Operating Instructions

nF 900
Nanosecond Flashlamp

(with Computer Controlled Power Supply)

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1. Introduction

The nF900 is an all-metal, triggered flashlamp, engineered with a fast switching thyratron, spark gap and charging resistor. The flashlamp is capable of producing nanosecond and sub-nanosecond light pulses with repetition rates typically up to 50kHz. The nanosecond flashlamp is the only known conventional light source with narrow pulses of sufficient high repetition rate suitable for time correlated single photon counting measurements. Depending on the discharge gas it can produce a broad spectral continuum and is therefore an ideal light source in fluorescence lifetime spectrometers based on time correlating single photon counting.

The electrical and mechanical design of the nanosecond flashlamp ensures maximum electrical to optical energy conversion during a clean, controlled spark discharge. The compact brass body ensures robustness and shields any RF emission from the spark discharge at source. The lamp has been designed so that stray capacitance is kept at a minimum to ensure maximum photon yield of the light pulses with minimum pulse width and tail.

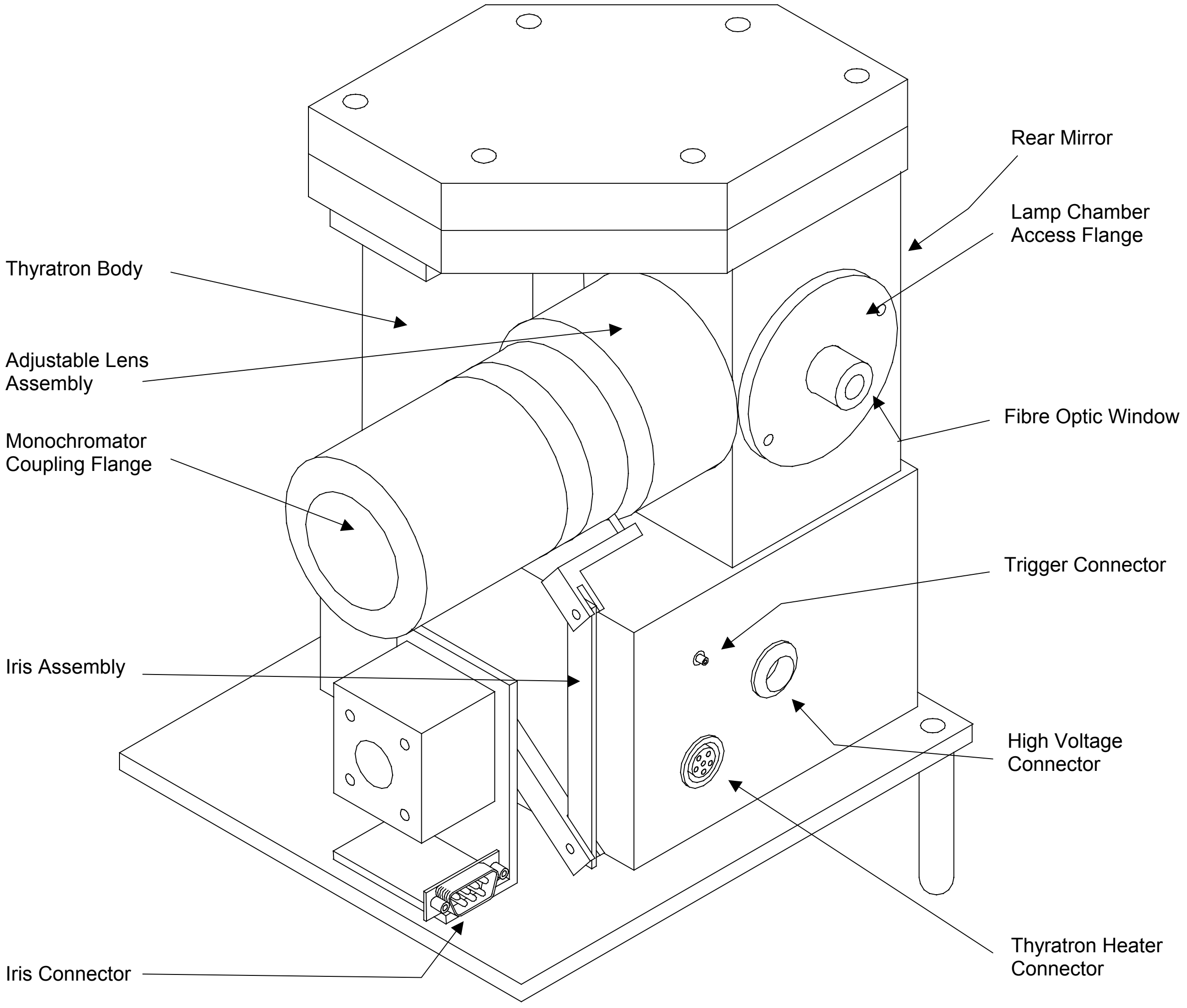
The nF900 can be operated with many gases and gas mixtures, the most popular gases, however, are pure hydrogen and nitrogen. The discharge chamber is sealed from other lamp components by pyrex insulators and O-rings to give excellent vacuum integrity over a wide pressure range. Routine cleaning and adjustment of the spark gap can be easily performed through the large access port on the side of the lamp body. Standard vacuum couplings are fitted for connection to the gas handling system (GF900) and a fibre optic interface connects the discharge chamber to the synchronisation photomultiplier.

The nF900 lamp is powered and controlled by the nF900 power supply. The nF900 power supply delivers the high voltage for the gas discharge, the heater current for the thyratron cathode and the trigger pulses for the thyratron discharge trigger. The power supply interfaces to the system controller of the spectrometer (CD900). This way the lamp is fully computer controlled. The high voltage and the trigger frequency can be demanded and monitored by the spectrometer software, furthermore the software monitors the gas pressure and the integrated intensity of the nanosecond flashlamp.

Warning

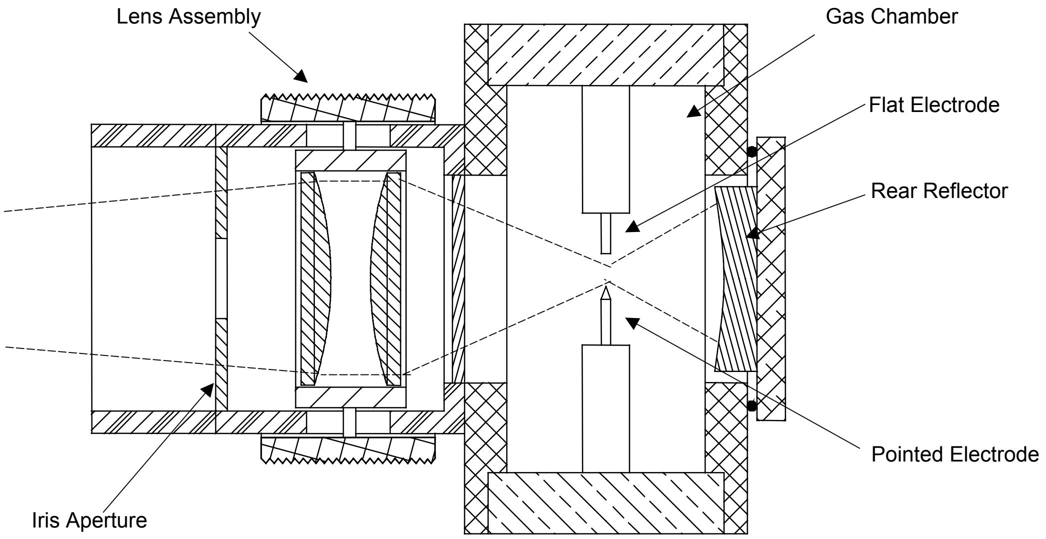
The Lamp is operated at dangerously high voltages (up to 8 kV). Never try to service the lamp while it is in operation.
Disconnect all electrical cable before cleaning.

