Instruction S1 – Assembly guide of 2LabsToGo

Preliminary remarks

General tools and materials needed
Hex ball head screwdriver M2.5
Hex ball head screwdriver M3.0
Screwdriver slit 2.5 mm
2.0-mm Allen key
1.5-mm Allen key
Set of hand taps: M2x0.4, 2.5x0.45, M3x0.5, M4x0.7, M5x0.8 (finishing tap)
Hand tap UNF 6x40 (finishing tap)
Set of drill bits (1–10 mm)
Portable drill
Side cutter
Carpet knife
Voltmeter
Superglue, Uhu Max Repair Power
Resin-free machine oil
Scissors

3D printed tools
Handles for the hand taps
Handles for Allen keys

3D-printing
To obtain stable 3D-printed parts, consult Instruction S3_3D-Printing guide

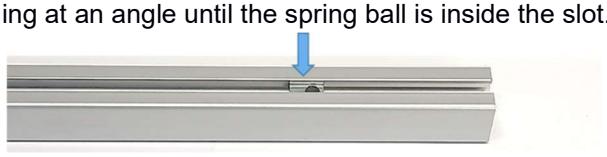
Screws
It is possible to have the screws themselves cut the thread into the 3D-printed parts, but it is best to cut an appropriate thread into all holes of 3D-printed parts, which are to receive a screw beforehand.

Do not overtighten screws that go into 3D-printed parts. Stop screwing if resistance is felt to avoid overtightening the screws. Screw slowly so as not to heat up the screws if the thread has not been cut beforehand.

Carefully re-cut all through screw holes, *i.e*. the screw goes into a nut, in the 3D-printed parts (drill bit), especially those that are not perfectly round-shaped (were printed in the x/y-direction on the build plate which makes them a bit oval).

Inserting sliding nuts
If an aluminum profile is still open on one side, sliding nuts simply can be pushed into the slot.

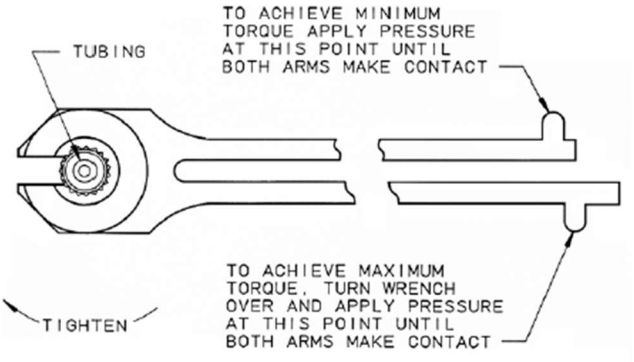
Otherwise, insert the sliding at an angle until the spring ball is inside the slot.



Take a small screwdriver and turn the nut until it engages in the slot and move it back and forth with the screwdriver to ensure that it can be moved easily in the slot. Be careful not to damage the thread.

Lee torque wrench

To properly connect the tubings with the Lee MINSTAC fittings, the Lee torque wrench should be used. The tool must not slip on the tubing fitting; this will damage the tool.



NOTE: Minimum recommended torque: 5 ozf•in (0.035 N-m)
Maximum recommended torque: 10 ozf•in (0.07 N-m)

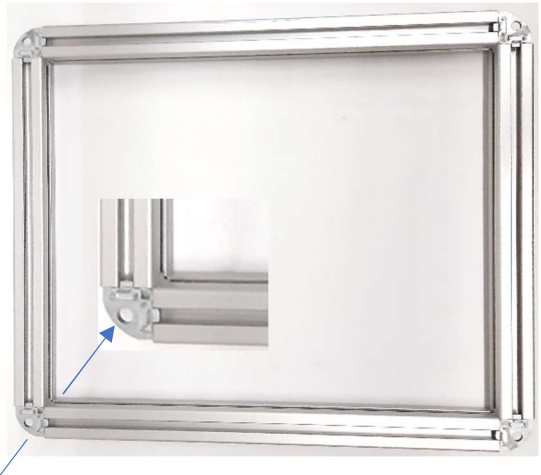
The Lee Company Electro-Fluidic Systems Handbook

Assembly

x/y-Rectangle for the base

Materials	Qty
Aluminum Profile 20x20L - 1N - I-Type Groove 5, 270 mm, machining both sides M5, 1 slot closed	2
Aluminum Profile 20x20L - 1N - I-Type Groove 5, 215 mm, machining both sides M5,1 slot closed	2
Corner angle 20 I-type groove 5 (edge connector)	4
Screw M5x12, DIN 7380	8

1

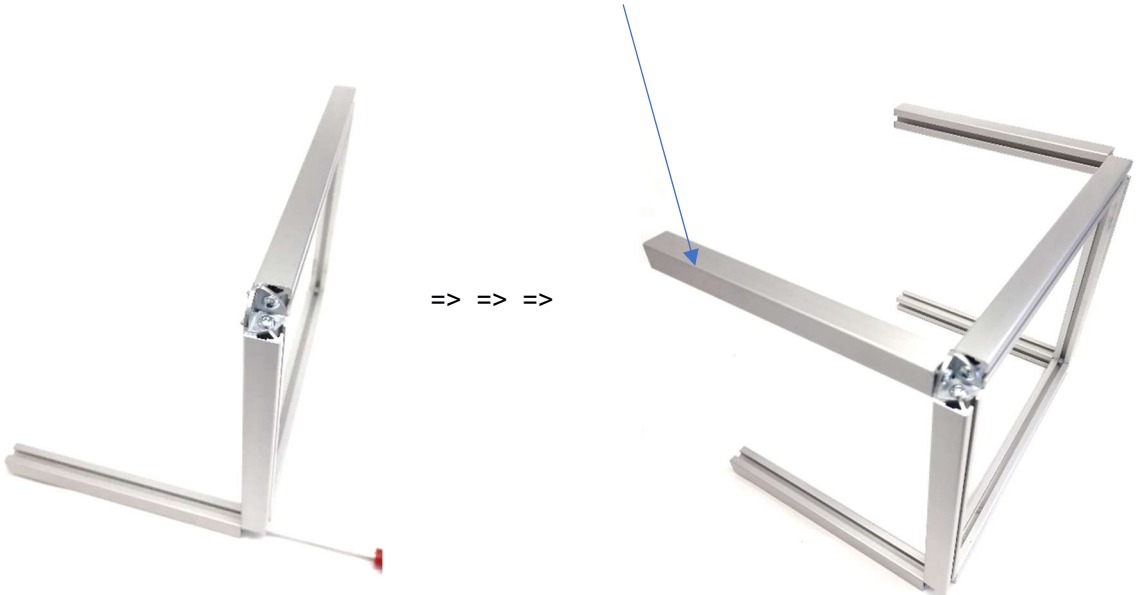


- The closed profile side points outwards.
- One of the 3 similar flat sides of each edge connector must point upwards.
- Connect the aluminum profiles with the edge connectors and the M5x12 screws.

z-Profiles outside

Materials	Qty
Aluminum Profile 20x20L - 2N-90° - I-Type Groove 5, 210 mm, machining both sides M5, 2 slots closed	4
Screw M5x12, DIN 7380	4

- Turn the base by 90° and connect the four aluminum profiles to the edge connectors of the base using the M5x12 screws. The two closed profile sides point outwards.



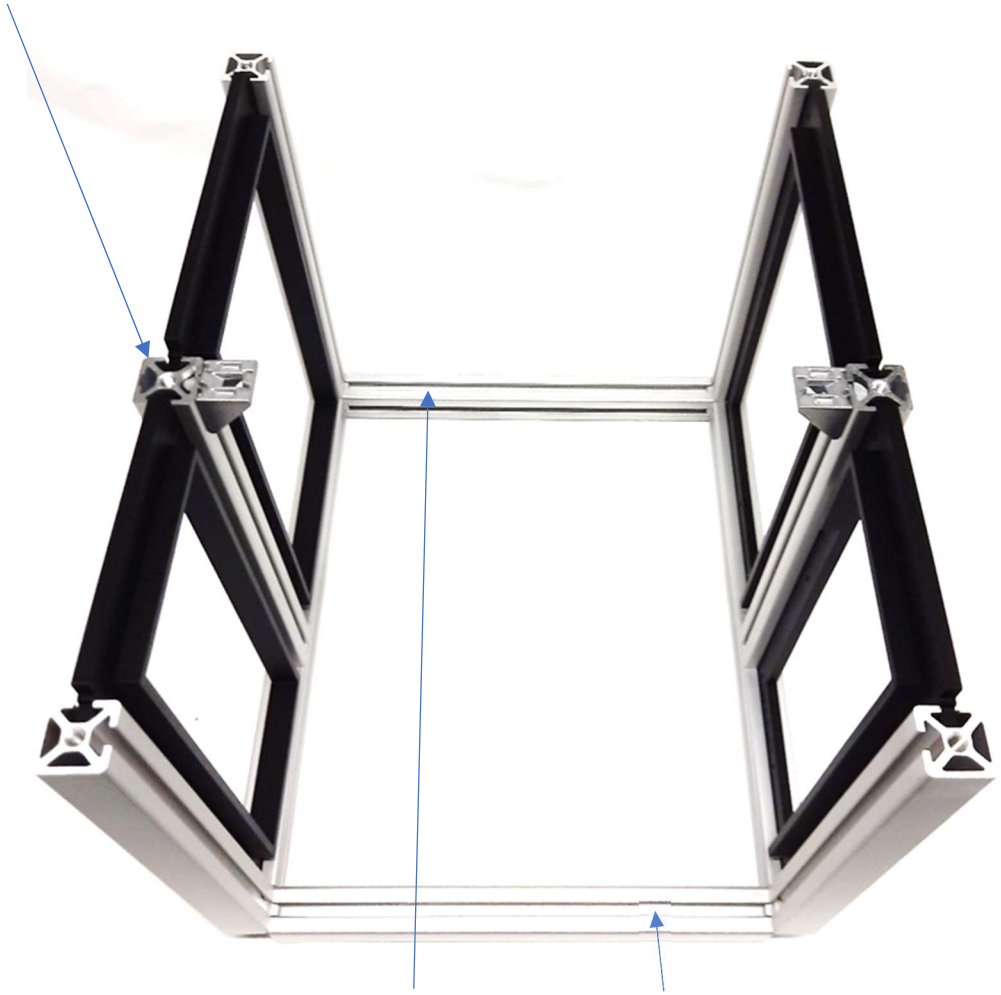
z-Profiles middle

Materials	Qty
Aluminum Profile 20x20L - 1N - I-Type Groove 5, 210 mm, machining both sides M5,1 slot closed	2
Angle 20 I-type groove 5	2
Sliding block M5 with web I-type groove 5	2
Screw M5x8 DIN 912	2
3D-printed frame_left_front	1
3D-printed frame_left_back	1
3D printed frame_right_front	1
3D printed frame_right_back	1

- Insert one M5 sliding nut into the profile slot opposite the closed slot.
- Connect each Angle 20 I-type groove 5 with one M5x8 screw.
- The Angle is flush with the end of the profile.

The closed profile sides point outwards.

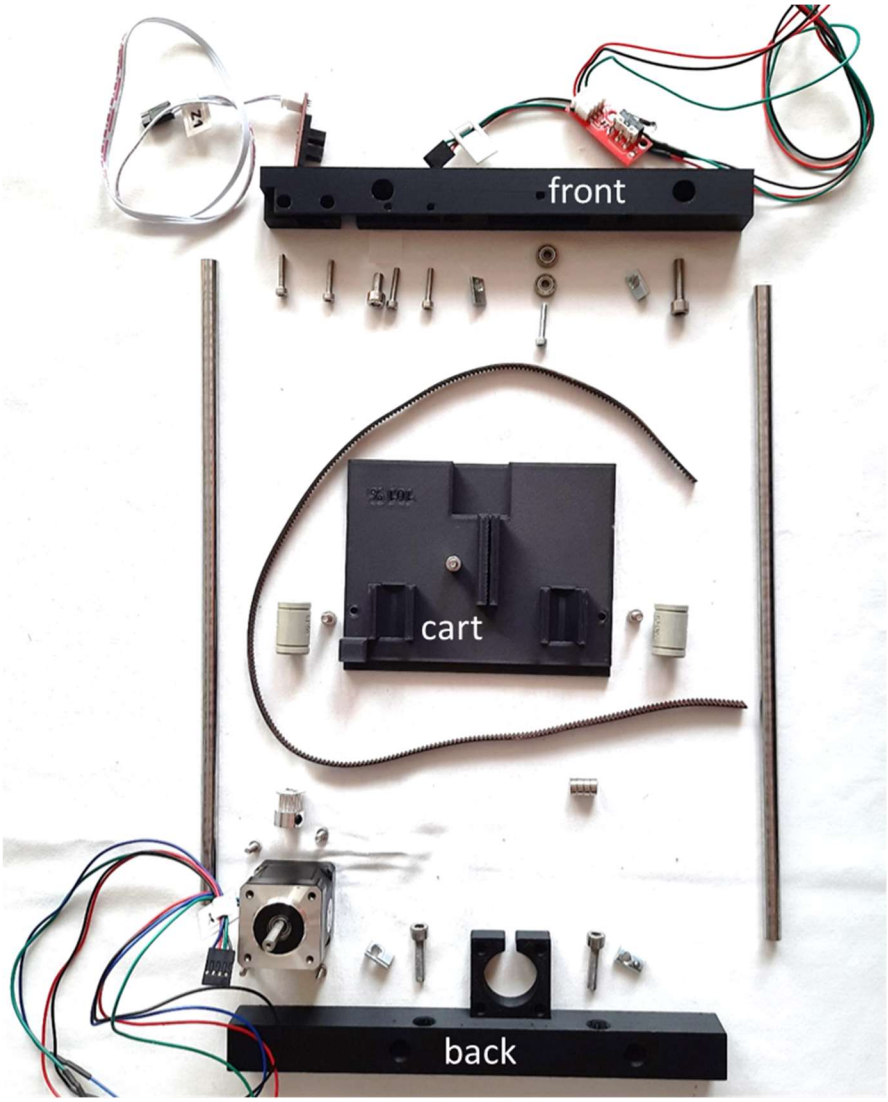
→ Take the x/y-rectangle for the base with outside z-profiles and insert the frames into the y-profiles (labels faced downwards and inwards).
→ Guide the prepared *z*-profiles *middle* into the space between the frames on both sides with the Angle 20 I-type groove 5 inside.



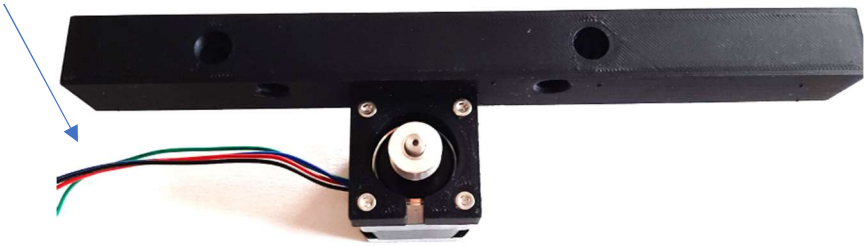
→ From this time, the back (the larger frames) and front (the smaller frames) of the casing are defined.
→ The top (Angle 20 I-type groove 5) and bottom are also defined, and consequently the left and right sides.

y-Axis

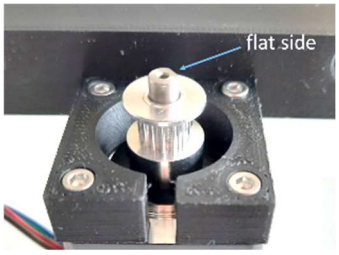
Materials	Qty
Motor Nema 14	1
Timing belt 6 mm, 600 mm	1
Optical endstop	1
Mechanical endstop	1
T16-2GT pulley	1
Slide bearing	2
Miniature ball bearing 3x10x4 mm	1
3D-printed tool miniature_ball_bearing	1
Steel rod, Ø 8 mm, 290 mm	2
Round magnets Ø 8 mm x 3 mm	4
Screw M3X10 DIN 912	4
Screw M3x16, DIN 912	5
Screw M4x10, DIN 912	3
Screw M5x20, DIN 7380	3
Screw M5x10, DIN 7380	1
Sliding block M5 with web I-type groove 5	4
3D-printed y-axis_back	1
3D-printed y-axis_front	1
3D-printed y-axis_cart	1
3D-printed y-axis_cork	1



- Mount the motor to the *3D-printed y-axis_back* with four M3x10 screws, with the motor cables pointing to the left.



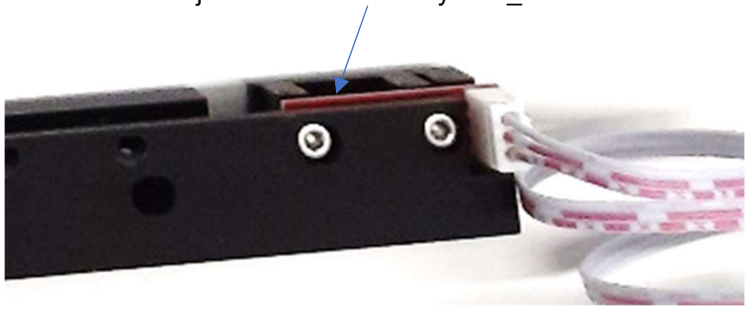
- Turn the flat motor axle side to the cutout of the *3D-printed y-axis_back.*



- Place the 2GT pulley onto the motor axle and align it: The motor axle should protrude approx. 1 mm and one screw should point to the flat side of the axle.
- Fix the pulley with both screws (2-mm Allen key, turn the pulley to fix the second screw).

- Note the markings on the cables of the optical endstop and the corresponding pin labels (V, S, G)! The correct assignment is important later.

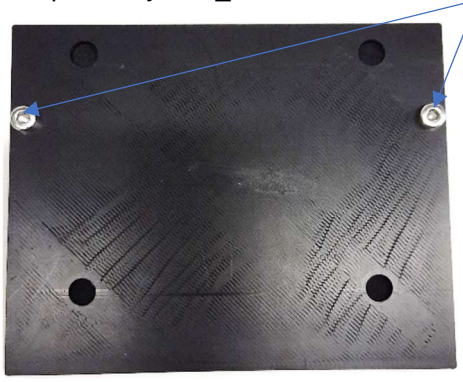
- Insert the optical endstop into the cutout of the *3D-printed y-axis_front* and fix it with two M3x16 screws, so that the screw's head just flushes with the y-axis_front.

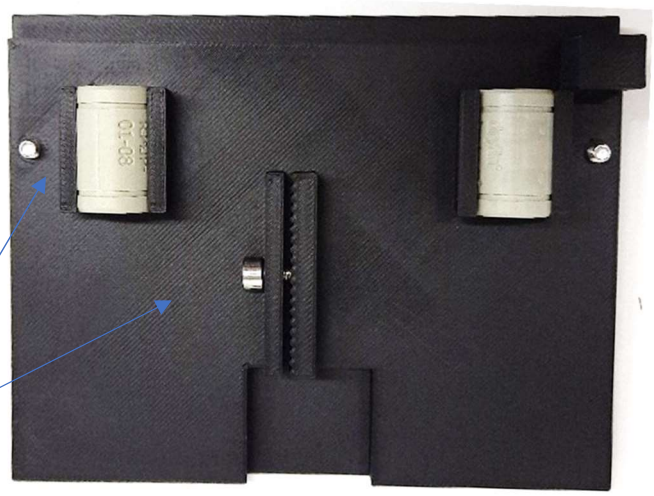


Possibly it is necessary to cut off the protruding pins at the underside of the endstop board.

- Insert the two ball bearings (as a sandwich) into the round cutout of the *y-axis_front* and fix them with an M3x16 screw, so that the screw head just touches the plastic part. It is easier to place the bearings with the provided 3D-printed *tool_miniature_ball_bearings*.

From the top of the *y-axis_cart* screw two M4x10 screws into the respective holes and tight them.

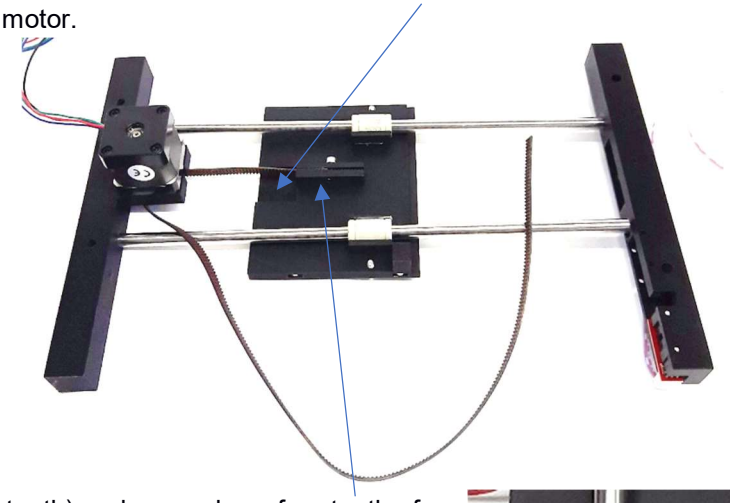




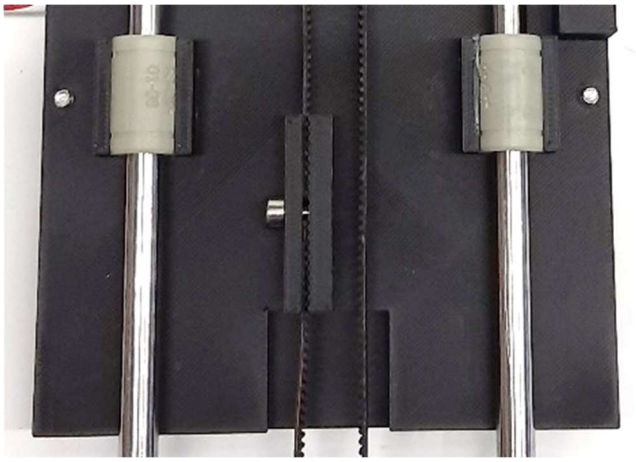
- Press the two linear bearings into the slots of the 3D-printed *y-axis_cart* and insert an M4x10 screw into the timing belt holder (do not tight it here).

- Insert the four round magnets into the slits on both sides of the y-axis_cart.
- Press them in by pressing the y-axis_cart upright onto the table with the magnets facing down.

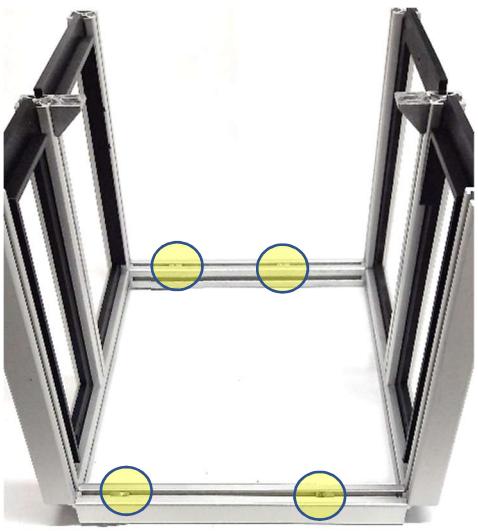
- Guide the two steel rods through the linear bearings and press the steel rod ends into the respective holes of y-axis_back and y-axis_front, with the cutout in the bottom of the y-axis_cart pointing to the motor.

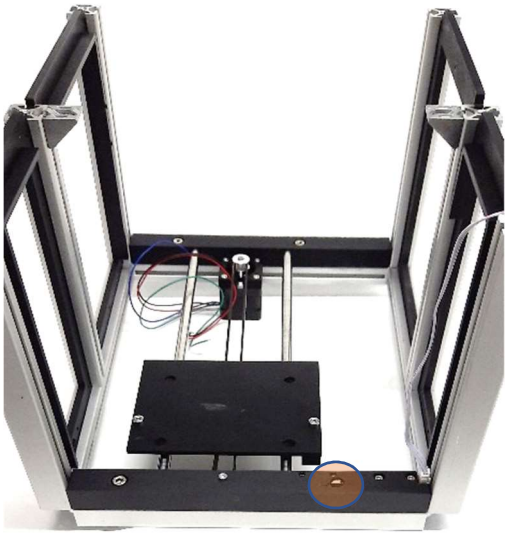


- Insert (teeth to teeth) and press down four teeth of the timing belt into the slit of the timing belt holder of the y-axis_cart.
- Guide the other end of the timing belt over the 2GT pulley and ball bearings in the y-axis_front towards the timing belt holder.
- Tighten the timing belt slightly (under tension) and cut it near the M4 screw with a scissor.
- Tighten the timing belt slightly again and press its end into the slit of the timing belt holder.
- Screw the M4 screw in, so that the timing belt is fixed tightly. Be careful not to overtight the screw.



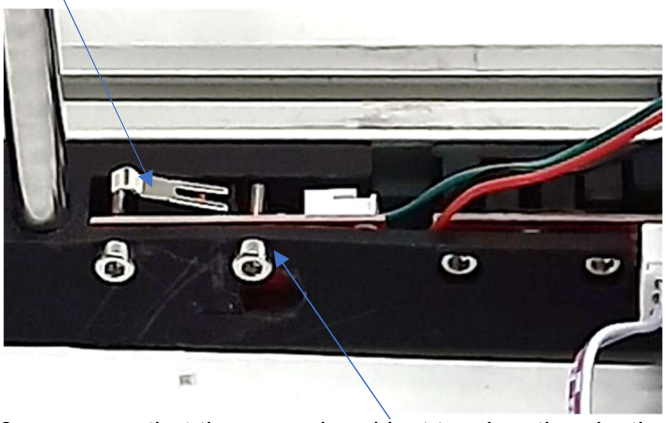
- Now, take the formerly prepared casing and insert two M5 sliding nuts into the top slot of each x-aluminum profile (circled yellow).
- Move them to fit with the M5 holes of the y-axis_back and y-axis_front.





- Place the y-axis onto the x-aluminum profiles, the motor to the back side (frames_back), and mount it with three M5x20 screws and one M5x10 screw (circled orange).
- Round the hole above the M5x10 screw with a 9.5-mm drill by hand.
- Turn the casing by 90° forwards, thus standing on the front side.

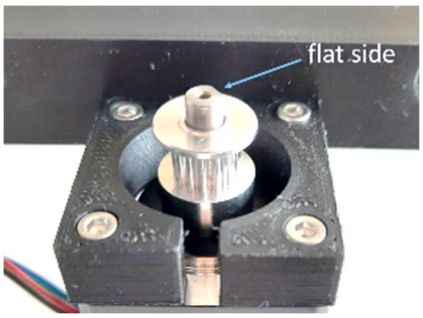
- Insert the mechanical endstop into the small slit at the bottom of the cutout next to the optical endstop, the cable plug pointing to the aluminum profile and optical endstop.
  Possibly it is necessary to cut off the protruding pins at the underside of the endstop board.



- Fix it with two M3x16 screws so that the screw head just touches the plastic front.

- Press in the y-axis_cork into the hole above the mechanical endstop, the label T pointing to the top.

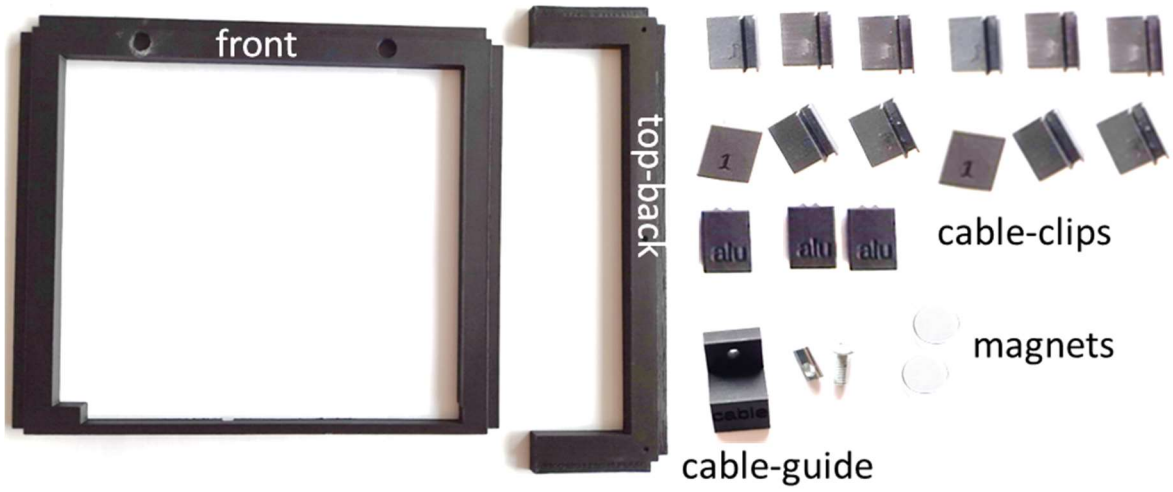
- Put some machine oil onto the steel rods.



- To finely adjust the position of the pulley on the motor axle, loosen the two screws (2-mm Allen key) of the pulley slightly, so that the pulley can move up and down but not turn over the motor axle.
- Then push the y_cart fully forwards and backwards, so that the pulley self-adjusts the optimal height on the motor axle.
- Fix the two pulley screws again without impacting its height on the motor axle. To reach the screws through the slit in the motor holder, move the y-cart, do not turn the pulley by hand.

x/y-Rectangle for the top

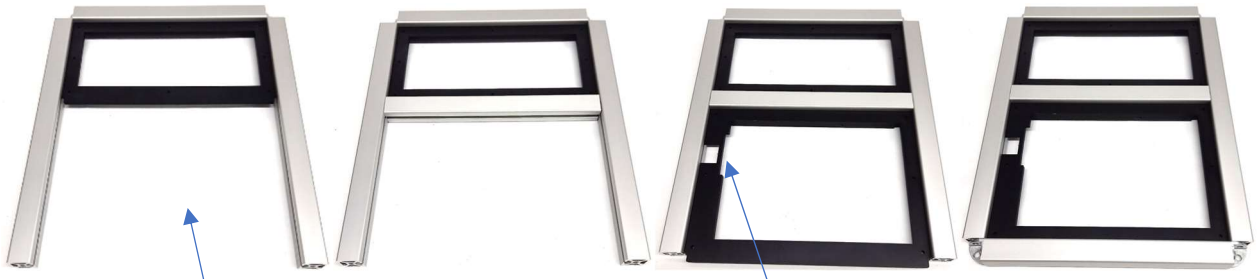
Materials	Qty
Aluminum Profile 20x20L - 2N-90° - I-Type Groove 5, 270 mm, machining both sides M5, 2 slots closed	2
Aluminum Profile 20x20L - 2N-90° - I-Type Groove 5, 215 mm, machining both sides M5, 2 slots closed	2
Aluminum Profile 20x20L - 1N - I-Type Groove 5, 215 mm, machining both sides M5, 1 slot closed	1
Corner angle 20 I-type groove 5 (edge connector)	4
Screw M5x12, DIN 7380	12
Screw M5x10, DIN 7380	1
Screw M5x8, DIN 7380	2
Sliding block M5 with web I-type groove 5	4
Round magnets Ø 8 mm x 3 mm	2
Pre-crimped wires, 30 cm, black	2
Pre-crimped wires, 30 cm, red	2
LED strip white, 7 cuts, 17.5 cm	1
3D-printed frame_top_back	1
3D-printed frame_top_front	1
3D-printed frame_front	1
3D printed frame_back, top part	1
3D-printed x-axis_cable_guide_top_left	1
3D-printed cable_clip_alu	3
3D-printed cable_clip1	12
3M 9088 Double-sided tape, 6 mm x 25 cm	1



The closed profile sides point upwards and outwards.

The corner angle side is down.

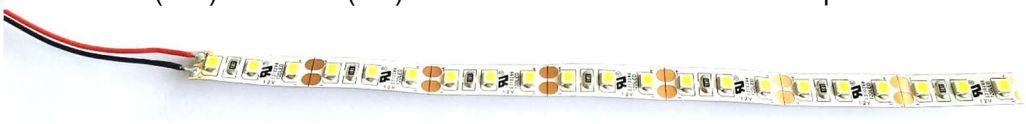
- Connect one x-axis aluminum profile to the two y-axis aluminum profiles with the help of two edge connectors and four M5x12 screws.



- From the open side of the y-aluminum profiles, insert the frame_top_front (label points downwards and to the middle.
- Place the x-aluminum profile (3N 215 mm, 1 slot closed) between the y-profiles and push it over the frame top_front.
- Insert the frame_top_back (label points downwards and the frame cutout is left).
- Finally, mount the remaining x-aluminum profile (2NVS 215 mm) with the help of two edge angle connectors and four M5x12 screws.

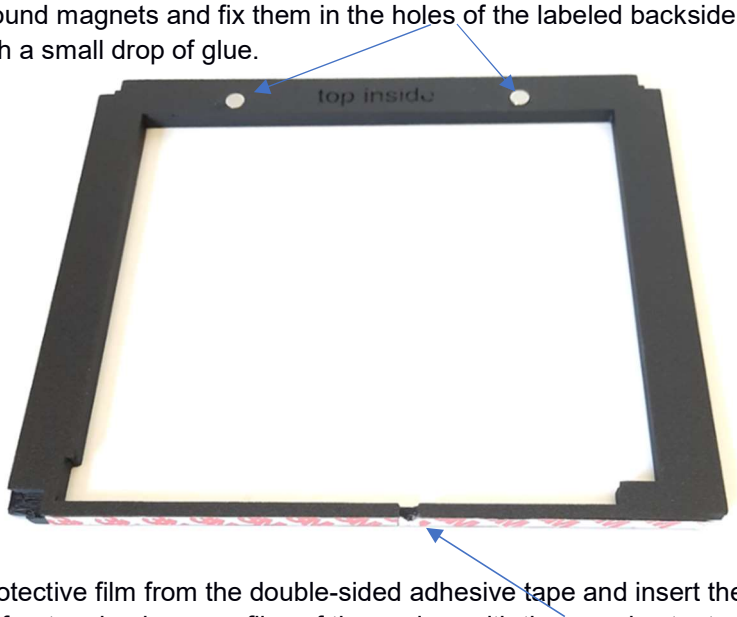
- Insert three M5 sliding nuts from the bottom into the middle x-aluminum profile (circled).
  One for the 3-way valve holder is mounted later.

- From one red as well as black pre-crimped wire, cut both female pins completely and strip 8 mm and 4 mm from one and the other wire ends, respectively.
- Cut another red as well as black wire in the middle and strip 8 mm from the wire ends. Extend the 30-cm wires by one-half of the cut wires (15 cm) with the 8-mm bare ends (Adjusting the cable length).
- Solder one red (to +) and black (to -) 4-mm bare wire end to the LED strip.



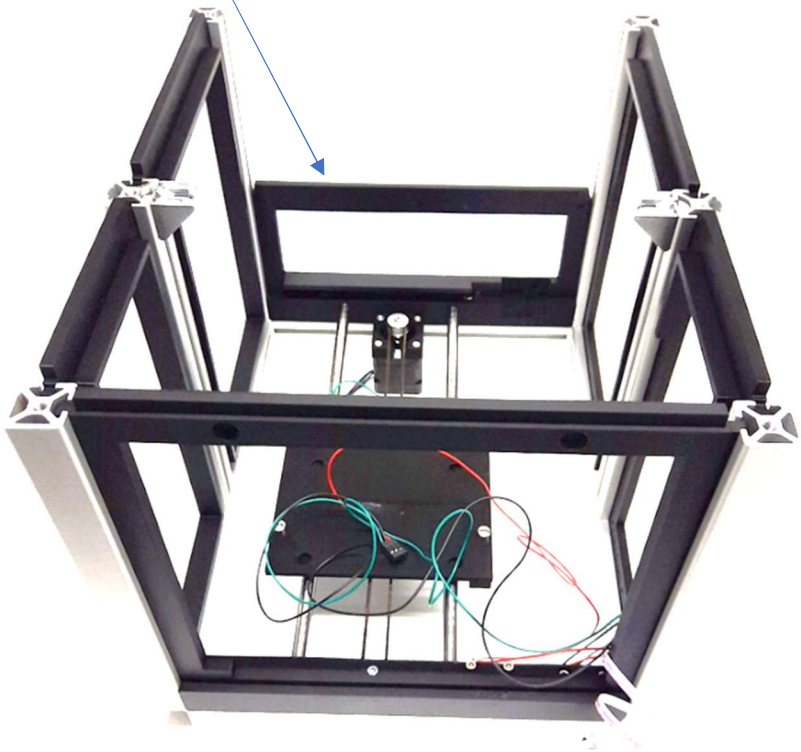
- Remove the protective film from the LED strip and stick the strip onto the frame_top_front (beveled bar), the wires pointing to the left.

- Stick the double-sided adhesive tape onto the bottom of the frame_front and cut it to size.
- Take the two round magnets and fix them in the holes of the labeled backside (top inside) of the frame_front with a small drop of glue.

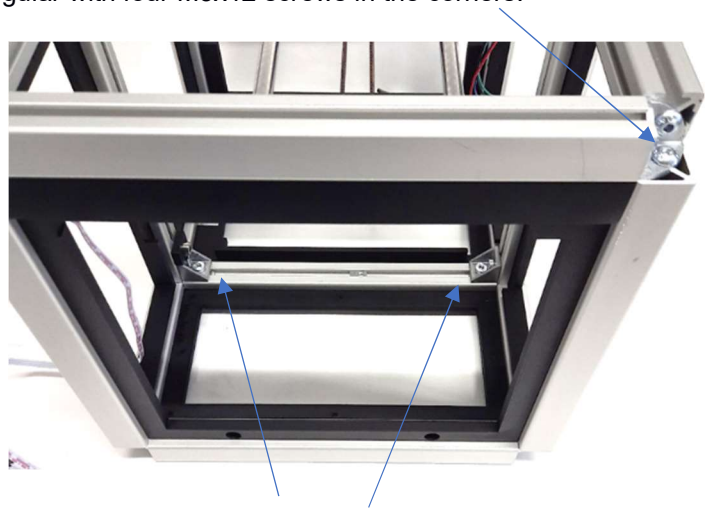


- Remove the protective film from the double-sided adhesive tape and insert the frame_front into the slots of the front *z*-aluminum profiles of the casing, with the round cutout on the small side pointing downwards and inside (magnets also inside). Press it down onto the y-axis_front.

- Insert the frame_back_top with the open side downwards and the label inside into the slots of the back *z*-aluminum profiles of the casing.

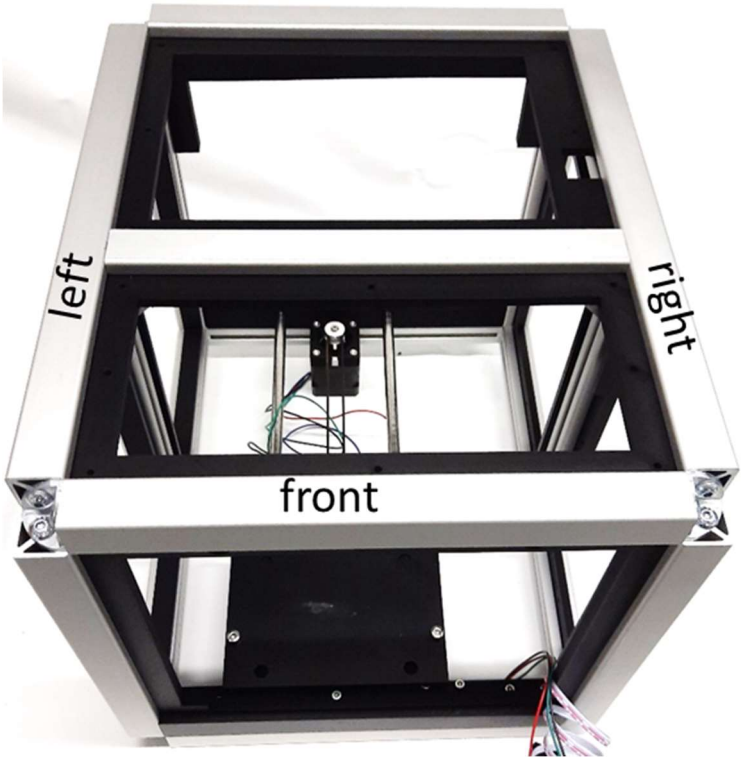


- Place the x/y-rectangle top onto the casing (smaller frame part and LEDs to the front frame).
- The frames should snap into the slots of the aluminum profiles and the teeth of the edge angle connectors snap into the *z*-aluminum profiles. Be careful not the give strong pressure onto the y-motor (optionally, place the casing top down and use your fists to press the top rectangle in).
- Mount the top rectangular with four M5x12 screws in the corners.

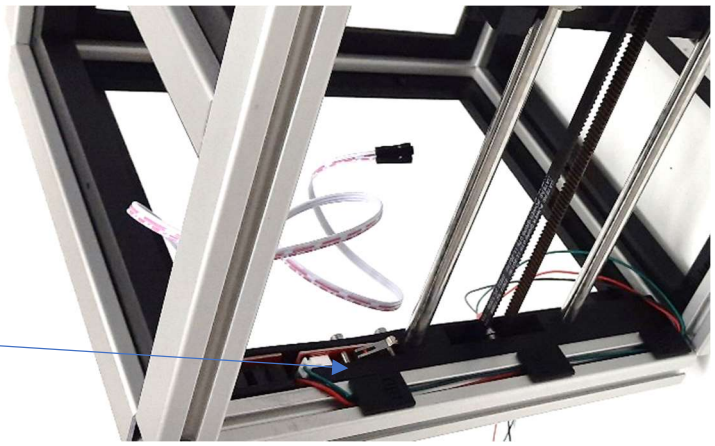


- Turn the casing top-down and move two sliding nuts in the middle top x-axis to meet the holes of the angles 20 I-type. Mount two M5x8 screws from inside.

Note the orientation of the instrument.

