

*What Event Producers
Should Know About*

Laser Shows



*Presented By
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Lasers are the most powerful light source on earth. With their thin shafts of light and rainbow-pure colors, “Star Wars”-style laser beams are a dazzling cross between theatrical lighting and fireworks. Another technique, animated laser graphics, communicates exciting messages using a medium more eye-catching than conventional slides or video.

The unique features of lasers help put the “spectacle” in spectaculars, and the “special” in special events. This document will help event producers understand the benefits and requirements of laser displays.

Using lasers at events

Lasers can be used at a variety of indoor and outdoor events, including:

- Indoor
 - Corporate shows
 - Openings, such as player introductions at basketball and hockey games
 - Themed parties
 - Parties held in planetariums
 - Beacons and displays in trade shows
- Outdoor
 - Major special events such as the Super Bowl or Olympics
 - Premieres, grand openings, launch parties
 - “Laser searchlight”

What lasers can do

There are many creative ways lasers can be used in a production. Most of these uses fall into the two broad categories of seeing beams in mid-air, and seeing graphics on a surface.

- With beams, the audience sees “structures” in mid-air, such as fans, cones and shafts of light. Usually theatrical fog or haze is required to make the light shapes more visible.
Beams can be fast or slow; they can give an event a “Star Wars” excitement, or a New Age mystical calm.



- Laser graphics can display a client's logo, animate their product, tell a story, or simply entertain. Because of technology requirements, these images are cartoon-like outlines, without any interior fill or detail.

This can be a limitation, but it also helps make laser graphic shows very different and attention getting, compared with familiar video images.



Often beams and graphics are combined. For example, “screen and beam” shows use graphics on a single center screen or two side screens, with beams coming from below the screen(s) and over the audience.

Laser graphics can be seen on just about any relatively smooth, relatively light surface. You can use conventional projection screens, an indoor or outdoors wall, water screens, inflatable screens, buildings and even mountains.



(Incidentally, laser companies are sometimes asked to project logos on clouds. This is impractical; Mother Nature does not often provide the required smooth, low, dense cloud cover.)

Laser show choices

Laser show producers have three general types of shows for you to choose from: stock, semi-custom, and custom.

- **Stock shows** have already been produced. If an audience is not familiar with laser shows, these may work fine. But some stock shows are very well known in the laser industry and thus they have been shown over and over again.

Therefore, you may want to ask about the source of the stock show. Did it come with the laser software (meaning that many laser companies could be using it), or was it done by a single laser company only for its clients' use?

- **Semi-custom shows** can be the best value. Your logos, or perhaps custom animation sequences, are added to a stock show. If the already-existing show is appropriate to

your event, this gives a custom look at stock price.

For example, one very popular post-September 11 show uses patriotic images and music. The client's logos are added at the end. The images provide a powerful impact, with the client benefiting from the patriotic association.

- For **custom shows**, the music, the storyboard, the images, are all created for you. While some sequences may be from stock and thus are very common (flying eagles, rotating earths, shaking hands), all elements of the production are designed for your needs. The cost of producing custom artwork for a 4-minute song can add anywhere from \$1000 to over \$10,000, depending on artistic complexity.

Producing laser graphics

How laser graphics work

To make a laser graphic, two tiny computer-controlled mirrors aim the beam at a screen. The beam bounces first off of one mirror moving horizontally, then off another at right angles, moving vertically.

The computer literally “connects the dots”, aiming the mirrors from one place to another fast enough that the viewer sees a single outline drawing. This process is called “scanning”. The computer-controlled mirrors are galvanometer “scanners”.



The scanners move from point to point, at a rate of around 30,000 points per second. Due to technical limitations, it is not possible to go significantly faster. This “30K” speed limits how complex a single image can be. (A second set of scanners can be used to add additional detail to a scene.)

Laser graphics are not TV

It is very important to realize that laser graphics normally are *not* TV-like raster images. Instead, they are like a connect-the-dots drawing – cartoon-like outline vector images. This means that you just can't hand a photo or videotape to a laser company, and immediately have it be projected as a cartoon-like outline. Otherwise, it would just be a laser-projected TV. (Laser TVs do exist but tend to be complex and expensive.)



