Particle Image Velocimetry (PIV)

Particle Image Velocimetry (PIV) is an advanced optical measurement technique for non-intrusive analysis of microscopic and macroscopic flow fields in transparent fluids with high resolution. Thanks to the enormous developments in recent years in the fields of lasers, digital cameras, computer performance, memory capacity, and processing algorithms, very precise measurements are now possible in many research areas and the field of application is being continuously expanded. Due to its performance and efficiency, PIV is also increasingly used in industry. The measurement technology thus thus provides deep insights into the flow phenomena, no matter how high the flow velocities are.

High Energy systems for PIV: SpitLight PIV Compact and Standard

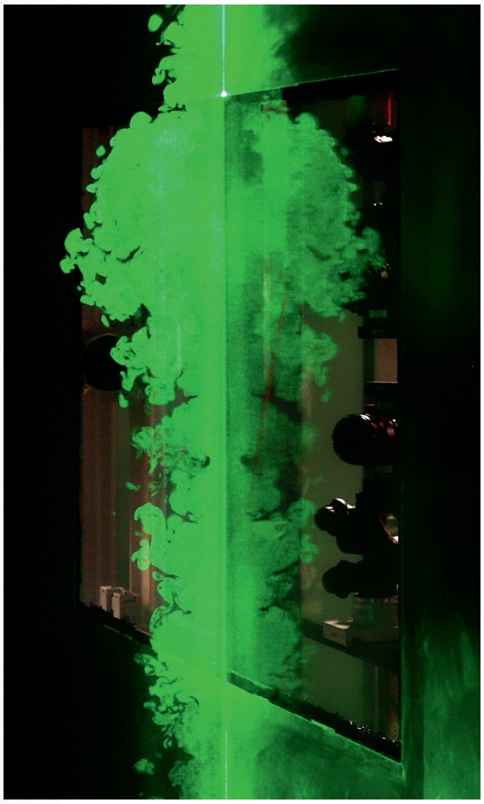
Timing and pulse energy of the laser double pulses must be freely tunable for flexible experiments. Ideally the beam quality has to be near diffraction limit with minimum intensity modulations and divergence to achieve a nearly constant light sheet thickness over long distances. Typically each laser pulse has an energy of 50 mJ to 500 mJ in the green at 532 nm with repetition rates of 10 Hz to 500 Hz, flash lamp or diode pumped. Double pulses on demand are emitted with tunable pulse separation times of a few µs and a jitter of below 1 ns . This means the compact and easy-to-use laser source is 4-dimensional perfectly defined - in space and time.

InnoLas' special solutions for the PIV demands

- **Multiple laser cavities** (two and up to four) are integrated in one rugged monolithic aviation-grade aluminum housing, which are temporally synchronized with a delay time of a few µs and spatially overlapped by a proprietary combining technology. Repetition rates of up to 50 Hz for flash lamp and 1000 Hz (high energy) for diode pumped systems are possible.
- **Four-pulse laser systems**
  - Single laser head with multi pulse option (see "Pulse Train Option")
  - Dual rail laser head with double pulse option for each laser cavity
  - Since 15 years InnoLas offers the double pulse option to obtain two balanced pulses with separation times down to 100 ns. Combined with two independent pulsing lasers it offers relative high flexibility with low costs
  - Quad rail lasers: four independent lasers combined to one single output (Flash lamp pumped or diode pumped)
- **New: Pulse Train Option**
  From a single cavity, pulse sequences with up to 10 pulses and a freely-selectable temporal separation of down to 150 µs (corresponding to ~6 kHz) can be generated by a Pulse Train mode. The average number of pulses per second is defined by the laser model (e.g. up to 50 Hz for lamp pumped and up to 1000 Hz for diode pumped systems). The Pulse Trains can be predefined synchronized to the multiple cavities of a PIV laser and allow the recording of velocity fields with a rate of up to 6 kHz, corresponding to the minimum separation time of about 150 µs.
- **High-Speed Multi-Kilohertz PIV: InnoLas Photonics lasers "NANIO" and "BLIZZ"**
  - Pulse on demand (Single shot to 400 kHz), 10 W to 80 W at 532 nm, diode-pumped, outstanding pulse to pulse stability, perfect beam quality and focus quality
  - "Constant Pulse Energy" Mode in an extremely robust industrial system
  - Life time 35.000h, maintenance free, short delivery.

Ask for customization: Based on constant technological progress in laser technology, InnoLas PIV sources can be customized to a wide range of measurement requirements due to their modular and flexible system design.

Large light sheets with homogenous high energy illumination

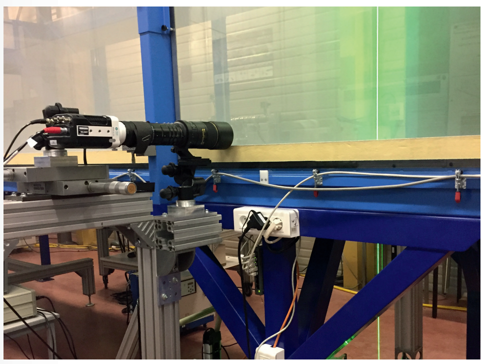


At the Institute of Fluid Mechanics and Aerodynamics of the Bundeswehr University Munich PIV measurements at large-scale structures are performed in the Atmospheric Wind Tunnel. The group around Prof. Kähler studies the fluid dynamics of large-scale structures in turbulent boundary layers.

The picture shows a light sheet with a vertical height of about 1 m and a normal height of maximum 14 cm at an angled view onto a window of the wind tunnel. The flow is horizontal, parallel to the window surface. The PIV measurement captures structures in turbulent boundary layers with zero pressure gradients, seen in the cloud-like green areas. The homogenous light sheet was created with a "SpitLight PIV Compact 400" irradiated from above.

The measurements demand a high - near diffraction limited - beam quality in a nice smooth Gaussian beam profile to generate the displayed large light sheets in a long distance of a few meters from the laser exit. InnoLas Laser could fulfill flexibly the scientists' requirements and custom-tailored the laser output parameters to create a round Gaussian beam profile in a large distance of about 5 m.

High Speed PIV: High repetition rates to capture highly turbulent flows



Dr. Christian Willert from the DLR Institute of Propulsion Technology in Cologne synchronizes a NANIO AIR laser from InnoLas at repetition rates of 20 kHz to 200 kHz with high speed cameras to capture the dynamics of turbulent flows at high magnification. Shown on the left (top) is a setup for turbulent boundary layer measurements in the closed-loop wind tunnel of the Laboratoire de Mécanique des Fluides de Lille (France).

At the Institute of Propulsion Technology two NANIO AIR are used to investigate high speed flows within turbomachinery components. Shown on the left is a kerosene fueled combustion chamber operating at flight realistic conditions (p>10 bar, U ~ 100 m/s) with high-speed PIV being performed at 40 kHz with a pulse separation of 4 µs.

In both cases, Dr. Willert relied on light sheets of a few mm width and 200 – 300 µm thickness. Here a smooth Gaussian intensity distribution and homogeneous beam profile are important – both are provided perfectly by the InnoLas Photonics NANIO AIR lasers.

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