



BILLINGSLEY
AEROSPACE & DEFENSE

HELHOLTZ COIL ASSEMBLY MANUAL



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Helmholtz Coil Assembly Instruction

Materials:

- 3/8-16 x 3/4 316SS Hex Head Cap Screw (96 pcs)



- 3/8-16 316SS Fin Hex Nuts (96 pcs)



- 3/8 316SS Flat Washers (96 pcs)



- 3/8 316SS Lockwashers (96 pcs)



- Aluminum Brackets, Black (48 pcs)



- Helmholtz Coils (Large (2), Medium (2), Small (2))



- PVC Spacers (26 pieces)



- Tie wrap anchors and tie wraps



- Pairing wires (3 pairs - X,Y,Z)



Tools Needed:

- Ratchet with 9/16 socket
- 9/16 open/close wrench
- Phillips head screwdriver
- Rubber mallet (optional)
- Electrical Tape

Assembly Procedures:

NOTE: Initial setting up of the coil will require a minimum of 6 people. Assembly of the coil should be done at the spot where the coil would be used, with the terminals close to the user station.

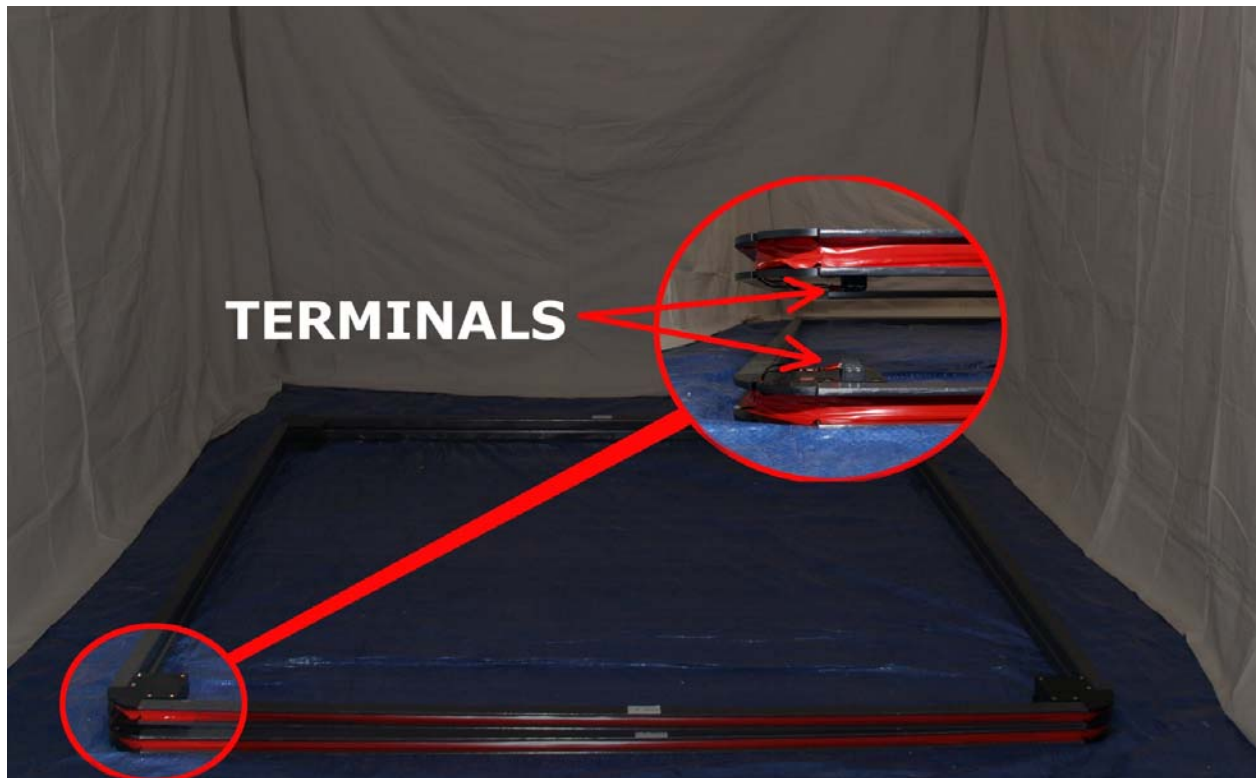
There are three coil pairs and they are labeled +X and -X, +Y and -Y, and +Z and -Z

First start with the smallest coil pair, this should be the Z pair. Lay the coil labeled “+Z coil” flat on the bottom (see photo below), with the **terminal connection facing up**.



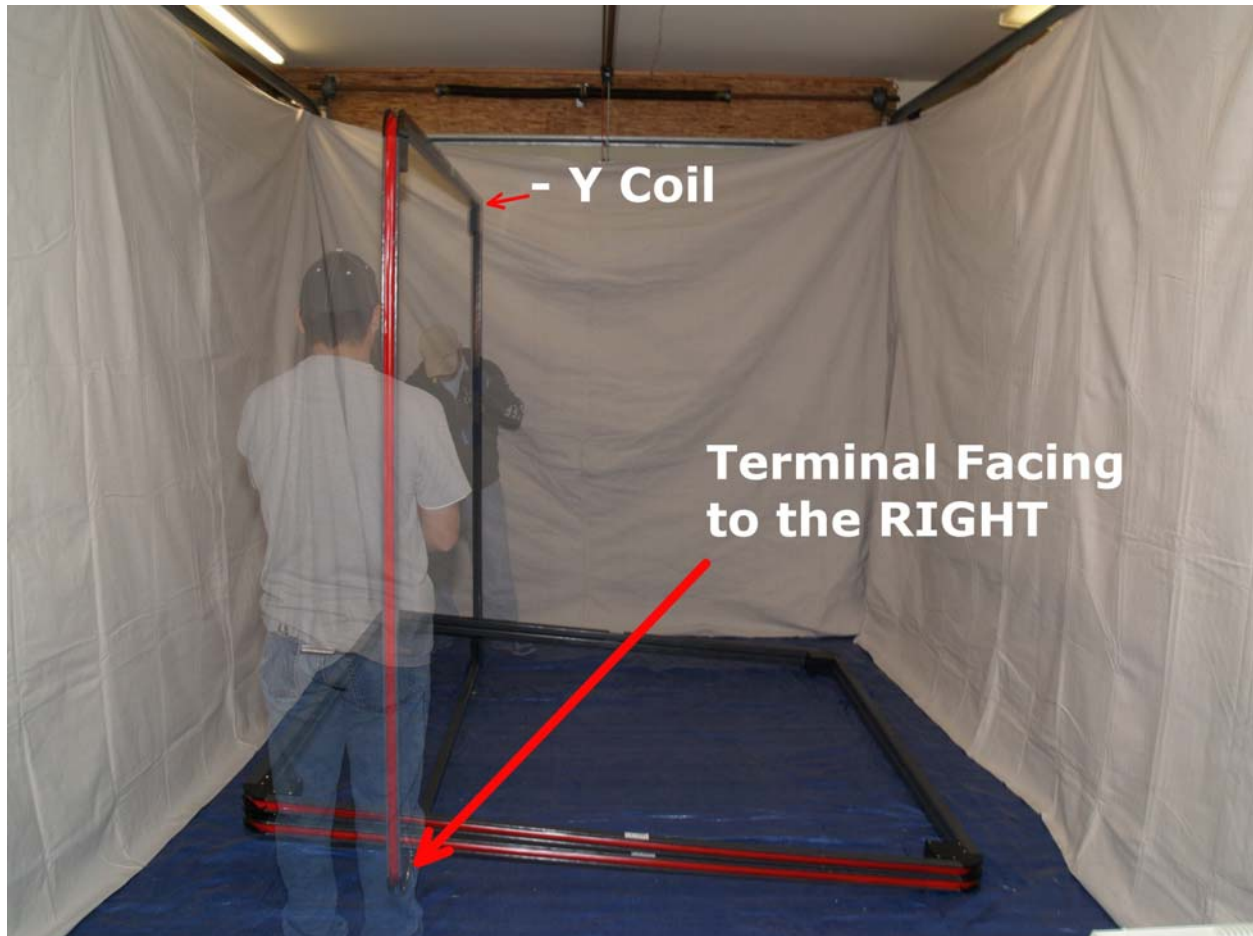
+Z Coil on the floor (terminal on bottom left, facing up)

Next place the coil labeled “-Z coil” on top of the +Z coil with the terminal connection facing down. Make sure that the terminal connection is on the same side as the +Z coil (see photo below).



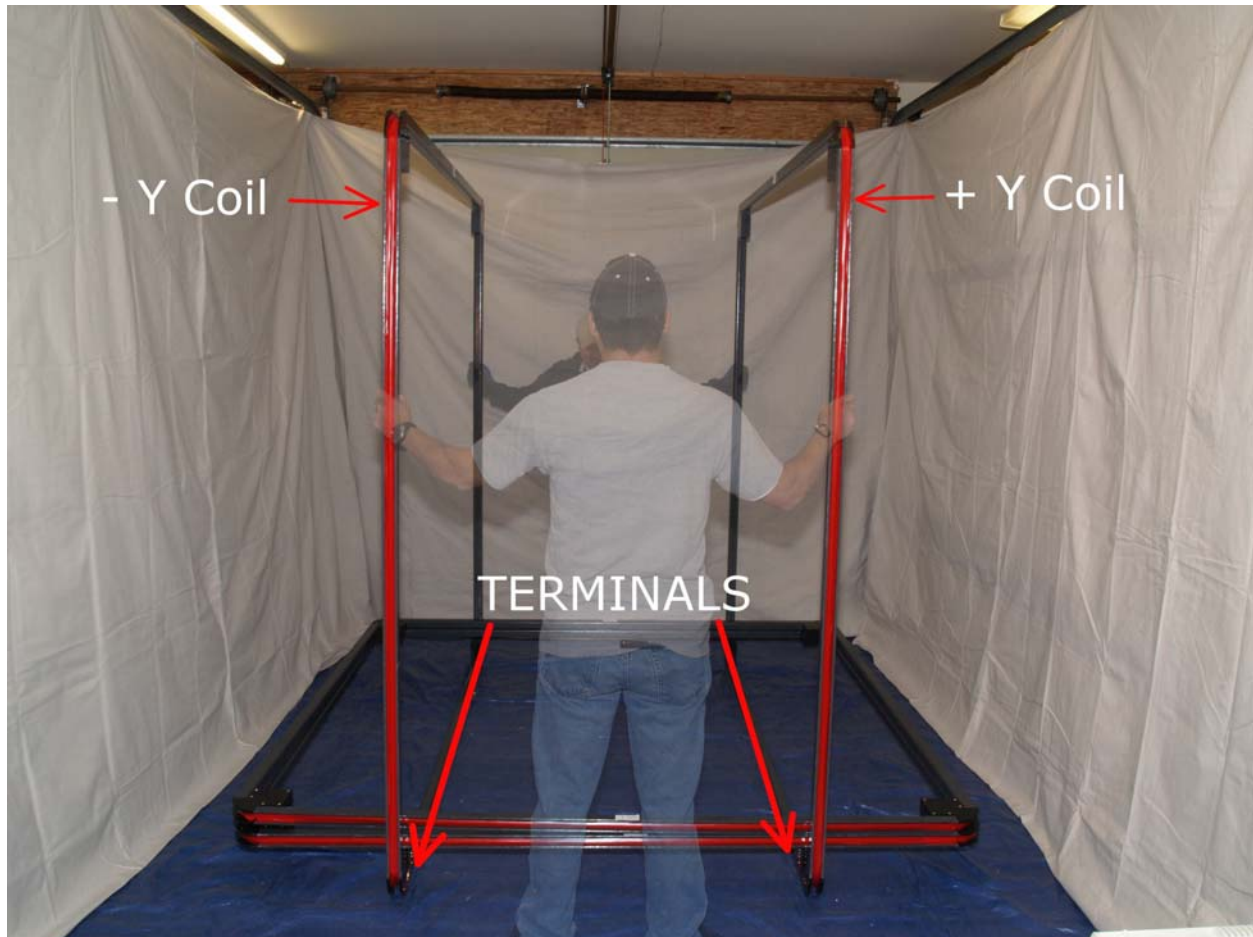
-Z coil on top of + Z Coil

Next, have 2 people lift one end of the Z coil pairs (looking at the picture, the terminals should be on the left side) and 2 people insert the coil labeled “–Y coil” into the Z coil pair. Ensure that the –Y coil corner with the terminal is on the bottom, facing inward and is located in the same area where the terminals are located in the Z coil pair (see photo below) **Note: the Y coil is not square, insert the end with wider opening. Also, the terminals for the Z coil should be on the right side of the –Y coil. Do not let go of the coils, doing so may cause them to fall and damage the coils.**



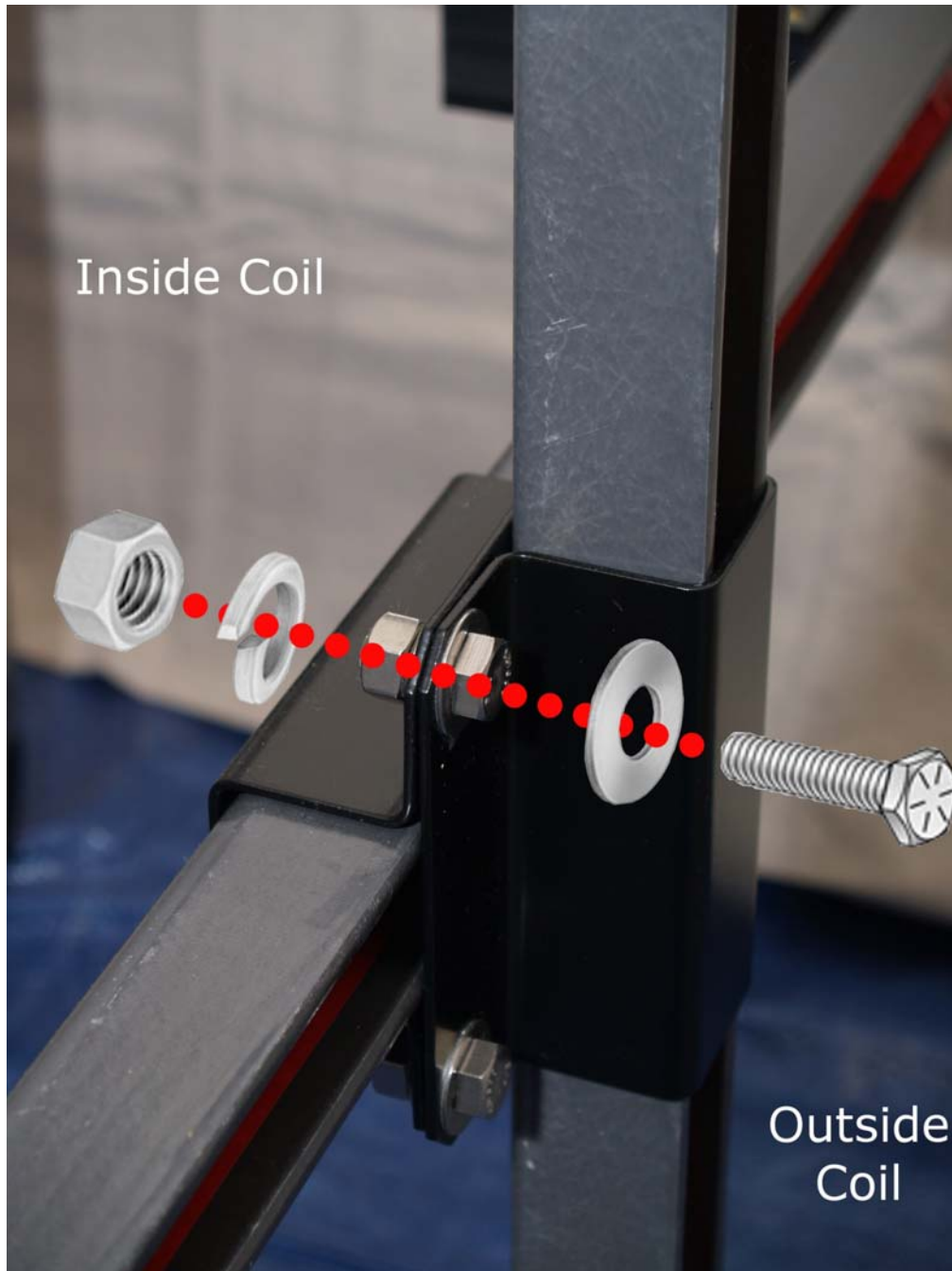
Insert –Y Coil from left looking at the picture,
–Y coil terminal on bottom left of picture facing inward.

