Light that is right

Optics 101

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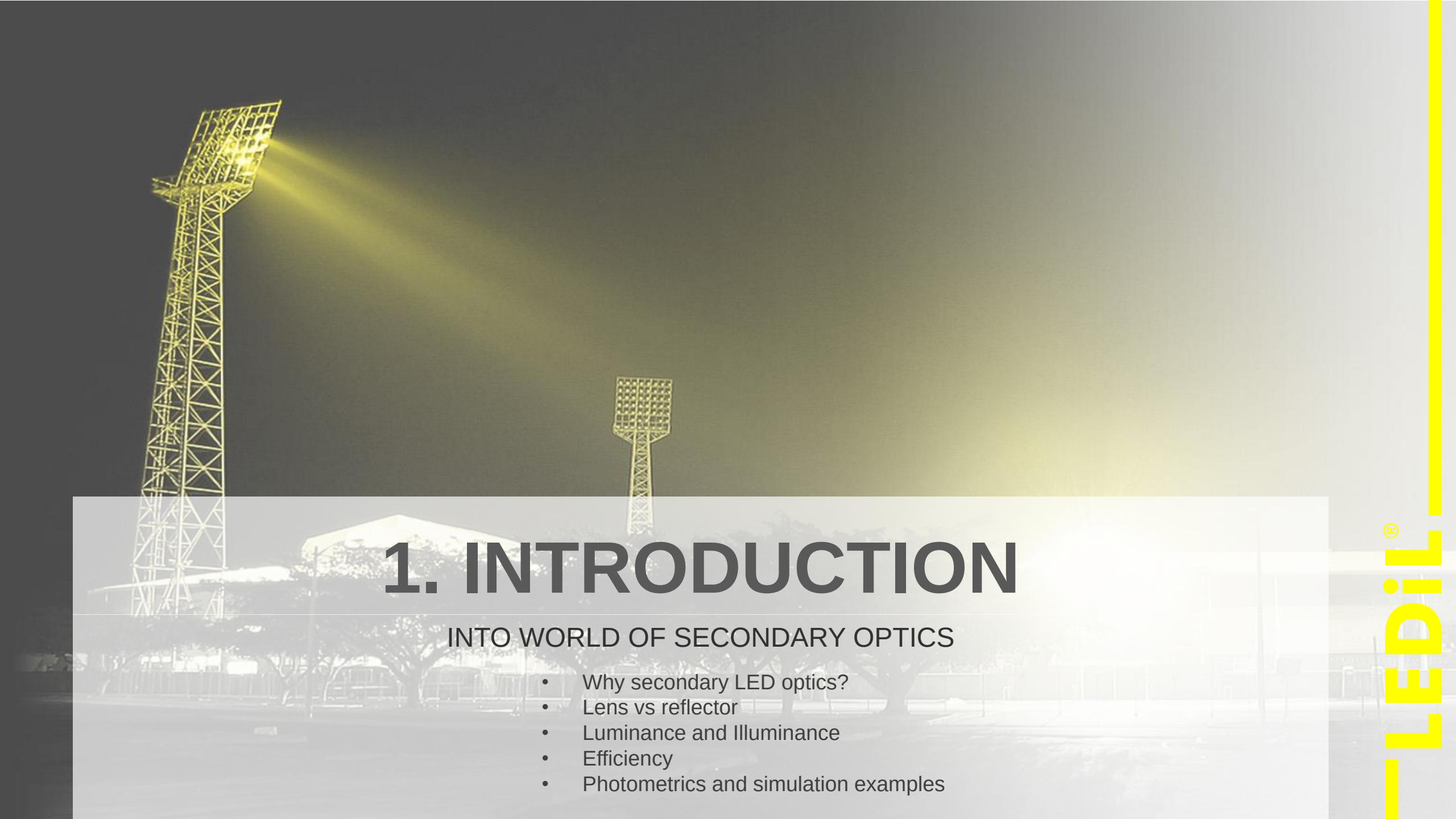


1. INTRODUCTION

INTO WORLD OF SECONDARY OPTICS

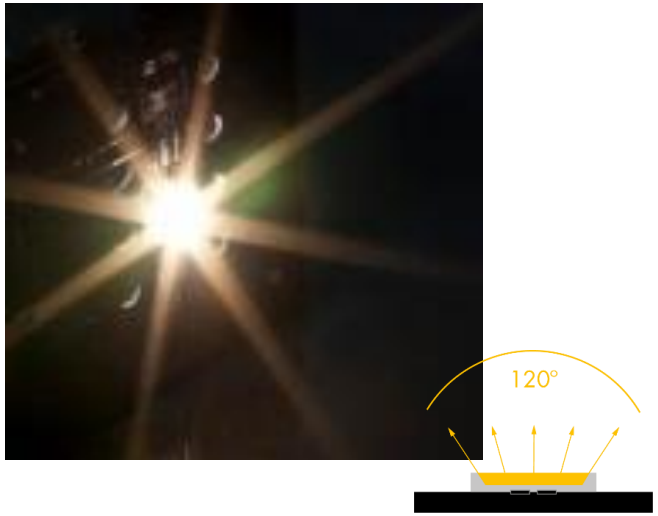
- Why secondary LED optics?
- Lens vs reflector
- Luminance and Illuminance
- Efficiency
- Photometrics and simulation examples

Why secondary LED optics?

Light where you need it

LED without optics

- All LEDs emit light in many directions!
- Uncomfortably bright (glare)
- Relatively low intensity
- Suitable for simple applications



LED with secondary optics

- Enables light management
- Pleasant light, reduced glare
- Enables advanced lighting design
- Choose between lenses or reflectors

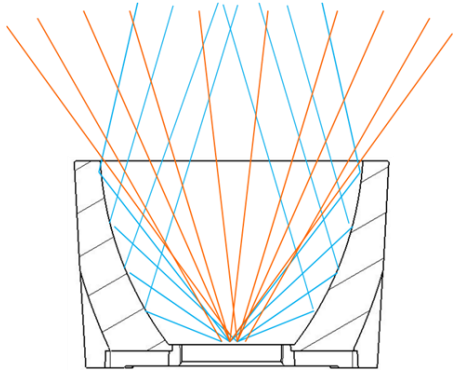
Lens vs Reflector

Same FWHM – different size, appearance & performance

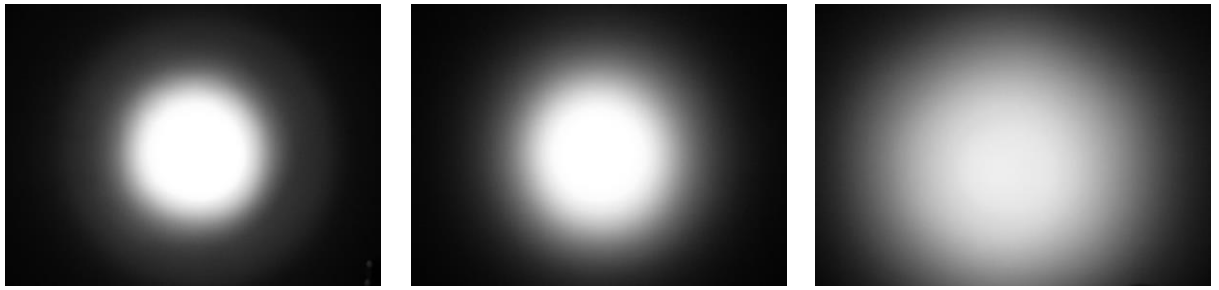
Beams that are controlled by an optical surface

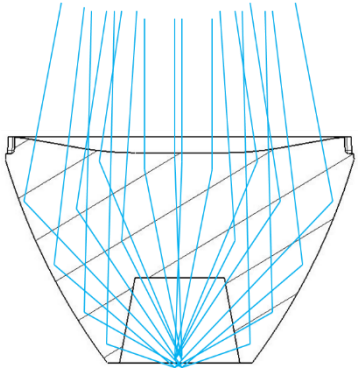
Beams that do not touch any optical surface

REFLECTOR

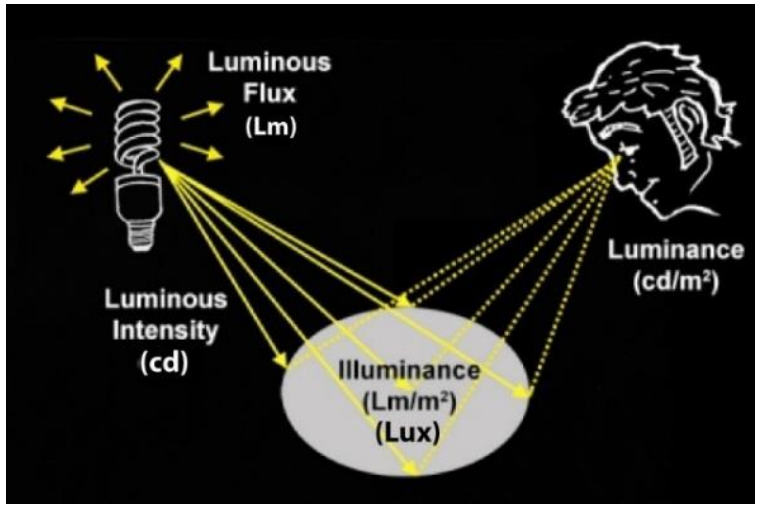


TIR-LENS

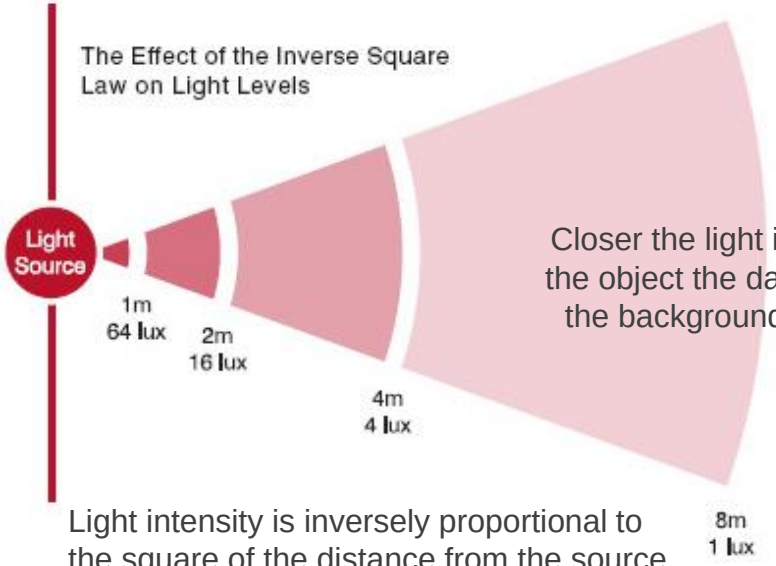




Luminance & Illuminance



Term	Measure	What does it mean?
Luminous flux	lm	Total light emited by a source
Luminous intensity	cd	Light emitted in specific direction
Illuminance	lux (or lm/m2)	Light falling on surface
Luminance	cd/m2	Perceived brightness of surface



Closer the light is to the object the darker the background is

Light intensity is inversely proportional to the square of the distance from the source

Lux Level	Work Activity and Function	Example of User Area
20 - 80	Public walking	Public parks and open-air carparks
100 - 140	Casual non-visual task	Corridors, changing rooms, office restrooms
150 - 180	Some perception of detail	Warehouses, stores, plant rooms, lift lobbies
200 - 240	Continuous occupation	Entrance halls, dining rooms
250 - 300	Very easy visual task	Public toilet, classrooms
300 - 400	Moderately easy visual task	Private office, libraries, lecture theatres
500 – 600	Moderately difficult visual task	Offices, laboratories, retail outlets
750 – 900	Difficult visual task	Supermarkets, technical drawing offices
1000 – 1300	Very difficult visual task	Operating theatres, polishing and painting plant
1500 – 1800	Extremely difficult visual task	Assembly plants, inspection plants
>2000	Exceptionally difficult visual task	Precision assembly, fine work inspection


10 000 lx

100 000 lx

Recommended light levels (lux) for different work spaces

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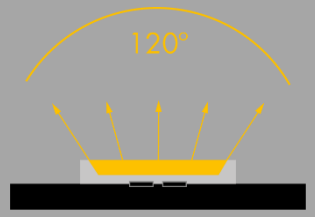
Efficiency

- **Luminous efficiency** is a measure of how well a light source produces visible light. It's a ratio of luminous flux to power of light source (lm/W).
- **Optical efficiency** is a percentage of how much of the produced flux is actually extracted from luminaire (Efficiency % or Light Output Ratio, LOR%)

LED only



LOR 100 %

In use efficacy may suffer as light is not always directed to the target.

Street lighting optics

Typ. LOR >90 %

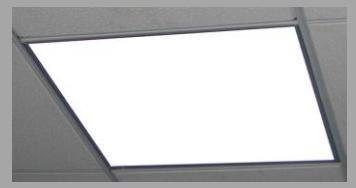
Efficiency requirements from tenders. In use efficacy is very important.

Indoor lighting lenses & reflectors

Typ. LOR 80–90 %

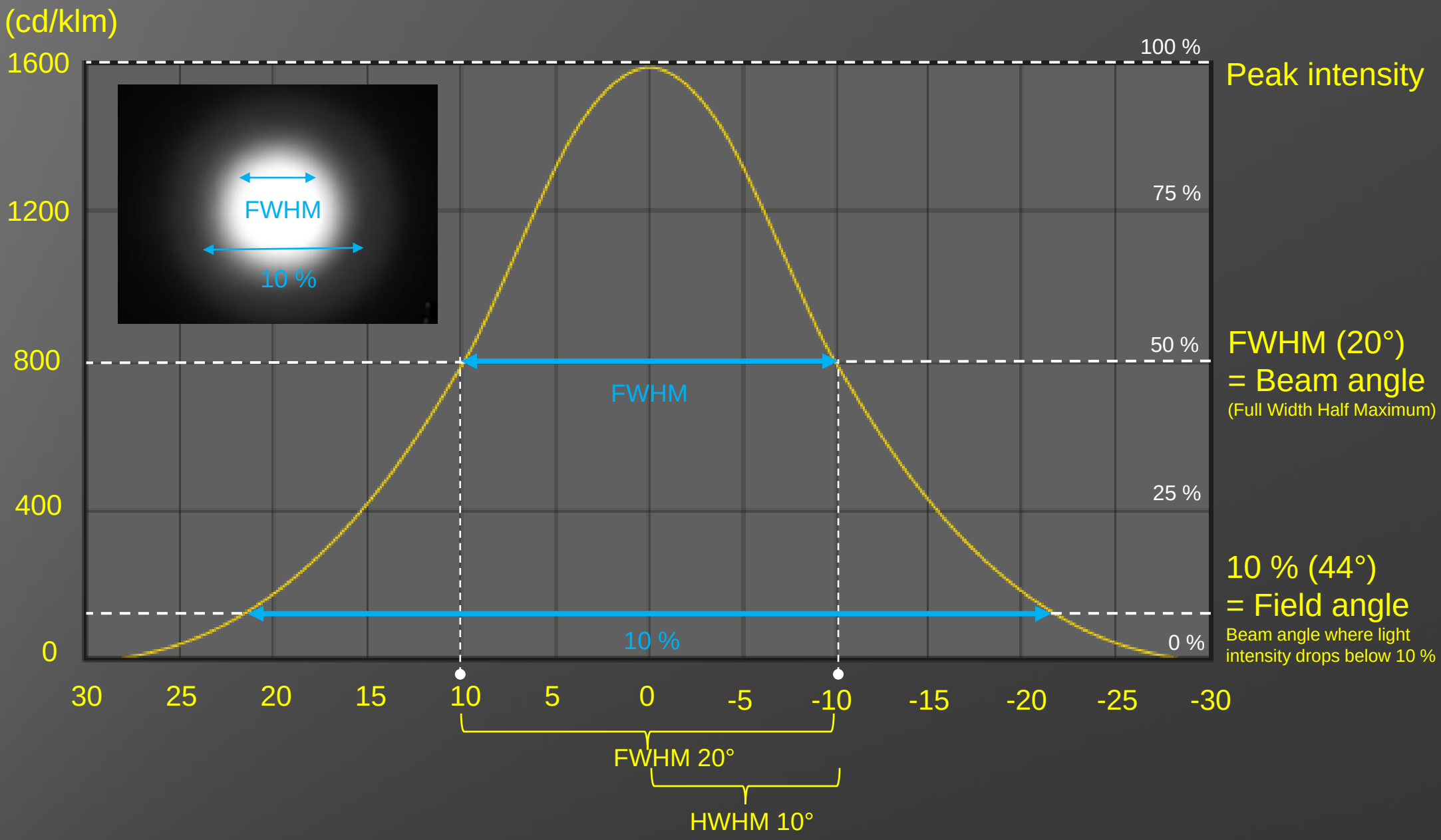
Light quality is most important, even at the minor cost on efficiency

Diffusive plates and extrusions



Typ. LOR <<80 %

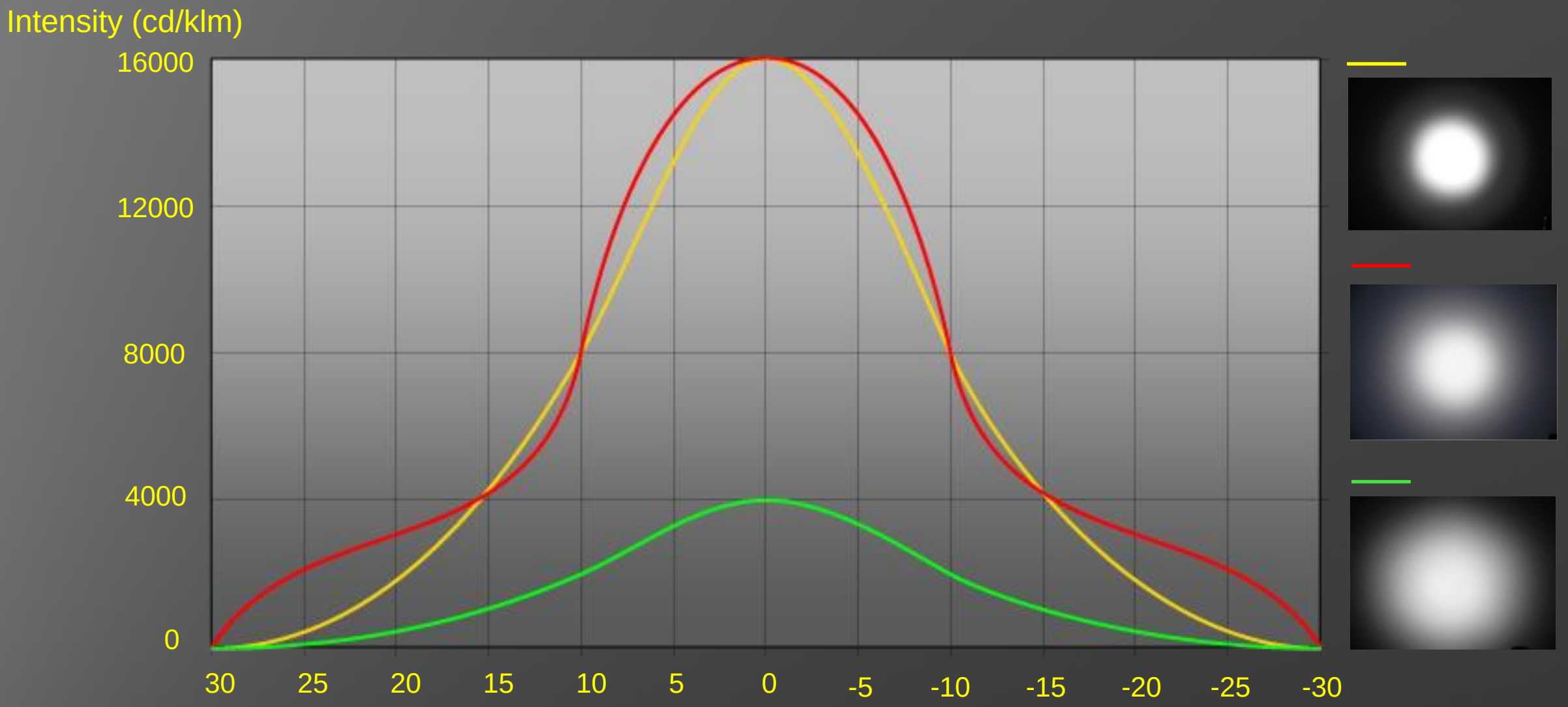
Internal reflections under the diffusor have significant impact on the efficiency



