

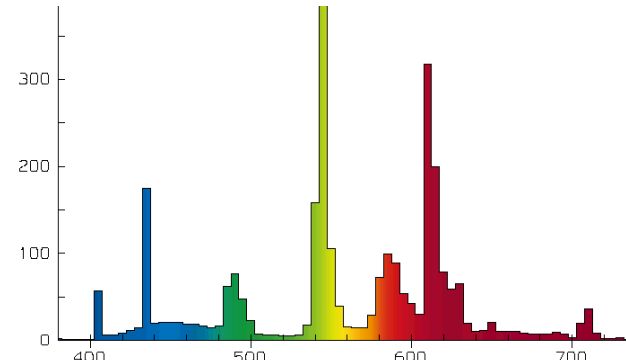


Spectral power distribution

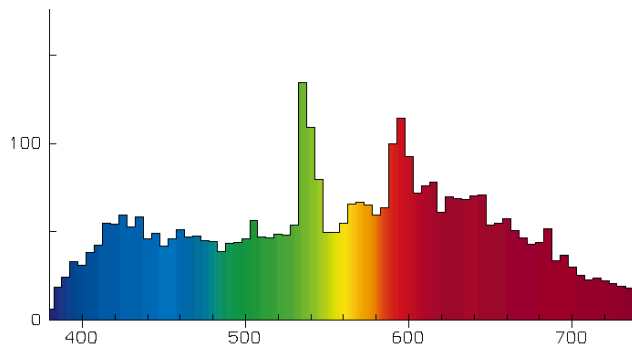
90PAR38/Halogen



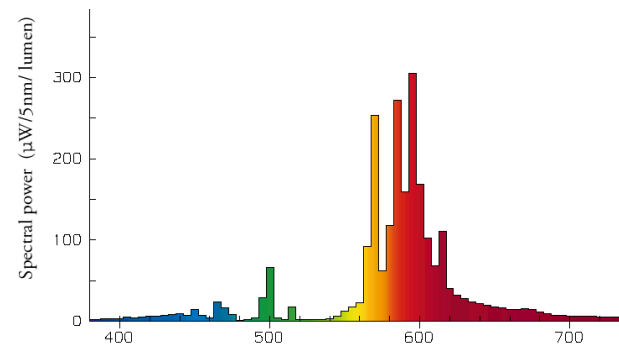
F32T8/835



70-watt ceramic MH

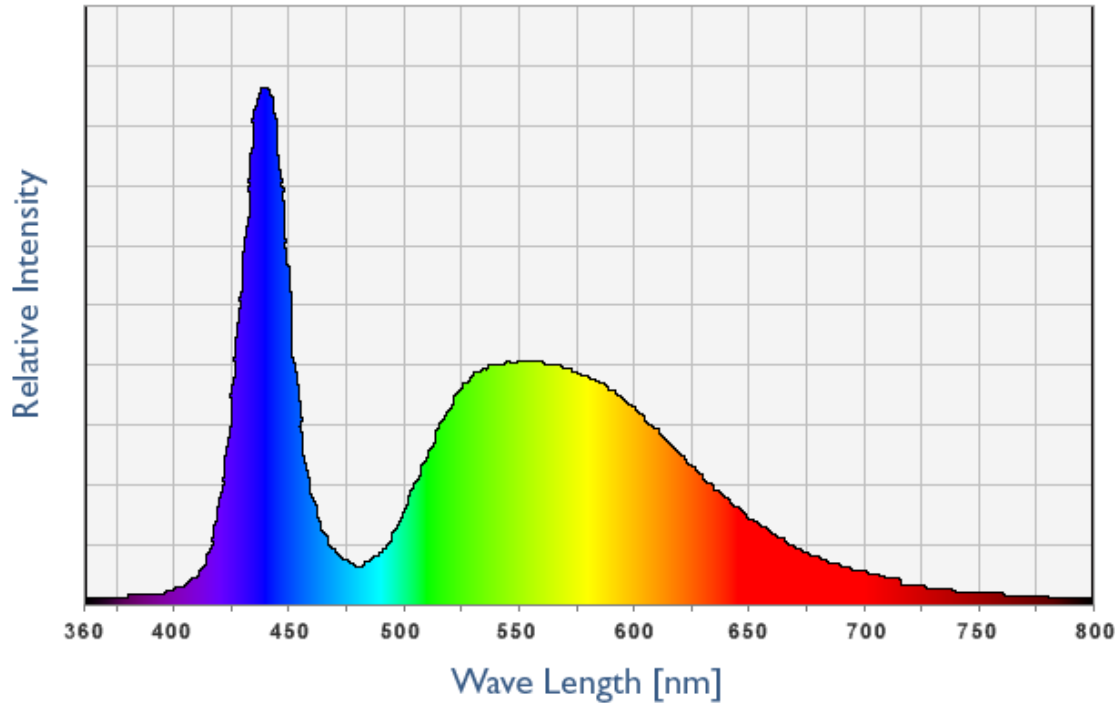


400-watt HPS



LED – SPD curve

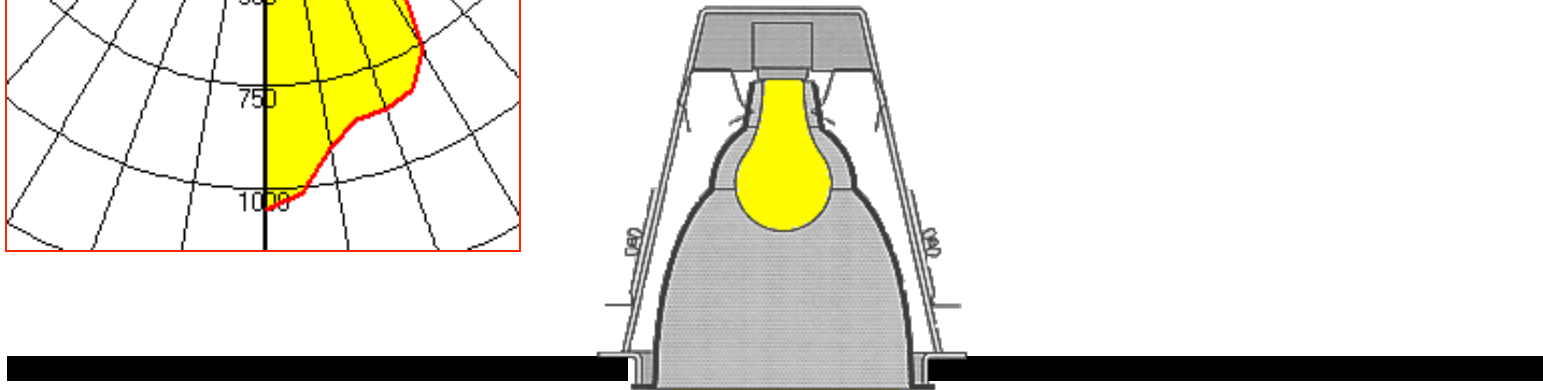
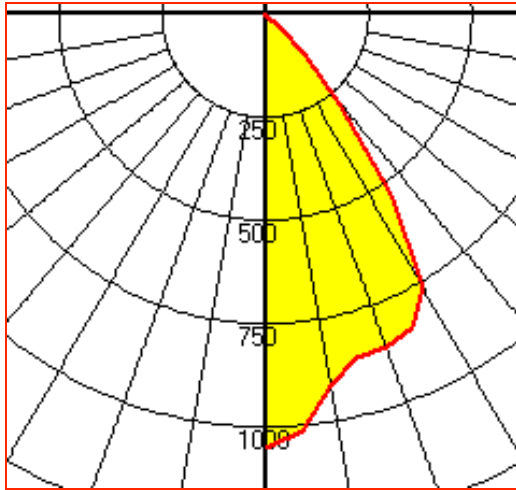
5500K White LED (InGaN + Phosphor)



PG&E Pacific Energy Center 2007

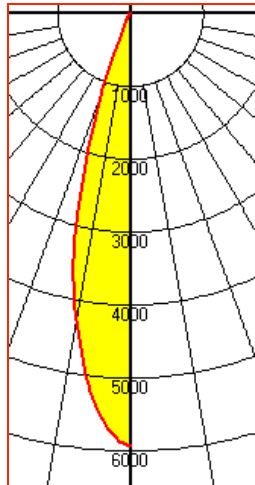
- Continuous curve
- Blue weighted
- Varies for color LEDs

Downlight efficiency



