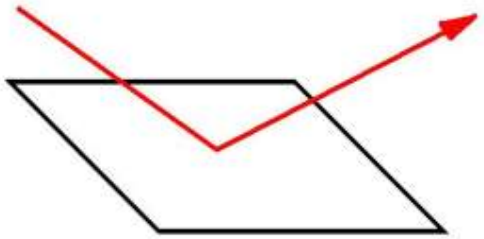
What Can You Do With Light?

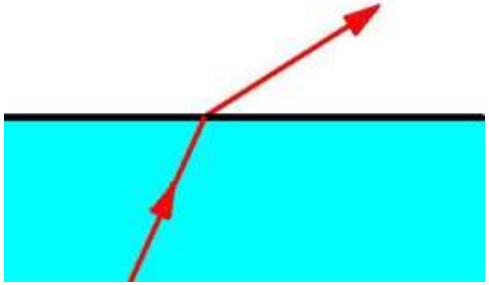
Reflect

- From metallised surfaces
- Using Total Internal Reflection, (TIR)
- From white diffuse surfaces



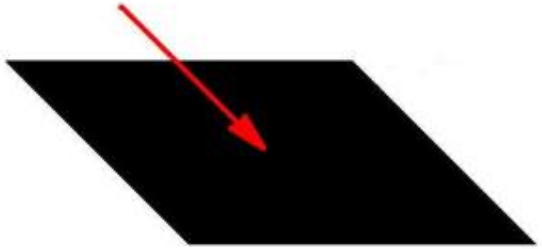
Refract

- Bend it using prisms.
- Focus it using lenses.
- Spread it using diffusers.



Absorb

- Using black surfaces
- Using structured surfaces



First steps

- Always do a light budget before you start any new job.

- Be realistic about the amount of Lumens you will get from your LED's.

- Don't forget to specify where you don't want illumination.

Designers Tip

You can increase the concentration of light within a system using optics - *but you can't create* light!

No Optics

Main Uses

- **Area Illumination**

Advantages

- **What could be simpler!**
- **Even Wide Output Pattern**

Disadvantages

- **Low intensity**
- **Uncomfortably Bright**

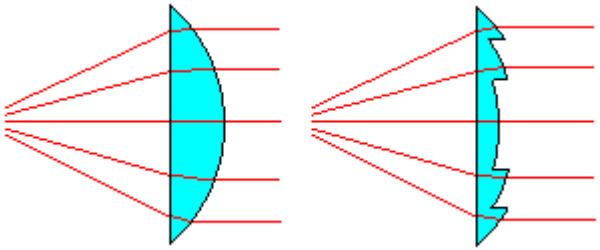
Designers Tip

Make sure you have enough Lumens available.

Also remember to shade areas where you don't want light.

Simple Lenses

(Either Conventional or Fresnel)



Main Uses

- **Spot Lights**

Advantages

- **Low cost**
- **Can be fabricated as large arrays**

Disadvantages

- **Poor Efficiency ~50%**

Designers Tip

Don't try too produce a very tight spot of light. If you do it will produce an image of the LED chip. Either deliberately defocus or use in combination with a diffuser.

Simple Reflectors

Main Uses

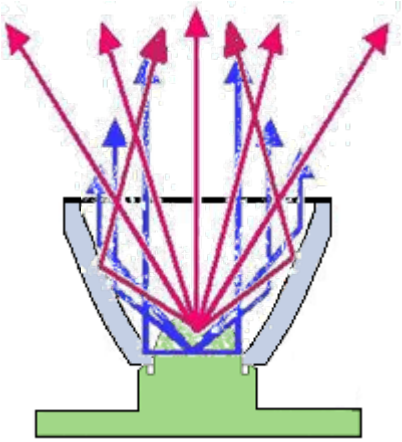
- **Area Illumination, spots, wall wash.**

