PerkinElmer®
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operating instruction

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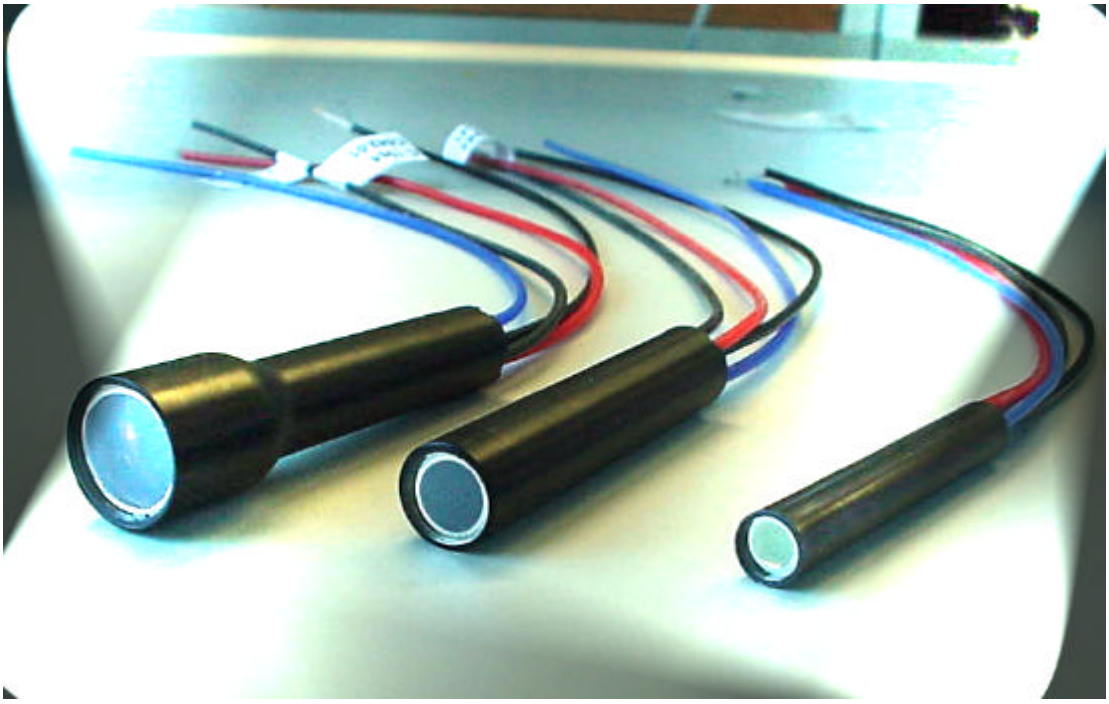
Heimann Opto

CPM- Channel Photomultiplier



C900- C1300- C1900-Series

Operating Instruction

Contens:

Warnings: All text frames indicated with ⓘ express cautions, which necessarily have to be obeyed

All text frames indicated with â express recommendations

CPM - Channel Photomultiplier – Operating Instruction

Models C9XX, C9XX P, C13XX, C13XX P, C19XX, C19XX P

CAUTION: HIGH VOLTAGE WARNING

This product operates at high voltage. Extreme care must be taken to ensure operator safety and to avoid damage to other instruments. Avoid direct contact with the CPM when high voltage is applied. Avoid placing conductive material close to the cathode.
Ensure that no light levels are applied, generating higher anode currents than specified.
All given values are nominal/typical @ 20 °C ambient temperature; specification subject to change without notice

1. Important Notes

(Before operating CPM, please read carefully):

1.1 Technical Recommendations

- All grounds are common . Please connect all Ground contacts of measuring devices, power supplies and CPM to a common ground
- It is recommended to start all measurements with 0 volts high voltage supply and increase high voltage to your required bias voltage slowly by raising control voltage
- To avoid over-exposure to light, it is recommended to observe simultaneously the output signal of the CPM by a high bandwidth (min. 400 MHz) oscilloscope, or a pico-amperemeter. Since the sensitivity of an oscilloscope is limited, an additional amplifier may be required
- Anode output current must never exceed 10µA for more than 30 seconds
- When mounting the CPM, do not apply high voltage to the detector
- Turn off all power supplies immediately, if the CPM does not work properly
- In the latter case, review all connections of the power supply and signal output

1.2 Mechanical Recommendations

When installing the CPM, avoid any material close to the front window (approx. 5mm, see Fig.1). Do not mount front end of the CPM into a holder.

