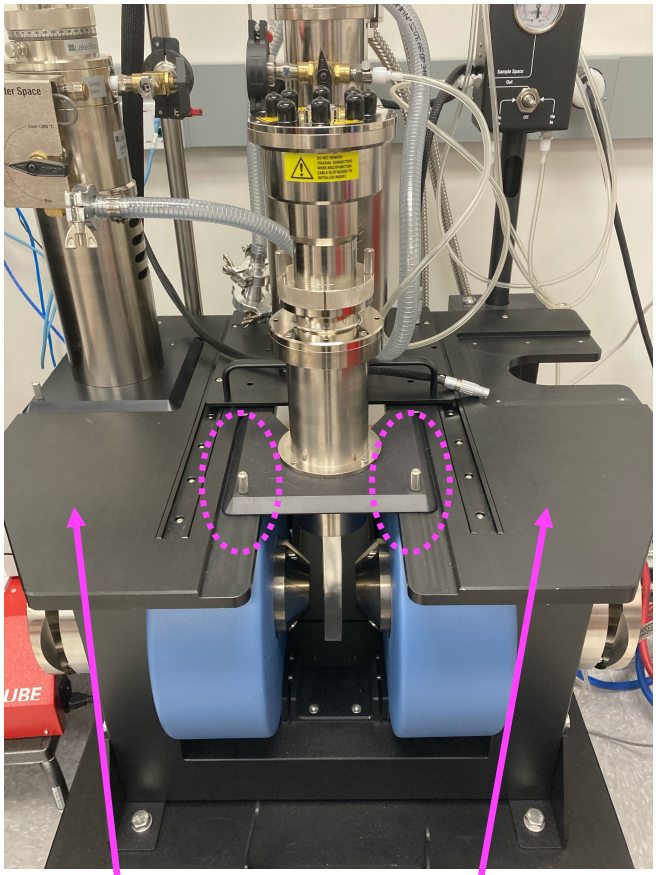
Room Temperature Head Operating Instructions

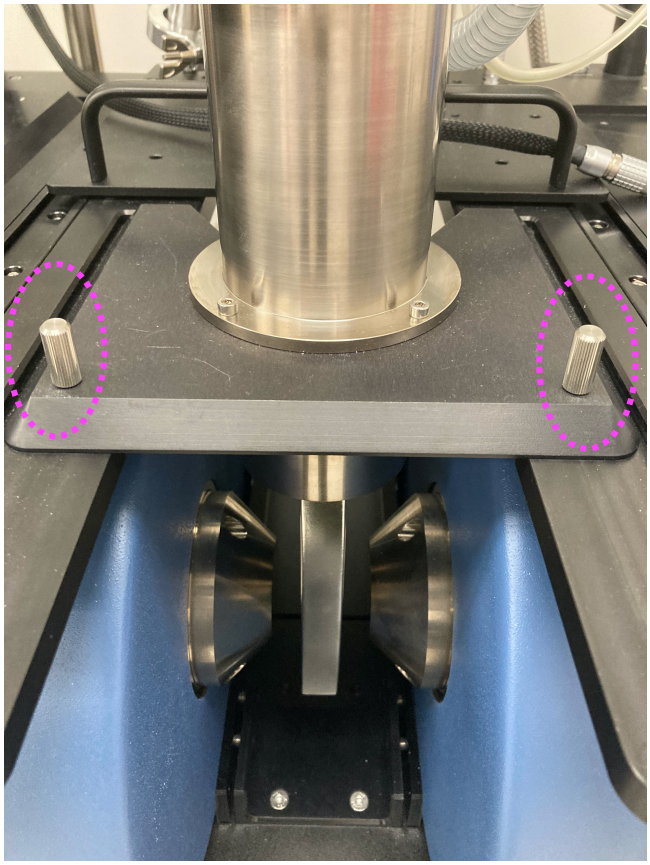
Standby Condition

1. Coax cables and control cable should be disconnected.
2. NO sample should be mounted inside the RT head.
3. LakeShore system must be OFF, and tables should be clean.

Operating Room Temperature Head

1. **Enable Lakeshore on Badger.**
2. **Wear gloves when handling the tool!**
   Ensure that RT Head is in the measurement station, with both screws tightened at the base.





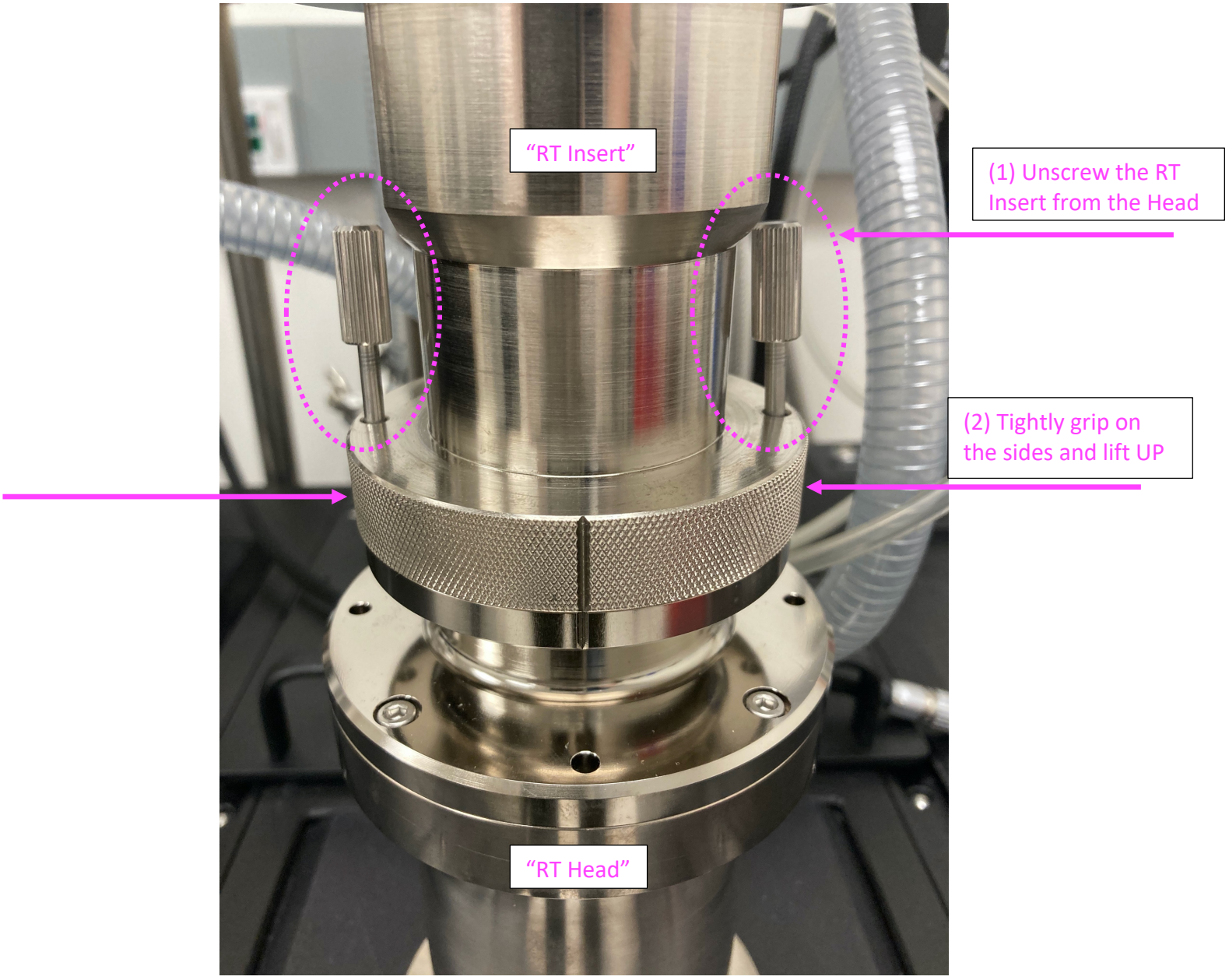
Side Note: The fields on these machines are very high (~1 T).