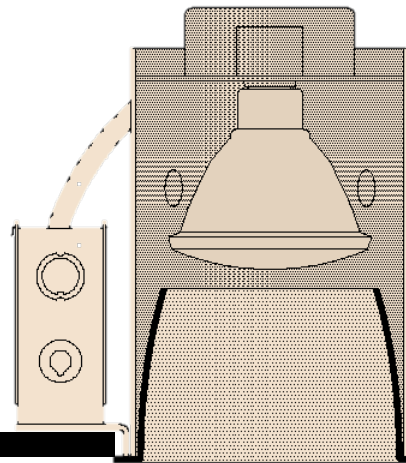
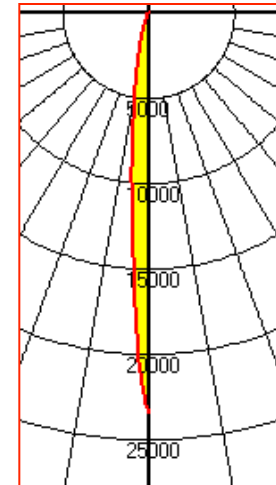
A-lamp downlight
Efficiency = 67.2%

Downlight efficiency



(40° flood)

(10° spot)



PAR-lamp downlight

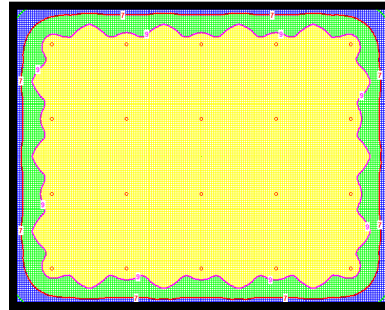
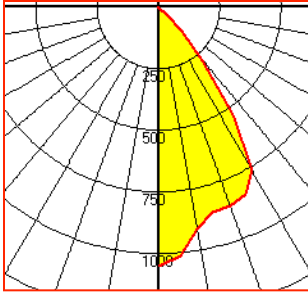
Efficiency = 68.8% - 75%

Distribution & uniformity

(20)

A

9.2



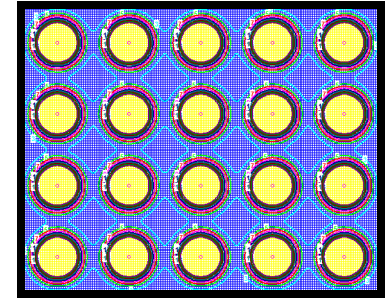
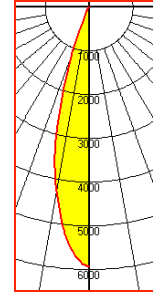
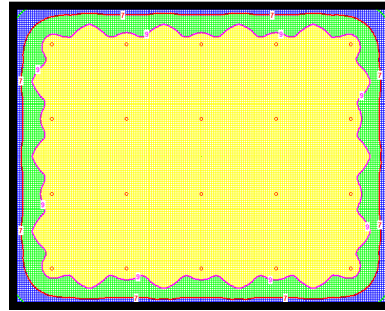
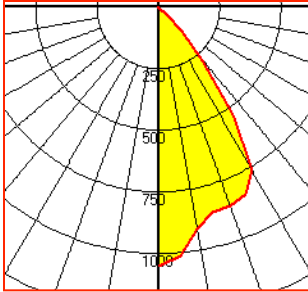
A = 100A19/IF incandescent

Distribution & uniformity

(20)

A

9.2



(20)

