x.sight
service manual

cytena GmbH

Supporting models

c.sight
b.sight
f.sight

CONFIDENTIAL DOCUMENT

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Content

1 About this manual

This manual is intended for service issues. All actions and processes described within this document shall only be performed by trained personnel.

This manual contains information about the device hardware and how to maintain and repair it. The manual is containing hints and warnings (caution) helping to guide the technical service employee and show him/her where to pay special attention. These are color coded like shown below:

> ***HINT:*** *Hints shall help the user to understand certain controls or situation better. Hints can also contain practically relevant tips and tricks.*

> ***DANGER:*** *this is a safety relevant text. Danger indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury. This signal word is limited to the most extreme situations.*

> ***WARNING:*** *this is a safety relevant text. Warning indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.*

> ***CAUTION:*** *this is a safety relevant text. Caution indicates a potentially hazardous situation which, if not avoided, could result in minor or moderate injury. It may also be used to alert against unsafe practices.*

The chapters are marked accordingly with the color code of the models (blue, green, gray).

2 Electrical and chemical risks and safety

	**WARNING: High voltage hazard!** Pay special attention when opening the device while it is still powered or when you power an open device. The device contains circuits which carry power supply voltage. Pay special attention on the piezo driver electronics. That carries a DC voltage of 180 V. Even when you disconnect the power supply to the electronics, this voltage can remain in the circuits for several minutes due to a capacitance in the circuits!
	**WARNING: Danger of fire, explosion and injury by use of aggressive liquids!** Do not use or clean electrical parts of the device with flammable or chemical aggressive media or solvents. Always wear protective gloves, eye protection and lab coat when operating the device. Always consult the safety data sheets of the liquids used for dispensing and ensure that the required safety measures are taken.
	**WARNING: Injury and safety risks! Hand injuries!** Never let foreign objects or materials such as screws or liquids enter into the device. It is forbidden to place any other objects than the specified onto the carrier. Do not leave any tools or equipment inside the device. When you open the device and operate it with defeated interlocks, you will have access to moving parts. Pay special attention to those. Do not touch moving parts. Do not place any parts of your body (finger, hand, etc.) next to or into the driving area of such parts. Moving parts will not stop. Risk of serious injury. During service, you may work inside the open device. Pay attention, there might be sharp corners and edges (especially of metal parts). Risk of injury.
	**WARNING: Biohazard! Environmental issues!** Only place the x.sight in a closed room, on a level surface. It is advisable to place the device in a biological laboratory in a laboratory bench or in a biosafety cabinet. Do not expose the device to extreme environmental conditions. Normal environmental issues are: • Temperature: 5°C – 40°C • Humidity: 10 – 80 % (non-condensing) The cytena GmbH does not guarantee the proper operation of the x.sight device, should it be operated outside of the above ambient conditions.
	**WARNING: Heavy loads (>30 kg)** The x.sight devices weigh between 30 kg and 35 kg. Lifting heavy loads can result in injury. Do not lift the device yourself, but always with the help of a second person. Do not lift and/or carry the device if you have health problems or disabilities. Inform yourself at your responsible laboratory supervisor or safety officer about possible further risks.
	**WARNING: Laser radiation! – Laser class 1** Concerning f.sight models only! Under normal operation, the f.sight is subject to laser class 1 according to DIN EN 60825-1: 2014 and FDA 21 CFR 1040.10 and 1040.11. No further safety measures are mandatory.

3 Laser safety

3.1 Laser compliance statement

Complies with IEC 60825-1:2014. Complies with 21 CFR 1040.10 and 1040.11 except for conformance with IEC 60825-1 Ed. 3., as described in Laser Notice No. 56, dated May 8, 2019

3.2 Laser safety

WARNING: Laser radiation! – Laser class 3B

Concerning f.sight models only!

CLASS 3B LASER RADIATION WHEN OPEN AND INTERLOCK DEFEATED.
AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION.

The embedded laser module itself is subject to protection class 3B according to DIN EN 60825-1: 2014 and FDA 21 CFR 1040.10 and 1040.11. The accessible laser radiation is dangerous for the eye and in special cases also for the skin. Diffused scattered light is generally considered harmless. During service cases or under non-normal operation safety class 1 may not be guaranteed and further safety measures may be mandatory.

Compliance references:

- FDA 21CFR 1040.10 and 1040.11 (incl. Laser Notice 56)
- IEC 60825-1:2014

3.3 Laser module information

The following laser module can be embedded:

CNI-473	473 nm (blue)	100 mW (class 3B)	f.sight Rev.1
OBIS-488	488 nm (blue)	100 mW (class 3B)	f.sight Rev.2
OBIS-561	561 nm (blue)	100 mW (class 3B)	f.sight Rev.2

3.4 Laser classes information tables

The follow table provides a good overview over laser classes and their potential hazards for a human operator. Please make yourself familiar with this table.

ANSI and IEC laser classification	Class 1		Class 2		Class 3		Class 4
Sub-class	Class 1	Class 1M	Class 2	Class 2M	Class 3R	Class 3B	Class 4
U.S. FDA laser classification	Class I	No special FDA class	Class II	No special FDA class	Class IIIa (definition is different but results are similar)	Class IIIb	Class IV
Human-accessible laser power (for visible light)	For visible light, emits beam less than 0.39 milliwatts, or beam of any power is inside device and is not accessible during operation.		Emits visible beam of less than 1 milliwatt.		For visible light, emits beam between 1 and 4.99 milliwatts.	For visible light, emits beam between Class 3R limit (e.g. 5 milliwatts) and 499.9 milliwatts	For visible light, emits beam of 500 milliwatts (1/2 Watt) or more
Caution/warning indication	No special caution/ warning indication		No special caution/ warning indication		CAUTION	WARNING	DANGER
Label descriptive text		DO NOT VIEW DIRECTLY WITH OPTICAL INSTRUMENTS	DO NOT STARE INTO BEAM	DO NOT STARE INTO BEAM OR EXPOSE USERS OF TELESCOPIC OPTICS	AVOID DIRECT EYE EXPOSURE	AVOID EXPOSURE TO BEAM	AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION

ANSI and IEC laser classification	Class 1		Class 2		Class 3		Class 4
Sub-class	Class 1	Class 1M	Class 2	Class 2M	Class 3R	Class 3B	Class 4
U.S. FDA laser classification	Class I	No special FDA class	Class II	No special FDA class	Class IIIa (definition is different but results are similar)	Class IIIb	Class IV
EYE AND SKIN HAZARDS							
Eye hazard for intraocular exposure (having a direct or reflected beam enter the eye)	Safe, even for long-term intentional viewing. For visible light, usually applies when the laser is enclosed inside a device (ex: CD or DVD player) with no human access to laser light.	Safe for unaided eye exposure. May be hazardous if viewed with optical instruments such as binoculars or eye loupe.	Safe for unintentional exposure less than 1/4 second. Do not stare into beam.	Safe for unintentional (< 1/4 sec) unaided eye exposure. May be hazardous if viewed with optical instruments such as binoculars or eye loupe.	Unintentional or accidental exposure to direct or reflected beam has a low risk. Avoid intentional exposure to direct or reflected beam.	Eye hazard; avoid exposure to direct or reflected beam.	Severe eye hazard; avoid exposure to direct or reflected beam.
Maximum or typical Nominal Ocular Hazard Distance (for 1 milliradian beam, exposure time less than 1/4 second)	Not an eye hazard -- does not apply	Consult an LSO as described in the Technical Note below	**NOHD of 0.99 mW beam:** 23 ft (7 m)	Consult an LSO as described in the Technical Note below	**NOHD of 4.99 mW beam:** 52 ft (16 m)	**NOHD of 499.9 mW beam:** 520 ft (160 m)	**NOHD of 1000 mW (1 Watt) beam:** 733 ft (224 m). **NOHD of 10 W beam:** 2320 ft (710 m)
Eye hazard for diffuse reflection exposure (looking at the laser "dot" scattered off a surface)	None	Consult an LSO	None	Consult an LSO	None	Generally safe. Avoid staring at the laser "dot" on a surface for many seconds at close range.	To avoid injury, do not stare at laser "dot" on a surface. The light is too bright if you see a sustained afterimage, lasting more than about 10 seconds.
Skin burn hazard	None	Consult an LSO	None	Consult an LSO	None	Can heat skin if beam is held long enough on skin at close range	Can instantly burn skin. Avoid direct exposure to the beam.
Materials burn hazard	None	Consult an LSO	None	Consult an LSO	None	Can burn materials if beam is held long enough on substance at close range	Can instantly burn materials. Avoid direct exposure to the beam, for materials susceptible to burning.
VISUAL INTERFERENCE DISTANCES							
Maximum or typical flashblindness distance (FAA 100 µW/cm², for 1 milliradian beam, 555 nm green light)	Not applicable; beam is usually contained inside a device such as a CD or DVD player	Consult an LSO	**For a 0.99 mW beam:** 117 ft 36 m	Consult an LSO	**For a 4.99 mW beam:** 261 ft 80 m	**For a 499 mW beam:** 2,614 ft (1/2 mile) 797 m (0.8 km)	**For a 1 Watt beam:** 3,696 ft (0.7 mile) 1,127 m (1.1 km) **For a 10 W beam:** 11,689 ft (2.2 miles) 3,563 m (3.5 km)
Maximum or typical glare distance (FAA 5 µW/cm², for 1 milliradian beam, 555 nm green light)	See above	Consult an LSO	523 ft 159 m	Consult an LSO	1,169 ft 356 m	11,689 ft (2.2 miles) 3,563 m (3.5 km)	**For a 1 Watt beam:** 16,531 ft (3.1 miles) 5,039 m (5 km) **For a 10 W beam:** 52,275 ft (9.9 miles) 15,933 m (16 km)
Maximum or typical distraction distance (FAA 0.05 µW/cm² or 50 nanowatts/cm², for 1 milliradian beam, 555 nm green light)	See above	Consult an LSO	5,227 ft (1 mile) 1,593 m (1.6 km)	Consult an LSO	11,689 ft (2.2 miles) 3,563 m (3.5 km)	116,890 ft (22 miles) 35,628 m (35.6 km)	**For a 1 Watt beam:** 165,307 ft (31 miles) 50,386 m (50 km) **For a 10 W beam:** 522,746 ft (99 miles) 159,333 m (160 km)
Technical Notes	For a 1/4 second exposure to accessible visible-light beams, Class 1 limits are the same as Class 2, and such lasers are usually labeled as Class 2.	We are unaware of any Class 1M laser devices intended for consumer use. If you do have such a laser, consult a qualified Laser Safety Officer for more detailed analysis.	Class 2 (and 2M) only applies to visible lasers. Infrared and ultraviolet lasers cannot be Class 2 (or 2M).	We are unaware of any Class 2M laser devices intended for consumer use. If you do have such a laser, consult a qualified Laser Safety Officer for more detailed analysis.	Class 3R is either: (1) From 1 to 4.99 mW into a 7mm aperture (e.g., pupil of the eye) or (2) five times the Class 2 limit of 2.5 mW/cm², which works out to be 12.5 mW/cm². The second method is used by LaserSafetyFacts to determine NOHD.		
	Class 1	Class 1M	Class 2	Class 2M	Class 3R	Class 3B	Class 4
	Class 1		Class 2		Class 3		Class 4

4 Electrostatic safety

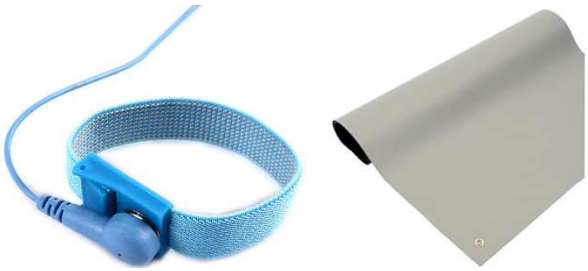
When working on the open device (no protective cover), some parts and components are accessible that are vulnerable to electrostatic discharge. These parts are especially:

- FTDI micro-controller board (central IC)
- Arduino micro-controller board (central IC)
- R5 micro-controller IC
- SSD hard drive on the bottom of the mainboard
- RAM on the top side of the mainboard

CAUTION: *Some parts and components are vulnerable to electrostatic discharge! Do not touch them and do not get in close proximity without wearing proper safety equipment.*

Parts and components can be damaged irreversibly!

In your toolbox you should carry an ESD (electro-static discharge) wristband. Use a discharge mat when possible.



Wear it and connect it to the GND of a nearby power socket.

CAUTION: *Make sure the power socket you are connected to has GND connected to common ground! Some sockets in some countries do not have this.*

Discharge will not work without proper GND connection!

5 User groups

5.1 Intended users

The intended user group is service and field service personnel. These persons have a technical understanding (technical background) and are trained. Training typically covers normal operation as well as maintenance and technical service. These persons are trained to use the technical tools required to maintain and service the x.sight device.

5.2 Unintended users

This manual and the actions described within are not meant to be performed by normal users. Those people typically have a laboratory background (chemistry, biology, physics, etc.) and are only trained in normal operation. Any other persons that are not trained at all on the devices are also unintended users.

6 Intended use

This manual is made for technical service. It includes all actions required to perform a maintenance or service on the x.sight devices. That covers opening and closing of the protective lid and housing. Measurements and tests on integrated hardware such as computer, electronics, mechanics and optics. Defeating of interlocks to calibrate and maintain safety critical components such as lasers. The service personnel must use the tools intended to these procedures.

7 Unintended use

7.1 Use of non-specified material

The use of any other substrates than the specified ones, can lead to severe damage of the device. Especially, well-plate formats that are higher than the clearance of the move-in slot for plates on the device is. Such plates will get stuck and are very likely to damage sensible optical components. The use of any other printing cartridge than original, certified cartridges can lead to severe damage of the device.

7.2 Liquids

Do not insert any liquids into the device. Especially, do not spill liquids in, do not load any open container with liquid into the device. Liquid shall only be kept inside specified well-plates (liquid is prefilled in form of required media or agents to perform your cell experiments). Do not fill more liquid into your well-plate as the well-plate can take (maximum filling volume per well shall not be exceeded). Do not use any other than the specified cleaning reagents. Do not flush any parts of the device, only use spraying and wiping for cleaning purposes.

7.3 Interlocks

Do not defeat interlocks at any time, only if it is required to perform a specific service or maintenance step. Remove the defeat after completing this step. Do not modify or bypass interlocks. In any such cases, the operator can/will get injured severely. Only authorized and trained service personnel is allowed to defeat interlocks for service purposes.

7.4 Cleaning

If you do not follow the specified cleaning protocols, there is a chance that contamination will happen. You operate with living biological organisms of which some may be able to survive and proliferate within the device, when not being cleaned properly.

7.5 Ventilation and air flow

The device requires sufficient amount of surrounding air to cool its electrical components via the internal fans. Do not place the device in any environment, where insufficient air is provided. Do not operate the device outside the specified environmental conditions. Do not block, screen or in any other way hinder the system ventilation (fans and air slits) to operate as intended.

7.6 Installation

Do not place the device on unsolid or uneven ground. Do not operate it next to vibrating or shaking device (e.g. centrifuge, shaker incubator, mixer, vortexer, etc.). Those vibrations can lead to significant disturbance of the operation (optical detection, etc.).

7.7 Sterility

Do not use the device outside sterile environment (e.g. biosafety cabinet) when you require to work sterile. Do not unpack cartridges, well-plates, etc. from their sterile seal bags outside sterile environment (e.g. biosafety cabinet) when you require to work sterile.

7.8 Heat sources

Keep away the device and peripherals (monitor, keyboard, mouse) from strong heat sources such as ovens, lamps, etc.

7.9 Electric and magnetic fields

Keep away the device and peripherals (monitor, keyboard, mouse) from sources of strong electric and/or magnetic fields such as field generators, CT, MRT, etc.

7.10 Power, fuses & grounding

Do not connect the device to any power grid or line or socket that is not grounded. Do not connect it to power grids that are operated outside the specified range. Do not use other fuses than specified on the device (see fuse label on the backside). Do not disconnect the main ground from the device.

7.11 Embedded computer

The embedded computer is delivered with pre-installed operating system and pre-installed cytena control software. There is no security software installed (antivirus, firewall, etc.). This has to be done by the customer IT according to their IT safety policy. However, if you do not install security software, sufficient for your environment, this may lead to safety issues.

7.12 Data

Do not modify any data (e.g. files, folder) that is part of the cytena control software installation. Modifications of this data may lead to damage of the device and/or falsely generated data output (images, log files, etc.). Do not modify any of the generated data (images, log files, etc.). If you do so, it can no longer be used as supporting material for internal and regulatory affairs (assurance of clonality).

7.13 Mobile hard drives

Do not connect USB-powered mobile hard drives (magnetic or SSD, not flash drives) to any of the devices USB-ports. Such hard drives take a lot of current from the USB and may be compromising the USB-camera performance (embedded cameras). There is a chance that the cytena control software becomes instable and cameras do freeze or crash during operation, when such a hard drive is connected.

7.14 Power saving mode

Do not activate Windows power saving mode. Do not activate USB power saving mode in Windows (it allows Windows to reduce the current for connected USB-devices). There is a chance that the cytena control software becomes instable and cameras do freeze or crash during operation, when such modes are active.

8 Misuse

8.1 Modifying devices

Modifying any parts of the protective housing (including lid) is prohibited. The protective character of the housing is no longer given, when this is the case. Any form of modification be it on mechanical or electrical or any other parts, is prohibited. This especially covers wiring or bypassing any electrical circuit. Operating a device without the lid (and defeated interlocks) gives the operator access to moving parts and light radiation sources (laser). Those are potentially dangerous and can cause severe injury to the operator.

8.2 Use of non-specified tools

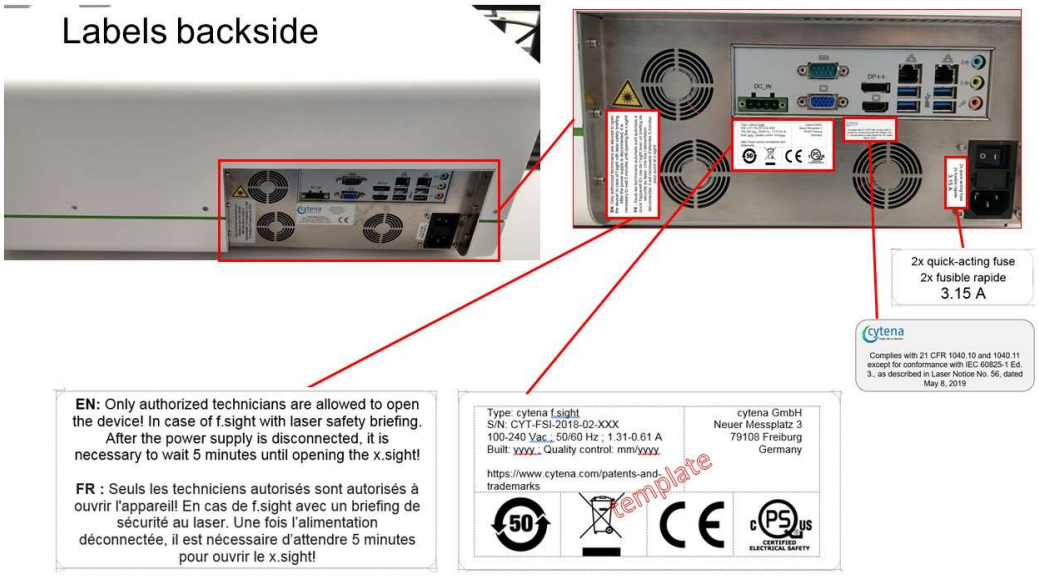
Do not use equipment (tools) that is not specified. Do not use equipment that is not intended for the intended use. Do not use equipment that is damaged or in any other way unsuitable for the intended use.

8.3 Override of safety features

Partial or permanent overriding, bypassing or any other modification of safety features is strictly prohibited. This excludes temporary defeating for service purposes.

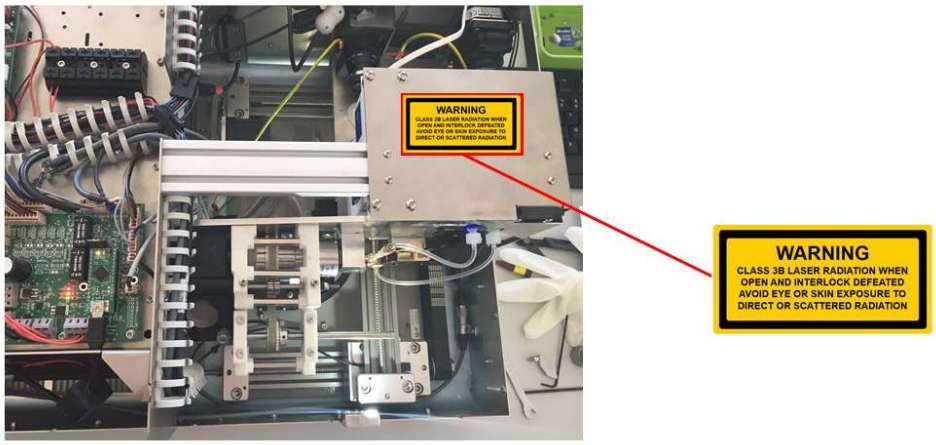
9 Safety labels

The following safety labels can be found on the rear side of the devices:



For the f.sight the following laser safety labels can be found on the protective lid:

For the f.sight the following laser safety labels can be found inside the device, when the protective housing is opened:



10 Hardware revisions

10.1 Models and revisions

Model	Revision #	Production date	Serial no.
c.sight	1	JAN 2018	CY-CSI-2018-01-xxx
f.sight	1	JAN 2018	CY-FSI-2018-01-xxx
f.sight	2	OCT 2019	CY-FSI-2019-10-xxx
b.sight	1	MAY 2018	CY-BSI-2018-05-xxx

10.2 Revision history

Model	Revision #	Changes
c.sight	1	First series in production at factory
f.sight	1	First series in production at factory
f.sight	2	Upgrade to new laser modules (Coherent) and implementation of few mechanical updates
b.sight	1	First series in production at factory

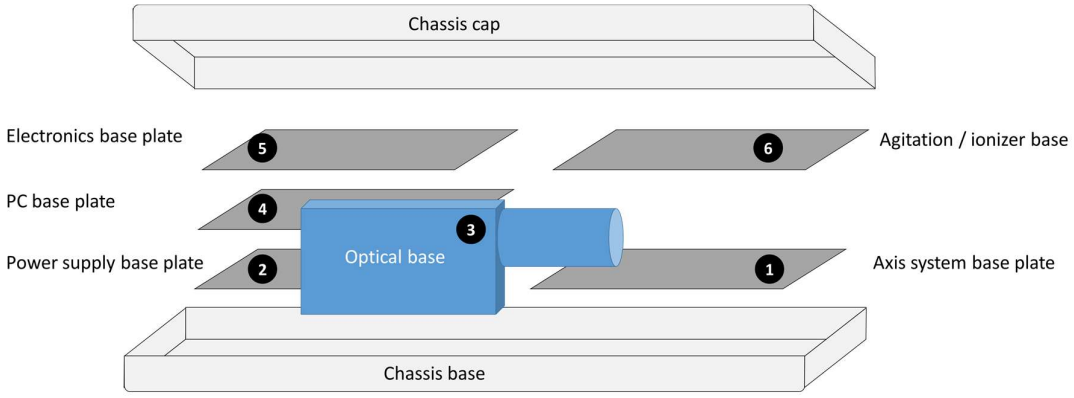
10.3 Compliance certifications

Last changed: 21 MAR 2019

certification	c.sight	f.sight	b.sight	cartridge
CE	yes	yes	yes	*n.a.*
CB	yes	yes	yes	*n.a.*
QPS	yes	yes	yes	*n.a.*
CCC	yes	yes	yes	*n.a.*
EN laser safety	*n.a*	yes	*n.a.*	*n.a.*
FDA laser safety	*n.a*	yes	*n.a.*	*n.a.*
RoHS	yes	yes	yes	*n.a.*
China RoHS	yes	yes	yes	*n.a.*
WEEE	yes	yes	yes	*n.a.*
Reach	*n.a.*	*n.a.*	*n.a.*	*n.a.*
Animal component free	*n.a.*	*n.a.*	*n.a.*	yes
TSE / BSE free	*n.a.*	*n.a.*	*n.a.*	yes

11 Schematic device overview

The x.sight units are built in a modular system. Associated parts are pre-assembled as sub-units on base plates. The base plates are then assembled into the chassis one by one. The following schematic view shows the position of each sub-unit.

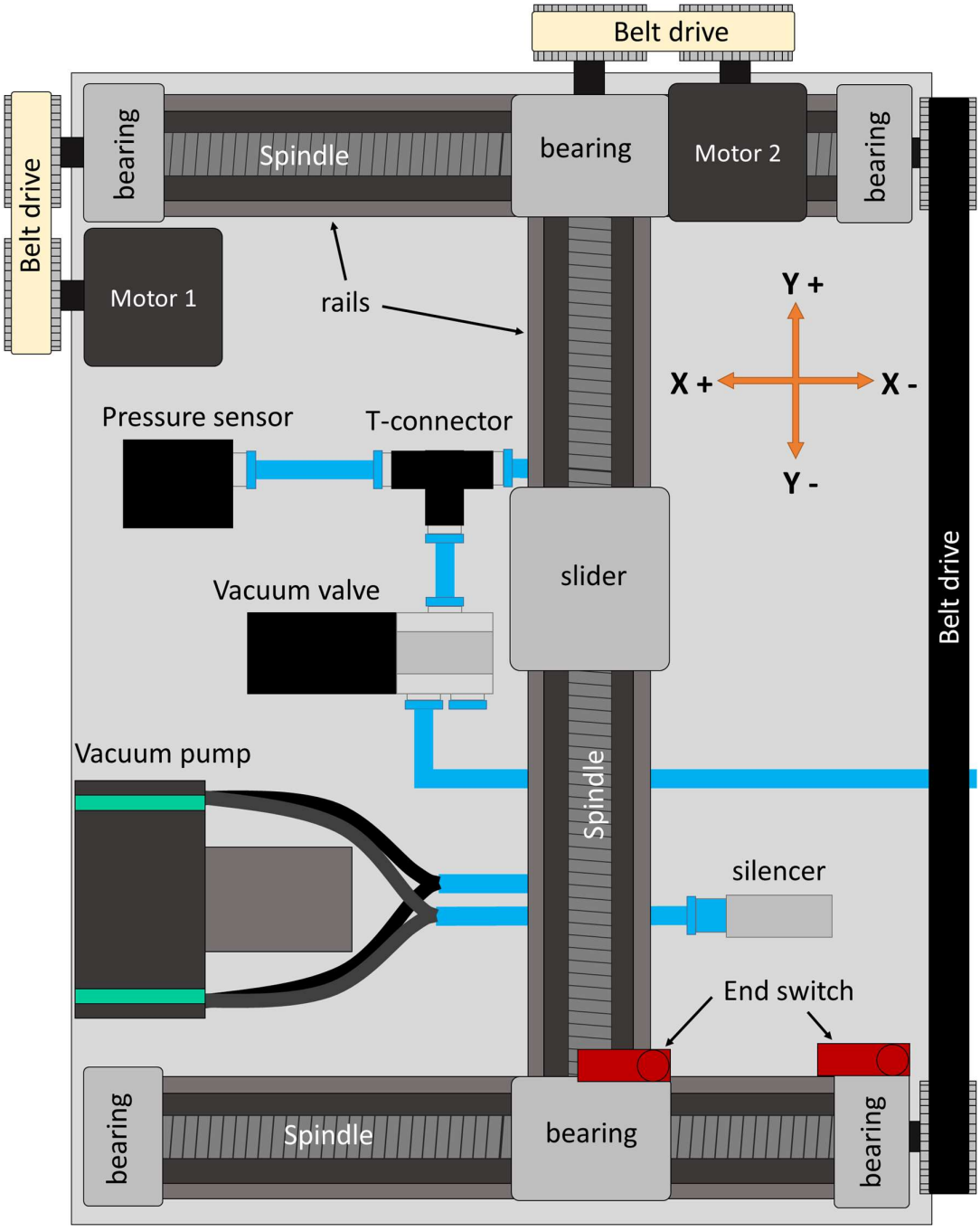


The order of assembly into the chassis base is:

1. Axis system
2. Power supplies
3. Optical structure
4. PC
5. Electronics
6. Agitation and ionizer

11.1 Axis system base plate

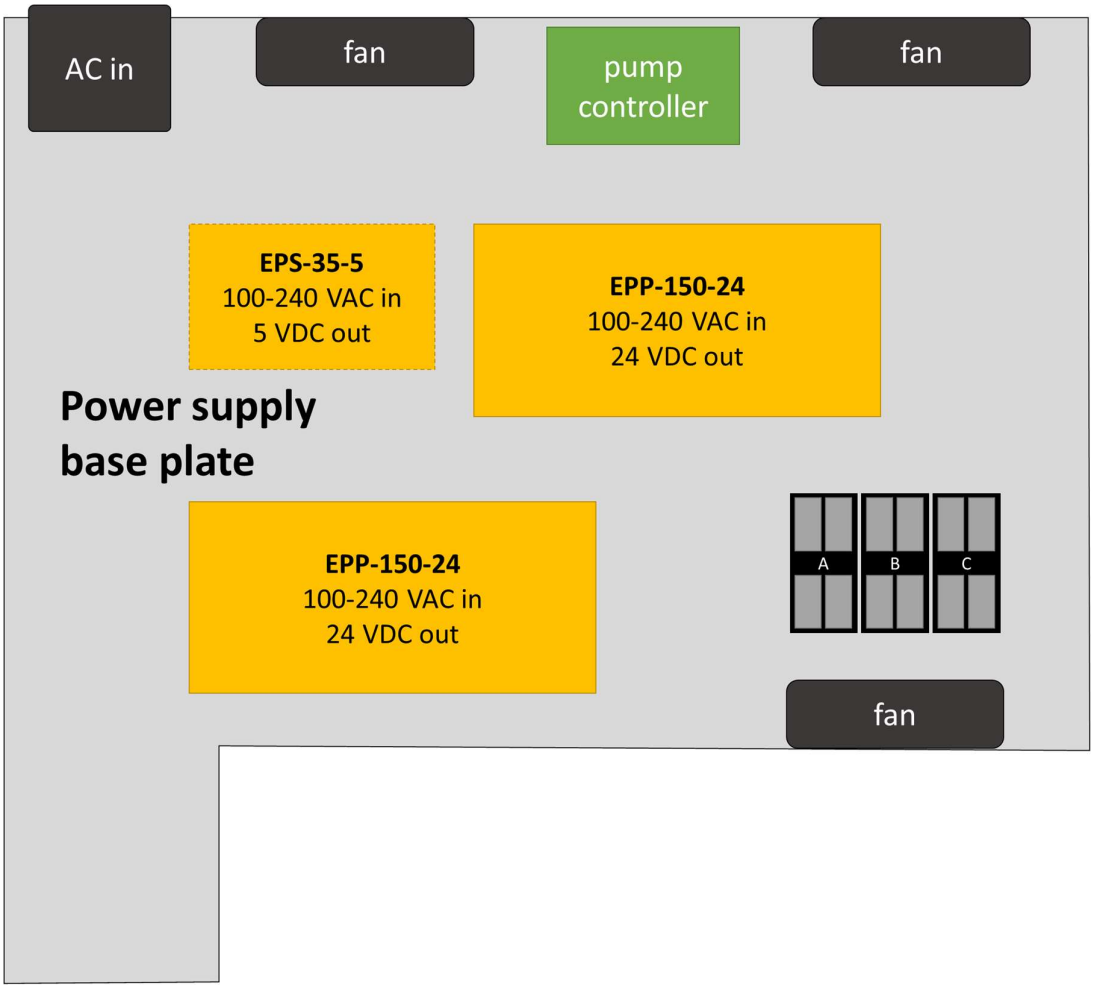
The axis system is an H-portal. Ball-nut spindles, driven by two stepper motors. Its base plate also holds the vacuum pump, valve, and pressure sensor. The following schematic gives an overview including naming convention:



Home position is on the front right, where the end switches are located. Respectively, X-direction is from left to right and Y-direction from front to rear side as indicated by the orange coordinate cross. Motor 1 is driving X and Motor 2 is driving Y.

