Manual

Low Energy Electron Microscope

Model LEEM III

with

Energy Analyzer

and

Abberation Corrector

Version V1.7

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IMPORTANT SAFETY IMFORMATION

WARNING!

This LEEM equipment generates voltages that are dangerous and can cause fatal accidents. Use extreme caution when working with this equipment.

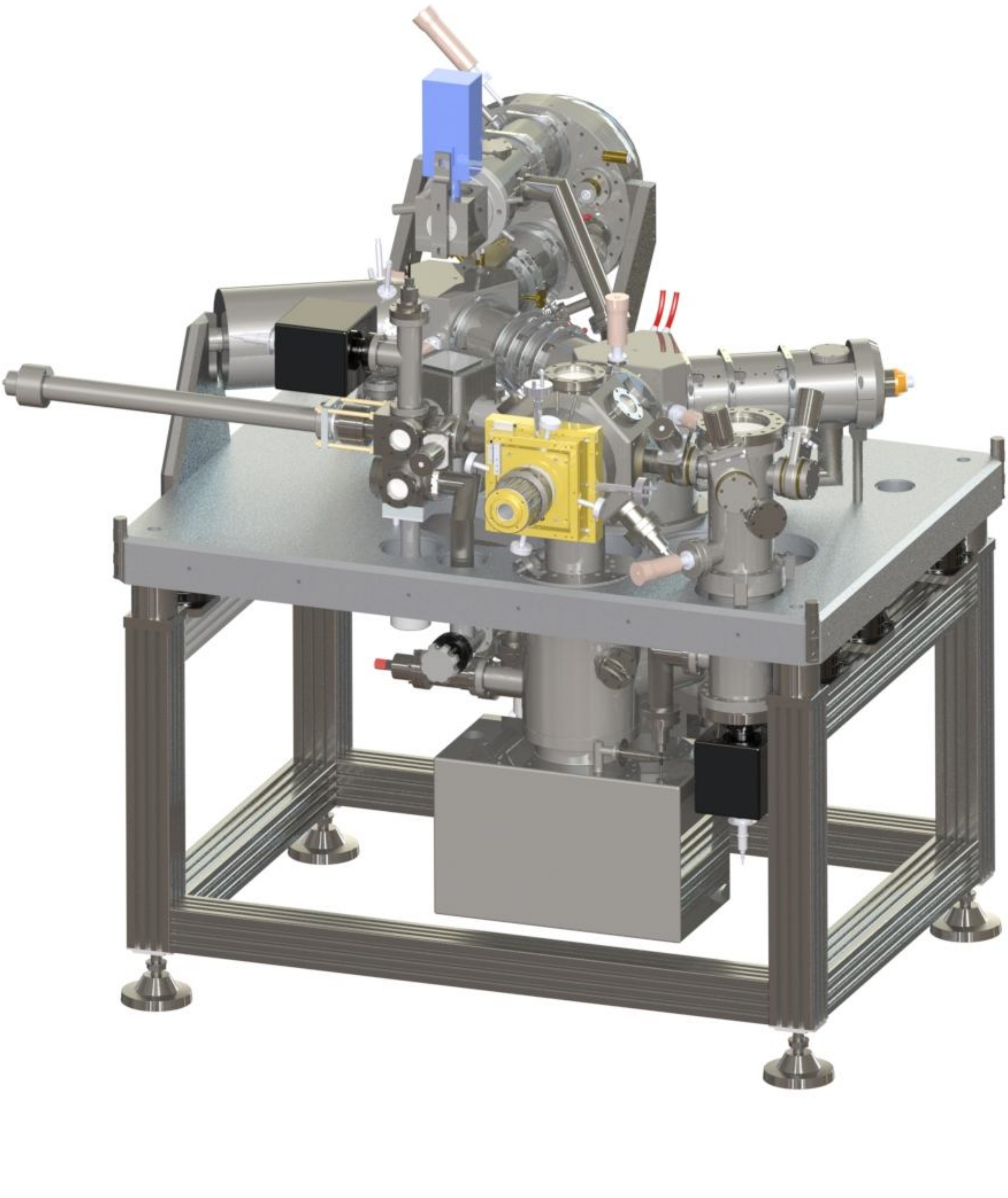
Read this document thoroughly before proceeding to use your LEEM. Failure to follow the instructions given in this manual will void the warranty and may cause personal injury or death.

Warning! The LEEM is equipped with a five-wire grounded cable. The yellow-green wire has to be connected to earth ground, otherwise personal injury or death may occur.

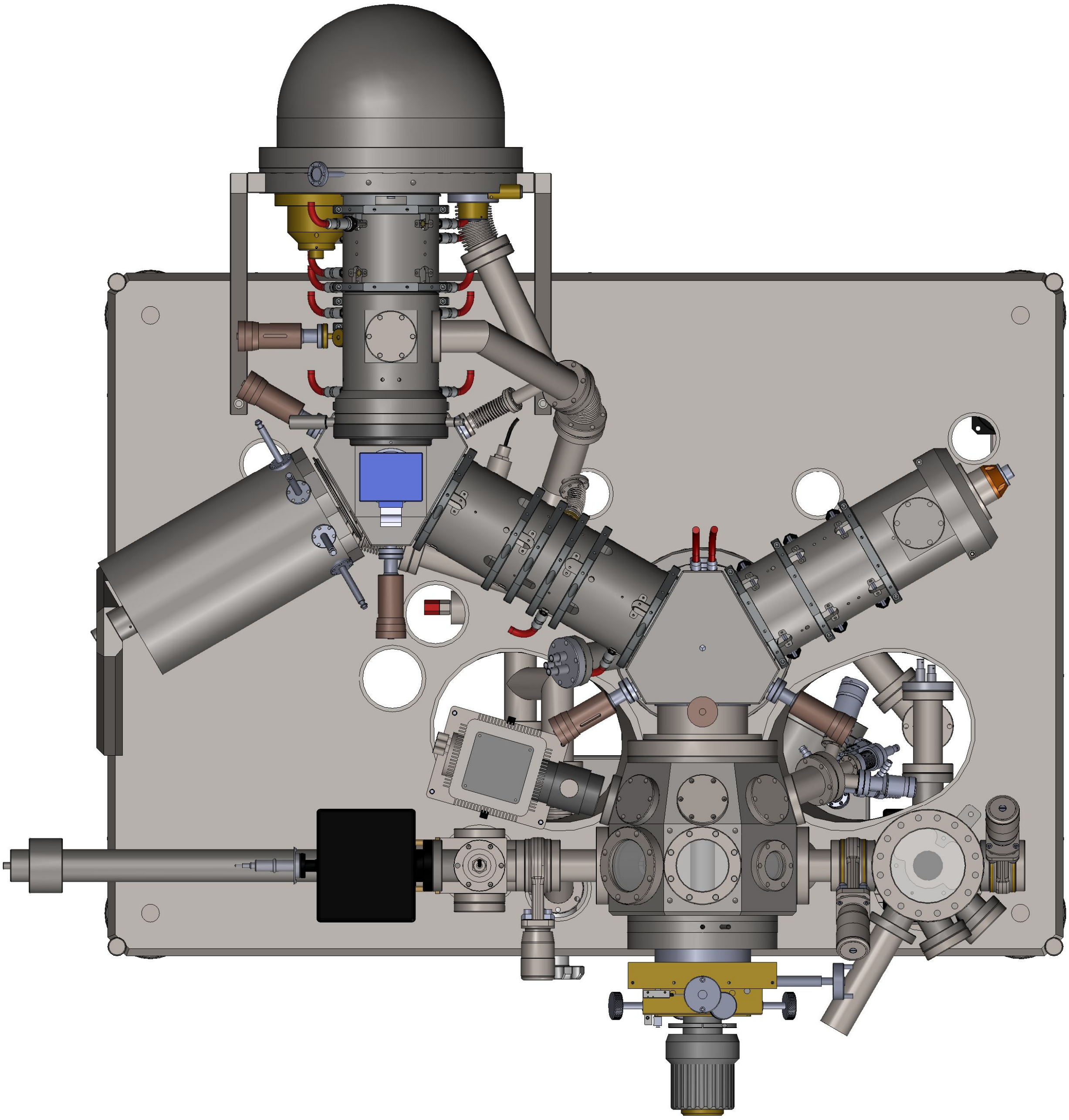
Important Safety Instructions

- **All power supplies must always be properly grounded. All covers must be installed and instrument cabinets be closed and all connectors be safely secured in their sockets before the equipment is powered.**
- **Do not touch connections unless the equipment is switched off and the capacitance of both load and power supply is discharged by directly shorting the high voltage output and the load conductor to ground.**
- **Do not ground yourself or work under wet or damp conditions.**
- **Servicework on this equipment should only be done by qualified and electrotechnically trained personnel aware of the electrical and safety hazards of working with high voltages up to 30 kV.**

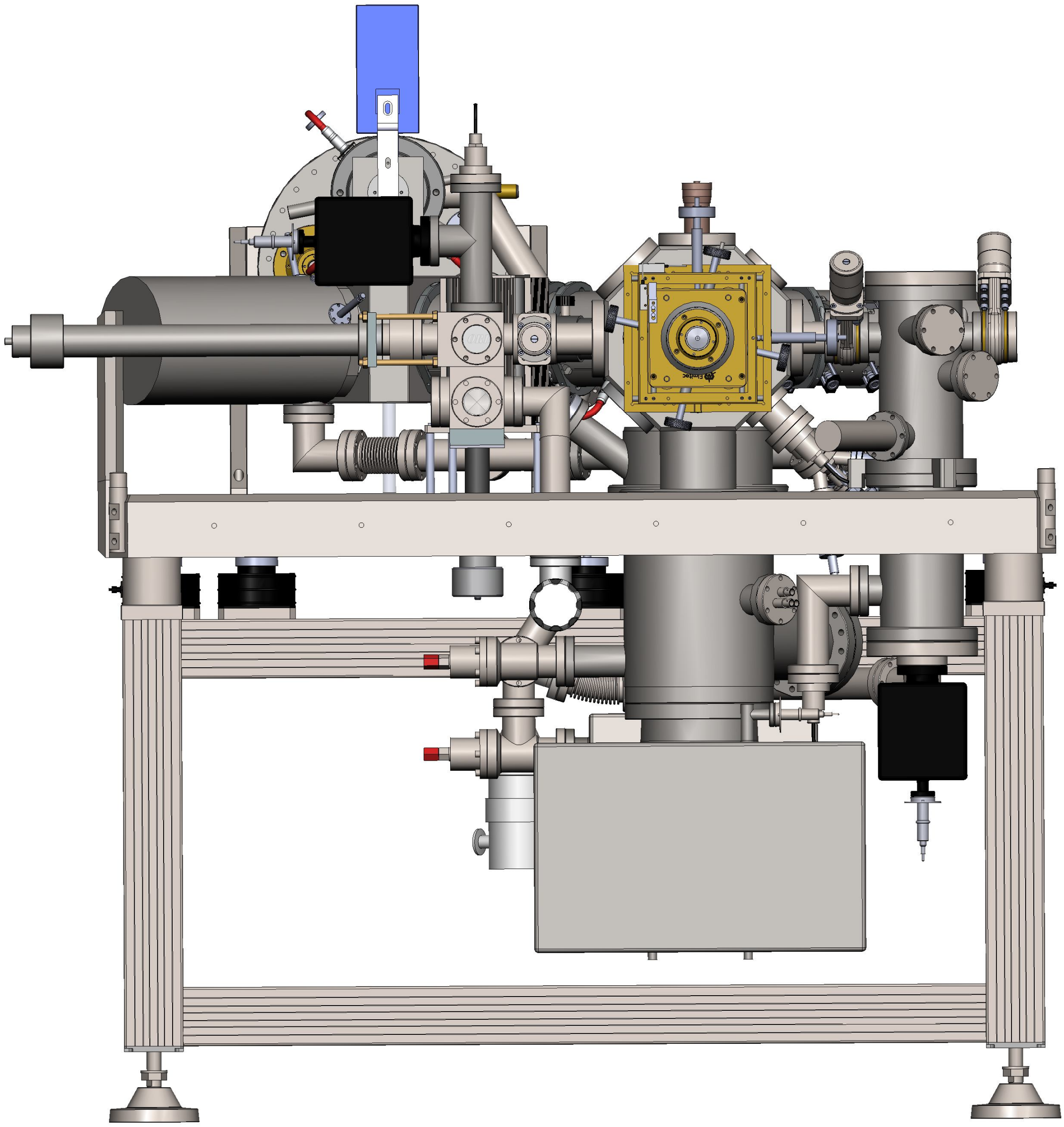
ACSPELEEM III with additional preparation chamber



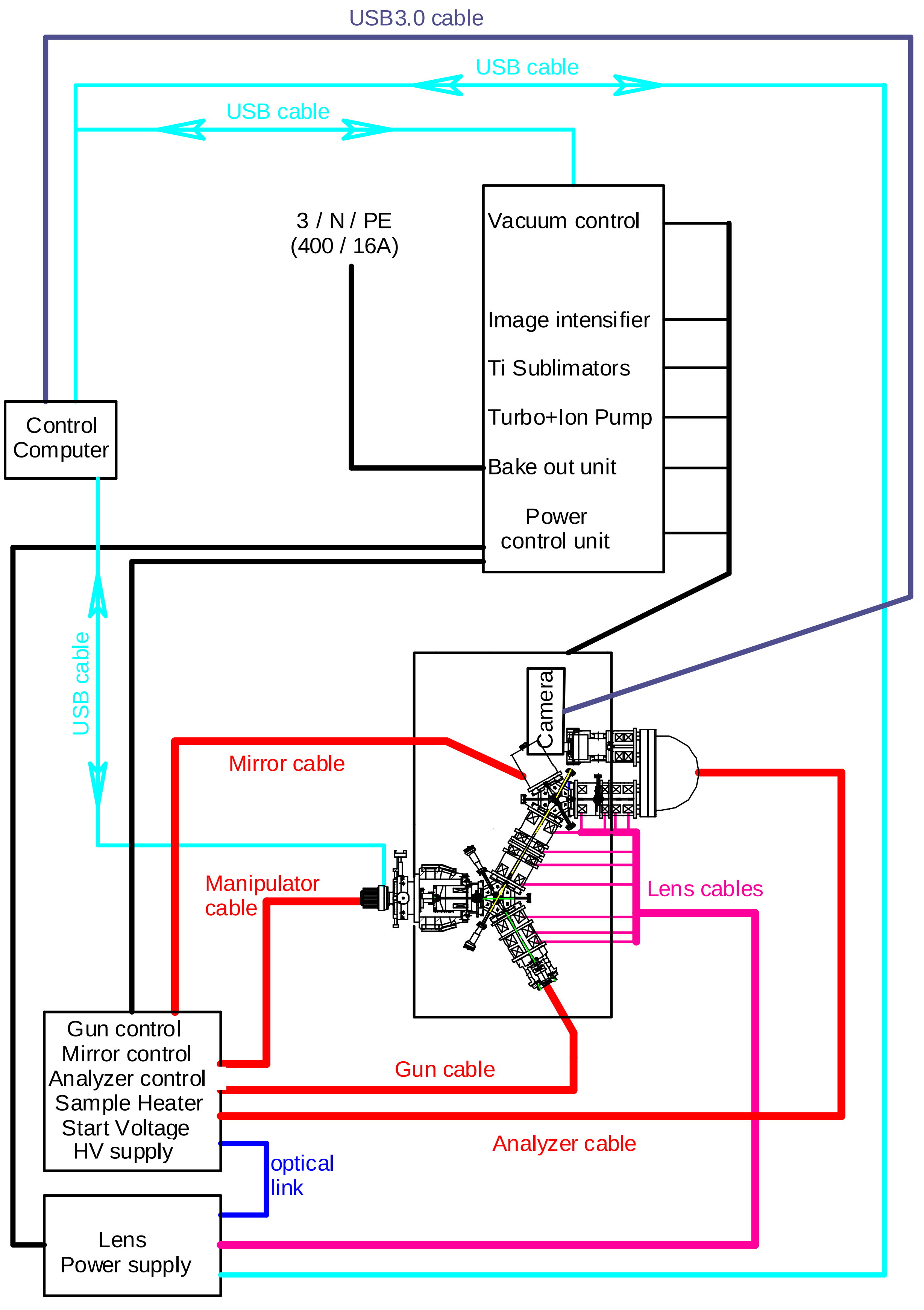
ACSPELEEM III (top view)

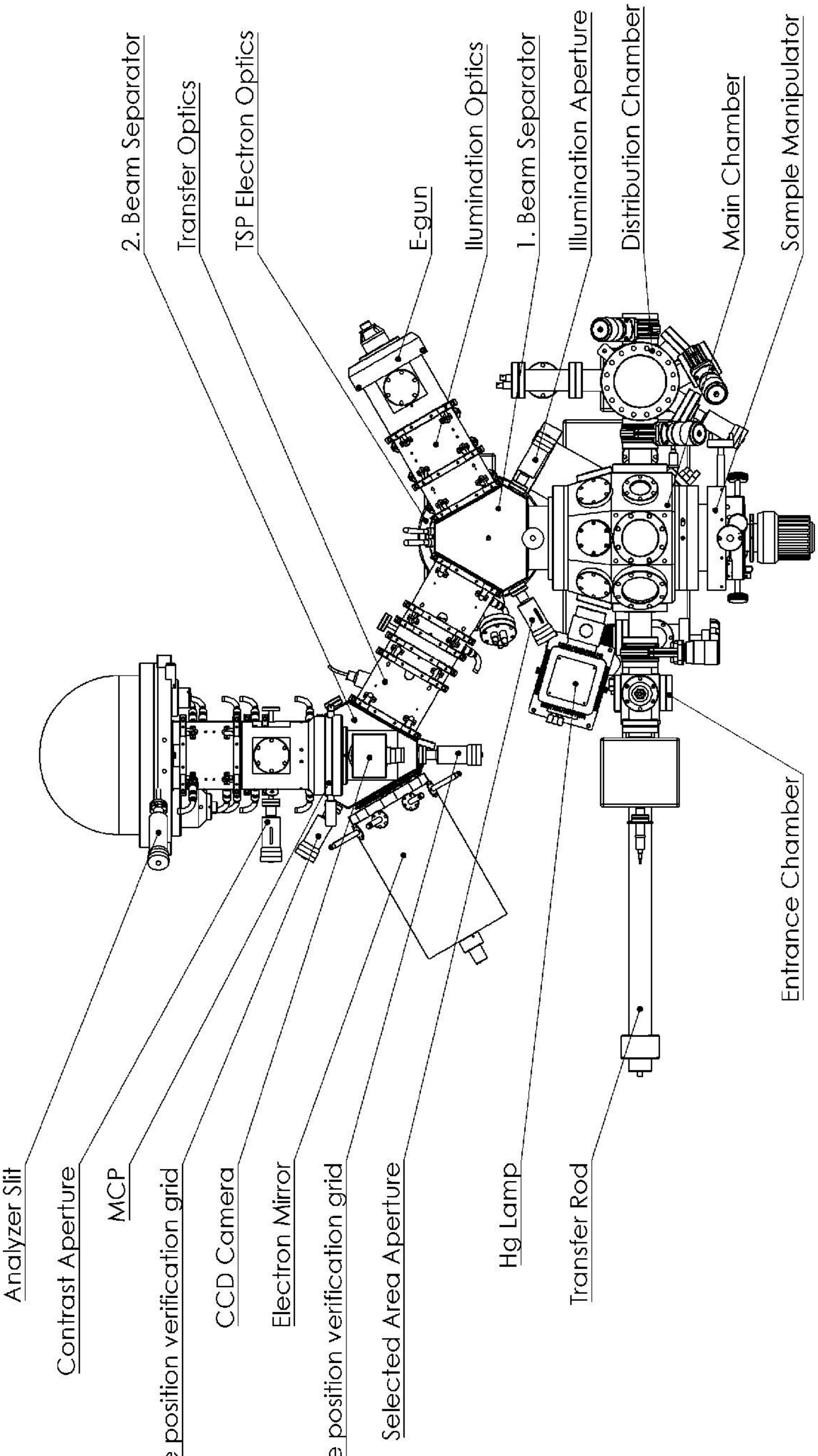


ACSPELEEM III (side view)

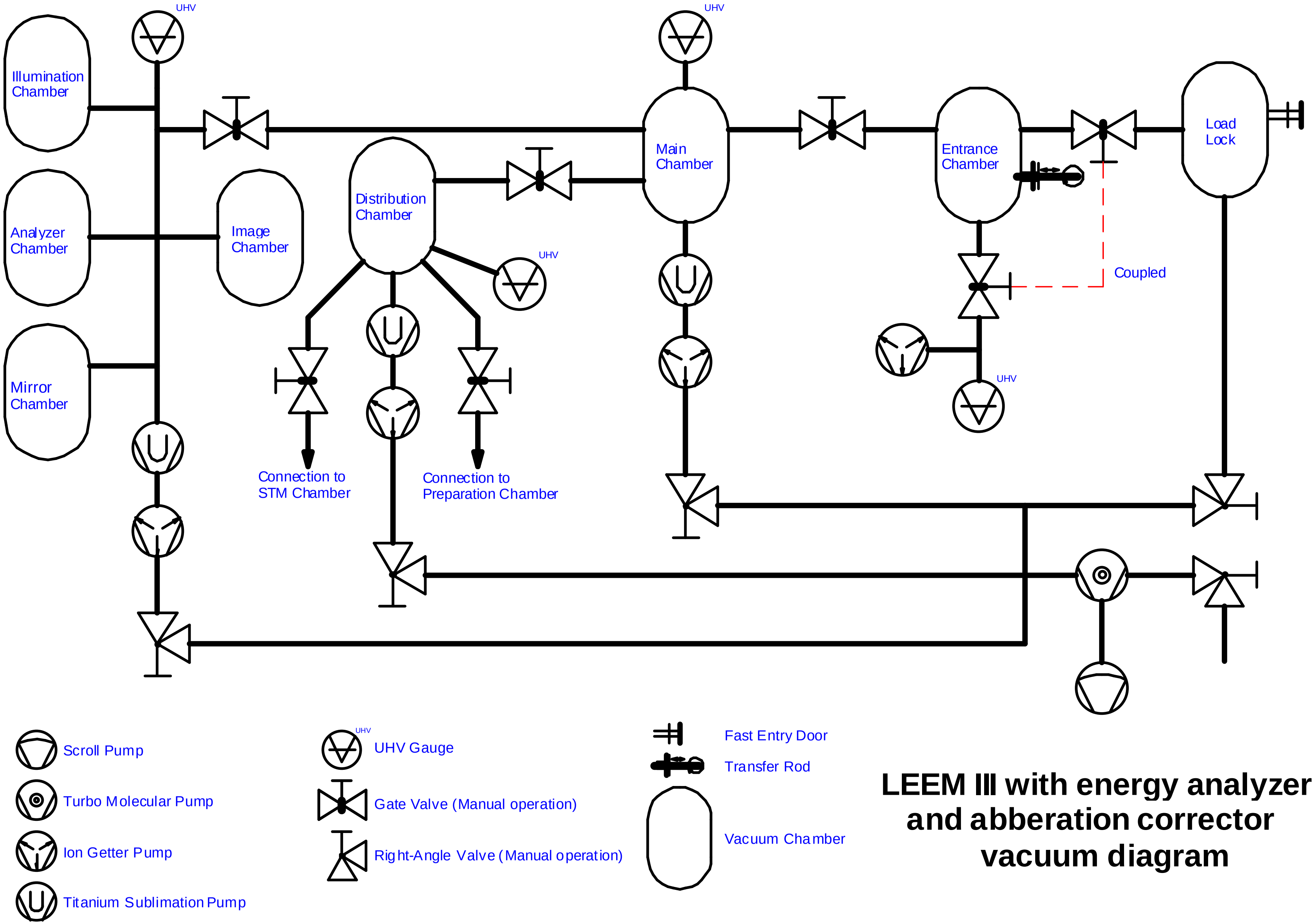


General Layout of Instrument

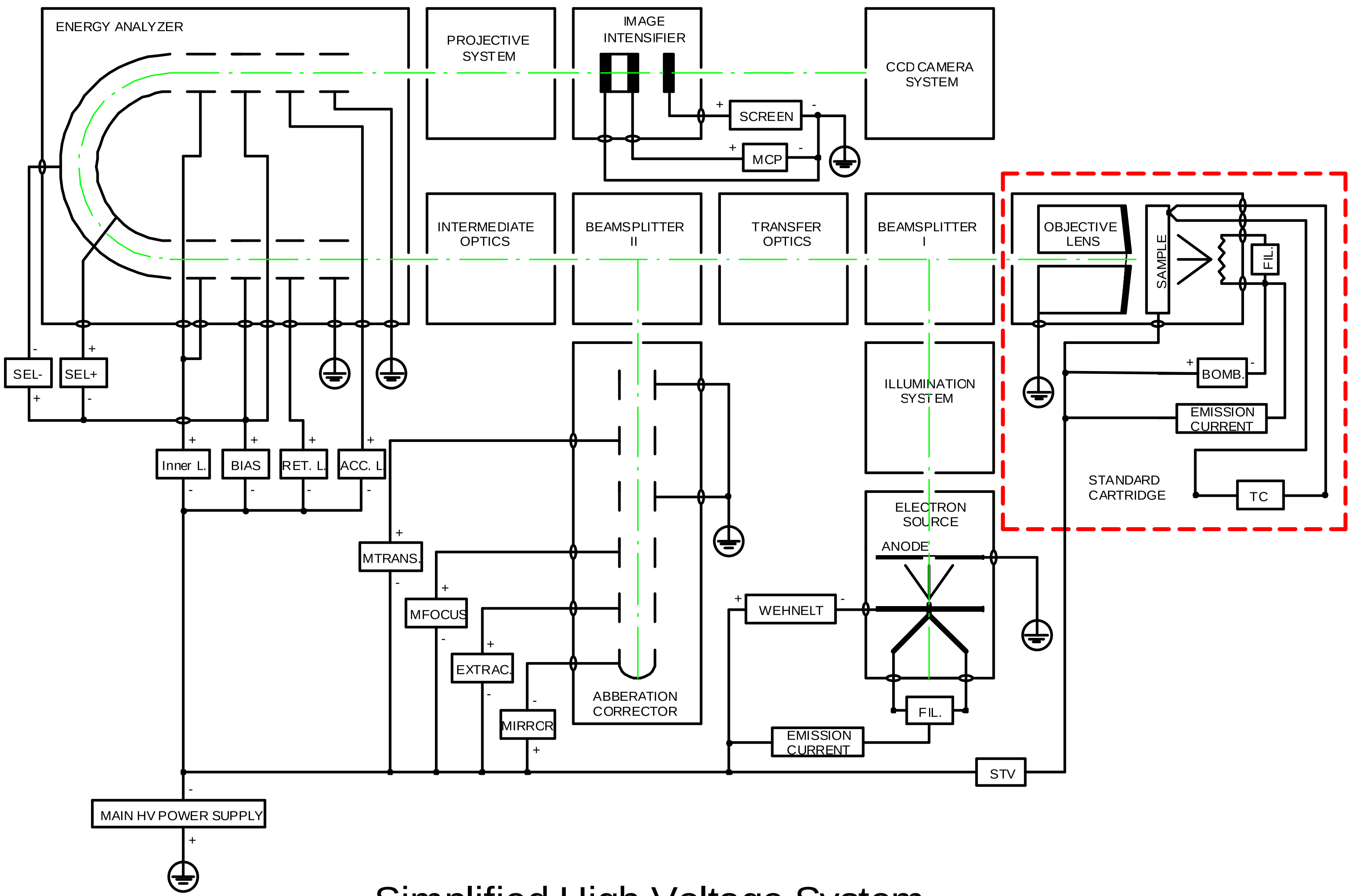




2. Beam Separator
Transfer Optics
TSP Electron Optics
E-gun
llumination Optics
1. Beam Separator
Illumination Aperture
Distribution Chamber
Main Chamber
Sample Manipulator
Entrance Chamber
Analyzer Slit
Contrast Aperture
MCP
Image position verification grid
CCD Camera
Electron Mirror
Image position verification grid
Selected Area Aperture
Hg Lamp
Transfer Rod

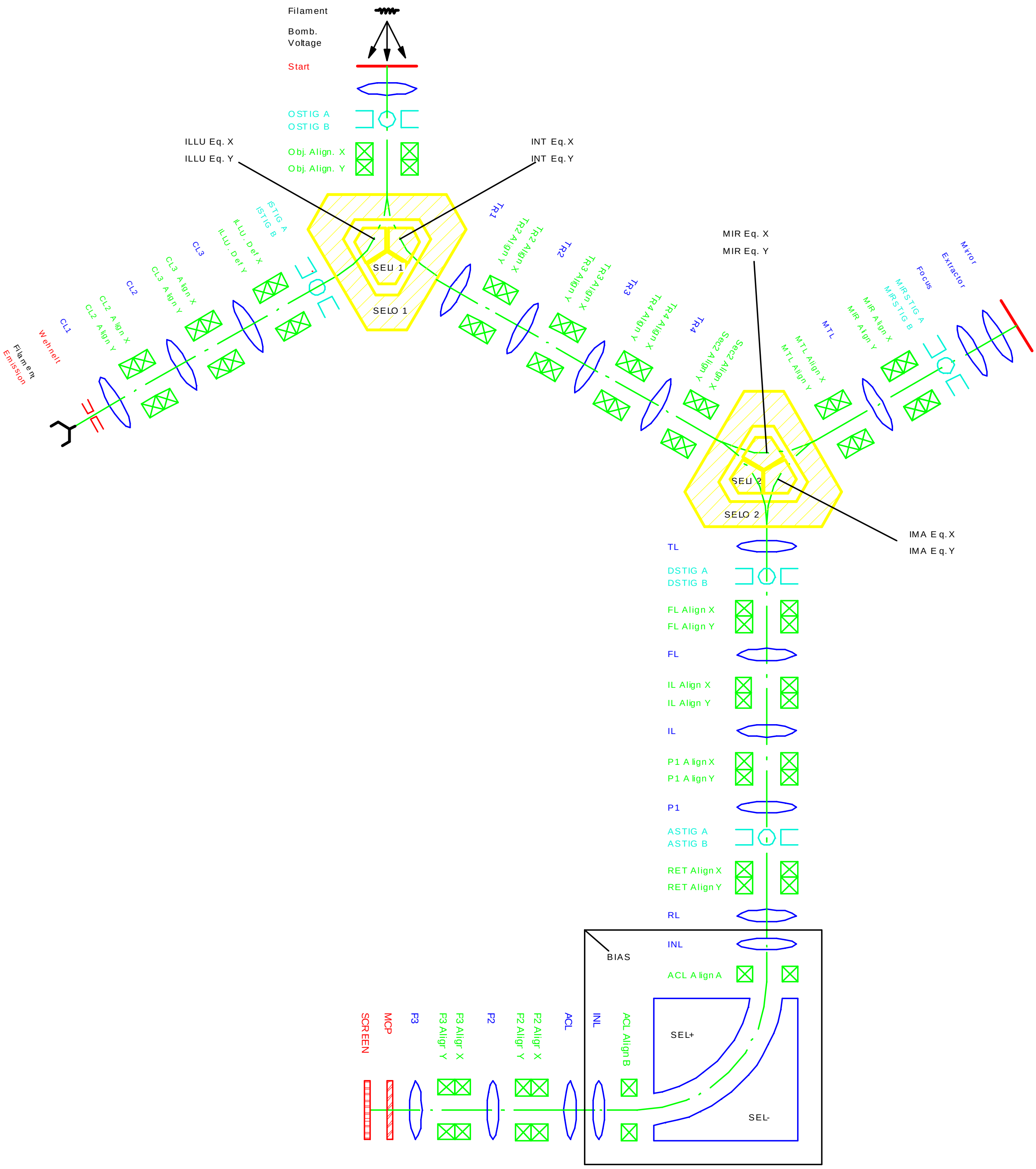


LEEM III with energy analyzer and abberation corrector vacuum diagram



Simplified High Voltage System

Position of Lenses and Deflectors



1. Vacuum System

1.1. Vacuum configuration

The ELMITEC LEEM III microscope is composed of five main vacuum parts:

- main chamber
- illumination, intermediate and imaging columns
- distribution chamber
- entrance chamber
- roughing pump system

The main chamber is connected directly to a Titanium (Ti) sublimator pump which is screwed to the main table. The bottom flange of the Ti sublimator (NW 150CFF) is connected to an AGILENT 300 l/sec ion pump. The Titanium sublimation pump is connected via a full metal valve VAT NW35CFF to the roughing pump system. It is used for venting the microscope UHV part and for initial pumping. This valve separates an UHV part of the microscope from the roughing pump system. These pumps are located under the table. Above the table the main chamber is connected to the first beam separator, distribution chamber and to the entrance chamber.

The connection to the first separator is done by a special ELMITEC gate valve, whereas the connection to the distribution chamber and the entrance chamber are done by VAT gate valves (NW 35 CFF). The illumination part is composed of the small gun chamber, in which the gun cathode and the Wehnelt/Extractor are located, and of a vacuum tube connected directly to the first beam separator. On this vacuum tube all the magnetic lenses of the gun are installed. The intermediate part is connected to the third output of the first beam separator. On the end of the intermediate part the second beam separator is mounted. The electron mirror is connected to the second outlet of this beam separator. The imaging part is connected to the third output of the second beam separator. This part is composed of the imaging chamber in which the microchannel-plates and the screen are installed, the energy analyzer and the tube connecting to the separator. As in the illumination part, all the lenses of the intermediate and imaging part are mounted on the tubes. The illumination chamber, the imaging chamber, mirror, energy analyzer, intermediate optics and the 2^{nd} beam separator are connected to the Ti sublimator pump. This pump is connected to an AGILENT 75 l/sec ion pump below the table. On the vaccum tube which connects the sublimator pump with the electron mirror the Bayard-Alpert gauge is mounted.

