



## 2.1 Translation stage subassembly

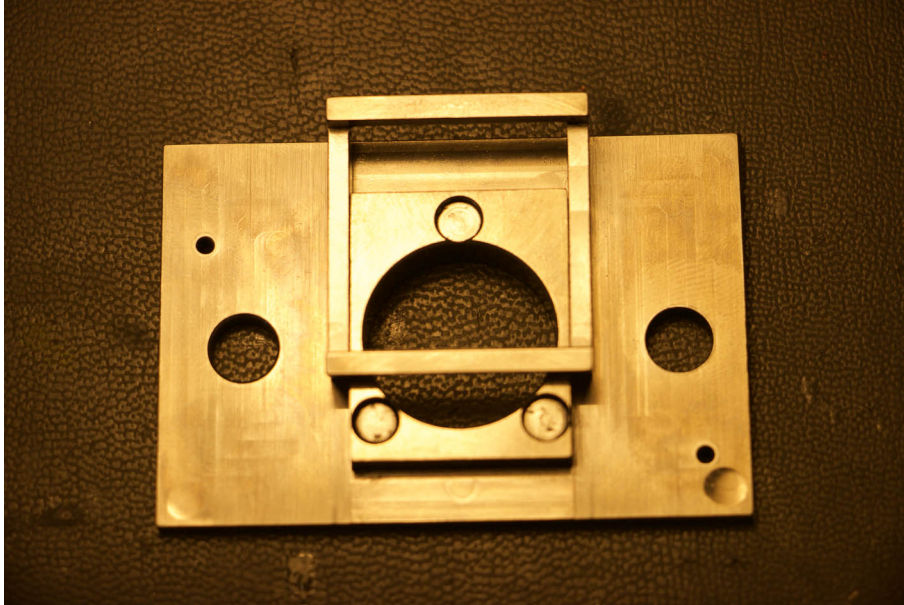


Figure 2: The **translation stage middle guide** must glide easily, but without slop, on the **translation stage top plate**. The sides of the boss of the **translation stage top plate** may need to be polished. We typically use a very fine-grit sandpaper or grindstone for this purpose.



Figure 3: Place a small amount of epoxy glue (2-tonne is best) into the bottom of the holes in the **translation stage bottom plate** with the **3 mm steel balls** placed at the top of the hole.

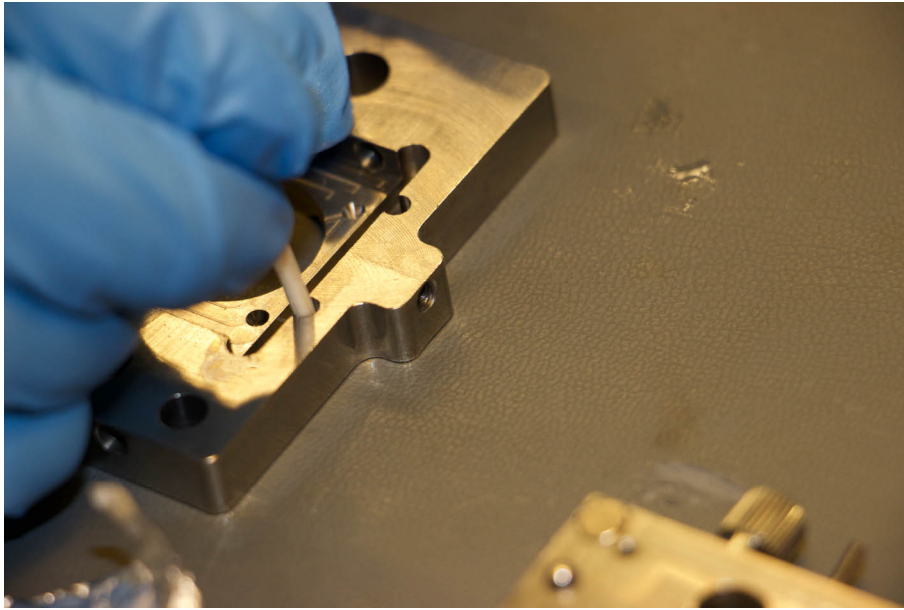


Figure 4: Press the two **3 mm steel balls** down into place with a small stick or other similar object.

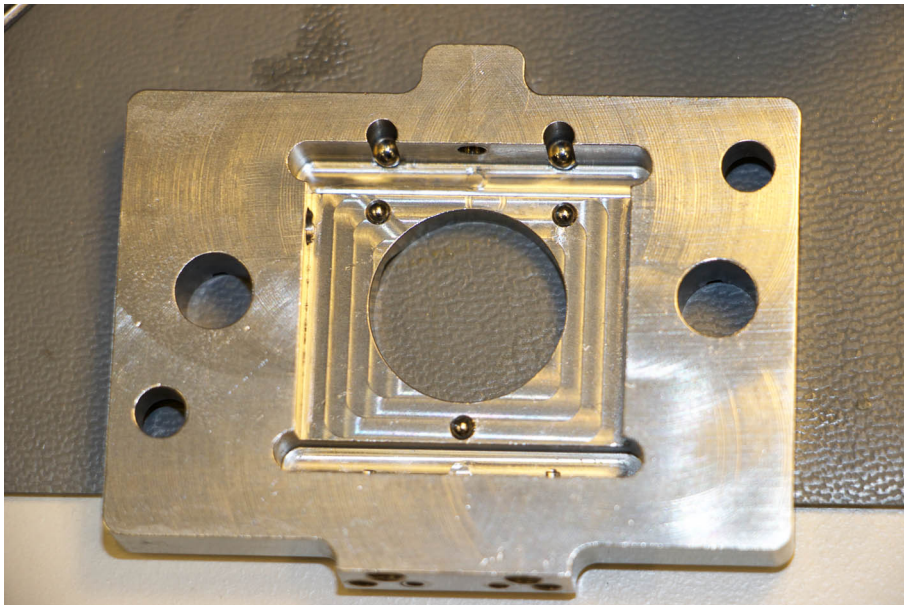


Figure 5: Glue the three **2 mm steel balls** into place with small amounts of glue placed in the conical holes. Avoid excess glue spilling out and covering the steel balls.

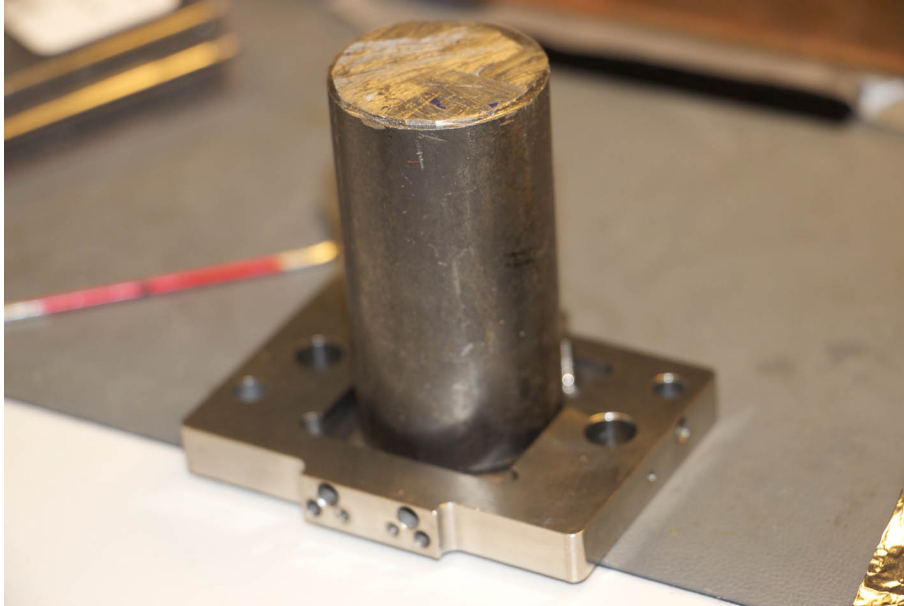


Figure 6: A suitable weight can help to seat the **2 mm steel balls** while the glue cures.



Figure 7: The **translation stage middle guide** gets held in place by the two **3 mm steel balls** that were glued in in the previous step, and two **2.5 mm steel balls** that are held in place by two compression springs (Gutekunst Federn model **D-042F-03**) and two **3 mm flat end set screws** (4 mm length could also work). First ensure that the surface of the **translation stage bottom plate** upon which the **translation stage middle guide** slides (including the **3 mm steel balls**) is clean and greased lightly. Set the **translation stage middle guide** in place and hold it with a finger. Drop the greased **2.5 mm steel balls** into the tapped M3 holes in the back of the **translation stage bottom plate**, followed by the **D-042F-03** springs, and the **3 mm set screws** with some thread lock. Tighten the screws until there is a significant restoring force on the **translation stage middle guide**, but that it still slides easily.

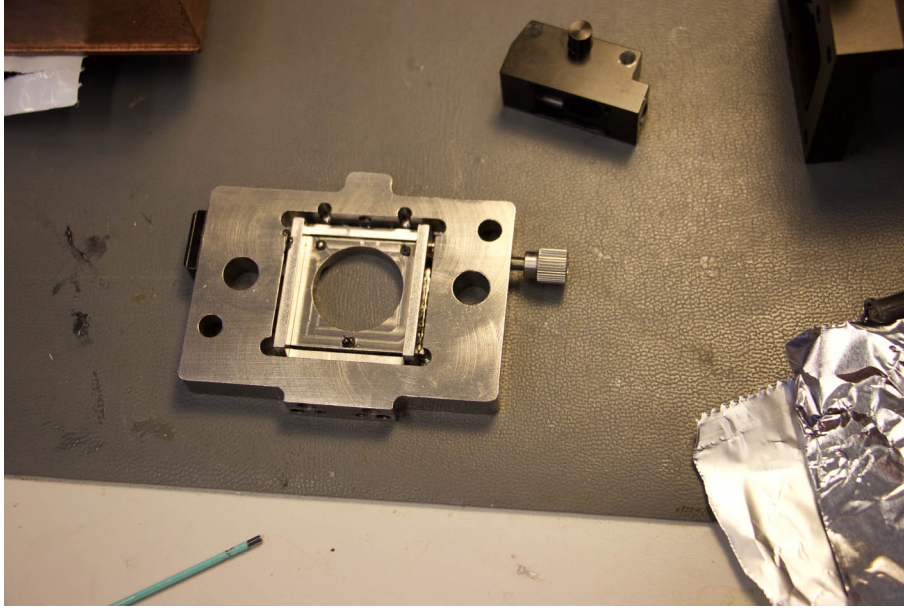


Figure 8: The horizontal translation uses a Thorlabs **MAS20** M3×0.25 fine adjustment screw (or F3SS25 rod and F3SSK1 knob), with restoring force provided by a **1/8 in steel ball** and a compression spring (Gutekunst Federn model **VD-085H**). The spring is held in place with the **translation stage side stop**. Grease the adjustment screw, ball and spring and put in place. Compress the spring with the **translation stage side stop**, and fix it in place using two **M2x8 countersunk screws** with thread lock.

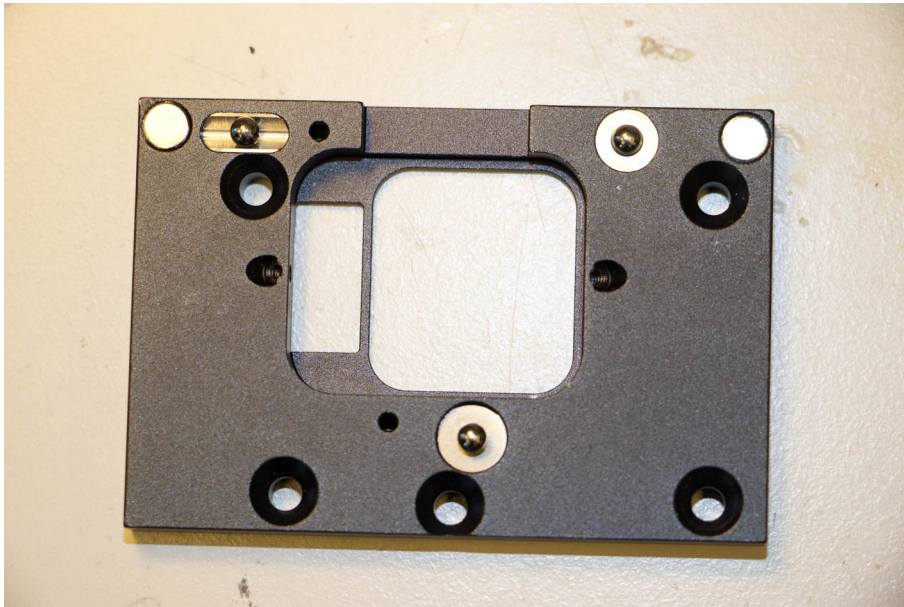


Figure 9: The **translation stage top plate** has 3 **sphere magnets** (Supermagnete **K-03-C**) that act as a kinematic mount for the head housing. It's best to use a partially-assembled **base plate** as an assembly jig to properly orient the **sphere magnets**.

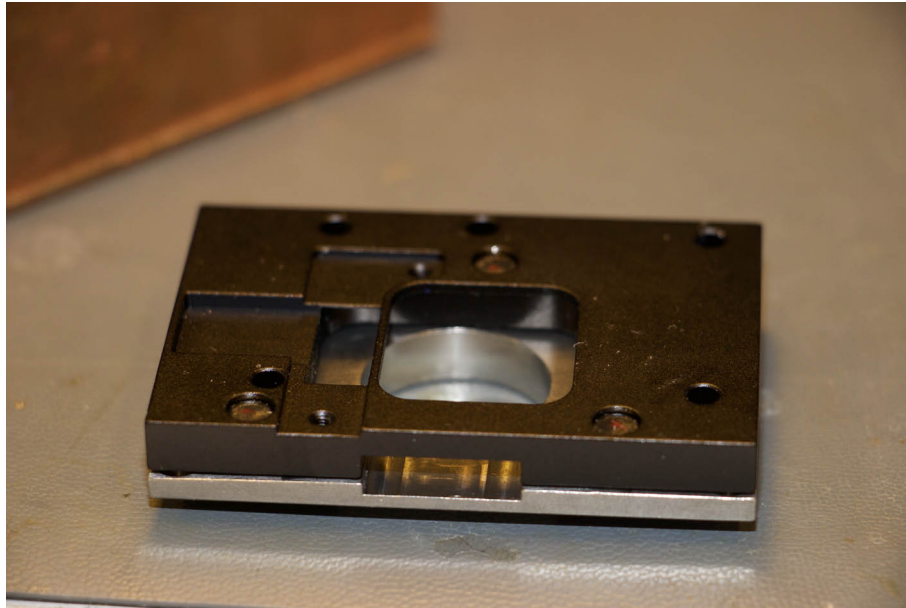


Figure 10: Put some glue onto the conical holes in the top of the **translation stage top plate** that will hold the **sphere magnets**. Don't use too much glue or the glue will overflow and cover the top of the **sphere magnets**. Place the **base plate** with the **sphere magnets** onto the **translation stage top plate** and use a large weight to seat the **sphere magnets** properly while the glue cures.

