Delayline Detector
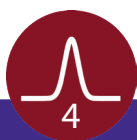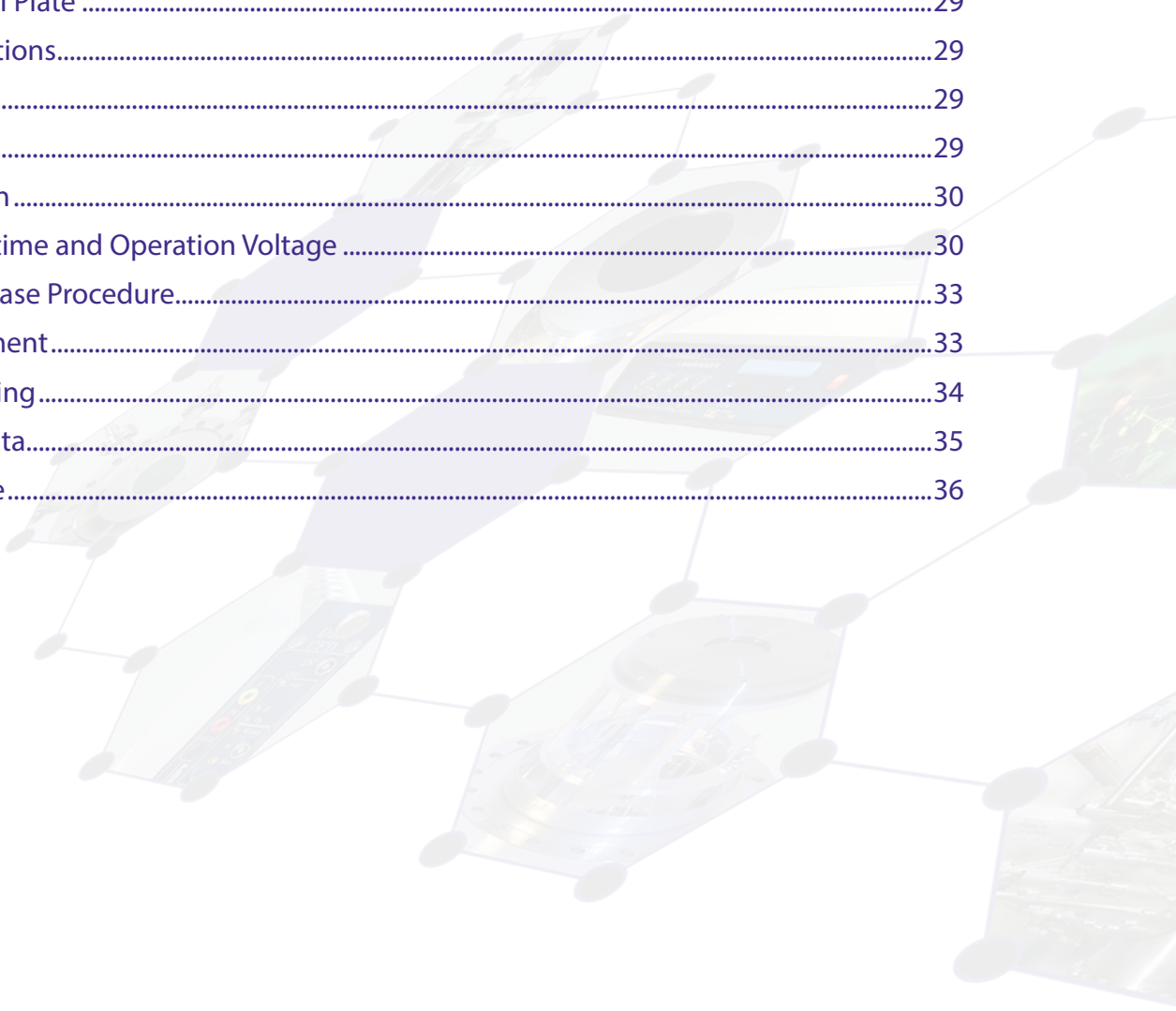# DLD6060-8S
(Release 1.10)

Manual

SURFACE
CONCEPT

Surface Concept GmbH

Manual for the Delayline Detector
DLD6060-8S
Release 1.10
Manual Version 2.2
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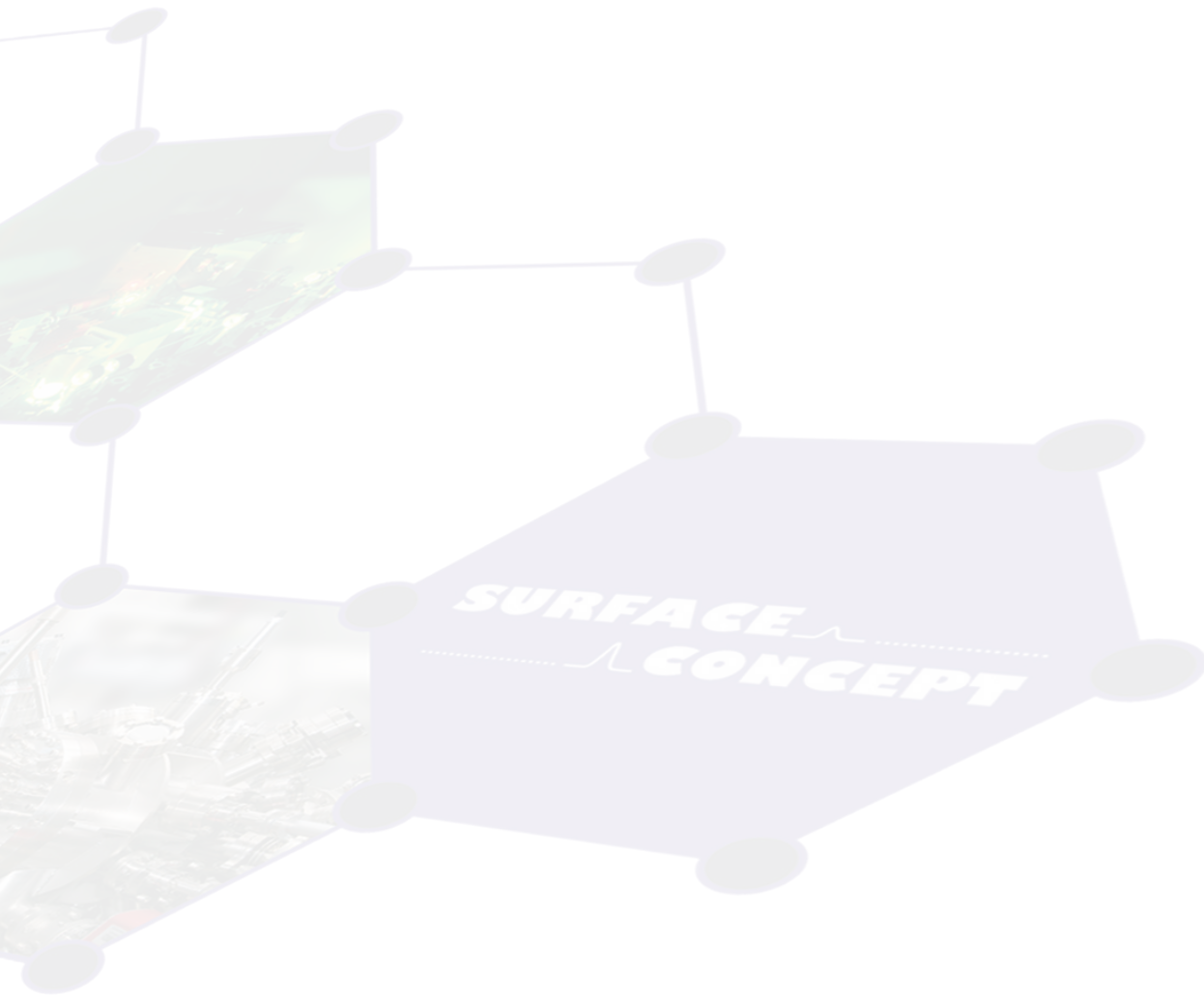# 1 Table of Contents

2 Introduction

2.1 General Information

This manual is intended to assist users in the installation, operation and maintenance of Release 1.10 of the Delayline Detector DLD6060-8S as part of the PHOIBOS Hemispherical Analyzer Series. It is divided into 11 chapters. The chapter "Introduction" contains a brief description of the DLD. The chapter "Installation" refers to installation and cabling. Further chapters explain the theory of the DLD, the technical details of the detector readout package and the operation of the DLD.

2.2 Safety Instructions

Caution

Please read this manual carefully before performing any electrical or electronic operations. Please also consult the "SURFACE CONCEPT Safety Instructions" and the manual of the PHOIBOS Hemispherical Analyzer Series respectively, before using this device. Strictly follow the safety rules given within each of the manuals.

The following symbols appear throughout the manual:

! Note

The "note symbol" marks text passages, which contain important information/ hints about the operation of the detector. Follow these information to ensure a proper functioning of the detector.

Caution

The "caution symbol" marks warnings, which are given to prevent an accidentally damaging of the detector or the readout system. Do NOT ignore these warnings and follow them strictly. Otherwise no guarantee is given for arose damages.
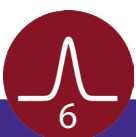
2.3   General Overview of the System

The Surface Concept Delayline Detectors are particularly developed for the needs of 1D(x), 2D(x,t), 2D(x,y) or 3D(x,y,t) area and time detection of electrons, ions, x-ray and UV-light.

The layout of the DLD6060-8S detector has been specially designed for the detection of multi hit events with the PHOIBOS 150/225 Analyzer. For the PHOIBOS Analyzer Series, the standard Channeltron Detector, the CCD Imaging Detector, and the Delayline Detector can be used without any physical modification to the analyzer ("plug and play").
The DLD6060-8S consists of a chevron microchannel plate stack and different layers of segmented meander structured delaylines. The image is sampled by the DLD readout electronics. The 3D (x, y, t) detection bases on the measurement of time differences and time sums of signals, with a high temporal resolution in one device. The count rate can reach several MHz in the commonly used 4-fold coincidence measurement.

