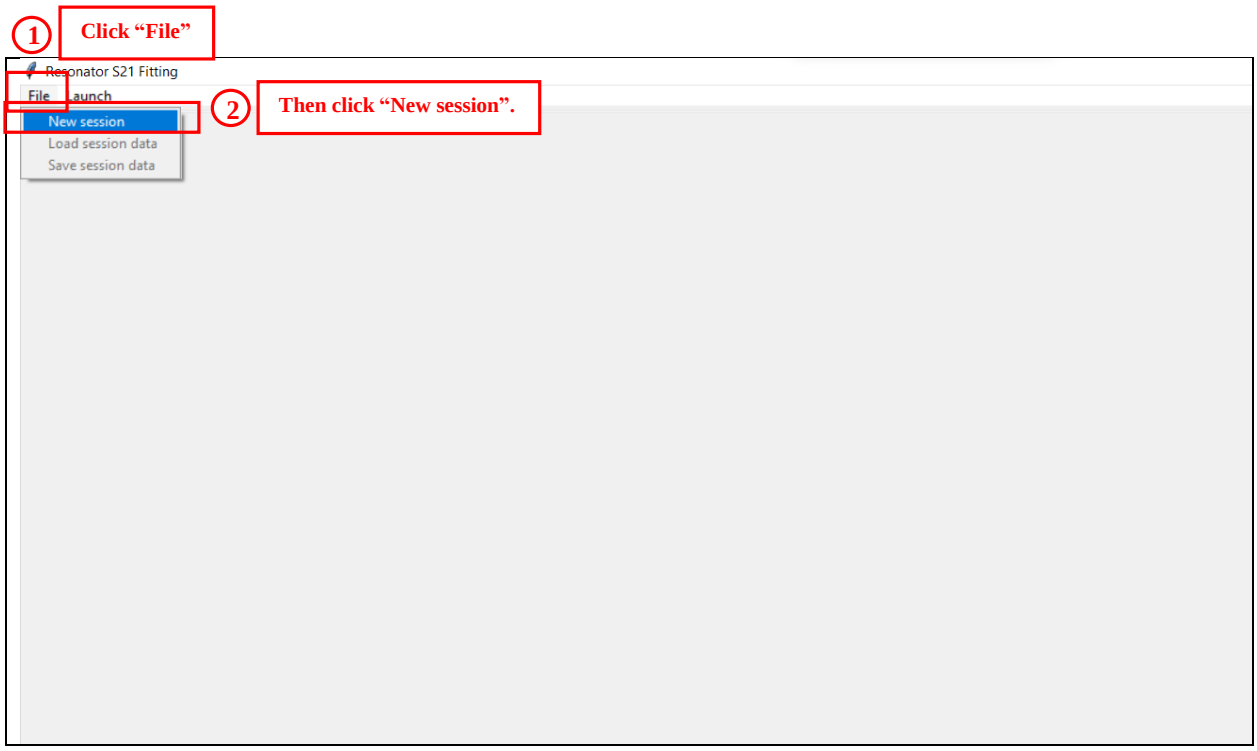
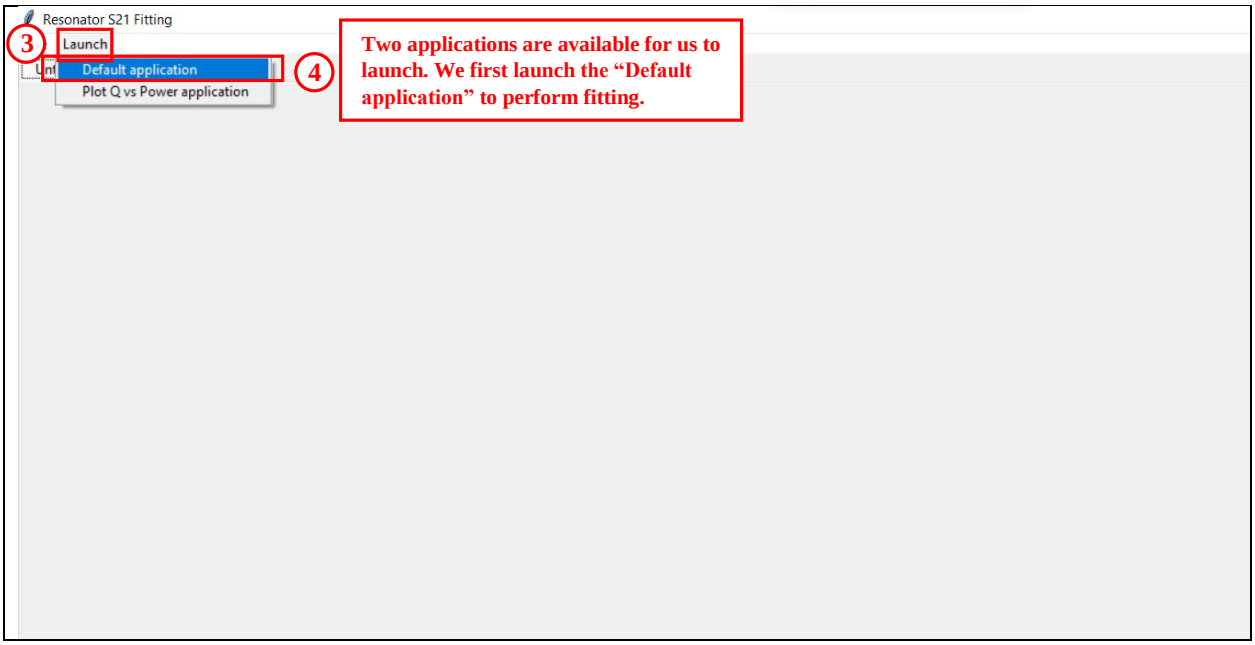
Table of Contents