Thus, these surfaces must be EMPTY. Metallic objects will respond to the field, and personal electronics may be damaged.

3. MOUNTING YOUR SAMPLE

i) Unscrew the RT insert completely and *carefully* lift from the head. Be gentle!

Carefully set the Insert on the metal table on your right, with the probe card facing up.

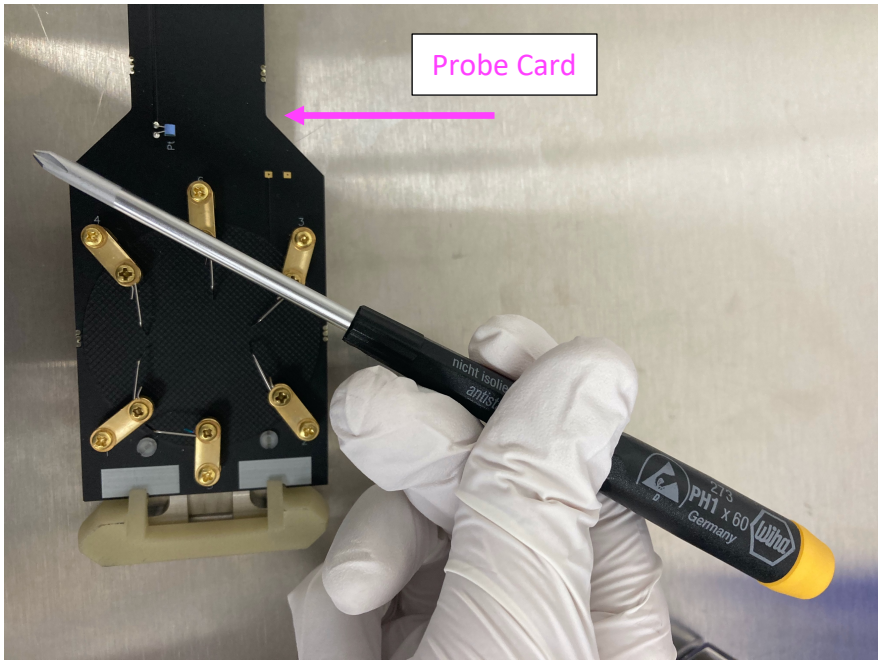


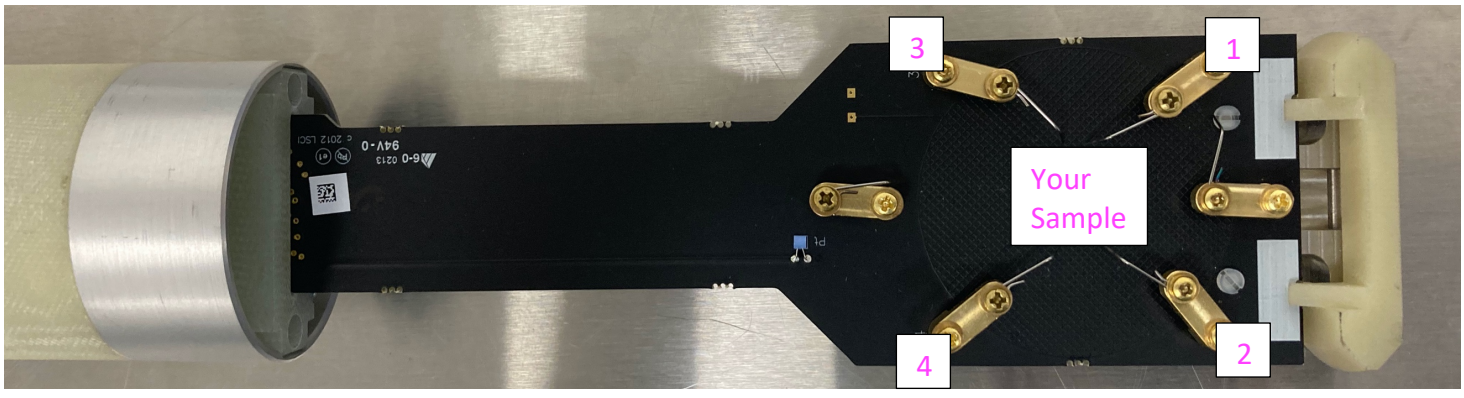
ii) Use the screwdriver to mount your sample onto the probe card.
The probe card must be kept CLEAN.
No invasive pastes and adhesives are permitted, although Kapton tape is OK.

For a standard van der Pauw structure, each corner should be in contact with probes 1 through 4, as shown below. Other Hall bar structures may use the additional two probes.

Ensure that your sample firmly anchored. Do not overtighten screws.