Critical Cathode Area (C9xx, C13xx, C19xx)

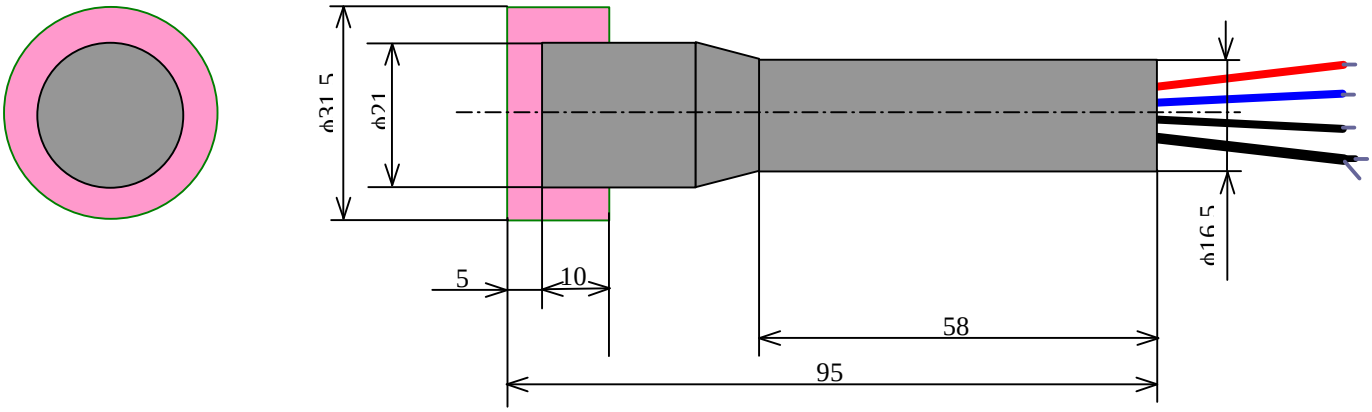
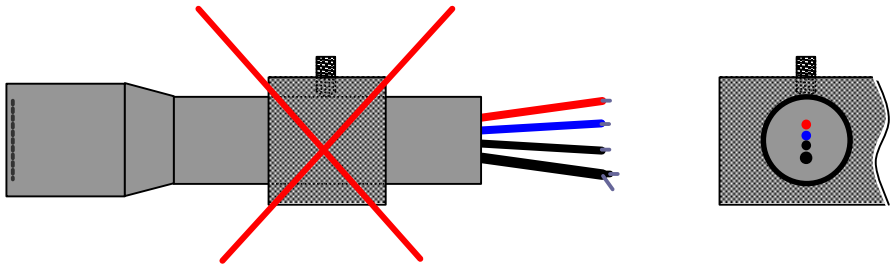


Fig.1:
This space to be ensured by having no material when using negative High Voltage Power Supply

CPM Mounting

Not-Recommended



Recommended

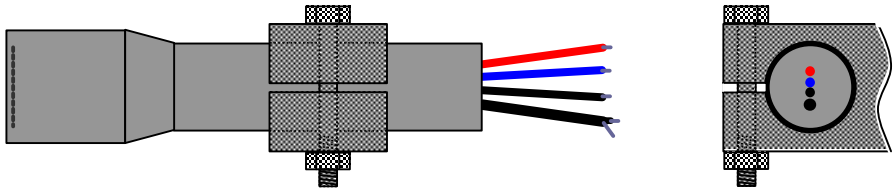


Fig.2
How to fix a Channel Photomultiplier (CPM)

2. Operating the CPM

For operating the CPM, the following additional components and devices may be required:

- 100 V Zener diode, model 1N5378 100V (Motorola) or ZY100 (ITT) (not necessary when using CHV30 N or CHV30P high voltage supply)
- 1 MOhms resistor (not necessary when using CHV30 N or CHV30P high voltage supply)
- High voltage power supply (-3000Volts/+3000Volts, min. 70µA)
- Measuring equipment (i.e. for testing CPM-pulses, a high speed (400 MHz) oscilloscope, for analog dc-mode a high sensitive ampère meter, for single photon counting mode an universal counter).

2.1 Selecting Operating Mode

The output impedance of a Channel Photomultiplier can be considered as an ideal current source. The output signal itself is a negative (fig. 3) current pulse with amplitudes, depending of adjusted gain (applied high voltage).

