How does the Marinebeam Long Range Illuminator RLT really work?

To understand how the Long Range Illuminator works, one must first understand etendue, or more simply "throughput". If we want to make a flashlight have a very bright beam, and illuminate an object a long distance away, we are essentially trying to maximize the radiant power from the source (the LED) to the area illuminated by the spot. If we could get all of the radiant (or photometric) power from the light to actually make it out to the object that we want to illuminate, then, we would have 100% throughput.

Unfortunately, no optical systems are 100% efficient. They are limited primarily by the source area, the aperture size, and the input acceptance angles from the source. If we have an optical system that has a very efficient throughput, then we could add that system to any LED, regardless of lumens, and always land more lumens (have higher lumen density) that a lower efficiency system. So, with a more efficient system we can get a more intense beam with less power.

To explain this more simply, a flashlight has: 1) a light source (the LED); 2) an aperture (the open end of the flashlight);, and 3) a collimating lens (or sometimes a reflector) that is usually the same size as the aperture. Because the light source always produces a beam that is wider than the limiting aperture, then only a portion of the available light coming from the source can pass through the aperture. Photographers know this well. A lens with a bigger diameter, or aperture, will let more of the available light through the lens, than a small lens with a small aperture. Makes sense, right?

So imagine a flashlight tube, with a 2" lens, or aperture. Only a small portion of that available beam can make it through the lens, because it is a small aperture relative to the size of the beam coming from the source. So, when one tries to maximize the light through the system, one either has to increase the size of the source, maximize the aperture size, or somehow change the input acceptance angles (e.g move the aperture closer to the source). The normal solution for long range spotlights is to make the lens huge, to use reflectors, or try to position the lens as close to the source as possible. This gets either extremely expensive (big lenses are expensive) or optically tricky.

We mention all of the above to let you understand that if one could somehow improve just the throughput through the system by 2.5X, then the resultant beam will be 2.5X brighter than it would without it. This is independent of lumens, or optics. So, no matter what the lumens of the source, and no matter who the manufacturer, if the throughput can be increased, we can make any light brighter. This is the way RLT improves the output. We increase the throughput of the light through the system by up to 2.5 times using a simple, but unique, light recycling method.

Said another way, if we started with two of the exact same LED flashlights, with the exact same lens, and the exact same amount of lumens, and we then add the RLT collar, the light throughput would now be improved by up to 2.5X. This is why Marinebeam is now licensing this RLT technology to other manufacturers. It is a technology that is applicable to all LED flashlights.

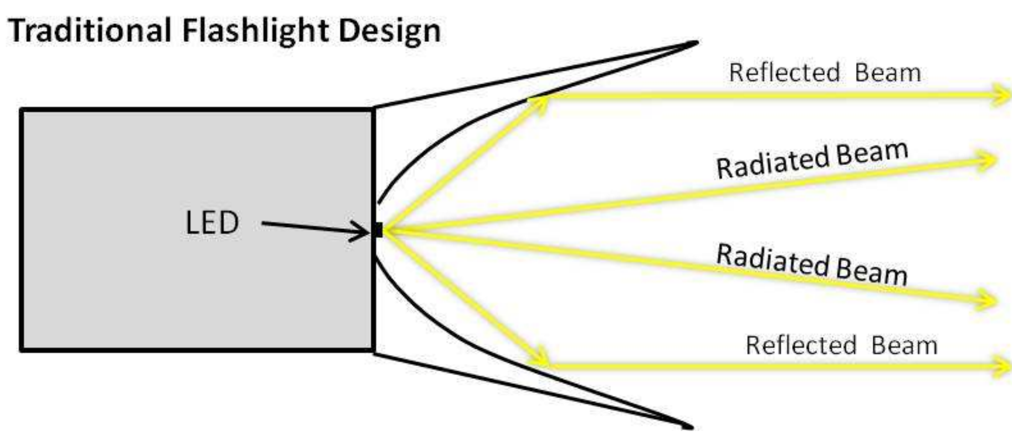
Because of these patented improvements to light output, no other LED flashlight can compete with the brightness and throw of the beam. Even at very low lumen levels our Illuminator outshines much more powerful flashlights.

We will get to the ways that RLT affects the brightness and throw shortly, but first let's look at the conventional LED flashlight, and see how it works.

Reflector Type Designs:

You may have noticed that some flashlights have reflector, with a clear glass cover, and other flashlights have no reflector, and instead have an aspheric lens.

Let's look at the reflector type first. The most important point to know is that all conventional spotlights using a reflector actually have 2 beams: The direct (or radiated) beam from the light source, and the light that has been reflected out by the reflector. This is obvious in the conventional LED and incandescent flashlights where you see two or more distinctive halos of light when you shine the beam upon a wall.

