PMA Series

Photomultiplier Detector Assembly

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Unternehmen für optoelektronische Forschung und Entwicklung

User Manual

Version 2.0

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1. Brief Description

The PMA Series detector is a single photon sensitive, fully integrated, fast time response and low noise photon sensor. The PMA integrates a fast Photomultiplier Tube (PMT), a high voltage power supply and a pre-amplifier.

The PMA Series are built in a gold plated iron or nickel coated aluminum housing to achieve high level of RF and magnetic shielding and protection against the interference with other devices. The built in pre-amplifier is specially targeted at timing sensitive applications such as Time-Correlated Single Photon Counting (TCSPC).

Different photocathodes are incorporated into the PMA Series: A blue sensitive, low dark count version with very high quantum efficiency covers the spectral range from 185 nm to 700 nm. The standard unit is sensitive in the range from 185 nm to 820 nm and an extended red sensitive cathode covers the 300 nm to 900 nm range

The PMA series detectors are available in three different versions. The OEM design contains no safety shutter. Standard PMA-M feature a security shutter, which can be interlocked with e.g. a sample chamber lid. Detetcors of the PMA-C type include an additional thermoelectric cooler to reduce dark counts and also incorporate an automatic overload detection function that closes the shutter in case of over-illumination.

Signal output for all models is a standard 50 Ohms SMA connector. The module only needs a 12 V DC supply line, which is delivered with the PMA-M and PMA-C versions.

2. Operation

2.1 Handling Photomultiplier Tubes

The Photomultiplier Tube (PMT) inside the PMA detector is an extremely sensitive device. It can be permanently damaged by over-exposure to intense light, despite of the built-in overload protection.

Never open or disassemble the PMA detector housing when the power supply unit is connected. The light leaking into the housing will reach the photo-cathode and will destroy the PMT despite of the automatically closed shutter.

Do not touch the window of the photomultiplier. Dirt or finger prints on the window will decrease light transmission. If the window needs to be cleaned, wipe it using alcohol and a soft cloth or dust free tissue.

Do not attach the delivered LEMO plug to the shutter interlock connector, or do not close the shutter interlock circuitry if the room light can reach the entrance window of the PMT.

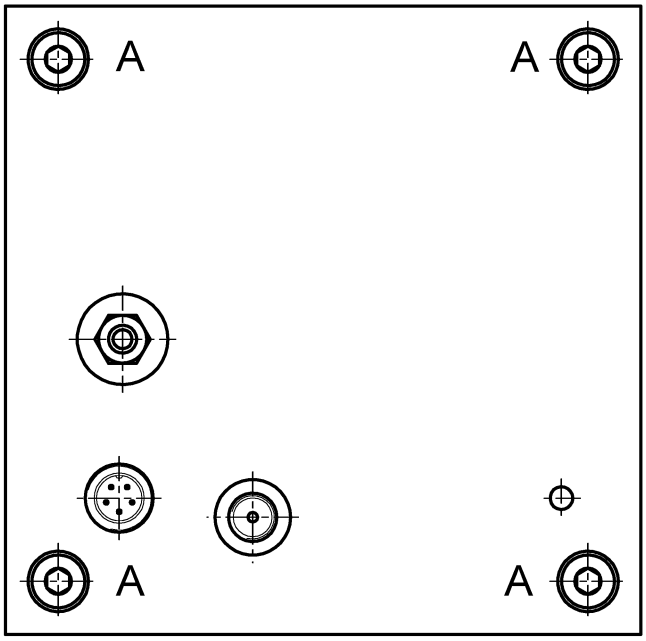
Handle the PMA detector with care. Do not drop it or expose it to excessive mechanical shocks or vibrations.

Do not attempt to modify the electronic control circuits inside the housing.

When the PMA detector is mounted on another instrument, take care that the connection is light-tight, especially if the detector is used for single photon counting.

2.2 Handling of uncooled PMA-M models

2.2.1 Mounting



The PMA-M is delivered with a black plastic cover to protect the sensor. This cover must be removed before mounting the detector by loosening the 4 srews on the front side.

The PMA-M has mounting holes suited, e.g., for Sciencetech 9030 monochromators. To mount the PMA-M, open the screws at the back indicated by the letter "A" on the drawing above and carefully separate the two halves of the detector. Note that a cable will still connect both halves. Make sure that cables are not crimped!

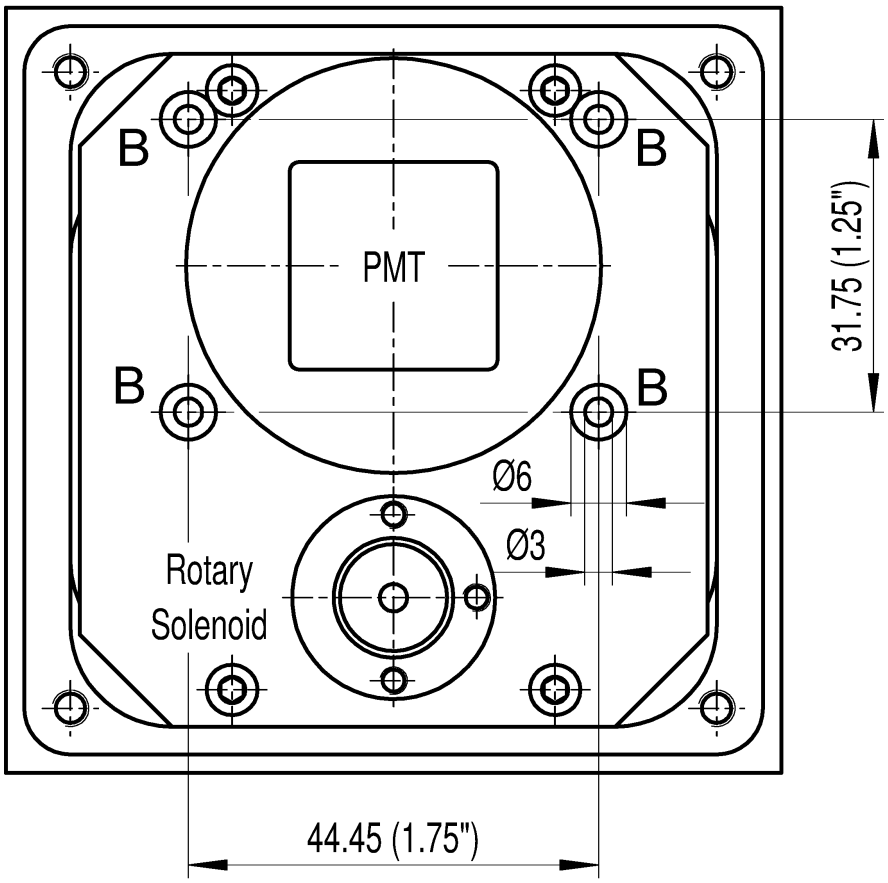
The PMA-M can then be mounted onto a monochromator, or any other instrument, using the four screws indicated by the letter "B" on the drawing below. The four screws may be either:

a) M3 sized screws (inside diameter = 3 mm, outside diameter = 6 mm), or
b) Socket Head Cap screws with thread UNC 4-40, length 1/2-inch or longer.

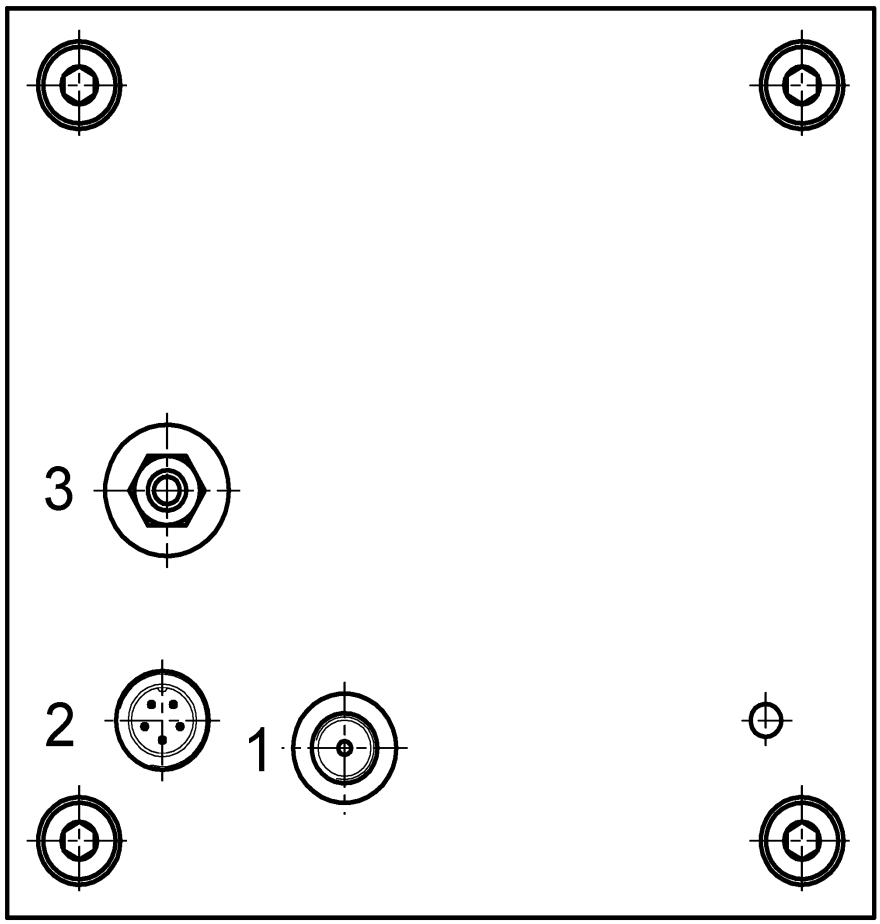
After the PMA-M has been mounted onto an instrument, close both halves of the detector and tighten the screws indicated by the letter "A".

Care should be taken to ensure that the mechanical connection is light-tight, especially if the PMA-M is to be used for single photon counting.

Inside view of housing front part:



2.2.2 Electrical connections

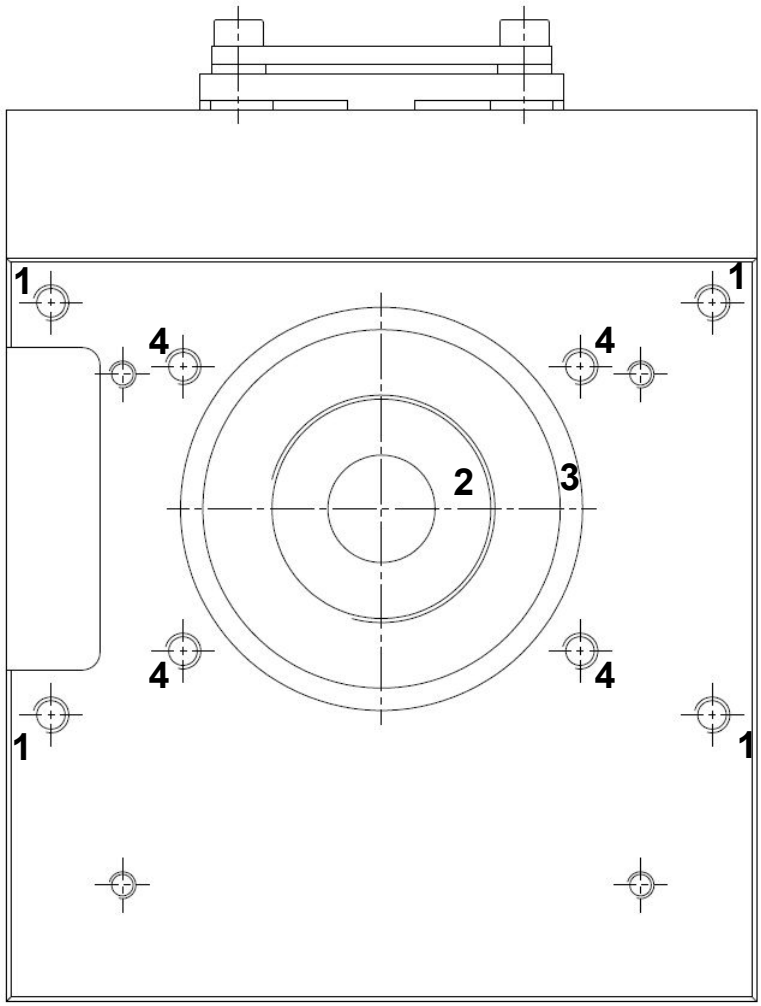


1 - Output signal (SMA female). Use a double shielded RG233/U coaxial cable to connect this signal to the appropriate input of e.g. PicoHarp 300, HydraHarp 400 or PHR 800 Router, etc.