TERMINOLOGY

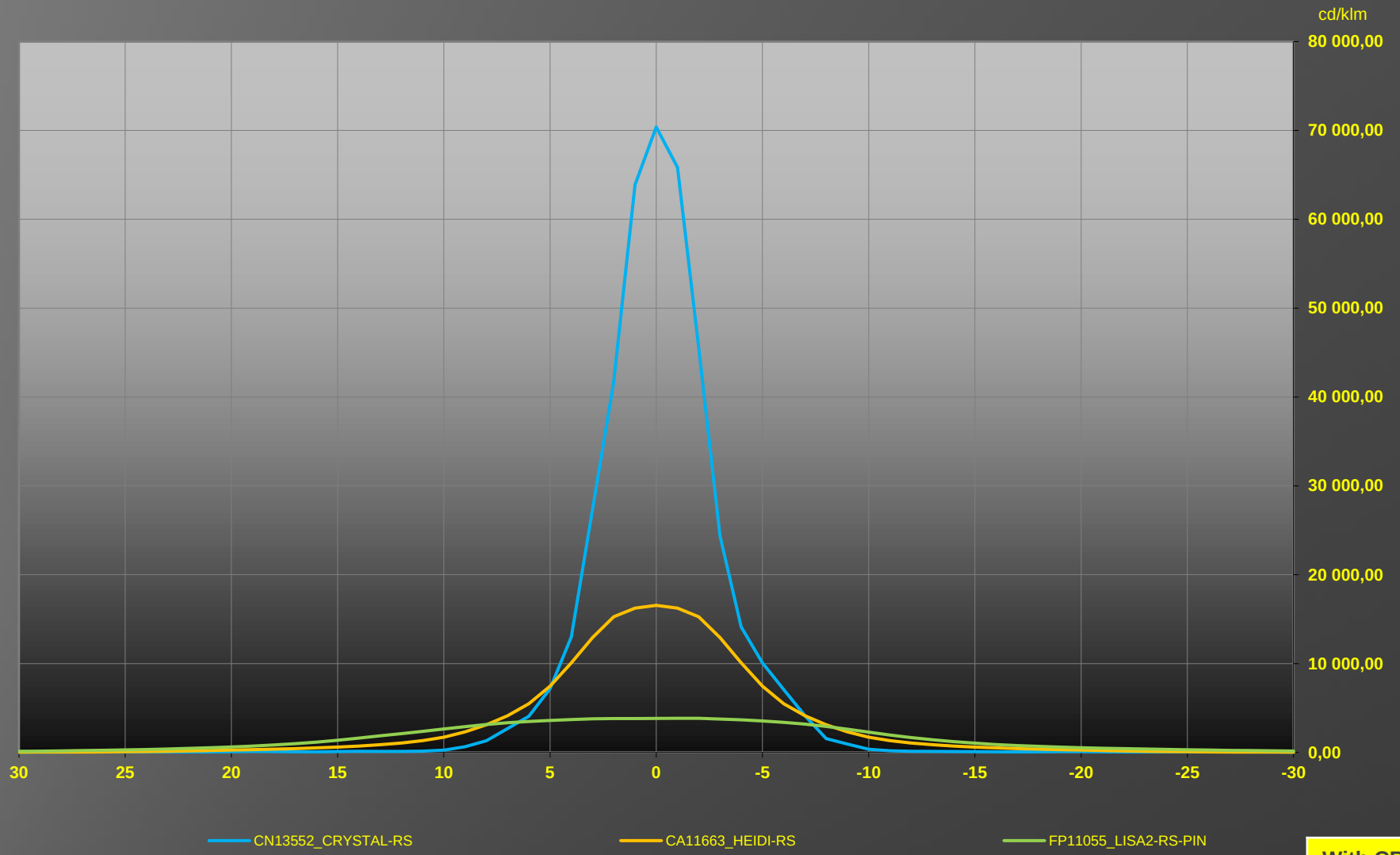
Linear grath wth FWHM, HWHM, 10 %, Beam angle, Field angle, Intensity, Peak intensity

TLEDiL®



20° BEAM

All three optics has the same FWHM but different peak intensities and 10 % values.



CRYSTAL-RS

HEIDI-RS

LISA2-RS

With CREE XP-G LED	Ø (mm)	FWHM (°)
CN13552_CRYSTAL-RS	46	4.6
CA11663_HEIDI-RS	21.6	9
FP11055_LISA2-RS-PIN	9.9	26

SIZE MATTERS

The bigger the optics the narrower and brigher the beam can be

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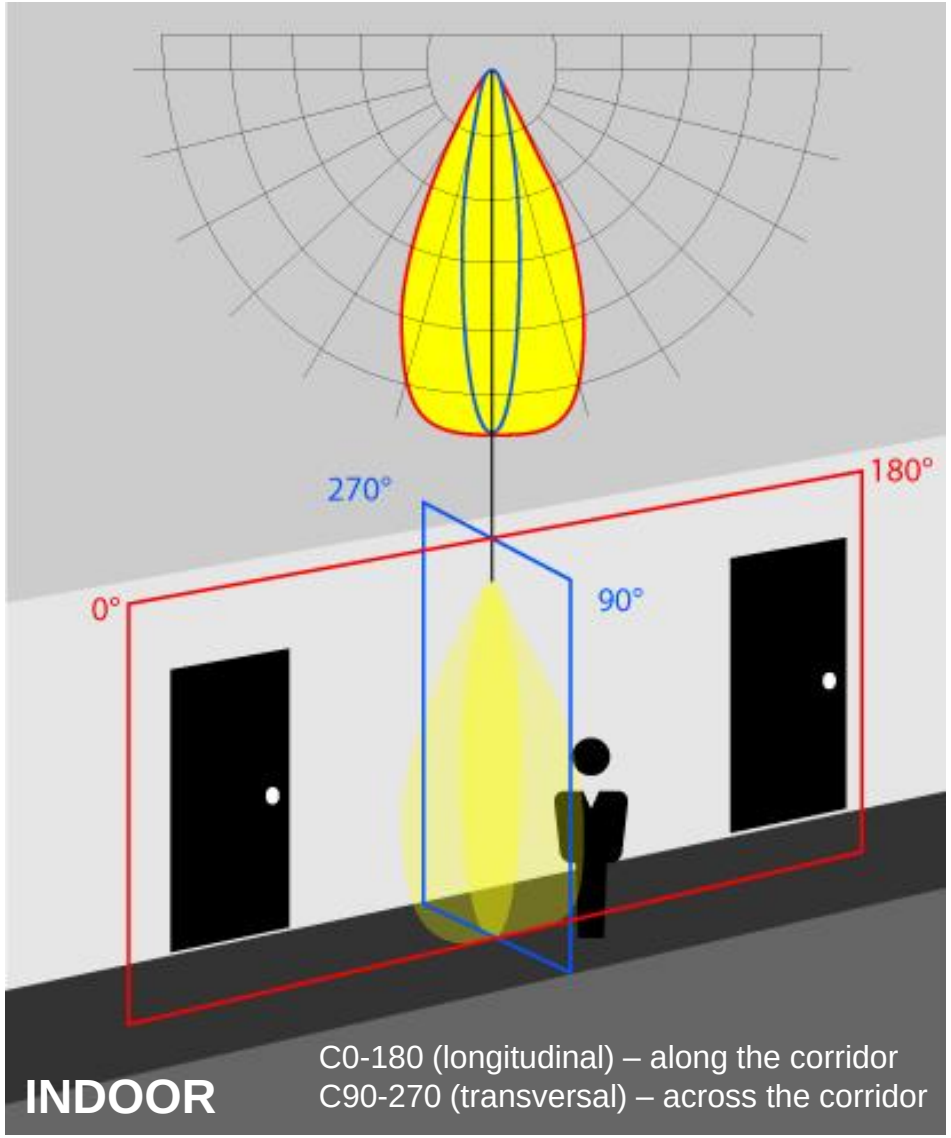
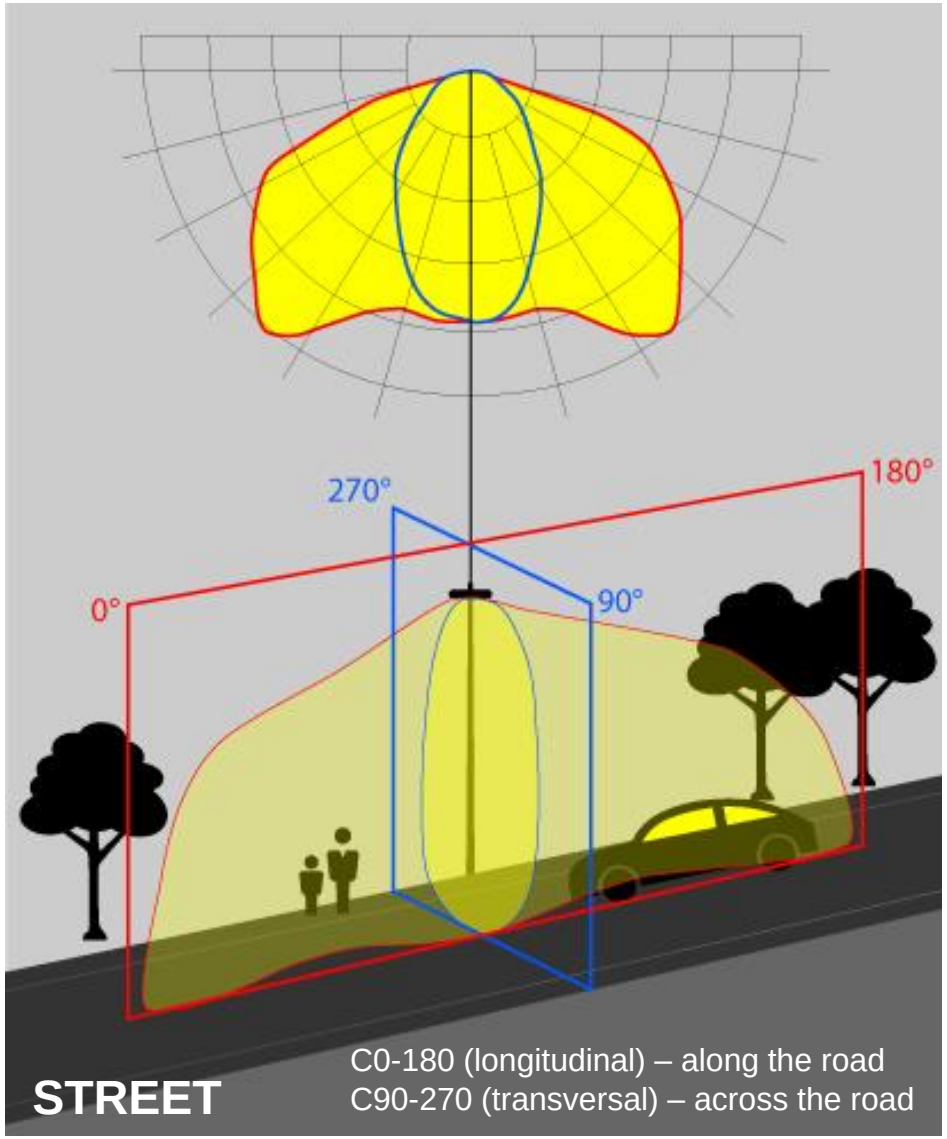
Photometrics (polar graph) – how to read?

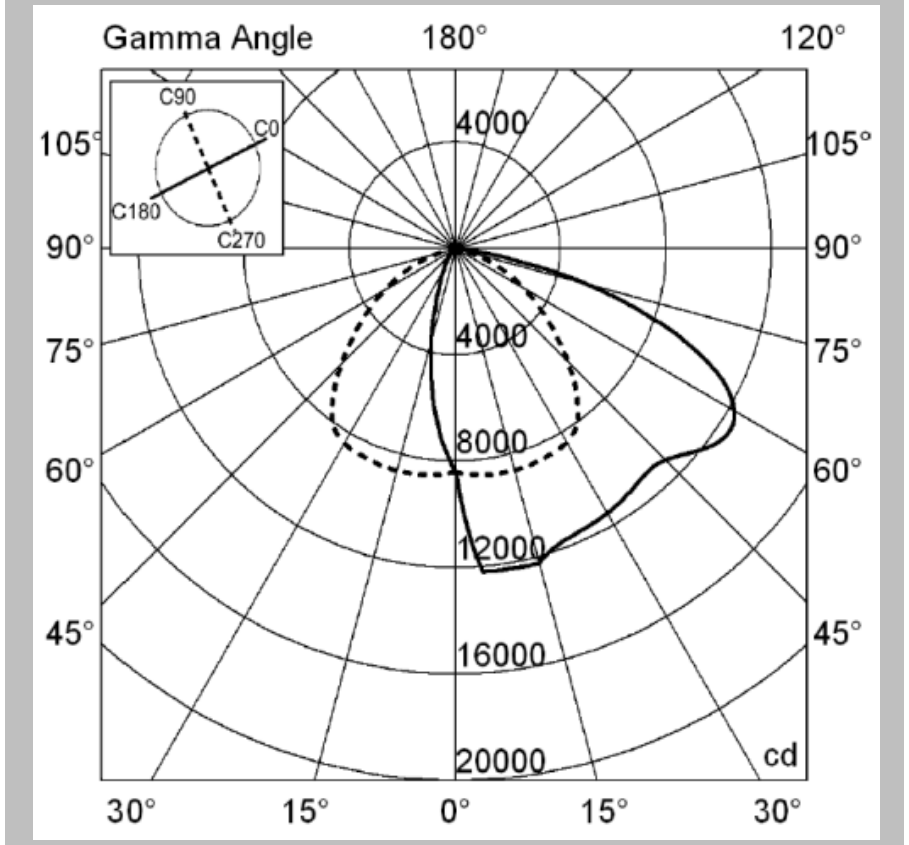
Based on IES-files. IESNA files are read other way around.





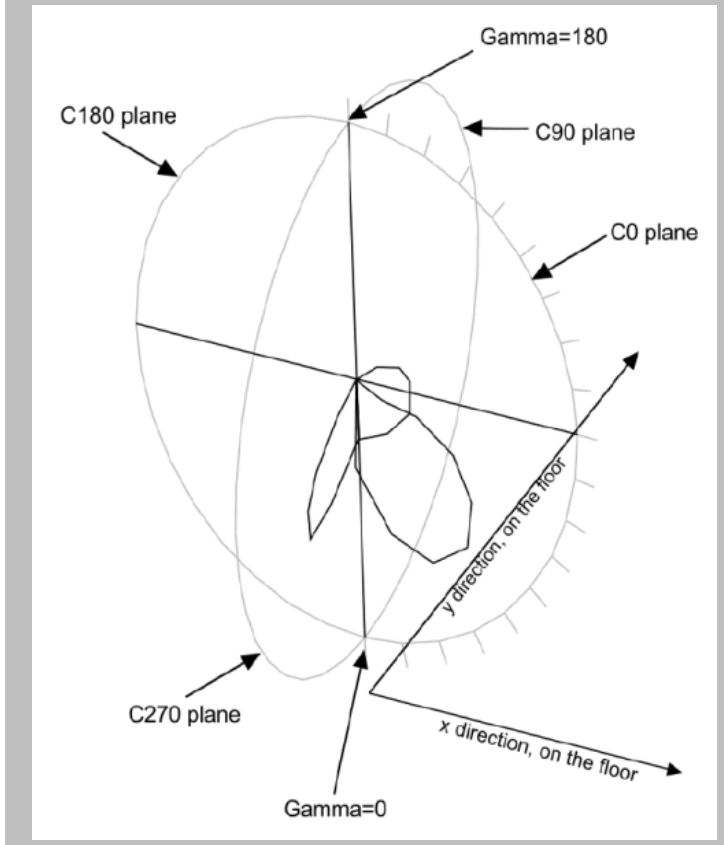
Photometries

Polar diagram



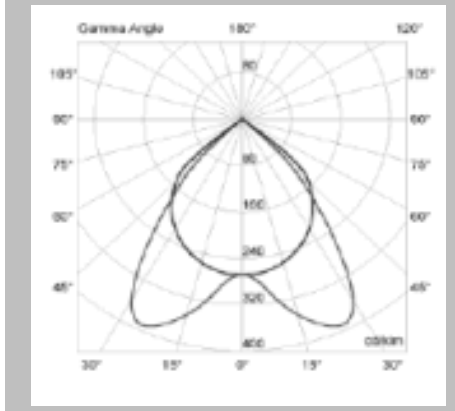
Shoots most of flux out to the left and is symmetrical in the C90-C270 plane

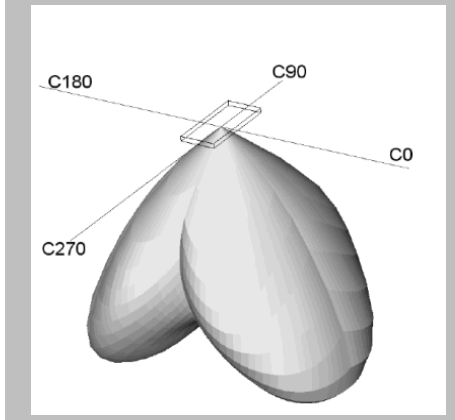
3D explanation of C-Gamma diagrams



The default positioning, the luminaire can be rotated and tilted. For symmetric light distributions gamma angle is usually 0 degrees and omitted.

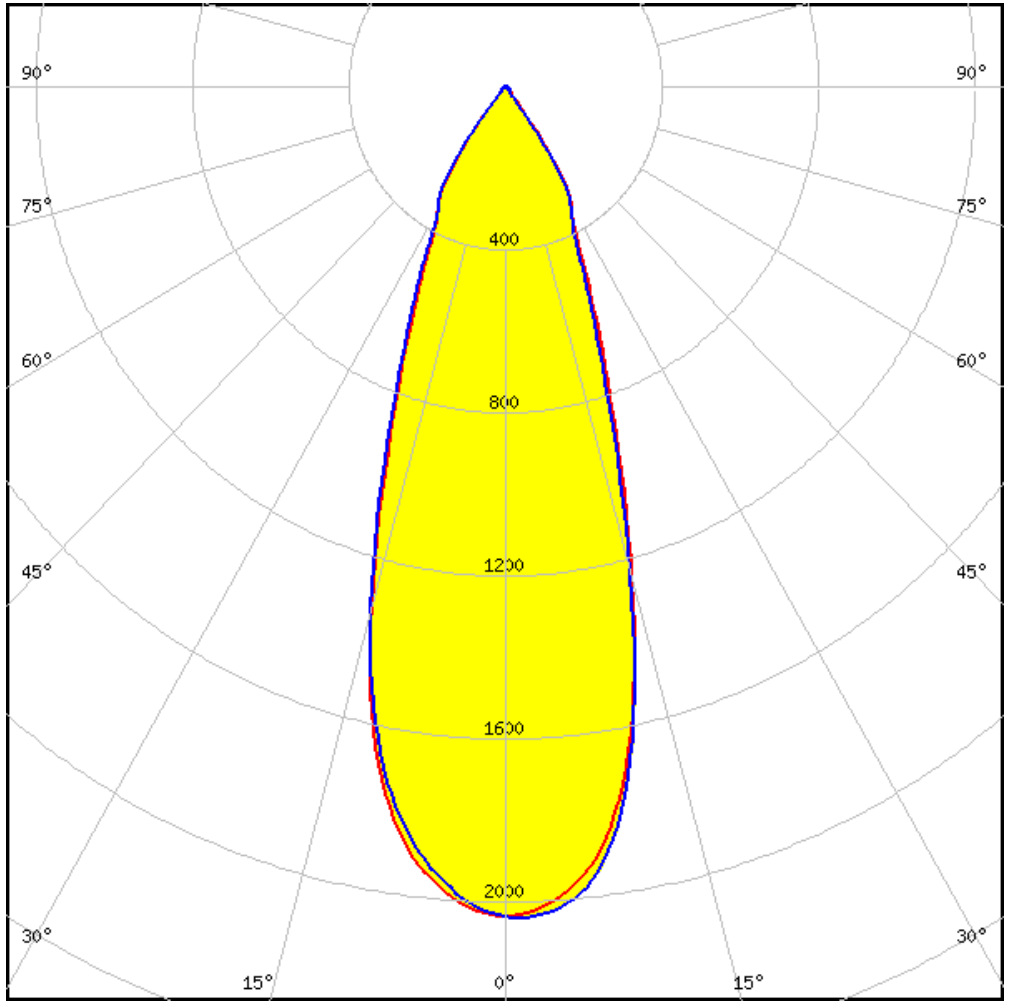
Complete ”photometric solid”

