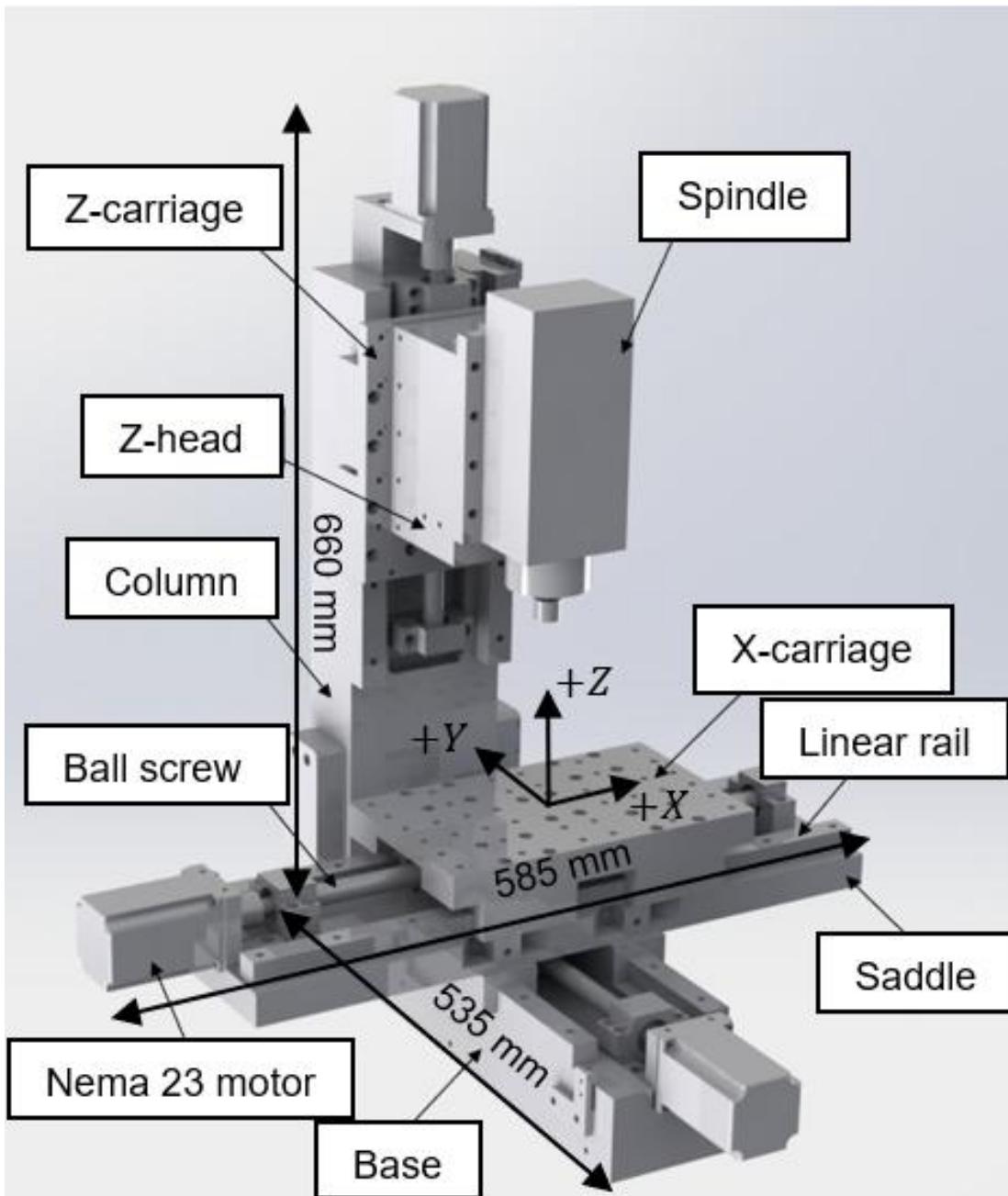
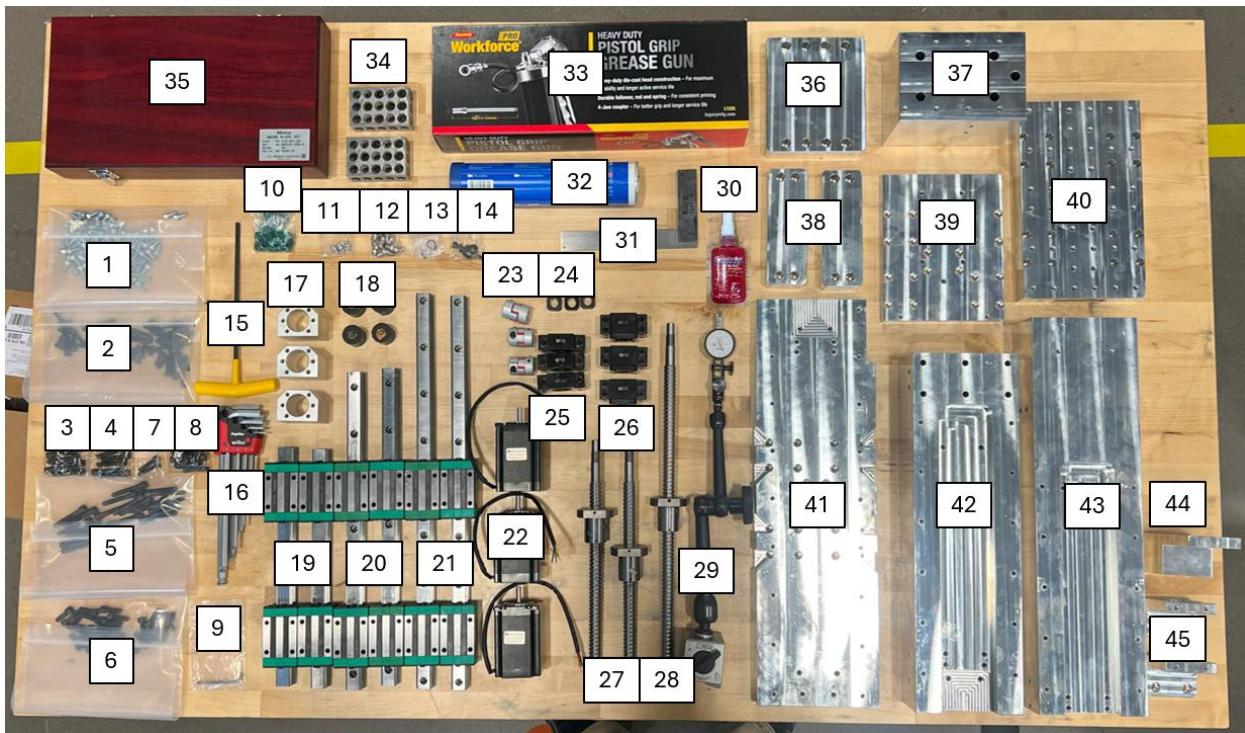


Desktop CNC milling machine: machine instructions





Item number	Description	Qty
1	M5 x 12 mm bolt	100
2	M5 x 16 mm bolt	18
3	1/4-20 x 1 1/4 in and 1/4-20 x 2 1/4 in bolt for 1-2-3 setup block	1
4	1/4-20 x 1 1/4 in bolt	11
5	1/4-20 x 1 5/8 in bolt	18
6	1/4-20 x 3/4 in bolt	50
7	M5 x 25 mm bolt	2
8	1/4-20 x 1 in bolt	8
9	Short nose Allen key	1
10	Linear rail counter bore cover	25
11	Ball screw grease fitting	3
12	Linear rail grease fitting	12
13	Snap ring	3
14	M5 x 40 mm bolt for 1-2-3 setup block	1
15	3/16 T-handle hex driver	1
16	Metric Allen key set	1
17	Ball screw carrier block	3
18	Machine feet	4
19	300mm linear rail	2
20	400mm linear rail	2
21	500mm linear rail	2
22	Nema 23 stepper motors	3
23	Motor couplers	3
24	Ball screw nut	3
25	BF12 bearing block	3

26	BK12 bearing block	3
27	300mm ball screw	2
28	450mm ball screw	1
29	Test dial indicator, Noga arm magnetic base	1
30	Thread locker	1
31	SPI precision square	1
32	Mobil 1 EP1 grease	1
33	Grease gun	1
34	1-2-3 setup block	2
35	Gauge block set	1
36	Bracing 2	1
37	Z-head	1
38	Bracing 1	2
39	Z-carriage	1
40	X-carriage	1
41	Saddle	1
42	Base	1
43	Column	1
44	Z-axis motor mount	1
45	X/Y axis motor mount	2

**NOTE:**

Items highlighted in yellow are not required if the linear rails are pre-assembled. Skip to step 27 if linear rails are pre-assembled.

The BOM does not include #35. Only the needed gauge blocks are in the BoM. Lastly please use the 1-2-3 setup block (34) as the 3 in. gauge block.

## GENERAL ASSEMBLY NOTES:

- Wear disposable gloves, especially when greasing any component.
- When threading a bolt into the machine, be cautious and do not cross-thread the bolt. The aluminum threads are susceptible to stripping and cross-threading when the steel bolts are not fed in straight. This is very easy to do but can be avoided; one method that works well is to spin the bolt counterclockwise until it “clicks” (lining up the first threads of each component). The bolts tend to go in easier from this position.
- When tightening a bolt on the machine, be cautious and do not overtighten. The aluminum threads can be stripped. All bolts can and should still be tight on the finished machine.
- All provided bolts will be labeled with “MI #item number” which stands for Machine Instructions and the item number on the above table.
- (Item number) is used throughout to call out item numbers for reference within the instructions.

1. Begin by gathering items: 2, 10, 16, 20, 29, 30, 31, 35, 42.



2. Assemble a gauge block stack that amounts to 3.48 inches



3. Use 6 M5 bolts (2) to loosely fasten the linear rail (19) to the base (42). Apply thread lock to each bolt (30). Do not fully tighten yet.



4. Use the precision square (31) to position the rail. And tighten the bolt circled in red. Repeat on the other end of the linear rail.



5. Check alignment with the test dial assembly (29) by securing it to the linear rail block. Zero the dial at one end of the rail. Move the dial across the inside channel of the base (42). Adjust by loosening the bolts previously tightened.



NOTE: Less than 0.0005 inches of deviation is acceptable.

6. Secure the remaining bolts on the linear rail (19).



7. Use 6 M5 bolts (2) to loosely fasten the second linear rail (19) to the base (42). Apply thread lock on each bolt. Do not fully tighten yet.



8. Use the gauge block stack (35) to position the rail and fully tighten the bolt circled in red while applying pressure. Repeat on the other end of the linear rail.



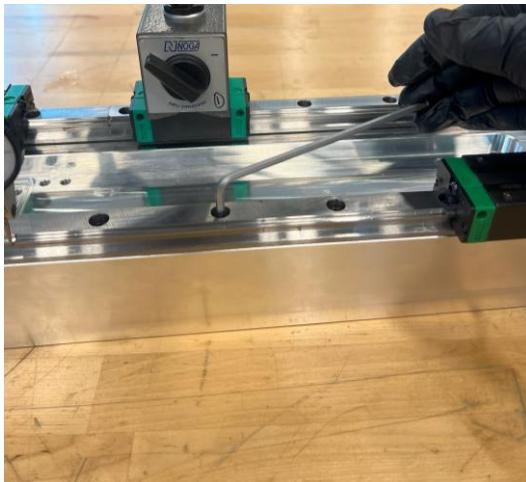
9. Attach the magnetic base (29) to the first linear rail mounted in step 3 and position the indicator to measure the second linear rail.



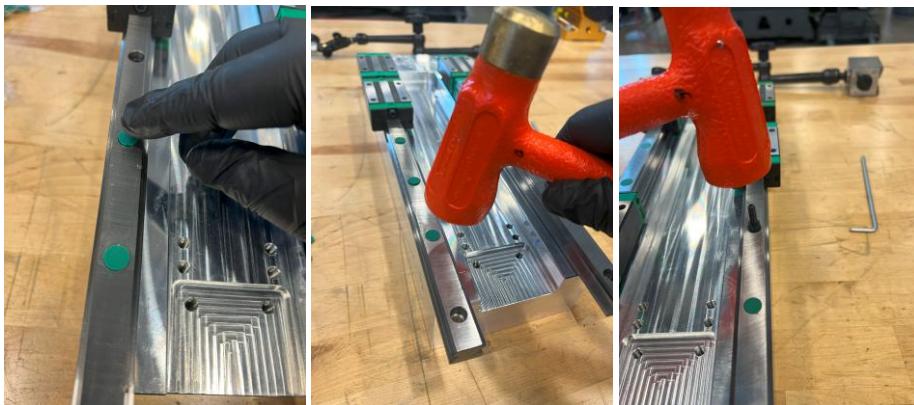
10. Check the parallelism of the rails with the test indicator (29) and adjust by loosening the bolts previously tightened.



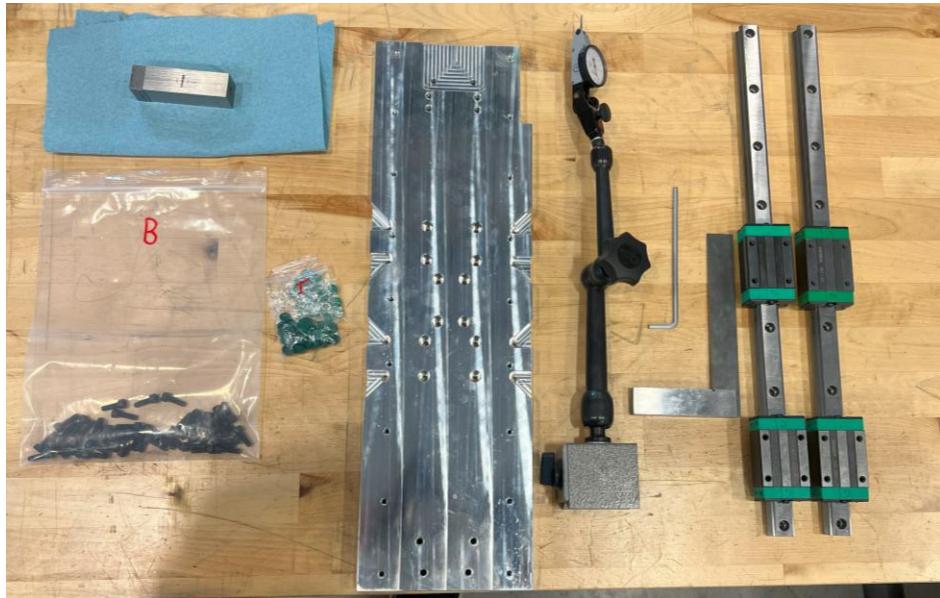
11. Secure the remaining bolts on the second linear rail.



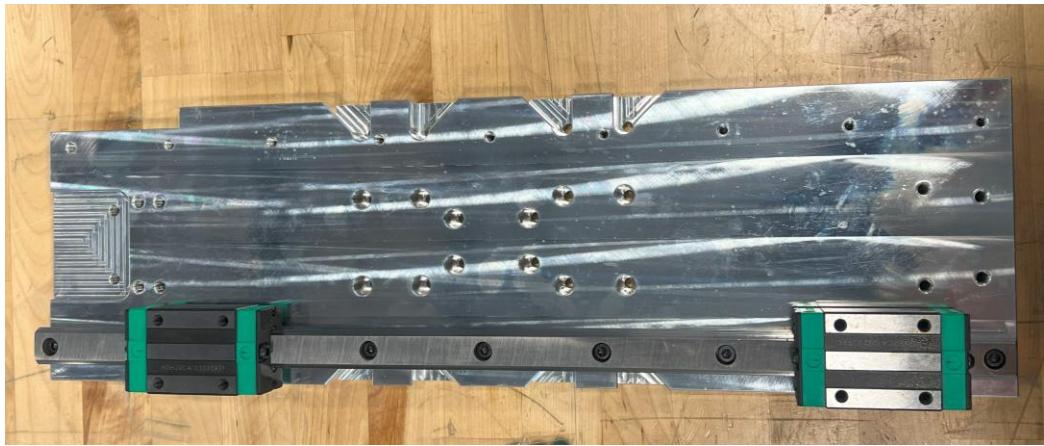
12. Position the linear rail counter bore cover (10) and secure with a soft blow hammer or rubber mallet. After securing a cover, ensure the rail glides over the cover without any disturbance. Use a spare M5 bolt to push the cover down further if needed.