2 - Power supply (5-pole Binder 711 type male connector). This is for +12 V DC power adapter which is delivered with the PMA-M. Alternatively, the appropriate cable that is available at PicoQuant spectrometer systems or LSM Upgrade Kits is connected here.

3 - Shutter interlock (4-pole LEMO EGG.00.304.CLL, female connector). Connect the shutter interlock cable here or attach the LEMO plug delivered with the PMA-M.

2.3 Handling and mounting the cooled PMA-C model
2.3.1 Mounting



1 - Four mounting holes with M4 thread. Use these holes to attach, for example, an adapter plate.

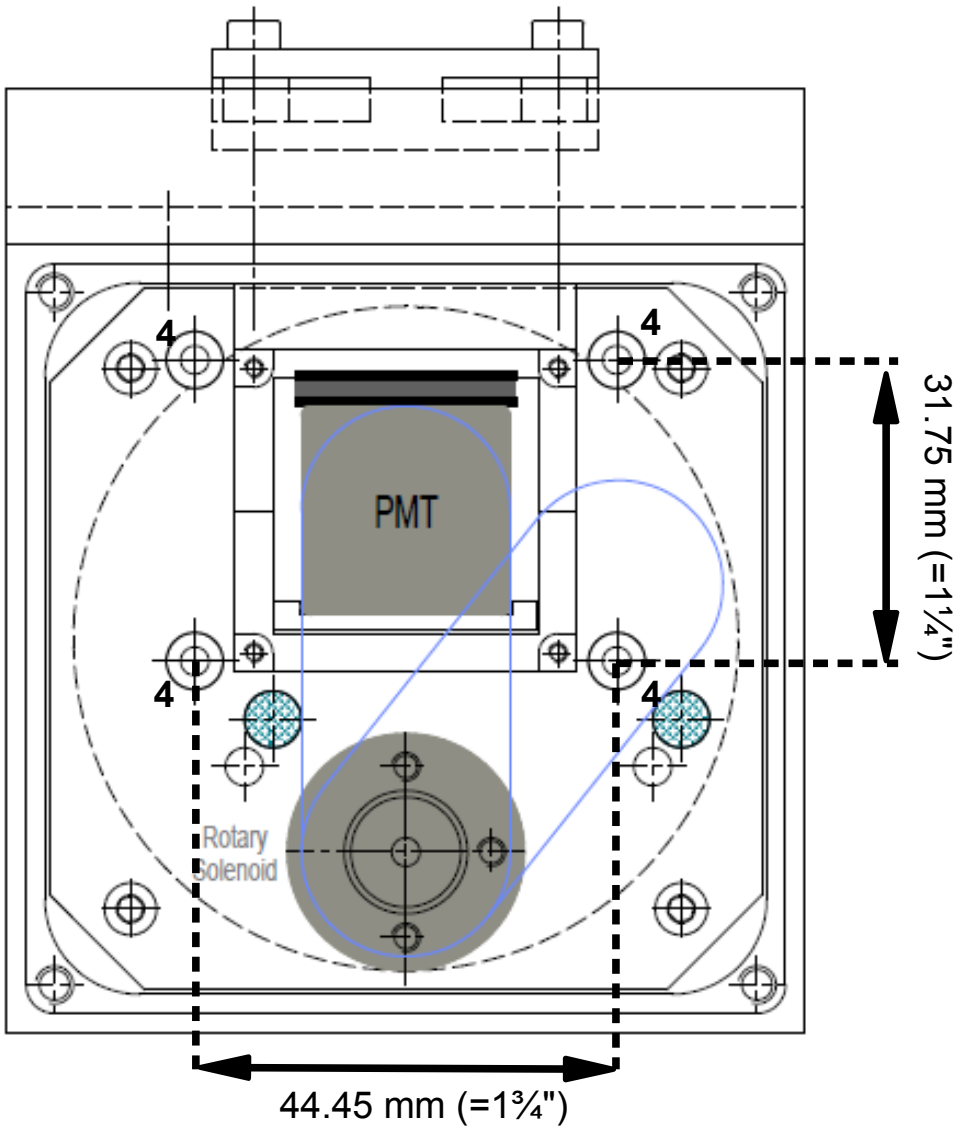
2 - C-mount thread, 1-32 UN. Note that you still have to support the weight of the detector when this mounting style is used.

3 - O-Ring. Ensures light-tight connection to a flat surface, for example to an adapter plate or monochromator side wall.

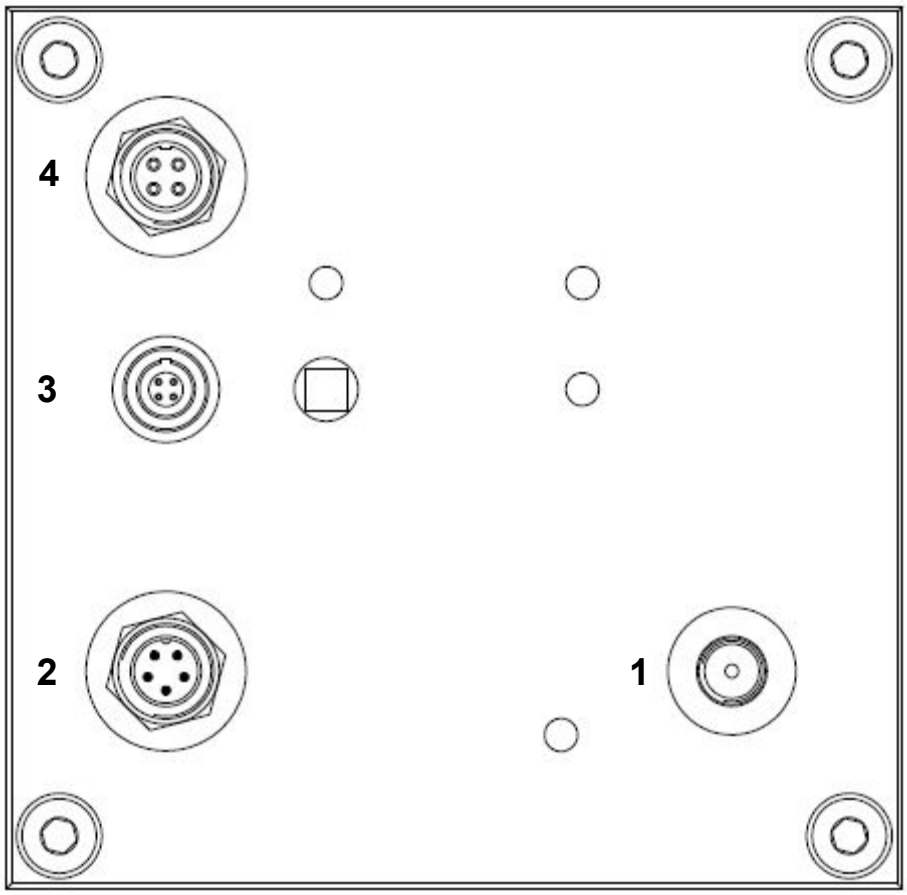
4 - Four additional mounting holes. These are normally closed with M4 grub screws. Remove these screws only in case when the PMA-C must be directly attached to another device without any adapter plate. Only in