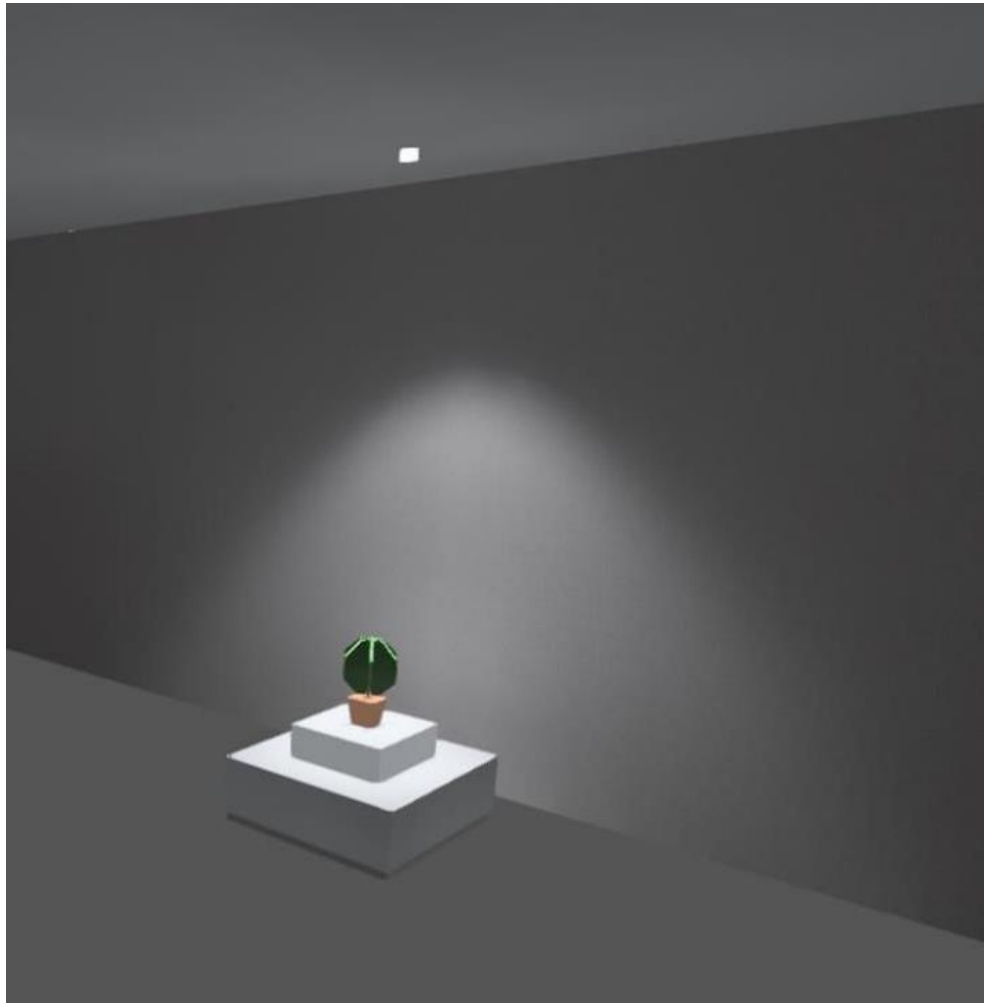




For analysis of uneven or assymetrical cases

Symmetrical light distribution

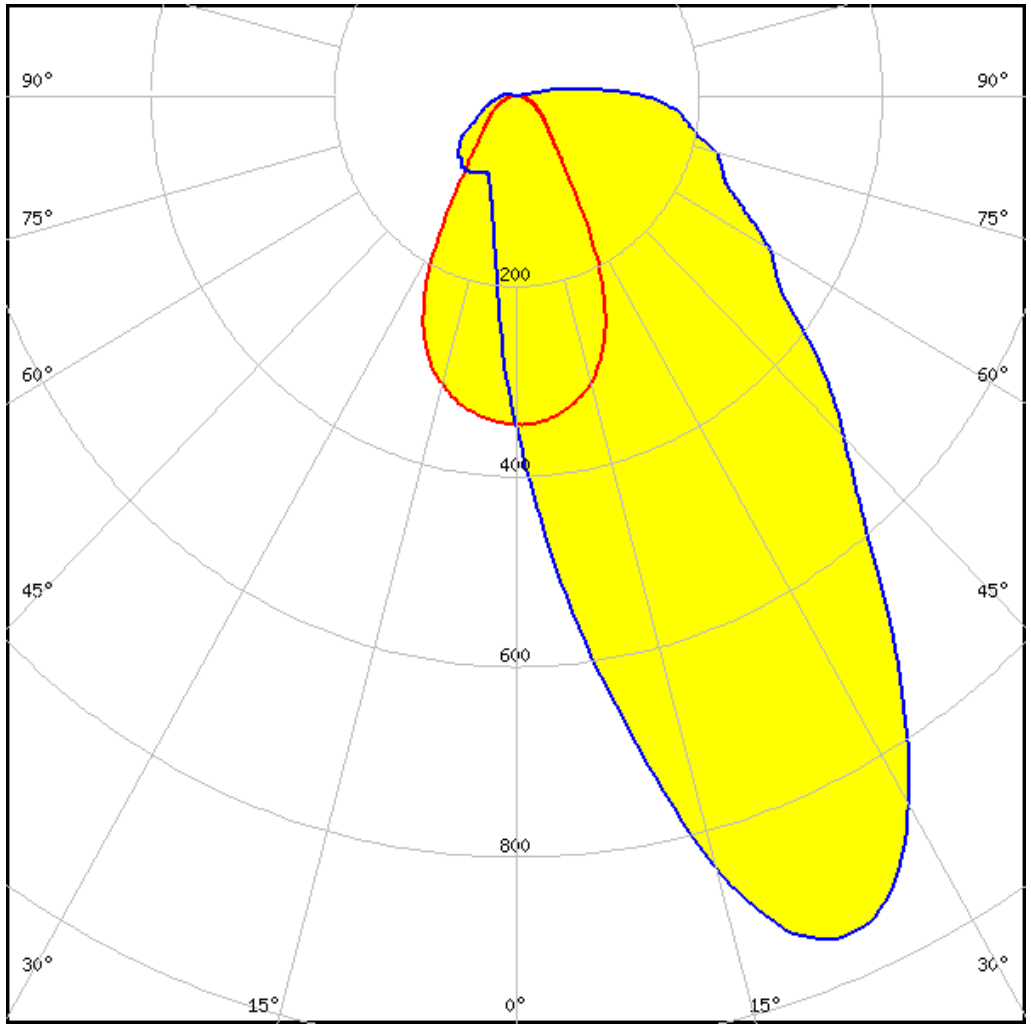


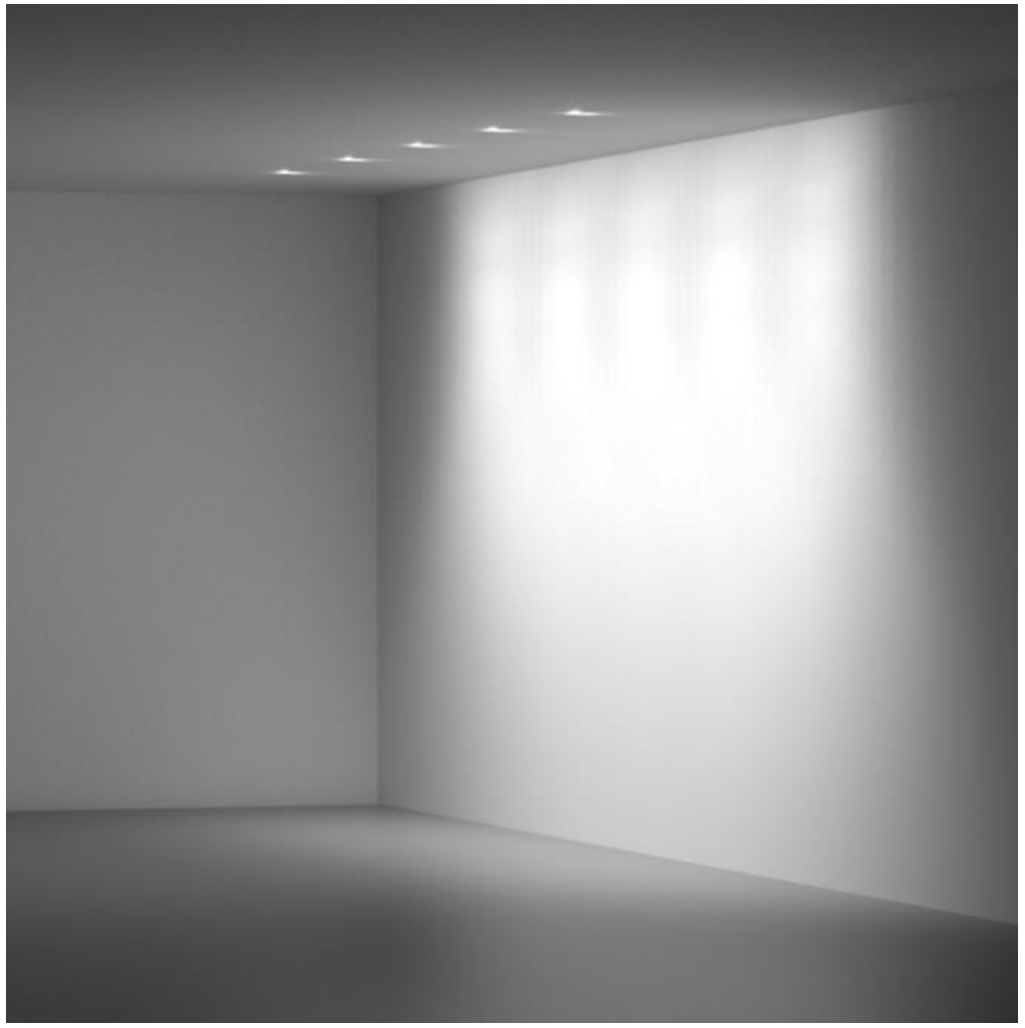


cd/klm

C0-C180 C90-C270

Asymmetrical light distribution



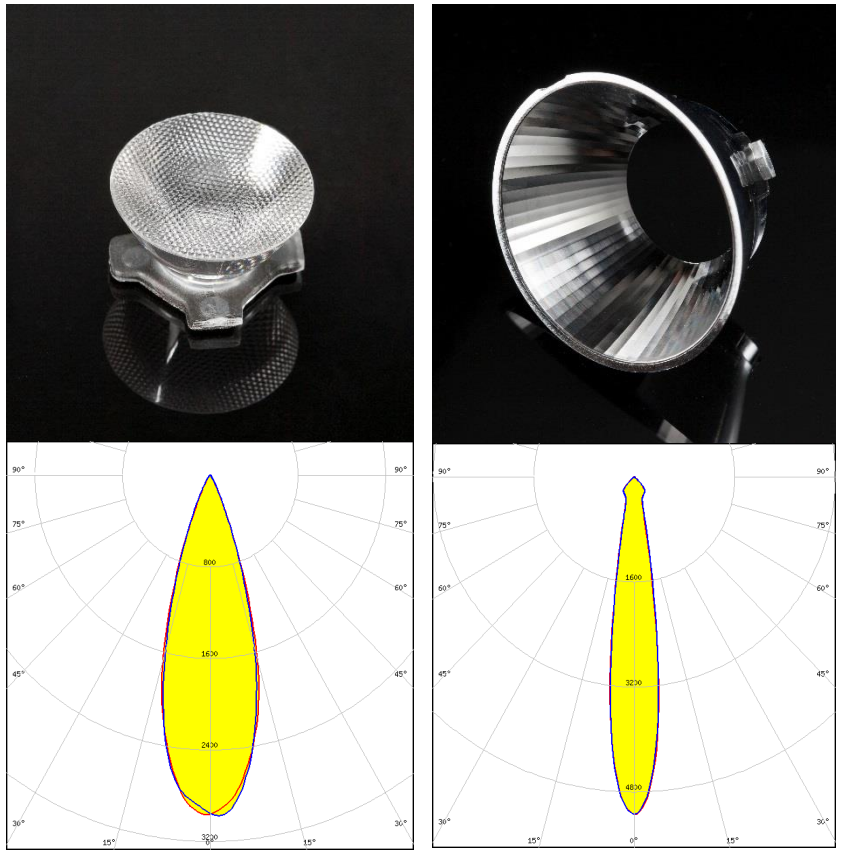


cd/klm

C0-C180 C90-C270

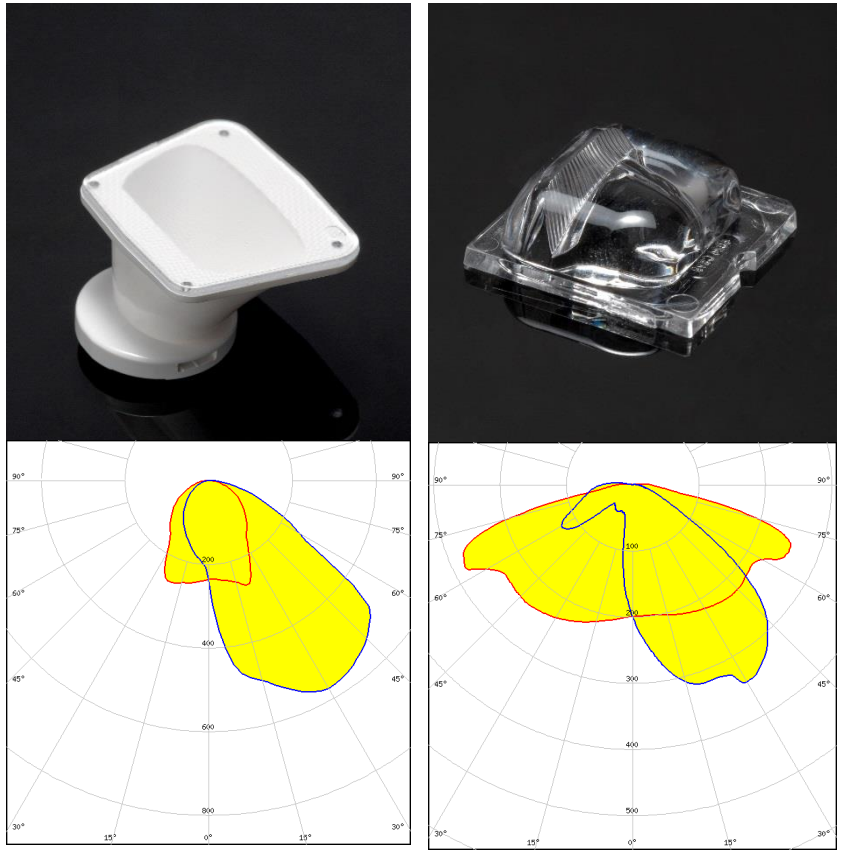
Regular design optics vs Freeform optics

Regular design optics



- Symmetrical beam patterns
- Simpler designs

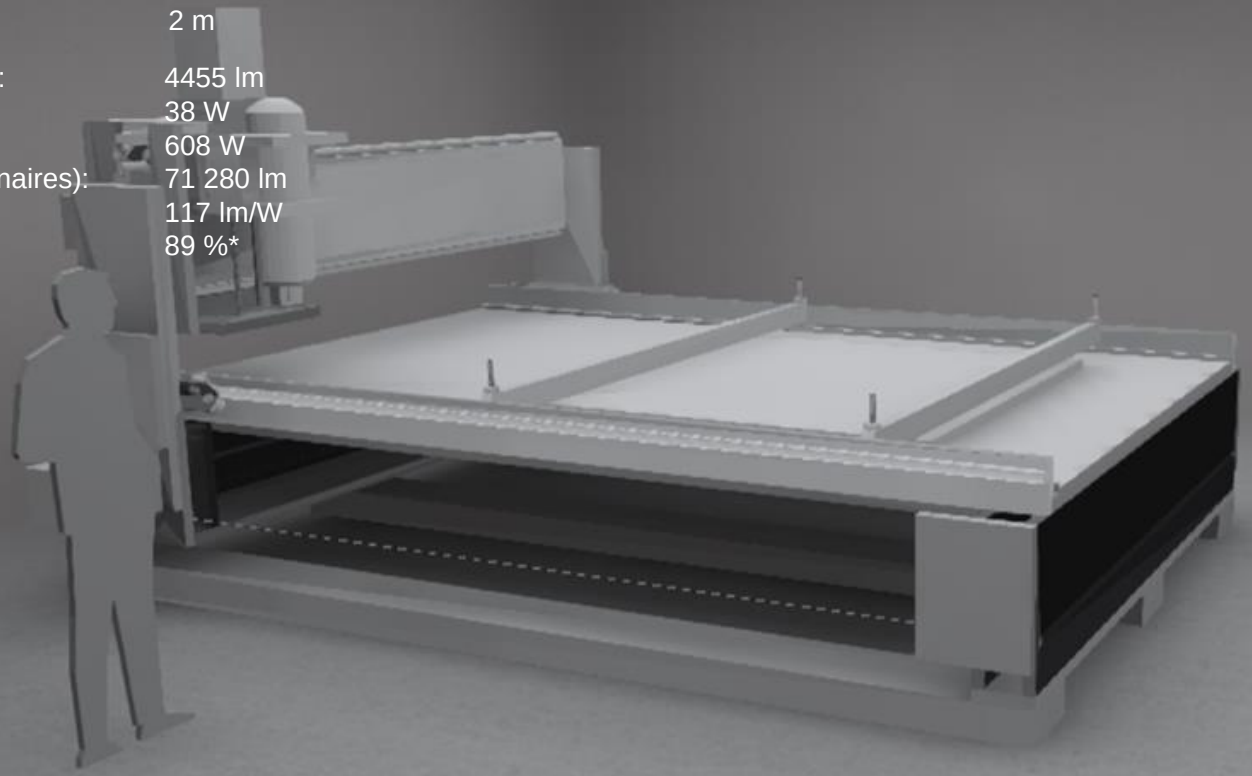
Freeform optics

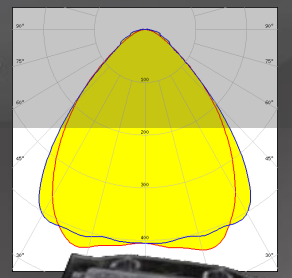


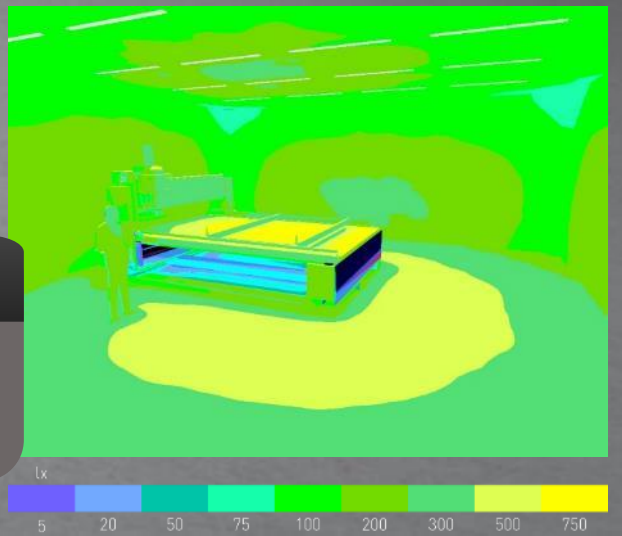
- Asymmetrical beam patterns
- Complete control of light
- More advanced optical designs

Simulation example#1: INDOOR, symmetrical beam

LED:	Philips Fortimo LG6030 (MP)
No. of optics in luminaire:	5 pcs
No. of luminaires:	16 pcs
Installation height:	4 m
Dist. between luminaire rows:	2 m
Dist. between luminaire centers in a row:	2 m
Luminous flux (luminaire):	4455 lm
Power:	38 W
Total load:	608 W
Luminous flux total (Luminaires):	71 280 lm
Luminous efficacy:	117 lm/W
Efficiency	89 %*







RESULTS
at 0.8 m height **:**

Average:	**708 lx**
Min:	**482 lx**
Max:	**859 lx**
u0:	**0.68**

*Transmittance at 3.2-mm thickness (standard D 1003) 88 %. Thinner thickness has better efficacy. Measured using white PCB with good reflectance.