Typical applications for a Delayline Detector are for example: Fermi surface mapping, band mapping, photoelectron diffraction measurements, and similar angular dispersion experiments as well as XPS, UPS, ESCA and AES and time resolved stroboscopic experiments.
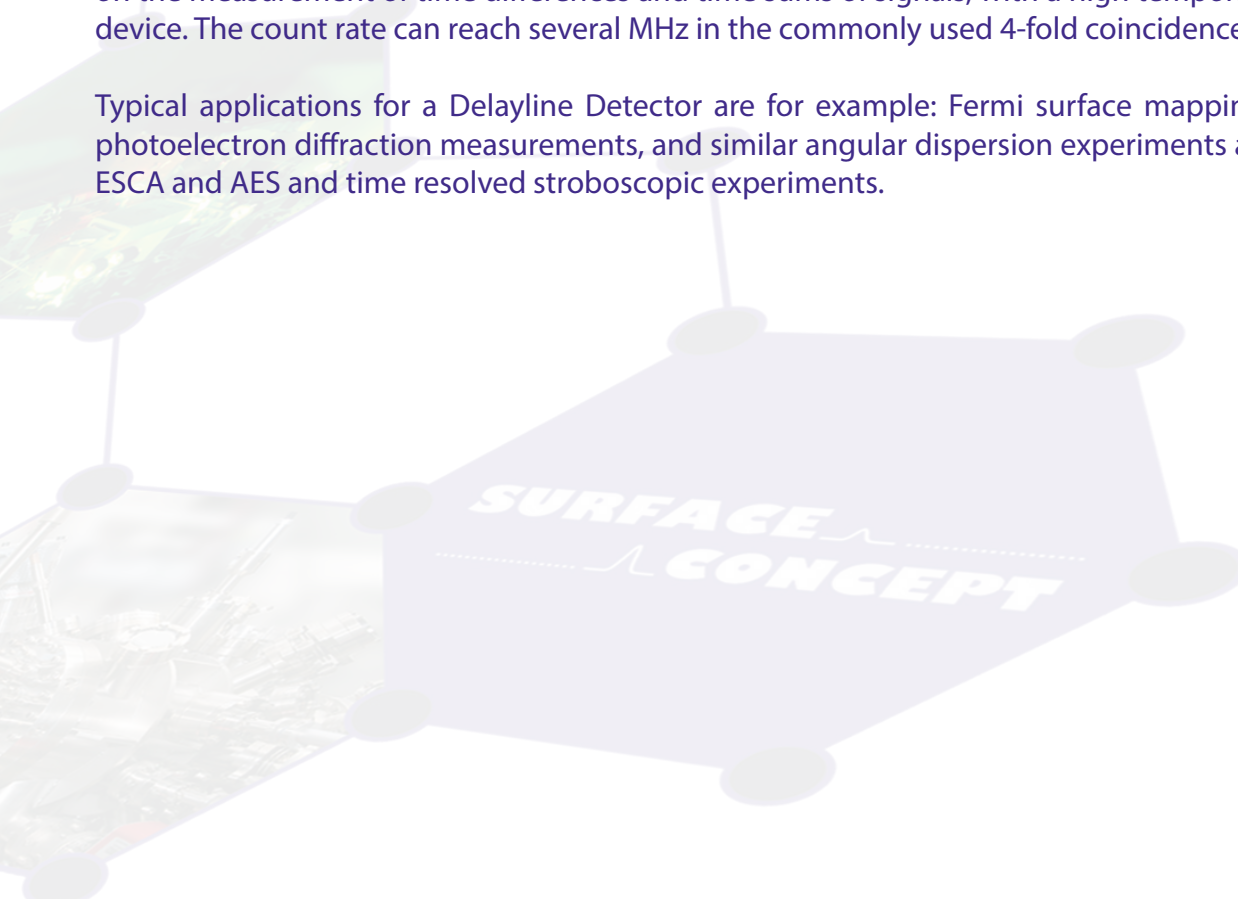
3 Installation

3.1 Initial Inspection

Visual inspection of the system is required to ensure that no damage has occurred during shipping. Should there be any signs of damage, please contact your provider immediately. Please check the delivery according to the packing list (**see Table 1**) for completeness.

- Delayline Detector Unit (delivered in a vacuum container)
- Pulse Processing Unit ACU
- 4 x DLD Readout Cable (HDMI)
- CD with Documentation and Software

Table 1: Packing list for the DLD6060-8S Detector.

> **!**
> **Note**
>
> **The vacuum container of the Delayline Detector must be stored for later use. Replacement will be done by shipping the detector/MCPs within this container. It can also be used to store the detector when not installed in a vacuum chamber.**

3.2 Installation

3.2.1 Mounting the Delayline Detector

The detector is transported under vacuum. Proceed as follows, to install it into your vacuum chamber:

- Vent the transport container **carefully** with N2.
- Release the M8 screws of the vacuum container and pull out the detector **carefully.**
- Before installing the detector to your chamber, check the front side of the MCP stack for particles.

> **⚠ Caution**
>
> **The microchannel plates in front of the detector should be protected from exposure to particle contamination. Particles that stick to the plate can be removed by using a single-hair brush carefully and/or with dry nitrogen. Reading the instructions "microchannel plates" in Chapter 8 is strongly recommended.**

- In most cases the detector head is stabilized again vibrations by a PTFE inlet within the transport container to protect the detector head during transportation. In some cases the detector head might still be stabilized by three transportation locks in the lower aluminum ring.

⚠ Caution **Remove the three M3 screws transportation locks (where applicable) before mounting the Delayline Detector (**see **Figure 1). Otherwise the analyzer can be seriously damaged.**
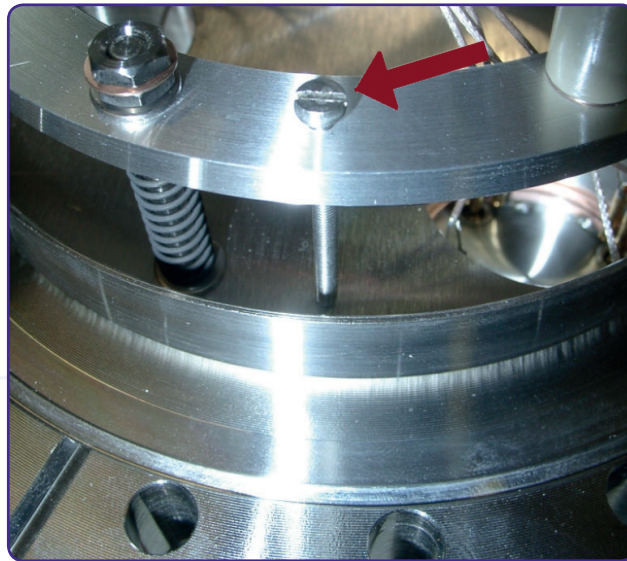
Figure 1: Removal of the transportation locks.

- When looking into the opened detector flange of the spectrometer from the bottom side, you can locate the "alignment hole" for the detector. Align the pin in the cover of the Delayline Detector with the corresponding hole in the ground plate (see **Figure 2**).

- Be sure that the detector is nearly parallel to the ground plate and push the detector carefully into its seat.

- While pressing the detector into its seat, make sure that the distance between the two flanges is approx. 4 mm before you feel that the springs are being compressed.

- Hold the detector in its position and tighten the flanges with the M8 screws together.
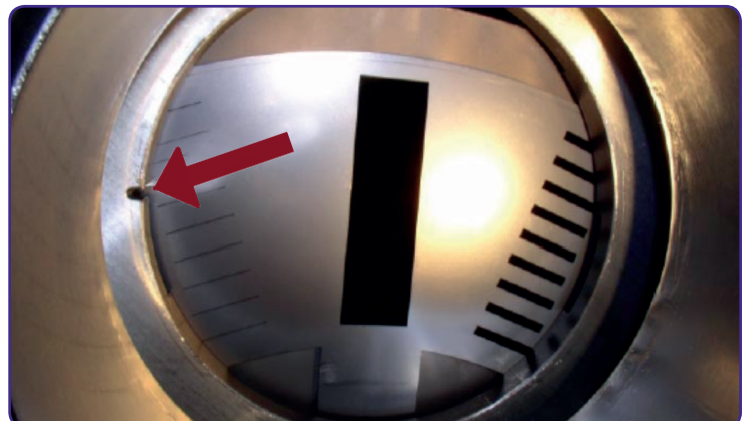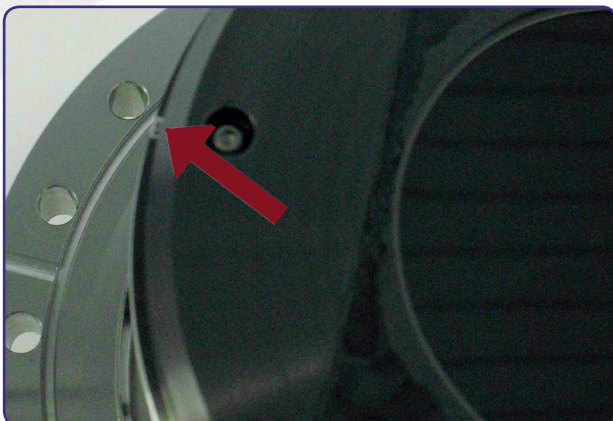
Figure 2: Orientation pin in DLD cover (for illustration only) and corresponding hole in the ground plate of a PHOIBOS Analyzer.

- Install the detector into your vacuum chamber.

- Keep the vacuum container in case that the detector must be sent back for repair. It can also be used to store the detector when not installed in a vacuum chamber.

!
Note   **The detector should be kept under vacuum all the time.**

3.2.2 Detector Orientation

- The red dot in **Figure 3** marks the 0/0 positions of the two DLD images (0° and 45° system). The 0/0 position of the 0° corresponds to the upper left corner of the image in the software.
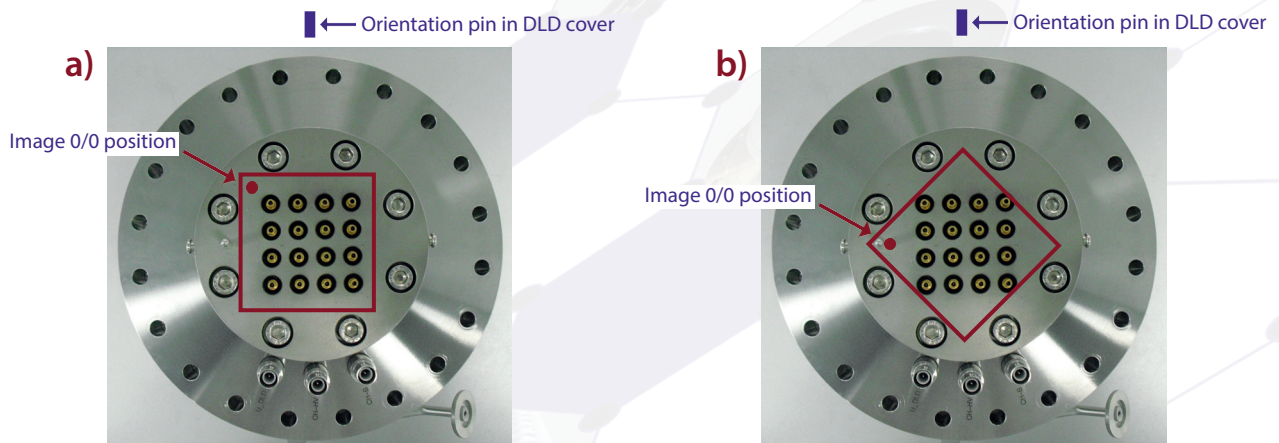
Figure 3: 0/0 position of the DLD image (red dot) for the a) 0° system and b) 45° system.