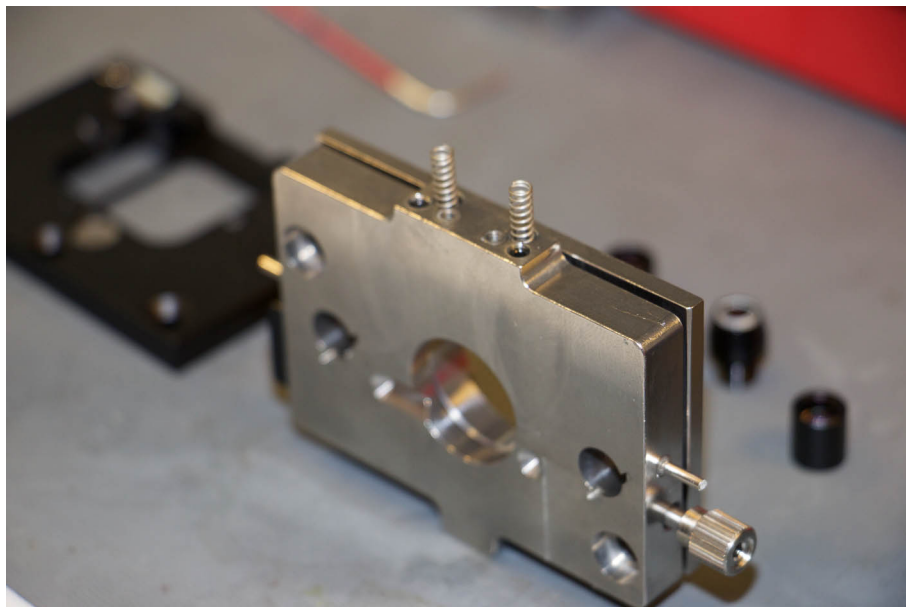


Figure 11: Grease the sides of the **translation stage top plate** that come in contact with the **translation stage middle guide**, and press it in place. Try to keep pressing it in place as much as possible while working to avoid having them separate. Drop into the holes in the back of the **translation stage bottom plate** two greased **1/8 in steel balls**, followed by two compression springs (Gutekunst Federn model **VD-057C**). Compress the springs with the **translation stage back stop** and hold in place with two **M2x8 countersunk screws** with thread lock.

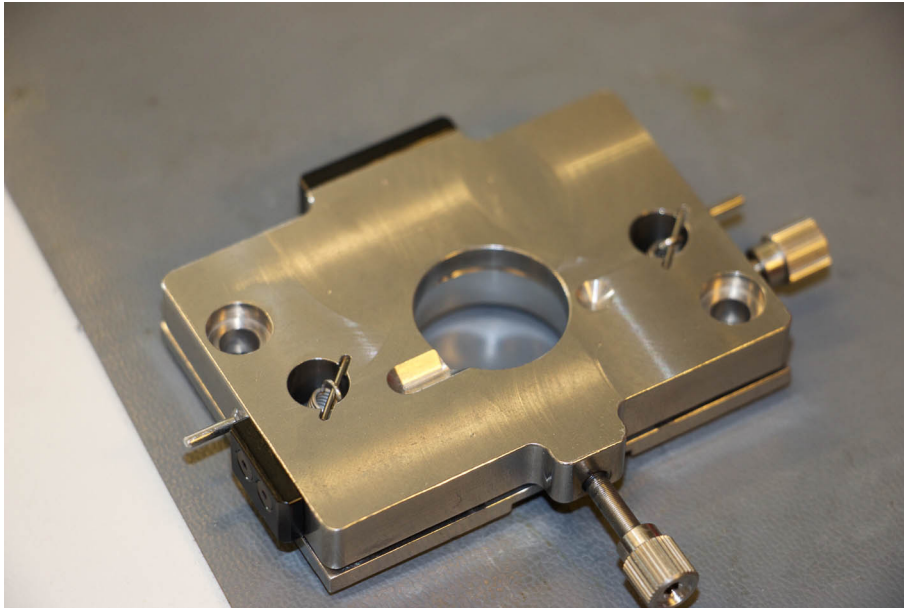


Figure 12: Place in the **translation stage tension springs** held by the **1x10 dowel pins**. The **translation stage tension springs** are Gutekunst Federn model **Z-024AAX**. Feed a **1x10 dowel pin** through one end of each **translation stage tension spring** and place the spring through the hole and seat the **1x10 dowel pin**. Then take a thin rod (a small hex key works well) and pry the other end of the **translation stage tension spring** until you can push the rod through and allow it to sit flat on the translation stage. (A sample photo of this can be seen in the optics block subassembly.) Then feed the other **1x10 dowel pin** in place, and remove the rod. You can also glue in the **side spring hooks** at this stage, or even earlier if you want. Use 2-tonne epoxy or equivalent. After the glue has set, bend the hooks upwards slightly. Screw in the two locking screws (**M2x8 socket head cap screws**) along with an **M2 washer** and an **M3 washer** in each. Tighten until the **translation stage top plate** can't rock at all but still can be translated easily, and apply some thread lock.

## 2.2 Base plate subassembly

It's a good idea to have an older **translation stage** handy to use as an assembly jig. The last steps of the subassembly also require the completed **cantilever holder**.

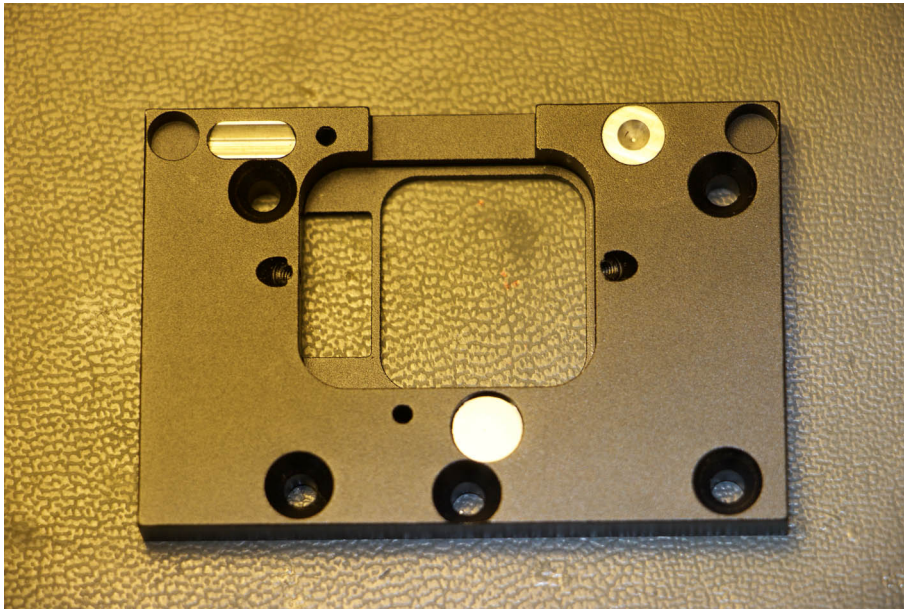


Figure 13: Begin by gluing in the **base plate flat insert**, the **base plate hole insert** and the **base plate slot insert**. 2-tonne epoxy is best.

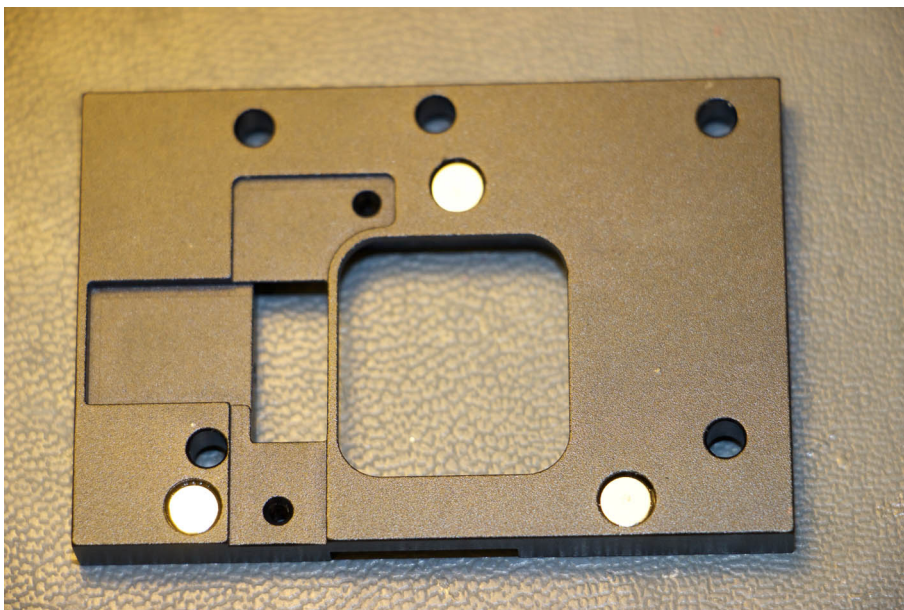


Figure 14: Right afterwards, you can also glue in the **5 mm disk magnets** on the back side. 2-tonne epoxy is best. Pay attention to the orientation of the magnets - use an old translation stage to serve as a reference.



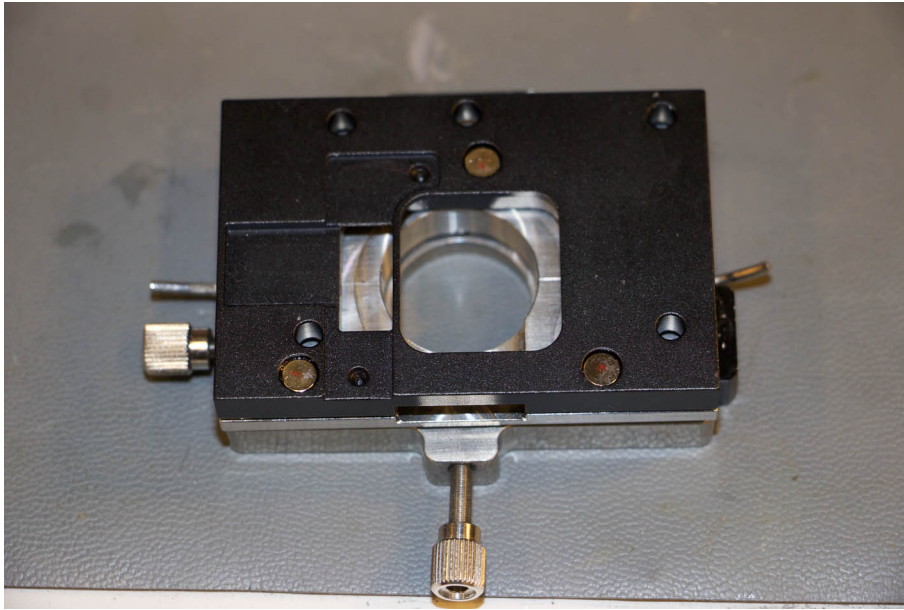


Figure 15: Set the **base plate** onto the **translation stage top plate**. Use a weight to hold it in place, and allow the glue to cure.

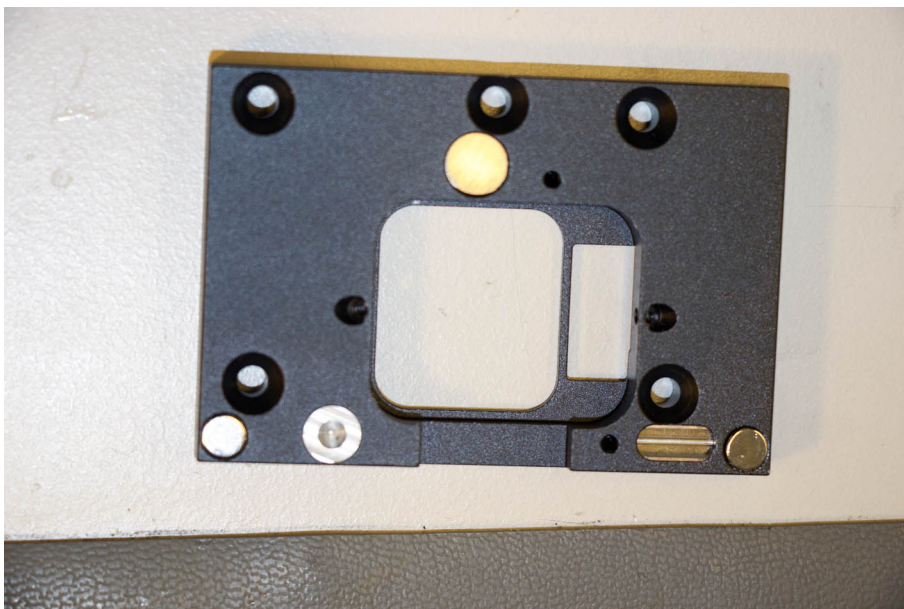


Figure 16: Again using an old translation stage as a reference for magnet orientation, glue in the two **5 mm disk magnets** in the corner of the **base plate**. 2-tonne epoxy is best.



Figure 17: Clean up as much excess glue as possible, then wrap the corners in Parafilm and place the **base plate** onto a flat surface with a large flat weight to press the magnets in place while the glue cures.