The synchronisation photomultiplier monitors the optical pulses generated by the flashlamp via optical fibre. The optical pulses are converted into electrical pulses which are delivered to the timing electronics of the lifetime spectrometer where they are used as START pulses in time correlated single photon counting measurements.



nF900 Flashlamp Head

The optical designed has been computer optimised for maximum light gathering by an f/1 focussing lens and matched for coupling into a 300mm focal length monochromator with f/4 aperture. An adjustable concave mirror on the rear side of the discharge chamber enhances the light output and an adjustable iris (directly controlled by the spectrometer controller) ensures variable attenuation of the flashlamp intensity.



2. Transit and Packing

The nF900 comes as part of the spectrometer system, normally packed in two crates.

The nF900 lamp head is packed separately with special protection to the lamp optics. The nF900 power supply is either supplied in a single unit (FL900 spectrometers) or in a double height unit (FL/FS900 spectrometers). The synchronisation photomultiplier module is mounted to the spectrometer tabletop.

The nF900 assembly comprises further:
- a mains cable
- a supply cable bundle, including the heater cable, the high voltage cable, and the trigger cable
- an optical fibre bundle
- a 25way interface cable to the CD900 controller.

The service kit for the nF900 comprises:
- a ring key
- a spare pair of electrodes
- a feeler gauge
- a pair of pliers
- an Allen key set
- carborundum paper
- ¼" nylon gas tubing
- fuses.

Cables and optical fibre bundle are packed separately. The components of the service kit are part of the spectrometer tool kit.

The nF900 lamp comes readily set up for operation with hydrogen gas, i.e. the electrode gap is aligned and adjusted for 1mm, the optical axes of the nF900 has been aligned.

3. Installation

3.1. Mechanical Set-up

Unpack the lamp head and place it on the spectrometer bench. Use the dedicated port of the excitation monochromator. The coupling flange of the lamp head slides over the tube fixed to the entrance slit of the monochromator port. The flange on the monochromator port has a mechanism to allow horizontal and vertical alignment. Horizontal and vertical adjustment is achieved by loosening the four M3 screws, movement of the coupling tube to the chosen position, and then re-tightening of the screws. Once the vertical alignment has been made the two feet on the back side of the flashlamp head should be re-adjusted to ensure horizontal alignment of the lamp head. Final alignment should be made using the signal count rate of a sample when the lamp is in operation.

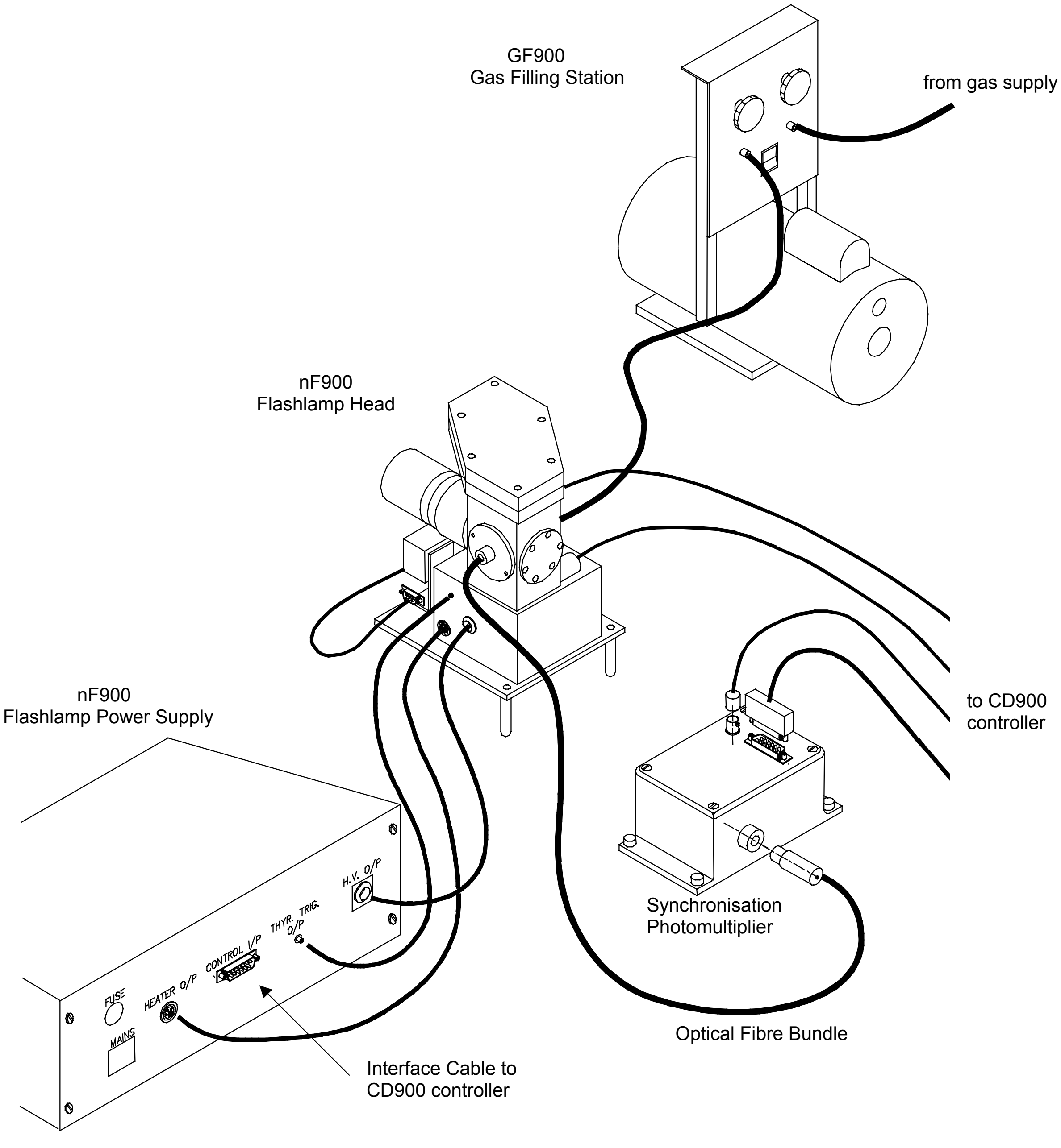
The nF900 supply unit should be placed at an appropriate distance to both the lamp head and the spectrometer controller, as the interconnecting cables are restricted to 2.5m. It has been found convenient to position the power supply units underneath the spectrometer table.