Advantages

- **Produce a sharp cut-off.**
- **Even output.**

Disadvantages

- **Can't produce narrow angle beams**
- **Need secondary windows**



Designers Tip

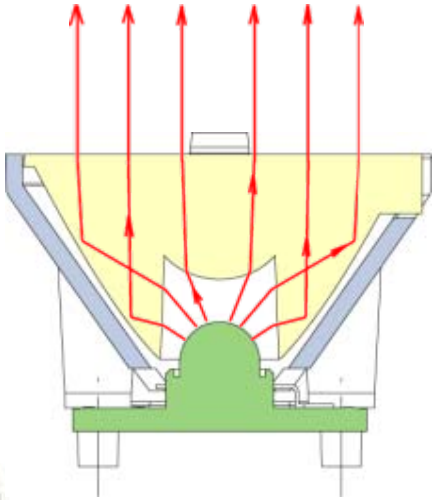
Don't put the LED at the focus of a parabolic reflector. This will produce a bright spot in the centre of the output beam.

TIR Optics

(A Total Internal Reflector Combined With A Lens)

Main Uses

- **Almost everything but particularly spots and wall washing.**



Advantages

- **Very efficient ~85%**
- **Compact**
- **Robust**
- **Can be used as window**

Disadvantages

- **Can't produce very narrow beams**
- **Fixed focus**

Designers Tip

The image from the light passing through the lens moves as the source is decentred but it does so in the opposite direction to the light reflected from the mirror. As a result dark holes can appear in the image so make sure the source is well centred.

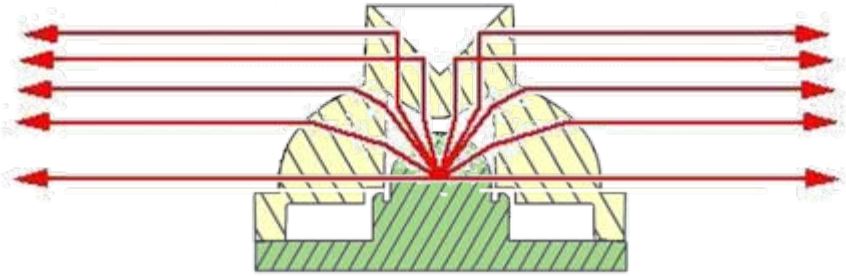
Side Emitting Optics

Main Uses

- **Beacons**

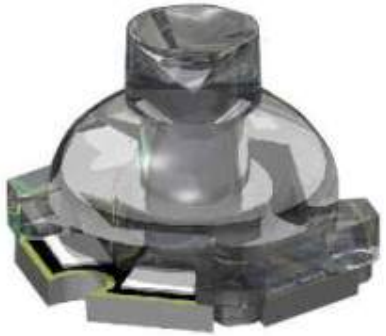
Advantages

- **Compact.**
- **Produces narrower beams than some LED side emitter chips.**



Disadvantages

- **Needs a window.**
- **Output divergence varies around the axis.**



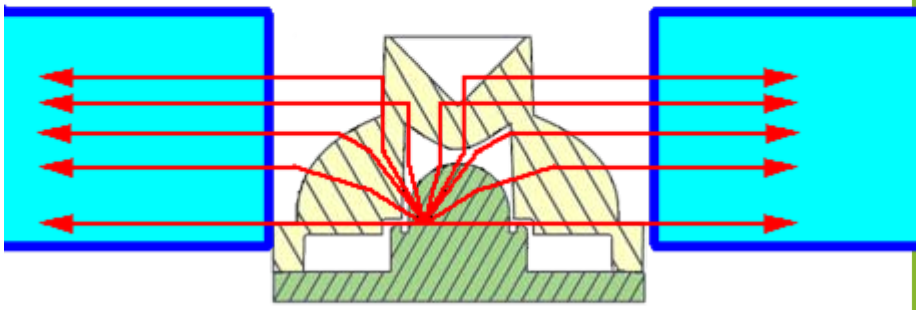
Designers Tip

Alignment with the horizontal plane is critical.