To the AGILENT 75 l/sec ion pump a full metal valve VAT NW35CFF is connected. This valve separates the UHV part of the electon optics UHV from the roughing pump system. It is used for venting the microscope UHV part and for initial pumping.

As mentioned above, the distribution chamber is connected to the main chamber with the VAT gate valve and is screwed to the main table. It is also connected with an AGILENT 20l/sec ion pump and a Titanium sublimation pump. These pumps are located below the table. The distribution chamber is connected via a full metal valve VAT NW35CFF to the rough pumping system.

The entrance chamber is equipped with the 700mm travel transfer rod, an AGILENT 20 l/sec ion pump, a Bayard-Alpert gauge and with the special sample lift. On this lift a viton O-ring is mounted, which is the main part of the sample lift valve. During the sample exchange, when the lift is in the lower (loadlock) position, the entrance chamber is sealed off from atmospheric pressure by this viton ring. In the upper position of the sample lift, the AGILENT 20 l/sec ion pump and the Bayard-Alpert gauge are separated from the entrance chamber vacuum. The sample lift has a connection through the AGILENT viton valve to the AGILENT turbo pump (V81-T). This allows evacuating the loadlock area to a pressure of 10^{-6} Torr in a short time (20 min. to 1 hour). The vacuum connection to the main chamber is done via a NW35CFF VAT gate valve.

Under the microscope table, the tubing is mounted which connects the different parts of the microscope to the valves and which connects the valves to the roughing pump system.

The system can be pumped in the different ways:

- *the whole system (microscope, main chamber, entrance chamber and load lock)*
  - the scroll pump and turbo pump have to be switched on.
  - all valves with exception of the special ELMITEC gate valve have to be open

- *only the microscopes main chamber*
  - the scroll pump and turbo pump have to be switched on.
  - the VAT NW35CFF right angle valve to the main chamber has to be open.
  - special ELMITEC gate valve has to be closed.
  - all other vlaves have to be closed

- *only imaging part of the microscope*
  - the AGILENT turbo-pump and its scroll pump have to be switched on.
  - the right angle VAT NW35CFF valve to the imaging part has to be open.
  - the special ELMITEC gate valve has to be closed.
  - all other vlaves have to be closed

- *only the distribution chamber*
  - the AGILENT turbo-pump and its scroll pump have to be switched on.
  - the valve which separates the distribiution chamber and main chamber has to be closed
  - the valve which separates the distribution chamber and STM chamber has to be closed
  - the valve which separates the distribution and preparation chamber has to be closed
  - the AGILENT NW35CF right angle valve to the rough pumping system has to be open
  - all other vlaves have to be closed

- *only entrance chamber*
  - the AGILENT turbo pump and its scroll-pump have to be switched on.
  - the AGILENT NW35CF right angle valve has to be open.
  - the “elevator” has to be in an intermediate position
  - all other vlaves have to be closed

The turbo pump can be switched on at quite high pressure - below 30 Torr. As a roughing pump a scroll pump is used. Using this pump only, a pressure of about 0,3…0,5 Torr can be obtained in the whole system. In this context it should be mentioned, that the turbo pump does not need any bakeout procedure and should be switched on while the pressure in the whole system is higher than 2…3x 10^{-5} Torr.

Before start to pump please analyze the attached Vacuum Diagram

1.2. Valves

There are eleven valves mounted in the system. Here, the function of all the valves is summarized. To improve the understanding of the vacuum system, the valves appear approximately in the order of decreasing system pressure, starting at atmospheric pressure.

- The first valve is of a small O-ring type valve which is used to vent the system (mounted on the turbo pump). While pumping the system by the scroll pump and the turbo pump this valve must be closed.
- A right angle valve which separates the electron optics from the AGILENT turbo pump is mounted under the table.
- A right angle mounted on the Titanium sublimation pump housing of the distribution chamber under the LEEM table which separates the distribution chamber from the turbo pump
- A right angle valve mounted on the Titanium sublimation pump housing under the LEEM table which separates the main chamber from the turbo pump.
- A right angle viton valve mounted on the vacuum connection under the LEEM table which separates the entrance chamber from the turbo pump.
- The sixth valve is mounted on the sample lift. It is an O-ring type and is automatically closed when the lift is in the lower position to unload or load the sample to or from the outside. During sample exchange, do not overtorque this valve (close hand-tight) because otherwise, the leaf springs which clamp the sample cartridge will probably deform. **Attention: this valve must be opened during bakeout**
- The next two valves are the VAT gate valves installed between distribution chamber and the main chamber respectively the main chamber and the entrance chamber. These valves are bake able in closed position up to 200°C. Remember to open these valves before a sample exchange is initiated, because your transfer rod will crash into them otherwise.
- The distribution is equipped with two additional VAT gate valves. One of it is used for the connection to the external prepartation chamber. The other one is planned for the connection to a further upgrade with an STM chamber or similar.
- The last of the major valves is a small gate valve mounted between main chamber and beam separator. During bake out, the valve can be left open or closed.

1.3. Pumps

The system is equipped with 4 AGILENT ion pumps, 3 titanium sublimation pumps, 1 AGILENT turbo pump and 1 AGILENT sroll pump. The AGILENT turbo pump and its scroll pump are used as roughing pumps to obtain a pressure in the range of 10^{-5} - 10^{-8} Torr in the microscope. The AGILENT pumps are also used during sample exchange to evacuate the sample lift area.

Below the table and connected to the main chamber an AGILENT 300 l/sec ion pump is mounted. Below the electron optics is an AGILENT 75 l/sec ion pump installed. The distribution chamber is pumped with an AGILENT 20 l/sec ion pump and the entrance chamber is pumped by an AGILENT 20 l/sec

1.4. Sublimation Pumps

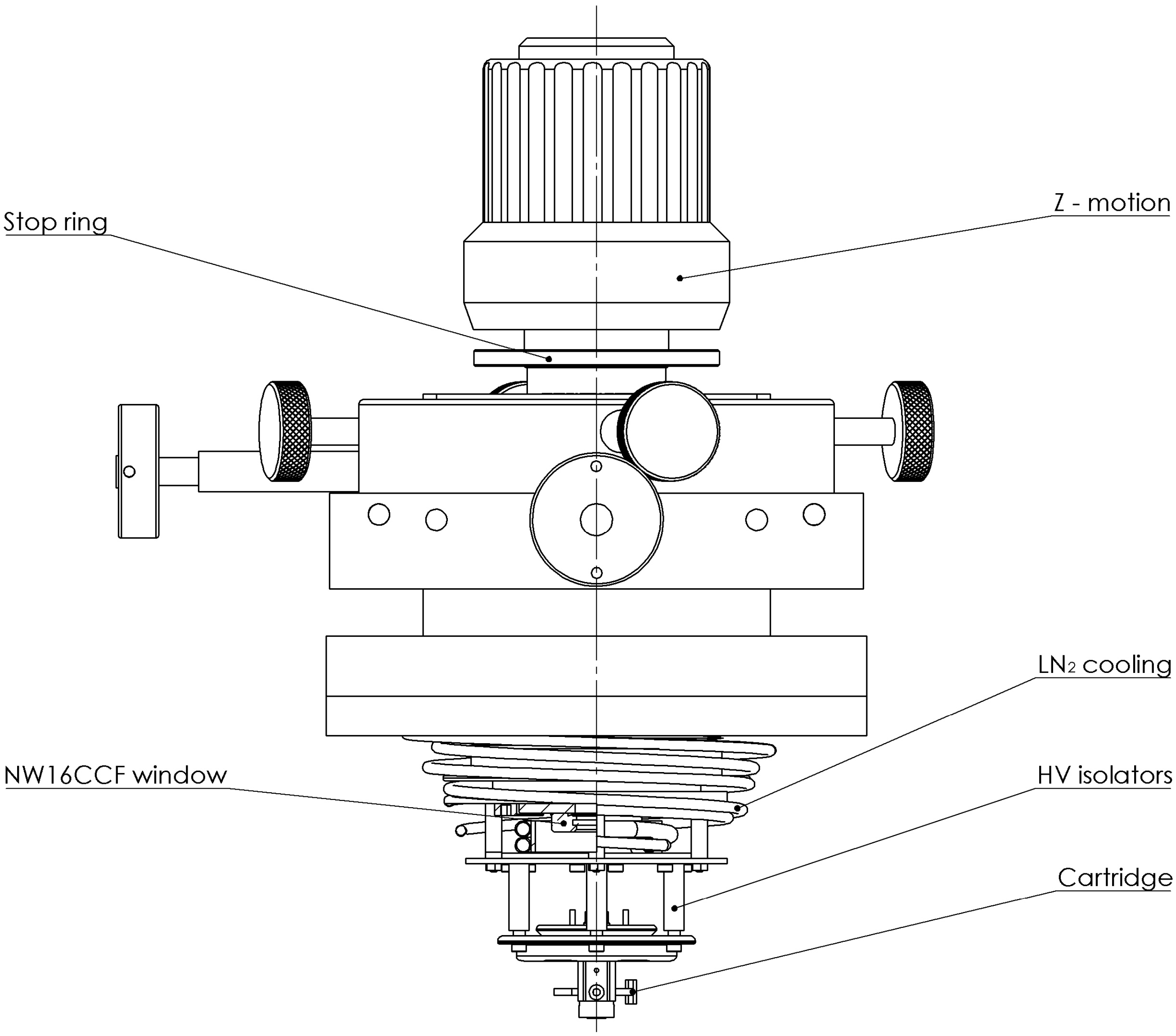
The three sublimation pumps located in main chamber, imaging optics and distribution chamber are built identically. They contain a Ti electrode and a tungsten filament. The Ti electrode is heated by electron bombardment at 1200V, 100mA. The tungsten filament is made in the form of a spring, mounted on a rod with a diameter of 2mm. It has 15 turns. In our design, a tungsten wire with a diameter of 0.15mm is used. The typical filament current is around 2.8 Amps. These values can be different when the number of turns or the diameter of the filament or the distance inbetween the Filament and the Ti electrode is different. The whole construction is mounted on NW CFF35 flange which is equipped with two HV BNC feedthrough labelled ‘FIL’ and one SHV feedthrough labelled ‘HV’.

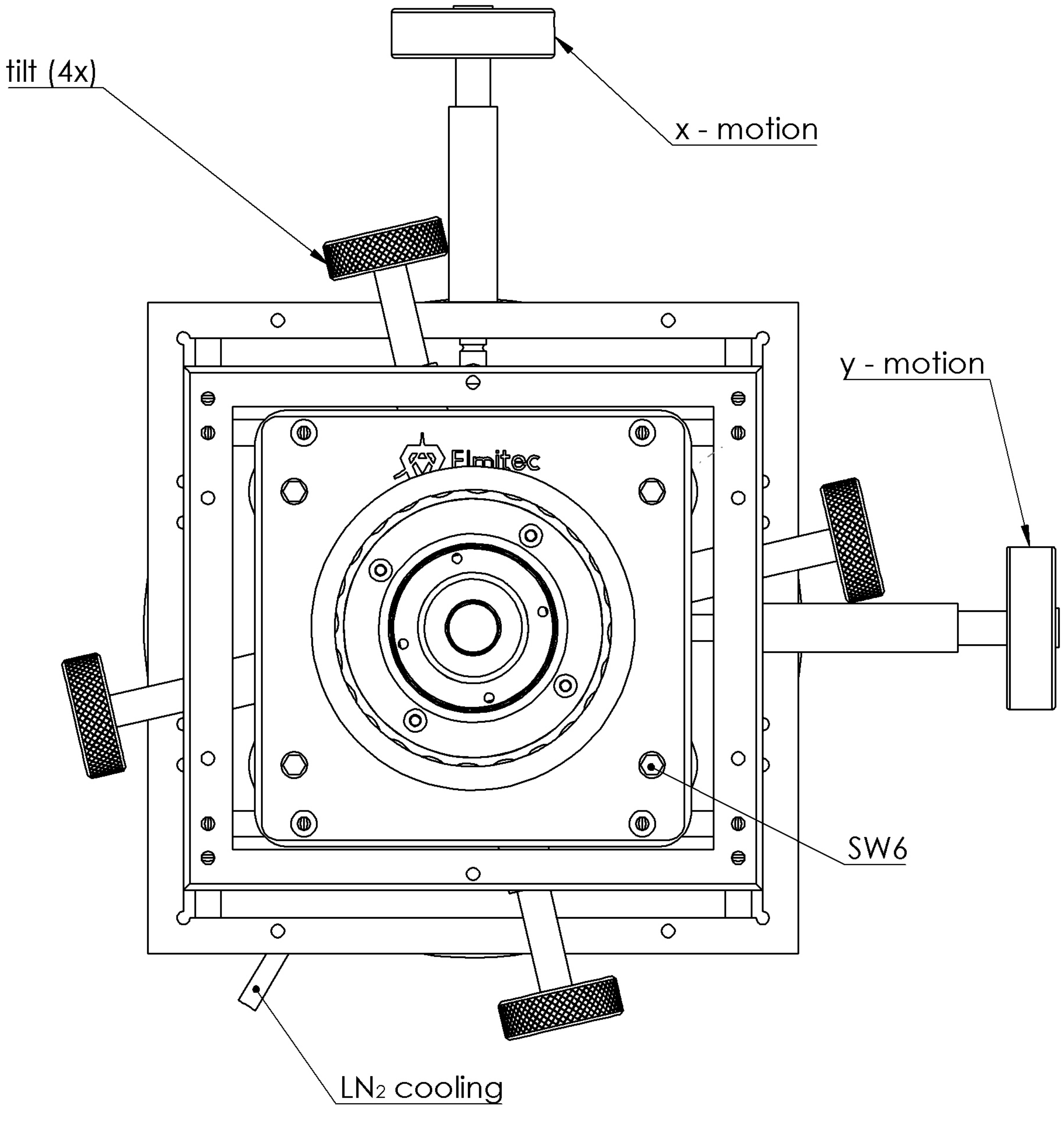
Warning! This unit generates hazardous voltage. Do not apply line voltage input unless adequate ground is connected to the unit and the high voltage output has been properly connected.
Warning! This unit can store hazardous voltage. Completely discharge the high voltage to ground before attempting removal of the high voltage cable.

1.5. Manipulator

1.5.1. General

The High Precision LEEM Manipulator is capable to precisely position a sample in an UHV chamber for surface research with the LEEM Microscope. The manipulator is suitable for an ultrahigh vacuum environment and is bakeable up to 180°C. It can be loaded with exchangeable sample cartridges with integrated electron bombardment heating. The sample temperature is measured with a W5%Re vs. W26%Re thermocouple.


Stop ring
Z - motion
LN2 cooling
NW16CCF window
HV isolators
Cartridge


tilt (4x)
x - motion
y - motion
Elmitec
SW6
LN2 cooling

1.5.2. Translation

The manipulator allows shifting the sample in X (±5mm), Y (±5mm) and Z (70mm) direction. The motions in X and Y direction are only possible at the Z position close to maximum (70mm), i.e. in front of the objective, at the working distance of the microscope.

Important: **Before moving Z backwards to the transfer rod position, it is necessary to center the X and Y motions!**

To move the sample in X and Y direction, use the outer screws in the drawing above, to move in Z direction use the manipulator head. The measurement position (Z direction) can be fixed by using the stop ring.

Important: **Before moving the Z motion make sure, that the tilt screws are tightened and centered!**

1.5.3. Tilt

With the two eucentric tilts it is possible to tilt the sample for ±2°. The tilt of the sample is only possible at a Z position close to maximum (70mm), i.e. in front of the objective lens, at the working distance of the microscope. When tilting, the vectorial sum of X and Y tilt motion (i.e. the distance to the center) must not exceed ±3°.

Important: **Before moving Z backwards to the transfer rod position it is necessary to center the tilts!**

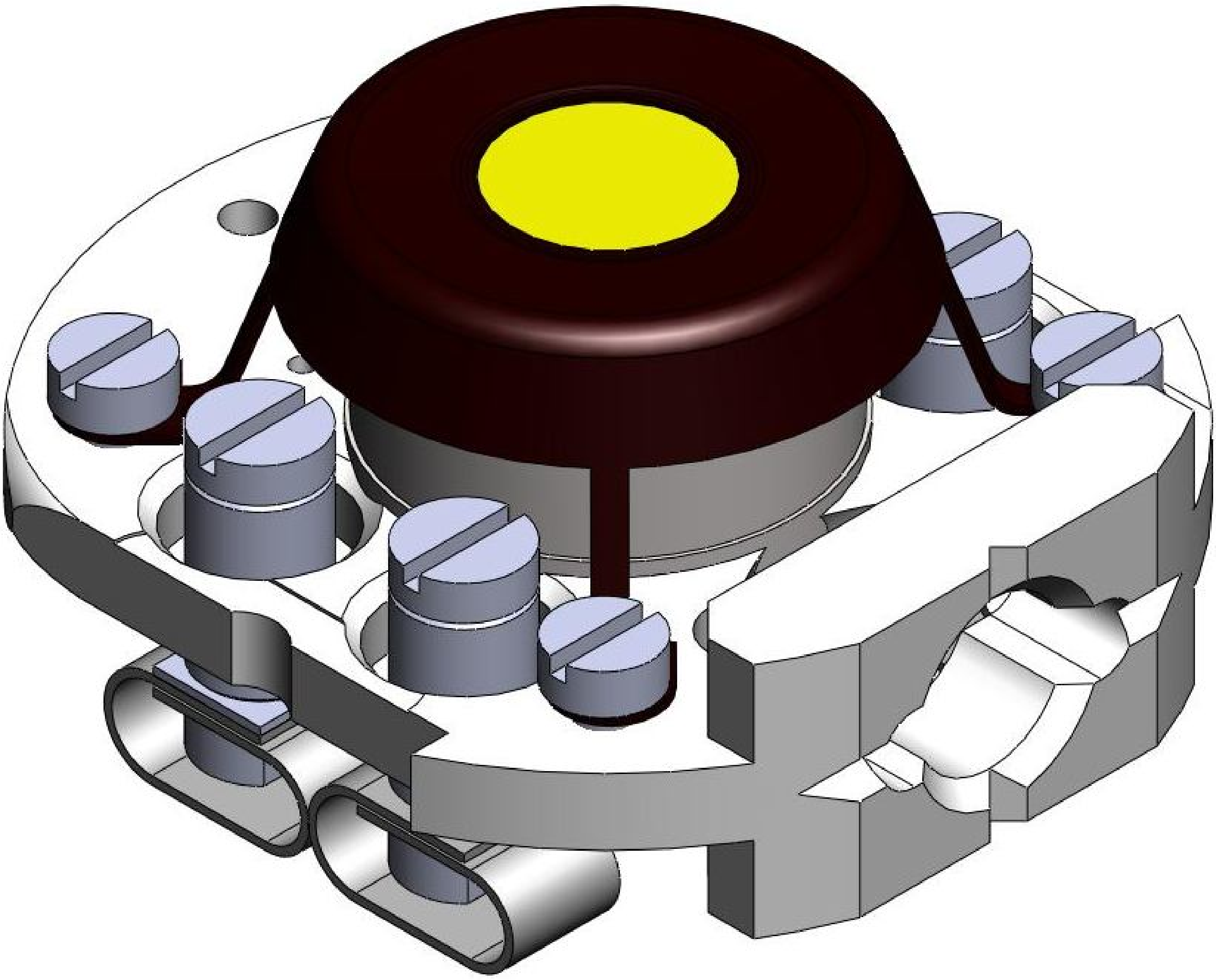
To adjust the tilt use the inner screws in drawing above. Loosen one of the screws first and then tighten the opposite one.

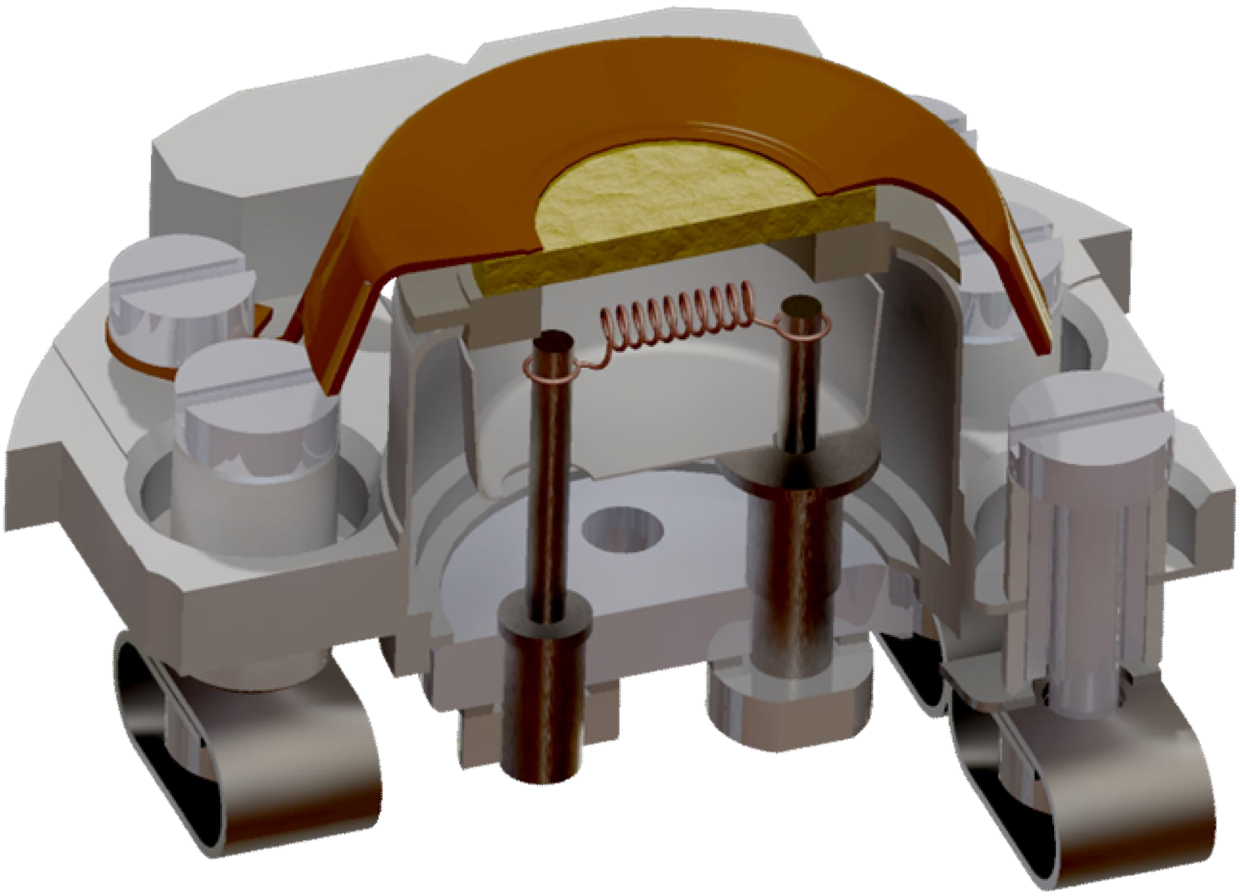
1.5.4. Sample heating

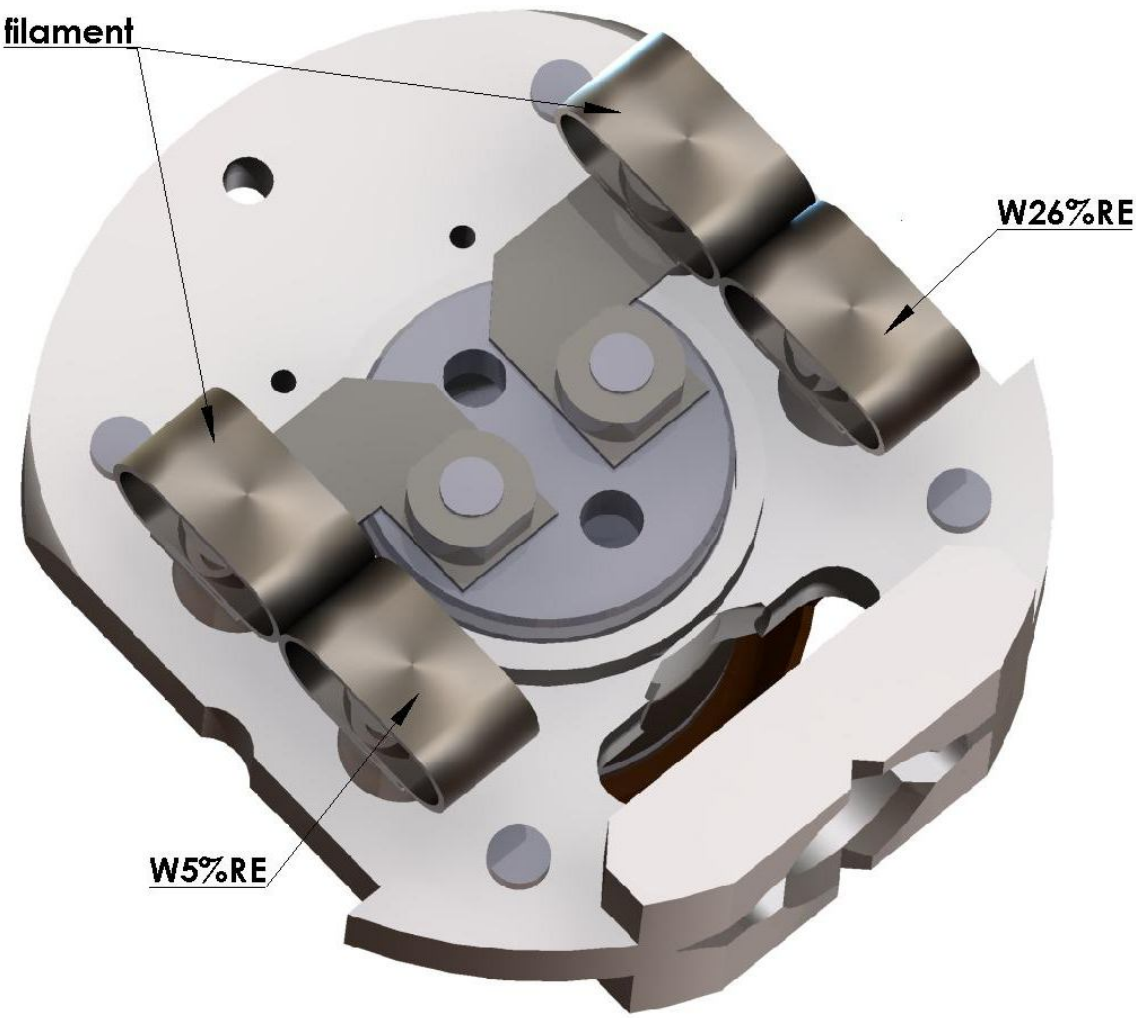
The sample can be heated by electron bombardment and by filament radiation. The heating by radiation only allows reaching a temperature of about 600°C. The maximum filament current is 2.75 Amps. The heating by electron bombardment allows reaching higher temperatures. It is possible to obtain a temperature of 1600°C with the heating power of about 150Watts. Even higher temperatures are possible, but only for a very short time.

Important: **During sample heating with electron bombardment, the maximum temperature rating of the sample cartridge base plate must not be exceeded. This temperature should not be higher then 650°C, otherwise the heating can cause permanent damage of the sample cartridge and of the manipulator, too.**

Standard ELMITEC sample holder






filament
W26%RE
W5%RE

1.5.5. Exchange of the sample

Exchange the sample according to the following instructions:

1. Install the cartridge in the aluminum holder.
2. Loosen the 4 screws (M2) holding the sample
3. Remove the sample cover
4. Remove the sample.
5. Install the new sample.
6. Install the sample cover.
7. Fixate the the cover with the four screws.

If the sample cover is fixed to weak than the sample can move unexpectedly during observation in the microscope. Too strong torque on the screws will cause heat losses during sample heating or even can crack the sample. For optimum fixation of the sample cover, some experience with the cartridge is required.

ATTENTION !!!

Sometimes, after heating the sample to very high temperatures, the sample cover can stick to the sample. In this case, hold down the sample while trying to remove the sample cover. The sample base plate below the sample must not move because the thermocouple which is spot welding to this part can easily break otherwise.

For the same reason, if the sample sticks to the sample base plate, hold the base plate down (e.g. with a pair of tweezers) to prevent the part from moving while removing the sample.

1.5.6. Compensation of the Pressure Load

Atmospheric pressure acting on the bellows along the manipulator Z axis (equivalent to a to a 60kg mechanical load) can cause problems with the X and Y motions. With the help of the 4 screws labeled SW6 (drawing: Manipulator top view), the effect of the atmospheric pressure load can be compensated. The screws SW6 act on strong springs (not shown in the drawings). Turning the screws SW6 clockwise causes a stronger compensation. At a too strong compensation, the manipulator moves more smoothly, but at the same time it gets strongly sensitive to mechanical vibration.

1.5.7. Bakeout

The manipulator is fully bakeable up to 180°C. To extend the live time of the manipulator it is better to keep the table and the head of the manipulator outside the bakeout unit.

1.5.8. Maintenance

After a few successive bakeouts the threads of the X and Y motion as well as the threads of tilt screws should be lubricated. Use the silicon lubricant supplied with the instrument for this purpose. The guiding rails of the X and Y motion should be lubricated with silicon oil. The manipulator head needs no lubrication.

1.5.9. Specifications

1.5.9.1. Translation

X-Motion	±5mm at Z-position in maximum (70mm)
Y-Motion	±5mm at Z-position in maximum (70mm)
Z-Motion	70mm maximum

1.5.9.2. Tilt

2 eucentric tilts	±2° at Z-position in maximum (70mm), the vectorial sum of X and Y tilt motion should not exceed ±3°

1.5.9.3. Bakeout

Maximum temperature	180°C

1.5.9.4. Sample Heating

Maximum temperature 1600°C
Temperature is measured by W5%Re-W26%Re thermocouple

Note: The manipulator is capable of full motion during sample heating.

1.5.9.5. Vacuum

Tested base pressure	5,9 x 10^{-11}Torr

2. Power Racks

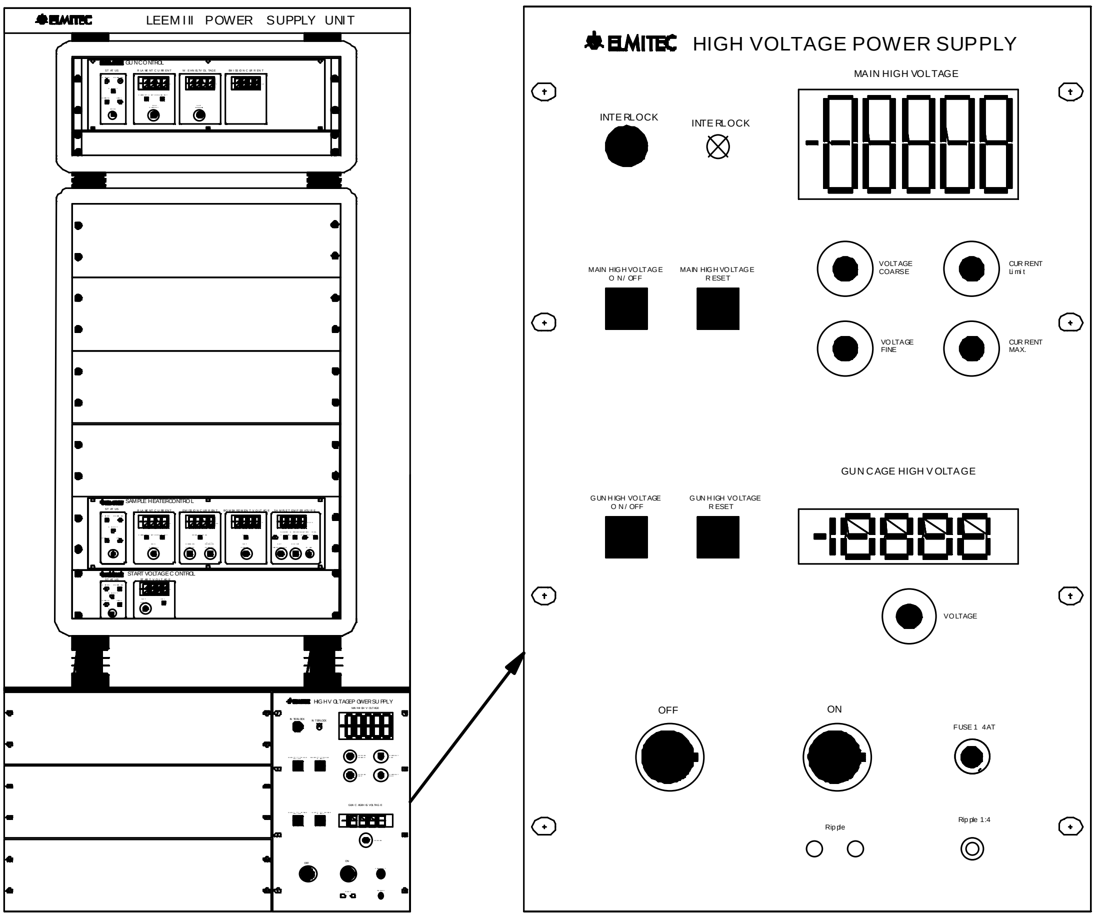
2.1. High Voltage Rack

The full description of the high voltage part of the power rack can be found in the following part of the manual. Here we only give a short introduction of how to use this part of the rack and what procedures need special attention.