11.2 Power supply base plate

The power supplies are mounted on one plate. The plate carries two identical main power supplies (EPP-150-24). In f.sight an additional small power supply for the laser (EPS-35-5) is mounted. Further, the vacuum pump control PCB and three air fans are included. The following schematic gives an overview including naming convention:



The AC input distributes the AC voltage to the individual power supplies where they are converted to the respective DC voltage.

The vacuum control PCB allows for regulation of the vacuum pump speed and therefore the negative pressure level respectively the air flow.

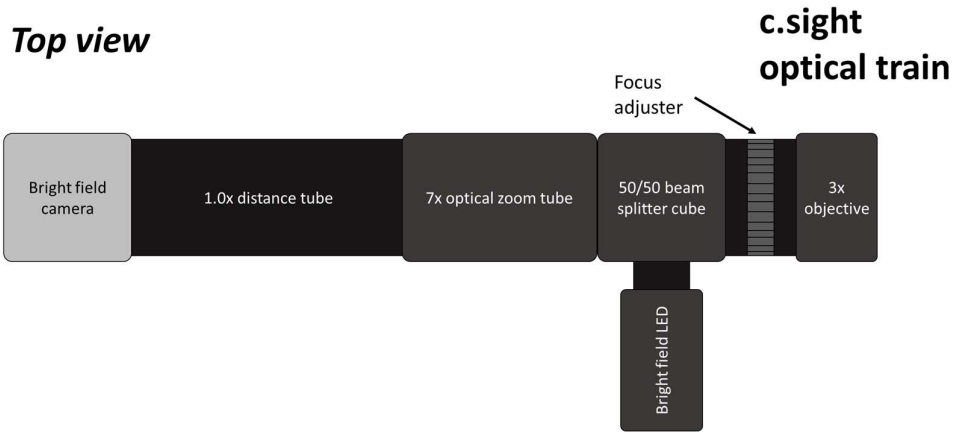
The ABC wire block connects and distributes cables.

11.3 Optical systems

The following schematics provide an overview on the different optical trains of the x.sight models. The optics is the main difference between the models.

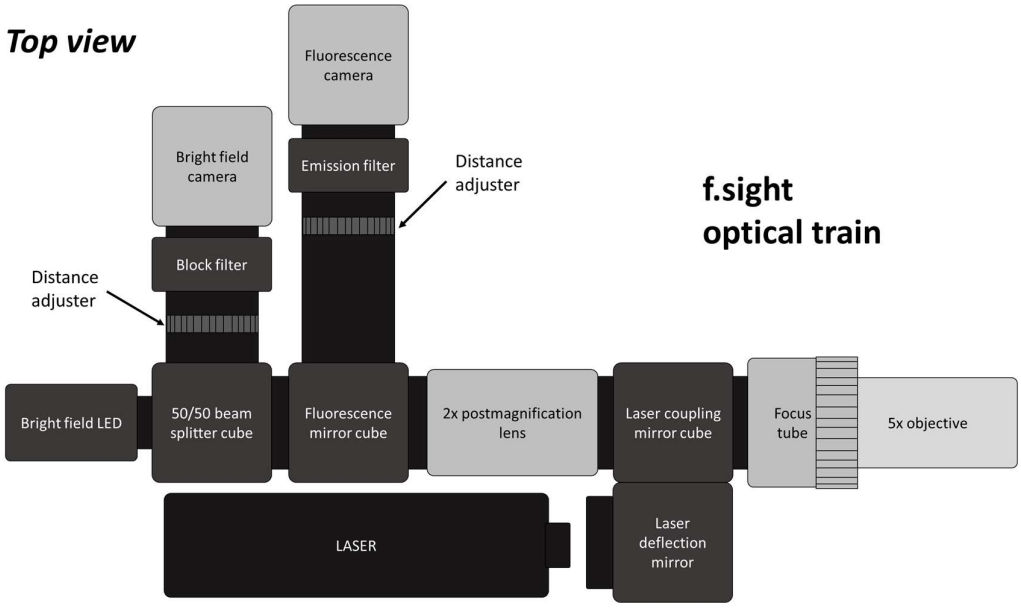
11.3.1 c.sight

The c.sight only provides bright field view. It features a 11x total magnification with a blue, coaxially coupled LED.



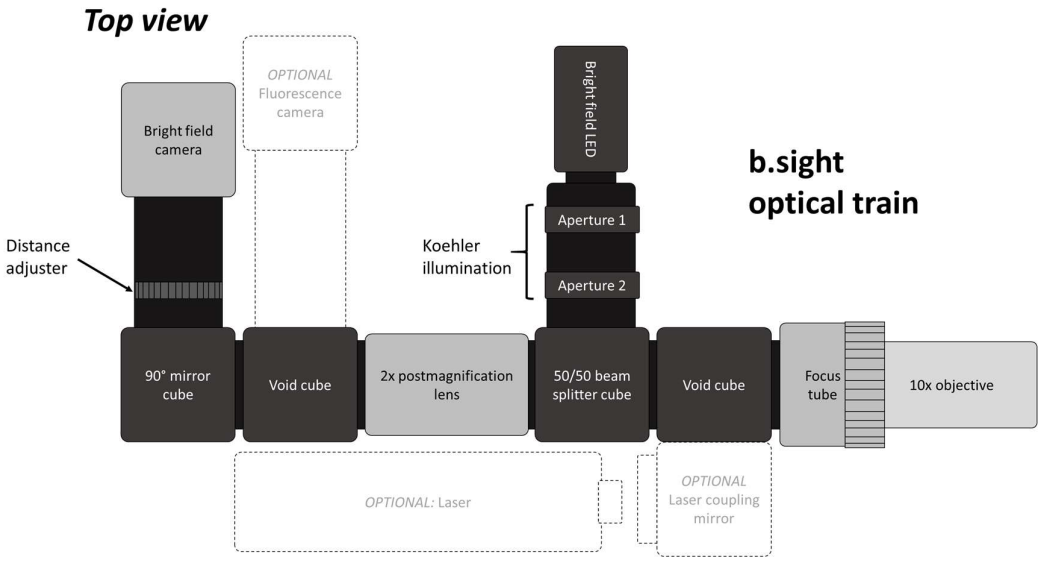
11.3.2 f.sight

The f.sight provides a bright field mode with 10x magnification including red, coaxially coupled LED illumination. In addition, it provides an additional fluorescence mode with an extra camera and a blue laser, enabling green fluorescence readout.



11.3.3 b.sight

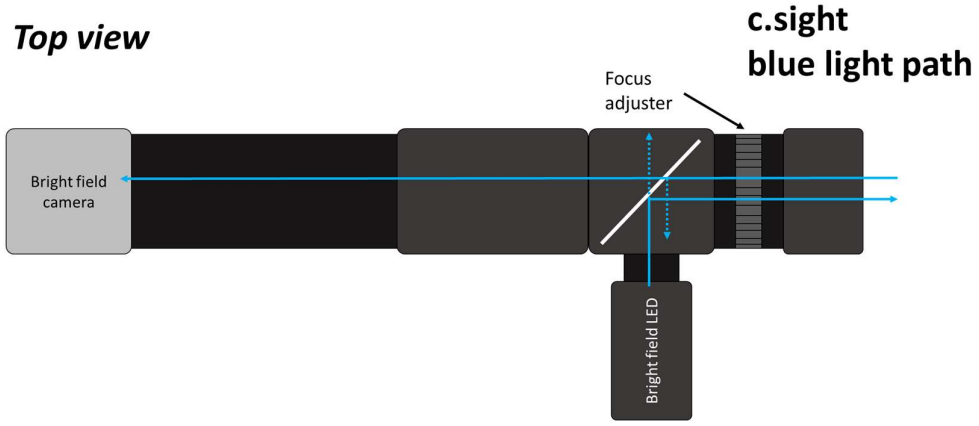
The b.sight provides a bright field view with 20x magnification and a blue, coaxially coupled LED. The LED light is further collimated by a Koehler illumination principle, enhancing the contrast. As a future optional modification single-channel fluorescence can be included. Two void (blind) cubes are already implemented to enable this feature.



11.4 Optical systems light paths

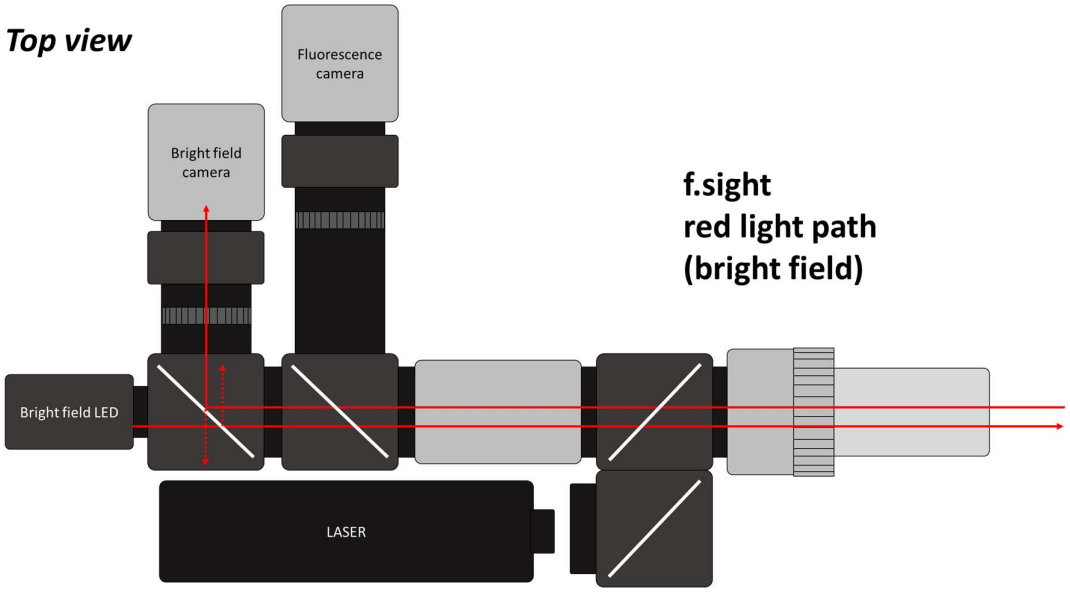
11.4.1 c.sight

The blue light path of c.sight is straight with only a beam-splitter used to couple the LED light into the main optical axis.

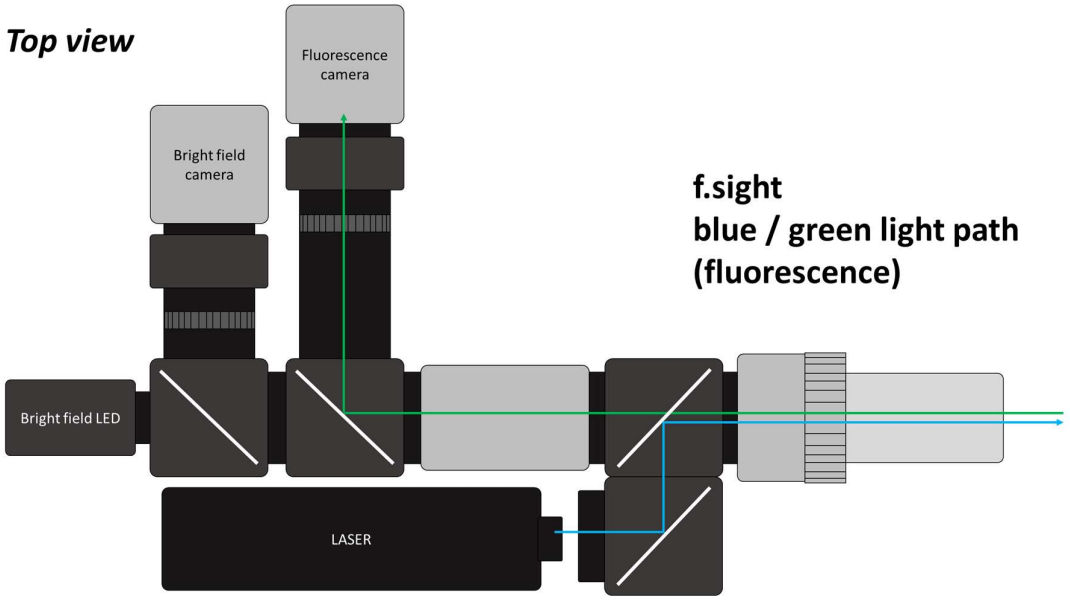


11.4.2 f.sight

The f.sight has two separate channels. One for bright field using the rear camera and a red LED. The bright field camera and the LED are connected over a beam-splitter. The front beam-splitter cubes are fully transparent to red light.

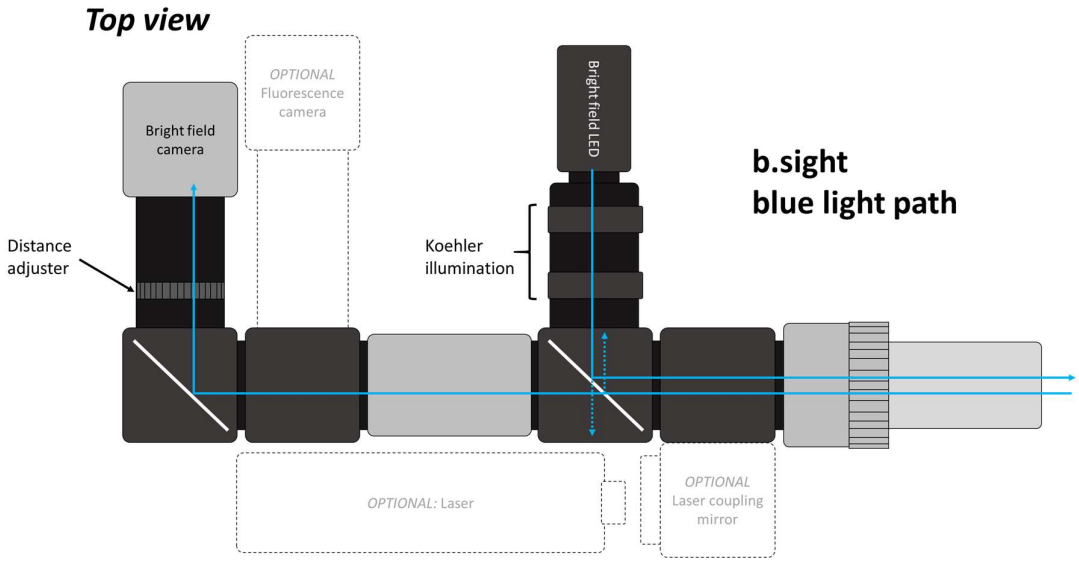


The fluorescence channel is using the front camera and the blue laser. The laser is couples through a pair of mirrors and a dichroic filter reflecting blue light and transmitting green light. The blue laser is exciting the sample which then emits green fluorescence light. The green light is transmitted towards the fluorescence camera. A second dichroic filter reflects the green light to the camera and transmits red light.



11.4.3 b.sight

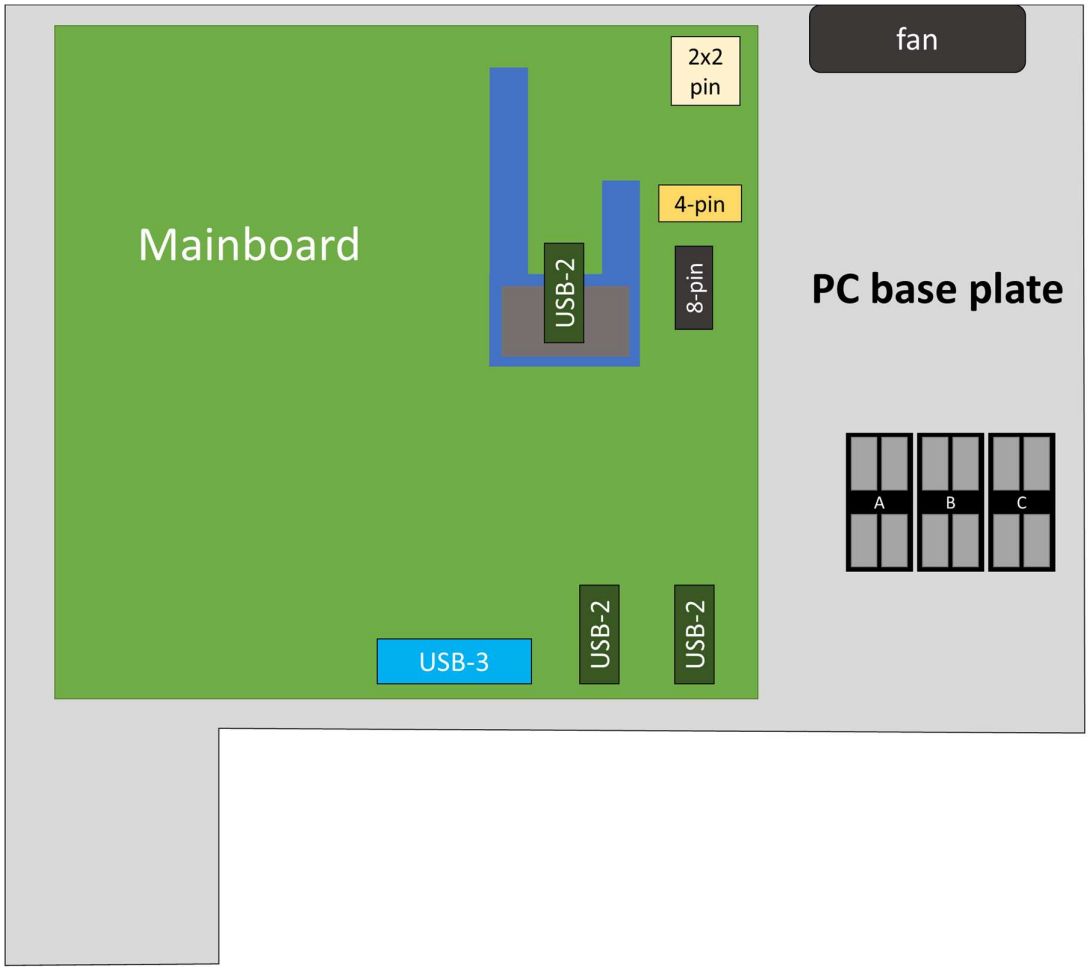
The b.sight uses bright field detection very similar to c.sight. The blue LED is in addition collimated with a Koehler illumination (two apertures). The LED light is coupled in the main optical axis by a beam-splitter. The image is reflected by a 90° mirror into the camera.



The b.sight optics includes two void cubes that are sealed. In future, the integration of a laser and a second camera would allow for fluorescence bacteria sorting as well.

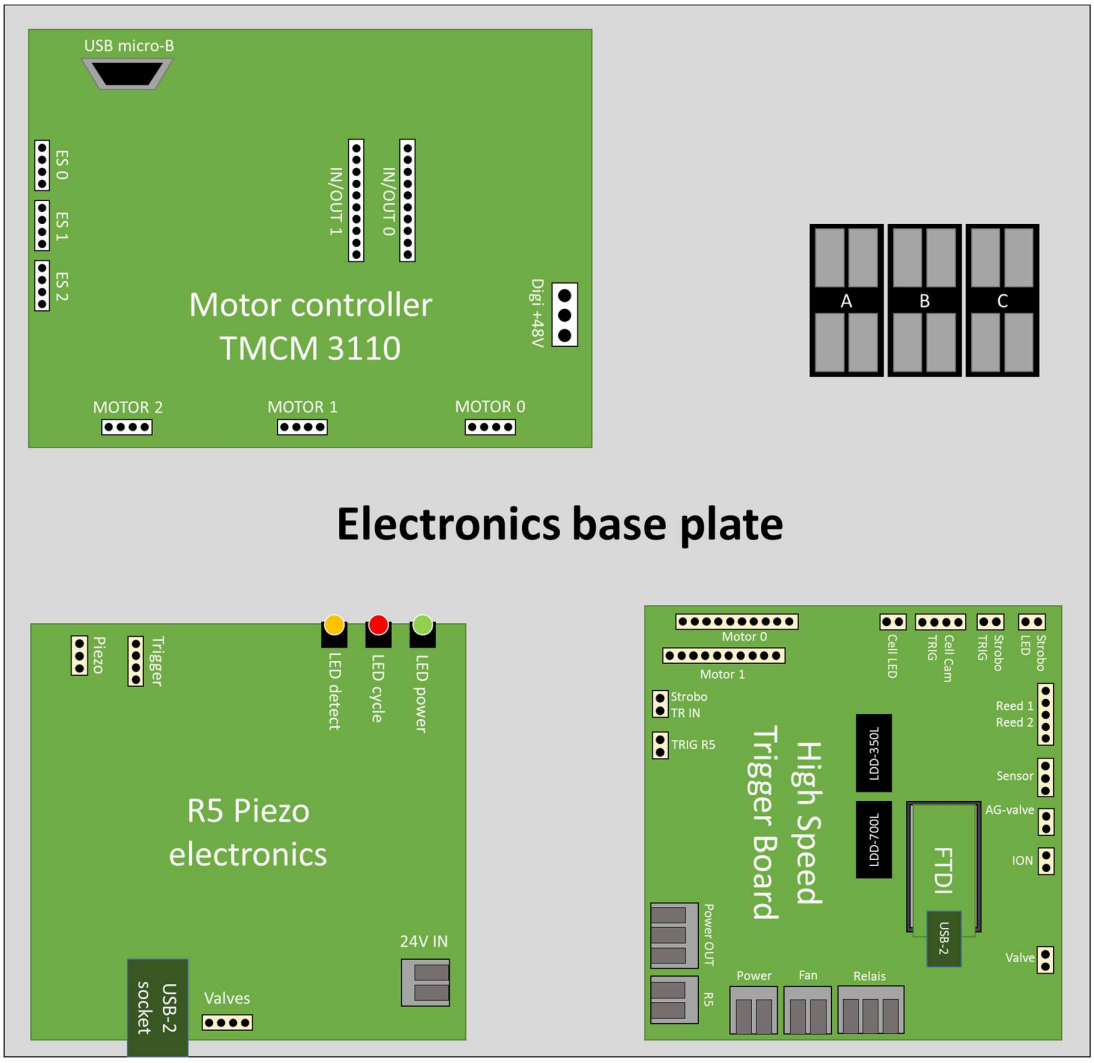
11.5 PC base plate

The PC is mini-ITX industrial format, mounted on the base plate. An air fan provides cooling and the ABC wire block connects and distributes the cabling. Several USB pin-headers are used to connect devices like cameras.



11.6 Electronics base plate

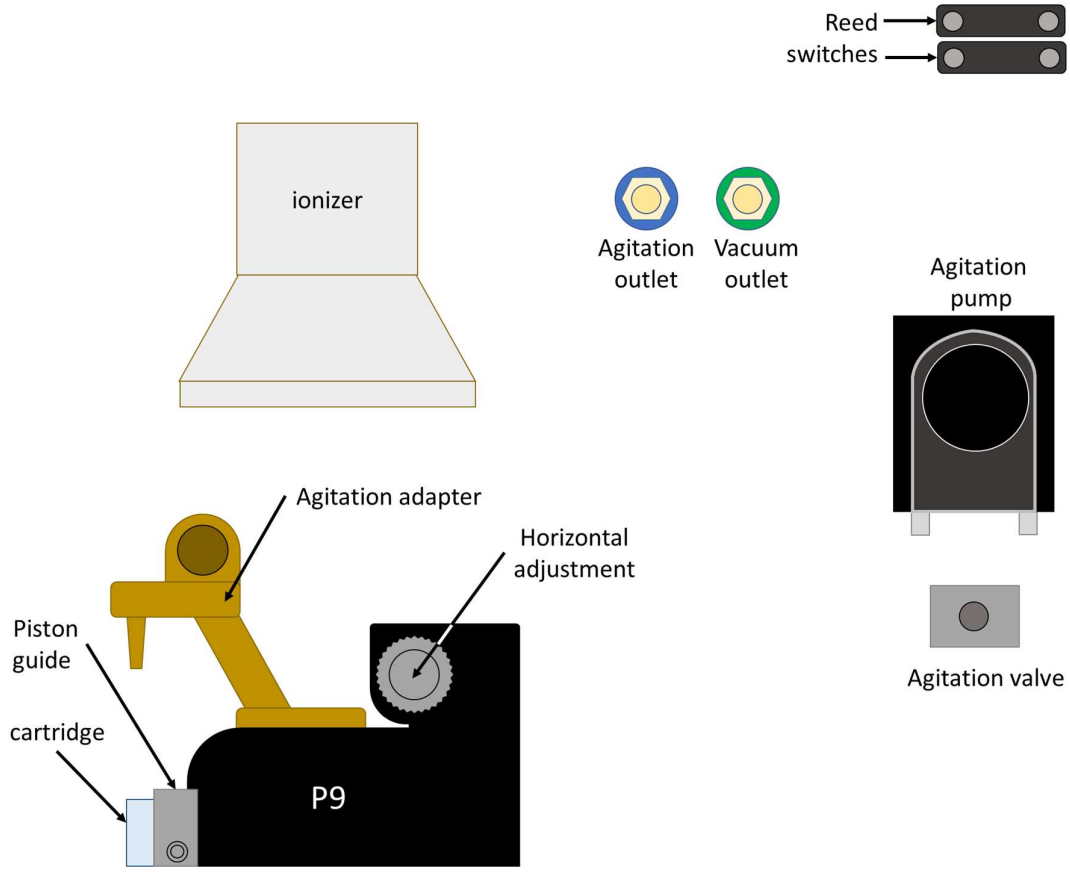
On the electronics plate the three main driver PCBs are mounted: Motor controller, piezo electronics and high-speed trigger interface including FTDI trigger controller. ABC wire block to connect and distribute. All three boards are controlled via USB.



11.7 Agitation and ionizer base

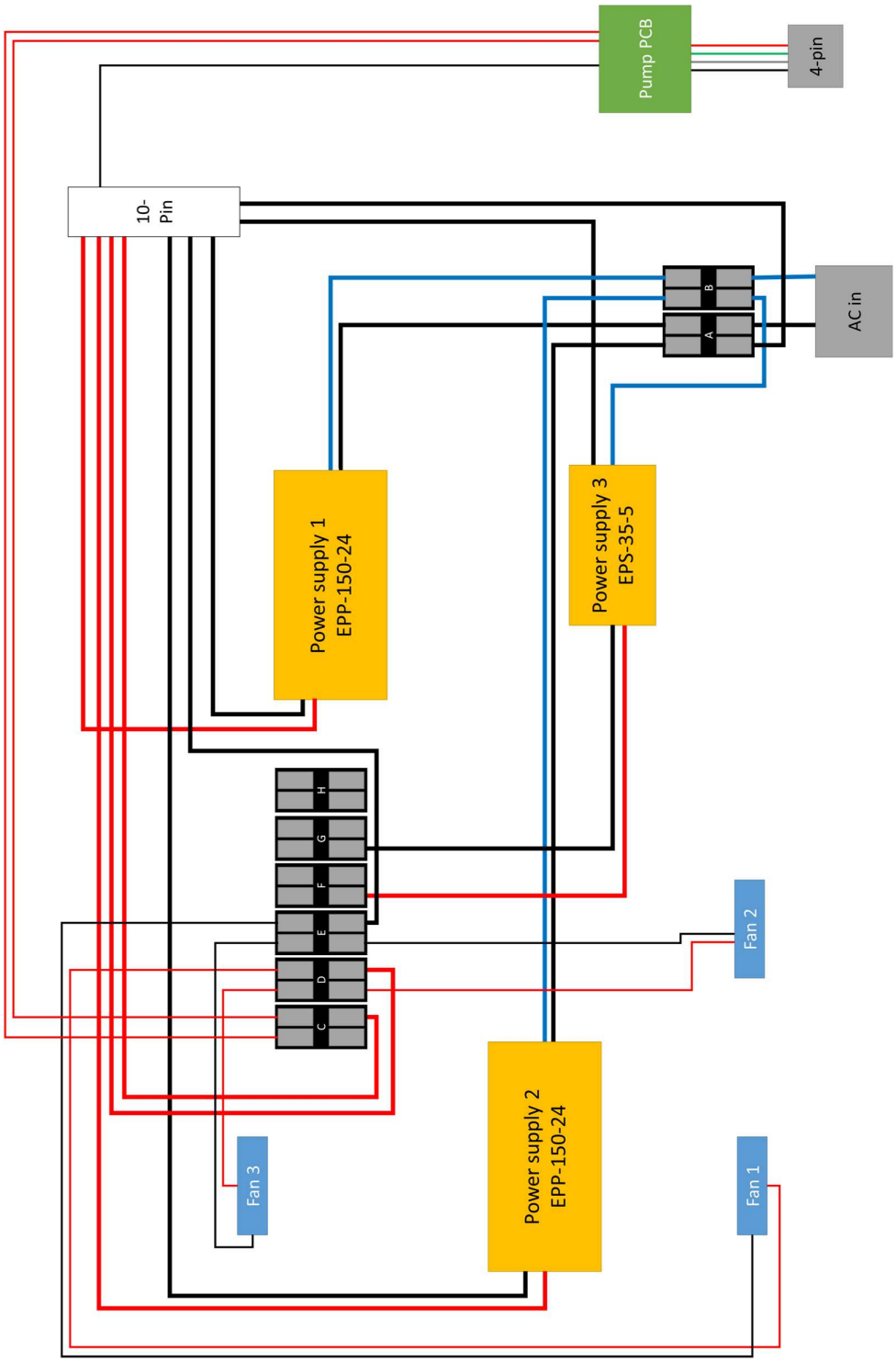
The top right Aluminum structure inside the x.sight units carry several parts:

- an ionizer to remove electrostatic charges from the well-plates
- the agitation pump to mix cells in the cartridge reservoir
- outlets for vacuum and agitation connections
- the P9 piezo-electric dispenser including agitation adapter
- two redundant Reed-switches for securing the device lid



12 Power supply connections

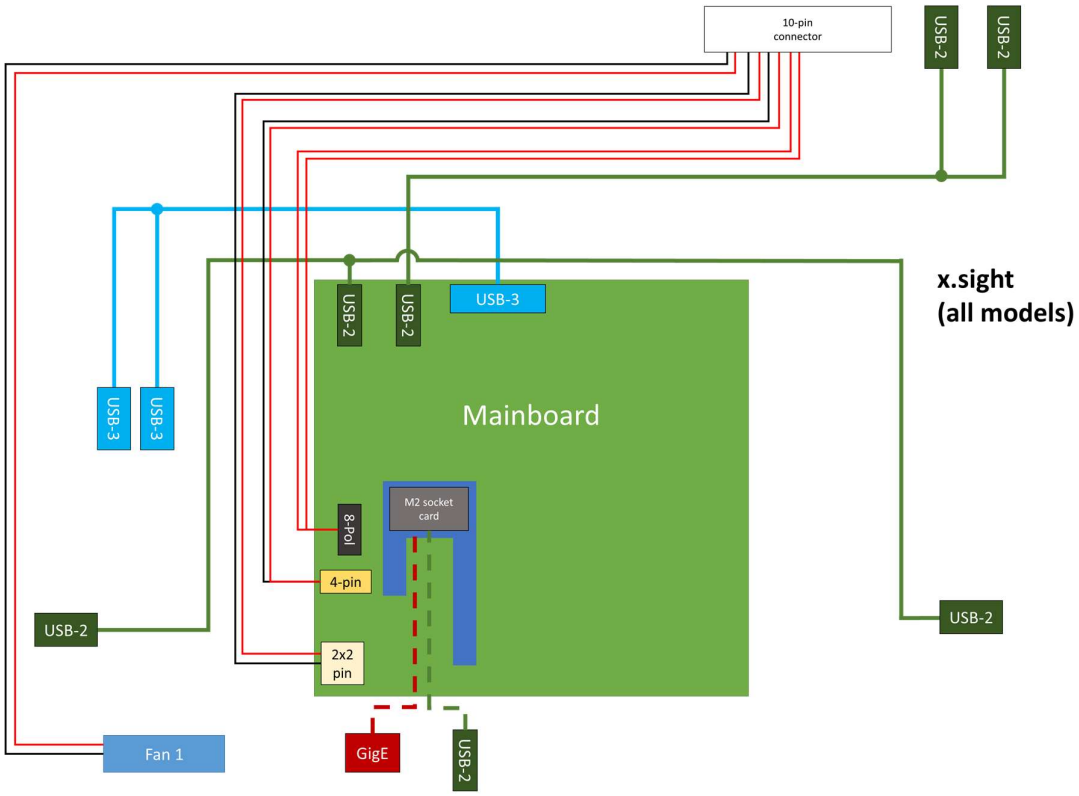
The power supplies are connected as follows. Blue wires are 100-240 VAC, red wires are 5-24 VDC, black wires are GND.