After inserting the $-Y$ coil, lift the other end of the Z coil pair up off the floor and insert the $+Y$ coil into the opposite side of the $-Y$ coil with the terminal on the bottom, facing inward (see photo below). **Again, do not let go of the Y coils, doing so may cause them to fall and damage the coils. At this point at least 2 (preferably 4) people should be holding the Y coils up to prevent them from falling.**



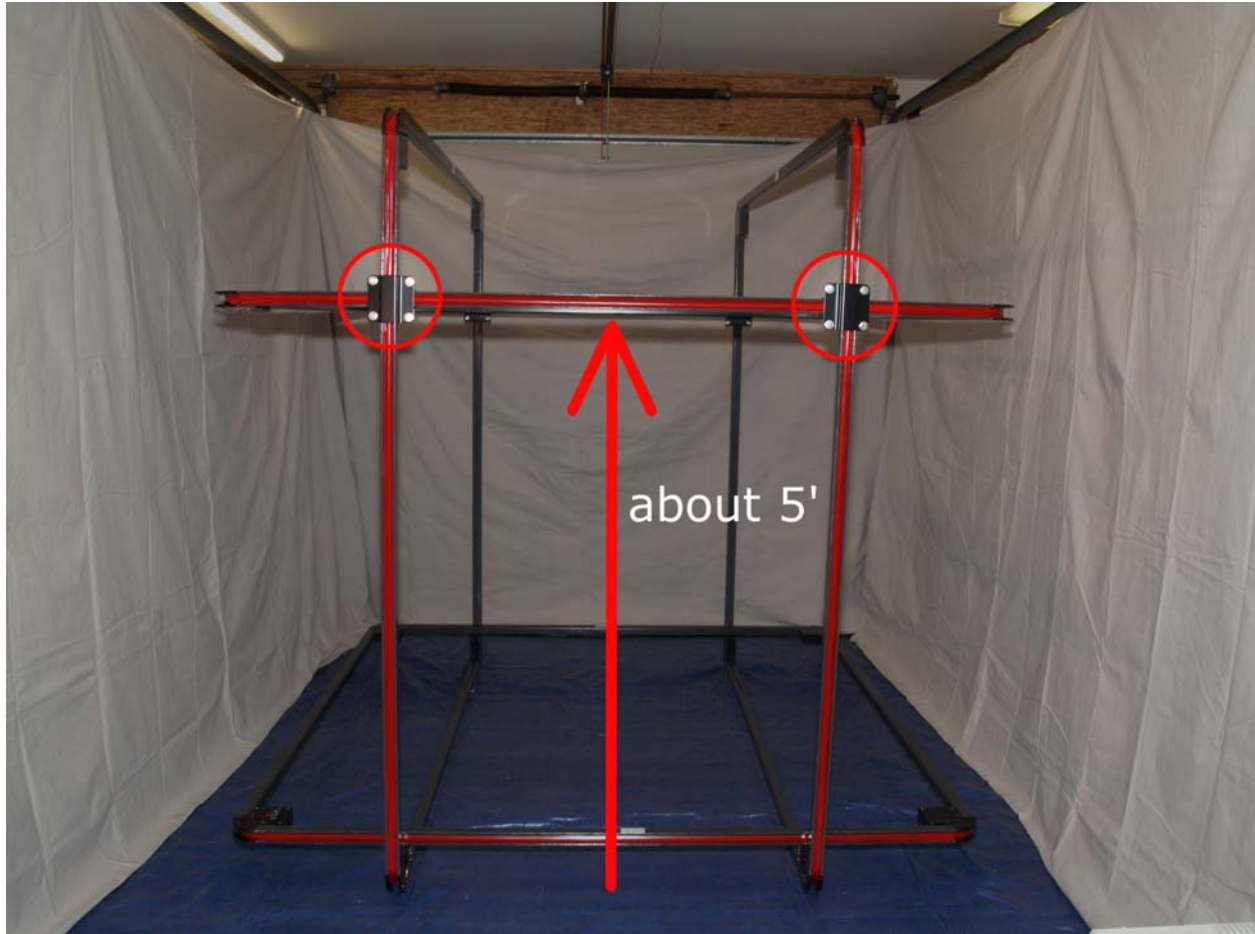
Insert $+Y$ Coil from right with $+Y$ coil terminal on bottom facing the $-Y$ coil terminal

Next, attached the brackets to hold the Y and Z coils together using the provided hex head cap screws, washers, lock washers and hex nuts (see photo below).



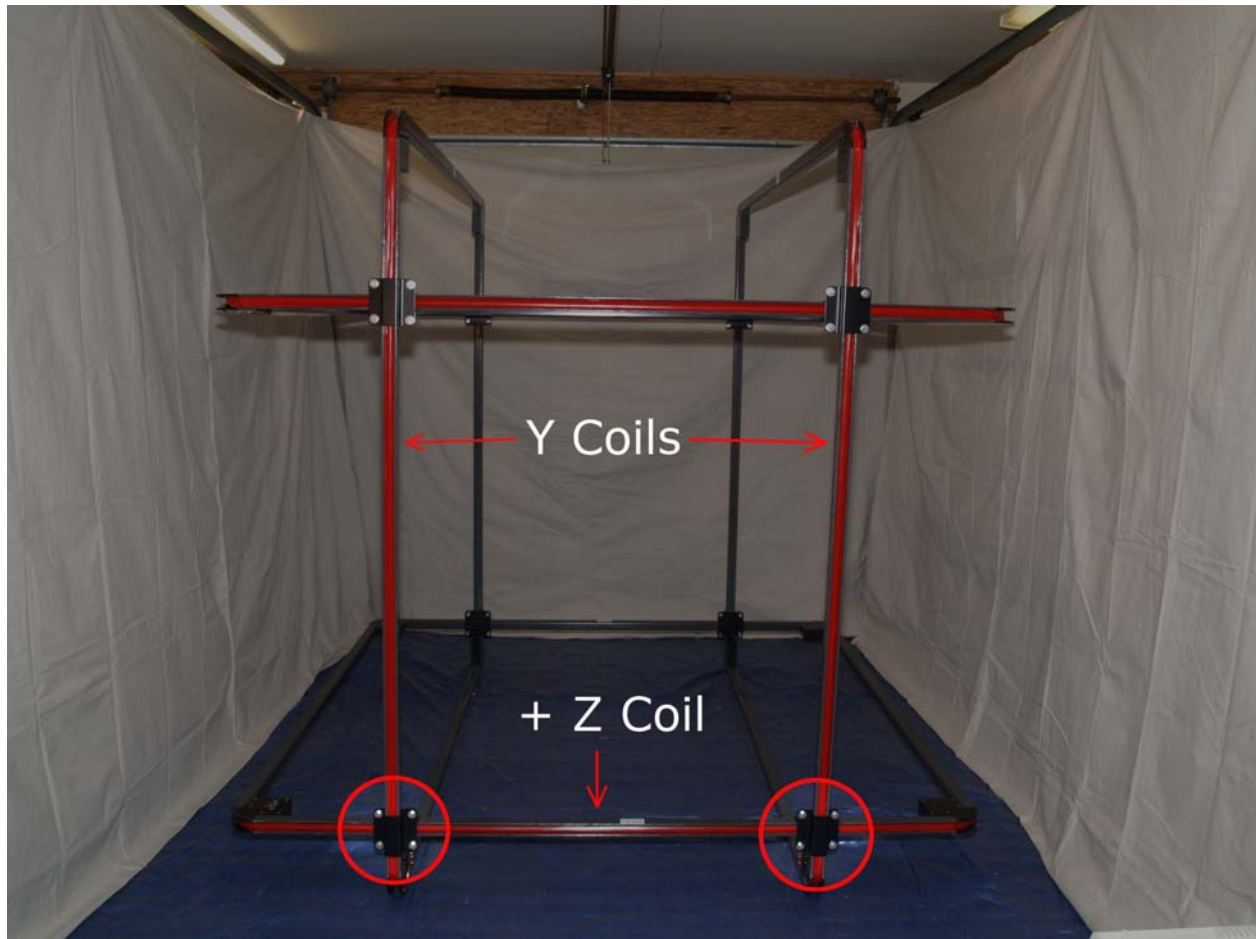
Bracket attachment using bolt, washer, lock washer and nut

Start by placing a pair of brackets to attach the $-Z$ coil (top coil) to the Y coils. Do this for all 4 corners. **Do not tighten the bolts at this time.** After all the brackets are attached, lift the $-Z$ coil about 5 feet off the ground and tighten the bolts enough so the $-Z$ coil stays in place and does not fall down (**do not over tighten the bolts at this time**) (see photo below).



Brackets attached to $-Z$ coil and Y coils, $-Z$ coil lifted about 5 feet off the ground

Next, attached the +Z (bottom coil) to the Y coils using the brackets and hardware as described above, see photo below. **Again do not tighten the bolts at this time.**



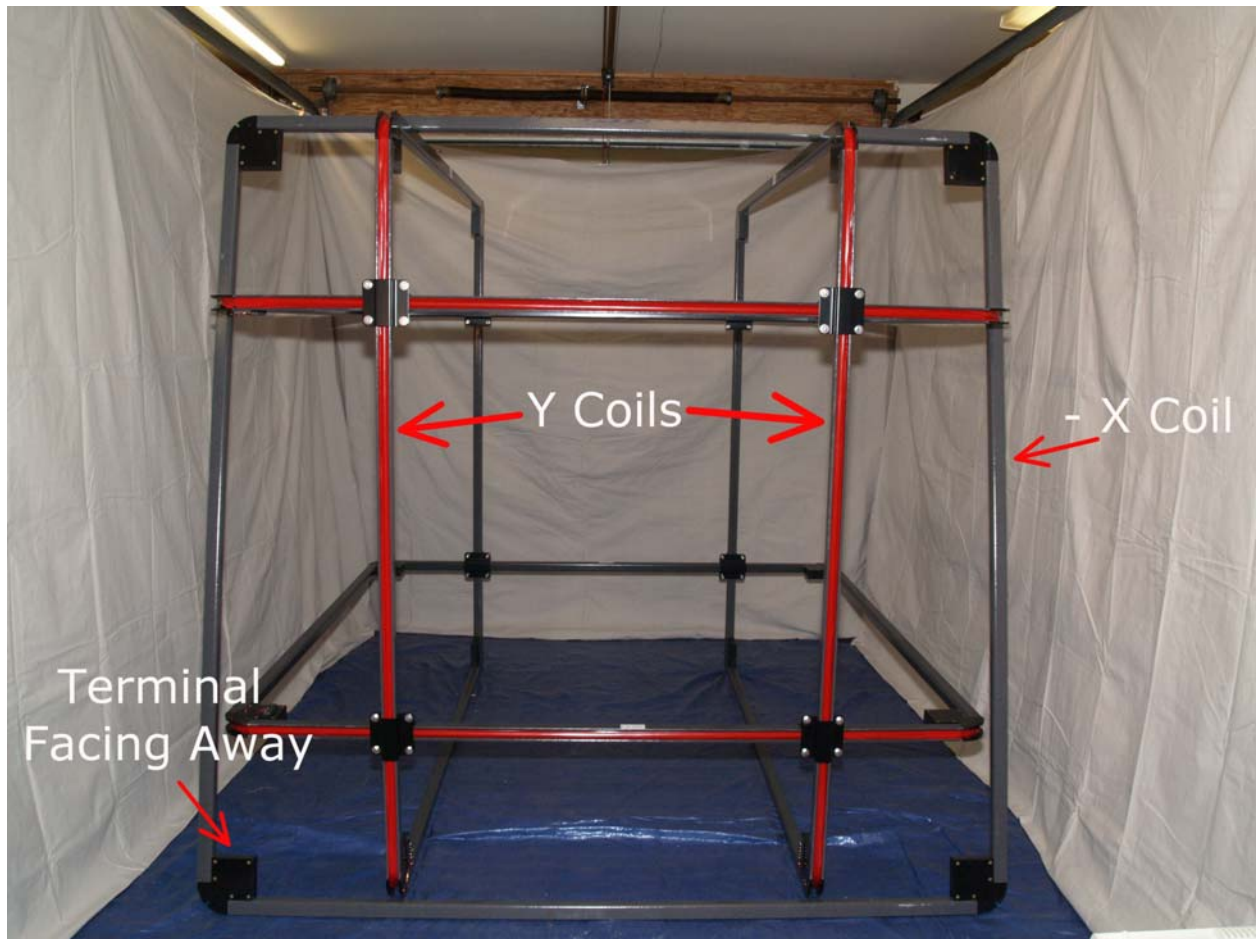
Brackets attached to the + Z coil and Y coils

After all the brackets are attached, lift the + Z Coil about a foot off the ground (see photos below).



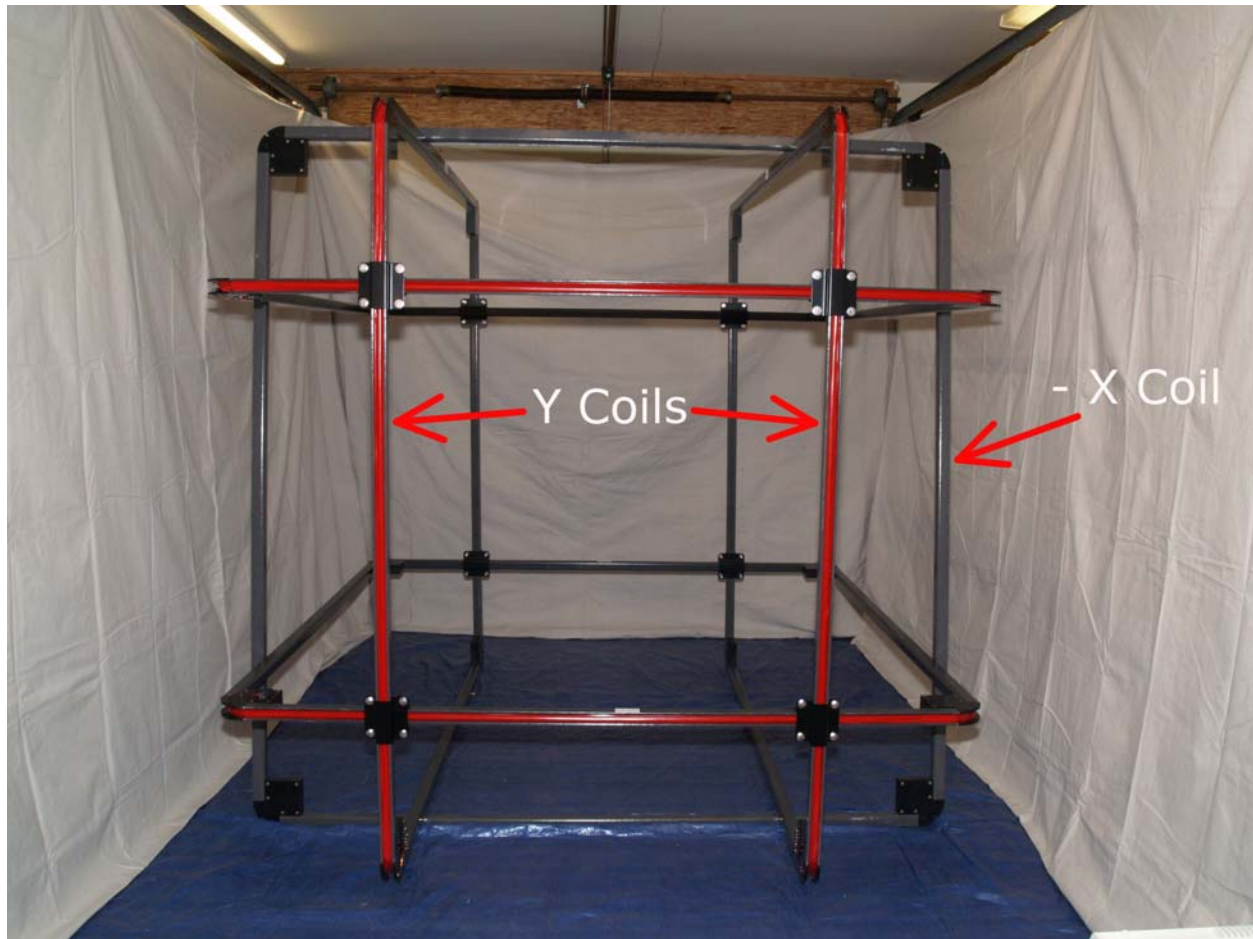
+Z coil lifted about a foot of the ground

Next, slide the $-X$ coil (large coil) into the top portion of the Y coil pairs, see photo below. Ensure that the terminal on the $-X$ coil is on the bottom, facing inward and on the same side as the $+Z$ coil and the $-Y$ coil terminals.