SIMULATION

Industrial hall lighting, Mid bay
FLORENCE-3R-IP-Z90
Linear luminaire with 5 optics

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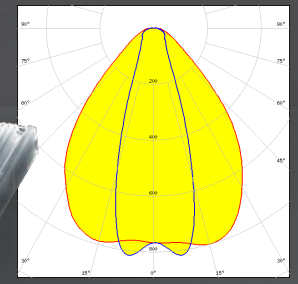
Simulation example#2: INDOOR, asymmetrical beam

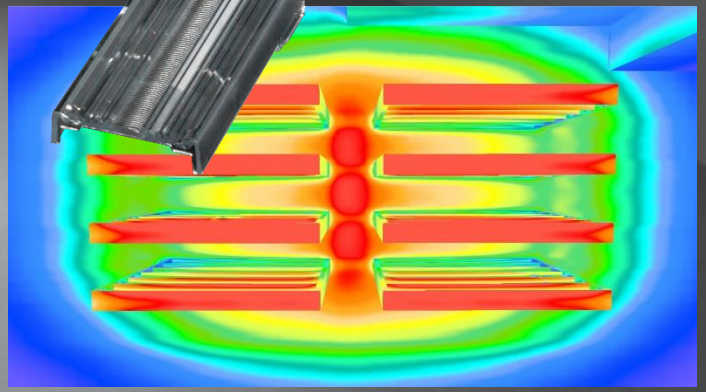
LED:	SAMSUNG LMB561+
Luminous flux (Luminaire):	3347 lm
Power (Luminaire):	27 W
Luminous efficacy:	124 lm/W
Efficiency:	84 %
Mounting height:	9 m
No. of luminaires in a row:	8 pcs
No. of luminaires in total:	40 pcs

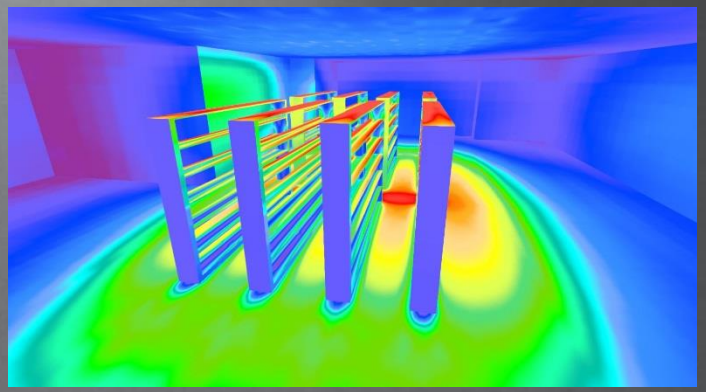


F15756_LINNEA-O

RESULTS
at 1.6 m height

Average:	**171 lx**
Min:	**143 lx**
Max:	**222 lx**
u0:	**0.84**
UGR max:	**25**



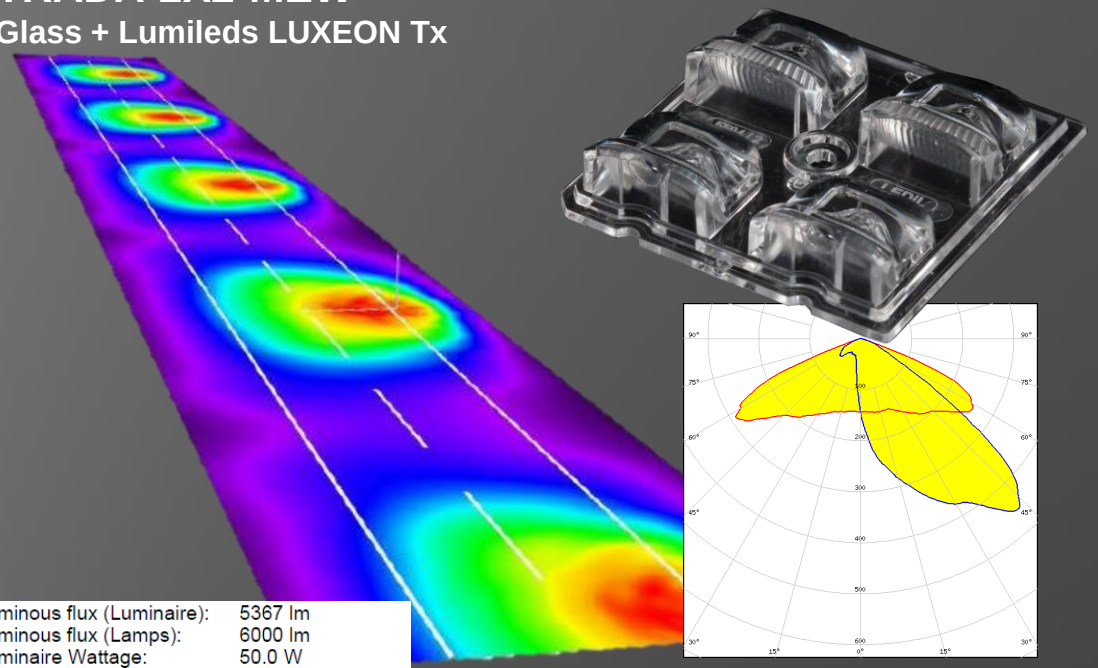


SIMULATION

Warehouse aisle and shelf lighting
Continous row
LINNEA-O

Simulation example#3: STREET, Europe & USA

STRADA-2X2-MEW
+ Glass + Lumileds LUXEON Tx



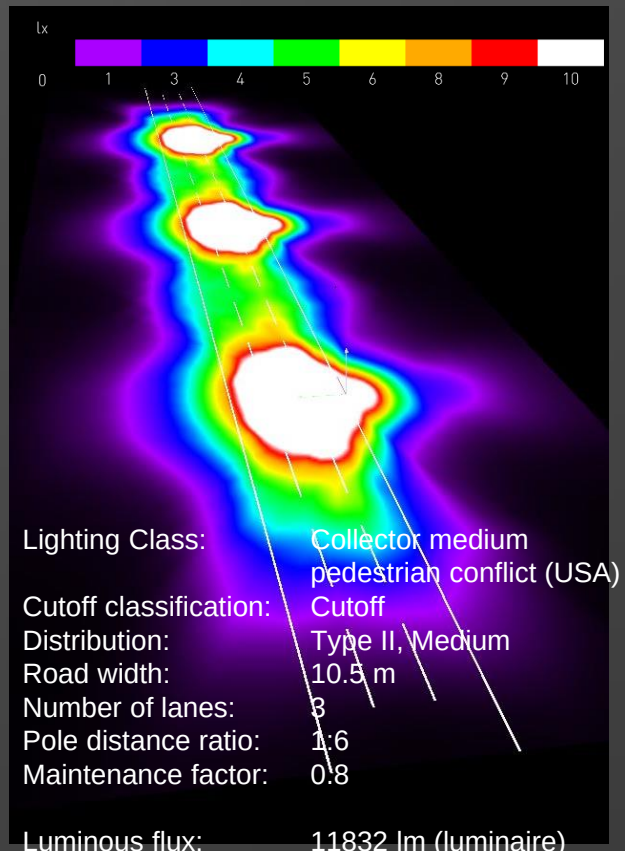
Luminous flux (Luminaire):	5367 lm
Luminous flux (Lamps):	6000 lm
Luminaire Wattage:	50.0 W
Arrangement:	Single row, bottom
Pole Distance:	38.000 m
Mounting Height (1):	8.010 m
Height:	7.910 m
Overhang (2):	-1.500 m
Boom Angle (3):	0.0 °
Boom Length (4):	0.000 m

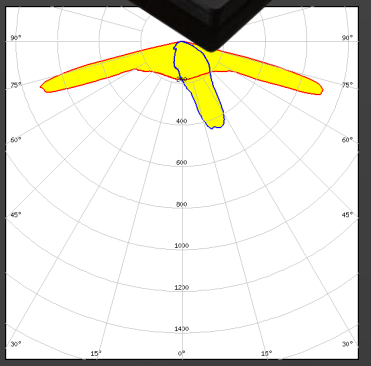
Uniformity coating for wet road q0 - 0.213 (vs 0.090 for dry road)

	L_{av} [cd/m²]	U0	Ul	TI [%]	U0 (wet)	E-class 3)
Calculated values:	0.66	0.46	0.35	5.5	0.24	E2
Required values according to class:	≥ 0.50	≥ 0.40	≥ 0.30	≤ 7.0	≥ 0.15	E2
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓	✓

Glare and uniformity in line with E2-class reqs

STRADA-2X2MXS-T2





Lighting Class:	Collector medium pedestrian conflict (USA)
Cutoff classification:	Cutoff
Distribution:	Type II, Medium
Road width:	10.5 m
Number of lanes:	3
Pole distance ratio:	1:6
Maintenance factor:	0.8
Luminous flux:	11832 lm (luminaire)
Power:	100 W (lumonaire)
Arrangement:	Single row, bottom
Pole distance:	60 m
Mounting height:	10 m
Overhang:	1 m
Boom angle:	0°

RESULTS:

Average:	**10 lx**
Min:	**3.6 lx**
Max:	**34 lx**
u0:	**0.36**

E_{av} (R3) [lx]	E_{av}/E_{min}	$L_{v\,max}/L_{av}$
10.0	2.8	0.4
≥ 9.0	≤ 4.0	≤ 0.4
✓	✓	✓

All lighting performance requirements are met

SIMULATION

Road in Denmark with E2-class requirements (including wet road) & STRADA-2X2-MEW
USA collector road & STRADA-2X2MXS-T2

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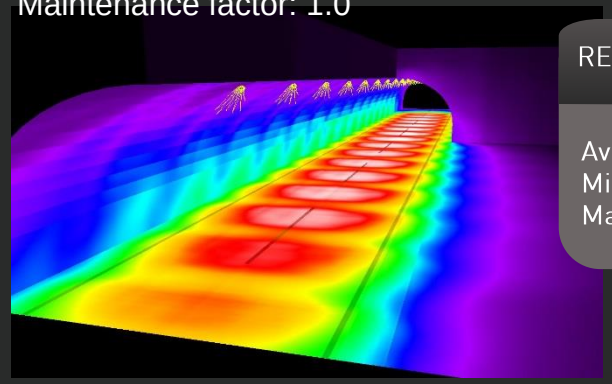
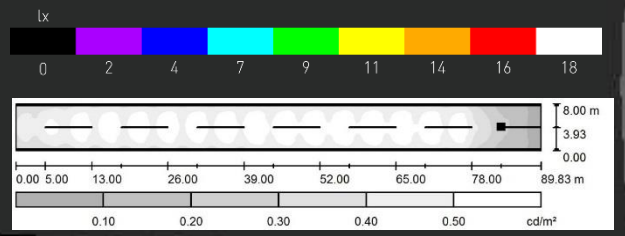
Simulation example#4: STREET, tunnel

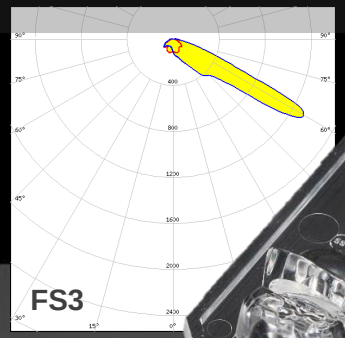
LED:	CREE XP-G3
Efficiency:	93 %
Luminous flux: (luminaire)	930 lm
Road width:	8 m
Number of lanes:	2
Spacing:	8 m
Mounting height:	5.4 m
Maintenance factor:	1.0

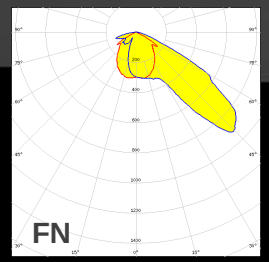


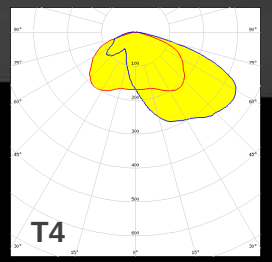


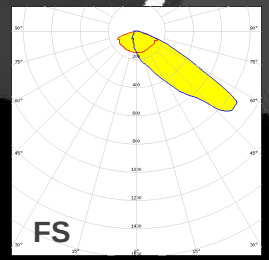
RESULTS (luminance):

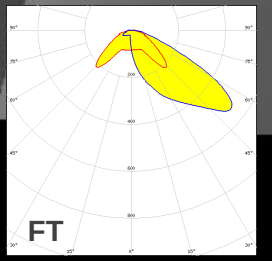
Avg:	0,45 cd/m2
Min:	0,07 cd/m2
Max:	0,59 cd/m2

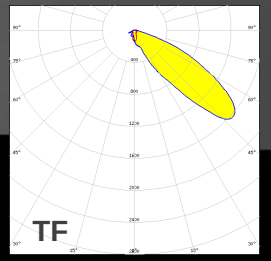










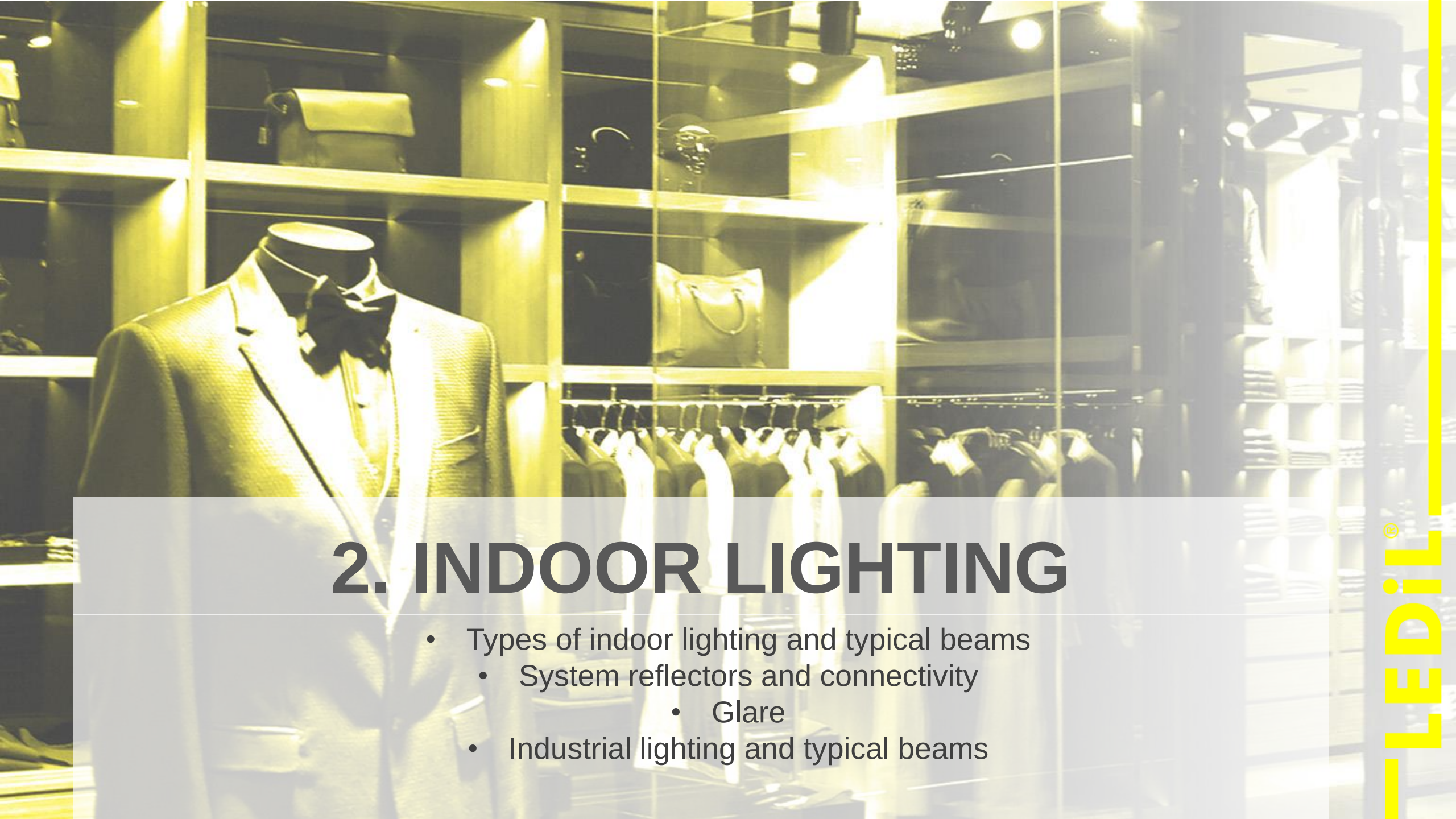


One way traffic

SIMULATION

Tunnel lighting
Asymmetrical counter-beam
STRADA-2X2-FS3

LEDiL®



2. INDOOR LIGHTING

- Types of indoor lighting and typical beams
- System reflectors and connectivity
- Glare
- Industrial lighting and typical beams

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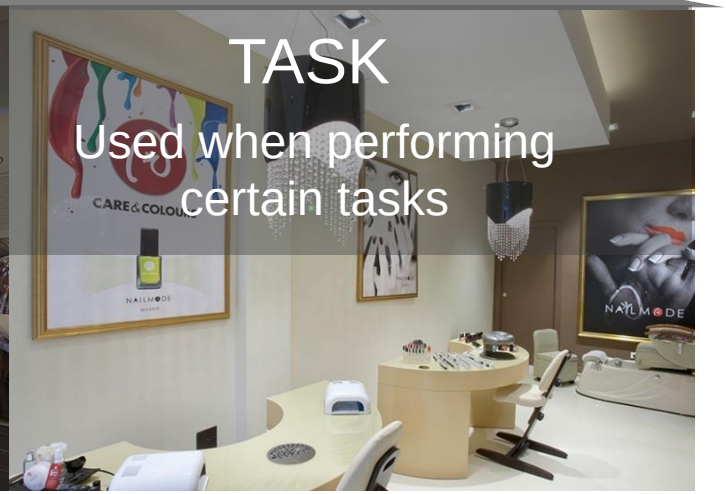
Types of indoor lighting & example beams

AMBIENT

Provides overall light to the room

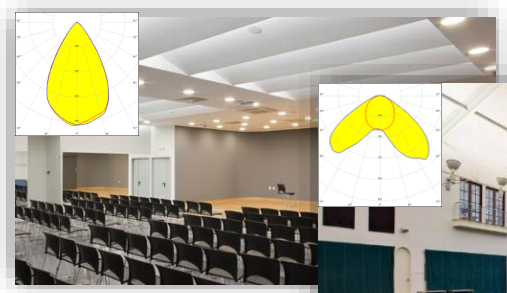
ACCENT

Highlight objects and structures



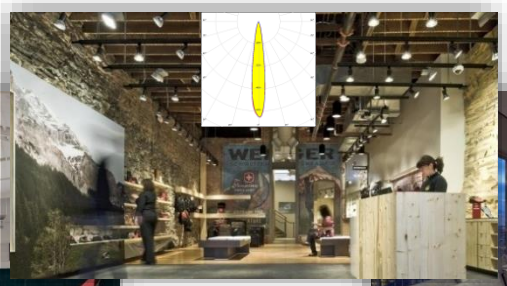
TASK

Used when performing certain tasks

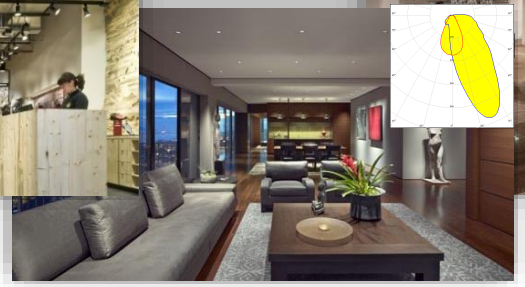


Downlighting

Uplighting



Track lighting



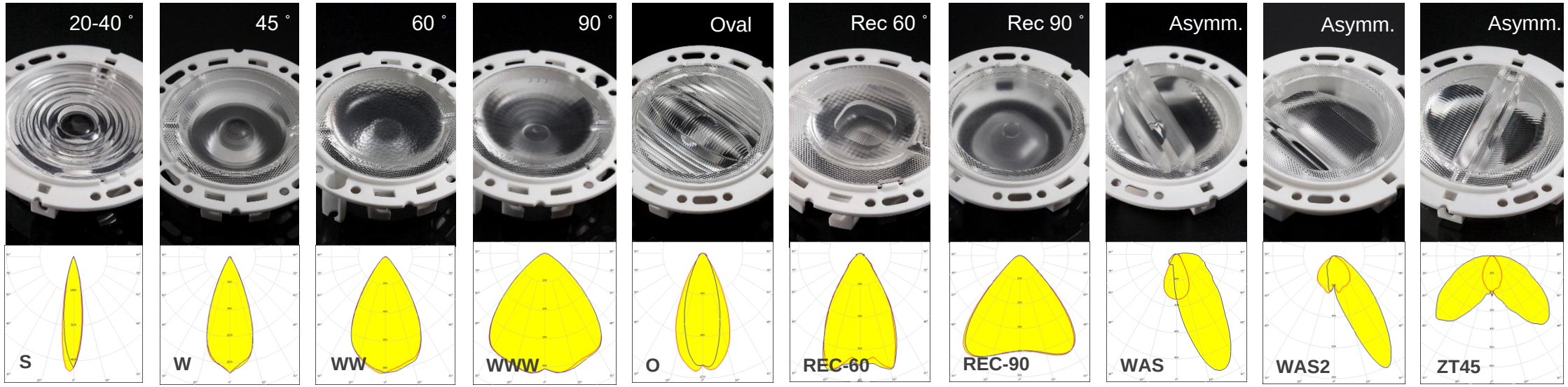
Washlighting

Decorative lighting

LEDiL®

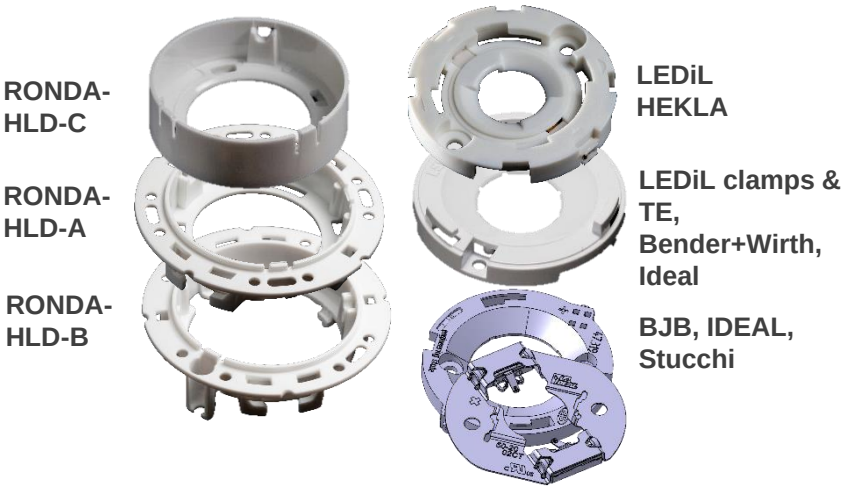
Example of indoor lighting beams

RONDA- low profile system for any indoor lighting needs



COMPATIBILITY

- LES sizes up to 16 mm, asymmetrical up to 14 mm
- Three holder versions to support most common connectors:
  - Holder A (Ø70 mm): LEDiL twist and lock base parts, 3rd party connectors from TE, Bender+Wirth and IDEAL
  - Holder B (Ø70 mm): 3rd party connectors from BJB, IDEAL and Stucchi
  - Holder C (Ø54 mm): LEDiL HEKLA