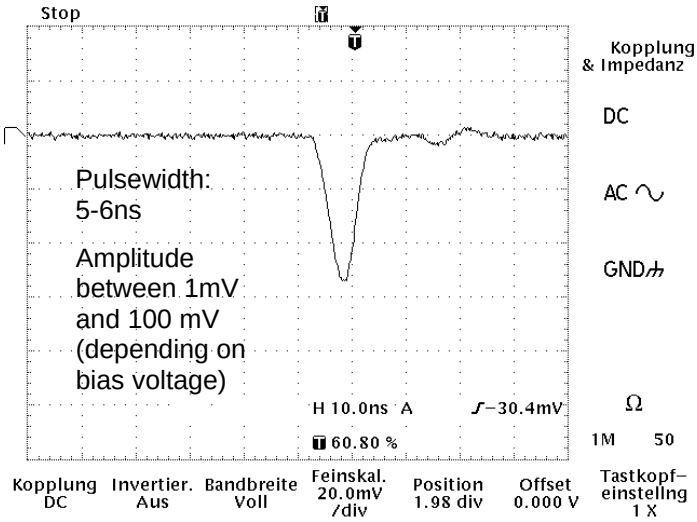


Figure 3:
Expected waveform of the output signal using a 400MHz Oscilloscope and termination of **50** W

The signal of a Channel Photomultiplier can be operated either in analogue dc mode, in photon counting mode or in pulse mode (not discussed here)

a. Photoncounting Mode (Only P-Types)

Photon counting is the best suitable operating mode when low light levels have to be measured. Using a pulse amplifier, a pulse height discriminator/and a pulse shaper, a digital signal can be generated, which is equivalent to each detected photon at the photocathode.

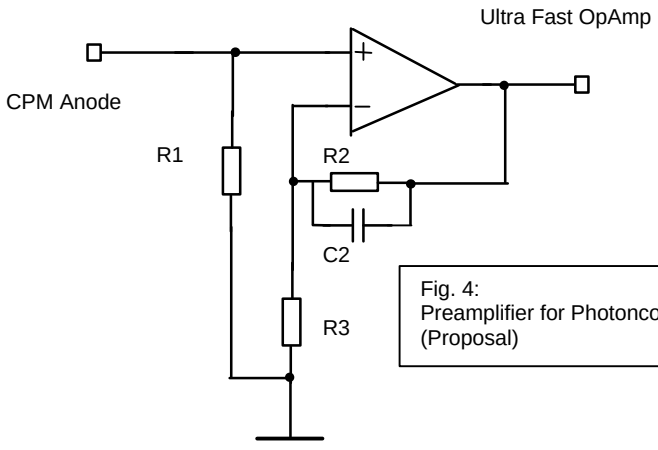


Fig. 4:
Preamplifier for Photoncounting circuit (Proposal)

However, it is essential to operate the CPM on the “single photo-electron plateau” in order to achieve the optimum bias voltage (fig. 5).
The single photo-electron plateau has to be measured individually for each CPM. By using a stabile light source, intensity has to pre-adjusted to around 2Kcps at 2200 volts bias voltage.
Then, supply voltage has to be increased stepwise by 50 volts, starting at 1500 volts. The referring count rate has to be recorded and will finally generate the “single photo electron plateau” curve. The best operating voltage is set to the beginning of the plateau, in the typical curve below (fig. 5) it would be around 2kV.

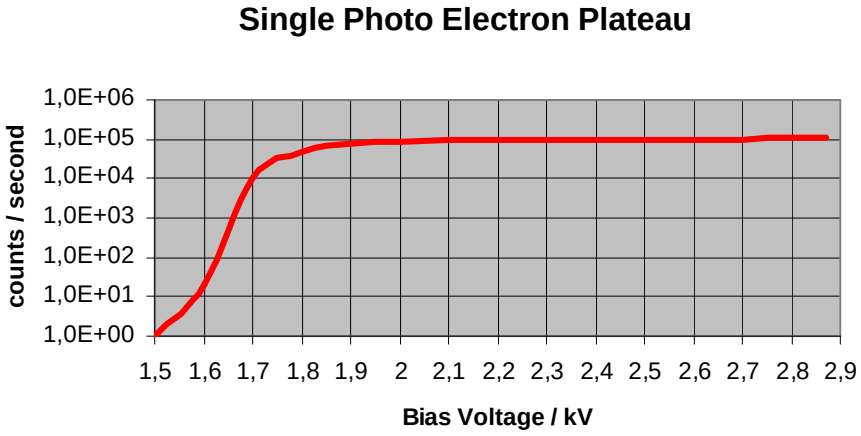


Fig.5:
Typical Count-Rate/Bias Voltage Curve (Single Photo Electron Plateau) when constant light level is applied

b. Analogue DC Mode (All Non-P and P-Types)

For analogue dc operating mode, a transimpedance amplifier / I/U-converter and a low pass filter are required. This method is recommended when high light levels have to be detected.
In this case, the DC component of the CPM anode signal is detected and thus anode potential has to be on ground (only negative high voltage can be used).