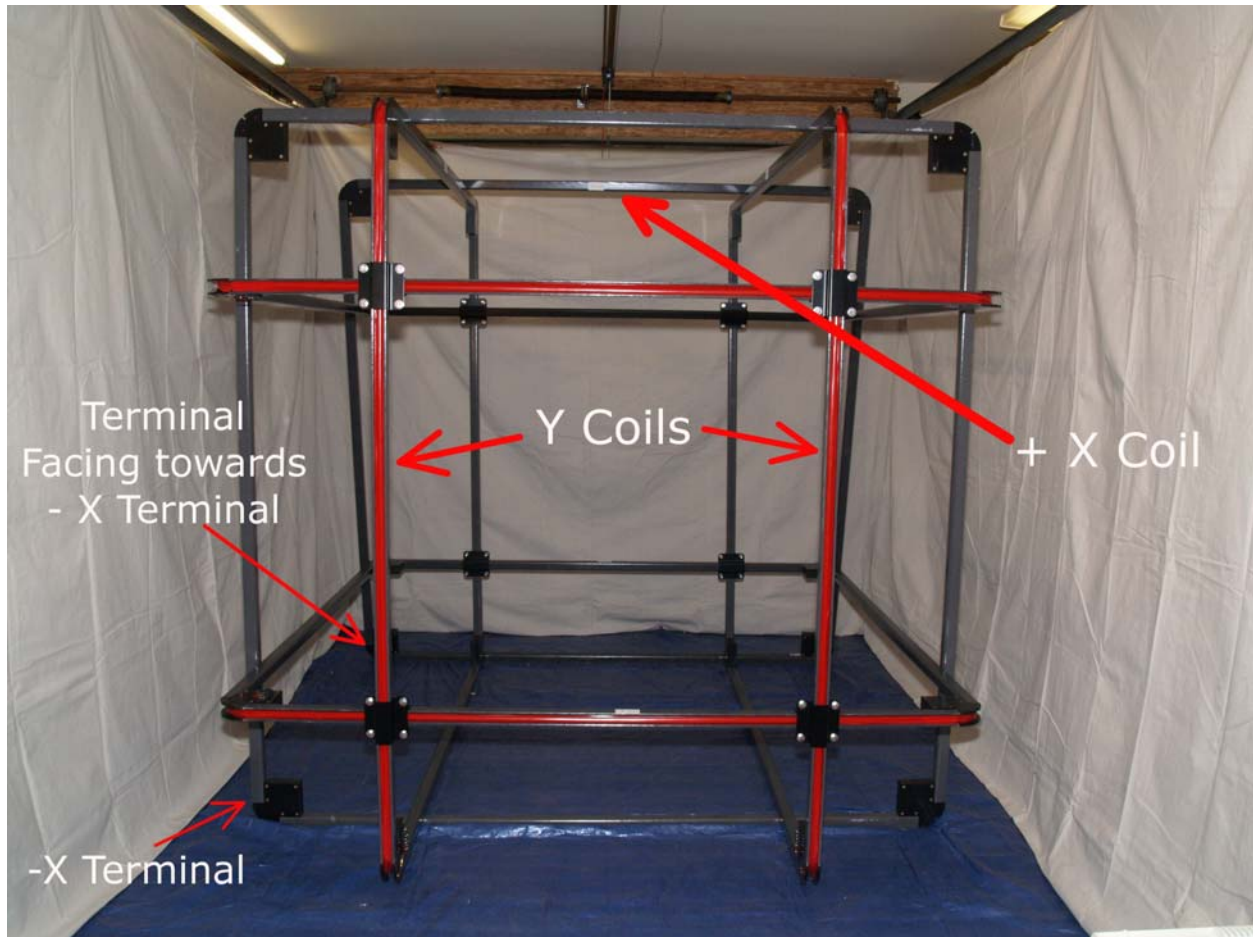
Top portion of the $-X$ coil inserted into the top portion of the Y coils

Next, have 2 people lift the bottom portion of the Y coils and insert the $-X$ coil about a foot into the Y coil pairs (see photo below).



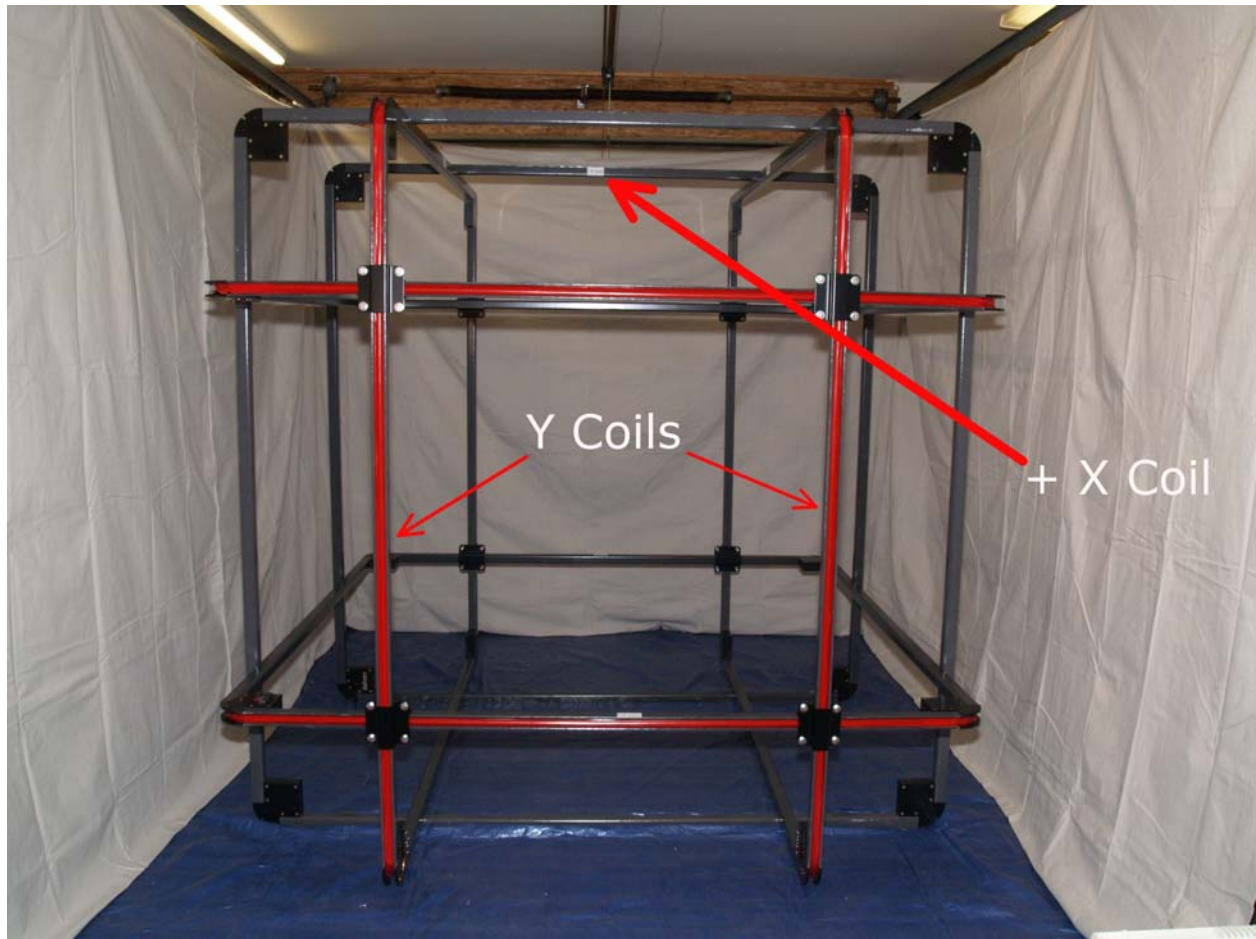
Bottom portion of the $-X$ coil inserted into the bottom portion of the Y coils

Next, slide the +X coil (large coil) into the top portion of the Y coil pairs, see photo below.
Ensure that the terminal on the +X coil is on the bottom and is facing the -X coil terminal



Top portion of the +X coil inserted into the top portion of the Y coils

Next, have 2 people lift the bottom portion of the Y coil pair on the end where the +X coil would go. Insert the +X coil about a foot into the Y coil pair (see photo below).



Bottom portion of the +X coil inserted into the bottom portion of the Y coils

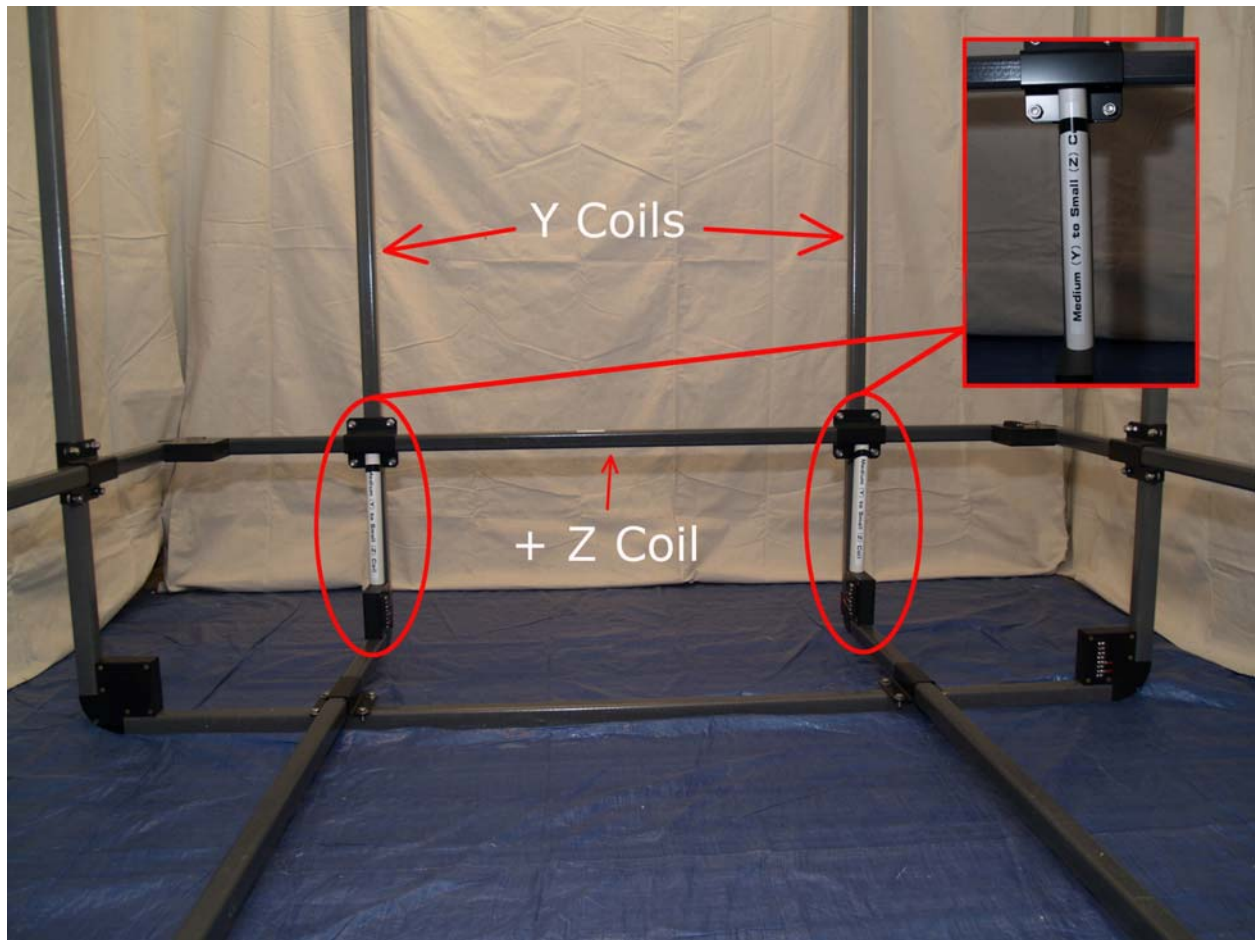
At this point, the Helmholtz coil is practically assembled. Start attaching the remaining brackets to the coil, there should be 16 pairs of brackets remaining (**do not tighten the bolts on the brackets at this time, see photo below**). After all the brackets are attached to the coil, start placing the PVC pipes to their proper locations. Note: The PVC pipes are labeled. Ensure that the correct PVC tube goes to the right locations. The next steps would involve the proper spacing for the Helmholtz coil to achieve the best performance.



Coil Assembled with all the brackets attached.

Coil Spacing Adjustment

Start by placing 4 (2 on each side) of the PVC tubes labeled “Medium (Y) to Small (Z) Coil” between the black delrin corners (these are on the Y coils) and the bottom of the brackets that attached the +Z coil and the Y coil together (see photos below). **Tape the PVC tubes to the coils to prevent them from falling.** Push down or gently tap down on the +Z coil using a rubber mallet such that the spacers are snug between the brackets and the corners.

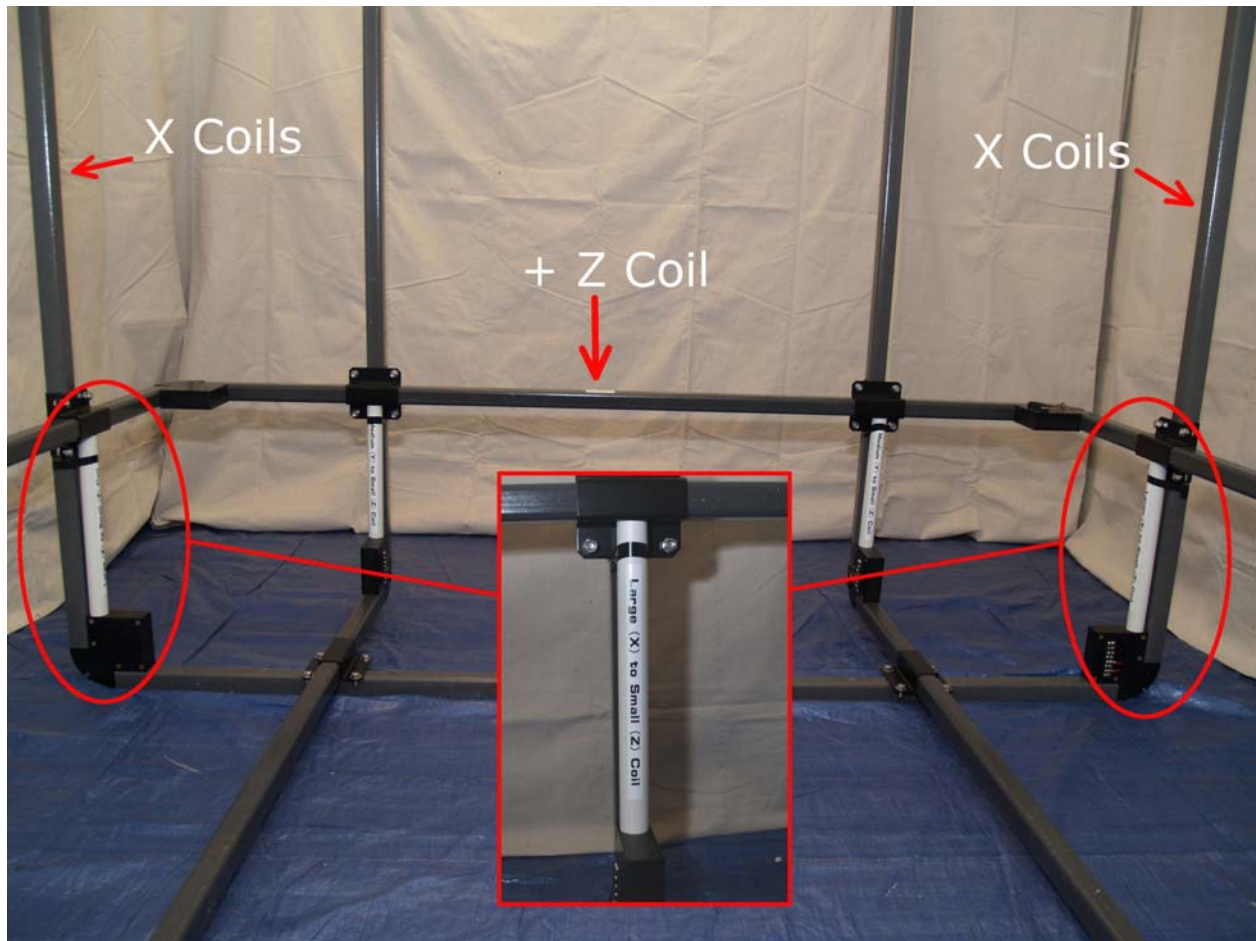


PVC tubes between +Z coil and Y coils



PVC tubes between +Z coil and Y coils (opposite end)

Next, place 4 (again 2 on each side) of the PVC tubes labeled “Large (X) to Small (Z) Coil” between the black delrin corners (these are on the X coils) and the bottom of the brackets that attached the +Z coil and the X coil together (see photos below). **Tape the PVC tubes to the coils to prevent them from falling.** Push down or gently tap down on the +Z coil using a rubber mallet such that the spacers are snug between the brackets and the corners.

