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Litron Total Laser Capability

# Lasers for PIV Applications

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Litron Lasers

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Our policy is to improve the design and specification of our products. The details given in this document are not to be regarded as binding.



Litron Lasers

# Lasers for PIV Applications

**L**itron offers an extensive range of flashlamp pumped and diode pumped PIV laser systems with output energies of up to 1J per pulse and repetition rates of up to 200Hz for flashlamp systems and up to 20kHz for diode pumped systems. All of the systems are twin head devices, meaning that the PIV laser head contains two totally independent lasers. The range of PIV systems is based around both the ultra-compact Nano series and the larger invar stabilised LPY and LDY series. The overriding factor that sets Litron's products apart is quality. This is evidenced not only in the design and construction of the product, but also in its performance.

In any imaging application the beam quality is of paramount importance as this completely determines the light sheet quality. By choosing a suitable resonator configuration the output beam quality can be controlled to give a very smooth spatial profile which remains homogeneous as it propagates through to the far field. Such resonators are almost always of a stable or stable-telescopic configuration. Unstable Gaussian-coupled resonators are not in general ideal for visualisation applications. These resonators produce very good Gaussian spatial profiles with low divergence in the far field, however, in the near to intermediate fields (within 10m of the laser output) the beam spatial profile often has significant structure to it. This phenomenon is typical of this resonator design and is a result of the physics of the system making it unsuitable for forming uniform light sheets.

It is our philosophy to provide a laser system that suits an application. A 'one system fits all' approach, as offered by most manufacturers, does not allow the customer to optimise their process. For applications such as PIV Litron has developed resonators that will yield extremely uniform light sheets whose pulse to pulse structure remains extremely constant. These are all based around our stable and stable - telescopic resonators.

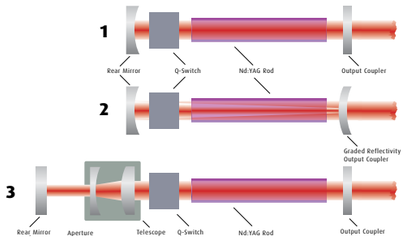
## Resonator Design
# The Heart of the Litron System

### Stable Resonator

A stable resonator provides the most flexibility in terms of output energy and repetition rate, as both parameters can be varied with minimal effect upon the alignment of the system.
In general, the output of such systems is multi-mode. With the addition of an intra-cavity aperture, a $TEM_{00}$ output can easily be realised at the expense of some of the overall energy.

### Gaussian Optics

In a Gaussian system, a graded reflectivity output mirror is used as part of a geometrically unstable resonator. Such systems give a high energy single transverse mode with a low beam divergence. The thermal lens formed by the laser rod is part of the optical arrangement. Therefore, Gaussian systems work best at a constant average input power (i.e. lamp energy and repetition frequency). As such, the laser is factory set at one pulse repetition frequency and output energy. To increase flexibility, Litron offers two options. The first option, the pulse repetition rate divider allows the user to divide the set repetition rate by 2, 4, 8 or 16. This works by allowing the flashlamp to pulse at a set frequency, thus maintaining the same thermal load on the laser rod, but only switching the Pockels cell on the desired pulses (i.e. every other pulse for divide by two operation).




Schematics showing oscillator design.
1) Stable
2) Gaussian
3) Stable Telescopic

$TEM_{00}$ resonators can also be offered with the inclusion of an intra-cavity aperture.

### Telescopic Resonator

To obtain high energy, low divergence beams, the preferred method is the use of a telescopic resonator. In this configuration, an intra-cavity telescope is used to reduce the beam diameter in the rear of the resonator. This makes the resonator appear longer, increasing the lower order mode volumes, leading to a superior output beam with very low divergence. With no optical adjustment at all, the laser can be varied over a wide range of pulse energies and repetition rates, maintaining a high quality, low divergence beam. With slight adjustment to the telescope (a simple procedure) the full range of energies and repetition rates from single pulse to the maximum can be achieved. For high energy $TEM_{00}$ beams, an intra-cavity aperture can be fitted behind the telescope. Varying the sizes of these apertures allow output beams that are to within 15% of the diffraction limit to about 3.5 times the diffraction limit. That is from an almost pure Gaussian $TEM_{00}$ to full energy in a uniform spatial profile, giving a high degree of control over light sheet characteristics.