The output current pulse of the CPM-Anode has to be converted into a voltage. The conversion factor is determined (when using an operational amplifier) by the value of the feedback resistor.
It is important, to select amplifiers with lowest input bias currents (femto, low pico Ampere range) in order to take full advantage of the superior dark current characteristics of the CPM-technology.
A variation of gain can be achieved by adjusting the bias voltage between (approx.) 1000 volts and 3000 volts max.

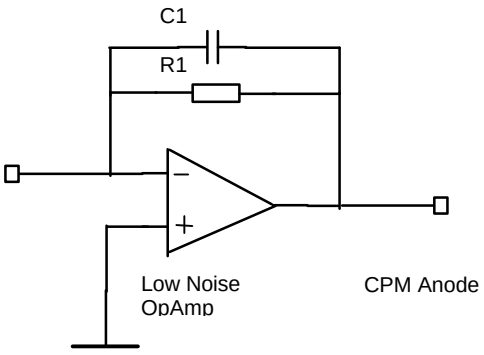


Fig. :6
Preamplifier for DC Mode (I/U conversion) (Proposal)

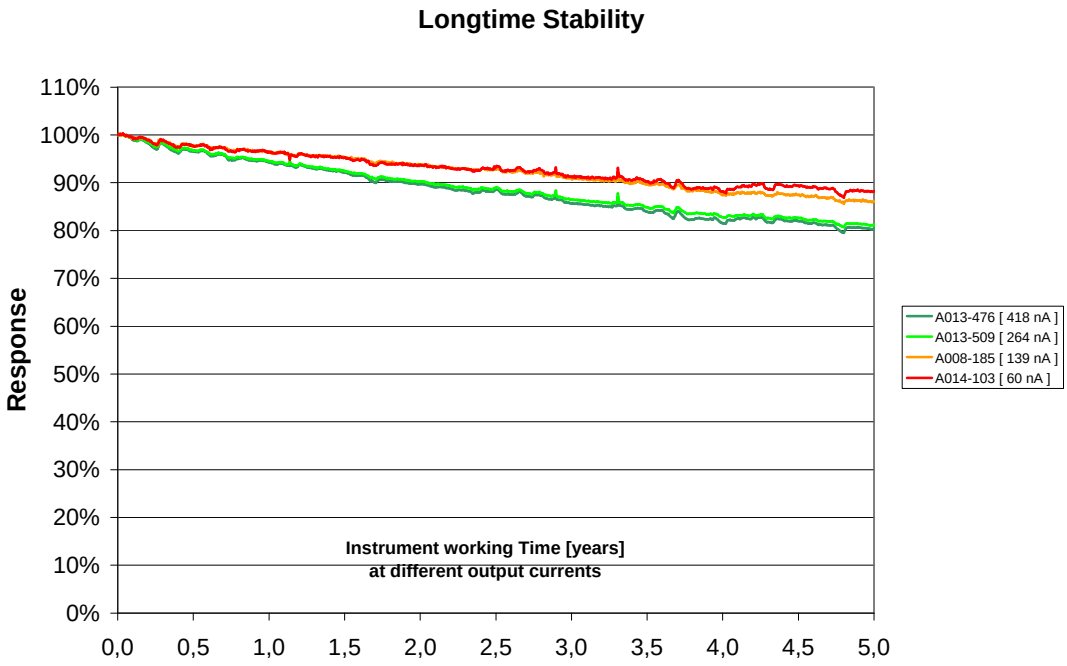


Fig. 7
CPM life time characteristics at different anode outputs

2.2 Calculation of CPM output current

The anode output current can easily be calculated by using the following equation:

Elemtary Charge (1.6e-19 As) x CPM-Gain x Photoelectrons/s = Anode output current (I_a)

Example:
Assuming, Gain is 1e7 and amount of photons per second is 200,000, the Anode current is:

1.6e-19As x 1e7 x 200,000 1/s = 320e-9 A or 320nA

In this case, output anode current is 320nAmps. Please also use this equation for determining the dark current of the CPM.

