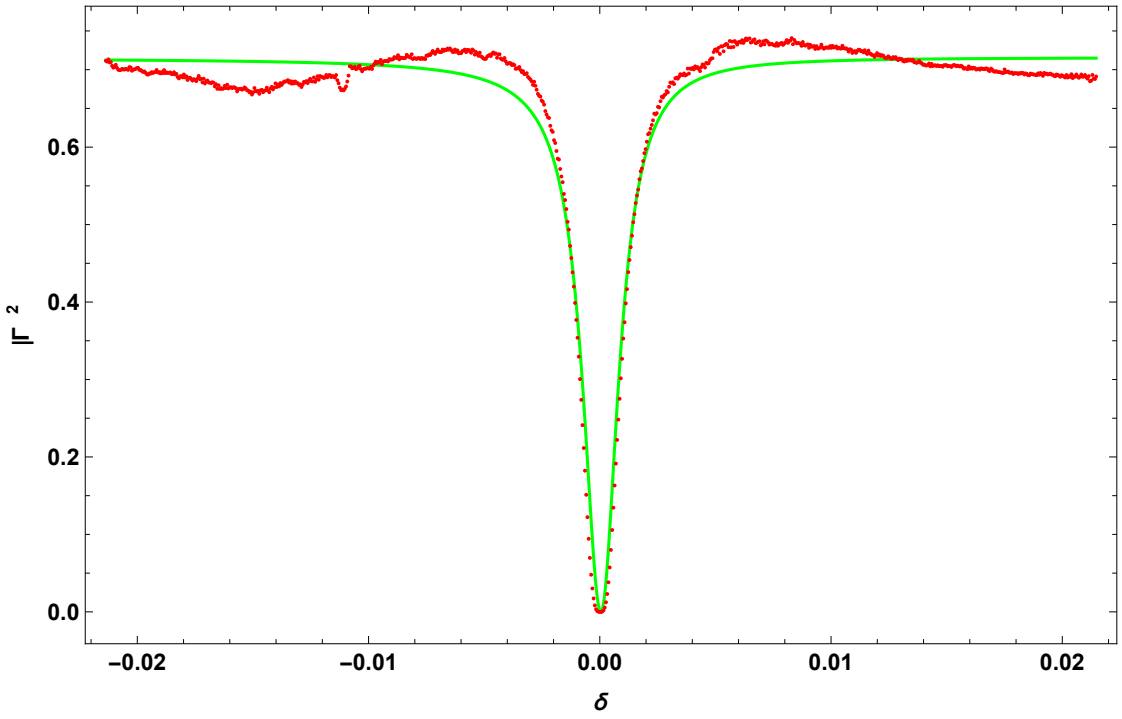
In[971]:=
```
ClearAll["Global`*"]
SetDirectory["/Users/lisaleemcb/ADMX/ouroboros/code/"];
(*the files in Users/baker/My Documents/data/10_9_13/TUNING
 are dB files and the Q script is made for re/im files. *)
fname = "../measurements/CAL_STRONG_S11.S1P";

file = Drop[Import[fname, "Table"], 12];
dataraw = file;
data = dataraw;
f = ToExpression[data[[All, 1]]];
S11dB = ToExpression[data[[All, 2]]];
S11ang = ToExpression[data[[All, 3]]];
(*S11Abs=Table[Abs[S11RE[[x]]+i S11IM[[x]]],{x,1,Length[S11RE]}];*)
Z0 = 50;
(*S11RE=(Z0*(1-(10^(S11dB/10))^2))/
  (1+(10^(S11dB/10))^2-2*(10^(S11dB/10))*Cos[S11ang Degree]);
S11IM=2*Z0*(10^(S11dB/10))*Sin[S11ang Degree]/
   (1+(10^(S11dB/10))^2-2*(10^(S11dB/10))*Cos[S11ang Degree]);*)
S11RE = (10^(S11dB / 10)) * Cos[S11ang Degree];
S11IM = (10^(S11dB / 10)) * Sin[S11ang Degree];
pos = Position[S11dB, Min[S11dB]][[1, 1]];
fresinitial = f[[pos]];

Sparam = Table[
   {(f[[x]] - fresinitial)/fresinitial, Abs[S11RE[[x]] + j * S11IM[[x]]]^2}, {x, 1, Length[f]}];
(*Sparam=Table[{(f[[x]]-fresinitial)/fresinitial,10^(S11dB[[x]]/10)},{x,1,Length[f]}];*)
t = 2 δ;
model = ρ^2 + (d^2 + 2 d ρ (Cos[ϕ] + QL (t - t0) Sin[ϕ])) / (1 + QL^2 (t - t0)^2);

vars = FindFit[Sparam, model, {{QL, 1400}, {ρ, 0.9}, {d, 0.5}, {ϕ, π}, {t0, 0}}, δ,
  MaxIterations → 10000, Gradient → "FiniteDifference", AccuracyGoal → 10]
pmod = Plot[model /. vars, {δ, Min[Sparam[[All, 1]]], Max[Sparam[[All, 1]]]},
   PlotRange → All, Axes → False, Frame → True,
   PlotPoints → 10000, PlotStyle → Green];
Splot = ListPlot[Sparam, PlotStyle → {Red, PointSize[Small]}];

Show[pmod, Splot, PlotRange → {{Min[Sparam[[All, 1]]], Max[Sparam[[All, 1]]]}, All},
 FrameLabel → {{"|Γ|^2", ""}, {"δ", ""}},
 FrameStyle → Directive[Bold, 16, Medium], ImageSize → 600]
fres = fresinitial + fresinitial * vars[[5, 2]];
QL = vars[[1, 2]];
ρ = vars[[2, 2]];
d = vars[[3, 2]];
ϕ = vars[[4, 2]];
t0 = vars[[5, 2]];

κ = (1/((1+ρ)/d - 1));
```

```
Q0 = (1/((1+ρ)/d - 1) + 1) QL;

"Q0 -> " <> ToString[Q0]
"fres[MHz] -> " <> ToString[fres]
"QL -> " <> ToString[QL]
"Coupling Coefficient -> " <> ToString[κ]
```