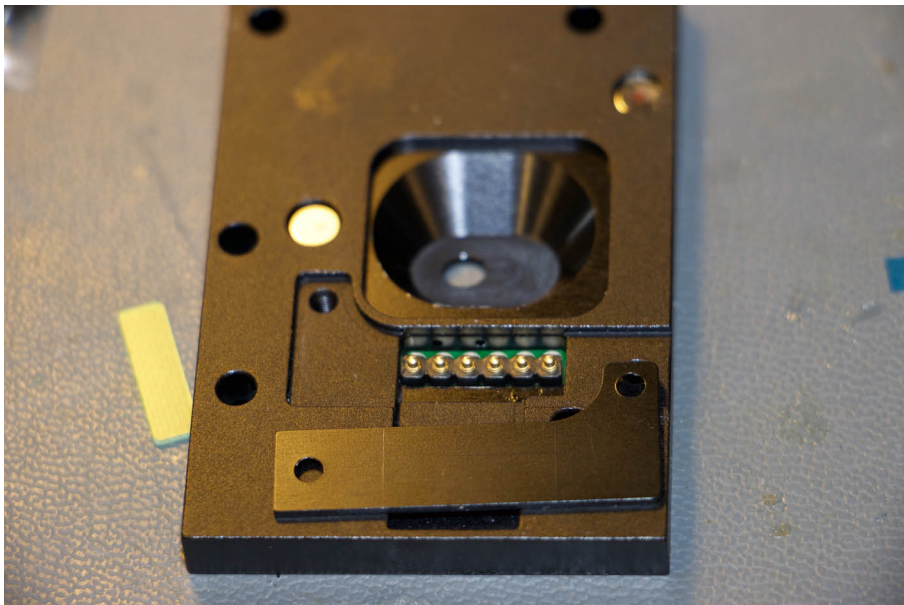


Figure 18: Put in the completed **cantilever holder** into the base plate and tighten the **M2 set screws** to fix it in place. Use the exposed **6-pin spring mount electrical connector** as a guide to mark out on the **base plate PCB cover** the proper position for the **base plate flex PCB** to be glued on the **base plate PCB cover**.

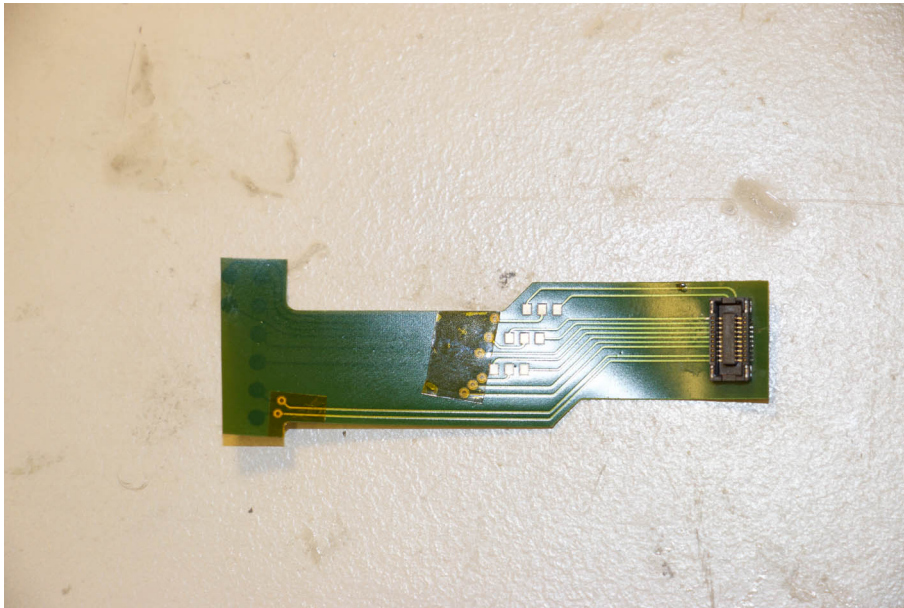


Figure 19: The **base plate flex PCB** needs to be protected in areas with kapton tape.

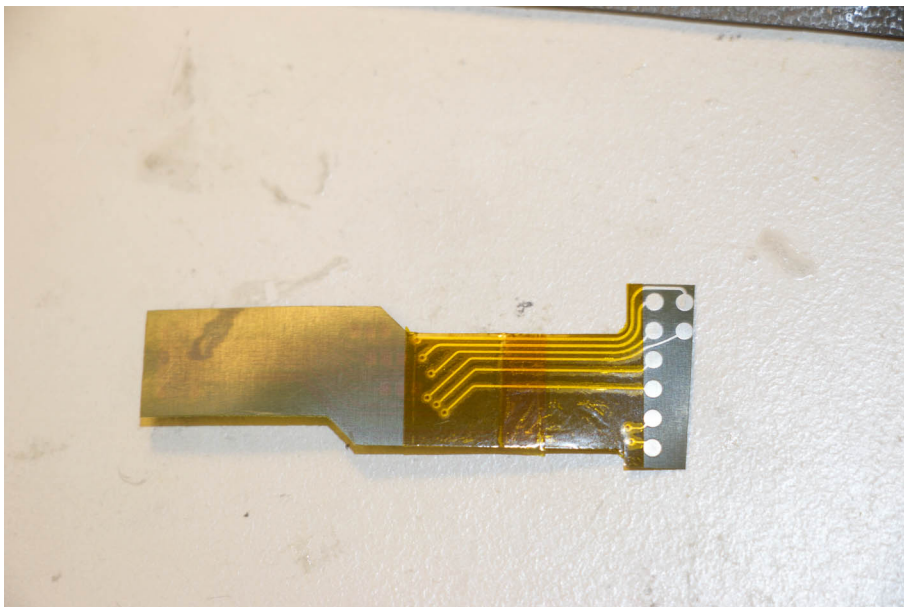


Figure 20: The **base plate flex PCB** needs to be protected in areas with kapton tape. Glue the **base plate flex PCB** onto the **base plate PCB cover**, with the pads oriented so that they will properly contact the **6-pin spring mount electrical connector**. When glued on the **base plate PCB cover**, some parts of the **base plate flex PCB** that extend past the front edge of the **base plate PCB cover** may need to be trimmed away.

### 2.3 Cantilever holder subassembly

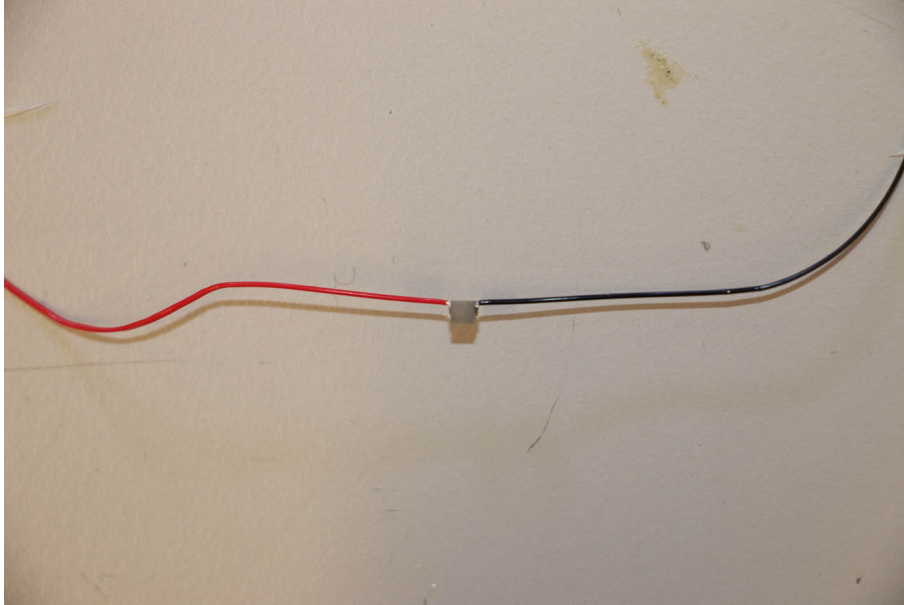


Figure 21: First take the **2x2x2 piezo** and carefully push the isolation as high up towards the piezo as possible, and bend the leads over so that they don't extend beyond the edge of the piezo. Be very careful, the leads can rip off the piezo very easily. Reinforcing with a bit of glue may help, but be sure to not get the glue onto the faces without the leads.

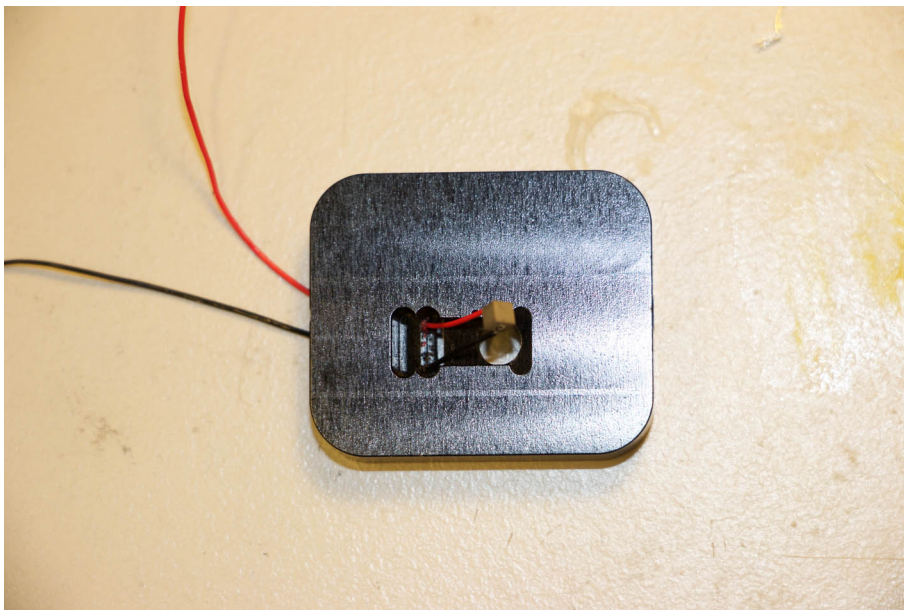


Figure 22: Insert the leads of the **2x2x2 piezo** through the holes of the **cantilever holder** as pictured. Keep the orientation consistent with respect to which lead goes in which hole.

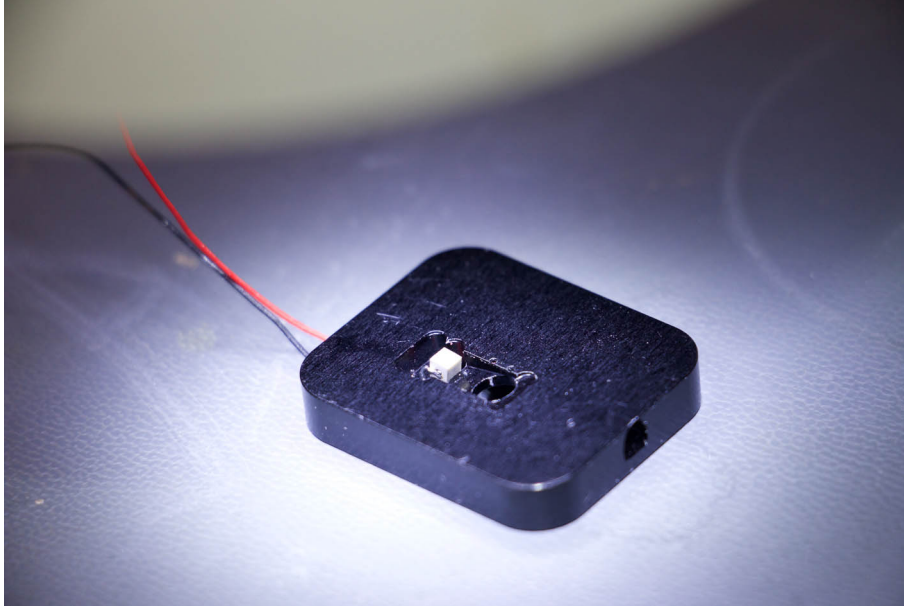


Figure 23: Insert the **2x2x2 piezo** into the pocket of the **cantilever holder**. It is quite difficult to insert, and the leads can rip off, so be careful. Tweezers can help. The orientation of the piezo must be such that it expands in the correct direction (the metal on the piezo gives the orientation; refer to piezo datasheet). Make sure it sits flat and all the way in the pocket, with the leads properly going into the holes.

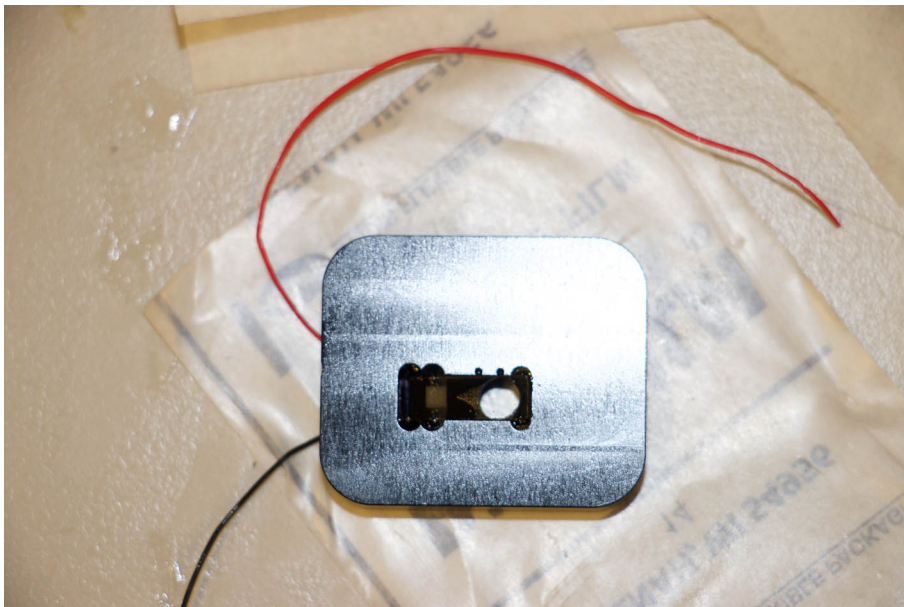


Figure 24: Glue the **2x2x2 piezo** in the pocket of the **cantilever holder**, from both the front and back side, and also glue in the **glass cantilever window**. Make sure that the glue goes all the way around the large hole in the **cantilever holder** and also covers the entire contact surface of the **glass cantilever window**, but does not obstruct the hole in any way (it is an optical path). Use glue sparingly. Allow glue to cure.

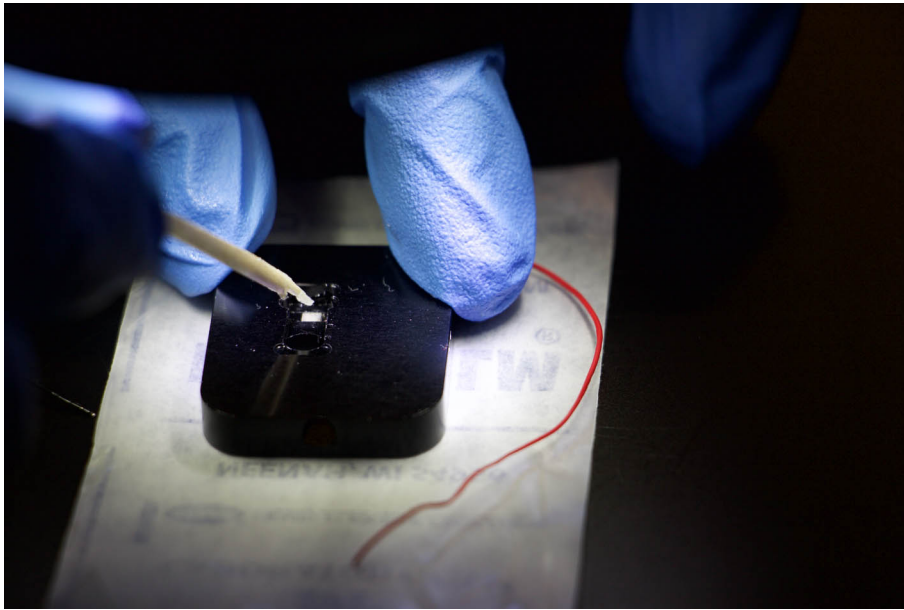


Figure 25: Add additional glue around the edge of the **glass cantilever window** to make sure that any potential leaks are sealed. Doing this (and the previous step as well) under a stereo-zoom microscope can be easier.

