BEYOND Beginner Course (Self Guided)

Document very much in Progress, there will be gaps but we prefer to publish what we have, so people can use it as fast as possible, Information may be in draft form, and inaccuracies may exist.

Welcome to the BEYOND Beginner Course, this started as the outline for in person trainings we held around the world, and it was decided to convert that workbook into a guided learning document. That will serve as outlines for trainings, as well as the ability for users around the world to learn from.

The materials provided in this document are the suggested order you learn lasers from scratch, however, feel free to just use this as a guide to learn different topics you would like to learn about.

One of the most useful aspects of this document is the number of links to external and internal sources. This Document will not re-hash any information that has been written in other manuals on the Pangolin Wiki, however any text that is in this document in each section is new content that isn't found in other internal sources. But instead, information to help provide context, and further information, that is not strictly technical. Most documentation on the wiki is designed to be “Technical Education” not “Practical Education” and this document will explore some more practical and real-world knowledge.

Introduction to Beginner Laser Technician Course (For in Person Training)

This course is designed for users completely new to lasers and Pangolin control and brings them up to speed so they can do shows for themselves. This course covers Projectors and how they work, show setups and cabling requirements, creating Laser content and shows, controlling your show from DMX consoles, and much more. Go from zero to hero with one of Pangolins skilled techs, as they teach you how to operate a laser show from no production experience to being able to do shows.

This course is for complete beginners to lasers, pangolin software and even show production itself. No experience is needed, and absolute beginners are encouraged to take this course. Those who have some production experience or are coming from different disciplines in the show production industry should consider this course. This course will not focus on detailed content creation, but touch on how you can start creating content for yourself and is more focused on getting the gig done.

What is Covered in Major Categories

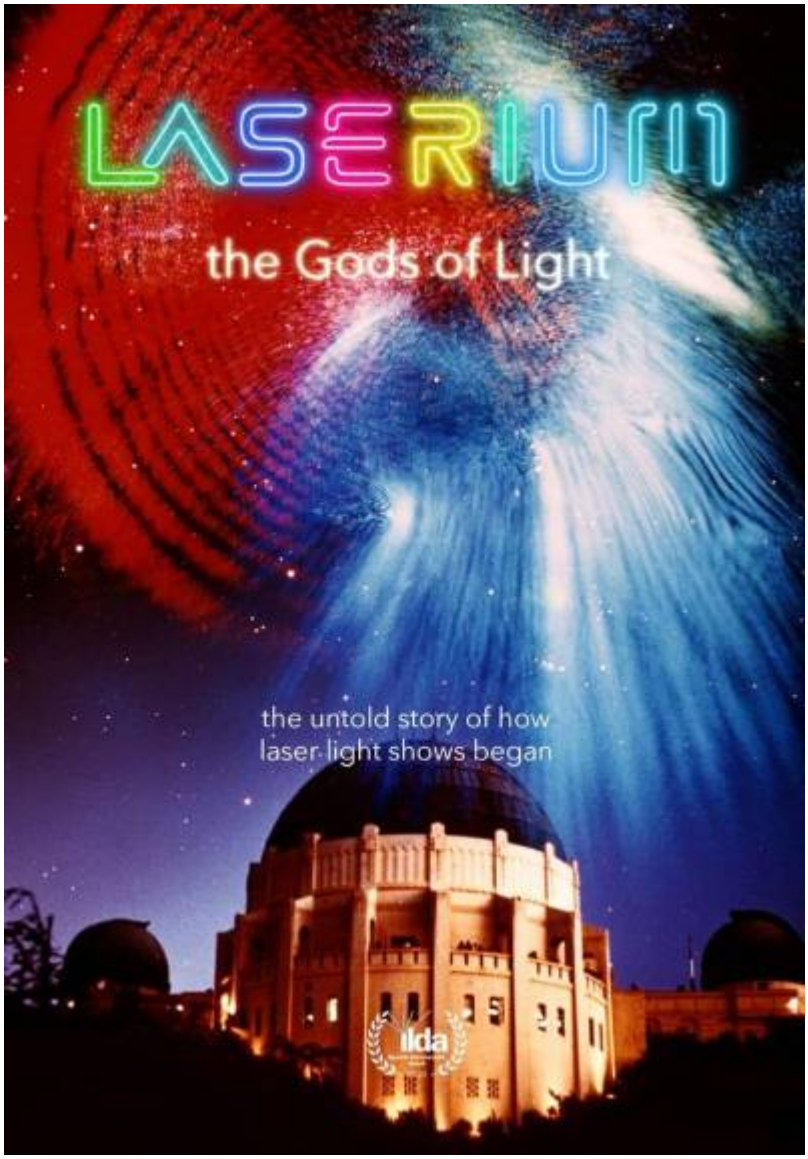
- History, safety, and operation of laser projectors
- Show rigging, cabling, and networking of lasers
- Software overview, Laser Projector settings, and Show operation
- Laser content creation for live, and timecoded shows

Recommended Course Preparation

It is recommended for students to bring their own windows computer and have BEYOND installed beforehand, 1 Month licenses will be provided free for all students to follow along with the course but is not required for participation.

No formal knowledge of lasers, its control systems is necessary. In fact, it's best for those taking this course to be complete beginners.

The Overview of the Laser Industry and History



Chapter Resources

Laserium, the Gods of Light, Movie about Ivan Dyer and the world's first Laser Shows

https://www.youtube.com/watch?v=t7ifBxTywB4

Old Pangolin sites with lots of historical posts and information

https://pangolinlegacy.com/ https://pangolinlegacy.com/resguide00.htm

Wikipedia Articles on related subjects

https://en.wikipedia.org/wiki/Laser https://en.wikipedia.org/wiki/Laser_lighting_display
https://en.wikipedia.org/wiki/International_Laser_Display_Association

History Links provided by ILDA (International Laser Display ASsociation)

https://ilda.com/laserhistory.htm

Origins of Laser Technology

Origins of Laser Shows

General Laser Safety Considerations

Chapter Resources

Pangolin Safety Links

https://lasershowprojector.com/pages/laser-show-safety
https://lasershowprojector.com/pages/audience-scanning
https://lasershowprojector.com/blogs/education/creating-safe-laser-shows
https://lasershowprojector.com/blogs/education/laser-show-compliance
https://pangolin.com/blogs/education/laser-classes

FDA documentation on Lasers

https://www.fda.gov/radiation-emitting-products/home-business-and-entertainment-products/laser-light-shows

