WHITEPAPER

Cinema laser projection

Illumination options for your cinema

CHRISTIE®

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For over 10 years, our industry has transformed from film to digital projection with the objective of improving and providing a consistent motion picture experience for your audience.

Simultaneously, the creative community has expanded their storytelling techniques with technology advancements such as 3D, High Frame Rate and High Dynamic Range. These advancements in storytelling have at times required an upgrade or replacement of the existing digital projector in order to showcase these movies to your audience. For exhibitors who are thinking about replacing their digital projection equipment or outfit a new build, one technology that has created new questions is laser projection.

Today's digital projectors have several illumination options (Xenon lamp, laser phosphor, and RGB laser) available. However, not all light sources provide the presentation experience you or your audience expect.

This illumination overview explores the reasons why, when considering a laser projection solution, RGB laser will soon become the dominant illumination technology for lighting cinema screens, provide a foundation for future technology advancements, and enhance the cinema experience.

What makes a great image on screen?

The answer is simple. Brighter is better, accurate colors appear more natural, higher contrast is critical, and high resolution displays finer details. In 2007, when studios defined the original DCI specifications for digital cinema projectors they specified these standards for on-screen brightness, color gamut, contrast ratio, and exact pixel resolutions based on the technology at the time.

What was known then:

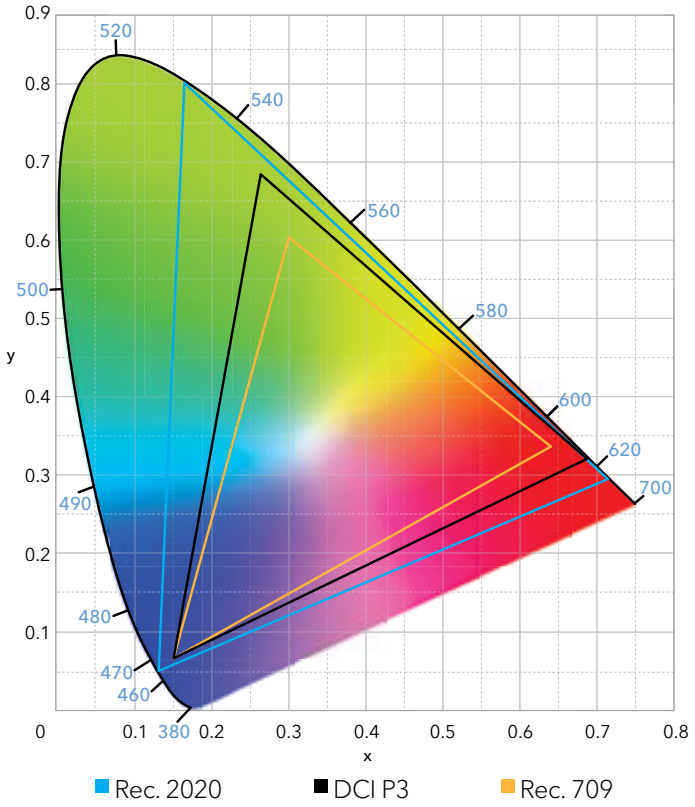
- How to light up screens to 14 fL (though not in 3D)
- Xenon lamps could easily reproduce the P3 color gamut
- Imaging chips could achieve a certain contrast ratio and resolution

So these became the standards.

Since then, the display industry has advanced rapidly. Consumers can now purchase display technology for the home with higher resolution, improved color and contrast that's comparable to many cinemas. The younger generation has become more tech-savvy and will begin to notice these visual differences, or lack of, if our industry fails to invest in keeping up with technological advancements.

Is red truly red?

Color is perhaps one of the most misunderstood aspects of the cinema experience.



The outer curved boundary is the spectral locus representing all the colors that can typically be perceived by the human eye. Note the triangles that are plotted on the curve. These triangles indicate the capabilities of various display technologies with respect to the entire visible spectrum. The innermost triangle defines the Rec.709 standard. This is a color standard defined in 1990 by the television industry for HDTVs. It is also very close to the capabilities of a typical computer display or conference room projector. The next triangle out is the DCI P3 color gamut for digital cinema projectors. Note the increased volume of colors in this triangle versus the innermost one, especially in various shades of green and deep reds. Of particular importance here is the red color. Most people can easily spot the difference between the orange-red in the Rec.709 triangle versus the deeply saturated reds in the DCI P3 specification. Not only is this a color which exists commonly in the world off-screen, but is also critical for reproducing natural skin tones. The largest triangle on the curve is the Rec.2020 color space, recently developed by the television industry as an aspirational goal for future UHDTVs. Note the significantly increased coverage of the CIE color diagram, bringing in many new colors that cannot be reproduced in the other color spaces. There are currently no TVs that can perfectly reproduce this gamut of colors. The only technology that can fully achieve this is an RGB laser projector.