this special case open the housing by releasing four long M4 screws at the rear panel. Use four pieces of M3 (beware, not M4!) or UNC 4-40 sized screws to fix the front panel to the other device. Then carefully close the housing, make sure that cables are not crimped.

A scheme of the inner side when viewed from rear is depicted below:



2.3.2 Electrical connections



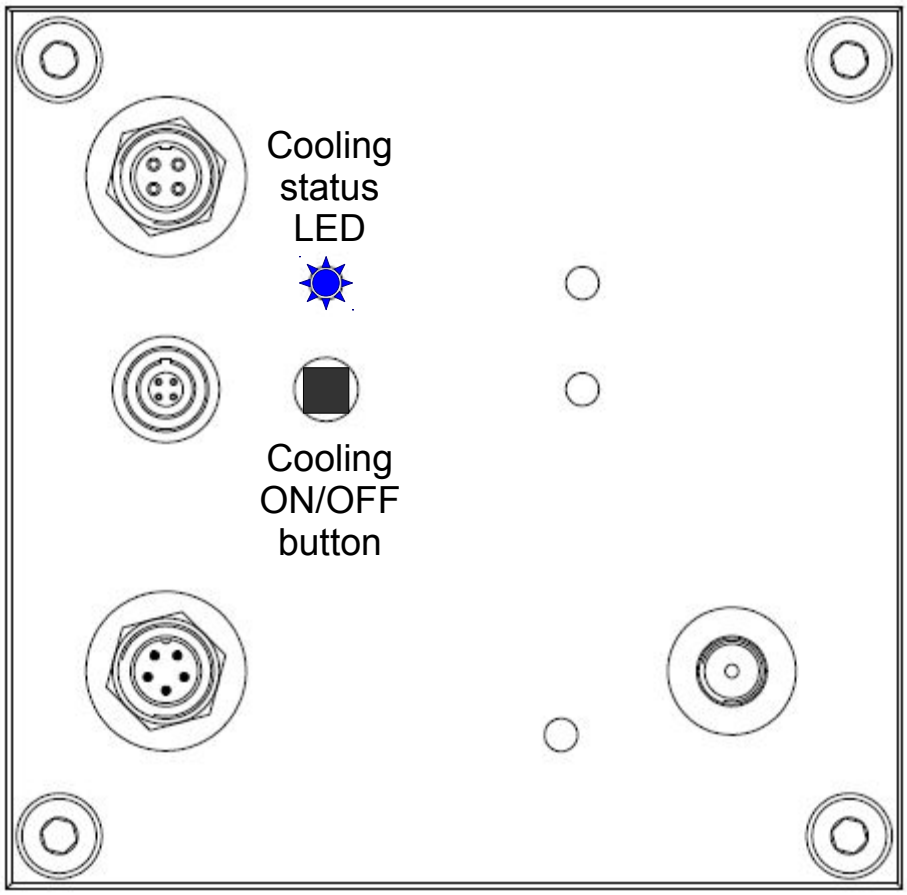
1 - Output signal (SMA female). Use a double shielded RG233/U coaxial cable to connect this signal to the appropriate input of e.g. PicoHarp 300, HydraHarp 400 or PHR 800 Router, etc.

2 - Power supply (5-pole Binder 711 type male connector). This is for +12 V DC power adapter which is delivered with the PMA-C. Alternatively, the appropriate cable that is available at PicoQuant spectrometer systems or LSM Upgrade Kits is connected here.

3 - Shutter interlock (4-pole LEMO EGG.00.304.CLL, female connector). Connect the shutter interlock cable here or attach the LEMO plug delivered with the PMA-C.

4 - Port for future use; DO NOT connect any signals here.