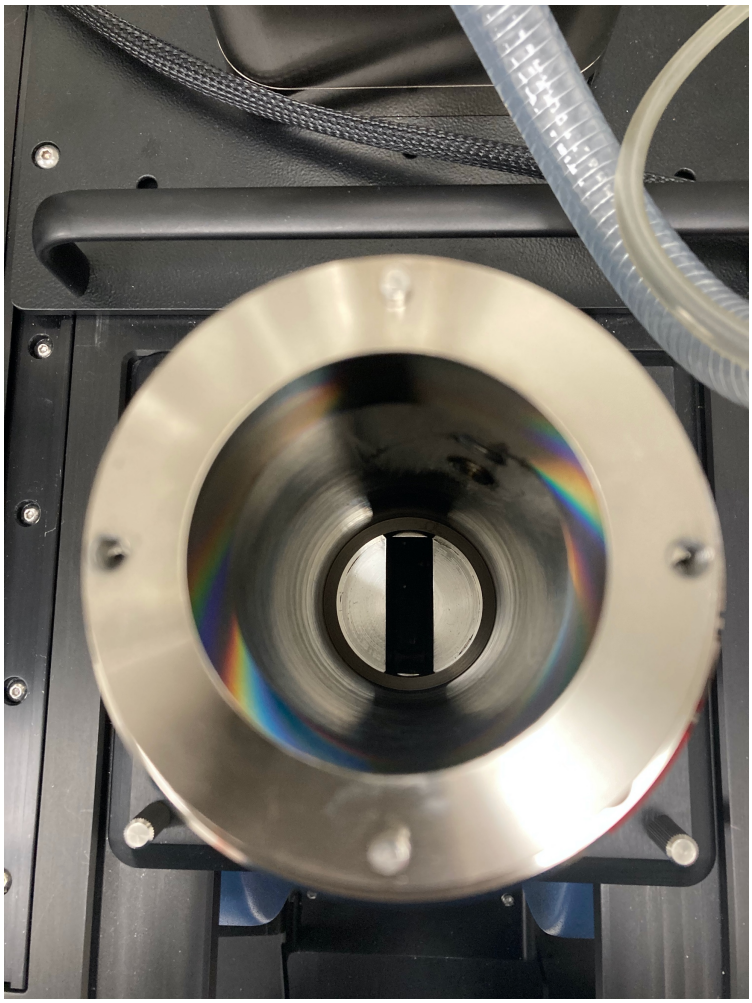
NOTE: The screwdriver is contained in the box labeled “8400 SAMPLE MOUNT ACC KIT”.

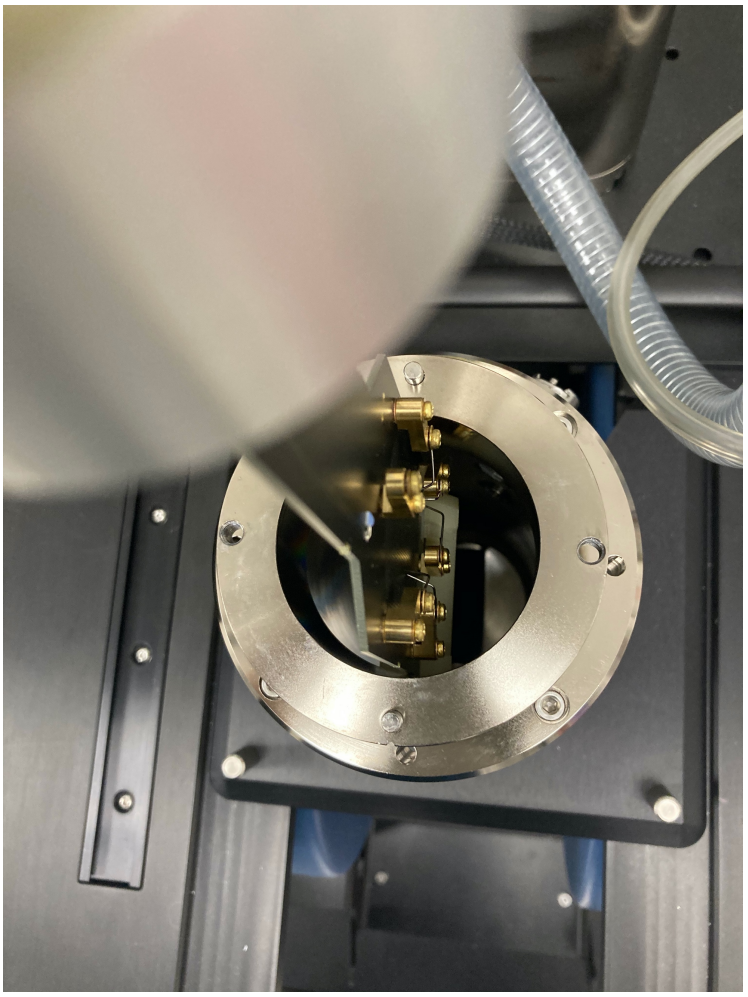




iii) Insert the RT Insert back into the Head.

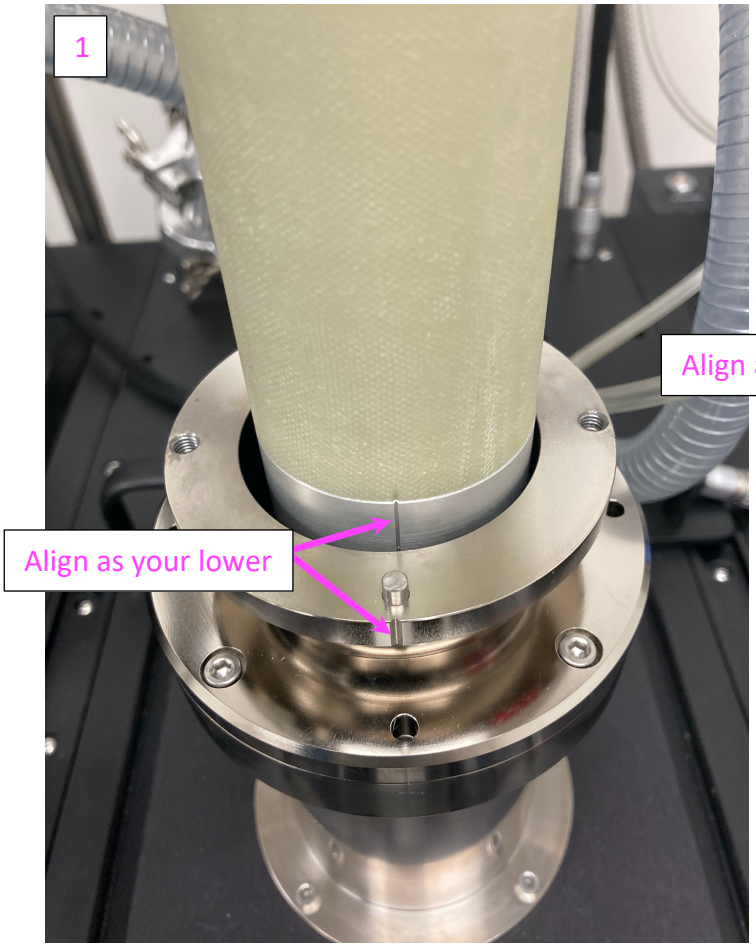
Take a look inside first. You must ensure that the probe card is aligned with the rectangular opening, with the sample side facing right. Picture below:

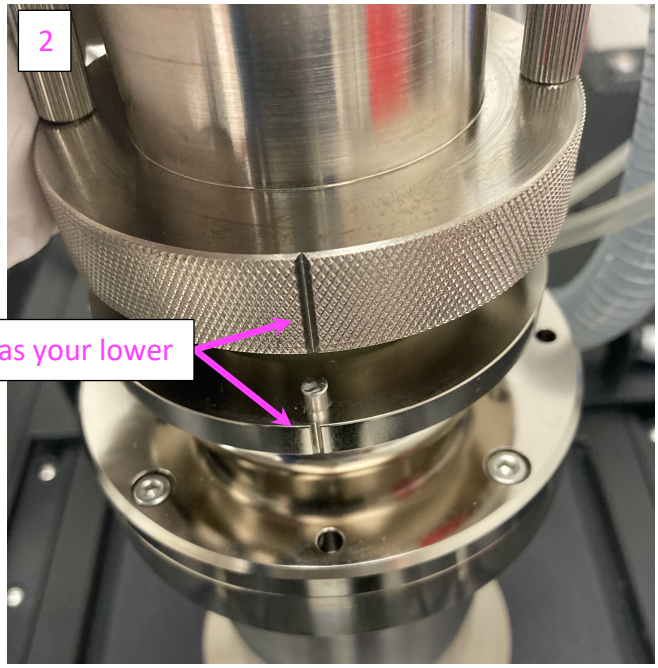


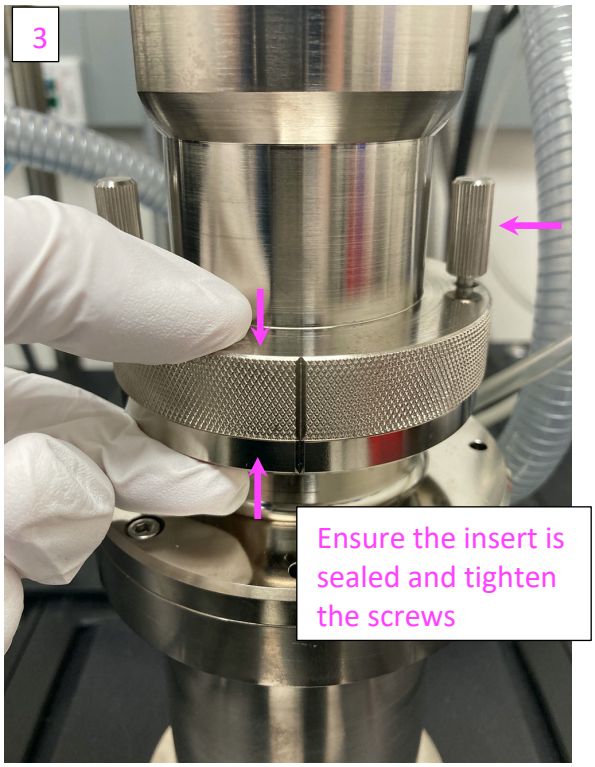


Slowly lower the RT Insert, as depicted in order below.
There are lines on the Insert that must align with the line on the RT Head.

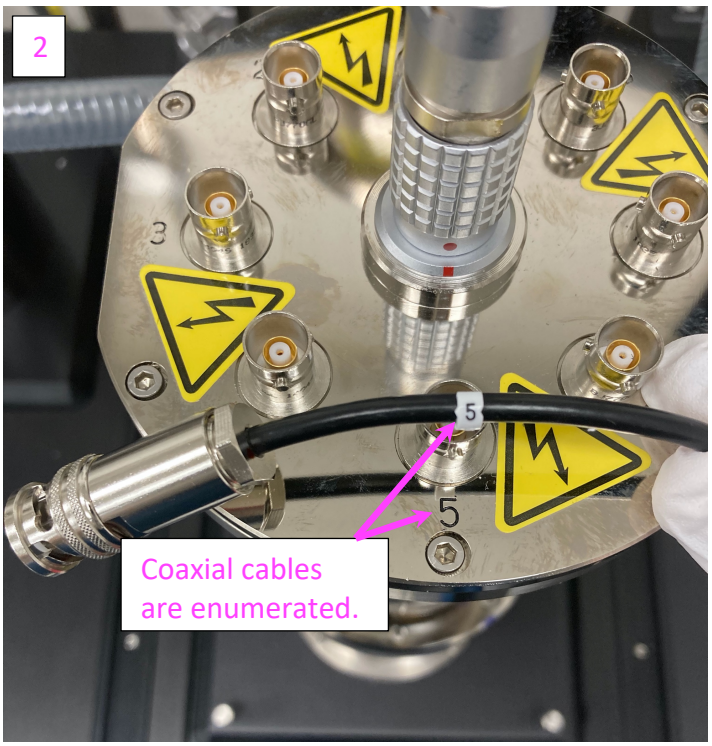
NOTE: Lower SLOWLY. It is very likely that you will collide the end of the Insert on the sides. If so, slightly lift the Insert and try realigning as best as possible before attempting to lower again. Eventually the Insert should slide in.