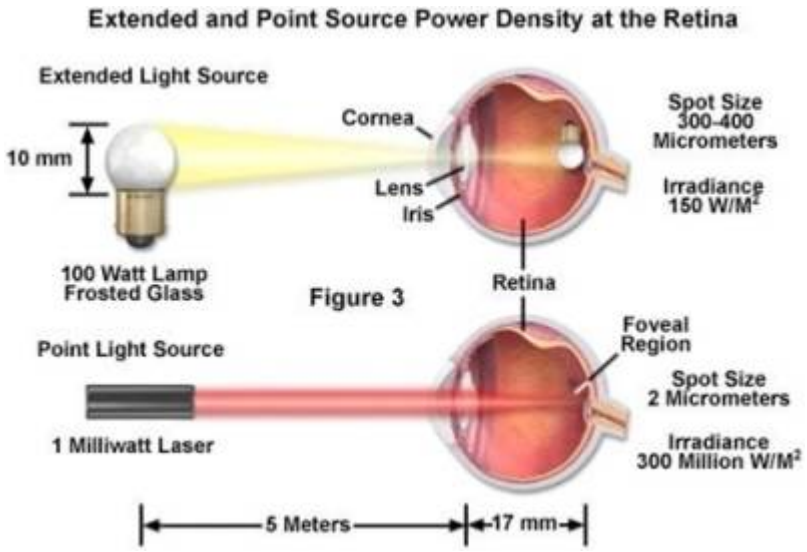
ILDA Basic Safety Priciples

https://ilda.com/safety-basics.htm

Standards Documents

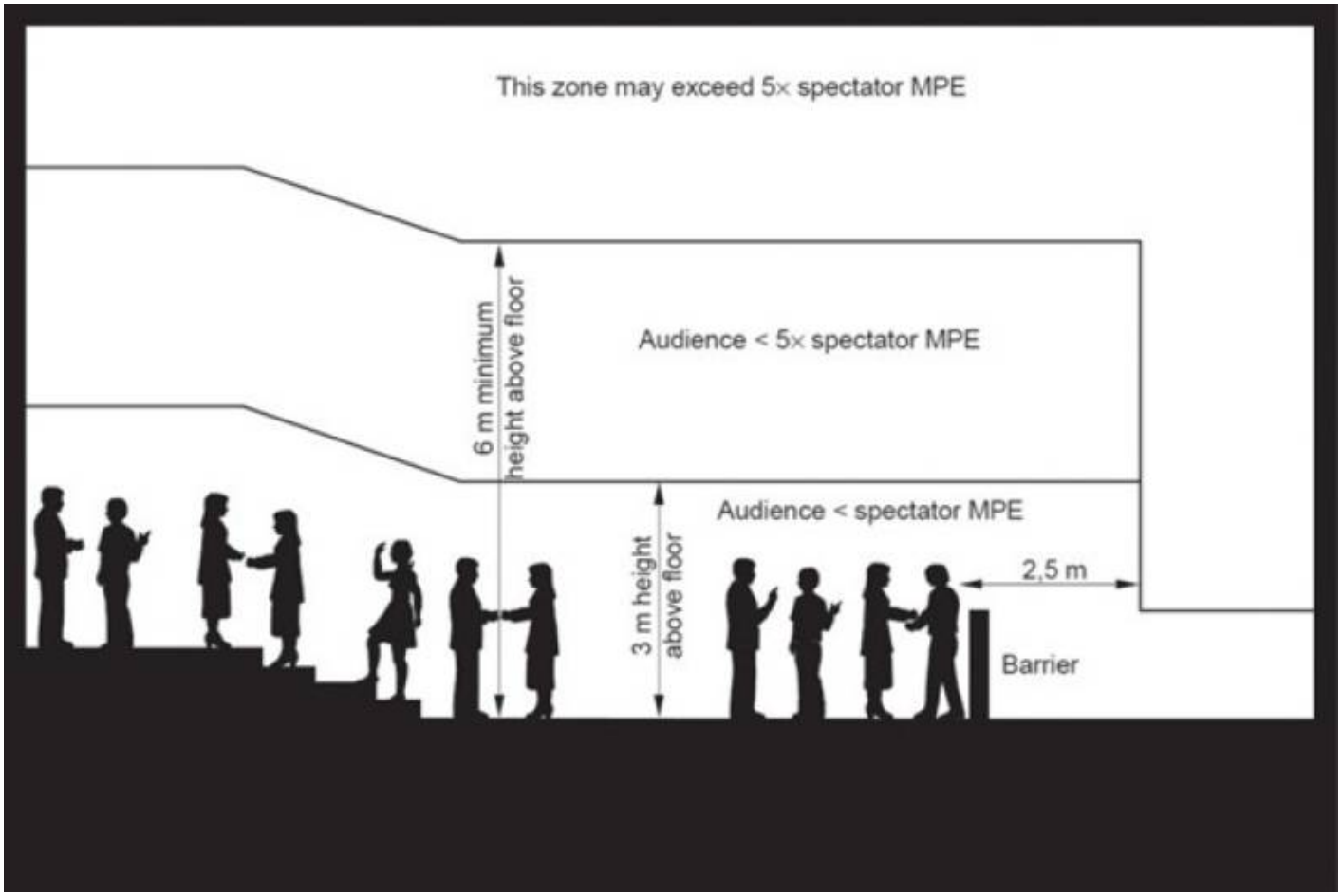
https://www.lia.org/resources/laser-safety-standards/ansi-z1361-safe-use-lasers
https://www.lia.org/resources/laser-safety-standards/ansi-z1366-safe-use-lasers-outdoors In Draft is Z136.10, the Ansi standard for Laser Light Shows, it is unpublished at time of writing.
https://webstore.iec.ch/en/publication/64984

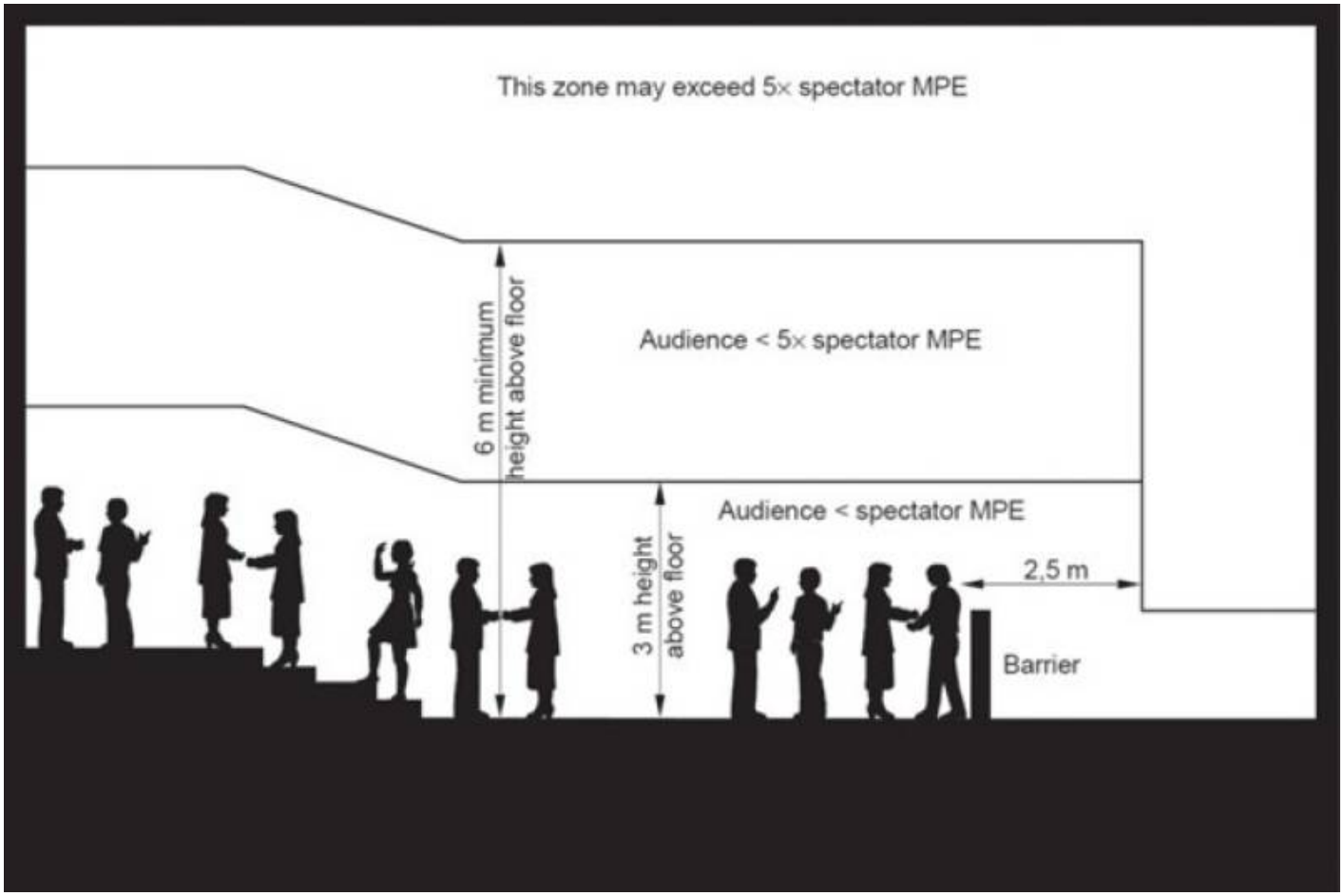
Why are Lasers Dangerous?