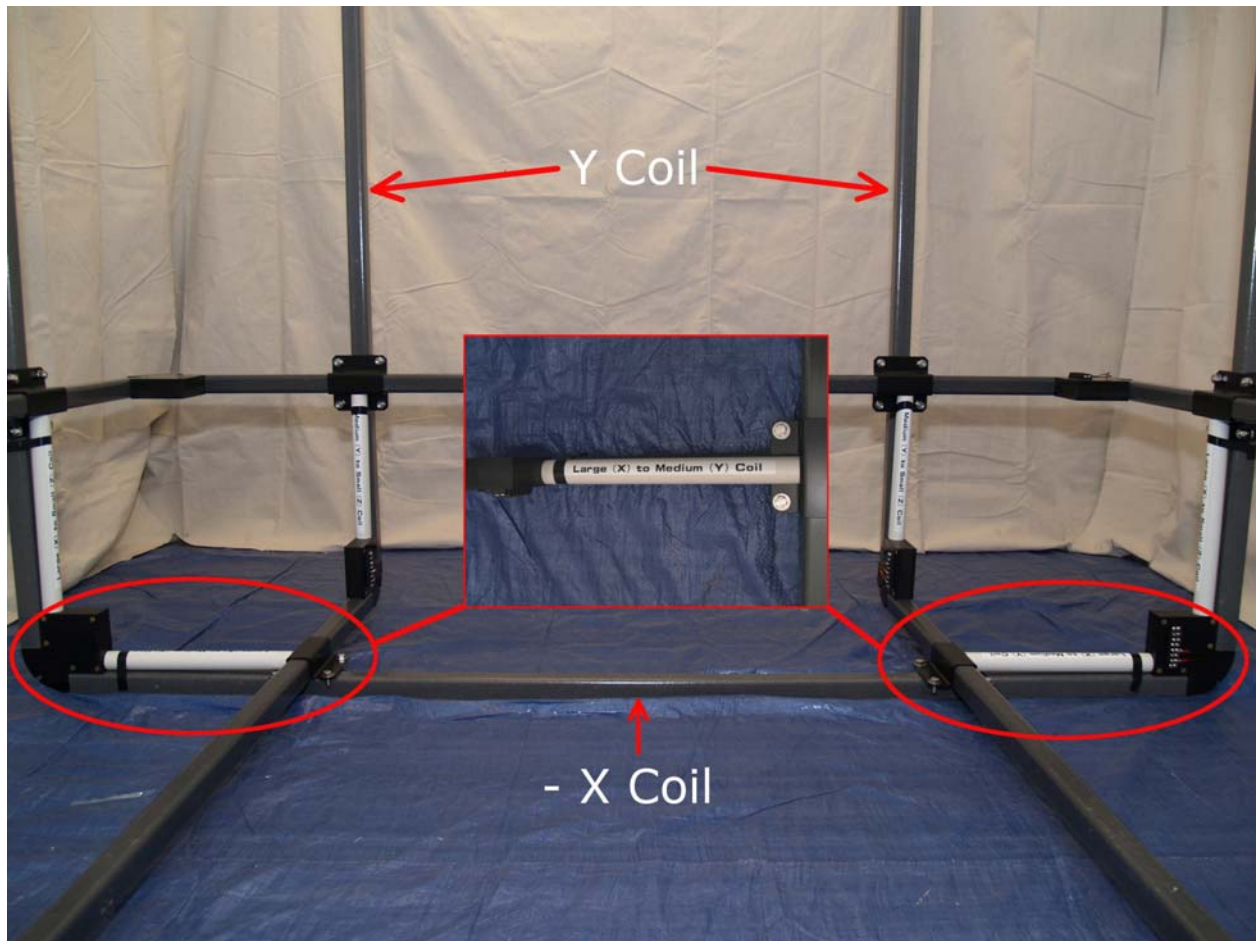


PVC tubes between +Z coil and X coils

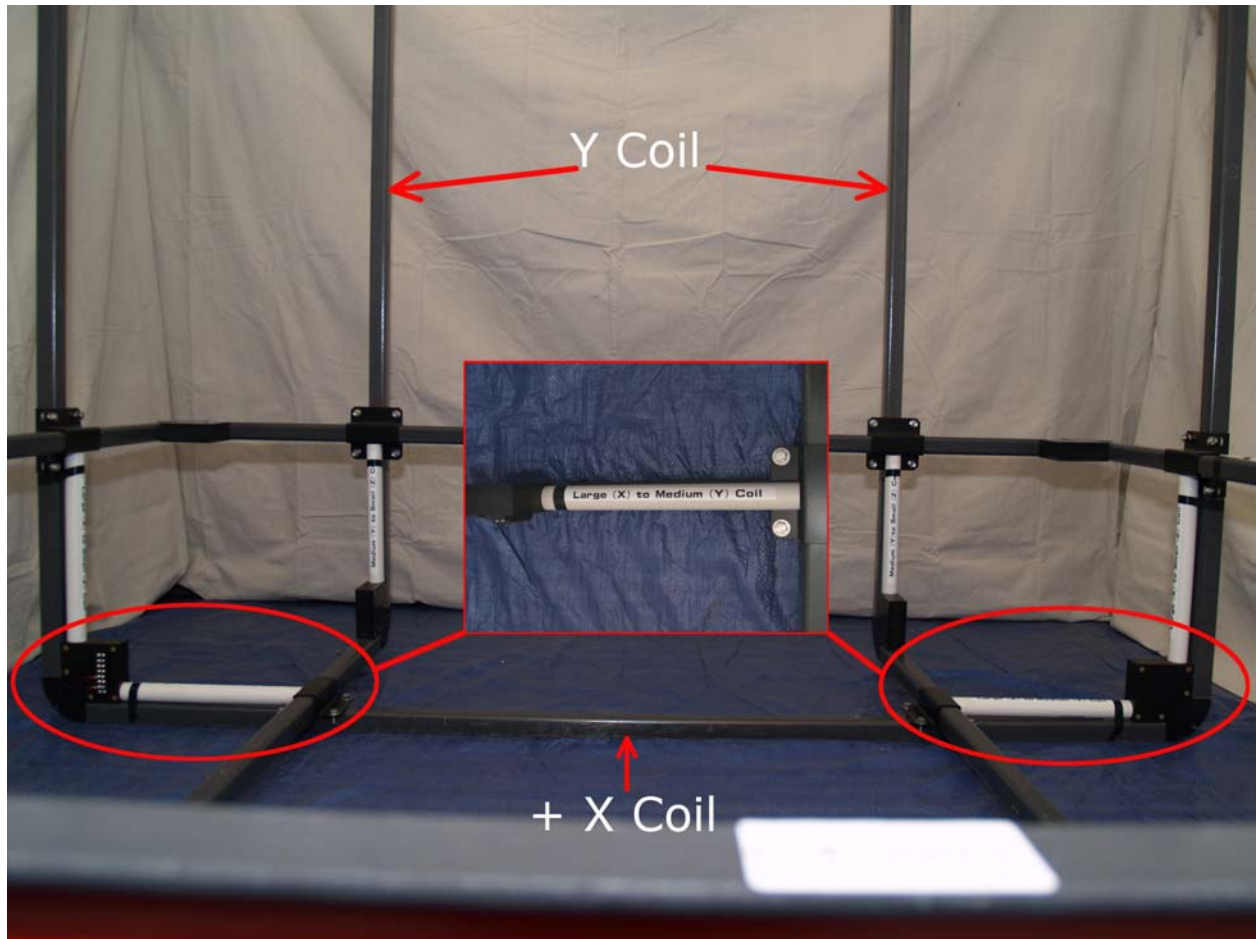


PVC tubes between +Z coil and X coils (opposite end)

Next, place 4 (again 2 on each side) PVC tubes labeled “Large (X) to Medium (Y) Coil” between the black delrin corners (these are on the X coils) and the brackets that attached the X coils and the Y coils together (see photos below). **Tape the PVC tubes to the coils to prevent them from falling.** Using a rubber mallet, gently tap on the +Y and the –Y coil such that the PVC tubes are snugged between the brackets and the corners.

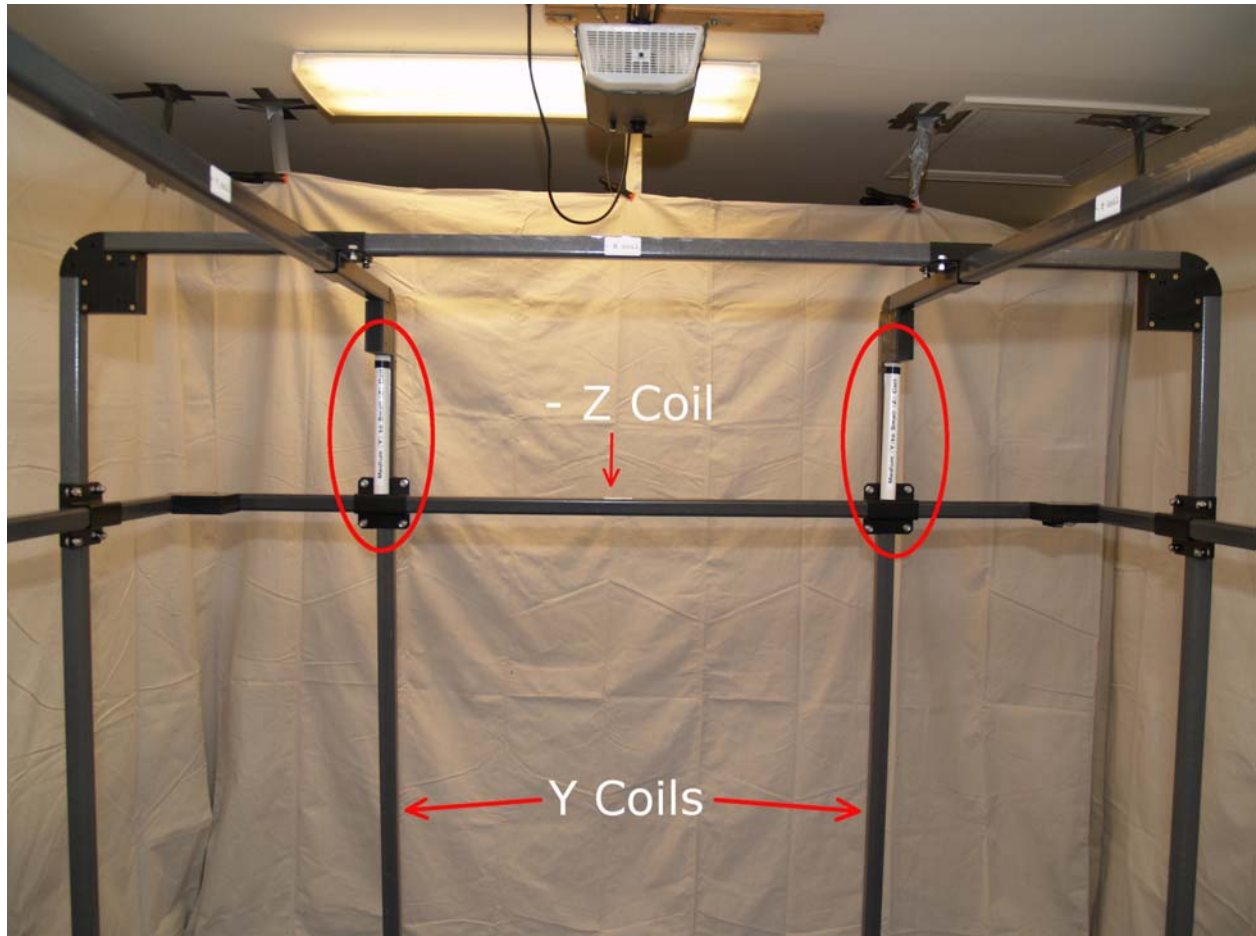


PVC tubes between –X coil and Y coils

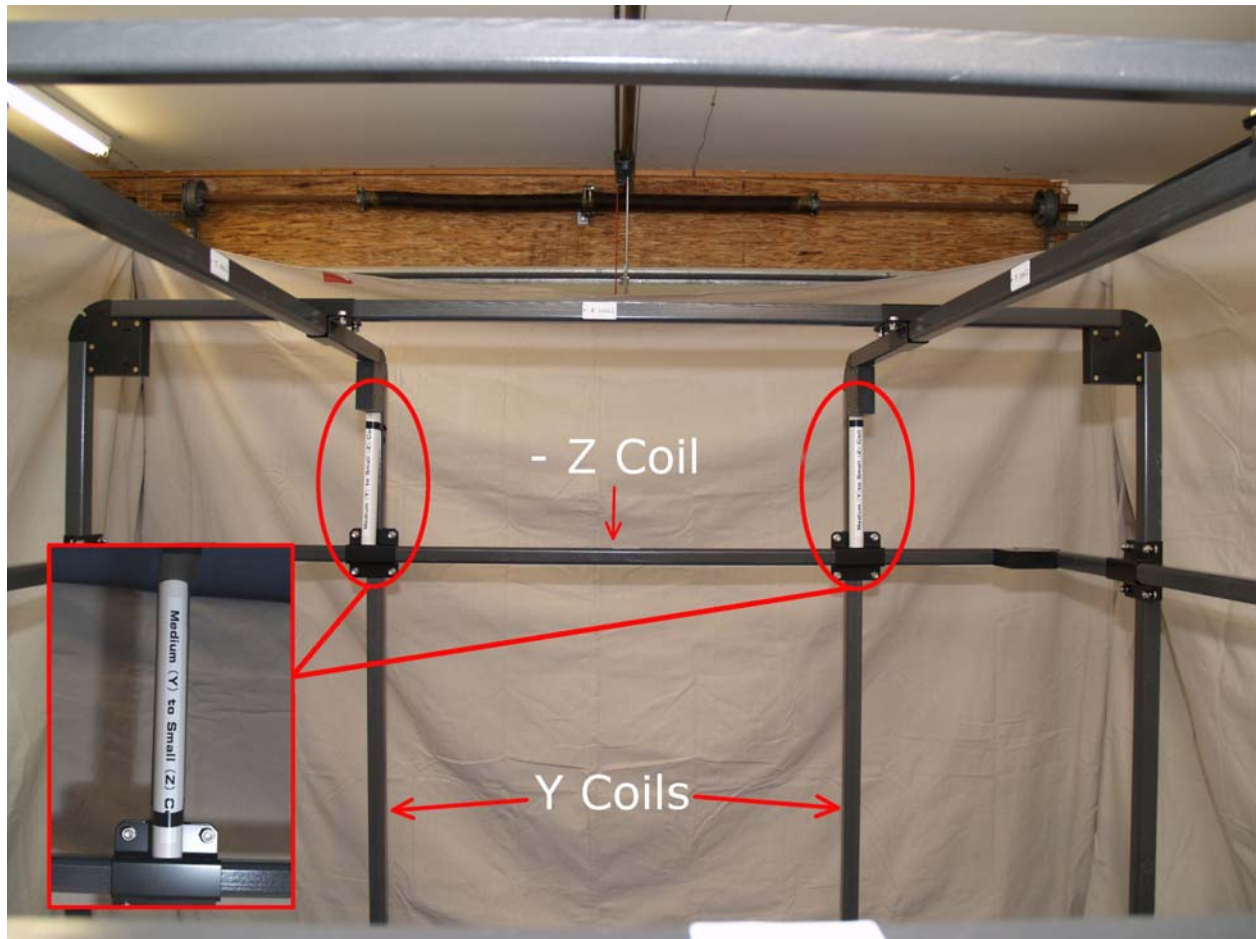


PVC tubes between +X coil and Y coils

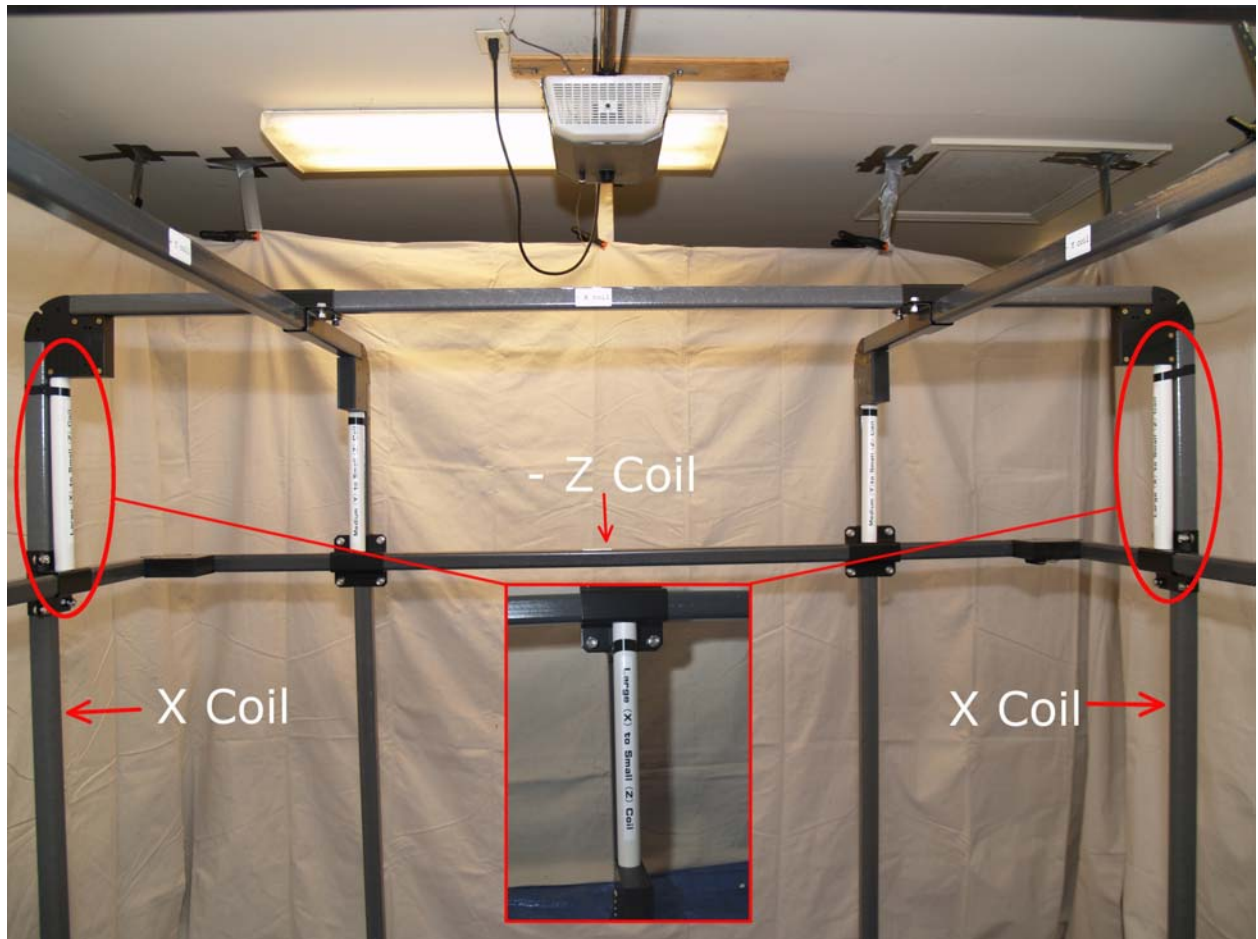
After all the PVC tubes are attached on the bottom section of the coils, proceed to the top portion of the coil by placing the PVC tubes on the top section of the coils using the same steps as the procedures mentioned above (see photos below). **Tape the PVC tubes to the coils to prevent them from falling.**