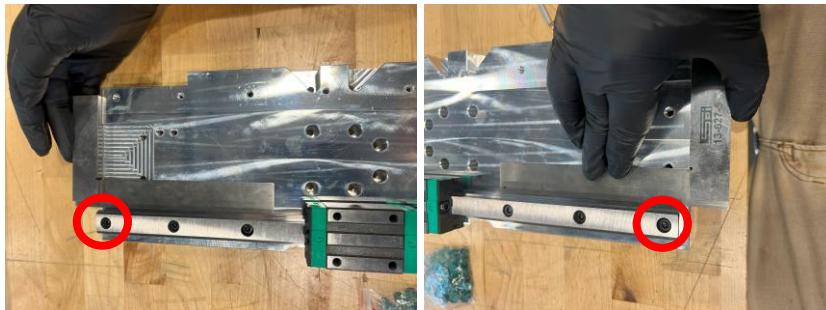
13. Set the finished Base (42) aside and gather the following: 2, 10, 16, 21, 29, 31, 35, 41



14. Use 9 M5 bolts (2) to loosely fasten the linear rail (21) to the saddle (41). Apply thread lock to each bolt (30). Do not fully tighten yet.



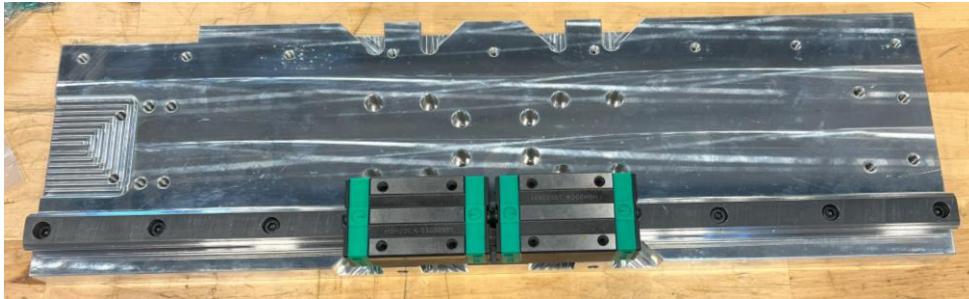
15. Use the precision square (31) to position the rail and fully tighten the bolt circled in red. Repeat on the other end of the linear rail.



16. Check parallelism with the edge of the saddle using calipers at each end of the rail. Adjust by loosening the bolts previously tightened.



17. Secure the remaining bolts.



18. Use 9 M5 bolts (2) to loosely fasten the second linear rail (21) to the saddle (41). Apply thread lock to each bolt (30). Do not fully tighten yet.



19. Use the gauge block stack (35) to position the rail and fully tighten the bolt circled in red while applying pressure. Repeat on the other end of the linear rail.



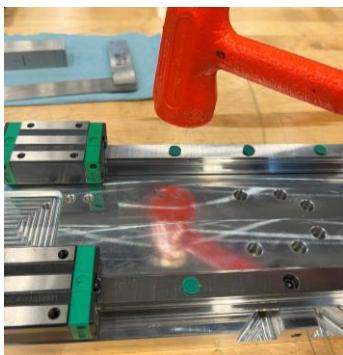
20. Check the parallelism of the rails with the test indicator (29) and adjust by loosening the bolts previously tightened. Measure in the same location shown in step 9



21. Secure the remaining bolts.



22. Position the linear rail counter bore cover (10) and secure with a soft blow hammer or rubber mallet. After securing a cover, ensure the rail glides over the cover without any disturbance.



23. Set the finished Saddle (41) aside and gather the following: 2, 10, 16, 19, 29, 30, 31, 35, 43



24. Repeat steps 3-12 with the column (43) and the above components. The final result is shown below.



25. Gather the Column, Base, and Saddle assemblies and the following: 12, 16, 32, 33. Follow the directions provided by the grease gun manufacturer to load and prime. Use the fittings (12) to grease each bearing block. Outlined in red below.



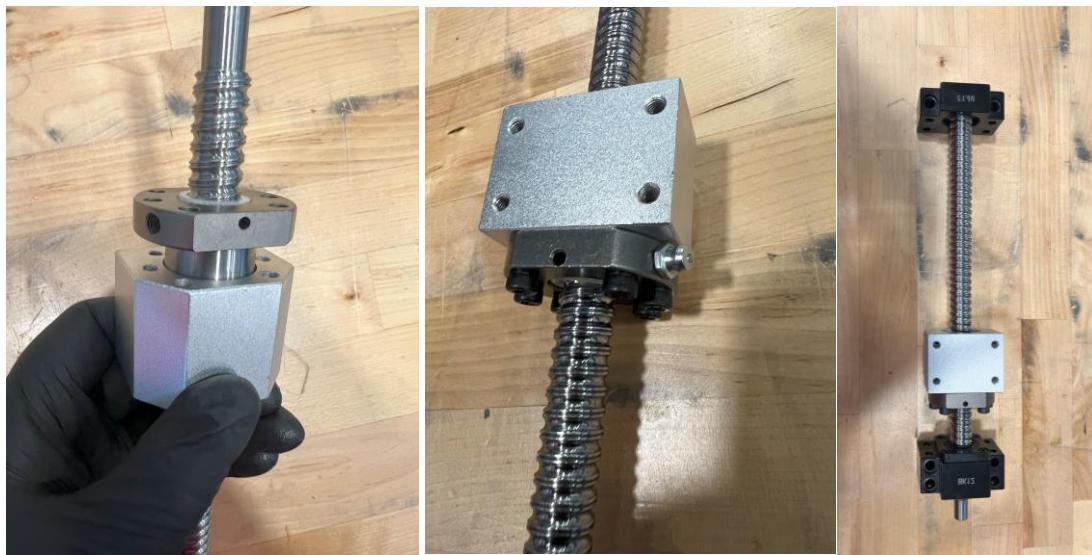
26. Remove both bolts on each bearing block and attach a grease fitting to one side. Bring the bearing block to the end of the rail and attach the grease fitting without removing the bearing block from the rail. Be sure that each block has grease inside as it moves along the rail, but do not overfill. Generally, a block is well-greased once grease begins to exit the block (other than around the fitting).



27. Gather the following items and begin the Column assembly: 1, 2, 5, 6, 11, 13, 15, 16, 17, 22, 23, 24, 25, 26, 27, 30, 33, 43, 44.

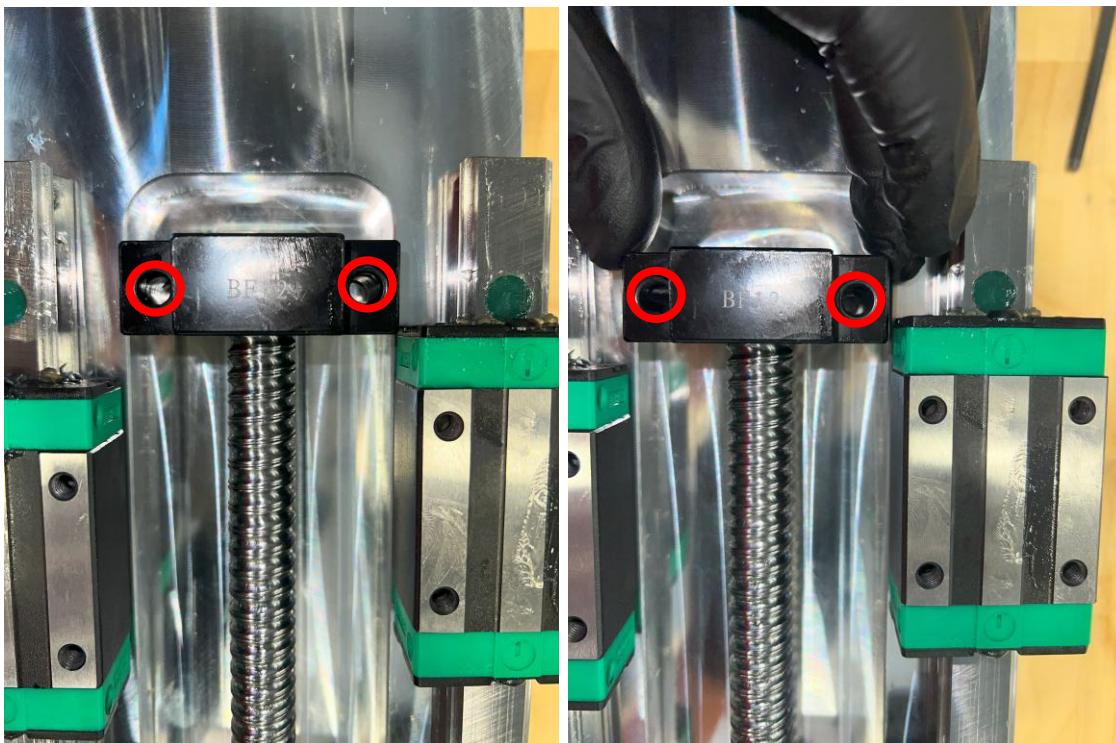
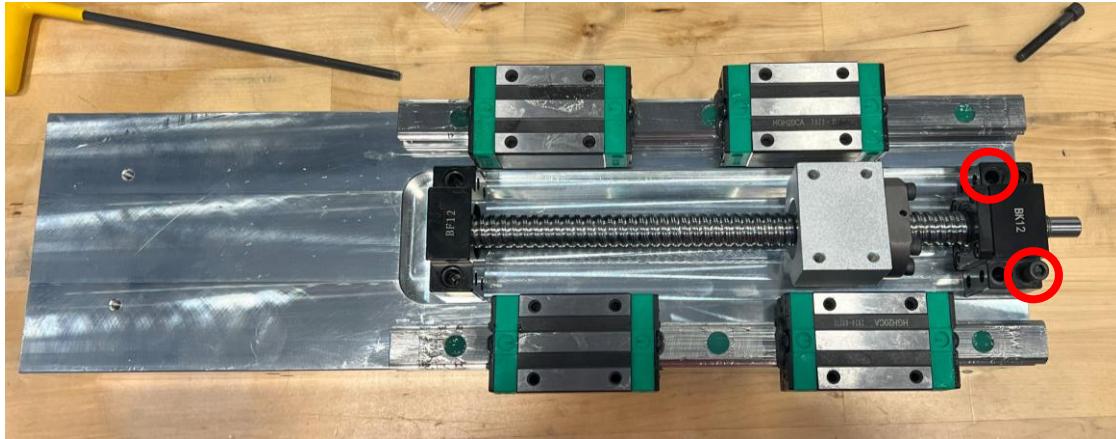


28. Secure the carrier block (17) to the ballscrew (27) using 6 M5 bolts (2). Attach the grease fitting supplied. Insert the ball screw into the bearing blocks (25 & 26) and attach.



NOTE: The snap ring provided with the ball screw is not used.

29. Loosely fit the BK12 (26) to the Column assembly with 2 diagonal bolts (5). The alignment of the BF12 (25) varies across manufacturers so the inside bearing of the BF12 (25) will need to pushed outward ultimately moving the BF12 closer to the threaded holes. See below.

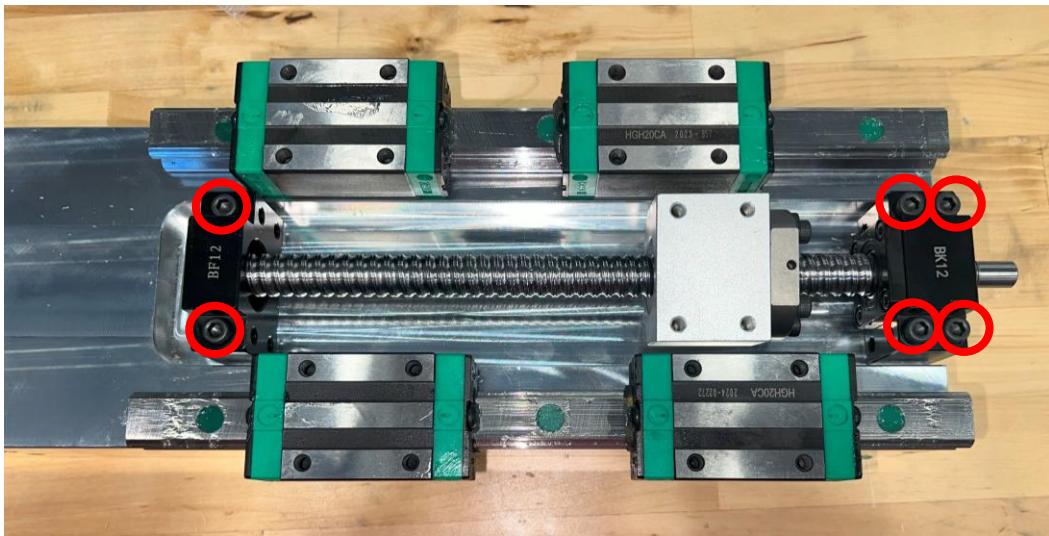


NOTE: Left figure is misaligned, and the right figure is aligned. See next page for alignment technique.

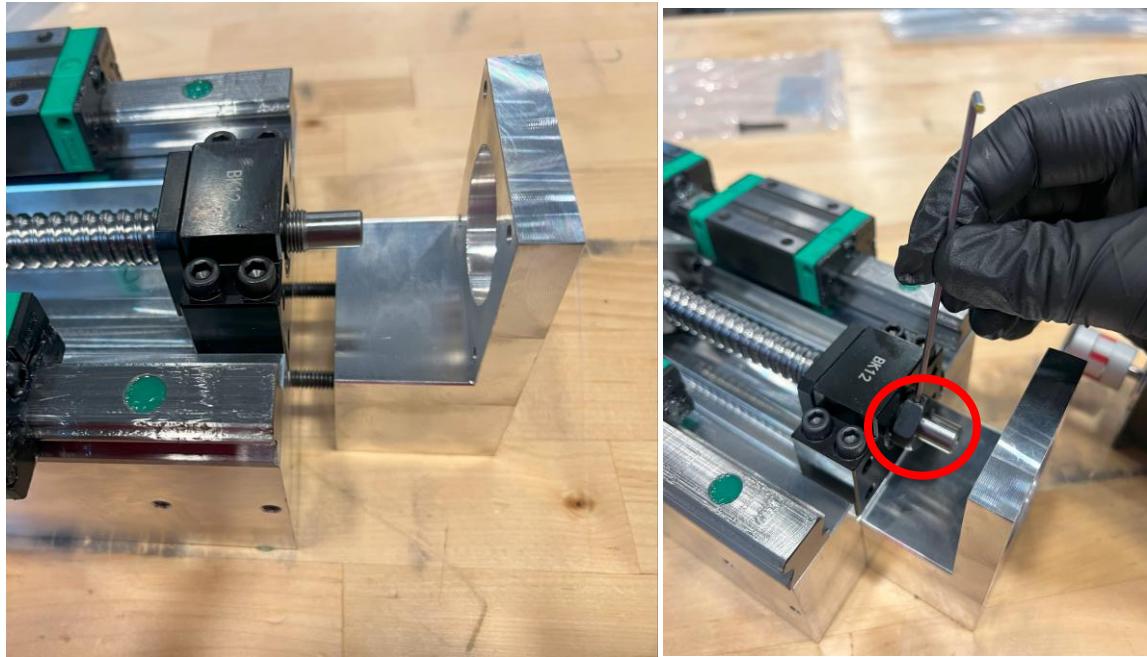
Remove the assembly. The bearing outlined in red needs to move in the direction of the red arrow. This can be done by standing the ball screw vertically and pushing down onto the table making sure not to grab the ball-screw nut, outlined in blue, during the process. A rubber mallet can be used on the other end of the ball screw if the bearing is stuck.



- Once aligned, apply thread lock (30) and tightly fasten the ball screw assembly with 6 bolts (5).