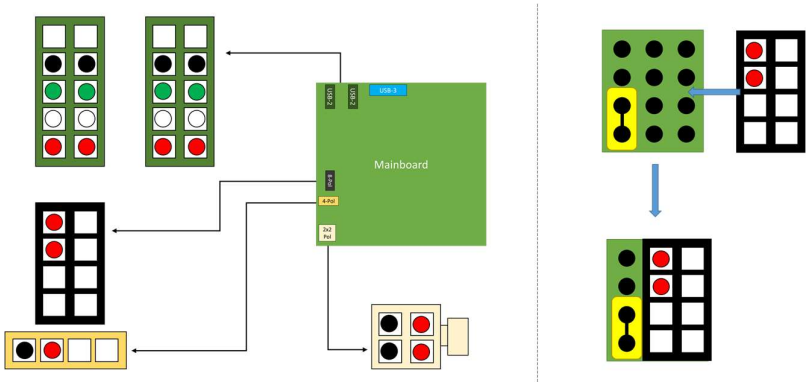
13 PC connections

13.1 General cable routing plan

This routing plan applies for all x.sight models. Four USB-2 and one USB-3 pin-headers are connected. On the mainboards M2 socket a card can be mounted suppling either more USB-2 or internal GigE connectors. Depending on the x.sight model different cameras are used.

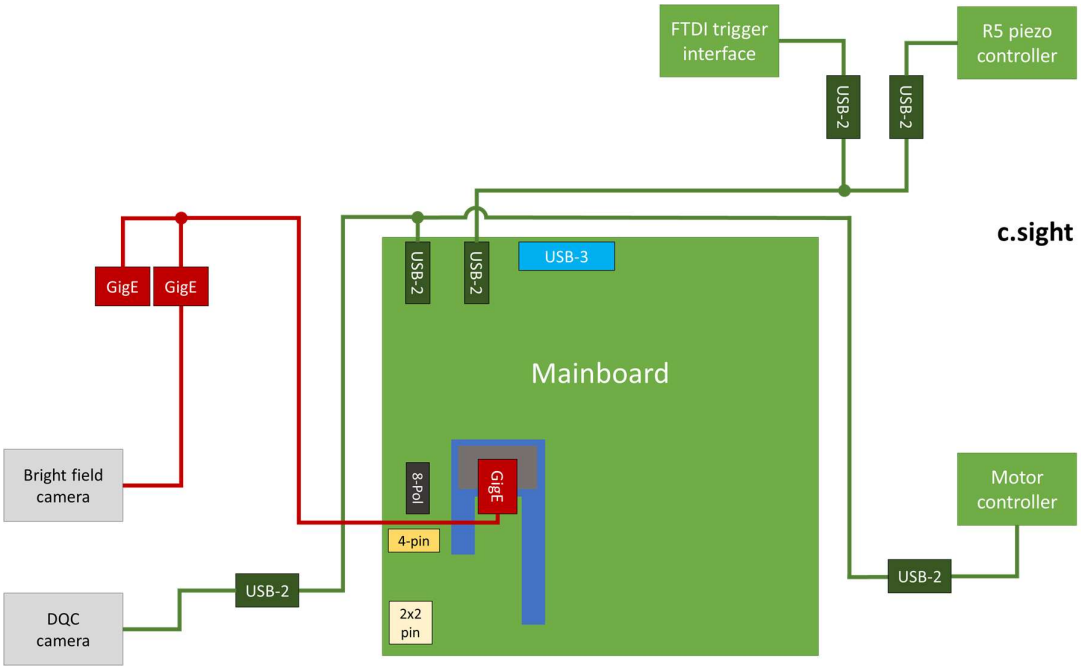


On the mainboard three additional connectors are plugged in: main power supply (2x2 pin, white connector), control pin (4-pin, orange) and … (8-pin, black). Please refer to the following detailed schematic to connect all those pin-headers correctly.



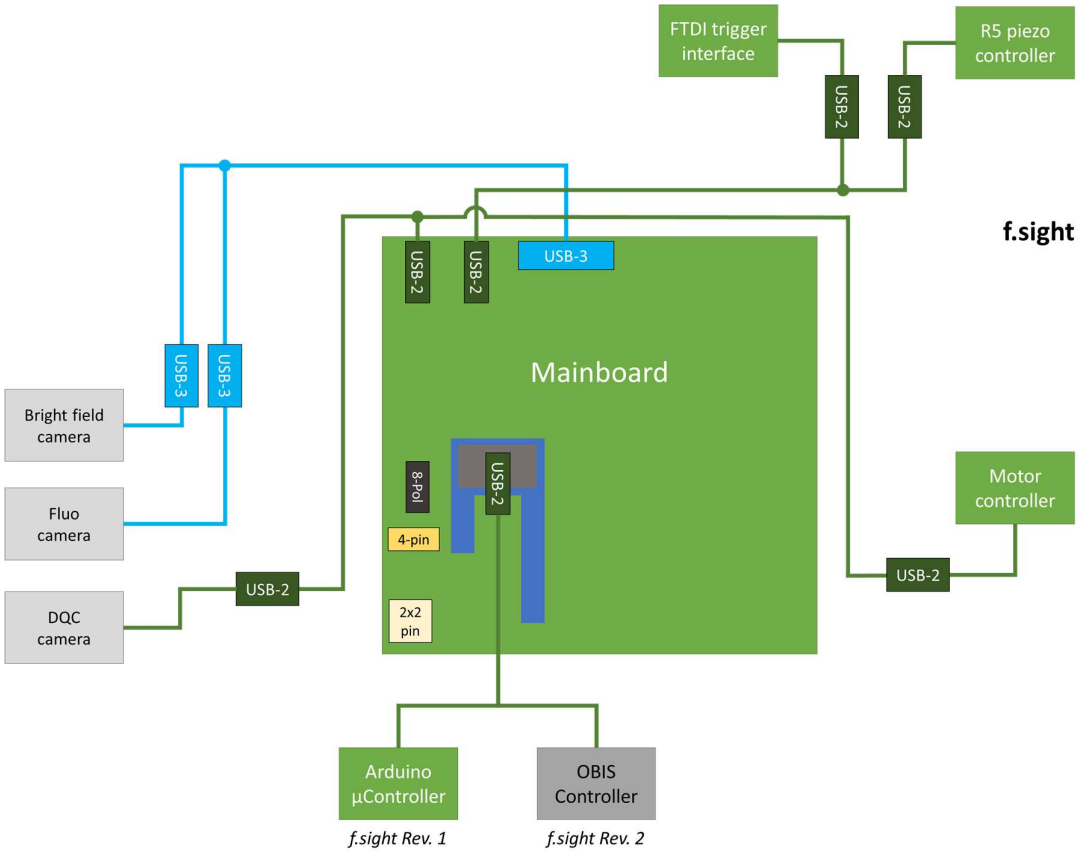
13.2 c.sight

On the c.sight the following components are connected to the respective ports. The c.sight runs with a GigE camera unlike the other models. Internal GigE connectors are supplied by the M2 socket card. The USB-2 ports are used to connect the electronics boards and the DQC camera. USB-3 is not in use here.



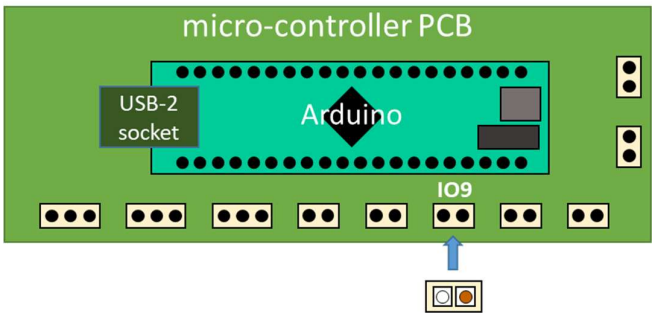
13.3 f.sight

On the f.sight the USB-2 connections stay identical while the two cameras for bright field and fluorescence are driven via USB-3. Both are connected to the pin-header. The M2 socket card provides an additional fifth USB-2 port to connect the Arduino µ-controller running the laser power control.



f.sight Rev.1

The Arduino micro-controller is only available in f.sight revision 1. The micro-controller is placed into a socket PCB and connected by USB-2 to the computer. The socket pin IO9 is connected to the laser controller. The PCB is located near the laser module

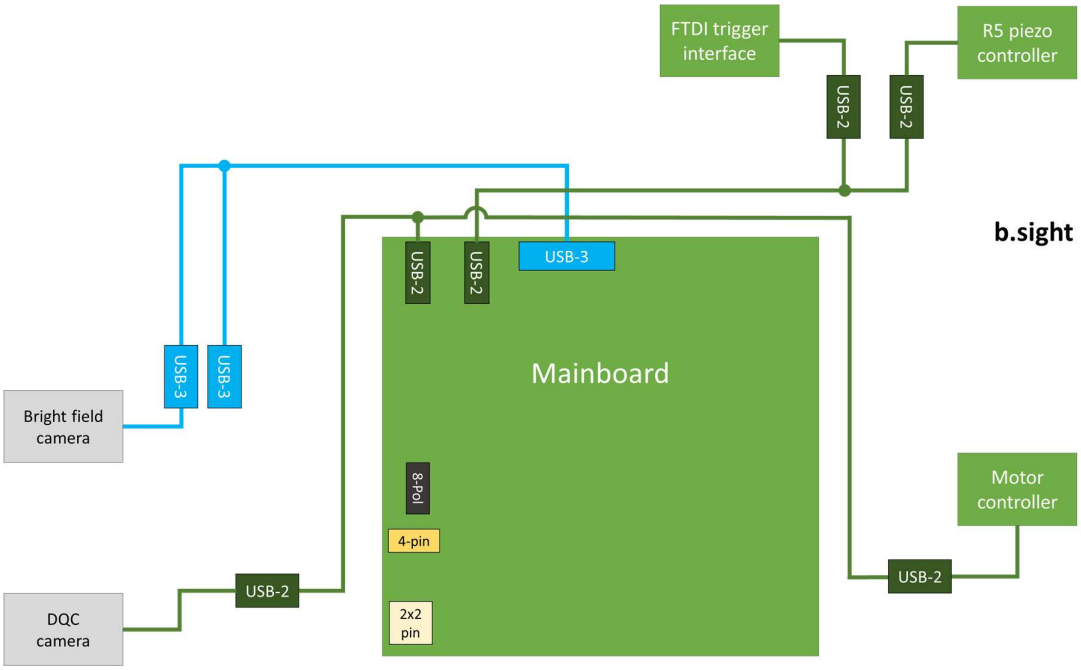


f.sight Rev.2

With the new OBIS laser modules, the micro-controller is no longer required. The OBIS laser modules are directly connected via USB-2 to the mainboard.

13.4 b.sight

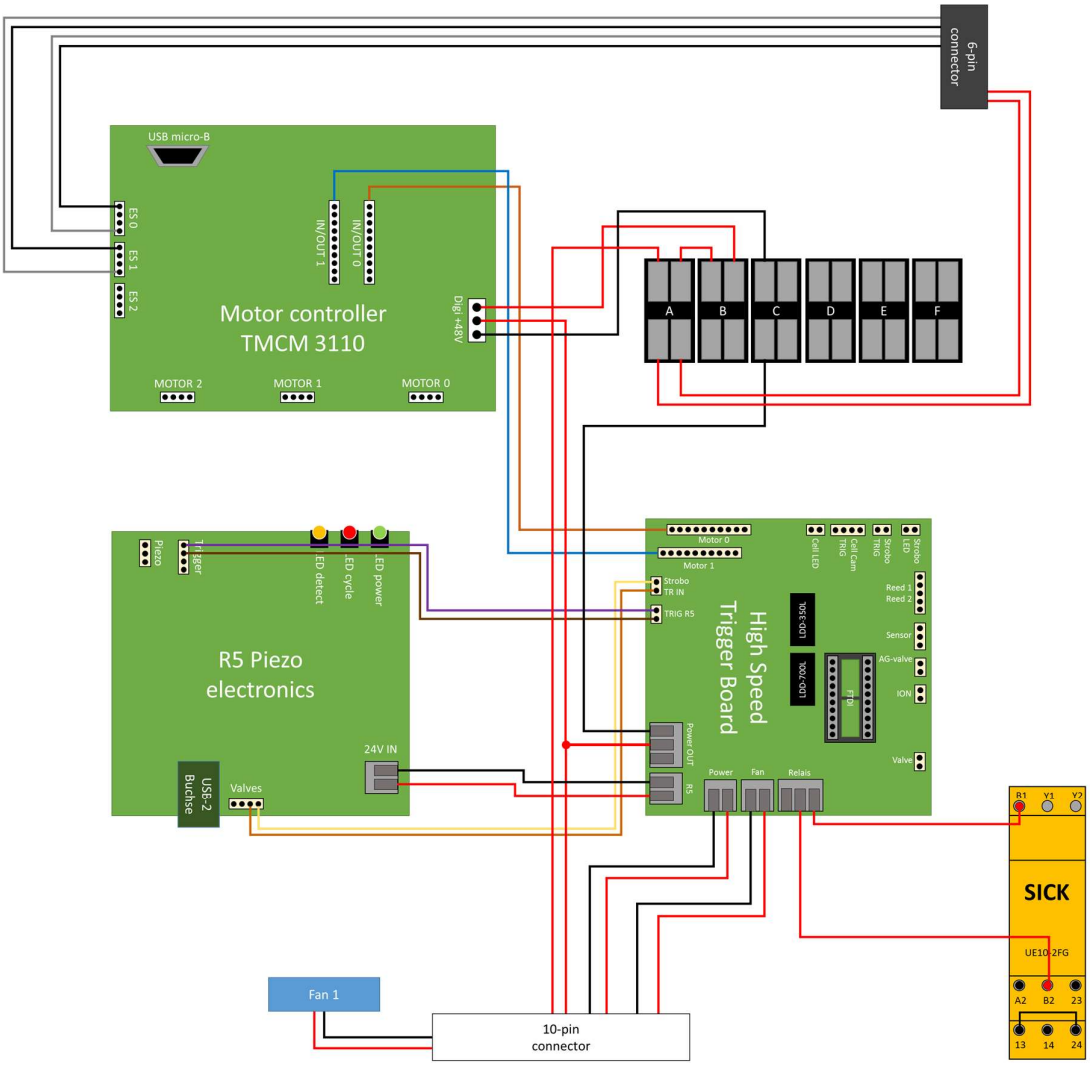
The b.sight is like f.sight running the camera via USB-3. There is only one bright field camera connected. There is nothing installed on the M2 socket.



14 Electronics connections

14.1 General cable routing plan

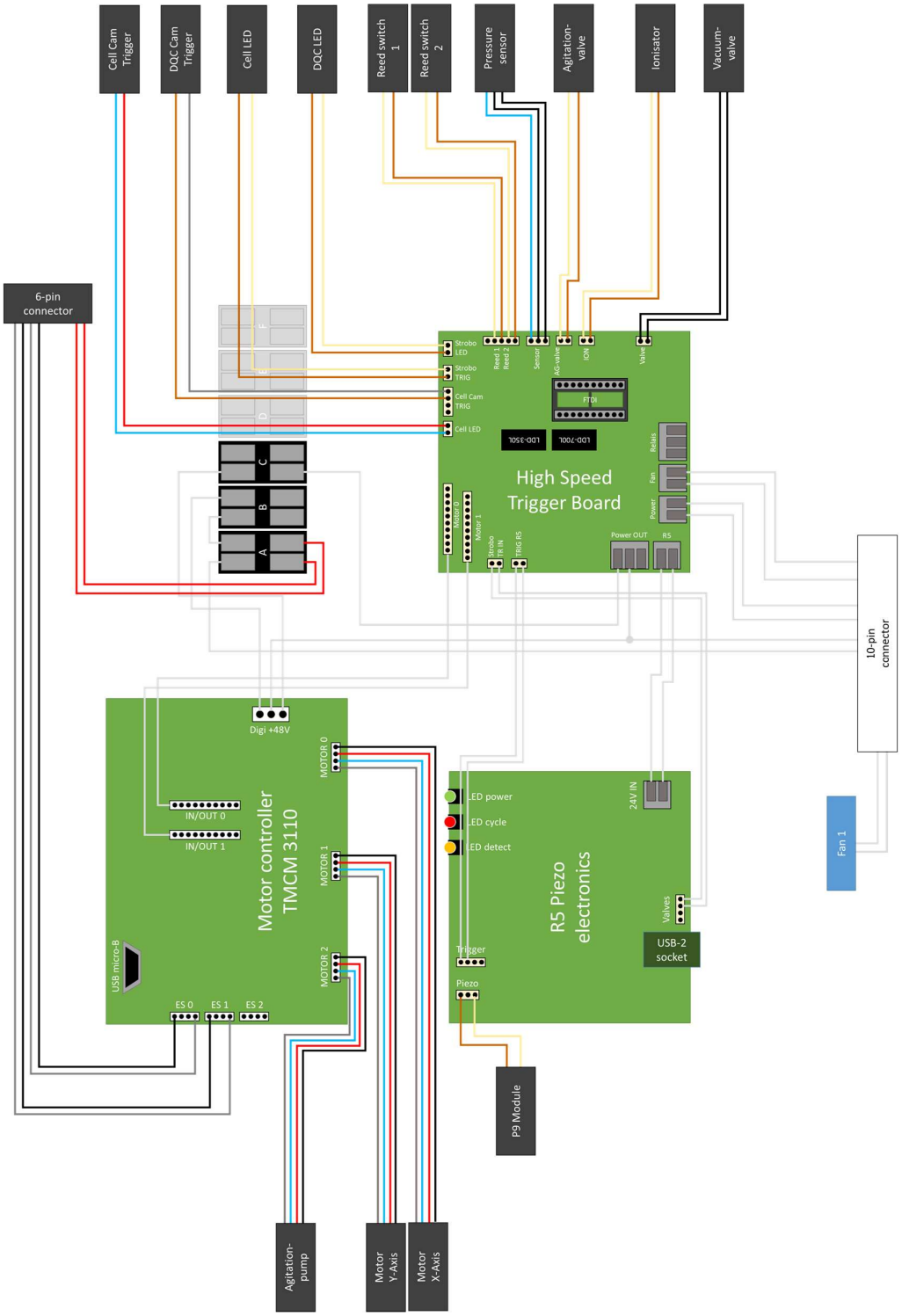
All x.sight models have the following cable and wire connections on the electronics base plate. The piezo electronics and motor controller are connected to the high-speed trigger interface which supplies the trigger signals. The 10-pin main connector provides the power supply lines (red and black) from underlying power supply base plate.



The yellow SICK laser security relay is only relevant for f.sight.

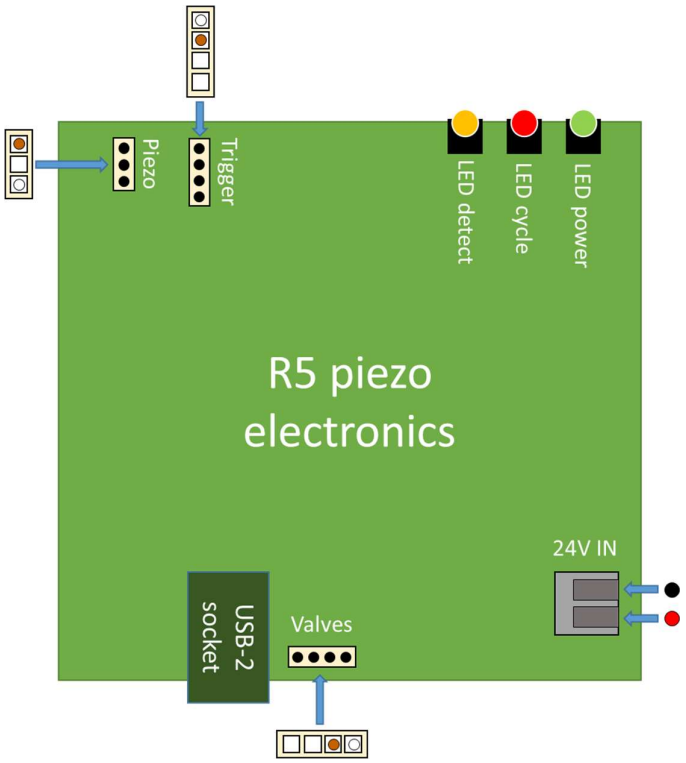
14.2 General components connection plan

The following plan shows the components (e.g. cameras, motors, etc.) that are connected to the electronics PCBs including the color codes of the wires.



14.3 R5 detailed connector plan

The R5 piezo controller PCBs is connected to the components and other PCBs like shown above. Here we look in detail on the color code and pin connections of each port.



The following table provides an overview on the pin color code and signals.

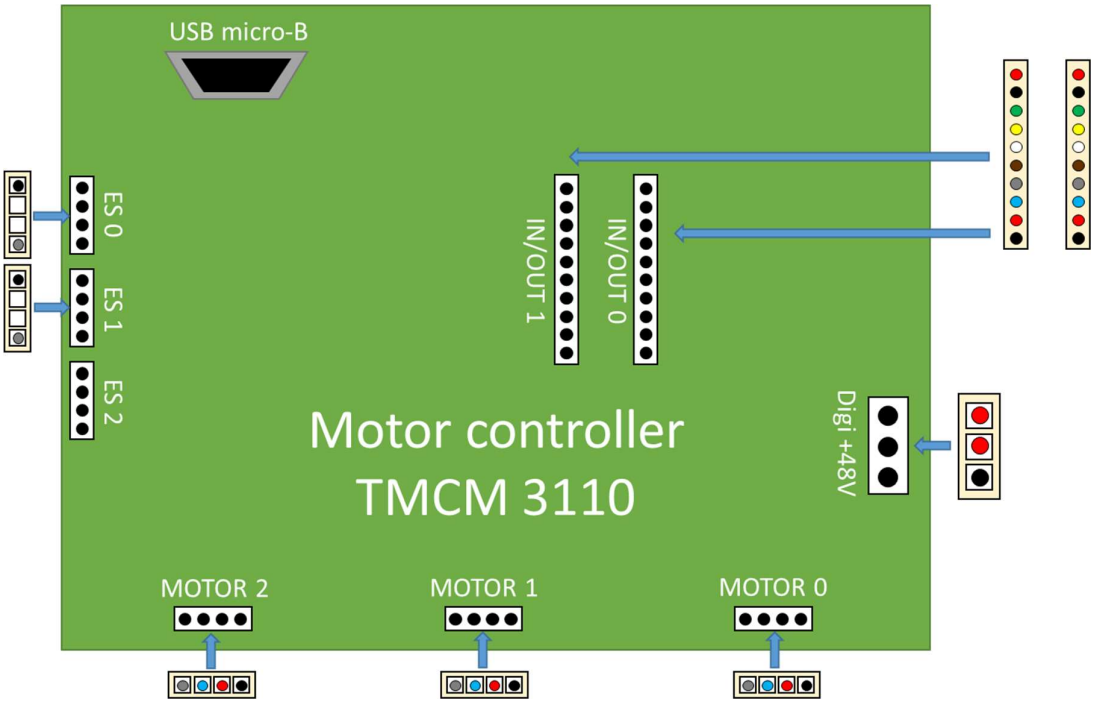
Connector	Pin color	Description	Voltage
Valves	White	digital I/O for sending and receiving trigger signals	0 / 24 VDC
	Brown	GND	0 VDC
24V IN	Red	Power supply	24 VDC
	Black	GND	0 VDC
Piezo	White	Actuator line for driving the piezo-electric stack actuator. High voltage!	**0 - 180 VDC**
	Brown	GND	0 VDC
Trigger	White	digital I/O for receiving external trigger signals	0 / 24 VDC
	Brown	GND	0 VDC
USB-2 socket	--	serial data transfer	0-5 VDC

The following table provides an overview of where the ports are connected.

Connector	Purpose	Direction
Valves	Trigger DQC camera	DQC camera trigger in
24V IN	Power supply	High-speed trigger interface power distributor
Piezo	Actuate the piezo stack	P9 piezo-electric dispenser
Trigger	Receive external trigger to actuate piezo stack	High-speed trigger interface
USB-2 socket	Control of board via cytena control software (COM port)	computer

14.4 Motor controller detailed connector plan

The motor controller TMCM 3110 PCB is connected to the components and other PCBs like shown above. Here we look in detail on the color code and pin connections of each port.



The following table provides an overview on the pin color code and signals.

Connector	Pin color	Description	Voltage
ES 0	Grey	Input for reference / limit switch right, integrated pullup to +5V	0 / 5 VDC
	Black	GND	0 VDC
ES 1	Grey	Input for reference / limit switch right, integrated pullup to +5V	0 / 5 VDC
	Black	GND	0 VDC
IN/OUT 0	Black 1	GND	0 VDC
	Red 1	Power supply	0 – 24 VDC
	Blue	AIN_0	0… +10V
	Grey	IN_1	0 / 24 VDC
	Brown	IN_2	0 / 24 VDC
	White	IN_3	0 / 24 VDC
	Yellow	OUT_0	0 / 24 VDC
	Green	OUT_1	0 / 24 VDC
	Black 2	OUT_2	0 / 24 VDC
	Red 2	OUT_3	0 / 24 VDC
IN/OUT 1	Black 1	GND	0 VDC
	Red 1	Power supply	0 – 24 VDC
	Blue	AIN_0	0… +10V
	Grey	IN_1	0 / 24 VDC
	Brown	IN_2	0 / 24 VDC
	White	IN_3	0 / 24 VDC
	Yellow	OUT_0	0 / 24 VDC
	Green	OUT_1	0 / 24 VDC
	Black 2	OUT_2	0 / 24 VDC
	Red 2	OUT_3	0 / 24 VDC
MOTOR 0	Grey	Motor coil A pin 1	
	Blue	Motor coil A pin 2	
	Red	Motor coil B pin 1	
	Black	Motor coil B pin 2	
MOTOR 1	Grey	Motor coil A pin 1	
	Blue	Motor coil A pin 2	
	Red	Motor coil B pin 1	
	Black	Motor coil B pin 2	
MOTOR 2	Grey	Motor coil A pin 1	
	Blue	Motor coil A pin 2	
	Red	Motor coil B pin 1	
	Black	Motor coil B pin 2	

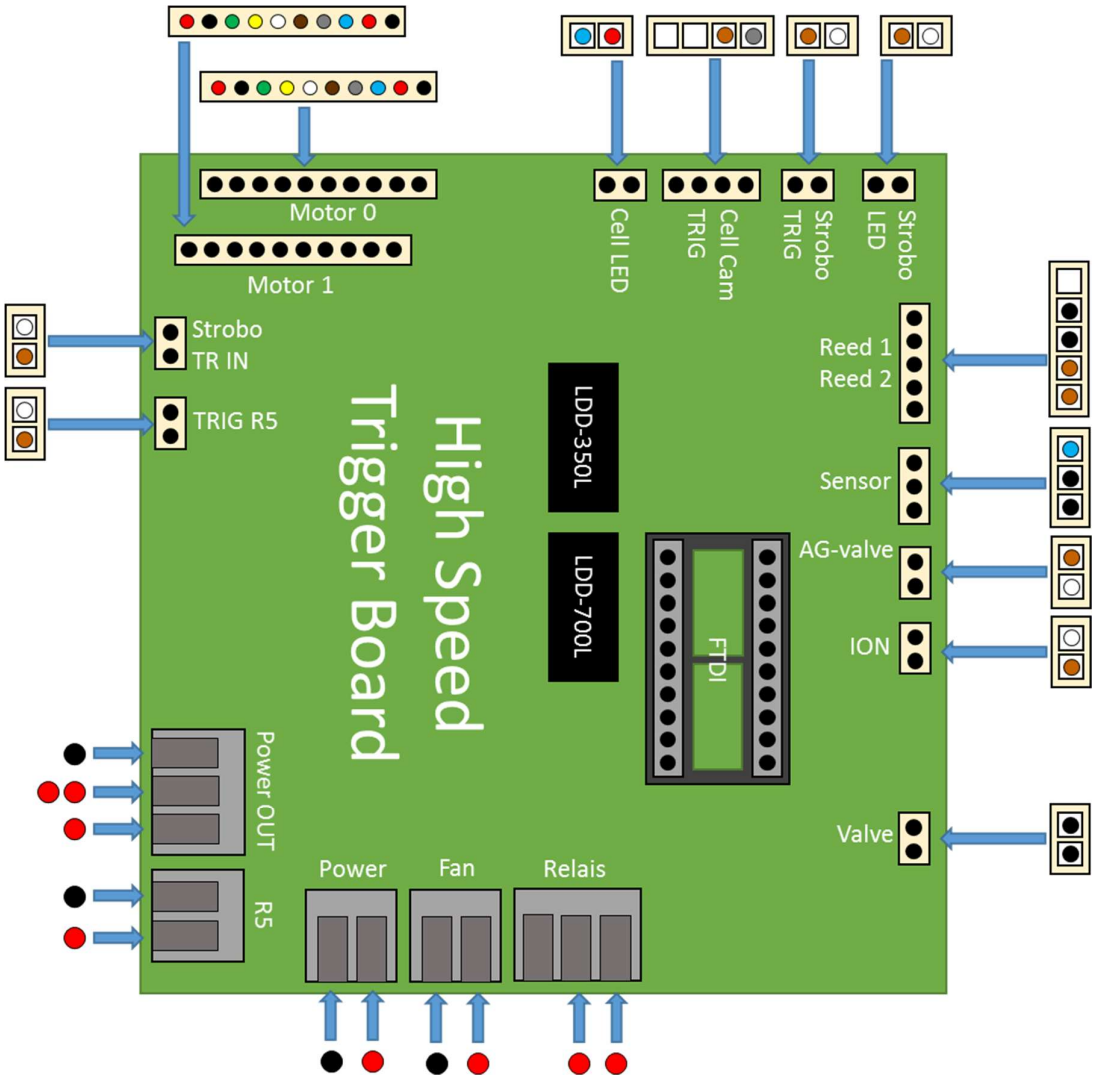
Connector	Pin color	Description	Voltage
DIGI +48V	Red 1	Supply voltage for everything else apart from the stepper motor driver ICs. An on-board voltage regulator will generate the necessary voltages for the digital circuits from this supply. This pin can be left unconnected.	0 – 48 VDC
	Red 2	Stepper driver supply voltage. Without this voltage, the stepper driver part and therefore any motor connected will not be energized.	0 – 48 VDC
	Black	Common system supply and signal ground	GND
USB-2 socket	--	Serial data transfer	0-5 VDC

The following table provides an overview of where the ports are connected.

