

# Manual for the portable spark chamber of Nikhef

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## Disclaimer

Nikhef can not be held liable for any damage caused by the in-act correctly, connect or handling of the Spark Chamber. The spark chamber is owned Nikhef and is only made available on loan.

## Use of the spark chamber

The spark chamber is exclusively available for demonstrations at exhibitions, museums and lectures and education (educational) purposes).

The spark chamber meets the following guidelines:

- 1) Low Voltage Directive (Directive 2006/95/EC, NEN3140)
- 2) Pressure vessels Directive (Directive 97/23/EC)
- 3) Work Equipment Directive (Directive 89/665/EEC)

## warning

It is forbidden to open the spark chamber, this is restricted to staff of Nikhef. By opening the spark chamber created by the death of-touch parts under high voltage (6000 V) stand.

The spark chamber emits a powerful electromagnetic pulse during machining. This may cause a pacemaker to malfunction. The EMC Directive (Di-rective 2004/108/EC) does not apply because it is a work plea for demonstration and educational purposes.

The weight of the spark chamber is higher than 25 kg. Lift, support and move the spark chamber is always at least 2 people.

Name/Function	Date	Initials
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## 1. Introduction

### a. Goal

- i. The spark chamber is used for visualization of cosmic radiation serving educational purposes. The device is normally at rest condition and is only activated by the passage of a charged elementary particle that has enough energy to pass through both scintillators. The device registers so no low energy particles such as particles as a result of radioactive decay ( $\alpha$ ,  $\beta$  and  $\gamma$  radiation). Cosmic radiation can be observed. This form of radiation reaching the earth usually as high-energy protons in the higher layers of the atmosphere fall into a multitude of others re-charged particles including muons. Only high energy muon (a kind of heavy electron) are capable of the rest of the atmosphere and the many material of the building in which we find working, to pass. The traces that we see in the von Court of Auditors are therefore almost always these particles originate.

### b. Operation of the Spark Chamber

- i. The visualization of elementary particles with the spark chamber begins working at the scintillators. These are sheets of perspex with an additive that flash of light emit when a charged elementary particle flies through. The flash of light with optical fibers to a photomultiplier led to an electrical pulse of it. The plates of the spark chamber have at this stage no voltage. When the trigger electronics finds that the two photomultipliers at the same time deliver a pulse, then the plates of the spark chamber and in order to respond quickly to high voltage by means of the spark gap (the white socket located on the rear side). The intermediate plates remain at ground potential.
- ii. In the gas between the plates is still a small number of electrons which have been released by interaction of the particle with the passing gas. Due to the sudden resulting voltage difference between the plates, these electrons are accelerated and thus form the core of a spark discharge. In this way, the trajectory of the particle is made visible.
- iii. Often the trace of a particle is visible as a nice straight line across the spark chamber around. But it also happens that there is hardly a trace is visible because the scintillators by two different particles simultaneously hit (shower). In this case, the spark chamber is largely a scattered image

of discharges again.

c. Gas

- i. For the proper functioning of the spark chamber, this with a suitable gas mixture to be filled. This mixture consists largely from which helium spark discharges at relatively low voltages can develop. 30% neon was added for a better visibility of the sparks. The sparks given this a pink color.
- ii. The spark discharge occurs in a sufficiently high electric field. The ionization of the passing particle serves as starting point of the arc. When there is too much oxygen in the gas than is the free electrons trapped prematurely by an O<sub>2</sub> molecule resulting in a O<sub>2</sub>-ion is created. Because ions about 1000 x heavier than free electrons, they will not easily lead to a spark discharge conditions. The spark chamber does not work with a lot of oxygen in the gas.
- iii. Due to the plastic walls of the device diffuses oxygen continuously, causing a continuous flow of gas is required to reduce the oxygen concentration in the gas mixture is sufficiently low. Experience has shown that a gas flow of 1.3 l / h is sufficient.

d. cylinder

- i. Normally you want to supply a 10 liter bottle (enough for about 50 days of continuous use). For a demonstration on the same day it is more convenient to use a spray (enough for approx 12 hours).