Out[988]= {QL → -537.237, ρ → 0.845591, d → 0.845748, ϕ → 3.16085, t0 → 0.000122118}

Out[991]=



Out[1000]= Q0 -> -991.675

Out[1001]= fres[MHz] -> 9
2.33541 10

Out[1002]= QL -> -537.237

Out[1003]= Coupling Coefficient -> 0.845881

In[958]:=
```
pl = ListPlot[Table[{S11RE[[a]], S11IM[[a]]}, {a, 1, Length[f]}], PlotStyle →
     {Red, Thick}, PlotRange → All, AspectRatio → Automatic, AxesOrigin → {0, 0}];

R1 = {5, 10, 20, 30, 40, 60, 100, 300, 500};
X1 = {10, -10, 100, -100, -50, 50, -25, 25};
chart = Graphics[{Circle[{0, 0}], Gray, Table[
      Circle[{1 - 1 / (1 + R1[[a]] / Z0), 0}, 1 / (1 + R1[[a]] / Z0)], {a, 1, Length[R1]}],
     Table[Circle[{1, Z0 / X1[[a]]}, Abs[Z0 / X1[[a]]]], {a, 1, Length[X1]}],
     Line[{{-1, 0}, {1, 0}}], White, Thickness[0.45],
     Circle[{0, 0}, 1.5]}, PlotRange → 1.1];
Show[chart, pl]
model
```

Part::pkspec1 : The expression x cannot be used as a part specification . >>

Part::pkspec1 : The expression x cannot be used as a part specification . >>

Part::pkspec1 : The expression x cannot be used as a part specification . >>

General::stop : Further output of Part::pkspec1 will be suppressed during this calculation . >>

Part::partw : Part 3 of

$10^{\frac{1}{10}}\{-0.739543, -0.74244, -0.733496, -0.745431, -0.744487, -0.759022, -0.766563, \ll 37 \gg, -0.789687, -0.78447, -0.788544, -0.776312, -0.788312, -0.78527, \cdot$