### Optical Attenuator

Energy output can be controlled via the variable optical attenuator. The output energy of the laser can be attenuated by the use of an extra-cavity polariser and half wave plate, whilst maintaining the beam quality and divergence.

This also has the advantage that the pulse to pulse stability is maintained even at very low output energies.

# Compact Lasers for PIV Applications
## The Nano PIV Series

### NANO PIV FEATURES

- ***Compact dual head design***
- ***Dedicated PIV laser head***
- ***Stable resonator design***
- ***Telescopic versions for low divergence***
- ***Rugged for industrial environments***
- ***3rd and 4th harmonics available for LIF and dual colour PIV***
- ***Rep. rates to 200Hz***
- ***Energies up to 425mJ @ 532nm***

**Nano PIV**

The construction of the Nano series of PIV laser systems is extremely robust. They have been developed as industrial tools that can be handled without worry of misalignment or damage. The PIV head is formed by an aluminium gauge-plate onto which two standard Nano series heads are mounted. The output beams are combined by dielectric polarisers and then frequency doubled, and if desired can be frequency tripled, quadrupled or quintupled. Many of the Nano PIV systems are powered by a single power supply unit, making the overall package both powerful and portable.

There are two twin power supplies available, the LPU450-PIV and the LPU550- PIV, the latter allowing outputs of up to 200mJ at 532nm at 15Hz from each laser. The laser systems are controlled via a remote controller or via RS232 interface . All trigger and synchronisation signals are TTL compatible and each laser is controllable entirely independently.

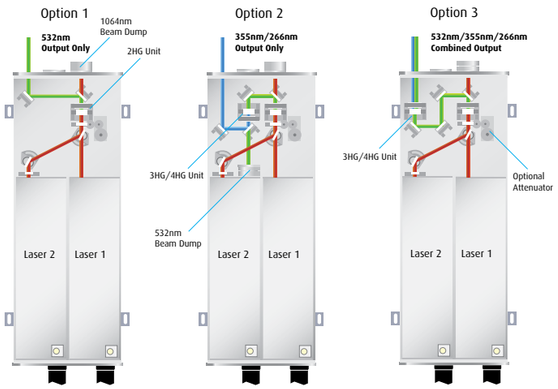
All Nano laser heads have a verified electronic intracavity safety shutter as standard, which ensures that the lasers cannot be started with the shutter open – an important safety feature.

The Nano L PIV range also includes high repetition rate models giving energies of up to 50mJ per pulse at 100Hz from each laser using a power supply that is completely air cooled.

The Nano T PIV range has been designed incorporating stable telescopic resonators, giving very low divergence output beams that allow thinner light sheets to be formed than from conventional stable resonators.

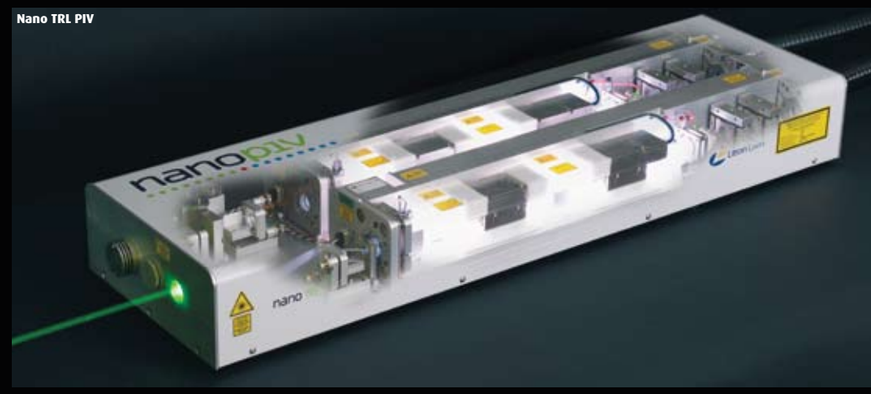
For large area illumination, high energies are achieved with the birefringence compensated Nano TRL range which achieves output energies of up to 450mJ per pulse at 532nm, 10Hz. The footprint of the head is an extremely compact at 908mm x 270mm.