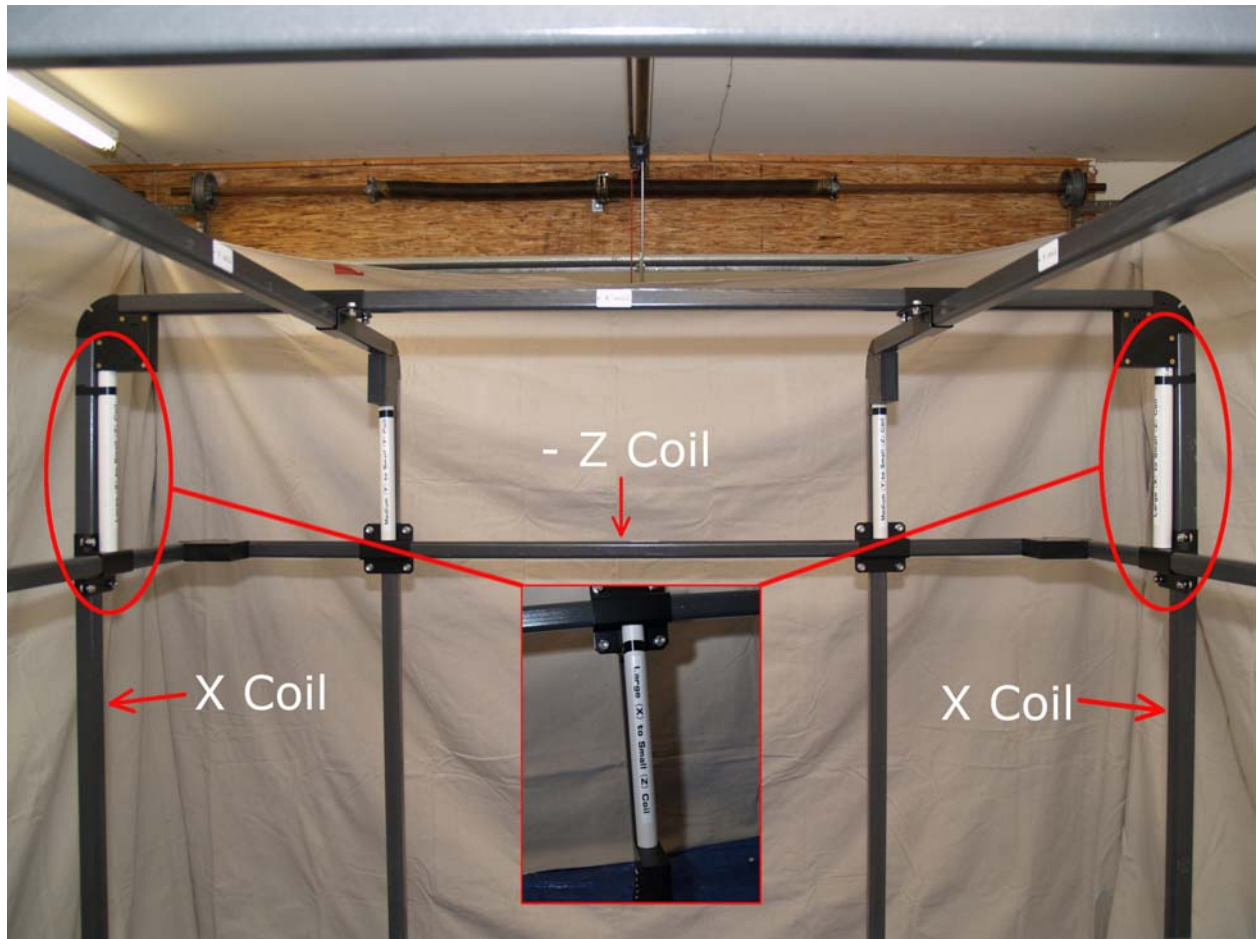
PVC tubes between -Z coil and Y coils



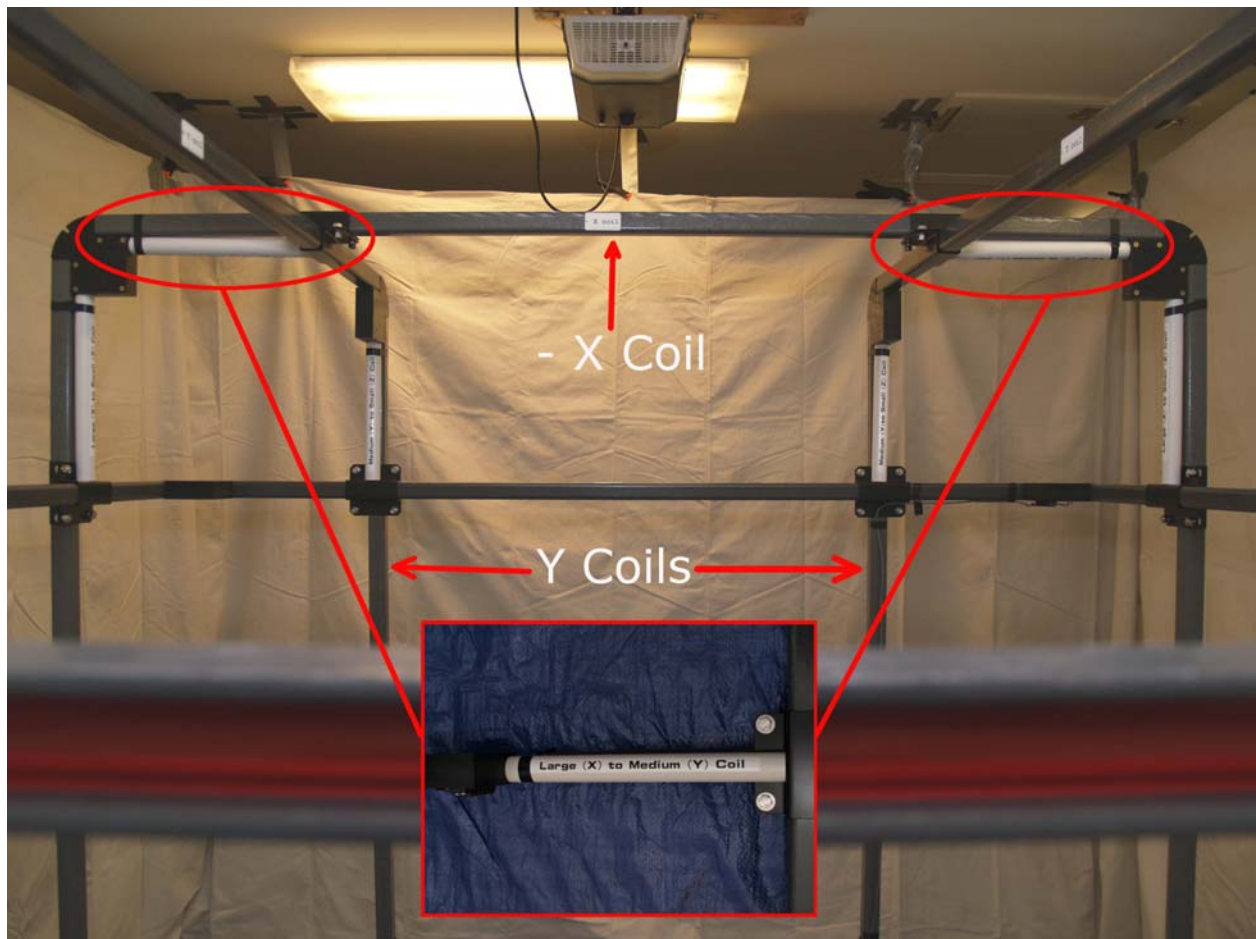
PVC tubes between -Z coil and Y coils (opposite end)



PVC tubes between -Z coil and X coils



PVC tubes between -Z coil and X coils (opposite end)

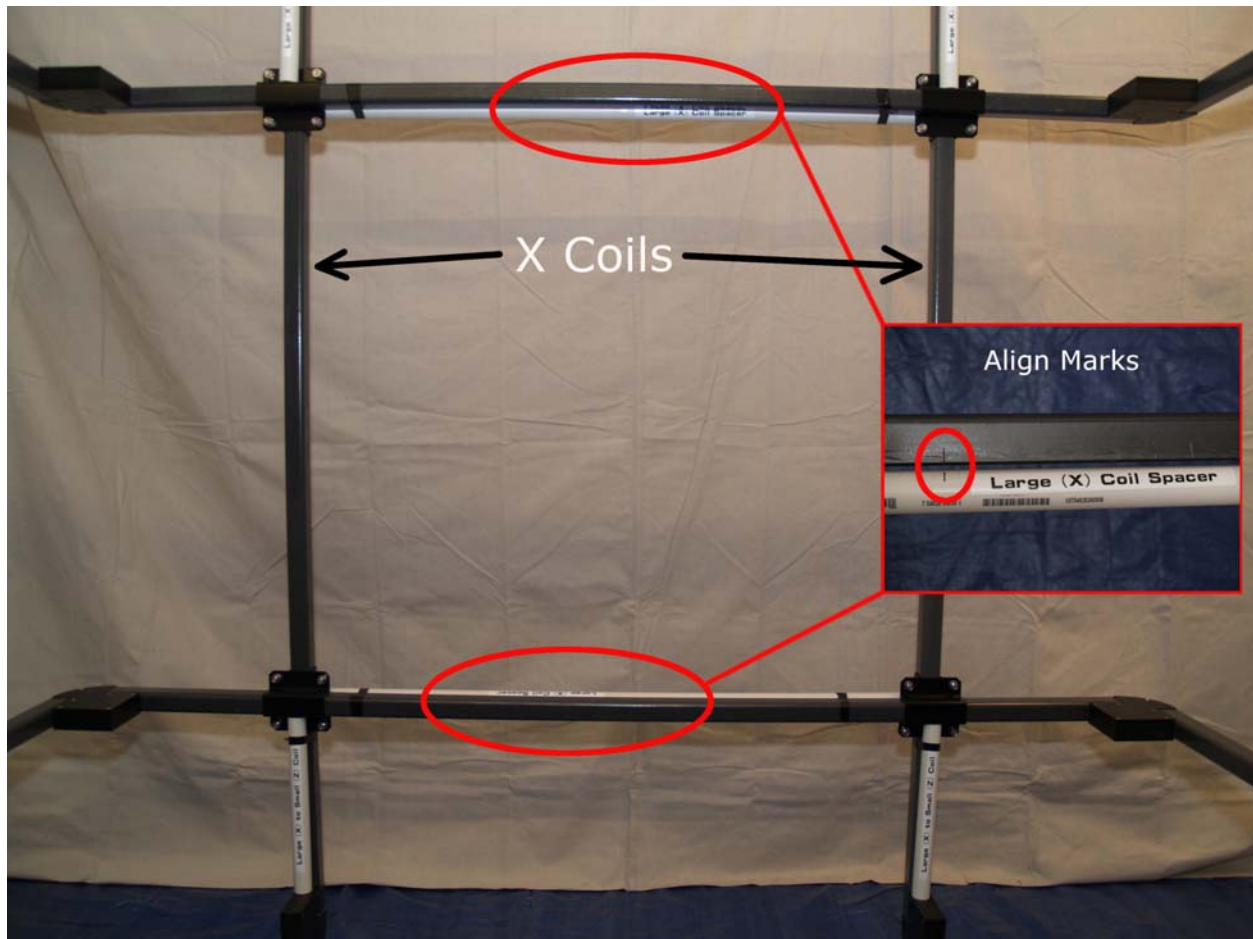


PVC tubes between -X coil and Y coils, top



PVC tubes between +X coil and Y coils, top

Next, set the spacing for the X (large) coils by locating the centerline marking on the +Z coil and the -Z coil. Next, place 1 of the PVC tube labeled “Large (X) Coil Spacer” along the +Z coil (between the brackets) where the centerline marking is located and between the +X and the -X coils. Place the second PVC tube labeled “Large (X) Coil Spacer” along the -Z coil (against the brackets) where the centerline marking is located and between the +X and the -X coils (see photo below). The PVC tubes have centerline markings on them also. Line the PVC tube centerline marking with the centerline marking on the +Z and -Z coils. After, the markers are aligned, tape the PVC tubes onto the +Z and -Z coils to prevent the tubes from falling down. Using a rubber mallet, gently tap on the +X and the -X coil to bring them together such that the +X and -X coils are butted against the PVC spacers (make sure that the centerline markings are still lined up together). **It may be necessary to tighten several of the bolts on the brackets after the correct spacing is set to prevent the X coils from moving.**



PVC tubes between X coils to set X coil spacing

After the spacing is done on the first side, proceed to the opposite side to adjust the X coils spacing on that side using the same procedure mentioned above.

At this point, the coil spacing should be set on all three coil pairs. Verify that the PVC tube spacing on the previous steps are still good and are still in place. If the tubes spacing are not correct, adjust them by gently tapping on the coils to bring them back in the proper place. When all the spacing are verified to be correct, start tightening the bolts on all the brackets making sure that the spacing does not change during the entire procedure.

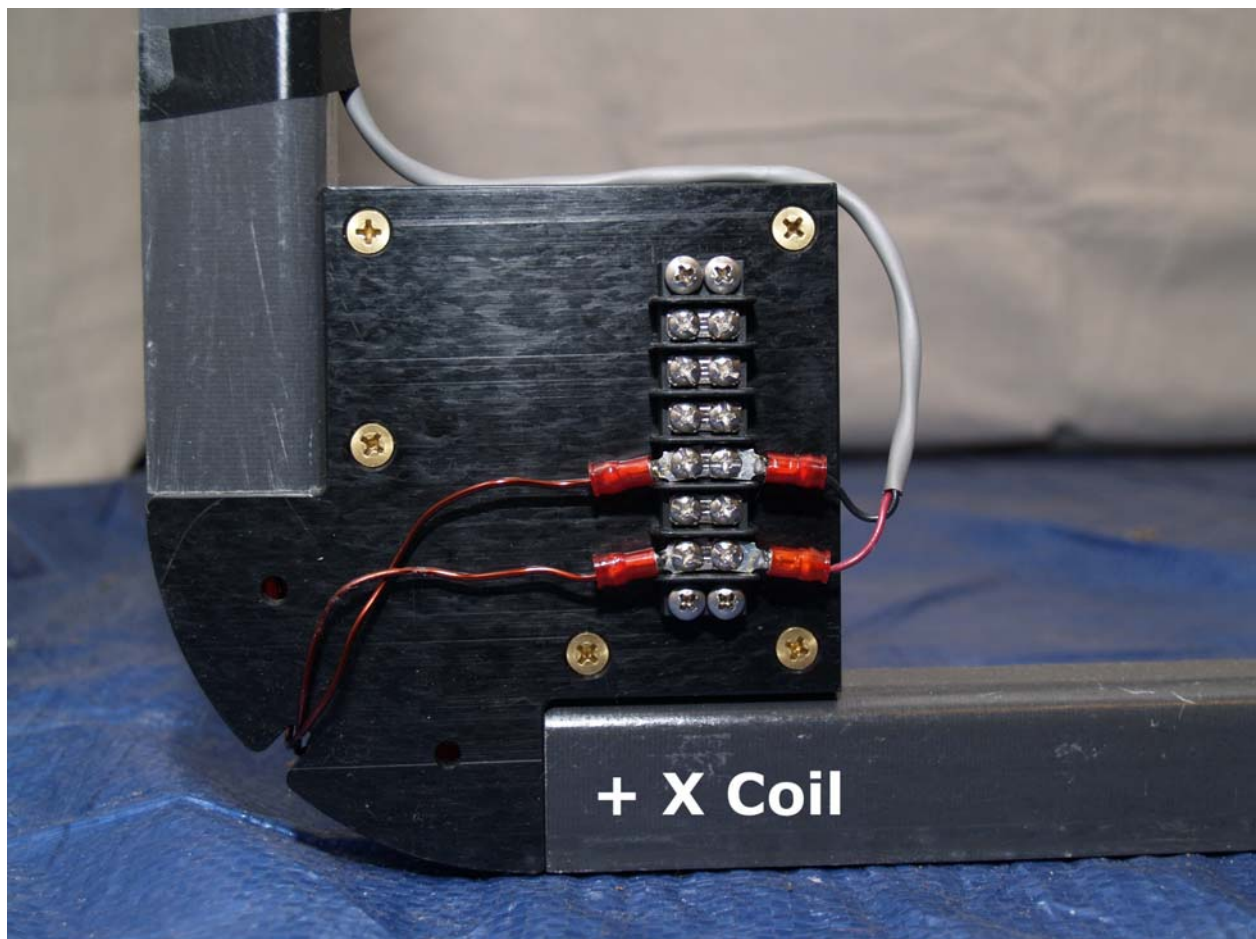
Helmholtz coil wiring.

Pairing wire Wiring

The three coil pairs need to be wired together for proper system operation.