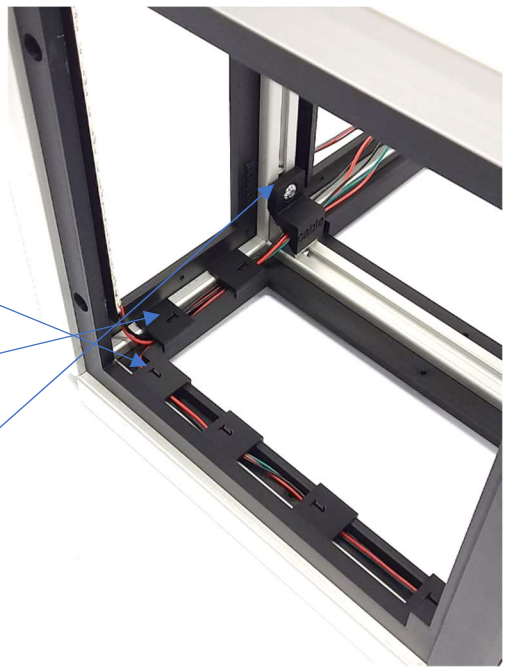


- View through the bottom to the front: Guide the mechanical endstop cable through the inner slot of the x-profile to the left side of the casing and fix it with three cable_clip_alu.



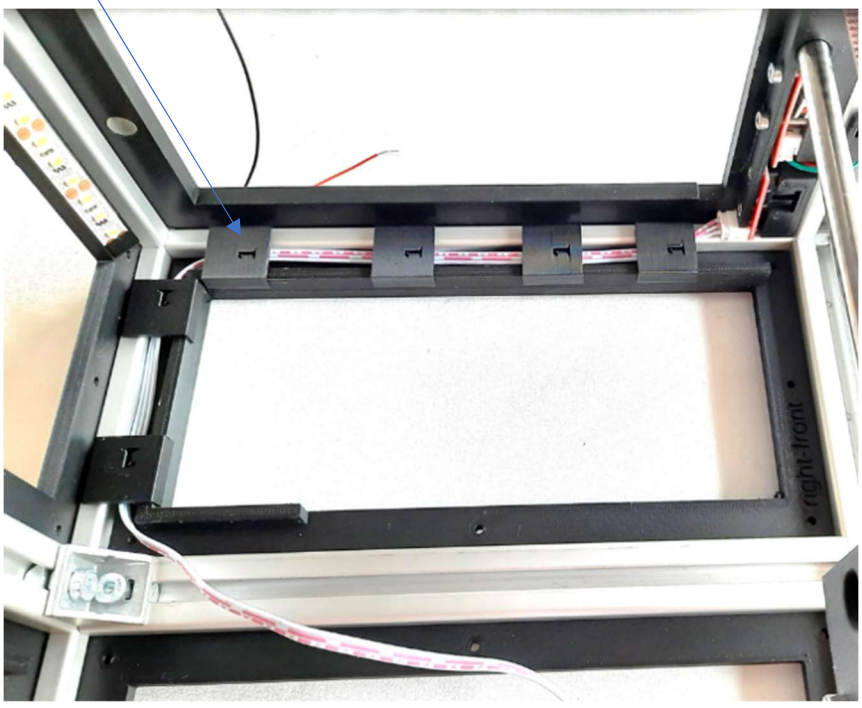
- Turn the casing 90° counterclockwise, thus laying on the left side.

- Further guide the endstop cable through the cable channel in the frame_left_front upwards and fix it with four cable_clip1.



- Then guide the endstop cable together with the wires of the LED strip through the upper cable channel in the frame_left_front backwards and fix them with two cable_clip1.
- Insert an M5 sliding nut into the middle aluminum x-profile at the left side (top of the casing) and mount the cable_guide_top_left with an M5x10 screw, guiding all wires through its slit.

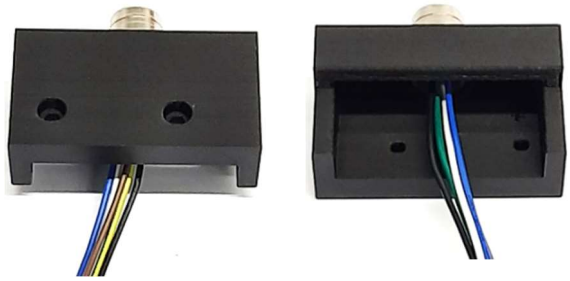
- Place the casing on the right side.
- Guide the optical endstop cable through the cable channel of the frame_front_right and fix it with six cable_clip1.



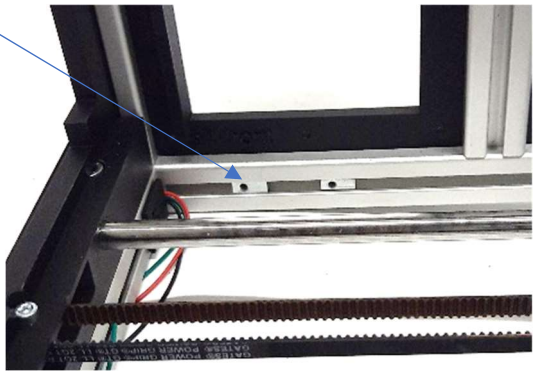
DC power jacket housing

Materials	Qty
Receptacle, 5 poles female to leads 50 cm	1
Screw M3x20, DIN 912	2
Sliding block M3 with web I-type groove 5	2
3D-printed DC-power-jacket_housing with cover	1
3D-printed cable_clip_alu	3

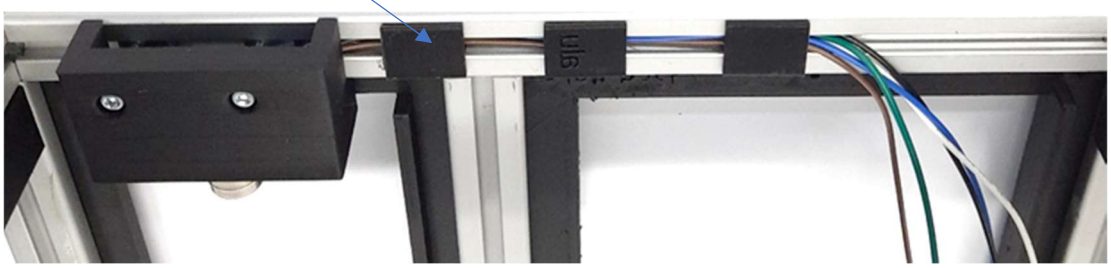
- Guide all wires of the receptacle from the top to inside of the DC-power_jacket_housing.
- Screw in and tighten the receptacle; use the cover as wrench.



- Insert two M3 sliding nuts inside the left bottom y-profile.
- Place the DC-power-jacket_housing onto the aluminum profile (near the frame_front). Thereby, guide the wires into the slot of the y-aluminum profile to the back of the casing so that the holes for mounting screws are freely accessible.
- Adjust the position of the M3 sliding nuts to the mounting holes of the DC-power-jacket_housing and fix the housing with two M3x20 screws.

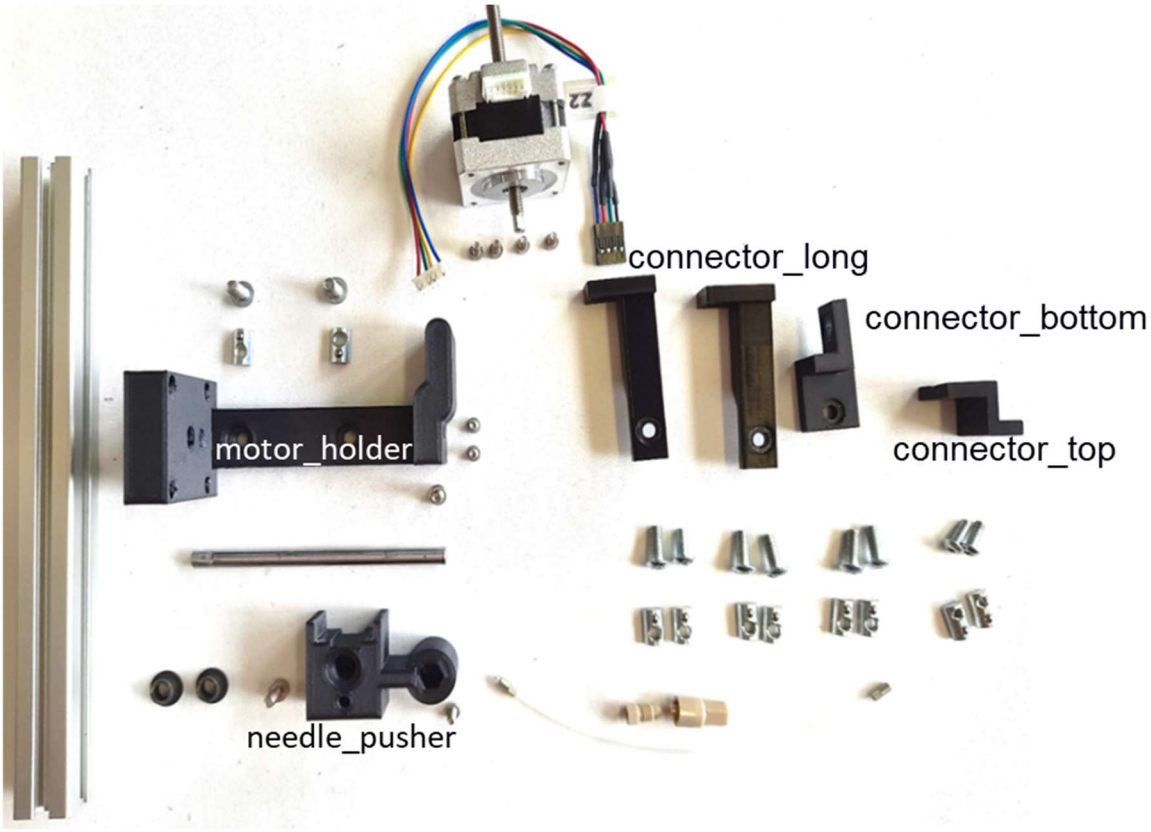


- Guide the wires of the receptacle through the inner slot of the y-aluminum profile backwards and fix them with three cable_clip_alu.

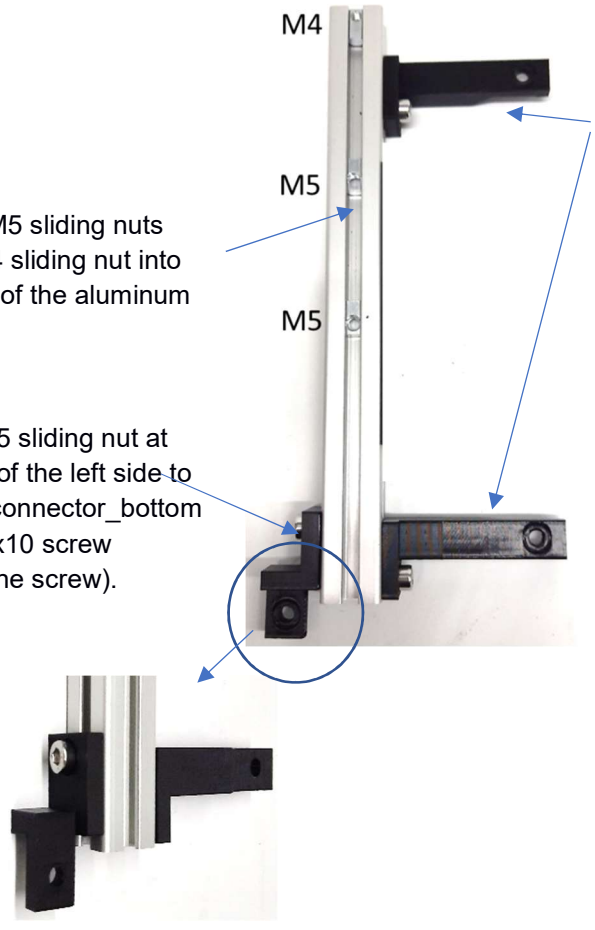


e-Axis

Materials	Qty
ACT 16HSL3404 Linear stepper motor, NEMA 16	1
Aluminum Profile 20x20L I-Type Groove 5, 210 mm	1
Steel rod, Ø 6 mm, 93 mm	1
PTFE tubing, 2 fittings 062 MINSTAC, ID 0.8 mm, L 15 cm (TUTC3216915L), The Lee Company	1
Luer adapter TMRA9503950Z, The Lee Company	1
Adapter TMDA3203950Z, The Lee Company	1
Bearing with flange (Form F) GFM-0608-05	2
Screw M3x8, DIN 912	2
Screw M3x10, DIN 912	5
Screw M4x10, DIN 7380	2
Screw M4x12, DIN 912	1
Screw M4x14, DIN 912	1
Screw M5x10, DIN 7380	8
Sliding block M4 with web I-type groove 5	2
Sliding block M5 with web I-type groove 5	10
3D-printed e-axis_needle_pusher	1
3D-printed e-axis_motor_holder	1
3D-printed e-axis_connector_long	2
3D-printed e-axis_connector_bottom	1
3D-printed e-axis_connector_top	1



Do not tighten the screws completely – all parts should still be movable!

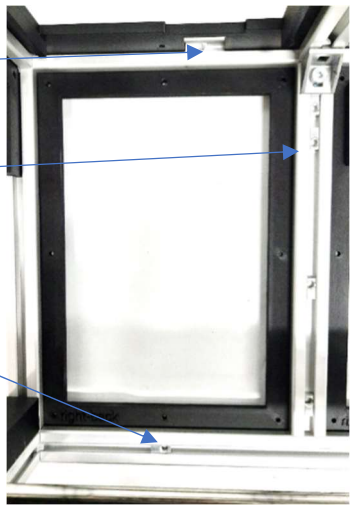


Insert two M5 sliding nuts into one slot of the aluminum profile and mount the two connector_long with an M5x10 screw each.

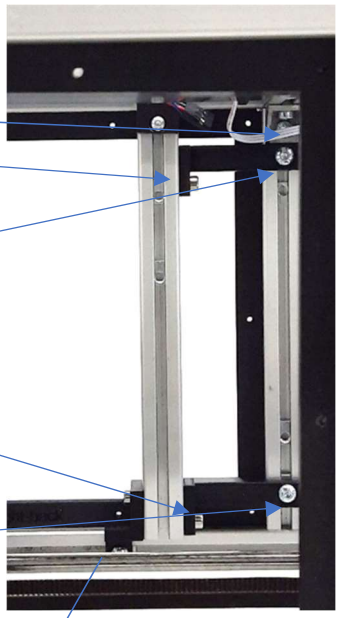
- Insert two M5 sliding nuts and one M4 sliding nut into the top slot of the aluminum profile.

- Insert an M5 sliding nut at the bottom of the left side to mount the connector_bottom with an M5x10 screw (do not fix the screw).

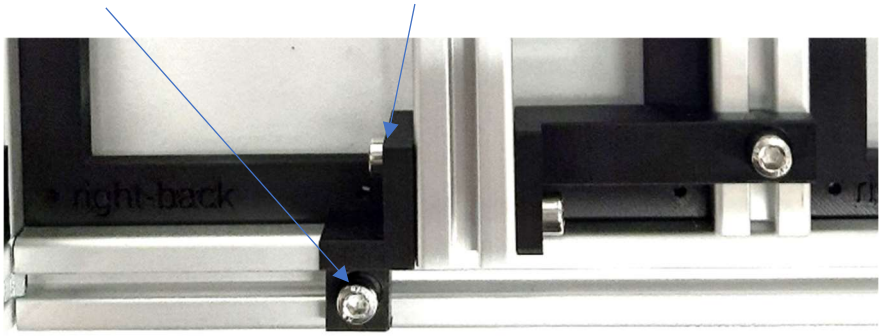
- Take the casing and insert an M4 sliding nut into the top y-profile (cutout of the frame_top_back).
- Insert four M5 sliding nuts inside the middle *z*-aluminum profile on the right side of the casing (two are for the x-axis later mounted).
- Insert one M5 sliding nut into the bottom y-profile on the right side.



- Bring the formerly prepared e-axis from inside in place.
- Move the upper connector_long and the upper sliding nut closest to the *angle 20 I-type* (edge connector) and tighten the screw at the e-axis.
- Insert an M5x10 screw into the upper sliding nut and fix it.

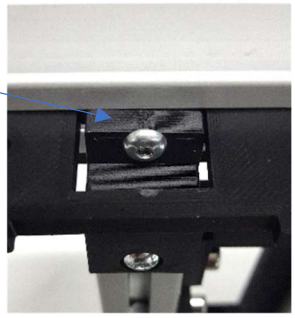


- Move the lower connector_long down so that it is flush with the e-axis aluminum profile and tighten the screw.
- Move the lower sliding nut to meet the hole of the connector_long, insert an M5x10 screw into the sliding nut and fix it.
- Move the sliding nut in the bottom y-profile to meet the hole of the e-axis_connector_bottom and fix it with an M5x10 screw. Tighten also the screw at the e-axis aluminum profile.



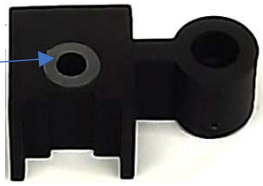
Turn the casing by 90° forwards.

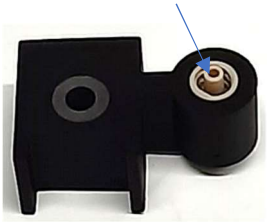
- Insert the connector_top at the top of the e-axis and mount it with two M4x10 screws.

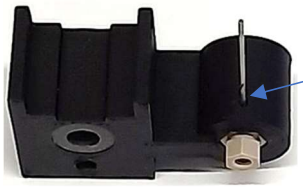


- Screw the two Lee adapters together to obtain a tight connection.

- Insert the bearings on both sides of the needle_pusher.
- Then insert the Lee adapter package into the neede_pusher.

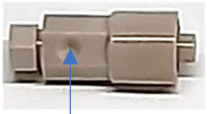






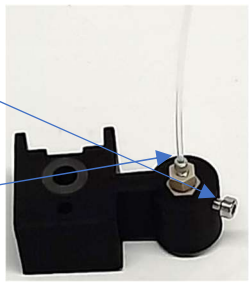
There is a 1-mm hole in the cylindric part of the pusher (note that there is also a 3-mm hole).

- With a 1-mm drill carefully drill a mark into the Lee adapter.

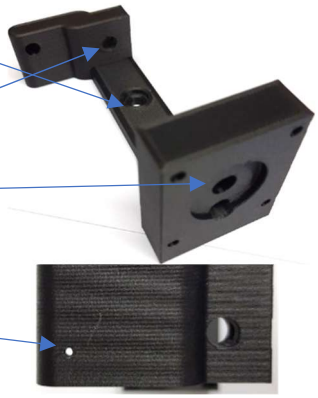


- Take out the Lee adapter and carefully enlarge the mark with a 4-mm drill to take up the tip of an M3x10 screw. Do not drill through the part!

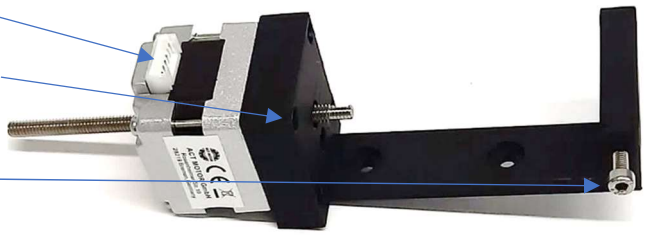
- Insert the Lee adapter back into the pusher pointing the mark to the 3-mm hole and slightly fix (until resistance is felt) the adapter with an M3x10 screw.
- Insert the tubing into the Lee adapter and fix it carefully with the Lee torque wrench (minimum torque).



- Smooth the rough surface of the e-axis_motor_holder with a file.
- Cut the existing holes for the steel rod in the needle guide part and the motor holder round with a 6-mm drill bit.
- Turn it around to view from the bottom and carefully cut the given small hole in the needle guide round with a 1.5-mm drill bit and clean the needle guide from particles.



- Mount the motor (cable plug pointing to the top) onto the e-axis_motor_holder with four M3x10 screws.
- Insert with only some turns an M4x12 screw into the opposite side.

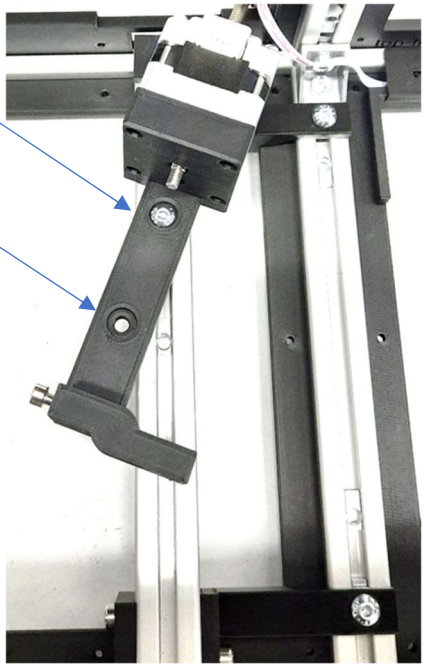


- Insert two M3x8 screws into the holes at the bottom of the e-axis_motor_holder near the needle guide.

Testing

- Insert the steel rod from the needle guide side half the way and slide the needle_pusher over the steel rod.
- Push the steel rod fully in and check if the needle_pusher is moving easily. Otherwise, file the motorholder a little bit more and also the bottom of the needle pusher.
- Push out the steel rod and take out the needle_pusher.

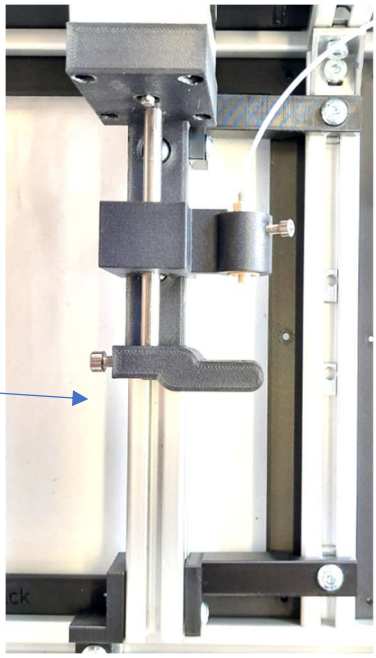
- Turn the casing so that the e-axis is at the bottom.
- Mount the e-axis_motor_holder onto the e-axis, first with one M5x10 screw. Do not tighten the screw completely.
- Turn the motor_holder slightly to move the sliding nut to hit the second hole of the motor holder and insert the second M5x10 screw.



- Slide the e-axis_motor_holder up until the top of the motor is flush with the frame_top_back.
- Tighten the two screws of the motor_holder on the e-axis aluminum profile.

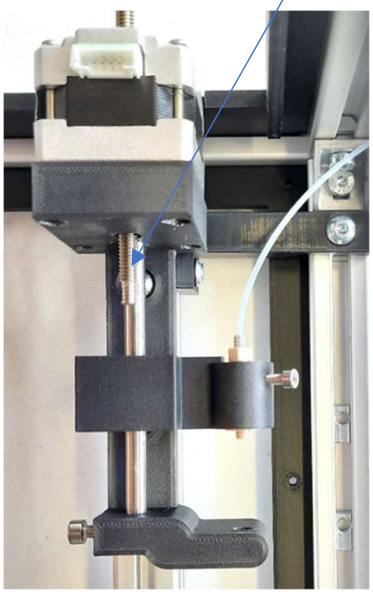
- Take the steel rod and file a notch, 8 mm long and 1 mm deep.

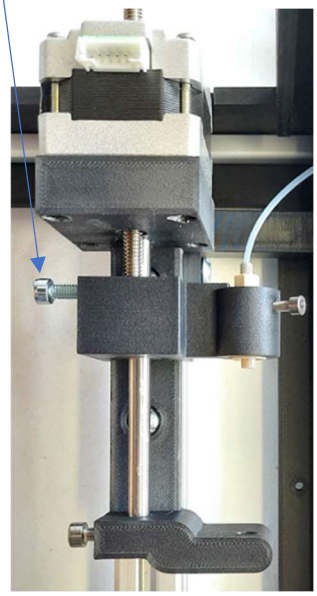
- Insert the steel rod (with the flattened side opposite the motor) from the needle guide side of the e-axis_motor_holder for some centimeters.
- Then slide the needle_pusher over the steel rod.



- Make sure that the flattened side face points to the fixing screw and push the steel rod completely into the respective hole of the motor_holder.
- Fix the steel rod with the screw (do not overtighten).

- Turn the motor spindle until it is about 20 mm outside the motor_holder, while the flattened tip points to the left (hole for the fixing screw).



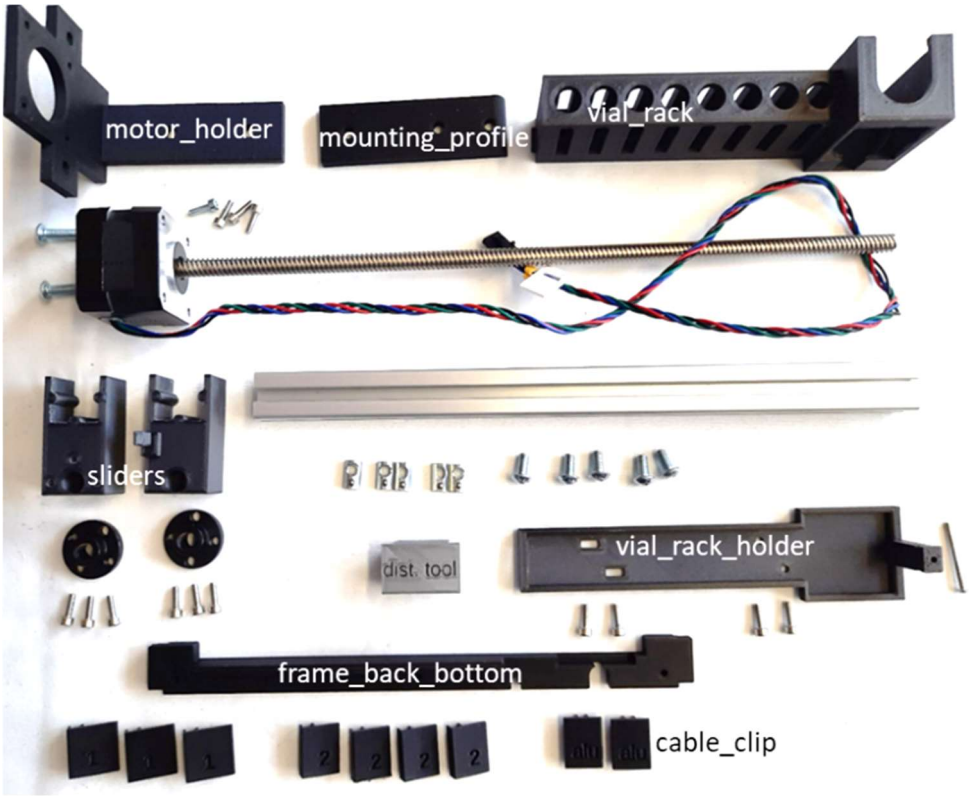


- Move up the needle_pusher until the flattened tip is hidden (until resistance).
- Fix the spindle with an M4x14 screw (until resistance).

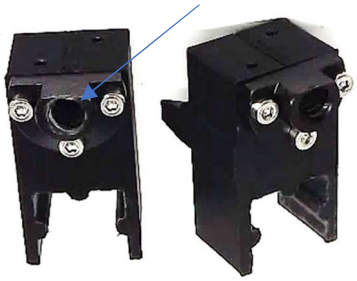
- Connect the motor cable with the motor plug.
- Put some machine oil onto the spindle and the steel rod.

z-Axis autosampler

Materials	Qty
Motor Nema 17 with 310-mm spindle	1
Aluminum Profile 20x20L I-Type Groove 5, 270 mm	1
Screw M2.5x25, DIN 912, stainless steel	1
Screw M3x8, DIN 912	4
Screw M3x10, DIN 912	10
Screw M5x20, DIN 7380	2
Screw M5x10, DIN 7380	5
Sliding block M5 with web I-type groove 5	5
Trapezoidal nut TR8	2
3D-printed autosampler_vial_rack_PA-rinsing-bottle	1
3D-printed autosampler_vial_rack_holder	1
3D-printed autosampler_slider	1
3D-printed autosampler_slider_tip	1
3D-printed autosampler_motor_holder	1
3D-printed autosampler_mounting_profile	1
3D-printed frame_back, bottom part	1
3D-printed cable_clip1	3
3D-printed cable_clip2	4
3D-printed cable_clip-alu	2
3D-printed distance-tool	1
3M 9088 double-sided tape, 6 mm	25 cm



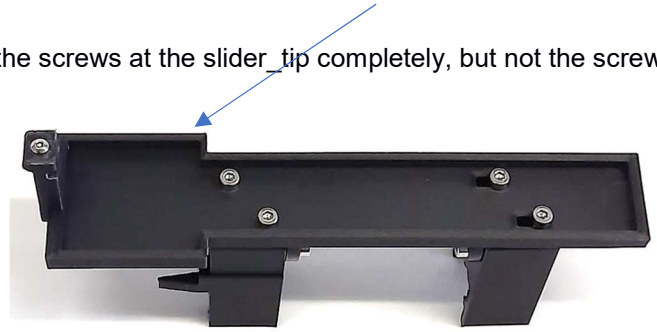
- Cut the motor spindle with a saw to a length of 300 mm.
- On both sliders, mount a trapezoidal nut with three M3x10 screws each and saw off the overhang.

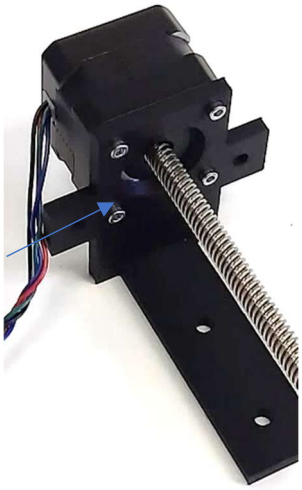


- Insert four M5 sliding nuts into the aluminum profile.
- Mount the mounting_profile with two M5x10 screws, but do not tighten them (still movable mounting plate).

- Using a handtap, cut a 2.5 mm thread into the tip of the vialrack_holder and screw in the M2.5x25 screw.

- Mount the vialrack_holder on top of the sliders with four M3x10 screws, while the trapezoidal nuts point each other and the slider_tip points to the enlarged part of the vialrack holder (here left).
- Tighten the screws at the slider_tip completely, but not the screws in the slit on the right side.

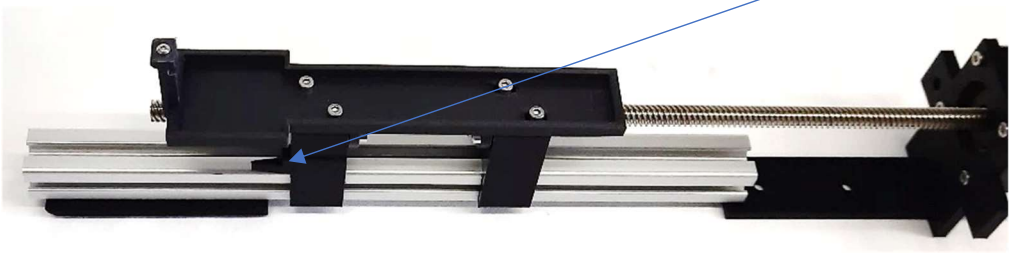




- Mount the spindle motor onto the motor_holder with four M3x8 screws, when the motor cables point to the left side.

- Screw in the motor spindle from the right side (small part of the rack holder) through both sliders. When the spindle touches the second trapezoidal nut, take care that the untightened screws on the right are in the slit's middle. Continue screwing in the spindle
- Tighten the two screws in the slits.

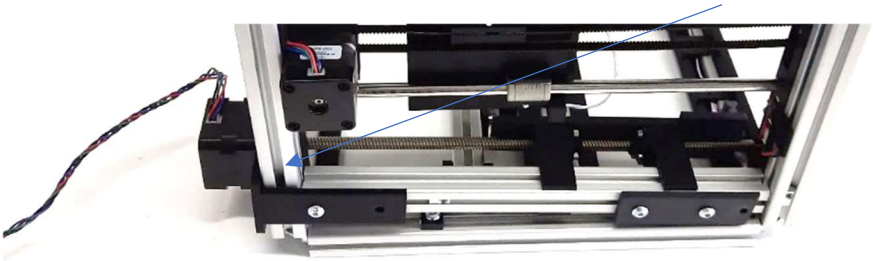
- Guide the vialrack_holder with the sliders onto the aluminum profile, while the slider_tip points to the mounting_profile (here left).



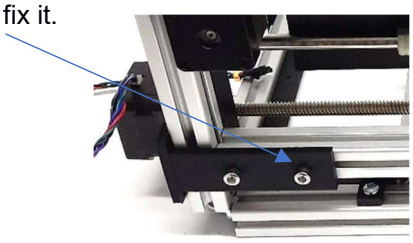
- Test if the spindle is freely and easily to turn and if the sliders are easily moving over the profile.
- Take the casing and place it on its right side (e-axis down).
- Insert an M5 sliding nut in the bottom of the front x-profile (circled).

- Loose the screw in the bottom angle corner of the y-profile.

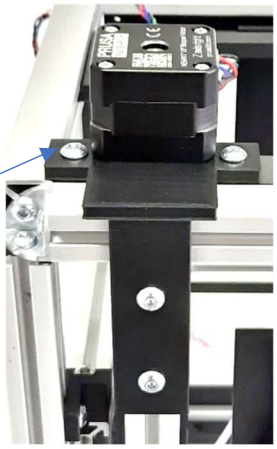
- Position the rackholder in the middle by turning the spindle.
- Insert the autosampler z-axis from the back and from inside between the two bottom x-axis profiles. Be careful not to scratch the y-axis_front endstop cables.
- Move the motor_holder to the back side until it touches the y-axis_back.
- The left hole of the motor_holder should meet the sliding nut. Insert an M5x10 screw and fix it.



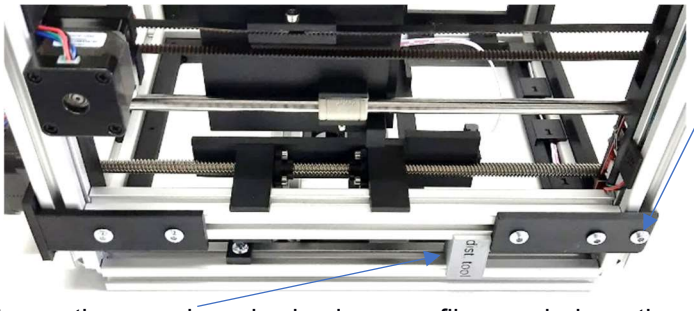
- Move the second sliding nut to meet the right hole in the bottom of the motor_holder, insert an M5x10 screw and fix it.



- Mount the motor_holder with two M5x20 screws onto the y-axis_back.

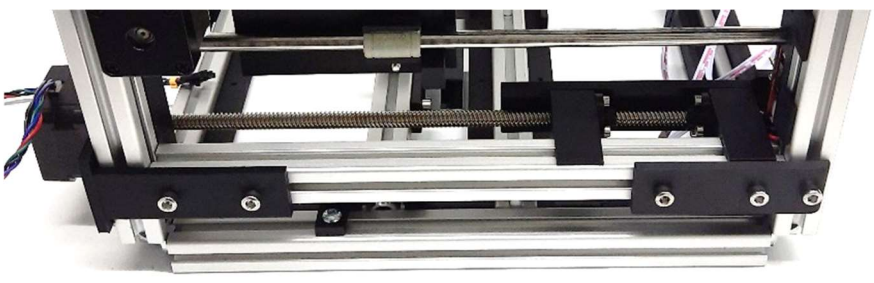


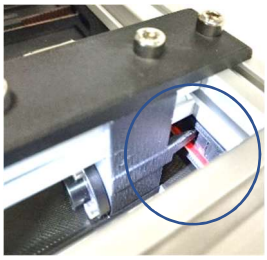
- Turn the spindle so that the vialrack_holder is in the middle of the z-axis.
- Move the mounting_profile to the front to meet the sliding nut in the x-axis and insert an M5x10 screw with some turns.



- Insert the distance_tool between the y- and z-axis aluminum profiles, push down the z-axis onto the tool, and tighten the three screws in the mounting_profile.
- Tighten the screw in the lower corner again and remove the distance_tool.

- By turning the spindle (from the motor side) counterclockwise, finally check, if the tip of the slider exactly meets the slit of the optical endstop. Be careful not to break the tip (circled).

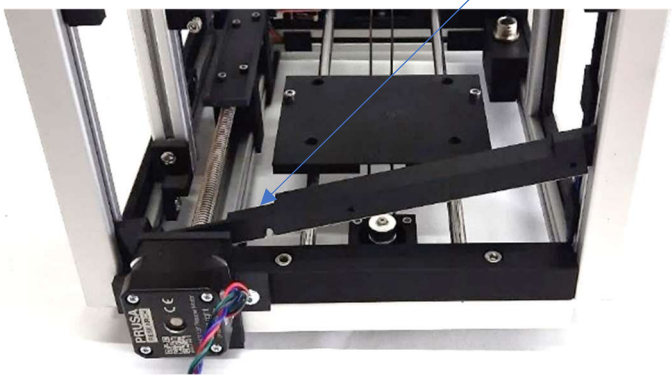


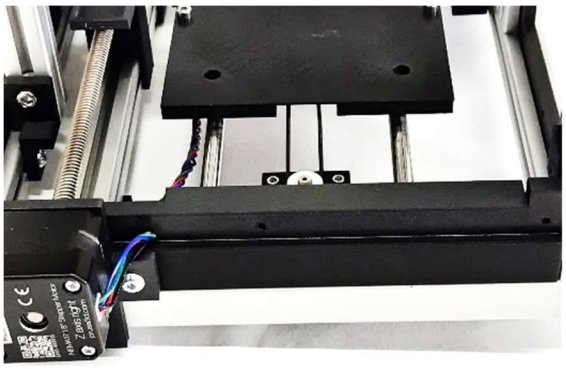


- Put some machine oil onto the spindle and the z-axis aluminum profile (where the sliders are moving).

- Stick the double-sided adhesive tape onto the frame_back_bottom and cut it under the two round frame cutouts.

- Remove the protective film and insert the frame into the slots of the back z-axes, guiding the motor cable inwards through the small cutout (the large round cutout is for the spindle), and press the frame onto the y-axis_back.



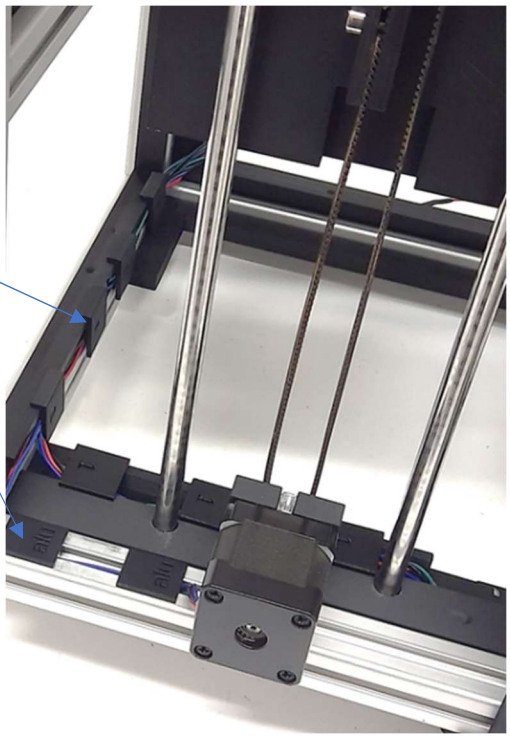


- Place the casing on its back side.

- Guide the autosampler motor cable through the cable channel inside the frame_back (bottom part) to the left side of the casing and fix it with three cable_clip1.

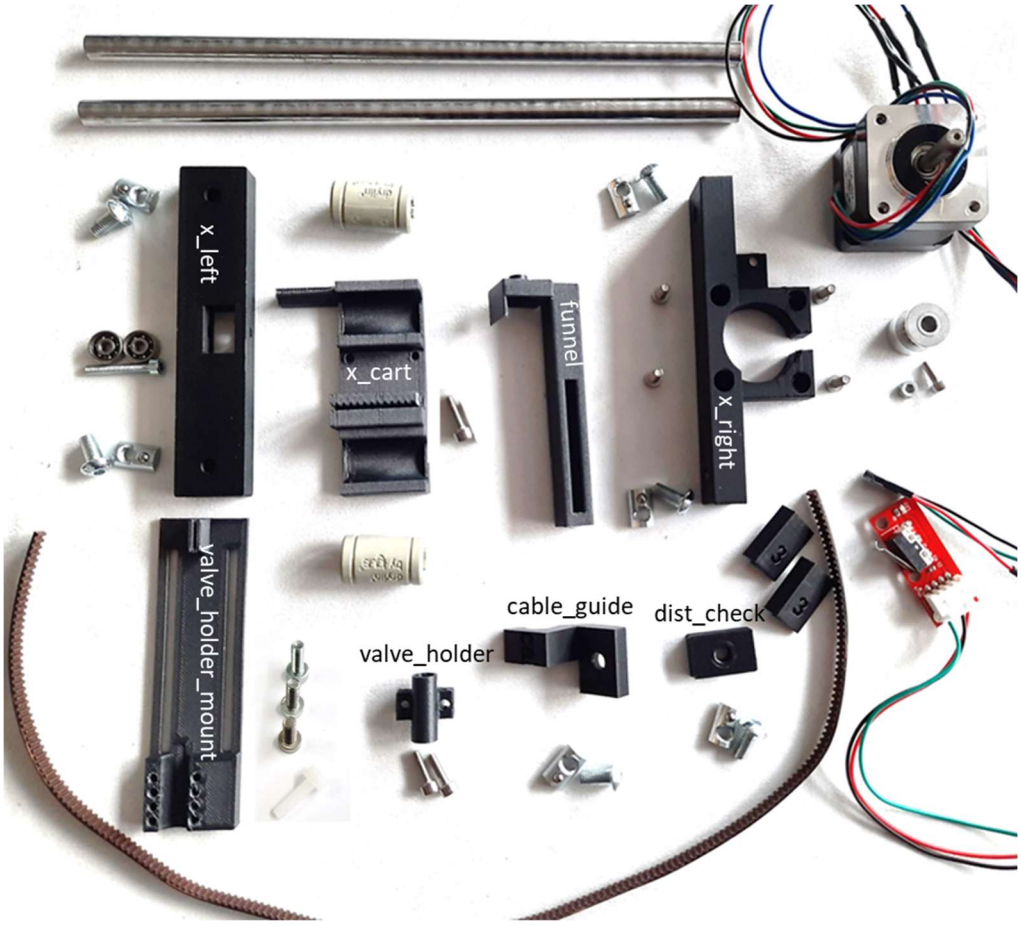
- Guide the y-motor cable inside the aluminum profile to the left side of the casing and fix it with two cable_clip-alu.