2.3.3 Cooling

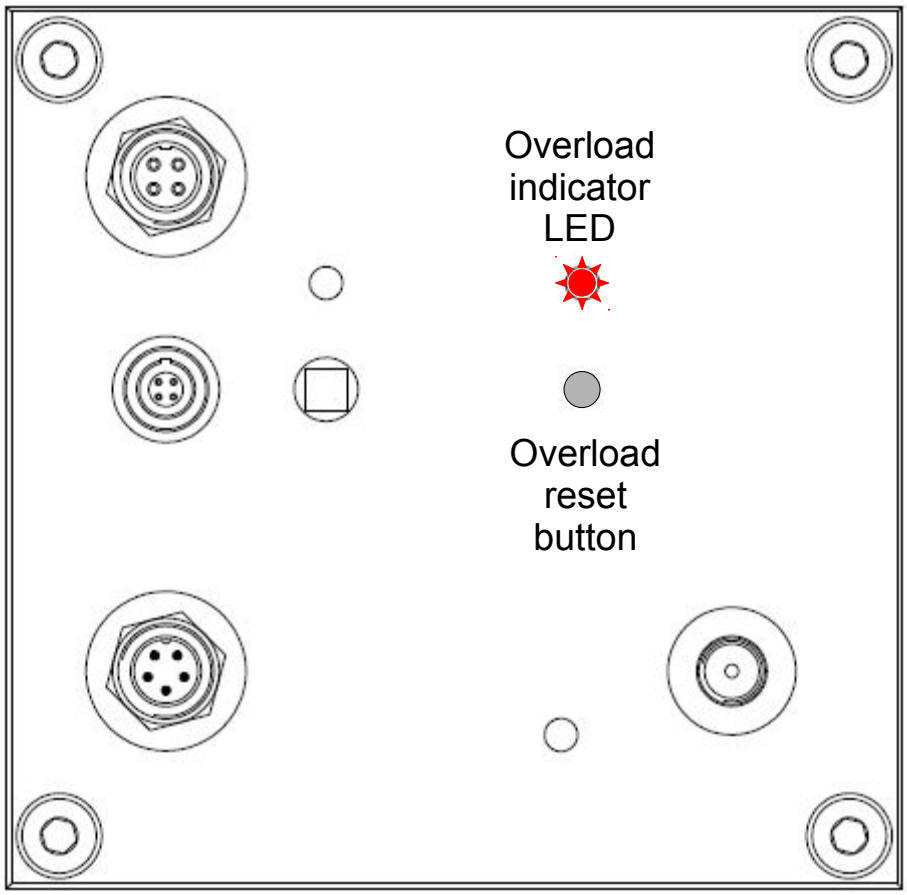


Cooling is started by pressing the black button at the rear panel of the PMA-C. When the thermoelectric cooling is activated, the blue LED indicator is shining and the fan rotates at increased speed.

It takes approximately 5 minutes to reach a stable, cooled state. You may want to use this time for preliminary measurements. Cooling reduces only the dark count rate without any effect on time resolution or photon detection efficiency. In order to prolongate the lifetime of the associated electronics, do not run the cooling permanently.

Pressing the same black button one more time turns the cooling off and the fan returns to its normal (slow) speed.

2.3.4 Overload protection PMA-C model (rear side)



In order to avoid permanent damage to the PMT, a fully automatic circuitry closes the shutter in front of the detector when the anode current becomes too high. This happens approximately at 9-10 million counts per second, a very high count rate at which the PMT is already working in quasi-analog mode rather than in photon counting mode.

Overload is indicated by a blinking red LED at the rear panel. The shutter is now closed, but otherwise the PMA-C is working normally. The normal dark count rate (dependent on the cooling status, which is not affected by the overload) should be detectable at the signal output.

The shutter remains closed (regardless of shutter interlock circuitry status) until manual reset. This button can be reached by a tip of a pen or other sharp tool, e.g. a small screwdriver.

This protection has a few millisecond latency and is meant as a last rescue only. Protect the PMA-C against over-illumination as much as possible.

3. Setting up PMA Detectors

1. Mount the detector to your experimental setup.

2. When the PMA is being used for the first time, it is advisable to place several high-valued neutral density filters directly in front of the PMT in order to protect it from bright emissions. If no light emission is detected, gradually remove the neutral density filters, one at a time. Take care not to saturate the PMT.

3. Connect the output signal (SMA socket) to the input of the signal processing electronics, for example, to a PicoHarp 300 TCSPC module.

4. Connect the delivered +12 V power supply to the 5-pin power socket on the PMA-M using the supplied connection cable.

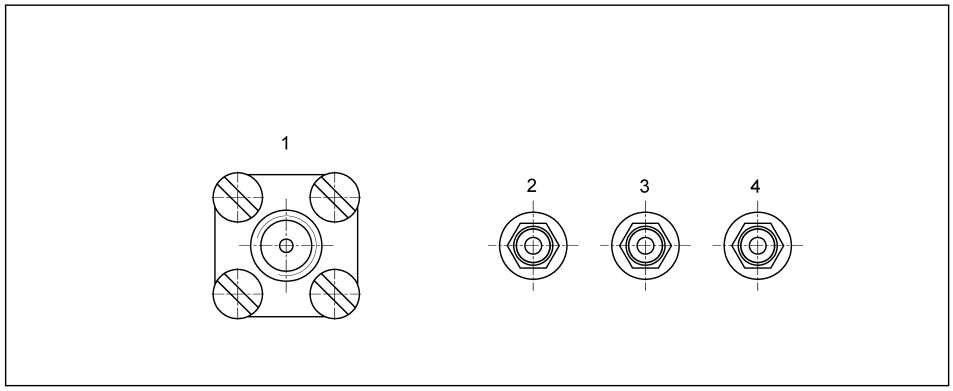
5. Make sure that the shutter interlock connector is unused (i.e. no cable or plug connected). Switch on the external +12 V DC power supply. The dark count rate of the detector should now be measurable.

6. Open the shutter of the PMA by inserting a suited connector to the shutter interlock. The detector is delivered with an interlock plug and a long lead with two bare ends that can be connected to the interlock circuit. The interlock is designed as an electrical short circuit which simply connects 12 V to the shutter of the entry port in order to keep it open. To open the shutter, plug in the interlock plug, which will keep the shutter open as long as the PMT is powered. Alternatively, use the two bare ends of the interlock cable to close the circuit. The idea of the interlock cables is to connect them, e.g., to a microswitch that opens and closes with a sample chamber lid.

7. *Only for PMA-C models:* Switch on the cooling by pressing the button in the rear side. The noise of the ventilation and a blue LED indicates the running cooling

8. To check if the PMA is working correctly, block the entrance to the PMA and connect an oscilloscope to the output socket of the PMA. The dark count signal should be visible as a short-pulse with a width of about 1 ns and a repetition frequency of 20-to-1500 Hz (depending on PMA model).

4. Usage of uncooled PMA Detectors (OEM Version)



Standard PMA Cable Connections

1. Output signal from PMA (SMA socket)
2. +12 V DC input
3. Ground (0 V)
4. No connection (test point)

1. In a dimly lit room, remove the protective light shield and mount the PMA in front of the sample to be monitored. The PMA can be mounted using the provided tapped holes on the front side.

2. When the PMA is being used for the first time, it is advisable to place several high-valued neutral density filters directly in front of the PMT in order to protect it from bright emissions. If no light emission is detected, gradually remove the neutral density filters, one at a time. Take care not to saturate the PMT.