3.2.3 Cabling and High Voltage

- The general connection scheme of the Delayline Detector including its readout package is shown in **Figure 4.**
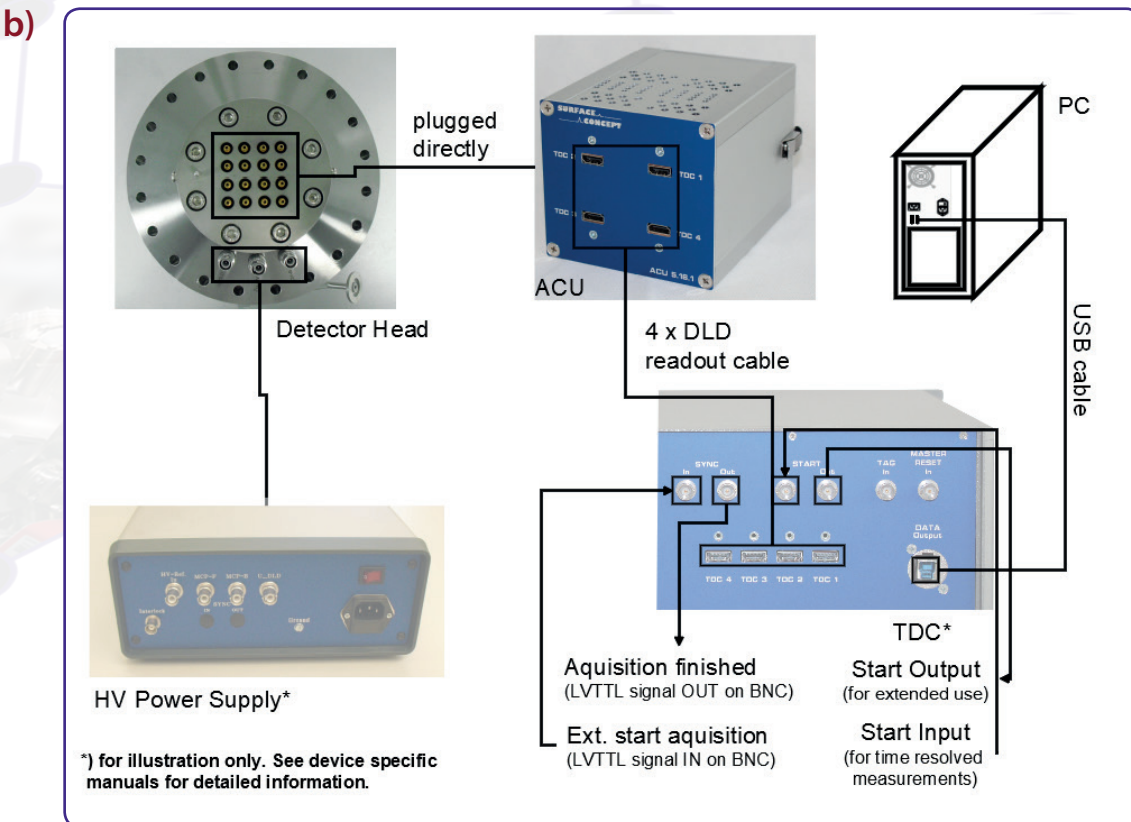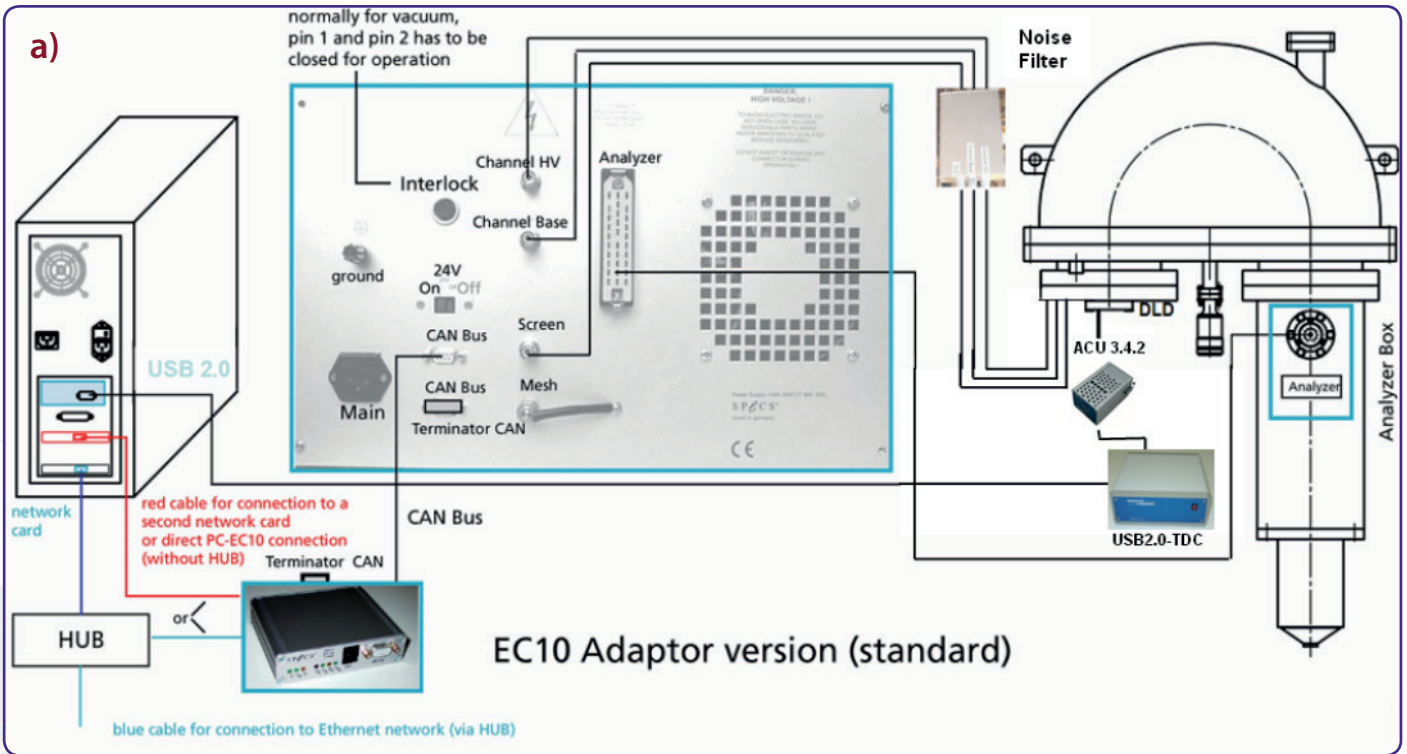
Figure 4: Connection scheme of a) the Delayline Detector to the PHOIBOS Analyzer and the SPECS Power Supply, b) the DLD6060-8S and its readout package.

- The pulse processing unit ACU can be connected directly to the DLD 16-fold SMB feedthrough. The metal pin gives the orientation. Fix the ACU with the two clips on the housing to the fastening bolds on the feedthrough.

⚠ **Caution**

Hold the ACU straight and plug it very carefully.
The middle pins of the SMB connectors in the 16-fold SMB feedthrough can be damaged when holding the ACU not straight while plugging.

- Use the DLD readout cables to connect the "Lines Out" sockets on the front of the ACU with the "TDC Input" sockets at the rear panel of the TDC (see the TDC manual for specific connection scheme of the TDC).

- The DLD6060-8S carries 3 SHV feedthroughs directly on the CF160 base flange. The three voltages are named "CH-B", "CH-HV" and "U_DLD". The naming can be found directly engraved on the base flange. "CH-B" is the contact to the front side of the MCP stack, while "CH-HV" is connected to the back side of the MCP stack and "U_DLD" is connected to the detector anode.

⚠ **Caution**

Be sure that all voltages are settled to zero before connecting the high voltage cables to the detector, otherwise serious damage to the detector can occur due to high voltage sparks.

- Connect the output of your high voltage power supply to the "CH-B", "CH-HV" and "U_DLD" connection of the detector.

! **Note**

HV power supplies always produce some noise level on the HV lines. An increased noise level can lead to a significant loss of spatial and time resolution. In such a case an appropriate noise filter between the HV power supply and the DLD HV connectors is highly recommended. HV power supplies as part of the DLD delivery have been explicitly tested for the DLD operation.

- Further information about detector operation voltages can be found in **Chapter 4**.

- Install the hardware drivers and the GUI – DLD software. See the GUI – DLD Software Installation manual for further details.

- Connect the power cable to the main connector of the TDC and use the USB cable to connect the TDC to the PC. Do not use PC front panel USB connectors; they are often restricted in performance.

- To perform time measurements with respect to an external clock, provide start pulses to the start input of the TDC. Use the corresponding BNC socket of the TDC (see the TDC manual for the specific connection scheme of the TDC).
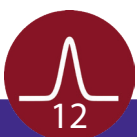
3.2.4 Recommended System Requirements

All operation functions for data readout of the detector package are encapsulated in a dynamic linked library (either "delayline_gpx3.dll" or scTDC1.dll). Data processing and presentation on the PC is realized by an end-user software (e.g. GUI). See the corresponding software manual for detailed information on the software package and the DLL interface.

The delivery package of the Delayline Detector includes a CD-ROM with hardware drivers and the GUI software. Insert the CD into your disk drive and install the software package as described in the DLD - GUI Software Installation Manual.

Read-out of the Delayline Detector is done via the USB port of the TDC (Time-to-Digital Converter). The specific PC system requirements can be found in the corresponding TDC manual.
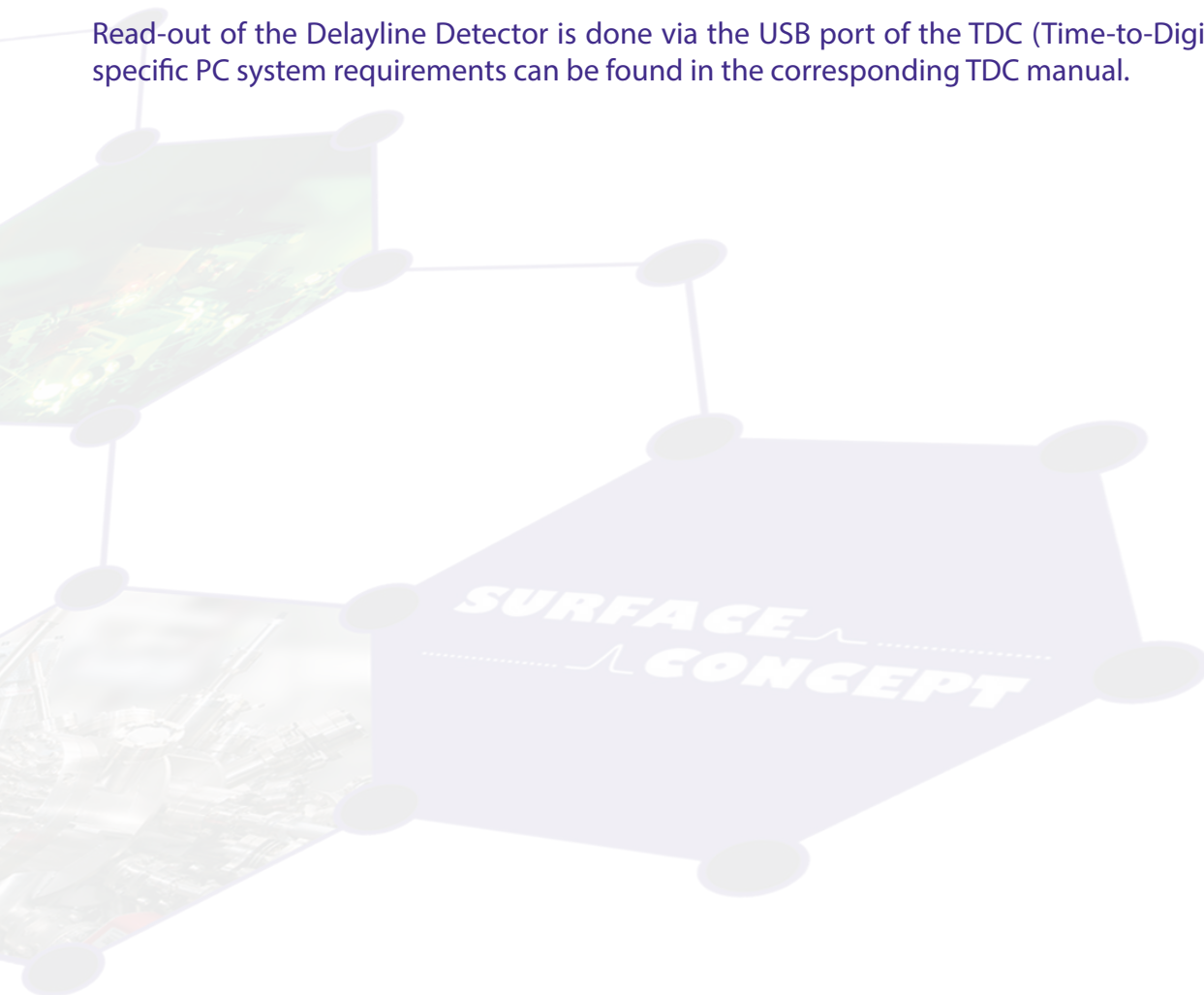
4   Operation of the DLD

! **Note**

Mistakes, which lead to complete wrong measurement results, can happen very easily while taking the Delayline Detector to operation. Therefore it is strongly advised to read the following sections completely before taking the detector to operation and to strictly follow all given advices within it.

All operation voltages for the detector are given within the detectors specification sheet.