The synchronisation photomultiplier module has been factory set-up on the spectrometer table top at an appropriate position close to the nF900 head. This will ensure the 50cm long optical fibre bundle can be interconnected between lamp head and synchronisation module.

3.2. Electrical Interconnections

The electrical interconnections should be made as indicated in the drawing below. Ensure all connectors on the lamp head and on the lamp power supply are correctly pushed home and that the optical fibre bundle is fitted and fixed by means of the grub screws provided before connecting the nF900 power supply to the mains.

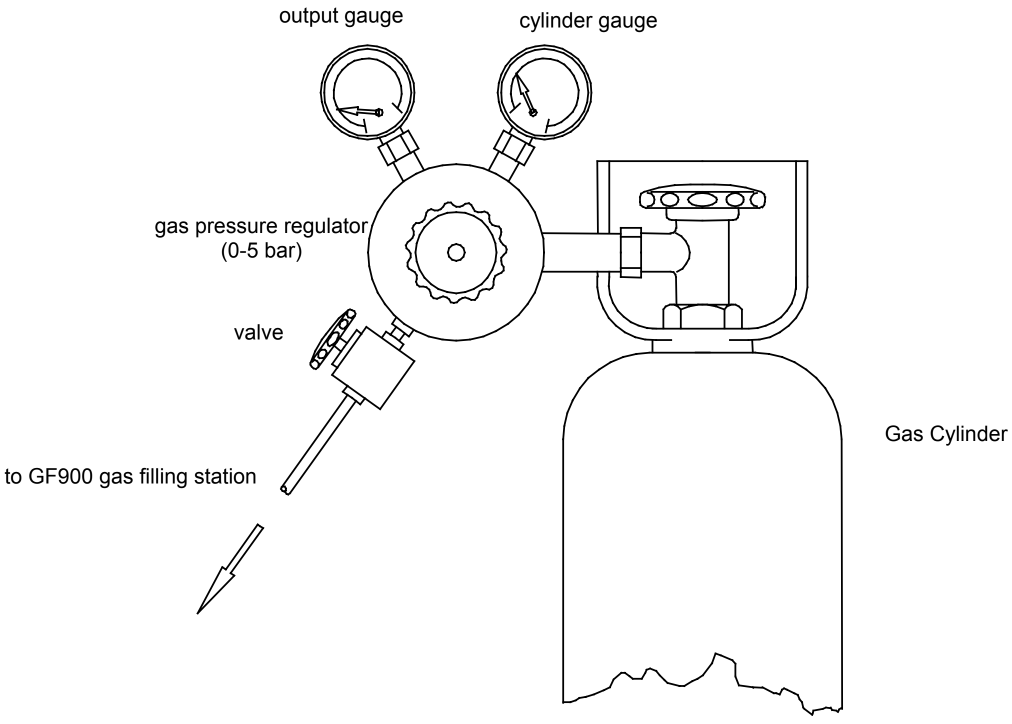
The nF900 power supply has a 230V mains input. For countries with other mains supply voltages a transformer is included in the delivery.



nF900 lamp assembly (lamp head and power supply) with GF900 gas filling station and synchronisation photomultiplier

3.3. Gas Connections

The gas inlet port of the flashlamp head has a ¼” (6.4mm OD) swage lock fitting. The flashlamp head must be connected to the gas filling station, which itself has ¼” fittings. The gas filling station receives the filler gas from a gas reservoir, usually a gas cylinder. The output of the gas cylinder should have a pressure regulator and an additional cut-off valve with ¼” fittings. The user is responsible for supplying the gas cylinder and the pressure regulator / valve. All gas connections should be made very carefully to ensure vacuum integrity. Please also refer to the manual of the GF900 gas filling station.

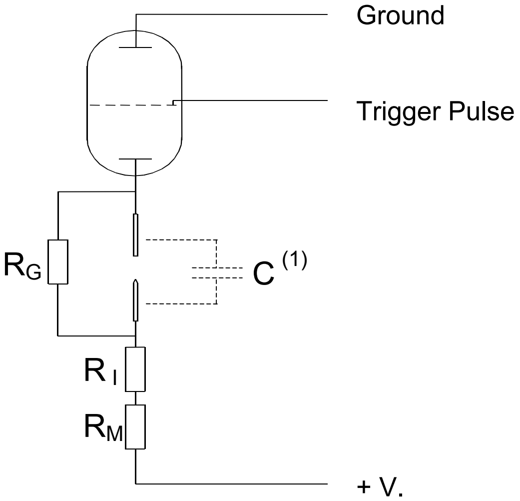


recommended gas supply set-up

4. Principle of Operation

The principle of the nanosecond flashlamp is based on a discharge, caused by an electrical breakdown between two electrodes due to a very high electrical field. The time of the discharge is triggered by a thyratron.

The electrical circuit of the flashlamp head is shown in the figure below.



A high positive voltage, +V, is applied to the anode electrode of the spark gap through the charging resistor $R_I + R_M$. The cathode electrode is connected to the anode of the thyratron and has a similar potential due to the intergap resistor R_G.

Sending a gating pulse to the grid of the thyratron causes it to switch abruptly to its conducting state, therefore switching the upper gap electrode, the cathode, to the ground potential. The intergap voltage, V_G, is thereby switched across the spark gap, causing a spark discharge providing V_G is greater than the gas breakdown voltage. When the lamp capacitance is discharged the anode current falls below its minimum holding value and the thyratron returns to its non-conducting state. The circuit resistance is large enough to ensure that the lamp current is below the holding current, otherwise continuous thyratron conduction would occur.

The pulse repetition frequency, f, is ultimately determined by the recharging rate and the finite times required for the spark and thyratron to recover from conduction. If f is small compared to $1 / (R_I + R_M)\, C$, then V_G can recover to near the applied voltage, +V, in between lamp pulses. As f increases, so V_G decreases giving lower energies per flash until V_G reaches the gap breakdown voltage and discharging can no longer occur.

The intergap capacitance, C, clearly affects the lamp characteristics. As C increases the energy per flash and the flash duration both increase and the repetition rate decreases

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(1) The gap capacitance comprises the intergap capacitance and the stray capacitance between each gap electrode and the flashlamp housing. For simplicity only the intergap capacitance is considered here.

because of the increased charging time. One of the principal design aspects of the nF900 has therefore been to keep C at a minimum.

The nF900 design is optimised for lowest possible capacitance between the electrodes and between the electrodes and the lamp walls. The charging resistor has been split into two parts, the main charging resistor, R_M, and an isolating resistor, R_I . The isolating resistor is mounted co-axially with the lamp anode making the whole discharge path, including the spark gap and thyratron, into a low impedance co-axial transmission line. This efficiently converts the electrical discharge energy into optical energy in an ultra high-speed pulse.