- Guide both motor cables through the cable channel (frame_back_left) upwards and fix them with four cable_clip2.

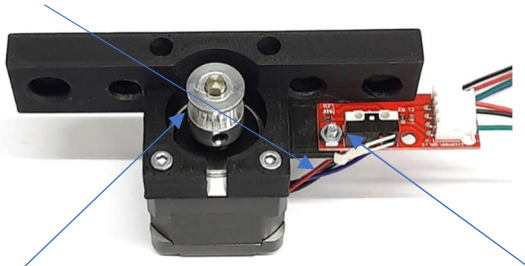


x-Axis

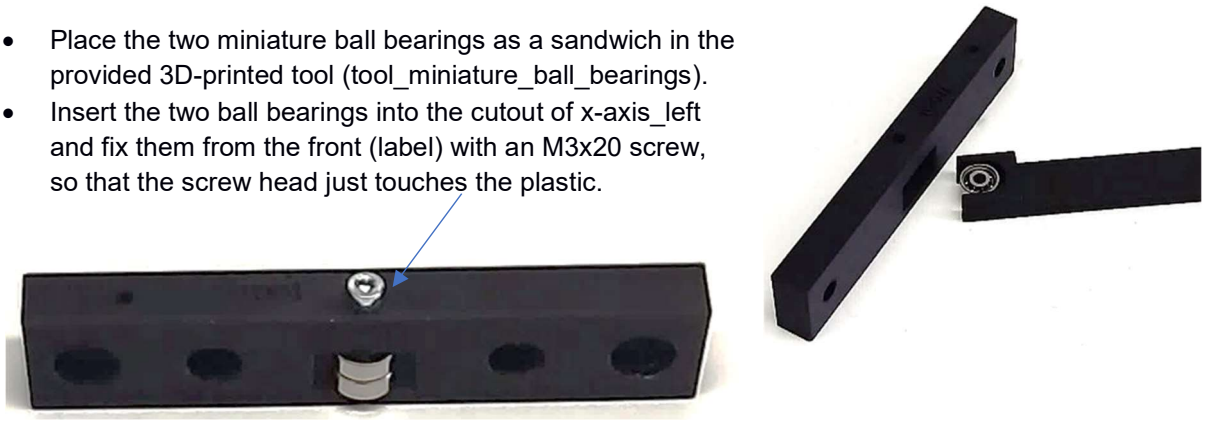
Materials	Qty
Motor Nema 14	1
Steel rod 205 mm, Ø 8 mm	2
Timing pulley T16-2GT	1
Timing belt Prusa MINI X-Axis	1
Linear bearing	2
Miniature ball bearing, 3x10x4 mm	2
(3D-printed tool miniature_ball_bearing)	(1)
Mechanical endstop	1
Screw M3x8, DIN 912	1
Screw M3x10, DIN 912	10
Screw M3x20, DIN 912	1
Screw M5x10, DIN 7380	6
Nut M3	1
Sliding block M5 with web I-type groove 5	4
Nylon screw M3x10	1
3D-printed x-axis_right	1
3D-printed x-axis_left	1
3D-printed x-axis_cart	1
3D-printed x-axis_valve_holder_mount	1
3D-printed x-axis_valve_holder	1
3D-printed x-axis_distance_check_left	1
3D-printed x-axis_cable_guide_top_right	1
3D-printed cable_clip3	2



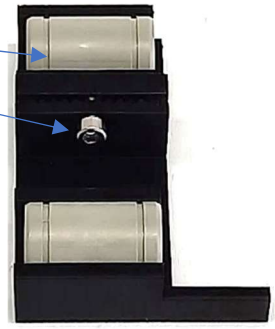
- Mount the motor to the x-axis_right with four M3x10 screws, the motor cables pointing to the endstop slit (here right).



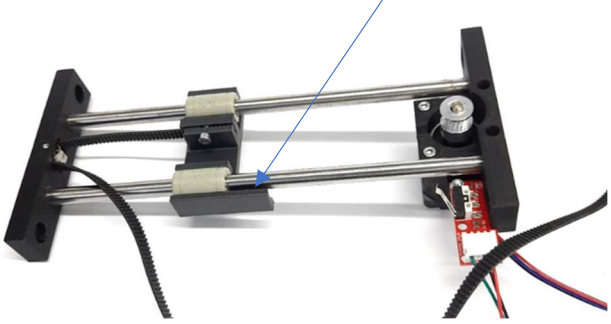
- Insert the mechanical endstop into the small slit and fix it with an M3x8 screw and M3 nut.
- Place the 2GT pulley onto the motor axle, with the axle protruding approx. 1 mm and one screw pointing to the flat side of the axle directed to the cutout. Fix the pulley with the two screws (2-mm Allen key).
- Place the two miniature ball bearings as a sandwich in the provided 3D-printed tool (tool_miniature_ball_bearings).
- Insert the two ball bearings into the cutout of x-axis_left and fix them from the front (label) with an M3x20 screw, so that the screw head just touches the plastic.



- Insert and press in the two linear bearing centrally into the slots of the x-axis_cart and insert an M3x10 screw into the timing belt holder (the screw head just touches the plastic).



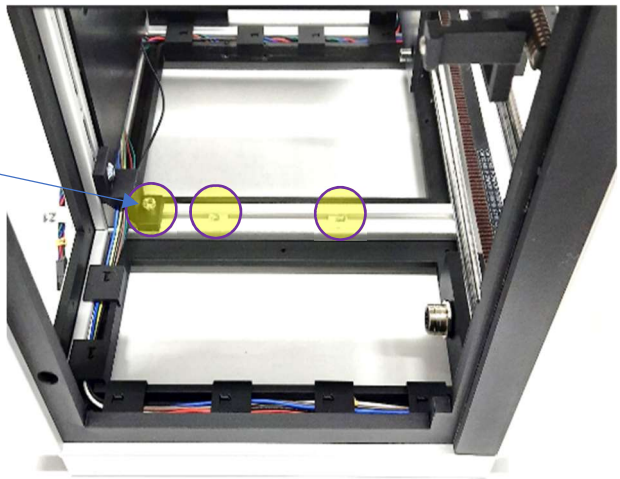
- Guide the two steel rods through the linear bearings and press the steel rods into the respective holes of x-axis_left (label front downwards) and x-axis_right (motor down). The tip of the x-axis_cart points to the endstop.
- Guide the timing belt over the ball bearings, draw it to the x-axis_cart, and press three teeth deep into the slit of the timing belt holder.



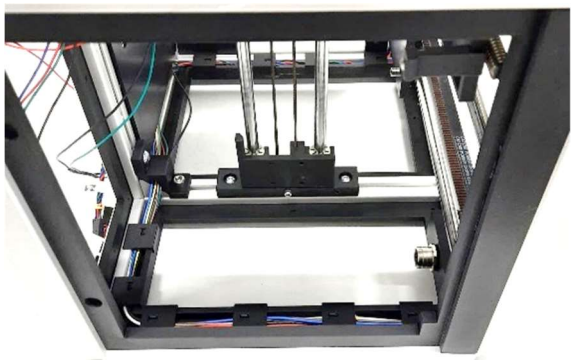
- Guide the other end of the timing belt over the 2GT pulley, draw it to the timing belt holder, and cut it near the screw.
- Under slight tension, press the timing belt deep into the slit of the timing belt holder.
- Tighten the M3 screw slightly to fix the timing belt.
- Put some machine oil onto the rods.

- To finely adjust the position of the pulley on the motor axle, loosen the two screws (2-mm Allen key) of the pulley slightly, so that the pulley can move up and down but not turn over the motor axle.
- Then push the x-cart fully forwards and backwards, so that the pulley self-adjusts the optimal height on the motor axle.
- Fix the two pulley screws again without impacting its height on the motor axle. To reach the screws through the slit in the motor holder, move the x-cart, do not turn the pulley by hand.

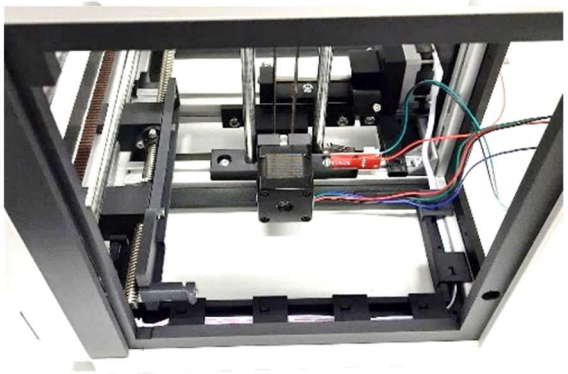
- Place the casing on the left side (DC-power_ jacket_housing pointing to the right).
- Insert three M5 sliding nuts inside to the left middle z-axis (circled).
- Mount the distance_check_left with an M5x10 screw (few turns).
- Loosen the screw at the cable_guide_top_left and move it slightly up. Move the distance_check_left completely to the left (touching the *Angle 20 I-type groove* 5) and fix the screw.
- Guide the cable_guide_top_left down again and fix the screw.



- Insert the x-axis with x-axis_left downwards, the motor pointing to the front.
- Move it over one sliding nut, insert an M5x10 screw and fix it loosely with the nut (still movable).
- Move the x-axis to meet the second sliding nut and insert an M5x10 screw as mentioned.

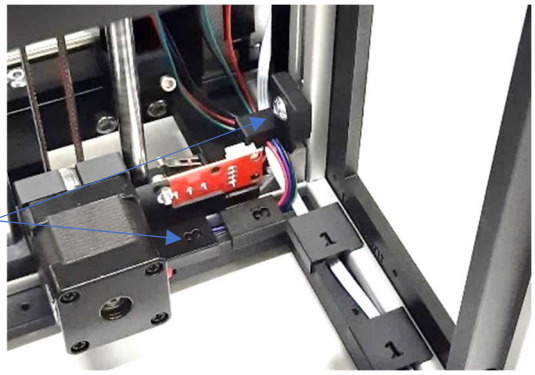


- Turn the casing by 180° (top down) and repeat the screwing processes with another two M5x10 screws (*the sliding nuts are already present in the z-profile from mounting the e-axis*).



Then push the x-axis upwards (here to the right) as far as it will go and tighten the M5 screws.

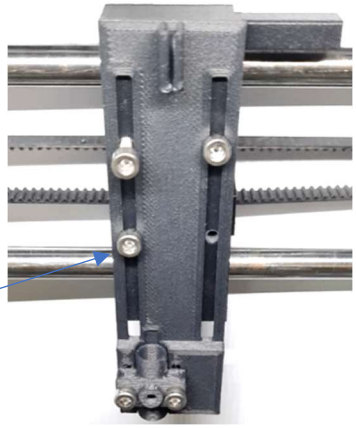
- Tighten also the M5 screws of the x-axis_left while pushing it upwards.



- Place the casing again on its right side.
- Guide the x-motor cable (4 wires) through the cable channel and fix it with two cable_clips3.

- Insert an M5 sliding nut in the middle x-axis top profile to mount the x-axis_cable_guide_top_right with an M5x10 screw, guiding the x-motor, the x-endstop and the optical endstop cables through its slit.

- Slightly rasp the x-axis_valve_holder <u>inside</u> with a round file or a knife (elephant foot possible).
- Mount the x-axis_valve_holder with two M3x10 screws onto the x-axis_valve_holder_mount.



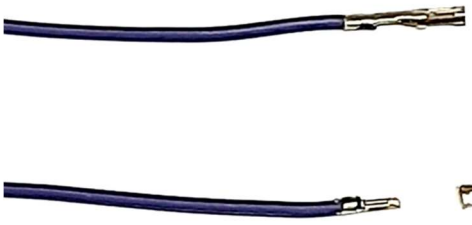
- Mount the x-axis_valve_holder_mount with three M3x10 screws onto the x-axis_cart. There is a fourth hole, but three screws are enough.

Adjusting the cables' length

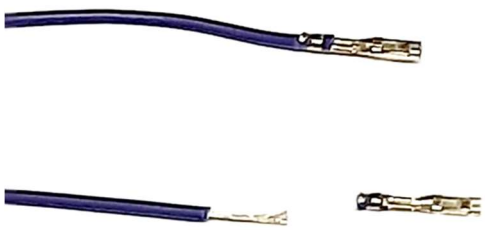
Materials	Qty
Precrimped wire F-F, 30 cm, black	3
Precrimped wire F-F, 30 cm, red	3
Precrimped wire F-F, 30 cm, green	3
Precrimped wire F-F, 30 cm, blue	2
Crimp connector housing, 1x4 pins	3
Crimp connector housing, 1x3 pins	2
Shrink tube, ID 2 mm, 2 cm	18
3D-printed cable_support_electronic_box	1
3D-printed cable_labels_X	2
3D-printed cable_label_Y	2
3D-printed cable_label_Z	2
3D-printed cable_label_E0	1
M3x10 screw	2

Cutting the precrimped wires

Cutting the female pin (only)

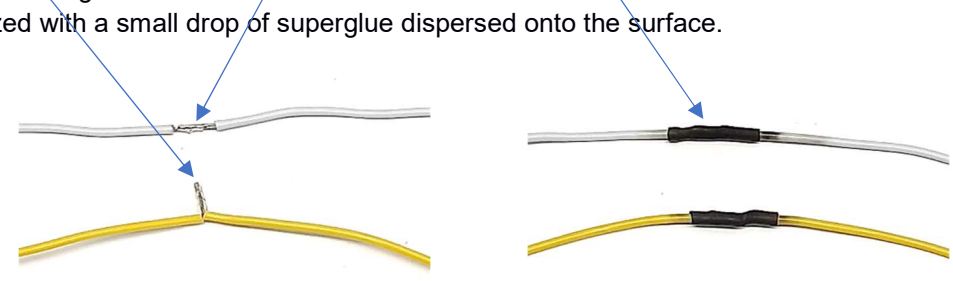


Cutting the precrimped pin completely and strip



Cable connections

In the following instructions, connecting means soldering or twisting together bare wire ends.
It is best to connect two wires by soldering, but wire ends can also simply be connected mechanically if soldering equipment is not available. Therefore, strip 8 mm of insulation from the wire ends, carefully twist them together and fix the connection with a shrink tube. The twisted wires can also first be stabilized with a small drop of superglue dispersed onto the surface.



However, soldering expertise is required for all LED boards, especially as there are only a few seconds available for soldering so as not to overheat and possibly destroy the LEDs.

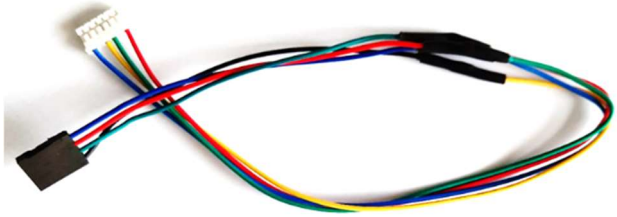
- Strip 8 mm from the x-motor wires and slide 2-cm shrink tubes over the wires.
- Cut four precrimped wires (black, red, green, blue) in the middle and strip 8 mm from the four 15-cm wires.
- Connect the x-motor cables with the same coloured 15-cm wires, slide the shrink tubes over the connections, and heat them for shrinking.
- Insert the four female pins into a 4-pin housing with the wire colour order:
  blue, red, green, and black.

- Seen from the black pin housing, cut the x-endstop wires (70 cm) at 50 cm (measured including the black pin housing) and slide 2-cm shrink tubes over the rest of the wires connected to the endstop.
- Shorten the wires (with the black 3-pin plug) to 12 cm (measured including the pin housing).
- Strip 8 mm from all wire ends and, connect the stripped wire ends (colour to colour), slide the shrink tubes over the connections, and heat them for shrinking.

- From the y-motor wires, strip 8 mm and slide 2-cm shrink tubes over the wires.
- Cut four precrimped wires (black, red, green, blue) to a length of 21 cm (measured including the female pin), strip 8 mm from the wire ends, connect them to the y-motor wires (colour to colour), slide the shrink tubes over the connections and heat them for shrinking.
- Insert the four female pins into a 4-pin housing with the wire colour order:
  blue, red, green, and black.

- Cut the wires of the e-axis motor to a length of 21 cm (measured including the motor plug), strip 8 mm from the wire ends, and slide 2-cm shrink tubes over the wires.
- Cut black, green, blue, and red precrimped wires (left over from the y-motor) to a length of 6 cm (measured including the female pin) and strip 8 mm from the wire ends.
- Connect the motor wire ends with the ends of the 5-cm extension wires with the following colour combinations:

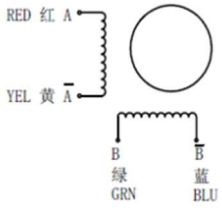
Motor cable color	Color of extending wire
blue	blue
green	red
red	green
yellow	black



- Slide the shrink tubes over the connections and heat them for shrinking.
- Insert the four female pins into a 4-pin housing with the wire colour order of the extending wires:
  blue, red, green, and black.

Explanation

The ACT motor is delivered with a 6-pin plug providing four wires. Coil A is supplied with the red and yellow cables, and coil B with the green and blue cables (different from Pololu Nema motors).



Cut the mechanical y-endstop wires directly at the pin housing, strip 8 mm from the wire ends and slide 2-cm shrink tubes over the wires (Adjusting the cables' length

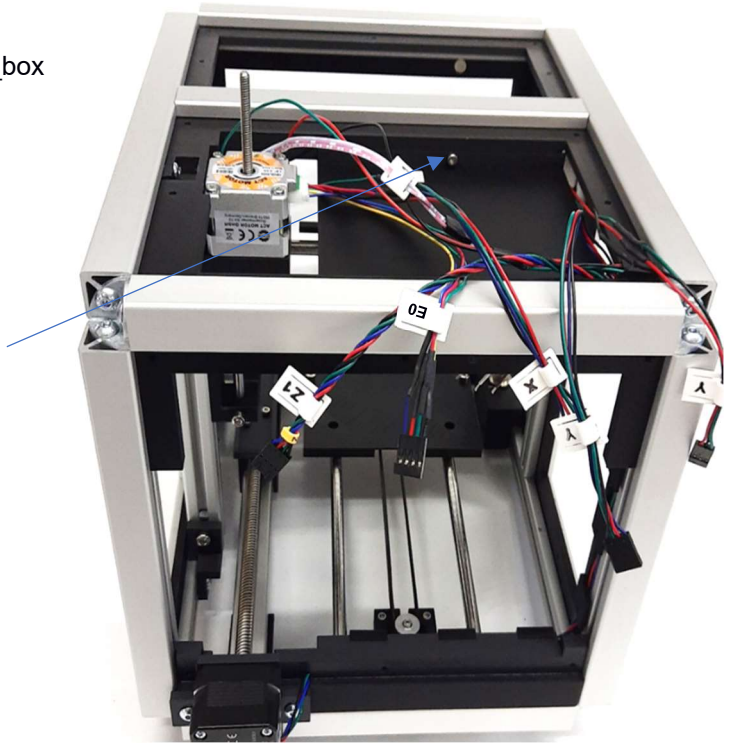
- Cut the precrimped wires left over from the x-motor (black, red, green) to a length of 11 cm (measured including the female pin) and strip 8 mm from the wire ends.
- Connect the endstop wire ends to the precrimped wire ends (colour to colour), slide the shrink tubes over the connections, and heat them for shrinking.
- Insert the three female pins into a 3-pin housing with the wire colour order: red, black, and green.

- From the optical endstop (mounted inside the y-front) cable, cut the wires at the pin housings and strip 8 mm from the wire ends.
- From red, black, and green precrimped wires cut 11 cm (measured including the female pin), strip 8 mm from the wire ends, and slide 2-cm shrink tubes over the wires.
- Check the notes made during mounting the y-axis (markings on the endstop wires and the endstop itself (V, S, G).
- Connect the wire ends of V, G, and S to the red, black, and green wire ends of the extending precrimped wires, respectively.

- Slide the shrink tubes over the connections and heat them for shrinking.
- Insert the three female pins into a 3-pin housing with the wire colour order: red, black, and green.

The cable of the autosampler spindle motor (Z1) is used without modifications.

- Guide all cables to the top.
- Insert the 3D-printed cable_support_electronic_box from inside, the quadratic cutout pointing to the middle, and press it onto the bars of the frame top_back.
- Align the panel so that its 3-mm holes meet the holes in the bars of the frame top_back.
- Fix the cable_support with two M3x10 screws.



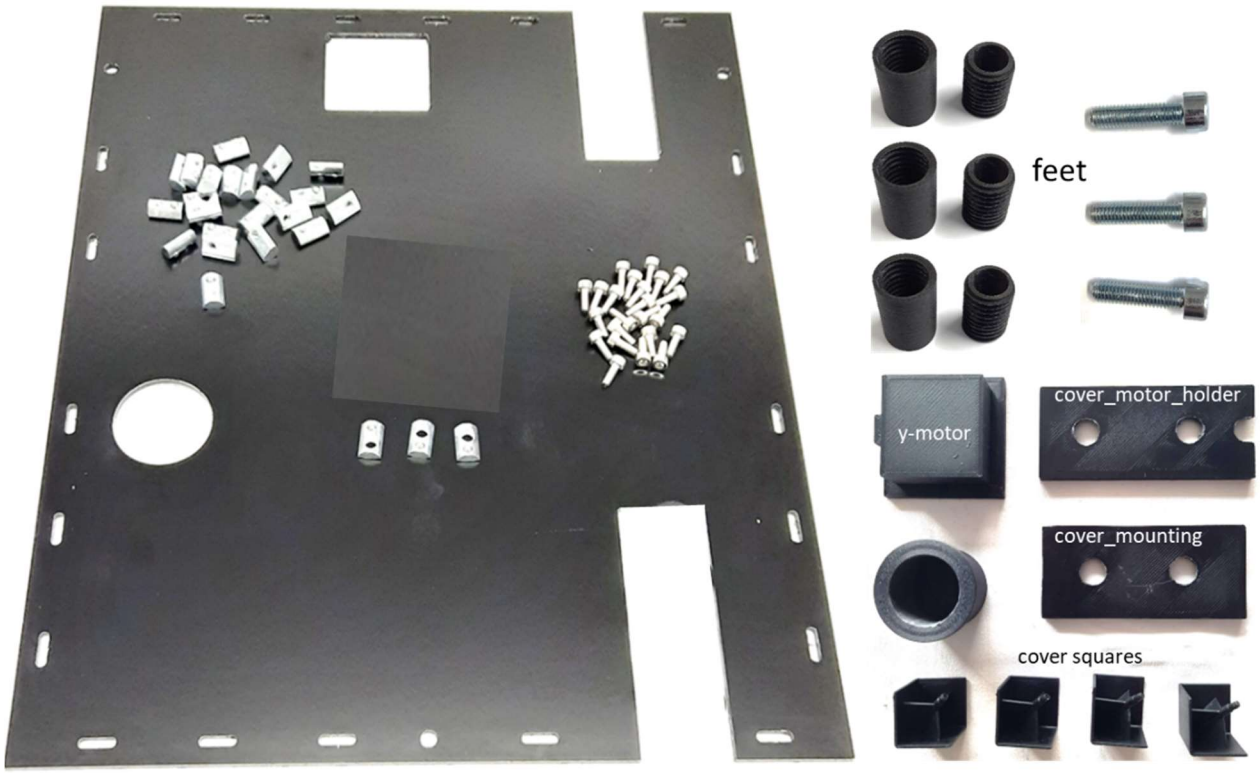
It is good practice to label the cables to avoid confusion when later connecting them to the electronic board. Motor and endstop cables are easy to distinguish; motors have four wires, endstops only three.

All in all five motors work independently:
- X axis (nozzle; timing belt)
- Y axis (plate holder; timing belt)
- Z1 axis (autosampler vial rack; spindle motor)
- Z2 axis (syringe pump; spindle motor)
- E0 axis (autosampler needle pusher; spindle motor).

The X, Y, and both Z axes have endstops for movement.

Bottom plate

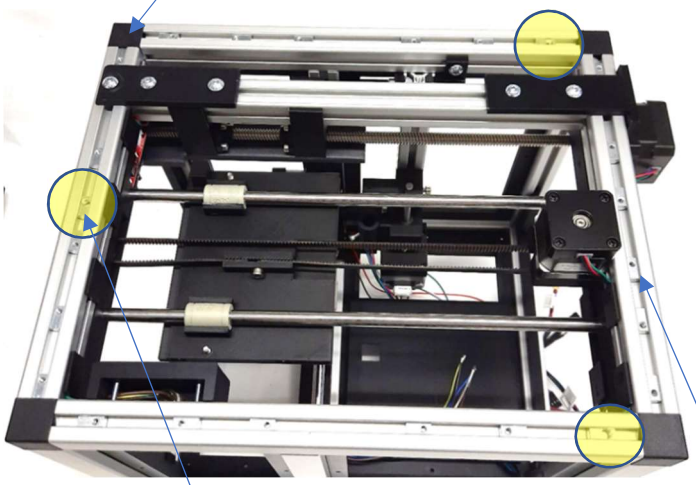
Materials	Qty
Alupanel aluminum brushed 3 mm, bottom	1
Screw M3x8, DIN 912	21
Screw M5x20, DIN 912	3
Sliding block M3 with web I-type groove 5	21
Sliding block M5 with web I-type groove 5	3
Cover square edge angle connector	4
3D-printed foot_inside	3
3D-printed foot_outside	3
3D-printed cover_y_motor	1
3D-printed cover_autosampler_mounting_profile	1
3D-printed cover_autosampler_z1_motor_holder	1
3D-printed waste_bottle_holder	1
3M 9088 double-sided tape, 6 mm	30 cm



- Turn the instrument top down.

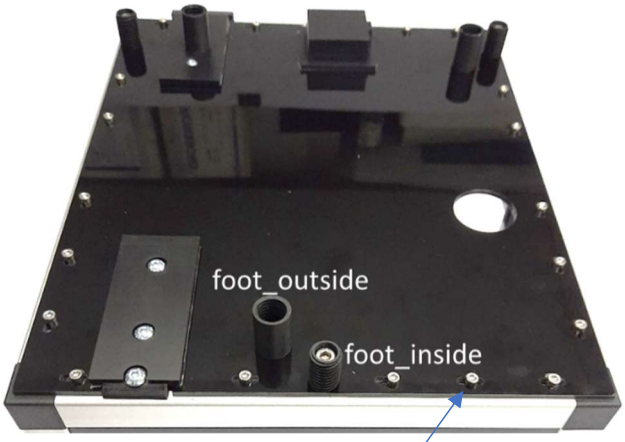
- In the edge angle connectors of the x/y-rectangle for the base, clean the holes for the cover squares from metal production residues (thin platelets).

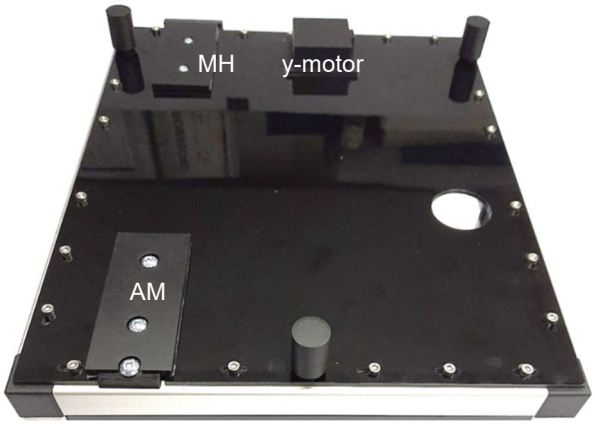
- Press the cover squares onto all four edges and hit its corners with the handle of a screwdriver to fix the covers.



- Insert three M5 (circled; at the specified positions) and 21 M3 sliding nuts into the aluminum profiles at the bottom, checking the approximate position according to the bottom plate.

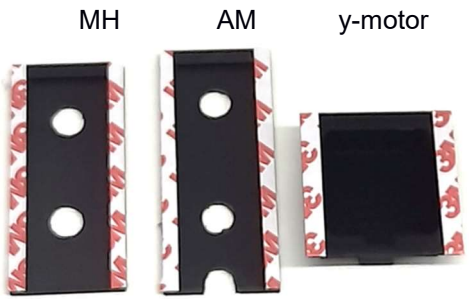
- Mount the three foot_inside with three M5x20 screws (do not tighten the screws firmly at first to leave some play).





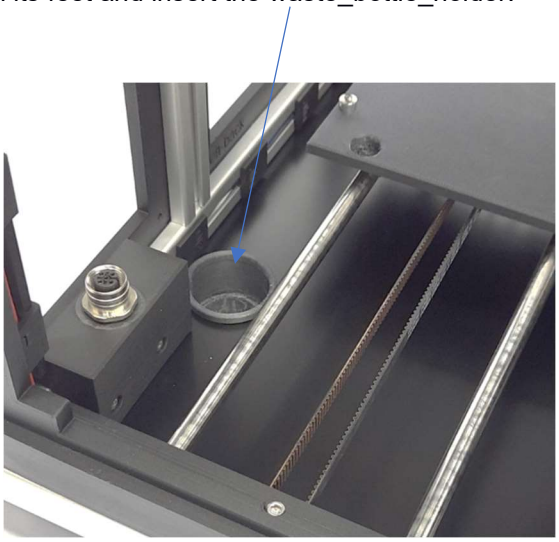
- Mount the bottom plate with 21 M3x8 screws (do not tighten the screws firmly at first to leave some play).

- Finally, tighten all screws and screw the feet_outside onto the feet_inside. The rotatable feet are used to align the instrument horizontally in the x-direction and with a tilt to the rear.



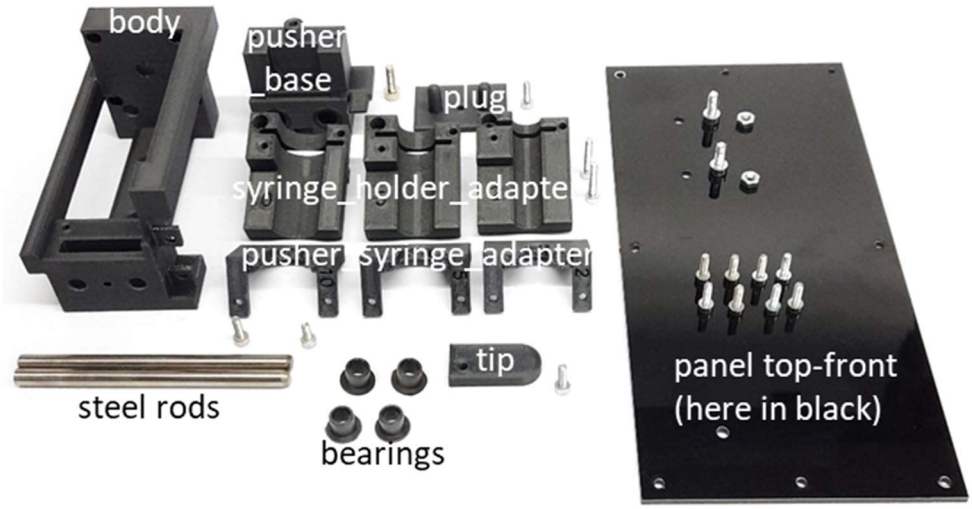
- Stick double-sided adhesive tapes onto the three covers and cut the tapes to size.
- Remove the protection films and press (as on the previous page) the covers over the y-motor, the autosampler motor holder (MH), and the autosampler mounting (AM).

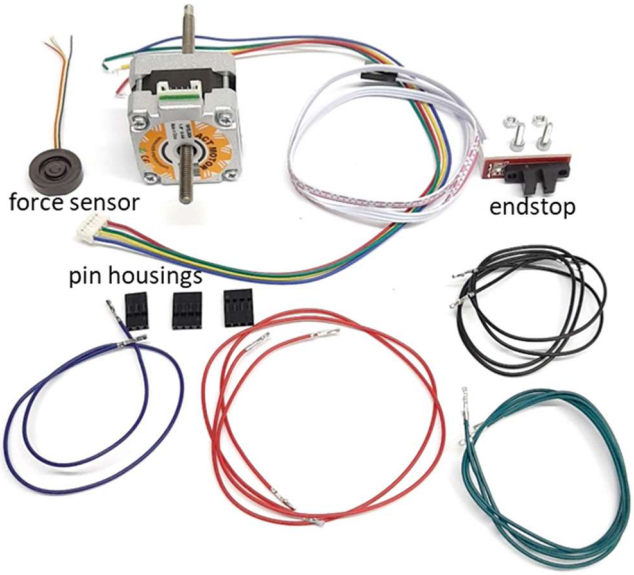
- Place the instrument on its feet and insert the waste_bottle_holder.



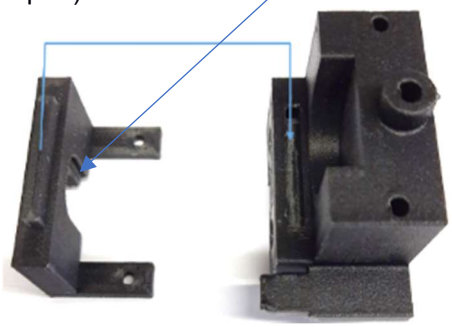
Syringe pump

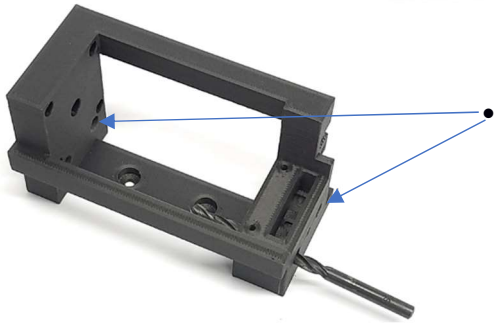
Materials	Qty
ACT 16HSL3404 Linear stepper motor	1
Optical endstop	1
Screw M3x8, DIN 912	8
Screw M3x10, DIN 912	9
Screw M3x16, DIN 912	2
Screw M4x14, DIN 912	1
Screw M4x10, DIN 7380	2
M3 nut	2
M4 nut	2
Steel rod, 93 mm, Ø 6 mm	2
Bearing with flange (Form F) GFM-0608-05	4
Force sensor	1
Precrimped jumper wires F-F, 30 cm, blue	1
Precrimped jumper wires F-F, 30 cm, black, green, red	2 each
Crimp connector housing, 4 pins	2
Crimp connector housing, 3 pins	1
3D-printed syringe-pump_body	1
3D-printed syringe-pump_plug_steel_rods	1
3D-printed syringe-pump_syringe_holder_adapter_2mL	1
3D-printed syringe-pump_syringe_holder_adapter_5mL	1
3D-printed syringe-pump_syringe_holder_adapter_10mL	option
3D-printed syringe-pump_pusher_base	1
3D-printed syringe-pump_pusher_syringe_adapter_2mL	1
3D-printed syringe-pump_pusher_syringe_adapter_5mL	1
3D-printed syringe-pump_pusher_syringe_adapter_10mL	option
3D-printed syringe-pump_clip	1
Alupanel aluminum brushed 3 mm, top-front	1





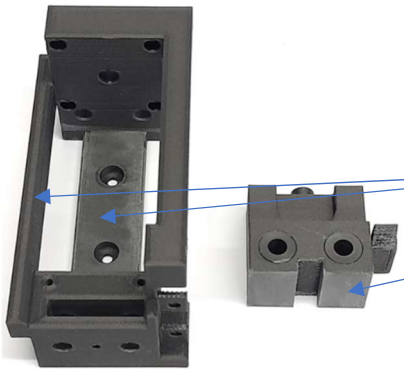
Regarding the 3D-printed parts, if needed, rasp the syringe adapters' connectors slightly with a file until they fit well but tight in the respective syringe adapter base part (exemplarily shown here for the pusher_base and its syringe_adapter).





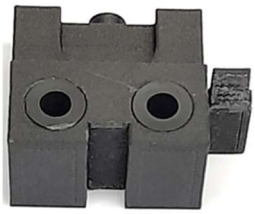
- Cut the holes for the steel rods in the pump_body on both sides round with a 6-mm drill so that the rods can be pushed in.

- Cut both holes for the bearings in the pusher_base round with an 8-mm drill so the bearings can be pushed in.

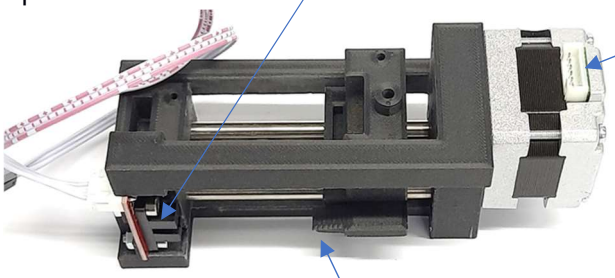


- Also, rasp the rough surfaces of the syringe_pump_body and the bottom of the pusher_base.

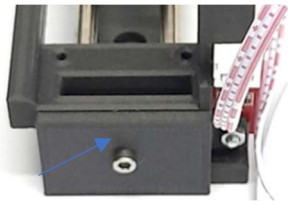
- Insert the bearings into the pusher_base on both sides. Be careful, do not break the tip!

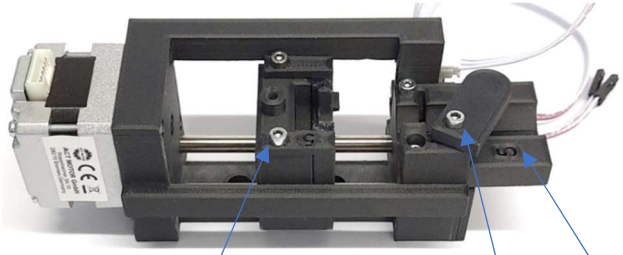


- Mount the optical end-stop with two M3x10 screws and M3 nuts.
- Unscrew the spindle from the motor and mount the motor with four M3x10 screws, the cable plug pointing to the top.



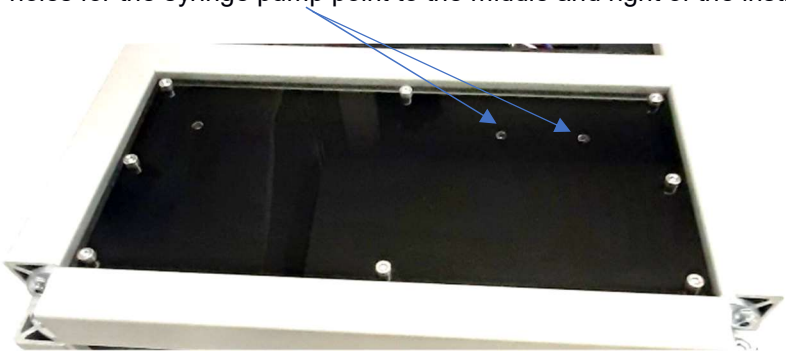
- From the side opposite to the motor, insert the steel rods halfway into the syringe-pump_body.
- Insert the pusher_base into the pump_body, the tip pointing to the endstop, move it over the rods, and push the rods fully in.
- Check if the pusher_base is easily moving.
- Insert the plug_steel_rods opposite the motor and fix it with an M3x10 screw.



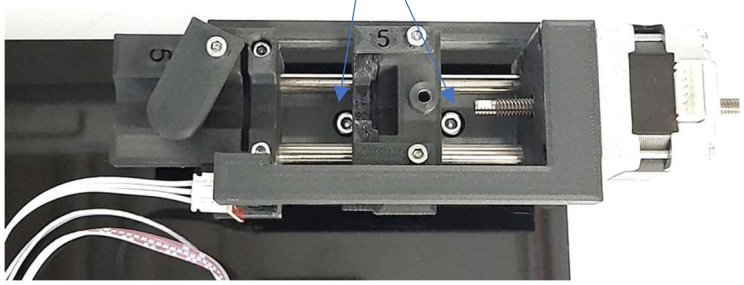


- Mount the pusher_syringe_adapter (two M3x10 screws), the syringe_holder_adapter (here shown for the 5-mL syringe; two M3x16 screws), and the tip (M3x10 screw, let it be rotatable).

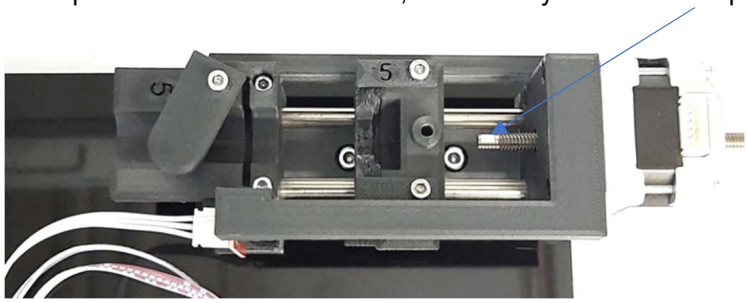
- Place the casing onto its feet. Mount the panel top-front (here black) with eight M3x8 screws, while the two holes for the syringe pump point to the middle and right of the instrument.