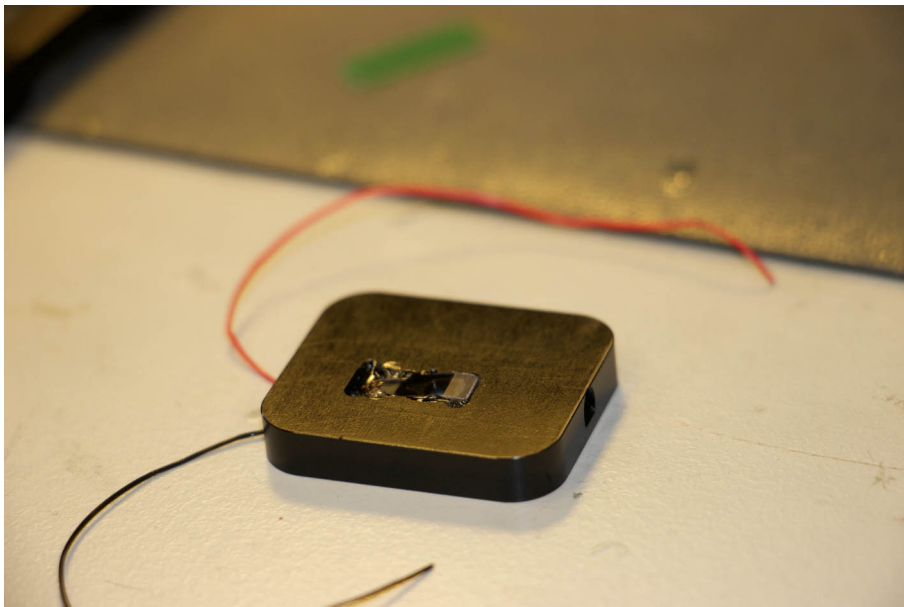


Figure 26: Grind or mill down the flat on the **glass cantilever window**. With a proper bit, milling is better and easier. The flat should be roughly in line with the front of the two fluid ports in the **cantilever holder** (the one furthest from the piezo), and the flat surface of the **glass cantilever window** sits 0.5 mm above the surface of the **cantilever holder**.



Figure 27: Glue in the **cantilever holder PCB** with superglue. Stack 2 copies of the 0.8 mm thick **cantilever holder PCB** under another one with the **6-pin spring mount electrical connector** to get the right thickness (the part was designed for a different thickness PCB than was manufactured). Solder the leads of the **2x2x2 piezo** to the appropriate pads as shown in the picture. Keep the leads as short as possible.

## 2.4 Photodiode housing and translation subassembly

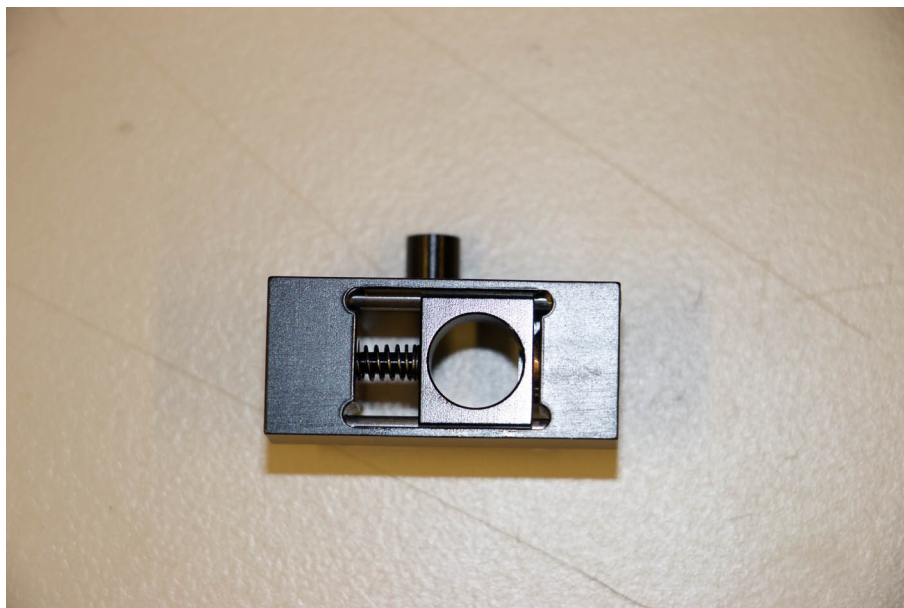


Figure 28: With the photodiode housing and translation subassembly, first make sure that all components fit properly without gluing in place. Some of the holes, especially for the horizontal adjustment in the **photodiode translation vertical slider**, may need reaming or further drilling out to. Alternatively, the V-grooves of the **photodiode translation horizontal slider** can be ground down to allow for freer movement. A completed subassembly minus the photodiode looks as shown in the picture.

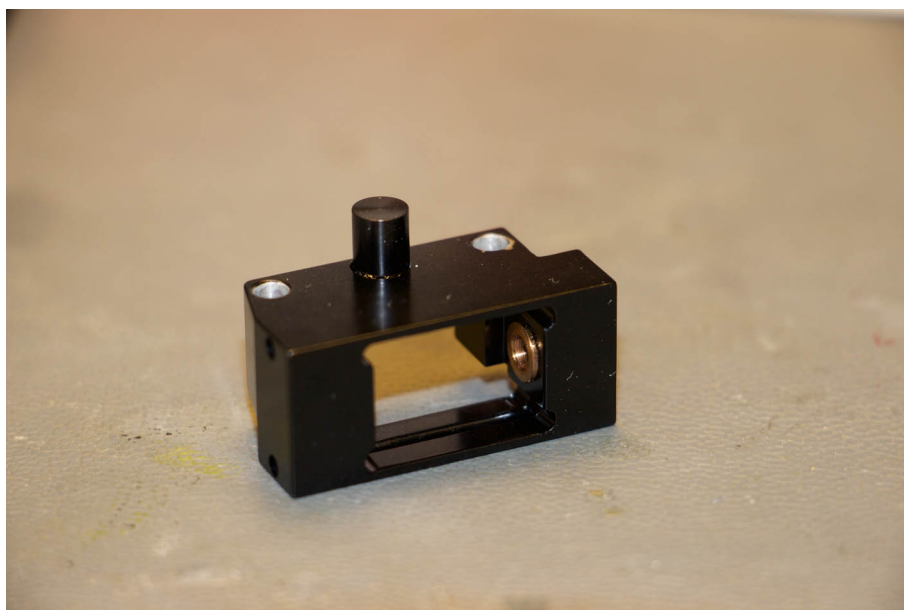


Figure 29: Glue on the **vertical micrometer pin** to the **photodiode translation vertical slider** with 5-minute epoxy or equivalent. Also glue on the Thorlabs **F3ESN1P bushing**. Having the flange oriented to the inside makes for a cleaner appearance but is not necessary for proper function.



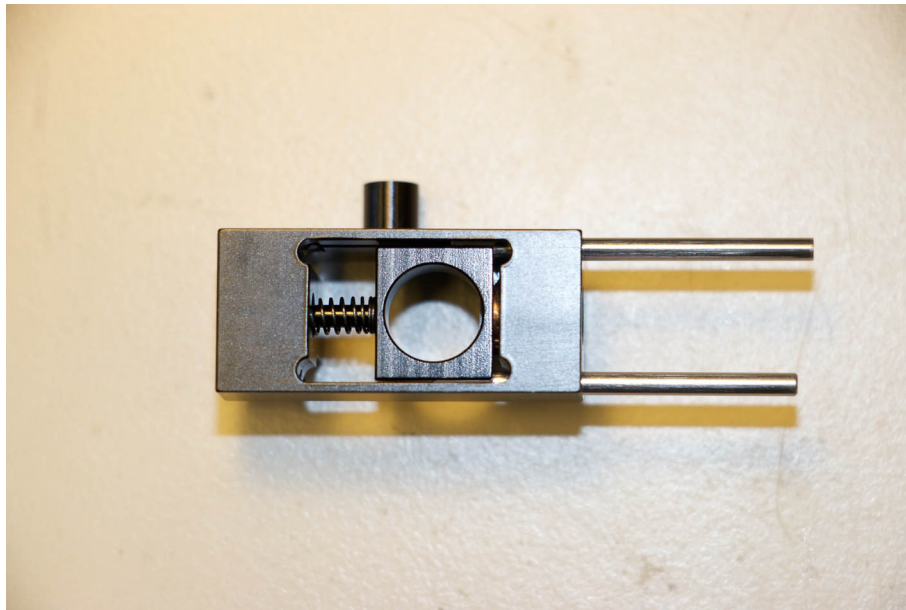


Figure 30: Put in the Gutekunst Federn **D-026R** compression spring followed by the **photodiode translation horizontal slider**. The spring sits in the hole in the **photodiode translation vertical slider** and the post of the **photodiode translation horizontal slider** helps to hold it in place. Feed in the two **horizontal slider pins** and press them partway through until the **photodiode translation horizontal slider** is held in place. Put a small amount of 5-minute epoxy or equivalent into the far-side holes of the **photodiode translation vertical slider**, and press the **horizontal slider pins** all the way through until the ends are flush. Allow the glue to cure.

## 2.5 Optics block subassembly



Figure 31: Glue the **aspheric lenses** into the **objective holder** and two **collimation housings**. All the lenses are Thorlabs **A390-A**. Put a very small amount of glue (2-tonne epoxy works well, a UV-curing glue could also work nicely) into the part where the lens will sit, and then drop the lens in. Avoid touching the surface of the lens or getting any glue onto the lens surface, it becomes very hard to clean afterwards. Keep things very clean as you work. Make sure the lenses are all sitting nice and flat. Refer to assembly technical drawings for orientation of the lenses if you're unsure.

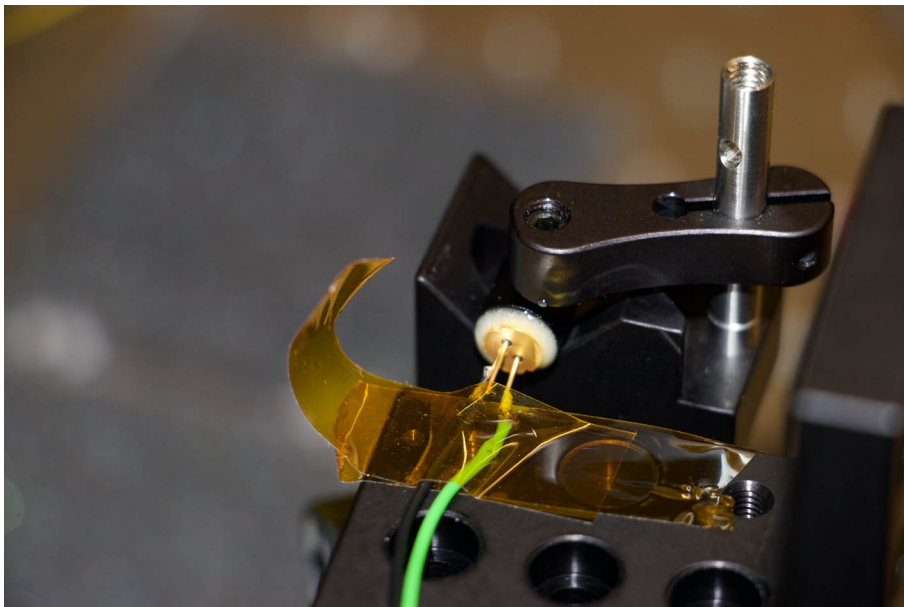


Figure 32: Solder suitable leads to a **laser diode** so that you can power it with a diode drive. The **laser diodes** are Thorlabs part nos. **HL6750MG** for the drive laser and **L637P5** for the readout laser. Create a suitable focusing jig that holds the **collimation housing** fixed in place and can adjust the position of the **laser diode** (using a precision translation stage or similar). Test it out without glue to make sure it is working well and can adjust the focus the laser. Working with one **collimation housing** at a time, put some 2-tonne epoxy around the **laser diode** can and insert it into the **collimation housing**, then collimate the laser. Two options are to focus the spot at a very long distance away, or to focus such that the beam width stays as consistent as possible over a very long distance.

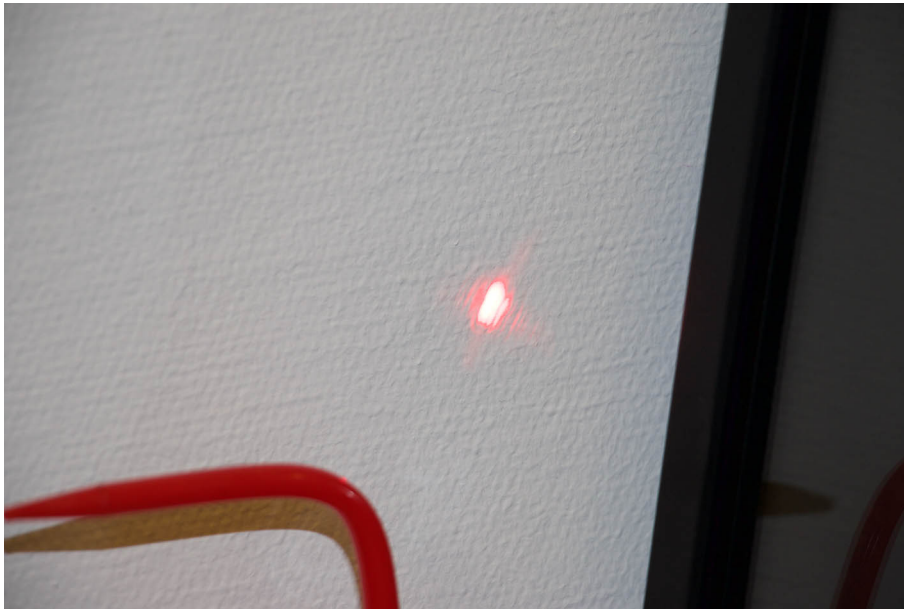


Figure 33: Once you have a suitable collimation, allow the glue to cure. Repeat with the other **laser diode** and **collimation housing**.

