DATE

7/12/2017

AUTHOR

Goran Stojmenovik
Sr. Product Manager Laser Projection
goran.stojmenovik@barco.com

whitepaper

Barco Smart Laser - High performance cinema projection

Better image, operational simplicity and low TCO

Introduction

Laser projection is rapidly becoming the technology of choice for Cinema. 2014 saw the first commercial installations of high-brightness RGB laser projectors from different companies in premium cinemas around the world. Since then, most manufacturers have announced a range of laser phosphor projectors and Barco has already supplied over 100 all-laser multiplexes around the world.
Despite this progress, there still might be questions regarding the customer benefits, product performance, as well as the laser technology itself.
This white paper offers a high-level overview and provides answers to why laser phosphor technology today is capable of offering high performance projection solutions for the evolving global cinema market.

Fig1. An example of a Barco Smart Laser projector
(heat exchanger mounted on top can be also positioned remotely)

Let’s start at the beginning

How is the light made?

Lamp-based projectors use either Xenon or high-pressure Mercury lamps to produce light, which is then directed toward the projector’s three “imagers” (DMD or LCoS chips). This process is very inefficient, because lamps output light in *all directions*, and only a small portion (10-15%) of this light actually reaches the screen.

Laser projectors use either three distinct laser types (red, green and blue), or blue lasers to excite a phosphor component. The phosphor absorbs the blue light, and radiates a bright, broadband light. Since the blue light is converted in this process, a separate blue laser is added, which is then mixed with the broadband phosphor light to create white light. Depending on the application, red or even green lasers can be added to the phosphor light. After this, the rest of the projector imaging system is basically the same as a lamp projector.

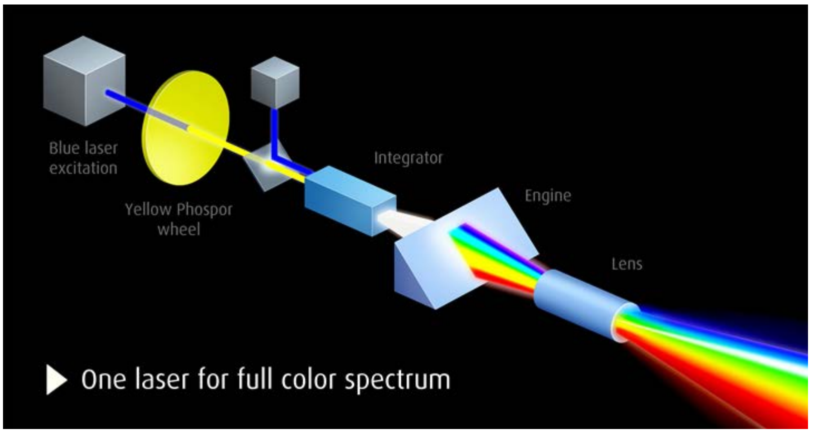

Fig.2 A high-level concept of a blue-pumped laser phosphor projector

How are the correct colors made for DCI cinema presentation?

The Digital Cinema Initiative (DCI) mandates a certain color gamut (certain saturation of red, green and blue) for cinematic presentation. In practice this means that the white light coming from the light source needs to be filtered in order to provide just the right saturation of red, green and blue light to reach that standard. This is done in lamp projectors (Xenon and high-pressure Mercury lamps), as well as in laser phosphor projectors. Because laser technology is much more efficient than lamps in producing light, even after the phosphor conversion and color filtering, the **optical efficiency of a laser phosphor projector can be two times that of the brightest lamp projectors!**

Benefits of Barco Smart Laser technology and its value to exhibitors

Laser technology can offer a lot of benefits for cinema projectors. But as is the case with anything, it's not the technology, but what you make of it – that provides the benefits.

The main goals cinema exhibitors aim to achieve are:

- **Increased profitability -** by sustaining a lower total cost of ownership (TCO)
- **Differentiation -** by assuring a better and more consistent image presentation
- **Less hassle and risk**, offering more peace of mind.

In order to achieve all of these benefits, Barco has optimized the design and engineering of laser phosphor technology for cinema projectors. We have chosen to call this our **'Smart Laser'** projector line: it is the smart choice for exhibitors that want to achieve all of the above goals.

All of Barco's **Smart Laser** models achieve the above goals with the following benefits:

- Very high efficiency
- Wide brightness range (7,000 – 35,000 lm)
- Durability and stability
- Superior image quality
- Ease of use

In the remainder of this white paper, we will describe these benefits in more detail.