Side Emitting Optics
with light guide

Main Uses

- **Backlights**

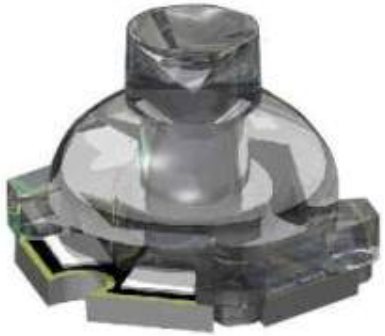


Advantages

- **Efficient coupling.**
- **Very little forward illumination.**

Disadvantages

- **Needs a reflective edge to the light guide.**
- **Output divergence varies around the axis.**

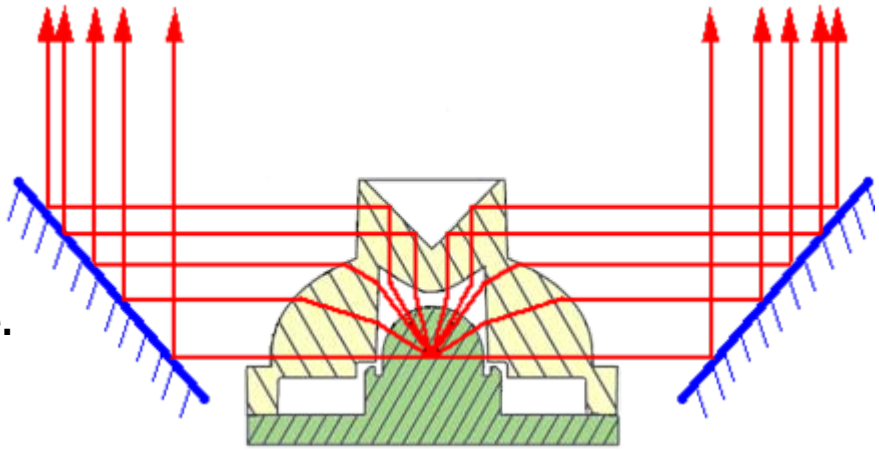


Designers Tip

Works best with light guides between 8 - 12mm thick.

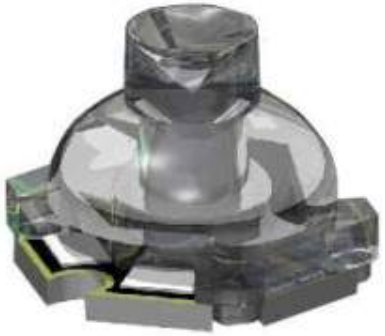
Side Emitting Optics
With Reflector

Main Uses
- **Spot lights**
- **Automotive rear lights**



Advantages
- **Retrofit to existing reflectors possible.**
- **Produces Narrow beams.**

Disadvantages
- **Needs a window.**
- **Sensitive to mirror misalignment.**
- **Can produce unsightly annular rings.**



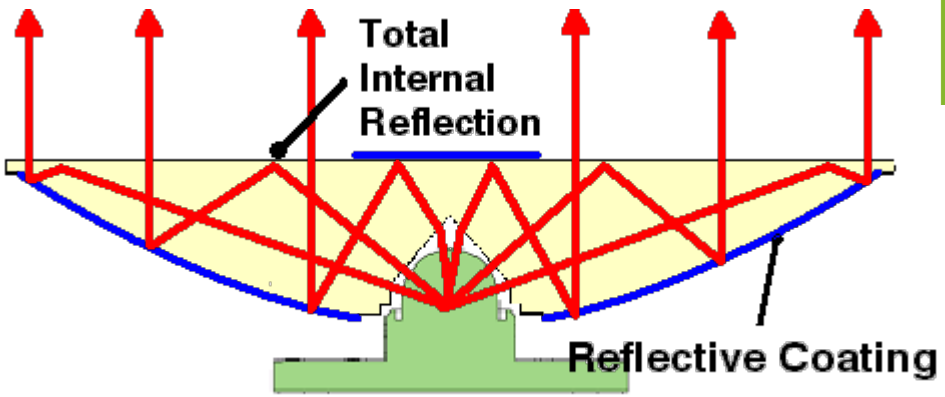
Designers Tip

Unless you are retrofitting an LED in to an existing product there is probably a better way producing a narrow beam.