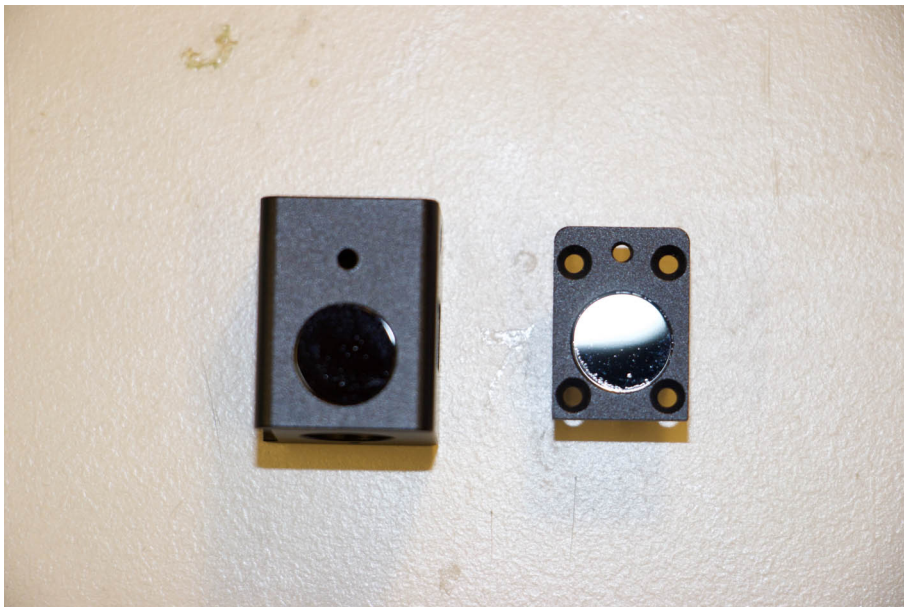


Figure 34: Glue in the two **9.5 mm diameter sapphire windows** into the **optics housing** and the **dichroic insert**. 5-minute epoxy works ok. Make sure the glue doesn't seep out over the **9.5 mm diameter sapphire windows**, clean it up before the glue cures if it does. Press the **9.5 mm diameter sapphire windows** in firmly.



Figure 35: Glue in the **2.5 mm diameter sapphire window**, the **pt cone insert** and the **pt slot insert** into the **pt optics housing**. 5-minute epoxy or equivalent is ok. The **pt cone insert** and the **pt slot insert** can be somewhat difficult to insert and may require the use of a vice or press. Make sure they are inserted straight. You can also glue on the **optics bushing** in the hole in the bottom of the **pt optics housing** at this stage as well.

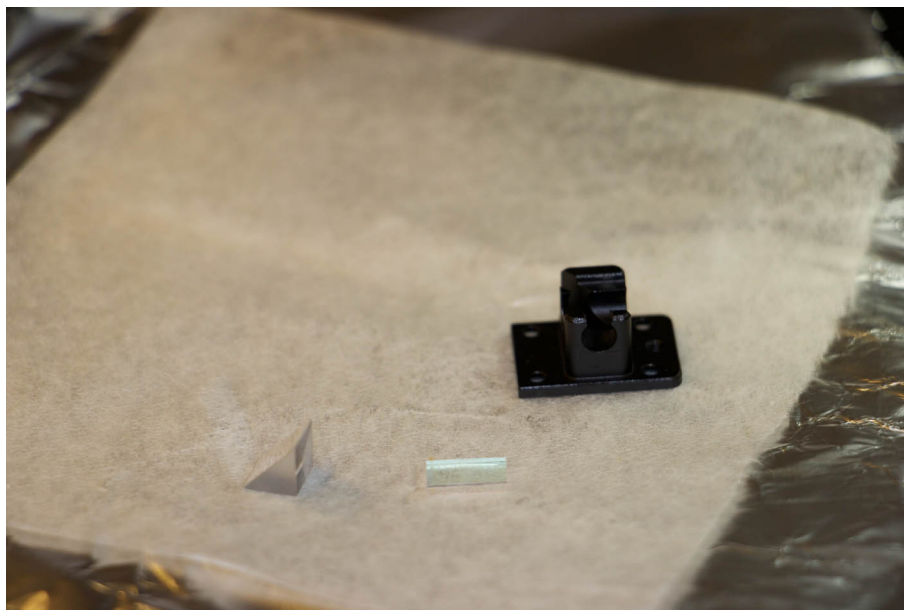


Figure 36: The **dichroic beamsplitter** (Edmund Optics part no. 69-217) and the **right-angle mirror** (Edmund Optics part no. 43-383) go into the **pt optics dichroic insert**. The **dichroic beamsplitter** is glued in first, and is pressed against the upper surface of the angled slot in the **pt optics dichroic insert** (side nearer the rounded edges of the large flange). The upper edge of the **dichroic beamsplitter** should be flush with the surface upon which the **right-angle mirror** sits once the glue sets, but initially put it in a little bit higher so the **right-angle mirror** will press it down in place. Use a very small amount of 5-minute epoxy or equivalent, only on the edges of the part (away from the beam path as much as possible) and a very small amount along the top edge of the **dichroic beamsplitter**. Work quickly. After the **dichroic beamsplitter** is in and before the glue sets, place small dabs also onto the parts of the **pt optics dichroic insert** where the **right-angle mirror** will sit. Place the **right-angle mirror** on and press down into place.

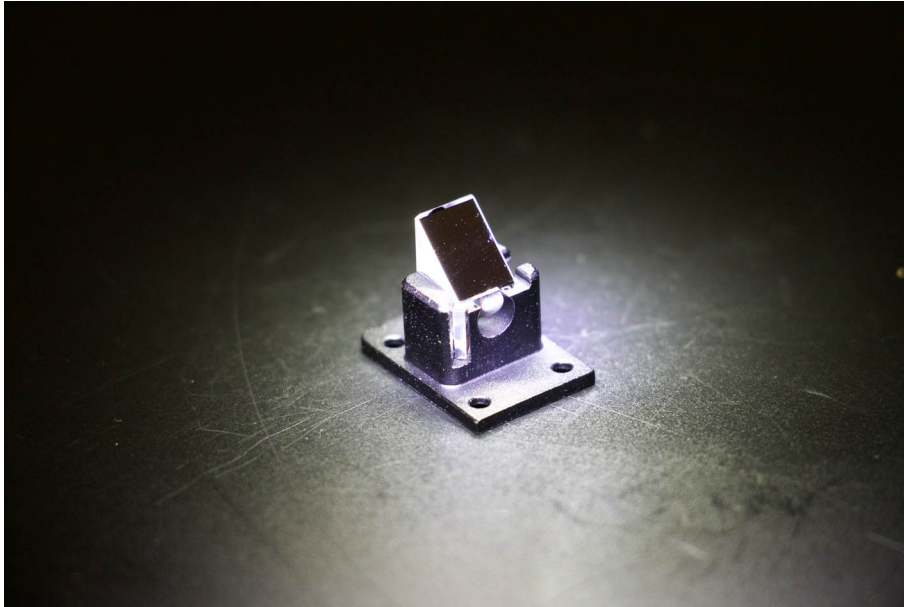


Figure 37: A completed **pt optics dichroic insert** assembly should appear as shown.

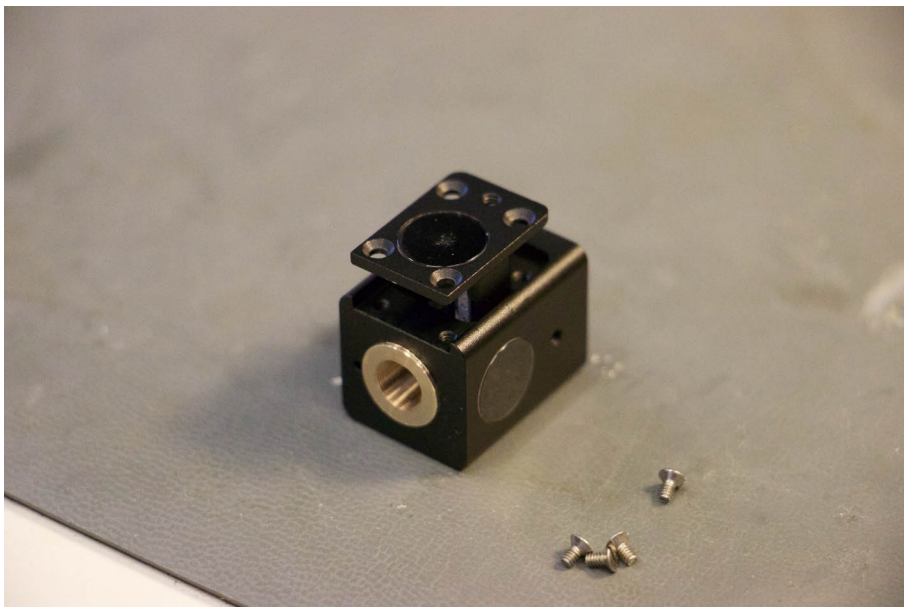


Figure 38: Press the **pt optics dichroic insert** into the **pt optics housing** and tighten with the **M1.6x3 countersunk screws**.



Figure 39: Glue in the Kozak Micro **M3 matched thread/bushing pairs** into the **pt optics kinematic mount** using 5-minute epoxy or equivalent. Put into the **pt optics kinematic mount** the **collimated drive laser diode assembly** in the correct orientation and tighten in place with an **M3 set screw**.

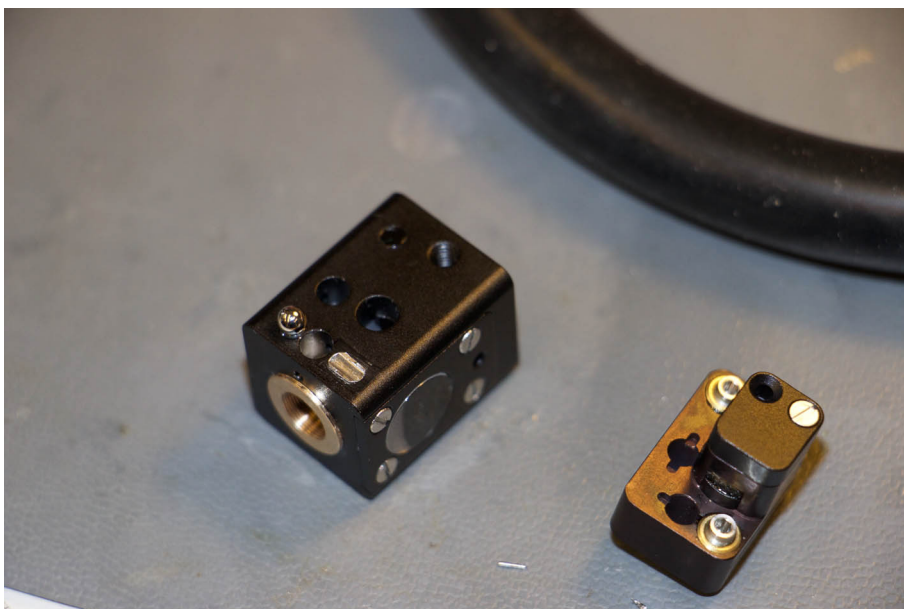


Figure 40: Capping the **drive laser diode** pins with the **drive laser cap** is a good idea while performing the next steps. Place a **3 mm steel ball** onto the **cone insert** of the **pt optics housing**.

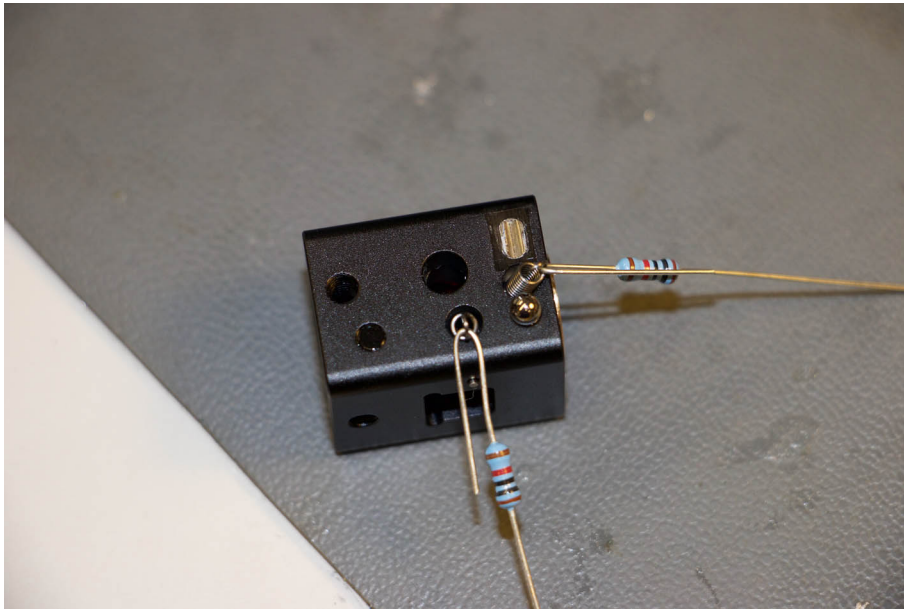


Figure 41: Put in the Gutekunst Federn **RZ-024AAX tension springs**. The bottom loops are held in with small **1x4.5 dowel pins**. Make two hooks for the upper loops (resistors work well, or use proper spring hooks).

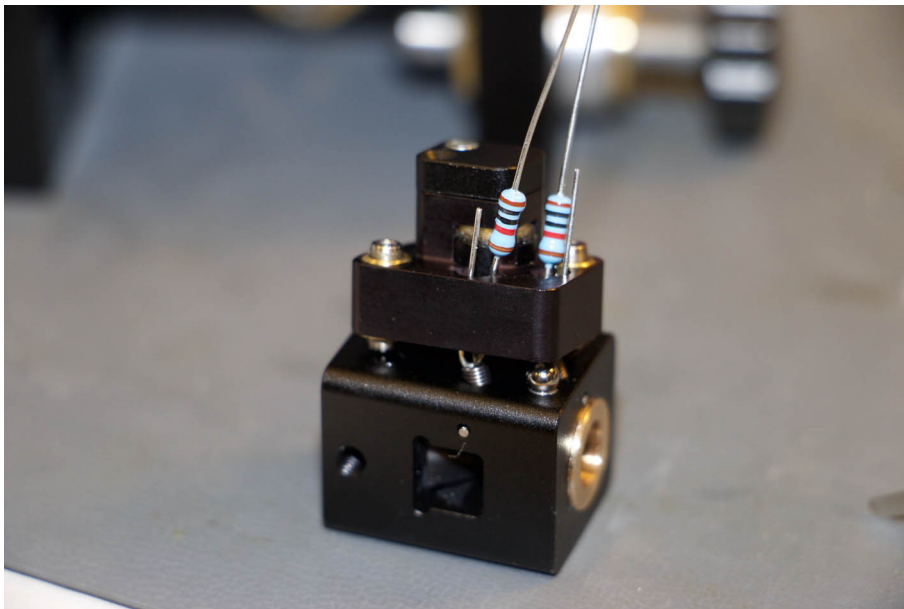


Figure 42: Feed the hooks through the holes in the **pt optics kinematic mount** and set it in place on the **pt optics housing**.