Due to gain degradation it will become necessary to increase the operation voltage from time to time. Please refer to Chapter 8.5 for detailed information.

4.1   Getting Started

4.1.1 "Start Up" Procedure

Follow this procedure when taken the detector to operation the first time and after every venting.

- Finish the complete cabling as described in **Chapter 3**.

- Turn on the TDC.

- Start your end-user software (e.g. GUI software) and within this software the rate meter, if available. For details see your end-user software manual.

- Be sure, that the vacuum pressure at the detector is remarkably below 1E-6mbar, otherwise the microchannel plates might be damaged by a local discharging (in general: the lower the pressure, the longer the lifetime of the MCPs).

- Turn off all sources for electrons, ions, light or X-rays that might hit the detector.

⚠ **Caution**

Ion gauges and ion pump are both sources for electrons and ions. Ion pumps can also be a source for X-rays. They can produce so many particles/ X-rays that the detector is in a complete overload, even when they are not facing the detector directly. This will wear out the MCPs very fast. Turn off ion pumps and ion gauges before turning on the high voltage of the detector.

- Turn on the high voltage carefully. The voltage increase should not exceed 400V per minute. A schematic sketch on how to ramp the voltages during the "Start-Up" procedure is given in **Figure 5**. The starting operation voltage is specified in the specification sheet of the detector.

- Watch the vacuum pressure while increasing the high voltage; turn the voltages back, if an unusual increase is observed in the pressure (indicator for high voltage sparking).

Caution
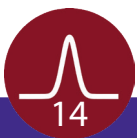
High voltage sparks may seriously damage the detector anode/ meander or the MCPs. Observe the chamber pressure carefully every time the high voltage is turned on. Switch off the high voltage immediately in case of a temporary pressure rise by an order of magnitude or more. This indicates high voltage sparking.
Wait some time (up to 5 min.). Start the "Start-Up" procedure again with an increased ramp time. Turn off the high voltage completely, stop the procedure and call your provider for further assistance, if is it not possible to reach the operation voltage without sparking.
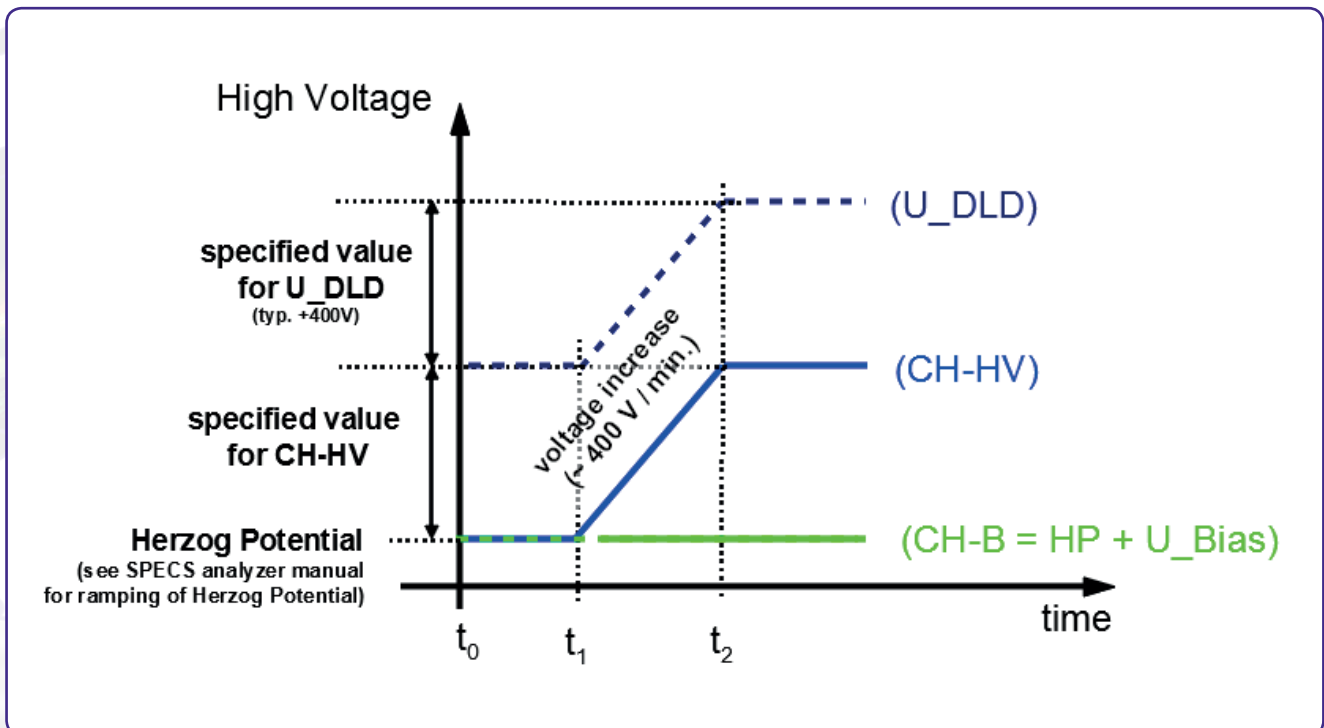
Figure 5: Schematic sketch on voltage ramping during "Start-Up" procedure. See the SPECS Analyzer manual for ramping of the Herzog Potential.

Note

The detector starting operation voltage for "CH-HV" is given in the specification sheet. The voltage for "U_DLD" is fixed to "CH-HV" + 400V, when using the Surface Concept HV Power Supply. It cannot be changed by the user and is therefore always increasing/ decreasing together with the voltage for "CH-HV". This might not be the case for different used HV supplies.
The voltage for "CH-HV" is always given in reference to the MCP front voltage "CH-B (which corresponds to the external reference voltage of the Surface Concept HV Power Supply). Depending on the detector setup the voltage difference between "U_DLD" and "CH-HV" can be different than 400V.

Example: The bias voltage U_Bias should always be set to 0V. Therefore the "CH-B" voltage is only defined by the Herzog Potential, which must be ramped first (see SPECS Analyzer manual for details). The "CH-HV" voltage is given in respect to the "CH-B" voltage. A ramp time of about 5min. should be used to change the "CH-HV" voltage from 0V to a target voltage of exemplary +1800V. The "U_DLD" voltage is given in respect to the "CH-HV" voltage and should be changed after the "CH-HV" voltage has been set.

> ⚠️ **Caution**
>
> **The analogue readout electronics has been adjusted to optimized detector voltages. The starting operation voltages are given in the specification sheet of the detector. Please note that one cannot compensate a voltage lower than the specified operation voltages by increasing the intensity to the detector. This will only lead to complete false measurement results.**
>
> **It is highly recommended to keep the U_Bias at 0V. Contact your provider before changing the bias voltage.**

4.1.2 Dark Count Rate Measurement

- Check the detector output by means of your end-user software (e.g. GUI software) after ramping to the operation voltage (the use of the rate meter where available is recommended).

- The dark count rate without any source should be as given in the specification sheet.

- Accumulate the dark counts for several minutes. The DLD image should appear homogeneous and sharply bounded (see **Figure 6** for an example).

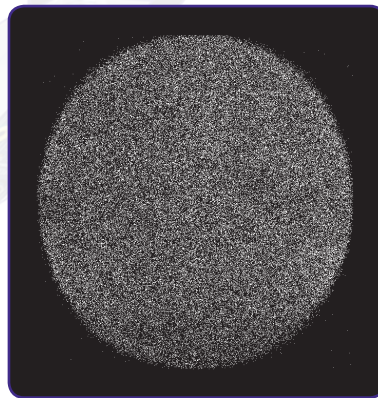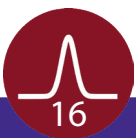
Figure 6: Example for DLD image of accumulated dark counts.

4.1.3 Standard DLD Measurement

- After finishing the dark count rate measurement with a satisfying result, you may now start carefully with an electron or light source observing the detector output.

> **! Note**
>
> **Keep in mind the description about the important operation details in Chapter 5.**

⚠ Caution

Turn off the high voltage, close the software and turn off the TDC before performing any changes of the cabling.

4.2   Standard Operation Procedure

Follow this procedure for all later operation starts, when the detector has already been operated in vacuum and has not been vented in between.

- Finish the complete cabling as described in **Chapter 3**.

- Turn on the TDC.

- Start your end-user software (e.g. GUI software) and within this software the rate meter (if available).
  For details see your end-user software manual.

- Be sure, that the vacuum pressure at the detector is remarkably below 1E-6mbar, otherwise the microchannel plates might be damaged by a local discharging (in general: the lower the pressure, the longer the lifetime of the MCPs).

- Turn off all sources for electrons, ions, light or X-rays that might hit the detector.

- Turn up the high voltage carefully and stepwise within 2 - 3minutes to the operation voltage. The starting operation voltage is specified in the specification sheet of the detector.

- Watch the vacuum pressure while increasing the high voltage; turn the voltages back, if an unusual increase is observed in the pressure (indicator for high voltage sparking).

⚠ Caution

High voltage sparks may seriously damage the detector anode/ meander or the MCPs. Observe the chamber pressure carefully every time the high voltage is turned on. Switch off the high voltage immediately in case of a temporary pressure rise by an order of magnitude or more. This indicates high voltage sparking.
Wait some time (up to 5 min.). Start the procedure again with an increased ramp time. Turn off the high voltage completely, stop the procedure and call your provider for further assistance, if is it not possible to reach the operation voltage without sparking.

- Now you may start carefully with an electron source observing the detector output.

! Note

Keep in mind the description about the important operation details in Chapter 5.

⚠ Caution

Turn off the high voltage, close the software and turn off the TDC before performing any changes of the cabling.

4.3 Bake Out Procedure

Note

It is strongly advised to read the following sections completely before baking out the detector and to strictly follow all given advices within it.
Please also read the bake out instructions in the main manual of the PHOIBOS Analyzer before proceeding.

Caution

The maximum allowed temperature for the detector is 150°C. Do not exceed this temperature.

- The detector electronics (ACU) must be removed before any bake out.

- Windows and feedthroughs should be wrapped with aluminum foil, to protect them from rapid temperature changes.

- The use of heating tapes and jackets is not recommended, due to danger of local overheating.

- Do not remove the blankets until the entire system has thoroughly cooled off.

- Do not operate the detector before the temperature has returned to ambient conditions.

Caution

After a bake out, the detector needs at least one day to cool down. If channel plates are operated at higher temperatures (> 70°C) they can suffer damage. Such channel plates will lose gain and exhibit a markedly higher detector plateau.

Even if the detector housing feels just warm, any internal parts seated on insulators (e.g. the detector anode) may still be too hot for safe operation. It is imperative that all users be informed of this issue and take the necessary precaution to ensure proper device operation.

5 DLD - Principle of Operation

5.1 Basics of Delayline Detection

The Delayline Detector (DLD) consists of a microchannel plate stack (required to amplify incoming electrons) and the detector anode. The DLD anode (for 4 quadrant DLDs: each single quadrant) consists basically of two meander structured delaylines; one rotated by 90° with respect to the other and both isolated from each other. The electron cloud from the MCP stack output is drawn to the detector anode by a positive potential difference between anode and back side of MCP stack, where it induces electrical pulses into the delayline by capacitive coupling. The pulses are traveling to the both ends of the meander within a time determined by the hitting position.