Instead, the laser company will use artists or a computer program to find the outline of your image, and then turn that into a series of dots. The laser quickly jumps from dot to dot, in order to draw the outline of that object.

Turning your artwork into laser graphics

From a production standpoint, this means that any custom laser show images need to be processed by a laser artist. You can't do this yourself. The artist has to translate any existing artwork into laser imagery.

There are a few programs that make it easier. One is a converter for 3D Studio Max. A laser artist can design 3D Studio Max scene with objects that translate well into laser, and can then render it into laser as an outline, or an outline with contour lines. But again, this is still a situation where the laser company must produce the final laser artwork for you.



Another program to convert artwork is able to turn photographs or video into TV-like raster images. However, the resolution is only about 60 pixels wide by 60 lines high. This is about 80 times less detailed than standard NTSC television resolution (based on the total number of pixels).

These laser raster images are good for certain uses, like showing a close-up of a familiar face. But in general they are limited to special effects. And for good reason: if you were to do an entire laser show with raster images, it would essentially be low-resolution TV. Just use a video projector instead!



Laser colors

One of the attractions of lasers is their brilliant colors – the purest in the universe. When planning with lasers, color is a key consideration.

Your event may need a certain color, which then dictates using a particular type of laser.



Or, you may not care about color, and you simply want the easiest and most visible laser light. Here's information about how to get various laser colors.

- **Lime-green.** This is the most frequently used laser color, because it is the best value. It is produced by relatively low-cost, easy-to-use solid-state lasers (YAG, DPSS). And, this color (532 nanometer wavelength) is the most visible to the human eye. One watt of lime-green light looks 2-3 times brighter than one watt of red or blue light.

A disadvantage is that this color is so commonly used, that audiences may not find it special.

- **Green, blue and cyan.** Argon-ion gas lasers produce green and light blue. These can be separated out into single colors, or can remain combined to produce a cyan color. It is more difficult to use argon lasers than an equivalent-visibility solid-state lime green laser. However, if a blue-green color is desired, argon is the best choice.



- **Red and deep blue.** It is more difficult for lasers to make red and deep blue. Also, these colors appear less bright than an equal amount (wattage) of green light. For these reasons, you rarely see beam shows with a lot of red or blue.

So if you want to match a client's red or blue corporate color, be prepared to pay more. In order to be sufficiently visible, the laser beam must be more powerful (greater number of watts), than if you specified a green color.

- **Yellow-green.** A copper-vapor laser produces a "gold" yellowish-green color. This laser is pulsed which is not optimum for graphics (it produces dotted lines). It works fine for beam shows.
- **Mixed-color.** Some companies put two relatively low power laser diodes together; one red and one green. This gives a limited palette ranging from red, through orange and yellow, to green. Often this combination is found in lower-cost disco-type projectors suitable for smaller spaces.
- **Full-color.** To get full-color laser light, you need red, green and blue laser light. There may be one, two or three separate lasers involved. Inside the laser projector, the light is mixed to become a single beam that is more or less white. A special crystal called



a “polychromatic acousto-optic modulator” or “PCAOM” acts as an electronic prism. Under computer control, the PCAOM lets through only the required color(s) at just the right time to color part of an image.

Full-color is mostly used for graphics. Beams can be done in full-color (as shown here) and are very beautiful, but these require lasers that are more expensive and harder to setup than equivalently visible lime-green beams.

An argon-krypton ion gas laser is usually used as a single white-light source. Powers range from 1 to about 20 watts. To get higher total power, an argon laser (green and blue) can be paired with a krypton laser (red).

As of this writing (2002) there are only a handful of commercial solid-state white-light lasers. They have the promise of easier utility requirements and smaller size. But being relatively new, they also are generally more expensive than gas white-light sources.

Utility requirements

Older-style gas lasers (“argon-ion”, “krypton-ion”) require special power and water supplies. Ion laser power requirements range from 220 volts single-phase, to 440 volts three-phase. They use so much power that they must be water-cooled. Some units come with recirculating chillers. Others need an external water supply (plus a drain) capable of supplying about 2 gallons of water per minute.

Most facilities can handle these utility requirements, although there may be extra charges for the power and water usage. Laser companies usually are very familiar with interfacing with your facility’s electricians and plumbers, to ensure they have the necessary utilities.