Before switching the rack on, check that all covers and cabinet parts are installed, all high voltage cables are connected (sample manipulator, e-gun, energy analyzer, etc.) and safely secured with their screws.

<u>Warning!</u> This unit generates hazardous voltages. Do not connect to power line unless adequate ground is connected to the unit and all high voltage leads have been properly connected.

<u>Warning!</u> This unit can store hazardous voltages. Completely discharge the high voltage to ground before attempting removal of the high voltage cable.



The HV part of the rack is separated in two cages one for the sample, analyzer and mirror and the other one for the electron gun. This separation is necessary for the use of a Schottky field emission source. For the field emitter it is important to keep the electron gun on high voltage during flashing or tranfering the sample. The two switches labeled GUN HIGH VOLTAGE

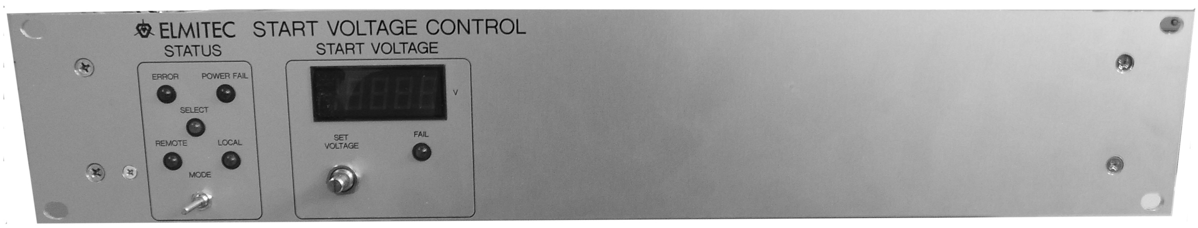
ON/OFF and GUN HIGH VOLTAGE RESET are not in use for a standard cathode. Two displays are showing the voltages on the two cages.

For switching on the rack follow these steps:

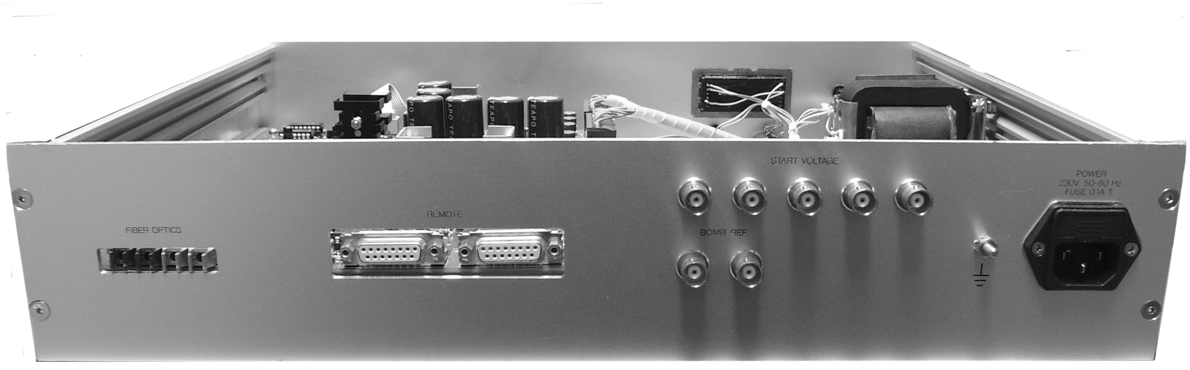
- Turn the interlock key to the horizontal position, the red interlock lamp should be off
- Check that all potentiometers on the high voltage control panel and the high voltage units inside the rack are set to zero
- Press the green „ON“ button
- Turn the CURRENT LIMIT potentiometer of the MAIN HIGH VOLTAGE to about 3.70
- Turn the CURRENT MAX. potentiometer of the MAIN HIGH VOLTAGE to about 4.00
- Press the green „HIGH VOLTAGE ON/OFF“ button of the GUN HIGH VOLTAGE
- Slowly (1kV/5min) turn up the GUN HIGH VOLTAGE to -10 kV with the VOLTAGE knop of the GUN HIGH VOLTAGE part. Now it is possible to apply the current to the electron source.
- Press the green „HIGH VOLTAGE ON/OFF“ button of the MAIN HIGH VOLTAGE
- Slowly (1kV/5min) turn up the MAIN HIGH VOLTAGE to -20 kV with the VOLTAGE COARS and FINE knop of the MAIN HIGH VOLTAGE part

2.2. Start Voltage Control Unit

2.2.1. General Information



Frontview of ELMITEC Startvoltage power supply
Switch on the left below the Staus LEDs is for selecting the mode of operation (local/remote)
Potentiometer on the right is controlling the output voltage in local mode



Backside of ELMITEC Startvoltage power supply
Left side: 2x fibre optical connectors for computer control (isolation voltage >20kV)
D-Sub connectors: computer conection of other units in the high voltage rack sytem
BNC-connectors: upper line: voltage output for the manipulator
lower line: voltage output for the ELMITEC sample heater

2.2.1.1. Introduction

This section contains technical description and operating instructions for the ELMITEC Start Voltage Control Unit. The SV Control Unit is integrated in a 19“ chassis mounted in the high voltage system rack and is used to control the start voltage. The unit can be controlled by the system controller (PC) or manually, at the front panel.

This unit generates the potential difference between the electron source and the specimen. It also floats the specimen heater, as decribed below. To account for the various possible contact potentials between electron source and the materials used in the experiments, the supply can, besides positive start voltages of up to 500 V, deliver also slightly negative start voltages up to –5V.

2.2.1.2. Safety Warning

In the HV system rack there are a number of power supplies generating high voltages. The handling of high voltage requires special precaution and safety measures. Calibration and repair work must be performed by trained personnel only. The Start Voltage Control Unit itself generates a maximum voltage of 1500V referenced to its chassis.

2.2.1.3. Applications

The SV Control Unit is designed to supply, control and monitor the start voltage.

2.2.2. Operation

2.2.2.1 Introduction

This section contains basic operating information of the Start Voltage Control Unit. It includes local control, remote control and start voltage setting.

2.2.2.2. Control

The SV Control Unit can be controlled by the system controller (PC) or manually, at the front panel. To protect the system from being damaged by software failures, the selection of the remote/local mode is only possible by the mechanical switch on the front panel of the unit. Switching the mode during operation requires extra care because the supply will immediately switchover to the potentials selected by the potentiometer settings on the front panel. A safe switchover is done by minimizing the difference between computer controlled voltage and potentiometer setting on the frontpanel at first, and then operating the local/remote mode switch. The user is responsible for the safe switchover.

Two isolated control ports designated ‘optical remote’ and ‘remote’ are provided for the data transfer between the system controller and the SV Control Unit. The optical remote port is usually used for very high isolation voltages up to several 10kV. The remote port allows an isolation voltage of up to 2kV.

2.2.2.3. Start Voltage

The SV Control Unit contains a precision high voltage module to supply the start voltage. This module consists of a 16Bit DAC, a HV amplifier and short circuit protection at the output. A switch on the front panel is used to allow local or remote control of the start voltage. The start voltage specifications are given below.

In the local control mode the output voltage can be set manually, on the front panel. To do so, use the following procedure:
- Turn the switch "MODE" on the front panel to the right. The LED "LOCAL" will get lit.
- Turn the potentiometer "SET VOLTAGE" to the right or left to increase or decrease the start voltage. The digital panel meter shows the start voltage.
- Watch the LED "FAIL". During normal operation, it is not lit.

In the remote control mode the output voltage can be programmed by the system controller (PC). To do so, use the following procedure:
- Turn the switch "MODE" to the left, the LED "REMOTE" will get lit.
- Use the start voltage menu on your control screen to set the voltage.
- Watch the control menu. During normal operation, the start voltage fail message must not appear on the screen.

2.2.3. Connectors

Four connectors are provided at the rear panel of the SV control chassis for start voltage, bombardment reference, optical remote and remote connections.

2.2.3.1. Start Voltage Connector

5 BNC sockets are used for the start voltage output. The center of the socket is connected to the start voltage. The shield of the socket is connected to the chassis.

2.2.3.2. Bombardment Reference Connector

The bombardment reference is used to float the sample heater circuit. Two BNC sockets are provided for the sample heater (bombardment). The center of the socket is connected to the start voltage. The shield of the socket is connected to the chassis. A standard BNC cable, for example RG 58, can be used to connect the the sample heater (bombardment) start voltage in to the sample heater.

2.2.3.3. Optical Remote Connector

On the SV Control board two fiber optical connectors are provided for the remote connection. Two fiber optical cables are used to connect the optical remote port of the SV Control Unit to the optical ports of the field bus adapter. This adapter is, in turn, connected to the field bus through the 'REMOTE OUT' socket in the Lens Power Supply Rack.

2.2.3.4. Remote Connectors

The remote port (15pin SubD connector) of the SV Control Unit is connected to the remote ports of other units in the high voltage rack such as the Sample Heater Control Unit, Mirror Control Unit, Analyzer Control Unit and the optical connection box for the Gun Control Unit.

2.2.4. Specifications

2.2.4.1. Start Voltage

Voltage Range:	-5V…+500V
Gain Error:	max. 1%
Output Current:	Max. 2mA, short circuit protected
Resolution:	16Bit, 7,7mV (remote control)
Operation Mode:	Remote or local, selected by a switch on the front

2.2.4.2. Start Voltage Control and Display

Digital Panel Meter:	Resolution 4 ½ digits, Accuracy: +/- 1 digit
FAIL:	This LED flashes if the start voltage fails
Operation Mode	Remote or local, selected by a switch on the front
Local Control:	A 10-turn pot is used for start voltage setting
Remote Control:	A 16-bit DAC is used for start voltage setting

2.2.4.3. Status Control and Display

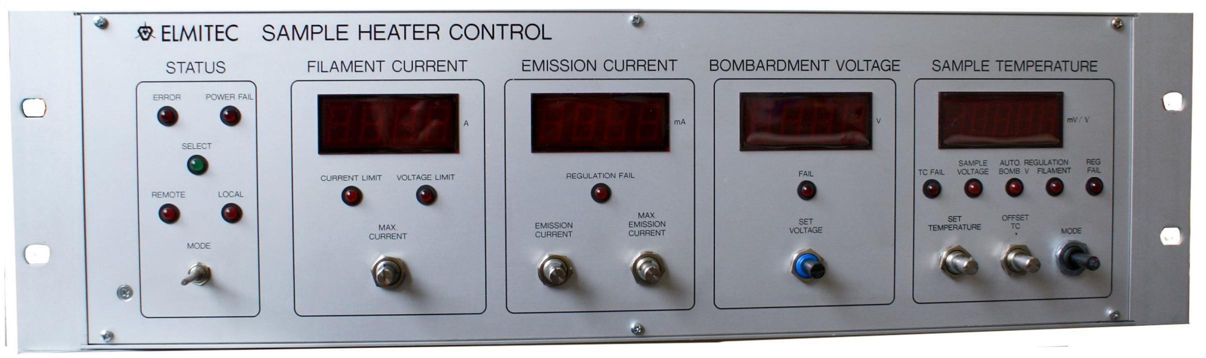
ERROR:	Indicates that the DAC contains wrong values
POWER FAIL:	This LED flashes if any supply voltage 5V/+15V/-15V fails
SELECT:	Indicates that the system controller selected the Start voltage control
REMOTE:	Indicates that remote control is selected by the switch „MODE“
LOCAL:	Indicates that local control is selected by the switch „MODE“
MODE:	Rotary switch to select local or remote control

2.2.4.4. General Operating Conditions

Line Voltage:	230V/115V/50-60Hz/10VA The line voltage is factory set to 230V. The configuration for a line voltage of 115V ac must be done at transformer inside the unit
Fuse:	1x 0.1A slow blow 230V
Operating Temperature:	10-35°C
Warm-up	½ hour to rated accuracy
Relative Humidity:	0-80%, non-condensing
Mechanical Design:	19“ cabinet for rack mounting
Dimension:	19“ front panel, 2 height units, depth 340mm

2.3. Sample Heater

2.3.1. General Information



Frontview of ELMITEC Sample Heater Control power supply
Switch on the left below the Staus LEDs is for selecting the mode of operation (local/remote)

Backside of ELMITEC Startvoltage power supply

Left side:	BNC-connectors:	"Start voltage in" for connection to the ELMITEC Start Voltage Power Supply "Ref. Voltage" for further upgrades
	3pin TC connector:	for connetion to the thermo couple of the sample manipulator
Centre left:	D-Sub connector:	computer connection of other units in the high voltage rack sytem
Center right:	2x Banana Plug:	for connetion to the filament of the sample Manipulator
Right side:	Power line and grounding	

2.3.1.1. Introduction

This section contains the technical description and operating instructions for the ELMITEC Sample Heater. The Sample Heater is integrated in a 19" chassis mounted in the HV system rack. The unit also contains the filament power, bombardment power supply. The values for filament current, bombardment voltage and emission current are controlled either by the system controller (PC) or manually, at the front panel. The sample is heated by bombarding it with electrons emitted from the filament. The electrons are accelerated by the bombardment voltage towards the sample.

2.3.1.2. Safety Warning

In the HV system rack there are a number of power supplies generating high voltages. The handling of high voltage requires special precaution and safety measures. Calibration and repair work must be performed by trained personnel only. The Sample Heater generates a maximum voltage of 1500V referenced to its chassis.

2.3.1.3. Applications

The Sample Heater is designed for control and monitoring of the filament current and of the emission current in the HV subsystem in order to heat the sample up to 2300°C. The functions of this unit are listed below:

- Control of the filament current up to 3A
- Control and regulation of the emission current up to 160 mA
- Generation of the bombardment voltage up to 1200 V / 160 mA
- Display of the filament, emission current, bombardment voltage and the sample temperature on the front panel

2.3.2. Operation

2.3.2.1. Introduction

This section contains basic operating information of the Sample Heater. It includes information on setting the filament current and the emission current. To heat the sample, the electrons emitted from the filament are accelerated towards the sample by applying the bombardment voltage. Suited samples can be heated up to 1600°C or more.

2.3.2.2. Control

The filament current, emission current and bombardment voltage are controlled manually by potentiometers on the front panel of the Sample Heater unit or by the system controller (PC).

2.3.2.3. Filament Current

The Sample Heater unit contains a circuit to supply and control the filament current. The maximum voltage and current are limited to 12V and 3A. The filament current is shown by a digital panel meter on the front panel. A LED on the front panel designated 'CURRENT LIMIT' flashes if the filament is working in current mode. A LED designated 'VOLTAGE LIMIT' flashes if the filament voltage exceeds the maximum voltage of 12V. The filament supply specifications are given below.

In local control mode the filament current can be set manually. The controls for manual operation are located on the front panel of the Sample Heater Control Unit. To set the filament current manually, use the following procedure:

- Check that the manual controls are set to zero.
- Select „LOCAL MODE“ through the switch on the front panel of the Sample Heater Control Unit.
- Turn the current potentiometer to the right or left to increase or decrease the filament current. A meter on the front panel of the Sample Heater Control Unit shows the filament current.

In remote control mode the Sample Heater Control Unit allows to set the filament current by the system controller (PC). The circuit consists of a 12Bit DAC. To set the filament current. in remote mode, use the following procedure:

- Check that the value for the filament current on the system controllers (PC) display is set to zero.
- Select ‘REMOTE MODE’ by the switch on the front panel of the Heater Control Unit.
- Use the filament current menu on your control screen to set the current.
- Observe the control menu. During normal operation, the filament current fail message must not be shown.

2.3.2.4. Emission Current

The Sample Heater unit contains a circuit to regulate the emission current. The emission current is shown by a digital panel meter on the front panel. A LED on the front panel designated ‘REGULATION FAIL’ flashes if the emission current regulation fails. A second potentiometer on the front panel labelled ‘MAX. EMISSION CURRENT’ with a scale from 0 to 10.00 is used to set the maximum allowable emission current. The scale 0 corresponds to 0mA and the scale 10.00 corresponds to 160mA. Use this potentiometer to adjust a safe temperature limit for your sample. This may get important in cases where the user has to blindly vary the emission current while being focused to the screen observing his experiment.

In local control mode the emission current can be set manually. The controls for manual operation are located on the front panel of the Sample Heater Control Unit. To set the emission current, use the following procedure:
- Check that the manual controls are set to zero.
- Select „LOCAL MODE“ through the switch on the front panel of the Sample Heater Control Unit.
- Turn the current potentiometer to the right or left to increase or decrease the emission current. A meter on the front panel of the Sample Heater Control Unit shows the emission current.

In remote control mode the Sample Heater Control Unit allows to set the emission current by the system controller (PC). The circuit consists of a 12Bit DAC. To set the emission current in remote mode, use the following procedure:

- Check that the value for the emission current on the system controllers (PC) display is set to zero.
- Select ‘REMOTE MODE’ by the switch on the front panel of the Heater Control Unit.
- Use the emission current menu on your control screen to set the current.
- Observe the control menu. During normal operation, the emission current fail message must not be shown.

2.3.2.5. Bombardment Voltage

The Sample Heater Control Unit contains a circuitry for controlling the bombardment power supply. The bombardment power supply itself is mounted in the Sample Heater Unit chassis, together with the filament power supply. The bombardment power supply generates a voltage of 0 to -1200V with a possible output current of 0...160 mA and floats on the start voltage, i.e. the ground of the bombardment PS is connected to the start voltage. This unit can be controlled in local or remote mode. The specifications of the bombardment PS are given below.

In local control mode the bombardment output voltage can be set manually. The controls for manual operation are located on the front panel of the Sample Heater Control Unit. To set the bombardment voltage manually, use the following procedure:

- Check that the manual controls are set to zero.
- Select „LOCAL MODE“ through the switch on the front panel of the Sample Heater Control Unit.
- Turn the voltage potentiometer to the right or left to increase or decrease the bombardment voltage. A meter on the front panel of the Sample Heater Control Unit shows the bombardment voltage.

In remote control mode the Sample Heater Control Unit allows to set the bombardment voltage by the system controller (PC). The circuit consists of a 12Bit DAC and an isolation amplifier for level shifting. To set the bombardment voltage in remote mode, use the following procedure:

- Check that the value for the bombardment voltage on the system controllers (PC) display is set to zero.
- Select ‘REMOTE MODE’ by the switch on the front panel of the Heater Control Unit.
- Use the bombardment voltage menu on your control screen to set the voltage.
- Observe the control menu. During normal operation, the bombardment voltage fail message must not be shown.

2.3.2.6. Sample Temperature

The sample temperature can be measured by the Sample Heater Control Unit. For this purpose a thermocouple allowing temperature measurements of up to 2300°C is connected to the Sample Heater control Unit. The thermocouple voltage value and the status of the thermocouple are displayed by a digital meter and a LED on the front panel of the control unit. The temperature and the thermocouple status can also be read out by the system controller (PC).

For the temperature measurement, the thermocouple voltage is amplified by an isolation amplifier because the thermocouple floats on start voltage. The amplified thermocouple voltage is displayed without any linearization, i.e. the display shows the plain thermocouple voltage rather than the temperature. Therefore, the displayed value must be converted to the temperature by using the thermocouple table given in Appendix B in this manual. The thermocouple voltage range is 0...37mV corresponding to the temperature range of 0...2300°C, respectively.

An indicator ‘THERMOCOUPLE FAIL’ on the front panel shows the status of the thermocouple. This indicator will flash if the thermocouple is not connected, broken, or the thermocouple temperature exceeds 2300°C which is the absolute maximum rating.

The Sample Heater Control Unit utilizes a 12Bit AD-Converter for thermocouple voltage readout by the system controller (PC). As on the front panel of the unit, the voltage range is 0...37.00mV corresponding to 0...2300°C. The thermocouple status can also be read out.

2.3.2.7. Sample Temperature Regulation

The Sample Heater Control Unit contains a circuit for automatic sample temperature regulation. The sample temperature can be controlled by the filament current, emission current and/or bombardment voltage. The unit provides two modes for sample heating, selected by a rotary swicht on the frontpanel. The filament mode is used for lower temperatures (500 … 600 °C). For higher temperature the bombardment voltage mode has be be used. Two indicators labelled ‘AUTOMATIC REGULATION’ and ‘REGULATION FAIL’ are provided on the front panel of the unit to show the status of the regulation circuit.

To regulate the sample temperature in filament regulation mode, use the following procedure:

- Make sure that the sample heater control unit is set to local control
- Set the bombardment voltage to zero using the manual control.
- Set the emission current close to zero using the manual control.
- Set the max. emission current slightly higher than the emission current value.
- Set the set temperature potentiometer to 0.
- Set the filament current to its nominal value previously determined.
- To obtain automatic temperature regulation, adjust filament current such that the temperature rises to about 10% above the desired temperature. Keep in mind that the maximum value determined above should not be exceeded.
- In the control menu, enable the automatic regulation filament. The indicator ‘AUTOMATIC REGULATION‘ will get lit. The indicator ‘REGULATION FAIL’ will flash.
- Set the desired temperature by using the set temperature potentiometer (see appendix C) The indicator ‘REGULATION FAIL’ will then turn off, when you reach the desired temperature.

To regulate the sample temperature in bombardment regulation mode, use the following procedure:

- Make sure that the sample heater control unit is set to local control
- Set the emission current close to zero using the manual control.
- Set the set temperature potentiometer to 0.
- Set the filament current to its nominal value previously determined.
- To obtain automatic temperature regulation, adjust bombardment voltage and emission current such that the temperature rises to about 10% above the desired temperature. Keep in mind that the maximum value determined above should not be exceeded.
- In order to operate the heating power supply in constant power mode the max. emission current value always has to be higher than the emission current value.
- In the control menu, enable the automatic regulation bombardment. The indicator ‘AUTOMATIC REGULATION‘ will get lit. The indicator ‘REGULATION FAIL’ will flash.
- Set the desired temperature by usind the set temperature potentiometer (see appendix C) The indicator ‘REGULATION FAIL’ will then turn off, when you reach the desired temperature.

2.3.3. Connectors

Four connectors are accessible from the rear of the Sample Heater chassis for filament supply, thermocouple, startvoltage in and remote control connections.

2.3.3.1. Filament Connector

Two connectors on the back plane are used to connect the filament cable. If the cable needs to get removed, be sure not to pull on the wires.

2.3.3.2. Thermocouple connector

A 3-pin socket is accessible from the rear of the chassis for the thermocouple connection. A special 2-wire cable with shielding is used to connect the thermocouple. Because the thermocouple floats on the start voltage, the cable shielding is connected to the start voltage and not to the chassis. The pin assignment is given below:

Pin1: TC+	Positive wire of the thermocouple
Pin2: TC-	Negative wire of the thermocouple
Pin3: STV	Start voltage

2.3.3.3. Start voltage connectors

A BNC socket is used for floating the sample on the start voltage. The center of the socket is connected to the start voltage. The shield of the socket is connected to the chassis.

2.3.3.4. Bombardment Reference connectors

This BNC socket is used for further upgrades.

2.3.3.5. Remote connectors

A 15 pin SubD connector is provided for remote port connection.

2.3.4. Specifications

2.3.4.1. Filament Supply

Filament Voltage Range:	0...12V
Filament Current Range:	0...3A

2.3.4.2. Bombardment Power Supply

Voltage Range:	0… -1200V
Output Current:	0…160mA
Voltage Stability:	0.1 %
Voltage Ripple:	0.1 %

2.3.4.3. Status Indicators

ERROR:	Indicates that the DAC contains wrong values
POWER FAIL:	This LED flashes if any supply voltage 5V/+15V/-15V fails
SELECT:	Indicates that the system controller selected the Sample Heater Control
REMOTE:	Indicates that remote control is selected by the switch „MODE“
LOCAL:	Indicates that local control is selected by the switch „MODE“
MODE:	Rotary switch to select local or remote control

2.3.4.4. Filament Current Indicators

CURRENT LIMIT:	This LED flashes if the supply is current regulation mode
VOLTAGE LIMIT:	This LED flashes if the filament voltage exceeds 12V

2.3.4.5. Emission Current Indicator

REGULATION FAIL:	This LED flashes if the emission current regulation fails

2.3.4.6. General Operating Conditions

Line Voltage:	230V/115V/50-60Hz/250VA The line voltage is factory set to 230V AC. Fuse: 1x 1A slow blow 230V
Operating Temperature:	10-35°C
Warmup	½ hour to rated accuracy
Relative Humidity:	0-80%, non condensing
Mechanical Design:	19“ rack mount cabinet
Dimension:	19“ front panel, 3 height units, depth 380mm

2.5. Energy Analyzer Control

2.5.1 General Information

Front Plate of ELMITEC Analyzer Control
Switch on the left side selects the control mode: local or remote
5 Potentiomters on the right: controlling the output voltages in local mode

Back Plate of ELMITEC Analyzer Control
Left side: connectors for computer control
Right side: connectors for the Analyzer voltage outputs.

2.5.1.1. Introduction

This manual contains technical description and operating instructions for the Elmitec Energy Analyzer Control. The Energy Analyzer Control is integrated in a 19“ chassis mounted in the high voltage system rack and is used to supply the energy analyzer. This unit can be remotely controlled by the system controller (PC) or manually on the front panel.

Two isolated control ports designated optical remote and remote are provided for data transfer between Energy Analyzer Control, the system controller (PC), and other units in the high voltage rack.

2.5.1.2. Safety Warning

In the HV system rack there are a number of power supplies generating high voltages. The handling of high voltage requires special precaution and safety measures. Calibration and repair work must be performed by trained personnel only. The Energy Analyzer Control itself generates a maximum voltage of 8kV referenced to its chassis.

2.5.1.3. Applications

The Energy Analyzer Control is designed to supply lens voltages for the Elmitec Energy Analyzer. The functions of this unit are listed below:

- Control and generation of voltages for Retardation Lens (0..8kV), Inner Lens (0..8kV), Acceleration Lens (0...3kV), and Bias (0...1.2kV)
- Control and generation of two voltages for SEL+ (0...100V) and SEL- (0…-100V)

2.5.2. Operation

2.5.2.1 Introduction

This section contains basic operating information of the Energy Analyzer Control. It includes local control and remote control.

The Energy Analyzer Control consists of the following units:

Two isolated remote control ports
Front panel unit
High voltage generator for Retardation Lens
High voltage generator for Inner Lens
High voltage generator for Acceleration Lens
High voltage generator for Bias
Bipolar voltage generator for SEL+/SEL-

2.5.2.2. Remote Control Ports

The EA Control can be controlled by the system controller PC, or manually at the front panel. For safety reason the selection of the remote/local mode can not be done by the system controller, i.e. this operation is done manually by the user who must be aware of what he is doing. So the system is well protected from being damaged by software error.

Two isolated control ports designated optical remote and remote are provided for data transfer between Energy Analyzer Control, the system controller (PC), and other units in the high voltage rack.

2.5.2.3. Front Panel Unit

The EA Control allows the user to control the high voltage generators from the front panel by using potentiometers. Several LEDs are provided to indicate the status of the Energy Analyzer Control.

The control and status groups on the front panel are described below:

Status	Rotary switch used to select local or remote mode LED “LOCAL” illuminates if local control is selected LED “REMOTE” illuminates if remote control is selected LED “ERROR” flashes if DAC contains wrong values LED “POWER FAIL” flashes if the internal power supply fails LED “SELECT” illuminates if the controller selectes the EA Control
Bias	Digital panel meter with a resolution of 4 ½ digit 10-turn potentiometer to set the voltage manually to 0...1.2kV
SEL+/SEL-	Digital panel meter with a resolution of 4 ½ digit 10-turn potentiometer to set the voltage manually to 0...100.00V
Acc. Lens	Digital panel meter with a resolution of 4 ½ digit 10-turn potentiometer to set the voltage manually to 0...3kV
Inner Lens	Digital panel meter with a resolution of 4 ½ digit 10-turn potentiometer to set the voltage manually to 0...8kV
Ret. Lens	Digital panel meter with a resolution of 4 ½ digit 10-turn potentiometer to set the voltage manually to 0...8kV

Voltage Generator for Ret. Lens

The EA Control contains a precision high voltage generator to supply the voltage of the retardation lens.

The high voltage generator consists of:
A 16Bit-DAC for programming the high voltage
A HV amplifier with an arc protection circuit at the output

A watch circuitry to detect DAC errors

The voltage generator specifications are given below:

Voltage Range:	0V...+8kV
Output Current:	max. 0.25mA, short circuit protected
Output resistance:	1MOhm, due to arc protection circuit

DAC Resolution:	16Bit
Stability:	50ppm/°C (remote control), 100ppm /°C (local control)
Voltage Ripple:	max. 100mVss.

The switch “MODE” on the front panel is used to allow local or remote control of the voltage generator.

In local control mode the output voltage can be set manually on the front panel. To do so, perform the following procedure:
- Turn the switch "MODE" on the front panel to the right, the LED "LOCAL" will illuminate.
- Turn the potentiometer "SET VOLTAGE" to the right or left to increase or decrease the output voltage. The digital panel meter shows the voltage at the output.

In remote control mode the output voltage can be programmed by the system controller. To do so, perform the following procedure:
- Turn the switch "MODE" to the left, the LED "REMOTE" will illuminate.
- Use the menu on the control screen to set the voltage.

Voltage Generator for Inner Lens

The EA Control contains an independent precision high voltage generator to supply the voltage for the inner lens.

This generator operates exactly the same way like the voltage generator for the retardation lens.

Voltage Generator for Acc. Lens

The EA Control contains a precision high voltage generator to supply the voltage of the acceleration lens.

The high voltage generator consists of:
A 16Bit-DAC for programming the high voltage
A HV amplifier with an arc protection circuit at the output

A watch circuitry to detect DAC errors

The voltage generator specifications are given below:

Voltage Range:	0V..+3kV
Output Current:	max. 0.5mA, short circuit protected
Output resistance:	180kOhm, due to arc protection circuit
DAC Resolution:	16Bit
Stability:	50ppm/°C (remote control), 100ppm /°C (local control)
Voltage Ripple:	max. 30mVss.

The switch “MODE” on the front panel is used to allow local or remote control of the voltage generator.

In local control mode the output voltage can be set manually on the front panel. To do so, perform the following procedure:
- Turn the switch "MODE" on the front panel to the right, the LED "LOCAL" will illuminate.
- Turn the potentiometer "SET VOLTAGE" to the right or left to increase or decrease the output voltage. The digital panel meter shows the voltage at the output.

In remote control mode the output voltage can be programmed by the system controller. To do so, perform the following procedure:
- Turn the switch "MODE" to the left, the LED "REMOTE" will illuminate.
- Use the menu on the control screen to set the voltage.

Voltage Generator for Bias

The EA Control contains a precision high voltage generator to supply the voltage of the bias.

The high voltage generator consists of:
A 16Bit-DAC for programming the high voltage
A HV amplifier with an arc protection circuit at the output

A watch circuitry to detect DAC errors

The voltage generator specifications are given below:

Voltage Range:	0V...+1.2kV (limited to 1.2kV)
Output Current:	max. 0.5mA, short circuit protected
Output resistance:	150kOhm, due to arc protection circuit
DAC Resolution:	16Bit
Stability:	50ppm/°C (remote control), 100ppm /°C (local control)
Voltage Ripple:	max. 20mVss.

The switch “MODE” on the front panel is used to allow local or remote control of the voltage generator.

In local control mode the output voltage can be set manually on the front panel. To do so, perform the following procedure:
- Turn the switch "MODE" on the front panel to the right, the LED "LOCAL" will illuminate.
- Turn the potentiometer "SET VOLTAGE" to the right or left to increase or decrease the output voltage. The digital panel meter shows the voltage at the output.

In remote control mode the output voltage can be programmed by the system controller. To do so, perform the following procedure:
- Turn the switch "MODE" to the left, the LED "REMOTE" will illuminate.
- Use the menu on the control screen to set the voltage.

Voltage Generator for SEL+/SEL-

The EA Control contains a precision bipolar voltage generator to supply two symmetrical voltages for SEL+ and SEL-.

The bipolar voltage generator consists of:

A 16Bit-DAC for programming the voltage
Two symmetrical amplifiers with two arc protection circuits at the positiv and negativ output

The bipolar voltage generator specifications are given below:

Positiv Voltage Range:	0 … +100V
Negativ Voltage Range	0 … -100V
Output Current:	max. 1mA
DAC Resolution:	16Bit
Stability:	50ppm/°C (remote control), 100ppm /°C (local control)
Bias Voltage:	max. 2000V referenced to the chassis potential

The switch “MODE” on the front panel is used to allow local or remote control of the voltage generator.

In local control mode the output voltage can be set manually on the front panel. To do so, perform the following procedure:
- Turn the switch "MODE" on the front panel to the right, the LED "LOCAL" will illuminate.
- Turn the potentiometer "SET Voltage" to the right or left to increase or decrease the output voltage. The digital panel meter shows the positiv output voltage.

In remote control mode the output voltage can be programmed by the system controller. To do so, perform the following procedure:
- Turn the switch "MODE" to the left, the LED "REMOTE" will illuminate.
- Use the menu on the control screen to set the voltage.

The bipolar voltage generator for SEL+/SEL- floats on the potential of the Bias which can be as high as 2000V, i.e. the ground of the bipolar voltage generator is connected to the output voltage of the bias voltage generator.

2.5.3. Connectors

2.5.3.1. Remote Connector

A 15pin connector is provided for remote port connection.

