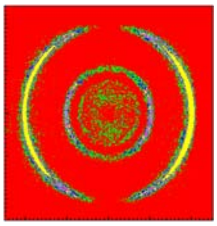
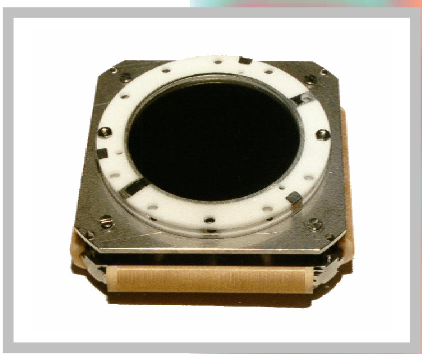
RoentDek
Handels GmbH

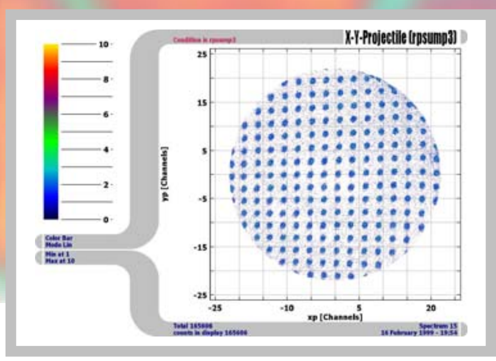
Supersonic Gas Jets
Detection Techniques
Data Acquisition Systems
Multifragment Imaging Systems



# MCP Delay Line Detector Manual

(Version 6.2.90.5)



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# Table of Contents

# 1 Detector System - Components

This manual describes all components of the RoentDek delay-line detector system as it can be delivered for the **DLD40**, **DLD80, HEX80** and **DLD120** and **HEX120** detector. Even if you have not purchased the complete system you will find valuable information in the chapters describing the different components about the link between the components and the operation. However, you might have received only the relevant parts of this manual.

If you have received special detector components, i.e. a detector of different size or type, or other electronic modules you will find a separate manual commenting on peculiarities of your special system. In this case the information given here is mostly relevant for your system but you might need extra information.

- **DLD** or **HEX** microchannel plate detector with delay-line anode
- **ATR19** module: 6 or 8-channel fast (differential) amplifier with integrated constant-fraction-discriminator (NIM or ECL-output)
- **FT12(16)-TP** 12-pin CF35 (and fourfold MHV) UHV-feedthrough flange(s) and CF100/CF150/CF200-CF35-adapter (optional)
  for Hexanode: additional 3 signal decouplers
- **TDC8** or **HM1** (optional)
- **HV2/4 BIASET2** and **BA2** or similar 4kV High Voltage Supplies (optional)
- Data acquisition and data analyzing software CoboldPC (optional)

# 2 The Microchannel Plate Detector

**Typical performance:**

| | |
|---|---|
| position resolution | < 0.1mm |
| overall linearity | 0.2mm |
| rate capability | 1MHz |
| multi-hit dead time | 20ns (with ATR19, intrinsic detector signal dead time 5ns) |

## 2.1 Characteristics

### 2.1.1 *Physical Characteristics of the Detector - Specification*

| | |
|---|---|
| Mounting Flange Size: | CF 100/CF 150/CF 200 |
| Height above Flange: | ≈ 100mm (adjustable) |
| Mounting Diameter: | 94/144/196/246mm |
| Baking Temperature: | 150°C Maximum |

### 2.1.2 *Physical Characteristics of MCPs*

| | |
|---|---|
| # of MCPs in Chevron stack | 2 |
| Outer Diameter: | 50*/86.6/127mm |
| Active Diameter: | 47*/83/120mm |
| L/D | 60:1* |
| Thickness | 1.5mm* |
| Pore size | 25µm* |
| Center-to-center spacing: | 32µm* |
| Bias Angle: | 7° ± 2° |
| Open Area Ratio: | >50% |
| Operating Temperature Range: | -50 to 70°C |
| Operating Pressure: | $< 2 \times 10^{-6}$mbar |

* for Photonis MCP: 46mm OD (42mm active), L/D 80:1 , 1mm thickness, 12.5µm pore size

### 2.1.3 *Electrical Characteristics of the Detector*

**Chevron (2 MCPs)**

| | |
|---|---|
| Electron Gain @ 2400Volts: | $1\times 10^7$ Minimum* |
| Operating Voltage: | 2400V typical* |

* for Photonis MCP: about 300V higher voltages are to be applied.

It is possible to further increase the gain by using triple stacks of these MCP. Please contact RoentDek for advice.

If you have chosen a detector set with central hole the hole size in the MCP is usually 6.4mm and the minimum active diameter 9mm.

## 2.2 General Description

The RoentDek MCP detector with delay-line anode is a high resolution 2D-imaging and timing device for charged particle or photon detection at high rates with multi-hit capability. The linear active diameter is at least 40mm for the **DLD40**, 80mm for the **DLD80** and about 120mm for the **DLD120**. The RoentDek **Hexanode** has a third delay-line layer that gives redundant detection opportunities either to improve the multi-hit performance or to allow the construction of a MCP setup with central hole and minimised blind detection area. In its usual version (**HEX80)** it has about 75mm redundant detection area (hexagonal) and covers at least 80mm linear total detection area with at least two layers (**HEX120**: 100mm redundant, 115mm linear, 120mm total). For detectors with central hole (**HEX40/o** and **HEX80/o**) most of the descriptions in this manual are relevant too.
The detector consists of a pair of selected rimless MCPs in chevron configuration, or sometimes of a triple stack (Z-stack) and a helical wire delay-line anode for two-dimensional position readout. The MCPs are supported by a pair of partially metallized ceramic rings (1.5/2mm thick, 65/105mm outer diameter for **DLD40/DLD80/HEX80**) and a 2D-position sensitive delay-line anode (helical wire pair). The metallization of the ceramic rings is Nickel (for **DLD80/HEX80** covered with Gold). The metal contacts on the ceramic rings are suitable for soldering, clamping or spot welding. For the **DLD120** and **HEX120** the MCP stack is mounted between a metal front ring and the holder plate.
For the 40 and 80 mm MCP, the MCP stack is mounted independently so that different anode types can be implemented (e.g. UHV-compatible Wedge-and-Strip anodes or timing anodes without position resolution, also available from RoentDek).
The MCP-holder system itself measures 66 × 6mm or 105 × 7mm.
The operation requires two DC voltages for MCP front and back contacts and three voltages for the support plate ("holder") and the wires. All voltages can be supplied by separate HV-supplies or a resistor chain. It is recommended to use individual power supplies for biasing of the MCP stack and the delay-line anode.
The baking limit for UHV applications is specified as 150°C.

## 2.3 Position Encoding

The position of the detected particle/photon is encoded by the signal arrival time difference at both ends for each parallel pair delay-line, for each dimension independently. While the signal speed along the delay line is close to speed of light in vacuum, one can define a perpendicular signal speed v given by the pitch of one wire loop (typically 1mm) and the time, which a signal needs to propagate though this loop. This defines the single path propagation "time" 1/v, given in ns/mm.
The corresponding ends of the delay-lined for each dimension are located on the opposite corners of the array (rear side). The electrical resistance of each wire is between 5 and 100Ω end-to-end, depending on the size of the delay-line and the wire type used. Corresponding ends of wires can such be identified. The four (or six) wire pairs from the delay-line ends of each layer have to be connected from the corner contacts of the anode to vacuum feedthroughs by a twisted-pair wire configuration (both wires of a pair must have equal lengths, within 5mm). From the feedthroughs the signals must be transmitted (after DC-decoupling) to a differential amplifier or signal transformer via twisted pairs.
The difference between the signal arriving times at the adjacent ends of each delay-line is proportional to the position on the MCP in the respective dimension. The sum of these arrival times is constant (within the time resolution of about one ns) for each event. The time sequence of the signals can be measured by two time-to-amplitude converters (TAC) or an n-fold time-to-digital converter (TDC). n is at least 4 or up to 7 (**Hexanode** with separate timing channel). As time reference (start of the TDC) the signal on the MCP back or front side can be used.

For the **DLD** detectors, the digital encoding to receive a 2d digital image (X/Y) is

$$X = x1 - x2 \quad \text{and} \quad Y = y1 - y2 \qquad \textbf{Equation 2.1}$$

with x1, x2, y1 and y2 denominating the TDC channel number for each event (see next chapter).
The fast timing signal picked up from an MCP contact or, in the case of a pulsed particle/photon source, a "machine trigger" signal can serve as time reference. The single path signal propagation time on the delay line is about 0.71ns/mm for **DLD40,** 0.98ns per mm for **DLD80** and 1.25ns per mm for **DLD120**. Thus the correspondence between position and time in the 2d image is twice this value: about 1.42ns/mm, 1.96ns/mm or 2.5ns/mm, respectively. Note that these numbers are only accurate within 5% and are slightly different for each dimension. In order to calculate the position in mm from the digital X and Y values you have to take into account the bin width of your TDC and the single path propagation time 1/v for the respective layer.

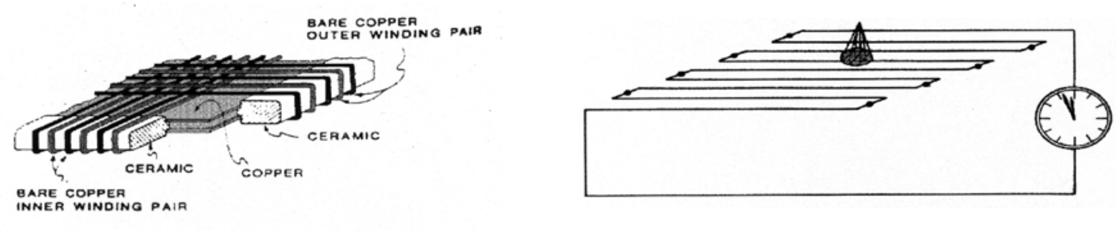



**Figure 2.1: Operation principle of the delay-line-anode**

The **Hexanode** has an additional layer. It is possible to calculate the two-dimensional particle position from the signals of any two layers. The signals from a third layer serve as a redundant source of information for cases where signals are "lost" due to electronic dead-time (multiple hit events), non-continuous winding schemes (anode with central holes) or non-perfect electronic threshold conditions/damping on special very large delay-line anodes.

If you mount the anode to your MCP set with the wires of the innermost layer aligned with respect to the desired up/down direction in your digital screen image (i.e. Y-direction) and if you follow the connection scheme in the next section, the position calculation can be done with following codes:

The position in a hexagonal coordinate frame is coded by the arriving time differences from signals in opposite corners of the anode.

$$u = (x1 - x2) * d1$$
$$v = (y1 - y2) * d2$$
$$w = (z1 - z2) * d3 + o$$

**Equation 2.2**

If $1/v_i$ is the single path signal propagation speed for a delay line layer I ($v_i$ is slightly different for each layer) then $d_i$ is given by

$$1/d_i = 2\, v_i * \Delta t$$

**Equation 2.3**

$\Delta t$ is the TDC channel width. $d_i$ must be precisely known to make the images obtained via different layer combination coherent. o is an offset value that shall unify the "time difference zero" of all three layers, i.e. it must be chosen so that geometrically the position lines for calculated u, v, w have a common crossing point, e.g w must be zero when u and v are zero.
For the **HEX80** approximate values for $v_i$ are 0.737, 0.706 and 0.684mm/ns, from inner to outer layer (u, v, w). o differs from anode to anode and is close to zero unless the connection cables have varying length.

To achieve optimal results $v_1$, $v_2$, $v_3$ and o must be calibrated for each delay-line by using acquired data (off-line).
The hexagonal frame can be transformed into a Cartesian coordinate system by the following equations using only two of the hexagonal coordinates respectively:

$$Xuv = u + Ox$$
$$Yuv = \frac{1}{\sqrt{3}}(u - 2v) + Oy$$
$$Xuw = Xuv$$
$$Yuw = \frac{1}{\sqrt{3}}(2w - u) + Oy$$
$$Xvw = (v + w) + Ox$$
$$Yvw = \frac{1}{\sqrt{3}}(w - v) + Oy$$

**Equation 2.4**

Ox and Oy are offsets.

For detectors with central hole, the gaps in the wiring have to be taken into account. Please contact **RoentDek** for the program codes appropriate for your detector.

The X and Y positions can be calculated from any combination of these equations. If for a given event more signals than from the minimum of two layers are available, it is recommended to choose signals from those two layers where the positions are most distant from the respective delay line ends (and gaps).

**Timing information:**

In order to determine the time difference between an outer time marker and the particle impact, the signal at the MCP contact can be used. But it is also possible to deduce the particle impact time from the delay-line signals:
If the MCP signal is used as the start of the TDCs, the "time sum" values

$$\begin{aligned} sumx &= x1 + x2 \\ sumy &= y1 + y2 \\ sumz &= z1 + z2 \end{aligned} \qquad \textbf{Equation 2.5}$$

are constant within the time resolution (less than one ns) for all positions. Thus it is also possible to deduce the particle impact time from these time sum values. In order to achieve a high resolution one should take into account that the time sum value on a layer varies slightly with the position on this layer in a fixed pattern. Please contact **RoentDek** for advice how to incorporate that into the code.
Even if the particle timing is not of interest, the time sum values can be used to verify a proper detector function.

## 2.4 Assembly of the MCP-Detector

The assembly should take place under clean and dry conditions.

### *2.4.1 List of Detector Assembly Parts*

- ceramic rings, partially metal coated (for **DLD40**, **DLD80** and **HEX80**)
- two multi-channel plates, selected for chevron configuration, matched in resistance
- metal spring clamps (for **DLD40**, **DLD80** and **HEX80**)
- plastic screws M3 with nuts (for **DLD40**, **DLD80** and **HEX80** only during assembly of the MCP holder)*
- 1 delay-line anode
- Assorted small parts for cable connections

You will usually receive the detectors pre-assembled. For **DLD40**, **DLD80** and **HEX80** the MCP holder with rear ceramic ring is placed on the delay-line anode, it is fixed by the retractable "shields" in a position that should be resumed after assembly of the MCP stack. Please observe the relative angle of the metallization structure and remount the MCP stack, after assembly, so that the rear ceramic ring is in about the same orientation as before (shown in Figure 2.2).

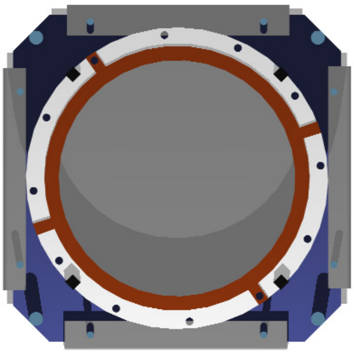


**Figure 2.2: Orientation of the rear ceramic ring on the Delay-line assembly (DLD40, DLD80 and HEX80)**

* For **DLD120** and **HEX120**: 6 Vespel M3 screws and 3 plastic M3 rods (only during assembly of the MCP holder)

All parts, especially the MCP and the wire anode structure should be handled with care. The MCP surfaces are very sensitive and should never be touched or scratched. Also the wire array is very delicate. The ceramic rings should not be exposed to mechanical or thermal stresses. Please read the whole assembly section before starting the mounting.

### 2.4.2 Preparation

1. Verify with an Ω meter that no dust particles have electrically shortened the anode wires. The anode contains one pair of wires for each position direction. Neither the two wires of one pair nor the wires of the x and y-direction must be shortened. Also verify that there is no electrical connection between the wires and the holder plate. Dust particles can be removed by gentle blowing with dry air. Check the resistance of each of the 4 wires. From one end to the other it should be around 5Ω for the **DLD40**, 12Ω for the **DLD80**, 17Ω for the **HEX80**, 25Ω for **DLD120** and about 40Ω for the **HEX120**. These are the values for the standard **RoentDek** anodes. If you have ordered and received a special type, the resistance might be different. Note, that even after testing for the absence of a short between wires, at any time, after assembly, installation or after biasing the detector, a metallic dust particle can short signal and reference wires. If such a problem persists contact **RoentDek** for advise. For **DLD120** or **HEX120** please continue with (4).

2. Remove the ceramic ring from the delay line. Two of the shields can be retracted to liberate the stack after the M2 screws are loosened. Note, that the shields must not touch any contacts on the ceramic rings and that the spring clamps that hold the stack together are mounted with about 45° angle with respect to the delay line so that they are not touching any metal part. This orientation has to be resumed when re-assembling the detector.

3. Optionally: a mesh can be glued, soldered or spot-welded directly onto the front side of the *front* ceramic ring, such being at a position of 1.5/2mm in front of the MCP surface. If you plan to solder a mesh on the ring you may order a different ring type from **RoentDek** where the metallization is already coated with solder. Be aware that this can affect the UHV/baking specifications of the detector.

4. Prepare the connection cables for the MCP detector and the delay-line anode. If you have ordered the option with feedthrough you should have received these connection cables. You need at least 11 (HEX: 15) cables: 8 (12) cables are used for connecting the anode wires, with each 2 cables forming a cable pair. For connecting these 8 (12) cables to the delay line special 2mm connector pins are provided. The two cables of a pair must have equal length within a few mm. The pair must be twisted at least 3 turns per 10cm to form a well-transmitting twisted pair cable line. Three other single cables are needed for "MCP front", "MCP back" and "Holder" which is the metal anode body (see also next section). A fourth single cable can be used for a mesh.

**Figure 2.3: Cables for holder and wires DLD40, DLD80 and HEX80**

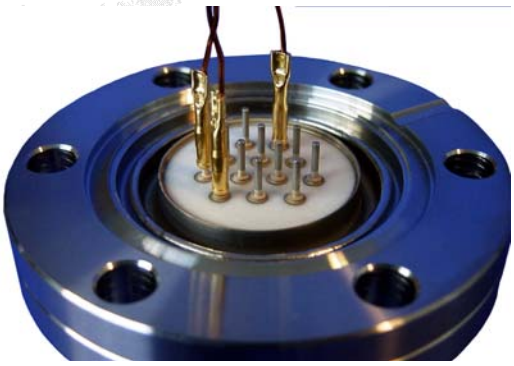


**Figure 2.4: Anode connection at the FT12 flange**

5. For **DLD40**, **DLD80** and **HEX80**: The cables for the MCP connection can be soldered or spot-welded directly onto the metallization of the ceramic rings or clamped to the ring with special M2 nuts and screws. If soldering preferably use the metallization strips which are not located at a hole of the ceramics. Do that *before* mounting the MCP. Alternatively a set of special M2 nuts with short M2 screws is provided for clamping, or special spring clamps that can be placed between the rings at the position of a metallization on a hole. Contact one side of each ring with a cable to bias “MCP back” and “MCP front” respectively. A cable for the “holder” can be connected anywhere at the metal anode body or at the connected metal parts
   For **DLD120** and **HEX120**: The cable for the “MCP back” connection can be fixed by a M2 screw to the rear MCP plate. The cable for the “MCP front” connection is clamped to the front ring with one of the M3 Vespel screws (see also chapter 2.4.3.3). A cable for the anode “holder” can be connected anywhere at the metal anode body or at the connected metal parts.

6. You may clean all parts ***except the MCPs*** in an ultrasonic bath for a few minutes with a mild solvent like isopropanol. MCP should only be exposed to a cleaning procedure if they have some surface contamination that cannot be removed by spraying with dry air. Please contact RoentDek for further advise. For MCP general handling see also instructions on the manufacturer’s web sites or in the Appendix of this manual. Touch MCPs only with care along the rim, preferably with gloves. If the MCPs need replacement mount a set with matching electrical resistance only.

### *2.4.3 Now the detector can be finally assembled*

(Preferably under clean room conditions).

#### 2.4.3.1 Connecting the Wires to the Delay-line Anode*

You need the set of 4 (6) twisted pair cables to connect the anode wires. In the four corners of the anode (back side) each pair must be connected to the M2 rods, preferably with the connector pins provided. Mounting the cable in a different way (i.e. by M2 nuts is not recommended. The M2 rods are not secured against torque. If you have purchased the **FT12(16)-TP** adequate cables with adequate connectors on both ends are provided. Use only so much force that the cables are safely connected and are not moving when gently wiggling on the cable. Also connect the anode holder itself with a cable, wherever suitable. This cable has to supply the anode holder potential. Before connecting the cables to a feedthrough it is important to distinguish the cables that connect to both ends of the same delay line wire. These must receive the *same* voltage ($U_{ref}$ or $U_{signal}$ see chapter 2.4.5). If you supply the detector connection via the **FT12(16)** feedthrough, odd and even pin numbers receive *different* potential. Ensure a connection to the **FT12** feedthrough according to chapter 2.4.5.
In order to later have an image on the PC monitor according to a phosphor screen (rear) view, the following connection scheme in the corners is recommended for the **DLD** detectors (rear view of the anode).

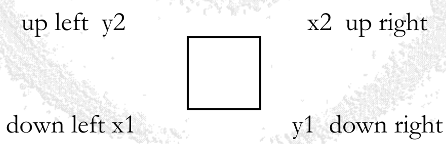



**Figure 2.5: Orientation of x and y position signals**

It is important to first orient the anode so that a thick (12 mm) ceramic rod is placed on the “upper” edge in order to ensure a proper position calibration in the data analysis with **CoboldPC** (see chapter 3.5.3). In this position the sliding shields are left and right.

* Note that the recommended cable connection scheme is the same as for the earlier **FT12(16)+DLATR6/8** combination.

For the **Hexanode**, the following wiring scheme is mandatory to comply with the position computations in Equation 2.4:

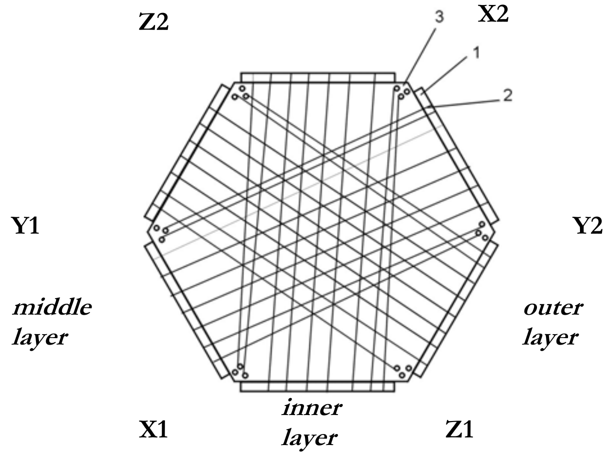



**Figure 2.6: Rear view of a Hexanode with suggested cable connection**

### 2.4.3.2 Assembly of the MCP-stack for the DLD40, DLD80 and HEX80

A cartoon about the assembly of the MCP stack for the **DLD40**, **DLD80** and **HEX80** can be found on our Web-Site in the *MOVIES* section. There you can also find cartoons showing the mounting of the MCP stack to the anode for **DLD40**, **DLD80** and **HEX80.**

First you have to decide if you want to solder the cables for the MCP contacts directly to the contacts pads on the ceramic ring. This is recommended. Even for UHV environment, a small amount of lead-free solder/flux is usually tolerable. In this case remove the screw from the front ring and solder a cable to a pad on each ring.
After soldering the parts should be cleaned.
If you prefer not to solder the cables to the ring, fix a cable with the screw/nut on the front ceramic ring now.

**Figure 2.7: Front ring with cable (DLD40 & DLD80)**

(In the following assembly drawings, no cables are shown)

1. Place the front ceramic ring (metallization on both sides), with the contact for MCP front side pointing upward, with inserted plastic screws, on a flat table:

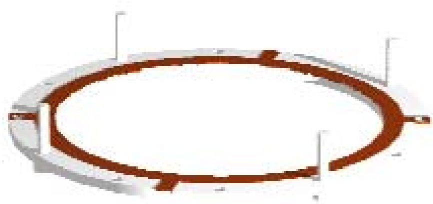


**Figure 2.8: Assembly of MCP-stack - Stage 1 (DLD40, DLD80 & HEX80)**

2. Remove the MCP carefully from their transport package and place them centered onto the metal contact of the ceramic ring. The delivered MCPs are matched in resistance within 10% for direct stacking.
    a. <u>For Burle MCP:</u> there is no intermediate contact ring needed, the MCPs are placed in direct contact. The marks on the MCPs (triangles on the outer rim on one side) should be turned by 180° for consecutive MCPs (the triangles indicate the tilt angle direction of the MCP pores). Note that the marks are only on one side of the MCP.

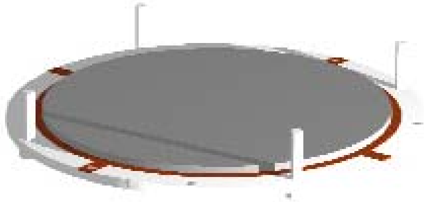


**Figure 2.9: Assembly of MCP-stack - Stage 2a (DLD40, DLD80 & HEX80)**

    b. <u>For Photonis MCP:</u> the thin shim ring must be placed between the MCPs. There is no need for a special tilt angle orientation.

**Figure 2.10: Assembly of MCP-stack - Stage 2b (DLD40, DLD80 & HEX80)**

***It is especially important to avoid that dust particles settle between the MCP during assembly.***
Dust particles can usually be blown away be spraying dry air on the MCP. Touch MCPs only with care along the rim, preferably with gloves. After the stack is piled you may check if it is well centered, adjustments can be done by carefully moving the MCPs on the ring.