Fitting

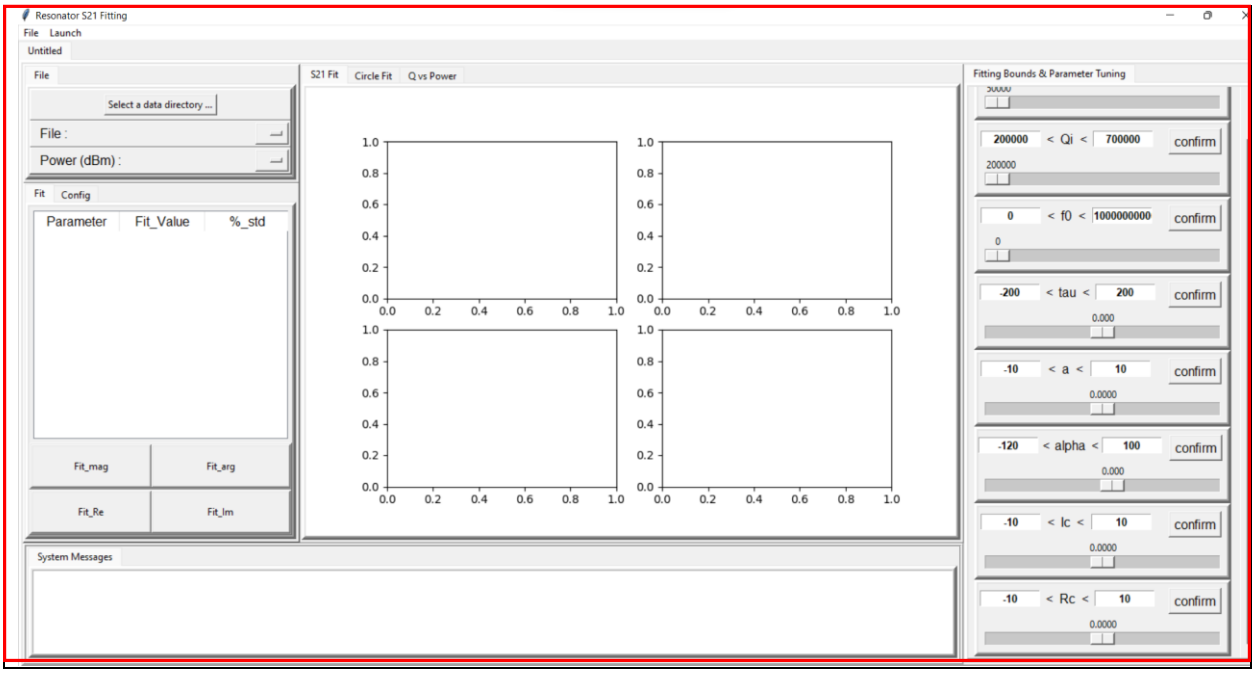
Create a Session



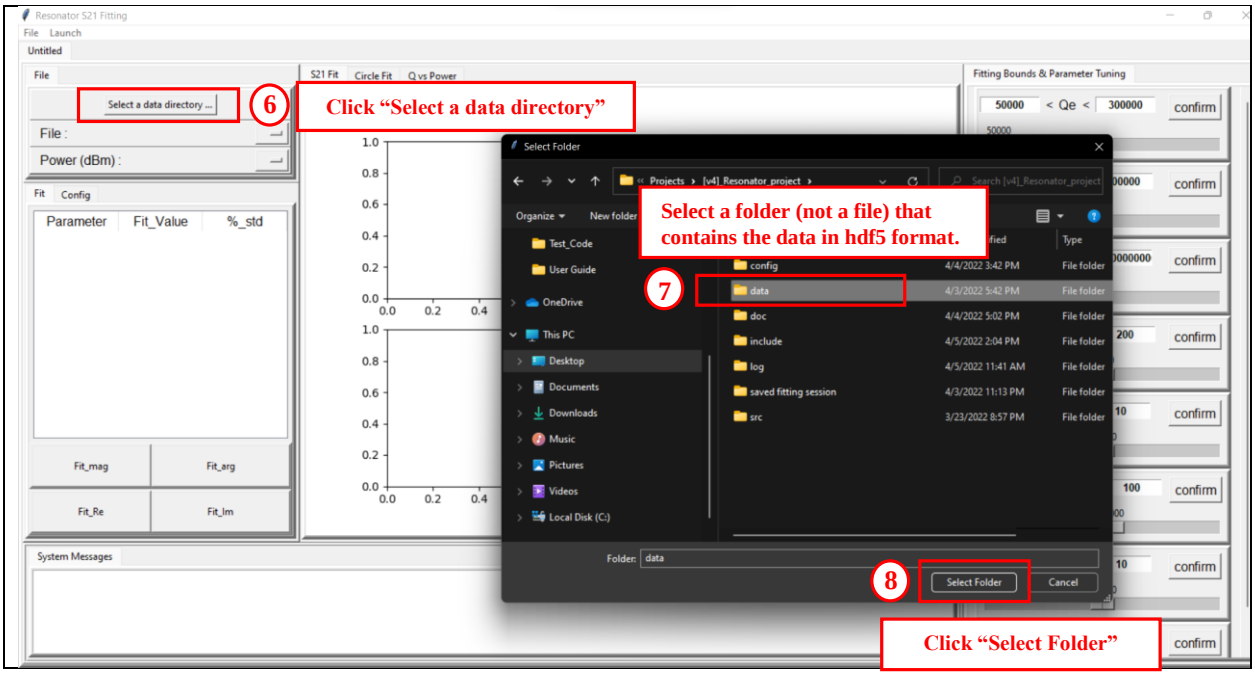
Launch application in a session

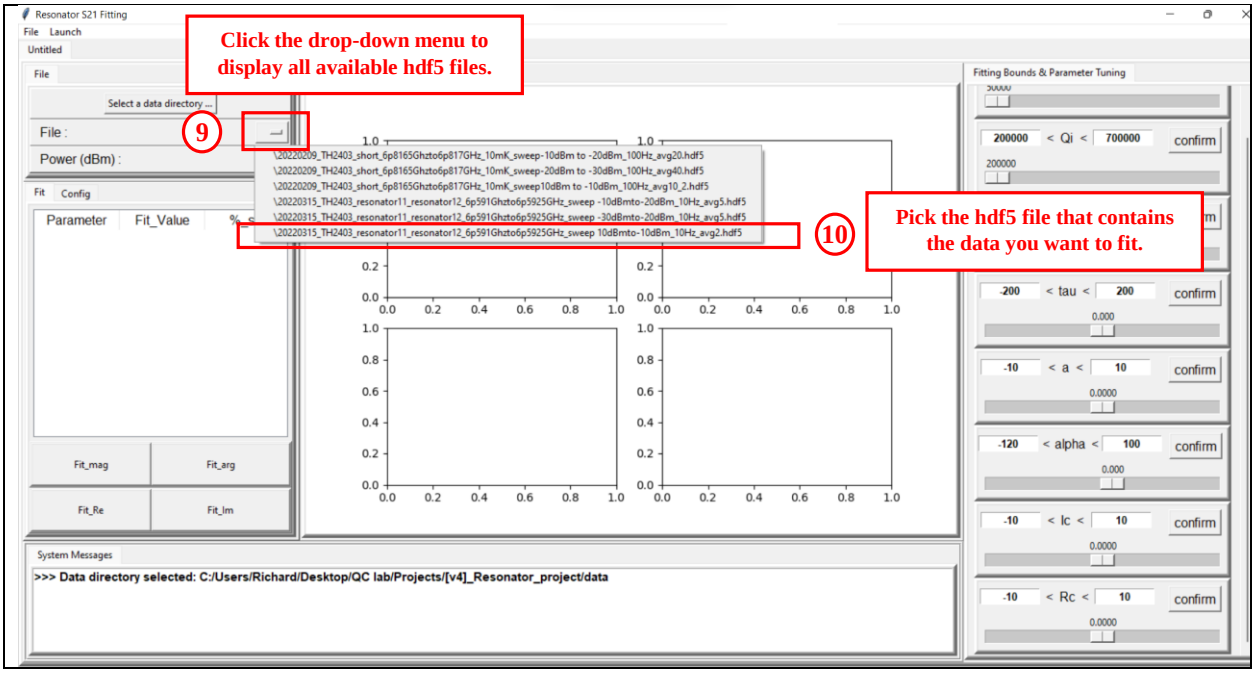


5 **After clicking the "Default application", we can see the following interface.**

