2016

N2 Educational Laser

MANUAL

WITS, DEPARTMENT OF PHYSICS

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N_2 laser kit manual

1. Introduction

This manual provides a step-by-step description on how to assemble a small N2 Laser. The Laser includes a low-power high-voltage supply, which operates from 12V. A wall-plug supply working from normal 220V mains providing 12V DC power is part of the kit but the laser can also be powered from a 12V battery. The N2 Laser is a gas discharge laser and uses nitrogen as its Laser medium. Hence, the Laser must be provided with nitrogen gas. The purity of the nitrogen gas is not critical and normally Laser action is obtained with a nitrogen content of more than about 90%. The Laser is relatively easy to assembly. All parts are pre-fabricated and are bolted or clipped together. Before continuing it is important to understand some of the terms and conventions used in the guide:

Perspex
Perspex is a type of plastic. Many components of the Laser are constructed from clear Perspex. In fact, the complete Laser is assembled onto a 6 mm thick Perspex base plate.

Bolts and nuts
Parts of the Laser are bolted together using several bolt sizes. In the guide detailed drawings are provided indicating which bolt size to use. Next to each bolt its size will be indicated, for example M4x8.

High-voltage

The Laser includes a high-voltage power supply. Therefore:

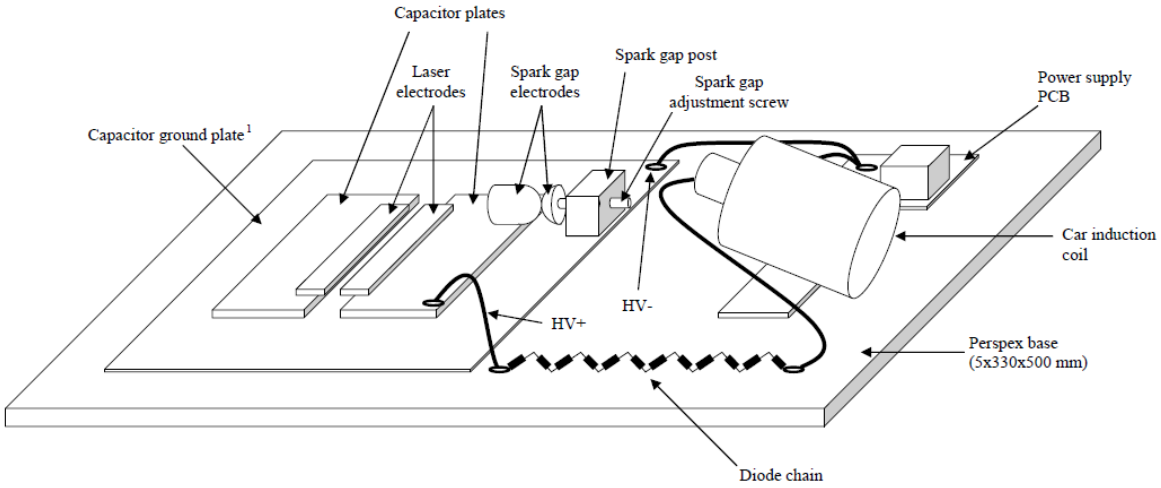
Warning

The high voltage used in this laser can be very dangerous. Therefore make sure that it is NEVER connected to the mains supply during construction!

Never do any adjustment to the laser or touch any voltage carrying parts of the laser while it is running.

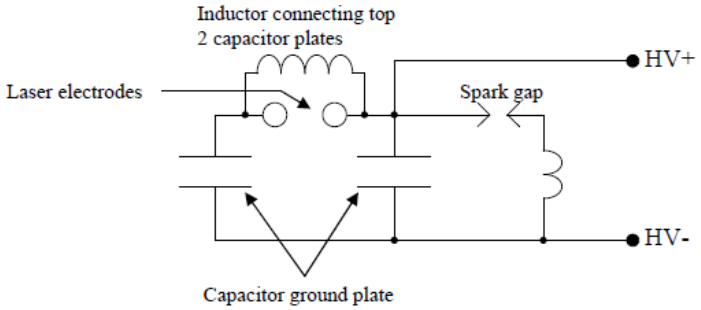
2. Mechanical Assembly

The figure below shows the general assembly of the laser. On the following pages a more detailed step-by-step assembly guide is provided.