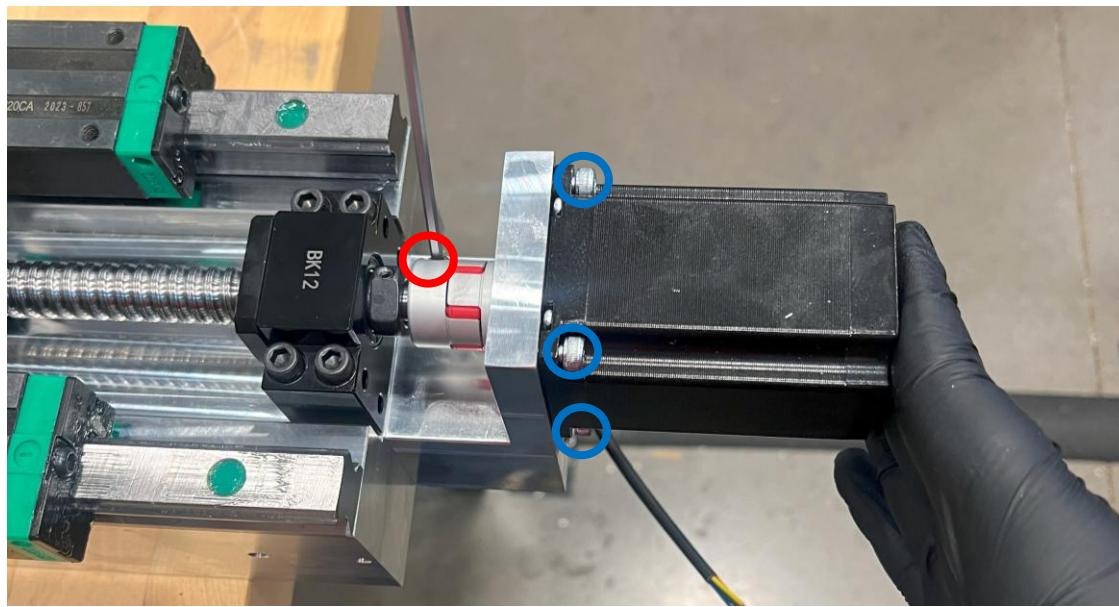
31. Attach the Z-axis motor mount (44) with the 2 bolts (5) prepped with thread lock. Thread on the nut shown in red on the right figure. Tighten the set screw on the nut.



32. Take the bolts out of the motor coupler (23) and apply thread lock (30). Prep the Nema 23 motor (22) with the motor coupler using a spare bolt (5) as a spacer. Tighten the bolt outlined in red and remove the spacer.  
NOTE: All spacer bolts should be very tight. Loose couplers will slip during axis motion.



33. Attach the motor to the ball screw by first pushing on the back of the motor and securing the coupler and tightening the bolt outlined in red. Second, loosely attach 4 M5 bolts (1) outlined in blue followed by tightening in a cross pattern. Apply thread locker to all bolts in blue.



34. Grease the ball screw through the fitting. Follow the directions provided by the grease gun manufacturer to load and prime.



NOTE: The figures depict a different orientation for the grease fitting. Any orientation is acceptable.

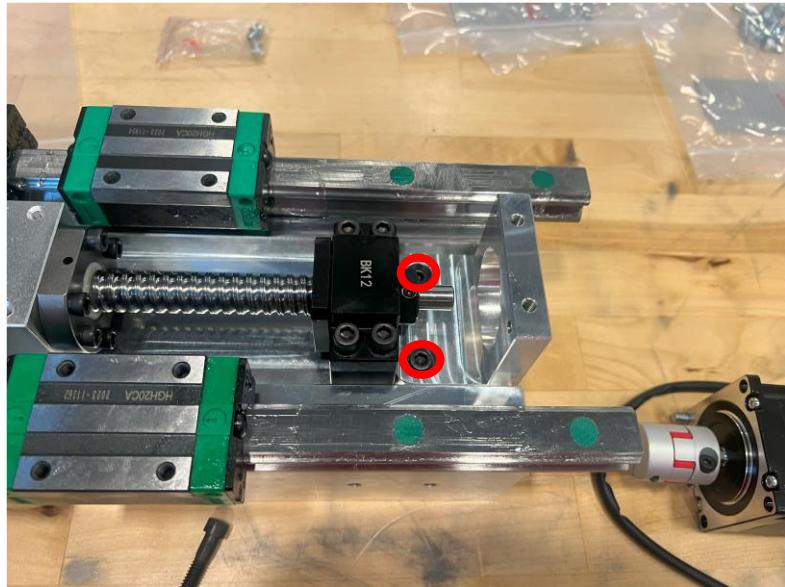
35. Gather the following items to begin the Base assembly: 1, 2, 5, 6, 11, 13, 15, 16, 17, 22, 23, 24, 25, 26, 27, 30, 33, 42, 45



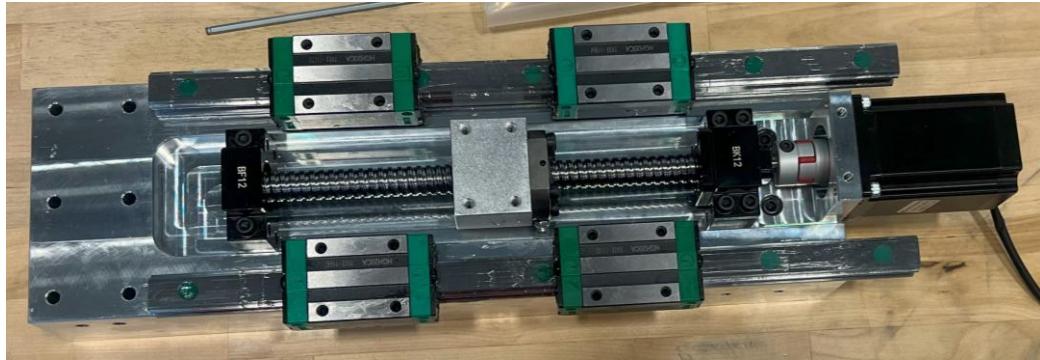
36. Repeat steps 28 & 29 to create the ball screw assembly and align it with the threaded holes in the base. The result is shown below. Be sure to attach the ball screw nut and tighten the set screw outlined in red.



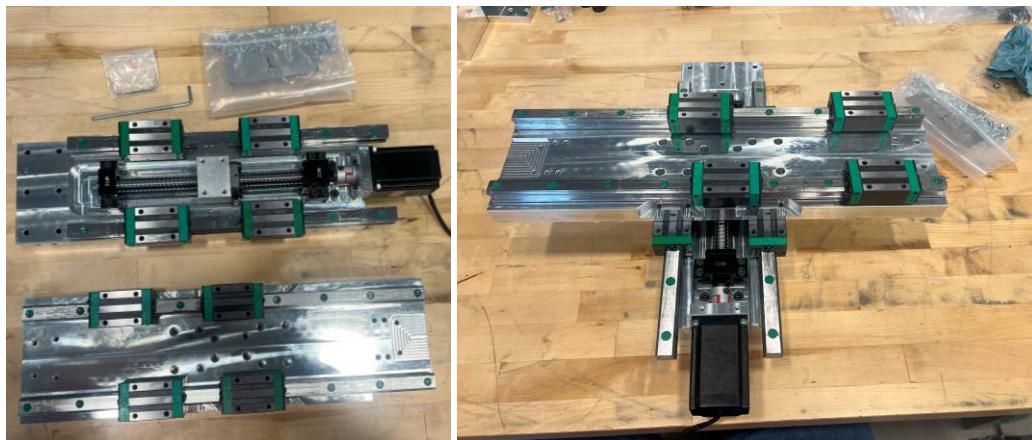
37. Attach the Y-axis motor mount (45) with 2 bolts (6) outlined in red.



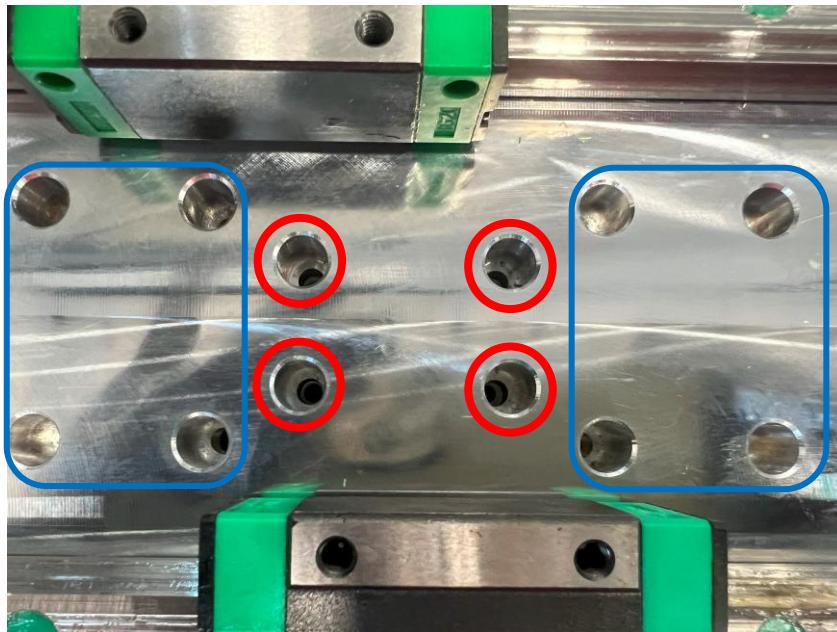
38. Repeat step 32 to prep a motor to be installed. Follow the same procedure for installing the motor onto the ball screw outlined in step 33. The result is shown below.



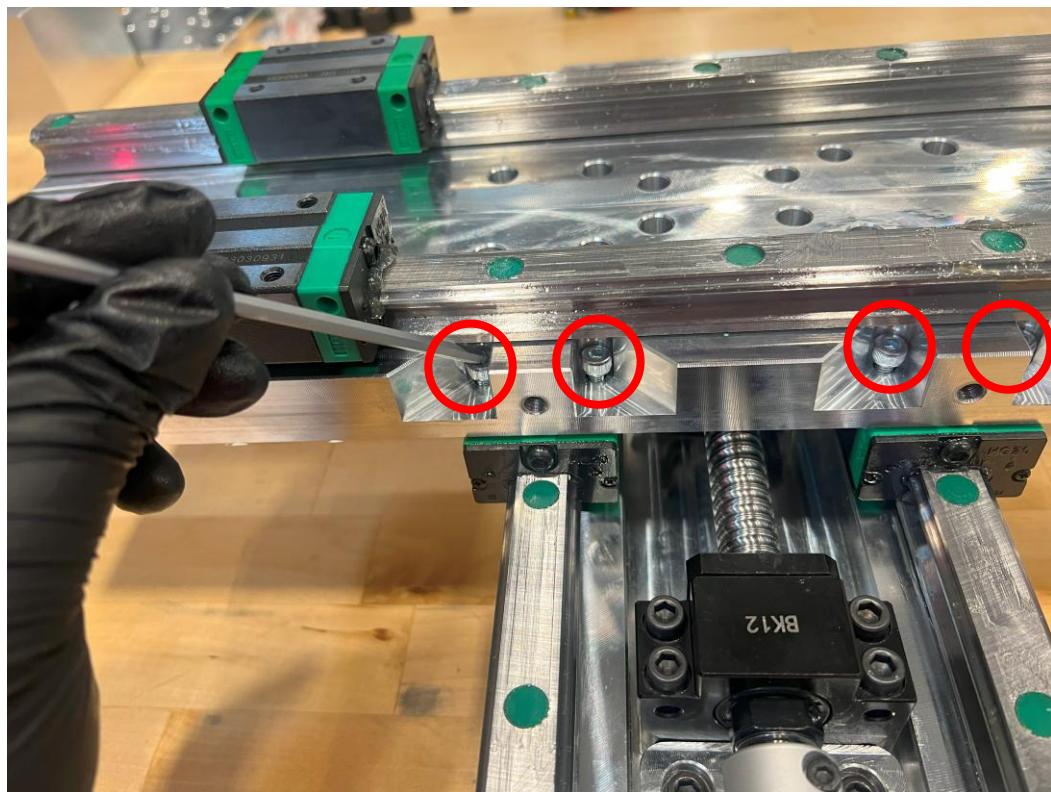
39. Gather the following items to attach the Base assembly to the Saddle assembly. Place the saddle on the base.



40. Align the Saddle to the ball screw carrier (17) of the Base assembly. First, use 4 M5 bolts (1) to loosely attach the Saddle outlined in red. Second, move the linear rail bearing blocks under the saddle to align with the holes on the saddle and loosely attach with 8 M5 bolts (1) outlined in blue. Do not fully tighten any of these bolts.



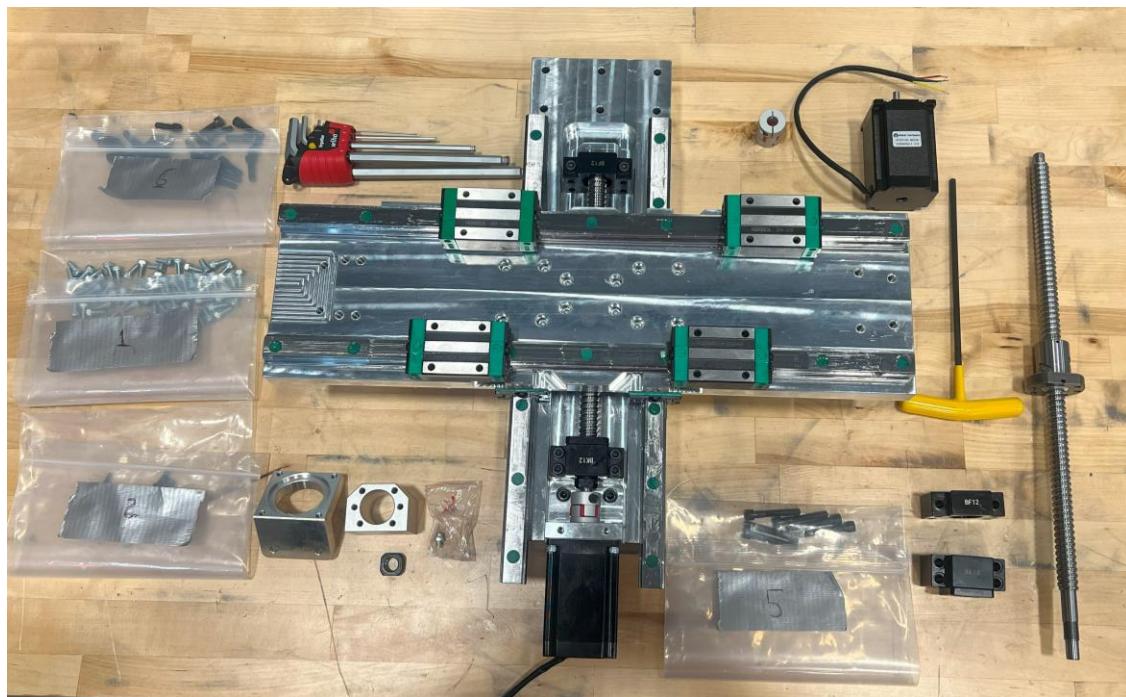
41. Use 4 M5 bolts (1) to loosely attach the saddle. The allen key has a ball end that allows you to thread the bolts from an angle. Repeat on the opposite side of the saddle.