More efficient than Xenon

In a Xenon lamp projector, a huge amount of light is lost in the process of focusing the light from a lamp, via reflectors, through the light processor and imaging optics. Just think of the very hot air that needs exhausting, and how hot the projector is at the back. In comparison, Barco Smart Laser projectors use very efficient lasers and also a very efficient phosphor wheel and 'coupling' optics. As a result, Barco Smart Laser projectors **consume 38-52% less electricity (watts per lumen)**, compared to the power-hungry Xenon technology:

Barco Smart Laser Projector	Barco Xenon counterpart (used lamp)	Brightness		Electric consumption incl. cooling (kWatt)		Electricity savings in favor of Smart Laser	
		Smart Laser	Xenon projector	Smart Laser	Xenon projector	Absolute	Per lumen
36BLP	**32B** (6.5kW lamp)	35,000	33,000	4.0kW	8.0kW	50%	53%
23BLP	**23B** (4.2kW lamp)	24,500	24,500	3.3kW	5.3kW	38%	38%
20CLP	**20C** (4.2kW lamp)	20,000	18,500	2.8kW	5.2kW	45%	50%
15CLP	**15C** (3kW lamp)	15,000	14,500	2.3kW	3.9kW	40%	42%
10SLP	**10S** (2.2kW lamp)	9,500	9,000	1.5kW	3.0kW	50%	52%
8SLP	**8S** (1.6kW lamp)	7,000	6,000	1.3kW	2.3kW	43%	52%

Table 1. Comparison of electric power consumption and efficiency gains between Smart Laser and Xenon projectors

Not only is the electricity bill lower, the efficient Smart Laser projectors can contribute to savings on heating, ventilation and air-conditioning (HVAC). Due to the lower electrical consumption, *the heat dissipation is also much lower*. So the need for 'shoving' air from one place to another is greatly reduced, leaving booths and projectors cleaner (less dusty), requiring less expensive (in materials and labor) ventilation systems, saving cost and unlocking efficiencies across the multiplex.
And of course… you completely eliminate all direct and indirect lamp costs!

As a result, when moving from lamp to Barco Smart Laser projectors, a typical multiplex can achieve and demonstrate an overall projector ***OPEX cost reduction of ~80%***.

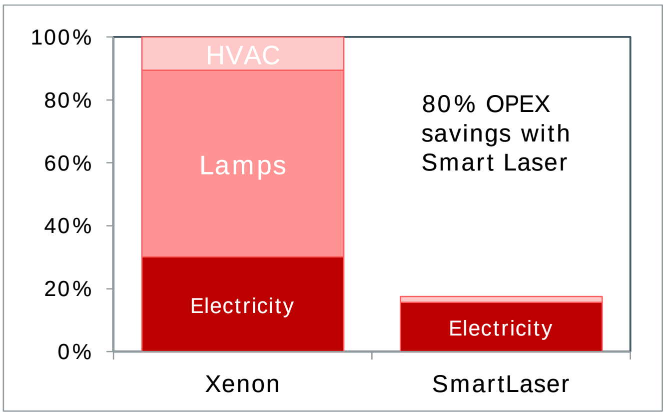

Fig 3. OPEX Savings for a typical 10-plex - Xenon Lamp vs. Barco Smart Laser projection

A whopping 35,000 lumen brightness

When introduced in 2014, the first laser-phosphor cinema projectors only provided about 4-5,000 lumens. Barco introduced its line with a 20,000 lumen Smart Laser projector in 2016 and now our portfolio covers a range starting from 7,000lm, all the way up to 35,000 lm.

Example: 2D screens

In the examples below, the projector models are selected to provide a *constant 14fL brightness* for 25-30,000 hours and a DCI compliant brightness (>11fL) over a period of >40,000 hours:

Projector	Brightness (lumens)	Screen (format / size / gain / curvature)				Achievable maximum brightness
DP4K-36BLP	35,000	Scope	21m/69ft	1.8	4%	23 fL (78 cd/m^2)
DP4K-23BLP	24,500	Scope	18m/59ft	1.8	4%	22 fL (75 cd/m^2)
DP2K-8SLP	7,000	Flat	8m/26ft	1.4	0%	24 fL (82 cd/m^2)

Table 2 Overview of different projector brightness levels and applicable screen sizes

So the days of low output laser phosphor projectors suitable only for small screens are gone: **Barco Smart Laser projectors are suitable for *all* mainstreams cinema screens**.