B

11.8

A = 100A19/IF incandescent

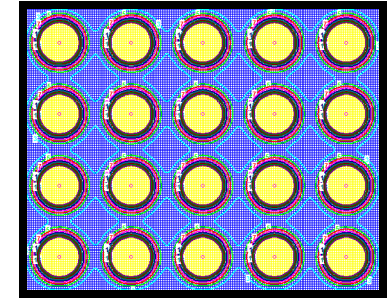
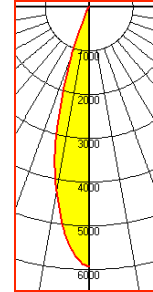
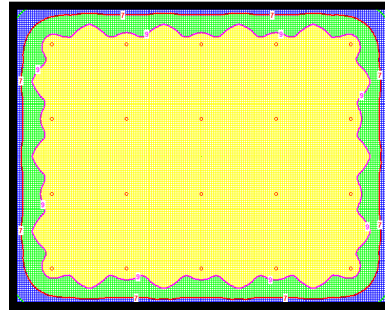
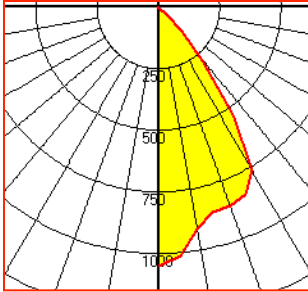
B = 100PAR38/FL incandescent

Distribution & uniformity

(20)

A

9.2



(20)

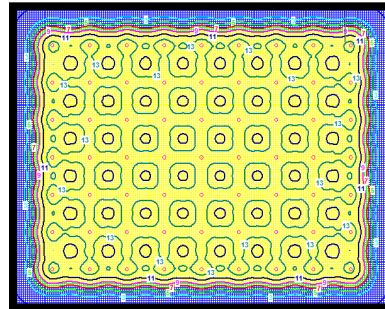
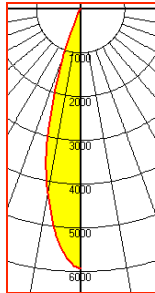
B

11.8

(63)

C

10.2



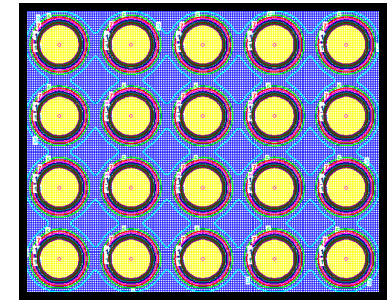
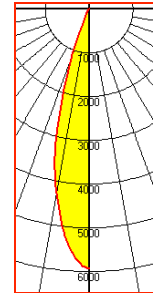
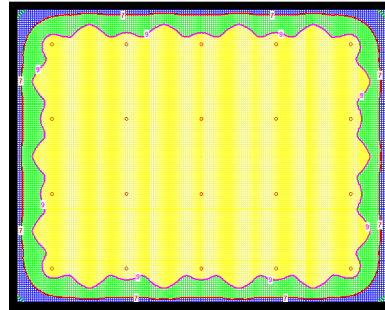
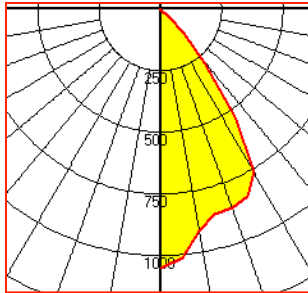
A = 100A19/IF incandescent
B = 100PAR38/FL incandescent
C = 45PAR38/FL incandescent

Distribution & uniformity

(20)

A

9.2



(20)

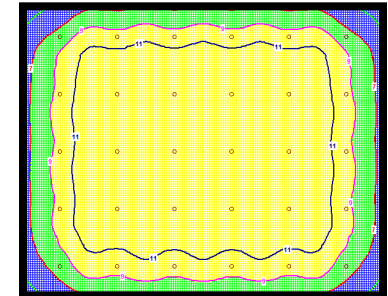
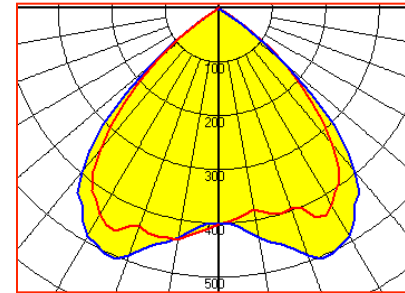
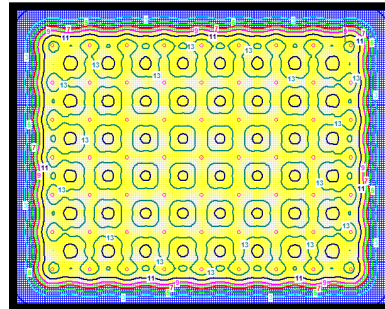
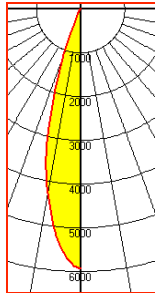
B

11.8

(63)

C

10.2



(30)

D

10.3

A = 100A19/IF incandescent

B = 100PAR38/FL incandescent

C = 45PAR38/FL incandescent

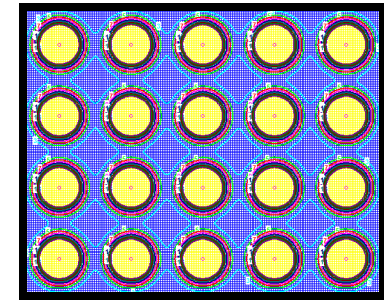
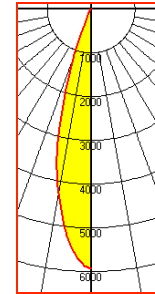
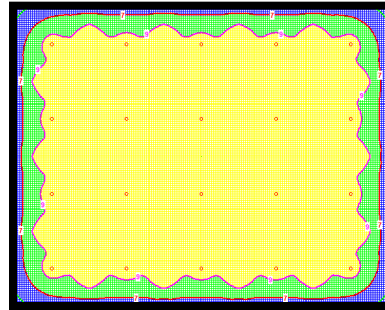
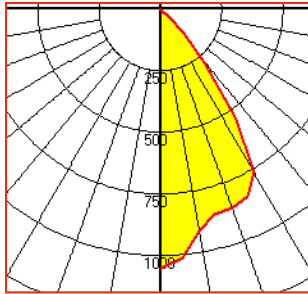
D = (2) 13-watt CFL