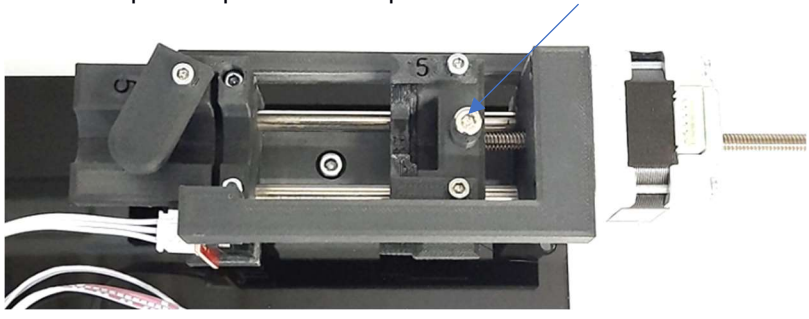
- Mount the syringe pump with two M4x10 screws and M4 nuts (from the bottom) onto the panel. Move the pusher to access the screw holes.



- Screw in the motor spindle for some centimeters, when finally the flattened spindle tip points to the top.



- Push the pusher over the spindle tip and fix the spindle with an M4x14 screw.

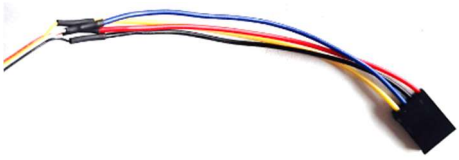


- Cut a blue, black, red, and green precrimped wire to 11 cm (measured including the female pin) and strip 4 mm from the wire ends.
- Solder the wire ends to the wire ends of the force sensor as follows:

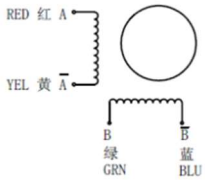
PIN	WIRE COLOR	OUTPUT SIGNAL		
		mV	0.5~4.5V	I²C
4	RED	V+	V+	V+
3	YELLOW	O+	O+	SCL
2	WHITE	O-	N/A	SDA
1	BLACK	V-	COMMON	V-

Cable extensions
Red to red
Yellow to green
White to blue
Black to black

- Insert the female crimp pins into a 4-pin housing with the order of the cable colors: red, black, blue, and green (here yellow instead of green).

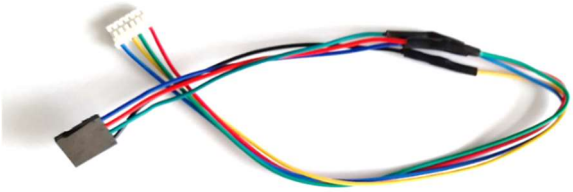


The ACT motor is delivered with a 6-pin plug providing four wires. Coil A is supplied with the red and yellow cables, coil B with the green and blue cables (different from Pololu Nema motors).

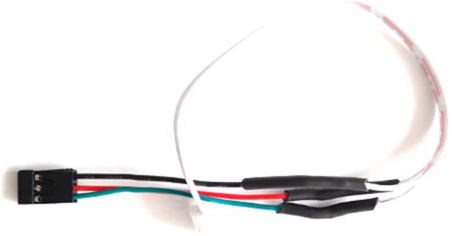


- Cut the motor wires to 21 cm length (measured including the motor plug) and extend them by 11 cm (measured including the female pin) with precrimped wires (left over from the force sensor) with the following cable colour combinations:

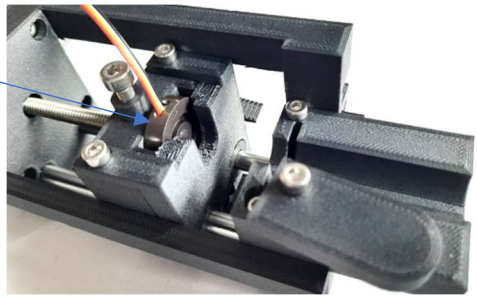
Motor cable color	Color of extending wire
blue	blue
green	red
red	green
yellow	black



- Insert the female crimp pins of the extending wires in the 4-pin housing in the following order: blue, red, green, and black.
- Check the label on the endstop and the labels on the wires.
- Cut the endstop cables to a length of 16 cm (measured including the endstop plug) and strip off 8 mm from the wire ends.
- From precrimped wires (black, red, green) cut 6 cm (measured including the female pin) and strip off 8 mm from the wire ends.
- Connect the extending wires to the endstop wires: red to V(+), green to S(ignal), and black to G(ND).
- Insert the female crimp pins into a 3-pin housing in the following order: green, red, and black.
- Insert the respective plugs onto the motor and the endstop.



- Insert the force sensor into the pusher_syringe_adapter, the flat side points to the motor!
  Handle the force sensor carefully; do not pull on the cable.
  To remove it, unscrew the syringe adapter first.



- Do not plug in or out the force sensor if the instrument is under power (otherwise the sensor will report strange values).

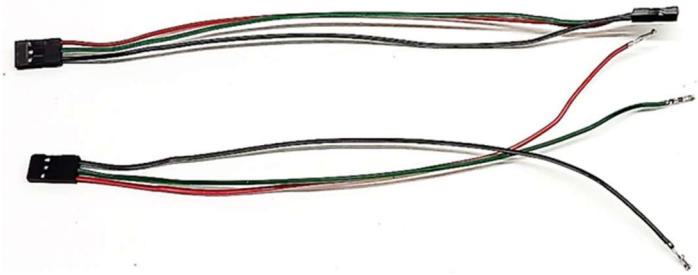
- Put some machine oil onto the spindle and the rods.

Camera cabinet

Materials	Qty
Raspberry Pi HQ camera, wide angle lens, Raspberry Pi HDMI cable 2 m	1 each
Neopixel RGBW stick	2
Connector header through hole 4 position 0.100" (2.54mm), Digikey No. 732-5317-ND	3
UV 265 nm LED board, assembled circuit board	2
UV 365 nm LED board, assembled circuit board	2
Hebo HU02 filter glass, 50 mm x 25 mm, 3 mm thick	2
Screw M3x16, DIN 912	4
Screw M4x14, DIN 912	6
M4 nut	6
Screw M3x8, DIN 912	16
Screw M2.5x10	4
Screw M2x10	4
3D-printed camera_cabinet	1
3D-printed camera_cabinet_top	1
3D-printed camera_cabinet_facing	1
3D-printed UV_filter_protect	2
3D-printed camera_cabinet_holder	1
Pre-crimped jumper wires F-F, 30 cm, green	2
Pre-crimped jumper wires F-F, 30 cm, red	6
Pre-crimped jumper wires F-F, 30 cm, black	6
Crimp connector housing, 3 pins (3-pin housing)	3

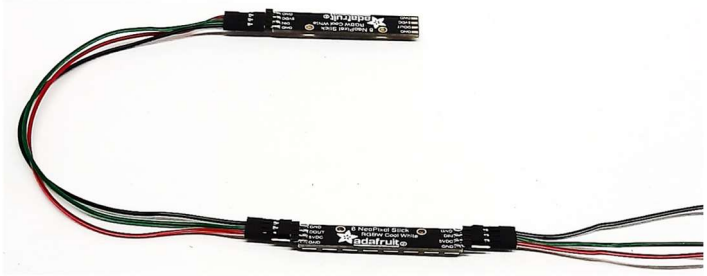
- Solder three 4-position headers onto the Neopixel sticks, one stick with one header on the DIN (data in) side, and the other stick with headers on both sides.

- Insert the female pins of both ends of three precrimped wires (black, green, red) into a 3-pin housing (colour order: black green, red).



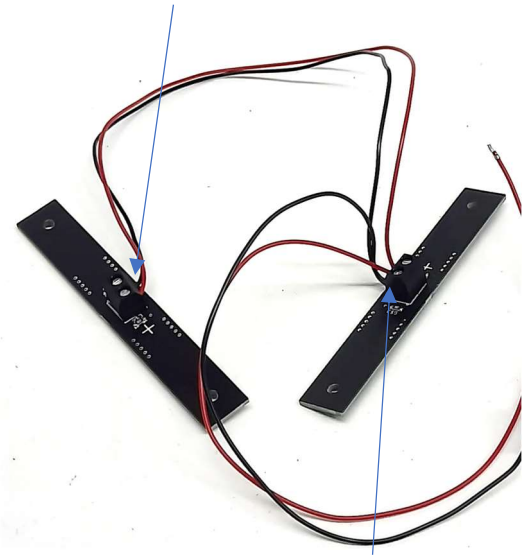
- Insert the female pins of one end of three precrimped wires (black, green red) into a 3-pin housing (colour order: black green, red).

- Connect the pin housings to the Neopixel sticks: black to GND, red to 5VDC, and green to DIN (data in) and DOUT (data out), respectively.



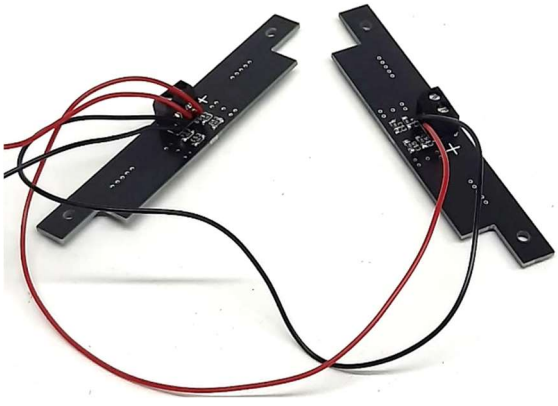
Cut the female pins from the three free wire ends (Adjusting the cables' length

- Cut all female pins completely from three precrimped wires (black and red) and strip 6 mm on both ends.
- Mount one black and red wire to one of the UV 265 nm boards, and the red wire to the plus (+) label.

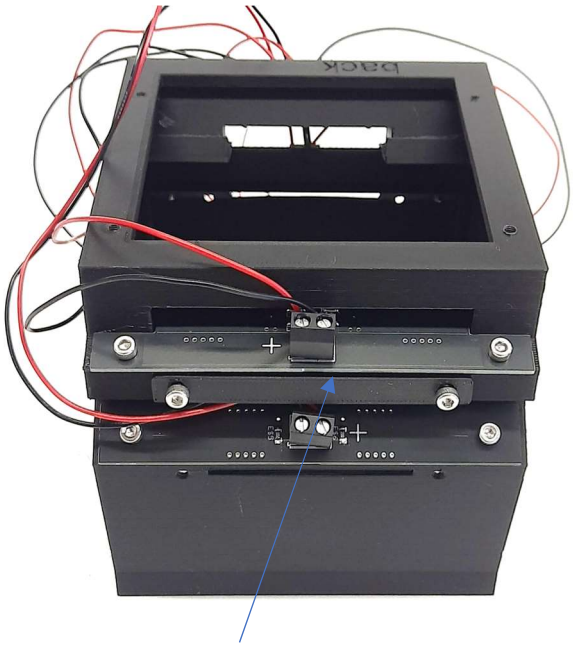


- Mount the other end of the red wire twisted with a second red wire end in the plus (+) label of the second UV 265 nm board. Repeat it analogously with the black wires.

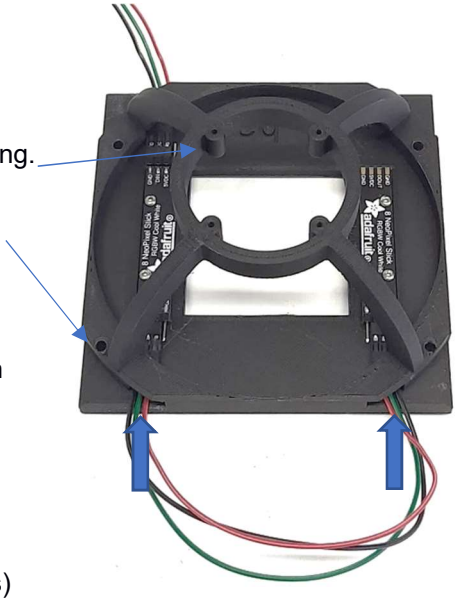
- Perform the same procedure with the two UV 365 nm LED boards.



- Cut M3 threads into all 3-mm holes of the camera_cabinet.
- Mount the LED boards to both sides of the camera_cabinet with eight M3x8 screws: the UV 365 nm boards onto the top slots, the UV 265 nm LED boards onto the bottom slots; the boards with the doubly attached wires are on the back side.



- Insert the Hebo glass filters into the slots under the 365 nm boards and fix them with the 3D-printed UV_filter_protect (two M3x8 screws) on both sides.



- Take the camera_cabinet_top.
- Cut M2.5 threads into the four holes for the camera in the top ring.
- Cut M2.0 threads into the four holes for the Neopixel sticks.
- Take the three free wire ends of the Neopixel stick and direct them from the front left to the back through the cutouts in the camera_cabinet_top. Insert the two Neopixel sticks and fix both with two M2x10 screws each (1.5-mm Allen key).

- Remove the ribbon camera cable: push the black cable clip slightly away from the plug (be careful, as the clip easily breaks) and pull out the white ribbon camera cable (this is not used anymore).
- Unscrew the tripod mount from the Raspberry Pi HQ camera (1.5 mm Allen key, strongly turn left)
- Unscrew the protection cap and the adapter ring from the camera.

- Remove both protection caps from the wide-angle lens and mount it onto the camera.

- Tighten the screw of the lens focus (NEAR-FAR).

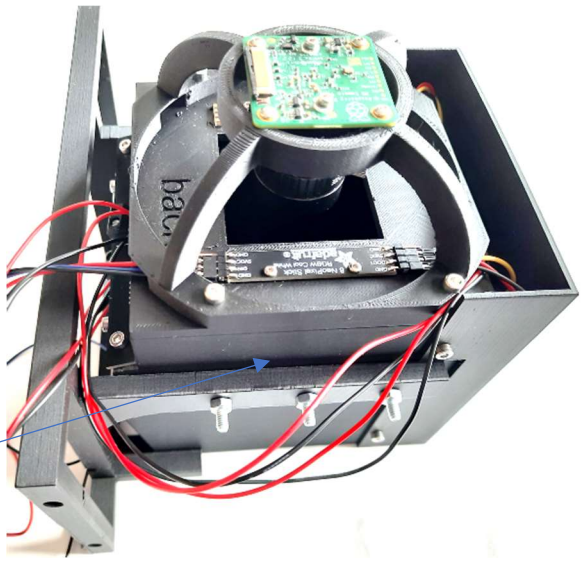
- Open the lens shutter completely and fix it with the screw.
- Loosen the screw of the lens focus and turn the lens completely to FAR.

- Mount the camera with four M2.5x10 screws onto the camera cabinet top (2-mm Allen key), the cable plug pointing to the back.

- Attach the camera_cabinet_holder from the back to the camera cabinet.
- Push six M4x14 screws from inside through the six mounting holes. Do not clamp in cables.
- Fix the six screws with six M4 nuts.

- Mont the camera_top onto the cabinet (back to back) with four M3x16 screws.

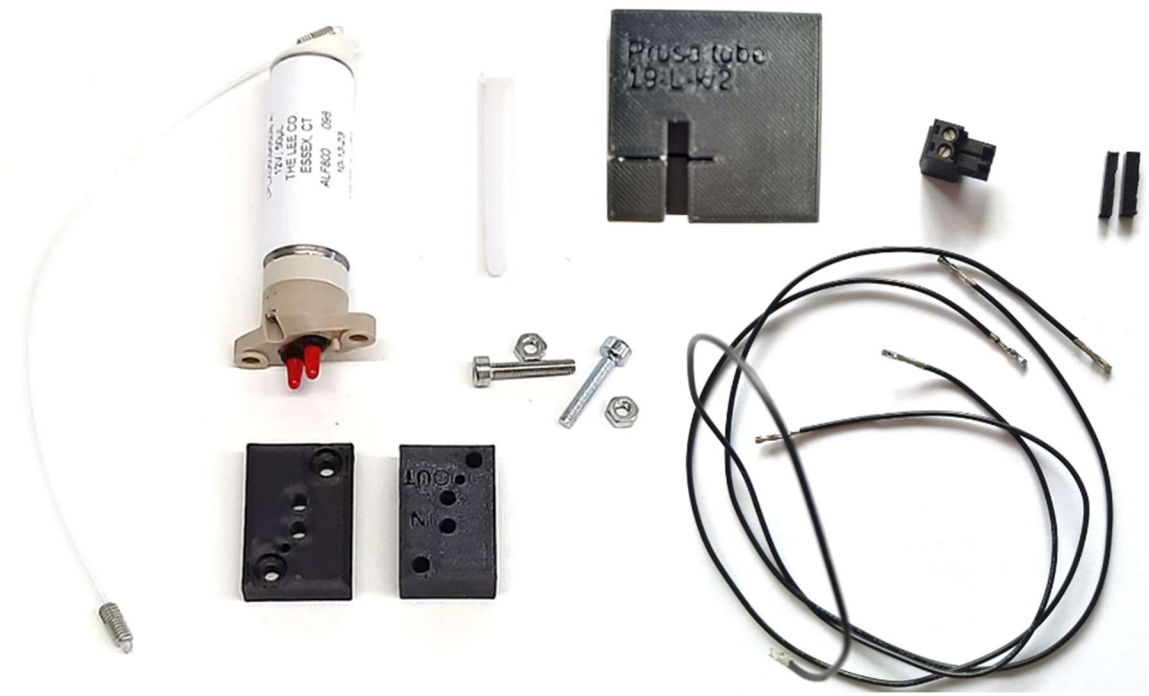
- Turn the cabinet by 90° onto the camera_cabinet_holder and attach the camera_cabinet_facing on top with four M3x8 screws. Do not clamp in cables.
  Do not overtight the screws.
- Push the Neopixel cable bridges into the gap between camera_cabinet and camera_cabinet_facing.



- Set the camera cabinet aside.

Micropump

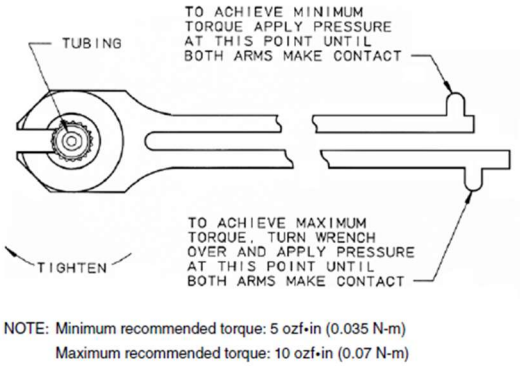
Materials	Qty
Micropump (LPLX0509650B), The Lee Company	1
Screw M3x16, DIN 912	2
Nut M3	2
Pre-crimped wires (30 cm), black	3
1-Pin housing	2
2-Position terminal block[1]	1
Shrink tube, 2 cm	2
PTFE tubing, 2 fittings 062 MINSTAC, ID 0.8 mm, L 15 cm (TUTC3216915L), The Lee Company	1
PTFE tube Prusa	1
3D-printed micropump_manifold	1
3D-printed micropump_manifold_drill-aid	1
3D-printed cutting_aid_Prusa_PTFE_tube	1



[1] If the mainboard is ordered from the Electronics Workshop (Justus Liebig University), the terminal block will be included.

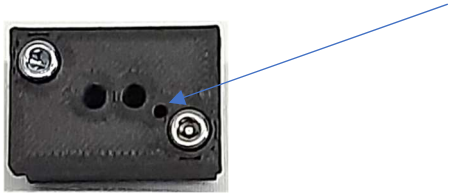
Lee torque wrench

To properly connect the tubings with the Lee MINSTAC fittings, the Lee torque wrench should be used.
The tool must not slip on the tubing fitting; this will damage the tool.



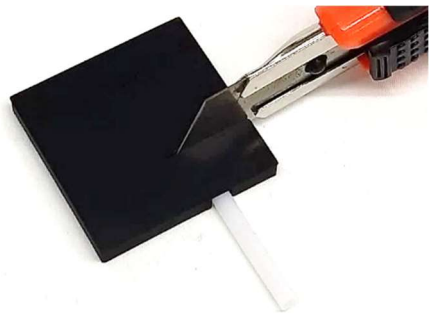
The Lee Company Electro-Fluidic Systems Handbook

- With two M3x16 screws and two M3 nuts, mount the drill aid onto the micropump manifold, obeying the small hole for the registration pin.

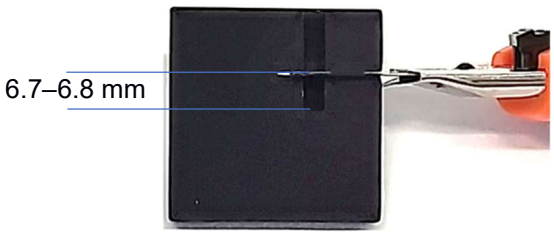


- With the UNF 6x40 handtap (finishing tap) cut the two threads through the drill-aid into the manifold.

- Unmount the manifold_drill-aid and clean the manifold carefully from dust.

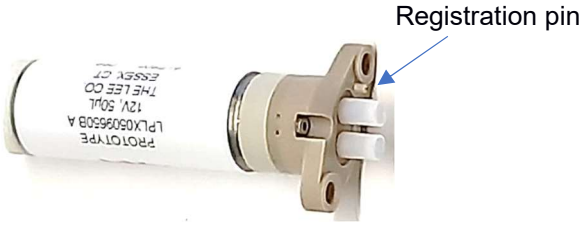


- Insert the PTFE tube in the 3D-printed cutting_aid_Prusa_PTFE-tube. First, cut a test tube from the PTFE tube with a sharp knife. Check if the test tube length is 6.7–6.8 mm. Otherwise, check if the cutting-aid was printed well and measure the distance between the cutout and the knife.



- If the length of the test tube is okay, cut two PTFE tubes from the formerly cut end.

- Remove the protection caps and the O-rings from the ports of the micropump and press the two PTFE tubes over the pump ports.



- Attach the micropump_manifold onto the pump with the registration pin inserted into the respective hole of the micropump_manifold.

- Mount it with the two M3x16 screws and M3 nuts used before.

- Screw the fitting of the 15-cm PTFE tubing into the OUT port, using the Lee torque wrench (min. torque).

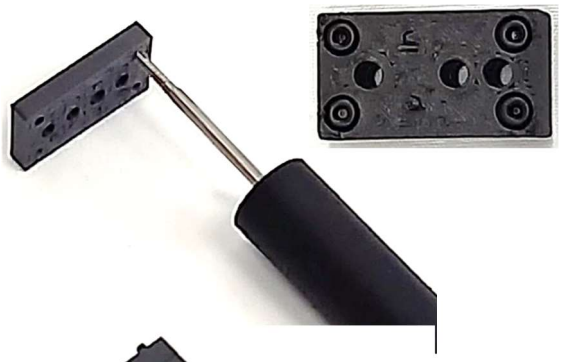
- Cut one pre-crimped wire (black) in the middle and strip 8 mm from the wire ends.
- From another two pre-crimped wires (black) cut both crimp pins completely, strip 8 mm from the wire ends, connect them with prepared 15-cm wires, and fix the connection with shrink tubes.
- Insert the female pins into two 1-pin housings and attach them to the contact pins of the micropump.
- Attach the other stripped wire ends to the 2-position terminal block.

3-Way valve

Materials	Qty
3-Way valve (LFRA1252370D), The Lee Company	1
Safety Screen - 062 MINSTAC, 12 µm, PEEK (INMX0350000A), The Lee Company	1
Screw M2x10, DIN 912	4
Screw M2.5x25, DIN 912	2
Pre-crimped wires (30 cm), blue	2
Pre-crimped wires (30 cm), green	2
1-Pin housing	4
2-Position terminal block[2]	2
PTFE tubing, 2 fittings 062 MINSTAC, ID 0.8 mm, L 15 cm (TUTC3216915L), The Lee Company	2
PTFE tubing, 2 fittings 062 MINSTAC, ID 0.8 mm, L 20 cm (TUTC3216915L), The Lee Company	1
062 MINSTAC nozzle, orifice ID 0.005" (0.13 mm), The Lee Company	1
VHS Series solenoid valve, dispensing valve (INKX0514100A), The Lee Company	1
3D-printed 3way-valve_manifold	1
3D-printed 3way-valve_manifold_drill-aid	1
3D-printed 3way-valve_holder	1

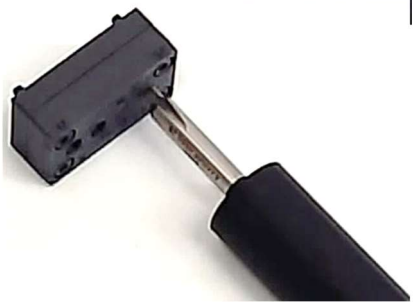
[2] If the mainboard is ordered from the Electronics Workshop (Justus Liebig University Giessen), the terminal block will be included.

- With the M2.0 hand tap, cut threads into the four holes in the corners of the 3way-valve_manifold.



- Mount the 3way-valve_manifold_drill-aid with four M2x10 screws onto the 3way-valve_manifold, while paying attention to the holes labeled pin, pointing in the same direction.

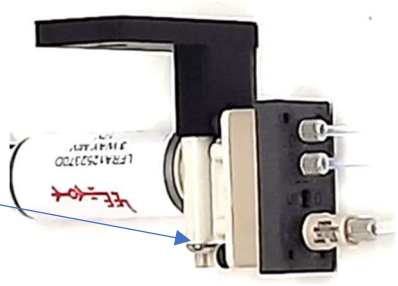
- With the UNF 6x40 hand tap (finishing tap) cut the threads into the three holes through the drill-aid into the manifold.
- Unmount the drill-aid and clean the manifold carefully from dust.



- Attach the 3way-valve_manifold onto the 3-way valve with the registration pin inserted into the respective hole of the 3-way valve. Mount the manifold onto the 3-way valve with the formerly used M2x10 screws.

- Screw in the safety screen finger-tight to the no (normally open) port of the 3-way valve manifold.
- Attach the PTFE tubing coming from the micropump OUT port to the safety screen, using the Lee torque wrench (min. torque).
- Screw the 15-cm PTFE tubing into the co (common) port (dispensing valve), using the Lee torque wrench (min. torque).

- Screw the 20-cm PTFE tubing into the nc (normally closed) port (syringe pump), using the Lee torque wrench (min. torque).
- Cut M2.5 threads into the two holes of the 3way-valve-holder and mount the valve onto the holder with two M2.5x25 screws.



- Insert two pre-crimped wires (30 cm, blue) into two 1-pin housings and attach them to the contact pins of the 3-way valve.
- From the other ends of the wires, cut the female pins and attach the wires to a 2-position terminal block.

- Attach the PTFE tubing coming from the co port of the 3way valve to the top port (near the contact pins) of the VHS valve (dispensing valve), using the Lee torque wrench (min. torque).
- Attach a nozzle to the lower port of the VHS valve (dispensing valve), using the Lee torque wrench (min. torque).

- Insert two pre-crimped wires (30 cm, green) into two 1-pin housings and attach them to the contact pins of the dispensing valve.
- From the other ends of the wires, cut the female pins and attach the wires to a 2-position terminal block.

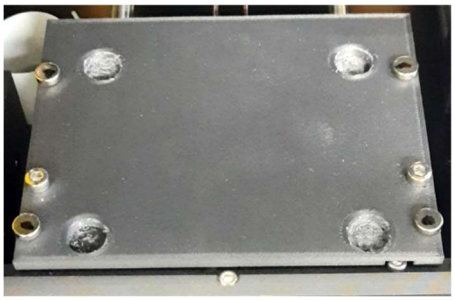
Here, the 3way-valve_holder was not mounted.

- Place the microfluidic system aside.

Plate holder simple

Materials	Qty
Round magnets, OD 8 mm x 3 mm	4
Cubic magnets, 5 mm	4
Glass plate 118 x 118 x 1 mm	
3D-printed plate-holder_simple_front	1
3D-printed plate-holder_simple_back	4

- Place the four round magnets onto the y_cart, so they are attracted by the round magnets of the y_cart.
- Mark the top side of the magnets with a spot.



- Take one after the other magnets and insert them in the right order in parallel into the slits on both sides of the plate holder, the mark pointing upwards.

- Place the plate holder upwards on the desk and press it down to fully push in the magnets.
- Redo the procedure with the other side.

- Insert a sandwich of the cubic magnets in both cubic cutouts on the back side of the plate holder.

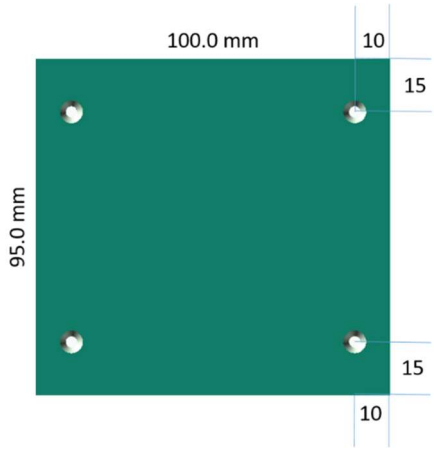
- Then push the plate_holder_back onto the protruding magnets.
- Turn the plate-holder top down and fix all magnets with a small drop of superglue

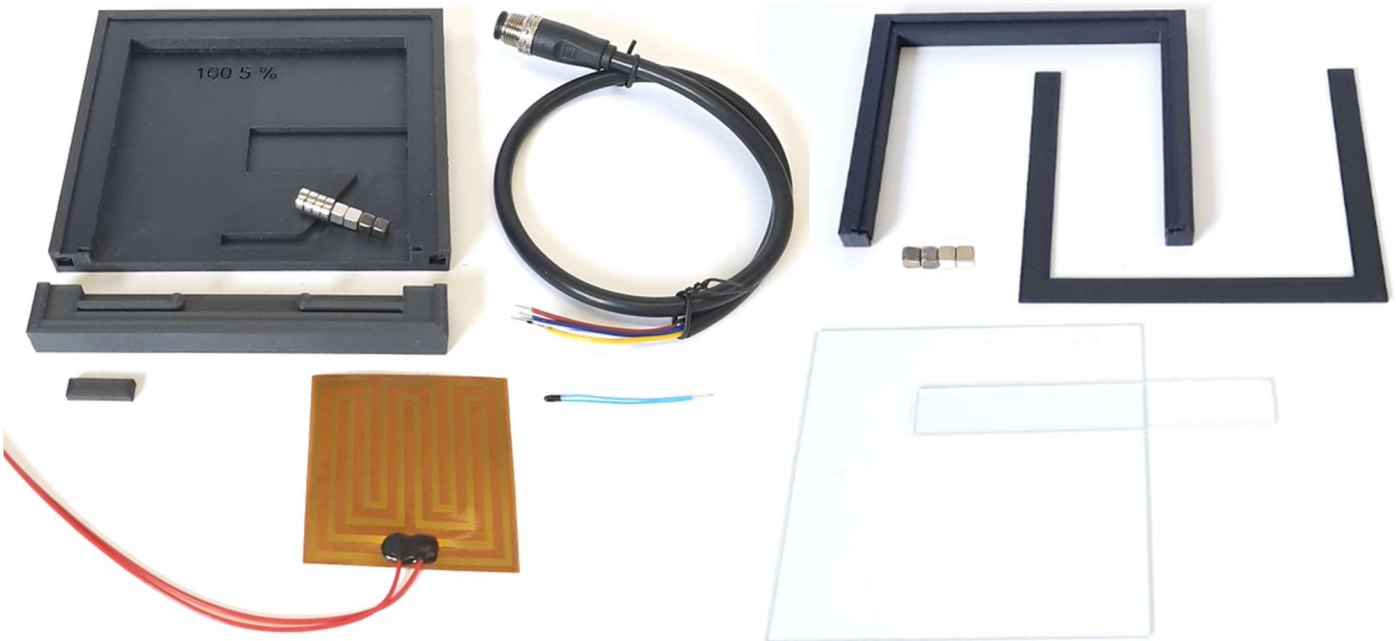
The listed glass plate is a cover for the plate holder to keep moist an HPTLC plate sprayed with bioluminescent *A. fischeri* bacteria during the capture of images with long exposure times.

Multifunctional plate holder

Materials	Qty
Round magnets OD 8 mm x 3 mm	4
Aluminum plate, 95 x 99 x 2 mm[3]	1
Polyamide thermal foil, 12V, 48 W	1
Cubic magnets 5 mm	4
Cable male to wire lead 5P 1.64' (500 mm), Digikey No. 839-10-04495-ND	1
Thermistor 100 kOhm	1
Heat shrink tubing 2 mm ID, shrinkage ratio 2 to 1, 1 cm	4
Glass plate 106 x 100 x 1 mm (top cover_development)	1
Glass plate strip 110 x 16 x 1 mm (front cover_development)	1
Screw M3x10, DIN 7991	4
M3 nut	4
Double-sided tape (6 mm), 30 cm	1
3D-printed multifunctional_plate_holder-front	1
3D-printed multifunctional_plate_holder-back	1
3D-printed cutout_plug	1
3D-printed multifunctional_plate_holder-cover_development	1
3D-printed multifunctional_plate_holder-cover_development_glass-plate_cover	1

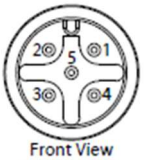
[3] A STEP file (alu-plate_plate-holder.step) is available at https://github.com/OfficeChromatography/2LabsToGo-Hardware/3D_parts/aluminum-plates.





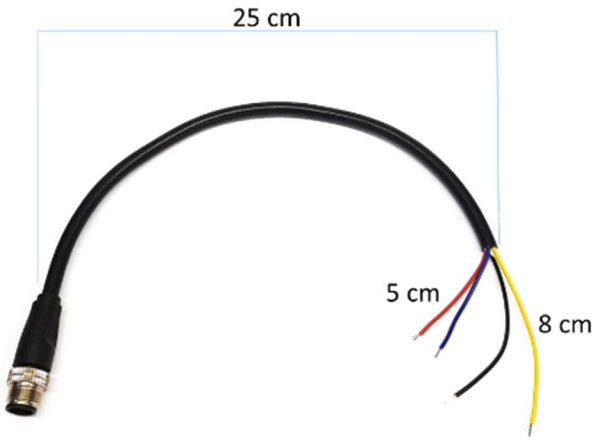
Wiring (with reference to the power_jacket_housing)

5-pin plug explanation:
The center pin 5 (blue wire) will receive 12 V+ from the electronic board.
The pin 1 (red wire) will be connected to the ground signal pin for plate heating.
Pins 2 (yellow wire) and 3 (black wire) will be connected to the bed thermistor input of the electronic board.
Pin 4 (white wire) is not needed here.

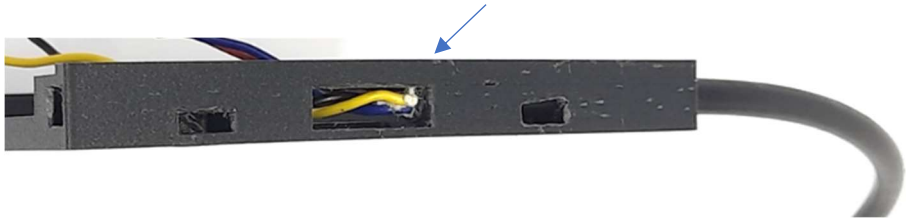


Wiring Diagram	
50-00960	wire color
1	red
2	yellow
3	black
4	white
5	blue

- Cut the 5-pin plug cable to a length of 33 cm.
- Remove 8 cm of the cable insulation.
- Cut the white wire completely (not needed).
- Cut the red and blue wire to a length of 5 cm.
- Strip 5 mm of insulation from all four wire ends.

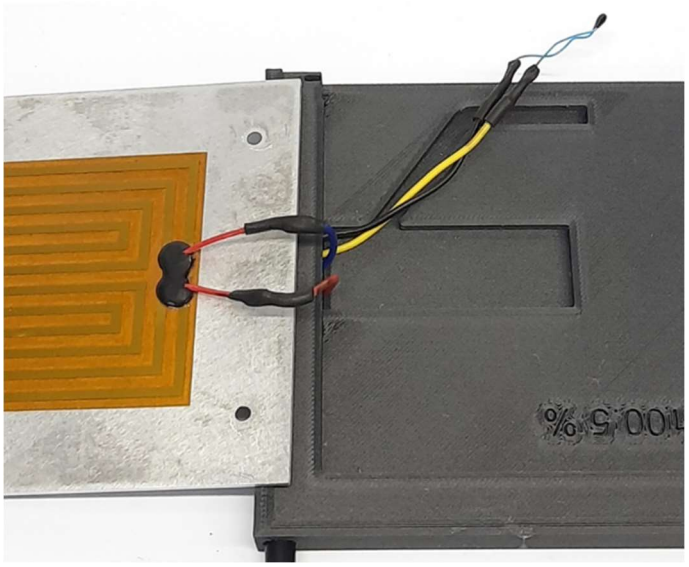


- Insert the wires through the hole in the front of the plate holder and push it in until the free wires are fully inside the plate holder (guide them with a small tool from outside through the cutout on the left side), whereafter the plug cable insulation is visible at the round cutout.



- Slide over 10-mm long heat-shrink tubes over the yellow and black wires, away from the bare ends.
- Solder the bare ends of the yellow and black wire to the thermistor wires.
- Slide the heat-shrink tubes over the connections and heat them for shrinking.

- Remove the protective film from the heating mat and stick it in the middle of the aluminum plate back side (without the countersinks) so that the cables are facing the shorter side (95 mm) of the aluminum plate.

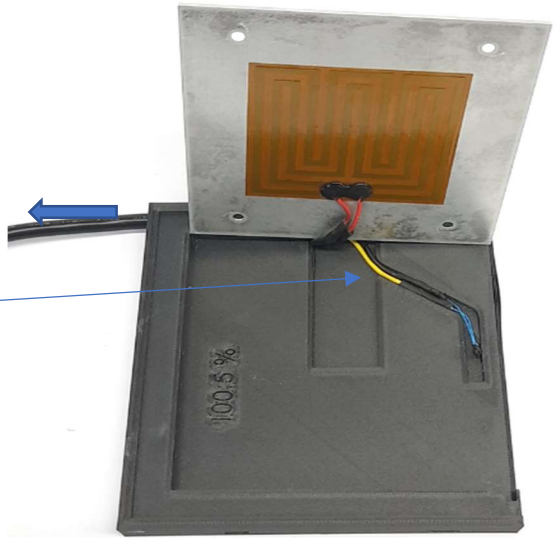


- Cut the heating mat wires to a length of 5 cm (from the edge of the heating mat) and strip 5 mm of the wire ends.
- Slide over 10-mm long heat-shrink tubes over the red and blue wires, away from the bare ends.
- Solder the heating mat wire ends to the bare ends of the white and blue plug wire, slide the shrink tube over the connections, and heat the tubes for shrinking.

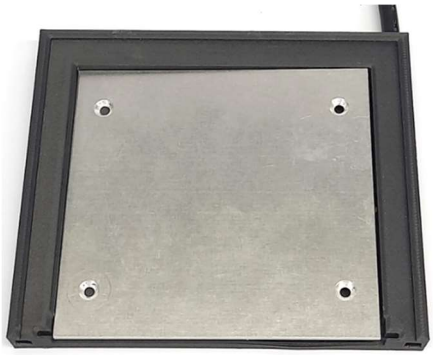
- Place the aluminum plate upright.

- Slowly and carefully pull the plug cable out of the plateholder, while guiding the wires with a small screwdriver into the cylindric cutout for the plug cable. The insulation of the plug cable should still be 5–10 mm inside the hole of the plate holder.

- Guide the thermistor into the slit guidance inside the plateholder.



- Place the aluminum plate onto the plate holder and align it with the back side (open side).
- With a 3-mm drill, drill holes through the aluminum plate holes into the plate holder.
- Mount the aluminum plate with four M3x10 screws (DIN 7991) and M3 nuts.
- Cover the cutout on the left side of the plate holder with the cutout_plug.

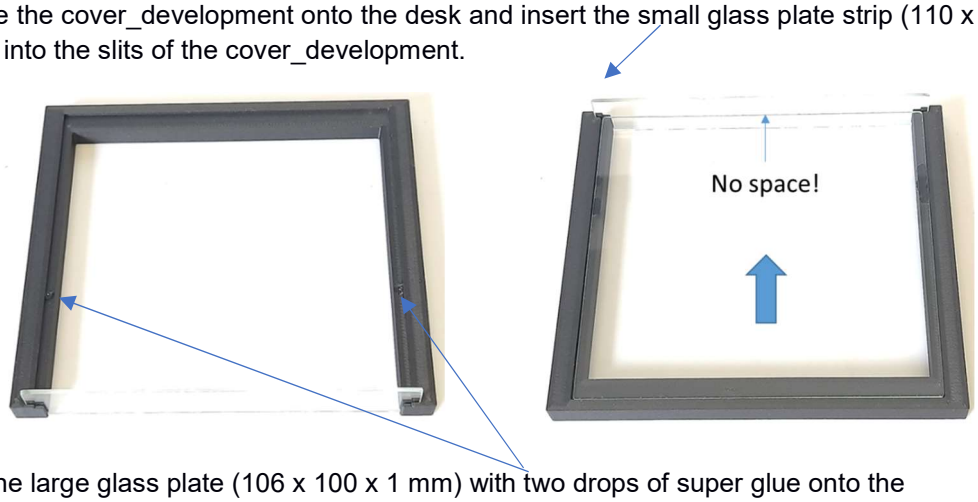


- Insert the round and cubic magnets as described for the plate-holder_simple. However, push the wires in the left front cutout upwards with a small screwdriver before inserting the round magnet.

- Place the plate holder onto the y-cart and insert the cable plug into the receptacle of the DC_power_jacket_housing.
- Rotate the cable slightly in the plate holder cutout so that there is no torsion.
- Take out the plate holder and fix the cable with a drop of glue (slit in the bottom).

Cover for development

- Place the cover_development onto the desk and insert the small glass plate strip (110 x 16 x 1 mm) into the slits of the cover_development.