Schematic showing the Nano PIV laser harmonic generation options.




Nano L PIV


Nano TRL PIV



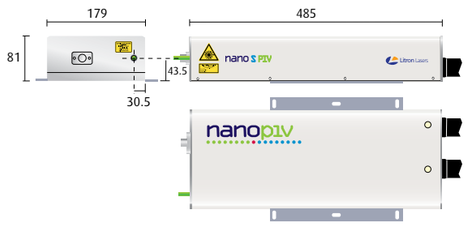

Harmonic Generation Unit

# The Nano PIV Series Specifications

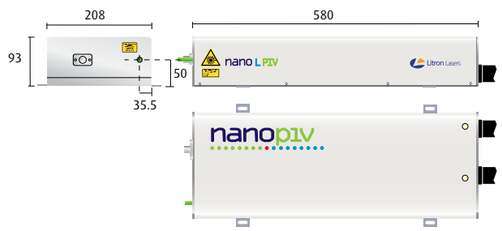
| Model | Nano S 30-15 PIV | Nano S 30-30 PIV | Nano S 50-20 PIV | Nano S 65-15 PIV | Nano L 200-15 PIV | Nano L 135-15 PIV | Nano L 50-50 PIV | Nano L 100-50 PIV | Nano L 50-100 PIV | Nano T 180-15 PIV | Nano T 135-15 PIV | Nano TRL 250-20 PIV | Nano TRL 325-15 PIV | Nano TRL 300-20 PIV | Nano TRL 425-10 PIV | Nano TRL 400-15 PIV | Nano TRL 400-20 PIV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Repetition Rate** per Laser Head (Hz) | 0-15 | 0-30 | 0-20 | 0-15 | 0-15 | 0-15 | 0-50 | 0-50 | 0-100 | 15 | 15 | 20 | 15 | 20 | 10 | 15 | 20 |
| **Output Energy at 532nm** per Laser Head (1) (mJ) | **30** | **30** | **50** | **65** | **200** | **135** | **50** | **100** | **50** | **180** | **135** | **250** | **325** | **300** | **425** | **400** | **400** |
| **Parameter** | | | | | | | | | | | | | | | | | |
| Pulse - Pulse Stability (±%) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Beam Diameter (mm) | 3 | 3 | 4 | 4 | 6.5 | 5 | 4 | 4 | 4 | 6.35 | 5 | 6.35 | 8 | 9.5 | 9.5 | 9.5 | 9.5 |
| Beam Divergence (mrad) | ~2.0 | ~2.0 | ~2.5 | ~2.5 | ~3 | ~3 | ~2 | ~2 | ~2 | 0.8 | 0.8 | <1.5 | <1.2 | <1.0 | <1.0 | <1.0 | <1.0 |
| Pulse Length @ 1064nm (ns) | 5-8 | 5-8 | 6-8 | 6-8 | 6-9 | 6-9 | 5-8 | 5-8 | 5-8 | 7-9 | 7-9 | 5-7 | 5-7 | 5-7 | 5-7 | 5-7 | 5-7 |
| Pointing Stability (µrad) | <100 | <100 | <100 | <100 | <100 | <100 | <100 | <100 | <100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Resonator Type | Stable | Stable | Stable | Stable | Stable | Stable | Stable | Stable | Stable | Telescopic | Telescopic | Telescopic | Telescopic | Telescopic | Telescopic | Telescopic | Telescopic |
| Lamp Life (pulses) | >5x10$^7$ | >5x10$^7$ | >5x10$^7$ | >5x10$^7$ | >5x10$^7$ | >5x10$^7$ | >5x10$^7$ | >5x10$^7$ | >5x10$^7$ | 5x10$^7$ | 5x10$^7$ | 5x10$^7$ | 5x10$^7$ | 5x10$^7$ | 5x10$^7$ | 5x10$^7$ | 5x10$^7$ |
| Timing Jitter (ns) | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| **Services** | | | | | | | | | | | | | | | | | |
| Voltage (VAC) | 110-250 | 110-250 | 110-250 | 110-250 | 110-250 | 110-250 | 110-250 | 220-250 | 220-250 | 110-250 | 110-250 | 220-250* | 220-250* | 220-250* | 220-250* | 220-250* | 220-250* |
| Frequency (Hz) | 47-63 | 47-63 | 47-63 | 47-63 | 47-63 | 47-63 | 47-63 | 47-63 | 47-63 | 47-63 | 47-63 | 50-60** | 50-60** | 50-60** | 50-60** | 50-60** | 50-60** |
| Power | Single Phase | Single Phase | Single Phase | Single Phase | Single Phase | Single Phase | Single Phase | Single Phase | Single Phase | Single Phase | Single Phase | Single Phase | Single Phase | Single Phase | Single Phase | Single Phase | Single Phase |
| Ambient(2) (°C) | 5-35 | 5-35 | 5-35 | 5-35 | 5-35 | 5-35 | 5-35 | 5-35 | 5-35 | 5-35 | 5-35 | 5-35 | 5-35 | 5-35 | 5-35 | 5-35 | 5-35 |
| Consumption (W) | <350 | <350 | <350 | <350 | <800 | <650 | <800 | <2500 | <2500 | <800 | <650 | <2500 | <2500 | | <2500 | <4500 | <5500 |
| Cooling | Air | Air | Air | Air | Air | Air | Air | Air | Air | Air | Air | Air | Air | Water | Air | Water | Water |
| Power supply | LPU450 | LPU550 | LPU450 | LPU450 | LPU550 | LPU550 | LPU550 | 2xLPU1000 | 2xLPU1000 | LPU550 | LPU550 | 2 x LPU1000 | 2 x LPU1000 | 19" Rack | 2 x LPU1000 | 19" Rack | 19" Rack |