3. Place the second ceramic ring (with the MCP back contact facing down) carefully on the MCP-stack. The plastic rods will guide the alignment. Note that the pads of the two ceramic rings should not be directly opposing each other.

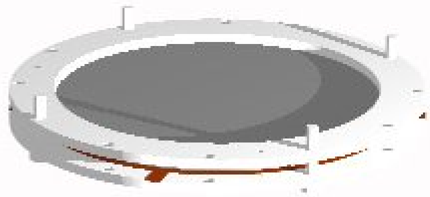


**Figure 2.11: Assembly of MCP-stack - Stage 3-1 (DLD40, DLD80 & HEX80)**

Now fix the stack with the plastic nuts gently and very carefully.

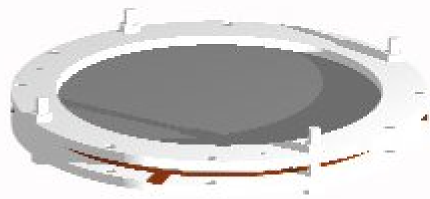


**Figure 2.12: Assembly of MCP-stack - Stage 3-2 (DLD40, DLD80 & HEX80)**

The MCP holder stack can now be finally fixed with 4 spring clamps.

**Figure 2.13: Assembly of MCP-stack - Stage 3-3 (DLD40, DLD80 & HEX80)**

Now remove the plastic screws again. The MCP holder stack can be used as an independent unit.

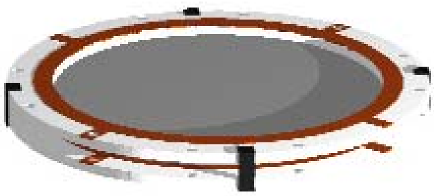


**Figure 2.14: Assembly of MCP-stack - Stage 3-4 (DLD40, DLD80 & HEX80)**

If you did not solder the wire to the MCP back side contact a special spring clamp is provided that can be inserted between the rings at a position with a contact pad on a hole on the back side ring. Make sure again that there is no such contact pad on the upper ring at this position.

**Figure 2.15: MCP stack with spring ring for MCP back cable (DLD40, DLD80 & HEX80)**

4. Now the MCP-stack can be mounted to the anode by inserting it into the butterfly shaped indent of the holder plate and fixed with the movable shields.

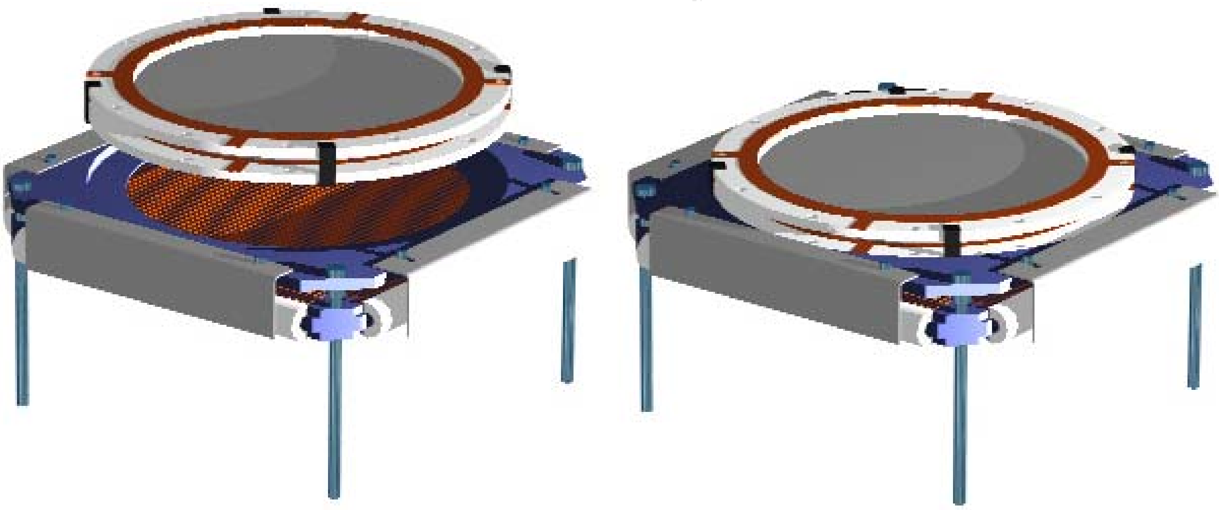


**Figure 2.16: Assembly of MCP-stack - Stage 4 (DLD40 & DLD80)**

***Attention: Excessive force when mounting may result in breaking the ceramic rings.***

Take care that neither the contact cables of the ceramic rings nor the 4 spring clamps have contact with the holder plate. Check with an Ω meter that there is no electric contact between "MCP back", "MCP front" and "holder" plate. There should be a resistance in the $10^7\Omega$ regime between "MCP back" and "MCP front". In the presence of humidity this MCP stack resistance may be less than the default value.

For disassembly reverse all steps.

For the **HEX80**, the same butterfly-shaped MCP holder plate as for the **DLD80** is used. Additionally, a hexagonally shaped intermediate plate connects the standard **DLD80** holder with the **Hexanode**. The shields are replaced by a pair of metal sheets that hold the MCP stack inposition.

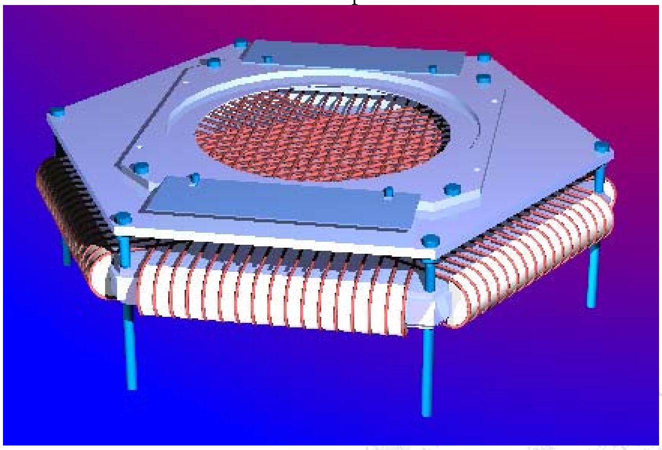


**Figure 2.17: Hexanode with holder**

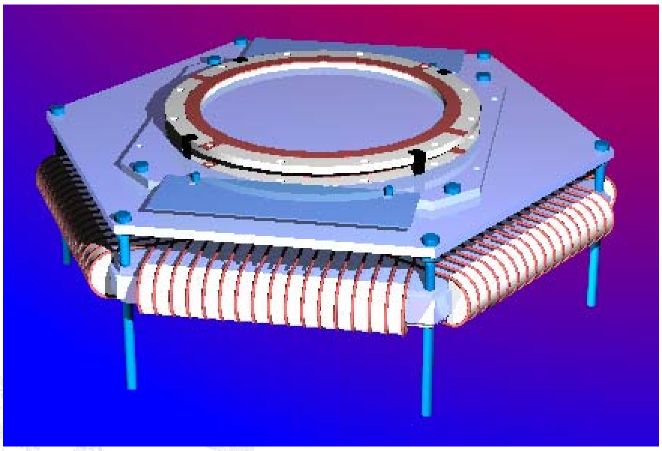


**Figure 2.18: Hexanode with mounted MCP-Stack**

#### 2.4.3.3 Assembly of the MCP-stack for the DLD120 and HEX120

A cartoon about the mounting of the MCP stack for the **DLD120** and **HEX120** can be found on our Web-Site in the *MOVIES* section.

For the 120mm MCP size the mounting is different than for the 40 or 80mm MCP sizes, no ceramic rings are used. Instead the MCPs are fitted between a metal square-shaped rear plate which mates to the delay-anode and a metal front ring. The rear plate and the front ring have indention for the MCP on one side and fix the MCP stack by 6 special M3 screws. The screws are made from (insulating) UHV-compatible polyimide material. M2 rods from the same material are than used to fix the MCP stack to the DL120 anode or any other anode.

1. Place the rear plate with the indention for the MCP pointing upward on a flat table according to the sketch below. Screw the three M3 guide rods symmetrically into three of the six M3 tapped holes. Remove the MCP carefully from their transport package and insert the first one centered into the indention, with the bias angle marker (triangle on the outer rim on one side) pointing upward.

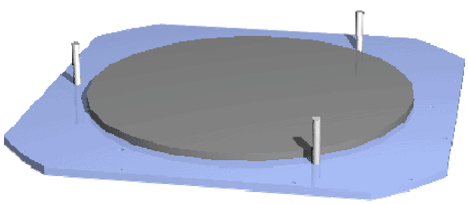


**Figure 2.19: Rear metal plate with one MCP (DLD120 and HEX120)**

2. Place the second MCP carefully onto the first on with the bias angle marker pointing upward and rotated to the first MCP's marker by about 180°. Make sure that the MCPs are well-aligned with each other and are centered in the indention.

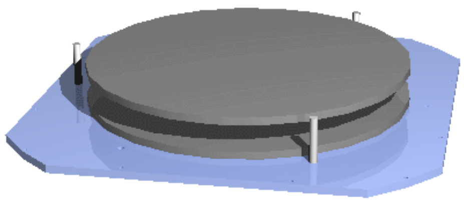


**Figure 2.20: Assembly of MCP-stage 2 (DLD120 and HEX120)**

***It is especially important to avoid that dust particles settle between the MCP during assembly.***

Dust particles can usually be blown away be spraying dry air on the MCP. For MCP general handling see also instructions on the manufacturer's web sites or in the Appendix of this manual. Touch MCPs only with care along the rim, preferably with gloves. After the stack is piled you may check if it is well centered, adjustments can be done by carefully moving the MCPs on the ring.

If the MCPs need replacement mount a set with matching electrical resistance only.

3. Place front metal ring with the indented side facing downward on the MCP. The guide pins will help in the alignment.

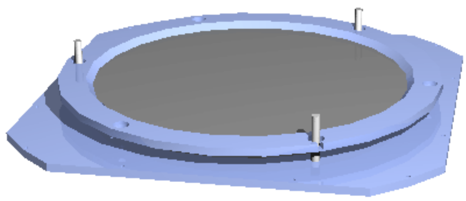


**Figure 2.21: Assembly of MCP-stack - Stage 3-1 (DLD120 and HEX120)**

Now fix the stack with three plastic screws very carefully and only lightly. Due to the indention if the rear plate and the front ring, the MCP will not fall out event if the screws are not entirely tight. Remove the guide pins and add the other three screws. Once all screws are in place fix them again slightly without excessive force except for the screw in the hole with a gap for the contact. Remove the screw from the hole with the gap for the cable, insert the MCP front contact cable and re-fix the screw as tight as the other

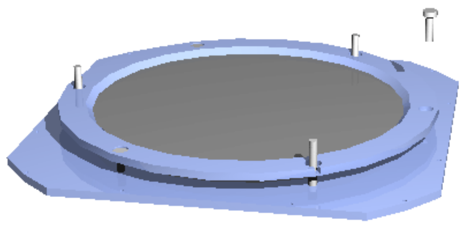


**Figure 2.22: Assembly of MCP-stack - Stage 3-2 (DLD120 and HEX120)**

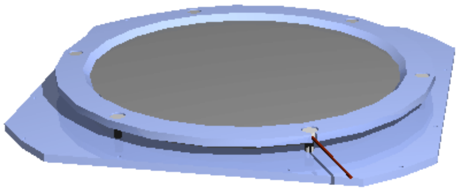


**Figure 2.23: Assembly of MCP-stack - Stage 3-3 (DLD120 and HEX120)**

4. Now the MCP back contact cable can be fixed to the rear metal plate on any of the M2 threads along the edges and the stack can be fixed to the delay-line anode.
   The Vespel M2 rods with nuts have to be screwed into the M2 threaded holes in the corners of the delay-line anode. It is only necessary to recess the M2 rods by 3-4mm into the anode body, so that they are safely fixed.

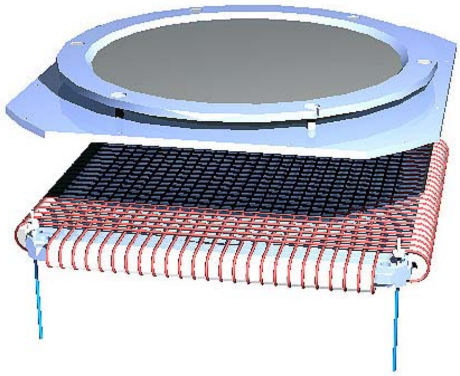


**Figure 2.24: Assembly of MCP-stack - Stage 4 (DLD120 and HEX120)**

Now the MCP stack can be placed onto the rods, the nuts maintaining a distance between the MCP back plate and the upper anode layer. Adjust the position of the nuts so that the distance between the MCP back plate and the anode body plate is about 6mm in all corners.

Now the MCP back plate with the MCP stack can be finally fixed by additional M2 nuts.

### 2.4.4 Mounting the Detector an experimental setup

**RoentDek** provides a product option for each detector type to mount it to a flange of "Conflat" norm. The size of the flange is given by the detector dimension. If you are not using this option you may instead use the outermost threaded holes (in the "holder") to mount the detector to your experimental setup. Please note that the holder plate will usually carry a much different potential than the mating part of your experimental setup. A proper insulation is needed.

***Notice: It is important to have at least 2 mm distance between any part of the detector and any other metal part of a setup, unless the voltage difference is small during operation.***

As a thumb-rule, you need at least 1mm distance for every 2000V of voltage difference, in the absence of sharp edges or tips.

***If this is not fulfilled discharge can occur during operation with the consequence of possible damage of the detector or the electronics. The vacuum port where the detector is mounted must have at least 100mm open diameter for*** **DLD40*****, 150mm for*** **DLD80*****, 200mm for*** **HEX80** ***and*** **DLD120** ***and 250mm for*** **HEX120*****.***

Cartoons about the mounting of the **DLD** and **HEX** detector to the mounting flange can be found on our Web-Site in the *MOVIES* section.

Mount the stainless steel support ring with the 4 threaded bolts to the delay-line anode (see Figure 2.24). You can may use one of these thread bolts to supply the anode holder voltage with an appropriate cable. Mount the support ring with 8 ceramic insulators and 8 nuts on the M3 threaded bolts on the flange. Adjust everything parallel to the flange and fix the nuts.

**Please note that the ceramic insulators will not tolerate excessive force when fixing the nuts.**

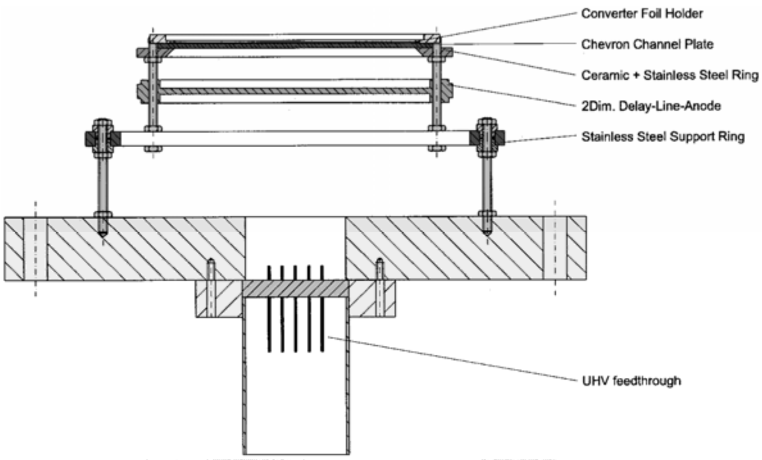



**Figure 2.25: Sketch of the detector (flange mounting option)**

### *2.4.5 Connecting the Signal Cables to the Feedtrough Flange*

Unless you have purchased the flange mounted option you will usually receive a spool of Kapton isolated cables which can be used in UHV. You need to produce single and twisted-pair cables of sufficient lengths as described before in this section. The cables should only be as long as necessary. Especially the quality (amount of "ringing") of the MCP signal is usually better if the connection cable is very short.

For the **DLD** connect all 8 signal cables from the delay-line and the other 3 or 4 high voltage cables (MCP front, MCP back, anode holder plate and optional mesh) from the vacuum side of the feedthrough flange. Figure 2.26 shows the flange from the vacuum side.

| Pin number **FT12** flange | Function | **FT12-TP** channel | **ART19** channel | TDC Channel **HM1 / TDC8** |
|---|---|---|---|---|
| No. 1 | X (e.g.Mesh) | | | |
| No. 2 | MCP front | No. 1 | No. 1 or No. 2 | "start"/common |
| No. 3 | MCP back | No. 2 | No. 1 or No. 2 | "start"/common |
| No. 4 | Anode Holder | | | |
| No. 5 | $x_1$-signal | No. 3 | No. 3 | x1 / 1 |
| No. 6 | $x_2$-reference | (No. 4) | (No. 4) | |
| No. 7 | $x_2$-signal | No. 4 | No. 4 | x2 / 2 |
| No. 8 | $x_1$-reference | (No. 3) | (No. 3) | |
| No. 9 | $y_1$-signal | No. 5 | No. 5 | y1 / 3 |
| No. 10 | $y_1$-reference | (No. 5) | (No. 5) | |
| No. 11 | $y_2$-signal | No. 6 | No. 6 | y2 / 4 |
| No. 12 | $y_2$-reference | (No. 6) | (No. 6) | |

**Table 2.1: FT12-TP pin description for DLD detectors**

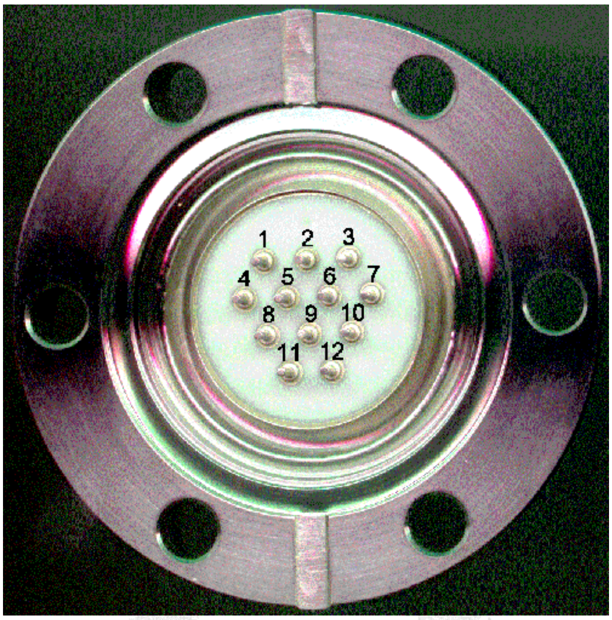



**Figure 2.26: CF35-12-pin-feedthrough flange (vacuum side).**
**The slit in the shielding on the air side of the connector has to point up.**

For the **Hexanode** the 12-pin feedthrough is used to connect only the delay-line wires. For the connections to Holder, MCP front, MCP back (and X) other feedthroughs must be used, for example the 4-fold MHV feedthrough on CF35 as supplied by **RoentDek** (in **FT16** packages) or individual coaxial SHV or MHV feedhroughs.

| Pin number **FT12** flange | Function | **FT12-TP** channel | **ATR19** channel | **TDC8** channel |
|---|---|---|---|---|
| No. 1 | $z_1$-signal | No. 1 | No. 7 | 5 |
| No. 2 | $z_2$- reference | (No. 2) | (No. 8) | |
| No. 3 | $z_2$- signal | No. 2 | No. 8 | 6 |
| No. 4 | $z_1$- reference | (No. 1) | (No. 7) | |
| No. 5 | $x_1$-signal | No. 3 | No. 3 | 1 |
| No. 6 | $x_2$- reference | (No. 4) | (No. 4) | |
| No. 7 | $x_2$-signal | No. 4 | No. 4 | 2 |
| No. 8 | $x_1$- reference | (No. 3) | (No. 3) | |
| No. 9 | $y_1$-signal | No. 5 | No. 5 | 3 |
| No. 10 | $y_1$- reference | (No. 5) | (No. 5) | |
| No. 11 | $y_2$-signal | No. 6 | No. 6 | 4 |
| No. 12 | $y_2$-reference | (No. 6) | (No. 6) | |

**Table 2.2: FT12-TP pin description for HEX detectors**

***If a connector pin is too close to the chamber wall or a neighboring pin, this may result in a discharge during detector operation, with further consequences to the electronics. Please give special attention to pins 1 and 2, which can have especially high potential relative to the others. We suggest a test procedure in the "getting started" chapter. However, this test can not verify the absence of a problem between pin 2 (MCP front) and 3 (MCP back). Also, all pins should not be bent outwards and thus get close to the wall. Avoid a too close distance to "ground" (the adapter flange opening).***

Note that the **FT12-TP** connection scheme is identical to that of the earlier **FT12/DLATR6/8** connection scheme however it does not allow to verify the in-vacuum connections via the connector plug.

### 2.4.6 Operation of the Delay-line Detector – General Description

Always evacuate the vacuum chamber slowly (50mbar/sec) in the presence of an MCP detector. The maximum recommended operating pressure for the detector is $2\times10^{-6}$mbar) and the MCP should be in vacuum for at least one hour before applying bias.

***However, after first installation a startup procedure is required. Please refer to the chapter "getting started". Generally, it is recommended to apply the bias voltages slowly (100V/sec), also to the anode, in order to avoid possible damage to electronic modules connected. When applying voltage to the detector never exceed relative voltages of 100V between the reference and signal wire and of 500V between holder and signal wires or holder and MCP back.***

The MCP can be operated with a relative bias voltage up to about 1300V for each MCP in the stack for MCP with L/D 60:1 or 80:1 (only 1000V per MCP with L/D of 40:1, for 80:1 even higher bias up to 1500V per MCP may be required). Lower relative bias on the MCP often yields sufficient performance and can increase the lifetime of the MCP stack. Higher voltages are not recommended and will only improve the performance if the amplifiers still have sufficient dynamics.
It is advisable to control the amplifier signals with an oscilloscope when applying voltage (see "getting started"). For supplying the MCP operation voltages it is strongly recommended to use power supplies with current limitation and fast shutdown for protection (as available from **RoentDek**). The optimal potential of the MCP front side with respect to ground depends on the particles to be detected. Ions should be pre-accelerated onto the detector with a potential of -2000V or higher. For most ion species it is suitable to operate the MCP back side on ground potential, thus the front side is in the range of –2kV to –3kV. Electrons should be accelerated to at least 300eV to ensure high detection efficiency. Thus the MCP front should be around +300V or higher with respect to the electron source for low energetic electrons. For UV photon detection the MCP front side potential is arbitrary.

The wire array consists of two double delay-line helical propagation lines (Lecher-line). For each dimension a wire pair is formed by a collection (signal) wire and a reference wire. A potential difference of about +20V to +50V of the signal wire with respect to the reference wire ensures that the electron cloud emerging from the MCP is mainly collected on the signal wires, shared almost equally between both wire layers. The anode holder has to be supplied with an intermediate potential with respect to the anode wires and the MCP back potential to ensure proper charge cloud propagation and spatial broadening in the drift zone between MCP and anode wires. The optimal voltage depends on the distance between the MCP holder plate and the anode wires.
Typically the wires should have about 300V more positive potential than MCP back side and the holder about +150V with respect to the MCP back.

Typical voltage settings are

| | Ion or Photon Detection | Electron Detection |
|---|---|---|
| MCP front | –2400V | +300V |
| MCP back | 0V | +2700V |
| Anode holder | 0V to 250V | +2700V to +2950V |
| Reference wires | +250V | +2950V |
| Collecting (Signal) wires | +300V | +3000V |

**Table 2.3: Detector voltage settings**

Avoid penetration of strong external electrical and magnetic fields into the electron cloud drift region (between MCP and wire anode). Electrical fringing fields can produce image distortions, magnetic fields (> 50Gauss) disturb the proper charge cloud broadening and will lead to malfunction of the anode.

When applying voltage to the MCPs most high-voltage power supplies have a too low input resistance (also the **RoentDek** power supply). Then it is possible that when you increase the MCP front voltage to –2kV the back voltage also increases although the high voltage power supply for MCP back is set to zero. This effect (the MCP back potential is "drawn away") usually disappears when the power supplies are switched to different polarity. It is anyway suitable when MCP front and back need to be set to the same polarity to use only one high voltage power supply for the MCP stack and a resistor to ground for the lower voltage end. The dimension of the resistor depends on the MCP stack resistance $R_{MCP}$ and should be of value

$$R = \frac{(2M\Omega + R_{MCP}) \times U_{MCP\ front}}{U_{MCP\ back}}$$ **Equation 2.6**

| | | | |
|---|---|---|---|
| Example: | desired MCP front voltage | +300V | |
| | desired MCP back voltage | +2700V | |
| | MCP stack resistance | 53MΩ | |
| | Resistor of choice | 10MΩ | (55MΩ x 300/2700) |

Alternatively it is possible to connect a 10MΩ (typical) resistor between "MCP front" and ground. This allows then to set desired voltages, however voltage setting on MCP front and back may influence each other and have to be adjusted iteratively.

By applying the anode-plate potential via a charge sensitive preamplifier, the total MCP-charge for each event can be extracted and recorded.