2.3 Life time considerations

Life time of a CPM is considered as being “Half Life” of the device.
Half Life defines the quantity of charge, the CPM has provided, until the anode current has decreased to 50% of its initial value at constant light- and power supply conditions

Half Life can vary between 3As and 5As (Coulomb), thus the typical value is 4 As.
Example:
Initial Anode current: 20nA, Half life assumed with 4 As:
Calculation: 4As / 20e-9A = 200e6 sec. or 56e3 hrs or 2333 days or 6.4 years.
In this case, after more than 6 years, the output anode current has decreased by 50% of the initial value.

The anode current can easily be re-adjusted to its initial value, by increasing the supply voltage.

Operating the CPM in Counting mode, half time is even beyond 3-5As, since running the CPM on the Single Photo Electron Plateau allows CPM-gain reduction (factor 2) without effecting the count rate significantly.

2.4 Connecting the CPM to the CHV30 N/P high voltage power supply

Before connecting any high voltage power supply, read operating instruction/datasheet of the high voltage device -supplied by the manufacturer- carefully.

Before installation of the CPM, ensure all power supplies of your system are turned off.
Connecting diagrams are shown in figure 8/9, using the hv-power supply CHV30N and CHV 30P or similar:

When using CHV30 N/P-series:

- Connect the colored cable of the CPM directly to the matching colored cable of the CHV30 N/P. Ensure proper soldering and insulation

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For insulation, of soldering, PKI recommends the use of self-adhesive capton tape and a double heat shrink tube

- Anode signal is available via the coax cable. The shielding must be connected properly to common ground when using a negative power supply (e.g. CHV30 N)

When using a positive power supply, please proceed as indicated in fig. 9.
A coupling capacitor has necessarily to be used.
Caution: Not using a coupling capacitor can damage connected instruments, electronics and other devices!

- Use the potentiometer for adjusting high voltage or apply an external control voltage (0 ... 3V) to $V_{set\ pin}$ of the CHV30 N.
- Connect the signal cable via high frequency connector to measuring equipment.
- Ground of measuring equipment is common ground.
- Ensure that the CPM operates in total darkness, any stray light can lead to wrong measuring results
- For further details, please refer to the operating instructions of the CHV 30 N/P series.

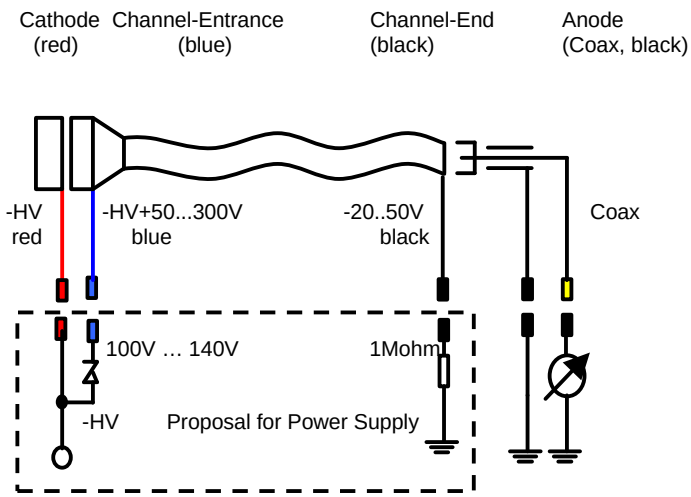

Fig. 8
Typical application circuit when using a ***negative*** high voltage supply (0 to – 3000 volts)

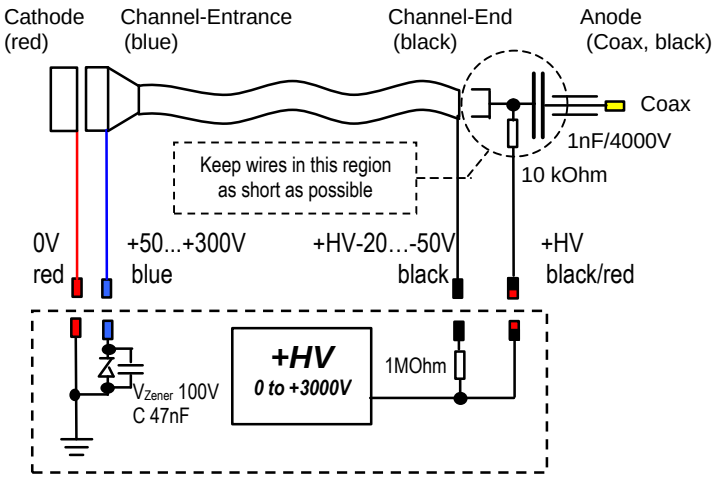

Fig. 9
Typical application circuit when using a ***positive*** high voltage supply (0 to + 3000 volts)

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When using a high voltage power supply, different from the CHV-series, an additional Capacitor in parallel to the Zener diode may be required in order to eliminate possible interferences caused by high voltage generation.