(1) At maximum rep. rate.
(2) 0-80% non condensing atmosphere.
* 110VAC option requires autotransformer to be specified on order.
** 50 or 60Hz to be specified on order.

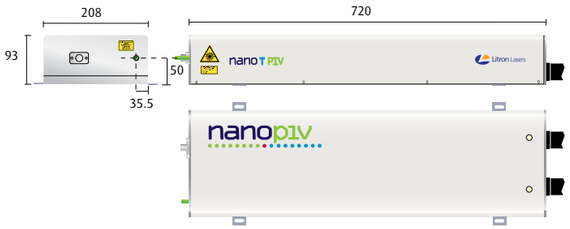
### Nano S PIV Laser Head



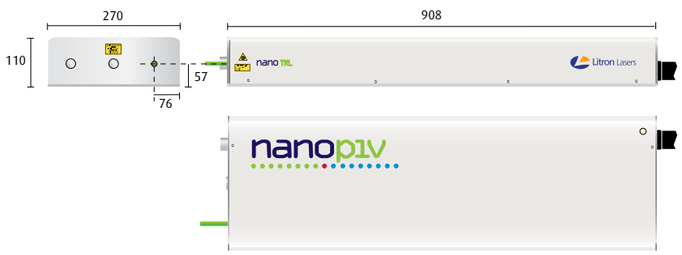

### Nano L PIV Laser Head



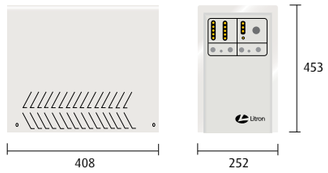

### Nano T PIV Laser Head



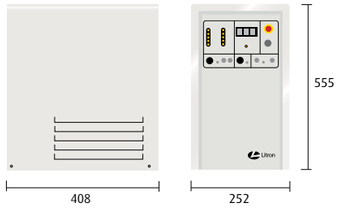

### Nano TRL PIV Laser Head



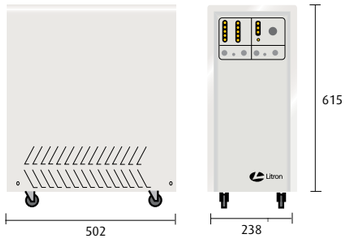

### LPU450 PSU



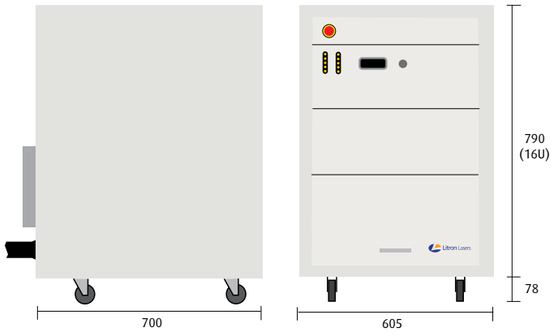

### LPU550 PSU



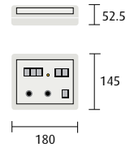

### LPU1000 PSU




### Rack-mount PSU




### Remote Control Box




All dimensions shown in mm

# Vibration & Shock Proof, Ultra Ruggedized Laser for PIV Applications in Demanding Environments
# The Bernoulli PIV Series