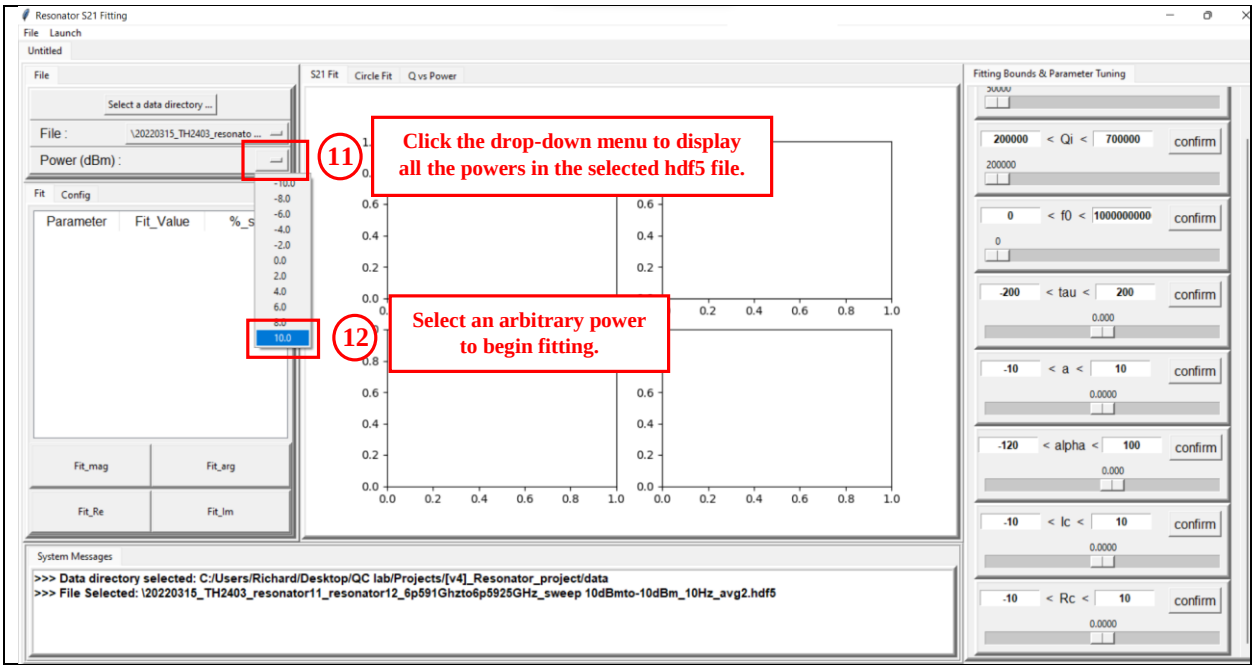


Load hdf5 file





Power selection



11 **Click the drop-down menu to display all the powers in the selected hdf5 file.**

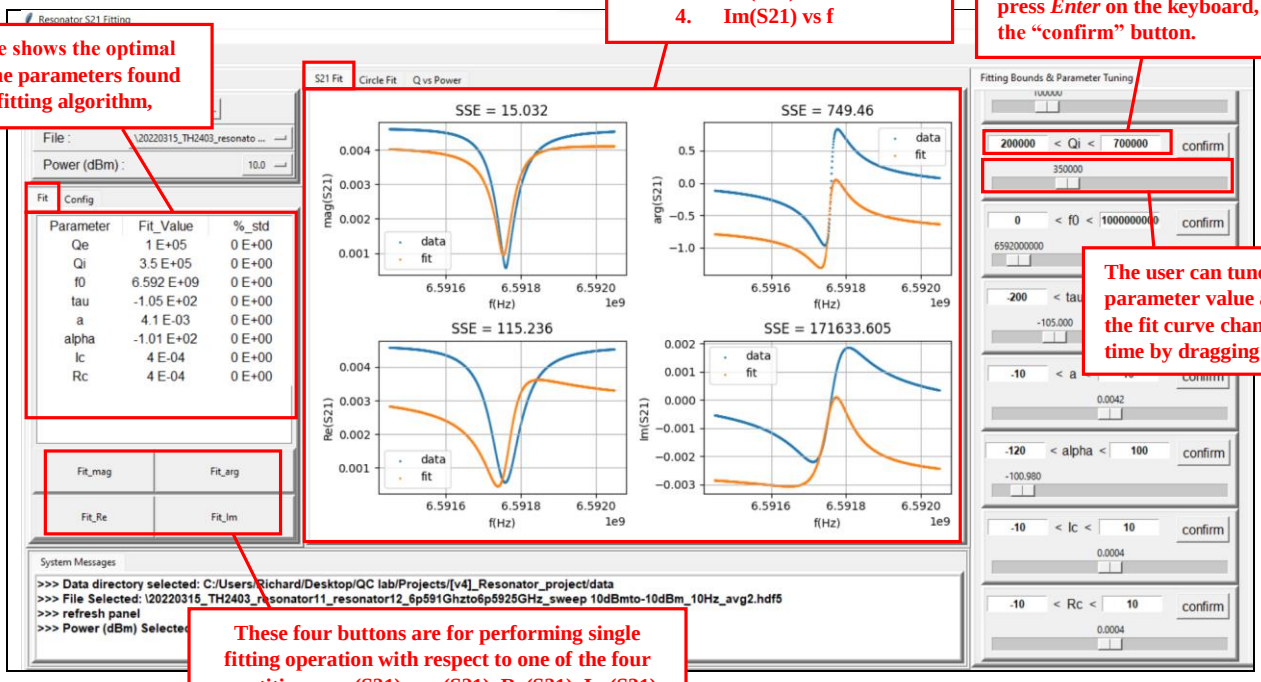
12 **Select an arbitrary power to begin fitting.**