- Fix the large glass plate (106 x 100 x 1 mm) with two drops of super glue onto the cover_development, while aligning the glass plate with the small glass plate strip in the slits. There should be no space in between. Wait for glue hardening.

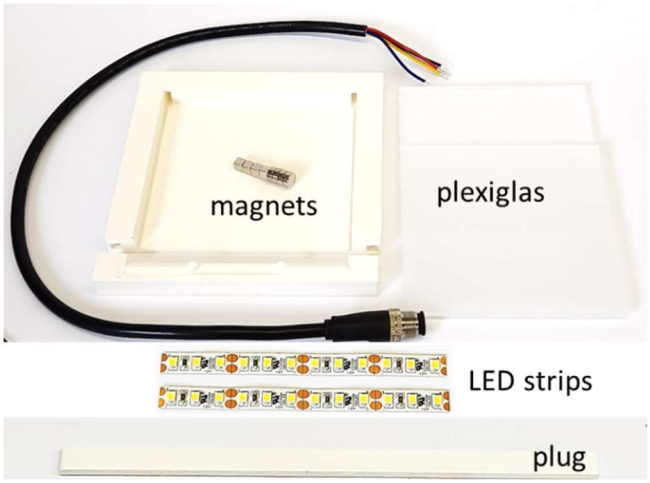
- Stick the double-sided tape onto the bottom of the glass_plate_cover.
- Remove the protective film and stick the glass_plate_cover onto the cover_development with the glued glass plate.

- Check the polarity of the round magnets: place the four cubic magnets onto the plate holder, so that they are attracted by the round magnets of the plate holder.
- Mark the magnet top with a spot.

- Insert the cubic magnets in the right order into the cubic cutouts at the bottom of the cover_development, the black mark pointing inside/downward.
  This way, the cover_development is tightly fixed onto the plate holder.

Backlight plateholder

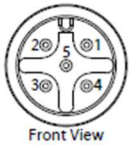
Materials	Qty
Round magnets Ø 8 mm x 3 mm	4
Cubic magnets 5 mm	4
Cable male to wire lead 5P 1.64' (500 mm), Digikey No. 839-10-04495-ND	1
LED strip, cool white, Digikey No. 1647-12V-MB-CW-12MCT-ND, 4 cuts, 10 cm	2
Wire AWG 24, red, 20 cm	1
Wire AWG 24, black, 20 cm	1
Heat-shrink tubes, 1 cm	2
Plexiglas Satinice CLEAR 0D010 DF, 97 mm x 97 mm x 3 mm	1
Plexiglas LED CLEAR 0E010 SM for edge lighting, 97 mm x 97 mm x 4 mm	1
3D-printed plate-holder_backlight_front	1
3D-printed plate-holder_backlight_back	1
3D-printed plate-holder_backlight_plug	1



- Remove the black outer insulation of the *cable male to wire lead* at a distance of 25 cm from the plug (measured from the homogenous cable start, as seen in the next photo).

Concerning the wire colors consult the data sheet of the *cable male to wire lead*. The pin assignment also refers to the 5-pin receptacle in the DC_power_jacket_housing.

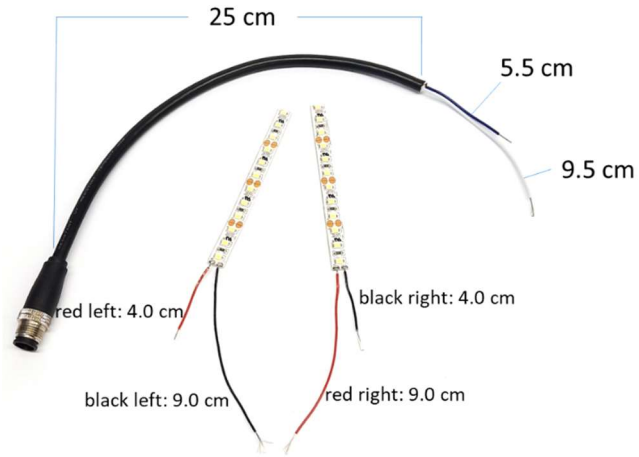
Pin 1, brown: Heating GND
Pin 2, white: Thermistor
Pin 3, blue: Thermistor
Pin 4, white: LED strip GND
Pin 5, blue: LED strip 12 V+



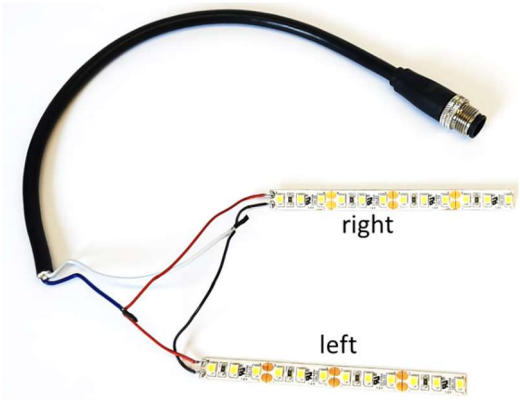
Front View
Not to Scale

Wiring Diagram	
50-00960	wire color
1	red
2	yellow
3	black
4	white
5	blue

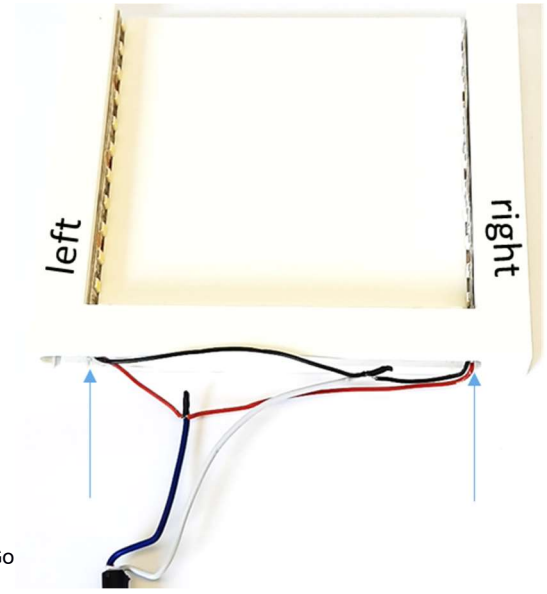
- Cut the red, yellow, and black wires completely at the outer insulation.
- Cut the blue wire to a length of 5.5 cm and the white wire to a length of 9.5 cm.



- Strip 10 mm from both wire ends.
- From the black and red wires, cut one wire of 4 cm and one wire of 9 cm each. Strip 4 mm on one wire end and 10 mm on the other end.
- Solder the 4-mm bare ends of the 4-cm black (-) and the 9-cm red (+) wire to one LED strip.
- Solder the 4-mm bare ends of the 4-cm red (+) and the 9-cm black (-) wire to the other LED strip.
- Strip 10 mm of all four wire ends.
- Onto the 9-cm wires of the LED strips, push a shrink tube (1 cm).
- Twist both black wire ends and the white wire end of the cable assembly together, fix the connection with a drop of superglue spread over the connection (soldering is an alternative).
- Twist both red wire ends and the blue wire end of the cable assembly together, fix the connection with a drop of superglue spread over the connection (soldering is an alternative).
- Move the shrink tube over the connection and heat it for shrinking.

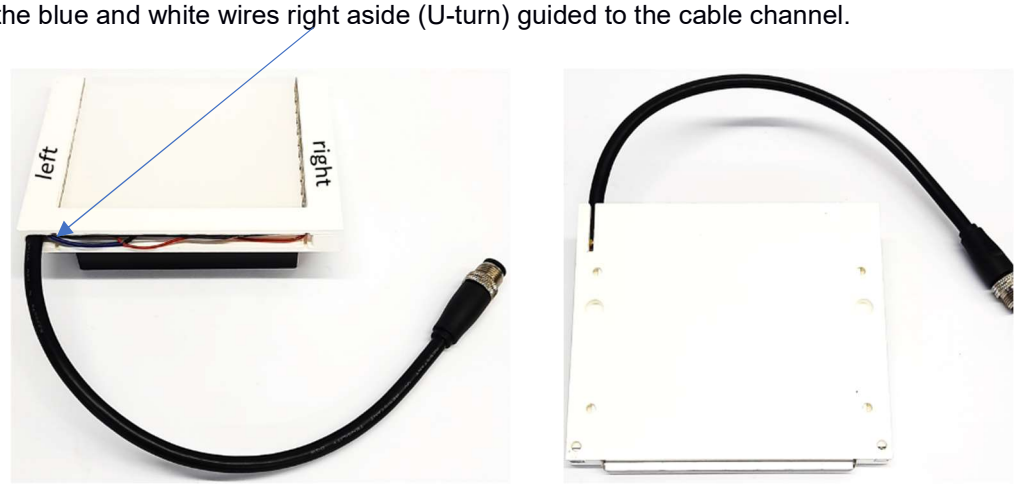


- Insert the LED strips from the cutouts from the front side into the respective slits; the right one is the strip with the shorter black wire.

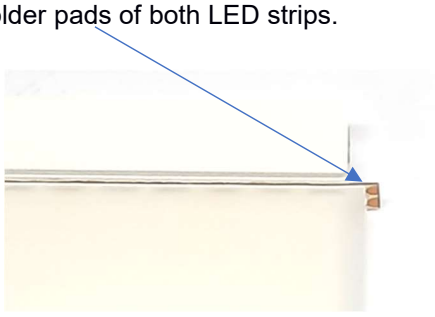


- Insert the Plexiglas for edge lighting between the LED strips. Take care that the LED strips are fully down in the slit and the LEDs are flush with the Plexiglas.
- Following the same procedure, insert the Plexiglas Satinice (diffusor).

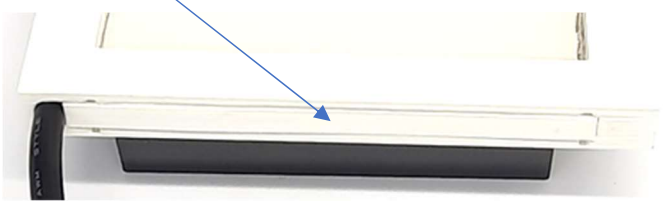
- Push the cable assembly with its outer insulation into the hole on the left side while guiding the blue and white wires right aside (U-turn) guided to the cable channel.



- Center both LED strips along the Plexiglas sandwich; the first and the last LED are near the edges.
- Cut the protruding solder pads of both LED strips.

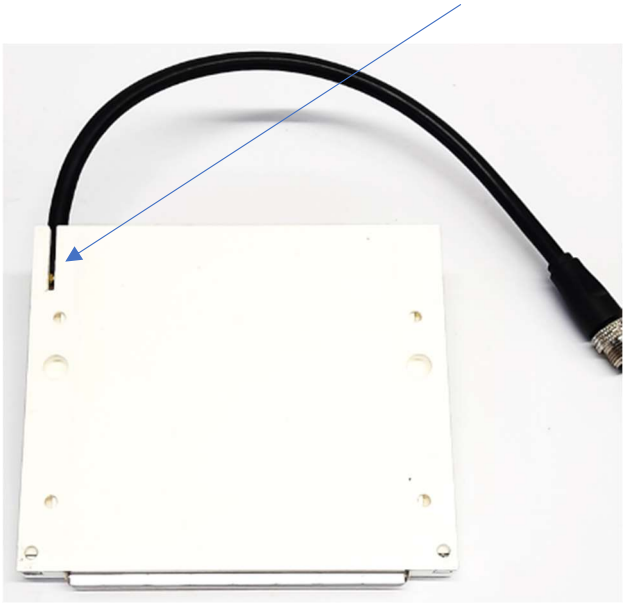


- Press the plate_holder_plug into the cable channel to cover the wires.



- Insert the round and cubic magnets as shown for the plate-holder_simple.

- Place the plate holder onto the y-cart and insert the cable plug into the receptacle of the DC_power_jacket_housing.
- Rotate the cable slightly in the plate holder cutout so that there is no torsion.
- Take out the plate holder and fix the cable with a drop of glue along the bottom slit.



Electronic box

Materials	Qty
Raspberry Pi 4B	1
Heat sinks for the Raspberry Pi, set of 4	1
SD card 64 GB	1
Camera cable (CSI cable), 50 cm	1
Electronic mainboard[4]	1
Status LED board[5]	1
40 Position cable assembly rectangular socket to socket 0.167' (50.80mm, 2.00")[5]	1
14 Position cable assembly rectangular socket to socket 0.312' (95.25mm, 3.75")[5]	1
2-Position terminal block5, Female Sockets, DigiKey No. WM7732-ND	1
5-Position terminal block5, Female Sockets, DigiKey No. WM7735-ND	1
7 Position terminal block5, Female Sockets, DigiKey No. WM7737-ND	1
Motor driver A4988 black edition	5
DHT22 sensor	1
2x3 jumper block5	5
2x4 jumper block5	1
Screw M3x8, DIN 912	2
Screw M4x12, DIN 912	4
Screw M5x8, DIN 7380	3
Nut M3	2
M5 Sliding nut	2
Screw M2.5x10, DIN 912	4
Screw M3x10 nylon	1
Luer-lock adapter (TMRA3201950Z), The Lee Company	1
Safety Screen - 062 MINSTAC, 12 µm, PEEK (INMX0350000A), The Lee Company	1
3D-printed e-axis_micropump_holder	1

[4] Eagle files and partlist are freely available at https//:github.com/OfficeChromatography/2LabsToGo-Electronics. The fully equipped and tested board can also be ordered from the Electronics Workshop by email to thomas.nimmerfroh@exp1.physik.uni-giessen.de, Dept. of Physics, Justus Liebig University Giessen, Heinrich-Buff-Ring 20, 35392 Giessen, Germany.

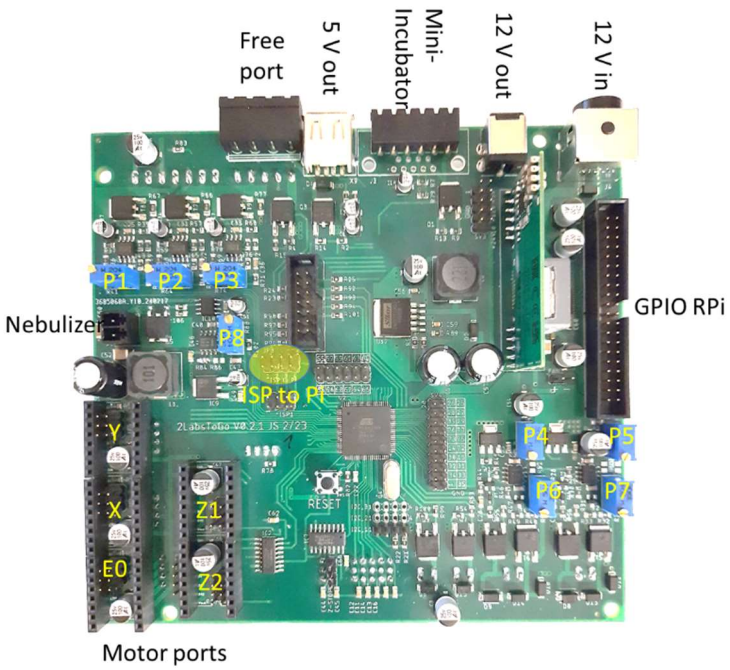
[5] If the mainboard is ordered from the Electronics Workshop (Justus Liebig University), these parts will be included.

3D-printed clip_alu	2
3D-printed electronic_box_washer	4
3D-printed electronic_box	1
3D-printed electronic_box_LED-label_frame (white PLA)	1
Printed LED label (on transparent overhead foil)	1
3D-printed electronic_box_cover	1

Precautions: Avoid touching the electronic parts with bare fingers. Wear gloves!

The mainboard

Top view



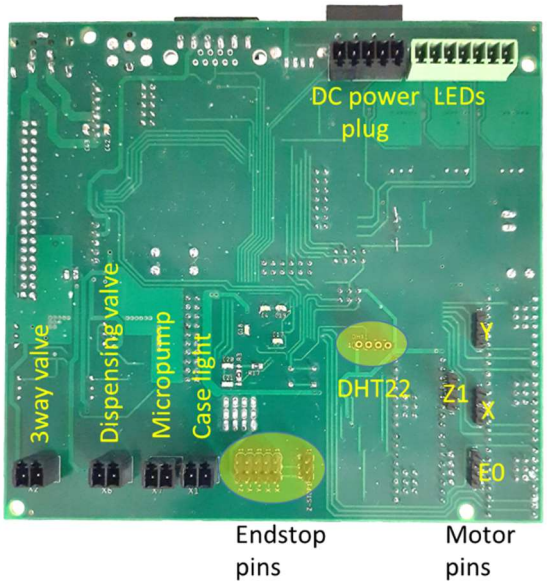
P1, P2, P3: potentiometers for the UV 265 nm, UV 365 nm, and backlight LED.

P8: potentiometer to adjust the frequency of the Nebulizer.

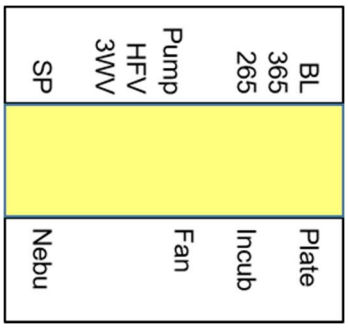
P4, P5: potentiometers to adjust the hold voltage of the VHS dispensing valve and 3-way valve, respectively.

P6, P7: potentiometers to adjust the spike time of the VHS dispensing valve and the 3-way valve, respectively.

Bottom view



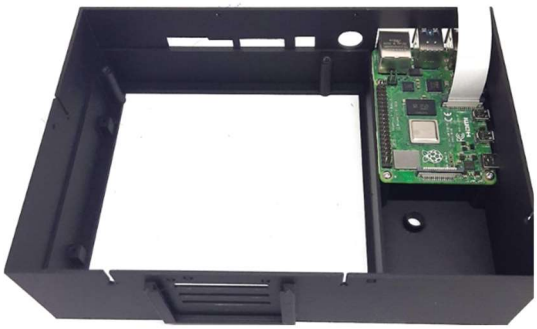
- Print this label image on a transparency film and cut it just outside the black frame.

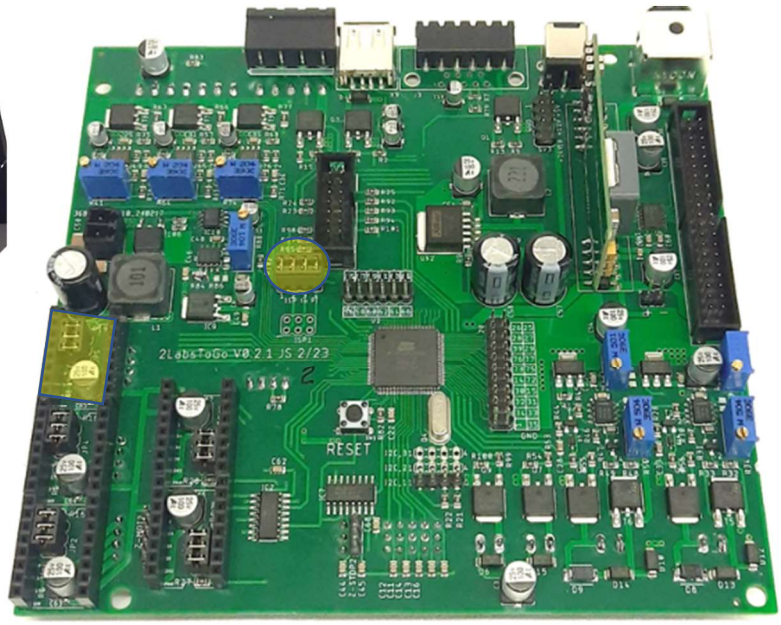


- With the help of hand taps, cut M2.5 threads into the four screw sockets for the Raspberry Pi (on the right side), M4 threads into the four screw sockets for the board, and M3 threads from the bottom of the electronic_box into the mounting holes.

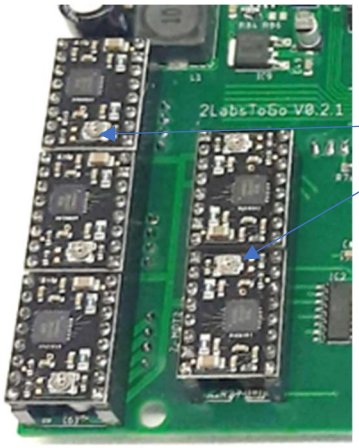
- Connect the 50-cm camera cable to the CSI port of the Raspberry Pi. Push the cable clip slightly upwards away from the board; be careful, the clip breaks easily. Insert the camera cable into the port with the contacts directed to the port contacts. Press down the clip.

- Place the Raspberry Pi into the electronic_box and mount it with four M2.5x10 screws.

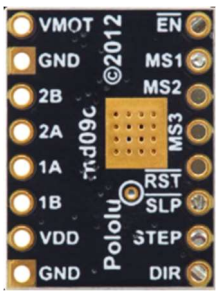




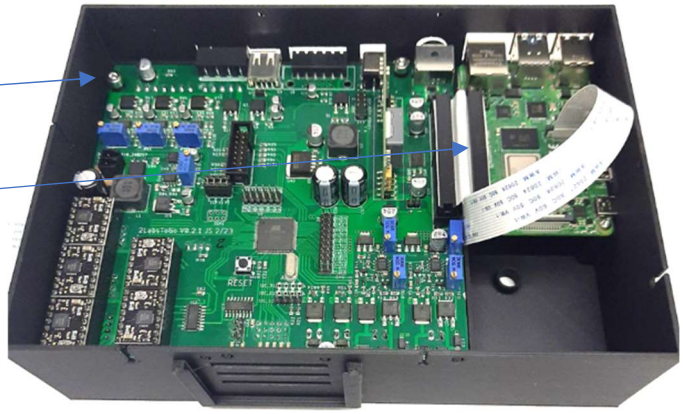
- At the top of the board, plug a 2x4 jumper block onto the *ISP to PI* pins (circled).
- Plug five 2x3 jumper blocks onto the pin rows inside each motor driver receptacle (one is framed).



- Insert the motor drivers into all five ports: E0, X, and Y with the cross-slit screw to the front; Z1 and Z2 with the cross-slit screw backward. Check that the Vmot pin of the motor driver board (look at the backside label) is positioned on the labeled Vmot port of the mainboard.



- Place the electronic mainboard into the electronic_box (guiding the camera cable downwards) and mount it with four M4x12 screws and 3D-printed washers.

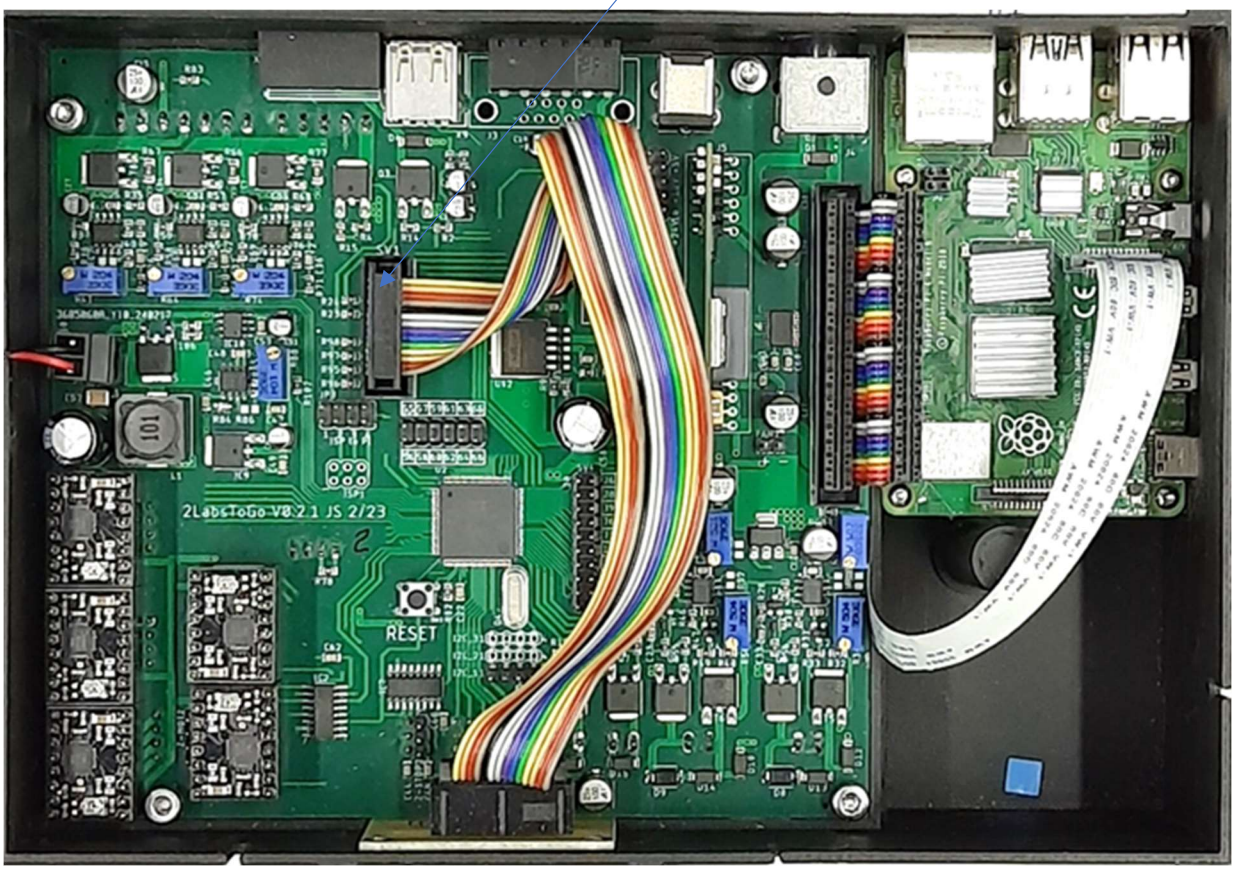


- Plug in one socket of the flat ribbon cable (40-position cable assembly socket to socket) to the 40 GPIO pins of the Raspberry. Fold the ribbon cable in the middle and plug the second socket in the 40 pins of the electronic board aside.

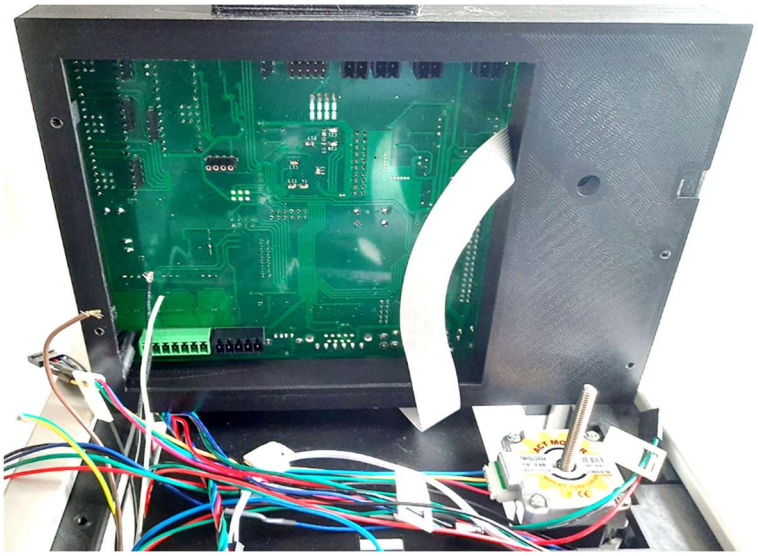
- Connect one socket of the 14-position cable assembly socket to the socket of the status LED board.
- Insert the white electronic_box_LED-label_frame into the slit in the front of the electronic_box.
- Insert the properly cut LED label into the slit of the label_frame.
- Insert the status LED board at the cutout for the LEDs from inside the electronic_box (between the mainboard and electronic_box front wall.

- Align it to the holes of the electronic_box and mount it with two M3x8 screws and M3 nuts.

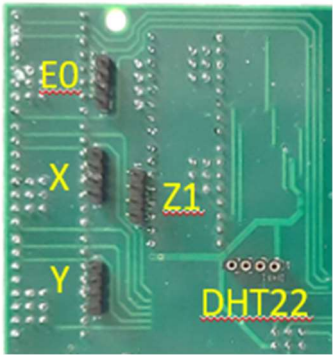
- Insert the other flat ribbon plug into the black slot SV1.



- Place the electronic_box upright on the frame_top_back of the instrument casing so that the underside can be reached.

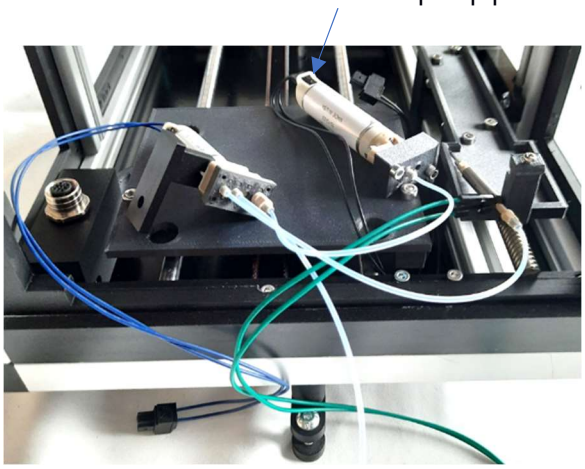


- Plug in the E0 (needle pusher), X (nozzle), Y (plate holder), and Z1 (autosampler) motor cable plugs onto the respective 4-pins (top left), the blue wires generally pointing to the top of the upright box.



- Insert two M5 sliding nuts from the outside into the e-axis aluminum profile and mount the micropump holder with two M5x8 screws. Do not tighten the screws, the holder must still be movable.

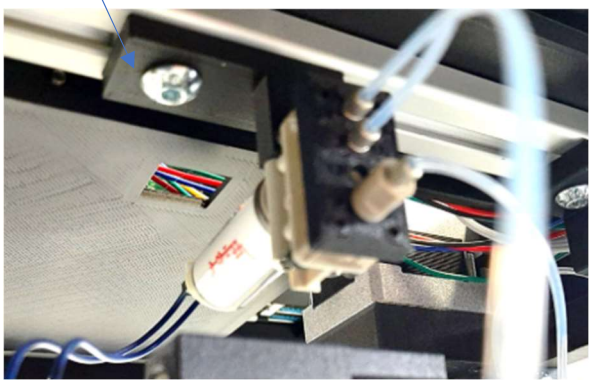
- Place the three fluidic parts onto the y-cart in the front.
- Remove the black wires from the micropump pins.

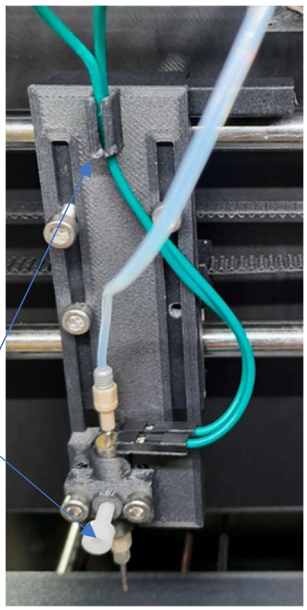


During the following steps, make sure that no tube is kinked.

- Take the micropump, carefully guide it over the x-axis on the right side, and let it hang outside between the e-axis and the middle z-axis.

- Push the y-cart holder backward.
- Mount the 3-way_valve_holder centrally on the middle aluminum profile on the top casing with an M5x8 screw, the tubes pointing to the front and the wires to the back (the respective sliding nut was already placed during mounting the x/y-rectangle for the top).

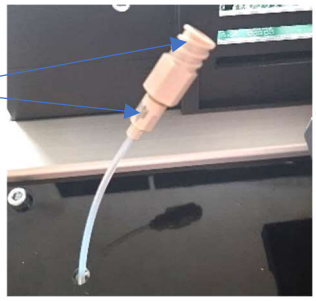




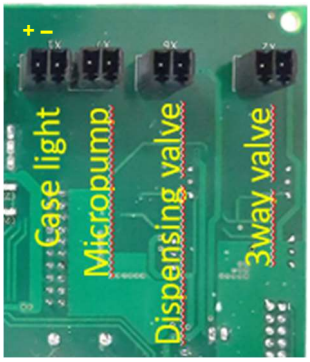
- Insert the dispensing valve into the valve holder of the x-axis with the wire pins pointing to the right and slightly fix it with an M3x10 nylon screw.

- Guide the green wires of the dispensing valve on the right side of the 3-way valve and insert them into the clip positioned on the top part of the x-axis_valve_holder_mount.

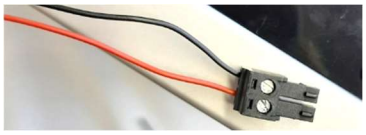
- Guide the 20-cm tube (coming from the 3-way valve) through the hole in the panel top-front to the syringe pump.
- Attach a filter screen to the fitting at the end of the tube, using the Lee torque wrench (min. torque).
- The Luer-lock adapter will be later screwed onto the filter screen (after inserting the needle).

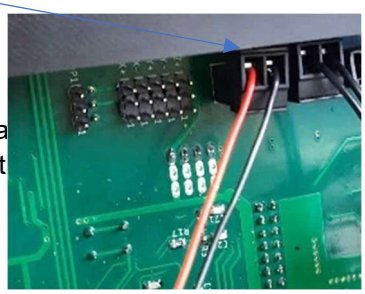


- Connect the black micropump wire plug to the electronic board (top right).
- Guide the wires downwards to the micropump along the e-axis aluminum profile.
- Guide the blue wire plug of the 3-way valve from inside through the cutout of the cable_support and connect the plug to the electronic board.
- Guide the green wire plug of the dispensing valve from inside above the x-axis through the cutout of the cable_support and connect the plug to the electronic board.



- Connect the black (–) and red (+) wires of the LED strip of the case light to a 2-position terminal block as shown in the image. Polarity is important here.
- Plug the 2-position terminal block with the red wire left into the electronic board.



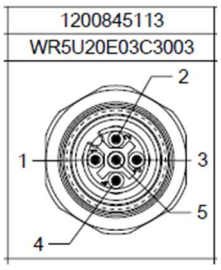


- Guide the camera cable downwards and backwards to the camera camera_cabinet_top. Insert the camera cable into the camera port down and press the clip onto the port.

- Check the orientation of the 5-position plug to be inserted into the black power-jacket_housing mainboard socket (bottom left).
- Strip 5 mm from all five wires coming from the power-jacket_housing.
- Check the datasheet of the 5-pin receptacle (screws upwards) to correctly connect the wires to the board! The pin data here also refer to the multi-functional plateholder and the backlight plateholder.

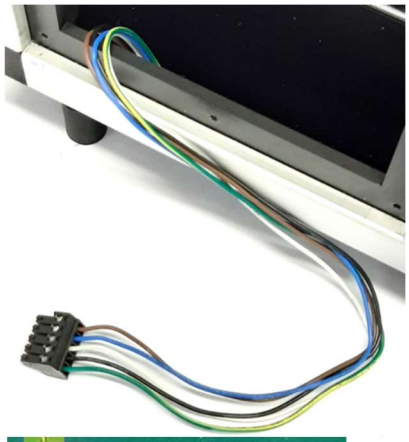
Pin 1, brown: Heating GND
Pin 2, white: Thermistor
Pin 3, blue: Thermistor
Pin 4, black: Backlight LED GND
Pin 5, green-yellow: 12 V+

IEC 60947-5-2	
PIN	COLOR
1	BROWN/braun
2	WHITE/Weiß
3	BLUE/blau
4	BLACK/schwarz
5	GRAY OR GREEN-YELLOW/ grau oder grüngelb



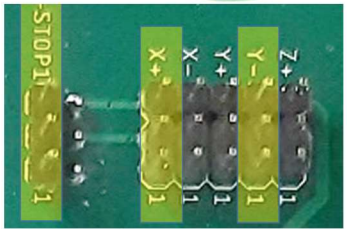
To the numbering 1–5 of the 5-position plug connect cable wires

1. green-yellow wire (12V+)
2. black wire
3. white wire
4. blue wire
5. brown wire

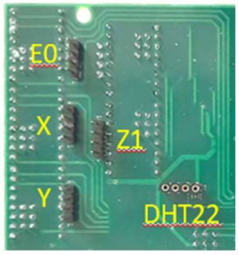


- Guide the 5-position plug through the slit aside the cable support to the electronic box and insert the plug into the black power-jacket_housing mainboard socket, aside the LED.

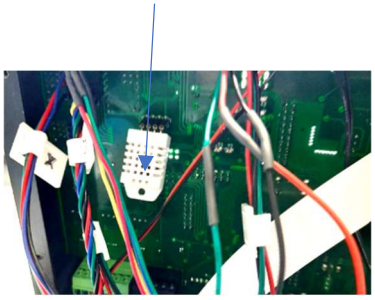
- Connect the endstop cable plugs (Z1 to Z-STOP1, X to X+, Y to Y-) to the respective 3 pins (top middle of the upright electronic_box); the green wire (signal) always points downward.

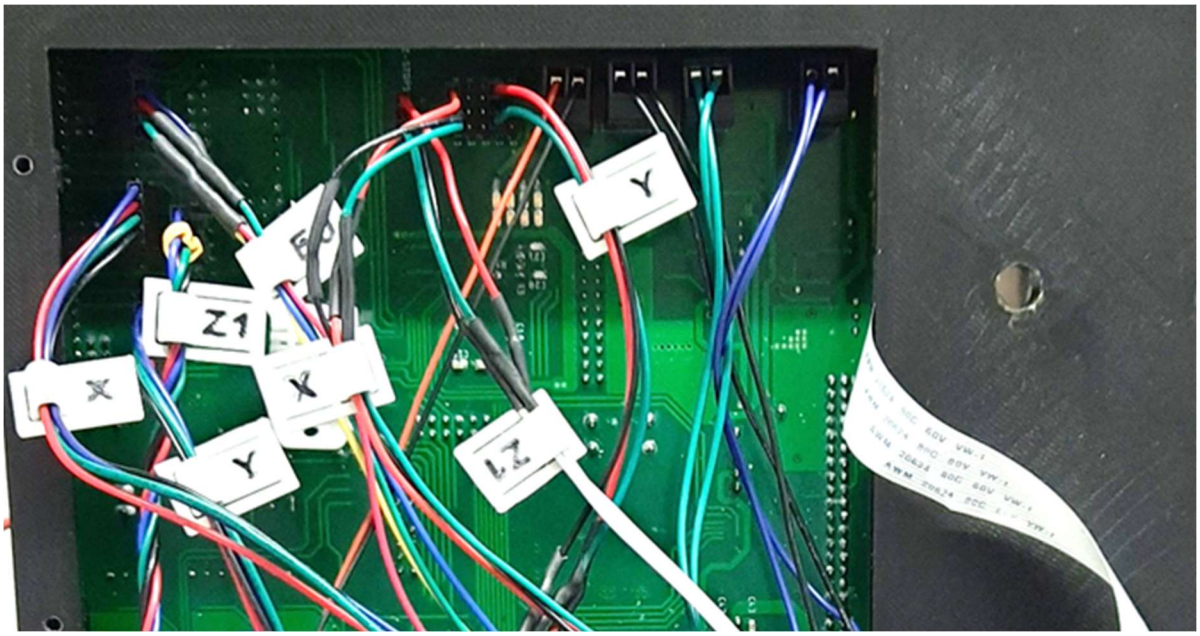


- Insert the DHT22 sensor into the respective port; pin 1 in the most right hole. Bend the sensor slightly downward.



Pin	Function
1	VDD----power supply
2	DATA--signal
3	NULL
4	GND

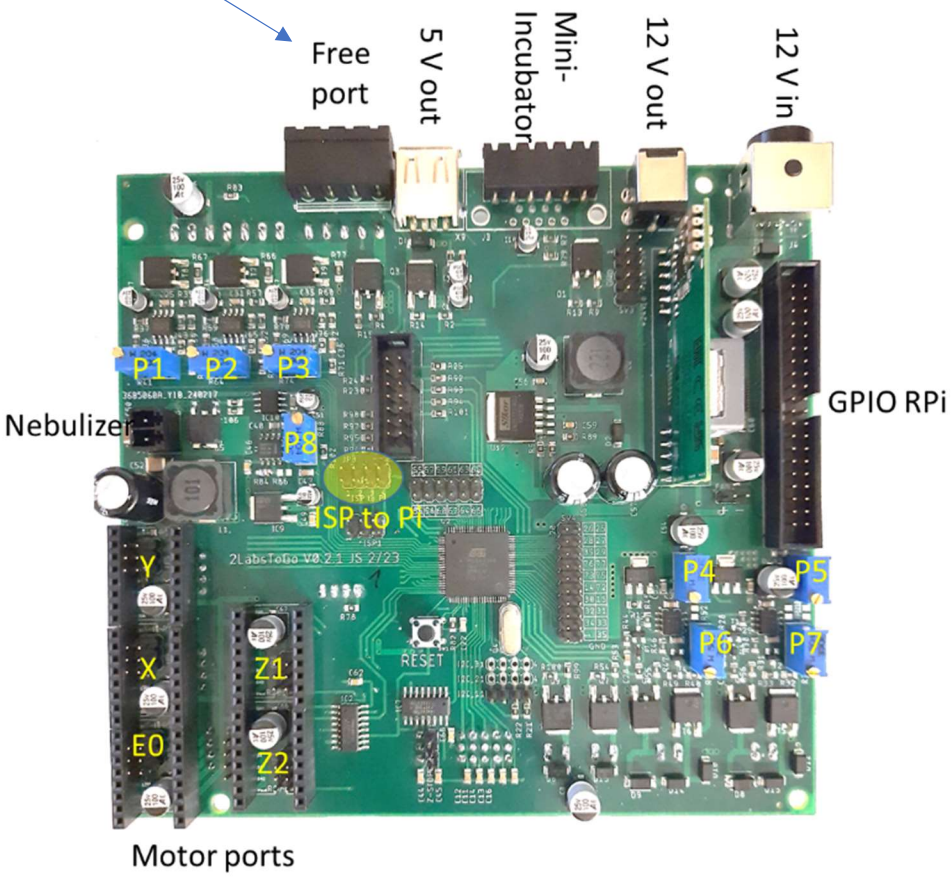




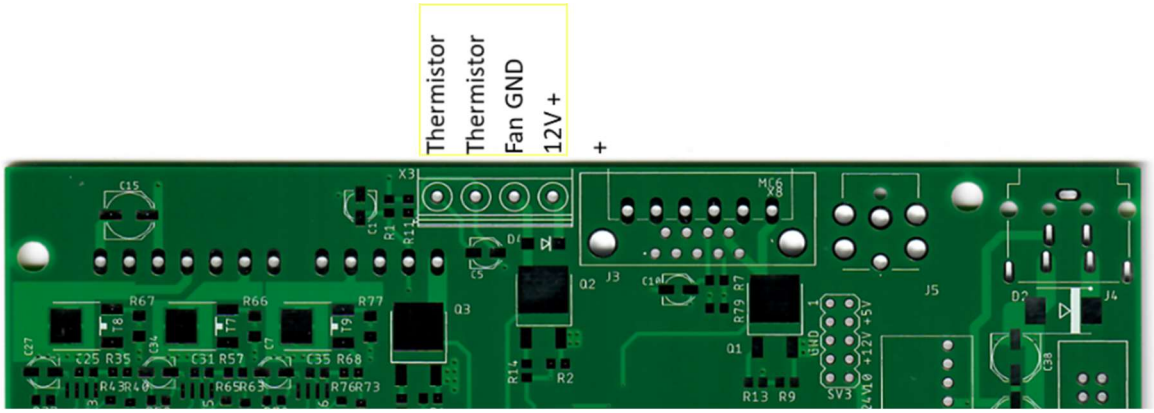
- Tilt the electronic_box forwards and place it onto the frame top_back guiding the motor spindle through the hole near the Raspberry Pi. Thereby, push all cables carefully under the box and avoid pinching of cables (push also cables away from the e-motor top).