The intergap resistance, R_G, is necessary to give the lamp stable operation over a wide range of conditions. Without it, leakage discharge would be the only mechanism for recharging the anode of the thyratron after a flash discharge. This can cause lamp instabilities, especially untriggered discharging ("free-run" events) if the gap anode recovers more rapidly than the thyratron anode. Therefore R_G needs to be large enough to hold off the intergap voltage V_G when the thyratron fires, but small enough to ensure an adequate recharging rate.

In addition to the electrical characteristics of the flashlamp, the lamp discharge also depends upon the pressure of gas, p, in the discharge chamber, and the electrode separation, d. The breakdown voltage, for a given gas, is proportional to p*d. By varying p and d it is therefore possible to obtain a wide range of over-voltage conditions which ensure a spark discharge. In practice, however, different spark characteristics are observed for different values of p and d, even though they give the same value for the breakdown voltage. This is because other spark parameters such as spark length, diameter, and gas dielectric constant also influence the optical pulse, especially for very short pulses.

As a general rule, the shortest optical pulses are obtained with the highest pressures and the smallest gaps. A wide range of operating conditions can give satisfactory lamp performance.

5. Operation

The nF900 is operated by the spectrometer software. The spectrometer software allows the user to monitor the gas pressure, control the high voltage, the pulse repetition rate, and monitor the average intensity. The spectrometer software also allows the user to operate the iris and thus attenuate the lamp intensity.

For the nF900 control options of the spectrometer software please refer to the software manual.

For stable operation of the nanosecond flashlamp with maximum light output and narrow pulses some important operating routines have to be followed. This involves the correct electrode alignment, correct optical alignment, correct gas filling, and the use of the correct operating voltage and frequency. Neglectance of the guidelines given below will result in reduced performance of the nF900 or might result in no operation at all.

5.1. Choosing the Filler Gas

The nanosecond flashlamp can operate with different filler gases. A large variety of gases and gas mixtures have been investigated for their use as filler gases in respect of stable operation and overall performance of the nF900. The following gases can be considered as useful: Hydrogen, deuterium, nitrogen, and nitrogen/hydrogen mixtures. From those gases and gas mixtures hydrogen is the most popular filler gas.

Different filler gases have different spectral characteristics and the nF900 output pulses have different temporal shapes. Different filler gases also require different operational conditions, such as electrode gap distance and gas pressure.

The two pictures below show the spectral and temporal characteristics of hydrogen, deuterium and nitrogen operated nanosecond flashlamps in comparison.

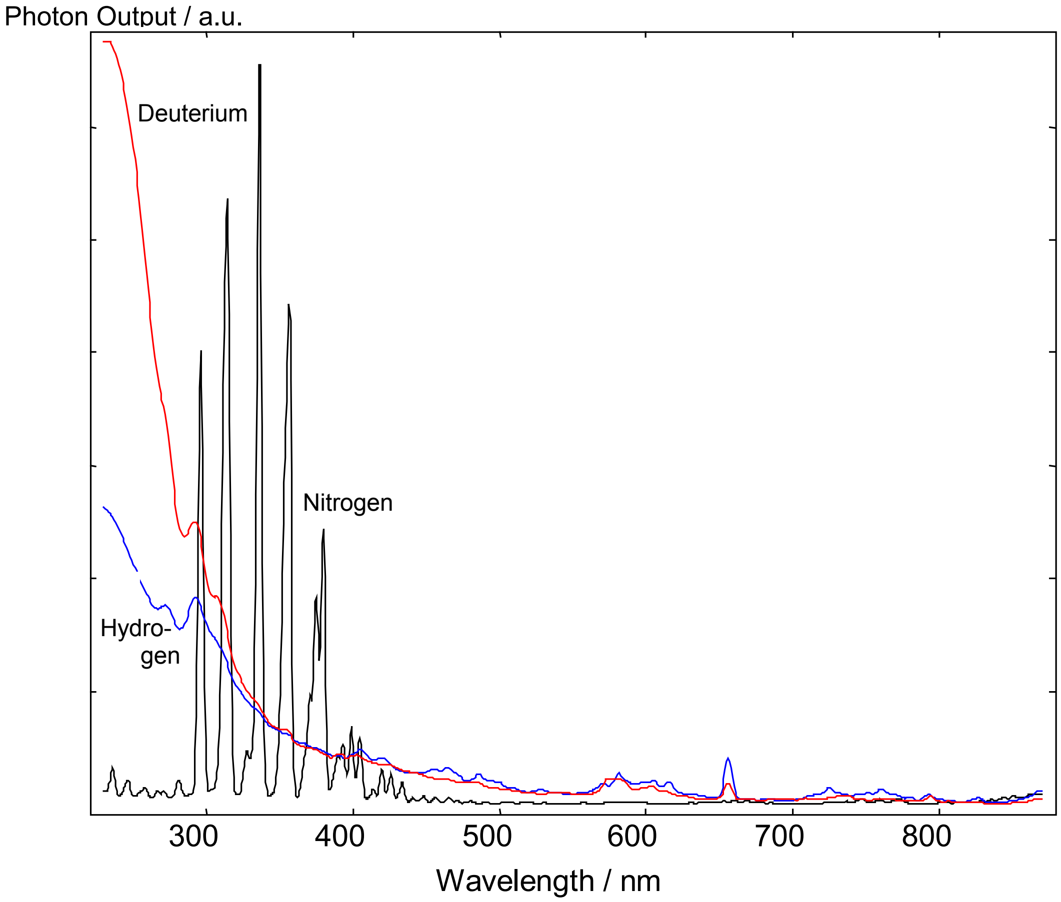
Hydrogen gas operated lamps have narrow pulses without an after-pulse tail. Photons are emitted over the entire visible spectral range, but the biggest photon yield is in the ultraviolet range. The spectrum is quasi continuum.

Deuterium gas operated lamps have similar characteristics to hydrogen filled lamps. The pulses are slightly broader, but also exhibit no after-pulse tail. The spectrum of deuterium lamps in comparison to hydrogen lamps is enhanced in the ultraviolet spectral range.