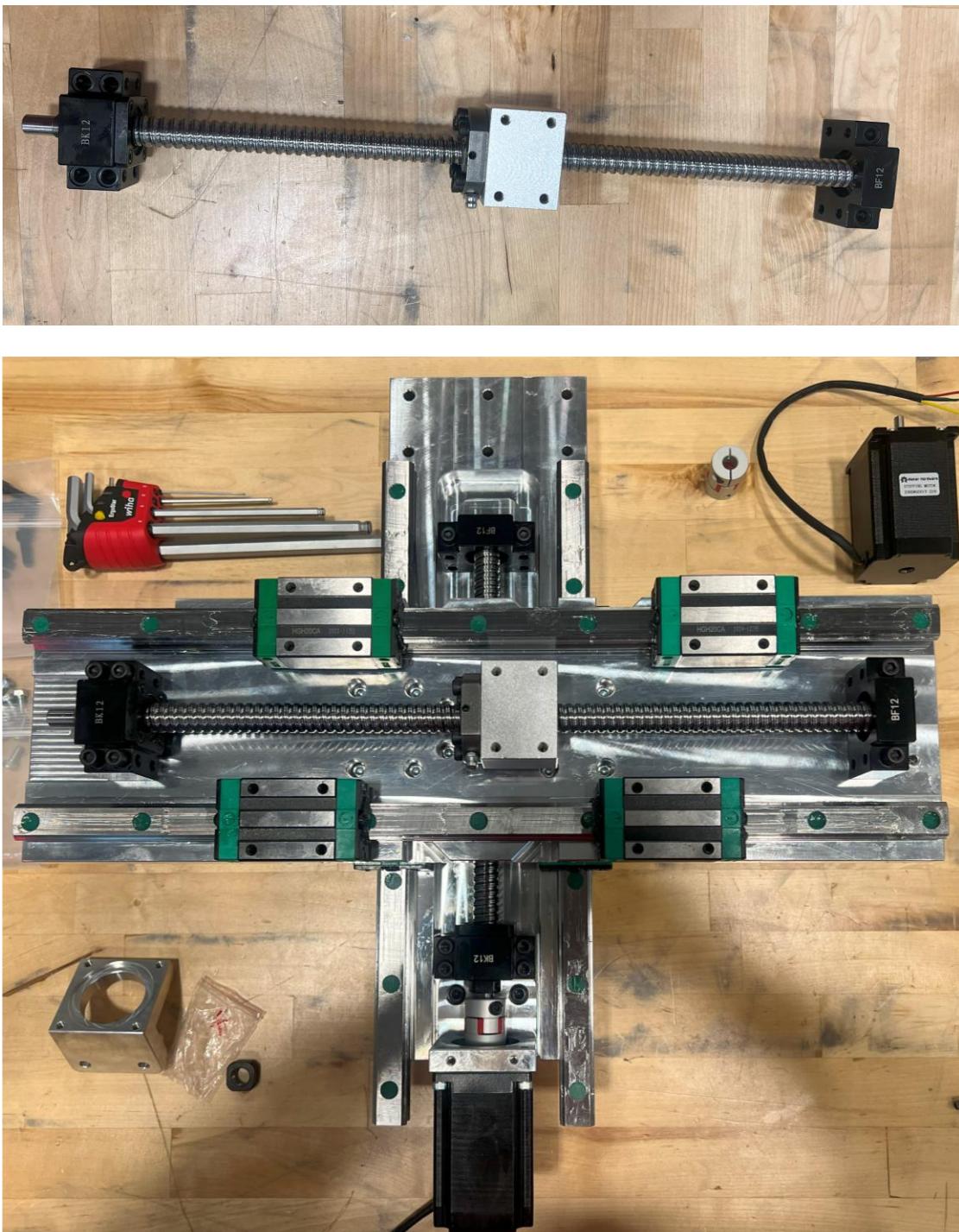
42. Fully tighten all the bolts ensuring the X and Y axes are roughly perpendicular. (This will be taken care of in the machine squaring instructions.) Use the short nose tool (9) provided to fasten the perimeter bolts on both sides of the saddle. Do not thread lock.



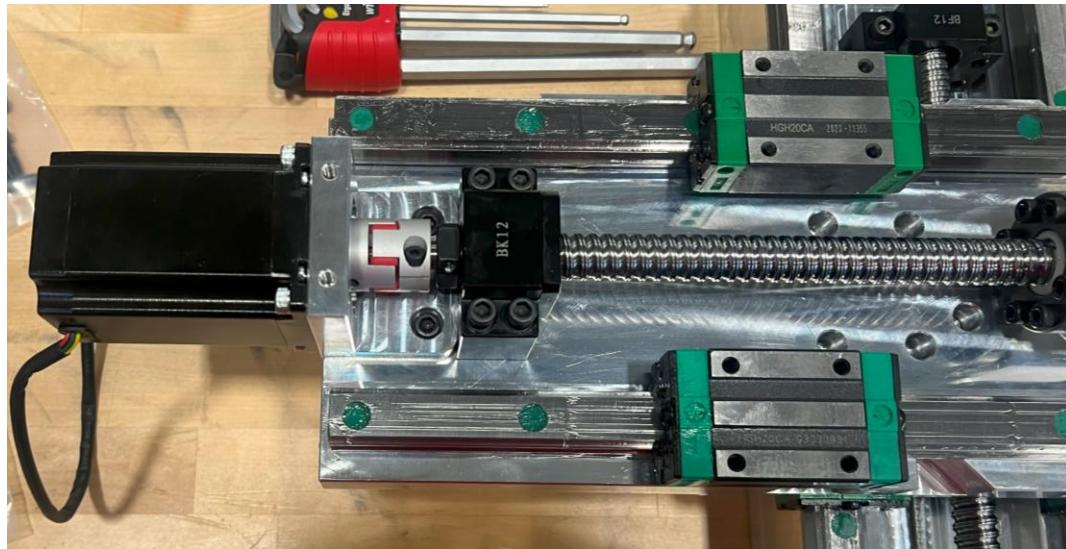
43. Begin the assembly of the saddle assembly by gathering these items: 1, 2, 6, 5, 11, 15, 16, 17, 22, 23, 24, 25, 26, 45



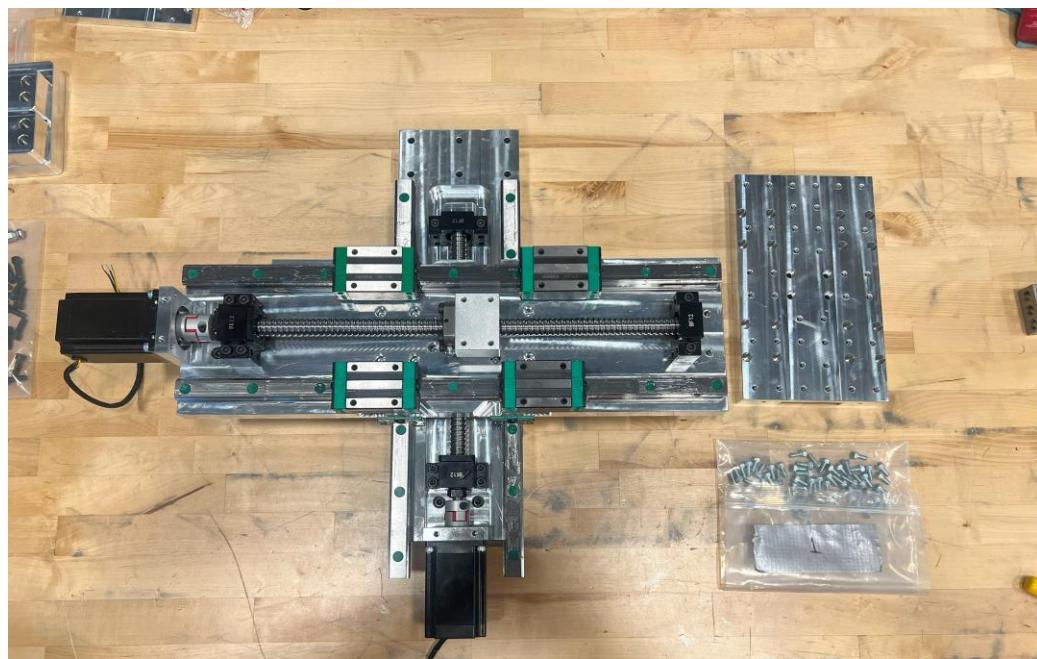
44. Repeat steps 28 through 30 with the 450mm ball screw (28) and attach it to the saddle. The result is shown below.

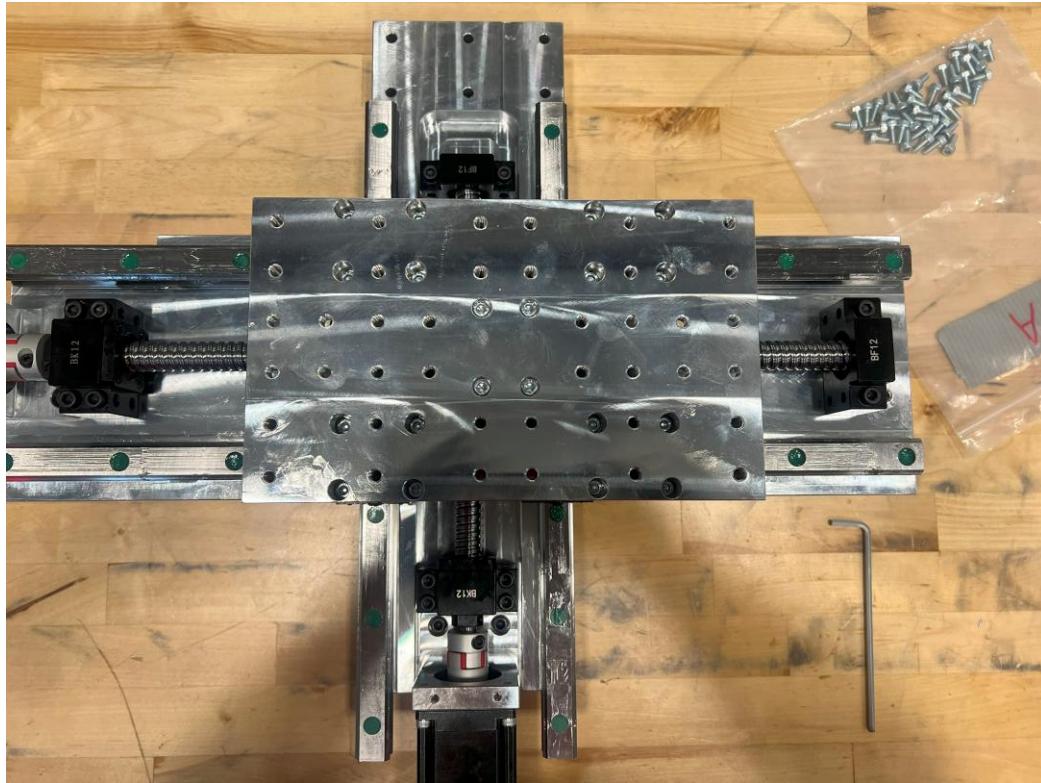


45. Repeat step 32 to prep a motor to be installed. Follow the same procedure for installing the motor onto the ball screw outlined in step 33. The result is shown below. Remember to attach the ball screw nut.

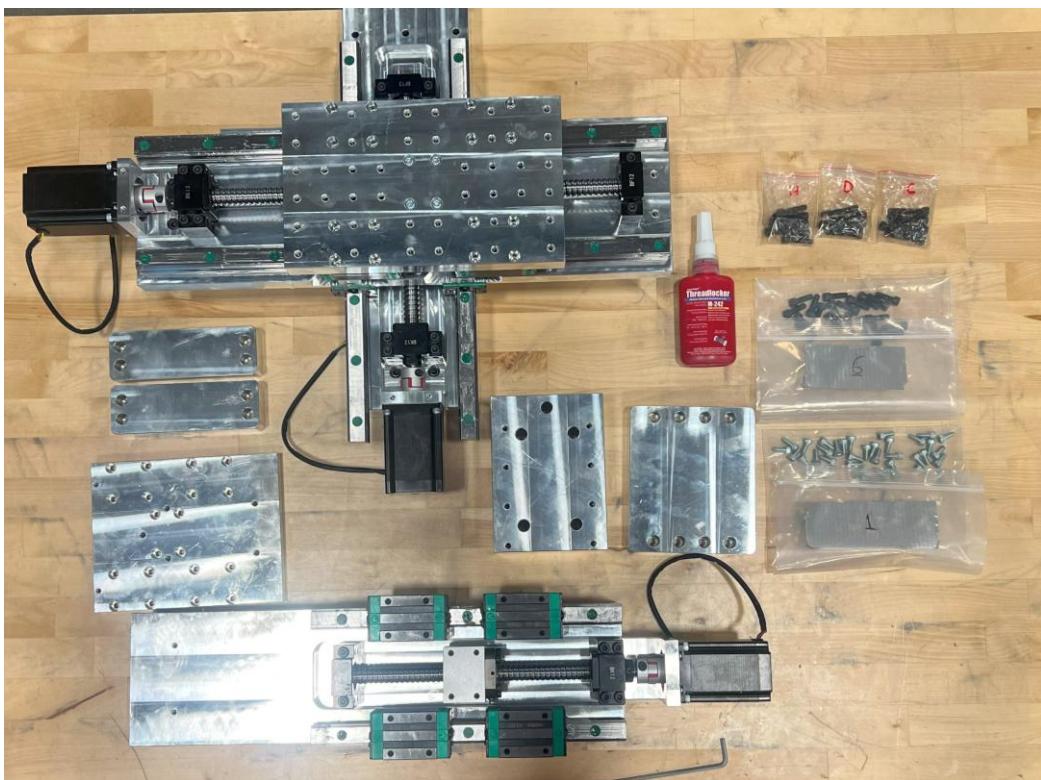


46. Attach the X-carriage to the Saddle using M5 bolts (1). Use a similar mounting process outline in step 40

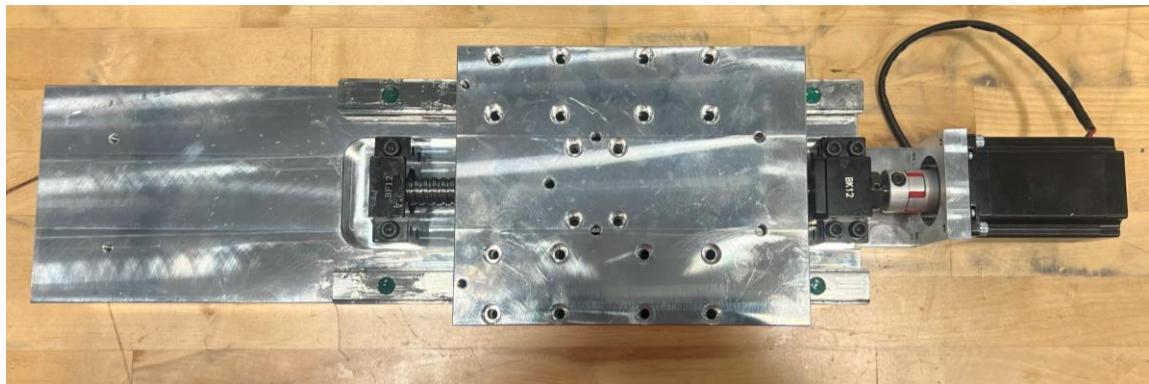




47. Gather the items below to attach the column to the base.



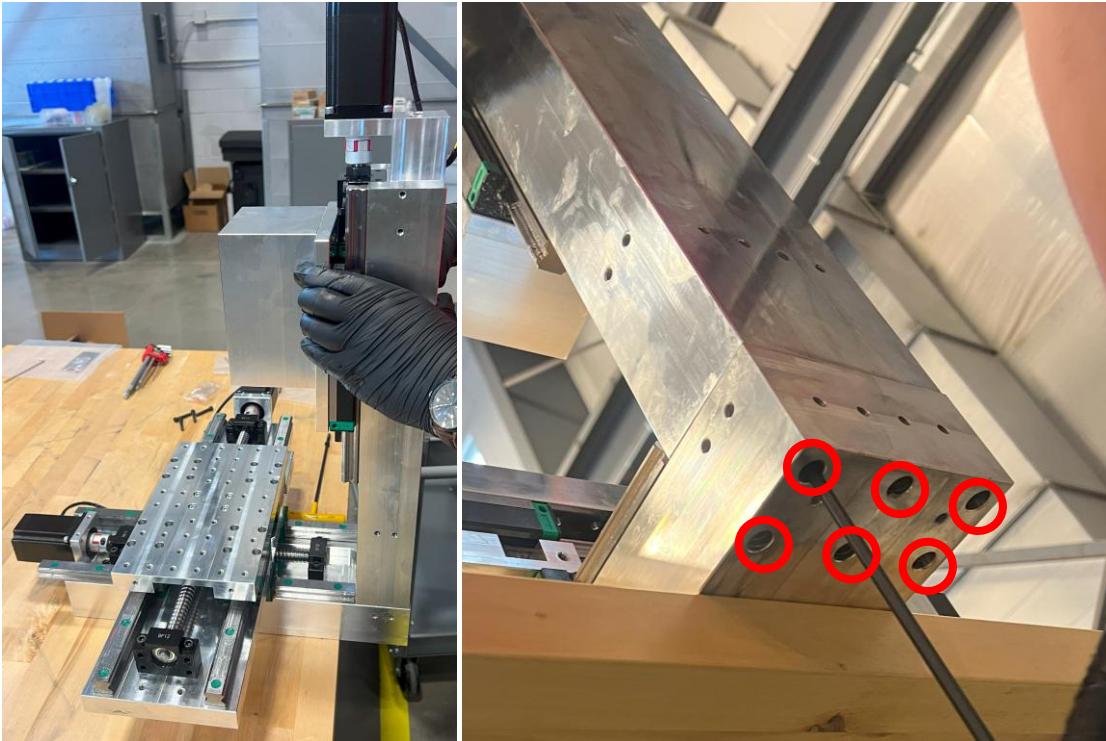
48. Attach the Z-carriage to the column using M5 bolts (1)



49. Attach the Z-head using 5 bolts (4). Make sure the top surface of the Z-head is flush with the Z-carriage.



50. Bring the base to the edge of the table so that the 6 thru holes are exposed. Position the column assembly on top of the base as shown below. Attach the 6 bolts (4) loosely. (Two people are recommended for this step for safety.)