Cos[° {−169.924 , −169.962 , −170.198 , −170.161 , −170.279 , −170.448 , −170.558 , −170.562 , ≪35≫, −174.036 , −174.145 , −174.272 , −174.315 , −174.522 , −174.564 , −174.671 , ≪751≫}[[x]]]

does not exist . >>

Part::partw : Part 3 of

$10^{\frac{1}{10}}\{-0.739543, -0.74244, -0.733496, -0.745431, -0.744487, -0.759022, -0.766563, \ll 37 \gg, -0.789687, -0.78447, -0.788544, -0.776312, -0.788312, -0.78527, \cdot$

Sin[° {−169.924 , −169.962 , −170.198 , −170.161 , −170.279 , −170.448 , −170.558 , −170.562 , ≪35≫, −174.036 , −174.145 , −174.272 , −174.315 , −174.522 , −174.564 , −174.671 , ≪751≫}[[x]]]

does not exist . >>

Part::partw : Part 4 of

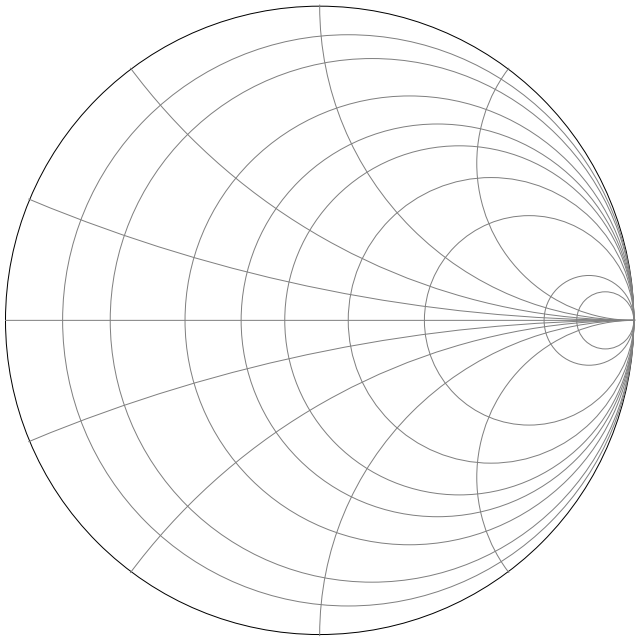
$10^{\frac{1}{10}}\{-0.739543, -0.74244, -0.733496, -0.745431, -0.744487, -0.759022, -0.766563, \ll 37 \gg, -0.789687, -0.78447, -0.788544, -0.776312, -0.788312, -0.78527, \cdot$

Cos[° {−169.924 , −169.962 , −170.198 , −170.161 , −170.279 , −170.448 , −170.558 , −170.562 , ≪35≫, −174.036 , −174.145 , −174.272 , −174.315 , −174.522 , −174.564 , −174.671 , ≪751≫}[[x]]]

does not exist . >>

General::stop : Further output of Part::partw will be suppressed during this calculation . >>

Out[962]=



$RecursionLimit ::reclim : Recursion depth of 1024 exceeded. >>

Out[963]= Hold[ρ^2]

In[964]:=
```
Γ = Abs[Exp[i (ϕ - γ)] (ρ + d Exp[i γ] / (1 + i QL t))]^2
Smithparam = Table[{S11RE[[x]], S11IM[[x]]}, {x, 1, Length[S11RE]}];

smithvar = FindFit[Smithparam, Γ, {γ}, δ]
ListPlot[Smithparam]
Γ /. smithvar

Plot[(Γ)^1/2 /. smithvar, {δ, -0.8, 0.8}]
```

$RecursionLimit ::reclim : Recursion depth of 1024 exceeded. >>

Out[964]= $e^{i\,(-\gamma+\phi)}$ Hold[ρ^2]

Part::partd : Part specification (−0.830414)[[1]] is longer than depth of object. >>

Part::partd : Part specification (−0.147564)[[1]] is longer than depth of object. >>

Part::partd : Part specification (−0.829958)[[2]] is longer than depth of object. >>

