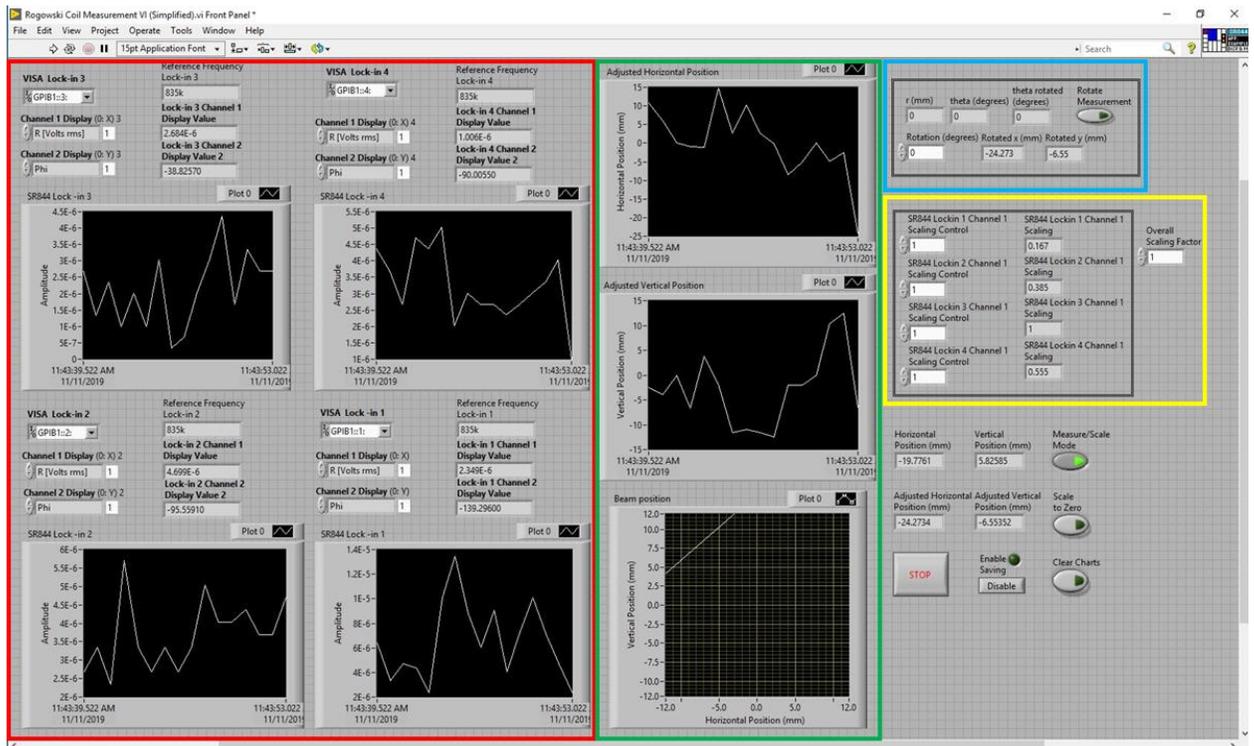


The Rogowski Coil LabView Program

- The Rogowski Coil is composed of four solenoids in a torus configuration with one solenoid at each quadrant. When an electron beam passes through the center of the torus a voltage will be induced in each of the solenoids. By measuring and comparing the induced voltage in each of the quadrants, the position of the electron beam can be determined.
- The signal from each coil is passed through a preamplifier (SR560) before being sent to a lock-in amplifier (SR 844).
- The measurement from each lock-in amplifier is displayed and recorded on by a LabView program. An image of the LabView program screen is shown below.



- The signals from the four lock-in amplifiers are represented by the four plots (in the red box). Each plot displays the induced voltage with respect to time. Each plot also has controls above it that describe which lock-in amplifier is being controlled. The reference frequency, measured induced voltage, and phase are also displayed here.