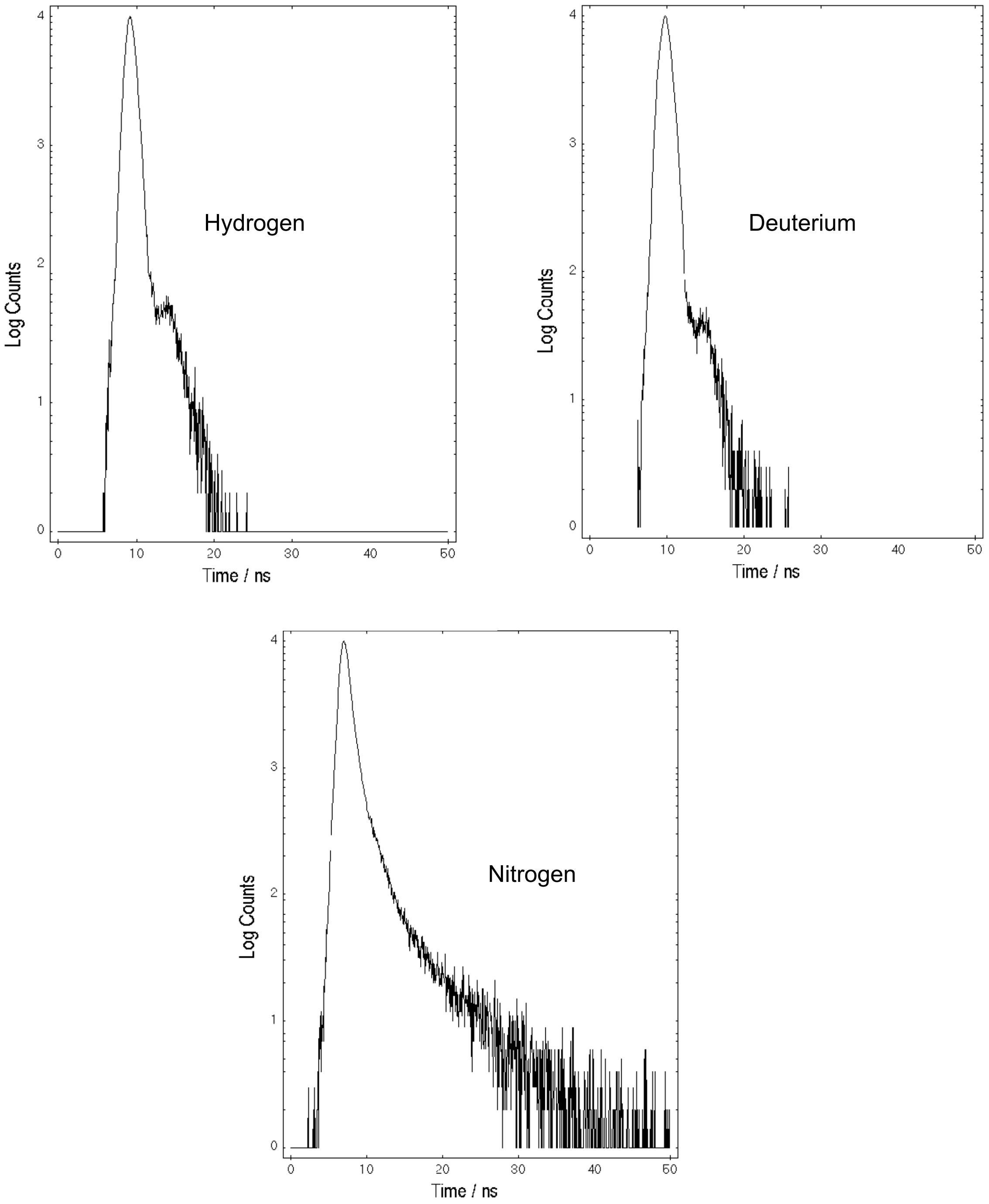
The pulses emitted from nitrogen gas filled lamps have typically a significant after-pulse tail, which reduces the dynamic range in TCSPC measurements. The height of the tail is slightly dependent on the spectral range. The spectrum is the typical nitrogen line spectrum, therefore only distinct wavelengths can be used for sample excitation. The advantage of nitrogen as a filler gas is the higher output (at the nitrogen wavelength in the UV spectral range).
A mixture of nitrogen and hydrogen (approx. 80/20) reduces the tail in comparison to lamps filled with pure nitrogen gas.

After the filler gas has been chosen it is important to know, that the gas quality is of major importance. Hydrogen (or deuterium) contaminated with nitrogen (even the smallest amounts) will result in an after-pulse tail. Oxygen or other gas vapour contamination is even worse as it will affect the stability of the lamp and the overall performance, as the electrodes will be heavily contaminated within a short period of operation. Zero grade gas quality (>99.9995) should always be used.

Under certain conditions the lamp may work with normal air, but the electrode will be covered with deposit within a short period, resulting in a progressive increment of misfires and then in an abortion of the lamp operation.



Spectral Output of the nF900 nanosecond flashlamp depending on the filler gas.
Note that these are typical curves. Characteristics can vary with operating conditions.



Instrumental Response Functions of the nanosecond flashlamp for different filler gases (measured with TCSPC, ordinate in logarithm). Note that these are typical curves. Characteristics can vary with operating conditions.

5.2. Standard Operating Conditions

Each filler gas has a range of operating conditions, i.e. electrode gap width, gas pressure, electrode high voltage, pulse repetition rate. The chosen operating condition will strongly effect the long-term stability, the output intensity (number of photons per pulse) at a given spectral range, and the pulse width.

As these operation parameters also depend on other parameters which are difficult to quantify, such as purity of the gas, quality of the cleaning, precision of the electrode alignment and of the pressure transducer as well as the age of the thyratron, it is difficult to give exact specification for the range of all parameters. The best set of operating parameters also depends on the specific use (measurement of long or short decays, emphasise on intense pulses or narrow pulses, narrow pulses or enhanced long term stability) and is often a matter of the users experience and best judgement.

The following table should be considered as a guideline. It includes standard conditions (which from experience give the best long-term stability) and an estimate for the tolerance range for some parameters. Please note that the parameters are not independent. If, for instance the electrode gap width is slightly reduced, then the pressure might be reduced too and the operating high voltage might remain in order to get best lamp stability, but pressure and operating voltage might be slightly increased in order to get narrower pulses.

Filler Gas		Standard Conditions	Range of operation parameters
Hydrogen	Electrode Gap Width Gas Pressure High Voltage Pulse Frequency	1.0 mm 0.4 bar 6.8 kV 40 kHz	0.7 ---- 1.1 mm 0.7 ---- 0.2 bar 6.2 ---- 7.2 kV 5 ------- 50 kHz
Deuterium	Electrode Gap Width Gas Pressure High Voltage Pulse Frequency	1.0 mm 0.4 bar ..6.8 kV 40 kHz	0.7 ---- 1.1 mm 0.7 ---- 0.2 bar 6.2 ---- 7.2 kV 5 ------- 50 kHz
Nitrogen (for short decay measurements)	Electrode Gap Width Gas Pressure High Voltage Pulse Frequency	0.3 mm 1.1 bar 6.5 kV 40 kHz	0.2 ---- 0.5 mm 1.3 ---- 0.8 bar 5.5 ---- 7.0 kV 10 ----- 50 kHz
Nitrogen (for long decay measurements)	Electrode Gap Width Gas Pressure High Voltage Pulse Frequency	0.3 mm 0.3 bar 3.5 kV 40 kHz	0.2 ---- 0.5 mm 0.2 ---- 0.5 bar 3.0 ---- 4.0 kV 10 ----- 50 kHz

5.3. Electrode Cleaning and Alignment

The shape of the electrodes at the spark gap, their separation and their state of cleanliness all affect the operation of the flashlamp. The pointed anode electrode blunts in use and occasionally needs to be re-sharpened. The flat end faced electrode, connected to the anode of the thyratron, may also need occasional cleaning and regrinding, as this electrode tends to be covered with deposit after a long period of use.