"S21 Fit" page shows four plots:

1. **mag(S21) vs f**
2. **arg(S21) vs f**
3. **Re(S21) vs f**
4. **Im(S21) vs f**

The two boxes allow the user to enter the lower bound and upper bound separately for each parameter. After entering the value, be sure either to press *Enter* on the keyboard, or click the "confirm" button.

"Fit" page shows the optimal value of the parameters found by the fitting algorithm,



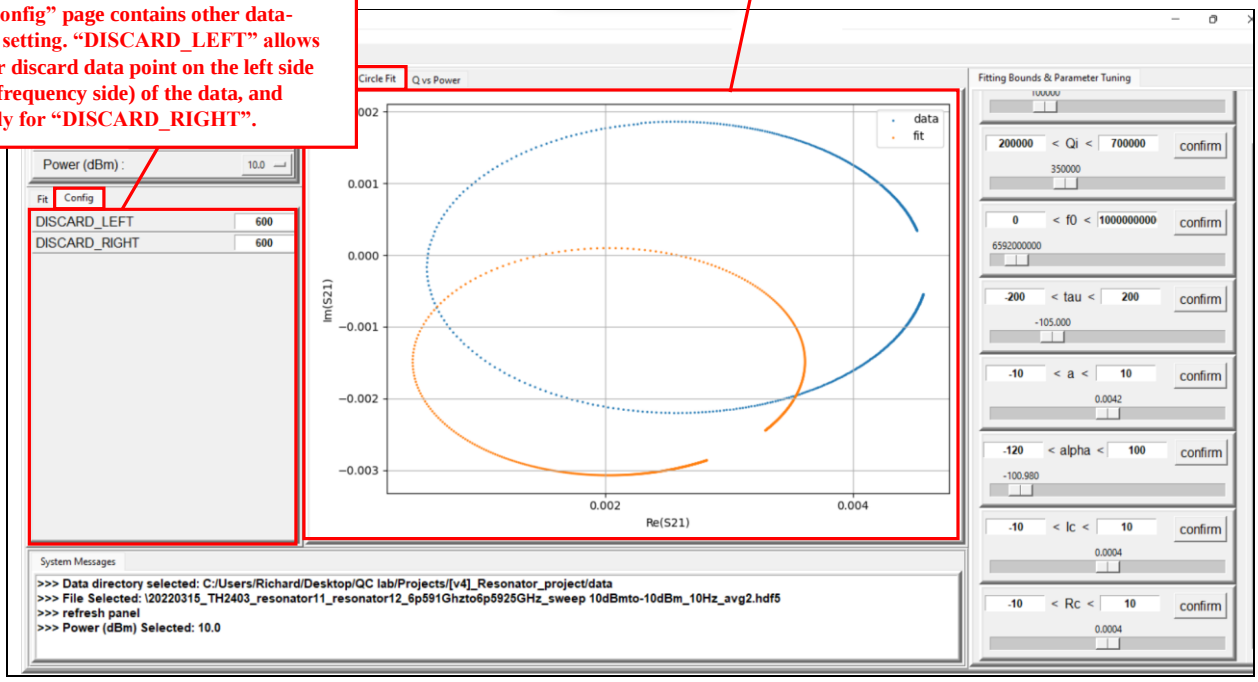
The user can tune the parameter value and see how the fit curve change in real time by dragging this handle.

These four buttons are for performing single fitting operation with respect to one of the four quantities: mag(S21), arg(S21), Re(S21), Im(S21).