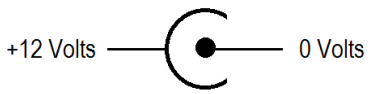


The capacitor ground plate must be covered by the provided sheet of Mylar acting as dielectric between the capacitor ground plate and the two top capacitor plates. One can also use one or two sheets of Mylar (200 micron combined thickness).

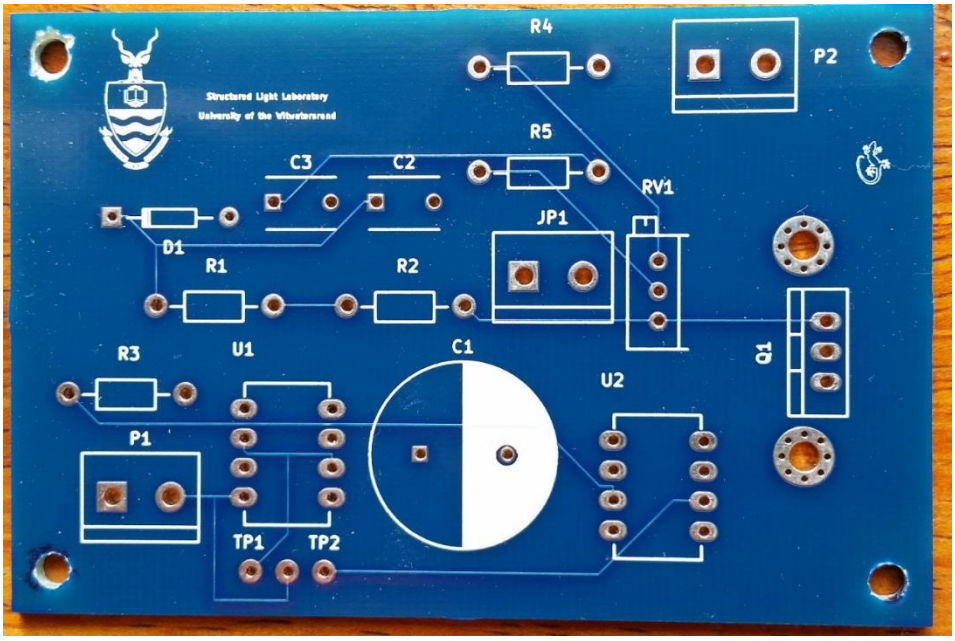
The equivalent electric circuit of the Laser:



1. The external 12V power supply at P1 has the following configuration. The outside terminal is ***positive 12V***



2. The Jumper JP1 is for safety. No pulses with be generated without JP1 in place.
3. Frequency of the pulses fed to the Ignition coil can be changed using the variable resistor RV1. Currently set to 340 Hz.



See circuit diagram in folder: N2 Schematic.