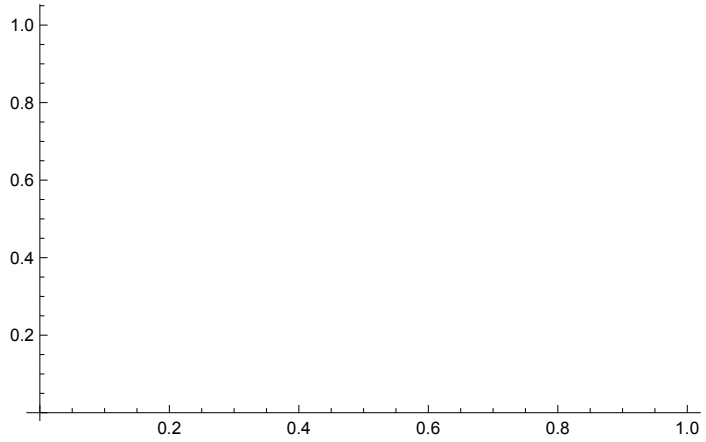
General::stop : Further output of Part::partd will be suppressed during this calculation. >>

FindFit::nrlnum : The function value {Γ − 1. (−0.147564)[[1]], Γ − 1. (−0.146914)[[2]]} is not a list of real numbers with dimensions {2} at {γ} = {1.}. >>

FindFit::nrlnum : The function value {Γ − 1. (−0.147564)[[1]], Γ − 1. (−0.146914)[[2]]} is not a list of real numbers with dimensions {2} at {γ} = {1.}. >>

Out[966]=
```
FindFit[
 {{(-0.830414)[[1]], (-0.147564)[[1]]}, {(-0.829958)[[2]], (-0.146914)[[2]]}}, Γ, {γ}, δ]
```

Out[967]=



FindFit::nrlnum : The function value {Γ – 1. (–0.147564)[[1]], Γ – 1. (–0.146914)[[2]]} is not a list of real numbers with dimensions {2} at {γ} = {1.}. >>

ReplaceAll::reps : {FindFit[{{(–0.830414)[[1]], (–0.147564)[[1]]}, {(–0.829958)[[2]], (–0.146914)[[2]]}}, Γ, {γ}, δ]} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing . >>

Out[968]=
```
Γ /. FindFit[
  {{(-0.830414)[[1]], (-0.147564)[[1]]}, {(-0.829958)[[2]], (-0.146914)[[2]]}}, Γ, {γ}, δ]
```

General::ivar : –0.8 is not a valid variable . >>

ReplaceAll::reps : {FindFit[{{(–0.830414)[[1]], (–0.147564)[[1]]}, {(–0.829958)[[2]], (–0.146914)[[2]]}}, Γ, {γ}, –0.8]} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing . >>

General::ivar : –0.8 is not a valid variable . >>

ReplaceAll::reps : {FindFit[{{(–0.830414)[[1]], (–0.147564)[[1]]}, {(–0.829958)[[2]], (–0.146914)[[2]]}}, Γ, {γ}, –0.8]} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing . >>

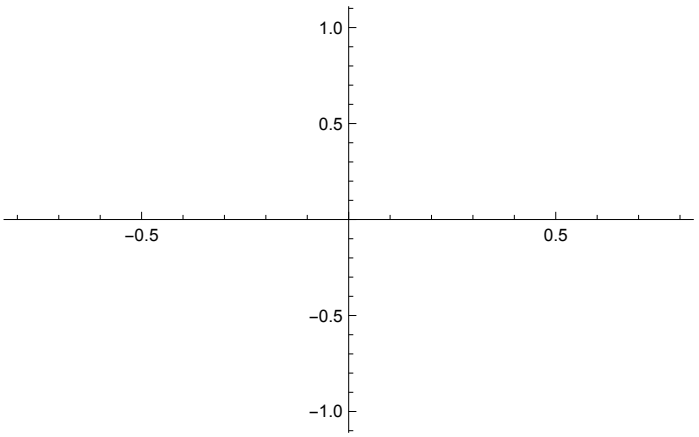
General::ivar : –0.799967 is not a valid variable . >>

General::stop : Further output of General::ivar will be suppressed during this calculation . >>