3. Connect the output signal (SMA socket) to the input of the signal processing card, for example, to a PicoHarp 300 TCSPC module.

4. With the external +12 V DC power supply switched off and disconnected from a power source, solder the 0 V and +12 V wires directly to the feed-through connector pins of the PMA.

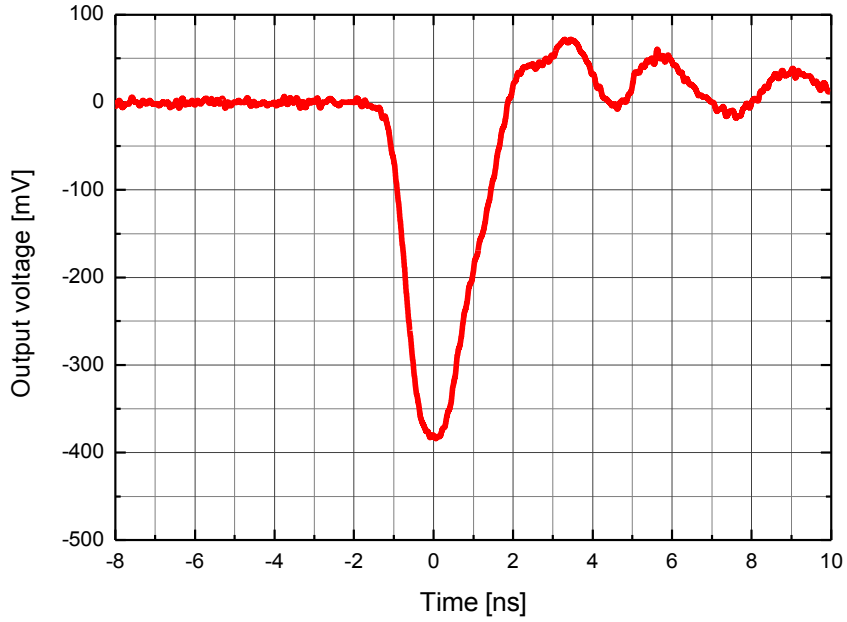
5. Switch on the external +12 V DC power supply.

6. To check if the PMA is working correctly, block the entrance to the PMA and connect an oscilloscope to the output socket of the PMA. The dark count signal should be visible as a short-pulse with a width of about 1 ns and a repetition frequency of 20-to-1500 Hz (depending on PMA model).

5. Typical performance

5.1 Temporal response

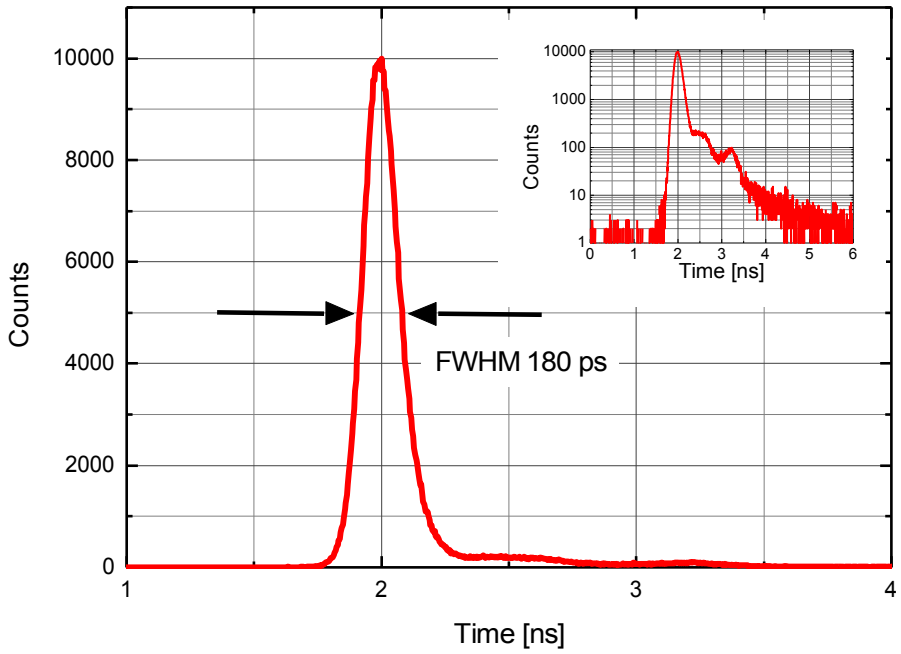
The PMA series units are suitable for time-resolved applications such as time-correlated single-photon counting (TCSPC) measurements. A typical electrical response of a PMA detector to a single photon impact is shown on the graph below:



The output signal is a short, negative going voltage pulse with an amplitude of -100 to -400 mV into 50 Ohms. Note that the electron multiplication process inside the PMT is a stochastic process resulting in random pulse amplitudes obeying a certain distribution.

The pulse duration is approximately 1.5 ns (full width at half of the maximum, FWHM). However, the ultimate time resolution achievable with a PMT is determined by the steepness of the leading edge and the photo-electron transit time spread (TTS). The leading edge of a typical output pulse has a 750 ps rise time and the TTS of the photomultiplier incorporated in PMA detector is less than 180 ps.