Each hit position is encoded by a fast data acquisition unit, which also may detect the hit time referenced to an external clock in repetitive (stroboscopic) experiments.
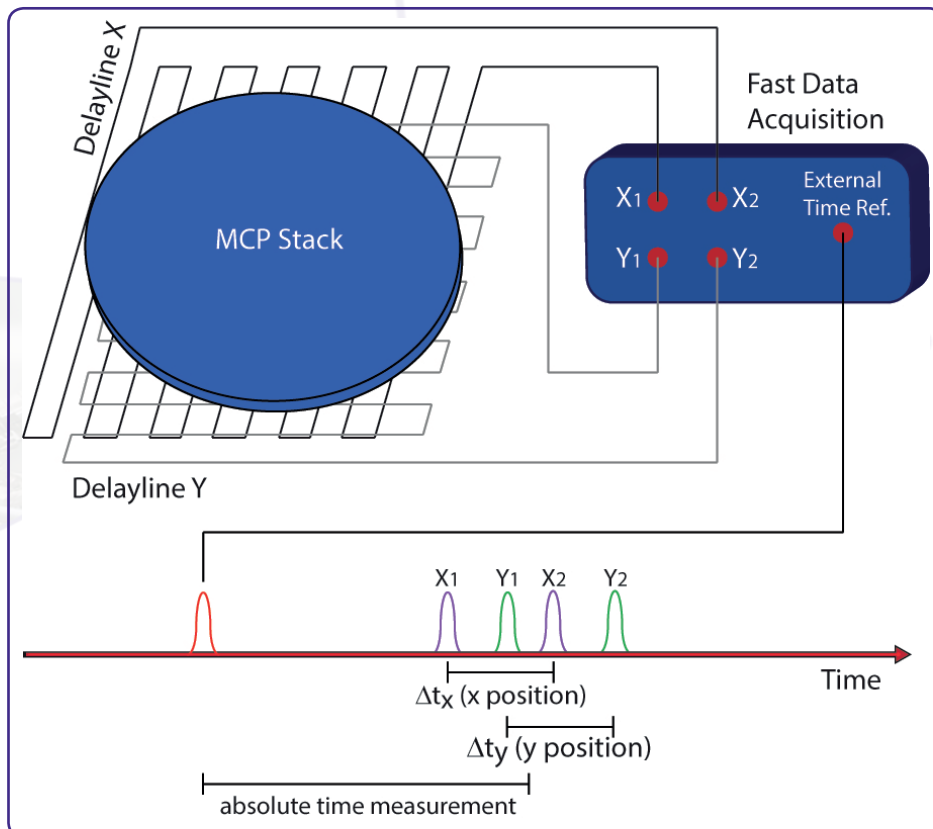
Figure 7: Schematic drawing of the basic assembly of a Delayline Detector.

Delayline Detectors are single counting devices; therefore the complete device works linearly even at extremely low numbers of incoming electrons. The maximum count rate in the 4-fold coincidence measurement is up to a few million counts per second. The exact value depends on the individual DLD layout (e.g. the size of the active area) and is given within the specification sheet of the DLD.

5.2 Basic Operational Modes of the Delayline Detector

5.2.1 2D(x, y) Area Detection

The arrival times of pulses per event at the 4 ends of the DLD meander/ quadrant are subtracted in order to determine a position in x and y (x: tx1-tx2; y: ty1-ty2). The 4 TDC stop signals are grouped internally in pairs to form the x- and y-coordinates. All DLD software adjustments are done by the end-user software according to the user's chosen parameters.

5.2.2 3D(x, y, t) Time Resolved Imaging

The Delayline Detector may measure all events in temporal reference to an external clock. For this mode, the user needs to start the TDC by an external clock, providing a low jitter LVTTL signal to the start input of the TDC.

Time measurements are performed by summing up the arrival times of pulses at the end of the DLD meanders, i.e. the same results which are used to determine positions for each event are summed. It is possible to sum only tx1 and tx2 (tsumx) or ty1 and ty2 (tsumy), because both sums should carry the same temporal information of a time related experiment. The total sum t(DLD) of all four time measurements (tx1, tx2, ty1, ty2) may be a good choice as well. The results of all those time sums correspond to t(sum) = t(offset) + t(hit), where t(hit) is the interesting time (e.g. ToF) in a given experiment and t(offset) is a device related constant, which depends on cable lengths, electronics propagation times, experimental setup etc. Therefore, it is possible to completely determine position and time of each event from only 4 precise time measurements. The software can group all measured time sums in plain 1D time histograms, which are valid for the chosen region of interest (ROI) with the correct time bin unit. The time bin unit for each single readout channel is around 27ps, but due to the calculation of the tsums and t(DLD), the time axis is expanded virtually (simplified expression). Therefore the channel width in the 1D histogram is different for the tsumx, tsumy and t(DLD) histograms. The correct value for a current setting is always shown by the software. The t(DLD) signature can be used in order to setup the regions of interest in time for measurements of time resolved images. The software is able to sample 3D histograms as image stacks in time, where each image corresponds to one channel width of the t(DLD) time histogram.

5.2.3 Specialties of the 8S Detector Anode

The anode of an 8S Delayline Detector differs by a special segmentation of the meander system as well as by a second, rotated meander system.
In opposite to a single Delayline Detector anode consisting of a single meander for the x and for the y direction, the 8S anode has two seperated meanders for each direction x and y.
In addition it has a complete second set of x and y meanders, rotated by 45° (R) anticlockwise in respect to the normal 0° system (N). Detailed information of the meander segmentation and orientation is given in **Chapter 6**.

5.3   Data Acquisition

Each readout line of the detector anode is connected to a fast amplifier followed by a constant fraction discriminator (CFD) for pulse shaping. They are encapsulated inside the pulse processing electronics (ACU = Amplifier-CFD-Unit or AU = Amplifier-Unit). The main function of the CFD is digital pulse discrimination, ideally without any time-walk even at varying pulse heights. A Time-to-Digital Converter (TDC) behind these chains serves as stop-watch for arrival time measurements.

The measurement results, in terms of differences and sums are fed into the PC via an USB interface and are completed to 2D images (with or without time stamps) by the histogram module of the data acquisition DLL. Data processing and presentation on the PC is realized by the end-user software (see the corresponding software manuals for detailed information on the software package).

5.4 Working with the DLD - Important Details

The DLD is a counting system that works in a laterally resolving sense by detecting four pulses from the four ends of the delayline meanders in 4-fold coincidence. It only works correctly within a certain range of the supply voltage. The MCP voltage has to exceed an operation threshold for the detector otherwise the pulse detection is not possible. This is due to the induced pulses on the delayline which have to reach a certain amplitude to be detected by the electronics, independent on the intensity of the electron source (e.g. mercury lamp). On the other hand, if the MCP voltage and/or the intensity of the electron source are too high, the detector overloads and again pulse detection is not possible. Saturation effects of the MCPs limit the amount of electrons provided by single pulses. An intensity increase of the electron source leads to an increased number of hits on the MCP. The current per bunch and therefore the amplitude of the pulses decreases.

There are two kinds of overloads: local and global ones. A local overload (locally high intensity on the MCP) leads to no count rate within this local area and to an absolute "black spot" in the images. An intensity too high and homogeneously distributed over the whole MCP first leads to diffuse images and with further increasing intensity to randomly distributed artificial structures up to no count rate at all (global overload). The explanation for the effects for a local overload is a pulse amplitude that is too low to be detected by the electronics. The explanation for the global overload effects is mainly the loss of the 4-fold coincidence condition of an incoming event and a fitting 4-fold coincidence of random pulses, respectively. High intensity on the MCPs always leads to a significant pressure increase. Therefore an observed pressure increase can always be taken as an indicator for an overload of the detector, when problems with the functionality of the DLD occur.
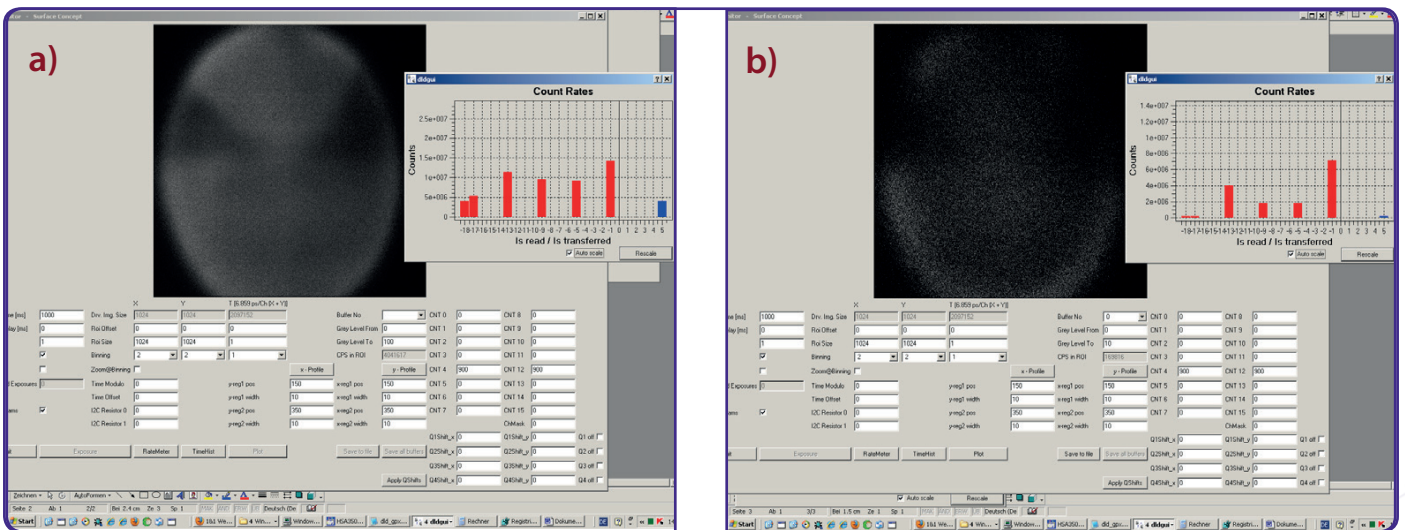
Figure 8: Example of a) a partial overload and b) a heavy (global) overload.

> **!**
> **Note**
>
> It is easy to mistake an overload for no signal at all. To distinguish between these two, check the pressure. A pressure increase indicates an overload.

The DLD has been calibrated for an optimized MCP voltage and it is strongly advised to use this optimized voltage value for operation. It is given in the specification sheet. A change of the MCP voltage can lead to artifacts within the images (see **Figure 9**). The MCP voltage should only be increased to compensate a decrease in amplification of the MCP stack do to degradation. MCPs degradation is recognizable by a slow permanent decrease of the count rate and happens either due to overloads or due to the normal behavior in the burn-in phase. In such a case a new detector operation voltage should be determined by making a detector voltage scan. In the worst case, the MCPs must be replaced. For further detailed information on MCP degradation and detector working voltages see **Chapter 8**.
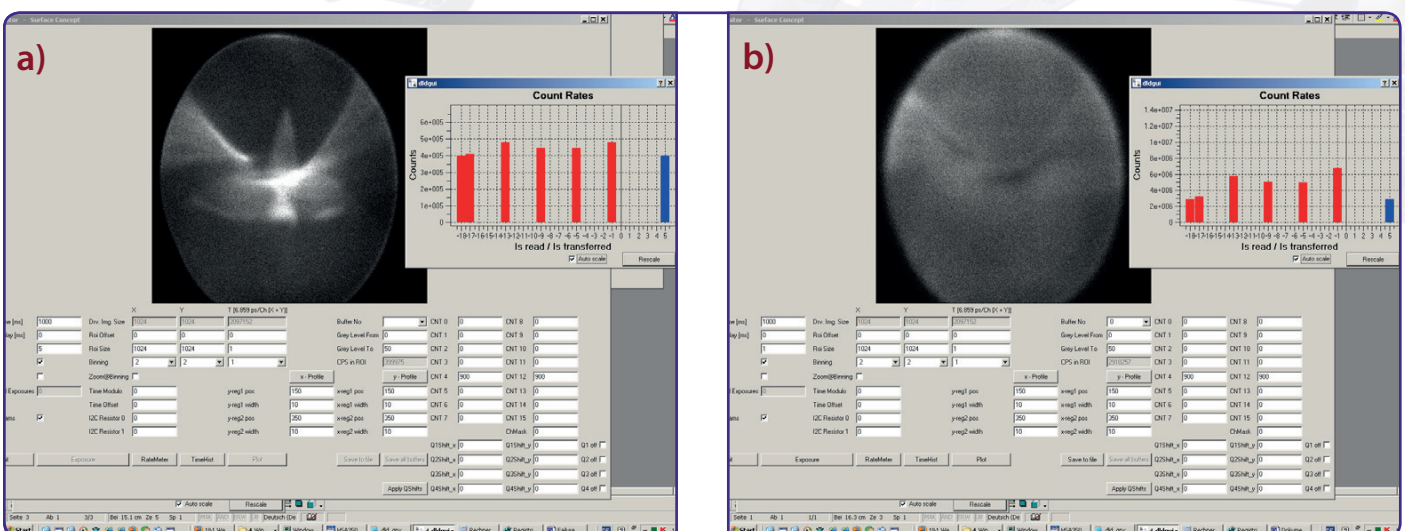

Figure 9: Example of a) an overvoltage on the MCPs and b) an undervoltage at high count rates.