Connector	Purpose	Direction
ES 0	End switch of motor 0	End switch X-axis
ES 1	End switch of motor 1	End switch Y-axis
IN/OUT 0	General control I/O lines	High-speed trigger interface board
IN/OUT 1	General control I/O lines	High-speed trigger interface board
MOTOR 0	Motor driving power supply lines connector to the motor coils	Stepper motor X-axis
MOTOR 1	Motor driving power supply lines connector to the motor coils	Stepper motor Y-axis
MOTOR 2	Motor driving power supply lines connector to the motor coils	Stepper motor agitation pump
DIGI +48V	Main power supply and motor driver power supply	Power supply
USB-2 socket	Control of board via cytena control software (COM port)	computer

14.5 High-speed trigger interface detailed connector plan

The High-speed trigger PCB is connected to the components and other PCBs like shown above. Here we look in detail on the color code and pin connections of each port.



The following table provides an overview on the pin color code and signals.

Connector	Pin color	Description	Voltage
Power OUT	Red 1	Power supply	24 VDC
	Red 2	Power supply	24 VDC
	Black	GND	0 VDC
R5	Red	Power supply	24 VDC
	Black	GND	0 VDC

Connector	Pin color	Description	Voltage
Power	Red	Power supply	24 VDC
	Black	GND	0 VDC
Fan	Red	Power supply	24 VDC
	Black	GND	0 VDC
Relais	Red 1	Power IN	0 / 24 VDC
	Red 2	Power OUT	0 / 24 VDC
	Black	*Not connected*	
Valve	Black 1	Power supply	0 / 24 VDC
	Black 2	GND	0 VDC
Ion	White	Power supply	0 / 24 VDC
	Brown	GND	0 VDC
AG valve	White	Power supply	0 / 24 VDC
	Brown	GND	0 VDC
Sensor	Blue	*n/a*	*n/a*
	Black 1	*n/a*	*n/a*
	Black 2	*n/a*	*n/a*
Reed 1	White	Power supply	0 / 24 VDC
	Brown	GND	0 VDC
Reed 2	White	Power supply	0 / 24 VDC
	Brown	GND	0 VDC
Strobo LED	White	Power supply	0 / 24 VDC
	Brown	GND	0 VDC
Strobo TRIG	White	Power supply	0 / 24 VDC
	Brown	GND	0 VDC
Cell Cam TRIG	White	Power supply	0 / 24 VDC
	Brown	GND	0 VDC
Cell Cam LED	Red	Power supply	0 / 24 VDC
	Blue	GND	0 VDC
Motor 0	--	*See motor controller*	
Motor 1	--	*See motor controller*	
Strobo TR in	White	Power supply	0 / 24 VDC
	Brown	GND	0 VDC
TRIG R5	White	Power supply	0 / 24 VDC
	Brown	GND	0 VDC

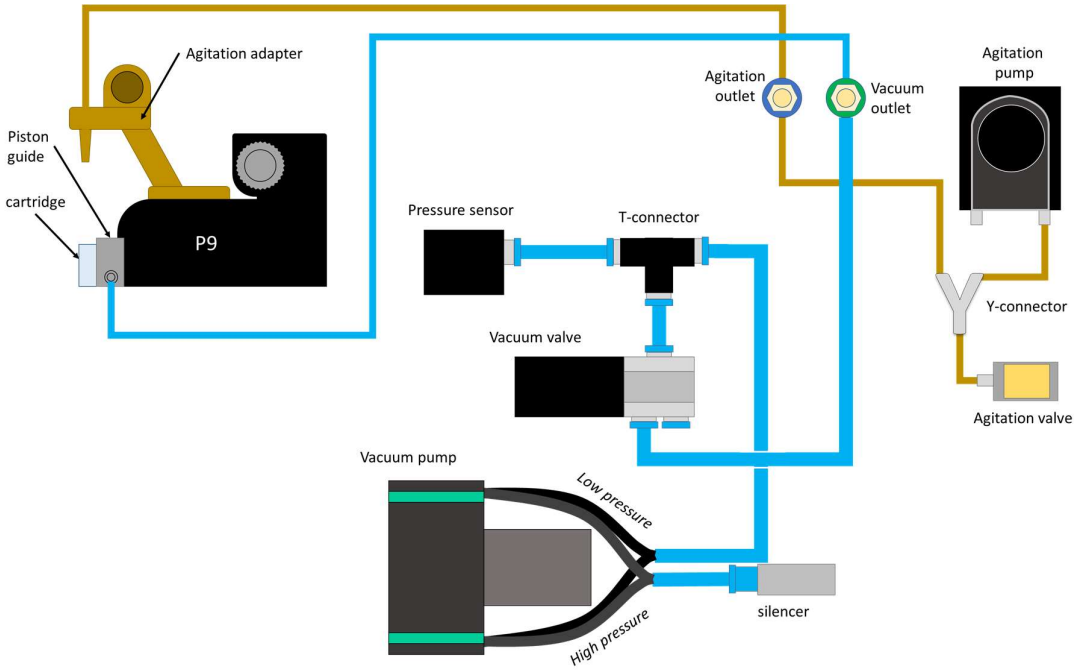
The following table provides an overview of where the ports are connected.

Connector	Purpose	Direction
Power OUT	General power supply distributor. Power to motor controller and wire block.	Power supplies
R5	Power to R5 piezo controller	R5
Power	General power supply input	Power supplies
Fan	*n/a*	*n/a*
Relais	Switching of laser control voltage via the security relays. Part of the redundancy security cycle for laser safety.	Laser controller and security relays
Valve	Switching I/O for the vacuum valve on the motor stage	Vacuum valve
Ion	Switching I/O for the ionizer mounted above the substrate carrier.	Ionizer
AG valve	Switching I/O for the agitation valve on the motor stage	Agitation valve
Sensor	Readout I/O for the pressure sensor attached to the vacuum pump und vacuum valve. Detects pump and valve failure	Pressure sensor
Reed 1	Readout I/O for the primary security switch on the device lid. Connected for all x.sight models	Reed switch 1
Reed 2	Readout I/O for the secondary security switch on the device lid. Connected for f.sight models only due to advanced laser safety regulations.	Reed switch 2
Strobo LED	Switching I/O for the DQC LED in front of the substrate loading dock	DQC LED
Strobo TRIG	Trigger I/O for the DQC camera mounted behind the substrate carrier on the axis system.	DQC camera
Cell Cam TRIG	Trigger I/O for the cell detection camera (short: cell cam) which is part of the optical assembly	Cell camera
Cell Cam LED	Switching I/O for the Cell camera LED mounted on the optical assembly. Switches different LEDs respective for each x.sight model.	Cell cam LED
Motor 0	General control I/O lines	Motor controller TMCM
Motor 1	General control I/O lines	Motor controller TMCM
Strobo TR in	Trigger I/O for receiving the trigger signal from the R5 piezo controller rerouted to the DQC camera.	R5 (valve)
TRIG R5	Trigger I/O for sending the trigger to actuate the piezo via the R5 controller	R5 (trig)
FTDI	32-pin socket for carrying the FTDI µ-controller which distributes all common trigger signals.	FTDI µ-controller

15 Vacuum shutter and agitation system

The x.sight series contains two independent air pressurized systems.

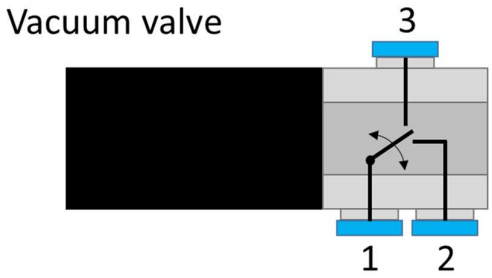
- Vacuum shutter system: takes off unwanted droplets during printing by a vacuum pneumatic shutter principle.
- Agitation system: constantly mixes the cartridge cell sample reservoir by using a peristaltic pump in alternating mode.



15.1 Vacuum shutter system

The vacuum pump generates a negative pressure. The low-pressure end is connected via a T-connector to the vacuum high-speed valve and a pressure sensor. The valve is connected to the P9 piston guide via the vacuum outlet.

The sensor controls the pressure level. The vacuum valve is normally open (1→3). Such, low-pressure is always present at the piston guide. When switching to close mode (1→2) the tubing from piston guide to valve is ventilated. Such, there is no vacuum present at the piston guide.



15.2 Agitation system

The peristaltic pump is slowly rotating in an alternating mode. Meaning it turns a certain number of degrees clockwise, followed by the same number counter-clockwise. It is on atmospheric gas level, no pump connected.

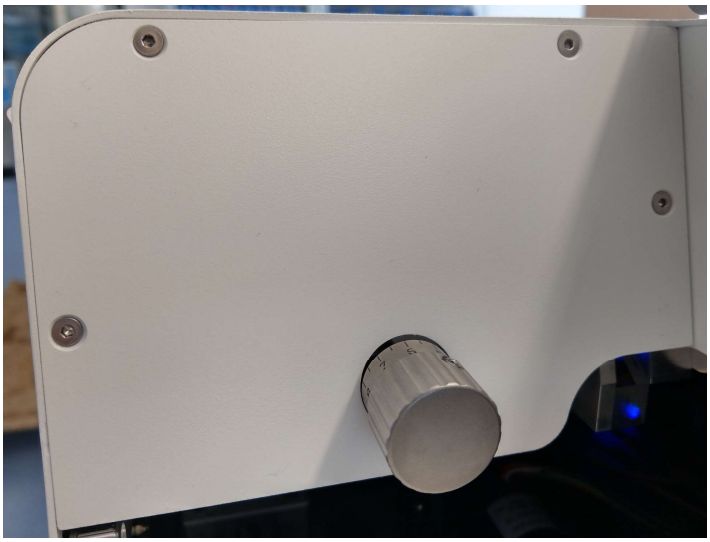
At the agitation adapter (mounted on the P9 dispenser) a pipette is connected which connects to the cartridge sample reservoir. The pump now aspirates (counter-clockwise) some microliters of sample into the pipette tip, hold's it for a second and dispenses it back into the reservoir (clockwise). After this, the system is ventilated to level the liquid in the tip. This is done to compensate for asymmetric aspiration dispensation cycles. In other words, it makes sure that always the same volume is aspirated and dispensed.

16 Access to the device interior

16.1 Opening the service lid

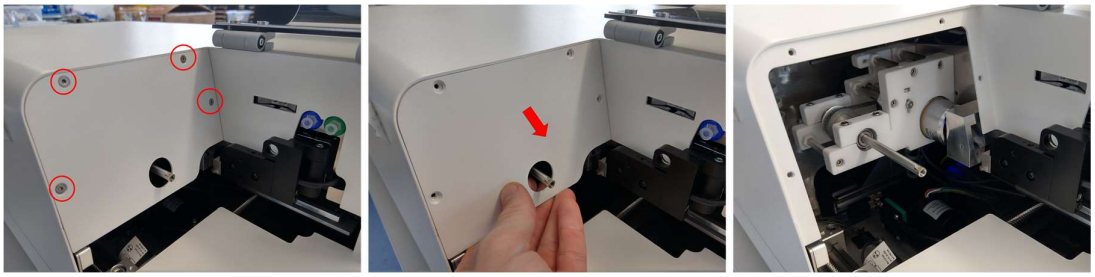
f.sight / b.sight Rev. 1

On f.sight and b.sight devices, there is a special service lid inside the loading dock that can be removed (see image below). It is made to facilitate service on optical parts, especially useful in laser adjustment on the f.sight.



To open the service lid, turn the focus adjustment knob until you see the headless screw. Use a hex-key to loosen the screw (do not remove it). Pull off the knob and place it aside. There is only the shaft remaining.

Now take a hex-key and remove the four countersunk screws that fix the service lid on the top cover. Support the lid with your hand, otherwise it will fall down. Remove the lid and place it aside. Now you have access to the interior with the optical focus stage and laser alignment mirrors.



f.sight / b.sight Rev. 2

With the new revision, the focus mechanics have been updated. They are now made of Aluminum with spring-loaded glide bearings and a fine-adjustment screw. Such, the method of opening the service lid has changed.

To remove the service lid, just loosen the four screws using a hex key. The fine-adjustment screw does not need to be removing any more. Support the lid with your hand, otherwise it will fall down.

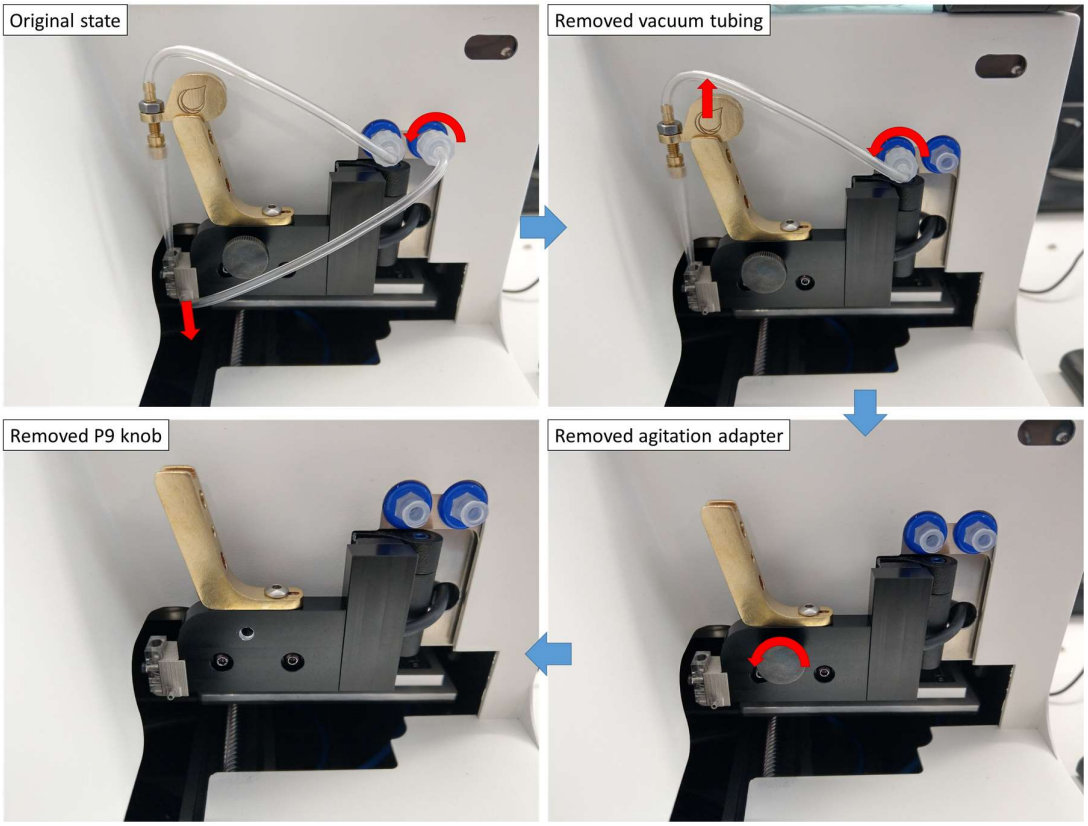
Remove the lid and place it aside. Now you have access to the interior with the optical focus stage and laser alignment mirrors.

16.2 Opening the protective housing

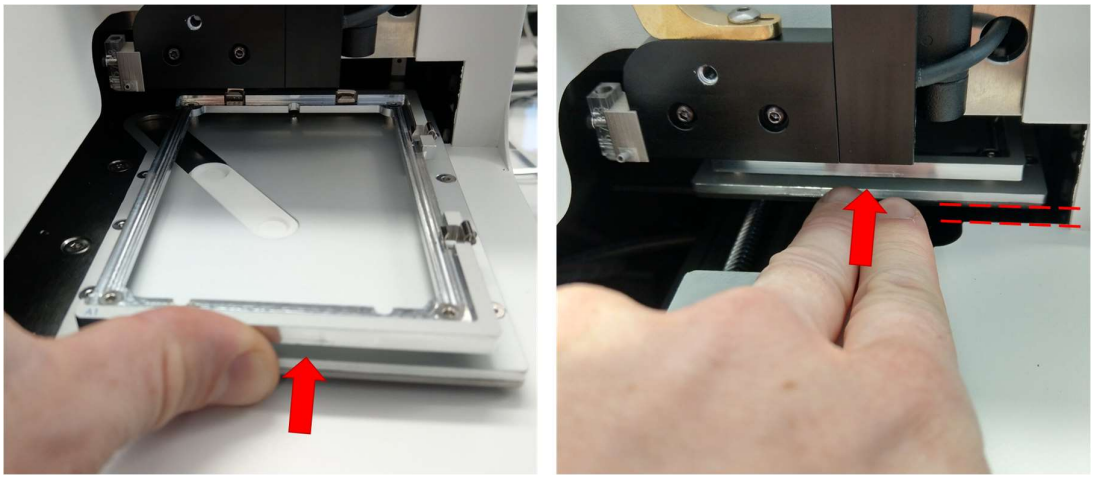
To open the device, place it on an even, solid underground such as a table. Detach all cables from the device including the power cord. Remove all securing screws from both sides and the back as indicated in the following figure:

16.2.1 c.sight specific instructions

Detach the vacuum tubing, the agitation tubing including agitation adapter and the black pulling knob from the P9 as shown below:



Use your hand to push the substrate carrier including axis slider into the device. Push it to the back until it has fully left the lower part of the housing (red dashed lines). The housing must be removable by lifting it vertically upwards.

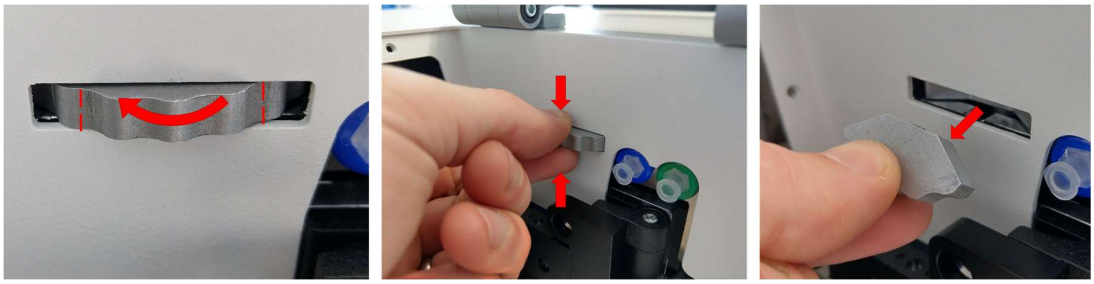


Make sure, the P9 is at its standard closed position. Now you are prepared to remove the top cover.

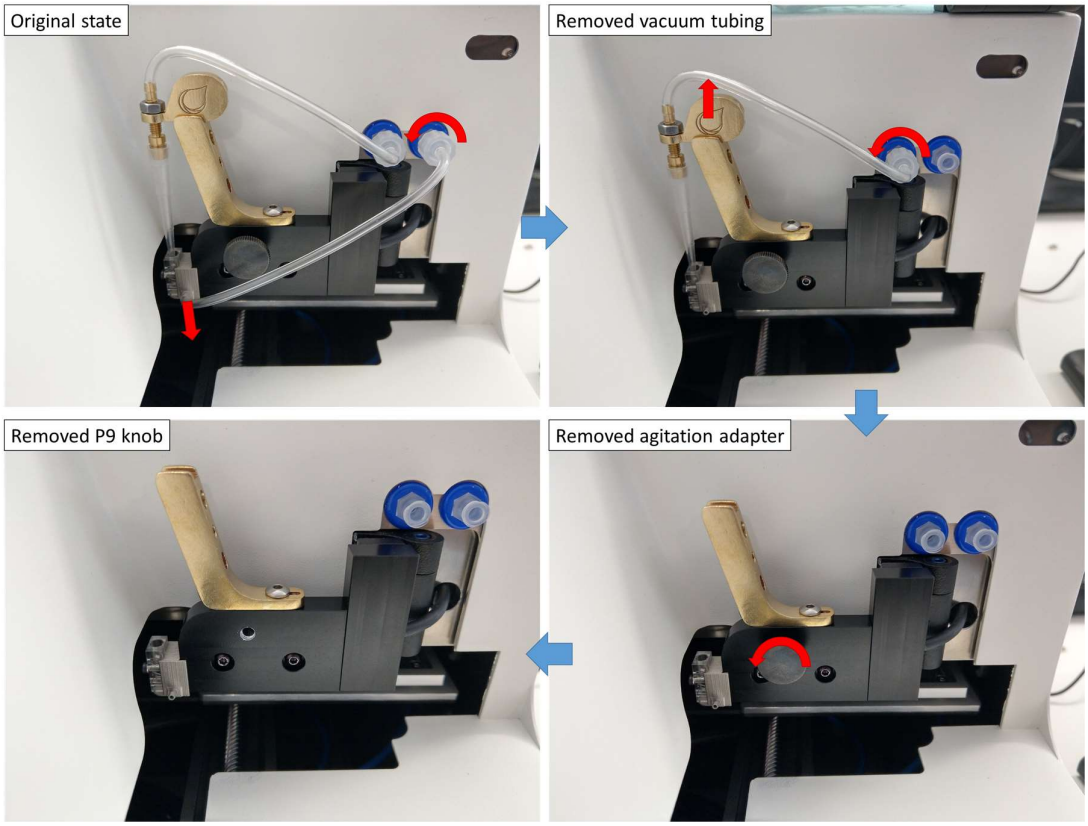
16.2.2 f.sight & b.sight specific instructions

On f.sight and b.sight there more parts to be removed before you can open the protective housing. Follow the instructions given below.

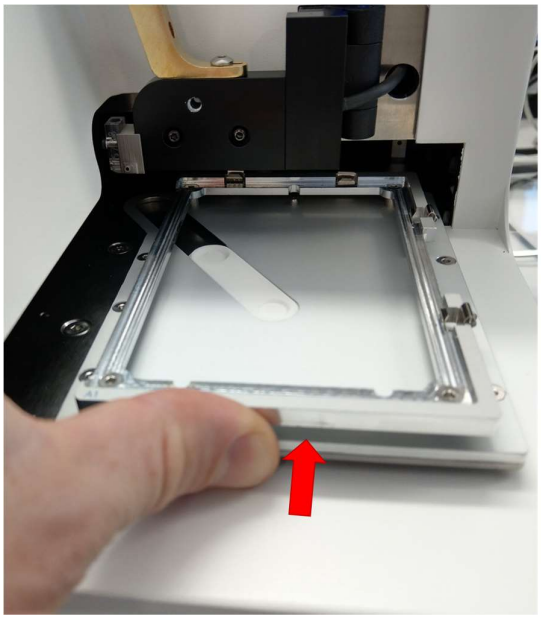
Turn the vertical adjustment wheel until you see the two slits / grooves facing towards you (red dashed lines in left image). Now grab the wheel and pull it out. Put it aside. Make sure that the remaining wheel is not in contact with the white metal housing.

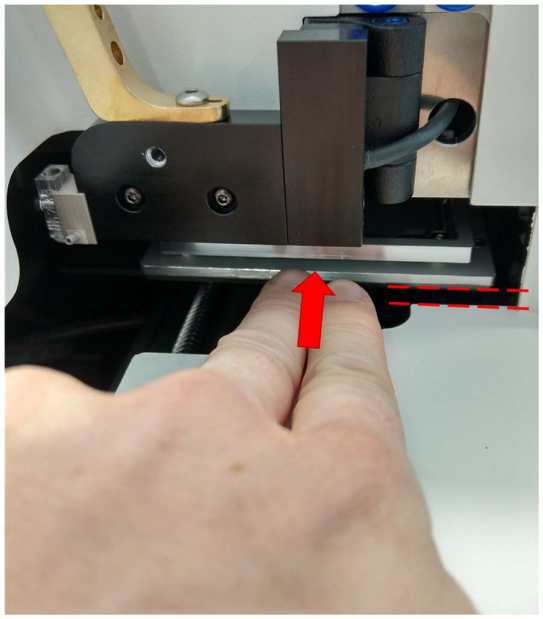


Detach the vacuum tubing, the agitation tubing including agitation adapter and the black pulling knob from the P9 as shown below:



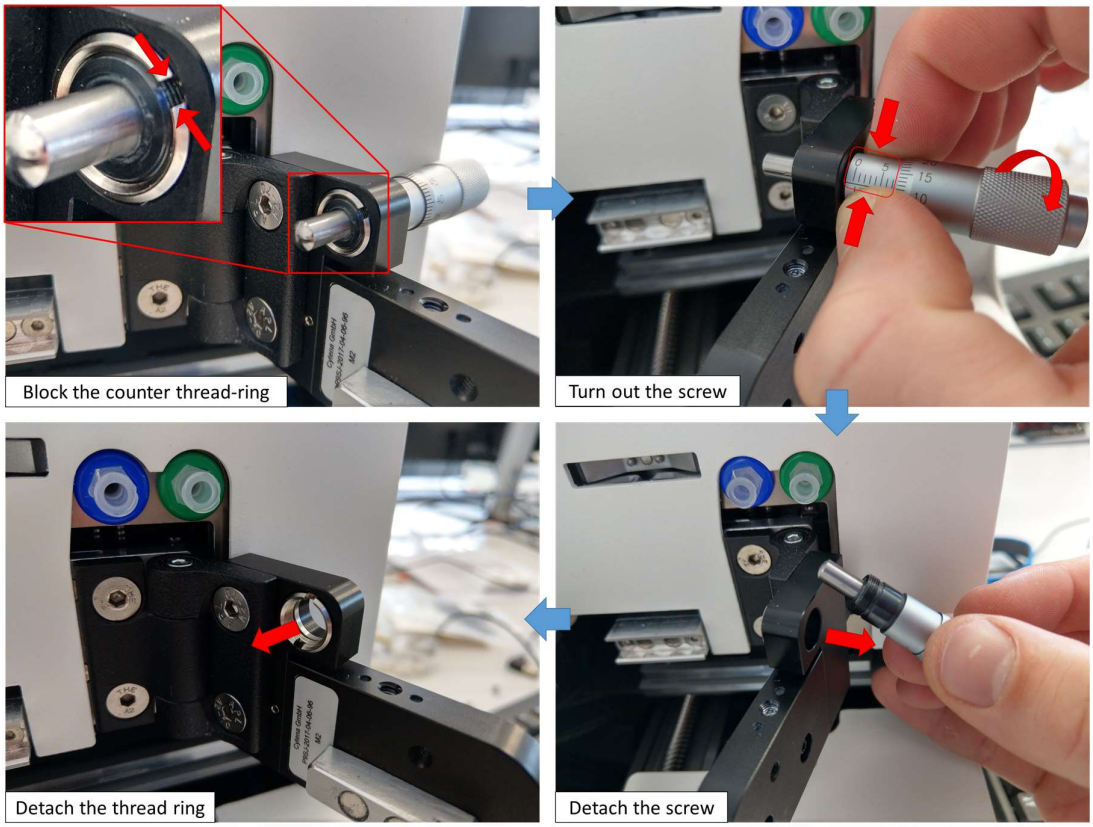
Use your hand to push the substrate carrier including axis slider into the device. Push it to the back until it has fully left the lower part of the housing (red dashed lines). The housing must be removable by lifting it vertically upwards.





16.2.3 Dispenser special

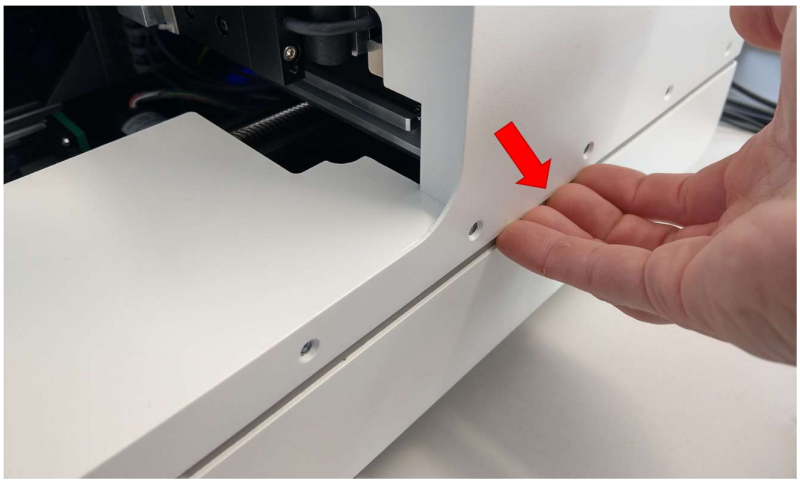
Swing out the P9 dispenser. You will find a counter thread-ring on the inner side that fixes the fine-adjustment screw on the front side. Use an appropriate tool to block the ring (press the tool into the small groove to block the ring). Now grab the screw neck as shown below (red box + arrows). Turn the neck to turn out the entire screw. Once the screw is free, remove it. Collect the counter thread-ring from the inner side and put both parts aside.



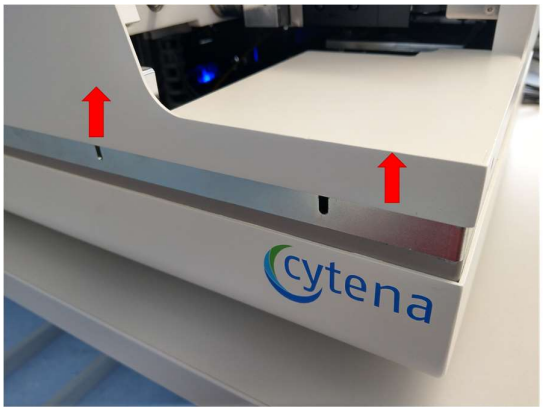
Swing back in the P9 dispenser. Now you are prepared to remove the top cover.

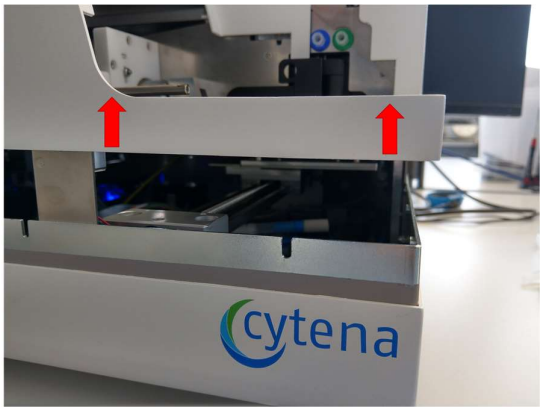
16.2.4 Removing the top cover

Grab the top cover on both long sides with your hand. To not use any metal or hard tools! They will damage the cover paint.

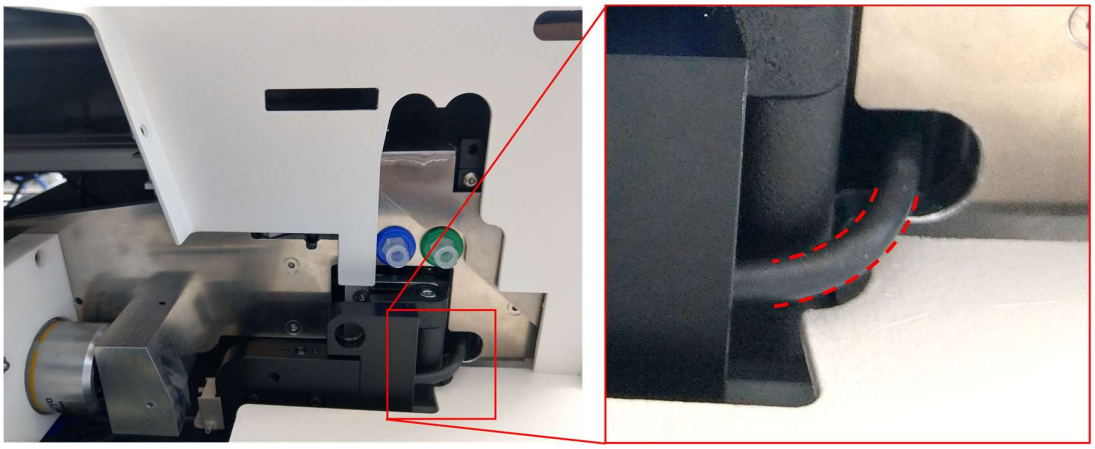


Lift the top cover of the housing slightly up until you detached it from the colored metal frame (grey color at b.sight in the image below).