Catadioptric Reflectors

Main Uses

- **Very narrow spot lights or lines when combined with linear spreaders**



Advantages

- **Compact**
- **Produce very tight beams.**

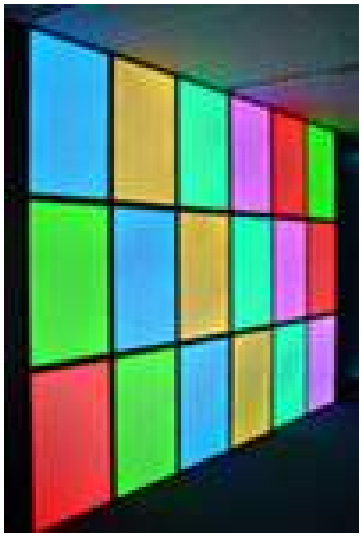
Disadvantages

- **Expensive**

Designers Tip

When used with secondary linear ripple windows they can produce very narrow lines.

Light Boxes



Main Uses

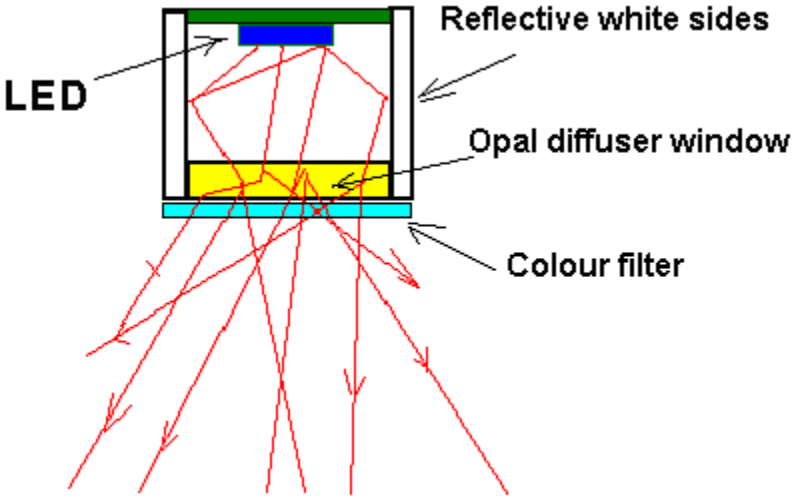
- **Back Illumination of floors, walls and ceilings.**

Advantages

- **Large area illumination.**
- **Even illumination.**

Disadvantages

- **Inefficient.**
- **Requires lots of LED's**



Designers Tip

A small change in reflectivity of the internal surfaces makes a big difference to the total efficiency.

Ripple Lenses

Main Uses

- **Widening and shaping beams**

Advantages

- **Can be incorporated in to optics and windows**
- **Can create a wide range of beam shapes**

Disadvantages

- **Used on exterior surfaces they are difficult to clean**
- **Can’t spread light out by more than 30 degrees**

Designers Tip

It is difficult to make very smooth circular patterns using ripples or pillows

Diffusers

Main Uses

- **Smoothing and widening light output.**

Advantages

- **Simple.**
- **Effective.**

Disadvantages

- **Can reduce efficiency.**
- **An additional component that increases cost.**

Designers Tip

Use the minimum diffusion to avoid wasting light. Usually they have a rough and a smooth side. Make sure you use them the right way round.

Summary of selecting optics

No Optics are usually both too bright to look at and to dim to use.

Simple Lenses are simple but inefficient.