2.5.3.2. Output Voltage Connectors

The output voltages and ground are available on the rear panel.

2.5.3.3. Line Voltage Connector

A line voltage connector with an integrated EMI filter and two fuses is provided on the rear panel.

2.5.4. Specifications

2.5.4.1. Status Control and Display

ERROR:	Indicates that the DAC contains wrong values
POWER FAIL:	This LED flashes if any supply voltage 5V/+15V/-15V fails
SELECT:	Indicates that the system controller selected the Analyzer Control
REMOTE:	Indicates that remote control is selected by the switch „MODE“
LOCAL:	Indicates that local control is selected by the switch „MODE“
MODE:	Rotary switch to select local or remote control

2.5.4.2. Ret. Lens

Output Voltage Range:	0...+8kV
Output Current:	Max. 0.25mA, short circuit protected
Output Resistance:	1MOhm, due to the arc protection circuit at the output
Output Voltage Ripple:	max. 100mVss.
DAC Resolution:	16Bit is used for voltage programming
Temp. Coeff.	50 ppm/°C (remote control), 100ppm /°C (local control)
Digital Panel Meter:	Resolution 4 ½ digit, Accuracy +/- 1 digit
Operation Mode	Remote or local, selected by the switch “MODE”
Local Control:	A 10-turn pot is used for voltage setting
Remote Control:	A 16-bit DAC is used for voltage setting

2.5.4.3. Inner Lens

Output Voltage Range:	0...+8kV
Output Current:	Max. 0.25mA, short circuit protected
Output Resistance:	1Mohm, due to the arc protection circuit at the output
Output Voltage Ripple:	Max. 100mVss.
DAC Resolution:	16Bit is used for voltage programming
Temp. Coeff.	50 ppm/°C (remote control), 100ppm /°C (local control)
Digital Panel Meter:	Resolution 4 ½ digit, Accuracy +/- 1 digit
Operation Mode:	Remote or local, selected by the switch “MODE”
Local Control:	A 10-turn pot is used for voltage setting
Remote Control:	A 16-bit DAC is used for voltage setting

2.5.4.4 Acc. Lens

Output Voltage Range:	0...+3kV
Output Current:	Max. 0.5mA, short circuit protected
Output Resistance:	180kOhm, due to the arc protection circuit at the output
Output Voltage Ripple:	Max. 30mVss.
DAC Resolution:	16Bit is used for voltage programming
Temp. Coeff.	50 ppm/°C (remote control), 100ppm /°C (local control)
Digital Panel Meter:	Resolution 4 ½ digit, Accuracy +/- 1 digit
Operation Mode	Remote or local, selected by the switch “MODE”
Local Control:	A 10-turn pot is used for voltage setting
Remote Control:	A 16-bit DAC is used for voltage setting

2.5.4.5 Bias

Output Voltage Range:	0…+1.2kV
Output Current:	Max. 0.5mA, short circuit protected
Output Resistance:	150kOhm, due to the arc protection circuit at the output
Output Voltage Ripple:	Max. 20mVss.
DAC Resolution:	16Bit is used for voltage programming
Temp. Coeff.	50 ppm/°C (remote control), 100ppm /°C (local control)
Digital Panel Meter:	Resolution 4 ½ digit, Accuracy +/- 1 digit
Operation Mode	Remote or local, selected by the switch “MODE”
Local Control:	A 10-turn pot is used for voltage setting
Remote Control:	A 16-bit DAC is used for voltage setting

2.5.4.6 SEL+/SEL-

SEL+ Voltage Range:	0... +100V
SEL- Voltage Range :	0... –100V
Output Current:	Max. 1mA
SEL+/SEL- Difference:	max. 50mV
DAC Resolution:	16Bit is used for voltage programming
Temp. Coeff.	50 ppm/°C (remote control), 100ppm /°C (local control)
Digital Panel Meter:	Resolution 4 ½ digit, Accuracy +/- 1 digit
Operation Mode	Remote or local, selected by the switch “MODE”
Local Control:	A 10-turn pot is used for voltage setting
Remote Control:	A 16-bit DAC is used for voltage setting

2.5.4.7 General Conditions

Line Voltage:	230V/115V/50-60Hz/100VA The line voltage is factory set to 230V. The configuration for a line voltage of 115V ac must be done at transformer inside the unit
Fuse:	1x 0.5A slow blow 230V
Operating Temperature:	10-35°C
Warm-up	½ hour to rated accuracy
Relative Humidity:	0-80%
Mechanical Design:	19“ housing for rack mounting
Dimension:	19“ front panel, 3 height units, depth 330mm

2.6. Mirror Control

2.6.1 General Information

Front Plate of ELMITEC Mirror Control
Switch on the left side selects the control mode: local or remote
4 Potentiomters on the right: controlling the output voltages in local mode

Back Plate of ELMITEC Mirror Control
Left side: connectors for computer control
Right side: connectors for the mirror voltage outputs.

2.6.1.1. Introduction

This manual contains technical description and operating instructions for the Elmitec Mirror Control. The Mirror Control is integrated in a 19“ chassis mounted in the high voltage system rack and is used to supply the electron mirror. This unit can be remotely controlled by the system controller (PC) or manually on the front panel.

Two isolated control ports designated optical remote and remote are provided for data transfer between Mirror Control, the system controller (PC), and other units in the high voltage rack.

2.6.1.2. Safety Warning

In the HV system rack there are a number of power supplies generating high voltages. The handling of high voltage requires special precaution and safety measures. Calibration and repair work must be performed by trained personnel only. The Mirror Control itself generates a maximum voltage of 9kV referenced to its chassis.

2.6.1.3. Applications

The Mirror Control is designed to supply lens voltages for the Elmitec Electron Mirror. The functions of this unit are listed below:

- Control and generation of voltages for Mirror Focus (0...9kV), Mirror Transfer Lens (0...9kV), Extractor Lens (0...6kV) and Mirror electrode (0...-3kV)

2.6.2. Operation

2.6.2.1 Introduction

This section contains basic operating information of the Mirror Control. It includes local control and remote control.

The Mirror Control consists of the following units:

Two isolated remote control ports
Front panel unit
High voltage generator for Mirror Focus
High voltage generator for Mirror Transfer Lens
High voltage generator for Extractor
High voltage generator for Mirror

2.6.2.2. Remote Control Ports

The Mirror Control can be controlled by the system controller PC, or manually at the front panel. For safety reason the selection of the remote/local mode can not be done by the system controller, i.e. this operation is done manually by the user who must be aware of what he is doing. So the system is well protected from being damaged by software error.

An isolated control remote port is provided for data transfer. The remote port allows isolation up to 2kV.

The remote port can be connected to the other units in the high voltage rack such as Sample Heater Control, Analyzer Control and Start Voltage Control.

2.6.2.3. Front Panel Unit

The Mirror Control allows the user to control the high voltage generators from the front panel by using a number of switches and potentiometers. Several LEDs are provided to indicate the status of the Mirror Control.

The control and status groups on the front panel are described below:

Status	Rotary switch used to select local or remote mode LED "LOCAL" illuminates if local control is selected LED "REMOTE" illuminates if remote control is selected LED "ERROR" flashes if the DAC contain wrong values LED "POWER FAIL" flashes if the internal power supply fails LED "SELECT" illuminates if the controller selectes the Mirror Control
Mirror Focus	Digital panel meter with a resolution of 4 ½ digit 10-turn potentiometer to set the voltage manually to 0…9kV
M. Trans. L.	Digital panel meter with a resolution of 4 ½ digit 10-turn potentiometer to set the voltage manually to 0…9kV
Extractor	Digital panel meter with a resolution of 4 ½ digit 10-turn potentiometer to set the voltage manually to 0…6kV
Mirror	Digital panel meter with a resolution of 4 ½ digit 10-turn potentiometer to set the voltage manually to 0...-3kV

Voltage Generator for Mirror Focus

The Mirror Control contains a precision high voltage generator to supply the voltage of the mirror focus.

The high voltage generator consists of:
A 16Bit-DAC for programming the high voltage
A HV amplifier with an arc protection circuit at the output
A watch circuitry to detect DAC errors

The voltage generator specifications are given below:

Voltage Range:	0V…+9kV
Output Current:	max. 0.25mA, short circuit protected
Output resistance:	1MOhm, due to arc protection circuit
DAC Resolution:	16Bit
Stability:	50ppm/°C (remote control), 100ppm /°C (local control)
Voltage Ripple:	max. 100mVss.

The switch "MODE" on the front panel is used to allow local or remote control of the voltage generator.

In local control mode the output voltage can be set manually on the front panel. To do so, perform the following procedure:

- Turn the switch "MODE" on the front panel to the right, the LED "LOCAL" will illuminate.
- Turn the potentiometer "SET VOLTAGE" to the right or left to increase or decrease the output voltage. The digital panel meter shows the voltage at the output.

In remote control mode the output voltage can be programmed by the system controller. To do so, perform the following procedure:
- Turn the switch "MODE" to the left, the LED "REMOTE" will illuminate.
- Use the menu on the control screen to set the voltage.

Voltage Generator for Mirror Tranfer Lens

The Mirror Control contains an independent precision high voltage generator to supply the voltage for the mirror transfer lens.

This generator operates exactly the same way like the voltage generator for mirror focus.

Voltage Generator for Extractor

The Mirror Control contains a precision high voltage generator to supply the voltage of the extractor.

The high voltage generator consists of:
A 16Bit-DAC for programming the high voltage
A HV amplifier with an arc protection circuit at the output
A watch circuitry to detect DAC errors

The voltage generator specifications are given below:

Voltage Range:	0V…+6kV
Output Current:	max. 0.5mA, short circuit protected
Output resistance:	150kOhm, due to arc protection circuit
DAC Resolution:	16Bit
Stability:	50ppm/°C (remote control), 100ppm /°C (local control)
Voltage Ripple:	max. 20mVss.

The switch “MODE” on the front panel is used to allow local or remote control of the voltage generator.

In local control mode the output voltage can be set manually on the front panel. To do so, perform the following procedure:
- Turn the switch "MODE" on the front panel to the right, the LED "LOCAL" will illuminate.
- Turn the potentiometer "SET VOLTAGE" to the right or left to increase or decrease the output voltage. The digital panel meter shows the voltage at the output.

In remote control mode the output voltage can be programmed by the system controller. To do so, perform the following procedure:
- Turn the switch "MODE" to the left, the LED "REMOTE" will illuminate.

- Use the menu on the control screen to set the voltage.

Voltage Generator for Mirror

The Mirror Control contains a precision high voltage generator to supply the voltage of the mirror electrode.

The high voltage generator consists of:
A 16Bit-DAC for programming the high voltage
A HV amplifier with an arc protection circuit at the output
A watch circuitry to detect DAC errors

The voltage generator specifications are given below:

Voltage Range:	0V…-3kV
Output Current:	max. 0.5mA, short circuit protected
Output resistance:	180kOhm, due to arc protection circuit
DAC Resolution:	16Bit
Stability:	50ppm/°C (remote control), 100ppm /°C (local control)
Voltage Ripple:	max. 30mVss.

The switch “MODE” on the front panel is used to allow local or remote control of the voltage generator.

In local control mode the output voltage can be set manually on the front panel. To do so, perform the following procedure:
- Turn the switch "MODE" on the front panel to the right, the LED "LOCAL" will illuminate.
- Turn the potentiometer "SET VOLTAGE" to the right or left to increase or decrease the output voltage. The digital panel meter shows the voltage at the output.

In remote control mode the output voltage can be programmed by the system controller. To do so, perform the following procedure:
- Turn the switch "MODE" to the left, the LED "REMOTE" will illuminate.
- Use the menu on the control screen to set the voltage.

2.6.3. Connectors

2.6.3.1. Remote Connector

A 15pin connector is provided for remote port connection.

2.6.3.2. Output Voltage Connectors

The output voltages and ground are available on the rear panel.

2.6.3.3. Line Voltage Connector

A line voltage connector with an integrated EMI filter and two fuses is provided on the rear panel.

2.6.4. Specifications

2.6.4.1. Status Control and Display

ERROR:	Indicates that the DAC contains wrong values
POWER FAIL:	This LED flashes if any supply voltage 5V/+15V/-15V fails
SELECT:	Indicates that the system controller selected the Mirror Control
REMOTE:	Indicates that remote control is selected by the switch „MODE“
LOCAL:	Indicates that local control is selected by the switch „MODE“
MODE:	Rotary switch to select local or remote control

2.6.4.2. Mirror Focus

Output Voltage Range:	0...+9kV
Output Current:	Max. 0.25mA, short circuit protected
Output Resistance:	1MOhm, due to the arc protection circuit at the output
Output Voltage Ripple:	max. 100mVss.
DAC Resolution:	16Bit is used for voltage programming
Temp. Coeff.	50 ppm/°C (remote control), 100ppm /°C (local control)
Digital Panel Meter:	Resolution 4 ½ digit, Accuracy +/- 1 digit
Operation Mode	Remote or local, selected by the switch “MODE”
Local Control:	A 10-turn pot is used for voltage setting
Remote Control:	A 16-bit DAC is used for voltage setting

2.6.4.3. Mirror Transfer Lens

Output Voltage Range:	0...+9kV
Output Current:	Max. 0.25mA, short circuit protected
Output Resistance:	1Mohm, due to the arc protection circuit at the output
Output Voltage Ripple:	Max. 100mVss.
DAC Resolution:	16Bit is used for voltage programming
Temp. Coeff.	50 ppm/°C (remote control), 100ppm /°C (local control)
Digital Panel Meter:	Resolution 4 ½ digit, Accuracy +/- 1 digit
Operation Mode:	Remote or local, selected by the switch “MODE”
Local Control:	A 10-turn pot is used for voltage setting
Remote Control:	A 16-bit DAC is used for voltage setting

2.6.4.4 Extractor

Output Voltage Range:	0…+6kV
Output Current:	Max. 0.5mA, short circuit protected
Output Resistance:	180kOhm, due to the arc protection circuit at the output
Output Voltage Ripple:	Max. 50mVss.
DAC Resolution:	16Bit is used for voltage programming
Temp. Coeff.	50 ppm/°C (remote control), 100ppm /°C (local control)
Digital Panel Meter:	Resolution 4 ½ digit, Accuracy +/- 1 digit
Operation Mode	Remote or local, selected by the switch “MODE”
Local Control:	A 10-turn pot is used for voltage setting
Remote Control:	A 16-bit DAC is used for voltage setting

2.6.4.5 Mirror Electrode

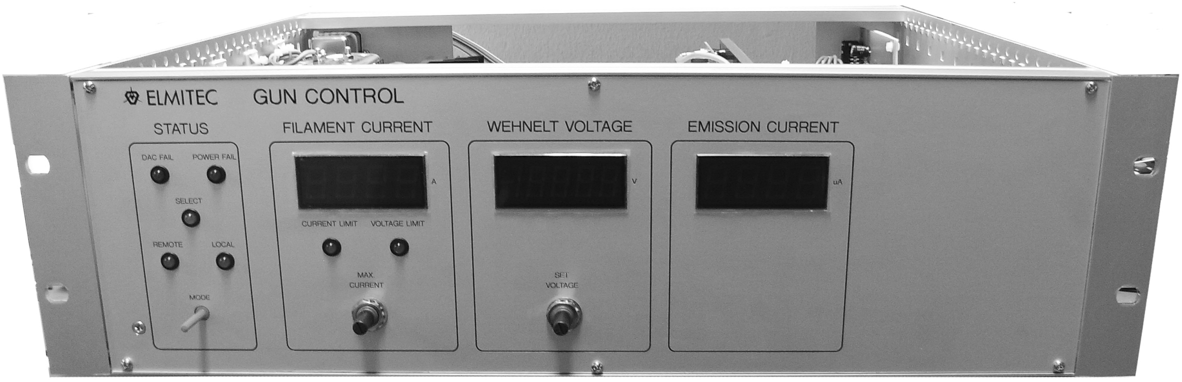
Output Voltage Range:	0…-3kV
Output Current:	Max. 0.5mA, short circuit protected
Output Resistance:	150kOhm, due to the arc protection circuit at the output
Output Voltage Ripple:	Max. 30mVss.
DAC Resolution:	16Bit is used for voltage programming
Temp. Coeff.	50 ppm/°C (remote control), 100ppm /°C (local control)
Digital Panel Meter:	Resolution 4 ½ digit, Accuracy +/- 1 digit
Operation Mode	Remote or local, selected by the switch “MODE”
Local Control:	A 10-turn pot is used for voltage setting
Remote Control:	A 16-bit DAC is used for voltage setting

2.6.4.6 General Conditions

Line Voltage:	230V/115V/50-60Hz/100VA The line voltage is factory set to 230V. The configuration for a line voltage of 115V ac must be done at transformer inside the unit
Fuse:	1x 0.5A slow blow 230V
Operating Temperature:	10-35°C
Warm-up	½ hour to rated accuracy
Relative Humidity:	0-80%
Mechanical Design:	19“ housing for rack mounting
Dimension:	19“ front panel, 3 height units, depth 330mm

2.7. Gun Control Unit

2.7.1. General Information



Front Plate of ELMITEC Gun Control
Switch on the left side selects the control mode: local or remote

Potentiomter on the leftt:	controls the heating current through the filament of electron source in local mode
Potentiomter on the right:	controls the output voltage of Wehnelt/Extractor electrode in local mode

2.7.1.1. Introduction

This manual contains the technical description and operating instructions for the ELMITEC Gun Control Unit. The Gun Control Unit is integrated in a 19“ chassis mounted in the HV system rack. It is used to manually control the filament current and the Wehnelt voltage. The Wehnelt Voltage can be also controlled by the LEEM2000 program.

2.7.1.2. Safety Warning

In the HV system rack there are a number of power supplies generating high voltages. The handling of high voltage requires special precaution and safety measures. Calibration and repair work must be performed by trained personnel only. The Gun control generates a maximum voltage of 2000V referenced to its chassis.

2.7.1.3. Applications

The Gun Control is designed for control and monitoring the filament current and the emission current in the HV subsystem. The functions of this unit are listed below:

- Control of the filament current up to 2.2A
- Generation of the Wehnelt voltage between 100 and 1000 V
- Display of the filament current, Wehnelt voltage and emission current on the front panel

2.7.2. Operation

2.7.2.1. Introduction

This section contains basic operating instructions for the Gun Control Unit. It includes information on setting the filament current and the Wehnelt voltage.

2.7.2.2. Control

The filament current is manually controlled by potentiometers on the front panel of the Gun Control Unit. The Wehnelt voltage can be controlled either local mode or in remote mode.

2.7.2.3. Filament Current

The Gun Control Unit contains the filament current power supply. The maximum voltage and current are limited to 6V and 2.2A. A potentiometer on the front panel with a scale from 0 to 10.00 is used to set the maximum filament current to 0...2.2 A, respectively. The filament current is shown by a digital panel meter on the front panel. A LED on the front panel designated ‘CURRENT LIMIT’ flashes if the power supply is operating in the current control mode. A LED designated ‘VOLTAGE LIMIT’ flashes if the filament voltage exceeds the maximum voltage of 6V.

2.7.2.4. Wehnelt Voltage

The Wehnelt voltage power supply is also located in the Gun Control Unit Chassis.

This unit can be controlled either local mode or in remote mode.

The control for manual operation is on the front panel of the Gun Control Unit. To set the Wehnelt voltage, turn the voltage potentiometer to the right or left to decrease or increase the Wehnelt voltage. A meter on the front panel of the Gun Control Unit displays the Wehnelt voltage.

2.7.3. Connectors

The Gun Control Unit is connected inside it’s chassis with the 20kV gun supply cable.

2.7.3.1. Filament Connector

Two flat faston connectors on the power supply board, designated F+ and F-, are used to connect the filament cable. If these need to be removed, be sure not to pull on the wires. Instead, use a tool and pull on the connectors.

2.7.3.2. Wehnelt Voltage Power Supply Connector

The connection of the Wehnelt voltage leads is done inside the chassis on a connector board with flat faston connectors. If these need to get removed, be sure not to pull on the wires. Instead, use a tool and pull on the connectors.

2.7.4. Specifications

2.7.4.1. Filament Supply

Filament Voltage Range:	0...6V
Filament Current Range:	0...2.2A

2.7.4.2. Wehnelt Voltage Power Supply

Voltage Range:	-100...-1000V
(Limits PS:	0…-2000V)
Output Current :	0…2mA
Voltage Stability:	0.005 % / hour
Voltage Ripple:	0.001 %

2.7.4.3. Status Indicators

Status	Rotary switch used to select local or remote mode
	LED "LOCAL" illuminates if local control is selected
	LED "REMOTE" illuminates if remote control is selected
	LED "ERROR" flashes if the DAC contains wrong values
	LED "POWER FAIL" flashes if internal power supply fails
	LED "SELECT" illuminates if the controller selectes the Gun Control

2.7.4.4. Filament Current Indicators

CURRENT LIMIT:	This LED flashes if the supply is current regulation mode
VOLTAGE LIMIT:	This LED flashes if the filament voltage exceeds 6V

2.7.4.5. General Conditions

Line Voltage:	230V/115V/50-60Hz/20VA The line voltage is factory set to 230V.
Fuse:	1x 0.5A slow blow 230V
Operating Temperature:	10-35°C
Warmup	½ hour to rated accuracy
Relative Humidity:	0-80%, non-condensing
Mechanical Design:	19“ rack mount cabinet
Dimension:	19“ front panel, 3 height units, depth 340mm

2.8. Lens Power Supply Rack

2.8.1 General Information

2.8.1.1. Introduction

This section contains the technical description and operating instructions for the ELMITEC Lens Power Supply Rack. The rack contains the various current sources needed for the lens coils and deflector / stigmator units. The individual sources are grouped in 19’’ rack mount cabinets called ‘clusters’. They are fully remote controlled by the system controller (PC).

2.8.1.2. Safety Warning

In the Lens Power Supply Rack and its rack mount cabinets, mains voltage (max. 230 V AC) is present. Calibration and repair work must be performed by electrotechnically trained, qualified personnel only.

2.8.1.3. Applications

The Lens Power Supply Rack is designed for supplying and controlling the lens and stigmator / deflector currents of the ELMITEC LEEM. Due to the different options which are available with the LEEM, the inidividual configuration as well as the number of current sources present in this unit may vary. The functions of this unit are listed below:
- Control and regulation of the lens currents with a range of 0…3 A
- Control and regulation of the lens currents with a range of 0…1 A
- Control and regulation of the stigmator/deflector currents with a range of –250...250 mA
- Control and regulation of the stigmator/deflector currents with a range of –500...500 mA
- Providing data communication from and to the system controller (PC)

2.8.2 Operation

2.8.2.1. Introduction

If all necessary lens element, data communication and power line connections are done, the rack can be switched on and off with the two buttons near the bottom of the rack. Press the green button to switch the rack on, the red button to switch it off.

When the rack is switched on, the current sources are power-on reset to zero, so no other initialization is necessary to switch the system to a safe startup condition.

2.8.2.2. Control

The Lens Power Supply Rack is fully remote controlled. To adjust current values, start the control software on the system controller (PC) after the Lens Power Supply Rack has been powered. At first, the software will poll the status of the current sources. An error message will appear if there is a faulty or non responding unit.

When the software is started, current values are varied by clicking on the elements and moving the trackball. Details of the software and its use are contained in the software manual.

On the current source boards inside the clusters, there are indicator LEDs that signal the status of the hardware. These are only visible when the front panel of the corresponding cluster is removed. During normal operation this will not be necessary, because error signalling is done on the fieldbus and the control software will display all occuring errors on the PC screen. In certain cases, however, it may be necessary to check the hardware status directly.

When a current source is selected, its green ‘SELECT’ LED will indicate this status.
When a current source senses an open load loop condition (e.g. plug at microscope not inserted or lead broken), the yellow ‘LOOP’ LED will get lit.
When an internal supply of a current source board fails, the red ‘FAIL’ LED will get lit.

Always load well established, safe setup files to start the work with the instrument.

2.8.2.3. Stability considerations

Even though state-of-the-art, the Lens Power Supply System will show a (minimal) thermally induced drift which is, during normal operation, not limiting the instruments performance.
However, in special occasions, thermalization effects may get observable. These, within the limits of the specifications given below, belong to the normal performance of the system and are not a symptom of failure. Some of these cases are:

- After powering the cooled-down unit, even though the system is workable rightaway, a warmup phase of several is recommended to reach the final stability.
- The ambient temperature changed abruptly. Stable ambient conditions can be achieved by e.g. the use of an air conditioner.
- When very large changes in load currents (e.g. lens excitations) are invoked, a slight thermalization can occur, but will vanish after some minutes.

2.8.3 Connectors

The connections to the unit are done from inside the rack. Because there is no interlock on the Lens Power Supply Rack door, be sure to separate the unit from mains before attempting to do any service work.

2.8.3.1. Mains Connectors

The mains connectors are standard 3-prong IEC-320 sockets labelled ‘mains’, located on the back of each cluster. In the rack, the mains power distribution to these units is already provided. Use the IEC-320 plugs which are included in the rack wiring to connect the clusters to mains, as only these carry mains switched by the power buttons in the rack.

2.8.3.2. Fieldbus Connectors

The fieldbus connectors are labelled ‘remote in’ and ‘remote out’. All the clusters must be put in a daisy chain. The very first input (‘remote in’) is then connected to the USB driven ELMITEC fieldbus adapter, the very last output (‘remote out’) is connected to an optical fieldbus interface which in turn is then connected to the HV rack by optical fibres.

2.8.3.3. Current Source Outputs

The connections of the lenses and stigmator/deflector units are done inside the individual clusters. The cables are attached by cable clamps to the cluster rear panels. Only in very rare occasions it is necessary to touch these connections. Be sure to contact ELMITEC before proceeding here as confusions introduced at this point will get very hard to track.

2.8.4 Specifications

2.8.4.1. Bipolar Current Source

Output Current:	-250mA...+250mA max.
Output Voltage:	-10V...+10V max.
Resolution:	16 Bit
Temperature Coefficient.	5ppm/°C max.

Output Current:	-500mA...+500mA max.
Output Voltage:	-10V...+10V max.
Resolution:	16 Bit
Temperature Coefficient.	5ppm/°C max.

2.8.4.2. Unipolar Current Sources

Output Current:	0...3A max.

Output Voltage:	0...+9V max.
Resolution:	16 Bit
Temperature Coefficient.	5ppm/°C max.

Output Current:	0...1A max.
Output Voltage:	0...+9V max.
Resolution:	16 Bit
Temperature Coefficient.	5ppm/°C max.

2.8.4.3. Status Indicators

Only internal indicators on current source boards, behind the cluster front panel:

SELECT LED (green)	Indicates the current source has been selected by the software
LOOP LED (yellow)	Indicates that the output voltage exceeded the compliance limit (9V /10V for unipolar / bipolar sources)
FAIL LED (red)	Indicates that eine of the internal supply volatges is not in the right range

2.8.4.4. General Operating Conditions

Power:	230V, 50-60Hz, 150VA max.
Cluster Fuse:	1x 1A slow blow 230V
Operating Temperature:	10°C - 35°C
Warm-up:	½ hour to rated accuracy
Relative Humidity:	0% to 80%, non condensing
Cluster Mechanical Design:	19“ rack mount cabinet
Cluster Dimension:	19“ front panel, 3 height units, depth 495mm

2.9. Operator rack

2.9.1. General

The Operator rack contains several different units:

- power control unit and bakeout control (on the bottom)
- AGILENT pump supply and turbo pump controller
- Ti sublimation pump supply
- image intensifier power supply
- Bayard-Alpert controllers

2.9.2. Power Control Unit

The Power Control Unit supplies all other units in the microscope supply system. This unit must be connected to a three phase line (230V each phase vs. neutral; use the black cable on back side of the unit; green-yellow lead = ground; blue lead = neutral; black or brown leads to L1,L2,L3 phases).

WARNING: The connection to the power line as well as all the necessary preparations while setting up, using and maintaining the instrument must be done by qualified, electrotechnically trained personnel. Observe and follow all safety instructions given in this manual (see in the beginning and throughout the text) as well as all other applicable safety regulations of your facility and national safety regulations. Failure to do this will void the warranty and can cause direct and consequential damage and death.

On the front panel of this unit, the main switch is installed, labelled "EMERGENCY OFF". If this switch is turned off, none of the units in the microscope supply system can be switched on. Also on the front panel, the main fuses are accesible (B16). The three phases are fused separately.

Next to the 'EMERGENCY OFF' switch, on the right hand side, two buttons are located which control the power to the control rack and the LEEM power supply unit.

Two override buttons allow bypassing safety features during special procedures:
One of them mutes the alarm sound which is indicating a too high pressure in the vacuum system, the other one allows to bypass the automatic, pressure-controlled high voltage switch-off safety feature of the power control unit.

These buttons must be used by trained personnel only, temporarily and during the occurrence of special situations (like e.g. initial Ti Sublimator degassing), otherwise damage can occur either immediately or after failure of other components (e.g. during bakeout).

Above the Power Control Unit the Bakeout Control Unit is installed. This unit controls both, the time and the temperature of the bakeout. To set the bakeout time, set the timer to the required bakeout time value. To set the temperature use the buttons on the temperature meter and adjust the required value (the temperature is measured in Celsius =°C). The bakeout starts automatically when the buttons labelled "BAKEOUT ON" and "START" are pressed. To change the bakeout time during the bakeout, at first press "STOP", then change the time parameter, and press "START" again. The change of the temperature can be done at any moment without interrupting the bakeout. By pressing the "BAKEOUT ON" the Lens Power Supply Rack, HV Power Supply Rack and the MCP unit will be switched off automaticly. It is importand that before pressing this button the Lens currents, High voltages are ramped down.

When the pressure in the vacuum system rises above the Bayard Alpert Controller setpoints, the bakeout will get interrupted. When the pressure drops below the setpoints, the bakeout will resume.

2.9.3. Scroll Pump

The scroll pump for the mainchamber and optics is located under the LEEM table. The scroll pump has its own power switch. The power line for the scroll pump is controlled by the LEEM power control unit. The sroll pump is used for rought pumping of the foreline system together with the small *AGILENT* turbo pump. For further information about the scroll pump please refer to its manuals.

2.9.4. Bayard-Alpert Controller

On the top panel of the Operator Rack, the four Bayard-Alpert controllers are mounted. The first one on the left shows the pressure in the distribution chamber. The second indicates the pressure in the entrance chamber. The next unit shows the pressure in the main chamber. The right controller displays the pressure in the optics. For further information concerning the operation of the Bayard-Alpert Controller please refer to the Vacom manual.

2.9.5. Ti Sublimation Pump Supply

Frontside of ELMITEC Ti Sublimation PUMP Supply

Backside of ELMITEC Ti Sublimation PUMP Supply
SHV connectors are for the HV bomabardement output
MHV connectors are for the filament connection
3-pin round connectors have to be connected to
the ion gauge controllers for vacuum interlocks

Above the Pump Control Units the Sublimator Pump Control is located. The Sublimator Pump Control chassis contains a filament and a bombardment power supply. You can choose with a rotational switch the chamber in which you like to evaporate Ti. If you switch in local mode please make sure the the filament curren is set to 0. Other wise the output will trip off and stay open until the filament current is set to 0.

Warning! This unit generates hazardous voltage. Do not apply line voltage input unless adequate ground is connected to the unit and the high voltage output has been properly connected.
Warning! This unit can store hazardous voltage. Completely discharge the high voltage to ground before attempting removal of the high voltage cable.

The Power supply can be operated in local or automatic control.

In **local control mode** it is not interlocked by the Bayard-Alpert controllers, so you have to be sure that the vacuum is at least in the 10^{-6} Torr range before you start to apply the filament current and the high voltage. You can set the Filament current by the “FILAMENT CURRENT ADJUSTMENT” knob on the front plate up to 3A. If you like to switch on / off the HV you have to press the “HV ON” button. The unit will regulate the filament current so that the emission current will stay at 100mA. Therefore the HV has to be switched on and the filament current has to be set to a value high enough (2.9A). During operation you should check that the vacuum is o.k. from time to time.

In **automatic control mode** the power supply unit is interlocked by its corresponding Bayard-Alpert gauge. You can operate the unit in between 1 x 10^{-6} and 2 x 10^{-10} Torr. If the pressure is out of this range the “INTERLOCK“ lamp is lit.
If you press the automatic button the automatic LED will be lit. Now you can choose in between evaporating Ti or you can degas the Ti sublimator. By pressing the “DEGAS“ button you select the degas mode. In this case the degas LED will be lit. In order to start the degas procedure you have to press the “HV ON “ button and then the “ START “ button. If the time past between pressing these two buttons is more than 4 seconds, the HV will switch off automatically. After starting this procedure the unit will slowly ramp the filament current up until you get 50mA emission current and hold this value for 1h. At the end of the procedure the filament and HV will be switched off automatically. During the whole procedure the “AUTOMATIC / LOCAL“ LED will blink. If the pressure during degassing rises too high the unit will reduce the Filament current until the pressure is getting better and the ramp it up again. If the pressure still gets worse the electronics will switched off the filament and the high voltage. It is possible to stop the procedure anytime by pressing the “START / STOP“ button. In order to evaporate Ti in remote control mode please check that the “AUTOMATIC / LOCAL“ LED is lit and the “DEGAS“ LED is off. As first step the evaporation time should be set. It can be done by rotating the “TIME“ knob in between 5, 7.5, 10 and 15 minutes. To start the evaporation procedure you have to press the “HV ON“ button and then the “START“ button. After starting this procedure the unit will slowly ramp up the filament current until you get 100mA emission current and hold this value for the time chosen. At the end the unit will switch off the filament and HV. During the whole procedure the “AUTOMATIC / LOCAL” LED will blink.