## 2.5 The FT12(16)-TP

The **FT12(16)-TP** feedthrough option allows the customer to use his own amplifier and timing discriminator/recording electronics to operate a **RoentDek DLD** (or **HEX** detector, see also **FT16-TP**). An example for an adequate amplifier/CFD is the **RoentDek ATR19** or the **FAMP1/8** (amplifier only).

The **FT12-TP** contains the standard 12 pin feedthrough **FT12** for the in-vacuum cables and the airside connector plug. The plug provides adequate RC decoupling circuits and special transformer circuits to turn the differential delay-line signals into single-line signals with 50Ω line impedance on Lemosa-type (Euro norm) output connectors. The detector voltages are supplied via input cables (SHV):

| | |
|---|---|
| $U_{Reference}$ | Reference wires, |
| $U_{Signal}$ | Signal wires, |
| $U_{Holder}$ | Anode-plate (Holder), not in hex-version |
| $U_{MCP\ front}$ | MCP front, not in hex-version |
| $U_{MCP\ back}$ | MCP back, not in hex-version |
| $U_X$ | is optional, i.e. can be used for a mesh in front of the detector, not in hex-version. |

**Figure 2.27: FT12-TP Plug**

**Figure 2.28: FT12-TP Plug (hex version)**

The "raw" (unamplified) signals from the MCP contact and/or delay-line contacts are delivered to the six Lemosa-type connectors. The numbers on the respective connectors correspond to the signal outputs from the detector according to Table 2.1 (or Table 2.2 for hex version).

***Notice: It is not recommended to connect these outputs to any unit which was not specified by RoentDek for this purpose without protecting the input of the unit.***

Adjustable resistors (potis 0-200Ω) for "Holder" and "X" contact allow to improve signal quality from the MCP. A third adjustable resistor inside a lemo connector (***Lemo Terminator***) is likewise used either on the MCP front (#1) or MCP back (#2) output. The other output is then used to receive the MCP signal. Depending on the environment of the detector and the in-vacuum cable lengths, ringing of the MCP signal may appear. The potis shall be used to optimize signal shape. Note that the signal outputs from MCP front and back can have different shapes.

For the Hexanode, the high voltage inputs and signal outputs/terminations on MCP front, MCP back contacts and "Holder" (and optionally "X") are supplied via individual ***HF-signal-de-coupler plugs*** (as in Figure 2.29. A fourfold MHV feedthrough on CF35 flange completes this to the **FT4** timing detector feedthrough option (as for **DET40**).
The Hex version of the **FT12-TP** and the **FT4** form the **FT16-TP** for the HEX detectors.


**Figure 2.29: Single HF-signal-de-coupler plugs, with terminator (left), with lemo cable to NDLATR8 (right)**

On demand the FT12-TP can be delivered without internal pulse transformers for the delay-line signal. In this case there are two lemo outputs for each delay-line end and the numbering is according to the pin numbers on the feedthrough plug (see Table 2.1 and Table 2.2). In this version a proper amplification of the signals from the delay-line anode require the use of differential amplifiers.

It is possible to operate this feedthrough version (**FT12d** or **FT12d-hex**) with an **ATR19** module, selecting adequate input setting for differential amplification.

***Attention: Although the outputs of the* FT12(16)-TP *are delivered with DC-coupling to ground potential, a discharge on a detector can damage the electronics which is used to analyze or amplify the signals.***

## 2.6 The ATR19 Amplifier & CFD Module

This is (Version 6.2.90.5)
Please look for updates of this manual at

http://roentdek.com/mitte/doppel/links/fuer_manu/detect_manuals/det_manuals.htm

The readout of the MCP and delay-line anode signals requires amplifying and timing (discrimination) circuits. Since a very high time precision is needed, the "constant-fraction" discrimination (CFD) method is recommended to produce digital signals like NIM or ECL signals for a time measuring device, e.g. a time-to-digital converter (TDC).
The **ATR19** module was especially designed for that purpose. It hosts up to four **DLATR** differential timing amplifier & CFD boards, each with two independent channels. It provides all input/output connectors, level controls and a 100-125V/200-250V AC power adapter.
The module is delivered in two versions, one for use with the **DLD** detectors (**ATR19-6**, 3 boards with 6 channels total), and one for the **Hex**-detectors (**ATR19-8**, 4 boards with 8 channels total). Each version can either provide the timing signals as NIM or differential ECL level, e.g. **ATR19-8-NIM** or **ATR19-8-ECL**, depending on the input requirements of the time measuring device.*
The amplifying stage of the internal **DLATR**-board has 200MHz band width and with differential 100Ω input impedance, DC coupled. However, the **ATR19** in the standard version contains capacitors for AC-coupling of the inputs.

* Unless otherwise specified you will automatically have received the **ATR19** version for your specific detector/TDC choice, e.g. **ATR19-6-ECL** for use with a **DLD** and **HM1-B** TDC, **ATR19-8-NIM** with **Hex** detector and **TDC8**.

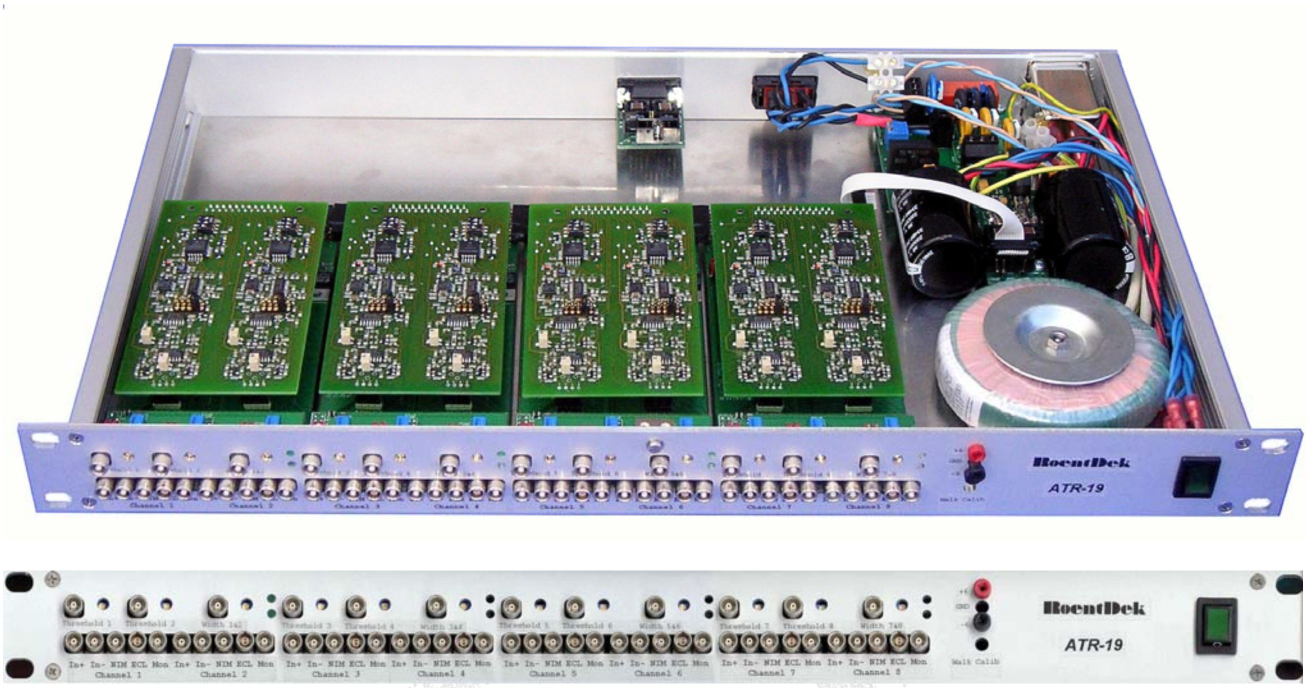



**Figure 2.30: The ATR19 module**

The **ATR19** can also be operated as a non-symmetric (single input) amplifier with 50Ω impedance to ground, inverting (-) or non-inverting (+). The non-symmetric operation is the default mode for the use of a delay-line detector in combination with the **FT12(16)-TP** feedthrough and decoupling plugs.
The outputs of the **ATR19** allow verification of the signals after the first amplification stage on the **DLATR** board ("analog" signal) and of the NIM or ECL timing output signals. Amplification, trigger threshold and timing signal width can be adjusted by potentiometers (default) or externally by DC levels (0 to +5V), the CFD "walk" adjust is automated (push-button). The double-hit dead-time of the CFD-outputs is about 20ns, depending on the input signal width.
Since the amplifier inputs are internally not tolerant to both signal polarities (no bipolar amplification), it is required to feed signals into the inputs of corresponding polarity. Therefore positive input signals (e.g. the signal from the MCP) must be connected via the inverting (-) input and negative signals have to be connected via the non-inverting (+) input. To ensure a proper 50Ω termination of single polarity signals the other side of the internal amplifier input must be terminated to ground (see chapter 2.6.1).

The recommended readout version of the RoentDek delay-line detectors involves the **FT12(16)-TP** plug with internal signal transformers for the delay-line signals.
When the **ATR19** is delivered, channel 1 and 2 are by default prepared for positive input polarity (inverting) and the other channels (used for the delay-line signals) for negative (non-inverting) signal polarity. If the voltages to the detector are supplied in the recommended way the signal from the MCP front or back contact (positive) has to be connected to ch1- or ch2- and the delay-line signals to ch3+ to ch6+ (or ch8+). Changing these settings requires to open the **ATR19** module (see chapter 2.6.5).

### 2.6.1 Signal inputs and amplification

The **ATR19** hosts 3 or 4 **DLATR** boards. Each board has two independent channels for amplification and timing discrimination. Each differential amplifying stage has 100Ω impedance (2x50Ω to ground) and a selectable differential amplification gain between 20 and 100. The gain can be adjusted by a potentiometer ("poti") on each board and channel independently through holes in the top lid of the **ATR19** module.

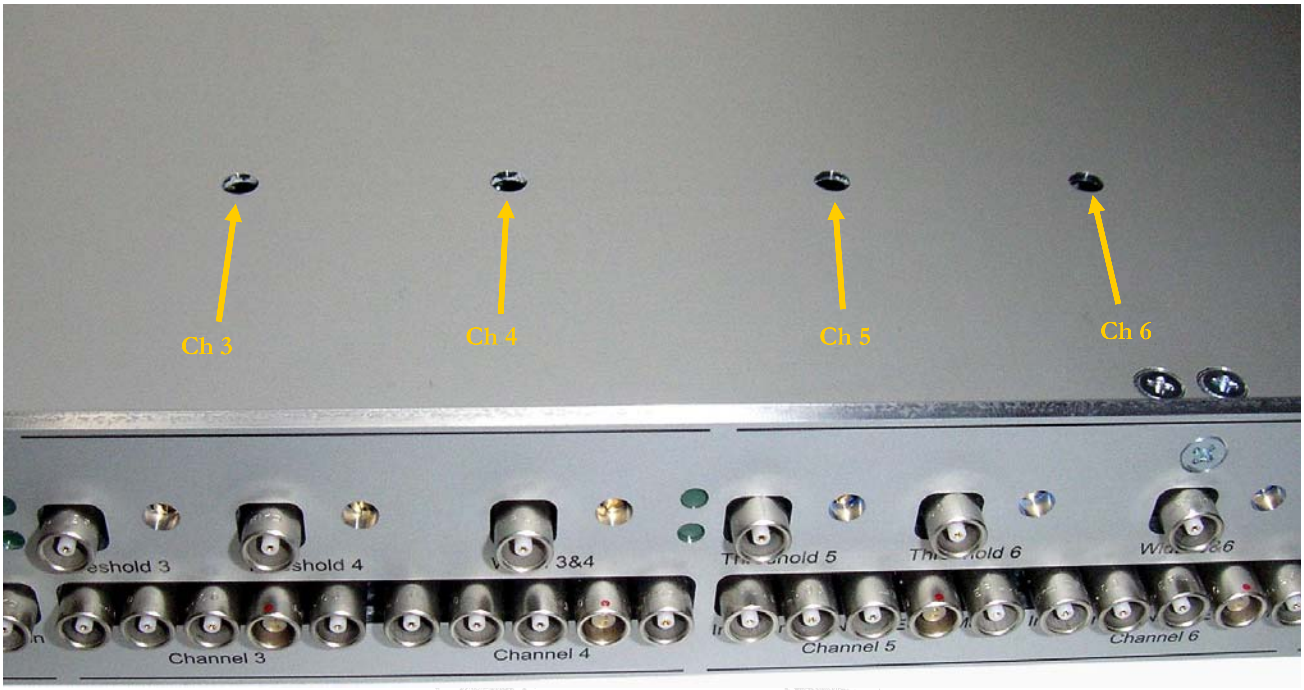



**Figure 2.31: Top lid of ATR19 with holes to reach the gain potentiometers.**
**turn clockwise: amplifier gain is increased, turn counter clockwise: gain is decreased**

The input to each amplifier is formed by a pair of coaxial LEMO connectors with 50Ω impedance to ground (AC-coupled). It is important to note the actual input settings for each individual channel inside the **ATR19**, i.e. the position of the termination jumpers JP5, JP6 (odd channel numbers of the ATR front panel) JP8 and JP9 (even channel numbers):

a) no jumpers: inputs + and – are active (differential) with 100Ω impedance. Please observe the polarity
b) jumper on JP6/JP9: input – (inverting 50Ω impedance to ground); can be used for positive input signals
c) jumper on JP5/JP8: input + (non-inverting 50Ω impedance to ground); can be used for negative input signals

Default settings are: ch1 and ch2 as (b) and ch3 to ch8 as (c)

If you want to change these settings please refer to chapter 2.6.5.

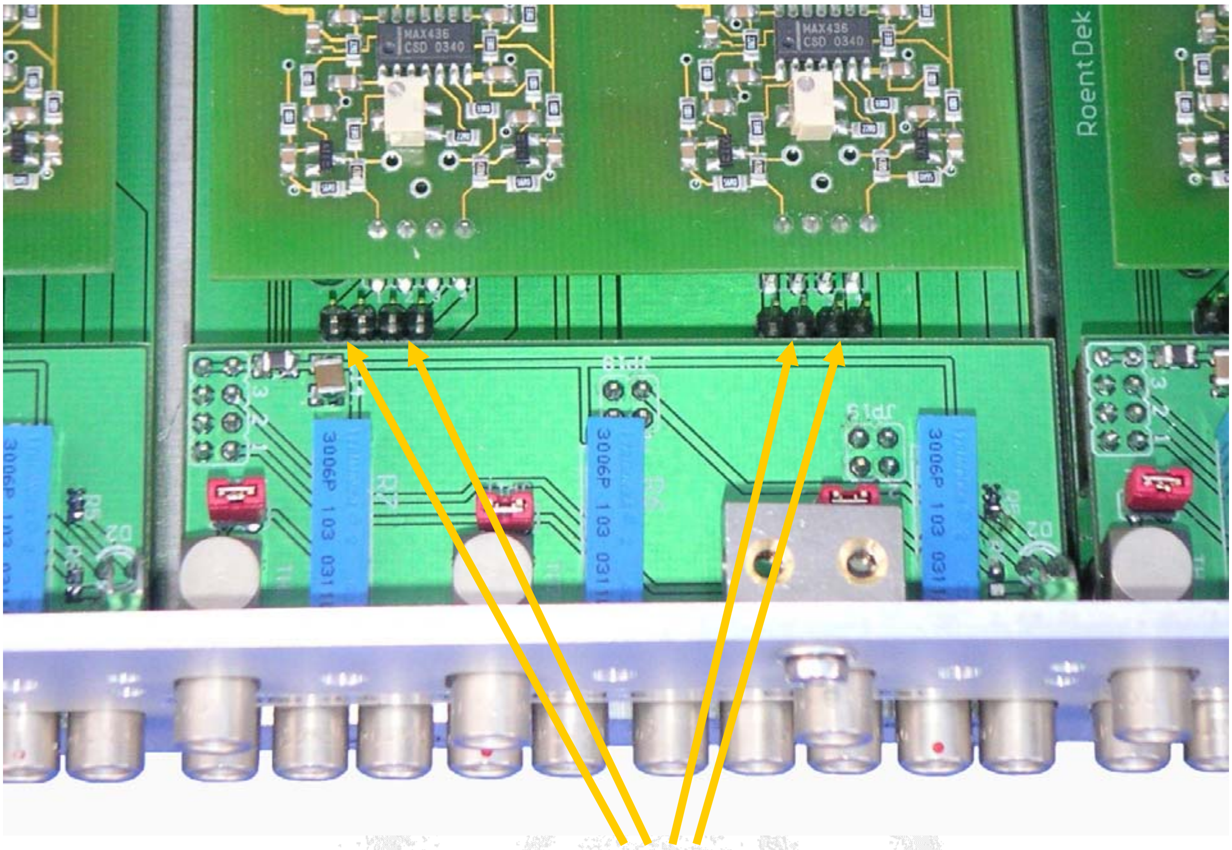


**Figure 2.32: ATR19 with input settings for differential input (no input jumpers set)**

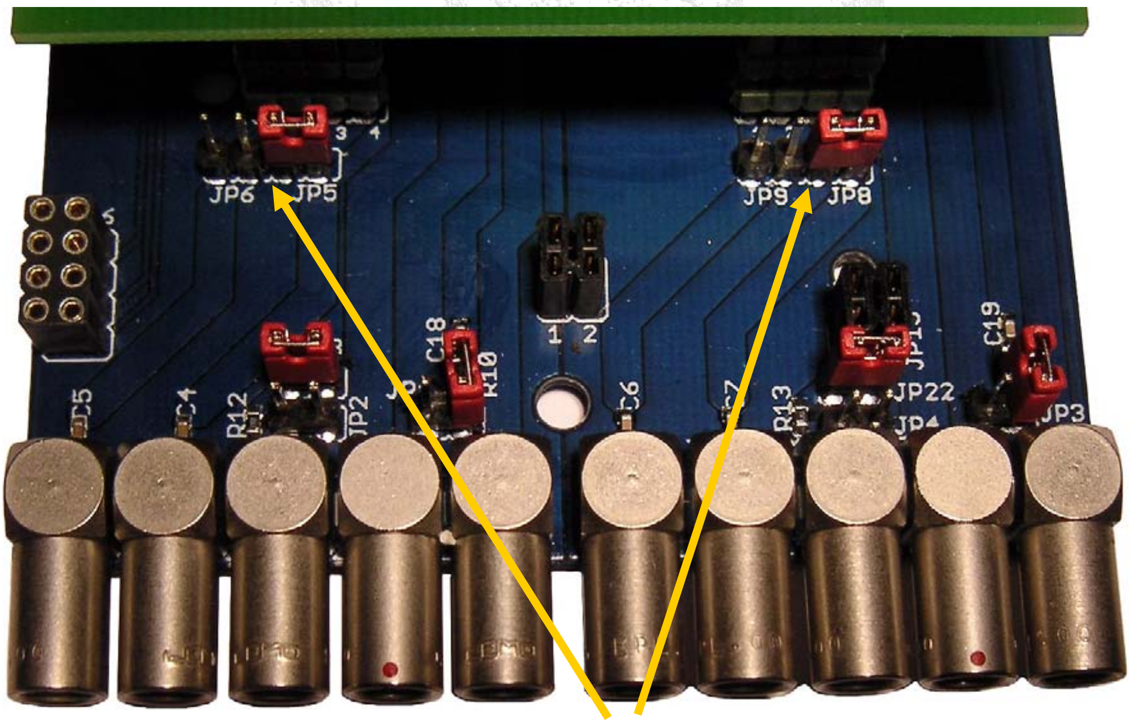


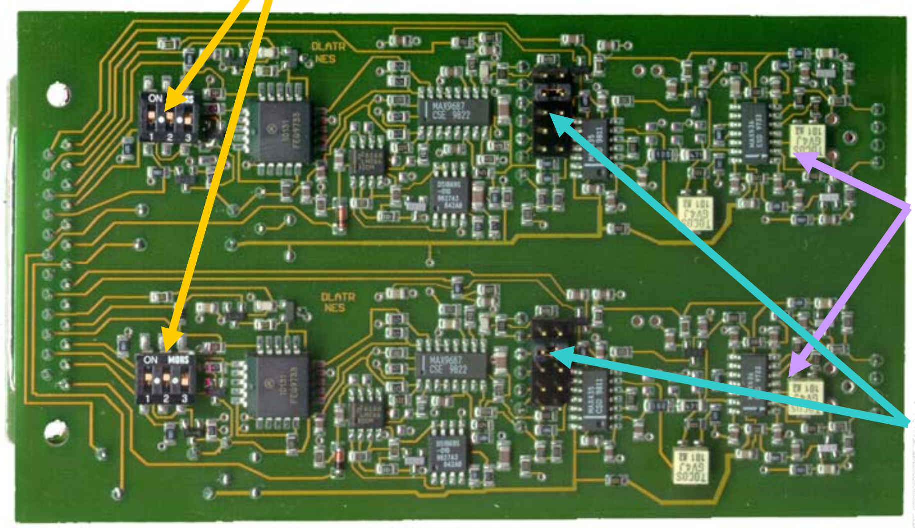
**Figure 2.33: ATR19 base board with input jumper settings for signal input through the "+" LEMO input (50Ω impedance to ground, non-inverting, for negative signal input). The level control board was removed here for better view.**

### 2.6.2 The DLATR board

The **ATR19** module contains 3 or 4 identical **DLATR** boards which can easily be exchanged. To change settings on the boards or exchange the boards please refer to chapter 2.6.5. The amplification gain can be changed without opening the **ATR19** unit.

These 3 switches for each channel define the output level NIM or ECL (number 3 must always be „off")

1: „on" ECL, „off" NIM
2: „on" ECL, „off" NIM



These potis adjust the amplification (70Ω default). Higher resistance corresponds to lower amplification.

These jumpers define the internal CFD-delay. The figure shows the default position (4ns). From top to bottom: 2,4,6,8,10ns

**Figure 2.34: DLATR Amplifier and constant fraction discriminator board**

If you insert a board make sure that the settings on the board are according to the requirements (e.g. signal level NIM or ECL). The switches have to be set according to the desired timing signals levels from the **ATR19** module.

***Always switch off the power when inserting or retracting a DLATR board or changing settings on a board.***

### 2.6.3 CFD controls and outputs

The **ATR19** has the following inputs, outputs and controls for each channel:
2 LEMO connectors In+ and In- for signal input (see chapter 2.6.1)
3 LEMO connectors for signal outputs:

- Mon — analog output signal, i.e. the amplified signal before the CFD-stage.
- ECL — Timing signal output from the CFD circuit (differential ECL). Only for the ECL version of the **ATR19**
- NIM — For the NIM version of the **ATR19**: NIM timing signal output from the CFD circuit. For the ECL version of the **ATR19**: modified ECL- signal level from the CFD circuit for threshold control

2 LEMO connectors and potis for CFD threshold control
1 LEMO connector and poti for signal width control (for both channels of the same **DLATR** board)
2 LED for power verification of +5.2V/-5.2V for each DLATR board

Additionally there is a push button for the walk calibration of all channels, a power switch and reading points for the internal DC voltage supply to all boards on the **ATR19** front panel. The rear panel hosts the mains power input and selection switch (100-125V or 200-250V AC) and an alternative DC power input. Please refer to chapter 2.6.5 if you want to use the DC power input.
Holes in the **ATR19** top lid allow access to the amplification gain potis of each channel.


**Figure 2.35: inputs, outputs and controls of the ATR19 for each internal DLATR board**

The "Mon" output allows a monitoring of the noise level and the signal quality from the delay-line. This output shows the amplified signal according to the input signal and input settings (jumpers JP5, JP6, JP8 and JP9, see chapter 2.6.1). For verifying the signal, the input of the oscilloscope must be 50Ω coupled and the CFD output (ECL or NIM) should be connected to the TDC.

The "ECL" output (only for ECL version of the **ATR19**) provides the timing signal (differential ECL) from the CFD circuit for use with a TDC of according input requirement. The TDC input should provide -2V via 50Ω or form a similar passive differential ECL input.

The "NIM" output provides

| | |
|---|---|
| for NIM version of the **ATR19**: | the timing signal (standard NIM signal) from the CFD circuit for use with a TDC of according input requirement.<br>The signal can be verified on an oscilloscope (50Ω coupling). |
| for ECL version of the **ATR19**: | the modified timing signal from the CFD circuit (ECL -) for monitoring on an Oscilloscope: select AC coupling with large impedance (e.g. 1MΩ) |

The CFD circuit requires the setting of a threshold in order to discriminate noise from real signals. This threshold is set by a DC level of 0 to +5V. This level can be set and controlled internally via the threshold poti for each channel or by directly supplying this voltage through the corresponding LEMO input. A jumper (JP11 and JP12) on the level control board inside the **ATR19** (see chapter 2.6.5) enables the threshold control by the poti (default setting). In this mode (jumper JP11/JP12 set) the LEMO output carries the DC voltage for control with an Ohm meter. If the jumper is removed the poti is disabled and the LEMO connector serves as input for the DC voltage from an external source.

A DC voltage of +5V corresponds to a threshold level of -100mV on the amplified signal (as obtained from the "Mon" output). The ratio between DC voltage on the LEMO connector and the threshold is -50.