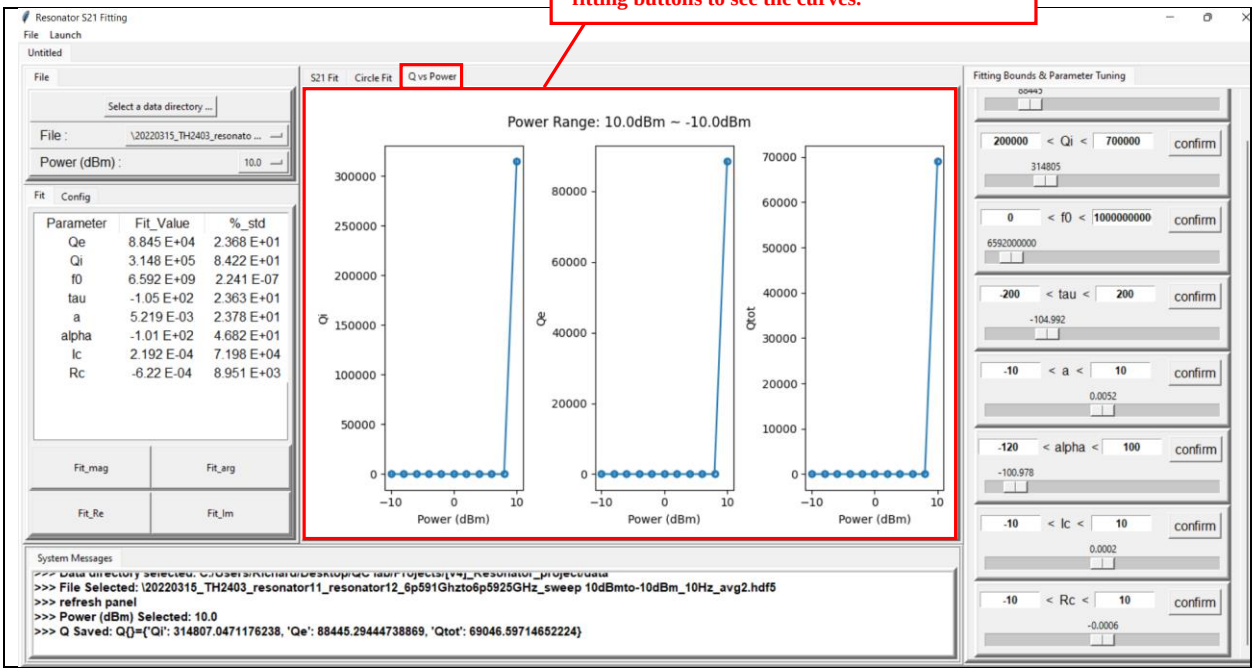
Discard data points

"Circle Fit" page shows the plot of Im(S21) vs Re(S21)

The "Config" page contains other data-related setting. "DISCARD_LEFT" allows the user discard data point on the left side (lower frequency side) of the data, and similarly for "DISCARD_RIGHT".

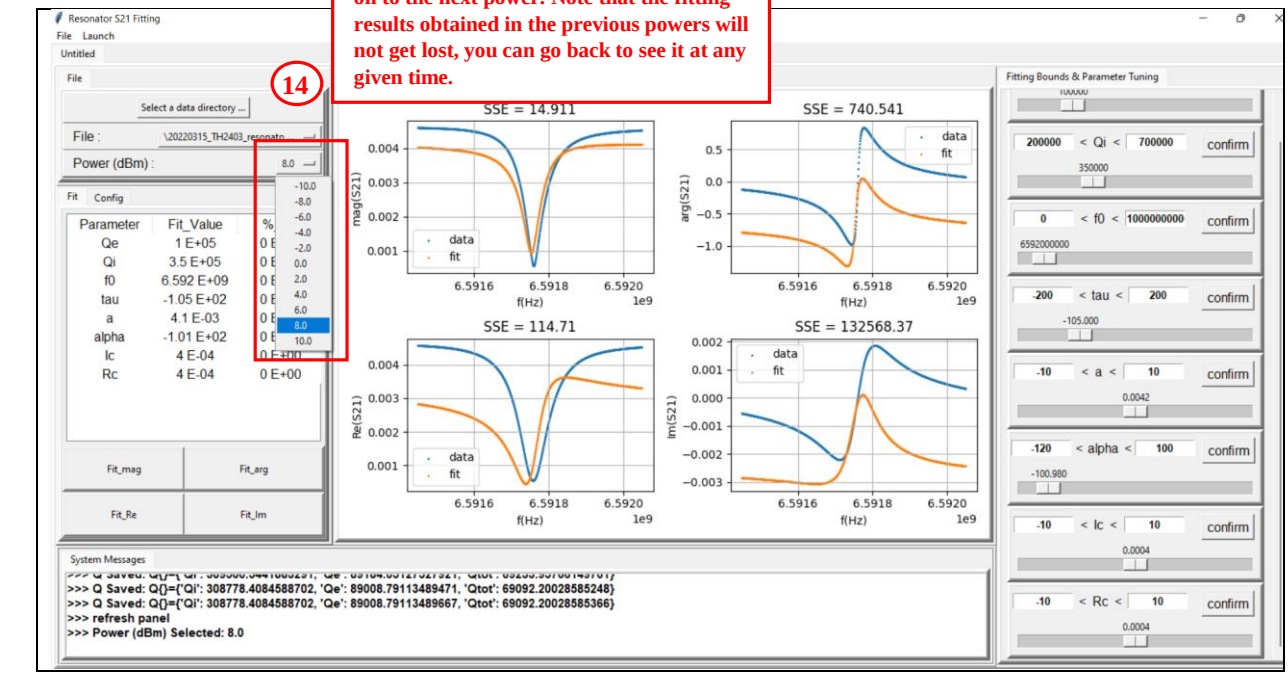


"Q vs Power" page shows Qe, Qi, and Qtot vs power. Note that the plot is empty initially, you need to click at least one time on any of the four fitting buttons to see the curves.