Reflectors are great for wide beams but not narrow ones

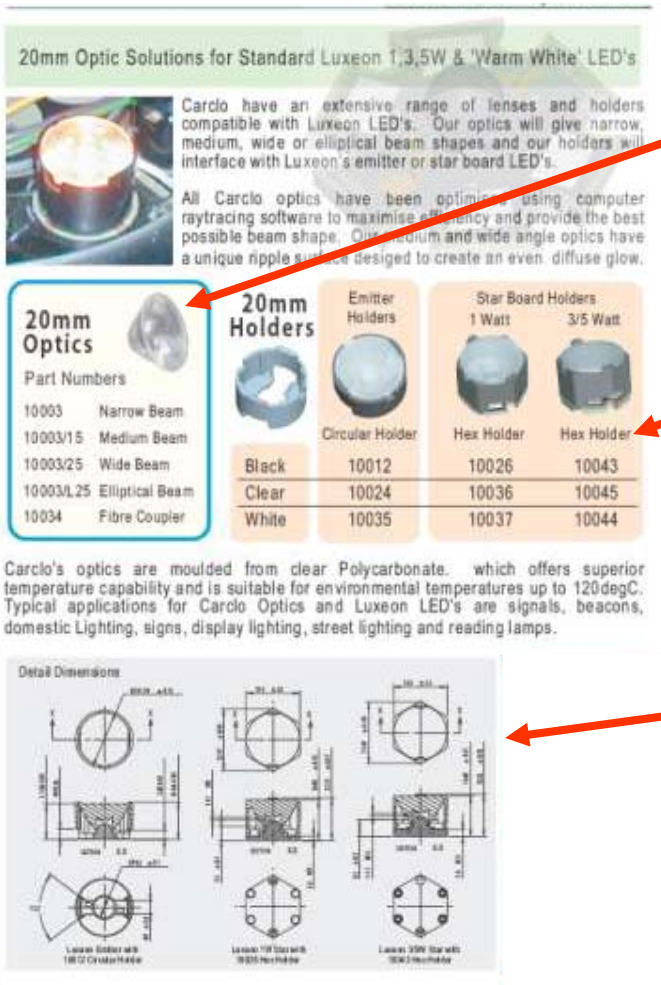
TIR Optics are the great all-rounders, but not best for special requirements

Double Reflectors are expensive but can't be beaten for narrow beams

Side emitters are often overlooked but do things others can't

Light Boxes are good for large areas or producing uniform illumination

Using Data Sheets 1



20mm Optic Solutions for Standard Luxeon 1,3,5W & 'Warm White' LED's

Carclo have an extensive range of lenses and holders compatible with Luxeon LED's. Our optics will give narrow, medium, wide or elliptical beam shapes and our holders will interface with Luxeon's emitter or star board LED's.

All Carclo optics have been optimised using computer raytracing software to maximise efficiency and provide the best possible beam shape. Our medium and wide angle optics have a unique ripple surface desiged to create an even diffuse glow.

20mm Optics

Part Numbers

10003	Narrow Beam
10003/15	Medium Beam
10003/25	Wide Beam
10003/L25	Elliptical Beam
10034	Fibre Coupler

20mm Holders

	Emitter Holders	Star Board Holders 1 Watt	Star Board Holders 3/5 Watt
	Circular Holder	Hex Holder	Hex Holder
Black	10012	10026	10043
Clear	10024	10036	10045
White	10035	10037	10044

Carclo's optics are moulded from clear Polycarbonate. which offers superior temperature capability and is suitable for environmental temperatures up to 120degC. Typical applications for Carclo Optics and Luxeon LED's are signals, beacons, domestic Lighting, signs, display lighting, street lighting and reading lamps.