As a rule of thumb the lamp will require cleaning after approximately 50 hours of operation.

Routine removal of the electrodes for cleaning and polishing can be performed through the access port at the side of the flashlamp. It is recommended to remove the lamp from the spectrometer for cleaning. This will also allow better assessment of the optical alignment after the cleaning process.

Warning

Switch of the nF900 power supply and remove all cables before accessing the electrodes. Ensure the synchronisation photomultiplier is powered off (by switching off the spectrometer controller).

Removal of the Electrodes

1. Switch OFF the lamp electronics and disconnect the electrical connection between the lamp head and the control electronics.
2. Remove the lamp head from the experiment.
3. Remove the chamber access flange using the ring key provided in order to access the lamp discharge chamber.
4. Using a 1.5 mm HEX Allen key from the tool kit loosen the M3 locking grub screws holding the electrodes.
5. Using a pair of long reach pliers or a pair of tweezers push one of the electrodes further into the holder and then remove the other electrode from it’s holder. Remove the second electrode.
6. Examine both electrodes for dirt and wear.

Cleaning of the Electrodes

Re-sharpening of the electrodes can be performed on 400 or 500 grade "wet and dry" carborundum paper. The tool kit contains some carborundum paper for this purpose. Ensure that the pointed electrode has a good point and the face of the flat electrode is flat and not curved. Both electrodes should be clean of dark oxide deposits.

Thoroughly de-grease the electrodes using a volatile alcohol, such as ethanol or isopropanol and place them on a clean piece of paper. It is worthwhile taking care with this step as it will help to ensure good lamp stability and that the discharge chamber remains clean for long periods at a time.

Fitting the Electrodes

Replacing the electrodes is the reverse of removal, but must be made with particular attention paid to the optical alignment to ensure maximum light output (see next paragraph).

When fitting the electrodes care must be taken not to compromise the cleanness of the electrodes (they should only be handled by pliers or tweezers). It is further important to fit the **pointed electrode** into the **bottom** electrode holder (next to the electronics containing box of the lamp body) and the **flat electrode** to the **top** holder (next to the hexagonal lid of the lamp head).

For the operation of the lamp it is of crucial importance to adjust the electrode gap width matching the operating gas. Refer to the previous paragraph for the recommended electrode gap width.

The gap adjustment can be made using a feeler gauge provided with the tool kit. Before using the feeler gauge ensure that it is clean and free of grease. Use acetone or isopropanol to clean it.

The electrode gap must be centred in respect to the optical axes. Before adjusting the optical axes an initial set-up can be made by pure optical judgement. Alternatively the feeler gauge body can be used as a help to find the centre for the electrode gap. (The feeler gauge body has roughly the width of the free length of the flat electrode.) Also a cardboard template can be used to find the centre between the electrode holders.

After the optical alignment (see next paragraph) and before finally closing the lamp discharge chamber double check the tightness of the electrode locking grub screws. Check the O-ring on the chamber access flange and tighten the flange thoroughly for vacuum integrity.

Reinstall all cables and fit the gas tubing and the optical fire.

5.4. Optical Alignment

The aim of the optical alignment is to bring the lens assembly, the electrode gap and the rear reflector into one optical axes (refer to the picture on page 3). This ensures that a maximum amount of light is focussed to one point, usually the entrance slit of the excitation monochromator. In this way best use is made of the limited amount of light emitted from the lamp.

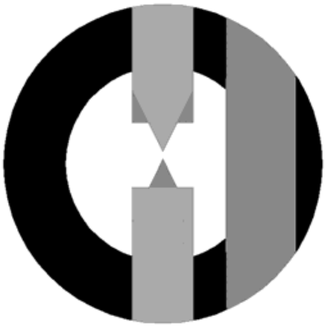
Optical alignment is best made by viewing the electrode gap through the focussing lens system:

1. Open the iris aperture.
2. Turn the lens as far away from the electrode gap as possible. (When viewing towards the lamp front side turn the lens adjustment clockwise.)
3. Hold the lamp head as far away from your eyes as possible (at least 30cm) and look through the condenser lens towards the electrode gap. Best viewing conditions are given if no direct light source is behind you. It is also recommended to close the open lamp chamber access part either by hand or by the sealing flange.

Finding the electrode gap first time may be difficult and a flashlight directly illuminating the electrodes might help initially. Please note that the direct image of the electrodes is magnified and reversed; the image from the rear reflector is itself reversed a second time.

Because the nF900 had to be adjusted at manufacture, the only misalignment after cleaning can result from the height of the electrode gap. Therefore only readjustment of the electrode gap height and gap distance (refer to the previous chapter) should be required.

The picture below shows options for height misalignment and gives indication for its correction:



gap too high

(move the flat electrode towards the centre and the pointed electrode out of the centre)

gap too low

(move the flat electrode out of the centre and the pointed electrode towards the centre)

correct alignment

In some cases it might be necessary to re-adjust the rear reflector. This should be made only if the user is sure that the adjustment of the electrode gap height can not further improve the overall adjustment.

A typical example for a misalignment of the rear reflector in height and width is given in the figure below:

To align the rear reflector loosen the six M3 screws on the rear flange, so that the flange can just be moved, but still holds in place when not held. Move the flange until the alignment is satisfactory and then re-tighten the screws.

5.5. Gas Filling

It is assumed that the flashlamp and the appropriate gas cylinder and regulator are already connected to the GF900 gas handling system. The gas filling procedure comprises a purge of the flashlamp chamber and the final adjustment of the gas pressure.

1. Ensure that the GAS, and PUMP valves are fully closed on the gas handling system.

2. Start the spectrometer system in order to monitor the gas pressure of the lamp chamber.

3. Carefully open the main valve on the gas cylinder and then open the pressure regulator valve, by turning clockwise, until the regulator gauge reads approximately 0.5 bar (this is above ambient pressure).

4. Switch ON the rotary pump of the GF900 gas filling station and open the PUMP valve to rough out the lamp discharge chamber. The pressure monitor should go down to 0.0 (corresponding to <0.01 bar total gas pressure).

5. Close the PUMP valve and open the GAS valve, the digital pressure monitor should now read about 1.5 bar of pressure.

6. Close the GAS valve and open the PUMP valve to rough out the gas.

7. The discharge chamber needs to be flush / pumped in this manner for several cycles to remove any contaminated gas from the chamber. Repeat sections 5 and 6 about five to ten times.

8. After the final gas fill, close the GAS valve and then use the PUMP valve to reduce the gas pressure in the chamber to the value chosen for flashlamp operation.

9. Close the PUMP valve and switch OFF the rotary pump.

10. Close the insulating valve and the main gas supply valve.

The gas pressure should be stable over a long period. A new gas refill should only be required after the next routine flashlamp cleaning.