2. Installation and adjustment of the gas system

a. 10 liter gas bottle connected

- i. Turn the bottle upright on a table top fixed with the clamping cylinders. Remove the protective cover if fitted, screw the FM62 PRV (please note that the nylon ring in the regulator is present) on the valve and tighten the nut with a wrench. Do this firmly but do not overdo it (fixed fixed). Insert the brass serpent in the shortcut to the red shortcut on the spark chamber until you hear a click. Tighten the cylinder valves open. Check out the output pressure of the regulator, this should 1.0 + / -0.1 bar. Use an 8mm Allen key to any pressure to set.
- ii. The output pressure can be adjusted with the 8 mm Allen key. If the pressure is found to be too high, turn the adjustment screw slightly to the left and let some gas escape through the inlet hose of the spark chamber to disconnect. Adjust the pressure off only when absolutely necessary.

b. 1 liter aerosol connect

- i. Mount the clip GLOOR valve on the spark chamber, slide the regulator in and lock it with the locking screw. Insert the brass shortcut at the end of the hose into the red connectors on the spark chamber until you hear a click (see photo rotameter) Tighten the canister quickly the pressure reducer. You will hear briefly some gas escape. Turn especially not further than necessary and do not use force to the O-ring of the valve could be damaged gene. Check output pressure of the reducing valve, this must be 1.0 + / - 0.1 bar<sup>2</sup> are. If necessary adjust with a screwdriver.

- ii. If the pressure is found to be too high, turn the adjustment screw slightly to the left and let some gas escape through the inlet hose of the spark chamber to disconnect. Adjust the pressure off only when absolutely necessary.
  - c. Conditioning of the spark chamber
    - i. If the spark chamber no gas contains more than you need 190 liters flush to a sufficiently low oxygen concentration (10/00) to get. Put the spark chamber during a day at the highest flow (knob on the rotameter fully open). This gives a gas stream of about 8 l / h by which the volume of gas in 4.5 hours and is flushed out once the oxygen concentration to 37% of the original value is reduced. You can check whether there is enough gas is flushed through to the change in pressure in the cylinder to look. With the 10 liter gas cylinder, the pressure in this case with 19 bar have decreased. When the oxygen concentration is too high (the spark chamber is malfunctioning, little or no sparks), then there is probably too much air in the gas, and there must also be some time - up to twenty-four hours - at the highest gas stream to be flushed to the chamber on condition.
  - d. Gas flow rate for continuous operation
    - i. Set the black ball off of the rotameter at position 20 with the black knob. This results in a gas flow of about 1.3 l / h, a volume change per day. The small 10 liter gas cylinder use than 3 bar per day. Never change the setting of the sealed brass flow control at the rear of the rotameter. Check the bubbler works (bub-belt) at position 20.
    - ii. If the spark chamber for longer than 5 days is not in use, it is advantageous to completely halt the flow of gas and start again with a day flushing with a gas flow of 8 l / h, when necessary.
    - iii. Clean the cylinder never completely empty but leave at least a residual pressure of 1 bar behind.
3. Electrical Connection
- a. Use only scintillators with photomultiplier H5783, another type of scintillator does not work with this spark chamber. These scintillators are performed with a 50 cm long cable with a DIN connector screw (1) for the power supply. The signal is given by the 50 cm long shielded cable with Lemo 00 connector (2). Connect both cables individually adjusted re scintillator with the connectors on the control panel, designated respectively "CH1" and "CH2". It is not necessary to make a distinction between the scintillators. The "Coincidence" connector on the control panel provides simultaneous trigger pulses and is not used for demonstrations.
  - b. Connect also the spark chamber via the Euro power cord (3) the supply.
4. Business
- a. Place one of the scintillators in the spark chamber and slide the other eronder. A surface area of 20 x 40 cm from the scintillator is active, the end of this is indicated by a black stripe.