The width of the timing signal from the CFD is set by another DC voltage (0 to +5V) which can likewise either be supplied by the corresponding poti (and controlled via the LEMO connector, JP13 set, default) or by directly supplying this DC voltage (JP13 off). Thus the width can be adjusted between 10 and about 100ns. Note that there is only one control for both channels on each **DLATR** board.

If the LED next to each **DLATR** in-/output connector group (on the right side) is not lit please verify the DC voltages on the reading points near the power switch on the front panel. If these are present and within the specified range (see chapter 2.6.4) refer to chapter 2.6.5 (opening the **ATR19**) and insure that the corresponding board is properly installed.
If the DC voltages on the reading points near the power switch on the front panel are not within specification verify the mains power or the external DC supply (see chapter 2.6.4)

Before starting a measurement the "walk" of the CFD on all boards can be adjusted. Usually this is not necessary. However, if you want to calibrate the walk at the beginning of a measurement please follow these steps:

1. Switch off the high voltage on the detector
2. Verify that the noise level is low and that there are no signals from the CFD outputs.
3. Press the walk button for at least 1 second.
4. Wait at least 15s for the automatic walk adjust
5. Apply voltage to the detector and start/resume your measurement

   (see also the "getting started" chapter of the detector manual)

### 2.6.4 Connecting and operating the ATR19

Before connecting the **ATR19** to any cable please ensure that the AC mains power from your socket complies with the setting of the switch on the rear panel.
The setting "230" complies with a mains power of 200-250V AC, 50-60Hz, main fuse: 250mA, time lag
The setting "115" complies with a mains power of 100-125V AC, 50-60Hz, main fuse: 500mA or 630mA, time lag

**Warning: A wrong setting can lead to damage of the ATR19 and/or any connected appliances**

After connecting the mains power through the standard mains cable input on the rear panel turn on the module with the switch on the front panel. Please verify that the DC voltages on the reading points on the front panel are between 5.5V and 6.5V - positive and negative - and that all LEDs are lit. If the DC voltages are not present please check the mains voltage and the main fuse in the mains connector, possibly the fuse must be replaced. The main fuse is located above the mains input socket..

If the main fuse, the switch position and the main power seem to be ok, open the ATR19 top lid and check the separate fuses for positive DC (1.6A, swift) and negative DC (2.5A, swift), possibly the fuse must be replaced. The fuses are located on the voltage adapter board.

If you want to use the external ±6V DC input instead of the internal mains power adapter please follow the steps in chapter 2.6.5 for opening the **ATR19** and remove the inside cable end from the mains adapter to the external input. If you have ordered the **ATR19** for use without AC mains adapter, the cable is already connected in the correct way. For operating the **ATR19** you need to supply DC voltages between -6V to pin 5 and between +6V to pin 8 (2A each), pin 1 and 2 must be grounded.[*]

The **ATR19** can also be supplied externally with ±5.2V (or ±5V) via the same connector and according pins. In this case the jumpers JP7 and JP10 (located under each **DLATR** board) have to be removed.

**Attention:** A few of the earliest **ATR19**, which have been delivered to customers, allow an external DC supply only with ±5.2V (JP7 and JP10 removed). Please contact **RoentDek** to insure that your module can also be operated with ±6V and JP7 and JP10 set.


**Figure 2.36: Rear panel of the ATR19**

Before you connect the input cables to the LEMO connectors on the **ATR19** front panel make sure that the detector voltages are switched off and that you are aware of the input jumper settings for the respective channels and the active input connectors (see chapter 2.6.1).

In the default versions of the **ATR19** ch1 and ch2 (inverting) are reserved for the (positive) MCP signal input via the "In-" LEMO connector, while the other channels are non-inverting for signals from the delay line ends which shall be supplied through the "In+" LEMO connectors. The delay-line signals are negative if the $U_{ref}$ and $U_{sig}$ voltages are provided to the corresponding connectors on the **FT12(16)-TP** as described in the detector manual. If these voltage inputs are interchanged, the signals from the delay-line will become positive and require connection via the "In-" inputs and changing the input jumpers inside the **ATR19** from their default settings (see chapter 2.6.1).

[*] adequate DC supply and cabling can be achieved from the **SPS1** and the **HV2/4** modules with corresponding cable.

Now you may also connect the "Mon", "ECL" and "NIM" outputs for signal verification and/or data acquisition with a TDC, depending on the **ATR19** version that you have obtained (see also chapter 2.6.1).

If you operate the threshold and width controls of the **DLATR** boards via the potis (JP11, JP12, JP13 set) you may now connect the threshold and width LEMO connectors to an Ohm-meter for verification. However, this is not necessary for the **ATR19** operation because these levels must only be checked during the tuning of the detector. Please refer to the "getting started" chapter of the detector manual.
If you operate the threshold and/or signal width DC levels with external voltages (JP11, JP12, JP13 off) you must now connect the corresponding LEMO inputs. Before you can obtain output signals from the CFD output (ECL and/or NIM) these voltages must be set from your external DC source.

### *2.6.5 Opening the ATR19 module*

You need to open the lid of the **ATR19** module **only** if

- you want to change the input impedance or inversion of an amplifier channel,
- exchange a **DLATR** board,
- switch between mains power supply to external DC power,
- change the setting method for CFD signal width or threshold levels,
- modify the CFD output level (ECL or NIM).*

To open the top lid please follow these steps:

1. **Switch off the ATR19 main power and retract any cables from the module.**
2. Remove the 4 screws on the rear panel and the two screws on the top lid. Now the back panel is not fixed anymore to the rest of the housing but connectors in the rear panel are still wired to the main AC adapter board inside the **ATR19**.
3. Without pulling too much on the cables it is possible to retract the rear panel carefully for about 2 cm. Now the top lid can be retracted from its guide slots.
4. Retract the top lid
5. Fix the rear panel to the housing again. It is sufficient to fix the rear panel only provisionally by a couple of screws. When reinserting the screws make sure that they are entering the thread correctly.

**Warning: when the lid is open you should not connect the mains cable to the socket. There is a severe risk of electroshock which might be fatal. The ATR19 shall not be operated with the lid open**

Now you may change settings and jumper positions or exchange **DLATR** boards. To remove a DLATR board pull gently (simultaneously) on the upper and lower edges of the board. When you insert a board again first mate it to the input pins near the front panel then press the 25pin connector gently into the socket and insure that the connections are firm. Make sure that the settings on the **DLATR** board are correct and correspond to the **ATR19** version (ECL or NIM, see chapter 2.6.2).

To close the top lid take off the rear panel again. Insert the top lid into the guiding slots and fix the rear panel tight with the screws.

In order to change the settings for the signal level of timing outputs (ECL or NIM) it is required to remove the level control boards from the base board after loosening the front panel from the housing. This procedure and especially the re-assembly is complicated and not a recommended procedure for inexperienced users. If you want to change your **ATR19** module between ECL and NIM versions please contact **RoentDek**.

These are the following options for the signal output levels on the ECL and NIM output connectors:

Standard NIM: JP1/JP3 and JP2/JP4 set, JP22/JP23 open (as in Figure 2.33)

The timing output from the CFD is present on the "NIM" LEMO connector as standard NIM level.

* although the jumper/**DLATR** settings to modify the ECL/NIM output function for the timing signals is outlined in this chapter it is NOT recommended to change these settings without contacting **RoentDek** for detailed advise on the procedures.

If JP1/JP3 is left open the CFD output signals will also be present on the upper pin (red dot) of the "ECL" LEMO connector as the positive ECL+ level. Please inquire before you intend to use this option.

Standard ECL: JP22/JP23 set, JP1/JP3 and JP2/JP4 open

The timing output from the CFD is present on the "ECL" LEMO connector as standard (differential) ECL levels. The ECL+ level is found at the pin near the red dot and the ECL- at the lower pin. Additionally, the ECL- level is supplied via a 50Ω resistor in line to the "NIM" LEMO connector for control (see chapter 2.6.3)

If JP2/JP4 is set and JP22/JP23 is left open the ECL- level is directly present on the "NIM" LEMO connector without in-line resistor. Please inquire before you intend to use this option.

If you change the settings of your **ATR19** between ECL and NIM you must also change the settings on the **DLATR** boards (see chapter 2.6.2).

# 3 Data acquisition Hard- and Software

**RoentDek** has developed data acquisition concepts for PCs, especially suited for correlated multi-parameter read-out. It consists of the software package **CoboldPC** with plug-ins for certain hardware applications. Currently Windows NT4.0(SP6), Windows 2000 and Windows XP operating systems are supported. Nevertheless **CoboldPC** should also run with Windows 9x and WindowsMe but is not supported and not recommended due to the fact that these operating systems are less "stable" than the supported ones.
For the data acquisition woth **RoentDek** delay-line detectors we have developed I/O cards that communicate with the **RoentDek** hardware or with standard CAMAC-modules via the **RoentDek** CAMAC controller **CCC1**. If you have purchased the **CCC1** please also refer to the separate **CCC1** manual for further reference. Separate manuals also exist for the **TDC8** and the **HM1**.
**RoentDek** is constantly observing the market for other useful TDC system and tries to make them available as components of a complete system.

## 3.1 The Time-to-Digital-Converters (TDC) for PC

**RoentDek** currently delivers two different TDC modules for PC, the **HM1** and the **TDC8**, both suitable as stand-alone units controlled by PC (**CoboldPC** software): The **HM1** can be delivered with an ISA or PCI I/O card that needs to be inserted into the PC. The **TDC8** exists as an ISA-PC plug-in board (product line discontinued) and in a PCI version. Furthermore **RoentDek** can deliver a controller (**CCC1**) and software for standard CAMAC modules.

### *3.1.1 The HM1 / HM1-B*

The **HM1** is based on the GP1-chip of ACAM. It has a common-start input and 4 channels of stop inputs, all differential ECL. The resolution is 133ps or better (adjustable) the range is 14bit or up to 30bit in a special long-range mode (resolution and pulse-pair separation ability reduced). It can be operated in three modes:

a) In the standard mode, *"transparent mode"*, it can detect up to 3 or 4 hits per channel with a pulse pair resolution of about 15ns. The data acquisition (DAQ) in this operation mode is managed by the PC. The DAQ speed is limited to about 18kHz, divided by the number of hits to be detected per channel. The data are stored in list-mode on the PC- hard disc. Two **HM1** modules can be combined to a double module featuring effectively an 8-channel version (with half read-out speed), e.g. for coincident read-out two **DLD** detectors (ISA version only).

b) The *burst mode* is a pre-calculated transparent mode (only available in the **HM1-B** module). The values for x1,x2,y1 and y2 are calculated inside the **HM1-B** Module to x, y and z. x, y and z is then coded into a single 32bit value. The number of bit for x,y and z can be programmed. This 32bit value is store in a small FIFO. Only 1 hit can be detected in this mode. This mode is mostly controlled by the **HM1-B** itself, therefore the DAQ speed is about 150kHz.

c) In the so called *histogram mode* (optional, not for **HM1/T**) the DAQ speed is significantly enhanced (more than 1MHz). The data (only single hits per channel are registered) are stored on the TDC board in a 2D histogram (X and Y position, 11bit) or 3D histogram (X, Y and Z=TOF) memory. After a measuring cycle the content of the histogram can be transferred to the PC in a block for further data treatment. A dual memory bank on the board allows continuous data taking even during data transfer to the PC. The range of the TDC is limited by the histogram partitioning.


Figure 3.1: HM1-B/T and HM1-B front panel


Figure 3.2: PCI interface card

The **HM1-B** is fully compatible to the **HM1** as well as the **HM1/T** model. Additionally to the **HM1** this module has the *burst mode* ability.

Details of the HM1(-B) operation is given in a separate manual.

### 3.1.2 The TDC8

The **TDC8** is based on the LeCroy MTD133B-chip (production discontinued). It has an input for common start or common stop operation and 8 channels. It operates only in "transparent mode" (list mode) and can collect up to 16 hits per channel. The resolution is 500 psec and the range is 16 bit. The input level is NIM. Up to three **TDC8** can be combined. Especially, two of the **TDC8** can be coupled to an effective 15 (ISA) or 16 (PCI) channel single start/stop TDC.


Figure 3.3: TDC8/ISA board

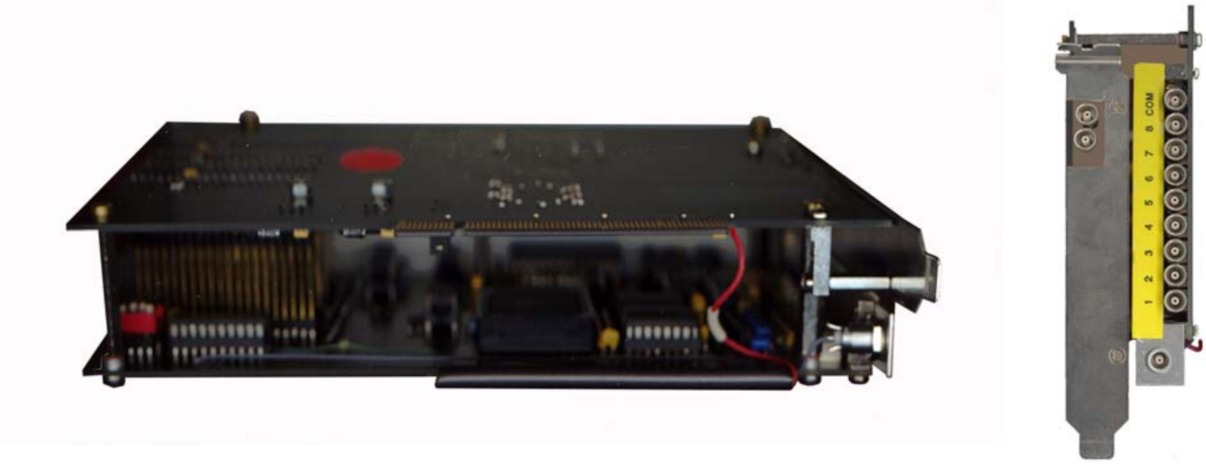



**Figure 3.4: TDC8/PCI board**

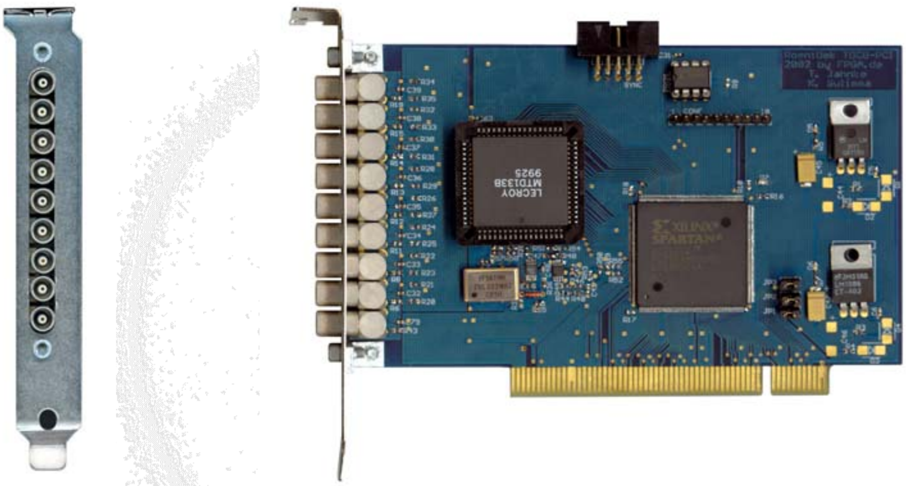



**Figure 3.5: TDC8PCI2 board**

For details of the TDC8 module versions please refer to the separate manual.

### 3.1.3 The CCC1

The **RoentDek**-**CCC1** is a double-width CAMAC Crate Controller. This controller conforms to all applicable CAMAC specifications, except that it controls only station number 1-16. The controller comes with an integrated simple Event-Controller and a PC-IO card.
The main purpose of using the **CCC1** is to allow an operation of the **RoentDek** detectors with commercial CAMAC TDCs, providing favorable features not found in the **TDC8** or the **HM1 / HM1-B**. Please refer to the separate manual.

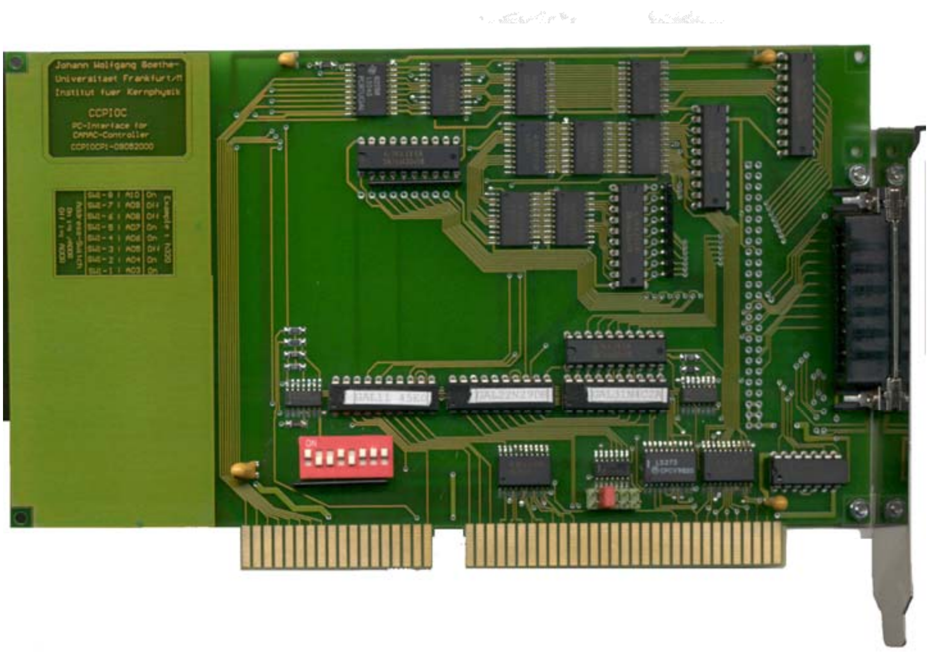



**Figure 3.6: CCC1 IO Card with CCC Module**

## 3.2 Hard- and Software Installation

### 3.2.1 HM1 / HM1-B

- Shut down your computer.
- For your devices safety, turn off the power to your computer and all peripheral devices.
- Drain static electricity from your body by touching the metal chassis (the unpainted metal at the back of your computer).
- For your personal safety, remove the power cord from your computer.
- Remove the cover of the computer as described in your computer's manual.

- If necessary adjust the I/O address setting on the I/O card to a free I/O address (ISA-I/O card version only). Do not forget to adjust *parameter 1* in your .ccf file to this I/O address or set the value of this parameter to 0 to automatically determine the I/O address.
- Locate a free ISA/PCI slot in your computer, and firmly insert the card into the selected slot. To avoid damaging our hardware, insert the card only into a slot with the same bus type as the card. Inserting the card into any other type of slot can damage your card, your computer, or both.
- Firmly secure the adapter with a screw (or clip), to ensure that the adapter is properly grounded to the computer's chassis.
- Replace the cover of the computer as described in your computer's manual.
- Connect the HM1 module with the I/O card using the connection cable. The three green LED on the HM1 module should be on now.

Note that the I/O card is not using SCSI signaling standard, although it has a SCSI socket and cable.
**Major damage to your hardware will occur if you connect a SCSI device to the HM1 interface card or the HM1 to an SCSI controller.**

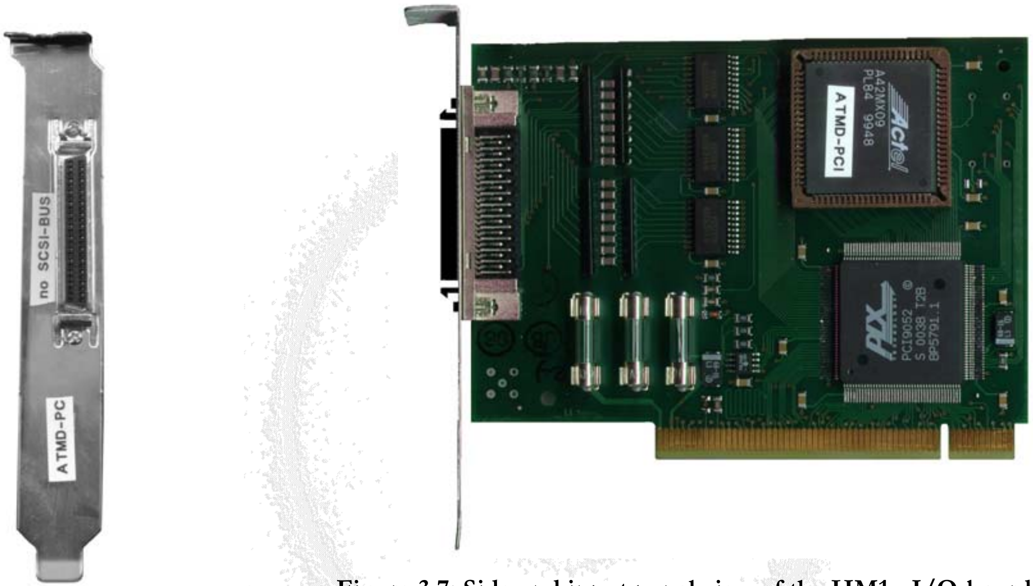



**Figure 3.7: Side and input panel view of the HM1 - I/O-board (PCI)**

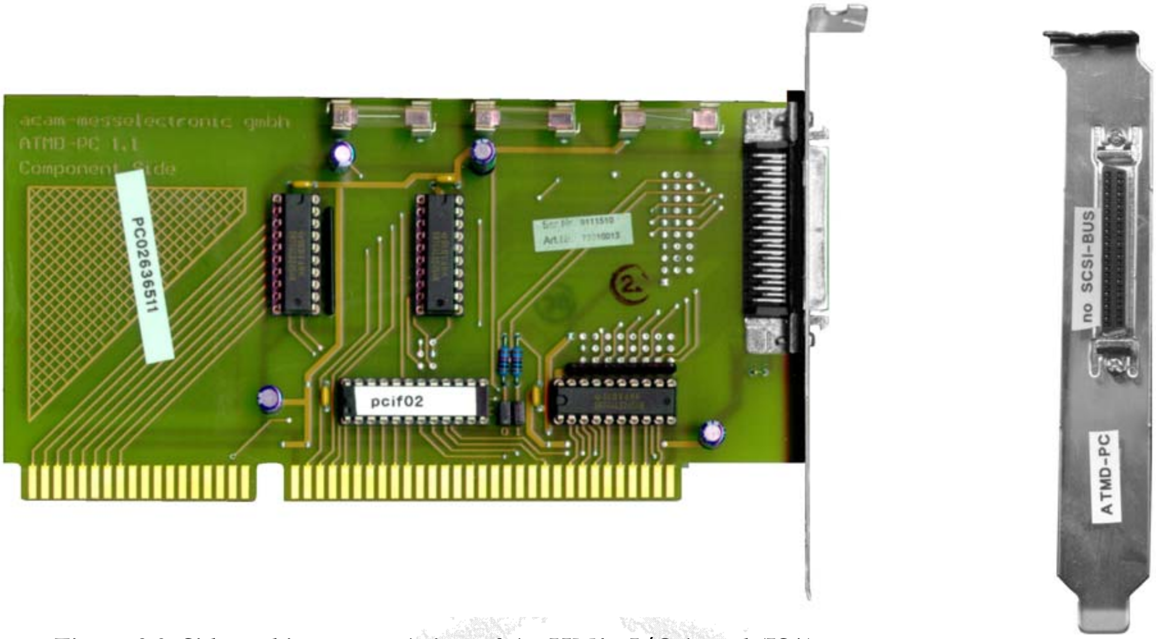



**Figure 3.8: Side and input panel view of the HM1 - I/O-board (ISA)**

For a detailed description please refer to the HM1-B Module manual

### 3.2.2 TDC8

- Shut down your computer
- For your devices safety, turn off the power to your computer and all peripheral devices.
- Drain static electricity from your body by touching the metal chassis (the unpainted metal at the back of your computer)
- For your personal safety, remove the power cord from your computer
- Remove the cover of the computer as described in your computer's manual.
- Adjust the I/O address setting on the card to a free I/O address.
  Do not forget to adjust parameter 1 in your .ccf file to this I/O address. For the PCI-Version set this parameter to 0.
- Locate a free ISA or PCI slot in your computer, and firmly insert the card into the selected slot. To avoid damaging your hardware, insert the card only into a slot with the same bus type as the card. Inserting the card into any other type of slot can damage your card, your computer, or both.
  The **TDC8PCI** needs two PCI slots even though it connects only to one PCI slot connector.
  The **TDC8PCI2** needs only one PCI slot!
- Firmly secure the adapter with a screw (or clip), to ensure that the adapter is properly grounded to the computer's chassis.
- Replace the cover of the computer as described in your computer's manual.

**Note for TDC8PCI(2) board!**
Normally the PCI support in the BIOS is set to "Plug and Play" for operating systems that can handle plug and play components like Windows 2000 or Windows XP. In very rare occasions, the TDC is not working in this mode. In this special

case the TDC card is detected but no data taking can be initiated. A DAQ Software like CoboldPC will therefore give no warning that the TDC could not be detected but the event rate will always be zero.
In this case try to switch the PCI support in BIOS from "Plug and Play" to "None Plug and Play" and try again.