## BERNOULLI PIV FEATURES

- ***Vibration & shock proof***
- ***Fully sealed laser head***
- ***2 year warranty***
- ***Ability to operate in all orientations***
- ***Compact size***
- ***Fast connections & start -up***
- ***Motorised attenuator fitted as standard***
- ***High frequency options also available***

**Bernoulli PIV Laser System.**

From wind tunnels to wind farms the bernoulli™ is suited to operation in almost any environment. The new bernoulli™ PIV from Litron is the most advanced plug and play' PIV laser system available today. It benefits from Litron's years of experience in this field and the expertise gained from being the World's leading PIV laser manufacturer.

**Rugged**

**Vibration and shock proof** - for use in rough environments.

**Fully sealed laser head** – protection from dust and moisture.

**Ruggedized oscillator** – fixed mirror design adds to oscillator alignment stability.

**Reliable**

**2 Year warranty includes Optics, PSU & Laser head.**

**2 Year warranted alignment and overlap** – All components locked into position in a separate compartment.

**Portable**

**Ability to operate in all orientations.**

**Compact size** – strengthened and lightened aluminium monolithic body.

**Fast connections at the laser head and PSU** – easy to transport and set-up.

**Intelligent**

**MOBIUS™** - Microprocessor control and monitoring of all laser parameters.

**Standardised PSU** – Mobius™ configures the PSU to the laser head.

**Accurate internal pulse generator** – No third party timing equipment required.

**Easy to Use**

**Auto start up and touch screen control.**

**LUCi™ remote interface** - provides all functions at the touch of a button.

**Motorised attenuator fitted as standard** – 1000 step energy control.

**Alignment mode** - sets attenuator to allow alignment of external optics.

b e r n o u l l i
p i v

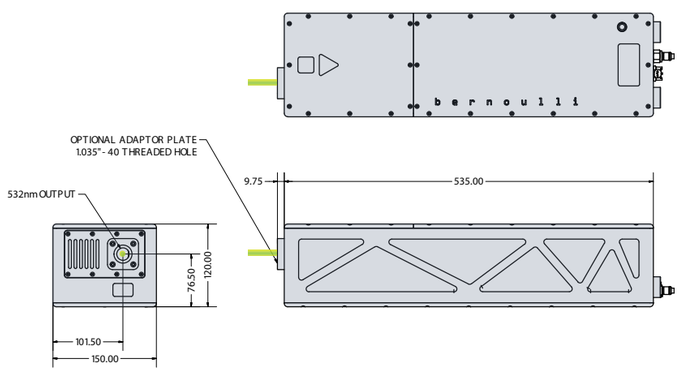
# The Bernoulli PIV Series Specifications

| Model | B-PIV 200-15 | B-PIV 135-15 | B-PIV 120-20 | B-PIV 100-25 |
|---|---|---|---|---|
| Wavelength (nm) | 532nm | | | |
| Pulse repetition rate (Hz) | 0-15 | 0-15 | 0-20 | 0-25 |
| Pulse energy @ 532nm (mJ)(1) | 200 | 135 | 120 | 100 |
| Pulse to pulse energy stability (%pk-pk) | <2 | | | |
| Pulse width (ns)(2) | ≤10 | | | |
| Near field beam diameter (mm) | 6.5 | 5 | 5 | 5 |
| Beam divergence (mrad)(3) | <3.5 | | | |
| Shot to shot pointing stability (µrad) | <100 | | | |
| Far field beam overlap (µrad) | ±100 | | | |
| Near field beam overlap (µm) | ±100 | | | |
| Polarisation | Linearly polarised, vertical plane | | | |
| Spectral Purity (%) | >99.5% | | | |
| **System requirements** | | | | |
| Power input (VAC) | 110-250 (50-60Hz) | | | |
| Operating ambient (°C) | 10 to 30 | | | |
| Storage ambient (°C) (4) | 5 to 50 | | | |
| Coolant | Deionised Water | | | |
| External trigger | 5V TTL | | | |
| Standard umbilical length (m) | 2.5 | | | |
| **System Data** | | | | |
| Laser head warranty | 24 Months | | | |
| PSU warranty | 24 Months | | | |
| Flash lamp warranty | 100 Million Shots/24 Months | | | |
| Laser head sealing (5) | IP67 | | | |
| Laser PSU sealing | IP21 | | | |