Currently, every compliant digital cinema projector is built to cover the DCI P3 standard to within reasonably tight tolerance. To achieve this, most projectors need a device called a Yellow Notch Filter (YNF), which is a glass optical element that cuts out yellow light, hence increasing the relative contribution of green, and more importantly, red light in the displayed image. However, by cutting out yellow light, we are also reducing the overall brightness of the projector. As a result, cinema projector engineers must carefully balance the design of YNFs to achieve the right color capabilities without sacrificing too much brightness.

Laser phosphor projection

One interesting innovation seen in the projection market recently is laser phosphor or blue-pumped phosphor. On the surface, this seems like a revolution as it allows us to create white projection light using only blue lasers, which are based on a mature and economical laser device technology that needs far less cooling than other lasers. This allows manufacturers to build relatively inexpensive projectors that need less maintenance than conventional projectors, since there are no lamps to be changed.

However, there are some major drawbacks with respect to laser phosphor technology, especially in a cinema environment. For example, laser phosphor projectors use a lot of energy (>50%) in the conversion of blue light to white light. Furthermore, the native color gamut produced by this type of projector is typically smaller than the Rec.709 triangle shown in the CIE diagram and is particularly deficient in the critical green and red colors that are essential for a natural looking image. As a result, projector engineers using a laser phosphor light source need to make tough decisions regarding the design of YNFs to retain brightness while still achieving some essence of acceptable color performance. For laser phosphor technology, the YNF will waste as much as 50% of the available light to achieve the demanding DCI P3 specification for cinema.

Xenon's total cost of operation

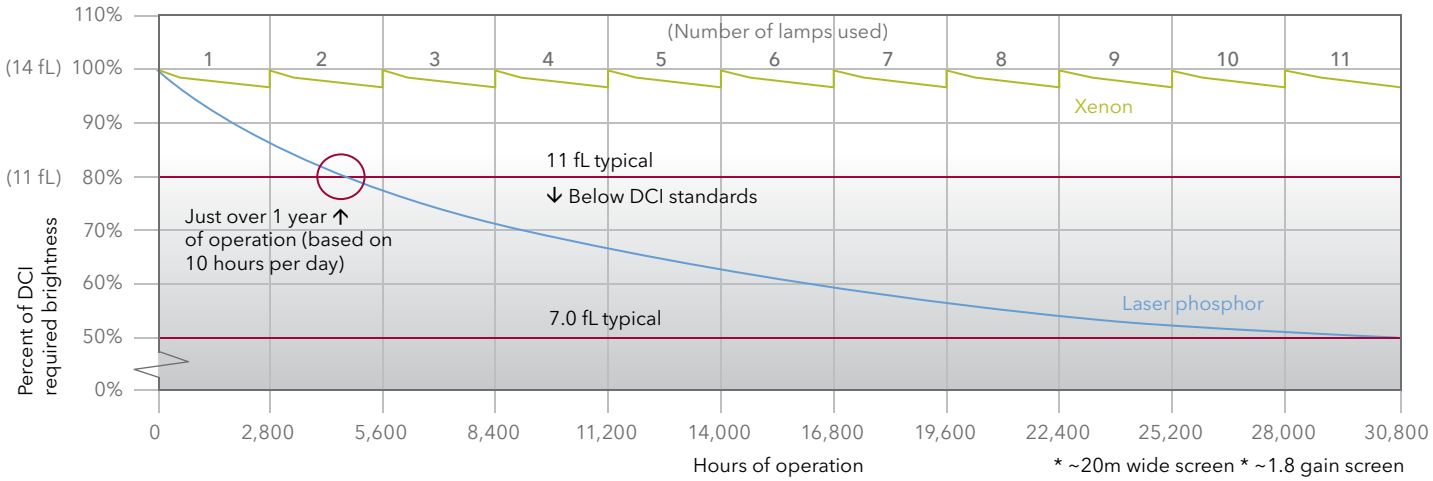
Cinema lamp technology has been in use for decades now and represents a solid value for exhibitors. The industry is familiar with lamps and cinema operations are established with lamp changes in the plan. Lamps can also provide an easy brightness boost on screen to maintain even brightness over years of operation or for special events like opening nights for the next new blockbuster. Reference the brightness over illumination lifetime chart below which demonstrates the total cost of ownership between Xenon and laser phosphor by outlining the benefit of restored brightness with Xenon lamps. Lamp-based projectors will continue to be installed for the next 3-5 years which will require the use of replacement lamps for 10-15 years following.