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5.5   MCP Outgassing during Operation

It is an intrinsic feature of the MCPs that they outgas during operation for quite a while due to desorption of gas molecules which are still available inside the MCP pores. This effect becomes mainly visible at low pressure which is reached after bake out and scales significantly with the size and the load of the MCPs. The increase can easily reach more than one decade starting from the 10E-10mbar range for new MCPs being operated with a load of a couple of million counts per second. The effect of outgassing reduces with operation time of the detector in-vacuum. The reduction of the outgassing can also be enforced by running a degas procedure, which consists in the end of the operation of the detector under high load from a homogeneously distributed intensity for a long time period. The degas procedure must be repeated to some extend after each venting. For further information on the degas procedure for MCPs see **Chapter 8**.

6 Delayline Detector Layout

6.1 Delayline Detector - Vacuum Wiring

The Delayline Detector DLD6060-8S consists of a detection area, defined by the detector cover, the MCP holders and the detector anode. The detector anode consists of two independend sets of meander structured delaylines. Each set of meander structured delaylines consists of two elements sensitive to one imaging direction (up resp. 1 and down resp. 2 for the x direction and left resp. 1 and right resp. 2 for the y direction), whereby the elements sensitive to the y direction are isolated and perpendicular orientated to the ones sensitive to the x direction. Therefore one independend set of meander structured delaylines consists of 4 delaylines. The both y delaylines are orientated in such a way that they are sensitive along the axis defined by the pin in the cover of the detector.

The second set of delaylines is rotated counterclockwise by 45° in respect to the first set of delaylines, providing a 45° rotated image in respect to the first set. Those two sets of delaylines are indicated with 0° resp. N and 45° resp. R. Therefore the detector comes with 8 meander structured delaylines in total. The naming of the 8 different delaylines is XuN, XdN, YlN, YrN for the 0° system and XuR, XdR, YlR, YrR for the 45° system respectively. **Figure 10** gives a schematic orientation of the delaylines.
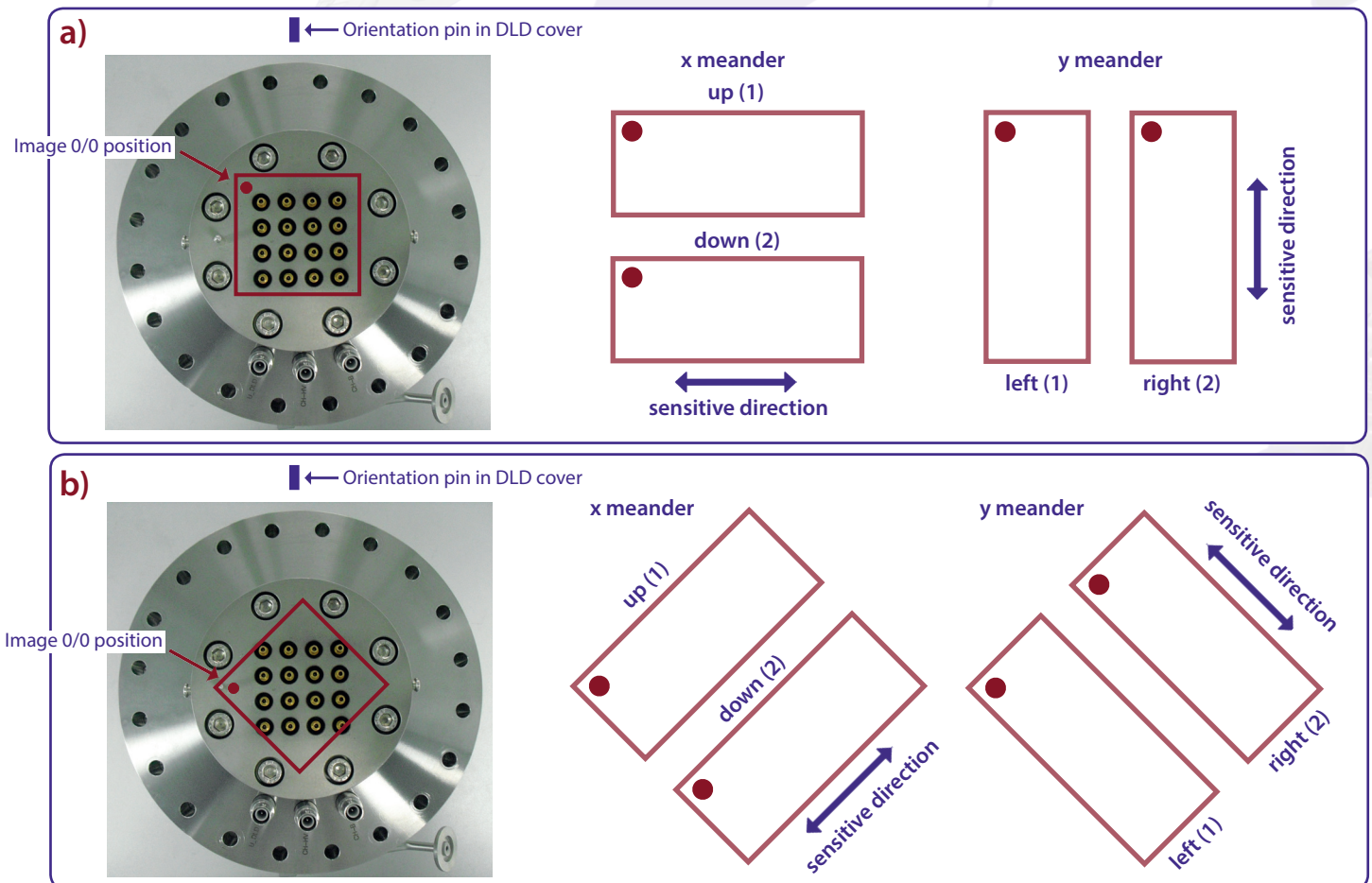

Figure 10: Schematic orientation and naming of the meander structured delayline for the DLD6060-8S for the a) 0° system (N) and b) 45° system (R).

The delaylines are close to ground potential (in respect to the high voltage of the MCPs). A pulse coupling layer is used to isolate the delaylines from the high voltage of the MCP stack as well as to couple pulses from the electron cloud into the delaylines. The MCP front (input) is electrically isolated from the housing. Signal readout is done via 16 readout lines. The naming for the signal lines orientates on the naming of the single delaylines but differes and is extended by the additional number 1 or 2. Hereby the definition of the two signal lines per delayline is made in such a way, that the first channel is positioned on the left side and the top side of the delayline respectively for the x and y direction of the 0° system, when looking from the back through the detector anode defining the zero position of the detector image (see **red dot** in **Figure 10**).

The naming of the signal lines is N or R for the 0° and the 45° system respectively, 1 or 2 for the two seperate delaylines per imaging direction and the X1 and X2 and Y1 and Y2 respectively for the two signal lines for the specific delayline. Therefore the signal naming is N1X1, N1X2, N1Y1, N1Y2; N2X1, N2X2, N2Y1, N2Y2; R1X1, R1X2, R1Y1, R1Y2; R2X1, R2X2, R2Y1, R2Y2.

6.2 Delayline Detector – Connection Ports

The Delayline Detector carries three single SHV feedthroughs soldered into the base flange for the high voltage supply and a CF65 flange, which holds 16 SMB feedthroughs for signal transfer as well as an orientation pin for correct orientation of the ACU. The allocation of the 16 signal channels on the "SMB flange" as well as the three high voltage potentials "U_DLD", "CH-HV" and "CH-B" can be taken from **Figure 11**. The three high voltage potentials are also engraved on the base flange. The internal connection of the high voltage is given schematically **in Figure 12**.

> ⚠️ **Caution**
>
> **Hold the ACU straight and plug it very carefully.**
> **The middle pins of the SMB connectors in the 16-fold SMB feedthrough can be damaged when holding the ACU not straight while plugging.**
> **Do not disconnect the high voltage cable from the Delayline Detector as long as high voltage is applied. This will lead to high voltage sparks which can damage the very sensitive detector, the MCPs and/or the analogue readout electronics seriously.**
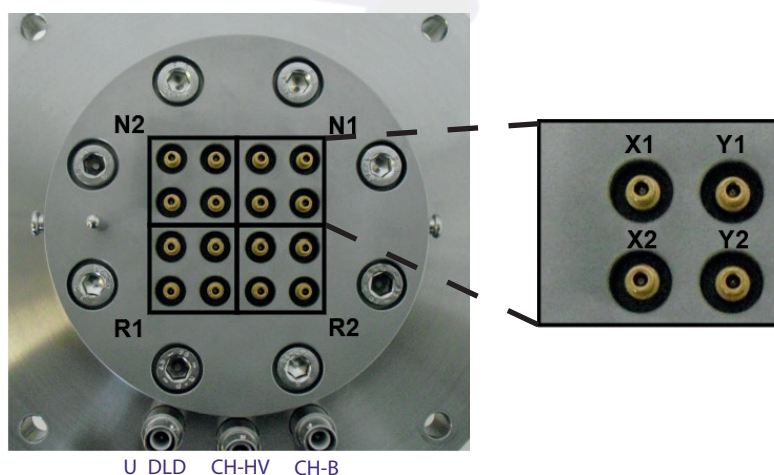

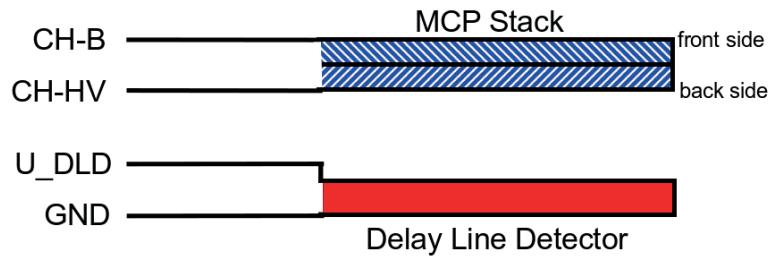Figure 11: Connection ports for the DLD6060-8S.

Figure 12: Internal connection of high voltage potentials (schematic).

> ! **Note**
>
> **The resistance between "CH-HV" and "CH-B" (resistance of MCP stack) should be in the range of 8 – 30 MΩ (the exact value is given in the specification sheet of your detector), while the resistance between "CH-HV" and "U_DLD" and "CH-B" and "U_DLD" respectively should be unlimited.**

The "CH-B" voltage is put together by the Herzog Potential of the analyzer + a Bias voltage (U_Bias). The "CH-HV" voltage is always given and measured in respect to the "CH-B" voltage and "U_DLD" is always given and measured in respect to the "CH-HV" voltage (**see Figure 13**).