The unit is equipped with an error LED. The LED will give you different error codes by its blinking period when the procedure was aborted.

1x blinking:	The Vacuum is worse than 1 x 10^{-6} Torr
2x blinking:	The Voltage at the recorder output of the multigauge controller is 0V. This can be due to pressure better than 2 x 10^{-10} Torr or error of the UHV gauge or switched off UHV gauge.
3x blinking:	The maximum emission current was exceeded. This can occur when the regulation for the filament current is broken.
4x blinking:	The emission current at low filament currents is too big (for example when you have some leakage current.
5x blinking:	The emission current at a fix value is too low. This can be after exchanging the filament or the Ti piece. The filament can be too short or the distance in-between the filament and the Ti piece is too big.
6x blinking:	The “TIME“ knob has been changed after starting the procedure.

In order to quit the error message you have to press the “START/STOP“ button.

Typical values for the currents are: Filament: 2.8 A; emission: 100 mA.

Warning! This unit can store hazardous voltage. Completely discharge the high voltage to ground before attempting removal of the high voltage cable. When reconnecting the sublimators, do not confuse the order of the plugs for high voltage (labelled ‘EMISSION’) and Filament (‘FIL’);

2.9.6. Image Intensifier Power Supply

Near the top of the rack, the microchannel plate HV supply is mounted. This supply is equipped with two HV supplies: A 2kV module for the channel plates and a 7.5kV module for the screen, controlled separately by two potentiometers in local mode or via the computer in remote mode. For changing from local to remote you have to press the remote switch and after that you should start the LEEM2000 sofware. Further details about the image converter are given in section 6.6. (Image converter).

Warning! The potential difference between channel plates and screen must never exceed 4.5kV

Warning! This unit generates hazardous voltage. Do not connect to line voltage unless adequate ground is connected to the unit and the high voltage output has been properly connected.

Warning! This unit can store hazardous voltage. Completely discharge the high voltage to ground before attempting removal of the high voltage cable.

3. Pumping the System

Before pumping the system you should be sure that all the flanges you have opened during the downtime are again closed. Close the small valve on the turbo pump used for venting. Start the scroll pump. The initially loud exhaust noise from the scroll pump will decrease when the system pressure drops. Then you can switch on the turbo pump. If the turbo pump spins up and settles to normal operation, wait for at least 30 minutes and then switch on the ion pumps.

When the pressure in the system is below $2x10^{-7}$ Torr close the open valves between turbo pump and the related microscope parts. If, after one hour elapsed, the pressure is still higher than $1...2x10^{-6}$ Torr, start to look for a leakage.

Switching on the ion pumps finishes the pumpdown procedure. Observe the pressure in the system for the next 1 to 2 hours. When the dropping pressure indicates no noticable leak, start the bakeout (see section 5) or leave the pumps running for 10…12 hours.

If 10...12 hours elapsed with no bakeout and the pressure is still higher than $3…4x10^{-8}$ Torr look for a leakage before baking the system.

4. Venting the System

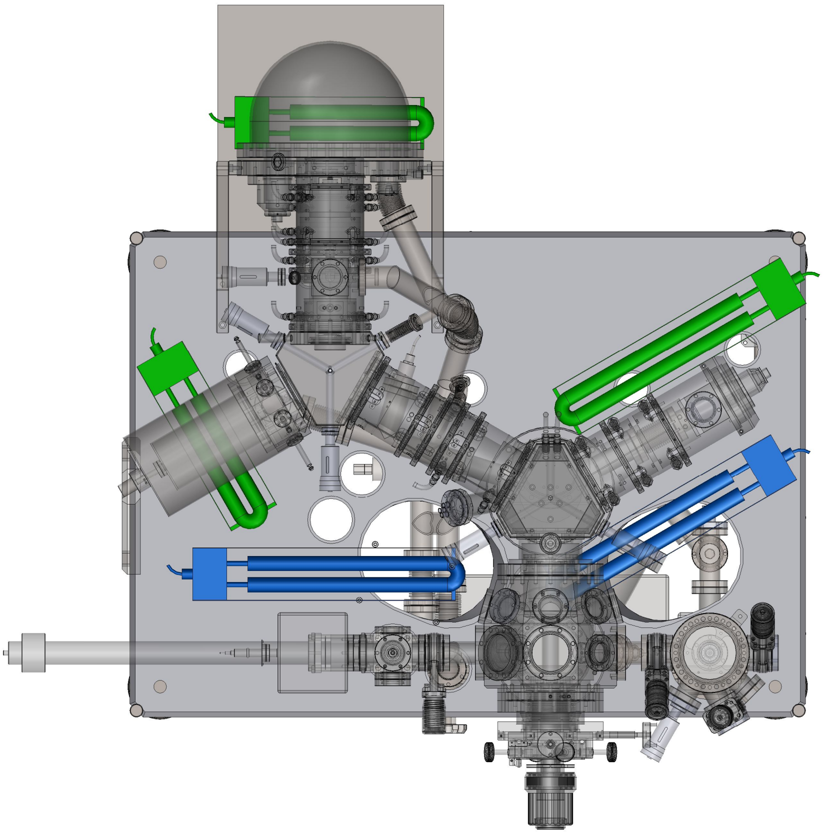
The first step to vent the system is to switch on the turbo pump and the scroll pump in order to decrease the pressure in the area between turbo pump and microscope.

Verify that all aperture are retracted.

Then switch off all ion pump supplies or close the related valves. Switch off all the Bayard-Alpert gauges and all heated filaments, wait until these elements are cooled down, and then open the valves between the turbo pump and the microscope part you like to vent.

Switch off the turbo pump and the scroll pump and slowly open the venting valve on the turbo pump. To avoid the excessive admittance of water vapor to the vacuum system, a dry nitrogen source can be attached to the venting valve inlet. To prolonge the life of several components in the microscope (e.g. channelplates) and to speed up the later pumpdown, we recommend the use of dry nitrogen for venting.

5. Bakeout procedure



Position of heaters during bake out
Blue heaters: Bakeout power outlet 1 (“Time&Temp.1”)
Green heaters: Bakeout power outlet 2 (“Time&Temp.2”)

5.1. Bakeout preparation

The microscope should be baked for at least 24 hours in the temperature range of max. 150°C. Before starting the bakeout, remove all non-bakeable cables you have used (e.g. ion gun cable, evaporator cables…). Cover all the viewports with aluminum foil. The bakeout parameters (time and temperature) are controlled by the Bakeout Unit. To start the bakeout you need to mount the bakeout tent on the table and to install the heaters inside. The heaters must be connected to sockets below the table of the microscope, as well as the heater installed on the sublimators under the table and the pump heaters. To start the bakeout push the switch signed "BAKEOUT ON" and "START" on the Bakeout Control Unit. Make sure that the current and voltages of Lens supply rack, the HV supply rack and the Image intensifier power supply are ramped down before you press the "BAKEOUT ON" button.

Attention: Before starting the bake out the BILZ vibration dampers have to be deflated. This should avoid overheating of the vibration dampers due to direct contact to the LEEM table. Also it has to be checked that if after starting the bake out then cooling fans of the dampers will work. Permant damage of the dampers will occur when they are overheated!

5.2. Bakeout parameters

As we have already mentioned in section 2.6. (Operator rack) both, time and temperature of the bakeout are controlled by the Bakeout Control Unit. At the LEEM microscope two Ni-Konstantan thermocouples are screwed to the system and connected directly to the temperature controller in Bakeout Control Unit. Use the buttons on the front panel of the meter to set the temperature. The bakeout time is controlled by the timer mounted next to the temperature meters. The time can be set by four switches on the timer in the range of few seconds up to 100 hours. To secure the system against an unexpected pressure rise, the bakeout is supervised via the setpoints in the Bayard-Alpert controller.

Attention: To change the time parameter during the bakeout, press the "STOP" button button at first, then change the time setting on the timer and press the "START" button again.

The temperature parameter can be changed at any time without interrupting the bakeout timer.

5.3. Pressure during bakeout

The Bayard-Alpert controllers (via the setpoints) stops heating when the pressure in any chamber of the microscope increases above 3.6×10^{-6} Torr and resumes heating when the pressure drops below this value. This value of the pressure threshold can be changed. The procedure is well-described in Vacom Bayard-Alpert controller manual. However, we recommend 3.6×10^{-6} Torr as a safe pressure threshold for the instrument which does not cause too many interruptions of the heating during the bakeout.

Make sure that the Interlock override button is not pressed, otherwise the interlock system will not work.

5.4. Outgassing procedure

To obtain a lower final pressure in the instrument, some of the parts should be well outgassed when, after the bakeout, the whole microscope is still hot. We recommend the following procedure:

- When the bakeout is finished, leave the bakeout tent on the system at first.
- Switch on all Ti sublimators and start the degas procedure
- Let the system cool down for at least half an hour.
- Use the sublimators once more, this time at operational values.
- If the pressure is in the low 10^{-8} Torr range, degas all the Bayard-Alpert gauges.
- Do not take off the tent before the temperature drops below 90°C.

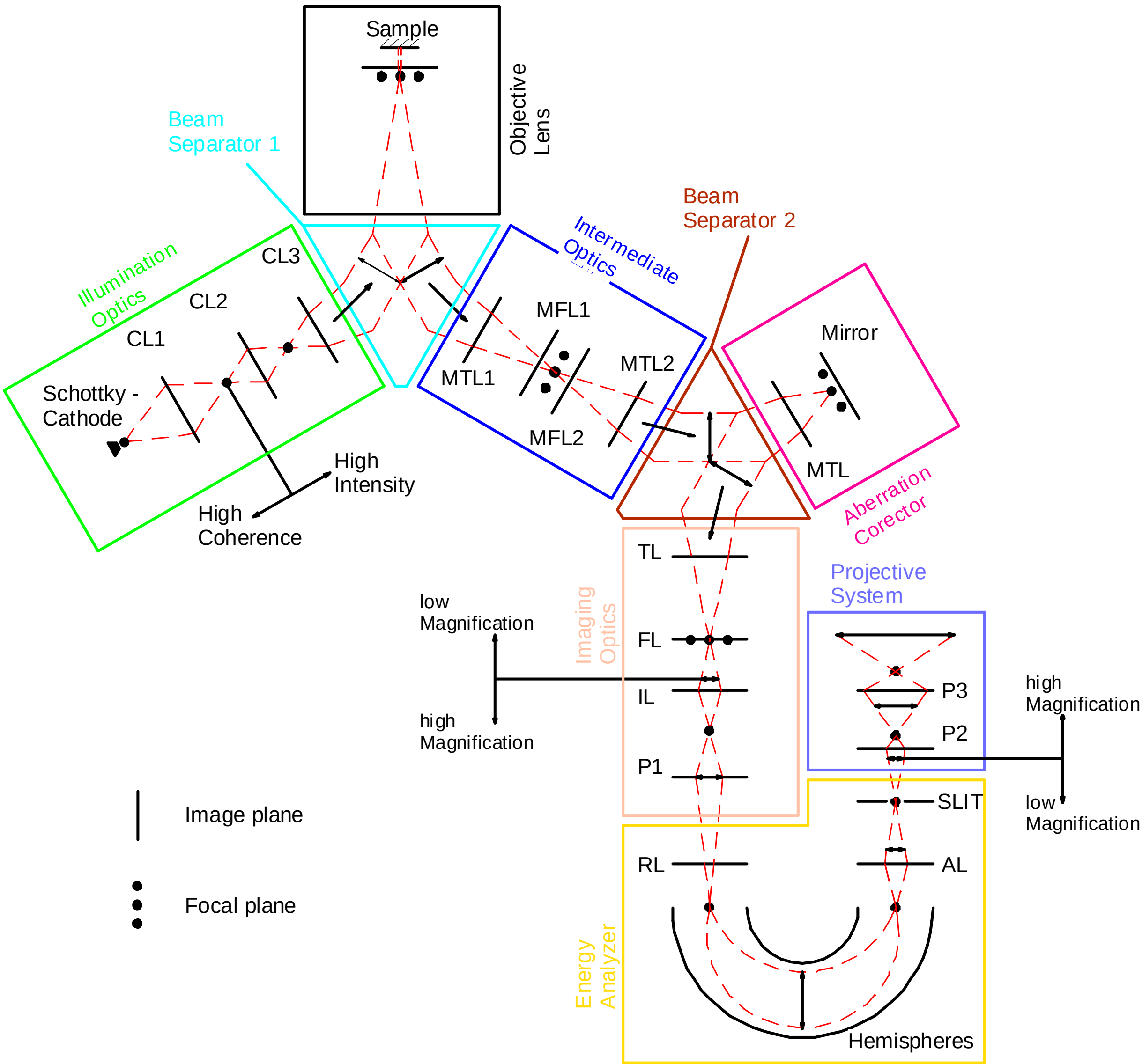
Attention! If you mounted additional parts in the microscope which are heated later on, do not forget to degas them now. For the degasing, follow the manufacturer's instructions.

6. Microscope

6.1. Introduction

The electron optics of the LEEM III microscope consists nine parts:

- illumination optics
- 2 beam separators
- magnetic objective
- intermediate optics
- aberration corrector
- imaging optics
- energy analyzer
- projective system



From the front of the microscope (manipulatorside), the illumination optics is located at the right hand side, going to the left it is followed by the first beam separator. The intermediate optics is located at the left hand side of the first beam separator. In front of the first beam seperator the objective lens is located in the main chamber which also contains the sample manipulator. The third outlet of the first beam separator is connected to the inlet of the intermediate optics. The outlet intermediate optics is coupled with the second beam separator. At the front left outlet of the second beam speparator the aberration corrector (electron mirror or “mirror”) is mounted. At the last remaining outlet of the second beam separator one can find the imaging optics. The imaging optics will lead to the energy analyzer on the far end of the microscope. The analyzer is bending the electron beam by 180°. Its outlet is connected to the Projective system which is located above of the imaging optics with the detector pointing in direction of the second beam separator.

In the illumination optics, a 20 keV electron beam is created and focused. Afterwards it is deflected by the first beam separator and transferred through the objective lens. It is then decelerated by the electric field in front of the objective lens and finally hits the sample. The first intermediate image of the sample surface is created by elastically backscattered electrons (LEEM image). The position of this image is determined by the objective lens and located in the center of the beam separator. The intermediate optics will transfer this first intermediate image 1:1 to the center of the second beam separator. The reason for that is the aberration corrector. It is designed to compensate the abberation of the objective lens not the aberrations of the beam separator. The 1:1 transfer of the image from the first to the second beam separator automatically correct these aberrations by geometry. In the aberration corrector is electrons will be decelerated to 0 eV and reflected by an electrical potential. On their way back the electrons will be recelarated to 20 keV and create an intermediate image in the center of the second beam separator. From there, the lenses in the imaging optics transfer this image via at least two further intermediate images into the energy analyzer. Behind the energy analyzer the intermediate image is transferred and magnified by two projective lenses to the image converter which consists of two microchannel plates and a phosphorous screen. The screen is mounted directly onto the vacuum side of a fibre optical window. Finally, the external CCD camera acquires the image from the window and sends the data to the computer for the observation in real time.

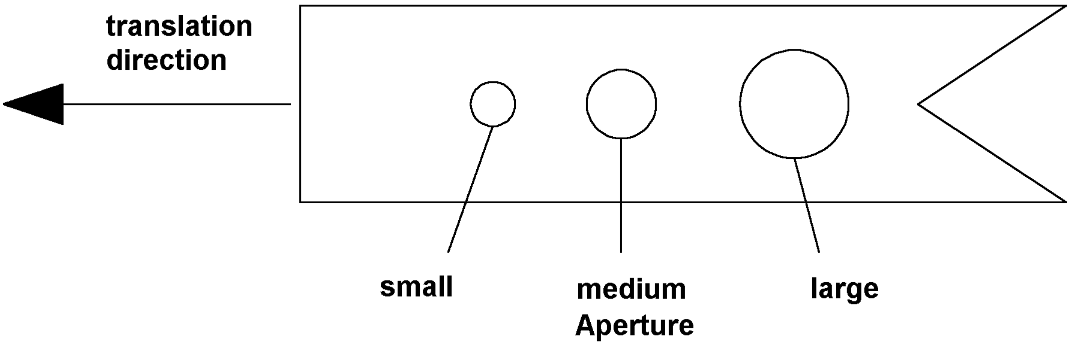
6.2. Magnetic objective - cleaning procedure

During experiments with in-situ deposition from evaporation sources of any kind, it is impossible to avoid the contamination of the objective electrodes with the evaporated materials. If the buildup on the lens electrode is already thick, charging effects could be observed in the objective area. This indicates that the objective lens should be cleaned.

To do this, first vent the system and open the manipulator flange. Now remove the µ-metal shielding around the objective lens. It is fixed from the side by one screw seize M3. To have easier access to the screw it is helpful to open the sideflange pointing directely to the screw. Loose the 8 screws which are holding the objective electrode in place. Remove the objective electrode from the chamber and note the orientation´, so that you can remeount it later in the same orientation. Start to clean the objective electrode using very small grain size polishing materials (Al_2O_3, diamond or similar). A grain size smaller than 1µm is mandatory.

After polishing, clean the electrodes at least three times in alcohol using an ultrasonic bath. In each of the steps, remove the accumulated residuents and use new alcohol. Finally, mount the objective electrode again (Important: remount in the same orientation). Tighten the screws simultaneously (in several steps) and use approximately equal torque on all of them.

6.3. Apertures



Three aperture mechanisms are installed in the microscope. The illumination aperture mechanism is located in the center of the first beam separator, the diffraction (contrast) aperture manipulator in the center of the field lens. On the illumination aperture rod, three apertures with the following diameters are mounted: 400µm, 100µm and 30µm round holes. They are used to limit the beam size in the separator in order to obtain smaller beam crossovers in the objective back focal plane. It is sufficient to use the 100µm aperture for mirror and LEED mode.

In a conjugated plane to the illumination aperture but on the image side the field limiting or selected area aperture is located. Its function is to limit the beam size in the energy analyzer and therefore enhance the energy resolution. On the selected aperture rod, three apertures with the following diameters are mounted: 100µm, 30µm and 10µm round holes

The diffraction aperture increases the contrast and spatial resolution during LEEM imaging. On this aperture rod, six apertures with the following diameters are mounted: 70µm, 60µm, 50µm, 30µm, 25µm and 10µm. In LEED mode the diffraction apertures must be removed from beam path.

After working with the instrument for extended periods of time, a contamination of the apertures can occur, indicated by charging effects. In this case, remove the aperture mechanisms from the microscope, dismount the apertures from the aperture holders and anneal them using a clean flame, e.g. Bunsen type burner. The apertures will withstand this procedure (standard in electron microscopy), because they are made from platinum.

Do not confuse the order of the apertures when you reassemble the aperture holders.

Attention!

- **before bakeout or venting the system, remove the apertures from the beam path**
- **after cleaning, mount the aperture flange in such a way that the aperture plane is perpendicular to the tube axes. The side of the holder into which the apertures are mounted must face the incoming electron beam.**

6.4. Sample manipulator maintenance

The adjustment of the manipulator should be done with the system under vacuum, in the following way:

- Rotate the manipulator head to bring the sample close to the objective lens (~2mm). The stop ring mounted on manipulator indicates a sample position of approximately 2mm in front of the objective lens. Be sure to watch the sample while approaching the objective lens, because the appropriate stop ring setting may differ for special specimen geometries.
- Try to move the manipulator 1-2mm forward and backward in X or Y direction and observe the digital reading.
- If the X or Y movements need excessive torque to turn or the manipulator is moving abruptly and is difficult to control, turn the four pressure compensation screws clockwise, about two turns.
- Try again to move the manipulator 1-2mm forward and backward in X or Y direction and observe the micrometer. If, after you stopped to turn the X or Y control, the digital readout continues to change, this means that the manipulator still relaxes into its new position, which is undesirable. In this case, turn the pressure compensation screws a little bit clockwise. Check the response to the X or Y movement once more.
- If the reaction to one movement control is smooth and no relaxation effects are visible, check the other direction. Adjust the compensation screws until the manipulator reacts smooth and with no undesirable relaxation of the position in both directions.
- Repeat this procedure during PEEM observations, using as criteria the movement of sample features on the screen.
- If the compensation screws are turned clockwise too far, the manipulator will get very sensitive to mechanical vibrations. In this case, turn the pressure compensation screws counterclockwise and repeat to optimize the performance as desrcribed above.

6.5. Sample exchange

The whole sample cartridge can be removed from or put into the sample manipulator without venting the microscope. To remove the sample from the system, use the following procedure:

- Switch off the high voltage in the HV rack. Turn off the sample heater.
- After centering X,Y and tilt controls, Turn the manipulator head to move the sample about 50mm back from the operating position (each turn corresponds to 1mm so, that means 50 turns are needed for the whole distance)
- Check the pressure in the preparation and entrance chamber: If it is not higher than 10^{-8} Torr, open the gate valve between the main and the entrance chamber.
- Move the transfer rod to the main chamber.
- Using the manipulator head and the alignment screws on the transfer rod mount, try to insert the tip of the transfer rod into the sample cartridge receptible.
- If successfully inserted, push the transfer rod little bit inwards and turn it by 90 degrees to engage it to the sample cartridge.
- Now pull the cartridge out of the manipulator with the transfer rod and move it to the prep chamber.
- Close the valve between the main and the entrance chamber.

With the next steps, remove the cartridge from the vacuum system:

- Pull the transfer rod out to the end to clear the lift area.
- Check if the loadlock area is pumped.
- Observing the entrance chamber pressure, move the sample lift upwards by turning the brass head clockwise.
- Look through the viewport into the entrance chamber: You should see a leaf spring (one in the front of the lift) – close to the spring leaf two rails inside the lift are allowing the insertion of the cartridge.
- To insert the cartridge, adjust the transfer rod and the alignment screws if necessary and push the cartridge in the lift rails.
- When the cartridge is fully inserted in the lift, push the transfer rod a little bit inwards and turn it by 90 degrees to disengage it from the cartridge.
- Pull the transfer rod out of the cartridge and completely remove it from the lift area. Verify that the specimen did not move in the lift rails while you removed the transfer rod. It must be fully inserted in the lift or it will get destroyed by the lift movement invoked in the next step.
- Carefully move the sample lift downwards until it stops in the lower position (turn counterclockwise). If you feel a sudden resistance on the way down, this may indicate a shifted or not correctly inserted sample cartridge. In this case, move the lift up again and inspect the cartridge position. When the lift stopped in the lower position, be sure to exert enough torque (hand tight only) on the sample lift head to seal the load lock area with the O-ring on the lift.
- Now vent the loadlock slowly and observe the pressure in the entrance chamber. When the loadlock is properly sealed, no change in the preparation chamber pressure will occur.
- Open the fast entery of the entrance chamber and take out the sample.

To transfer the sample into the vacuum system, use the following procedure:

- Insert the cartridge into the loadlock. Be sure it is fully inserted into the sample lift rails or it will get destroyed by the movement invoked in the next steps. Clear the lift area, if necessary, by pulling the transfer rod fully out.
- Close the fast entery and start the evacuation of the loadlock with the turbo pump (typical pumpdown times are 30 minutes to 1 hour).
- Slowly move the sample lift upwards. At first, the seal between entrance chamber and loadlock will be opened. Observe the pressure in the entrance chamber.
  If it increases too high, move the sample lift downwards and seal the loadlock off again. Pump the loadlock for a longer time and try the insertion later.
- If the sample lift is in the upper position, engage the transfer rod to the cartridge receptible as described above and pull the cartridge out of the lift. Clear the lift area by pulling the transfer rod fully out.
- Move the sample lift to the lower position and seal the loadlock from the entrance chamber.
- The sample cartridge should be degassed by heating in the entrance chamber before the transfer into the main chamber is done.
- After the heating of the cartridge, we recommend to wait until the pressure in the preparation chamber is in the 10^{-9} Torr range. Then open the gate valve to the main chamber.
- Move the cartridge to the main chamber and insert it into the manipulator receptable, using the manipulator head and the transfer rod adjustment screws, if necessary. When the

cartridge has been succesfully inserted, disengage the transfer rod by turning it about 90°. Carefully pull the end of the rod out of the cartridge. Be sure the cartridge remains fully inserted in the manipulator receptable.

- Pull the transfer rod fully out. Then close then gate valve between main and entrance chamber.

6.6. Image converter - microchannel plate system

The channel plate system is produced by Photonis and is installed in the microscope without any changes in the original design. **Study the manual from Photonis before using the channelplates!**

The ELMITEC **Image Intensifier Power Supply** is used to set adequate potentials to the channel plate output and to the screen. The channel plate input is grounded. Follow the Photonis instructions when turning on the voltage of the channel plates. **The potential difference between the screen and channel plate output must not exceed 4500V, or irreversible damage of the screen and/or the channelplates will occur.**

Typical working conditions are:

Screen	5500V
Channel plate output	1500V (1300-1600V)
Channel plate input	grounded (shorted plug must be in place!)

Attention: If you plan to leave the system vented for prolonged times, at first study the manual of Photonis before venting the system. Prolonged exposure to the atmoshere can impair the channelpate performance. Follow the manufacturer's instructions for the adequate storage of the channelplates.

Never switch on the channelplate or screen voltage when the system is vented, because this will instantaneously destroy your channelplates. The same holds true for pressures at which glow discharge could occur. For a safe operation of the channelplates, the pressure must be lower than $1x10^{-7}$ Torr.

If the channel plates show traces of contamination, use exclusively the cleaning procedure described in the Photonis manual.

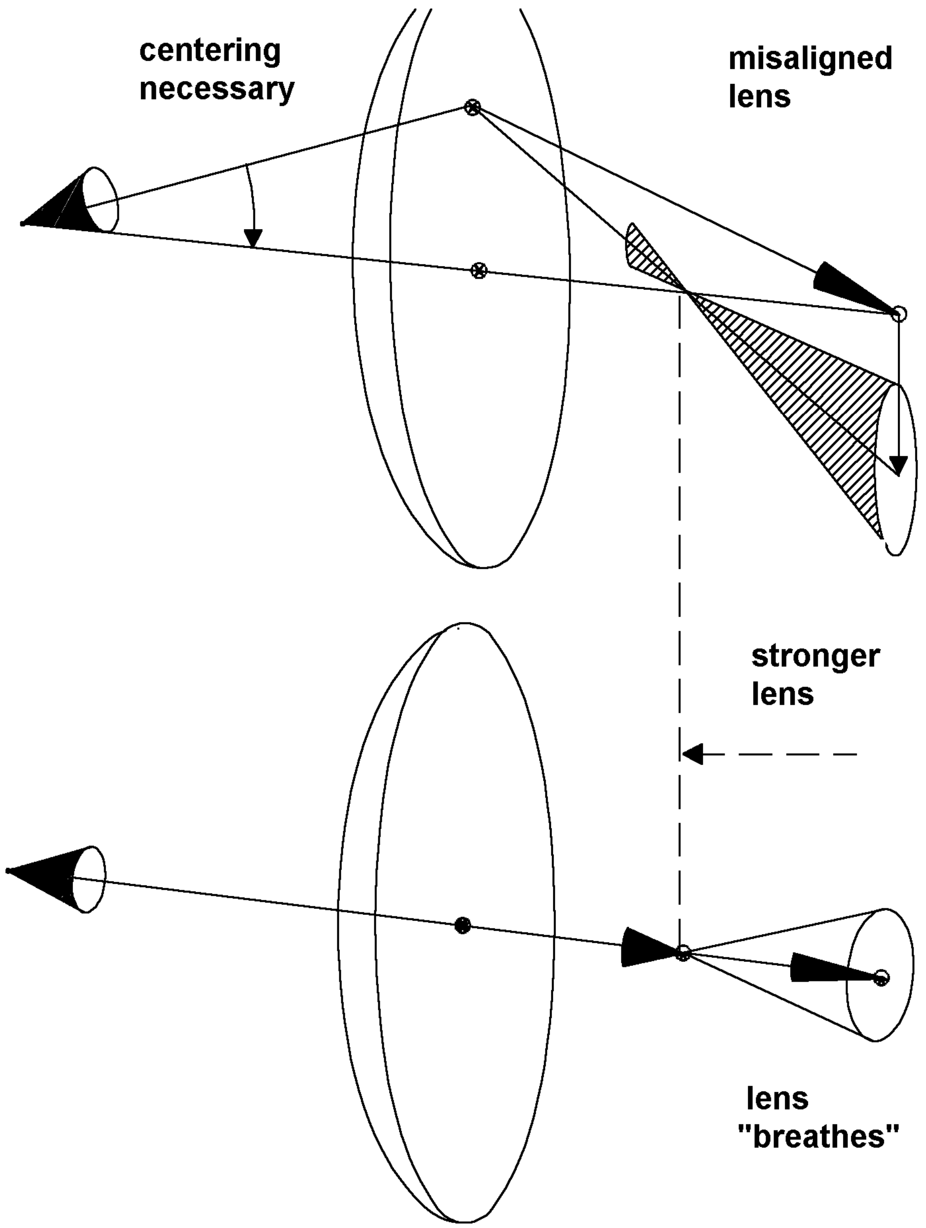
Attention: Never illuminate the detector system with a strong, focused electron beam, the channelplates and the screen will be damaged immediately.

7. LEEM III Alignment

7.1. General

The LEEM III alignment begins with the adjustment of the cathode and proceeds through the whole system, in the direction of the electron beam. This is done because the lenses of the instrument reach their best performance only when they are centered with respect to the optical axis. Image intensity and resolution will be high and parameter variations as e.g. the field of view or the switch between LEEM and LEED mode can be done without beam loss in this case only.

If an electron optical lens is centered to the optical axis and variations of the focusing action of that lens are being observed on a screen, they will be noticed as a concentric expansion or contraction of the beam profile. In the following, this appearance is called ‘breathing’ of the lens. If the optical axis does not pass through the center of the lens, the beam will also get displaced by it when the lens excitation changes. Therefore, a lot of the alignment work done below will aim at obtaining the ‘breathing’ state of all the lenses lined up in the microscope.



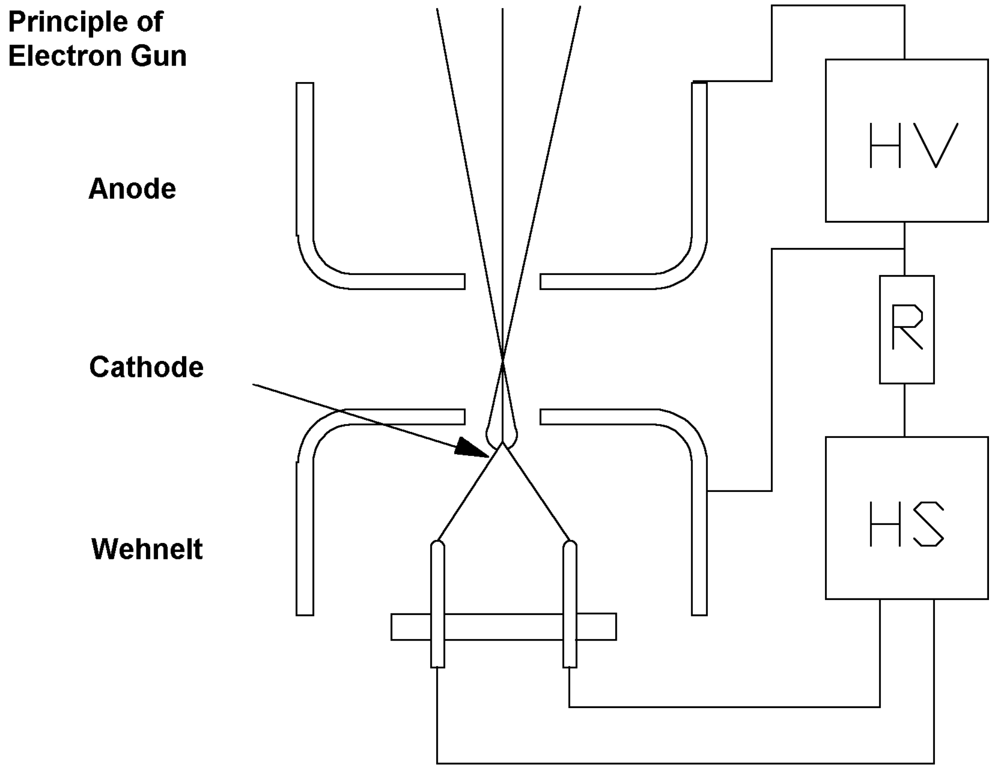
7.2. Alignment of the Cathode

In order to perform this alignment procedure it is nessessary to vent the electron optics and to mount a YAG screen at the position of the sected area aperture. The following steps should be done only after exchange of the electron source.

To examine the cathode alignment, switch off the first beam separator (SELO/SELI) and observe the beam profile on the auxilliary screen.

In the first step, the quality of the Schottky field emission cathode can be checked with the following procedure:

- Switch on the high voltage rack.
- Set the Wehnelt voltage to about -0,85kV
- Switch on the Gun Cage HV and increase it to 10 kV.
- Set the cathode heating current to 1.61A wait for at least 1 hour
- Switch on the main HV and increase it to 20 kV.
- Switch on the lens power supply rack.
- On the computer, start the control program.
- Set all coil, deflector and stigmator currents in the illumination column and sector field to zero.
- Using the Wehnelt control, set the emission current to about 0.2µA or less



At that moment the electron beam should appear on the auxilliary screen. If this is not the case, move two of the three alignment screws at the base flange of the electron gun. Please be careful not to destroy the elastic membrane of the gun flange by overstretching it with the screws. It may need some time to see the electron beam on the screen because the cathode tip must deviate from the optical axis by less than 0.2mm to make the beam visible.