External plug

There is a free 4-pin port, actually not used. Note that, in the latest version, the free port is shifted to the bottom of the mainboard.



This port provides 12 V and can be accessed with the Gcode M42I1P9Sx, where P9 is the pin number and x ranges 0–255. The pin 9 is pulse width modulation (PWM) capable, why a fan or cooling system can be controlled, for example, including a thermistor to be connected to the two other pins.



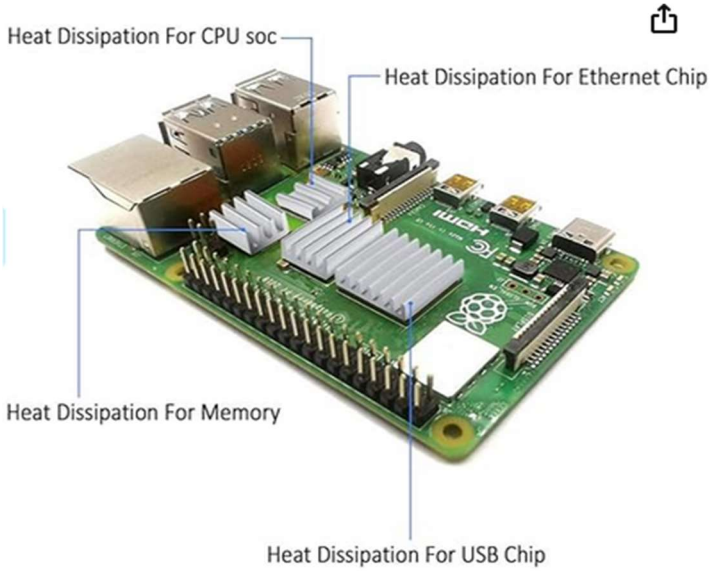
Preparing the Raspberry Pi

Preliminary remarks

For the 2LabsToGo-Software, the Raspberry Pi operating system (OS) Bullseye is suggested, which, however, does not run on the newest Raspberry Pi 5 using Bookworm as the newest OS. Bullseye has also the advantage that the RealVNC server is included; Bookworm has changed to Tiger VNC, not as comfortable as RealVNC.
Under Bookworm, it is not allowed to install Python packages systemwide, which are not supplied by Debian, but from PyPi or GitHub, for example. Therefore, the 2LabsToGo-Software must be installed inside a virtual environment. Additionally, there are still problems with the serial interfaces connecting the mainboard.

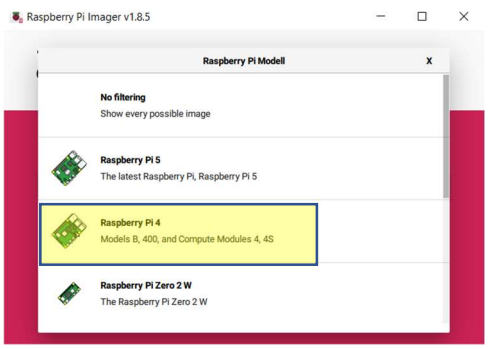
Heatsinks for the Raspberry Pi

- Mount the five heatsinks as shown (www.amazon.de).

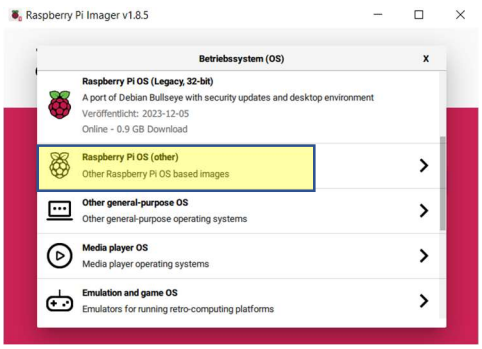


Operating system

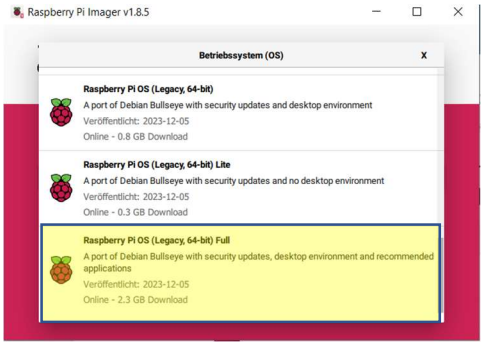
- Download the Raspberry P Imager www.raspberrypi.com/software and install the app on a PC.
- Insert the SD card in a card reader connected to the PC. Skip any attempts to format the SD card!
- Run the Raspberry Pi Imager.



– Select Model Raspberry Pi 4



– Select Raspberry Pi OS (other).

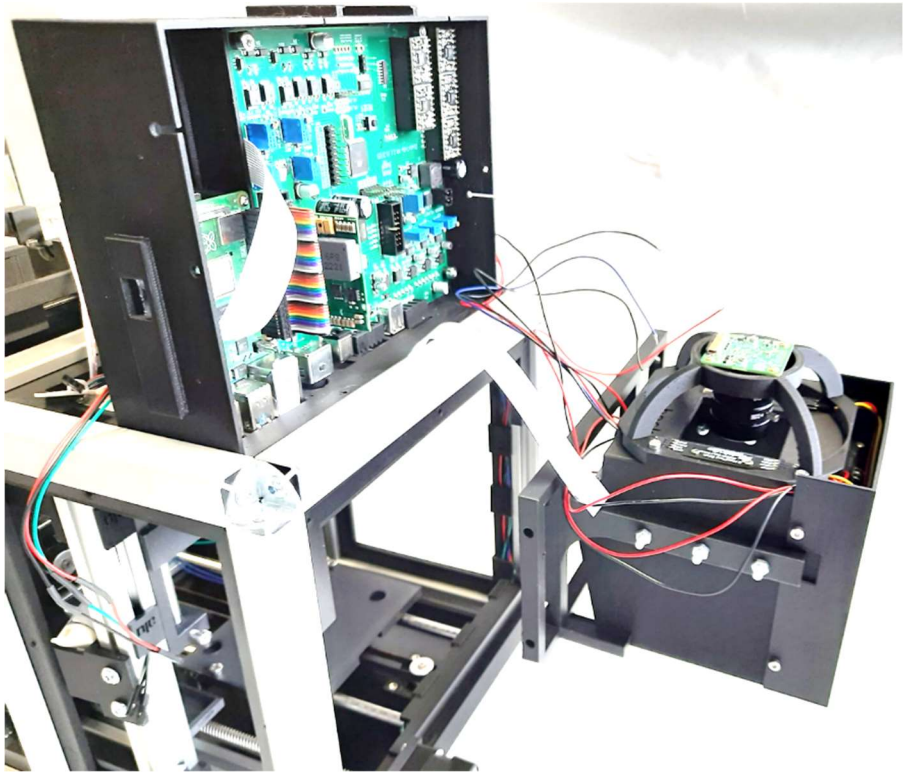


– Select Raspberry Pi OS (Legacy, 64-bit) Full (Debian Bullseye).
– Select the SD card.
– Start flashing the operating system.

After the process is finished, the SD card will automatically be unmounted.

- Remove the SD card from the card reader and insert it again. Skip any attempts to format the SD card!
- In a file manager, search for the SD card and open the file config.txt with a simple text editor.
- Scroll down to these lines and delete the hashtag before “arm_freq=800” (uncomment the line).
  #uncomment to overclock the arm. 700 MHz is the default.
  #arm_freq=800
- Then scroll down to the end of the file
  …..
  [all]
- and add this line:
  dtoverlay=uart3
- Save the file, close the editor, unmount, and remove the SD card from the card reader.
- Insert the micro-SD card into the Raspberry Pi, the contacts upwards (pointing to the board).

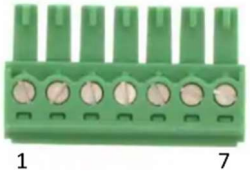
- Turn the instrument by 90° that the right side points to the front.
- Place the camera cabinet onto a small box (ca. 10 cm high) on the right side.



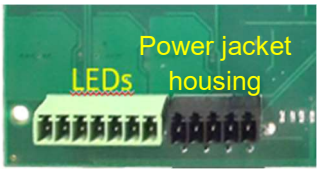
- Cut the female pins from all LED wire ends.
- Check the orientation of the 7-position plug and remind the numbering 1–7 (screws upwards, to be attached to the mainboard later).

To the numbering 1–7 connect cable wires from boards of LED

- RGBW
    1. black wire (Neopixel GND)
    2. green wire (Neopixel data)
    3. red wire (Neopixel 5V+)
- 365 nm
    4. black (GND); use a separate extra black wire
    5. red (12V+)
- 265 nm
    6. black (GND); use a separate extra black wire
    7. red (12V+)



- Guide the cable plug from the backside through the slit on the left side of the cable_support to the electronic_box. Press strongly the plug into the mainboard socket (bottom left).



- Tilt the electronic_box forwards and place it onto the frame top_back guiding the motor spindle through the hole near the Raspberry Pi. Thereby, push all cables carefully under the box and avoid pinching of cables (push also cables away from the e-motor top).

- Connect the keyboard, mouse (USB ports on the back of the electronic_box), and monitor (port on the right side of the electronic_box) to the Raspberry Pi.

Setting-up the operating system

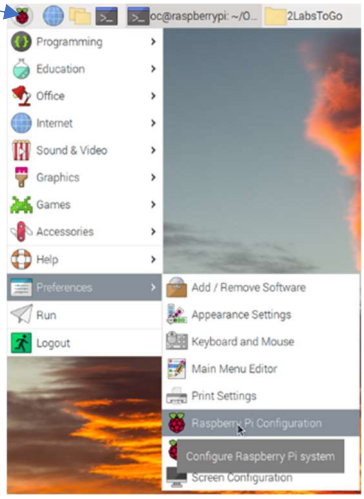
During the set-up, an internet connection is required (the set-up is searching for WiFi connections); otherwise, an upgrade will fail. The upgrade, however, can also be performed after the first set-up, when WiFi data or a static IP address (LAN) are available and the time server updated date and time.

- Connect the electronic board to power and wait for booting.
- Follow the instructions during the operating system setup.

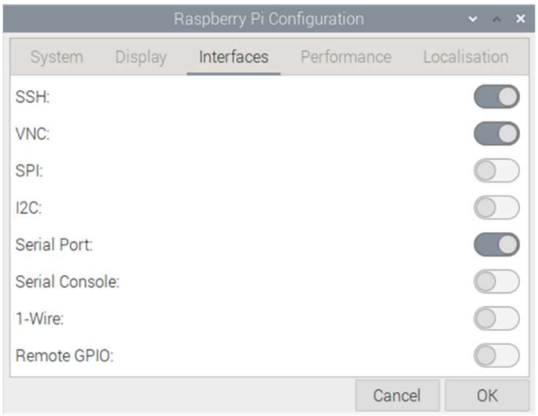
The system ends up in the Desktop screen of the Raspberry Pi OS.

Raspberry Pi configuration

- Click on the Raspberry (top left) and select Preferences/Raspberry Pi Configuration.



- In the tab Interfaces activate SSH, VNC, and Serial Port.

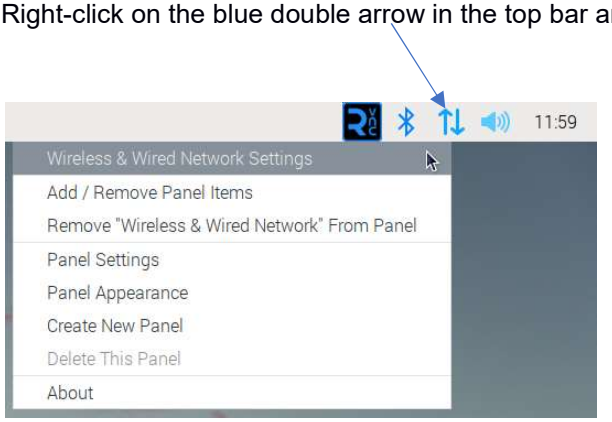


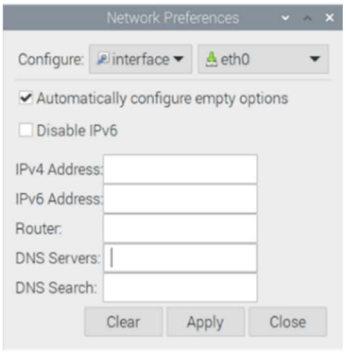
- Click OK and allow reboot.

Setting a static IP address

Before any software can be installed, an internet connection must be established (WiFi or LAN, when in a company or university network a static IP address is usually required).

- Right-click on the blue double arrow in the top bar and select Wireless & Wired Network Settings.
-

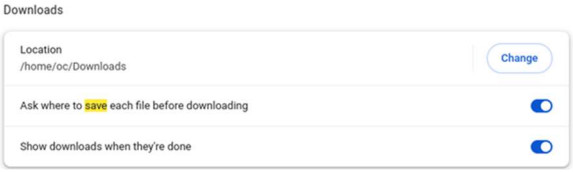




- Fill the form with the IPv4 Address, Router, and DNS Servers (time servers).

Settings the browser's download behaviour

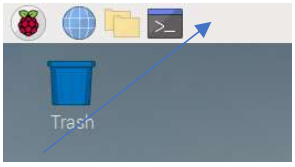
- Open the browser's settings and search for "download".



- Activate Ask where to save …
- Possibly change the folder for downloads.

Software installations

Each of the following commands (grey lines) are sent by pressing the ENTER key.

- Open a Linux terminal. 

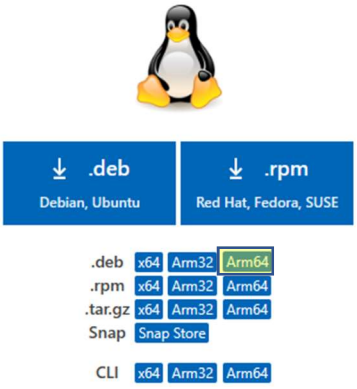
- Generally before a new installation, type
  sudo apt update
  sudo apt upgrade (if required)

pishrink (to prepare a compressed SD card image file as backup; Instruction S4_2LabsToGo-Software manual, Appendix)

```
sudo wget https://raw.githubusercontent.com/Drewsif/PiShrink/master/pishrink.sh
sudo chmod +x pishrink.sh
sudo mv pishrink.sh /usr/local/bin
```

visualStudioCode (to modify the Marlin firmware, and create a firmware file, and to edit software scripts)

Download: https://code.visualstudio.com/Download
Select .deb Arm64



Open the file manager and select the Download folder.
Right-click on the deb file and select "Installation with Package Installer".

gnome-screenshot (to take screenshots)

```
sudo apt install gnome-screenshot
```

Firefox

```
sudo apt install firefox-esr
```

avrdude (to flash bootloader and firmware)

```
sudo apt install avrdude
```

openCV (for camera position, fish-eye correction, and image cropping)

```
sudo apt update
sudo apt upgrade

sudo apt-get install libgl1-mesa-glx
sudo pip install opencv-contrib-python
sudo pip install typer
```

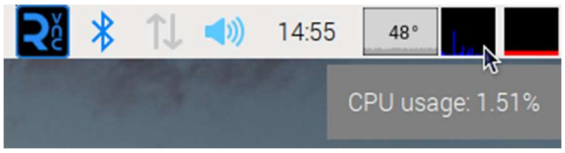
Options

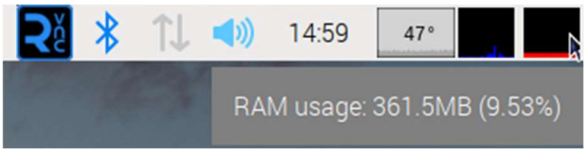
Activate CPU temperature monitor

Right-click on the task bar: select “Add/Remove panel items”.
Click Add and select CPU Temperature Monitor.

Activate RAM and CPU monotoring

Right-click on the task bar: select “Add/Remove panel items”.
Click Add and select Resource monitors.





Downloading 2LabsToGo-Software

Open a Linux terminal and type

```
sudo git clone https://github.com/OfficeChromatography/2LabsToGo.git
```

Installing the 2LabsToGo-Software (requires internet connection)

Change to the directory of the downloaded 2LabsToGo-Software

```
cd ~/2LabsToGo/2LabsToGo-Software
```

followed by

```
python3 install.py
```

and wait to finish the process.

Aliases (to define a shortcut for running the 2LabsToGo-Software)

Being in the home directory (cd ~), type in a Linux terminal

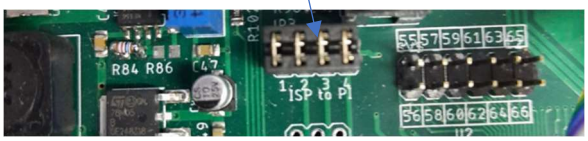
```
sudo nano .bashrc
```

Scroll down to the end of the file and add this line:
alias go='cd ~/2LabsToGo/2LabsToGo-Software && python3 run.py'
[2LabsToGo-Software is the folder of the software installation: /home/*username*/2LabsToGo/2LabsToGo-Software; the tilde (~) stands for /home/username]. “**go**” is here the selected shortcut (can be anything else).

A reboot is required to activate the alias; will be done later.
To later start the 2LabsToGo-Software, simply type **go** in a Linux terminal.

Arduino fuses, bootloader and firmware[6]

The fuses and a bootloader have first to be flashed to the Arduino chip of the mainboard, followed by flashing the 2LabsToGo-Firmware. [The 2x4 jumper block must be onto the “ISP to PI” pins of the mainboard!]



Checking the serial connection

On the Raspberry Pi, avrdude must have been installed. Check by typing in the terminal

```
avrdude -v
```

If it is not installed type

```
sudo apt update
sudo apt upgrade
sudo apt install avrdude
```

To check the connection, change to the directory 2LabsToGo-Firmware

```
cd ~/2LabsToGo/2LabsToGo-Firmware
```

and type in the terminal

```
sudo avrdude -p atmega2560 -C avrdude_gpio.conf -c 2LabsToGo -v
```

If everything is okay, the output of many lines ends up with

```
Programmer Type : linuxgpio
Description     : Use the Linux sysfs interface to bitbang GPIO lines
Pin assignment  : /sys/class/gpio/gpio{n}
  RESET   =  6
  SCK     =  11
  MOSI    =  10
  MISO    =  9

avrdude: AVR device initialized and ready to accept instructions

Reading | ################################################## | 100% 0.00s

avrdude: Device signature = 0x1e9801 (probably m2560)
avrdude: safemode: lfuse reads as FF
avrdude: safemode: hfuse reads as D8
avrdude: safemode: efuse reads as FD

avrdude: safemode: lfuse reads as FF
avrdude: safemode: hfuse reads as D8
avrdude: safemode: efuse reads as FD
avrdude: safemode: Fuses OK (E:FD, H:D8, L:FF)

avrdude done.  Thank you.
```

[6] If the mainboard is ordered from the Electronics Workshop (Justus Liebig University), the following steps have already been done.

Setting the fuses, flashing the bootloader and the firmware

- To make the bash script executable, type in the terminal
  `sudo chmod +x *.sh`

  and execute the script with
  `./flash_firmware.sh`

If everything worked fine, the end of the output should be like this:

…
avrdude done. Thank you.

Adjusting the LED currents[7]

UV LED

- Check the UV LED datasheets for the max. forward current (I_F), for example:

365 nm, 800 mW flux

Inolux — IN-C33ATN / IN-C33BTN / IN-C33CTN UV Series 3535 UV LED

Absolute Maximum Rating at 25°C

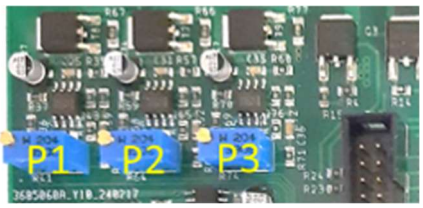
Characteristics	Symbol	Min.	Typical	Max.	Unit
DC Forward Current[1]	I_F		500	1000	mA
Pulse Current (@1/10 duty) [2]	I_P			1500	mA
Forward Voltage	V_F	3.2		3.8	V

265 nm, 18 mW flux

4. Absolute Maximum Ratings (T_a = 25 °C)

Parameters	Symbol	Ratings	Unit
Power Dissipation	Pd	1.20	W
Forward Current	I_F	150	mA

- Turn the potentiometers **P1** and **P2** some turns counterclockwise to safely reduce the preset current.
- Connect the open end of the black wire in position 4 and the black wire coming from the 365 nm LED board to multimeter clamps, set-up for ampere measurement.



P1, P2, P3: potentiometer for the UV 265 nm, UV 365 nm, and backlight LED, respectively.

- In the Linux terminal, change to the directory “Operational_qualification”
  `cd ~/2LabsToGo/2LabsToGo-Software/Operational_qualification` (press ENTER)
  followed by
  `sudo chmod +x *.sh *.py` (press ENTER to make the scripts executable)
  and
  `./uv365_on.py` (press ENTER, to switch on the 365 nm LEDs)

- Read the amperes of the multimeter.
- Turn the potentiometer **P2** clockwise/counterclockwise until the max I_F for the 365 nm LEDs is reached.

[7] If the mainboard and the UV LED boards is ordered from the Electronics Workshop (Justus Liebig University), the currents have already been set.

- In the terminal, type
  ./uv365_off.py (press ENTER to switch off the 365 nm LEDs)
- Disconnect the black wires from the multimeter clamps.

- Connect the open end of the black wire in position 6 and the black wire coming from the 265 nm LED board to the multimeter clamps.
- In the open Linux terminal, type
  ./uv265_on.py (press ENTER, to switch on the 265 nm LEDs)
- Read the amperes of the multimeter.
- Turn the potentiometer P2 clockwise/counterclockwise until the max I_F for the 265 nm LEDs is reached.
- In the terminal, type
  ./uv265_off.py (press ENTER to switch off the 265 nm LEDs)

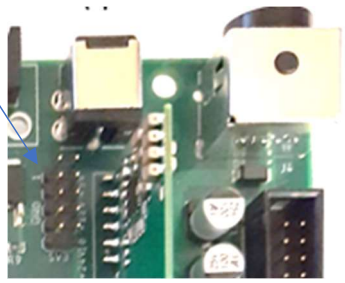
Backlight LED

- Plug in the backlight plate holder.
- In the open Linux terminal, type
  ./backlight_on.py (press ENTER, to switch on the backlight LEDs)
- Turn the potentiometer **P3** counterclockwise until the LEDs start to darken.
- Then turn the potentiometer slowly clockwise until the LEDs just provide maximum brightness, do not turn over this point.
- In the Linux terminal, type
  ./backlight_off.py (press ENTER, to switch off the backlight LEDs)
- Unplug and take out the backlight plate holder.

<u>Motor driver current adjustment</u>

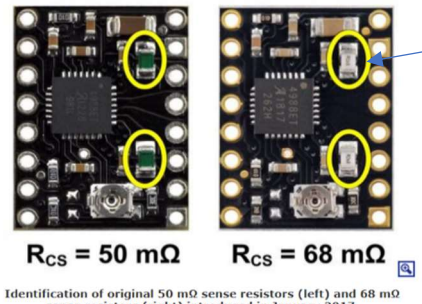
To run the motors with sufficient but not too high currents (heating the motors), the current should be limited for each motor.

- Connect one end of a precrimped wire (preferably black) to a ground pin of the mainboard (labeled with 1) and the other end to the black clamp (-) of a voltmeter.
- Connect the red clamp (+) of the voltmeter to a small slit screw driver (2 mm).
- Place the screwdriver into the cross slit of a motor driver and read the displayed voltage.



Turning the screw, the so-called reference voltage and respectively the current can be changed.

Depending on the production year, the driver “A4988 black edition” differs a little bit in terms of sense resistors. In the new driver boards, the resistors are also labeled with R068 (pololu.com).



Identification of original 50 mΩ sense resistors (left) and 68 mΩ sense resistors (right) introduced in January 2017.

The reference voltage is calculated by

$V_{REF} = 8 * I_{MAX} * R_{CS}$

I_{MAX} is given in the datasheet of the motor.

The following table shows the theoretical values of the reference voltages (V_{REF}) for the different motors installed in the 2LabsToGo.

Motor	ACT 16HSL3404 (E0, Z2)				Nema 14, 2.7 V, 1.0 A (X, Y)				Prusa (Z1)			
R_{CS}	0.05	Ohm	0.068	Ohm	0.05	Ohm	0.068	Ohm	0.05	Ohm	0.068	Ohm
I_{MAX}	0.4	A	0.4	A	1	A	1	A	1	A	1	A
V_{REF}	160	mV	218	mV	400	mV	544	mV	400	mV	544	mV

- Limit the current for all five motors referring to given data, but reduce the theoretical values by about 10%.

Timer and voltage adjustment for the valves[8]

To set the spike voltages and the spike duration, an oscilloscope is needed.
Measuring points are the pins with the mounted valves.

Dispensing valve

- Referring to the Electro-Fluidic Systems Handbook (The Lee Company), set the spike voltage of the dispensing valve (INKX0514100A) to 24 V and the spike duration to 0.50 ms (minimum).
- Set the hold voltage to 3.2–4.5 V (maximum).

3-Way valve

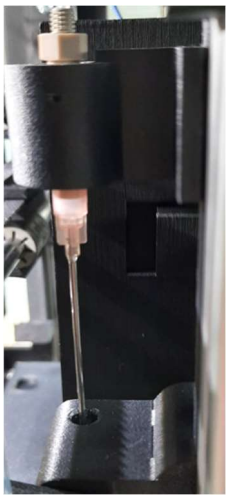
- Set the spike voltage of the 3-way valve (LFRA**12**52370D) to 12 V and the spike duration to 100 ms.
- Set the hold voltage to 6V.

[8] If the mainboard is ordered from the Electronics Workshop (Justus Liebig University Giessen), the adjustments have already been made.

Mounting the autosampler needle

Materials	Qty
Plastic syringe, 2 mL, with Luer-lock	1
Ethanol (3 mL)	1
3D-printed rinsing_bottle with cap	1
Syringe needle 18Gx2”, 1.2 x 50 mm	1

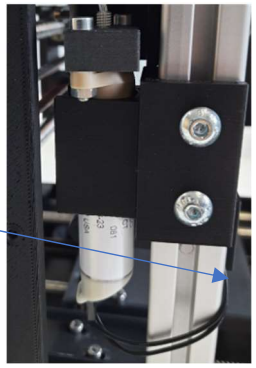
- Insert the needle, guiding the tip through the small formerly drilled hole of the needle guide downward.



- Fix the Luer-top of the needle in the Luer-lock system of the Lee adapter installed in the needle pusher.

- Mount fingertight the MINSTAC tube fitting coming from the needle_pusher to a Lee Luer-lock adapter.
- Fill a syringe with 3 mL ethanol and attach it to the adapter.
- Place the rinsing_bottle under the needle guide.
- Rinse the needle system by pressing the plastic syringe to remove any particles.

- Unscrew the MINSTAC tube fitting from the syringe and mount it to the IN port of the micropump manifold using the Lee torque (min. torque).
- Attach the two black wires to the pins of the micropump.

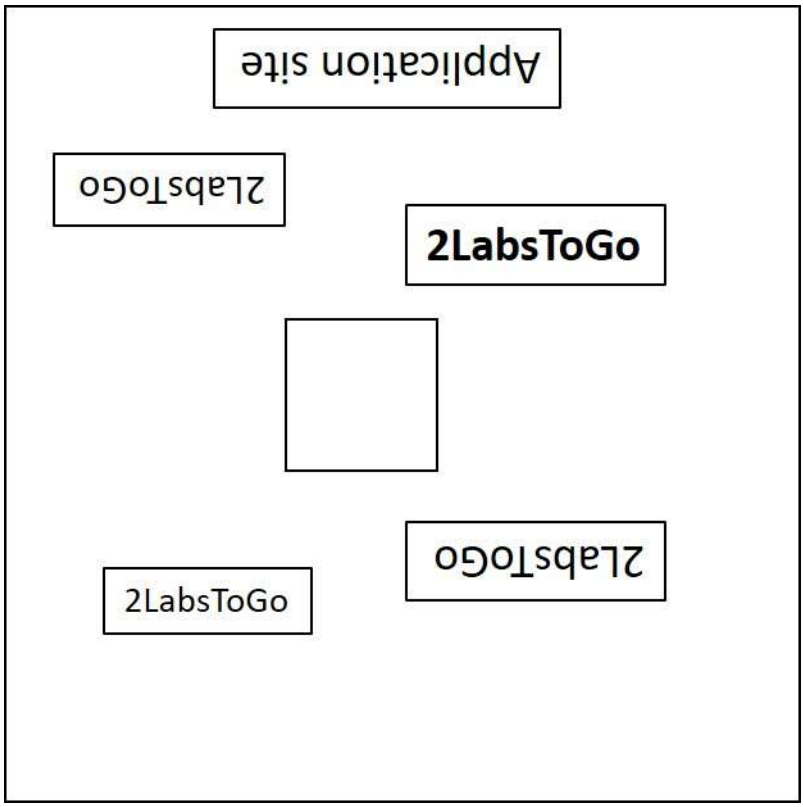


- Insert the micropump into the micropump_holder. The IN port tube is directed inside the instrument.
- Move the micropump_holder nearly up and fix the two screws on the e-axis.
- Guide the black wires through the e-axis aluminum profile (back side) and fix them with two clip_alu.

Focusing the camera

Materials	Qty
Glass plate 10 cm x 10 cm	1
Glue stick	1
Plate_holder_simple, already assembled	1
3D-printed_camera_lever	1

- Print this page on white paper, cut the image below just inside the black borders, and fix it with a glue stick onto a glass plate of 10 cm x 10 cm. Finally cut the overhanging paper from the back side carefully with a sharp knife along the glass plate edges.

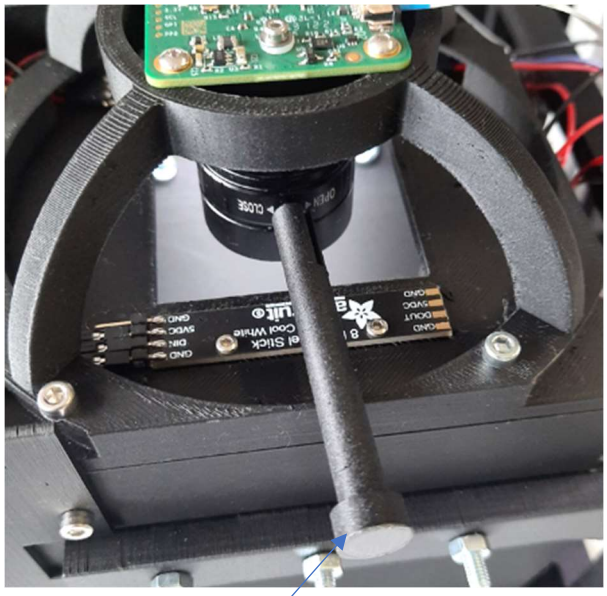


- Insert this test plate into the plate_holder_simple and place the camera_cabinet onto the plate holder (alignment does not matter).
- In a Linux terminal type
  cd ~/2LabsToGo/2LabsToGo-Software/Operational_qualification (and press the ENTER key).
- Make all files executable by typing
- sudo chmod +x *.py *.sh (and press the ENTER key),
  followed by
  ./white-LED-on.py (and pressing the ENTER key),
  and followed by
  libcamera-still -t 60000 (and pressing the ENTER key).

The preview window of the camera will be opened, showing the blurred plate image.

- Turn the camera lens stepwise (giving the camera the chance to settle down the gains) to NEAR until the sharpest image is obtained.

- With the above command, there are 60 s time. If more time is needed, repeat the libcamera command (on the keyboard simply press the arrow up ↑ and ENTER) for another 60 s.
- After a sharp image was obtained, type in the Linux terminal
  ./white-LED-off.py and press the ENTER key



- Carefully push the 3D-printed_camera_lever onto the lower camera screw (OPEN<->CLOSE, previously aligned for focusing the camera). This tool simply allows a later fine-tuning from the open right side of the instrument.

- Shutdown the Raspberry Pi and disconnect the mainboard from power.
  Disconnect the mouse, keyboard and the monitor from the Raspberry Pi.

- Remove the 2x4 jumper block from the “ISP to PI” port.

- Place the electronic_box upright again onto the frame_top_back of the instrument casing so that the underside can be reached.

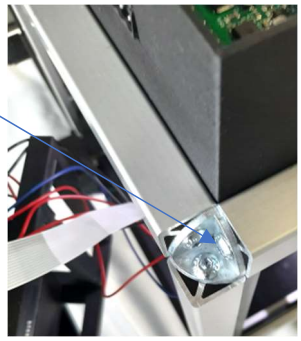
- Take off the 7-position plug and exchange the separate black wire in position 4 by the black wire coming from the 365 nm LED board.
- Exchange the separate black wire in position 6 by the black wire coming from the 265 nm LED board.
- Insert the 7-position plug in the electronic mainboard.

- Guide the camera cable downwards and backwards to the camera board mounted in the camera_cabinet_top.
- Insert the camera cable into the camera port (still open clip) with contacts to contacts and press the clip onto the port. By slightly drawing the cable test if it is fixed well.

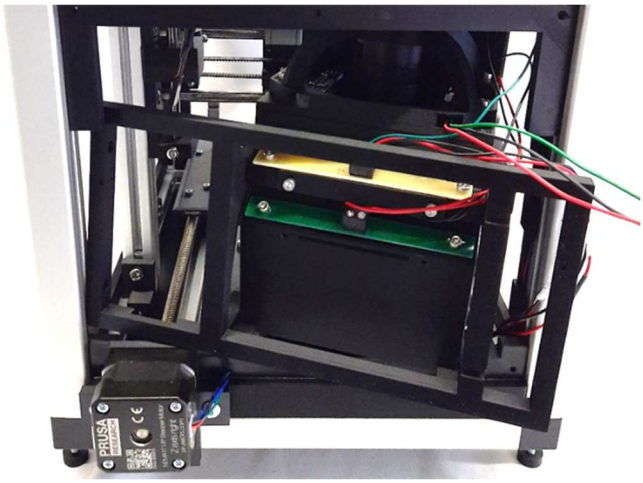
Installing the camera cabinet

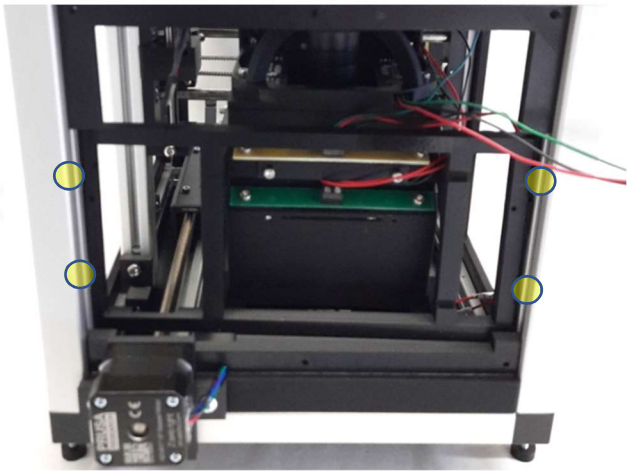
Materials	Qty
Sliding block M5 with web I-type groove 5	4
Screw M5x14, DIN7380	4
Screw M3x16, DIN 912	4
3D-printed electronic_box_e_motor_spindle_cover	1

- From the bottom of the camera_cabinet, check if there is no dust or a fingerprint on the camera lens.
- Loosen the two screws in the top x/y-rectangular (that fix each z-aluminum profile in the back).



- Insert two M5 sliding nuts into each z-aluminum profile in the back (circled).
- First guide the camera cabinet with its holder on the left side inside the instrument, behind the frames_back.
- Then guide the right side of the cabinet holder inside the instrument so that the cabinet holder is fully inside.





- Check the position of the sliding nuts in both z-aluminum profiles (circled) to meet the holes in both sides of the camera_cabinet_holder.
- Press the frame_back, top part, upwards and draw the cabinet_holder between the two-parted frame_back.
- Insert one upper M5x14 screw with some turns by the finger. Thereby, keep the cabinet_holder aligned flush with the two-parted frame_back.
- Insert the other upper M5x14 screws with some turns by the fingers, then the two lower M5x14 screws.

- Check if the cabinet_holder is exactly flush with the frames_back (circled; check with your fingers the flush contact of both parts) and tighten all four screws.
- Tighten the two screws in the rectangular top again.

- Guide the wires of the DC-power_jacket_housing together with the motor cables in the back left cable channel (remove the cable clips and fix the cables with cable clips again).

- Tilt the electronic_box forwards and place it onto the frame top_back guiding the motor spindle through the hole near the Raspberry Pi. Thereby, push all cables carefully under the box and avoid pinching of cables (push also cables away from the e-motor top).

- Connect the keyboard, mouse (USB ports on the back of the electronic_box), and monitor (port on the right side of the electronic_box) to the Raspberry Pi.

- Reconnect the board to power and wait for booting.

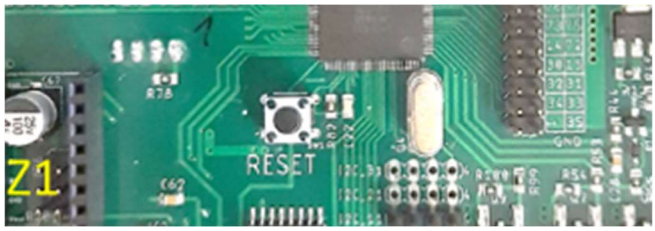
During booting, the x-axis will perform a homing process and the case light will be switched on, indicating that the firmware works.

Operational qualification

- In the still open Linux terminal being in the folder ~/2LabsToGo/2LabsToGo-Software/Operational_qualification (the shortcut ~/ stands for /home/username)
- Check that nothing is in the way inside the instrument, no tools or other materials.
- Insert an HPTLC plate silica gel F_{254} into the plate holder.
- Start the check script by typing

  `./show.sh`

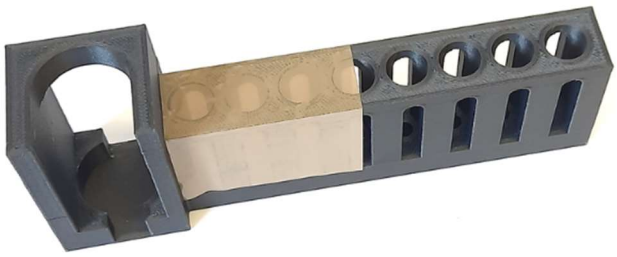
  and carefully observe comments in the terminal and the operations.
  If there is any problem, quit the script immediately with Ctrl+c and press the Reset button on the mainboard!



Autosampler vial positioning

Depending on the assembly, the position of the vials in the vial rack can slightly differ from the values defined in the software.

- Apply parcel tape to the openings of the first three vial positions.

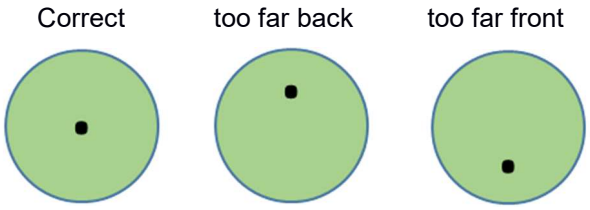


- Place the vial rack into the vial rack holder.

- In the still open terminal, type

  `./vial-pos.py`

  and observe the comments in the terminal and the operations.
- Take off the vial rack and check the needle punctures. If they are not centered in the y-direction, measure the distance to the center in mm.



If the hole is too far back, the correction value becomes *positive*, if too far front *negative*.

- Take the mean of the three vial deviations.
- In the file manager, go to the folder 2LabsToGo/2LabsToGo-Software/app/finecontrol/gcode and open the file “GcodeGenerator.py” with Geanny (right-click).