Detail Dimensions

LED OPTICS

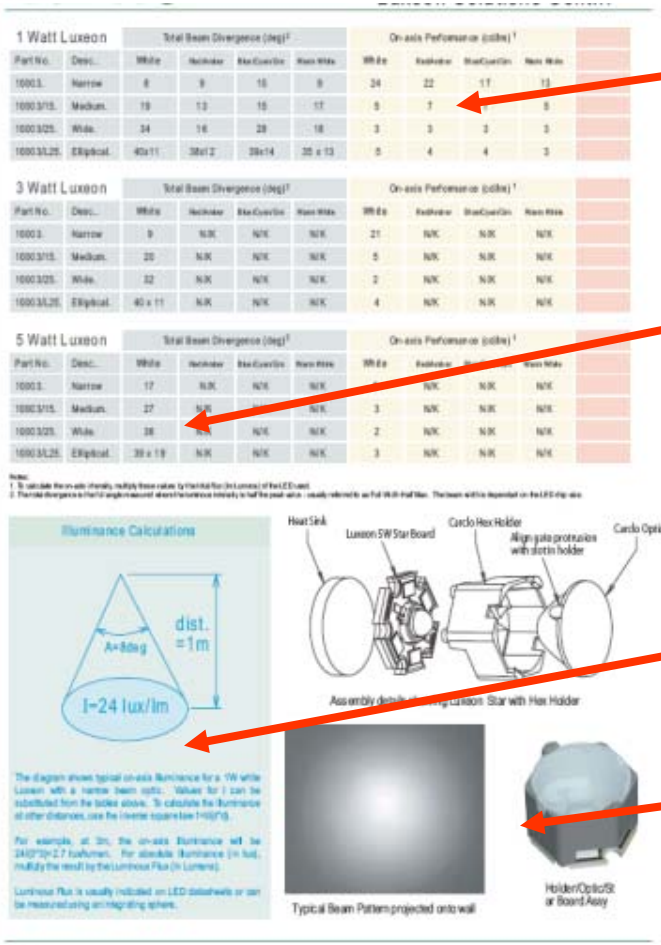
PC/0490 Iss.03

LED Optics description and part numbers

LED Optic holders description and part numbers

Assembly dimensions

Using Data Sheets 2



Candela output per Lumen of input light

Half angle, half width divergence in degrees

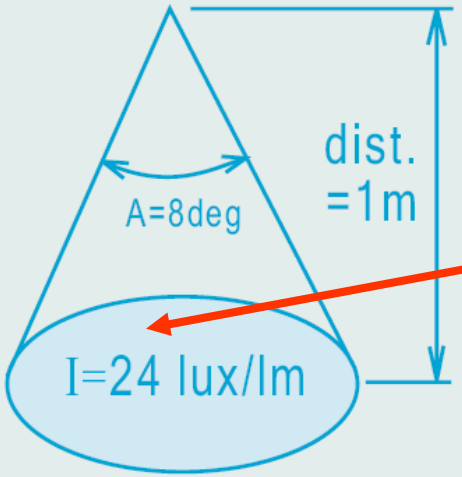
Assembly diagram

Method for calculating Lux from Candela values

Picture of typical beam output

Using Data Sheets 3

Illuminance Calculations



The diagram shows typical on-axis illuminance for a 1W white Luxeon with a narrow beam optic. Values for I can be substituted from the tables above. To calculate the illuminance at other distances, use the inverse square law I'=I/(d*d).

For example, at 3m, the on-axis illuminance will be 24/(3*3)=2.7 lux/lumen. For absolute illuminance (in lux), multiply the result by the Luminous Flux (in Lumens).

Luminous Flux is usually indicated on LED datasheets or can be measured using an integrating sphere.