- The orientation of the lock-in amplifiers has the lock-in amplifier labeled 1 in the bottom right corner and the numbering continues clockwise. This orientation is to ensure the beam position calculations are done right and understood visually.
- The reference frequency is provided and controlled by the modulation to electron beam in cave 1.
- By default, the LabView program displays the induced voltage and phase, but these can be changed via the controls, if needed.
- The signals from the lock-in amplifiers are used to determine the beam position of the electron beam passing through it. With the origin of the coordinate grid being through the center of the Rogowski coil, the horizontal and vertical beam positions are determined using the following equations:

$$x = \frac{(V_1 + V_4) - (V_2 + V_3)}{c_1 \sum_1^4 V_i}$$

$$y = \frac{(V_3 + V_4) - (V_1 + V_2)}{c_1 \sum_1^4 V_i}$$

$$c_1 = \frac{\pi\sqrt{R^2 - a^2}}{2}$$

- These calculations are done automatically by the LabView program and the results are shown in the green box. The adjusted horizontal and vertical beam positions are displayed in the top and middle plots. Together the coordinates of the electron beam are shown in the bottom plot. With respect to the coordinate grid used, during an experiment the bottom plot has the electron beam going into the page.
- The horizontal beam position and vertical beam position are also displayed numerically in the bottom right corner of the program. The raw beam position measurements are simply labeled horizontal position and vertical position. The adjusted horizontal and vertical positions are the beam positions after any scaling or rotation has been applied.
- The beam position can be rotated, if needed. A rotation could be needed if there is a misalignment with the Rogowski coil in the beamline. This is done by using the controls in the blue box. These controls display the current measurement in polar coordinates (r,θ). A rotation (in degrees) of the beam measurement can be inputted to rotate the measurement with respect to the coordinate axes. The rotated horizontal and vertical measurements are shown.
 - To enable a rotation, press the button labeled “Rotate Measurement”
 - When a rotation is not active, the rotated measurements display will just display the unrotated beam position.

- Due to imperfections in the Rogowski coil and its alignment, the beam position may need to be adjusted/scaled. This can be done by using the scaling controls shown in the yellow box.
 - By default, the LabView program is set to manual controls upon initializing the program with each coil set to un-scaled. The scaling to each individual coil measurement can be inputted to improve the beam position measurement. The scaling of each coil measurement that is actively in use is shown to the right of the inputs. (The scaling is done by multiplying a measured signal by the inputted factor e.g. 1 represents no scaling and 1.1 represents an increase of 10%)
 - When scaling the measurements is done the program should be set to measurement mode to prevent any unintended changes to the scaling. (Manual changes to the scaling will not register until the program exits measurement mode)
 - An additional feature to automatically scale the coil measurements to center of the Rogowski coil is to press the “Scale to zero” button while in measurement mode. This will scale all four coil measurements to set the current beam measurement to the origin.
 - If needed, the overall beam position can be scaled by changing the scaling factor labeled “Overall Scaling Factor”.
- Additional controls are displayed in the bottom right section of the LabView program.
 - The “STOP” button is used to stop the LabView program
 - The “Enable saving” button may be pressed to start saving measurements once the program has started. When presses the program will ask where to save the file. If the file has the same name as one that already exists, the new data will be appended to the already existing file.
 - The clear chart button clears the data displayed in the plots.

Rogowski Coil Operation (Remote Access Needed)

1. Before the beam test starts, ensure that the computer and all the electronics on the Rogowski coil rack are on and properly connected. Make sure all the preamplifiers are set to the same settings and the lock-in amplifiers are set to the appropriate settings.
2. When the beam test starts, start the Rogowski coil LabView program.
3. Ensure the displays for the lock-in amplifier signals are all set to the appropriate settings and the correct measurements (R and ϕ) are displayed in the lock-in displays.
4. With the lock-in amplifiers locked on to the provided electron beam modulation, center the electron beam using a higher current.
5. Scale the beam position measurement so the program is calibrated to the center of the Rogowski coil.
 - a. This can be done manually or automatically using the “Scale to zero” button while in measurement mode.
6. Enter measurement mode to prevent unintended changes to the scaling.
7. Move the electron beam around the center to see if the Rogowski coil is operating correctly. If measurements from the Rogowski coil don't match the other beam position monitors at higher current, the measurement can be further adjusted.
8. When the Rogowski coil is set to operate, clear the charts of calibration measurement and enable saving. The electron beam can now be lowered in current to continue the experiment.