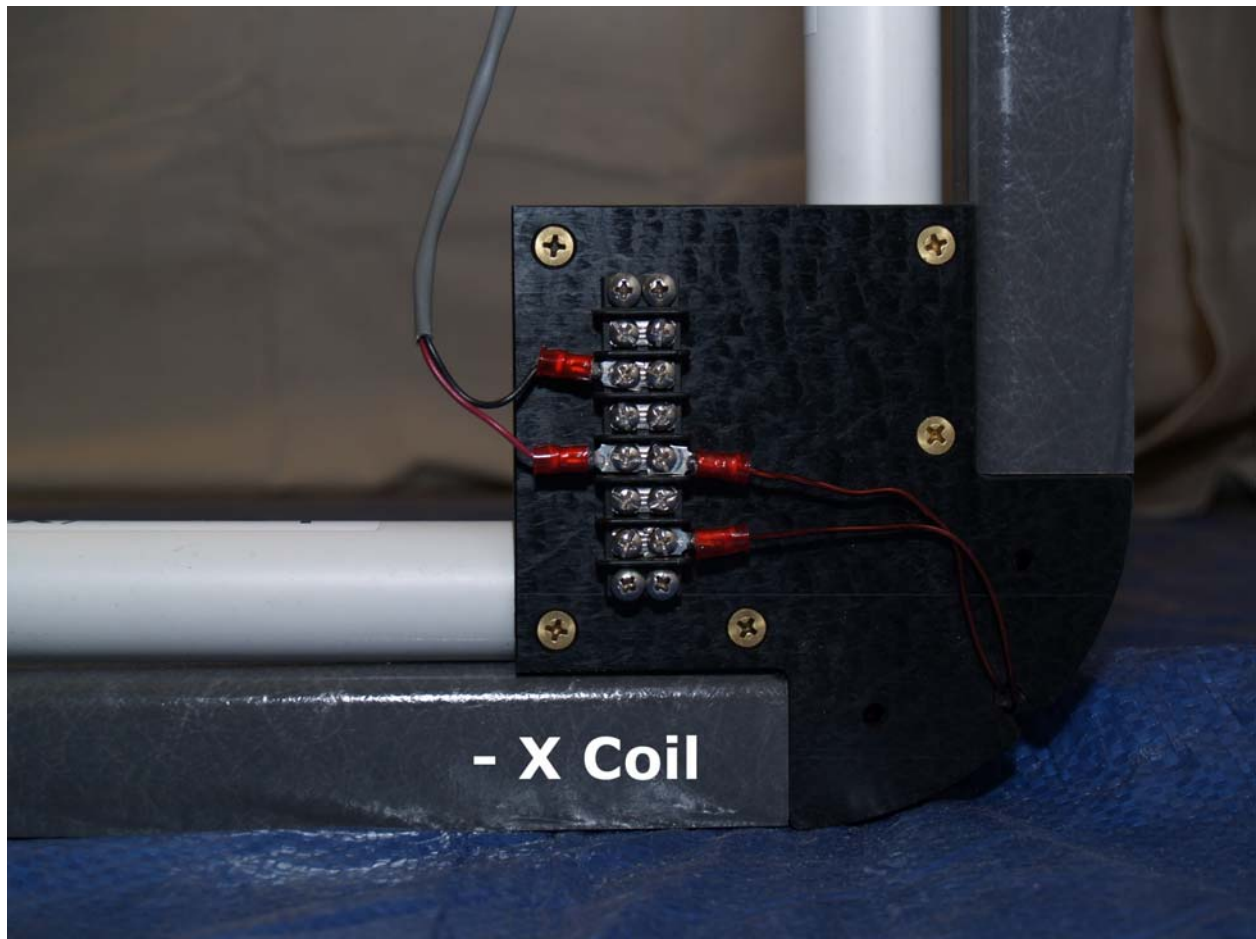
First, start with the X coil pair. Attached the pairing wire labeled “X Coil pairing wire” to the **+X coil** terminal by loosening the screws on the terminal and inserting the pairing wire as shown in the photo below (**Note: Polarity of the wires are very important and must be wired correctly, improper wiring may cause improper operation or damage to the Apex-CS Controller**).

Tighten all screws when finished.



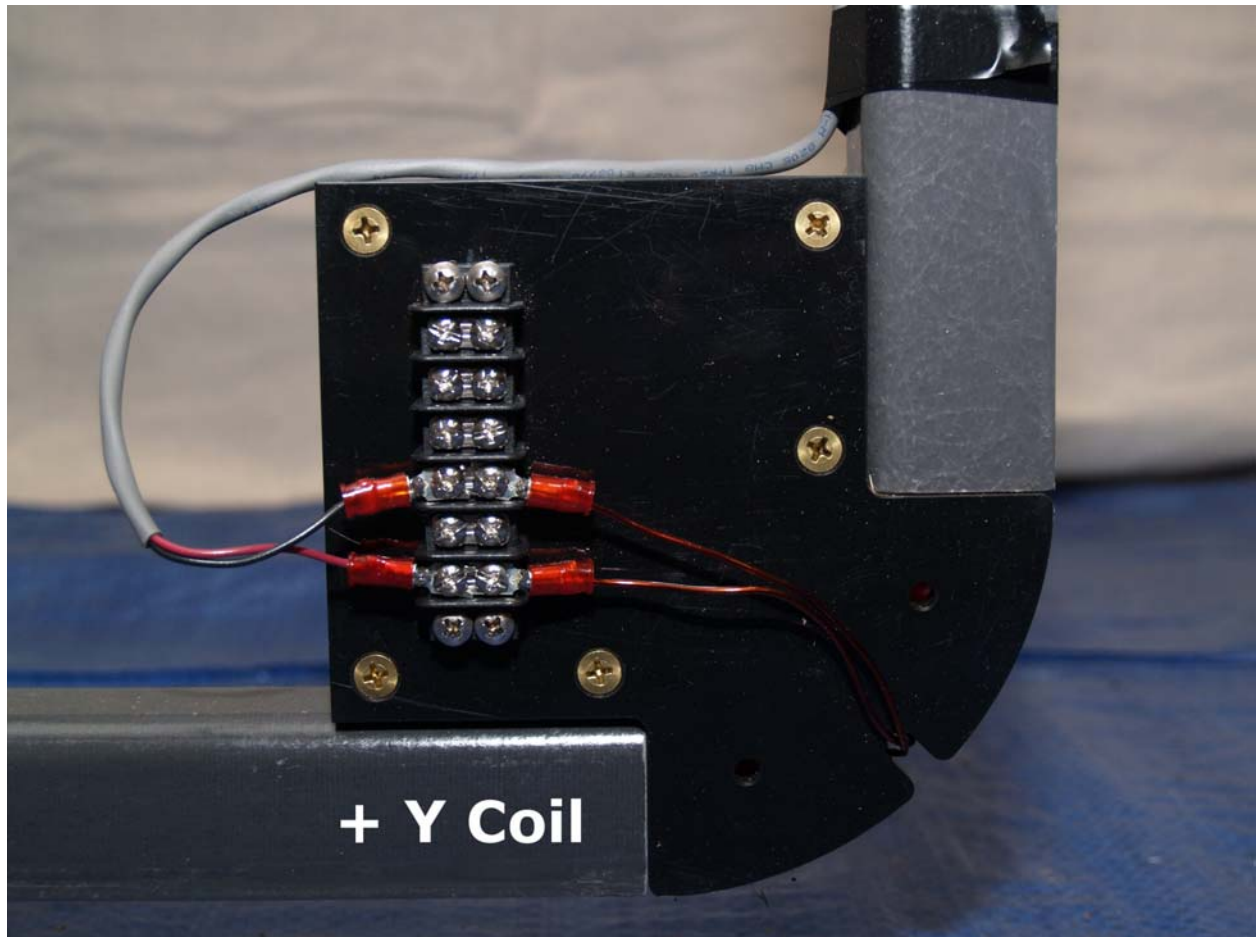
+X Coil Terminal Wiring

After the +X coil terminal wiring is done, attach the other end of the “X Coil pairing wire” to the –X coil terminal as shown below (**observe the location of the red and black wires on the pairing wire**).



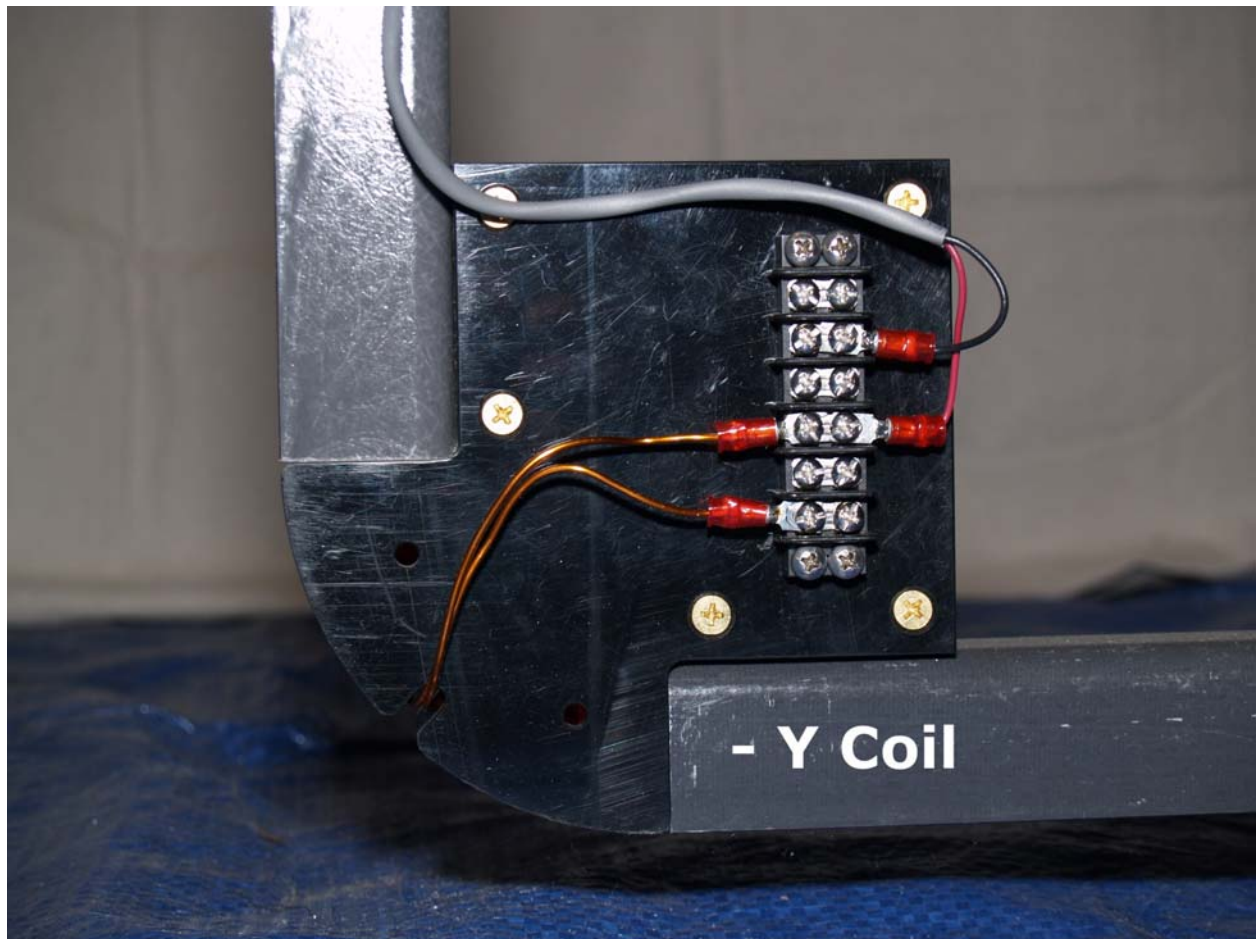
-X Coil Terminal Wiring

Next, proceed by wiring the pairing wire labeled “Y Coil pairing wire” to the **+Y coil** terminal as shown below (**observe the location of the red and black wires on the pairing wire**)



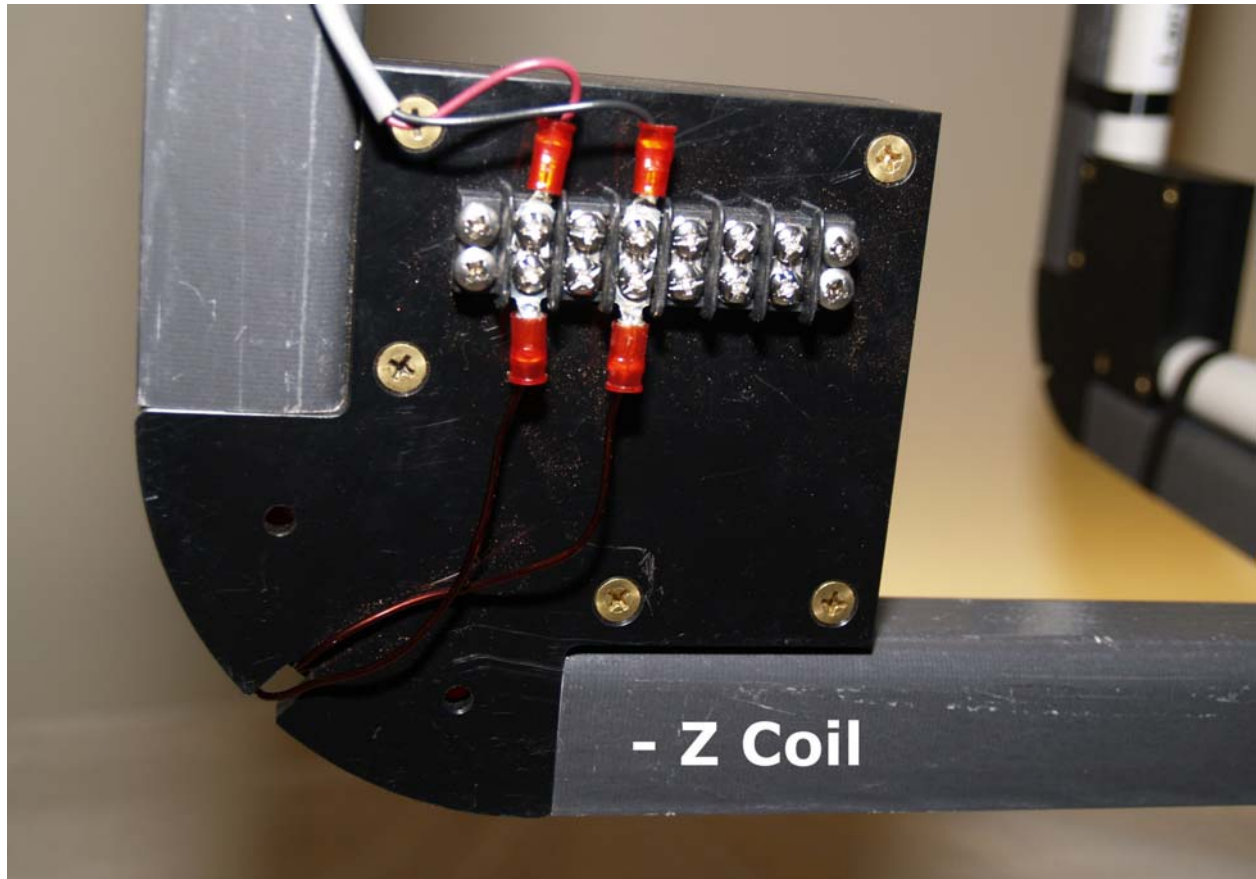
+Y Coil Terminal Wiring

After the +Y coil terminal wiring is done, attach the other end of the “Y Coil pairing wire” to the –Y coil terminal as shown below (**observe the proper location of the red and black wires on the pairing wire**).



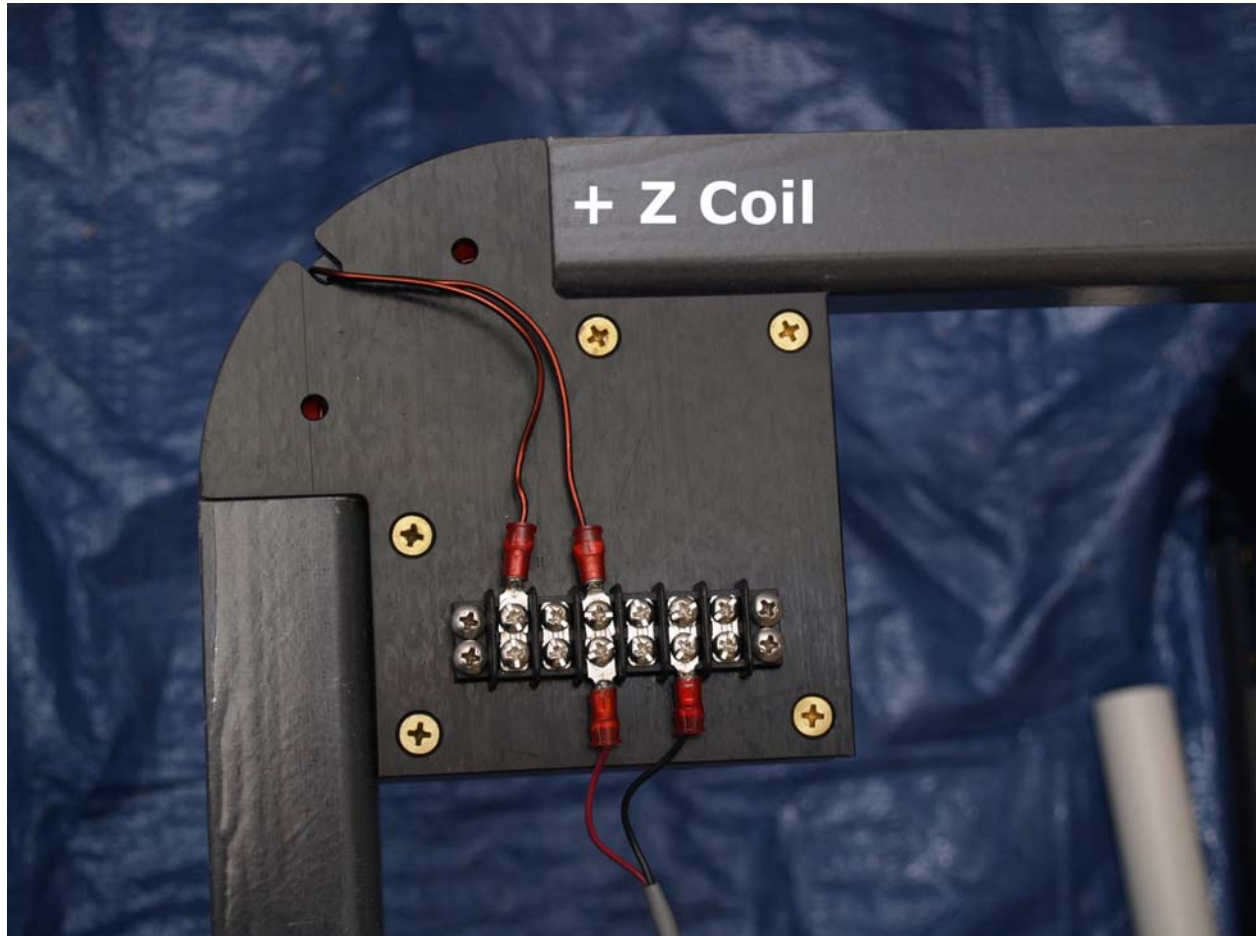
-Y Coil Terminal Wiring

Next, proceed by wiring the pairing wire labeled “Z Coil pairing wire” to the **–Z coil** terminal as shown below (**observe the proper location of the red and black wires on the pairing wire**)



–Z Coil Terminal Wiring

After the -Z coil terminal wiring is done, attach the other end of the “Z Coil pairing wire” to the **+Z coil** terminal as shown below (**observe the proper location of the red and black wires on the pairing wire**).