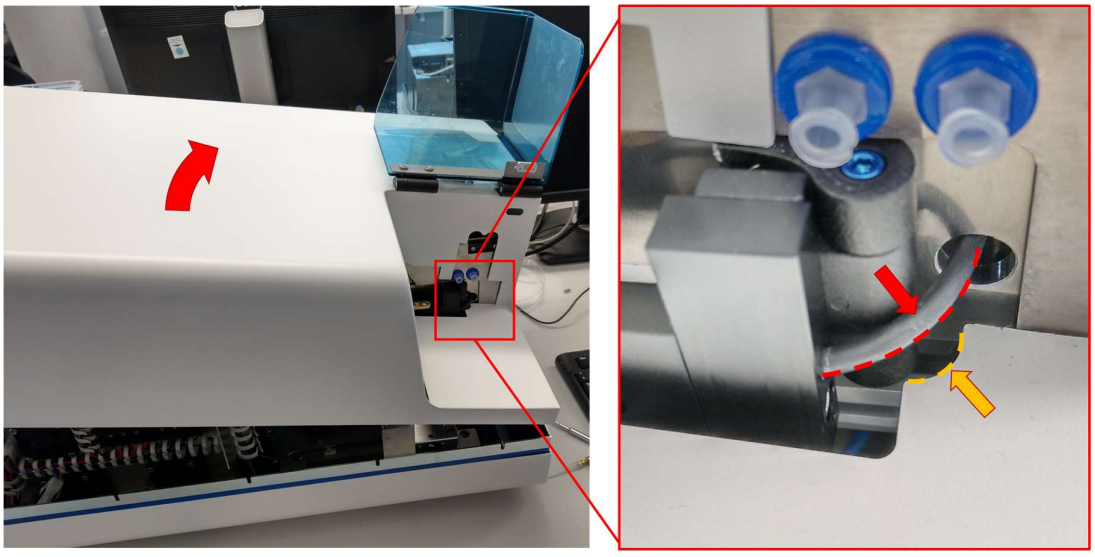




Move the cover upwards until you reach the P9 cable like indicated in the image below



Now tilt the entire top cover to the right as indicated in the picture below. While tilted, remove it completely. Take special care about the P9 cable (red dashed line). It must not be bended or jammed by the housing (orange dashed line).

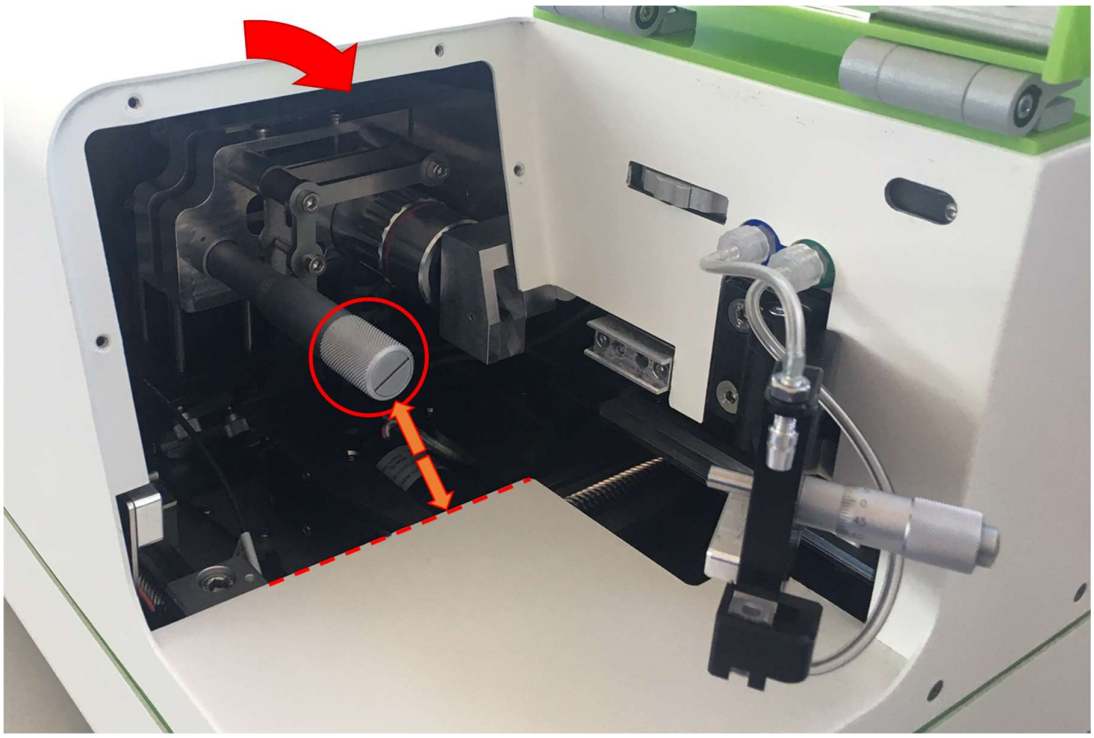


Remove the cover and place it at a safe place where it cannot be damaged or dropped by chance.

If required for testing, re-attach the specific parts (e.g. vacuum tubing, agitation adapter, etc.). Make sure those are properly fixed and correctly connected before starting your tests.

f.sight / b.sight Rev.2

With the new focus mechanics, it is no longer required to remove the focus screw / know. Instead, you can remove the housing directly. Please make sure that you avoid collision of the fine-adjustment screw with the housing (see arrows in picture).



16.3 Closing the protective housing

> ***CAUTION:*** *before closing the device, remove all measurement tools, cables, jumpers, etc. that you may have placed inside the device!*
>
> *Do not use brute force to apply the cover. Take care and double check if there is something maybe blocking the cover.*

> ***CAUTION:*** *take extreme care to not jam any cables or internal components when applying the top cover to the device! Jammed cables can cause shortcuts and let to injury or fire hazard.*

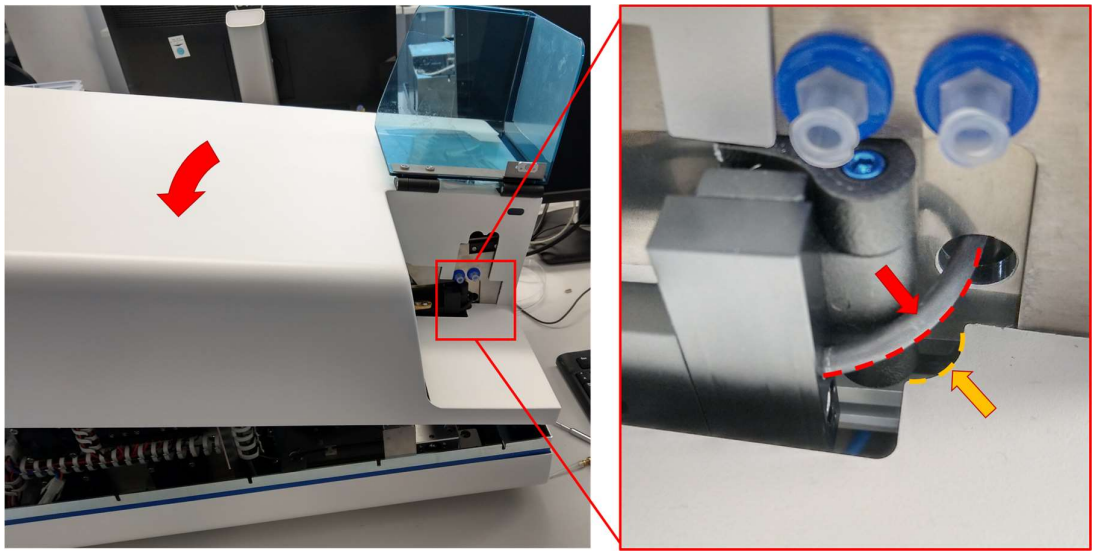
16.3.1 Preparations

Please make sure that the following points have been checked before applying the cover to the device:

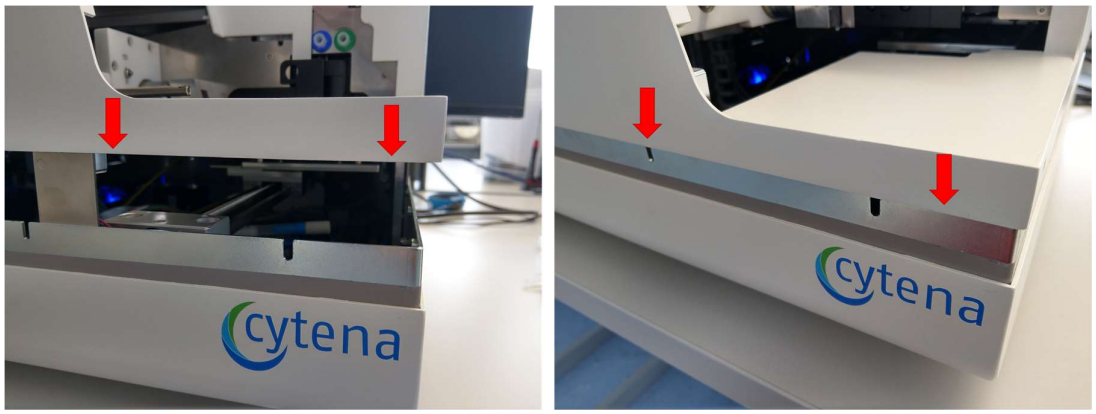
- Push back in the substrate carrier and axis slider. Make sure it is at the rear-most position otherwise it will block the cover
- If attached, remove vacuum tubing and agitation adapter. Otherwise they will block the cover.
- If attached, remove pulling knob (c.sight) respectively fine-adjustment screw (f.sight and b.sight). Otherwise it will block the cover.
- If attached, remove the focus knob. Otherwise it will block the cover.
- Remove the magnetic defeating tool from the Reed-switches.

16.3.2 Attaching the top cover

Start with the top cover slightly tilted. Make sure you securely pass the P9 cable (red dashed line) with corner or the cover (orange dashed line).



Now hold the top cover horizontal again and slide it down until you reach the colored metal frame (grey color for b.sight in image below).



Make sure that top and bottom cover are superimposable. Check the corners and edges like indicated by the dashed lines in the images below. On the rear side make sure that the PC access panel does not overlap or block the top cover (bottom left image). Slide down the cover until it is at the lowest position. Check the fixing screw holes to be concentrical with their respective threads in the inner metal frame (bottom right image).

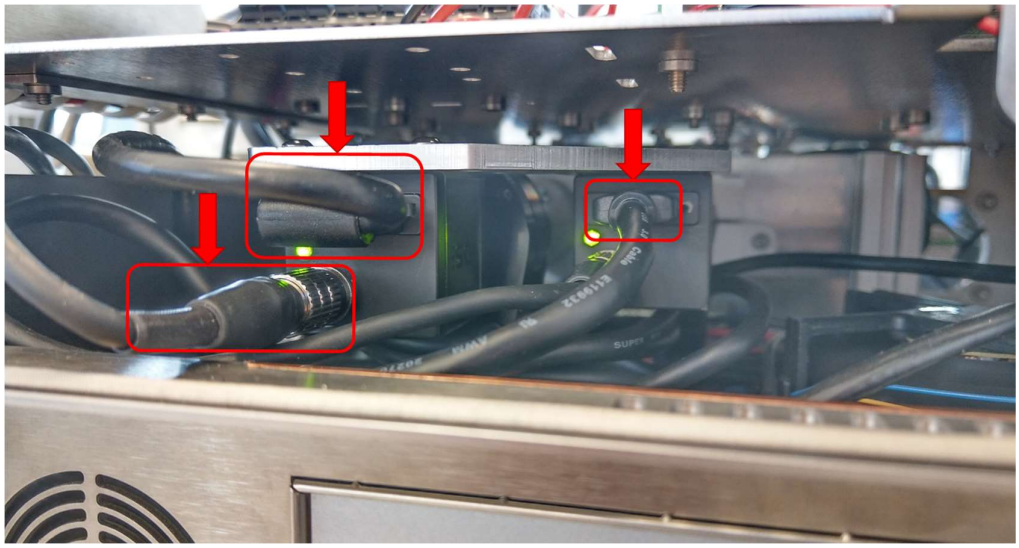
Make sure that the cover sits correctly. Use the countersunk screws to fix it.

> ***HINT:*** *It may be useful to check all functions and hardware before fixing all screws in the cover. Tip: only fix four screws and perform device testing. When all tests are passed, fix the remaining screws. In case you need to re-open the cover, this saves you time.*

16.3.3 Critical points

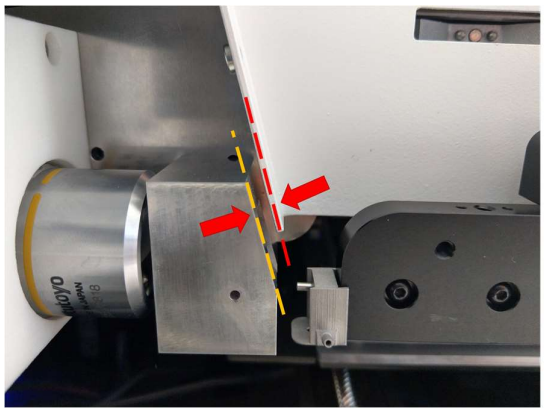
The following issues might occur when closing the cover. Please make sure that you take special care on these points.

Case 1: shearing off the camera USB cable (mainly f.sight) while moving down the cover



Case 2: jamming the camera USB-cable in the rear slot between cover and PC panel.

Case 3: insufficient clearance to prism or DQC LED after they have been adjusted.



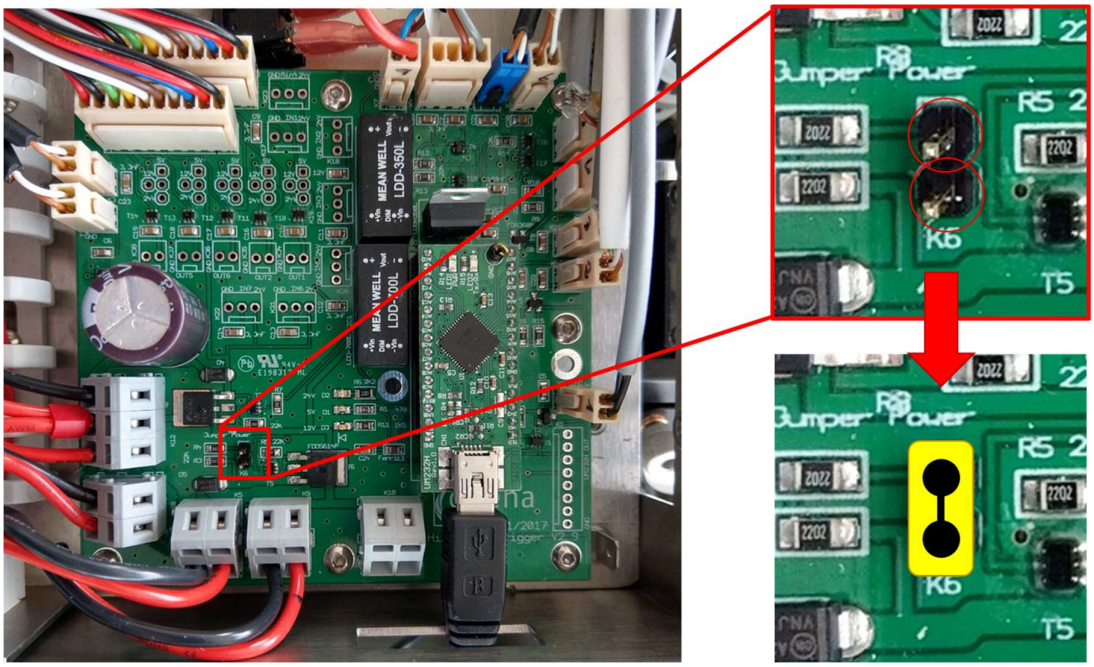
17 Special power modes for service

17.1 Power always-on

The device is started by the main power switch on the front. This switch only starts the mainboard. The majority of electronic boards (piezo driver, motor controller, etc.) is only powered when the cytena software is started.

For service cases it may be required to check certain functionality of these boards without the cytena software being started. In this case you can jumper the HSTI board to “power always-on” mode. Open the device housing (section 0) and follow the steps:

1. Take one of the free jumpers from the motor controller board
2. Place the jumper on the pins shown in the picture below

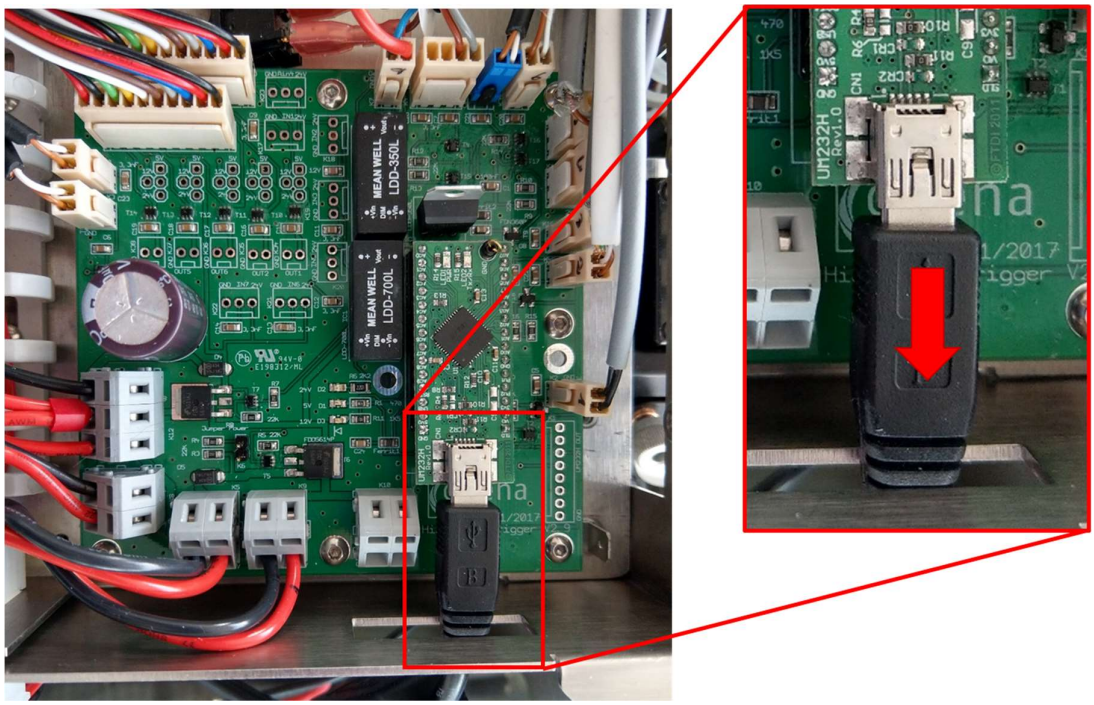


Remove the jumper when you are done and place it back on the motor controller. Close the housing.

> ***CAUTION:*** *make sure that you remove the jumper from the pins when you have finished your service task. Leaving on the jumper, closing the housing and starting the software will lead to unforeseen behavior and potential software crashes.*

17.2 Power cycling

In some cases, you may want to power cycle (= turn off and on again) certain electronic boards. To do so, remove the USB-cable from the FTDI (on the HSTI board) like shown below. Wait 2 sec and plug it in again.



18 Optics adjustment & calibration

The following sections provide instructions how to adjust optical components and ensure optimum image quality.

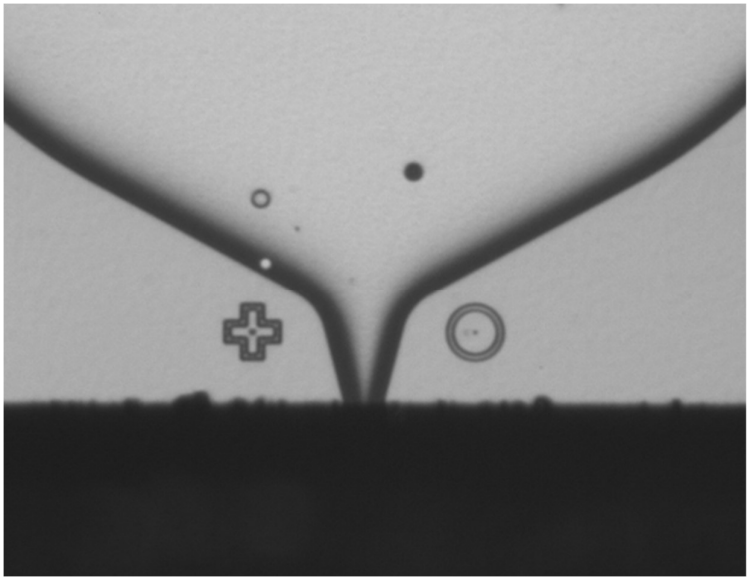
> ***CAUTION:*** *all optical components are sensitive and vulnerable to mechanical damage such as scratches. Please work concentrated and with caution.*
>
> *Adjustments on optical components will influence the image quality. Proper image quality is crucial for correct detection of cells and reliable function of the instrument. The following tasks shall only be performed by trained personnel.*

18.1 c.sight optics

The following steps illustrate how to adjust the optics in c.sight models.

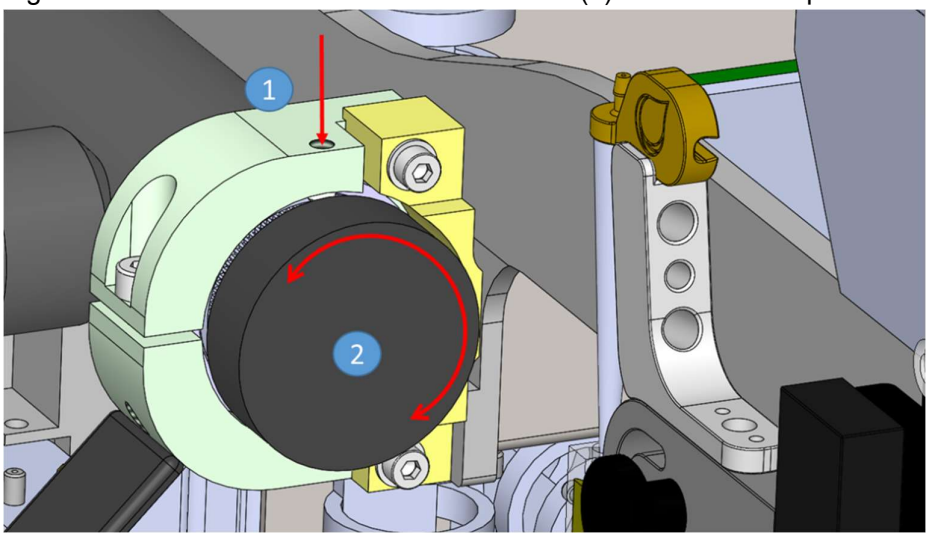
- Open the device (section 16) and defeat the interlock
- Start the software and mount a test cartridge to get an image in the camera view window
- The chip is at an optimum position, when
  - the nozzle is in the middle of the chip
  - below the nozzle a small black bar is (in order to tolerate potential variations of the chip position on the cartridge)
  - the edges of the wall are sharp (as well as the plus and the circle next to the nozzle)
  - The shadow on the left and the right side of the chamber have the same size.

- Reference image:



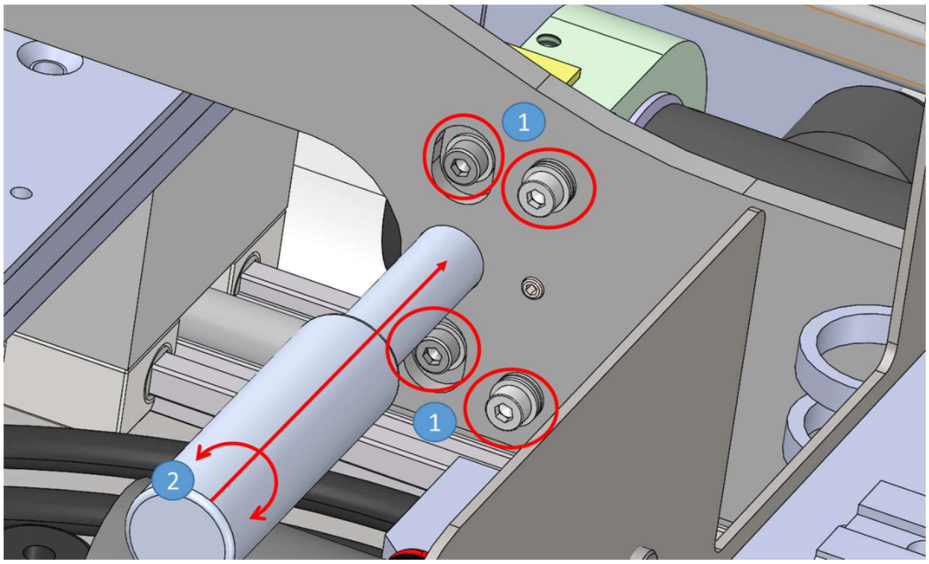
18.1.1 Adjust the focus

- Loosen the headless set screw above the lens (1)
- Adjust the focus by turning the lens (2)
- Tighten the headless set screw above the lens (1) to fix the focus position



18.1.2 Explanation: How to change the vertical position

- Loosen the cylinder head screws (1) at the optics beam.
- Change the height of the optics with the eccentric adjusting tool (2).
- Tighten the screws (1) of the optics beam.

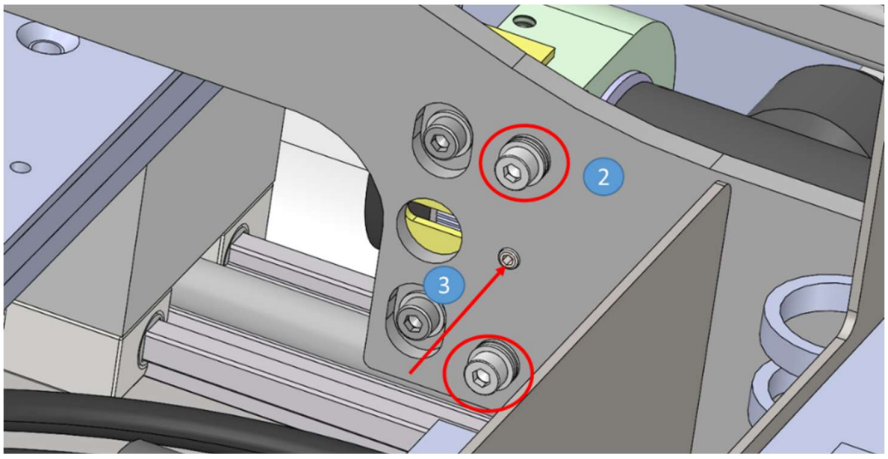

1
1
2

18.1.3 Explanation: How to change the horizontal position

- Loosen the M3 cylinder head screws next to the lens (1)

- Loosen the M3 cylinder head screws (2) above and below the set screw.

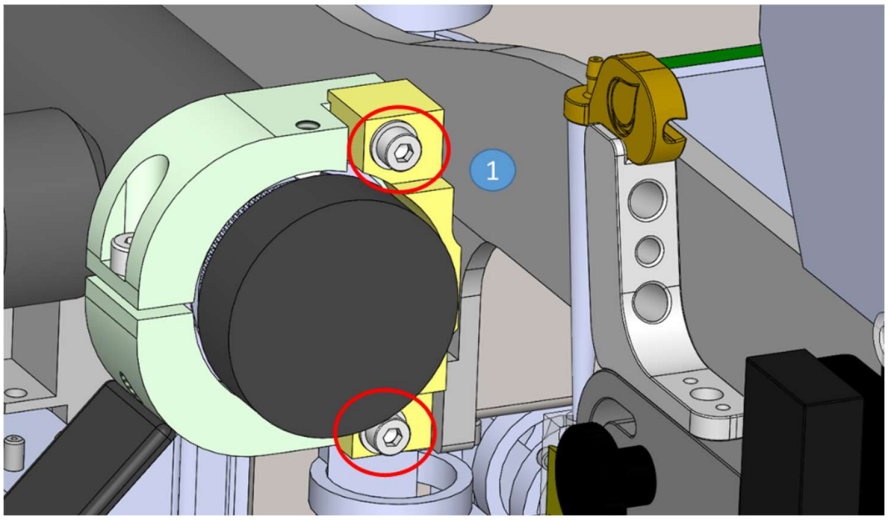
- The optics can be moved in both directions
  - In order to move the chip to the left side, the set screw (3) needs to be tightened.
  - In order to move the chip to the right side, the set screw (3) needs to be loosened.



- After the adjustment, tighten the screws above and below the set screw (2).

- Check the position of the Nozzle
  - Eventually you need to fine adjust the optics with the set screw (3) after tightening the screws above and below the set screw (2).

- When satisfied with the positioning, tighten the screws next to the lens (1) to fix the position.

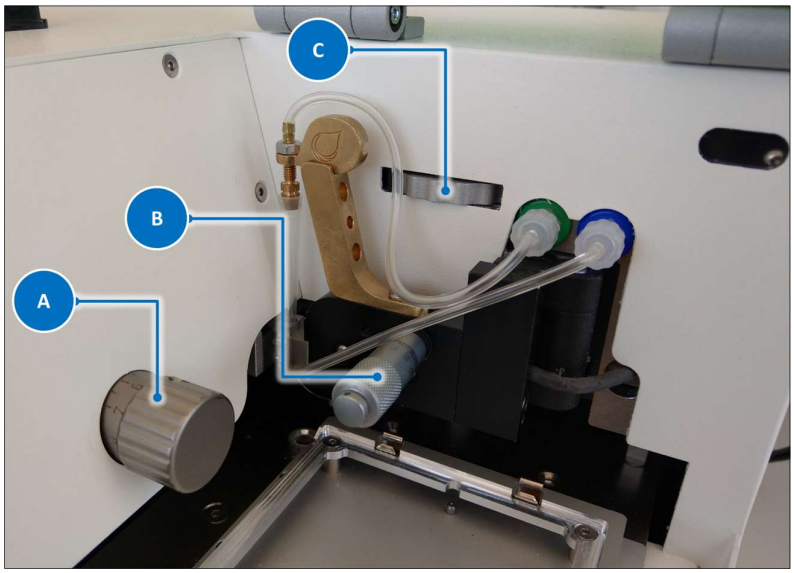


18.2 f.sight optics

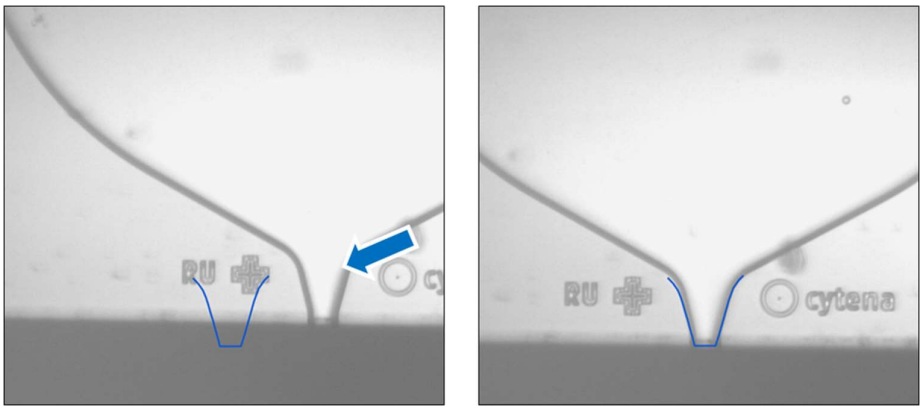
The following steps address different parts of the general calibration procedures available for the f.sight. Depending on which part you want to adjust, chose the respective section.