7.3. Alignment of the Illumination Column after new e-gun installation

Verify that all coil currents of the illumination column and of the separator (SELO/SELI) are set to zero.
The first element following the cathode is the condensor lens 1 (CL1). To align it, wobble CL1 around 850mA current value (the suggested current value for later operation) and vary the position of the cathode to obtain the "breathing" of the bright area on the auxilliary screen.

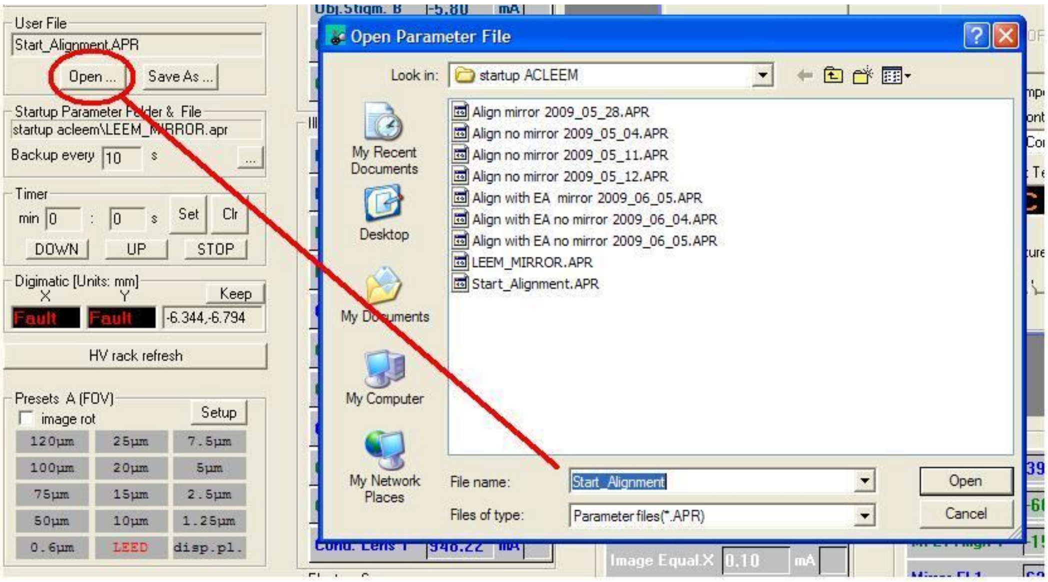
The next step is the condensor 2 (CL2) alignment. Focus the electron beam with CL2 on the YAG screen. Wobble CL2 around is value. Change the values of the CL2 deflectors (CL2DX,Y) until you see the cathode image "breathing" with CL2. Then set CL2 to 2500mA

Then align condensor 3 (CL3), Focus the electron beam at the YAG screen with CL3 and toggle around this value. Now use the same procedure for CL3 as you have used for CL2 but instead of the CL2 alignments use the CL3 deflectors (CL3DX,Y).

7.4. Sample Tilt Alignment

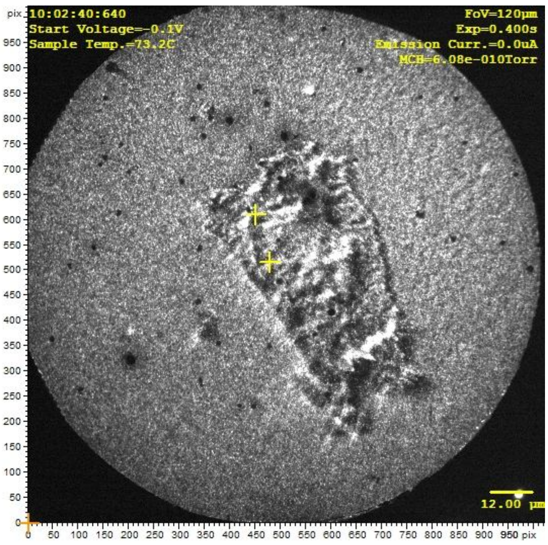
At first, verify that your CCD camera is switched on. Then, switch on the channelplate supply and increase the channelplate voltage (read out on the panelmeter) to 1.35kV. Then increase the screen voltage to 5.5kV. Remember that the maximum voltage between channelplate voltage and screen must never exceed 4500V.

The next steps are the adjustment of the sample tilt and the alignment of the imaging column. The best way is to start in the PEEM mode. Switch on the UV lamp and position it in front of the quartz viewport. Switch off the electron gun by increasing the Wehnelt potential to the maximum value. If you have a well established alignment you should use it as a starting point. In all other cases load the Start_Alignment.apr file from your LEEM folder.



Position the manipulator head approximately 1mm away from the stop ring. Set the objective lens current to a value of 1950mA and Start voltage to 0V. Now you should see the PEEM image on the monitor. If nothing is visible yet, adjust the UV lamp position observing the screen. If there is still no image visible, then check if your video camera is turned on or if another step of the preparation failed.

With some samples, a PEEM signal is hard to obtain. This is especially true, if no roughness or adsorbate layers reduce the work function of the sample. With these samples, it is best to adjust the tilt before the final cleaning procedure is done and to use the established tilt settings later, when the cleaned sample is giving no noticable PEEM signal any more.

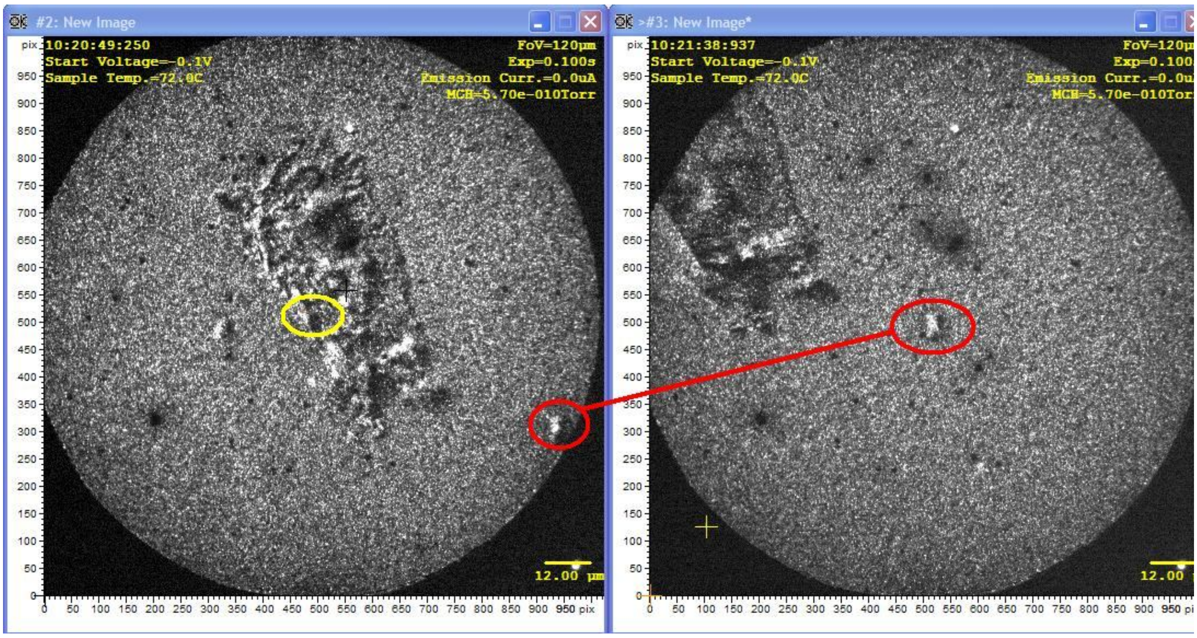


Typical PEEM image at this stage

When you already see the PEEM image try to find a feature on your sample and check the focus. The typical focusing current is about 2150mA. Adjust the distance between the objective lens and the sample if the focusing current is higher or lower than 2150mA. Now you can check the sample tilt. In order to do that, observe the response of the features on the sample image when the objective current is changed. The feature which is just in the center should look like if it "breathes", e.g. contract and expand but make no lateral movement. The objects located in the vicinity of the center should move towards the center when current is lower than for proper focus current and move in the opposite direction when the current becomes higher. Correct the sample tilt if a different appearance of the sample image is observed. For this procedure, at least three or four features in the field of view are needed.

7.5. Alignment of the intemediate optics

At first, the position of the objective lens image plane must be brought to the center of the separator. To determine the image position, use the following procedure:
Vary the SELI current and observe the reaction of the image on the screen. It will e.g. move to the right at first, and then stop and move back a little, and then resume the movement to the right. If you imagine this result as a graph showing the image displacement versus the SELI current, the curve will be ‘S’ shaped. The correct excitation value for SELI is right in the center of this ‘S’, at the turning point.
If you adjusted SELI to that value, calculate the ratio of the SELO / SELI excitations. It should be 1.895. If the ratio is outside this range, correct the SELO setting and repeat the adjustment for SELI as described. After a few iterations, both requirements will be fulfilled.



Yellow circle: brething center of MTL1 **Red circle: remarkable object**

Now you can start the alignment of the intermediate column. Observe the image while wobbling the lenses beginning with **M**irror **T**ransfer **L**ens **1** (MTL1). The image will symmetrically contract and expand ('breathe') with respect to a point that is not necessarily in the center of the screen.

Move a pronounced feature of your sample image to this point (now close to the screen center) using the sample manipulator (XY-movements). See image on top of this page. Stop the wobbling of the MTL1 current.

Then wobble the **M**irror **F**ield **L**ens **1** (MFL1) current. In most of the cases, the wobbling MFL1 current will cause a movement of the selected feature on the screen. Vary the MFL1 Align.Y deflector and SELO/SELI until this movement of the selected point vanishes. If you have to change SELO/SELI then you should ckeck if the object is still in the center of MTL1. If it is not the case then start again from "moving a remarkable object to the optical axis of MTL1".

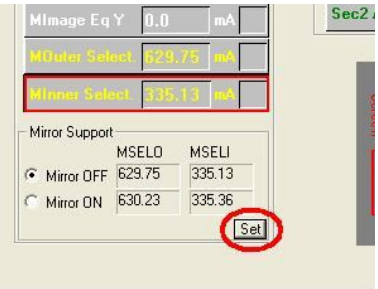
At this point it is good to check once more the sample tilt. Please overlap the breathing center of the objective lens with the position of the breathing center of MFL by toggeling the objective lens again and changing the tilt.

Next wobble the **M**irror **F**ield **L**ens **2** (MFL2) current. In most of the cases, the wobbling MFL2 current will cause a movement of the selected feature on the screen. Vary the MFL2 Align.X,Y deflectors until this movement of the selected point vanishes.

The last step for the intermediate optics is to wobble the **M**irror **T**ransfer **L**ens **2** (MTL2) current. In most of the cases, the wobbling MTL2 current will cause a movement of the selected feature on the screen. Vary the MTL2 Align.X,Y deflectors until this movement of the selected point vanishes.

7.6. Alignment of the imaging optics

Next you can start the alignment of the imaging column. Observe the behavior of the image during toggling the lenses beginning from **T**ransfer **L**ens (TL). It should breath overwise you should play with MSELO and MSELI to get the object as close as possible to the brething center of TL. The direction perpendicular to the direction of MSELO/MSELI should be corrected with the Sec2 Align.Y. Vary the MSELI current and observe the reaction of the image on the screen. It will e.g. move to the right at first, and then stop and move back a little, and then resume the movement to the right. If you imagine this result as a graph showing the image displacement versus the MSELI current, the curve will be 'S' shaped. The correct excitation value for MSELI is right in the center of this 'S', at the turning point.
If you adjusted MSELI to that value, calculate the ratio of the MSELO / MSELI excitations. It should be 1.895. If the ratio is outside this range, correct the MSELO setting and repeat the adjustment for MSELI as described. After a few iterations, both requirements will be fulfilled.



Next toggle **F**ield **L**ens (FL). Use FL Align.X, Y deflectors to see no movement of the chosen point during toggling. Go back to the transfer lens, check "breathing". Now store the values of MSELO/ MSELI like shown at the drawing by pressing the set button.
Next toggle **I**ntermediate **L**ens (IL). Use IL Align.X, Y deflectors to keep the chosen point "breathing" in the center of the screen. Toggle **P**rojective **1** (P1) and center it. When done check once more all previous lenses.

7.7. Alignment of the energy analyzer

7.7.1. Electron optical overview

The electron optics is shown schematically in Fig. 2. A straight line replaces the 180° deflection in the analyzer. The main optical components are: a) the objective lens in front of the surface, b) the four lens image column transferring both the intermediate image and the back focal plane to the entrance of the imaging analyzer (c) which consists of a combined **R**etarding (RL) and **I**ntermediate (INLS) **L**ens system, a hemispherical analyzer and a combined **A**ccelerating (AL) and **I**ntermediate (INLS) lens system, and finally the double lens projector (d) for imaging the electrons on the screen. The electron energy in the system is 20kV, except between objective and sample surface - where the electrons are decelerated to 0 - 500eV by adjusting the potential difference between sample and electron emitter in the gun (´sample potential`) and in the analyzer, in which the electron energy is 1025eV. The lenses of the image column transfer independently the image plane (IIP) and the back focal plane (BFP) of the objective through the system as indicated by arrows and dots. The gaussian plane of the surface is in the BFP and the image in the IIP is located in the center of the sectorfield. The transfer lens (TL) images the BFP into the focal point image plane (FPI) in the center of the field lens (FL) that images the IIP to a position between FL and IL. IL and the first projector (P1) transfer the image and the focal plane to the two special entrance planes (EP1, EP2) of the analyzer. In the imaging mode (Fig.2a) and in the dispersive plane mode (Fig. 2 c) the image of the surface is transferred into EP1, whereas the image of the BFP has to be in EP2. The analyzer images on the one hand the EP2 into the energy-dispersive plane (DP) and on the other hand EP1 into an image plane (IP) behind the DP. This double imaging produces the energy-filtered images when the energy selection slit is in the beam path and the projectors are excited to image the IP onto the screen. When the energy slit is fully open and the DP is imaged onto the screen (´dispersive mode`) then energy spectra are obtained. In a third mode (Fig. 2 b) it is possible to observe the focal plane on the screen, which is the photoelectron emission angular distribution (PEEAD). In this mode the image of the BFP and of the surface have to be exchanged in the two planes EP1 and EP2. Consequently the surface is imaged into the dispersive plane and the BFP can be observed in the IP by the projector. In order to realize energy filtering a slit has to be inserted in the dispersive plane (Fig. 2 a + b).

Furthermore in the imaging mode the contrast aperture in FL has to be used, firstly to reduce aberrations and secondly for create a reasonably small virtual entrance slit for the analyzer. For the PEEAD mode instead of the contrast aperture a selected area aperture can be inserted in the sectorfield. This enhances the sharpness of the pattern as well as defines a reasonably small virtual entrance slit for the analyzer. For the dispersive plane mode both the selected area and the contrast aperture are inserted to reduce aberrations and to form a virtual entrance slit.

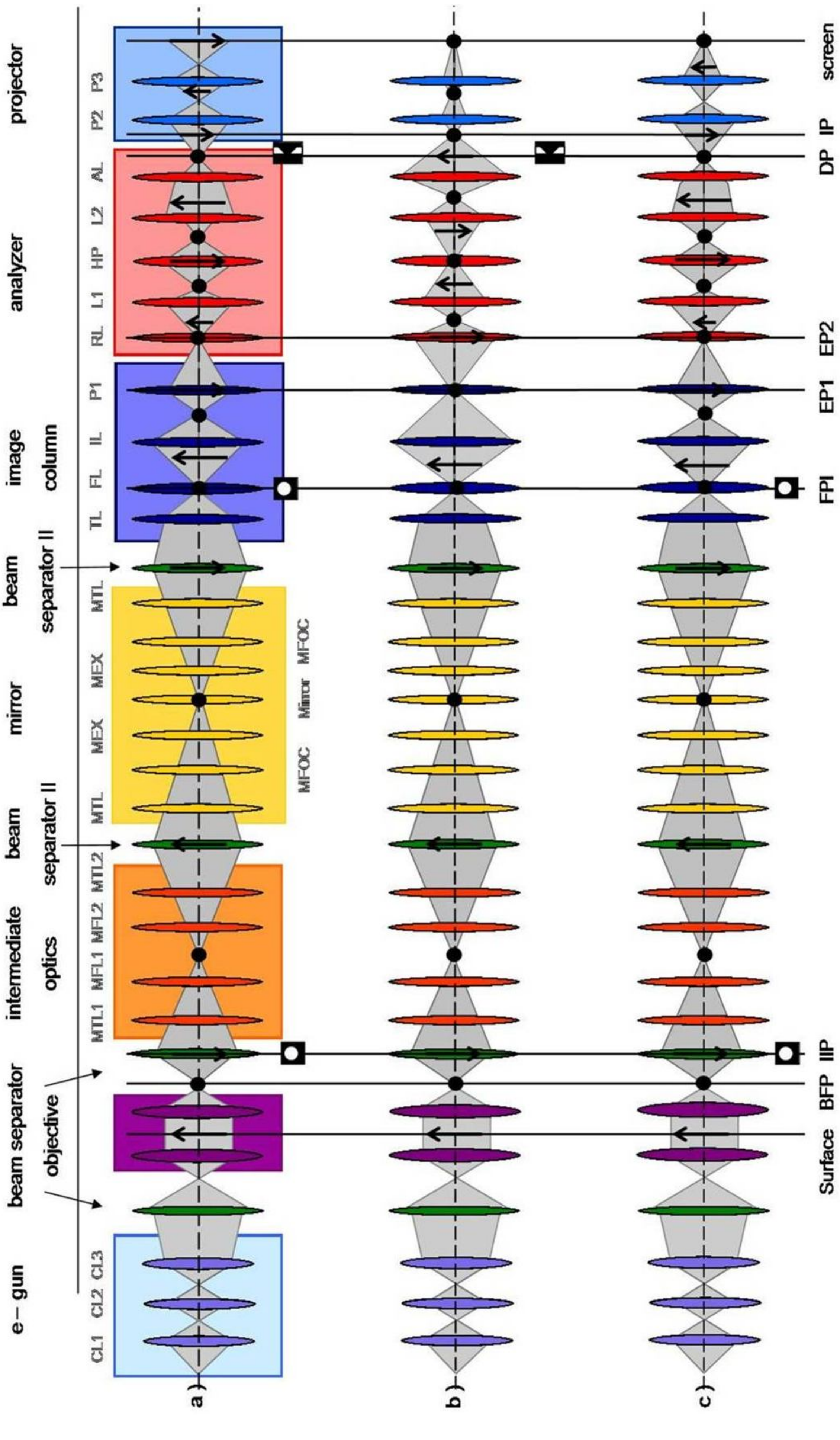
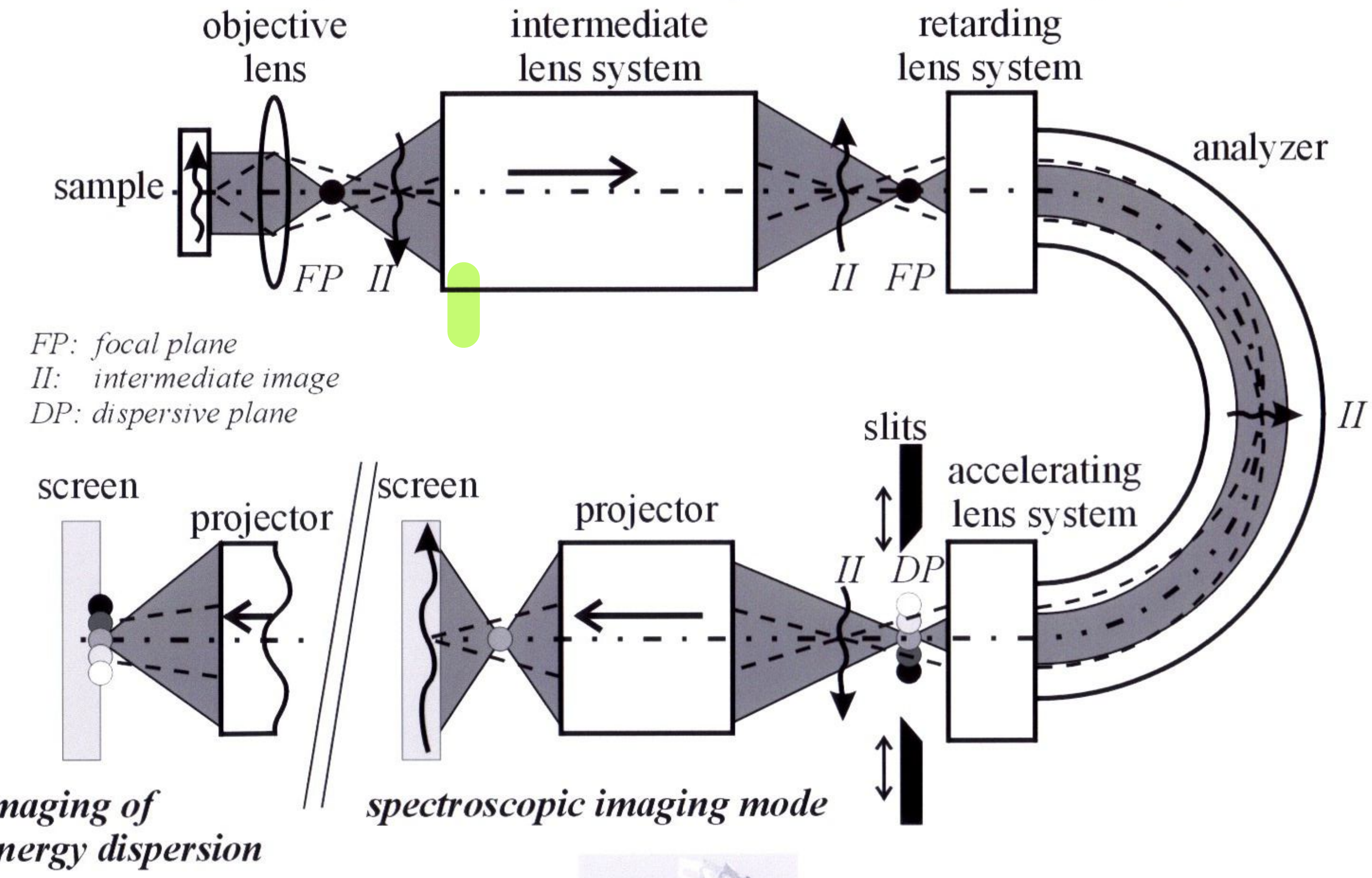


Fig2, Schmidt et al. mod.

Principle of Spectroscopic PEEM Imaging



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Thomas Schmidt

PrincAn3.CDR

Analyzer Schematics

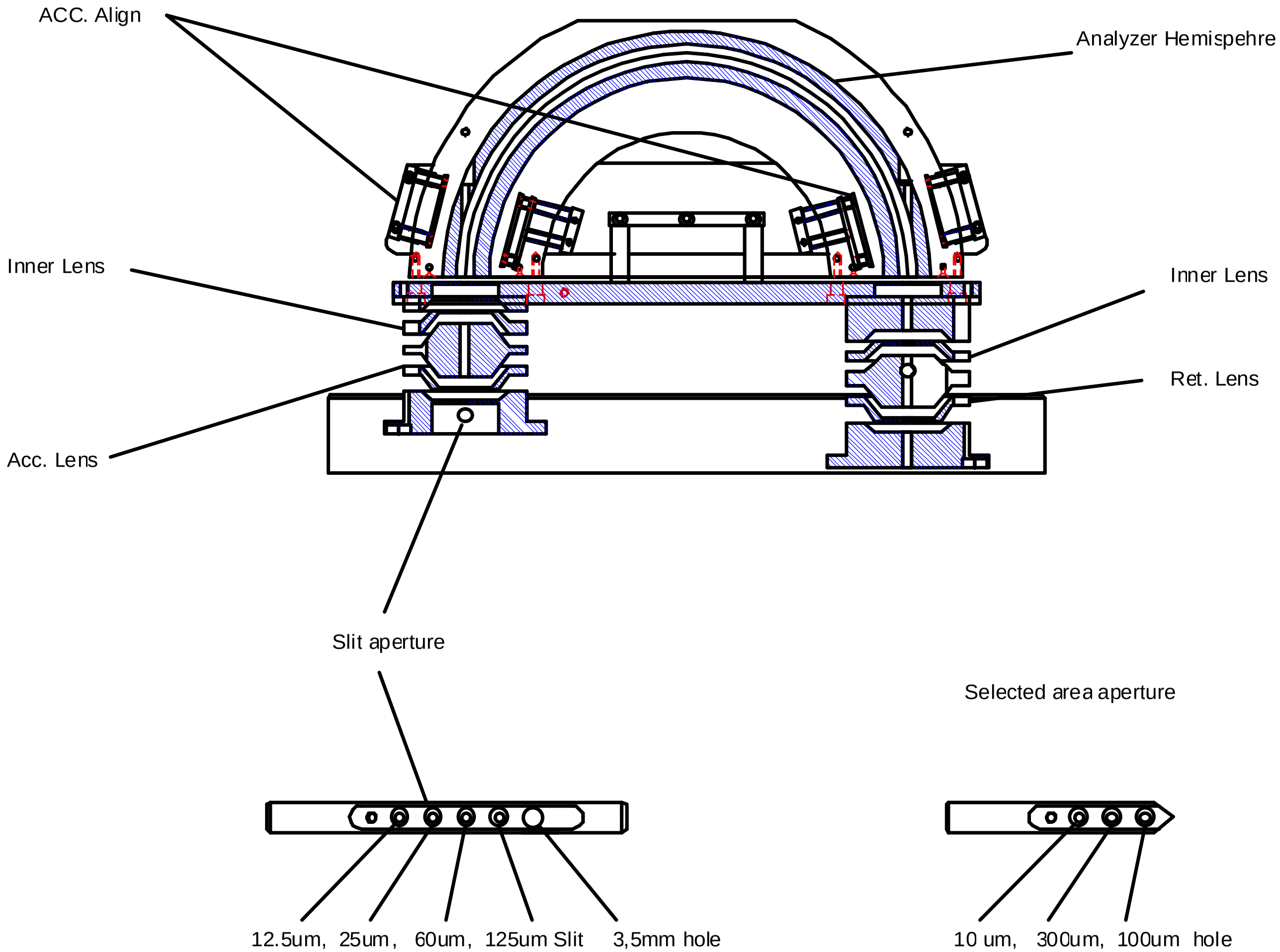


Fig 1

7.7.2. XPEEM

In x-ray generated photoemission electron microscopy (XPEEM), the kinetic energy of the emitted electrons ranges from zero to the photon energy minus the work function. The imaging energy analyzer allows selecting electrons within a narrow energy window as low as 0.2eV at pass energy of 1025eV for imaging. This reduces on the one hand chromatic aberration effects and on the other gives the possibility to image with selected core level electrons and is done by imaging the focal plane (FP) at the entrance (EP2) of the analyzer into the energy dispersive plane (DP) at its exit (see Fig. 2). The energy window can be set between less than 0.5eV and a few eV by choosing different slits in the dispersive plane or even smaller by reducing the pass energy (at the expense of the intensity). The intermediate image (II) at EP1 in front of the analyzer is transferred to an intermediate image plane behind the exit with a magnification of one, with another intermediate image at its center.
Changing the sample potential that requires a slight change of the objective lens focus changes the imaging kinetic energy. The advantage of this method is that all the other settings of the transfer and projector optics as well as of the analyzer remain fixed. By selecting kinetic energies that correspond to core levels, the images reveal pure element contrast. Chemical peak shifts can be used to map the chemical state of elements. In order to obtain full spectroscopic information of an area of interest; a series of images is collected with different energies.

7.7.3. Energy Resolution in XPEEM

The energy resolution of the analyzer is important for the contrast between two or more species with core levels of similar energy and the minimization of the chromatic aberration of the objective lens.
In order to obtain the spectra from samples and monolayers a series of about 40 images has to be taken. For each image the kinetic energy of the electrons used for imaging has to be changed in steps of 0.1 to 0.2 eV. After the acquisition of all the images, the spectrum has to be constructed by measuring the integrated intensity in an area of about 0,25 um^2 as a function of energy.

7.7.4. Imaging of the dispersive plane

The mode of spectrum acquisition just described is quite time consuming: The collection of 20 images takes a total time of about 5 to 20 minutes with an acquisition time of the CCD-camera of about 3 seconds. The advantage is that full information is obtained from the whole field of view. For some applications spectroscopic information with full lateral resolution it is not needed, e.g. when the spectrum of a small area selected by PEEM or XPEEM is to be measured. Therefore, a direct spectrum acquisition mode has been developed. In XPEEM the projector system transfers the intermediate image plane behind the analyzer to the screen (Fig. 2). For direct spectrum acquisition the projector lens is excited so that the energy dispersive plane of the analyzer is imaged, that is that a sharp image of the analyzer slits appears on the screen. After removing the slits, a line of intensity can be seen along the energy axis.

The spectrum covers an energy range of about 12eV.
Changing the start potential of the sample shifts the spectrum along the energy axis and other parts of the spectrum become visible.

The energy scale of the spectrum can be calibrated by correlating the change of the sample potential with the resulting shift of a peak position in the spectrum. Another possibility is to use the known distance between two peaks for scaling of the energy axis. The energy resolution depends on the size of the contrast aperture in the focal plane that is in fact the source imaged by the analyzer into the dispersive plane. In this mode of operation the instrument is working as a spectrometer in the multi channel mode, producing spectra of small areas on the micrometer scale (micro-spectroscopy), whereas in the imaging mode a surface area of several micrometers in diameter is imaged with a spatial resolution down to 25nm with spectroscopic contrast (spectro-microscopy). The advantage of the micro-spectroscopy mode is the fast acquisition time.

Furthermore, if an overview of the chemical composition is desired, a larger selected area aperture can be chosen.

The short acquisition time enables time-resolved observation of fast processes, such as crystal growth, annealing or chemical reactions on a micrometer scale.

7.7.5. Alignment of the electron beam inside the analyzer

Toggle RL and use the retarding lens align (RetAX, Y) in order to center it. Toggle the acceleration lens and center it with Sel+/- and AccA1, 2. The next element is the projector 2 (P2) – toggle it and center with P2DX, Y deflectors. As last step you should toggle projector 3 (P3) and center it with the P3DX,Y defelctors. Go back and check the whole column, make corrections if required.

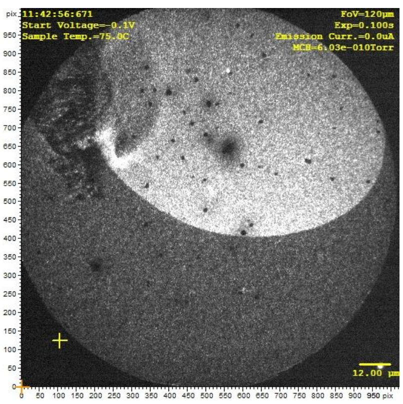
Toggle Sel+/- and minimize the motion with the Acc.Lens. Next toggle MSeli and minimize the image motion with FL.Then check the value of TL. This lens together with the separator (beam separator is also a lens) projects the objective back focal plane to the first diffraction plane (in the center of FL which is the diffraction aperture plane, too). This means that in this plane not only the LEED pattern is projected but also the PEEM image crossover. So observe the PEEM image on the screen and move the diffraction aperture. Try to find the image with first 70 microns aperture and center it with two screws to see the image of the identical size as before. This means that the TL value is set proper and the crossover is in aperture. To check it better move aperture forward and repeat the procedure with 30 microns aperture. If you are now not able to see the full image without any dark regions regulate a little bit TL and observe behavior of image. When you already see the image without vignitations you can try to do the same with the smallest aperture (10μm). Do not worry if you are not successful. This aperture is perhaps smaller than the crossover of the image, so you have to see a very dark image. During operation with the aperture you can also regulate a little bit the diffraction stigmators DSTIGA, B. This should also help if the previous regulation during the observation was not quite correct.

When this is finished remove apertures and checks once more the column alignment (there are now new values on TL and perhaps also on DSTIGA, B). If any corrections are required repeat also the procedure with diffraction aperture.

Now you have to move the energy selection slit in the beam path. You should see a uniformly illuminated image (keep in mind that the channel plates have some gradient). If not change the value of P1 until you reach a uniformly illuminated image. Focus the image with FL.

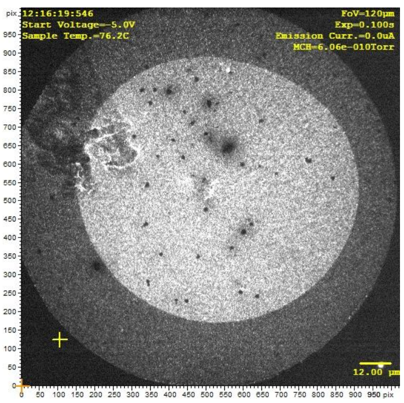
7.8. Electron beam alignment

We assume that according to this manual you already aligned the illumination column on the auxiliary screen (before image column alignment). If you have not done it do it now. Next you have to repeat once more the image column alignment because small changes can appear while switching on and off the beam separator.