Distribution & uniformity

(20)

A

9.2



(20)

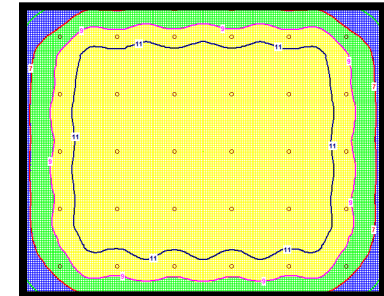
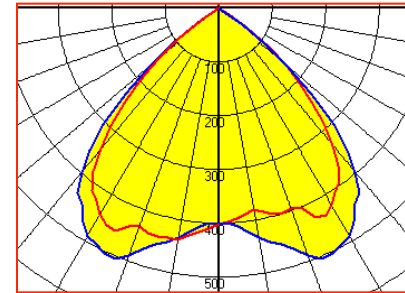
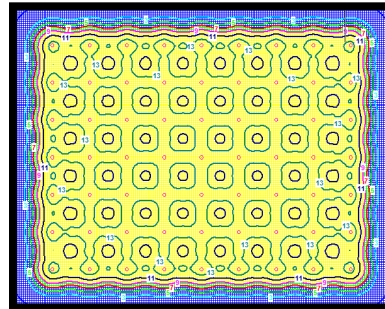
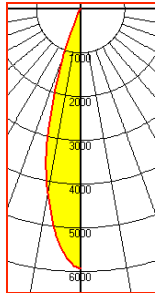
B

11.8

(63)

C

10.2



(30)

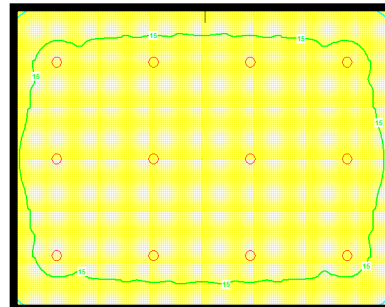
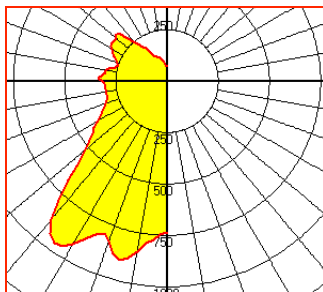
D

10.3

(12)