- b. When the gas from the spark chamber is of sufficient quality (see Section 2) and the scintillators and the mains supply, the von Court of Auditors in operation by switching the "MAINS" switch (4) and then the "HV" switch (5).
  - c. Momentarily disabling the spark chamber is best done by that only the "HR" switch (5) to convert. Turn off all long for the first time "HR" switch (5) and wait a few moments until the room is no longer fires. As a result, the high-voltage capacitors largely discharged. Put then the "MAINS" switch (4).
  - d. The amount of cosmic radiation that is observed depends on the quantity of material which the particles must pass. In a vault or un-der some thick concrete ceilings are much less visible particles, for example under a thin roof.
- 5. Preparing for Transport
  - a. 10 liters gas cylinder. Turn the valve of the gas cylinder and disconnect the spark chamber the hose from the red shortcut through the red ring inwards. The red shortcut closes automatically when the hose is removed. The pressure reducing valve is thus released and can be unscrewed from the bottle. Beware that you have the nylon ring of the coupling on the bottle is not lost. Place the screw cap on the bottle (if any) to the valve during transport to protect. Getting the bottle never screwed reducer. The transport of gases is basically governed by the ADR with extensive regulation. These rules do not apply to the carriage of gas cylinders of 10 liters which is seen as a "small amount". This is subject to the following rules: the bottle must be fixed so that it does not put the car can move freely in and during an emergency (ie hard braking) the vehicle can move like a loose cannon. These rules fall under "good home paternity".
  - b. Aerosol. Connect the spray just before transport to a pre-conditioned room and hold during transport connected. It is recommended to do the same when the 10l cylinder will be used. Without a continuous flow, the room especially in winter, cool under pressure which could arise and, through ever-present small leak air would be sucked.
  - c. Disconnect the AC power and the scintillators from the spark chamber
  - d. Collect all accessories (power cord, scintillators, gas bottle, regulator, wrench 30 mm, 8 mm Allen key, table clamp, spray with accessories and manual).
- 6. Warning
  - a. Due to the action of an electromagnetic pulse at each discharge is the use of the spark chamber only allowed to exhibitions and educational demonstrations in operation by a user who is aware of the security risks, especially for that pacemaker.
- 7. Security
  - a. Gas
    - i. The gas used (70% helium and 30% neon) is not toxic and can without objection in small quantities are inhaled. Use the spark chamber in a small, poorly ventilated room to the danger of suffocation to avoid.
  - b. High Voltage
    - i. Inside the spark chamber is a high voltage of 6000 V, adequately shielded. This dangerous voltage may still be present long after the

device is off-put. DO NOT open the electronics compartment at the rear. Repairs and maintenance may only be performed by qualified technicians at Nikhef.

c. Electromagnetic interference

- i. During the firing of the spark chamber inevitably creates a fairly powerful electromagnetic pulse. This pulse can cause interference (tikge denominated) on electromagnetic receivers (radio, TV) and perhaps also on portable electronic devices (MP3 players, mobile phones). When this problem should be to contact with Nikhef. With computers has been no interference was observed.
- ii. Warning: the electromagnetic pulses (EMP) can pose a risk for people with pacemakers. The EMP can affect the operation of the pacemaker to malfunction.

8. Maintenance

a. External cleaning.

- i. The spark chamber contains electrical components and a high-voltage power supply while the housing largely of PVC sheet and transparent plastic sheet exists. Therefore NEVER use water and organic solvents such as alcohol, thinner or acetone to clean the room but exclusive one (slightly damp) cloth.

b. Periodic maintenance.

- i. The room should once a year for maintenance to Nikhef be charged.