2.5 Warm Up

In order to obtain stabile measuring results, it is highly recommended to apply power supply to the detector, min. 6 minutes before operating / measuring starts.
After warm up time of 6 minutes, stabile operating conditions (e.g. temperature of the device) can be expected.

3. FAQ
Frequently Asked Questions

1. What are the main advantages of the CPM ?

In respect to conventional photomultiplier tubes (PMTs) the main advantages of the CPM is the higher anode sensitivity, higher dynamic range, lower dark noise and the compact design. For many analytical applications detection limits can be extended.

2. Why is the dark noise level of the CPM significantly lower in respect to conventional photomultipliers

The sole contribution to the CPM background is practically only the thermionic noise of the photocathode. The photocathode area of the CPM is smaller in respect to most of the conventional PMTs. The electron multiplication in the channel of the CPM is virtually silent in contrast to the significant dynode noise found in all conventional PMTs. Typical background contributed from the channel of the CPM is only 0.1 to 0.01 counts per second (cps). Electrical leakage currents are as well negligible for the CPM.

Since conventional PMTs have three effects which contributes to the background (thermionic noise, dynode noise, leakage curents), the CPM has effectively only the thermionic noise contribution. Typical dark noise level of the CPM is therefore one to three orders of magnitude lower in comparison to conventional PMTs.

3. Can the CPM be used in photon counting mode ?

The CPM shows very good characteristics for the use in photon counting mode. The pulse height distribution spectrum of single photoelectron events shows extremely good peak to valley ratio. Discrimination between noise and events is very easy compared to conventional photomultipliers. Dark noise is quite low, typically 10 cps for Bialkali CPMs. CPMs selected for photon counting applications have an additional P attached to the type number, like C 944P.

4. How to mount the CPM ?

The CPM can be mounted in the central and the back end part of the CPM. Do not press or put mechanical forces to the plastic encapsulation since the CPM inside might break. Do not pull the cables.

If the cathode is operated with negative high voltage make sure that no materials (and specially no conductive materials) are close to the cathode. It is advantageous to keep any materials 3 to 10 mm away from the cathode. If materials are used close to the cathode operated at negative high voltage electrical fields might create unwanted noise. Special CPM holders will be available soon.

5. What is the recommended high voltage power supply ?

The most easiest way for operating the CPM is the high voltage module CHV 30 N (or CHV30P for Photon Counting or Pulse Mode). These modules are designed especially for the CPM.
Only connect the CPM cables with the corresponding module cables. Make sure that CPM anode shield is on common ground with high voltage and the read out electronics. The CHV-series has the possibility for fast gating. One CPM can be operated with the module CHV 30. If more than one CPM have to be operated other modules are available.

6. How to start first operation of the CPM ?

- Make sure that all parts are at common ground.
- Before wiring the CPM with the high voltage make sure that the high voltage is set to zero volts.
- Connect the CPM with the high voltage power supply. In case of using the CHV module follow instructions under 5 and in the CHV 30 data sheet.
- For other HV power supplies follow recommendations given in the CPM data sheet.
- Make sure that the CPM is in the dark or at the appropriate low light level.
- Watch the anodes output signal with an oscilloscope or picoampere meter and slowly increase bias voltage.
- The anode current should not exceed 5 µA.

7. What are the recommended operation values of the CPM ?

For long time operation it is recommended to operate the CPM with an average anode current of 1 nA to 30 nA. Linear range is given up to approx. 5 µA. Operation in the µA-range is recommended only for short term up to 30 sec.

8. Are CPM modules and subsystems available ?

Three Different CPM modules and three different formats are available.
The sizes are ⅓ “(9mm window), ½” (13mm window) and ¾” (19mm window).
The modules are:

1. Photon counting module series MP 900/1300/1900, consisting of the CPM with high voltage power supply and pulse counting electronics with TTL output.
2. Amplifier module MD 900/1300/1900 consisting of CPM with high voltage power supply and amplifier with 0...10 V linear output.
3. The simple MH 900/1300/1900 consisting of the CPM and the high voltage power supply without additional readout electronics.

All modules are available with optional external fast gating.