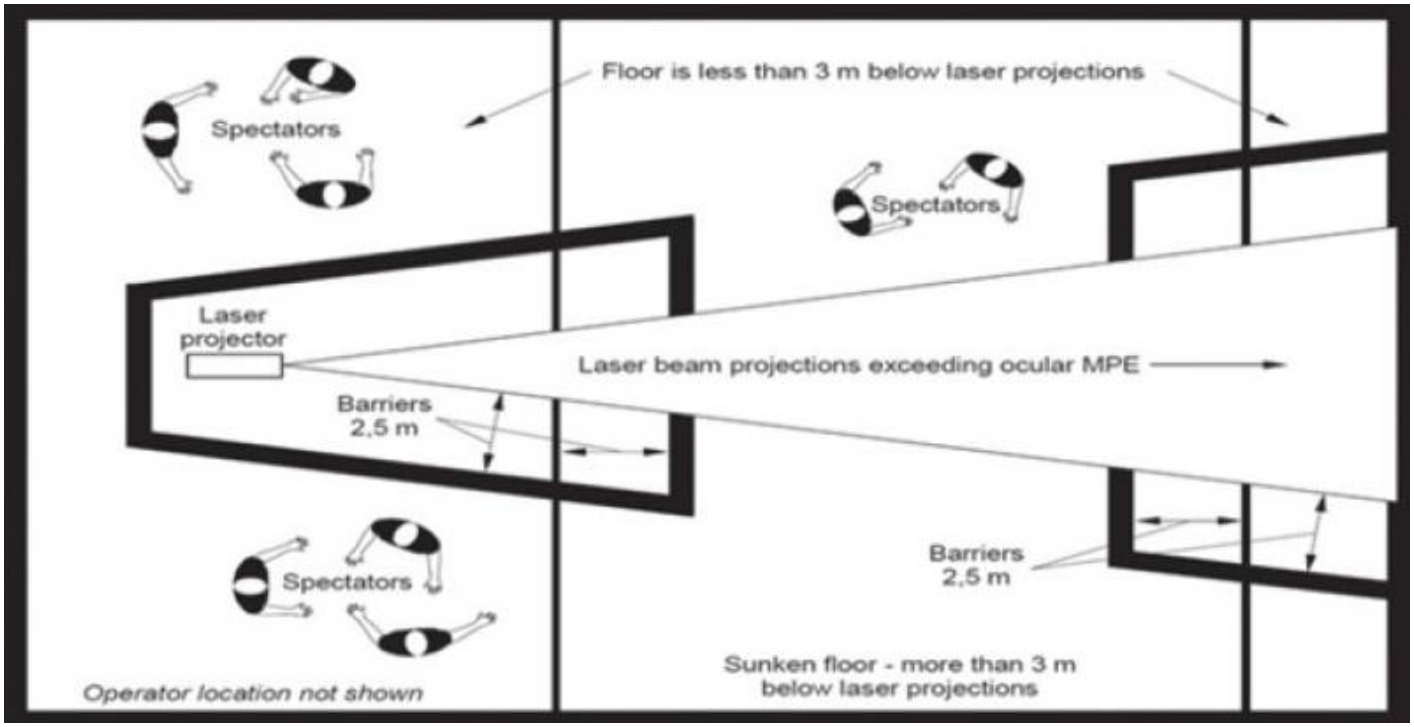


You don’t need to be afraid, but you do need to understand, that lasers are a very intense form of light and have unique characteristics that can cause damage to your eyes. And here is why:

Basically, Regular light is not nearly as focused as laser light, and the way your eye happens to be shaped, is to take defocused and scattered light, cross in the middle of your eye, and project largely on the back of your eye. Fun fact, your vision is actually upside down, but your brain corrects it for you. However with Laser light being so focused, instead of crossing in the middle and flipping onto the back, the beam condenses and comes into a very tight point into the back of your eye. This causes significant heat, burning the rods and cones in your eye.


This zone may exceed 5× spectator MPE
6 m minimum height above floor
Audience < 5× spectator MPE
Audience < spectator MPE
3 m height above floor
2,5 m
Barrier


This zone may exceed 5× spectator MPE
6 m minimum height above floor
Audience < 5× spectator MPE
Audience < spectator MPE
3 m height above floor
2,5 m
Barrier


Floor is less than 3 m below laser projections
Spectators
Spectators
Laser projector
Laser beam projections exceeding ocular MPE
Barriers 2,5 m
Barriers 2,5 m
Spectators
Operator location not shown
Sunken floor - more than 3 m below laser projections

Best Practices When Using, Operating and Maintaining Lasers

When operating a laser, it's important to always consider the risks of the intense light, and be mindful when opening lasers, setting them up, and designing shows.

View this post on Instagram

A post shared by UNITY Lasers (@unitylasers)

Lasers and the Law

Example of variance in the USA, however there are rules in different countries, regions, states counties and even cities. The person who sold you the laser should be able to educate you on your region. If not, consider other manufacturers and suppliers.

How Laser Projectors Work

Chapter Resources

Pangolin links about Projectors

https://lasershowprojector.com/blogs/education/laser-light-show-projector
https://lasershowprojector.com/blogs/education/rgb-laser
https://lasershowprojector.com/blogs/education/laser-projector-purchasing-guide
https://lasershowprojector.com/blogs/education/laser-show-projectors-explained

ILDA Links on Projectors

https://www.ilda.com/projectorspecs.htm https://www.ilda.com/controllerfaq.htm
https://ilda.com/hardwaresafetylist.htm

Wikipedia

https://en.wikipedia.org/wiki/Laser_projector

Laser Sources

- Diode Based
- OPSL
- Other Types

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A post shared by Pangolin Laser Systems Inc. (@pangolinlasersystems)

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Scanning Systems

- Galvos
- Stepper Motors
- Scan-Through Effects

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A post shared by Pangolin Laser Systems Inc. (@pangolinlasersystems)

Extra Components

- Power Supplies
- Shutters
- Mirrors and Optics

Optional Features

- PASS
- BeamBrush
- Motorized Dichroic Filters

Laser Projector Safety Functions

This Section is covered in the safety video, but separated for the purpose of talking about laser projectors.

Chapter Resources

ClubMax Series manual, discussing safety features

https://download.pangolin.com/_Prn/Kvant%20Manuals/clubmax_fb4_series_manual.pdf

ILDA Hardware Safety List suggestions

https://ilda.com/hardwaresafetylist.htm

Estop System

- The Button
    - Mushroom Switch
    - Twist or Pull
    - Manual Reset
    - Key
    - Terminator
    - Cable Output
- Projector Side
- Looping and Chaining
    - Estop Splitter Rack Mount

Safety Functions of Projector

- Key
- Estop Input
- Masking Plate
    - Cinefoil

- Shutter
- Safety Labels
    - Aperture Label
    - Logo Type Label
    - Inside Class 4 Radiation, Interlock Label
    - Variance, Manufacturing information
- Internal Interlocks for Maintenance
- PASS Crowd Scanning Hardware
- Scan Guard in FB4
- Scan Fail Hardware Based not Controller Based

Rigging of Lasers

Before we talk about the how, we must first define what a “secure” laser is. Many legal requirements with lasers require the laser to be “secure”. When a laser is “secure” then the laser can be setup safe, an unsecure laser is no longer safe even if everything else is done correctly, as something as simple as touching it could move it enough that it is no longer safe.

A Secure laser is a laser that is physically restrained from movement with at least one redundancy to a device, or structure that is mounted to earth or the same structure where all beam paths can enter (Like a cruise ship theatre venue), or otherwise restricted from movement, with at least one redundancy.

All the safety equipment, preparation and software setup will all be completely null and void if the actual equipment moves separately from the space that its in.

There are two pieces to this puzzle, first being the mounting of the laser to the structure and ensuring the structure will only move with the space it occupies.

Chapter Resources

Securing a Laser to a Structure

There are many ways you can secure a laser to a structure. The most common thing in the lighting industry for temporary fixtures is lighting clamps. These are designed to bolt to the lighting fixtures yoke, or mount, and then wrap around and tighten around truss and pipes. These clamps vary significantly in size and use, and its best to choose what works best for you. There are three considerations:

- Working Load – The Clamp should be able to handle the weight of your fixture
- The attachment bolt size – The bolt needs to be able to fit into the hole on your projector. In the US its common for ½ inch, and in Europe its common to use 10MM bolts.
- The clamp most be designed for the size of pipe (usually 1.5 Inches to 2 Inches).