40,000 hour laser lifetime, anyone?

While Xenon lamps can drop to about 50-60% of the initial maximum brightness over a period as short as 500 hours, laser light sources lose brightness very slowly and drop to 50% of the initial maximum over a period of *years,* not weeks.

There are two key factors that contribute to the brightness decrease of the laser source:

- the working temperature of the laser diode determined by the *cooling and ambient temperature* and
- the driving level (drive current) of the laser, determined by the required screen brightness versus maximum available projector brightness

For a passive cooling system supporting a Barco Smart Laser, a 5°C (9°F) difference in ambient temperature can have about 20% impact in the expected lifetime. While running the Smart Laser projector at full power can yield lifetime values of 20-30,000 hours (depending on temperature), running the projector at a lower power than maximum can also significantly extend the lifetime. Using the projector at a lower level can extend this lifetime to 40,000 hours or even more! Note that as 'lifetime' we consider the point in time when the maximum brightness of the projector has dropped by 50% from the initial maximum brightness of a new projector.

This means that we need to consider laser technology differently than a lamp: specifying the right projector for the right application can help extend the required brightness for e.g. 14fL on screen to the duration of the economic lifetime of the projector (be it 5, 7 or 10 years)!

Example:

Consider the example (graph below) of a Barco Smart Laser DP4K-23BLP projector running 2D on an 18m/59ft scope screen, gain 1.8, with a 25°C/77°F ambient temperature at the projector heat exchanger input.

This combination is capable of 22fL at full power. Running it continuously at this level will reduce this brightness by half (to 11fL) within about 28,000 hours (red curve and lines).
Now, typically this projector would be calibrated to 14fL 2D and kept in 'CLO' (constant light output mode). This translates to 65% of the projector brightness setting. Using it like this (green curve), will prolong the projector lifetime to 40,000 hours, while still maintaining DCI-compliant brightness!

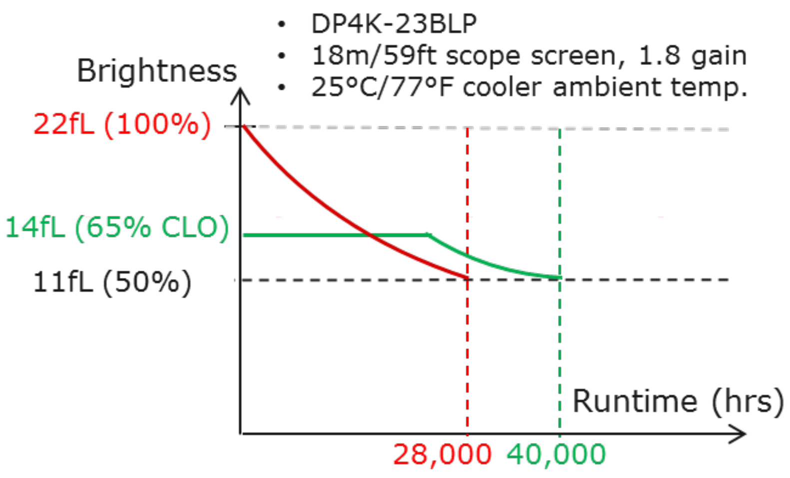

Fig 4. Indicative brightness drop curves for different use cases

Selecting a lamp projector for the same screen, you'll need a DP4K-23B projector with a 4.2kW lamp, if you are to have any reserve for the fast drop in lamp brightness. In fact, for the duration of 40,000 hours you'll save about 30 lamps and save about 80 MWh on electricity (around $8,000 if your price is $0.10/kWh) when using a 23BLP instead of a 23B projector, while with the Smart Laser projector you can always have stable and DCI compliant brightness.

Good, better, best

Laser projection provides better, more consistent image quality in a number of ways. Typically this means higher brightness, contrast, uniformity, color gamut and sharpness, but also reduced temporal artifacts, such as lamp flicker, and general image (brightness, color) stability over time.

Currently there are SMPTE and IEC standards based on DCI recommendations that define the parameters for cinematic presentation in terms of brightness and color saturation ranges, and minimal contrast and uniformity ratios.

These standards are made to ensure a good and consistent image quality in cinemas, to differentiate digital presentation from film, and to ensure the delivery of the film-maker's 'creative intent'.