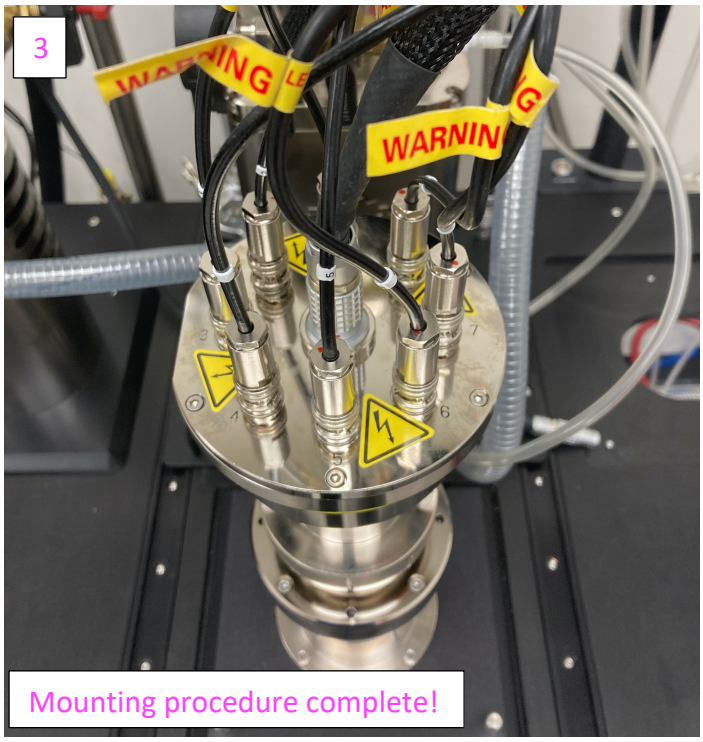




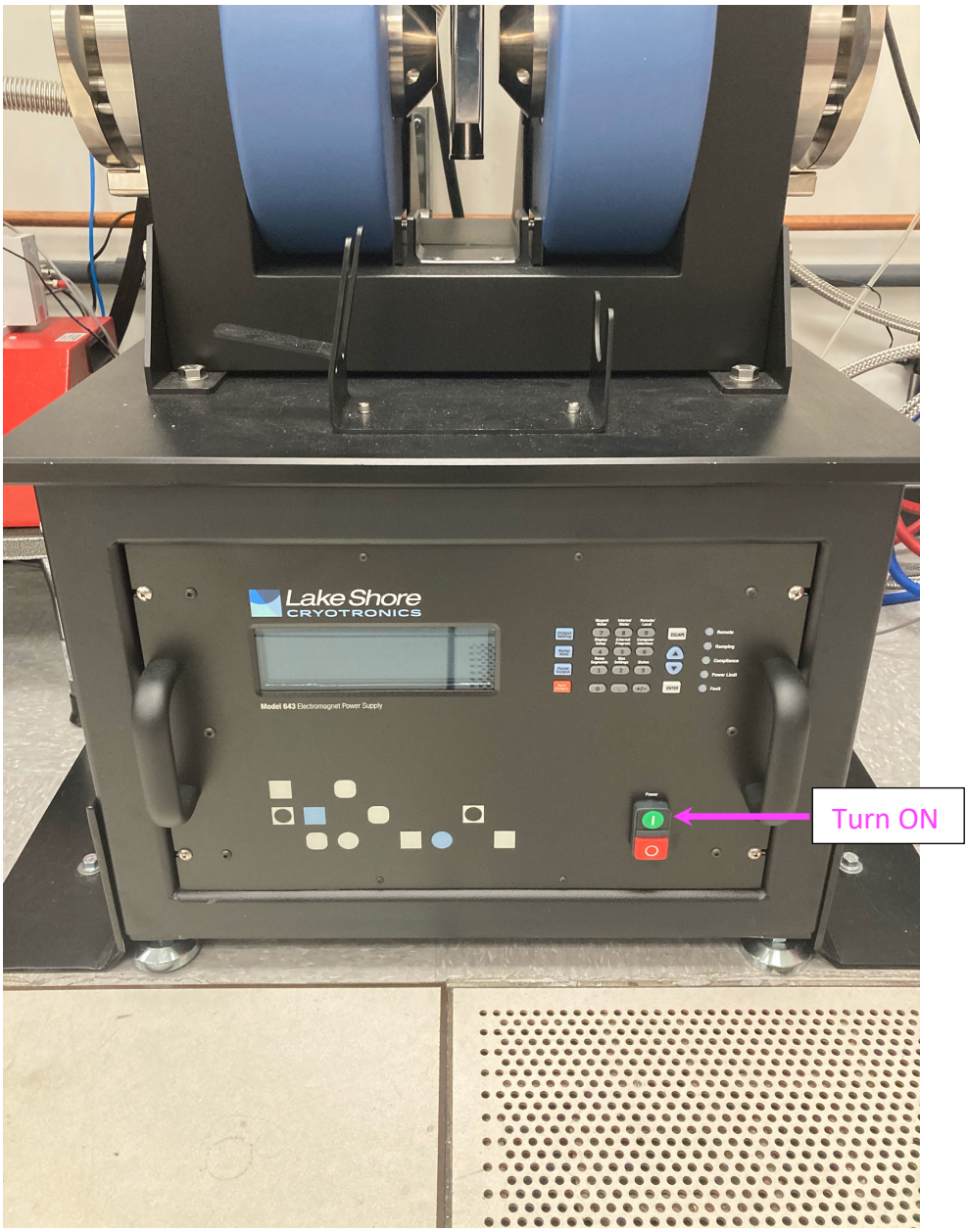


iv) Connect the Control port and the coaxial cables, as depicted below in order.