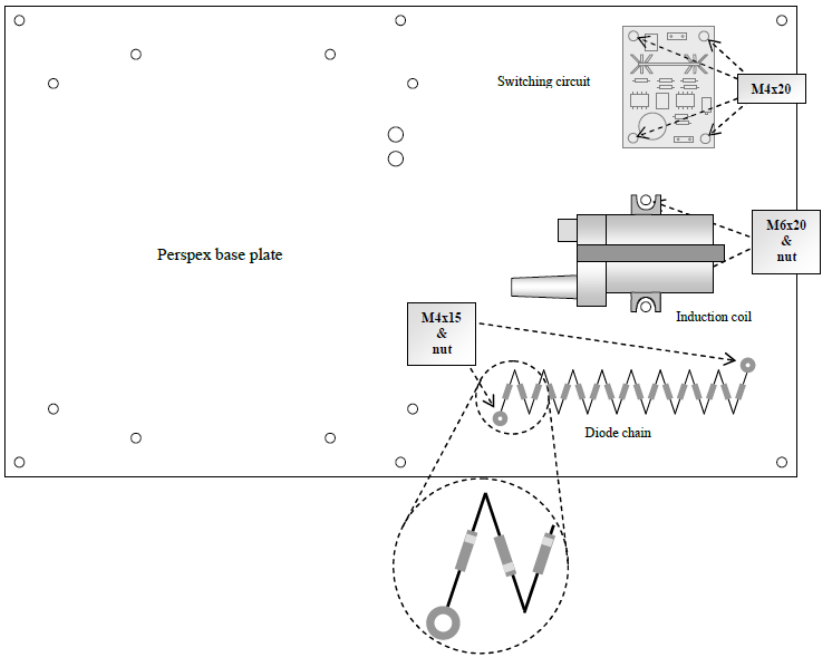
2.1. The High Voltage Power Supply

The high voltage power supply consists of:

1. Switching circuit on a PCB (printed circuit board)
2. External 12V power supply
3. An induction coil to step-up the voltage from 12V to about 18000V
4. A high voltage rectifier (diode chain)

Power supply assembly

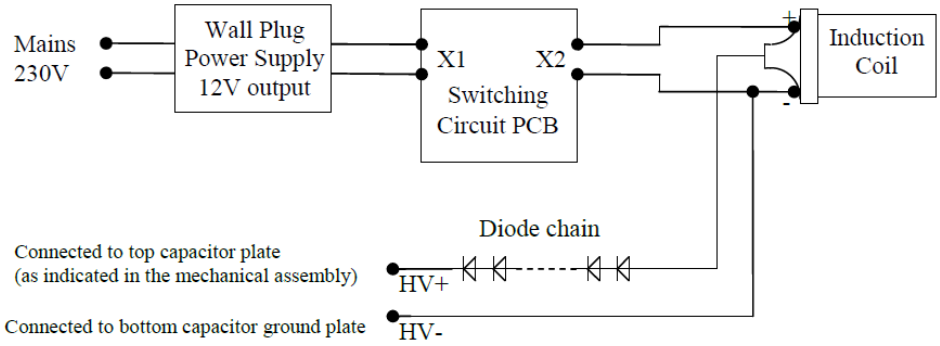
The diagram below shows how the components of the power supply are arranged on the Perspex base plate:



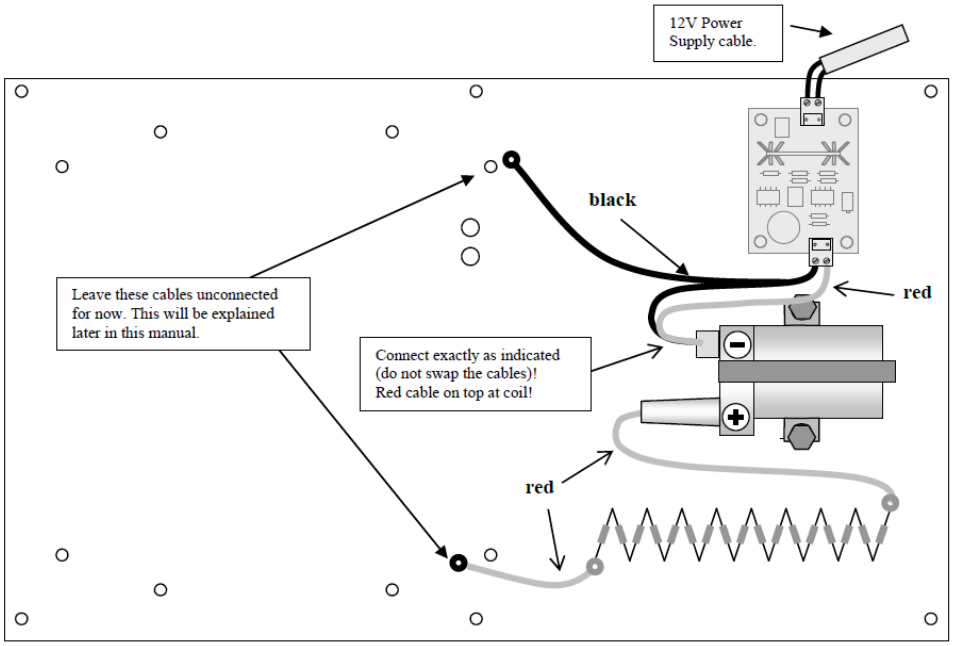
The switching circuit, induction coil and diode chain must be bolted to the Perspex base plate using the pre-drilled holes and the supplied bolts and nuts. Remember to place the short plastic spacers below the switching circuit PCB, i.e. do not bolt the PCB directly onto the Perspex plate. The diode chain must be placed in the right direction. Each diode in the chain has a white stripe at one end. Ensure that the white stripes are oriented as indicated in the figure above. In some cases the diode chain must be reversed (see Section 3).