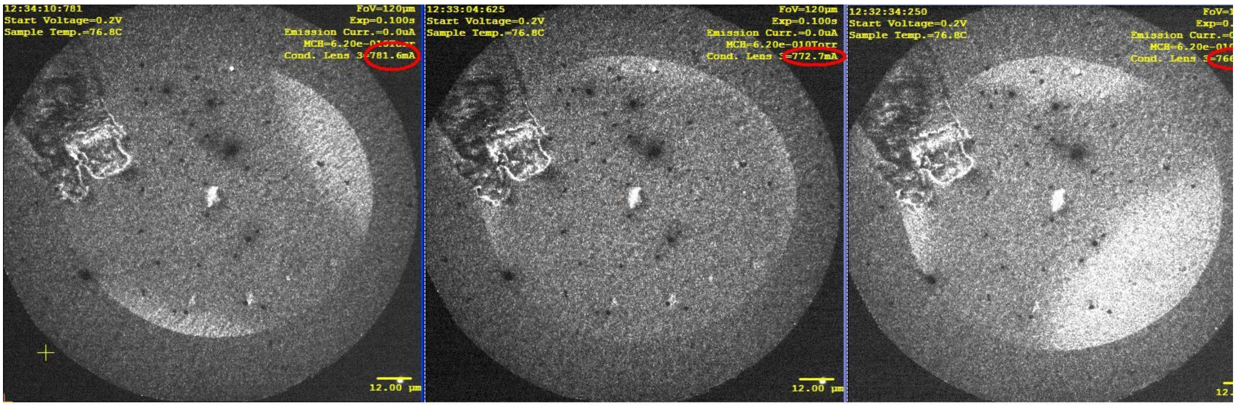
PEEM image with electron beam at the upper side

Check if START voltage is set to 0V to reflect electron beam from the sample. Decrease slowly Wehnelt potential and observe PEEM image. If you do not see the electron beam set the Wehnelt so that you have around 0.2 µA of emission current. Change the ILUDX, Y deflectors to find the beam in the PEEM image. You have to be very careful. The beam can be very strong so, you should decrease emission current seeing beam at the edge of screen. Try to regulate emission current to have comparable intensity of the electron beam and PEEM image. Using ILUDX, Y deflectors position electron beam in the center of PEEM image.



PEEM image with centered electron beam

Decrease slowly the negative potential on START voltage - you should see the black spot in the electron beam shape. Once more you should use the ILUDX, Y and try to center the dark spot in the bright beam area. This means that beam is centered in the objective lens. Check it by wobbling the objective - the image should "breathe". Make also the following observation. CL3 is set about 950mA. For CL2= 2500mA decrease CL3 to 780mA. Increase start voltage to +0.5V. Now change CL3 around this value. You should see on "both sides" of CL3 the bright shape with the dark spot inside. Both for lower and higher CL3-values the dark spot should be centered in the bright area. This means that changing CL3 you move the beam crossover along the objective axis, i.e. the beam is exactly perpendicular to the sample surface.

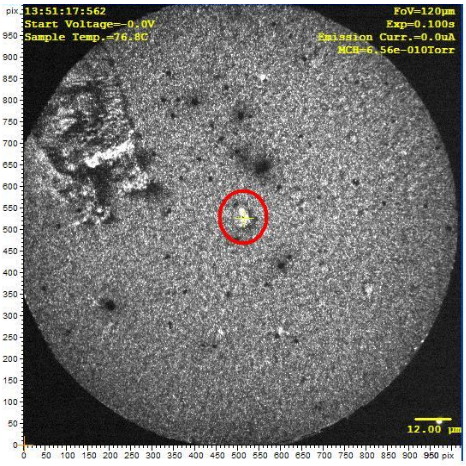


CL3: too short focal length **CL3: right focal length** **CL3: too long focal length**

Use ILUDX, Y to center it if the observed behavior is different. You should see the sequence above by changing the CL3 value. Reaching right value the size of the black spot should be maximized. When the beam is centered in the objective you can see a MIRROR image. Electrons scattered in a very short distance in front of the sample, so they „reflect" the spatial distribution of surface potential create this image. To see this image change the start voltage (should be about -0.5 to -1V or more negative for W sample) and regulate the MOBJ in order to see a sharp image. The image detail in the center of the screen should breathe with objective. If not then make small corrections on ILUDX, Y deflectors. Check once more the centering of the whole image column. Probably some corrections should be done. Go back to CL3 and check centering. Make corrections on CL3DX, Y if required. Go to objective and make corrections on ILUDX, Y deflectors if it does not "breathe".

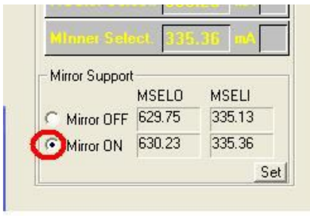
The next step is an operation with the illumination aperture installed in the beam separator. This aperture decreases the beam size on the sample, so it improves the quality of LEED and LEEM images. Observe the mirror image and move the aperture mechanism. The first one is a large hole with diameter 100µm, the second one is 50µm. Move the aperture and try to put it close to the center of the observed image. Now check if the aperture is in focus otherwise correct a little bit the objective lens. After both of these operations are finished check once more the image column and make corrections if required.

7.9. Abberation corrector alignment

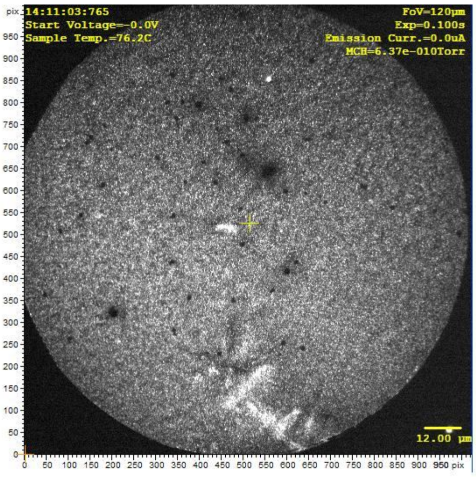


Object position marked by a yellow cross (highlighted by a red circle)

In order to align the aberration corrector it is nessessary to have a well aligned LEEM system. Please make sure that you have performened the alignemt procedure described in the earlier chapters. Start with a PEEM or LEEM image without any aperture. Also you should have a remarkable object on the optical axis of all lenses. Mark the object with a cross by using the uview software like shown on the image at the left side. Now click the at the mirror support field the mirror on button.

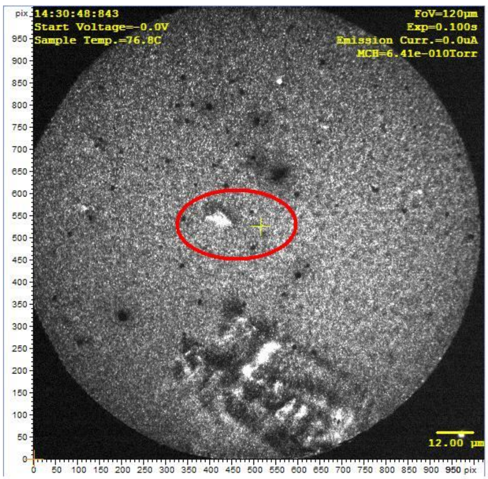


Normally the image will be looking much worse than before because the electron beampath for a not well aligned aberration corrector creates much additional aberrations. The image is showing a typical imaged with a non aligned electron mirror. Please be aware that the image is mirrored in comparison to the non-corrected image.

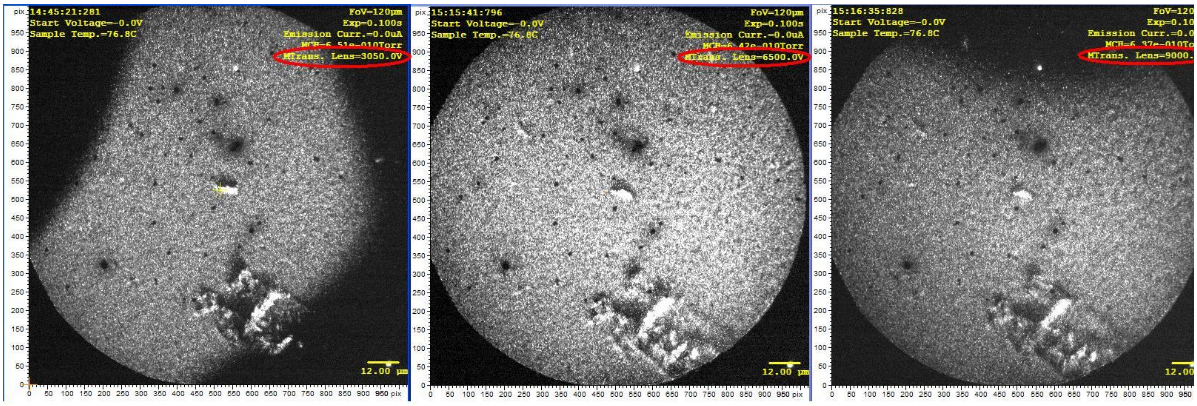


Typical image when switching on the aberration corrector

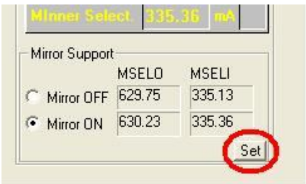
Set the MTL Align. X, Y to Zero and get the best image condiotion by changing MSELI. Check the ratio MSELO/MSELI. If it is not 1.895 then iterate the values of MSELO and MSELI to reach this ratio by keeping the best imaging condition.In order to make sure that you will get the right electron beam path toggle the mirror electrode (Mirror) and get your remarkable oject breathing by using MSELI and Sec2 Align.Y. In most cases the position of your remarkable object at the screen will differ from the position of the yellow cross set by the Uview software. It means that the Mirror Align. X, Y are not at the right values. Change the Mirror Aligns. X, Y in the way that your object is just under the yellow cross. In that case the imaging optics and the energy analyzer are aligned for both cases: with mirror and without mirror. After big changes of Mirror Align. X, Y please recheck the values for the MSELI and Sec2 Align.Y. The last step is to introduce the contrast aperture and check the vignitation of the electron beam. The sequence below shows the behavior by changing the exitation of TL. The right value is when no image information is lost by the edge of the aperture.



Yellow cross and remarkable object are not overlapping



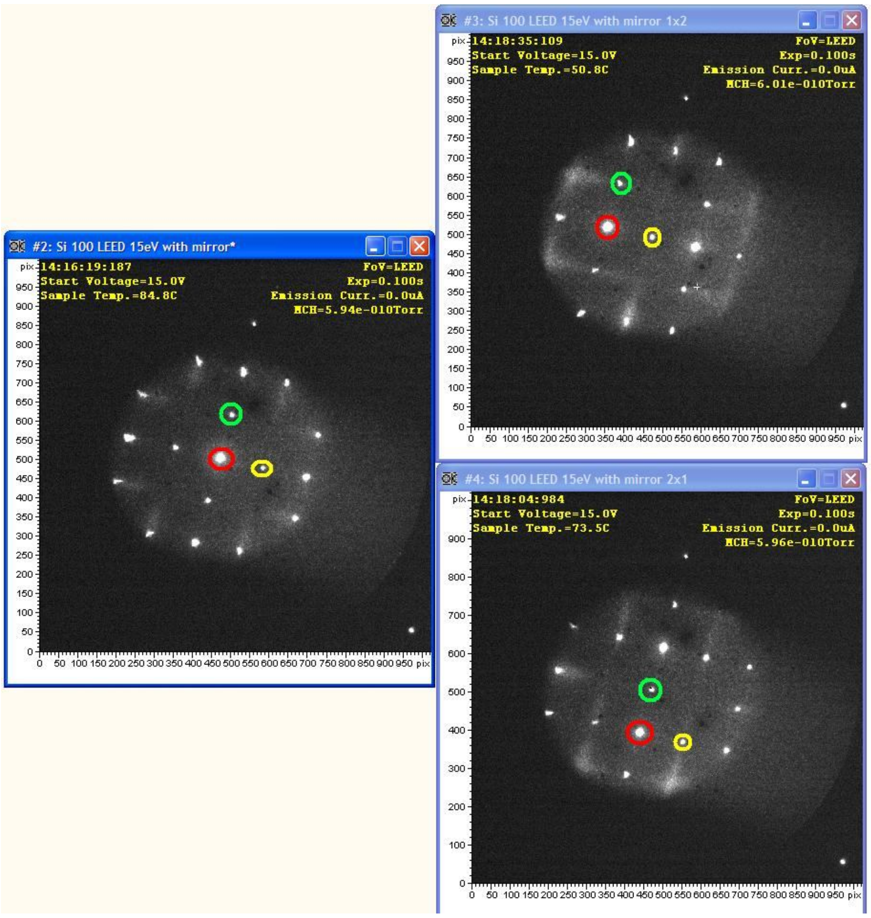
TL value too low **TL value correct** **TL value too high**



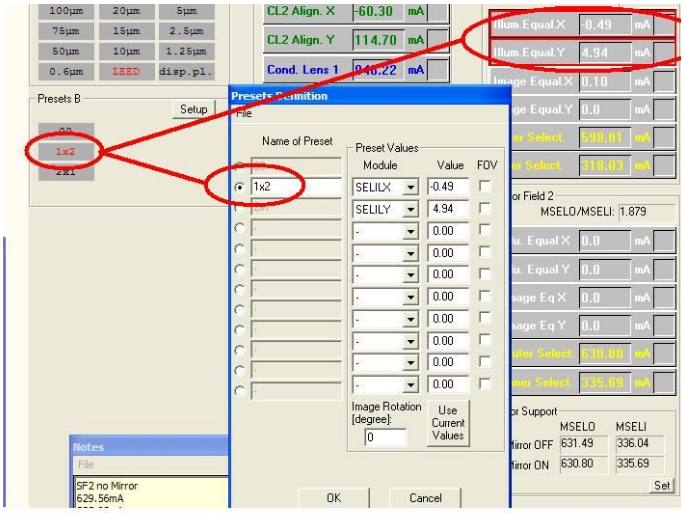
Now the values for MSELO and MSELI should be stored. There for press the set button in the Mirror support image. This special window leads to the ability to change from corrected to non-corrected mode and vise versa by just one click.

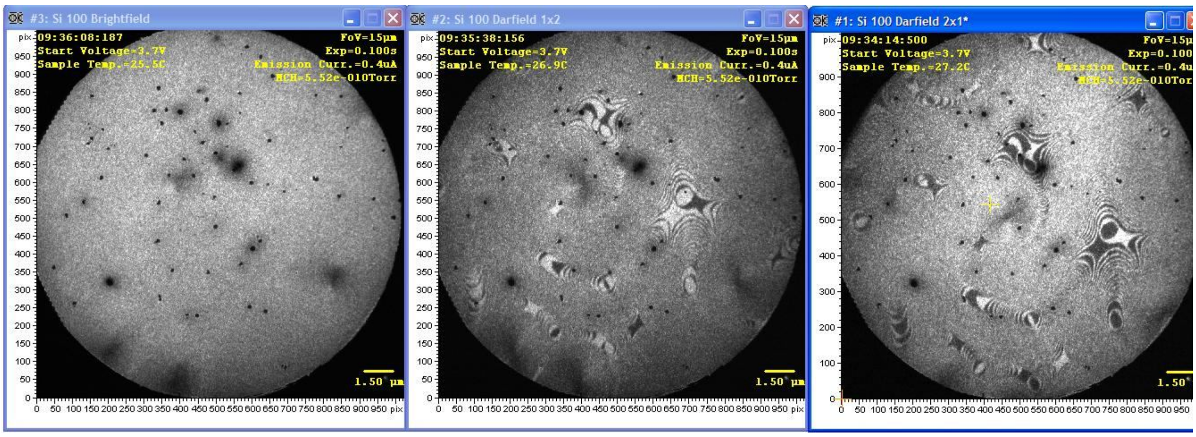
7.10. Darkfield imaging

Normally in LEEM the direct reflected beam (00) will be used for imaging. This method is called bright field imaging or bright field LEEM. For some specific samples it may be helpful not to look at the (00) beam but at some other LEED spots. As an example we have choosen a clean Si(100) crystal. This crystal has two overstructures: 1x2 and 2x1. For the darkfield imaging the whole alignment is the same like for normal bright field imaging. On the left side of the following picture you see the LEED pattern of this crystal. The Ewald-sphere is centered around the (00) beam. This alignemt is done with the Illum. Defl. X and Y.



The red circle marks the position of the (00) beam in all three images. In the upper right image the LEED spot highlighted in yellow is in the center of the Ewald-sphere. It is the so called 1x2 overstructure spot. In the lower left the 2x1 spot highlighted in green is in the center. These adjustments are done by the Illum. Equl. X,Y and programmed by the presets B. So it is possible to change from one spot to the other during imaging. The easiest way to procced is to mark the position of the (00) with a cross. Use the illumination equalizers to move the desiered spot at the position of the cross, open the Setup B, choose a slot and press the use-current-values-button. Now the values are stored and can be recalled by pressing the preset button.





Brightfield image Si100
Red highlighted (00) spot

Darkfield using 1x2 spot
(highlighted yellow)

Darkfield using 2x1 spot
(highlighted green)

8. Lens Settings for Selected Fields of View

HV= -20 kV; MObj=2150 mA; MTL1,2= 412 mA; MF1,2= 604 mA;
$TL_{without\ Mirror}$= 555 mA; $TL_{with\ Mirror}$= 587 mA; InL= 4489 V
Ratio (Selo/Seli) =1.895; Ratio (MSelo/MSeli) =1.895; RL=7986V

Field of view /µm	***FL /mA***	***IL /mA***	***P1 /mA***	***RL /V***	***Al /V***	***P2 /mA***	***P3 /mA***	***Rot. "on"***	***Rot. /° "off"***
120	2179	998	1347	7986	1026	1058	2650	31	291
100	2179	998	1347	7986	1169	1119	2650	33	288
75	2179	998	1347	7986	1358	1225	2650	39	283
50	2069	1068	1258	7986	1358	1225	2650	41	279
40	2061	1094	1182	7986	1358	1225	2650	47	273
25	1885	1218	1142	7986	1358	1225	2650	48	272
20	1795	1291	1106	7986	1358	1225	2650	50	270
15	1722	1401	1064	7986	1358	1225	2650	55	266
10	1646	1593	1008	7986	1358	1225	2650	64	256
7,5	1581	1835	990	7986	1358	1225	2650	75	245
2,5	1455	2900	887	7986	1632	1499	2650	143	176
1,25	1455	2900	887	7986	1777	2111	2650	179	144
0,7	1455	2900	887	7986	1888	2682	2650	211	170
LEED	2209	826	751	7986	874	1010	2650		
Disp.Pl.						855	1850		

9. Mirror Settings for different Energies

Start Voltage /V	Extractor /V	Focus /V	Mirror /V	Transfer Lens /V
904.2	1550	6046	-2368	7187
310.5	1575	6087	-2343	7179
158.0	1600	6136	-2321	7169
96.3	1625	6187	-2299	7157
65.2	1650	6238	-2279	7145
47.1	1675	6289	-2261	7133
35.8	1700	6338	-2243	7121
28.2	1725	6387	-2227	7109
22.9	1750	6434	-2212	7097
19.0	1775	6480	-2197	7085
16.0	1800	6524	-2184	7074
11.9	1850	6609	-2159	7052
9.3	1900	6689	-2138	7031
6.2	2000	6833	-2102	6993
4.2	2100	6958	-2075	6958
3.4	2200	7064	-2053	6926
2.7	2300	7155	-2038	6897
2.2	2400	7230	-2027	6870
1.6	2600	7344	-2015	6824
1.4	2700	7384	-2014	6804
1.2	2800	7415	-2015	6785
0.9	3000	7454	-2024	6751
0.8	3100	7463	-2032	6736
0.7	3200	7468	-2041	6722
0.6	3400	7463	-2064	6696
0.5	3600	7446	-2091	6673
0.4	3800	7419	-2123	6653
0.3	4400	7310	-2241	6603
0.25	5000	7192	-2380	6565

10. Comparative analysis of ACPEEM and PEEM modes

{InL=4550 eV, AL=1660 eV, U_p =1024.2 eV,U_o =20 keV}
(including the dependence δs (δ_E) in ACPEEM in “AC” mode CA-contrast aperture,µm
in tables $CA_{(opt)}$: δs= min;{ M,FV,ES }opt:{ δE,T }=optimum (δE) =max ; ES energyslit width, µm

E_C=1eV	ACPEEM mode (ES=optim.) $CA_{(opt)}$ =48µm; δs_{min} =2,6nm;						PEEM mode (ES=ES_{AC}) $CA_{(opt)}$ =27.2nm; $\delta_{s\ min}$ =4.6nm;					
FV/µm	.7	1.0	1.5	2.0	3.0	5.0	.7	1.0	1.5	2.0	3.0	5.0
$ES^{(opt)}$ /µm	2.3	3.0	3.9	4.7	6.1	8.6	2.3	3.0	3.9	4.7	6.1	8.6
δ_E(opt)/eV	.04	.052	.07	.08	.11	.15	.03	.04	.06	.07	.09	.12
$\delta_s(\delta_E)$/ nm	2.6	2.6	2.6	2.6	2.6	2.7	4.6	4.6	4.7	4.8	5.0	5.3

T_{AC} (2.6)/T_{PE} (4.6) =3.1;
T_{AC}(4.6)/T_{PE} (4.6) =3.9;
(CA_{AC}=53.7µm; CA_{PE}=27.2µm)

here and below

(D): diffraction limit marker
δ_E : energy window,eV
δ_s: resolution limit,nm
$T_{AC}(\delta_S)$,$T_{PE}(\delta_S)$-transmissions in AC and PEEM modes by the resolutions δ_S

E_C=2eV	ACPEEM mode (ES=optim.) $CA_{(opt)}$ =54µm; δs_{min} =1,6nm;						PEEM mode (ES=ES_{AC}) $CA_{(opt)}$ =26.8nm; $\delta_{s\ min}$ =3.3nm;					
FV/µm	.7	1.0	1.5	2.0	3.0	5.0	.7	1.0	1.5	2.0	3.0	5.0
$ES^{(opt)/}$µm	2.5	3.2	4.2	5.0	6.6	9.3	2.5	3.2	4.2	5.0	6.6	9.3
δ_E(opt)/eV	.04	.06	.07	.09	.12	.16	.03	.04	.06	.07	.09	.13
$\delta_s(\delta_E)$/nm	1.6	1.6	1.6	1.6	1.7	1.7	3.3	3.3	3.4	3.5	3.6	3.9

T_{AC}(1.64)/T_{PE}(3.3) =4.06;
T_{AC}(3.3)/T_{PE}(3.3) =5.3;
(CA_{AC}=6.2µm;CA_{PE}=26.8µm)

E_C=3eV	ACPEEM mode (ES=optim.) $CA^{(opt)}$=58µm;$\delta s^{(min)}$=1.25nm;						PEEM mode (ES=ES_{AC}) $CA^{(opt)}$=26.7µm; $\delta s^{(min)}$=2.7nm;					
FV/µm	.7	1.0	1.5	2.0	3.0	5.0	.7	1.0	1.5	2.0	3.0	5.0
$ES^{(opt)}$/µm	2.6	3.3	4.4	5.3	6.9	9.7	2.6	3.3	4.4	5.3	6.9	9.7
δ_E(opt)/eV	.05	.058	.077	.093	.122	.171	.035	.045	.059	.071	.093	.130
$\delta_S(\delta_E)$/nm	1.2	1.3	1.3	1.3	1.3	1.3	2.7	2.7	2.8	2.9	3.	3.3

T_{AC}(1.25)/T_{PE}(2.7)=4.7;
T_{AC}(2.7)/ T_{PE}(2.7)=6.4;
(CA_{AC}=67.6µm;CA_{PE}=26.7µm)

E_C=4,8eV	ACPEEM mode (ES=optim.) $CA^{(opt)}$=62µm;$\delta s^{(min)}$=0.9nm;						PEEM mode(ES=ES_{AC}) $CA^{(opt)}$=26.0µm;$\delta s^{(min)}$=2.2nm;					
FV/µm	.7	1.0	1.5	2.0	3.0	5.0	.7	1.0	1.5	2.0	3.0	5.0
$ES^{(opt)}$/µm	2.7	3.5	4.6	5.5	7.2	10.0	2.7	3.5	4.6	5.5	7.2	10.0
$\delta_E^{(opt)}$/eV	.05	.06	.081	.10	.13	.18	.04	.05	.06	.07	.10	.13
$\delta s(\delta_E)$/nm	0.9	0.9	0.9	0.9	0.9	0.9	2.2	2.2	2.3	2.3	2.4	2.6

T_{AC}(0.9)/T_{PE}(2.2)=5.7;
T_{AC}(2.2)/ T_{PE}(2.2)=8.2;
(CA_{AC}=74µm;CA_{PE}=26µm)

Appendix A

1st Chassis Lens Name Address No	1 P3DX B55	2 P3DY B56	3 P2 U41	4 P3 U80	5	6	7 MIRST 78	8 MIRST 79
Cable	8	Pin	4Pin	4Pin			8	Pin
2nd Chassis Lens Name Address No	MSTIGA B71	MSTIGA B72	TMDX B73	TMDY B74	MFL2DX B69	MFL2DY B70	MTL1 U83	MFL1 U84
Cable		8	Pin		8	Pin	4Pin	4Pin
3rd Chassis Lens Name Address No	SELI2 U81	SELO2 U82	IMEQX2 B61	IMEQY2 B62	ILEQX2 B63	ILEQY2 B64	MFL1DX B65	MFL1DY B66
Cable	4 **1A**	Pin **1A**		8	Pin		8	Pin
4th Chassis Lens Name Address No	MTL2DX B67	MTL2DY B68	ASTIGA B57	ASTIGB B58	RETDX B59	RETDY B60	MTL2 B85	MFL2 B86
Cable	8	Pin		8	Pin		4Pin	4Pin
5th Chassis Lens Name Address No	SELI1 U34	SELO1 U35	IMEQX1 B15	IMEQY1 B16	ILEQX1 B13	ILEQY1 B14	SEC2AX B75	SEC2AX B76
Cable	4 **1A**	Pin **1A**		8	Pin		8	Pin
6th Chassis Lens Name Address No	ILDX B21	ILDY B22	IL U39	P1 U40	DSTIGA B17	DSTIGB B18	FLDX B19	FLDY B20
Cable	8	Pin	4Pin	4Pin		8	Pin	
7th Chassis Lens Name Address No	P2DX B25	P2DY B26	ACCDX B27	ACCDY B28	CL3 U33	CL2 U32	P1DX B23	P1DY B24
Cable	8	Pin	8	Pin	4Pin	4Pin	8	Pin
8th Chassis Lens Name Address No	CL3DX B3	CL3DY B4	OSTIGA B9	OSTIGB B10	OBJDX B11	OBJDY B12	TL U37	FL U38
Cable	8	Pin		8	Pin		4Pin	4Pin
9thChassis Lens Name Address No	MOBJ U36	CL1 U31	ILLSTIGA B7	ILLSTIGB B8	CL3DX B5	CL3DX B6	CL2DX B1	CL2DY B2
Cable	4Pin	4Pin		8	Pin		8	Pin
HV-Board Address No	STV 42	BOMB 43	TEMPC 45	TEMP 46	EA 49	MIRROR 51	WEH 48	

Appendix B

Calibration table for W5%Rh vs. W26%Rh.

Temperature / °C	*Thermovoltage /mV*
-175	-1,50
-150	-1,35
-125	-1,22
-100	-1,01
-75	-0,79
-50	-0,55
-25	-0,29
0	-0,05
100	1.38
200	3,15
300	4,95
400	6.723
500	8.657
600	10.620
700	12.580
800	14.499
900	16.375
1000	18.224
1100	20.016
1200	21.786
1300	23.476
1400	25.137
1500	26.728
1600	28.279
1700	29.784
1800	31.189
1900	32.509
2000	33.778
2100	34.929
2200	36.010
2300	37.011

Appendix C

Calibration table for Temperature Regulation

Potentiometer / Turn	***Thermovoltage / mV***	***Temperature / °C***
0	-1,6	-190,7
1	3,86	239,8
2	7,72	456,1
3	11,58	648,9
4	15,44	848,2
5	19,3	1058,9
6	23,16	1277,8
7	27,02	1519,1
8	30,88	1786,3
9	34,74	2090,2
10	37,0	2305,8

Appendix D

Vacuum Interlock (Setpoints)

Setpoints Main chamber (MCH)

SP1:	1.0 x 10^{-6} Torr	HV Rack, Image Intensivier off
SP2:	1.0 x 10^{-7} Torr	Beeper, MCH pressure limit exceeded
SP3:	3.6 x 10^{-6} Torr	Bake out off
SP4:	5.0 x 10^{-9} Torr	TSP MCH, Voltage Vacuum Monitor override

Setpoints Columns (COL)

SP1:	5.0 x 10^{-8} Torr	HV Rack, Image Intensivier, Evaporator COL off
SP2:	1.0 x 10^{-8} Torr	Beeper, COL pressure limit exceeded
SP3:	3.6 x 10^{-6} Torr	Bake out off
SP4:	5.0 x 10^{-9} Torr	TSP COL, Voltage Vacuum Monitor override

Setpoints Distribution chamber (DCH)

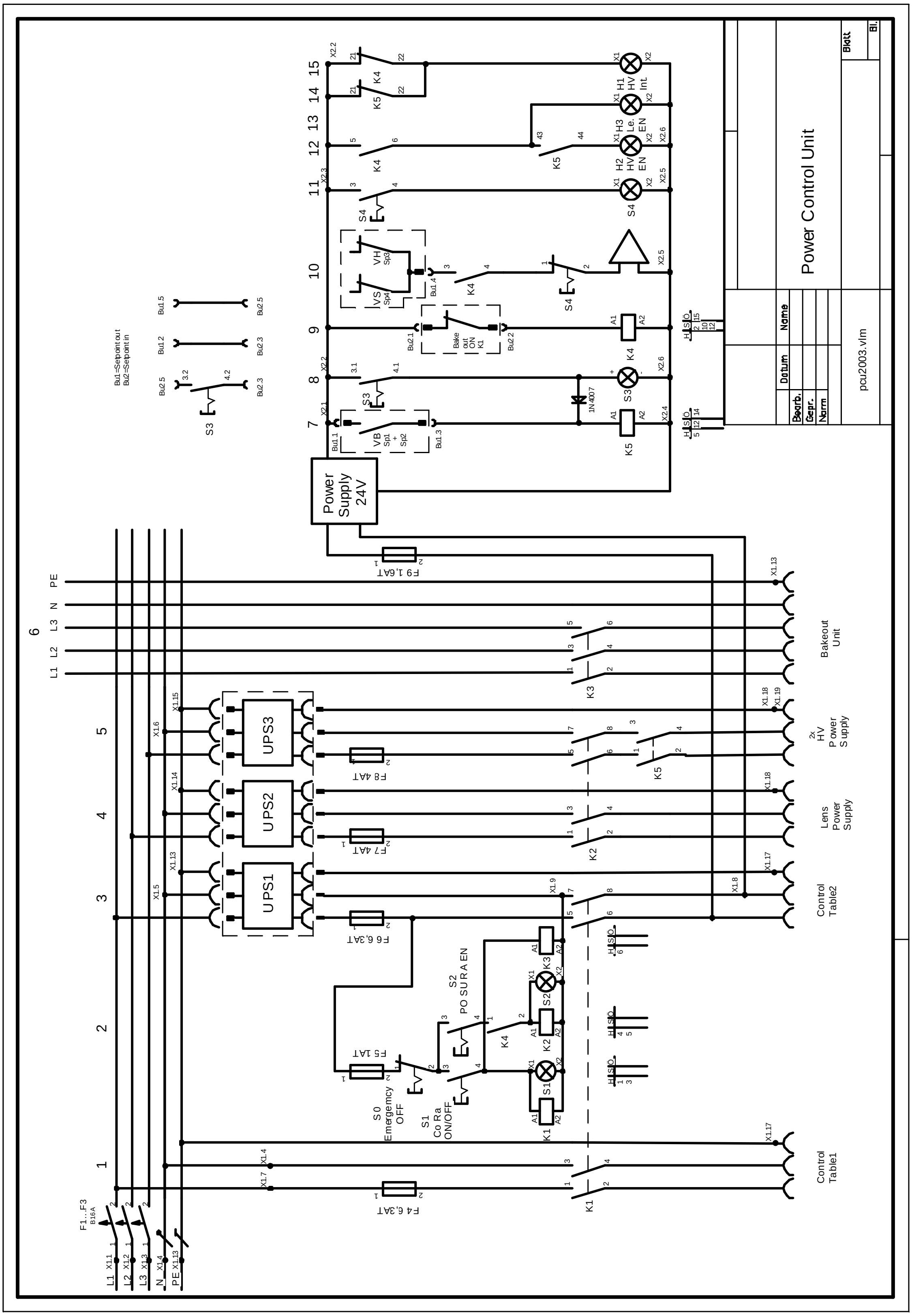
SP3:	3.6 x 10^{-6} Torr	Bake out off
SP4:	5.0 x 10^{-9} Torr	TSP PCH, Voltage Vacuum Monitor override