E

16.2



A = 100A19/IF incandescent

B = 100PAR38/FL incandescent

C = 45PAR38/FL incandescent

D = (2) 13-watt CFL

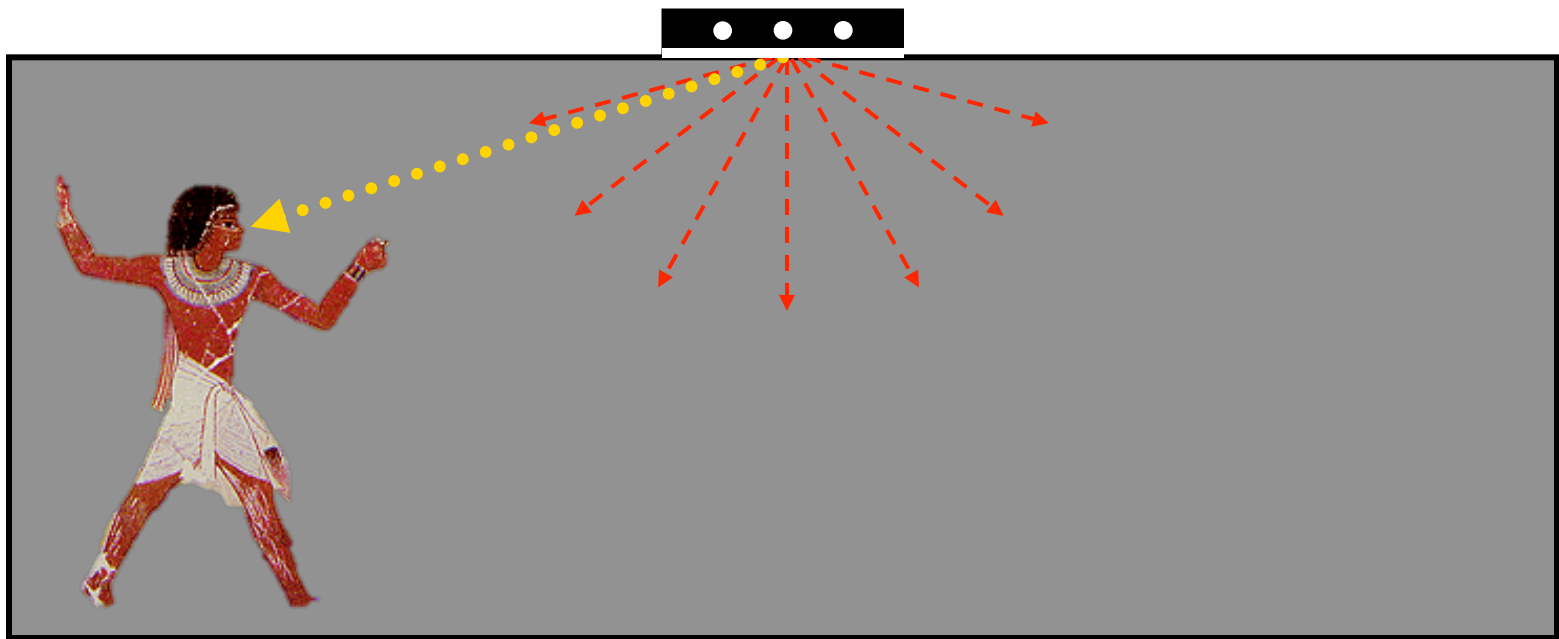
E = 70-watt Metal Halide

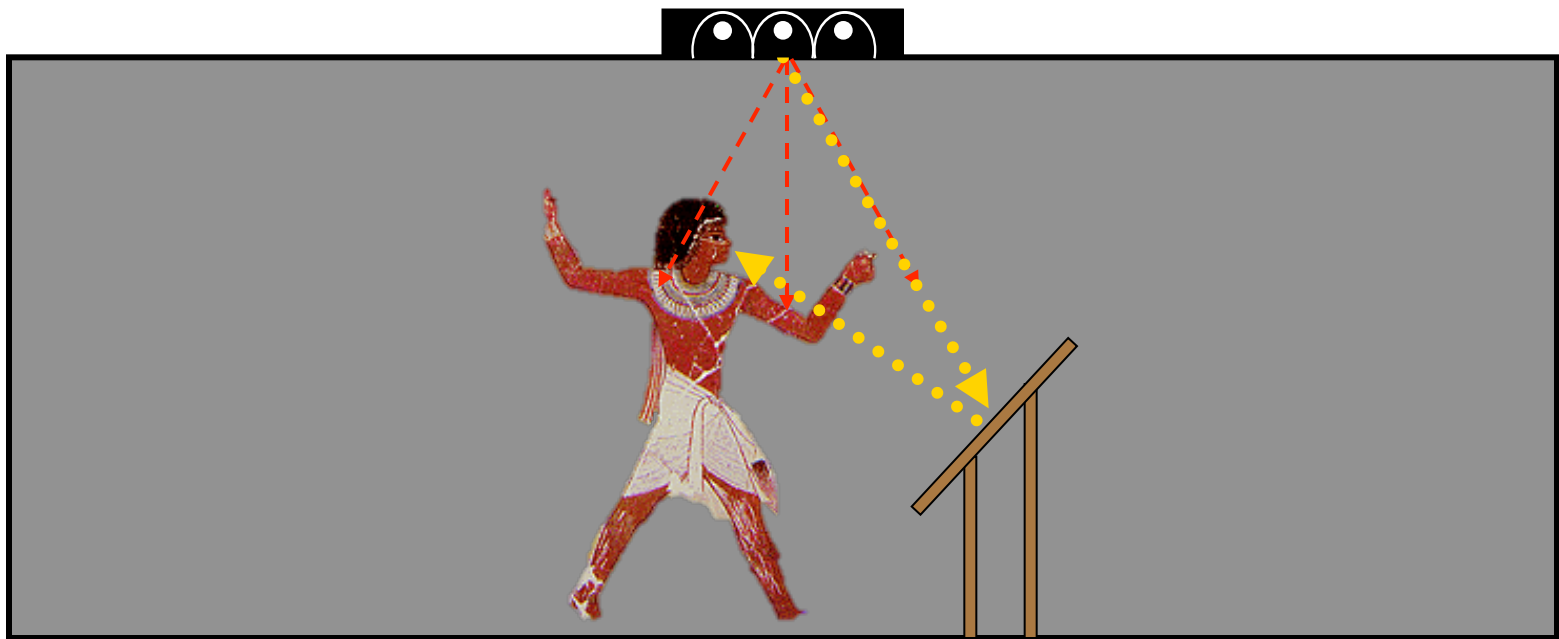
50' x 40' x 10' lobby lighting

fixture, wattage & light level comparison

Fixture	Efficiency	Lamp	Watts Each	# of Fixtures	Total Wattage	Power Density
A-lamp	67.2	100A19/IF	100	20	2000	1.00
PAR-lamp	68.8	100PAR38/HIR 40	100	20	2000	1.00
PAR-lamp	68.8	45PAR38/FL30	45	63	2835	1.42
CFL	50.5	(2) 13-watt QFL	28.6	30	858	0.43
MH pendant	87.7	70-watt MH clear	75	12	900	0.45

Fixture	Lumens Each	Total Lumens	Average fc.	Maximum fc.	Max/Min	Spacing ratio	O.C. spacing
A-lamp	1700	34000	9.2	10.8	2.9:1	1.02	10'
PAR-lamp	2070	41400	11.8	45.6	32.6:1	0.46	10'
PAR-lamp	560	35280	10.2	14.9	16.6:1	0.46	5'
CFL	1800	54000	10.3	12.7	3.2:1	1.59	8'
MH pendant	5600	67200	16.2	19.5	2.1:1	1.54	13'