+ Z Coil Terminal Wiring

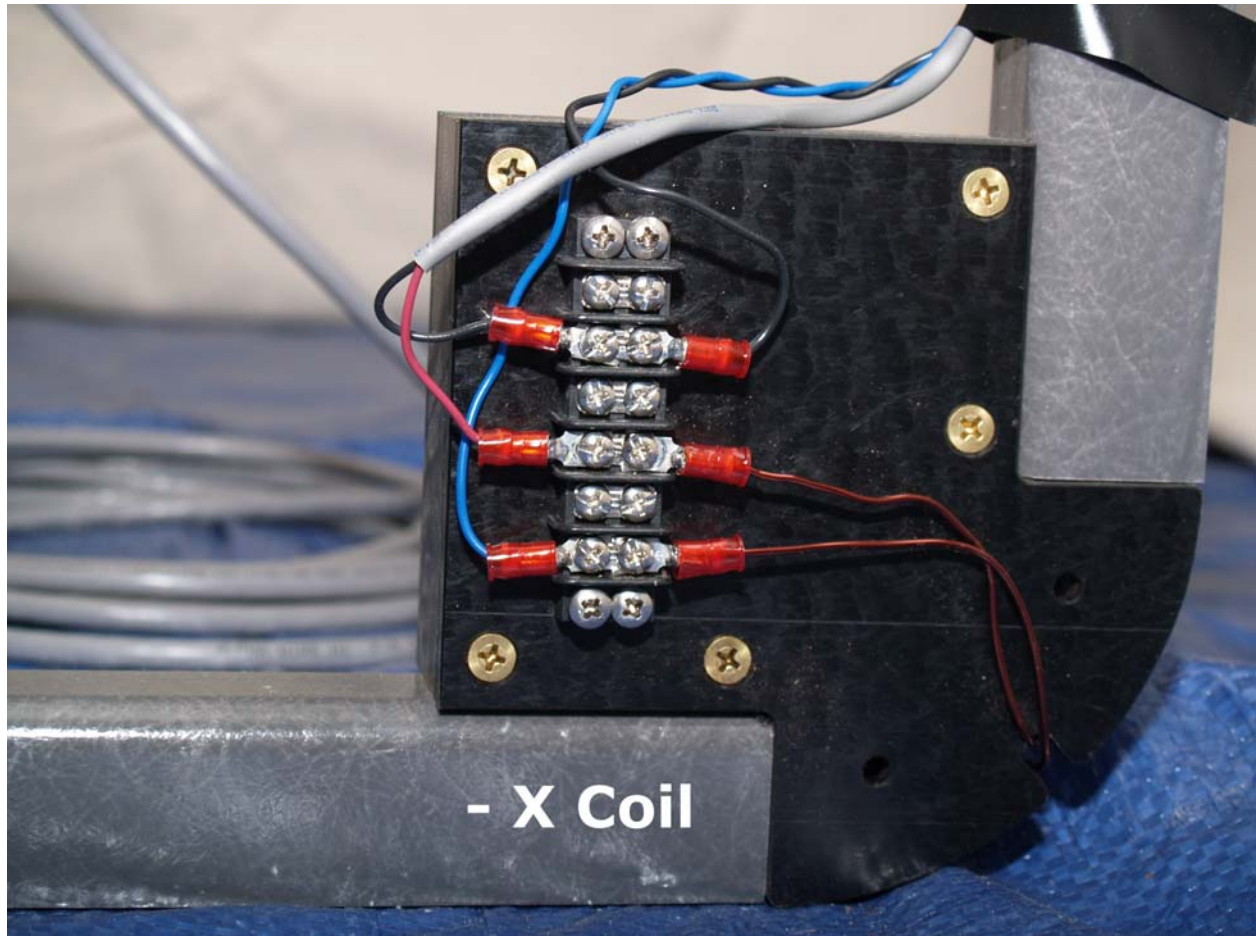
Helmholtz Coil Drive Wiring

Locate the corners where the $-X$, $-Y$, and $+Z$ coil terminals meet (see photo below).



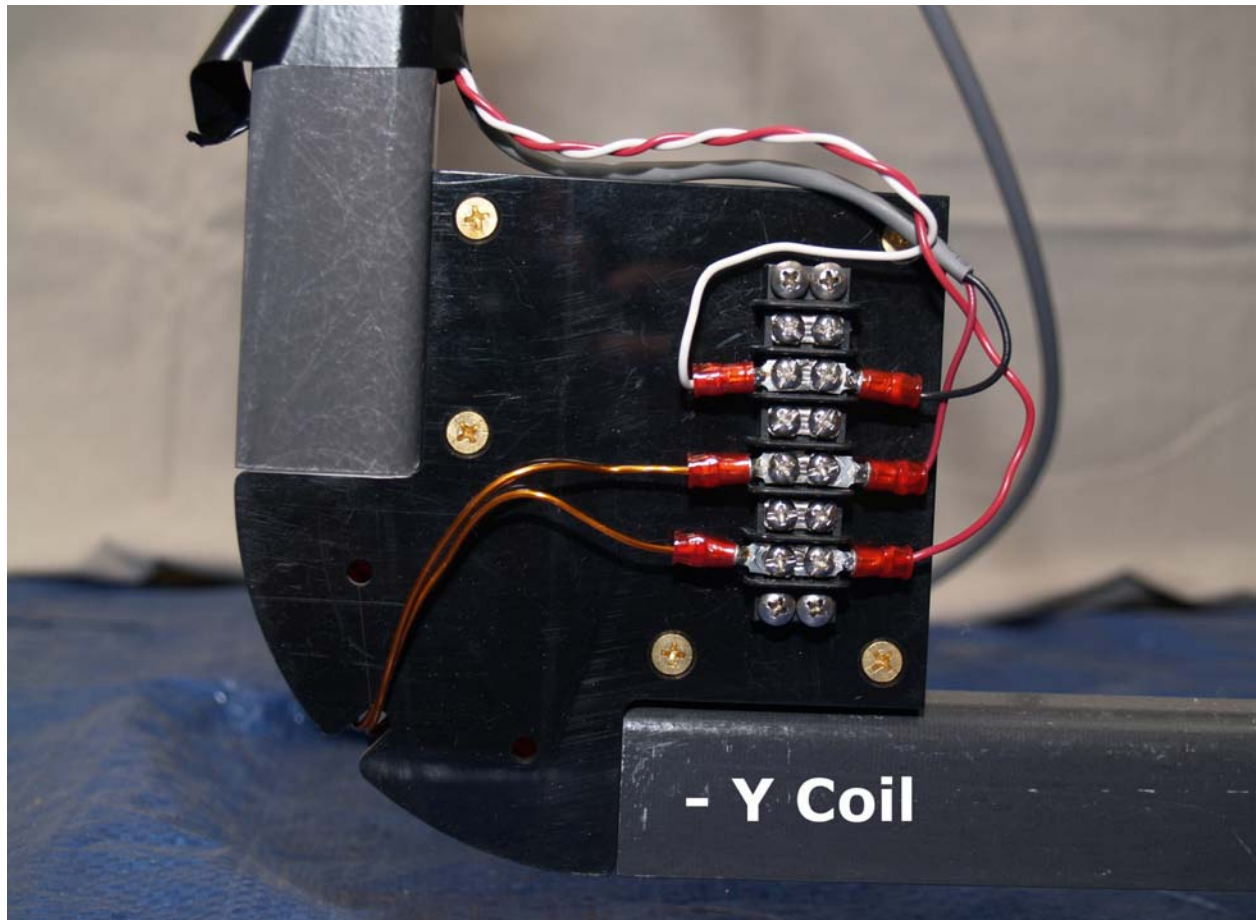
Coil corner $-X$, $-Y$, and $+Z$ coil terminals

Wire the **blue and black wire pair** of the X Coil Drive of the cable labeled “Drive to Helmholtz Coil” to the -X Coil terminal as shown below.



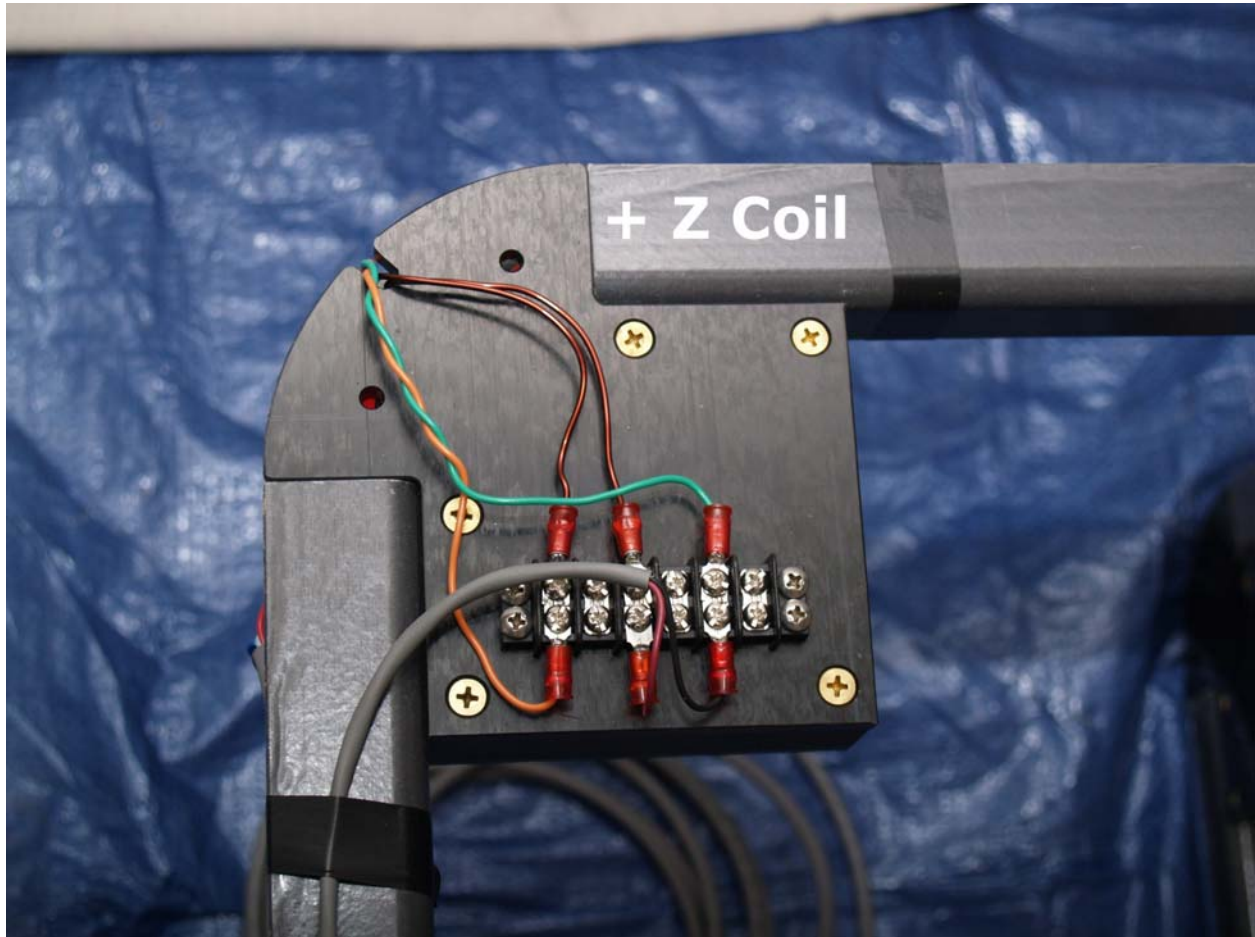
X Coil Drive Wiring

Next, wire the **red and white wire pair** of the Y Coil Drive to the –Y Coil terminal as shown below.



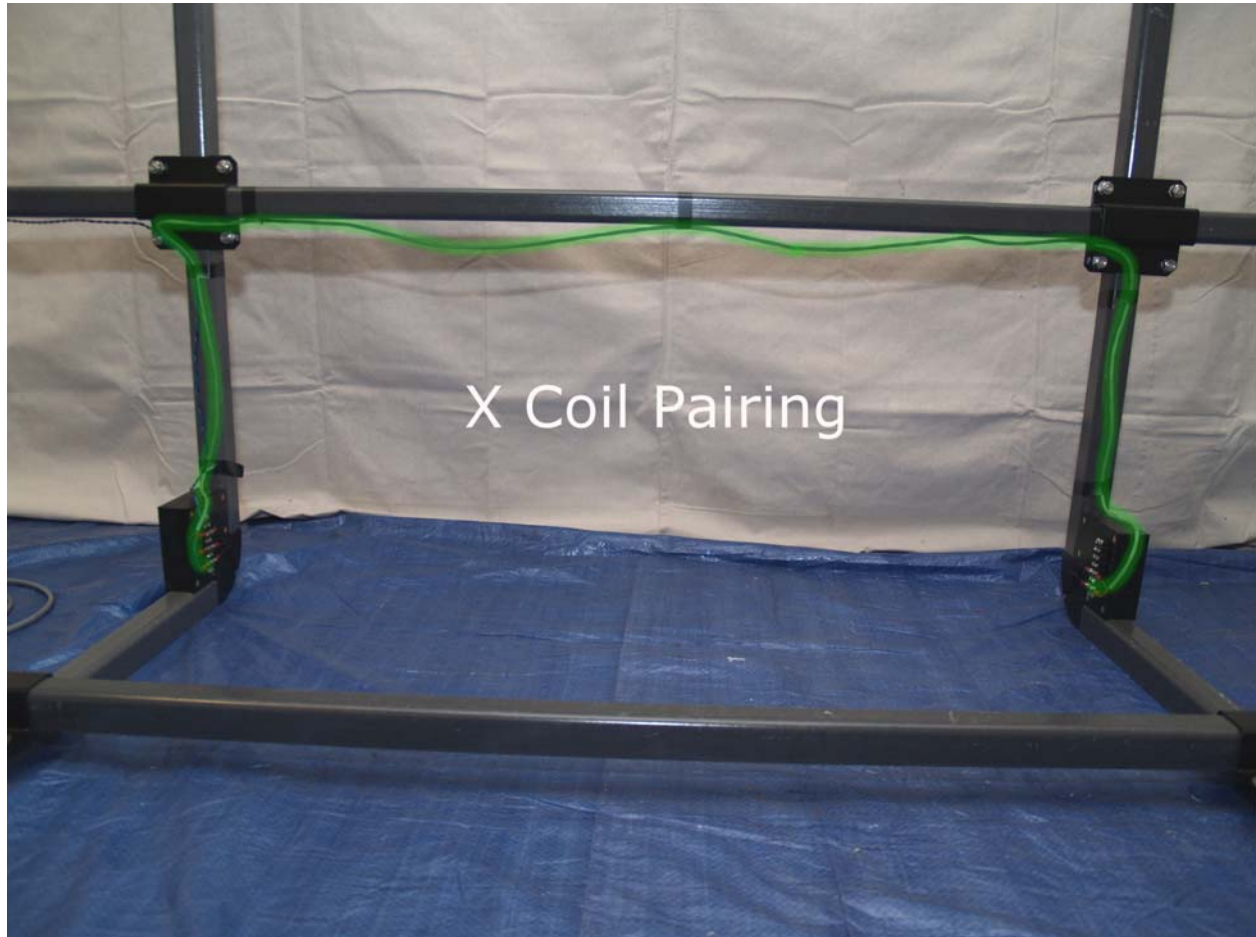
Y Coil Drive Wiring

Next, wire the **orange and green wire pair** of the Z Coil Drive to the +Z Coil terminal as shown below.