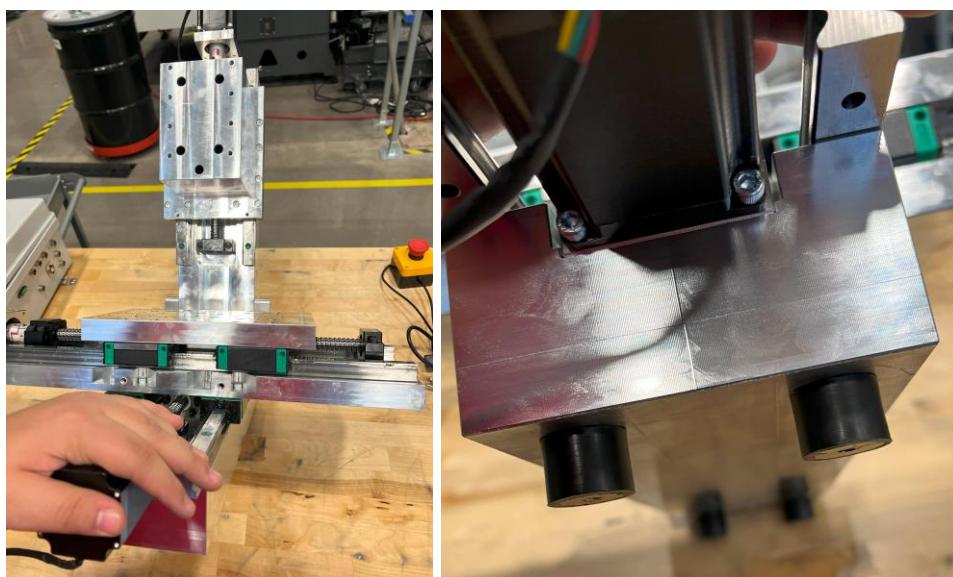
51. Attach the Column bracings (36 & 38) to the back and both sides. Loosely fit all 3 bracings with the bolts provided (6) followed by tightening in the following order: left bracing (red), back bracing (blue), and right bracing (green).



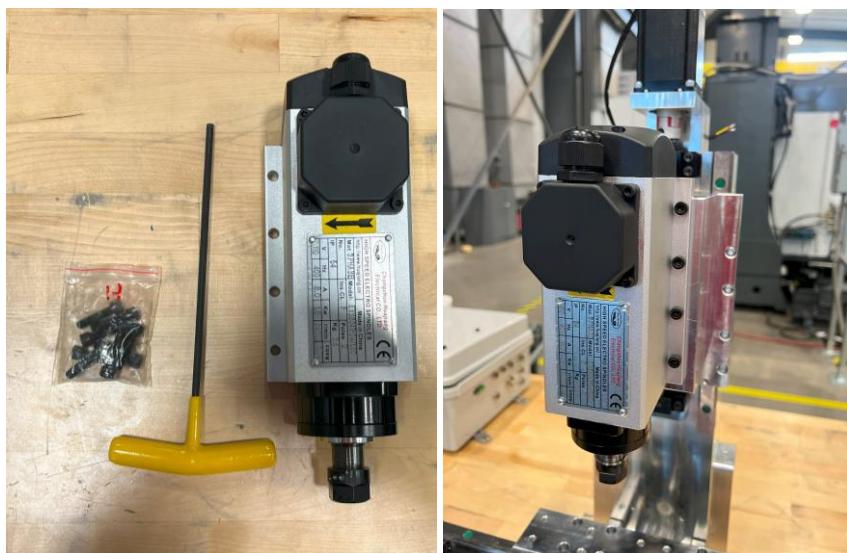
52. Attach the feet of the machine (18) in the outline threaded holes.



53. Tilt the machine back and attach the last two feet for the machine (18).



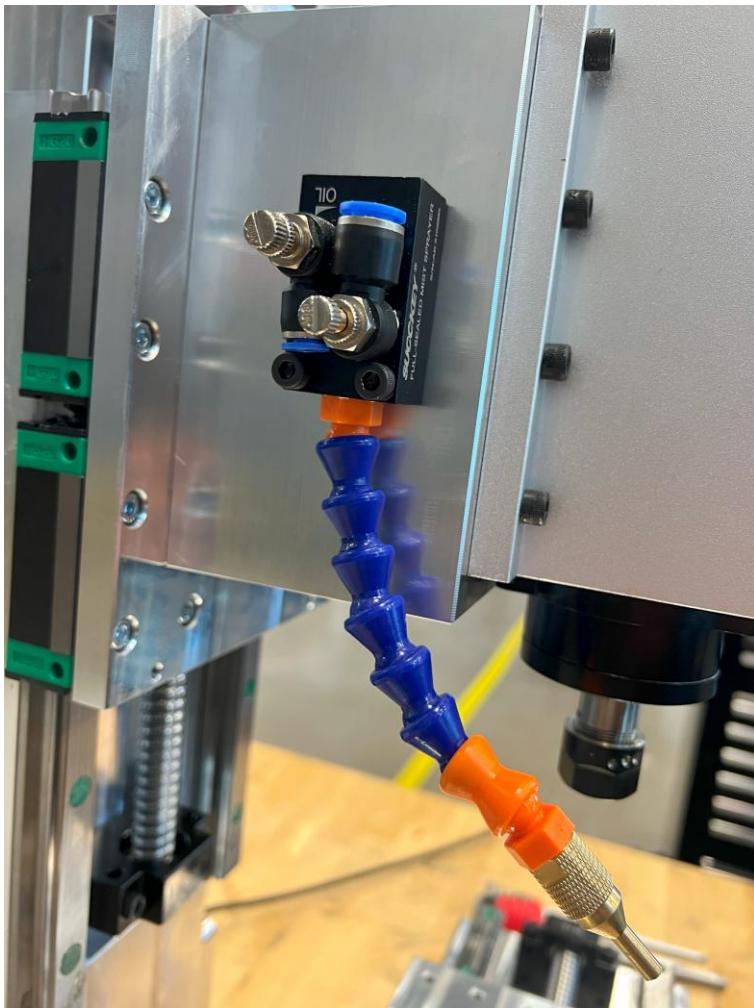
54. Gather the spindle and the bolts (8) shown below to attach the spindle.



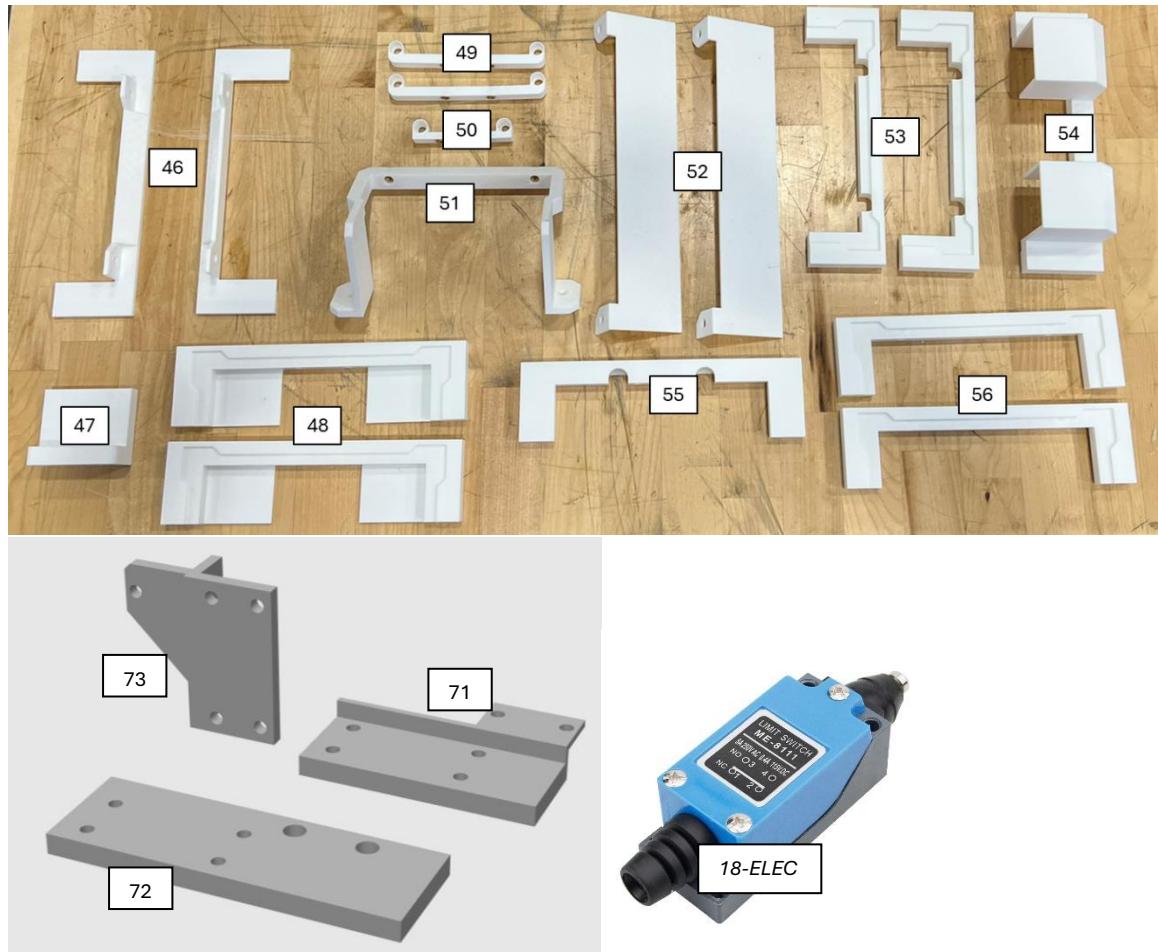
**55. Proceed to the squaring instructions.**

...

**56. Attach the coolant hose to the side of the Z-head with two M5x25 bolts (7).**

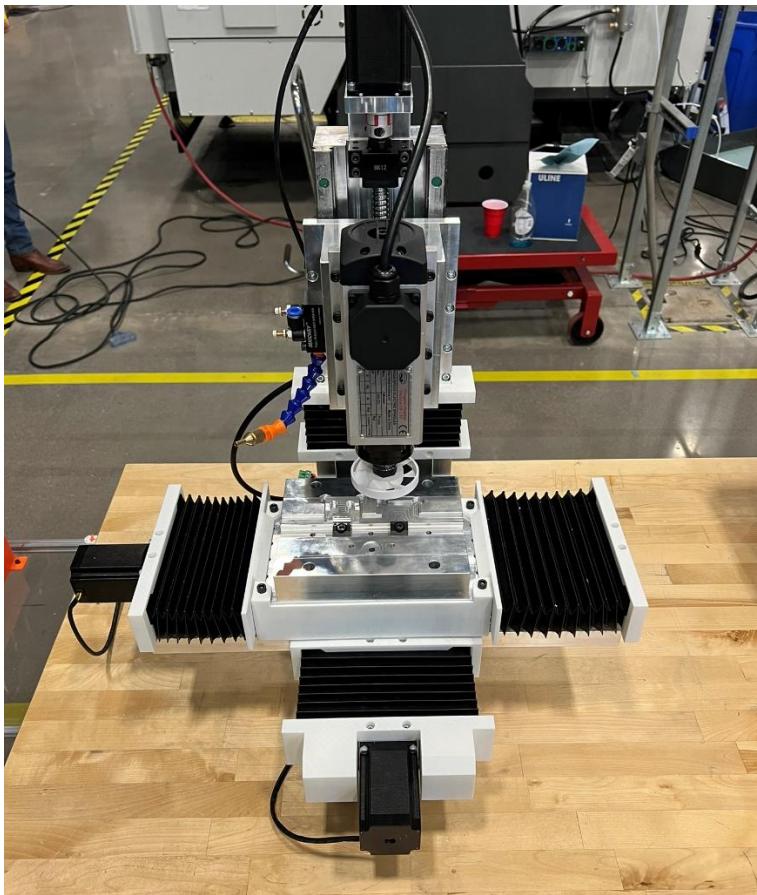


57. After the machine is squared, acquire the 3D printed components shown below.



Item number	Description	Qty
46	X-carriage cover end	2
47	X-axis end mount	1
48	X-motor cover end	2
49	Y-axis end mount	2
50	Column end mount	1
51	Z-axis end mount	1
52	X-axis hard cover	2
53	Y-axis cover end	2
54	Y-motor cover end	1
55	Column cover end	1
56	Z-axis cover end	2
71	X-limit switch mount	1
72	Y-limit switch mount	1
73	Z-limit switch mount	1
18-ELEC	Limit switch	3

This system will help keep chips and other debris off the greased rails. Continue below.



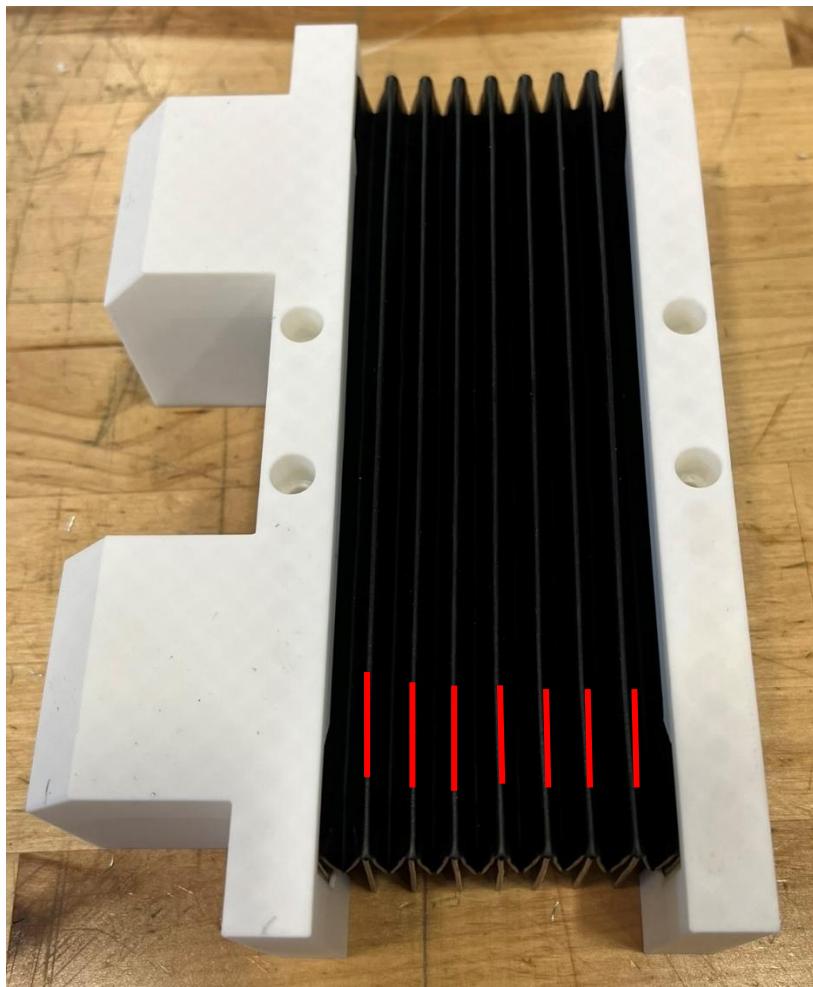
58. Cut the thick piece of plastic off the way cover. Cut as close to the red line as possible.



59. Grab the Y-motor cover end (54). Insert the way cover where it was cut in the previous step as shown below. To get the right side into the 3D printed part, bend the way cover slightly then slide into place.