LEDiL Reflector Portfolio

System Reflectors

Ø – diameter (mm)
H – height (mm)
LES – light emitting surface
RZL– color mixing lens
DL – diffuser lens
CL – clear lens
New generation available

REFLECTORS

SYSTEM REFLECTORS

Ø mm

120
100
80
60
40
20

BLONDIE
Ø92 X 78.3, H45
A; 3 inserts

RITA
36+29, H17-19
A,WAS, -RZ

REGINA
Ø15.9, H19
S

BOOM
Ø22.2, H14
M,S,W,XW

BRIDGET
Ø22.6, H12.8
S,M,W-UNI

MIRELLA
Ø50, H23.6
LES 14 mm
S,M,W,XW in basic,
PIN & PF variants
RZ, CL, DL lenses

PF variants:
LEDiL PF
Sockets

BROOKE
Ø45, H19.7
LES 18 mm
S,M,W,XW, SCR-M,W
RZ lens

BARBARA
Ø70, H19
LES 19 mm
S,W,WW,XW in
basic & PF variants
RZ lens

VENLA
Ø45, H25
S,M,W,WW,S-IRIS

MINNIE/-LT
Ø35, H15
M,W,WWW,XW

HEKLA-sockets
& -connectors

BARBARA-G2
Ø70, H19
LES 17 mm
S,W,WW
RZ lens

MIRELLA-G2
Ø50, H23.6
LES 12 mm
S,M,W
RZ, CL, DL
lenses

BROOKE-G2
Ø45, H19.7
LES 18 mm
S,M,W
RZ lens

LENA
Ø111, H86
LES 35 mm
M,S,SS,W,WAS
DL,CL lenses

Base parts for
LENA/LENINA

LENINA
Ø74, H46
LES 35 mm
S,M,W, XW
DL, CL
lenses

ANGELA
Ø120, H74.5-79.3
LES 32 mm
S,M,W,XW
RZ lens

ANGELETTE
Ø110, H57.3
LES 32 mm
S,M,WW,WAS
Plain: S,M,W
RZ, CL, DL lenses

ANGELINA
Ø82, H31
LES 32 mm
S,M,W,XW
RZ lens

LEDiL clamps

HP 3535
HP 7070
COB

LED type

LEDiL®

SYSTEM REFLECTORS

ANGELA / ANGELINA / ANGELETTE & ACCESSORIES

LEDiL Clamps:

Cree
CXA15 & 18
C14123_CLAMP-CXA15-18

Cree
CXA25 & 30
C14036_CLAMP-CXA25-30

Bridgelux
Vero13 & 18
C13658_CLAMP-VERO13-18

Bridgelux
Vero29
C13584_CLAMP-VERO29

Philips Lumileds
LUXEON Sxxxx
C13395_CLAMP-S2000
C13397_CLAMP-S3000
C13399_CLAMP-S5000

ZHAGA Book3
SLM MODULES:

F13325_ANGELINA-S
F13659_ANGELINA-S-B

F13401_ANGELINA-M
F13660_ANGELINA-M-B

F13402_ANGELINA-W
F13661_ANGELINA-W-B

F13838_ANGELINA-XW
F13839_ANGELINA-XW-B

F13671_ANGE-RZ-LENS

F13379_ANGELA-S
F13662_ANGELA-S-B

F13380_ANGELA-M
F13663_ANGELA-M-B

F13381_ANGELA-W
F13664_ANGELA-W-B

F13840_ANGELA-XW
F13841_ANGELA-XW-B

F13671_ANGE-RZ-LENS

F14619_ANGELETTE-S-PLAIN
F14624_ANGELETTE-S-B-PLAIN

F14620_ANGELETTE-M-PLAIN
F14621_ANGELETTE-M-B-PLAIN

F14622_ANGELETTE-WW-PLAIN
F14623_ANGELETTE-WW-B-PLAIN

C14346_ANGELETTE-WAS

F13671_ANGE-RZ-LENS

F14532_ANGELETTE-S
F14616_ANGELETTE-S-B

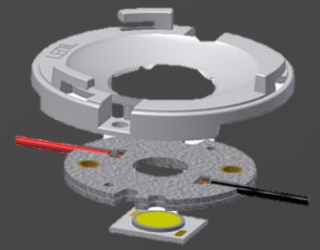
F14533_ANGELETTE-M
F14617_ANGELETTE-M-B

F14534_ANGELETTE-W
F14618_ANGELETTE-WW-B

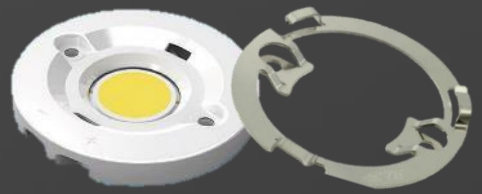
F15176_ANGELETTE-LENS

F15412_ANGELETTE-DL

F13671_ANGE-RZ-LENS



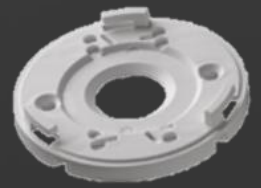
B+W Solderless connector + LEDiL clamp
B+W 4xx Typ L1, L2, L3 + C13658_CLAMP-VERO13-18



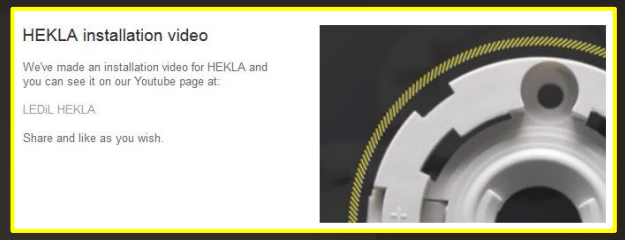
TE solderless connector + TE metal adapter
TE Z50 optical clip Type1

IDEAL solderless connector + IDEAL plastic adapter
IDEAL Chip Lok + adapter 50-2100AN

BJB solderless connector 50 mm



Molex solderless connector 50 mm



HEKLA

Ø44 mm sockets & solderless connectors

- **COMPATIBLE**: support for many COBs and LEDiL optics
- **USABLE**: easy to use twist & lock mechanism
- **DURABLE**: long lasting materials that can handle high temperatures without losing grip
- **INNOVATIVE**: Same system – freedom to choose between solderless connector or mechanical socket

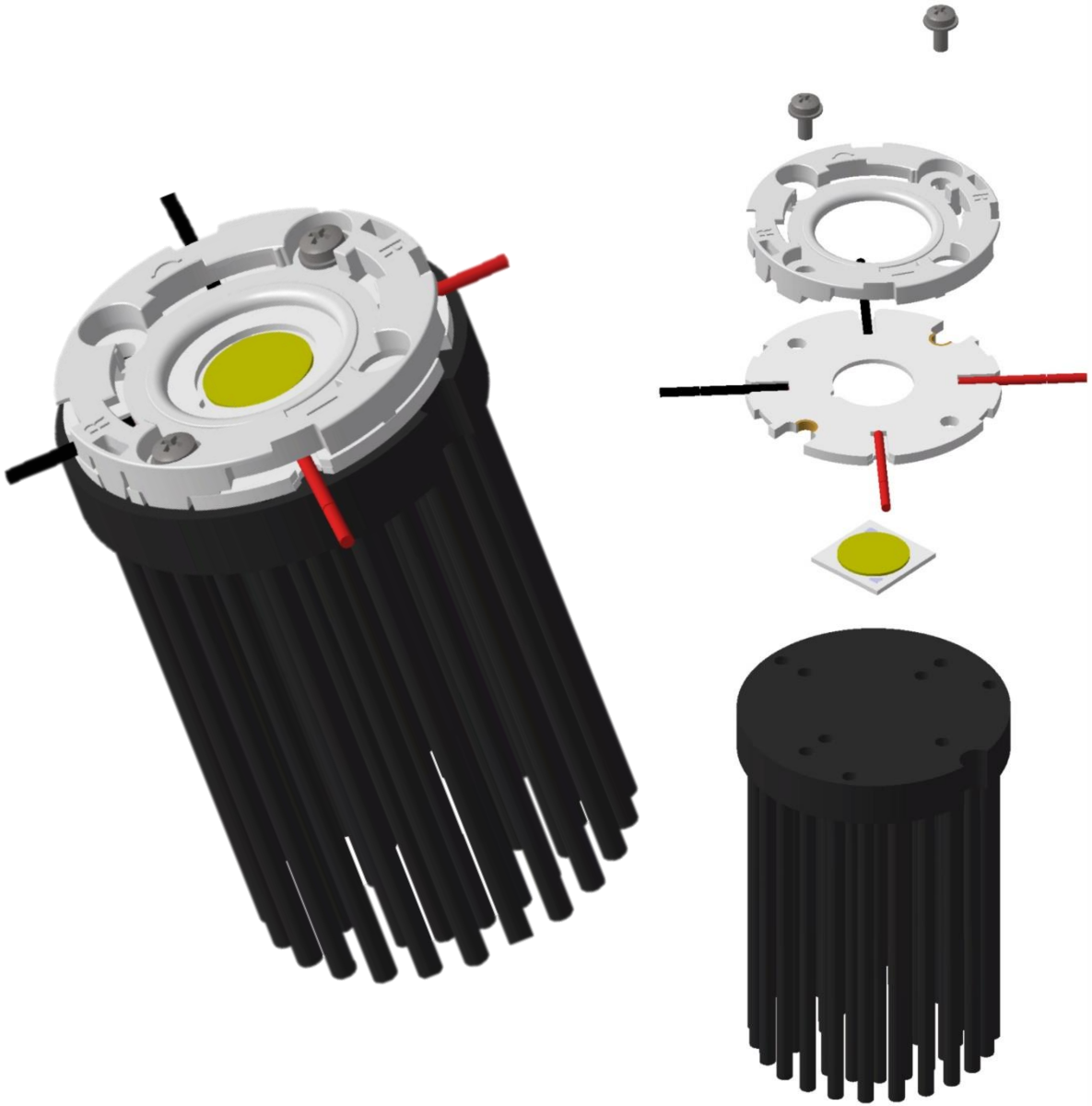
	HEKLA
Rated voltage	50 V
Rated current	3 A
Rated operat. temp.	110 ˚C
Wire size	AWG 22 Solid wire AWG 20 Tinned (solder dipped) AWG 22 Tinned (solder dipped) AWG 20 ~ 0.50 mm^2 AWG 22 ~ 0.35 mm^2

Solderless connector

Socket

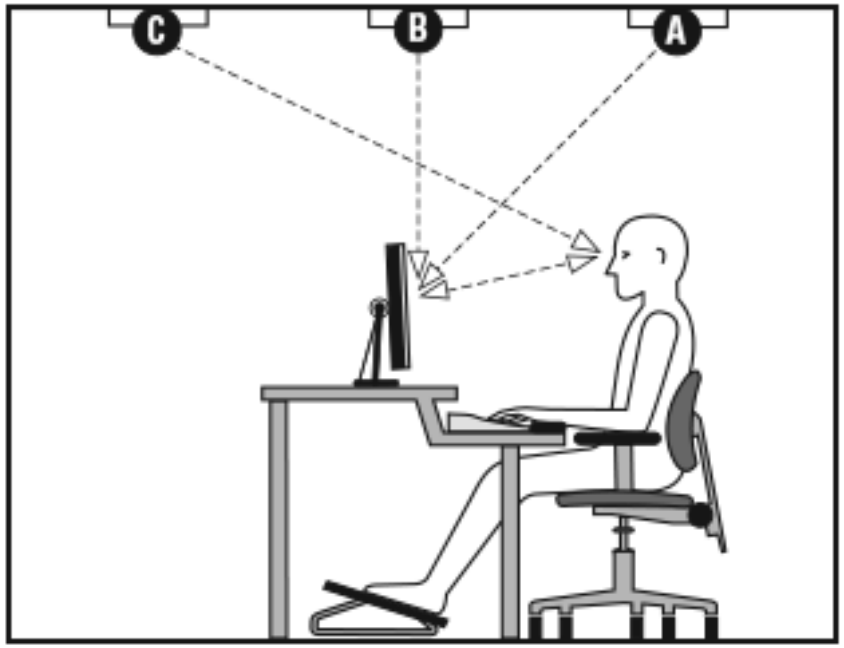
Modular light engine reference design

- Based on LEDiL's HEKLA platform
- Same basic light engine design can be used in a range of applications
  - Spotlights
  - Downlights
  - Scalable – suits for tunable or normal white
- Built on standard off the shelf components
- Tunable white version
  - LEDiL HEKLA-SOCKET-K
  - B+W 481 Typ L8 solderless connector
  - Citizen LCN-C02B tunable white COB
  - MTX LPF4768-ZHP Pin Fin LED Cooler ø47mm
- Fixed white version
  - LEDiL HEKLA-SOCKET-K
  - B+W 481 Typ L8 solderless connector
  - Citizen CLU 700 / 701 White COB
  - MTX LPF4768-ZHP Pin Fin LED Cooler ø47mm



GLARE

Glare is the sensation of discomfort in the vision produced by bright areas within the visual field, such as lit surfaces, parts of the luminaires, windows and/or roof. Glare shall be limited to avoid errors, fatigue and accidents.



Disability glare: affects your visual performance, can be measured
Discomfort glare: subjective evaluation, feels uncomfortable but not **necessarily** affect your visual performance

Direct glare (C) -> bright lamps, measurable and has a clear affect on your performance
Reflected glare (A & B) - reflection of light on wet or shiny work surfaces

LEDiL®

REFERENCE

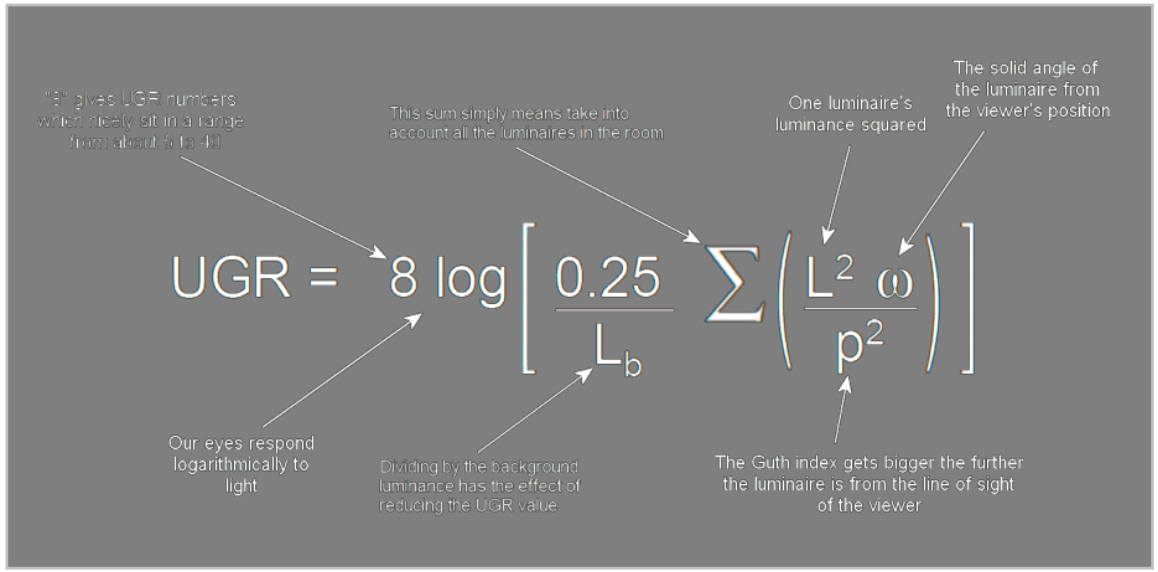
Uniformity on light emitting area
LINNEA-90 vs comptetitors
FLORENCE-Z90 vs competitor

LEDiL®

How to measure and evaluate glare?

1. UGR observer / UGR table as part of any lighting calculation software (CIE – most common). **NOTE!! UGR is assuming uniform luminance over the entire light exit window and is not always accurate with small point sources.**
2. Detailed light planning and visual evaluation
3. Sollner diagram
4. Luminance mapping (old vs new)

Tools: 1) Human eye 2) Computer 2) Luminance meter

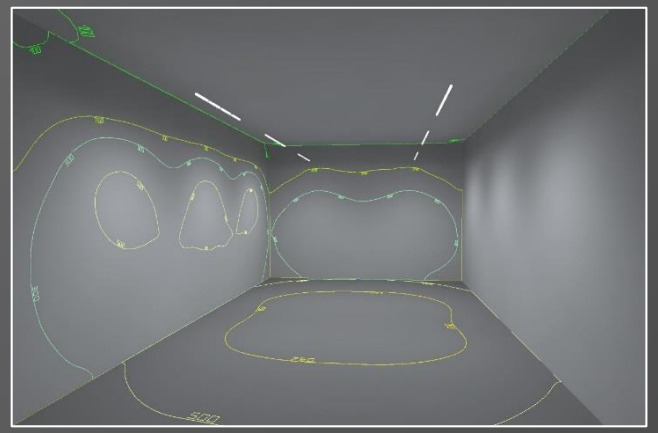


UGR	Discomfort Glare Criteria
10 and under	Imperceptible
13	Just perceptible
16	Perceptible (suited for accurate eye tasks)
19	Just acceptable (suited for average eye tasks)
22	Unacceptable (suited for moderate eye tasks)
25	Just uncomfortable (suited for simple eye tasks)
28 and over	Uncomfortable

LEDiL®

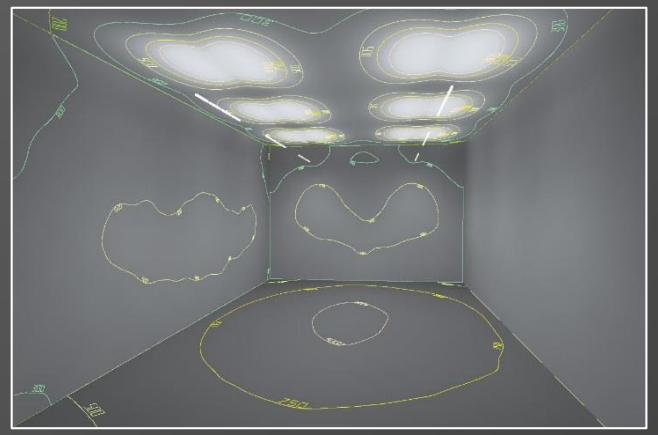
SIMULATION

1. Downlighting only



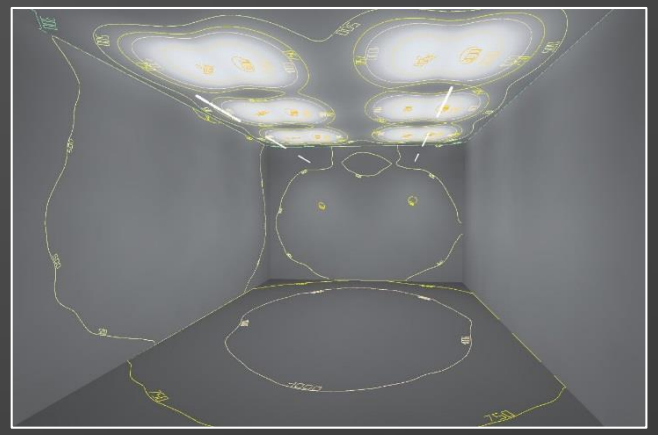
- UP: 0 lm per module
- Z90: 2000 lm per module
- UGR = 19

2. Downlighting and some amount of uplighting



- UP: 1000 lm per module
- Z90: 2000 lm per module
- UGR <17

3. Equal amount of downlighting and uplighting



- UP: 2000 lm per module
- Z90: 2000 lm per module
- UGR <15

Simulation of upligh affect on UGR
4 modules per luminaire, 2 X 3 luminaires installed
FLORENCE-1R-Z90

LEDiL®

UGR table in use

Room reflectances %

Viewing directions to lamp axis, crosswise/endwise

Room size factors – column, H=height.