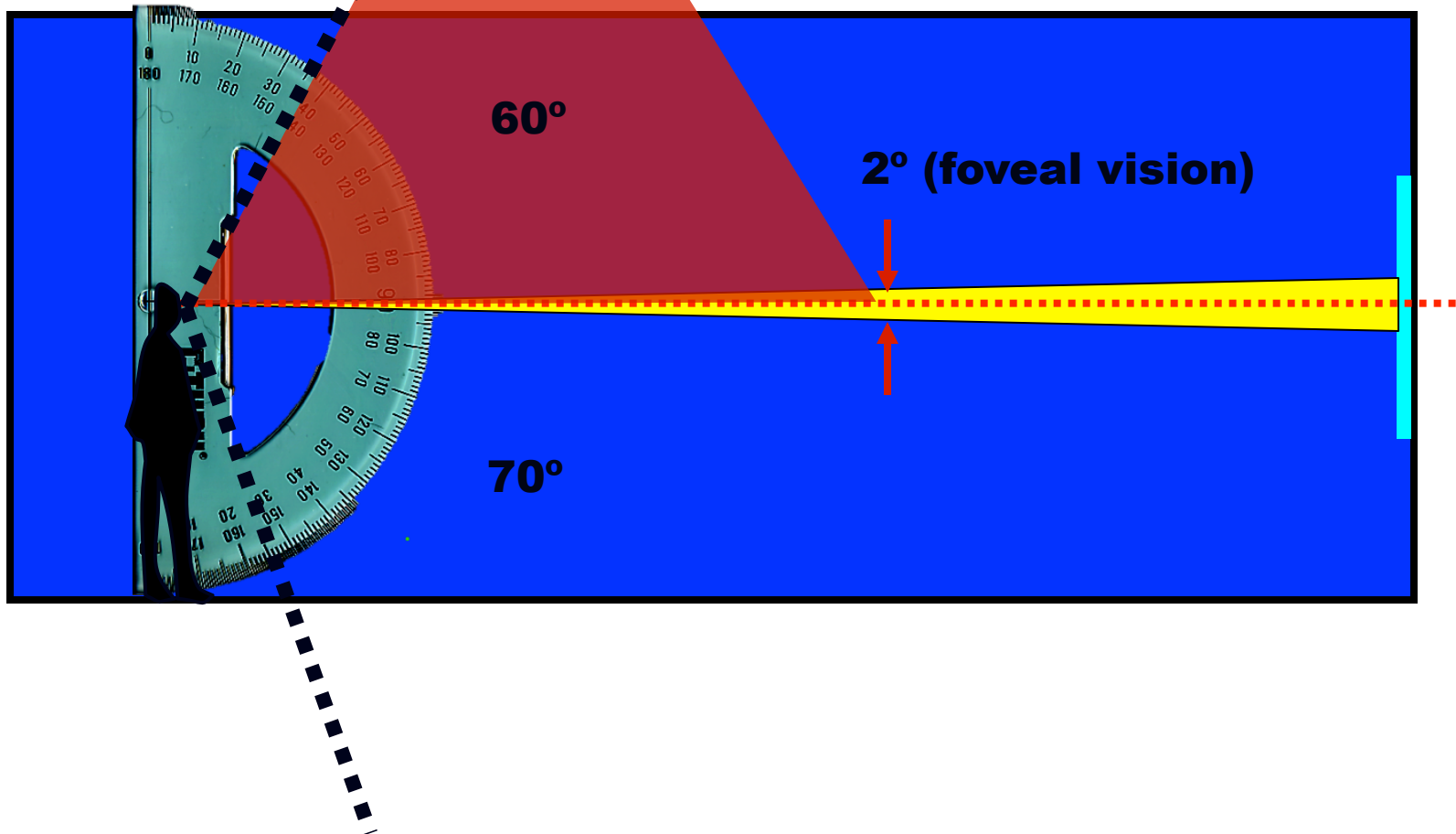




**Audience
experiment**

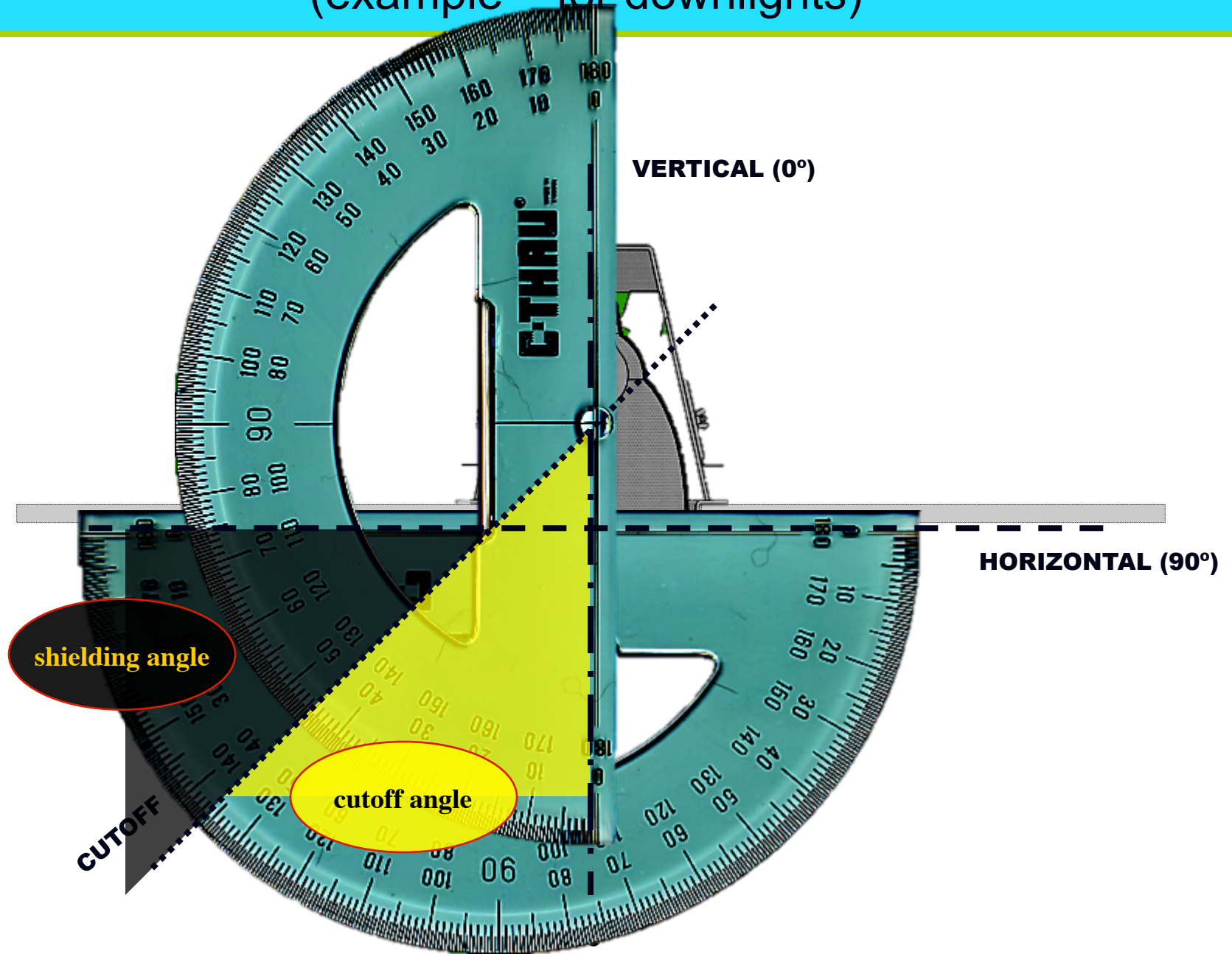
Vision

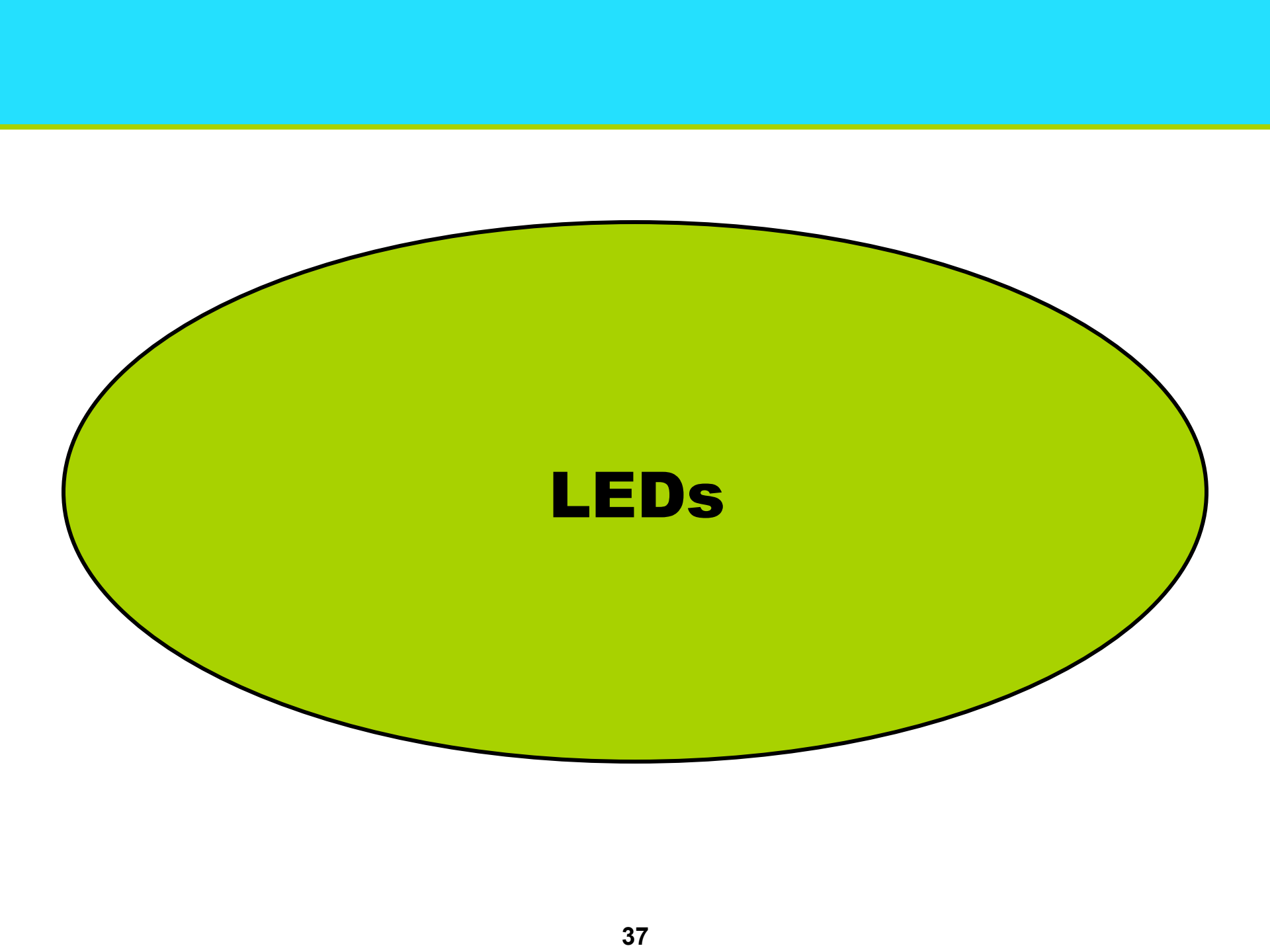
Visual field – in the vertical plane



Cutoff vs. shielding angles

(example – for downlights)





LEDs

LED MR16 “replacement lamps”



LED PAR38 lamp; 4" & 6" O.D. downlights



Evaluating LEDs: The CALiPER Program

- Commercially Available LED Product Evaluation & Reporting
- Developed & managed by DOE Solid State Lighting Program
- Tests specific LED products under real-world conditions for light output, color performance, etc.
- Frequently, the reality doesn't live up to manufacturers' claims.
- <http://www1.eere.energy.gov/buildings/ssl/caliper.html>