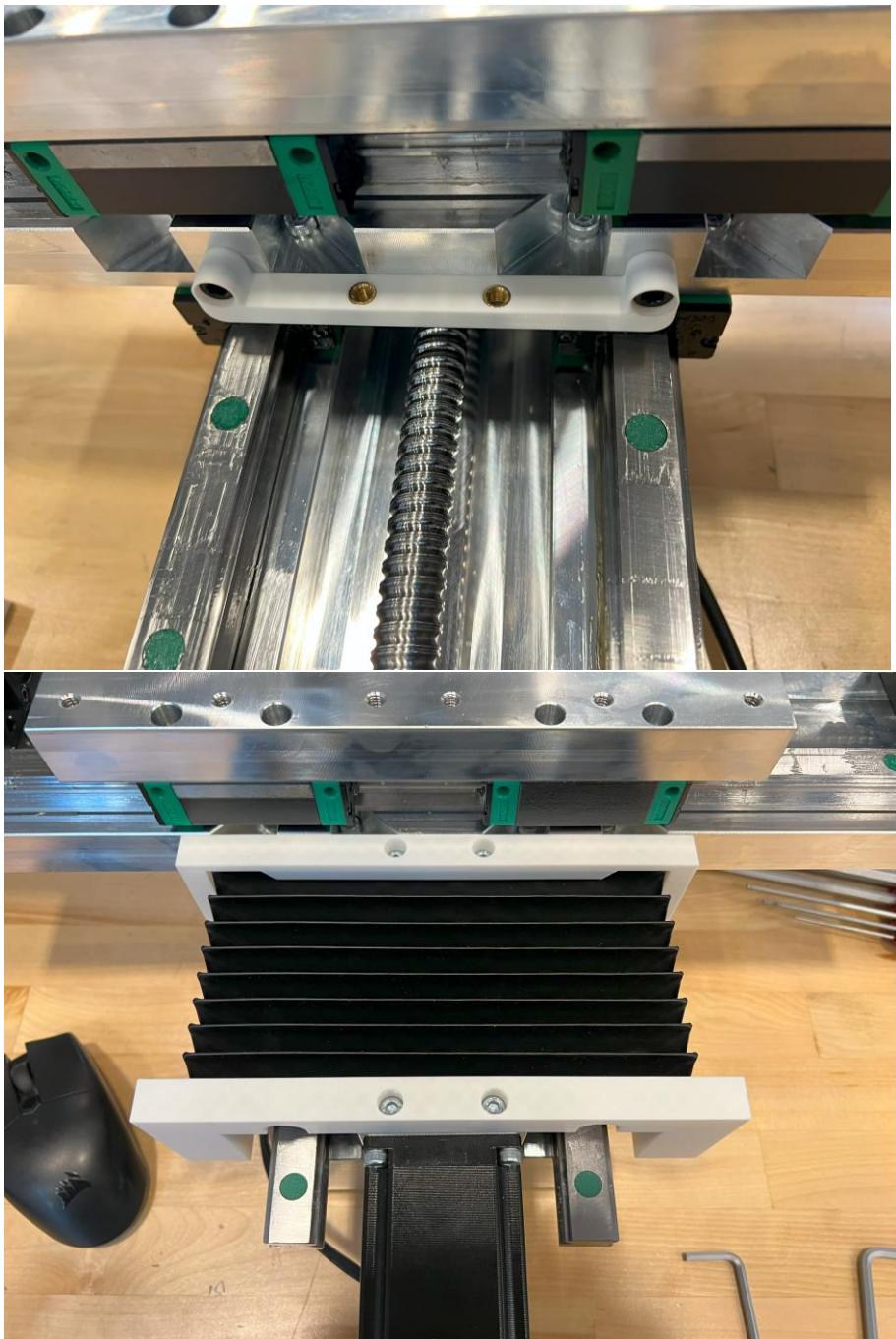


60. Cut the way cover so that there are 7 folds in between the 3D printed parts. In total this cover will have 9 folds, including the two that are inserted into the printed part. Insert the other end of the cover into Y-axis cover end (53).



61. Grab the Y-axis end mounts (49). Attach these to the front and back side of the saddle using 2 bolts (6) and then secure the first Y-axis way cover made in the previous step with 4 M5 bolts (1).





62. Repeat the previous steps to create the second Y-axis way cover (49) (53). This cover should have 7 folds.



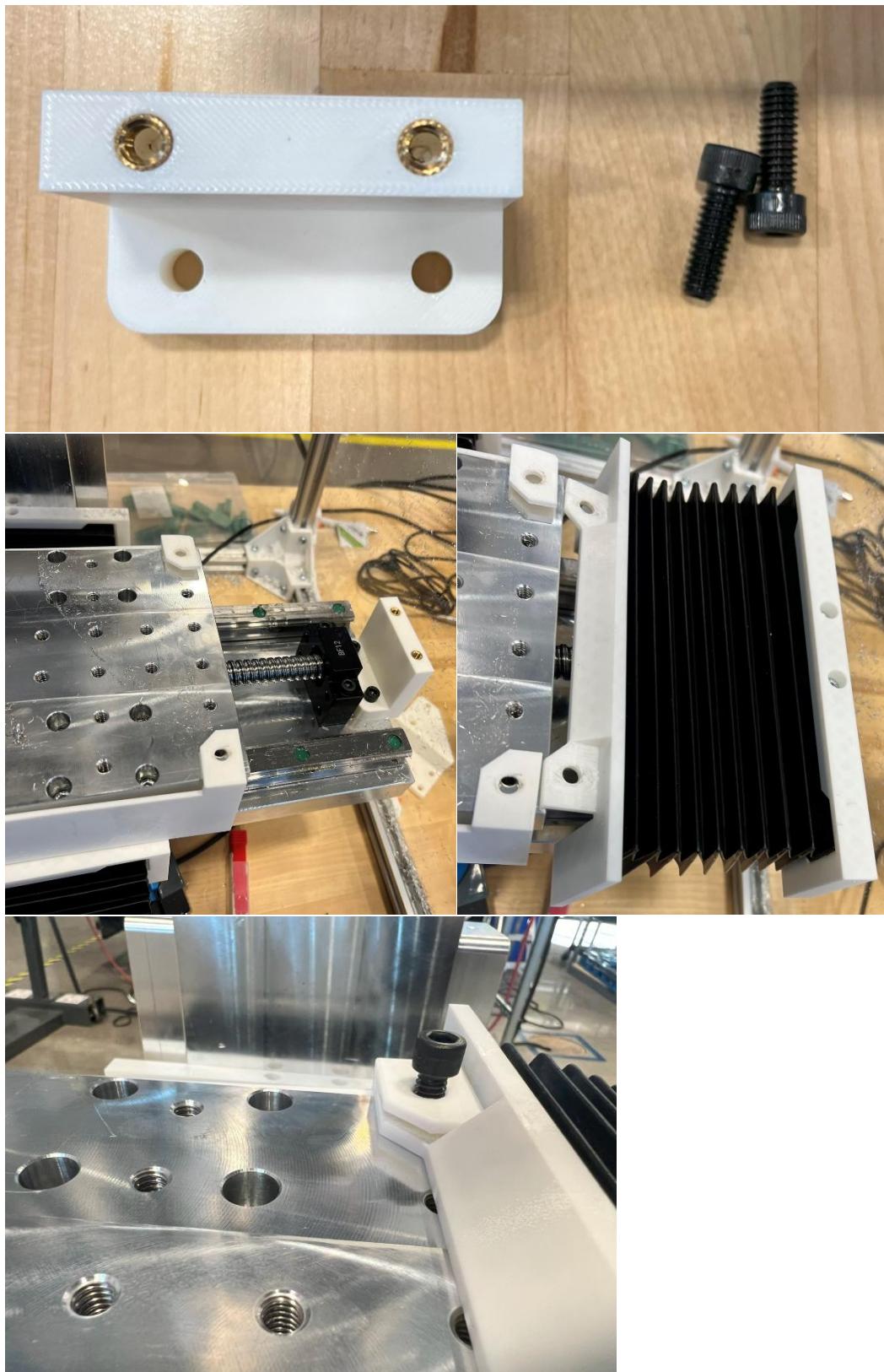
63. Attach the column end mount (50) to the column (43) using 2 M5 bolts (1). Secure the cover made in the previous step using 4 M5 bolts (1).



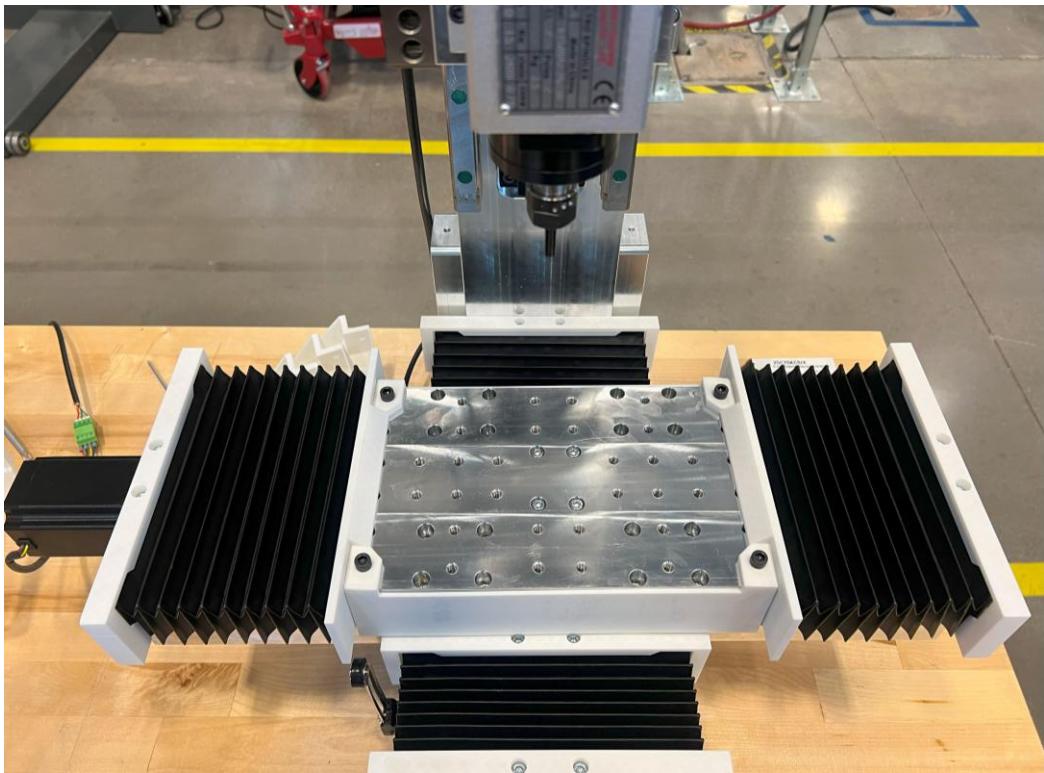
64. Assemble both X-axis covers using the X-carriage cover ends (46) and X-motor cover ends (48). This cover should have 9 folds in between the two 3D printed parts. These parts are identical.



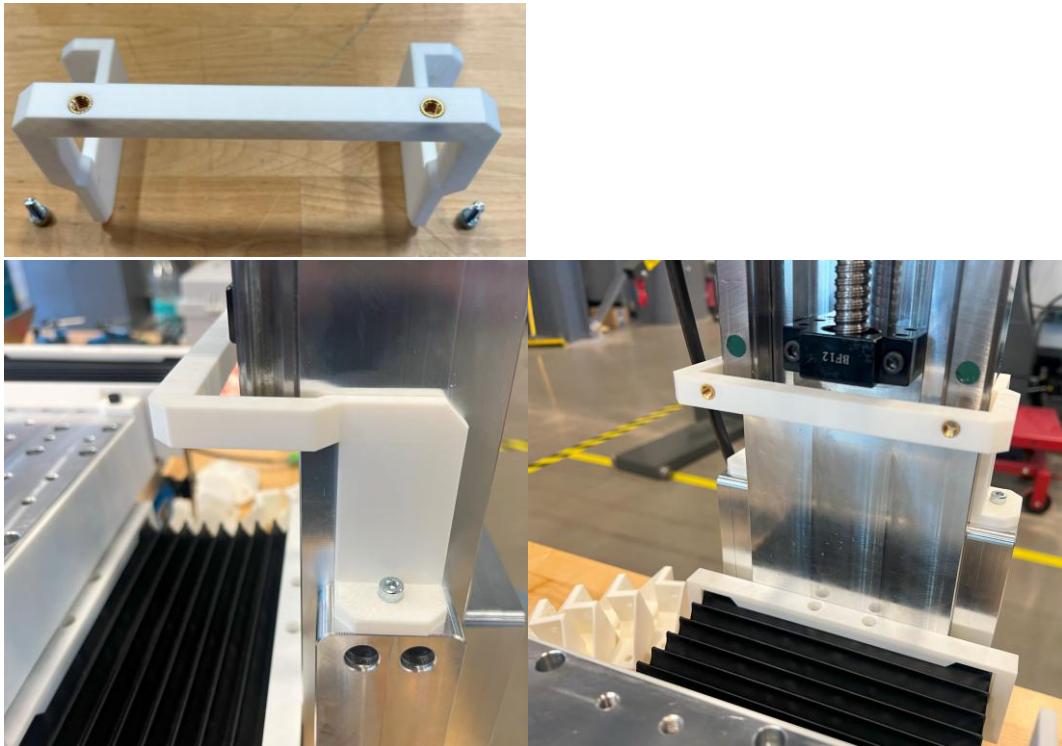
65. Attach X axis end mount (47) using two 1/4-20 bolts (6). Attach the hard covers (52) on top of the way cover end (46) and secure it with two 1/4-20 bolts (6). Repeat this with the other side of the X-carriage (40).



The X and Y axis way covers are complete, and the result is shown below.



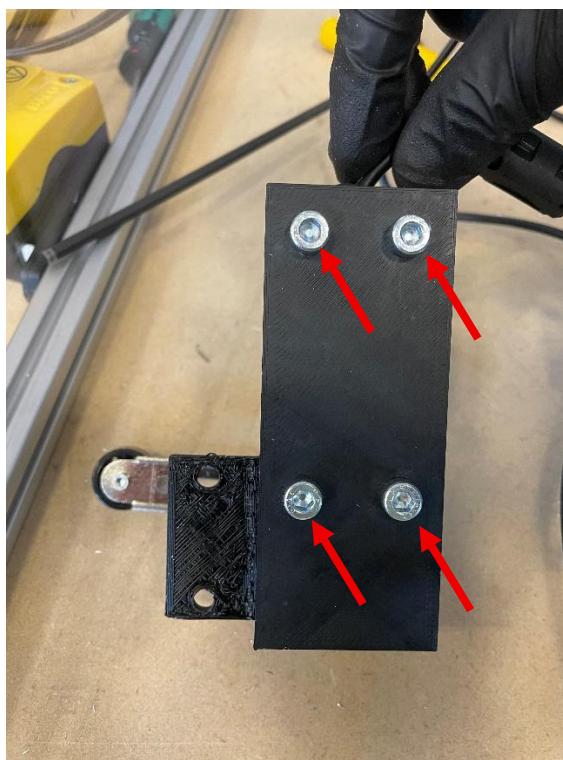
66. Grab the Z-axis end mount (51) and attach it to the column bracings (38) with two M5 bolts (1)



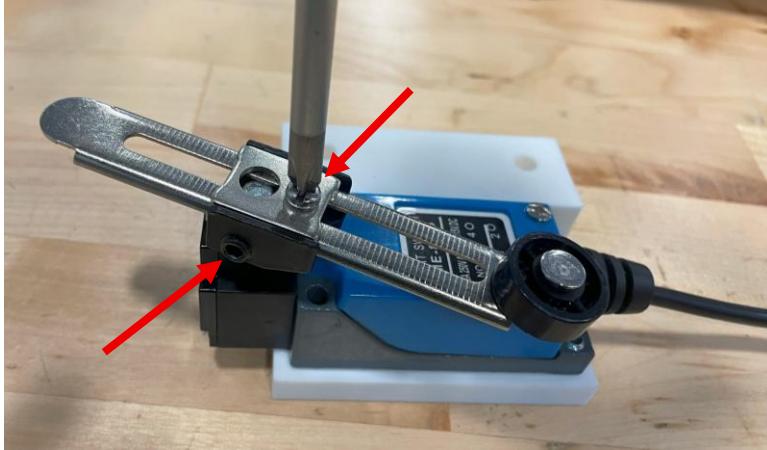
67. Attach the way cover to the Z axis cover ends (56) as shown below. This cover should have 5 folds in between the 3D printed components. Attach this cover to the Z-carriage and the Z-axis end mount (51) using four M5 bolts (1).