For a detailed description please refer to the TDC8 manual

## 3.3 Connecting the ATR19 with the TDC

Before you finally connect the TDC with the **ATR19** you should have verified that the detector and the **ATR19** unit are operating properly.

### *3.3.1 HM1 / HM1-B*

Connect the TDC start via the short two-pin cable with the **ART19** constant fraction ("timing") output of channel 1 or 2. Use the four long cables to connect the (stop) channels x1, x2, y1 and y2 with the **ATR19** timing output channels 3, 4, 5 and 6 (see Table 2.1).
If you operate two **HM1 / HM1-B** as a double unit, the "start" needs to be supplied to both modules (ISA version only).

### *3.3.2 TDC8 (or other TDCs, e.g. via CCC1)*

*(You should have installed the* **TDC8** *card already in the PC)*

Connect via the short LEMO coax cable the TDC common (start) input with the **ATR19** timing output (NIM) of channel 1 or 2, i.e. the MCP signal. Use the four or six long cables to connect the channels 1 to 4(6) with the **ATR19** timing output outputs 3 to 6(8) (see Table 2.1). This is only the standard connection scheme, other connecting schemes are possible, but the software must then be adapted. The additional channels can be used for other signals to be correlated (i.e. from a second detector or a TOF trigger).
For some multi-hit measurements it can be advisable to additionally connect the MCP signal to a free channel.
For coincidence experiments it is often of advantage to operate the **TDC8** in "common stop" mode and supply a delayed trigger signal to the common input (to arrive after the last significant signal in channels TDC 1-8). Such a signal can be a coincidence trigger, to collect only selected events.
If you operate two **TDC8** modules, both common inputs have to receive the same (trigger) signal. Additionally one TDC channel in each module must receive the same signal to ensure correlation between the modules (by software).
Note, that the TDC8 needs a minimum time difference of about 10ns between start and stop signals (for common start operation only). It is advisable to use cable sets so that the *common* input cable is at least 3m shorter than the other input cables.

### *3.3.3 CCC1*

Besides connecting the CAMAC TDC (see above) you need also to organize the read-out of this TDC as it might not automatically enabled by a start command as the **TDC8** or **HM1**. Also it might by necessary to provide additional signals to the module (i.e. a "gate" signal to validate the start and stop signals).
The recommended mode of "CAMAC event handling" is to send a NIM-Signal to the "Event in" of the **CCC1**. The signal may for example come from the MCP signal ("start") or some event trigger. This will start a readout loop. Be sure to adjust the "wait time", i.e. the internal delay between the event in signal and the moment when the CoboldPC program will actually begin the readout of the CAMAC modules (see separate manual).

## 3.4 Starting the CoboldPC Software:

Once the software is successfully installed you are ready to run a **CoboldPC** session from a pre-acquired list-mode file to make you acquainted with the software. For this it is not necessary to install or operate any hardware. We have provided you with a sample file (list-mode file) that was acquired with the hardware that you have received (or similar hardware) on the CD*. From now on you may also refer to the **CoboldPC** manual as this small section can give only a very brief overview how to get started.
During installation you will select the DAN.DLL and DAQ.DLL files which support the readout of your hardware (TDC or CCC1). These files will be placed in the main Cobold directory. If you want to replace the files please navigate into the directory where you have installed the **CoboldPC** main program, then find the DAN.DLL and DAQ.DLL in the respective folders. Copy these two files into the main directory, overwriting any existing DAN.DLL and DAQ.DLL. You will recognize the files as the folder or file names refer to your hardware. All files can be found again on the installation CD in case you have overwritten some.
If you have purchased the **HM1** with histogramming option please refer also to the **HM1**-TDC manual. The following procedure is mainly describing the start-up in the standard (transparent mode), which is recommended for first use of the detector system.
Now you can start the **CoboldPC** program. In this state the program has linked the proper program parts and waits for input from the command line (type the command text and "enter") or the tool bar buttons. With the command "exe filename.ccf" or from the drop down menu you can start a "batch-file", i.e. a series of commands as written in the file (new line = next command). For example any "xxx Standard.ccf" file (see below) defines a set of parameters, coordinates, conditions, and spectra necessary for a **CoboldPC** session. A dialogue box will ask you to define the type of session, hardware acquisition or re-sorting of a previously acquired listmode-file.

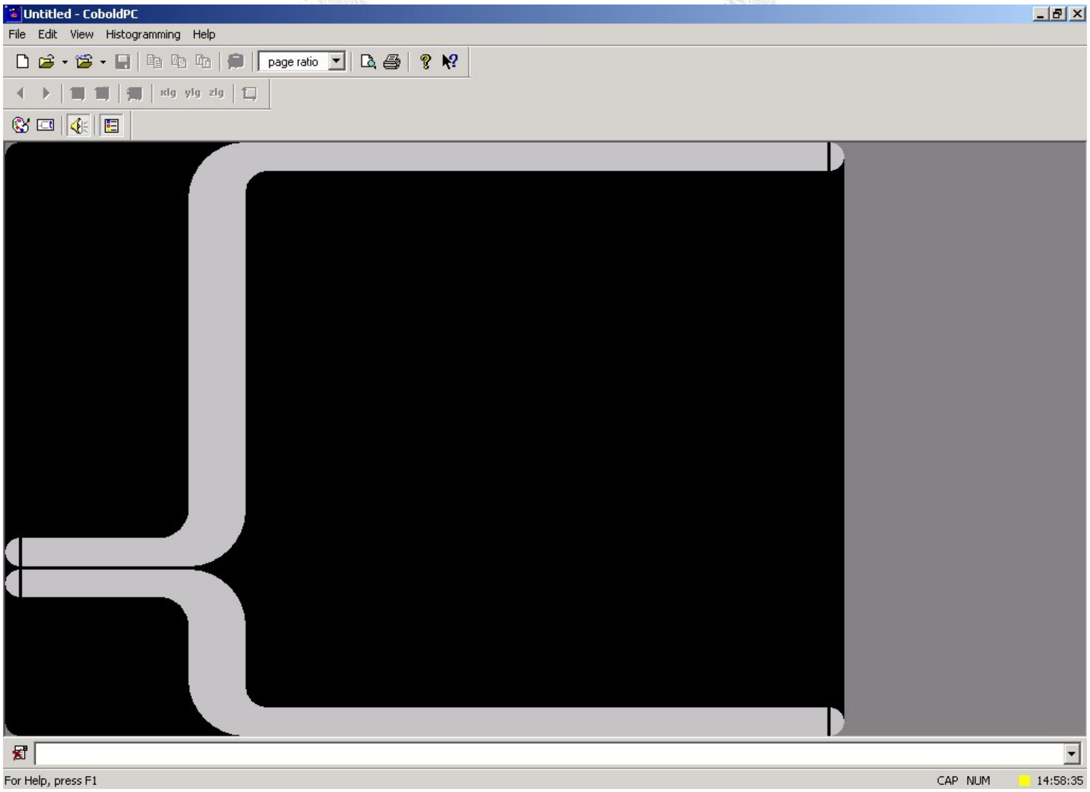



**Figure 3.9: Screen after starting the CoboldPC program**

You will recognize corresponding files easily from the similarities in the filenames. Browse for a filename.lmf and select it.* If you have selected an adequate listmode file. The program will resume and sort the file. Now you can look at the spectra with the "view" command. First you may check with the "show spectra" command which spectra are defined and can be

* If you should not find the file corresponding to your hardware please contact software.development@roentdek.com.

displayed. If you have not yet referred to the CoboldPC manual so far, it is time for that now in order to proceed. Some frequently used standard commands are listed below:

| | |
|---|---|
| **exe** | calls a command file |
| **new hardware** | prepares for starting hardware acquisition |
| **start** | starts the acquisition |
| **pause** | pauses the acquisition (for starting again use the start command) |
| **stop** | stops the acquisition (for starting again use the new hardware and the start command) |
| **clear all** | clears the contents of all spectra (instead of all, a certain spectrum number is also possible to clear only one spectrum) |
| **restart** | deletes all coordinates, parameters, conditions and spectra for a total reset |
| **coordinate** | defines a coordinate |
| **parameter** | defines a parameter |
| **condition** | defines a condition |
| **define1** | defines a 1-dimensional spectrum |
| **define2** | defines a 2-dimensional spectrum |
| **view 1** | shows spectrum 1 |
| **show status** | shows the status report window |
| **help** | shows the help file |

## 3.5 The "xxx Standard.ccf"

We have prepared sample command files "xxx Standard.ccf" (replace xxx by **CCC1**, **TDC8** or **HM1** etc.) according to your DAQ hardware for first use. It provides already most of the desired data, i.e. 2d position spectra and time-of-flight spectra in various coordinate representations. The program calls several subprograms that define parameters and coordinates which are attributed to the data acquisition part and the data analysis part of the event handling. Finally it defines spectra and conditions. Due to this modular construction it is possible to use almost the same data analysis sequences for different hardware (i.e. TDC types). Some users find this sequenced structure of the "xxx Standard.ccf" file not adequate for their work. If so you may create your own "xxx Standard_personal.ccf" by replacing the "exe" commands by directly pasting the subprogram commands into the new "xxx Standard_personal.ccf". Please observe the order of commands.
The standard defined coordinates, spectra and condition gates in the "xxx Standard.ccf" are (please refer also to the commented lines in the "xxx Standard.ccf"):

| | |
|---|---|
| **restart** | (reset of earlier commands) |
| **execute subDAQ\XXX\Standard-Parameters.ccf** | (executes the commands in the specific file) |
| **execute subDAN\Standard-Parameters.ccf** | (executes the commands in the specific file) |
| | |
| **execute subDAQ\XXX\Standard-Coordinates.ccf** | (executes the commands in the specific file) |
| **execute subDAN\Standard-Coordinates.ccf** | (executes the commands in the specific file) |
| | |
| **execute subDAN\Standard-Spectra.ccf** | (executes the commands in the specific file) |
| | |
| **; prepare measurement** | (no command, only comment) |
| **new** | (defines the session type, calls selector box) |
| **start ; start measurement** | (see comment) |
| **show status ; show the status screen** | (see comment) |

In the following we describe the structure and the meaning of commands in the ccf-files.

### 3.5.1 DAQ parameters (here for TDC8PCI2 as an Example)

Please refer to the manual for your TDC hardware for a detailed description of your TDC DAQ parameters!

| | |
|---|---|
| Parameter 1 | Address of the I/0 card or 0 for PCI bus auto detection mode. PCI bus auto detection is only valid for the **TDC8** Modules with PCI IO cards. A value smaller than 16 specifies the Device # of the TDC8PCI(2) board starting with 0. |
| Parameter 2 | Time stamp for an event as obtained from the PC in µs. Setting this parameter to 1 or 2 will record the computer clock with the event as 32bit or 64bit value from the time data acquisition start. Please note that the accuracy of the recorded time is not guaranteed.<br>The time information is also dependent on the mother board of your PC.<br>0 = no Timestamp,<br>1 = 32Bit Timestamp (Low.Low, Low.high)<br>2 = 64Bit Timestamp (Low.Low, Low.high, High.Low, High.high) |
| Parameter 3 | System reset time (in seconds) in case of missing signals (do not change without consulting RoentDek) |
| Parameter 5 | Time scaling (internal parameter)<br>Used to calibrate the time stamp. |
| Parameter 6 | DAQ-version number (internal parameter) |
| Parameter 7 | Start time of list mode file (internally set) |
| Parameter 8 | DAQ-ID (internal parameter)<br>DAQ_ID_RAW 0x000000 for RAW (no Data)<br>DAQ_ID_TDC8 0x000002 for TDC8/ISA/PCI<br>DAQ_ID_2TDC8 0x000005 for 2 TDC8 (Advanced Burst Mode) |
| Parameter 9 | LMF-version number (internal parameter) |
| Parameter 14 | Defines whether common start or common stop mode is used. Default is 0 = common start. If the common stop mode (= 1) is used, the TDC output values should be considered being negative numbers. In this case the definition of coordinates x1,x2,y1,y2,z1 and z2 as function of the raw TDC values CmH1 changes: the values are additionally multiplied by the factor (-1). |
| Parameter 20 | TDC resolution (internally set).<br>For the **TDC8** the resolution (LSB) is fixed to 500ps, the range is 16bit (32µs). |
| Parameter 21 | TDC data type information (internally set)<br>0 = Not defined<br>1 = Channel information<br>2 = Time information (in ns) |
| Parameter 30 | Event open time in µs.<br>Maximal time after the start that the TDC waits for stops. |
| Parameter 32 | number of channels to be read out |
| Parameter 33 | maximum number of hits to be read out |
| Parameter 40 | DataFormat (Internally set) |
| Parameter 45 | gate delay<br>gate delay *33ns+150ns = gate delay[ns] |
| Parameter 46 | acquisition gate opentime<br>gate open time *33ns = gate open time[ns] |
| Parameter 47 | write empty events<br>0 discard empty events<br>1 write empty events |
| Parameter 48 | trigger falling edge<br>0 disable |

```
                         1 enable
Parameter 49       trigger rising edge
                         0 disable
                         1 enable
Parameter 50       EmptyCounter, sum (Internally set)
Parameter 51       EmptyCounter, since last Event (Internally set)
```

### 3.5.2 DAQ coordinates

According to the settings of the DAQ parameters the **CoboldPC** program will retrieve the following coordinates from the hardware and (if selected) will store them event by event to the hard disc. Usually the retrieved set of coordinates is complete in the sense that all available information from the hardware is collected for each single event.
The format is defined in the **CoboldPC** manual, each event is an n-tupel {... , ... , ... , ... , ...} of the consecutive coordinates as binary numbers depending on the settings of parameters 2, 32 and 33:

```
{
  TRaw1,TRaw2,TRaw3,TRaw4 - if selected    (TimeStamp raw information)
  S1,C1H1,...,C1Hn        - n = para 33    (H stands for hit number)
  ..., ..., ..., ..., ...,                 (S stands for the status register)
  Sm,CmH1,...CmHn         - m = para 32    (C stands for TDC channel number)
}
```

Further coordinates are calculated by the DAN (data analysis part), however these will not be stored to disc but appended to the list, all coordinates (from DAQ and DAN) are internally numbered:

```
pEventData->GetAt(0)
pEventData->GetAt(1)
pEventData->GetAt(2)
. . .
```

Normally for the “xxx Standard.ccf” n is set to 1 (one hit read-out only) and m equals 4 (6 in case of the *Hexanode*, see additional manual), the number of stored DAQ coordinates is 8 (12) if the timestamp is disabled, otherwise 12 (16).

### 3.5.3 DAN parameters and coordinates:

While the parameters of the DAQ part have only the function to define and organize the hardware (and are mandatory), the DAN parameters are used in the data analysis part. The DAN.dll is a data analysis subprogram that complements the raw DAQ coordinates by computed coordinates, such as the position or time sum (TOF) derived from the raw data. It also comprises some correction, shifting and rotation computations and coordinate system transformations, so that the basic computations for experiments with a position and time sensitive detector are already available without changing the DAN.dll supplied here.
The computations yield in an additional set of coordinates (DAN-coordinates) that are internally treated as independent coordinates and are internally listed by numbers, following the last hardware coordinate (although they are not stored to hard disc in the list-mode file). This DAN.dll may be altered using a MS-C++ or DEC-Fortran compilation (see **CoboldPC** manual) and the list of coordinates may be changed, creating additional coordinates (and parameters) for further computation, unused DAN coordinates may be removed. Any newly defined coordinate is available for further computations. Note that the program will only operate well, if all definitions in the filename.ccf (e.g. the “xxx Standard.ccf”) are in accordance with the DAQ.dll and DAN.dll used. After the **new** or **start** command the program makes a consistency check and may give an error message if the number of coordinates and parameters defined are not sufficient, however, it will not detect all eventual discrepancies.

#### 3.5.3.1 DAN parameters (here for TDC8PCI2 as an Example)

Even though the parameters from 1 to 99 are mainly used for the DAQ module some of this information is also useful for the data analyses. So some parameters are again listed here. During offline analysis these parameters are automatically set from the parameter information (settings during data acquisition) that is stored in the lmf-file. So these are DAN-parameters but they are reread from List-Mode file header.

```
Parameter  2       Save TimeStamp
                         0 = no Timestamp,
                         1 = 32Bit Timestamp     (Low.Low, Low.high)
                         2 = 64Bit Timestamp     (Low.Low, Low.high, High.Low,
```

| | |
|---|---|
| | High.high) |
| Parameter 5 | TimeScaling (Internally set, tics per s) |
| Parameter 6 | DAQ Version # (Internally set) |
| Parameter 7 | Start time of list mode file (internally set) |
| Parameter 8 | DAQ_ID<br>DAQ_ID_RAW 0x000000 for RAW (no Data)<br>DAQ_ID_TDC8 0x000002 for TDC8/ISA/PCI<br>DAQ_ID_2TDC8 0x000005 for 2 TDC8 (Advanced Burst Mode) |
| Parameter 20 | Resolution of TDC in ns (internally set)<br>For the **TDC8** the resolution (LSB) is fixed to 500ps, the range is 16bit (32µs). |
| Parameter 21 | TDC data type information (internally set)<br>0 = Not defined<br>1 = Channel information<br>2 = Time information (in ns) |
| Parameter 32 | number of Channels (reread during offline) |
| Parameter 33 | number of hits (reread during offline) |
| Parameter 40 | DataFormat (Internally set) |

The following DAN-parameters used in the DAN-part can have the function of variables for computations, of pointers or of flags. Some are mandatory, some are optional. Standard DAN will use the parameter range 100-299. The following parameters and coordinates are used in the "xxx Standard.ccf":

| | |
|---|---|
| Parameter 100 | Conversion Parameter for RAW data<br>Usually (parameter value 0), the data output from a **TDC8** TDC channel is coded in ***channel numbers***[*]. The ***channel number*** is the number of resolution bins (i.e. LSB). If it is set to 1 the unit is transformed to ns, using the TDC resolution value (parameter 20). If the parameter is 2, a position in mm is calculated, using the values of parameters 110 and 111 (and 112). The time sum values are in ns unless the parameter is 0. |
| Parameter 102 | Hexanode calculations<br>0 = no Hexanode<br>1 = Hexanode<br>If a Hexanode is used additional calculations are required to retrieve the position information. For these parameters and coordinates please refer to the add-on manual. |
| Parameter 103 | R-Phi conversion<br>0 = RAD [-π..π]<br>1 = RAD [0..2π]<br>2 = DEG [-180..180]<br>3 = DEG [0..360]<br>This parameter defines the angular range and unit for the Phi coordinate in the R-Phi representation of the 2d-image. |
| Parameter 105 | Start of DAQ Data for DAN<br>This pointer value defines for the DAN program part the position in the coordinate list where the first of the TDC data appears (s1). Usually you can set this value also to 0 and the program will automatically enter the right number. |
| Parameter 106 | Start of DAN Data<br>This pointer value defines the position in the coordinate list where the DAN coordinates begin, i.e. it should equal the number of hardware coordinates<br>(See chapter 0)<br>If you want to analyze the data from the first hit you can set |

[*] This expression is always written in *italic* font, not to be mistaken for the term "TDC channel", which denominates a TDC input slot.

this value also to 0 and the program will automatically enter the right number.

Parameter 107 — Hit number to be analyzed. Usually the position is calculated from the first hit in the TDC channels (default value: 1). If you want to get position and time sum calculations with the standard "TDC8 Standard.ccf" for a different hit number you have enter the hit value here. Note, that it can happen that the registered ***channel numbers*** do not necessarily correspond to the real particle hit if reflections on the raw amplifier signals produce "false" additional hits in a certain TDC channel number, or if hits are "lost" due to low signal height/high threshold settings.

Parameter 110 — pTPCalX
Time to Position calibration factor for x ($1/v_\perp$ in mm/ns)
DLD40: 0.76, DLD80: 1.02, DLD120: 1.26
For Hexanode: … for u ($1/v_\perp$ in mm/ns), 1.3565 for HEX80.

Parameter 111 — pTPCalY
Time to Position calibration factor for y ($1/v_\perp$ in mm/ns)
DLD40: 0.70, DLD80: 0.96, DLD120: 1.20
For Hexanode: … for u ($1/v_\perp$ in mm/ns), 1.4164 for HEX80.
These two parameters define the value of position to time calibration, the effective signal propagation speed across the delay-line. It depends on the size and geometry of the delay-line used. The suggested values are only accurate within few percent for a given delay-line. If a higher precision is needed one needs to make a position calibration with a test mask in front of the detector. If the detector shows an oval shape please exchange the values for X and Y (only for DLD) and try again to sort the data, possibly the physical dimensions of the anode have been exchanged during mounting.

Parameter 112 — pTPCalW
Time to Position calibration factor for w ($1/v_\perp$ in mm/ns), only for Hexanode: 1.4620 for HEX80

Parameter 120 — pCOx Rotation Offset Center for PosX
Parameter 121 — pCOy Rotation Offset Center for PosY
These parameters define the center point for an online detector image rotation and also the center point in the X/Y plane for a coordinate transformation into R/Phi representation. Note that a R/Phi transformation will only give good results if the position unit is mm (see parameter 100).

Parameter 122 — pRotA Rotation Angle mathematical direction
Rotation angle (counter clock wise) for an online detector image rotation
(value to be supplied in RAD or DEG depending on parameter 103)

Parameter 125 — TDC channel number p of the MCP signal (default 0). If the MCP timing signal is not used for the common start or common stop, the x1,x2,y1,y2,z1 and z2 coordinate definitions are modified: The raw values CmH1 are reduced by the raw value in the TDC channel p (CpH1) of the MCP signal in this TDC channel number p before further computation according to parameters 14 and 21 are eventually performed. p = 0 means: no substraction. The MCP timing signals must then be connected to TDC channel p.

Parameter 135 — pOPx Offset for PosX
Parameter 136 — pOPy Offset for PosY
These two parameters are offset (additive) constants for shifting the detector image in the X/Y plane. Note, that in case of the Hexanode these values define the offsets for the calculated x and y and not for the raw u and v values.

| | |
|---|---|
| Parameter 137 | pOPw<br>Offset for third anode layer (added to w, only for Hexanode) |
| Parameter 138 | pOSum<br>Offset for Sum/Diff calculations<br>This offset value is an additive constant to all time sum/diff coordinates |

#### 3.5.3.2 DAN coordinates, primary

The DAN coordinates are by definition only the additional coordinates that are computed from the (raw) DAQ coordinates retrieved from the hardware or from a previously accumulated event file. This "xxx Standard.ccf" picks only one set of delay-line coordinates for one of the hits (default: first hit, see parameter 105) and calculates position and time values for these coordinates. If you have changed parameter 2, 32 or 33 from their default value (first hit only) or if you sort a list-mode file acquired with a non-default parameter settings) you need to adjust the (pointer) parameters 105 and 106. It is such possible to apply the position and time calculations to the next hits if such are (or have been) acquired by adjusting these pointer parameters. The DAN.dll will read the values of the status registers and the *channel numbers* in the 4 (Hexanode: 6) coordinates defined by parameter 105 (default: first hits) and calculate the desired position and time informations. Note that even for the use of a DLD (4 delay-line signals only), the coordinates for two additional delay-line signals (as from the Hexanodes) are defined and set to 0. A first set of DAN coordinates is created by using the defined set of DAQ coordinates:

| | |
|---|---|
| AbsoluteEventTime | absolute time of event from the start of data acquisition in µs (only if enabled, see parameter 2) |
| DeltaEventTime | time between an event and the previous event in µs (only if time stamp recording is enabled, see parameter 2).<br>This spectrum can be used to determine the average event rate (use the "fit exp" **CoboldPC** command on the acquired spectrum) |
| EventCounter | number of event from the start of data acquisition |
| True | internal coordinate |
| ConsistenceIndicator | The value of this number for each event is:<br>$\sum u \cdot 2^{i-1}$,<br>i is the TDC channel, u =1, if at least one hit in the TDC channel i was registered, otherwise 0. If each TDC-channel for the selected hit number has received at least one hit of the value is 15 for a DLD and 63 for a Hexanode. This assumes that the first TDC channels are used for the delay-line signals. Up to 16 TDC channels are supported by this function. |
| PLLstatus | not used for **TDC8** (but must be defined) |
| n1 | number of hits in TDC channel 1 |
| n2 | number of hits in TDC channel 2 |
| n3 | number of hits in TDC channel 3 |
| n4 | number of hits in TDC channel 4 |
| n5 | number of hits in TDC channel 5 |
| n6 | number of hits in TDC channel 6 |
| x1 | ***channel number*** of hit in channel 1 (default: hit 1) |
| x2 | ***channel number*** of hit in channel 2 (default: hit 1) |
| y1 | ***channel number*** of hit in channel 3 (default: hit 1) |
| y2 | ***channel number*** of hit in channel 4 (default: hit 1) |
| z1 | ***channel number*** of hit in channel 5 (default: hit 1)<br>only for Hexanode |
| z2 | ***channel number*** of hit in channel 6 (default: hit 1)<br>only for Hexanode |
| | The values in these coordinates are calculated from the retrieved ***channel numbers*** of the selected DAQ-coordinates, e.g. (see above). Depending on parameters 100, 101, 104 these values have the specified units (corrected or uncorrected) and are the basis for all |

```
following computations. If a Hexanode is not used, z1 and
z2 are set to zero. Note that channel 5 and 6 (for TDC8)
can still be used for other timing signals. The
corresponding coordinates are the DAQ coordinates for
these TDC channels
```

These DAN coordinates are called primary because they retrieve the basic information in the DAQ coordinates for a first data review, assuming a delay-line detector is used. The following secondary DAN coordinates are computed from the primary coordinates and represent the first step of a (user defined) more elaborated data analysis. If you want to define additional coordinates you should append them to the secondary DAN coordinates. Here, basically the position in a given direction (e.g. x = x1 - x2) and the time sums (e.g. sumx = x1 + x2) are calculated from the primary DAN coordinates. Note that the "unit" of the secondary DAN coordinates is also defined by parameter 100. Additional shift parameters can be included and coordinate transformation or image rotation codes are provided. For the Hexanode please refer to the add-on manual.