If you aren’t working with truss and pipe, you instead will want to bolt your projector with at least two bolts to a solid structure, ideally to metal that is attached to building its in. Its recommended to add thread locker or nylock nuts to permanent installs where rigging to solid building mounting points.

If you are mounting to a flat surface and you cannot bolt down, for temporary shows its acceptable to use tie downs like ratchet straps to secure a fixture to a surface. This is common practice for placing lasers on top of a plate, speaker, or shelf. Straps should be tight and its recommended to use multiple straps in these scenarios.

One of the biggest suppliers of clamps in the USA is here and you can find many examples of different kinds of clamps: https://www.thelightsource.com/products/

Defining a "Secure Structure"

Laser Controllers and "Dac's"

Chapter Resources

https://pangolin.com/blogs/education/understanding-laser-show-setups

https://lasershowprojector.com/blogs/education/how-to-control-multiple-laser-show-systems

USB Based Controllers

The laser industry has gone from network controllers to USB and back to network, as we are a bit out of the USB generation, there are few USB based laser control devices. Due their size, they are most commonly used as license dongles, or where lowest cost is the highest priority, usually among hobbyists or as a home programming device.

Network Based Controllers

Since moving away from USB, most modern controllers are network based. These devices are usually “smart” in the sense that they don’t just provide output, but also have many modes or functions beyond direct control to software or other control devices. These devices usually are either sold as an “OEM” type hardware designed to be built into a laser projector directly, or an “External” Version, designed to be sold separately and use ILDA cable to connect to a laser.

Controller Functionality

Within the Pangolin Ecosystem, The FB4 Hardware Includes Functions below, while USB Hardware generally only provides streaming data from software to ILDA.

- Streaming Open and Closed
- Onboard processing (Instead of direct streaming)
- DMX/ Artnet/ sACN
- ILDA Input
- AutoPlay (Basic)
- Primary and Secondary functionality (unfortunately named master/slave)
- AutoPlay (Scheduler)
- Timecode
- Monitoring and feedback
- Test Modes

What controller you use these days normally depends on what software or control system you wish to work with, as most devices are closed, or even if they are open, only some software is open to those controllers. The general reasoning for this depends on business model, cross device compatibility, performance and copyright/ security of content created with the software.

Cabling Lasers

All Lasers need cables! And in the production world there are some important aspects you will need to know so that when you end up on the jobsite you will know what you need, what to bring, and how to connect everything up.

Chapter Resources

Power

Historically lasers were very high-power draw devices, requiring very high voltages and water cooling. However, these days most laser projectors run on standard available voltages and draw very little power. When ensuring you have the correct and enough power there are two main considerations:

- Voltage
    - The voltage is like the pressure inside a water hose, The higher the voltage the more flow of water there is, and likewise with power the more current that can be run through the line.
        - Common voltages are:
            - 120V 60Hz (Most households in the USA)
            - 208V 60Hz (Two pole power in the USA)
            - 220V 60Hz (Most countries in Europe and the world)
        - Most Lighting fixtures and lasers use what are known as “Switching power supplies” which can take any of these voltages. You will usually see a rating on the projector for this written something like this
            - 100-240V AC 50-60Hz
        - This means the power supply can accept all voltages provided by normal outlets around the world.
            - In Show production, It is common for more eccentric power options to be used,

including three phase high voltage power. Normally as a laser technician you won't need to figure this out, but instead just provide the Master Electrician what voltages your laser can accept, and what consumption.
    - One important thing to note, over long runs of cable, voltage gets lower and lower, if you have extremely long runs of cable, its recommended to test the voltage of the power at your drop to ensure its not at the edges of the voltage ranges, voltages under 105V for example can be damaging to equipment, and proper voltage is required for optimal performance.

- Consumption
    - Power consumption is like how much water is inside your hose from the earlier example. Consumption is usually measured in amperage, but can also be measured in watts. Either way its measured, this is how much power is actually being used. You may see on your equipment a amperage number, usually between 1 and 16. This number is usually rated at the lowest operating voltage.
    - Somewhat confusingly, Amperage is a function of voltage, and 1 Amp at 240 Volts is twice as much current/ Consumption as 1 Amp at 120 Volts. This is why many people use watts, as watts in an absolute measurement and not a relative measurement.
    - To calculate wattage, Multiply the amperage by the voltage, So a laser that specifies its 5 Amps and it says its range is 110V to 240V you multiply 5 Amps by 110 and get 550Watts. This isn't a perfect equasion, but will satisfy your needs in most scnarios.
    - Most "Circuits" are designed to max out at 20Amps peak, and 16 Amps continuous, This is true for both 120V, and 240V. So when figuring out how many lasers you can put on one electrical circuit, this is important. Most lasers represent their "Peak" Power in their ratings.

- Power Connectors around the world
    - When it comes to connectors on your projectors, there are three you will probably see.
        - Neutrik True 1
        - Neutrik PowerCon
        - IEC C13/C14 (Male and female)
        - On the other end, you will find the following for standard power Supplies:
        - Neutrik Ture 1
        - Neutrik Powercon
        - Edison/NEMA 5-15 and NEMA 5-20 (US Standard Household)
        - Schuko (EU Cable)
        - UK/ BS 1363 (United Kingdom)
        - AS/NZS 3112:2011 (Australia, New Zealand and China)
    - There are many more standard power connections around the world. A great resource on cables in different countries can be found here:
        - https://en.wikipedia.org/wiki/AC_power_plugs_and_sockets

It is important to note, there are significantly more types of connectors when connecting high voltage and high amperage lines including camlock, commonly used in the united states, and IEC 60309 Commonly used in Europe. However a regular technician will not be dealing with these connectors, as the master electrician on site will be dealing with this.

Data

Lasers need to be controlled somehow, right? We touched on data when discussing laser controllers and dac's, but we didn't really discuss how that data will get between the control system and the controller itself. So lets talk about some of the most common options.

- ILDA
  - ILDA is the classic big 25 pin cable that everyone familiar with, back in the 90's the International Laser Display Association created the "ILDA" Standard, this used the DB-25 cable and connector to transmit the actual direct signals for each component in laser projectors. https://www.ilda.com/technical.htm
  - This makes projectors that just have an ILDA input "Dumb" projectors, just taking outside signals and transmitting them directly to the hardware. You can still find ILDA connectors in use all around, however in most professional environments these are not used and instead have been replaced by network based controllers.
  - ILDA Cable is technicaly not different to standard DB-25 cable, suppliers for which are becoming fewr and fewer, But one company in the USA that continues to supply DB-25 cable with high durability is L-COM
  - https://www.l-com.com/d-sub-heavy-duty-d-sub-25-position-male-female-cables-20awg-conductors-double-shielded
  - It should be noted that ILDA does have a network based standard known as "IDN" However its adoption has yet to be widespread.
- Networking
  - As the next chapter of this course covers networking in depth, I will mainly focus on the cables you may encounter or should use
    - Cat5e
      - Cat5e is the most ubiquitous cable standard you will interact with; this cable can transmit 1gbps at up to 100 meters. The downside with this cable, is unless you buy production grade cable from the likes of TMB, it is very fragile and can be broken easily.
    - Cat6a
      - Cat6a is much more recommended for our use if you aren't going to get production grade cable. This cable can transmit 10Gbps at up to 100 meters, which for the speed isn't needed for lasers, but to achieve this lots of shielding, reinforcements, and protection was needed. This makes for a very solid cable for production use, without much extra cost compared to production cable.
    - Fiber
      - If you need runs longer then 100 meters, then you have two options, you can either put switches every 100 meters, or you can use fiber instead. This will require switches with fiber capable SPF+ connections, as well as what are known as "fiber injectors" on those switches. Fiber injectors are rated at a speed and distance and the correct injector will need to be picked.
      - Fiber is often used for "backbone" lines, as fiber can handle a large amount of data, its not uncommon for a show and install to use a 2 or 4 pair line of fiber from stage to FOH, and run everyone's data down that line. This normally requires someone with significant networking knowledge, or using show

production grade/designed networking equipment.