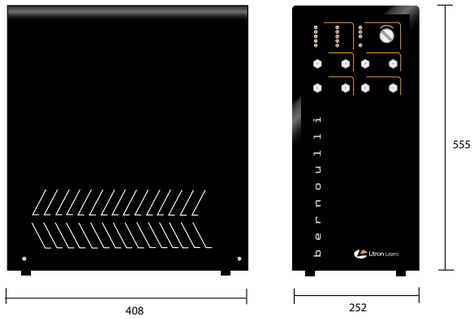
(1) Per laser at maximum rep. rate.
(2) At maximum energy 532nm (FWHM)
(3) Full angle for 90% of the output energy.
(4) All cooling water removed.
(5) With suitable connector set as an option, not suitable for full immersion.

**High Frequency Options** - 50Hz and 100Hz variants are also available.

### Laser Head




### LPU550 Power Supply




### LUCi Romote Controller

# High Energy & High Repetition Rate Lasers for PIV
# The LPY PIV Series

## LPY PIV FEATURES

- ***Dedicated PIV laser head***
- ***Frequencies up to 200Hz***
- ***High pulse energies up to 1J***
- ***True $TEM_{00}$ output available***
- ***Stable resonator design***
- ***Telescopic versions for low divergence***
- ***3rd and 4th harmonics available for LIF and dual colour PIV***
- ***Low profile INVAR optical rail***
- ***Line narrowed versions***
- ***Rugged industrial design***

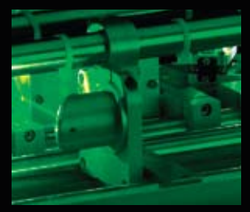
**LPY PIV**

For higher energy systems or systems where very low divergences are required Litron offers twin configurations of its invar stabilised LPY series. Output energies of up to 1J per pulse of 532nm at repetition rates of up to 20Hz are available as standard, as are outputs of 100mJ at 532nm at 200Hz.

The modular construction of the LPY series laser heads allows for easy customisation of systems.

Options include variable optical attenuation, line-narrowing etalons, injection seeding and third, fourth and fifth harmonic outputs.

The LPY PIV series are based around a rugged, self supporting, invar rail. This imparts both a large degree of mechanical and thermal stability to the system suiting them to use in both research and industrial applications with little need for maintenance.



The LPY PIV series can have a stable or a stable - telescopic resonator design, with the intra-cavity telescope yielding a lower divergence output. All LPY700 series systems feature a birefringence compensating twin-rod design to give the best possible beam homogeneity, essential for the formation of uniform light sheets.