18.2.1 Focus and nozzle position

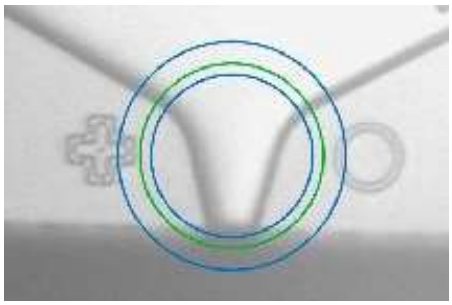
- Open the lid, a bigger screen showing the nozzle will appear.
- Use the three fine-tune screws: (A) focus, (B) lateral position and (C) vertical position

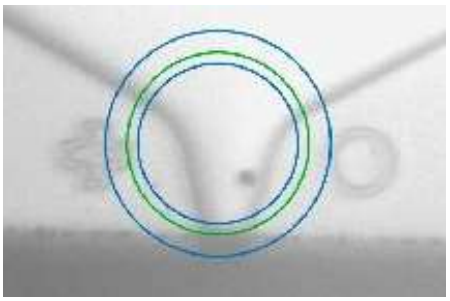


- To center the nozzle in the camera window use the target contour:



- First find the right focus by using screw (A). If you see the ring and the plus mark in focus you are close to a good focus. Examples:


good focus

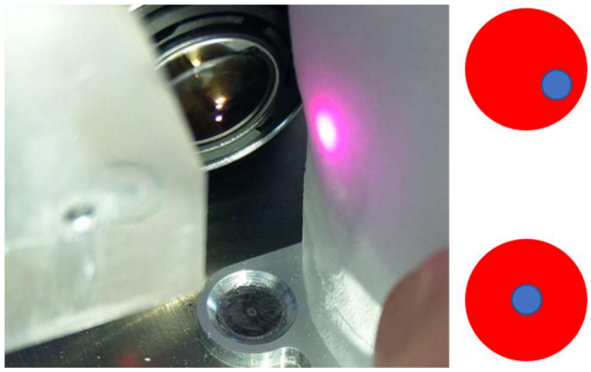

bad focus

18.2.2 Laser spot alignment

	**WARNING:** CLASS 3B LASER RADIATION WHEN OPEN AND INTERLOCK DEFEATED. AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION.	

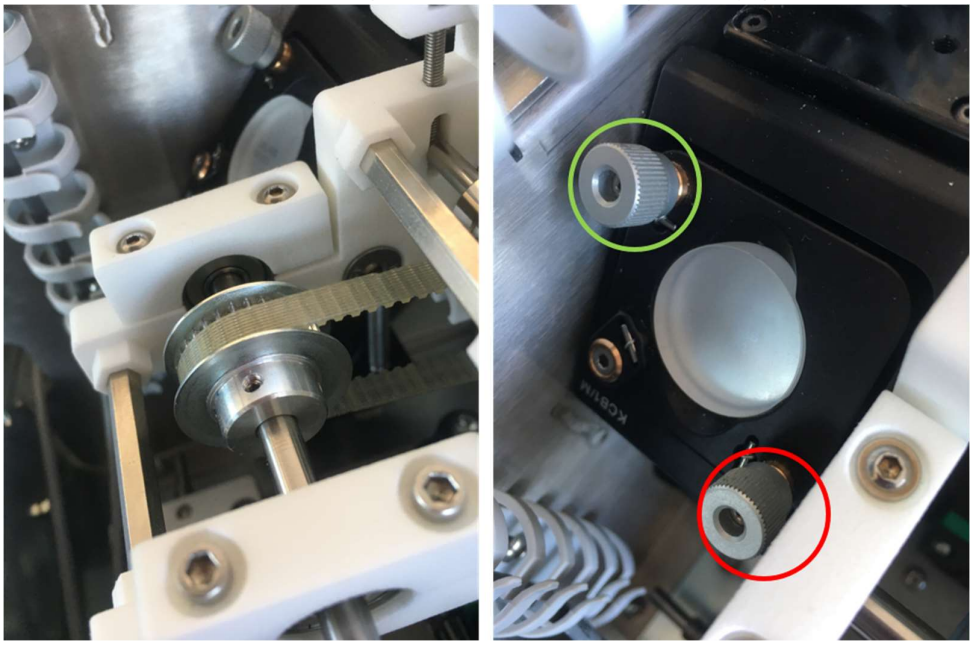
WARNING: Please read and follow the instructions about laser safety (chapter 0) before continue here!

- Start the instrument and the software. Mount a fluorescent target cartridge.
- In “**Settings**” tab set “**Laser Intensity**” to 1 % and stepwise increase it until you see a clear fluorescent signal from your sample beads in the “cell camera” view.
- In “**Settings**” tab set “**FL Camera Exposure**” to 1 ms
- Defeat the interlocks (section 22.1) to start the laser.
- Swing out the P9 dispenser and insert a blank white piece of paper in front of the optical prism.
- You will see a larger red spot caused by the red bright field LED and a smaller blue spot from the laser (see image in the left). What you want is that the red spot is concentric to the blue spot like indicated in the lower schematic. What you might face is a misalignment looking like the upper schematic where the laser spot if off center.



- If the laser spot is off center, you have to readjust it. To do so, you need access to the adjustment mirrors. To access them open the service lid (section 16.1).

- Behind the focus adjustment mechanics (white parts in left image) you can locate the mirror with its two screws (marked by circles in right image)



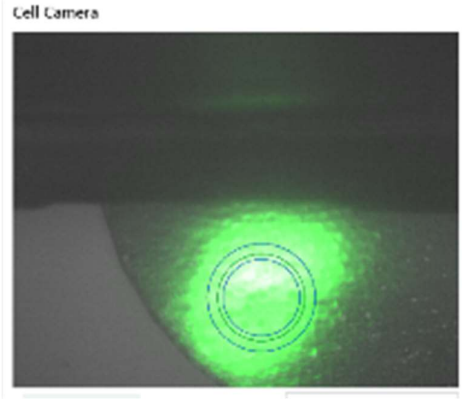
- By turning screw, **A** (green) on the upper mirror you adjust the vertical position of the laser to be centered in the red dot.

- By turning screw **B** (red) on the upper mirror you adjust the horizontal position of the laser to be centered in the red dot.

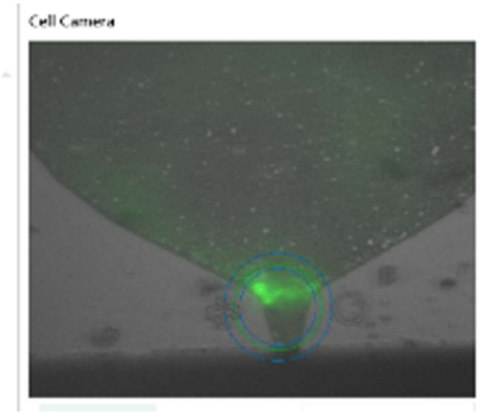
- Once you have centered the laser spot in the red-light spot, switch back to software. Center the ROI over the nozzle by either clicking onto the nozzle in the image or pressing the "**Auto ROI**" button below the camera view window.

- If not already set, switch to "brightfield and fluorescence" channel view using the dropdown menu below the camera view window.

- Now move the cartridge down until you see a bright signal like this:



- With the mirror screws **A** and **B** position the laser spot to illuminate the region within the ROI



- Note: if the green channel signal is over exposed (= everything in the image appears green) navigate to "**Settings**" and reduce the "**FL Camera Exposure**"
- If the laser excites the area of the ROI bring the cartridge back up so the nozzle is back in the ROI region
- If the beads in the nozzle are illuminated you are done
- Close the service lid and put back the knob to its position.

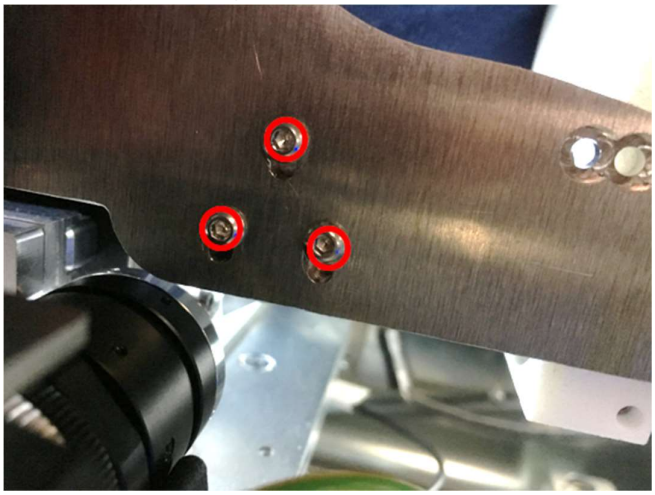
18.3 **b.sight optics**

…

18.4 **Optical prism (f.sight / b.sight)**

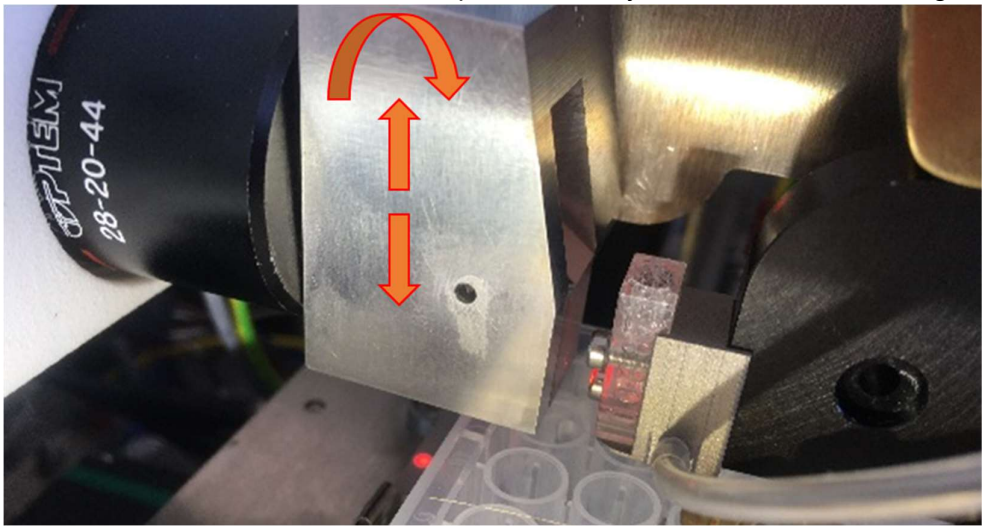
The prism is sensitive part of the instrument and important for image quality. Please not readjust this part unless it is absolutely necessary.

- Open the device (section 16) and defeat the interlock
- Start the software and (in case of f.sight) switch off the laser under "**Settings**"
- Mount a test cartridge to get an image in the camera view window
- On the back of the optics main carrier there are three screws that hold the prism from the backside. Release (not remove!) those screws (marked with red circles in the image below)



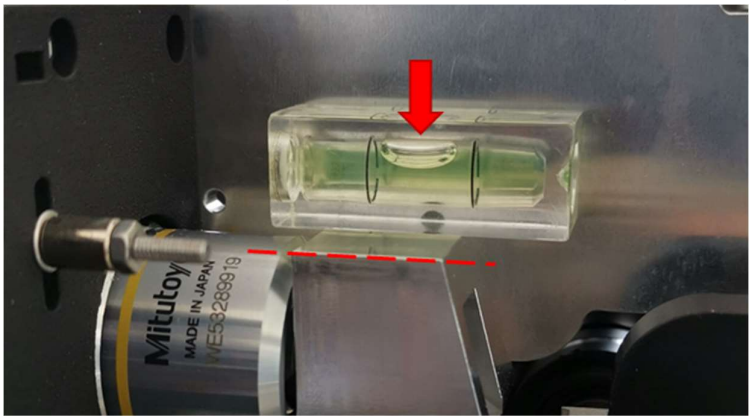
(rear view with DQC optics in the lower left corner)

- You should now be able to move the prism vertically and tilt it to a certain degree

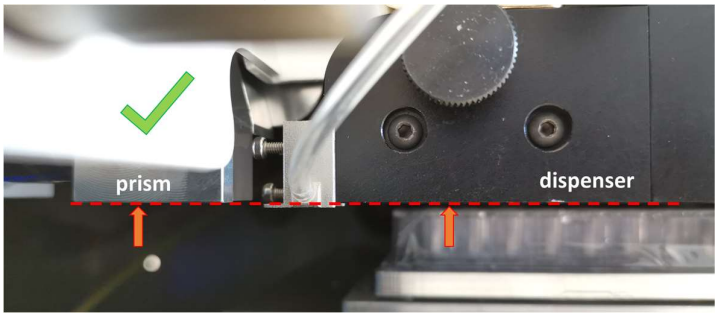


- Move prism slightly up or down and adjust its angel so that:

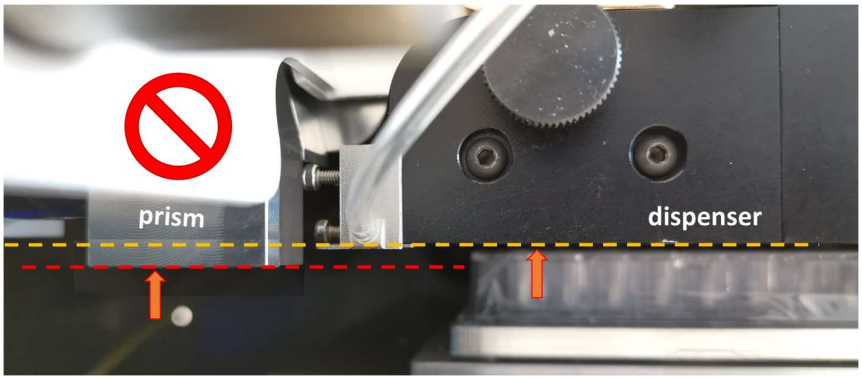
- the prism is horizontal (check with water spirit level)



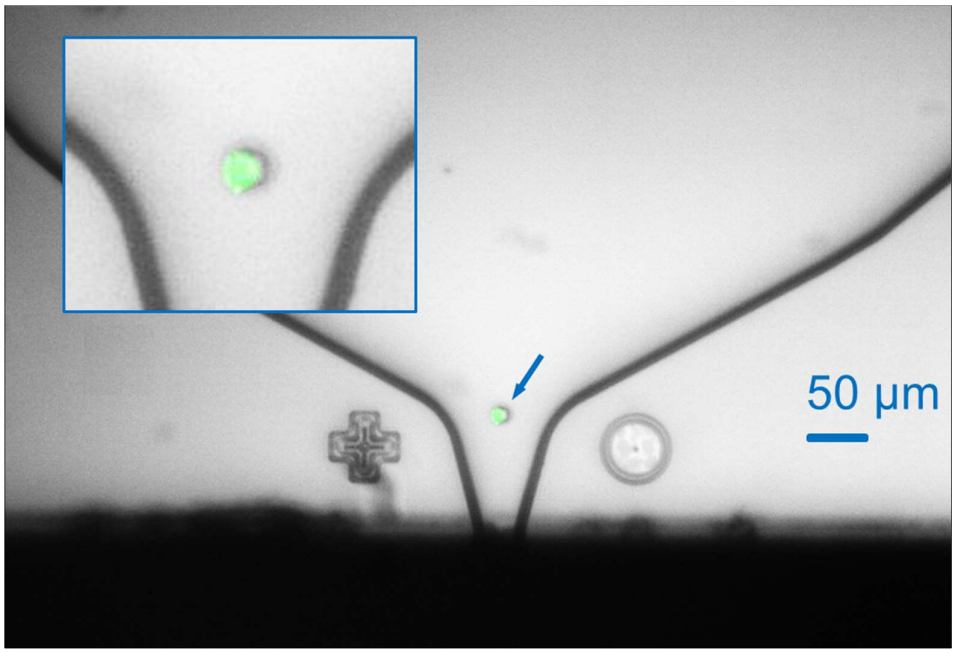
- The prism bottom edge is parallel to the dispenser bottom edge:



CAUTION: *make sure that the prism is not lower than the bottom edge of the dispenser. If it is lower, there is significant risk that the prism touches the plate during operation which could lead to severe damage of the instrument.*



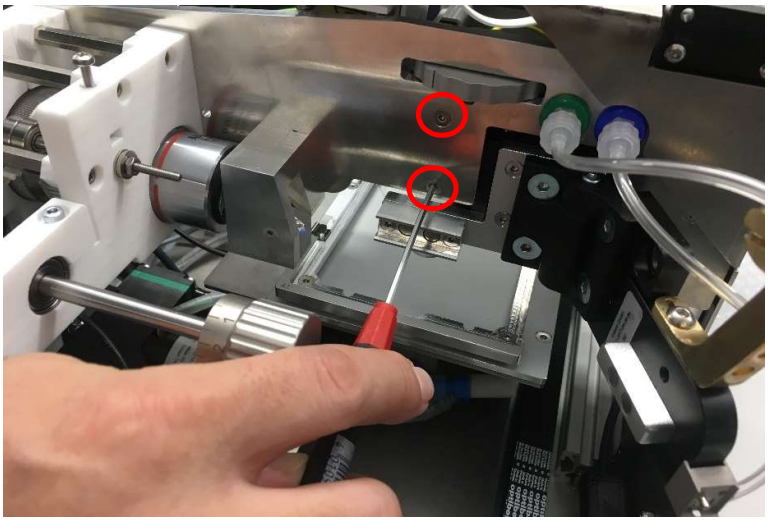
- You see a sharp image in the software:



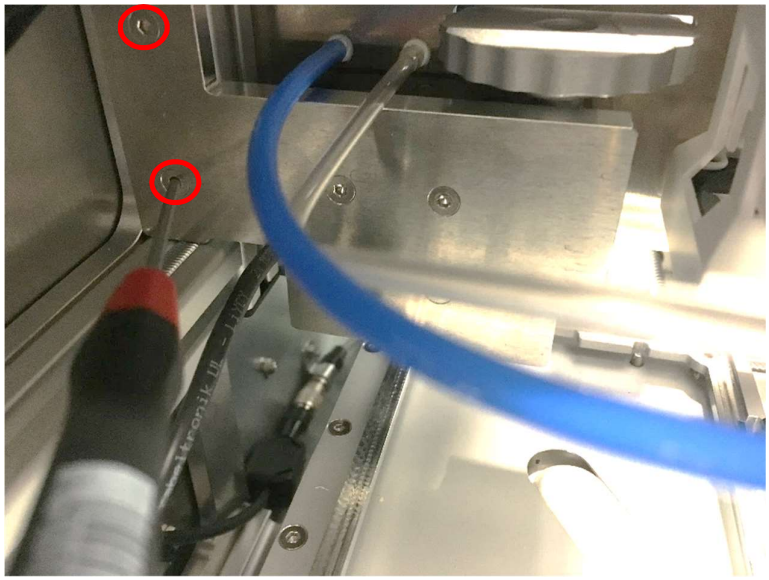
18.5 Dispenser Adjustment (f.sight / b.sight)

The dispenser is fixed on a vertical linear stage that allows alignment of the optics to the dispenser, respectively the microfluidic chip inside the cartridge (the latter being attached to the dispenser).

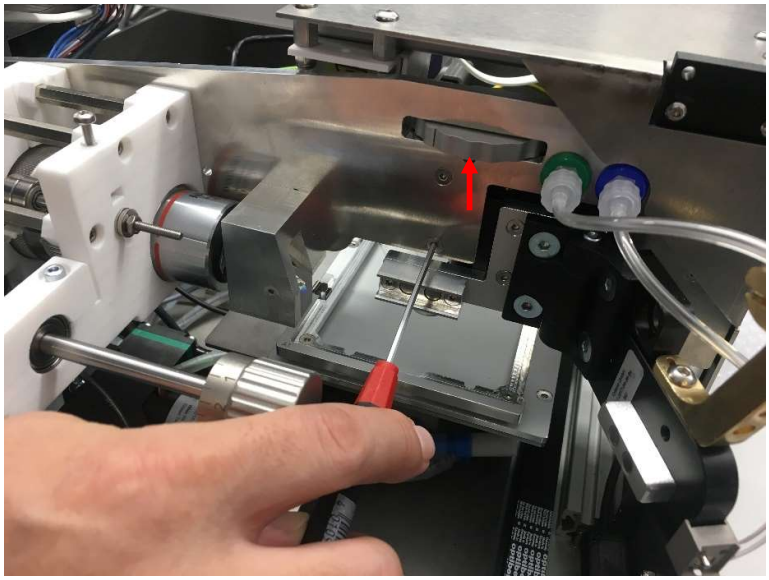
- Remove the protective cover from the device
- Loosen the two screws in the front of the optical beam (you do not have to remove them all the way). See image below



- Last look at the back of the optical beam, loosen the two screws on the side (indicated in the image below)



- Move the whole unit up a little bit so that the wheel (marked with red arrow) can move freely again



- Tighten all 4 screws again

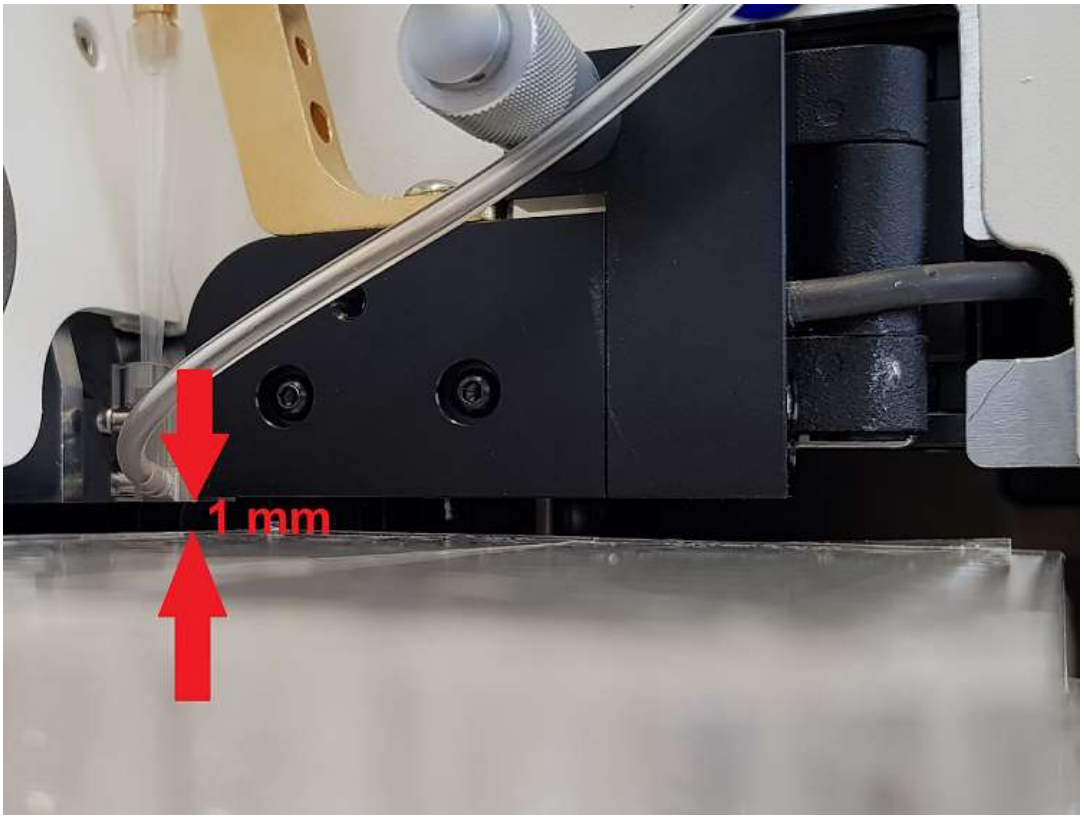
19 Plate calibration & clearance

Please read the following note carefully before starting:

> ***CAUTION:*** *Change coordinates carefully. Setting wrong coordinates can damage the instrument. The device can move in a way that axis can collide with some deck parts (substrate carrier, DQC camera system).*

19.1 Well plate clearance

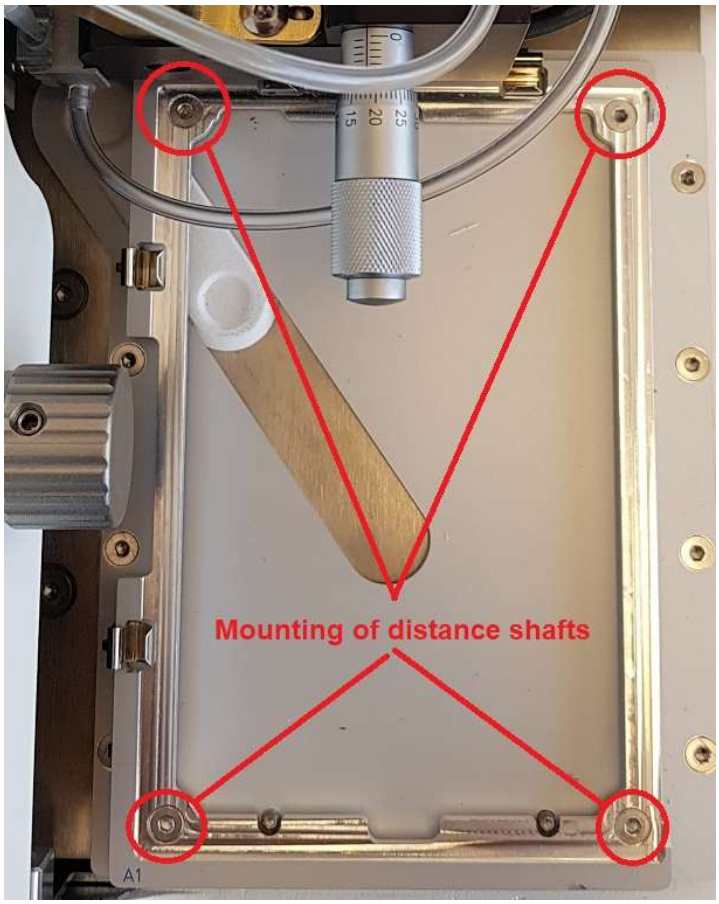
First, check if the distance of the P9 dispenser to your desired well plate offers sufficient clearance. Place a respective test plate on the plate carrier. Visually check if there is at least 1 mm clearance between dispenser bottom and plate surface (see image below).



Generally, the **clearance should be between 1 and 3 mm**. Below 1 mm the chance of physical contact between plate and dispenser is high, resulting in a possible crash. Above 3 mm the chance that the droplet does not land in the well increases.

> ***CAUTION:*** *some well-plate types do have elevated edges. Please check the clearance carefully. Make sure that the test plate is proper mounted to the substrate carrier before checking the clearance.*

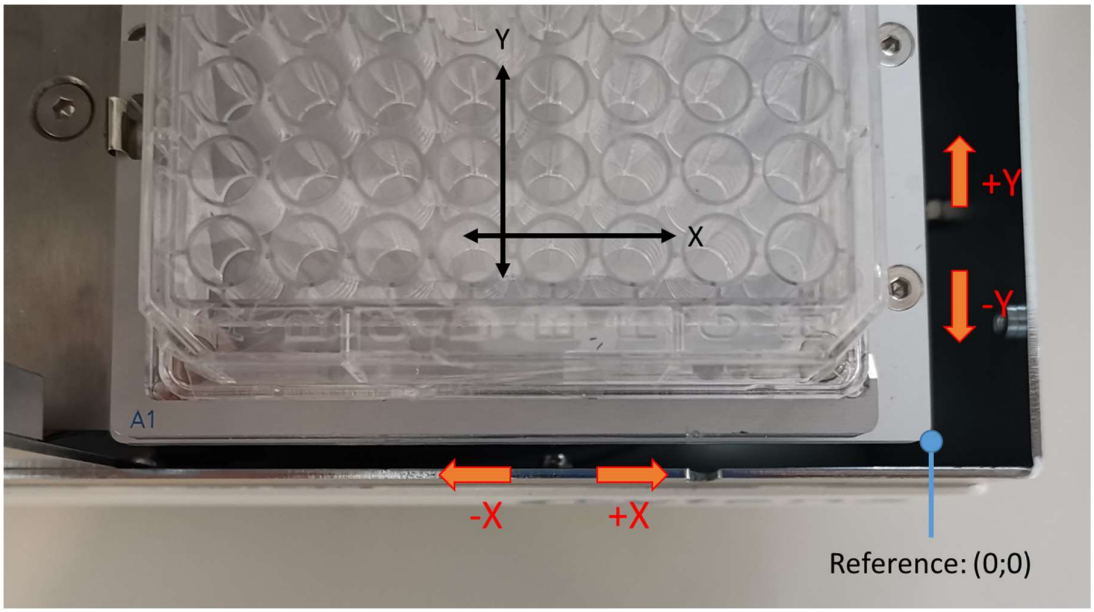
If the Z position (the clearance) needs to be adapted, you have to exchange the distance shafts of the carrier. Take the respective set of distance shaft and fitting screws. You can level the carrier by using lower or higher shafts. The shafts come in lengths steps of 2mm, meaning you can vary between 3, 5, 7, 9 and 11 mm elevation. The default is 5 mm shafts.



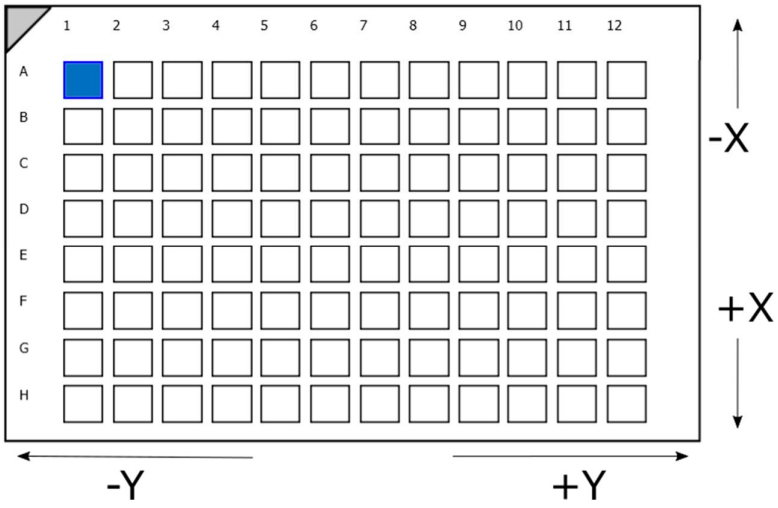
19.2 Orientation of the plate and axis system

The axes of the x.sight are defined as follows:

- The x-axis left and right from front view
- The y-axis back and forward from front view



Respectively, the digital plate view in the software is oriented like shown below:



19.3 Location of Substrates Coordinate Files

Make a backup copy of the following files before modifying them.

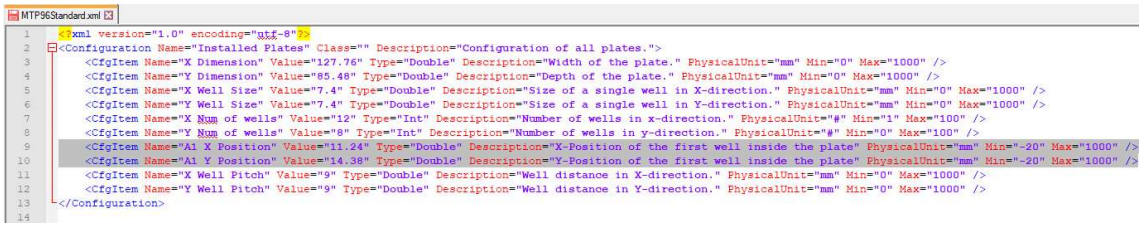
> ***CAUTION:*** *Make a backup copy of all files that you open and modify before you do any modification on them. Editing xml files can lead to severe errors and you need to be able to restore original files in that case.*

The starting coordinates for the axes are stored in XML config files. When coordinates need to be adapted, changes in these config files are required.

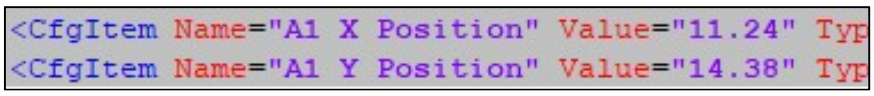
Open the config file for the respective plate type stored in the software installation folder as follows:

- "..\Settings\Substrates\MTP96Standard.xml"
- "..\Settings\Substrates\MTP384Standard.xml"

Example screenshot:



Line 9 and 10 are storing the X and Y values for well A1 in mm:



Change the "Value" value in order to change the position for well A1.