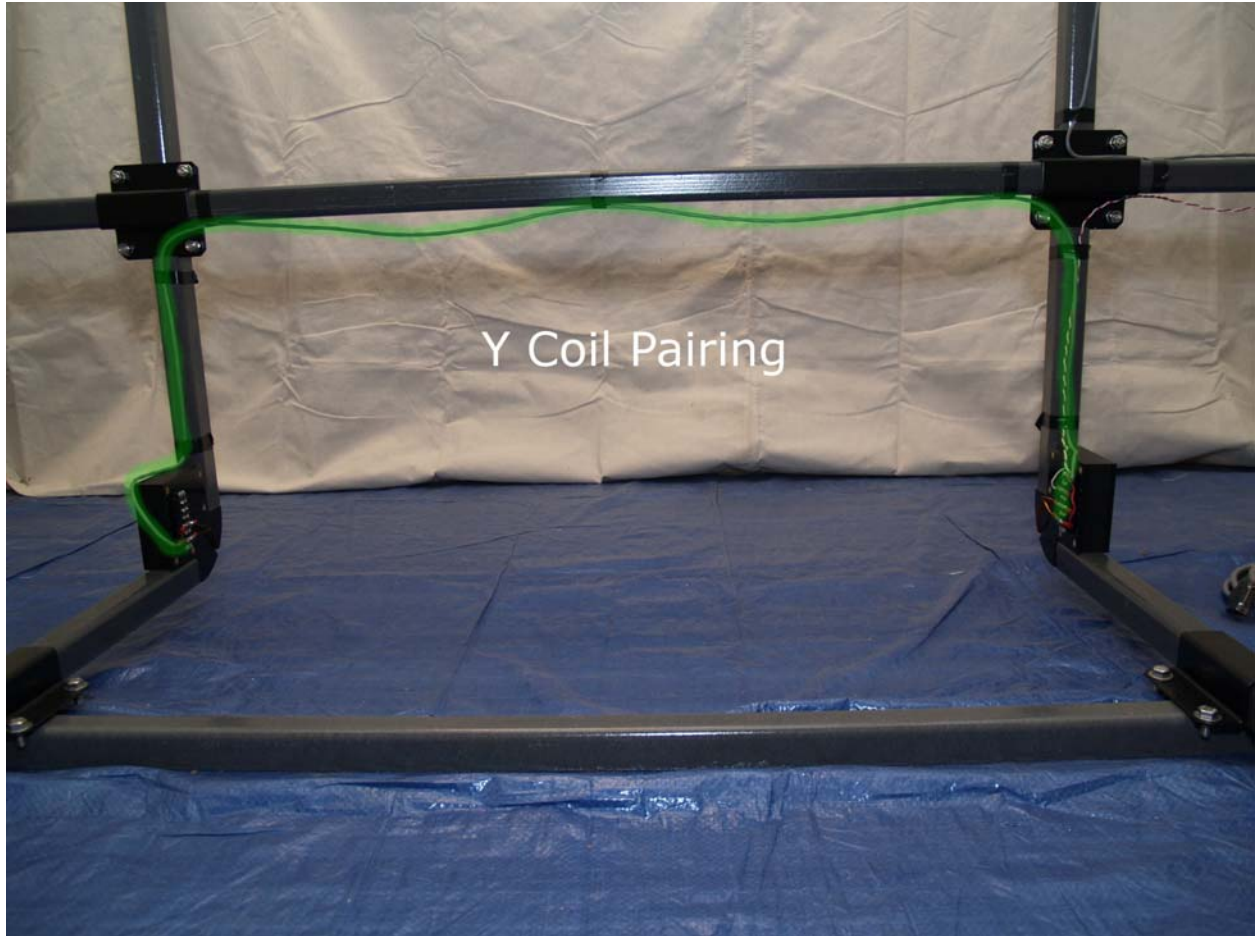


Z Coil Drive Wiring

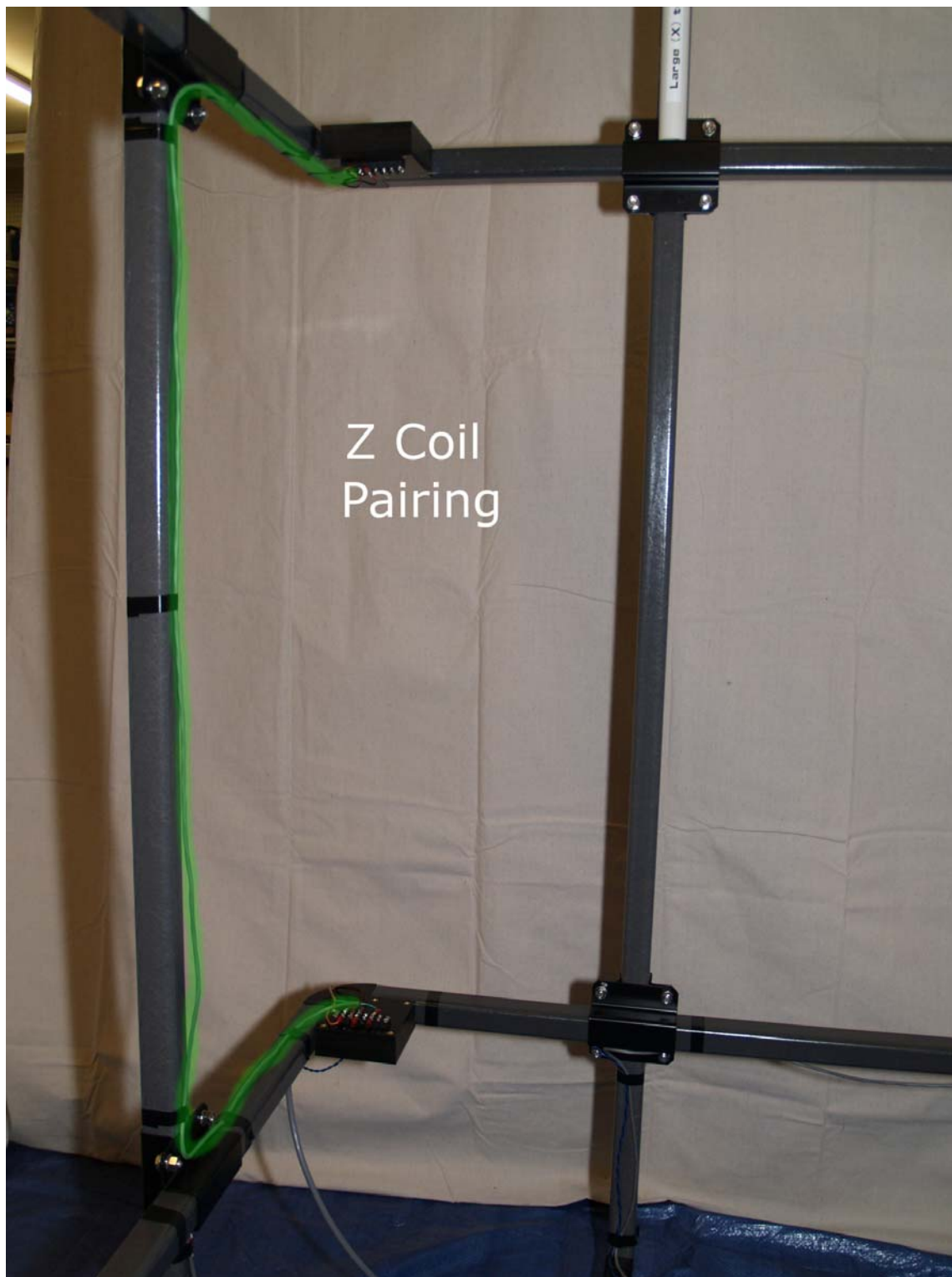
After all the pairing wire are wired, dress up the wiring using the provided tie wraps and tie wrap anchors so the wires are neatly tucked away as shown below.



X Coil Pairing wire Dressing



Y Coil Pairing wire Dressing



Z Coil Pairing wire Dressing

Apex-CS Controller Wiring:

Materials:

- Apex-CS Controller



- Reference Magnetometer



- Servo Magnetometer



- Serial Cable



■ Drive to Helmholtz Coil Cable

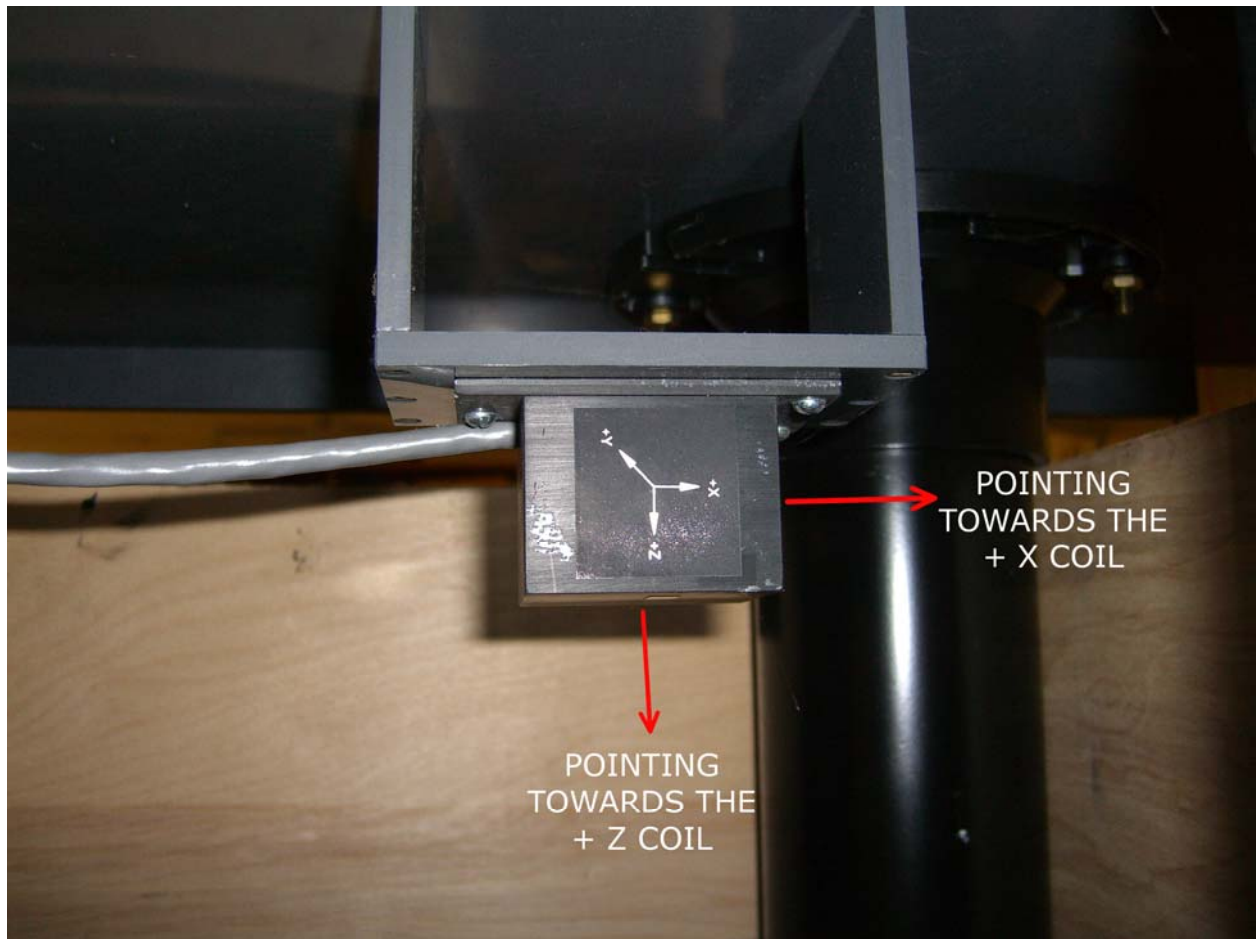


■ Power Supply with cable



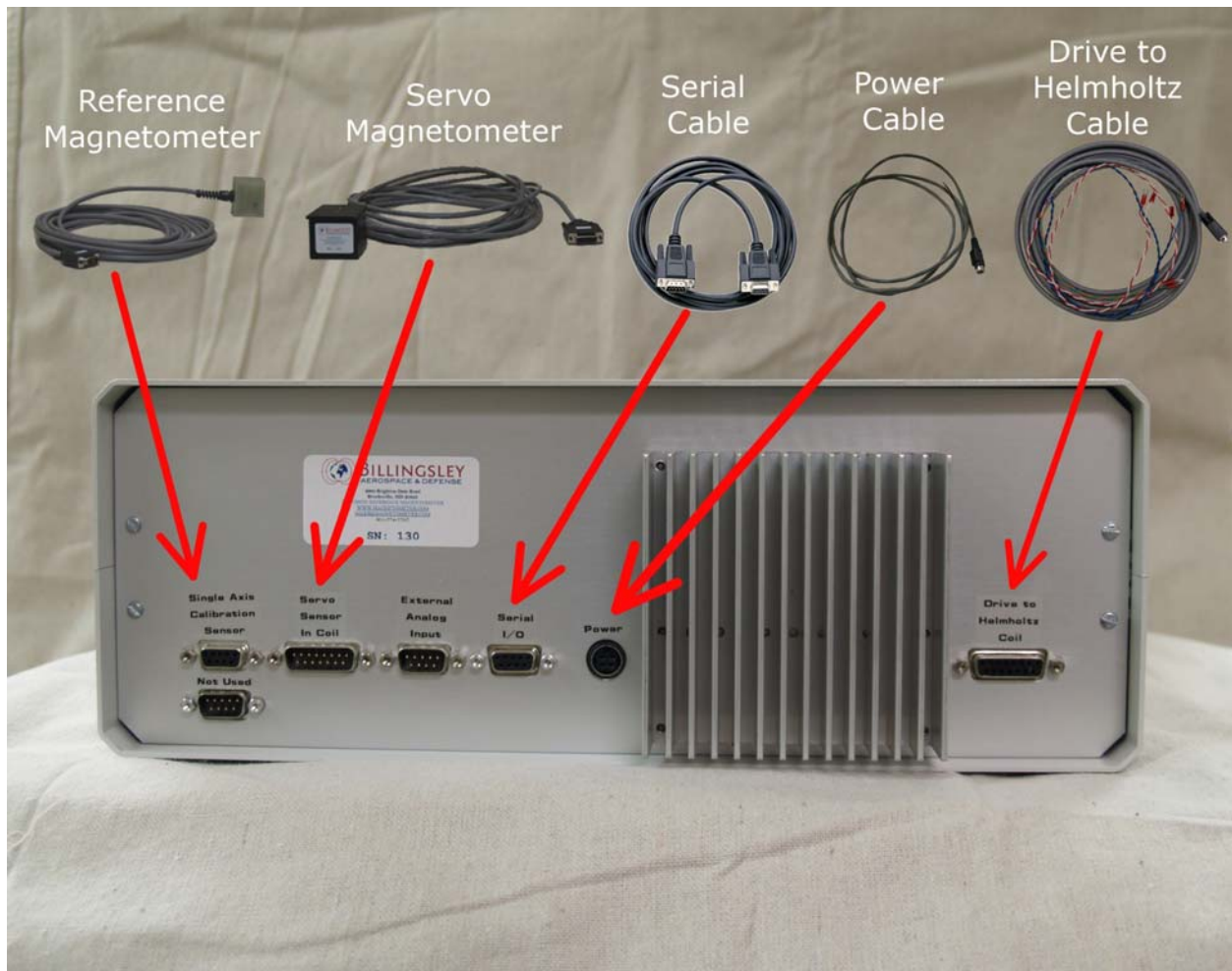
NOTE: Do not power the Apex-CS controller before properly setting up the Servo Magnetometer (also referred to as Servo Sensor) inside the Helmholtz Coil System; doing so may damage the Apex-CS Controller.

- Insert the Precision Reference Magnetometer (Fiberglass Cube) into the female DB-9 connector labeled “Single Axis Calibration Sensor” on the back of the Apex-CS controller
- Find a location inside the Helmholtz coil (preferable close to the center) and mount the Servo Magnetometer (Black Delrin Cube) to a platform (platform is not supplied and must be provided by the customer) such that the +X of the Servo Magnetometer points to the +X Coil and the +Z of the Servo Magnetometer points to the +Z Coil of the Helmholtz coil, (see photo below for reference). **(Note: the Servo Magnetometer mounting orientation is very important and can only be mounted as noted above, improper orientation of the Servo Sensor can damage the Apex-CS Controller).**



- Insert the Servo Magnetometer (Black Delrin Cube) into the male DB-15 connector labeled "Servo Sensor In Coil" on the back of the Apex-CS controller
- Insert the male end of the Serial cable into the female DB-9 connector labeled "Serial I/O" on the back of the Apex-CS controller
- Insert the female end of the Serial cable into the male serial port on the back of the computer
- Insert the Drive to Helmholtz Coil cable into the female DB-15 connector labeled "Drive to Helmholtz Coil" on the back of the Apex-CS controller
- Insert the Power Cable into the round connector labeled "Power" on the back of the Apex-CS controller

- Verify that all the connections are correct. If everything is correct, plug the grounded AC plug to an AC outlet to turn on the Apex-CS Controller, refer to Apex-CS Manual for further information on the Apex-CS Controller.



Back of Apex-CS Controller

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