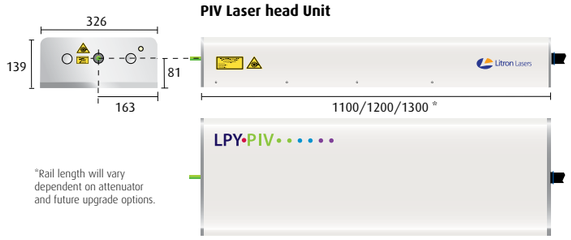
LPY•PIV• • • • • •

# The LPY PIV Series Specifications

| Model | LPY 706-20PIV | LPY 707-20PIV | LPY 704-30PIV | LPY 706-15PIV | LPY 707-15PIV | LPY 704-100PIV | LPY 703-200PIV | LPY 742-100PIV | LPY 742-200PIV |
|---|---|---|---|---|---|---|---|---|---|
| **Repetition Rate** per Laser Cavity (Hz) | 20 | 20 | 30 | 15 | 15 | **100** | **200** | **100** | **200** |
| **Output Energy at 532nm** per laser head (mJ) | **300** | **400** | **200** | **325** | **425** | 100 | 50 | 200 | 100 |
| **Parameter** | | | | | | | | | |
| Pulse Stability @ 532nm (±%) | <3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 |
| Beam Diameter (mm) | 8 | 9 | 6.5 | 8 | 9 | 6.5 | 4 | 6.5 | 6.5 |
| Beam Divergence (mrad) | 0.8 | ~3 | 0.8 | 0.8 | ~3 | ~3 | ~3 | ~3 | ~3 |
| Pulse Length @ 532nm (ns) | 7-11 | 7-11 | 7-11 | 7-11 | 7-11 | 10-12 | 10-12 | 10-12 | 10-12 |
| Pointing Stability (µrad) | <70 | <70 | <70 | <70 | <70 | <70 | <70 | <70 | <70 |
| Lamp Life (pulses) | $5x10^7$ | $5x10^7$ | $5x10^7$ | $5x10^7$ | $5x10^7$ | $10^8$ | $10^8$ | $10^8$ | $10^8$ |
| Timing Jitter (ns) | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 |
| **Services** | | | | | | | | | |
| Voltage(1) (VAC) | 220-250 | 220-250 | 220-250 | 220-250 | 220-250 | 220-250 | 220-250 | 220-250 | 220-250 |
| Frequency(2) (Hz) | 47-63 | 50 or 60 | 50 or 60 | 50 or 60 | 50 or 60 | 50 or 60 | 50 or 60 | 50 or 60 | 50 or 60 |
| Power | Single Phase | Single Phase | Single Phase | Single Phase | Single Phase | Single Phase | Single Phase | Single Phase | Single Phase |
| Water Temp Max. (°C) | Air cooled(3) | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| Inlet Pressure (bar) | - | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Cooling | Air | Water | Water | Water | Water | Water | Water | Water | Water |
| Power Supply | 2 x LPU1000 | 16U Rack | 16U Rack | 16U Rack | 16U Rack | 16U Rack | 16U Rack | 2 x 16U rack | 2 x 16U rack |

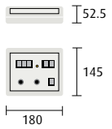
(1) 110VAC option requires autotransformer to be specified on order.
(2) 50 or 60Hz to be specified on order.
(3) Ambient Temperature 5-35°C. (0-80% non condensing atmosphere.)

**PIV Laser head Unit**



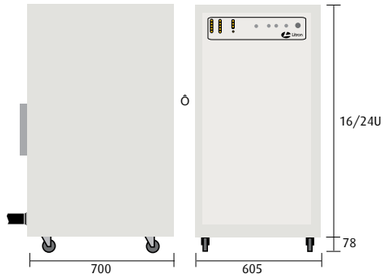

*Rail length will vary dependent on attenuator and future upgrade options.

**Remote Control Box**

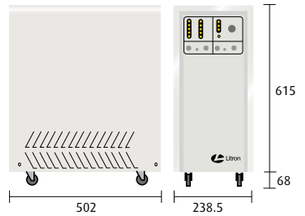



All dimensions shown in mm

**Rack-mount PSU**




**LPU1000 PSU**



# High Repetition Rate Lasers for High Speed Imaging Applications
# The LDY300 PIV Series

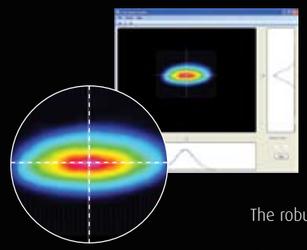
## LDY PIV FEATURES

- ***High Energy at 527nm***
- ***0-20kHz continuously variable***
- ***Field replaceable pump module***
- ***Dedicated PIV laser head***
- ***Low profile INVAR optical rail***
- ***Rugged industrial design***

**LDY PIV**

The LDY300 series are diode pumped, dual cavity, Q-switched Nd:YLF laser systems ideally suited to high speed PIV imaging applications. Output energies of up to 30mJ at 1kHz per cavity at 527nm are available. The lasers are built around a rugged self supporting invar rail that bestows excellent mechanical and optical stability. This, coupled with the proprietary resonator design, leads to excellent output beams that are spatially and temporally extremely smooth and stable, giving rise to light sheets that offer almost identical shot to shot illumination.