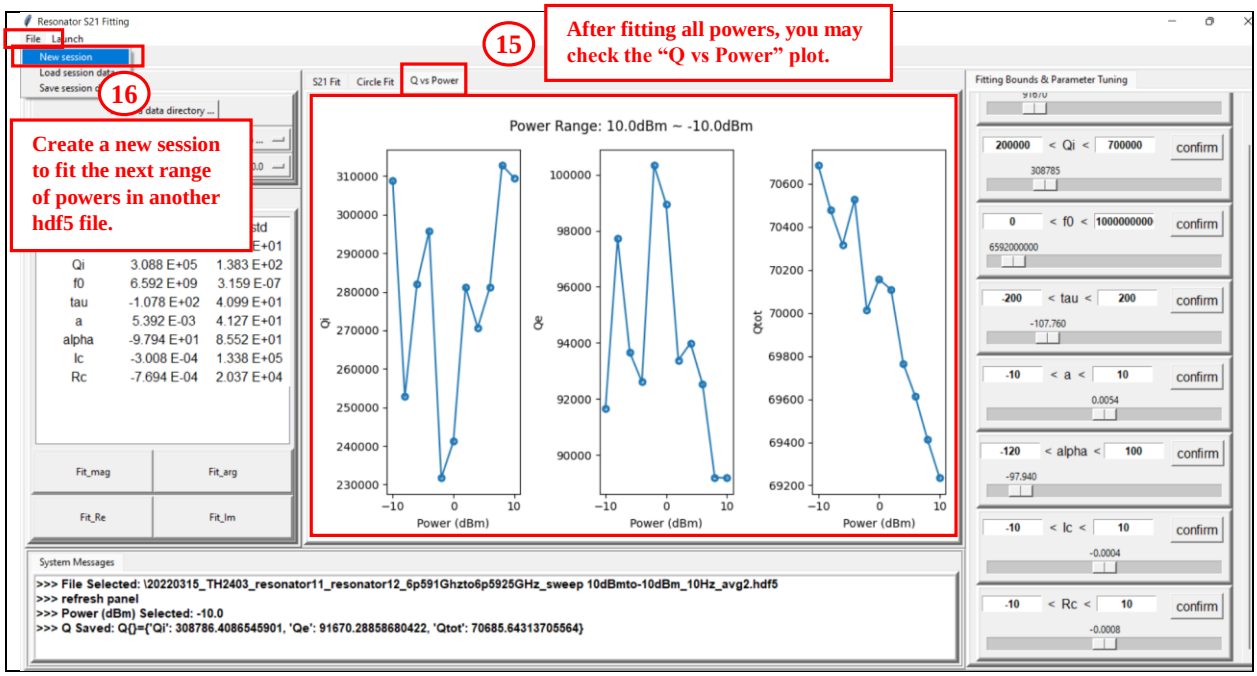


Fitting

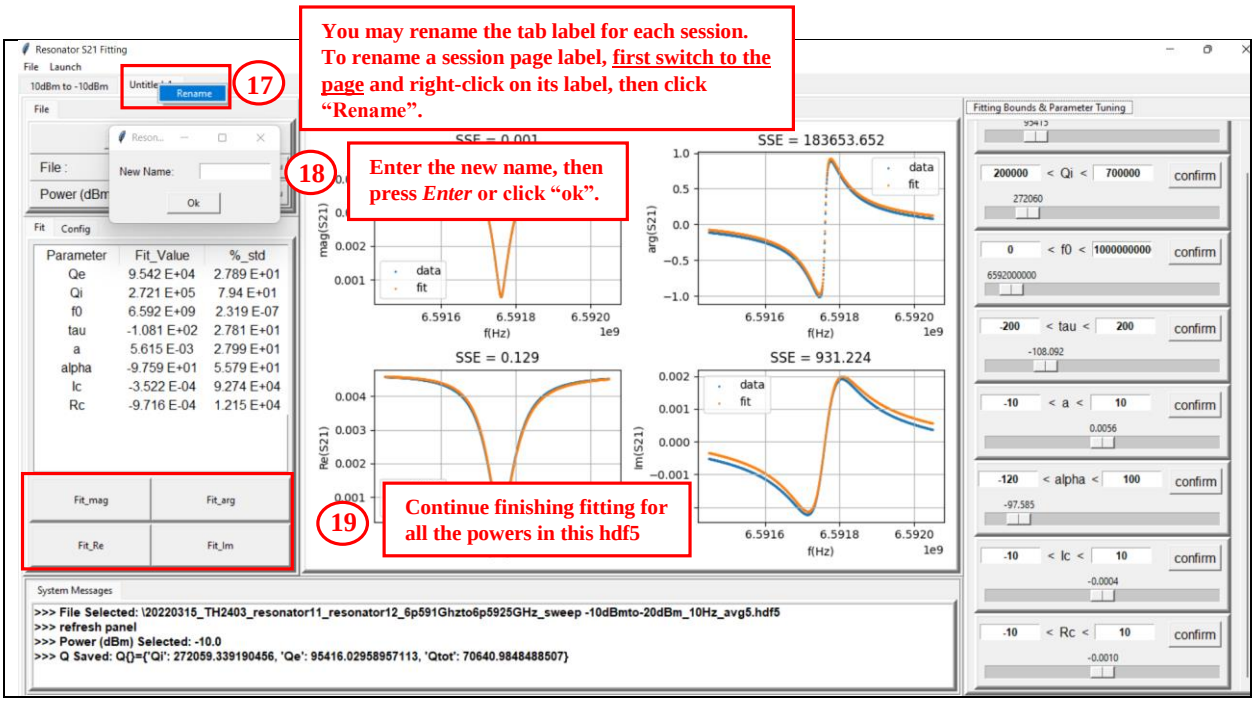
Switch to other power



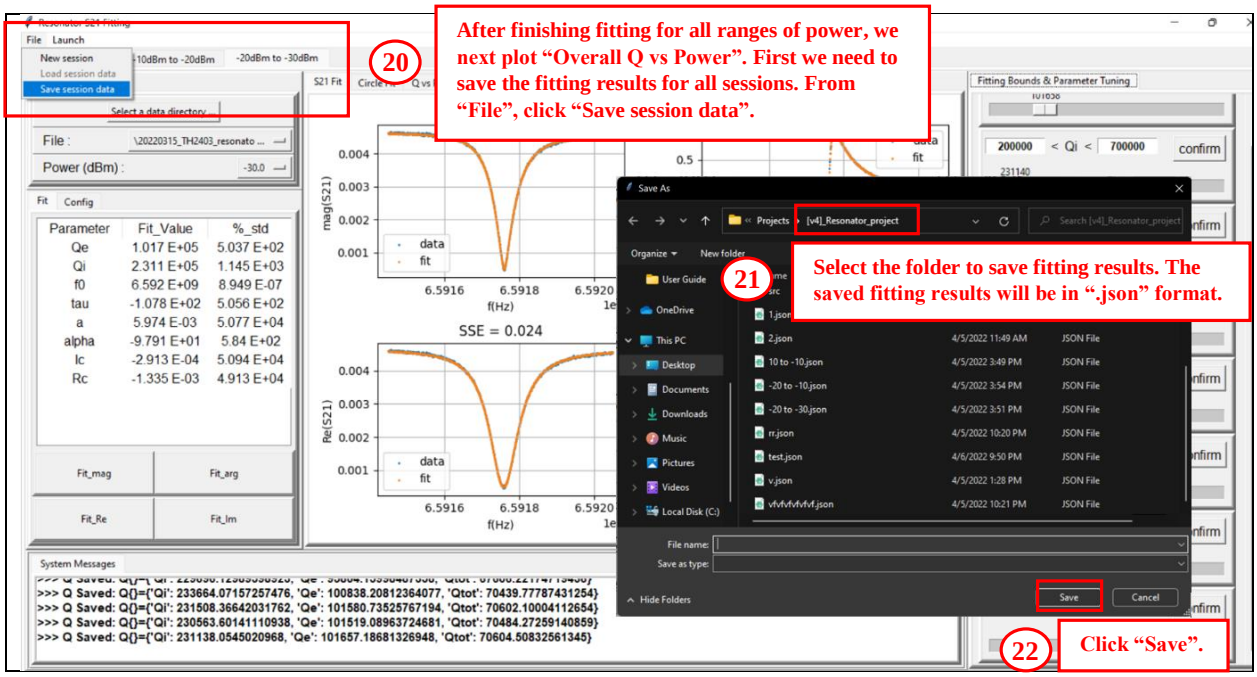
Create a second session page



Rename the session page

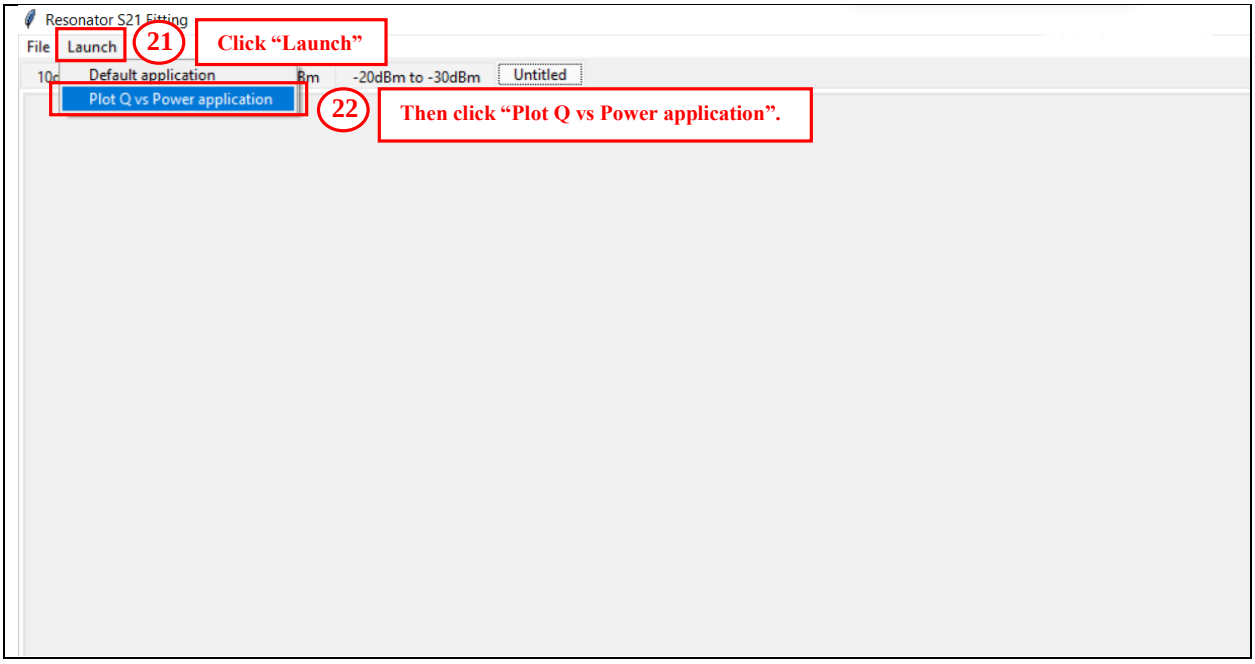


Save fitting results

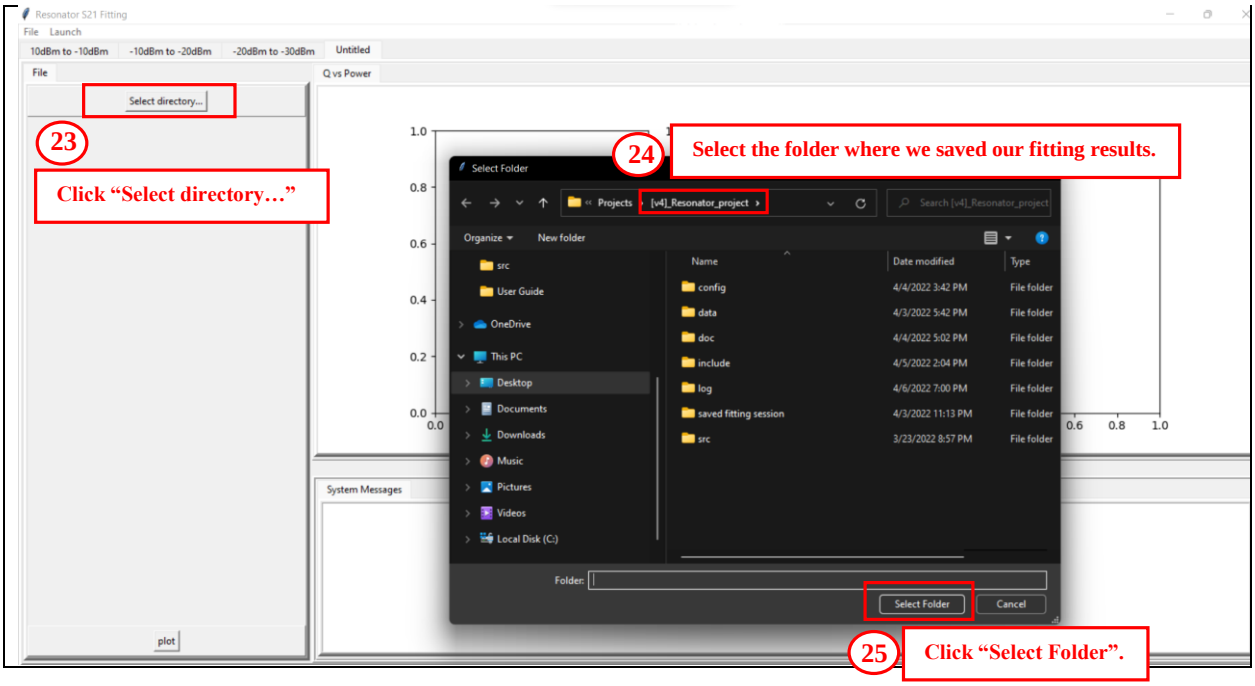


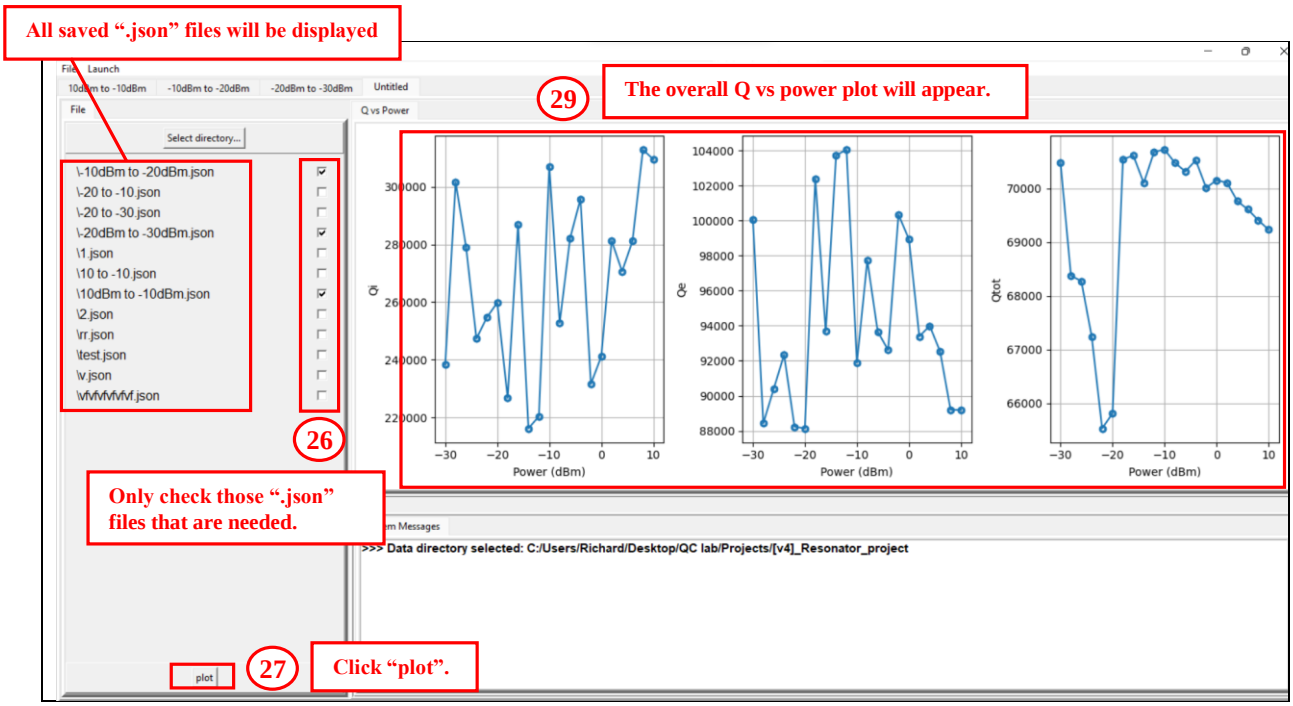
Plot overall Q vs power

Launch "Plot Q vs Power" application



Select multiple saved fitting results to plot overall Q vs power




All saved ".json" files will be displayed
29
The overall Q vs power plot will appear.
Launch
10dBm to -10dBm
-10dBm to -20dBm
-20dBm to -30dBm
Untitled
File
Q vs Power
Select directory...
\-10dBm to -20dBm.json
\-20 to -10.json
\-20 to -30.json
\-20dBm to -30dBm.json
\1.json
\10 to -10.json
\10dBm to -10dBm.json