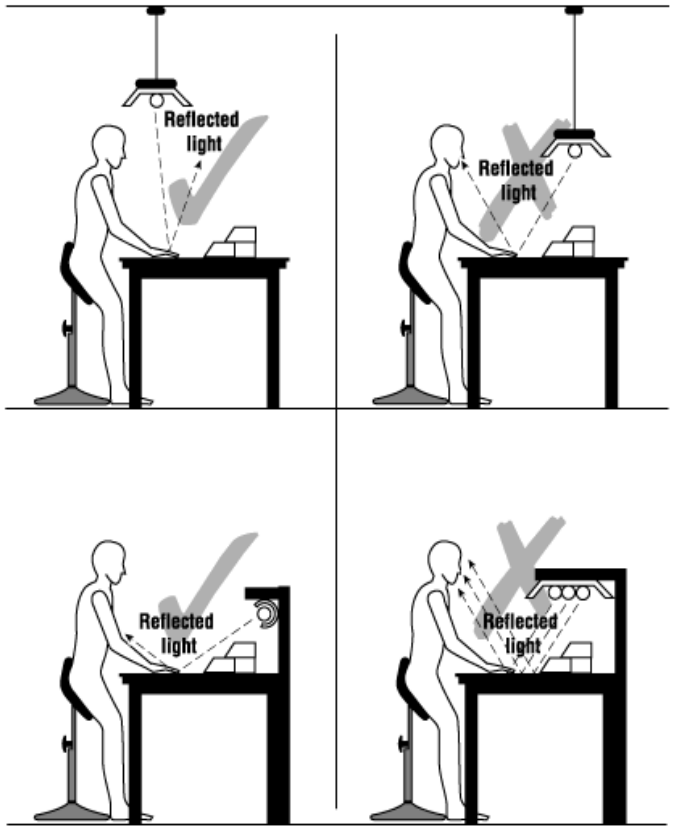
Glare Evaluation According to UGR

ρ Ceiling		70	70	50	50	30	70	70	50	50	30
ρ Walls		50	30	50	30	30	50	30	50	30	30
ρ Floor		20	20	20	20	20	20	20	20	20	20
Room Size X	Y	Viewing direction at right angles to lamp axis					Viewing direction parallel to lamp axis				
2H	2H	18.7	19.6	19.0	19.8	20.0	16.9	17.8	17.1	18.0	18.2
	3H	18.6	19.4	18.9	19.6	19.8	16.7	17.5	17.0	17.8	18.0
	4H	18.5	19.2	18.8	19.5	19.8	16.7	17.4	17.0	17.7	17.9
	6H	18.4	19.1	18.8	19.4	19.7	16.6	17.3	16.9	17.6	17.9
	8H	18.4	19.0	18.7	19.3	19.6	16.6	17.2	16.9	17.5	17.8
	12H	18.4	19.0	18.7	19.3	19.6	16.5	17.1	16.9	17.4	17.8
4H	2H	18.5	19.3	18.8	19.5	19.8	16.7	17.5	17.1	17.7	18.0
	3H	18.4	19.0	18.8	19.3	19.6	16.6	17.2	17.0	17.5	17.8
	4H	18.3	18.9	18.7	19.2	19.5	16.6	17.1	16.9	17.4	17.8
	6H	18.3	18.7	18.7	19.1	19.5	16.5	16.9	16.9	17.3	17.7
	8H	18.2	18.6	18.6	19.0	19.4	16.4	16.8	16.9	17.2	17.6
	12H	18.2	18.5	18.6	18.9	19.4	16.4	16.8	16.8	17.2	17.6
8H	4H	18.2	18.6	18.6	19.0	19.4	16.4	16.8	16.9	17.2	17.6
	6H	18.1	18.5	18.6	18.9	19.3	16.4	16.7	16.8	17.1	17.5
	8H	18.1	18.4	18.6	18.8	19.3	16.3	16.6	16.8	17.0	17.5
	12H	18.0	18.3	18.5	18.7	19.2	16.3	16.5	16.7	17.0	17.5
12H	4H	18.2	18.5	18.6	18.9	19.4	16.4	16.8	16.8	17.2	17.6
	6H	18.1	18.4	18.6	18.8	19.3	16.3	16.6	16.8	17.0	17.5
	8H	18.0	18.3	18.5	18.7	19.2	16.3	16.5	16.7	17.0	17.5
Variation of the observer position for the luminaire distances S											
S = 1.0H S = 1.5H S = 2.0H		+2.1 / -6.4 +4.0 / -15.0 +6.0 / -19.3					+2.8 / -9.2 +4.0 / -17.0 +5.8 / -17.8				
Standard table		BK00					BK00				
Correction Summand		-1.0					-2.8				
Corrected Glare Indices referring to 1100lm Total Luminous Flux											

The UGR values have been calculated according to CIE Publ. 117 Spacing-to-Height-Ratio = 0.25.

How to reduce glare?

- **Suitable beam for the purpose**
  - Narrow beam for office / task lighting
  - Limiting light intensity above 45˚ angle
- **Increased luminous emitting area size and uniformity**
  - Same lumen output evenly from bigger area - less bright
  - No bright spots on lighting surface
- **Blocking visibility to source**
  - Shading / Shielding
- **Decreasing light output**
  - Not always possible without adding more luminaires
- **Luminaire placement** (light planning)
  - Luminaires positioned so that they do not cause glare in the task area
  - Accent/local lighting (light increased where needed, task light or retail spot lights)
- **Increasing ambient lighting level** (also with indirect light) - less contrast, eyes can adapt to more brightness
  - Wall washing (lower contrast, LES hidden)
  - Uplight (lower contrast, LES hidden)

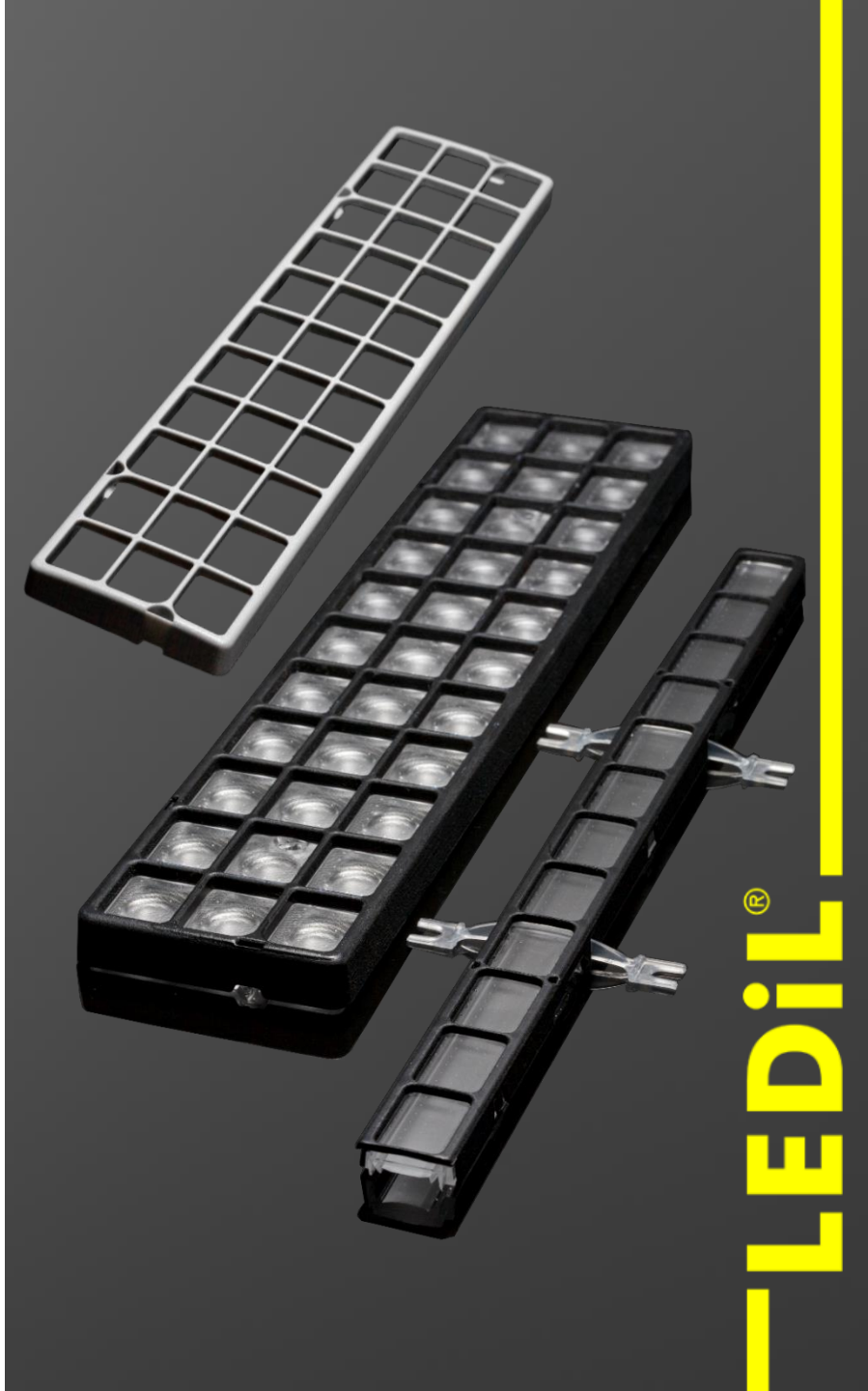


Glare control

FLORENCE-1R and -3R families

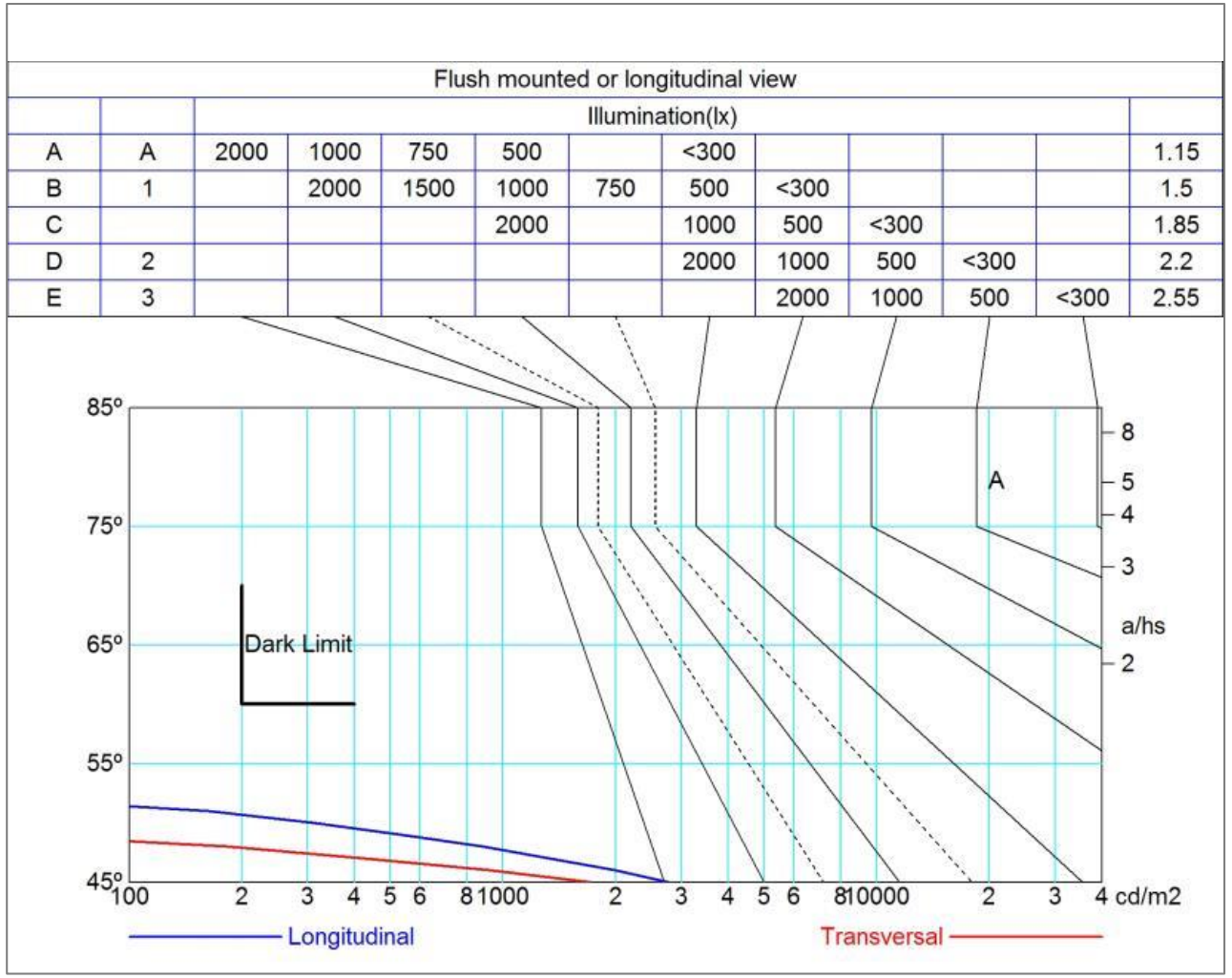
- **FLORENCE-1R and -3R** lenses are designed for the best possible efficiency **with minimal glare in mind**

- UGR rating can be further reduced with additional shades:
  - Easy to use clip-on design
  - Available in grey and black



LEDiL DARK LIGHT CONCEPT

- Zero-Glare designs
- Glare below Sollner dark limit
- No visible light sources, only effect of light itself
- Based on black reflectors



FLORENTINA blocks all light after 55˚ viewing angle no matter what the light output is

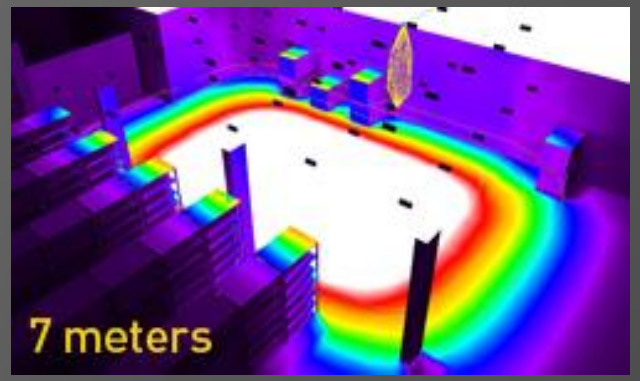
REFERENCE

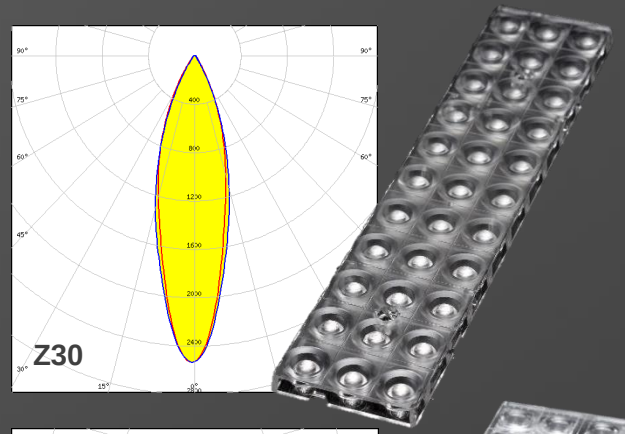
LEDiL Dark Light Concept
FLORENTINA-2X2

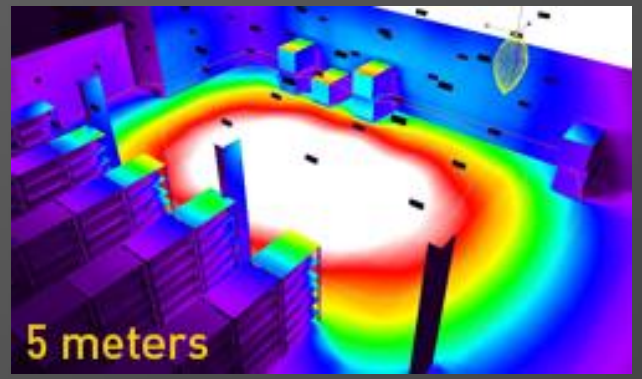
HIGH BAY

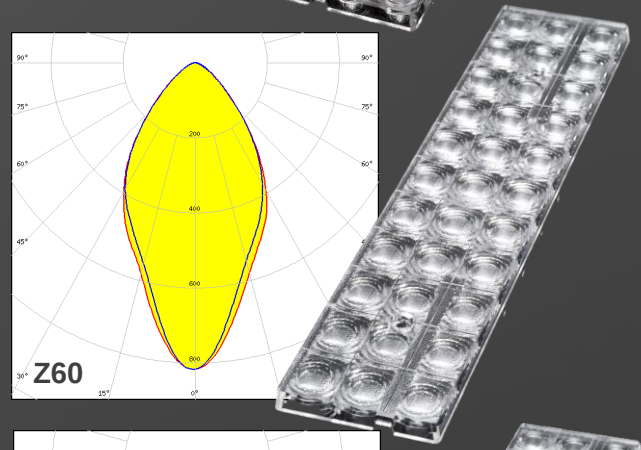
MID BAY

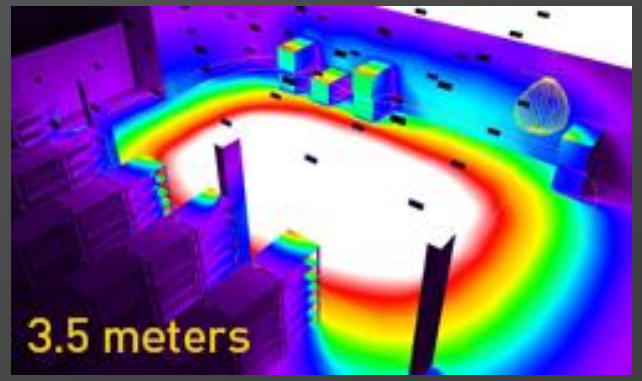
LOW BAY

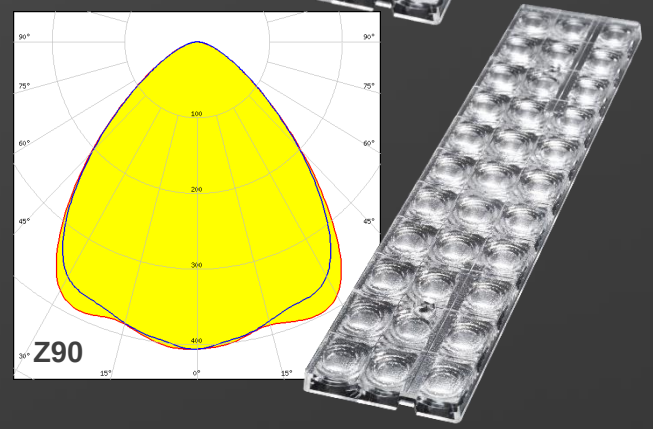












INDUSTRIAL

High, mid and low bay lighting
Distance between luminaires 1.6 x 2 m with same illuminance level on the floor level
FLORENCE-Z30, -Z60 and –Z90

LEDiL®

Typical beams for industrial lighting

Many beams in different product families optimized for different LEDs

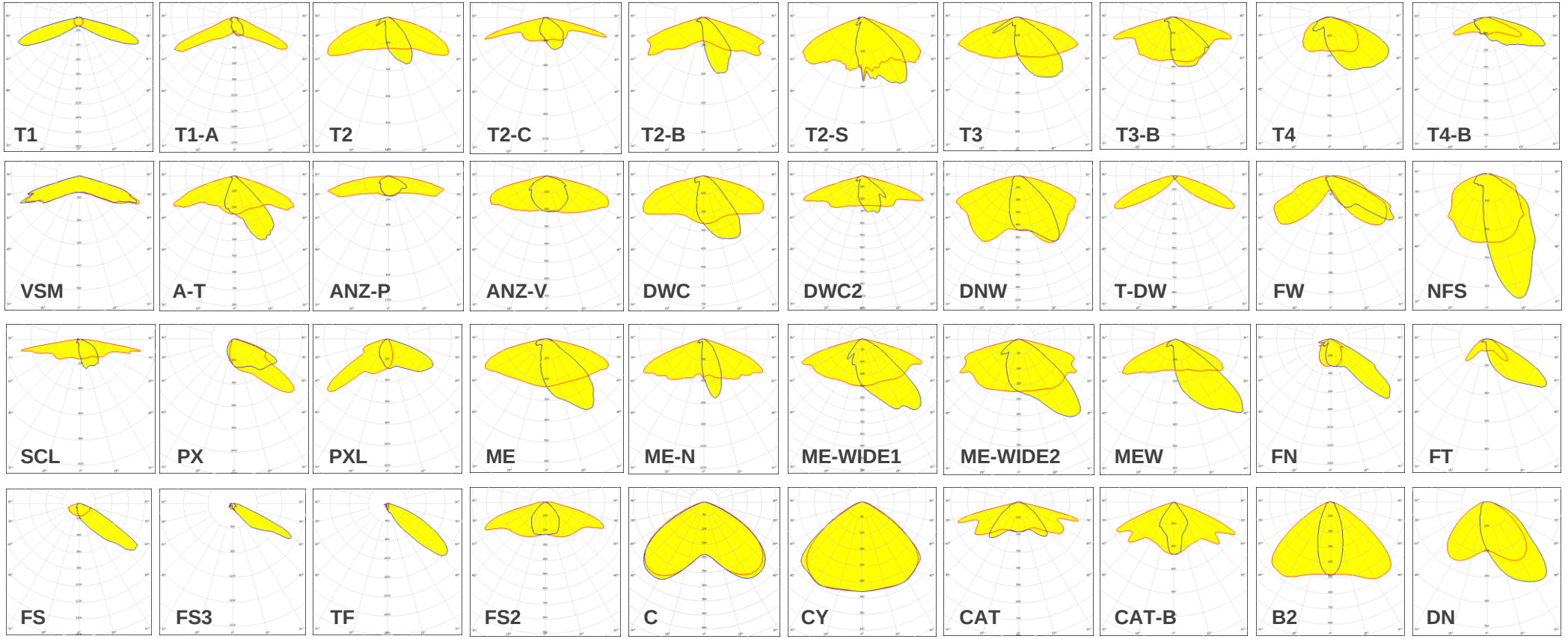
BEAMS	DESCRIPTION	Typical Installation Height (m)	HB-SQ	HB-2X2	HB-IP-2X6	HB-2X2MX-8	HB-2X2MXS	STELLA	STRADEL LA-HB	STRADEL LA-8-HB	STRADEL LA-16-HB	FLORENCE -1R	FLORENCE -3R	FLORENCE -3R-IP	LINNEA
~ 15 ˚	High bay	10>		RS	RS			RS							
~ 30 ˚	High bay	7		M	M	M		FRESNEL	S	S	S		Z30		
~ 45 ˚	Mid bay	5-7	A	W, RW		W									
~ 60 ˚	Mid bay	5		WW, WWW	W		WW	HB	M	M	M	Z60	Z60	Z60	60
~ 90˚	Low bay	3			WWW	WWW	WWW	WWW	W	W	W	Z90	Z90	Z90	90
Oval	Aisle lighting			x	x					x	x	x	x	x	x
Asymm.	Aisle lighting											x	x		x
Double asymm.	Aisle lighting											x			x