Cable connections

The diagram below shows the connection diagram for the high voltage power supply:



Below the connections in the practical set-up are shown (the colours of the cables are also indicated):

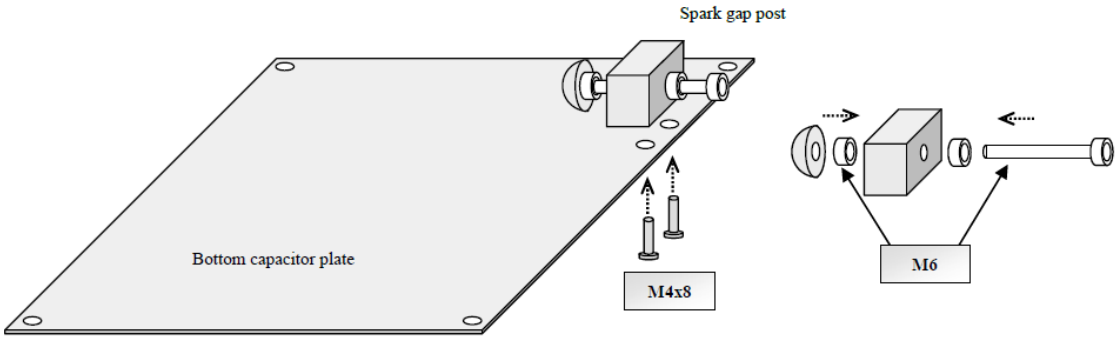


Be sure that the cables are connected exactly as indicated in the diagram above. Do not swap any of the cables. This will result in the power supply not functioning effectively.