Another important fact about Xenon lamps is that they offer a very high-value proposition for cinemas operating in the 20K lumen range for medium-sized screens. This is where 65% of the world's cinemas operate, and as such, new lower Xenon prices and longer lifetimes have played an important role in cost reduction of lamps, improved performance, and longevity. Medium-sized screens really are the "sweet spot" where Xenon lamps provide the best value for those concerned about total cost of ownership.

Setting aside the image performance for a moment, some projector manufacturers are pitching elusive financial benefits of laser phosphor projectors for cinema use. However, when calculating the net present value cost of all the lamps required over the expected lifetime of a projector, in most cases, the actual cost will be less than the cost of the laser phosphor projector.

Brightness over 30,000 hours

20K lumen-class, Xenon versus laser phosphor*



* ~20m wide screen * ~1.8 gain screen

The efficiency of laser

There is no doubt that lasers hold the promise of dramatically improving the image quality on cinema screens, and RGB laser projectors help the industry achieve those goals. With RGB laser projectors, the white light comes from combining red, green, and blue laser light sources in a precise way that can cover up to and include the Rec.2020 color gamut. At the same time, having red and green lasers means that there is absolutely no conversion efficiency loss that is observed in laser phosphor projectors. For cinema applications, a YNF is not needed so there is no brightness loss from this device required to achieve the DCI P3 color spec. If more red light is needed in an RGB laser projector, more red lasers could be added. In fact, an RGB laser system is over four times more efficient than a laser phosphor projector at converting laser light into cinema quality white light. As a result, RGB laser projectors can achieve much higher brightness levels than laser phosphor projectors and also offer advantages in terms of the contrast ratio that can be achieved. Commercially, RGB lasers are the only cinema illumination technology that currently delivers High Dynamic Range (HDR) on cinema screens.

Next generation RGB laser projection

Recent advancements in red and green laser technology are far more efficient than those currently operating in premium cinemas around the world. These next generation lasers don't need to be cooled like today's lasers, allowing a huge reduction in system complexity, size, reliability issues, and cost. Manufacturers will soon begin introducing RGB laser projectors for mainstream cinema screens that can operate at an equivalent cost of ownership to a comparable lamp or laser phosphor-based projector. These new RGB laser projectors will put a dramatically better image on screen in terms of brightness, color, and contrast ratio.

With consumers being introduced to a variety of technologies and devices to consume content, our industry must continue to strive to provide spectacular on-screen experiences audiences can only enjoy in cinema. The creative vision of today's directors' takes advantage of these technologies, such as high dynamic range and high contrast. RGB lasers are the presentation engine to achieve these visions and improve cinema for everyone. Exhibitors must be aware that laser phosphor for cinema is a short-term solution and only suitable for small cinema screens, where projectors require less lumens or can operate at low brightness with the YNF intact. In addition, laser phosphor projectors cannot take advantage of high dynamic range and high contrast content. As manufacturers' ramp up RGB laser production to achieve economies of scale and next generation RGB laser projectors are being introduced to the market, RGB laser will soon dominate the cinema industry as the primary illumination source. The benefits in RGB laser illumination will continue to make cinema the primary motion picture experience for audiences.

Summary

- Not all laser projectors are the same – exhibitors in the market for laser projectors must understand the differences between laser phosphor and RGB.
- Laser phosphor projectors are a step backwards in image quality and the cinema experience.
- RGB laser projectors can dramatically improve the image quality on cinema screens.
- The cost of a Christie® Xenon lamp projector with inclusion of all Christie lamps required over the expected lifetime is less than the cost of a laser phosphor projector.
- Next generation RGB laser projectors, which exist as prototypes in labs today, will soon become the dominant illumination technology in cinema.

Connect with an expert

If you have additional questions, or if you need some help in selecting the right solution, please contact us. We can connect you with a network of experts who will be happy to help you work through the final steps of your procurement process.

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