Newer-style solid-state lasers (“YAG”, “DPSS”) usually run on common 110 or 220-volt single-phase power. Cooling is simple, with built-in fans or water recirculation.

At this time (2002), most solid-state lasers produce a lime-green color. For full-color solid-state lasers, there is one that is high-powered (10 watts), and a few which are lower-powered (~1 watt). A high-powered red YAG is available, as well as a few very low power (<1 watt) blue diode lasers.

Old vs. new

Certainly people want a laser that is easy to set up. Solid-state lasers have gained in popularity for just this reason. But there may be many other reasons to use older, more complex lasers. For example, you may need a range of colors that are only available in sufficient power by using gas lasers. Or, the beam quality of a gas laser may be better (tighter beam; smaller line width for graphics) than an equivalent-power solid-state laser. Finally, your laser company cannot stock every possible laser and thus a gas laser may be the only one available for a particular job.

Other requirements

In addition to power and water, there are some other factors to consider when you add lasers to your production. All of these should be very familiar to a laser show company. These factors are mentioned here so you have an idea of what to expect.

- **Beam direction:** For beams, the laser equipment is usually positioned in front of the audience. Beams will be aimed over their heads.

This is because laser beams appear brightest when they come straight towards you (the light scatters forward when it hits dust and smoke particles). They appear second brightest when they come from straight behind you, and least bright when they are crossing your field of vision.

- **Graphics screen:** For graphics, rear-projection is generally preferred over front-projection. The images seem a bit more “magic” because the audience does not see the beams that create the graphics.

The graphics projector should be no closer than the largest dimension of the screen area. For example, if projecting onto a 20’ x 30’ screen, the laser should be no closer than 30’. The farthest distance is roughly 100 feet. These dimensions can vary if lenses are used for wide-angle or beam sharpening. They can also vary depending on how close the audience is to the screen.

- **Equipment positioning:** *Direct-feed projectors* join the laser and scanners as a single unit. For larger direct-feed systems, space needs to be allocated for a scaffold or similar platform. Smaller direct-feed systems, generally built around single-color solid-state lasers, may be compact enough that the entire projector can be mounted on a stand or flown in the rigging.

Fiber-fed projectors (where a fiber-optic cable brings laser light to a remote scan head) have more flexibility in positioning. They can be put on a stand or flown. One hundred feet is a typical distance for the cable run. Because the fiber-optic cable is delicate it must be prevented from being run over, severely bent, kinked, etc.



- **Control positioning and setup time:** Lasers require roughly the same setup time and control console space requirements as lighting and audio.

The control console location should allow the laser operator to see the audience. If this is not possible, a laser safety observer must be in front, with a headset or walkie-talkie for immediate communication with the laser operator.

- **Safety regulations:** As listed elsewhere, both the show and the projector must comply with federal requirements and have a valid variance. Some states and localities may also have requirements. If lasers are used outdoors, then the FAA must be notified (even if the beams are terminated on nearby buildings) and must not object to the show setup.

The laser show company must take care of these reporting requirements. They cannot be put off onto the producer or venue (For fixed installations, the venue may be the variance holder but almost always it is the laser show company which handles the application process.)

- **Ceiling heights:** In the U.S., normally the beam is required to be 3 meters (10 feet) above where the audience could stand, and 2.5 meters (8 feet) laterally from where the audience could reach sideways.

In practical terms, this means the venue ceiling must be a minimum 12 feet high (giving a foot or so for the beam effects). It also means that if a projection is coming from behind the audience, towards a screen, the beam must always be at least 10 feet above the floor where the audience is seated.

- **Reflective surfaces:** Many facilities have reflective surfaces such as mirror strips and chandeliers. Other reflective surfaces such as the mirrors on intelligent lighting and silver truss can also be present.

If the laser projection could bounce off these surfaces, into audience areas, then the beam must be masked to prevent any stray audience reflections.

- **Safety setup:** Time should be built into the production schedule for aiming and fine-tuning the laser projections. There should be no one in the laser areas except the laser company's technicians. A good time for setup is when the other crews are taking a meal break, or after they have finished their calls.

- **Communications:** Ideally, each person manning a laser location will be on headset. If this is not possible, then the operator at the main laser controls must be on headset with the producer; the other laser technicians can be on walkie-talkies with the laser operator.