#### 3.5.3.3 DAN coordinates, secondary, for DLD detectors

```
x             x coordinate of the event     (x = x1 – x2)
y             y coordinate of the event     (y = y1 – y2)
w             set to zero
sumx          time sum of x                 (sumx = x1 +x2 + pOSum)
sumy          time sum of y                 (sumy = y1 +y2 + pOSum)
sumw          set to zero
sumxyw        sum of time sums              (sumxyw = sumx + sumy - pOSum)
diffxy        difference of sums            (diffxy = sumx – sumy + pOSum)
PosX          x-position                    (PosX = x + pOPx)
PosY          y-position                    (PosY = y + pOPy,
                                                 If hex flag not set)
                                            (PosY = Yuv,
                                                 If hex flag set)
r             r coordinate after transformation in r/phi coordinates
              (from PosX/PosY)
phi           phi coordinate after transformation in r/phi coordinates
              (from PosX/PosY)
xRot          x-position after rotation
yRot          y-position after rotation
```

```
The following coordinates are only filled with valid information for the Hexanode
setup. Even though they have to be defined!

Xuv           x + pOPx
Yuv           1/sqrt(3) * (x-2y) + pOPy
Xuw           Xuv
Yuw           1/sqrt(3) * (2w-x) + pOPy
Xvw           (y+w) + pOPx
Yvw           1/sqrt(3) * (w-y) + pOPy
dX            Xuv - Xvw
dY            Yuv – Yvw
```

In order to take full advantage of the **Hexanode**'s ability to resolve multi-hits or to read-out detectors with a central hole you may need additional support and software from **RoentDek**. Please contact **RoentDek** as soon as you have the detector operable and have acquired first data with the ***TDC8PCI2-Hex Standard.ccf.*** Note, that in order to provide this support it is required for **RoentDek** to receive a data set acquired with your detector and to know details of the application. Please look for manual updates on our website http://roentdek.com.

### *3.5.4 Spectra and conditions*

The final purpose of the data acquisition is to display and manipulate the acquired data. For this purpose it is possible to define ***spectra*** for display of all defined coordinates. A spectrum is a histogram with fixed bin width either with a one- or two dimensional array of "slots". For a one-dimensional spectrum (for example a time spectrum) this array is a row along the ordinate (X-axis) of a graph, the slots (or bins) correspond to the values of the corresponding coordinate. When data are

acquired or re-sorted from a list-mode file, the value of the coordinate for each event will be attributed to the closest bin's value and the histogram content in this bin will be incremented by one unit (along the Y-axis of the graph). For example such a histogram (spectrum) could show the distribution of time sum values for a number of acquired events.
Likewise it is possible to display two-dimensional spectra, i.e. the coincident occurrence of values in two coordinates within the corresponding bin widths (for example the 2d position distribution of the detected particles). To visualize such a histogram the two coordinates span a plane (X/Y), the value in each bin (Z) is displayed as gray or color code, or contour lines are used for the display. The range of the displayed spectra in X, Y (and Z), the bin size and the "unit" of incrementing can be defined for optimal visualization and manipulation.
To analyze higher dimensional coordinate correlations it is possible to "gate" the sorting process into a histogram (spectrum) by defining a ***condition*** for this spectrum. Such a condition can be a "window" on the occurrence of a certain range of values in a third coordinate for the events. For example one needs to visualize the (2d) position spectra of particles as function of their time-of-flight (TOF)*. Then one can define several conditions (gates) on the TOF coordinate (e.g. time sum peaks) and several 2d position spectra with the different conditions. It is possible to link different conditions (e.g. by an "AND") to allow the analysis of even higher dimensional coordinate correlations.
For details about the definition of spectra and conditions, for spectrum manipulation options and data I/O to other programs please refer to the **CoboldPC** manual. In the "spectra.ccf" you find some pre-defined conditions (as an example) and spectra that will allow you to view the most important coordinates. For example, you will immediately be able to see a position spectrum.

You may now edit the "xxx Standard.ccf" and all subprograms (especially the "spectra.ccf") to adjust them to your needs, e.g. setting the right condition gates on the time sum peak(s), omitting spectra that you do not need, adjust parameters (for shifting or rotating the spectra, calibrating position and time), changing or adding spectrum definitions.
Please note that these functions are only "first level" modifications of the data acquisition and analysis option provided by **CoboldPC**. More advanced data treatments like defining new (computed) coordinates to the analysis can be done by additionally modifying the DAN.dll using a MS C++ or Fortran compiler. Please refer to the **CoboldPC** manual for details.
Also, there is a "zero-level" of operating for the recent **CoboldPC 2002** versions, allowing to address the **CoboldPC** commands by a scripting language. Again, for details refer to the **CoboldPC** manual.

If you are ready to run a session with the hardware now, you may execute the "xxx Standard.ccf" file again and click the hardware button. But before make sure to follow the steps lined out in the chapter 5.

* In order to allow for such a measurement one needs to use a different TDC connection scheme than the proposed start-up configuration in section 5.3

# 4 The Detector Power Supplies HV2/4 and BIASET2 with battery box BAT2

## 4.1 The HV2/4:

The RoentDek 2×4kV Power Supply is especially designed for the use of biasing multi-channel-plate detectors, featuring low-ripple and regulated current limitation and protection. It has to be powered by a NIM crate*, or externally using the 9 pin socket on the rear side panel, supplying the voltages (NIM-crate standard) according to the table on the manual. $U_e$ of ±24V (800mA) and ±6V (100mA) DC have to be provided to power the module.

The switches on the side panel will set the respective channels to negative or positive output polarity, indicated by an LED on the front panel. Only change polarity when the power is off.

If a channel of the power supply is switched on (indicated by an LED), and the "control" switch is set to upward position, the 10-turn potentiometers at the front panel can be used for manual voltage setting $U_a$ (10 turns correspond to 4000V, linear progression). This is the recommended procedure for operating the RoentDek detectors.
The voltages can also be ramped externally with an analog voltage input to the Lemo-sockets on the rear panel (10V analog input corresponds to 4000V output, linear progression). For this the "control" switch must be set to "DAC"

The A/B switch will set the display to channel A/B, the V/I switch will enable voltage or current reading of the respective channel. The accuracy of the reading is within a few volts and a few µA (typically 1µA), respectively.

The maximum current delivered is 3mA, the maximum voltage is ±4kV. Both can be restricted in 10% steps from 0.3mA (400 V) to 3mA (4000V) which is 100%.
Please set the maximum current to 10%, i.e. 0.3mA when using it with a RoentDek MCP detector unless otherwise directed. .

If the trip protection switch is set to "enable kill" the voltage will be turned off in case of over-current or over-voltage, according to the settings of $V_{max}$ and $I_{max}$. Otherwise the module will try to engage the voltage again after limiting the current for a while (and usually dropping the voltage), however it will trip again if the problem persist. It will never deliver more voltage/current than pre-set.
A TTL signal ("high") on the "inhibit" input will also deactivate the voltage, like the event of an over-current, according to the position of the "enable kill" switch.
The red "error" LED will indicate the event of an over-current, over-voltage or "inhibit".
The hardware ramp speed is 500V/sec max. (power switch on/off).

In case of an error turn down the voltage and turn the module off and/or engage the enable switch again after verifying a proper state of your hardware.


**Figure 4.1: 2x4kV Power Supply (front panel)**

*Notice:*
*The safest operation mode for MCP is the "enable kill" position. If the current limitation is set low and the switch is on this position it can happen that an error is indicated when starting to increase the voltage on a certain detector part, although no problem of the hardware actually exist. This is due to the loading current of capacitors in the power supply itself or in the DLATR6 module. In that case set the switch to the other direction when starting to increase voltage. You may switch to the "enable kill" position later after the voltage setting is finished.*

* For a choice of suitable NIM Crates please contact RoentDek

On the rear panel you find a 9-pin socket where the external power cable for the **RoentDek** amplifier modules of type **DLATR6** can be powered.


Figure 4.3: 2x4kV Power Supply (rear-panel)

***Warning: the HV output of this power supply can be hazardous if not properly operated. Never operate the module with open housing. RoentDek denies any responsibility for accidents with their products and is protected by German laws. If you need special instructions how to handle high voltage power supplies please contact RoentDek.***

**Further specifications:**

| | |
|---|---|
| Operation temperature: | 0 ... +50°C |
| Storing temperature* | -20 ... +60°C |
| Ripple (peak-to-peak) | < 50mV |
| Stability | $\Delta U_a < 2 \times 10^{-4}$ or $5 \times 10^{-5}$ of $\Delta U_e$ |
| Temperature coefficient | $< 1 \times 10^{-4}/°C$ |

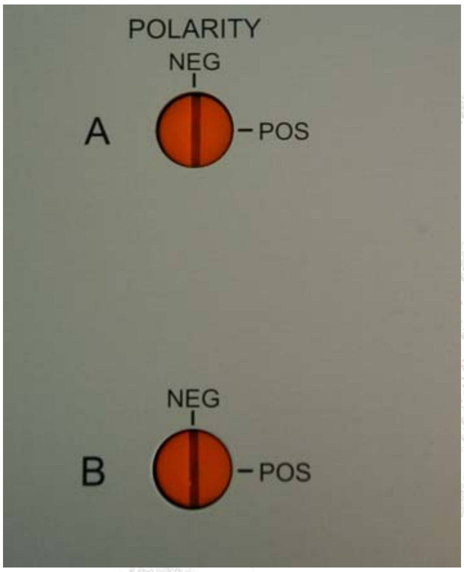



**Figure 4.2: 2x4kV Power Supply (side-panel)**

***Changing the Polarity of Channel A and/or B***

To change the polarity of either channel, A or B, locate the "red knobs" on the left side-panel (see Figure 4.2) and place the module flat on a table showing the side-panel. Gently adjust the slit of the "red knob" to the desired polarity using either an adequate screwdriver or a coin. Please make sure that the screwdriver is not tilted. ***Do not press on the knob! Do not use force!*** The channel is adjusted if you hear and feel the lock in place.

## 4.2 The BIASET2

The **BIASET2** is a high voltage power supply set with up to four individual high voltage power supplies for the use with **RoentDek** detectors. The individual power supplies are very similar in their function to the **HV2/4** modules, although each unit provides only one high voltage and there is no external 6V or 12V output to supply operation voltages for the **(N)DLATR** or **FAMP1** modules.

The modules are powered by a 3U-crate with 100-120V or 210-250V AC power input.


**Figure 4.4: BIASET2 Crate with four HV1/4**

#### *4.2.1* ECH 114 – K (BIASET2 Crate)

# ECH 114 – K (BIASET2 Crate)

## 3U - Crate with Power Supply for HV-PS
## EHQ 1xxx series

The Crate ECH 114 - K carry up to 4 modules of our EHQ 1xxx series. A common PS provides the necessary voltages.

During operation the unit has to be supported with enough airflow. A fan is normally not necessary.

During desktop operation a height of minimum 40 mm under and above has to be assured.
Crates mounted into racks or several crates mounted in stack must be cooled by fans.

The analogue set voltages per channel are available on the rear side of the crate.

The state of readiness will be achieved with the main switch „POWER“ on the rear.

## Technical Data

| | | ECH 114 - K |
|---|---|---|
| Supply voltage AC | | 230 V $^{+10\%}/_{-15\%}$<br>(fused with 2 * 1,6 A/T on the main plug) |
| Supply voltage DC | | + 24 V ( 2,5 A)<br>- 24 V ( 2,5 A) |
| Power | | max. 120 W |
| Housing | | Standard housing ½-19"/ 3U / ca. 260 depth |
| Module connector | | 96-pin connector according DIN 41612 |
| | + 24 V | A3 B3 C3 |
| | GND | A5 B5 C5 |
| | - 24 V | A7 B7 C7 |
| | $V_{SET}$ | B15 |
| analogue set voltage $V_{SET}$ | | $V_{SET}$1 to $V_{SET}$4 with 1-pin Lemo-hub |

**Table 4: Technical Data of the ECH 114-K**

### *4.2.2* EHQ 104M_AIO (HV1/4) Operators Manual

# EHQ 104M_AIO (HV1/4)

# Precision High Voltage Power Supplies in 3U Eurocard Format with analogue I/O

# Operators Manual

## Contents:



## Attention!

-It is not allowed to use the unit if the covers have been removed.

-We decline all responsibility for damages and injuries caused by an improper use of the mo-dule. It is highly recommended to read the operators manual before any kind of operation.

### Note

The information in this manual is subject to change without notice. We take no responsibility whatsoever for any error in the document. We reserve the right to make changes in the product design without reservation and without notification to the users.


**Figure 4.5: EHQ 104M (HV1/4) Module**

#### 4.2.2.1 General information

The EHQ´s are two channel high voltage supplies in a 3U Eurocard Chassis, 8TE wide. The units offers manual control and operation via analogue I/O
The high voltage supplies special provide high precision output voltage together with very low ripple and noise, even under full load. Separate 10%-steps hardware switches put voltage and current limits. An INHIBIT input protects connected sensitive devices. The high voltage output protected against overload and short circuit. The output polarity can be switched over.

#### 4.2.2.2 Technical data

| **Type (with _AIO)** | | **EHQ 102M** | **EHQ 103M** | **EHQ 104M** | **EHQ 105M** |
|---|---|---|---|---|---|
| Output voltage $V_O$ | | 0 ... 2 kV | 0 ... 3 kV | 0 ... 4 kV | 0 ... 5 kV |
| Output current $I_{O\,24}$ | | 0 ... 6 mA | 0 ... 4 mA | 0 ... 3 mA | 0 ... 2 mA |
| Ripple and noise | | < 2 $mV_{P-P}$ | | | < 5 $mV_{P-P}$ |
| Resolution of current measurement | | 1 µA; Option 0n1: $I_{O\,max}$ = 100 µA ⇒ 100 nA | | | |
| Resolution of voltage measurement | | 1 V | | | |
| Accuracy | current measurement | ± (0,05% $I_O$ + 0,02% $I_{O\,max}$ + 1 digit) for one year | | | |
| | voltage measurement | ± (0,05% $V_O$ + 0,02% $V_{O\,max}$ + 1 digit) for one year | | | |
| LCD display | | 4 digits with sign, switch controlled<br>- voltage display in [V]<br>- current display in [µA] | | | |
| Stability | $\Delta V_O$ (no load / load) | $< 5 * 10^{-5}$ | | | |
| | $\Delta V_O/V_{INPUT}$ | $< 5 * 10^{-5}$ | | | |
| Temperature coefficient | | $< 5 * 10^{-5}$/K | | | |
| Voltage control | CONTROL switch in position | -manual: 10-turn potentiometer, | | | |
| | | -DAC: control via analogue I/O<br>EHQ 102M to 104M $V_{SET} = V_O / 400$<br>EHQ 105M $V_{SET} = V_O / 1000$<br>EHQ 102M to 104M $V_{MON} = V_O / 400$<br>EHQ 105M $V_{MON} = V_O / 1000$ | | | |
| Rate of change of output voltage | HV -ON/OFF | 500 V/s (hardware ramp) | | | |
| Protection | | -separate current and voltage limit<br>(hardware, rotary switch in10%-steps)<br>-INHIBIT (external signal, TTL level, Low=active) | | | |
| Power requirement $V_{INPUT}$ | | ± «Ie_mAUeEHQ» V (< 500 mA), **Option:** ± 12 V ⇒ $I_{O\,12} = I_{O\,24} * 2$ | | | |
| Operating temperature | | 0 . . . 50 °C | | | |
| Storage temperature | | -20 . . . +60 °C | | | |
| Packing | | 3U Euro cassette / 160 mm depth / 40,8 mm wide | | | |
| Connector | | 96-pin connector according to DIN 41612 | | | |
| HV connector | | SHV-Connector at the front panel | | | |
| Inhibit connector | | 1-pin Lemo-hub | | | |

**Table 5: Technical Data of the EHQ 104M_AIO Module**

#### 4.2.2.3 EHQ Description

The function is described at a block diagram of the EHQ. This can be found in Appendix A.

High voltage supply

A patented high efficiency resonance converter circuit, which provides a low harmonic sine voltage on the HV-transformer, is used to generate the high voltage. The high voltage is rectified using a high speed HV-rectifier, and the polarity is selected via a high-voltage switch. A consecutive active HV-filter damps the residual ripple and ensures low ripple and noise values as well as the stability of the output voltage. A precision voltage divider is integrated into the HV-filter to provide the set value of the output voltage, an additional voltage divider supplies the measuring signal for the maximum voltage control. A precision measuring and AGC amplifier compares the actual output voltage with the set value given by the analogue I/O (DAC control) or the potentiometer (manual control). Signals for the control of the resonance converter and the stabilizer circuit are derived from the result of the comparison. The two-stage layout of the control circuit results in an output voltage, stabilized with very high precision to the set point.
Separate security circuits prevent exceeding the front-panel switch settings for the current $I_{max}$ and voltage $V_{max}$ limits. A monitoring circuit prevents malfunction caused by low supply voltage.
The internal error detection logic evaluates the corresponding error signals and the external INHIBIT signal. It allows the detection of short overcurrent due to single flashovers in addition.

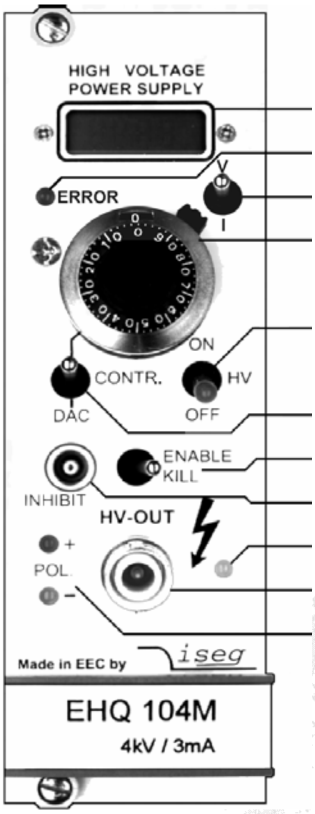
Digital control unit

A micro controller handles the internal control, evaluation and calibration functions of both channels. The actual voltages and currents are read cyclically by an ADC with connected multiplexer and processed for display on the 4 digit LCD display. The current and voltage hardware limits are retrieved cyclically several times per second. The reference voltage source provides a precise voltage reference for the ADC and generation of the control signals in the manual operation mode of the unit.
The set values for the corresponding channels are generated by a 16-Bit DAC in computer controlled mode.

Filter

A special property of the unit is a tuned filtering concept, which prevents radiation of electromagnetic interference into the unit, as well as the emittance of interference by the module. A filtering network is located next to the connectors for the supply voltage and the converter circuits of the individual devices are also protected by filters. The high-voltage filters are housed in individual metal enclosures to shield even minimum interference radiation.

### 4.2.2.4 Front panel




[1] 4 digit LCD display
[2] Error indicator
[3] Measuring switch
[4] 10-turn potentiometer
[5] HV-ON switch
[6] CONTROL switch
[7] KILL switch
[8] INHIBIT input
[9] HV-ON indicator
[10] HV output
[11] Polarity indicator

**Figure 4.6: Front Panel of the EHQ 104M_AIO (HV1/4) Module**

#### 4.2.2.5 Handling

The state of readiness of the unit is produced at the 96-pin connector according to DIN 41612 on the flipside.

The Output polarity is selectable with help of a rotary switch on the cover side (see appendix B). The chosen polarity is displayed by a LED on the front panel [11] and a sign on the LCD display [1].

**Attention!** It is not allowed to change the polarity under power!

An undefined switch setting (not at one of the end positions) will cause no output voltage.

High voltage output is switched on with HV-ON switch [5] at the front panel. The viability is signalled by the yellow LED [9].

**Attention!** If the CONTROL switch [6] is in upper position (manual control), high voltage is generated at HV-output [10] with a ramp speed from 500 V/s (hardware ramp) to the set voltage chosen via 10-turn potentiometer [4].
This is also the case, if analogue control is switched over to manual control while operating.

If the CONTROL switch [6] is in lower position (DAC), high voltage will be activated only after setting the analogue set voltage.

On the LCD [1] output voltage in [V] or output current in [µA] will be displayed depending on the position of the Measuring switch [3].

If working with manual control, output voltage can be set via 10-turn potentiometer [4] in a range from 0 to the set maximal voltage.

If the CONTROL switch [6] is switched over to analogue I/O control (DAC), high voltage will be activated only after setting the analogue set voltage in a range from 0 to the maximal set voltage.

Maximum output voltage and current can be selected in 10%-steps with the rotary switches $V_{max}$ and $I_{max}$ (switch dialled to 10 corresponds to 100%) on the cover side (see appendix B) independently of programmable current trip. The output voltage or current which exceed the limits is signalled by the red error LED on the front panel [2].

Function of KILL switch [7]:

| | |
|---|---|
| Switch to the right position: (ENABLE KILL) | The output voltage will be shut off permanently without ramp on exceeding $V_{max}$, $I_{max}$ or in the presence of an INHIBIT signal (Low=active) at the INHIBIT input [8]. Restoring the output voltage is possible after operating the switches HV-ON [5] or KILL [7]. |
| Note: | When capacitance is effective at the HV-output or when the rate of change of output voltage is high (hardware ramp) at high load, then the KILL function will be released by the current charging the condenser. In this case use a small rate of output change or select ENABLE KILL not until output voltage is set voltage. |
| Switch to the left position: (DISABLE KILL) | The output voltage will be limited to $V_{max}$, output current to $I_{max}$ respectively; INHIBIT shuts the output voltage off without ramp, the previous voltage setting will be restored with hardware ramp on INHIBIT no longer being present. |

#### 4.2.2.6 Analogue I/O

Control with analogue I/O is possible with using analogue set and monitor voltages.

These voltages are dependent on the max. output voltage of the unit:

for $2kV \leq V_{Omax} \leq 4kV$ is $0 \leq V_{SET/MON} \leq V_O / 400$ and
for $V_{Omax} > 4kV$ is $0 \leq V_{SET/MON} \leq V_O / 1000$ .