- DMX
  - DMX is the protocol that the lighting industry uses to control their lighting fixtures, I comes in a few main versions:
    - DMX – 5 Pin XLR cables, sometimes 3 Pin XLR cables (though the specification is for 5 pin) and is a low voltage hybrid digital/analog signal that is sent directly to the lighting.
    - Artnet – Is a network version of DMX, this converts the data to network packets and runs over standard networking equipment.
    - sACN – The latest protocol being adopted, it is much more efficient and reliable then Artnet and is quickly being adopted over Artnet.
  - Many laser controllers accept DMX to be controlled by a lighting console, as well as laser software. It is just the standard communication protocol for lighting, so lots of industry applications and tools and hardware all accept one or more of these forms of dmx data.

- Some industry protocols you may come into contact with in the entertainment industry:
  - OSC – Command line based network control system, allows for many systems to talk to each other for commands, using the same format, even though they are all very different applications.
  - Midi – Originally designed for music way back in the day, it has turned into a great protocol for external control devices like midi controllers, keyboards, button pads and more to communicate with software's. It can also be used for Timecode.
  - LTC – An audio form of timecode, this is run down microphone./ audio cable, and is an audio based piece of timecode, Systems can send and read this audio's many notes to distinguish what time is being sent. Timecode is explained later in this course.
  - NDI – A network-based video streaming protocol, used often by video software and video servers.

Most of these protocols are network-based protocols, and some do not always play nicely with each other. Artnet for instance is well known for not playing nice with other things on the network, and it's advised for those who aren't experienced with networking to keep different protocols on separate local area networks if you can.

Other protocols are done via analog cables, and generally each protocol that is analog has a specific type of connector dedicated to it, like Audio being 3 Pin XLR, and DMX being 5 Pin XLR. Some protocols like MIDI can be sent over an analog cable specifically designed for midi, but also can be communicated over the network with converters, or just over USB for direct connections.

Estop

For lasers, an extra cable we end up having to deal with is a line for emergency stopping the laser. While the requirements vary greatly around the world on what constitutes a emergency stop, here are some of the examples you may run into. Estop systems usually serve the purpose of closing the shutter of the laser, and cutting the signal wires to the laser drivers to cut the output, and in some cases cut the power to some or all of the internal components in sequence to ensure a proper safe shutdown.

- 3Pin Kvant
  - In Kvant lasers, you will find a 3 Pin XLR estop system, This system was designed to satisfy the rules around the world with different requirements when slightly modified or in a different configuration. This system is not just a contact closure system, but also has a data line to give feedback about the state of the system. This is to allow for the “manual reset” requirement (in some countries) to be on the e-stop button instead of on the laser itself. The negative for this system is that you cannot just wire more in line without the signal processor, so Kvant sells Estop Splitter units to go in and out in many directions, and of course you can string this estop from one system to another.
- DB9 options
  - Many systems with less compliant concerns may use cheap connectors like the DB-9, and just use two pins on it for a contact closure. These systems normally do not provide a manual reset option at all, or place it on the projector chasse itself, inconvenient if needed to be pressed if rigged up high. These systems normally don’t satisfy all legal requirements where manual resets are required.

- Ethernet options
  - There are a few systems these days that use ethernet based cables to carry the estop signal. Normally these just use two pins on the ethernet to communicate the estop signal.
  - Other systems even “inject” the estop signal into the network cable used for control, however these are normally systems that actually take a way two lines in that cable from the network communication protocol and use them for the estop. While this does put both signals down both cables, your network communication speeds and reliability are sacrificed as while usually with two pins removed the communication over network can continue, its at greatly reduced speeds.
    - Its important to note that these systems do not inject the estop into a network based protocol, they steal two wires from the network cable. True “Network” based estops do not satisfy the regulations in countries with estop regulations.

- Power cut only
  - Some countries and regulatory bodies around the world do not require any specific estop controls, and just want the ability to turn the laser off in an emergency. In these environments usually production companies build an estop system into their power systems, and will have power distribution racks with estops, which will just cut the power to all the lasers if pressed.
  - This allows those who can to not have to run an extra cable to each laser, or sacrifice control signal. But this option is not legal in all places and most places that have stop regulations, request a hardware to each laser type instead.

"Daisy Chaining"

The act of “Daisy Chaining” devices is when you don’t have to run a single set of wires to each laser, but instead go in one laser, and out to the next. This allows you to power, send data, and estop between systems and only need one run back to power an data distribution.

When chaining laser projectors together, you will need to consider which will be the first to run out of ability

- Power may run out of capacity over many lasers
- Data runs may not have fast enough timings or to much data to be switched in and out of each laser over and over
- Estop signals may degrade over distance, or a single break may ruin an entire show.

Its important to remember, if somewhere in a chain is causing issues, every fixture afterwards will also experience those issues. It is recommended that users consider all factors when daisy chaining systems.

A simple rule is never go over your power limit, or never go over 8 fixtures in a row max. Either way you will keep the number under 8 lasers or less, and not overlimit any of your signal cables. While its possible you could go further, its not worth the risk in the common opinion of technicians for failure between lines.

Networking and PC Specifications

The Networking Document

Networking for Lasershows, BEYOND, and Entertainment

To be Frank, the article above has everything you could need to know about networking and system tuning tuning you could ever want, so please refer to that document.

What Computer should I get?

When choosing a PC for BEYOND, you will need to take a few things into consideration, will it be a rackmount desktop? Or a laptop? Will you be doing mostly smaller shows under 10 lasers? Or do you focus on large scale multimedia shows while also interfacing with lots of other disciplines. All of these are important to consider. So lets go part by part and explain what is needed.

- CPU

For the processor of your computer there is a sweet spot. Generally, BEYOND prefers and good number of super-fast cores over tons of cores at slower speeds each. This generally means you are looking for CPUs designed for the Pro-sumer or High-end desktop range. Normally these are top of the range consumer chips, from intel often known as “i7 or i9” and with AMD “Ryzen 7 or Ryzen 9” These chips maintain this naming scheme as generations continue however, and its important to only consider the most modern generations of chips when looking at these figures.

For very large setups, lots of CPU cache is recommended, however most high-end desktop chips these days do have enough for 99% of users. On in extremely large zone setups would it be necessary, (over 100 zones). These days the AMD chips seem to have more cache, but getting the highest cache may be a small concern for some.

- RAM

For most users just running BEYOND 16GB with a low cast latency and reasonably good speed is all you will need. Users who plan on using lots of graphic animations, large video files or visualization on the same pc will likely want to bump that up to 32GB in most cases and 64GB of all of those things are priorities.

- GPU

When it comes to a graphics card in your computer, if you are just running beyond, its good to just get a entry level gaming graphics card. This will take some of the UI elements off of the CPU allowing the CPU to more focus on laser output. If you plan on using visualizers alongside BEYOND, you will want to consider high end graphics cards, top of the line gaming cards can sometimes not even be enough for visualizers running large scenes.

- Networking

Often overlooked, the networking on your PC plays a huge part in the reliability, performance and ease of use from your computer system.

The easy answer is use an Intel based network adapter. However, this is easier said than done. All of the requirements up till now lend themselves greatly to “gaming” laptops. Unfortunately, these days most gaming laptops are coming with network adapters from a company called “Killer ethernet” these adapters are great! But only for gaming, our data transmissions to killer ports are basically ignored by default and performance is terrible for BEYOND.

If you cant find out, most USB ethernet dongles actually use either intel or Realtek, and never use killer, so you will often be better off using those, instead of the built in adapter.

Killer ports can be “massaged” into working great, but it’s a hassle and beyond the scope of this course.

If you are building a desktop, getting a 2 port 10GbE intel based add in card is a great way to give you options and reliability to your system.