4. **Turn ON Lakeshore system (below the magnets).**

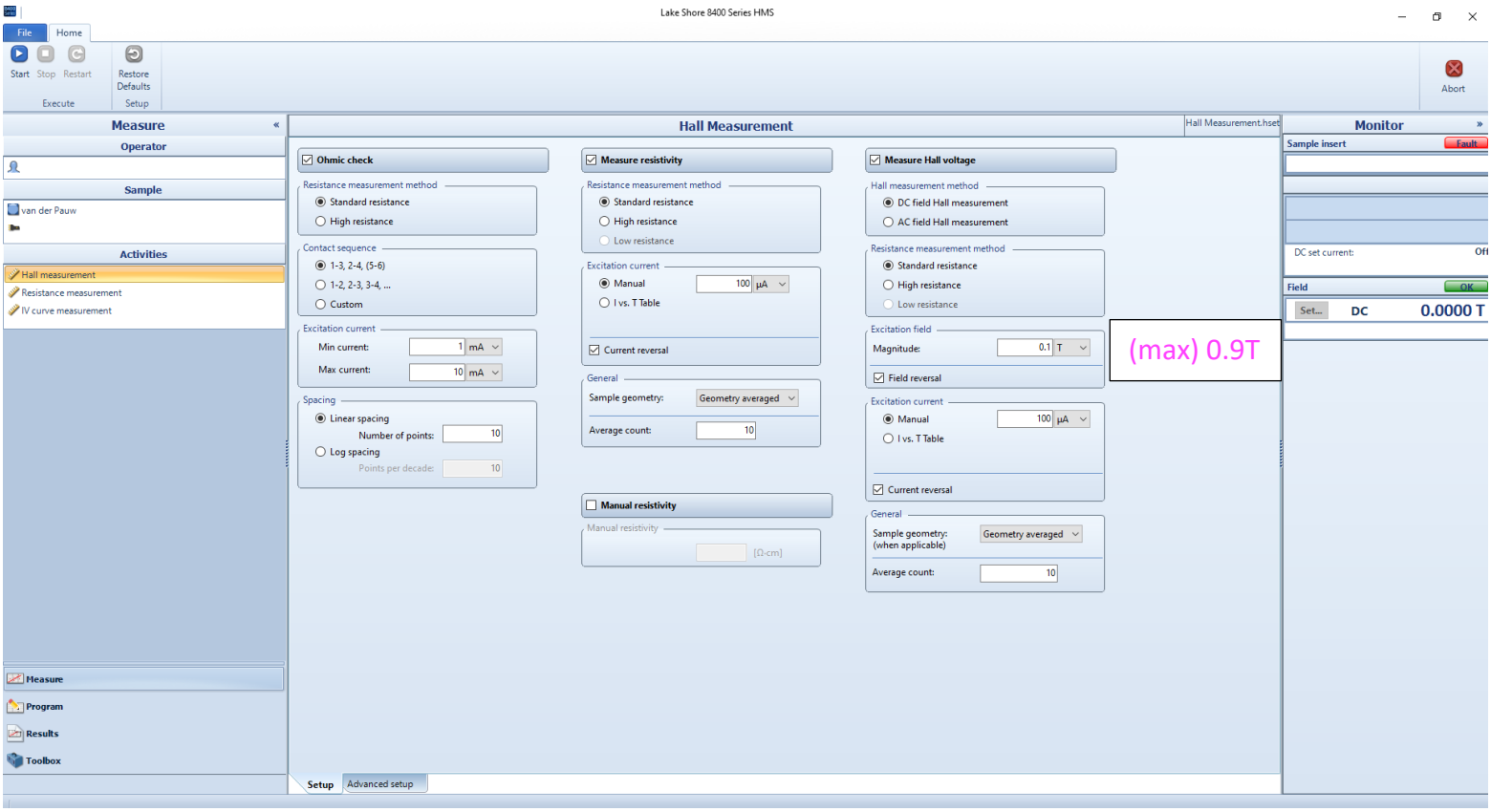


5. TAKING MEASUREMENTS

On the PC, open the “Lake Shore 8400 Series HMS” software on the LakeShore desktop. Click OK on any warnings.

NOTE: PC password is “LakeShore”, without the quotes.

The following window will open:



There are three measurement columns in the window above:
Ohmic check, Measure resistivity, and Measure Hall voltage.

i) **Ohmic check** simply applies a current and measures the resulting voltage and calculates the resistance. Do this to check if good contact is made on your Hall device. The resulting plot should be as linear as possible.

NOTES:

- You can select the contact sequence (by default, the resistance in measured on pins 1-3 and 2-4).
- “Excitation current” is specific to your sample! Very resistive samples should have very low excitation currents.
- “Standard resistance” option is usually fine. The “High resistance” option should be used for resistances >> 1 MOhm

ii) **Measure resistivity** measures the sheet resistance of your Hall device (e.g., units of Ohm/square).

NOTES:
- As with Ohmic check, ensure that the Excitation current is reasonable for your sample.
- By default, the Current reversal option is left checked.
- By default, the Sample geometry is “Averaged” with a count of 10.

iii) **Measure Hall voltage** measures the Sheet Carrier Concentration (e.g., units of cm^{-2}). <u>The maximum Excitation field is 0.90 T.</u>

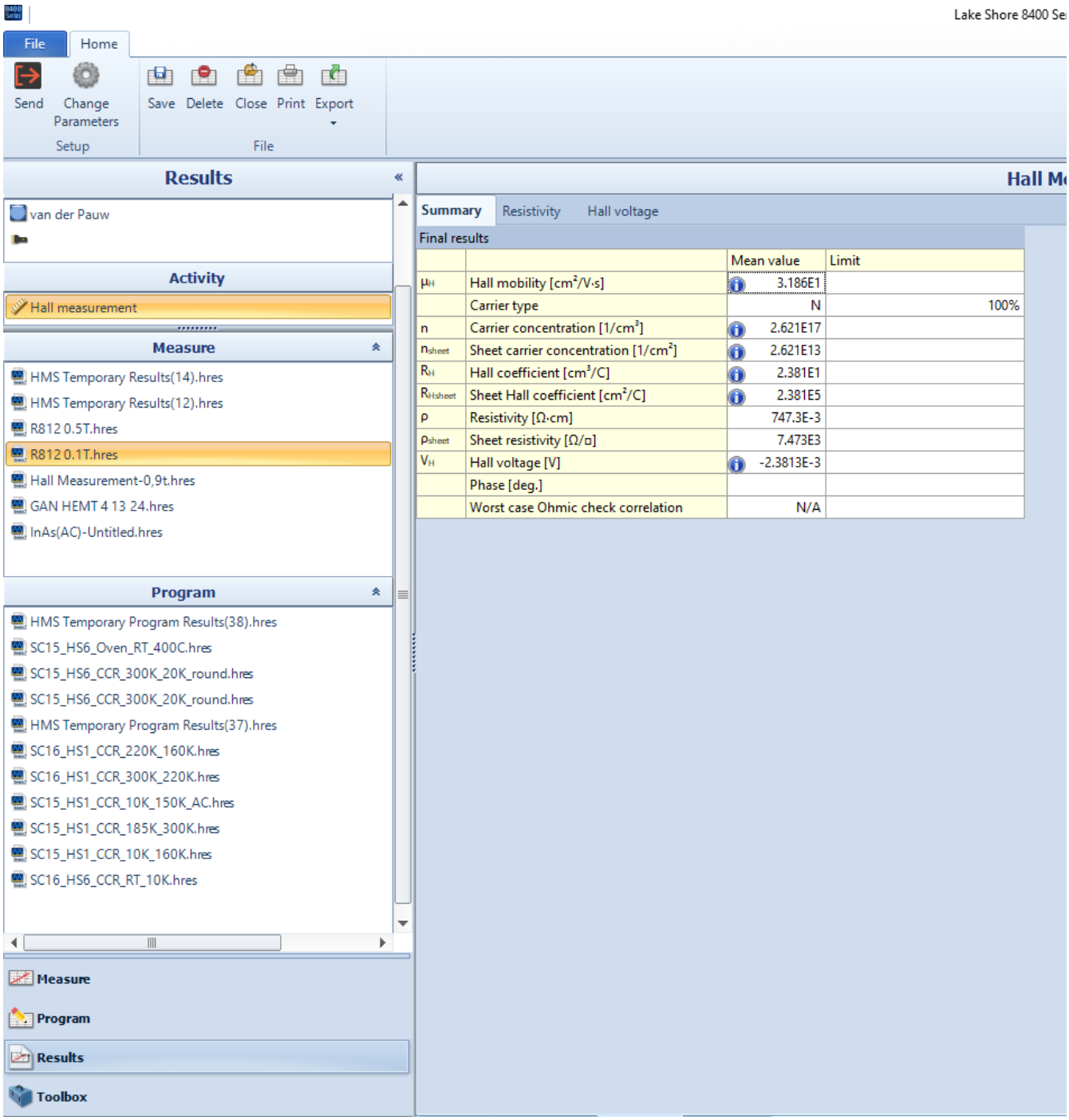
NOTES:
- Hall Measurement method is maintained at DC field Hall Measurements. AC field measurements are an excellent way to accurately measure *highly resistive* samples, particularly those with very low mobilities. If you’re interested in this option, reach out to the training staff and we’ll help you set it up.
- The “Excitation field” is the maximum magnetic field magnitude that will be applied during Hall measurements. Usually, higher fields are necessary for more resistive samples. The maximum possible field you can apply here is 0.90 T.
- Ensure that the “Excitation current” is appropriate for your sample.