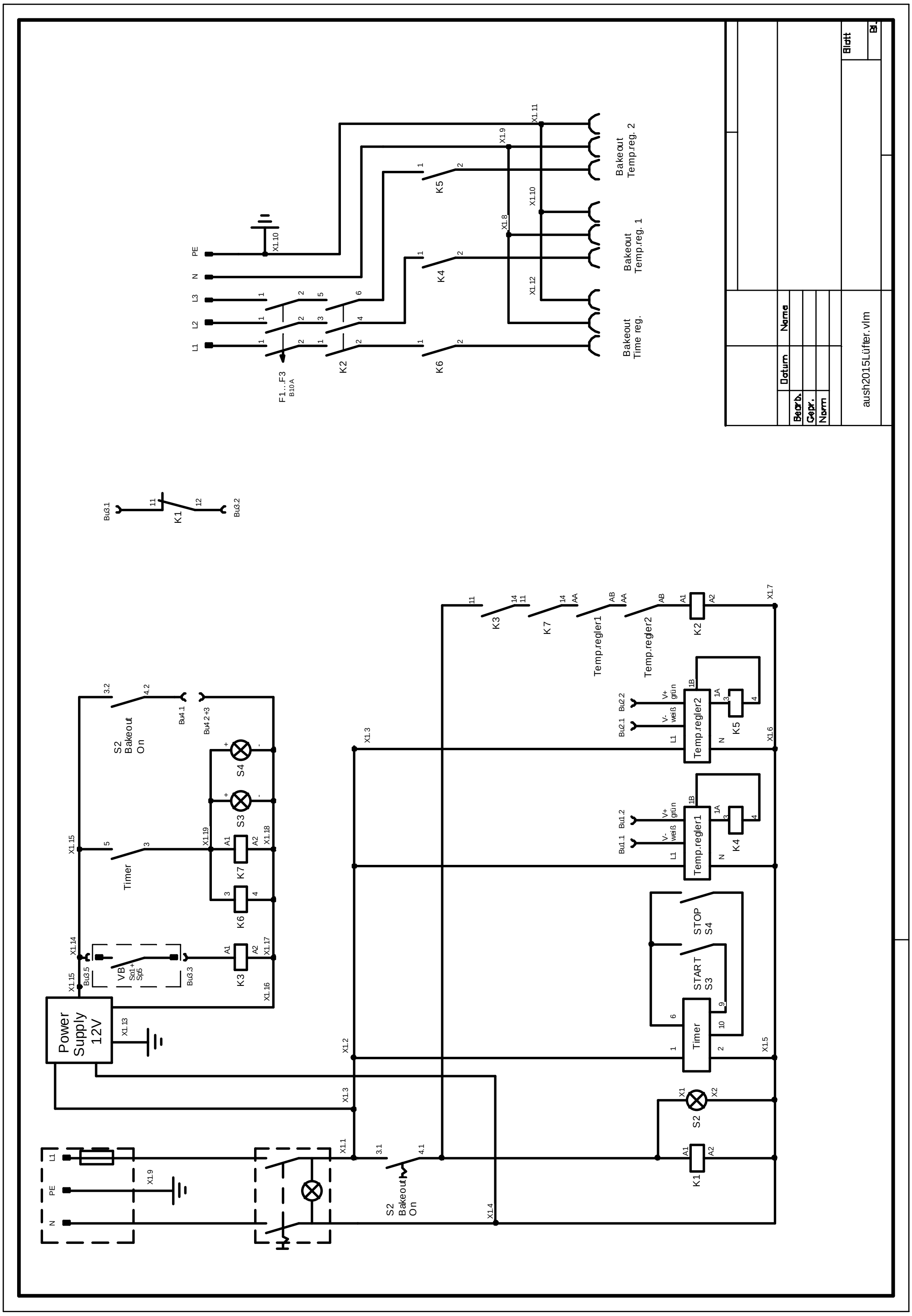
Setpoints Entrance chamber (ECH)

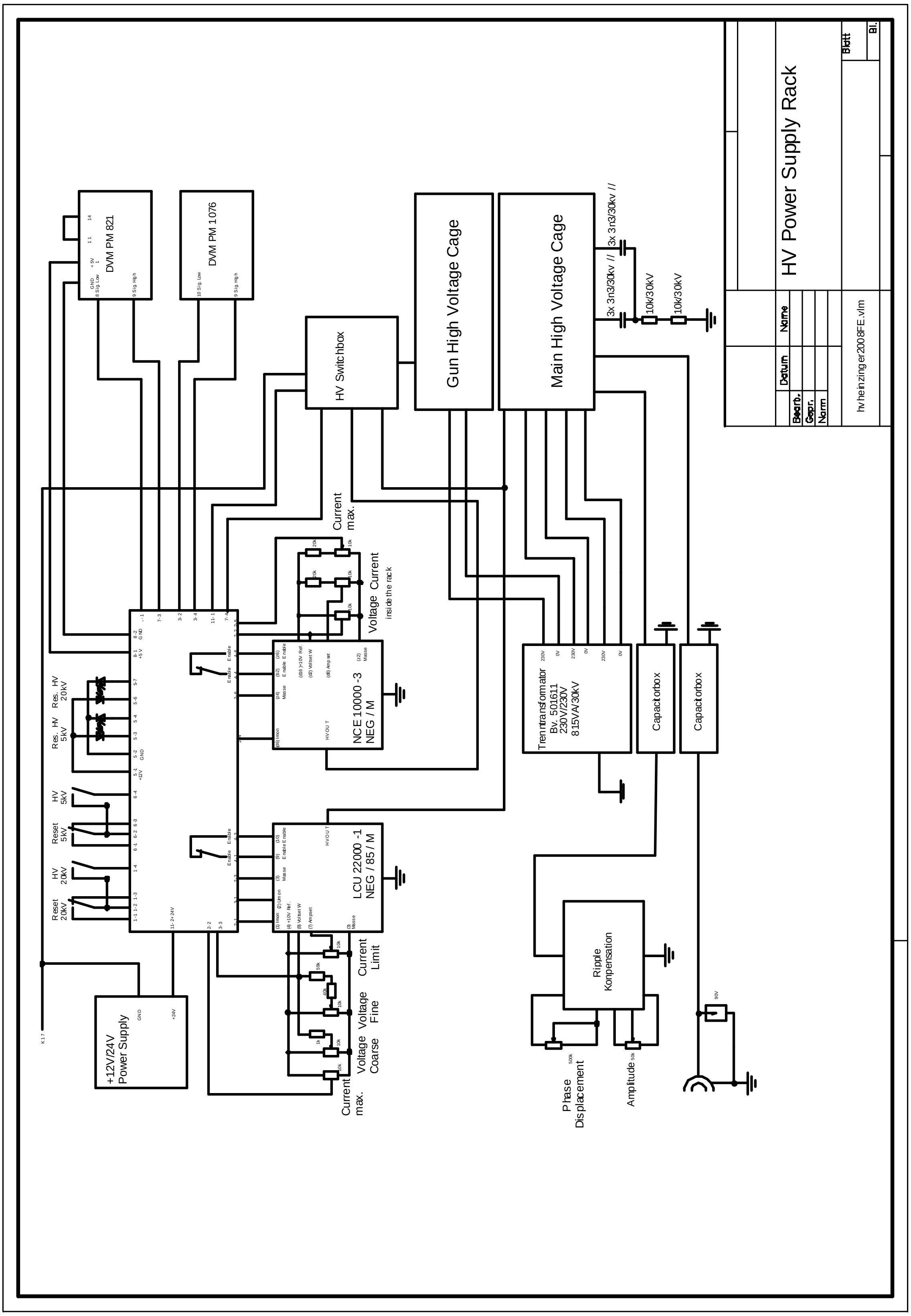
SP3:	3.6 x 10^{-6} Torr	Bake out off

Appendix E

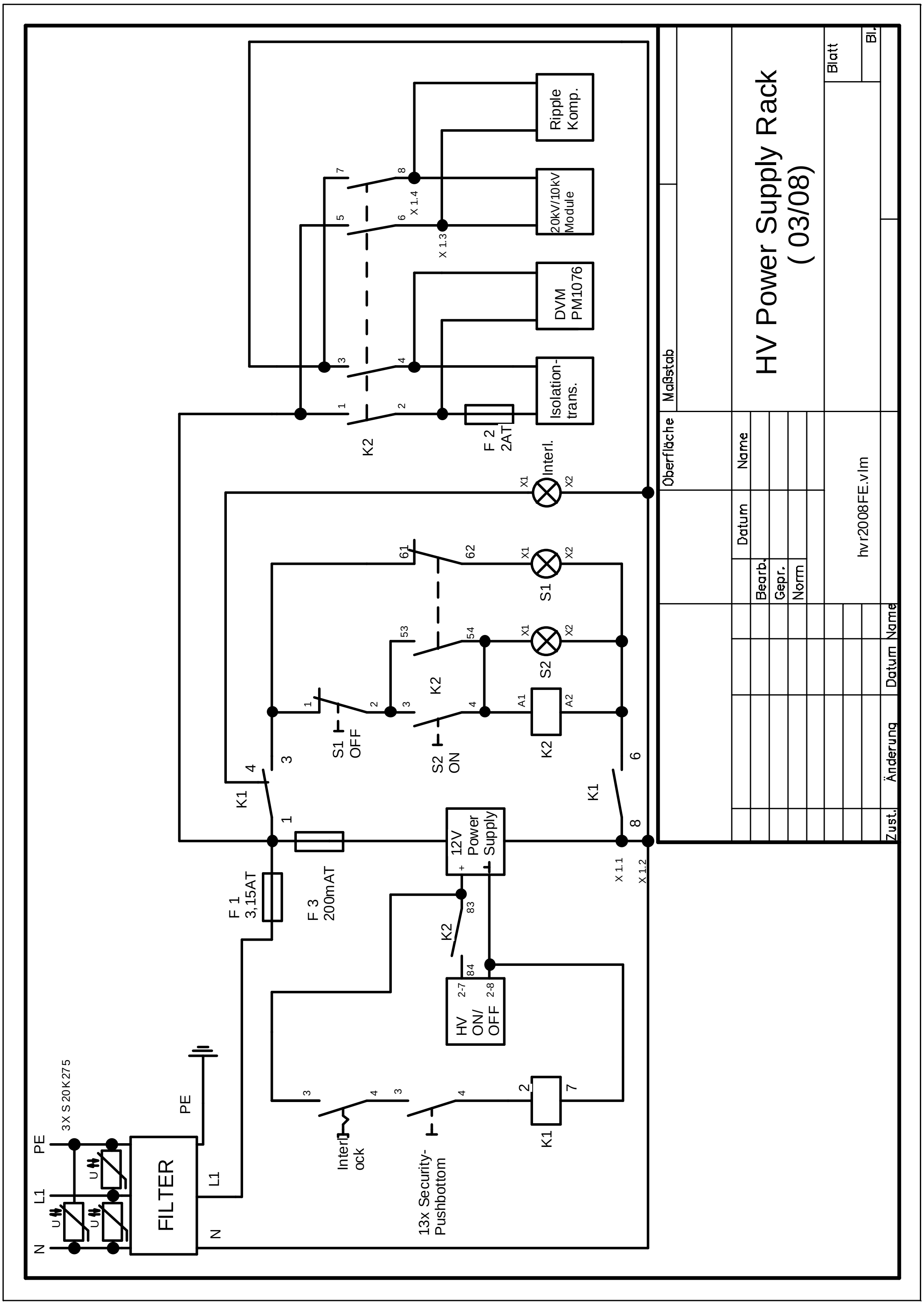
Power Supplies Schematics



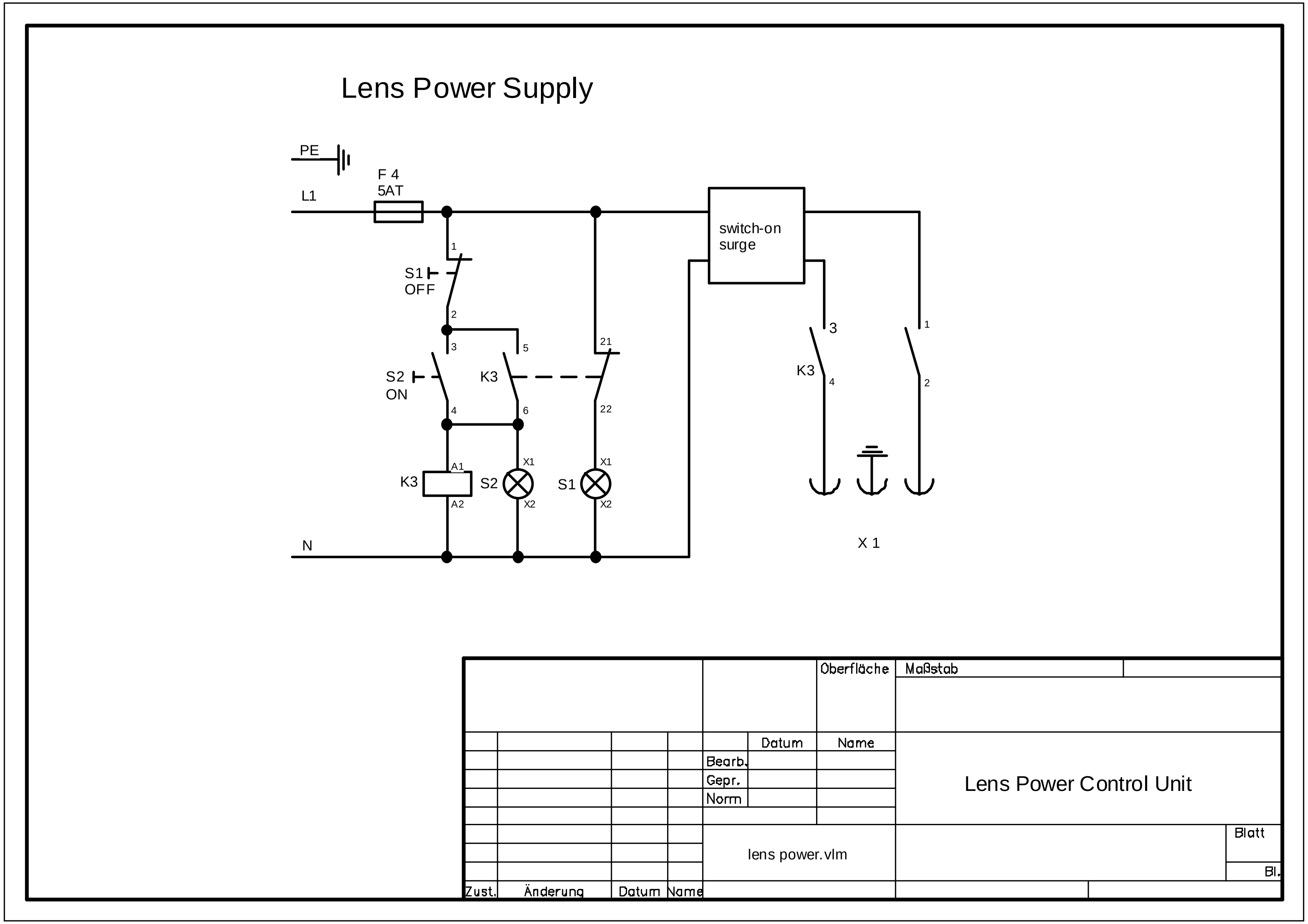

Bakeout
Temp.reg. 2
Bakeout
Temp.reg. 1
Bakeout
Time reg.
F1...F3
B10A
K2
K4
K5
K6
K1
Power
Supply
12V
S2
Bakeout
On
Timer
Temp.regler1
Temp.regler2
STOP
S4
START
S3
K3
K7
Datum
Name
Bearb.
Gepr.
Norm
Blatt
aush2015Lüfter.vlm



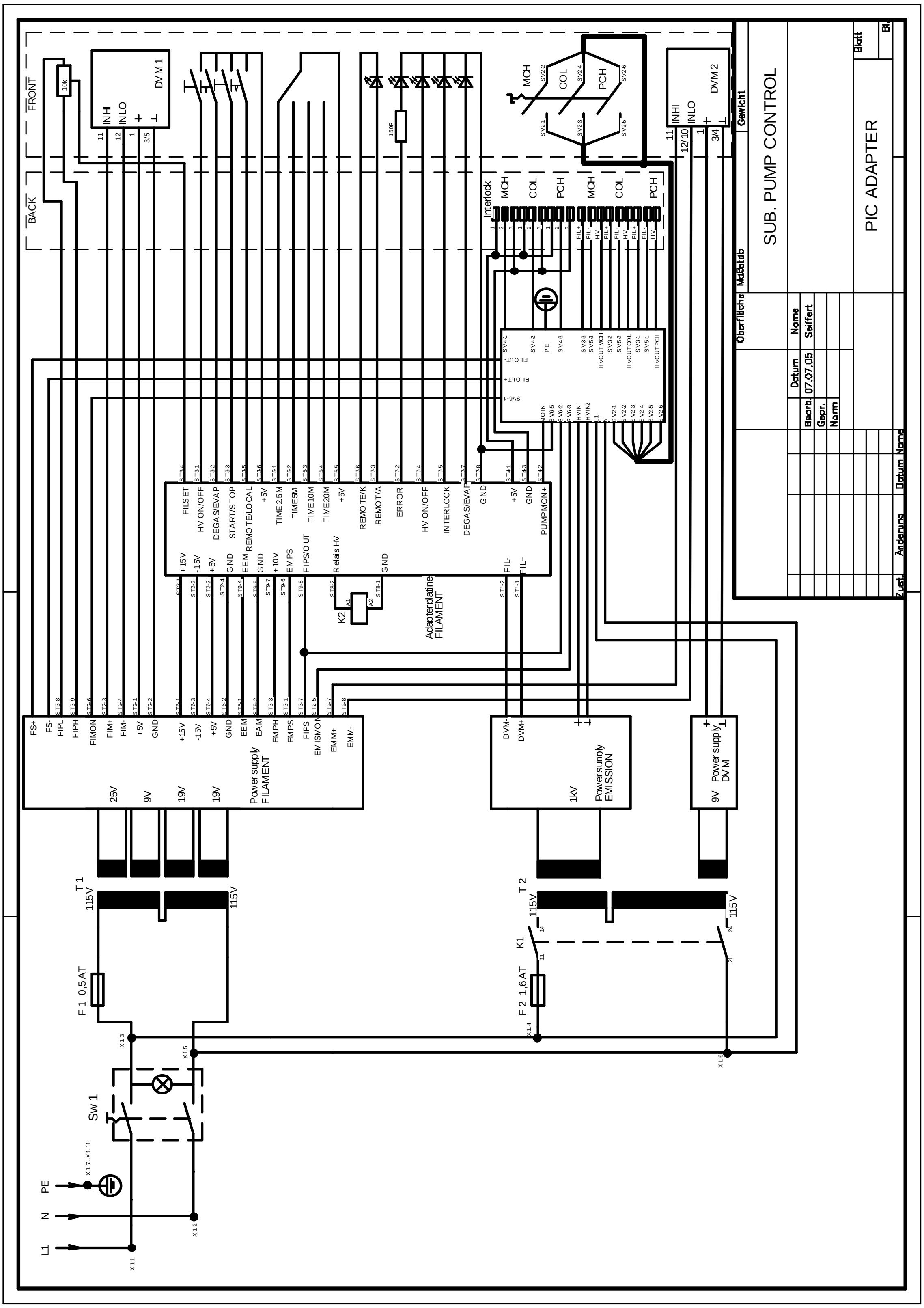
HV Power Supply Rack
Datum
Name
Bearb.
Gepr.
Norm
hv/heinzinger2008FE.vlm
Blatt
Bl.
DVM PM 821
DVM PM 1076
HV Switchbox
Gun High Voltage Cage
Main High Voltage Cage
3x 3n3/30kv //
10k/30kV
Current max.
Voltage Current
inside the rack
NCE 10000 -3
NEG / M
LCU 22000 -1
NEG / 85 / M
Trenntransformator
Bv. 501611
230V/230V
815VA/30kV
Capactorbox
Capactorbox
Ripple Konpensation
Phase Displacement
Amplitude
Res. HV 20kV
Res. HV 5kV
HV 5kV
Reset 5kV
HV 20kV
Reset 20kV
+12V/24V Power Supply
Current Limit
Voltage Fine
Voltage Coarse
Current max.



HV Power Supply Rack
(03/08)
hvr2008FE.vlm
Oberfläche
Maßstab
Bearb.
Gepr.
Norm
Datum
Name
Zust.
Änderung
Datum
Name
Blatt
Bl.
Ripple Komp.
20kV/10kV Module
DVM PM1076
Isolation-trans.
F 2 2AT
K2
Interl.
S1
S2
K2
S1 OFF
S2 ON
K1
12V Power Supply
F 1 3,15AT
F 3 200mAT
HV ON/ OFF
K2
Interl ock
13x Security-Pushbottom
K1
FILTER
3 X S 20 K 275
PE
L1
N
X 1.1
X 1.2
X 1.3
X 1.4



Lens Power Supply
PE
L1
F 4
5AT
S1
OFF
S2
ON
K3
switch-on
surge
X 1
N
Oberfläche
Maßstab
Datum
Name
Bearb.
Gepr.
Norm
Lens Power Control Unit
lens power.vlm
Blatt
Bl.
Zust.
Änderung
Datum
Name


SUB. PUMP CONTROL
PIC ADAPTER
Bearb. 07.07.05 Seifert
FRONT
BACK
DVM 1
DVM 2
Interlock
MCH
COL
PCH
Adapterplatine FILAMENT
Relais HV
K2
Power supply FILAMENT
Power supply EMISSION
Power supply DVM
T 1
T 2
115V
F 1 0,5AT
F 2 1,6AT
K1
Sw 1
PE
N
L1

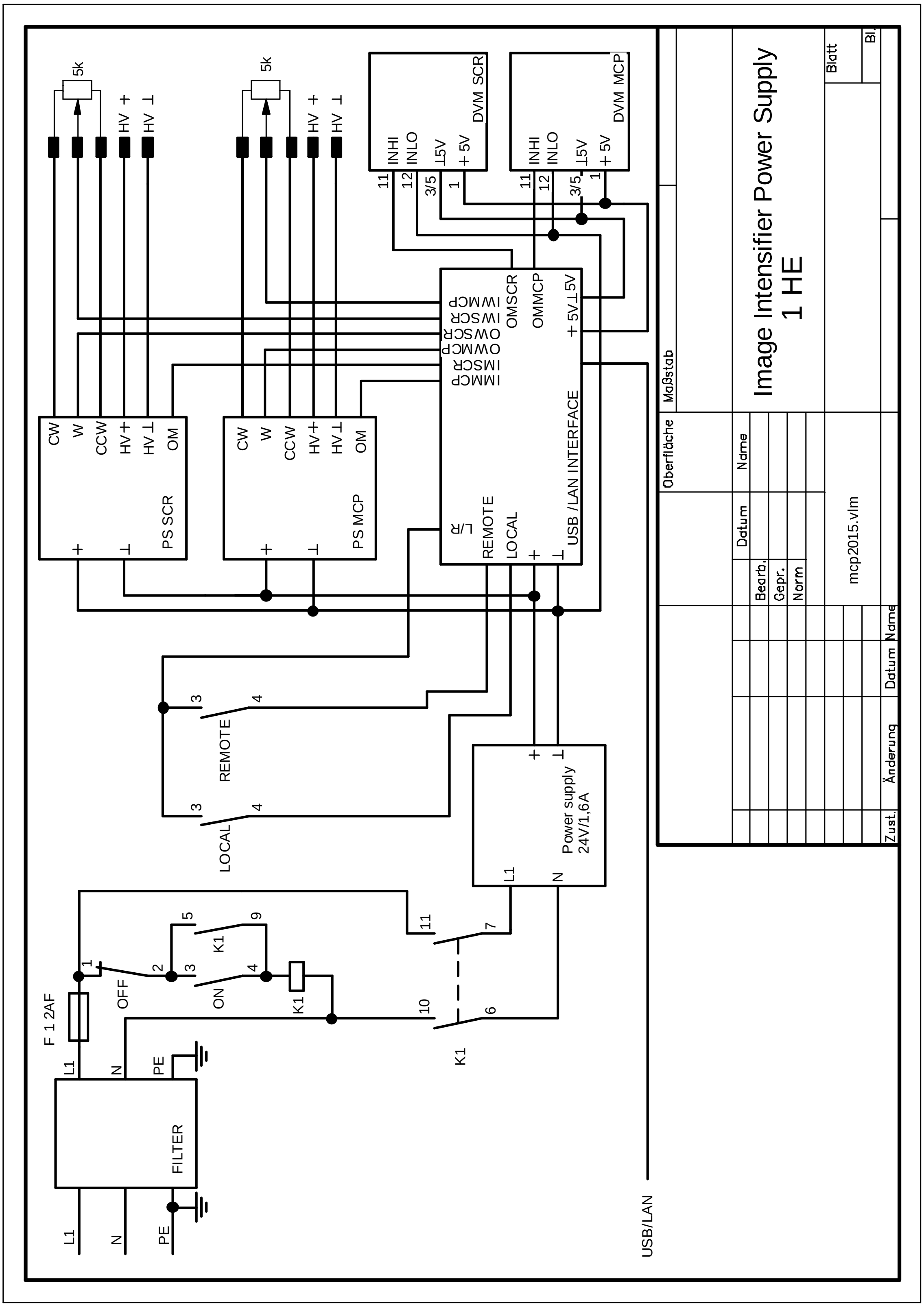
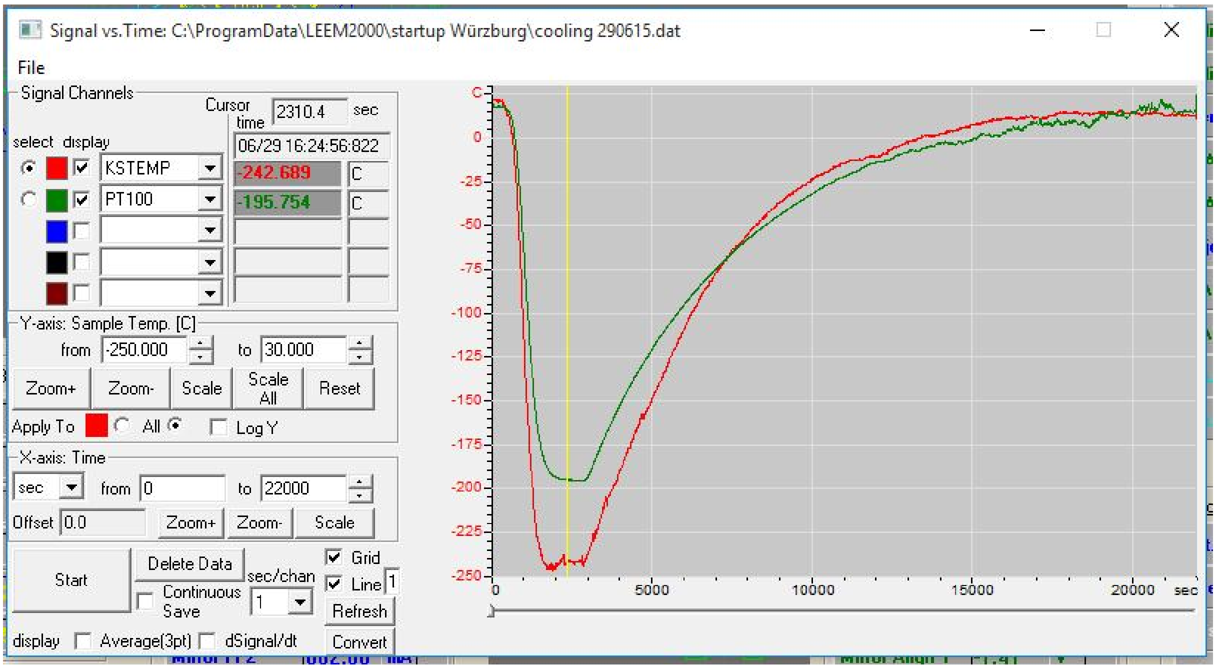


Image Intensifier Power Supply
1 HE
mcp2015.vlm
Blatt
Bl.
Maßstab
Oberfläche
Name
Datum
Bearb.
Gepr.
Norm
Zust.
Änderung
Datum
Name
DVM SCR
DVM MCP
INHI
INLO
⊥5V
+ 5V
11
12
3/5
1
5k
HV +
HV ⊥
CW
W
CCW
HV+
HV⊥
OM
PS SCR
PS MCP
OMSCR
OMMCP
+ 5V⊥5V
IWMCP
IWSCR
OWSCR
OWMCP
IMSCR
IMMCP
L/R
REMOTE
LOCAL
USB /LAN INTERFACE
Power supply
24V/1,6A
L1
N
PE
FILTER
F 1 2AF
OFF
ON
K1
USB/LAN

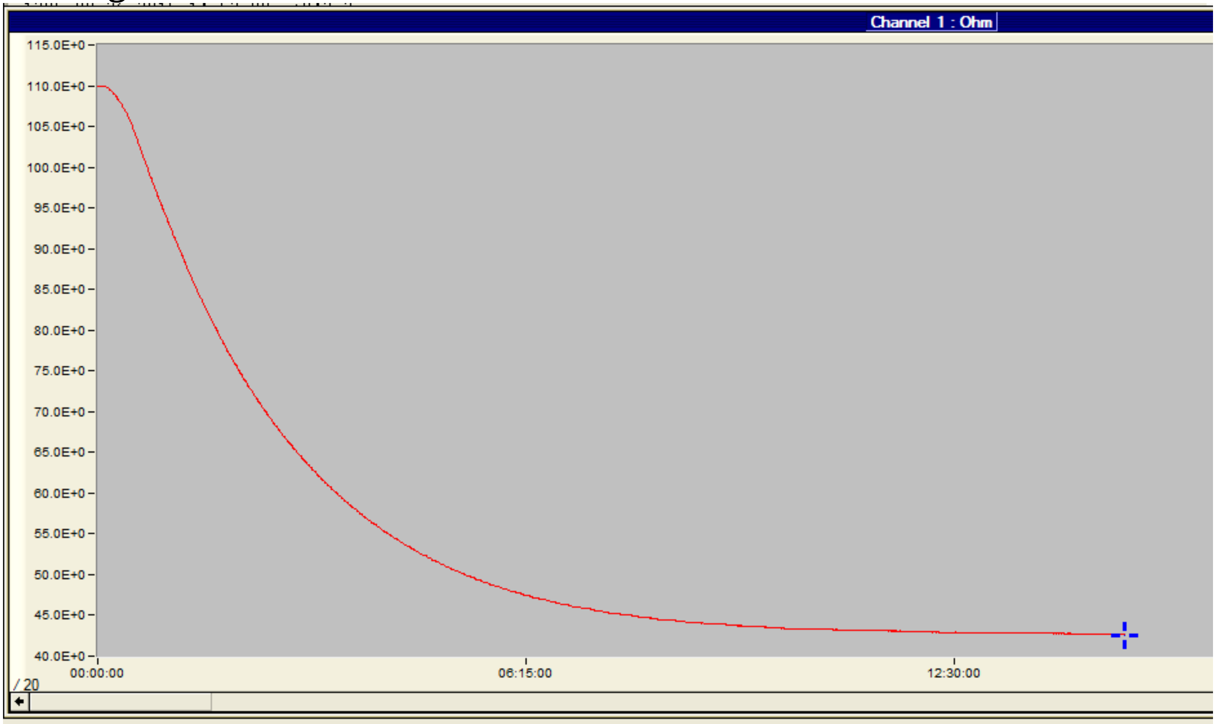
Appendix F

Cooling curves of Main chamber and Distribution chamber



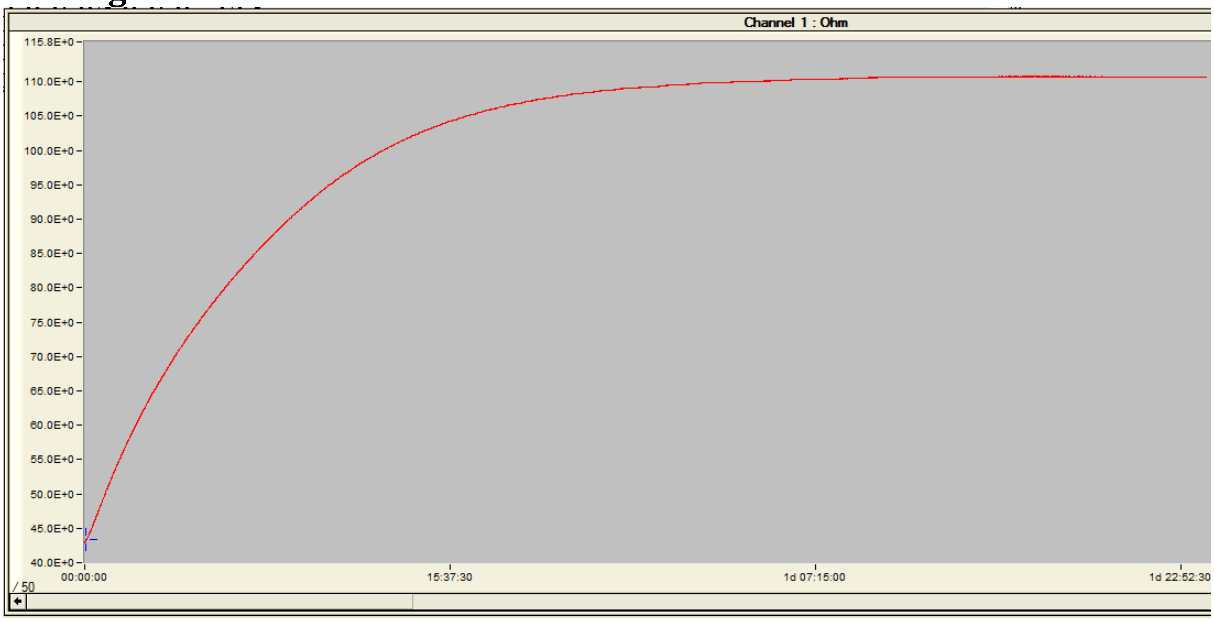
Cooling Main chamber

Cooling curves of Main chamber



Cooling of Distribution chamber

Cooling curves of Distribution chamber



Warming up of Distribution chamber after cooling