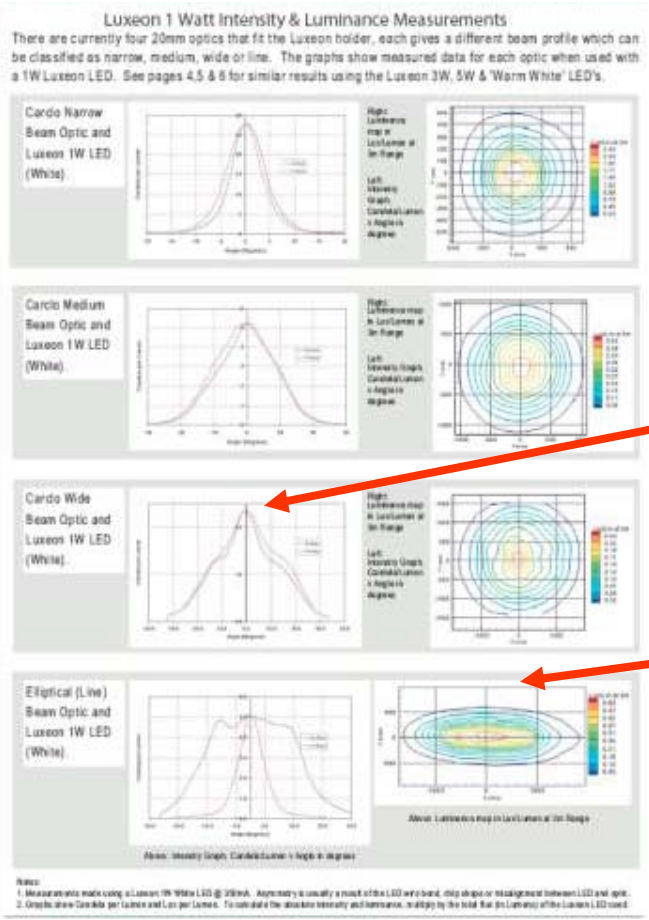
How to calculate the Lux values on a surface from the Candela output per Lumen of input light

If the distance from the LED to the surface is 1meter then the Candela values are the same as the Lux values.

Light irradiance follows the inverse square law. Double the distance and the irradiance falls by a quarter

Finally scale by the number of Lumens output from the LED

Using Data Sheets 4



Luxeon 1 Watt Intensity & Luminance Measurements

There are currently four 20mm optics that fit the Luxeon holder, each gives a different beam profile which can be classified as narrow, medium, wide or line. The graphs show measured data for each optic when used with a 1W Luxeon LED. See pages 4,5 & 6 for similar results using the Luxeon 3W, 5W & 'Warm White' LED's.

Cardo Narrow Beam Optic and Luxeon 1W LED (White)

Cardo Medium Beam Optic and Luxeon 1W LED (White)

Cardo Wide Beam Optic and Luxeon 1W LED (White)

Elliptical (Line) Beam Optic and Luxeon 1W LED (White)

More detailed information on the projected light.

Graphs of Candela per Lumen

Contour maps of Lux per Lumen output from the LED at a distance of 3m

Developing New Applications

Before You Start Detail Design

- **Consider where the light will be used.**
- **Find out if any regulations cover the product and make sure you understand them.**
- **Be realistic about the Lumens output from your LED's.**

When Carrying Out Design

- **Start by doing basic light budgeting.**
- **Have a look at what others have done.**
- **Don't just copy if you can innovate.**

Afterwards

- **Remember you have a legal duty to ensure that your products are safe. Particularly check the eye safety aspects.**

Photobiological Safety

High brightness LED's are NOT unconditionally safe!

- **They have a very small source size and the light from this can be focussed to a point on the retina.**
- **The focussed light can be damaging to end users eyes.**
- **It can be dangerous for those assembling or repairing units.**

The relevant safety regulations are

- **IEC 60825-1 where LED's are treated as lasers.**
- **CIE S 009/E:2002 where LED's are treated as lamps.**

In the future

- **LED's will be removed from IEC 60825 and incorporated in to CIE S 009 and this will then become a joint IEC/CIE standard.**
- **There will be an 'EC physical agents directive (optical radiation)' to be incorporated in to European Law.**

Summary

Understand LED's

- **Play to the strengths of LED's.**
- **Be aware of the weaknesses of LED's.**

When selecting optics

- **There are many different types of optics that can be used.**
- **Don't just think about where you want the light, remember to consider where you don't want it.**
- **Optics that were designed for conventional light sources are unlikely to give good performance.**

Designers Tip

- **Always start with the design of the optics with the smallest divergence first. It's much easier to widen the divergence rather than to narrow it.**