ReplaceAll::reps : {FindFit[{{(–0.830414)[[1]], (–0.147564)[[1]]}, {(–0.829958)[[2]], (–0.146914)[[2]]}}, Γ, {γ}, –0.799967]} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing . >>

General::stop : Further output of ReplaceAll::reps will be suppressed during this calculation . >>

Out[969]=



In[970]:= **S11RE**

Part::pkspec1 : The expression x cannot be used as a part specification . ≫

Part::pkspec1 : The expression x cannot be used as a part specification . ≫

Out[970]= $10^{\frac{1}{10}}$ {-0.739543,-0.74244,-0.733496,-0.745431,-0.744487,-0.759022,-0.766563,-0.763719,-0.754953,-0.7672,-0.774757,-0.7

Cos [

° {-169.924, -169.962, -170.198, -170.161, -170.279, -170.448, -170.558, -170.562,
-170.795, -170.838, -170.941, -171.003, -171.051, -171.243, -171.314,
-171.388, -171.421, -171.592, -171.662, -171.843, -171.933, -172.012,
-172.05, -172.127, -172.253, -172.417, -172.476, -172.58, -172.739, -172.815,
-172.903, -172.995, -173.076, -173.131, -173.321, -173.351, -173.452,
-173.594, -173.588, -173.687, -173.846, -173.834, -173.927, -174.036,
-174.145, -174.272, -174.315, -174.522, -174.564, -174.671, -174.832,
-174.906, -175.054, -175.14, -175.272, -175.436, -175.501, -175.624,
-175.774, -175.877, -175.986, -176.122, -176.235, -176.313, -176.455,
-176.56, -176.627, -176.856, -176.884, -176.983, -177.114, -177.246,
-177.385, -177.437, -177.531, -177.643, -177.811, -177.962, -178.009,
-178.131, -178.222, -178.271, -178.431, -178.621, -178.676, -178.736,
-178.767, -178.912, -179.062, -179.167, -179.287, -179.358, -179.458,
-179.584, -179.711, -179.832, -179.95, 179.947, 179.865, 179.793, 179.566,
179.536, 179.428, 179.227, 179.123, 179.01, 178.939, 178.815, 178.66, 178.503,
178.418, 178.307, 178.275, 178.042, 178.023, 177.842, 177.701, 177.657,
177.493, 177.438, 177.291, 177.25, 177.113, 177.002, 176.917, 176.745,
176.67, 176.535, 176.451, 176.329, 176.266, 176.151, 175.993, 175.94, 175.85,
175.755, 175.611, 175.531, 175.407, 175.278, 175.289, 175.126, 175.074,
174.984, 174.905, 174.756, 174.709, 174.637, 174.563, 174.405, 174.296,
174.173, 174.114, 173.987, 173.945, 173.865, 173.67, 173.665, 173.528,
173.378, 173.373, 173.218, 173.192, 173.072, 172.991, 172.893, 172.751,
172.658, 172.576, 172.441, 172.371, 172.203, 172.149, 171.994, 171.899,
171.797, 171.793, 171.599, 171.506, 171.406, 171.256, 171.216, 171.094,
170.999, 170.877, 170.751, 170.674, 170.54, 170.403, 170.283, 170.087,
170.058, 169.979, 169.928, 169.857, 169.83, 169.692, 169.619, 169.575,
169.494, 169.347, 169.274, 169.173, 169.153, 168.992, 168.937, 168.812,
168.719, 168.598, 168.477, 168.419, 168.32, 168.244, 168.12, 168.003, 167.939,
167.835, 167.66, 167.555, 167.474, 167.36, 167.255, 167.094, 167.001, 166.873,
166.764, 166.666, 166.58, 166.454, 166.371, 166.247, 166.207, 166.101,
165.986, 165.859, 165.783, 165.674, 165.548, 165.496, 165.401, 165.27,
165.221, 165.053, 164.976, 164.813, 164.708, 164.608, 164.486, 164.415, 164.3,
164.189, 164.079, 163.947, 163.828, 163.742, 163.643, 163.573, 163.392,