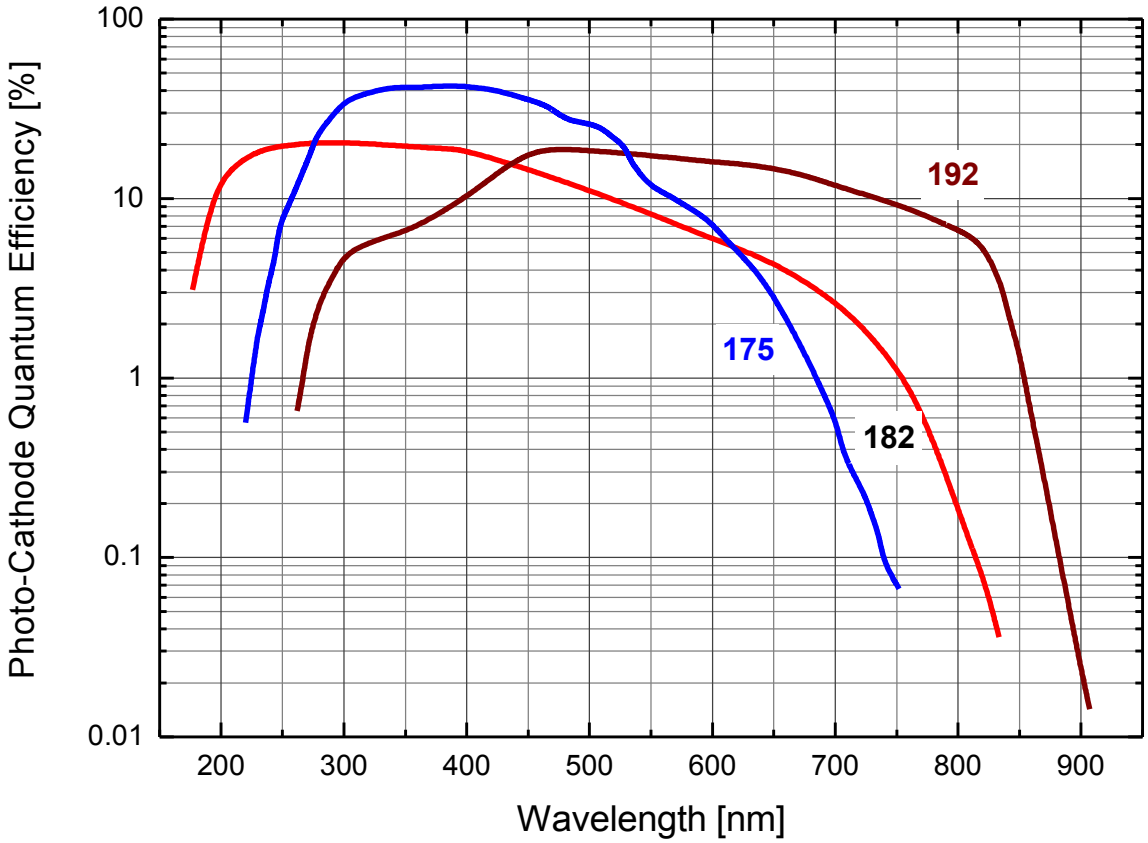
With a well designed TCSPC setup an instrument response function (IRF) shorter than 200 ps FWHM can be achieved, as shown in the graphs below.



This IRF has been recorded on a FluoTime 200 spectrometer equipped with PMA-C-192-N-M detector and PicoHarp 300 TCSPC module. The sample was a strongly diluted Ludox scattering solution irradiated with 440 nm light pulses of approximately 70 ps optical duration from an LDH-P-C-440 picosecond pulsed laser diode.

5.2 Spectral response

The spectral sensitivity of a detector based on photomultiplier tube (PMT) is mainly determined by the photo-cathode material. Three different cathode versions are available for the PMA series with the following spectral sensitivities:



An unavoidable effect of extended red-sensitivity (that is: increased quantum efficiency for longer wavelengths) is an increased anode dark current due to heat sensitivity. In photon counting applications this means increased dark count rate. Cooling reduces the dark count rate (anode dark current). It has no effect on the detection quantum efficiency (QE). Cooling of blue sensitive PMTs has practically no effect because the photo-cathodes of these sensors are not sensitive to heat.

Be careful when comparing the spectral sensitivity specifications of various detectors. Manufacturers of detectors often specify the sensitivity in terms of cathode radiant sensitivity $S(\lambda)$ which is defined as the photo-cathode current

divided by the incident photon power (typical units: mA / W). For photon counting applications, the $QE(\lambda)$ is more relevant. There is a simple relationship between these two figures:

$$QE(\lambda) = \frac{hc}{e\lambda} \cdot S(\lambda)$$

h, Planck constant; c, speed of light in vacuum; e, electron charge, λ, wavelength.

6. Technical Data

6.1 Specifications

Electrical Parameters

Model.....PMA 175.....PMA 182.....PMA 192
Wavelength range.....185 – 700 nm.…300 – 820 nm.…300 – 900 nm
Dark count* (uncooled).…< 50 cps.....< 900 cps.....< 10000 cps**
Dark count* (cooled).....----.....< 200 cps.....< 3000 cps**

* typ. value at 20ºC ambient temperature
** lower dark counts might be available on special selection

Signal Output

Connector.....SMA female
Impedance.....50 Ohm

Single photon response

Polarity.....negative
Pulse width.....1.5 ns (FWHM, typ. value)
Leading edge.....750 ps (10% to 90% of peak)
Amplitude.....-50 to -400 mV (typ. values)
Transit time spread.....<180 ps (typ. value)

Power Supply

Input.....12 V DC
Max. current consumption (uncooled).....220 mA
Max. current consumption (cooled).....450 mA

Dimensions and weight

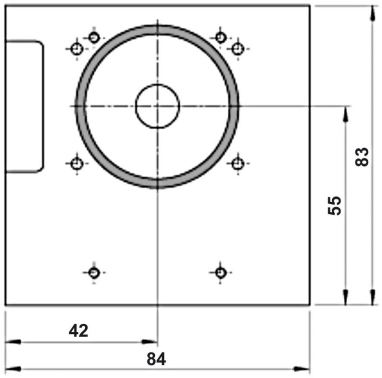
OEM model.....134 x 84 x 34 mm (w x l x h)
.....1.15 kg
PMA-M model.....72 x 84 x 84 mm (w x l x h)
.....1.75 kg
PMA-C model.....120 x 84 x 110 mm (w x l x h)
.....2.4 kg (PMA-C)
Detector area diameter.....8 mm