- **Interfacing with audio:** Some laser companies take their audio from the main production; SMPTE or other methods are used for sync. Other laser companies provide their own audio, which is fed (as a line-level signal) to the main mixer.

It is best if the laser equipment and control areas are separated from the audio (and lighting) areas. This helps prevent hum in the audio, and noise in the laser image.

- **Interfacing with lighting:** Lights should be off, or as low as possible during the show. Some laser companies prefer to add some complementary lighting, such as a low red wash when green lasers are used. This is usually done with existing fixtures, simply by

coordinating with the lighting director.

Video projectors should be masked or turned off to prevent video “gray” from illuminating screens.

ILDA membership

You may want to ask if a laser company is a current member of ILDA, the International Laser Display Association. Membership can help indicate that the company has a professional artistic and business approach.



ILDA runs an annual awards competition. Ask if your company enters (indicating confidence in their quality) and what awards they may have won. More information on ILDA is at www.laserist.org.

Special laser uses

Lasers are such a unique light source, they often go beyond “screen and beams”. A projector used in a planetarium for 360° X 180° scanning can also be used in a tent or party environment, to produce a ceiling-filling spray of laser beams.

The same projector, put at the mouth of an Airstar lighting balloon, can display an in-the-round laser show on the entire surface of the balloon. (Remember that the laser beam is always in focus, unlike a video projector that would be hard to keep in focus onto a sphere.) This is a unique effect that is hard to duplicate in any other animated medium.



Lasers have projected fish inside an empty aquarium, and animated graphics on the side of a mountain.

Lasers and 3D

While lasers can do a lot of amazing things, it is not yet possible to create a mid-air floating hologram like the “Princess Leia” projection from R2-D2 in the original Star Wars movie. Despite this, you can achieve various 3D effects with lasers:

- **True 3D.** Many people are familiar with 3D movies and theme park attractions that use polarized or shutter lenses. Laser shows can be made in the same way, so that when

wearing glasses, the audience sees truly three-dimensional images.

- **Chromatic 3D.** Chromadepth glasses make red images appear closer while yellow, green and blue images appear successively farther. The laser show is created with smaller red foreground images and larger background images to enhance the illusion.
- **Scrims.** By projecting laser graphics onto dark scrims in a dark room, images can hang in mid-air. Each scrim is a flat screen so it is a sequence of flat planes that is not truly 3D. However, by making the image itself look three-dimensional (e.g., a rotating 3D object), a convincing simulation of mid-air holography can be achieved.
- **Mid-air beam effects.** These are mentioned here because lasers can project planes, cones, fans, etc. of laser light. These are truly 3D, even though it is not possible to “stop” the light in mid-air to create complex floating objects.
- **Traditional “tricks”.** At Disney’s Haunted Mansion, many of the 3D effects are done using mirrors. These tricks can be done with lasers as well, so a laser image appears superimposed on a scene or set.

Laser safety

Lasers have an admirable safety record, especially considering the millions of people who have attended laser shows in the past quarter-century. One reason for this excellent record is that laserists understand the vital importance of having safe shows.

There are three main aspects of laser show safety. One is eye and skin safety – the laser beam must not harm anyone. For outdoor shows, aircraft safety is important – the beam must not distract a pilot. And of course regulatory safety must be considered – the show must comply with all applicable health and aviation regulations.

The laser company normally takes care of all safety and regulatory concerns. If you have any questions, feel free to inquire about their preparations and ask to see the regulatory paperwork.

One other thing to keep in mind: Safety is paramount. Although the laser company’s goal is “the show must go on”, the company must stop lasing if an unforeseen hazard arises. For example, if an aircraft buzzes an outdoor show, or an unruly audience member climbs onto a chair, the laser company may need to shut down the show until the hazard is past.

U.S. national regulations

U.S. laser companies must certify both their equipment (the laser and projector) and the actual laser show (where the audience is in relation to the lasers, how the equipment is used, etc.). Anyone doing a laser show or demonstration must apply for a “variance” to the Center

for Devices and Regulatory Health (CDRH), a division of the Food and Drug Administration (FDA). As its name implies, a variance gives the holder permission to vary from the FDA's laser safety regulations.