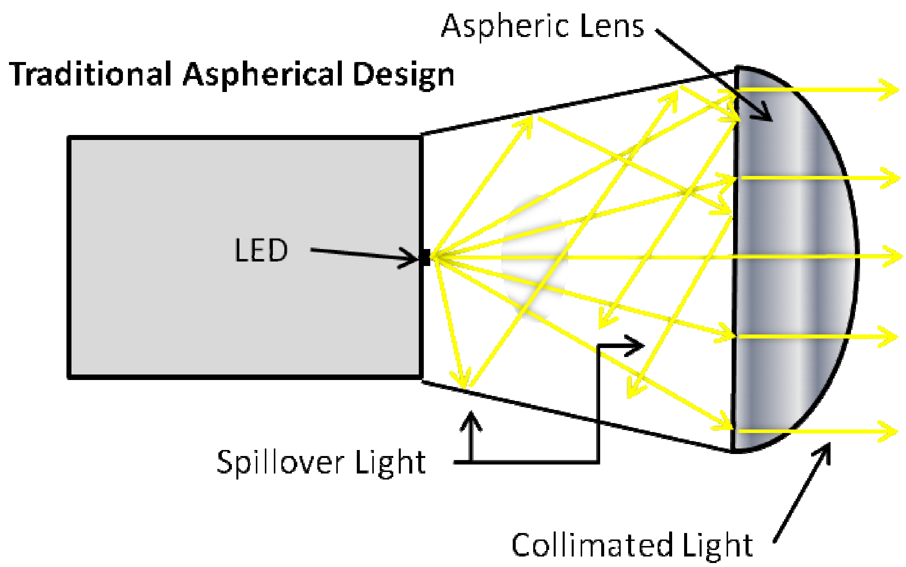


These flashlights have a parabolic reflector to redirect the wider angle light to get it to go out the end of the flashlight. If you shine a traditional LED or incandescent flashlight against a wall you will see that the second-beam is less bright and much wider than the center "hot spot". This dimmer and wider light is the reflected "spillover" light. This wider halo can contain up to 50% of the light energy coming out of the flashlight. Most of that light energy never makes it down range, as it is diverging with distance. Only the center spot is able to project down-range.

The RLT technology does not use such a reflector, and has no spill-over light, so, all of the light energy the LED is projecting is in the center beam.

Aspheric Lens Type Designs:

The second type of design uses an aspheric collimating lens. Flasdhlights that have this type or lens will never have a reflector, because for the lens to collimate its light, the light must pass through the focal point of the lens, and the reflected light would not do so. So, the light must come directly from the source, which is positioned exactly at the focal point of the lens.



Lenses are ideal for long-range designs because they can collimate the light coming from the source.   All of the light passing through the focal point of the lens is collimated and can project a very long distance.   Unfortunately, these designs are still affected by throughput, and if fact have a low throughput.

Here is the important part – remember that this lens is effectively the limiting aperture of the flashlight's throughput. Only a very small portion of the available light coming directly from the source is passing through the lens.   This is easy to imagine by envisioning this type of flashlight with a crystal clear body (tube). In other words, a clear bodied flashlight where you could see right through it. While you would see some of the light passing through to the lens, you would also see most of the light missing the lens entirely and lighting up the room 360 degrees around the axis of the flashlight.   While all of that light is coming from the source, and passing through the focal point, unfortunately none of this "spillover" light that you see is making its way through the lens, nor is it reaching its target. It is all wasted. Only the portion of the beam that goes through the aperture (the lens in this case) is being used. Again more than 50% of the energy can be wasted in these designs.

"But wait", you say, " there are many flashlights on the market using aspheric lenses that project an image and seem to have no spill-over light. How is this so?" The answer is that these lights still have two beams. The second beam (the one that was lighting up the room in the example) is just bouncing around endlessly inside the flashlight housing to be lost forever. Even if it eventually reaches an angle that could pass through the lens, it wouldn't collimate, as it needs to pass through the focal point in order to do that. So, in most low-spillover designs, this second beam is merely hidden.