Pin assignment 96-pin connector on the flip side

| | | |
|---|---|---|
| A3 B3 C3 | +24V | |
| A5 B5 C5 | GND | |
| A7 B7 C7 | -24V | |
| B15 | $V_{SET}$ | internal connected to GND with 1 MΩ |

### 4.2.2.7 Block diagram EHQ

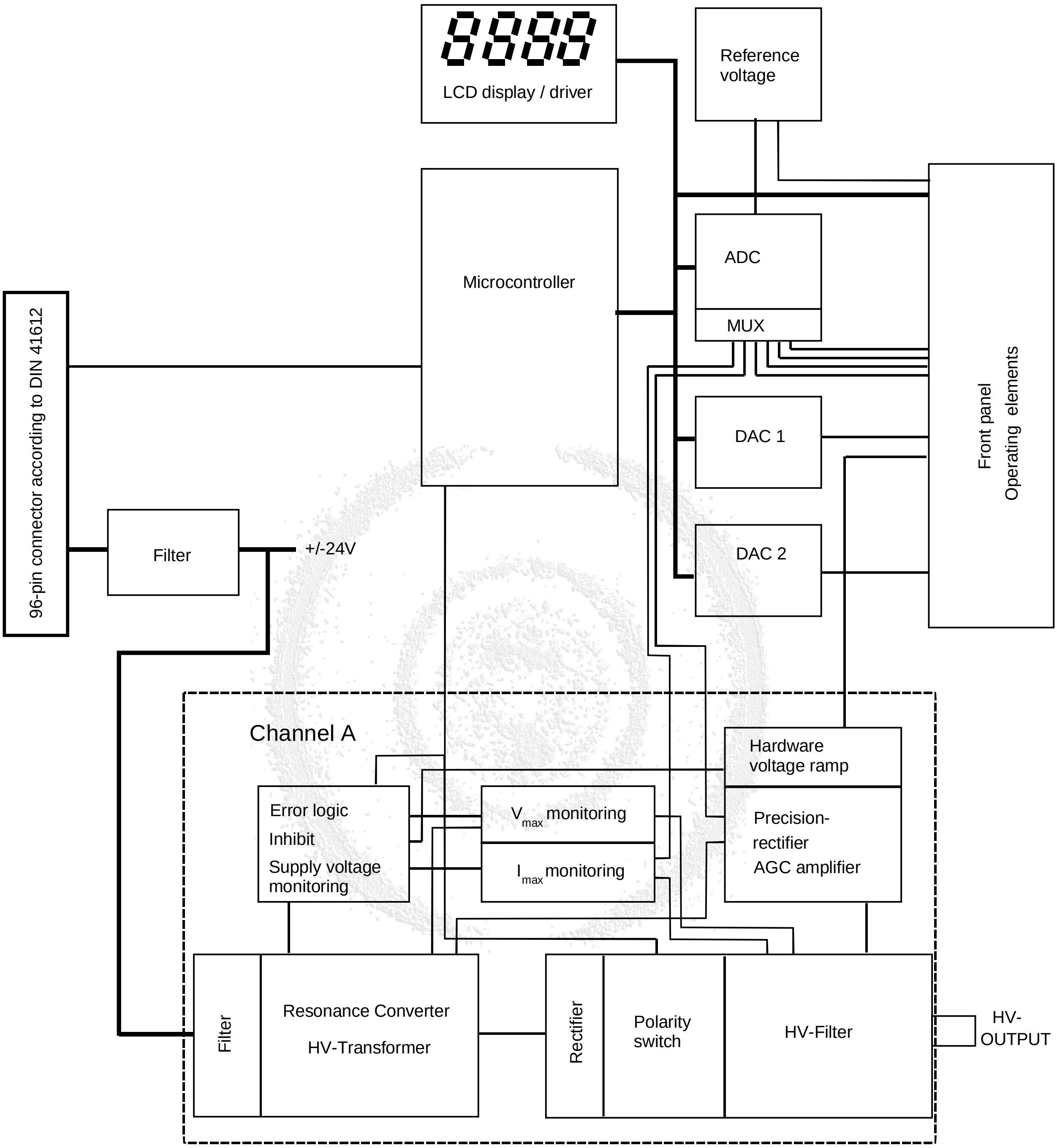



**Figure 4.7: Block diagram EHQ (HV1/4)**

### 4.2.2.8 EHQ side cover

Polarity rotary switch (e.g.: polarity negative)
Rotary switches for $V_{max}$ and $I_{max}$

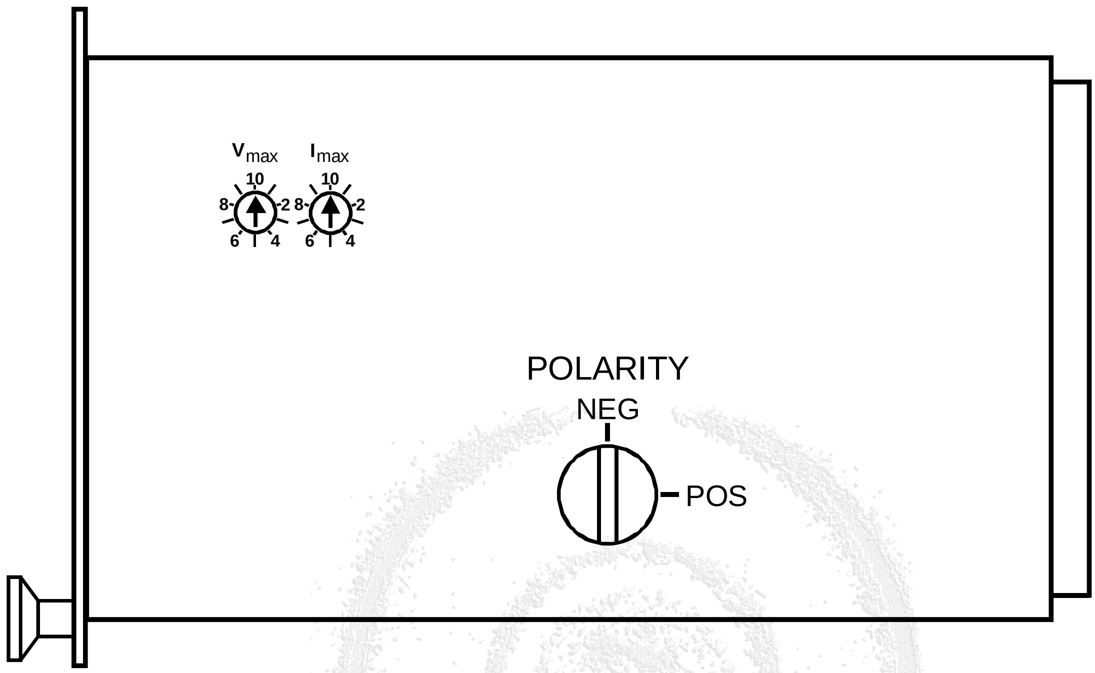



**Figure 4.8: EHQ (HV1/4) side cover**

#### *Changing the Polarity*

To change the polarity of either channel, A or B, locate the “red knobs” on the left side-panel (see Figure 4.8) and place the module flat on a table showing the side-panel. Gently adjust the slit of the “red knob” to the desired polarity using either an adequate screwdriver or a coin. Please make sure that the screwdriver is not tilted. ***Do not press on the knob! Do not use force!*** The channel is adjusted if you hear and feel the lock in place.

## 4.3 Bat2 Box

It is usually sufficient to operate the delay-line with a voltage difference of 20 to 50V between the reference and the signal wires. To supply this constant voltage offset between the wires a battery can be used. The **RoentDek BAT2** battery pack provides this offset of either 24V or 48V (selectable by a switch).

If you want to use the **BAT2** for supplying the wire potentials you need to connect the $U_{ref}$ and $U_{sig}$ outputs (SHV) of the **BAT2** with the corresponding voltage inputs of the **FT12-TP plug**. The desired potential for the reference wire ($U_{ref}$) must then be supplied to the $U_{in}$ reverse connector of the **BAT2** with the special cable.

Note, that the battery is not discharged during normal operation as no current is flowing between $U_{ref}$ and $U_{in}$. Even in the presence of a short on the delay-line anode, there is still a 1MΩ resistance between the plus and minus pole of the internal battery pack. The lifetime of the battery pack is therefore very long (several years) you can check the battery voltage with the internal voltmeter. The individual batteries are standard 12V cells, which can found in camera shops. If you need help in replacing the battery please contact **RoentDek**.


**Figure 4.3.1: BAT2 box (top-view)**

## 4.4 Bat3 Box

It is usually sufficient to operate the delay-line with a voltage difference of 20 to 50V between the reference and the signal wires. To supply this constant voltage offset between the wires a battery can be used. The **RoentDek BAT3** battery pack provides this offset of 35-40V.

If you want to use the **BAT3** for supplying the wire potentials you need to connect the SHV output "HV +36V" to the $U_{sig}$ input of the **FT12-TP plug** and the other SHV output "HV" with the $U_{ref}$ input. The desired potential for the reference wire ($U_{ref}$) must be supplied to the single SHV input on the opposite side "HV input" of the **BAT3**.

Note, that the battery is not discharged during normal operation as no current is flowing between $U_{ref}$ and $U_{in}$. Even in the presence of a short on the delay-line anode, there is still a 1MΩ resistance between the plus and minus pole of the internal battery pack. The lifetime of the battery pack is therefore very long (several years). The individual batteries are standard 12V cells which can found in camera shops. If you need help in replacing the battery please contact **RoentDek**.

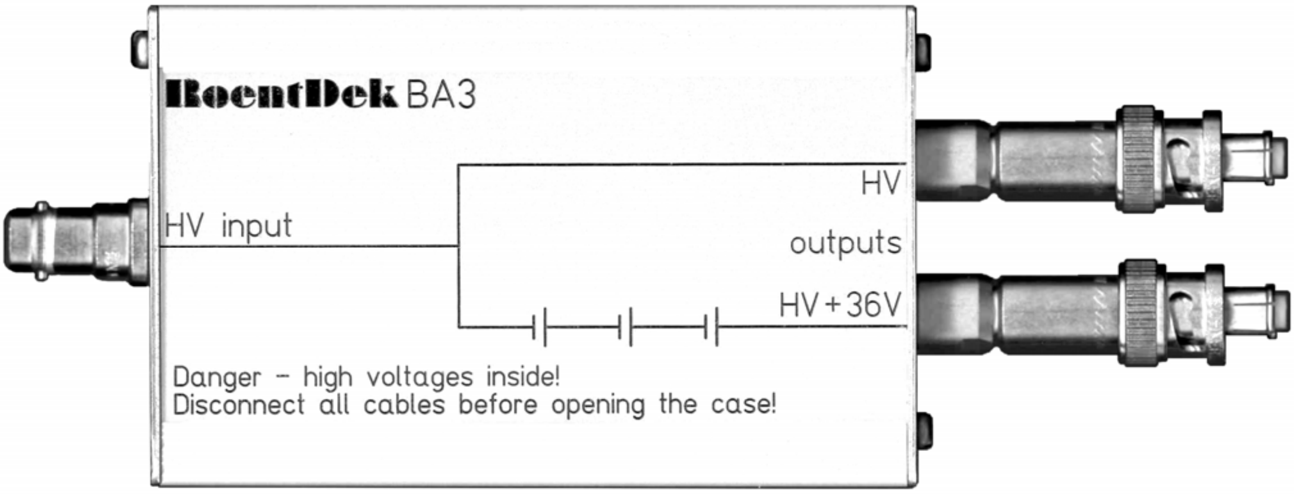



**Figure 4.4.1: RoentDek BAT3 battery box.**
**The voltage input is on the left side. This voltage ($U_{ref}$) is routed to the voltage output on the right side (up) and produces with the internal battery pack the signal voltage $U_{sig} = U_{ref} + 36V$ on the lower output connector.**

# 5 Getting started

The usual startup procedure of **RoentDek** detectors is very important to avoid damage to the MCP stack or the electronic circuits. **RoentDek** is not responsible for errors due to mechanical damage after unsafe handling of the products or unsafe operation. From here on we also describe the operation with **(N)DLATR6(8)** amplifier and CFD modules (see separate manual).

***It is especially important to accurately follow this initial startup procedure.***

By now you should have assembled the detector and verified the proper connections between the detector and the feedthroughs with an Ω meter. It should be installed at your setup or a test setup in vacuum of $10^{-6}$hPa at least for the last 12 hours. Please also refer to the separate manual on how to handle MCPs for further reference.

Connect the **DLATR6(8)** to the feedthroughs or plug in the **FT12-TP** plug (and the single decouplers).

To test the MCP stack connections again you can now apply a potential of less than 500V to either "MCP back" or "MCP front" while the other remains on ground potential. You are now able to measure a current on the display (if your power supply has this option) that roughly corresponds to the expected current according to the MCP stack`s internal resistance. If you fail to detect a current there is a wiring problem or the MCP stack is not properly connected on at least one of the ceramic holder rings. In that case you have to verify the connections again with an Ω meter.

Now check with an Ω meter the resistance between $U_{sig}$ and $U_{ref}$ SHV inputs. The resistance should be infinite (>20 MΩ).
If you measure any other resistance (like 1 MΩ) there is a false cable connection between any signal and reference wire or a short. It may happen that dust particle settles on the delay line and produces a "short". Note that there are several 1 MΩ in-line resistors in the **DLATR6(8)** and **FT12TP** that will not allow to measure precisely any erroneous resistance on the anode.

## 5.1 Checking the Noise Level

When all cables including those to the high voltage power supplies (voltages still down) and the TDCs are connected, you may switch on the **(N)DLATR6(8)/ATR19** module and check the noise level of the An (n = 1 or 2 and 3-6 or 3-8) monitor outputs. The monitor outputs that correspond to the delay-line signals (3-8) should always show low noise, typical below 20mV. This may vary with the actual amplification setting. The noise level of the monitor output corresponding to the MCP signal (1 or 2) should be below 50mV. If you find higher noise levels on some channels please set the corresponding CFD thresholds to the maximum level of about 100mV (5V to ground on the test point) and try again.

If the noise level is too high look for noise sources in your lab and verify the cable connections (if necessary also inside the **(N)DLATR6(8)** on the amplifier inputs).

## 5.2 Verification of the High Voltage Safety

Even if all contacts are verified there is still a chance that a too-close distance between cables on the feedthrough on the detector or between the detector and other parts of your setup give rise to discharge when high voltage is applied to the detector.

***As a consequence the amplifier circuits can be damaged.***

Disconnect the cable to the TDC and all high voltage cables (SHV) except the cable to MCP back. Bias the part of your spectrometer/setup which is close to (< 5mm) the MCP to its default value (e.g. through the "X" connection).

If you are using the **FT12(16)-TP** you should disconnect the lemo cables to the **NDLATR6(8)/ATR19** amplifier inputs. Continue with step 6 of the following instructions.

For use with the **DLATR6(8)** you should follow the steps below to verify that your system is in a safe condition for starting the operation.

1. Remove the power cable of the **DLATR6(8)** or retract it from the NIM crate so that the power is not engaged.

2. Set the switches for "MCP front" and "MCP back" signal to "poti".

3. Open the side panel of the **DLATR6** (the one with only 6 fixing screws) or the lid of the **DLATR8** respectively and remove the input cables of the amplifiers 3-6(8). The cables are labeled accordingly. Remember where to place them again later. Notice: Some **DLATR6(8)** models have extra protection circuits ("fuses") between the amplifier input and the connection cable. Leave them connected to the cable board.

4. Close the side panel (lid) again.
   ***Warning: If you leave the side-panel (lid) open and increase the voltage for any detector part, this voltage is exposed on various contacts inside the module and you risk a potentially fatal electro-shock when touching these contacts !***

5. Remove "MCP back" and "Holder" input cable (SHV inputs) on the front side panel of the **DLATR6(8)** module. Now the "Holder" and "MCP back" potentials are floating. If you now apply voltage to the "MCP front", the whole MCP stack will follow this voltage (for that reason the holder potential must also be floating). There is no voltage across the MCP stack now.

6. Raise the potential of "MCP front" to whatever voltage you want to apply in later operation. While you increase the potential you should verify that no current is flowing through the MCP stack (MCP back is floating). If no discharge occurs after a few minutes reduce the voltage again, turn off the power supply and reconnect the "MCP back" and "Holder" SHV inputs on the rear panel.

   The detector can already be considered rather safe now for *ion detection mode* (high negative potential on "MCP front", low potential to ground on "MCP back" and the anode). If you want to operate in this mode you may open the side panel again, re-connect the amplifier inputs inside the **DLATR6(8)** module and close the side panel. Resume power to the **DLATR6(8)** module and set the switches for channels 1 and 2 to the "on" position. If you use the **FT12/16-TP** connect the outputs to the **ATR19/NDLATR6(8)** again. Connect all high voltage cables. Verify the noise levels again. You may continue with section 5.3.
   For *electron detection mode* continue with step 7.

If a discharge occurs you must verify all your connections inside the chamber again. Verify that there is sufficient distance to any part close to the detector which carries different potentials than the detector parts. After sufficient pumping time resume the test procedure from the beginning. If the problem persists, contact **RoentDek** for some advice.

If you plan to operate the detector in *electron detection mode* (high potentials on "MCP back" and the anode) you need to verify the high voltage safety of the rear detector parts.

7. For *electron detection mode* you must verify the high voltage safety of the anode and the "MCP back" contact. Connect all high voltage cables except the "MCP front" (SHV) input on the **DLATR6(8)** front panel or the **FT12(16)-TP**. The front side of the MCP stack is now floating. If "MCP front" is close (< 5mm) to another biased part of your setup (mesh on contact "X"? Spectrometer exit?), set this part on floating potential, too.

8. Raise the potentials on "MCP back" and the anode to the expected operation potentials. Note again that there is no current due to the floating "MCP front". If no discharge occurs after a few minutes reduce the voltage again, turn off the power supply and re-connect the "MCP front" SHV input, and all other previously removed connection. The detector can be considered rather safe now also for *electron detection mode*. Set the switches for channels 1 and 2 to the "on" position again.

9. Open the side panel (lid) of the **DLATR6(8)**. As you have applied potential to the anode wires, the cables that connect with the amplifier inputs can carry an electric charge. Avoid touching the metal cable contacts and discharge each one (pair) of the cable contacts with a grounded wire before reconnecting them to the amplifier inputs. Close the side panel and resume power to the **DLATR6(8)** module. If you use the **FT12(16)-TP** connect the outputs to the **ATR19/NDLATR6(8)** again.

If a discharge occurs you must verify all your connections inside the chamber again. Verify that there is sufficient distance to any part close to the detector which carries different potentials than the detector parts. After sufficient pumping time resume the test procedure from the beginning. If the problem persists, contact **RoentDek** for some advice.

In rare cases it happened that after shipping either the connection cable or the **DLATR6(8)** box underwent damage and the reason for a discharge can actually be found in the cable or the **DLATR6(8)** box. In order to check this, remove the cables from the feedthrough and repeat the procedure. No discharge should occur now. Otherwise contact **RoentDek**.

Whenever you make changes to the detector hardware or the cable connections you should repeat this procedure.

## 5.3 Initial Start-up Procedure

If you apply voltage across the MCP stack for the first time this must be done very slowly and in a very controlled way, also if you increase the voltage further after operating formerly at lower voltage. Please also refer to the separate manual for MCP handling.
Even after you have verified that there was no discharge when applying voltages to the detector, you could not yet verify a possible discharge problem between "MCP front" and "MCP back" contact. Usually the risk for that is very small. Although there is a minimum chance for amplifier damage by such a connection problem you should from now on operate with amplifiers active to verify the MCP stack during the startup procedure.
If you want to apply voltages in the *electron detection mode*, connect the MCP front output (#1) of the **FT12(16)-TP** plug to the **ATR19/NDLATR6(8)** channel 1 or 2 and terminate the MCP back output (#2) with an adjustable lemo terminator. In case of the **DLATR6(8)** use the A1 output to verify the signal from the MCP stack (front side). The switch for channel 2 on the **DLATR6(8)** front panel should be set to "poti". This is the safest way for the electronics in the event of a discharge. It is recommended, however, to start the MCP operation for the first time in *ion detection mode*.
If you want to apply voltages in the *ion detection mode*, connect the MCP back output (#2) of the **FT12(16)-TP** plug to the **ATR19/NDLATR6(8)** channel 1 or 2 and terminate the MCP front output (#1) with an adjustable lemo terminator. In case of the **DLATR6(8)** use the A2 output to verify the signal from the MCP stack (back side). The switch for channel 1 on the **DLATR6(8)** front panel should be set to "poti". This is the safest way for the electronics in the event of a discharge.

The *ion detection mode* will generally be easier for the following start-up procedure as in this case the anode potential can be kept constant and only one potential ("MCP front") must slowly be increased, when putting operation voltage to the MCP stack. Therefore this mode is strongly recommended for the following procedure, even if you plan to run the detector in *electron detection mode* later.

1. Turn off all ion gauges and any sources emitting a high rate of charged particles (ion pumps?) or high energetic photons (UV and higher) in the vicinity of the detector. All detector potentials are on ground potential or close to that.

2. Set the potentials for the anode (holder, signal wire, reference wire) to the voltages for *ion detection mode* as recommended in the "operation" sub-section.

Now the voltage across the MCP stack must be increased. For *ion detection mode* you only need to increase "MCP front", leaving "MCP back" at ground potential. For *electron detection mode* you should leave "MCP front" at or close to ground potential while you increase "MCP back" and consequently also the anode potential to proper voltages between the anode and "MCP back". In this case also verify that the "MCP front" or "MCP back" potential, whichever you expect to stay near ground potential really does so while you increase the potential on the other side of the MCP stack (see section 2.4.6). In the following only the relative voltage across the MCP stack will be referred to and the other potentials must be adjusted in *electron detection mode* to maintain proper operation condition. Please refer to section 2.4.6 about these relative voltage limits.

3. Increase the voltage across the MCP stack (bias) to 1000V. From now on verify the signals from the MCP on Outputs A1 or A2 (monitor). Any real MCP signals (i.e. some "dark" counts) will not appear before 1500V MCP bias. In the following you will increase the MCP bias in steps of 100V about every 10 minutes. If you see other signals on the oscilloscope than electronic noise, or if you experience a discharge then reduce the bias to zero and start again. In case of discharge verify that the amplifier still gives the "normal" noise level, otherwise it could have been damaged (contact **RoentDek**). If the discharge problem persists or if a high rate of dark counts appears you have some connection problem inside or the MCP stack is damaged. Check if you can rule out the presence of any real particle sources (note, that a sharp tip like on a damaged mesh can emit electrons in the presence of a strong field). If you can not find the reason for the malfunction please contact **RoentDek**.

4. At a certain MCP bias (around 2000V) you should see a few dark counts (usually less than 50/s for the **DLD40** and < 200/s for the DLD80). MCP signals from particle counts or dark counts at the An (monitor) outputs are fast negative signals of a few ns rise time. They have amplitudes between noise level and about 400mV (on 50Ω input). Before you reach 2500V MCP bias you should stop the procedure.

Now the detector is ready for operation with real particles.

5. Reduce the voltage and start a real source of particles. The expected rate should be well below $10^6$ cts/sec at this time. You can now increase the voltage again to 2400V. In order to increase the pulse height you can slowly (100V/10m) increase the voltage further, never exceeding the maximum specified voltage across the MCP stack.

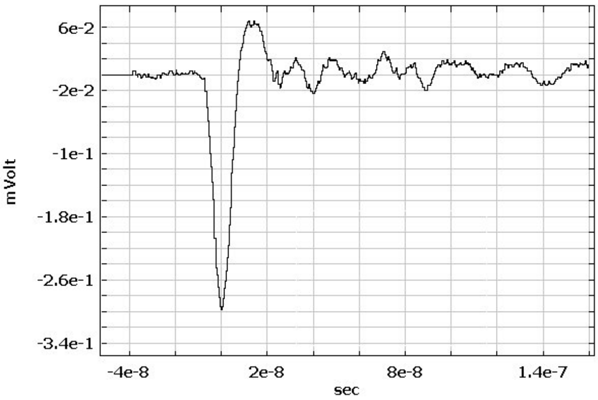



**Figure 5.1: Typical pulse shape from a (N)DLATR6(8) An or ATR19 monitor output**

Please refer to the "operation" subsection now. From now on the MCP bias can be raised more swiftly to the maximum voltage that was safely reached during this startup procedure. If you have to increase further in the future you have to do it slowly again (100V/10m).

You should resume the startup procedure if you have made changes to the hardware or the detector was stored outside its operation vacuum for a longer period (i.e. a few weeks).

***Notice:***
We deliver some of our **DLATR6(8)** units with intermediate connection shoes between the inputs of the **DLATR** boards and the cables inside the **DLATR6(8)** box.
They the circuit from damage in case of discharges and/or shall serve as replaceable "fuses". In case of a discharge please verify the diodes on the connection shoes are damaged. With a diode tester you should measure a voltage of 550mV ±10mV between the center and the outer contacts. If the value deviates by 10% or more replace the shoe or the damaged diode.

## 5.4 Final Adjustment

During the initial start-up procedure you have verified the MCP and the noise level. Assuming all wire connections are correct and all detector potentials are applied you should see similarly shaped analog output signals on MCPfront/back and the delay-line A1/2, A3-8 (monitor). The outputs from the delay line should have similar signal heights. If not, the amplification factors on the DLATR boards should be adjusted (see chapter 2.6).

The analog signal height on MCP back or front (channel 1 or 2) linearly corresponds to the charge of the electron cloud delivered from the MCP for a respective particle. As long as the pulse height is smaller than 400mV (negative polarity) the shape of the pulse on any A*n* output is identical to the input signal that enters the constant fraction stage. The analog output saturates at this value, however, internally (at the CFD input stage on board) the pulse height can be higher and is still linear. For normal noise levels below 50mV sufficient imaging results are obtained if the pulse heights distribution has a mean value of 300mV. The lowest pulse height should be still higher than the noise level. To increase the pulse height one can increase the MCP bias (not exceeding the maximum recommended value!) or the amplifier gain. If you increase the amplifier gain be aware that the noise level increases also proportionally with the amplification factor.

If the analog outputs are satisfactorily, one can check the corresponding outputs timing outputs T*n*. If your module has NIM-output levels you can directly verify the signals on an oscilloscope (coax input, 50Ω terminated). For the ECL version the signals can be checked likewise using the ECL-TTL converters on the front panel (only for **(N)DLATR6(8)ECL**). For the **ATR19** please refer to the corresponding section in this manual.

Now the thresholds of the channel 1/2 or 3-6 can be reduced, so that even the smallest pulse heights are above the threshold but noise is still discriminated. You may connect the T*n* outputs to the TDC now (see chapter 3.3) and start to take data. During data acquisition you should not supply signals to the ECL-TTL converter.

A walk adjust of the **(N)DLATR6(8)/ATR19** is usually not needed. If you press the walk button follow the instructions in section 2.6.
The potis on the front panel of the **DLATR6(8)** or of the **FT12(16)-TP** can be used to reduce ringing and reflections of the analog signals. This is of importance for multi-hit detection tasks. When you optimize the signals be sure that there is no input to an ECL-TTL converter (only for **(N)DLATR6(8)ECL**).

# 6 Performance

Images demonstrating the typical detector performance are displayed here. You should be able to achieve similar results with the same hardware.