In the top of the file, the vial positions are defined:

```
6   class GcodeGenerator:
7       pos_common= "G0Z"
8       vial_9= "145" #rinse bottle
9       vial_8= "268.5" #vial 8
10      vial_7= "254.5" #vial 7
11      vial_6= "240.5" #vial 6
12      vial_5= "226.5" #vial 5
13      vial_4= "212.5" #vial 4
14      vial_3= "198.5" #vial 3
15      vial_2= "184.5" #vial 2
16      vial_1= "170.5" #vial 1
17      rin_bot= "145" #rinse bottle
```

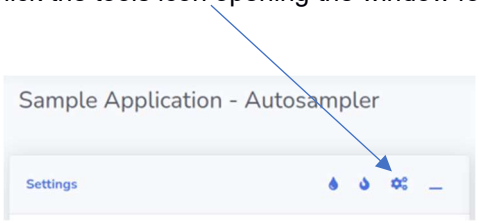
- Simply over-write the values for **all vials** and **the rinse bottle** by adding or subtracting the measured mean deviations in mm and close the file with saving.
  For example, over-write 145 by 145.5.

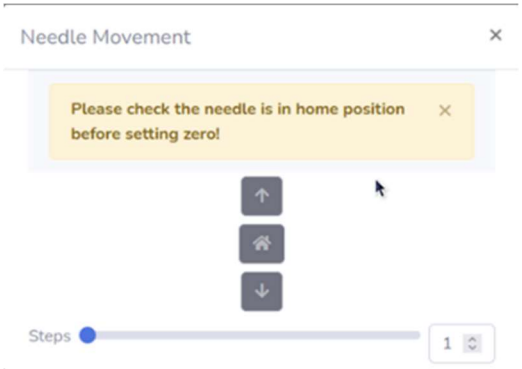
Starting the 2LabsToGo-Software and connecting the board

- In the still open Linux terminal type “go” and press ENTER.
- Wait to finish the server script. It takes a while the first time.
- Open the Firefox browser and type: 127.0.0.1:8000 in the address field (wait to load the page; this starts the 2LabsToGo-Software at the local host).
- Click on the button “Connect”. In the MONITOR screen window and in the status line, it is shown that the instrument is connected.

Adjusting the needle position

- In the left menu bar, left-mouse-click on “Sample Application” and right-mouse-click on “Autosampler” and then select “Open Link in New Tab”. Click on the new tab and wait to load the page.
- Click the tools icon opening the window for Needle Movement.





- Step-by-step click on the arrow UP to move the needle pusher upwards (one click = 1 mm) until the needle tip can just be felt with the finger at the exit of the needle guide.
- Then click on the button with the house icon (between the arrows) to save the zero position of the needle pusher. Close the window.

Photo position and image cropping

Depending on mounting the camera cabinet and the y-axis including the y-endstop, the image position and image cropping values might be different from the actual values set in the 2LabsToGo-Software.

To check, if the pre-set values of the photo position are correct:

- Place the prepared glass plate with the printout scheme used for camera focusing (“Application area” pointing to the back) onto the multi-functional plate-holder, bring the plate-holder into place on the y-cart, and plug in the cable plug.
- In the side bar menu of the 2LabsToGo-Software, left-mouse-click on “Detection” and right-mouse-click on “Capture Image” and then select “Open Link in New Tab”. Click on the new tab (Detection) and wait for loading the page.
- Select “Auto Exposure: on” and set the WhiteR LED to 255.
- Click on the microscope icon (image position y) to move the plateholder under the camera cabinet. Note that the x-axis and the autosampler vial rack holder will also be moved.
- Click on “Capture Image”.
- Wait for the image is displayed in the Plate Preview window.

If there is no black border on any side of the image, everything is fine. Otherwise both the photo position and possibly the cropping parameters have to be modified.

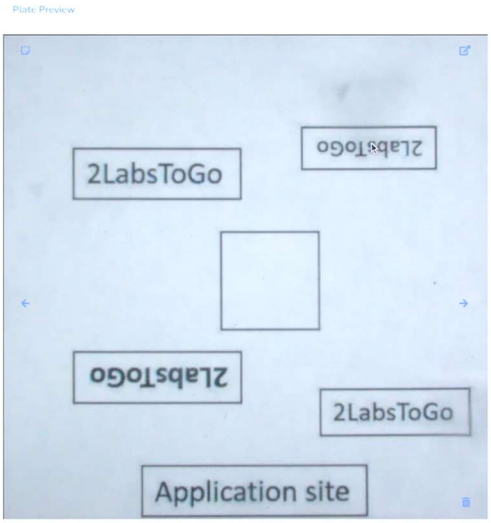
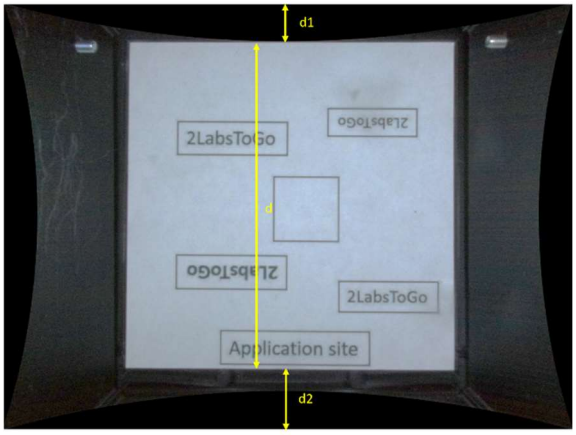


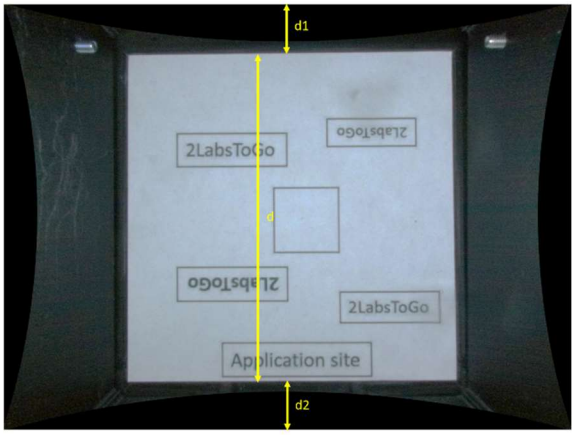
Photo position correction

- Open a **new Linux terminal**, change to the 2LabsToGO-Software directory:
- cd ~/2LabsToGo/2LabsToGo-Software/Operational_qualification
  type
  ./photo-pos.sh and press ENTER
- Wait until the script is finished (system prompt).

The captured image (photo-pos.jpg) is in the folder
2LabsToGo/2LabsToGo-Software/Operational_qualification
and the fisheye-corrected image (photo-pos_corrected.jpg) in the subfolder “corrected”.

- Open the corrected image with the Image Viewer (mouse right-click). Examples are:





The plate is too far in the front: d1<d2. With the help of a ruler, measure d, d1 and d2 in mm directly on the screen. The y-correction is then calculated by y_corr=(d2-d1)*100/d/2	The photo position is correct (d1=d2).

To change the photo position, go to the folder (file manager)
2LabsToGo/2LabsToGo-Software/app/templates/js/oclab/
and open the file “detection.js” with Geany (right click) and scroll down to the section:

```
//put camera into position
$('#cameraposbttn').on('click', function (e) {
    e.preventDefault()
    gcode = 'M92Z400'
    console.log(gcode);
    sendToMachine(gcode)
    gcode = 'M203Z15'
    console.log(gcode);
    sendToMachine(gcode)
    gcode = 'M42P55S0'
    console.log(gcode);
    sendToMachine(gcode)
    gcode = 'G28Y\nG1Y90Y158Z270' //Y value depends on each system
    console.log(gcode);
    sendToMachine(gcode)
})
```

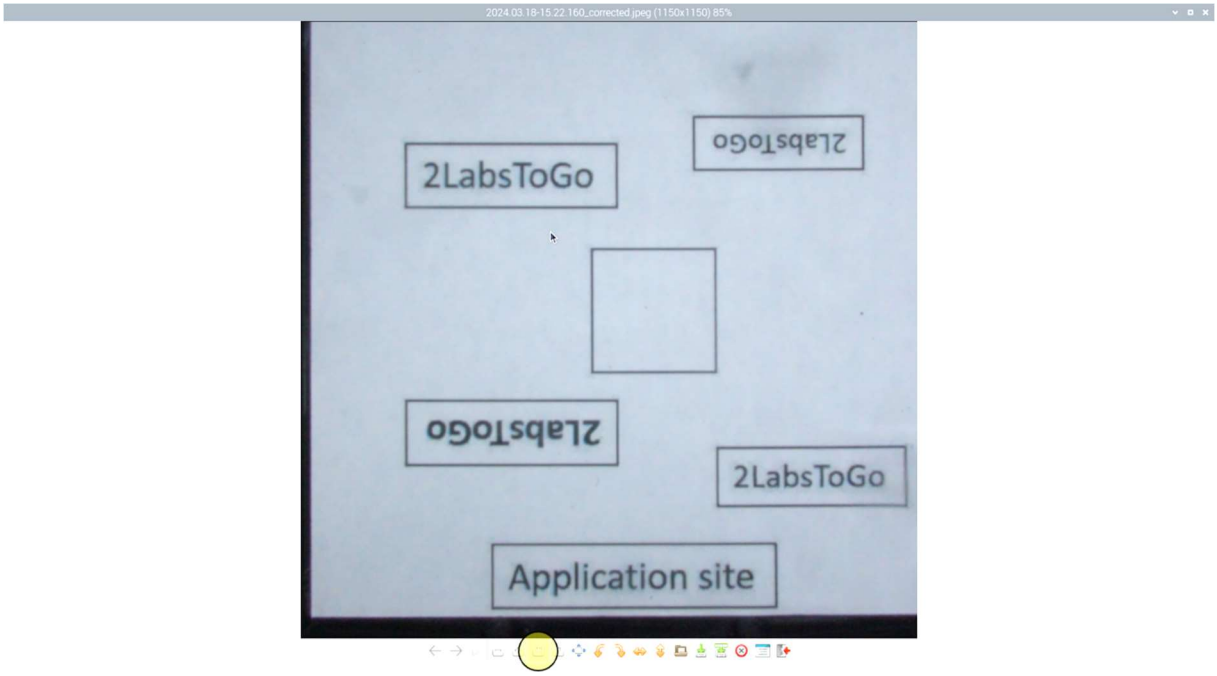
- Change the value in the gcode line (here Y158, circled) by adding y_corr to 158 (can also be a comma value using the dot), and save the file. If y_corr is negative, it has to be substracted. For example, if y_corr is 2.5, then overwrite 158 by 160.5.

- Reload the page “Detection” in the browser and and capture an image once more and check the result. If the result remains unchanged, empty the browser’s cache and re-capture an image.

<u>Image cropping</u>

If there is no black border on any side of the last image (photo position corrected), everything is fine. Otherwise the cropping parameters have to be modified.

- In the folder
  2LabsToGo/2LabsToGo-Software/app/media/Images/
  open the last image (time stamp) with the Image Viewer and enlarge the image to full size (yellow circle).



- Measure the *width* of the image (incl. the black borders) and the black borders themselves (here left and bottom) in mm on the screen (*black-x, black-y*).

The correction values (in pixels) are then:

x_corr = round((black-x*1150/width); 0)

y_corr = round((black-y*1150/width); 0)

The values are given a negative sign, if the black borders are on the left and on the top of the image, otherwise positive!

To correct the values, go to the folder (file manager)

2LabsToGo/2LabsToGo-Software/app/detection/

and open the file “takeimage.py” with Geany (right click) and scroll down to the section:

```
242         # crop the image
243         #x, y, w, h = roi
244         y=150   #cropping 5 pixel, about 1 mm
245         h=1150
246         x=440   #cropping 5 pixel, about 1 mm
247         w=1150
```

- Add the correction values (positives or negatives) to the pre-set y and x values:
  For example, simply type +5 or -5 after y=150.
- Close the file with saving.

Changing python scripts, the running Django server will disconnect the board.

- Therefore, reload the “Connection” tab and connect the board again.

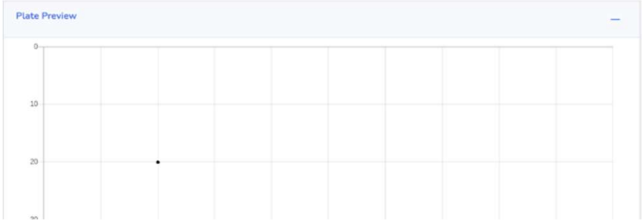
- Capture a new image with the -Sofware and check, if the cropping is okay now.
- Click on the HOME bottom to home the plate holder.

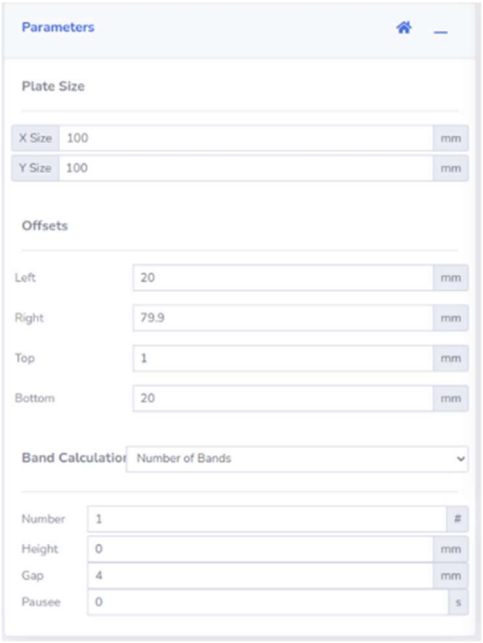
<u>Testing the micropump</u>

- Fill the rinsing vial with solvent (best 90 % ethanol), insert it into the vialrack to be inserted into the vialrack holder.
- In the former terminal being in the directory 2LabsToGo/2LabsToGo/Operational_qualification, type
  ./micropump.py and press ENTER.
  Observe the comments in the terminal and the operations.
  If there is any problem, quit the script with Ctrl+c!

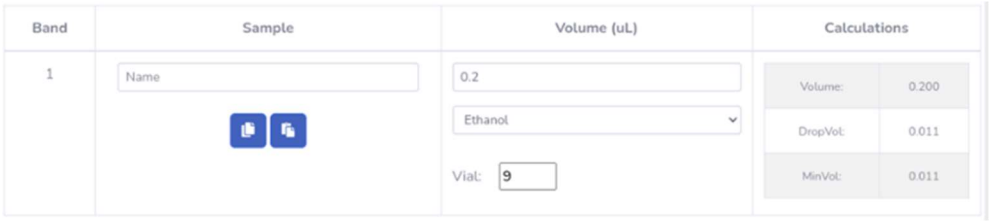
<u>x,y-Zero position</u>

- In the side bar menu of the 2LabsToGo-Software, left-mouse-click on “Sample Application” and right-mouse-click on “Autosampler” and then select “Open Link in New Tab”. Click on the new tab (Autosampler) and wait for loading the page.
- Set the frequency to 1200.
- In the “Parameters” window select Number of Bands 1.
- Set the Offsets Left to 20 and Right to 79.9. In the Plate Preview window, a small dot is shown at the position 20,20.

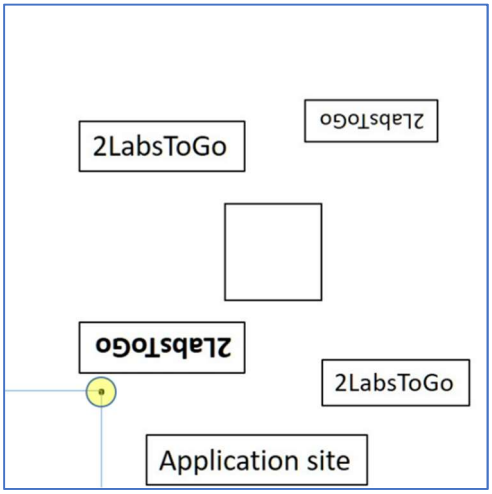




- In the sample list, type 0.2 for the µL to be applied, select Ethanol as solvent, and **Vial 9** (is the rinsing vial).
- Fill about 10 mL ethanol into the rinsing vial, insert it into the vial rack to be placed onto the vial rack holder.



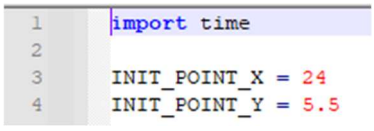
- Start the application with the glass plate covered with the paper printout, which still should be in place on the multifunctional plate holder.
- When the application has finished, mark the wet dot with a felt-tip pen.
- Take out the plate and measure the distance of the marked dot (yellow circle) from the left and the bottom.



When both distances are 20 mm, everything is okay. Otherwise the zero position must be corrected in the software:

x_corr = 20 - measured from the left
y_corr = 20 - measured from the bottom

- In the file manager go to the folder
  2LabsToGo/2LabsToGo-Software/app/Finecontrol/gcode/
  and open the file “GcodeGenerator.py” with Geany (right-click)

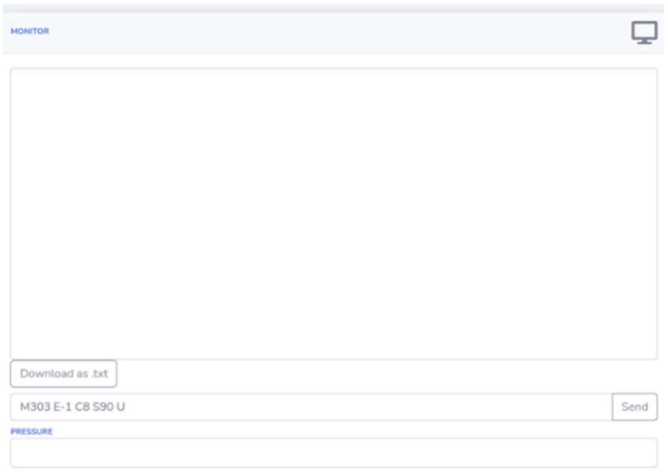


- Correct the values for INIT_POINT_X and INIT_POINT_Y by adding x_corr and y_corr to the pre-set values. Simply type the corrected values (including their signs) after the given values. For example: 24+1.5 or 24-2.
- Close the file with saving.

PID Tuning

To calibrate the thermistors in both the multi-functional plate holder and the Mini-Incubator, Marlin tune procedures have to be called.

- Insert the test plate with the paper print out into the multi-functional plate holder being in the home position and the plug connected.
- Go the connection tab of the 2LabsToGo-Software.
- In the input box below “Download as.txt”, type the Gcode
  M303 E-1 C8 S90 U
  and click on “Send”.



The plate holder will eight times be heated up to 90 °C and cooled down (observe the Monitor), wherafter the calibration values will be reported and saved in the Arduino chip.

- Connect the Mini-Incubator and repeat the procedure with the Gcode
  M303 E0 C8 S40 U (click on “Send”)

The Mini-Incubator will eight times be heated up to 40 °C and cooled down (observe the Monitor), wherafter the calibration values will be reported and saved in the Arduino chip.

Backlight plate holder

Place the backlight plate holder onto the y-cart and plug in the cable.

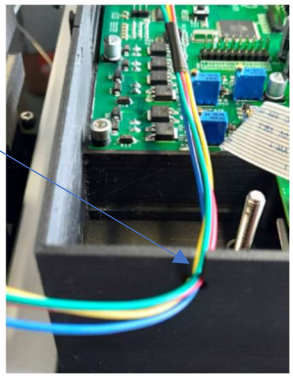
- In the side bar menu of the 2LabsToGo-Software, left-mouse-click on “Fine Control” and right-mouse-click on “Backlight Plate Holder” and then select “Open Link in New Tab”. Click on the new tab (Backlight) and wait for loading the page.

- Click “Turn On”
  LEDs are working?
- Click “Turn Off”.

- Shutdown the Raspberry Pi and take the mainboard from power.
- Remove the keyboard, mouse and the monitor cables from the Raspberry Pi.

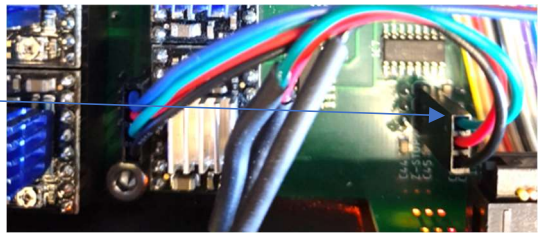
- Connect the syringe motor (Z2) cable plug to the four pins aside the motordriver Z-MOT2 on the top of the mainboard, the blue wire pointing to the back (as follows).

- Guide the motor cable through the slit on the right side of the electronic_box.

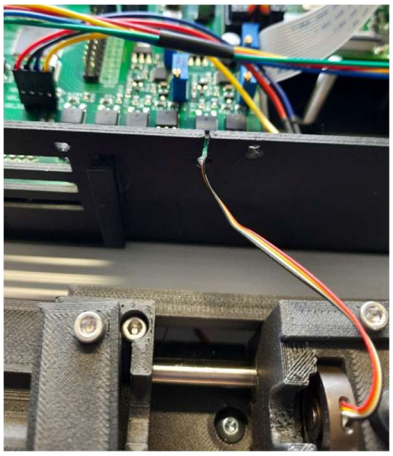


- Connect the syringe pump endstop cable plug to the three pins on the top of the board (Z-STOP2), the green wire pointing to the back.

- Guide the cable through the slit on the left side in the front of the electronic_box.

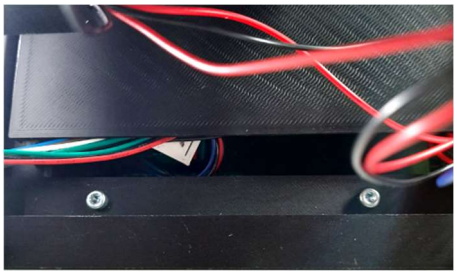


- Connect the force sensor plug to the first I2C port on the top of the board, the green wire (here yellow) pointing to the right. Guide the cable through the slit on the right side in the front of the electronic_box.

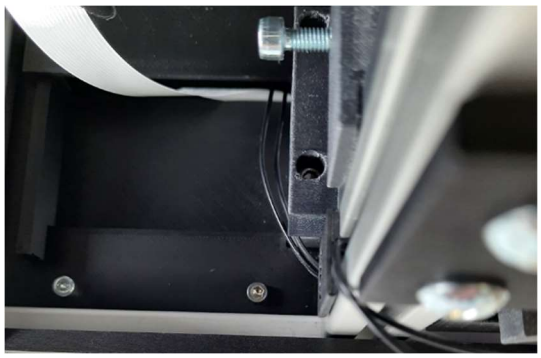


Screwing on the electronic box

- Turn the casing top down (take care holding and not to damage the electronic_box).
- Fix the electronic_box from inside with four M3x16 screws.



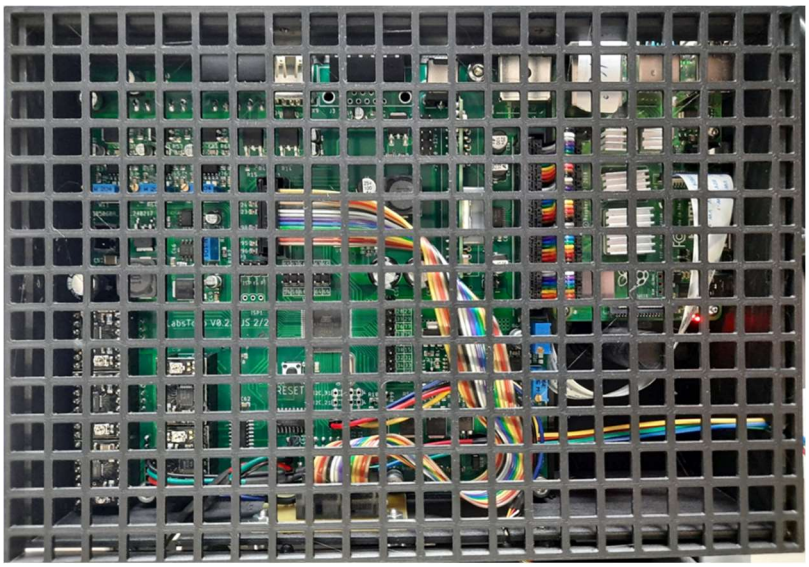
left side



right side

- Turn the casing upright.
- Place the spindle_cover over the spindle inside the electronic_box and press it down.

- Align the 3D-printed electronic_box_cover to the screw cutouts and close the electronic_box by pressing the cover on top of the electronic_box.



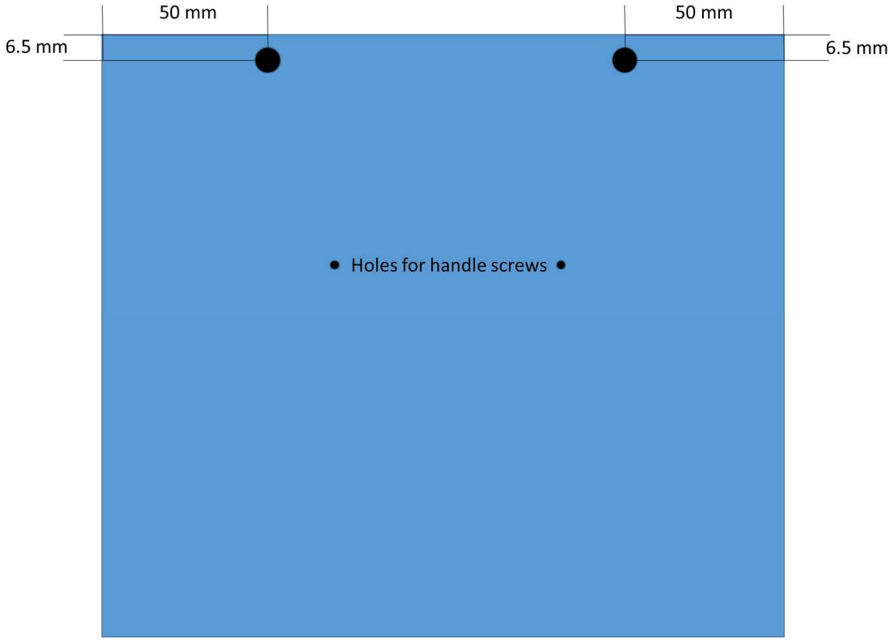
Mounting the walls and the front cover

Materials	Qty
Alupanel aluminum brushed left_back	1
Alupanel aluminum brushed left_front	1
Alupanel aluminum brushed right_back	1
Alupanel aluminum brushed right_front	1
Alupanel aluminum brushed back	1
Alupanel aluminum brushed front	1
Screw M3x8, DIN912	40
Screw M3x10, DIN912	2
Round magnets Ø 8 mm x 3 mm	2
3D-printed holder_front	
3D-printed cover_z1_motor	

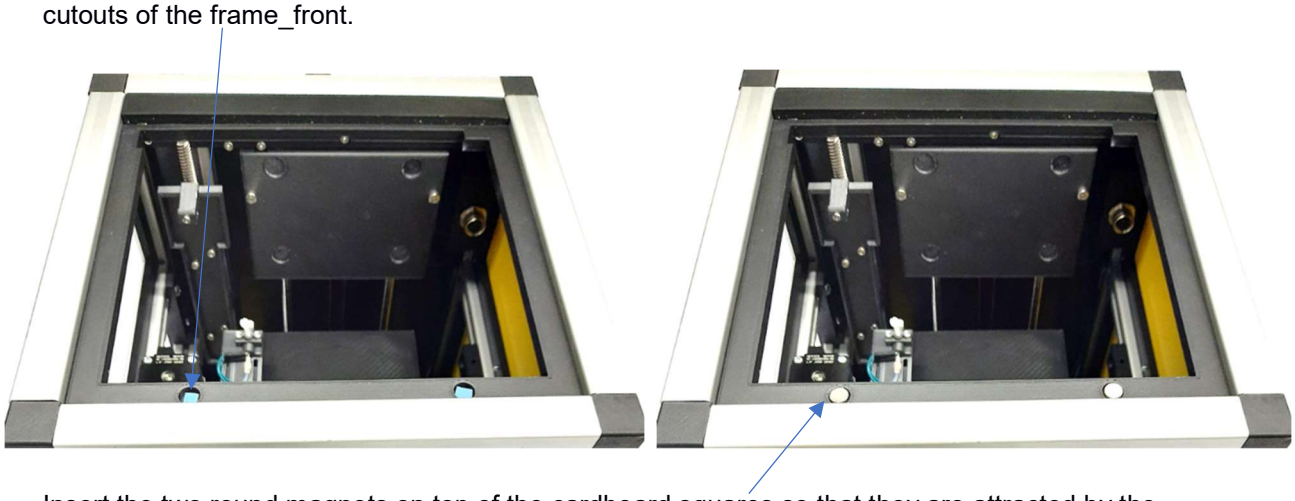
<u>Alupanel front</u>

- Mount the handle on the shiny outside of the alupanel front with two M3x10 screws from inside.

- Score the matt surface on the inside of the alupanel front at the two positions given above several times crosswise with a small screwdriver. This helps to stick the round magnets firmly in place.



- Place the 2LabsToGo casing on the back.
- From a 1 mm thick cardboard, cut two squares of just under 6 mm and insert them into the round cutouts of the frame_front.

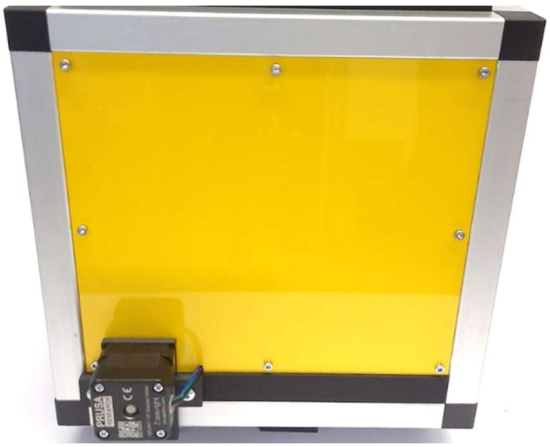


- Insert the two round magnets on top of the cardboard squares so that they are attracted by the magnets inside the frame_front.
- Place a small drop of superglue (not too much) in the center of the two magnets and insert the alupanel front (using the handle) in between the aluminum profiles and the y-axis_front. Press the alupanel slightly down and center it between the aluminum profiles and the y-axis_front.

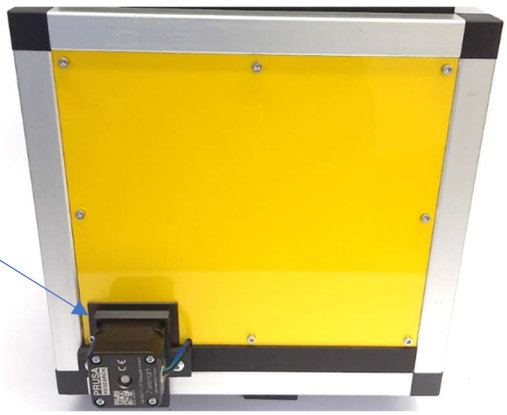
- Wait for the glue to harden.
- Then remove the alupanel front and remove the cardboard squares.
- Place the 2LabsToGo casing onto the feet, the back to the front.

Alupanel back

- Insert the alupanel back guiding the z1-Motor cable through the small cutout and mount the panel with eight M3x8 screws.
- Stick double-sided tape onto the back of the z1-motor_cover and cut it to size.

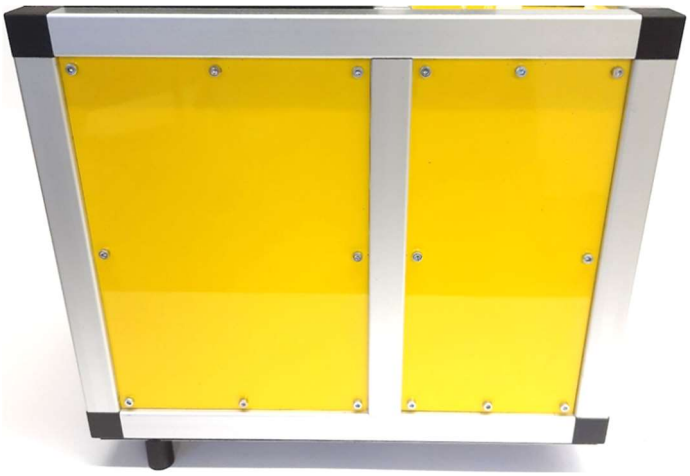


- Remove the protective film, guide the coverz1-motor onto the motor (open side down) and stick it onto the alupanel back.



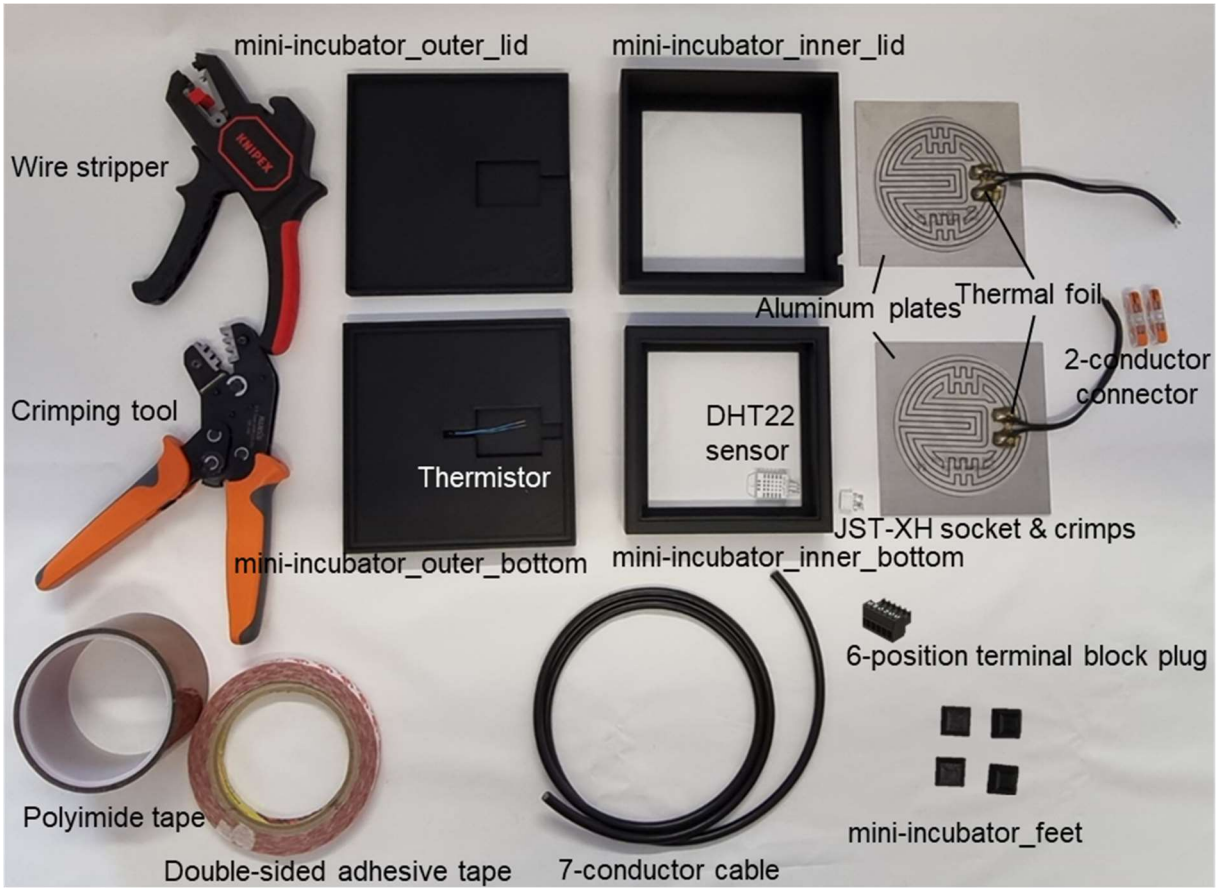
Alupanels left and right

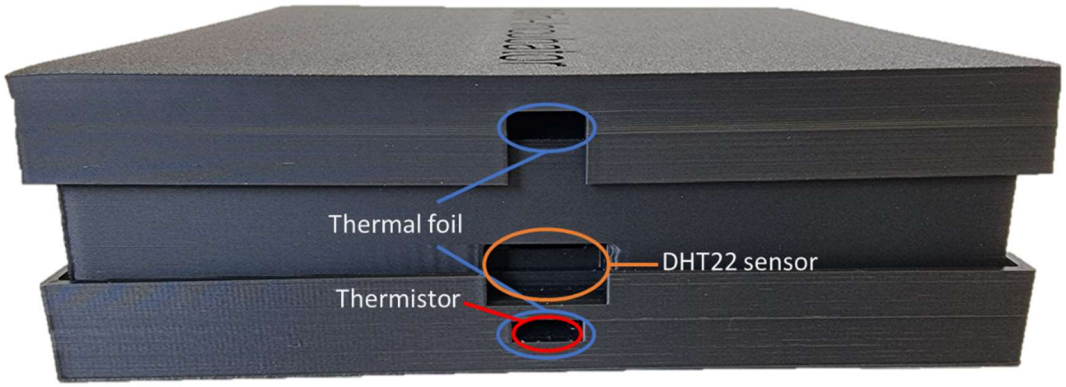
- Mount the panels onto the respective frames with M3x8 screws.
- The matt panel side should be inside.



Mini-Incubator

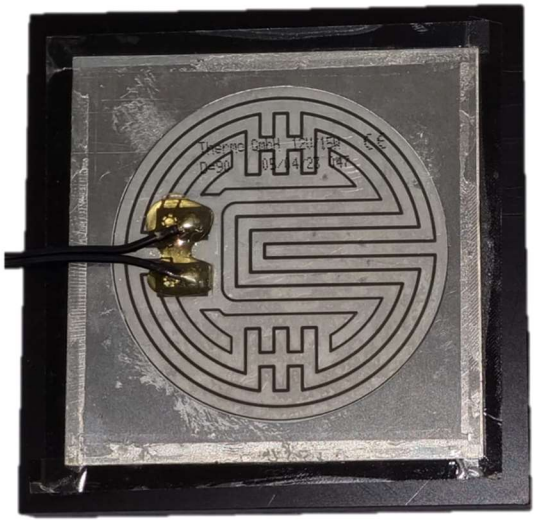
Materials	Qty
2-conductor connector (WAGO)	2
Polyester thermal foil 15W	2
DHT22 sensor	1
NTC-Thermistor, 100 kΩ	1
Aluminum plate, 110 x 110 x 2 mm	2
7-conductor cable, 22 AWG	1
JST-XH, female socket, 4 pins	1
JST-XH, crimp contact, socket	3
3D printed mini-incubator_inner_bottom	1
3D printed mini-incubator_outer_bottom	1
3D printed mini-incubator_inner_lid	1
3D printed mini-incubator_outer_lid	1
3D printed mini-incubator_feet	1
Crimping Tool	1
Wire Stripper	1
Double-sided adhesive tape	1
High Temperature Polyimide Film Tape	1


mini-incubator_outer_lid
mini-incubator_inner_lid
Wire stripper
Aluminum plates
Thermal foil
2-conductor connector
Crimping tool
DHT22 sensor
Thermistor
JST-XH socket & crimps
mini-incubator_outer_bottom
mini-incubator_inner_bottom
6-position terminal block plug
Polyimide tape
mini-incubator_feet
Double-sided adhesive tape
7-conductor cable


Thermal foil
DHT22 sensor
Thermistor

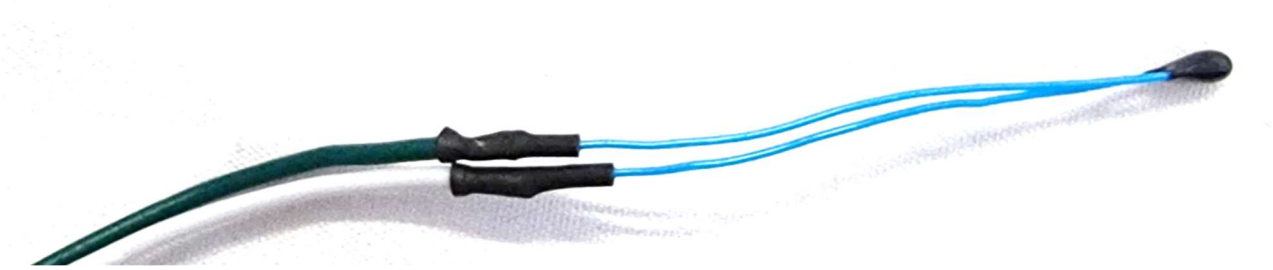
- Stick the self-adhesive thermal foils centrally onto the aluminum plates

- Place the aluminum plates onto the respective cutouts of 3D printed parts mini-incubator_inner_bottom and mini_incubator_inner_lid with the cables showing in the direction of the cutouts. Fix the aluminum plates with double-adhesive tape.



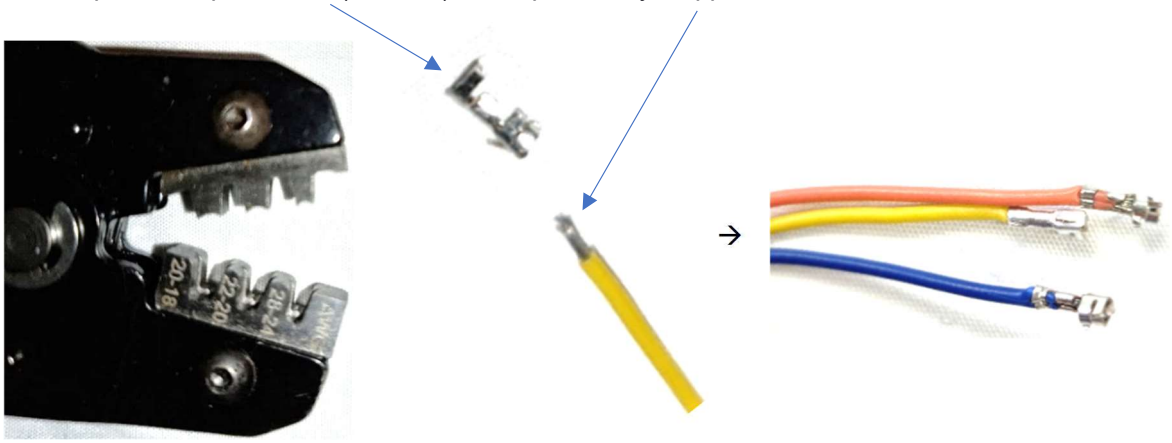
- Strip 8 cm of insulation from one side of the 7-conductor cable.