Schematic display of power supplies arrangement

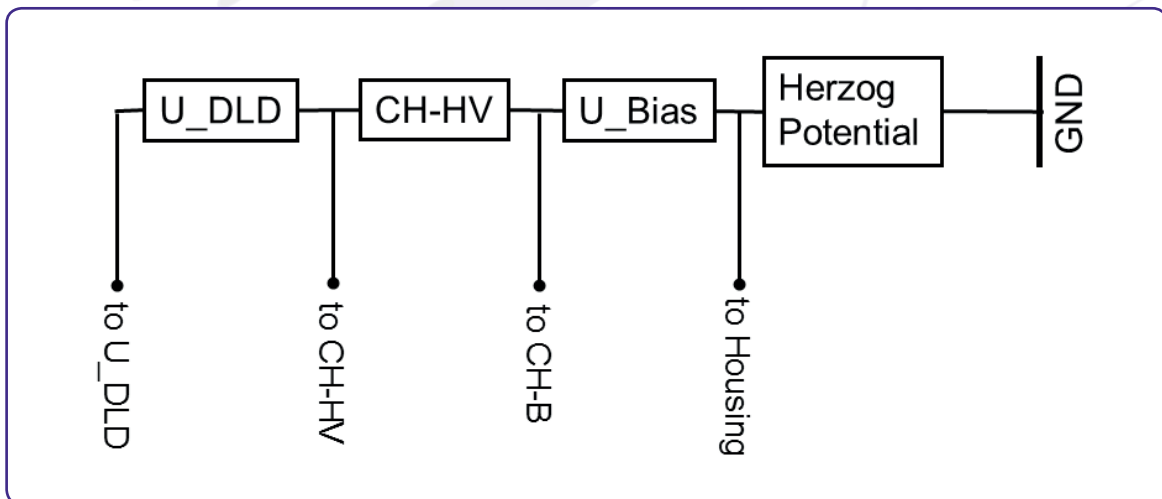
Figure 13: Schematic display of arrangement of power supplies to illustrate relative potential relations for the DLD supplies.

7 Pulse Processing Electronics

The pulse processing electronics ACU (Amplifier-CFD-Unit) and AU (Amplifier-Unit) hold all devices like the amplifiers, pulse shapers, and constant fraction discriminators to turn the analogue pulses from the detector into digital pulses suitable for the Time-to-Digital Converter. Pulse decoupling is either performed within the pulse processing electronics or directly in-vacuum, depending on detector type and layout. Some pulse processing electronics also contain an integrated high voltage power supply for the complete detector. This also depends on the layout of the detector as well as the pulse processing electronics.

7.1 Pulse Processing Electronics ACU 5.16.1

The ACU 5.16.1 contains the amplifiers, pulse shapers and constant fraction discriminators for signal processing.

1. 16x SMB sockets for signal transfer from SMB feedthrough

2. Guide bush for orientation pin from SMB feedthrough

3. 2 Clips for fastening the ACU to the detector flange

4. Connection sockets for DLD readout cables with M3 thread to fasten the strain reliefs of the readout cables

Figure 14: Layout of ACU 5.16.1.

The ACU can be plugged directly onto the 16-fold SMB feedthroughs. Fasten the two clips of the ACU to the fastening bolts of the CF65 flange to fix it to the detector. **Figure 14** shows the layout of the ACU 5.16.1.

7.1.1 Positions of the Discriminator Threshold Regulators

Discriminator threshold regulators of the 16 DLD channels as well as potentiometers for an additional adjustment can be found on the corresponding boards inside the ACU. They can be reached through the holes on the top and bottom side of the ACU housing (see **Figure 15**).
The adjustment of the readout electronics goes hand in hand with the detector voltage. In fact there is only a small "window" for an optimum setting of the readout electronics for a given operation voltage. Changes of the detector voltage, other than to compensate loss in the amplification of the MCP stack due to degradation effects, will directly lead to a loss in performance of the readout electronics (artifacts within the image, increased dark count rate etc.). The readout electronics is adjusted to its best performance to the starting operation voltage of the detector when delivered. A new adjustment should not be needed. The starting operation voltage is given in the specification sheet. The operation voltage is not fixed but must be re-adjusted over time to compensate gain degradation of the MCPs. See **Chapter 8.5** for further details.

The sensitivity of the CFD is increased (threshold decreased) by turning the screw of the potentiometer clockwise and vice versa for decreasing the sensitivity of the CFD. This is only to be used under some circumstances where adjusting becomes necessary at all.

⚠️ **Caution**

The readout electronics is adjusted to its best performance to the starting operation voltage of the detector when delivered. Do not change the adjustment at all.
Changing the adjustment can easily end up with a status, where a readjustment must be made by Surface Concept.
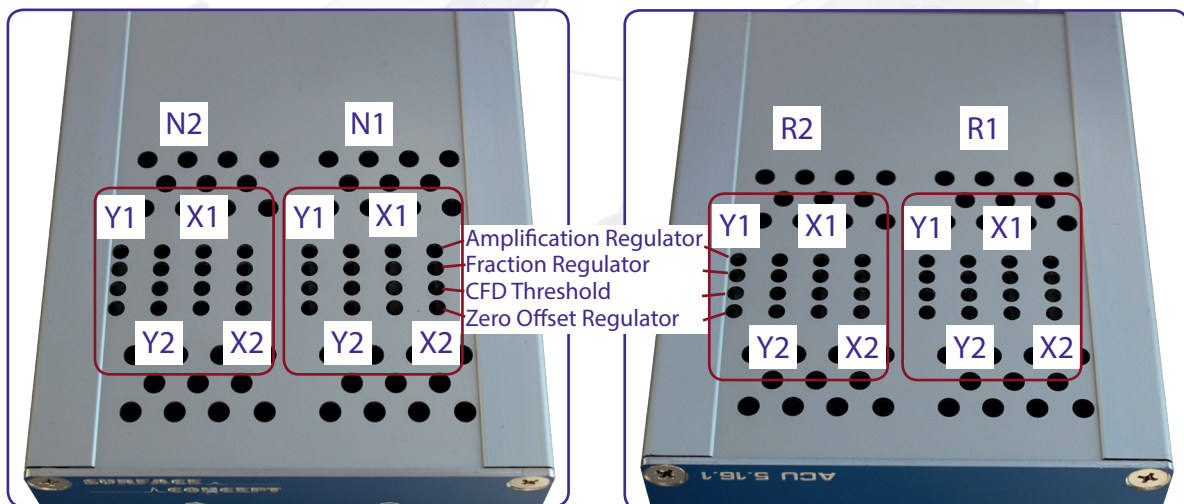

Figure 15: Labeling of discriminator threshold and amplification regulators.

8 Microchannel Plate

8.1 Specifications

Please check the specification sheet of the DLD for the exact MCP specifications.

8.2 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:

- The most effective long-term storage environment for an MCP is an oil-free vacuum.

8.3 Handling

- Shipping containers should be opened only under class 100 Laminar flow cleanroom conditions.

- Personnel should always wear clean, talc-free, class 100 clean-room compatible, vinyl gloves when handling MCPs. No physical object should come into contact with the active area of the wafer. The MCP should be handled by its rims, there is no solid glass border! Use clean degassed tools fabricated from stainless steel, Teflon™ or other ultra-high vacuum-compatible materials. Handling MCPs 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.

- The MCP should be protected from exposure to particle contamination. Particles which become affixed to the plate can be removed by using a very pure and low pressure air flow such as from a clean rubber bellows.

- 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. The pressure should be 1E-6mbar or lower at the microchannel plate before applying voltage. Otherwise, damaging ion feedback or electrical breakdown will occur.

8.4   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 1E-6mbar or better is preferred. Higher pressure can result in high background noise or even to damaging due to ion feedback or to an electrical breakdown.

- Apply voltages as defined in **Chapter 4**. If fluctuations 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 MCPs should not exceed the maximum voltage given in the specification sheet of the detector. Higher potentials may result in irreversible damage.

- MCPs can be degraded by exposure to various types of hydrocarbon materials which raise the work function of the surface, causing gain degradation.

- Operation at higher temperatures (> 50°C) will cause gain degradation.

- MCPs can degas for quite a while during operation. The pressure increase also depends on the number of initial particles given to the MCP (e.g. pressure increase from 5E-10mbar up to 1E-8mbar for a new chevron MCP stack and DLD count rates of a few Mcps). A degas procedure for MCPs is described in **Chapter 8.6**.

8.5   MCP Lifetime and Operation Voltage

The lifetime of the MCPs is determined by the MCPs gain degradation over time, whereas the gain degradation is a function of the extracted output charge. Therefore the lifetime of the MCPs strongly depends on the count rate applied to the detector over time.
The typical gain degradation of a MCP is shown in **Figure 16** as a function of extracted output charge in terms of coulombs per square centimeter.
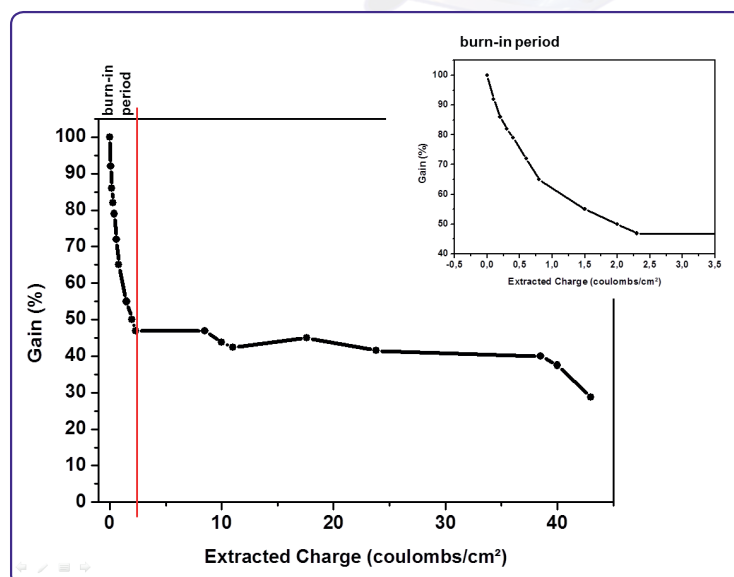

Figure 16: Typical gain degradation of MCPs as function of the extracted output charge.

After an initial burn-in period, in which the detector gain changes as a result of electron induced chemical allocation together with degassing residual gas molecules from the inside of the channels, the MCP performance is very stable over a large amount of extracted output charge. The MCP gain is also a function of the detector operation voltage. Therefore gain degradation can always be compensated by increasing the detector voltage.

The delivery of a detector will happen with the MCPs operating within the burn-in period, although the detector always undergoes an initial burn-in procedure with highest count rates during the test phase. Gain degradation will be still significant in the first month of operation (or even longer, depending on applied count rates) and becomes obvious by a decline of the detector performance. Therefore it will become necessary evaluate the current operation voltage by measuring a so called MCP curve from time to time. There is a recommended maximum operation voltage, to which the detector voltage can be increased to compensate gain degradation over time. This voltage is given in the specification sheet of each detector.