163.286, 163.174, 163.076, 162.937, 162.864, 162.742, 162.599, 162.504,
162.386, 162.243, 162.136, 161.974, 161.874, 161.698, 161.514, 161.461,
161.326, 161.263, 161.009, 160.92, 160.807, 160.601, 160.475, 160.361,
160.147, 160.071, 159.877, 159.789, 159.601, 159.548, 159.395, 159.285,
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156.626, 156.432, 156.312, 156.176, 155.989, 155.834, 155.738, 155.552,
155.356, 155.159, 154.959, 154.736, 154.535, 154.4, 154.189, 154.014, 153.773,
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151.907, 151.662, 151.449, 151.228, 151.052, 150.776, 150.59, 150.226,
149.941, 149.721, 149.447, 149.196, 148.915, 148.593, 148.292, 147.938,
147.722, 147.36, 147.034, 146.73, 146.303, 146.053, 145.563, 145.255, 144.87,
144.501, 144.013, 143.543, 143.152, 142.679, 142.131, 141.664, 141.099,
140.561, 140.079, 139.439, 138.757, 138.086, 137.447, 136.606, 135.994,
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−148.306, −150.635, −152.986, −155.405, −157.995, −160.268, −162.367,
−164.358, −166.33, −168.032, −169.723, −171.281, −172.758, −174.186,
−175.418, −176.677, −177.789, −178.952, −179.89, 179.094, 178.241, 177.337,
176.568, 175.89, 175.191, 174.44, 173.789, 173.219, 172.715, 172.139, 171.647,
171.125, 170.622, 170.146, 169.692, 169.233, 168.77, 168.359, 168.023,
167.546, 167.176, 166.722, 166.478, 166.115, 165.747, 165.375, 165.04,
164.768, 164.331, 164.108, 163.845, 163.636, 163.247, 163.058, 162.778,
162.542, 162.321, 162.044, 161.734, 161.582, 161.38, 161.141, 160.927,
160.801, 160.599, 160.297, 160.081, 159.834, 159.618, 159.369, 159.233,
159.054, 158.816, 158.726, 158.477, 158.234, 158.004, 157.909, 157.658,
157.524, 157.365, 157.164, 156.807, 156.597, 156.401, 156.036, 155.892,
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153.664, 153.427, 153.336, 153.119, 152.991, 152.764, 152.575, 152.531,
152.298, 152.122, 152.075, 151.936, 151.715, 151.561, 151.406, 151.267,
151.157, 151.003, 150.905, 150.779, 150.605, 150.467, 150.4, 150.324,
150.099, 149.958, 149.842, 149.69, 149.531, 149.446, 149.367, 149.198,
149.096, 148.913, 148.811, 148.617, 148.538, 148.434, 148.235, 148.139,
148.078, 147.822, 147.761, 147.566, 147.573, 147.389, 147.231, 147.152,
146.972, 146.889, 146.754, 146.641, 146.529, 146.419, 146.281, 146.176,
146.051, 145.98, 145.876, 145.778, 145.542, 145.601, 145.384, 145.368,
145.221, 145.032, 144.975, 144.868, 144.796, 144.603, 144.525, 144.448,
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132.58, 132.429, 132.363, 132.251, 132.143, 132.085, 131.961, 131.866,
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```
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129.14, 129.015, 128.958, 128.857, 128.73, 128.633, 128.578, 128.471,
128.402, 128.278, 128.209, 128.055, 127.983, 127.921, 127.756, 127.663,
127.518, 127.456, 127.282, 127.259, 127.133, 127.005, 126.933, 126.839,
126.73, 126.703, 126.594, 126.499, 126.39, 126.336, 126.206, 126.092,
125.963, 125.898, 125.861, 125.708, 125.617, 125.533, 125.425, 125.334,
125.245, 125.13, 125.035, 124.944, 124.833, 124.766, 124.641, 124.525,
124.5, 124.342, 124.296, 124.179, 124.082, 124.014, 123.879, 123.808,
123.743, 123.621, 123.543, 123.415, 123.279, 123.203, 123.064, 123.009,
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122.074, 121.989, 121.888, 121.749, 121.677, 121.625, 121.538, 121.399}[[x]]]
```