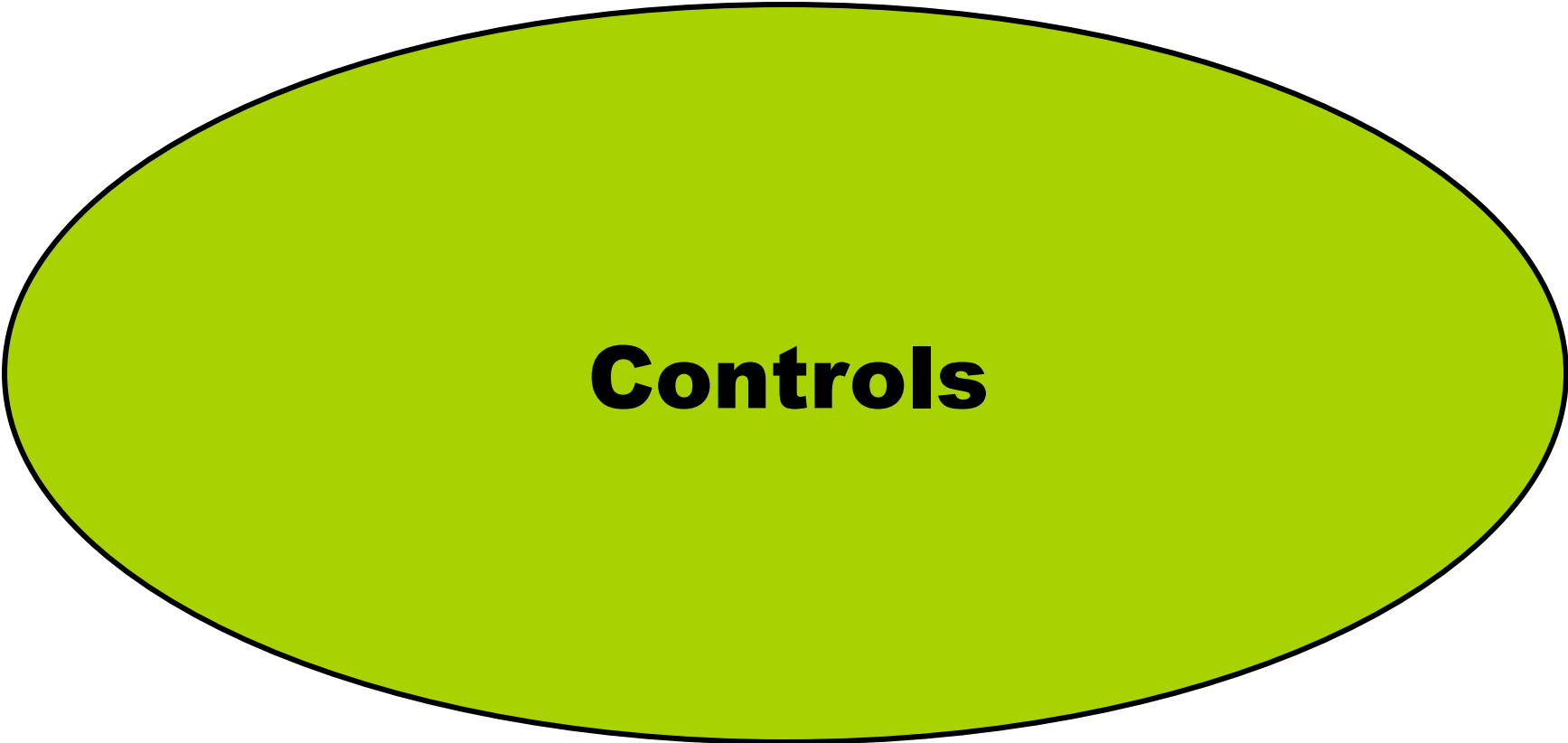












Controls

Lutron CL dimmers



Lutron Maestro wireless dimmer & remote



Lutron Maestro wireless occupancy sensor

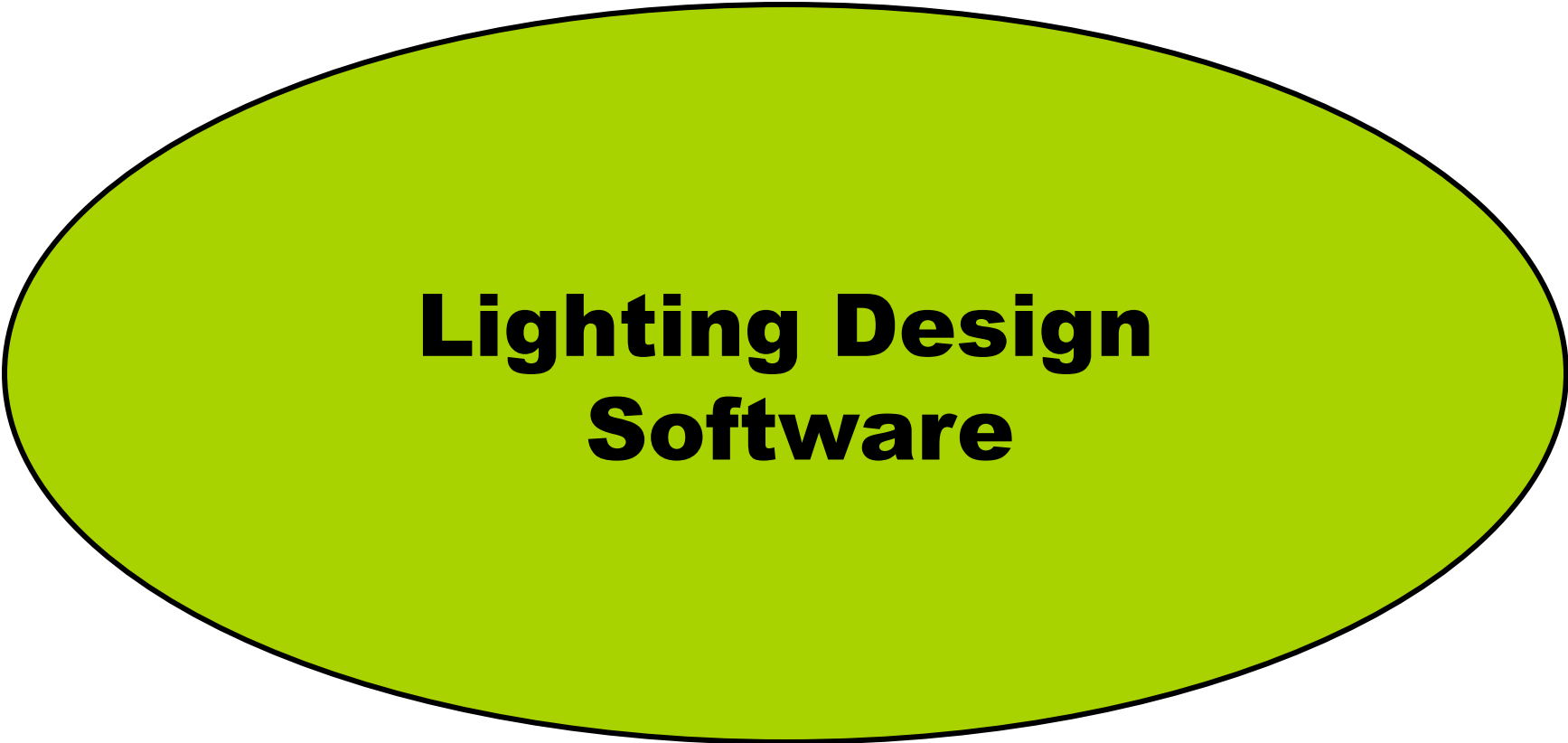
Wireless Wall-Mount Occupancy and Vacancy Sensors

369-268 1 06.29.10

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Lighting Design Software