- Other Nice to haves

Getting a laptop with a touchscreen is a great bonus, getting one with two touch screens is a dream. Lots of laserists are buying the new “Asus Zenbook Duo” These laptops have two touchscreen displays, one main and one smaller one above the keyboard, and are designed around workstation users, so they don’t come with killer ethernet ports, have great cpu and gpu combos, and are generally a great choice all around for users.

If you can’t get one with touch, then finding an external touchscreen display can be a huge benefit. Of course, there are full sized desktop monitors with touch, but there is also these “portable touch screen monitors” that exist, which are often powered by USB, and also have touch, these are also a great option for people flying gig to gig.

It’s also nice to find a system that already has a lot of ports on it, lots of USB, thunderbolt, video outs and whatever you can get your hands on, this will just make the system more versatile, and give you more options when on site.

NVME based SSD drives, these are super fast hard drives that interface with your cpu directly. Most laptops these days are providing NVME SSD's for their main drives, but ensuring this is what you have will increase loading times, and responsiveness of your PC dramatically.

Laptop vs Rackmount Desktop

If we want to make it simple, if you are a touring designer, operator etc, getting a laptop is going to be your only option. The drawbacks of which are in the nuances. When windows is running on a laptop, a lot of power saving, battery health, and performance adjustments are made. This can drastically change how well your computer can run beyond reliably and with full performance.

If you are running a laptop, you should make sure that you check all of these power saving, performance changing aspects of your laptop and ensure everything is set to "highest performance" so whatever battery destroying mode you can pick is what you should pick.

The best option if you are your own production company and the one shipping the lasers around is really to either buy or build a rackmount based PC, and put it in a FOH vibration isolated rack. Full sized desktop computers have faster CPUs, better temperatures, can more effectively utilize the hardware they have, and you can pick the add in cards for more video outputs or adding fiber connections and more.

Setting up a new PC to be "Show Ready"

While its possible to take a new PC out of the box and go do a show with it, it is highly recommended you complete a few steps to ensure your pc is truly show ready.

- Freshly install your windows install.

Many PC's bought off the shelf come with a ton of bloatware, presets and setup profiles that are likely to get in the way of show performance. It is recommended for users to install windows fresh when they get a PC for the first time. This allows the PC to have as little bloat as possible.

- Disable Windows Updates

For show computers, you will want to disable windows updates properly, usually in basic settings you cannot disable them permanently, only put them off until a later date. In windows 10, you could edit the update service to never get updates, and in Pro versions of windows you have been historically able to turn them off in settings indefinitely.

You will need to research how to disable them for good on your version of windows, so that you don't run into issues with updates.

- Disable firewalls, and security functions

You probably don't want to do this to your normal at home PC, however for show computers, these settings can get in the way of communications of industry protocols and cause hidden issues you just don't want to deal with when you are on a show site and time is vital. Normally the main thing that can

get in the way is not windows security functions, but things like VPN's or third-party security software. It is recommended to leave windows internal security functions, but remove any 3rd party apps, and ensure no software is enabling VPN behavior on your network adaptors.

- Understand how to setup IP Addresses and your computer in general

Something you will need to do all the time is set IP addresses, and while you know what the address should be based on our previous section, its important to learn how to actually set these values on the correct network adaptor on your PC. This varies between versions of windows and can be easily searched online, its recommend to do so when you get a new pc. Its also important to understand how to manage files, use the windows explorer, and have general computing understanding, this will help solve a lot of headaches and time sucks as you go about your journey in the industry.

- Turn off Power saves, and create a high performance mode

Windows computers have lots of power saving functions, this is great for laptops, but terrible for a show computer. In windows you can find your "Power Plan" and enable highest performance possible, we want absolutely no battery saving going on for a show computer.

- Setup network adapters for best settings
    - Energy-Efficient Ethernet Off
    - Jumbo Packet Off
    - Wake events

Overview of BEYOND

BEYOND is an all-in-one solution for laser designers, show operators and system integrators alike. Because of this, its important to understand how these tools are integrated inside of BEYOND, and how they relate to each other or not. So before we go into the details, lets get an overview of the three types of users and briefly cover the types of tools they may use all inside BEYOND. If we were to compare BEYOND and Lasers to video, we could consider BEYOND to basically be the Full Adobe Suite, Plus Video playback servers like AI or Hippo and Live video software like Resolume , and Control systems like Pharos,

- Creative and Design
- Show Operation and Live control
- System Design and Integration

There is even more in BEYOND then we can list below, but we think it's important for users to know the extent of the tools inside BEYOND before we dive in, to keep features in context of the entire system.

Creative and Design

BEYOND provides a lot of tools related to creating content, from basic to tools you wouldn't even expect:

- Over 15 Cue type tools
    - Equivalents to Photoshop, Illustrator, synthesizers and touch designer
- 3D Animation and external tools
    - Plugins for Blender, Cinema 4D, 3DSMax, and BEYOND 3D built in Plus support for Touchdesigner, MadMapper, and Adobe Animate.
- Timeline Programming
    - Equivalent to Premier, DaVinci resolve, After Effects etc.
- Effects engine
    - With many effect types for repeating looks, time based key effects and frame based color type effects there are over 175 different effects
- Visualizer Support
    - Including Depence, Vectorworks, Capture, Wysiwyg, Light Converse, and L8

Show Operation and Live Control

- Internal Live controls
    - Lots of live laying effects, add ons, chases, and more
- External Control
    - Inputs for DMX consoles, Midi Controllers, and external inputs like OSC and Net data
- Live rendering
    - Allows for effects and parameters to be brought in to live control your laser output for human interface devices, instruments and whatever you can think of
- Laser Configuration
    - Detailed zoning, configuration, and optimization of laser projectors, to get the best possible output.

System Design and Integration

- Internal Scripting Language
    - Known as “Pangoscript” this internal language allows users to script their own macros, automations, quick tools, schedules, and connect any element from BEYOND to another.
- Protocol Support
    - Artnet, DMX, sACN, Midi CITP, OSC, ILDA, SNTC, Midi Timecode, Artnet Timecode, SMPTE Timecode, HTPS, Net control, and more
- UI Builder
    - BEYOND universe is a UI building tool built for live control or install control and can be used in place of many show control tools.
- Object Tree
    - BEYOND as a system allows users to access all internal values and parameters that exist, you can pull data, change data and set data for every single filed in BEYOND directly with code and link these parameters to external systems.
- SDK
    - If you still cant get what you want out of our internal tools, we have an SDK that allows users to build their own apps, wile still outputting to BEYOND, allowing for all the safety and post

processing BEYOND can provide.

License System

The Flow of Content

In order for your ideas to turn into safe and beautiful laser light, there are a lot of creative steps and tools, that get processed through settings and configurations, and out over a network to your laser where its then turned into laser light. To be a proficient laser designer and technician it’s important to understand this path, and we will cover all aspects in the next half of the course. We call this the “Flow of Content”.

Beyond is an Hourglass

There are a lot of steps content goes from simple shapes to things that output on your laser, if we were to imagine this it would be like an hourglass. On one end there is projectors and its settings and processing, on the other end its content and effects, live control and timelines. In the middle is projection zones. The list goes something like this.

- Frames
- External Inputs
- Effects
- Post FX
- Routing
- Zones
- Projector Settings
- Streaming
- Network transmission
- Output by Controller
- Hardware output

Each piece of this puzzle plays a part in the overall process of creating content. Often times when you find yourself trying to achieve something unusual or something that doesn’t have a clear tool or direction, you can consider this whole list about where to inject different changes to get the result you are going for.

Knowing these steps also helps when troubleshooting, it will help identify where the issue you may be experiencing is coming from, and help determine if its content, processing, system, or the projector itself.

FB4 Settings

Chapter Resources

FB4 Settings Basics

FB4 QuickStart Guide

Overview on FB4 Settings

FB4 settings window is a network terminal for accessing all the settings on your FB4 remotely. This is mostly the settings on the FB4's display. The configurable options are listed below.