- Solder the thermistor to the green and white wire.

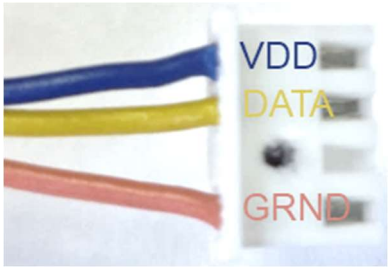


- Strip the yellow, orange and blue wire by 2-3 mm.

- Crimp the crimp contacts (JST-XH) to the previously stripped wires.

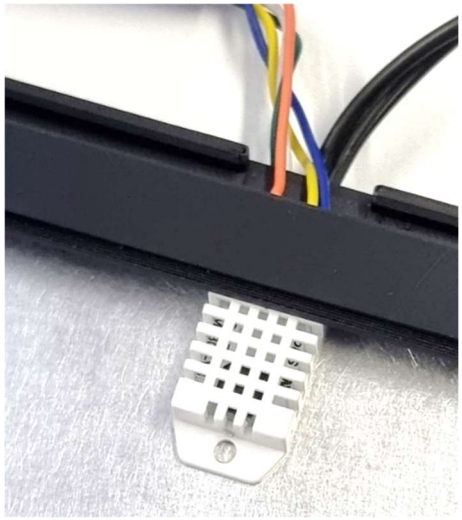


- Insert the crimped wires into a female JST-XH socket with 4 pins, leaving one space empty.

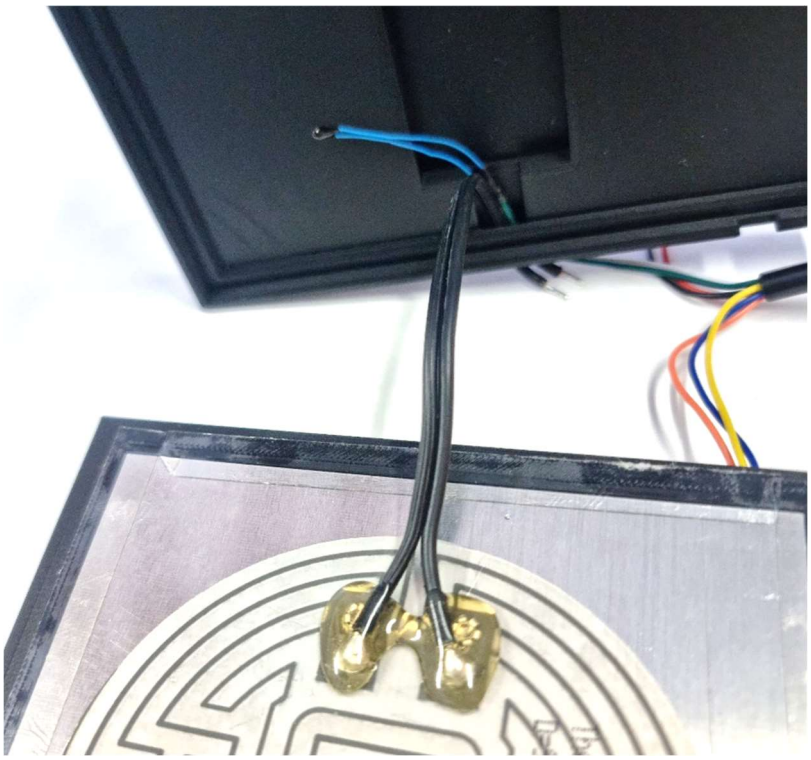


- Strip the red and black wire for the thermal foils by 11 mm.

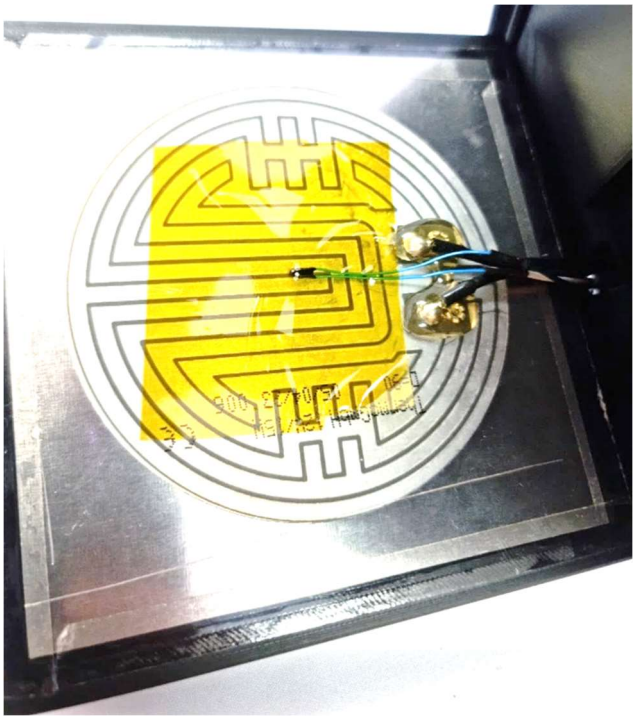
- Put the prepared JST-XH socket into the respective cavity of the printed mini-incubator_inner_bottom part and plug in the DHT22 humidity sensor from the inside.



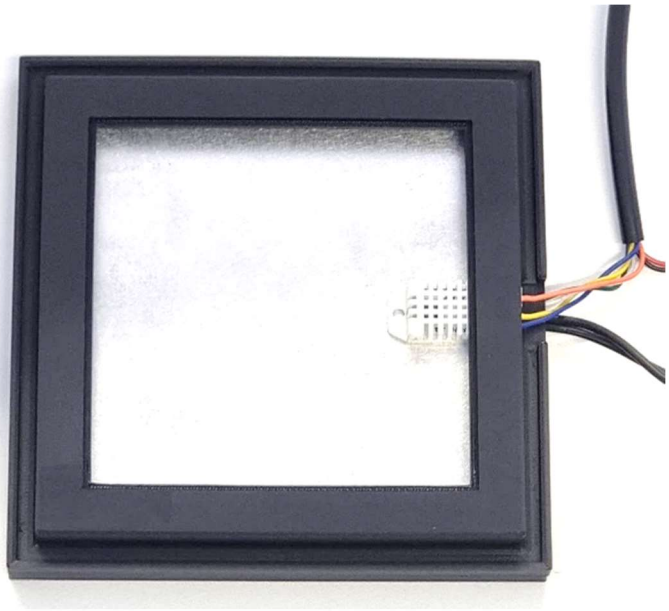
- To build the bottom part, lead the thermistor through the cavity to the inside of the mini-incubator_outer_bottom part and the cables of the thermal foil of the mini-incubator_inner_bottom part through the cavity to the outside.



- Fix the thermistor centrally on the thermal foil using polyimide tape.

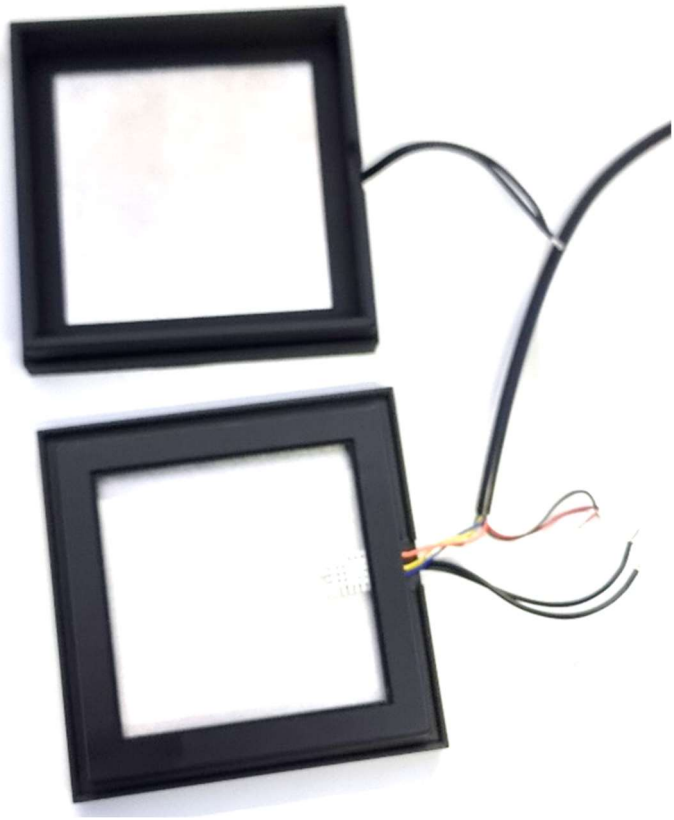


- Put the prepared inner and outer bottom parts together. They will be fixed together with the double-sided adhesive tape.

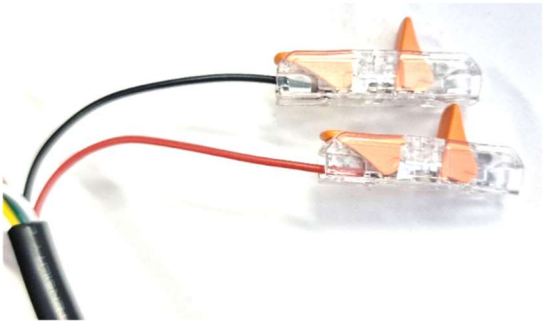


- Put the outer part of the lid on the inner part, paying attention to the cutouts. They will be fixed together with the double-sided adhesive tape.

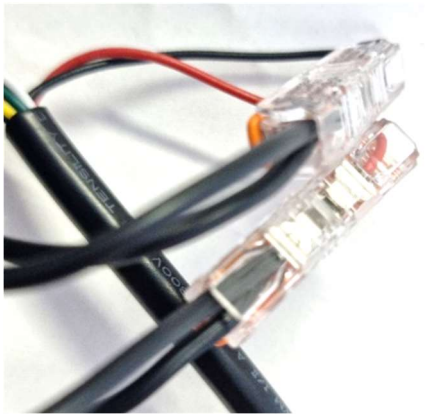
The assembled parts should look like this.



- Connect the stripped red and black wire of the 7-conductor cable to a 2-conductor connector.



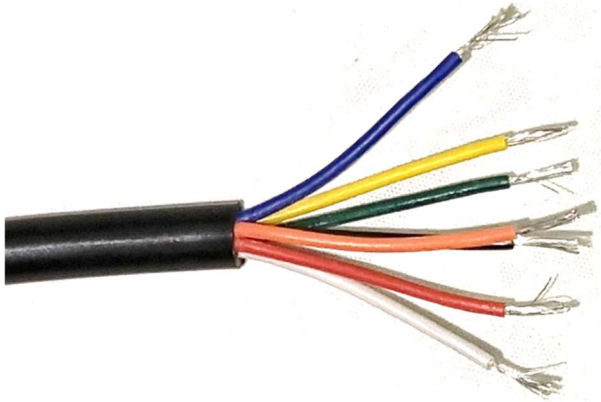
- Connect one cable each of the lid and bottom thermal foils (polarity does not matter) to one of the 2-conductor connectors.



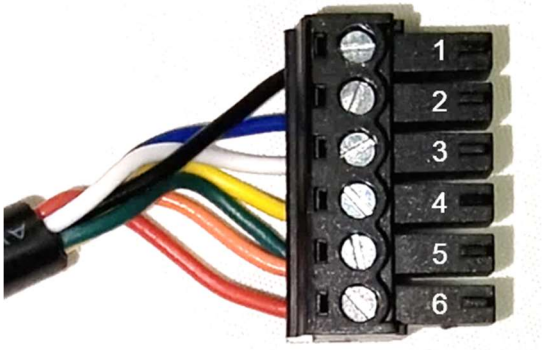
- Attach the 3D printed mini-incubator_feet in the edges of the bottom with the double-sided adhesive tape.

Connection of the Mini-Incubator to the 2LabsToGo system

- Strip the 7-conductor cable on the other side by 3 cm.
- Strip all wires on this side by 7 mm.



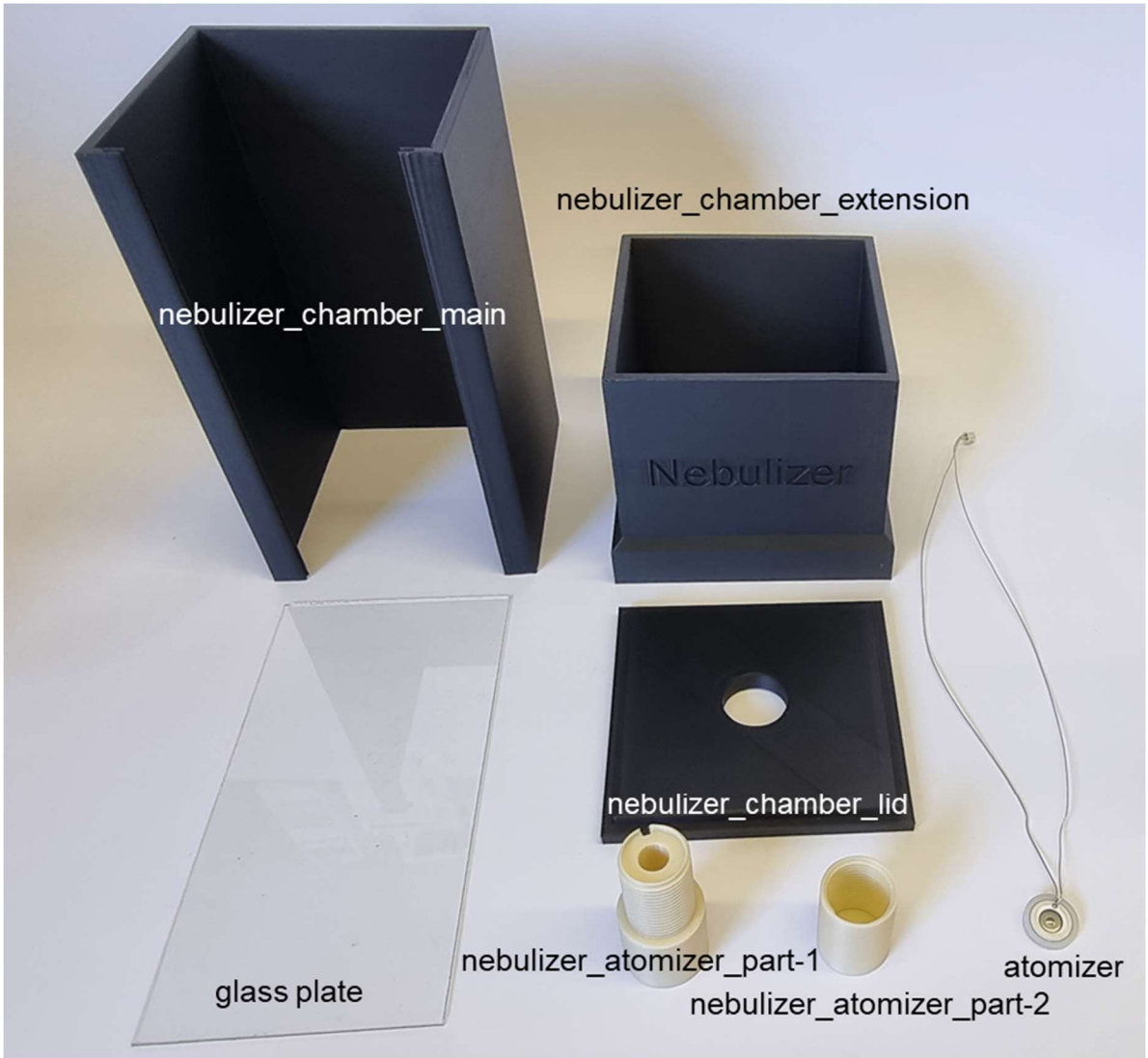
- Put the wires as shown in the 6-position terminal block plug and tighten them with the screw.



Position	Wire color	Function
1	black	Heater GND
2	blue	DHT22 +5V
3	white	Thermistor +5V
4	yellow	DHT22 data
5	green/orange	Thermistor/DHT22 GND
6	red	Heater +12V

Nebulizer

Materials	Qty
3D printed nebulizer_chamber_main	1
3D printed nebulizer_chamber_extension	1
3D printed nebulizer_chamber_lid	1
3D printed nebulizer_atomizer_part-1	1
3D printed nebulizer_atomizer_part-2	1
Glass plate 200 x 100 x 1.2 mm	1
Ultrasonic Piezo Atomizer 16 mm 108 kHz	1+



- Insert the glass plate into the respective slits of the 3D printed nebulizer_chamber_main part of the Nebulizer.

→

- Put the 3D printed nebulizer_chamber_extension part of the Nebulizer on top of the 3D printed nebulizer_chamber_main part with the lettering in front.

- Put the 3D printed nebulizer_chamber_lid part on top of the previously assembled main chamber.

- Place the atomizer as shown in the 3D-printed nebulizer_atomizter_part-1.

- Screw the 3D-printed nebulizer_atomizer_part-2 onto the main part while pressing the cables of the atomizer into the cable duct.

- For usage, place the atomizer holder in the cavity in the lid of the chamber.

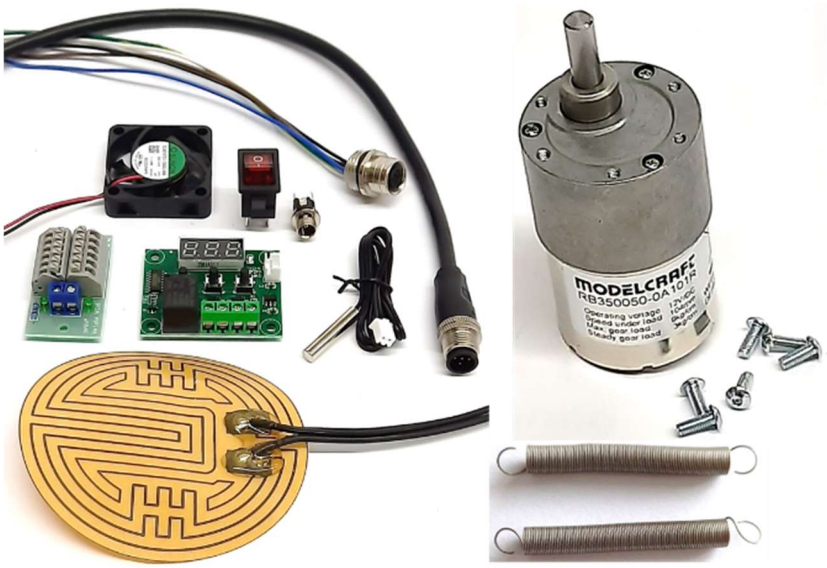
Cleaning the Nebulizer

1. Wash out the atomizer 3 times with distilled water and dispose the cell waste (if cells have been sprayed) without the cable coming into contact with the water.
2. Wipe the atomizer from below with a wet paper cloth (with distilled water) to remove any residue.
3. Wipe the inside of the chamber with the used cloth.
4. Fill the atomizer with 2 mL ethanol and spray in the previously used chamber on a fresh paper cloth.
5. Let the atomizer dry on a paper cloth.
6. Rinse out the chamber with a spray bottle containing a mixture of ethanol/water 7:3.
7. Rinse the chamber completely with distilled water.
8. Let the chamber dry on a paper cloth.
9. Disinfect the sprayed area with ethanol/water 7:3 if cells were sprayed.

Mini-Shaker[9]

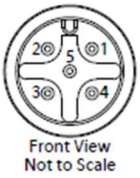
Materials (for ordering details see BOM list)	Qty
Gear motor Modelcraft RB350050-0A101R, 12 V, 1:50, 120 rpm	1
Rocker switch	1
DC chassis mount socket, 5.5 mm/2.1 mm	1
Extension spring, 50 mm => 200 mm (see data at the end of this instruction)	2
Screw M3x8, DIN 7380	6
Screw M3x8, DIN 912	9
Screw M3x10, DIN 912	14
Screw M3x16, DIN 912	4
Nut M3	6
Ball bearing, 22 mm x 8 mm x 7 mm	5
ONPIRA Power distributor, 8 A, 2 x 6 positions	1
XH-W1209 T Thermostat board, 12 V	1
5-Pin plug male to 22 AWG wire leads 50 cm	1
Receptacle 5 poles female to 22 AWG leads 50 cm	1
Eurostyle terminal strip with screws, 12 positions, 0.5 - 1.5 mm^2	1
Shrink tube, 2 mm ID, 2 cm	2
Cable Assembly 2.5mm ID, 5.5mm OD Plug to Plug (1.83m)[10]	1
Self-adhesive device foot	4
Glass plate, 87 mm x 87 mm x 1 mm	1
Double-sided tape, 6 mm x 15 cm	1
3D-printed mini-shaker_case	1
3D-printed mini-skaker_case_cover	1
3D-printed mini-shaker_platform_support	1
3D-printed mini-shaker_motor_adapter	1
3D-printed mini-shaker_excenter	2
3D-printed mini-shaker_burling	3
3D-printed mini-shaker_platform	1
3D-printed mini-shaker_board_holder	1
3D-printed mini-shaker_heated_hood	1
3D-printed mini-shaker_heated_hood_cover	1
3D-printed mini-shaker_heated_hood_cable_support	1
3D-printed mini-shaker_washer	2

[9] Inspired by a Thingiverse project (www.thingiverse.com/thing:2633507), modified in many aspects.
[10] Alternatively, use a power supply, 12 V, 5 A, plug 5.5/2.5 mm



Preliminary remarks: For the following photos, separate black and red wires were used.
However, from the cuts of the 5-pole receptacle and the 5-pin plug male to wires, enough wires are left to be used for the connections described, 25 cm and 40 cm wires from the 5-pin plug cable and the 5-pole receptacle, respectively. Instead of red wires, also the 35 cm brown wire left over from the 5-pole receptacle can be used for destinct plus (+) connections.
However, the colour of the wires could be different; check the respective data sheets for colour and pin numbers.

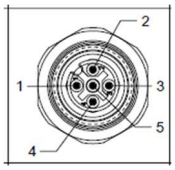
plug



Front View
Not to Scale

Wiring Diagram	
50-00960	wire color
1	red
2	yellow
3	black
4	white
5	blue

receptacle

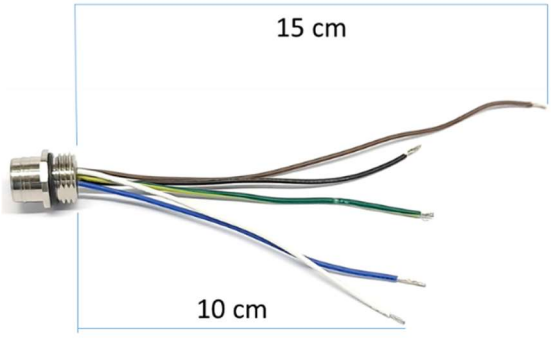


IEC 60947-5-2	
PIN	COLOR
1	BROWN/braun
2	WHITE/Weiß
3	BLUE/blau
4	BLACK/schwarz
5	GRAY OR GREEN-YELLOW/ grau oder grüngelb

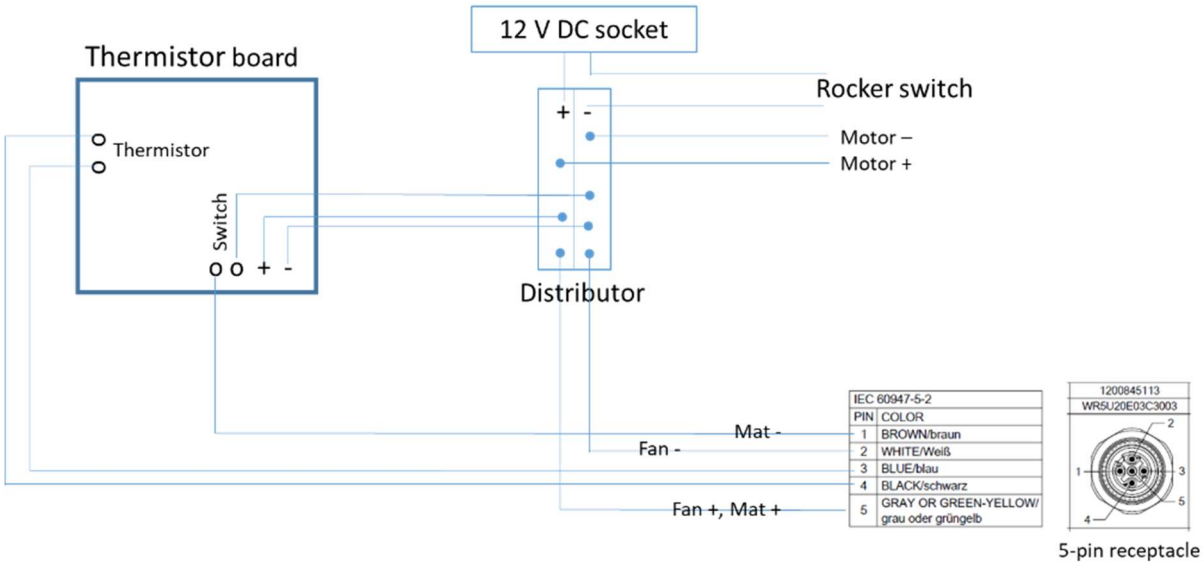
(copied from the repective data sheets)

- Cut the 5-pin plug male to wires to a length of 25 cm. Strip off 4 cm of the outer insulation. Then, strip off 8 mm from each of the 5 wire ends.

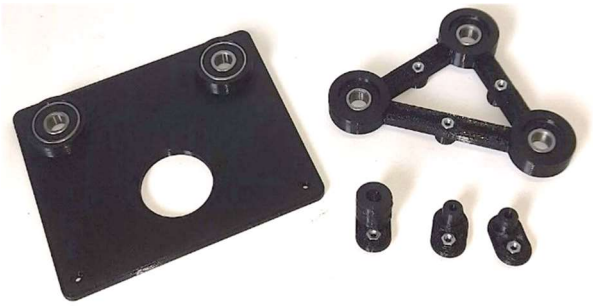
- Cut the brown wire of the 5-pole receptacle to 15 cm, the rest of the wires to 10 cm. Strip off 8 mm from the blue and black wire ends, 6 mm from the other three wire ends.



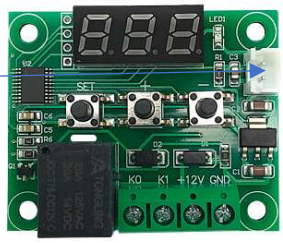
Wiring diagram – Mini-Shaker case



Assembly



- Place the five ball bearings in the mini-shaker_platform_support and the mini-shaker_cover while fixing them with two drops of superglue at the bottom of the cutouts.
- Press three M3 nuts into the shaker_platform_support. From the opposite side, screw in an M3 screw to draw the nut completely into the cutout (the screw is unscrewed again). Analogously, press one M3 nut into the mini-shaker_motor_adapter, and one M3 nut in each mini-shaker_excenter.

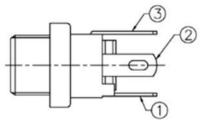


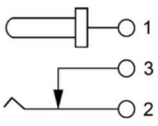
- Unsolder the white plug from the top of the thermistor board and solder it to the bottom of the board.

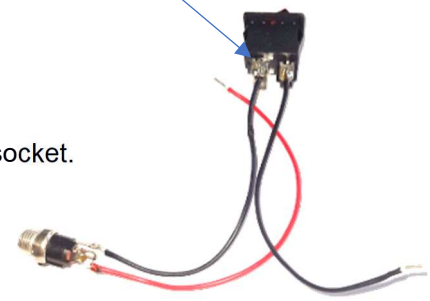
- Solder two wires (brown and black, 12 cm each) to the motor (brown to + and black to -).
- Insert the motor from the bottom of the mini-shaker_case (motor axle pointing inside) and fix it with six M3x8 screws (DIN 7380, pan head screw). Then guide the two wires through the side-cutout inside the case.

- Solder two black wires (12 cm each) to the two pins (on the same side) of the rocker switch.

- Solder one of the black wires to pin 2 (-) of the DC chassis mount socket.

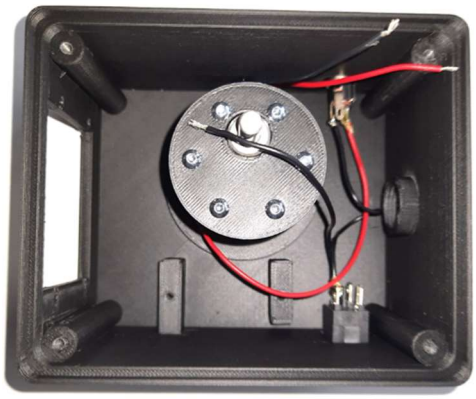




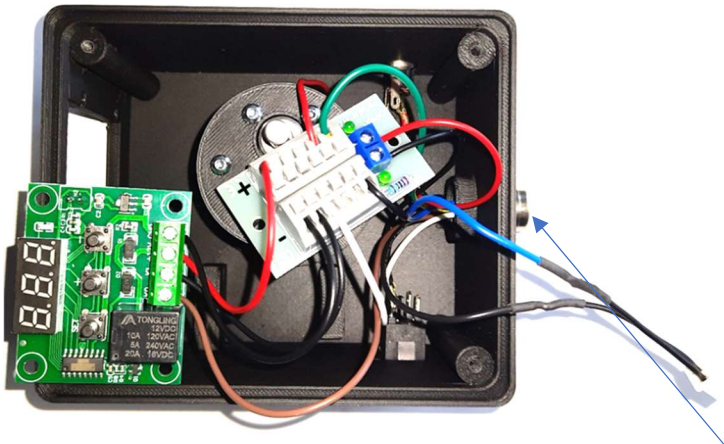


- Solder one brown wire (12 cm) to pin 1 (+) of the DC chassis mount socket.

- Insert the Rocker Switch into the cutout in the front of the mini-shaker_case by guiding the DC chassis mount socket in.
- Push the DC chassis mount socket through the hole in the back of the mini-shaker_case and fix it with the respective screw from outside (with a washer).



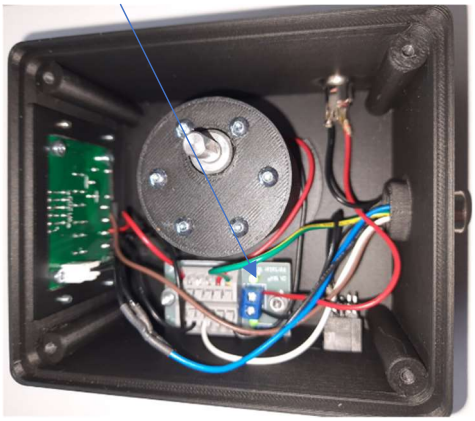
- Connect the brown wire (coming from the DC chassis mount socket) and the black wire (coming from the rocker switch) to the power distribution board (blue screwable plug). The black and the brown wire now marks the minus (-) and plus (+) ports row of the distribution board (power in).



- Connect the thermistor board with brown (+ 12V) and black (- GND) wires (8 cm each) to the power distribution board (plus to plus, minus to minus/GND).
- Connect the switch port K1 of the thermistor board with a black wire (8 cm) to a minus port of the power distribution board.

- Guide the cables of the 5-pole receptacle from outside into the mini-shaker_case (thread cutout on the right side) and screw in the receptacle. Use the DC-power-jacket_housing_cover as tool.
- Connect the brown cable of the 5-pole receptacle to the other switch port (K0) of the thermistor board.
- Connect the white cable of the 5-pole receptacle to a minus port of the power distribution board.
- Connect the green-yellow cable of the 5-pole receptacle (pin 5 of the receptacle) to a plus port of the power distribution board.
- Cut the thermistor cable at a 5-cm distance from the plug and strip the wires by 8 mm. Connect them (soldering or twisting) to the blue and black wires of the 5-pole receptacle and protect the connections with shrink tubes (1 cm).

- Connect the brown and black motor cables to a plus and minus port of the power distribution board, respectively.
-
- With two M3x10 screws and the two white spacer washers (delivered with the board), mount the power distribution board onto the 3D-printed sockets at the bottom inside the mini-shaker_case, the blue plug pointing to the rocker switch.



- Insert the thermistor board into the 3D-printed mini-shaker_board_holder and fix it with four M3x8 screws (plus the 3D-printed washers for the two upper screws in the smaller part of the board holder).
- Connect the white thermistor plug to the thermistor board.
- Press the mini-shaker_board_holder from inside into the cutout on the left side of the mini-shaker_case and fix it with four M3x8 screws, inserted from outside.

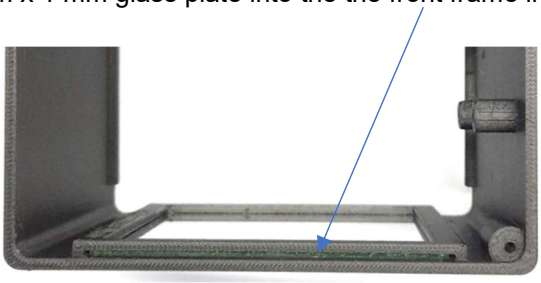
- Press the two excenters into the ball bearings of the mini-shaker_cover, while fixing them with a drops of superglue (if needed). Place the cover onto the mini-shaker_base (ball bearings with excenters upside), and fix the cover with four M3x10 screws.
- Place the mini-shaker_motor_adapter over the motor axle and fix it with an M3x8 screw pointing to the flattened side of the axle. Do not overwind the screw! The motor adapter's height is adjusted after the platform support is mounted (next step).

- Press in the three mini-shaker_burlings into the three ball bearings of the platform-support (use a drop of superglue to fix them if needed).
- Place the mini-shaker_platform_support (nuts pointing downwards) onto the excenters and the motor_adapter and mount it with three M3x10 screws. (turn the motor axle slightly to meet the M3 nuts

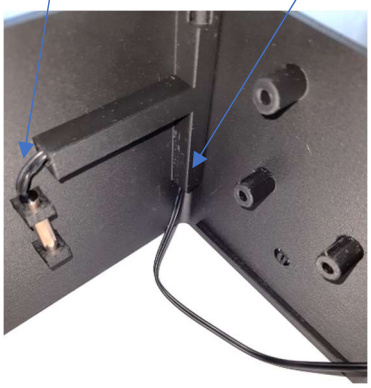
- Loosen the screw of the motor adapter slightly and let the platform support freely adjust in height; then fix the motor adapter screw again.

- Place the mini-shaker_platform onto the platform support and mount it with three M3x10 screws.
- Fix the two extension springs in the third hole at each side (see image below).
- Stick four self-adhesive device feet under the mini-shaker_case to avoid moving on the desk surface during shaking.
- Fill a 100-mL conical Chicane flask with max. 25 mL culture to ensure a good oxygen transfer into the culture during shaking. Insert the Chicane flask. The motor speed is fixed at the maximum (not adjustable).

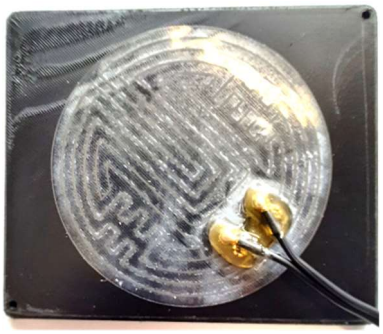
- Insert the 87 mm x 87 mm x 1 mm glass plate into the the front frame inside the heated_hood.



- Insert the thermistor (cable up) into the holder on the backside of the heated hood. Guide the cable through the cable channels downwards. Cut the cable at 6 cm measured from the end of the cable channel. Strip off 8 mm of each of the two wires.

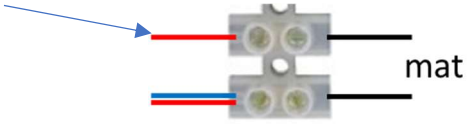


- Mount the fan onto the four short columns on the the right side of the heated_hood with four M3x16 screws.
- Remove the protecting film from the heating mat. Take the mini-shaker_heated_hood_cover and position the cable of the heating mat exactly pointing to the edge labelled cable (edge without a hole) and stick it centrally on the heated_hood_cover.



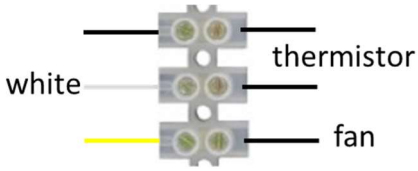
- Place the heated_hood_cover onto the heated_hood by guiding the heating mat cable into the right back cable channel downwards and mount the cover with two screws M3x10.

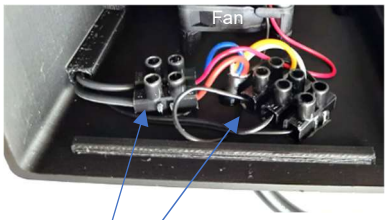
- Guide the 5-pin plug cable from outside through the hole on the right side of the heated_hood to the inside.
- Cut two positions from the terminal strip and connect the two wire ends of the heating mat to it. Connect the red cable of the 5-pin plug cable to the opposite side of the terminal strip.



- Cut the fan cable to 10 cm and strip off 8 mm from the wire ends.
- Twist (or solder) the red fan wire together with the blue wire of the 5-pin plug cable and connect both to the terminal strip.

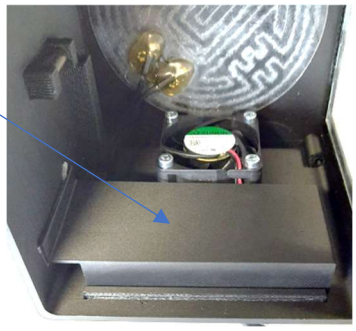
- Cut three positions from the terminal strip and connect the two thermistor wires individually to it. On the opposite side of the thermistor wires connect the black and white wire of the 5-pin plug cable to the terminal strip.





- Connect the black wire of the fan to the 3-position terminal strip and then the yellow cable of the 5-pin plug cable to the opposite side.

- With the help of double-sided tape (or super glue) fix both terminal strips underneath the fan at the right wall of the heated_hood.
- Finally, mount the mini-shaker_heated_hood_cable_support with the help of double-sided tape (or supperglue) inside onto the right wall directly underneath the fan.



Mini-Shaker to power (12 V)

- Connect the cable assembly (2.5mm ID, 5.5mm OD Plug to Plug) to the DC socket of the mini_shaker_case and the respective socket of the 2LabsToGo mainboard.

To alternatively operate the mini-shaker as a stand-alone device, a separate power supply (12 V, 5 A, plug 5.5/2.5 mm) is needed.

- Switch the rocker switch to on, when the shaker starts shaking with the maximum shaking speed of 120 rpm (not adjustable). The heating hood must not be connected in this moment. The LCD displays 888 indicating that no thermistor is connected.

Operational control

Before using the thermostat board, some settings must be performed in the options menu (see table below).

- Press the SET button for longer than 3 s to enter the menu with the option P0 to set the mode of operation. The preset is C (cooling control). Press the SET bottom briefly followed by pressing the + bottom to switch to heating control (H). Press the SET bottom briefly to save the value.
- Press the + bottom briefly to enter the option P1 to set the return difference. Press the SET bottom briefly and use the - bottom to set this value to 0.2 (°C). Press the SET bottom to save the value.
- Press the + buttom briefly to enter the option P2 to set the upper temperature limit. Press the SET bottom briefly and use the - bottom to set this value to 50 (°C). Press the SET bottom briefly to save the setting.
- Switch the shaker off.

- Put a flask with 25 mL water (normally the culture flask) in between both springs to have it fixed.
- Place the heating hood onto the shaker platform and connect the 5-pin plug to the 5-pole receptacle.
- Switch the shaker on, the LCD display shows the actual temperature inside the hood.
- Press the SET buttom briefly and use the + bottom to set the temperature to 37 °C, followed by briefly pressing the SET buttom. The hood is heating up to the set 37 °C, which takes about 15 min until the LCD display provides a constant temperature of 37 ± 0.2 °C.

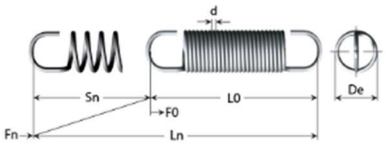
- Let it run 30 min while having an eye on the temperature. Then switch off the mini-shaker, remove the heating hood and and place it top down on the desk. Take off the flask, place it inside the heating hood to prevent rapid cooling, and immediately measure the temperature of the water with an external thermometer.
  Adjust the temperature deviation in the option P4 of the setting menu.
  Example: When the temperature measured is only 35.5 °C, then the temperature adjust is set to -1.5 to reach finally 37 °C for the subsequent measurement.
- Repeat the incubation at 37 °C for 30 min and check if the temperture is correct now.

Options table

Press the SET bottom for longer than 3 s to enter the options menu of the thermistor board.
With the + and – bottom switch between the codes. After briefly pressing the SET buttom the respective value is presented and can be changed with the + and – bottoms. Thereafter, briefly press the SET buttom to save the value.

Code	Indicating	Set range	Initial Setting
P0	Mode set (Heating or Cooling)	C/H	C
P1	Set return difference, °C	0.1-15	2
P2	Up limit, °C	110	110
P3	Down limit, °C	-50	-50
P4	Temp. Adjust, °C	-7 to +7	0
P5	Delay start time, min	0-10	0
P6	High temp. Alarm, °C	0-110	off

Springs for the platform support
www.industrial-springs.com/e02400182000s



Material	Stainless steel 302
d - Wire diameter (mm)	0.46
De - External diameter (mm)	6.10
L0 - Unloaded length (mm)	50.80
Ln - Max. loaded length (mm)	219.46
Sn - Maximum travel (mm)	168.66