Barco's projector design has always been focused on reducing TCO while raising the bar on image quality. As it turns out, Barco Smart Laser image quality does strike a chord with movie-going audiences. A recent test done by an external research company indicated that 80% of people do notice *and appreciate* the superior image quality of Barco Smart Laser over Xenon projection. With its higher contrast, uniformity and image consistency, Barco Smart Laser raises the bar to become the new technology of choice for mainstream cinema projection.

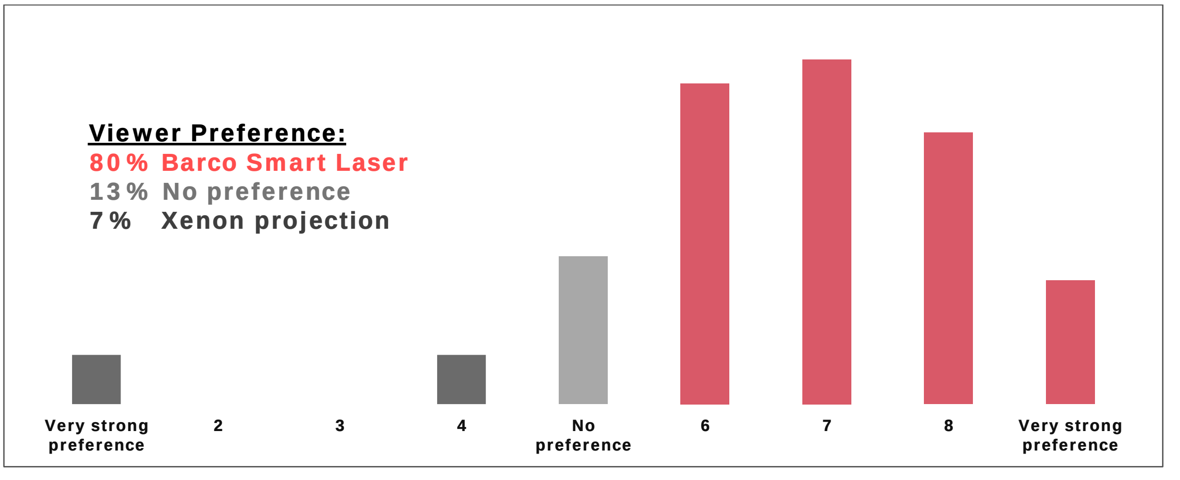

Fig 5. Audience research done by TNS Kantar. Sample of 98 people.

No pain, lots of gain

Last but not least – next to the elimination of all lamp costs and dramatic reductions in electricity bills, a big relief of exhibitors' headaches comes from operational excellence, risk avoidance and just good old peace of mind.

One example - having no lamps to worry about (planning lamp purchase? Arranging disposals? Finding time to change lamps? Calibrating after every change? Oops… need to claim warranty after the lamp explosion…). Another example - having a reliable technology that provides constant brightness and only needs looking after on general projector maintenance intervals.
How about the large dimming range of lasers (down to 30%) that means you can show both 2D and 3D movies on the same screen with the correct brightness with a press of a (virtual) button, and you don't need to worry about the room scheduling?

Remember the maxim 'no pain, no gain'? That doesn't seem to hold for Barco Smart Laser projection – the gains are obvious wherever you look!

Summarizing the obvious

Barco has brought Laser projection a long way in a short time! In just two years since their introduction in 2016, Barco now has Smart Laser projectors illuminating thousands of screens worldwide, providing a complete portfolio of Smart Laser projectors for virtually all mainstream cinema screens, unlocking cost savings and efficiencies across the multiplex and providing better image quality than Xenon.

Exhibitors can enjoy an immediate reduction of operating costs of up to 80% compared with Xenon projection (based on the combination of lamp, electricity and HVAC savings) which increases their profitability. At the same time, operational hassles linked to lamps, maintenance and facility management have been drastically reduced. Furthermore, Barco Smart Laser projectors provide a demonstrated image quality improvement over Xenon projection.

Having the right benefits that unlock financial, marketing and psychological value for exhibitors, and increased satisfaction of their customers, it’s no wonder that Barco Smart Laser projectors are widely utilized in ‘all laser multiplexes’ worldwide. Going all laser is a now a very smart choice!

Key messages

- 7-35,000 lumen projectors for screens of 20m/65ft or more
- Up to double the efficiency (lm/W) of comparable Xenon projectors
- Up to 80% lower operational costs
- 20% better contrast than Xenon projectors
- 40,000 hours of DCI compliant brightness

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