This window can be incredibly useful when addressing fixtures, setting IPs, or trying to find a missing laser that hasn't connected to your BEYOND software yet and is stuck in the wrong mode. FB4 controllers will be visible in this screen even if they are not showing up in the hardware window in BEYOND, needing firmware update, and sometimes can be identified even if outside of IP ranges.

Its interesting to note that this tool is in BEYOND and QS, and can be used as a utility tool while another computer on the network is connected to the lasers, so if a technician needs to diagnose a laser, or change settings while another programs, it can be done.

- IP Address
- Master Settings
- Color Masters
- DMX Functions
    - Mode
    - Channel
    - RDM
    - Universe and subnets for network
- Autoplay
- Clock
- Geometric Correction
- Timecode
- Scan Guard

FB4 Quick Start Guide

For general information regarding the FB4, please view the Quick start guide on the wiki.

FB4 QuickStart Guide

As well as see all files on FB4.

FB4 interface

FB4 Protocols for More Control

There are external control options for FB4 including OSC, Net controls and more, these functions are not discussed further in this course, but its important to know they exist as they progress.

One fun function example is the “nudge” feature. This was added for permanent installs to slightly move their DMX content up down left and right so they could do an alignment without requiring software.

There is a lot hidden underneath the little display to explore when you eventually need it.

If you think you need these tools, please contact support for supporting documentation, In the same way the SDK is reserved and upon request, these tools are upon request.

Projector Settings (Optimizing Laser Output)

Projector settings is where you set the output settings for your projector. These detailed options and modifications use to matter a lot more many years ago when most lasers were not manufactured on assembly lines but one at a time by who was going to use them. In order to get all these mismatched projectors to look good with each other, they all needed very unique settings within projector settings.

These days projectors are made in production lines that have much stricter quality control, and use the same parts for years at a time, minimizing the differences and allowing for many of the “default” options within Projector Settings to work for most lasers.

However, there are a few settings that users will still likely need to concern themselves with. Including Scan Size, Scan Speed, Color Shift and Color Tuning.

To understand how content becomes laser output however, first we will cover how a laser “frame” gets rendered in software, and how its built for a laser to output it.

Anatomy of a Laser Frame

Use Infographic to be built about anatomy of a frame

- Visible Points
- Visible Lines
- Blanked Points
- Blanked Lines
- Anchors vs Lines

What is spacing?

Size and Position

The first option is size and position, this is the master “usable” space for your laser projector to use. People either use this to adjust the maximum size to limit themselves from driving their content to larger, use it to try and tun their bigger scanning lasers to their smaller scanning lasers, or use it as a backup safety zone to limit the area where the laser could possibly scan. Commonly however, most users tend to set this to 100×100 and instead do all sizing within projection zones which is covered soon.

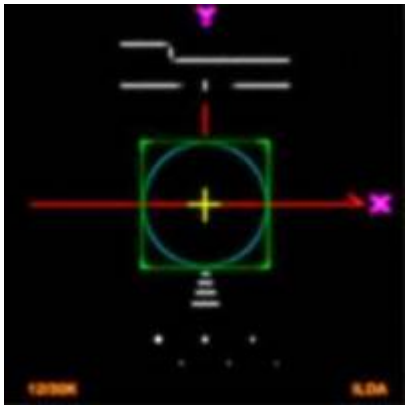
- Master Size vs Zoning
- Maximum possible output and area

Note: Its recommended that for most beam effects, scanning at a max angle of 100×100 is usually fine, but a buffer of 10% (90×90) is recommended, for graphics, the maximum scan angle for graphics is recommended at 50×50, with a preferred 25×25. If that isn’t enough to cover the projection surface, its recommended to place the laser further, and only increase the size beyond 50×50 if you slow the scan speed down.

Scanrate

Scanrate is the speed at which the scanners within your projector run. There is a bit of a disconnect between software and the lasers themselves, projectors don’t really know what their speed is and the software thus cannot know either. This leaves this important setting up to the user.

- The ILDA Test Pattern

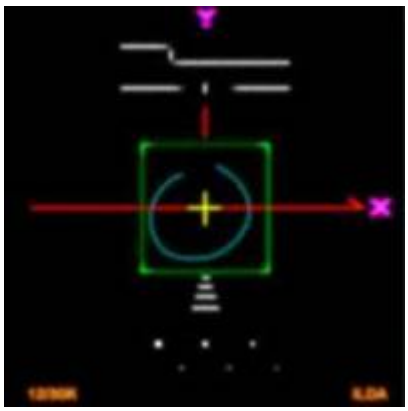


The ILDA test pattern is a tool used to determine the scan speed of a particular scanner and is also used by manufacturers to tune and test for a specific speed. The main idea being that if all scanners can display this pattern correctly, then any content created that works on one scanner, will work on the rest.

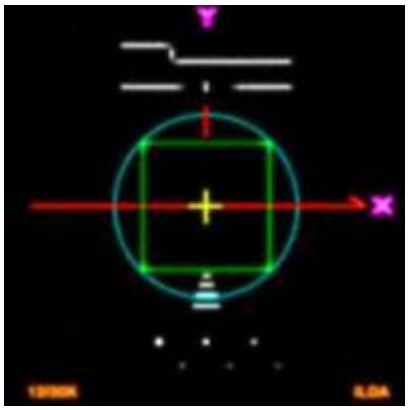
Users can utilize this tool to determine at what speed their scanners can handle using the blue circle in the green square. Blue circle being to small, or broken up within the green square means scanning to fast, and being outside the green square means to slow. When the correct speed is achieved, the blue circle should be just touching the edges of the green square.

Note: The ilda test pattern is only relevant for small scan angles, and tests are commonly stated at 8 degrees can angle for the pattern, in BEYOND we have provided a scaled version that puts the pattern within 8 degrees based on 60 degree scan angle., and should be used when end users are testing, running the test pattern at full angle can cause damage to the scanners.

To fast:



To Slow:



- Setting Scanrate

Normally you can just set the speed specified in the specifications of the laser. This should be okay for most lasers running beams at 100% scale and graphics at 50% scale.

- Color Shift

Color shift is in relation to the fact that laser drivers that turn the lasers on and off are faster then scanners, because of this we “shift” the color data and scanner data a very small amount of time, so they line up. Utilizing the ILDA test pattern, use the white horizontal lines in the upper center portion of the pattern, when the correct value is set, it will look like the drawing in the previous pictures.

Color shift will need to be adjusted with scan speed, however 4, or 5 is usually good for 30k scanners. But can vary from projector manufacturer.

- Minimum Number of Points

Minimum number of points is a setting for the minimum amount of data in a single frame, this helps

make output more stable and avoids accidental “too few point” situations that can damage scanners. Its best to leave this setting alone at 200.

Color Settings

Every laser model has different powers of each color in the laser, and often they can have different wavelengths of each color, or even 4th or 5th color lines for very expensive systems. This can cause differences in output between each fixture, and you may want to correct this color output to get mor in line with what you want.

Its also important to note that laser output power does not linearly relate to brightness. This means if you want to double the “apparent brightness” of a laser, you need to quadruple the actual wattage of the laser. However when lasers are tuned in the factor, they are tuned in a power linear function, so color tuning serves to fix this physical limitation, and get better output for your projector overall.

- Basic

Normally this should be left alone, this will in turn give you the “natural” or “highest brightness” output on your projector. If you would like more definition, you can do the simple color correction trick of taking the minimum values up until just before the laser starts outputting and setting log curve. This will maintain the “natural” color balance of your projector but give you more definition between each hue and better fade outs.

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- Advanced color settings

If you want a perfect color balance and to match every laser in your setup, you will need to do a little more work. This is where the advanced color tuning tool is used. Utilizing a couple of the test patterns provided, you can set perfect brightness curves for each color channel in your laser, which gives you the definition between colors. Then you can go to each hue on the left and tune how much of each laser color you would like for that hue. Its recommended to use the medium color test pattern, and add a hue for every 30 degrees to get each circle on the test pattern represented.

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A post shared by Pangolin Laser Systems Inc. (@pangolinlasersystems)

When tuning a whole rig, its important to pick your “worst performing” or “most constrained” projector to create an original tune with, then use that as the master to reference as you tune the rest of the lasers. This way you can actually get them all to look the same.