9. Failures

a. There are no sparks visible

- i. Check that the mains voltage is connected and the unit is fully armed (the MAINS and HV switch are lit).
- ii. Check the sparkgap (the white van in the electronics compartment) irregular light with a frequency of 0.15 - 1 Hz. If this is not the case, then check the operation of the scintillators in the light of the LEDs on the four yellow trigger board attached to the back of the device are visible.
- iii. The rightmost LED should always be ON (power of the trigger board).
- iv. The two adjacent LEDs indicate if there is of the scintillation pulses are Latoren. They burn almost always with some brief ( $\sim 0.1$  s) interruptions. Check the connection of the scintillator tower as one of them almost permanently lit.
- v. The leftmost LED indicates the coincidences to. These flashes irregularly with frequency of 0.15 - 1 Hz.
- vi. If sparkgap be fired but no sparks are visible, then the gas may contain too much oxygen or the room is sufficiently flushed. If the gas flow is interrupted, urges through leaks in the air within enclosure quickly when under pressure. Negative pressure can occur by diffusion through the walls (helium diffuses much faster than outside air diffuses inwards), changes in barometric pressure and temperature fluctuations. Rinse the chamber for a long period of time (see 0.) To make sure that the gas is of

sufficient quality.

vii. Also make sure the bubbler still works. If that is not the case then there may be a large leak through which air enters the spark chamber. There may also be a defect in the gas supply after the rotameter. In these cases, the spark-chamber to Nikhef be returned.

- b. Irregular sparks, sparks very end, no clear traces
  - i. Traces very back spark can occur if the room is not sufficiently rinsed. The gas in the back is purer than the gas between the plates causing sparks preferably located behind development. This effect disappears gradually after several hours coils.
  - ii. Verify that the scintillators are well placed: one on top of the room, under the room. Note that the scintillator already replaced only sensitive over a length of 40 cm to the black line.
  - iii. For other faults, the appliance must be at Nikhef to-spinal brought for repair.
- c. The bubbler gas flow leaves no more, but the room is continuing normally.
  - i. This is an indication of a gas leak. There is no immediate action is required, the fault is with the annual maintenance remedied.

#### 10. Specifications Nikhef portable spark chamber

- a. Gas volume: 35 l
- b. Composition chamber gas: He / Ne 70/30
- c. Minimum gas flow during operation: 1.3 l / h (2.77s/ml)
- d. Gas flow during conditioning: 8 l / h (22.5s/50ml)
- e. Maximum oxygen concentration: 1 ‰.
- f. High voltage: 5.5-6 + kVDC
- g. Plate capacitance: 152 pF
- h. Capacitance coupling capacitor 2500 pF
- i. Total capacity plate pack: 29 nF
- j. Scintillator input CH1 and CH2
  - i. Power over 5p DIN connector IEC 60130-9 Discrimination level: -30 mV
  - ii. Impedance: 470  $\Omega$
  - iii. Mains voltage 230 + / - 10 VAC
- k. Weight: 34 kg (without scintillators and other accessories)

#### 11. Composition spark chamber package with the 10 liter gas cylinder (use for long periods of time)

- a. 1 bottle capacity 10 liters
- b. 1 power cord 2m euros
- c. 1 table clamp for cylinder
- d. 1 pressure reducer FM62 200/1.5 bar with RU1 bottle jack adjusted at 1.0 bar outlet pressure with 2 m hose and nylon Kuhnke shortcut
- e. 1 spark chamber
- f. 2 scintillators H5783 PM
- g. 1 wrench 30 mm
- h. 1 8 mm Allen key to adjust any of the reducer (not on picture)

- i. 1 manual
  - j. 1 Quick Start Guide
  - k. 1 tube of posters on proton decay in the atmosphere
  - l. 1 flightcase for scintillators
12. Composition spark chamber package with the 1 liter spray (use up to 12 hours)
- a. 1 bedroom with 1 liter spark spray, GLOOR reducer with hose and valve clip
  - b. 1 power cord 2m euros
  - c. 2 scintillators H5783 PM
  - d. 1 manual
  - e. 1 Quick Start Guide
  - f. 1 tube of posters on proton decay in the atmosphere
  - g. 1 flightcase for scintillators