A constant gas pressure is essential for long term operation. A change in gas pressure towards ambient pressure (1 bar) is a first sign of a gas leak and must be investigated thoroughly. A slight increase in gas pressure (about 0.02 bar) at the beginning of operation is no reason for concern as the lamp body and the gas inside will warm up and therefore the gas will expand.

5.6. Routine Lamp Start-Up and Operation

Provided the flashlamp has been set up correctly (i.e. gas chamber and electrodes are clean, the gap width is correct, the optical alignment has been made, all cables and tubes are fitted, and the lamp has been filled with the operating gas at correct gas pressure – refer to the previous chapters) the lamp will be operated as follows:

1. Switch on the spectrometer controller and the nF900 lamp power supply.

2. Wait about 5 min to allow the thyratron to be warmed up. This is a good time to initialise the instrument, to check the gas pressure, the synchronisation photomultiplier voltage, and the correct fitting of all cables, the gas tube, and the optical fibre.

3. After the warm-up period set the high voltage in the flashlamp control menu to the required operating voltage (refer to the table in paragraph 5.2).

4. The start-up frequency should not exceed 5 kHz. Start the lamp with the start-up frequency. The lamp should now switch on. The indicators for the operating lamp are: (a) an increase of the signal of the pulse repetition rate monitor (generally corresponding to the requested start-up pulse rate);
   (b) an increase of the signal of the intensity monitor;
   (c) a high pitch acoustic noise corresponding to the requested pulse repetition rate.

5. After a successful start of the lamp the pulse repetition rate should soon be increased to the anticipated operating frequency (refer to the table in paragraph 5.2).

For all measurements a stable operating lamp is important. The pulse repetition monitor is the safest indicator for the lamp operating conditions. The frequency should not vary by more than 50 Hz.

It is good practice not to run the flashlamp at more than 7.5 kV. Higher voltages will decrease the lifetime of the thyratron.

The light output can be optimised by adjusting the lens assembly. This is generally made while a signal count rate is observed at the same time. A re-adjustment of the lens assembly is of particular importance after the lamp has been cleaned, as for the optical alignment procedure the lens position has been alternated.

The lamp can be switched off and re-started at any time (provided the thyratron has been warmed up). It is recommended to allow the lamp (especially one which has been freshly cleaned) to settle down. This might take about 10-20 min of operation before doing high quality measurements.

After a long period of operation (approx. 50 hours) the lamp will require cleaning. This will manifest itself in the instrumental response pulses getting broader and a tail becoming more significant.

6. Trouble Shooting

The nF-900 is designed for routine and reliable use. If the flashlamp is not operating correctly then these guidelines are suggested as a means of determining the nature of the problem.

6.1. The Lamp Does Not Seem To Start.

If the lamp monitors (Flashlamp Menu in the Spectrometer software) do not indicate that the lamp is operational (although attempts have been made to start the lamp) than this does not necessarily mean that the lamp is out of order. A malfunctioning of the monitoring equipment can also be the reason. But before investigating the instrument in greater detail please check the following thinks:

1. Is the nF900 power supply switched on? If not, switch it on, wait for 5 min and try to re-start the lamp again.

2. After the nF900 power supply has been switched on, does the MAINS ON indicator light go on? If not, check the fuse on the back of the power supply and replace it if necessary.

3. Are all electrical connections correctly made, i.e. The heater cable, the high voltage cable and the trigger cable are all connected to the nF900 head and the nF900 power supply?

4. Have you waited 5 min between the lamp power supply being switched on and the start-up of the lamp? Remember the thyratron needs time to warm up!

5. Is this the first start-up after cleaning?
   - Has the electrode gap been correctly adjusted?
   – Has the flashlamp been refilled with the correct gas?
   – Has the gas pressure been adjusted?

6. Has the voltage on the synchronisation photomultiplier been changed? If yes, re-set it to the recommended voltage.

If these simple tests above are all made and no solution to the problem has been found, then the next step is to check whether the lamp monitors or the nF900 lamp are malfunctioning.

The spectrometer software monitors an average light intensity (the current of the synchronisation photomultiplier) and the number of pulses from the synchronisation photomultiplier (pulse repetition rate). If both of these signals are not present after starting the lamp, then an alternative way to check whether the lamp is firing or not should be followed, as detailed below:

7. Does the lamp produce the familiar high pitch acoustical noise after being switched on? (The frequency of the noise depends on the chosen lamp frequency up to about 13 – 15 kHz.)

8. A safer test for lamp operation is to view the ark. This can be made by removing the optical fibre and observation of the ark through the fibre window on the lamp head.

Warning:
Ensure the high voltage of the synchronisation photomultiplier has been set to Zero before removing the optical fibre. Exposure by room light can destroy the synchronisation photomultiplier.

If the lamp is actually firing, but still none of the two monitors operational (after re-fitting the optical fibre and re-setting the synchronisation photomultiplier voltage), then the synchronisation photomultiplier might be faulty or the photomultiplier does not receive bias voltage. Check the cable connections between the synchronisation photomultiplier and the system controller!

If the intensity monitor is operational, but no repetition signal is observed, check the BNC cable from the synchronisation photomultiplier. If this is correct, arrange for service.

If the repetition signal is present, but no signal intensity signal, then the instrument is principally operational. Service would be required to repair the signal intensity monitor.

6.2. The Lamp Does Not Start.

If all checks in chapter 6.1 have been made the lamp actually does not start. Continue checking as follows:

1. Is the high voltage feedback monitor similar to the requested high voltage value (after switching the lamp to ON) ? If no (it remains at Zero or “1”) check the fuse FS1 in the nF900 power supply. The power supply will need to be opened for this. Only trained personnel should be allowed to do this. Be aware that lethal voltages may be present!

2. If the high voltage feedback monitor is similar to the requested high voltage (after switching the lamp to ON), than the lamp may not be receiving trigger pulses from the lamp power supply. Check fuse FS2 inside the nF900 power supply. If the fuse is in order a non-protected electrical part may be broken and the trigger pulses can be checked with an oscilloscope (Be aware: +200V, 2μs pulses!)

3. The thyratron trigger inside the nF900 head may be broken. Thyratrons have only a limited lifetime. A broken thyratron, however has also other symptoms, see chapter 6.3. Contact Edinburgh Instruments Ltd. for a new thyratron and for fitting instructions.

4. If none of the points above help to solve the problem, please contact the service department at Edinburgh Instruments Ltd..

6.3. The Lamp Does Not Operate At Higher Repetition Rates.

A broken thyratron might be the reason. If the lamp pulse rate can not be increased to values above about 25 kHz (under conditions were the lamp usually should give 40kHz or so) then the thyratron is likely to be broken. Ask Edinburgh Instruments Ltd. for a new thyratron and instructions on how to fit it.