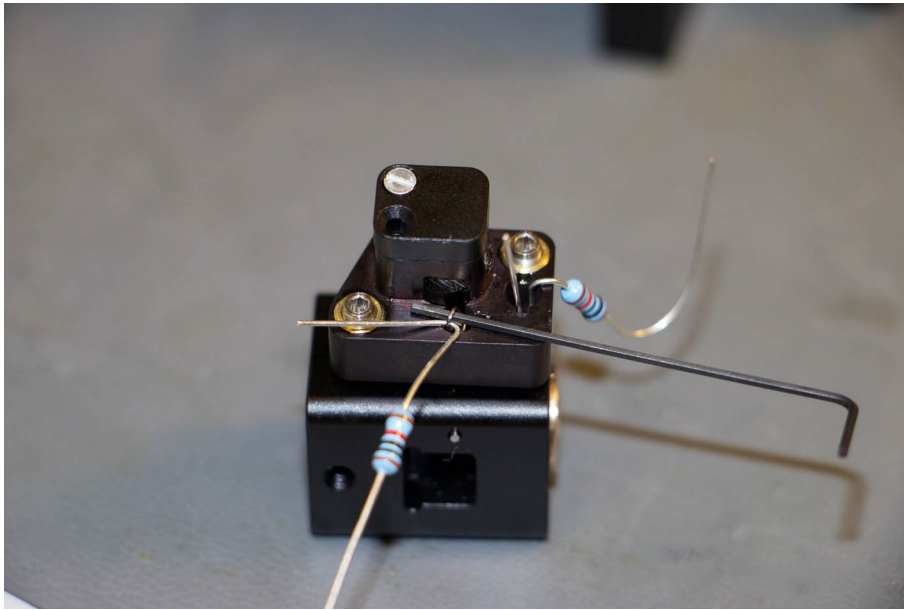


Figure 43: Pull up one of the **RZ-024AAX tension springs** using the hook, and feed through a small hex key or similar item to hold the spring in place.

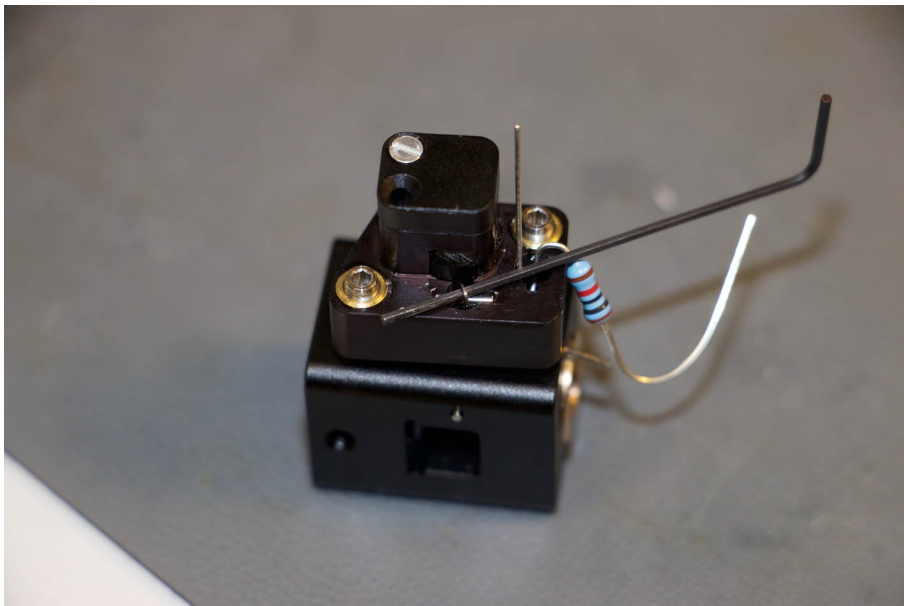


Figure 44: Feed through the upper loop of the **RZ-024AAX tension spring** a **1x4.5 dowel pin**. Pull out the hex key to allow the **RZ-024AAX tension spring** to sit in place on the **1x4.5 dowel pin**.



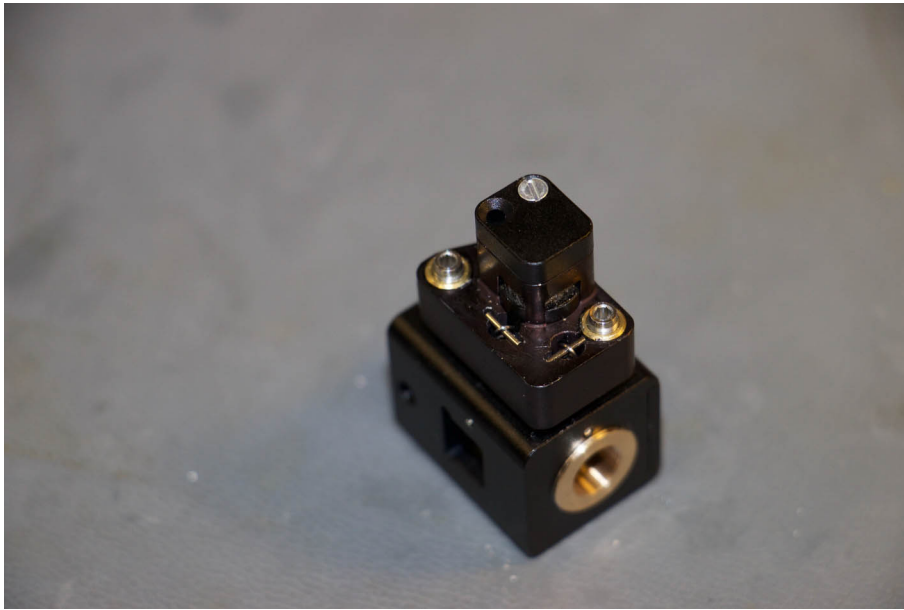


Figure 45: Repeat this procedure for the second **RZ-024AAX tension spring**.

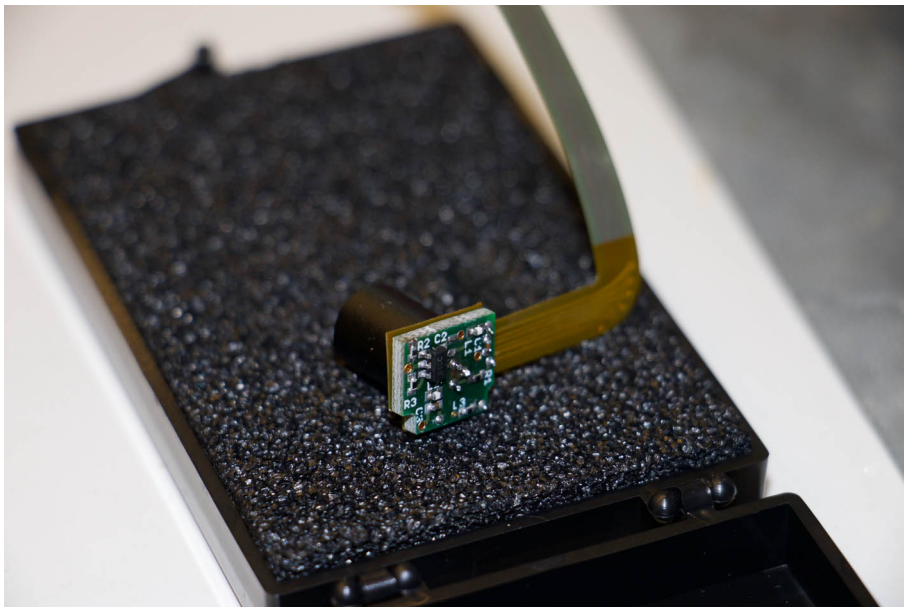


Figure 46: Solder on the **modulator PCB** with **flex PCB** to the **readout laser collimated assembly**. The **modulator PCB** comes in two different orientations (at 90 degrees to each other). Choose the correct one for the laser such that the wide part of the collimated beam is would go across the width of the cantilever when in the optics block.

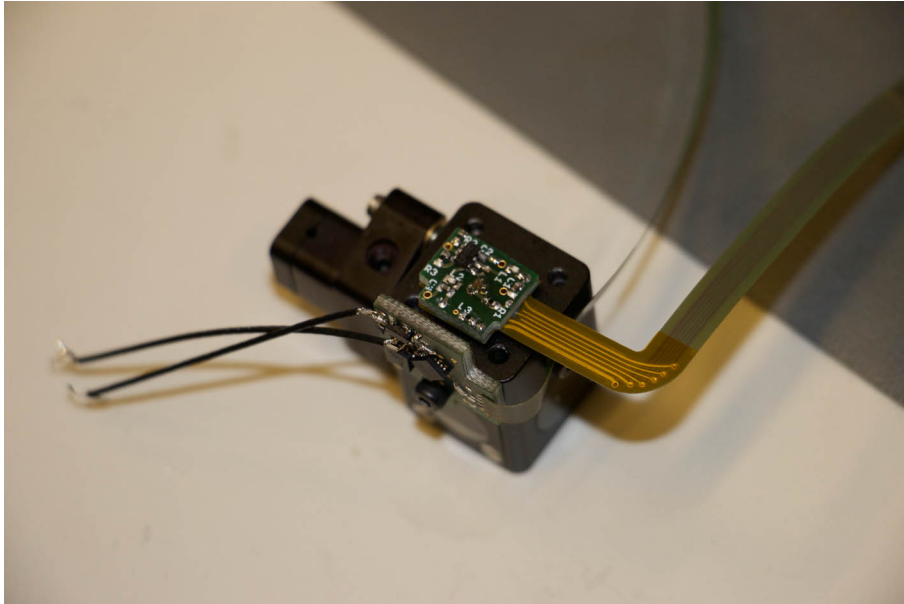


Figure 47: Place the **collimated readout laser assembly with PCB** into the **pt optics housing**. Fix in place with an **M3 set screw**. The **drive laser flex PCB** and **sattelite PCB** can also be fixed onto the **pt optics housing** with **M2 socket head cap screws**. The thread length of the screws must be reduced to  $\sim 2$  mm or less.

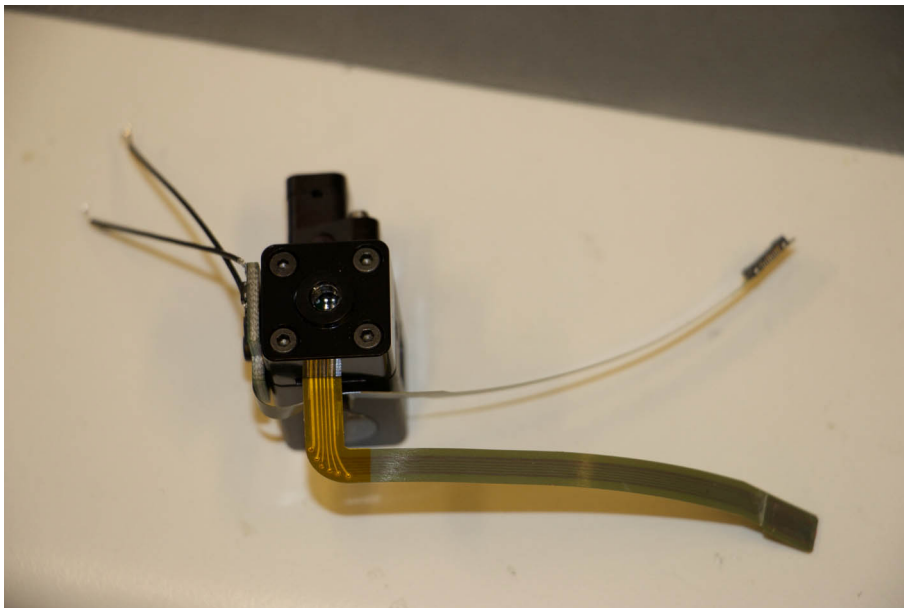


Figure 48: Screw on the **optics cap** onto the **pt optics housing** using 4 **M2x8 socket head cap screws**.

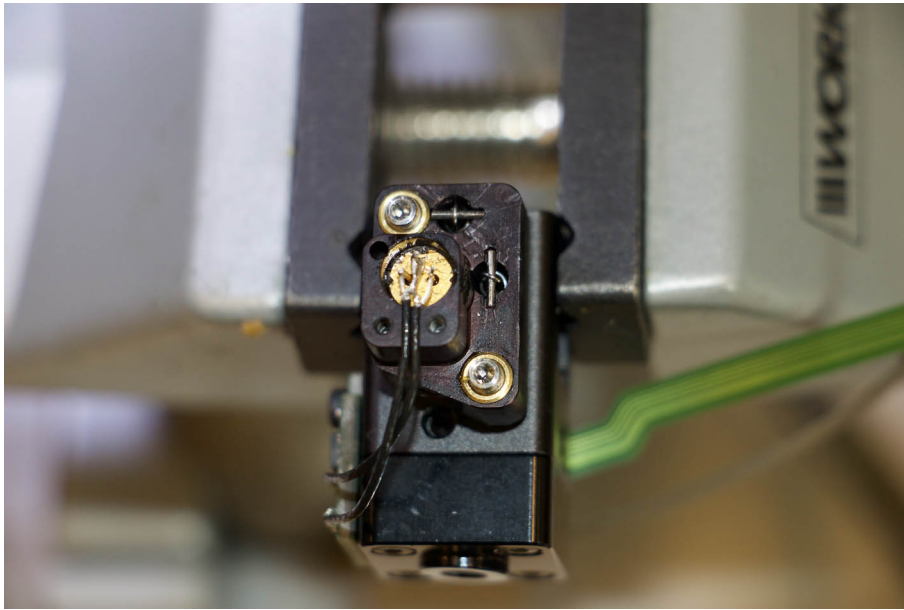


Figure 49: Remove the **drive laser cap** and solder on to the **drive laser diode** the two coaxial cable connections. Refer to electronics documentation for proper wiring orientation.