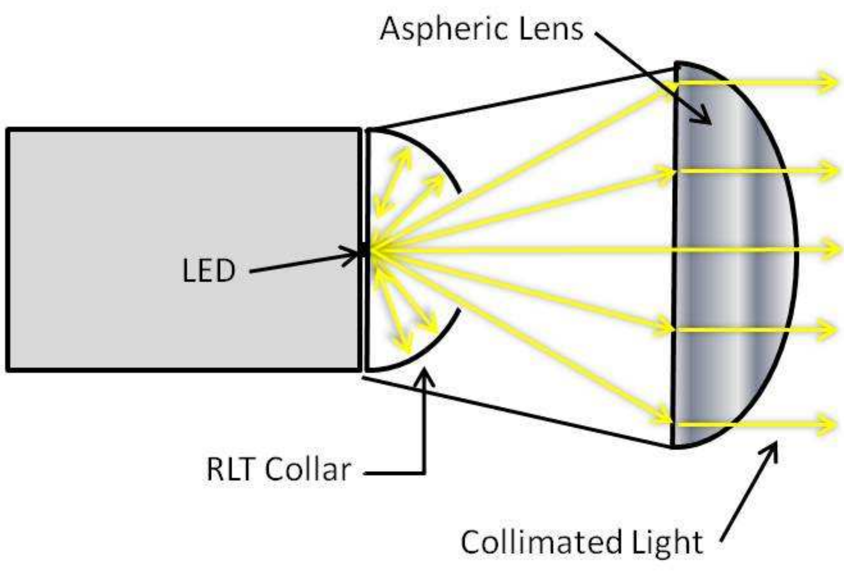
In the case of the RLT, this wasted light is actually captured, intensified, and added back to the main beam. So, it is not only brighter, but it all goes through the focal point and through the lens at relatively small angles. There is no wasted spill-over light, and most of the available energy from the LED goes down range

How does it do it?

Well, imagine that we could somehow improve the throughput of the system by passing more of the available light through the aperture lens. To do that without changing the source, and without changing the size of the lens, we would have to somehow create a light beam whose angle matched the lens's input acceptance angle, but do so without losing the energy. We would also have to do it in a way that all the light energy still passes through the focal point of the lens. So, traditional lenses and reflectors are out. A seemingly tough problem, but one that is simply solved by the RLT.

The RLT is in fact a spherical collar with a hole in its center. Its reflective inner surface faces the LED itself. It works by capturing all of the wide angle spillover light, and re-directing it back onto the surface of the LED. That is, sending all of that spill-over light back to the LED chip. This light re-excites the LED's phosphors, which creates more white light in the center beam. In the center of the RLT collar is a hole, which allows all of this narrow angle light to pass through to the lens. This means both the LED's original center beam plus the recycled light, passes through the collar to the lens. The spillover light is essentially added to the main beam, and boosted by the re-exciting of the phosphors. Now, much more of the available light energy matches the lens's input acceptance angle, and is collimated by the lens.

Marinebeam RLT Design



To understand this effect better, it helps to know that white LED light is actually made by starting with a blue LED, and then adding a phosphor mix to its surface, which will absorb that blue wavelength light emitted by the LED die and re-emit it in a new wavelength (technically a group of different wavelengths that combine to make up white light). The resultant white LED light sometimes still has a bluish cast, and that is because it still has a dominant blue wavelength. What the RLT does is send that light back to the LED so it is re-converted into more white light. The RLT has taken the normally wasted spillover light, and not only redirected it into the center beam, but also given it a boost by creating more white light. So, there are really at least two mechanisms at work here.

When the blue light is converted to white light, it actually converts to a warmer color temperature as well. This means that we can start with a bluer or cooler LED, which has more efficacy than a warmer white light, yet still end up with a more aesthetically-pleasing and “whiter” light. Brighter too!

So, we not only capture and redirect the normally wasted spillover light, but we also recycle that light to create more white light.

With our Illuminator, we are not necessarily trying to make the most powerful LED light. Quite the contrary. What we are trying to do is increase the efficiency of the light so we can use the least amount of LED energy to create the brightest light, with the longest beam distance. So, fewer Watts, but more landed light at a distance.

With the RLT mechanism described above, we have already removed the spillover light and then added it, with a boost, to the main beam. Something no other flashlight or LED can do. So, at this point there is already only a single beam. While the beam is already more intense, we now need to collimate the light into a narrower beam to get the distance we want.

Collimation is essentially making a spot light with an infinite focal distance. To do that, we use an aspheric lens. An aspheric lens collimates (or makes parallel) any light beams which travel through its focal point. So, positioned correctly, it makes a nice long beam. It also “images” the LED chip. This means that is projects a picture of the chip on the wall. A nice clean projected image, with sharp and defined edges.

To review, here is a recap of some of the mechanisms contributing to the brighter, longer range light with RLT:

1. The RLT captures the spillover light and redirects it back to the LED.
2. The LED is re-excited and converts the blue wavelength in the LED light to more white light.
3. Unconverted and converted light are also redirected due to scatter.
4. The second beam is removed entirely, allowing all of the light to travel through the focal point of the lens and be collimated. No wasted light, no second beam.
5. A more powerful, but bluer cool-white LED, can be specified, yet result in a warm LED color. This means you can get a brighter more efficacious light, and still get the pleasing color of a less bright selection.