> ***CAUTION:*** *Do not change anything else than the numbers behind "Value=". Typing errors, deletion or modification of any kind on the names or variables will lead to software errors.*

In case one or both of these positions are offset, try to measure the offset and change the values of x and y in the configuration file.

- **Increasing** the X value moves the dispenser **left**
- **Increasing** the Y value moves the dispenser **to the front**

Refresh the dispensing position by following the described "Routine to change the well plate position" if necessary.

19.4 Routine check of well plate coordinates

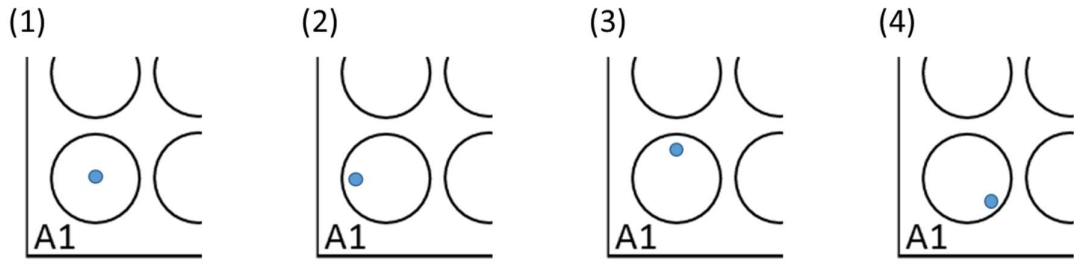
Please note:

> ***CAUTION:*** *Make sure that plate clearance is sufficient before conducting the following steps. With insufficient plate clearance, there is a high chance of crash.*

The coordinates of the well positions are loaded during start of the software only. In order to check the plate A1 coordinates, follow these steps:

1. Start the x.sight software
2. Mount a cartridge filled with water
3. Place your dry test plate on the substrate carrier
4. Chose your plate format from the starting screen (96 or 384)
5. Place the ROI on the nozzle
6. In “PRINT” Choose A1 well
7. Choose “print every droplet” = 200 droplets
8. Start the printing run with the “PLAY” button

After the 200 droplets have been printed, take out the plate and check well A1 by eye. You will see an accumulated bigger droplet on the well bottom. Basically, there can be different scenarios:



(1) The droplet has landed perfectly in the center of the well. → no adjustment of the plate coordinates needs to be done. You are good to start.

(2) The droplet is deviated to the left. → You have to decrease the value of x (e.g. from -11.4 to -12.3) to relocate the droplet

(3) The droplet is deviated to the top. → You have to increase the value of y (e.g. from 7.9 to 8.5) to relocate the droplet

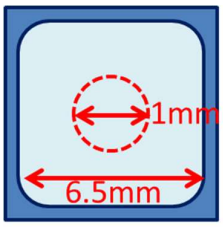
(4) The droplet is deviated to the front right. → You have to increase the value of x (e.g. from -11.4 to -10.2) and decrease the value of y (e.g. from 7.9 to 6.6) to relocate the droplet

If you face situations like (2) to (4) you need to adapt the plate A1 coordinates. The previous chapter section showed you how to do this. In order to make changes effective,

you have to restart the software. Repeat the test in this section until you have achieved situation (1).

19.5 Extended check of well plate coordinates

- Restart the software to apply the new position values
- Mount a cartridge with beads suspension to the instrument or use already mounted
- Perform droplet quality control to ensure proper droplet generation.
- Set the following test experiment:
    - A1 every droplet with 200 droplets
    - H12/P24 (96/384 well plate) every droplet with 200 droplets
- Start the cell printing
- Check visually (by eye, microscope, DinoLite) if droplet is landing in the center region of the well bottom. Landing area should ideally be within a circle of 1mm radius around the center of the well. For a 96-well plate the well diameter is approx. 6.5mm.



- If droplet landing can such be confirmed: well plate coordinates are ok.
- If droplet lands outside, plate coordinates must be re-teached according to the aforementioned procedure

20 Axis system maintenance

The following sections explain general maintenance and show you how to deal with several issues that might appear.

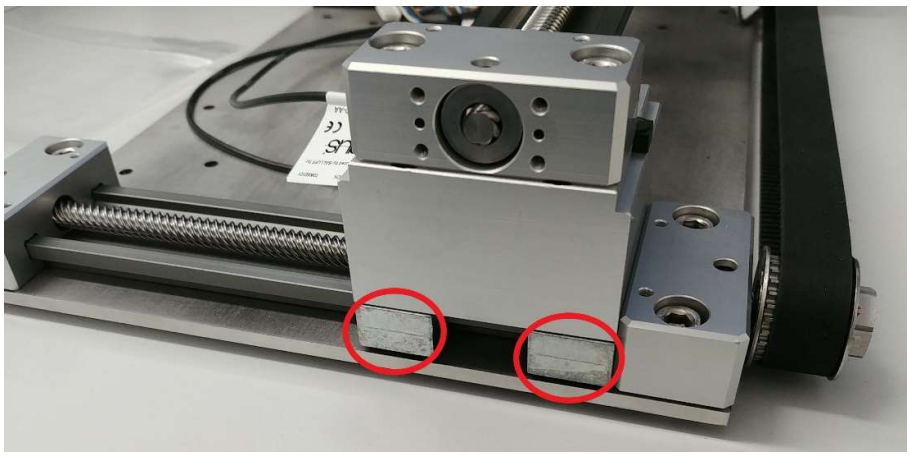
General information:

- The axis run lubricant free
- The sliders are made of low-friction polymers
- Backlash is typically low but can increase over life time

20.1 Inspection sliding elements

When the axis system is not running smoothly but shows stronger vibrations or an unusual sound is present, sliders might have come loose. To investigate if this the case, please follow the next steps.

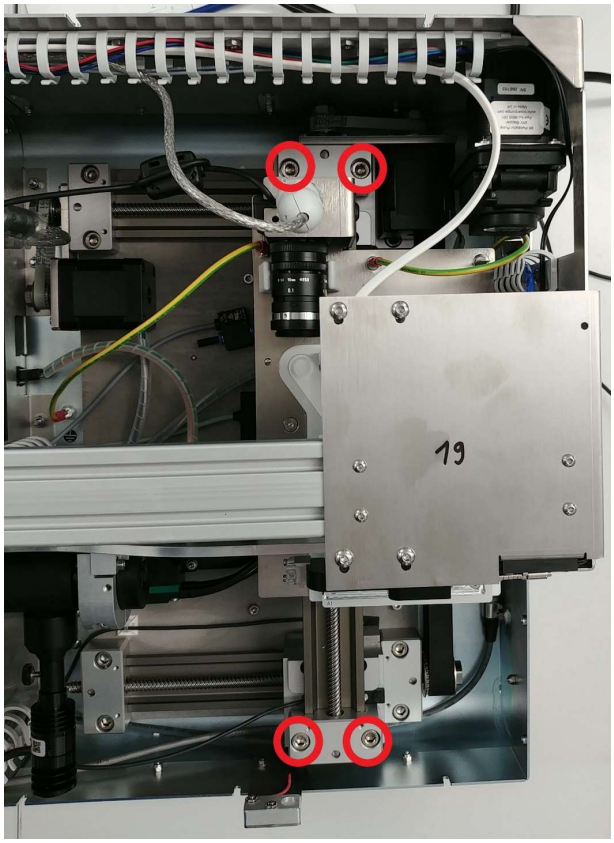
- Each carrier has four sliding elements, two at each side (see red marked circles in following image).
- Check with manually if they are loose. You can feel it.



- If they are fixed and you can’t feel any play between slider and rail, everything is ok. If not, please continue with the following steps.

20.2 Fix the sliding elements

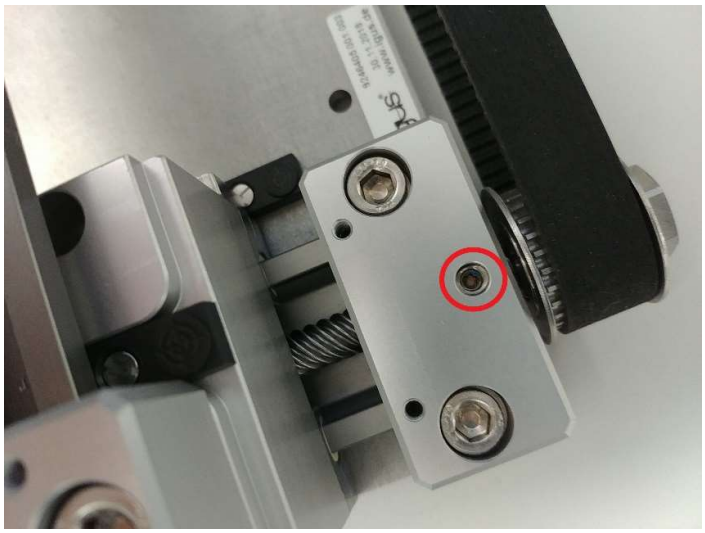
- If one of the sliding elements is loose the Y- axis needs to be removed first to access the sliding elements screws.
- To remove the Y-axis, the marked screws have to be removed.



- Disconnect all cables from the Y-axis and the carrier platform.
- Carefully lift out the Y-Axis from the housing and put it aside.
- After that you will see the screws which are fixing the sliding elements.
- While fixing the sliding elements please pay attention that they don't tilt against the carrier
- Put the Y-Axis back in and fix the Y-Axis with the screws
- Caution: Make sure the axis is aligned parallel to the housing!

20.3 Inspection of the set collars of the spindles

- On each side of the spindles you will find a headless screw in the set collars
- You can push or pull the tooth belts in order to rotate the spindles. This way you can find the headless screw



- Check if they are all fixed.
- Caution: Don't apply too much torque! Headless screws can easily be damaged.

20.4 Fix the set collars

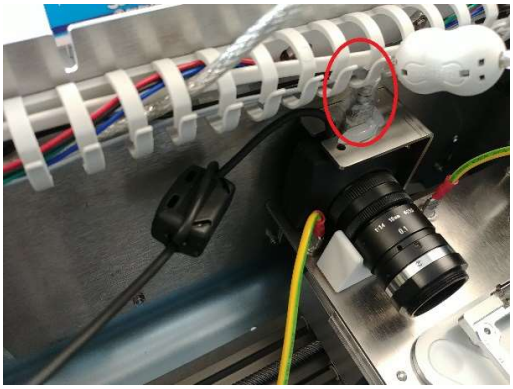
- If one of the set collars is loose, they need to be fixed
- Push the set collar in the direction of the spindle
- Maybe you need a tool like a small Allen key in order to push the set collars
- Tighten the headless screw of the set collar

20.5 Check the torque of the X-Axis

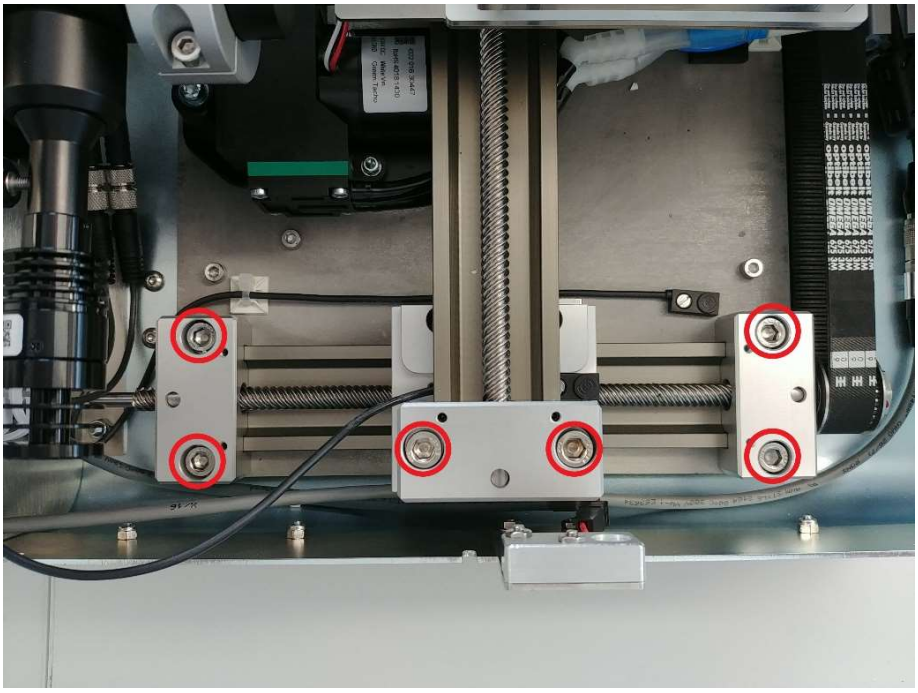
- Check the torque of the X-Axis by moving the carrier from one side to the other. Use the tooth belt in order to move the carrier by hand.
- If the torque is changing during the travel of the carrier, the axis needs to be adjusted

20.6 Adjust the axis

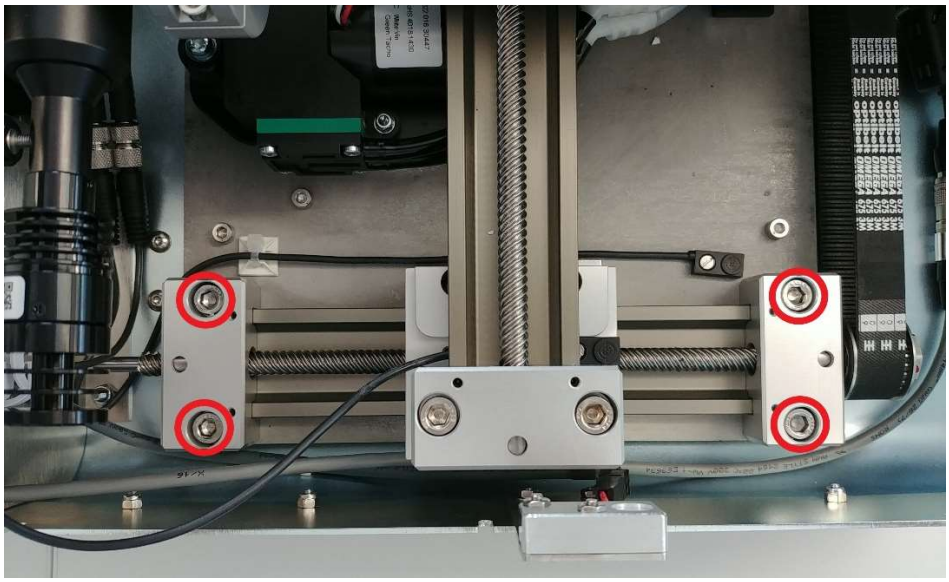
- Move the Y-carrier to the middle of the Y-Axis. Be careful, that the camera is not colliding with the backside and the carrier with the optics bar

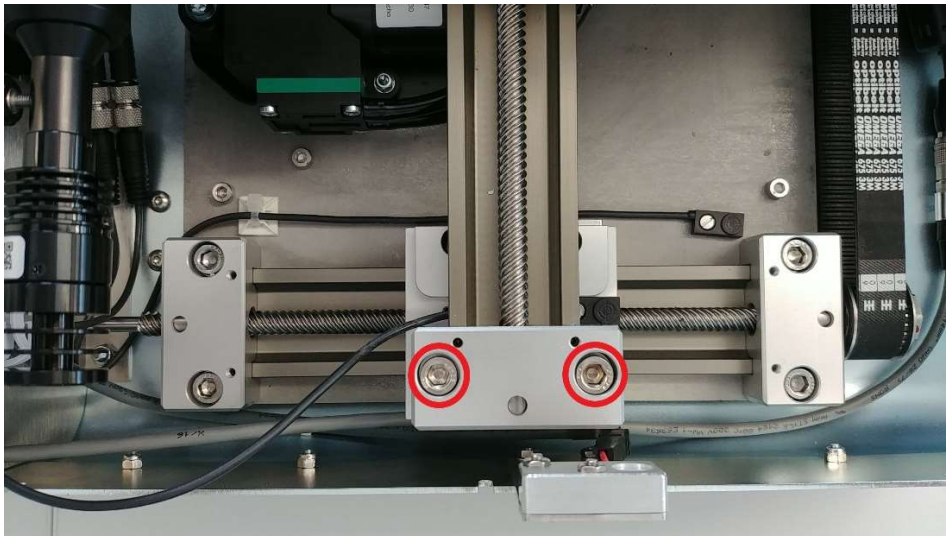


- Loosen the marked screws



- Move the X-carrier to the left side of the X-Axis.
- Tighten the marked screws on the left side of the axis
- Move the X-carrier to the right side of the X-Axis
- Tighten the rest of the screws





20.7 Control

- Check again if every screw is really fixed and the movement of the axis are ok
- If the torque of the X-Axis is still changing during the movement, repeat the adjustment of the axis
- Caution: check if the cables will not be damaged by running the axis and by closing the housing.

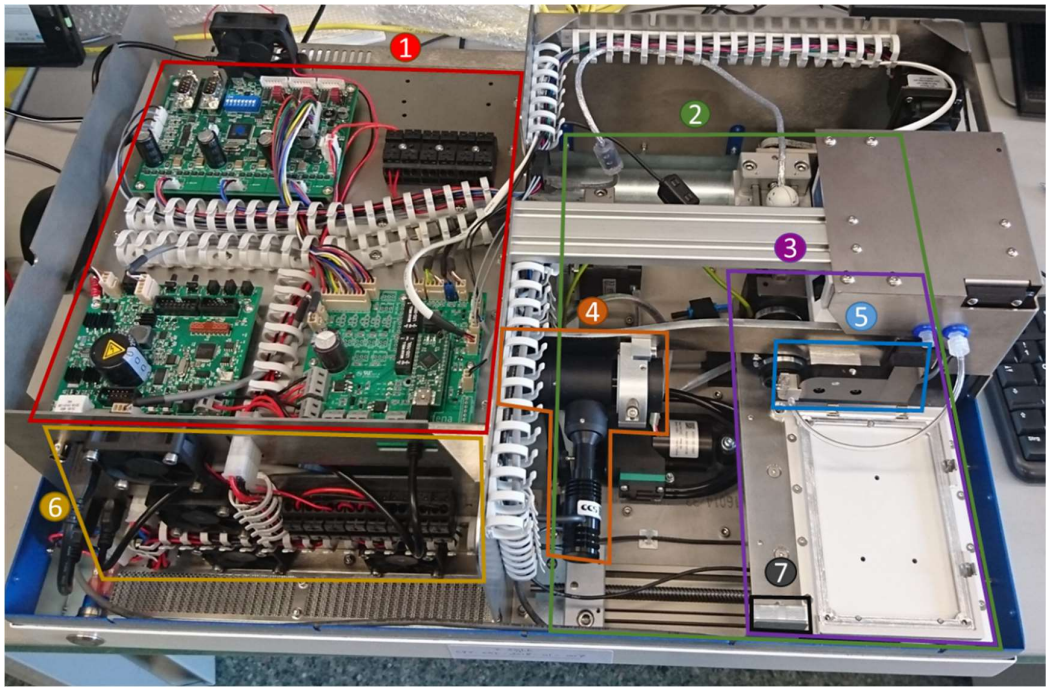
21 Parts exchange

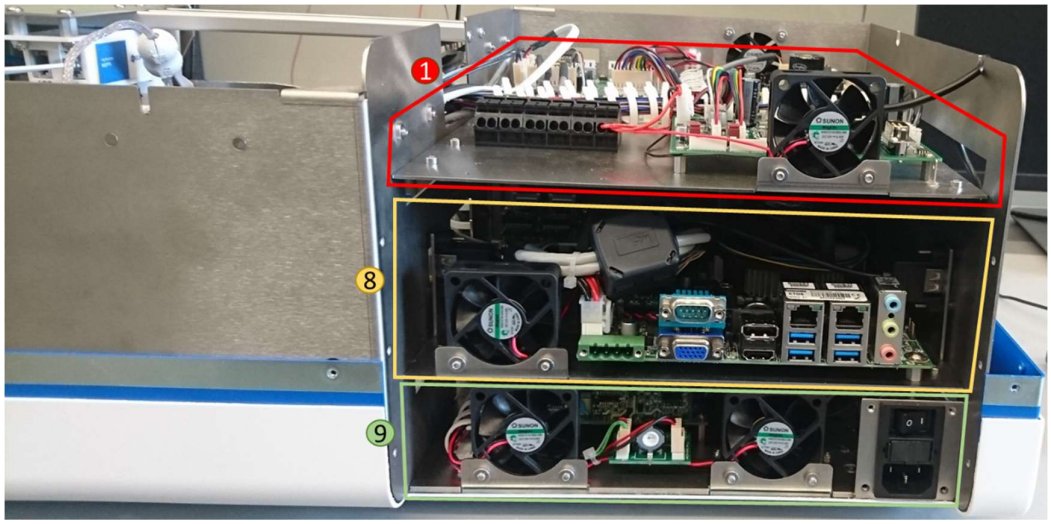
This chapter explains the exchange of certain parts inside the device. Most chapters are applicable to all device models, some are specific.

21.1 Overview

The x.sight devices are build out of several modules. The main modules are:

(1) The electronics plate including motor controller, dispenser board and highspeed trigger board
(2) The axis system including the vacuum pump and the vacuum valve
(3) The substrate carrier including the strobe camera
(4) The optics module including cell LED
(5) The dispenser including mechanical stopper
(6) The main power wiring and the fans
(7) The strobe LED
(8) The PC plate
(9) The power supply plate



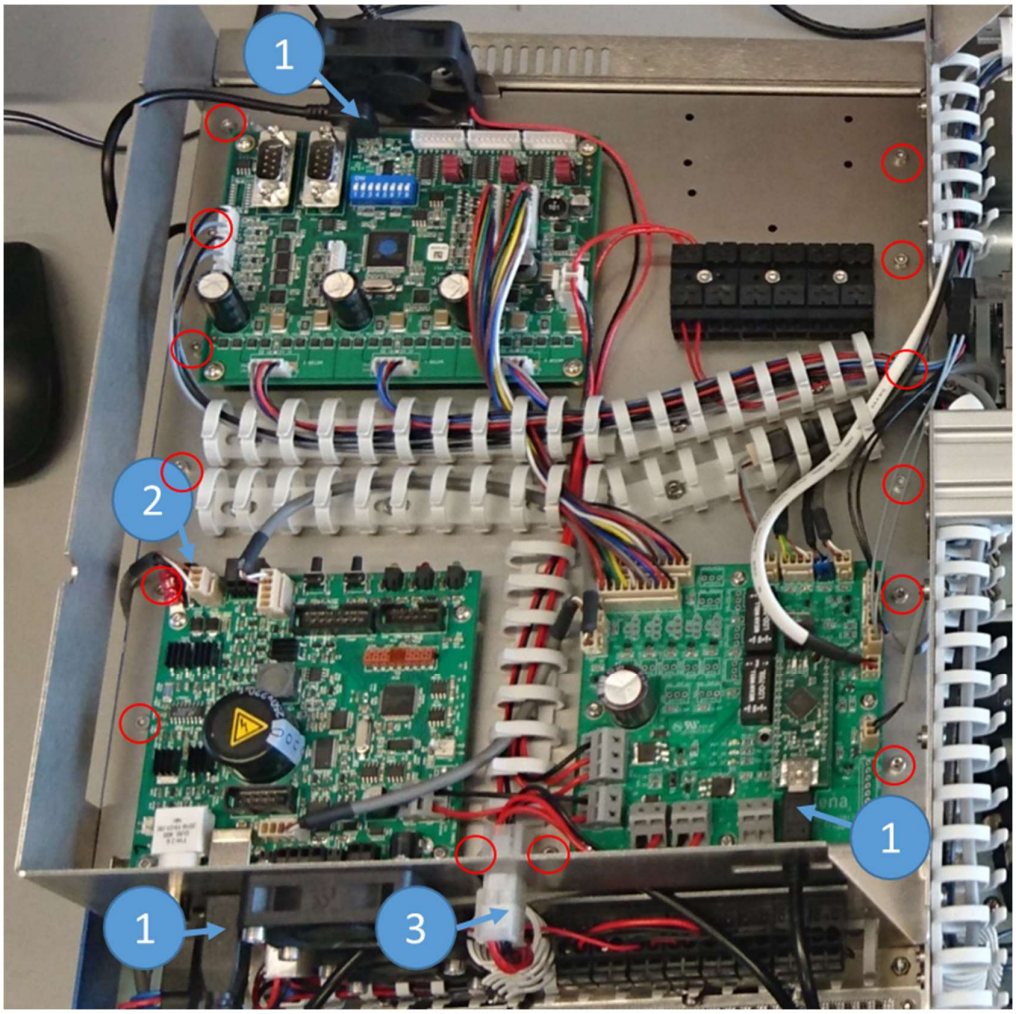


Details of specific parts can be found in chapter 11 to 15.

21.2 Remove electronics base plate

- Unplug all USB cables (1) going to the electronics (R5, motor controller and high-speed trigger board)
- Unplug the dispenser cable (2) and unscrew the ground cable at the screw
- Unplug the power connector (3) of the electronics plate
- Unscrew the M3 screws of the electronics plate (red circled)
- Flip the electronics plate to the side

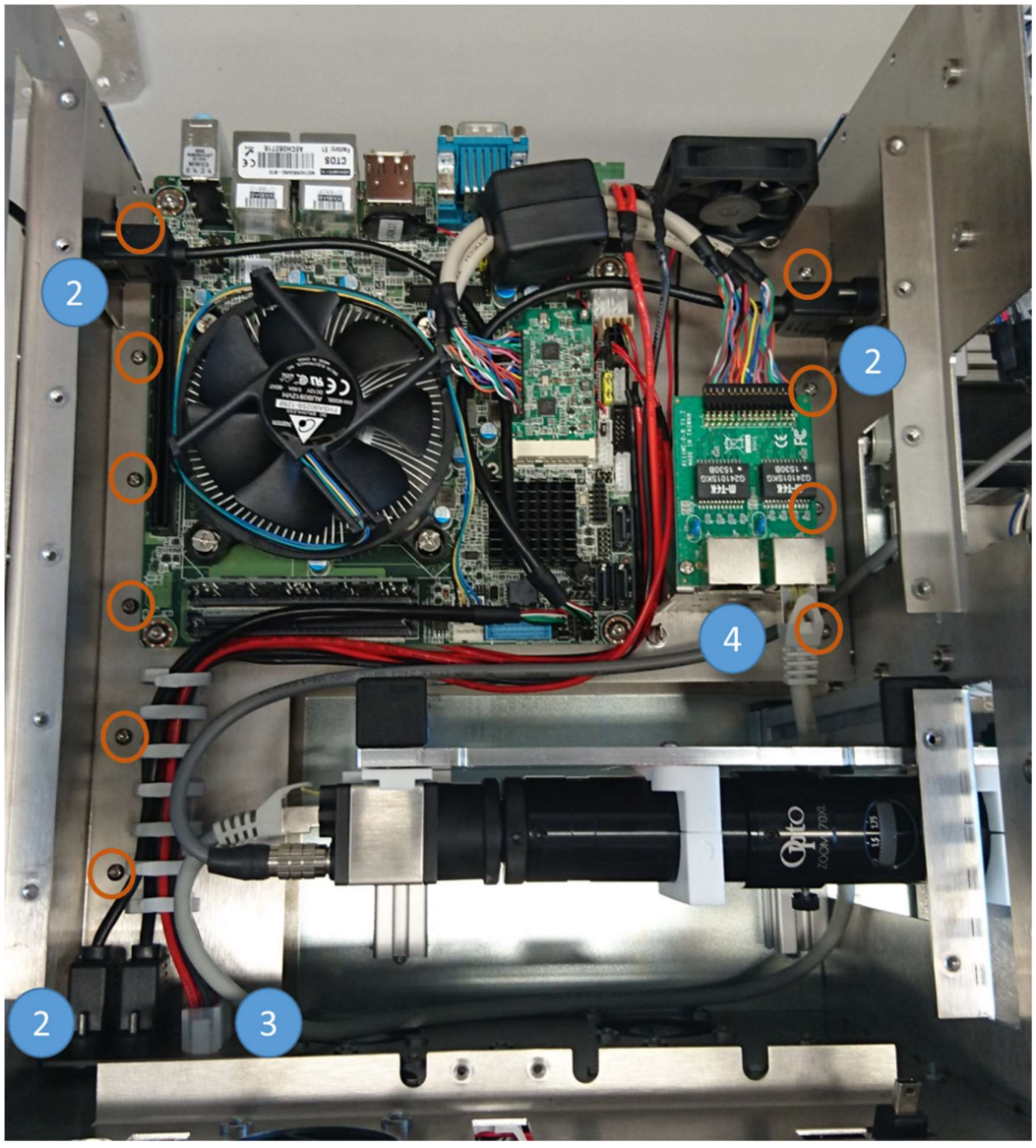
You have now access to the camera and the PC



21.3 Remove the PC base plate

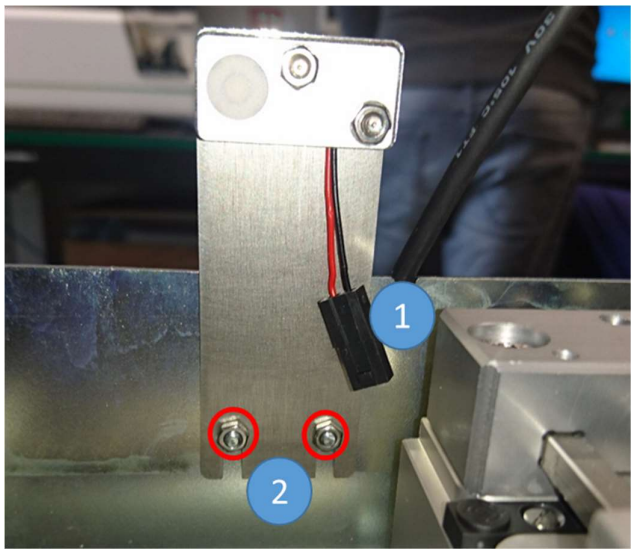
- Remove the electronics plate
- Unplug all cables at the back of the x.sight
- Turn the x.sight to the rear
- Unscrew all 10 M3 screws of the back plate (1)
- Remove the back plate
- Unplug all four USB cables of the PC plate (2) (one at each side and two next to the fans)
- Unplug the Power connector of the PC plate (3)
- Unplug the Ethernet cable of the network card (4)
- Unscrew all screws of the PC plate (orange circles)
- Remove the PC plate
- You have now access to the power supplies


REAR VIEW
1
DC_IN
DP++


2
2
4
2
3

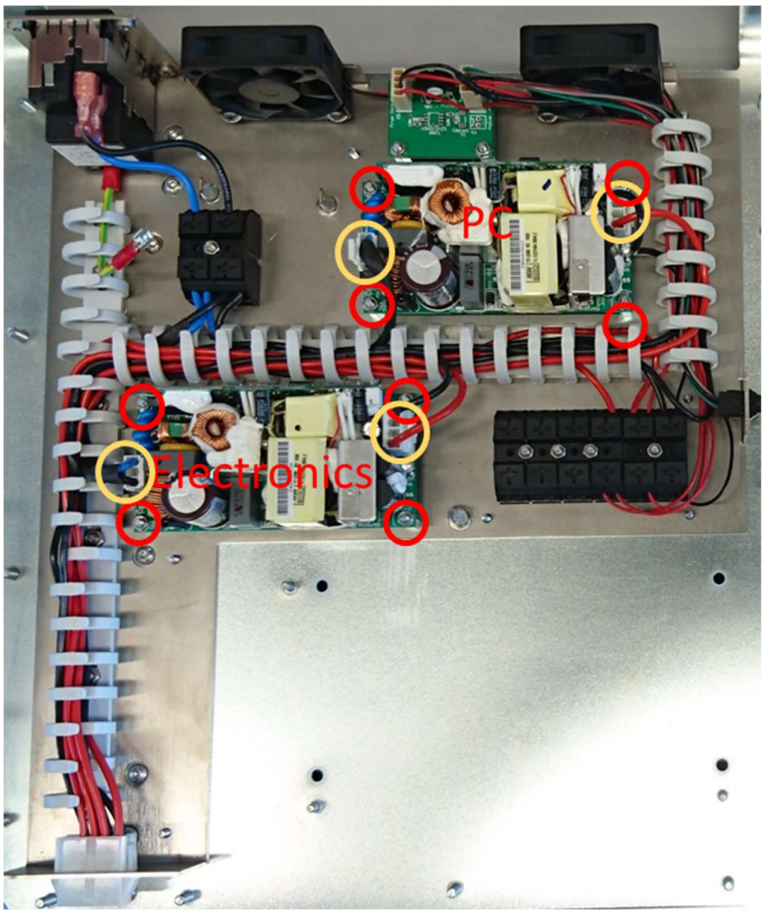
21.4 Exchange the DQC LED

- Push the axis system to the left side
- Unplug the connector of the LED module (1)
- Loosen the nuts of the LED module (2)
- Remove the LED module
- Place the new LED module on the screws (2)
- Tighten the nuts (2)
- Plug the connector in (1)