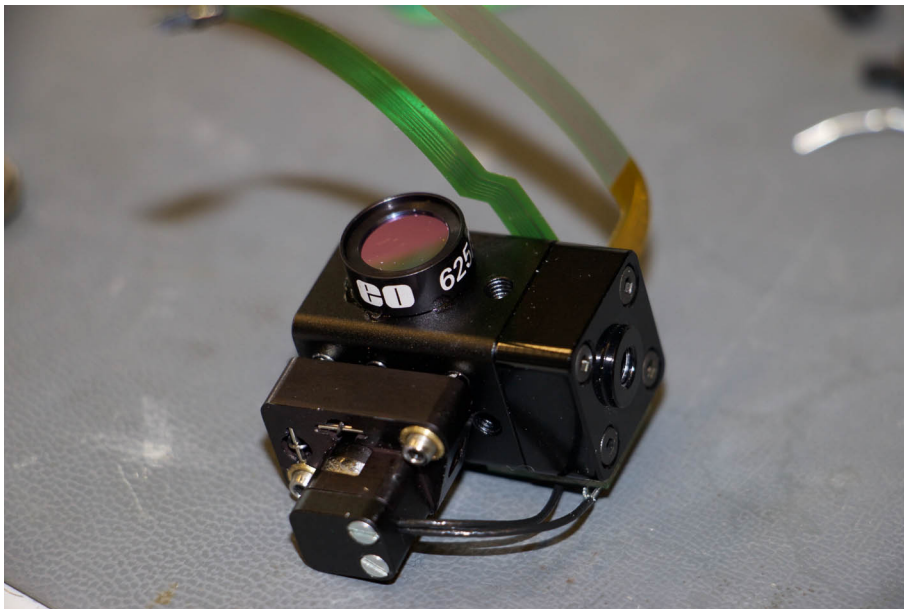


Figure 50: Glue on the **bandpass filter** (Edmund Optics part no. 86-941) onto the **pt optics housing** using superglue or 5-minute epoxy. The proper orientation of the **bandpass filter** is given on its housing.

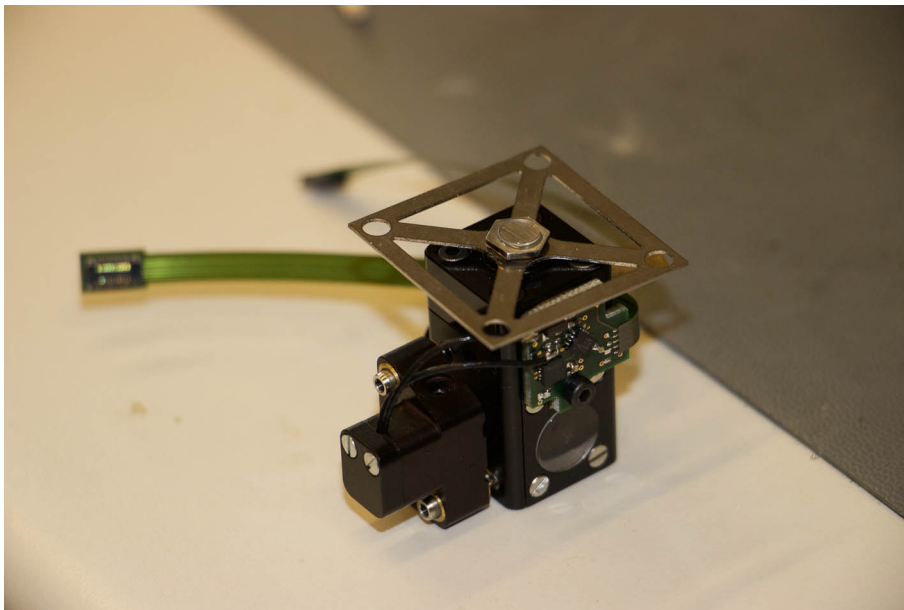


Figure 51: Screw on the **optics flexure** onto the **optics cap** using the **cutdown M4 hex bolt with 5 mm diameter sapphire window**. The **optics flexure** can be correctly oriented by leaning the **pt optics housing** and **optics flexure** on a side where both edges should be flat (the one opposite to the **pt optics kinematic mount** is ok to use) while screwing on the **optics flexure**.

## 2.6 Main housing subassembly

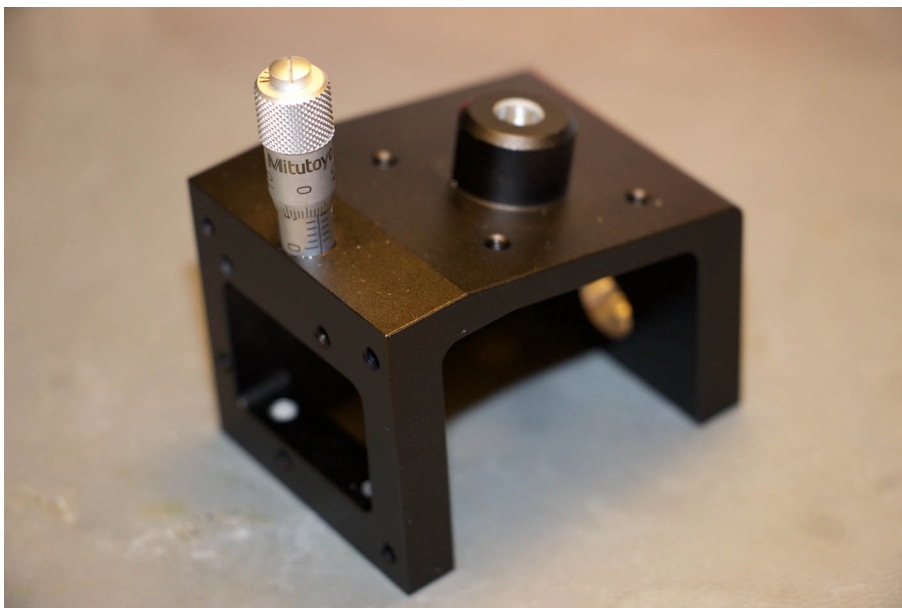


Figure 52: Glue in a **micrometer head** (Thorlabs part no. **148-205ST-H**) into the **head housing** using 2-tonne epoxy.

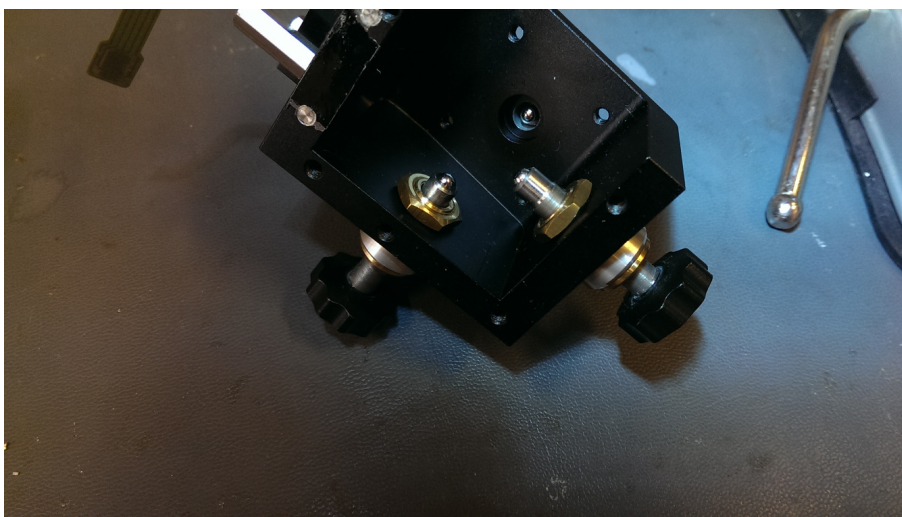


Figure 53: Screw on the textbf ultra-fine-pitch screws (Newport part number **AJS254-0.5K-NL**) using the **longitudinal micrometer spacer** and **transverse micrometer spacer** to make the correct thicknesses for the bushings.



Figure 54: In another **micrometer head** (Thorlabs part no. **148-205ST-H**), cut a V-groove using a file or mill. The proper position of the groove can be marked by placing the **micrometer head** into the **head housing** hole for the focus micrometer and marking with a sharp object through the set-screw hole.

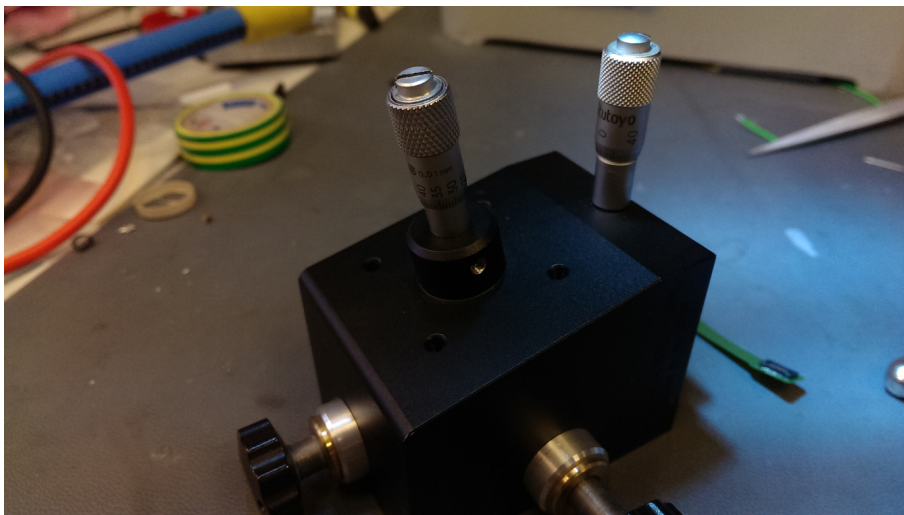


Figure 55: Screw the **micrometer head** in place in the focus hole using an **M3 set screw**.

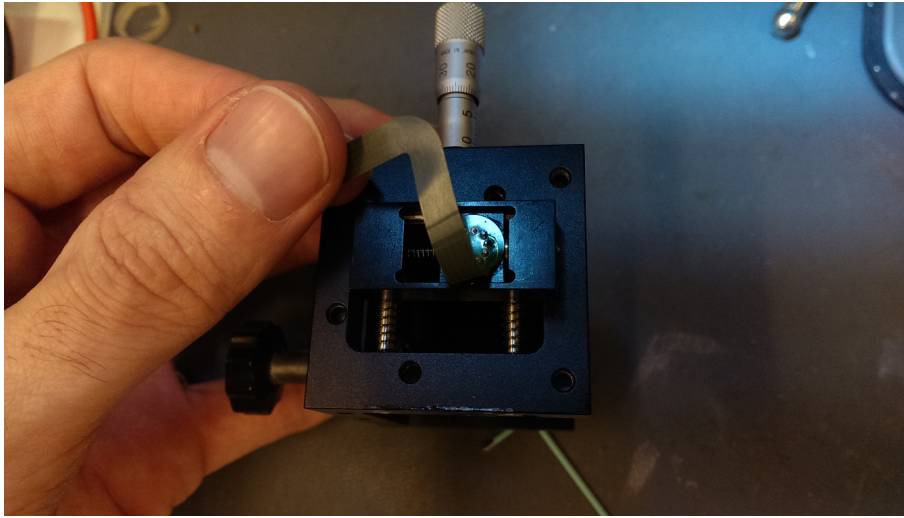


Figure 56: Put the **photodiode subassembly** into the **head housing** using the **vertical slider pins** and two Gutekunst Federn **D-030 compression springs** as pictured. The **vertical slider pins** will slide in easily until near the top but are a press fit into the upper holes in the **head housing**. A vice can be used to press them fully in place. Grease the **vertical slider pins** so that the **photodiode subassembly** slides smoothly. The **quadrant photodiode** (Hamamatsu **S4349**) can be glued in place using 5-minute epoxy (make sure it is nicely horizontal), and the **photodiode flex PCB** can be soldered on, then the leads of the **quadrant photodiode** can be trimmed down.

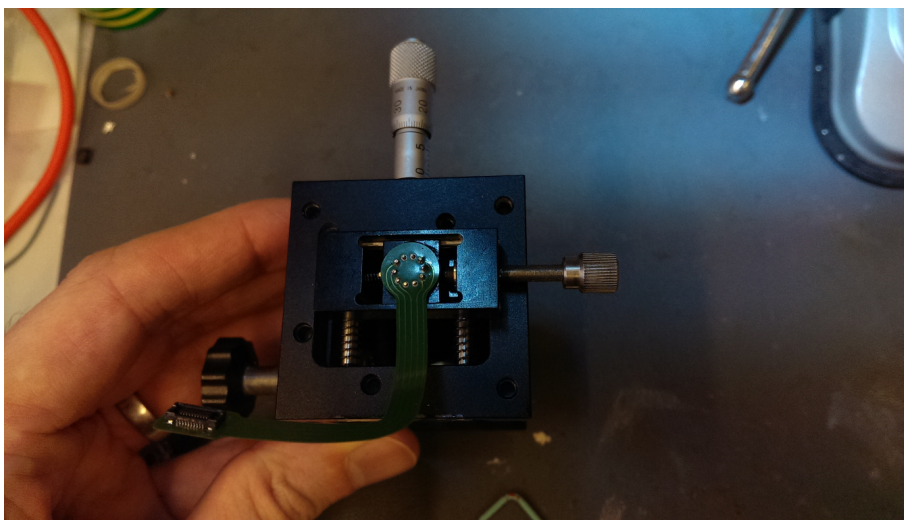


Figure 57: Screw on the Thorlabs **F3ES25 adjustment screw** with **F3ESK1 knob** in for horizontal adjustment.

### 3 Final assembly

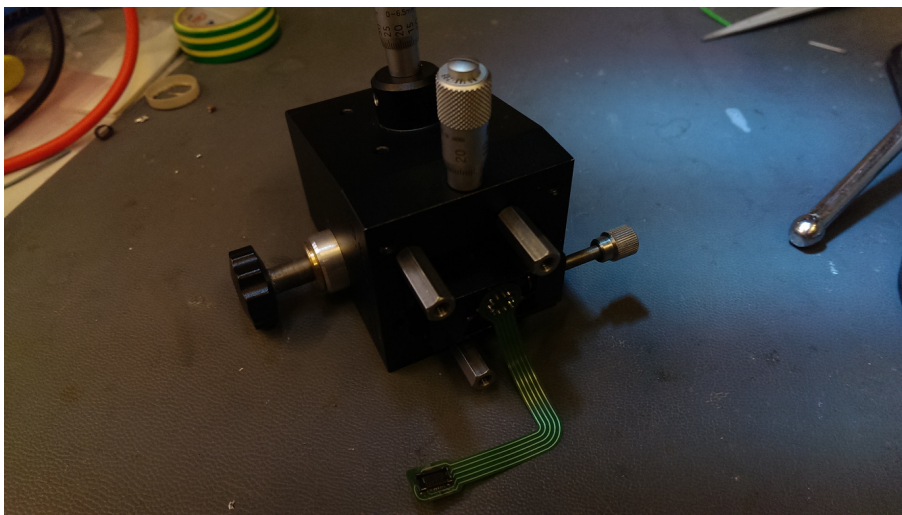


Figure 58: Screw on the 3 **M3 hex standoffs** onto the **head housing**.