6.2 Mechanical layout

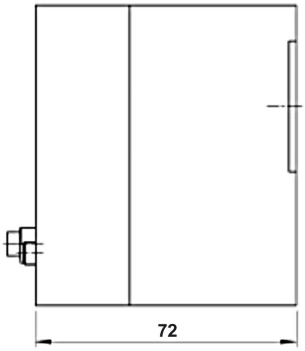
PMA-M

shutter with PMT inside
all dimensions in mm

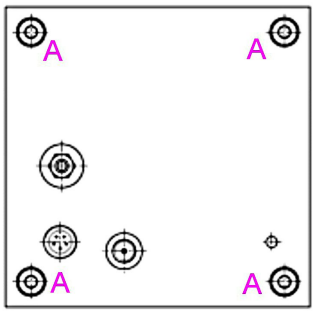
outside view of housing front part



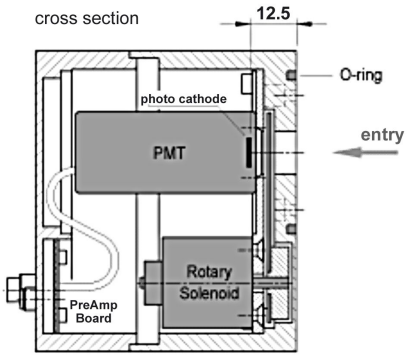
side view



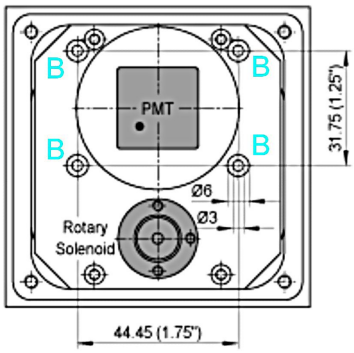
outside view of housing rear part



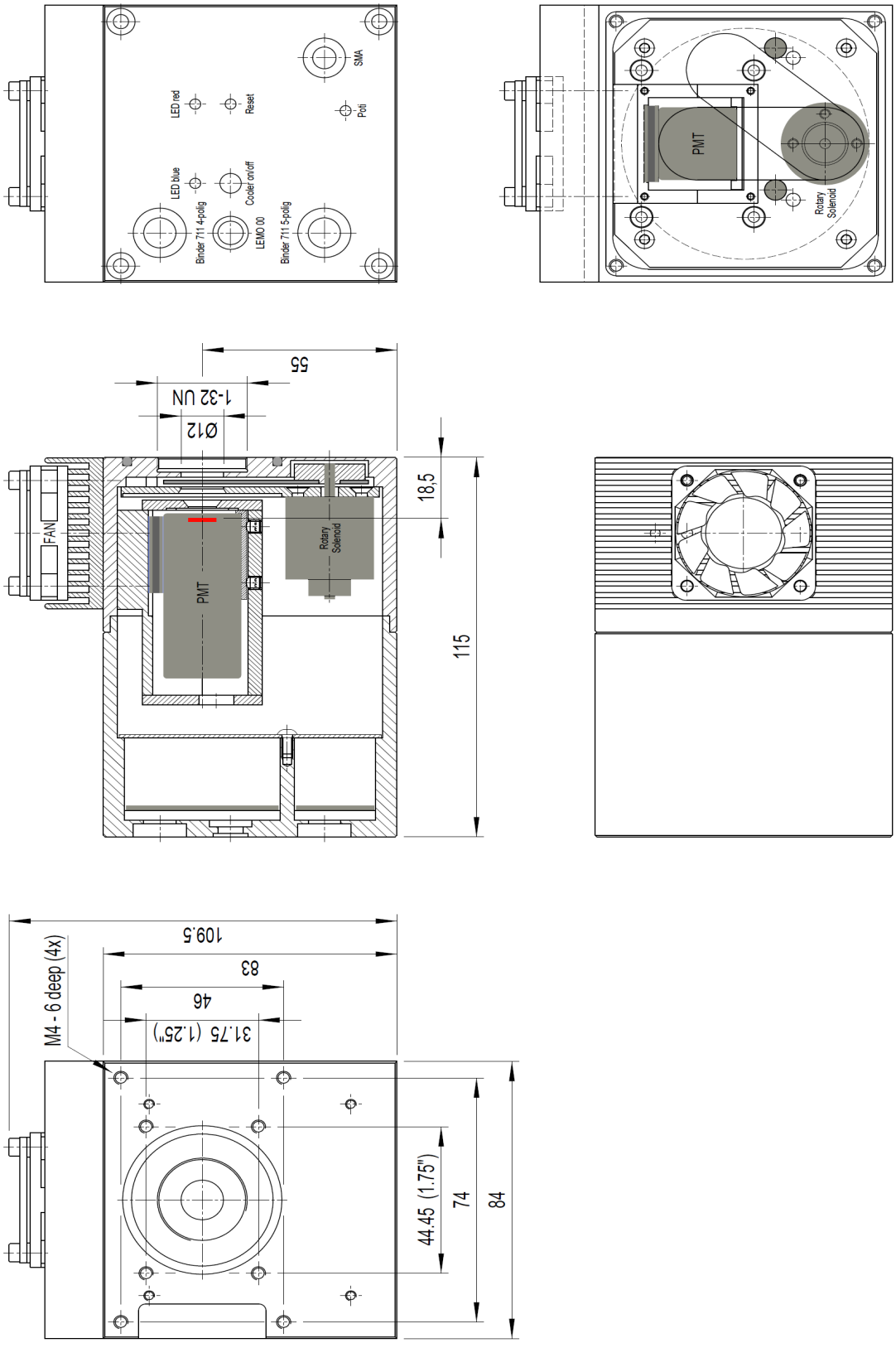
cross section



inside view of housing front part
with dimensioned mounting holes



PMA-C


SMA
LED red
Reset
Poti
LED blue
Cooler on/off
Binder 711 4-polig
LEMO 00
Binder 711 5-polig
PMT
Rotary Solenoid
55
1-32 UN
Ø12
18,5
115
FAN
M4 - 6 deep (4x)
109.5
83
46
31.75 (1.25")
44.45 (1.75")
74
84

7. Support

The PMA series detectors have gone through thorough testing at PicoQuant. It is stable and reliable. Nevertheless, we continually make improvements that will be incorporated into future versions.

In any case, we would like to offer you our complete support. Please do not hesitate to contact PicoQuant if you would like assistance with your system. If you observe any errors, please e-mail a detailed description of the problem and relevant circumstances, to info@picoquant.com Your feedback will help us to improve the product and documentation.

Of course we also appreciate good news. If you have obtained exciting results with one of our systems, we would like to know! If you have obtained exciting results with one of our systems, please let us know, and where appropriate, mention us in your publications. At our website we maintain a bibliography of hundreds of publications related to our instruments and research. See http://www.picoquant.com/scientific/references Please submit your references for addition to this list.

Retraction of Old Devices

Waste electrical products must not be disposed of with household waste. This equipment should be taken to your local recycling center for safe treatment.

WEEE-Reg.-No. DE 96457402

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