Alpha detector

09100.00

Operating instructions

1 PURPOSE AND DESCRIPTION

The alpha detector is a light-proof silicone surface barrier layer counter which is used for the energetic spectroscopy of α particles. For α particles of medium energy, till about 12 MeV, the charge pulses given off to the barrier layer counter are strictly proportional to the energy of incident radiation.

Before the charge pulses can be transferred to a subsequent electronic circuit for processing, they must be converted proportionally to (amplified) voltage pulses.

As α particles loose their total energy in air at atmospheric pressure after a trajectory of a few centimetres, exact energy measurements can only be carried out in a vacuum.

The α detector also can detect β particles. However, as already β particles with relatively low energy do not lose their total energy within the barrier layer, no proportionality exists between the charge of the single pulses and the energy of the β particles. Surface barrier layer counters are thus not adequate for β spectroscopy, but they can be used to detect β particles. Surface barrier layer counters are far more sensitive than counting tubes and have the further advantage that the β counting rate cannot be distorted through possible γ radiation.

The α detector consists of a p conducting silicone disk with both sides coated with metallic layers deposited by evaporation in vacuum, which act as electrodes. One side is coated with aluminium, the other with gold. The silicone disk is fixed in a metal casing in such a way that the aluminium electrode, which practically does not slow down α particles due to its very small thickness of 40 $\mu g/cm^2$, acts as an entry window for the particles.

A p-n junction is formed between the surface of the crystal and the aluminium layer, so that the detector surface acts as a barrier layer after the operating continuous voltage is applied with the correct polarity.

The barrier layer of the α detector works as a solid state ionisation chamber under this set up. The α particles which penetrate the barrier layer generate free charges along their path (electron-hole pairs). The amount of charge generated in this way is directly proportional to the energy of the incident α particles, if the particles are completely braked within the barrier layer. The thickness of the barrier layer increases with working voltage. The maximum thickness of the barrier layer is about 100 µm, so that α particles up to 12 MeV generate energy charge pulses proportional to energy.

2 HANDLING

2.1 General indications

The α detector is an extremely sensitive sensor which must be protected against all coarse environmental influences. These are especially:

- mechanical stress
- reductive gases
- humidity
- oil vapours
- strong UV irradiation
- high temperatures and temperature fluctuations
- strong α and β irradiation

Never drop the detector!
Hard blows can cause mechanical damage beyond repair.

If the detector is placed in a vented vessel, the latter may never be vented over the oil pump. Oil vapour depositions on the detector surface reduce resolution. For this reason, the flexible tube between pump and vessel must always be closed off with a pinch clamp before switching off the pump.

The front contact surface (counting surface) may not be touched by hard objects which might scratch it. Furthermore, this surface must be protected against humidity and oil. Always close the detector with its plastic cap when it is not in use and keep it in its transport container, or leave it in the vessel.

The detector should never be submitted to strong radioactivity longer than necessary. This is also valid when using the detector in experiments with low intensity preparations, because even in this case long term radiation damage effects may deteriorate the performance of the detector, especially its resolution.

2.2 Connection to peripherals

The α detector can only be used together with a charge sensitive preamplifier. Preamplifier 09100.10 for the α detector is for example an adequate unit.

To connect the α detector to the input of the preamplifier, a BNC cable as short as possible ($l \leq 300$ mm) with contacts in perfect conditions must be used. Connection with the cable must always be carried out before the operating continuous voltage is applied, because large instant voltage jumps may damage the detector. This is why a delay circuit is integrated in preamplifier 09100.10, which assures the necessary gradual increase of voltage at start up. (Attention! The corresponding reversing switch must always be in the »-« position). In practice, a voltage of -2 V is sufficient for nearly all experiments involving α particles. Higher voltage is only recommended if the extremely high resolution of the detector is required to its full extent, e. g. to analyse the resolution of the fine structure of the α lines of Am-241. An adequate continuous voltage of -100 V is obtained from amplitude analyser 13725.93 and applied to the detector over the preamplifier.

The high resolution of the detector only is fully available if the detector is used in a vacuum and in connection with a sufficiently powerful processing electronic unit. The use of the vessel for experiments in nuclear physics 09103.00 is recommended. The detector is directly plugged to the BNC socket in the vessel, where it is conveniently protected against damage and contamination even when not in use.

Attention! The pressure range between 10^{-2} and 1 mbar must absolutely be avoided within the admissible voltage range of -15 V till -100 V, as otherwise a damaging microplasma might be generated on the detector surface (if the detector is being supplied with the -12 V voltage provided by preamplifier 09100.10, this limitation of the exterior pressure range does not apply).

2.3 Indifference towards light

One of the main advantages of the α detector is its indifference towards light. The aluminium coating on the front surface does not let light penetrate into the barrier zone, thus avoiding counting errors due to light quanta. However, direct irradiation of the detector with ultraviolet light must be avoided.

2.4 Servicing

Contrarily to the usual silicone detectors with gold surface, the surface of this aluminium coated front electrode and light indifferent detector may be carefully cleaned.

Should detecting performance be impaired through dirt on the surface, this may be cleaned in the following way, making absolutely sure not to use any hard object which might scratch the surface:

- pour some methanol into a clean vessel,
- wet a wad of cotton wool in the methanol and carefully wipe the detector surface,
- if the cotton wool shows traces of dirt, repeat with fresh cotton wool,
- once the surface is clean, pour some methanol onto the detector surface and evaporate it with a jet of clean air or nitrogen.

3 TECHNICAL SPECIFICATIONS

Measuring surface	50 mm^2
Energy resolution for α particles at 5.486 MeV	$\leq$19 keV (for 100 V operating voltage)
Time constant	0.5 μs
Maximum barrier layer thickness	100 μm
Maximum operating voltage	100 V
Operating voltage polarity	negative

Quotient $\frac{charge}{particle\ energy}$ $4.42 \cdot 10^{-20}\ \frac{As}{eV}$

Indication: with each detector, a measurement report with individual data is provided.

4 LITERATURE REFERENCES

Experimental Units in Physics, Nuclear Physics 3	16150.51
University Laboratory Courses in Physics 1-3	16502.01

5 LIST OF ACCESSORIES

Preamplifier for alpha amplifier	09100.10
Amplitude analyser	13725.93
Vessel for experiments in nuclear physics	09103.00
Diaphragm ring with gold foil for Rutherford experiment	09103.02
Ring diaphragm with aluminium foil for Rutherford experiment	09103.03
Plotter, xyt	11416.97