68. We will now secure the limit switches to the machine. This should be done after the switches are wired as detailed in the *Electrical Instructions*. Attach a limit switch (18-ELEC) to the X-axis holder (71) with 4 M5 bolts (1).



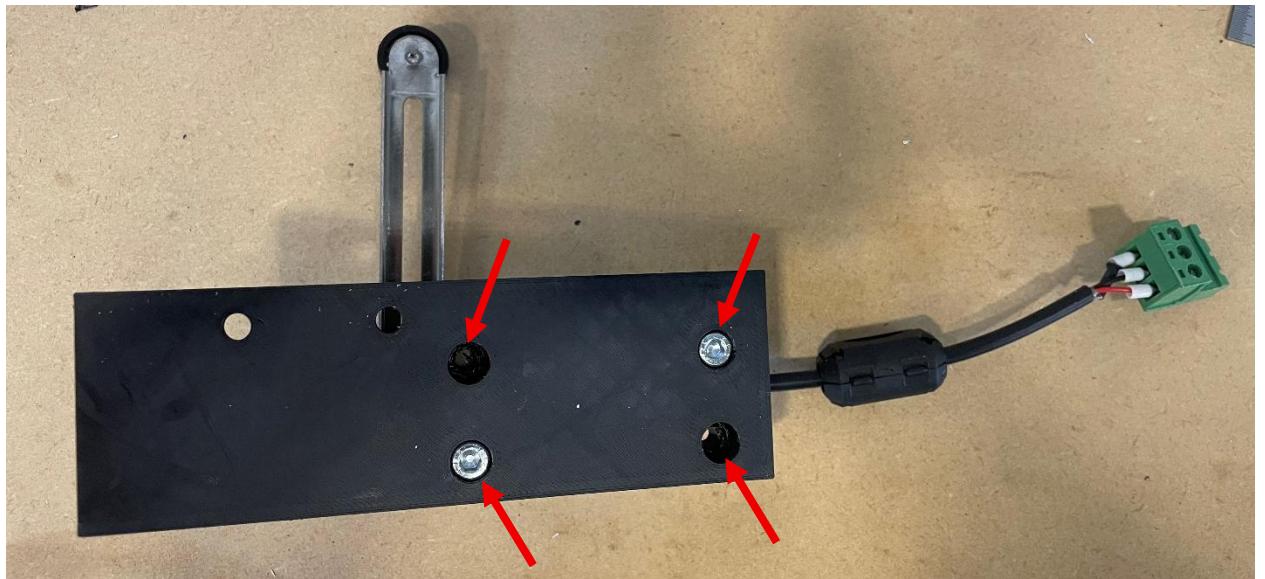
69. Now set the length and angle of the limit switch. Use a screwdriver to loosen the set screw on the front of the limit switch. Set the lever extension. Once in place, tighten the screw. Loosen the set screw on the side of the lever arm with a hex key. Now rotate the arm to the desired position. Hold in place and tighten the set screw.



70. Use the following picture with step 69 to set the rough position of the limit switch and attach it to the machine by the two holes shown with M5 bolts. Test the limit switch by jogging the X-axis. The two surfaces marked in green should meet and trip the limit switch (audible click and signal on control software) BEFORE the way cover is fully compressed.



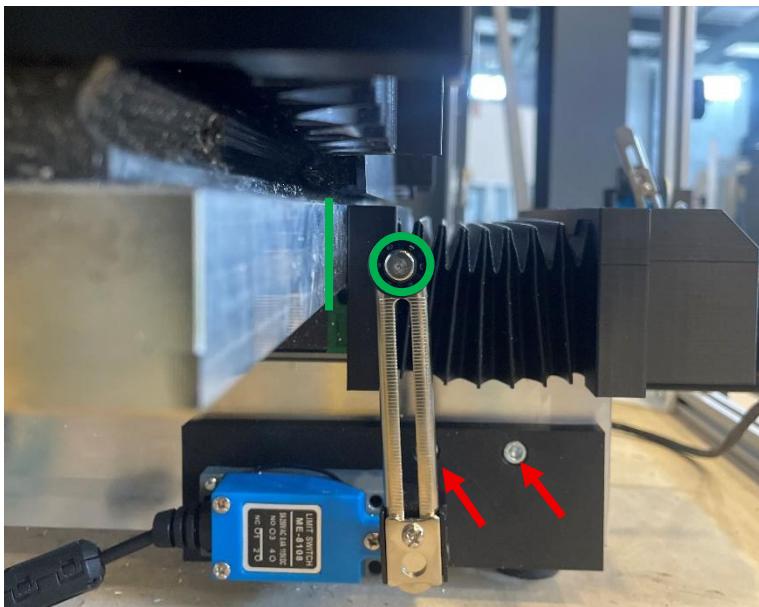
71. Attach a limit switch (18-ELEC) to the Y-axis holder (72) with 4 M5 bolts (1).



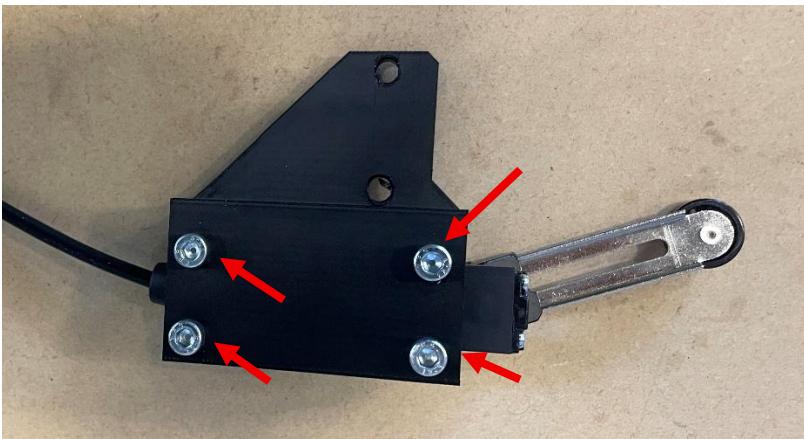
72. Follow step 69 to set the lever position roughly as seen below.



73. Attach it to the machine by the two holes shown with M5 bolts. Test the limit switch by jogging the Y-axis. The two surfaces marked in green should meet and trip the limit switch (audible click and signal on control software) BEFORE the way cover is fully compressed.



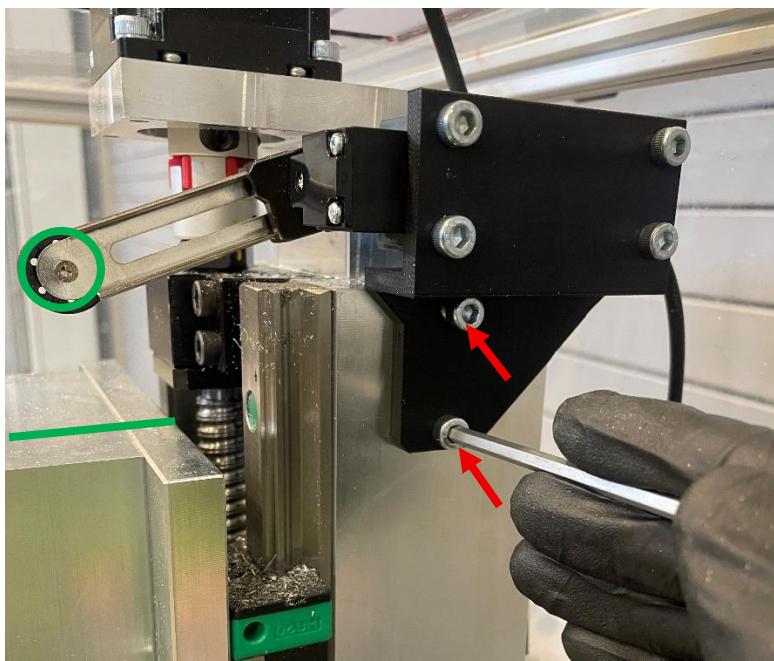
74. Attach a limit switch (I8-ELEC) to the Z-axis holder (73) with 4 M5 bolts (1).



75. Follow step 69 to set the lever position roughly as seen below.



76. Attach it to the machine by the two holes shown with M5 bolts. Test the limit switch by jogging the Z-axis up. The two surfaces marked in green should meet and trip the limit switch (audible click and signal on control software) BEFORE the way cover is fully compressed.



77. Grab all the required components to build the enclosure.

Item Number	Description	Qty
57	20/20 Al extrusion: 25 in	4
58	20/20 Al extrusion: 23.5 in	8
59	Corner bracket	8
60	Drop in t-nuts	100
61*	Side panels	2
62*	Front panel	1
63*	Back Panel	1
64*	Top Panel	1
65	Panel clip assortment	1

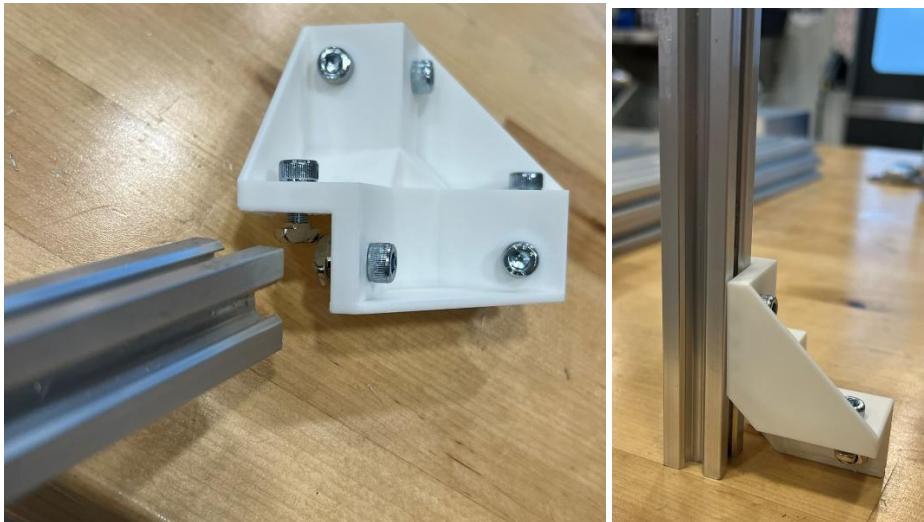


\*Not pictured

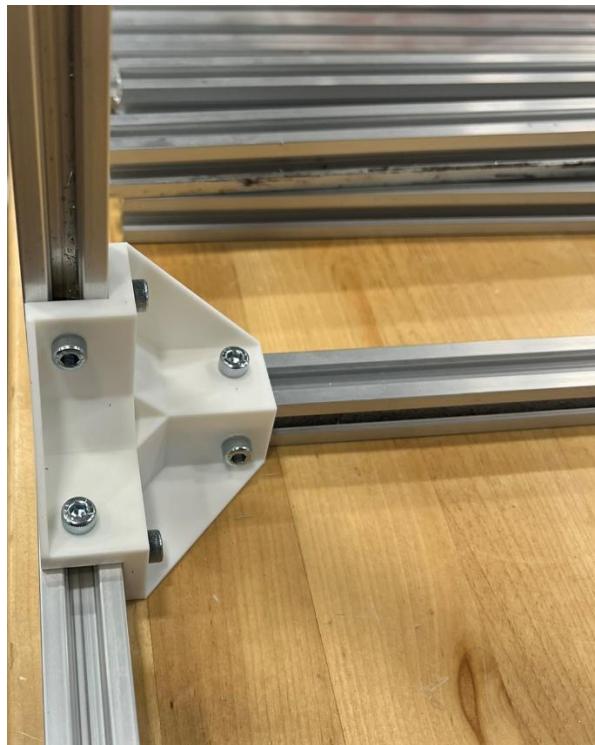
78. Prepare all 8 corner brackets (59) with 6 M5 bolts (1) and 6 drop in t-nuts (60). When assembling the enclosure, **be sure that the 4 brackets with extra holes are facing the table**. These will be used to bolt the enclosure to the table.



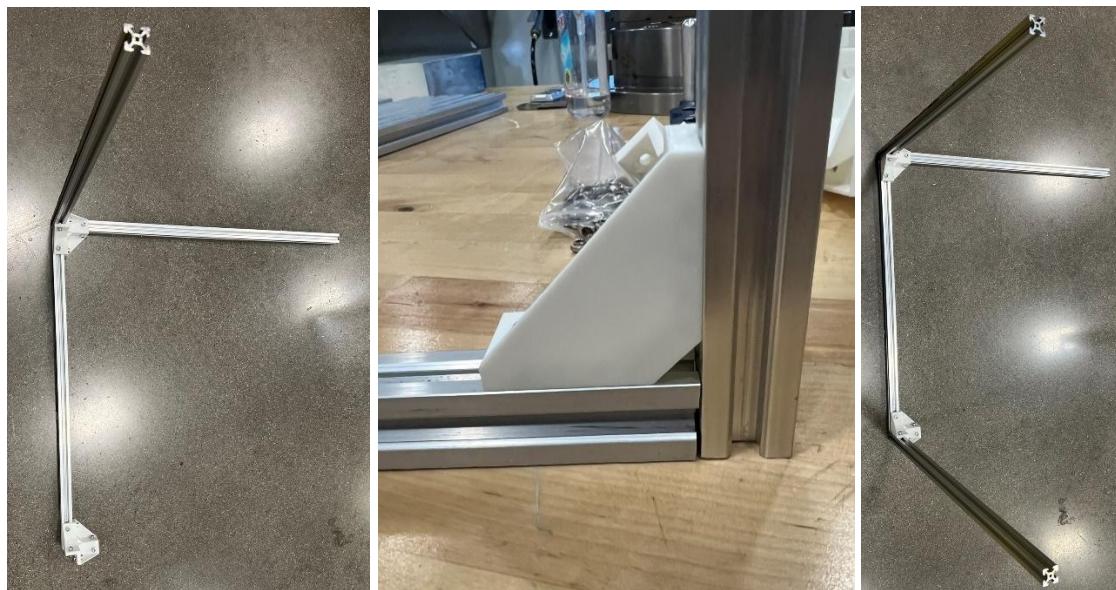
79. Slide in one of the four longer 20/20 extrusions (57) as shown. Place it on a relatively flat table and tighten both top bolts.



80. Slide in two of the smaller aluminum extrusions (58) and tighten the remaining four bolts.



81. Attach another corner bracket to the end of one of the extrusions from the previous step. Insert the longer extrusion vertically and tighten all four bolts.



82. Attach two more corner brackets and smaller extrusions. The four vertical extrusions should all be the longest in length.



83. Slide on the final four corner brackets and tighten them enough so they don't slide down.



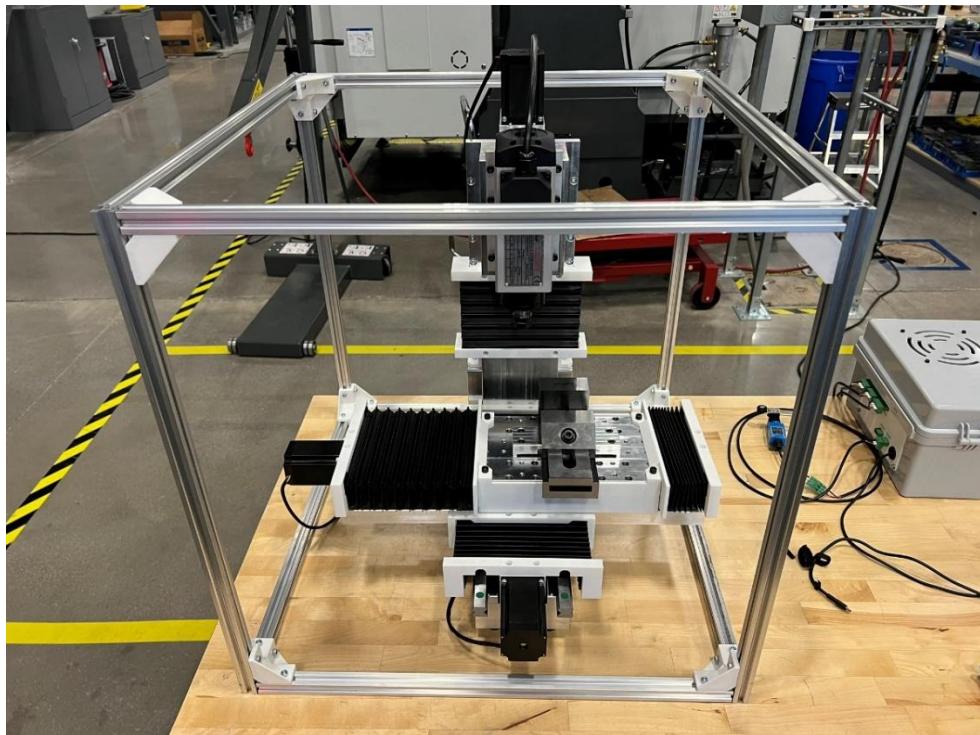
84. Slide one of the smaller aluminum extrusions between the two vertical extrusions. Loosely tighten the four bolts. Repeat with the remaining 3 extrusions.