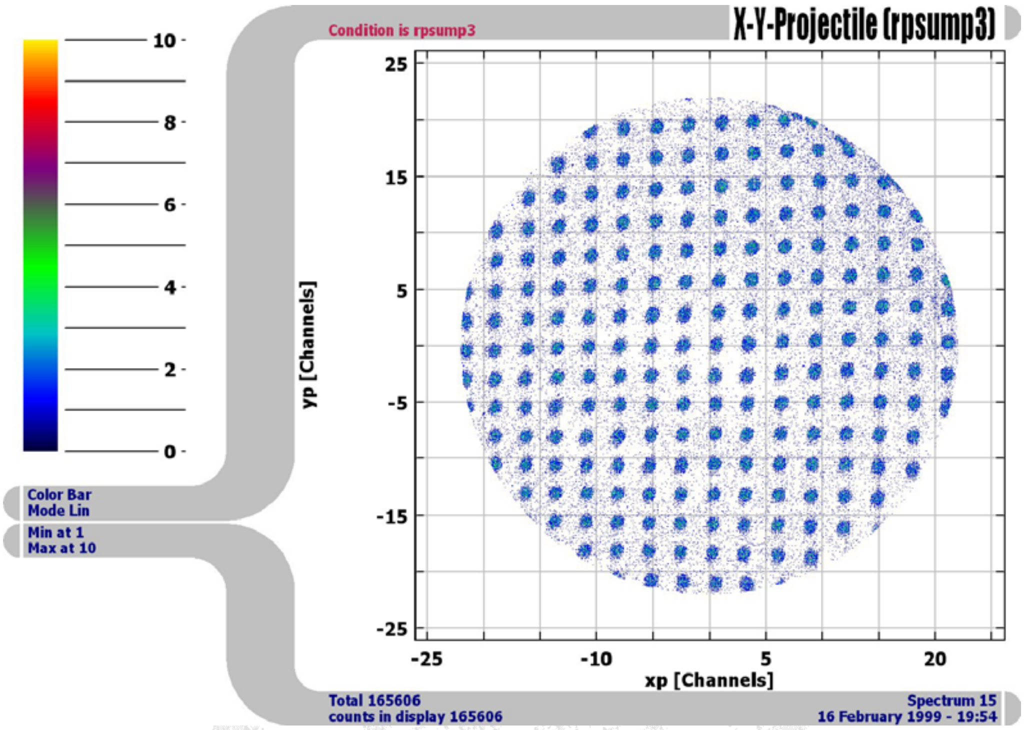



**Figure 6.1: Imaging of a shadow mask on DLD40 Detector. The detector was irradiated by α-particles with about 6 MeV kinetic energy**

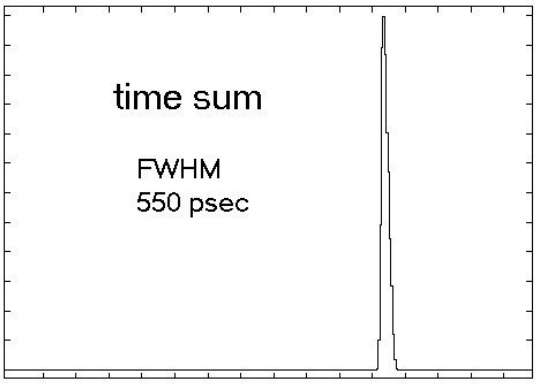



**Figure 6.2: Time sum peak for one dimension at fixed position***

* Note that the apparent time sum integrated over all positions in the respective dimension will usually show a broader time sum spectrum due to slight variations of the absolute time sum as function of the respective position. Wherever a narrow time sum is required this position dependence must be corrected in the data analysis.

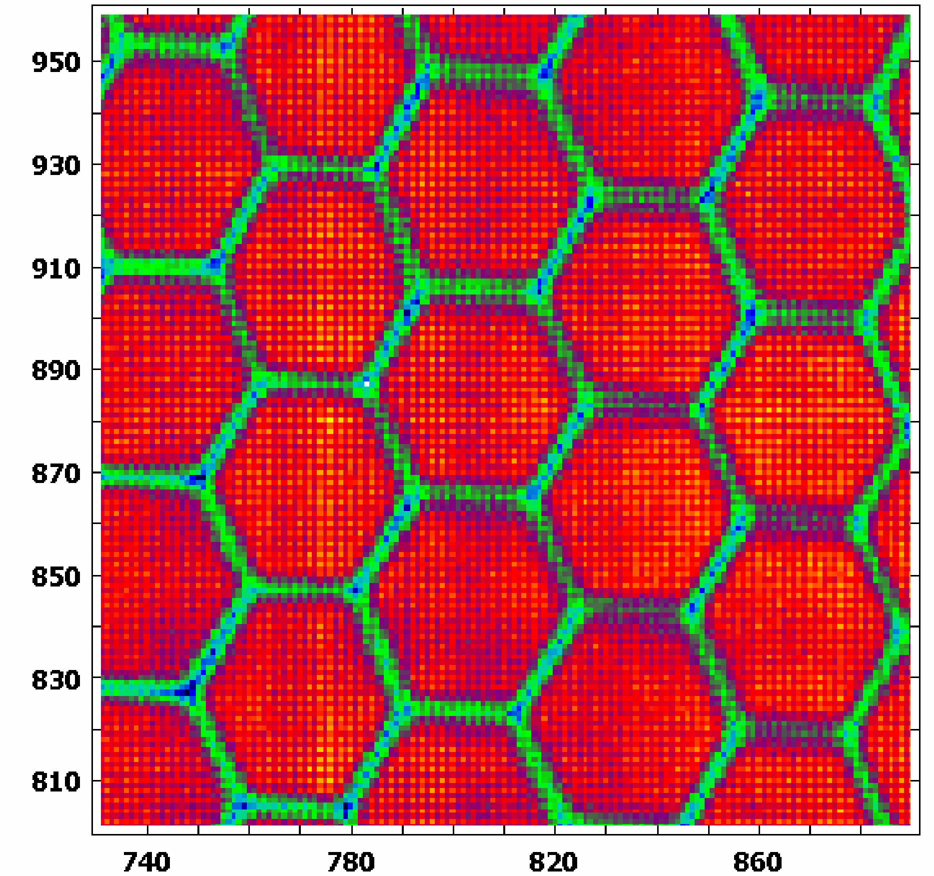



**Figure 6.3: Enlargement from of a shadow mask image, obtained by a DLD80 detector that was read out with HM1. The hexagons are 3 mm wide, the obstacles have 0.2mm width. One channel corresponds to approximately 0.08mm**

# 7 Trouble Shooting/FAQ

This chapter contains a collection of questions that are frequently asked by detector users and some answers to it. It also gives a few hints how to find the cause for real or apparent malfunctions and how to solve or track down the problem.

This chapter is constantly modified and amended. You may find an updated FAQ-list on our web-site http://roentdek.com

***PROBLEM:***
***"I believe the detector hardware and electronics operate well (all signals have been verified) but I don't get data into the computer after starting my "ccf"-file for hardware data acquisition and …***

***a) in the status window the displayed event count rate is zero."***

- Verify again if the "start" signal really makes it all the way to the "start" (or "common") input of the TDC with proper signal shape (NIM/ECL).
- Execute the original "ccf"-file that is used for startup of hardware DAQ as supplied by **RoentDek**.
- Is the I/O address setting in the "ccf"-file (*parameter 1*) and on the board correct (any address conflict with other PC cards possible)?
- For **HM1**: Set *parameter 9* to "1" in the "ccf" file and execute it again (only some of the stop signals might be missing, see below)
- For **HM1**: check if the three green LED of the **HM1** are lit. If not, fuses on the **HM1**-I/O board (inside the PC) must be exchanged.
- Are the incoming data not fulfilling the minimum event pattern multiplicity as defined in *parameter 2*?
- Are the DAN.dll and DAQ.dll. which correspond to your hardware, in the main CoboldPC directory?
- Make sure that you have installed the CoboldPC program properly. In case of WinNT/Win2000/WinXP OS: did you log on as ADMINISTRATOR for the installation procedure? Were there any error or warning messages during installation?
- Does your PC meet the hardware specification "US-compatible"?

***b) although the event count rate seems to make sense I don't get a satisfactorily detector image, at least one of the time sum spectra does not show a clear prominent peak."***

- Verify if all the signals at the inputs just before going into the TDC channels are present and have proper shape (NIM/ECL). Are they in the right sequence (start before the stops)? Do all the stops arrive?

***RELATED QUESTION:***
***"How can I find out if a certain or which of the "stop" channels is missing without using an oscilloscope?"***

You can check for the presence of the individual stops in the corresponding spectra as defined in the original "ccf"-file from **RoentDek**. For **HM1**: Set *parameter 9* in this "ccf"-file to "1" and execute it again.

***PROBLEM:***
***"The time sum peaks look ok but the 2D image seems not be right compared to what I should see from my source of incoming particles, there are …"***

***a) spots that should not be there."***

These are probably dark counts or there is corona current close to your MCP from a sharp tip emitting electrons or ions (meshes close to the detector?). To verify possible corona, change potentials on suspicious parts of the setup and observe if the spots and their rate are changing.
A certain rate of dark counts is normal, sometimes they are concentrated locally, forming minor "defects". If a local dark count rate at a defect is higher than 100cts/s contact **RoentDek**. The "normal" dark counts that are acquired

can be reduced by increasing the CFD threshold and/or by reducing the MCP bias. However, this might also reduce the detection efficiency for the real particles.

***b) more counts that I would expect, but rather diffusely distributed."***

Is there any other source of charged particles/UV photons (ion gauge, corona discharge somewhere in the chamber)?

***c) areas of reduced efficiency."***

The MCP bias might be too low and/or the CFD settings too high, also the electronic amplification might be too low.

**d) sharp lines in the middle of the detector, "ghost" images at left, right, above or below the central image."**

The CFD thresholds are not set properly. The signals induced by some incoming particles are above threshold for channels 1/2 (MCP start) but not for at least one of the "stop" channels (channels 3-8). Reduce the threshold for channels 3-8 until you get similar count rate from all channels. Make also sure that none of the CFD channels triggers in the noise. If the count rate from channels 3-8 differ by more than 10% relative to each other even for good signal-to-noise ratio and low threshold then it is advisable to adjust the amplifications of the **DLATR** boards.

***PROBLEM:***

### *"All analog output signals (channel 1 or 2 and channels 3-8) look ok but not the CFD outputs (Tn), at least one of the outputs is missing or has too low/too high count rate."*

- Adjust thresholds until you get similar count rate from all channels. Make sure that none of the CFD channels triggers in the noise. If the count rate from channels 3-8 differ by more than 10% relative to each other it is advisable to adjust the amplifications of the **DLATR** boards.
- Have amplifiers been damaged due to prior incidents of discharge, power failure, etc.?
- Is the power source for the **(N)DLATR6** strong enough (sufficient current, correct voltage)?

***PROBLEM:***

### *"The analog output from the MCP front/back (channels1/2) looks ok but not all of the delay-line signals (channels 3-8), …*

***a) all are missing."***

- Make sure that the potentials on "holder", "signal" and "reference" on are correct.
- Is there a wiring error? Remove "signal" and "reference" SHV inputs on the **DLATR6(8)** rear panel or **FT12-TP** and verify the absence of any resistance below 20MΩ between these inputs (cable on the front panel or plug still connected to the detector). Verify that all cables are connected by identifying with an Ω meter the four (six) pairs of contacts that connect to the ends of each wire on the connection cable to the feedthrough.
- Have amplifiers been damaged due to prior incidents of discharge, power failure, etc.?
- Make sure that all the cables on the **DLATR** boards inside the **(N)DLATR6(8)** are connected (you need to power down and open the box for that). In case of **ATR19**: Did you connect the right inputs (+/-)?
- Is the power source for the (**N)DLATR6** strong enough (sufficient current, correct voltage)?

***b) some are missing, some other look ok."***

- Make sure that the potentials on "holder", "signal" and "reference" on are correct.
- Is there a wiring error? Remove "signal" and "reference" SHV inputs on the **DLATR6(8)** rear panel or **FT12-TP** and verify the absence of any resistance below 20MΩ between these inputs (cable on the front panel or plug still connected to the detector). Verify that all cables are connected by identifying with an Ω meter the four (six) pairs of contacts that connect to the ends of each wire on the connection cable to the feedthrough.
- Have amplifiers been damaged due to prior incidents of discharge, power failure, etc.?
- Make sure that all the cables on the **DLATR** boards inside the **(N)DLATR6(8)** are connected (you need to power down and open the box for that). In case of **ATR19**: Did you connect the right inputs (+/-)?
- Is the power source for the (**N)DLATR6** strong enough (sufficient current, correct voltage)?

***c) only one signal is missing."***

- verify that all cables are connected by identifying with an Ω meter the four pairs of contacts that connect to the ends of each wire on the connection cable to the feedthrough.
- Have amplifiers been damaged due to prior incidents of discharge, power failure, etc.?
- Make sure that all the cables on the **DLATR** boards inside the **(N)DLATR6(8)** are connected (you need to power down and open the box for that). In case of **ATR19**: Did you connect the right inputs (+/-)?
- Is the power source for the **(N)DLATR6** strong enough (sufficient current, correct voltage)?

***d) delay line signals start with positive tail and seem to be very small"***

- Power down, exchange Uref and Usig input. Try again.

**e) channels 3-8 have significantly different pulse heights."**

- adjust the amplifications in the **DLATR** boards.
- Have amplifiers been damaged due to prior incidents of discharge, power failure, etc.?
- Is the power source for the **(N)DLATR6** strong enough (sufficient current, correct voltage)?

***PROBLEM:***
### *"At least some analog outputs from the detector look ok, but especially the analog output of channel 1/2 is missing"*

- Is the corresponding switch on the **DLATR6(8)** front panel for channels 1 or 2 engaged? In case of **ATR19**: Did you connect the right inputs (+/-)?
- Have amplifiers been damaged due to prior incidents of discharge, power failure, etc.?
- Make sure that all the cables on the **DLATR** boards inside the **(N)DLATR6(8)** are connected (you need to power down and open the box for that).
- Is the power-source for the **(N)DLATR6** strong enough (sufficient current, correct voltage)?

***PROBLEM:***
### *"I have increased all CFD thresholds to maximum but there is still too high noise on channel 1/2 outputs."*

Turn off the high voltage and remove the high voltage cables on the **DLATR6** rear side. If the noise has disappeared, a power supply or power supply cable connection might be noisy, otherwise try the following, while the high voltages should stay off:

- For **DLATR6(8)**: switch off channel 1 or 2 on the front panel, that might reduce the noise of the other channel to an acceptable level
- check if the noise is due to a poor contact at the respective **DLATR** input connector inside the **(N)DLATR6(8)** module. Open the **(N)DLATR6(8)** box and check for the noise on the analog output of the noisy channel while you wiggle on the connection to the respective **DLATR** board (the power of the **(N)DLATR6(8)** must be on).
- Wiggle on the cables between **DLATR6/8** and the feedthrough while checking for the noise on the analog output of the noisy channel.
- Verify the detector wiring again. First check if there is the current through the MCP stack (from front to back contact) according to the internal resistance (indicating that the MCP is properly connected and should deliver signals on channels 1 or 2 if biased for operation). But verify also the absence of any electrical contact between any other detector part, between detector and parts of your setup and to ground.
- Find the noise source in your lab or on your setup that is inducing noise to the detector or directly into the electronics. Read comments to "how can I track down the noise source in my lab?"

***PROBLEM:***

***"I have increased all CFD thresholds to maximum but there is noise on at least one of the channels 3-8."***

Turn off the high voltage and disconnect the high voltage cables to the power supplies. If the noise has disappeared, a power supply or power supply cable connection might be noisy, otherwise try the following, while the high voltages should stay switched off:

- check if the noise is due to a poor contact at the respective **DLATR** input connector inside the **(N)DLATR6(8)** module. For that turn off all high voltages, open the **(N)DLATR6(8)** box and check for the noise on the analog output of the noisy channel while you wiggle on the connection to the respective **DLATR** board (the power of the **(N)DLATR6(8)** must be on).
- Wiggle on the cables between **DLATR6(8)** and the feedthrough while checking for the noise on the analog output of the noisy channel.
- Verify the detector wiring again. First check if there is the current through the MCP stack (from front to back contact) according to the internal resistance (indicating that the MCP is properly connected and should deliver signals on channels 1 or 2 if biased for operation). But verify also the absence of any electrical contact between any other detector part, between detector and parts of your setup and to ground.
- Find the noise source in your lab or on your setup that is inducing noise to the detector or directly to the **DLATR6**. Read comments to "how can I track down the noise source in my lab?"

***PROBLEM:***

***"The detector is biased properly but I get no signals."***

- Is the power-source for the **(N)DLATR6** strong enough (sufficient current, correct voltage)?
- Engage both switches on **DLATR6(8)** front panel for channels 1/2, look for signals at A1 and A2.
- All cables connected?
- Have amplifiers been damaged due to prior incidents of discharge, power failure, etc.?
- Make sure that all the cables on the **DLATR** boards inside the **(N)DLATR6(8)** are connected (you need to power down and open the box for that)
- Is the vacuum ok?
- Is there any source of charged particles/UV-light (ion gauge) in the vacuum that can produce an excessive particle rate to the detector (this may look like "no signals")
- Verify the detector wiring again. First check if there is the current through the MCP stack (from front to back contact) according to the internal resistance (indicating that the MCP is properly connected and should deliver signals on channels 1 or 2 if biased for operation). But verify also the absence of any electrical contact between any other detector part, between detector and parts of your setup and to ground.

***QUESTION:***

***"How can I track down the noise source in my lab?"***

If you have verified that the noise is not due to a problem with the immediate detector setup or the **RoentDek** electronic modules (see above) you must look for the external sources that produce a too high noise level for detector operation. Commonly reported noise sources are:

- so called ground loops, "different ground" for electronic bins and bits of experimental setup
- noisy AC power of electronic modules
- floating or insufficiently grounded parts of the experimental setup.
- power supplies, frequency generators, turbo pumps, RF-sources in general, AC power cables with high alternating currents, laser power supplies, CPUs, monitors; even if not directly connected to the setup.

No straightforward recipe to find noise sources or how to solve/reduce the problem can be given here. However, for identifying the noise source it can be helpful to observe the noise level while removing certain cable connections between the detector and the electronics/the **FT12-TP** plug. Note that a changing in the noise while wiggling on some detector related part does not necessary mean that this part is faulty. Only the noise from an external source may by picked up in a different way. If possible, switch of suspicious electrical units (turbo pumps) for a short while and check the noise.

***QUESTION:***

***"How can I verify if a certain amplifier channel is damaged or if the problem of a bad analog signal output on a certain channel is due to a bad amplifier?"***

Open the **ATR19/(N)DLATR6(8)** **(power down first!)** and exchange two **DLATR** boards. In case of **(N)DLATR6(8)** you can instead simply swap inputs of two boards, one with a properly working channel and a questionable one. When you operate the detector again you can identify the problem by analyzing which of the channel gives satisfactory output now.

***QUESTION:***
***"I have some skills in working with a solder iron and a basic understanding of electronic circuits, so I would like trying to repair a broken channel on a* DLATR *board. Can I do that and how?"***

If the analog output of the bad channel is still operating and only a CFD output is missing or looks disturbed it is **not** recommended to try a self-repair. Remove the **DLATR** board with the damaged channel from its socket and send it to **RoentDek**. **RoentDek** offers a "repair/exchange service" at reasonable costs.

If the analog output is missing (after a discharge) it is worth to try an easy and often successful repair, because very likely only a pair of SMD double diode (BAV99), and two pairs of SMD resistors (56Ω and 47Ω) need to be replaced. These are located close to the amplifier input. When you have replaced all marked parts try to operate the channel again. If the channel is still not working properly then send the **DLATR** board to **RoentDek** for repair.

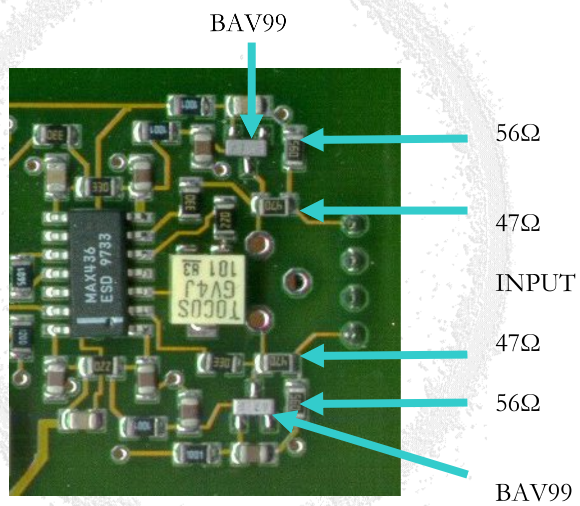



**Figure 7.1: Input region of the DLATR board**

***QUESTION:***
***"I have broken one of the delay-line wires close to the contact. Can I repair that and how?"***

This is a difficult task!

But it has been done before with none or only minor degrading of detector performance.

We offer to send an exchange anode for fixed price. Anyway, you may try to fix it but even if you succeed, the delay-line on this side will be at least one mm shorter than before, or more, depending on how many of the windings have lost tension already. Also the baking tolerance of the detector might be reduced from now on.

So here is reparation recipe without guarantee for success, much will depend on "good hands":

First check how many windings have lost tension by inspecting the anode edge-on. As far towards the broken end where the wire is still straight the anode may be saved, usually only the last 1 or 2mm show a bending if the anode was handled carefully after the accident.
The repair procedure is certainly easier if the trouble happened on the outer layer and not on an inner one.

Aim is now to take one or two windings off at the broken corner contact. The broken wire and the parallel one will later need to have same length again, so after shortening and reconnecting the broken one you need to take off the same number of windings on the parallel one. Work on one after the other.

It is important that the wires are not loosing tension on the still straight part of the anode while you unwind it, so the "shorter" delay-line wire will be bent and will not touch other wires.

One way to do this is firmly gripping the anode with the fingers on the ceramic edges so that the loose wire can not become even looser on the turns that are still straight. With the other hand then one or several turns of the broken wires can be unwound.

In order to fix it again on the connection screw there are two options: If the screw is still long enough to except and additional M2 nut for fixing the wire AND the M2 nut for fixing a contact wire, this should be done like this.
If it is too short one must break the seal on the M2 nut that was fixing the wire before. This can be done by using a screwdriver or by loosening the screw with the right mixture of care and force.

In any case remember you need to do this procedure on both pair contacts.

If successful the remaining shorter anode will have rather straight wires also at the battered side and no short between the wires. Give the anode an edge-on inspection again to verify the straightness and check for the absence of a short contact.

Good luck!

# Appendix A. (MCP's):

## STORAGE, HANDLING and OPERATION of MICROCHANNEL PLATES

from Galileo Corp.

### *STORAGE*

Because of their structure and the nature of the materials used in manufacture, care must be taken when handling or operating MCPs. The following precautions are strongly recommended: Containers in which microchannel plates are shipped are *not suitable* for storage periods exceeding the delivery time. Upon delivery to the customer's facility, microchannel plates must be transferred to a suitable long term storage medium.

- Dessicator type cabinets which utilize silica gel or other solid dessicants to remove moisture have been proven *unacceptable*.
- The most effective long-term storage environment for an MCP is an oil free vacuum.
- A dry box which utilizes an inert gas, such as argon or nitrogen, is also suitable.

### *HANDLING*

- Shipping containers should be opened only under class 100 Laminar flow clean-room conditions.
- Personnel should always wear clean, talc-free, class 100 clean-room compatible, vinyl gloves when handling MCPs. No physical object should come in contact with the active area of the wafer. The MCP should be handled by its solid glass border using clean, degreased tools fabricated from stainless steel, Teflon™ or other ultra-high vacuum-compatible materials. Handling MCPs with triceps should be limited to trained, experienced personnel.
- MCPs without solid glass border should be handled *very* carefully with great care taken to contact the outer edges of the plate ***only***.
- All ion barrier MCPs should be placed in their containers with the ion barrier facing down.
- The MCP should be protected from exposure to particle contamination. Particles which become affixed to the plate can be removed by using a single-hair brush and an ionized dry nitrogen gun.
- The MCP should be mounted only in fixtures designed for this purpose. Careful note should be taken of electrical potentials involved.
- ***CAUTION:*** Voltages must not be applied to the device while at atmospheric pressure. Pressure should be $1x10^{-5}$bar or lower at the microchannel plate before applying voltage. Otherwise, damaging ion feedback or electrical breakdown will occur.

### *OPERATION*

- A dry-pumped or well-trapped/diffusion-pumped operating environment is desirable. A poor vacuum environment will most likely shorten MCP life or change MCP operating characteristics.
- A pressure of $1x10^{-6}$bar or better is preferred. Higher pressure can result in high background noise due to ion feedback.
- MCPs may be vacuum baked to a temperature of 480°C (***no voltage applied***) and operated at a maximum temperature of 350°C.

When a satisfactory vacuum has been achieved, voltages may be applied. It is recommended that this should be done slowly and carefully. Current measuring devices in series with power supplies aid in monitoring MCP behaviour. Voltage drop across the Ω meter should be taken into consideration when calculating the applied voltage.

- Voltage should be applied to the MCP in 100V steps. If current is being monitored, no erratic fluctuations should appear. If fluctuations do appear, damage or contamination should be suspected and the voltage should be turned off. The assembly should then be inspected before proceeding.
- Voltage across single thickness MCPs should not exceed 1000V. Higher potentials may result in irreversible damage.

# List of Figures

## List of Tables