6.4. The Operating Frequency Is Significantly Higher Then Requested.

Free-run events occur. Free-run events can be a result of too low gas pressure, too narrow electrode gap, and two high voltage across the gap. If these free-run events occur, however, abruptly at standard conditions, where the lamp used to operate correctly, then the inter-gap resistor might be broken and needs to be replaced.

6.5. The Lamp Does Not Run Stable.

If the lamp had started correctly and the standard operating frequency of 40kHz had been obtained during the start-up, but after several minutes of operation the lamp frequency slowly tends to decrease until finally the lamp switches off, then this is usually a sign for bad cleaning conditions. These symptoms usually happen after the lamp had been recently cleaned.

Also a gas leak should be considered (see paragraph 6.6).

There is unfortunately no real alternative to a repetition of the cleaning procedure. After re-cleaning of the electrodes particular attention should be paid to a correct gap-distance alignment. A too large gap distance can have a similar effect on the pulse frequency of the nanosecond flashlamp.

If all efforts were made and the lamp pulse repetition rate still drops after several minutes of operation, try a slightly lower gas pressure.

6.6. Cleaning Is Required Very Frequently.

In the course of normal operation deposits will inevitably form on the electrodes, thus decreasing the electrode separation. The rate of deposit forming is dependant on gas purity.

1. Check the gas purity or exchange the gas supply.
2. Check the gas pressure during operation. If it is increasing (or decreasing) towards ambient pressure than a gas leak might be present and might cause gas contamination during operation.
3. Make sure the gas is not contaminated during the re-filling process (by having a gas leak in the tubing in front of the gas-filling station.
4. Check that no oil from the rotary pump enters the flashlamp chamber during the re-filling process.

7. Technical Specification

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General

Operating Principle: Controlled gas discharge (thyratron triggered)
Operation: Computer controlled
Operating Gases: Hydrogen, Deuterium, Nitrogen, Nitrogen / Hydrogen

	Hydrogen	Nitrogen
Pulse width (1):	1.0 – 1.6 ns	1.2 – 1.8 ns
Pulse tail (2):	$< 10^{-4}$	ca. 10^{-3}
Photons / pulse (3):	10^{10}	$5\ 10^{10}$
Pulse Repetition Rate (4):	$\leq$ 50 kHz	$\leq$ 50 kHz
Spectral Range:	ca.220-800 nm (quasi continuum)	ca. 290-400 nm (line spectrum)

nF900 Lamp Head

Design: All metal
Size: 120mm (W) x 190mm (W) x 120mm (L)
Weight: 5.2 kg
Connections: High Voltage (LEMO socket)
Thyratron trigger (SMB, panel mounting plug, Conhex)
Thyratron heater (6-way, panel mounting socket, LEMO)
Pressure Transducer (4-way plug)
Optical Fibre
Gas Inlet (1/4” –6.4mm OD – swage lock)
Focus adjustment: 250 mm to infinity
Lens aperture: 40 mm
Lens material: Spectrosil B
Rear reflector: MgF_2 coated
Electrode Material: Tungsten / Thorium (90/10)
Trigger pick-up: Optical fibre bundle, signal delivered to synchronisation photomultiplier
Pressure Range: <0.01 bar to 2 bar

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(1) For standard operation conditions (refer to paragraph 5.2); optical pulse duration (no detector response included).
(2) For standard operating conditions, measured 10ns after pulse peak.
(3) At standard operating conditions, integrated from 200 to 800 nm
(4) For standard operating conditions

nF900 Power Supply

Supply:	230 V ± 6% @ 50/60 Hz
Power:	150 W
Fuse Rating:	1.6A (anti surge)
Size	530mm (W) x 160mm (H) x 460mm (L)
Weight:	8 kg
Front Panel:	ON /OFF switch with indicator LED
Rear Panel Connections:	Mains Input High Voltage (LEMO socket) Thyratron trigger (SMB, panel mounting socket, Conhex) Thyratron heater (6-way, panel mounting socket, LEMO) Controller interface (25 way D-type, panel mounting socket)
High Voltage:	1kV – 8 kV, computer controlled
Heater Voltage:	6.2 Vdc, stabilised
Trigger pulses:	+200V, 2μs
Trigger Frequency:	1kHz – 100kHz, computer controlled

8. Warranty

1 a) The Company guarantees the equipment forming the subject of the contract/quotation against defective materials and workmanship for a period of one year from the date of delivery to the Purchaser.
  b) In the case of sub-assemblies of equipment not manufactured by the Company, but incorporated in the equipment ordered, the Purchaser will be entitled only to the benefit and/or limitations of any guarantee given by the makers of such assemblies.
  c) In no event shall the Company be liable for any consequential loss or damage arising from failure of the equipment under warranty.
  d) At the end of the one year period referred to herein, all claims upon all liability of the Company shall be absolutely at an end.

2 a) The Company also warrants that the equipment conforms to specifications contained in current brochures or to extra specifications confirmed in writing at the time of order acknowledgement.
  b) No warranty is made or implied as to the suitability of any equipment for the Purchaser's intended use beyond such performance specifications as form part of the contract.

3. The purchaser warrants:
  a) That he will carefully examine and list all parts of the equipment supplied by the Company and notify the Company in writing of any shortage, defect or failure to comply with the contract, which is or ought to be apparent upon such examination and test, within 48 hours of the equipment being delivered to or collected by the Purchaser.
  b) The equipment will be operated in accordance with the instructions and advice detailed in the appropriate operating instructions manual, or any other instructions which may be provided by the Company. The Company shall not be held responsible for any defect arising from the Purchaser's failure to comply with these recommendations and instructions or from damage arising from negligence or exposure to adverse environmental conditions.

4. The warranty is effective when:
  a) Any defects in the equipment supplied are notified immediately by the Purchaser to the Company.
  b) The equipment is returned to the Company at its Edinburgh premises, transportation and insurance prepaid, and undamaged by the failure to provide sufficient packaging.
  c) The Purchaser has made payment in full for the contract in accordance with the Company's normal trading terms, i.e. 30 days from date of invoice.

5. The warranty covers:
  a) Engineer's time costs during inspection and repair.
  b) Any materials or components, which require to be replaced.
  c) Return carriage costs to the Purchaser

6. However, if the Purchaser requests a service engineer to carry out the necessary inspection and repair of the equipment covered by the warranty on site, the Purchaser will be liable, at the Company's discretion, for:
  a) Engineer's travelling time costs.
  b) Engineer's travelling and accommodation expenses.

The timing of the inspection and repair of the equipment will be determined entirely at the discretion of the Company.

9. CE Declaration of Conformity

Manufactured by:

Edinburgh Instruments Ltd.
2 Bain Square
Kirkton Campus
Livingston
EH54 7DQ, United Kingdom
Tel.: + 44 (0)1506 425300
Fax.: + 44 (0)1506 425320

Applicable Standards:	Generic Immunity	EN 50082-1 : 1992
	Generic Emission	EN 50081-1 : 1992
	Electrical Safety Standards	EN 61010-1 : 1993

Edinburgh Instruments Ltd. certify that this equipment conforms with the protection requirements of the above Directives.