Check again and make sure there are NO personal items near the magnet.
Once your inputs are ready, click “Start” on the top-left to begin your measurements.
The software will automatically switch to the “Results” menu on the bottom left.

<u>OTHER NOTES:</u>

i) During measurement, the monitor on the LakeShore software will specify the field magnitude and applied current.
ii) You should hear a *clicking* sound in the magnets once they’re activated. This is a water valve opening to cool the coils (since amperes of current run through them).
iii) Recall that this measurement system is *current controlled*. By default, there is a voltage compliance set at 20 V, so take extra precautions of your “Excitation currents” if your sample is sensitive to these voltage magnitudes.
iv) Feel free to explore the “Resistance measurement” and “IV curve measurement” options in the “Activities” section on your left.

Once your measurement finishes, a “Summary” tab is created. If you measured both the Resistivity and Hall voltage, the Hall mobility and Carrier type will automatically be calculated for you in the Summary tab.



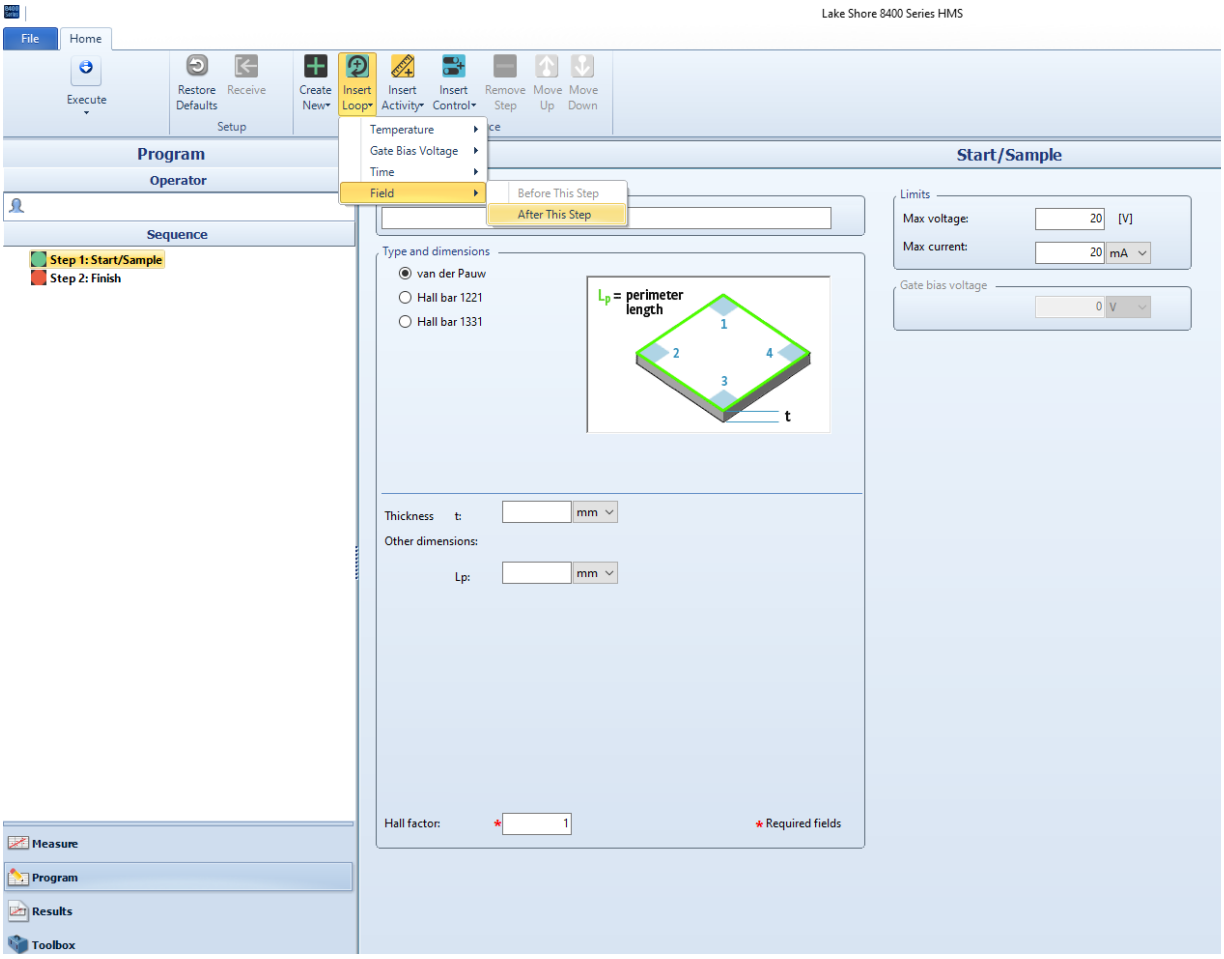
Export your data by clicking “Export” on the top-left. We recommend exporting as an Excel file.