3. STREET LIGHTING

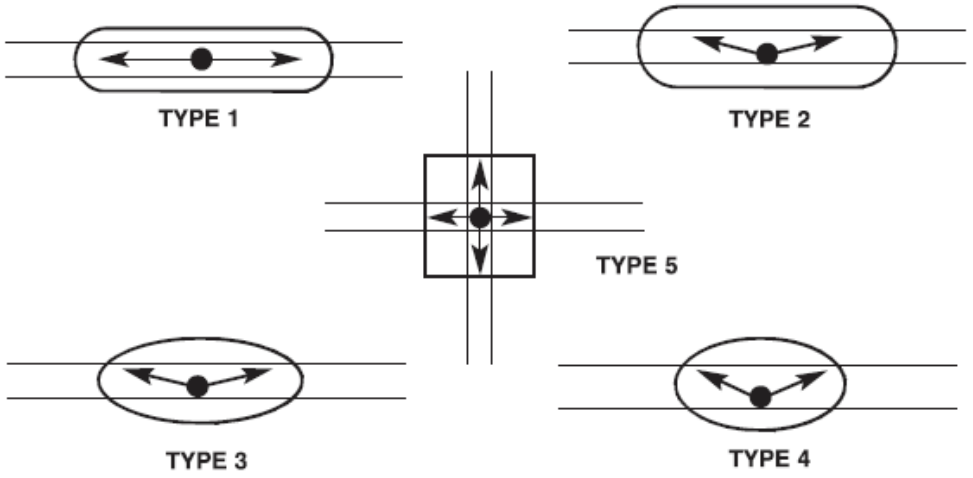
- IESNA
- Beams

Suitable beam for any installation!

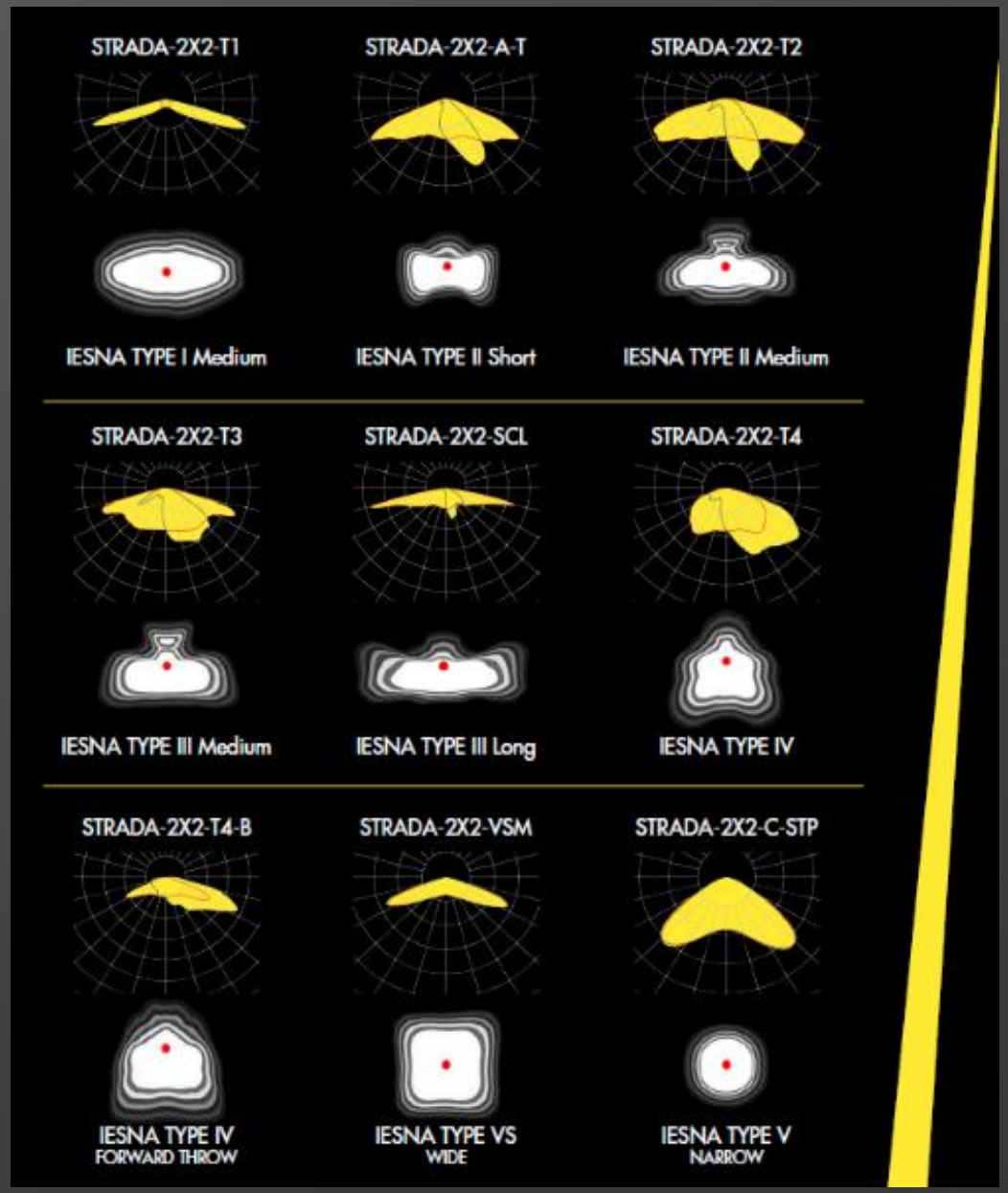
Existing street lighting beams



AREA LIGHTING CLASSIFICATIONS

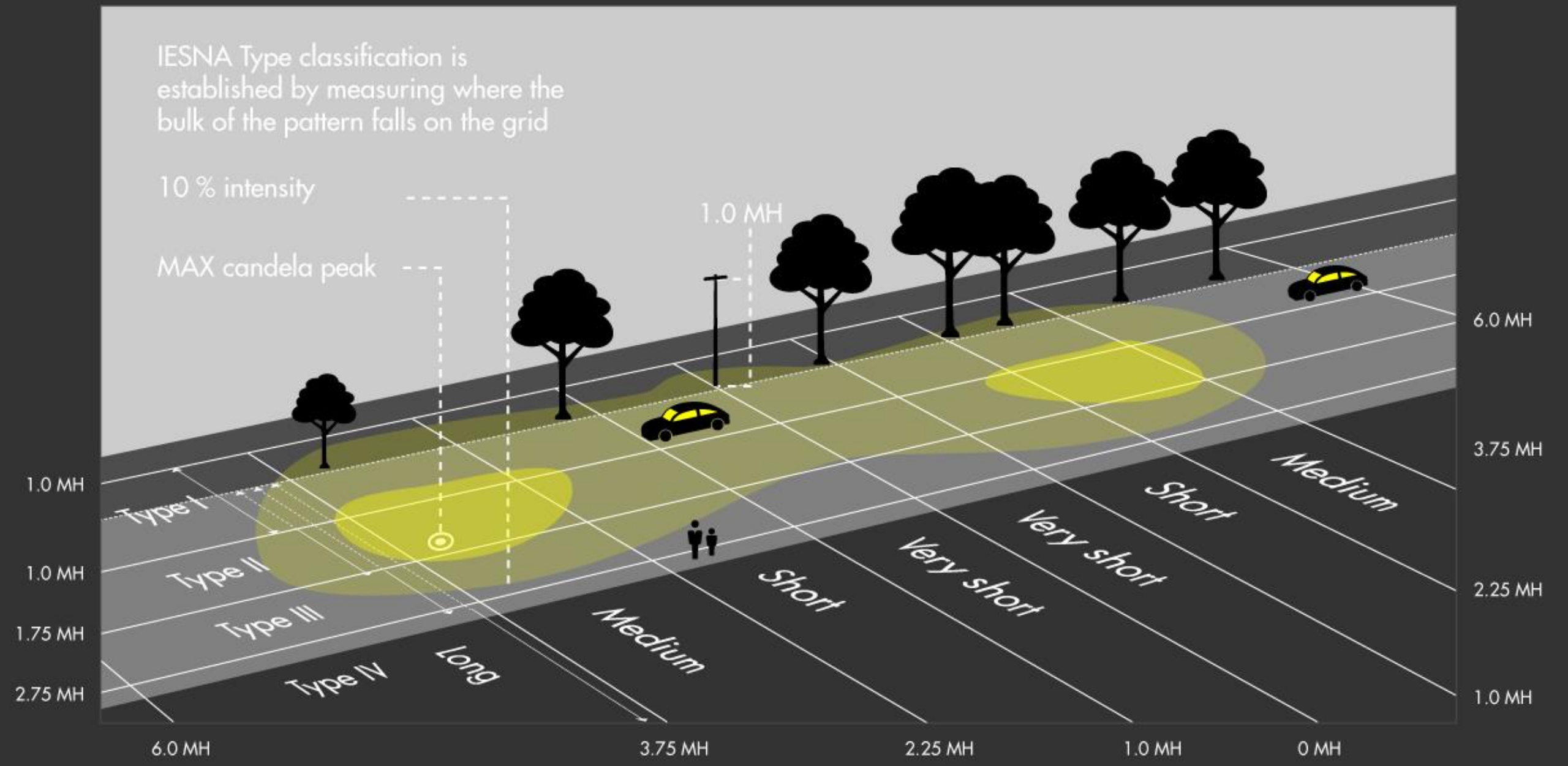


IESNA types vs road width vs mounting height	Mounting types	
	One side mounting	Both side mounting
Type I (symmetrical)	Roadways up to 2 times MH in width	
Type II	Up to 1 times MH	Up to 2 times MH
Type III	Up to 1.5 times MH	Up to 3 times MH
Type IV	Up to 2 times MH	Up to 4 times MH
Type V (symmetrical)	Up to 4 times MH in total width	



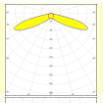
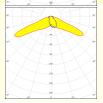
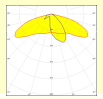
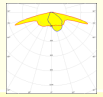
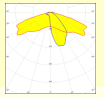
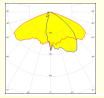
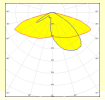
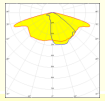
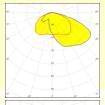
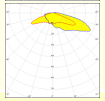
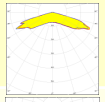
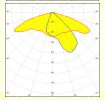
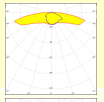
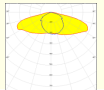
IESNA I-V

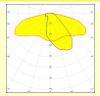
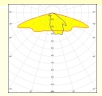
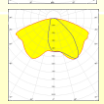
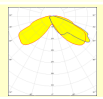
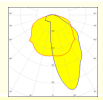
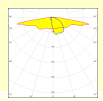
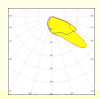
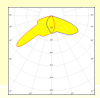
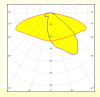
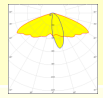
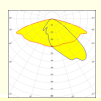
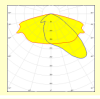
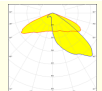
LEDiL®

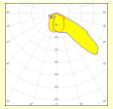
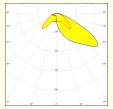
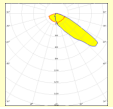
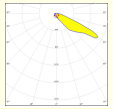
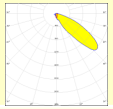
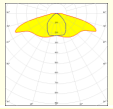
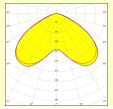
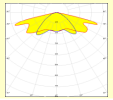
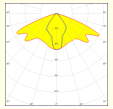
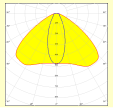
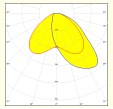


IESNA I-V

IESNA type is defined by position of highest candela intensity

BEAMS	POLAR	DESCRIPTION	STRADA-SQ	STRADA-2X2	STRADA-IP-2X6	STRADA-2X2MX	STRADA-2X2MXS	STRADELLA	STRADELLA -8/9	STELLA
T1		Symmetric IESNA Type I (medium) beam for narrow roads and paths with long pole distance and tilted armature		x						
T1-A		Asymmetric IESNA Type I (short) beam. Results a Type II beam with tilted poles. Targeted for Indian market						x	x	
T2		IESNA Type II (medium) beam, applicable for European P-class standard pedestrian lighting and M-class roads.	x	x	x	x	x	x	x	
T2-C		IESNA Type II (medium) beam with added house side backlight. Designed for tilted and long armatures		x						
T2-B		IESNA Type II (medium) with minimized house side backlight.	x		x					
T2-S		IESNA Type II (short) light distribution perfect for high or dense pole setups and European ME roads. Ideal for the US car dealership front row lighting.				x				
T3		IESNA Type III (medium) beam for typical road lighting setups.	x	x	x		x	x	x	
T3B & T3-B		IESNA Type III (medium) with minimized backlight	x		x					
T4		IESNA Type IV for wider roads and area lighting like parking lots and yards.	X (+NP)	x						x
T4-B		Wide IESNA Type IV beam with forward-throw beam for wide area lighting like parking lots.		x	x	x	x	x	x	
VSM (T5)		IESNA Type V (square) for wide areas such as parking lots.	x	x	x	x	x		x	x
A-T		Short IESNA Type II for narrow roads or high poles with extremely low glare.	x	x					x	
ANZ-P		Pedestrian lighting (P4 & P5) in Australia & New Zealand.	x							
ANZ-V		For vehicular road lighting (AS/NSZ V3) in Australia & New Zealand	x							

BEAMS	POLAR	DESCRIPTION	STRADA-SQ	STRADA-2X2	STRADA-IP-2X6	STRADA-2X2MX	STRADA-2X2MXS	STRADELLA	STRADELLA-8/9	STELLA
DWC/T-DWC		Universal road lighting beam with excellent mixed illuminance and luminance uniformity. (Typically IESNA Type III Medium)	x	x	X (+90 deg turned version)	x				
DWC2		Universal road lighting beam with excellent mixed illuminance and luminance uniformity. (Typically IESNA Type II Medium)				x	x			x
DNW		Soft wide beam with good illuminance uniformity.		x						
T-DW		Soft wide beam with good illuminance uniformity.	x							
FW		Wide light distribution with good illuminance uniformity. Residential street lighting & staggered pole setups.	x	x	x					
NHS		Narrow beam with minimal house side backlight.		x						
SCL		Type II/III (Long) for very wide pole to pole distances. Ideal for pedestrian paths and residential roads. (EN13201 P-classes)	x	x	x	x			x	
PX		Fully asymmetric beam designed to highlight pedestrian crossings for right side traffic.	x	x						
PXL		Fully asymmetric beam designed to highlight pedestrian crossings for left side traffic.		x						
ME		Fulfilling EN13201 M-class requirements where road width is equal or less the pole height. Excellent longitudinal luminance uniformity.	X (+NP)	x	x				x	
ME-N		Fulfilling EN13201 M-class requirements where road width is less than the pole height. Designed for high poles.							x	
ME-WIDE1		Fulfilling EN13201 M-class requirements where road width is equal or less the pole height. Excellent longitudinal luminance uniformity. With added house-side backlight.		x						
ME-WIDE2		Fulfilling EN13201 M-class requirements where road width is equal or less the pole height. Excellent longitudinal luminance uniformity with staggered pole setups.		x						
MEW		Fulfilling EN13201 M-class requirements for wet road surfaces in north Europe. Extremely low glare.		x						

BEAMS	POLAR	DESCRIPTION	STRADA-SQ	STRADA-2X2	STRADA-IP-2X6	STRADA-2X2MX	STRADELLA	STRADELLA-8/9	STELLA
FN		Narrow forward throw beam for area lighting. Excellent for lighting stadiums and airport fields.		x					
FT		Forward throw beam for area lighting.	x						
FS		Forward throw beam for area lighting.	x						
FS3		Forward throw beam optimized for European tunnels, resulting extremely efficient lighting with counter-beam method.	x	x					
TF		Narrow forward throw beam optimized for European tunnels.		x					
FS2		For symmetrical tunnel lighting and parking garages. Ideal for caternary street lighting.	x						
C		Area and street lighting such as parks and pedestrian walkways	x	X					
CY		Canopy lighting with batwing light distribution. Suitable for symmetrical tunnel lighting.	x	x			x		
CAT		Caternary street light beam optimized for EN13201 M-classes.		x					
CAT-B		Narrow caternary street light beam, optimized for EN13201 M-classes and tilted poles		x					
B2		Area lighting and applications demanding a wide oval beam pattern		x					
DN/T-DN		Area lighting with shorter illumination distances	x	x					

4. THINGS TO CONSIDER

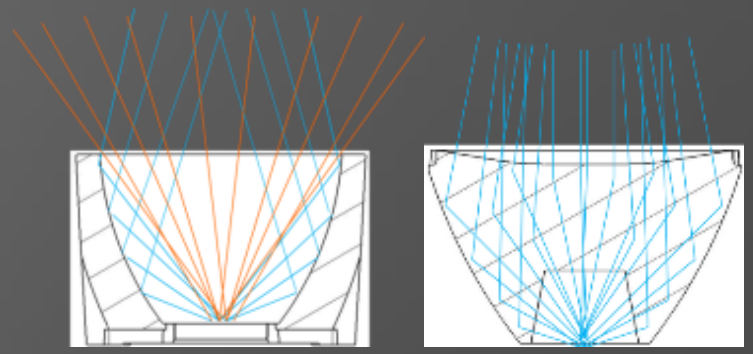
WHEN CHOOSING THE RIGHT OPTICS

- Flexibility and modularity
- LEDs
- Materials
- IP67
- System cost and in-use efficacy

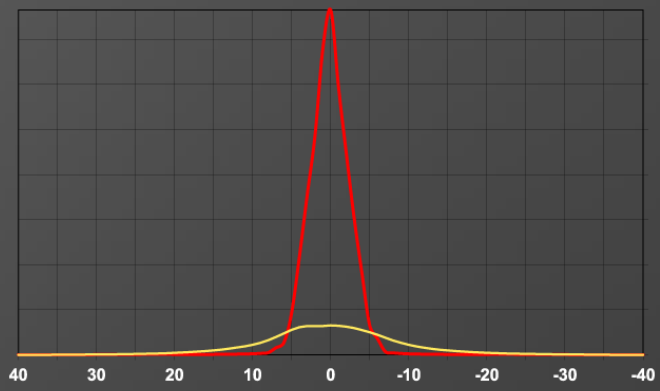
Things to consider

when choosing the right optics **for the luminaire**

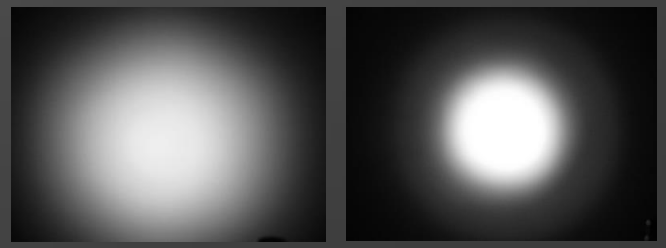
- **Mechanical constraints / demands**
  - Product design / strategy
  - Miniaturization, IP / IK classes
  - Multiple source arrays (e.g. LED / CSP clusters)
- **Ease of manufacturing**
  - Modules, product lifecycle (short vs long)
  - Positioning pins / clips
- **Cost constraints**
  - Price vs. performance
- **Thermal constraints**
  - PC vs. PMMA vs. Silicone
- **Lifecycle costs**
  - LEDiL interchangeable systems



Reflector vs Lens

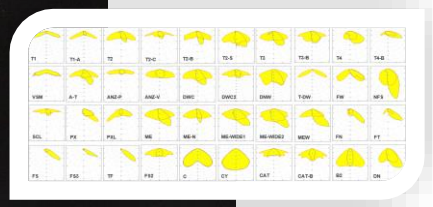


Size of the optic – 46 mm vs. 10 mm real spot



Flexibility of design

- LEDiL designs and manufacturers standard optics to fit and work with **different LEDs**
- Wide range of different solutions and beams ensures you can find close to optimal results **for each application and requirement**
- We carefully study **different installations** while we optimize the result for each application
- Innovative solutions and **patented technologies**



Modularity

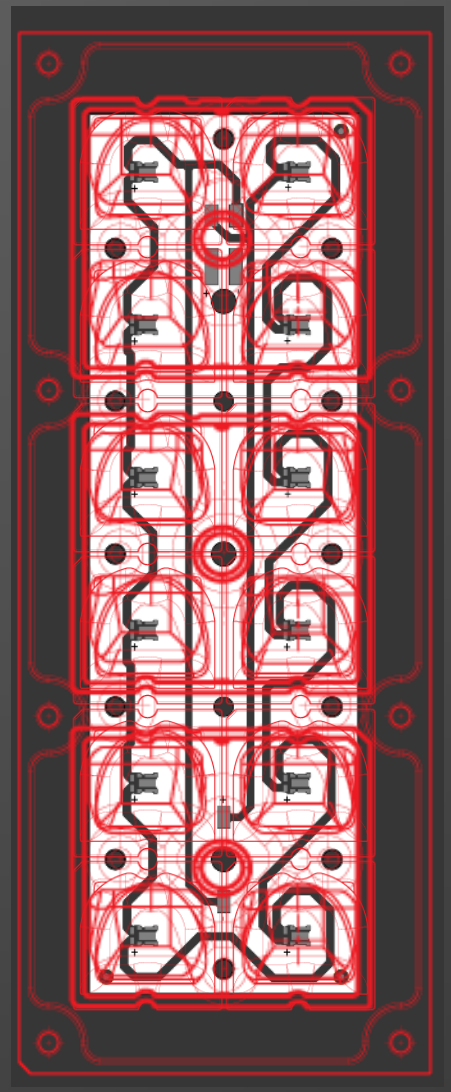
Wide compatibility & easy modification

- LEDiL offers a variety of standardized products with modular structure resulting in lower manufacturing costs and faster time to market

- Same light engine can be used with

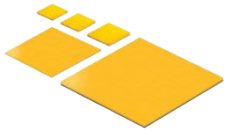
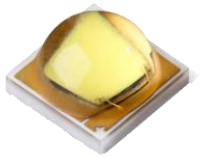
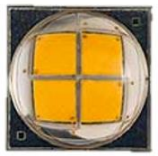
    - **12x STRADA-SQ** (up to 7070 LED packages) - for higher lumens
    - **3x STRADA-2X2** (up to 5050 LED packages) – the biggest family
    - **1x STRADA-IP-2X6** (up to 5050 LED packages) - up to IP67

- One light engine – many lighting solutions!