The power supply and closed-circuit chiller are all housed in a compact 10U or 12U 19″ cabinet. The system can be controlled either by the in-built LCD or via RS232 interface using the supplied software suite or dll. The system can be externally triggered for output frequencies from 0 - 20 kHz using the TTL interface.

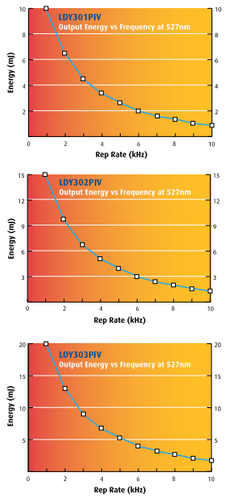



The robust design of these lasers make them suitable for the harshest of industrial environments and research applications alike.


LDY•300PIV• • • • •

## The LDY PIV Series Specifications

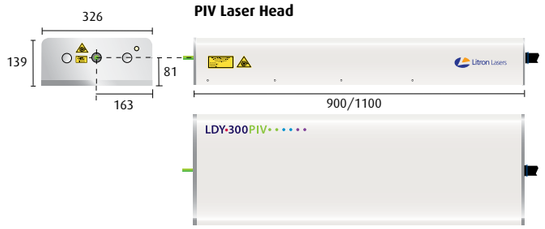
**Performance Data**



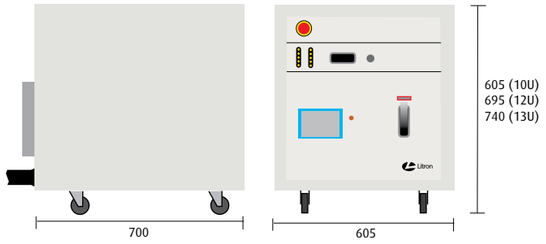

| Model | LDY301 PIV | LDY302 PIV | LDY303 PIV | LDY303HE PIV | LDY304 PIV |
|---|---|---|---|---|---|
| Repetition rate (each cavity) (kHz) | 1-20 | 1-20 | 1-20 | 1-20 | 0.2°-20 |
| **Output Energy at 1kHz at 527nm** per laser head per pulse (mJ) | **10** | **15** | **20** | **22.5** | **30** |
| Pulse - pulse stability (±%) | 1 | 1 | 1 | 1 | 1 |
| Beam diameter (mm) (4) | 5 | 5 | 5 | 5 | 5 |
| Beam divergence (mrad) (5) | <3 | <3 | <3 | <3 | <3 |
| Pulse width @ 1kHz (ns) | ~150 | ~150 | ~150 | ~150 | ~150 |
| $M^2x$, $M^2y$ | 12, 7 | 12, 7 | 12, 7 | 12, 7 | 12, 8 |
| **Services** | | | | | |
| Voltage(1) (VAC) | 220-250 | 220-250 | 220-250 | 220-250 | 220-250 |
| Frequency(2) (Hz) | 50 or 60 | 50 or 60 | 50 or 60 | 50 or 60 | 50 or 60 |
| Power | Single Phase | Single Phase | Single Phase | Single Phase | Single Phase |
| Ambient(3) (°C) | 5-30 | 5-30 | 5-30 | 5-30 | 5-30 |
| Consumption (W) | 1000 | 1800 | 2700 | 2700 | 2700 |
| Power Supply | 19″ 10U Rack | 19″ 12U Rack | 19″ 13U Rack | 19″ 13U Rack | 19″ 13U Rack |

(1) 110VAC option requires autotransformer to be specified on order
(2) 50 or 60Hz to be specified on order.
(3) 0-80% non condensing atmosphere
(4) Beam diameter is achieved with output telescope.
Standard diameters quoted. Other diameters are available on request. In all cases $M^2$ is unchanged.
(5) At specified beam diameter.
(6) $M^2$ values differ in the x and y directions. Beam rotation optics are available as an option to allow the thinnest light sheets to be formed in any plane.

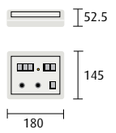
**PIV Laser Head**




**Rack-mount PSU**




**Remote Control Box**




All dimensions shown in mm