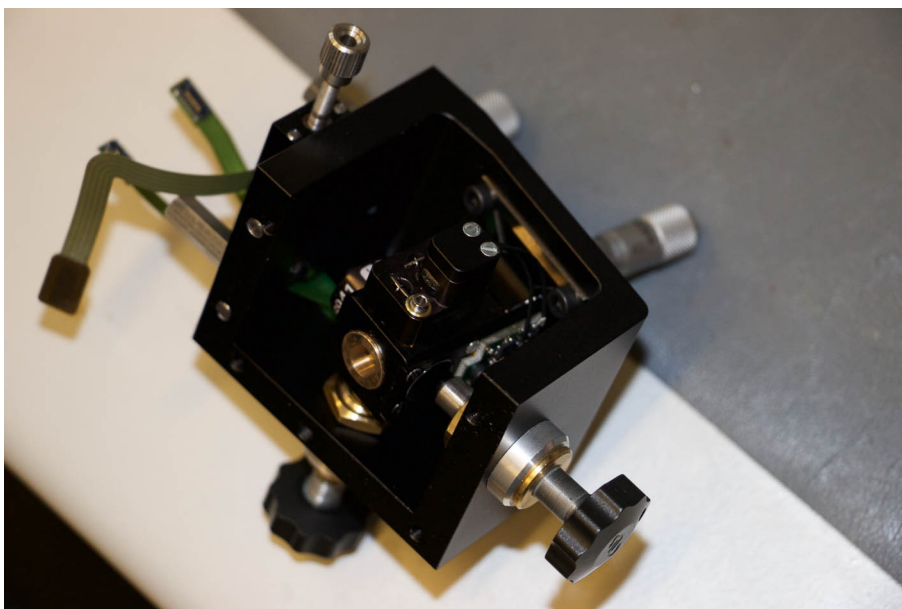


Figure 59: Feed the two **flex PCBs** of the **optics subassembly** around the side of the **photodiode subassembly**, and screw the **optics subassembly** in place by 4 **M3x5 socket head cap screws** that fix the **optics flexure** onto the **head housing**.



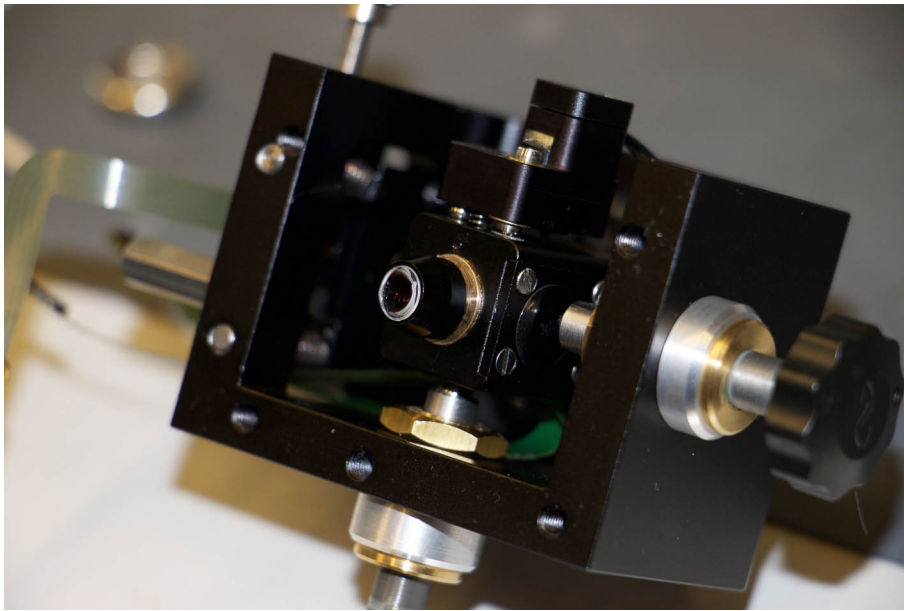


Figure 60: Screw onto the **optics subassembly** the **focusing objective**. Make sure the threads fit snugly. A layer of teflon tape or just a bit of grease might be necessary to remove any slop. Screw on the **focusing objective** until there is about a 1 mm gap between the lip of the **focusing objective** and the **pt optics housing**. This coarse focus will have to be adjusted later on once a cantilever is in place.

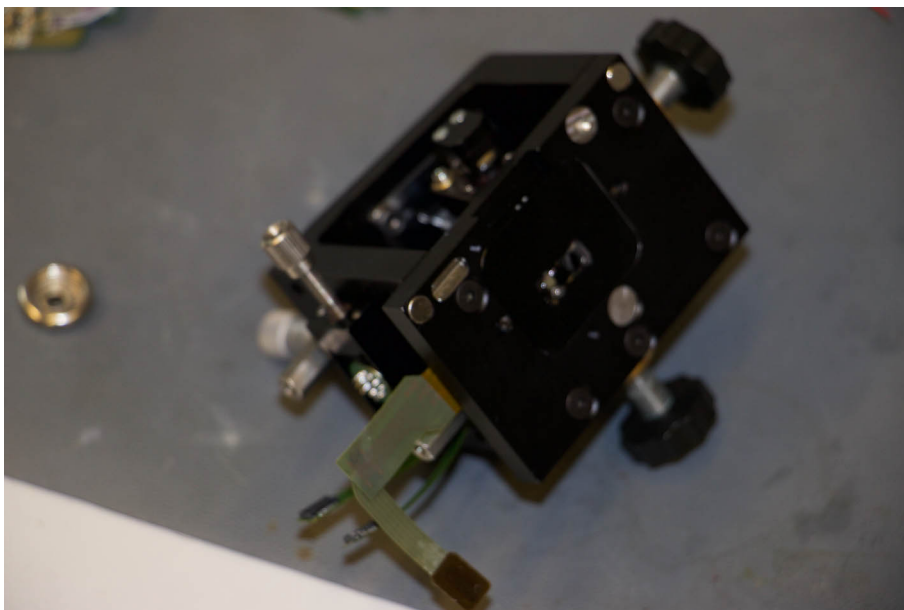


Figure 61: Screw on the **baseplate subassembly** (complete with **PCB cover** and **baseplate flex PCB**) onto the **head housing** using 5 **M3x10 countersunk screws**.

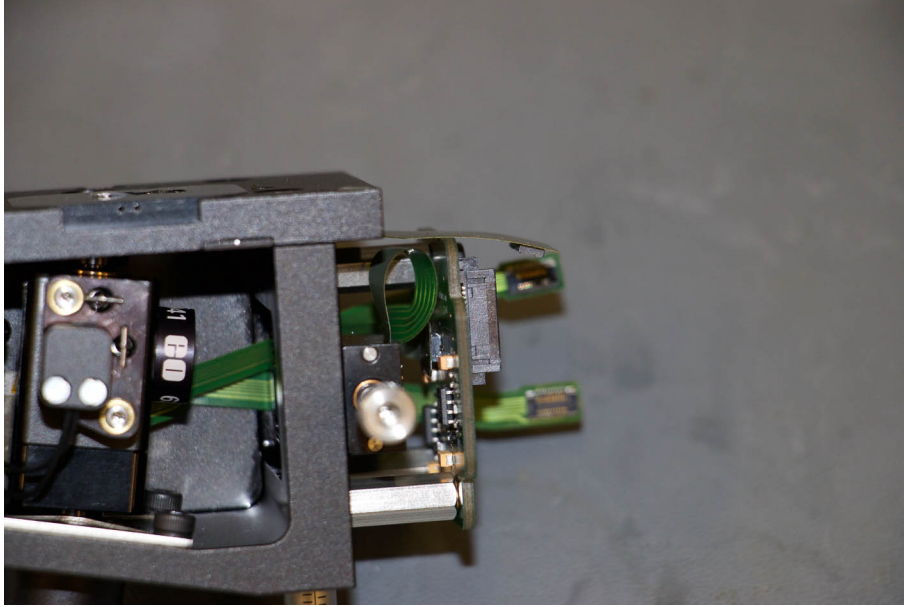


Figure 62: Attach the **photodiode flex PCB** to the appropriate connector on the **readout pcb**.

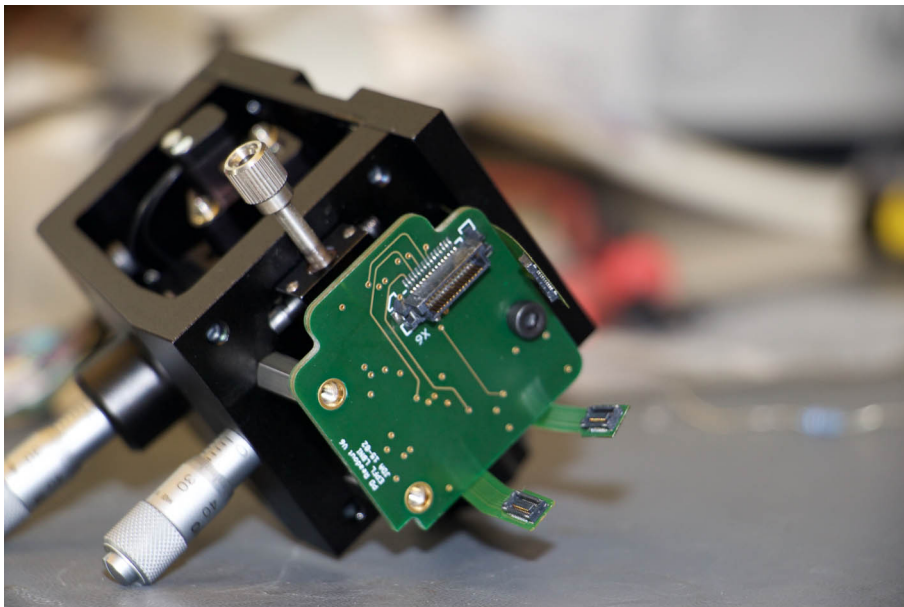


Figure 63: Screw the **readout pcb** in place using one **M3x5 socket head cap screw**.

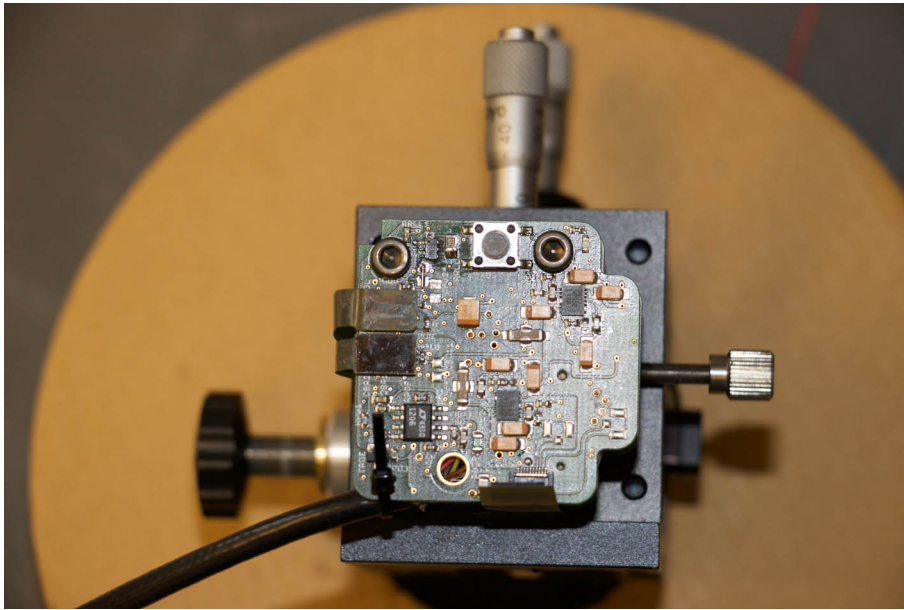


Figure 64: Place on the **Drive and power PCB** and fix with 2 **M3x12 socket head cap screws** with **6 mm PCB spacers**. Connect the **readout laser, drive laser and baseplate flex PCBs**.

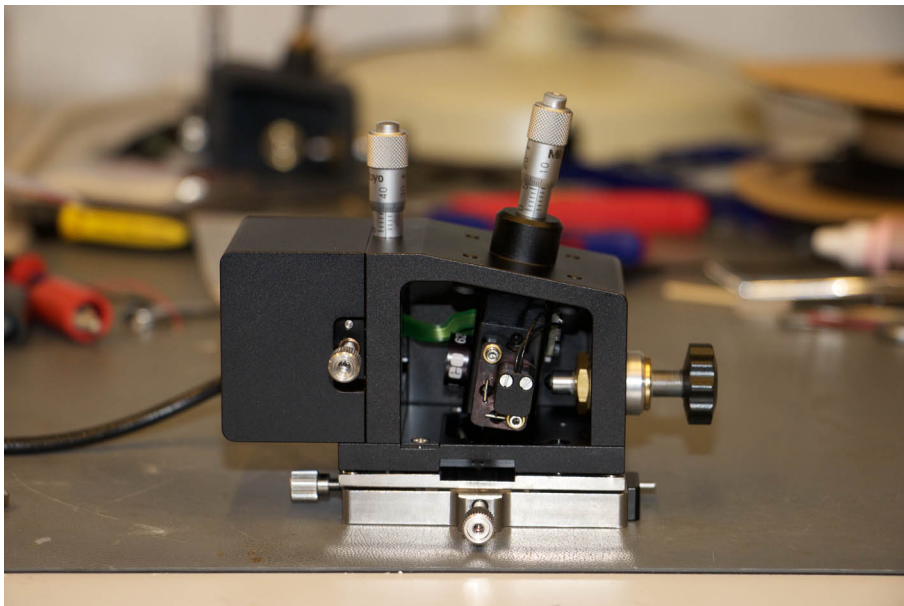


Figure 65: Screw on the **electrical housing**, and place the **head** onto the **translation stage**. Assembly is completed, time for testing!