Picture contains animation – go to presentation mode

Different type of LEDs

LED Categories	Low/Mid power	Chip Scale Package (CSP)	3535	5050	7070	COB
						
Package/LES size	5630, 6030, 7030, 3014, 4014, 3030, 3535 ...	1080-2200	3535	5050	7070	LES 6-30mm
Nominal power	<1W	<1W or >1W	>1W	>4W	>8W	3-900W
Lumens	20-140 (up to 180)	20-300 (up to 700)	150-300 (up to 700)	300-600 (up to 1200)	600-1500 (up to 4000)	300-50 000 (up to 100 000)
LED Power categories	Mid Power	Mid Power or High Power	High Power	High Power or Super High Power	Ultra High Power	COB

CREE
NICHIA
OSRAM
LUMILEDS
PHILIPS
CITIZEN
EVERLIGHT
LG Innotek
LUMINUS
LED Light for you
plessey
bridgelux
SAMSUNG
LED ENGIN
XICATO
TRIDONIC
TOSHIBA
Leading Innovation
SEOUL
SEOUL SEMICONDUCTOR

LEDiL

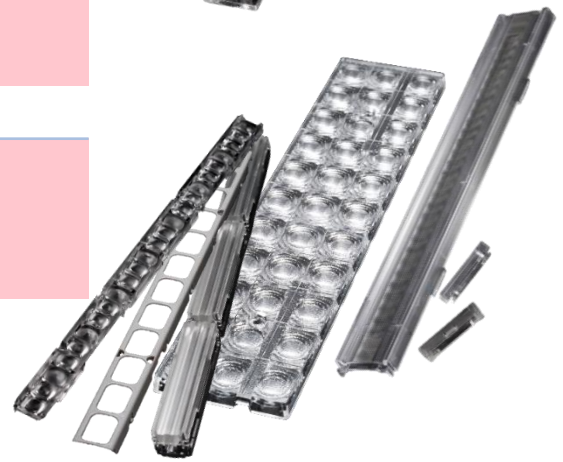
Typical LED compatibility

LEDiL product families for industrial usage vs LEDs

Mech OK
OK
Recommended
Mech NOK

MP = Mid Power LEDs
HP = High Power LEDs
CSP = Chip Scale Package LEDs

Single lenses	CSP small	CSP big	3535 MP	3535 HP	5050 HP	7070 HP	COB small <=10 mm	COB big >10 mm
STRADELLA-HB								
HB-SQ								
STELLA								
Modules								
HB-2X2								
STRADELLA-8-HB			2chip					
STRADELLA-16-HB			1chip					
IP Modules								
HB-IP-2X6								
HB-2X2MX								
HB-2X2MXS								
Linear								
FLORENCE-1R								
FLORENCE-3R								
LINNEA								



LEDiL®

Materials

- **PMMA** (polymethylmethacrylate = acrylic)
  - High resistance for outdoor UV aging
  - High transmittance 93 %
- **PC** (polycarbonate)
  - Better impact but lower UV resistance than with PMMA
  - Suitable for special requirements e.g. Fire rating and glow wire
- **Optical silicone**
  - Great UV and thermal resistance; sealable designs
  - Higher material cost but can reduce system cost as well as prolong a lifetime of a luminaire

	PMMA	PC	SILICONE
Max recomm. temp.*	80 °C	110 °C	150 °C
UL RTI	90 °C	115 °C or higher	150 °C
Transmittance (Typ.)	93 %	88 %	94 %
UV resistance	++	-	+++
IK resistance	-	++ (up to IK10)	+++

*LEDiL max recommended temperature taking light absorbtion and other environmental circumstancies into account

LEDiL®

MP = Mid Power LEDs
HP = High Power LEDs
COB = Chip On Board LEDs

Up to IP67 lenses

STRADA/HB-IP-2X6

Up to 5050 size

HP

(HB-)2X2MX

Up to 7070 size

Ultra HP

(HB-)2X2MXS

Up to 7070 size

Ultra HP

STELLA

Up to 30 mm LES

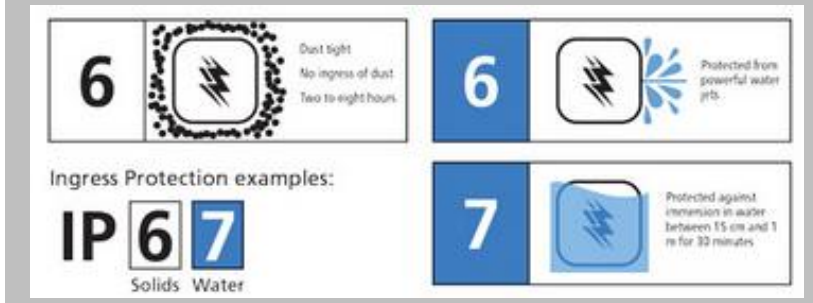
COB

FLORENCE-3R-IP

3x11 mid power modules

MP
HP

Dust



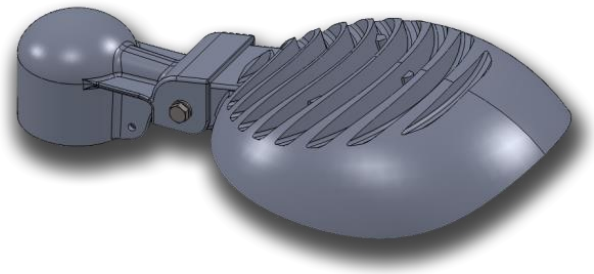
System cost

Design example glass vs silicone

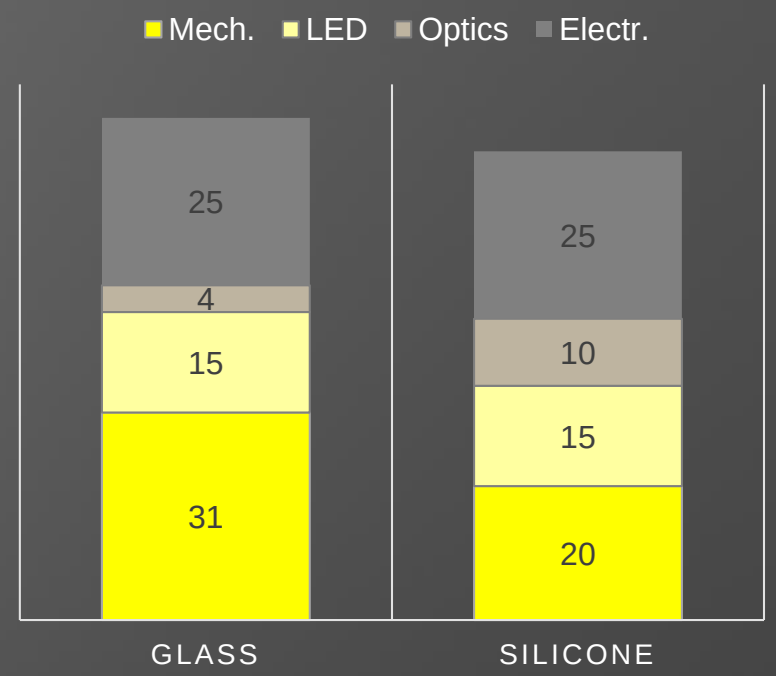
Glass

30 W Street light IP65 (glass)
- 3 die-cast alloy parts
- Several sheet metal parts
- 18 screws
- Assembly time 10 minutes
- 3.5x tooling costs
- Limited optimization of beam types

Silicone



30 W Street light IP65 (silicone)
- 2 (1) die-cast alloy parts
- 6 screws
- Assembly time 3 minutes
- 1x tooling cost
- Freeform optics allow precise and controlled light distributions



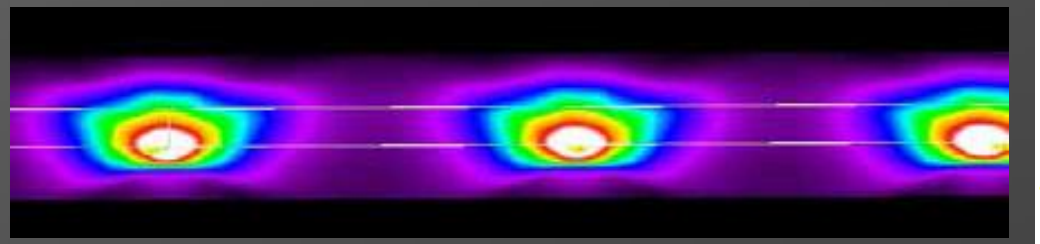
- Secondary optics can offer substantial manufacturing cost savings
  - Mechanical design
  - Structural parts
  - Ease of assembly
  - Logistics
- Cheapest optical solution doesn't necessarily achieve lowest BOM cost!
  - Higher power needed
  - More complicated design
  - Quality problems
  - More complicated manufacturing

Not all optics are equal

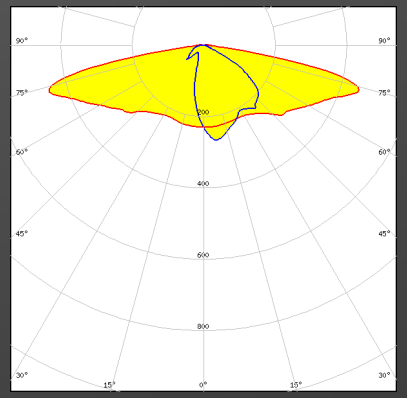
LEDiL optics have better light control resulting in less luminaires needed

STRADA-IP-2X6-SCL

- Better light control
- No disturbing backlight
- Lower power consumption
- Less light poles & luminaires needed



Residential road S4 Class (EN 1320-1) simulation

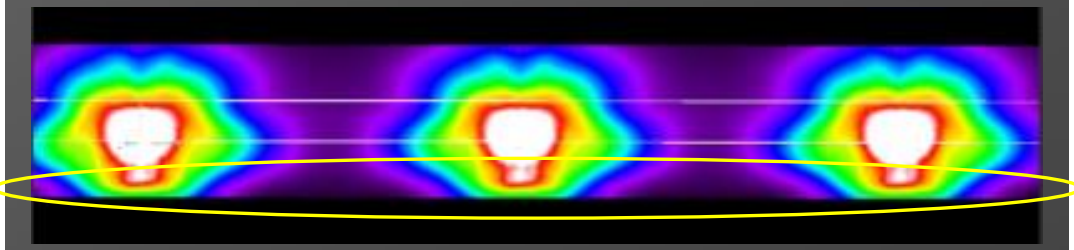


Luminous flux	3 500lm
Pole height	6 m
Pole spacing	48 m
Road width	5 m
Overhang	-0.5 m
Boom angle	0°
u0	0.196

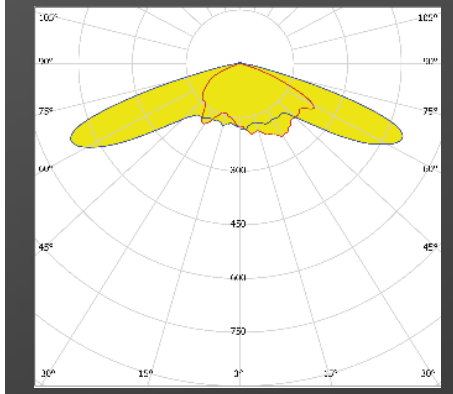
E_{av} (lx)	E_{min} (lx)
5.14	1.01
≥5.00	≥1.00
✓	✓

COMPETITOR

- Worse light control
- A lot of backlight
- Bigger power consumption
- More light poles & luminaires needed



Residential road S4 Class (EN 1320-1) simulation



Luminous flux	5 300lm
Pole height	6 m
Pole spacing	42 m
Road width	5 m
Overhang	-0.5 m
Boom angle	0°
u0	0.146

E_{av} (lx)	E_{min} (lx)
6.94	1.01
≥5.00	≥1.00
✓	✓

Profitability calculation example per km

With LEDiL optics ~2x less energy cost and ~2x less LEDs needed

	LEDIL STRADA-IP-2X6	COMPETITOR 2X6	COMPETITOR 2X2
Luminaire efficiency (lm/W)	120 lm/W	120 lm/W	120 lm/W
Luminous flux (lm)	3500 lm	5300 lm	5500 lm
Power/luminaire (W)	30 W	45 W	45 W
Pole distance (m)	48 m	42 m	45 m
Poles/1km (pcs)	21 pcs	24 pcs	22 pcs
W/km	630 W = 0.63 kWh	1080 W = 1,08 kWh	1000 W = 1 kWh
Avg eur electricity price (€/kWh)	0.14 €/kWh	0.14 €/kWh	0.14 €/kWh
Lights are on/year (h)	365 d*12 h=4380 h	365 d*12 h=4380 h	365 d*12 h=4380 h
Energy cost/km/year (€)	**387 €**	**662 €**	**613 €**
Amount of LEDs needed per luminaire with 3535 HP (300lm)	**12**	**24 (17.7)**	**20 (19)**
Amount of LEDs needed per km (pcs)	**252**	**576**	**440**

GOOD OPTICAL DESIGN MEANS GOOD LIGHTING WITH

- **LESS** watts **MORE** luxes
- **LESS** lumens **MORE** lighting
- **LESS** luminaires **MORE** light
- **LESS** cost **MORE** savings
- **LESS** waste **MORE** eco-friendly

With LEDiL optics you can achieve
LIGHT THAT IS RIGHT

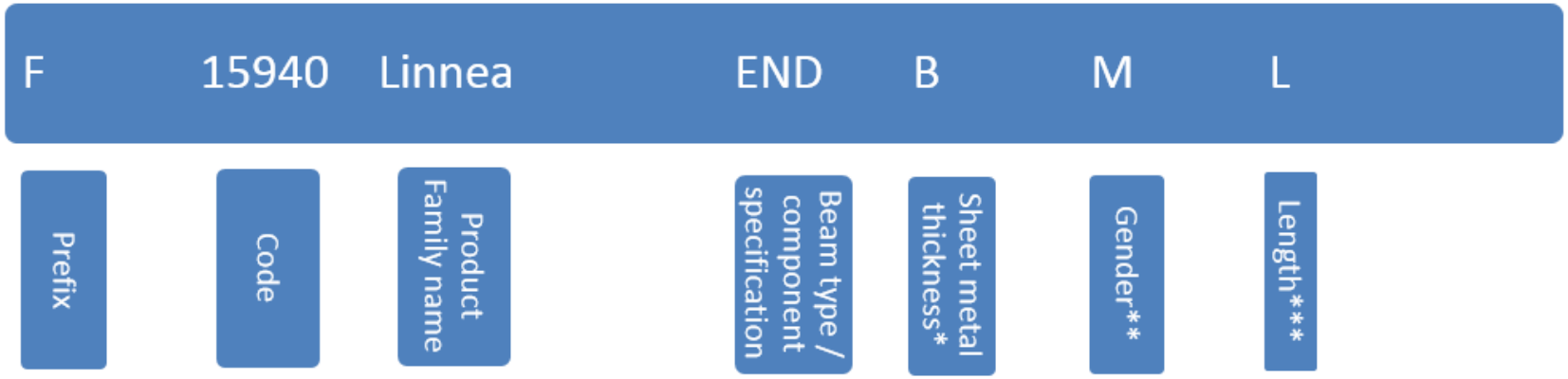
LEDiL®

5. PRODUCT NAMING & ABBREVIATIONS

Product naming

F15954_LINNEA-END-B-ML

F	15954	LINNEA	END	B	ML



LEDiL prefixes tells you the following information:

- Country of origin (CoO)
- Does the product have one or multiple components
- If the product is preassembled or not
- Does the product have tape or not

F	FI/Component
C	CN/Component
FA	FI/Assembled components with tape
CA	CN/Assembled components with tape
FP	FI/Assembled components without tape
CP	CN/ Assembled components without tape
FX	FI/Unassembled components with tape
CX	CN/Unassembled components with tape
FN	FI/Unassembled components without tape
CN	CN/Unassembled component without tape

Abbreviations in product names

RS	Real Spot	**O**	Oval	**RZ**	RZ Diffuser (Patented color mixing)	**3R**	Optics in 3 rows	**PF**	Press fit assembly
SS	Smooth Spot	**WAS, ZT25**	Wall washer	**D**	Diffused spot	**1R**	Optics in 1 row	**PIN / P**	Pin assembly
S	Spot	**Z**	Compliant with Zhaga standard	**GC**	Glare control	**2X2S/ MXS**	Variants made from silicone	**B**	Version compatible with BJB; Version (after A); For 0.5 mm thick sheet (LINNEA
M	Medium	**ZT45, Z2T25**	Double asymmetrical beam angle	**HB**	High bay	**IP**	Ingress protected	**M**	Male
W	Wide	**SE**	Side emitter	**CL**	Clear sublens	**HV**	High voltage	**F**	Female
WW	Wider	**REC**	Rectangular	**DL**	Diffused sublens	**FLAT**	Flat bottom design for wider PCB design compatibility	**L**	Long
WWW	Very Wide	**BW**	Batwing	**RZL**	Colour mixing sublens	**PLAIN**	Version with plain surface and not possible to attach sublenses on top	**G2**	Second generation
XW	Extra wide	**20,40,60 Z30,Z60 etc.**	Beam angle in numbers	**HLD**	Holder	**PC**	Made from polycarbonate		

Abbreviations

CCT	Correlated Color Temperature
CFL	Compact Fluorescent Lamp
COB	Chip-On-Board
CRI	Color Rendering Index
FWHM	Full Width Half Maximum
HID	High Intensity Discharge Lamp
HWHM	Half Width Half Maximum
.ies	Photometric data file with inverted longitudinal and transversal directions
IESNA	Illumination Engineering Society of Norh America
IK	Protection against mechanical impacts
IP	Ingress Protection
LED	Light-Emitting-Diode
LES	Light Emitting Surface

LOR	Light Output Ratio
MF	Maintenance Factor
MH	Mounthing Height
PC	Polycarbonate
PCB	Printed Circuit Board
PMMA	Polymethylmethacrylate
RGB	Colour model. Red + green + blue
RGBW	Colour and tunable with capable. Red + Green + Blue + White.
RI	Room Inder
RTI	Relative Thermal Index
SSL	Led-based solid state lightning
TIR	Total Internal Reflection
UGR	Unified Glare Rating
UF	Unitilization Factor