A typical behavior of the detector voltage increase over time to compensate gain degradation is given schematically in **Figure 17**.
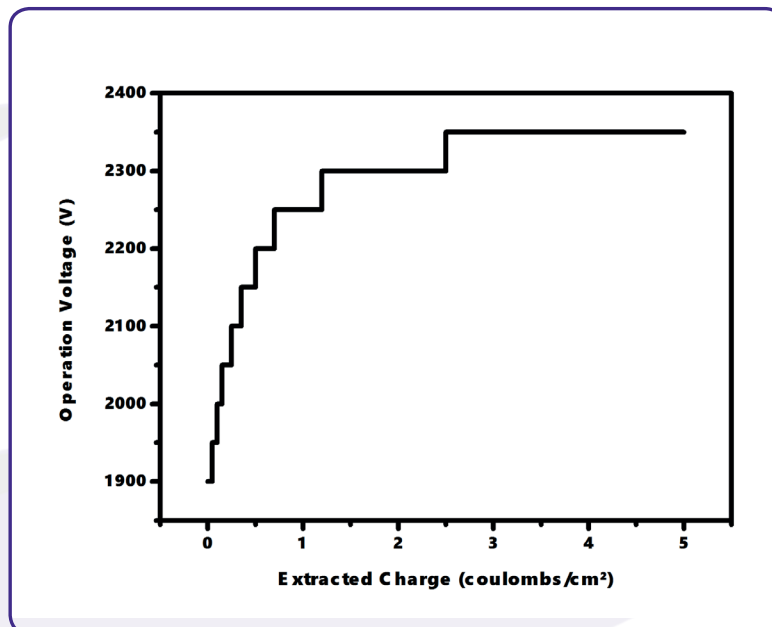

Figure 17: Schematic plot of increasing the operation voltage to compensate gain degradation over time as function of the extracted charge (all values are only exemplary).

!
Note

It is not unusual that the operation voltage must be increased several times especially in the first month of operation.

Typically, the final operation voltage at the end of the burn-in period will be close to the recommended maximum operation voltage. An increase of the operation voltage above the recommended maximum operation voltage is in principal possible and allowed, as long as there is no significant increase in the dark count rate, bright spots at the detection area and/or appearance of high voltage sparking.

It can be sufficient to estimate the correct operation voltage by monitoring the detector results, when increasing the voltage to compensate the gain degradation. The exact operation voltage can always be determined by measuring a so called MCP curve. The MCP curve plots the detected count rate as a function of the operation voltage. Do as follows to measure an MCP curve:

• Start the detector operation with a homogeneous illumination (as good as possible).

• Open the rate meter in your end-user software to monitor the count rate output of the detector.

• Decrease the operation voltage until the count rate of the detector is reduced to zero.

• Increase the operation voltage in steps of e.g. 50V until far above the last operation voltage (please re-spect the recommended maximum operation voltage) or until the detector shows significant artifacts. Measure the count rate for each voltage step.

• Plot the measured count rate as a function of the operation voltage. This is the MCP curve. It should show a change in the slope of the rising curve, which indicates the beginning of the area of operation.

• The new value for the operation voltage should be a bit above the position of the change in the slope.

Figure 18 shows an example of an MCP curve with the specified operation voltage. The MCP curve for specifying the starting operation voltage for a detector can always be found in the specification sheet.
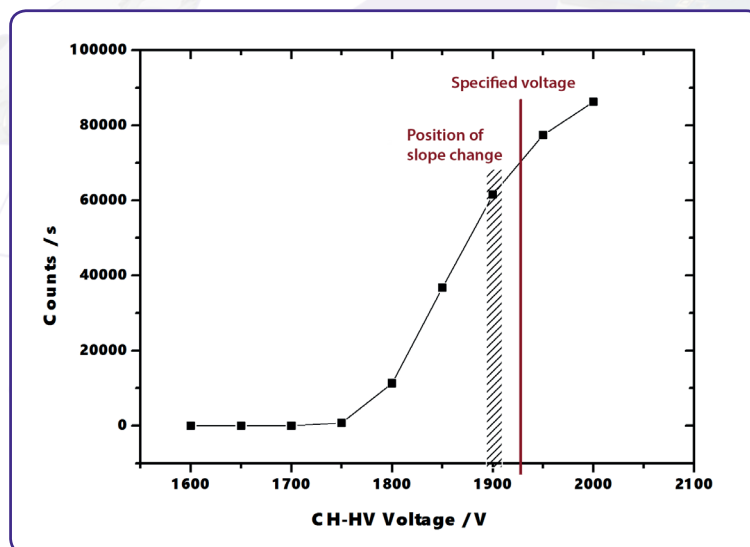

Figure 18: Example of MCP curve (for illustration only).

The life time of MCPs can be very large, due to the high stability of the operation performance over a large amount of extracted output charges after the burn-in period. The main reason for an often much shorter operation time of the MCPs is an inhomogeneous irradiation of the MCPs. This is connected to a locally (strong) different gain degradation, which results in an inhomogeneous detector response. Locally different gains can still be compensated by increasing the operation voltage, but very often the increasing voltage step must be much larger to reach again a homogeneous detector response.
Gain degradation also depends strongly on the environment in which the MCPs are being operated. Care should be taken to prevent exposure to high concentrations of hydrocarbons and halogens. Also prevent MCP operation at higher temperatures (> 50°C, e.g. respect an appropriate cooling phase after bake out).

!
Note

Strong inhomogeneous irradiation of the MCPs lead to strong locally different gain degradation and to an inhomogeneous detector response, which is the main reason for a shortened operation time of the MCPs.

8.6   MCP Degase Procedure

The effect of MCP outgasing can be reduced by running a degas procedure. To do so the detector must be operated at a high count rate of about the maximum count rate (check your specification sheet) for a time period of about 8 hours.

Caution

It is really important that the detector is irradiated homogeneously over the complete active area. Otherwise the MCPs will degenerate at various positions differently, which will lead to an inhomogeneous flat field of the detector.

Operate the detector continuously. During the degas procedure the pressure increase should reduce significantly to an acceptable pressure range. Then switch to the final application. The pressure increase for a smaller count rate should now be much smaller. The detector will be delivered already pre-conditioned. Unfortunately the degas procedure must be started anew (to a certain extend) after each venting of the detector.

8.7   Replacement

!
Note

Contact your provider before performing a replacement.

Please contact your provider before performing any MCP replacement. He will provide you with a detailed step by step description.
Please take care to note the orientation of the MCPs. The channels in the MCPs include a certain angle against the surface normal to the plate and the MCPs must be mounted in a chevron configuration. All parts of the detector, especially the MCPs should be handled with great care. The MCP surfaces are very sensitive and should never be touched or scratched.
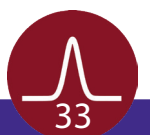
9 Troubleshooting

Consult the Hints_and_TroubleShootingDLDs Manual (part of the detector delivery) in case of any problems prior to contacting your provider.
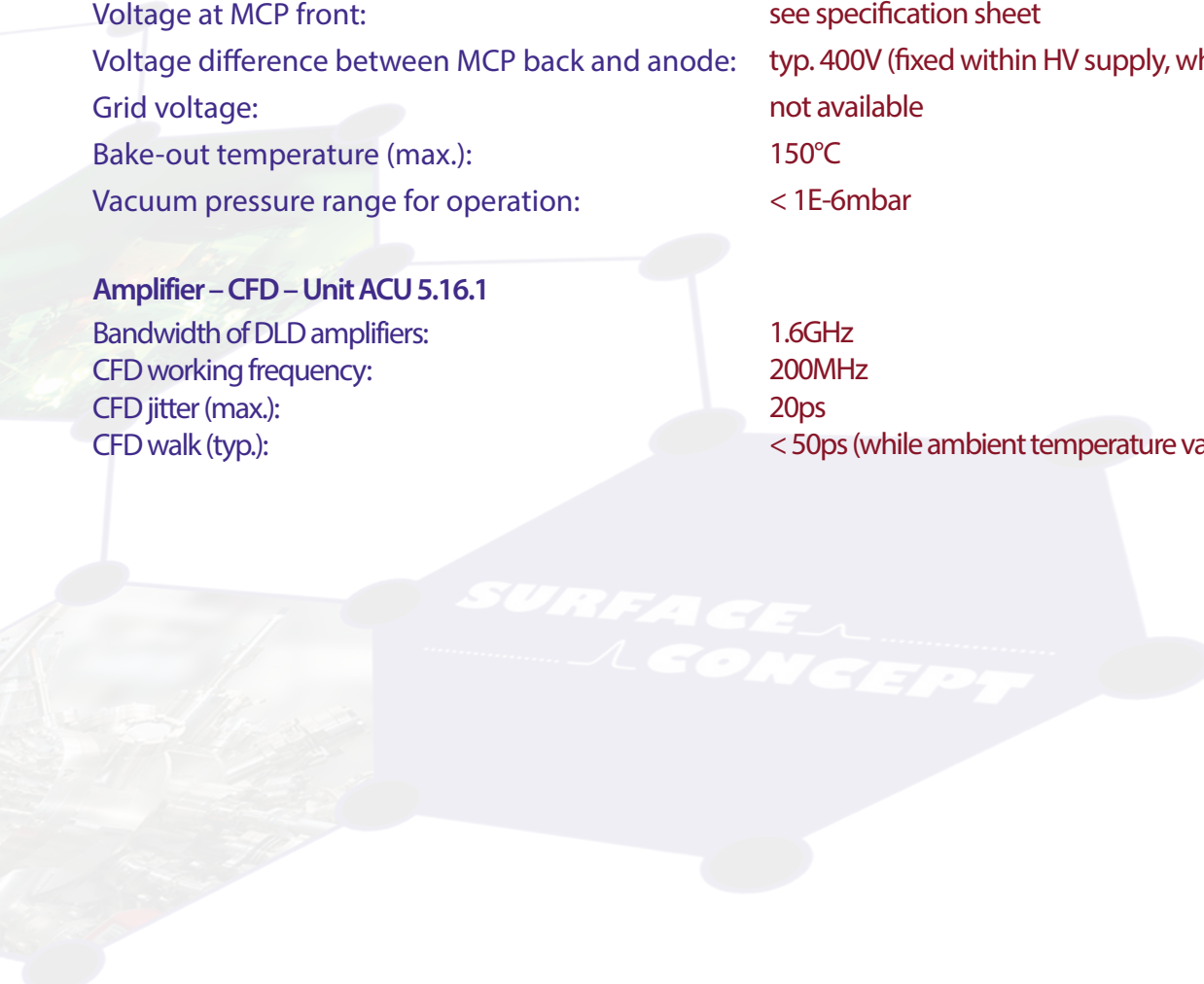
10 Technical Data

Delayline Detector General

HV Capability for floating base voltage:	none (see specification sheet for details)
Active area:	Ø 65mm round
Operation voltage at detector:	see specification sheet
Voltage at MCP front:	see specification sheet
Voltage difference between MCP back and anode:	typ. 400V (fixed within HV supply, when part of delivery)
Grid voltage:	not available
Bake-out temperature (max.):	150°C
Vacuum pressure range for operation:	< 1E-6mbar

Amplifier – CFD – Unit ACU 5.16.1

Bandwidth of DLD amplifiers:	1.6GHz
CFD working frequency:	200MHz
CFD jitter (max.):	20ps
CFD walk (typ.):	< 50ps (while ambient temperature varies less then 5 K)

11   List of Figure

EC Declaration of Conformity

Manufacturer

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Product   Delayline Detector DLD6060-8S
Model No.

The above named products comply with the following European directive:

| 89/336/EEC | Electromagnetic Compability Directive, amended by 91/263/ EEC and 92/31/ EEC and 93/68/EEC |
| 73/23/EEC | Low Voltage Equipment Directive, amended by 93/68/EEC |

The compliance of the above named product to which this declaration relates is in conformity with the following standards or other normative documents where relevant:

EN 61000-6-2:2005+AC:2005	Electromagnetic compatibility (EMC): Generic standards - Immunity for industrial environments
EN 61000-6-4:2007+A1:2011	Electromagnetic compatibility (EMC): Generic standards - Emission standard for industrial environments
EN 61010-1: 2010	Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use

For and on behalf of **Surface Concept GmbH**

Mainz,……01.06.2018……….   **Legal Signature…………………………………………**
(Date)   (Dr. Andreas Oelsner)

This declaration does not represent a commitment to features or capabilities of the instrument. The safety notes and regulations given in the product related documentation must be observed at all times.