6. WRITING A PROGRAM

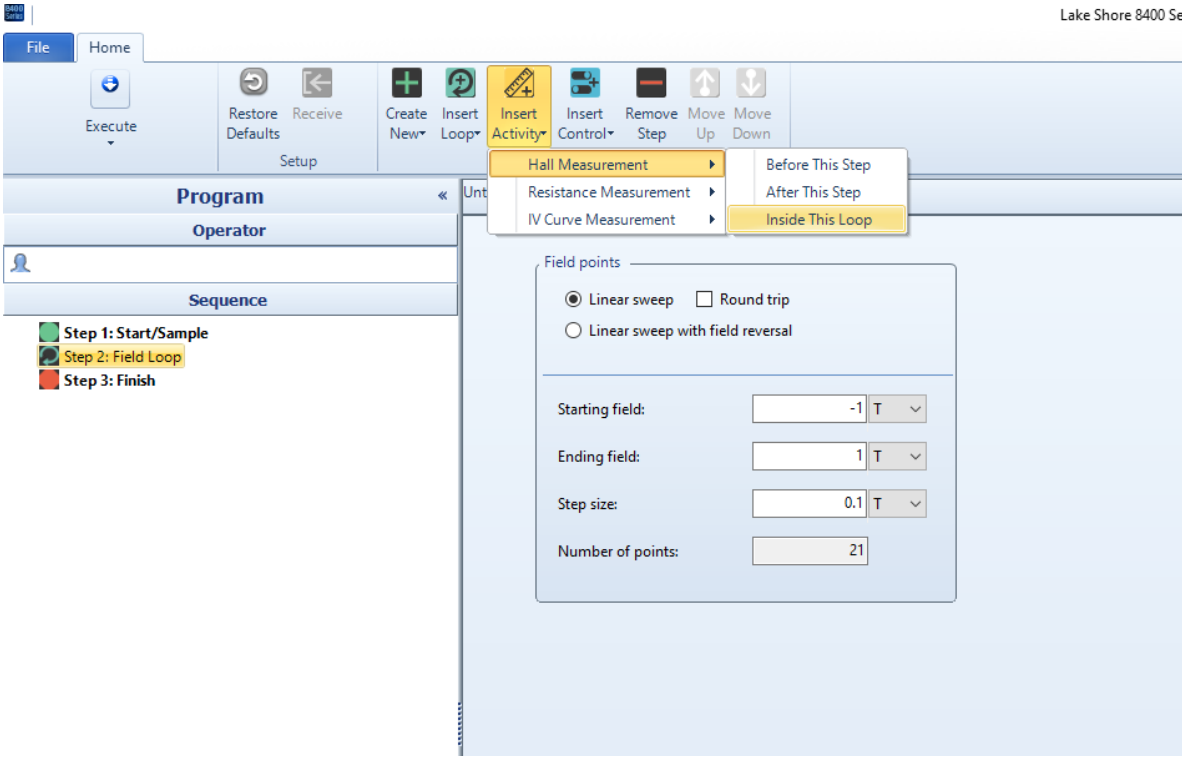
A program can be very useful in automating measurements.

For example, let's say we wish to take Hall measurements at different magnetic field magnitudes, ranging from -1 T to 1 T, in increments of 0.1 T. This is how we would do it.

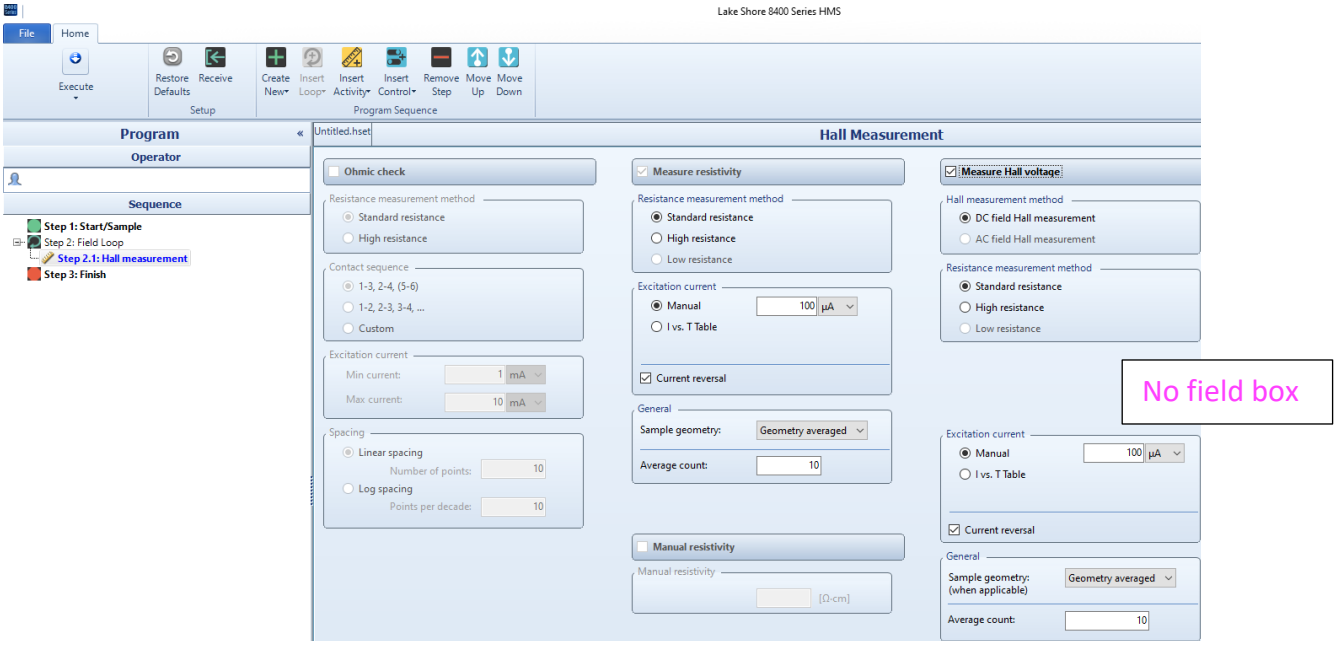
First, click on the "Program" menu on the bottom-left.
Second, click on "Step 1: Start/Sample" under Sequence.
Third, click on Insert Loop → Field → After This Step



A new item will appear under Sequence called “Step 2: Field Loop” .
Select this item and click on Insert Activity → Hall Measurement → Inside This Loop



Below is how it should look. Notice that the “Excitation field” box is missing since we’ve already defined the magnetic field magnitudes. The program will automatically perform Hall measurements iterating through -1 to 1 T in 0.1 T increments.



Once finished, click “Execute” on the top left.
Feel free to customize your program as you wish, and reach out to us if you need assistance.

7. **FINALIZING MEASUREMENTS AND UNLOADING**

    - Create your personal folder located in:
C:\Users\HMS Administrator\Documents\8400 Series HMS\Users\[YOUR NAME]

    - Export your data into this folder. Feel free to save onto your USB drive or email to yourself. Open the exported data to ensure that it contains all of the information that you need.

    - Close the Lake Shore software.

    - Disconnect the coaxial cables and control port and hang the cables over the arm. Make sure you're wearing gloves when handling the tool.

    - Complete step 3 above to retrieve your sample.

    - Turn OFF the LakeShore system (step 4 above, but OFF).

8. **Fill out log book.**
   The Internet Explorer should be open with the logbook tab.
   If it is not, the link is here:
   https://tinyurl.com/y4c2njkx

   The requested information should be straightforward.

9. **Clean the used spaces (e.g. metal table, PC area, etc…) and disable tool on Badger**.