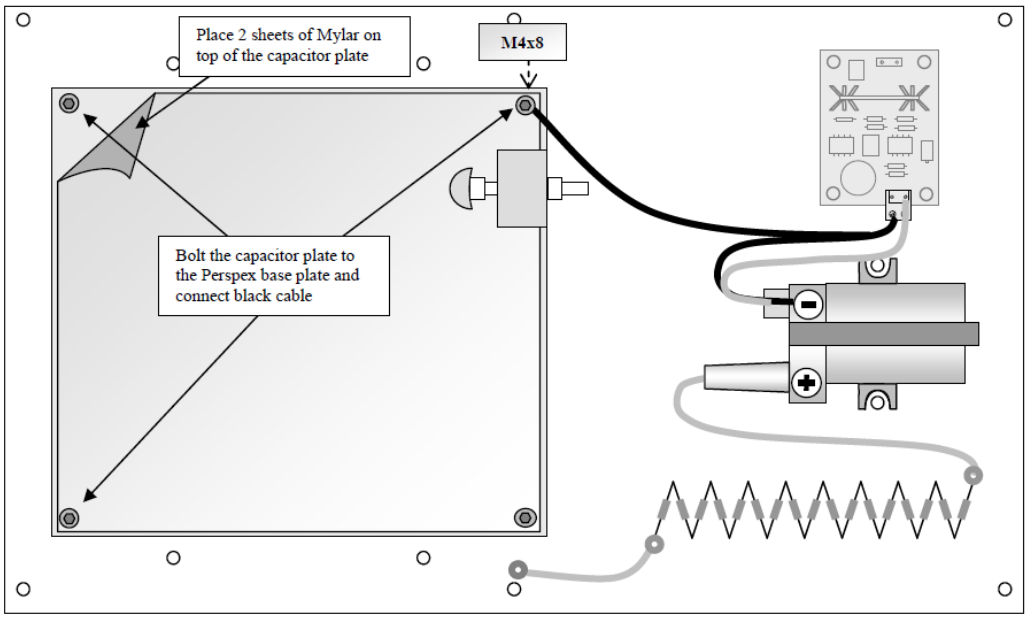
2.2. The Laser Head

Capacitor ground plate assembly

The first step is to assemble the bottom capacitor plate (i.e. capacitor ground plate) and the spark gap as depicted in the figure below:

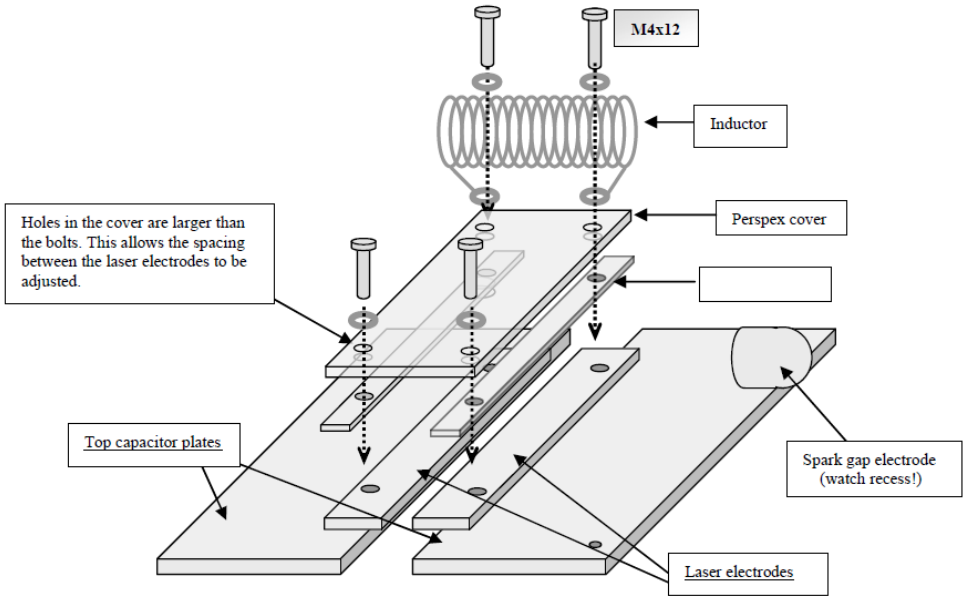


Bolt the pre-assembled spark gap post to the bottom capacitor plate. The next step is to bolt the bottom capacitor plate to the Perspex base plate as shown in the figure below. In addition, two Mylar plastic sheets must be placed on top of the capacitor plate:

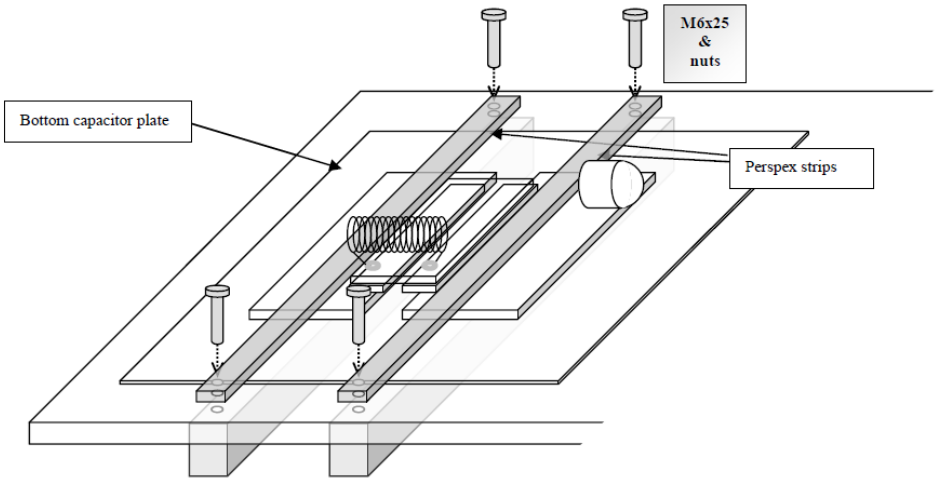


Laser electrode assembly

The next step is to assembly the laser electrodes as depicted in the figure:



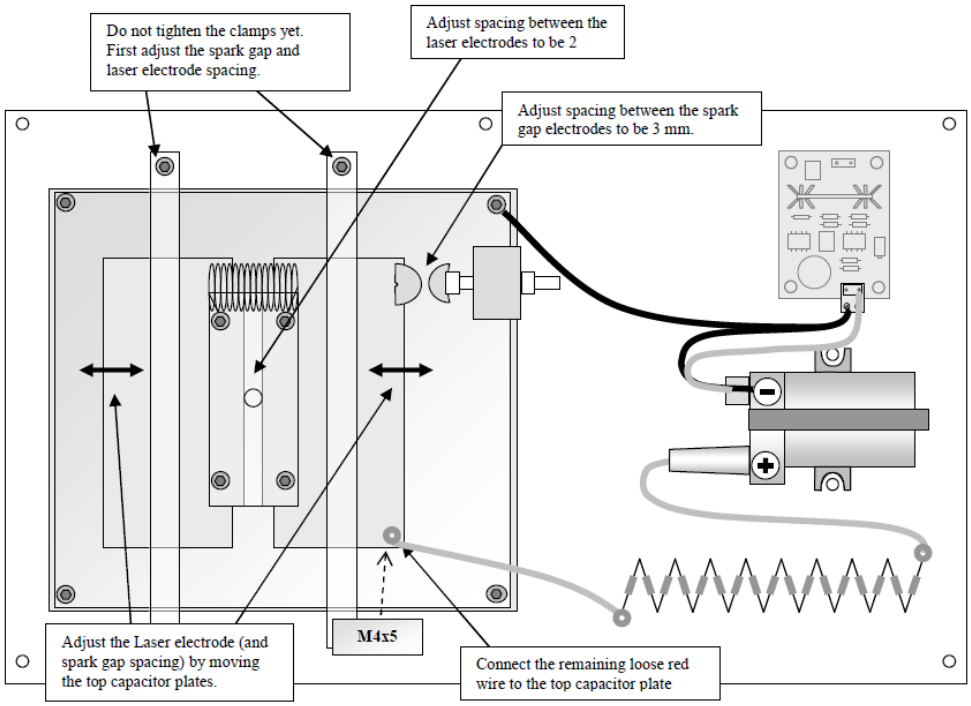
The Perspex cover, inductor, laser electrodes and spark gap electrode are all bolted to the top capacitor plates. Note, that the holes in the Perspex cover are larger than the bolts. This allows the spacing between the laser electrodes to be adjusted slightly. Make sure you use the screws of correct length and the provided washers. Tighten the bolts only slightly. Check the assembly that none of the screws are protruding from the bottom of the plates. This could damage the Mylar foils. Now mount the complete assembly onto the bottom capacitor plate as shown in the figure below:



The top capacitor plates are clamped onto the bottom capacitor plate by two thin Perspex strips on the top and two thick ones from the bottom. Do not tighten the bolts yet!