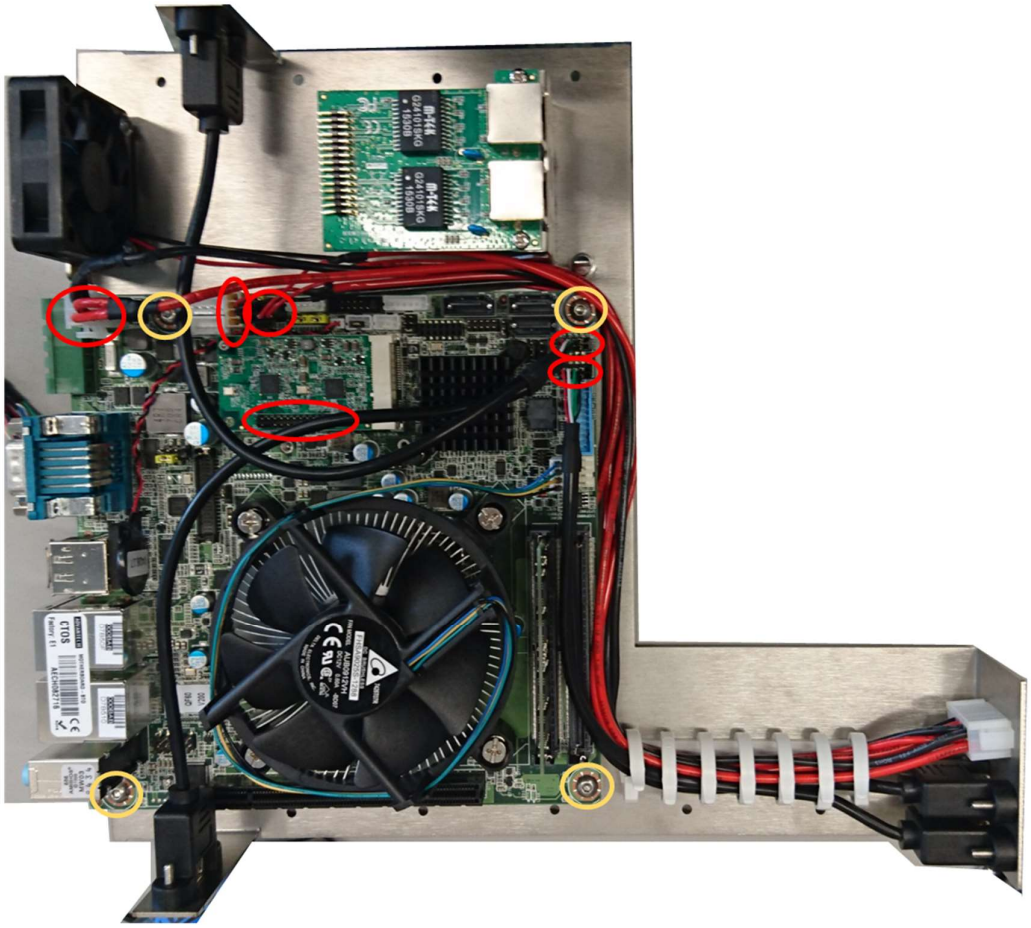
21.5 Exchange a power supply

- Remove the electronics plate
- Remove the PC plate
- Locate the concerning power supply
  - The power supply closer to the rear is the one for the pc
  - The other one is for the PC
- Remove the plugs of the power supply (yellow circles)
- Unscrew the nuts of the power supply (red circles)
- Remove the power supply
- Insert the new power supply
  - Pay attention of the orientation.
- Screw the nuts of the power supply in (red circles)
- Connect the plugs of the power supply (yellow circles)
- Assemble the pc plate back in
- Assemble the electronics plate back in



21.6 Exchange the Mainboard

- Remove the electronics plate
- Remove the PC plate
- Remove all connectors of the main board (red circles)
- Unscrew the screws of the mainboard (yellow circles)
- Remove the mainboard
- Place the new mainboard on the plate
- Screw the screws of the mainboard back in (yellow circles)
- Plug all connectors back in (yellow cirlces)
- Assemble the PC plate back into the c.sight
- Assemble the electronics plate back in



21.7 **Exchange the cell cam (c.sight)**

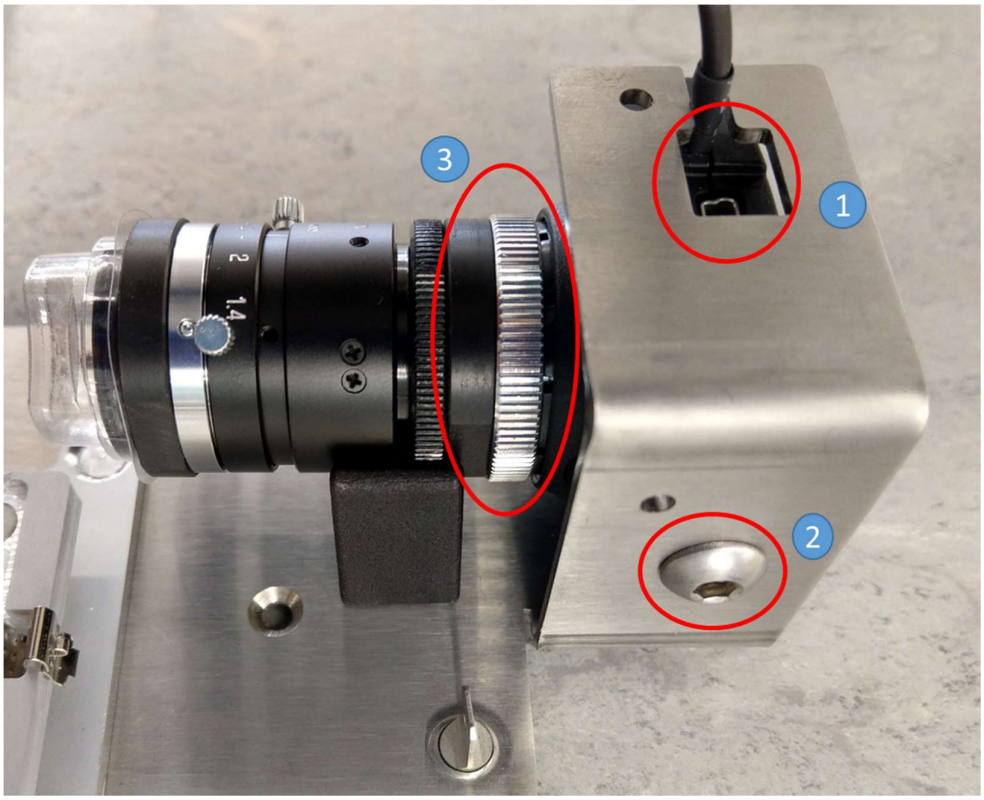
- Remove the electronics plate
- Remove the cables of the cell cam (Ethernet and trigger)
- Loosen the set screw of the optics next to the camera (1)
- Unscrew the C-mount adapter of the camera (2)
- Remove the camera
- Insert the new camera
- Screw the C-mount adapter onto the new camera (2)
- Tighten the set screw of the optics (1)
- Plug the cables back in
- Assemble the electronics plate back in
- Check the position of the chip and potentially adjust it

21.8 **Exchange the BF / Fluo Cam (f.sight)**

- Remove the electronics plate
- Remove the cables from the cell cam (USB and trigger)
- Loosen all 8 screws of the metal plate connecting the 2 cameras (1)
- On the ring in front of the camera loosen the 3 headless screws (2)
  (green = BF cam / purple = Fluo cam)
- Pull the camera to the back (3)
- Unscrew the part of the double male c-mount adapter left on the camera (4)
- Screw the male c-mount adapter onto new camera
- Insert the new camera
- And tighten all 3 small screws again
- Plug the cables back in
- Assemble the electronics plate back in
- Check the position of the chip and potentially adjust it

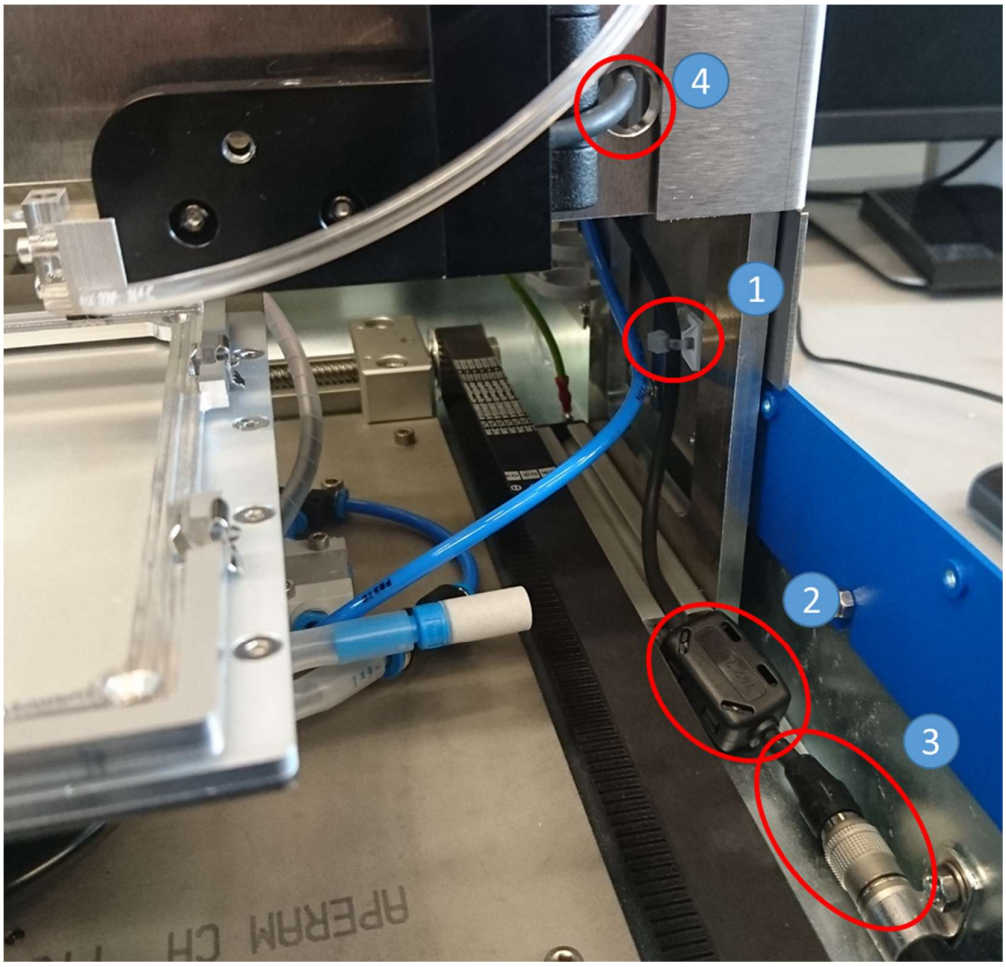
21.9 Exchange the DQC camera

- Push the axis system to the back
- Unplug the cables (1) of the camera (Trigger cable at highspeed trigger board)
- Unscrew the screw of the camera (2)
- Remove the camera
- Unscrew the objective of the camera (3)
- Screw the objective to the new camera (3)
- Insert the new camera
- Screw the new camera in (2)
- Plug the cables of the new camera in (1)



21.10 Exchange the dispenser

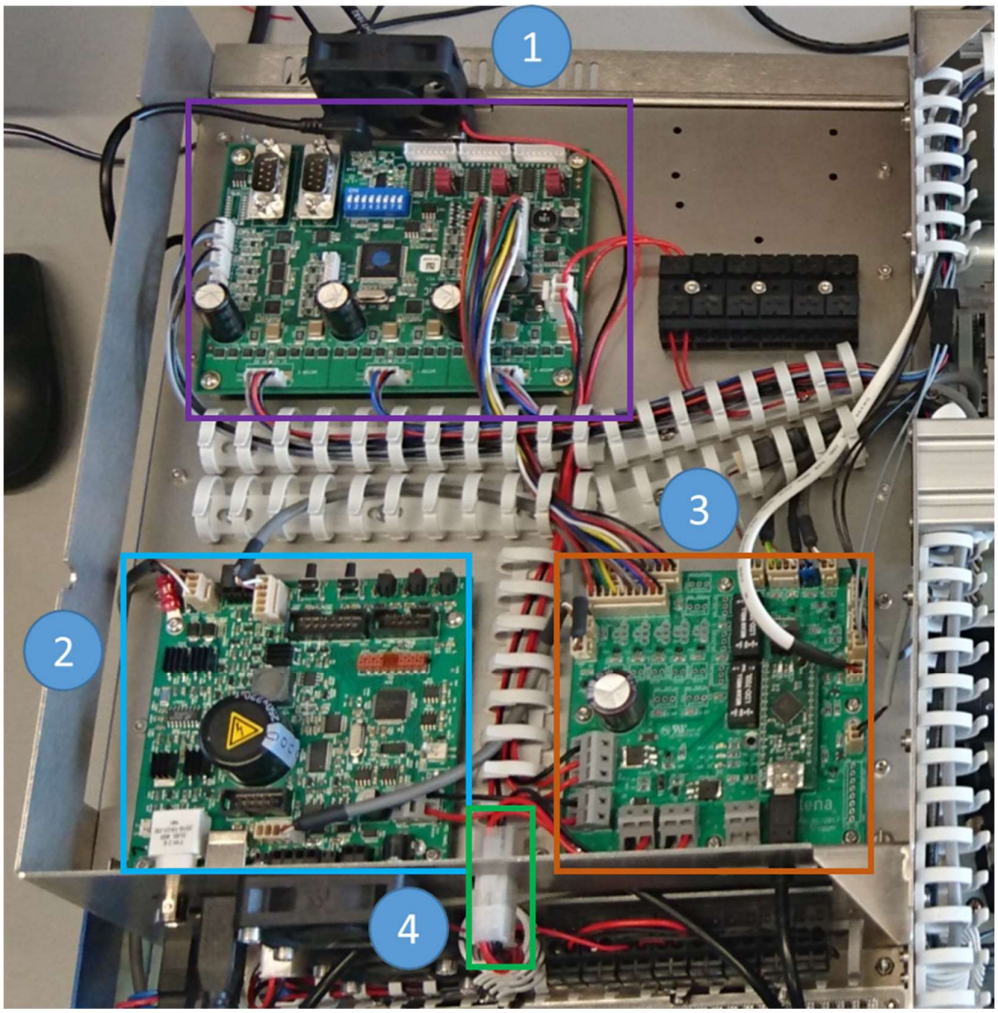
- Remove the cable tie of the dispenser at the right side of the c.sight (1)
- Remove the ferrite with the ferrite opener (2)
- Unplug the dispenser (3)
- Guide the connector through the hole of the optics beam (4)
- Unscrew the dispenser from the hinge
- Remove the dispenser from the c.sight
- Unscrew the mechanical stopper from the dispenser
- Screw the mechanical stopper to the new dispenser
- Insert the cable of the new dispenser into the optics beam
- Screw the dispenser to the hinge
- Loosen the screws of the mechanical stopper and check if the stopper is closing to the opposite part
- Tighten the screws of the stopper in the dispensing position
- Guide the connector through the hole of the optics beam (4)
- Plug the dispenser cable in (3)
- Snap the ferrite onto the cable (2)
- Fix the cable to the wall with a cable tie (1)



21.11 **Exchange PCBs**

- Before you remove any of the boards on the electronics base plate, unplug the main power supply (4)
- For the motor controller (1)
  - unplug all connected cables by hand
  - remove the four corner screws
- For the piezo controller R5 (2)
  - Use the WAGO tool to remove the power cables from the gray clamping connectors
  - unplug all connected cables by hand
  - remove the ground wiring from the piezo cable with a hex key
  - remove the four corner screws
- For the high-speed trigger interface PCB (3)
  - Use the WAGO tool to remove the power cables from the gray clamping connectors
  - unplug all connected cables by hand

- remove the nine surrounding screws



- Exchange the PCBs
- Turn on the screws first
- Then attach the power cables using the WAGO tool
- Then plug in all remaining cables
- Attach USB connectors
- Finally plug in the main power connector (4)

22 Laser safety during service

WARNING:

CLASS 3B LASER RADIATION WHEN OPEN AND INTERLOCK DEFEATED. AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION.

The following instructions are given specifically for laser service. Such service requires to open the protective housing and defeat the safety interlocks to start the laser. This means, you will be operating the system under protection class 3B and you will have access to the laser beam.

The f.sight devices contains laser module(s) with 100 mW maximum optical output power. These laser modules are subject to laser class 3B. In this case it is imperative to observe the following rules and to guarantee the minimum safety requirements listed below.

WARNING: Avoid the following actions under all circumstances:

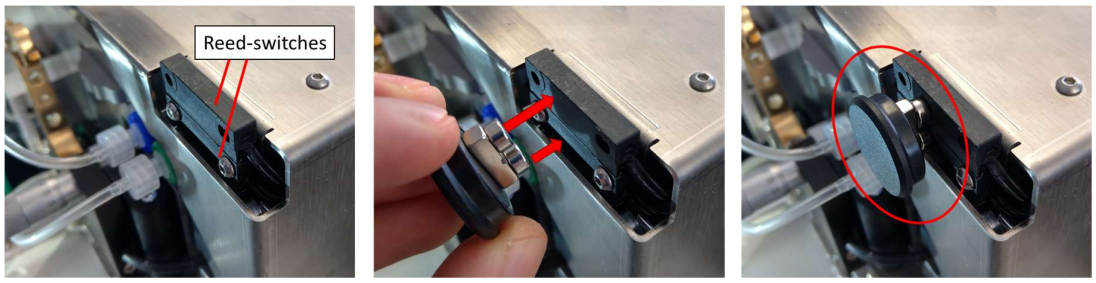
- Do not stare into the beam directly
- Do not use eye-pieces or other focusing optical elements to visually inspect the beam or part of the instrument where laser radiation is present
- Do not stare onto the laser spot for more than 10 s from close proximity
- Do not place reflecting tools or materials into the free beam
- Do not expose parts of your body or skin directly to the beam
- Do not use a mirror or other reflecting tools to reflect the laser beam

Mandatory safety requirements:

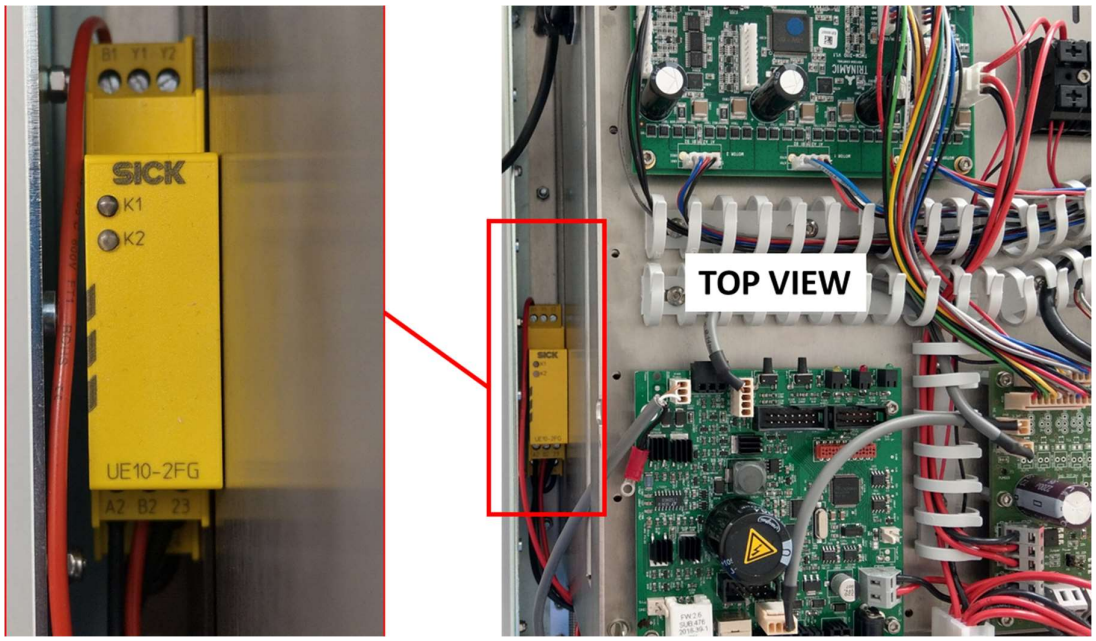
- Before starting work, contact the local safety representative to clarify the nature and scope of the safety measures to be taken. Pay particular attention to local, legal conditions. Personal health and safety are of utmost importance.
- Always wear appropriate safety goggles (at least OD2.0 for specific wavelengths)
- Make sure all persons in the same room also wear appropriate safety goggles OR make sure that all persons leave the room before starting the work.

22.1 Interlock defeat mode

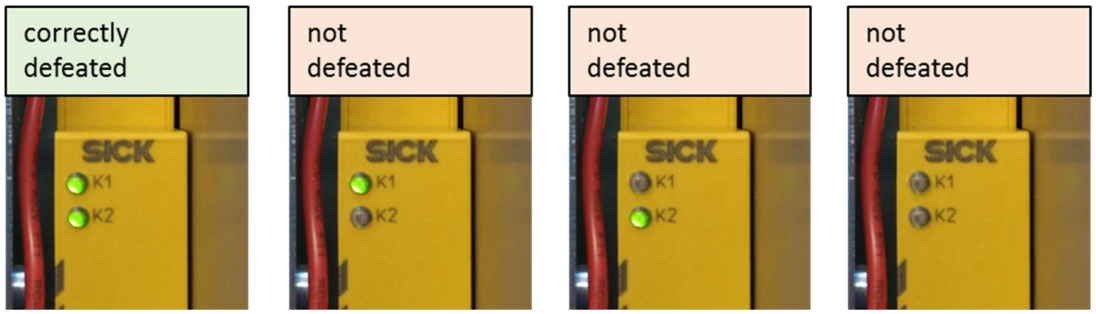
When the device protective housing is removed, take the interlock defeating tool from your tool box and place it onto the two interlocks (Reed-switches).



On the left side of the device, inside the bottom shell, check the SICK fail-safe relay for showing green permanent-on LED signals at K1 and K2.



Only when both LED are lighted, the interlocks are defeated. When only one LED is lighted, the defeat did not work. When no LED is lighted the defeat did not work. Correct the location of the defeating tool until both LEDs light up.



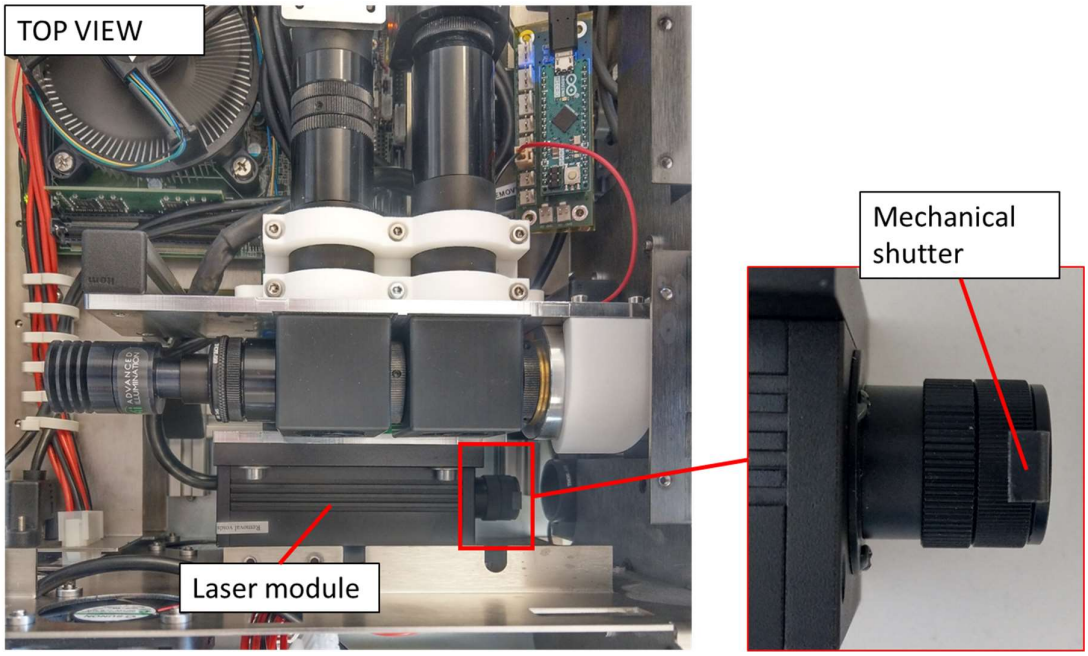
22.2 Securing the laser in defeat mode

There might be service cases, where an interlock defeat is required, although the laser beam is actually not required to be active for this action. In such cases, the operator can be protected against the laser beam. The laser module built in the f.sight features a mechanical shutter preventing the laser exiting the module.

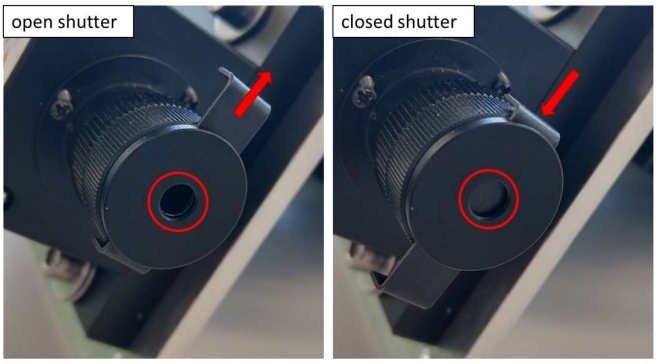
Close the mechanical laser shutter by hand in case you need to operate in interlock defeat mode. To do so, remove the electronics base plate and locate the laser module inside the lower shell:

f.sight Rev .1

The following pictures concern f.sight model revision 1 (S/N: CYT-FSI-2018-01-xxx) with the built-in laser module CNI 473 nm (CWL), 100 mW +/- 5% optical output power.



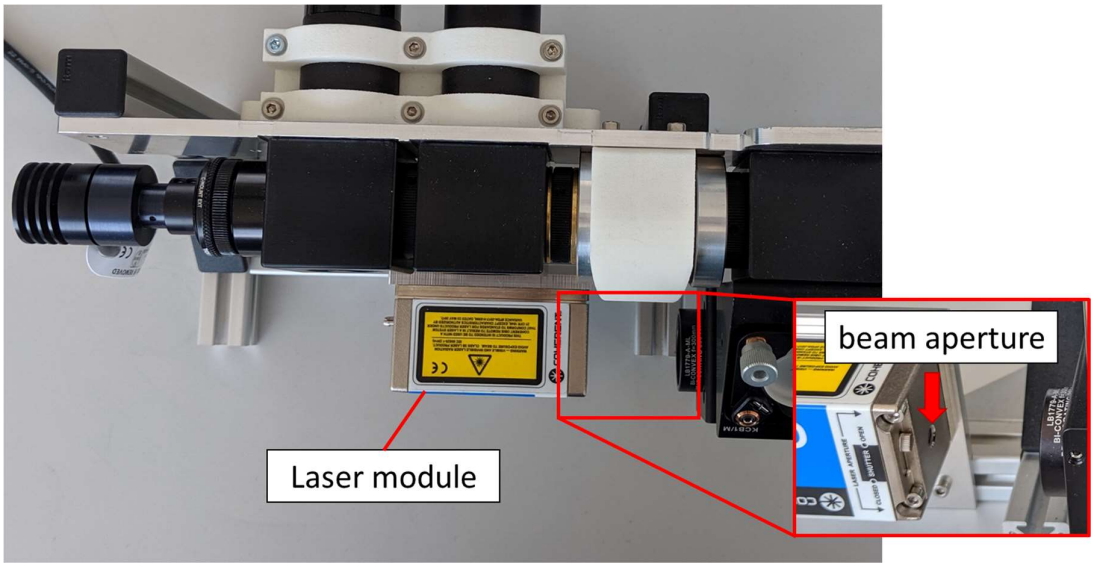
Press the shutter down with your finger in order to close it. Once your work is done, pull the shutter upwards to open it again.



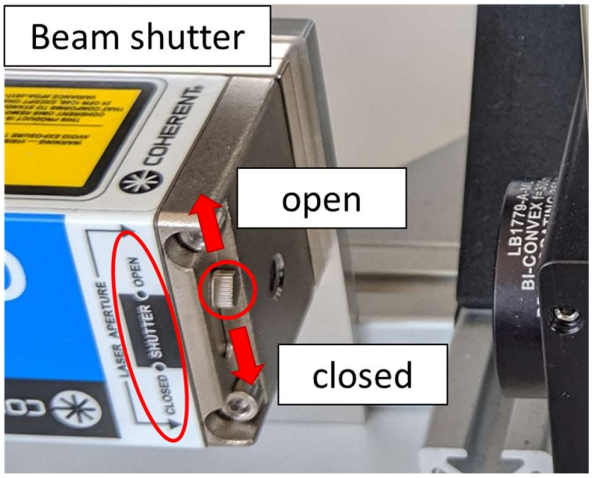
f.sight Rev .2

The following pictures concern f.sight model revision 2 (S/N: CYT-FSI-2019-10-xxx) *with the built-in laser modules* *OBIS 488 nm (CWL), 100 mW +/- 5% optical output power* *OBIS 561 nm (CWL), 100 mW +/- 5% optical output power*

The OBIS laser module is more compact. Orientation and aperture are very similar to the former CNI module.



The module also comes with mechanical shutter to prevent the beam from existing the module. Use the little lever on the side to adjust the shutter. Top position is “open” and bottom position is “closed”. Please also refer to the print on the module clearly showing the status of the shutter depending on position of the lever.



Revision history

Rev #	date	changes	Who
1	2018-10-29	Document started	AG
2	2018-10-31	Added device revisions table Added compliance table	AG
3	2018-11-09	Added section about vacuum shutter and agitation Added connection tables for connectors	AG
4	2018-11-23	Laser safety notifications updated acc. to FDA CDHR Added section about laser safety during service	AG
5	2018-12-05	Added section about how to open the device Added section about how to close the device	AG
6	2018-12-19	Added section about optical adjustment for all models	AG
7	2019-03-11	Updated technical tables Added section about axis system calibration / maintenance	AG
8	2019-06-04	Updated technical tables Updates on Laser Safety and labelling of the f.sight	AG
9	2019-11-29	Added chapter 21 – Parts exchange Added 18.5 – dispenser alignment Updated color code bars under each chapter caption to indicate the reference to the device models (f.s = green, c.s = blue, b.s = gray)	AG
10	2020-03-18	Changes due to new hardware revisions of f.sight and b.sight Updated wiring in chapter 13.3 (Arduino) Updated pictures and description in chapter 16.1 (new focus mech.) Updated pictures and description in chapter 16.2 (new focus mech.) Updated pictures and description in chapter 16.2.4 (new focus mech.) Updated pictures and description in chater 22.2 (new lasers)	AG

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