85. Loosen each corner bracket and ensure the top face of the vertical extrusion coincides with the two horizontal extrusions before the corner bracket is tightened. This can be done by inspection or by placing the corner on a flat table.



86. Place the enclosure over the milling machine.



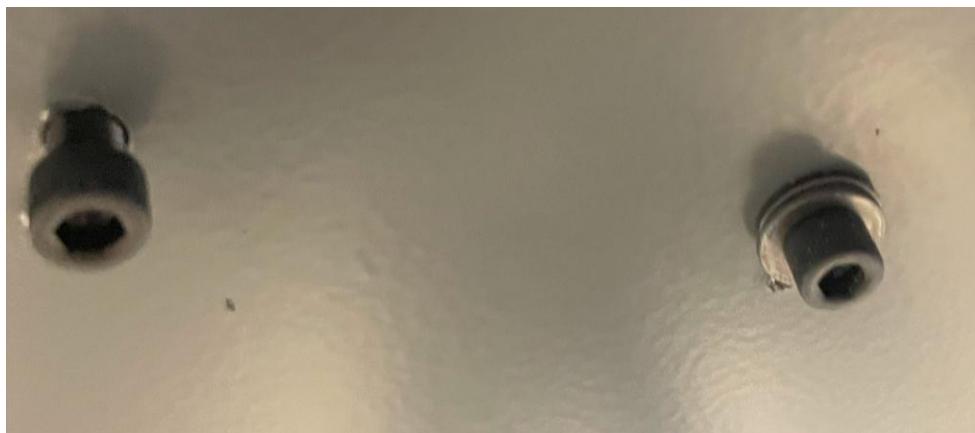
87. Decide the best place for your milling machine and enclosure. The machine should be located on a sturdy table capable of handling the machine's weight and motion. Ensure that the machine is fully inside the enclosure, then create markings on the four enclosure corners and at the feet of the desktop mill.



88. Move machine and enclosure, then SAFELY drill holes at the correct places on your table. These holes should be big enough for  $\frac{1}{4}$  - 20 bolts. NEVER operate power tools without proper training and personal protective equipment (PPE).



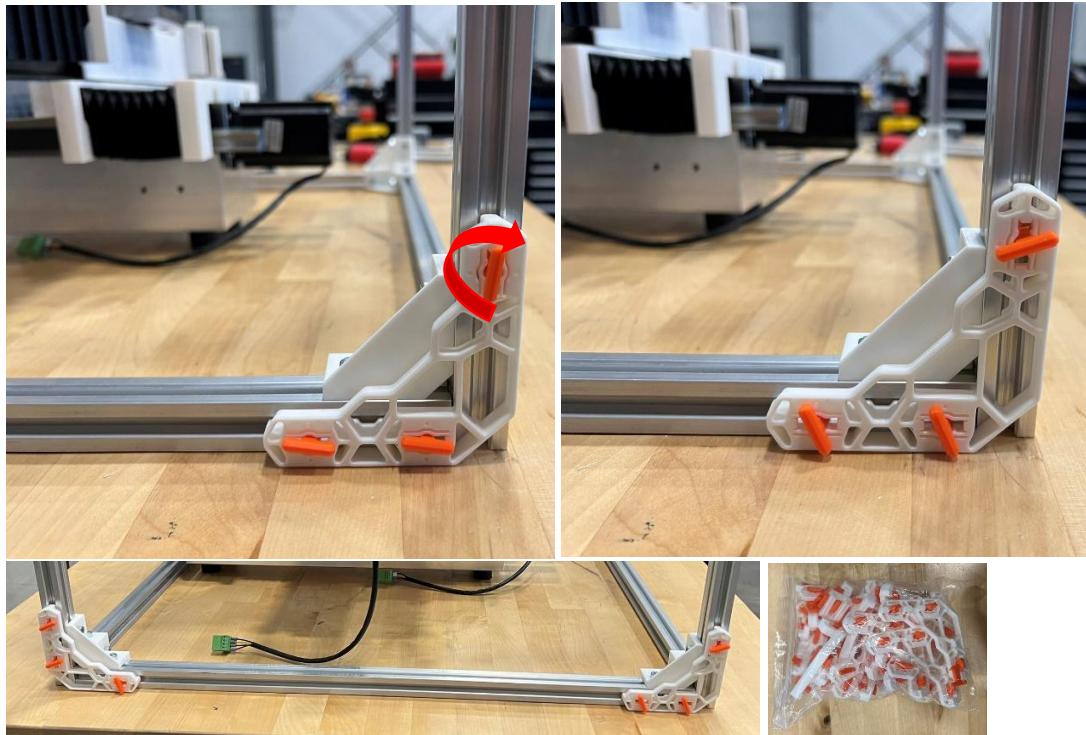
89. Use  $\frac{1}{4}$  - 20 bolts and washers to secure the machine tool to the table.



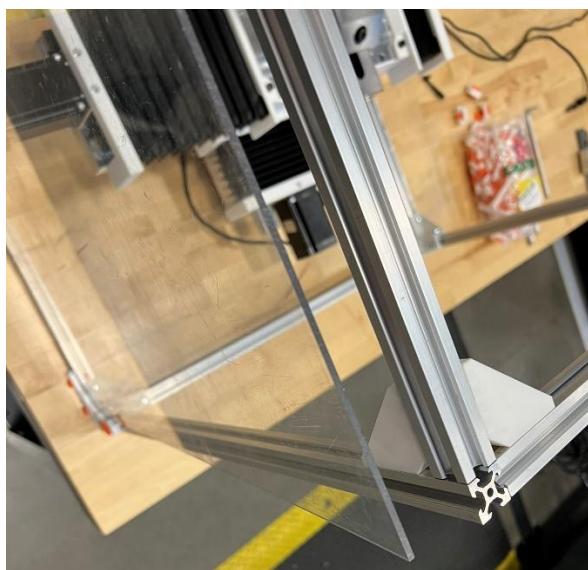
90. Use  $\frac{1}{4}$  - 20 bolts, washers, and nuts to secure the enclosure in position.



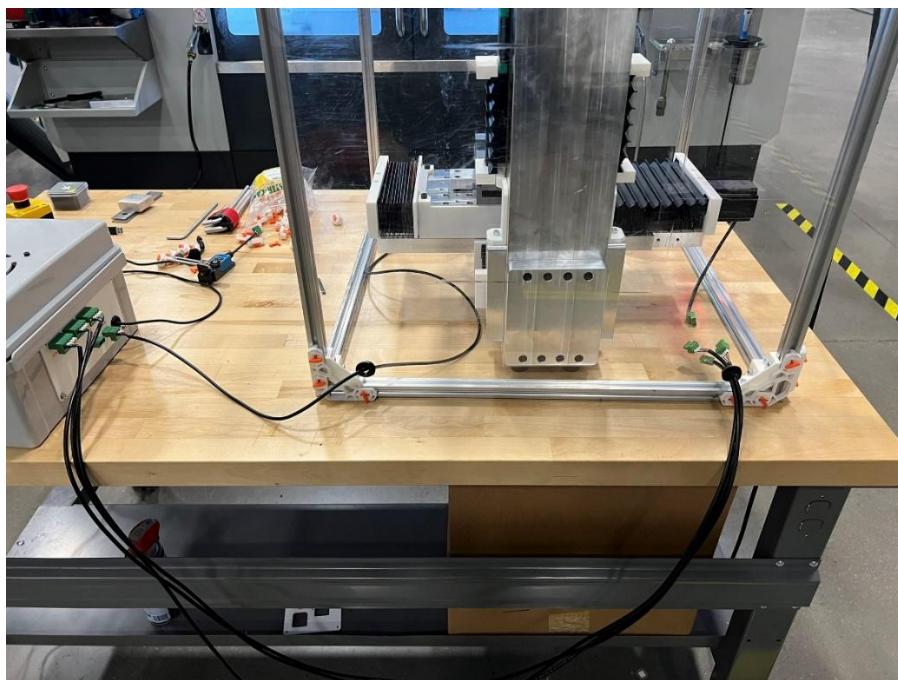
91. Place a corner panel clip (65) on the bottom of each side of the enclosure. Rotate the orange clip clockwise to secure the panel clip. The orange clip will only rotate just shy of 90 degrees.



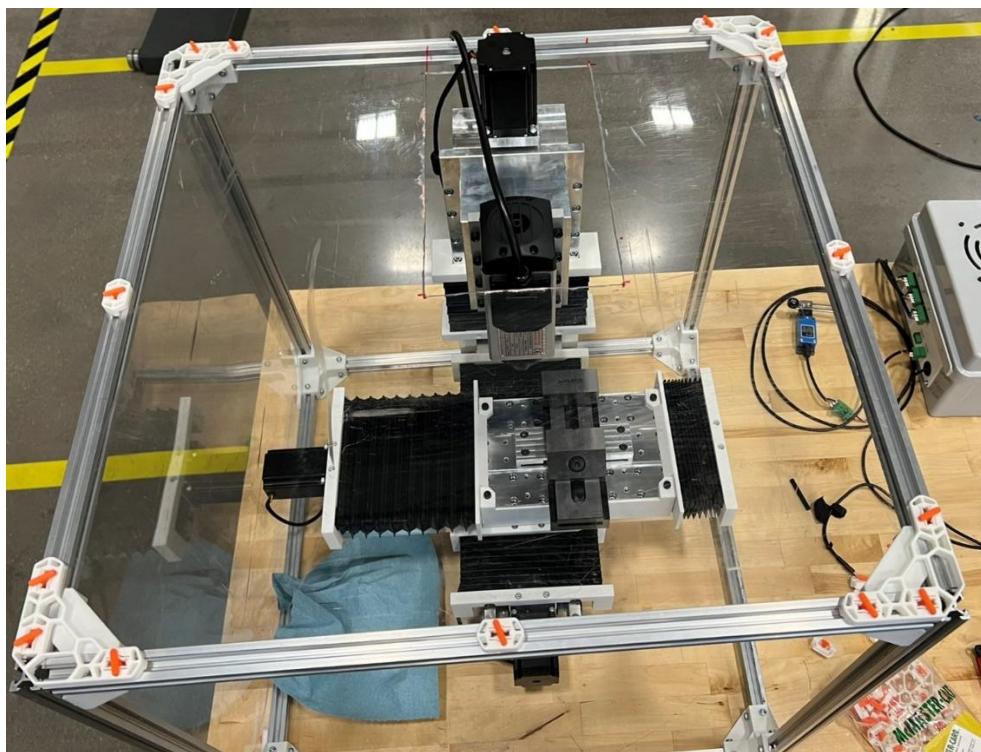
92. Slide in the polycarbonate sheets with no cut outs (61) on the left and right side of the machine.



93. Slide in the polycarbonate sheet with two rubber grommets (63) on the back side of the enclosure. Secure it with four corner panel clips. The terminal blocks may need to be removed and reinstalled once the motor and safety door cables are fed through the panel.



94. The polycarbonate panel with a large rectangle cut out of it (64) can be placed on the top of the enclosure and secured with 4 corner panel clips. Secure small panel clips (65) along the panel sides to fully secure enclosure panels.



95. Gather the following items for enclosure attachments.

If in place, remove the front enclosure panel.



Item number	Description	Qty
66	Safety door mount	1
67	Front panel holder	3
68	Front panel handle	2
69	Connector cover pair	4
70	*Top enclosure cover	1
18-ELEC	Limit switch	1

96. Secure the top enclosure cover (70) to the top panel with M5 bolts and M5 nuts.



97. Place the limit switch on the safety door mount (66) and secure with 4 M5 bolts.



98. Use a screwdriver to loosen the set screw on the front of the limit switch. Set the lever extension to be roughly half its length. Once in place, tighten the screw.



99. Feed 2 M5 bolts through the remaining holes and prepare with drop-in T-nuts.



100. Place the assembly inside the front-right corner of the enclosure and tighten the 2 bolts with T-nuts against the extrusion. The switch should be installed near the bottom of the enclosure.

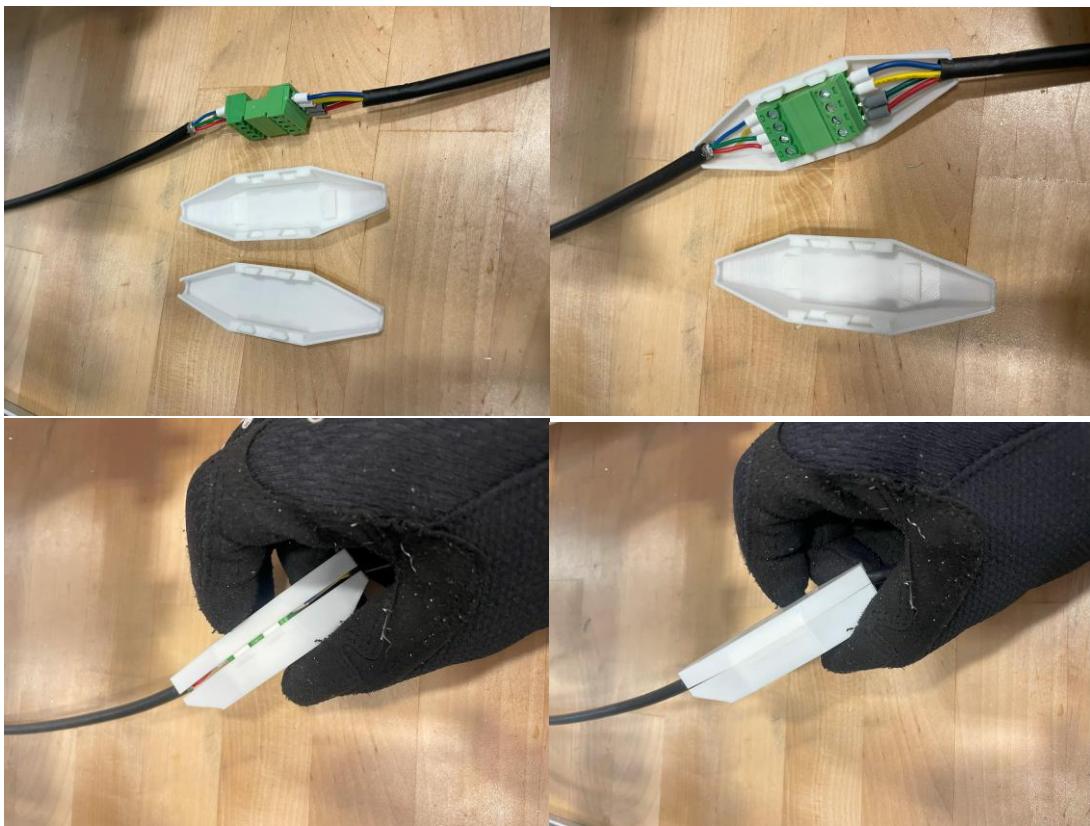


101. Loosen the set screw on the side of the lever arm with a hex key. Now rotate the arm until its wheel is mostly protruding from the enclosure as seen below. Hold in place and tighten the set screw.

Try sliding the front panel down to ensure proper door switch operation. It is recommended that a small clip is placed just above the limit switch to make sliding the front door down easier. There should be an audible click from the switch when both removing and replacing the door. Adjust as necessary.



102. If the electrical box is built and wires have been run into the enclosure, connector covers (69) can be used to protect connectors from loose chips and other debris. Simply place the connection in one half of a connector cover pair, place the other half over the top and press until the plastic snaps into place.



This cover can be undone by separating the halves.