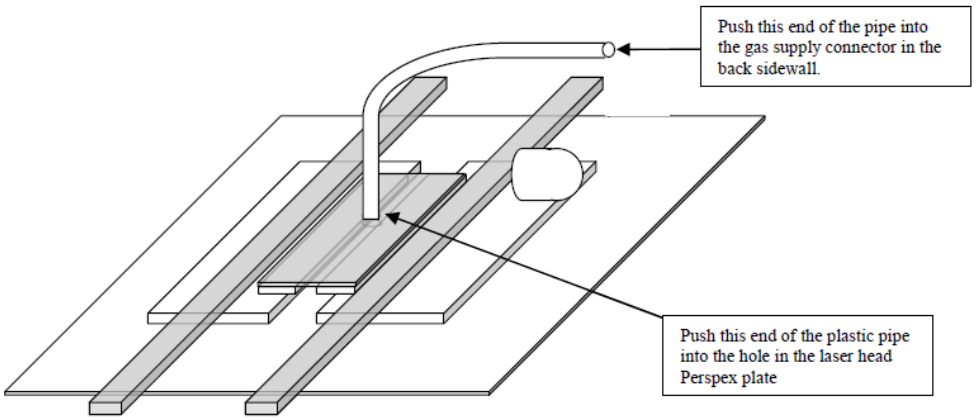
Laser electrode and spark gap spacing

The top view of the Laser:



As depicted in the above figure, the laser electrode and spark gap spacing are adjusted by moving the top capacitor plates. Set the initial spacing of the spark gap to 3 mm and the initial spacing of the laser electrodes to 2.0 mm. Ensure that the laser electrodes are well aligned, i.e. the laser electrodes must be parallel. The spacing between the electrodes may not vary by more than 0.1 mm. Fine adjustment of the spark gap can be done at the spark gap post. After this is done, tighten the clamp bolts. Also tighten the four bolts of the laser electrode assembly (be careful and make sure that the electrodes do not move while tightening).

2.4. Gas Supply



3. Running the Laser

The Laser is complete. In order to run the laser N2 gas is still needed. The N2 gas can be supplied via the gas connector in the back sidewall (described earlier).

Follow these steps when turning on the Laser:

1. Notify bystanders that the Laser will be turned on.
2. Check that the N2 gas supply is connected and that a small N2 gas flow is provided.
3. Check that the Laser is complete enclosed and the top cover is fastened.
4. Turn on the Laser.

If there are no errors, a purple, uniform discharge should be observed between the Laser electrodes. When a white piece of paper is placed in front of the Laser "window" a blue flash will be seen on the paper each time the Laser discharges. This is the Laser light that fluoresces when it hits the paper.

When the Laser does not function correctly, the following problems can be observed:

- Spark gap and laser electrodes do not discharge:
  The spark gap spacing is too large – reduce the spacing. Also check that the high-voltage power supply is functioning correctly (when turned on it should emit a humming sound). If this is not the case, check whether the fuse of the power supply is still intact and that the diode chain is correctly connected. Also try reversing the diode chain.
- Spark gap fires, but there is no Laser discharge:
  The Laser electrode spacing is too large or the spark gap spacing is too small. Increase the spark gap spacing (not too much, otherwise the spark gap will not fire). If the Laser still does not discharge, decrease the laser electrode spacing.
- Laser discharge arcs at one end of the Laser electrodes:
  The Laser electrodes are not aligned (parallel) – realign them.
- Laser discharge arcs at different places along the Laser electrodes:
  Make sure that the N2 gas supply is not too strong. Reduce the N2 gas flow. The spark gap spacing may also be too small and/or the Laser electrode spacing too large. Try to increase the spark gap spacing first. If this does not help, reduce the Laser electrode spacing. If this does not help, check that the laser electrodes are smooth and polished.

The laser output can be increased significantly and be made more directionally by providing feedback. Place a small Perspex or glass plate at the one end of the electrode gap so that some of the radiation from the discharge is reflected back through the discharge gap resulting in signal amplification.