When you have a rig of all the same lasers, often you only need to do this advanced color tune on one, and then you can copy these settings to each and get 95% of the way there, and probably 100% there if all the lasers are from the same date of manufacture. (this becomes less reliable the older the lasers are and the difference in hours on the lasers)

- Wavelengths to Hues and mixing

Lasers are specific colors, and depending on what actual wavelength of colors within your laser, they may represent different “hue values” on the hue circle. This should be considered when tuning your lasers. Two common situations where this would be is

445nm vs 455nm blue (Hue 240 vs Hue 230) And 520nm vs 525nm vs 532nm Green (Hue 130 vs Hue 125 VS Hue 120)

Normally the “green” or “blue” in your laser should just be the true hue values of 240 for Blue and 120 for Green, but when working with lasers of different wavelengths you may want to consider their actual wavelength to hue value. This becomes increasingly important as you have extra color channels like 577 Yellow vs 590 Amber. Both are yellow, but neither are exactly the 60 Degrees of hue for yellow.

Vector Display Settings and Track Settings

When you use “generators” In BEYOND to create content, (which is most of what you will be doing when making content in BEYOND) BEYOND will use the vector display settings and track settings to determine how to draw from a technical level what you want to see. These use the pieces from the “anatomy of a laser frame” to create that frame, and here you can set how many of each and how dese those pieces will draw.

Track Settings is the settings used to go between objects if there is two frames of content being played at once.

Pretty much all users will never touch these settings, as the defaults for these settings have been crafted around the ILDA test pattern, and with testing on thousands of lasers of different manufacture and parts over the years.

Beam Attenuation Map (BAM)

The Beam Attenuation Map or (BAM) for short is where you can block out portions of your projectors potential output so that no lasers output in those areas. This is useful for reflective surfaces, camera lenses, or video projector lenses. All of which could be dangerous for the audience, or dangerous to the function of the equipment being hit.

There is also BAM within projection zones, and which to use will depend on your style of programming, (focusing on projection zones or using Projector settings and zones in conjunction).

Extras

- FB4 Serial Port DMX

FB4 serial port dmx output is a tool used to output control signal to something within the laser itself, normally this is for motorized gratings, or drop in filters, and allows you to use FB4 to control these things

using DMX control within BEYOND.

Note: This function is only usable if something is actually hooked up inside the laser, and is not designed to be a dmx node which utilizes the DMX out on the projector.

- Beam Brush

BeamBrush is a extra function of some Kvant lasers that allows you to control the size and width of the laser beam in real time, this advanced hardware that goes inside the laser needs to be controlled somehow, and this window is visible when beam brush is installed in the laser. BeamBrush is run by a scanner, and thus requires some of its own tuning and configuration options.

- Motorized Dichroic Filters

Similarly, motorized dichroic filters are an option in some Kvant lasers, these allow you to do color alignment of the lasers remotely without opening the laser up. This tab will appear when this function is installed in the laser. Giving you control of these movements remotely.

Best Practices "Defaults"

Extra Resources

Projector Settings Menus

https://lasershowprojector.com/blogs/education/laser-scanners-the-ilda-test-pattern

https://www.youtube.com/watch?v=EEmBM25YovM

Laser and Emulaser Controller Hardware Window

The “Laser and Emulaser Controller Hardware Window” is located under “Settings> Laser and Emulaser Controller Hardware…”. This window will show you all control hardware connected to your system, and usable for output.

Here you can also add demo projectors as placeholders, or add the “Emulaser” tool, which is a video output version of your laser output, to be used either as a simulation tool, or with a video projector to create a “laser like” output. This can be a great tool to use when trying to program at home and a cheap video projector is easier to get a hold of, or in the high end, used as a high power audience scanning laser like look when paired with high quality video projectors.

This order in this list is important, it is the order of projectors in the bottom bar of BEYOND, and the order seen in many menus.

When a projector is disconnected, they remain in this list. This is because of how important the order is,

and index. So, when you later bind other things to these projectors, they are actually bound to the index number, not the hardware itself. If you are exchanging one laser out of your show, then you replace that fixture in this list in the same position, everything bound to the index will automatically know which hardware to output to.

To help keep yourself organized, it is recommended to set the IP addresses on your lasers in the order you will want them for this list, As you can click on the dropdown: “Sort>Sort by IP” and it will list them in order. This can drastically speed up setup inside BEYOND, with some minor work on the rig, and will also help you identify what laser is where either way.

Chapter Resources

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Projection Zones

Chapter Resources

Projection Zones in BEYOND

Real Life Parameters in Zones

- General Tab
- Geometric Correction
- Beam Attenuation Map

Preview and Content Changes in Zones

- Preview Pane
- Effect Tab

Stitching, Stacking, and Distribution (Canvasing)

- Stacking and Stitching options
    - Stacking For Brightness
    - Stacking for Content
    - Stitching for size
- Tools To achieve it
    - Also To
    - Distribution

Designing a Zone File (and thus your show)

- Creating a layout/ the layout for your show.

- Determining where the beams will go from each laser and if multiple locations are needed.
- Creating names for each zone, and area you want beams to go and for which laser.
- Using Preview to create a preview of your setup from real life to your preview pane.
- Pre-setting geometric correction to a zone setting you guess is correct
- Using minimum brightness to identify which projector is which in the list, Assign the projectors to their respective zones.

Content (What kind of content do lasers create?)

https://lasershowprojector.com/pages/types-of-laser-shows

Chapter Resources

Live Content

Pre-Programmed Content

Show Control Programming

Types of "Content"

Chapter Resources

Shape Generators

Drawing

Tools and Builders

The Universal Pool of Effects

Chapter Resources

Using Effects in BEYOND

https://www.youtube.com/playlist?list=PLYN8RZ0FldXHMhaZI6YQF9A-WbB-MJssW

Oscillating Effects

Key Effects

Color Type or Point Effects

The Grid and Live Content

Chapter Resources

Grid Toolbar

Cue Grid

Cue Properties

Live Control in BEYOND

Laser Preview Window

Laser Preview Window

QuickTools overview

QuickTools

Grid Area of BEYOND

The “Grid” area of BEYOND is in its most basic sense, the area for storing content and playing shows live. To achieve this, you have many areas of the grid mode.

Quick Tabs

Right Tabs Area

The "Workspace" File

The content you see in the Grid mode including the content in all the pages, and QuickFX tab are all stored in what is known as the “Workspace” file. This file can be found under “file” “Open, Save, and Save As”. This file you can consider being your content file when it comes to your live shows.

Workspaces are mainly comprised of categories of pages, of which store content, content FX, content destinations and more. Each page consists of 256 cues; however most are generally hidden and the “visible” amount of cues depends on your “Grid Size” which can be adjusted in the configuration window. Each cue cell has an index of Page, cue number. Content in the workspace can be seen as either keyboard shortcuts, index number, DMX Assignment (for 16 channel mode) or without any marking. Most advanced users choose cue indexes as this is most relevant for scripting and accessing the data non visually.

Each cue cell can host a bunch of different content and just browsing through the default workspace you will be able to see many of the options.

If you right click on an empty cell, you can see many options for copying, saving and its properties. You can create new content by going to the create option.

Under create you can see many of the content creation tools available to you in BEYOND. Note: Different tiers of BEYOND have different numbers of tools to create content.

DMX Control

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Chapter Resources

DMX Input Options

16 Channel Modes (Whole Software Control)

39 Channel Modes (Direct Control)

DMX Server (Fixture to Zone)

Using Physics for DMX Server

CITP

The Timeline and Pre-Programmed Content

Chapter Resources

Timeline Area of BEYOND

Tracks and Types of Tracks

Cue list, Effect List

Effect Tab and Event Tab

Using Timecode

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The Configuration Window

Chapter Resources

Just Read It

Basic Troubleshooting and Monitoring Tools

Chapter Resources

FB4 Data Transmission Monitor

Core Monitor

Performance Tuning

Further Reading, Where To Go From Here?

Return to Guided learning