\2.json
\rr.json
\test.json
\v.json
\vfvfvfvfvfvf.json
26
Only check those ".json" files that are needed.
Qi
Qe
Qtot
Power (dBm)
>>> Data directory selected: C:/Users/Richard/Desktop/QC lab/Projects/[v4]_Resonator_project
plot
27
Click "plot".

Appendix

Function definitions

```
def Rt(f, Qe, Qi, f0, tau, a, alpha, Ic, Rc):
    x = (f - f0)/f0
    N = ( Qe + 1j * Qe * Qi * 2*x ) * a * np.exp(1j*(2*np.pi*alpha + tau*f*10**(-9)))
    D = Qi + Qe + 1j*2*Qe*Qi*x
    return np.real(N/D) + Rc
```

Re(S21)

```
def It(f, Qe, Qi, f0, tau, a, alpha, Ic, Rc):
    x = (f - f0)/f0
    N = ( Qe + 1j * Qe * Qi * 2*x ) * a * np.exp(1j*(2*np.pi*alpha + tau*f*10**(-9)))
    D = Qi + Qe + 1j*2*Qe*Qi*x
    return np.imag(N/D) + Ic
```

Im(S21)

```
def arg_t(f, Qe, Qi, f0, tau, a, alpha, Ic, Rc):
    R = Rt(f, Qe, Qi, f0, tau, a, alpha, Ic, Rc)
    I = It(f, Qe, Qi, f0, tau, a, alpha, Ic, Rc)
    arg = np.angle(R + 1j*I)
    return arg
```

arg(S21)

```
def mag_t(f, Qe, Qi, f0, tau, a, alpha, Ic, Rc):
    R = Rt(f, Qe, Qi, f0, tau, a, alpha, Ic, Rc)
    I = It(f, Qe, Qi, f0, tau, a, alpha, Ic, Rc)
    mag = np.absolute(R + 1j*I)
    return mag
```

mag(S21)

```
def SSE(data ,fit):
    e = data - fit
    e = e/np.mean(data)
    return np.sum(e**2).round(3)
```

Sum of squared normalized error

Reference

[1] Kurtis Lee Geerlings. *Improving Coherence of Superconducting Qubits and Resonators*. p.199, equation A.18.

[2] D. Zoepfl, P. R. Muppalla, C. M. F. Schneider, et al. *Supplemental Material: Characterization of low loss microstrip resonators as a building block for circuit QED in a 3D waveguide.* p.2, equation S1.