One of the variance conditions is that the beams are kept 3 meters (10 feet) above where the audience can stand, and 2.5 meters (8 feet) laterally from where the audience could reach out. Performers can have lasers on them under specified conditions. But in the U.S., audiences cannot normally be exposed to direct or reflected laser light. CDRH variances cover these and other conditions.

All reputable laser companies will have current, updated, valid variances for their equipment and shows. As part of the variance, they must also inform the CDRH of the date and location of each show. You should insist on this paperwork for your show. Ask to see it. If it is not forthcoming, this indicates 1) the company may not be following safe procedures and 2) you may be liable should a laser safety issue arise.

State and local regulations

Some states have additional regulations. In New York, a NY-licensed laser operator must supervise the laser show. Texas has an active regulatory division that requires annual registrations. Other states and localities may have their own regulations.

Again, the laser company should know about and meet all state and local regulations.

Fire watch not required

Sometimes there is a misperception that a "fire watch" is required when using lasers indoors at sites like hotels. This is not true; there are no special fire requirements for the laser *per se*.

If fog machines are used to help make the laser beams visible, then a fire watch may be required. The facility's smoke detectors are often turned off to prevent false alarms from the fog. A fire watch is then needed during the fogging period.



Audience scanning

Probably the most stunning laser effect is deliberate audience scanning. Beams and shapes are intentionally projected directly onto the audience. It is beautiful – like swimming in an ocean of light.

Audience scanning is actually safe if various factors are met: the beam must have a relatively large diameter, and the power must be relatively low. Should you happen to be in audience-scanned beams, a quick check is whether the light level feels pretty comfortable (generally safe), or if you

instinctively close your eyes, turn away or have long afterimages (unsafe).

Many people may tell you that deliberate audience scanning is banned in the U.S., or that there are differences between U.S. light levels and overseas light levels. These

statements are completely false. Audience scanning is legal in just about every country. Safe and unsafe exposure levels are about the same in every country.

However, U.S. regulators insist on extra safety measures such as redundant backups and detailed analyses. This is why there are very few approved U.S. variances for deliberate audience scanning. These are usually for high-inertia effects such as beams on a mirror ball; if the ball slows down this can be detected well before the beam stops moving. Most overseas regulators do not require the same level of redundancy and caution as U.S. regulators.

It should be noted that deliberate audience scanning has a very safe record. There are very few reports of accidents or even incidents after two decades of scanning on millions of people worldwide.

Aircraft safety

Outdoors, lasers need to be kept away from aircraft. At very close ranges the beam may be an eye hazard. At longer distances the brief but bright flash as the plane flies through the beam could temporarily flashblind a pilot.

To remain safe, laser show operators take into account the direction and power of beams, as they relate to airports and air routes. They also plan for control measures such as spotters, who turn off the laser temporarily if aircraft come too close.

In the U.S., this pre-planning is submitted to the Federal Aviation Administration at least 30 days in advance of the outdoor show. If the FAA does not object to the shows, and other CDRH requirements are met, then the CDRH will grant a variance to allow the use of laser displays outdoors.

What to look for in a laser show company

Picking a laser show company is much like choosing a video or production house. Cost is a factor, but even more important is reliability, equipment, and production quality. Ask about the following:

- Years in business
- References from satisfied clients (and check the references)
- Variety of lasers available
- Other equipment available – screens, audio, lighting (if you need these as well)
- Artwork production: Done in house? Using clip art?
- Awards won from ILDA and similar industry organizations

The future of lasers

Pencil-thin shafts of laser light, and brilliantly colored unique laser graphics will always have

a place in the arsenal of special effects. Laser beams reach out and almost touch the audience. Laser graphics have a futuristic look very different from the dozens of TV screens we see each day.

Solid-state lasers will continue to improve in power, color, beam quality, and pricing. Eventually, full-color (RGB) solid-state lasers will eliminate the need for harder-to-use gas ion lasers.

Laser graphics will become easier to create and to synchronize with music. Programs such as the 3D Studio Max converter will make higher quality images.

Many laserists hope to see some type of audience scanning become widespread in the U.S. Be prepared, because if this happens, you'll have a powerful new effect that is like putting your audience right in the middle of a fireworks show.